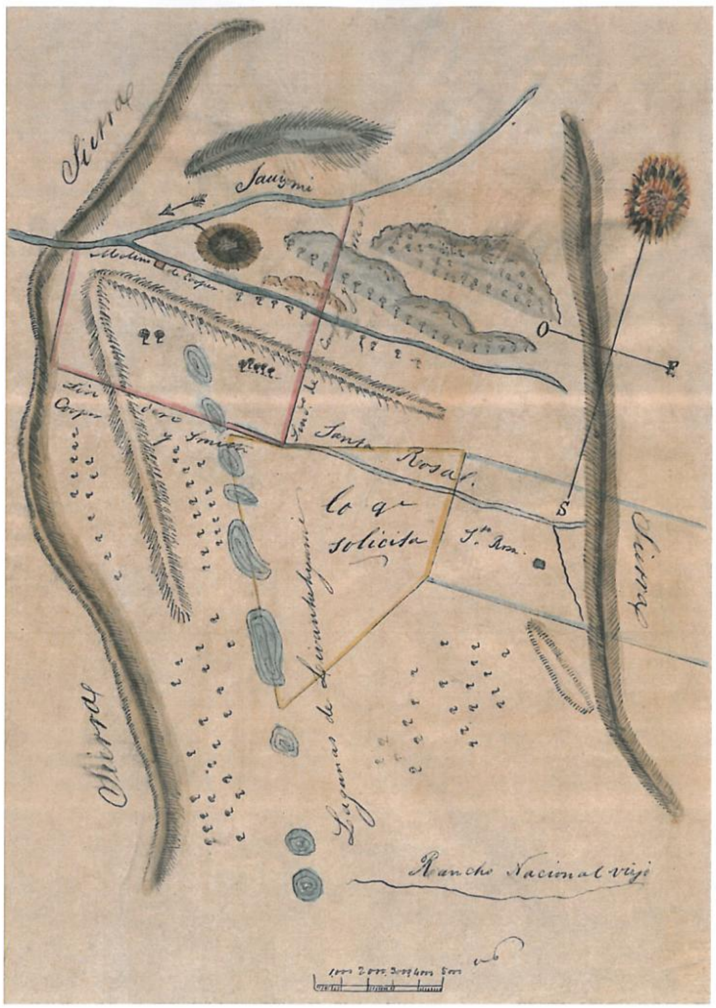
Laguna de Santa Rosa
Historical Hydrology Project
Headwaters Pilot Study



FINAL REPORT

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PURPOSE

The primary purpose of this study was to create a detailed map and document surface hydrology conditions in the southern headwaters of the Laguna de Santa Rosa at the time of European-style settlement in the mid-19th century. This report also includes some preliminary information on historical vegetation and wildlife uncovered during our research.

Knowledge of historical patterns is an essential foundation for sustainable planning and is fundamental to designing projects aimed to achieve multiple benefits, such as improved water quality, ground water recharge, flood reduction, and habitat restoration. This report is intended to assist the Sonoma County Water Agency, the North Coast Water Quality Control Board, the cities of Rohnert Park and Cotati, the Laguna de Santa Rosa Foundation, private landowners, and other stakeholders concerned with improving the ecosystem function of the southern headwaters of the Laguna and areas downstream.

OVERVIEW

Human population growth and climate change are causes for increasing local concern over future water supply, flood management, and effective restoration of ecosystems. These pressures make it more important than ever to understand and work with the landscape patterns and processes upon which modern infrastructure has been built. Human-caused changes over the last two centuries have obscured natural patterns and processes, making it difficult to incorporate them into planning and management. As a result, ongoing land development continues to cover or impact important water recharge and wildlife habitat areas, rainfall is increasingly diverted into ditches and storm drains for fast run-off, only to cause erosion and flooding downstream, and restoration efforts may be based on unfounded assumptions about historical processes and ecosystem function and so fail to produce lasting benefits.

Encompassing the uppermost section of the Laguna main stem and several tributary streams, including Crane and Copeland Creeks, this study combined an intensive analysis of the historical record with field surveys to develop a picture of mid-19th century surface hydrologic conditions to a high level of detail. The following narrative is a best estimate of these conditions, based on a wide variety of corroborating sources.

At the time of settlement, Copeland, Crane, and other tributary creeks did not have continuous channels connecting their headwaters to the Laguna's main stem (Martin 1859; Bowers 1867; United States District Court c. 1840; United States District Court c. 1844). During the dry season, their waters petered out as they reached their alluvial fans at the base of the hills (Figure 1). With the arrival of winter storms, these creeks began to flow across their fans and the valley 'flats' beyond. Some waters reached the Laguna's main channel, while the rest was either absorbed into the soil or collected in depressions to create seasonal wetlands of all sizes. Hydrologically and floristically, these seasonal wetlands were probably similar to vernal pools or swales in other parts of the Laguna watershed. These seasonal creek channels shifted periodically on their alluvial fans, with Copeland Creek actually switching watersheds, sometimes flowing into the

Laguna/Russian River watershed, other times heading south to the Petaluma River and San Pablo Bay (Bowers 1867, Cardwell 1958, Cook 2010).

Among the seasonal wetlands were two large ephemeral lakes in the Cotati/Rohnert Park area (Martin 1859). One of these was probably along the Laguna main channel, while the other may have been one of the largest vernal pools in the county at that time. As the year progressed into the dry season, these lakes evaporated and disappeared, leaving behind desiccated annual forbs and grasses on a hard, dry surface. Only one perennial lake persisted on the Laguna main stem (U.S. District Court c. 1840; Bowers 1867). During the summer, this lake likely had no surface flow in or out as the main Laguna stem itself was intermittent. A strip of perennial marsh may have existed along the margin of this lake, but does not appear to have existed elsewhere in the study area. Most of the study area would likely have been quite open, with small groves of oaks separated by large expanses of grassland, forbs, and seasonal wetland, with riparian trees and shrubs along the main channel of the Laguna.

The historical conditions described above would have provided important seasonal habitat for egrets, herons, migratory and resident dabbling ducks, shorebirds, and many amphibians and invertebrates. The perennial upper reaches of Copeland Creek, and probably others, supported an abundance of native trout (Cummings 2005).

Settlement brought with it the desire for faster drainage. Ditches for roads, agriculture, and railroads began stitching together formerly disconnected channels. Rather than ponding in shallow basins, the creek waters that historically fed the seasonal wetlands were directed into the Laguna's main stem. By the 1870s, both Copeland and Crane Creeks had channels connecting their headwaters directly to the Laguna main stem. This trajectory of increasing connectivity continues to the present day, with earth-moving machines carving channels across the flats in the 1970s, storm drains installed in recent housing developments, and drainage tile placed under vineyards.

While analysis of the effects is beyond the scope of this study, the consequences of these historical changes probably include habitat loss, decreased groundwater recharge, decreased water quality, and increased erosion and flooding downstream. The historical conditions of the watershed and these outcomes are important factors to consider in the planning of effective projects for restoration of the Copeland, Crane and entire Laguna watersheds.

METHODS

We compiled, analyzed, and integrated historical and physical evidence to document and map the historical alignments of creeks, wetlands, and water bodies in the project area. Mapping was done using standards developed and used for historical hydrology mapping of nearby areas of northern California (Egan and Howell 2001; San Francisco Estuary Institute 2006; Sonoma Ecology Center 2009) in the following sequence:

- The project's focus area was chosen during a meeting of stakeholders at the Laguna de Santa Rosa's headquarters in November 2009 (Figure 1).

- Historical maps, mid-19th century General Land Office (GLO) surveys, 1942 aerial photographs, modern geological and soil maps, and recent aerial photos were compiled, digitized, and georectified as needed, analyzed in GIS (Geographic Information System), and used as the basis for developing a preliminary map of the project area's estimated historical surface hydrology. We also researched and considered information from written historical accounts.
- We gleaned additional information from several books and reports on the area. An oral history from long-time residents John and Kate Fomasi, was also consulted.
- We made field visits to refine and 'ground-truth' the preliminary map. We recorded field observations using GPS (Global Positioning System) devices. We also collected information from several local residents during these field visits.
- After analyzing all sources, we mapped each historical feature once. To account for varying levels of doubt, we assigned each feature a certainty level for presence; shape, size or extent; and location (Table 1.)

	PRESENCE	**SHAPE, SIZE, or EXTENT**	**LOCATION**
HIGH	Appears in historical record before 1877 and confirmed by additional sources, including at least one of the following: aerial photos, modern topo map, or field observation.	Pre-1877 data are confirmed by additional sources, including at least one of the following: aerial photos, modern topo map, or field observation. (Estimated maximum error =10%)	Confirmed by at least one of the following: aerial photos, modern topo map, or field observation. (Estimated maximum error = 250 feet)
MEDIUM	Does not appear in historical record before 1877, but at least two sources support its presence, at least one, no later than 1942.	Attributes confirmed by at least one of the following: aerial photos, modern topo map, or field observation; OR two other sources. (Estimated maximum error = 50%)	Location confirmed by at least two sources. (Estimated maximum error = 500 feet)
LOW	Presence supported by only a single source.	Attributes supported by only a single source. (Error defined by individual case)	Location supported by only a single source. (Estimated maximum error = 1000 feet).

Table 1. Certainty Level Standards for the Laguna de Santa Rosa Historical Hydrology Project, Headwaters Pilot Study

For more information, see "Appendix A: Background and Techniques used for Historical Data Sets."

RESULTS

Results of the mapping based on historical research and field surveys are shown in the following Figures:

- Figure 1. Estimated Historical Surface Hydrology, Laguna de Santa Rosa Headwaters, c. 1850, plotted on a topographical base map; and Figure 2, with the same information plotted on a simple 10-foot contour interval map.
- General Land Office survey observations, 1853 to 1865, are shown in Figure 3.
- A photograph of the lake at Las Casitas de Sonoma Mobile Home Park is shown in Figure 4.
- Four conceptual maps highlighting changes between 1867 and 1980 are shown in Figure 5.

The historical record suggests the following conditions:

Disconnected Tributary Channels: Maps drawn before 1877 consistently show the channels of Copeland, Crane, and several unnamed creeks draining the western slopes of Sonoma Mountain and then stopping on the valley flats long before reaching the Laguna's main stem (Martin 1859; Bowers 1867; United States District Court c. 1840; United States District Court c. 1844). General Land Office (GLO) surveys from the same period also do not record any tributary channels connecting to the Laguna main stem in the study area.

Cardwell (1958) mentions that Crane and Copeland Creeks "are perennial for varying distances upstream from the edge of the valley floor, but . . . have through flow to the Laguna only during the rainy season." This matches the earliest known description of the study area, from July 1823: "Descending to the plain, we followed the arroyo which was said, by the Indians and men in our company who had seen it on other occasions, to carry the most water. But we found only a small pond. Out on the plain, this arroyo dries up to nothing." The party had to continue south for several miles, nearly to present-day Petaluma, before a small spring was found (Altimira 1823).

See Figures 1, 2, 3, 6, 7, and 9.

Tendency of Copeland Creek to Switch Watersheds: Copeland Creek is shown in 1867 (Bowers) as draining into both the Petaluma River and the Laguna watersheds. Cardwell (1958) mentions that: "Copeland Creek, according to unconfirmed local reports, formerly was tributary to Petaluma Creek, but during the early stages of land development was channeled to Laguna de Santa Rosa to improve local drainage conditions."

During the 2005 New Year's Eve flood, the property manager for the parcel containing Copeland's upper alluvial fan observed the creek jumping its banks and flowing into Roberts Creek, a tributary of the Petaluma River (Cook 2010). Another long-time resident related that, in 1915, a previous owner had used a horse and a plow to divert Copeland Creek so that it would drain into the Laguna watershed rather than the Petaluma River (Grossi 2010).

See Figures 1, 2 & 9.

Presence of Seasonal and Perennial Lakes: Two mid-19th century maps (U.S. District Court c. 1840; Bowers 1867) show the Laguna's southernmost perennial lake. Rectifying the Bowers (1867) map with the current topo for the project area (USGS 1980), showed that a small remnant of this lake might still be there. A field visit confirmed that a remnant of this lake still exists within the Las Casitas de Sonoma mobile home park at 7545 Bridgit Drive, Rohnert Park, just off the Laguna's modern main channel. The lake is described in the mobile home park's literature as "spring-fed" (Blaker 2010) and, while modified, appears to be a natural feature (Figure 4).

In addition to this perennial lake, two large seasonal lakes (>100 acres) appear on an early road survey (Martin 1859) through the project area. The area of one of these probably included the smaller perennial lake mentioned above. John Fomasi, a long-time resident described what is probably the same phenomenon: "In the years when we had a lot of rain – if that creek [upper main channel of the Laguna] couldn't take it all – it would drift out into the Rohnert Park seed farm – it was all open land out there, all the way across the flat" (Fomasi 2010). These seasonal lakes were given "Medium" certainty levels for presence" and shape, and a "Low" certainty level for location.

See Figures 1, 2, 5, 6, 8, and 9.

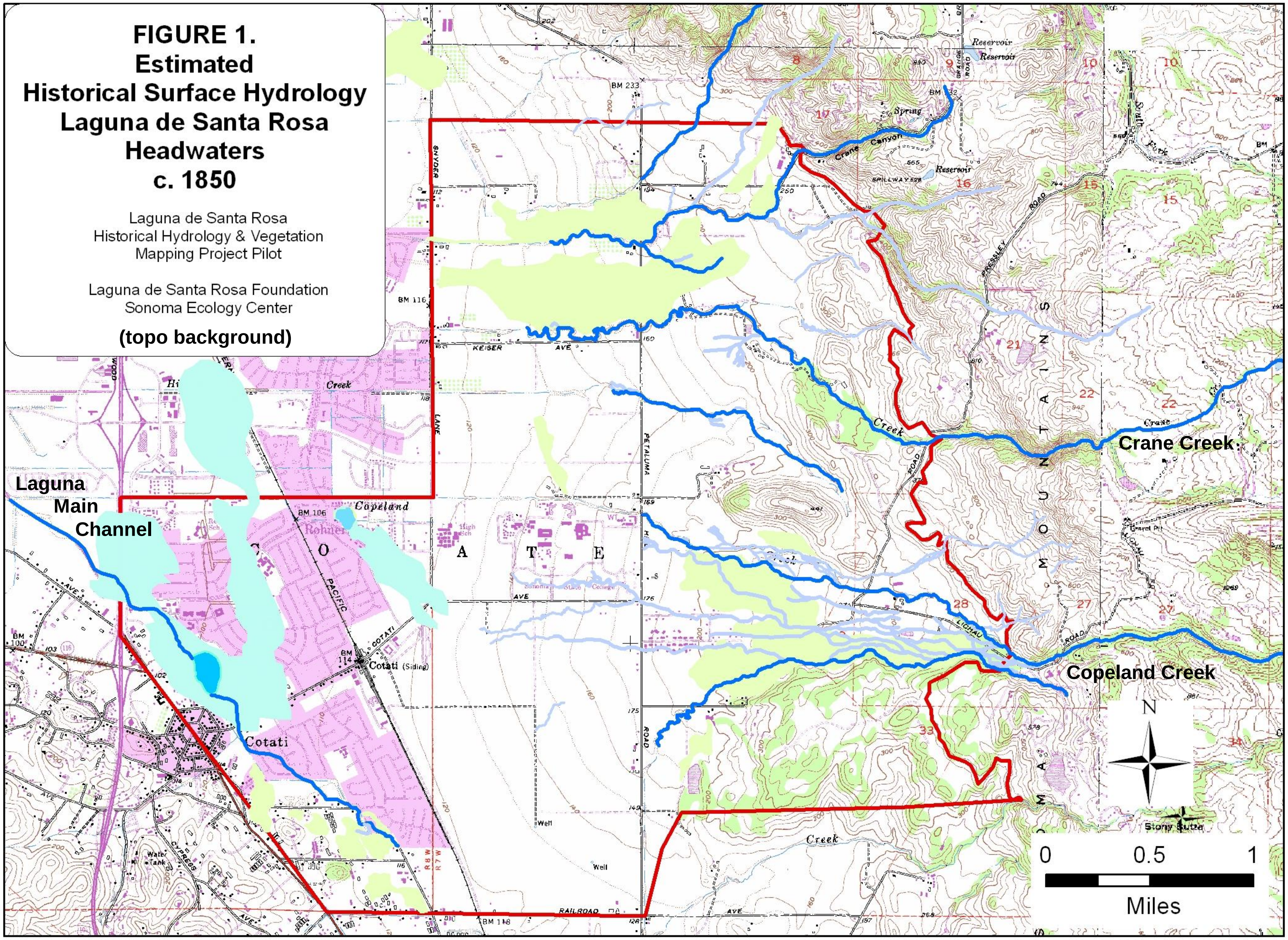
Seasonal Wetlands: The predominance of Clear Lake clay soils and the historical drainage pattern, suggest that the study area probably supported a seasonal wetland mosaic (Barbour 2007) with areas of standing water ranging in size from small vernal pools to the large seasonal lakes mentioned above. Such seasonal wetlands show great seasonal variation, supporting "dominant species such as smartweeds, watergrass, spiked rush, docks, and flowering annuals" in "dense stands in early spring." By mid-summer however, these plants would all but disappear, leaving "no apparent sign of emergent vegetation on what appear[ed] to be a dry, hard soil surface" (CH2MHill 1990). Likewise, Miller (1972) states where Clear Lake clay soils have not been cultivated they support "chiefly annual or perennial grasses and forbs."

We found no record of perennial marsh areas on any historical map, survey, or illustration. Other known perennial marshes in Sonoma County, such as the Kenwood Marsh and the marsh by Tolay Lake show up clearly in the historical record (O'Farrell 1848; Peabody 1851; Sonoma County Surveyors Office 1860). Long-time resident John Fomasi confirmed this condition, at least for much of the 20th century: "It wasn't marshy—it was pretty much like it is now if you look at our place [at the head of the Laguna main channel]" (Fomasi 2010).

See Figures 1, 2, 3, 6, 7, 8, and 9.

Lack of Dry Season Surface Flow in the Laguna's Upper Channel (in Normal Rainfall Years): Two sources support this conclusion: 1) An early survey note refers to the Laguna main channel as an "arroyo" at the Rancho Cotate boundary in August 1857 (Denton 1857); 2) An early map depicts the Laguna as an unconnected chain of lakes (U.S. District Court c.1840). Santa Rosa received 25 inches of rain in the winter preceeding the survey (1856– 1857), following three years of similar or slightly higher precipitation (Thompson 1877), which is close to the modern average.

See Figure 6. Survey observation is downstream of study area and not shown in Figure 3.



LEGEND

- Winter Lake (1859)
- Perennial Lake
- Swales & Ponded Soils
- Project Focus Area
- Major Channels mapped 1844-1867
- Minor Channels & Distributaries

Cartography by Arthur Dawson, Historical Ecologist, Sonoma Ecology Center

(Background: U.S.G.S. quadrangles Cotati, Santa Rosa & Kenwood)

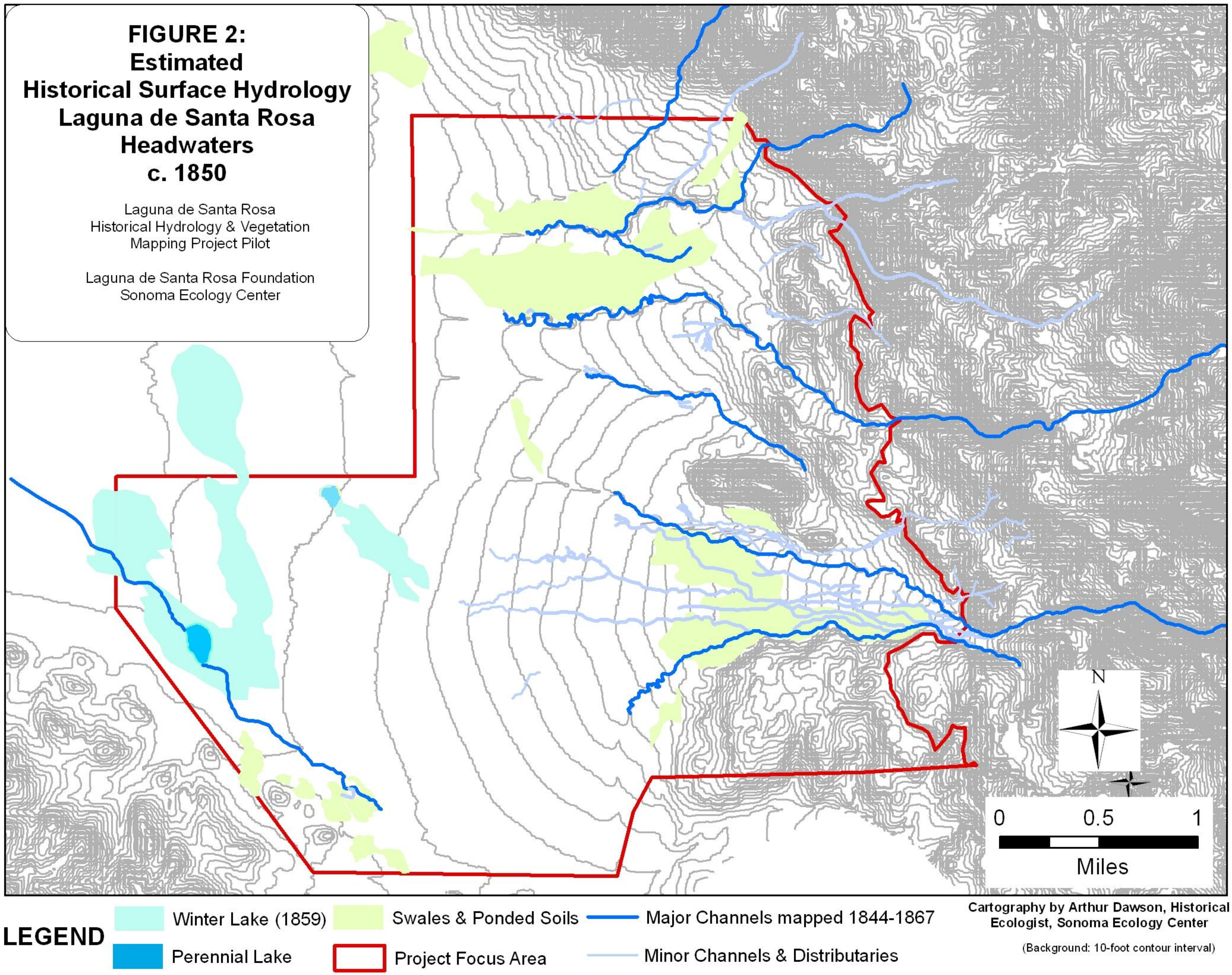
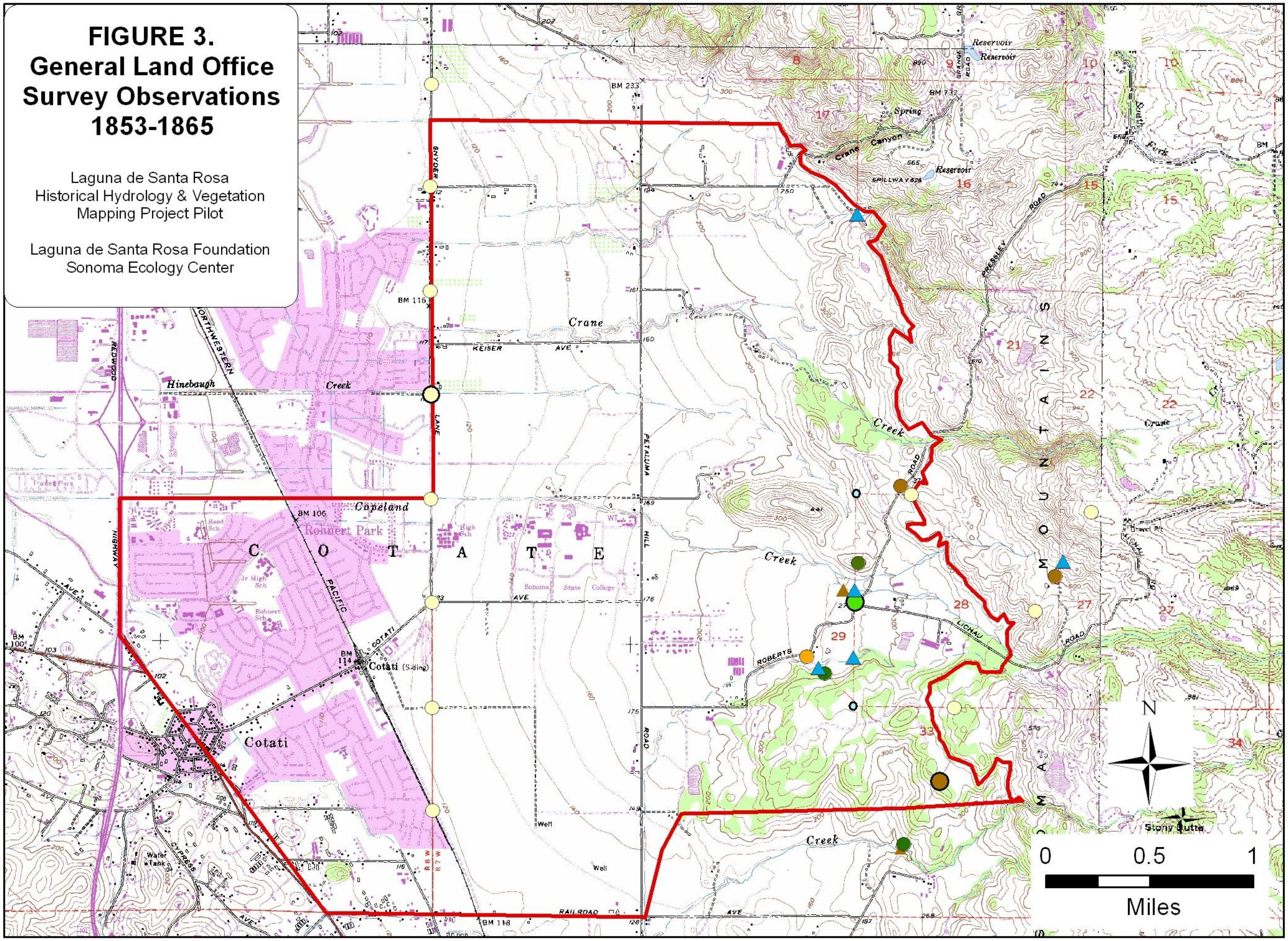


FIGURE 2:
Estimated
Historical Surface Hydrology
Laguna de Santa Rosa
Headwaters
c. 1850
Laguna de Santa Rosa
Historical Hydrology & Vegetation
Mapping Project Pilot
Laguna de Santa Rosa Foundation
Sonoma Ecology Center
N
0
0.5
1
Miles
LEGEND
Winter Lake (1859)
Perennial Lake
Swales & Ponded Soils
Project Focus Area
Major Channels mapped 1844-1867
Minor Channels & Distributaries
Cartography by Arthur Dawson, Historical Ecologist, Sonoma Ecology Center
(Background: 10-foot contour interval)

FIGURE 3. General Land Office Survey Observations 1853-1865

Laguna de Santa Rosa
Historical Hydrology & Vegetation
Mapping Project Pilot

Laguna de Santa Rosa Foundation
Sonoma Ecology Center



LEGEND

- "Arroyo" (Dry channel)
- "Creek" or "Living run"
- No trees
- "Oak"
- "Alder"
- "Maple" & "Buckeye"
- "Timber"

Cartography by Arthur Dawson, Historical Ecologist, Sonoma Ecology Center

(Background: U.S.G.S. quadrangles Cotati, Santa Rosa & Kenwood)

<u>Presence of Salmonids</u>: In the spring of 1862, the *Sonoma County* Journal reported that "304 trout had been taken from Copeland Creek in three hours"(Cummings 2005). Three years later a deputy surveyor for the General Land Office wrote that Copeland Creek "abounds with speckled trout"(Millington 1865). John Fomasi gave a second-hand report of salmonids using the Laguna main channel. Recalling a comment made by the woman he bought his property from in 1953, he said: "This creek [Laguna main channel] . . . she used to catch salmon in it" (Fomasi 2010).

See Appendix C.

<u>A Predominantly Open Landscape with Few Trees</u>: Early maps, GLO survey notes, and historical illustrations suggest that the landscape between the base of the hills and the Laguna channel was predominately open with a few scattered oak groves (Whitacre 1853; Thompson 1877; United States District Court c. 1844). Several heritage oaks (diameter >42"; age >170 years) were discovered in the study area. An illustration from the 1870s (Thompson 1877) shows the study area almost devoid of trees. Miller (1972) describes Clear Lake clay, the predominant soil type in the area as supporting "chiefly annual or perennial grasses and forbs" when left uncultivated. Tree canopy cover appears to have been under 10%.

See Figures 3, 6, and 7.

<u>Increasing Connectivity since Mid-19th Century:</u> The increase in channel connectivity between 1867 and 1980 is traced in Figure 4 as a series of four maps. These maps should be considered conceptual as the majority of the constructed drainage network, including road ditches, storm drains, and hardscape, is not shown. Mapped channels in the sequence increase from 104,000 to 135,000 feet within the project area (30%). Considering the omissions mentioned above, this figure is probably only a small fraction of the added drainage network.

The Thompson County Atlas (Thompson 1877) is the first to show Copeland and Crane Creeks draining directly into the Laguna's main channel. Smaller drainages remained disconnected well into the early 20th century. The development of the modern lower channels, which now connect with the main stem of the Laguna was documented in a variety of sources. One long-time resident described how the course of Copeland Creek was altered in about 1915 with a horse-drawn plow. He also described channels being cut across the flats by big machines in the 1970s (Grossi 2010). One of the earliest maps showing the connection of Copeland Creek with the Laguna main stem labels its upper channel "Copeland Creek," and its lower channel "Copeland Ditch" (Smyth c. 1890)

See Figure 5.

Figure 4. Spring-fed lake, Las Casitas de Sonoma Mobile Home Park,
7545 Bridgit Drive, Rohnert Park.
Photograph by Arthur Dawson, May 10, 2010.

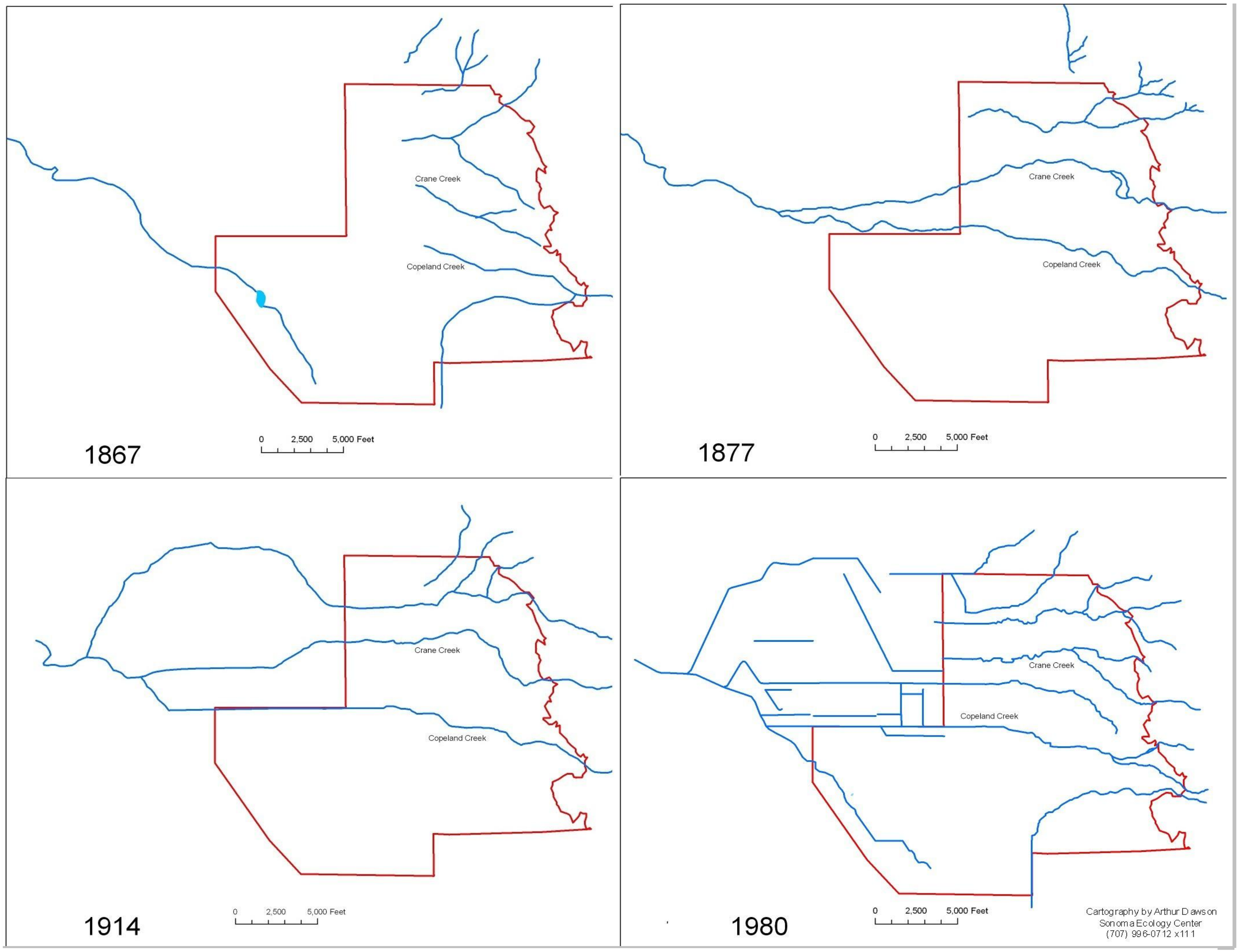


Figure 5. Changes in Surface Hydrology, Laguna de Santa Rosa headwaters. As mapped, 1867 – 1980.
(Sources: Bowers 1867; Thompson 1877; USGS 1916; USGS 1980)

DISCUSSION

This study documents a number of dramatic changes to the surface hydrological patterns of the Laguna's southern headwaters and tributaries over the last 170 years. At the beginning of settlement in the mid-19th century, tributaries such as Copeland and Crane Creeks lacked direct channel connections to the Laguna mainstem. While perennial in their upstream reaches, these streams did not flow very far beyond the base of the hills during the dry summer months. With the arrival of winter storms, these streams spread out over their alluvial fans in a network of channels and swales and flowed into low-lying basins on the valley floor, including the main channel of the Laguna itself, creating a mosaic of seasonal wetlands. These wetlands ranged in size from small vernal pools to seasonal lakes up to a hundred acres or more in size. They may have supported flowering annuals and other plants in dense showy stands in early spring, similar to the flora found in vernal pools in other parts of the Laguna watershed. As spring progressed into early summer, these wetlands evaporated and disappeared, leaving behind desiccated plants and hard, dry soil. This annual cycle allowed for maximum groundwater recharge; filtration, as sediment dropped out of the stormwaters flowing slowly across the flats; and maintained important seasonal habitat for a variety of birds, amphibians, and invertebrates.

The only perennial surface water below the base of the hills was a lake on the main stem of the Laguna. Covering about 20 acres, this lake appears to have been an isolated feature in the dry season, with no surface flow in or out. As no other water was available within two miles or more, this would have provided an important summer water source for mammals, birds, and other wildlife on the Santa Rosa Plain. A strip of perennial marsh may have existed along the edges of this lake. The conclusion that the surrounding landscape was predominately open with few trees is consistent with a study of historical vegetation in Sonoma Valley (Dawson 2008) which found only a few heritage oaks growing on Clear Lake clay soils. Much of the study area was probably covered with annual forbs and grasses.

Reports of abundant trout in Copeland Creek in the 1860s agree with observations of salmonids in other parts of Sonoma County at that time. It was not until the 1870s that steep declines in fish populations were noted in Santa Rosa and Sonoma Creeks (Sonoma County Democrat 1875; Munro-Fraser 1880), which coincided with declines in other parts of California. The first fish hatchery in California was established on the McCloud River in 1872, and the first hatchery in Sonoma County was built in Glen Ellen in 1880. Planting trout in county streams, as a response to their decline, probably did not begin until after 1870. Thus, observations of trout in Copeland Creek in the 1860s suggest that this was a native population. Whether these were steelhead or landlocked trout is unknown. Since Copeland Creek has a tendency to switch watersheds between the Petaluma River and the Laguna, perhaps these fish were able to migrate out to sea and return when conditions became favorable. Even in the absence of a continuous lower channel, winter flows could have been enough to provide passage to and from the ocean, at least in some years. On the other hand, landlocked native trout are found in mountain streams of the Great Basin, where connection to the ocean has not existed for a very long time.

Because other researchers have concluded that the Cotati/Rohnert Park area supported a large, perennial marsh (CHM Hill 1990) it seems worthwhile to examine this question in more detail. Before reviewing the previous research, the terms used in this report should be defined. We divided wetlands documented in the historical record into three categories: “Open Water,” “Perennial Marsh,” and “Seasonal Wetland.” Characteristics of these are summarized in Table 2.

Wetland Designation (with synonymous terms)	**Hydrology**	**Vegetation**	**Nearest analogues as defined in other studies**
Open Water Perennial Lake	Perennial, lake or pond-like water body	Submergent plants such as duckweed, pondweed, marsh pennywort, widgeon grass	“Laguna lakes” (Waaland 1989) “Open Water” (CH2M Hill 1990)
Perennial Marsh	Inundated for most or all of the year; saturated all year	Emergent plants such as tules, cattail, bulrush, sedge	“Freshwater Marsh” (Helley 1979; Best 1996) “Marsh: perennial” (Waaland 1989) “Perennial Marsh” (CH2M Hill 1990)
Seasonal Wetland Seasonal Lake Vernal pool	Seasonally inundated, surface dry for at least several months each year	Desiccated during dry season. Closely analogous or identical to vernal pools. Meadowfoam, goldfields, Sonoma sunshine and other annual forbs and grasses.	“Vernal pools” (Best 1996) “Seasonal wetland*” (CH2M Hill 1990) “Seasonal marsh” (Waaland 1989)

Table 2. Wetland designations used in this study

*see the Discussion for more on the use of this term in the CH2M Hill study

Cardwell (1958) describes the Cotati area as characterized by low mounds and poorly drained depressions, which are typical of Pleistocene deposits in northern California. Clear Lake clay soils cover much of the study area, and are described in the County Soil Survey as forming “under poorly drained conditions . . . They are on plains and flat basin areas.” “Poorly drained soils” are defined as “wet for long periods,” while “very poorly drained soils are wet nearly all the time.” Where Clear Lake clay soils have not been cultivated, they support “chiefly annual or perennial grasses and forbs” (Miller 1972). Barbour (2007) mentions Clear Lake soils as supporting several types of vernal pools.

Helley (1979), a geomorphologist, characterized most of the study area as “fine-grained alluvium,” giving it the designation “Qhaf.” Qhaf is described as “moderately to poorly sorted silt and clay rich in organic material" which is "seasonally saturated" and "locally contains Holocene, molluscan fossils." It is "found in poorly drained, nearly horizontal basins between active and abandoned stream levees at the outer margins of alluvial fans . . . in the lower parts of broad coastal valleys." Qhaf is "deposited from standing flood-waters that periodically inundate low, interfluvial basin areas and locally form seasonal, freshwater marshes" with "seasonal standing water."

A geologic report (California Division of Mines and Geology 1980) describes a large part of the project area as "interfluvial marsh-like basin deposits." This designation roughly corresponds with a large expanse of Clear Lake clay soil (CeA). In Sonoma Valley CeA soil is found in the lower areas of some alluvial fans and supports a small number of heritage oaks (Dawson 2008), trees which do not tolerate year-round saturation. These areas were not mapped as marsh on an early map of the Rancho Petaluma (O'Farrell 1848.), though the same map shows perennial freshwater marsh along the southeast shore of Tolay Lake and salt marsh by San Pablo Bay.

Waaland (1989) mentions that Clear Lake clay soils are hydric, one of three criteria needed to qualify an area as wetland under the Clean Water Act (the other two criteria are water regime and vegetation). This author mentions "the large area of seasonal marsh that occurred on the Cotati Plains [Santa Rosa Plain] prior to drainage for agriculture." Unfortunately, the term "seasonal marsh" is not well defined and is described as "similar to perennial marsh" supporting tules and cattails.

The above sources appear to be in general agreement and confirm the conclusions of this historical study. However, Waaland's use of the term "seasonal marsh," while technically correct, is unfortunate. We prefer the term "seasonal wetland," which accurately describes conditions and avoids confusion with perennial marshes that support plants adapted to year-round water or soil saturation, such as tules and cattails.

The basis upon which the CH2M Hill (1990) report concluded that a large perennial marsh existed in the Cotati/Rohnert Park area is unclear. In addition, several apparently contradictory statements about the presence of seasonal and perennial marshes are made. The report states that "Clear Lake soils are often hydric," but cautions that "the determination must be based on site-specific conditions and varies from location to location." The author observes that "the present-day distribution of freshwater marshland provides an indication of the historic distribution" and that "the remaining perennial marsh is found primarily in the northern portion of the Laguna floodplain," while "relatively large acreages of seasonal marsh are still present, especially in the southern portion of the study area, where Clear Lake clays are abundant." Yet it concludes that "There was probably more perennial marsh in the Rohnert Park/Cotati area in the past (Cardwell 1958). The hypothesized distribution of this vegetation type is based on the mapped distribution of Clear Lake clay (Miller 1972), which formed under marshy conditions in basins (Helley *et al.* 1979). . . A large proportion of the historic freshwater marsh was probably a seasonal wetland that floristically resembled vernal pools (which are smaller versions of seasonal freshwater marshes). Perennial wet areas were in the Cotati area." Despite the citations, these earlier studies do not mention perennial marsh in the Cotati area. The description of seasonal wetland does agree with the conclusions drawn by the other researchers, and seems to be an accurate historical description of the Cotati area. The presence of extensive perennial marsh in the Cotati area does not appear to follow the lines of reasoning made in the CH2M Hill study, nor the work of other researchers.

Implications for Management

Reflecting on the changes documented over the last 170 years suggests that increased channel connectivity has had the greatest impact on historic ecosystem function. Stormwater now moves more quickly across the landscape, is more concentrated into channels, and is less spread out than it was at the time of settlement. Precipitation has less time to sink into the ground, and less chance for natural filtration before it reaches the Laguna main stem. Increased connectivity has effects on natural and human systems both in the study area and downstream. These likely include:

- Increased erosion from the beds and banks of natural and artificial channels. (Documented by SEC (2006) in Sonoma Valley)
- Increased sediment delivery to the Laguna main stem, causing infilling of the channel, perennial marshes, and lakes down-stream.
- Diminished seasonal wetland habitat through draining of wetlands.
- Infilling of the Laguna's perennial marshes and lakes.
- Changes in the temperature profile as the water column becomes shallower. (Coho salmon prefer cold, off-channel habitat for rearing (The Trust for Public Land 2004). Some of the Laguna's historical lakes may have been thirty feet deep (Cummings 2004), possibly enough to maintain a layer of cold water even in summer.)
- Increased flooding downstream.
- Decreased groundwater recharge.
- Decreased water quality in the Laguna, both from sediment and other pollutants.
- Conditions favorable to the establishment of invasive plants such as *Ludwigia hexapetala.*

While beyond the scope of this study, there are probably site-specific opportunities within the southern Laguna headwaters to restore or mimic some of the baseline conditions outlined here. Designing projects to "slow, spread, and sink' stormwater, such as returning diverted flow to distributary channels, preserving and restoring seasonal wetlands, and adding sinuosity and inset terraces to modified channels would provide multiple benefits. These include flood reduction, increased groundwater recharge, improved water quality, and habitat restoration.

An example of this type of approach currently underway is the Upper Sonoma Creek Channel Improvement Project, funded by the Sonoma County Water Agency. Design for this project began with a historical hydrological study similar to the one described in this report. The conceptual design for this project includes restoring water at high flows to historical distributary channels, creating inset terraces in the incised channel of Sonoma Creek, permeable culverts, and developing rain gardens or other stormwater detention basins.

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APPENDICES

APPENDIX A: Background and Techniques Used for Historical Data Sets

Historical Maps are often the only historical source for water features which were rapidly altered or drained during the early American era (1846 – 1875). Detail and accuracy varies widely but shows a general increase from the Mexican era (1823 – 1846) to the early American era. Potential errors include orientation of creeks and other features, and modern interpretation of symbols. Studies in Sonoma Valley have shown that maps created after 1875 depict substantially modified stream channels and confluences as compared to earlier maps (Dawson 2004). As long as this is kept in mind, later maps can be effectively used to map some features. The first county atlas (Thompson 1877) also includes ground level illustrations, which provided valuable information for some areas.

Digital copies of historical maps were scanned into GIS and georectified to a modern topo map. Surface water features on the maps were digitized into shapefiles and associated attribute tables recorded the source, feature name, and notes on interpretation.

General Land Office surveys represent some of the most detailed records of the California landscape in the 19th century. These surveys laid out the township and range lines shown on modern topographic maps. Notes from the GLO surveys recorded vegetation and other features at specific points along the survey lines. At each section corner, surveyors were instructed to mark and record the size and species of “four bearing trees, if within a reasonable distance . . . one to stand within each of the four sections.” (General Land Office 1855) At the half-way points, or “quarter-section corners,” they were to record two bearing trees, one on each side of the line. Surveyors also recorded trees on the survey line itself, other vegetation data (e.g. “entering chaparral”), stream crossings, ponds, roads, fences, fields, houses, and other features. In addition, they were required to record general descriptions of vegetation (in order of abundance) along each section line.

In general, these surveys are believed to be quite accurate and trustworthy. Surveyors signed sworn oaths to be meticulous and honest in their work. The ramifications of these surveys on land ownership suggest a high degree of accuracy would have been demanded of the surveyors by the government and the public. Distance measurements were collected to accuracies of 1 link (7.92 inches). Bearings were taken to a tolerance of ¼ degree, giving a potential maximum error of about 20 feet per mile of survey. An intensive field study of GLO surveys at Pepperwood Preserve found that survey points could be located with an accuracy of 200 feet (60 m) or better on the ground (Dawson 2008).

Three GLO surveys were carried out in the study area between 1853 and 1865 (Whitacre 1853; Denton 1857; Millington 1865). All available GLO data was digitally mapped, with survey notes attached as attributes to each point. Where surveyors recorded no trees at section and quarter-section corners, it was assumed that no trees were within 3 chains (198 feet or about 60 m.) of these points (the furthest distance of any recorded tree from a survey point was less than 4 chains). In some cases the surveyors explicitly stated that no trees were nearby. Notes containing comments such as “placed post in rock mound” and no mention of trees were assumed to indicate open conditions with no trees nearby.

Altimira's Journal: as the first written description of the project area, made in 1823, this is an extremely valuable source of data. Altimira's route can be traced with reasonable accuracy, sometimes to within a few hundred yards on the ground. Sources of potential error include reading and translating handwritten, early 19th century Spanish; possible misunderstandings when some of the information was originally translated from Coast Miwok into Spanish; and separating direct observations from assumptions or second-hand information.

A short passage from July 2, 1823 describes conditions in the project area and confirms the hydrological picture presented by later sources.

Oral Histories While not part of this pilot, a formal oral history from John Fomasi was collected by Jenny Blaker (Cotati Creek Critters) while this study was underway. Several other long-time residents were also consulted during the field work and provided valuable information. An oral history project in Sonoma Valley (Dawson 2002) produced a detailed record of the ecological history of that area through much of the 20th century. Cross-checking with other sources has confirmed the value and reliability of this type of information. The most common error made by elders during that project was in fixing dates to events. Occasional errors or exaggerations in individual accounts were identified when compared to other historical sources.

Information from John Fomasi and the other elders tended to confirm other historical sources, thus raising the confidence level for some features. These elders also provided some unique information, particularly details about channel alterations and the presence of fish and other wildlife. Where applicable, these oral histories are listed as a secondary source for mapped features.

Aerial photographs taken at the beginning of the Second World War in 1942 provide a detailed record from the mid-20th century (U.S. Department of War 1942). While the landscape had been significantly altered by 1942, the alignments of many historical channels and other features shown in earlier maps are visible and can be mapped in GIS with a high degree of precision. The greatest source of potential error is determining which features had persisted since pre-settlement times, and which had been more recently created by land-use practices.

Using road intersections and other identifiable features visible in recent aerial photos, these early aerial photos were georectified in GIS. Features appearing on earlier maps were digitally mapped from the 1942 photos and given high confidence ratings. Features appearing in 1942 which could not confirmed by earlier sources but which appeared to pre-date settlement were digitally mapped and given medium or low confidence ratings.

Field Surveys were conducted in March and April, 2010. A hand-held GPS (Global Positioning System) unit was used to mark the locations of channels, swales, and other features. Determining whether these features had been present in the mid-19th century was the greatest source of potential error. Features which appeared consistent with expected natural patterns and which showed no evidence of alteration were given a medium level of confidence.

These points were subsequently converted into GIS shapefiles with corresponding observations recorded in an attribute table. Field data was compared with historical sources and used to adjust and refine the preliminary map to its final version.

USDA Soil Survey: this source has proved extremely useful in mapping historical vegetation on the floor of Sonoma Valley (Dawson 2008), particularly for wetlands and the presence (or absence) of valley oaks (*Quercus lobata*) or valley oak hybrids.
For this pilot project, the soil survey was primarily used for mapping swales and ponded soils. It also allowed a preliminary estimate of some vegetation types, particularly the likely presence or absence of valley oaks (or valley oak hybrids).

APPENDIX B: Selected Historical Maps

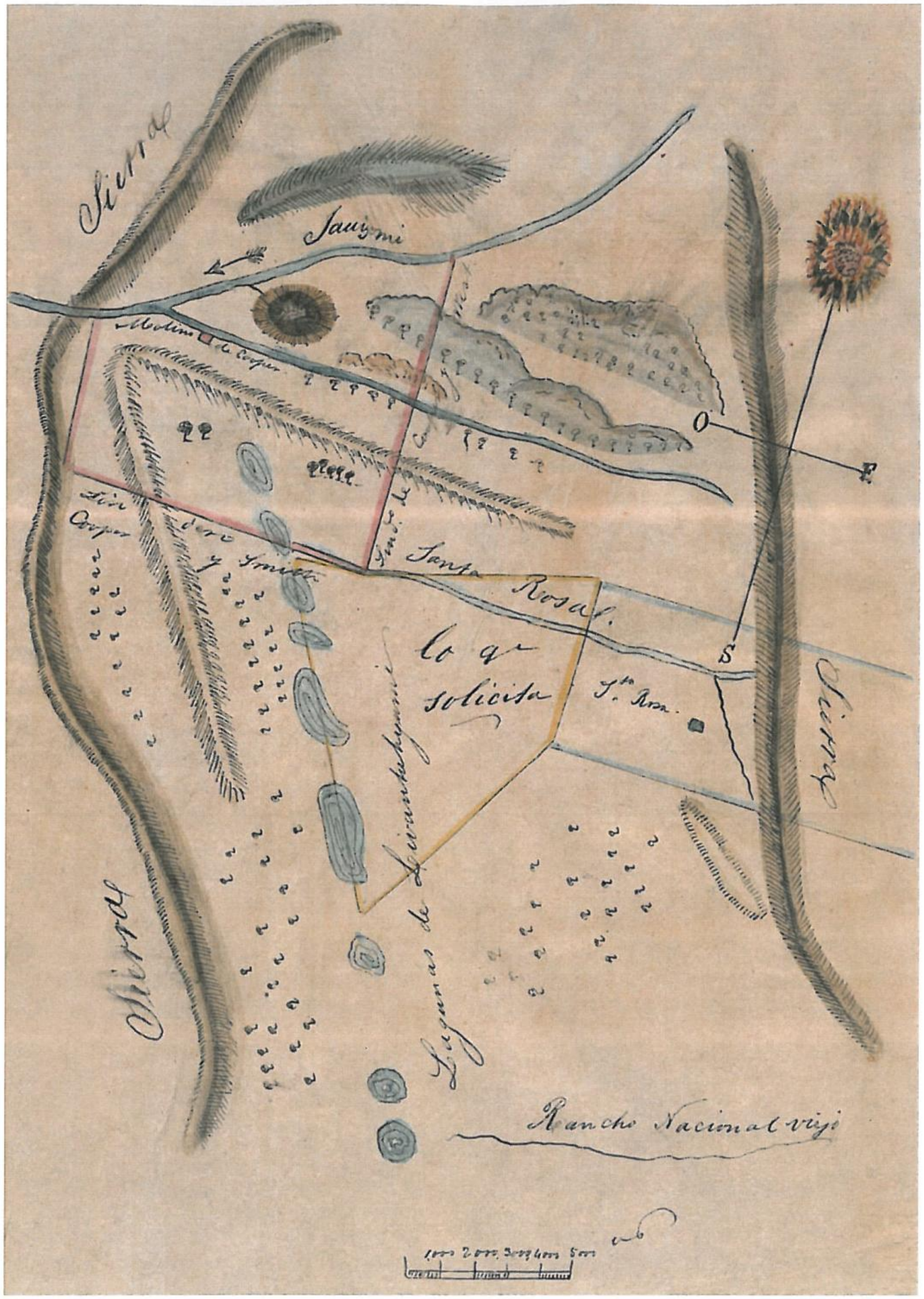

Figure 6. ***Diseño del Rancho Llano de Santa Rosa: Calif.*** Earliest known map of the Laguna de Santa Rosa. United States District Court, C. N. D. (c. 1840).

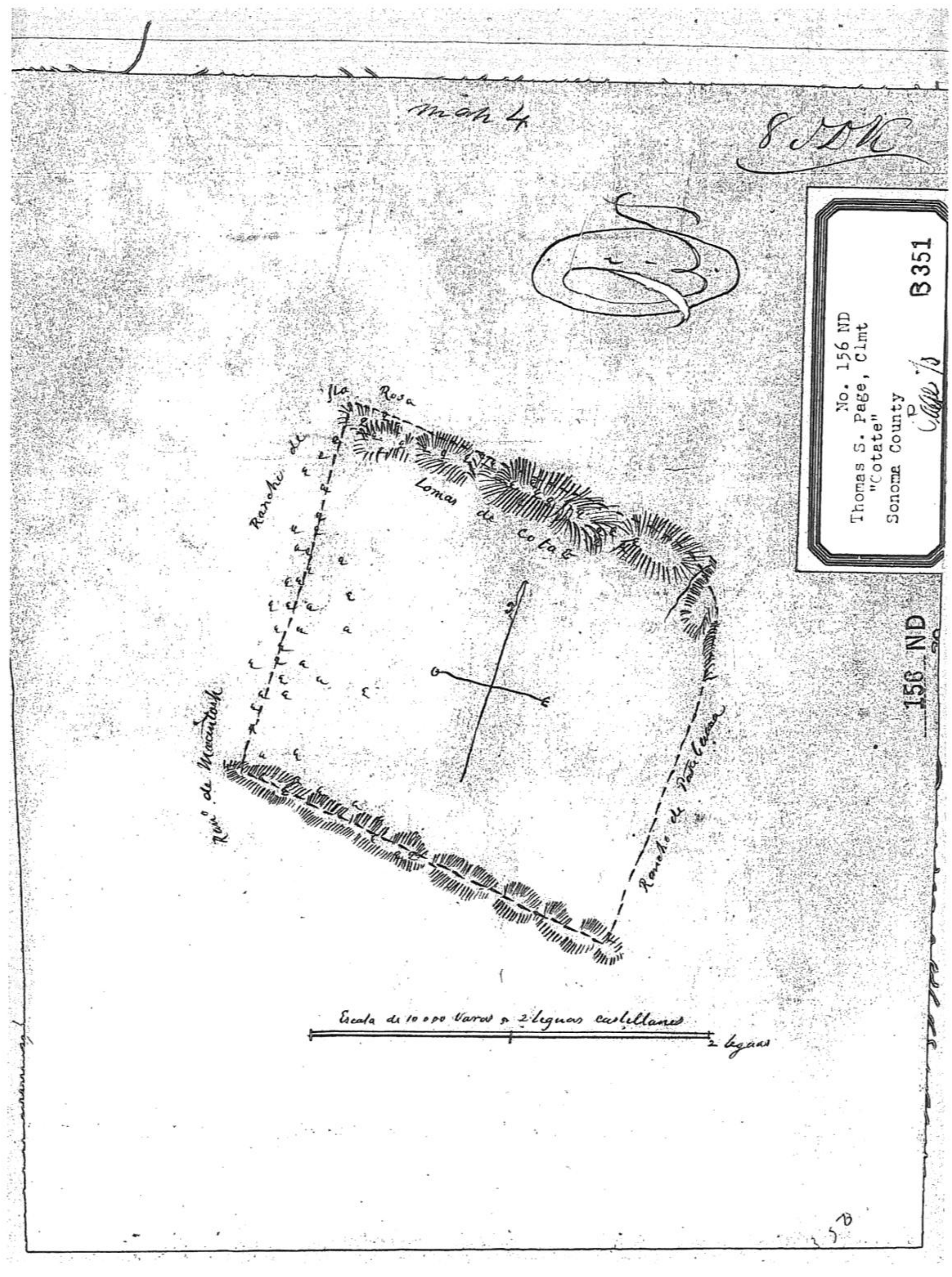

Figure 7. ***Diseño del Rancho Cotate*****: Sonoma Co.** Calif. United States District Court, C. N. D. (c. 1844). Diamond-shaped boundary is shown on modern U.S. Geological Survey topographic maps.

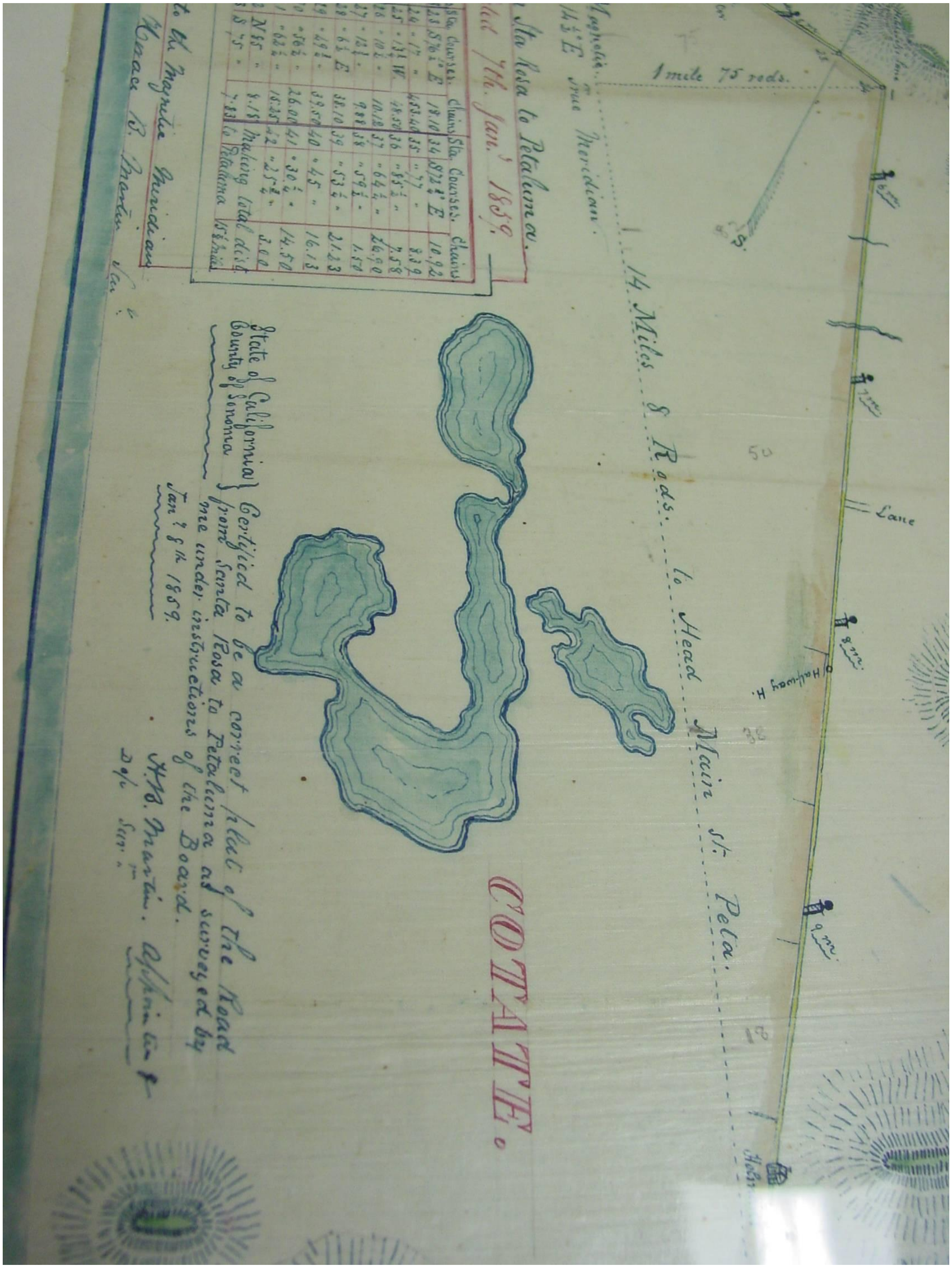

Figure 8 "Plat of Road Survey from Santa Rosa to Petaluma." Book A of Road Surveys for Sonoma County. Martin, H. B. (1859). Yellow line with mileposts on the right is modern-day Petaluma Hill Road.

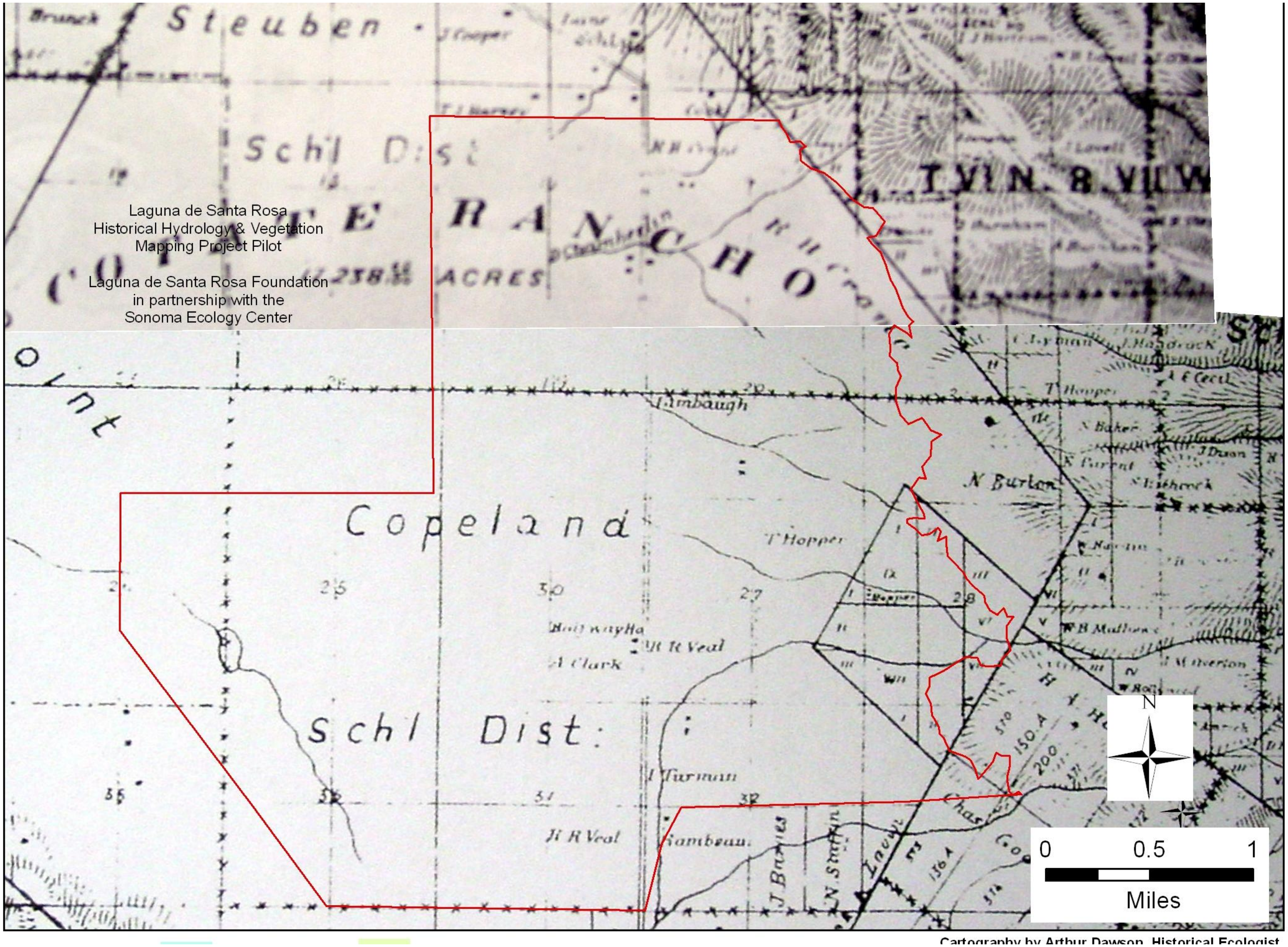

Figure 9. ***Map of Sonoma County California.*** Bowers, A. B. (1867).
(boundary of project focus area superimposed in red)

APPENDIX C: Selected Historical Quotes

"Descending to the plain, we followed the arroyo which was said, by the Indians and men in our company who had seen it on other occasions, to carry the most water. But we found only a small pond. Out on the plain, this arroyo dries up to nothing . . . as it was now growing late, we began searching between the hills for a little water for the horses and ourselves to drink. We continued searching as night fell, but everything was dry until we reached the small spring of the Petaluma *rancheria*, and from there hurried to reach the small *Arroyo Lema*."

(Describes journey from about Crane Canyon south through the study area. *Rancheria* was south of the study area, near Adobe Road/Hardin Lane. *Arroyo Lema* is probably Adobe Creek in the vicinity of Vallejo's later Petaluma Adobe).

Jose Altimira, July 2, 1823
(Altimira 1823)

". . . a report in the Sonoma County Journal in the spring of 1862, that 304 trout had been taken from Copeland Creek in three hours."

A Big Puddle: The Early Laguna de Santa Rosa
(Cummings 2005)

"The quality of soil in this township is about 2nd rate. It is watered with springs and branches and some portions of it is as high as any land in Sonoma County. It is well adapted for grazing and there are some localities well situated for orchards and vineyards and there are some very large vineyards already set out and bearing from which there has been considerable wine made this season. Mill Creek [Copeland] abounds with speckled trout and affords water enough for mill purposes."

Seth Millington, Deputy Surveyor, 1865
(Millington 1865)

APPENDIX D: Sources Relating to the Presence of Seasonal or Perennial Marsh, and other features in the Study Area

(Notes and comments in brackets, sections of high interest in bold.)

Cardwell (1958) describing the Santa Rosa Valley:

"Along the western side a swampy area, Laguna de Santa Rosa, forms the lowest part of the valley trough. Along the eastern side lies a flat, gently sloping alluvial plain, 1-2 miles wide, which merges with the alluvial plains of Mark West and Santa Rosa Creeks and, to the south, with the Cotati Plain."

"The southern part of this area is characterized by low mounds and poorly drained depressions which are typical of Pleistocene deposits in northern California."

p. 8

"Surface outflow from Laguna de Santa Rosa usually is not perennial."

p. 10

"Crane and Copeland Creeks drain into Laguna de Santa Rosa and Lichau Creek is tributary to Petaluma Creek. All are perennial for varying distances upstream from the edge of the valley floor, but Crane and Copeland Creeks have through flow to the Laguna only during the rainy season. Copeland Creek, according to unconfirmed local reports, formerly was tributary to Petaluma Creek, but during the early stages of land development was channeled to Laguna de Santa Rosa to improve local drainage conditions."

p. 11

"Evapotranspiration occurs on a large scale along the Laguna de Santa Rosa at the western side of Santa Rosa Valley in a swampy area that varies with seasonal rainfall conditions but averages about 1,000 acres during the summer (McBride, 1945). This area is subject to natural losses by evaporation from the water surface and by transpiration from **reeds, tules, willows, and other water-loving plants which flourish around the margin of the Laguna."**

p. 85

Soil Survey (Miller 1972)

"The Clear Lake series consists of clays that formed under poorly drained conditions. . . They are on plains and flat basin areas."

[definition of "poorly drained" on page 186: "**<u>Poorly drained</u> soils are wet for long periods .** . ." compared to: **"<u>Very poorly drained</u> soils are wet nearly all the time."]**

"Where not cultivated, the vegetation is chiefly annual or perennial grasses and forbs"

<u>“Clear Lake clay, 0 to 2 percent slopes (CeA)</u>—This soil is in poorly drained basins and on flood plains. Most of the acreage is characterized by extremely long smooth areas. [this is the dominant soil type in our study area]”

<u>“Clear Lake clay, ponded, 0 – 2 percent slopes (CfA)</u> –This soil is similar to Clear Lake clay, 0 – 2 percent slopes. This soil is in basinlike areas and is subject to temporary ponding . . . the surface does not dry down so fast as in adjacent areas.“ [this suggests that CeA dries down faster than CfA soil]

“. . . In the Laguna de Santa Rosa near Sebastopol, some areas of this soil are inundated and stay wet into late spring.”

p. 22 - 23

Helley (1979)

Majority of the study area was “fine-grained alluvium” designated as Qhaf:

“Fine-grained alluvium (Qhaf)

Physical description and lithology

Unconsolidated, plastic, moderately to poorly sorted silt and clay rich in organic material. **Seasonally saturated**, irregularly bedded. Locally contains Holocene, molluscan fossils.

Distribution and stratigraphy

Found in poorly drained, nearly horizontal basins between active and abandoned stream levees at the outer margins of alluvial fans . . .in the lower parts of broad coastal valleys.

Origin of deposit

Deposited from standing floodwaters that periodically inundate low, interfluvial basin areas and **locally form seasonal, freshwater marshes.**

Potential geologic hazards and problems

. . . periodic flooding; poorly drained, **seasonal standing water** due to high water table.”

p. 23

Waaland (1989) **(**pages 8 – 23 and Tables W1-2 and W1-3 in Appendix)

“. . . the Clear Lake clay soil series . . . is the dominant soil in the Laguna floodplain. Those areas that are the flattest (zero to 2 percent slope) at the lowest elevation of the Laguna are subject to a hydrologic regime of frequent flooding in which very fine particles of sediment settle out. The parent material of fine sediments is impermeable and poorly drained; conditions which allow marsh vegetation to become established. The large volumes of organic debris produced by the marsh vegetation become incorporated into the substrate giving it a dark color. The interaction of these factors resulted in the formation of the Clear Lake soil series (Helley et. al., 1979; Miller 1972)" [NOTE: this specific description could not be found in either reference)

"Classification of a soil as hydric is one of three attributes needed to qualify an area as a wetland subject to regulation by Section 404 of the Clean Water Act . . . Water regime and vegetation are the other two attributes for wetland classification."

"The hydric soils of the Laguna de Santa Rosa listed by the SCS are the Clear Lake clay and the ponded phases of the Huichica loam."

"<u>Clear Lake Clay</u>. This soil is found on floodplains and flat basin areas close to the Laguna de Santa Rosa channel [NOTE: Clear Lake clay in the study area also extends a long way from the channel—2 miles or more]. It is the most extensive soil with the Laguna's 100-year flood plain because it is derived from fine-grained alluvium parent material which settled out of still floodwaters as "basin deposits" . . . Permeability is very slow and runoff would be high but the flat terrain causes water to pond. The soil is very dark and high in organic matter because the water regime supports marsh vegetation that contributes large volumes of debris. **Much of this soil has been** artificially drained and **cleared of the native riparian forest and marshes** . . ." [evidence?]

"In 1945 a U.S. Fish and Wildlife Service biologist estimated the total dry season wetland acreage at 1,000 acres (Cardwell 1958, p. 85). At that time it is likely most of the wetland was riparian forest north of Highway 12. This estimate does not include **the large area of seasonal marsh that occurred on the Cotati Plains prior to drainage for agriculture.** Wetlands are defined by COE (1987) as follows:

> Those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support a prevalence of vegetation typically adapted to life in saturated soils."

"There are several basic wetland types in the Laguna de Santa Rosa:"

"<u>Laguna Lakes</u>: these small lakes occur within the Laguna channel, increasing in frequency toward the mouth. They are not actually lakes but places in the Laguna channel that pond water and may not be connected to surface flow during the dry season. In extreme drought they may be completely dry. . . Vegetation is composed of obligate hydrophytes such as submergent plants like featherfoil (*Myrriophylum spp.*)"

"<u>Marshes</u>: Marshes of the Laguna de Santa Rosa are most prevalent in the mid-section of the study area. These marshes are classified as part of the "palustrine" ecological system which means they possess shallow standing water or saturated soils and are dominated by plants known as emergents. Emergents are erect, rooted, herbaceous hydrophytes represented in the Laguna by perennial species such as bulrush, tules, cattail, and willows. . ."[Cultivated, seasonal, and perennial marshes occur and are described below]

“Perennial Marsh. Perennial marshes in the Laguna de Santa Rosa are dominated by herbaceous emergents such as tules and cattails. Surface water can persist throughout the growing season, but when absent, soils are still saturated.

“Seasonal Marsh. Seasonal marshes in the Laguna de Santa Rosa are similar to perennial marshes but surface water is present for shorter periods of time. A class of seasonal marsh includes shrubby willow species, an indication that the previously cleared riparian forest [evidence?] **may be regenerating.**

“Cultivated Marsh. Most of this wetland was previously riparian forest [evidence?]. It was flooded for lengthy periods before channelization changed the water regime to shorten the flooding season.

“Riparian Forest. Riparian forest consists of trees found amidst standing water that is present for significant periods throughout the year. . . **Aerial photographic evidence of large stands of riparian forest occurring south of Highway 12 has not been found. . . Wide expanses of riparian forest were probably limited to the 2-year floodplain where the water regime requirements of the trees were attained regularly. . .**

“The dominant trees in this forest are all deciduous hardwoods: valley oak, box elder, Oregon ash, and various willows. . . Surface water can persist throughout the growing season, but when absent, soils are still saturated [Valley oaks are not adapted to year-round surface water or saturation]. . . Based on the presence of Clear Lake clays on the annual floodplain (where riparian forest is most prevalent) and existing riparian forest patterns and distribution, **a conservative estimate of riparian forest cleared before 1941 is 501 acres, most of it north of Occidental Road.”**

“Vernal Pools. Vernal pools are distributed across the Santa Rosa Plain, forming a mosaic in the oak savannah. Oaks occur on the mounds between the small, water-filled, vernal pools.

“For vernal pool habitat to exist, the soil profile must have a restrictive horizon which causes ponding by preventing rainwater from percolating downward “

. . .

From “Table W1-2: Soils of the Laguna de Santa Rosa (from Miller 1972)”

“Clear Lake clay: 0-2% slope; Floodplain, basins; Seasonal wetlands; Hydrologic group D; Water regime—not shown; Hydric soil

[from page 11: “**Group D soils either support wetland vegetation presently or have in the past . . . The potential for wetland restoration . . . is very high.**”]

“Clear Lake clay, ponded: 0-2 % slope; Floodplain, basins; Riparian forest, marsh; Hydrologic group D; Water regime--Flooded, wet into late spring; Hydric soil”

From “Table W1-3 Classification of Wetlands of the Laguna de Santa Rosa (derived from Cowardin et. al., 1979 and USFWS 1976, 1985)”

“Marsh: perennial; Class—emergent; Water regime—Saturated/semi-permanent/seasonal; Dominant vegetation—tules, cattails; Topographic location—Annual floodplain

“Marsh: seasonal; Class—emergent; Water regime—Intermittently flooded, temporary; Dominant vegetation—tules, cattails, annual herbs; Topographic location—Depressions, 5-year floodplains

“Vernal pools; Class—emergent; Water regime—Intermittently flooded, temporary; Dominant vegetation—annual herbs; Topographic location—hummocky topography, closed basins

“Riparian forest: Class—forested; Water regime—Intermittently flooded, temporary; Dominant vegetation—oak, ash, willow; Topographic location—5-yr, floodplain

“Riparian forest: Class—forested; Water regime—Saturated/semi-permanent/seasonal; Dominant vegetation—oak, ash, willow; Topographic location—annual floodplains”

CH2M HILL (1990)

“Vernal pools occur in shallow depressions on ponded phases of the Clear Lake and Huichica soils.”

p. 1-3

“Wetlands in the Laguna system include seasonal and perennial marshes, riparian forests, and vernal pools.”

p. 1-4

“Clear Lake soils are often hydric, although the determination must be based on site-specific conditions and varies from location to location. These soils probably supported marsh vegetation in pre-Columbian time.”

p. 5-4

“Freshwater Marsh
The next most extensive historic vegetation type was the freshwater emergent wetland, occupying approximately 16 percent (4,400 acres) of the study area, mostly in the southern portion . . . **The remaining perennial marsh is found primarily in the northern portion of the Laguna floodplain (Figure 6-5). The present day distribution of freshwater marshland provides an indication of the historic distribution. There was probably more perennial marsh in the Rohnert Park/Cotati area in the past (Cardwell 1958. NOTE—unable to find reference to this in Cardwell). The hypothesized distribution of this vegetation type is based on the mapped distribution of Clear Lake clay (Miller 1972), which formed under marshy conditions in basins (Helley *et al.* 1979). . . A large proportion of the historic freshwater marsh was probably a seasonal wetland that floristically resembled vernal pools (which are smaller versions of seasonal freshwater marshes). Perennial wet areas were in the Cotati area (Figures 6-1 to 6-3) [Evidence?]**. Remnants of perennial freshwater marsh still occur near the Laguna channel. These perennial marshes were dominated by bulrush (*Scirpus californicus, S. acutus*), cattail (*Typha latifolia*) and bur-reed (*Sparangium eurycarpum*). **Relatively large acreages of seasonal marsh are still present, especially in the southern portion of the study area, where Clear Lake clays are abundant.”**

pages 6-10

“Drainage of the wetlands of the Cotati Valley. Grains were planted in much of the Cotati valley, as the more productive soils went to other agricultural uses. These soils developed under marshy conditions (Helley *et. al.* 1979), and were considered the most marginal soils for cultivation in the Santa Rosa Plain area. An 1867 map, the earliest known map of the Laguna (Figure 6-1), shows the creeks tributary to the upper Laguna disappearing without defined channels into the wetlands [wetlands not visible on this map] of the Cotate Rancho. By 1877 (figure 6-2), the area had been traversed by the San Francisco and Northwestern Pacific Railroad, and two of the major creeks draining the west slope of Sonoma Mountain, Copeland Creek and Crane Creek, showed defined channels crossing the Cotati Valley and connecting directly with the Laguna de Santa Rosa on the western side of the valley. By 1915 these channels had been further straightened (6-3). The construction of the railroad likely prompted the need to drain the east side of the tracks, in order to prevent the creation of a miles-long dam restricting outflow from Sonoma Mountain. This effort worked in tandem with local desire to increase productive use of the land, **thereby draining a large acreage of what was once a vast seasonal and perennial wetland”** [Evidence for perennial?].

p. 6-5

“Figure 6-4 Estimates of the Historic Distribution of Vegetation in the Laguna de Santa Rosa Area” shows the **area east of 101 in the Rohnert Park/Cotati area as “Freshwater Marsh (Seasonal and Perennial)”**

pages 7-16 to 7-18: definitions of Perennial and Seasonal Marshes, Open Water, Perennial Marsh, and Seasonal Wetland:

“Open Water. This palustrine wetland has a water regime characterized by permanent flooding. Vegetation, characterized by submergent plants such as pondweed, duckweed, marsh pennywort and widgeon grass, forms aquatic beds floating around the perimeter of open water.”

“**Perennial Marsh** Classified as a palustrine system, this wetland possesses a semi-permanently flooded water regime. It is a persistent emergent wetland dominated by grasslike perennial plants such as bulrush, cattails, and bur-reed, although broadleafs such as water plantain and loosestrife are also common.

“**Seasonal wetland**. This palustrine wetland system typically exhibits a seasonally flooded water regime. **Vernal pools and margins of marshes are examples of this habitat type. These habitats are considered non-persistent, emergent wetlands because the plants fall to the surface of the substrate, or below the surface of the water at the end of the growing season. For example, the dominant species such as smartweeds, watergrass, spiked rush, docks, and flowering annuals may form dense stands in early spring, but at mid-summer there may be no apparent signs of emergent vegetation on what appears to be a dry, hard soil surface.** This habitat provides an important seasonal food resource for migratory and resident dabbling ducks and shorebirds (Weller 1989). Spring dewatering creates mudflat conditions attractive to migrant shorebirds and ducks, and induces germination of the seedbank. The amphibian and aquatic invertebrate prey base is utilized by egrets and herons, and a host of shorebirds. Reflooding in the fall makes seedheads accessible and shallow depths make the seeds and invertebrates of the bottom available to migrant waterfowl and shorebirds. Dabbling ducks such as teal, mallard, and pintail find ideal food and water conditions in such situations.”

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