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Appendix C: Geomorphic Analysis for Yreka Creek Greenway Floodplain Construction Projects, City of Yreka

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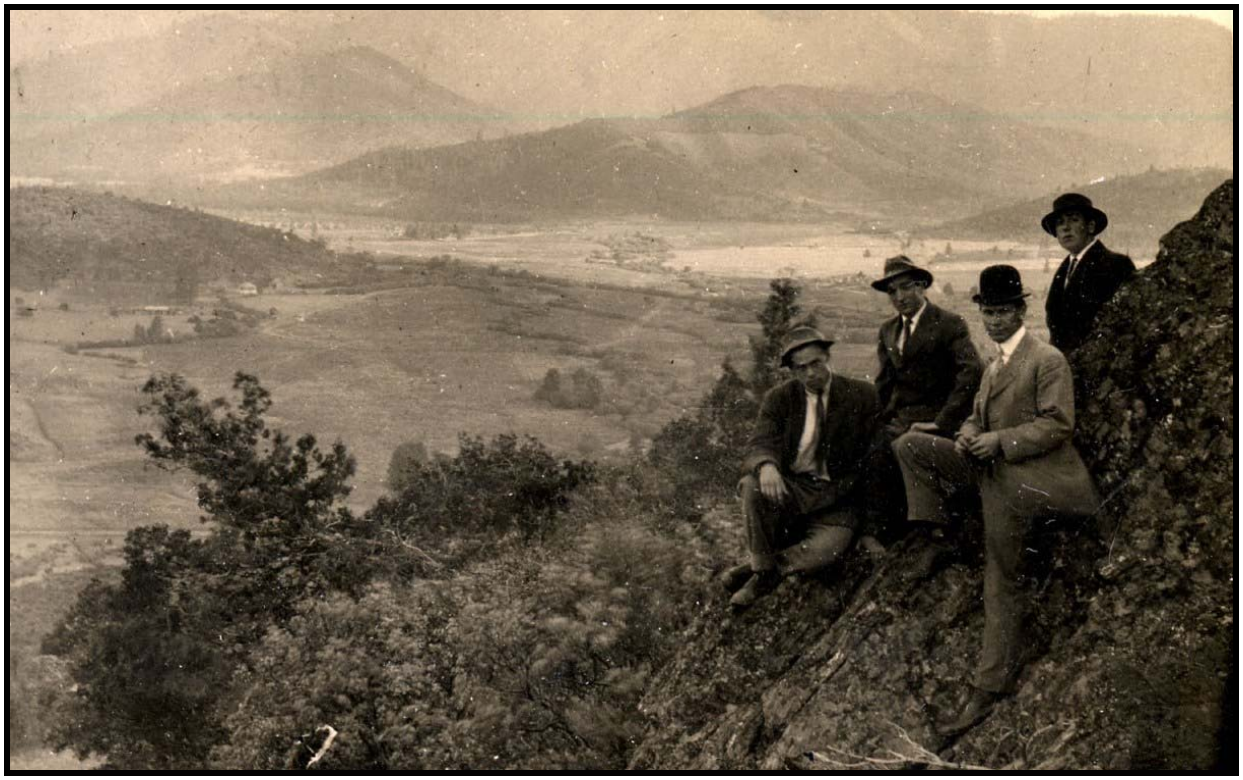

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1.0 Introduction and Objectives

The geomorphic analysis incorporated existing geomorphology and assessment documents, researched historic information and data, researched recent documents containing historic information, conducted field mapping, utilized photogrammetric topographic mapping, and hydrologic and hydraulic modeling data to perform the necessary calculations to develop geomorphic parameters needed for stream channel and floodplain design. The design considered frequent storm events (i.e., Q_2) at one extreme for channel and floodplain health (channel maintenance flows, easily-accessible floodplain), and infrequent events (i.e., Q_{10} to Q_{100}) at the other extreme for quantifying the channel forming discharge and developing stream channel and floodplain restoration recommendations. Watershed and channel features measured include:

- Historic channel location and meander patterns;
- Historic floodplain extent and patterns;
- Historic side channel, overflow channel, and natural channel patterns;
- Historic extensive beaver locations and patterns;
- Alterations to historic channel and floodplain conditions;
- Existing channel and floodplain conditions;
- Design channel width, depth, and sinuosity;
- Design floodplain width and height above channel bottom;
- Design floodplain side channels and overflow channels;
- Design beaver habitat areas relative to role in creating fish/wildlife habitat; and
- Sediment transport regimes and connectivity.

The main objective of the geomorphic analysis was to qualify and quantify stream channel restoration design parameters for input into planning, design, and construction documents. While conducting geomorphology fieldwork, various features were field-checked to evaluate the completeness of existing mapping and provide information and data needed for other parts of the planning process.

2.0 Methods

2.1 Hydrology Methods

Standard hydrologic methods were used to characterize the hydrology of Yreka Creek. The hydrologic analysis focused on the relationship between catchment form, storm and flood magnitude, frequency, duration, and timing. Results from the Hydrology Report were where applicable and were most relevant for the Q_{100} flood event. Precipitation and stream flow data were used to calculate the flood frequency statistics for the Q_2, Q_5, Q_{10}, Q_{25}, Q_{50}, and Q_{100} flood events.

2.2 Geomorphology Methods

Standard geomorphic methods were used to characterize the historic and existing stream channel condition and identify the types and location of treatments likely to reduce flood risk, reduce reach scale channelization, and rehabilitate the stream reach scale effects of channel incision (e.g., Shields et al., 1999). Rehabilitating the effects of

channelization at the reach scale requires an understanding of the channel forming discharge, in this case assumed to be the Q_2 or bankfull flood event, stable channel geometry, sediment yield, and engineering properties of bed and bank materials (Schumm, 1999, Hey et al., 1997, Simon et al., 2006, and Hooke, 1997).

Mainstem Yreka Creek and major tributaries were used to sub-divide the stream channel into analysis and design reaches. Eight discrete reaches were delineated (Appendix A, Figure 1) and Table 1. Historic and field data are summarized by reach below.

Table 1. Geomorphic analysis reaches.

Reach Name	Reach Code
Yreka Creek Westside Road to Juniper Creek	1
Yreka Creek Juniper Creek to Greenhorn Creek	2
Yreka Creek Greenhorn Creek to East Oberlin drainage	3
Yreka Creek East Oberlin drainage to Little Humbug Creek	4
Yreka Creek Little Humbug Creek to Long Gulch	5
Lower Juniper Creek (Rolling Hills Drive to confluence)	6
Lower Greenhorn Creek (dam to confluence)	7
Little Humbug Creek (Humbug Hollow to confluence)	8

Field Surveys of Stream Channel and Floodplain Geometry and Channel Substrate

Field surveys of Yreka Creek, Juniper Creek, lower Greenhorn Creek, and Humbug Creek were completed. Yreka Creek was mapped from Station 0.0 at the confluence with the Shasta River to Station 41,075 near the Highway 3 and Wicklow Woods Drive intersection (Appendix A, Figure 1).

Data collected include stream channel geometry for the upper bank, lower bank, and channel bottom. Other features mapped include:

- Stream channel/bank erosion sites and other problem areas;
- All storm drain outlets and other outfalls found, including pipe sizes;
- Any storm outlets or other outfalls that are flowing during dry weather periods;
- Adjacent storm drain connectivity (also satisfies MS4 Subtask E.9.a).
- Other utilities encountered (pipe crossings, manholes, etc.);
- Retaining walls and other infrastructure not showing on maps;
- Field-check of new mapping;
- Major populations of invasive plant species;
- Large deposits of trash, concrete, asphalt, and other debris;
- Leaks, oil sheen, and other indications of potential contamination;
- Obvious cultural resources;
- Localized/hidden wetland areas;
- Any species of concern;
- Beaver dams; and
- Other relevant planning and design data.

Field maps and a Trimble GeoXT GPS were used to map the stream channel and other features. The GPS has a horizontal accuracy of about 1 foot and a vertical accuracy of about 20 feet. The 2014 DEM and existing data were used as background files for the field maps.

Stream classification methods used include:

- Schumm, Harvey, and Watson (1984)-Stages I through V;
- Montgomery and Buffington (1993); and
- Rosgen.

Geomorphic field parameters measured include:

- Valley slope and length;
- Channel bankfull width, depth, slope, and sinuosity;
- Floodplain width and depth;
- Bed material texture and armoring (e.g., D_{50}); and
- Upper and lower bank stability.

Field measurement types include:

- Reach mapping;
- Cross sections (channel plus floodplain) at midpoints and transitions of each facet (riffle, run, pool, and glide);
- Channel longitudinal profile (facet midpoints and transitions); minimum 20 times bankfull width and/or 1 to 2 meander wavelengths; channel bottom and water surface elevations; and
- Bed material texture and facies.

Historical and Existing Stream Channel and Floodplain Geomorphic Analysis

Historical information and data were gathered to include: eye witness accounts, oblique photographs, historical records (e.g., County Assessors Plat maps), aerial photographs, and topographic maps. Results of the historical analysis and field mapping were used to characterize and quantify the existing and design stream channel and floodplain conditions.

Stream Channel and Floodplain Restoration Design

The types, stages, evolution, causes, and effects of channel incision are determined by a complex set of intrinsic and extrinsic factors that are often difficult to accurately predict (Werritty, 1997). Active channel incision, in response to a change in the mass balance between streamflow, debris flux, and/or the strength of bed and bank material, shapes landforms over a wide range of spatial and temporal scales (Leopold et al., 1964, Darby and Simon, 1999). The Lane (1955) equation is commonly used to help define and quantify the type of channel incision and state of equilibrium (Hey, 1997):

$QS = Q_S * D_{50}$.

Where:
Q = channel forming discharge
S = stream gradient
Q_S = sediment yield
D_{50} = median diameter of bed material.

Channel incision can occur as rills and gullies that form on a recently graded fill-slope, after a 15 minute thunderstorm, or as an entrenched stream channel that forms as a result of erosion and deposition over thousands of years. Large floods interact with the channel network, and both commonly determine the state of channel equilibrium and rate of incision (Schumm, 1999, Benda et al., 2004, and Montgomery, 1999). For a given channel network, the type and cause of active incision varies in space and time as a function of these extrusive disturbance processes (Darby and Simon, 1999 and Montgomery, 1999).

Results from the hydrology analysis, historical analysis, and geomorphic field mapping were used to populate the Lane (1955) equation for existing conditions. The findings were then used to develop stream channel and floodplain restoration design recommendations.

3.0 Results and Discussion

3.1 Hydrology and Channel Forming Discharge

Available precipitation and stream flow data and statistics were summarized as part of the Hydrology Report and SWPPP Information Document. This section focuses on the precipitation and flow frequency of occurrence as related to floods that cause geomorphic change.

The geomorphic analysis area is within a semi-arid climate zone (steppe climate) with an average air temperature of 54 ^{o}F and an average precipitation of about 13 to 20 inches per year. Most of the precipitation falls between October and May, and the timing and duration of precipitation events is highly variable. The amount of precipitation varies spatially and there are measured differences in average precipitation for long term precipitation gages within 2.5 mile of one another. This is typical of a steppe climate zone and is in part due to high intensity thunderstorms that occur during the summer months and can produce very localized measurable precipitation.

The available precipitation data show that the Brazie Ranch station is the most representative gage for the Yreka Creek Subwatershed, and these data were used to characterize long-term climatic trends (i.e., wet versus dry cycles). Flow data from the Shasta River downstream of Yreka Creek and from lower Yreka Creek itself were used to further refine the flood flow values. One year of data are available for the lower Yreka Creek gage. For the 2015 water year, data from the Shasta River and lower Yreka Creek

were compared, stage discharge relationships were developed, and peak flow values for annual peak flow events were predicted for Yreka Creek.

Flood events can occur during wet and dry cycles but are most frequent during wet periods (Figure 1). Most of the large flood events measured on the Shasta River over the past 80 years have occurred during wet cycles. The five largest flood events recorded occurred in 1964 (peak of record), 1974, 1997, 2005, and 2015.

The available stage and flow data show that when the lower Yreka Creek stage increases so does the Shasta River (Figure 2). This relationship can be used to predict un-measured flow values at the lower Yreka Creek gage. Using this relationship, this analysis predicted the annual peak flow values for the 80 years of record and developed a flood frequency curve for Yreka Creek (Figure 3). This gage to gage relationship provides a reliable peak flow estimate for the Q_2, Q_5, Q_{10}, Q_{25}, Q_{50}, and Q_{100} flood events (Table 2).

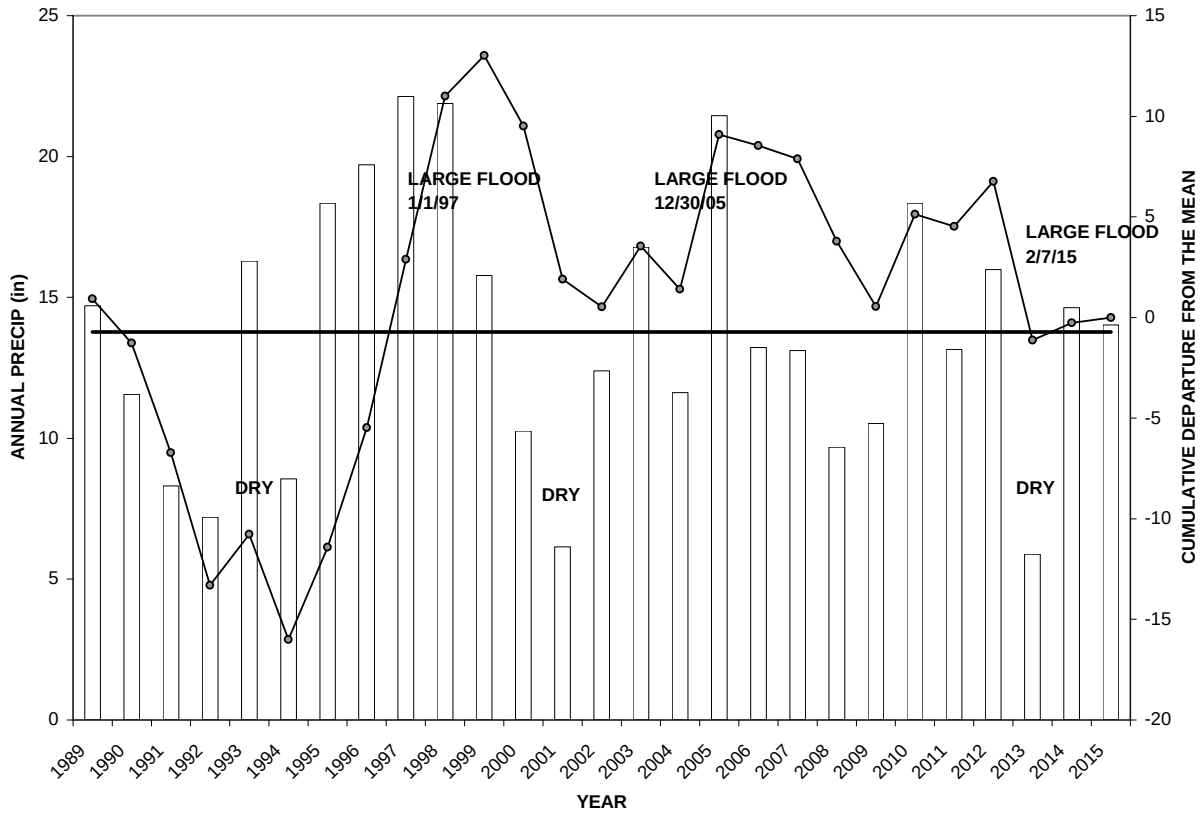

Figure 1. Cumulative departure from the mean graph for the Brazie Ranch Station period of record.

Table 2. Predicted peak flow values for lower Yreka Creek.

Recurrence Interval	Q Low Estimate (cfs)	Q High Estimate (cfs)
Q_2	150	400
Q_5	300	700
Q_{10}	700	1000
Q_{25}	1000	3000
Q_{50}	3000	6000
Q_{100}	5000	8000

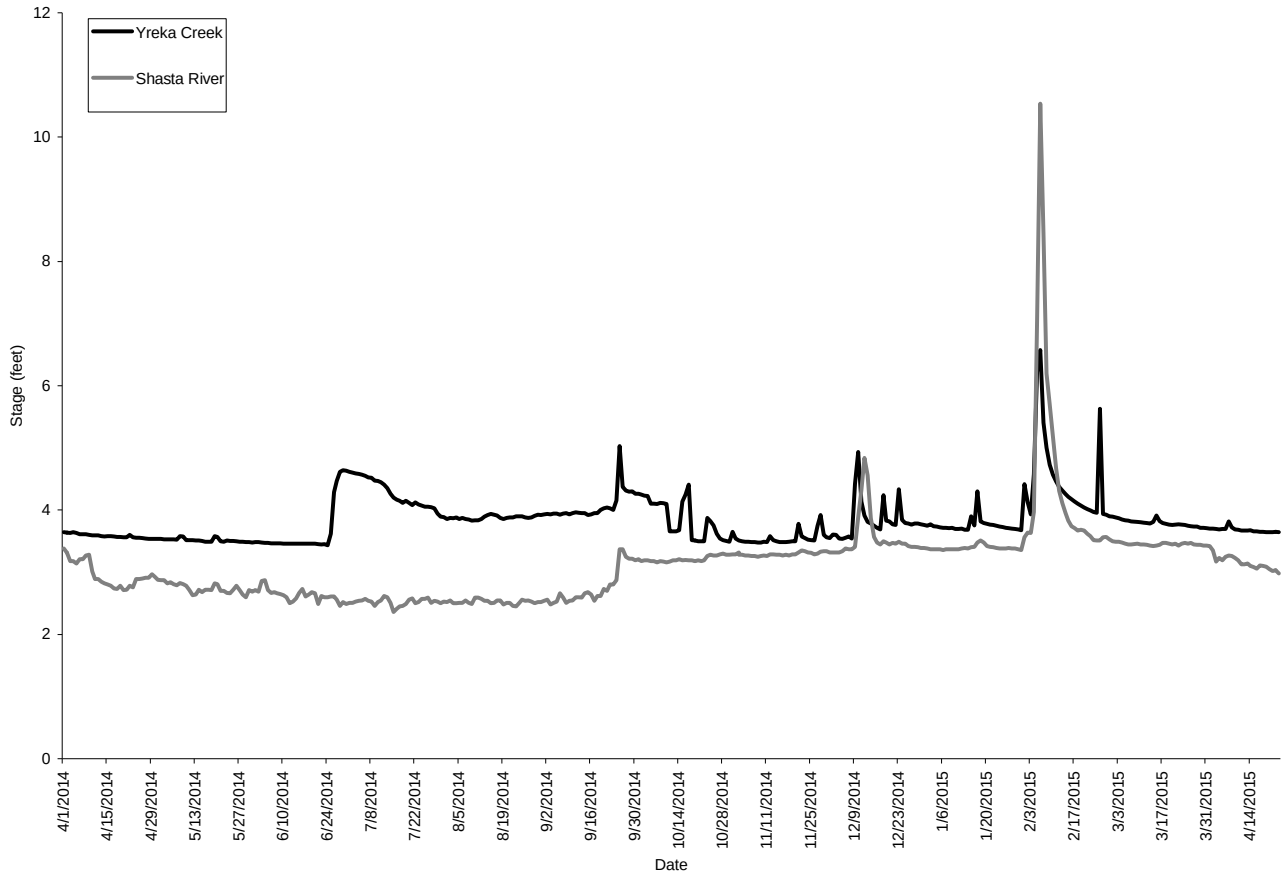

Figure 2. 2014-2015 stage relationship between lower Yreka Creek and the Shasta River. Table 2 summarizes the peak flow estimates.

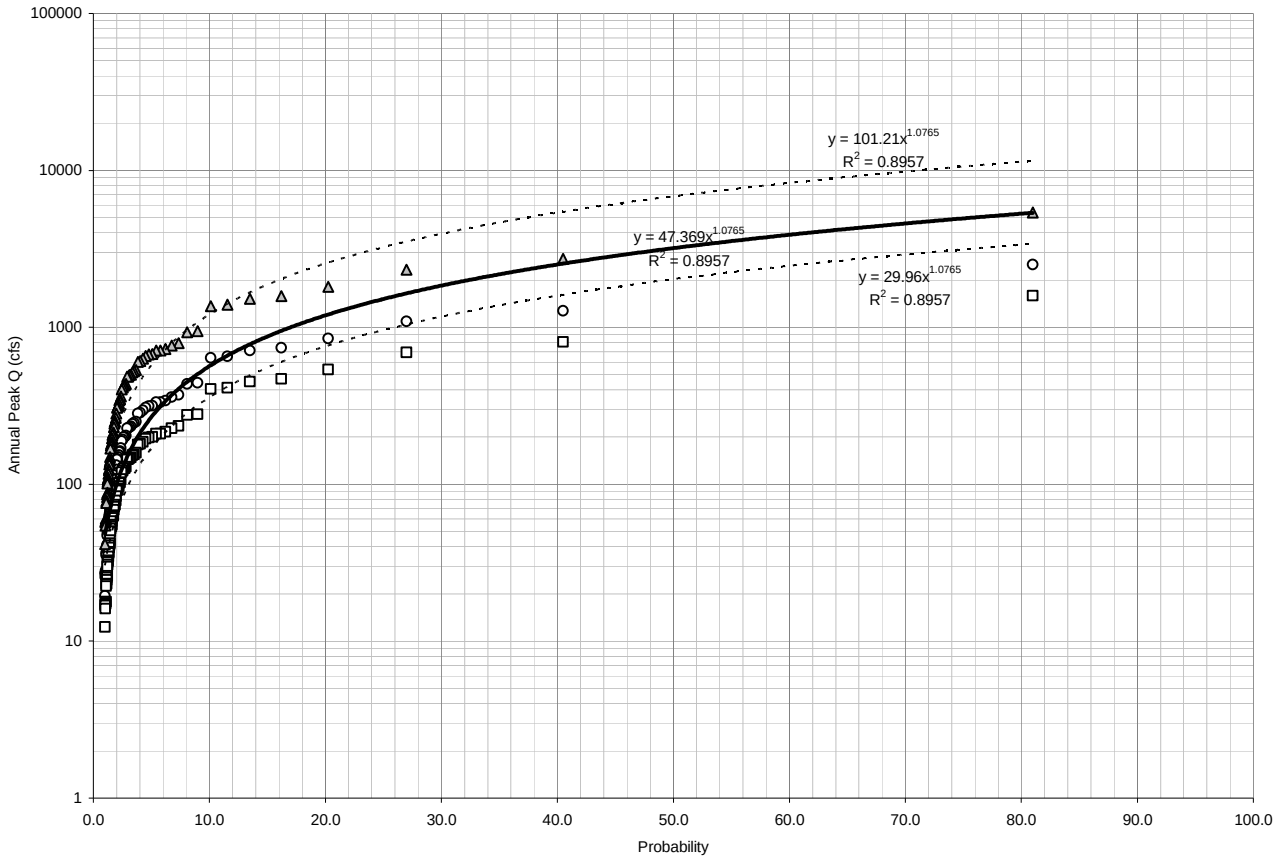

Figure 3. Predicted flood frequency curve for lower Yreka Creek based on the Shasta River near Yreka stream gage flow record.

This analysis collected flow data during the February 7, 2015 flood event and mapped channel changes after the flood. This was the 5th largest flood since 1934 and was a Q_{16} flood event. This was a channel forming flood event that scoured and deposited bed material, eroded banks, filled pools and riffles, and created large debris jams. This event provides measured data for the actual flow regimes and geomorphic thresholds. These data indicate that the Q_{10} flood is likely the channel forming discharge.

3.2 Historic Geomorphic Conditions

The geomorphic analysis found that historic floodplain extent and pattern varied as a function of drainage area, valley shape, stream gradient, and bed and bank material properties. The upper portion of the Yreka Creek Subwatershed has relatively steep valleys and stream channels cut into the Klamath Mountains geology. The historic floodplain of these source channels were narrow and v-shaped. The lower portion of Yreka Creek is relatively flat with broad valley bottoms and relatively flat stream channels in the Quaternary Alluvium geology. The pool-riffle channels within this floodplain were likely wide and braided and meandered across the valley floor.

Historic Channel Conditions
This analysis used the best available data to characterize the historic channel conditions. The channel location, meander patterns, floodplain extent and patterns, side and overflow channel patterns, and the extent and patterns of beaver dams were all evaluated. The most relevant historical evidence found were eye witness accounts and old oblique photographs (see Appendix B). Other information includes a historic topographic map from 1939 and historic aerial photographs from 1941.

The condition of Yreka Creek was documented in 1850 by Joseph Lane. "As he and his fellow travelers first saw Yreka Creek he described it as having many trees and willows around the riparian zone. The stream, as they found it, was radically different from what we see to-day (i.e., 1881)." As Joseph Lane described it, "It was a succession of deep holes, filled with clear water, having on clearly defined channel, as at the present".

Analysis of the available historic information and data shows that before 1850 the mainstem of Yreka Creek was an alluvial pool-riffle channel with winding meanders and a wide riparian corridor. These channel attributes are visible in the oblique photograph comparison in Appendix B. This analysis attempted to map the historic channel location and pattern from these photographs in two locations and are shown as blue lines in Appendix A, Figure 2.

Yreka Creek Westside Road to Juniper Creek (RC-1), Yreka Creek Juniper Creek to Greenhorn Creek (RC-2), and Yreka Creek Greenhorn Creek to East Oberlin drainage (RC-3)
These reaches had a wide flat valley bottom on both sides of the stream. The historic channel meandered through the valley bottom with frequent side channels (Appendix A, Figure 2). The floodplain was likely wide and shallow with thick riparian vegetation. The channel and floodplain areas were likely used by beavers. Stream channel location and pattern were likely influenced by beaver dams.

Yreka Creek East Oberlin drainage to Little Humbug Creek (RC-4) and Yreka Creek Little Humbug Creek to Long Gulch (RC-5)
These reaches had a wide moderately flat valley bottom on west side of the stream and a steep valley wall to the east formed by the Klamath Mountains geology (Appendix A, Figure 2). The east side of the valley confines the stream channel and blocks it from migrating east. The historic channel meandered through the valley bottom with infrequent side channels and small tributary junctions. The floodplain was likely wide with a thick riparian corridor. Like the upper reaches, channel form and function were likely influenced by beaver dams

Lower Juniper Creek (Rolling Hills Drive to confluence) (RC-6)
This reach has a wide moderately flat valley bottom on the west side of the stream and a moderately steep valley wall to the east. The stream channel was likely similar to RC-1 and RC-2 (Appendix A, Figure 2).

Lower Greenhorn Creek (dam to confluence) (RC-7)
This reach had a narrow moderately flat valley bottom on the north and south sides of the stream (Appendix A, Figure 2). The valley walls confined the stream channel. The historic channel meandered through the valley bottom with infrequent side channels. The flood plain was likely narrower than Yreka Creek; however, Greenhorn Creek is within the Quaternary Alluvium and likely had pool-riffle reaches. Beavers likely used this reach, especially near the top before the valley apex.

Little Humbug Creek (Humbug Hollow to confluence) (RC-8)
This reach has a wide moderately flat valley bottom on the north and south sides of the stream. The valley walls do not confine the stream channel (Appendix A, Figure 2). The historic channel meandered through the valley bottom with frequent side channels. The floodplain was likely very wide and shallow with moderately thick riparian vegetation. Given the small size of the stream channel, beaver activity was likely limited.

3.3 Alterations to Historic Channel and Floodplain Conditions

In natural alluvial pool-riffle channels, the active channel itself typically does not contain more than the Q_2 to Q_5 flood events, with most of the larger flows accommodated on the floodplain. The Q_2 and Q_5 refer to the annual peak flood flows experienced on average once every 2 and 5 years, respectively. However, entrenched channels are typically narrow and can convey the entire Q_2 to Q_{100} in the rectangular channel. In these narrow and confined reaches, the unnatural lack of adequate floodplain width typically results in scour of sediment and steep unstable banks. In many natural alluvial channels, infiltration of storm runoff into the streambank can reduce flood peaks downstream, a process classified as bank storage (Todd, 1955). Lack of floodplain and stream bank storage means that storm runoff is efficiently conveyed downstream, increasing the magnitude and frequency of peak flows. These effects can result in increased flooding problems downstream. In addition, groundwater recharge within the floodplain can be reduced by the shortened duration of peak flows, decreasing the floodplain area, and decreasing base flows.

The portion of the Yreka Creek Subwatershed that is now the City of Yreka was developed around 1850. Roads and structures were build along Yreka Creek and represent the first channel alterations (Appendix A, Figure 2). Not until the 1930s onward, the areas where Yreka and Greenhorn Creeks flow through Quaternary Alluvium were being heavily dredge mined (see Appendix B). Hard rock and tunnel mining were also occurring throughout the valley. As part of development and mining, the channel location was moved laterally and vertically. Historical evidence suggests that at one time the flow of Yreka Creek was conveyed through a tunnel under the town. There are several known abandoned tunnels, shafts, and wells within the city limits and most of them convey groundwater.

After the late 1800s, the once wide and sinuous floodplain form was replaced with narrow straight channels with narrow floodplain width (Appendix A, Figure 2). Yreka Creek became a perennially entrenched alluvial channel and the rate of incision

increased. The depth of incision and scour were a function of the occurrence of large floods and bed and bank material strength. Urban structures, roads, and dredger tailing piles directed the flow patterns of Yreka Creek from lower Greenhorn Creek downstream to the confluence with Shasta River (Appendix A, Figure 2). The coarse and armored nature of the dredger tailings held the Yreka Creek channel laterally. Subsequently, the channel has adjusted vertically through the process of incision.

3.4 Existing Geomorphic Conditions

The existing geomorphic conditions are summarized in Appendix A, Figure 3 through Figure 9 and Table 3. Background research, field geomorphic mapping, and spatial and tabular data analysis were used to characterize and quantify the existing geomorphic conditions. The following types of data were used in this analysis:

- Historic channel data and information;
- Historic maps, photographs, and aerial photographs;
- Hydrograph and flood frequency data;
- Cross-section and longitudinal profile data;
- Substrate data; and
- Sediment transport data (coarse sediment connectivity).

Upper Bank Elevation Versus Thalweg Longitudinal Profile

The longitudinal profiles of the existing stream channel thalweg and of the west upper bank of Yreka Creek were plotted to visually show the amount of incision within the entrenched channel by reach (Figure 4). The plot also helps identify where there is potential for sediment supply from bank erosion. For Yreka Creek, the amount of incision increases in a downstream direction and the average bank height is 8 feet (Figure 4). The upper reach (RC-1) has the least amount of incision with an average bank height of 6 feet. Roads and structures that cross the channel can increase or decrease upper bank height.

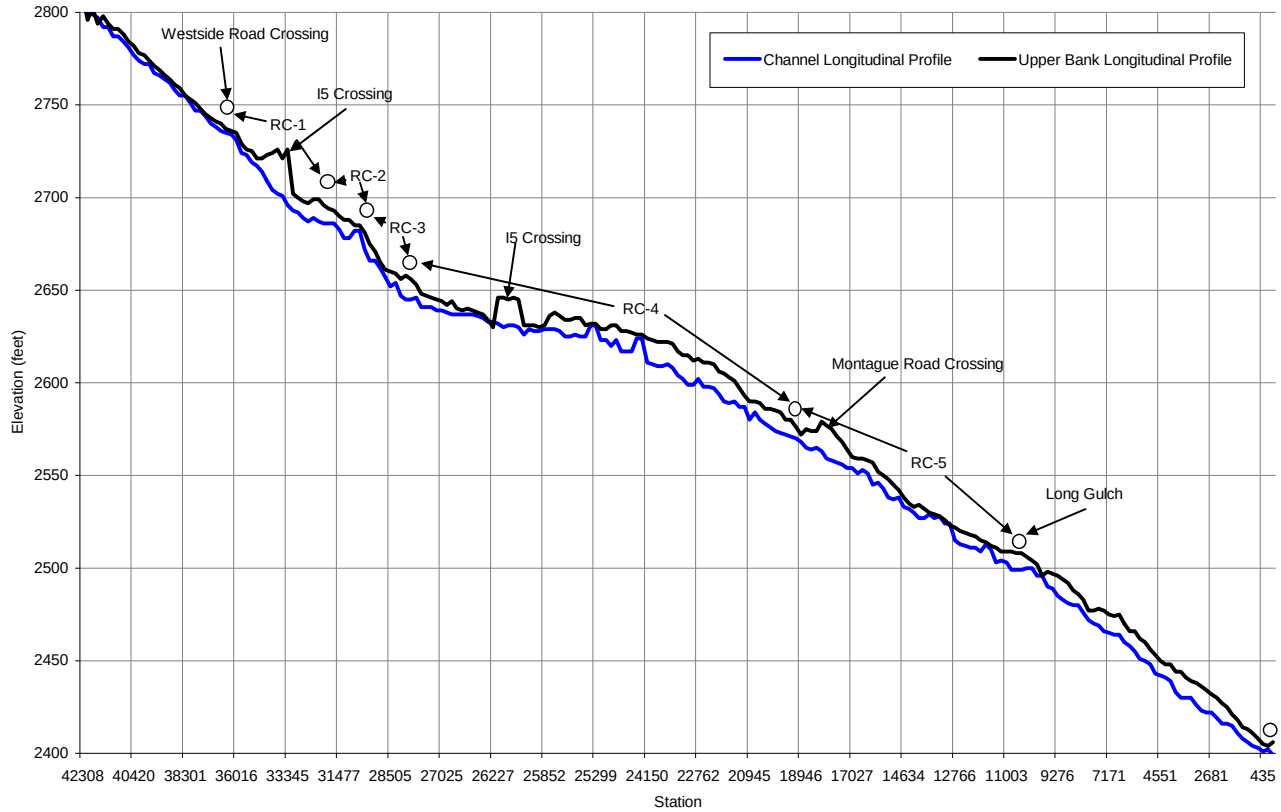

Figure 4. Longitudinal profile of mainstem Yreka Creek thalweg (blue line) and west upper bank (black line) measured every 200 feet from DEM.

Stream Channel Cross-sectional Geometry

The results of the field geomorphic mapping are summarized for mainstem Yreka Creek and each reach (Appendix A, Figure 3 to Figure 9 and Table 3). Over 500 geomorphic features were mapped. Results show that the existing stream channel is a pool-riffle channel with an average gradient of one percent. The channel geometry was averaged for each of the seven reaches and for all the reaches. Typical cross-sections and longitudinal profiles were plotted to analyze the existing channel condition. Several cross-sections were surveyed within each reach, and one typical cross-section was chosen per reach; usually near the downstream end of a given reach. The flow conveyed through the typical cross-sections was modeled using the slope area method. These results were used to confirm the field mapped bankfull and flood prone width and depth measurements. The typical cross-sections are shown in Appendix C.

The results of the channel cross-section analysis help demonstrate that the mainstem of Yreka Creek and major tributaries are dominantly channelized and entrenched. There is an overall lack of access to the historic channel locations and floodplains. This has resulted in increased flood risk, altered the sediment transport regime, and degraded aquatic habitat. Graphical and statistical analysis of the channel cross-section geometry data demonstrate this channel condition. Figure 5 shows the reach drainage area versus

Table 3. Existing hydrologic and geomorphic conditions.

Reach Name	Yreka Creek Westside Road to Juniper Creek	Yreka Creek Juniper Creek to Greenhorn Creek	Yreka Creek Greenhorn Creek to East Oberlin drainage	Yreka Creek East Oberlin drainage to Little Humbug Creek	Yreka Creek Little Humbug Creek to Long Gulch	Lower Juniper Creek (Rolling Hills Drive to confluence)	Lower Greenhorn Creek (dam to confluence)	Little Humbug Creek (Humbug Hollow to confluence)
Reach Code	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Top Station (feet)	36,332	32,153	30,710	27,924	19,278	2,554	3,394	9,358
Bottom Station (feet)	32,153	30,710	27,924	19,278	10,634	0	0	0
Reach Length (feet)	4,140	1,425	2,790	8,644	8,638	2,533	3,394	9,358
Drainage Area (acres)	8,064	13,066	21,162	23,115	27,779	4,960	7,705	2,452
Q2 (cfs)	65	105	169	185	222	40	62	20
Q5 (cfs)	121	196	317	347	417	74	116	37
Q10 (cfs)	202	327	529	578	694	124	193	61
Q25 (cfs)	484	784	1,270	1,387	1,667	298	462	147
Q50 (cfs)	1,089	1,764	2,857	3,121	3,750	670	1,040	331
Q100 (cfs)	1,564	2,535	4,105	4,484	5,389	962	1,495	476
JH Q100 (cfs)	2,979	4,384	6,619	6,619	7,411	1439	2300	792
Top Elevation (feet)	2,734	2,688	2,674	2,646	2,570	2,713	2,724	2,790
Bottom Elevation (feet)	2,688	2,674	2,646	2,570	2,498	2,688	2,674	2,570
Reach Gradient (%)	1.1	1.0	1.0	0.9	0.8	1.0	1.5	2.4
Bankfull Width (Wbkf)	18	18	23	31	31	14.0	13	17
Mean Bankfull Depth (dbkf)	1.3	1.5	2.0	1.8	2.3	1.3	1.5	0.8
Bankfull X-Sect Area (Abkf)	23	27	46	54	70	17.5	20	13
Width/Depth Ratio (Wbkf/dbkf)	14	12	12	18	14	11.2	9	23
Maximum Bankfull Depth (dmbkf)	1.5	2.0	2.5	2.0	2.5	1.5	2.0	0.8
Channel Forming Q Width (Wcfq)	30.0	28.0	32.0	38.0	44.0	19.0	15.0	34.0
Channel Forming Q Depth (dcfq)	3.0	3.5	3.8	4.0	4.5	1.8	1.5	1.0
Width of Flood Prone Area (Wfpa)	97	31	40	45	55	22.0	23	400
Maximum Flood Prone Depth (dmfpa)	3.5	3.0	5.0	4.0	5.5	2.0	5.5	2.0
Entrenchment Ratio (ER)	1.7	1.6	1.4	1.2	1.3	1.4	1.2	2.0
Channel Material D50	16.0	16.0	32.0	32.0	32.0	5.0	11.6	11.6
Water Surface Slope (S)	1.7	1.4	1.4	0.7	0.6	1.5	1.5	4.2
Channel Sinuosity (K)	1.0	1.0	1.1	1.0	1.1	1.0	1.0	1.0
Pools per 1000' of Channel	7	13	8	11	7	5	4	0
Riffles per 1000' of Channel	6	11	10	11	7	7	4	0
Runs per 1000' of Channel	0	0	0	0	1	3	0	0
Glides per 1000' of Channel	0	0	0	0	1	3	0	0
Pool to Riffle Ratio	1.3	1.2	0.8	1.0	1.0	0.7	1.1	0
Sediment Transport Rate (tons/Q10)	2.0	3.0	30.0	35.0	55.0	0.5	1.0	0.2

the channel forming discharge width and depth plotted next to regional curves. In un-altered pool-riffle channel systems (i.e., regional curves), there is a statistical relationship between drainage area, channel forming discharge, and channel geometry (Leopold et. al., 1964).

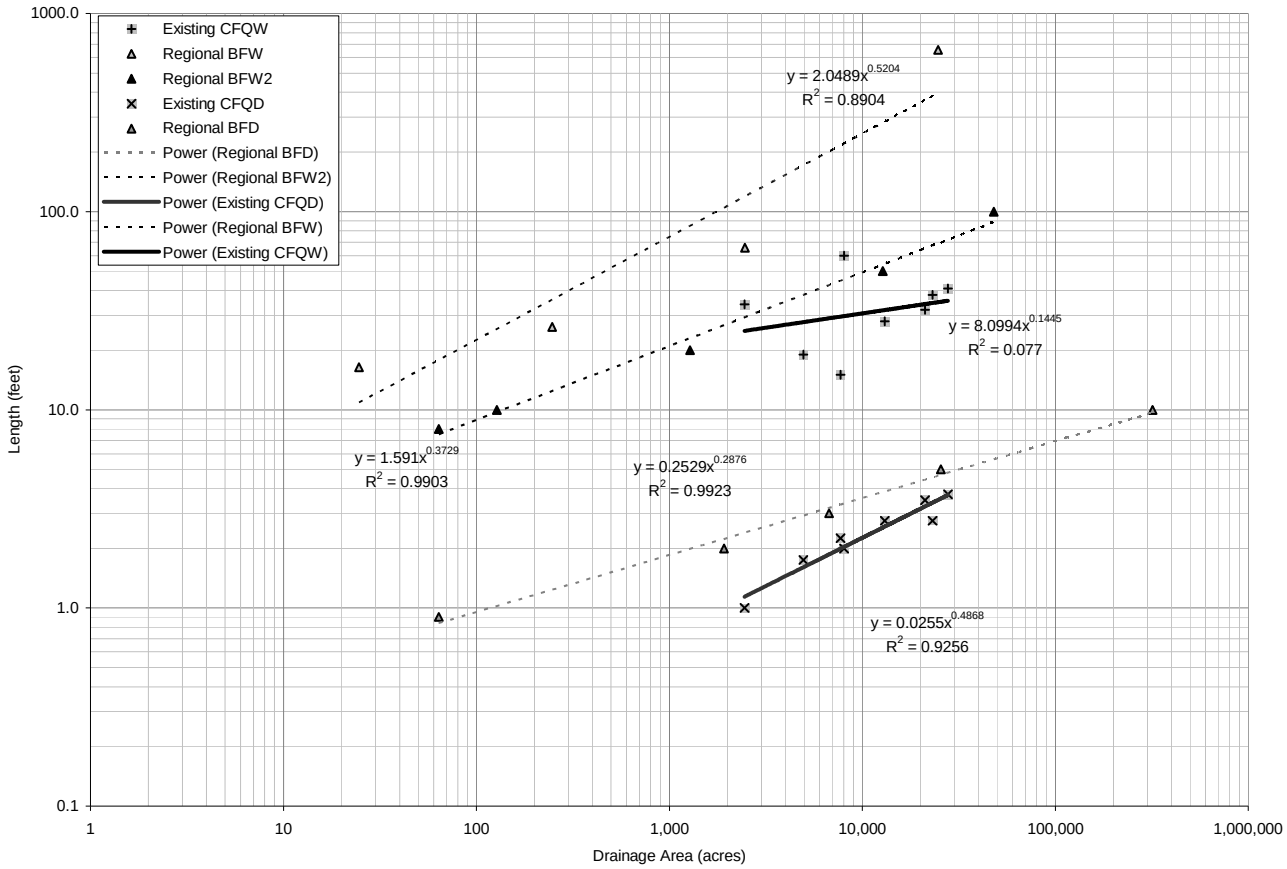

Figure 5. Drainage area versus channel forming discharge channel geometry.

Channelization has reduced the width of the channel forming discharge and triggered drainage scale incision. The effect of this on channel geometry is fundamental and can be demonstrated using the Lane (1955) equation. If the channel forming discharge (Q) is unchanged and stream gradient has increased (S), the result is an increase in sediment yield and the bed material D_{50}. Channelization causes and increase in stream power, and the water velocity and bed shear stress are higher. Fine grained bed material is detached and transported away leaving the stream bed armored with coarse bed material. Once the bed material is no longer detachable, flow moves laterally and scours the lower bank. Scour of the lower bank destabilizes the upper bank and the overall sediment supply sequentially increases. These are the conditions measured along Yreka Creek and the relative amount of channel instability increases in a downstream direction (Figure 4).

Stream Channel Pool and Riffle

In pool-riffle channels, hydraulic forces, bed and bank material strength, and geomorphic complexities (e.g., beaver dams and large woody debris jams) will create pools and riffles at frequent intervals. Without obstructions, these intervals relate to the wavelength of the channel meander, and pools form at the outside of bends. Because the sinuosity and wavelength of meanders are related to the channel forming discharge and stream gradient, the minimum expected spacing of pools is usually predictable.

The pool and riffle spacing are shown in Figure 6. The analysis mapped 256 pools and 253 riffles. Pool frequency decreases in a downstream direction. The pool to riffle ratio remains relatively constant, but they are less frequent along the channel.

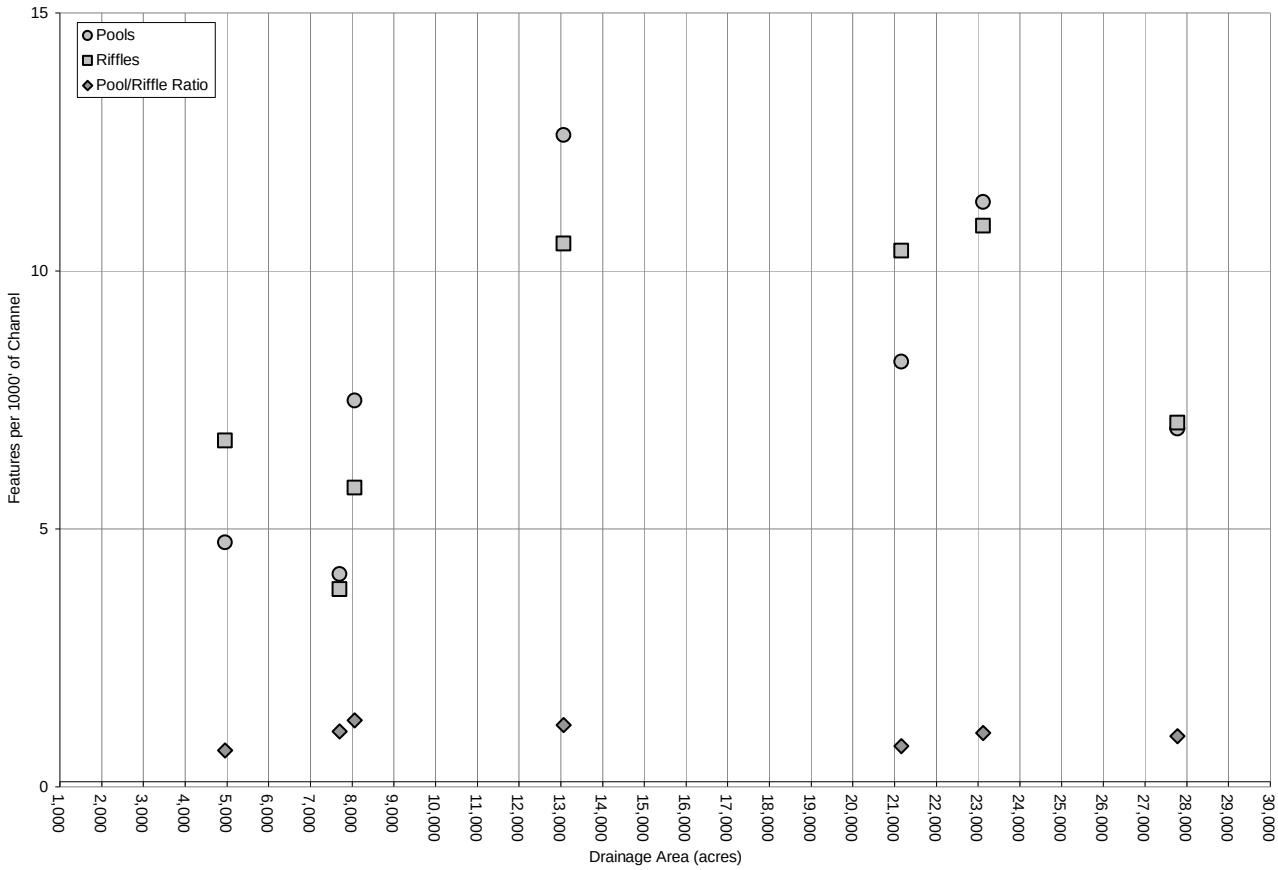

Figure 6. Drainage area versus pool spacing.

Existing Upper and Lower Bank Conditions

The condition of the upper and lower banks were evaluated and mapped. Overall, the banks are over-steepened and higher than the average bankfull depth. Most of the active bank erosion occurs continuously along the lower bank; however, where the upper bank is tall (>10 feet) there is substantial bank erosion. The areas of upper bank erosion tend to be localized (Appendix A, Figure 4).

Large Wood and Other Debris
There is a large amount of large woody debris within Yreka Creek and the amount increases downstream (Appendix A, Figure 4). Most of the debris consists of willows, cottonwoods, and oaks that have fallen into the channel. There is also a lot of smaller woody debris that collects within the riparian zone and at large wood jams.

A large amount of trash was mapped within the channel. The amount of trash increased substantially downstream of the main urban areas.

Sediment Supply, Transport, Routing, and Deposition
Sediment supply, transport, routing, and deposition were characterized and quantified. Overall, the bed material in the channel bottom has a D_{50} of about 32 mm. The bed coarsens in a downstream direction. The sediment stored in the active floodplains has a finer texture with a D_{50} of 11.6 mm. The grain size distribution is relatively consistent along Yreka Creek. There are larger cobble, boulder, and bedrock areas that remain in-place at most flows.

The bedload sediment transport rate was estimated for each of the reaches. Calculation results show that bedload transport is highly episodic, occurring one out of every 10 years. Presently, the bankfull discharge does not have enough stream power to mobilize the bed material greater than 32 mm. The coarser bed material is only mobile during larger flood events like the Q_5 and Q_{10}. Bedload transport calculations indicate that the unit bedload transport rate is 0.002 tons/acre/Q_{10} flood event. For the February 7, 2015 flood, Yreka Creek at Long Gulch likely transported about 55 tons of sediment (Figure 7).

Bedload mobilization and transport starts and ends quickly, and a given gravel particle likely only travels about 1000 to 2000 feet during flooding. This results in sequential sediment mobilization, transport, and deposition. Most of the deposition occurs on gravel bars; however, during larger floods the pools and riffles can fill. Empirical data collected during the February 7, 2015 flood event demonstrate that coarse sediment is routed slowly through Yreka Creek. Years to decades can pass between events that actually mobilize coarse sediment. Given this, local effects of channel bed scour and deposition can be long-term. For example, sediment deposited upstream of a narrow bridge often needs to be removed mechanically to prevent bridge failure.

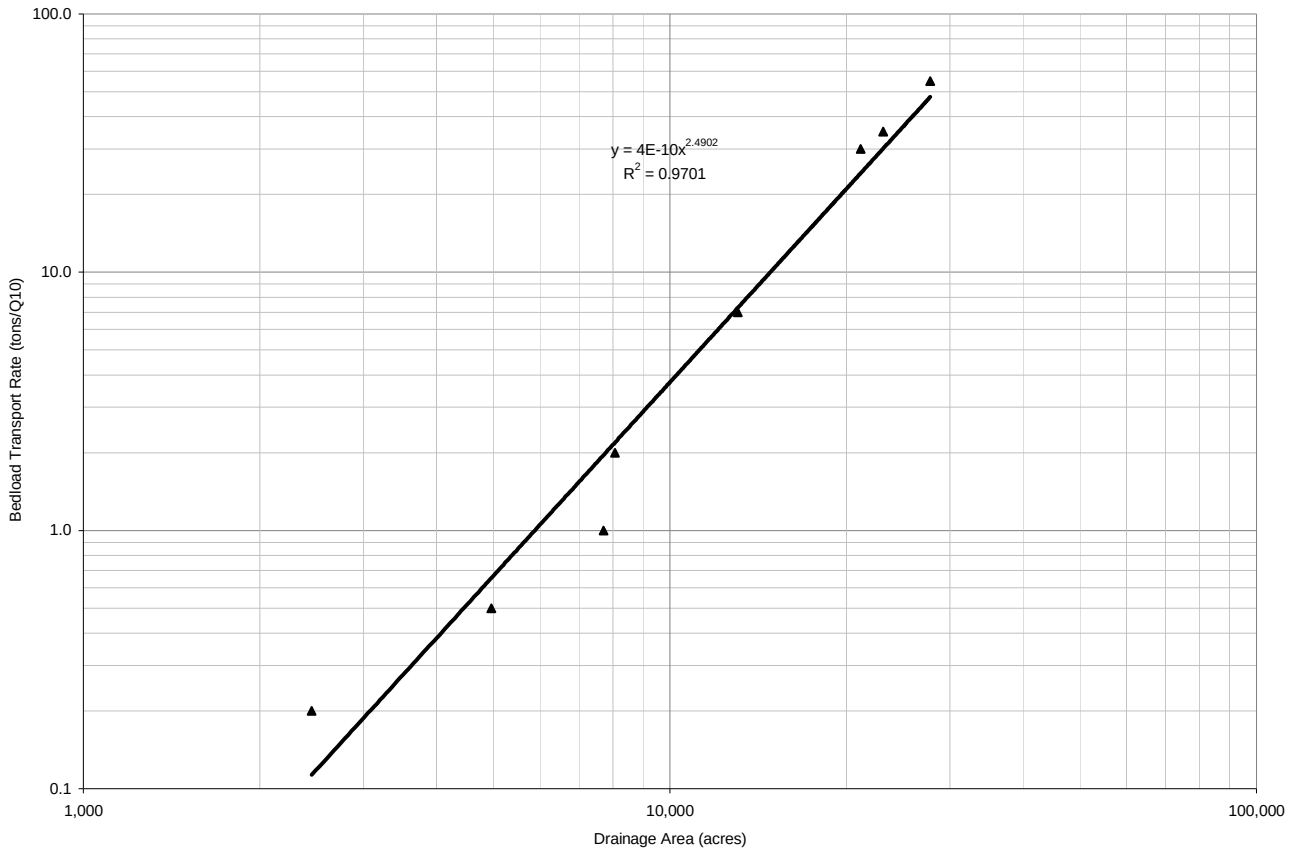

Figure 7. Yreka Creek bedload transport rating curve.

Sediment is routed throughout Yreka Creek. The largest sediment sink is Greenhorn Reservoir. This area captures and stores all of the coarse sediment from Greenhorn Creek above the dam. This represents about 27% of the drainage area above Long Gulch and a large portion of the Yreka Creek sediment supply (30% to 50%). Greenhorn Creek likely produces more coarse sediment than upper Yreka Creek and Juniper Creek given the steepness of the drainage and geology of the Greenhorn drainage. The abundance of Quaternary Alluvium in Greenhorn Creek versus upper Yreka and Juniper Creeks is direct evidence supporting this conclusion. The presence of Greenhorn Reservoir leaves lower Greenhorn Creek with high sediment transport potential but low sediment supply. The lack of sediment supply has caused channel incision in lower Greenhorn Creek and reduced the amount of coarse sediment in Yreka Creek.

Yreka Creek below Greenhorn Creek mobilizes, transports, and deposits coarse sediment during floods larger than Q_5 event. Given the relative lack of upland sediment supply, it is likely that most of the sediment transported through Yreka Creek below Greenhorn Creek is from upper and lower bank erosion and channel scour. The lack of sediment supply and entrenched stream channel cause channel degradation, and the channel tends to erode or scour until an immobile boundary is reached (e.g., bedrock or very coarse dredger tailings).

Beaver Activity in the Stream Channel
Beavers are active in Yreka Creek and evidence of beaver activity was observed in all of the reaches. A total of five active beaver dams were mapped (Appendix A, Figure 4). There is evidence of beavers all along the channel mainly in the form of chewing on riparian zone trees. Several beavers were seen while mapping.

Structures Crossing the Stream Channel
Within the geomorphic analysis reaches there are 24 road crossings (Appendix A, Figure 4). Most of them are bridges. Several of the crossings constrict flood flows and there is sediment deposition above the crossing and channel scour below.

Bank Armor, Structures, and Storm Drains Along the Stream Channel
There are multiple armored banks, structures, and storm drains along Yreka Creek (Appendix A, Figure 4). The bank is armored to help protect structures and roads near the stream channel and at locations of channel bottom scour. Most rock structures, concrete walls, and bridge abutments have evidence of scour near the bottom of the features. A total of 26 storm drains were mapped; however, there are likely more storm drains that were not visible or were not seen during this mapping effort.

4.0 Geomorphic Analysis Design Recommendations

4.1 Stream Channel Restoration Design

The results of the geomorphic analysis demonstrate that the mainstem of Yreka Creek is a perennially entrenched channel and that restoration treatments should be focused on the following:

- reducing average stream gradient to less than one percent;
- increasing the average bankfull discharge (Q_2) width from 20 to 25 feet and maintaining the average Q_2 depth;
- increasing the average channel forming discharge (Q_{10}) width from 30 to 100 feet and decreasing the average Q_{10} depth to 2.5 feet;
- increasing the entrenchment ratio;
- increasing sinuosity;
- creating side channels active during the Q_2 flood event;
- decreasing the rate of lower bank erosion;
- decreasing the rate of channel bottom scour;
- enhancing and facilitating beaver activity within Yreka Creek and main tributaries;
- mimicking the historic pool-riffle channel sediment transport and deposition regimes; and
- increasing coarse sediment supply at lower Greenhorn Creek and Little Humbug Creek confluences with Yreka Creek.

4.2 Stream Channel Restoration Design Benefits

The following are the potential benefits of the recommended stream channel and floodplain restoration treatments:

- reduced flood risk;
- improved stream channel stability;
- increased summer base flows;
- improved water quality;
- increased groundwater recharge;
- improved riparian and wetland habitat; and
- improved aquatic habitat.

4.3 Stream Channel and Floodplain Restoration Design Parameters

The recommended stream channel and floodplain restoration design parameters are listed in Table 4. Figure 8 shows the existing channel conditions versus design conditions for bankfull discharge widths relative to the regional curves. By increasing width, reducing stream gradient, and maintaining or reducing water depth, the stream channels will move towards a more stable form similar to unaltered riffle-pool streams in semi-arid climates.

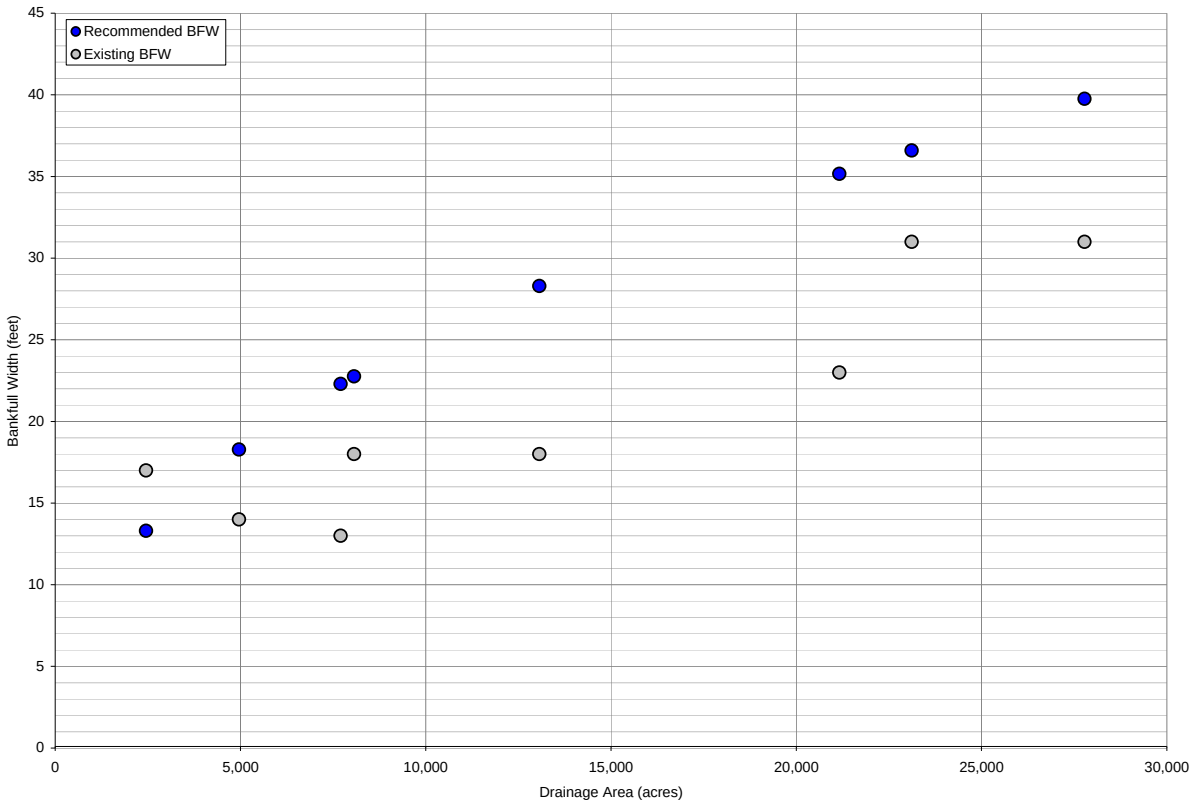

Figure 8. Existing compared to design conditions for bankfull and channel forming discharge widths relative to the regional curves.

Table 4. Stream channel and floodplain design parameters.

Reach Name	Yreka Creek Westside Road to Juniper Creek	Yreka Creek Juniper Creek to Greenhorn Creek	Yreka Creek Greenhorn Creek to East Oberlin drainage	Yreka Creek East Oberlin drainage to Little Humbug Creek	Yreka Creek Little Humbug Creek to Long Gulch	Lower Juniper Creek (Rolling Hills Drive to confluence)	Lower Greenhorn Creek (dam to confluence)	Little Humbug Creek (Humbug Hollow to confluence)
Reach Code	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Top Station (feet)	36,332	32,153	30,710	27,924	19,278	2,554	3,394	9,358
Bottom Station (feet)	32,153	30,710	27,924	19,278	10,634	0	0	0
Reach Length (feet)	4,140	1,425	2,790	8,644	8,638	2,533	3,394	9,358
Drainage Area (acres)	8,064	13,066	21,162	23,115	27,779	4,960	7,705	2,452
Q2 (cfs)	65	105	169	185	222	40	62	20
Q5 (cfs)	121	196	317	347	417	74	116	37
Q10 (cfs)	202	327	529	578	694	124	193	61
Q25 (cfs)	484	784	1270	1387	1667	298	462	147
Q50 (cfs)	1089	1764	2857	3121	3750	670	1040	331
Q100 (cfs)	1564	2535	4105	4484	5389	962	1495	476
Top Elevation (feet)	2,734	2,688	2,674	2,646	2,570	2,713	2,724	2,790
Bottom Elevation (feet)	2,688	2,674	2,646	2,570	2,498	2,688	2,674	2,570
Design Parameter Recommendations	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Stream Gradient (%)	0.8	0.9	0.9	0.6	0.6	1.0	1.5	2.0
Bankfull Width (Wbkf)	23	28	35	37	40	18	22	13
Mean Bankfull Depth (dbkf)	1.3	1.5	2.0	1.8	2.3	1.3	1.5	0.8
Bankfull X-Sect Area (Abkf)	118	162	223	237	267	23	33	10
Width/Depth Ratio (Wbkf/dbkf)	18	19	18	21	18	15	15	18
Maximum Bankfull Depth (dmbkf)	3.2	3.7	4.5	5.0	5.0	2.5	3.2	2.5
Channel Forming Q Width (Wcfq)	85.0	120.0	134.0	140.0	155.0	50.0	70.0	34.0
Channel Forming Q Depth (dcfq)	2.0	2.0	2.5	3.5	3.8	1.0	1.2	0.5
Width of Flood Prone Area (Wfpa)	100	150	150	160	175	55	80	55
Maximum Flood Prone Depth (dmfpa)	4.5	4.5	5.5	6.5	7.5	4.0	4.0	3.0
Entrenchment Ratio (ER)	4.4	5.3	4.3	4.4	4.4	3.0	3.6	4.1
Channel Material D_{50}	16.0	16.0	32.0	32.0	32.0	5.0	11.6	11.6
Meander Radius of Curvature	80	80	150	180	180	70	70	70
Channel Sinuosity (K)	1.2	1.1	1.2	1.2	1.2	1.1	1.1	1.1

5.0 References

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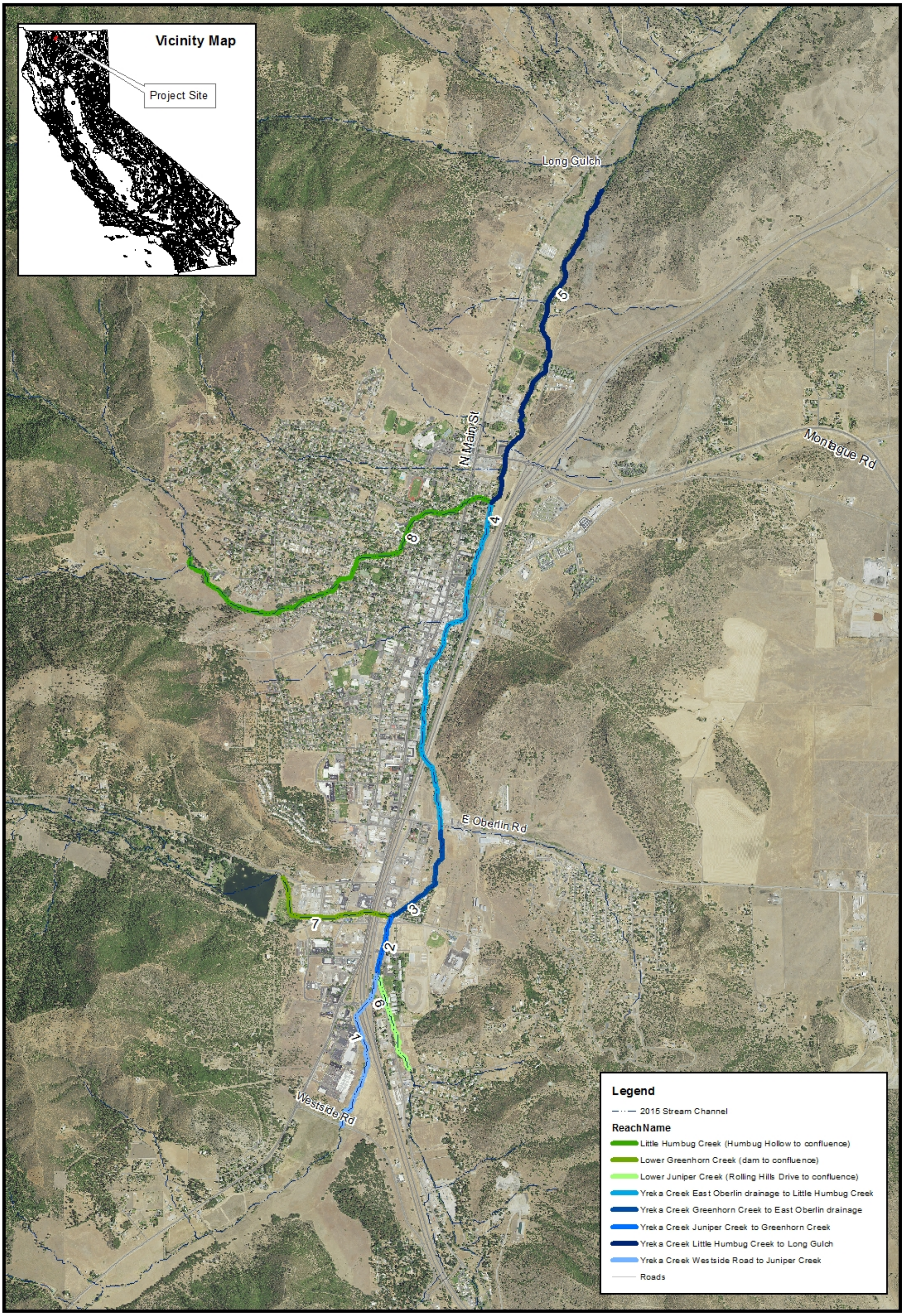
Appendix A:

Geomorphic Analysis Maps



Prepared By:

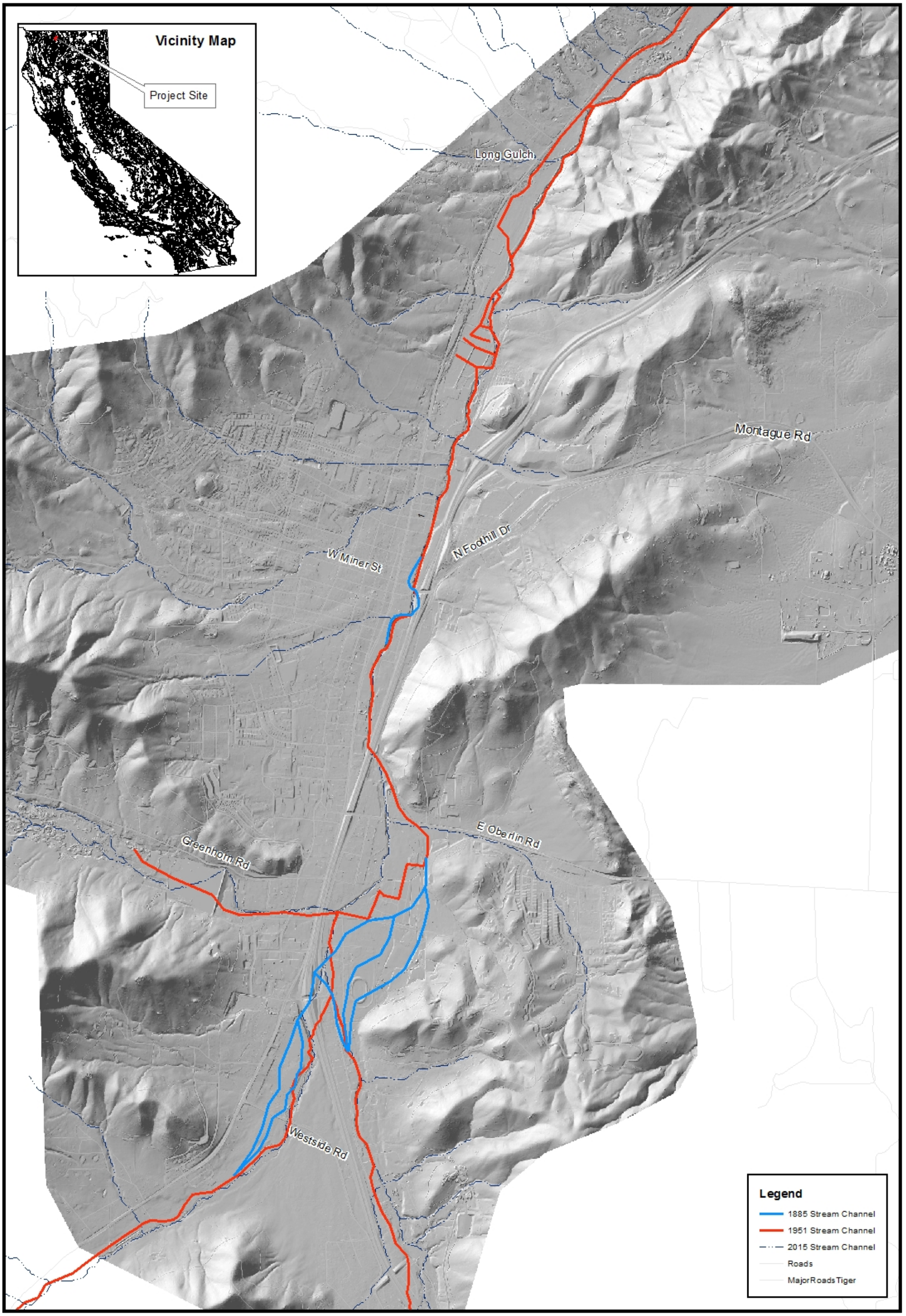
GeoServ
Engineering Geologists
Rock - Soil - Water

Project: Geomorphic Analysis for Yreka Creek
Greenway Floodplain Master Plan, City of Yreka
Location: Siskiyou County, CA
Figure 1: Geomorphic Analysis Reach Map.

0 0.25 0.5 1 Miles

Coordinate System: NAD 1983 StatePlane California I FIPS 0401 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983

Date: 1/20/2016



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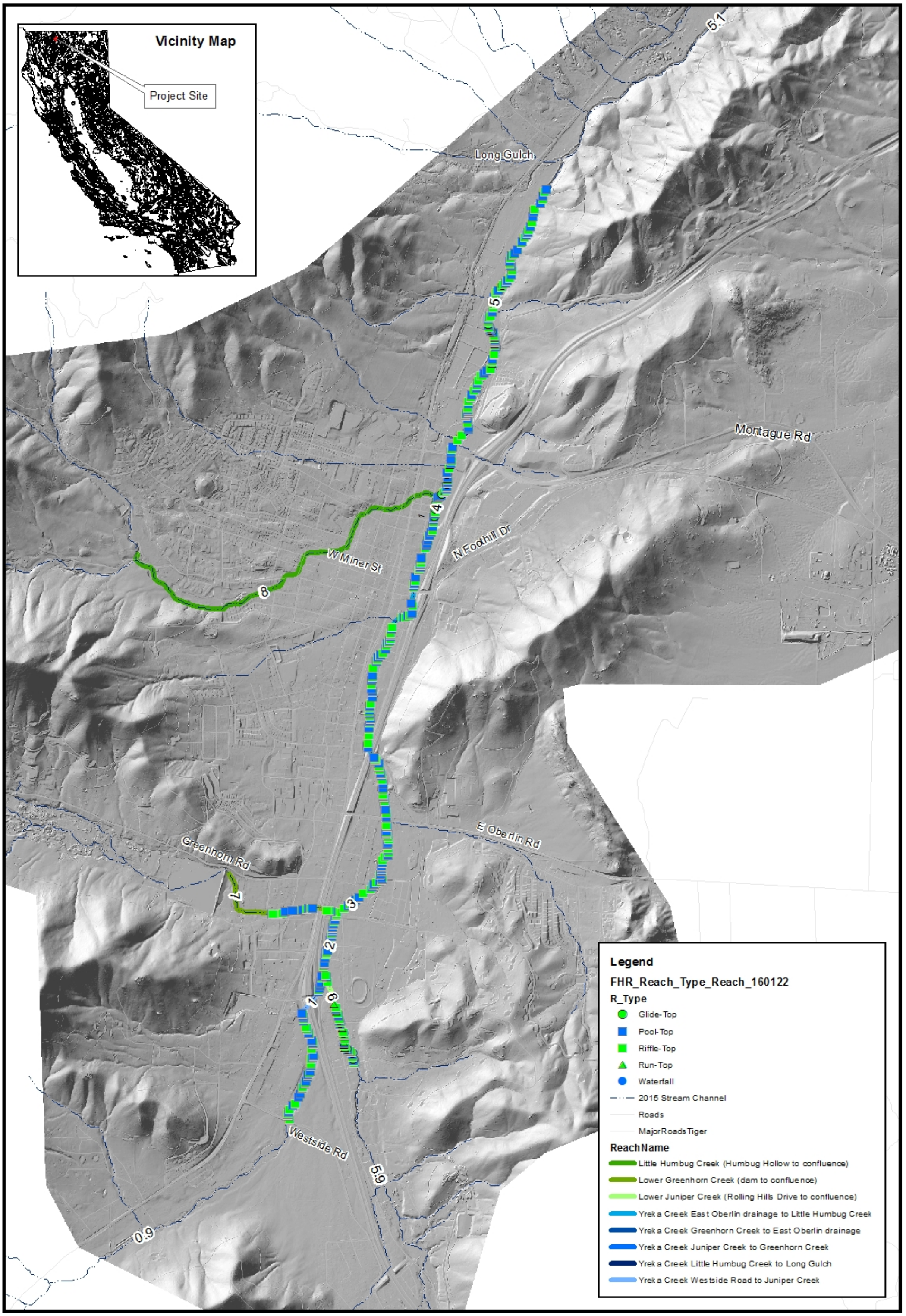
Project: Geomorphic Analysis for Yreka Creek
Greenway Floodplain Master Plan, City of Yreka
Location: Siskiyou County, CA
Figure 2: Geomorphic Analysis Historic Cannel
Extent and Pattern Map.

0 0.25 0.5 1 Miles

Coordinate System: NAD 1983 StatePlane California I FIPS 0401 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983

Date: 1/20/2016



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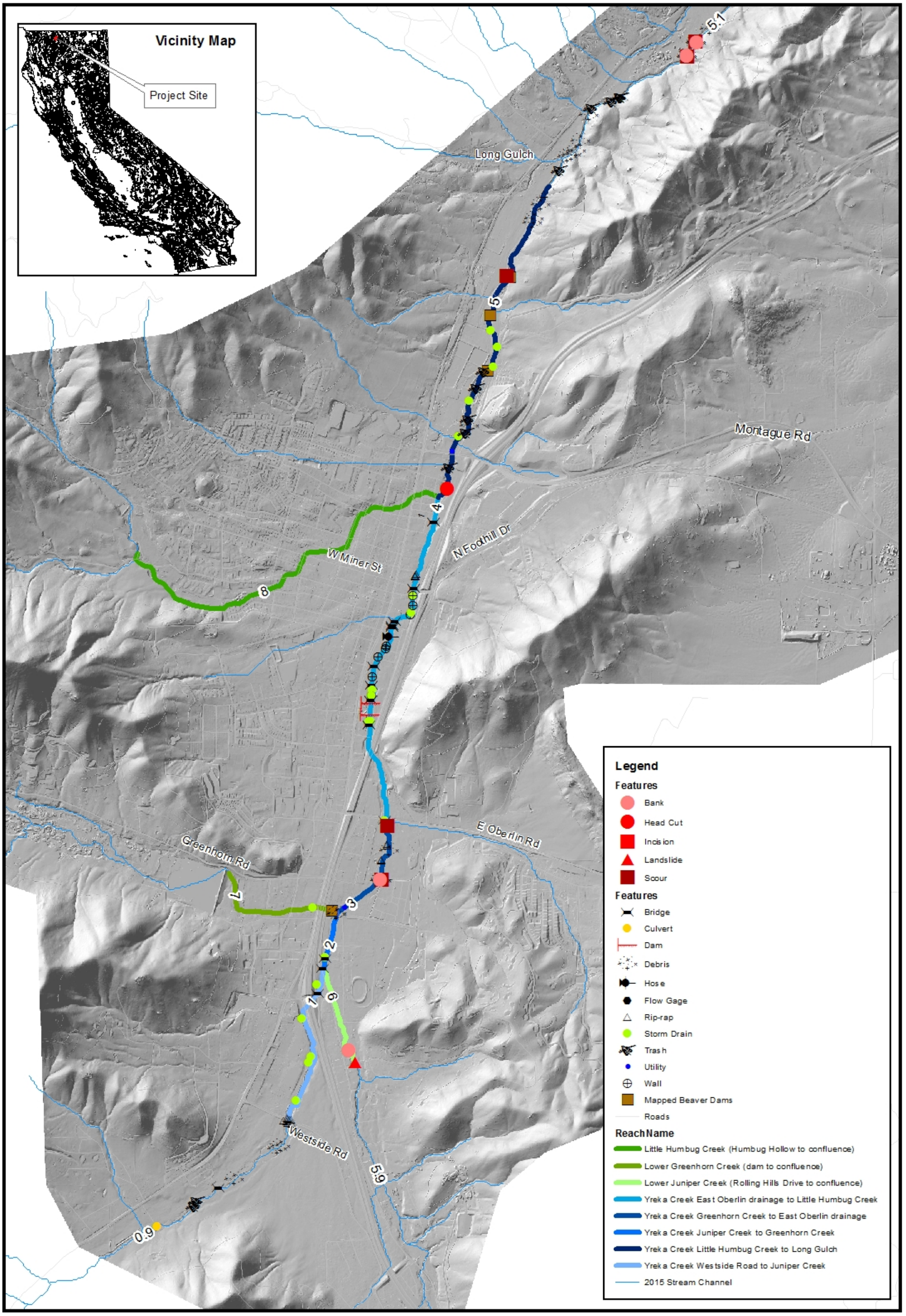
Project: Geomorphic Analysis for Yreka Creek Greenway Floodplain Master Plan, City of Yreka
Location: Siskiyou County, CA
Figure 3: Geomorphic Analysis Mapped Channel Features.

0 0.25 0.5 1 Miles

Coordinate System: NAD 1983 StatePlane California I FIPS 0401 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983

Date: 1/24/2016



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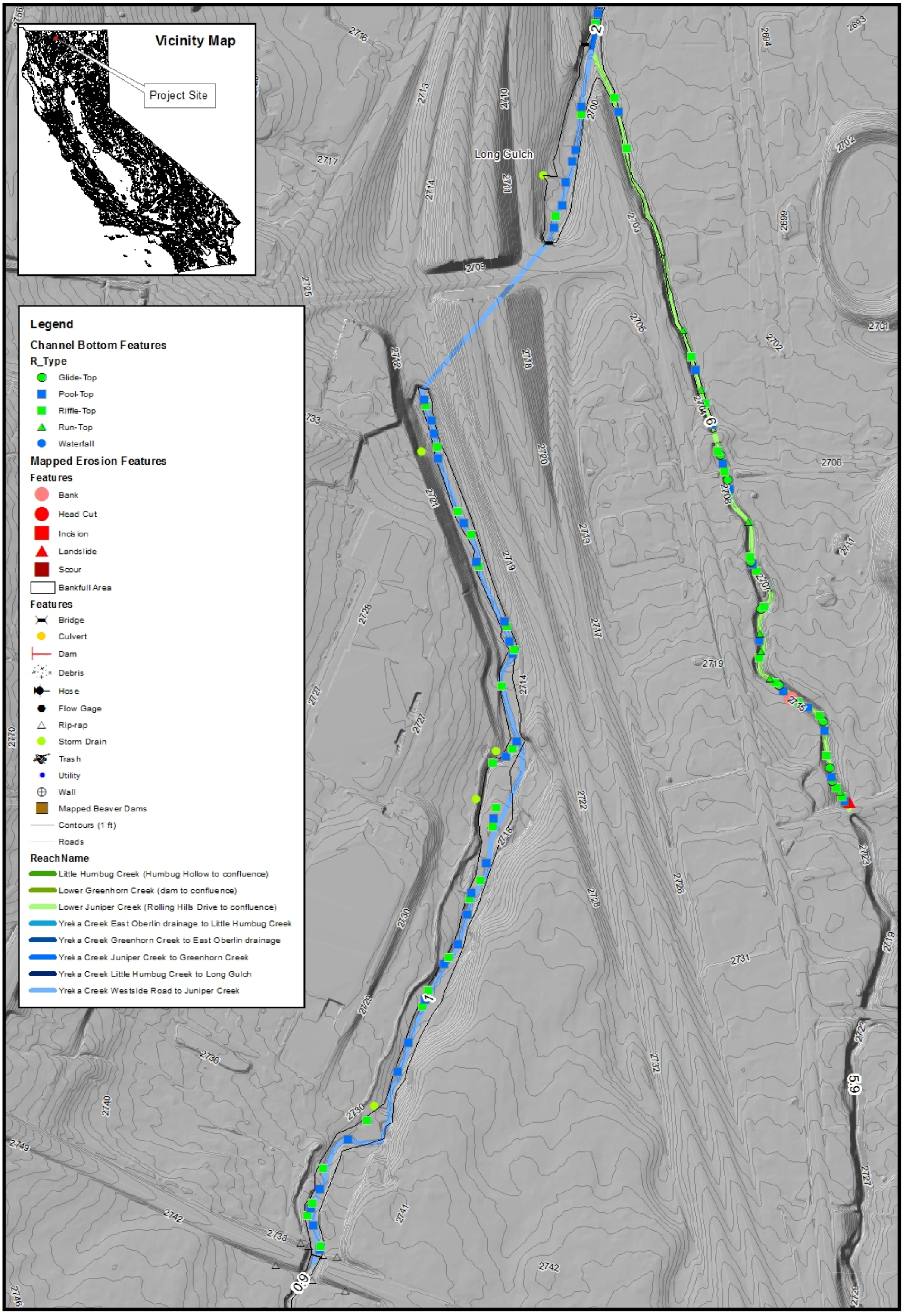
Project: Geomorphic Analysis for Yreka Creek
Greenway Floodplain Master Plan, City of Yreka
Location: Siskiyou County, CA
Figure 4: Geomorphic Analysis Mapped Channel Features Map.

0 0.25 0.5 1 Miles

Coordinate System: NAD 1983 StatePlane California I FIPS 0401 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983

Date: 1/24/2016



Prepared By:

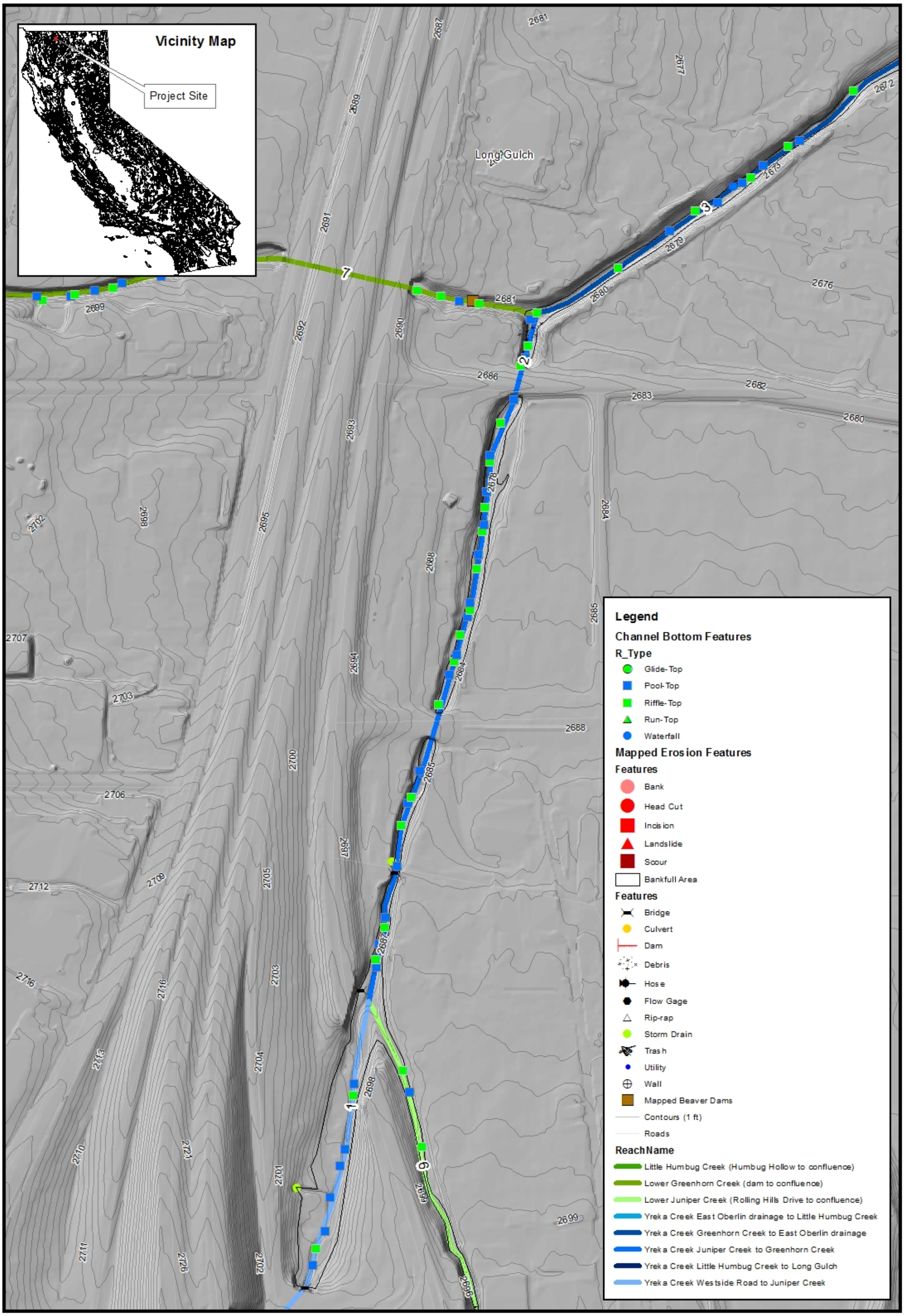
GeoServ Engineering Geologists Rock - Soil - Water

Project: Geomorphic Analysis for Yreka Creek Greenway Floodplain Master Plan, City of Yreka
Location: Siskiyou County, CA
Figure 5: Yreka Creek Westside Road to Juniper Creek Map.

0 250 500 1,000 Feet

Coordinate System: NAD 1983 StatePlane California I FIPS 0401 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983

Date: 1/24/2016



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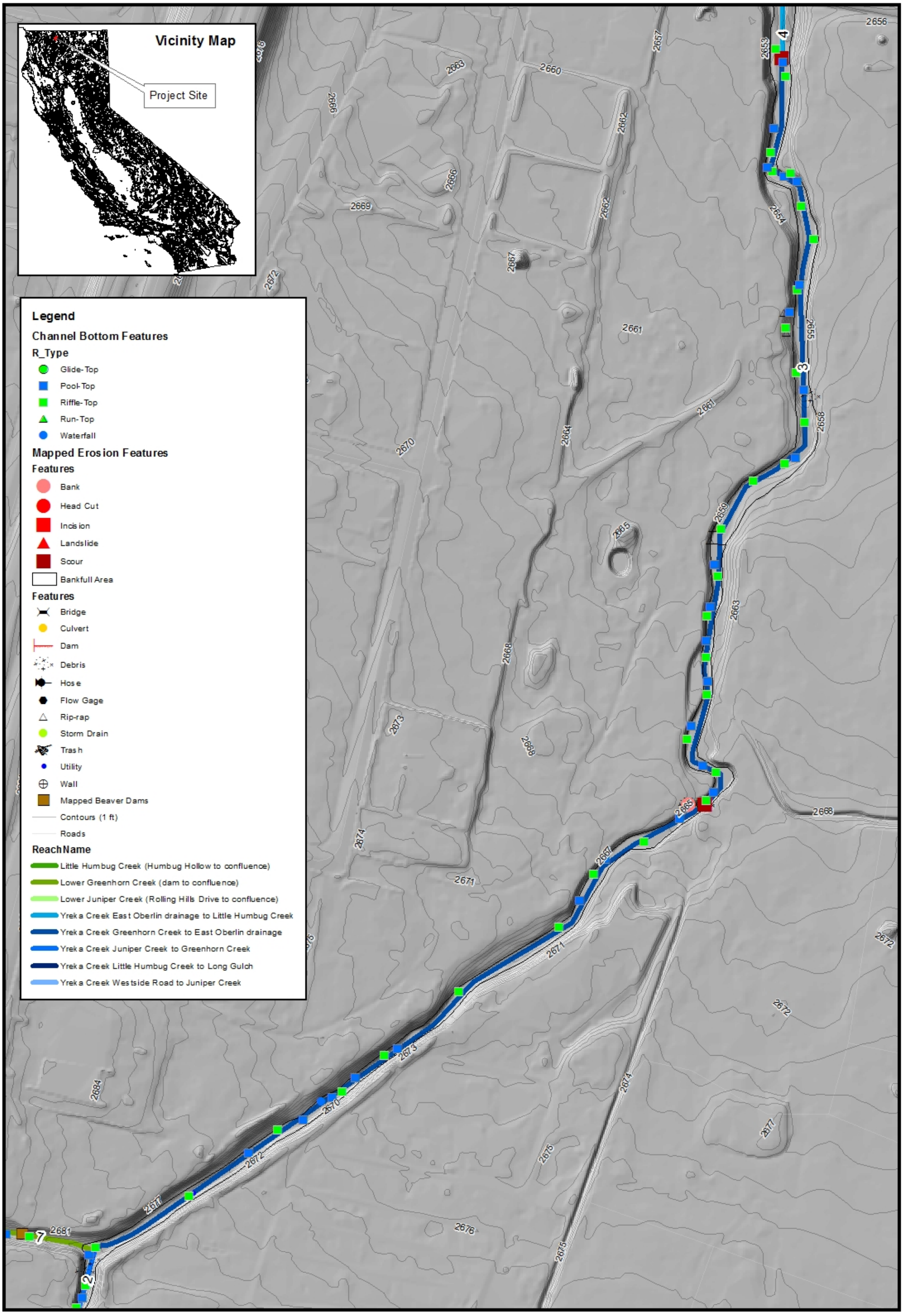
Project: Geomorphic Analysis for Yreka Creek Greenway Floodplain Master Plan, City of Yreka
Location: Siskiyou County, CA
Figure 6: Yreka Creek Juniper Creek to Greenhorn Creek Map.

0 125 250 500 Feet

Coordinate System: NAD 1983 StatePlane California I FIPS 0401 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983

Date: 1/24/2016



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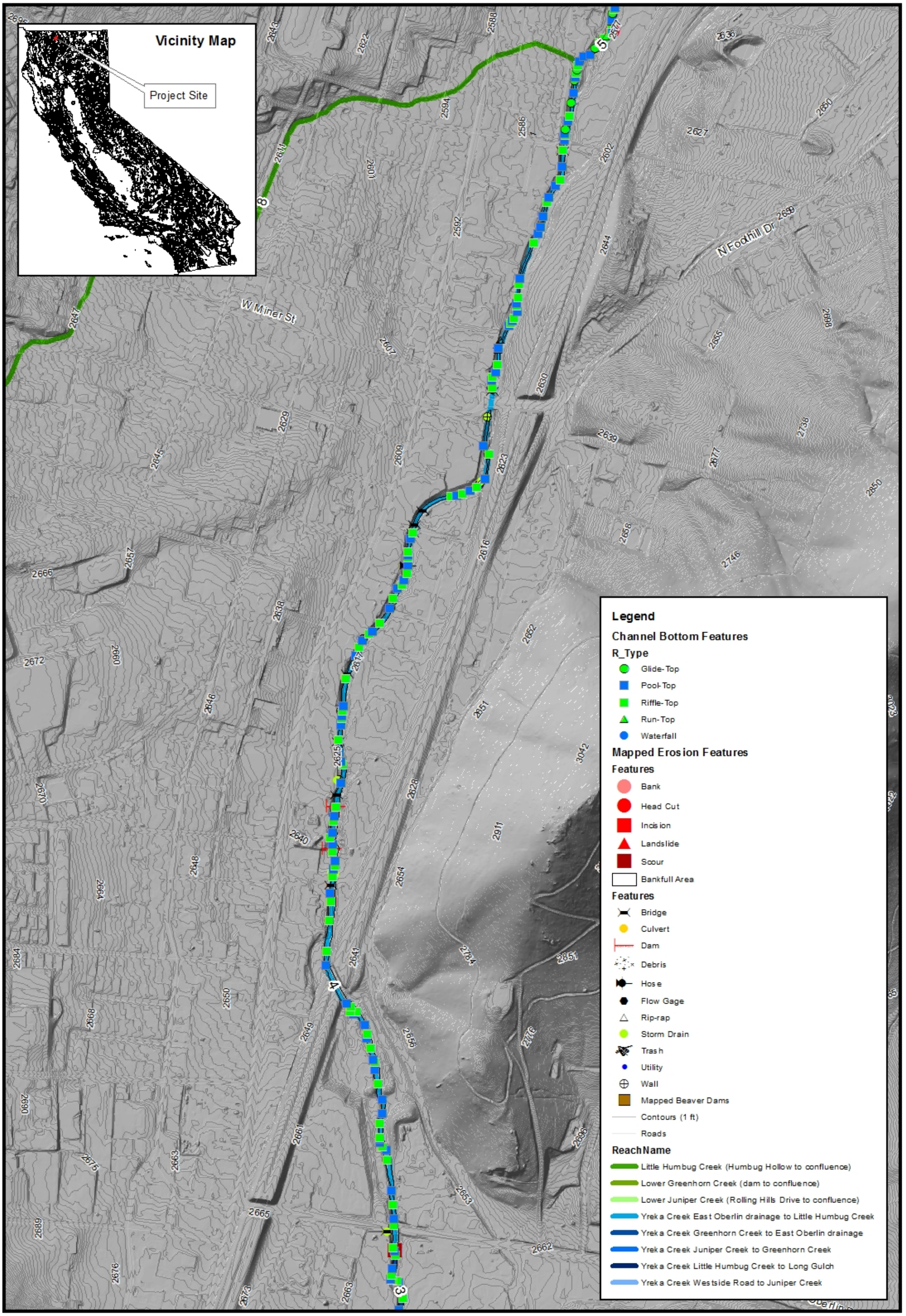
Project: Geomorphic Analysis for Yreka Creek Greenway Floodplain Master Plan, City of Yreka
Location: Siskiyou County, CA
Figure 7: Yreka Creek Greenhorn Creek Map to East Oberlin drainage.

0 125 250 500 Feet

Coordinate System: NAD 1983 StatePlane California I FIPS 0401 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983

Date: 1/24/2016



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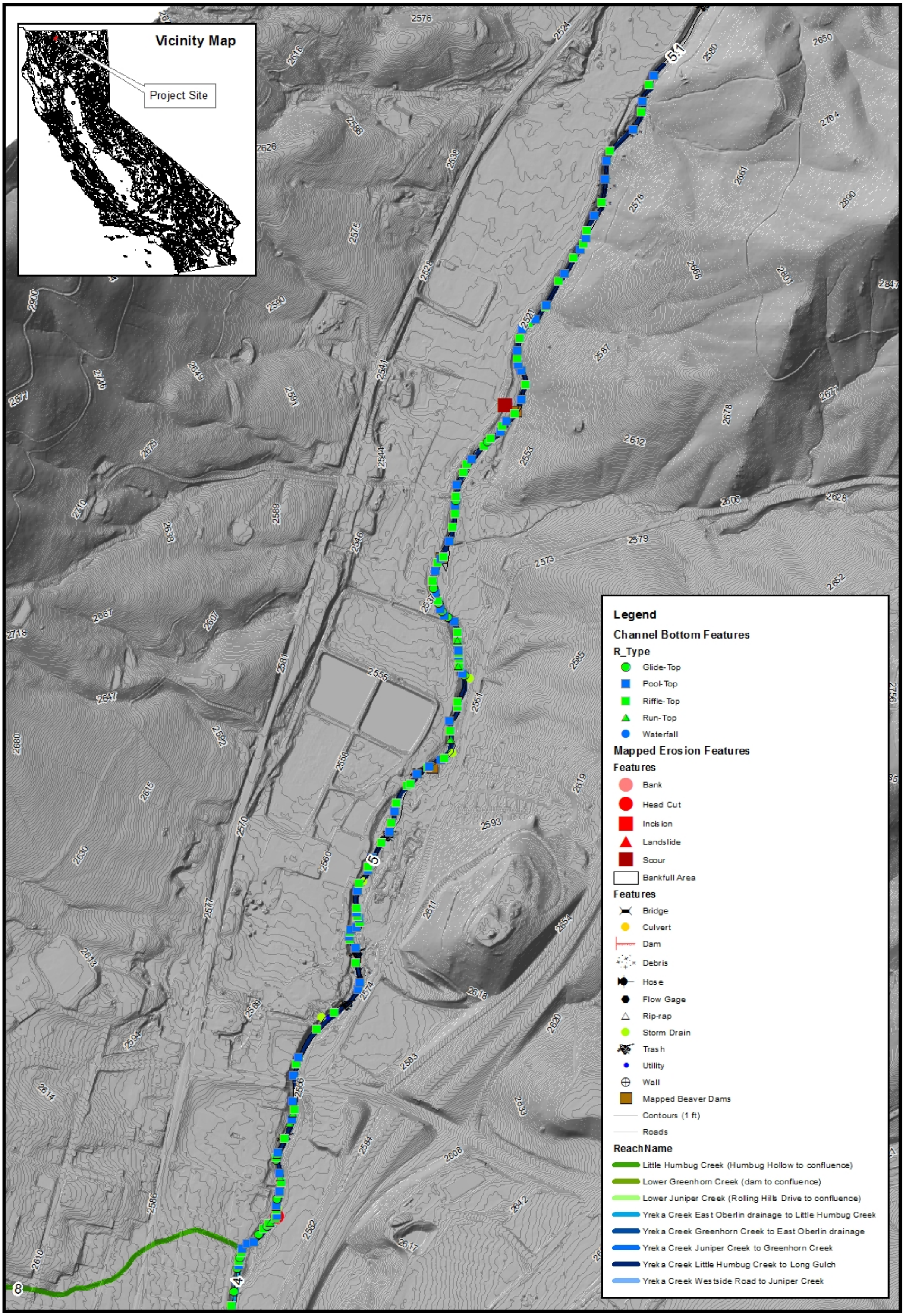
Project: Geomorphic Analysis for Yreka Creek Greenway Floodplain Master Plan, City of Yreka
Location: Siskiyou County, CA
Figure 8: Yreka Creek East Oberlin drainage to Little Humbug Creek.

0 500 1,000 2,000 Feet

Coordinate System: NAD 1983 StatePlane California I FIPS 0401 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983

Date: 1/24/2016



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Project: Geomorphic Analysis for Yreka Creek Greenway Floodplain Master Plan, City of Yreka
Location: Siskiyou County, CA
Figure 9: Yreka Creek East Little Humbug Creek to Long Gulch.

0 500 1,000 2,000 Feet

Coordinate System: NAD 1983 StatePlane California I FIPS 0401 Feet
Projection: Lambert Conformal Conic
Datum: North American 1983

Date: 1/24/2016

Appendix B:

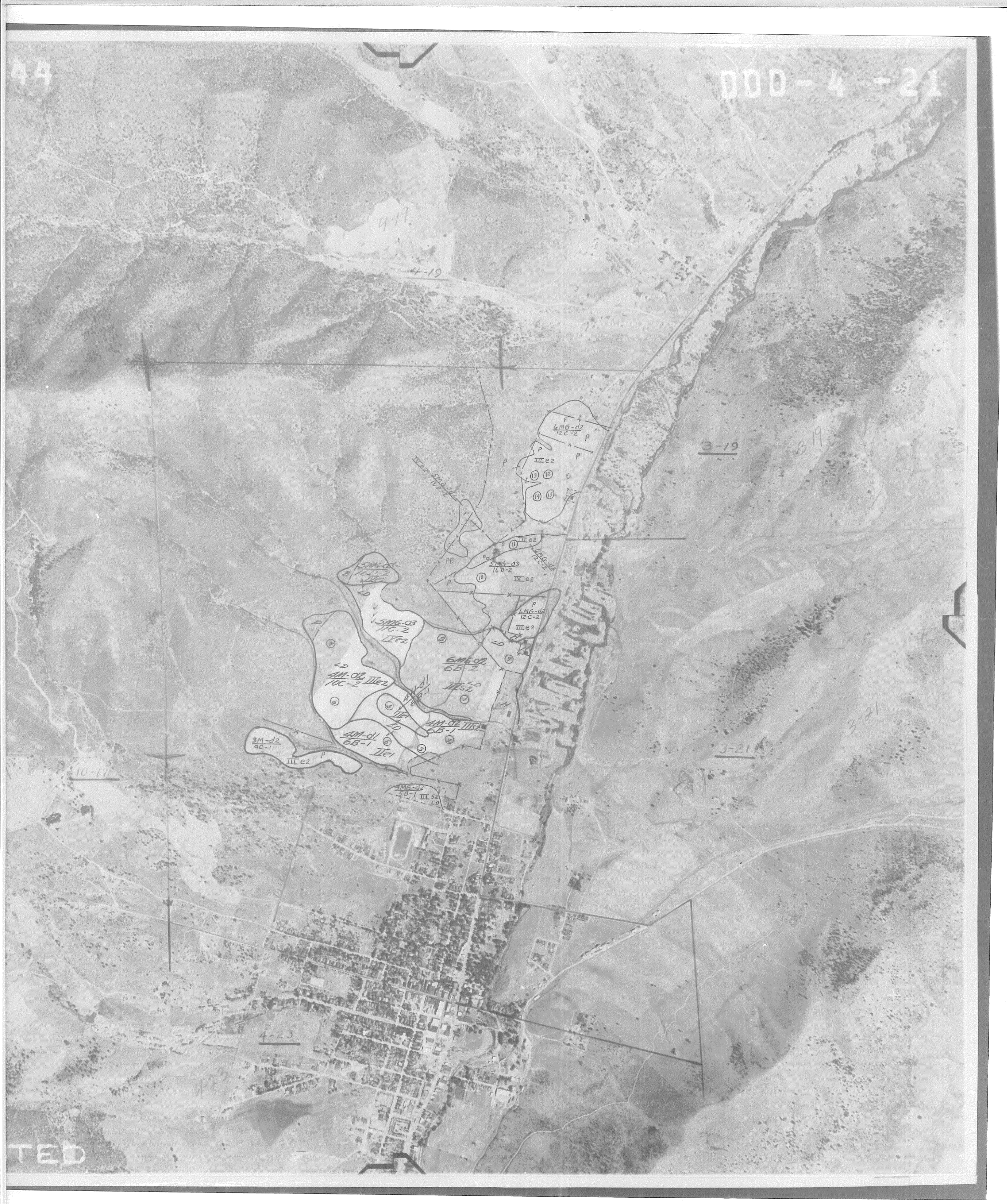
Geomorphic Analysis Historic Information

Yreka Creek looking north-west in 1885.

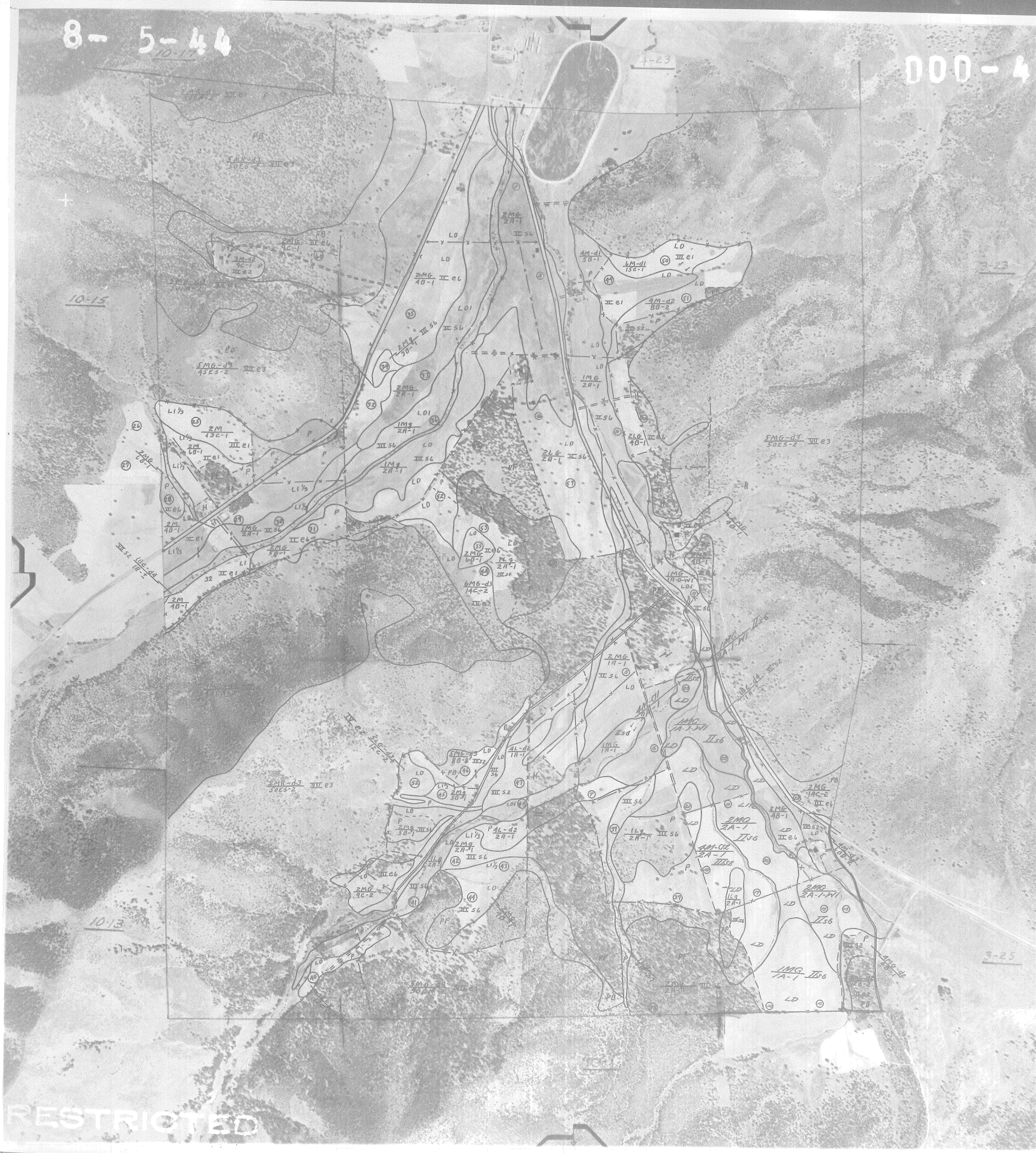
Yreka Creek looking north-west in 2015.

Yreka and Juniper Creeks looking south-west in 1885.

Yreka and Juniper Creeks looking south-west in 2015.


44
DDD-4-21
4-19
3-19
3-21
10-17
4-23
6MG-d2
12C-2
IIIe2
5MG-d3
16D-2
IVe2
5MG-d3
11C-2
IVe2
6MG-d2
6B-2
IIIs2
4M-d2
10C-2
IIIe2
4M-d2
6B-1
IIIs2
4M-d1
6B-1
IIe1
3M-d2
9C-1
IIIe2
4MG-d2
5B-1
IIIs2
TED

8- 5-44
DDD-
4-21
10-17
DRIVE IN THEATRE
3-23
4-25
RESTRICTED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DDD-4
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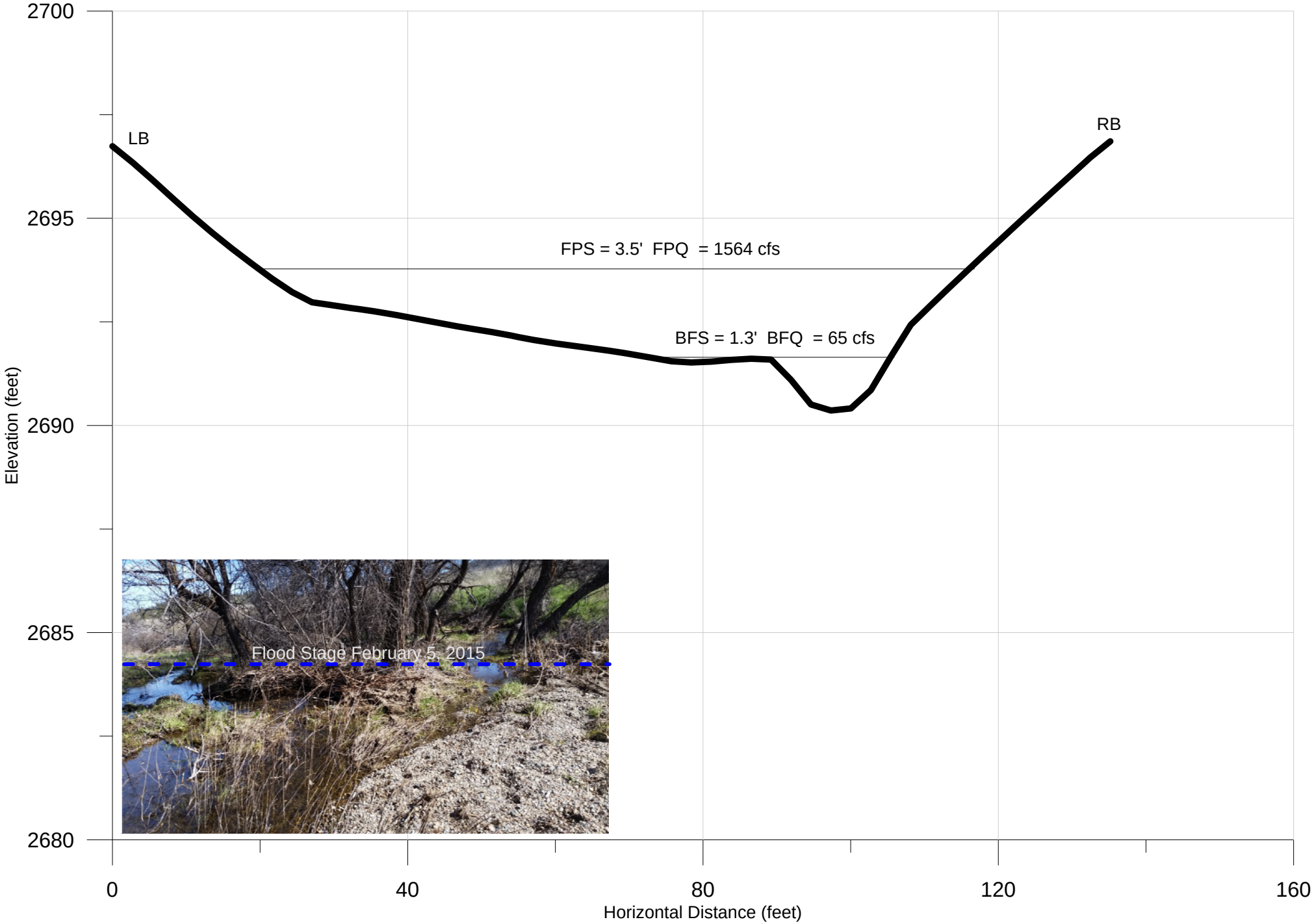
Appendix C:

Geomorphic Analysis Field Mapping Data

Yreka Creek - Reach 1 Typical Cross-Section - Station 32497



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Run Date:               01/21/16
Analysis Procedure:     Hydraulics & Regression
Cross Section Number:   1
Survey Date:            12/13/14


Subsections/Dividing positions


Resistance Method:      Manning's n
            SECTION         A
      Low Stage n         0.040
      High Stage n        0.030

Unadjusted horizontal distances used


 STAGE  #SEC      AREA    PERIM   WIDTH    R       DHYD         SLOPE
n          VAVG       Q            SHEAR
  (ft)            (sq ft)   (ft)   (ft)    (ft)     (ft)         (ft/ft)
  (ft/s)    (cfs)          (psf)
  0.25    T       1.24     7.16    7.13  0.17     0.17          0.0166
0.040     1.49        1.85          0.18
  0.50    T       3.36     9.85    9.77  0.34     0.34          0.0164
0.040     2.36        7.91          0.35
  0.75    T       6.05    11.91   11.77  0.51     0.51          0.0163
0.039     3.09       18.70          0.52
  1.00    T       9.27    14.19   13.98  0.65     0.66          0.0161
0.039     3.68       34.12          0.66
  1.25    T      13.74    31.85   31.59  0.43     0.43          0.0160
0.038     2.81       38.61          0.43
  1.50    T      22.79    41.54   41.24  0.55     0.55          0.0158
0.038     3.32       75.66          0.54
  1.75    T      34.46    51.72   51.39  0.67     0.67          0.0157
0.037     3.80      131.08          0.65
  2.00    T      48.38    60.58   60.20  0.80     0.80          0.0155
0.037     4.32      209.05          0.77
  2.25    T      64.55    69.57   69.16  0.93     0.93          0.0153
0.037     4.81      310.37          0.89
  2.50    T      83.05    79.81   79.38  1.04     1.05          0.0152
0.036     5.23      434.02          0.99
  2.75    T     104.00    87.05   86.58  1.19     1.20          0.0150
0.036     5.77      600.09          1.12
  3.00    T     126.15    90.91   90.41  1.39     1.40          0.0149
0.035     6.42      809.91          1.29
  3.25    T     149.19    94.46   93.93  1.58     1.59          0.0147
0.035     7.05     1051.67          1.45
  3.50    T     173.10    97.91   97.34  1.77     1.78          0.0146
0.034     7.65     1325.08          1.61
  3.75    T     197.86   101.32  100.71  1.95     1.96          0.0144
0.034     8.24     1630.33          1.76
  4.00    T     223.46   104.68  104.04  2.13     2.15          0.0143
0.033     8.81     1968.41          1.90
  4.25    T     249.88   107.98  107.30  2.31     2.33          0.0141
0.033     9.37     2340.37          2.04
  4.50    T     277.10   111.19  110.47  2.49     2.51          0.0139
0.033     9.92     2747.83          2.17
  4.75    T     305.11   114.37  113.61  2.67     2.69          0.0138
0.032    10.46     3190.82          2.29
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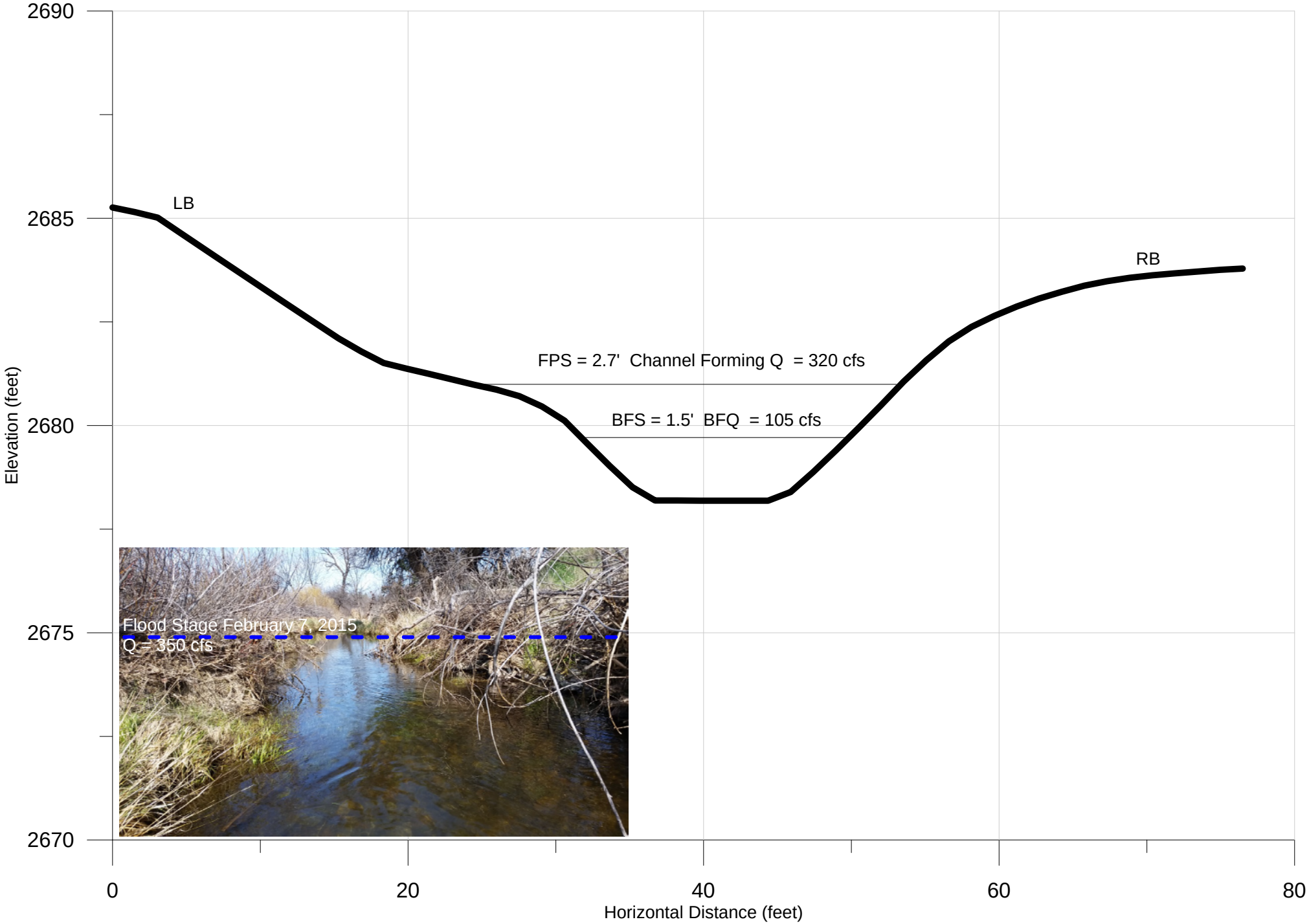
  5.00    T     333.90   117.51  116.71  2.84     2.86          0.0136
0.032    10.99     3670.65         2.42
  5.25    T     363.46   120.65  119.80  3.01     3.03          0.0135
0.031    11.52     4188.08         2.53
  5.50    T     393.80   123.78  122.90  3.18     3.20          0.0133
0.031    12.05     4744.04         2.64
  5.75    T     424.92   126.96  126.04  3.35     3.37          0.0132
0.030    12.56     5338.76         2.75
  6.00    T     456.82   130.17  129.21  3.51     3.54          0.0130
0.030    13.08     5974.15         2.85

 STAGE        ALPHA    FROUDE
  0.25     1.000000       0.630152
  0.50     1.000000       0.708345
  0.75     1.000000       0.760281
  1.00     1.000000       0.797040
  1.25     1.000000       0.750876
  1.50     1.000000       0.787060
  1.75     1.000000       0.818602
  2.00     1.000000       0.849488
  2.25     1.000000       0.877078
  2.50     1.000000       0.900346
  2.75     1.000000       0.927793
  3.00     1.000000       0.957864
  3.25     1.000000       0.985669
  3.50     1.000000       1.011579
  3.75     1.000000       1.035969
  4.00     1.000000       1.059219
  4.25     1.000000       1.081606
  4.50     1.000000       1.103383
  4.75     1.000000       1.124595
  5.00     1.000000       1.145387
  5.25     1.000000       1.165832
  5.50     1.000000       1.186000
  5.75     1.000000       1.205913
  6.00     1.000000       1.225673

 Q = aR^b     a=252.729813  b=2.699289  r^2=0.972968  n=24
 Q = aZ^b     a=16.153088  b=3.260  r^2=0.996161  n=24
```

Yreka Creek - Reach 2 Typical Cross-Section - Station 31186



```
*******************************WinXSPRO*********************************
D:\GS\Projects\140902_YC_FPH\Geomorph\Analysis\Xsects\FHR_2_31186.out
Input File:
D:\GS\Projects\140902_YC_FPH\Geomorph\Analysis\Xsects\FHR_2_31186.txt
Run Date:               01/21/16
Analysis Procedure:     Hydraulics & Regression
Cross Section Number:   1
Survey Date:            12/13/14


Subsections/Dividing positions


Resistance Method:      Manning's n
            SECTION         A
      Low Stage n         0.040
      High Stage n        0.030

Unadjusted horizontal distances used

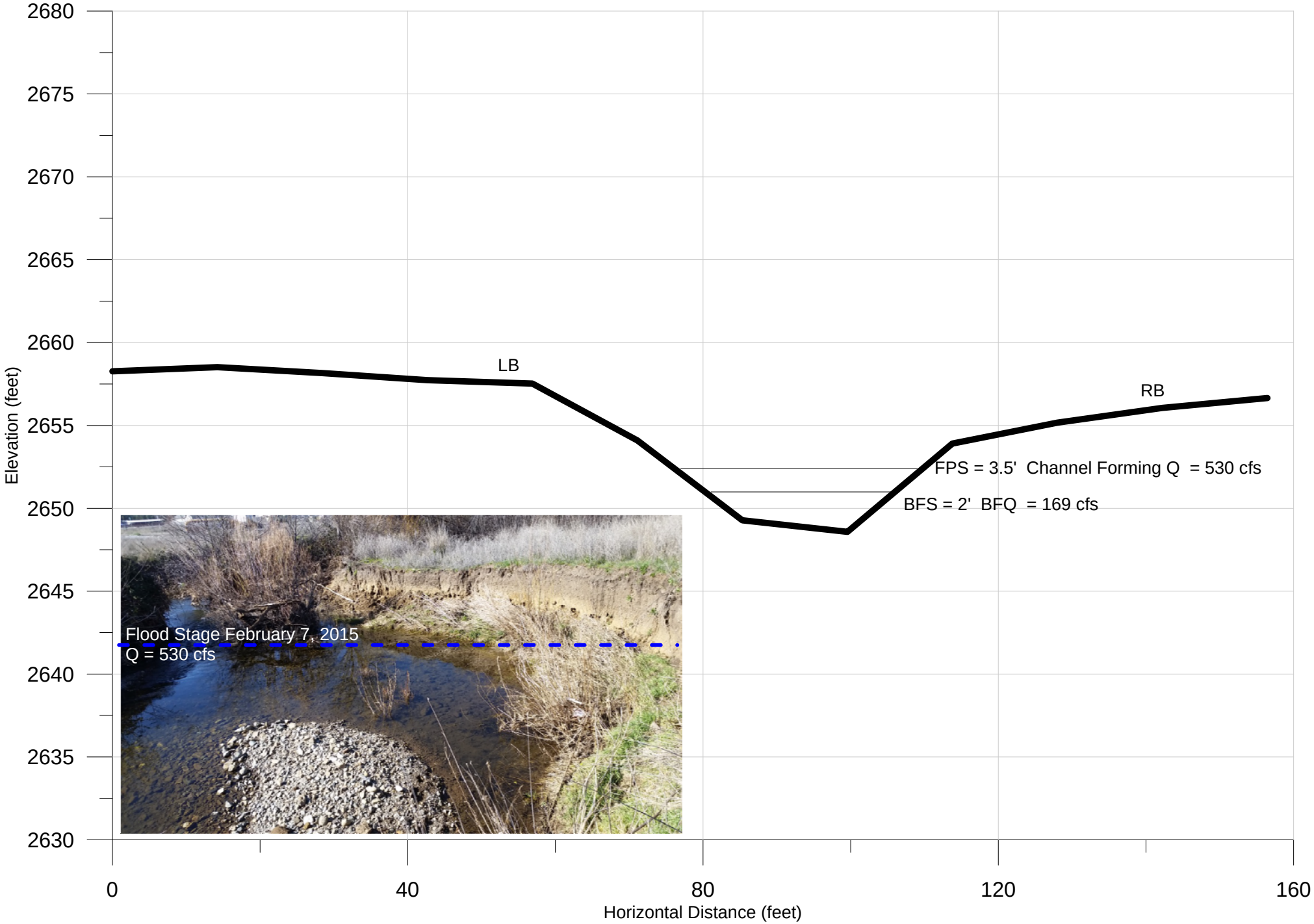

 STAGE  #SEC      AREA    PERIM   WIDTH    R       DHYD         SLOPE
n          VAVG       Q            SHEAR
  (ft)            (sq ft)   (ft)   (ft)    (ft)     (ft)         (ft/ft)
  (ft/s)    (cfs)          (psf)
  0.25    T       2.27    10.52   10.47  0.22     0.22          0.0141
0.040     1.59        3.60          0.19
  0.50    T       5.10    12.26   12.14  0.42     0.42          0.0140
0.040     2.49       12.69          0.36
  0.75    T       8.33    13.87   13.67  0.60     0.61          0.0139
0.039     3.20       26.68          0.52
  1.00    T      11.93    15.41   15.13  0.77     0.79          0.0138
0.039     3.83       45.65          0.67
  1.25    T      15.89    16.94   16.57  0.94     0.96          0.0137
0.038     4.39       69.75          0.80
  1.50    T      20.21    18.43   17.98  1.10     1.12          0.0136
0.038     4.91       99.29          0.93
  1.75    T      24.88    19.92   19.38  1.25     1.28          0.0135
0.037     5.41      134.52          1.05
  2.00    T      29.91    21.51   20.88  1.39     1.43          0.0134
0.037     5.86      175.25          1.16
  2.25    T      35.35    23.38   22.68  1.51     1.56          0.0133
0.036     6.25      221.12          1.25
  2.50    T      41.29    25.61   24.85  1.61     1.66          0.0132
0.036     6.59      272.10          1.33
  2.75    T      47.88    28.93   28.11  1.65     1.70          0.0131
0.035     6.77      324.22          1.35
  3.00    T      55.38    32.68   31.81  1.69     1.74          0.0130
0.035     6.95      384.64          1.37
  3.25    T      63.79    36.39   35.47  1.75     1.80          0.0129
0.034     7.18      457.69          1.41
  3.50    T      73.01    39.04   38.06  1.87     1.92          0.0128
0.034     7.57      552.58          1.49
  3.75    T      82.80    41.22   40.18  2.01     2.06          0.0127
0.033     8.02      664.02          1.59
  4.00    T      93.11    43.44   42.34  2.14     2.20          0.0126
0.033     8.46      787.88          1.69
  4.25    T     103.97    45.74   44.59  2.27     2.33          0.0125
0.032     8.89      924.62          1.77
  4.50    T     115.43    48.34   47.13  2.39     2.45          0.0124
0.032     9.29     1072.42          1.85
  4.75    T     127.56    51.20   49.95  2.49     2.55          0.0123
0.031     9.66     1232.57          1.91
```

```
  5.00    T     140.43    54.44   53.14  2.58     2.64          0.0122
0.031    10.00     1404.48         1.96
  5.25    T     154.17    58.36   57.02  2.64     2.70          0.0121
0.030    10.28     1584.53         1.99
  5.50    T     169.15    65.16   63.79  2.60     2.65          0.0120
0.030    10.28     1738.36         1.94

 STAGE        ALPHA    FROUDE
  0.25     1.000000       0.602185
  0.50     1.000000       0.675853
  0.75     1.000000       0.722958
  1.00     1.000000       0.759217
  1.25     1.000000       0.789537
  1.50     1.000000       0.816350
  1.75     1.000000       0.840758
  2.00     1.000000       0.862992
  2.25     1.000000       0.882995
  2.50     1.000000       0.900976
  2.75     1.000000       0.914351
  3.00     1.000000       0.927731
  3.25     1.000000       0.942927
  3.50     1.000000       0.962953
  3.75     1.000000       0.984483
  4.00     1.000000       1.005599
  4.25     1.000000       1.026352
  4.50     1.000000       1.046239
  4.75     1.000000       1.065567
  5.00     1.000000       1.084189
  5.25     1.000000       1.101477
  5.50     1.000000       1.112132

 Q = aR^b     a=104.612976  b=2.534198  r^2=0.979780  n=22
 Q = aZ^b     a=23.946833  b=2.431  r^2=0.997931  n=22
```

Yreka Creek - Reach 3 Typical Cross-Section - Station 28286



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*******************************WinXSPRO*********************************
D:\GS\Projects\140902_YC_FPH\Geomorph\Analysis\Xsects\FHR_3_28286.out
Input File:
D:\GS\Projects\140902_YC_FPH\Geomorph\Analysis\Xsects\FHR_3_28286.txt
Run Date:               01/21/16
Analysis Procedure:     Hydraulics & Regression
Cross Section Number:   1
Survey Date:            12/13/14


Subsections/Dividing positions


Resistance Method:      Manning's n
            SECTION         A
      Low Stage n         0.040
      High Stage n        0.030

Unadjusted horizontal distances used


 STAGE  #SEC      AREA    PERIM   WIDTH    R       DHYD         SLOPE
n          VAVG       Q            SHEAR
  (ft)            (sq ft)   (ft)   (ft)    (ft)     (ft)         (ft/ft)
  (ft/s)    (cfs)          (psf)
  0.25    T       0.72     5.84    5.79  0.12     0.13          0.0135
0.040     1.08        0.78          0.10
  0.50    T       2.90    11.69   11.58  0.25     0.25          0.0134
0.040     1.72        4.97          0.21
  0.75    T       6.49    16.55   16.39  0.39     0.40          0.0134
0.039     2.34       15.18          0.33
  1.00    T      10.76    18.04   17.79  0.60     0.60          0.0133
0.039     3.11       33.45          0.49
  1.25    T      15.38    19.53   19.20  0.79     0.80          0.0132
0.039     3.76       57.83          0.65
  1.50    T      20.36    21.02   20.60  0.97     0.99          0.0131
0.039     4.33       88.25          0.79
  1.75    T      25.68    22.51   22.01  1.14     1.17          0.0131
0.038     4.86      124.78          0.93
  2.00    T      31.36    24.01   23.41  1.31     1.34          0.0130
0.038     5.34      167.56          1.06
  2.25    T      37.39    25.50   24.82  1.47     1.51          0.0129
0.038     5.80      216.80          1.18
  2.50    T      43.77    26.99   26.22  1.62     1.67          0.0129
0.037     6.23      272.73          1.30
  2.75    T      50.50    28.48   27.62  1.77     1.83          0.0128
0.037     6.65      335.60          1.41
  3.00    T      57.58    29.97   29.03  1.92     1.98          0.0127
0.037     7.04      405.66          1.52
  3.25    T      65.01    31.46   30.43  2.07     2.14          0.0126
0.037     7.43      483.21          1.63
  3.50    T      72.80    32.95   31.84  2.21     2.29          0.0126
0.036     7.81      568.54          1.73
  3.75    T      80.93    34.44   33.24  2.35     2.43          0.0125
0.036     8.18      661.94          1.83
  4.00    T      89.42    35.93   34.65  2.49     2.58          0.0124
0.036     8.54      763.73          1.93
  4.25    T      98.26    37.43   36.05  2.63     2.73          0.0124
0.035     8.90      874.23          2.02
  4.50    T     107.45    38.92   37.46  2.76     2.87          0.0123
0.035     9.25      993.75          2.12
  4.75    T     116.99    40.41   38.86  2.90     3.01          0.0122
0.035     9.60     1122.65          2.21
```
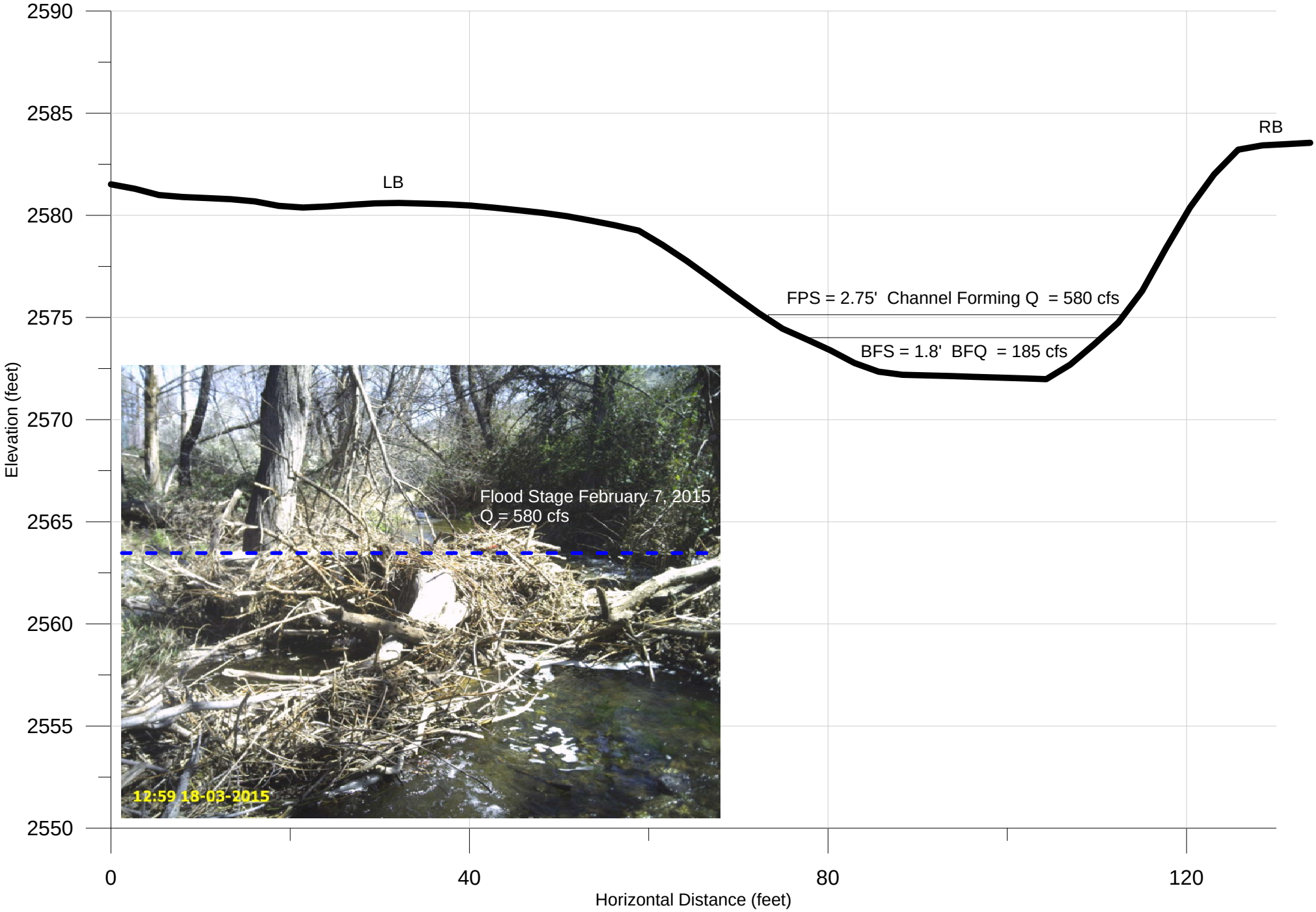

```
  5.00     T     126.88    41.90   40.27  3.03     3.15          0.0121
0.035     9.94     1261.24          2.29
  5.25     T     137.12    43.39   41.67  3.16     3.29          0.0121
0.034    10.28     1409.90          2.38
  5.50     T     147.84    46.36   44.58  3.19     3.32          0.0120
0.034    10.40     1537.60          2.39
  5.75     T     159.47    50.24   48.42  3.17     3.29          0.0119
0.034    10.42     1662.38          2.36
  6.00     T     172.05    54.14   52.28  3.18     3.29          0.0119
0.033    10.49     1804.97          2.35
  6.25     T     185.60    58.04   56.14  3.20     3.31          0.0118
0.033    10.59     1966.21          2.35
  6.50     T     200.12    61.94   60.00  3.23     3.34          0.0117
0.033    10.73     2146.60          2.36
  6.75     T     215.66    66.60   64.62  3.24     3.34          0.0116
0.033    10.80     2330.02          2.35
  7.00     T     232.45    71.65   69.63  3.24     3.34          0.0116
0.032    10.88     2528.84          2.34
  7.25     T     250.48    76.70   74.64  3.27     3.36          0.0115
0.032    10.99     2752.96          2.34
  7.50     T     269.77    81.92   79.83  3.29     3.38          0.0114
0.032    11.12     2999.01          2.35
  7.75     T     290.60    88.98   86.85  3.27     3.35          0.0114
0.031    11.12     3231.90          2.31
  8.00     T     313.93   116.62  114.45  2.69     2.74          0.0113
0.031     9.84     3087.57          1.90
  8.25     T     348.95   155.21  153.01  2.25     2.28          0.0112
0.031     8.78     3062.22          1.57
  8.50     T     389.08   170.12  167.89  2.29     2.32          0.0111
0.031     8.93     3474.76          1.59
  8.75     T     432.65   182.84  180.58  2.37     2.40          0.0111
0.030     9.19     3977.14          1.63
  9.00     T     479.45   198.75  196.46  2.41     2.44          0.0110
0.030     9.37     4492.19          1.66

 STAGE        ALPHA    FROUDE
  0.25     1.000000       0.536158
  0.50     1.000000       0.604540
  0.75     1.000000       0.655208
  1.00     1.000000       0.704493
  1.25     1.000000       0.740065
  1.50     1.000000       0.768445
  1.75     1.000000       0.792431
  2.00     1.000000       0.813482
  2.25     1.000000       0.832453
  2.50     1.000000       0.849888
  2.75     1.000000       0.866152
  3.00     1.000000       0.881503
  3.25     1.000000       0.896128
  3.50     1.000000       0.910169
  3.75     1.000000       0.923733
  4.00     1.000000       0.936906
  4.25     1.000000       0.949756
  4.50     1.000000       0.962340
  4.75     1.000000       0.974703
  5.00     1.000000       0.986885
  5.25     1.000000       0.998917
  5.50     1.000000       1.006457
  5.75     1.000000       1.012300
  6.00     1.000000       1.019081
  6.25     1.000000       1.026693
  6.50     1.000000       1.035002
  6.75     1.000000       1.042156
```

```
 7.00     1.000000       1.049320
 7.25     1.000000       1.057322
 7.50     1.000000       1.065696
 7.75     1.000000       1.071439
 8.00     1.000000       1.046563
 8.25     1.000000       1.024066
 8.50     1.000000       1.033838
 8.75     1.000000       1.046552
 9.00     1.000000       1.056948

Q = aR^b     a=123.714264  b=2.468222  r^2=0.923681  n=36
Q = aZ^b     a=14.735052  b=2.646  r^2=0.982561  n=36
```

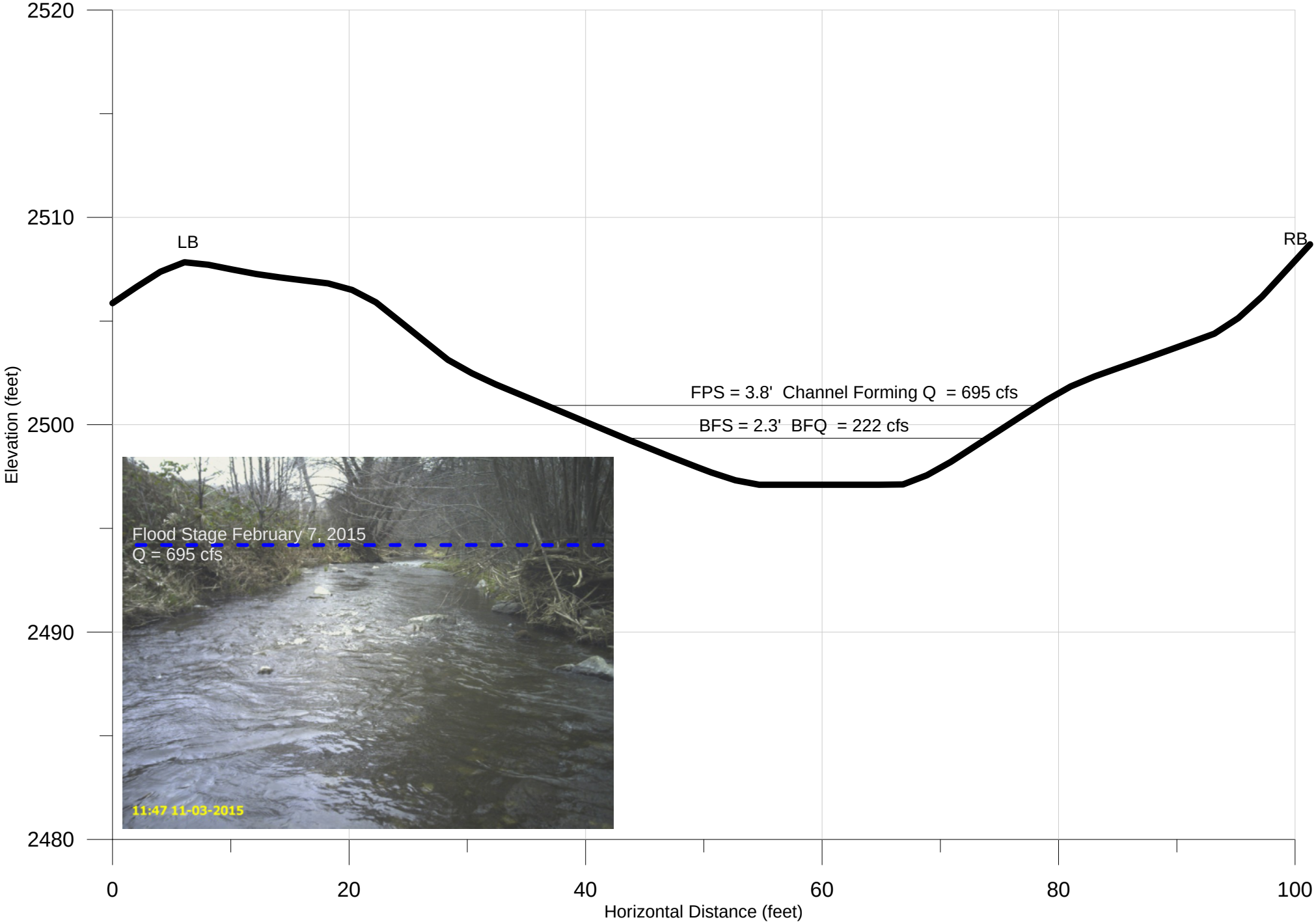
Yreka Creek - Reach 4 Typical Cross-Section - Station 19559



```
*******************************WinXSPRO*********************************
D:\GS\Projects\140902_YC_FPH\Geomorph\Analysis\Xsects\FHR_4_19599.out
Input File:
D:\GS\Projects\140902_YC_FPH\Geomorph\Analysis\Xsects\FHR_4_19599.txt
Run Date:               01/21/16
Analysis Procedure:     Hydraulics & Regression
Cross Section Number:   1
Survey Date:            12/13/14


Subsections/Dividing positions


Resistance Method:      Manning's n
            SECTION         A
      Low Stage n         0.030
      High Stage n        0.016

Unadjusted horizontal distances used


 STAGE  #SEC      AREA    PERIM   WIDTH    R       DHYD         SLOPE
n          VAVG       Q            SHEAR
  (ft)            (sq ft)   (ft)   (ft)    (ft)     (ft)         (ft/ft)
  (ft/s)    (cfs)          (psf)
  0.25    T       2.26    17.56   17.53  0.13     0.13          0.0066
0.030     1.03        2.33          0.05
  0.50    T       7.21    21.48   21.39  0.34     0.34          0.0066
0.029     1.98       14.27          0.14
  0.75    T      12.88    24.00   23.87  0.54     0.54          0.0065
0.029     2.74       35.32          0.22
  1.00    T      19.08    25.91   25.71  0.74     0.74          0.0065
0.028     3.44       65.65          0.30
  1.25    T      25.73    27.74   27.45  0.93     0.94          0.0064
0.028     4.08      104.86          0.37
  1.50    T      32.81    29.61   29.26  1.11     1.12          0.0064
0.027     4.66      152.97          0.44
  1.75    T      40.36    31.59   31.17  1.28     1.30          0.0064
0.027     5.21      210.31          0.51
  2.00    T      48.39    33.54   33.05  1.44     1.46          0.0063
0.026     5.74      277.94          0.57
  2.25    T      56.89    35.53   34.96  1.60     1.63          0.0063
0.026     6.26      356.27          0.63
  2.50    T      65.87    37.48   36.84  1.76     1.79          0.0062
0.025     6.78      446.63          0.68
  2.75    T      75.27    39.06   38.34  1.93     1.96          0.0062
0.025     7.34      552.36          0.74
  3.00    T      85.02    40.49   39.67  2.10     2.14          0.0062
0.024     7.91      672.83          0.81
  3.25    T      95.10    41.90   40.97  2.27     2.32          0.0061
0.024     8.49      807.67          0.87
  3.50    T     105.50    43.22   42.19  2.44     2.50          0.0061
0.023     9.09      958.48          0.92
  3.75    T     116.20    44.55   43.41  2.61     2.68          0.0060
0.023     9.68     1125.29          0.98
  4.00    T     127.20    45.88   44.63  2.77     2.85          0.0060
0.022    10.29     1309.19          1.04
  4.25    T     138.51    47.20   45.85  2.93     3.02          0.0059
0.022    10.91     1511.54          1.09
  4.50    T     150.12    48.45   46.98  3.10     3.20          0.0059
0.021    11.56     1735.04          1.14
  4.75    T     162.00    49.67   48.07  3.26     3.37          0.0059
0.021    12.22     1980.25          1.19
```

```
  5.00    T     174.16    50.89   49.17  3.42     3.54          0.0058
0.020    12.91     2248.03         1.24
  5.25    T     186.59    52.13   50.28  3.58     3.71          0.0058
0.019    13.61     2539.95         1.29
  5.50    T     199.29    53.36   51.38  3.74     3.88          0.0057
0.019    14.34     2858.27         1.34
  5.75    T     212.28    54.59   52.49  3.89     4.04          0.0057
0.018    15.10     3205.19         1.38
  6.00    T     225.55    55.87   53.65  4.04     4.20          0.0057
0.018    15.88     3581.08         1.43
  6.25    T     239.11    57.17   54.83  4.18     4.36          0.0056
0.017    16.69     3990.33         1.47
  6.50    T     252.96    58.47   56.01  4.33     4.52          0.0056
0.017    17.54     4436.40         1.51
  6.75    T     267.12    59.85   57.27  4.46     4.66          0.0055
0.016    18.42     4918.98         1.54
  7.00    T     281.60    61.26   58.57  4.60     4.81          0.0055
0.016    19.33     5444.61         1.58

 STAGE        ALPHA    FROUDE
  0.25     1.000000       0.504784
  0.50     1.000000       0.600416
  0.75     1.000000       0.658240
  1.00     1.000000       0.703726
  1.25     1.000000       0.741979
  1.50     1.000000       0.775807
  1.75     1.000000       0.806823
  2.00     1.000000       0.836483
  2.25     1.000000       0.865161
  2.50     1.000000       0.893570
  2.75     1.000000       0.922963
  3.00     1.000000       0.952578
  3.25     1.000000       0.982308
  3.50     1.000000       1.012521
  3.75     1.000000       1.043158
  4.00     1.000000       1.074393
  4.25     1.000000       1.106408
  4.50     1.000000       1.139408
  4.75     1.000000       1.173468
  5.00     1.000000       1.208708
  5.25     1.000000       1.245273
  5.50     1.000000       1.283361
  5.75     1.000000       1.323152
  6.00     1.000000       1.364688
  6.25     1.000000       1.408310
  6.50     1.000000       1.454287
  6.75     1.000000       1.502674
  7.00     1.000000       1.553890

 Q = aR^b     a=144.613037  b=2.214640  r^2=0.994171  n=28
 Q = aZ^b     a=28.944130  b=2.657  r^2=0.992892  n=28
```

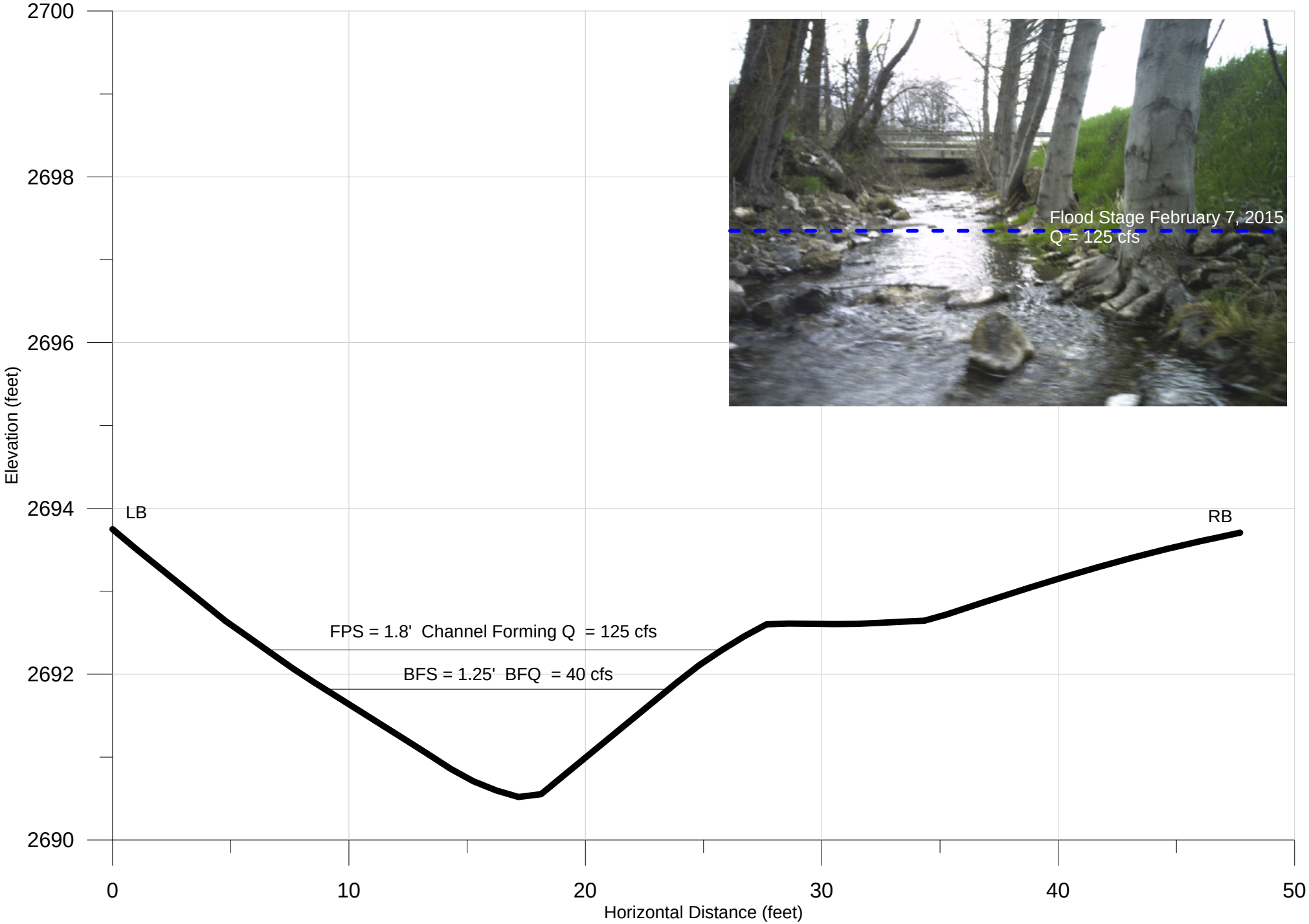
Yreka Creek - Reach 5 Typical Cross-Section - Station 10637



```
*******************************WinXSPRO*********************************
D:\GS\Projects\140902_YC_FPH\Geomorph\Analysis\Xsects\FHR_5_10637.out
Input File:
D:\GS\Projects\140902_YC_FPH\Geomorph\Analysis\Xsects\FHR_5_10637.txt
Run Date:               01/21/16
Analysis Procedure:     Hydraulics & Regression
Cross Section Number:   1
Survey Date:            12/13/14


Subsections/Dividing positions


Resistance Method:      Manning's n
            SECTION         A
      Low Stage n         0.040
      High Stage n        0.020

Unadjusted horizontal distances used


 STAGE  #SEC      AREA    PERIM   WIDTH    R       DHYD         SLOPE
n          VAVG       Q            SHEAR
  (ft)            (sq ft)   (ft)   (ft)    (ft)     (ft)         (ft/ft)
  (ft/s)    (cfs)          (psf)
  0.25    T       3.42    15.42   15.38  0.22     0.22          0.0055
0.040     1.01        3.46          0.08
  0.50    T       7.58    17.93   17.84  0.42     0.42          0.0055
0.039     1.58       11.94          0.14
  0.75    T      12.30    20.01   19.85  0.61     0.62          0.0054
0.039     2.05       25.20          0.21
  1.00    T      17.50    22.01   21.79  0.80     0.80          0.0054
0.038     2.47       43.18          0.27
  1.25    T      23.18    23.91   23.62  0.97     0.98          0.0054
0.037     2.85       66.18          0.32
  1.50    T      29.31    25.76   25.40  1.14     1.15          0.0053
0.037     3.22       94.42          0.38
  1.75    T      35.88    27.60   27.17  1.30     1.32          0.0053
0.036     3.57      128.15          0.43
  2.00    T      42.89    29.44   28.93  1.46     1.48          0.0053
0.035     3.91      167.75          0.48
  2.25    T      50.34    31.25   30.67  1.61     1.64          0.0052
0.035     4.24      213.69          0.52
  2.50    T      58.23    33.06   32.40  1.76     1.80          0.0052
0.034     4.57      266.33          0.57
  2.75    T      66.54    34.87   34.14  1.91     1.95          0.0051
0.034     4.90      326.16          0.61
  3.00    T      75.30    36.67   35.87  2.05     2.10          0.0051
0.033     5.23      393.72          0.65
  3.25    T      84.48    38.47   37.59  2.20     2.25          0.0051
0.032     5.56      469.59          0.70
  3.50    T      94.09    40.27   39.32  2.34     2.39          0.0050
0.032     5.89      554.29          0.73
  3.75    T     104.14    42.07   41.05  2.48     2.54          0.0050
0.031     6.23      648.51          0.77
  4.00    T     114.62    43.88   42.78  2.61     2.68          0.0050
0.030     6.57      752.92          0.81
  4.25    T     125.53    45.73   44.56  2.74     2.82          0.0049
0.030     6.91      867.70          0.84
  4.50    T     136.90    47.63   46.39  2.87     2.95          0.0049
0.029     7.26      993.89          0.88
  4.75    T     148.73    49.55   48.24  3.00     3.08          0.0049
0.028     7.62     1132.61          0.91
```

```
  5.00     T     161.04    51.65   50.28  3.12     3.20          0.0048
0.028     7.96     1282.48          0.94
  5.25     T     173.86    53.72   52.29  3.24     3.32          0.0048
0.027     8.33     1447.79          0.97
  5.50     T     187.21    55.89   54.40  3.35     3.44          0.0048
0.026     8.70     1627.87          0.99
  5.75     T     201.06    57.98   56.43  3.47     3.56          0.0047
0.026     9.09     1827.06          1.02
  6.00     T     215.42    60.08   58.46  3.59     3.68          0.0047
0.025     9.49     2045.24          1.05
  6.25     T     230.26    61.96   60.27  3.72     3.82          0.0046
0.025     9.94     2289.12          1.08
  6.50     T     245.55    63.82   62.04  3.85     3.96          0.0046
0.024    10.41     2556.18          1.11
  6.75     T     261.28    65.65   63.80  3.98     4.10          0.0046
0.023    10.90     2848.00          1.14
  7.00     T     277.45    67.49   65.55  4.11     4.23          0.0045
0.023    11.41     3166.39          1.17
  7.25     T     294.06    69.32   67.31  4.24     4.37          0.0045
0.022    11.95     3513.77          1.19
  7.50     T     311.06    70.72   68.61  4.40     4.53          0.0045
0.021    12.56     3907.69          1.23
  7.75     T     328.36    72.03   69.82  4.56     4.70          0.0044
0.021    13.21     4339.07          1.26
  8.00     T     345.97    73.35   71.04  4.72     4.87          0.0044
0.020    13.90     4808.46          1.29

 STAGE        ALPHA    FROUDE
  0.25     1.000000       0.378290
  0.50     1.000000       0.426184
  0.75     1.000000       0.459049
  1.00     1.000000       0.485158
  1.25     1.000000       0.507876
  1.50     1.000000       0.528470
  1.75     1.000000       0.547682
  2.00     1.000000       0.566010
  2.25     1.000000       0.583832
  2.50     1.000000       0.601325
  2.75     1.000000       0.618672
  3.00     1.000000       0.636011
  3.25     1.000000       0.653458
  3.50     1.000000       0.671085
  3.75     1.000000       0.688986
  4.00     1.000000       0.707227
  4.25     1.000000       0.725787
  4.50     1.000000       0.744779
  4.75     1.000000       0.764309
  5.00     1.000000       0.784143
  5.25     1.000000       0.804782
  5.50     1.000000       0.826049
  5.75     1.000000       0.848360
  6.00     1.000000       0.871621
  6.25     1.000000       0.896289
  6.50     1.000000       0.922117
  6.75     1.000000       0.949185
  7.00     1.000000       0.977582
  7.25     1.000000       1.007439
  7.50     1.000000       1.039714
  7.75     1.000000       1.073849
  8.00     1.000000       1.109881

 Q = aR^b     a=81.336617  b=2.456982  r^2=0.989422  n=32
 Q = aZ^b     a=22.374142  b=2.477  r^2=0.998449  n=32
```

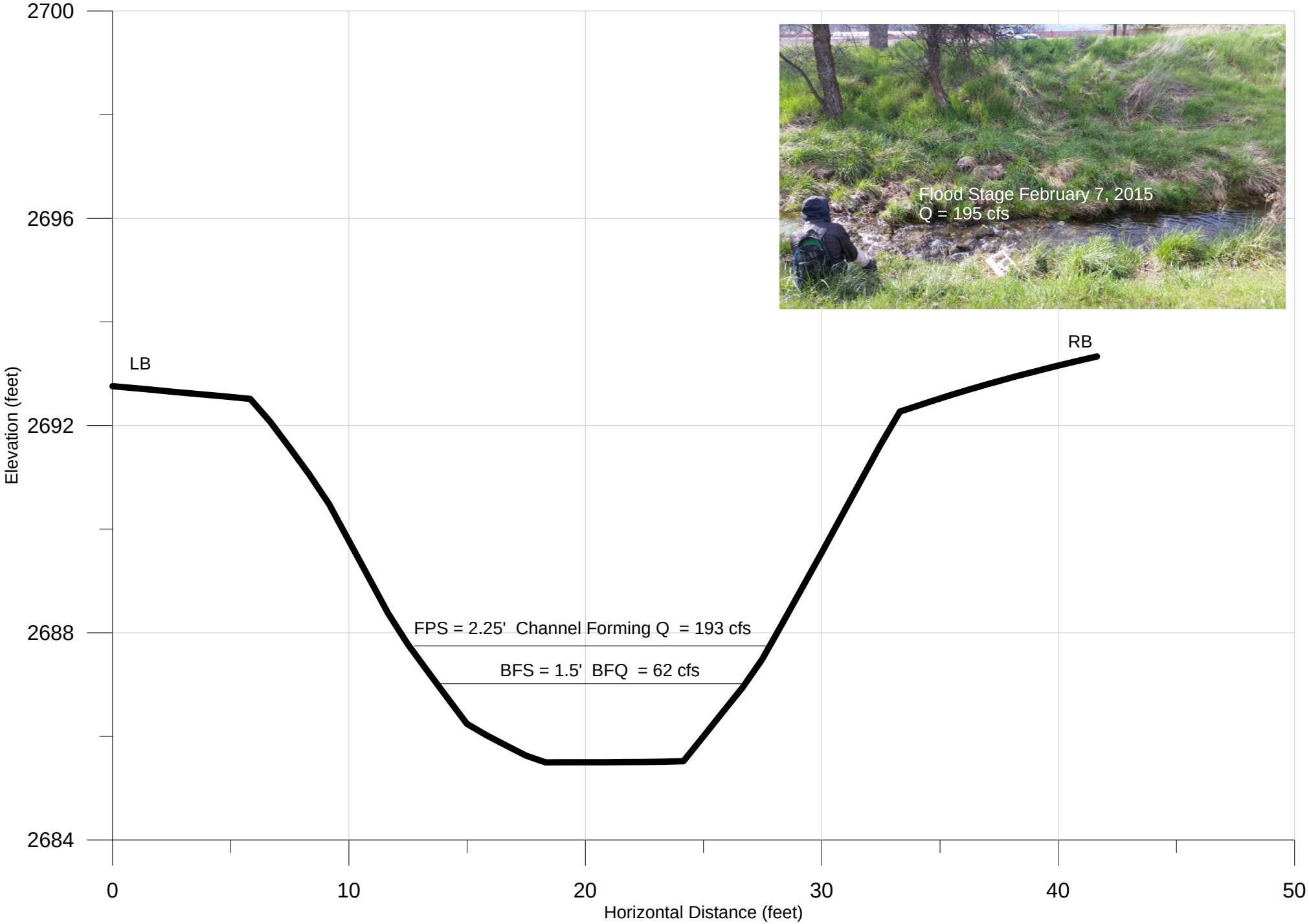
Juniper Creek - Reach 6 Typical Cross-Section - Station 189



```
*******************************WinXSPRO*********************************
D:\GS\Projects\140902_YC_FPH\Geomorph\Analysis\Xsects\FHR_6_189.out
Input File:
D:\GS\Projects\140902_YC_FPH\Geomorph\Analysis\Xsects\FHR_6_189.txt
Run Date:               01/21/16
Analysis Procedure:     Hydraulics & Regression
Cross Section Number:   1
Survey Date:            12/13/14


Subsections/Dividing positions


Resistance Method:      Manning's n
            SECTION         A
      Low Stage n         0.040
      High Stage n        0.020

Unadjusted horizontal distances used


 STAGE  #SEC      AREA    PERIM   WIDTH    R       DHYD         SLOPE
n          VAVG       Q            SHEAR
  (ft)            (sq ft)   (ft)   (ft)    (ft)     (ft)         (ft/ft)
  (ft/s)    (cfs)          (psf)
  0.25    T       0.64     4.21    4.17  0.15     0.15          0.0153
0.040     1.32        0.85          0.15
  0.50    T       2.01     6.77    6.68  0.30     0.30          0.0152
0.038     2.14        4.29          0.28
  0.75    T       3.98     9.27    9.13  0.43     0.44          0.0151
0.036     2.86       11.41          0.40
  1.00    T       6.57    11.78   11.58  0.56     0.57          0.0149
0.035     3.57       23.49          0.52
  1.25    T       9.78    14.29   14.05  0.68     0.70          0.0148
0.033     4.30       42.08          0.63
  1.50    T      13.60    16.81   16.51  0.81     0.82          0.0147
0.031     5.08       69.01          0.74
  1.75    T      18.03    19.36   19.02  0.93     0.95          0.0146
0.029     5.90      106.41          0.85
  2.00    T      23.12    22.13   21.74  1.04     1.06          0.0145
0.027     6.77      156.50          0.94
  2.25    T      29.94    32.00   31.57  0.94     0.95          0.0144
0.025     6.71      200.86          0.84
  2.50    T      38.31    35.84   35.37  1.07     1.08          0.0142
0.024     7.86      301.21          0.95
  2.75    T      47.64    39.85   39.34  1.20     1.21          0.0141
0.022     9.14      435.45          1.05
  3.00    T      58.02    44.32   43.77  1.31     1.33          0.0140
0.020    10.55      612.01          1.14

 STAGE        ALPHA    FROUDE
  0.25     1.000000       0.591119
  0.50     1.000000       0.687255
  0.75     1.000000       0.763974
  1.00     1.000000       0.836195
  1.25     1.000000       0.909188
  1.50     1.000000       0.985769
  1.75     1.000000       1.067817
  2.00     1.000000       1.156433
  2.25     1.000000       1.214043
  2.50     1.000000       1.331485
  2.75     1.000000       1.463770
  3.00     1.000000       1.614716
```

```
Q = aR^b      a=181.686203  b=3.057942  r^2=0.975562  n=12
Q = aZ^b      a=10.335515  b=3.390  r^2=0.998213  n=12
```

Greenhorn Creek - Reach 7 Typical Cross-Section - Station 796



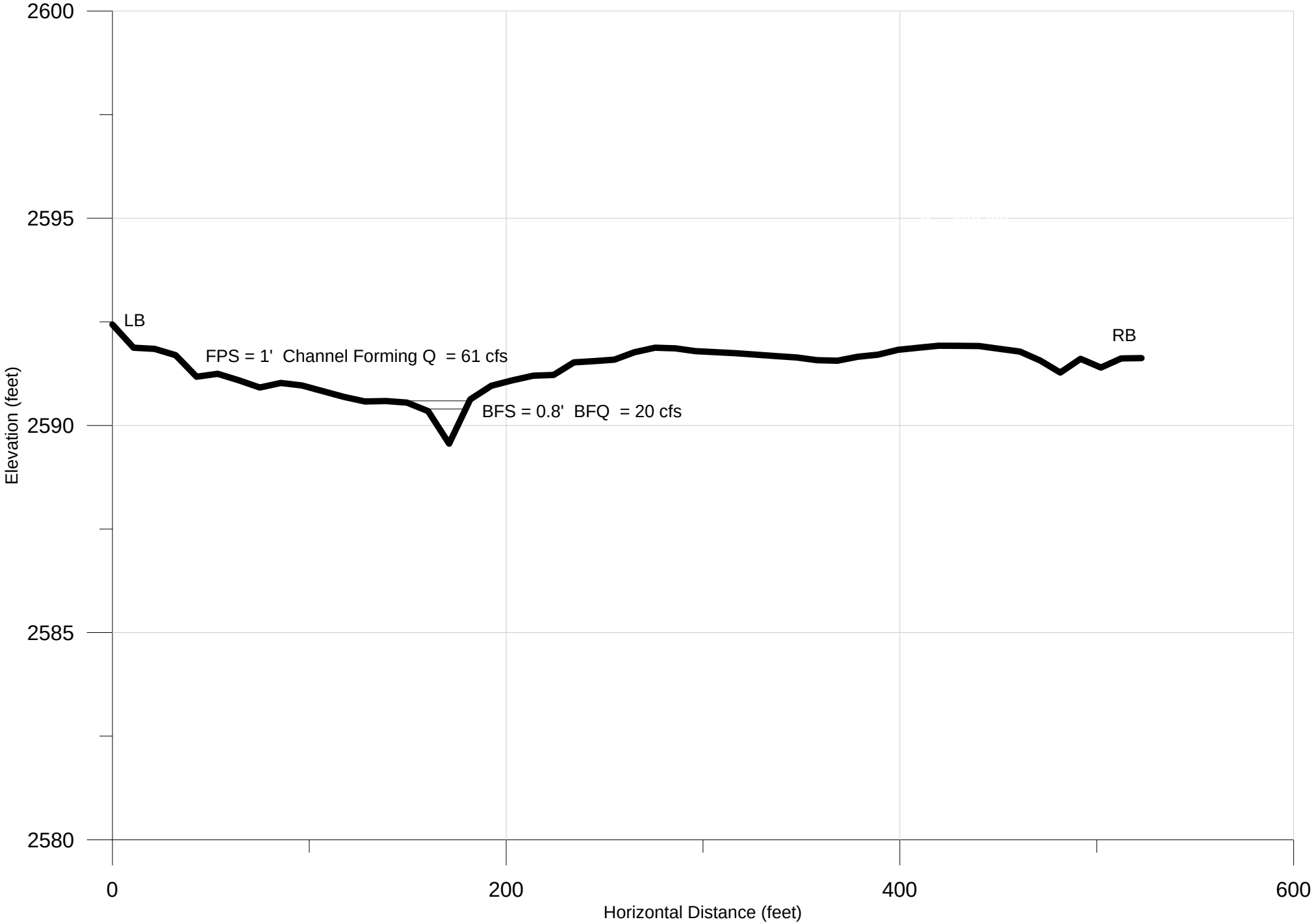
```
*******************************WinXSPRO*********************************
D:\GS\Projects\140902_YC_FPH\Geomorph\Analysis\Xsects\FHR_7_796.out
Input File:
D:\GS\Projects\140902_YC_FPH\Geomorph\Analysis\Xsects\FHR_7_796.txt
Run Date:               01/21/16
Analysis Procedure:     Hydraulics & Regression
Cross Section Number:   1
Survey Date:            12/13/14


Subsections/Dividing positions


Resistance Method:      Manning's n
            SECTION         A
      Low Stage n         0.040
      High Stage n        0.020

Unadjusted horizontal distances used


 STAGE  #SEC      AREA    PERIM   WIDTH    R       DHYD         SLOPE
n          VAVG       Q            SHEAR
  (ft)            (sq ft)   (ft)   (ft)    (ft)     (ft)         (ft/ft)
  (ft/s)    (cfs)          (psf)
  0.25    T       1.64     7.65    7.57  0.21     0.22          0.0147
0.040     1.62        2.66          0.20
  0.50    T       3.72     9.24    9.06  0.40     0.41          0.0147
0.039     2.52        9.37          0.37
  0.75    T       6.16    10.72   10.44  0.58     0.59          0.0148
0.039     3.25       20.06          0.53
  1.00    T       8.88    11.70   11.29  0.76     0.79          0.0148
0.038     4.00       35.49          0.70
  1.25    T      11.81    12.69   12.14  0.93     0.97          0.0149
0.037     4.68       55.24          0.86
  1.50    T      14.95    13.67   12.98  1.09     1.15          0.0149
0.036     5.33       79.63          1.02
  1.75    T      18.29    14.60   13.77  1.25     1.33          0.0150
0.036     5.96      109.07          1.17
  2.00    T      21.83    15.53   14.55  1.41     1.50          0.0150
0.035     6.59      143.80          1.32
  2.25    T      25.56    16.40   15.26  1.56     1.67          0.0151
0.034     7.22      184.53          1.47
  2.50    T      29.46    17.23   15.92  1.71     1.85          0.0151
0.033     7.86      231.61          1.61
  2.75    T      33.52    18.06   16.58  1.86     2.02          0.0152
0.033     8.51      285.23          1.76
  3.00    T      37.75    18.86   17.21  2.00     2.19          0.0152
0.032     9.17      346.08          1.90
  3.25    T      42.12    19.64   17.81  2.14     2.37          0.0153
0.031     9.84      414.69          2.04
  3.50    T      46.65    20.42   18.41  2.28     2.53          0.0153
0.030    10.53      491.43          2.18
  3.75    T      51.33    21.21   19.01  2.42     2.70          0.0154
0.030    11.24      576.97          2.32
  4.00    T      56.16    21.99   19.61  2.55     2.86          0.0154
0.029    11.97      672.08          2.46
  4.25    T      61.13    22.76   20.21  2.69     3.03          0.0155
0.028    12.72      777.66          2.59
  4.50    T      66.26    23.54   20.80  2.81     3.19          0.0155
0.027    13.50      894.57          2.73
  4.75    T      71.53    24.32   21.39  2.94     3.34          0.0156
0.027    14.31     1023.83          2.86
```

```
  5.00    T      76.96    25.10   21.99  3.07     3.50          0.0156
0.026    15.16     1166.52          2.99
  5.25    T      82.54    25.93   22.66  3.18     3.64          0.0157
0.025    16.02     1322.48          3.11
  5.50    T      88.28    26.76   23.32  3.30     3.79          0.0157
0.024    16.93     1494.85          3.23
  5.75    T      94.20    27.62   24.01  3.41     3.92          0.0158
0.024    17.88     1684.43          3.35
  6.00    T     100.29    28.48   24.71  3.52     4.06          0.0158
0.023    18.88     1893.84          3.47
  6.25    T     106.56    29.36   25.43  3.63     4.19          0.0159
0.022    19.94     2124.88          3.59
  6.50    T     113.01    30.24   26.16  3.74     4.32          0.0159
0.021    21.06     2380.21          3.71
  6.75    T     119.64    31.17   26.94  3.84     4.44          0.0160
0.021    22.24     2661.16          3.82
  7.00    T     126.62    33.29   28.97  3.80     4.37          0.0160
0.020    22.96     2907.48          3.80
```

STAGE	ALPHA	FROUDE
0.25	1.000000	0.612616
0.50	1.000000	0.691311
0.75	1.000000	0.746296
1.00	1.000000	0.794304
1.25	1.000000	0.836094
1.50	1.000000	0.874681
1.75	1.000000	0.911559
2.00	1.000000	0.947502
2.25	1.000000	0.983065
2.50	1.000000	1.018636
2.75	1.000000	1.054489
3.00	1.000000	1.090887
3.25	1.000000	1.128031
3.50	1.000000	1.166181
3.75	1.000000	1.205554
4.00	1.000000	1.246358
4.25	1.000000	1.288785
4.50	1.000000	1.333049
4.75	1.000000	1.379371
5.00	1.000000	1.427988
5.25	1.000000	1.479323
5.50	1.000000	1.533529
5.75	1.000000	1.590937
6.00	1.000000	1.651872
6.25	1.000000	1.716740
6.50	1.000000	1.785973
6.75	1.000000	1.860011
7.00	1.000000	1.935635

```
Q = aR^b     a=74.739784  b=2.449106  r^2=0.990036  n=28
Q = aZ^b     a=18.338205  b=2.523  r^2=0.998928  n=28
```

Little Humbug Creek - Reach 8 Typical Cross-Section - Station 902



```
*******************************WinXSPRO*********************************
D:\GS\Projects\140902_YC_FPH\Geomorph\Analysis\Xsects\FHR_8_902.out
Input File:
D:\GS\Projects\140902_YC_FPH\Geomorph\Analysis\Xsects\FHR_8_902.txt
Run Date:               01/21/16
Analysis Procedure:     Hydraulics & Regression
Cross Section Number:   1
Survey Date:            12/13/14


Subsections/Dividing positions


Resistance Method:      Manning's n
            SECTION         A
      Low Stage n         0.040
      High Stage n        0.020

Unadjusted horizontal distances used


 STAGE  #SEC      AREA    PERIM   WIDTH    R       DHYD         SLOPE
n          VAVG       Q            SHEAR
  (ft)            (sq ft)   (ft)   (ft)    (ft)     (ft)         (ft/ft)
  (ft/s)    (cfs)          (psf)
  0.25    T       0.74     5.92    5.90  0.12     0.13          0.0420
0.040     1.90        1.40          0.33
  0.50    T       2.95    11.85   11.80  0.25     0.25          0.0418
0.038     3.19        9.42          0.65
  0.75    T       6.64    17.77   17.70  0.37     0.38          0.0416
0.036     4.43       29.42          0.97
  1.00    T      12.69    34.15   34.07  0.37     0.37          0.0413
0.033     4.70       59.64          0.96
  1.25    T      28.64    79.40   79.32  0.36     0.36          0.0411
0.031     4.92      140.90          0.93
  1.50    T      54.13   135.04  134.95  0.40     0.40          0.0409
0.029     5.67      306.86          1.02
  1.75    T      94.58   189.41  189.30  0.50     0.50          0.0407
0.027     7.09      670.74          1.27
  2.00    T     147.19   246.62  246.50  0.60     0.60          0.0404
0.024     8.69     1279.07          1.51
  2.25    T     231.07   415.47  415.15  0.56     0.56          0.0402
0.022     9.09     2101.38       *  1.40
  2.50    T     353.26   516.11  515.53  0.68     0.69          0.0400
0.020    11.57     4088.06       *  1.71

 STAGE        ALPHA    FROUDE
  0.25     1.000000       0.948959
  0.50     1.000000       1.124841
  0.75     1.000000       1.275295
  1.00     1.000000       1.356387
  1.25     1.000000       1.442990
  1.50     1.000000       1.577615
  1.75     1.000000       1.768171
  2.00     1.000000       1.981720
  2.25     1.000000       2.148176
  2.50     1.000000       2.463628

 Q = aR^b     a=16812.218750  b=4.911612  r^2=0.910478  n=10
 Q = aZ^b     a=29.122581  b=4.572  r^2=0.993464  n=10
```