HISTORICAL CHANGES IN CHANNEL ALIGNMENT
along Lower Laguna de Santa Rosa and Mark West Creek

PREPARED FOR SONOMA COUNTY WATER AGENCY
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INTRODUCTION

Located on the western edge of the Santa Rosa Plain in Sonoma County, California, the Laguna de Santa Rosa (Laguna) is the largest tributary to the Russian River and the second largest freshwater wetland complex in northern California. One of the major tributaries to the Laguna, Mark West Creek, flows west across the Santa Rosa Plain and connects with the Laguna just east of Forestville.[1] Together these freshwater systems provide habitat for a wide range of fish and wildlife species, including the federally endangered coho salmon *(Oncorhynchus kisutch)* and federally threatened steelhead trout *(O. mykiss;* Fawcett et al. 1990, CDFG 2004, Good et al. 2005, NMFS 2010). In addition, the Laguna functions as an important regulator of flood flows on the Russian River by acting as a natural reservoir for storm runoff (Curtis et al. 2013). In 2010 the Laguna de Santa Rosa Wetland Complex was designated a Wetland of International Importance by the Ramsar Convention on Wetlands (Ramsar 2014).

Over the past century and a half, the hydrology of the Laguna de Santa Rosa watershed has been altered by a variety land use changes, including urbanization, agricultural development, draining and filling of wetlands, and channelization of streams. These changes have impacted the function of the Laguna and Mark West Creek and contributed to a range of contemporary management problems, including habitat degradation, impaired water quality, altered sediment dynamics, salmonid stranding, flooding, and trash accumulation (Honton and Sears 2006, Sloop et al. 2007, Potter and Hiatt 2009, Curtis et al. 2013). In the downstream portion of the watershed (herein referred to as the lower Laguna region), major changes in the historical channel alignment of lower Mark West Creek have altered flow and sediment dynamics in both Mark West Creek and the Laguna.

Pinpointing the timing and location of historical changes in channel alignment will help managers seeking to improve the ecological, hydrologic, and geomorphic functioning of the lower Laguna region. Understanding the nature and context of these changes will help direct a path toward future restoration efforts. To address this need, we collected, compiled, and synthesized a wide range of historical documents in order to reconstruct 1) the channel alignment of lower Mark West Creek, lower Laguna de Santa Rosa, and surrounding tributaries during the mid-19th century, and 2) the major changes to channel alignment over the past 150 years. Despite the major land use changes that have impacted the ecological functioning of streams and wetlands within the region, many remnants of the historical landscape still exist, and many of the physical controls that shaped the landscape in the past continue to operate today. Thus, examining the historical landscape and the processes that sustained it can not only reveal the underlying causes of contemporary management challenges, but can also improve our ability to predict the outcome of proposed management efforts and to design successful, integrated strategies for stream restoration, flood protection, sediment management, and other watershed concerns. This research was conducted as part of the Laguna de Santa Rosa Historical Ecology

[1] The status of Mark West Creek as a tributary of the Laguna de Santa Rosa is a subject of debate. Upstream of the confluence, the catchment size of the Laguna (approximately 170 sq. mi.) is significantly larger than that of Mark West Creek (approximately 40 sq. mi.), and therefore we refer to Mark West Creek as a tributary of the Laguna. Historically, however, there may have been periods in which flows from the Laguna did not reach Mark West Creek and flows downstream of the confluence were derived entirely from the Mark West Creek drainage. Indeed, some historical sources appear to show Mark West Creek as the primary channel below the Laguna confluence (e.g., Gray 1857b). At other times, Mark West Creek spread out across its alluvial fan and sank subsurface upstream of the confluence with the Laguna de Santa Rosa. Further research will be necessary to resolve this uncertainty.

Initiative, a broader suite of ongoing historical ecology studies intended to improve our understanding of past landscape patterns and processes throughout the region and to support an array of interlinked management activities.

Environmental Setting

The Laguna de Santa Rosa lies at the western edge of a 254 square mile watershed in Sonoma County (Figure 1). Mark West Creek connects with the Laguna just east of the town of Forestville. Numerous other tributaries, including Santa Rosa Creek, Matanzas Creek, and Windsor Creek, originate in the Mayacamas and Sonoma mountains to the east and flow west across the Santa Rosa Plain. The Laguna drains into the Russian River approximately six miles downstream of the confluence with Mark West Creek, from which point the combined waters flow 24 miles to the Pacific Ocean.

The Laguna de Santa Rosa is located in a tectonic depression along the boundary of two crustal blocks (Curtis et al. 2013). The Wilson Grove Formation, dominated by marine sandstone, forms the hills to the west of the Laguna (Delattre and Koehler 2008). The Sonoma Volcanics form the mountains on the eastern side of the watershed (Honton and Sears 2006). The Santa Rosa Plain, which extends from the Laguna to the Mayacamas Mountains on the east, is comprised of eroded sediments carried down from the surrounding ranges by alluvial processes. The Trenton Thrust Fault runs northwest-southeast through the study area to the south of River Road (Delattre and Koehler 2008).

Plant communities on the Santa Rosa Plain include grasslands, oak woodlands, and vernal pools. Interior mixed hardwood and coniferous forest dominate the hills to the east of the Santa Rosa Plain (Honton and Sears 2006, USDA 2009). Altogether, open space (including rangeland) comprises approximately 14% of the watershed. Developed areas, including the cities of Santa Rosa, Rohnert Park, Windsor, Cotati, and Sebastopol, occupy approximately 53% of the watershed, while agricultural lands, concentrated on the western side of the Santa Rosa Plain, occupy 33% (ABAG 2005).

Study Area

The study area encompasses just under three square miles of unincorporated Sonoma County located west of Santa Rosa, north of Sebastopol, and east of Forestville (Figure 2). It was chosen to include the lower reaches of Mark West Creek and Laguna de Santa Rosa near their confluence, and extends to Slusser/Oakwild Road on the east, Guerneville Road on the south, and (nearly) to Steele Ranch Road on the north. The western boundary corresponds approximately to the extent of alluvial deposits within the valley basin. Mark West Creek enters the study area on the northeast side and flows in a southwesterly direction towards its confluence with the Laguna. The Laguna flows south to north along the western edge of the study area. About three-quarters of the land in the study area is in agricultural use (ABAG 2005).

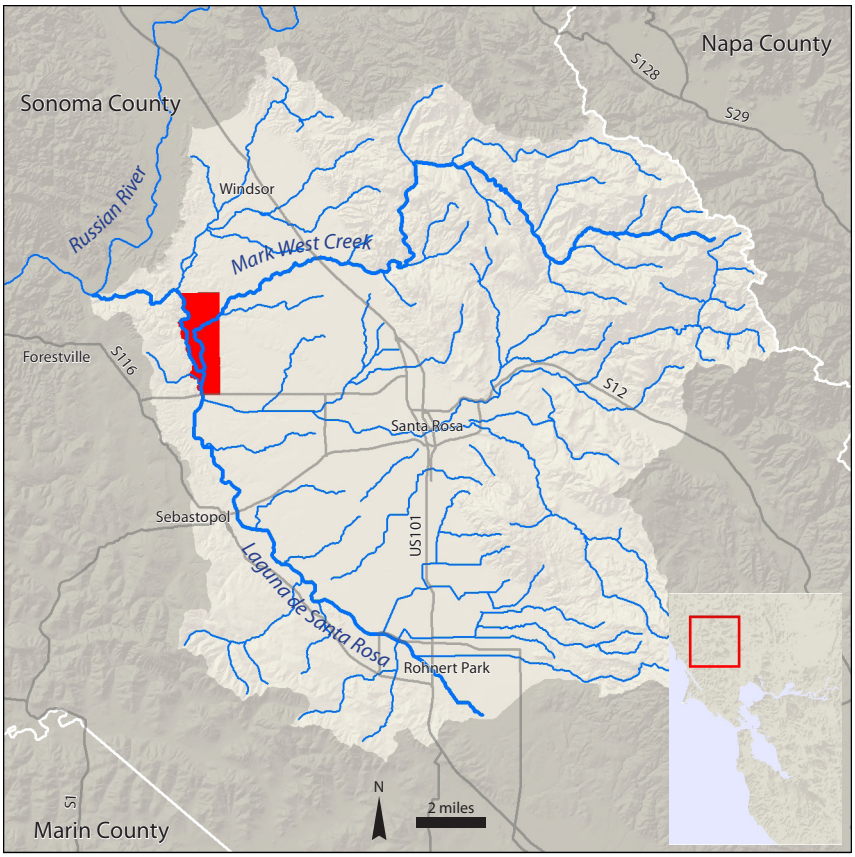
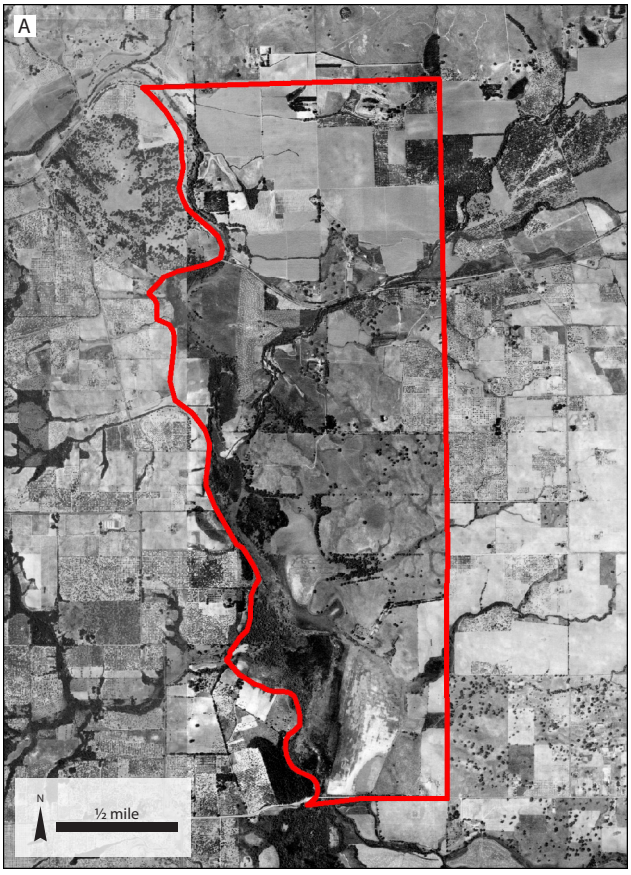
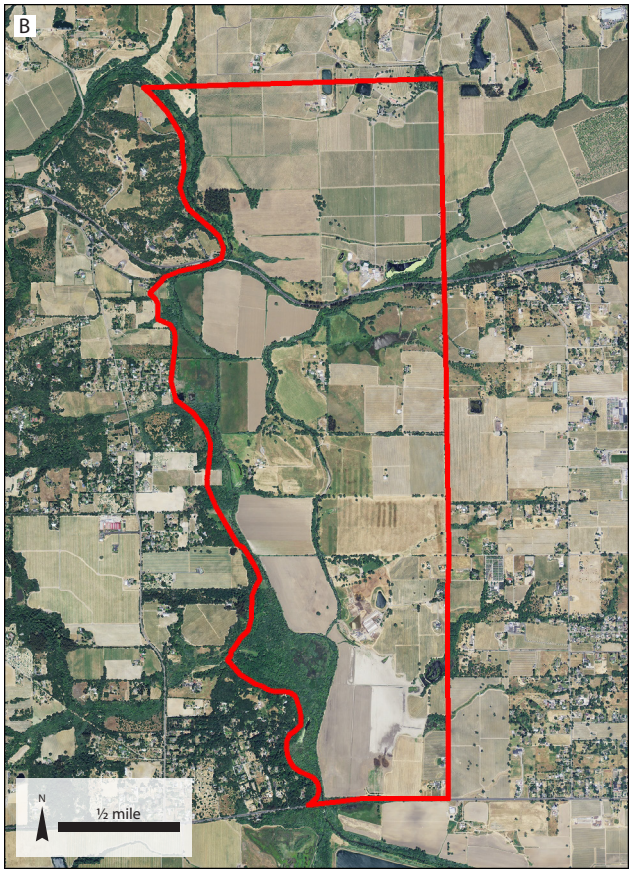


Figure 1. (left) The Laguna de Santa Rosa watershed encompasses 254 square miles in Sonoma County. The three square mile study area, highlighted in red, includes the lower portions of Laguna de Santa Rosa and Mark West Creek near their confluence.

Figure 2. (below) The study area (outlined in red) includes the lower portions of Mark West Creek and Laguna de Santa Rosa near their confluence. A: The left image shows a 1942 historical aerial photomosaic of the study area. B: The aerial photo on the right shows the same area in 2012. (CDF 1942, courtesy UC Berkeley Earth Science & Map Library; NAIP 2012)





METHODS

About Historical Ecology

The use of historical data to study past ecosystem characteristics is an interdisciplinary field referred to as historical ecology (Swetnam et al. 1999, Rhemtulla and Mladenoff 2007). Historical ecology is a powerful tool to reconstruct the form and function of past landscapes, enhancing our fundamental understanding of contemporary landscapes and helping us envision their future potential. It is a critical component in identifying locally appropriate restoration targets, providing the context needed to document change over time, and enabling us to recognize both the constraints and opportunities posed by the contemporary landscape.

Historical ecology relies on the synthesis of a broad array of archival and environmental data. The mapping and analyses developed in this study drew on a diverse range of historical sources created by early surveyors, local residents, and photographers, as well as more contemporary research and datasets. This section details how these sources were collected, interpreted, and mapped.

Data Collection and Compilation

This study drew upon a large number of records from archives, agencies, libraries, and online databases. We visited nine source institutions (Table 1) and consulted numerous online databases to find relevant materials.

The data assembled for this study include written accounts (e.g., General Land Office records, early travelogues and newspaper accounts, and interviews with local landowners), maps (e.g., Mexican land grant maps, property maps, soil and geological surveys, railroad surveys, and U.S. Geological Survey topographic maps), and aerial photographs, as well as a limited number of landscape photographs, lithographs, and drawings. Our efforts focused on 19th century sources, though early- to mid-20th century sources were also collected in order to analyze changes in channel alignment over time. Altogether, we assembled approximately 60 maps, 85 photos, and 60 textual sources for this study.

Once collected, maps, textual data, and photographs were organized geographically, chronologically, and topically. We used ERDAS LPS 9.3 to orthorectify six 1942 aerial photos, providing complete aerial photo coverage of the study area from the earliest available time period (Figure 2a). We also georeferenced[2] 14 of the most detailed and spatially-accurate maps.

Mapping and Data Interpretation

Historical data were synthesized to create a series of GIS layers showing both the historical (ca. 1850-70) channel network as well as changes in channel alignment over time within the study area. The resulting GIS layers depict the mainstem channel configuration of Mark West Creek and Laguna de Santa Rosa over four time periods: ca. 1850-70, ca. 1900-20, ca. 1930-46, and 2012. These time periods were selected as those that would best represent the historical channel network and major modifications to channel alignment given the available data; the map layers are not intended to show all of the changes in channel configuration that have occurred since ca. 1850. In addition, we mapped smaller tributary channels within the study area for two time periods, representing historical (19th century) and contemporary conditions. Channels were mapped as one-dimensional line features. Though

[2] Georeferencing is a process performed using GIS software to define the location of scanned maps, aerial imagery, or other spatial data within a particular coordinate system.

Table 1. Source institutions visited for this study.

Source Institution	Location
The Bancroft Library	Berkeley
Curtis & Associates, Inc.	Healdsburg
North Coast Regional Water Quality Control Board	Santa Rosa
Sonoma County History & Genealogy Library	Santa Rosa
Sonoma County Library	Santa Rosa
Sonoma County Recorder	Santa Rosa
Sonoma County Surveyor	Santa Rosa
Sonoma County Water Agency	Santa Rosa
Sonoma State University Library	Rohnert Park

extensive wetlands existed along the Laguna de Santa Rosa and in other portions of the study area, wetland mapping was not conducted as part of this study (we expect this step will be conducted in a subsequent phase of the Laguna de Santa Rosa Historical Ecology Initiative).

The 2012 GIS layer is based on North Coast Aquatic Resource Inventory (NCARI) mapping for the Santa Rosa Plain (SFEI-ASC 2013). To create GIS layers for the three earlier time periods (ca. 1850-70, ca. 1900-20, and ca. 1930-46), we used the 2012 mapping as a starting point and modified the channel alignment in areas where historical sources clearly indicated a different alignment. To account for uncertainty associated with map scale, georeferencing error, and accuracy of historical sources, we modified the channel location only where the offset between the 2012 mapping and the channel alignment depicted in historical sources was greater than approximately 15 meters (50 feet). In cases where the offset was less than 15 meters, we retained the 2012 mapping as the digitizing source (the source used to trace the channel course in GIS) and supplemented the interpretation with earlier documents. Where the offset between the 2012 mapping and the alignment shown in historical sources was greater than 15 meters, we used a combination of the historical sources as well as physical data (digital elevation models, soil maps, and surficial geology maps) to determine the historical location of the channel. In those cases where we were able to discern a significant change in channel alignment, we used the most spatially-accurate historical source to map the historical channel alignment.

In addition to digitization sources, each segment of the channel network was also attributed with interpretation sources where possible. Interpretation sources are historical sources used to interpret or verify the presence and location of the channel segment during the relevant historical time period. For example, early sources such as General Land Office (GLO) surveys and 19th century property maps support the general alignment of many segments of Laguna de Santa Rosa shown in the 2012 mapping; the historical sources were thus used as interpretation sources for these segments in the ca. 1850-70 GIS layer, while the 2012 mapping was used as the digitizing source. Each mapped channel segment was attributed with certainty levels (high, medium, low) for presence, shape, and location.

The time spans represented by the three earliest layers (ca. 1850-70, ca. 1900-1920, and ca. 1930-46) were chosen to include a range of years within which historical sources depicted the channel configuration with a high degree of consistency. Nevertheless, the historical sources used to create each layer span multiple decades, and thus these layers necessarily represent an integrated or generalized depiction of the channel configurations for these time periods. The year 1946 was chosen as the cutoff in the ca. 1930-46 layer based on clear evidence for major channel re-alignments in that year.

RESULTS

Mark West Creek

Our analysis shows that the channel alignment of lower Mark West Creek has changed substantially over the past 150 years. Historically (ca. 1850-70), lower Mark West Creek flowed northwest across its alluvial fan approximately one-half to three-quarters of a mile north of present-day River Road (Whitacre 1853; Gray 1857a,b; Thompson 1862a; U.S. Surveyor General's Office 1866, 1868; Bowers 1867; Thompson 1877; Reynolds and Proctor 1898; CDF 1942). The confluence of Mark West Creek and Laguna de Santa Rosa was located about two miles north of the present-day confluence, approximately a half mile north of the River Road crossing (Figure 3a).

Between the late-19th century and the 1960s the alignment of lower Mark West Creek shifted progressively further to the south. These shifts appear to have been due primarily to anthropogenic diversions, but in some cases could have been at least partially the result of natural course migration. The first southward shift occurred during the late 1800s: maps from this period show the creek bifurcating near the eastern boundary of the study area (near present-day Slusser Road). One branch of the creek extended northwest, while a second branch extended southwest and converged with the Laguna about a quarter of a mile southwest of the River Road crossing (Figure 3b; Reynolds and Proctor 1898, USACE 1915, Watson et al. 1915, Hicks 1922b, Laughlin 1929, CDF 1942). The alignment of this southern branch corresponds closely to the historical alignment of Woolsey Creek, another tributary to the Laguna (PWA 2004b). It appears that at some point in the late-19th century a new channel connection was created to redirect Mark West Creek south into the Woolsey Creek channel. It is unclear whether the two branches depicted in sources from this period were active simultaneously, or if instead flows occurred predominately in one branch or alternated between the branches. Multiple sources show the northern branch as the dominant course (e.g., Reynolds and Proctor 1898, Hicks 1922a, Laughlin 1929), while others show the southern branch as dominant or show both branches as equally dominant (e.g., USACE 1915, Watson et al. 1915).

Figure 3. (opposite page) Changes in channel alignment of lower Mark West Creek and Laguna de Santa Rosa, ca. 1850 to 2012.

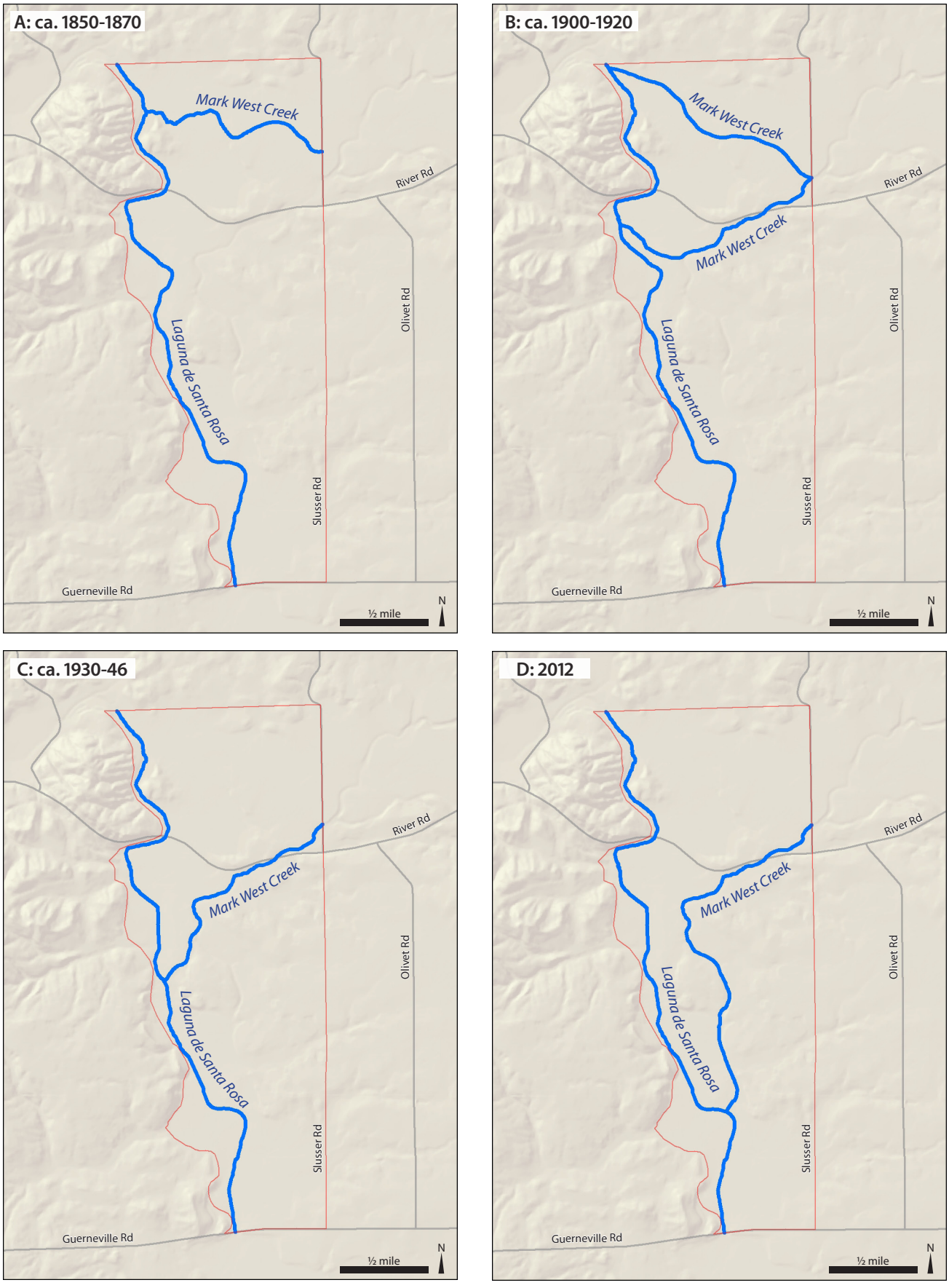
A: Historically (ca. 1850-70), lower Mark West Creek flowed northwest and converged with the Laguna approximately a half mile north of present-day River Road.

B: By the late-19th/early-20th century, the northern branch of Mark West Creek connected with the Laguna approximately three quarters of a mile northwest of the River Road crossing. A bifurcation of the creek near present-day Slusser Road diverted flows into the historical Woolsey Creek channel, which connected with the Laguna about a quarter mile southwest of the River Road crossing.

C: By the mid-1930s the northern branch of Mark West Creek had been eliminated. The creek flowed southwest across the plain, and for most of its course maintained the same alignment as in ca. 1900-20. The lowermost portion of the creek, however, had shifted further south, so that the Laguna-Mark West Creek confluence was located approximately three quarters of a mile south of the River Road crossing.

D: The modern Mark West Creek channel loops south and connects with the Laguna approximately three quarters of a mile north of Guerneville Road.

While the map layers are intended to show most of the major changes in channel alignment over the past 150 years, there were likely additional small changes in alignment that are not reflected in these four "snapshots."


A: ca. 1850-1870
Mark West Creek
River Rd
Olivet Rd
Laguna de Santa Rosa
Slusser Rd
Guerneville Rd
½ mile
N
B: ca. 1900-1920
Mark West Creek
River Rd
Mark West Creek
Olivet Rd
Laguna de Santa Rosa
Slusser Rd
Guerneville Rd
½ mile
N
C: ca. 1930-46
River Rd
Mark West Creek
Olivet Rd
Laguna de Santa Rosa
Slusser Rd
Guerneville Rd
½ mile
N
D: 2012
River Rd
Mark West Creek
Olivet Rd
Laguna de Santa Rosa
Slusser Rd
Guerneville Rd
½ mile
N

The northern branch of lower Mark West Creek appears to have persisted in some form at least until 1929 (Laughlin 1929). However, by the mid-1930s the northern branch had been entirely replaced by agricultural fields, and the primary channel was located to the south of River Road (Figure 3c; USGS [1933-5]1942, CDF 1942, California Department of Natural Resources 1945). The Laguna-Mark West Creek confluence had been shifted further south by this time, and was located approximately three-quarters of a mile south of the River Road crossing, along a stretch of the Laguna that supported an approximately 40-acre perennial body of water known as Ballard Lake (Cummings 2004).

Several additional diversions in the mid- to late-20th century shifted the lower portion of Mark West Creek even further south. In 1946 a new channel was excavated that rerouted Mark West Creek to the southeast and around a small hill, where it terminated in a field connected to the Laguna wetland complex (USGS 1954, Denner 2002). In 1963, the creek was again shifted further to the south, establishing the basic channel alignment that has persisted until the present time (Wallace 1964, Denner 2002). Today lower Mark West Creek flows south to connect to the Laguna approximately three-quarters of a mile north of Guerneville Road (Figure 3d; NAIP 2012).

Laguna de Santa Rosa

Though we mapped the Laguna de Santa Rosa as a one-dimensional line feature, historically many portions of the Laguna within the study area were part of a wetland complex without a clearly defined channel; in these areas, the mapping represents the approximate centerline of the wetland complex. Analyzing changes in channel alignment is therefore less relevant for Laguna de Santa Rosa than for Mark West Creek and other tributaries with more defined channels.

The primary morphological changes to the lower Laguna de Santa Rosa over the past 150 years have been the loss of floodplains, lakes, and marshes due to draining, filling, and channelization (Smith and Cummings 1990, Honton and Sears 2006). In the 1920s, for instance, the San Francisco and North Pacific Railroad dynamited the Laguna channel downstream of the trestle adjacent to River Road to increase drainage and reduce flooding (Denner 2002). Ballard Lake was drained in the mid-20th century, and a portion of the Laguna to the north of the lake was ditched and straightened (PWA 2004b, SFEI-ASC 2013). Likewise, a section of the Laguna just north of Guerneville Road at the southern end of the study area was channelized in the 1960s (Waaland 1989). Because wetland mapping was not conducted as part of this study, the substantial decrease in the extent of wetlands and open water along lower Laguna de Santa Rosa is not reflected in the GIS layers.

Tributaries

In addition to changes in the channel alignment of Mark West Creek and the loss of historical wetland habitat along the Laguna de Santa Rosa, there have been substantial changes to the configuration of smaller creeks and tributaries within the study area. These changes appear to have decreased the overall sinuosity and increased the connectivity of the tributary network.

Historically, numerous streams and swale complexes originated in the Santa Rosa Plain to the east of the Laguna and flowed west (Figure 4a). Additional tributaries drained east from the steeper hills to the west of the Laguna. Many of the tributaries draining towards the Laguna likely lost definition or joined with the larger wetland complex before reaching the mainstem of the Laguna. As agricultural development expanded, many of these tributaries were straightened and ditched. As a result, tributary

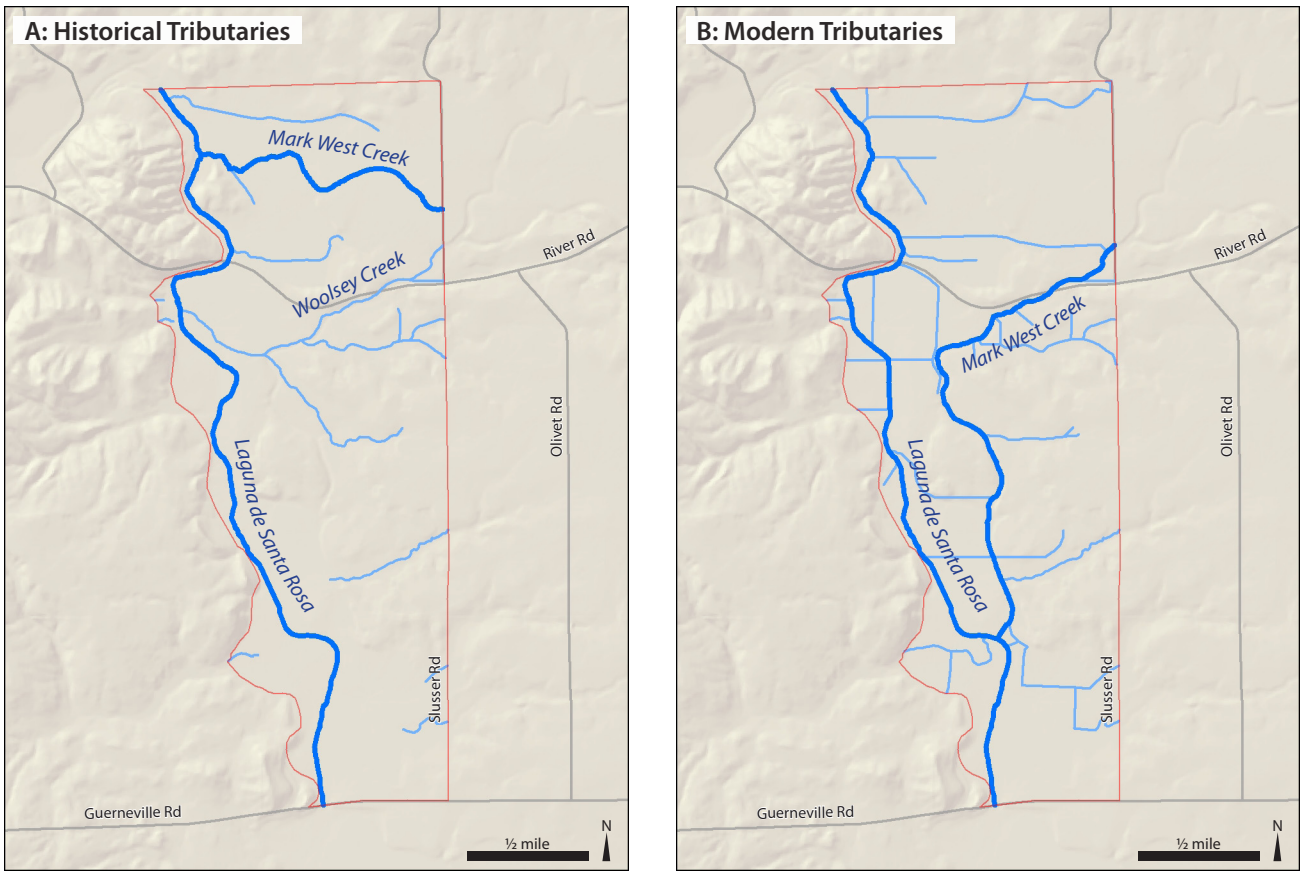


Figure 4. Changes in the tributary network within the study area. A: Historically, numerous small tributary streams drained into the Laguna from the Santa Rosa Plain to the east and from the Wilson Grove Formation to the west. Some of these tributaries lost definition or joined the Laguna de Santa Rosa wetland complex before reaching the mainstem of the Laguna. Numerous small swale complexes (not mapped) also contributed to drainage from the Santa Rosa Plain historically. B: Extensive ditching and diversions appear to have increased the connectivity and decreased the sinuosity of the tributary network.

Woolsey Creek can be seen in the historical tributary layer flowing southwest across River Road. It appears that in the early 1900s Mark West Creek was ditched to run south into the Woolsey Creek channel; the modern Mark West Creek channel alignment still occupies this channel in the vicinity of River Road.

streams that were historically disconnected from the mainstem channels during most of the year are now directly connected to Mark West Creek or Laguna de Santa Rosa (Figure 4b; Potter and Hiatt 2009).

Timeline of Key Sources and Events

A graphical timeline of selected historical sources and events is provided in the following pages. The sources included in the timeline represent the key evidence used to reconstruct the channel alignment of lower Mark West Creek and Laguna de Santa Rosa over time.

Timeline of Key Sources and Events

CITY OF SANTA ROSA INCORPORATED (1868)

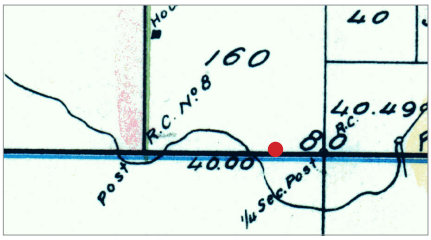
1850 1860 1870

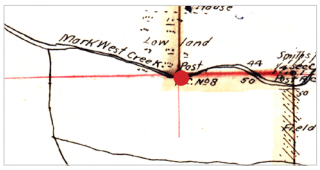
General Land Office survey notes and plats

Early General Land Office survey notes and plats document Mark West Creek flowing northwest as it approaches the Laguna. (Plats: Gray 1857b, U.S. Surveyor General's Office 1866, 1868, courtesy of Bureau of Land Management; Thompson 1862a, courtesy of The Bancroft Library, UC Berkeley)

"To Mark West creek 50 lks. wide course N.W."

—WHITACRE 1853



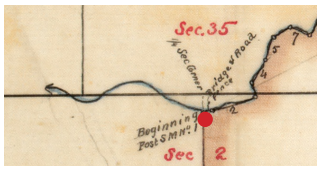


"Near the north bank of the creek."

—GRAY 1857A

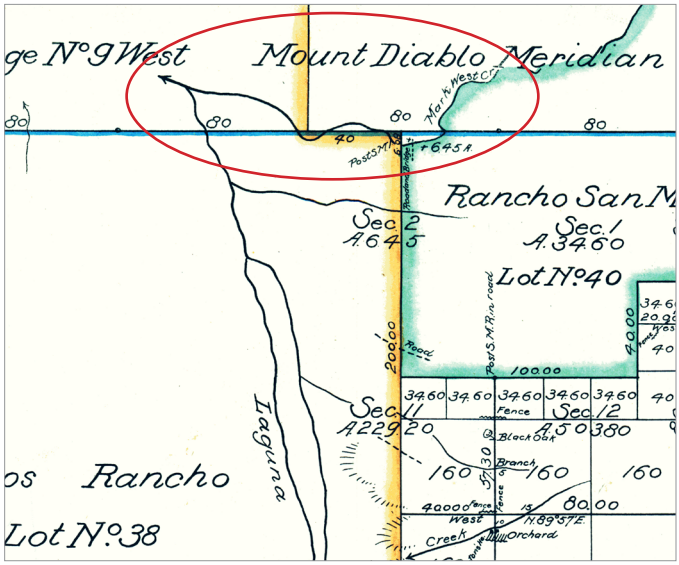
"Cross Mark West creek 80 links course southwest."

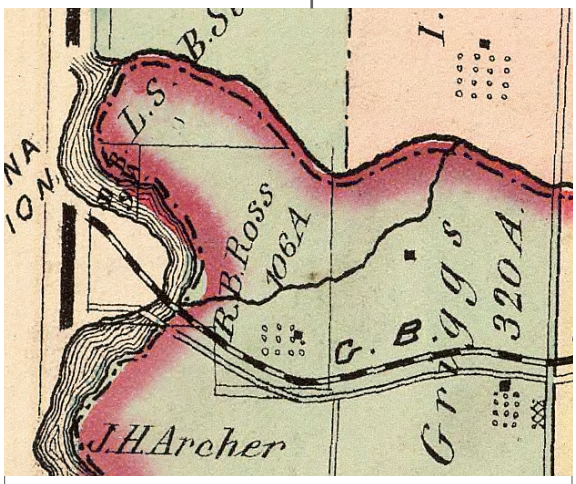
—GRAY 1857A



"On the left bank of the Mark West Creek."

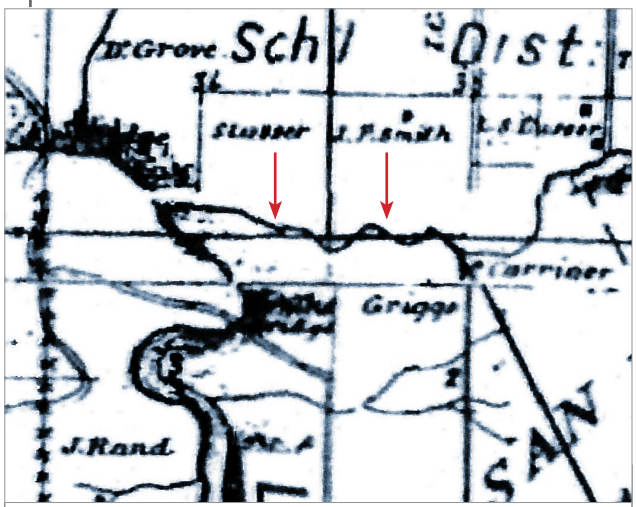
—THOMPSON 1862B





Thompson 1877

It is possible that the initial diversion of Mark West Creek occurred as early as the 1870s: Thompson (1877) shows the primary Laguna-Mark West Creek confluence about a half mile north of River Road, with a secondary branch diverging from the mainstem of Mark West Creek and flowing southwest to connect with the Laguna near the River Road crossing. Note that the secondary (southern) branch shown in Thompson 1877 is located further to the northwest than the secondary branch shown in later maps (e.g., see Reynolds and Proctor 1898, facing page). (courtesy of David Rumsey Map Collection)



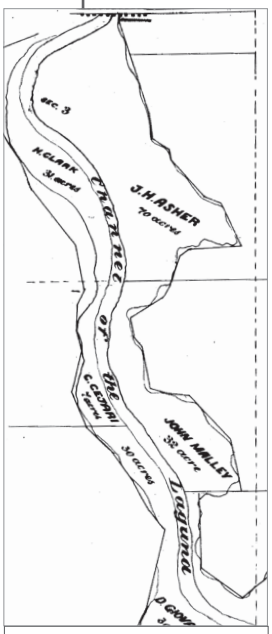
Bowers 1867

Mark West Creek can be seen flowing northwest in this 1867 county map. (courtesy Sonoma State University Library)

FULTON AND GUERNEVILLE BRANCH OF SAN FRANCISCO AND NORTH PACIFIC RAILROAD COMPLETED (1877)

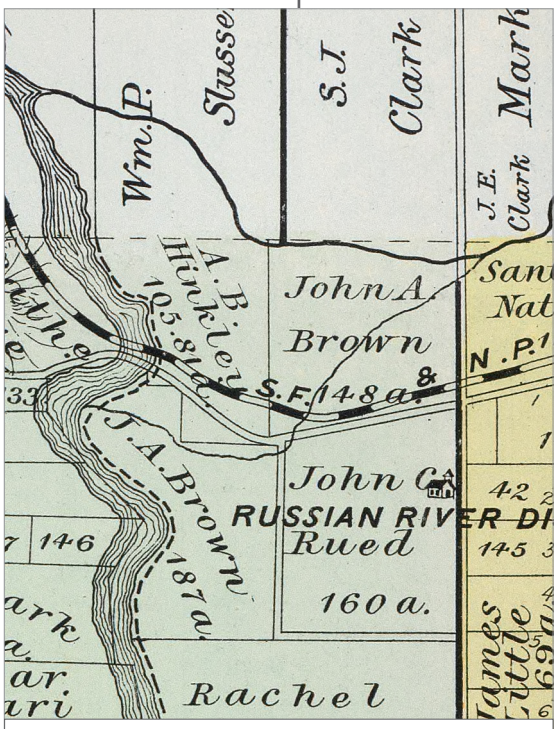
CITY OF SEBASTOPOL INCORPORATED (1902)

1880 1890 1900



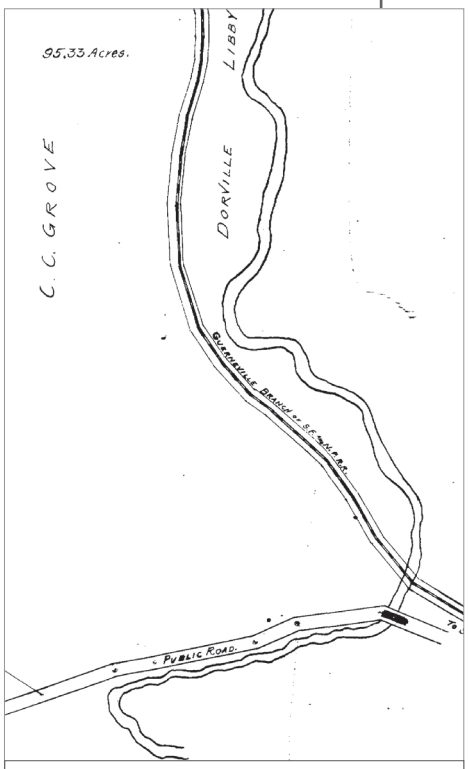
Davis 1879

This 1879 plat of the Laguna Drainage District shows the position of the mainstem channel of the Laguna as well as the extent of the surrounding wetlands (not included in our map layers). (courtesy of Sonoma County Recorder)



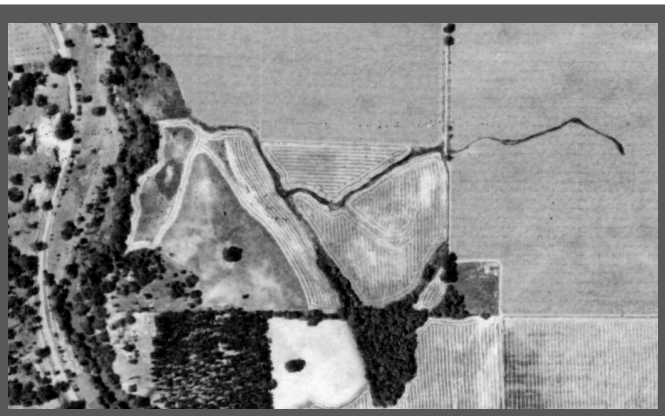
Reynolds and Proctor 1898

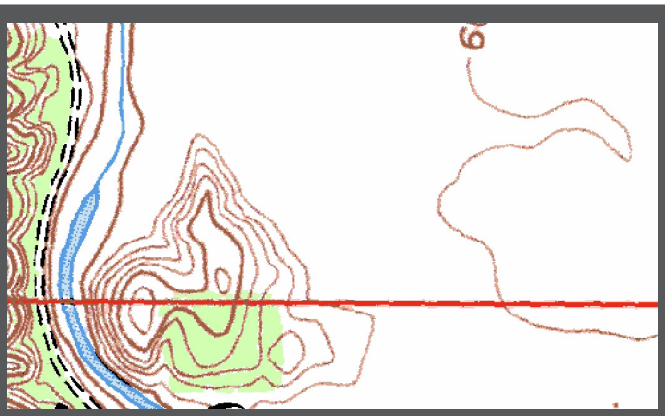
By the late 1890s, Mark West Creek bifurcated near modern-day Slusser Road. A northern branch extended to the northwest, closely following the historical alignment, while a southern branch extended southwest and converged with the Laguna approximately a quarter mile to the southwest of the River Road crossing. (courtesy of David Rumsey Map Collection)



Ricksecker 1899

The alignment of the mainstem Laguna de Santa Rosa channel in the vicinity of the River Road crossing as shown on this detailed 1899 property map is similar to the modern channel alignment. (courtesy of Sonoma County Recorder)



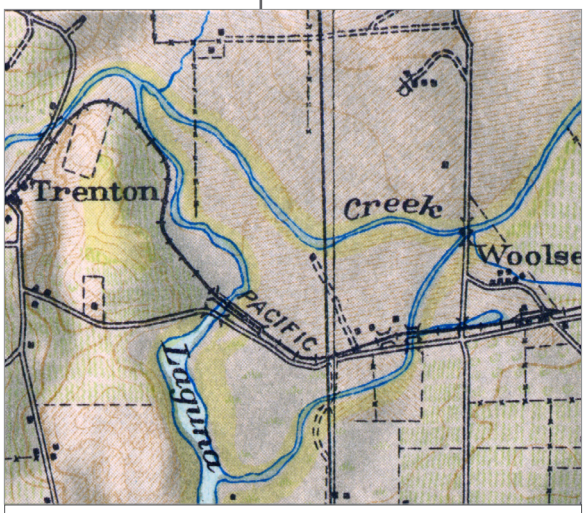


Remnant features in later sources

Traces of historical channels often persist in the landscape for decades or centuries, and later sources which reveal these remnant features can be used in conjunction with early records to map historical channel configurations. The 1942 aerial photo (left), for example, shows a remnant portion of the ca. 1850-70 Mark West Creek channel just east of the Laguna, surrounded by agricultural fields. Though this feature is no longer present today, modern topographic mapping (right) shows v-shaped depressions in the old alluvial fan of Mark West Creek, indicating persistent low spots where the channel once flowed. (Sources: CDF 1942, USGS 1981.)

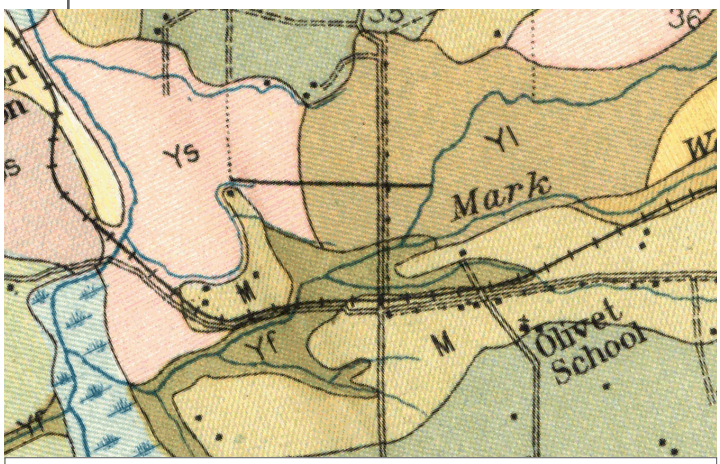
Timeline of Key Sources and Events (continued)

1910 1920 1930



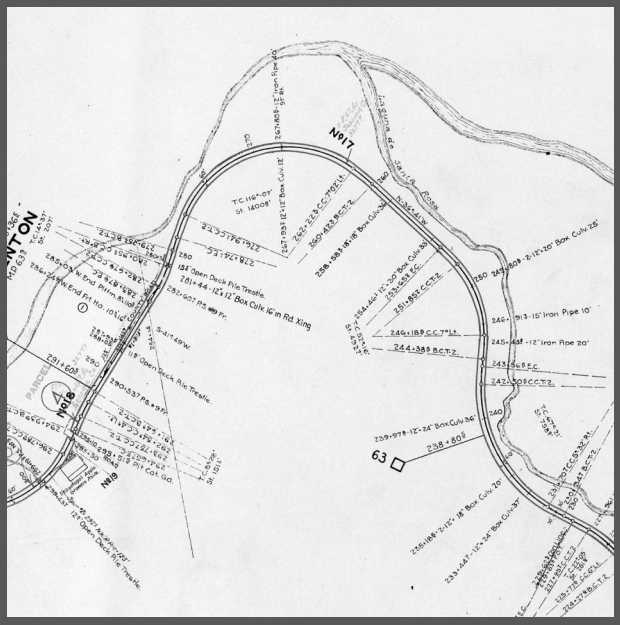
USACE 1915

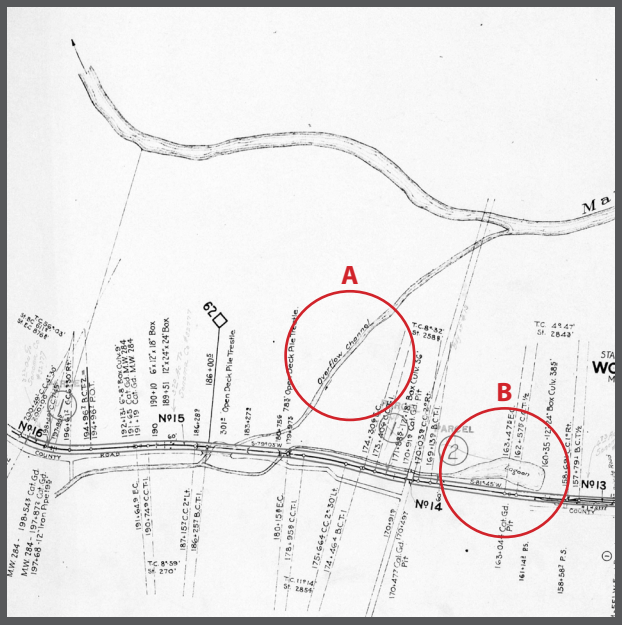
This 1915 topographic quadrangle shows both a northern and southern branch of Mark West Creek. Neither branch is depicted as dominant. (courtesy of Curtis & Associates, Inc.)



Watson et al. 1915

Though a northern branch of Mark West Creek persisted throughout the 1920s (e.g., Hicks 1922a,b, Laughlin 1929), this 1915 soil map shows only a southern channel (in contrast to USACE 1915, left), indicating that flows may have been concentrated in the southern branch or may have alternated between the two branches during this time. (courtesy of University of Alabama)





Hicks 1922a,b

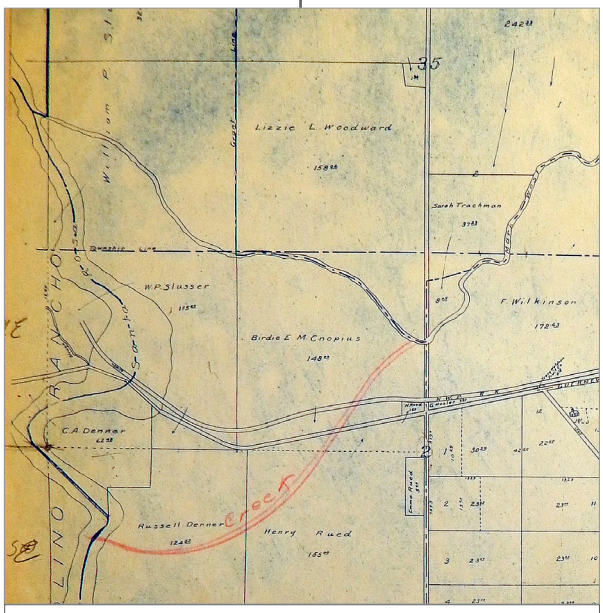
The ditch diverting flow from the historical Mark West Creek channel into the Woolsey Creek channel is labeled as "Overflow channel" in this 1922 railroad map (A - right; Hicks 1922a). The "Lagoon" feeding into Woolsey Creek is visible in the bottom right corner (B). In contrast to the depiction in Watson et al. (1915; above), the relative size of the channels in this map suggests that the northern branch of Mark West Creek was still the dominant channel at the time this map was produced. A second sheet of the map (left; Hicks 1922b) shows the confluence of the Laguna and the northern branch of Mark West Creek further downstream. (courtesy of Sonoma County Recorder)

SONOMA COUNTY AIRPORT (SANTA ROSA ARMY AIRFIELD) CONSTRUCTED (1941-42)

MARK WEST CREEK DIVERTED TO FLOW SOUTHEAST AROUND SMALL HILL ON DENNER PROPERTY (1946)

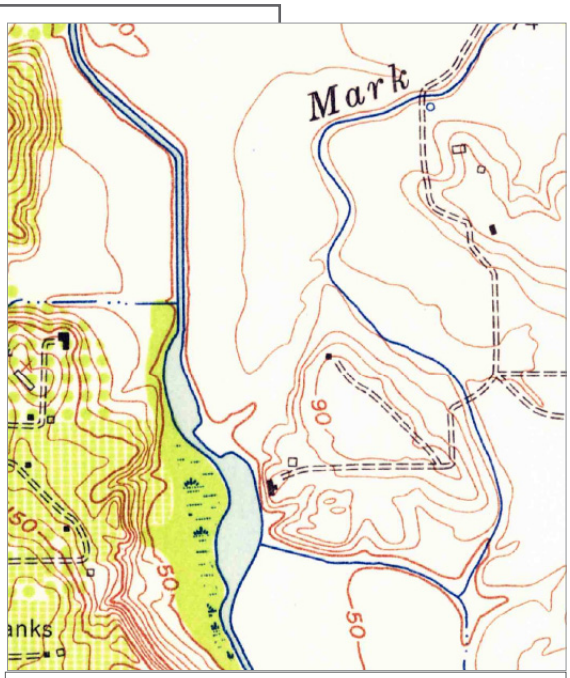
MARK WEST CREEK RE-ALIGNED, RESULTING IN APPROXIMATE OUTLINES OF MODERN CONFIGURATION (1963)

1950 1960 1970



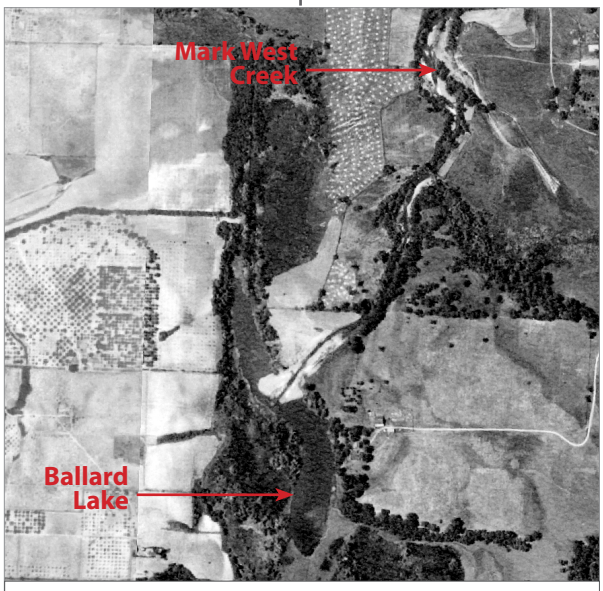
Laughlin 1929

This 1929 map contains the last depiction of the northern branch of Mark West Creek that we were able to locate. The southern branch, labeled "creek," is sketched in with much less precision than the northern branch, suggesting that the northern branch may still have been the dominate channel at this time. (courtesy of Curtis & Associates, Inc.)



USGS 1954

Local resident Stan Denner recalls that in 1946 his father "cut a slot through the hill east of Mark West Creek" and diverted the creek further to the south (Denner in LeBaron 1990). The USGS 1954 topographic quadrangle appears to show this altered alignment, with Mark West Creek flowing southeast around a small hill before turning west again and flowing into the Laguna wetland complex.

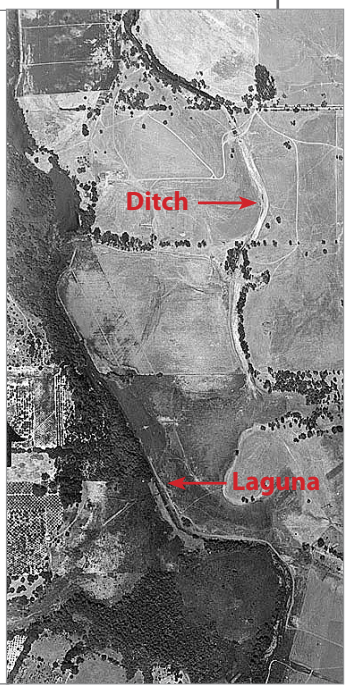


CDF 1942

By 1942, only the southern branch of Mark West Creek remained. The lower portion of the channel had shifted south, and the creek flowed into the Laguna in the vicinity of Ballard Lake.

Wallace 1964

The modern alignment of Mark West Creek had mostly been established by the mid-1960s. Denner recalls, "In 1963 my brother and I ditched the creek": the ditch is visible running north-south in this August 1964 aerial photo (Denner in LeBaron 1990). (courtesy of Sonoma County Library)



DISCUSSION

Our analysis reveals a series of major southward shifts in the channel alignment of lower Mark West Creek over the past century and a half. In the mid-19th century this portion of the creek flowed northwest across the Santa Rosa Plain to its confluence with the Laguna de Santa Rosa. Major changes in the alignment of the creek occurred in the late-19th century and again in the early- to mid-20th century. Today, the Laguna-Mark West Creek confluence is located approximately two miles south of the historical confluence.

It is possible that significant anthropogenic changes in channel alignment may have occurred as early as the mid-19th century, though we were unable to find documentation for changes during this period.[3] For example, one local resident hypothesized that in the 1840s and 50s Mark West Creek entered the Santa Rosa Plain south of its current alignment and flowed across present-day Coffey Lane in the vicinity of Piner Creek (east of the study area; Unknown 1991). This resident claimed that Mark West (an early settler for whom the creek is named) intentionally diverted the creek to flow further north. This scenario appears plausible given the topography of the eastern Santa Rosa Plain and the proximity of Mark West and Piner creeks in this area, but we were unable to locate any direct evidence to substantiate this alternate alignment.

We found relatively little historical documentation to allow us to determine whether the late-19th century changes in the alignment of Mark West Creek were due to natural course shifts or anthropogenic modifications. Mark West Creek flowed across an alluvial fan of its own making, created by natural sediment deposition along alternate courses. Over geologic time, the creek would have naturally switched course, radiating in different directions, so some changes reflected in the historical record may have been natural. However, the few pieces of evidence available suggest that the southern branch of the creek that first appeared in the late-19th century (see Figure 3b) may have been the result of efforts to prevent flooding along the San Francisco and North Pacific Railroad line (which closely paralleled the course of modern-day River Road) and surrounding property. Damage or delays caused by flooding could at times be significant: in March of 1879, for instance, the *Sacramento Daily Union* reported, "The train on the Guerneville branch was four hours and twenty minutes crossing the trestle work at the laguna [sic] yesterday. The water stood three feet deep on the track." Sediment deposited at the Laguna-Mark West Creek confluence could have backed up flows upstream in the Laguna and contributed to inundation of the railroad line (Waaland 1990, Cummings 2004, PWA 2004a). This explanation is supported by the earliest map showing a secondary channel for Mark West Creek (Thompson 1877, see page 10), which perhaps depicts an early effort to realign the creek and was produced in the same year that the Fulton and Guerneville branch of the railroad was completed (Schubert 2013).

There is substantial documentation indicating that the mid-20th century changes in the alignment of Mark West Creek were undertaken by local landowners to manage sediment and increase the availability of land for agricultural use. According to an interview given by landowner Stan Denner in 2002, soil excavation associated with the construction of the Sonoma County Airport (then called the Santa Rosa Army Airfield) just to the north of Mark West Creek, coupled with several seasons of heavy rains

[3] Though the earliest documented changes in the channel alignment of Mark West Creek were during the late-19th century, modifications to a free-flowing Laguna de Santa Rosa/Mark West Creek began as early as 1834, with the construction of California's first water-powered grist and lumber mill by John B. R. Cooper, recipient of the El Molino land grant (1833) and brother-in-law to General Vallejo. The mill was located to the west of the study area on Laguna de Santa Rosa (called Mark West Creek in some sources – see footnote about tributary ambiguity on page 1), approximately 1,000 feet upstream of the Russian River (Clar 1957).

in the early 1940s, resulted in heavy sediment inputs to Ballard Lake. In response, in 1946 Denner's family hired contractors to create an artificial channel which rerouted Mark West Creek to the southeast and shifted sediment deposition to a field adjacent to the Laguna wetland complex. Denner stated that, over a period of 17 years, sediment inputs from the creek raised the elevation of the 50-acre field by approximately five feet (Denner 2002). Likewise, the channel excavated in 1963 directed sediment to agricultural fields further south, where it again significantly raised elevations (Denner 2002).

The changes in channel alignment that have occurred over the past 150 years along lower Mark West Creek have likely had a variety of impacts on ecological and hydrogeomorphic functioning within the lower Laguna region. One major effect has been to alter sediment transport dynamics and patterns of localized sediment deposition. The historical lower Mark West Creek alignment that existed from ca. 1850-70 had a relatively direct route to the downstream extent of the Laguna de Santa Rosa and a relatively steep gradient compared to the present-day channel. As a result, it is likely that a relatively high proportion of the historical Mark West Creek sediment load would have been transported to the lowest reach of the Laguna or deposited on the adjacent alluvial fan. Sediment from Mark West Creek that was deposited in the lower Laguna de Santa Rosa channel historically likely caused local impoundment of flows in the Laguna and contributed to the formation and maintenance of upstream lakes and wetlands, such as Ballard Lake (PWA 2004a, PWA 2004b).

Compared with the historical configuration, the modern alignment of lower Mark West Creek is longer, has a lower gradient, and enters the Laguna de Santa Rosa approximately two miles further upstream. Because of the increased length and reduced channel gradient, the modern channel has a lower sediment transport capacity relative to the historical course, causing more of the sediment load to be deposited in-channel and on the surrounding floodplain. Winzler & Kelly-GHD (2012) also note that the channel's "hooked alignment" near the confluence with the Laguna contributes to flow accumulation during high flow events and the subsequent deposition of sediment and debris on the adjacent floodplain. In addition, Mark West Creek currently delivers sediment further towards the head (or upstream end) of the Laguna, which contributes to a higher rate of Laguna sediment accumulation and infilling than existed in the mid-1800s (PWA 2004b). Thus, while sediment deposition occurred naturally near the historical Laguna-Mark West Creek confluence, the current rate of sediment deposition and associated ecological impacts along lower Mark West Creek are undoubtedly different than they were historically. In fact, sedimentation at the Laguna de Santa Rosa-Mark West Creek confluence has been recently shown to contribute to flooding in the Laguna de Santa Rosa upstream of the confluence and to alter aquatic habitat quality and functioning (PWA 2004a, Winzler & Kelly-GHD 2012).

Changes in the Mark West Creek channel alignment may have also contributed to changes in the extent of the Laguna wetland complex. Though wetland mapping was not conducted as part of this study, the substantial reduction in the historical extent of the Laguna wetland complex has been well-documented (Smith and Cummings 1990, Honton and Sears 2006). As noted above, sediment deposited at the historical Laguna-Mark West Creek confluence would have partially blocked flows within the Laguna channel and increased the extent of upstream pools and wetlands. By shifting direct sediment inputs away from the historical Laguna-Mark West Creek confluence, the diversion of Mark West Creek likely contributed to the reduction of open water and wetland habitat upstream.

The channelization of portions of Laguna de Santa Rosa and many of the smaller tributaries draining into the wetland complex has also affected ecological and hydrogeomorphic functioning in the lower Laguna region in a variety of ways. Where slow-moving water once spread out and sustained large off-channel wetlands, artificial ditches now convey flows more rapidly downstream, likely contributing to

a reduction in wetland habitat (Waaland 1989, Smith and Cummings 1990). During storm events, concentrated flows can quickly exceed channel capacity, resulting in more intense flooding downstream (Curtis et al. 2013). Sediment deposition from the smaller drainages was historically dispersed through a network of distributary channels, which were often disconnected from the mainstem channel of the Laguna; today, flow and sediment loads are concentrated in artificial channels, leading to increased in-channel deposition and higher sediment input to the Laguna (Sloop et al. 2007).

Another effect of channel modifications in the lower Laguna region over the past 150 years has been a reduction in the quality and extent of fish habitat. Changes in the alignment of lower Mark West Creek, for instance, have reduced steelhead access to and from upstream spawning habitat by creating conditions that have led to stranding on the surrounding floodplain (Winzler & Kelly-GHD 2012). In addition the faster, "flashier" flows and lack of refugia that characterize the straightened tributary channels are unfavorable to salmonids such as coho salmon, which require low-velocity off-channel habitat during high flows (Moyle 2002, NMFS 2010). Other native fish species that are potentially present in the lower Laguna region and have likely been impacted by channel modifications or wetland loss include Sacramento blackfish (*Orthodon microlepidotus*), Sacramento sucker (*Catostomus occidentalis*), Sacramento pikeminnow (*Ptychocheilus grandis*), hardhead (*Mylopharodon conocephalus*), hitch (*Lavinia exilicauda*), California roach (*L. symmetricus*), riffle sculpin (*Cottus gulosus*), prickly sculpin (*C. asper*), tule perch (*Hysterocarpus traskii*), Pacific lamprey (*Entosphenus tridentata*), and Western brook lamprey (*Lampetra richardsoni*) (O'Rear et al. 2008, Chase pers. comm.).

NEXT STEPS AND FUTURE RESEARCH

Restoring lower Mark West Creek to a course closer to its ca. 1850-70 channel alignment could potentially alleviate some of the management problems resulting from the current alignment, such as high rates of sediment deposition in the Laguna, flooding, trash accumulation, and poor quality fish habitat. Such a change could also make the lower Laguna region more resilient to future land and water uses changes within the watershed, such as increased urban runoff or changes in sediment supply resulting from upstream erosion. To date, relatively low levels of development within the Mark West Creek basin have kept sediment production at low levels relative to nearby catchments, but the steep, erodible topography of the headwaters region means that future land use changes could greatly increase sediment production, further impairing ecological functioning downstream (PWA 2004b, Sloop et al. 2007). Any changes in channel alignment would require further study and collaboration with local landowners.

We recommend a number of additional research avenues to build on the findings of this study and further enhance understanding of the historical conditions and ecological functions of the lower Laguna area; some of these items may be investigated as part of the larger Laguna de Santa Rosa Historical Ecology Initiative:

- Conduct historical wetland and terrestrial habitat mapping within the study area to enhance understanding of historical ecological functions (e.g., the extent and quality of salmonid rearing habitat), water storage and transport (e.g., the location and hydrology of Ballard and Jonive lakes), and other elements of the historical landscape.

- Extend historical channel mapping to the entire Mark West Creek basin to document upstream changes in channel alignment and provide a watershed perspective for interpreting changes that have occurred in the lower Laguna region.
- Model sediment transport based on the historical channel alignments of Mark West Creek and lower Laguna de Santa Rosa to provide a quantitative basis for comparison of historic and current sediment dynamics and geomorphic functioning.
- Conduct additional research on key land and water use changes (e.g., agricultural development, groundwater extraction, urbanization, etc.) to provide additional context for understanding the causes and effects of observed hydrologic and geomorphic changes.
- Develop conceptual models illustrating the ecological impacts (i.e., loss of ecosystem services and species support functions) associated with channel modifications and other land use changes within the lower Laguna area. Conceptual models can be powerful tools for summarizing and communicating findings to managers and other stakeholders.

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