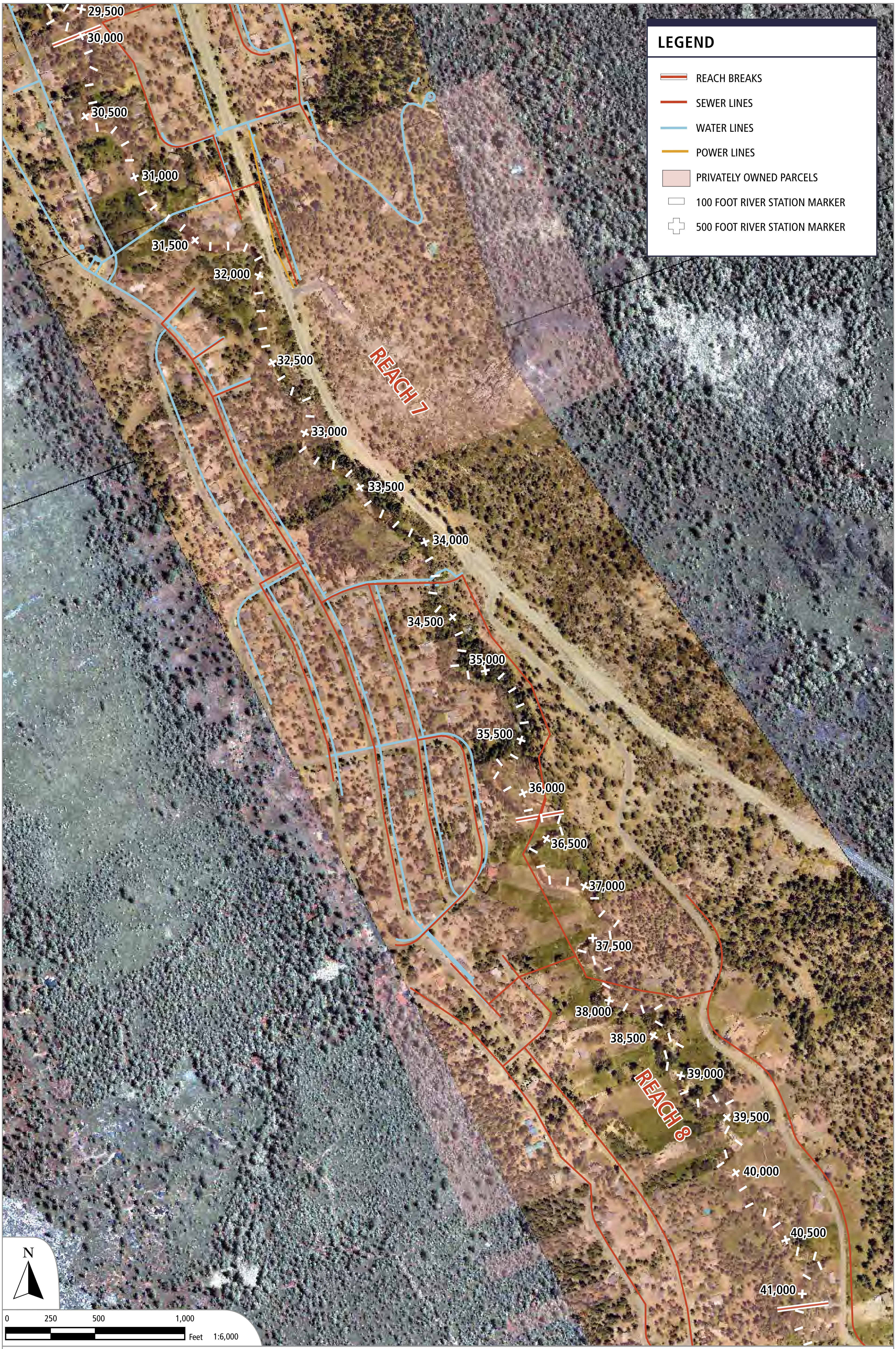

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FIGURE 3.13D: Map indicating location of sewer and water lines relative to the Upper Truckee River (Reaches 7-8).

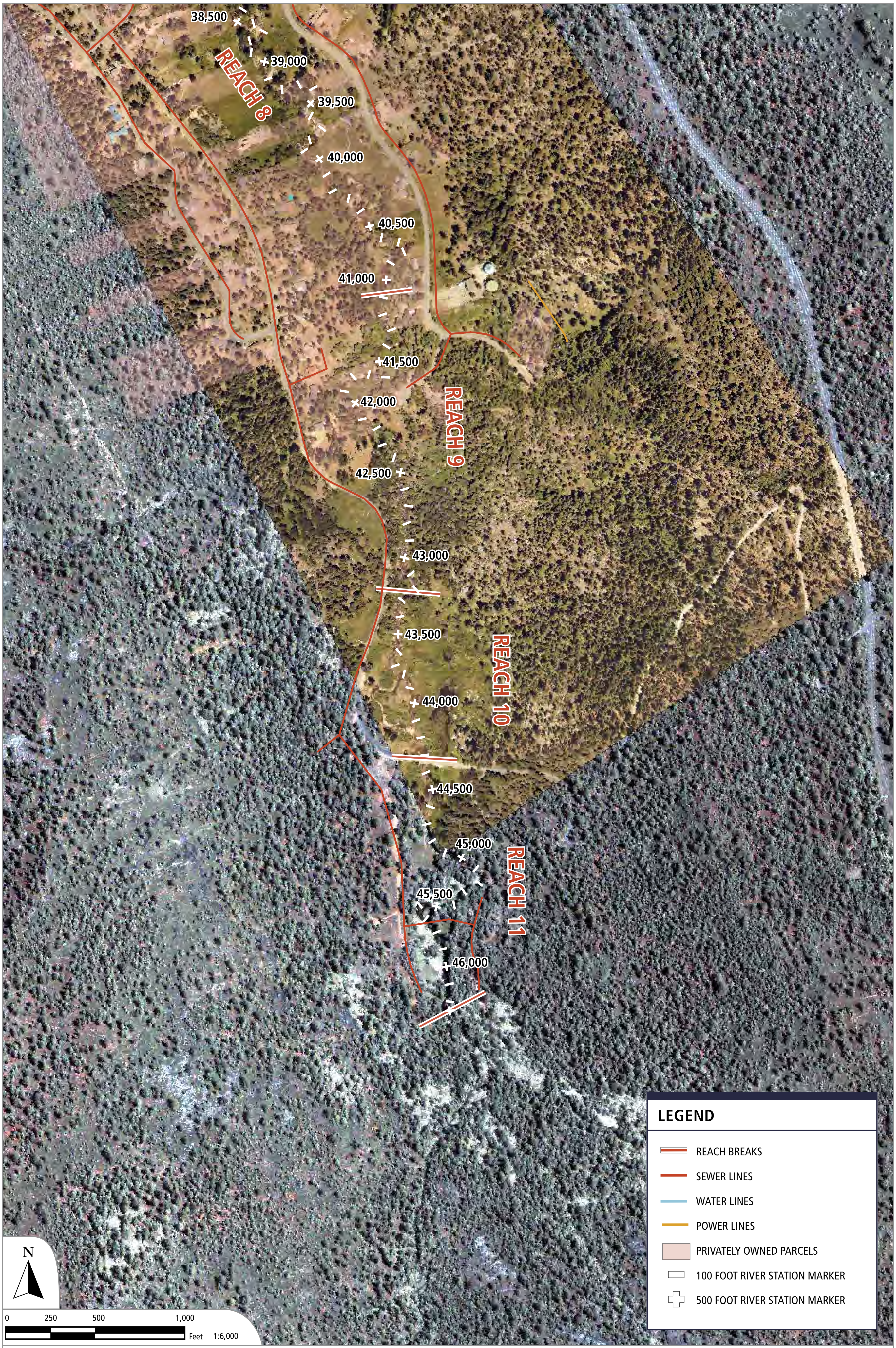

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FIGURE 3.13E: Map indicating location of sewer and water lines relative to the Upper Truckee River (Reaches 9-11).

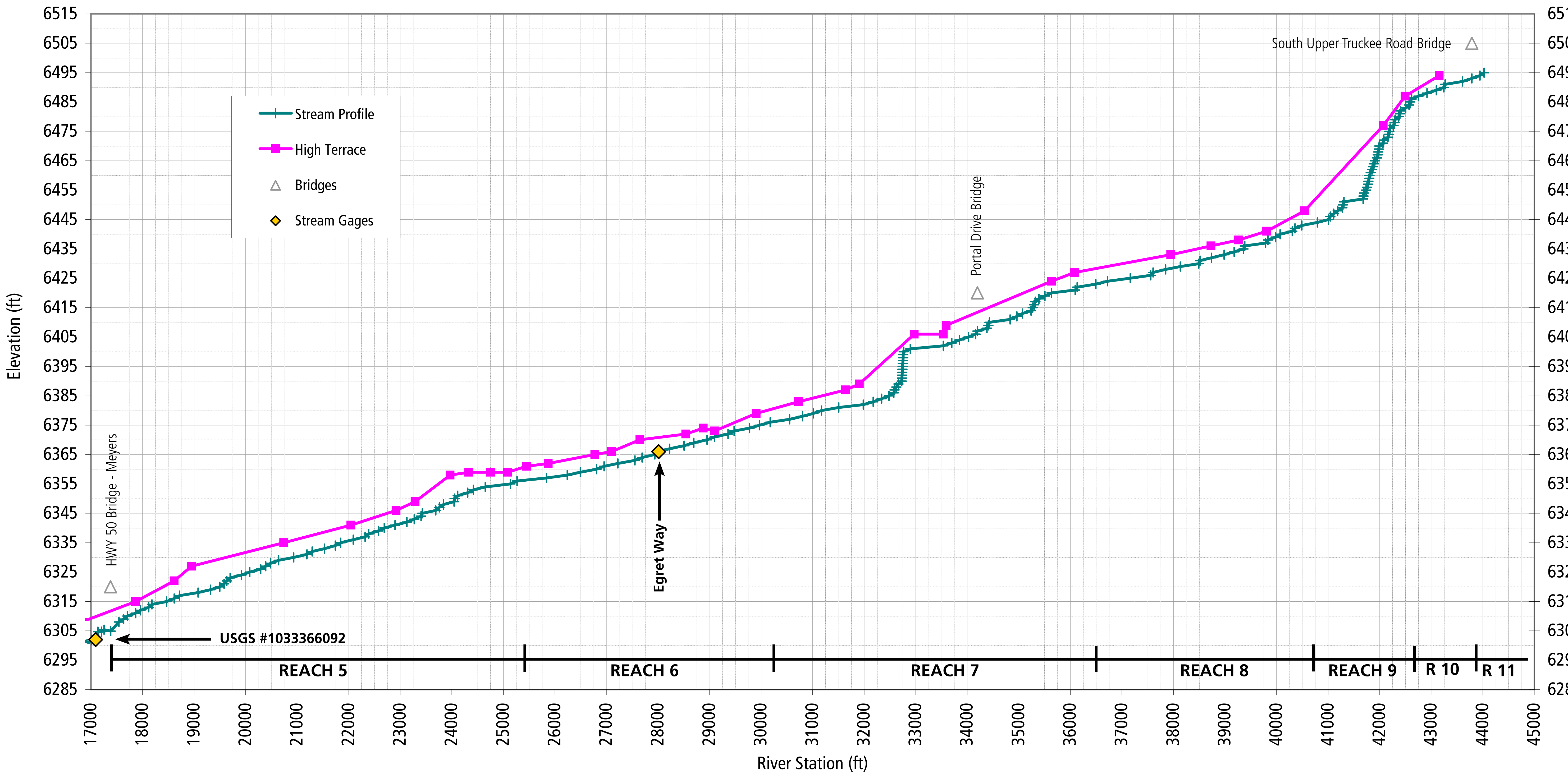

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FIGURE 3.14: Longitudinal profile of Upper Truckee River from Meyers Highway 50 crossing to the South Upper Truckee Road Bridge (Reaches 5-11). Profile and high terrace elevations were created using the 2003 LIDAR survey.

the profile. The Christmas Valley profile reveals several significant steep bedrock or boulder control reaches separated by several reaches of flatter meadow sections.

Sequential long profile plots provided by the CDPR (ongoing from 1992) show profile instability in the movement of headcuts along with areas of pool development (Figure 3.15).

Channel Geometry

Channel hydraulic geometry relationships for the UTR were developed for multiple locations. Channel geometry was measured at repeated cross sections set up by CDPR, in addition to several other locations established by SH+G. Three stage recorders were installed in Reaches 1 through 4 and one in Christmas Valley from March through July 2003 to record the stage and water surface elevations of various flows occurring during the 2003 snowmelt (Figure 3.1). The instrument installed in Christmas Valley failed and no useful data was obtained from that station. Stage measurements at each cross section were correlated with the continuous flow measurements taken at the USGS stream gage Upper Truckee River near Meyers (#106633092). Rating curves were created to relate water surface elevation to streamflow. Based on cross-sectional area measurements, channel geometry and water surface elevation for key discharge values for channel forming features (bankfull stage, terrace elevations) were calculated for each of the three gage locations. Additionally, during the longitudinal profile survey, measurements of channel forming features were taken, including the elevation of bankfull indicators and terraces. The results of this monitoring are shown in Figures 3.16A-C through 3.18A-C.

As the cross-sections illustrate, the clearest bankfull indicators of recent geomorphic floodplain formation occur in the narrow zone of the incised channel between 350 and 400 cfs. This bankfull flow agrees with the partial duration flood frequency analysis of 1.5-year flow at the USGS gage in Meyers (Table 3.2), as well as with past measurements and estimates of bankfull flow in the UTR (Table 3.3), which also correspond to the 1.5-year peak flow for snowmelt events (Swanson, 2003; Hanes and Swanson 1997; 1995). Based upon the spring 2003 stage measurements and channel geometry, the estimated channel flood capacity at these three sites is on the order of 600 to 800 cfs.

Sequential cross sections (ongoing since 1992) plotted by the CDFG show significant bank erosion and incision in recent years (Appendix A). Some of this change was likely due to the record 1997 flood, however there are changes that do signify ongoing instability in cross section and planform, suggesting continuing adjustment to channelization (Figure 3.19). This must be carefully considered in designing any restoration plan.

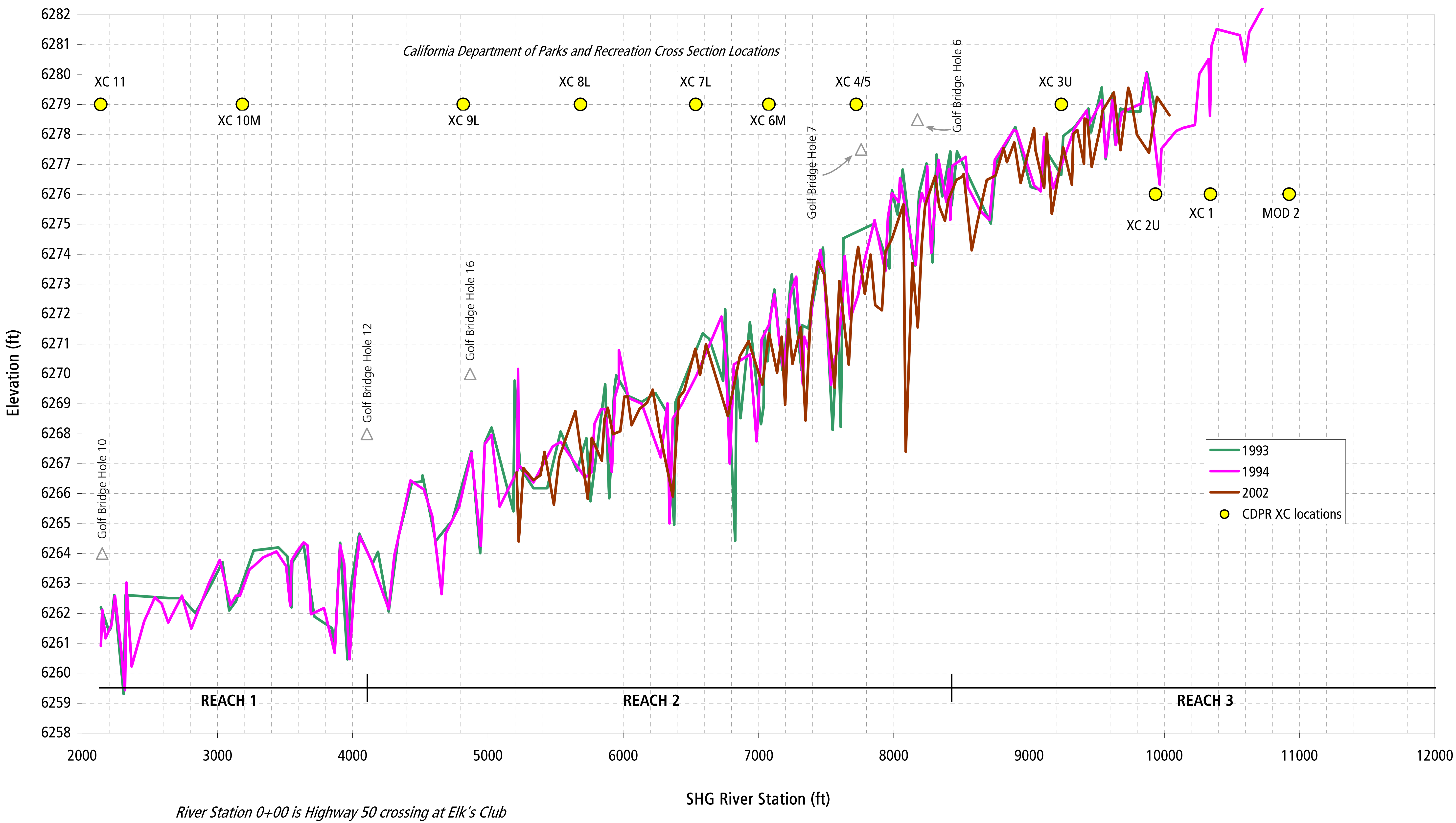

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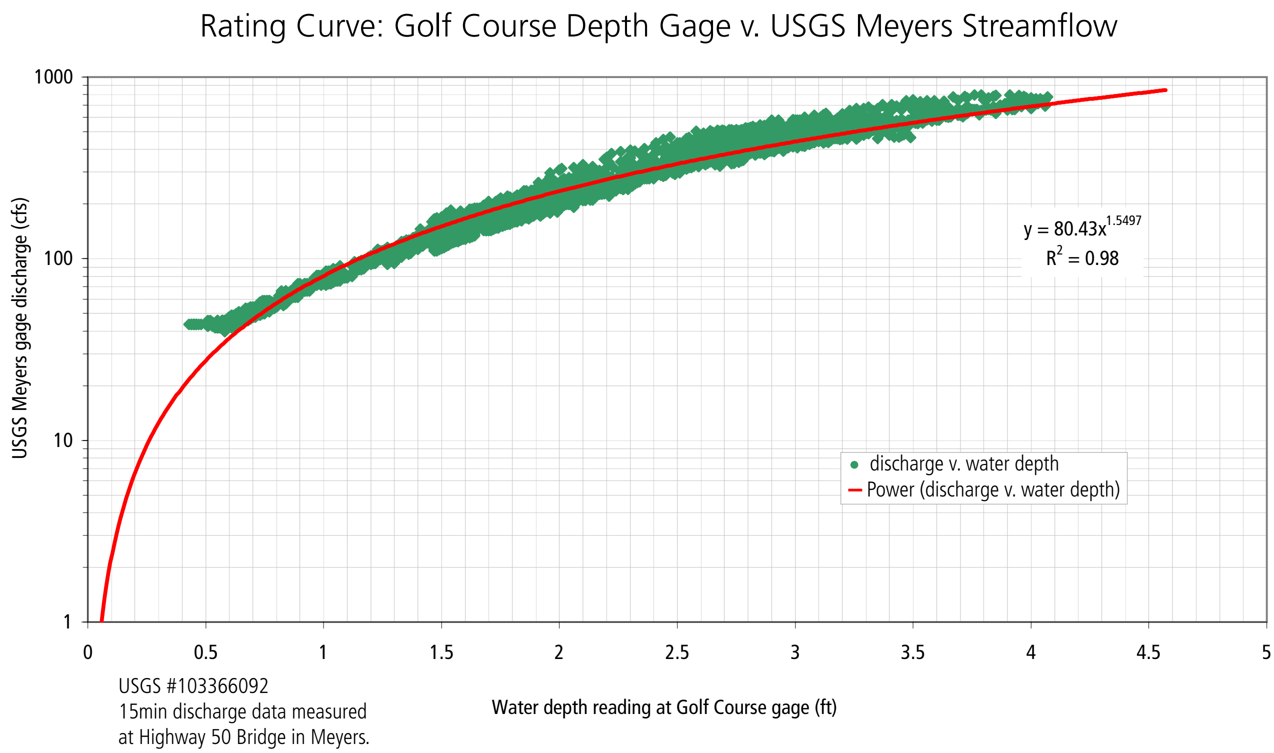
FIGURE 3.15: Comparison of longitudinal profile of Upper Truckee River in Reaches 1-3 as surveyed by the California Department of Parks and Recreation in 1993, 1994 and 2002. Note the movement of the active headcuts through the profile. See Appendix A for site locations.

SH+G GOLF COURSE GAGE



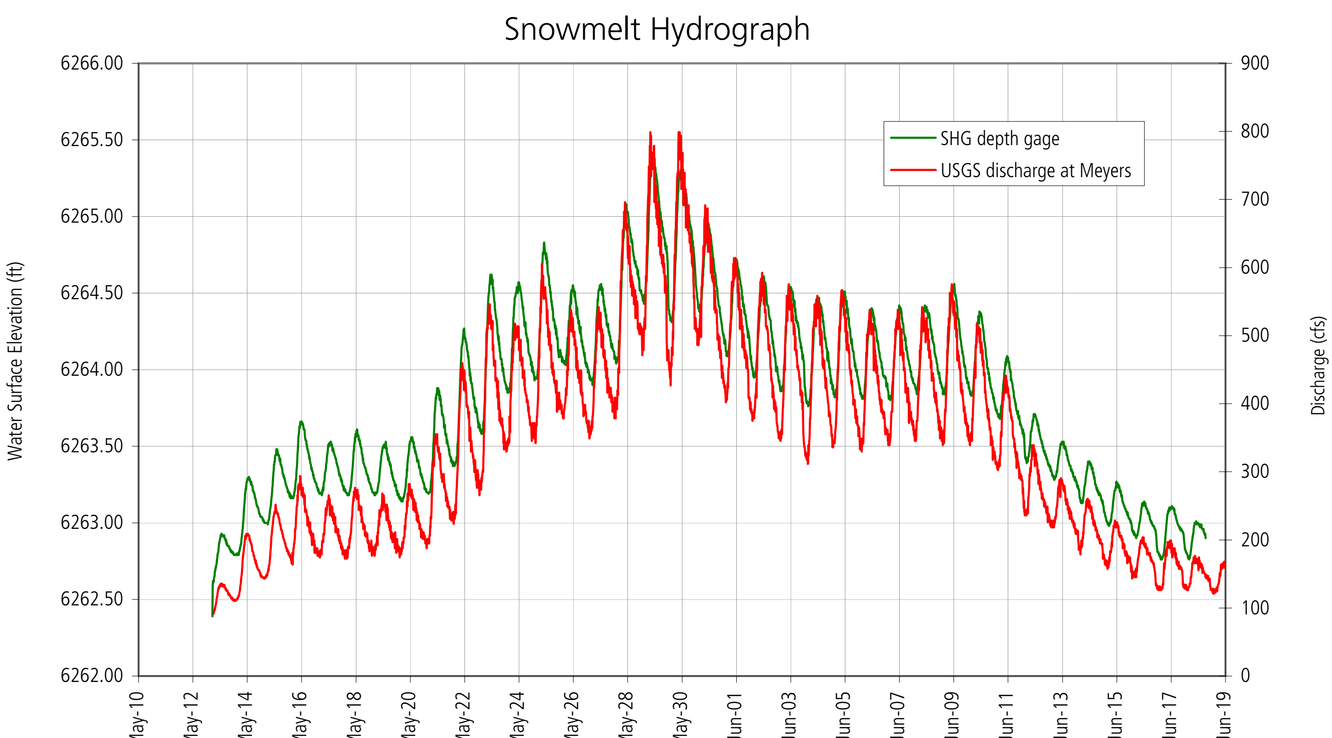


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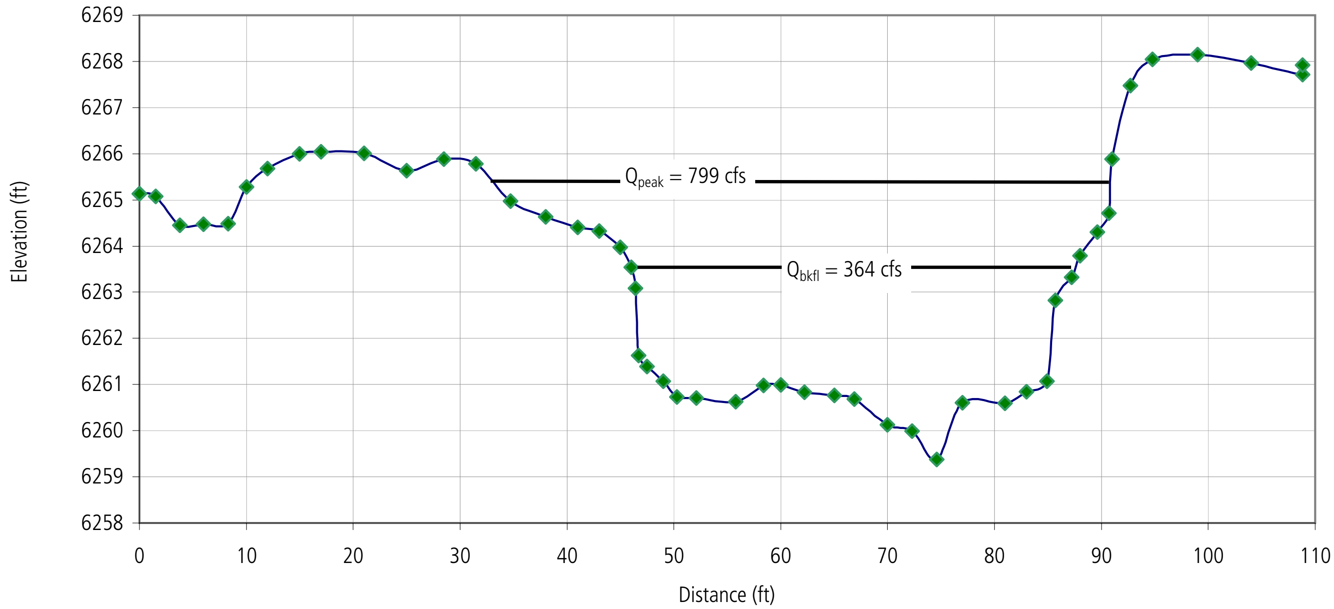
FIGURE 3.16A: WY 2003 snowmelt data for the Upper Truckee River at the SH+G Golf Course gage (see Figure 3.1 for gage locations). Upper graph presents simultaneous readings at USGS #103366092 and SH+G Golf Course depth gage. The bottom graph is the snowmelt hydrograph recorded by the SH+G Golf Course gage and USGS gage.

SH+G GOLF COURSE GAGE

Channel Cross-section at Gage and Key Channel Features



Q_{peak}: 2003 SHG depth gage peak on 5/29/03

Q_{bkfl} : based on channel features

Photo of Channel at Gage Looking Downstream

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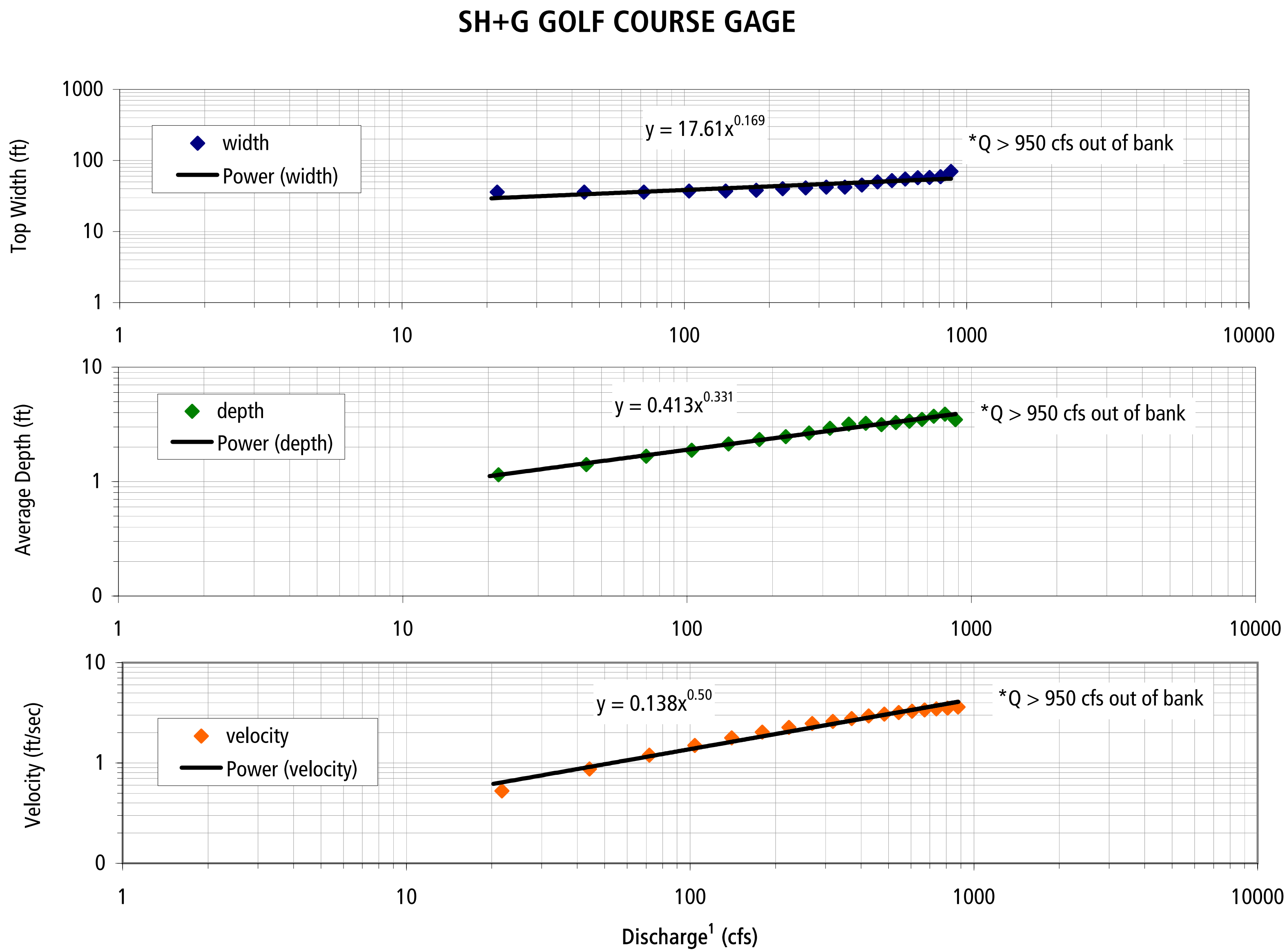
FIGURE 3.16B: Channel cross-section surveyed at location of SH+G Golf Course gage by California State Parks in September, 2003. Key channel features were identified in the field and associated discharge was calculated using depth gage data.



[1] discharge measured at USGS Gage #103366092 in Meyers

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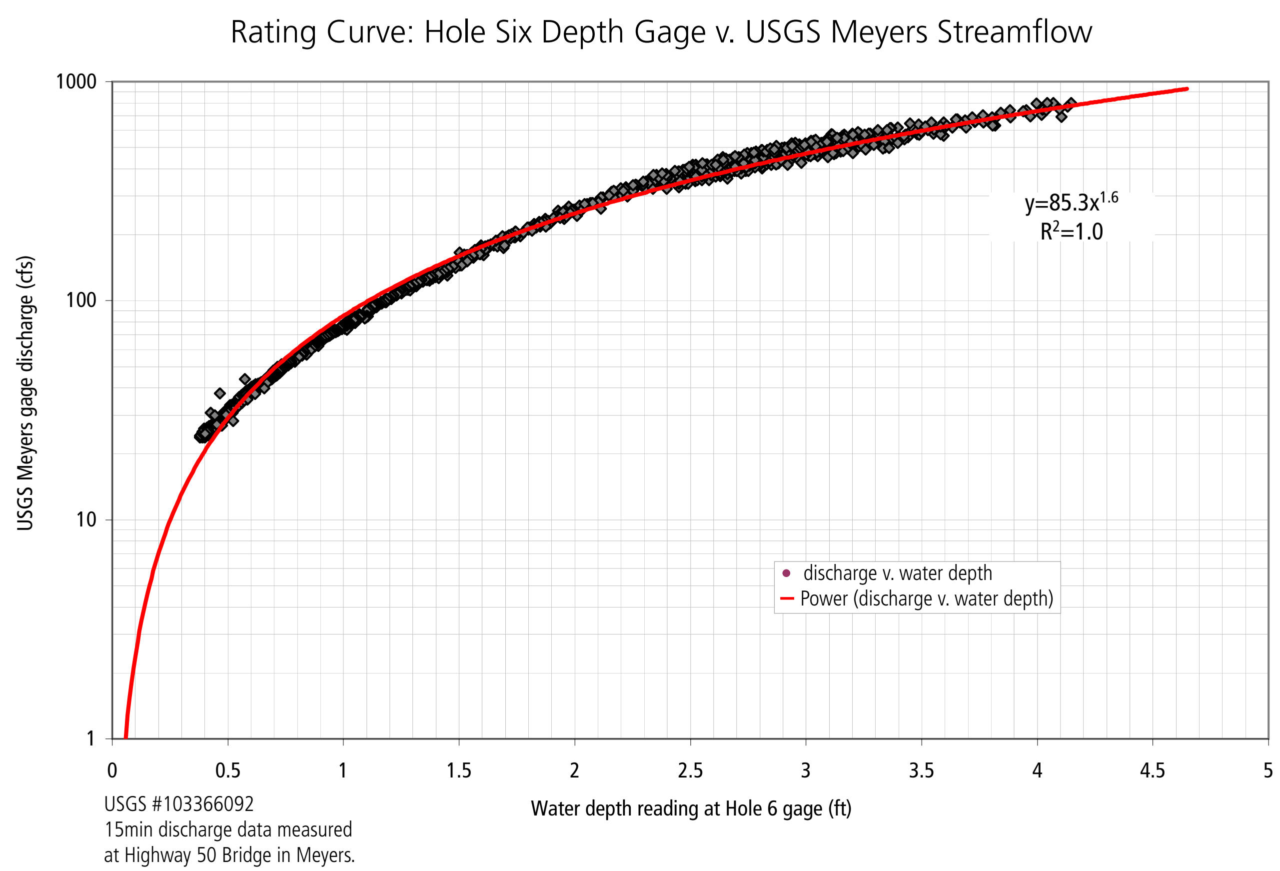
FIGURE 3.16C: Channel geometry calculated for Upper Truckee River at SH+G Golf Course Gage.

SH+G HOLE 6 GAGE



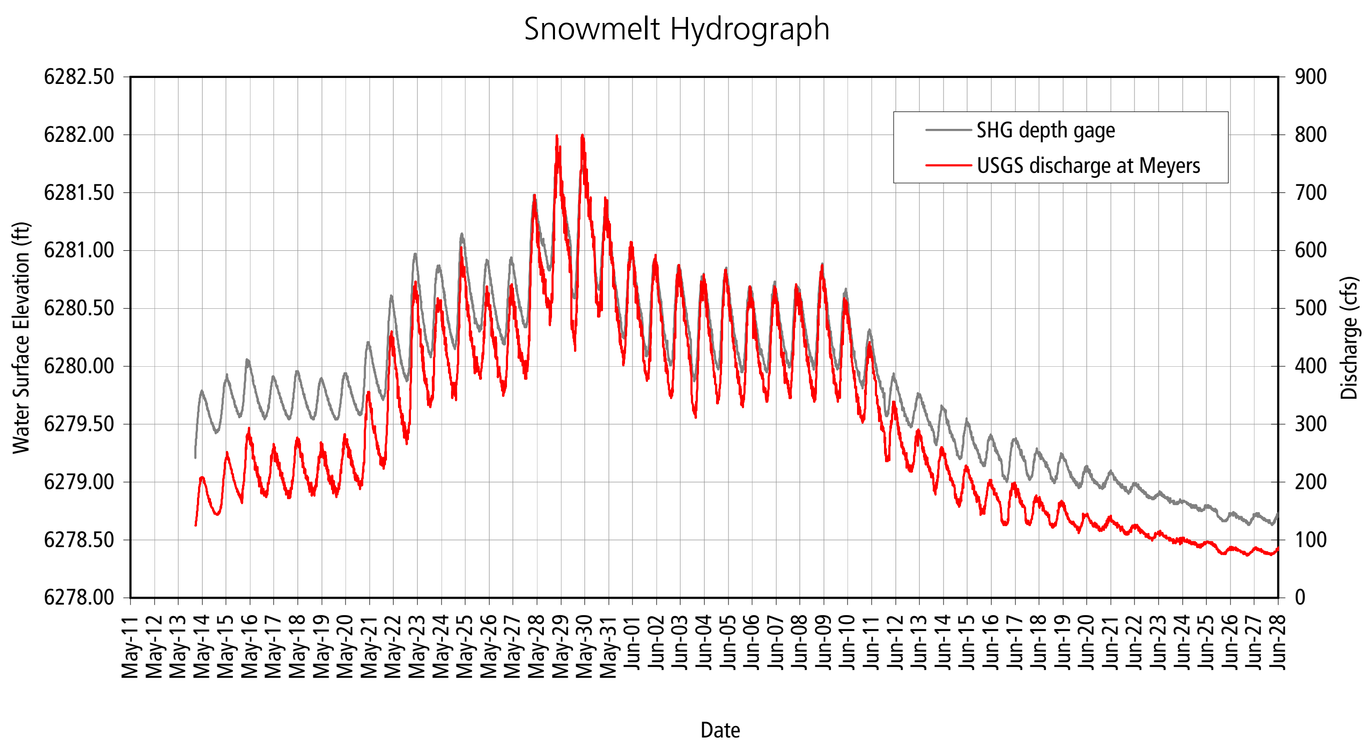


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FIGURE 3.17A: WY 2003 snowmelt data for the Upper Truckee River at the SH+G Hole 6 gage (see Figure 3.1 for gage locations). Upper graph presents simultaneous readings at USGS gage #103366092 and the SH+G Hole 6 depth gage. The bottom graph is the snowmelt hydrograph recorded by the SH+G Hole 6 gage and the USGS gage.

SH+G HOLE 6 GAGE

Channel Cross-section at Gage and Key Channel Features

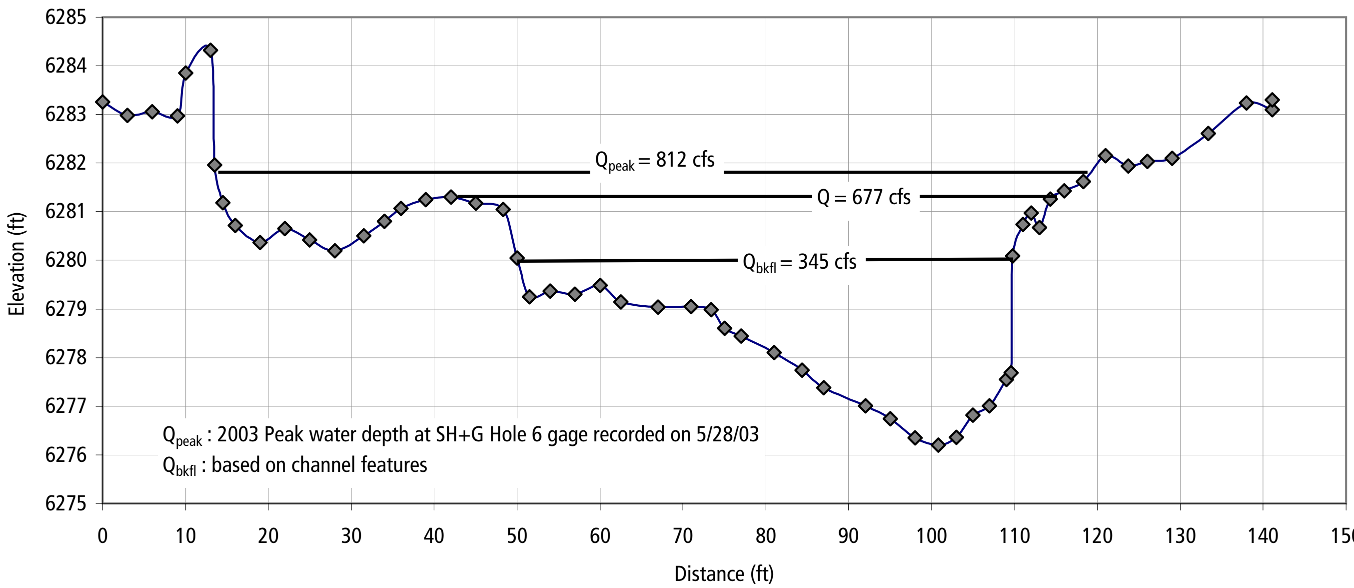

Photo of Channel at Gage

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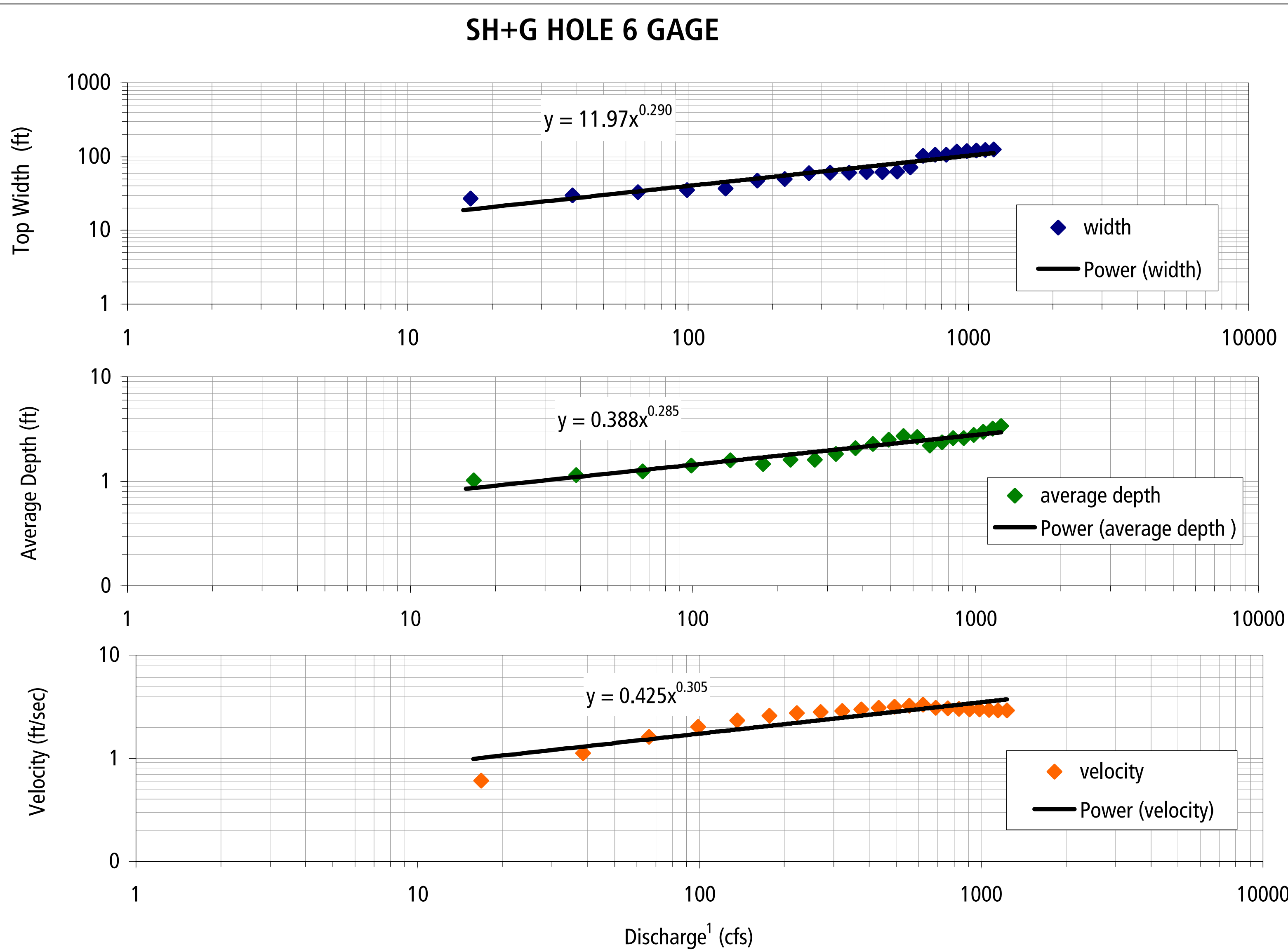
FIGURE 3.17B: Channel cross-section surveyed at location of SH+G Hole 6 gage by California State Parks in September, 2003. Key channel features were identified in the field and associated discharge was calculated using depth gage data.



[1] discharge measured at USGS Gage #103366092 in Meyers

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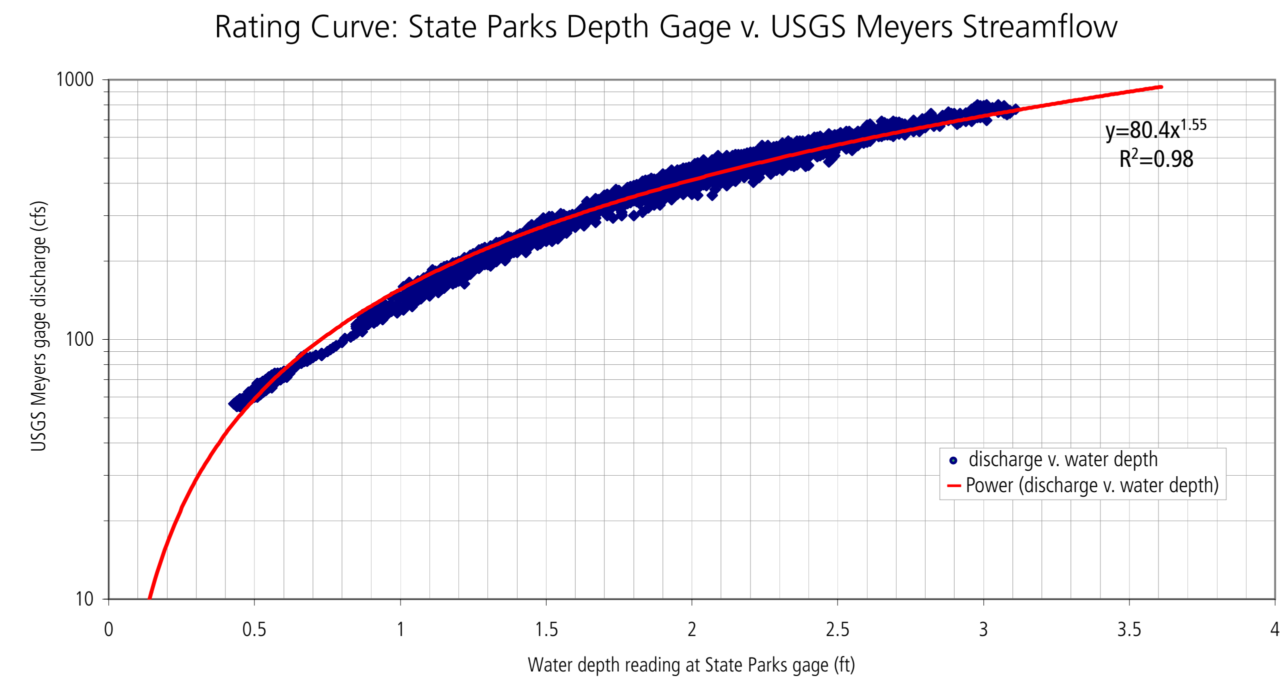
FIGURE 3.17C: Channel geometry calculated for Upper Truckee River at SH+G Hole 6 Gage.

SH+G STATE PARKS GAGE



USGS #103366092
15min discharge data measured
at Highway 50 Bridge in Meyers.

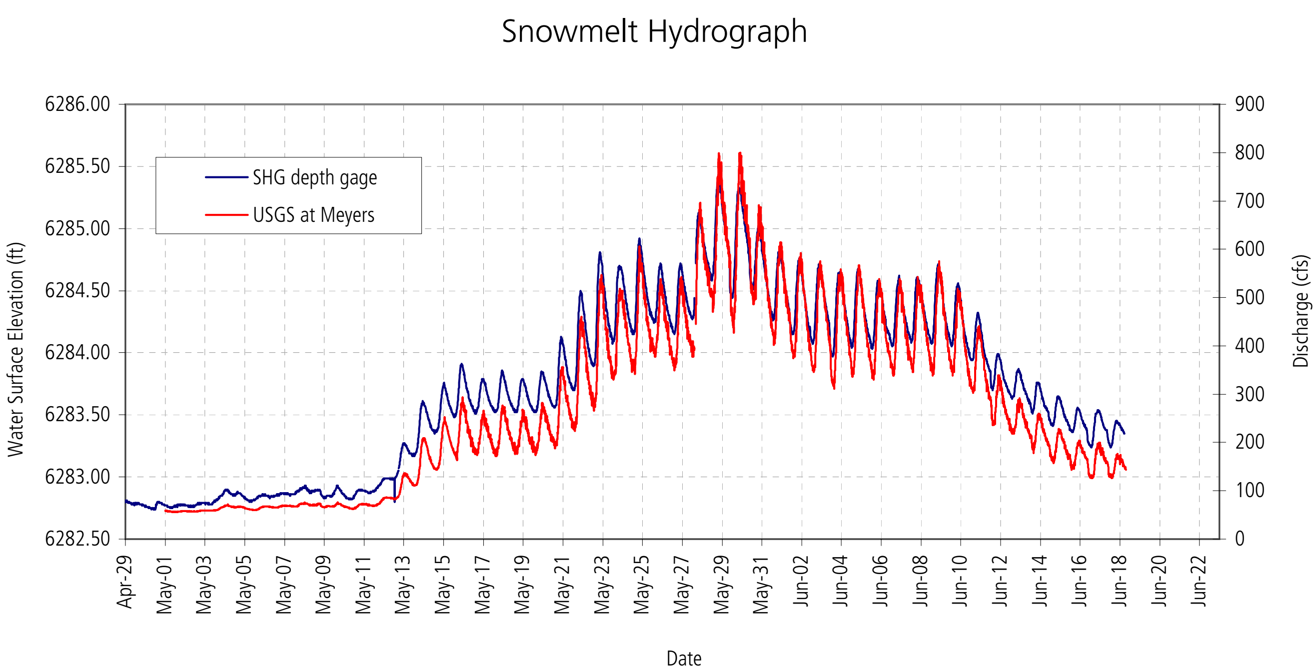


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FIGURE 3.18A: WY 2003 snowmelt data for the Upper Truckee River at the SH+G State Parks gage (see Figure 3.1 for gage locations). Upper graph presents simultaneous readings at USGS #103366092 and SH+G State Parks depth gage. The bottom graph is the snowmelt hydrograph recorded by SH+G State Parks gage and USGS gage.

SH+G STATE PARKS GAGE

Channel Cross-section at Gage and Key Channel Features

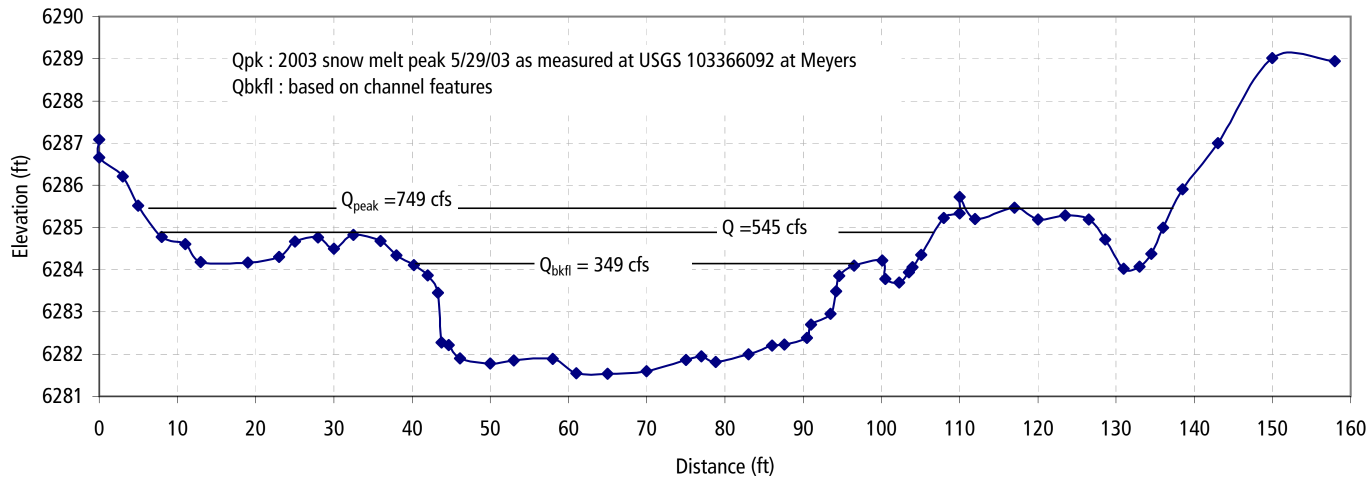

Photo of Channel at Gage Looking Upstream

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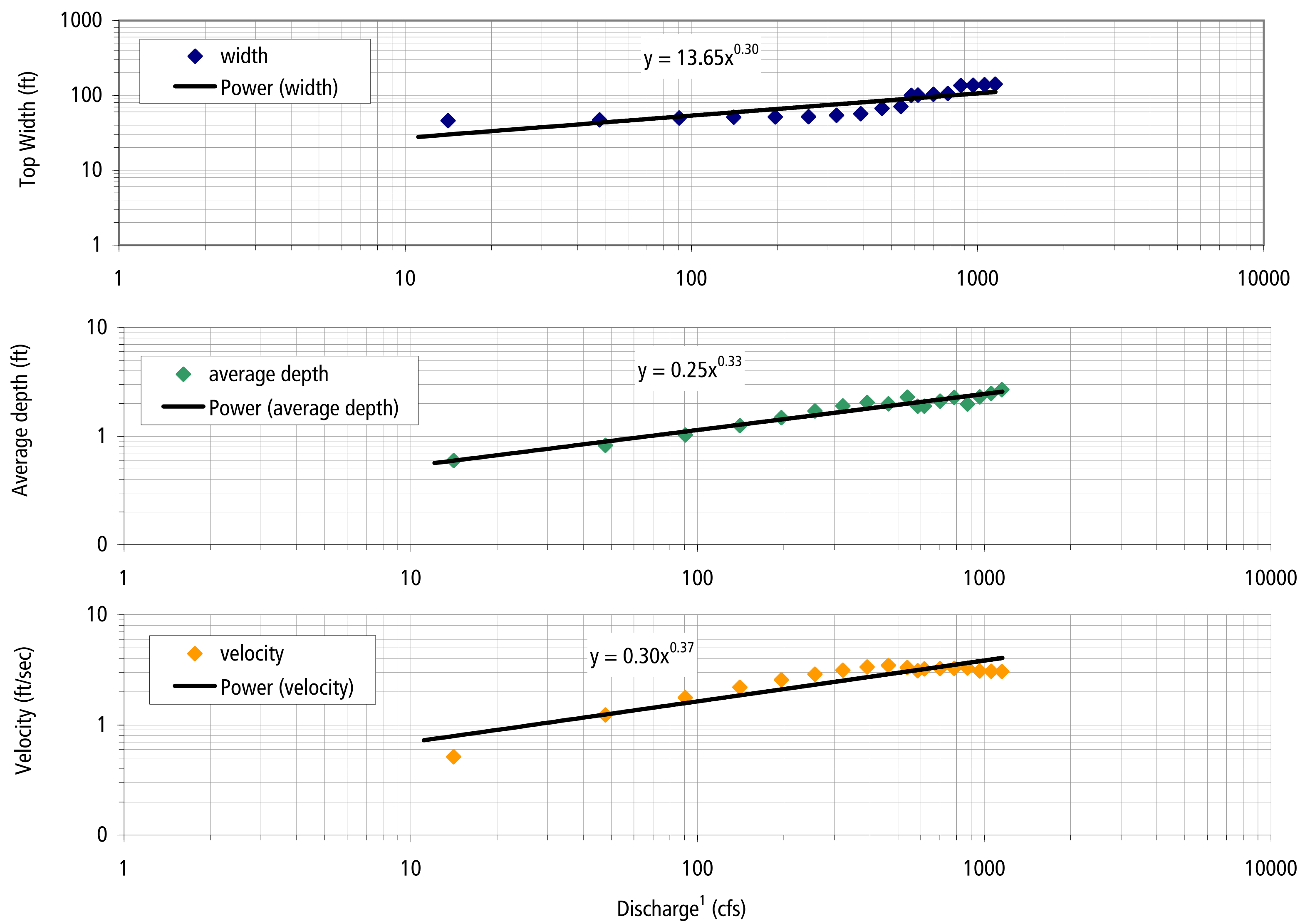
FIGURE 3.18B: Channel cross-section surveyed at location of SH+G State Parks gage by California State Parks in September, 2003. Key channel features were identified in the field and associated discharge was calculated using depth gage data.

SH+G STATE PARKS GAGE



[1] discharge measured at USGS Gage #103366092 in Meyers

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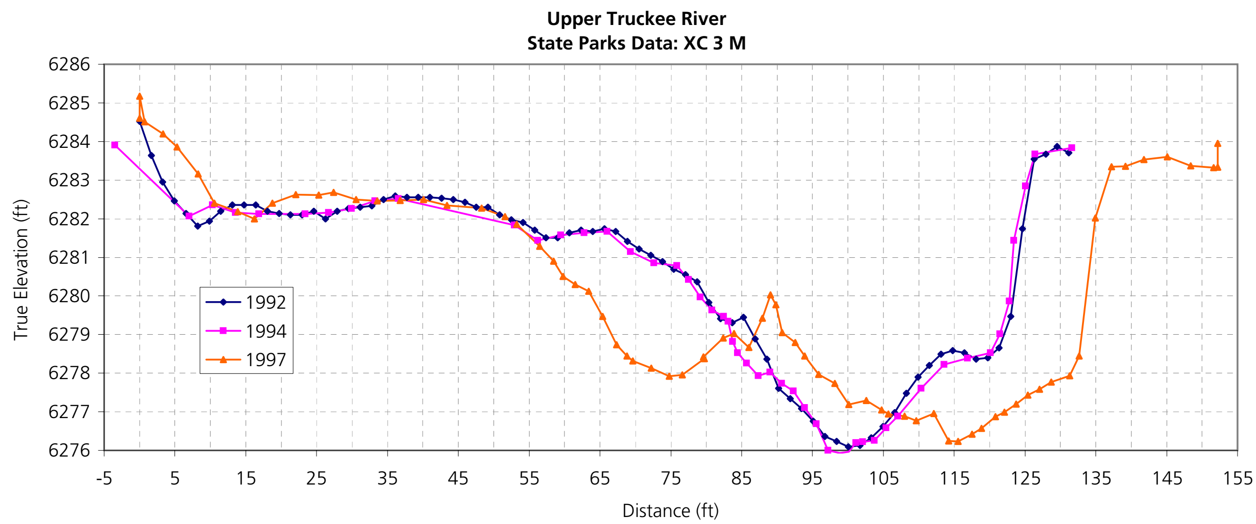
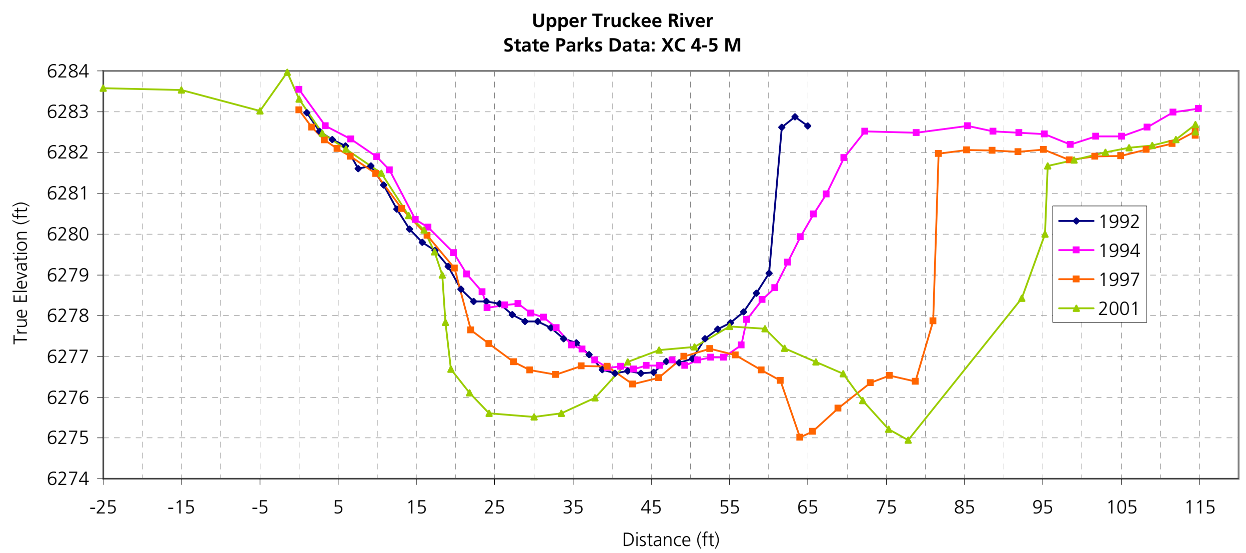
FIGURE 3.18C: Channel geometry calculated for Upper Truckee River at SH+G State Parks Gage.





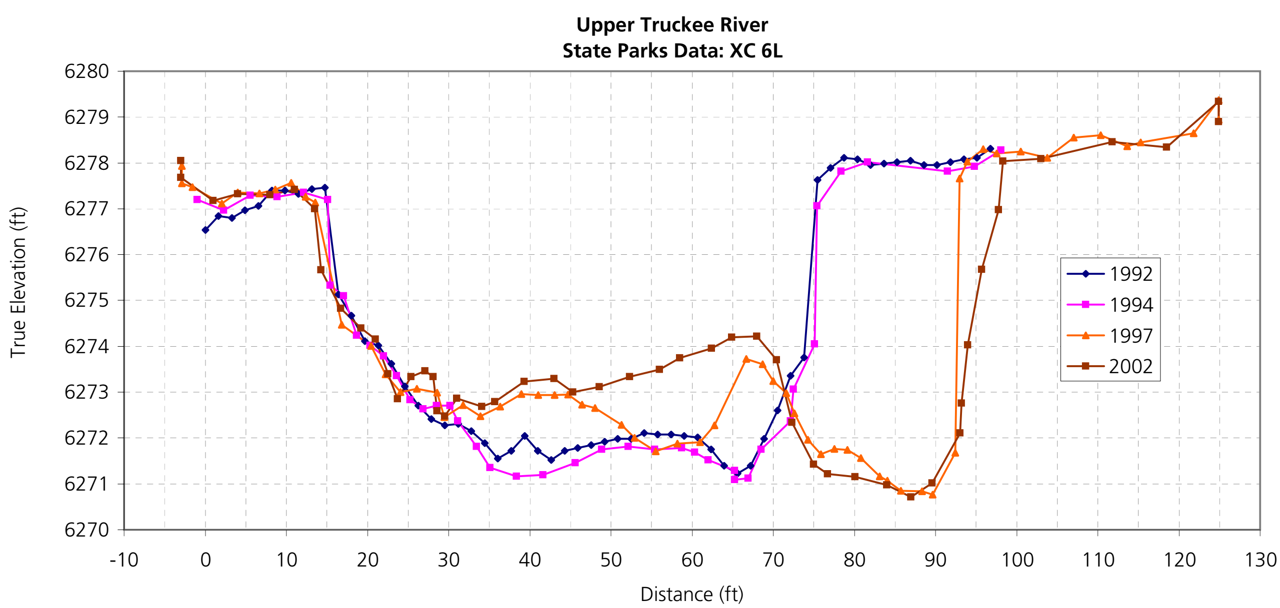


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FIGURE 3.19: Comparison of cross-section surveys of the Upper Truckee River by California Department of Parks and Recreation from 1992-2002. See Appendix A for locations of cross sections.

Upper Truckee River
Bankfull Channel Charactertistics

	Station Location[1]	Station Operator	Station ID	Date of Measurements[2]	Q_{bkfl}	Channel Geometry at Bankfull Flow: mean depth (ft)	top width (ft)	mean velocity (ft/s)
upstream								
	SHG River Station 17000 DA= 34.3 mi^2	USGS	#103366092	2003	336	1.8	62	3.2
	SHG River Station 10800	SHG	State Parks	2003	364	2.9	56	2.6
	SHG River Station 8900	SHG	Hole 6	2003	346	2.1	65	2.5
	SHG River Station 1600	SHG	Golf Course	2003	349	1.7	79	2.6
	Downstream of Elks Club (Station -1750)	SHG	Elks Lodge Reach Ave	1997	370	2.4	68	2.4
	Downstream of Elks Club (station -3600)	SHG	Lodgepole Reach Ave	1997	370	2.7	63	2.3
downstream	Downstream of Elks Club (station -6000)	SHG	Airport Reach Ave	1997	370	2.3	51	3.2
				Recent	**Ave**	**2.3**	**63**	**2.7**

1995 channel comparison

pre-1997 storm	Downstream of Elks Club (Station -1750)	SHG	Elks Lodge Reach Ave	1995	370	2.3	58	2.8
	Downstream of Elks Club (station -3600)	SHG	Lodgepole Reach Ave	1995	370	1.6	41	5.7
	Downstream of Elks Club (station -6000)	SHG	Airport Reach Ave	1995	370	2.2	47	3.7
					1995 Ave	**2.0**	**49**	**4.1**

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TABLE 3.3: Summary of bankfull flow and channel geometry measurements taken on the Upper Truckee River from 1995 to 2003. [1]SHG 2003 Upper Truckee River at Elks Club Hwy 50 crossing 0+00; Approximate distance (ft) upstream (+) or downstream (-) of Elks Club provided. [2]SHG 2003 data from this study; USGS 2003 data from USGS 9-207 forms; SHG1995 & 1997 from Upper Truckee River prepared for The California Tahoe Conservancy, by Swanson Hydrology & Geomorphology and Hydroscience. October 27, 1997.

Planform Sinuosity

Changes in planform sinuosity were assessed using aerial photographs, the longitudinal profile survey, and field evidence of past channel and floodplain formation. Some planform characteristics were presented in Chapter II and plotted in Figure 2.7. The historic loss of planform was greater in Reaches 1 – 4 and less pronounced in Reaches 5-11. The present values are shown in Table 2.1 and range between 1.2 and 1.7.

The historic assessment found evidence in planform sinuosity reduction and consequent channel incision. There has been between one and eight feet of channel bed incision historically in the project reach. This corresponds to the difference between terrace elevations and bankfull presented in Figures 2.5 and 3.14.

CHANNEL BANK EROSION SURVEY

A database of erosion hazard potential for the banks of the UTR was completed in the spring and summer of 2003. SH+G used a methodology modified after Rosgen (1996) that measures key geomorphic and vegetative variables associated with bank stability. These were mapped for each uniform segment of bank along the mainstem UTR from the Elks Club Highway 50 crossing to the USFS Bridge Tract Summer Homes over seven miles upstream. In addition, several of the main alluvial tributaries to the mainstem UTR were surveyed and measured, including Big Meadow Creek in Cookhouse Meadow and select reaches of Grass Lake Creek and are discussed below.

The results of the mainstem UTR bank erosion survey are presented in Figures 3.20A-F and 3.21 and summarized in Table 3.4 (the complete database is presented in Appendix B). The data reflect the recent history of channel incision, with many reaches of unstable banks undercutting bank vegetation, especially in Reaches 1-4. High erosion hazards are also found in the alluvial reaches of Christmas Valley, especially the meadow areas of Reaches 5, 7, 10 and 11. The erosion hazard rating also reflects the fact that many of the banks rating high erosion potential or above are chronic sources of fine sediments. Areas exhibiting low or moderate erosion hazards occur in reaches lined in boulders or bedrock. An interesting exception occurs in the lower end of Reach 3, where it appears that the stream bed is being held nearly at grade with adjacent valley flat similar to the relief that would have been expected prior to disturbance; this appears to be the result of an erosionally resistant layer of older glacial outwash cobble and small boulder underlying the stream bed.

Beyond the bank erosion survey, it is worth noting the effects of the beaver on the UTR, apparent since their introduction in the 1920s and 1930s. Beavers have a profound effect on channel morphology, erosion, and the hydrology of wetlands on the valley floor, and there are many active colonies in the study area and on other streams in the Tahoe Basin. Interviews conducted with Washoe Elders for this study did not reveal any recollection of beavers in the original landscape (see Section III.5); given the attention paid to the riparian landscapes by Washoe Tribe in their plant gathering and hunting activities, this seems to be reliable information. In other cases, there

Reach 1 Statistics

Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach	Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach
Right Bank	Very Low	476	12.7%	Left Bank	Very Low	95	2.5%
	Low	377	10.0%		Low	0	0.0%
	Moderate	997	26.6%		Moderate	1364	35.8%
	High	1191	31.7%		High	2352	61.7%
	Very High	305	8.1%		Very High	0	0.0%
	Extreme	410	10.9%		Extreme	0	0.0%
	Total	3756	100.0%		Total	3811	100.0%

Reach 2 Statistics

Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach	Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach
Right Bank	Very Low	640	12.0%	Left Bank	Very Low	397	8.5%
	Low	636	11.9%		Low	397	8.5%
	Moderate	1932	36.1%		Moderate	1916	41.0%
	High	308	5.8%		High	213	4.6%
	Very High	1391	26.0%		Very High	663	14.2%
	Extreme	440	8.2%		Extreme	1082	23.2%
	Total	5346	100.0%		Total	4667	100.0%

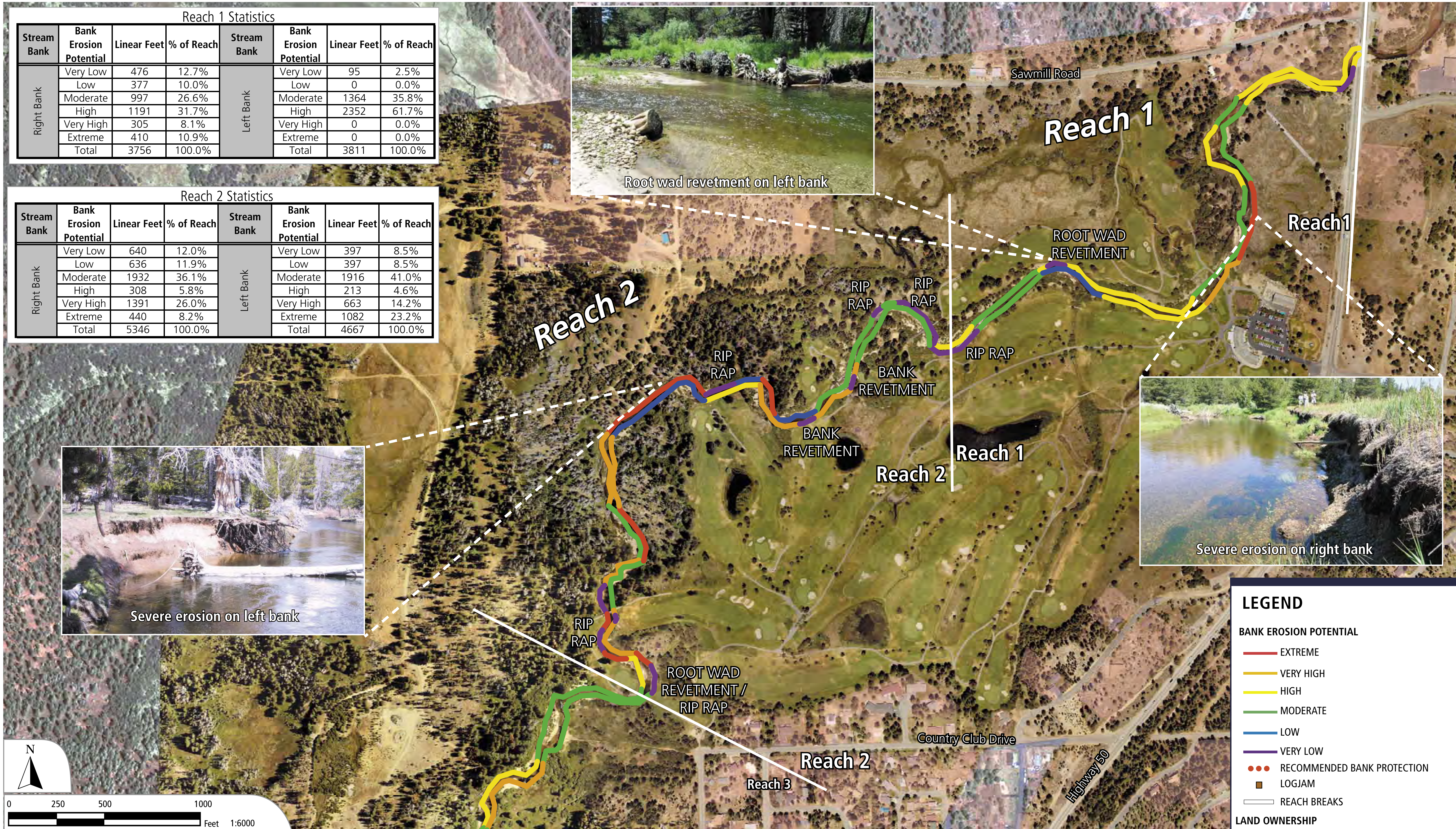

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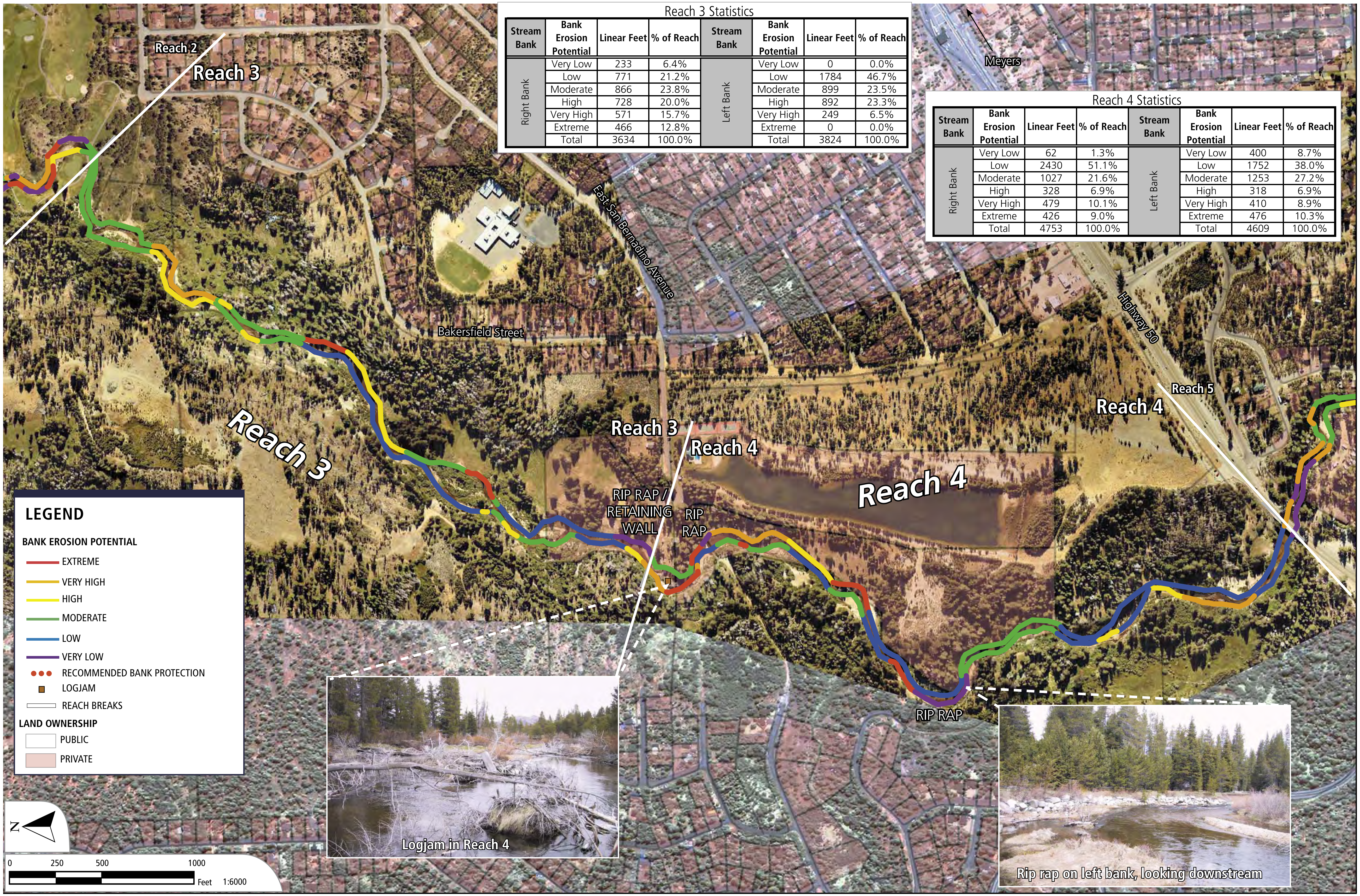
FIGURE 3.20A: Results of channel bank erosion survey for Reaches 1-2. Statistics by reach are summarized and photos provide visual reference for bank erosion potentials. Locations of bank erosion stabilization efforts are noted.



Reach 3 Statistics

Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach	Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach
Right Bank	Very Low	233	6.4%	Left Bank	Very Low	0	0.0%
	Low	771	21.2%		Low	1784	46.7%
	Moderate	866	23.8%		Moderate	899	23.5%
	High	728	20.0%		High	892	23.3%
	Very High	571	15.7%		Very High	249	6.5%
	Extreme	466	12.8%		Extreme	0	0.0%
	Total	3634	100.0%		Total	3824	100.0%

Reach 4 Statistics

Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach	Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach
Right Bank	Very Low	62	1.3%	Left Bank	Very Low	400	8.7%
	Low	2430	51.1%		Low	1752	38.0%
	Moderate	1027	21.6%		Moderate	1253	27.2%
	High	328	6.9%		High	318	6.9%
	Very High	479	10.1%		Very High	410	8.9%
	Extreme	426	9.0%		Extreme	476	10.3%
	Total	4753	100.0%		Total	4609	100.0%

FIGURE 3.20B: Bank erosion potential ratings for Reaches 3 and 4.

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Reach 5 Statistics

Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach	Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach
Right Bank	Very Low	118	1.5%	Left Bank	Very Low	440	5.8%
	Low	220	2.9%		Low	236	3.1%
	Moderate	1338	17.5%		Moderate	1050	13.9%
	High	600	7.8%		High	656	8.7%
	Very High	5380	70.3%		Very High	5002	66.4%
	Extreme	0	0.0%		Extreme	148	2.0%
	Total	7656	100.0%		Total	7531	100.0%

FIGURE 3.20C: Bank erosion potential ratings for Reach 5.

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Reach 6 Statistics

Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach	Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach
Right Bank	Very Low	577	11.1%	Left Bank	Very Low	177	3.3%
	Low	0	0.0%		Low	0	0.0%
	Moderate	932	17.9%		Moderate	987	18.7%
	High	607	11.6%		High	961	18.2%
	Very High	2703	51.9%		Very High	2637	49.9%
	Extreme	394	7.6%		Extreme	525	9.9%
	Total	5212	100.0%		Total	5287	100.0%

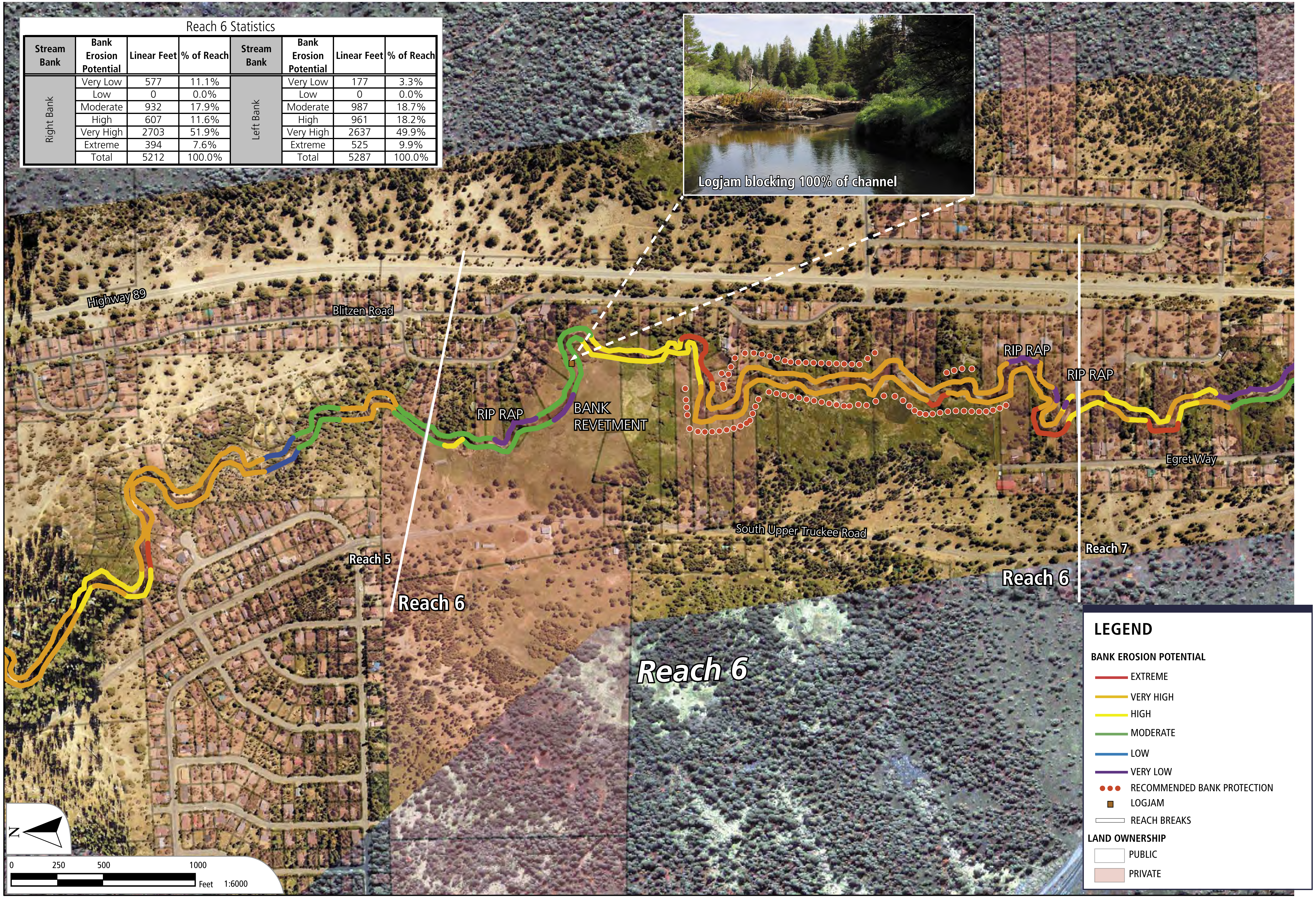

FIGURE 3.20D: Bank erosion potential ratings for Reach 6.

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Reach 7 Statistics

Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach	Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach
Right Bank	Very Low	1427	21.6%	Left Bank	Very Low	590	9.0%
	Low	1115	16.9%		Low	164	2.5%
	Moderate	0	0.0%		Moderate	1378	20.9%
	High	3533	53.6%		High	2105	31.9%
	Very High	485	7.4%		Very High	1102	16.7%
	Extreme	33	0.5%		Extreme	1250	19.0%
	Total	6593	100.0%		Total	6589	100.0%

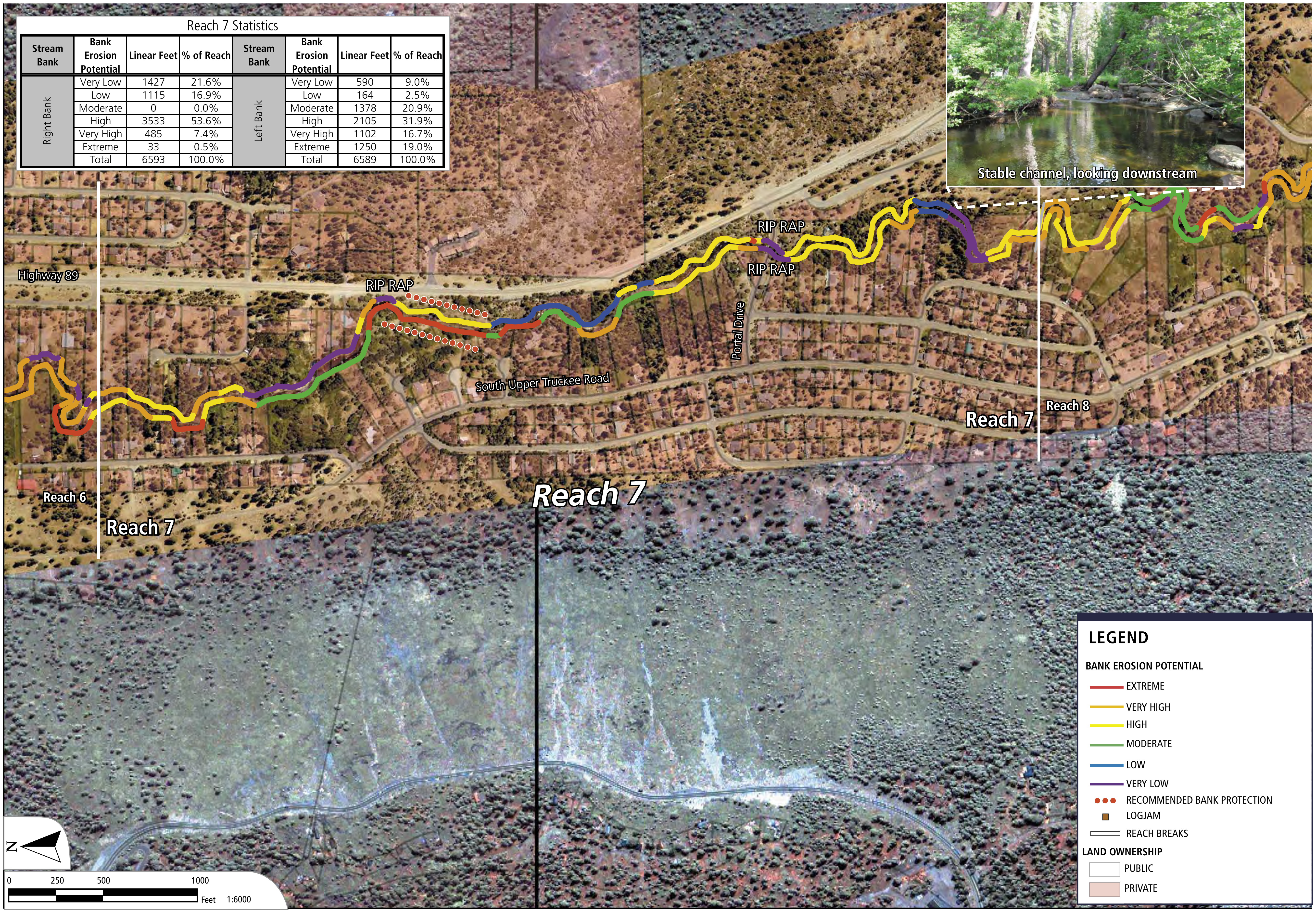

FIGURE 3.20E: Bank erosion potential ratings for Reach 7.

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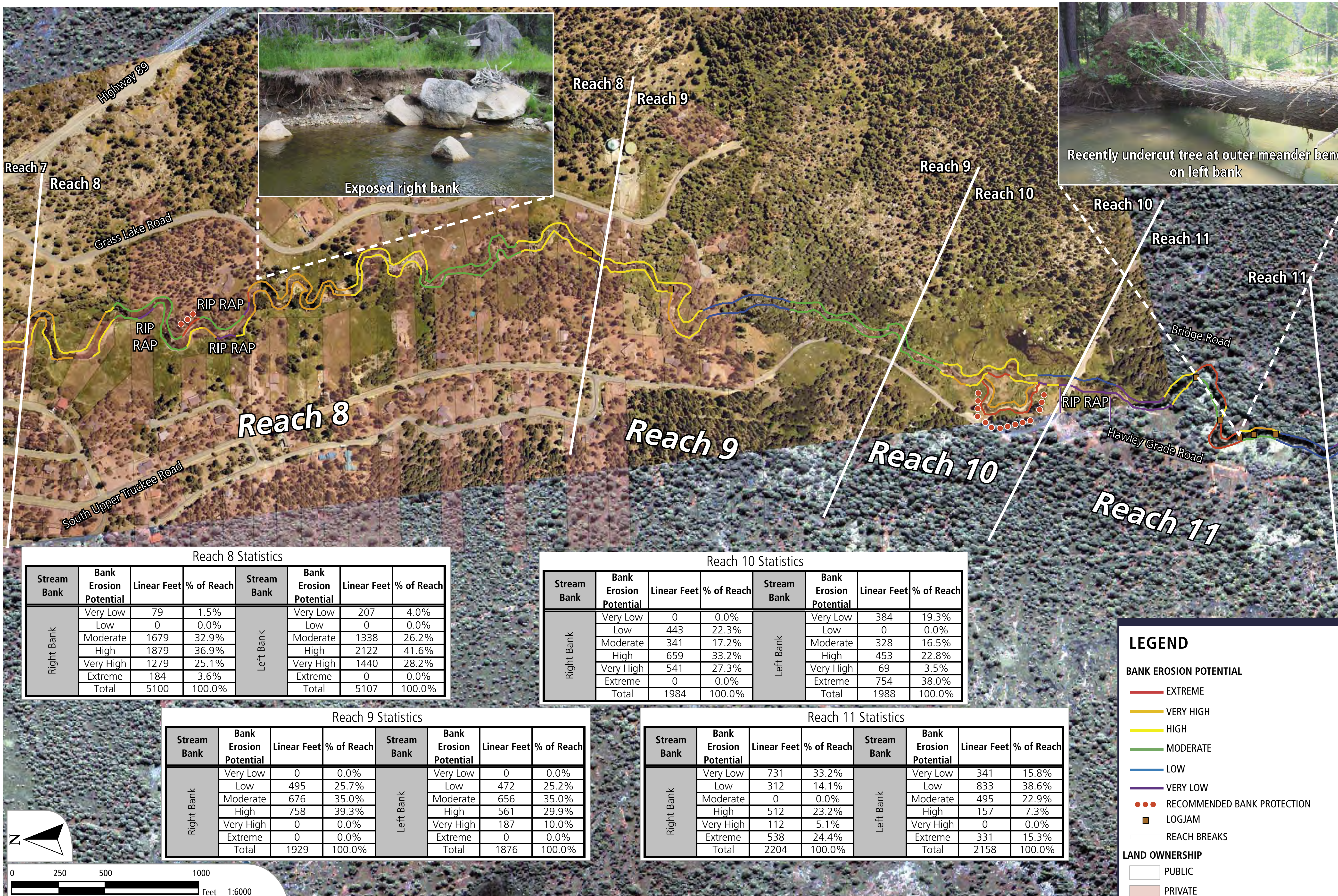

Reach 8 Statistics

Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach	Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach
Right Bank	Very Low	79	1.5%	Left Bank	Very Low	207	4.0%
	Low	0	0.0%		Low	0	0.0%
	Moderate	1679	32.9%		Moderate	1338	26.2%
	High	1879	36.9%		High	2122	41.6%
	Very High	1279	25.1%		Very High	1440	28.2%
	Extreme	184	3.6%		Extreme	0	0.0%
	Total	5100	100.0%		Total	5107	100.0%

Reach 10 Statistics

Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach	Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach
Right Bank	Very Low	0	0.0%	Left Bank	Very Low	384	19.3%
	Low	443	22.3%		Low	0	0.0%
	Moderate	341	17.2%		Moderate	328	16.5%
	High	659	33.2%		High	453	22.8%
	Very High	541	27.3%		Very High	69	3.5%
	Extreme	0	0.0%		Extreme	754	38.0%
	Total	1984	100.0%		Total	1988	100.0%

Reach 9 Statistics

Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach	Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach
Right Bank	Very Low	0	0.0%	Left Bank	Very Low	0	0.0%
	Low	495	25.7%		Low	472	25.2%
	Moderate	676	35.0%		Moderate	656	35.0%
	High	758	39.3%		High	561	29.9%
	Very High	0	0.0%		Very High	187	10.0%
	Extreme	0	0.0%		Extreme	0	0.0%
	Total	1929	100.0%		Total	1876	100.0%

Reach 11 Statistics

Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach	Stream Bank	Bank Erosion Potential	Linear Feet	% of Reach
Right Bank	Very Low	731	33.2%	Left Bank	Very Low	341	15.8%
	Low	312	14.1%		Low	833	38.6%
	Moderate	0	0.0%		Moderate	495	22.9%
	High	512	23.2%		High	157	7.3%
	Very High	112	5.1%		Very High	0	0.0%
	Extreme	538	24.4%		Extreme	331	15.3%
	Total	2204	100.0%		Total	2158	100.0%

FIGURE 3.20F: Bank erosion potential ratings for Reaches 8, 9, 10, and 11.

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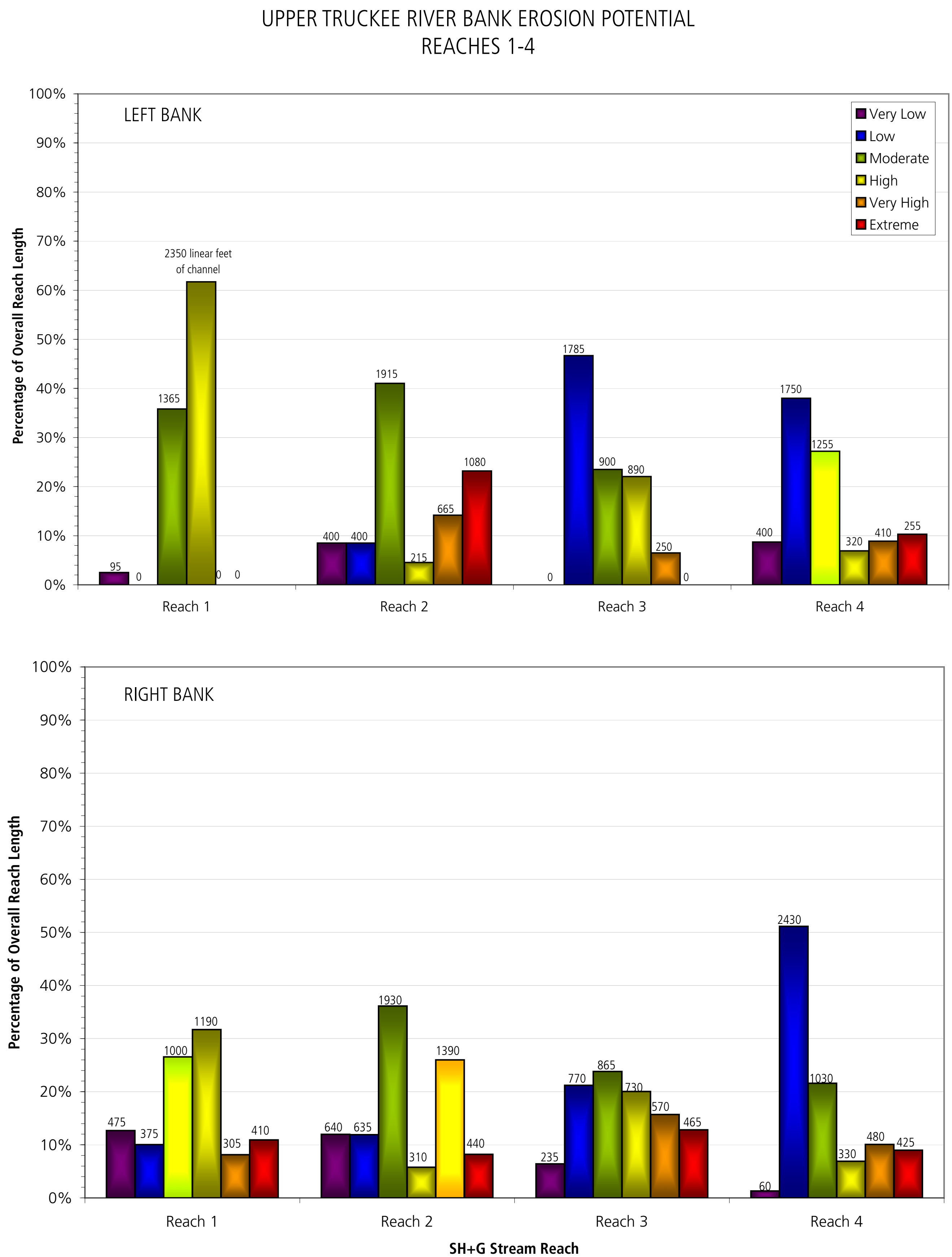

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FIGURE 3.21A: Histograms illustrating the bank erosion potential for the left and right banks of Reaches 1-4 by percentage of overall reach length. See Figures 3.20A and B for locations.

UPPER TRUCKEE RIVER BANK EROSION POTENTIAL
REACHES 5-11

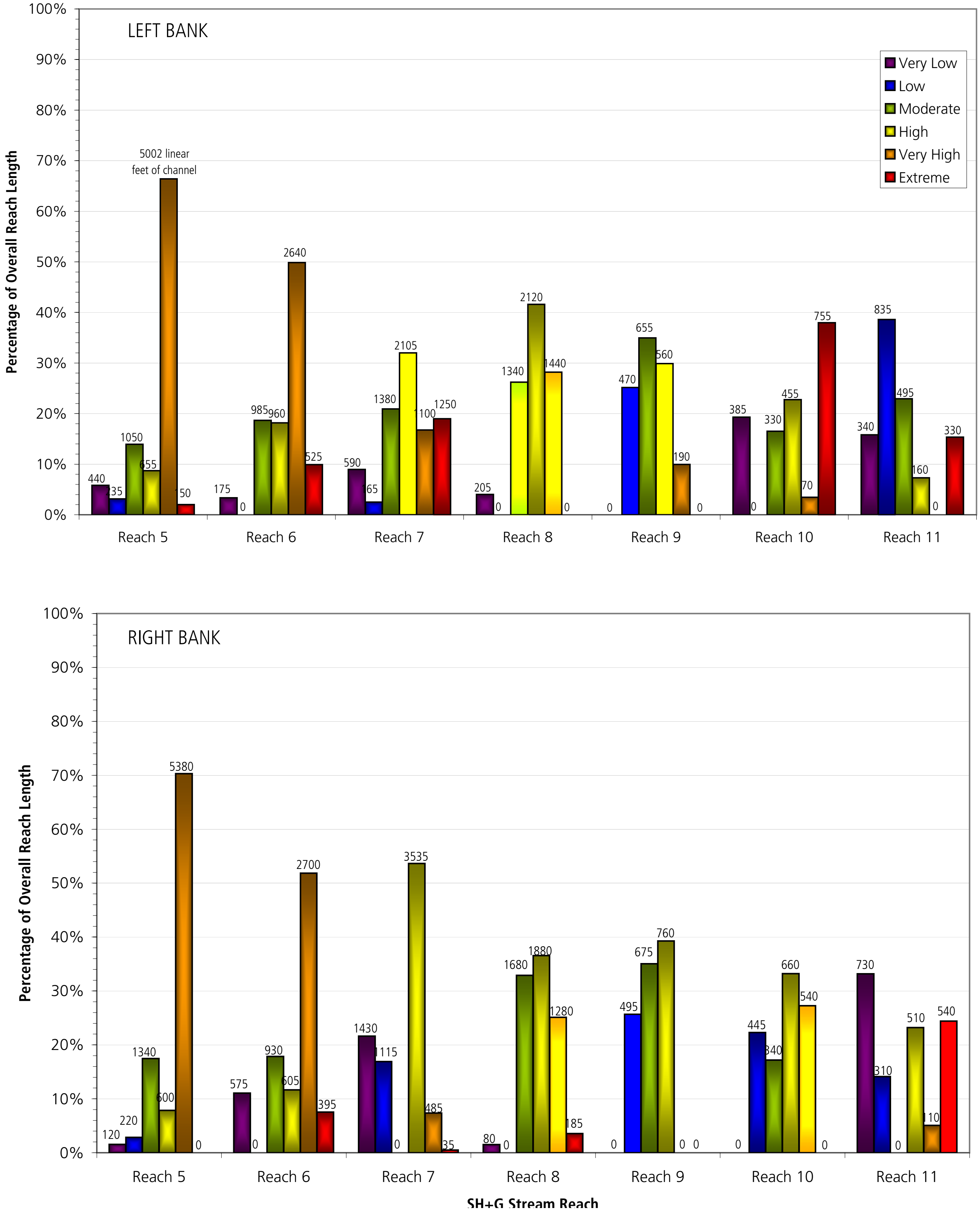

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FIGURE 3.21B: Histograms illustrating the bank erosion potential for the left and right banks of Reaches 5-11 by percentage of overall reach length. See Figures 3.20C-E for locations.

Reach	Left Bank												Right Bank											
	Very Low		Low		Moderate		High		Very High		Extreme		Very Low		Low		Moderate		High		Very High		Extreme	
	ft	%	ft	%	ft	%	ft	%	ft	%	ft	%	ft	%	ft	%	ft	%	ft	%	ft	%	ft	%
Reach 1	95	2.5	0	0.0	1364	35.8	2351	61.7	0	0.0	0	0.0	476	12.7	377	10.0	997	26.6	1190	31.7	305	8.1	410	10.9
Reach 2	397	8.5	397	8.5	1915	41.0	213	4.6	663	14.2	1082	23.2	640	12.0	636	11.9	1931	36.1	308	5.8	1390	26.0	439	8.2
Reach 3	0	0.0	1784	44.1	898	22.2	892	22.1	249	6.2	220	5.4	233	6.4	770	21.2	865	23.8	728	20.0	570	15.7	466	12.8
Reach 4	400	9.1	1751	39.9	1252	28.6	318	7.2	410	9.3	255	5.8	6232	1.3	2430	51.1	1026	21.6	328	6.9	479	10.1	426	9.0
Reach 5	440	5.8	236	3.1	1050	13.9	656	8.7	5002	66.4	148	2.0	118	1.5	220	2.9	1338	17.5	600	7.8	5380	70.3	0	0.0
Reach 6	177	3.3	0	0.0	987	18.7	961	18.2	2637	49.9	525	9.9	577	11.1	0	0.0	932	17.9	607	11.6	2703	51.9	394	7.6
Reach 7	590	9.0	164	2.5	1378	20.9	2105	31.9	1102	16.7	1250	19.0	1427	21.6	1115	16.9	0	0.0	3533	53.6	485	7.4	33	0.5
Reach 8	207	4.0	0	0.0	1338	26.2	2122	41.6	1440	28.2	0	0.0	79	1.5	0	0.0	1679	32.9	1879	36.9	1279	25.1	184	3.6
Reach 9	0	0.0	472	25.2	656	35.0	561	29.9	187	10.0	0	0.0	0	0.0	495	25.7	676	35.0	758	39.3	0	0.0	0	0.0
Reach 10	384	19.3	0	0.0	328	16.5	453	22.8	69	3.5	754	38.0	0	0.0	443	22.3	341	17.2	659	33.2	541	27.3	0	0.0
Reach 11	341	15.8	833	38.6	495	22.9	157	7.3	0	0.0	331	15.3	731	33.2	312	14.1	0	0.0	512	23.2	112	5.1	538	24.4

% = percent of reach classified by specified rating

TABLE 3.4: Summary of channel bank erosion survey in the Upper Reach Study Area for the left and right banks. Ratings range from very low bank instability to extreme bank instability. See Figures 3.20A-F for maps showing exact location of instabilities.

have been accounts of beaver signs in the late 1800s in the adjacent Carson River basin to the south (Tappe, 1942). Beavers reportedly were introduced as a commercial venture and for habitat enhancement by CDFG (Tappe 1942). The effects on stream channel behavior and morphology were profound, since beaver dams on some streams are able to withstand snowmelt runoff events and thus impound flow and sediment. When the impoundment has filled with sediment, the dams are often abandoned and subsequent flows breach the dam. This leaves an area of marsh with a knickpoint in the stream profile that de-stabilizes the local reach. Subsequent erosion outflanks the dam and avulses the channel. Beaver dams appear to be far less effective on the UTR, as the hydraulic force of snowmelt flows is sufficient to breach and remove the dams each year. Beavers re-build dams beginning in late summer and into the fall. It is possible that some marsh surfaces in the historic floodplain were formed by beaver activity rather than geomorphic processes, as occurs in areas of their natural habitat. The role of beavers is discussed further in the wildlife section below (Section III.3).

ROADS AND SUBWATERSHED EROSION SURVEY

The level of disturbance of the urbanized watersheds adjacent to the main UTR corridor was evaluated through a detailed assessment of soil disturbance and erosion along roads (road cuts, shoulders and drainage ditches) and in tributary stream channels. The roads database was developed using a modified method developed by NRCS (2000), as well as reconnaissance of connecting tributary streams. The assessment attempts to prioritize subwatersheds for erosion and drainage control treatment based upon a combination of the degree of soil disturbance, the slope of the subwatershed, the effects of any installed erosion control and sediment retention facilities, and the connectivity of the tributary to the main stem UTR. The methodology is summarized in flow chart shown in Figure 3.22 and the full methodology is described in Appendix C. The results of the road and subwatershed survey are shown in Figure 3.23 and Table 3.5. The full roads database is presented in Appendix D.

The assessment found that the erosion along Highway 89 (Luther Pass Road) is unusually high. There has been little BMP retrofit (scheduled by Caltrans for 2007/2008) on steep roadcuts of unconsolidated glacial deposits and the sediment discharges directly into Grass Lake and Big Meadow Creeks, which flow along the road corridor. The other high priority watersheds are situated in Meyers and lower Christmas Valley, where steep areas covered in subdivision roads are untreated.

A preliminary, reconnaissance-level survey of channel conditions on tributaries to the Upper Truckee River was conducted in the spring of 2003 to assess potential cumulative land use impacts and determine the need for more site-specific surveys. During the reconnaissance-level surveys, tributaries within urbanizing or road influenced areas were assessed at road crossing or other public right-of-way locations. General notes on incision, bank erosion, access to floodplain, channelization, straightening, sedimentation, and overall health of the channel were noted. This information was integrated with an assessment of the level of connectivity between road

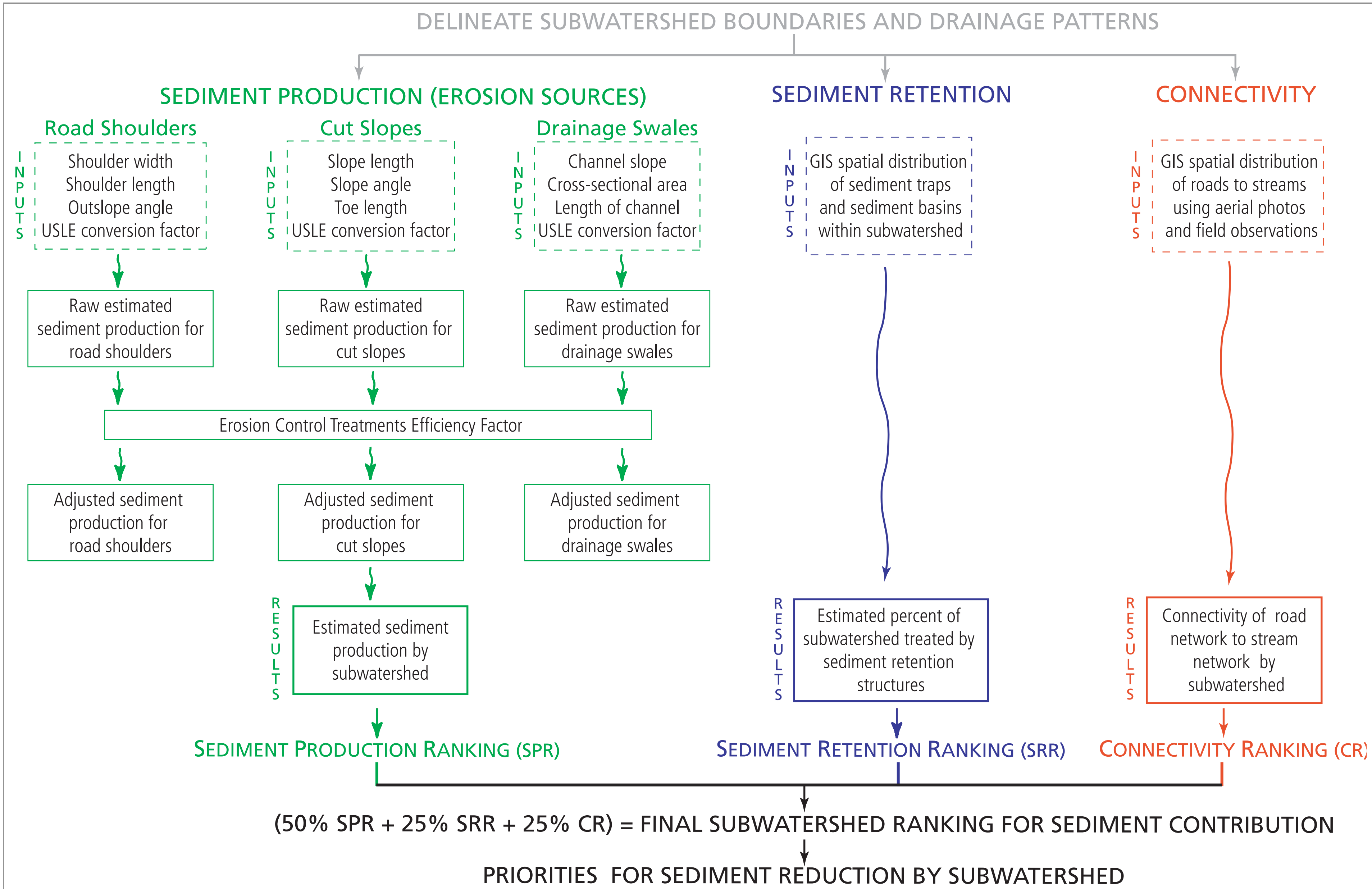

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FIGURE 3.22: Flow chart illustrating the process by which priorities for sediment reduction by subwatershed were determined. All rankings were scaled from 1 to 5 (1 = low priority). Rankings for sediment production (1 = low production), sediment retention (1 = high retention), and connectivity (1 = little connectivity) determined the final subwatershed ranking for sediment contribution.

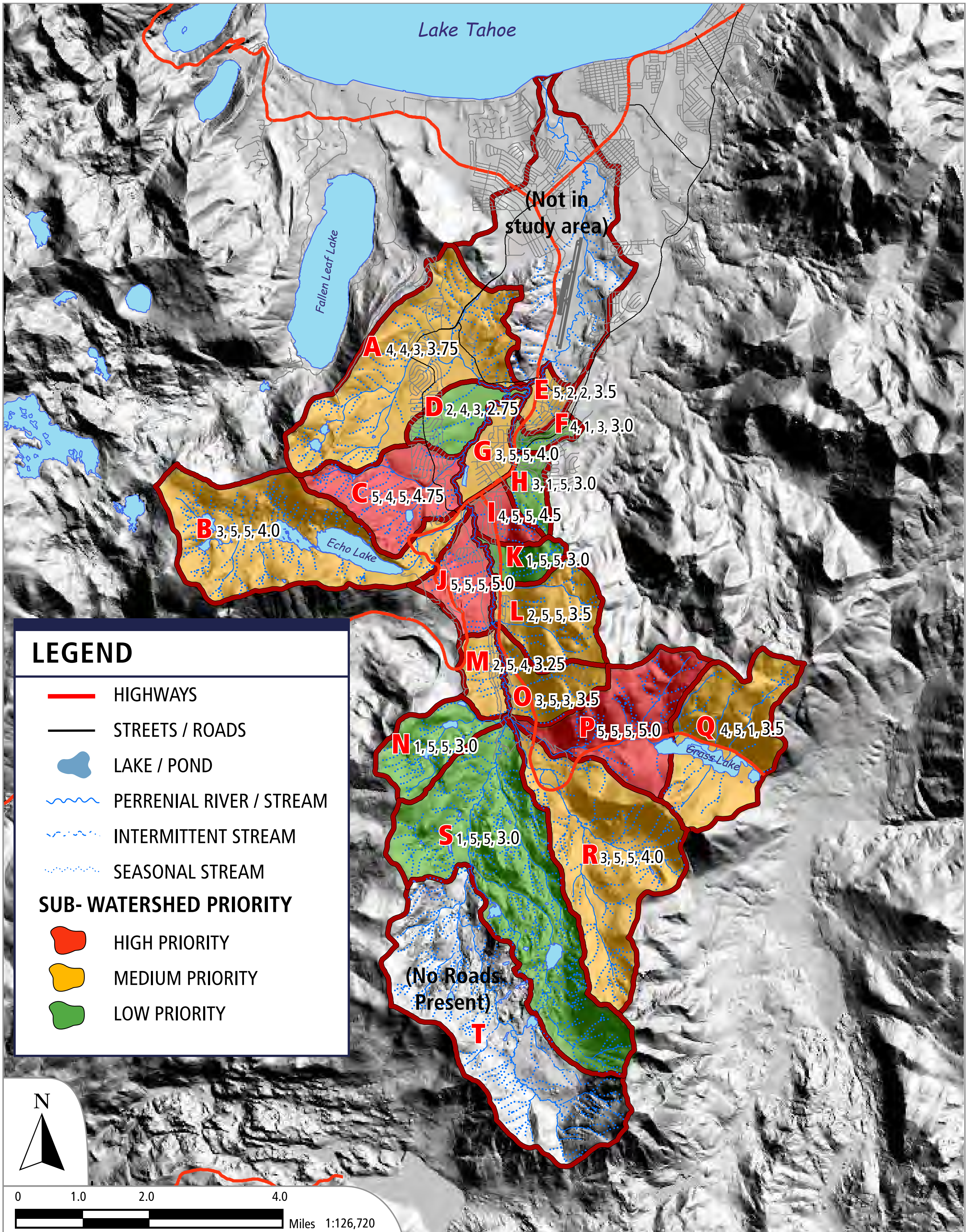

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FIGURE 3.23: Map indicating subwatershed priority based on cumulative ranking from the road and subwatershed survey. Numerical rankings are ordered as follows: Erosion Control Rank, Sediment Retention Rank, Connectivity Rank, Final Rank.

Sub-watershed ID	Erosion Control Rank - Primary Treatment (50% of Ranking)	Sediment Retention Rank - Secondary (25% of Ranking)	Connectivity Rank (25% of Ranking)	Final Ranking in Order of Treatment Priority	Priority	Recommended Treatments	Treatment Discussion
P	5	5	5	**5**	HIGH	Cut slope treatments, drainage swale improvements, sediment traps at cross culverts, upgrade Forest Service access road	This subwatershed primarily consists of road runoff from Hwy 89. Recommended treatments include rock lining of bare drainage swales and sediment vaults at cross culverts. The campground access road through the Forest Service campground should also be upgraded to reduce erosion from poor drainage conditions.
J	5	5	5	**5**		Cut slope treatments, sediment traps at cross culverts from Hwy 50, sediment basins at base of Hwy 50 slope, curb and gutter and drainage swale improvements in neighborhood off of S. Upper Truckee Road	Though this neighborhood is fairly flat and primarily consists of road shoulders with a few cut slopes, it was ranked as a high priority due to the fact that it is well connected and has several tributary channels that have been modified and straightened into drainage swales. Many of these channels originate from Hwy 50 which is untreated and well connected to the Upper Truckee River.
C	5	4	5	**4.75**		Curb and gutter, drainage swale improvements, cut slope treatments, sediment basins	Fairly steep subwatershed with little to no treatment of runoff. One sediment basin occurs on the upstream end of N. Upper Truckee Road and one drainage swale is lined. Otherwise, road runoff is discharged directly to well-connected channels. Recommend curb and gutter, improvements to drainage system, and installation of sediment basins.
I	4	5	5	**4.5**		Cut slope treatments, drainage swale improvements, sediment traps, sediment basins	This neighborhood is a mix of commercial, industrial, and residential land uses. There is evidence of high sediment production in several untreated drainage swales that occur through this neighborhood. Road cuts on the east side and large road shoulders used by heavy equipment likely contributes a significant amount of sediment directly to the Upper Truckee River.
B	3	5	5	**4**	MODERATE	Curb and gutter, drainage swale improvements, cut slope treatments, sediment basins	This neighborhood is closely connected to the neighborhood in subwatershed C. Similar road and drainage improvements within this subwatershed could be implemented in conjunction with the improvements in subwatershed C.
G	3	5	5	**4**		Curb and gutter, drainage swale improvements, restoration of historic wet meadow	Much of this neighborhood is flat with exposed road shoulders and an efficient, untreated drainage system that eventually flows through the golf course and into the Upper Truckee River. On the east side of this subwatershed, just downstream of Hwy 50 on a tributary to the Upper Truckee, there is an opportunity to restore a degraded wet meadow area that is currently under public ownership. This project could be used to treat some of the runoff in this neighborhood and runoff from subwatersheds #18 and #20.
R	3	5	5	**4**		Cut slope treatments, drainage swale improvements, sediment traps at cross culverts	This subwatershed primarily consist of road runoff from Hwy 89. Recommended treatments include rock lining of bare drainage swales and sediment vaults at cross culverts.
A	4	4	3	**3.75**		Curb and gutter, cut slope treatments	Much of watershed has secondary treatments. Erosion control is recommended within neighborhoods off of N. Upper Truckee Road including curb and gutter and treatment of road cuts. This subwatershed is also treated by restoration projects recently developed on Angora Creek.
E	5	2	2	**3.5**		Drainage swale improvements, cut slope treatments, sediment traps.	Some treatments exist within this watershed including vegetated drainage swales and cut slopes and secondary treatment through sediment basins. Much of the subwatershed is steep and additional primary treatment elements could be implemented.
Q	4	5	1	**3.5**		Cut slope treatment, drainage swale inprovements, sediment traps at cross culverts	Runoff from Hwy 89 discharges directly into Grass Lake Creek which acts as a treatment area prior to discharging into Grass Lake Creek and on to the Upper Truckee River.
O	3	5	3	**3.5**		Cut slope treatments, drainage swale improvements, sediment traps at cross culverts	This subwatershed primarily consist of road runoff from Hwy 89. Recommended treatments include rock lining of bare drainage swales and sediment vaults at cross culverts.
L	2	5	5	**3.5**		Curb and gutter, sediment traps, sediment basins	This neighborhood is fairly flat and consist primarily of untreated road shoulders. Drainage is well connected with the Upper Truckee River and tributary channels have been modified and straightened to act as drainage swales for roads.
M	2	5	4	**3.25**		Curb and gutter, sediment traps, sediment basins	This neighborhood is fairly flat and consist primarily of untreated road shoulders. Drainage is well connected with the Upper Truckee River and tributary channels have been modified and straightened to act as drainage swales for roads.
F	4	1	3	**3**	LOW	Upgrades to existing erosion control treatment, sediment traps, sediment basins	Many of the erosion control treatments in this neighborhood are older and require some upgrades (treatment of cut slopes consist of shockcrete walls that are failing in some areas). Secondary treatments are absent and could be added, inlcuding diversion of much of the runoff through a proposed wetland enhancement in subwatershed #17.
H	3	1	5	**3**		BMP's on golf course	Implement BMP's on Golf Course. Neighborhood within subwatershed is well treated.
K	1	5	5	**3**		Curb and gutter, sediment traps, sediment basins	This neighborhood is fairly flat and consist primarily of untreated road shoulders. Drainage is well connected with the Upper Truckee River and tributary channels have been modified and straightened to act as drainage swales for roads.
S	1	5	5	**3**		Curb and gutter, drainage swale improvements	The only road through this subwatershed is a portion of S. Upper Truckee. Some gullies have formed as road drainage is discharged into the Upper Truckee River.
N	1	5	5	**3**		Curb and gutter, drainage swale improvements	The only road through this subwatershed is a portion of S. Upper Truckee. Some gullies have formed as road drainage is discharged into the Upper Truckee River.
D	2	4	3	**2.75**		curb and gutter, sediment traps	Much of the drainage within theis neighborhood is distributed, rather than concentrated. N. Upper Truckee Road has been treated.

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TABLE 3.5: Priority Ranking Matrix. Treatment rankings from Levels 1 (Erosion Control Treatment) through 3 (Connectivity) are combined to produce a final treatment priority ranking in order of importance. Subwatersheds with higher erosion estimates are given a higher priority ranking when ties occur. Erosion control elements include BMP's that treat the erosion source such as rock slope protection, retaining walls, curb and gutter, and rock lining of drainage swales. Subwatersheds with higher erosion source rankings have higher sediment production from erosion source features. Sediment retention elements filter or retain sediment delivered from an erosion source before it reaches a drainage feature that provides direct connectivity to the stream network. Sediment retention includes sediment traps, sediment basins, or distributed flow paths. Subwatersheds that lack sediment retention elements were assigned a value of 5. Connectivity is a ranking of the efficiency of the drainage system to deliver sediment to the stream network. Highly connected subwatersheds receive a value of 5.

runoff and stream channels, as discussed in Appendix D. Table 3.6 summarizes the results of the preliminary survey for the channels that are experiencing a degree of cumulative impacts.

Table 3.6: Preliminary survey results for tributary channel conditions within Upper Truckee River Study Area.

Tributary	Survey Segment	Level of Impact	Discussion
Grass Lake Creek	Grass Lake to 1st Hwy 89 crossing	High	Channel and floodplain constricted and straightened along Hwy 89 right-of-way. Channel subsequently incised with lack of complexity.
	First Hwy 89 to 2nd Hwy 89 crossing	Moderate	High gradient channel crosses a Forest Service recreation road in several places. Road is poorly maintained resulting in delivery of sediment and bank erosion in more alluvial reaches.
Grass Lake Creek tributaries	Hwy 89 crossings between 1st crossing and Grass Lake	Moderate	Road runoff and roadside drainage swales empty directly into these tributaries. Ditch relief culverts interact directly with natural drainage system.
Big Meadow Creek	Cookhouse Meadow	High / Moderate	Historic downcutting has resulted in an incised channel with no floodplain access.
Unnamed tributary near Meyers	Through Paradise Golf Course	High	Stream channels denuded of vegetation. Likely to have significant water quality impacts.
Unnamed tributary near Meyers	Highway 50 / Santa Fe Road to San Diego Road	High	Realigned and channelized away from historic wet meadow adjacent to Hwy 89.
Unnamed tributary near Meyers	San Diego Road to Country Club Drive	Moderate	Historic downcutting and evidence of recent bank sloughing. Very little riparian vegetation. May experience some flooding due to urban runoff volumes.
Unnamed tributary near Meyers	Through Lake Tahoe Golf Course	Moderate	Channelization has occurred in most areas though riparian vegetation is present. Impacted areas occur as channel crosses fairways or is culverted.

Channels determined to have a significant level of impact with potential for future restoration were surveyed in more detail. Impacted alluvial channel reaches on Grass Lake and Big Meadow Creeks were assessed using a bank erosion potential method developed by Rosgen (1996). This method is discussed in more detail in the section of this report describing the Channel Bank

Erosion Survey for the mainstem of the Upper Truckee River. Survey results for the Big Meadow and Grass Lake Creek drainages are presented in Figure 3.24. The Unnamed Tributary was assessed via a detailed walk-through of the channel to identify impacts and potential restoration opportunities.

The Unnamed Creek near Meyers flows northward from the Lake Tahoe Paradise Golf Course, across Highway 50, through the East San Bernardino residential neighborhood, and into the Lake Tahoe Golf Course where it meets the mainstem UTR (see Figure 5.1). Much of its runoff originates from the commercial and residential areas located between the Paradise Golf Course and the East San Bernardino neighborhood. The headwaters in the Paradise Golf Course have been extensively modified, including channelization and removal of riparian vegetation. In many cases, turf grass abuts the channel banks, resulting in the potential for direct discharge of fertilizers and other inorganic compounds, creating water quality concerns. Highway 50 road runoff is also discharged directly into the channel as it intersects roadside ditches before crossing Highway 50 at the Santa Fe Road intersection.

Downstream of the Santa Fe Road crossing, the tributary has been channelized away from a historic wet meadow between Arrowhead Drive and Highway 50. This channelization likely occurred to make room for development of a commercial area along Highway 50. A recent attempt has been made to divert flow out of the channelized section of creek and back into the meadow. To do this a berm was placed across the channel. Subsequent storm flows have overtopped the berm, resulting in a large scour hole downstream that may have initiated or exacerbated downcutting and channel widening within that reach (Figure 3.25). Given the absence of development on the historic wet meadow, there may be an opportunity to restore this feature, providing flow attenuation for downstream residents and water quality treatment for the Paradise Golf Course and adjacent neighborhoods. This and other restoration opportunities are discussed in great detail in Chapter 5.

Morphologically, channels and banks within the Grass Lake and Big Meadow Creek drainages consist of resistant material derived from lateral moraine deposits that have been reworked by periodic channel migrations. Abundant large woody material, natural stable boulder weirs, and access to secondary or floodplain channels during high flow events provide relative stability and a capacity to store and attenuate transport of fine sediment that is delivered to the channel from disturbances within the watershed. Several "alluvial" reaches do occur within these drainages, namely Cookhouse Meadow on Big Meadow Creek and the lower gradient reach of Grass Lake Creek just downstream of Grass Lake.

Cookhouse Meadow is thought to have historically been a wet meadow. Currently, the meadow is deeply incised into the meadow, the causes of which are being assessed as part of a watershed analysis and meadow restoration plan being funded by the USFS. The lower gradient reach of Grass Lake Creek has been directly impacted by development of Highway 89. It is likely that Grass Lake Creek was moved to the edge of the valley to accommodate Highway 89, resulting in the loss

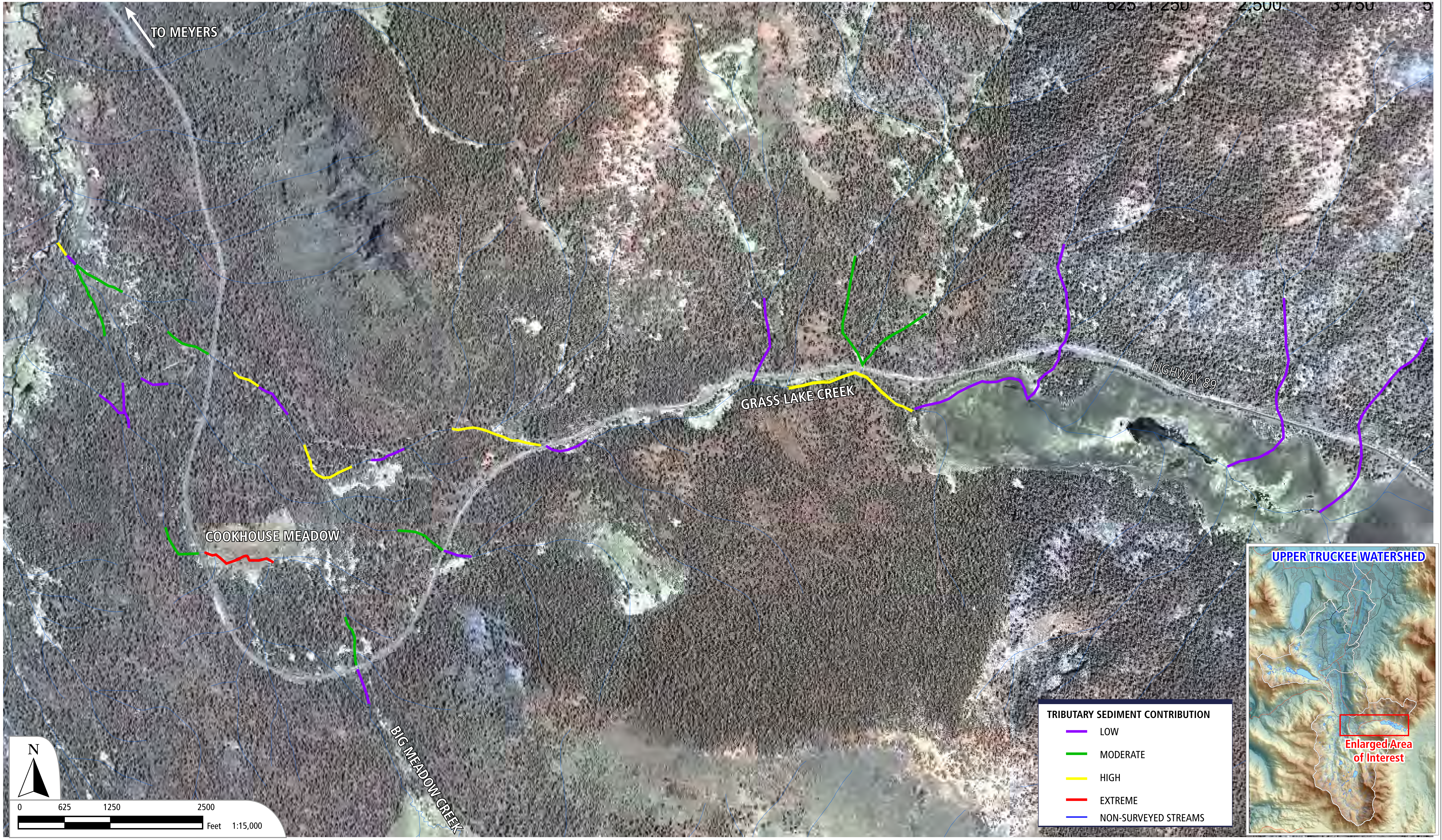

FIGURE 3.24: Map indicating the relative contribution of sediment of tributaries to the Grass Lake and Big Meadow Creek reaches of the Upper Truckee Watershed observed during June 25-26, 2003 site visit.

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FIGURE 3.25: Photo of the unnamed tributary near Meyers downstream of the Santa Fe Road crossing. A berm was placed across the channel to divert flow from the channelized creek back to the adjacent floodplain. Subsequent flows have overtopped the berm, creating the large scour hole shown in the photo above.

of channel complexity, efficient movement of delivered sediment, and an increase in bank erosion as the channel attempts to rebuild lost floodplain.

Upper Watershed Surveys

The Upper Watershed was surveyed on a reconnaissance basis in order to assess the condition of tributary streams and drainages that flow into the mainstem UTR. The LTBMU is preparing a watershed assessment of Big Meadow Creek Drainage, which includes treatment of a large gully in Cookhouse Meadow, and it is assumed that detailed plans will be addressed under that plan.

Grass Lake Creek has been highly impacted by the construction of Highway 89, which filled the creek and floodplain along much of its length from Grass Lake to the Highway 89 crossing near the Big Meadow Trailhead. Several stream reaches and tributaries were surveyed during the road erosion survey. Grass Lake Creek is also affected by fill and crossings on South Upper Truckee Road; these areas are noted on the roads survey.

Besides the roads affecting Grass Lake and lower Big Meadow Creeks, there are no road networks in the Upper Watershed. In general, the Upper Watershed streams flow through bedrock, alluvial fans and fills, meadows, glacial deposits, or boulder/bedrock reaches. All of the meadows have been historically grazed (Figures 2.10 and 2.11) and beavers have been influential factors in stream and marsh vegetation development and forest mortality (Figure 3.26).

The limited survey indicates that the UTR appears to be in reasonably good condition, although the aftereffects of grazing are visible. Meiss Meadow was heavily grazed by sheep and cattle between the 1860s and the 1970s. It is likely that the meadows and lakes were areas of intensive grazing, while the steep alluvial slopes and conifer forests offered little forage. The sage/aspen communities support some grasses on alluvial slopes. Historical photos provide an indication of the historic density of herds (Figures 2.10 and 2.11). Reoccupation of photographed sites shows some recovery. However, other areas exhibit remnant soil pedestals and exposed regolith and subsoil (Figure 3.27).

One striking feature of the Upper Watershed is the observed erosion and sediment production rates of the Tertiary volcanic rocks (Tv) that form the rim of the Upper Watershed. These are predominately volcaniclastic rocks (breccias) that form cliff faces (Figure 3.28), but are readily weathered and eroded. The erosion rates of the volcanic bluffs were demonstrated by the immense volume of post-glacial alluvial fans formed below the bluffs and the recent evidence of debris-flow landslides that occurred with the severe thunderstorm event of August 21, 2003 (Figure 3.29). Beyond the shear volume and erodibility of the Tertiary volcanics, the erosion and weathering products include fine sediments and clays that may be dispersive in nature and an important factor for Lake Tahoe clarity. It is doubtful that the areas underlain by Tertiary volcanics, or the alluvial deposits derived from them, were ever impacted heavily by historic grazing, given the fact that little forage occurs under the predominately old growth Jeffrey pine and red fir