

Stream Network and Landscape Change in the Rodeo Creek Watershed

Report for the Muir Heritage Land Trust



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by

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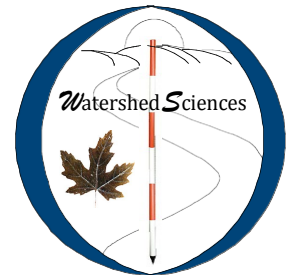


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Printing Note: Map images on pages 23, 35, 39 and 44 have details best viewed by printing on paper size 11" x 17".

Stream Network and Landscape Change in the Rodeo Creek Watershed

I. Introduction

An analysis of the history of Rodeo Creek watershed was conducted for the Muir Heritage Land Trust. This report will provide helpful information about why and how the Rodeo Creek network has achieved its present condition. Providing a context of geomorphic change will help develop a foundation for the Watershed Vision Plan that is being developed by the Contra Costa Resource Conservation District. The Vision Plan is considered the first step toward implementation of many creek, wetland, and watershed projects that will directly benefit the residents of the watershed and the water quality of Rodeo Creek.

The report is laid out first with objectives, a simple site description, definition geomorphic terms and concepts, a watershed overview, a description of methods, and map results of landscape change are combined with a timeline with discussion of cause and effect. This is followed by a very brief summary of conclusions and recommendations. The analysis was conducted within a very short timeframe, thus recommendations are given that will enhance the future applicability and transfer of information to future users.

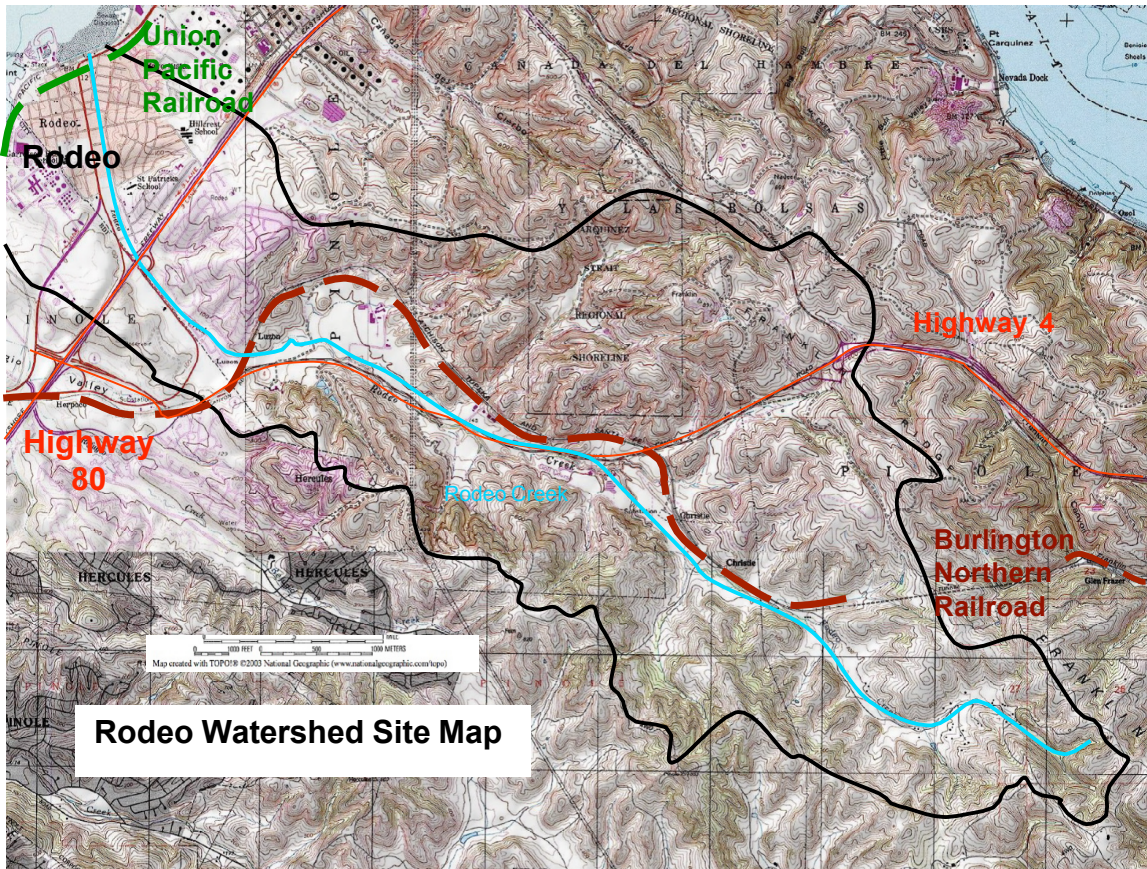
II. Objectives

The major components of the project were to collect and assess historical documents, including historical aerial stereo photos, maps, and reports to provide maps and a report synthesizing the information.

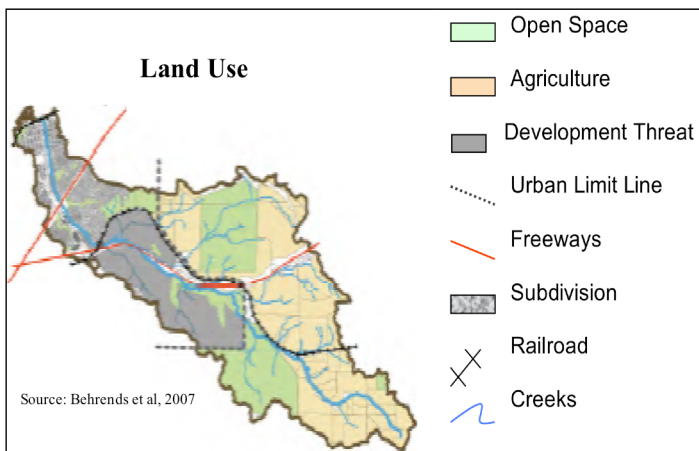
III. Location and Site Description

Flowing northwestward into San Pablo Bay from Franklin Ridge in Contra Costa County, California, Rodeo Creek drains about 10 square miles of landscape that in the middle and upper portions of the watershed is predominantly grassland and to a lesser extent oak/bay woodland. The lower quarter of the watershed yields to relatively recent urban development that has spread outward from the incorporated shoreline town of Rodeo. The towns of Hercules and Pinole are to the south and Crockett is to the north. Major industrial development of Conoco Phillips Refinery at Oleum is adjacent to the northeastern Boundary of Rodeo watershed, but not within its boundary. There is a smaller Conoco Phillips Carbon Plant in the middle segment of Rodeo watershed and it is the largest industrial development in the drainage.

There are two major roadways and railways dissecting the watershed. I-80 cuts the lower watershed, while Highway 40 dissects the middle. Burlington Northern Railroad extends through the middle watershed, and continues through a portion of the upper watershed until it disappears into a tunnel toward Franklin Canyon.



The Union Pacific Railroad hugs the shoreline of the lower watershed. The generally rounded hillsides of the entire watershed confine three distinct broad valleys. The lower valley widens bayward through an urban and commercial environment and ends near the Burlington Northern stream crossing of Rodeo Creek. A flood control channel has been constructed through the entire lower valley. The middle valley is the largest and broadest, spanning about 2000 feet. It has few residential sites. The upper valley, starting at about the intersection of Hwy 40 and the Burlington Northern Railroad, is long and narrow. It has some rural residences and agricultural properties along Christie Road that parallel the creek along its valley floor. The railroad tunnel begins in one of the upper valley tributaries. Watershed elevation ranges from mean seal level to 1,100 feet and mean annual rainfall is 21 inches (CCCCDP 2003).

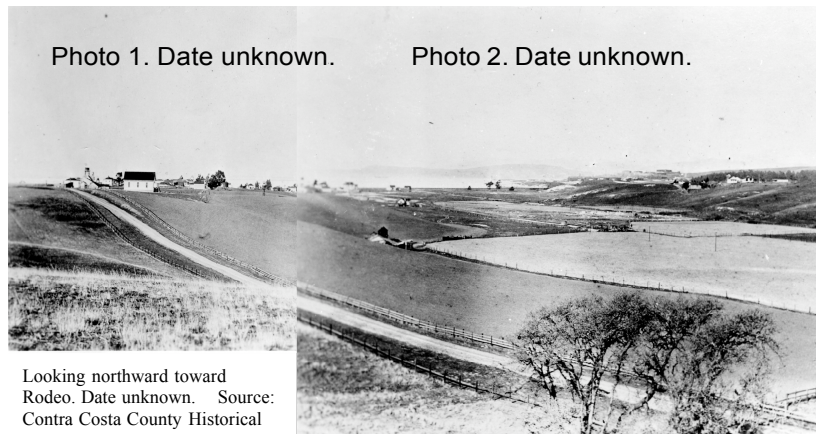


Behrens et al (2007) divided

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the watershed into units of open space, agriculture, sub-division, and development threat, as shown in the map above. They determined that without the proposed development, shown in solid grey upstream and south of the Burlington Northern Railroad, the watershed is currently about 1/3 urban and about 2/3 agricultural. Open space includes lands of the East Bay Regional Park District and the Muir Heritage Land Trust.

Threatened and/or endangered species of Red-Legged Frog, Western Pond Turtle, California Whip Snake, and Coopers Hawk are found in the middle watershed. Paul Detjens, Contra Costa County Public Works, states that red-legged frogs have also been found to inhabit the flood control channel (verbal communication 2008). Steelhead/Rainbow trout have not been found in Rodeo Creek even though professional surveys have been conducted by others in 1974, 1981, or 1994 (Leidy *et al* 2005). Leidy sites that California Department of Fish and Game considers that limited habitat resources are the likely problem. Presently, two grade-control drop structures from the flood control channel have limited the potential for fish migration since the early 1960s, however as shown in this report, early land use activities in the late 1800s had the first and perhaps most profound impacts upon anadromous fish.



Looking northward toward Rodeo. Date unknown. Source: Contra Costa County Historical

IV. Definition of Geomorphic Terms and Concepts Used in This Report

Terms used in this report require definition to provide clarity to the reader. The following definitions of terms are derived from Leopold and Dunne (1978), and Rosgen (1996), while general descriptions of process are based upon general theories in fluvial geomorphology and professional observations of other Bay Area streams.

* Bankfull flow is the discharge that occurs at the incipient level of flooding just before water flows onto the floodplain. The recurrence interval (RI) of this flow is about 1.3 years to 1.7 years, typically referred to as the 1.5-yr RI. In this region, bankfull flow is considered the channel maintaining flow from which the

stream develops its pattern, profile, and dimensions to transport the bulk of its water and sediment supply over the long-term.

* Bankfull width is the width of the channel at its insipient level of flooding on to its floodplain, if one is present, or the level that would correspond to the 1.5-yr RI.

* Floodplain is commonly the broad flat bench that floods at frequencies greater than 1.5-yr RI. Within incised streams, the floodplain might be a narrow bench, and in unstable streams, a floodplain might not exist.

* Terrace is an abandoned floodplain. Terraces are common along Bay Area channels and can be floodprone even though they are above the floodplain.

* Floodprone width is defined as the width measured at two times the maximum bankfull depth (Rosgen, 1996). It is not associated with any particular level of flood frequency.

* Entrenched channels become increasingly unstable the more their floodprone width decreases below approximately two times their bankfull width. Deeply entrenched channels can lower the water table across much of their floodplain.

* Stable stream is a channel that maintains its bankfull channel dimensions and profile without degrading or aggrading its bed. Overtime it can laterally migrate and still maintain its dimensions and profile.

* Factors influencing channel stability include supply of water, supply of sediment and changes in particle size, riparian vegetation that contributes to bank stability and large woody debris, channel width, depth, gradient, and sinuosity. A change in any one of these factors can initiate a response in one or all the other factors depending upon degree of severity.

* Incised channels in this report are considered channels that have their bankfull flow well below their valley flat. They can be stable or unstable depending upon degree of entrenchment, which is a measure of floodprone width divided by bankfull width. Unstable channels that are in the process of incising tend to increase sediment supply from streambed and bank erosion, and reduce the level of the adjacent groundwater table of the valley flat. The latter two factors can cause a loss of riparian vegetation on the valley flat adjacent to the creek. Once an incising stream becomes sufficiently stable within its terrace banks, a new age class of riparian vegetation develops on a confined floodplain bench. Sequences of terraces indicate numerous periods of stability and instability. Depending upon the severity of incision, minor to extreme floods can become fully contained within their terrace banks, which can lead to loss of connection and function of the former floodplain. In addition, the large floods that become contained within their terrace banks exert higher shear stresses on the streambed and banks than when the floodwaters could spread over a wide floodplain. This increases the potential for initiating more instability. This cycle can be repetitive until bank and terrace erosion has created a sufficiently floodprone width within the incised channel.

* Alluvial fans are broad fan-shaped depositional features typically found at the transition between steep and flatter slopes. Alluvial fans can often disconnect the channel network because surface flow converts to subsurface flow as

sediment is deposited on the fan. Sediment deposition occurs due to lack of carrying capacity, alternatively sediment can be dispersed through numerous distributaries, which are inherently unstable.

* Nick points or head cuts are sites of abrupt change in streambed elevation. They can migrate upstream and destabilize the channel and are often caused by bank erosion and streambed scour at culvert outfalls or from changes in erosivity of the streambed.

* Colluvial hollow is a bedrock depression typically at head of a first order channel that is filled with colluvium, rock debris, and soil. Colluvium is soil and rock material that has been transported by gravitational processes. Debris slides are commonly initiated within colluvial hollows in response to intense rainfall.

V. Watershed Overview

Certain geographic features in the watershed are referred to in this report because they have had geomorphic significance with respect to channel change. Working downstream from the top of the watershed, they include: the Burlington Northern/Santa Fe RR Tunnel in an excavated tributary valley; Christie Road culvert on Rodeo Creek, which now has at



least a 10-foot nick point at its culvert outfall; Kinder Morgan high-pressure gas pipeline, which has been threatened by channel incision (its original construction and protection might have exacerbated downstream bed incision); the Burlington Northern/Santa Fe RR Crossing and culvert, which required major fill to be placed across Rodeo Valley, and thereby inducing backwater flooding at the culvert inlet and stream incision at the outlet (presently the outfall has a constructed 4-foot drop in gradient within the flood control channel); the I-80 Highway fill, which is at the site of the former dam of the Rodeo Reservoir; the town of Rodeo, which has a 1.1 mile flood control channel; and the Union Pacific tracks that cross the concrete channel at the mouth of Rodeo Creek at San Pablo Bay.

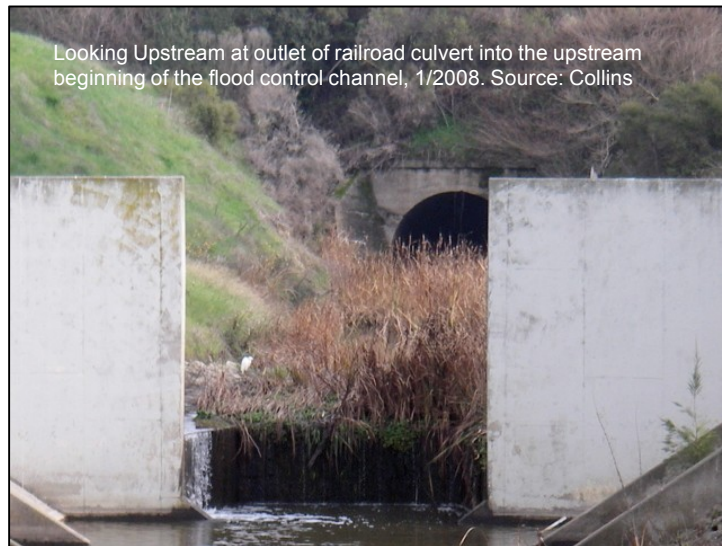
Climate and Basic Watershed Statistics

Climate at the Fernandez Ranch site is influenced by cool summers and mild winters, typical of San Francisco Bay Area in the Coast Range Geomorphic Province. Summers are usually dry and most of the precipitation falls between November and April. Temperature ranges from 39° F to 89° F. Mean annual rainfall is about 21 inches.

A long-term rainfall record does not exist specifically for the Rodeo watershed; however, a 155-yr record exists for San Francisco, a 117-yr record for Berkeley, and a 122-yr record for Antioch. The record for San Francisco ranges from 1850 to 2005. By reviewing all these records, reasonable assumptions can be made about historical rainfall in Rodeo.

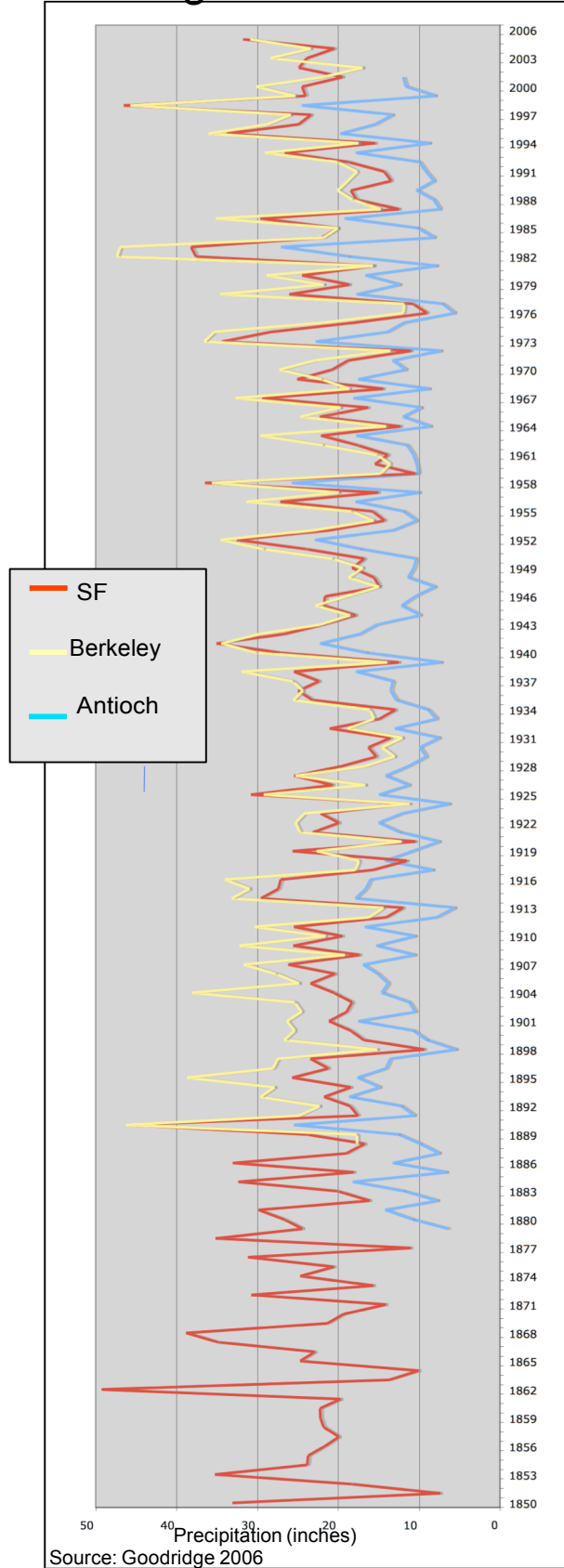


Watershed and Rodeo Creek Statistics		
Population Estimate		8,900 people ¹
Geography	Watershed Size	10.4 sq mi ¹
	Maximum Stream Length	8.35 mi ¹
	Lowest Elevation	0 ft MSL
	Highest Elevation	1,100 ft ¹
	Percent Impervious Surface Area	20 % ¹
Typical Temperature Range		39° – 89° F ⁶
Average Annual Rainfall		21 in ¹
Rainfall Frequency	2-yr Storm Total	3.2 in ³
	50-yr Storm Total	7.9 in ³
	100-yr Storm Total	9.0 in ³
	10-yr Storm Total	5.5 in ³
	Year of Greatest Estimated Rainfall	
Stream Bank and Length Conditions Measured from Stream Maps in Watershed Atlas*	Combined Length of Large Order Channels	31.64 mi ¹
	Natural	28.71 mi (90.7%) ¹
	Concrete	1.25 mi (3.9%) ¹
	Earth (constructed)	1.50 mi (4.7%) ¹
	Underground	0.88 mi (2.8%) ¹
Estimated Mean Daily Flow		7.0 cfs ¹
Flood Frequency of Creek at Rodeo	SF Bay Area Regional Curve Estimated Bankfull Discharge (~1.5-yr Flow)	430 cfs ²
	10-yr Flood Flow	1,760 cfs ⁴ 1,440 cfs ³ 1,720 cfs ⁵
	50-yr Flood Flow	2,660 cfs ⁴ 2,030 cfs ³ 2,140 cfs ⁵
	100-yr Flood Flow	2,960 cfs ⁴ 2,320 cfs ³ 2,900 cfs ⁵
	Project Design Flow for Flood Control Channel in Rodeo	
Total Length of Flood Control Project		1.1 mile ⁷
Land Use	Open Space/Parks	28%
	Multiple and Single Family Residential	36%
	Agricultural	4%
	Commercial, Business Parks, and Industrial	19%
Data Sources:	5. Contra Costa County, 1986 6. Mills, 2002. 7. USACE , 1962 * The maps in watershed Atlas do not indicate many first, second and third order tributaries.	
1. Contra Costa County Community Development, 2003		
2. Leopold and Dunne, 1978		
3. URS Corps, 2004.		
4. FEMA, 2001		



Looking Upstream at outlet of railroad culvert into the upstream beginning of the flood control channel, 1/2008. Source: Collins

Regional Rainfall



Rainfall totals at all three stations tend to parallel each other. Therefore, years with high rainfall at all stations probably indicate high annual rainfall in Rodeo watershed. Based upon review of the records for the three long-term regional stations, the top twenty years of high annual rainfall for Rodeo have been estimated in descending order of possible importance. Presence of the historical Rodeo Reservoir and the Flood Control Channel are noted based upon their potential influences on downstream flooding in Rodeo.

Estimated Ranking of Highest Rainfall	Water Year	Historical Rodeo Reservoir Functioning	Post Flood Control Channel
1	1862		
2	1890	?	
3	1998		X
4	1868		
5	1983		X
6	1982		X
7	1958		
8	1853		
9	1878		
10	1867		
11	1941		
12	1973		X
13	1952		
14	1995		X
15	1850		
16	1886		
17	1884		
18	1876		
19	1986		X
20	1914	?	

These high rainfall years are likely associated with high peak discharges but not all noted floods at Rodeo are necessarily associated with high annual rainfall. Three main reasons exist. First, some floods might be associated with

high intensity storms that do not necessarily coincide with high annual rainfall. Second, increased drainage density from ditches, impervious surfaces, and stormdrains, increases runoff characteristics such that high annual rainfall is not required to create floods. Third, direct artificial changes to the creek has at times either reduced or increased its potential to flood. For example, the historical Rodeo Reservoir, while it was in commission and properly functioning, reduced flow and flooding to Rodeo. After it was abandoned (or decommission-ed), undersized culverts and bridges locally reduced channel capacity, thereby increasing potential flooding to lower amounts of total rainfall. After construction of flood control channel, the potential for flooding in Rodeo is only expected for extreme rainfall that exceeds the 100-yr design capacity of the channel.

Additional years of flooding have occurred in Rodeo but these floods are not associated with the top 20 estimates of high rainfall years. Known floods are listed to the left. URS (2004) reported that flooding was experienced in Contra Costa County in February 1940, December 1955 (WY 1956), April 1958, and

Flooding Noted at Rodeo 1900s	Water Year
Dec 1937	1938
Sept 1939	1940
Feb 1940	1940
Jan 1943	1943
Oct 1950	1951
Nov 1950	1951
Dec 1955	1956
Apr 1958	1958
Sept 1959	1960
Jan 1963	1963

January 1963. Nearby Wildcat and San Pablo Creeks flooded in 1982. Severe erosion was noted by URS in Rodeo Creek during 1998, which might have been the third highest annual rainfall during the last 155 years, but flooding at Rodeo Creek did not occur due to earlier flood control channel construction. Review of the rainfall data and historical photos indicates that flooding also occurred at Rodeo during WY 1937 and September 1939. It might have occurred many other years but documentation of smaller floods and earlier events might have been minimal and is difficult to find.

Estimated Ranking of Drought Years	Water Year
1	1851
2	1976
3	1898
4	1924
5	1864
6	1931
7	1977
8	1920
9	1972
10	1877
11	1913
12	1939
13	1871
14	1933
15	1863
16	1934
17	1912
18	1885
19	1929
20	1887

The average number of years between high rainfall years was analyzed to look at patterns or differences between the 1800s and 1900s. For the 50 years between 1850 and 1900, occurrences of high annual rainfall had an occurred an average of every 5 years with a range between 3 to 10 years. The average was essentially the same for the 1950s to 2000, and high rainfall ranged between 1 and 12 years apart. The 50-year period from 1900 to 1950 was markedly different with only one high rainfall that occurred in 1941. The range in time between high annual rainfalls to the other 50-yr periods was 45 and 51 years. The 1930s depression era dustbowl years marked this period, which had droughts particularly concentrated between 1929 and 1934 with high drought occurring every two years. The top twenty years where drought was expected to be greatest are shown in descending order of importance to the right.

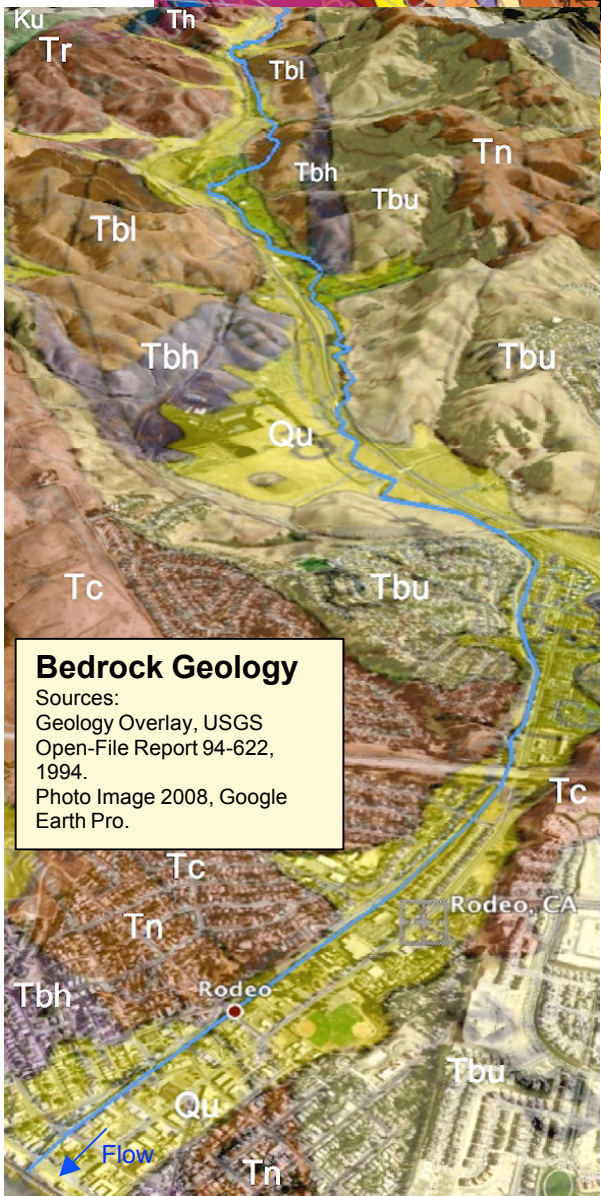
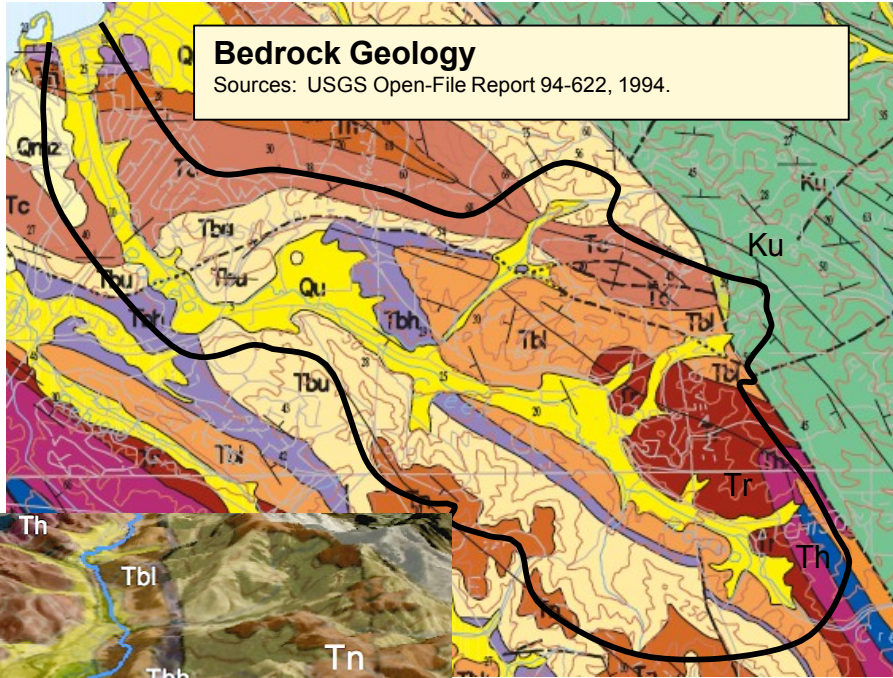
The interval between drought conditions was about 7 years for the 50-year period starting in the 1850s. During the 1900s through WY 1950, it averaged about 4.3 years, and during the 1950s through WY 2000, the interval between droughts was greater, averaging 9.3 years as shown in the table below.

Average Occurrence of Droughts and Deluges

Period	Number of Years with High Rainfall	Average Interval Between High Rainfall (Yrs)	Number of Extended Drought Years	Average Interval between Extended Drought (Yrs)
1850 -1900	10	4.4	6	8
1900 -1950	2	17	8	4
1950- 2000	8	5	4	9



Flooding in Rodeo, Date unknown. Source: Jennifer Dowling



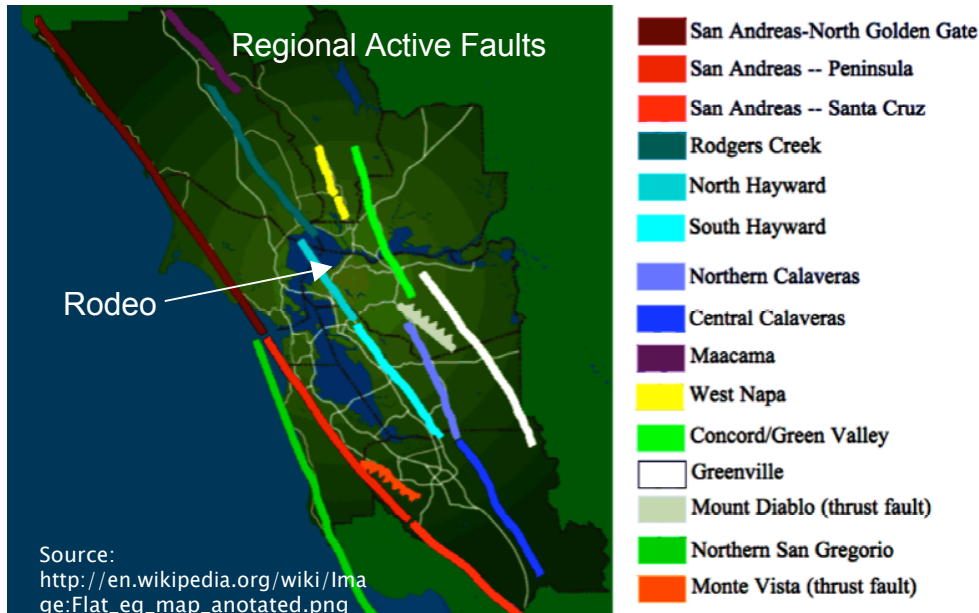
Map Key to Bedrock Geology

- Qu Surficial deposits - undivided (Pleistocene and Holocene).
- Tn Neroly Sandstone – volcanic rich, shallow marine sandstone, with minor shale, siltstone, tuff, and andesitic conglomerate (Miocene).
- Tc Cierbo Sandstone - minor marine sandstone, minor conglomerate, tuff, and shale (Miocene).
- Tbu Upper sandstone and shale member of Briones Formation.
- Tbh Hercules Shale member of Briones Formation, gray shale and siltstone.
- Tbl Lower sandstone and siltstone member of Briones Formation.
- Tr Rodeo Shale - Brown siliceous shale with carbonate concretions. (Miocene).
- Th Hambre Sandstone – Massive, medium-grained sandstone, minor conglomerate, and siltstone, marine (Miocene).
- Ku Great Valley Sequence – Sandstone, siltstone, shale, and minor conglomerate (Cretaceous).

Source: USGS Open-File Report 94-622, 1994

Geology and Sediment
 Throughout most of its length, Rodeo Creek has incised into its valley floor, which has deep fills of Pleistocene and Holocene alluvium. The geology has been mapped by

US Geological Survey (1994) as seen above. Active faults have not been reported in the watershed although the area could be affected by strong seismic shaking from a quake, particularly from the San Andreas, Hayward, or Concord/Green Valley faults. The latter two, which are respectively 6 miles southwest and 8 miles northeast of the central portion of the watershed.



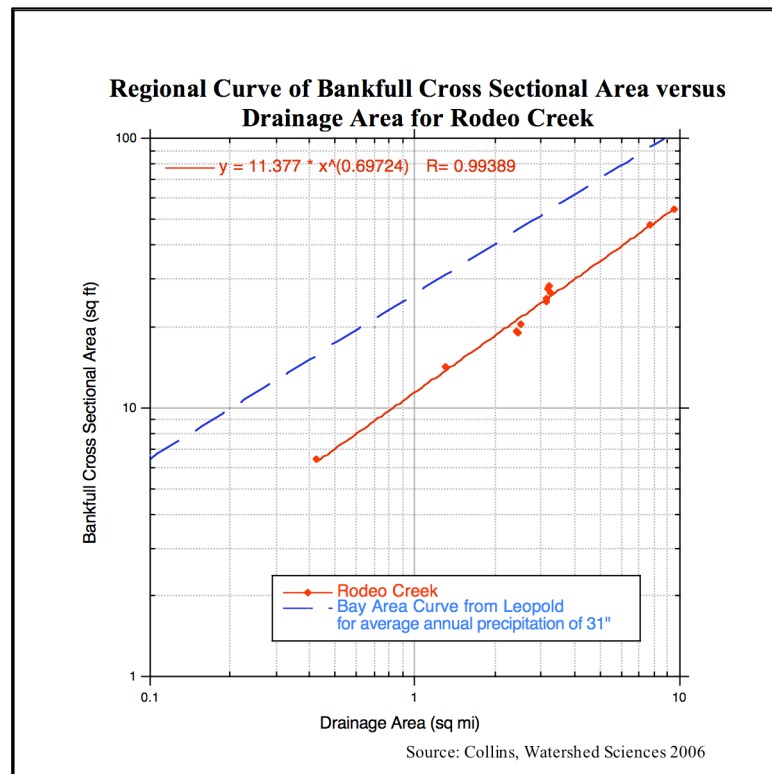
The bedrock geology of the watershed is predominated by fine-grained marine sedimentary rocks, particularly of the shales of Th and Tr Units. Although, the Tbu and Tbl units have sandstone they also have abundant shale and siltstone. This means that the bedrock tends to be very erodible and cannot prevent deep stream incision within the finer grained units. Bed and bank erosion in the bedrock and fine-grained terrace banks produces abundant fine sediment that can be rapidly transported downstream and out of the watershed as washload. The channel in many areas lacks large woody debris, which would usually augment sediment storage and slow the rate of streambed incision. Lack of mature vegetation also means that there will be a long lag time in the recruitment of large woody debris, meaning loss of sediment storage functions and reduced aquatic habitat diversity as well.

Reports of sediment accumulation problems have not surfaced, except for the downstream tidal segment of the flood control channel where 2 to 3 feet of sediment has accumulated (verbal communication Paul Detjen, Contra Costa County Public Works). Apparently, dredging has not been conducted since 1998 but it was done infrequently before. Stream observations along the mainstream channel from Christie Road culvert, to the Flood Control Channel indicate that the alluvial gravel veneer seems shallow, often only a few feet or less. The area that might have the most storage of gravel-sized sediment might be the stream segments through the golf course (Detjens, verbal communication).

The fine-grained shale bedrock units tend to be prone to earthflows and slumps that can move (creep) slowly or with sudden surges. They tend to respond to high rainfall totals and movement of the largest earthflows can lag weeks behind the original rainfall. The sandstone-rich bedrock tends to have more rapid-moving and often shallower types of slides, such as debris slides and debris flows that are initiated during intense rainfall. A quarter inch of rainfall for more than 4 hours after 9 inches of antecedent rainfall tends to trigger these types of slides (Ray Wilson, USGS, verbal communication 1984). The source area is typically steep colluvial hollows above the channel heads or along deeply incised channels where lateral support has been removed.

Hydrology

Rodeo Creek is perennial through its flood control channel at Rodeo. Bankfull discharge of about 430 cfs has been estimated from a Regional Curve for the San Francisco Bay Area (Dunne and Leopold, 1978) and mean daily flow is 7 cfs (CCCCDP 2003). Although the Army Corps ultimately determined that the design storm for the flood control channel would need to accommodate 3000 cfs, they reduced the design capacity discharge to 2500 cfs because the Burlington Northern/Santa Fe RR culvert upstream of the project area could not convey discharges greater than 2500 cfs (USACE 1962). Different flood recurrence intervals have been determined by others and are listed in the Watershed and Rodeo Creek Statistics Table on page 9.



A regional curve of estimated bankfull cross sectional area is shown above to compare values derived by Dunne and Leopold's curve for the general Bay Area to values derived from various cross sections surveyed specifically along Rodeo Creek (Collins 2006). For a 10 square mile drainage area the Bay Area curve predicts a bankfull cross sectional area of about 105 square feet while the locally derived curve predicts a much smaller cross section, approximately 60 square feet. These variations are likely due to differences in average rainfall. The San Francisco Bay Area Curve is derived from various streams that have a combined average rainfall of 31 inches, while average rainfall in the Rodeo watershed is only 21 inches.



Flooding 1940s

Source: Jennifer Dowling



Flooding 1958

Source: Jennifer Dowling

VI. Methods

Historical Documents

Meetings and interviews were held with the following entities to collect and obtain historical documents and information:

- Contra Costa Historical Society
- Paul Detjen of Contra Costa County Public Works Department
- Gregory Connaughton of Contra Costa County Public Works Department
- Jennifer Dowling Posedale, author of images of America Rodeo and resident
- Joe Mariotti, resident of Pinole
- Wayne Nelson, Conoco Philips Carbon Plant
- Robin Grossinger, San Francisco Estuary Institute

The types of documents obtained were photos, maps, and reports that contained relevant information to Rodeo Creek or its landscape.

Stereo Aerial Photos

Three sets of stereo aerial photographs were obtained from the UC Berkeley Library and Pacific Aerial Surveys to map the stream network and active landslides in the Rodeo watershed. The years covered were 1939, 1957, and 1999. The photos were at a scale of 1:24,000. The 1939 and 1957 photos were black and white, while the 1999 coverage was color. Additional non-stereo 1958 photos were viewed of portions of the watershed.

Map Production

While viewing the photos stereoscopically, the stream network and landslide features seen on the photos were mapped in different colors on Xerox copies of photos taken in 1939 and 1999. For 1957, the features were mapped on a base map of the watershed while viewing the original photos at the Pacific Aerial Surveys' Oakland photo library. Restoration Design Group of Berkeley provided a watershed base map with contour lines and aerial imagery from 2004. Each aerial photograph with drawn features was scanned. Line features were next digitized as an overlay in Power Point and added to the 2004 base map image. Slight variations in photo distortion in some areas prevent the channels from exactly matching the topography of the base map.

Accuracy of the aerial photo interpretation and mapping is limited by scale and visual clarity of the aerial photos and by vegetation canopy, which obscures streams and landslides. Only landslides that appeared to be recently active within a probable 25-year span were mapped in the watershed. The importance of these landslides is that they provide sediment to the stream network, and influence its stability. They provide insight into landscape response to climatic conditions and land use. Large inactive bedrock slides, earthflows, or small slides that appeared stable were not designated. These maps, therefore, do not provide a picture or aerial extent of all landslides in the watershed.

Four sets of watershed maps were made. For each set of aerial photos, a map was made that cumulatively depicts influences of the earlier year's photo analysis. In addition, a map was made of the estimated 1856 historical channel network.

For the 1939 stream network maps, some historic features from 1856 and 1908 were shown, including 1939 channels, culverts, railroad, water bodies, and extent of urban development. Culverts and artificial stream crossings were not mapped for years beyond 1939 and road mapping was beyond the project scope but the recent road network can be seen on the base map aerial image. The channels were designated into categories to help establish stream condition and history. These included the following:

- Channel appears to be in its natural alignment. It may or may not be stable.
- Existing channel appears to have severe active incision based upon bare soil features, lack of vegetation, and sharp breaks in topography.
- Channel appears new, artificial, or extending upslope through recent headward erosion. Artificial channels include those formed by road drainage, gully erosion in previously un-channelized slopes or valleys, and diversion and drainage ditches.
- Channel appears to have been recently abandoned, typically due to influences of roads, ditches, and diversions.

The 1856 historical channel network conditions was determined from historic maps of the lower valley and from evaluating the 1939 channel network by removing the artificial channels, reconnecting recently abandoned channels, removing headward extending channels, and disconnecting channels that were potentially separated from the stream network by un-channelized alluvial fans.

The 1957 stream network mapping incorporated a few additional features from 1950 and 1958. The maps therefore have additional features representing a time span of the 1950s decade. Only active landslides, urban development, water bodies, and streams showing extremely active incision and instability were mapped over the 1939 stream network. The entire 1957 stream network was not remapped and streams put into stormdrains and culverts could not be seen on the aerial photos. This requires additional work beyond project scope.

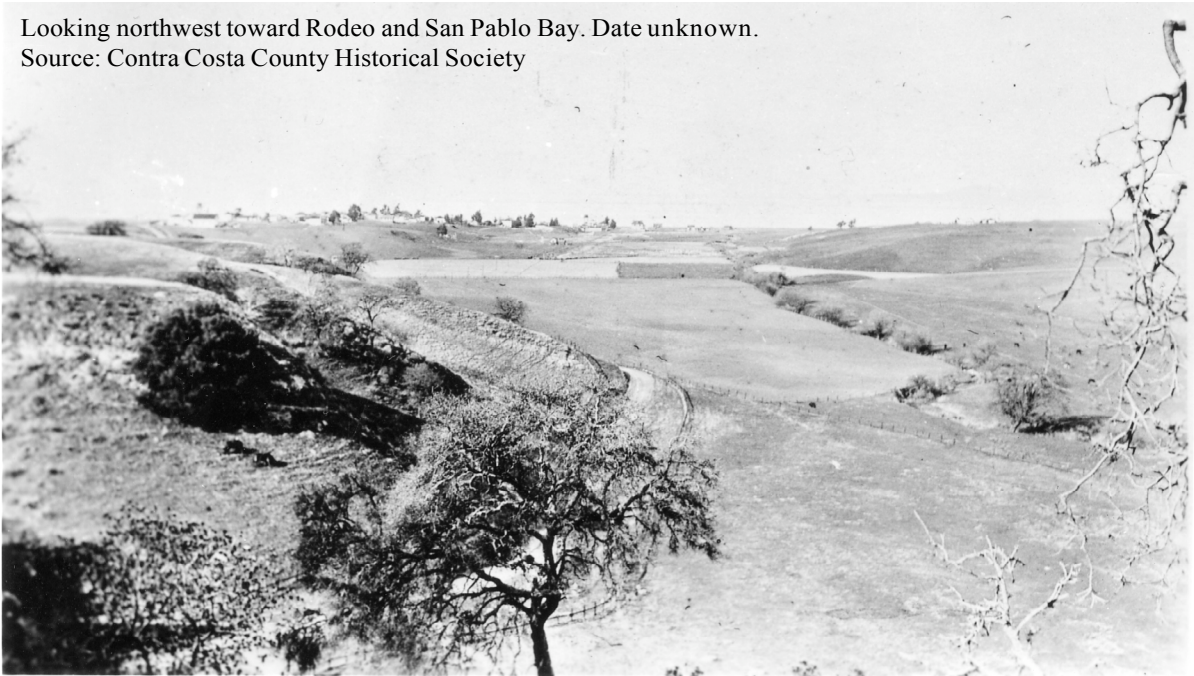
The 1999 stream network maps incorporated some additional information from 1988 to 1999 such as progression of development and possible concrete v-ditches, as well as 1999 stream network information on very active stream incision and artificial channels. Again, entire 1957 stream network was not remapped and streams put into stormdrains and culverts could not be seen on the aerial photos.

The circa 1939, 1957, and 1999 map information was compiled on one map to show cumulative change.

A simplified map of extent and rough age class of riparian vegetation was created for the mainstream Rodeo Creek from the 1939 photos. Five categories of condition were color coded on the Xeroxed stereo images. The information was transferred to a Google Earth base map. The categories were:

- High percentage of older vegetation.
- Sparse percentage of older vegetation and channel appears to have very active incision and bank erosion.
- Minimal to no vegetation.
- Sparse percentage of new (young) vegetation.
- Abundant new vegetation

Looking northwest toward Rodeo and San Pablo Bay. Date unknown.
Source: Contra Costa County Historical Society



Looking westward at the incised condition of Rodeo Creek at Fernandez Ranch, 2006. Source: L. Collins

VII. Map Results of Landscape Change and Timeline of Relevant Stream Network Information

The map products are integrated into the timeline under the relevant dates. Pertinent information has been listed and referenced in a timeline that provides discussion about possible cause and effect relationships on the stability of the stream network.

Pre 1800s – Native occupation of western Contra Costa County extends to at least 5000 to 7000 years before present. The Rodeo territory was occupied by *Costañoan* people, who are sometimes synonymously referred to as the Ohlone (Pastron *et al*, 2006).

1810~1850s – The Rodeo watershed was part of the extensive East Bay Ranch Holdings of San Francisco's Mission Delores. The land practices conducted by native people, including burning, diminish.

1823 – The Mission relinquishes land to Don Ignacio Martinez, which becomes Rancho Pinole and includes the Rodeo watershed.

1832 – By this time in nearby Wildcat Creek, a Contra Costa County watershed to the south near Richmond and the Berkeley Hills, geomorphic adjustments in the landscape were occurring in response to cattle grazing practices that had been underway since 1817 (SFEI, 2001).

1830s general -The specifics for Rodeo require further research but the hide and tallow trade of the Mission Era was probably fully underway by the 1830s and it is possible that Rodeo watershed was experiencing similar heavy grazing pressures as Wildcat Creek. Carlson (1973) states that during the rancho period, Rodeo was formerly the site of cattle raising operations and probably semi-annual roundups were held in the vicinity.

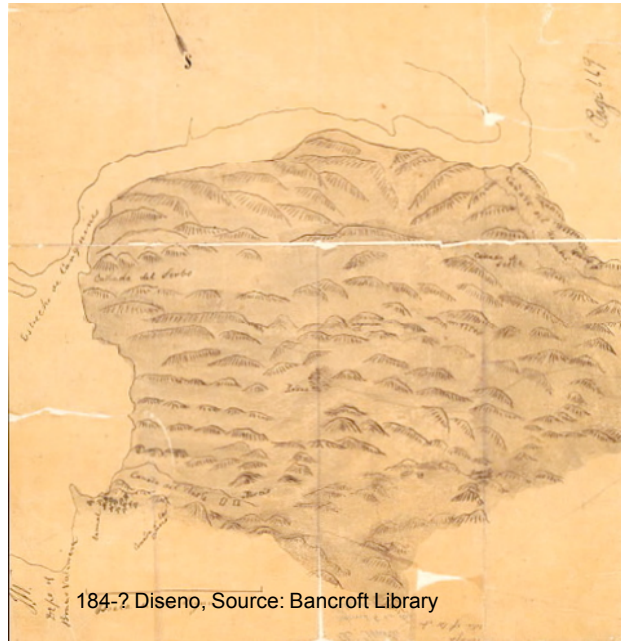
Knowing that portions of the Rodeo hillsides have probably been intermittently or continuously grazed for at least 175 years or more, it is important to briefly discuss the associated geomorphic processes that initiate changes in delivery of water and sediment to the stream network that ultimately influence its stability. The direct, observable impacts of cattle grazing include trampling of streambeds and banks, compaction of soils in areas of intense concentration, development of terracettes on the hillsides, destruction of riparian vegetation, and major reduction in thatch cover of grasslands. All these factors can become extreme in areas that are perpetually overgrazed.

Indirect effects of grazing can include increased runoff, caused by reduced evapotranspiration from less plant cover, and subsequent channel erosion as the channel geometry adjusts to increase flow, which can be pervasive from many grassland tributaries in a heavily grazed watershed. Associated with the introduction of cattle was a change in predominantly native perennial grass cover

to predominantly non-native European annuals. The root characteristics of these two grass types are sufficiently different that a change in one species to another can lead to an increase in shallow landsliding (Collins 2000; SFEI 2001) and extension of small headward channels (referred to as headward extension). The headward extension of the channel head occurs because the annual grass roots have reduced resistance to shear forces exerted by overland flow on steep grassland slopes (Montgomery 1999). The increased shallow landsliding is associated with differences in rooting depth and viability of the roots at times of soil saturation (SFEI 2000).

In combination, the changes in grassland combined with grazing influences caused some headwater tributaries to incise and extend headward. In areas previously un-channelized, such as small alluvial fans or colluvial hollows, a new channel cut through the feature and increased the connectivity to the drainage network. The evidence of various stages of incision and recovery in Rodeo Watershed were evident in the earliest 1939 stereo photographs.

1840s – Rodeo watershed is part of the El Rancho de Pinole, owned by Don Ignacio Martinez, the former *comandante* of the Pueblo of San Francisco. (Dowling 2007). The earliest map found for the region is the *Diseño* of Rancho Pinole for U.S. District Court Land Case 205, shown to the right.

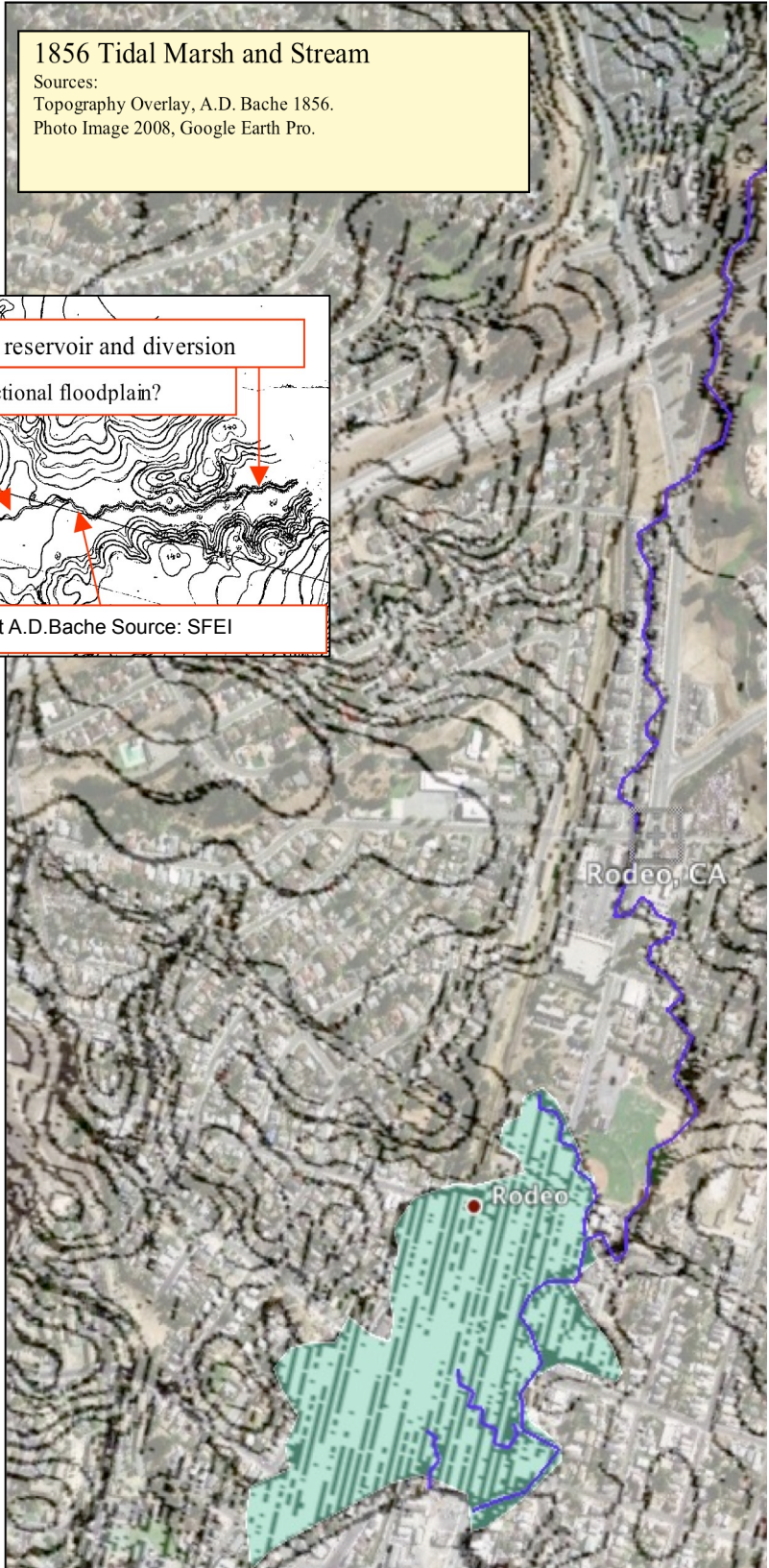


1850 – Probable year of high rainfall.

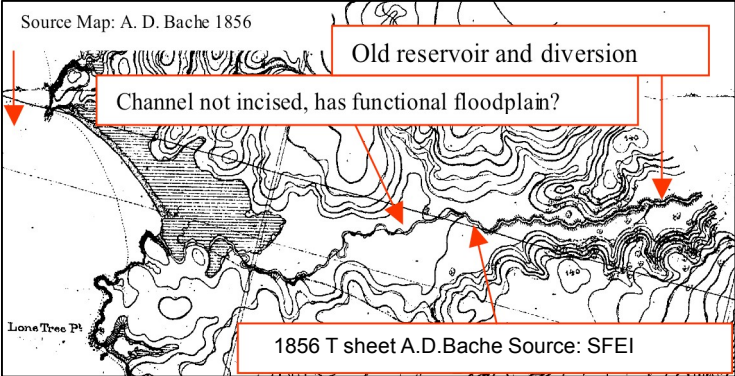
1851 – Probable drought year.

1856 – First topographic survey (T Sheets) was conducted of the tidelands and adjacent shoreline of the Rodeo area by A.D. Bache. As seen on maps on the next page, a small diversion reservoir and diversion appears to be indicated on the map along Rodeo Creek that had significant meander sinuosity upstream and through the tidal marsh. The creek appears to be incised within its terrace banks about 1/2 mile upstream of the upstream tidal margin. This is indicated by hachured lines along the stream corridor, which Robin Grossinger, Historical Ecologist at the San Francisco

Estuary Institute, suggests was a map symbol often used to indicate arroyos or incised channels confined within the valley floor.

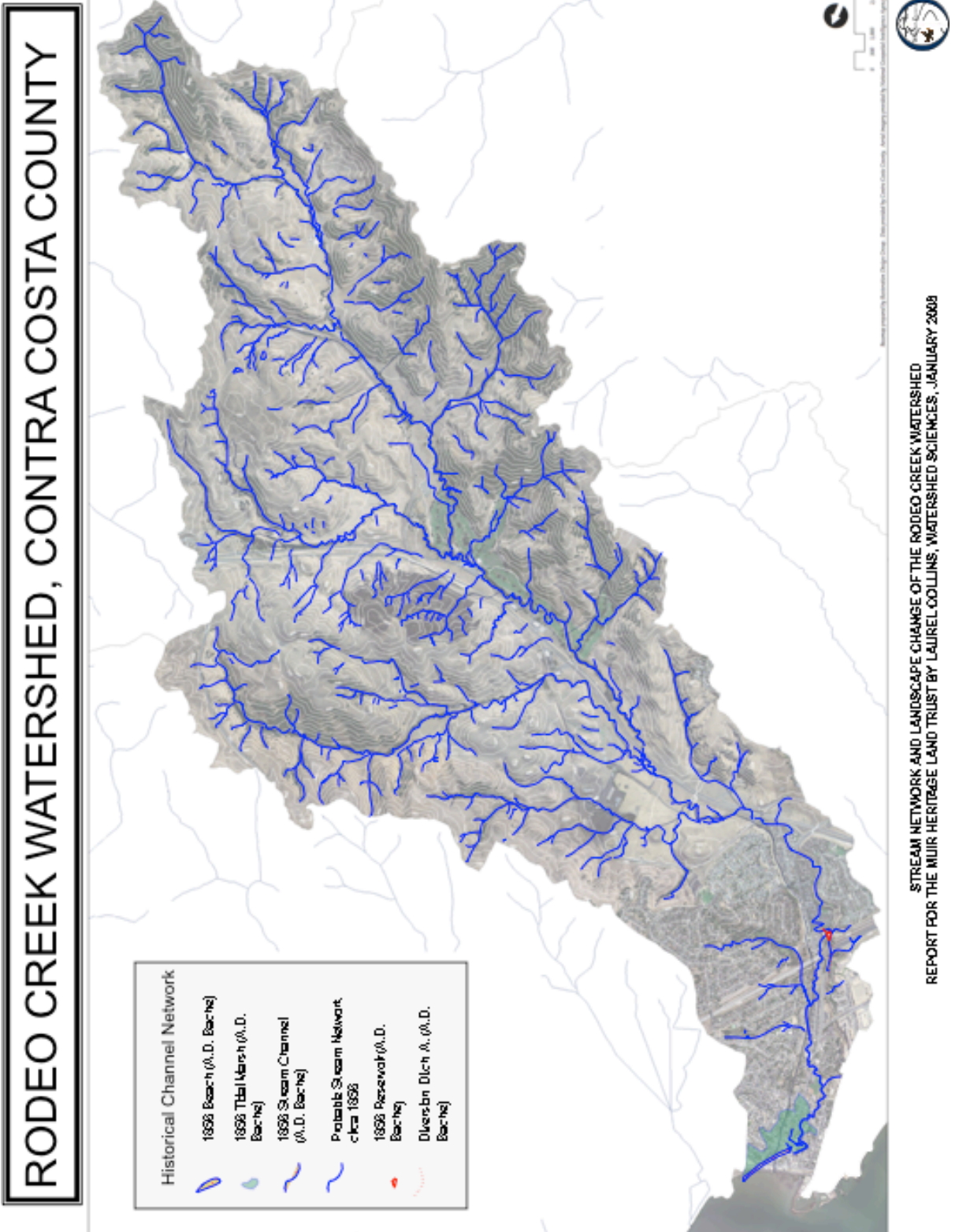


1856 Tidal Marsh and Stream
Sources:
Topography Overlay, A.D. Bache 1856.
Photo Image 2008, Google Earth Pro.



The overlay map to the right shows that much of the Rodeo was situated on a former tidal marsh. The creek flowed along the southern valley edge.

The Historical Channel Network Map (next page) represents the possible 1856 conditions as analyzed from the maps to the right, and interpretation and assumptions from the 1939 photos. Note some of the stream channels are disconnected from the mainstream. Interpretation of 1856 landslide conditions could not be made.



1862 - Probable year of extreme rainfall ranked as the highest for the entire period of record.

1863 – Probable drought year

1864 – Probable drought year

1865 – Irish-born brothers John and Patrick Tormey purchase 7,000 acres of land from the Martinez heirs and divide the land with Patrick taking the land that became known as Rodeo (Dowling 1973). The name Rodeo was borrowed from the place name Rodeo Valley, which Dowling states was on a 1860s map. She defines the Spanish word rodeo to connote a cattle enclosure at a market that came to mean the rounding up of cattle for taking to market.

1867 - Probable year of high rainfall.

1868 - Probable year of high rainfall.

1871 – Probable drought year. State Geological and United States Survey Map indicates a road or trail through Rodeo but Railroads are not indicated. Rodeo Creek still seems to be in its historical alignment with continuous sinuosity through its valley. Four tributaries are shown, which might indicate presence of perennial flow.



1874 – Southern Pacific Railroad, now the Union

Pacific, was constructed along the San Pablo Bay shoreline sometime between 1871 and 1874, as indicated by Whitney’s 1873 map (below). This might have been when Rodeo Creek was first altered through its tidal marsh to provide efficient drainage beneath the railway crossing. Alternatively, the creek might have been straightened earlier by local farmers to increase arable land and hasten drainage of the floodplain upstream of the tidal marsh. Whitney’s map does not provide sufficient detail of Rodeo Creek to assess change. The map does show the same road or trail extending through the valley, which might have been the road to Martinez. This map shows the same tributaries as the earlier map. Sounding depths of the Rodeo shoreline are shown as 5 fathoms, which

would be about 30 feet. Later San Pablo Bay bathymetric maps developed by Jaffe *et al* (1998) show the bay becoming increasingly shallow during the early 20th century. Whether the bulk of sedimentation at the outlet of several local Bay Area streams is associated with their local watershed deliveries or from earlier Sierran hydraulic mining sediment, has not been well established and tends to be the subject of debate.

(Collins, 2007)

1877 – Probable drought year.

1878 - Probable year of high rainfall.

1882 – About 9000 acres of Rancho Pinole was sold to Bernardo Fernandez.

1849 – Fernandez Ranch appears to have been used continually for cattle grazing during the period

1848 to 1900. A bridge or road crossing Rodeo Creek was required to get to the Ranch. Subsequent incision and erosion require the crossing to be re-sited to a downstream location.



1885 – An 1885 map by McMahon and Minto shows Rodeo Valley and Rodeo Creek but does not indicate the town of Rodeo. The planform of the creek indicates more detail of additional tributaries, at least 12 that are confluent to the mainstream of Rodeo Creek. A spot located on the middle reach of Rodeo Creek near the western boundary of the present Day Franklin Canyon Golf Course might be a small water body. There is a questionable marking in a similar location on the earlier 1874 map.

1890 - Probable year of high rainfall.

1890 general – This is the first reference to a school. It was probably located in the low hills north of the town.

The dream of creating the “porkopolis of the west” for Rodeo was envisioned by early settlers and venture capitalists that built the Union Stockyard during the early 1900s. The stockyard, and possibly the railroad probably had the most profound influences on lower Rodeo Creek. Ruth Kearney Carlson spent many hours in the UC Berkeley Bancroft Library researching the history of the Stockyard. Stockyards and corrals were formerly situated along Railroad Avenue between Vaqueros Avenue and the railroad. Excerpts from her writing are shown

as italics in the timeline section. Her descriptions of the stockyard era are far more detailed than the excerpts provided here, which mostly pertain to potential influences on Rodeo Creek.

During 1890 Beef and pork packing houses were in the planning stages to be built adjacent to the stockyards between Rodeo Creek near where railroad Avenue ran into Parker Avenue. Sometime perhaps during the early 1890s the California Redwood Company purchased the land next to Rodeo that would later become Oleum (Dowling 2007). The word “oleum” means fuming sulfuric acid (Feb 2008, written comment from Paul Craig, Muir Heritage Land Trust Board Member).

At the same time the lower channel was altered by the Union Stockyard in lower Rodeo, the Santa Fe Railroad system, now the Burlington Northern Railroad, was constructing a railway in the middle through the headwater portion of the watershed. In the headwater reaches of the watershed a railroad tunnel was being constructed upstream of the area labeled Christie Station (map on page 7). Historical maps indicate that the railroad tunnel appeared between 1885 (McMahon) and 1894 (Wagner).

Specific information has not been found about the construction of the tunnel but placement of fill on the floodplain near and downstream of the Christie Railroad Station, as well as excavation of the tributary valley for maintaining the railroad grade, had profound effects on the stability of the upstream reaches of Rodeo Creek (Collins 2006; URS 2004). Construction of the railroad required Christie Road to be re-aligned and placed to the south side of the tracks (URS 2004). Placement of the fill on the floodplain encroached on the floodprone width of the channel and excavation of the tributary valley increased runoff and peak flows. The cumulative effects probably resulted in the commencement of an incision and destabilization cycle in the Rodeo Creek reaches downstream of Christie Station and along the reaches along Fernandez Ranch.

Downstream of Christie Road through the middle segment of the watershed a railroad crossing had to be constructed across Rodeo Creek as well as many of the tributary channels. It is not known what type of crossing structures were used during the 1890's and how many of them have been altered or replaced. The fill that was placed across Rodeo Creek is still in position today. A substantial amount of material was used to fill the valley and connect the tracks across a low saddle to maintain the gradient. A logical assumption is that rock excavated from the tunnel construction upstream, provided fill material for the valley crossing.

Many of the new stream-crossing structures probably created localized erosion. This would have been associated with altered drainages, constriction of flow at inlets and associated backwater flooding causing localized stream bank erosion when there were debris blockages, and channel incision and/or bank erosion at the outflows where stream velocity was accelerated. The type of computations

that were used at the time to size bridges and pipe crossings is unknown. However, 100-yr RI flood estimates performed by the Army Corps (USACE 1962) indicate the Burlington Northern/Santa Fe Railroad culvert has limited capacity and could not convey the Corps estimated 100-yr storm discharge of 3000 cfs. The railroad culvert was assessed to only convey 2500 cfs. This means that backwater flooding and sediment deposition during large storm events is likely upstream of the railroad embankment, especially since the channels is not deeply incised.

1890 – *Great Land Sale near Point Pinole (according to Carlson, most of the literature about Rodeo during 1889 and 1890, refers to the site of Rodeo land as Point Pinole). An option was taken out on the land and money was paid to Patrick Tormey and his wife who were original landowners since the division of Ranch Pinole. Land surveys were conducted by T.A. McMahon for Armour and company of Chicago.*

April 1890 – *Enterprise of Union Stockyard Company of San Francisco starts to materialize in Rodeo. The packinghouses were to have a daily capacity of 4000 hogs, 1200 beef, and 1500 sheep. The area was planned to be the pork and beef market of the entire west with the whole Pacific area as the market. The Pinole (Rodeo) and Armour meet packing interests planned to provide employment to over 4000 men and revolutionize all Pacific Coast butchering.*

June 1890 – *Site selected for the Union Stockyard Hotel and 1200 railroad ties were purchased to run up the valley between the old town Pinole and the company enterprises located near Rodeo Creek.*

A plaster mill was being located at the stockyard site, yet it is unclear whether this required water diversion or if the site was next to the creek.

July 1890 – *1400 acres of land purchased by Union Stockyard becomes known as Tormey Station.*

August 1890 – *Men are working on the grade of railroad track about a half mile from Tormey Station. A large force of men was employed in grading areas for the large hotel, dwellings, and packinghouses on the Union Stockyard Company.*

September 1890 – *Farmers near the Stockyard hoped to sell large quantities of fruit, poultry, eggs, and vegetables to company workmen. Promoters announced that eight acres of the stockyard property would be planked over with two-inch planks. Two packinghouses would be built to be operated independently of the stockyards but subject to the company's rules of cleanliness and sanitation. Rodeo Creek with its watershed of [about] 7000 acres would furnish a water reservoir, which would be constructed under the direction of Mr. Schussler, superintendent of the Spring Valley Water Works of San Francisco [which became part of the San Francisco Public Utility Commission].*

October 1890 – An average of four carloads of lumber a day was hauled to the Tormey Station at Rodeo.

November 1890 -The Semi-Weekly Gazette published plans of the Union Stockyard Company that included descriptions of *the three story, 170 feet wide hotel, and the stockyard itself, which had had an area of ten acres floored with two-inch planks laid on Redwood sills thirty inches apart center to center and provided with surface drains and twelve inch iron stone sewer pipes and circular brick catchment basins. There were 54 cattle pens with space for 20 to 50 cattle each. On two sides of each pen were troughs, one for water, and one for food. Seventy-two pens were constructed for sheep and hogs with similar arrangements.*

Parallel to the double track of the Southern Pacific Company was the double track of the Union Stockyard Company. Another double track would run from the packinghouses across the main line with an easy grade to the wharf and along the wharf to the bay so large cargo vessels could load and discharge cargo. Killing houses, canning factories, lard houses, fertilizer houses, office and market buildings were all designed and planned.

In order to provide water for the Union Stockyard's various enterprises, company officials contracted for much work on a dam and reservoir.



1894 map by Theodore Wagner Source : Contra Costa County Historical Society

The reservoir was at the end of a landlocked valley with Rodeo Creek running through a watershed of 8 to 10 thousand acres. Mr. Schussler directed the building of the reservoir and dam. The dam was 100 feet high constructed of puddle clay and earth. [It is not clear where the clay and earth

was from for dam construction. It might have been from excavation just upstream of the dam, or it might have been associated with material excavated from the tributary valley and the train tunnel upstream of Christie Station.] The length of the dam at the top was 1,000 feet narrowing down to 300 feet or less. When the

reservoir was full, it would retain three billion gallons of water. The bottom of the reservoir was 100 feet higher than the roof of the Rodeo Hotel. The distance from the bay front to the dam in an airline was about 1 3/4 miles.

Rodeo creek was a small stream during the summer sometimes became a raging torrent in spring rains and this creek wound through one corner of the Union Stock Yards so it was necessary to control the flow of water. In this section, the creek was piled with four rows of heavy squared piles in the upper part and five in the lower part where the creek was wider. The sides of the creek were piled with 3-inch redwood planks driven 10 feet into the ground and heavily spiked to stringers. A double railway track crossed the creek on a truss bridge.

The influences of these alterations on lower Rodeo Creek were significant in several ways. The construction of the dam would disconnect flow from the lower valley except through managed releases. Sediment would be deposited and stored within the reservoir. Straightening of the creek in the downstream reach would increase the steepness of the gradient which would tend to initiate incision. This was prevented by boxing the stream through the stock yard but sediment deprivation below the dam might also cause downcutting if there were large releases or uncontrolled spills from the reservoir. The operational hydrology of the reservoir is unknown. As the dam filled the water table upstream of the riparian vegetation existing along the creek would have died if it wasn't already cut down.

1891 – *Little information was publicized about the Union Stock Yard enterprises during the year of 1891.*

April 1892 – *The Contra Costa Semi-Weekly Gazette described the bustling activity of Rodeo where a schooner unloaded 1,500,000 board feet of lumber, 150 men were employed, and the*



bar room of Hotel Rodeo was the finest in the country. Four hundred and fifty head of cattle had arrived from Wilcox Arizona.

August 1892 – *The mammoth plans of the Union Stock Yard advanced further. Stockholders advertised that the canning and packing procedures planned by the company would revolutionize industries on the whole Pacific coast. Hundreds of men and teams were employed day and night at the stockyard project and numerous carloads of modern machinery were going into positions. The Rodeo dam capable of holding 1,100,000,000 gallons of water was nearing completion.*

December 1892 – *trouble developed with the Rodeo Reservoir in December 1892. It sprang a leak due to a large amount of rain. At that time, the dam was 60 feet high and 400 feet thick at the base and 120 feet thick at the top. A large amount of water was lost before the dam could be repaired. By December 24th, the dam was being repaired.*

May 1893 - *Operations commence at the Stock Yard.*

July 1893 – *Contra Costa Gazette announced that a Rodeo excursion and auction land sale drew about 2000 persons to look at property. One hundred and ten lots were supposed to have been sold for an aggregate amount of \$14,000.*

August 1893 – *By this time, the Rodeo Packing Company of the Union Stock Yard had to start laying men off due to various outside financial difficulties.*

1894 general – *An 1894 map by Wagner shows the dam as proposed and that the Rodeo Creek has a straight course through the stock yard where it is likely still in its redwood culvert. The road grid of the town is shown to extend over the former tidal marsh. The long wharf is also shown. An additional map by Wagner shows a slightly different version of the reservoir with additional shading that extends the reservoir to the old Santa Fe Railroad tracks. This might reflect a revised projected waterline or a later revision of when the water level was at its peak prior to leakage problems.*

January 1894 – *Farmers and stockmen in the Rodeo vicinity regretted suspension of the stockyard company operations. *The stoppage of work at the very commencement of operations was disappointing*, as stockmen had raised cattle, sheep, and hogs in anticipation of good prices. San Francisco newspapers announced that the whole plant would pass into the hands of other capitalist and the plan of operations would be changed so the packing house at Rodeo would be used for slaughtering and curing purposes only. It was necessary to stop work at the Stock Yard Company while financial irregularities could be resolved.*

February 1894 – *It was announced that not much was being done in Rodeo, but preparations were being made for extensive operations in the spring of this year at the stockyards, which were the largest in the state. This suggests that very*

large numbers of cattle were probably locally raised and concentrated on the hillsides and valleys of the Rodeo watershed.

January 1895 – The Rodeo Reservoir was damaged again. At this time, the dam was supposed to be 700 feet in length and 400 feet thick at the base and 120 feet thick at the top. The dam was 30 feet high. A weir was placed at a height of 20 feet to carry off surplus water. At the time of the damage the weir was closed and an immense amount of rainfall filled the reservoir so high that the water was running over the top and cut down the dam about 8 feet. Looking at just the annual rainfall record for Antioch, the total ranks twentieth from the extreme event recorded since the period of record began in 1879.

February 1885 – Packing company operations were active again at Rodeo.

June 1895 – *An announcement was made that the Union Oil Company had purchased real estate and a wharf from the old California Lumber Yard Company of Rodeo. It was announced that the Union Oil Company would erect a refinery with an investment of \$100,000 and would offer employment to about sixty men.*

December 1895 – *A terse statement was made by a correspondent who stated how nice it would be if the packinghouses were running at Rodeo.*

July 1895 – *The Union Stock Yard Company was declared an insolvent debtor. A later July article in the Contra Costa Gazette regretted the foreclosure said the County regretted the foreclosure suit against the Company. Operations at the company were carried on at a limited scale, but were never commensurate with the magnitude of the huge plant.*

March 1897 – *The Rodeo Hotel burned to the ground.*

1898 – Probable drought year

1899 – A map titled Crockett Cal (Rodeo) Oct 1899 shows the Rodeo Creek Channel leading to the stock yards and then still completely disappearing beneath the wood culverts described by Carlson. The creek at its entrance to the enclosure is labeled Rodeo Creek dry sometimes and then it is shown disappearing into a culvert. There are various notes on the map including that just one map works at the packing house and one at the stock sheds and that the site has not been in operation since 1896. There is a night watchman there at all times.

1900s general - David Claves a former rancher, born 1898, that had been interviewed by J. Posedale said that Rodeo Creek used to flood often due to debris creating obstructions at small footbridges (Posedale verbal communication, 2008).

May 1900 – A decree of foreclosure of the Union Stockyard was rendered by the superior court.

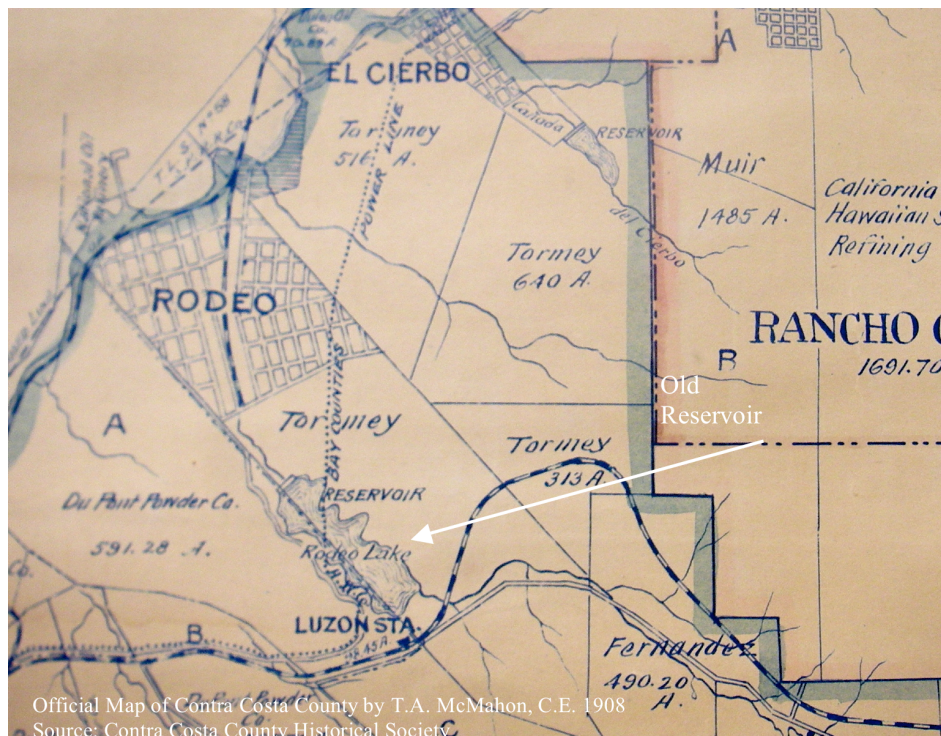
July 1900 – Commissioner Glass read a notice of sale, which stated that all the buildings, the wharf, the wharf franchise, the railroad, all corals, machinery, and forty acres of land would be sold. Amongst the property were seven four story buildings, two complete ice plants with 5 miles of ammonia pipes, two miles of water pipe, and thousands of feet of shafting. The wharf was a thousand feet long. The engine department had complete engines and pumping plants. The whole outfit was the most complete and elaborate plant west of the Rocky Mountains.

April 1901 – Judge William Wells filed an opinion in the Superior Court of Contra Costa County that eventually after more years of legal wrangling, allowed the Great Western Smelting and Refining Company to acquire and eventually remove most of the previous holdings of the Stock Yard.

1902–1906 – The packing plant buildings became a shell of their former selves.

April 1906 – The Great earthquake of 1906 leveled all the big structures of Rodeo. The former packinghouse buildings became a rubble of brick and beam.

1908 - A Rodeo Town site and Improvement Company was active again and advertising Rodeo as one of the fastest growing towns in California. Purchasers were urged to look over a map and select their lots. This map was a small replica of the original [1891] map of the town when it was laid out by surveyors McMahon and Compton for the Union Stock Yard Company. The map still had its



beef and porking houses located between Rodeo Creek and Parker Avenue. The immense hotel was still shown even though it had burned down in 1897.

Western Oil Company was located at Rodeo and the town site of Oleum adjoined Rodeo where the Union Oil Company employed several hundred workmen. At this time, Rodeo had stores, a hotel and a blacksmith shop and schools. Investors in Rodeo were promised that the town would have its own water works and electric lights.

A 1908 map by McMahon shows the reservoir in place and no longer labeled as proposed. Rodeo Creek still disappears once it enters the town, indicating that the channel is still in its wooden culvert.

1908 – 1920s - *While various Town and Improvement Companies operated frequently to promote Rodeo's growth, the population did not increase rapidly until World War II brought pressure of population to the Bay Area and residents moved to Rodeo to be near work at Vallejo, Oleum, Pinole, or Richmond.*

1912 – A dairy farm and homestead was constructed at the Fernandez Ranch.

1913 – Probable drought year.

1914 – Arnold and Glass, on their 1914 map, show Rodeo Creek running nearly straight through the town of Rodeo. This indicates that by this time the redwood culvert had been removed and the channel day lighted. Some of the redwood used as the culvert was probably removed but some of the piers remained as indicated in later cross section surveys conducted by the Army Corps of Engineers (USACE 1962). The channel below the former Rodeo Reservoir, which is not indicated on this map, is shown to straight and wider than the channel upstream of the dam. It is likely that this is indicated a constructed ditch that went through the old dam to help drain it after it was abandoned. Unfortunately, records of what happened with the decommissioning of the dam have not been found although a search of Bancroft Spring Valley Records might be fruitful. If all the rows of piers remained in the day-lighted channel after the dam was removed, it is probable that flooding would have been exacerbated in the town.

The area upstream of the dam probably developed a new channel on its own, yet most likely, people determined where it should go and ditched it to the north edge of the valley to maximize drainage and increase arable landscape. The records discuss earlier flood events and overflows. Little is known about how much incision might have occurred in the channel downstream of the dam but we do know that the channel gradient had to be steeper as a result of shortening its length by removing its meanders and placing it in a straight ditch. Once the dam was decommissioned, the new channel within the former reservoir had to adjust its grade to a downstream channel that now had a steeper slope. This might

have had profound impacts on the upstream channel by initiating an incision cycle that could migrate headward. Given enough time, and incision, tributaries that were confluent to the incising mainstream channel could eventually be destabilized and develop their own migrating nick points.

An alternative hypothesis of incision is that it started happening upstream of the dam shortly after it was built, but is contingent upon how the dam was constructed. If it was constructed from local material that was excavated from the upstream side of the dam, which would have also increased future water holding capacity, the channel upstream of the excavation would have been started to incise at the nick point caused by the excavation. Since the valley is known to be primarily fine alluvial sediments, headward incision could have proceeded upstream. Given enough sediment deposition over time and lifespan of the reservoir, the excavation would have eventually filled and been exceeded by ongoing reservoir sedimentation. Unfortunately, details of dam construction and decommissioning are presently unknown.

The upstream Santa Fe RR crossing (now Burlington Northern) might have also influenced how far headward incision might have propagated. It is unclear whether the concrete stream crossing structure that is there today, is the same as when it was built in the 1890s. The present structure observed in the fill appears as if it might be the original from 1939.

1920 – Probable drought year

1924 – Probable drought year.

1925 – Rodeo had a population of 1000 people.

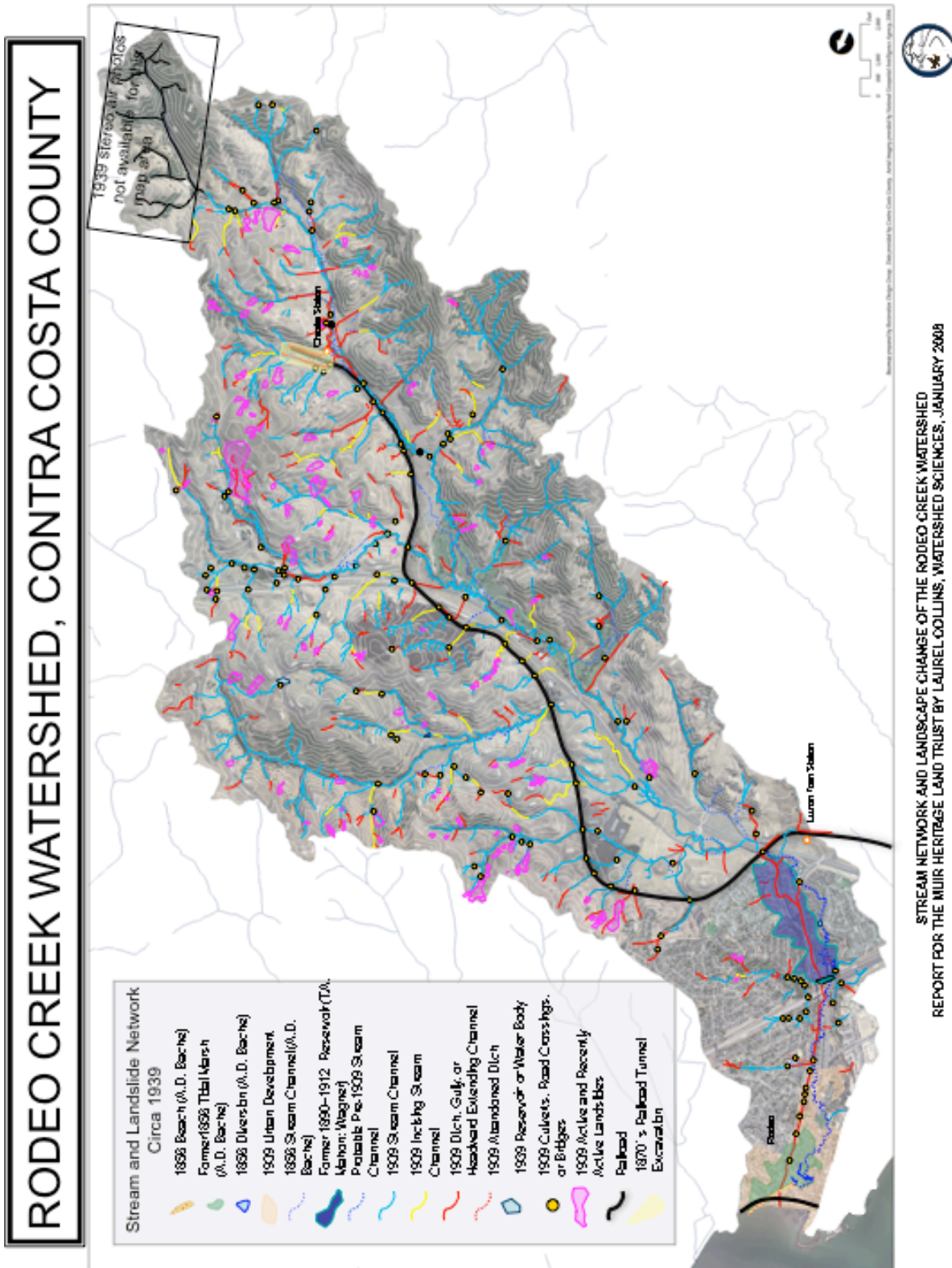
1931 – Probable drought year.

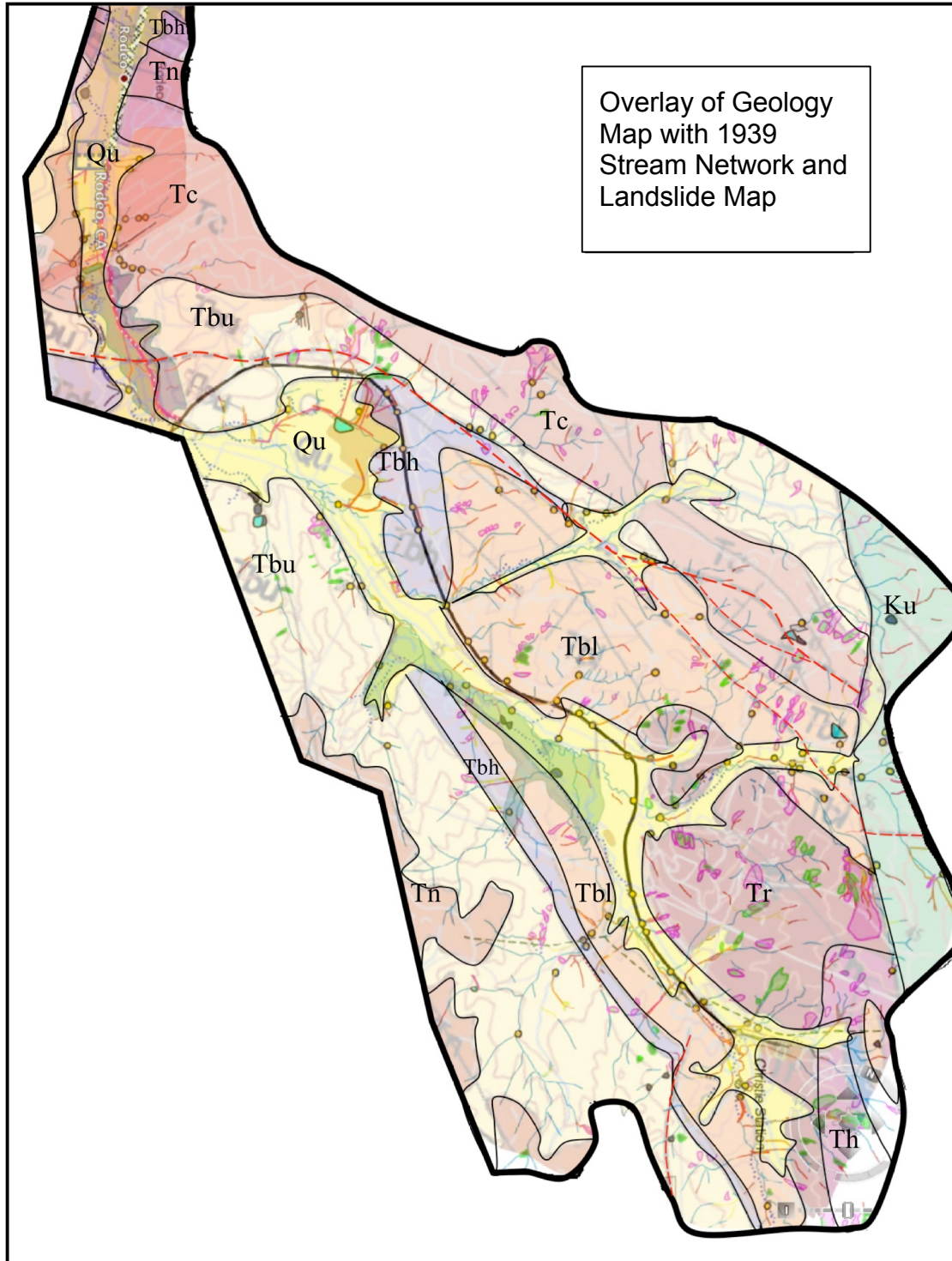
1933 – Probable drought year.

Dec 1937 – Flooding in Rodeo (WY 1938) (Dowling, 2007).

Sept 1939 - Flooding reported in Rodeo (WY 1940).

The Stream Network and Landslide Maps for this period show that the channel network has become more connected through artificial channels (red lines) and that many channel heads have extended upslope. The yellow lines indicate severe active erosion primarily from streambed incision. Culverts and road crossings (yellow dots) are shown to depict the influence of structures on channel condition. The tidal marsh is shown to have given way to development and numerous, formerly sinuous channels have become abandoned from water diversion, drainage, and agricultural activities. The landslides are most active in





shale rich units and are particularly concentrated in the Tr unit (Rodeo Shale). These are indicated on the geology overlay above. Note that the map above shows the same geologic units indicated by USGS (1994) on page 12 and that the active landslides from 1939 aerial photos are shown in maroon. The shale-rich Tr unit is toward middle right portion of the map.

Feb 1940 – Population grows to 2,124 people. Flooding in Rodeo (URS 2004).

1941 - Probable year of high rainfall.

1943. Probable flooding in Rodeo (Posedale, hand-written notes 2007). 1948-

1949 – Rodeo had a population of 7500 people.

Apr 1950 – The photo below shows the location of the remnant dam for Rodeo Reservoir before the site was later used as fill for Highway 80.



Oct – Nov 1950 - According to Posedale (notes on photographs) there was flooding in Rodeo (WY 1951).

1952 - Probable Water Year of high rainfall.

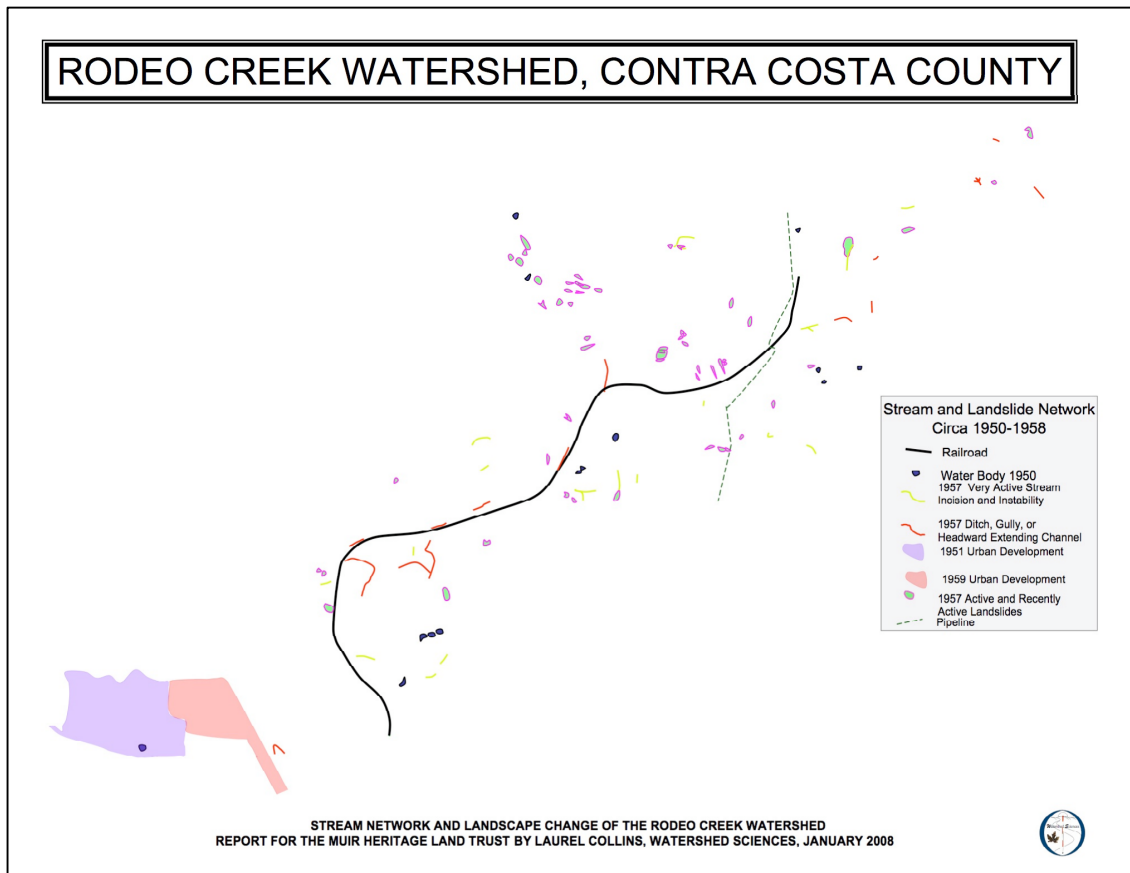
1953 - Probable year of high rainfall.

Dec 1955 - Flooding in Rodeo December (WY 1956) (historical pictures from Posedale; URS 2004).

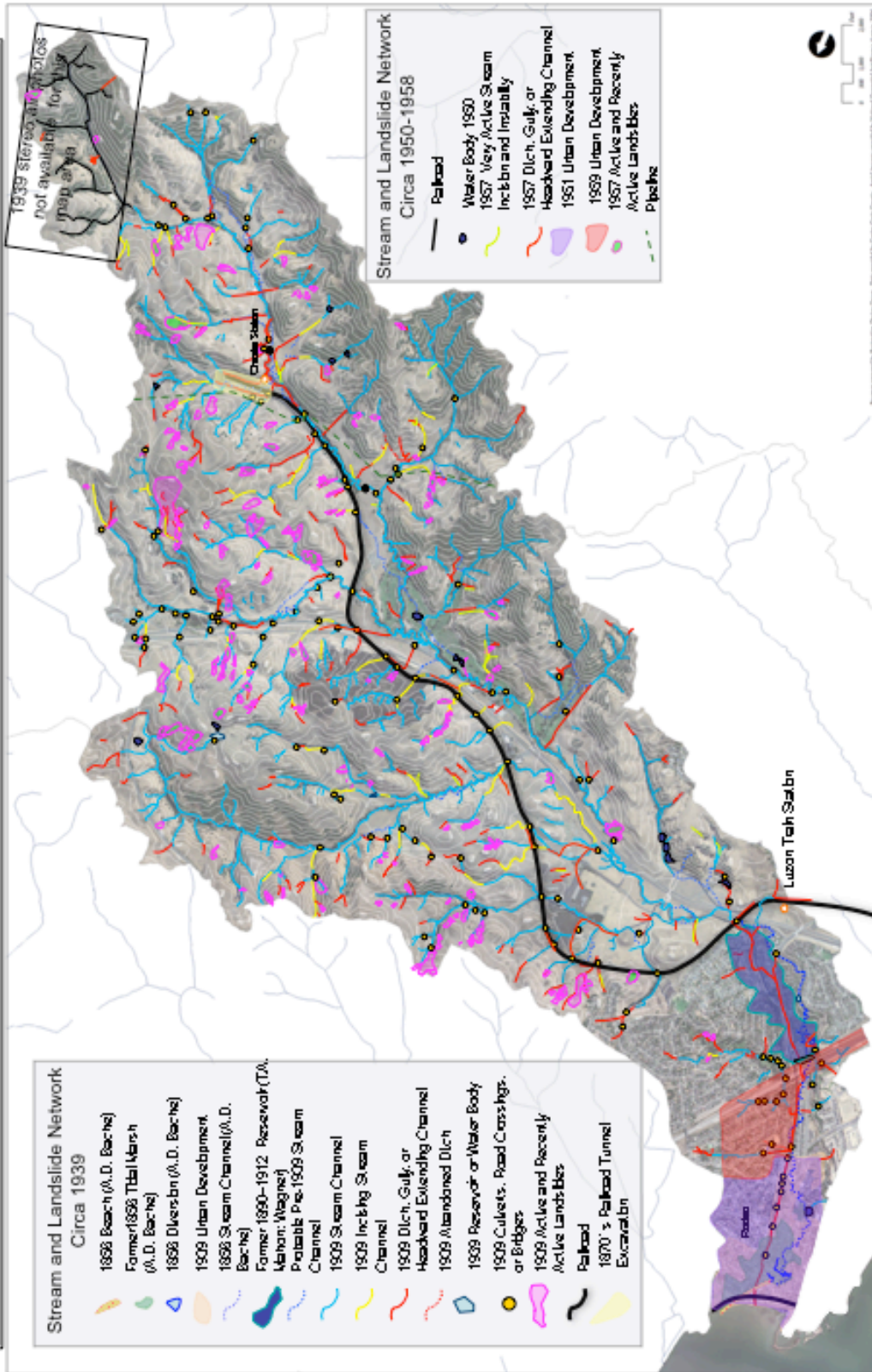
1956 – A high-pressure gas pipeline was constructed across the creek by Kinder Morgan in 1956.

1957 - The Stream Network Map for 1957 is shown both below as a simple line drawing and compiled on the 1939 base maps on the next page. This seems to be a general period of recovery. There were fewer active landslides except they still concentrate in the Tr unit (Rodeo shale) in the eastern hillsides. Interestingly the geologic maps also show this area to have a concentration of faults (not active), but it is likely that they have probably mechanically weakened the bedrock and reduced its strength properties.

The maps show increased development. The remnant dam of Rodeo Reservoir was still in place but had a canal cut through it. A few new artificial alterations to the streams occurred and several headwater-extending channels were observed from the photos to be associated with road runoff. More small reservoirs appear. About a dozen small tributary channels are demonstrating severe active incision throughout various locations of the watershed. The Kinder Morgan gas pipeline appears in the Christie Road and Fernandez Ranch area.



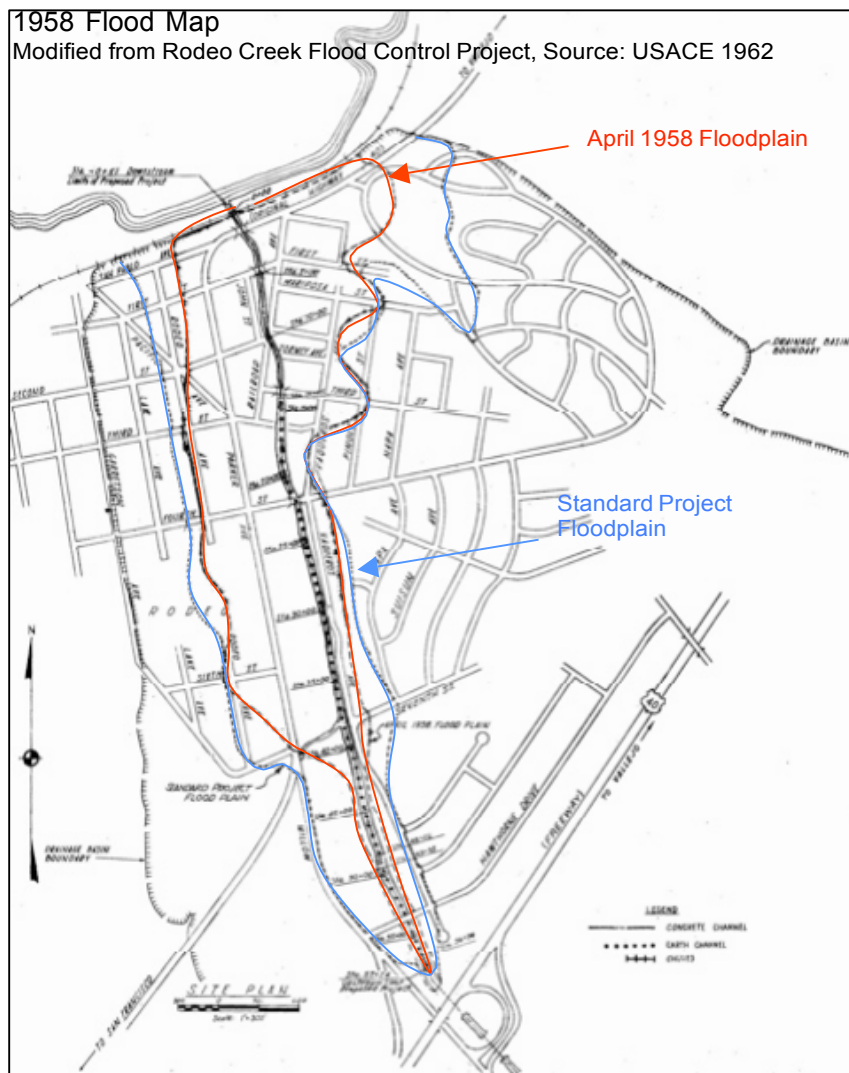
RODEO CREEK WATERSHED, CONTRA COSTA COUNTY



Stream Network and Landscape Change of the Rodeo Creek Watershed
 Report for the Muir Heritage Land Trust by Laurel Collins, Watershed Sciences, January 2008

A probable reason for the reduced instability of the watershed is that the previous 50 years had relatively little rainfall to saturate soils. The principle land use was still grazing in the hillsides. Urbanization extended up valley from the lowlands. Significant impacts to the floodprone width were not as great as those during the 1800s.

Apr 1958 - Year of high rainfall and reported flooding in Rodeo (Dowling 2007; URS 2004). A map of extent of flooding during 1958 is shown below and compared to the Army Corp's designated standard project floodplain.



The 1958 photo below shows the beginning of construction for I-80 at the old Rodeo dam site in the upper left corner of the picture. The photo indicates that coffer dams were constructed upstream of the highway fill. The Santa Fe/Burlington Northern Railroad crossing can be seen in the middle of the photo. Note the lack of vegetation throughout most of the channel length.



Sept 1959 - - Possible flooding in Rodeo (WY 1960). (Posedale, hand-written notes 2007).

1960s general – The opening of the US I-80 brought major change to the town of Rodeo and divided the watershed at the same place where the Rodeo Dam had been located in the 1890s. Fill for the highway was placed exactly where the dam was located. It is not known what happen with the original dam material and if it was used as part of the highway fill. Aerial photos from the 1950 show that the dam still existed but that a canal had been cut completely through the old feature.

Nov 1962 – Local Flood Control Project for 1.1 mile of channel starting at San Pablo Bay is designed by the Army Corps of Engineers. The lower 1260 feet is a concrete-lined rectangular section and the upstream 4370 feet is earth trapezoid. The County Flood Control District is placed in charge of its maintenance.

Jan 1963 – Flooding in Rodeo (URS 2006).

2/16/65 – Flood Control Commission adopted resolution to acquire real property for Rodeo Creek channel project.

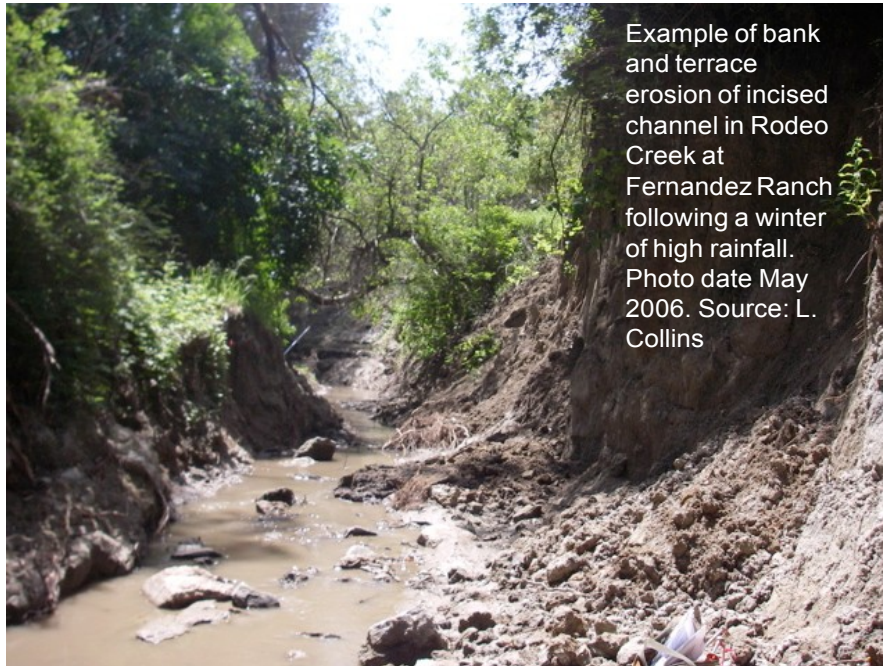
4/12/65 – Authorization to take real property for the flood control channel project was effective. The project widened the pre-existing creek. Four temporary

crossings identified on the USACE (1962) map were removed as part of the project and 51 parcels were taken all or in part for the project. A disposal site was identified at Willow and 7th Street. At some unknown date, an asphalt path was constructed between Investment Street and I-80.

1967 - Probable year of high rainfall.

1972 – Probable drought year.

1973 - Probable year of high rainfall.



1976 – Probable drought year.

1977 – Probable drought year.

1982 - Probable year of high rainfall.

1983 - Probable year of high rainfall.

1987 - By 1987, according to URS (2004), the original Kinder Morgan gas pipeline was approximately 10 feet above the streambed and the erosion in Rodeo Creek forced the abandoning of the pipeline structure. The replacement pipeline was placed at a design depth of approximately 17 feet below the 1987 streambed. A 2001 investigation followed by field verification found that the pipeline was only about 3 feet below the streambed at that time. URS reports that reconciliation of the data provided in the 1987 and 2001 surveys suggest that the original placement of the pipeline in 1987 might have been between 5 and 6 feet

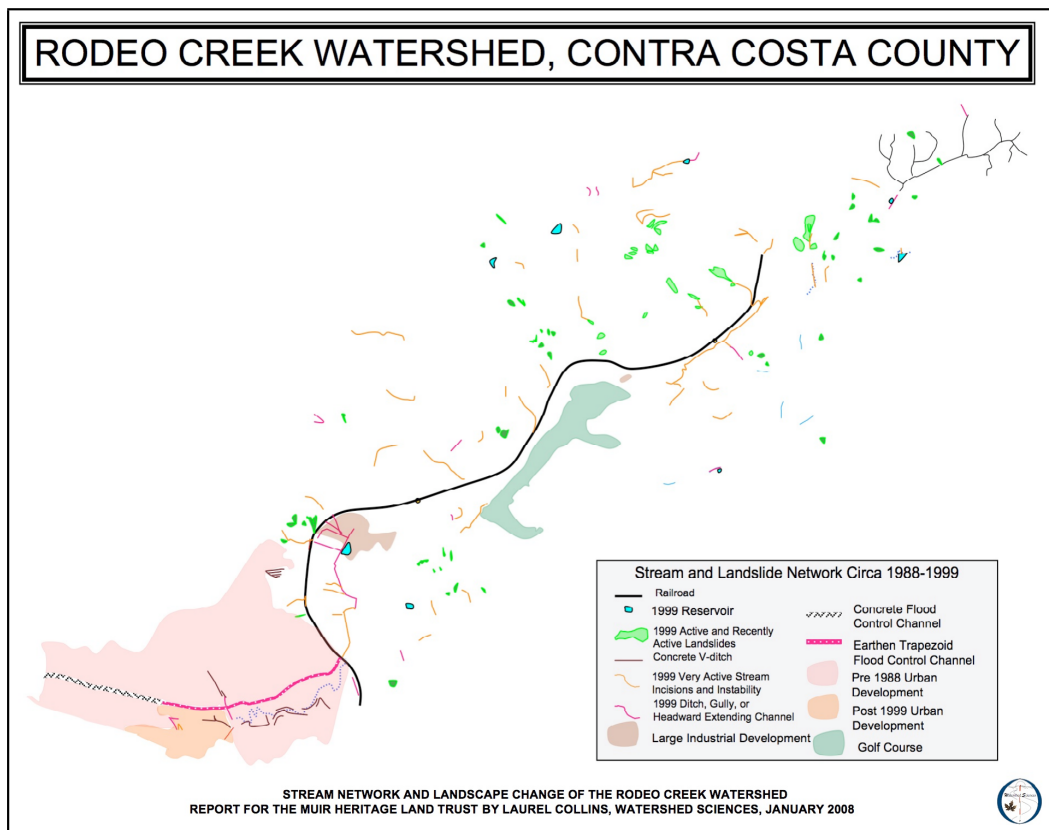
higher than the design elevation. These findings indicated that the streambed had degraded between 8 and 9 feet over a period of approximately 14 years.

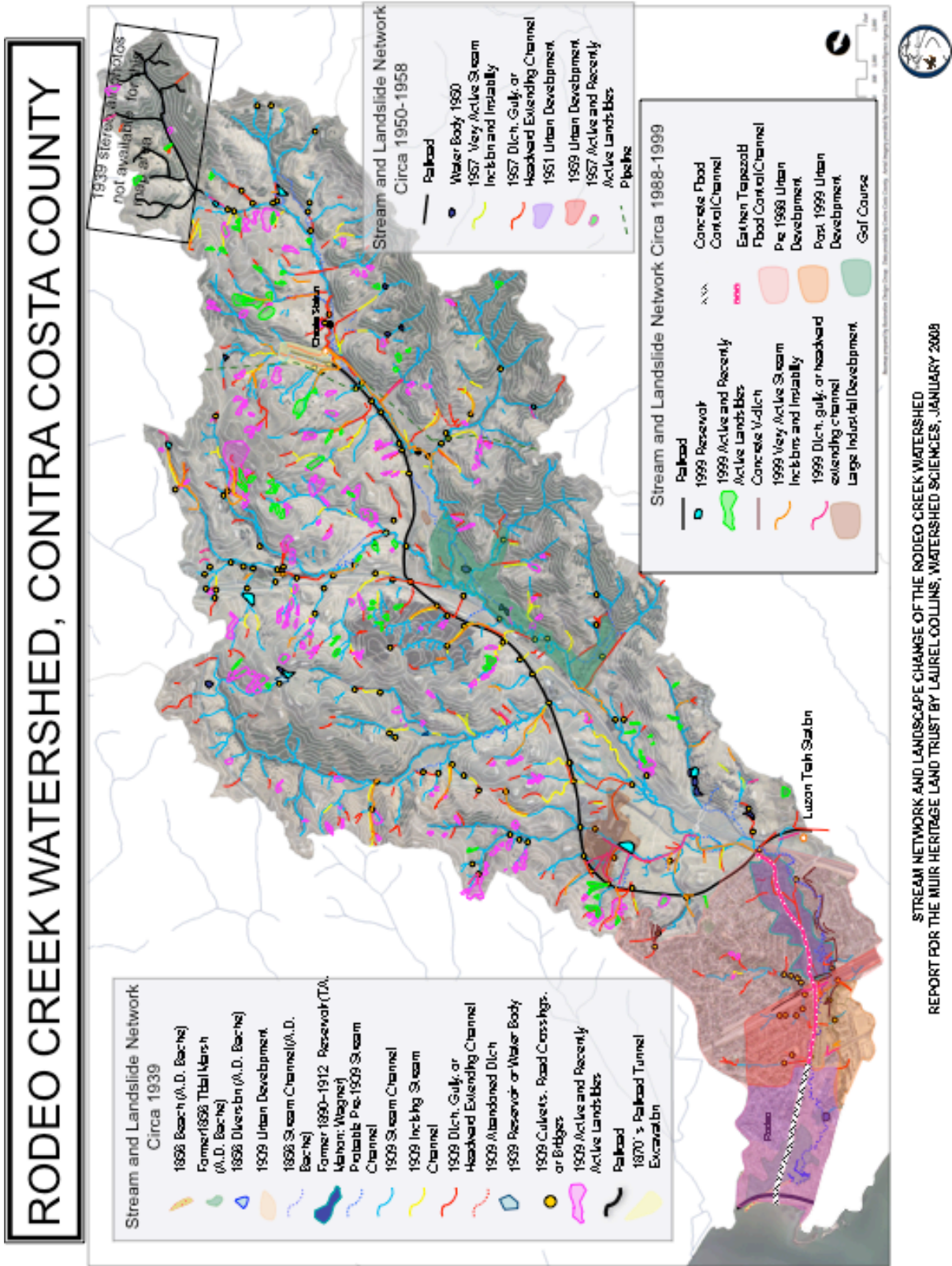
11/15/93 – A Public Notice posted by the Contra Costa County Flood Control and Water Conservation District proposed dredging of 5000 cubic yards of sediment that collected along the lower 1600 feet of flood control channel. About 5800 cubic yards of sediment was proposed to be dredged from the concrete segment and 200 cubic yards from the earthen channel. About 185 cubic yards was expected to be released into San Pablo Bay and 30 square feet of cord grass was to be removed near the mouth of the channel. Sediment deposits in the channel were estimated to be two to four feet deep. Dredging was required to return the flood control channel to its design capacity and to free blocked flap gates of tributaries and prevent water from backing up in side drainages.

1995 - Probable year of high rainfall.

1998 - Probable year of high rainfall, and probably the highest total for the 20th century at Rodeo.

1999 – The Stream Network and Landslide Maps for the 1999 period are shown as single line drawings below and as a compilation on the 1939 and 1957 Maps. Urbanization and the flood control project extend to the Burlington Northern RR crossing.





STREAM NETWORK AND LANDSCAPE CHANGE OF THE RODEO CREEK WATERSHED
REPORT FOR THE MUIR HERITAGE LAND TRUST BY LAUREL COLLINS, WATERSHED SCIENCES, JANUARY 2008

The lower segment of the flood control channel is concrete while the upper section is an earthen trapezoid. At least two distinct grade changes are incorporated into the structure, probably because of previous knickpoints.

Upstream in the middle valley, a golf course has been constructed and tributary channels through some segments of the course have disappeared underground. This is true for the developed areas as well. The Conoco Phillips Coal plant has also developed a portion of the middle valley.

At least three times as many tributary channel segments are exhibiting severe incision and active landsliding appears slightly greater, with mostly very small slides occurring in the headwaters and similar concentrations, as shown for the 1957 period, in the Tr Rodeo Shale Unit. There are fewer headwater extending streams and new gullies. Perhaps this is because of improved erosion control along dirt roads. The number of new reservoirs is slightly less. A similar very long reach of Rodeo Creek along Christie Road has reactivated in the same reach that was eroding in 1939. A picture of this segment is shown below. The valley flat is a natural terrace surface.

2002 – URS (2204) reported that the undermining of Christie Road became so severe at the location of the pipeline crossing that portions of the road collapsed into the ravine. An erosion repair project was completed in 2002 to replace and stabilize the damaged area.

December 2005 – The return period of the December 31st storm was determined to have about a 23-yr RI (Boucher 2006).



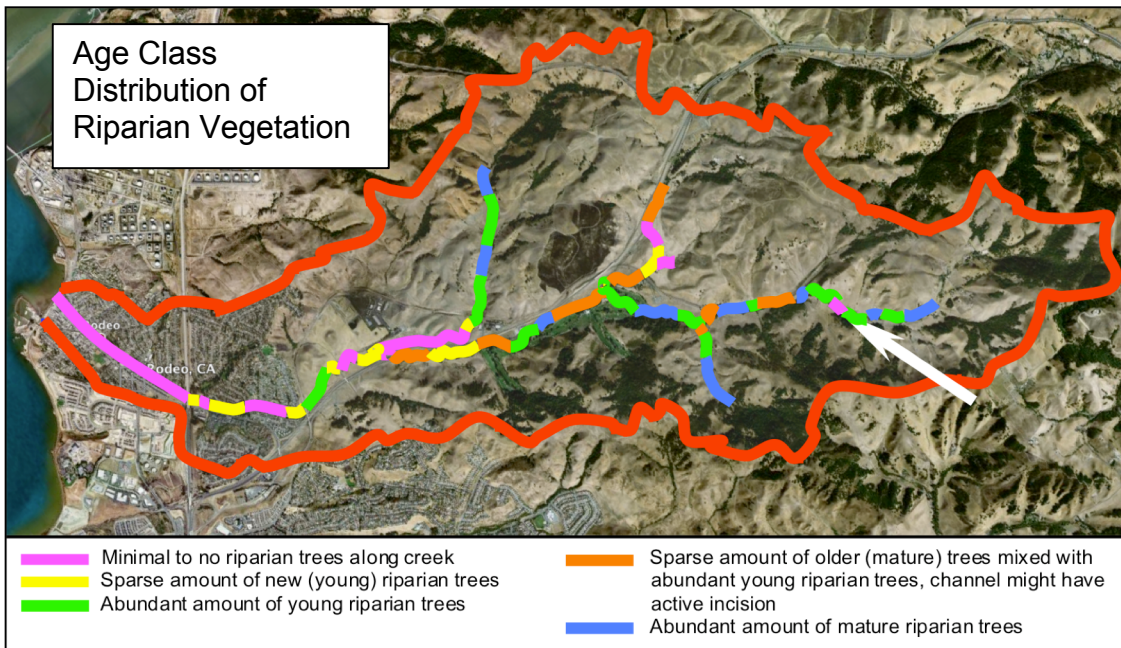
July 2006 – Stream profiles are surveyed in Rodeo Creek along Fernandez Ranch and significant nick points were measured in the channel. One, at the

Christie road culvert was greater than 10 feet and the other, just upstream of the old Fernandez Ranch bridge site was greater than 12 feet (Collins 2004). Other nick points are expected to be between these sites but have not been surveyed, yet significant bank slumping has been observed. An approximate 13-foot nick

point has migrated about 150 feet upstream on the main “Fern” tributary near the old Ranch area. A longitudinal profile surveyed on this creek demonstrates that several smaller nick points, less than 5 feet, extend half way up the grassy hillside to the next culvert outfall that has a 6.5-foot nick point (Collins 2006).

The vegetation map on page 35 indicates the status of vegetation. It shows that there are numerous bare zones with minimal riparian trees (pink lines). Some zones are starting to recover with a new generation (yellow lines) of sparsely spaced riparian trees, while other areas have more abundant but still relatively

young riparian trees (bright green lines). Orange lines indicate zones where there is a mix of riparian age classes with amounts of older mature trees diminishing and young trees increasing. These areas tend to be experiencing or have recently undergone active streambed incision or bank erosion. They indicate that remaining mature vegetation is at risk in some areas. Blue lines indicate zones where there is still mostly mature, riparian tree canopy. Condition category patterns probably reflect migrating zones of instability and recovery. Surveys of the tributary that is shown as dark blue in the Fernandez Ranch are at risk of instability from headward migrating nick points.



VIII. Summary Conclusions

Historically before the 1800s, landslides were probably the most significant supplier of sediment to the stream network. Today and perhaps since the early 1900s stream erosion has become the predominant source of sediment. Although land use practices might not be as harsh to the landscape as they were in the past, for example grazing is much less intense, and stream alteration projects are not as invasive or constrictive of flow, nick point migration will still have the potential to destabilize relatively healthy reaches.

Rodeo Creek is unstable and downcutting throughout portions of its mainstream. Many of its tributaries have significant migrating nick points and will continue to be threatened by new ones as Rodeo Creek continues to adjust and incise. Where the mainstream and tributary creeks are not incising, there will still be significant bank erosion in areas of insufficient floodprone width. The incision cycle was set in motion by significant historical changes to the channel that started with influences of grazing in the early 1800s but were greatly accelerated by stream course alterations and addition of instream structures including fill from activities particularly associated with dam and railroad construction before the turn of the 1900s.

Land use practices of the 20th century continue to increase the number of artificial segments of the stream network and instream structures with stormdrains and more road crossings on tributaries. Continued urbanization of the hillsides upstream of the Burlington Northern Railroad crossing will increase the amount of runoff to sections of channel where natural stream/riparian habitat could be increasingly threatened because these channel reaches have not been altered for flood control purposes. As climatic influences change, with higher sea level and potentially increased rainfall, the zone of sediment deposition within the flood control channel will move uptown and the natural reaches of Rodeo Creek will continue to adjust their channel geometry to accommodate changes in the delivery of water and sediment.

IX. Recommendations

1. Transfer the information developed on the base maps to a Geographical Information System (GIS) to perform an analysis of change in drainage density that will quantitatively describe the different conditions of the 1939 and 2000 times of the watershed.
2. Add to a GIS, information on present-day culvert, and storm drain extent and conditions.
3. Add to the GIS, information obtained by field observation and evaluation of the stream network on significant erosion sites and location of nickpoints that have the potential to migrate and destabilize upstream channel reaches.
4. Consider purchasing new 2008 stereo photographs of the watershed to map stream, landslide, and riparian vegetation conditions in detail to assess

whether they differ from 2000 conditions because of intense rainfall during December 2005 and potentially high annual total from WY 2008.

5. Create an online interactive archive of channel conditions on a GIS that is housed at an entity such as Contra Costa County or the San Francisco Estuary Institute. An interactive map could be created that shows known information on past and present channel conditions, type and size of structures, location of nick points, severe erosion sites, restoration areas, active landslides, and areas of past or potential flooding that could be associated with tributaries or undersized storm drains. This information system could be utilized by all entities seeking creek information.

6. Establish a monitoring program.

7. Develop conceptual model graphic diagrams that show historic change and cause and effect relationships that can be easily conveyed to the public.

8. Additional research time and efforts should be allotted to seek information from Bancroft Library and the SFPUC with regard to the Spring Valley Water Company development of the old Rodeo Reservoir, Union Pacific and Burlington Northern about historical photos and construction techniques used for tunnels and bridge crossings, and Conoco Phillips Refinery at Oleum for historical information. Local ranchers should be sought that can provide historical perspectives on the landscape.

9. Develop funding sources and programs to re-establish vegetation and habitat along the flood control channel.

10. Create an on-line Rodeo Creek site that provides oral histories (written and short film clips), a repository for reports and other items relative to the watershed, and a watershed directory that includes information and contacts for different agencies responsible for the natural resources of the creek, including numbers to call for problems such as spills, pollution, flooding, or erosion problems.

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