The levee was sparsely vegetated by pioneering species like blazing star, Russian thistle, sweet white clover, and seedlings of mountain big sagebrush and rubber rabbitbrush. Large, mature black cottonwoods occupied the stream terrace at the upper cross section location on the right side, providing picnic and camp sites for area recreationists.

Past beaver activity (+/-10 years) was indicated by a 12 inch diameter cottonwood stump. The herabaceous understory was sparse to absent. The topographic depression located between the levee and the highway was developing into an emergent wetland community dominated by cattail. At the higher end of this depression (where it was drier), a large stand of bull thistle was present. Coyote willows also occupied the drying end of this area.

A woody regeneration transect was established adjacent to the right side of the river on an elevated terrace. Mature black cottonwood provided an almost continuous canopy cover. The age class distribution of the woody species showed a ratio of approximately 2.7:1 sprout and saplings to mature, decadent, and dead black cottonwood, woods rose, mountain alder and willow species.

Data developed as part of the present study (Table 4.10) indicate that the area is dominated by early and mid successional status ratings. Vegetation in the area is adjusting to past disturbances (recreation) and current fluvial processes.

Table 4.10. Reach EF7 successional status data.

Successional Status	Percent Occurrence
Early	43.4
Mid	32.9
High	23.8

A management recommendation would be to remove the existing bull thistle stand and monitor to prevent its reestablishment.

Analysis and Summary: To assess impacts of the levee on channel hydraulics the cross sections were modified; both a levee and a no levee condition were reviewed. Results suggest that shear is consistently reduced from the levee to no-levee condition. High shear and velocity values during high magnitude flood events likely result in considerable strain on the gravel levee due to the constricted cross-section. Consequently, during high magnitude events, with a return period of 50- and 100-years, the levee would be overtopped and would likely fail.

The purpose of the existing levees is to block flow pathways that, if active, would potential undercut and damage the adjacent roadway. Our HEC-RAS modeling suggests that the levee would serve this function during low and moderate runoff events, including the annual snow melt, but would not provide protection during high magnitude discharge events that are typically the most damaging to the road infrastructure. Consequently, the benefit of the levee is marginal, whereas the impact to channel and floodplain function and ultimately riparian and aquatic habitat is significant.

A more useful approach to protecting Highway 89 could include the following options:

- raise the road surface out of the floodplain to protect against flooding; and/or
- fortify the toe of the road slope to guard against undercutting and washout.

Both of these measures would aid in the restoration of a functional channel and floodplain through the segments of the East Fork Carson River that are directly influenced by the presence of Highway 89 and associated levee development. Consequently, restoring channel and floodplain function would result in improved aquatic habitat and riparian community conditions.

4.2.8 Reach MC2

Rosgen Channel Type: B1/4
Valley Form: Canyon
Bed Mobility: High
Restoration Objective: Maintain in-stream flows, add roughness elements

Reach MC2 is located on Markleeville Creek, just upstream of the town of Markleeville (see Figure 2.2 and maps contained in Section 3.2.4.2 of this report). A large diversion, located just upstream of the detailed study reach diverts water into an irrigation channel on the left bank that is used to irrigate pasture land adjacent to Markleeville. The survey reach was selected at a transition point between a wider depositional area and a narrow bedrock dominated channel. A longitudinal profile and cross sections of the reach are provided in Figure 4.15, while discharge and sheer data are presented in Figure 4.16.

Geomorphic Characteristics: Reach MC2 of Markleeville Creek is characterized by a morphology that alternates between depositional areas where the valley is flat and wide and transport areas where the valley is narrow and steep.. In the depositional areas, a series of low terraces occur that record past sedimentation events. In the narrow valley areas, bedrock is exposed on the bed of the channel and along the banks.

This reach is likely to experience episodic aggradation following a fire or other sediment generating event. Following the aggradation event, a new channel is reincised into the deposited sediment, leaving a terrace surface that is periodically inundated and reworked during high magnitude discharge events. Bank erosion is also likely to occur throughout this reach in the years following an aggradation event or a high magnitude discharge event. Aggradation would occur as the stream reworks unconsolidated, unsorted bank deposits that lack a dense vegetation cover.

Eroded bank and terrace deposits can prove to be a benefit to aquatic habitat by remobilizing coarse gravel and cobble, building riffle and spawning habitat (Dvorsky 2000). Hydraulic data suggest that much of the bed is mobile, even during low magnitude discharge events. Consequently, much of the bed has been scoured down to bedrock or only contains a thin veneer of sediment. Episodic aggradation events associated with fire provide a reservoir of long-term sediment storage that is continually mined in the interim, providing benefits to the aquatic ecosystem. If these deposits were not available, much of the stream would be scoured to bedrock, providing few benefits to the aquatic ecosystem.

Though a natural pattern of aggradation and subsequent scour is observed throughout Reach MC2, an important component of a functioning channel is missing, namely large roughness elements such as large woody debris. Large wood acts to attenuate the natural cycle of aggradation and scour, providing longer-term storage of coarse sediment in the channel, lessening accelerated bank erosion, and providing cover habitat for fish. Reducing the rate at which coarse sediment is scoured from the bed also allows for more rapid recolonization of riparian vegetation on exposed banks and bars. Bedrock exposure in the channel bed and significant bank erosion suggest that there is a lack of large wood through this reach.

Aquatic Habitat Characteristics: In general, aquatic habitat conditions are good throughout Reach MC2. Pools are present, aquatic macroinvertebrates are abundant, and there is variability in cover habitat present for fish. In order of importance, the most significant factors limiting aquatic habitat quality relates to the lack of adequate summer flow and the lack of large woody material. The diversion site located just upstream of the study segment appears to dewater or significantly reduce flow in the lower portions of Markleeville Creek.

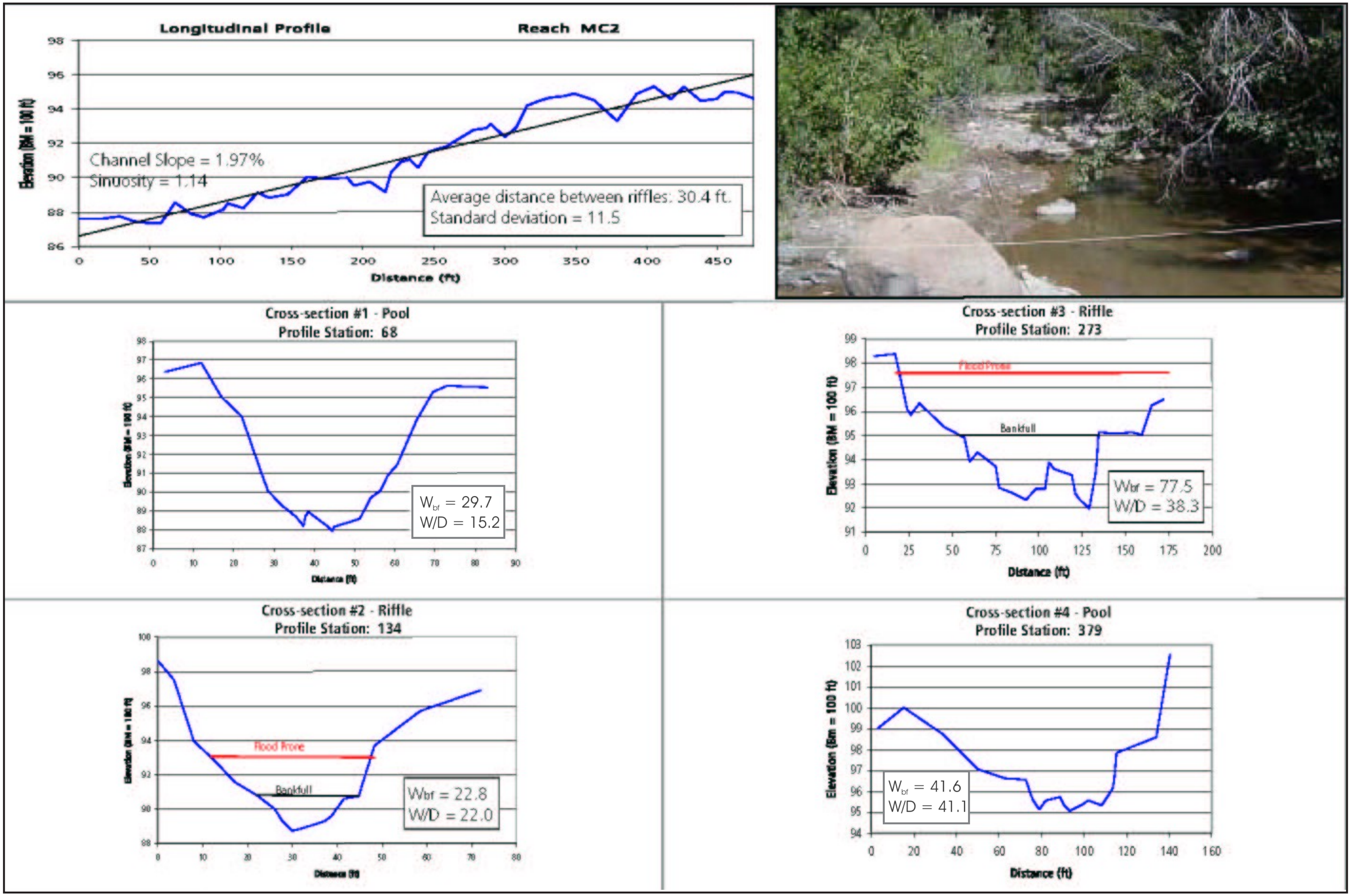


Figure 4.15. Longitudinal profile and cross-section geometry for Reach MC2.

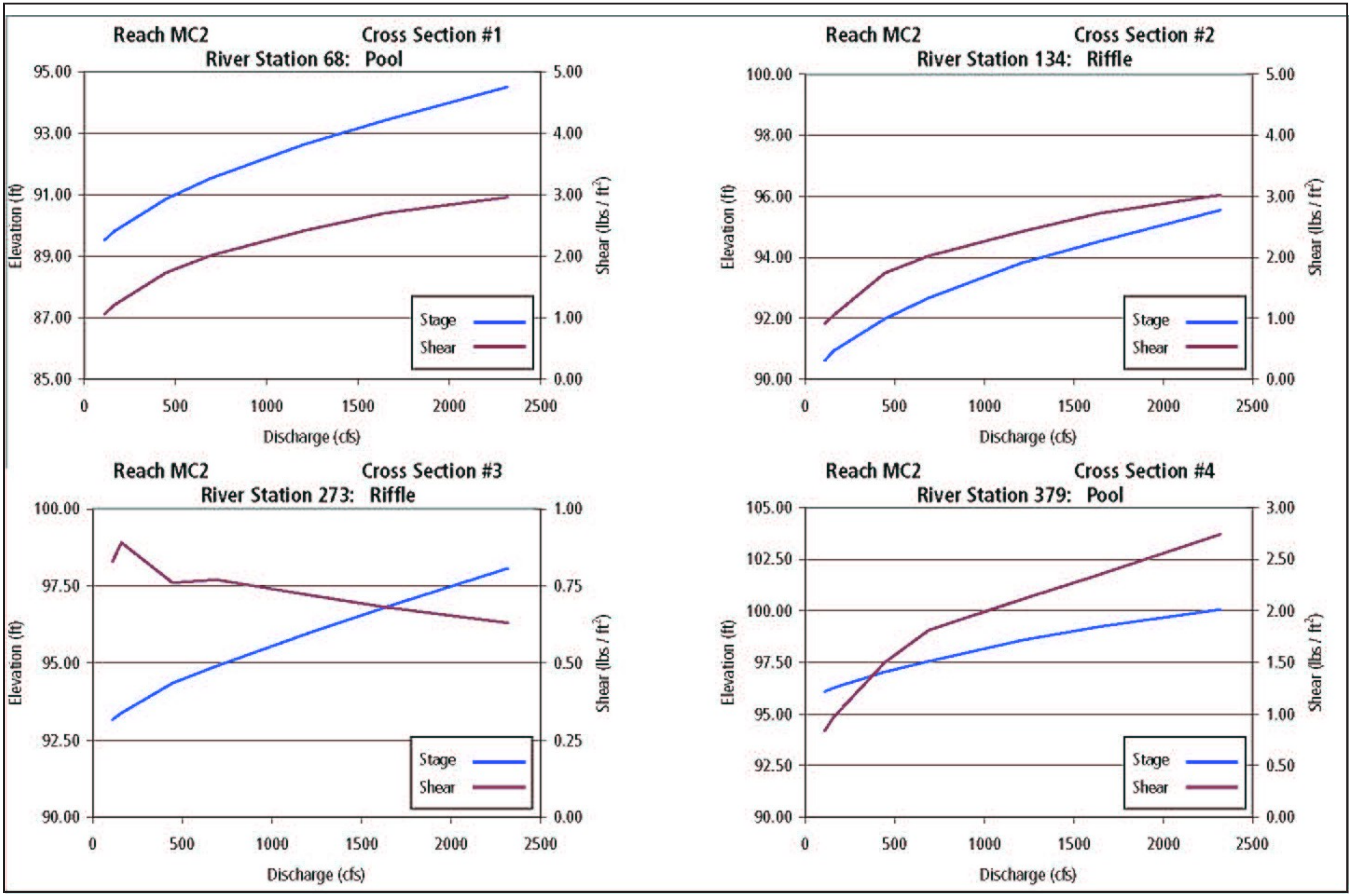


Figure 4.16. Discharge versus shear and stage for Reach MC2.

Vegetation Characteristics: Eleven riparian vegetation community types were documented within this reach. Influences on the reach included the presence of a water diversion, and access for flood waters to the floodplain. A mid channel bar was present that was heavily vegetated by willow species and alder. Evidence of past flooding included the presence of a woody debris area on the right bank that is approximately 75 feet wide. Woody debris ranged from 18 inch diameter logs and stumps, to 0.5 inch diameter branches. Wood's rose provided almost continuous cover adjacent to the diversion ditch, and has become well established on soils excavated from the ditch. A sparse to moderate herbaceous layer is also present; an occasional aspen was noted. Areas of active deposition in the floodplain have been colonized by coyote willow and assorted herbaceous species. Steeper banks are vegetated with mountain alder, yellow willow and an occasional Pacific tree willow. Black cottonwood and some aspen stands are present on the elevated stream terrace.

All age classes of Wood's rose were recorded indicating that the community has been present for many years. Evidence of disturbance was noted in that up to 50 percent of the surface area was bare soil and that weedy, annual species like prickly lettuce are present. Observed aspens were mostly 1- 3.5 inch dbh and up to 30 feet tall. In one area several 2-3 inch diameter aspens had been felled. Mature mountain alder was present and exhibited an almost closed canopy; few sprouts and saplings were present at floodplain elevations. The mountain alder community type was shaded in turn by mature black cottonwoods. One stand of black cottonwood was observed with all age classes present. Otherwise, some black cottonwood sprouts were noted at floodplain elevations. Also, black cottonwood saplings and juveniles were noted where herbaceous cover was dominated by creeping wild rye and Kentucky bluegrass. Willow sprouts and saplings were present on sand/gravel bars in the floodplain, while more mature willows were present on stream terraces and banks. One large mature Pacific tree willow stem had resprouted in the channel, presumably relocated after a flood event.

Data developed as part of the present study (Table 4.11) indicate that the area is dominated by early successional status ratings. Vegetation in the area is adjusting to past disturbances and current fluvial processes.

Table 4.11. Reach MC2 successional status data

Successional Status	Percent Occurrence
Early	66.6
Mid	24.0
High	9.3

Analysis and Summary: Though there are some adjacent land use impacts associated with road development the primary impact on aquatic habitat and riparian conditions through Reach MC2 is the presence of a large water diversion and the lack of large woody material in the channel. Aquatic habitat conditions are directly affected by the diversion through the loss of streamflow which can be directly related to the quantity of available habitat. At the time of the survey much of the water was being diverted into the irrigation channel. Finding a compromise between agricultural use of water and maintenance of instream conditions will require a long-term water management solution.

In the short-term, geomorphic, aquatic habitat, and water quality goals can be met by restoring the role of large woody material through Reach MC2. Large woody plays an important role in building physical habitat storing sediment behind log jams, reducing velocities by increasing overall channel roughness, and sorting sediment by created heterogeneity in shear and velocity across the channel. Much of this function has been lost due to low recruitment of new wood associated with historic logging and streamside development. Past management practices have also resulted in direct removal of debris jams and large woody material from the stream due to the potential impact to bridges and other infrastructure.

4.2.9 Reach MC4

Rosgen Channel Type: F3 transitional to B3c
Valley Form: Steep Meadow
Bankfull Flow (based on field indicators): 335 cfs (Q5)
Top of Bank Flow: 1,800 cfs (Q100)
Bed Mobility When Flow is at Top of Bank: 96%
Restoration Objective: Revegetate, introduce woody material

Reach MC4 of Markleeville Creek flows through a dry meadow system adjacent to Grover Hot Springs (see Figure 2.2 and maps contained in Section 3.2.4.4 of this report). The reach was selected for detailed study to represent a meadow segment on Markleeville Creek within a highly visible setting (Grover Hot Springs). A longitudinal profile and cross sections of the reach are provided in Figure 4.17, while discharge and sheer data are presented in Figure 4.18.

Geomorphic Characteristics: This reach of Markleeville / Hot Springs Creek occurs at a location that is transitional between a confined canyon upstream and a wider meadow downstream. Though a meadow exists here, there is some invasion of conifers, especially on the right bank suggesting that they meadow may be sustained by high ground water and slightly saline soils associated with the springs and geothermal activity at the Grover Hot Springs site. The originally wide meadow morphology may have been formed during the Pleistocene from a combination of glacial outwash deposits and downstream constrictions associated with terminal moraines.

Subsequent to formation of an at-grade meadow, the channel appears to have incised, as evidenced by the presence of cut banks and abandoned channels on several terraces that are currently inaccessible to the active channel. Such a process may be a result of less sediment delivery in the following the glacial period and not necessarily the result of land use impacts. Regardless of the mechanism that has produced an incised channel within the large meadow, the current channel appears to have reached a new equilibrium state in several areas where new overflow channels, bars, and floodplain have formed. In other areas it still appears to be entrenched and significant bank erosion is occurring.

Aquatic Habitat Characteristics: High quality aquatic habitat characteristics, such as deep pools, clean riffles, roughness elements, and places to hide are present throughout the survey reach. Large boulders and woody material provide the necessary elements to scour pools, create pockets of clean gravel, and provide cover for fish.

The primary limiting factor observed through the study reach was the presence of a significant quantity of fine sediment, which may have been deposited during the intense thunderstorms that occurred in the summer of 2003. Some of the most intense cloudbursts hit Charity Valley which is a few miles upstream of the project site. Fine sediment is well documented as a limiting factor for fish by clogging spawning gravels, filling pools, reducing escape cover, and affecting macroinvertevrate production in riffles.

Vegetation Characteristics: Fifteen vegetation community types were noted. Many consisted of herbaceous wet to dry meadows dominated by sedge species located on stream terraces. Others included woody riparian vegetation relegated to stream banks. Woody vegetation consisted of a combination of mountain alder, creek dogwood, yellow willow, Geyer's willow, Lemmon's willow and Pacific tree willow. One rhizomateous sedge meadow type included a high percentage of aster, yarrow and dandelion as dominant forbs. Kentucky bluegrass also provided cover in three community types.

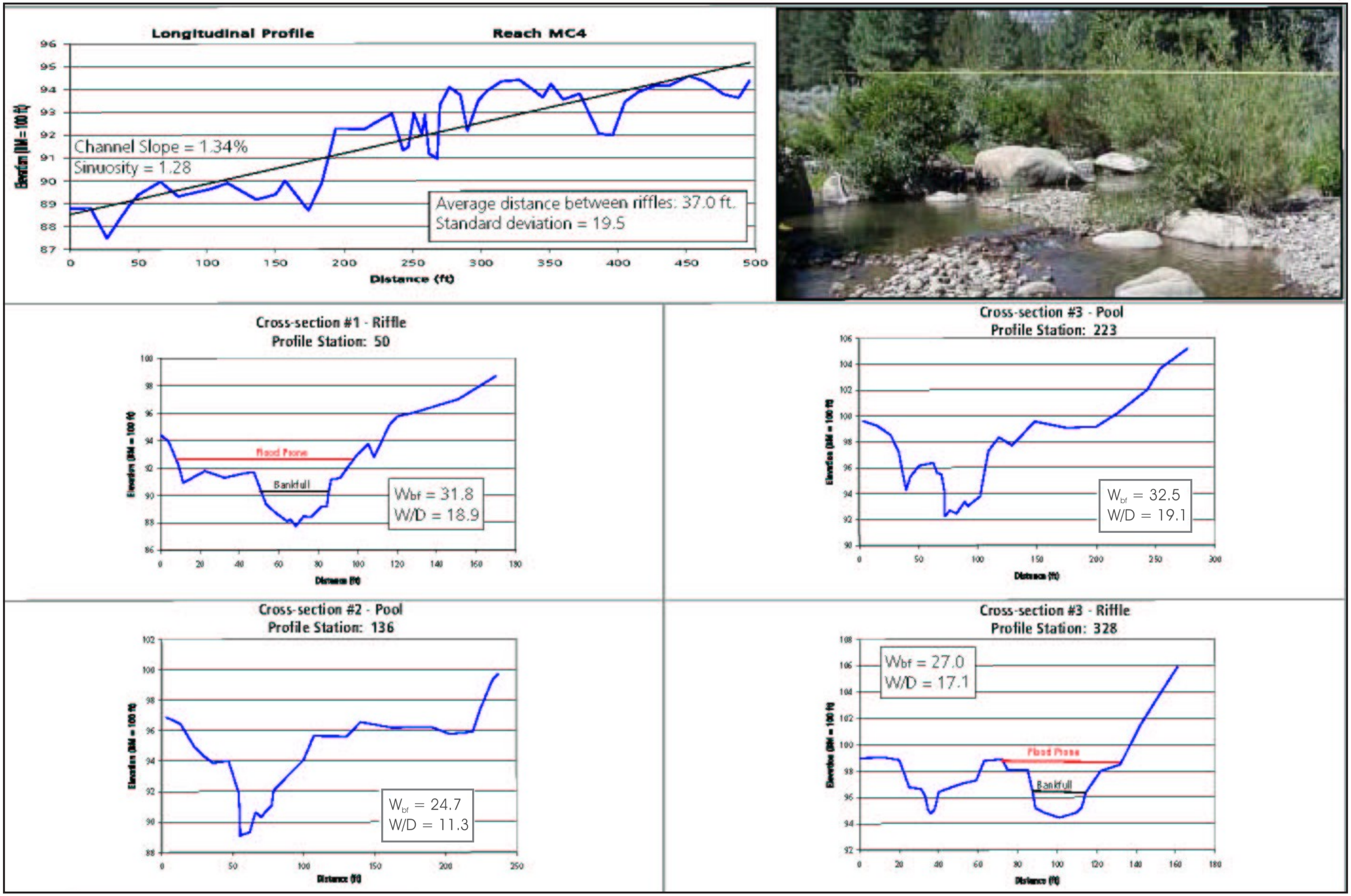


Figure 4.17. Longitudinal profile and cross-section geometry for Reach MC4.

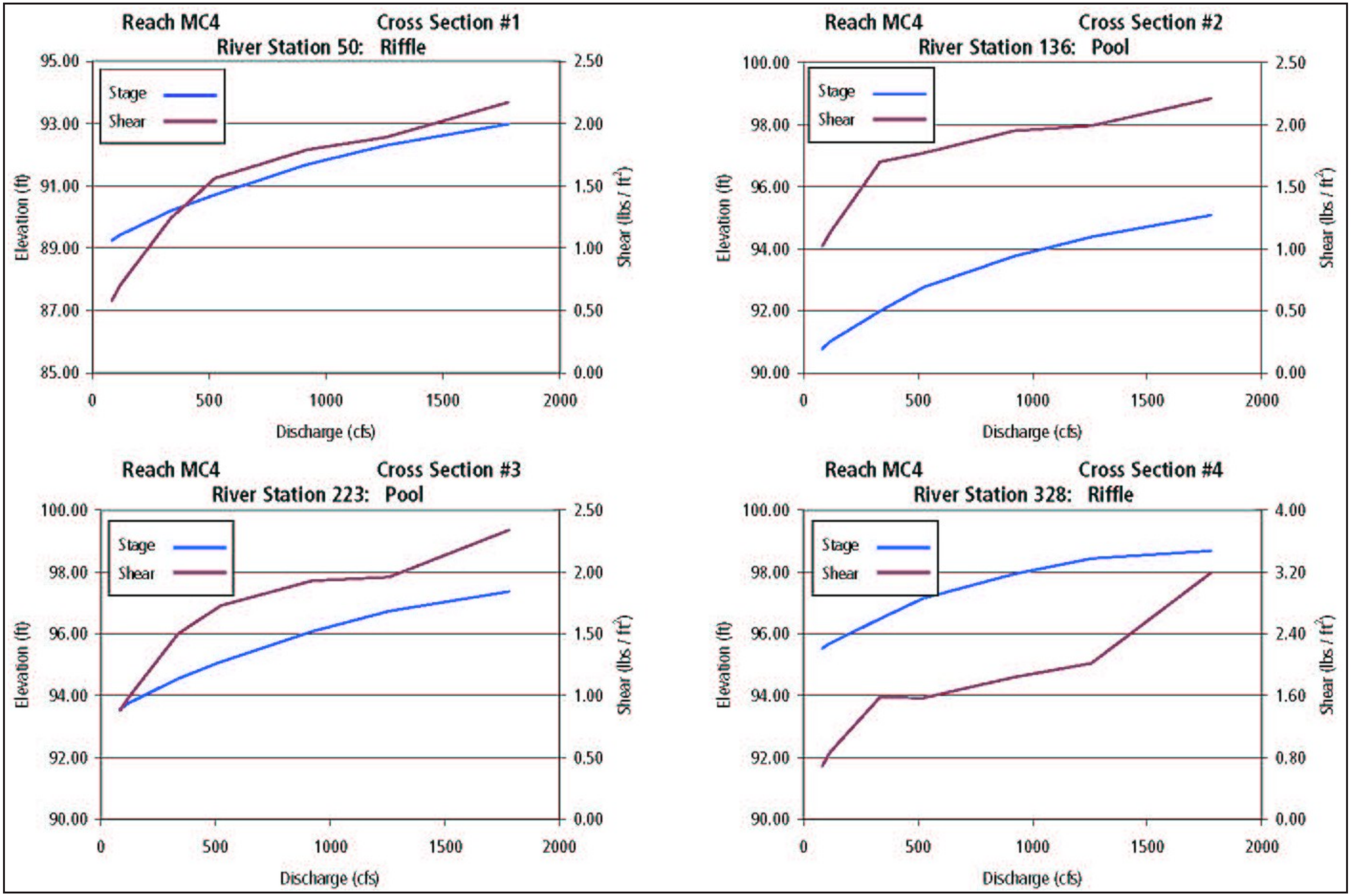


Figure 4.18. Discharge versus shear and stage for Reach MC4.

Gravel bars provided the substrate and hydrology for recruitment of willow species as sprouts and saplings, while banks were generally vegetated by more mature age classes of willows and alder. At one location, mature, sapling and decadent Geyer's and coyote willow were observed on the bank.

Past disturbance was suggested by the presence of increaser species like aster, yarrow and dandelion. The presence of these species at one location at the top of the left bank on the second cross section may lead to increased bank instability. It appeared that active recruitment of willow species was occurring, thereby enhancing bank stabilization and species diversity throughout the reach.

A USFS Ecology Team conducted plant community sampling in the meadows near the downstream end of this reach (plots 96723 through 96726). Community types sampled were not comparable with the present effort. Their findings ranged from low to high ecological status ratings. Data developed as part of the present study (Table 4.12) indicate that the area is dominated by early and mid successional status ratings. Vegetation in the area is adjusting to past disturbances (livestock grazing) and current fluvial processes.

Table 4.12. Reach MC4 successional status data.

Successional Status	Percent Occurrence
Early	5.0
Mid	63.2
High	31.7

Analysis and Summary: Though in general, Reach MC2 on Markleeville/Hot Springs Creek is in good condition there are significant risks to aquatic and riparian habitat associated with adjacent activities at Grover Hot Springs and land use impacts in Charity Valley. Though it is likely that the large amount of fine sediment delivered to this reach during the 2003 thunderstorm activity is overwhelmingly derived from natural sources, land use activities that cause bank instability or adjustments to hydrologic regimes can exacerbate the problem.

Channel and habitat complexity in Reach MC2 is provided by the presence of some large woody material and boulders but it is likely that historic densities were much higher given the likelihood of debris flow events in the upstream narrow canyon that delivered wood to this transitional reach. Restoration opportunities should focus on improving habitat conditions through riparian vegetation planting efforts and the introduction of channel complexity, such as large woody material.

4.3 Hydraulic Analyses

Limited hydraulic modeling was conducted at four locations within the assessment area. Those locations were identified during the preliminary field investigation. The hydraulic analysis provides estimates of the channel capacities, flooding associated with modifications or impingements on historic channel geometry, and hydraulic characteristics of the channels. Emphasis is placed on describing how the bridges influence hydraulic conditions in the channel.

At each study location, cross sections were surveyed at specific locations along the stream, both upstream and downstream of the bridge. These data provide a rough composite representation of channel and bridge geometry. Photographs were taken for use in developing an estimate of stream roughness characteristics. This information was used to develop a preliminary hydraulic model of each site. This allowed the assessment team to approximate channel capacities and assess hydraulic conditions in the channel at various discharge rates. It is important to note that analyses were completed based on limited modeling of the selected sites. The model provides detailed output, but it was conducted at an assessment level only. A detailed, in-depth hydraulic model would need to be completed in advance of any recommended action associated with the bridges.

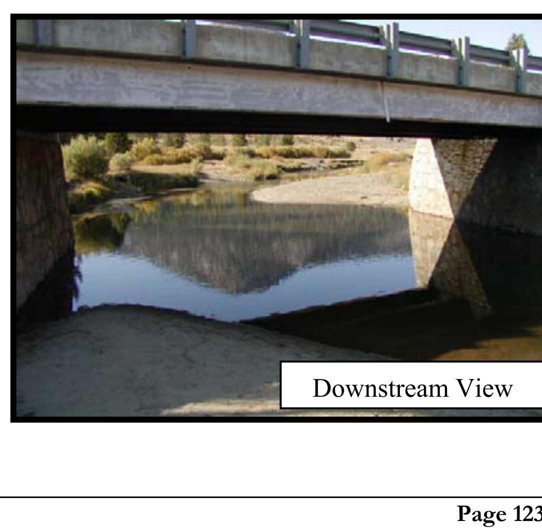
HEC-RAS (v. 3.1.1), a water surface profile software application developed by the US Army Corps of Engineers, was utilized to construct a hydraulic model at each of the bridge locations (USACE 1992, 2003). Output from the models was provided to the Alpine Watershed Group and Alpine County under separate cover.. The following limitations/assumptions formed the basis of the modeling effort:

- normal depth was assumed at the upstream and downstream ends of each of the four stream sections, based on channel slopes;
- a mixed flow regime was specified (sub- and supercritical flows permitted);
- debris analyses were not performed; clear flows were assumed;
- scour analyses were not performed;
- flood plain encroachment analyses were not performed, and, therefore, impacts to adjacent property were not identified;
- cross sections were interpolated between surveyed sections; and,
- discharge rates used in the models were derived from regional regression equations published by the USGS (Waananen & Crippen 1977).

Two to three cross sections were surveyed both upstream and downstream of each bridge, in addition to the two cross sections surveyed at the upstream and downstream face of the bridges, for a total of between six and eight cross sections per site.

4.3.1 Hope Valley Bridge

The Hope Valley Bridge is located along Highway 88 where it crosses the West Fork of the Carson River. The bridge carries two lanes of traffic, and is perpendicular (0 degree skew) to the river streamlines. Field observations indicate that the streambed consists primarily of fines up to rounded gravel material, mostly smaller than a few inches in diameter. This reach has a slope of approximately 0.2%.


Downstream View

The Hope Valley Bridge appears to have adequate capacity to convey the 100-year event without overtopping the roadway. The water surface profile (Model data, Figure H3) through the bridge reveals an average freeboard (distance from the bottom of the bridge deck to the water surface) of approximately 1.9 feet for the 100-year flow.

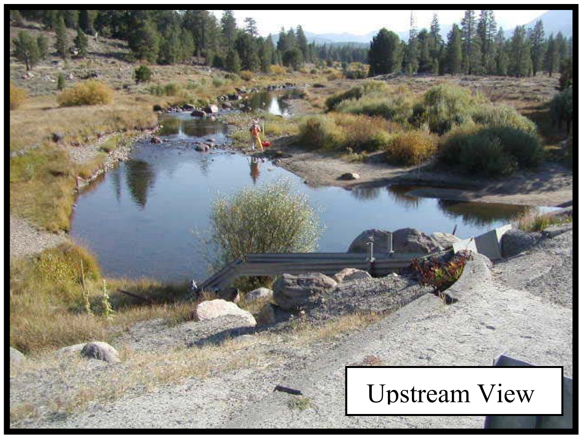
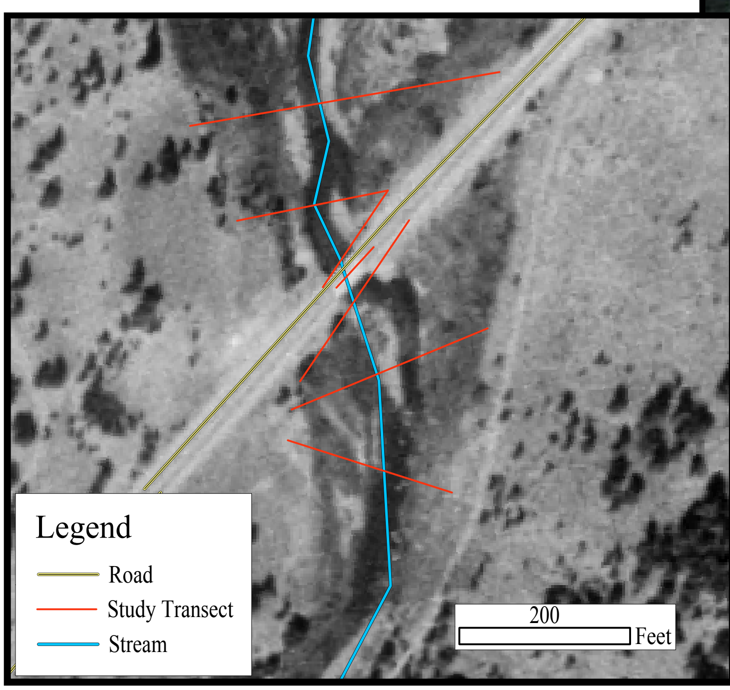


Table 4.13. Hope Valley Bridge Flows by Recurrence Interval

Recurrence Interval	Flow Rate (cfs)
2-yr Flow	220
5-yr Flow	607
10-yr Flow	936
25-yr Flow	1,645
50-yr Flow	2,236
100-yr Flow	3,152

The Hope Valley Bridge significantly narrows the flow path for the stream. Figure H1 (Model data) is a graph showing the top width of flow for the recurrence intervals versus the main channel distance. The highest value on the x-axis represents the upstream end of the evaluated channel section. As shown in Figure H1, the channel constriction begins at main channel distance 227 feet, which is the upstream end of the bridge. It is evident that flows generally resume their previous widths downstream of the bridge (main channel distance 200 feet). Additionally, the stream power (velocity multiplied by shear) significantly increases at the bridge for flows equal to and exceeding the 25-year recurrence interval (see photo above), due in part to the narrower flow path through the bridge. The bridge-related constriction and increased stream power are most likely responsible for channel incision. As can be seen in Figure H3 (Model data), the elevation of the channel bottom drops significantly at the bridge.

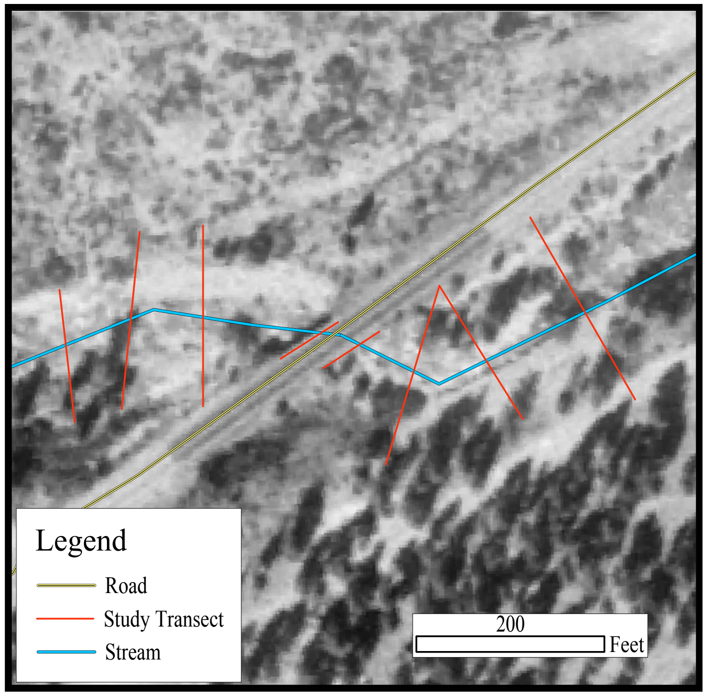


To estimate hydraulic characteristics of the channel without a bridge at this location, a simulation was run removing the bridge from the model. Cross sections through the bridge area were interpolated by looking at cross sections located upstream and downstream of the bridge location.

Figures H4 and H5 (Model data) provide model results for the 100-year flow. They show the top width of flow and stream power versus the main channel distance. The figures also compare conditions with and without the bridge. As can be seen in Figure H4, there is a slight increase in the top width of flow upstream of the bridge before the flow is constricted downward to flow through the bridge. Downstream of the bridge, the top widths for both simulations, with and without the bridge, are the same. Figure H5 shows a much higher spike in stream power in the model that includes the bridge than in the one without the bridge.

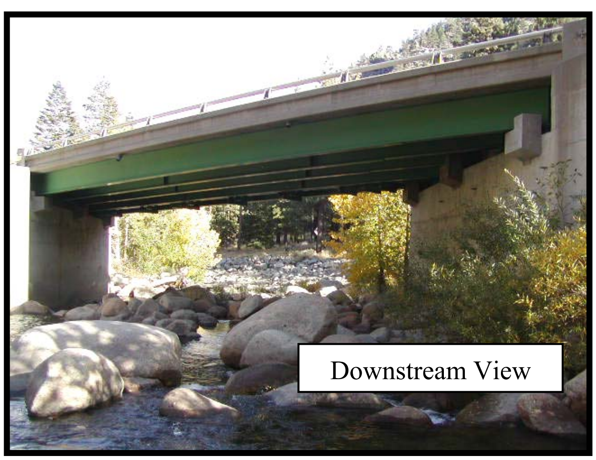
4.3.2 Highway 88 Bridge at Woodfords

The Highway 88 Bridge at Woodfords is located on the West Fork of the Carson River. The bridge carries two lanes of traffic, and is at an approximate 20 degree skew to the river streamlines, however the abutments are not skewed. Field observations indicate that the streambed material is large, consisting primarily of angular and rounded boulders approximately between 8- to 24-inches in diameter, with several boulders outside of this range as well. This reach is relatively steep at a slope of nearly 5 percent.



The Highway 88 Bridge appears to have adequate capacity to convey the 100-year event without overtopping the roadway. The water surface profile (Model data, Figure W3) through the bridge reveals an average freeboard of approximately 10.7 feet at the 100-year flow rate.

As shown in Figure W1 (Model data), the Highway 88 Bridge does not appear to narrow the available flow path when compared to cross sections measured just upstream (main channel distance 305 feet) and downstream (main channel distance 260 feet) of the bridge, for evaluated flows (2-year through 100-year).



The stream power, however, spikes significantly at the upstream end of the bridge for the 25-year and higher flows, but drops at the downstream end of the bridge (see Figure W2, Model data). It is important to note that the stream power also spikes significantly a few hundred feet upstream of the bridge and about 100 feet downstream of the bridge as well. The spikes and drops in stream power indicate that this portion of the river is highly dynamic, whether or not the bridge is present. The bridge does not appear to significantly affect hydraulic characteristics of the stream anymore than the existing natural channel geometry. As can be seen in the stream profile

(Figure W3, Model data), the spike in stream power at the upstream end of the bridge does not appear to have resulted in any consequential degradation of the streambed at this location.

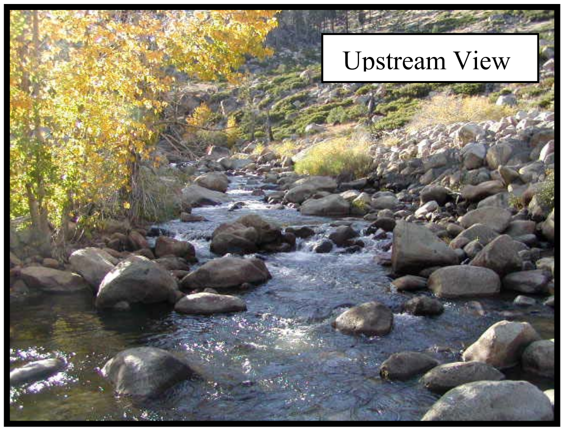


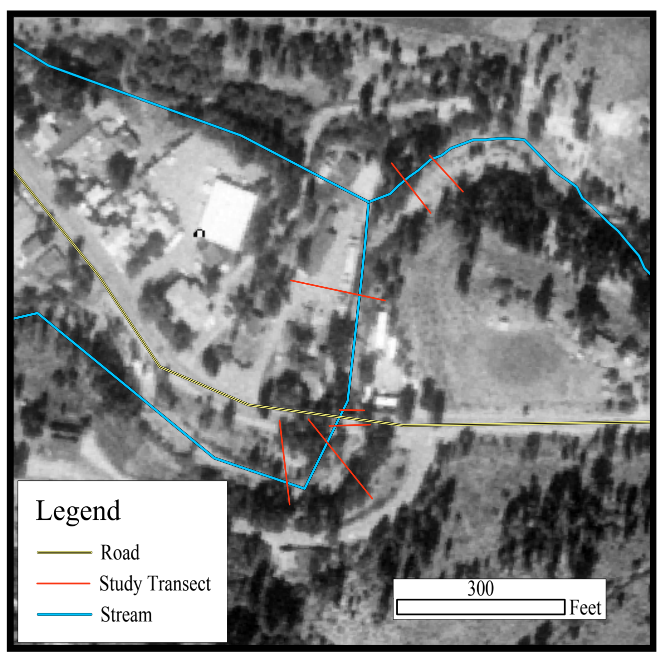
Table 4.14. Highway 88 Bridge Flows by Recurrence Interval

Recurrence Interval	Flow Rate (cfs)
2-yr Flow	382
5-yr Flow	1,009
10-yr Flow	1,533
25-yr Flow	2,668
50-yr Flow	3,597
100-yr Flow	5,026

The hydraulic characteristics of the channel without a bridge present were simulated. The bridge was removed from the model and cross sections through the bridge area were interpolated based on cross sections upstream and downstream of the bridge location. Figures W4 and W5 (Attachement Two) show the top width of flow and stream power versus the main channel distance, respectively, for the 100-year flow, with and without the bridge. Figure W4 indicates that the bridge may be responsible for some undulations in the top width of flow when compared to the top width indicated in the simulation without the bridge. The stream power also appears to be fairly turbulent in the vicinity of the bridge, Figure W5, when compared to the model that excludes the bridge.

4.3.3 Markleeville Bridge

The Markleeville Bridge crosses Markleeville Creek along Highway 89. The bridge carries two lanes of traffic, and is perpendicular (0 degree skew) to the river streamlines. Vertical rockery walls, approximately seven feet tall extend more than 100 feet downstream of the bridge.



A footbridge is located about 90 feet downstream of the Markleeville Bridge. Homes are located along the creek upstream and downstream of the bridge. Additionally, a Forest Service Guard Station is located a few hundred feet downstream of the bridge. Field observations indicate that the streambed consists primarily of fines up to rounded gravel material, mostly smaller than eight inches in diameter. This reach has an approximate slope of just over one percent.

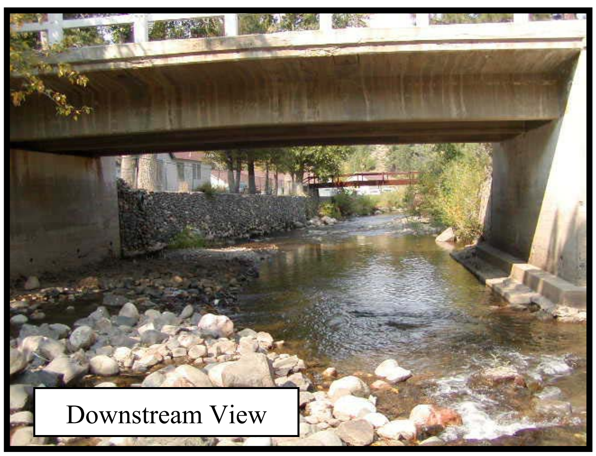
Although the Markleeville Bridge appears to have adequate capacity to convey the 100-year event without overtopping the roadway, the preliminary analysis indicates that the bottom of the bridge may seal during the 100-year event. This means that a pressure flow situation could occur. Additionally, the Forest Service Guard Station and other nearby buildings are impacted by 50- and 100-year events when flows overtop the rockery wall that separates the main channel from the Guard Station. The footbridge downstream of the Markleeville Bridge will also be impacted by these storm events.

Table 4.15. Markleeville Bridge Flows by Recurrence Interval

Recurrence Interval	Flow Rate (cfs)
2-yr Flow	378
5-yr Flow	993
10-yr Flow	1,505
25-yr Flow	2,613
50-yr Flow	3,517
100-yr Flow	4,904


Upstream View

The Markleeville Bridge and the downstream rockery walls erected on the banks of the stream represent a narrowed flow path for the passage of Markleeville Creek (see Figure M1 in Model data). The bridge starts at main channel distance 427 feet. The constriction caused by the bridge and the rockery walls continues downstream for approximately 200 feet before the stream is no longer confined (one wall continues further downstream than the other).

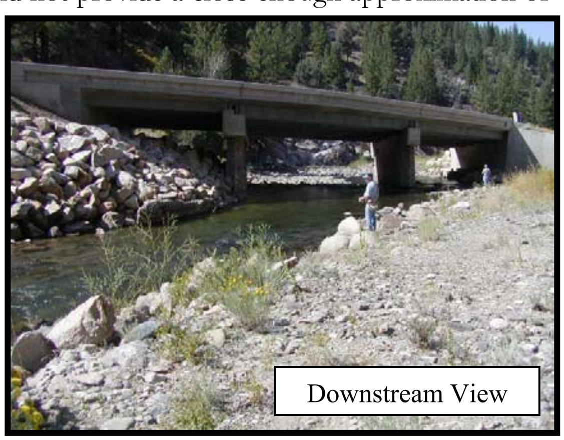

Downstream View

The channel constriction is most likely responsible for the increase in stream power at the bridge, for flows equal to and exceeding the 25-year recurrence interval (Figure M2, Model data). The constriction and subsequent increase in stream power contribute to the channel incision, as can be seen on the stream profile in Figure M3 (Model data). The channel bottom drops significantly at the bridge.

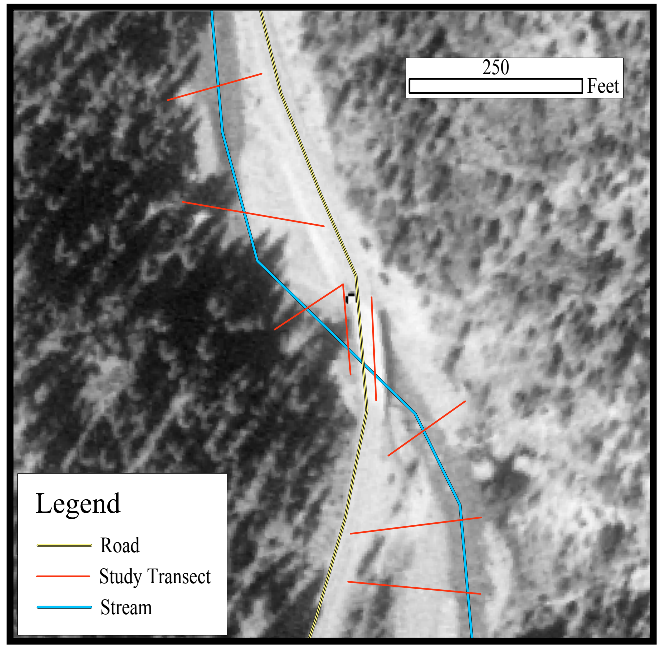
Due to extensive improvements imposed onto the historic channel geometry of Markleeville Creek, including the bridge and rockery walls, a comparison between channel conditions with and without these improvements would not yield useful results. The reason is due to the fact that the improvements have likely influenced upstream and downstream conditions to such an extent that interpolating cross sections across the improvements would not provide a close enough approximation of what one could reasonably expect to find in the absence of those improvements.

4.3.4 Centerville Flat Bridge

The Centerville Flat Bridge crosses the East Fork of the Carson River along Highway 4. The bridge carries two lanes of traffic, and is at an approximate 20 degree skew to the river streamlines, however, the abutments and piers are only at about a 5 degree skew. Field observations indicate that streambed material consists primarily of angular and rounded boulders


Downstream View

approximately between 6 and 18inches in diameter, with several boulders outside of this range as well. Larger, and mostly angular, boulders can be found around the bridge abutments. This reach has a slope of approximately 1.5 percent.



The Centerville Flat Bridge appears to have adequate capacity to convey the 100-year event without overtopping the roadway. The water surface profile (Figure C3, Model data) through the bridge reveals an average freeboard of approximately 1.4 feet at the 100-year flow rate.

The flow path available at the Centerville Flat Bridge does not vary significantly with respect to flow path widths evident upstream (main channel distance 454 feet) or downstream (main channel distance 410 feet) of the bridge (see Figure C1 in Model data). In fact, one cross section measured approximately 150 feet upstream of the bridge is significantly narrower than the cross section through the bridge. The stream power spikes at a few locations within the channel, but neither of these locations are at the bridge (see Figure C2 in Model data). The Centerville Flat Bridge does not appear to be significantly impinging upon the natural hydraulic characteristics of the channel.

Table 4.16. Centerville Flat Bridge Flows by Recurrence Interval

Recurrence Interval	Flow Rate (cfs)
2-yr Flow	945
5-yr Flow	2,347
10-yr Flow	3,494
25-yr Flow	6,020
50-yr Flow	8,033
100-yr Flow	11,111

To estimate the hydraulic characteristics of the channel without a bridge at this location, a simulation was prepared without the bridge. Cross sections through the bridge area were interpolated using cross sections upstream and downstream of the bridge location. Figures C4 and C5 (Model data) show the top width of flow and stream power versus the main channel distance, respectively, for the 100-year flow, comparing conditions with and without the bridge. Figure C4 shows some slight differences in the top width of flow between the two simulations. Figure C5 actually shows the stream power to be higher through the bridge area and for a few hundred feet downstream of the bridge, for the simulation without the bridge. This can be largely attributed to the fact that the bridge simulation accounts for a much higher channel roughness throughout the bridge area, due to the presence of heavy rock riprap around the bridge abutments, than is present in the simulation without the bridge. Therefore, the simulation without the bridge incorporates a much lower channel roughness value, which leads to higher velocities, and consequently, higher stream power.

4.4 Aquatic Biology and Water Quality

Although the main objective of this assessment was to provide an analysis of fluvial geomorphology, the team reviewed habitat conditions at our detailed assessment sites (discussed in the preceding section). Available data on the effects of land use to aquatic biology and water quality were also reviewed. In this section, we provide a qualitative summary of available information and biological effects.

4.4.1 Existing Data and Studies

The California Department of Fish and Game (CDFG) is currently preparing an administrative report on the status and distribution of fish resources within the East and West Forks of the Carson River (personal communication, Dave Lens, CDFG). It is expected that these reports will be completed in the first part of 2004. These reports will summarize the results of fish population surveys conducted during the 1980's and 1990's. Fish populations will be the primary focus, although in some cases habitat within study reaches also will be assessed.

Alpine County, the Alpine Watershed Group, the Carson Water Sub-Conservancy District, and the South Tahoe Public Utility District are conducting a water quality monitoring program that extends throughout the current assessment area. The program will evaluate water quality in the East and the West Forks of the Carson River, Markleeville Creek, Millberry Creek, and Indian Creek. The program will extend over several years and a final report is due in 2007.

4.4.2 Water Quality Impairment

Water quality data are available from several sources. Data regarding metals are available for Bryant Creek, while information on nitrogen, phosphorous, sodium, and pathogens is available for the West Fork. Specific data sets are also available for Indian Creek (habitat alteration and pathogens), Monitor Creek (aluminum), and Wolf Creek (sedimentation and siltation). Until recently, two areas within the watershed were listed on the 303d list for impaired water quality - Indian Creek along the West Fork for phosphorus, and the East Fork for sediment. Recently, however, the East Fork was delisted.

The Leviathan Mine operated intermittently from the early 1860s through the early part of the twentieth century. Its major period of operation was between the 1910s and about 1962. During this time, the Leviathan Mine was the largest sulfur producing mine in the country. About 22 million tons of overburden containing sulfide minerals was discarded in the mine area. Bryant Creek, a tributary to the East Fork Carson River, and several of its tributaries receive acidic drainage and trace metals from the mine. The Lahontan Water Quality Control Board is conducting operations intended to remedy water quality issues at the Leviathan Mine.