PRELIMINARY ASSESSMENT
OF FLOODING
IN LOWER ELK RIVER

PREPARED BY

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FOR

ELK RIVER SEDIMENT TMDL

NORTH COAST REGIONAL WATER QUALITY CONTROL BOARD

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INTRODUCTION

In response to questions about the degree of change in the flooding conditions in lower Elk River, Regional Water Quality Control Board (Regional Water Board) staff has conducted an analysis of known and available historic and contemporary stream gage records. The analyses conducted and the results are presented herein. The analyses, though limited by available data, do provide a clear indication of channel capacity reduction as a result of sediment deposition and increased frequency of floodwaters inundating the floodplain.

PHYSICAL SETTING

Elk River drains a basin area of 56.1 square miles on the west slope of the northern California Coastal Ranges. Elevations in the basin vary from near sea level to approximate 2,400 feet. The channel gradient in the upstream reaches is quite steep, averaging approximately 3% or 150 feet per mile (Rantz 1964). The river meanders through the coastal plain at a very low gradient of approximately 0.08% or 4 feet per mile, before discharging into Humboldt Bay, south of the city of Eureka.

DEFINITIONS

Bankfull stage	The stage at which the water fills the channel completely and the water surface is level with the floodplain.
Bankfull discharge	The discharge at which the water fills the channel completely and the water surface is level with the floodplain.
Channel capacity	The cross sectional area at which the water fills the channel completely and the water surface is level with the flood plain.
Exceedance probability	The probability of the occurrence of events equal to or greater than a certain magnitude.
National Geodetic Vertical Datum of 1929 (NGVD 29)	Sea Level Datum of 1929: A vertical control datum established for vertical control in the United States by the general adjustment of 1929.
North American Vertical Datum of 1988 (NAVD 88)	The vertical control datum established in 1991 by the minimum-constraint adjustment of the Canadian-Mexican-U.S. leveling observations.
Stage-discharge rating curve	A graph of discharge plotted against the corresponding elevation of the water surface.
Recurrence interval (or return period)	The average interval (in years) between events equaling or exceeding a given magnitude.
Stage	The elevation of the water surface above a defined datum.
Thalweg	The deepest part of the channel in a given cross section.

HISTORIC DATA: USGS GAGE STATION 11-479700, ELK RIVER[1]

On September 23, 1957, United States Geologic Survey (USGS) in cooperation with California Department of Water Resources established stream gage station 11-479700 on the mainstem of Elk River. This station maintained monthly gage records for ten water years[2] (1958 – 1967). The gage records have been compiled and analyzed to illustrate hydrologic and hydraulic conditions in Elk River during the 10-year period of record. Several years of data are currently not filed in the USGS archive and consequently are not referenced in these analyses.

Monthly discharge, stage, and channel conditions were among several parameters monitored at USGS gage station 11-479700. Cross sectional topography has been reconstructed by converting water surface stage into mean sea level elevation. An analysis of the flood frequency during the record period examines the probabilities of a peak discharge to occur. These historic records give us a benchmark in the recent past to characterize monthly channel dimensions and discharge. A comparison of historic data with current conditions in Lower Elk River demonstrates changes in bed elevation, channel capacity, and flood frequency.

VERTICAL DATUMS

USGS Benchmark H 33 is located at N40°41'56" W124°08'40", south of Elk River Road and labeled "BM 69" on the USGS 7.5-minute Fields Landing quadrangle map (1972). The H 33 benchmark was used to establish three on-site vertical benchmarks (RM # 1- 3) and the level of zero gage (Table 1). Due to the age of these records, all reported elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29), supplementary adjustment of 1956. To convert elevations at this site to the North American Vertical Datum of 1988 (NAVD 88), add 3.28 feet.

Table 1. Historic Benchmarks and Gage

Benchmark	Elevation (ft, gage)	Elevation (ft, NGVD 29)	Level Date	Description
H 33	--	68.99	1940	USGS brass cap set in concrete post stamped "1940 H 33 69."
RM #1	6.22	35.83	9/3/57	Spike driven in staff backing. Not found 7/11/61.
RM #2	18.05	47.66	7/11/61	USGS bronze marker set in pad of concrete 7 ft shoreward under walkway.
RM #3	23.25	52.86	6/16/65	Chiseled cross on northwest corner of concrete walkway pad.
Gage	0.0	29.61	--	Well gage, staff w/ enamel face; limits 0.0 ft to 27.1 ft (gage).

[1] The official title of USGS gage station 11-479700 is "Elk River near Falk".

[2] The term "year", "years" or "annual" in this report refers to the water year, starting on October 1 of the year previous to the year cited and ending on September 30 of the cited year (e.g. water year 1958 starts October 1, 1957 and ends September 30, 1958).

Site Description

USGS gage station 11-479700 is located just downstream of Elk River's main tributaries, North Fork and South Fork, where the river egresses from uplands onto the coastal plain (Figure 1). The drainage area above this gage station is 44.2 square miles. Railroad Gulch and Clapp Gulch, two small, steep tributaries are located upstream and downstream of the historic gage site, respectively.

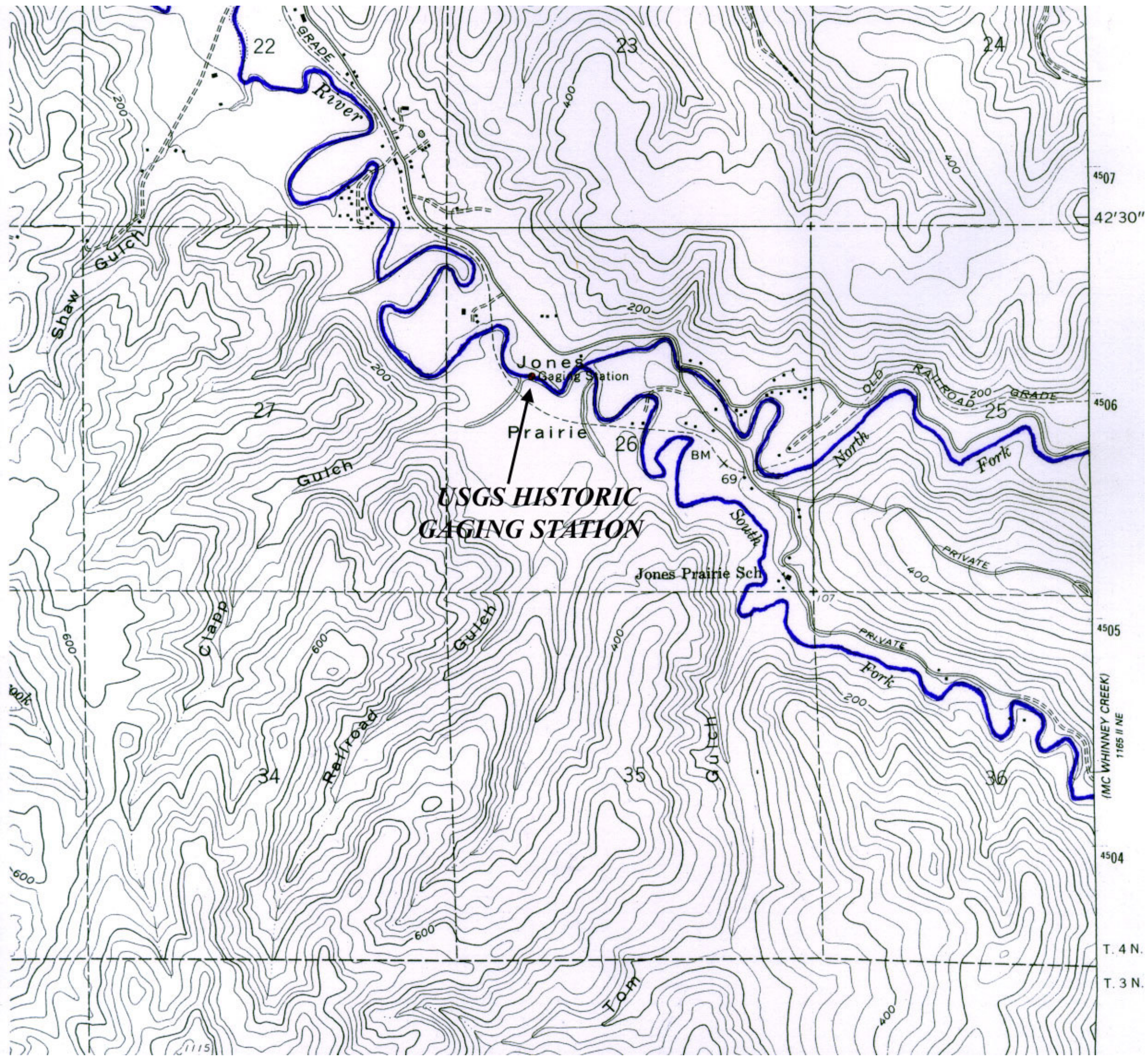

Figure 1. Location of Historic USGS Gage 11-479700, Elk River

The historic gage station was comprised of a digital recorder tape punched at 15-minute intervals, housed in a single section 48-inch diameter by 35.4 feet tall-galvanized corrugated pipe well. The well gage included a single section staff plate, limited between 0.0 feet and 27.1 feet (gage). Two sections of staff plates were located outside the well. The lower elevation staff plate, limited between 2.2 feet and 10.1 feet (gage), was located 49 feet downstream of the gage well. The higher elevation staff plate, limited between 10.1 feet and 25.5 feet, was located on the downstream side of the gage well.

Low-water discharge (gage height less than 6 feet) was measured by wading into the river within the vicinity of the gage. A cableway and sit-down aluminum car with a Canfield reel mount was located 20 feet downstream of the gage well and was used to measure discharge during high-water flow events (gage height greater than 6 feet). The cableway consisted of a ¾ - inch diameter galvanized plow steel that spanned 120 feet between two A-frames.

Location Corrections

USGS notes describe gage station 11-479700 to be located 500 feet downstream of Clapp Gulch. Contrary to USGS survey notes and reports from gage station 11-479700, data suggest that the location of the gage was approximately 500 feet downstream of Railroad Gulch, not Clapp Gulch. This location corresponds to a second reported location that the gage was approximately 1300 feet downstream of the North Fork-South Fork confluence and approximately 1000 feet upstream of the historic railway crossing. The USGS 7.5-minute Fields Landing quadrangle map locates the gaging station upstream of Clapp Gulch (1972). The quadrangle map however, depicts Railroad Gulch draining into South Fork Elk River, which is incorrect. Railroad Gulch empties into mainstem Elk River. Figure 1 displays the location of the historic gage and the adjacent tributaries.

Cross Sectional Area

Monthly cross sectional topography of the Elk River channel was reconstructed for a full record of water years (WY) 1958, 1959, 1960 and 1967, in addition to available individual records within WY 1961 through 1966. Since cross sectional area is derived from a measurement of water stage, high-water discharge records tend to be more topographically descriptive than low-water discharge records. Therefore, only three records that were measured during high-water events were used to determine the historic topography. Figure 2 illustrates cross sectional channel topography in WY 1958, 1959, and 1965.

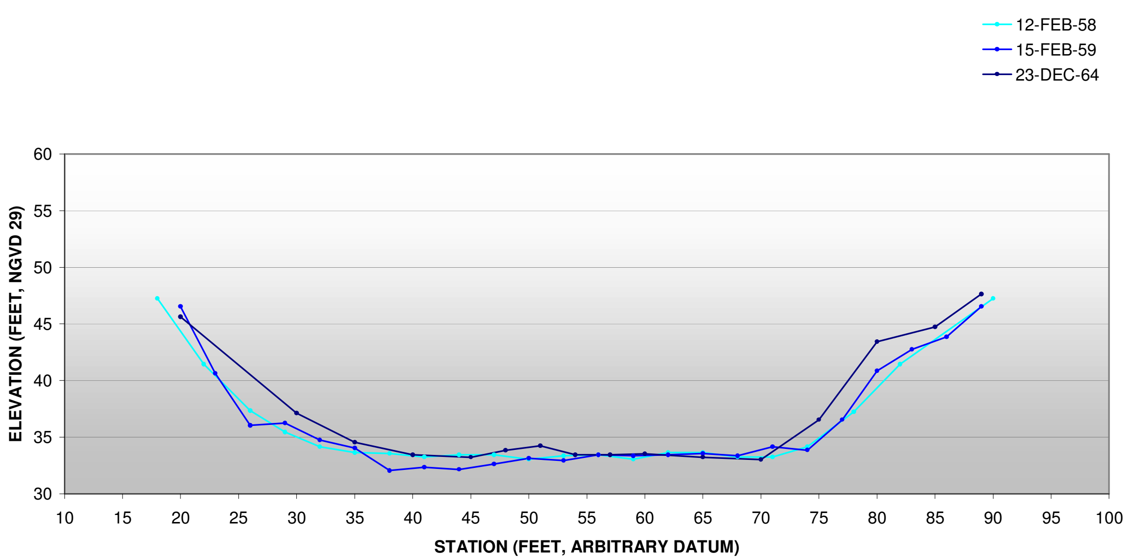

Figure 2. Cross Sectional Channel Topography at Historic USGS Gage Station 11-479700

To compare the relative changes in channel cross sectional area, estimated cross section area related to bankfull stage and discharge is used. The cross sectional area at which the water fills the channel completely and the water surface is level with the flood plain will be referred to as the channel capacity.

Channel Capacity

USGS report a bankfull stage of 23 feet gage elevation (52.61 feet elevation, NGVD 29) and a bankfull discharge of 2250 cubic feet per second (cfs) (Young and Cruff 1967). USGS report bankfull discharge at gage station 11-479700 to be the discharge at which the water fills the channel completely and the water surface is level with the floodplain. All monthly measurements occur at a stage below bankfull, therefore the channel capacity is estimated to be the sum of the measured cross sectional area and the area above the measured area up to bankfull stage (Figure 3). This method may underestimate the channel capacity; however, this method is applied consistently. Table 2 summarizes estimated channel capacity as a function of cross sectional area in square feet (ft^2) for WY 1958, 1959, and 1965.

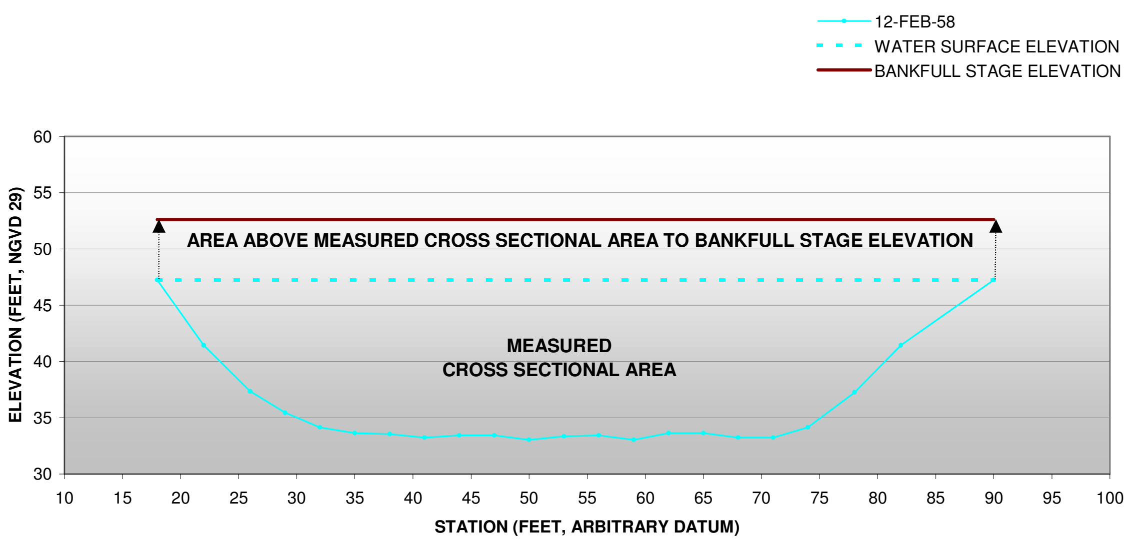

Figure 3. Method of Measuring the Channel Capacity

Table 2 . Estimated Channel Capacity

Water Year	Cross Sectional Area (ft^2)
1958	1180
1959	1163
1965	1158

CHANNEL BED ELEVATION

Channel bed elevation changes are analyzed by observing relative changes in channel thalweg elevations over time. Because the cross sectional data available from the USGS stream gage were not recorded at the exact location for each measurement, the annual median of the data is used. Reports of bed elevation fluctuations and changes in channel bed composition throughout the seasons suggest that the hydraulic system was episodic. USGS Water Supply Paper 1879-E tracks the variations in low-water streambed elevations at selected stream-gage stations in northern California (Hickey 1969). The reported difference between 1964 and 1965 low-water streambed elevation at USGS gage station 11-479700 is +0.7 feet. Figure 4 illustrates seasonal bed elevation fluctuations and relative elevations changes over time. The data suggest that the channel bed fluctuated over a stable median elevation prior to the December 22, 1964 flood event, after which the channel aggraded approximately 1 foot before WY 1967.

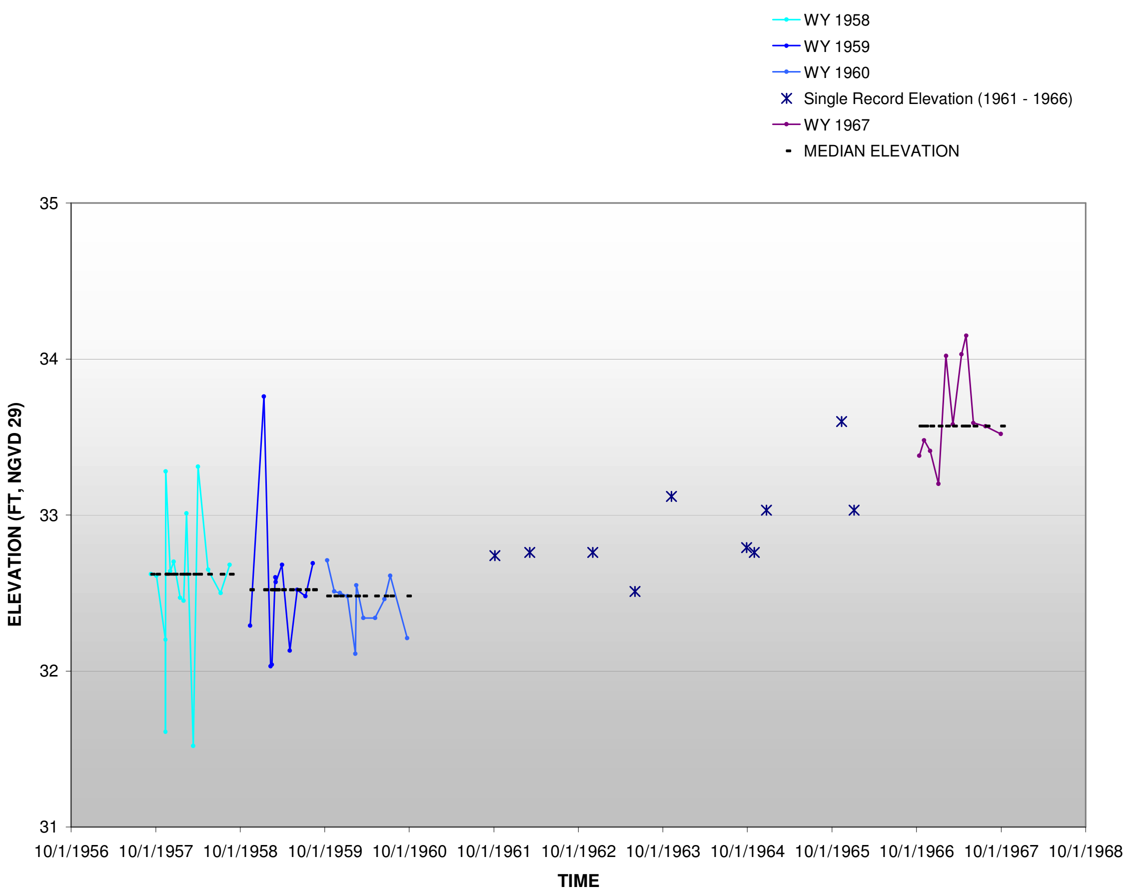

Figure 4. Channel Bed Elevation Fluctuation over Time

Consistent with the episodically driven bed elevation fluctuations, USGS records describe varying bed materials including gravel, stones, sand, silt and mud. USGS observed a seasonal pattern of finer material (silt and mud) in the channel during winter months, which washed away to expose remaining gravels and stones in summer months.

STREAM DISCHARGE

USGS measured velocity and cross sectional area in cells incrementally across the channel. Historic stream discharge is calculated from a sum of cell velocities and areas.

Rating Curves

Rating curves were constructed by USGS for interpolating and extrapolating discharge based on known stage. New rating curves were developed periodically throughout the period of record to reestablish the relationship between stage and discharge, which varies with channel geometry.

Instantaneous Annual Peak Discharges

Annual peak discharges and corresponding stages are reported for the gage station for all years of record. Table 3 summarizes the instantaneous peak stages and discharges.

Table 3. Instantaneous Peak Stages and Discharges

Date	Peak Stage	Peak Discharge
2/12/58	22.80	2790
2/14/59	27.62	3220
2/8/60	22.12	2090
2/11/61	22.58	2160
1/19/62	22.34	2120
4/12/63	23.02	2220
1/20/64	27.13	2950
12/22/64	28.09	3430
1/4/66	27.43	3270
12/5/66	26.71	3110

Another notable discharge that is not on record occurred in WY 1971; Civil Engineering Consultant William Langenbach prepared a bridge report for the concrete bridge crossing over North Fork Elk River (at the intersection of Elk River Road and Wrigley Road) that describes drift and silt signs, indicating that the north end of the bridge deck was inundated positively 1.0 feet and possibly 2.5 feet (1971). Data referenced to the concrete bridge, however cannot be linked at this time to the mainstem site due to a lack of necessary information and a routing model.

Flood Frequency Analysis

Instantaneous annual peak flows with recurrence intervals of 1.5-, 2-, 5-, 10-, 25-, 50-, 100-, 200- and 500-years are estimated with the use of PEAKFQ (v. 4.1). PEAKFQ is an algorithm that applies the Pearson Type III frequency distribution to fit the logarithms of instantaneous annual peak discharges following Bulletin 17B guidelines of the Interagency Advisory Committee on Water Data (1982). Results from applying the frequency distribution to Elk River historic data are presented in Figure 5 and Table 4. The Interagency Advisory Committee on Water Data suggests a generalized skew coefficient of -0.3 for the region of analysis, which was utilized in the analysis (1982).

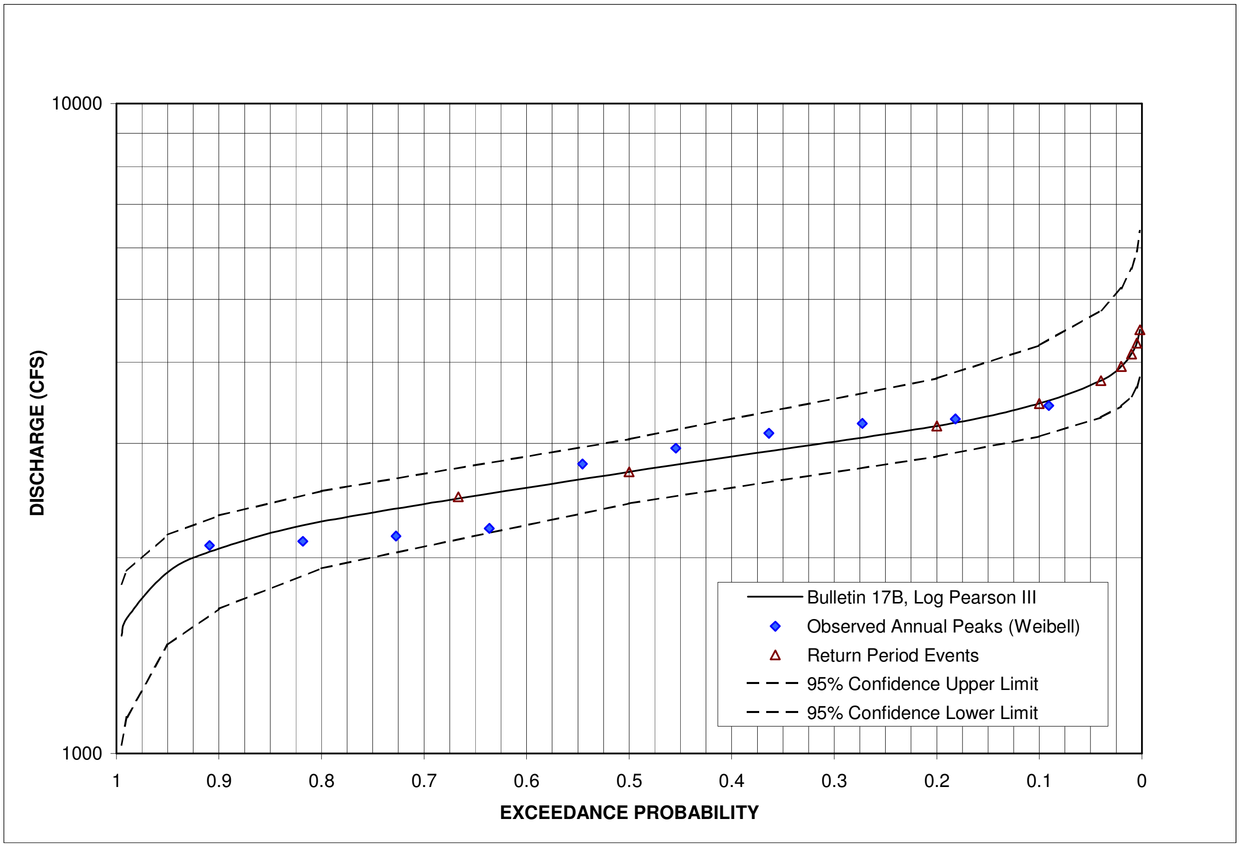

Figure 5. Estimated Probable Discharge Events from PEAKFQ Log-Pearson III Frequency Distribution

Table 4. Summary of Estimated Probable Discharge Events

Annual Exceedance Probability	Recurrence Interval (years)	Estimated Discharge (cfs)
0.667	1.5	2483
0.500	2	2713
0.200	5	3191
0.100	10	3456
0.040	25	3748
0.020	50	3942
0.010	100	4119
0.005	200	4284
0.002	500	4486

1.5-Year Peak Discharge

Bankfull discharge is often characterized as the instantaneous peak discharge with a 1.5-year recurrence interval. Please take note that the 1.5-year recurrence interval discharge estimate is 2483 cfs, which is relatively close to the USGS reported bankfull discharge of 2250 cfs.

CURRENT CONDITIONS

DATA COLLECTED

Since WY 2000, William Conroy (Humboldt State University graduate student), PALCO (formerly The Pacific Lumber Company) hydrology staff, and Salmon Forever (a non-profit citizen monitoring organization) have independently measured discharge on the mainstem, North Fork and South Fork Elk River. Each operator has developed a rating curve for predicting discharge from measured stage. The eight referenced monitoring stations are described in Table 5. Three of these stations' locations are not described in detail because the data was not available prior to submittal of this study. The confluence in the following descriptions is referring to the confluence of North Fork and South Fork Elk River, unless otherwise stated.

Table 5. Referenced Discharge Monitoring Stations

Operator	Station	Description
Bill Conroy	OERTCRB	"Old Elk River Timber Co. Railcar Bridge" mainstem monitoring station located at what is now PALCO's 509 station, approximately 1200 feet downstream of the confluence (approximately 100 feet upstream of the historic USGS gage station).
PALCO	509	Mainstem monitoring station located at PALCO's steel bridge crossing, approximately 1200 feet downstream of the confluence (approximately 100 upstream of the historic USGS gage station).
PALCO	510	South Fork monitoring station located upstream of the confluence, downstream and in close proximity to station SFM.
PALCO	511	North Fork monitoring station located upstream of the concrete bridge (upstream of the confluence and station KRW).
PALCO	514	Railroad Gulch monitoring station located south of the mainstem at a bridge crossing.
Salmon Forever	SFM	South Fork monitoring station located at a private residence's bridge that crosses the South Fork (8050 Elk River Road), approximately 2600 feet upstream of the confluence.
Salmon Forever	KRW	North Fork monitoring station located at Kristi Wrigley's apple orchard (2550 Wrigley Road), approximately 3250 feet upstream of the concrete bridge (5050 feet upstream of the confluence).

Salmon Forever	NFE	North Fork monitoring station located at the concrete bridge (at the intersection of Elk River Road and Wrigley Road), approximately 1800 feet upstream of the confluence.

In order to assess if changes have occurred that may influence flooding in lower Elk River, physical parameters (i.e. cross sectional area, bed elevation) are analyzed in relation to stream discharges and flood frequency. Historic data does not provide information on the tributaries to the mainstem, therefore channel dimensions are only considered at the mainstem stations, Bill Conroy's OERTCRB and PALCO 509.

CROSS SECTIONAL AREA

Bill Conroy and PALCO measured annual cross sectional topography at the mainstem station for WY 2000 – 2003 (Figure 6). Comparative changes in cross sectional area can be estimated similarly to the method used to estimate historic channel capacity.

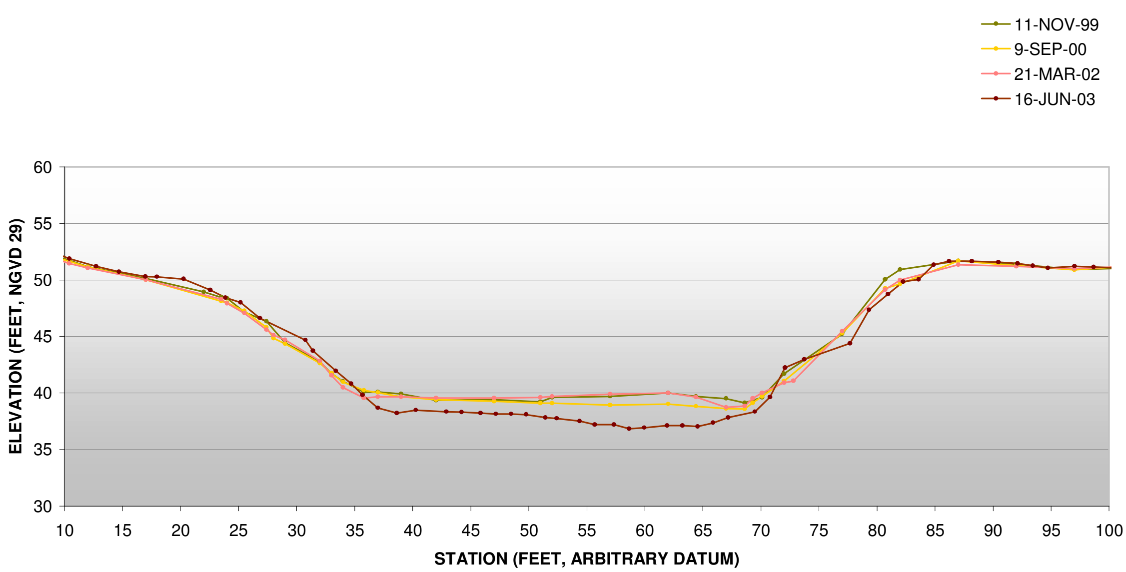

Figure 6. Annual Cross Sectional Channel Topography at Recently Maintained Gage, stations OERTCRB and 509

Channel Capacity

Bankfull elevation is assumed to be the same as historic reports at 52.61 feet elevation, NGVD 29 and bankfull discharge is reported to be 882 cfs (Conroy 1998). Consistent with the method to estimate historic channel capacity, current channel capacity is estimated to be the sum of the measured cross sectional area and the area above the measured area up to bankfull stage (Figure 3). This method appears to slightly overestimate the channel capacity because the elevation of bankfull stage is approximately one foot above where discharge appears to overtop the banks and spill onto the floodplain. Table 6 summarizes estimated channel capacity as a function of cross sectional area for each year of record.

Table 6. Estimated Channel Capacity

Water Year	Cross Sectional Area (ft^2)
2000	703
2001	733
2002	736
2003	758

CHANNEL BED ELEVATION

Comparable to the assessment of historic trends, current channel bed elevation is analyzed by observing relative changes in channel thalweg elevations over time. Unlike USGS records, thalweg estimates are only reported annually; therefore seasonal fluctuations are not acknowledged. However, the data suggest that since the cross sectional topography appears to be unchanged during WY 2000 - 2002, the channel bed did not fluctuate significantly. Channel scour appears to have occurred in the 2003 cross sectional measurement, subsequent to a series of winter storms.

STREAM DISCHARGE

As mentioned above, several organizations monitor stream discharge within the lower watershed of Elk River. Similar to USGS methods, each operator measures velocity and cross sectional area in cells incrementally across the channel. Current stream discharge is calculated from a sum of the products of cell velocities and areas. WY 2003 was considered for this analysis because it was the first year that there were continuous stage recordings on both of the principal tributaries and the mainstem during a winter period. In addition, WY 2003 recorded high flood stages and extended the previous rating curve ranges of discharge estimation.

Rating Curves

Rating curves have been developed for all gage stations, with varying detail and verification. These rating curves are used to interpolate and extrapolate discharge based on known stage. Periodic redevelopment of rating curves reestablishes the relationship between stage and discharge.

Rating Curve Robustness

A robust rating curve is a curve that is well fit to a series of field measured data points, over the range for which it is to be used. The rating curves that were established for PALCO stations 509 on the mainstem and 511 on the North Fork appear to lack robustness; a discussion of why follows. WY 2003 rating curve for station 509 appears to be developed from data correlated to PALCO station 510 on the South Fork. It is unclear from PALCO's Final Monitoring Report of the extent to which measurements were made in the field to verify the stage-discharge relationships (PALCO 2003).

Data points within the rating curve developed for PALCO 509 station on the mainstem did not correspond to reported measurements on corresponding dates. Due to these discrepancies, the rating curve is not considered robust.

The rating curve developed for PALCO 510 station on the South Fork appears to be robust because the curve is well fit to the field measured data points, over the range for which it is proposed to be used.

The rating curve for PALCO 511 station on the North Fork was developed from stage-discharge relationships up to 3 feet stage measured at the site. The curve however extends to 16.4 feet stage with the inclusion of high-water points from the stage-discharge relationship developed for Salmon Forever's stations downstream. It is unclear whether a correlation was verified between these three stations.

The rating curve developed for Salmon Forever's SFM station on the South Fork appears to be robust because the curve is well fit to the field measured data points, over the range for which it is proposed to be used.

The rating curve developed for Salmon Forever's KRW station on the North Fork utilizes discharges measured at the NFE station due to access limitations. Hydrologist, Randy Klein performed a correlation between these two sites to develop the rating curve at this station and it appears to be robust (Klein, 2004).

2003 Hydrographs for Principal Tributaries and Mainstem Elk River

Based on rating curves and continuous stage records, hydrographs of continuous discharge were calculated for South Fork and North Fork Elk River. These hydrographs were only calculated for the SFM and KRW stations because the equipment at PALCO 510 and 511 stations appears to have failed to register stage above 20 feet and 17 feet, respectively, and therefore missed the storm peaks. Figure 7 graphically depicts the missing data. Figures 8 and 9 are the estimated hydrographs at monitoring stations SFM and KRW, respectively.

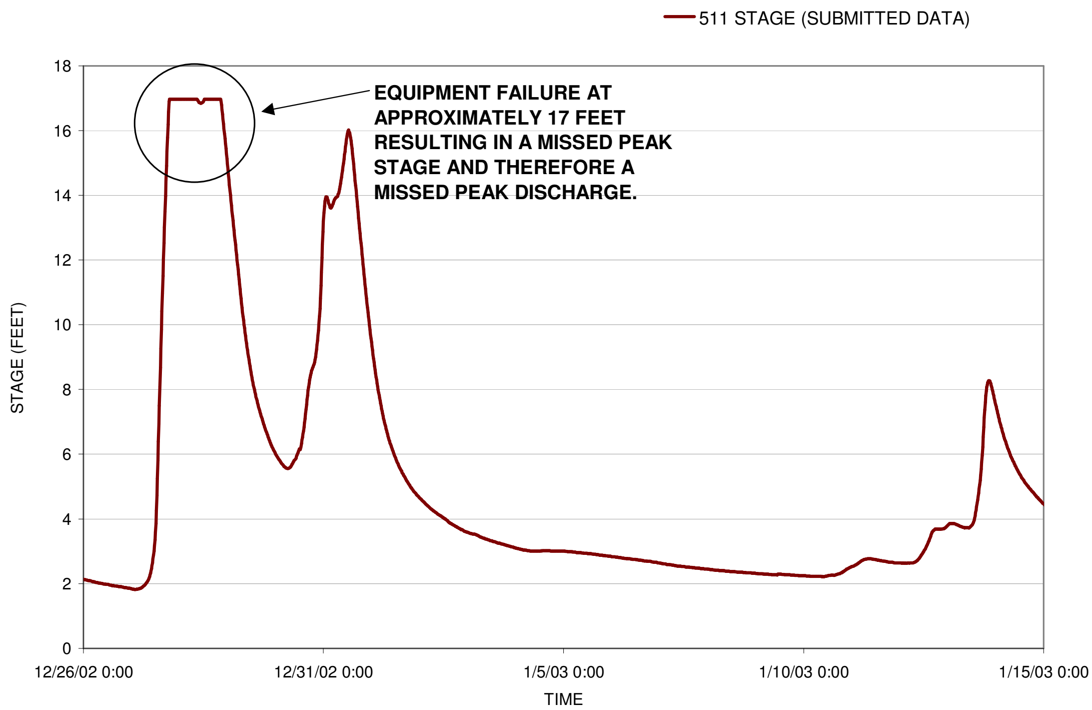

Figure 7. Hydrograph peaks at Station 511 illustrates why PALCO station 510 and 511 discharge data cannot be used for WY 2003

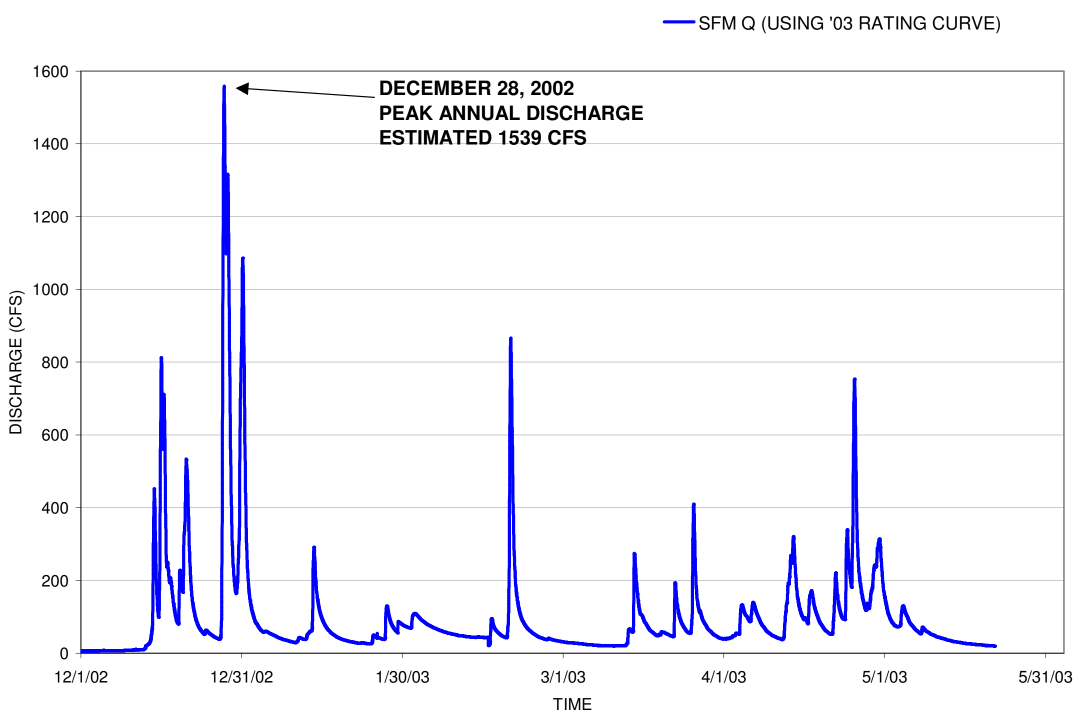

Figure 8. Estimated South Fork Hydrograph at Station SFM

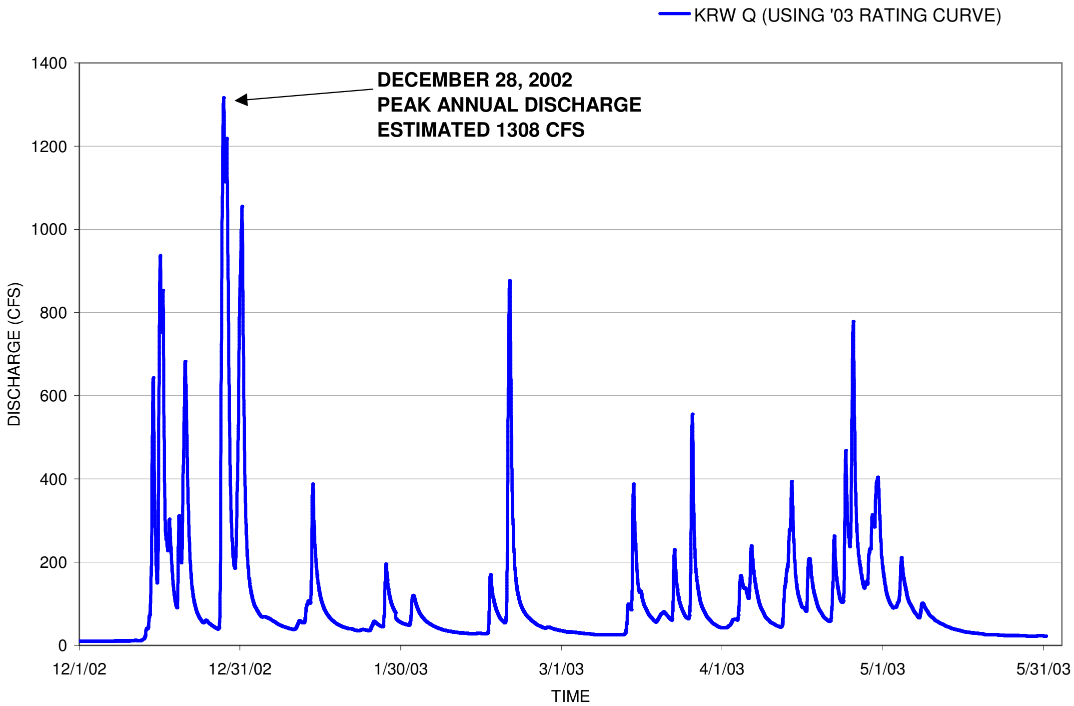

Figure 9. Estimated North Fork Hydrograph at Station KRW

Equipment failures at PALCO station 509 resulted in a loss of stage data during the winter period of WY 2003. In response to this unfortunate event, PALCO submitted a synthesized hydrograph correlated to the 510 South Fork station. Upon review, Regional Water Board staff found inconsistencies in the synthesized hydrograph. Additionally, the discharge data calculated at the 510 station did not capture the peak discharges (in relation to peak stages), as discussed above.

In order to perform an analysis, Regional Water Board staff has synthesized a hydrograph from data recorded in both the North and South Forks at stations KRW and SFM, respectively. Upon detailed review and observation that the timing of the peak storm events is similar between the KRW and SFM records, these two hydrographs were summed.

The resulting hydrograph however was not sufficient to route back to the historic USGS gaging site or PALCO station 509 on the mainstem because a small tributary, Railroad Gulch, flows into the river just downstream of the confluence. In order to account for the relatively small influence of Railroad Gulch, a synthetic hydrograph was constructed for this tributary by correlating discrete discharge measurements at PALCO station 514 during recorded times with the SFM gage. The relationship was not robust, but it is considered a sufficient estimate for the purposes of this study. Railroad Gulch discharge does not contribute significantly to the synthesized hydrograph peak discharge, however the flows were added.

Figure 10 displays the synthesized hydrograph for mainstem Elk River downstream of Railroad Gulch. This hydrographic data will be used to determine stage at the PALCO 509 station and determine whether flood frequency has significantly changed over time.

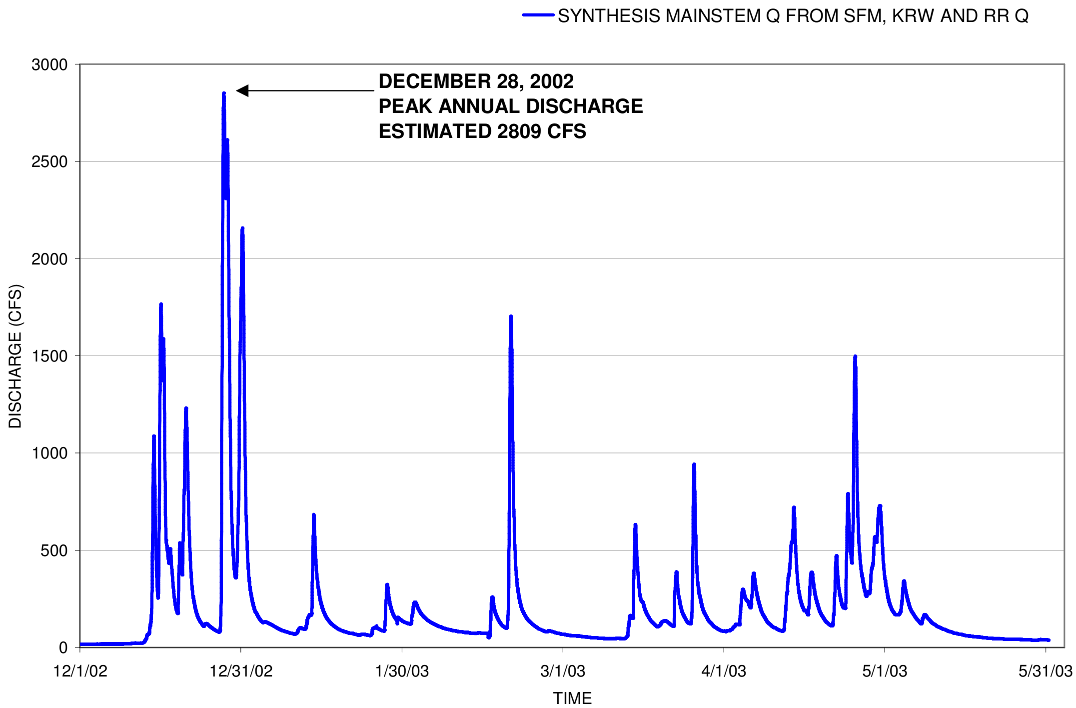

Figure 10. Synthesized Hydrograph for Mainstem downstream of Railroad Gulch

Flood Frequency: Use of Current Annual Peak Discharges

Current instantaneous annual peak discharges were not added to the flood frequency analysis because it is evident that significant changes have occurred in both the watershed and the channel that affect flooding. It is advised by USGS to only ignore gaps between systematic record periods if the lack of record in the interim is unrelated to hydrologic conditions (Thomas, W.O. et al. 1998). The data suggest that excessive flooding is not only a result of intense storm events, but also of decreased channel capacity, as well as changes in peak flow runoff related to land management (i.e. compaction and canopy removal).

RESULTS

The following results to the flooding assessment are limited to the data that were readily available. In short, due to equipment failures and difficulties interpreting some of the submitted monitoring data, only data that appear robust and verifiable are utilized. These results tend to be consistent with previous flood studies performed within lower Elk River watershed.

Relative Changes in Channel Morphology

Several findings have been assessed for lower Elk River. Most pronounced is a change in the streambed dimensions due to aggradation and bank deposits. A constriction of the channel and an increase in bed elevation appears to be the cause of frequent flooding. It was reported during

WY 2003, that the channel overflowed significantly into the floodplain eight times (Wrigley 2003). Please note that based on the historic flood frequency, the estimated 2809 cfs peak discharge that (December 28, 2002) would have been considered a 5-year event in the mainstem, at most, and would have risen no more than 5 feet above bankfull stage. It is reported that the December 28, 2002 flood event measured 23 inches into Kristi Wrigley's red house, located approximately 1000 feet upstream of gage station 509. Comparatively, historic records kept by the Ms. Wrigley's father state that the December 22, 1964 flood event of 3430 cfs resulted in 2 inches of floodwater in the red house (Wrigley 2003).

Channel Bed Elevation

The channel's bed aggraded approximately 5.5 feet between WY 1967 and 1999. A recent decrease in the channel bed elevation subsequent to the winter storms cannot yet indicate a trend. However, the channel bed was previously appearing unresponsive to winter discharges throughout the previous recent record and the decrease in elevation of 1.9 feet can be taken as a good sign of channel scour. Figure 11 illustrates these bed elevation changes through time.

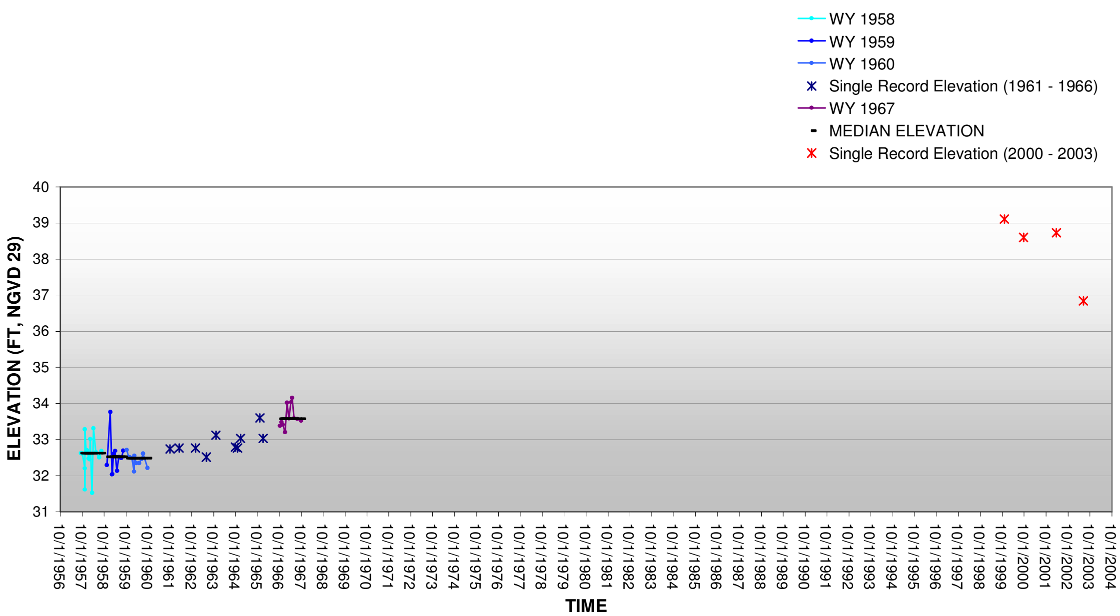

Figure 11. Channel Bed Elevation Changes over Time

Bankfull Depth

Assuming that the elevation of bankfull discharge has not changed in relation to the two systematic periods of record, the current 2003 bankfull depth is 3.85 feet shallower than the 1965 historic bankfull depth. Another perspective is that bankfull depth has decreased by at least 20%:

Bankfull Depth (ft)	Year
19.60	1965
15.75	2003

Cross Sectional Area

A significant change in channel capacity as a function of cross sectional area is observed in mainstem Elk River (Figure 12). Assuming again that the elevation of bankfull discharge has not changed in relation to the two systematic periods of record, the current 2003 channel capacity is 400 square feet less than the 1965 historic channel capacity. Another perspective is that channel capacity as a function of cross-sectional area has decreased by at least 35% or that the channel currently has 65% of the historic cross sectional area available to convey instream discharge downstream:

Cross Sectional Area (ft^2)	Year
1158	1965
758	2003

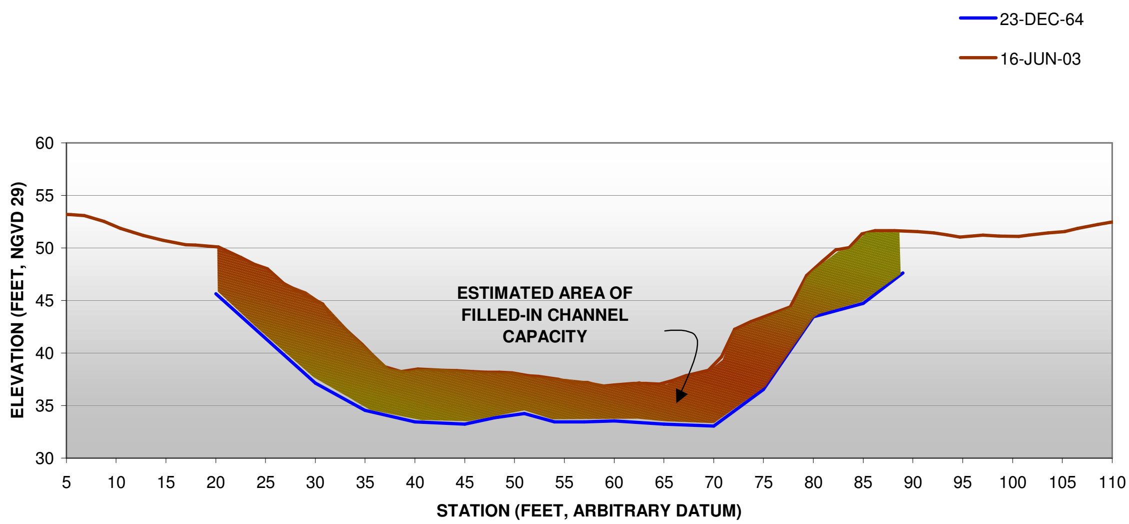

Figure 12. Illustration of Diminished Channel Capacity, Compared between WY 1965 and 2003

Stream Discharge

Finally, significant changes in channel dimensions result in significant changes in the volume of water that the channel can hold during a frequent storm event, pending flooding onto the floodplain. A comparison of stream discharge from WY 1965 to WY 1998 is used because more recent measurements of bankfull discharge have not been verified in the mainstem. Assuming again that elevation of bankfull discharge has not changed in relation to the two systematic periods of record, the reported 1998 bankfull discharge is 1370 cubic feet per second less than the 1965 historic bankfull discharge (Conroy 1998). Another perspective is that bankfull discharge has decreased by 60% or that the channel can currently only contain 40% of the instream discharge that it was capable of conveying historically:

Bankfull Discharge (ft^3/sec)	Year
2250	1965
880	1998

DISCUSSION

This study has illustrated that there indeed has been a significant volume of sediment deposited in lower Elk River that is hindering its ability to convey frequent discharge events. In addition, the assessment of available data has provided a target channel capacity as a function of cross sectional area. Not addressed in this study, however are instream velocities and velocity-discharge relationships, which are significant parameters still missing from the picture. Without these hydraulic parameters, discharge conveyance is assumed to be controlled primarily by cross sectional area. Anecdotal information suggests that due to a brushy, densely vegetated riparian corridor, velocities control discharge behavior significantly, especially once the floodwaters escape the channel. Consistent with this idea, in the California Department of Transportation (Caltrans) bridge inspection reports are a series of photographs at two bridges that cross the mainstem (at Zanes Road and Berta Road) in addition to the concrete bridge, which crosses North Fork Elk River (at the intersection of Elk River Road and Wrigley Road), show the change in vegetation at these sites over the past 50+ years (Caltrans 2000). It is apparent that the banks where native grasses previously grew are currently overgrown by invasive Himalaya blackberry. Willows have thickened not only within the riparian corridor proper, but also instream. Future endeavors to identify the hydrology and hydraulics controlling flood stages in this watershed need to take these issues into consideration. Further, future restoration should consider reestablishment of the native vegetative community.

CONCLUSIONS

The data available all point to the same conclusion: the channel conveyance capacity has been diminished significantly during the interim of the systematic monitoring periods. The scarcity of necessary data to conduct a comprehensive flood analysis is the limiting factor in this study. Future analyses can be performed as data becomes available and trends develop from the current monitoring record. Suggested studies include, but are not limited to:

- Compare instream velocities during similar discharge events and develop velocity-discharge relationships for periods of record,
- Verify a measured stage-discharge relationship for mainstem Elk River,
- Verify a measured bankfull discharge and bankfull stage to aid in the determination of current channel conditions,
- Identify flood elevations throughout the lower watershed relative to rating curve measured stage-discharge relationships,

- Develop a hydraulic routing model that considers major tributaries and the length of the mainstem that floods (possibly as far downstream as the mouth),

- Conduct a comprehensive channel monitoring to determine other areas where water stage is limited by channel capacity,

- Analyze the current conditions of the channel in the context of the watershed in order to control the sediment inputs contributed from upstream.

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