FINAL REPORT

COYOTE CREEK WATERSHED HISTORICAL ECOLOGY STUDY

HISTORICAL CONDITION, LANDSCAPE CHANGE, AND RESTORATION POTENTIAL IN THE EASTERN SANTA CLARA VALLEY, CALIFORNIA

SAN FRANCISCO ESTUARY INSTITUTE

PREPARED FOR THE SANTA CLARA VALLEY WATER DISTRICT

MAP LEGEND

- Shallow Bay/Channel
- Tidal Flat
- Tidal Marshland with Channels and Pannes
- Saltgrass-Alkali Meadow | *Salitroso*
- Wet Meadow
- Seasonal Lake | *Laguna Seca* and Perennial Freshwater Wetland | *Tular*
- Perennial Freshwater Pond | *Laguna*
- Willow Grove | *Sausal*
- Sycamore Grove | *Alisal*
- Bars, Islands, and Inset Benches - Sycamore Alluvial Woodland and Riparian Scrub
- Valley Oak Savanna | *Roblar*
- Dry Grassland
- Stream

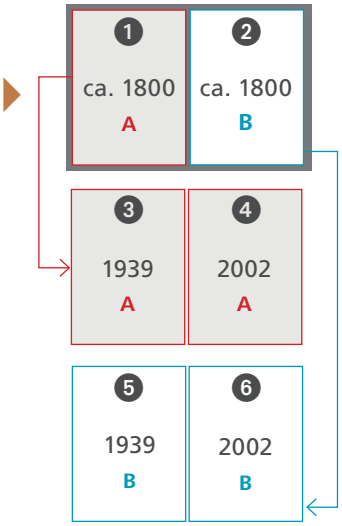
MAP GRAPHICS

To coordinate the presentation of information at different scales, we use **3 standard map scales**.

1) The overview maps showing the full Coyote Creek valley floor area are made at **1: 200,000 scale, or 1 inch equals approximately 3 miles.**

2) Each section in Part III begins with a **six-page 1: 40,000 (1" = 3333')** map series showing the area **circa 1800** (using the project GIS), in **1939** (using the georectified aerial photomosaic), and in **2002** (using a true color photomosaic by AirPhotoUSA).

3) About 20 "zoom-ins" distributed throughout the text focus on half-mile squares at **1: 10,000 (1" = 833')**. Features are thus enlarged fivefold and fourfold, sequentially.



COVER MAP FROM U.S. DISTRICT COURT, NORTHERN DISTRICT [184-?]B. LAND CASE MAP E-900. COURTESY THE BANCROFT LIBRARY, UC BERKELEY.

FINAL REPORT

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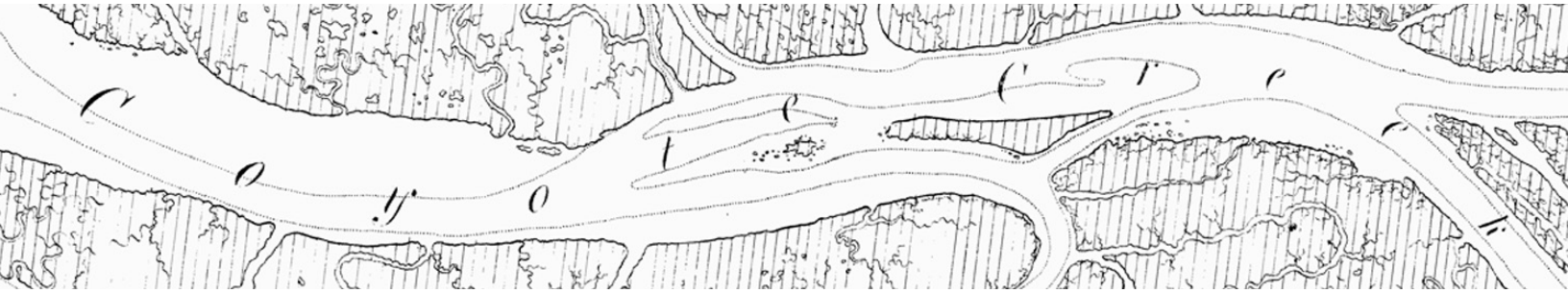

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EXECUTIVE SUMMARY

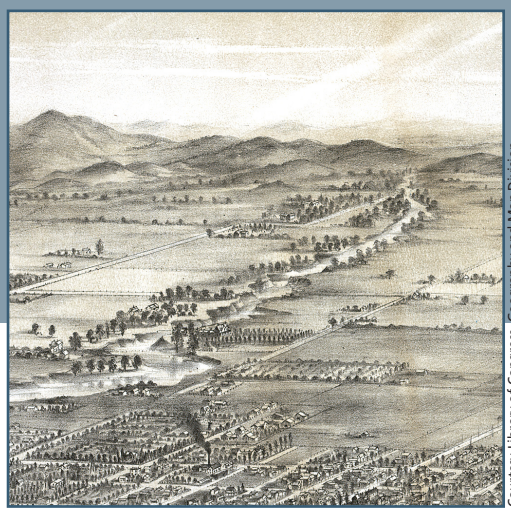
COYOTE CREEK WATERSHED HISTORICAL ECOLOGY STUDY

HISTORICAL CONDITION, LANDSCAPE CHANGE, AND RESTORATION POTENTIAL

IN THE EASTERN SANTA CLARA VALLEY, CALIFORNIA

Prepared for the
Santa Clara Valley Water District

By the San Francisco Estuary Institute



Courtesy Library of Congress, Geography and Map Division.

Coyote Creek: 1869 Birdseye View

This report synthesizes historical evidence into a picture of how Coyote Creek looked and functioned before intensive modification. This new view shows how the contemporary landscape was shaped and provides an array of tools for the restoration of watershed functions, natural flood protection, and integrated water management.

STUDY OVERVIEW

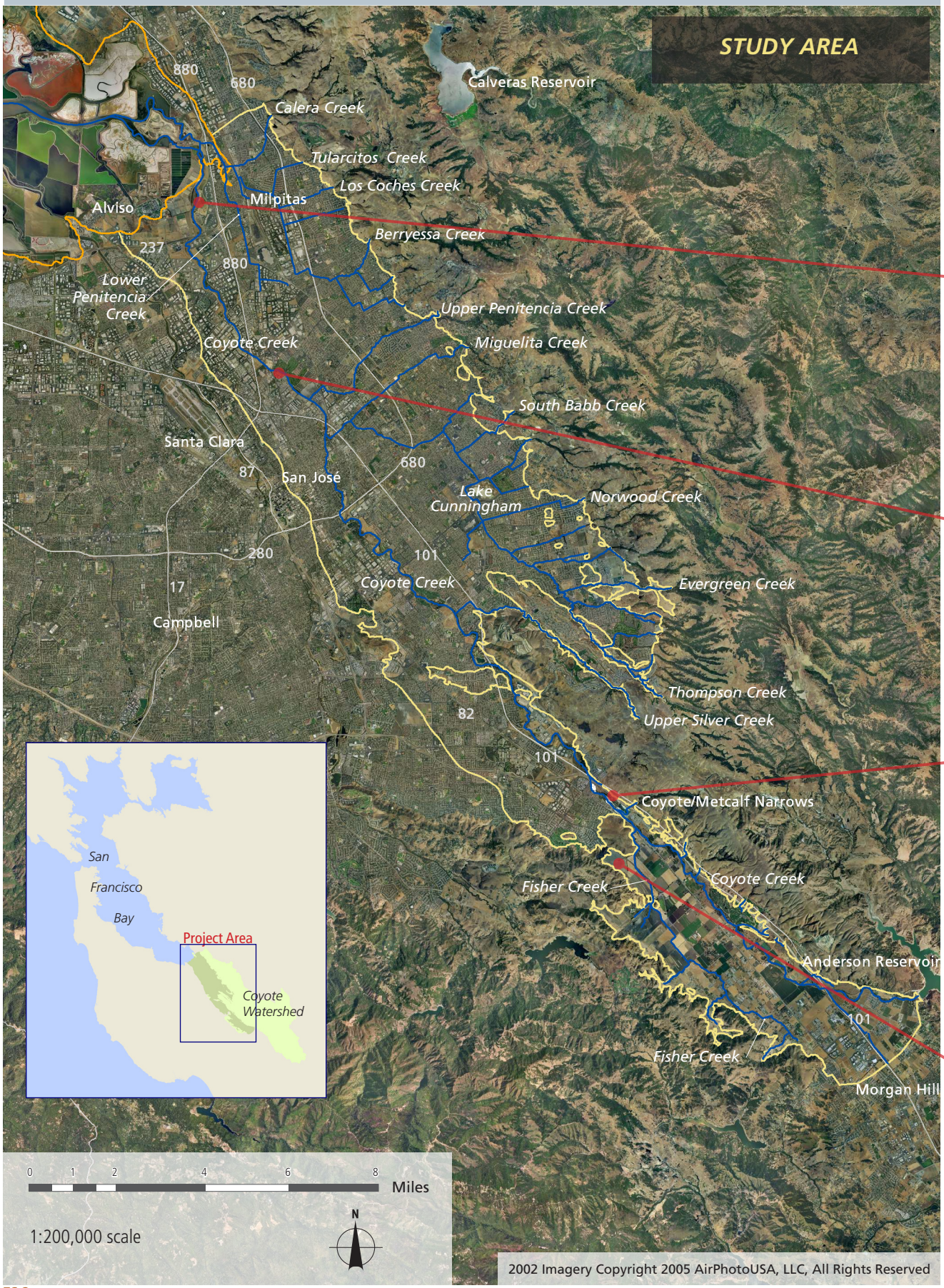
In recent years, a number of environmental research and management efforts in the Santa Clara Valley ("Valley") have recognized the need for a better understanding of historical conditions as a basis for developing locally appropriate habitat goals and guidelines for restoration design. Understanding how habitat patterns and their controlling physical processes have been altered helps determine the relative potential for recovery, and suggests appropriate measures to implement. Fortunately, the Santa Clara Valley has a wealth of historical information which represents an untapped resource for understanding the origins and potential of today's landscape.

HISTORICAL OVERVIEW

Coyote Creek's naturally wide footprint has led to an unusual amount of publicly owned lands along the stream. This imposing morphology — including broad, flood-prone stream benches and long, dynamic braided reaches — tended to restrict streamside development. As a result, there is a relatively high proportion of city and county parkland that could contribute to stream health, through coordinated stream restoration and natural system-based flood protection activities. Additionally, while modified in many ways, Coyote Creek has escaped major straightening. Unlike most Bay Area streams, the channel tends to follow its historical route. These basic aspects of the stream's history contribute to significant present-day restoration potential.

EXECUTIVE SUMMARY CONTENTS

In this study, we mapped historical landscape patterns for the valley floor draining to Coyote Creek – an approximately 100-square-mile area on the eastern side of the Santa Clara Valley. This portion of Santa Clara County includes parts of the cities of San Jose, Milpitas, and Morgan Hill. The aerial photograph below shows the study area in 2002. A sampling of early images illustrates historical habitats mapped on the facing page.



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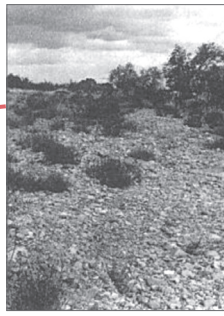
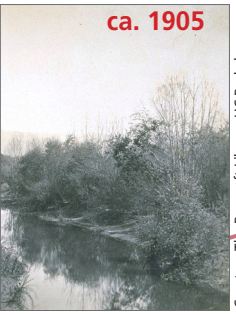
Low gradient, perennial reach.


Narrow reach with perennial water and gravel bars.

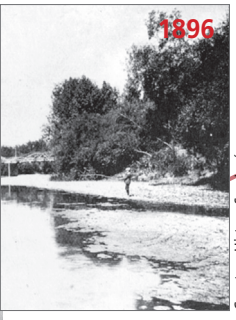

Broad, gravelly, intermittent Coyote stream bed.


Laguna Seca: tules and ponds.

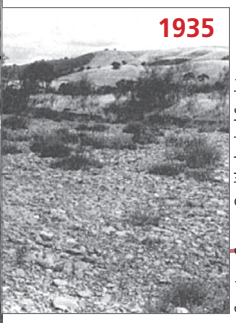
Before the modifications of the 19th and 20th centuries, the lands along Coyote Creek supported a remarkably diverse mosaic of habitats. Native grasslands and the celebrated valley oak savannas occupied the well-drained alluvial fans and natural levees along Coyote Creek. These areas (in yellow and orange on the map) became the most productive agricultural lands, primarily fruit orchards.



Courtesy The Bancroft Library, UC Berkeley.

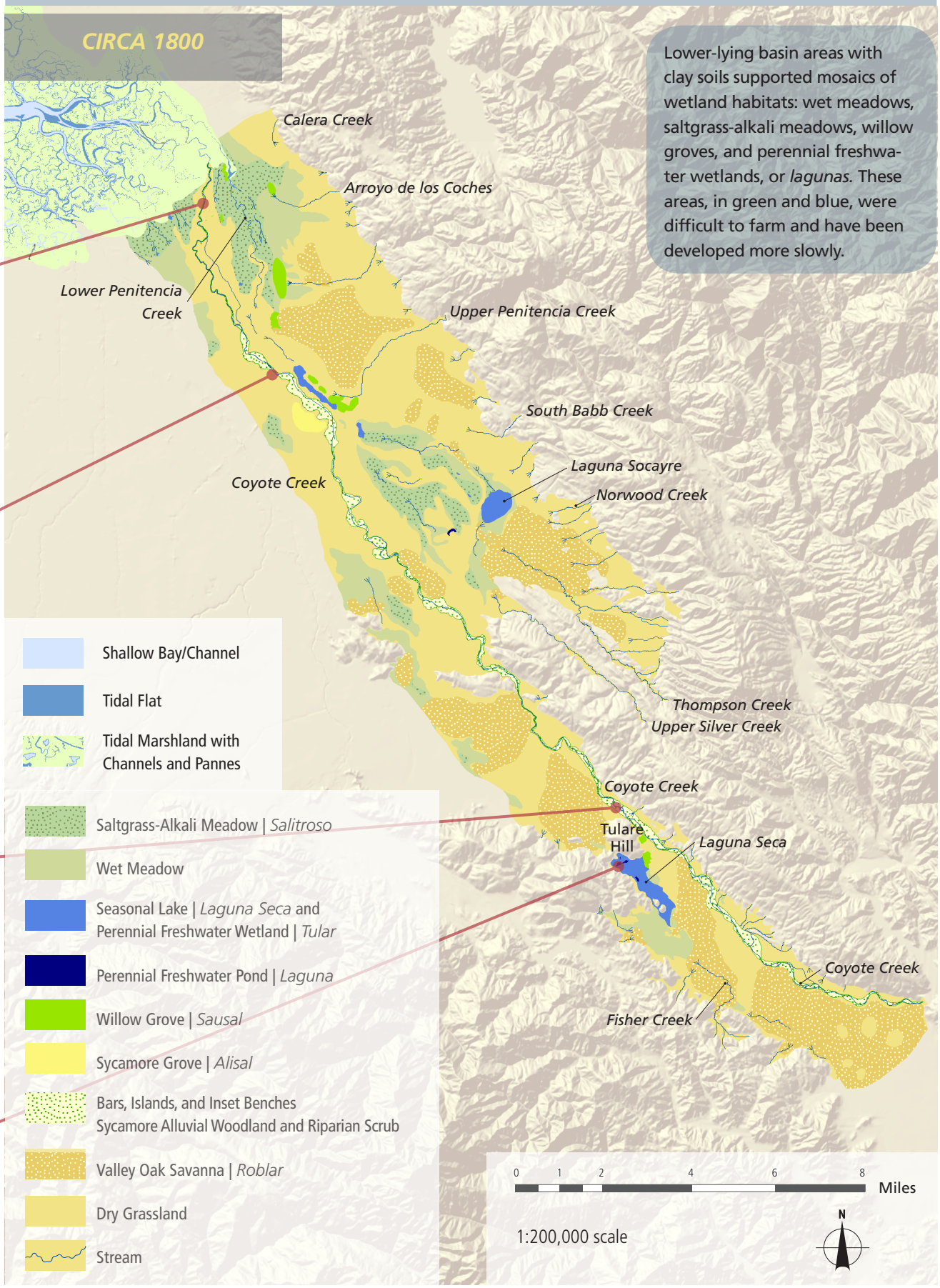


Courtesy History San José.



Courtesy Cooper Ornithological Society.

Courtesy the Santa Clara Valley Water District.



UNDERSTANDING LANDSCAPE CHANGE

Many changes are easily overlooked, yet have significant present-day ramifications.

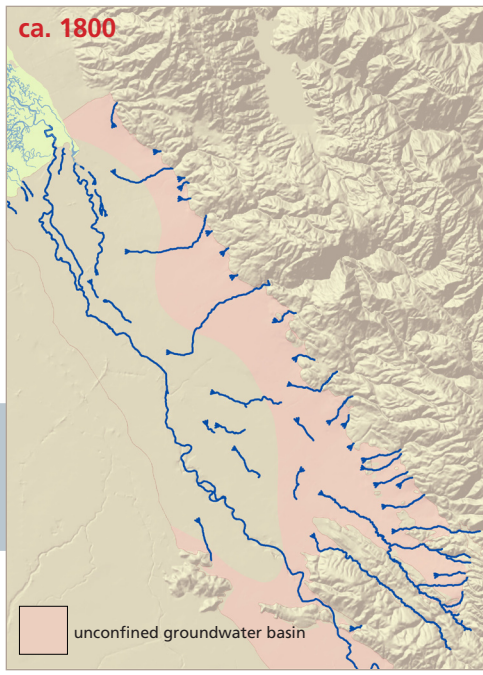
DRAINAGE INTENSIFICATION

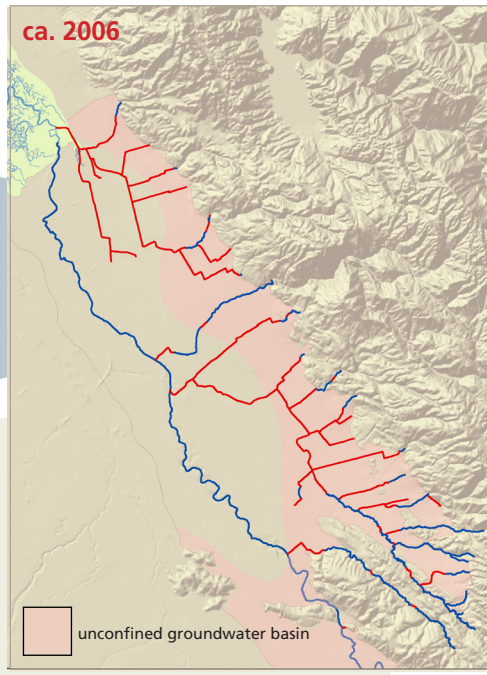
Today nearly 50% of the valley floor water courses draining into Coyote Creek are constructed channels. These channels convey runoff across areas that previously had no surface drainage. The natural drainage network was highly discontinuous, supporting groundwater recharge on the coarse alluvial fans and wetlands in the valley bottomlands.

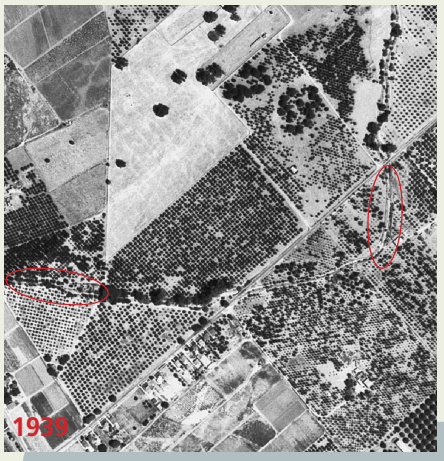
Before modification, most stream channels were discontinuous…they spread out on the valley floor.

The construction of drainage ditches and channels, which took place largely prior to 1900, has increased the density of drainage to Coyote Creek by about 40%. Furthermore, the expansion of the underground storm drain network has resulted in nearly a tenfold increase in drainage density. Over 20 miles of artificial channel and 120 miles of large, concrete storm drains now convey water from the unconfined groundwater zone that would otherwise contribute to recharge.

Drainage density has increased dramatically… resulting in reduced infiltration and more rapid delivery of stormwater to Coyote Creek.







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RIPARIAN RECOVERY In this set of aerial photographs, riparian forest along Upper Penitencia Creek – heavily impacted by agriculture in the 1930s – has significantly expanded with the creation of a protective land use buffer.

Trajectories of change vary substantially from place to place… and there are some positive examples.

SPATIAL VARIABILITY

While riparian forest has been lost along many creeks, a few reaches have shown notable improvement during the past few decades. Some streams have incised greatly, while others show almost no change over the past 150 years. We can look to these sites that have beneficial, positive trajectories as contemporary models for watershed protection and recovery.

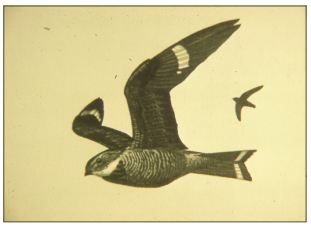
MANAGING WATERSHED FUNCTIONS AND PROCESSES

Historical information provides a starting point for setting appropriate local goals.

RIPARIAN HABITAT: ONE SIZE DOESN'T FIT ALL.

While we tend to think of riparian habitat as a dense, closed canopy forest, this was not the dominant riparian type on Coyote Creek, where open savanna/woodland, riparian scrub, and large, unvegetated gravel bars were all important riparian components. Given that these habitat types have been disproportionately lost, watershed management efforts should consider their restoration at appropriate sites.

SYCAMORES AND NIGHTHAWKS: INTERMITTENT IS NOT NECESSARILY BAD.



Under natural conditions, most of Coyote Creek was seasonally dry (see center spread). The combination of intermittent reaches and perennial reaches (which were limited to the top and bottom of the valley), supported a wide range of native species, including the Lesser Nighthawk, which once nested in the gravelly creek beds but is no longer a breeding resident species.

SYCAMORE ALLUVIAL WOODLAND: THE CHARACTERISTIC HABITAT OF COYOTE CREEK

Historical evidence indicates that Coyote Creek's dominant riparian habitat was Sycamore alluvial woodland. Now mostly eliminated along the creek (and throughout the state), this habitat of episodic, gravel-dominated Central Coast streams had a relatively open tree canopy with widely-spaced sycamores — in contrast to the densely wooded contemporary conditions.

RIPARIAN CONVERSION: COTTONWOOD FOREST REPLACES SYCAMORE WOODLAND

Since the construction of Coyote Dam in 1936, peak flows from most of the upper watershed have been reduced, while summer flows have increased. As a result, trees have invaded the active channel, largely eliminating unvegetated bars and open riparian habitat, and converting one riparian habitat type to another. While clearly possessing riparian value, these new habitats should probably be assessed for long-term viability and ecological function.

Imagery Copyright 2005 AirPhoto USA, LLC, All Rights Reserved.

RIPARIAN HABITAT CONVERSION in the vicinity of Cottonwood Lake.

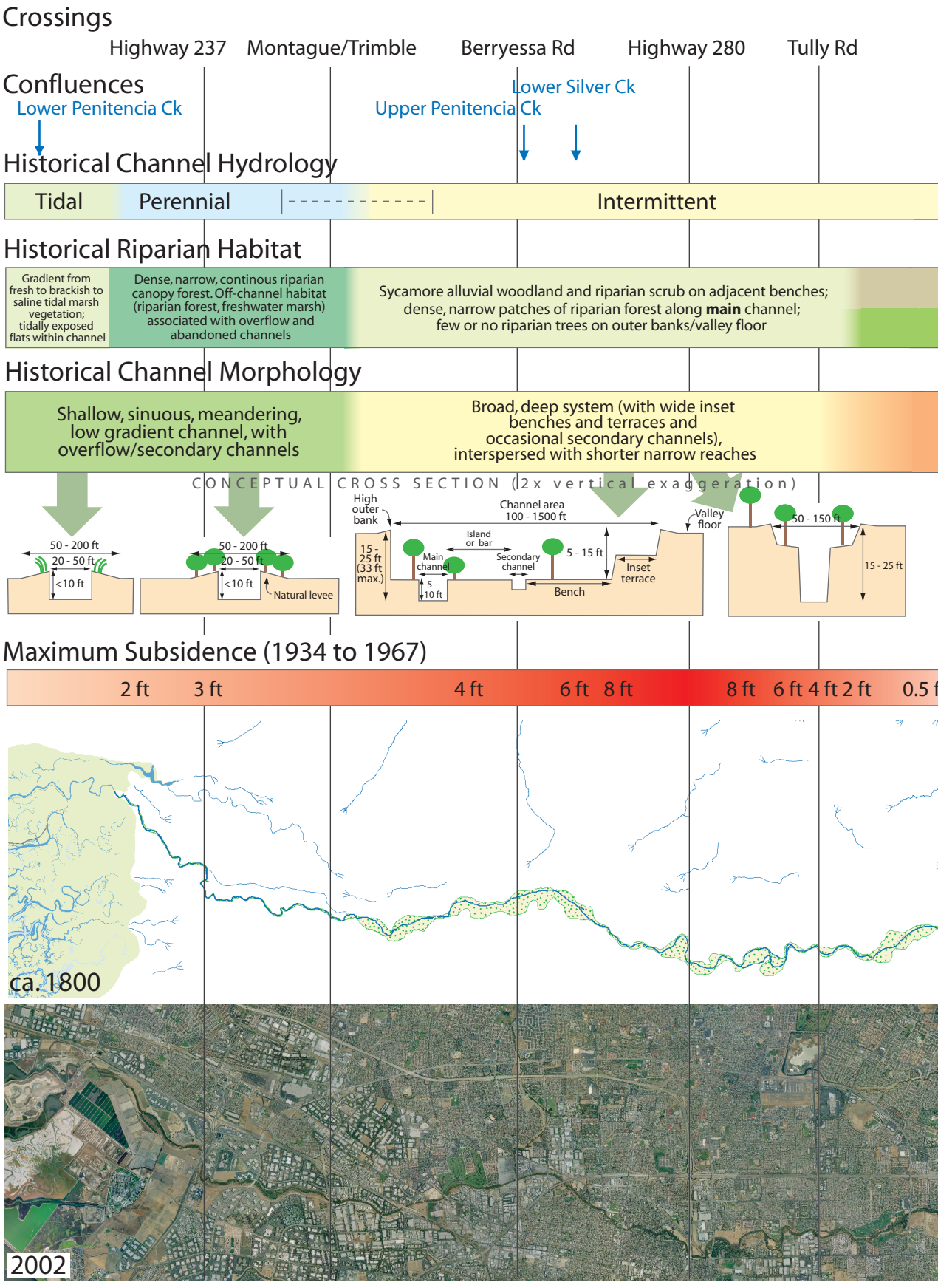
"…whose course is marked with groups of giant sycamores, their trunks gleaming like silver through masses of glossy foliage…"

- Bayard Taylor, describing Coyote Creek circa 1850 (in Carroll 1903: 185)

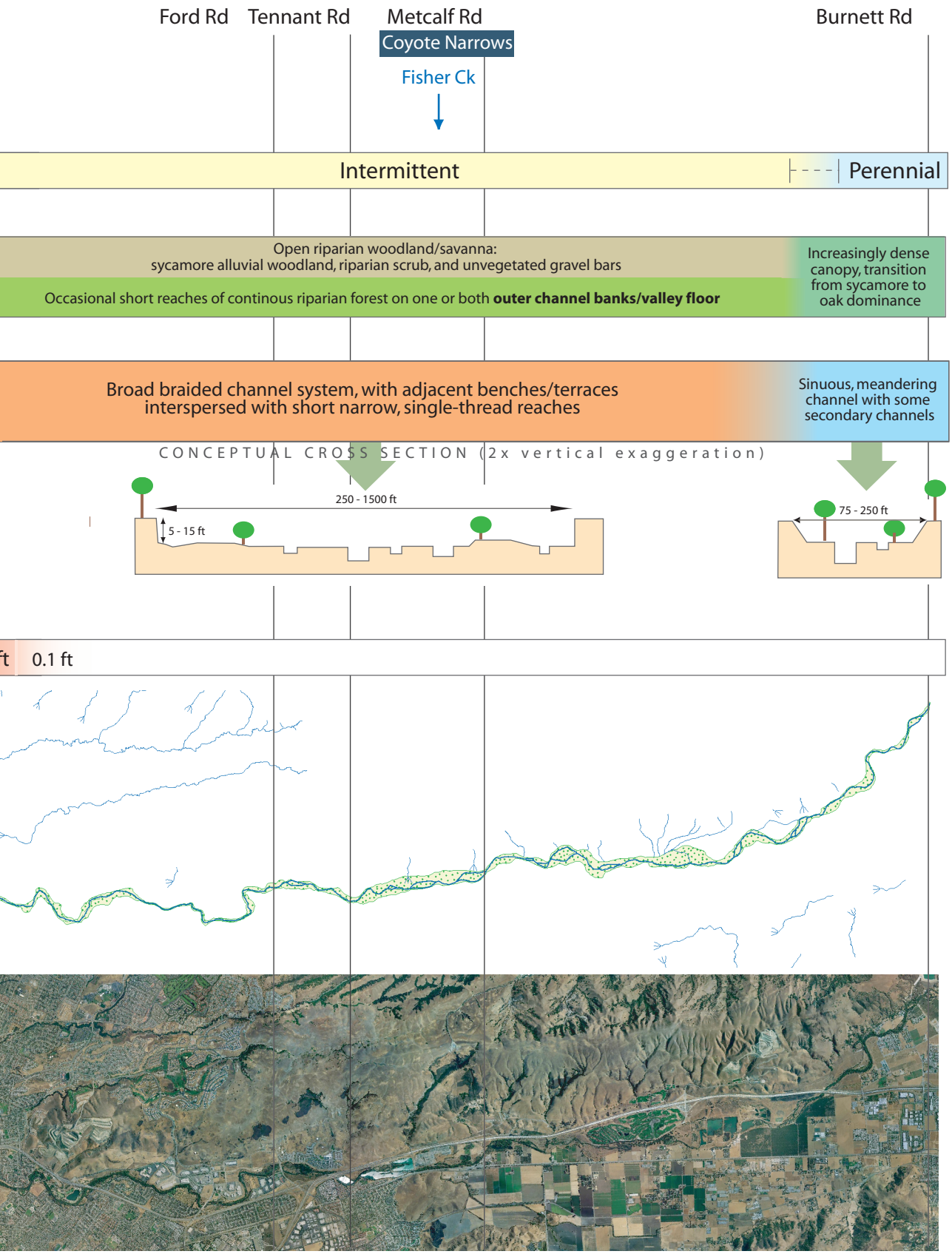
COYOTE VALLEY REACH: RESTORATION AND PRESERVATION OPPORTUNITIES.

Some of the best existing examples of Coyote Creek's pre-modification riparian habitat can be found in Coyote Valley between Sycamore Avenue and Highway 101. This reach maintains fish assemblages with a relatively high proportion of native species and has been recognized as a significant remnant of Central Coast Sycamore Alluvial Woodland. Plans for the long-term viability of this community should consider the potential negative impacts associated with summertime flows and the potential benefits of high flow pulses in the winter. Restoration at Ogier Ponds could contribute significantly to this important reach.

COYOTE CREEK'S HISTORICAL HYDROLOGY, HABITAT, AND MORPHOLOGY



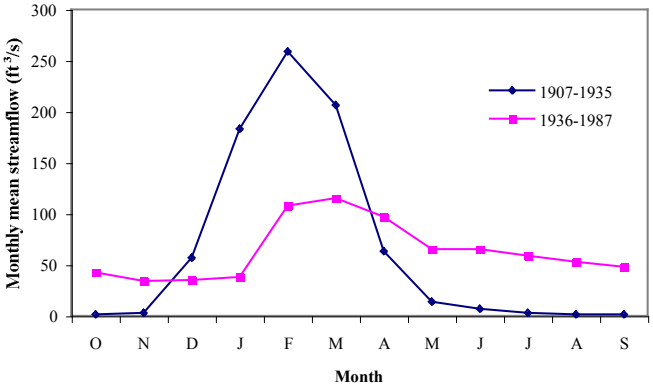
This diagram shows how key attributes of the creek varied naturally by reach. The close relationships between morphology, habitat, and hydrology indicate how physical and ecological processes are interrelated. Transitions between reaches were gradual and varied through time. Cross-sections illustrate reaches based upon historical data (2002 Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).


Ford Rd
Tennant Rd
Metcalf Rd
Coyote Narrows
Fisher Ck
Burnett Rd
Intermittent
Perennial
Open riparian woodland/savanna:
sycamore alluvial woodland, riparian scrub, and unvegetated gravel bars
Occasional short reaches of continous riparian forest on one or both outer channel banks/valley floor
Increasingly dense canopy, transition from sycamore to oak dominance
Broad braided channel system, with adjacent benches/terraces interspersed with short narrow, single-thread reaches
Sinuous, meandering channel with some secondary channels
CONCEPTUAL CROSS SECTION (2x vertical exaggeration)
250 - 1500 ft
5 - 15 ft
75 - 250 ft
0.1 ft

MANAGING WATERSHED FUNCTIONS AND PROCESSES

CONSIDERING REGULATED FLOWS IN A NATURAL CONTEXT: TOOLS FOR INTEGRATED WATER MANAGEMENT

Strategically modifying regulated flows to more closely mimic natural patterns could benefit native fishes and habitats. It could also help summer water conservation.



CHANGE IN MONTHLY RUNOFF DISTRIBUTION FOR COYOTE CREEK. Since the construction of Coyote Dam in 1936, the creek has received reduced winter flows and greatly increased summer flows. (Gauge location approx. 1.2 mi. downstream of Anderson Dam and 1 mi. upstream of Hwy 101 crossing.)

Greater variability could be important to stream health:

- **Augmentation of stream flows may have unintended effects.** The conversion of most of the stream to perennial flow has significantly altered riparian and aquatic habitats.
- **The braided channel habitats in the vicinity of the Coyote Creek Golf Club have probably maintained their relatively natural character partly because of the Coyote Diversion Canal.** This portion of the stream has been excluded from strong summertime flow increases and has not converted to dense riparian forest. Future alterations to the flow regime should consider potential ecological effects within a temporal context.
- **Historical sites of perennial stream flow and groundwater discharge may be particularly important given future climate uncertainty.** These sites, and their dependent native species, are more likely to persist than areas requiring supplemental water, particularly during extended drought and/or limited summer water supply periods. This information can help better direct the use of water for environmental needs.
- **Controlled high flow releases could have benefits.** Modest but significant pulse flows, particularly with some augmented sediment and gravel supply, could have geomorphic benefit and select for native fishes over non-native species.

COULD THE COYOTE CREEK DELTA BE RESTORED?

A century ago the tidal and lower reaches of Coyote Creek supported natural fresh and brackish tidal marshlands with a fish assemblage largely similar to those found in the Sacramento-San Joaquin Delta. Treated effluent inputs could be used to reestablish these wetland gradients—now a regionally rare habitat type. Restoration of some of these habitats and their fish populations—a miniature delta—could be of regional significance.

These habitats could be linked to other restoration opportunities in the vicinity of the San Jose-Santa Clara Water Pollution Control Plant. Preservation of local agriculture by the City of San Jose has maintained relatively high habitat potential here at the Baylands edge. Wet meadows and saltgrass-alkali meadows as part of the "Artesian Slough Habitat Template" could be part of an integrated restoration plan for this lowest part of the watershed.

HISTORICAL (CA. 1800) BRACKISH MARSHLAND PATTERNS: tidal sloughs and pannes.

OPPORTUNITIES FOR HABITAT RESTORATION

CAN VALLEY OAKS PERSIST WITHIN THE URBAN FRAMEWORK?

VALLEY OAK ALONG COYOTE ROAD.

Valley oak savanna—grand, widely spaced trees with a grassland understory—was the signature habitat of the Santa Clara Valley. Despite general loss, a surprising number of trees have survived, partly because they have always been recognized for their beauty and shade. But they will need stewardship to survive into the future.

Valley oaks could be restored in elements through coordinated local efforts. The naturally "scattered" distribution of valley oaks means that they can be relatively successfully integrated within the urban framework. Young trees need to be established to maintain this local habitat into the future.

RESIDUAL VALLEY OAK AMONG PALMS, BLOSSOM HILL DRIVE. This grand tree has been preserved as a landscape centerpiece.

Courtesy The Bancroft Library, UC Berkeley.

DEPICTION OF VALLEY OAK SAVANNA showing a grove along Monterey Road (Healy, U.S. Dist. Court 1859, courtesy The Bancroft Library, UC Berkeley).

Courtesy History San José.

PART OF THE GREAT VALLEY OAK SAVANNA SOUTH OF LAGUNA SECA, CIRCA 1896 (Shortridge 1896, courtesy History San José).

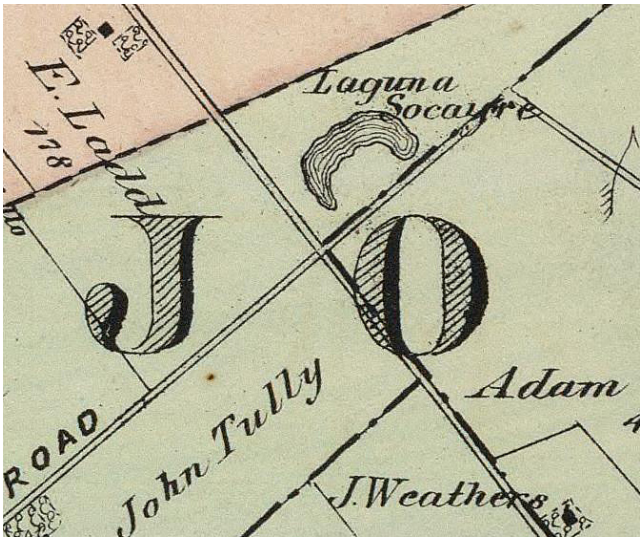
OPPORTUNITIES FOR HABITAT RESTORATION

RESTORING WETLAND MOSAICS IN CONCERT WITH NATURAL PROCESSES

The map of historical landscape patterns reveals sites where topography, soils, and hydrology are likely to support sustainable wetlands.

In Coyote Valley, Laguna Seca offers a rare opportunity to restore natural wetland functions and a diverse wetland habitat mosaic. Laguna Seca restoration would link to existing buffers and have regional significance as a large, natural, valley floor wetland. Successful wetland restoration at Laguna Seca could support a wide range of valued species, including rare plants, amphibians, and water birds.

Identifying and preserving habitat remnants. Strategic preservation and enhancement efforts of the saltgrass meadows at Lake Cunningham Park could improve this rare habitat while coexisting with surrounding recreational activities. There are likely other opportunities for restoration in the vicinity of the historical Laguna Socayre.

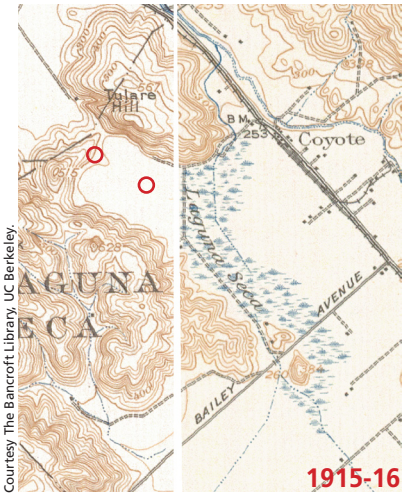


Courtesy David Rumsey, Cartography Associates.

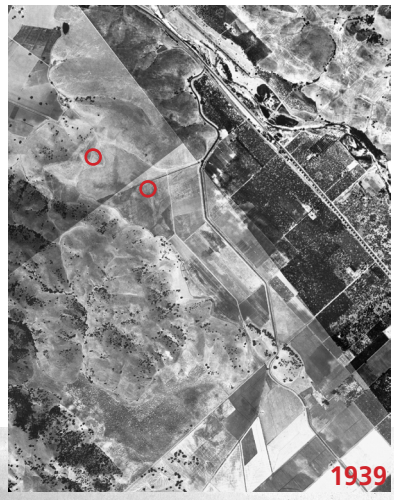
SMALL PERENNIAL POND OF THE LAGUNA SOCAYRE COMPLEX, 1876 (Thompson and West 1876, courtesy David Rumsey, Cartography Associates).

LAGUNA SECA, 1916. Looking southeast across the northern end of the *laguna:* tall tules, open water ponds, Tulare Hill at left (letters on photographs refer to photographer's notes; red circle at extreme left in Laguna Seca map series above shows photographer location).

LAGUNA SECA THROUGH TIME



Courtesy The Bancroft Library, UC Berkeley.



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In the center and deepest part tall tules rise many feet above one's head, and in these numbers of Tule Wrens build their deceptive nests. A great many Coots breed here, and I am told our Bitterns also nest in the dense tules…

Along the shore in many places… marsh grass grows and along the edges of this thick clusters of clover thrive, which offer favorable sites for Ducks' nests...

- Fred Schneider 1893

Courtesy The Bancroft Library, UC Berkeley.

BERRYESSA CREEK SPREADS INTO A WILLOW GROVE, CIRCA 1840. U.S. District Court 1870 [Land Case Map D-494], courtesy The Bancroft Library, UC Berkeley.

TOOLS FOR NATURAL FLOOD PROTECTION

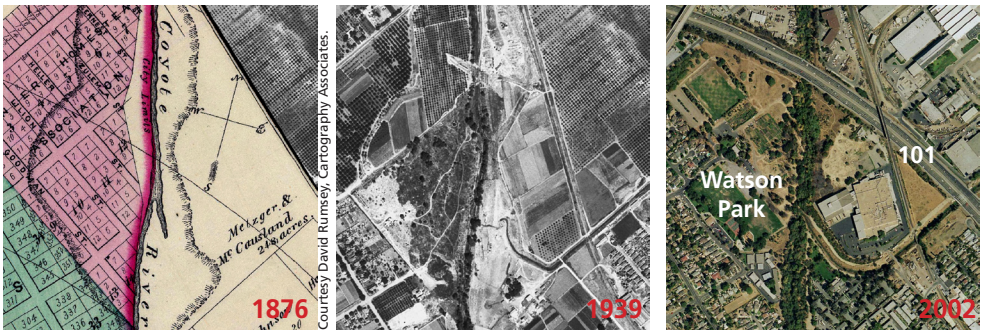
Historical data help identify places where natural approaches can be used to reduce flood risk.

INFILTRATION VERSUS DRAINAGE—REDESIGNING THE WAY WATER MOVES THROUGH THE VALLEY

The dramatic increase in constructed drainage tends to decrease groundwater recharge while increasing flood peaks downstream. Reducing drainage connectivity through off-site storage, swales, and neighborhood-scale infiltration projects will be important to both flood protection and water supply, especially given predicted climatic changes and increased impervious surfaces.

Restoration of natural hydrogeomorphology of Laguna Seca and the Fisher Creek drainage network could provide significant off-site flood peak attenuation as well as wetland habitat for a range of native species.

IDENTIFYING FLOODPLAIN RESTORATION OPPORTUNITIES—NATURALLY WIDE VERSUS NARROW REACHES

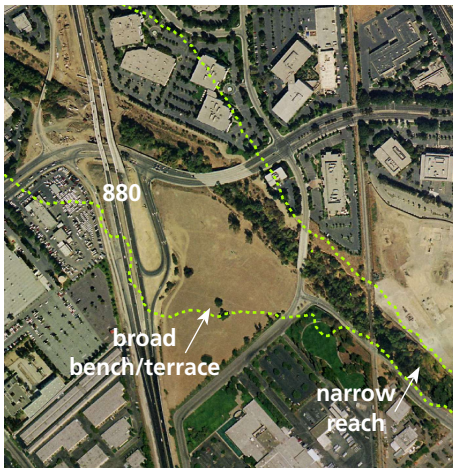


Courtesy David Rumsey, Cartography Associates.

A ONCE-BROAD CHANNEL AREA with wide inset stream benches becomes a city landfill and then Watson Park.

(BELOW) DOTTED LINE IDENTIFIES AREAS OCCUPYING FORMER STREAM BENCHES.

Coyote Creek displayed a natural pattern of long, broad reaches with adjacent inset benches and terraces interspersed with narrow, more confined reaches. This pattern suggests appropriate places for floodplain restoration projects to increase flood capacity.



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STREAM BENCHES—COYOTE CREEK'S NATURAL MORPHOLOGY REVEALS FLOOD PROTECTION OPPORTUNITIES

Existing flood-prone benches provide potential flood capacity. In the Mid-Coyote reach, there are many broad stream benches still subject to flooding. A number of these areas remain in public ownership, some of which could be designed to support and benefit from occasional flooding.

This publication is the Executive Summary from the report:

Coyote Creek Watershed Historical Ecology Study: Historical Condition, Landscape Change, and Restoration Potential in the Eastern Santa Clara Valley, California. Grossinger et al. 2006. Contribution No. 426, San Francisco Estuary Institute, Oakland, California.

For more information please see the full report, available at *www.sfei.org* or from the Santa Clara Valley Water District.

Santa Clara Valley Water District

THIS REPORT WAS PREPARED FOR THE SANTA CLARA VALLEY WATER DISTRICT BOARD OF DIRECTORS:

Rosemary Kamei • Joe Judge • Richard P. Santos • Larry Wilson, Chair • Gregory Zlotnick • Tony Estremera, Vice Chair • Sig Sanchez

A NOTE ABOUT USING HISTORICAL INFORMATION //

A historical landscape perspective is important not for sentimental or idealistic reasons, but because it helps us understand the contemporary landscape and its future potential.

Historical information is not directly predictive of the future. Controlling factors, including land use and climate, can change. Historical analysis helps recognize the controlling factors affecting local habitats and how they have changed, or stayed the same.

Reaching the past through restoration is not practical in all places. The past does not inherently represent what is needed now or in the future. It helps identify restoration and management options — ones well-calibrated to local landscape processes and history. It can reveal the resiliency and potential of the landscape. It shows how the pieces fit together.

What has been changed by the hands of people is not necessarily wrong. Landscapes need to be modified to meet the needs of people. But priorities are always changing. The landscape 100 years from now will be very different from today, based on our decisions.

Knowing the past helps us know how the present has evolved — the roles of human and natural history in shaping the present landscape. It helps identify where sustainable natural processes still persist and how to support them. It helps recognize both opportunities and constraints.

This knowledge yields options about how to move forward. It provides a basis for making informed decisions to maintain and improve the health of the local landscape.

ACKNOWLEDGEMENTS //

This project builds upon previous and related efforts by a number of local institutions, several of which we would like to mention specifically. Many staff of the Santa Clara Valley Water District (SCVWD) contributed their time, expertise, archives, and previous research on Coyote Creek. Mike Rigney and other staff of the former Coyote Creek Riparian Station were involved in early research efforts. Staff of the Environmental Services Department of the City of San José have also contributed to local historical landscape mapping efforts. The Santa Clara University Environmental Studies Institute, including Amy Shachter, Lisa Kealhofer, Russ Skowronek, Elianna Strode, and Shana Weber, has been an indispensable partner in reestablishing local historical ecology studies. We would also like to recognize the pioneering research done by Dr. Alan K. Brown, which has been inspirational.

As described below, the Coyote Creek Watershed Historical Ecology Study is part of a coordinated effort by a number of organizations and individuals to establish a foundation of historical landscape understanding for local environmental management. This effort has been funded through several related but distinct projects. We would like to thank those project managers for their help in producing a seamless set of products with long-term value: Rick Morat of the United States Fish and Wildlife Service San Francisco Bay Program, Christopher Richard of the Oakland Museum of California, Sarah Young of the SCVWD, and Luisa Valiela of the US Environmental Protection Agency Region IX. The project has also benefited from interactions with our partners on the SCVWD Watershed Stewardship Project, including Andy Collison of Philip Williams and Associates, Lucy Buchan of Eisenberg, Oliveri, and Associates (EOA), David Early and Isabelle Minn of Design, Community, and Environment, and team leader Clayton Creager of Tetra Tech.

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Bob Johnston, California Room, San José Public Library

Carolyn Jones, Map and Imagery Laboratory, Davidson Library, UC Santa Barbara

Kent Lightfoot, Archaeological Research Facility, UC Berkeley

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Paul Rogers, San José Mercury News

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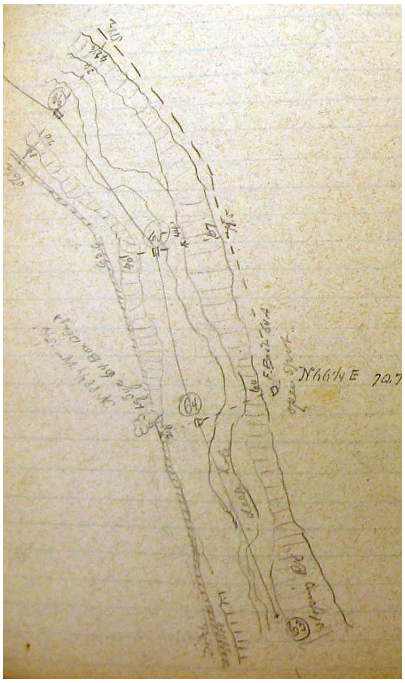
PART I //

INTRODUCTIONS AND METHODS

In Part I, we describe the context for the project and provide an overview of the methodologies used in data collection, compilation, and interpretation.



Herrmann 1874a: Survey Notes of June 24 [Coyote Book 3]

INTRODUCTION

In recent years, a number of environmental research and management efforts in the Santa Clara Valley ("the Valley") have recognized the need for a better understanding of historical conditions. Historical information is an essential tool for setting specific, locally appropriate habitat goals and developing specifications for restoration design. Understanding how the different habitats that comprise the Valley have been altered through sequential modifications helps determine their relative potential for recovery and appropriate measures to take. Fortunately, the Santa Clara Valley has a wealth of historical information, representing an untapped resource for understanding the origins and restoration potential of the present-day landscape.

The Coyote Creek Watershed Historical Ecology Study was designed by Santa Clara Valley Water District (SCVWD) staff, the San Francisco Estuary Institute (SFEI), and other interested parties as a stand-alone yet integrated component of a larger Santa Clara Valley Historical Ecology Project. This coordinated regional effort includes, in addition to the Coyote Creek Study, work carried out by SFEI as part of the SCVWD Watershed Stewardship Project, the Historical Tidal Marsh Maps Project, the Oakland Museum *Baylands and Creeks of the South San Francisco Bay* map, and the Silicon Valley Pollution Prevention Center-sponsored Santa Clara Valley Historical Ecology Project. The work presented here benefits directly from these efforts.

The Study, including this report and the associated Geographic Information System (GIS) database, is intended to support the development of a more integrated and synergistic vision for the diverse environmental management activities taking place in the Coyote Creek Watershed. It is designed to be used in the Mid-Coyote Flood Protection Project for the identification of restoration opportunities and the application of natural flood protection principles. The Study is also made available for use by other stream management and regional planning efforts such as the Santa Clara County Habitat Conservation Plan/Natural Community Conservation Plan (HCP/NCCP), Coyote Creek Parkway Master Plan project, and others.

This report is structured as follows. In **PART I**, we describe the project context, contributors, sources of information, and general methodology. **PART II** describes Historical Conditions at the Watershed Scale, summarizing conditions along the Coyote Creek Valley floor and defines landscape and habitat types. This section establishes a landscape framework for the subsequent sections, while explaining how we identified and mapped historical features. **PART III**, Historical Conditions at the Local Scale, describes early conditions in the Coyote Creek watershed in more detail, by dividing the valley floor portion of the watershed into four geographic areas. In **PART IV**, Landscape Change, we summarize key aspects of the complex human history that has shaped the watershed, assess how different components of the landscape have changed , and discuss the implications for restoration and management.

METHODOLOGY

This methodology section describes the general methods used to acquire, interpret, and synthesize historical data into technical products. More information about the interpretation of specific landscape features and processes is presented throughout the report in the relevant sections.

DATA COLLECTION & INTERPRETATION

While many environmental research projects still assess historical landscape change using only a few relatively recent historical documents, the dataset potentially available to researchers is actually remarkably extensive. It can be time-consuming to access these data, but neglecting the wealth of early information risks erroneous interpretations about natural condition and the origins of present-day environmental issues (Grossinger and Askevold 2005). To develop as strong a historical dataset as possible, we acquired materials from a wide variety of institutions. Inevitably, additional historical resources still exist to be found, and will likely reveal new and relevant information. For this reason we carefully documented the sources used in the GIS. We also note some potentially valuable sources of information that we were not fully able to assess in the course of this project.

We collected information about historical conditions from an array of sources. These included materials produced by federal and local agencies, individuals, Spanish/Mexican-era residents, professional and non-professional cartographers, photographers, writers, and engineers. Since these materials were produced for divergent reasons using a range of techniques, we developed substantial background scholarship to guide accurate interpretation. This process involved understanding three key aspects of historical document context: the technical methods or techniques, the social/personal context that determined why the document was created, and the document's timing in relation to contemporary and prior land use (Grossinger and Askevold 2005; **FIGURE I-1**). The use of multiple, complementary documents to compare and calibrate historical data sources, in combination with source scholarship, allows the maximum value of data to be acquired from a given data source (**FIGURE I-2**). To record variations in confidence level associated with different mapped features in the project GIS, we used a system of certainty levels (Grossinger 2001).

While describing the hundreds of historical data sources used in this project in detail is beyond the scope of this report, in the following section we briefly review several of the most important sources. These examples illustrate both the impressive skills of some of these early documentarians of the landscape and the diverse range of information sources that can be useful to a historical ecology study. Recognizing the different purposes and origins of historical documents improves the likelihood of accurate interpretation.

We also attempt to incorporate in the report, to the extent practical, a selection of historical imagery — both to illustrate the landscape and to provide a sampling of the graphic data available to future research efforts on related topics. These images represent just a small portion of the historical record for the region.

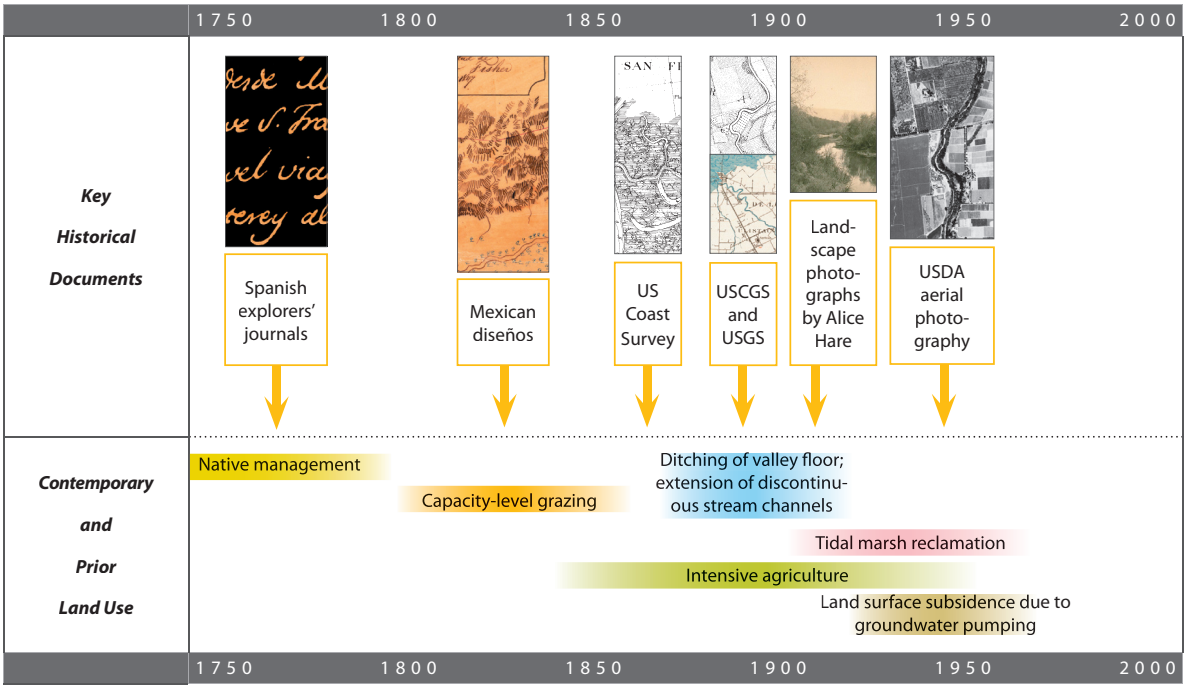


FIGURE I-1. DOCUMENT TIMING IN RELATION TO LAND USE HISTORY. Historical documents should be examined with an understanding of the prior land uses that have shaped a given site (from Grossinger and Askevold 2005).

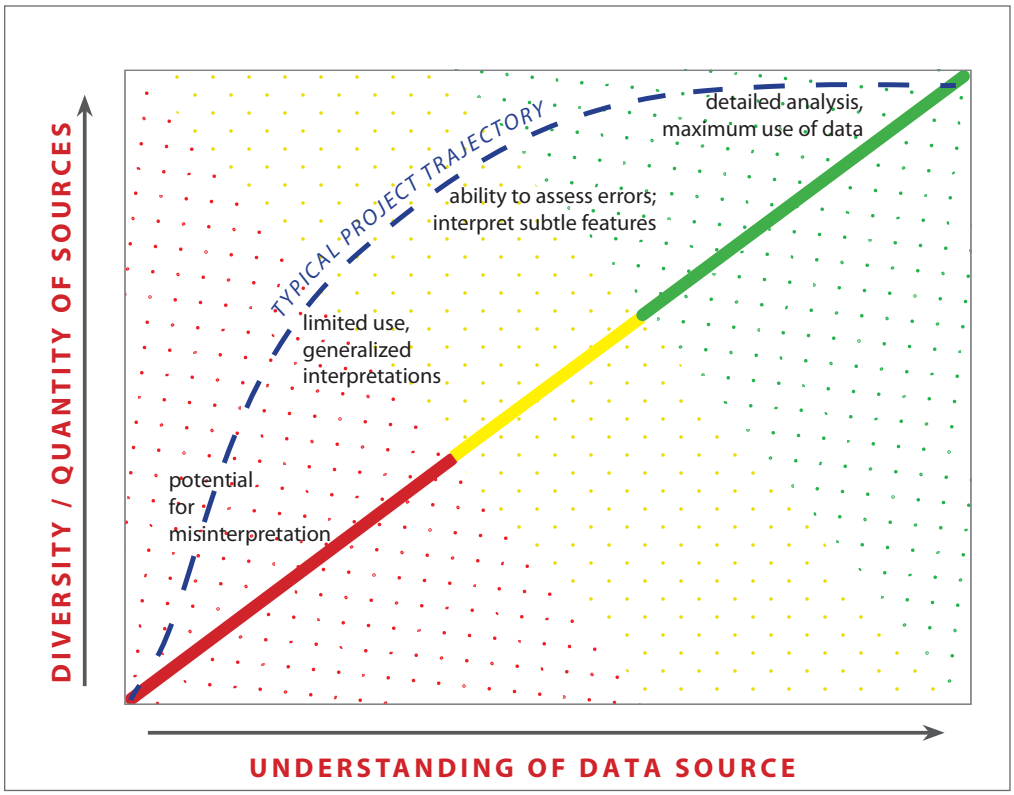


FIGURE I-2. IMPORTANCE OF A LARGE DATA SET AND SOURCE SCHOLARSHIP to accurate interpretation of historical data. In early stages of a project, there are many new sources and relatively little understanding of them. After an aggressive data collection phase, the number of new available documents diminishes and comparative analysis increases source understanding.

MEXICAN LAND GRANT SKETCHES (*DISEÑOS*), 1830s AND 1840s

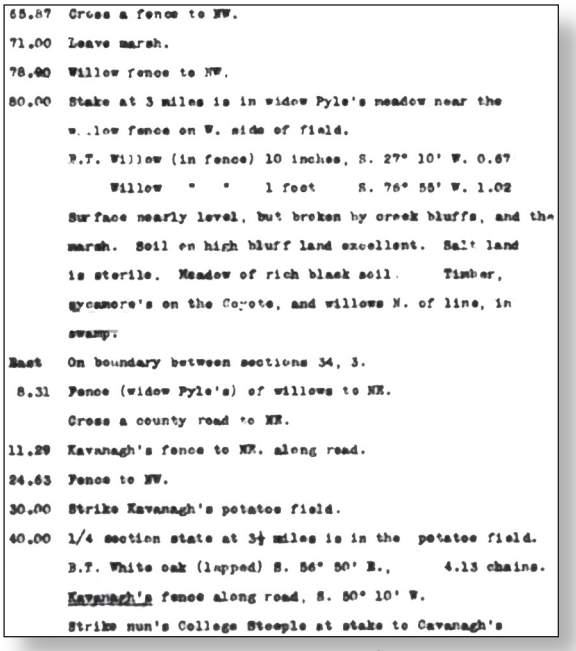
As the Mission system disintegrated, influential Mexican citizens submitted claims to the government for land grants. The accompanying sketches of desired land, generally produced by anonymous, untrained men, show distinctive features of the land such as creeks, wetlands, and woods, often with watercolors, handwritten annotation, and varying systems of symbols and styles. Despite their substantial infomation content, they have been rarely used for environmental research.

US District Court, Northern District [184-?]a. Land Case Map E-900.
Courtesy The Bancroft Library, UC Berkeley.

"THE LONG LINE FOLLOWED GENERALLY THE COURSE OF THE SANJON, BEING A LITTLE WITHOUT IT AT THE SOUTHERN END, AND A LITTLE WITHIN IT AT THE NORTHERN END." (DAY 1852)

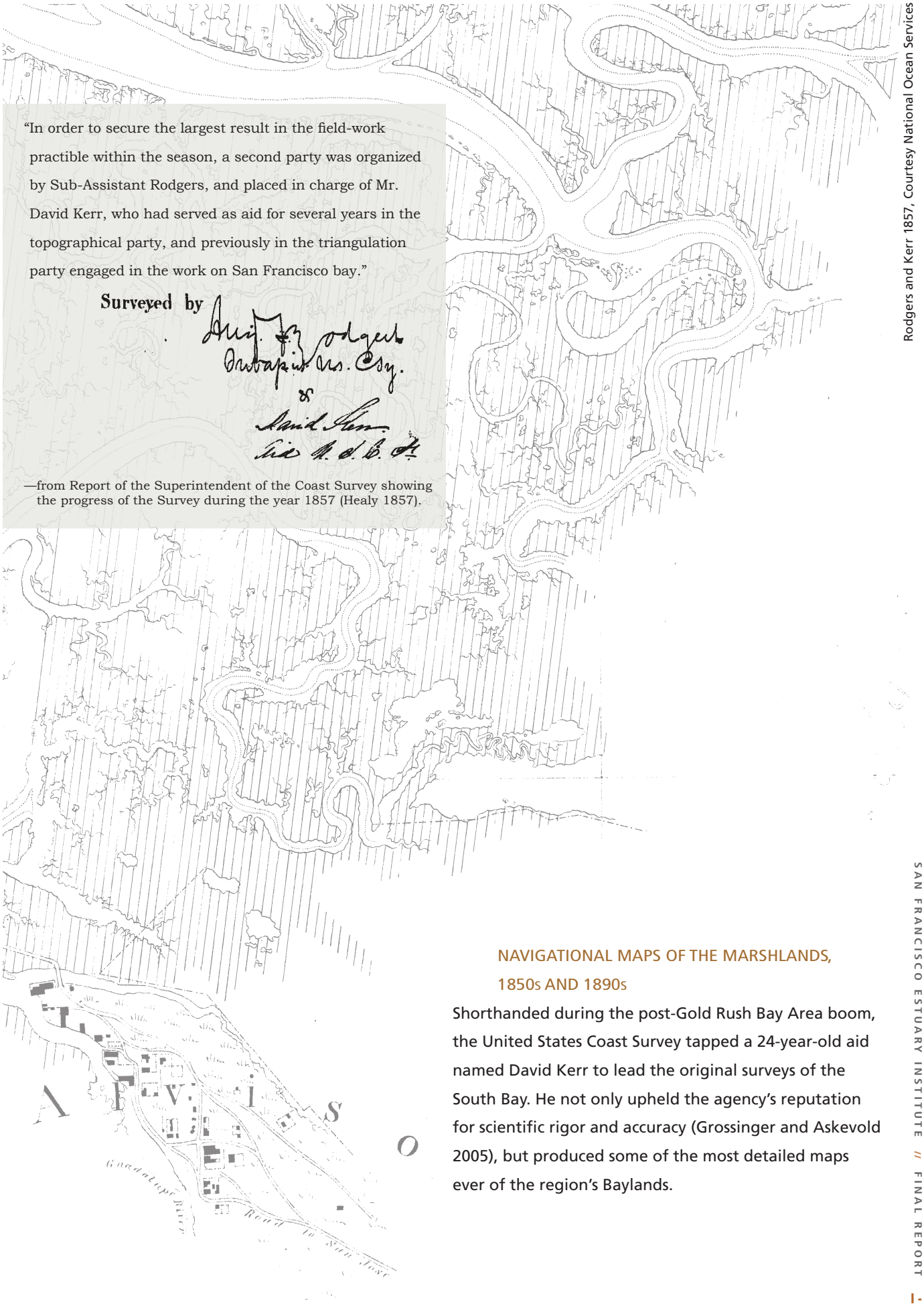
PUBLIC LAND SURVEY TRANSECTS, 1850s TO 1870s

Across the country, Public Land Surveys authorized by the U.S. Surveyor General established the ubiquitous pattern of Township quadrants, each divided into 36 "sections" one square mile in size. In Santa Clara Valley, as in most of California's coastal valleys and plains south of the Russian River, the abstract rectangular grid was broken by the landscape-based Mexican land grants. Official surveys attempted to follow the original grant boundaries, meaning they had to find and map the natural landmarks such as creeks, marshlands, and willow groves, in addition to the standard sectional boundaries.



65.87 Cross a fence to NW.
71.00 Leave marsh.
78.00 Willow fence to NW.
80.00 Stake at 3 miles is in widow Pyle's meadow near the willow fence on W. side of field.
B.T. Willow (in fence) 10 inches, S. 27° 10' W. 0.67
Willow " " 1 foot S. 76° 55' W. 1.02
Surface nearly level, but broken by creek bluffs, and the marsh. Soil on high bluff land excellent. Salt land is sterile. Meadow of rich black soil. Timber, sycamore's on the Coyote, and willows N. of line, in swamp.
East On boundary between sections 34, 3.
8.31 Fence (widow Pyle's) of willows to NE.
Cross a county road to NE.
11.29 Kavanagh's fence to NE. along road.
24.63 Fence to NW.
30.00 Strike Kavanagh's potatoe field.
40.00 1/4 section state at 3¼ miles is in the potatoe field.
B.T. White oak (lapped) S. 56° 50' E., 4.13 chains.
Kavanagh's fence along road, S. 50° 10' W.
Strike nun's College Steeple at stake to Cavanagh's

Day 1854. Courtesy the Bureau of Land Management.



"In order to secure the largest result in the field-work practible within the season, a second party was organized by Sub-Assistant Rodgers, and placed in charge of Mr. David Kerr, who had served as aid for several years in the topographical party, and previously in the triangulation party engaged in the work on San Francisco bay."

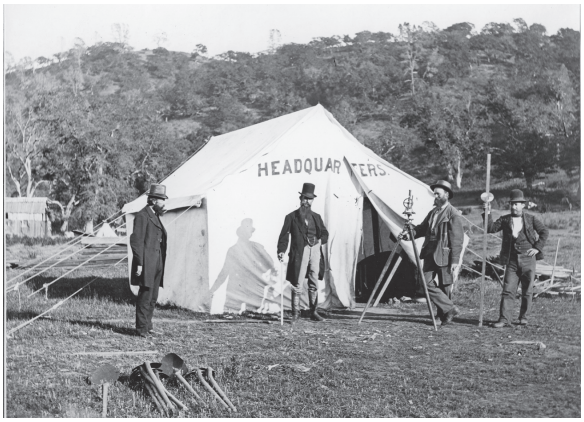
Surveyed by
Asst. J. Rodgers
Assistant U.S. Csy.
&
David Kerr
Aid U.S.C.S.

—from Report of the Superintendent of the Coast Survey showing the progress of the Survey during the year 1857 (Healy 1857).

Rodgers and Kerr 1857, Courtesy National Ocean Services

NAVIGATIONAL MAPS OF THE MARSHLANDS, 1850s AND 1890s

Shorthanded during the post-Gold Rush Bay Area boom, the United States Coast Survey tapped a 24-year-old aid named David Kerr to lead the original surveys of the South Bay. He not only upheld the agency's reputation for scientific rigor and accuracy (Grossinger and Askevold 2005), but produced some of the most detailed maps ever of the region's Baylands.



Saunders ca. 1875. Courtesy Sourisseau Academy.

A. T. HERRMANN, SURVEYOR AND ENGINEER, 1870s TO 1920s

A prolific and fastidious professional, Adolph Herrmann produced maps of the Santa Clara Valley for over half a century. He and his brother Carl immigrated from Germany and established the firm Herrmann Bros. Each served as Santa Clara County Surveyor for several years. A descendent saved his extensive field notes, including survey books on Coyote Creek, from being discarded. His maps and field notes now reside at the County Surveyors Office.

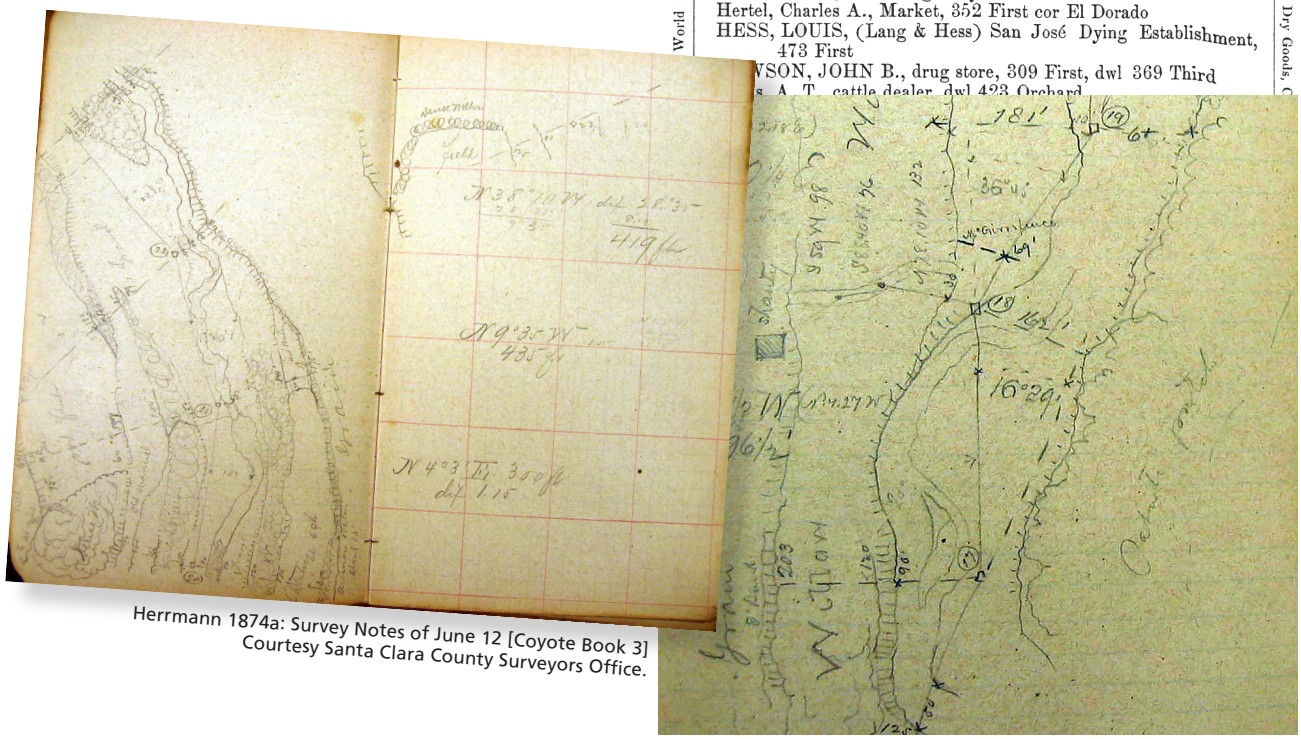
Pulverman's Politeness Prompts Purchasing.

SAN JOSE CITY [H] DIRECTORY. 69

HEPPE, CHARLES G., merchant tailor, 278½ First, dwl 204 San Carlos
Herel, Daniel, laborer, dwl 198 San Carlos
Herera, Katrina Mrs., dwl 133 Fifteenth
Hernandes, Augustine, painter, dwl 274 San Pedro
Hernandes, Mariano, blacksmith, dwl 274 San Pedro
Hernandes, R. B., (widow) dwl 274 San Pedro
Hernandes, Valentine H., carpenter, 325 Santa Clara, dwl 536 Santa Clara
Herold, Philip, boot and shoemaker, 325 First, dwl 598 Second
Herriman, M. Miss, dress and cloakmaker, 290 First
HERRINGTON, D. W., attorney at law, 289 Santa Clara, room 11, dwl at Santa Clara
Herringer, John C., fruit grower, dwl 671 Julian
HERRMANN, A. T., surveyor and civil engineer, 289 Santa Clara, room 4, dwl Montgomery
Herrmann, Carl, surveyor and civil engineer, 289 Santa Clara, room 4, dwl Montgomery
Hertel, Charles A., Market, 352 First cor El Dorado
HESS, LOUIS, (Lang & Hess) San José Dying Establishment, 473 First
WSON, JOHN B., drug store, 309 First, dwl 369 Third
s A. T., cattle dealer, dwl 423 Orchard

World at HEERING'S. Colahan & Pomeroy 1870

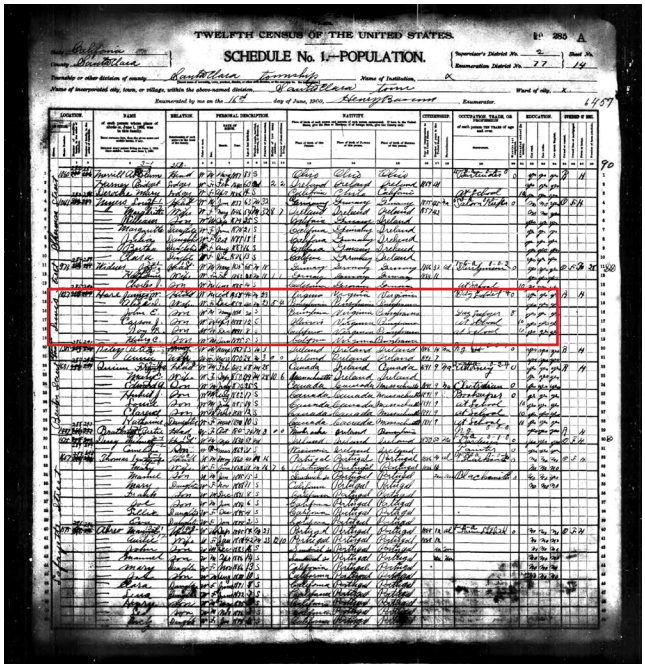
C. J. MARTIN & CO., dealers in Dry Goods, C



Herrmann 1874a: Survey Notes of June 12 [Coyote Book 3] Courtesy Santa Clara County Surveyors Office.

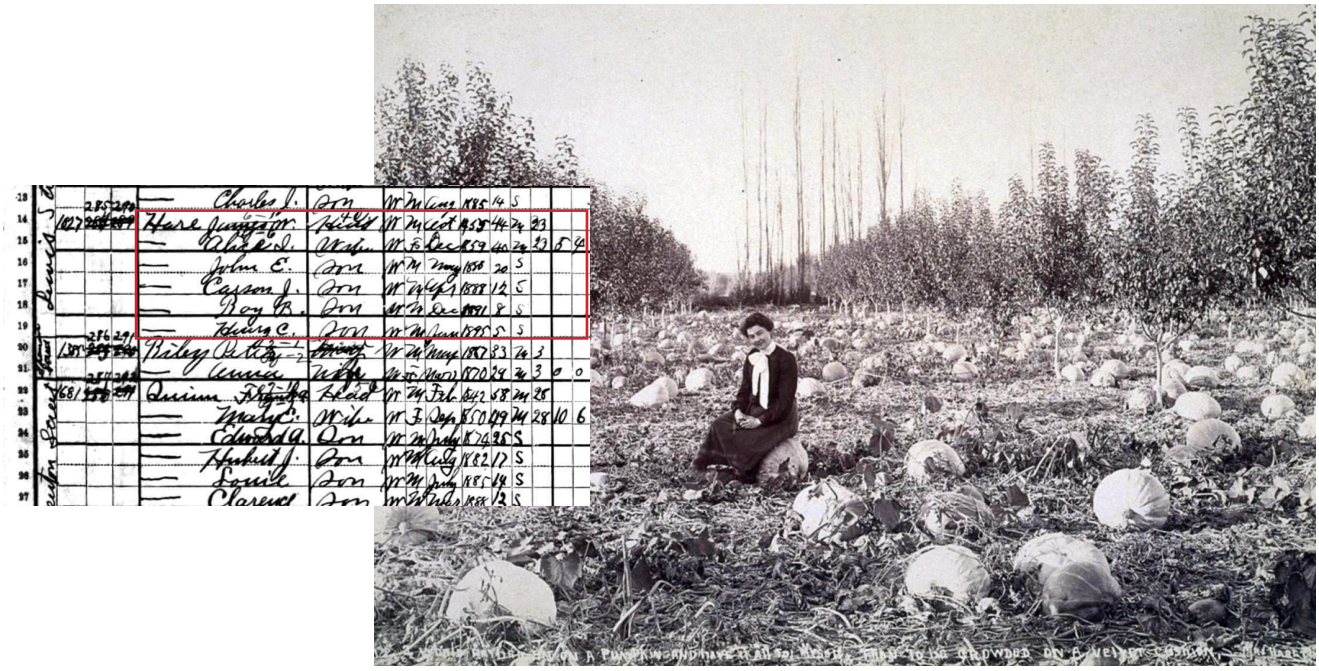
ALICE IOLA HARE, PHOTOGRAPHER, CIRCA 1900

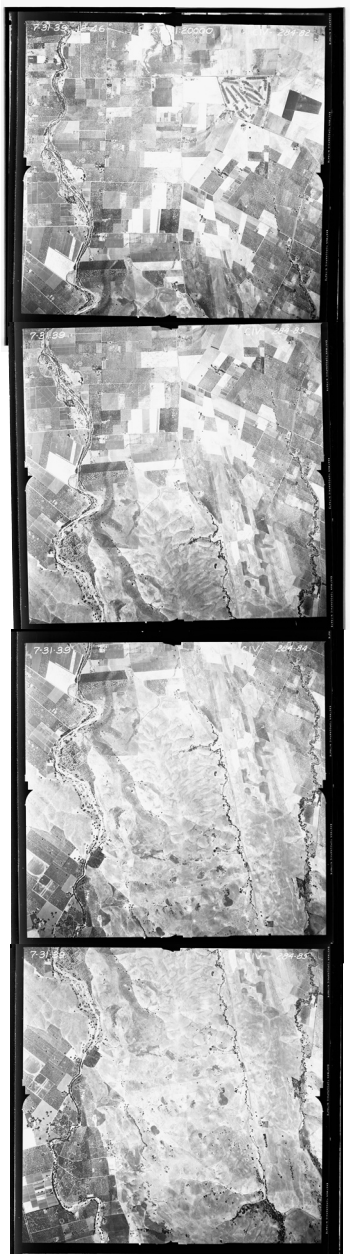
A mother of four, Alice Iola Hare produced some of the earliest photographs of the Santa Clara Valley's natural landscape features, while most people were photographing new buildings. Now recognized as a significant turn-of the-century body of work, her photographs are stored at the UC Berkeley's Bancroft Library. Photographs by Hare and other anonymous photographers, especially as part of the extravagant photograph expeditions conducted for the San Jose Mercury's centennial publication (Shortridge 1896), together provide a set of early creek images in which we can often identify channel depth, riparian vegetation, and fish habitat.


TWELFTH CENSUS OF THE UNITED STATES.

SCHEDULE No. 1.—POPULATION.

U.S. Census 1900


Hare ca. 1905c. Courtesy The Bancroft Library, UC Berkeley.



AAA 1939

AGRICULTURAL ADJUSTMENT ADMINISTRATION AERIAL PHOTOGRAPHY, 1939

Following the Depression, the government turned to aerial photography to develop an organized approach to managing crop production. Hundreds of images taken from 20,000 feet over the Santa Clara Valley in the summer of 1939 created the first comprehensive photography of the region. Details from the photomosaic we created are used throughout the report.

HISTORICAL REFERENCE DATABASE

To track the voluminous historical data set involved in this type of study, bibliographic software and methods must be chosen carefully and well in advance of the onset of data collection. Given the many obscure sources we use, standardized citation formats often were not available, so we developed formats and adapted the software to maintain consistency and transparency throughout the data gathering process. This process was undertaken with the goal of not only reporting the materials gleaned from historical sources, but making the user aware of their existence, recommending their expanded use, and presenting our citations in a manner that will lead the reader easily to those resources.

We customized the database software Endnote to fit the project needs. Documents were input into the database and physically labeled with a record number corresponding to the database. With records such as Land Case testimonies, each witness referred to in the report becomes the "reporter" and was given an independent record number, with the entire record for the Land Case duplicated for each witness. A similar approach was used with the various maps and survey notes recovered from Santa Clara County's Surveyor's Office and the Bureau of Land Management.

MAPPING METHODOLOGY

MAP BOUNDARY

The study area for this project is the valley floor portion of the Coyote Creek watershed, downstream from Anderson Dam. We used the most recent regional mapping of bedrock-alluvial soils contacts to define the edge of the Valley floor (Knudsen et al. 2000). Since the modern watershed boundary between Coyote Creek and Guadalupe River follows storm drain catchments, we defined a generalized historical boundary between the two streams based upon topography. In concert with the Historical Tidal Marsh Mapping Project, the historical picture was extended into the Baylands. In defining the Coyote Creek watershed mapping area through the Baylands, tidal sloughs directly connecting to the tidal portion of Coyote Creek were included, but not the entire watersheds draining to those areas (which would have included Guadalupe River and a number of Alameda County watersheds).

TARGET TIME PERIOD

We use a wide variety of source materials to document prevailing conditions prior to significant Euro-American modification. Because landscape modification occurs heterogeneously and over time, information sources from the time of European contact through to the present can provide evidence of "time of contact" conditions. Documents are examined in the context of the contemporary activities and climate to identify relatively pristine features or, in more modified areas, evidence for prior condition.

Landscape conditions change through time naturally, even prior to the extreme modifications following colonization. While recognizing that the landscape is dynamic, we aim to map prevailing or average condi-

tions in the decades surrounding initial Euro-American occupation, circa 1769-1850. We map features that tend to persist over several centuries or more — such as stream channels, topographically controlled wetlands, oak woodlands — controlled by geomorphic and climatic processes that have been relatively stable in the western United States for the past several hundred years (e.g. Meko et al. 2001). The mapped condition reflects the best available evidence for habitat type, size, and location prior to significant Euro-American modification.

DEVELOPMENT OF EARLY AERIAL PHOTOGRAPHY PHOTOMOSAIC

Relatively early black and white aerial photography exists for the entire project area, and most of the Coyote Creek watershed is covered by three continuous flight lines from 1939. For the remaining areas not covered by the 1939 flight lines — in the south portion of Coyote Valley — eleven additional aerial photographs were acquired, including imagery flown in 1940, 1948, and 1950. Digital images of the aerial photographs were acquired from a wide variety of sources, including the Santa Clara Valley Water District, the U.S. Geological Survey in Menlo Park, and the University of California at Santa Barbara, Santa Cruz, and Berkeley. We used digital versions when available but otherwise scanned the images at 600 pixels per inch (ppi) using SFEI's in-house large format flatbed scanner (Microtek ScanMaker 9800XL). Because considerable overlap exists between each photo — approximately 15% overlap between each photo along the flight line and 25% overlap on each side — we were able to ensure that only the most accurate part of the photo were used.

Each photo was processed for georectification using the Leica Photogrammetry Suite module of ERDAS Imagine 8.7. Both vertical and horizontal reference data were used to georectify the photographs. Aerial imagery from 2002 was used as the horizontal reference to tie the historical photograph to geographic space, and 30-meter digital elevation model data was used as the vertical reference to adjust the photographs for vertical displacement.

The aerial photographs were linked to an already georeferenced image by finding corresponding points between the historical aerial image and the contemporary image. Ten to fifteen points were located for each photo, and these were used by the software to generate additional points through an automatic tie point generating process. These were then used as control points in the triangulation process, which places each photograph in geographic space.

Locating corresponding points was not always an easy task given the highly altered landscape. Road intersections or railroad crossings were commonly used, though this was tempered by the knowledge that roads on the modern photography have usually been widened or re-engineered, possibly changing the absolute location and certainly the width of the road. In the undeveloped hills, oaks that persisted could be found. Again, these had to used carefully, as the tree's crown shape could change significantly.

Once individual photographs were georectified, they were used to create a continuous photomosaic of the study area. Whenever possible, only the center of the individual photograph was used. Because of the various sources of the images, differences in tone and occasionally in image quality can be seen in the mosaic, especially at the very south end of the watershed. Additionally, the resulting imagery more closely corresponds spatially to contemporary georectified imagery in flatter rather than hillier areas. As such, alignment agreement ranges from 0 to 15 meters in relatively flat areas, to 15 to 30 meters in the hilly areas.

HISTORICAL MAP GEOREFERENCING

Through the data collection process, we acquired a wide variety of historical maps. Each of these maps was evaluated for their potential usefulness as georeferenced sources. Georeferencing a map — linking features on the historical map to corresponding points in an already georeferenced source — allows the historical map to be used in a GIS.

Each map was evaluated for its suitability for inclusion in the GIS. Factors considered include: the potential of the map to be effectively georeferenced (i.e. were suitable control points available for georeferencing?); the quality of the information available on the map (i.e. does the map contain critical data?); and are the features on the map not available on an already georeferenced source (i.e. would georeferencing duplicate an already captured source?). If the map met these criteria, it was georeferenced.

Steps taken to complete this process were as follows:

- High resolution scans of paper maps were imported into ArcGIS;
- Ground control points were located on both the historical map and on georeferenced contemporary aerial photography (called the reference data);
- Using a georeferencing tool, links were added to tie the point on the historical map to the reference data for each ground control point;
- The historical map was evaluated for how well it corresponded to the reference data by measuring the difference between features that occur on both historical and modern sources. When the best possible fit was obtained, the georeferencing was finalized.

GIS DEVELOPMENT

ArcMap GIS software was used to collect, catalog, analyze, and display the spatial components of the study area. Georeferencing historical maps and early aerial photographs allowed us to compare historical layers to each other and to contemporary aerial photography and maps. We were able to essentially look through time by assembling maps from different time periods, which allowed us to both assess the different data sources and to better understand change. Additionally, the georeferenced maps could be used as means to geographically locate textual information gathered from surveyor notes, early explorers' journals, travelers' accounts, and newspaper articles.

The GIS was also used to create a synthesis of the historical landscape as GIS vector layers. By synthesizing selected data from georeferenced maps and photographs combined with narrative sources, we constructed a composite map representing the historical landscape. Polygons, lines, and point layers were developed to depict features in the historical landscape.

Polygon features include wet meadow, saltgrass-alkali meadows *(salitroso),* seasonal lake *(laguna seca),* perennial freshwater ponds and wetlands *(lagunas/tular),* willow grove *(sausal),* sycamore grove *(alisal)*, valley oak savanna *(roblar),* and dry grassland. Historical creeks and their distributaries were captured as linear features. The Coyote Creek channel was depicted as both a single line and as a wider polygon area. The riparian area of Coyote Creek—bars, islands, and regularly flooded inset benches—was created as a polygon feature. The tidal marsh area was developed from detailed maps created by the U.S. Coast Survey in 1853 and 1897 and Herrmann (1874c), and shows the many pannes and complex network of channels and tidal flats.

ATTRIBUTION OF MAPPED FEATURES

To record the variations in source data and confidence level associated with different features on the map, we developed a set of feature attributes used in the project GIS. The use of attributes on a feature-by-feature basis allows the GIS to serve as a catalogue of information sources and a basis for a range of practical uses in the future (Grossinger 2001). Using this report and the GIS, users can assess the accuracy of different parts of the map and identify the original sources. Certainty definitions are described below and in **TABLE I-1**. A sample from the GIS attribute table is presented as **TABLE I-2**. Additional technical specifications about the GIS are available in the metadata.

CERTAINTY OF INTERPRETATION

The following certainty level codes are used in the coverage attribute "InterpCert":

High (H): Feature definitely representative of conditions circa 1769-1850.

Medium (M): Feature probably representative of conditions circa 1769-1850.

Low (L): Feature possibly representative of conditions circa 1769-1850.

CERTAINTY OF SIZE AND SHAPE

The following certainty level codes are used in the coverage attribute "Shape_Cert":

High (H): Accurate source material that probably closely follows actual shape; estimated to be correct to within 10% of actual area.

Medium (M): Less accurate source material that probably generally follows actual shape; estimated to be correct to within 50% of actual area.

Low (L): Not necessarily representative of actual shape/size.

CERTAINTY OF LOCATION

The following certainty level codes are used in the coverage attribute "Loc_Cert":

Very High (XH): Expected maximum horizontal dis-

placement less than 15 meters.

High (H): Expected maximum horizontal displacement less than 50 meters.

Medium (M): Expected maximum horizontal displacement less than 150 meters.

Low (L): Expected maximum horizontal displacement less than 500 meters.

Very Low (XL): Expected maximum horizontal displacement less than 2500 meters.

SOURCE

The major source materials used to map the feature are listed using, to the extent possible, standard textual citation form. Full bibliographic information can be obtained from the corresponding record in the bibliographic database and/or report bibliography.

	INTERPRETATION	SIZE	LOCATION
EXTRA HIGH *(Location only)* *"Definite"*	–	–	Expected maximum horizontal displacement less than 15 meters.
HIGH *"Definite"*	Feature definitely representative of conditions circa 1769-1850.	Accurate source material that probably closely follows actual shape; estimated to be correct to within 10% of actual area.	Expected maximum horizontal displacement less than 50 meters.
MEDIUM *"Probable"*	Feature probably representative of conditions circa 1769-1850.	Less accurate source material that probably generally follows actual shape; estimated to be correct to within 50% of actual area.	Expected maximum horizontal displacement less than 150 meters.
LOW *"Possible"*	Feature possibly representative of conditions circa 1769-1850.	Not necessarily representative of actual shape/size.	Expected maximum horizontal displacement less than 500 meters.
EXTRA LOW *(Location only)* *"Possible"*	–	–	Expected maximum horizontal displacement less than 2500 meters.

TABLE I-1. CERTAINTY LEVELS for historical landscape synthesis. Standards can vary depending on scale and emphasis.

ID	Habitat_Type	Primary_Source	Secondary_Source	Interp. Certainty	Shape Certainty	Location Certainty
1	Sausal	SCVWD 1916 photos: 116, 130, 132, 137	USGS Morgan Hill 1917	M	M	M
2	Laguna Seca	Lyman 1847	USGS Morgan Hill 1917, USGS Los Gatos 1919, Thompson and West 1876, SCVWD Vault 1917 photos: 104, 105, 108	H	M	H
3	Tular	USGS Morgan Hill 1917	Lyman 1847	H	M	M
4	Laguna	SCVWD 1916-18 photos: 64-65, 97, 146	AAA 1939	H	M	M
5	Laguna	Thompson and West Map Sheet Five 1876		H	H	M
6	Laguna	SCVWD Vault 1916-18 photos: 64-65, 97, 146	AAA 1939	H	M	M
7	Laguna	SCVWD Vault 1916-18 photos: 58-59, 64-65, 97, 146	AAA 1939	H	M	M
8	Sausal	Palou 1774 in Bolton 1933		H	L	M
9	Tular	USGS San Jose 1899, Thompson 1866: 511	U.S. District Court 1859a. (Yerba Buena), Thompson and West 1876	M	M	M
10	Laguna Seca	USGS San Jose 1899, Thompson 1866: 511	U.S. District Court 1859a. (Yerba Buena), Thompson and West 1876	H	M	M
11	Sausal	Westdahl 1897, Houghton 1860, Pico 1860, Pomeroy 1860		L	H	XH
12	Sausal	Westdahl 1897, Houghton 1860, Pico 1860, Pomeroy 1860		L	H	L
13	Sausal	Wallace 1859, Brewster 1999 (Land Case sketches)	Healy 1860, Houghton 1860, Pomeroy 1860	H	L	L
14	Sausal	Wallace 1859, Brewster 1999 (Land Case sketches)	Healy 1860, Houghton 1860, Pomeroy 1860	H	L	L
15	Sausal	Wallace 1859, Brewster 1999 (Land Case sketches)	Healy 1860, Houghton 1860, Pomeroy 1860	H	L	L
16	Sausal	Wallace 1859, Brewster 1999 (Land Case sketches)	Healy 1860, Houghton 1860, Pomeroy 1860	H	L	L
17	Sausal	Wallace 1859, Brewster 1999 (Land Case sketches)	Healy 1860, Houghton 1860, Pomeroy 1860	H	L	L
18	Tular	Westdahl 1897	AAA 1939	M	M	XH
19	Tular	Westdahl 1897	AAA 1939	M	M	XH
20	Tular	Westdahl 1897		M	M	XH
21	Tular	Gardner et al. 1958, AAA 1939		H	H	H
22	Sausal	Day 1851, U.S. District Court 1870b. (Los Tularcitos)	USGS Milpitas 1980 (topography)	H	M	XL
23	Sausal	Day 1851, U.S. District Court 1870b. (Los Tularcitos)	USGS Milpitas 1980 (topography)	H	M	XL
24	Laguna Seca	Day 1854: 507	AAA 1939	H	L	H
25	Sausal	Day 1851, Stratton 1862a: 159, Stratton 1862b (map), Thompson 1857a: 51, Thompson 1857b (map)	U.S. District Court 1870b. (Rancho Tularcitos), U.S. District Court [184-?]b. (Pueblo Lands of San Jose)	H	M	H

TABLE I-2. DATA RECORDED IN THE LANDSCAPE SYNTHESIS GIS. This sample shows some of the fields used to track source and certainty level, allowing the GIS to serve as a supporting database for future research. See text at left for certainty level definitions, Table II-1 and Glossary for Habitat Type definitions.

TECHNICAL ADVISORY GROUP

A group of experts provided advice and guidance about specific project methodologies and interpretations as well as general comment and review (**TABLE I-3**). Because of the diverse areas of expertise represented, we held focused meetings between Technical Advisory Group members and the project team dedicated to individual topical areas (e.g. interpretation of plant communities, fluvial geomorphology). Technical Advisory Group members also provided review of the draft report. While the Technical Advisory Group contributed substantially to the project, technical findings and conclusions are solely the responsibility of the report authors.

Advisor	Affiliation	*Expertise*
Josh Collins, Ph.D.	Wetlands Science Program Director, San Francisco Estuary Institute	*Wetland classification and geomorphology*
Laurel Collins, B.S.	Principal, Watershed Sciences	*Fluvial geomorphology*
Andrew Collison, Ph.D.	Associate Principal, Philip Williams and Associates	*Fluvial geomorphology*
Charlene Duval, M.A.	Sourisseau Academy for State and Local History, San Jose State University	*Santa Clara Valley history*
Todd Keeler-Wolf, Ph.D.	Senior Vegetation Ecologist, CA Department of Fish and Game	*Vegetation classification*
Ken Lajoie, Ph.D.	US Geological Survey [Ret.]	*Geology*
Robert Leidy, Ph.D.	US Environmental Protection Agency, Region IX	*Stream fish habitat*
Lester McKee, Ph.D.	Watershed Science Program Director, San Francisco Estuary Institute	*Watershed hydrology*

TABLE I-3. TECHNICAL ADVISORY GROUP MEMBERS.

PART II //

HISTORICAL LANDSCAPE CONDITIONS AT THE WATERSHED SCALE

In Part II we develop a landscape framework for the Coyote Creek watershed. In the first section, we summarize the drainage patterns and habitats that characterized the Coyote Creek watershed prior to Euro-American modification, with particular attention to the valley floor. In the second section, we divide the watershed into five major landscape types that help explain landscape history and organize thinking about environmental restoration and management. The third section defines the major habitat types of the Santa Clara Valley and describes how we map them.

U.S. District Court 1870 [Land Case Map D-494].
Courtesy The Bancroft Library, UC Berkeley

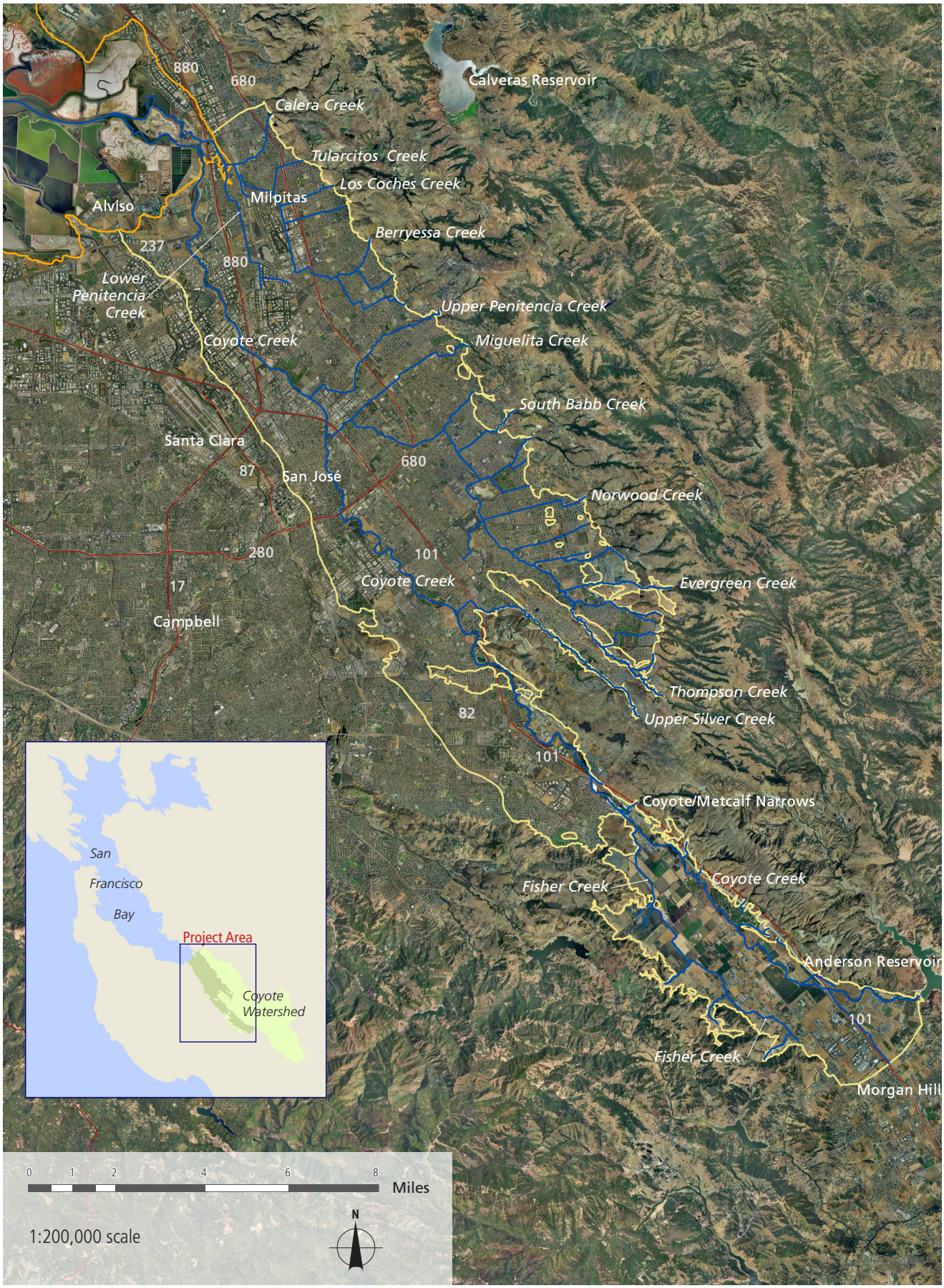


FIGURE II-1. THE PROJECT STUDY AREA follows the eastern side of the Santa Clara Valley, from Morgan Hill to Milpitas. It includes the valley floor draining to Coyote Creek and the receiving tidal marshlands (Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

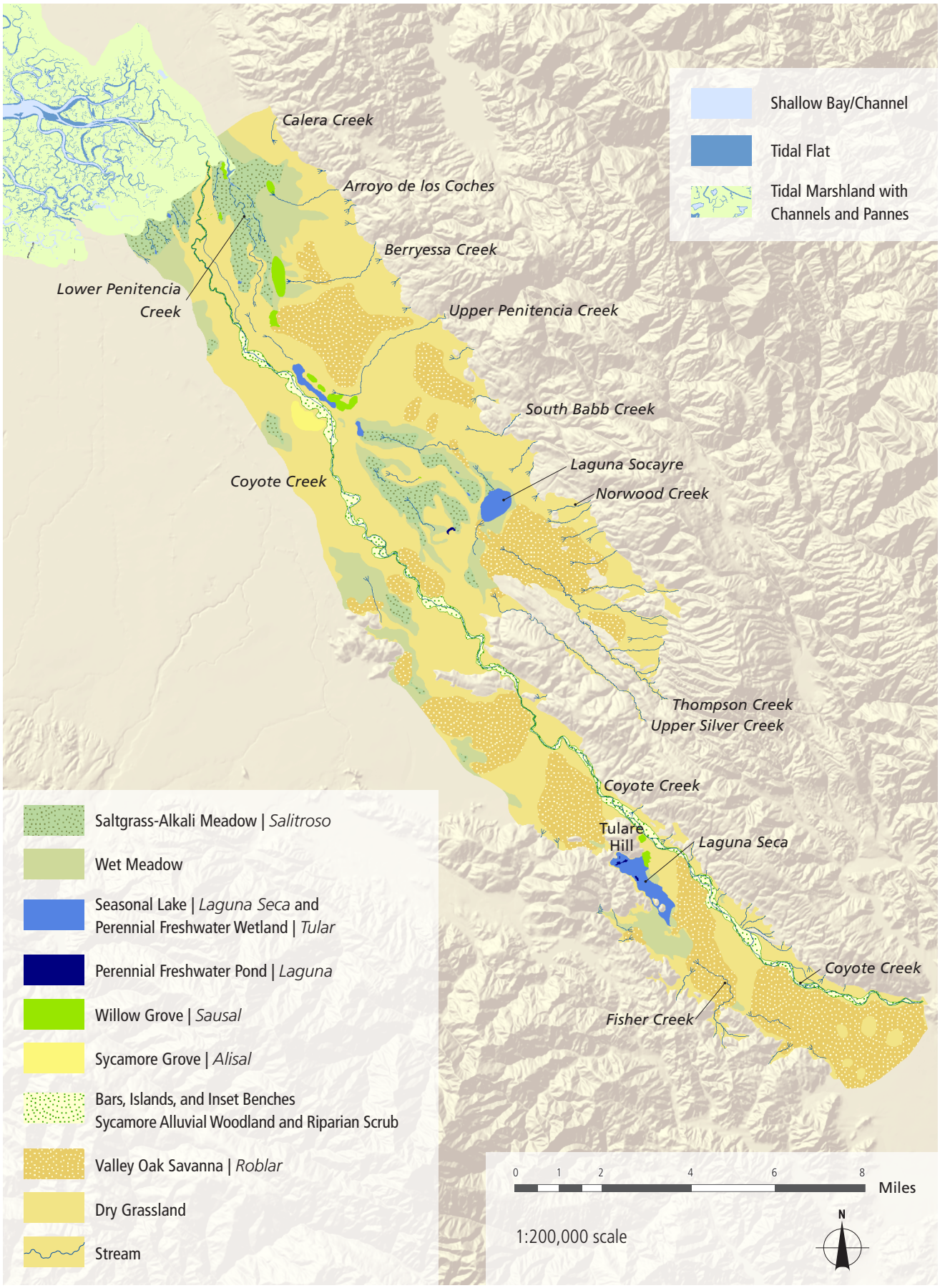


FIGURE II-2. HISTORICAL LANDSCAPE PATTERNS ALONG COYOTE CREEK. This composite map based on numerous historical data sources illustrates prevailing habitat conditions during initial Euro-American settlement, circa 1769-1850. The certainty level varies among features; valley oak savanna is a preliminary estimate. More information is available in the project GIS.

HISTORICAL CONDITIONS SUMMARY

The eastern side of the Santa Clara Valley, where the Coyote Creek watershed originates, is bounded by the deceptively stark hills of California's Coast Range, regionally known as the Diablo Range. Its dry, grassy slopes (both before European contact and since) conceal small but fertile intermontane valleys scattered historically with *lagunas* and *tularcitos* (little tule marshes). Almost three hundred square miles of the Range drains to the Valley, creating at least 30 identifiable streams. From Babb to Quimby, Calera to Coyote, the streams of the Diablo Range (plus a few small ones from the Santa Cruz Mountains to the west) together established the complex landscape pattern of the eastern Santa Clara Valley — a diverse array of habitats organized on the stream deposits between the hills and the Bay (**FIGURES II-1** and **II-2**).

Coyote Creek, the largest of these streams, is the dominant physical feature along the eastern Valley edge, maintaining a wide zone of influence along its 26 mile course across the plain, from the canyon mouth near Morgan Hill to the tides near Milpitas. Coyote's natural attributes were spatially heterogeneous, sometimes counterintuitive, and largely unique for the Valley. As a result, the creek has often been misunderstood, particularly in relationship to neighboring Guadalupe River.

COYOTE CREEK MORPHOLOGY

While Guadalupe's perennial waters gave birth to a mission, pueblo, town, and prominent mills, much of Coyote Creek was dry at the surface most of the year. Coyote was bordered by broad benches or terraces for most of its middle reaches, typically inset 10 to 15 feet below the adjacent valley surface. This imposing channel morphology, often 500 to 1500 feet wide, dictated transportation corridors and urban growth patterns, creating a barrier rather than a center **(FIGURE II-3).** The "deep, very wide, and irregular channel" (Foote 1888: 160) was also a barrier to high flows; there are indications that flooding was not a problem from Coyote Creek for San Jose until the city expanded in the 20th century. Reaches farther upstream, especially in Coyote Valley, were shallower and had a strong braided, multithread channel character. Wide reaches predominated along the stream but were interspersed with shorter, narrow reaches.

COYOTE CREEK RIPARIAN HABITAT

This physical template supported a complex riparian habitat pattern. Along Coyote Creek, dense, closed-canopy riparian forest was relatively limited. Instead, the dominant riparian habitat was an open riparian woodland or savanna. Widely spaced trees occupied the dry, gravelly bed and adjacent stream benches, with broad areas of scattered riparian scrub and unvegetated gravel bars. Grand sycamore trees in "splendid groves" (Day 1854) were the prevalent tree, forming the now-rare Sycamore Alluvial Woodland vegetation type and an associated community of native fish and wildlife species.

LOWER COYOTE

Near its downstream end, in the vicinity of present-day Trimble Road, Coyote's morphology shifted to a relatively shallow, sinuous, meandering channel, presumably in response to the base level set by tidal processes. This reach intercepted near surface groundwater and had the character of a slow-moving, perennial lowland stream. Dense but narrow riparian forest dominated by willows followed the low, frequently overflowed banks downstream, until precluded by the salinity of the tidal influence (near the present-day downstream limit alongside the San Jose-Santa Clara Water Pollution Control Plant). In this lower reach, Coyote flooding had its widest influence as high flows regularly jumped the main channel to form an extremely broad, occasionally-used system of overflow channels extending all the way from Guadalupe River to Lower Penitencia Creek.

THE MARSHLANDS

Coyote Creek also had a broad impact on the tidal marshlands, especially their landward margin. Unlike most Santa Clara Valley streams, this creek directly joined a major tidal slough, creating fresh and brackish tidal marsh habitats within a larger mosaic of salt marsh. Because of the highly branched and interconnected network of tidal channels prior to artificial levees, the twice-daily rising tide could push Coyote Creek's freshwater onto the marshland along Coyote's tidal channel. At flood stage, Coyote waters also entered the marsh through the lateral overflow channels across the lower alluvial plain, creating additional points of brackish influence. Tidal influence extended inland along these high flow channels scoured by Coyote Creek (some are still visible today) while artesian flow created brackish and fresh conditions year-round (e.g. Artesian Slough). Towards the open bay, Coyote Creek's tidal channel was broad enough to support hundreds of acres of tidal flat, used by shorebirds when exposed at low tide.

DISCONTINUOUS CREEKS

In contrast to the tidal marshlands, where channel connectivity was high and has been reduced by subsequent management, creeks on the valley floor were mostly discontinuous. Coyote Creek was the only creek in the watershed with a continuously connected channel from hills to Bay. Many of the creeks that are today considered tributary to Coyote Creek were in fact distributary, spreading out on the valley floor before reaching a mainstem channel. In fact, Coyote Creek did not have a single tributary downstream from Coyote Narrows.

GROUNDWATER RE-EMERGENCE

Of these distributary or terminal creeks, only a few (such as Berryessa and Upper Penitencia) maintained a channel more than a couple miles beyond their canyon mouth; most lost a defined channel within a mile and sank into the coarse soils of their alluvial fan. As a result, shallow groundwater was efficiently charged by stream flow, and would reemerge downslope to form the freshwater wetlands of the Valley: wet meadows, saltgrass-alkali meadows, willow groves, seasonal lakes, perennial ponds, and freshwater marshes. Like Coyote, whose commonly dry

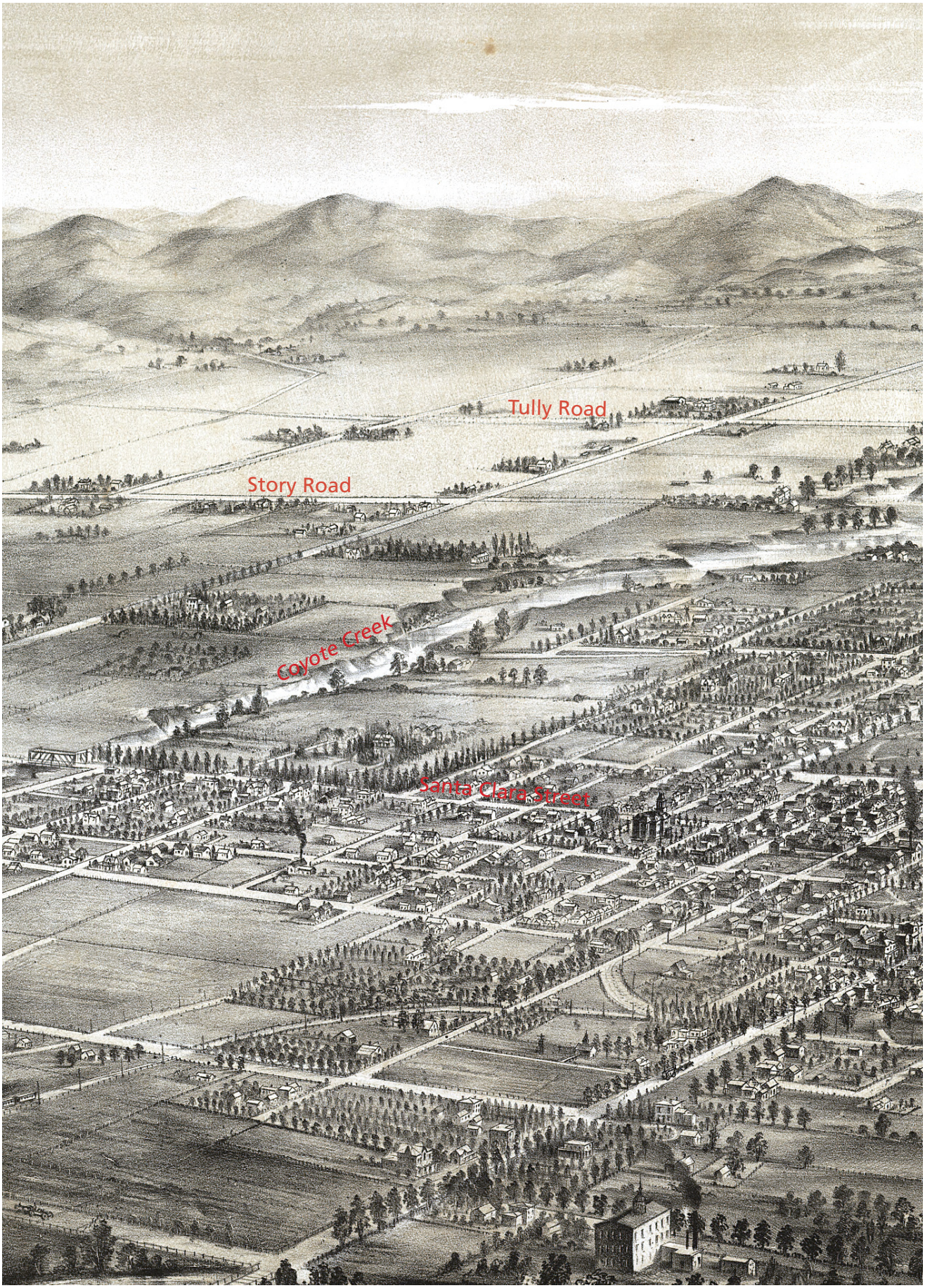


FIGURE II-3. BIRDSEYE VIEW OF COYOTE CREEK IN 1869. This highly detailed lithograph provides an unusual three dimensional perspective of Coyote Creek during the mid-19th century. The portion shown here follows the creek from Santa Clara St. south to Coyote Narrows. At this time, the creek lies on the outskirts of town, with the Santa Clara St. Bridge the only crossing. Abrupt banks can be seen as the creek area widens upstream of

Santa Clara St. A few groves of trees — likely sycamores — occupy inset benches. Upstream of Tully Road, occasional groups of riparian trees line the outer channel banks, but further downstream there are few or no riparian trees on the valley floor terrace (Gray and Gifford ca. 1869, courtesy Library of Congress).

channel nevertheless supported sycamore groves and mixed riparian forest with subsurface flow, the markedly dry appearance of the small creeks was somewhat deceptive. Their waters supported lush perennial habitats farther downslope.

WETLANDS AND DRY LANDS

The mosaic of wetland and dry land habitats on the valley floor was mostly controlled by patterns of alluvial deposition, and their effect on the movement of water through the Valley. Dry land habitats — expansive, fertile grasslands often accompanied by "scattering" oak trees — occupied the slightly higher, well-drained soils along current and geologically recent stream courses. Between the alluvial fan deposits, low-lying bottomlands received flood overflows and the fine-grained clay soils deposited at the terminus of floodwater energy.

ROBLARS

The well-drained grasslands, consisting mostly of perennial grasses with numerous wildflower species, comprised two thirds of Coyote Creek's valley floor. These habitats occupied the rich soils that enabled the great success of Valley ranching and agriculture, and the celebrated oak "parklands" that awed visitors. The elegant *roblars*, groves of widely spaced, large valley and live oaks (mostly valley in the Coyote area) were perhaps the signature habitat of the Valley; against all odds, a surprising number remain today.

BOTTOMLANDS

Roughly alternating with the broad dry land areas, smaller bottomlands presented contrasting hydrological, ecological, and cultural characteristics. These basin areas were formed by simple and persistent topographic conditions associated with poor drainage. In each case, Coyote Creek again exerted broad influence over the valley floor, its natural levee (a stream-built ridge of sediment deposited along the creek) creating a barrier to surface runoff. In combination with a bedrock wall (at the north end of Coyote Valley), a broad fan built by adjacent creeks (Penitencia and Berryessa), and extremely flat topography (at the Baylands margin), Coyote Creek's former and present course shaped drainage and resulting ecological patterns. Similarly, on the west side of the creek, the point where the former and present stream levees diverge created conditions supporting a large sycamore grove.

FRESHWATER WETLANDS

On the "black adobe" soils of the bottomlands, occasionally flooded wet meadows surrounded smaller perennial wetland complexes of freshwater marshes and *lagunas*. Along the landward edge of the tidal marshlands, the accumulation of minerals from high-tide overflow and the evaporation of seasonal ponds created a subtype of wet meadows with distinctive salt-tolerant flora, including saltgrass plains and a mix of now-rare species often referred to as an alkali meadow. Seasonal evaporation created similar salt-affected *salitroso* lands scattered throughout the Valley's wet meadows, often with vernal pool characteristics. Poor drainage and mineral salts shaped a different historical course for the wet meadows, mostly precluding agri-

culture, slowing development, and leaving significant present-day restoration opportunities. By attenuating both flood flows and stream-borne sediment from the upper watersheds, these basin areas performed important watershed storage functions that modern-day watershed management efforts are increasingly seeking to emulate.

SAUSALS

In the bottomlands, willow groves, or *sausals* — dense thickets often 50 to 100 acres in size — provided the only wooded areas outside of a few isolated riparian stream reaches. Like the tidal marsh ecotone, willow groves were one of the important habitats associated with the edge between major landscape types, often located at the intersection of alluvial fan and bottomlands soils where the clay seal of the latter forced groundwater to the surface as springs and seeps.

LAGUNAS

Two of the Santa Clara Valley's three large freshwater wetland complexes, or *lagunas,* were found in the Coyote watershed. The first was located east of downtown San Jose, where an old levee of Coyote Creek created Laguna Socayre, which intercepted flood flows from the surrounding distributary creeks and probably received emergent groundwater. Groundwater emergence and surface runoff formed the second wetland, Laguna Seca, a renowned wetland complex in a natural hollow that retains significant hydrological function and ecological potential today. (The third, the *Tulares de las Canoas*, was tributary to Guadalupe River.)

HABITAT CONTROLS

Since these habitat patterns emerged from the most fundamental physical characteristics of the Santa Clara Valley — geologic structure, alluvial topography, groundwater movement — their basic controls remain surprisingly intact in many places. Restoration and maintenance of the Valley's natural heritage will depend upon identifying the persistent and recoverable elements of these patterns and processes in the context of the contemporary landscape.

The rest of this report documents the characteristics and geographic distribution of these historical conditions in more local detail and discusses landscape changes affecting present-day watershed management and restoration. The report provides a set of information resources and initial interpretation to support the establishment of quantitative and geographically specific resource goals, as well as a foundation for more detailed studies as part of project implementation.

LANDSCAPE TYPES

This section provides an overview of the basic landforms comprising the Santa Clara Valley and establishes a landscape perspective for understanding habitat distribution, stream processes, and local history.

Like all valleys, the Santa Clara represents the physical expression of the unrelenting movement of sediment, water, and rock. During winter rains, small creeks pick up sediment from the hills, carry rocks, sand, and silt through the canyons, and deposit the materials in

elaborate patterns creating the valley floor. Moving back and forth across the surface, the creeks direct the deposition of soil into a rippling surface of alluvial (stream-built) topography.

Unlike many valleys, Santa Clara Valley runs, in a very short distance, the full length of potential watershed character — from the initiating geology of the Santa Cruz Mountains and Diablo Range to the receiving salt-water geology of the sea. Most unusual among valleys, it meets the tides in a highly enclosed setting, the lower South San Francisco Bay, resulting in a broad extension of the Valley in the form of Baylands. As a result, at its low end the Valley is being submerged by the rising seas. Stretching between the hills and the Bay, the Valley exists in perpetual motion, continually re-shaped by the fluxes of land and water at either end.

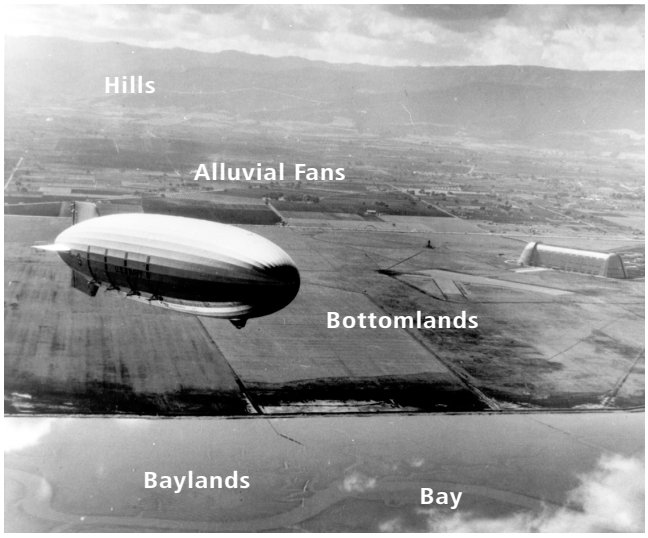


FIGURE II-4. LAND USE PATTERNS. By 1934, this portion of the Baylands has been diked for salt production, and the Alluvial Fans intensively developed for agriculture and housing. Large military/industrial/technological industries have begun to recognize the available space of the undeveloped Bottomlands (View of the rigid dirigible USS Macon over Moffett Field; U.S. Navy 1933-34, courtesy The Moffett Field Historical Society and Museum).

Despite this continual activity — flooding streams, buried land, rising tides — people and plants and animals have managed to find ways to live coherently in the Valley in patterns that have persisted for hundreds, and sometimes thousands, of years. Not all of this activity happens in the same place at the same time. In fact, the landscape is highly organized, focusing the forces of water and sediment into distinctive patterns — patterns that are reliable for centuries at a time. The distribution of forests, grasslands, and wetlands is guided by these patterns. Human activity, when most sustainable, is well calibrated to this dynamic, but organized landscape.

Looking across the Santa Clara Valley from a good vantage point, we can recognize five distinct landscape types that together form the highest level of this pattern (**FIGURE II-4**). Moving from low elevation to high, these include: the open waters of the Bay, the intertidal Baylands, the adjacent low-lying Bottomlands, the gently sloping alluvial fans and natural levees, and the steeper, bedrock Hills (**FIGURE II-5**). These landscapes join seamlessly, yet are clearly evident as separate kinds of places. Each landscape is created by different formative processes and supports a different suite of habitats.

These five landscapes can still be identified from above, but are largely hidden from view by human structures. They are perhaps the most basic patterns of the land. Thus they explain a significant amount about the past, present, and future of the Valley, including development trends, engineering challenges, species distribution, and restoration opportunities. They provide a framework for

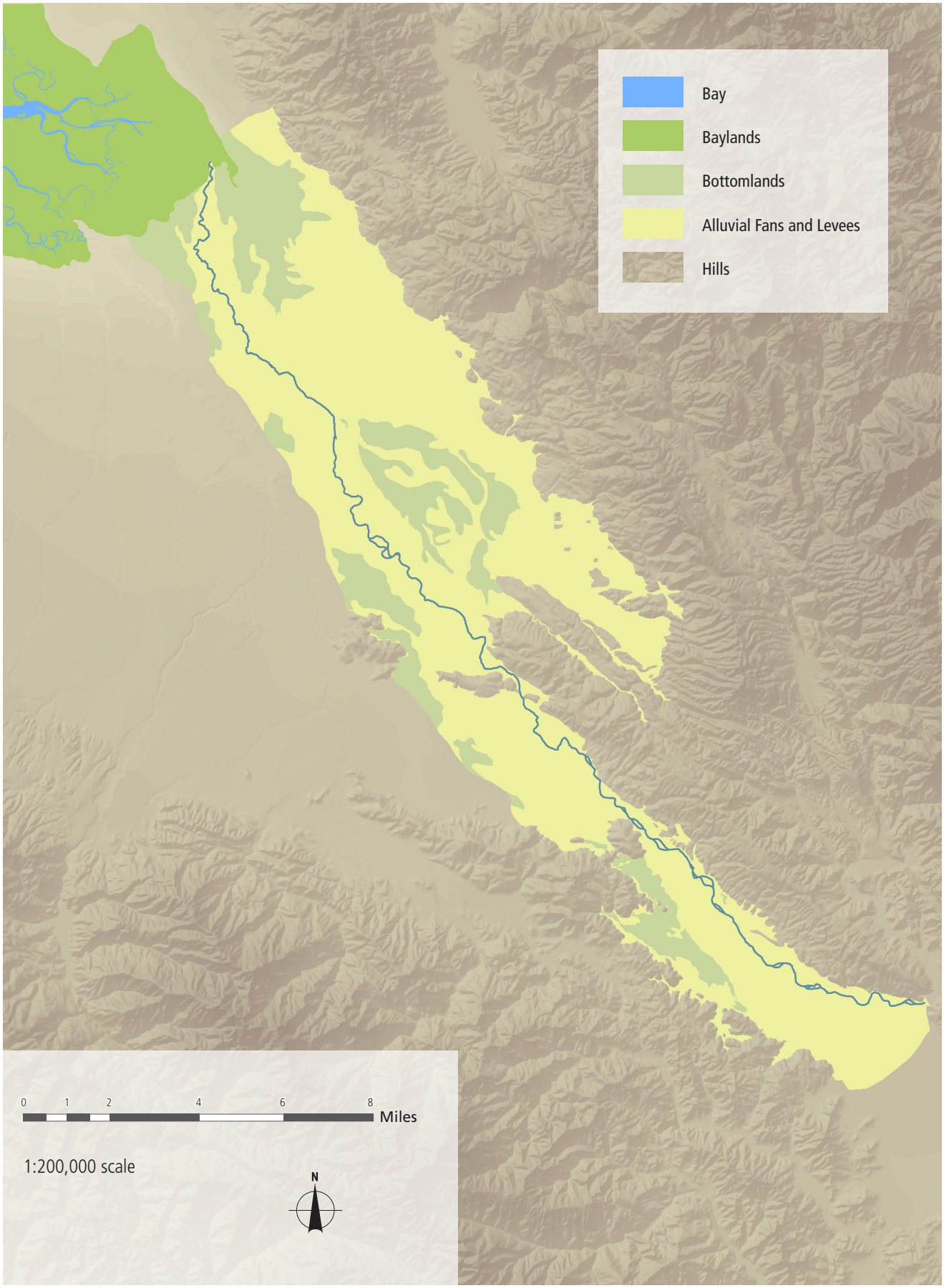


FIGURE II-5. LANDSCAPE TYPES characterizing the valley floor along Coyote Creek. Hills are bordered by alluvial fans (except where runoff is insignificant off small hills and no alluvial fan exists). The fans and levees form higher ground around the bottomlands. Bottomlands merge into the Baylands at the northernmost part of the Valley, while the Bay extends toward land through tidal sloughs.

understanding the interwoven patterns of native habitats and cultural constructions.

Detailing the distinct characteristics and spatial distribution of the five landscapes is particularly useful because of what takes place at their edges. Important processes tend to happen at the transition between two or more landscape types. As a result, many present-day problems are the unintended consequence of changes in how the five landscapes connect to each other (either by increasing or decreasing their connectivity). The following few pages give thumbnail descriptions of each landscape type; their component habitats are discussed in the next section.

THE BAY

The bottom end of the Santa Clara Valley is shaped by the southern arm of the San Francisco Estuary — an inland extremity of the Pacific Ocean. Rising gradually since the last ice age, and more quickly in recent years, the South Bay is slowly inundating the surrounding valleys and plains. This submerged landscape is the driving force for many characteristics of the Valley, providing tidal energy, a modulated climate, limitless salt, and a giant perennial water body. In a region without large navigable rivers, the Bay represents the reliable water surface for transportation, enabling Santa Clara Valley to boom economically decades before the railroad, providing transport for Mexican-era cattle hides, American grain, and a myriad of other products of the land. Where the open waters of the Bay approach the adjacent alluvial land surface, they create a broad transitional environment with an array of distinct characteristics — the Baylands landscape.

THE BAYLANDS

While the Bay is a perpetual tidal water surface, the Baylands lie at the edge of the ocean's influence and are submerged by the tides only part of the time. This intertidal landscape is made of both earth and water. Birds can walk on it and a few specialized plants can grow, but humans inevitably will get their feet wet or even sink waist deep.

The protected nature of the South Bay and the gentle underlying slope of the already-submerged portion of the Santa Clara Valley make for unusually wide baylands. In fact, a band of intertidal habitats more than a mile (and as much as 3 miles) wide runs east-west between the Bay and land, forming a mostly impenetrable barrier to navigation and shipping, as well as high tides and storm surges. But the edge between Bay and Baylands is intricate: the Baylands are split by large tidal sloughs which extend the Bay's waters through the Baylands and inland, creating conduits for human commerce and for the distribution of tidal energy, nutrients, and sediment-carrying water.

The Baylands have shaped land use in particular ways. Despite rich organic soils with access to transportation, agricultural efforts in the Baylands have failed. Despite centrally located, flat surface, the hazards of unstable land and flood risk (which slowed development long enough for environmental protection to take hold) have mostly precluded urban and commercial development.

Their natural characteristics led to a single dominant industry — commercial salt production. The peculiar development history places them both at the center and at the hinterlands, creating the potential for large-scale urban ecological restoration, as is currently taking place through the South Bay Salt Pond Restoration Project.

The dominant natural habitat of the Baylands is tidal marshland. Other important habitats occur at the Bay edge — such as tidal mudflats — and at the inland edge where the Baylands merge with the Bottomlands, and, in a few places, merge with Alluvial Fans to produce transitional habitats — fresh/brackish tidal marsh, *salinas,* and the saltgrass-alkali meadows of the tidal marsh ecotone.

THE BOTTOMLANDS

Like the Baylands, the Bottomlands are naturally quite flat and wet. But, at least presently, they lie above the reach of the tides. Where they are positioned adjacent to the Baylands, they will be the next parts of the Valley to be submerged if the seas continue to rise and no actions are taken. The term Bottomlands has been used locally (e.g. by Broek 1932) to describe the poorly drained interfluvial basins (Helley & Lajoie 1979:35) that lie between adjacent, slightly higher alluvial fan and levee deposits. While the Baylands form where tidal energy dissipates and drops sediment, the Bottomlands are formed by the waning energy of stream overflows over the fans and levees. The lightest, finest stream sediment is deposited in these low areas, forming heavy clay soils. These areas have almost no creeks, except rare sinuous low-gradient streams at the Bay edge and occasional distributary creeks terminating in the Bottomlands. These clay-sealed basins with little drainage capture freshwater in the winter and gradually evaporate it through the year.

The Bottomlands are also largely the "artesian lands," famous for their natural supply of pressurized groundwater sealed by the clay soils. They are characterized by springs, ponds, and wet meadows — the vast "fens" described in early waterfowl accounts. The Santa Clara Valley's few large freshwater ponds or *lagunas* were found in the Bottomlands, often persisting as modern drainage challenges. Special habitats at the edge of this landscape include the *salinas* and *salitroso* lands along the extremely flat gradient to the Baylands, and *sausals*, or willow groves, which were often found where the Bottomlands met Alluvial Fans. Most of the present-day water courses of the Bottomlands are artificial drainage channels.

As in the Baylands, the heavy clay soils of the Bottomlands slowed and redirected the common trajectory of American development. Most agriculture, including orchards, was precluded by poor drainage and seasonal flooding. Roads and towns avoided the areas. As higher lying lands were subdivided into lucrative orchards and town sites, the Bottomlands continued to produce relatively low value crops, such as hay, grain, and pasture land, in comparatively large tracts. As a result, these lands contain some of the few significant areas with substantial potential for restoration and preservation on the valley floor.

At the same time, however, this open land has been one of the engines of Silicon Valley growth, providing

a standing supply of open land for the development of large industrial/technological centers since the first decade of the 20th century, from Hendy Iron Works and Moffett Field to Westinghouse, Lockheed, Cisco, and Google.

THE ALLUVIAL FANS AND NATURAL LEVEES

While all five landscapes are clearly integral to the Valley as we know it, the alluvial fans and levees have received most of the glory. These alluvial deposits form gently sloping, well-drained surfaces between the steeper Hills and nearly flat Bottomlands. The alluvial fans and levees comprise the famous Santa Clara Valley agricultural lands that supported a century of prune and apricot orchards. Earlier, they supported the great valley oak parklands described by almost every early European visitor. Many stream reaches, particularly towards the top of the alluvial fans, were naturally incised and less prone to flooding than the bottomlands. The best places for year-round settlement, the alluvial fans were the location for nearly all of the significant Spanish and American towns and have been rapidly and sequentially subdivided, from large farms to smaller "fruit ranches," to modern developments.

The alluvial fan and levee deposits contain the natural, historical streams and are now often important sites of significant bank erosion, sediment transport, bed incision, and groundwater recharge.

THE HILLS

There are two major sets of hills defining the Santa Clara Valley, providing the parent bedrock geology to the downstream landscapes. On the east, the relatively dry, mostly unwooded Diablo Range is locally called the Mt. Hamilton range. On the south and west, the Santa Cruz Mountains receive more rainfall and are substantially forested with pockets of redwoods. The hills have been sites of sawmills and woodcutting, reservoirs and mines, parks and hunting, grazing and foothill crops. The canyon mouths are particularly dynamic sites — serving as the transition between the hills and the alluvial fans. Here, reservoirs benefit from the water resources and the steep topography on the hill side of the transition. On the west side of the Valley, early homesteads and towns were often centered immediately downstream of the canyon mouth (e.g. Los Gatos, Saratoga, Stevens' creekside location) for the access to perennial water, low flooding risk along incised streams, and proximity to the resources of both the hills and Valley.

PRECEDENTS FOR LANDSCAPE TYPES

The landscape patterns described above have been recognized in practical ways by the people who have inhabited the Santa Clara Valley for thousands of years. They have also been described by researchers over the past century as part of significant regional studies. In fact, these strongly evident landscape patterns of the Valley, combined with proximity to the academic research centers at Stanford and UC Berkeley, have inspired several important earlier studies that inform this landscape classification.

Ecologist William S. Cooper used the dramatic Santa Clara Valley landscape pattern as the basis for his 1926 paper in the journal *Ecology,* "Vegetational development upon the alluvial fans in the vicinity of Palo Alto, California." The geographer Jan Otto Marius Broek built upon this work in an impressive dissertation, *The Santa Clara Valley, California: a Study in Landscape Changes*, describing, for example, the transition between Bay, Baylands, and Bottomlands: "Behind the amphibious saltmarsh bordering the San Francisco Bay lay an open meadowlike belt" (1932: 29). Broek also uses the terms "compound fan" and "bottomlands" (26). Another geographer, Edward Torbert (**FIGURE II-6**), focused on agricultural patterns, noting, for example, that "a broad zone of fine-textured, low-lying soils landward from the tidal marshes of the Bay has not been occupied by prune and apricot growers" (Torbert 1936). These distinctions were reflected in the soil surveys carried out by the US Department of Agriculture by Lapham (1903), Holmes and Nelson (1917), and Gardner et al. (1958), typically separating upland, basin, and alluvial fan/levee soils.

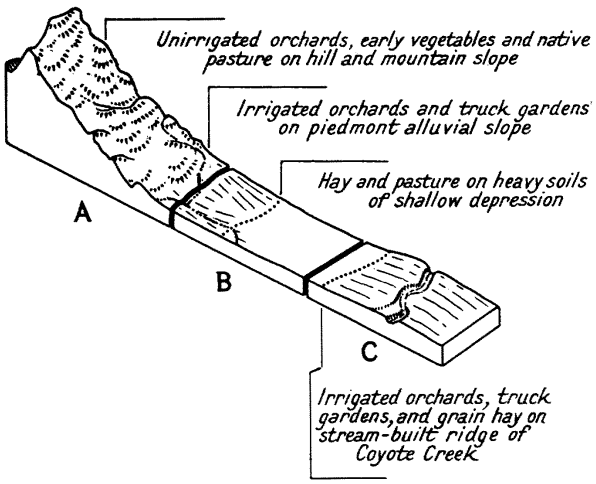


FIGURE II-6. TORBERT'S 1936 DIAGRAM SHOWING LANDSCAPE TYPES: hillslopes, alluvial slope and natural levee, and depressional bottomlands (Torbert 1936, courtesy American Geographical Society).

HABITAT TYPES

This section describes the fluvial, riparian and wetland features that comprise the pre-modification Santa Clara Valley as well as our approach to mapping them. We focus on the components of the three central landscape types — Baylands, Bottomlands, and Alluvial Fans and Levees — because of their extensive historical modification in comparison to the Bay and Hills. Each habitat is mostly or completely associated with a landscape type or the interface between two types. To set the context for assessing landscape change, each habitat is described with regard to its historical depiction and ecological/physical characteristics. **TABLE II-1** illustrates the linkage between habitats recognized historically, through maps and written descriptions, and current wetland and vegetation classifications.

HABITATS OF THE BAYLANDS

TIDAL FLAT

As a boat approaches the southern end of San Francisco Bay, tidal flats mark the transition from the open water of the Bay to the intertidal Baylands. Tidal flats are the first semi-solid surface to be encountered, emerging from the Bay at low tide to present temporary obstructions to waterborne traffic. For this reason, the habitat was mapped in detail by early navigational charts (**FIGURE II-7**), as well as described in travelers' accounts of accidental stranding by ill-timed tides. Tidal flats are also recorded as a substrate desirable for oysters and other shellfish. Prior to development of the Baylands, there were hundreds of acres of tidal flat along the intertidal portion of Coyote Creek and the many tidal sloughs branching from the creek into the surrounding tidal marshland.

Tidal flats are conventionally defined as the areas of bare clay and silt, sand, or shell hash between local Mean Lower Low Water (MLLW) and the foreshore of tidal marshland (or, if no marsh is present, local Mean Tide Level (MTL); Goals Project 1999). We map the historical tidal flats along Coyote Creek based primarily upon the hydrographic and topographic surveys of the United States Coast Survey (USCS), carried out in 1857-58 to facilitate waterborne commerce between the Santa Clara Valley and commercial centers in the Central Bay. The USCS data are being compiled in a concurrent SFEI project to digitize and georeference historical tidal marsh maps of the South Bay, supported by Santa Clara Valley Water District and Santa Clara Valley Urban Runoff Pollution Prevention Program (see http://maps.sfei.org/tSheets/viewer.htm). Through coordination with this project, we obtained the most current versions of the USCS data.

FIGURE II-7. DOTTED LINES representing low tide separate tidally-exposed flats from Bay waters in an early U.S. Coast Survey map (Rodgers and Kerr 1857, courtesy National Ocean Service).

		WETLAND CLASSIFICATION AND WATER REGIME (Cowardin1979)	VEGETATION CLASSIFICATION (NDDB: Holland 1986, MCV: Sawyer and Keeler-Wolf 1995)
BAYLANDS	Tidal Flat	Estuarine intertidal unconsolidated shore. Regularly flooded.	-
BAYLANDS	Tidal Marshland	Estuarine intertidal persistent emergent wetland. Regularly flooded, permanently saturated.	Pickleweed alliance, Cordgrass alliance, Saltgrass alliance, Bulrush alliance (MCV); Northern coastal salt marsh (NDDB)
BOTTOMLANDS	Saltgrass-Alkali Meadow *(Salitroso)*	Palustrine emergent saline wetland. Temporarily flooded, seasonally to permanently saturated.	Saltgrass alliance, Alkali sacaton alliance, Ashy ryegrass alliance, Creeping ryegrass alliance (MCV); Alkali Meadow (NDDB)
BOTTOMLANDS	Wet Meadow	Palustrine emergent wetland. Temporarily flooded, seasonally to permanently saturated.	Ashy ryegrass alliance, Creeping ryegrass alliance (MCV); Valley wild rye grassland (NDDB)
BOTTOMLANDS	Perennial Freshwater Wetland *(Tular)*	Palustrine persistent emergent freshwater/saline wetland. Temporarily to seasonally flooded, permanently saturated.	Bulrush series (MCV)
BOTTOMLANDS	Seasonal Lake *(Laguna seca)*	Palustrine persistent emergent freshwater/saline wetland. Seasonally flooded, permanently saturated.	Bulrush series (MCV)
BOTTOMLANDS	Perennial Freshwater Pond *(Laguna)*	Permanently flooded.	Bulrush series (MCV)
ALLUVIAL FANS AND LEVEES	Willow Grove *(Sausal)*	Palustrine forested wetland. Temporarily flooded, permanently saturated.	Arroyo willow alliance (MCV)
ALLUVIAL FANS AND LEVEES	Riparian Forest	Riparian, lotic, forested, mixed species (NWI 1997). Temporarily flooded.	Coast live oak series, Mixed willow series (MCV) Central coast live oak riparian forest, Central Coast arroyo willow riparian forest, Central Coast cottonwood-sycamore riparian forest (NDDB)
ALLUVIAL FANS AND LEVEES	Sycamore Alluvial Woodland and Other Riparian Habitat	Temporarily flooded, permanently saturated at depth.	Sycamore alliance, Mulefat alliance (MCV); Sycamore Alluvial Woodland, Central Coast Riparian Scrub (NDDB)
ALLUVIAL FANS AND LEVEES	Valley Oak Savanna	Intermittently flooded, saturated at depth.	Valley oak alliance (MCV); Valley Oak Woodland (NDDB); Valley oak/grass association (Allen et al. 1991)
ALLUVIAL FANS AND LEVEES	Dry Grassland	-	Ashy ryegrass series (MCV)

TABLE II-1. HABITAT "CROSSWALK" TO WETLAND AND VEGETATION CLASSIFICATIONS. NDDB refers to the California Natural Diversity Database (2005); MCV refers to the Manual of California Vegetation (Sawyer & Keeler-Wolf 1995).

TIDAL MARSHLAND

In the South Bay, tidal marshlands are the dominant habitat of the Baylands — vast vegetated plains representing a significant percentage of the West Coast's tidal wetlands (Atwater and Hedel 1976).

Tidal marshes are defined as intertidal areas that support at least 10% cover of vascular vegetation adapted to intertidal conditions. The lower marsh edge is called the foreshore, and the high edge along the uplands is called the backshore. Tidal marshes are composed of several characteristic habitat elements: marsh plains, marsh pannes, *salinas*, and drainage networks (SFEI 2005).

The tidal marshlands adjoining Santa Clara Valley had extensive drainage networks of repeatedly branching tidal channels, or sloughs. The larger sloughs, such as the tidal

portion of Coyote Creek, were particularly important as transitional environments where the Bay extended inland through the Baylands and close to land. Thousands of shallow enclosed ponds, or pannes, dotted the surface of the marshlands. Distinctive elongated pannes along the backshore, called *salinas*, evaporated water naturally to produce salt (Grossinger and Askevold 2005).

Spanish explorers were impressed by the extent and complexity of the South Bay marshes: "To the south, the sea-arm or estuary turns into great numbers of other inlets, and I suppose lakes as well. I had a clear view of it, and it looks like a maze" (Crespi 1769 in Stanger and Brown 1969: 105-106). Spanish *diseños* illustrated the general concept of complex patterns of sinuous channels and pannes, but it was not until the USCS that this environment was mapped with precision (**FIGURE II-8** and **II-9**).

The accuracy of the historical USCS maps of tidal marshland in the San Francisco Bay Area has been well-documented (Grossinger 1995, Grossinger et al. 2005, Askevold 2005). We digitized most of the tidal marshland information for the Santa Clara Valley from these "T-sheets," through the Historical Tidal Marsh Map project. The mapping of the tidal reaches of the Coyote Creek channel is described in the Streams section below.

The landward boundary of tidal marshland has been mapped previously at a regional scale by Nichols and Wright (1971) and SFEI (1998). With additional local information, we slightly modified the SFEI version through the Historical Tidal Marsh Map project and this study. This interpretation is described in the Lower Coyote Creek section.

HABITATS OF THE BOTTOMLANDS

Prior to reclamation efforts, the low-lying bottomlands

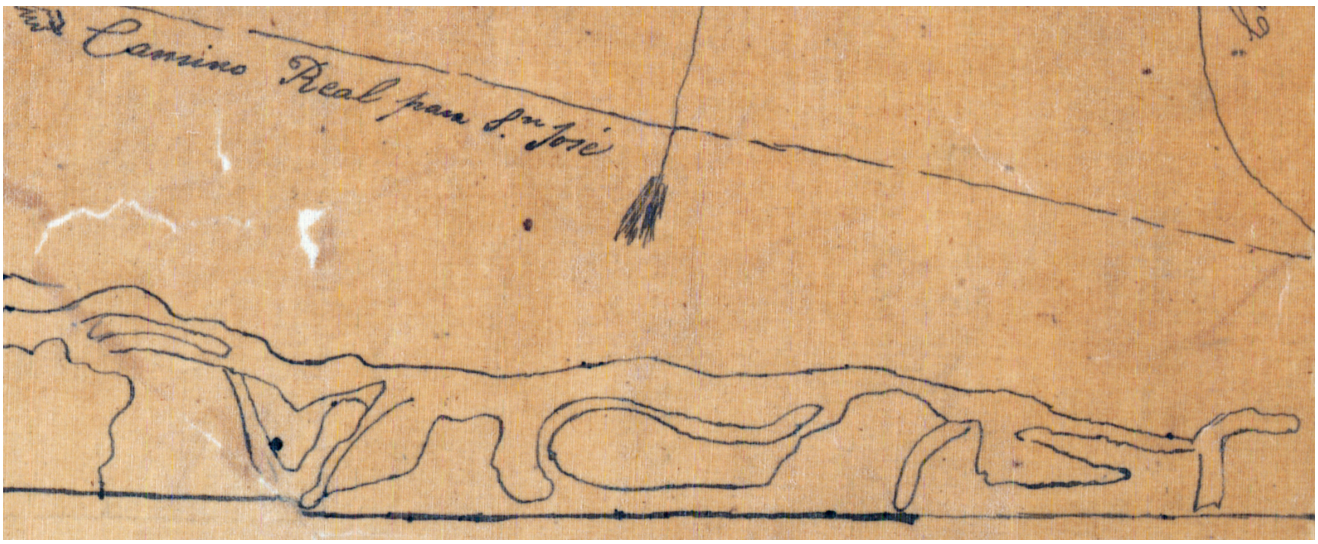


FIGURE II-8. CONCEPTUAL REPRESENTATION OF TIDAL MARSHLAND on the *diseño* for Rancho Los Tularcitos, circa 1840 (U.S. Dist. Court 1841, courtesy The Bancroft Library, UC Berkeley).

of the Valley supported a diverse range of wetland habitats with varying hydrology and associated ecological support functions. Temporarily flooded, seasonally saturated wet meadows covered the largest area, while perennial freshwater ponds, or *lagunas*, had highly restricted distribution. More subtle variation distinguished the wetland habitats with intermediate characteristics between the wet meadows and the *lagunas*.

The historical record presents several types of information useful for distinguishing these habitat types. Occasionally, written accounts describe water depth and/or duration. Vegetation types can sometimes be distinguished from landscape photography. Descriptive terminology used by local residents or travelers can also be useful. One of the most useful sources is Spanish terminology, as applied and recorded in the Mexican land grant *diseños*, which distinguishes several palustrine wetland types. Because of the similarity of many western U.S. landscapes to those in Spain, many Spanish geographical terms described the features of the American West particularly effectively and were often adopted by subsequent English-speaking immigrants (Austin 1933). When available, we use the concise Spanish terms as well as the longer American versions.

While usage varies somewhat, the term *laguna* was used by both Mexican and American residents to describe areas with more perennial surface water. *Laguna* refers to open water ponds; presumably the local features are too small to be called *lago*, lake (correspondingly, they are also too small (less than 20 acres) to be called lacustrine in modern terminology; Cowardin 1979). *Tular*, or *tulare*, translates as "place of tules" (Gudde 1998: 402), indicating freshwater emergent wetland. *Laguna seca*, literally translated as "dry lagoon,"or small lake, appears to be used to distinguish

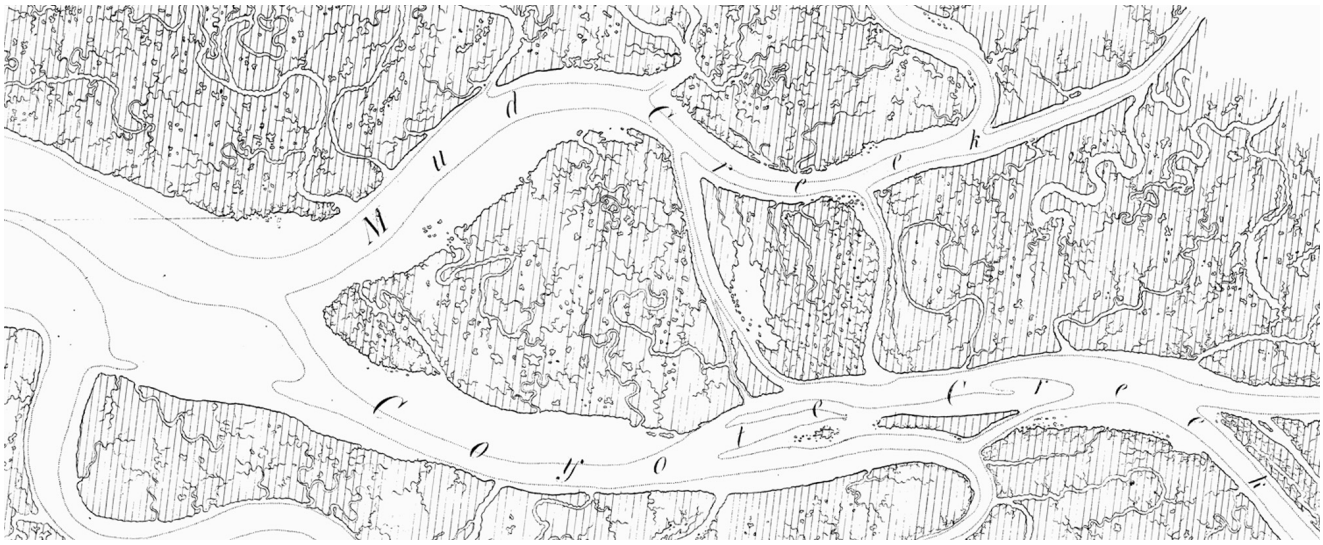


FIGURE II-9. PLANE TABLE SURVEY OF TIDAL MARSHLAND by David Kerr (Rodgers and Kerr 1857, courtesy National Ocean Service).

areas of freshwater marsh vegetation with notably persistent standing water — places where "the water has stood for some time before drying" (Austin 1933). Both *tular* and *laguna seca* thus describe emergent palustrine wetlands that would typically flood in the winter, but *laguna seca* would have standing water much or most of the year.

These habitats generally existed in mosaics with subtle gradations between the different components. Their relative extent would vary substantially with seasonal, interannual, and longer-term climatic variation. The mapped boundaries indicate an approximate average condition, providing a flexible template for understanding and designing freshwater habitat mosaics, rather than precise designations.

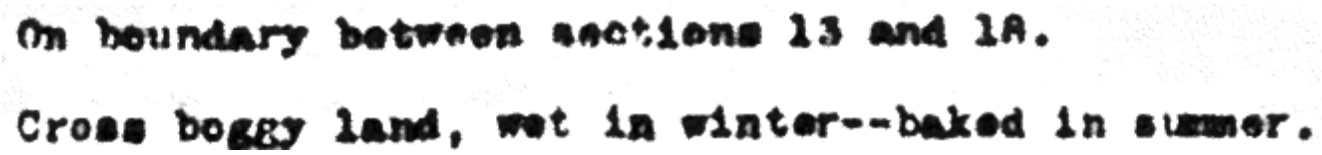
WET MEADOW

Wet meadows, which covered broad areas of the Santa Clara Valley prior to hydromodification, are characterized by poorly drained, moist to saturated soils with standing water present for brief or moderate duration. The dominant plant species were probably rhyzomatous ryegrasses *(Leymus* spp.; Holstein 1999) with a significant component of obligate or facultative wetland plant species (U.S. EPA 2005, Illinois Department of Natural Resources 2005, Ratliff 1988). They were well-documented in the Santa Clara Valley because they hindered agriculture.

Nationally, wet meadows are reported at a range of elevations, often including "low-lying farmland" (e.g. U.S. EPA 2005, Illinois Department of Natural Resources 2005). In California, wet meadows are conventionally associated with alpine or subalpine environments. However, Ratliff (1988) notes that California valley and foothill grasslands can potentially include wet meadow conditions, but that these sites "dry rapidly" and are dominated by annual grasses and forbs. Prior to Euro-American modification, we find that significant parts of the Santa Clara Valley exhibited conditions consistent with the basic hydrological and botanical attributes of wet meadow.

To create a map of wet meadows in the Santa Clara Valley prior to Euro-American modification, we used the mid-20th-century U.S. Department of Agriculture (USDA) Soil Surveys of the region, with refinements and calibration from a number of other data sources. The major portion of the area mapped as wet meadow is based on the identification of heavy textured, poorly drained basin soils by Gardner et al. (1958). This survey covers the entire western portion of Santa Clara Valley and extends southward along Coyote Creek to The Narrows. The fieldwork was carried out during 1940-1941, prior to most suburban expansion, and with the benefit of 1939 aerial photography. In the Coyote Valley area, our mapping is based upon the 1967 USDA Soil Survey of Eastern Santa Clara Area (Lindsey 1974; fieldwork carried out 1960-65), which describes equivalent soil types. We also used a variety of earlier historical sources. The wet meadow soil type boundary transmits strongly through time and land use patterns, providing additional confirmation (see **FIGURE III-7**).

Gardner et al. (1958: 47-48) combined 13 soil types into the general category Soils of the Basins. They describe



Day 1854: 511, courtesy Bureau of Land Management

this group of soils as "developed under various degrees of slow or very slow runoff and high groundwater levels", typically having "smooth and nearly level relief (<0 .5% in slope)", and mostly "heavily textured." They report that these soils had, either at the time of survey or in recent historical times prior to modification, poor drainage and herbaceous vegetation (as opposed to woodland or brushland).

Largely because of the poor drainage, some of these areas were alkaline. The general category "Soils of the Basins" included eight basin soil types "commonly free of salts and alkali" and five additional soil types that were mapped as basin soils "commonly containing salts and alkali." We combined these 13 categories of Soils of the Basins into wet meadow, and defined a secondary category of salt-affected areas called Saltgrass-Alkali Meadow (described in the next section).

Hydrological and Ecological Characteristics

The Santa Clara Valley's low-lying bottomlands were dominated by open, treeless wet meadows, except for isolated willow swamps and a few stream reaches at the Baylands edge. In his reconstruction of pre-modification vegetation patterns in the vicinity of Palo Alto, Cooper (1926: 15) described the habitat as an "open meadow-like belt" around the edge of the Bay. Broek (1932: 14) described the same areas in the 1930s as an "open landscape" contrasting with the surrounding "forest of orchards" (fruit trees being almost completely excluded from the "Basin Soils" by the saturated clays). Preliminary data collected by SFEI show that oak savanna, a widespread historical habitat of the Santa Clara Valley, is strongly non-coincident with wet meadow. Of the 1,098 historical valley oaks we identified through aerial photography, only 15% occur in the areas mapped by soil type as wet meadow. Of the coincident 15%, more than half are found close to (within 500 feet of) the outer edge of wet meadow areas, suggesting fine scale error or gradation in the soil boundary. It is likely that the few trees lying well within the wet meadow area represent finer scale topographic variation, occupying slightly higher, more well-drained topography such as old stream ridges not mapped by the soil survey (Cooper 1926: 20, 23). While Santa Clara Valley's wet meadows do not precisely fill the classic image of openings in dense forest, they represent the equivalent unwooded component in the semiarid, savanna-dominated local landscape.

Historical evidence provides additional descriptions of wet meadow characteristics. These "waterlogged areas" became "impassible swamp lands" in the rainy season (Broek 1932:29). Crossing the lower Santa Clara Valley in March 1776, Font reported that "All this road is through very level and low land and therefore miry, so that when it rains heavily it becomes impassible" (Font in Bolton 1933: 353-355). Federal surveyor Westdahl (1897c: 5) notes the exclusion of orchards by seasonal flooding: "Orchards are being planted everywhere owing to the greater profit derived from horticulture, and it is safe to predict that this entire region will be devoted to it as soon as the low country can be protected from overflows." Because of these conditions, wet meadows remained almost devoid of roads and urban

development through much of the 20th century, being used instead to yield hay and grain, or were simply left unused. Cooper's 1926 reconstruction indicates that substantial changes had taken place in the plant community, but notes remnants of native composites, describing what he calls a "Willow-Composite Community."

Baye (1999) identifies several plant species that fit Cooper's narrative, including common spike weed (*Hemizonia pungens*) and Aster species. These soil types sometimes include "hogwallow" topography and vernal pool systems. Contra Costa goldfields (*Lasthenia conjugens*) was recorded on wet meadow soils east of Coyote Creek in 1958 (CNDDB 2005). Two historical records of *Plagiobothrys glaber* (hairless popcorn-flower; 1892 and 1955) appear to be associated with the wet meadow areas (CNDDB 2005). Congdon's tar plant (*Centromadia parryi* var. *congdonii*) was identified in 1928 in the wet soil areas just east of the Coyote Creek at Milpitas, and Hoover's button-celery (*Eryngium aristulatum* var. *hooveri*) was recorded (1902) in wet meadows just east of Guadalupe River. Alkali milk-vetch (*Astragalus tener* var. *tener*) occurred at both of these areas in 1905 (CNDDB 2005). The latter species was recorded generally in "saline areas along San Francisco Bay" including the Santa Clara Valley (Thomas 1961 *in* Baye et al. 1999).

In the lower Santa Clara Valley, wet meadows often border tidal marshland. Because of the nearly flat topographic gradient, the transition between these two habitats was unusually gradual, forming a broad area distinguished by intermediate characteristics such as occasional tidal influence and alkali effects. Since this ecotone has substantial ecological significance and has been identified distinctly throughout the local history, we describe it in more detail in the Saltgrass-Alkali Meadow section.

The wet meadows occupy nearly flat or depressional lowlands. Torbert (1936) describes how surface drainage of the shallow basins south and east of San Jose "has been cut off by stream-built ridges." Bedrock hills preventing drainage of the lower Coyote Valley created wet meadows with perennial marshes and ponds (Clark 1924).

Most of the wet meadows appear to have received seasonal surface runoff or stream overflow, plus emergent groundwater. Substantial floods on larger streams such as Coyote Creek and Guadalupe River would spread water beyond the coarse alluvium immediately adjacent to the channel into the lower lying basins. In many places the greater water source was flood flows from the many terminal or distributary streams that would send sheet flow across the lower ends of alluvial fans into the wet meadows. In 1776 Font observed this pattern:

> "On the way we found some lagoons of water formed by the arroyos which run from the sides of the sierras and, flowing toward the estuary of the port, become lost in those plains and flats" (Font in Bolton 1933: 323).

Stanford zoologist John Snyder (1905: 329-330) also described the formation of seasonal ponds from terminal creeks in the lowlands, and the potential importance for lateral fish migration:

> "Most of the streams of this basin converge toward the southern end of the bay... Before reaching the sloughs, however, this water often spreads out, forming large ponds. The union of two or more of these temporary ponds, the shifting of a creek channel caused by some obstruction, the change in the direction of a slough, or a combination of these conditions may form between two streams a continuous passage well adapted for the migration of fresh-water fishes".

The wet meadows were also supplied by springs in some places, resulting in persistent moisture and perennially wet willow swamps and freshwater ponds. These were reliable places for late-summer cattle grazing, as Taylor (2000: 50) noted in September 1849, describing "the fertile and sheltered plains of Santa Clara": "Large herds of cattle are pastured in this neighborhood, the grass in the damp flats and wild oats on the mountains affording them sufficient food during the dry season."

The clay soil layer precluded widespread groundwater emergence, but produced artesian conditions that probably created a wide sphere of influence around natural seeps and springs. Despite a high water table and "good grass cover most of the year," the adobe soils exhibited shrink/swell characteristics: "in dry weather shrinking into hard blocks separated by wide cracks, and in wet seasons becoming exceedingly sticky, the water standing on its flat surfaces for days" (Broek 1932: 77). Gardner et al. (1958: Sheet No. One) described the sponge-like wet meadow soils characteristics: very slow surface runoff, occasional high water table, and moderate to high water-holding capacity.

Interpretation of Gardner et al. (1958)

Gardner et al. (1958) can be considered the first mature soil survey of the region, partly because it was able to build upon two significant earlier efforts (William Reed, personal communication). "Soil Survey of the San Jose Area, California" carried out by pioneering soil scientist Macy Lapham (1904) was one of the first-ever USDA soil surveys. The Valley was revisited in 1917 as part of a reconnaissance survey for the entire San Francisco Bay region (Holmes and Nelson 1917). Upon later reflection, Lapham himself admitted that the turn-of-the-century surveys were relatively coarse and experimental (Lapham 1949), but after nearly four decades of experience, Lapham again participated in the 1940-41 survey, as Senior Soil Scientist. So there is reason to expect that the 1940-41 survey reflects well-developed mapping techniques and empirical understanding of the region.

While soil boundaries generally cannot be mapped with extreme precision, recent assessments have found the 1940-41 soil mapping to be very accurate. The new mapping of Santa Clara Valley soils by the USDA Natural Resource Conservation Service (NRCS) has confirmed the general accuracy of boundaries, particularly the contact between gently sloping alluvial fans with loamy soils and clay-rich, nearly level basin soils, which

is relatively easy to identify in the field (Reed, personal communication).

Adjustment at Santa Clara

In the vicinity of Santa Clara, the Orestimba loams occupying the final site of the Santa Clara Mission were excluded from the Wet Meadow soil type because of substantial historical evidence that the Mission occupied significantly higher and drier ground. For example, Lewis (1861) emphasizes the shift from "dark alluvial soil" to "soil of more gravelly description" and a corresponding step up in elevation of about 2 feet. Lapham (1904) also distinguishes this area from the surrounding adobe soils.

Recent Burial of Basin Soils

Gardner et al. (1958: 95-96) identify a large area of shallow, recent deposits that have buried former basin clay soils during historical times, labeled "Mocho loam/sandy loam/fine sandy loam, over basin clays." They ascribe this to large-scale erosion since 1850 due to agricultural practices, which, ironically, have improved downstream clay soils by burying them with a layer of lighter, well-drained material. They describe the effect as follows: "[I]n the Santa Clara Area suspended material from eroded areas has been deposited over rather large areas of the Valley floor. This recently deposited material makes up the soils of the Mocho series. In many places along the larger creeks the deposits are more than 6 feet deep, but the largest areas have an overwash of less than 6 feet over basin clays. Differences in depth of Mocho soil material on either side of old levees or road embankments and statements made by people who have directly inherited land taken up at the beginning of the intensive settlement of the Valley indicate that nearly all of the material that has become the Mocho soils has been deposited since about 1850" (Gardner et al. 1958: 177). Land case testimony from farmers along Coyote Creek indicates that some increased deposition goes back as far as the 1830s or 1840s (see discussion in Lower Coyote Creek section).

To represent pre-modification conditions, we added these areas of previously basin soils to the other basin soils. Comparison of the reconstructed extent of Wet Meadow with the 1904 soil survey clearly shows the expansion of loams over basin clays during the first decades of the 20th century.

Comparison to Modern Quaternary Geology

The wet meadow soil types correspond substantially with Quaternary Holocene Basins as mapped by Knudsen et al. (2000), but covers more area. We found that several areas of known historical seasonal/perennial freshwater wetlands corresponded more closely to Gardner et al. (1958). For example, Lewis (1851) shows a broad area of wetlands surrounding the higher ground of the early town of Santa Clara. These features correspond closely to basin clay soils that are shown by the soil survey, but not the more recent quaternary geology map.

Wet meadows also coincide generally with the loca-

tion of "Fine-grained Alluvium," as identified in the regional USGS map of surficial geology (Helley and Lajoie 1979). Fine-grained Alluvium displays characteristics typical of seasonally wet areas:

> "Distribution and Stratigraphy: Found in poorly drained, nearly horizontal basins between active and abandoned stream levees at the outer margins of alluvial fans adjacent to San Francisco Bay. Origin of deposit: Deposited from standing floodwaters that periodically inundate low interfluvial basin areas and locally form seasonal fresh-water marshes. Presently being formed but depositional processes severely disrupted by modern cultural activity" (Helley and Lajoie 1979).

Interpretation of Lindsey (1974)

Wet meadow soils were derived from the Soil Survey of Eastern Santa Clara Area, California (Lindsey 1974) based upon the same rationale as described above for Gardner et al. (1958). Lindsey describes the drainage of the Santa Clara Valley as "generally well developed" (1974: 85), identifying only a single association of poorly drained soils: the Clear Lake-Pacheco-Sunnyvale association. This association is mapped in only two areas, "near Soap Lake and Tulare Hill," (1974: 4); both are well-confirmed areas of historical freshwater wetlands.

The soils in this association that we used in the Coyote watershed are: Clear Lake clay (Cg); Clear Lake clay, drained (Ch) ; Clear Lake clay, saline (Ck); Pacheco clay loam (Pd); and Sunnyvale silty clay, drained (Sv). These soils are "poorly drained" clays or clay loams and, in the Coyote Valley area, they each coincide in full or in part with the historical extent of Laguna Seca, confirming their wetland character.

Topographic Adjustment

Differences in scale and/or registration caused the wet meadows layer to slightly overlap with steep bedrock topography in several places. We adjusted the wet meadow boundary in our GIS to conform to these topographic controls at Laguna Seca in Coyote Valley.

SALTGRASS-ALKALI MEADOW (TIDAL MARSH-WET MEADOW ECOTONE; *SALITROSO*)

The Saltgrass-Alkali Meadows represent a subset of the wet meadow habitat type. Their largest representatives in the watershed were found at the northern end: a complex zone of transition poised at the upper limit of tidal influence and the lower limit of the terrestrial land. The width of this "ecotone" between Bayland and Bottomland varies depending upon the slope of the underlying topography. In the Guadalupe-Coyote-Penitencia area, the nearly flat topographic gradient created a broad and distinctive habitat described explicitly by a range of historical sources.

Mexican and early American residents referred to this area at the edge of the Bay, and other salt-affected areas with limited or no tidal influence, as *salitroso* lands (literally "salt petrous"). We use this convenient term interchangeably with Saltgrass-Alkali Meadow. The habitat is similar or equivalent to "alkali meadow" (Holland 1986) and the "Saltgrass series" (Sawyer and

Keeler-Wolf 1996). These alkaline grasslands are recognized as a scarce native grassland type (Faber 2005, Holstein 1999).

Unusually high concentrations of salt in alluvial soils (not Bay mud) created a distinctive flora as well as limitations to agricultural use. Typical salts include sodium chloride, sodium sulfate, sodium bicarbonate, and sodium carbonate (Gardner et al. 1958: 178). There are multiple mechanisms for salt accumulation in these low gradient areas. Evaporative processes of seasonally flooded depressional areas are the typical mechanism for forming alkali deposits, and at the edge of the Bay, additional processes contributed salts of marine origin. Land case testimonies describe occasional tidal inundation over much of the saltgrass-alkali meadow area, which would result in saltwater effects. Gardner et al. (1958: 60, 178) note the importance of saltwater seepage into the groundwater along the Bay's edge. The strength and prevailing direction of local winds suggests that aeolian deposits may also have contributed to the inland extension of salt influence.

There were a number of other alkali areas in the Santa Clara Valley that were not tidally influenced, as Antonio Maria Pico described in the Rincon de los Esteros land case:

> **Question 25:** Are there not spars of this alkali or *salitroso* land that you have spoken of scattered all over the land in various ranchos and plains in the Valley of San Jose?
> **Answer:** Yes sir, in some parts. (Pico 1860: 121)

The most noteworthy nontidal *salitroso* lands occupied parts of the Soap Lake area at the very southern end of the Santa Clara Valley (Broek 1932). While this area had no tidal effects and lies outside our study area, it shared similar ecological characteristics to the edge of the South Bay, including broad, white, evaporative, salt-crusted flats.

Early conditions in Rincon de los Esteros area are discussed in detail as part of the Berryessa land case, with particular attention to the extent of tidal influence several decades earlier, because of the traditional designation of tidelands as state property: "I shall not extend the grant beyond... the line of division between the marsh and the dry land" (Parker 1863: 201-202). The litigators use the same indicators used by present-day historical ecologists: extent of tides, vegetation, soil characteristics, and agricultural use.

Local residents' testimony provides explicit evidence for the saltgrass-wet meadow habitat. Parker (1863: 221-224) stated that one third of his grain crop was "eaten out by alkali" and that the next year he kept hogs on it rather than farming. Pico (1860: 119-120) reported that "the character of the land is '*salitroso*' or alkali lands" which are "not as good for grazing as the other," but used nevertheless. And the predominant vegetation is described repeatedly as saltgrass.

In the 20th century, local botanists took interest in the area. As part of his reconstruction of historical vegetation in the Palo Alto area conducted in 1915-16, Cooper (1926) interviewed local resident G.F. Beardsley

about conditions circa 1870. Beardsley described a strip of "wiry hard grass," interpreted as *Distichlis* by Cooper, "several hundred yards to one-quarter mile wide" at the upland edge of the "line of natural salt pan" (Cooper 1926). Gardner et al. (1958: 60) affirmed the transitional salt marsh character of the zone, describing the vegetation on Alviso clays along the marsh margin as consisting "largely of grasses, saltgrass predominating, and pickleweed and brass buttons."

The saltgrass-wet meadows represent an important ecological habitat supporting a number of regionally rare, threatened, endangered, or now extinct species. Botanical evidence for these transitional areas around San Francisco Bay describes a unique plant community with characteristics of high tidal marsh, alkali flats, and vernal pools (Baye personal communication, Baye et al. 1999). The presence of the rare annual milk vetch, hairless popcorn flower, and Contra Costa goldfields in the saltgrass-alkali meadows along Coyote Creek and Guadalupe River near the tidal marsh margin (described in the Wet Meadows section) suggests the presence of vernal pool-like habitat (Baye et al. 1999).

To define the extent of saltgrass-alkali meadow, we use the descriptions of high tide extent and saltgrass in the Berryessa land case and the mapping of alkali-affected areas by Gardner et al. (1958) as the primary sources. These largely confirm each other, but the land case testimony explicitly described saltgrass beyond the Alviso-Milpitas Road (approximately present-day Highway 237), so we follow that source.

Located at the edge of two major landscape types, the saltgrass-alkali meadows in the lower Valley represent the interplay of both alluvial and tidal processes, with processes operating at different time scales overlaying each other to create a complex pattern of vegetation and hydrology. With ongoing sea level rise, tidal marsh and *salitroso* lands are gradually moving inland. Therefore, preserving the existing saltgrass-alkali meadows is critical to the future of tidal marshlands; with natural or heightened estuarine transgression, the *salitroso* will become fully tidal.

Over a longer time period, as the tides gradually intersect steeper topography, the *salitroso* zone will narrow. Superimposed upon this longer-term process of inundation, fluvial deposits during major floods create slightly lower and higher places, sometimes temporarily reclaiming newly tidal areas to the land side. While the fluvial deposition observed by early Mexican and American farmers in the mid-19th century may have been exacerbated by recent land use, the habitat pattern described is illustrative (Bloomfield 1863).

> **Court:** "Describe the character of the land lying North of the Milpitas road as you first knew it in 1852, and state how much has since been reclaimed?"
>
> **Stephen Bloomfield:** "...The land as I first knew it was Salt Marsh beyond the Milpitas road except some few knolls which were made by freshets."

Reed (1862) captures some of the complexity of the ecotone:

> "In running this line it was impossible to follow the exact line between the Marsh and the upland, for the reason that the line would have been very crooked as narrow strips of Marsh land extended up into the uplands and corresponding strips of the upland extended into the Marsh lands. I ran that line as to leave as much Marsh land on the side of upland as there was upland left outside of the Rancho, running down into the swamp land."

Intermediate vegetation patterns at the interface between tidal marshland and saltgrass-alkali meadow undoubtedly reflected gradual adjustment to increased saline tidal influences, colonization of younger flood deposits, relict populations, and persistent alkali areas. As Reed (1862) notes, "it was a medium between the two, it was neither like the upland nor like the Salt marsh, but it partook of the character of both."

Gardner et al. (1958) suggest that salt effects extended farther inland during the first decades of the 20th century due to land subsidence. Given the close correspondence between Gardner et al. 1940-41 mapping of alkali-influenced areas and the land case testimonies about the extent of alkali, saltgrass, and *salitroso* land, we think it is unlikely that the saltgrass-wet meadow area represents a substantial expansion during historical times. In fact the observation of large alkali-affected areas after a century of active and passive reclamation efforts including soil deposition, plowing, and drainage indicates strongly persistent conditions. These soil characteristics, and potentially suitable habitat for several listed species, may still be recognizable in some places, and are likely to increase over time with saltwater intrusion along the Bay edge.

PERENNIAL FRESHWATER POND: *LAGUNA*

Persistent fresh surface waters were relatively rare in the Santa Clara Valley's semiarid climate. As a result, historical documents reliably record the few, important perennial water bodies that persisted outside the tidal lands. Spanish, Mexican, and early American accounts and maps use the term *laguna* for these permanently flooded, unvegetated wetlands. Twentieth century American descriptions often refer to these places in regard to their use by dabbling waterfowl, indicating standing water several feet deep (e.g. "duck ponds" (Cooper 1926), "Mallard Pond" (SCVWD Vault 1916: 146)). These features are too small to be considered lakes (greater than 20 acres) within National Wetlands Inventory (NWI) classification, and *laguna* translates to lagoon; so we use the term pond. However, while the open water area is generally relatively small, the historical usage of the term *laguna* generally applies also to the full wetland complex, including seasonally-flooded areas as well as the perennial portions.

On the valley floor around Coyote Creek, we were able to distinguish small *lagunas* as part of the Laguna Seca wetland complex using the reclamation photographs (SCVWD Vault 1916-1917) and associated caption descriptions of water depth and avian use. Healy (1861; "water") and Thompson and West ([1876]1973) show

perennial waters of the Laguna Socayre complex.

PERENNIAL FRESHWATER WETLAND/ SEASONAL LAKE (*TULAR, LAGUNA SECA*)

While the wet meadows flooded temporarily, for days or weeks at a time, and *lagunas* were permanently flooded, there were at least two additional habitat types with intermediate hydrology. *Tular* and *Laguna Seca* each refer to perennial emergent freshwater wetlands that have groundwater at or near the surface through most, if not all of the year. *Laguna Seca*, or seasonal lake, has expansive and prominent surface water for much of the year, which disappears at the height of the dry season, at least during some years. The traditional Spanish-American term for these features where "the water has stood for some time before drying" is *laguna seca* (Austin 1933). In the wet season these features covered relatively large areas, greater than 20 acres, and looked like open water. Thus, although they were vegetated, we refer to them as seasonal lakes. *Tular* has similar freshwater tule vegetation, but less expansive, deep, or persistent seasonal flooding. We mapped these as distinct feature types, based upon historical evidence for hydrology, but combine them into the single perennial freshwater wetland category in most map graphics.

Mexican *diseños* describe two major freshwater wetlands as *laguna seca* adjacent to Coyote, including the eponymous *Laguna Seca* in Coyote Valley and the Laguna Socayre. While it is difficult to define the exact spatial extent of these seasonally and inter-annually variable habitats, historical data give some guidance. The latter feature is labeled *Laguna Seca* by Yerba Buena land case map B-465 (US District Court 1859). Lyman (1847) and USGS Los Gatos (1919) each depict Coyote Valley's Laguna Seca as a large area of wetland vegetation with a smaller open water area. Also, the Laguna Sega reclamation photographs report that the water level was 4-5 feet above the ground before reclamation (**FIGURE II-10**), describing the open water area mapped earlier. They also indicate a visible discoloration line on the tall tule vegetation at a similar height indicating the "height of water before drainage" (**FIGURE II-11**). These data suggest a water level several feet deep for much or most of the year, yet with emergent vegetation. Hence we defined the wetter, northern end of the complex as *laguna seca*, with an adjacent area of freshwater marsh or *tular*.

It is also possible that drainage efforts prior to 1916 had already reduced the persistence and depth of flooding, permitting vegetation encroachment, and that the open water area shown by Lyman and USGS was truly perennial. In this case, the surrounding area that we have mapped as temporarily flooded *tular* would have been a more persis-

FIGURE II-10. "WATER STOOD FIVE FEET ABOVE GROUND SURFACE BEFORE RECLAMATION" [text from original photo caption]. Photograph taken immediately following the construction of drainage ditches through Laguna Seca (SCVWD Vault 1917).

FIGURE II-11. "LAGUNA SECA RECLAMATION", 1916. "Bottom of Lagoon on December 28, 1916, showing Clam-shell machine at end of Ditch. Discoloration on tulles [sic] shows height of water before drainage. Small shallow pools are from drainage water still coming from tulles and flowing to Ditch" [text from original photo caption] (SCVWD Vault 1916: 66-67).

tently flooded *laguna seca*.

We defined "*tular*" as the peripheral, less flooded area of the Laguna Seca and Laguna Socayre complexes and other, smaller freshwater wetlands. Evidence for additional freshwater marshes in the Rincon de los Esteros area is available in the form of small features mapped by the United States Coast and Geodetic survey (Westdahl and Morse 1896-97) using traditional freshwater marsh symbols, and even by Gardner et al. (1958). Efforts to drain many of these features are evident at the time of the survey, providing additional confirmation. Several of these areas are also clearly evident as dark, mottled patterns in the 1939 aerial photography; in these cases, we used the imagery to define a more precise feature boundary (see **FIGURE III-7**). These features likely had similar vegetation and seasonal flooding to the *laguna secas* but, because of size or water depth, would not be considered seasonal lakes.

HABITATS OF THE ALLUVIAL FANS AND LEVEES

WILLOW GROVE: *SAUSAL*

A grove of willows at a sink along a creek, at the downstream end of distributary creeks, or on the bottom lands near a seep or spring is a "*sausal*." *Sausals* (*sauce* = willow) are forested, nontidal wetlands; the dominant tree is arroyo willow (*Salix lasiolepis*; Cooper 1926). Surface water is usually present temporarily to seasonally and the water table is consistently close to the land surface, but the woody vegetation does not tolerate prolonged inundation. *Sausals* are not strictly riparian nor lacustrine in nature.

Sausals are and were strongly associated with areas of emergent groundwater along the boundary between the bottomlands and alluvial fans, but also occur near sites of groundwater emergence not immediately along the edge. Within the open vistas of the lower alluvial plain, *sausals* constituted important landmarks in the native landscape. Pictographs illustrating clumps of trees, often with green watercolor, appear commonly in Mexican land grant *diseños*, usually labeled as "*sausals*," "*sausales*," "*sauzal*," or the diminutives "*sausalito*" and "*montecito*" (little thicket). American maps use similar variations of the term as well as "willow grove," "willow marsh," or "willow thicket" (**FIGURE II-12**).

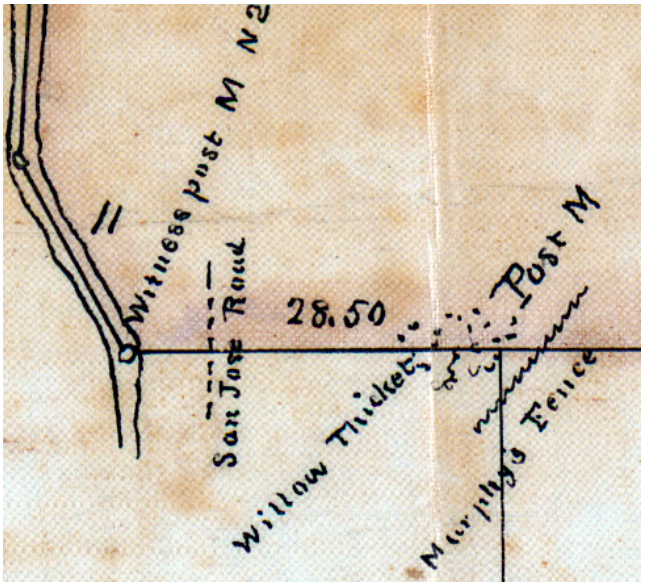
Written accounts also describe willow groves. Cooper (1926) describes "dense thickets sometimes 30 feet in height" with blackberry and wild rose. A visitor

approaching San Jose in 1850 reinforces the size and density of a mature willow grove:

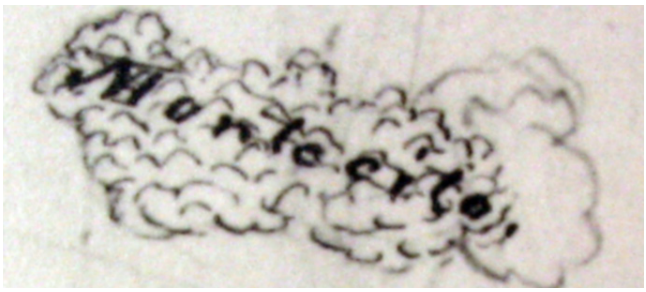
> "I came, within two or three miles of San Jose, to a large extent of willows, so thickly woven together with wild blackberry vines, wild roses, and other thorny plants, that it appeared as if I could never get through it. But I found a winding trail made by the cattle…the willows were in places 50 feet high and a foot in diameter. The willows where I came from were mere bushes and these astonished me (Manly 1850 in James and McMurry 1933).

Perhaps contrary to expectation, *sausals* were popular cultural sites. Their common association with shellmounds indicates long-term occupation by indigenous peoples (Striplen et al. 2005) and, during the American era, the edges of willow groves were often selected as homesites for leading citizens, with the trees molded into elegant gardens. At least one Bay Area *sausal* became a significant local destination, the San Lorenzo Grove, a willow grove near Hayward that was advertised as "The Picnic Paradise of California" (Grossinger and Brewster 2004).

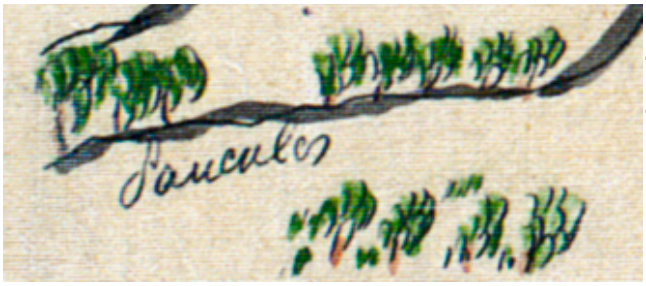
Willow groves provided valuable avian habitat. Evens (1993: 129) describes one of the few significant regional remnants, the Olema Marsh, a large alder-willow thicket that provides some of the most important habitat for breeding, wintering, and migrating birds in the Point Reyes area. Early naturalists' accounts and more recent intensive studies have documented a remarkable concentration of bird species (over 80) within the small



Thompson 1857a.



Day 1851



U.S. District Court [184-?]a.

U.S. District Court 1870.

FIGURE II-12. DEPICTIONS OF WILLOW GROVES DOWNSTREAM OF UPPER PENITENCIA CREEK (top three images) and **BERRYESSA CREEK** (lower image) in early Spanish and American maps (courtesy Santa Clara County Surveyors Office (top two maps), and The Bancroft Library, UC Berkeley).

area, including a number of now relatively rare wetland bird species. Interestingly, the willow marsh was managed for hunting during the early part of the 20th century using fire, presumably to reduce willow and cattail vegetation, increase open water for waterfowl, or to foster fresh browse for larger game (Anderson 2005).

Since willows can rapidly colonize large areas in response to favorable changes in environmental conditions (e.g. new alluvium at Elkhorn Slough, Monterey County (Byrd et al. 2004); former overflow channel area at Wildcat Creek, Contra Costa County (SFEI 2001)), it should be considered whether *sausals* reported in the mid-19th century might be the result of recent expansion due to landscape changes such as erosion and sedimentation. However, it is unlikely that willow groves would have expanded during this period given their use for firewood, and the effects of cattle browsing. Descriptions of the *sausal* along Penitencia Creek during the 1840s and 1850s attest to the restrictive effect of intensive cattle grazing on willows:

> "There was a considerable extent of land around it on which long straight willows were growing. They are not very high but there are a great many of them. The cattle cut off the tops in the winter. They would spring up thickly every year" (Houghton 1860).

Pico (1860) describes similar effects — "the cattle have eaten off the tops of the trees leaving the stumps"— indicating that the *sausals* recorded during this era are likely a conservative estimate of the original extent.

The Rincon de los Esteros land case testimony describes in some detail an additional related habitat type between Coyote Creek and Lower Penitencia Creek near the edge of the Baylands — "scattering willows." Healy (1860b) testifies that these are persistent but not dense enough to be considered a *sausal*. For the sake of simplicity, we mapped the individual clumps as *sausals* (based upon their distribution as shown by Westdahl (1897).

STREAMS (CREEKS, DISTRIBUTARIES, "SPRING RUNS"; *ARROYO, RIO, SANJON*)

Santa Clara Valley's streams are among its longest standing cultural resources. They are some of the oldest named features in the region; their courses have dictated human settlement patterns, both providing perennial water and precluding development by flooding. Before the expansion of the road network, streams were the most important landmarks defining Valley geography. As a result, their locations are extensively recorded in the historical record.

Despite similar climate and general geology, streams in the Coyote Creek watershed exhibited a wide range of morphology. To represent the important and consistently-identifiable distinctions of the historical streams, we defined and mapped several different fluvial feature types.

Except for Coyote Creek itself, streams in the watershed were narrow. They were less than 100 feet wide (usually much less) — much thinner than the corridor of mature

riparian trees along their channels. We mapped these features as linear (polyline) features. While we mapped the Coyote Creek channel as a polygon because of its substantial width, we also created a line to represent its main channel. This synonymy permits measurements of stream length and allows all fluvial features to be maintained within the same GIS data set. Where multi-thread reaches were evident, they were represented as branches with additional lines, creating islands.

Features mapped as streams therefore include mainstem channels of large creeks, such as Coyote Creek, overflow channels (e.g. along lower Coyote Creek), spring runs or *sanjons* that received artesian water and overland flow (e.g. between Coyote Creek and Guadalupe River), and distributary creeks, which had discontinuous channels along the Valley floor (most of the watershed's streams). We only mapped streams with well-defined channels and banks (i.e. not swales or wetlands) as recorded by historical maps, aerial photography, or field notes. Within the tidal marshland extent, we classified channels as tidal, rather than fluvial.

At the downstream end of discontinuous creeks, where fluvial flow spread out or sank underground, we followed early map convention by depicting a trifurcation or "crowfoot." These features were coded separately in the GIS as "distributaries." The point of distribution — the termination of a defined channel — was often well documented by historical maps. The location at which a channel loses definition can also be seen quite clearly where unmodified by the time of early aerial photography (**FIGURE II-13**). Where channels were extended by ditching by this time, the sudden shift from sinuous to straight-line plan form generally matches historical sources and, in places with no earlier sources, was used to infer the historical point of distribution. Because of the high resolution of the orthorectified photomosaic, we were able to clearly identify the downstream extent of distinct, defined, unstraightened channel on most creeks, and avoid potential errors in interpretation associated with using small-scale prints. For this reason, as well as additional historical sources, our mapping of historical channel position differs in places from previous efforts.

The extension of discontinuous channels by the construction of ditches took place surprisingly early on many Santa Clara Valley streams. Creeks such as Upper Penitencia, Stevens, and Permanente were extended to the Bay (through extension to Coyote Creek in the case of Upper Penitencia) by 1876. Since many hydrological alterations appear in late-19th-century maps, it is important to consult mid-19th-century maps to construct an accurate picture of pre-modification drainage patterns.

Other descriptive sources can also provide important corroborating data. For example, Westdahl (1897a: T2312) labels the straight lower reaches of Adobe, Barron, and Matadero Creeks with "ditch," confirming their anthropogenic origin. In the Descriptive Report for the neighboring map, he notes that "The small creeks on the East side, between Warm Springs and Milpitas, have been

FIGURE II-13. THE LOWEST NATURAL REACHES OF NORWOOD CREEK, 1939 (LEFT) AND 2002 (RIGHT). The creeks flow right to left; Norwood Creek is above, an unnamed smaller creek is below. Spiderlike cow path patterns can be seen in the grazed area at lower right. Norwood and Ruby Avenues intersect at upper middle (AAA 1939; 2002 imagery copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

confined to ditches dug for them from the point where they issue on the flat lands (Westdahl & Morse 1896-1897: T2313). Accordingly, the general extension of distributary streams in straight channels across the seasonally flooded bottomlands is celebrated in an 1885 newspaper article:

> "Over immense stretches of swampland…once useless as veritable quagmires, may be seen the deep furrows of the plow, and the long even drains and ditches that in sections run to the bay and appear like so many streaks of glass in the morning light." (San Francisco Monitor January 10, 1885 in Gullard and Lund 1989: 79).

Early surveys confirm the absence of a channel in many places where they cross the routes of present-day creeks, often noting a "hollow" or nothing at all. Occasionally, they even specifically comment on the absence of a creek: "42.00 Lowest point in valley, no creek." (Day 1854: 503).

For streams with a relatively wide channel area, however, a single line representation does not effectively convey the spatial extent of fluvial process and riparian habitat. For Coyote Creek, we were able to find detailed historical data showing bars, islands, and inset benches and terraces that defined a broad channel area (as wide as 500-1500 feet). These features were well documented by multiple sources (and are still visible today in places). Since precise flood return intervals could not be defined from available data sources, we classified the area generally as "Riparian," and refer to it as the riparian or channel area, with detailed descriptive information where available. Characteristics of the riparian habitat, which include Sycamore alluvial woodland, riparian scrub, and open unvegetated gravelly areas, are described in more detail in that section.

Coyote Creek General Approach

For the nearly 26-mile valley floor length of Coyote Creek, we mapped both a low flow channel and the outer banks defining the riparian/active channel area (**FIGURE II-15**). Where significant secondary channels could be identified, we mapped these along with the main channel.

The sources of historical channel information vary substantially along the valley floor length of Coyote Creek, from tidal waters to Anderson Dam. For the Lower and Mid-Coy-

FIGURE II-14. THOMPSON CREEK IN 1939 (LEFT) AND 2002 (RIGHT). Thompson Creek flows to the northwest here, immediately downstream of Aborn Road. Note expansion of riparian vegetation (AAA 1939; 2002 imagery copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

ote reaches, we were able to create nearly continuous coverage using 19th-century map sources with remarkable detail and accuracy. This was fortunate because channel modifications were extensive by the time of aerial photography. A key source for assessing the accuracy of the historical cartography, and our interpretation of it, was the field notes of the General Land Office (GLO), which describe crossing the creek in several places with explicit width measurements. Early soil survey data also confirmed historical channel area in most places, although with less detail.

In general, for the upper reaches channel modifications were more limited prior to 1939, so aerial photography often gives more direct evidence of unmodified channel banks. Nevertheless, gravel extraction and agricultural activity occupied a few substantial areas by 1939, so additional sources had to be used in concert with the aerial photography. In addition, 1850s GLO field notes reveal substantial, apparently natural, channel changes in comparison to aerial photography. We used GLO notes, soil survey data, and several detailed 19th-century maps to identify pre-1939 channel pattern and to calibrate our interpretation of the aerial imagery.

Coyote Creek Main Channel

The main active channel is the dominant low flow channel occupied by all flow events (e.g. Graf 2000, Kondolf et al. 2001). Historical maps of Coyote Creek consistently show a relatively narrow main channel with parallel banks and more widely spaced lines indicating a set of outer banks encompassing adjacent bars, inset benches and/or terraces (**FIGURE II-15**). As would be expected, the position of the main channel has been more dynamic than these channel banks; its movement can be traced over time in a number of places (see **PART IV**). Where detailed early maps were unavailable, we mapped the main channel from early aerial photography. The unvegetated, main channel is generally readily apparent as a white (if dry) or a black (if water is present) sinuous feature.

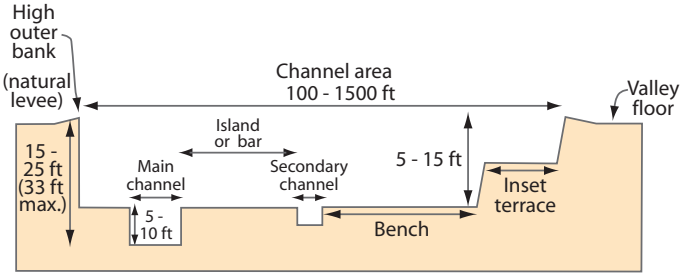


FIGURE II-15. CONCEPTUAL DIAGRAM OF TYPICAL HISTORICAL CHANNEL CROSS- SECTION FOR BROAD PORTIONS OF THE MID-COYOTE REACH. Diagram is based on an array of historical data discussed in Part IV.

Coyote Creek Benches

The deep chasm along Coyote Creek was a defining feature of the eastern side of the Valley and noted by a wide range of source materials.

Maps such as Herrmann (1905, along the entire stream length) and Thompson and West ([1876]1973, in the middle reaches) use the conventional symbology of hatch marks to indicate steep banks bounding broad inset surfaces along the active channel (**FIGURE II-16**). A number of other, independent sources indicate that these outer banks were distinct, particularly in the Mid-Coyote reach. These sources, discussed in **PART IV**, include Day (1850), Herrmann's (1874a) survey notes (referring to, for example, "top line of bank"), Foote's description of the steep banks in the vicinity of Santa Clara Avenue (1888), and the Gray (1869) birdseye view of the channel (see **FIGURE II-3**). Historical cross-sections (**FIGURE II-17**) and residual present-day topography confirm these wide, inset flood-prone areas along the creek.

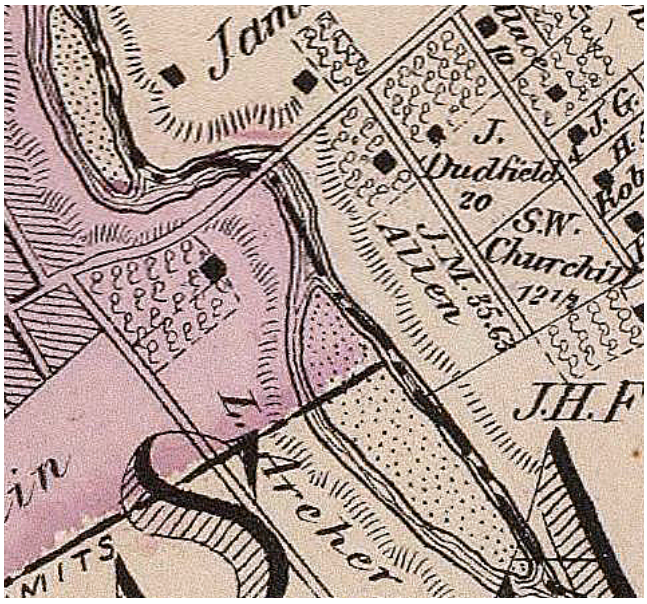


FIGURE II-16. COYOTE CREEK AT STORY ROAD, 1876. While this County Atlas depiction of channel plan form is not spatially precise, it provides strong qualitative evidence for steep, widely spaced channel banks and large unvegetated mid-channel islands (Thompson and West [1876]1973, courtesy David Rumsey, Cartography Associates).

The documentation of the broad, inset benches along Coyote Creek is both historically and spatially consistent, suggesting that it was a natural condition. Despite extensive descriptions of the creek in land case testimonies, and descriptions of it as the San Jose boundary, as well as notations by GLO surveys, we have found no mention of the extremely dramatic changes on the creek that would have had to occur in the first half of the 19th century if the observed channel form was the result of rapid changes in response to Spanish or early American land use.

Additionally, the outer banks have subsequently been quite stable, which would be unlikely to be consistent with rapid downcutting. For example, multiple independent maps closely agree about the outer boundaries of Coyote Creek for the two mile reach between Berryessa Road and Reed St. during 1850 and 1904 (**FIGURE II-18**), indicating both that these banks were a distinct feature in the field and that it was relatively stable over this half-century period.

There is evidence that the wide benches mapped along Coyote Creek were not surfaces completely abandoned by recent geological downcutting. Early historical evidence shows that this fairly incised condition precedes the era of general gully erosion in the western United States, 1880-1920, described by Leopold (1994).

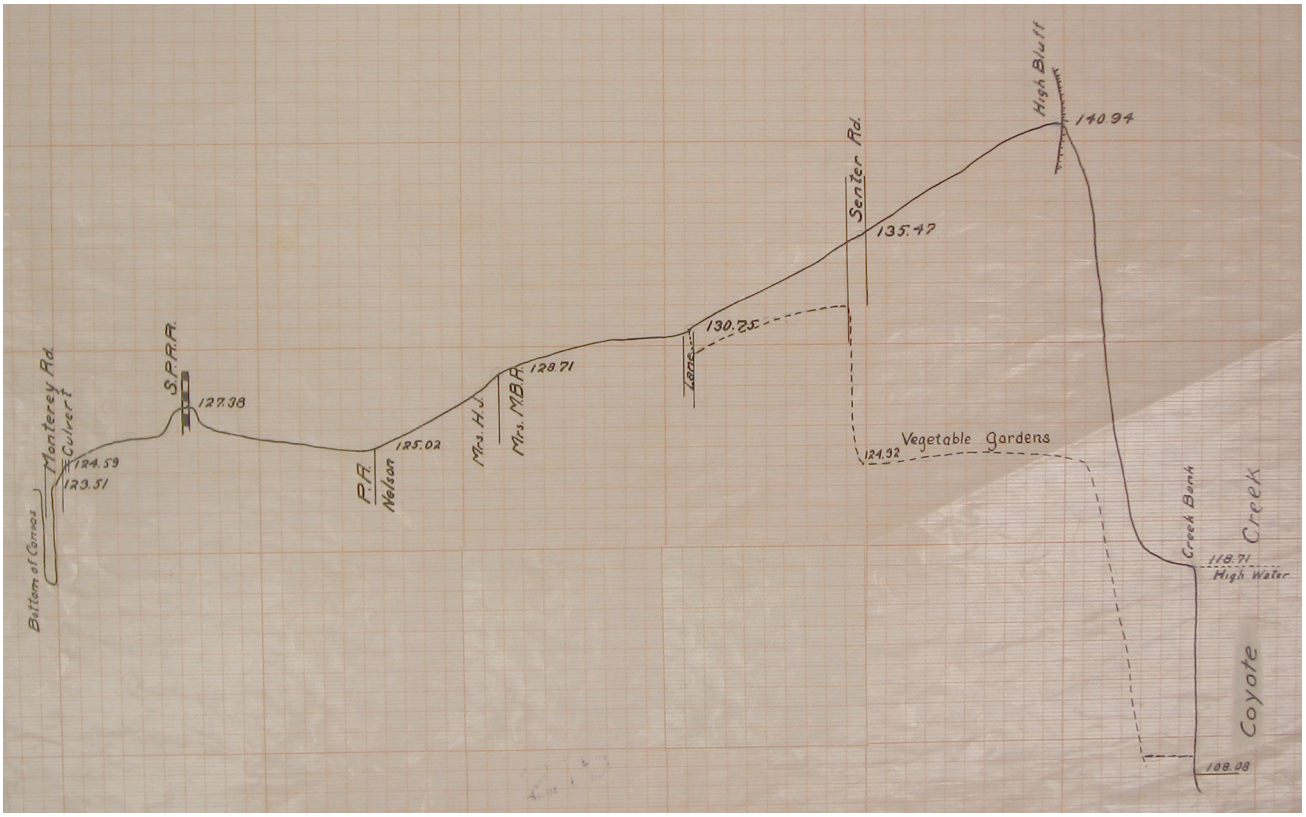


FIGURE II-17. "PROFILE [OF] PHELAN AVENUE FROM MONTEREY RD. TO COYOTE CREEK. MARCH 29, 1907." This county survey illustrates the natural levee along Coyote Creek ("High Bluff") and an inset bench with "Vegetable Gardens." The creek curves abruptly here, so the surveyor depicted two, adjacent sections of the stream bank (Hermann (?) 1907, courtesy Santa Clara County Surveyors Office).

A number of sources indicate fairly frequent overflow onto the benches. Aerial photography shows channel scour patterns and riparian trees. Several sources specify "gravel bars" or "gravel beds," indicating active depositional process (e.g. Herrmann 1874b,c). A number of maps, including Thompson and West ([1876]1973) and McMillan (1902), employ a stiple pattern to show the broad areas along the creek, a symbol conventionally indicating an unvegetated surface composed of sand or gravel (see **FIGURE II-16**). We expect that most of these areas received flow on a decadal time scale if not more frequently. Some of the lower benches were likely the active floodplain, while higher inset terraces were above the floodplain. These elevational differences might be distinguished and mapped through further fieldwork.

The outer channel area boundary, as indicated by early maps is also well-corroborated by the soil survey of 1940-41 downstream of the Narrows (Gardner et al. 1958). Almost all of these broad channel areas revealed by historical maps occupy the soil classification "Mocho soils, undifferentiated, one to three percent slopes," albeit at a coarser scale. The soil description, like other historical sources, puts these areas between five and 10 feet above the main channel, which we would expect to be within the range of occasional flooding:

> "The soils occupy small, recently formed "benches" that are generally five to ten feet higher than the channel of Coyote Creek and five to ten feet lower than adjacent soils of the Sorrento series. The "benches" are the result of cutting and filling by the creek and are subject to overflow during exceptional floods" (Gardner et al. 1958: 99).

This survey and associated land use follow a decade of drought, so these areas may well have appeared less prone to flooding than normal.

The less intensive agricultural development of these areas (open space, gardens, younger or less vigorous

orchards in early aerial photography) — when adjacent land was already intensively farmed — suggests significant practical limitation to their use, presumably soil characteristics and/or flood potential. Most of these surfaces are still preserved below adjacent valley surfaces today and prone to flooding.

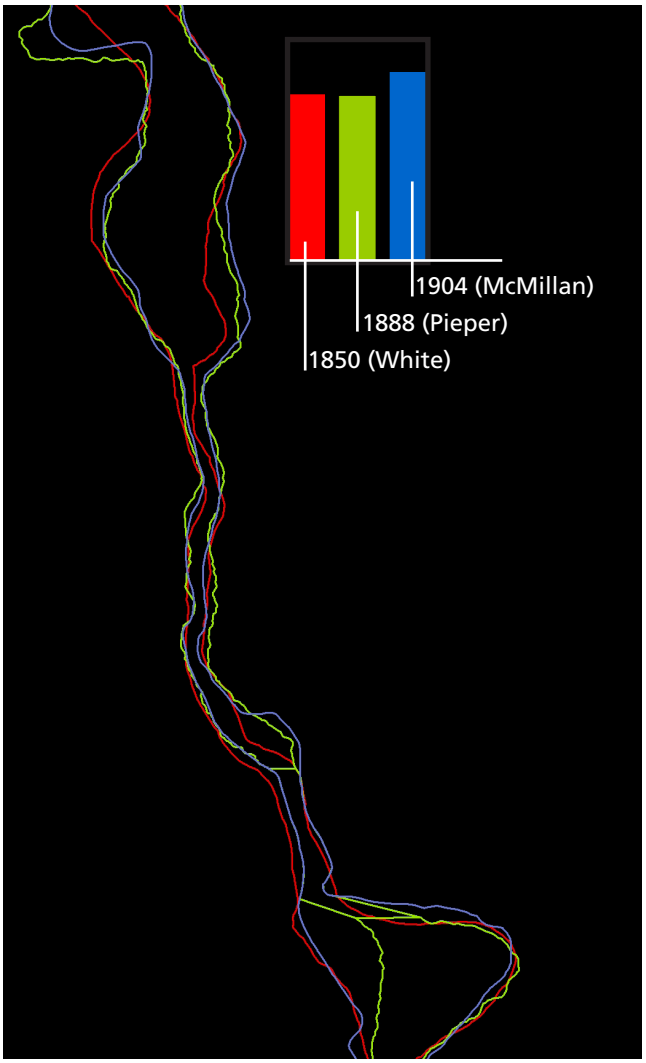


FIGURE II-18. INDEPENDENT MAPS OF COYOTE CREEK, 1850-1904. Each map has been geo-referenced and the outer boundary shown for this reach of Coyote Creek (Mabury Rd. to William St.) digitized. The amount of the area mapped as channel by each surveyor is within 10% (bars at upper right). The close correspondence (and lack of directional change where different) suggests both channel stability and competent surveyors.

Upstream of approximately Tully Road, the creek exhibited a strong braided channel pattern, with multiple diffuse channels, wide reflective scoured areas, and sparse riparian vegetation. Broad areas with adjacent benches were still interspersed with relatively narrow reaches, presumably the result of previous geologic/climatic events. Not coincidentally, the braided reaches became sites for gravel quarrying and managed stream percolation.

RIPARIAN HABITAT

Riparian vegetation consists of trees or shrubs associated with rivers, streams, lakes or artificial water bodies (SFEI 2005). For the purposes of historical analysis, we focused on identifying patterns of streamside vegetation that could be consistently revealed by historical documents. Willow groves can be considered a riparian habitat type but are not directly associated with surface waters; we mapped them separately and describe them in a separate section.

The natural diversity of riparian habitat along Santa Clara Valley streams reflected the variety in channel morphology and hydrology. Some fluvial channels supported dense, but narrow, corridors of riparian forest, creating classically shaded woody stream settings. Other stream reaches had few or no trees, even on the valley floor (see **FIGURE II-14**). Where channels were wide and gravelly, especially on Coyote Creek, a broad, open riparian woodland with scattered large sycamore trees and riparian scrub dominated. We identified these different kinds of habitats based on a variety of sources.

Because of its narrow shape, especially along smaller streams, riparian habitat can be challenging to map. Riparian features are also not always as precisely recorded by historical maps as creeks and other types of wetlands. For these practical reasons, we qualitatively assessed riparian habitats for all valley floor streams, but limited GIS mapping to the well-documented riparian habitat along Coyote Creek.

Riparian habitat on distributary creeks

Nearly all creeks that flowed from the hills onto the valley floor appear to have supported at least occasional riparian trees in their canyon reaches. The distance that riparian canopy continued downstream from the canyon mouth was highly variable, however. Riparian trees typically stopped some distance before the point at which channel definition was lost and the stream sank into its alluvial fan, often leaving 1000-3000 feet of channel completely without tree cover.

Streams that initiated from groundwater sources on the valley floor, with relatively small watersheds (i.e. not including Lower Penitencia Creek), show little or no evidence of riparian trees. These are often referred to *"sanjon"* in Mexican and early American documents, which literally translates as "ditch," likely reflecting the lack of normal streamside trees. However, streams without dense riparian tree cover undoubtedly maintained distinctive channel-side flora and associated ecological values, albeit not including shaded pool habitat.

The primary source of information about the riparian vegetation on smaller creeks is early aerial photography, which reflects substantial landscape modification. It is likely that riparian vegetation had been significantly altered on some streams by this time. However, the downstream extent of riparian trees is generally similar on adjacent streams of similar size, across multiple properties and land uses, (**FIGURE II-20**), suggesting that the overall pattern has not been modified. On many of the distributary creeks, riparian trees, where present, are widely spaced rather than continuous. This pattern would not result from widespread clearing, but could possibly be the result of gradual riparian tree loss due to grazing and agriculture (and has often filled in during recent decades, see **PART IV**). Riparian canopy width, where continuous, is generally one tree wide, roughly 40-80 feet across.

Riparian habitat on Coyote Creek

Historical evidence and comparison to modern field conditions revealed several distinct forms of natural riparian habitat along Coyote Creek, associated with hydrogeomorphic variation. Prior to modern modifications, Coyote Creek displayed an alternating pattern of broad and narrow channel morphology along its length. Reaches with broad inset benches or terraces, often 500-1000 feet wide, were separated by narrower reaches several thousand feet in length. Superimposed upon this morphology were limited perennial influences at either end of the Valley, for a couple miles downstream from the canyon mouth and upstream from the tidal interface.

Narrow stream reaches consistently supported a continuous band of narrow, dense riparian forest. Linear strands

FIGURE II-19. COYOTE CREEK AT HIGHWAY 880: 1874 (LOWER LEFT), 1939 (UPPER LEFT), AND 2002 (RIGHT). Change in this reaches been extensive. In 1874, Hermann's Coyote River Survey documented a narrow main channel with some linear riparian habitat and broad adjacent benches partly occupied by willow thickets (his field notes indicate the tree species). By 1939, much of the former active channel area is occupied by agriculture, although the location of the willows and parts of the adjacent bars or benches can still be identified. The 1972 flood control project removed the channel's sharp turn; the banks have since been colonized by riparian vegetation (AAA 1939; 2002 imagery copyright 2005 AirPhotoUSA, LLC, All Rights Reserved; Herrmann 1874c).

of riparian forest were also found occasionally along one of the outer banks of the braided channel areas. There is some indication that riparian forest also followed the main channel in the broad, entrenched reaches downstream of Tully Road to approximately Trimble Road, but this is less certain (**FIGURE II-19**).

The wide benches and gravel bars along the creek were mostly dominated by a more open riparian pattern. The most common trees of these broad gravelly channels were large, well-spaced California sycamores (*Platanus racemosa*), suggesting that many reaches would be classified today as Sycamore Alluvial Woodland (Holland 1986) California Sycamore series, or Central California Sycamore Alluvial Woodland (Sawyer and Keeler-Wolf 1996). California's Sycamore Alluvial Woodland is recognized as "Very Threatened" by The Nature Conservancy's Heritage Program (Sawyer and Keeler-Wolf 1996).

There were also large, frequently flooded areas with few or no trees, scattered riparian scrub, and unvegetated gravel bars (characteristics of Central Coast Riparian Scrub, Holland 1986; Mulefat series, Sawyer and Keeler-Wolf 1996). Some elevated, less frequently flooded benches/terraces appear to have been mostly grass covered (**FIGURE II-21**). These patterns were well evi-

FIGURE II-20. QUIMBY CREEK AT THE BASE OF THE FOOTHILLS IN 1939 (LEFT) AND 2002 (RIGHT). Downstream extent of visible riparian vegetation in 1939 is similar on Quimby Creek (image lower right), the unnamed creek to the north, and other nearby systems. By 2002, the creek to the north is no longer aboveground and riparian vegetation has expanded on the remaining portion of Quimby Creek. Chaboya Road runs through the middle of both images (AAA 1939; 2002 imagery copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

denced in many places along the creek less than 75 years ago in aerial photography and written description. For example, Gardner et al. (1958: 99) described vegetation of the "benches" along Coyote Creek in 1940-41: "Where not cultivated, the soils support a growth of grass and brush."

At the upstream end of the Valley, the channel was more densely wooded. Palou (1926) describes this mixed riparian forest in 1774 as "thickly grown with cottonwoods, sycamores, and willows." There appears to be a general upstream increase in riparian tree cover (but still not a closed canopy), as visible in the early aerials, from approximately the present-day Ogier Ponds area to the site of Anderson Dam. This makes sense given historical documentation of perennial water extending a few miles downstream of the canyon mouth and corresponds with the shift from California sycamore to coast live oak-dominated woodland present currently in the vicinity of the Highway 101 crossing (Sawyer and Keeler-Wolf 1996).

At the downstream end, presumably where near-surface groundwater was intercepted, the broad channel area had large willow thickets on bars. Downstream of approximately Trimble Road, both Penitencia Creek and Coyote Creek had thick riparian forest along a narrow single thread channel. Hermann's Coyote River surveys (1873 field notes) document mostly willow trees along Lower Coyote Creek.

As described in the Streams section, we mapped a "riparian" area occupied by the bars, islands, and occasionally flooded benches or terraces along Coyote Creek. This area falls within clearly defined outer channel banks and includes the riparian patterns described above. In addition, we noted the presence of linear segments of continuous Riparian Forest as a qualitative assessment.

FIGURE II-21. CATTLE GRAZING on stream bench along Coyote Creek (Gardner et al. 1958).

Evidence for Sycamore Alluvial Woodland and Open Riparian Character

Given that most of Coyote Creek currently exhibits a dense, closed canopy riparian forest, the identification of historically open woodland and savanna conditions is nontrivial. Evidence for the prior condition, however, is robust and diverse. Notably, while extensive illustration of open riparian habitats is available from the early aerial photomosaic, substantial corroborating data also come from both earlier eras and present-day remnants. In fact, the reach between Ogier Ponds and Highway 101 has been recognized as one of 17 significant existing occurrences of Central California Sycamore Alluvial Woodland in the state (Sawyer and Keeler-Wolf 1996).

Sycamore alluvial woodland and related riparian scrub habitats are typical of highly episodic, intermittent gravel-dominated Central California stream beds. Within the Santa Clara Valley, a similar pattern (broad braided channel reaches supporting sycamore alluvial woodland alternating with narrow, naturally confined reaches of dense, linear riparian forest) was described on lower Guadalupe Creek (Jones and Stokes 2001: 33-40) which, despite smaller size, had similar morphology to Coyote Creek. Jepson, in his classic description of California trees (1910: 247), closely ties the sycamore to "[I]ts favorite habitat in the beds or on benches of flood streams." He adds:

> "[T]he Sycamore reaches its greatest development as a tenant of river beds in the low valleys of 10 to 800 feet altitude, so that the stream-bed habitat and the very irregular crown with divided, leaning, or trailing trunks are associated characteristics."

A range of 19th-century historical sources indicate that California sycamore was the predominant tree along the broad areas of historical Coyote Creek. For example, several mid-19th-century General Land Office surveys follow the creek south of Tully Road, consistently reporting sycamores. The trees occur in recognizable groups or groves of well spaced trees. Live oaks are mentioned occasionally and appear to be associated with the linear stretches of riparian forest. None of these surveys mention cottonwoods, which appear to be the dominant tree today.

Day (1854: 524-525) described this pattern as he summarized timber resources for a one square mile section, characterizing Coyote from Tennant Road downstream to approximately the Highway 101 crossing: "splendid groves of oak and sycamores along the Coyote which flows from ¼ to ¾ mile E. of the line."

Following Coyote Creek — the western boundary of Rancho Yerba Buena — on consecutive GLO surveys, Wallace (1858: 429) and Tracy & Healy (1860-1863: 432) both recorded "[T]hree large sycamores in middle of creek," and Healy also notes a six-foot diameter sycamore bearing tree (a witness tree that was "notched" or "blazed" by the surveyor to facilitate relocation of the survey). These observations can be mapped precisely to the areas alongside present-day Cottonwood Lake, just downstream of the Highway 101 crossing, which show scattered trees in a wide, scoured, mostly unvegetated channel in 1939 (see **FIGURE III-20**). Along the long Yerba Buena border, following the creek from Tully Road to Coyote Narrows, the only other trees recorded are another sycamore and two live oaks. Of the oaks, one is located at The

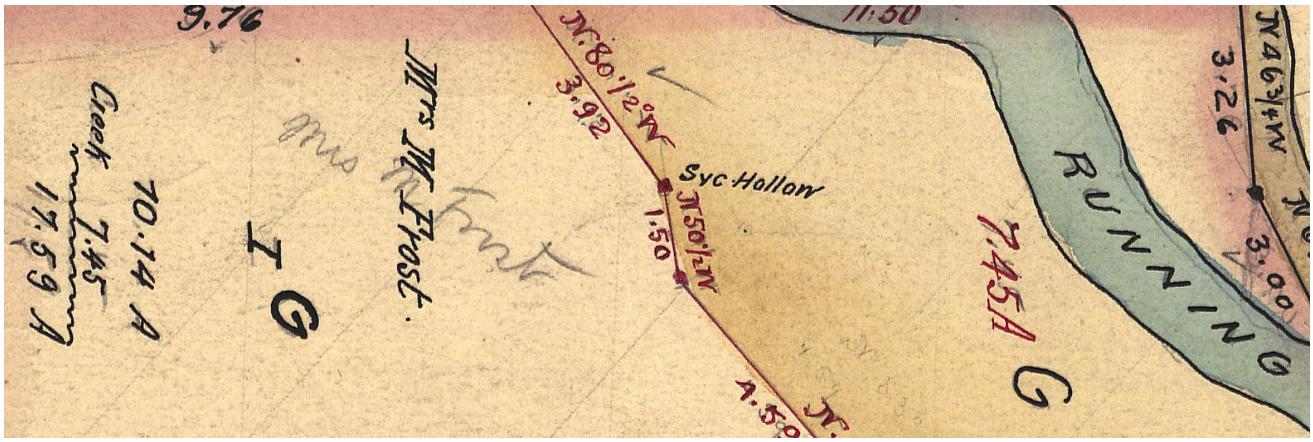


FIGURE II-22. SYCAMORE BEARING TREE ON A HERRMANN SURVEY ("Syc Hollow"; Herrmann 1874a, courtesy Santa Clara County Surveyors Office).

Narrows, and the other at the present-day Silver Creek Valley Road crossing (corresponding with a short segment of dense west-bank riparian forest identifiable in early aerial photography).

Similarly, the six bearing trees used by Howe (1851: 89-90) in the Coyote channel (at two sites about 1000 feet apart) in the present-day Ogier Ponds area include five sycamore trees (18 to 30 inches in diameter) and one white oak (valley oak). The sycamores range 36 to 105 feet from the quarter section posts. He recognizes the open spacing, referring to this area as having "some little scattering timber."

A subdivision map by County Surveyor Herrmann (January 26, 1874, Herrmann 1874a.) shows the reach just downstream of Malech (which was highly modified prior to 1939) as a gravel bed. Three sycamore trees are used to survey the boundary between gravel bed and "good soil" (**FIGURE II-22**).

An additional source provides cryptic information in support of sycamore trees along Coyote Creek from approximately the present-day Upper Penitencia Creek confluence to Anderson Dam (U.S. District Court [184-?]b). This *diseño,* created to define lands of the Pueblo of San Jose, quite accurately depicts a variety of other landscape features, such as the location of *sausals*, the discontinuous channels of Penitencia and Berryessa Creeks, and Valley topography. The map annotates Coyote Creek with the letter "A" at four widely spaced intervals.

The interpretation of this clue is complicated, as the map legend is poorly executed. Part of the legend reads "M = *Montey*," an obvious misspelling of "*monte*," which means thicket. The legend entry for the letter "A" is "*Misal*," which has no known translation. However, existing *diseños* in California are generally copies of the originals (Askevold 2005) and given the similarity of the letters "Al" and "M" in the map's calligraphy, the annotation likely refers to "*alisal*," or sycamore grove (Brown, personal communication, September 2005). (*Aliso* literally means alder, but in Spanish California referred to sycamores (Gudde 1998: 8, SFEI unpublished data)). Thus, this map provides additional confirmation of sycamore woodland along most of the stream's length from the canyon mouth into downtown San Jose.

Early aerial photography provides the most extensive illustration of open riparian habitat. Most of the broad reaches on Coyote Creek upstream of Hellyer Road not directly impacted by land use show scattered, widely-spaced large trees in the circa 1939 aerial photomosaic. Field visits to several of the sites with residual large trees (as identified by comparative aerial photo overlays) show that they are primarily California sycamore (**FIGURE II-23**).

Additional Evidence for Riparian Scrub

While sycamore groves were the most prominent vegetation in broad channel reaches, there were also large areas of mostly unvegetated gravel bars with scattered shrubs that likely received more frequent flooding.

These conditions are often indicated by the descriptors "gravel bar" or "gravel bed" (e.g. Herrmann 1874b,c), showing recent sediment transport/deposition, and are generally noted by Gardner et al. (1958) as "a growth of grass and brush" on the Coyote Creek "benches." Amateur naturalist Mary Carroll (1903) notes the presence of *Mentzelia laevicaulis* in "sandy beds of the dry creeks" generally within Santa Clara Valley.

A field study on Coyote Creek during 1929-1936 gives more detail about the riparian scrub community occupying gravel beds in between, and as understory to, sycamore groves. Pickwell and Smith (1938) carefully documented the vegetation of the "gravel beds" just downstream of Coyote Narrows, emphasizing the presence of mulefat *(Baccharis salicifolia)* along with a variety of other shrubs and herbs characteristic of seasonally dry gravel stream beds (**TABLE II-2**). In their accompanying map they also indicate sycamore trees.

FIGURE II-23. SYCAMORE on occasionally flooded terrace of Coyote Creek, near Coyote Creek Golf Club.

Consideration of early impacts

It should be considered whether or not the sparse riparian tree cover consistently observed along the broad channel reaches of Coyote Creek in early aerial photography could be the result of prior land use impacts. Local historians have noted the extent of woodcutting during the Spanish, Mexican, and early American eras, and some have emphasized the effect on riparian habitat. However, some of these interpretations are based upon the assumption of a densely wooded valley floor and generalization of specific impacts.

For example, when the settler Bernard Reid noted, in Santa Clara in 1851 (Friedly 2000: 312), that "wood for fuel already had to be hauled from 3 miles away, indicating a dearth of lumber within that radius," he was describing an area largely surrounded by clay-rich bottomlands that precluded most trees. The complaint was about natural condition rather than deforestation. Similarly, Schick (1994: 24-25) suggests that the Santa Clara Mission deforested extensive riparian forests to make space for agriculture. That nearby riparian forests were not clear-cut is confirmed by the presence of riparian tree corridors in early mapping of, for example, lower Coyote Creek, Guadalupe River, and Penitencia Creek (e.g. Day 1852, Herrmann 1873, Westdahl 1897b; **FIGURE II-19**).

SCIENTIFIC NAME (NATIVE SPECIES IN BOLD)	COMMON NAME
ABUNDANT PLANTS	
Baccharis viminea ***[B. salicifolia]***	Mulefat
Chrysopsis oregano ***[Heterotheca oregona]***	Goldenaster
Senecio douglasii ***[S. flaccidus var. douglasii]***	Douglas' Groundsel, Shrubby Butterweed,
Mentzelia laevicaulis	Blazing Star, Smooth-stem Blazing Star
Brickellia californica	California Brickellbush
Brassica adpressa	Mediterranean Mustard
SCATTERED PLANTS	
Lepidospartum squamatum	Scale-Broom, California Broomshrub
Heliotropium curassavicum	Heliotrope, Seaside Heliotrope
Verbascum thapsus	Woody Mullein
Xanthium canadense ***[Xanthium strumarium]***	Cocklebur
Amaranthus blitoides	Mat Amaranth, Prostrate Pigweed
Chenopodium botrys	Jerusalem Oak Goosefoot
Centaurea melitensis	Tocalote, Napa Star Thistle
Artemisia vulgaris var. heterophylla	Mugwort
Eremocarpus setigerus	Turkey Mullein, Dove Weed
Antirrhinum glandulosum ***[A. multiflorum]***	Sticky Snapdragon, Chaparral Snapdragon
Antirrhinum vagans	
Salix melanopsis	Dusky Willow
Salix laevigata	Red Willow

TABLE II-2. "FLORA OF GRAVELLY FLOOD BEDS." Plant list for a half-mile reach of Coyote Creek immediately downstream from Coyote Narrows based upon field studies 1929-1936. From Pickwell and Smith 1938.

These historical interpretations did not have the benefit of historical cartographic and photographic evidence, and a spatial compilation, and therefore appear to be somewhat overstated. Dramatic, explicit descriptions of deforestation appear limited to the Santa Cruz Mountain redwood groves and *sausals* (e.g. Foote 1888: 21). There is also no evidence that most natural local riparian corridors (excepting Coyote Creek) were ever broader than the narrow "ribbons" typically shown by maps and reported by written descriptions.

Part of the reason that riparian forest substantially persisted, while the redwood groves were rapidly clear-cut, is that local riparian trees were fortuitously useless for most purposes other than firewood. For example, in a thorough description of County resources, County Surveyor Healy (1857) describes the trees of the Valley — the "white oak" (valley oak), "Evergreen, or Live oak," sycamore, "cotton-wood," and willow — and reports that "None of these trees furnish timber of a good quality; all that is used in the manufacture of wagons, plows, etc., is necessarily brought from abroad." Grossinger et al. (2004: 38) found similar limitations to the extractive use of riparian trees, including for fuel, in the Napa Valley.

Also, despite many evident examples, we should not assume complete exploitation of all possible resources at all times, particularly where they were managed for personal use. Alfred Doten's 1861 journal entry "Cut the lower limbs of the big live oak over the hen house, for firewood," cited by Friedly as evidence for widespread clearing, seems actually quite restrained (Doten 1973: 606, Friedly 2000: 312). Jepson, describing the Fremont cottonwood (1910: 185), states that "Mexicans never cut down the tree but pollard it by cutting off the main branches and thus insure a continuous crop."

With regard to Coyote Creek riparian habitat, then, it is unlikely that extensive modification would have taken place prior to the GLO surveys of the 1850s and 1860s. This is particularly true given that most of the valley floor length of Coyote Creek was some distance from the center of Spanish and early American activity. Most important, mid-19th-century descriptions closely corroborate riparian patterns visible in early aerial photography. It is still possible that these patterns exhibit some more minor effects of woodcutting, grazing, and other earlier impacts, such as reduced tree density and understory vegetation.

Fortunately, the 1939 aerial photography closely follows the construction of Coyote Dam (1936) and precedes Anderson Dam, so it provides a good illustration of conditions prior to flow regulation. Except for localized areas of direct impact from gravel quarrying, Coyote Creek riparian characteristics south of San Jose (roughly Tully Road) circa 1939 appear to well-represent patterns of the prior century.

In summary, numerous sources of evidence from throughout the historical record confirm an open riparian habitat along the broad, intermittent reaches characterizing much of Coyote Creek. The prominent writer Bayard Taylor, who visited Santa Clara Valley in the 1850s, succinctly summarized habitat and hydrology on Coyote Creek, capturing the grandeur of distinct,

FIGURE II-24. EARLY AERIAL PHOTOGRAPHIC EVIDENCE FOR VALLEY OAK SAVANNA. Several large trees scattered within the orchard at upper left in the 1939 image (left image) are probably valley oaks. Additionally, the circular disease patterns visible at center right indicate the probable location of valley oaks recently removed for orchard planting, whose roots have caused oak root rot. There are no obvious residual trees in 2002 (right image) (AAA 1939; 2002 imagery copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

non-continuous sycamores on a seasonally dry stream:

> "[t]he dry bed of a winter stream, whose course is marked with groups of giant sycamores, their trunks gleaming like silver through masses of glossy foliage" (Carroll 1903: 185).

VALLEY OAK SAVANNA

Perhaps the signature habitat of the Santa Clara Valley, valley oak savanna (*Quercus lobata*) dominated the alluvial fans. Valley oak lands were naturally scarce in the Bay Area, limited to a few fertile valleys including Santa Clara (Grossinger unpublished data, Holstein 1999). Within Santa Clara Valley, varying patterns of density and oak species composition were found, but stands of widely spaced valley oaks, often of remarkable size and age, characterized the fans along the Coyote. The valley oak savanna was among the most well described and celebrated components of the Santa Clara Valley landscape, from Font's 1776 description of "a very beautiful plain full of oaks" to Vancouver's famous description. Before the proliferation of property lines and roads, the *roblars*, "white oak groves," were an important landmark, noted in historical accounts and land case testimony.

Some authors have suggested that the valley oak savanna described by many accounts was itself remnant of much more dense woodland, reduced by Spanish and early American logging (e.g. Friedly 2000: 312-318). Schick (1994: 24-25), for example, states that "the Spanish deforested any oaks that were in the way." Yet very early accounts repeatedly describe the Valley as "scattered" or "studded" (Santa Clara Mission report for 1782 *in* LoCoco n.d.) with trees in a park-like setting. Healy (1857) describes the "[O]ak openings, which are not close enough together to prevent the growth of grass and have the appearance from a distance of vast orchards." Intensive logging appears reserved to the Santa Clara Mountain redwoods, which had much higher value for lumber than valley oaks.

This is not to say that most of the oaks were not cut down over time, but that the decline was gradual and heterogeneous, varying by property and land use (as can be seen by examining remnant patterns in the 1939 aerial photography). In those parts of the Bay Area naturally endowed with valley oak savanna, there tended to be some recognition of their cultural value. For example,

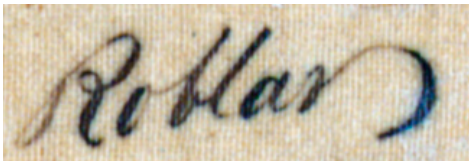


FIGURE II-25. DEPICTIONS OF VALLEY OAK SAVANNA using a tree stamp and text (lower right) (Healy, U.S. Dist. Court 1859, courtesy The Bancroft Library, UC Berkeley).

Thompson, in the General Remarks for a Napa GLO survey (1857a), notes that "the scattered oak trees and groves afford tasteful sites for residences." Chaparral and scrub oak seemed to have been the preferred firewood sources.

At this time, we have created only a preliminary sketch of the distribution of oak savanna for illustration. This picture should not be used for technical or planning purposes. This initial view is based upon, in particular, over 1000 "probable valley oak trees" mapped from the early aerial photomosaic (**FIGURE II-24**). These data were supplemented with mid-19th-century Mexican *diseños* and General Land Office surveys. A number of other important sources have not yet been used and compilation is still at a coarse scale. Fuller compilation and analysis will allow an accurate assessment of historical distribution and abundance as well as spatial characteristics such as patch size, spacing, and density.

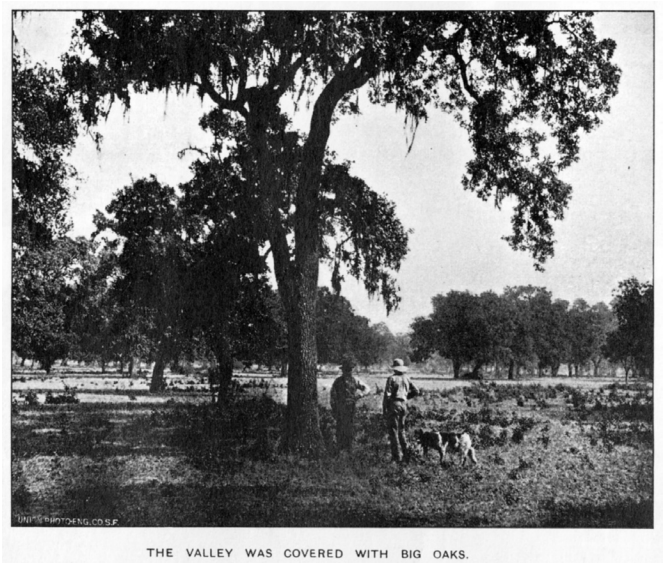


FIGURE II-26. "THE VALLEY WAS COVERED WITH BIG OAKS." Image from the San Jose Mercury's centennial yearbook (Shortridge 1896, courtesy History San José).

From this preliminary analysis, however, it is clear that valley oak savanna, currently a recognized rare and "Very Threatened" oak habitat (Sawyer and Keeler-Wolf 1996), covered substantial portions of the valley floor, and that while habitat reduction has been dramatic, a surprising number of trees from this original habitat still remain. While willow groves and redwood groves were rapidly clear-cut in the mid-19th century, the decline of valley oak savanna has been more gradual. As a result, preservation and restoration of historic valley oak habitat within the Santa Clara Valley has potential.

On Spanish maps, *roblar* is represented by various methods: numerous, individually drawn trees, the use of an oak tree "stamp," the word itself sometimes with additional spatial information (e.g. "*punto del roblar*", point of the oak grove), or, simply, the letter "R" (**FIGURE II-25**).

Of all the Valley's habitats, oak savanna, particularly the grand valley oaks, received the most appreciation by American immigrants. Parallel to their widespread destruction, smaller numbers were also revered and preserved, reproduced in postcards and lithographs, eloquently eulogized (**FIGURE II-26**). More so than most habitats, they could be selectively integrated into the new landscapes of American towns and farms. Ac-

FIGURE II-27. BLOSSOM HILL ROAD IN 1939 (LEFT) AND 2002 (RIGHT). Aerial photographic overlay allows the identification of at least one persisting, heritage oak tree, shown in **FIGURE II-28** (AAA 1939; 2002 imagery copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

cordingly, a surprising number of trees have persisted in yards and along roads, preserving portions of the *roblars* that intersected fortuitously with the rectilinear division and development of the alluvial fans (**FIGURES II-27** and **II-28**).

SYCAMORE GROVE

In the Coyote watershed, most evidence of sycamore trees was associated with the riparian habitats along Coyote Creek. However, we identified a single, large sycamore grove outside of the Coyote channel area — on the valley plain adjacent to the creek near the present-day Oakland Road and Highway 101 crossings. Characteristics are described in the Mid-Coyote section.

DRY GRASSLAND

The dry grasslands have many similar species to the wet meadows, but they occupy well-drained alluvial fans and consequently have less of a wetland component. Within the region, the well-drained grasslands were composed primarily of rhizomatous grasses and perennial bunch grasses (Holstein 1999). Frequent low intensity fires set by Native Californians probably had a strong influence on the maintenance of dry grasslands as an open, herbaceous habitat. In the absence of Indian burning, large areas would likely have converted to brushland or woodland (Stewart 2002). Dry grassland also comprised the understory of valley oak savanna.

FIGURE II-28. RESIDUAL VALLEY OAK AMONG PALMS, BLOSSOM HILL DRIVE. This grand tree has been preserved as a landscape centerpiece.

PART III //

HISTORICAL LANDSCAPE CONDITIONS AT THE LOCAL SCALE

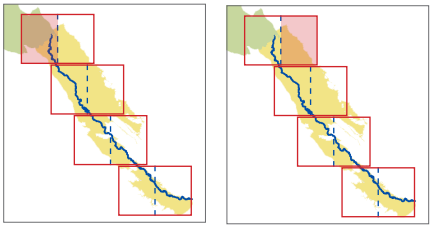
Part III examines conditions prior to Euro-American modification in more detail, focusing on channel morphology, wetland types, plant communities and their controlling physical processes. We also describe the evidence supporting these interpretations.

GEOGRAPHIC DIVISION

To organize the discussion of historical conditions, we divide the valley floor along Coyote Creek into four major sections **(FIGURE III-1)**:

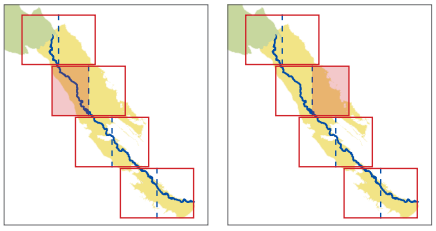
1

Lower Coyote Creek and Adjacent Areas covers the creek from the tidal marshlands, near the confluence with Mud Slough, upstream to the Montague Expressway crossing. It also incorporates the valley floor west and east, including Calera, Berryessa, and Lower/Upper Penitencia Creeks.



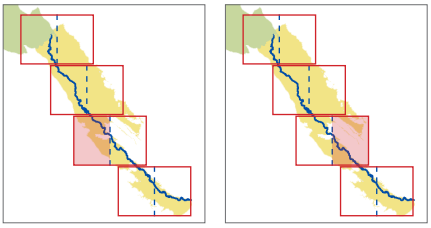
2

Mid-Coyote Creek and Adjacent Areas covers the creek from Montague Expressway to Highway 280 — the Mid-Coyote Flood Protection Project extent. To standardize map scale and area, it also includes a small additional length of creek, to Tully Road. Adjacent areas include the bottomlands east of downtown San Jose and distributary creeks such as Silver, Thompson, and Norwood.



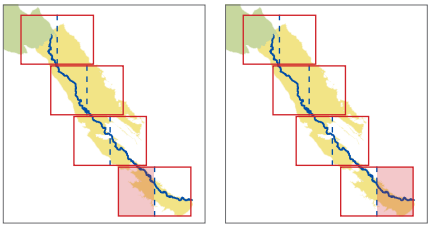
3

Coyote Creek/South San Jose covers the creek from Tully Road to Coyote Narrows and the relatively narrow adjacent valley lands.



4

Coyote Creek/Coyote Valley covers the creek from the Narrows to Anderson Dam, and the adjacent Coyote Valley.



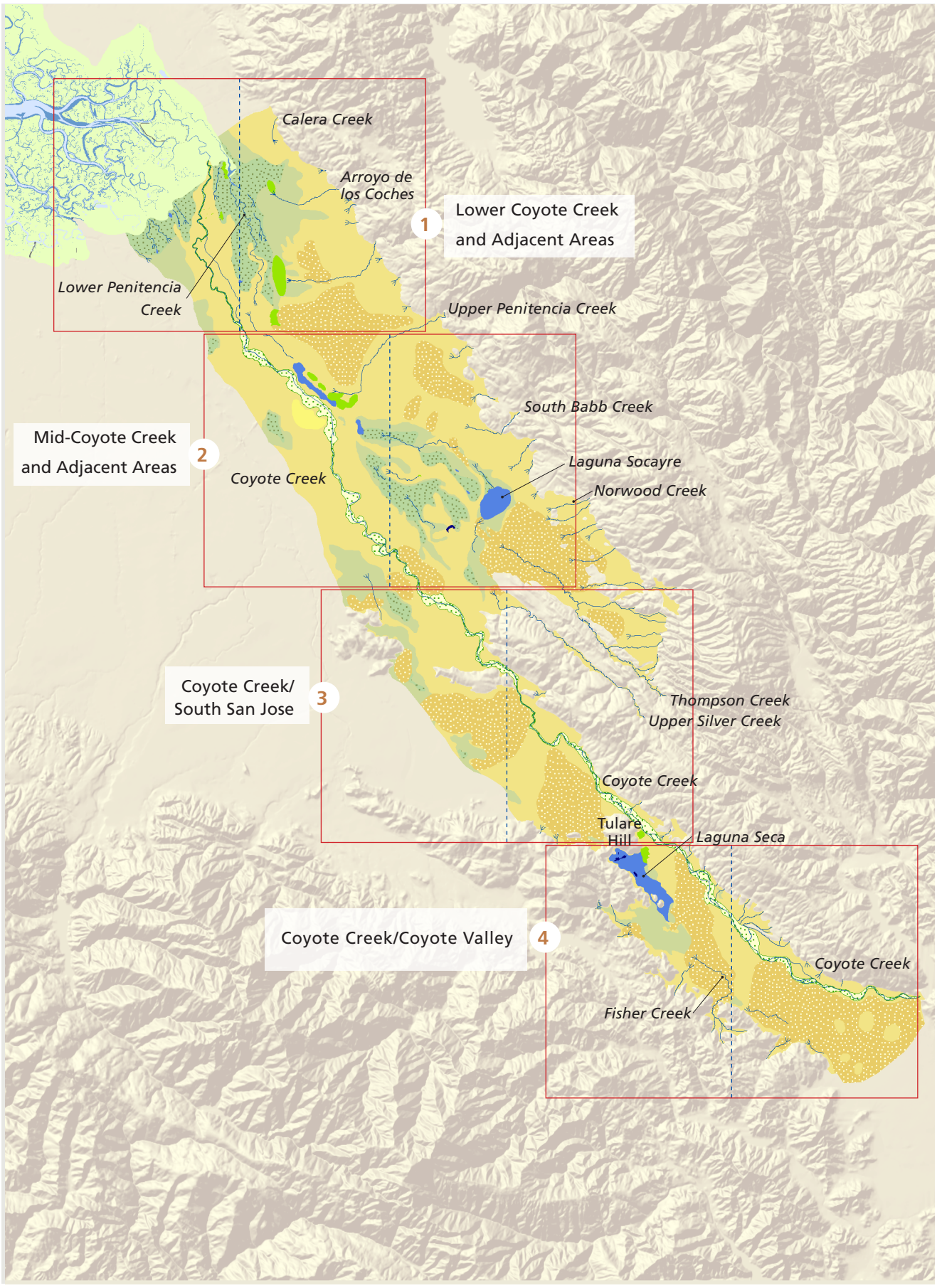


FIGURE III-1. REFERENCE MAP DIVIDING COYOTE CREEK AND ITS ATTENDING VALLEY FLOOR INTO FOUR MAJOR SECTIONS. See inside front cover for legend.

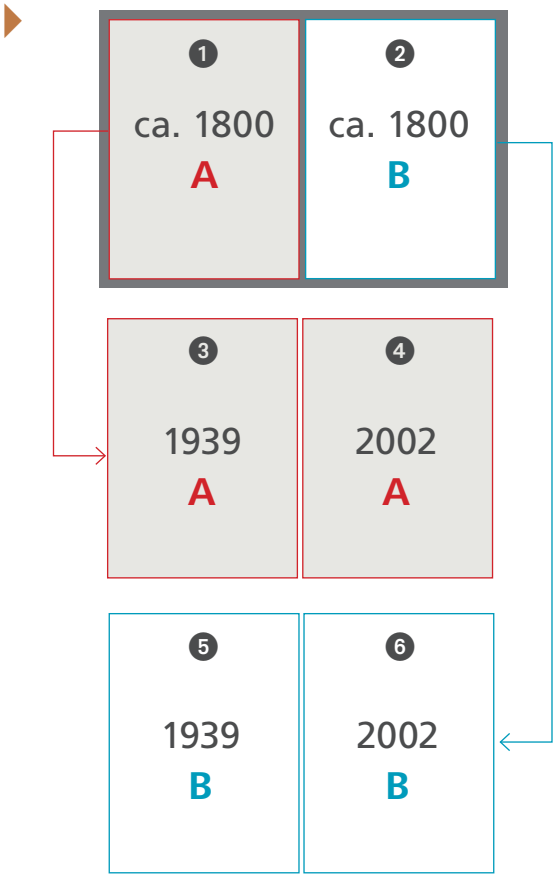
MAP GRAPHICS

To coordinate the presentation of information at different scales, we use **three** standard map scales. All standard maps are oriented with North at the top of the page.

- The overview maps showing the full Coyote Creek Valley floor area are made at 1:200,000 scale, or 1 inch equals approximately 3 miles.

- Each section in Part III begins with a 6-page 1:40,000 (1"= 3333') reference map series showing the area circa 1800 (using the project GIS), in 1939 (using the georectified aerial photomosaic), and in 2002 (using a true color photomosaic by AirPhotoUSA). Past and present place names are shown here.

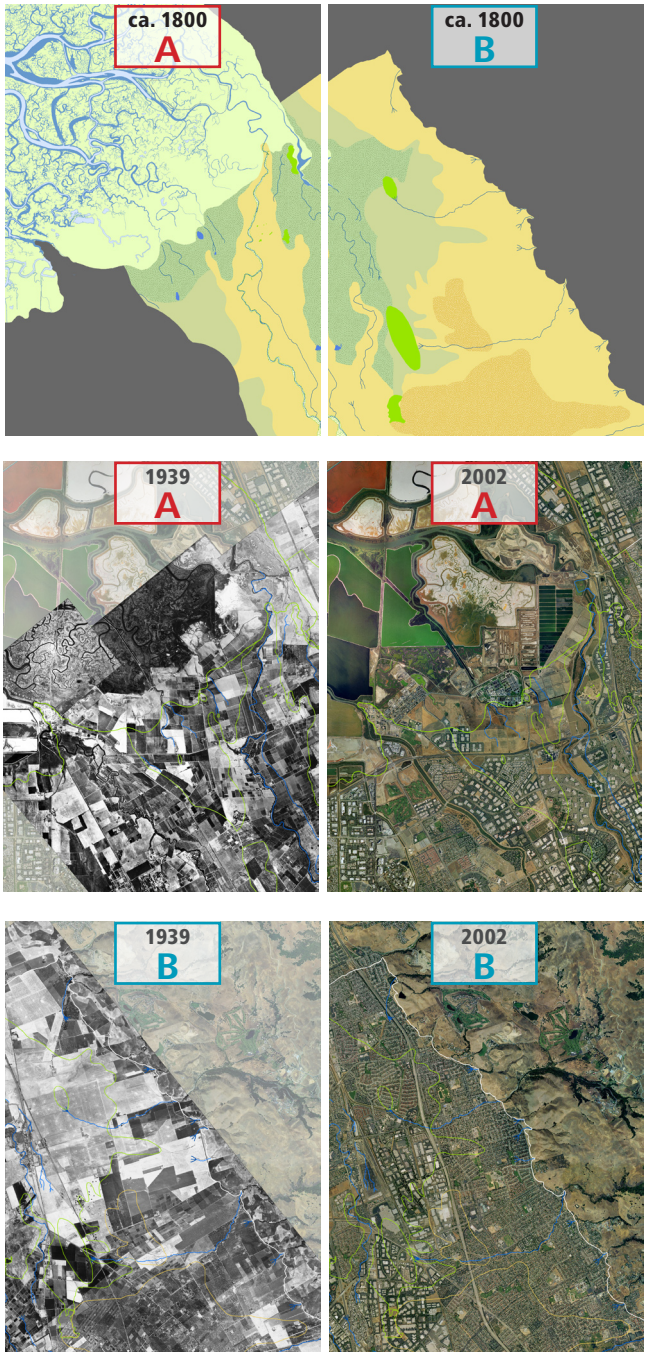
- About 20 "zoom-ins" distributed throughout the text focus on half-mile squares at 1:10,000 (1"= 833'). Features are thus enlarged fivefold and fourfold, sequentially.

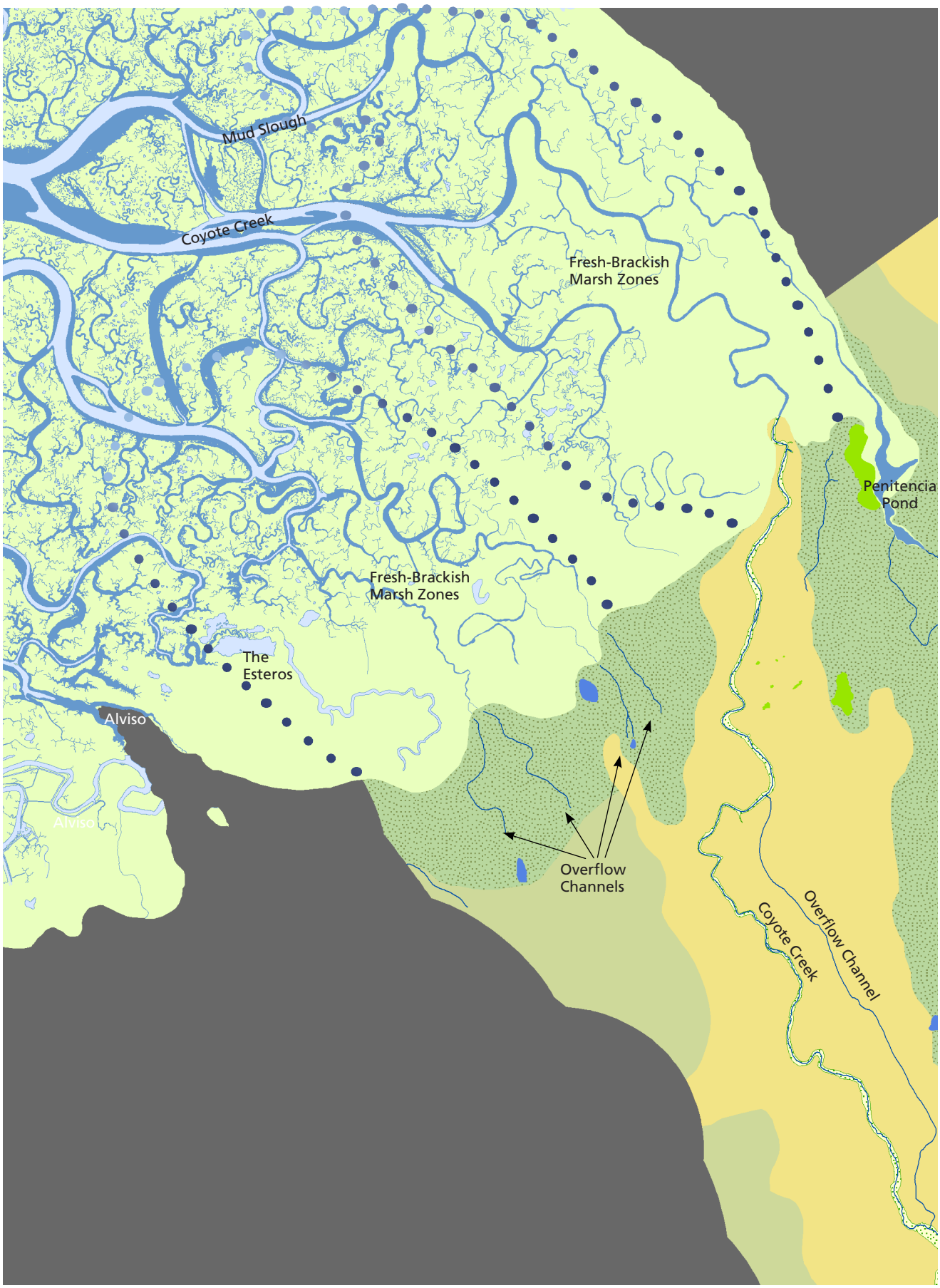


1

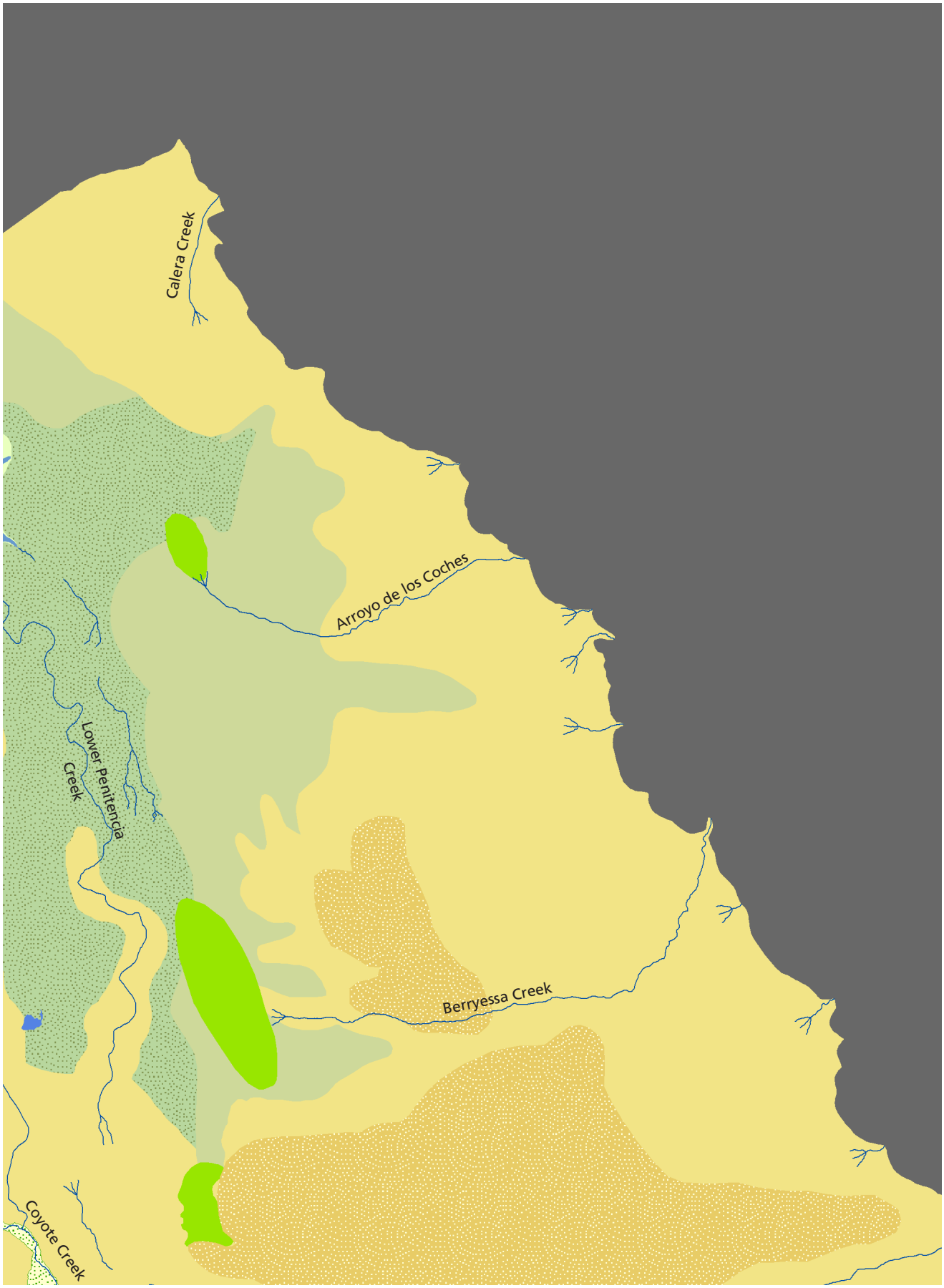
LOWER COYOTE CREEK AND ADJACENT AREAS

This section covers Coyote Creek from the tidal marshlands, near the confluence with Mud Slough, upstream to the Montague Expressway crossing. It also incorporates the valley floor west and east, including Calera, Berryessa, and Lower Penitencia Creeks.

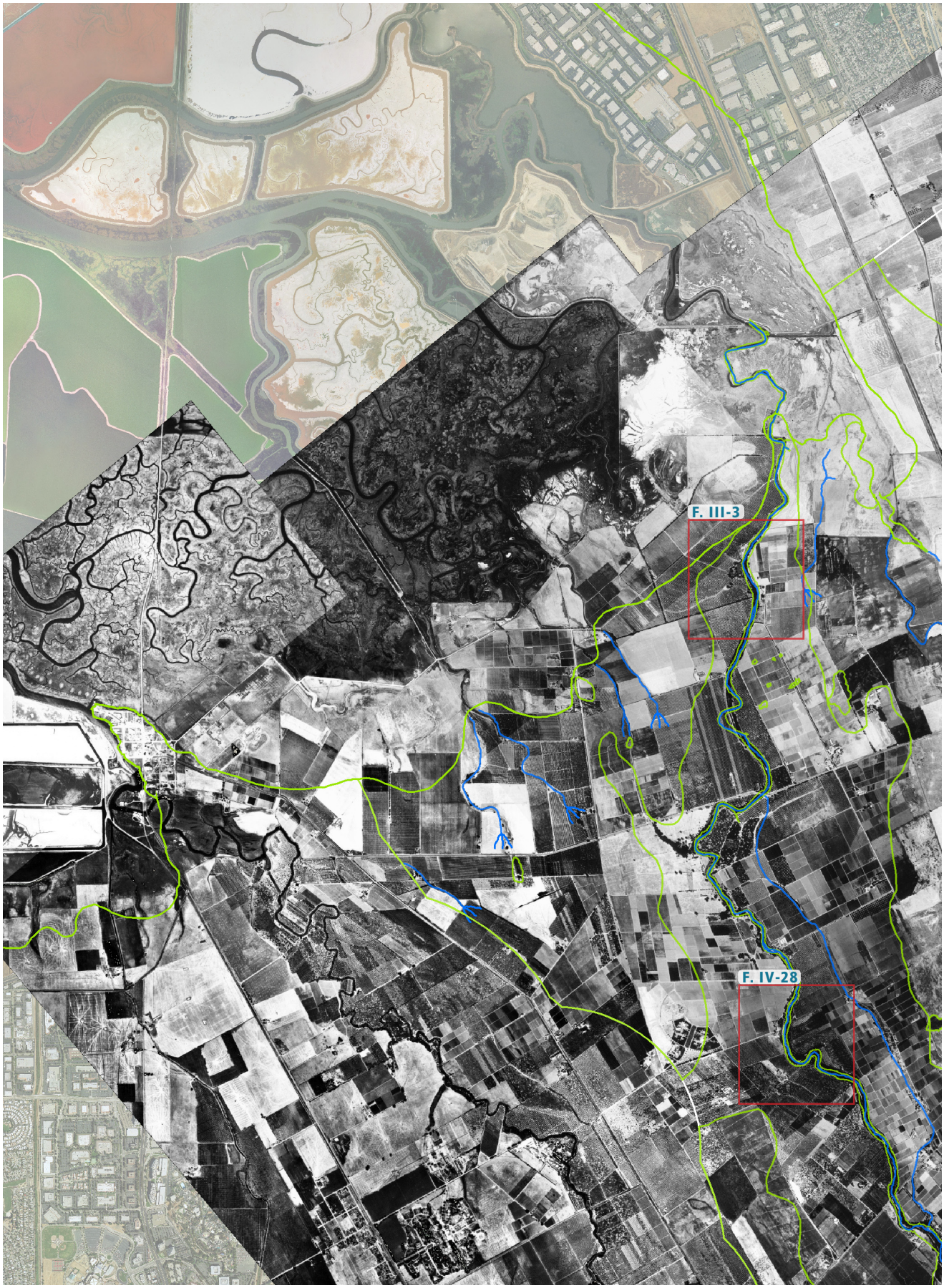




MAP 1A-CA.1800. LANDSCAPE FEATURES DURING INITIAL EURO-AMERICAN SETTLEMENT, CIRCA 1769-1850. Certainty level varies among features; valley oak savanna is a preliminary estimate. More information is available in the project GIS (scale 1:40,000; 1"~3300'; 1 square inch ~250 acres). See inside front cover for map legend.

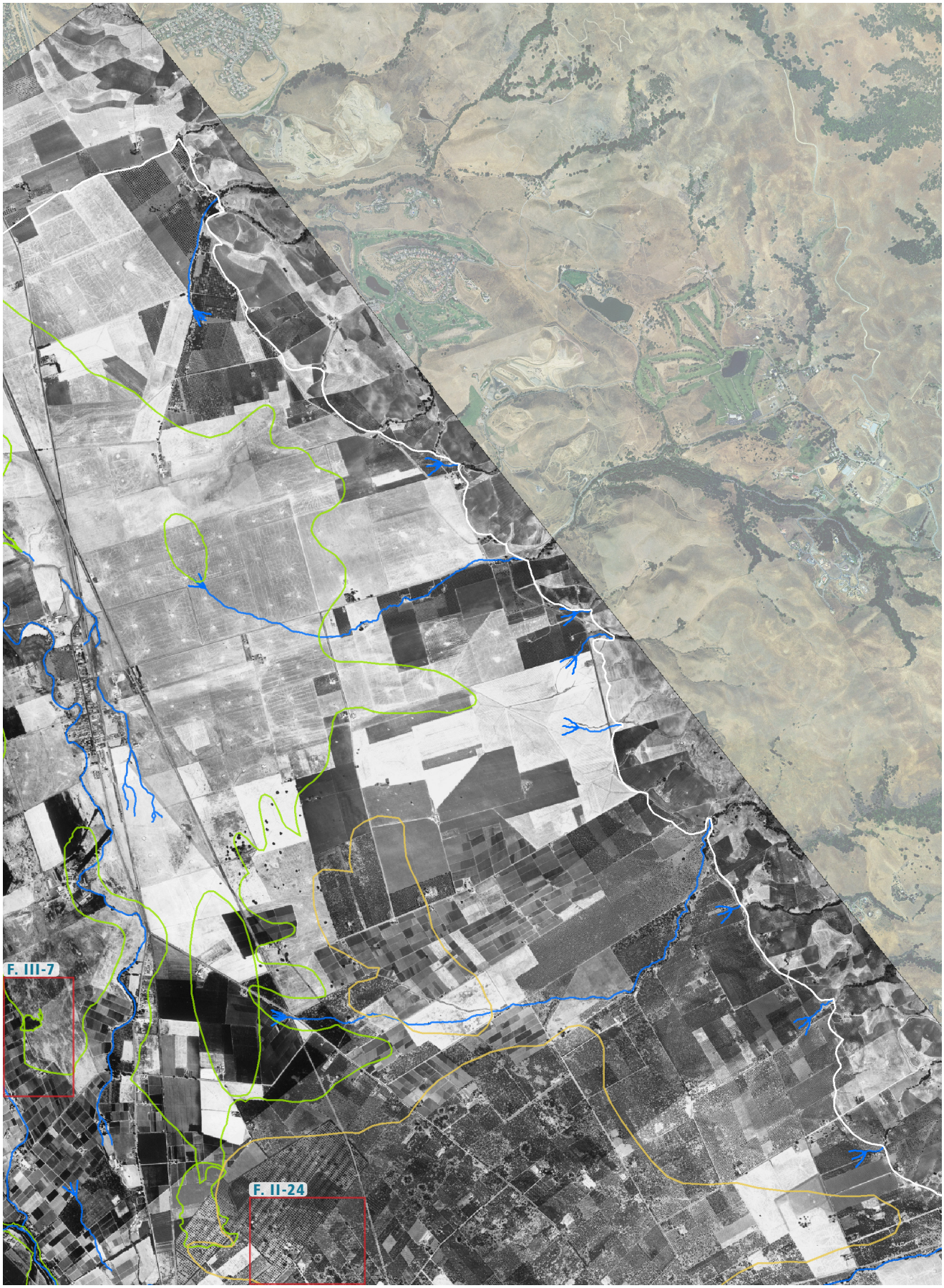


MAP 1B-CA.1800. LANDSCAPE FEATURES DURING INITIAL EURO-AMERICAN SETTLEMENT, CIRCA 1769-1850. Certainty level varies among features; valley oak savanna is a preliminary estimate. More information is available in the project GIS (scale 1:40,000; 1"~3300'; 1 square inch ~250 acres). See inside front cover for map legend.



MAP 1A-1939. PHOTOMOSAIC OF EARLY AERIAL IMAGERY, WITH HISTORICAL LANDSCAPE FEATURES OVERLAY. Historical fluvial features in blue; other features, green; project boundary, white (scale 1:40,000; 1"~3300'; 1 square inch ~250 acres; original photographs courtesy SCVWD, USGS Menlo Park, and UC Santa Cruz, UC Santa Barbara, and UC Berkeley).

MAP 1A-2002. MODERN AERIAL IMAGERY, WITH HISTORICAL LANDSCAPE FEATURES OVERLAY. Historical fluvial features in blue; other features, green; project boundary, white (scale 1:40,000; 1"~3300'; Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).



MAP 1B-1939. PHOTOMOSAIC OF EARLY AERIAL IMAGERY, WITH HISTORICAL LANDSCAPE FEATURES OVERLAY. Historical fluvial features in blue; other features, green; project boundary, white (scale 1:40,000; 1"~3300'; 1 square inch ~250 acres; original photographs courtesy SCVWD, USGS Menlo Park, and UC Santa Cruz, UC Santa Barbara, and UC Berkeley).

MAP 1B-2002. MODERN AERIAL IMAGERY, WITH HISTORICAL LANDSCAPE FEATURES OVERLAY. Historical fluvial features in blue; other features, green; project boundary, white (scale 1:40,000; 1"~3300'; Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

In the Lower Coyote Creek Area, Coyote Creek's natural levee extends across the lower valley floor and into the Baylands. Prominent natural levees follow the creek's present and former routes. The smaller, steeper alluvial fans of Calera Creek, Arroyo de los Coches, Berryessa Creek, and Upper Penitencia Creek descend from the east side. In between the alluvial fans of the eastside creeks and Coyote, there was a large bottomlands area through which Lower Penitencia Creek meandered.

Willow groves, freshwater marshes, wet meadows, and salt grass-alkali meadows occupied the bottomlands areas. The smaller creeks dissipated on the alluvial plain near their canyon mouths, but the larger creeks —Arroyo de los Coches and Berryessa Creek — maintained defined channels into the bottomlands, where they ended in giant willow thickets. Trees were found along creeks, but outside of the riparian corridors and *sausals*, most of the area was a treeless plain. Wallace describes Rincon de los Esteros: "the land is perfectly level and destitute of timber except on the banks of the creeks" (Wallace 1858: 197). Numerous overflow or secondary channels carried flood flows from Coyote Creek and Lower Penitencia Creek. At the southeastern edge of the area, valley oak savanna appears on the Berryessa and Upper Penitencia Creek fans.

Fluvial sediment primarily entered the Baylands where Lower Penitencia Creek and Coyote Creek joined tidal sloughs. West of Coyote Creek, the overflow channels were apparently supplied by artesian water, creating additional points of freshwater influence into the Baylands. During floods, overland flow ran across the entire Baylands-Bottomlands interface, creating large areas of temporary ponding (**FIGURE III-2**).

Gradients of fresh to brackish to saline tidal marsh extended a substantial distance from the points of freshwater influence into the Baylands, creating tule-lined channels. Extreme high tides spread beyond the limits of the tidal marsh, well into the *salitroso* lands — the saltgrass-alkali meadows adjacent to the tidal marsh.

LOWER COYOTE CREEK

Lower Coyote Creek was one of the relatively few Bay Area streams to maintain a continuous, well-defined channel across the entire valley floor and directly join a tidal slough. The channel supported a narrow but continuous, dense riparian forest along this reach, as shown

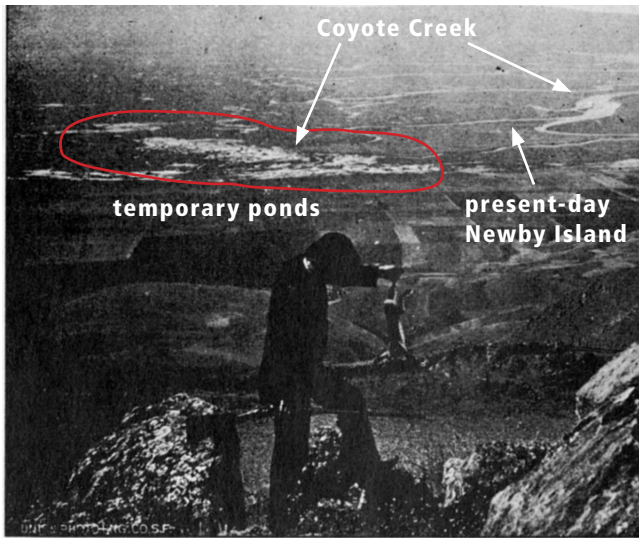


FIGURE III-2. SEASONAL PONDING IN THE BOTTOMLANDS ALONG LOWER COYOTE CREEK, 1896. This view looks east across the South Bay Baylands at the fluvial-tidal interface on Coyote Creek (Shortridge 1896, courtesy History San José).

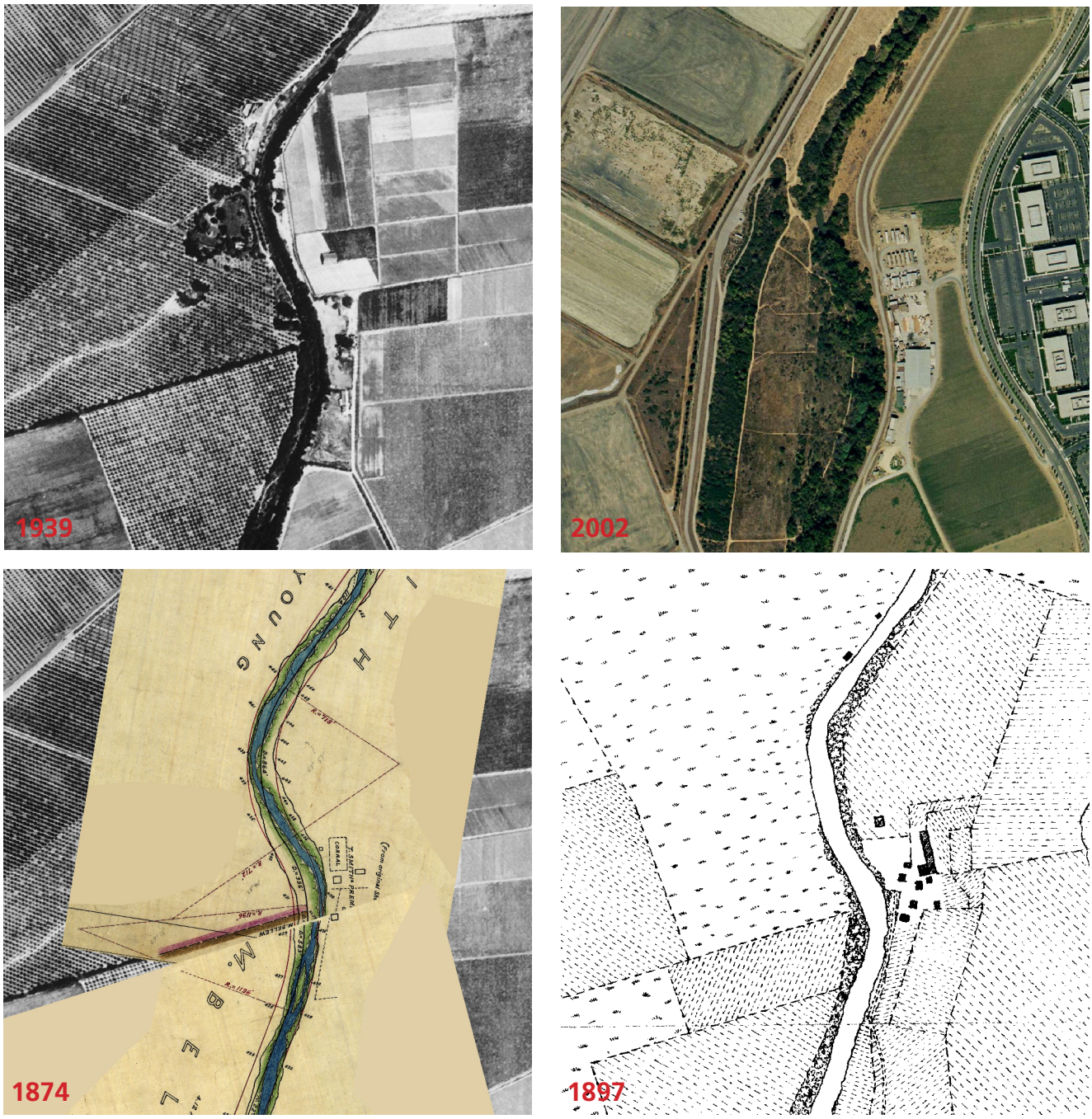


FIGURE III-3. SEQUENTIAL IMAGES OF LOWER COYOTE CREEK ADJACENT TO THE PRESENT-DAY SAN JOSE-SANTA CLARA WATER POLLUTION CONTROL PLANT. These data illustrate conditions in 1874 (lower left, Herrmann 1874, courtesy Santa Clara County Surveyors Office), 1897 (lower right, Westdahl & Morse 1896-97, courtesy National Ocean Service), 1939 (upper left; AAA 1939), and 2002 (upper right; Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved). These views indicate a nearly continuous, narrow riparian corridor that has persisted through time, with some expansion in recent decades. This reach is also the likely location for the following landscape photographs by Hare circa 1905 (**FIGURE III-4**).

by Herrmann (1874c), Westdahl & Morse (1896-97), and early aerial photography (**FIGURE III-3**).

Brown (2005: 16-18) speculates, based upon limited evidence and inference, that there may have been several "natural sinks" associated with large sycamore groves between present-day Highway 101 and Highway 237. While the downstream disappearance of many other Santa Clara Valley streams into sinks, seasonal wetlands, and willow groves is well-documented by many sources, there is little evidence for this pattern on Coyote Creek. A number of sources not cited by Brown contradict the

FIGURE III-4. LOWER COYOTE CREEK CIRCA 1905. These images were titled "A winding stream near Milpitas Cal." and "Coyote Creek near San Jose" but examination of the trees at left indicates that they were taken from the same location at different times. Broken branches indicate that the image on the left was taken later (Hare ca. 1905a&b, courtesy The Bancroft Library, UC Berkeley).

interpretation of the Coyote Creek channel as discontinuous (e.g. Pueblo lands survey [US District Court [184-?]a, White 1850, Herrmann 1874; as well as its sinuous plan form, not consistent with ditching).

A range of evidence indicates that Lower Coyote Creek was naturally less deep than Mid-Coyote Creek (or Lower Guadalupe River). Herrmann (1874c) carried out a longitudinal profile immediately downstream of Highway 237 after the sedimentation and "backing up" of the channel. His notes indicate that the bed was only several feet deep, and the target depth of the proposed excavated channel is only 4-6 feet.

A pair of photographs taken by the noted artist Alice Iola Hare illustrates these general conditions on Coyote Creek at the turn of the 20th century (**FIGURE III-4**). While levees had been constructed along the creek upstream of Highway 237 by this time (Westdahl & Morse 1896-97), these photographs appear to have been taken downstream of Highway 237 (accordingly, one of the captions specifies "near Milpitas"). Taken at two different times of year, the photographs show shallow, sinuous channel with slow-moving water. Riparian vegetation is dense but young, suggesting frequent overflow and disturbance by flood.

Present-day riparian vegetation is robust along Lower Coyote Creek (**FIGURE III-5**, see also **FIGURE III-3**). It appears from comparison of historical maps and photographs that riparian forest has extended slightly farther downstream during the past 130 years. This may be due to reduced tidal prism resulting from diking. It is notable that the downstream extent of the riparian forest has persisted (or increased) despite the dramatic decreases in local groundwater levels during the mid-20th-century. This may reflect the reliability of groundwater emergence into the lower reaches of the channel.

Riparian vegetation also appears taller presently than in the photographs by Hare a century earlier. This change would be a predicted result of decreased high flows and reduced flooding. This new hydrologic regime could lead to a lack of disturbance-associated vegetation types.

OVERFLOW CHANNELS

During high flow events, Coyote Creek overflowed into a number of adjacent overflow channels with freshwater vegetation. Some of these may have been former routes of the main Coyote channel. They represent a significant component of the riparian and palustrine habitat of the lower valley floor and a site for backwater or "off-channel" features with fish habitat value. The overflow channels between Coyote Creek and Guadalupe River, which joined tidal sloughs, were described by Burnett (1860;

FIGURE III-5. LOWER COYOTE CREEK 2005. These photographs likely approximate the location of Alice Iola Hare's photographs 100 years earlier (facing page).

"these sloughs were apparently formed by the overflow from the Coyote, the Tidewater runs in some of them"), and Houghton (1860), who notes that they are "mere gullies caused by the waters of the Coyote overflowing [,] there being a depression in the land about where these sloughs are located." Healy (1860b) clarifies that these channels have tidal flow to a variable point upstream but that the channels themselves "extend into good arable or grass lands upwards of a mile." Remnants of several of these apparently artesian, tidally-influenced features can still be seen in the present-day landscape (**FIGURE III-6**).

The hydrology of the overflow channel paralleling Coyote Creek for about a mile upstream of Highway 237 was described by Day (1852): "Water Course during freshets." The feature was labeled as a "slough" by Lewis (1853), suggesting that it may have held water through much of the year, and matching the depiction by Westdahl & Morse (1896-97), which shows remnant riparian trees and freshwater marsh following some draining efforts.

FRESH-BRACKISH TIDAL MARSH ZONES

While most of the South Bay Baylands were characterized by salt marsh, there were distinct areas of fresh and brackish tidal marsh associated with points of freshwater influence from adjacent creeks. Evidence for these fresh-brackish "intrusions" into the salt marsh matrix comes from a variety of sources, and is described in detail by SFEI (1999). The pattern observed in the vicinity of Coyote Creek conforms to regional findings (Grossinger 1995).

Collections of brackish marsh plants by academic botanists during the early part of the 20th century provide general evidence for freshwater effects in the marshlands near Guadalupe, Coyote, and San Francisquito creeks prior to diking. For example, in the vicinity of Palo Alto, C.F. Baker noted *Cordylanthus maritimus* as "common in the salt marshes" (1903), *Senecio hydrophilus* ("small colonies in the marshes"; 1902a), and *Triglochin maritima* ("tufts common in salt marshes"; 1902b), while other researchers have reported *Glaux maritima* (Halsey 1908, in Baye 1999) and *Juncus xiphoides* (Thomas 1961 *in* Baye 1999) in the same area. These plants suggest a picture of localized but distinct brackish marsh conditions.

FIGURE III-6. RESIDUAL "SPRING RUN" MORPHOLOGY. A distinct swale indicates a former spring-fed, tidally-influenced channel in the vicinity of the San Jose-Santa Clara Water Pollution Control Plant.

More spatially specific evidence comes from a series of 19th-century descriptions. William Thomes reports having been "surrounded by high tullies [sic]" on a boat trip to Mission San Jose (Thomes 1840: 199 *in* Friedly 2000). A careful reconstruction of the route places the observation near the mouth of Warm Springs Slough on Mud Slough, on the north side of present-day Pond A19. The boaters were rescued by "a ranchero, [who] mounted on a splendid-looking horse galloped up, looked over the rushes, and said that he would tow us to the landing if we desired." The perspective of the rider looking down over the tules suggests they are quite tall, and his galloping arrival suggests a marsh plain with low vegetation behind the channel-side vegetation.

Wilkes (1856) noted "grass and rushes on each side" of Guadalupe Slough. Photographs of marshes adjacent to the Alviso Boat Landing in the late 1890s also show low vegetation, suggestive of *Schoenoplectus maritimus* (formerly *Scirpus maritimus*). C.F. Baker also reports "small colonies [of *S. maritimus*] occasional in the marshes" at Alviso (1902b). Photographs at Drawbridge (Dewey 1989) and a specimen collected by R.C. Wilson in the same vicinity (1938) suggest a transition to *S. maritimus*.

These descriptions indicate a pattern of locally specific intrusions of fresh-to-brackish tidal marsh vegetation. One of these freshwater zones, at the fluvial/tidal interface where a spring run (later connected to Saratoga Creek) entered the Baylands west of Alviso, was a landmark for the boundary of the land grant Refugio. Sunol (1853:7-8), describing conditions 10-20 years earlier, describes "an arm of the Estuary there overgrown with rushes (*tulare*)."

Surveyor Reed (1863) also describes the overflow channels between Coyote and Guadalupe River as tidal sloughs with freshwater marsh vegetation: "The width of these sloughs vary I think from 20 to 60 feet or thereabouts, the banks of them are sloping, soft and covered with tule." Reed's corresponding survey (1862) indicates that he is referring to sloughs crossing approximately the present-day location of Los Esteros Road in the vicinity of the San Jose-Santa Clara Water Pollution Control Plant.

The extension of freshwater down Coyote Creek may explain the early attempts to dike the marshland for hay and grain between Coyote Creek and Mud Slough (Westdahl 1897b; now Newby's Island), the only area within the body of the marsh which was reclaimed by this time. Slough water was allowed into the island for irrigation and leaching of salts, as along Napa Creek marshes during the same era (Stanly 1885).

TIDAL MARSHLAND

Fresh and brackish vegetation was probably limited to a narrow zone along the channels carrying freshwater inputs from perennial streams and spring seasonal flows. Away from these influences, saline tidal marsh dominated, with an array of associated habitats. Hundreds of small pannes ranging from a fraction of an

acre to several acres in size were scattered across the marsh surface between branching networks of sinuous sloughs. A complex of unusually large marsh pannes formed a key landmark in the Rincon de Los Esteros land case. "*The Esteros*", located at the edge of present-day New Chicago Marsh at Alviso, were "large ponds" (White 1860, Burnet 1860) filled by extreme high tides: "the spring tides come up into them" (Burnett 1860).

TIDAL REACH OF PENITENCIA CREEK AND PENITENCIA POND

Because of the Coyote Creek fan, tidal marshland did not extend as far south at Coyote Creek, except along the Penitencia Creek slough — where the tides reached surprisingly far inland. Twitchell's General Land Office survey of the Rancho Los Tularcitos (1859) shows the "Arroyo de la Penitencia" widening from a relatively narrow fluvial creek into a broad tidal slough not far downstream from the town of Milpitas. His field notes correspondingly put the "mouth of creek and head of the main slough" near the present-day confluence with Calera Creek (1859b: 160-61). Tidal marsh appears to have been limited, however, to the immediate surroundings of the slough, as shown by a later compilation of GLO surveys. The narrow southward extension of tidal marsh along the Penitencia Slough was ratified by the Land Commission, establishing the angular grant boundary still visible on contemporary USGS quadrangles.

The extension of tidal influence farther into the Valley along Penitencia Creek indicates that the Valley is relatively lower here than it is along Coyote Creek. This difference is reasonable given that the dominant sediment load would have been delivered along Coyote, producing the protrusion of coarse grained sediment into the wet meadows evident in soil maps (Gardner et al. 1958). As Brown (2005) has pointed out, Penitencia Creek may in fact have been the dominant outlet for Coyote Creek at some point in recent Holocene times. This would explain the unusually wide slough, now abandoned and transgressed by the rising seas, as well as the wide riparian forest present along the reaches of the creek immediately upstream, shown by Westdahl and Morse (1896-97). It should also be noted that, in addition to natural fluvial, fan-building dynamics, seismic activity may well affect the repositioning of creek routes in this area.

Another consideration is the documentation of historical flood deposits uncovered by Elise Brewster as part of SFEI research into the Rincon de los Esteros land case testimony. Using some of these data, Brown (2005) infers that tidal marsh extended substantially farther inland; we use the *salitroso* classification to describe these zones of subtle, landward tidal effects. Farmers did, in fact, report that recent fluvial deposits of 4-10 inches (Parker 1863: 213) and 18-20 inches (Bloomfield 1863: 219) have permitted the "reclamation" of marshland for hay and grain farming. However, the area of these deposits appears to be limited; one witness estimates about 400 acres in the entire area north of the Milpitas-Alviso Road by 1863 (Bloomfield 1863: 220). The stability of the upper limit of tidal marsh during the subsequent period between 1858 (Wallace) and 1897

(Westdahl and Morse 1896-97), during which time even greater mass wasting of hillsides is documented due to agriculture (Gardner et al. 1958), also seems to make a rapid change from tidal marsh to arable land during the previous two or three decades less likely. Farmers described having to plow these fresh deposits into the "natural soils" (Parker 1863: 212-213) to improve fertility, a scenario more likely to have been successful in the transitional *salitroso* lands rather than Bay-mud based tidal marsh.

THE TIDAL MARSH-ALKALI MEADOW ECOTONE

Saltgrass (*Distichlis spp.*) dominated alkali meadows at the landward edge of the tidal marsh and extended well beyond regular tidal influence, creating a broad ecotone. Defining the boundary between tidal marsh and terrestrial habitats here is challenging because of the gradual transition along this very flat topographic gradient and the absence of 1850s-era US Coast Survey data. However, a number of indicators are available, including remnant sloughs visible in Westdahl and Morse (1896-97)and aerial photography (1939). Other historical map information is available as well; for example, Herrmann (1874c) notes "SWAMP LAND" beginning along Coyote Creek at the boundary we show.

Day (1854:490-491) describes alkali meadows several times in his survey in the vicinity of Milpitas, reporting clay soils "rather wet in winter with some alkali" and "strongly tinctured with alkali." The alkali meadows were characterized by native grasses, wetland plants, and an array of presently rare plants associated with vernal pools and alkali flats (see description in **PART II**). Soil conditions precluded agriculture quite dramatically, forming distinct land use boundaries (**FIGURE III-7**).

PENITENCIA POND

The mysterious Penitencia Pond was also located in this vicinity, two miles downstream from Milpitas and near where "the Penitencia and Coyote join" (Fernandez 1860: 150, Gallagher 1860). Both witnesses locate the "lake (*laguna*)" (Fernandez 1860: 150) near the downstream *sausal*. The feature appears to have been a muted tidal lagoon. A landmark in the Rincon de los Esteros grant testimony, it also happened to be intersected by the Mt. Diablo Meridian and a Township boundary between Five and Six South.

Day (1854: 490) notes that the "tide slough [is] now dry, but often wet." This feature was surprisingly wide: Day (1854: 490-491) requires five chains (330 feet) to cross the "dry bed of salt slough" near the present-day Calera confluence. He and other surveyors are able to cross the slough except when it is flooded, indicating relatively solid substrate and less frequent tidal inundation. In 1866, Thompson approaches the Penitencia Laguna along the Township line from the West and describes entering and leaving the willows and the "Tuley [sic] swamp." The *sausal* is five chains wide (330 feet) and the presence of willows and tule suggests brackish tidal influence.

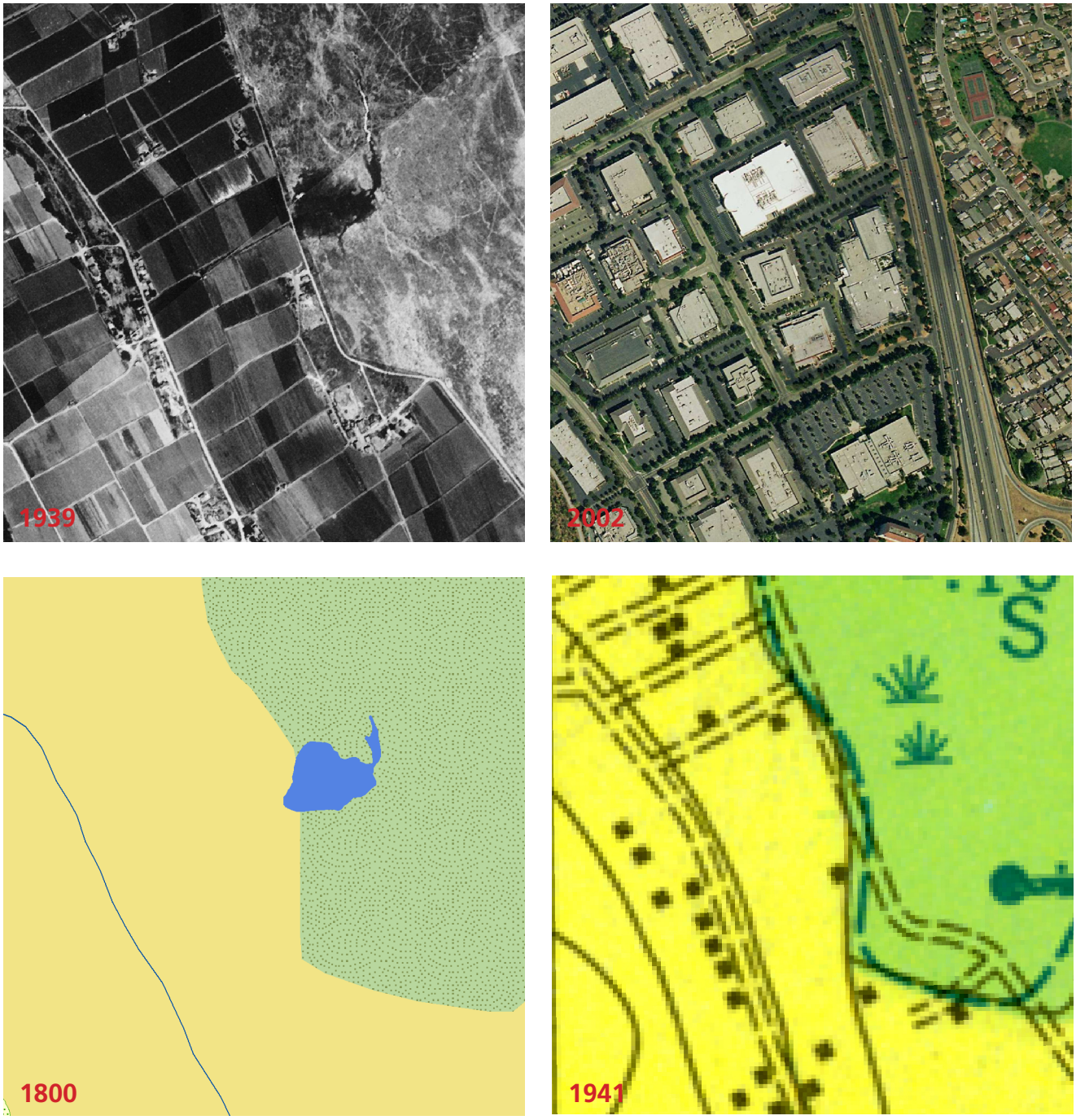
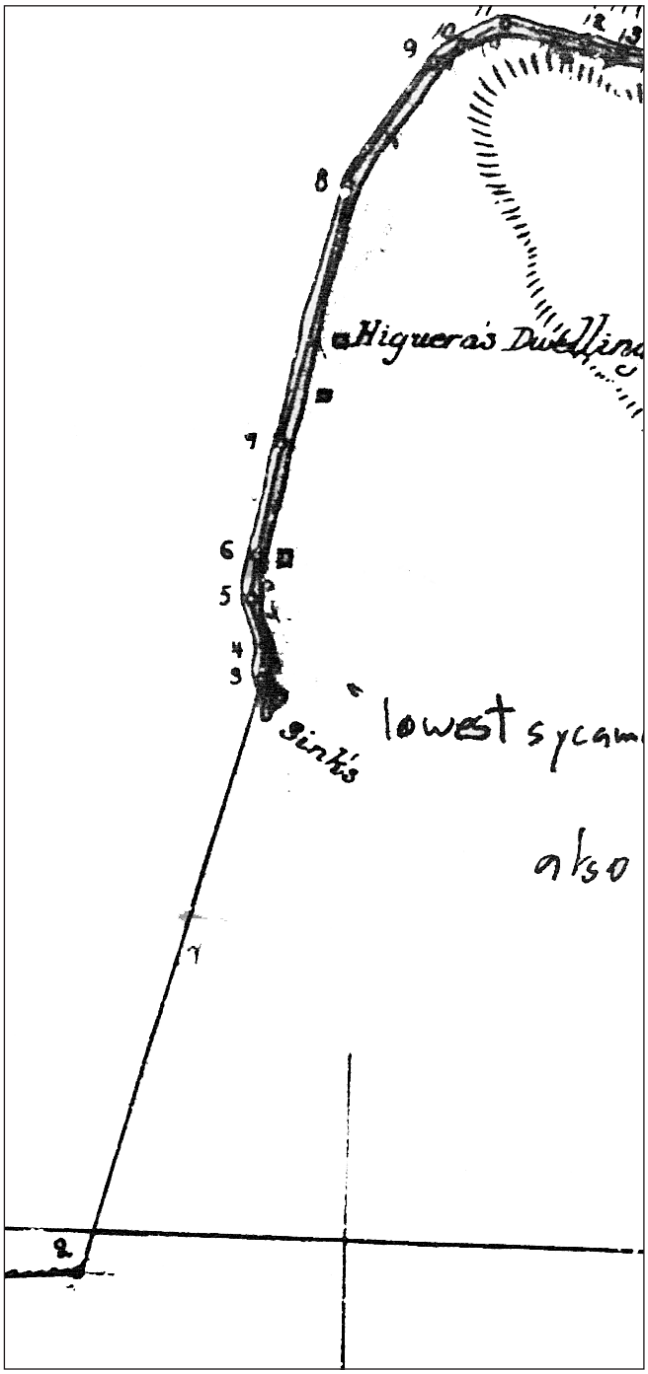


FIGURE III-7. BOTTOMLAND BOUNDARY IN MILPITAS. The 1800 view (lower left) shows dry grassland occupying Coyote Creek's broad natural levee on the left and alkali meadow, with a perennial freshwater marsh, in the bottomlands to the right. These boundaries are based upon the 1940-41 soil survey (Gardner et al. 1958; lower right), which also generally indicates the small marsh with two wetland symbols. Farmers have developed the well-drained, coarse alluvial deposits in 1939 (upper left; AAA 1939), but poor drainage and salt effects in the bottomland soils have precluded agriculture, forming a distinct land use boundary. The shape of the freshwater marsh is indicated by darker, saturated soils. Highway 880 and the Montague Expressway offramp can be seen presently (2002; upper right; Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

LOWER PENITENCIA CREEK

US Deputy Surveyor Edward Twitchell (1859: 160-161) explicitly describes the transition from fluvial to tidal feature as he surveys north along the Penitencia Creek boundary of the Rancho los Tularcitos, encountering "the mouth of the Creek and head of the main slough." [U]pstream of this point, Penitencia Creek flowed in a highly sinuous, thickly wooded channel, presumably perennial because of the interception of the high groundwater table. Thompson's 1857 sum-



mary of Rancho Milpitas describes thick riparian forest along the creek (Calaveras Boulevard to Rock Avenue): "on the Arroyo de la Penitencia a good growth of oak timber of an inferior quality fit only for fuel" (Thompson 1857: 53).

DISTRIBUTARY CREEKS AND SAUSALS

As the Northern boundary of Rancho Tularcitos, Calera Creek was surveyed by US Deputy Surveyor Edward Twitchell in 1859. His survey explicitly indicates that the stream "sinks" not long after entering the alluvial plain, just below present-day Highway 680, at about 100 foot elevation (**FIGURE III-8**). He set his course to "the lowest sycamore" on the creek.

The historical route and natural termination of the stream can still be seen on the modern USGS quadrangle, in which the grant boundary follows the curves of the creek with short line segments and then, in the absence of a creek to follow, establishes two long straight lengths to close the rancho boundary at Penitencia Creek. In a reversal of sorts, the creek then was extended downslope as a ditch, along the abstract property line. There is no evidence of a *sausal*, probably because the termination of the stream was so high in the alluvial plain, removed from clay soils and groundwater emergence.

Compared to Calera Creek, Arroyo de los Coches maintained a continuous channel across more of the alluvial plain and did spread directly into a large willow grove. The coincidence of distributary and *sausal* is well-docu-

FIGURE III-8. CALERA CREEK SINK, 1859. Calera Creek maintained a channel from the hills to just below present-day Highway 680. At this point, surveyor Twitchell, following the creek as the general boundary between adjacent land grants here, found no further channel to follow and set a straight-line course downslope (Twitchell 1859).

mented here by both Higuera's *diseño* for Rancho los Tularcitos (U.S. District Court, Northern District, 1870 [Land Case Map D-494]) and Day's attractive survey (1851). Although the exact size and location are uncertain, the stream appears to have extended into the wet meadows to approximately 40-50 feet in elevation. Willows here are colonizing slightly coarser materials at the stream mouth, while intercepting subsurface dry season flows.

Higher on the alluvial plain, after exiting the canyon mouth, Arroyo de los Coches crisscrosses the Tularcitos/Milpitas Rancho boundary, including several crossings of the grant line on the Valley floor, now Calaveras Boulevard. Just downstream from the canyon mouth, near Alviso house and present-day Evans Road, Calaveras Boulevard originally jogged to the north to accommodate the creek, but the stream and road were straightened by 1895 (USGS San Jose [1895]1899). The earliest available survey of the line (Day 1851) clearly shows Arroyo de los Coches crossing the line again farther downstream, heading northwest in the vicinity of the present-day Highway 680 crossing. Subsequent surveys by Twitchell (1859) and Stratton (1862a,b) make no mention of this crossing and the route does not show up clearly in 1939 aerial photography. However, the area is described in some detail by Day, including Alviso's gardens and the downstream willow grove. Day was a professional surveyor who became the U.S. Surveyor General for California, so it is not unlikely that the map is accurate and that the shallow channel filled with sediment subsequent to Day's survey.

Berryessa/Milpitas Creek also terminated in a willow grove at a similar position on the valley floor to Arroyo de los Coches (outer edge of wet meadows, 40-50 feet in elevation). The location is well recorded and illustrated by a number of documents, including Stratton (1862), who illustrates the distributary and willow grove with the annotation "*Sausal* at sink of Milpitas Creek" (**FIGURE III-9**); Healy (1863), who draws only the distributary; the Pueblo San Jose map circa 1840 ("*sausales*"); the Tularcitos *diseño* (U.S. District Court, 1870 [Land Case Map D-494]); and Day (1851), who shows the feature as a very large marsh. While the size of the willow grove is somewhat uncertain, the location can be pinpointed using the illustration by several maps of the features intersecting or lying just below an old road (now Capitol Avenue), and the bearing and distance reported by Stratton as he passed to the south along the Tularcitos boundary: "*Sausal* at the sink of the Milpitas Creek bears North 20 East distant 57 chains" (Stratton 1862a: 159). These independent data correspond precisely.

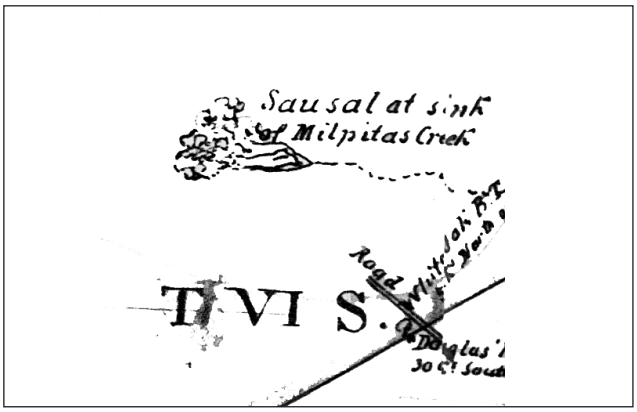


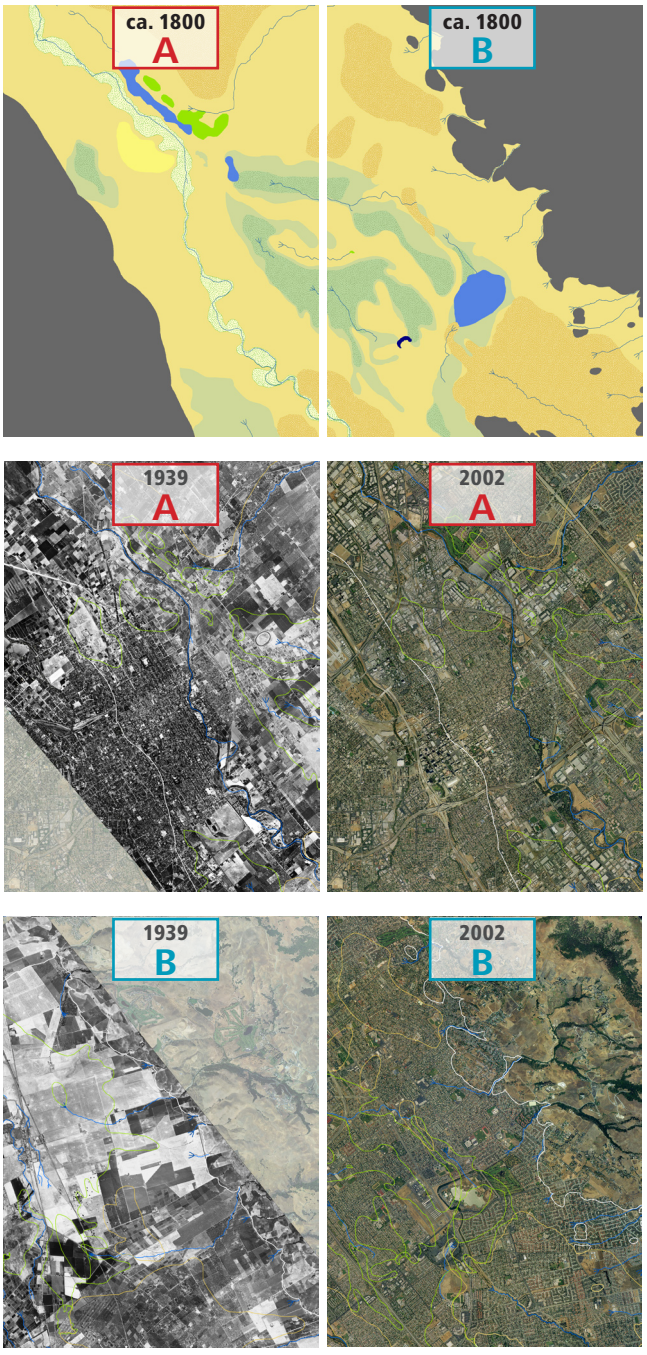
FIGURE III-9. "SAUSAL AT SINK OF MILPITAS CREEK." Berryessa Creek (formerly Milpitas Creek) ended in a willow grove just below today's Capitol Ave. ("Road", Stratton 1862b, courtesy The Bancroft Library, UC Berkeley).

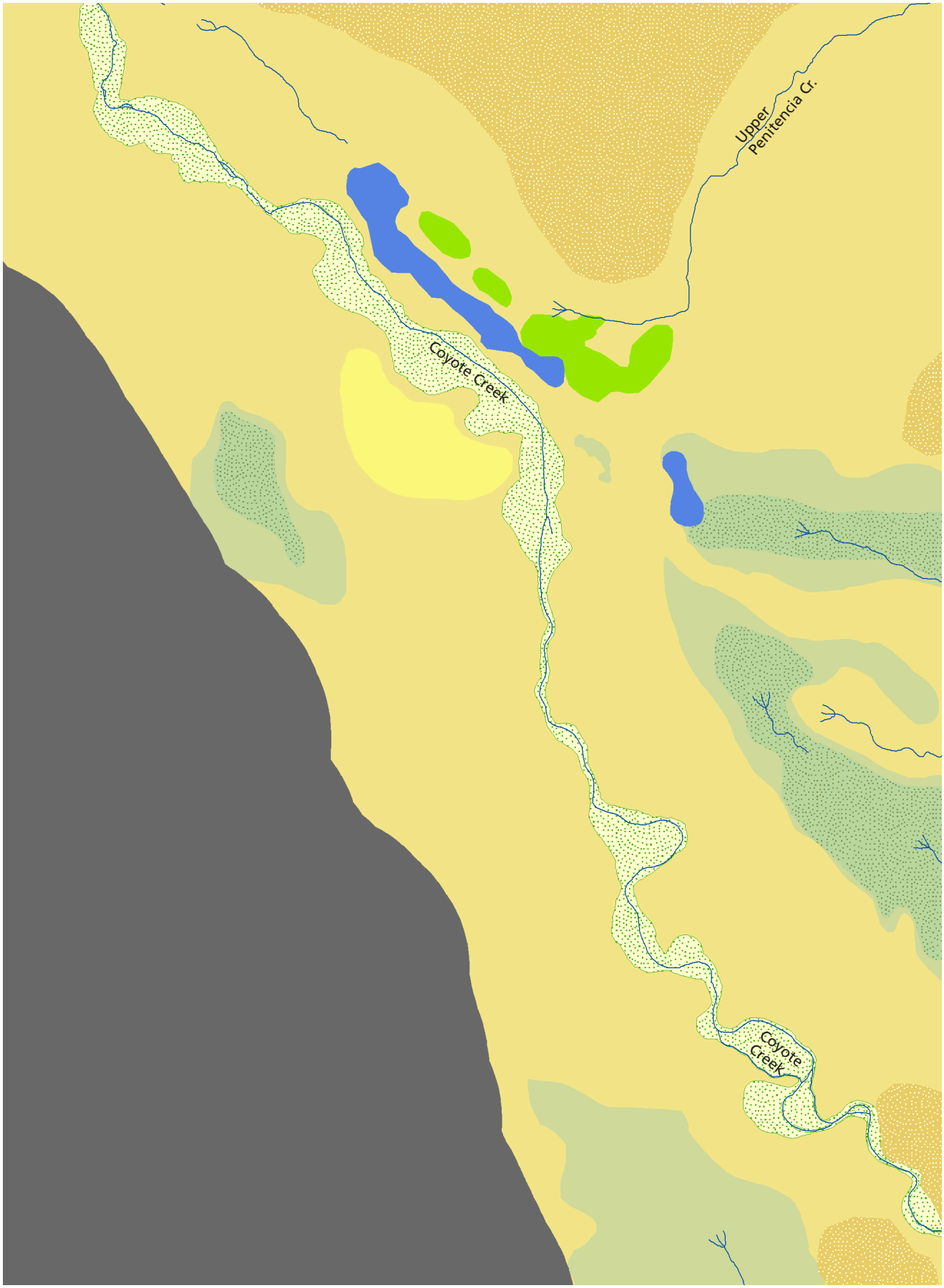
Upper and Lower Penitencia Creeks, now completely independent systems, have a particularly complicated hydrological history. During the Mexican land grant era, these reaches were discontinuous enough to be considered separate creeks. At this time, the creek running parallel to Coyote Creek, in the general location of the contemporary constructed channel we call Lower Penitencia Creek, was simply called Penitencia Creek (for its use as a meeting point for the priests of Mission San Jose and Mission Santa Clara to exchange confessions). Present-day Upper Penitencia Creek was referred to as Arroyo Aguaje (e.g. US District Court, Northern District [184-?]a, [Land Case Map E-900], Thompson and Herman 1879), the name now used, with slightly different spelling (Aguague), for a tributary in the upper watershed. The streams were only indirectly hydrologically connected through a series of discontinuous channels and freshwater wetlands. While Arroyo Aguaje/Upper Penitencia Creek was diverted directly into Coyote Creek as early as 1852 (see Land Use Chronology in **PART IV**), subsequent maps suggest that the diversion was not completely effective and that flow continued to the north with an increasingly continuous channel into "Lower" Penitencia Creek (e.g. Hare 1872, Hoffman 1873). Presumably this temporary connection resulted in the extension of the name to the entire system, before their full disconnection during the later 19th century.

2

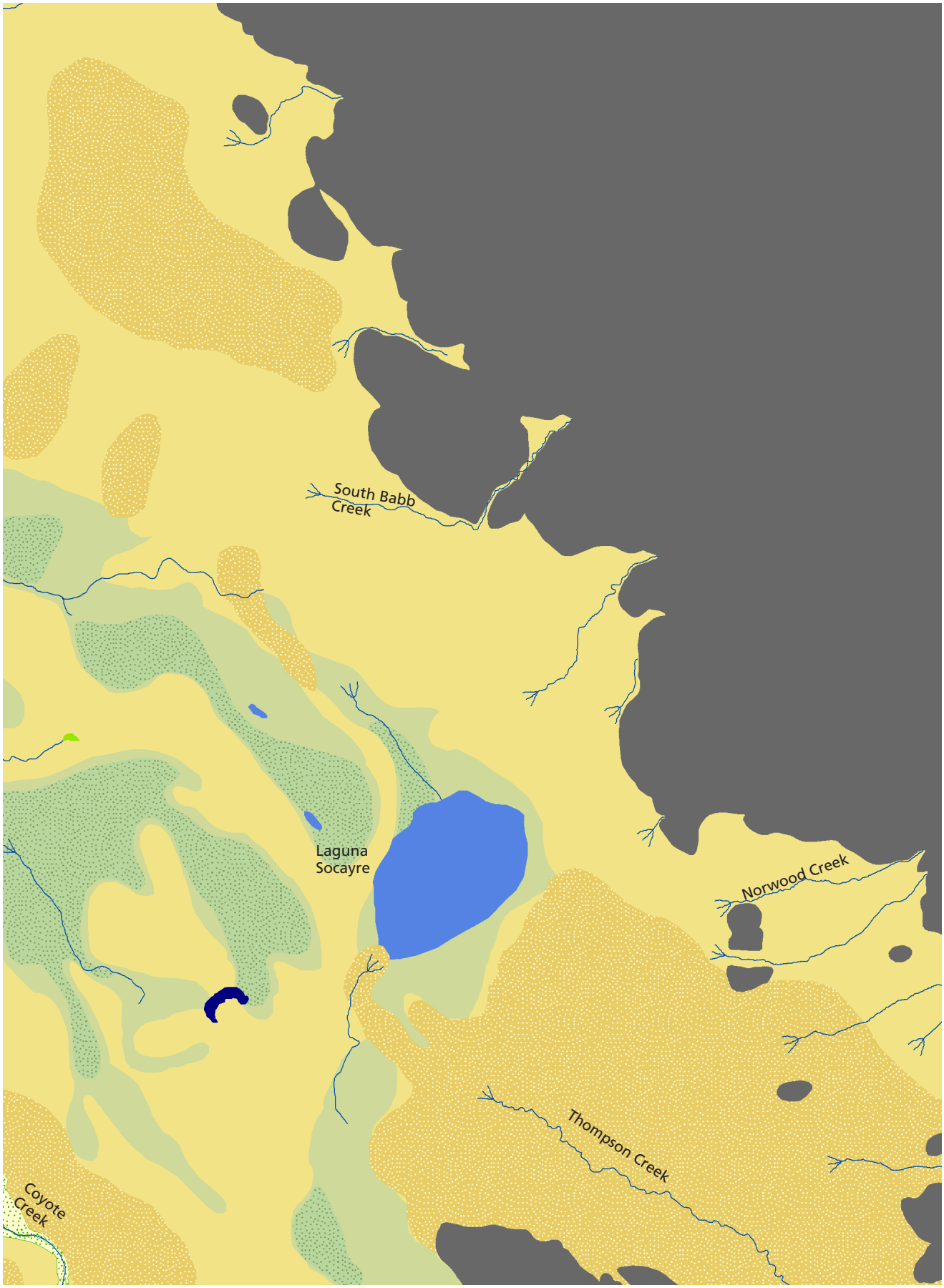
MID-COYOTE CREEK AND ADJACENT AREAS

This section follows Coyote Creek from Montague Expressway to Highway 280 – the Mid-Coyote Flood Protection Project extent. To standardize map scale and area, it also includes a small additional length of creek, to Tully Road. Adjacent areas include the bottomlands of East San Jose and distributary creeks such as South and North Babb, Norwood, Quimby, and Thompson.

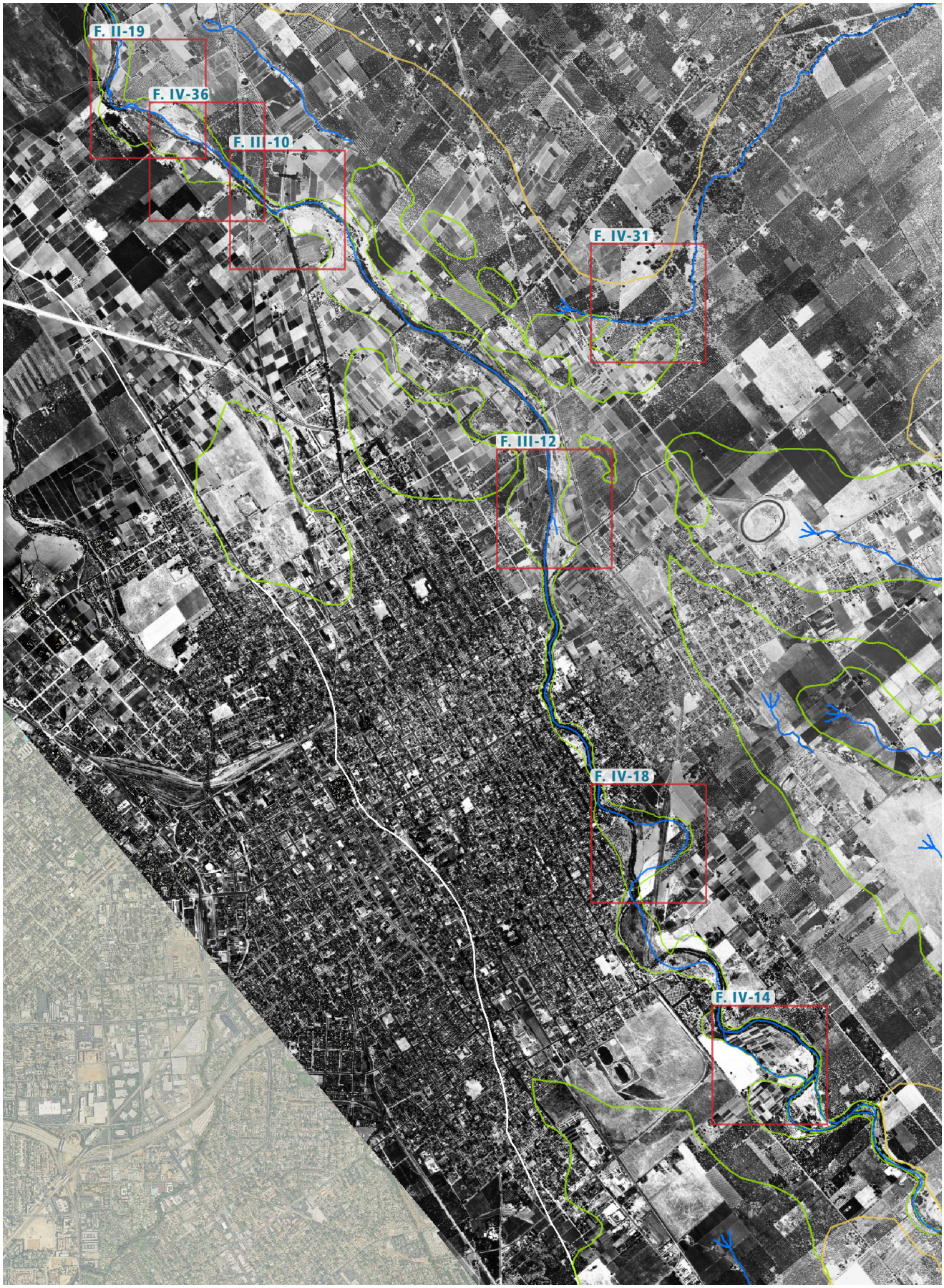




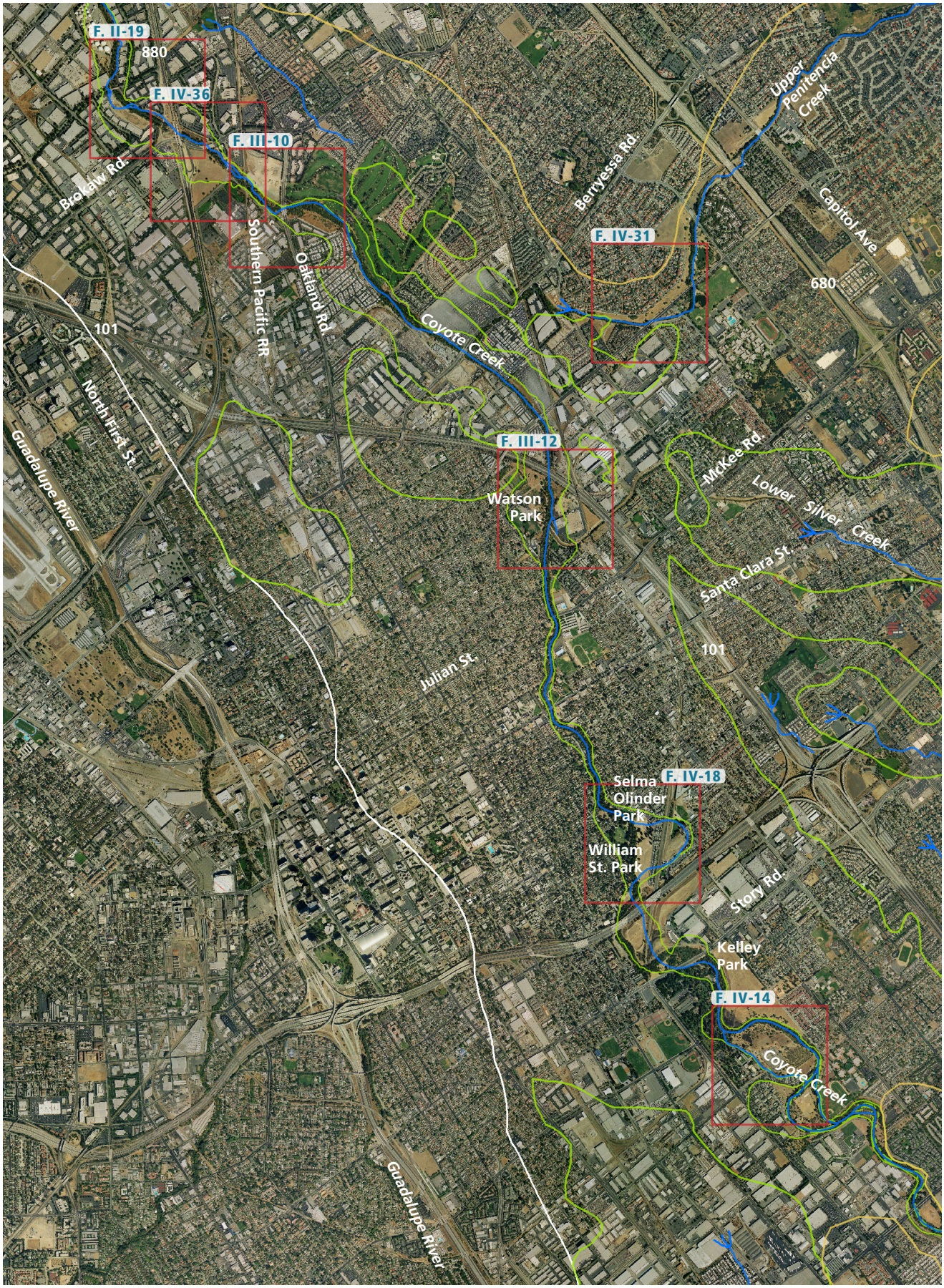
MAP 2A-CA.1800. LANDSCAPE FEATURES DURING INITIAL EURO-AMERICAN SETTLEMENT, CIRCA 1769-1850. Certainty level varies among features; valley oak savanna is a preliminary estimate. More information is available in the project GIS (scale 1:40,000; 1"~3300). See inside front cover for map legend.



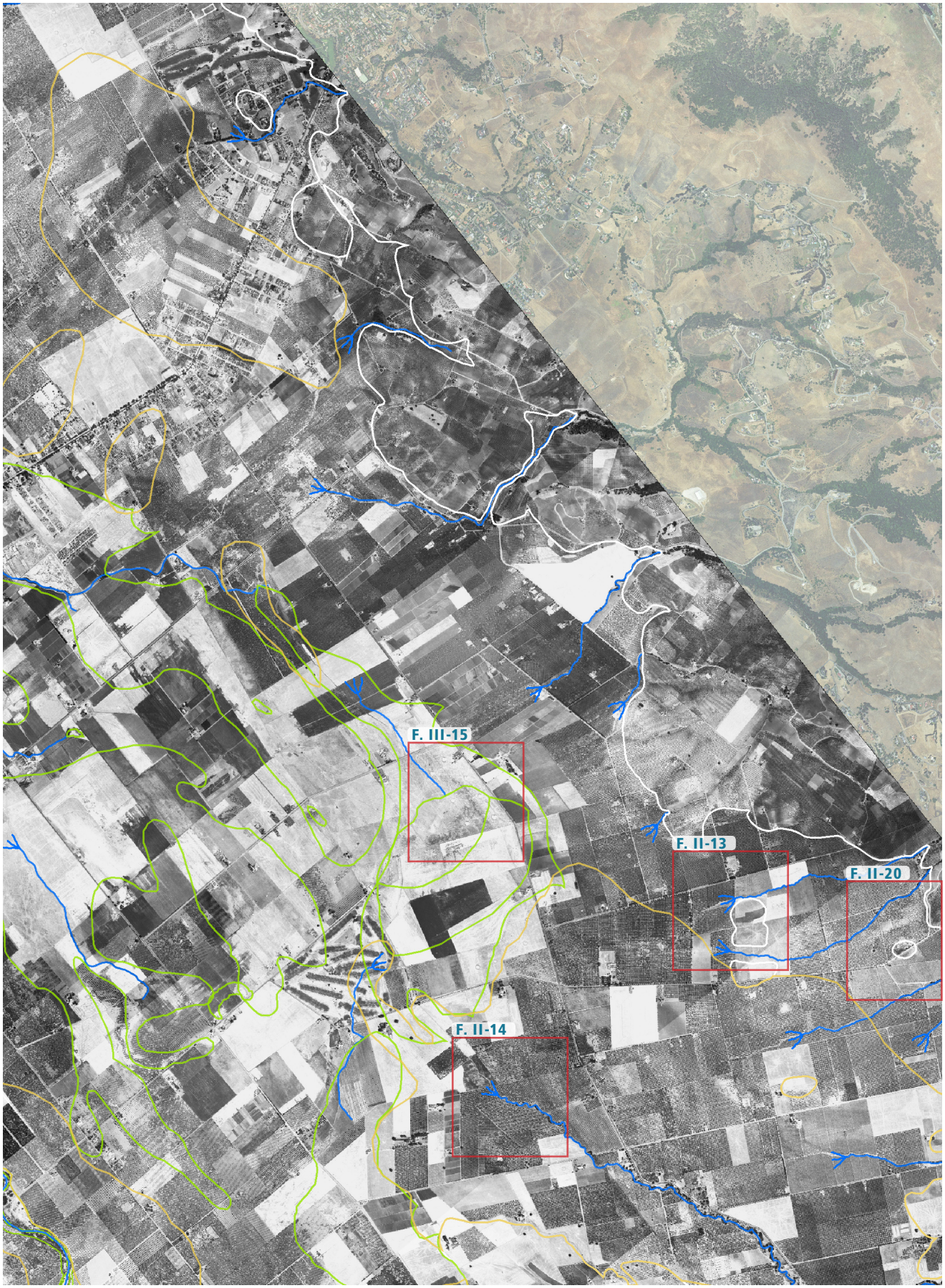
MAP 2B-CA.1800. LANDSCAPE FEATURES DURING INITIAL EURO-AMERICAN SETTLEMENT, CIRCA 1769-1850. Certainty level varies among features; valley oak savanna is a preliminary estimate. More information is available in the project GIS (scale 1:40,000; 1"~3300'; 1 square inch ~250 acres). See inside front cover for map legend.



MAP 2A-1939. PHOTOMOSAIC OF EARLY AERIAL IMAGERY, WITH HISTORICAL LANDSCAPE FEATURES OVERLAY. Historical fluvial features in blue; other features, green; project boundary, white (scale 1:40,000; 1"~3300'; 1 square inch ~250 acres; original photographs courtesy SCVWD, USGS Menlo Park, and UC Santa Cruz, UC Santa Barbara, and UC Berkeley).



MAP 2A-2002. MODERN AERIAL IMAGERY, WITH HISTORICAL LANDSCAPE FEATURES OVERLAY. Historical fluvial features in blue; other features, green; project boundary, white (scale 1:40,000; 1"~3300'; Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).



MAP 2B-1939. PHOTOMOSAIC OF EARLY AERIAL IMAGERY, WITH HISTORICAL LANDSCAPE FEATURES OVERLAY. Historical fluvial features in blue; other features, green; project boundary, white (scale 1:40,000; 1"~3300'; 1 square inch ~250 acres; original photographs courtesy SCVWD, USGS Menlo Park, and UC Santa Cruz, UC Santa Barbara, and UC Berkeley).

MAP 2B-2002. MODERN AERIAL IMAGERY, WITH HISTORICAL LANDSCAPE FEATURES OVERLAY. Historical fluvial features in blue; other features, green; project boundary, white (scale 1:40,000; 1"~3300'; Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

FIGURE III-10. COYOTE CREEK AT OAKLAND ROAD IN 1939 (LEFT) AND 2002 (RIGHT). Long-standing crossings such as Oakland Road (center, running north-south in each image) and the Southern Pacific Railroad (left side) were established at this short, naturally narrow reach. On the right side of the 1939 image (AAA 1939), a broad active channel area can be seen in the form of scour patterns and unvegetated areas excluding agriculture. These stream benches are now occupied primarily by the South Bay Mobile Home Park, which has been subject to flooding, the San Jose Golf Course, and the North Coyote Park (brown area at middle right, 2002 Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved), which provides some undeveloped floodplain capacity.

In the Mid-Coyote reach, Coyote Creek shifted to a mostly wide, entrenched system with broad flood-prone benches. Wide reaches were interspersed with narrow reaches (**FIGURE III-10**). This pattern of constriction and expansion significantly shaped transportation patterns on the east side of San Jose, with important crossings associated with the narrow reaches between the S. Pacific Railroad and Oakland Road (**FIGURE III-11**). and between Julian Street and San Antonio Street. Agriculture and garbage dumps encroached upon the stream benches, then commercial development and other uses – but little housing. Many former dumps are now city parks (**FIGURE III-12**).

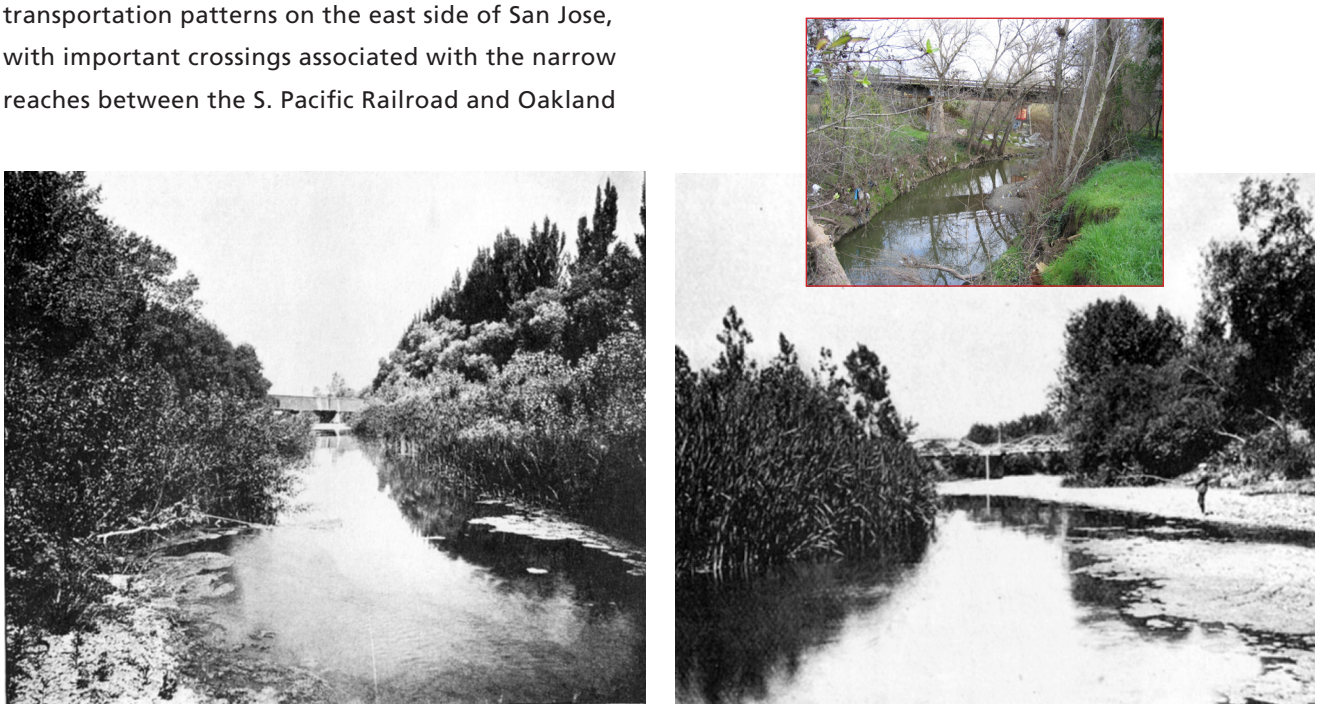


FIGURE III-11. PHOTOGRAPHS OF COYOTE CREEK BETWEEN THE OAKLAND ROAD AND SOUTHERN PACIFIC RAILROAD CROSSINGS, 1896. This pair of photographs shows the dense and tall riparian forest canopy along this relatively narrow channel reach. Even the narrow reaches had significant unvegetated gravel bars and pools. Such a clear view is no longer possible as vegetation has now encroached substantially into the former channel, with some apparent incision (see inset) (Shortridge 1896: 20,174, courtesy History San José).

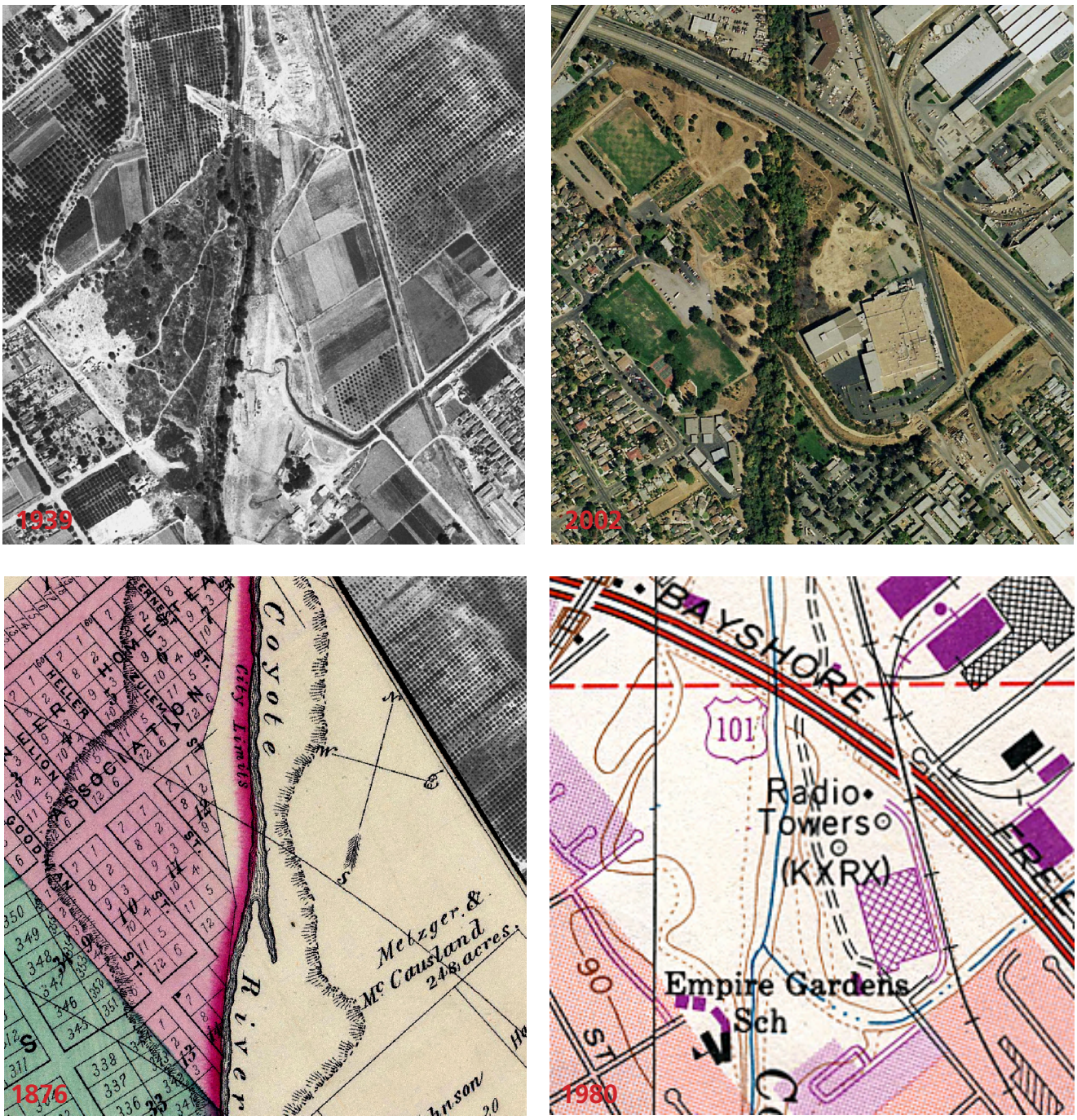


FIGURE III-12. STREAM BENCHES BECOME PARKS. In the contemporary image (upper right; Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved), Watson Park is located immediately left of the Coyote Creek riparian forest. Highway 101 crosses diagonally. Each park occupies large lateral stream benches still subject to flooding. In 1939 (upper left; AAA 1939), agriculture and landfill operations take place in the future location of Watson Park. The location of the outer channel banks/valley floor is evident as hatch marks in the 1876 map (lower left; Thompson and West 1876, courtesy David Rumsey, Cartography Associates), breaks in land use in the 1939 image, and contours in the USGS (San Jose East & West 7.5 min 1980) quadrangle (lower right).

To the east, several thousand acres of bottomlands lay at the foot of alluvial fans and the broad alluvial levee of Coyote Creek. Wet meadows with saltgrass and alkali patterns captured water and fine sediment. Laguna Socayre, one of the great *lagunas* of the Santa Clara Valley, lay at eastern edge of the valley floor, at the base of the Thompson Creek fan. The bottomlands were broken up by slightly higher, grass-covered rises deposited by earlier courses of Coyote Creek. Many discontinuous streams flowed from springs, willow groves, and the Laguna. These probably had few or no riparian trees, except in some cases sycamores at their

FIGURE III-13. RESIDUAL ELEMENTS OF THE FORMER LOWER PENITENCIA CREEK CHANNEL. Low area through center of photograph indicates historical channel location. A large, historic sycamore has resprouted.

downstream ends (Brown 2005). The discontinuous channel between Upper and Lower Penitencia Creek can be seen in the map series, with a remnant swale and a stump-sprouting, historic sycamore still visible at the former downstream distributary, located at the present-day Orchard Elementary School (**FIGURE III-13**; see also Sowers and Thompson 2005).

Trees were rare in this landscape, outside of the localized areas of valley oak savanna and a few, albeit large, groves of willows or sycamores. In the vicinity of today's Highway 101 crossing, Day (1854) reported limited trees: "timber sycamores on the Coyote and willows N. of line, in swamp."

WETLANDS AT THE BASE OF THE PENITENCIA CREEK FAN

A significant wetland complex formed at the base of the Upper Penitencia Creek alluvial fan, behind Coyote Creek's natural levee, near today's San Jose Golf Course to Mabury Road. One of the willow groves, the "*Montecito*" ("little thicket," despite covering as much as 50 acres) served as an important landmark in the vicinity of present-day Ringwood Ave. and Concourse Drive. Stratton carefully centers his survey on the "Center of the *Monticito* [sic]" that set the southern boundary of Rancho Milpitas, and reports 16 chains (1,056 feet) between entering and leaving it (Stratton 1862: 159). It took Thompson (1857: 51) 10.5 chains to cross the same "willow thicket" from a slightly different angle while establishing the sectional boundary.

The freshwater marshes here apparently had significant perennial surface water, as Sherman Day (1854) described "water knee deep" when crossing them in July 1854. The *sausal* at the former downstream end of Upper Peniten-

cia Creek is also noted by Day. On his survey along the Section line to the south, Day (1854: 507) noted the "willows N. of line, in swamp," locating the feature within the square mile of Section 33, which includes the area where the Upper Penitencia Creek appears likely to have ended. These wetlands may have even extended more continuously into the willow groves at the downstream terminus of Berryessa Creek, as suggested by Brown (2005).

LAGUNA SOCAYRE

Laguna Socayre was an array of freshwater wetlands located above and below present-day Capitol Expressway between Story Road and Tully Road. These included a series of ponds mapped by Healy with the annotation "water" and the distinctive, crescent-shaped feature shown by Healy (1861) and Thompson and West (1876; **FIGURE III-14**). The heart of Laguna Socayre was a large freshwater marsh partly coinciding with present-day Lake Cunningham. Drainage was blocked by an old natural levee of Coyote Creek (Sowers and Pearce 2003).

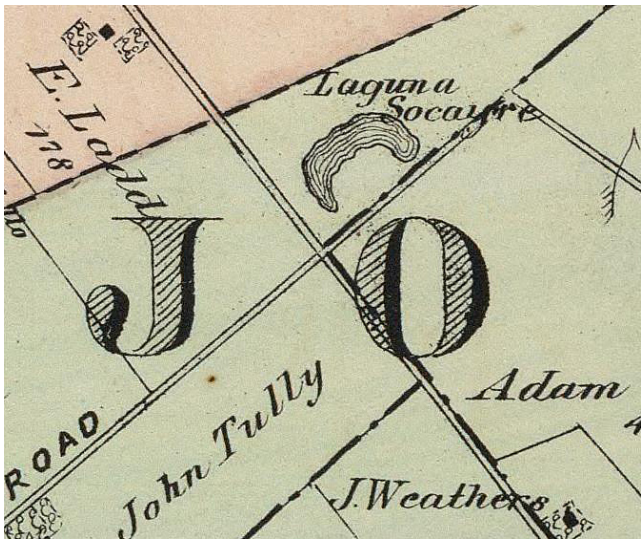


FIGURE III-14. SMALL PERENNIAL POND OF THE LAGUNA SOCAYRE COMPLEX, 1876. The larger marshland area was located immediately to the northwest (Thompson and West 1876, courtesy David Rumsey, Cartography Associates).

Stanford ornithologist John Schneider celebrated the Laguna in an 1893 article about cinnamon teal nesting (Schneider 1893). He describes vegetation, hydrology, and use by water birds:

> "The swamp is covered with a variety of vegetation. In the center and deepest part tall tules rise many feet above one's head, and in these numbers of Tule Wrens build their deceptive nests. A great many Coots breed here, and I am told our Bitterns also nest in the dense tules. Last year I found a Marsh Hawk's nest in the same place.
>
> Where the water is quite shallow rushes grow luxuriantly and in the dead bunches Soras and California Clapper Rails, Gallinules, Coots and others nest, but very rarely the Cinnamon Teal.
>
> Along the shore in many places, where the water is very shallow or the ground merely damp, coarse marsh grass grows and along the edges of this thick clusters of clover thrive, which offer favorable sites for Ducks' nests... The ground here is covered with water about an inch deep."

Day describes parts of this wetland complex in summer 1854, crossing the meadows and marshes: "grassy and boggy land," "bulrushes and weeds," and the "dry bed of an alkaline dragoon."

FIGURE III-15. LOCATION OF LAGUNA SOCAYRE AND LAKE CUNNINGHAM IN 1939 (LEFT) AND 2002 (RIGHT). Cow paths mark the unfarmed area of the historical Laguna Socayre in 1939 (AAA 1939). Part of the area has now been excavated to create Lake Cunningham, a storm-water detention basin. Some elements of alkali meadow persist in the fields along the north edge of the lake. A blue circle indicates the location of **FIGURE III-16** and red circles locate the images in **FIGURE III-17** (2002 Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

These conditions limited agricultural development such that grazing, not orchards, was dominant in the 1930s (**FIGURE III-15**). As a result, a number of large, institutional land uses currently predominate here, including Reid Hillview Airport, Lake Cunningham, and Pleasant Hills Golf Course — and some wetland features are still apparent. Low areas of the golf course, coinciding with the historical Laguna boundary, form ponds in the winter (**FIGURE III-16**). Saltgrass meadows with seasonal ponds coexist with grassy fields on the north edge of Lake Cunningham at the exact site of Day's alkaline description 150 years earlier (**FIGURE III-17**).

SYCAMORE GROVE

A large, well-documented sycamore grove occupied the valley floor terrace along the west side of Coyote Creek between the Oakland Road and Highway 101 crossings. Hutton's (1847) notoriously inaccurate map (Arbuckle 1986: 55-56) subdividing the Pueblo lands shows the feature following the creek across parts of three properties, but a General Land Office survey also recorded the grove, in the same location. Day (1854: 505-506), establishing the southern boundary of Township 6 South, Range 1 East, placed the quarter section stake in the grove, noting that the "line passes through the S. edge of a grove of large sycamores." The trees were indeed giant — he records two bearing trees ten feet in diameter and one five feet across — and were widely spaced in an open savanna pattern. (The distances to these bearing trees, a standard indicator of historical stand density, are 37, 141, and 308 feet.) These "few large sycamores" are reported the only timber in the area.

Along Oakland Road, within the estimated boundary of the sycamore grove (Medium Location Certainty, 150 m), an unusual row of California Sycamore trees may be descendent of the original grove (**FIGURE III-18**).

FIGURE III-16. TEMPORARY PONDING AT HISTORICAL LAGUNA SOCAYRE. Surface water and wetland vegetation can be identified in scattered places, corresponding to the former wetland area.

FIGURE III-17. SALTGRASS-ALKALI MEADOW AT LAKE CUNNINGHAM REGIONAL PARK. Reddish-brown areas are predominantly *Distichlis* patches. Scattered ponds form during rainfall events. The lower image shows a well-defined panne with mud bottom and forage for dabbling ducks; other ponds are more temporary.

DISTRIBUTARY CREEKS

Immediately upon entering the Valley, streams were well-defined, in gullies or gulches. Channel dimensions are often recorded by early GLO surveys; however, we have not catalogued all of these at this time. For example, Day crossed South Babb Creek in July, 1854 at the base of the foothills just above Clayton Road, reporting: "deep gully (8 feet deep) 50 links wide to SW, with water running" (1854: 509). This small creek had substantial flow at the base of the hills in July. Depth and width can be compared to present-day channel geometry. Notably, he calibrates the term "deep," indicating that eight feet is relatively deep. We can infer that streams of this general size in the area are typically shallower, or not much deeper, than this.

Norwood Creek, like other neighboring creeks, did not extend far from the canyon mouth, but "the little stream called Arroyo de los Alisos" (for its sycamores farther up in the canyon (Soto 1853: 7, Healy 1861) was still the distinguishing feature for the boundary between the Pala and Yerba Buena grants (Noriega 1854: 8; Pico 1854: 10). Noriega (1854: 9) provides an explicit description of Norwood Creek as discontinuous: "the arroyo spreads out on the plain and does not run into any other stream."

The streams between Norwood Creek and Thompson Creek were recognized as smaller — called *aguaje* rather than *arroyo* (U.S. District Court 1833) — and terminating at the *roblars* of the valley floor. The seasonality of Thompson Creek is confirmed by its historical

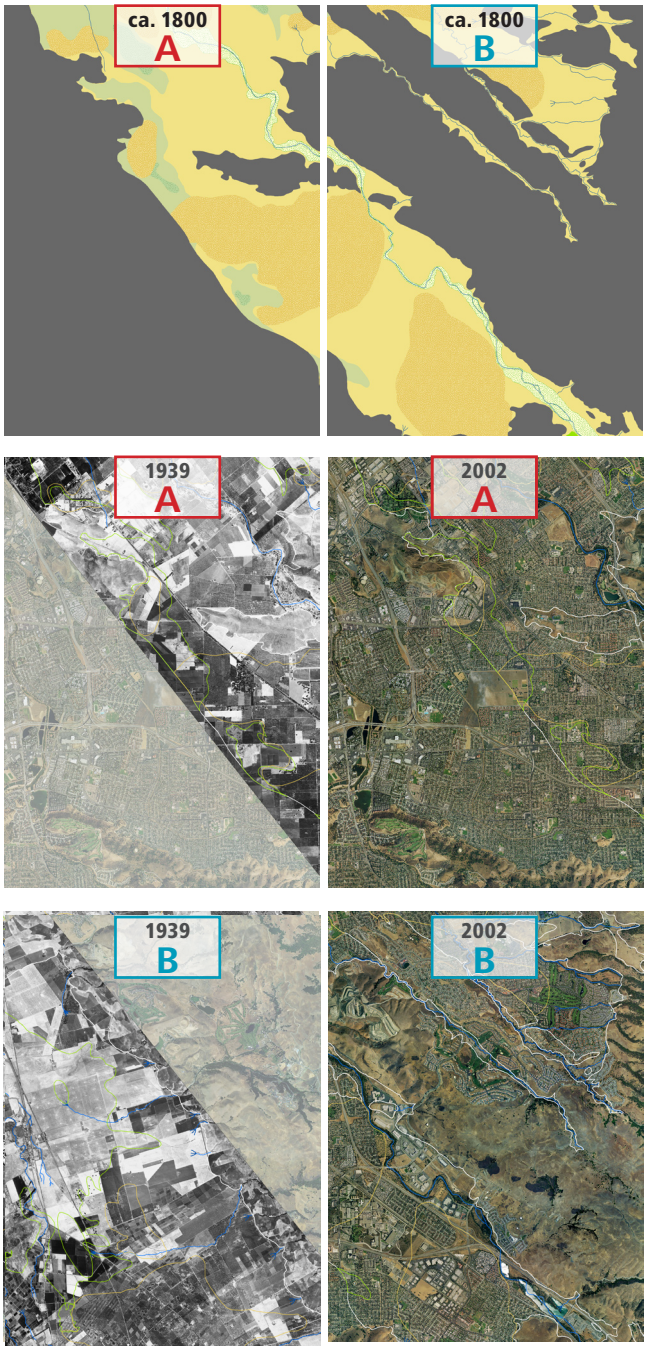
FIGURE III-18. CALIFORNIA SYCAMORES ALONG OAKLAND ROAD. Recurved branching pattern and distinctive leaves indicate that these street trees are the native *Platanus racemosa*, rather than the more common Western Planetree. There appear to be other California sycamores in the neighborhood, potentially descending from the historical grove.

name in the American era "Dry Creek" (USGS Palo Alto 1899, Hoffman 1873) and was also apparently referred to as *Arroyo del Yedral* earlier. Silver Creek had Spanish names of *Arroyo de Socayre* (Soto 1853: 7) and "*Arroyo Seco*" (466).

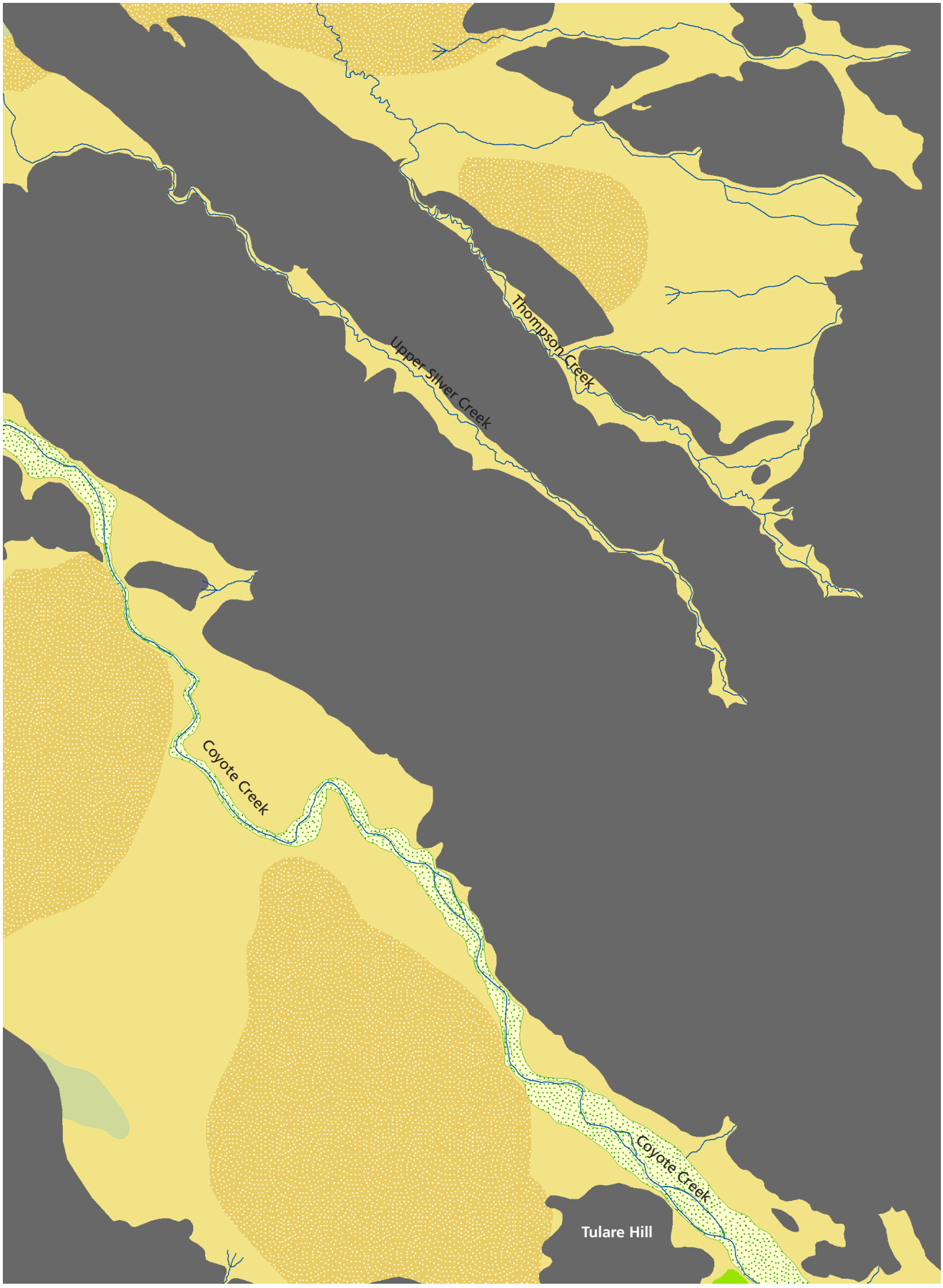
3

COYOTE CREEK/SOUTH SAN JOSE

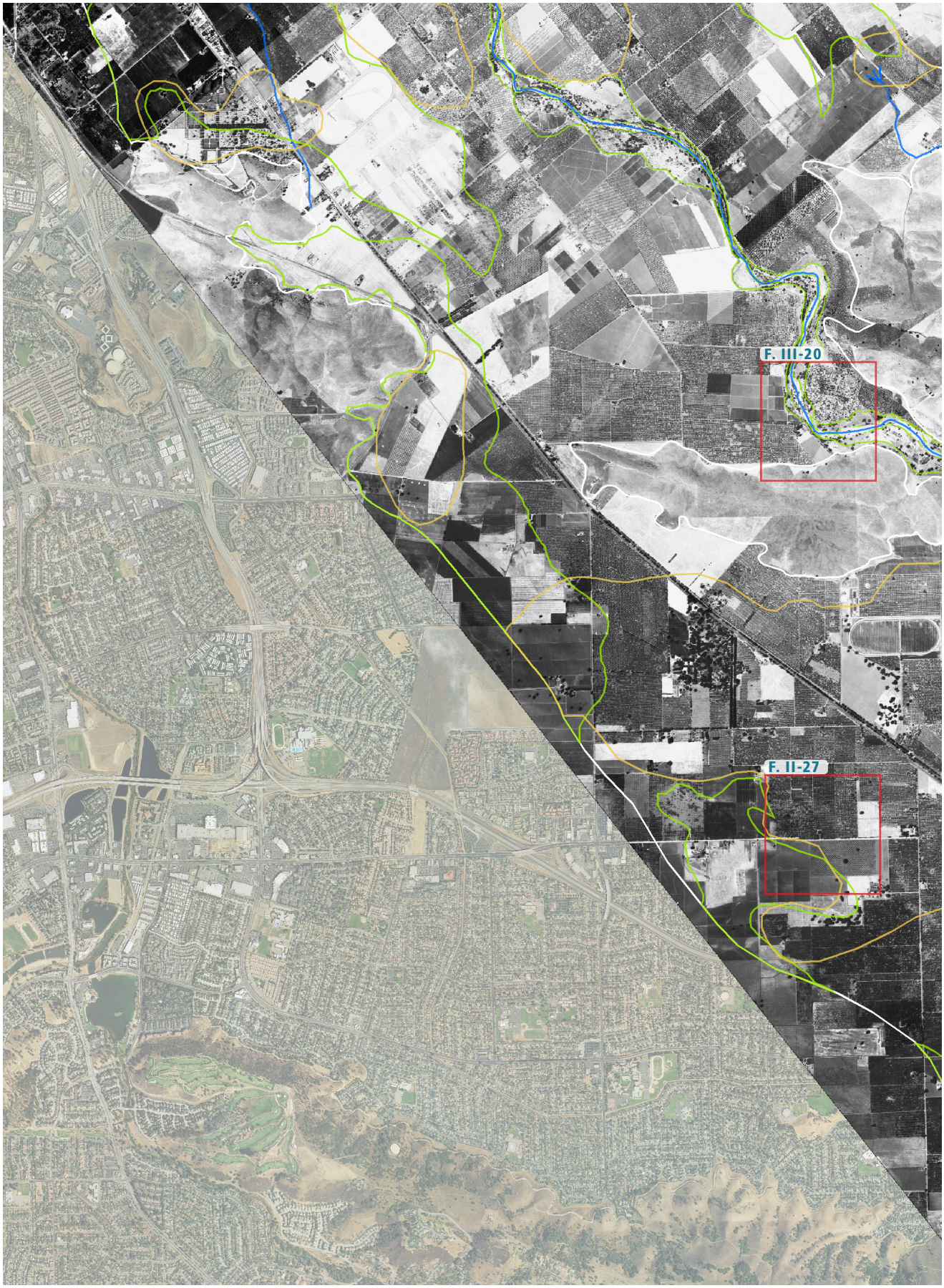
This section covers Coyote Creek from Tully Road to Coyote Narrows, and the adjacent valley lands.



MAP 3A-CA.1800. LANDSCAPE FEATURES DURING INITIAL EURO-AMERICAN SETTLEMENT, CIRCA 1769-1850. Certainty level varies among features; valley oak savanna is a preliminary estimate. More information is available in the project GIS (scale 1:40,000; 1"~3300'; 1 square inch ~250 acres). See inside front cover for map legend.

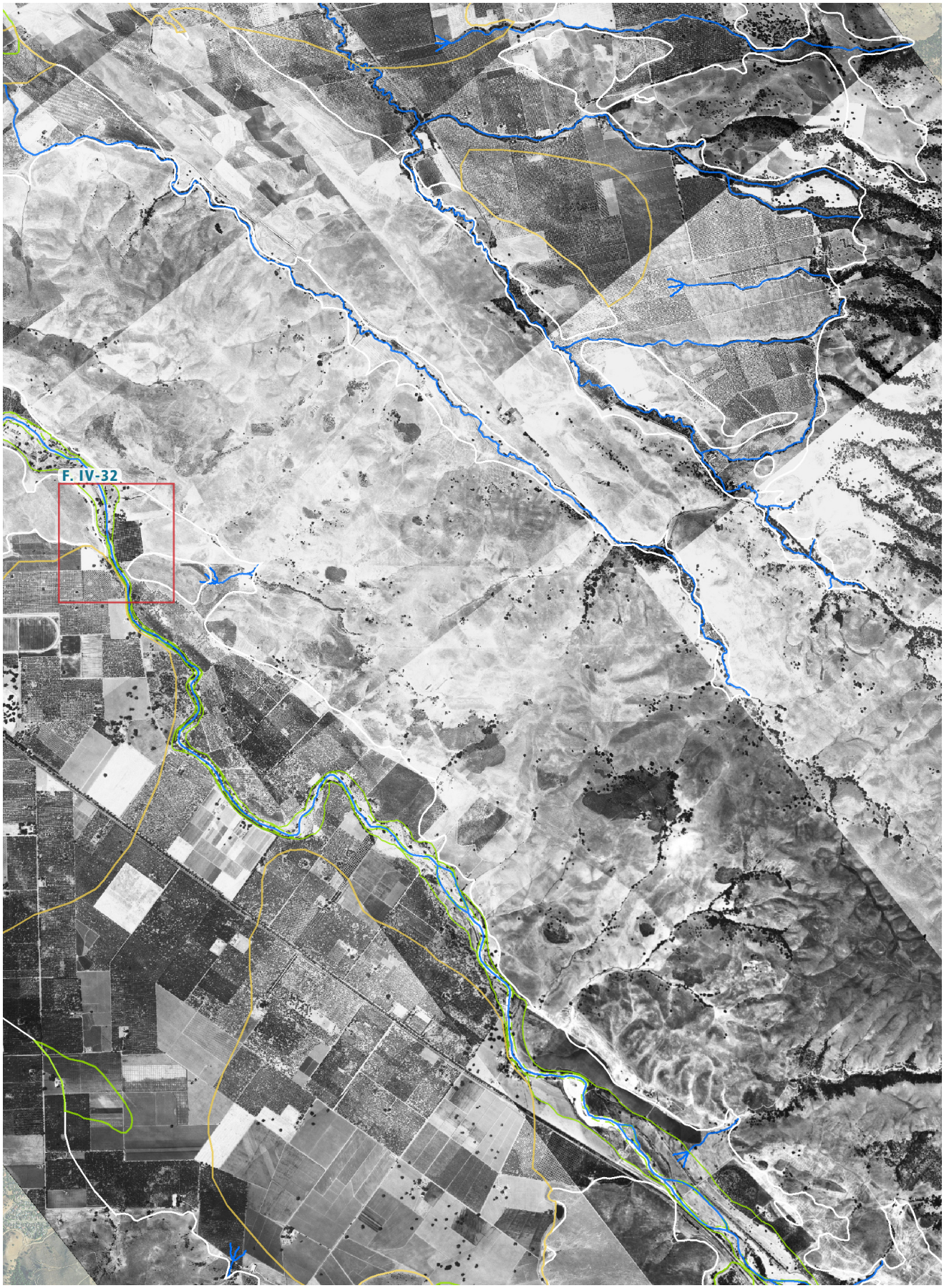


MAP 3B-CA.1800. LANDSCAPE FEATURES DURING INITIAL EURO-AMERICAN SETTLEMENT, CIRCA 1769-1850. Certainty level varies among features; valley oak savanna is a preliminary estimate. More information is available in the project GIS (scale 1:40,000; 1"~3300'; 1 square inch ~250 acres). See inside front cover for map legend.

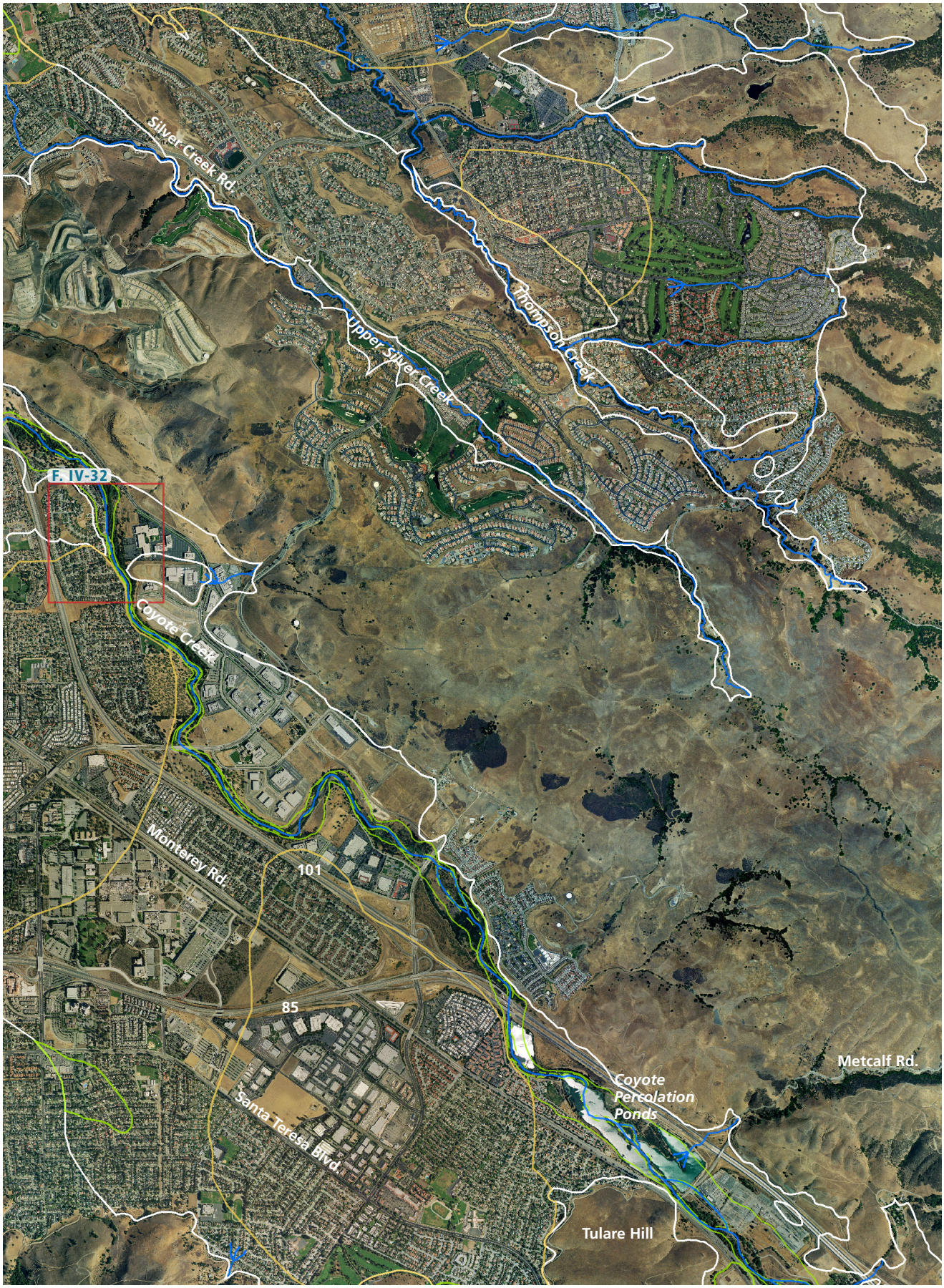


MAP 3A-1939. PHOTOMOSAIC OF EARLY AERIAL IMAGERY, WITH HISTORICAL LANDSCAPE FEATURES OVERLAY. Historical fluvial features in blue; other features, green; project boundary, white (scale 1:40,000; 1"~3300'; 1 square inch ~250 acres; original photographs courtesy SCVWD, USGS Menlo Park, and UC Santa Cruz, UC Santa Barbara, and UC Berkeley).

MAP 3A-2002. MODERN AERIAL IMAGERY, WITH HISTORICAL LANDSCAPE FEATURES OVERLAY. Historical fluvial features in blue; other features, green; project boundary, white (scale 1:40,000; 1"~3300'; 1 square inch ~250 acres; Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).



MAP 3B-1939. PHOTOMOSAIC OF EARLY AERIAL IMAGERY, WITH HISTORICAL LANDSCAPE FEATURES OVERLAY. Historical fluvial features in blue; other features, green; project boundary, white (scale 1:40,000; 1"~3300'; 1 square inch ~250 acres; original photographs courtesy SCVWD, USGS Menlo Park, and UC Santa Cruz, UC Santa Barbara, and UC Berkeley).



MAP 3B-2002. MODERN AERIAL IMAGERY, WITH HISTORICAL LANDSCAPE FEATURES OVERLAY. Historical fluvial features in blue; other features, green; project boundary, white (scale 1:40,000; 1"~3300'; 1 square inch ~250 acres; Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

FIGURE III-20. COYOTE CREEK AT COTTONWOOD LAKE IN 1939 (LEFT) AND 2002 (RIGHT). In the earlier image, we can see a wide main channel with little vegetation except for patches of riparian scrub. Larger trees are located on the adjacent stream benches and, in places, there are linear strands of riparian forest along the outer banks of the channel area. The contemporary image shows a more dense and continuous riparian forest. The sycamore shown in **FIGURE III-21** is indicated by a red circle in both images (AAA 1939; 2002 Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

FIGURE III-19. VALLEY OAK ALONG COYOTE ROAD.

While each of the other three sections of Coyote Creek's valley floor had large areas of bottomlands and wetland complexes, this section was quite well-drained. Oak savanna covered large areas — remnant trees of the savanna are evident in historical aerial photography and scattered within the present-day landscape (**FIGURE III-19**, see also **FIGURES III-27** and **III-28**).

Coyote Creek displayed a braided channel pattern throughout this reach. Scattered sycamore trees occupied islands, bars, and benches in the broad channel reaches. Linear strands of riparian forest were occasional on the outer banks of the channel area. **FIGURE III-20** shows this riparian pattern along present-day Cottonwood Lake, where surveyors Wallace and Healy reiterated the wide spacing of sycamore trees in the mid-19th century (see **PART II**, Riparian Habitat), and a few remnant trees can be found presently (**FIGURE III-21**). Riparian habitat has shifted to a dense forest dominated by cottonwoods.

While extensive evidence agrees that Coyote Creek was seasonally dry in this reach, there is reason to believe that pools persisted through the summer in places, probably associated with the reaches with riparian overstory and scoured outside bends. For example, Day (1854: 514) describes "water in holes" in the vicinity of present-day Cottonwood Lake in mid-July. In February 1905, Hermann (1905) maps a series of large pools (80-120 feet long) along the outer edge of the Coyote Creek channel as it bends to the north at the downstream side of present-day Shady Oaks Park — a densely forested ripar-

FIGURE III-21. SYCAMORE CIRCLE AT COTTONWOOD LAKE. These trees are sprouts from a giant stump in the center, potentially one of the "large sycamores" reported by Wallace and Healy in 1858-1863 (see page II-42).

ian segment reach. These pools would have provided important summer refugia for native stream fish.

The GLO field surveys conducted during the 1850s documented a broad, active channel area recording, for example, that the creek between Tenant Avenue and Coyote Narrows ranges from three to eight chains wide (198-528 feet), corresponding closely with our mapped channel area. Photographs taken in the early 1930s as part of a study of Lesser Nighthawks show channel morphology and vegetation immediately downstream of Coyote Narrows at the present-day location of the Coyote Percolation Ponds (**FIGURE III-22**). Close-ups of nighthawk nests show a wide range of poorly sorted sediment sizes, indicative of braided channel character (**FIGURE III-23**). Conversion here has been dramatic, with the creek now flowing through a large, impounded water body.

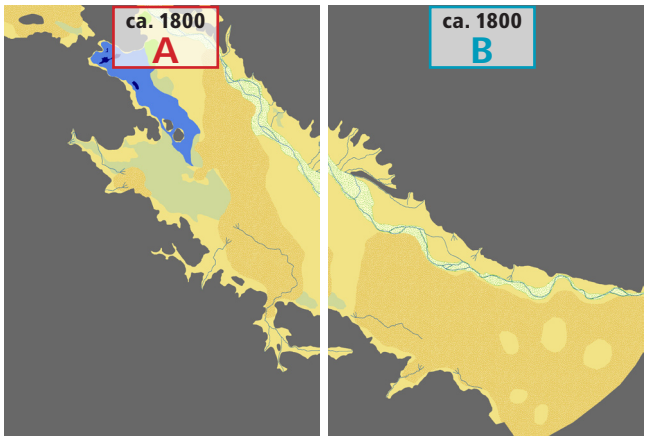
FIGURE III-22. BROAD, GRAVELLY COYOTE CREEK BED IMMEDIATELY DOWNSTREAM OF COYOTE NARROWS, CIRCA 1930. Vegetation is described in **TABLE II-2** (Pickwell and Smith 1938, courtesy Cooper Ornithological Society).

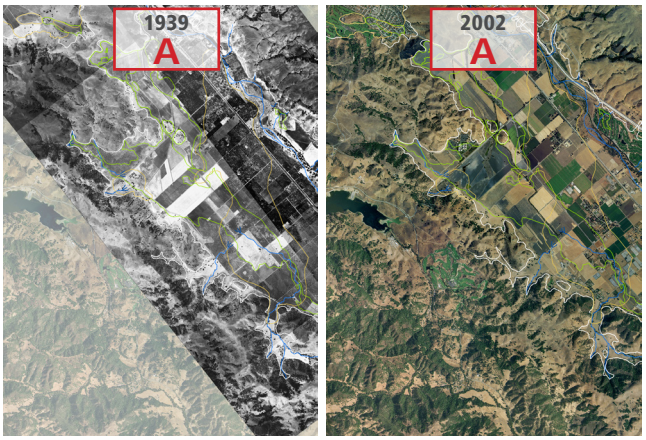
FIGURE III-23. THE SUBTLE NEST MADE BY A LESSER NIGHTHAWK IN THE DRY GRAVELLY BED OF COYOTE CREEK (Pickwell and Smith 1938, courtesy Cooper Ornithological Society).

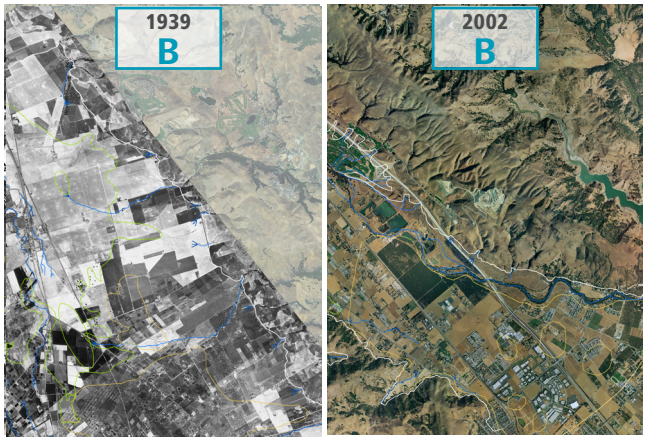
4

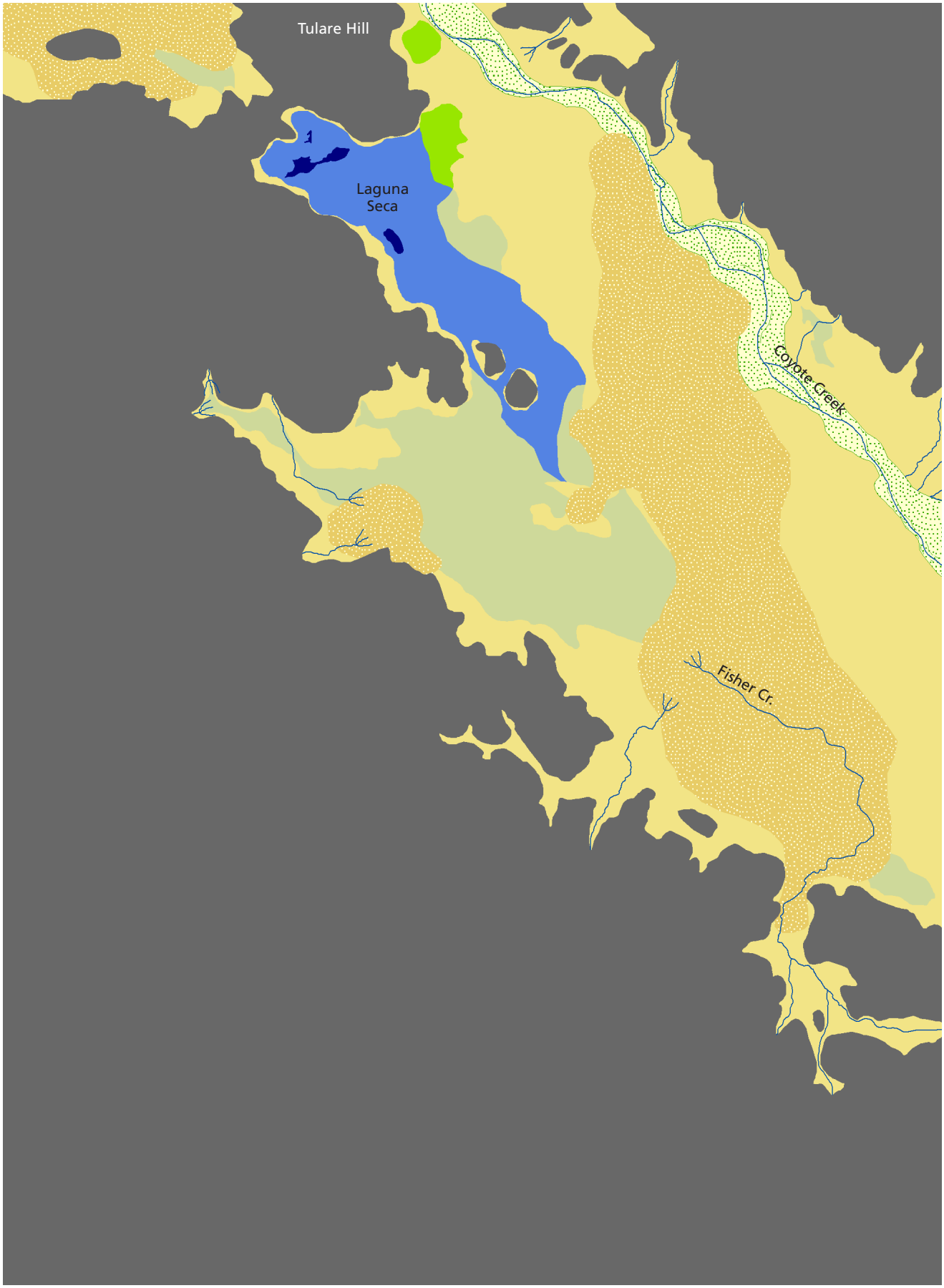
COYOTE CREEK/COYOTE VALLEY

This section covers Coyote Creek from the Narrows to Anderson Dam, and the adjacent Coyote Valley.



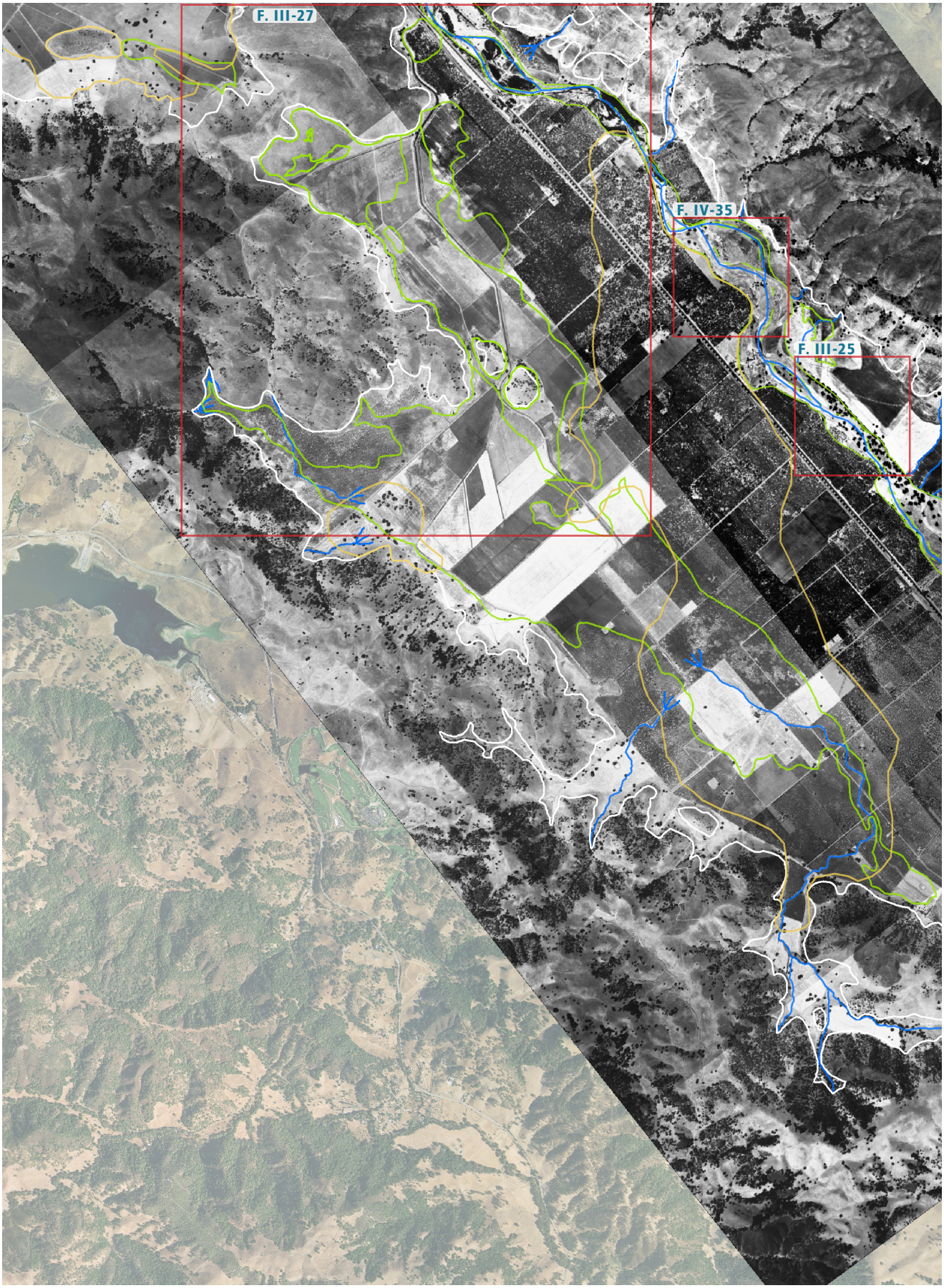




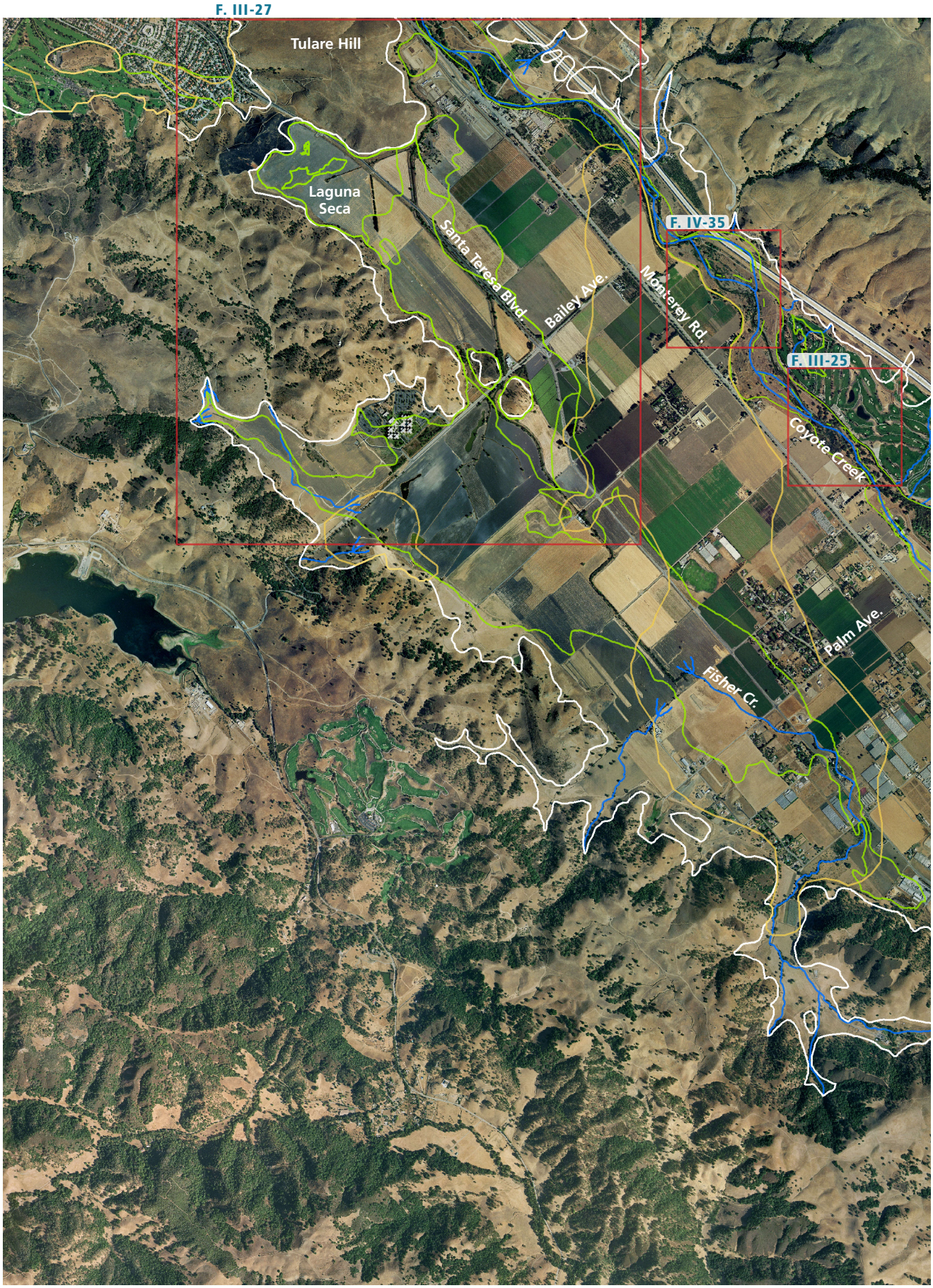


MAP 4A-CA.1800. LANDSCAPE FEATURES DURING INITIAL EURO-AMERICAN SETTLEMENT, CIRCA 1769-1850. Certainty level varies among features; valley oak savanna is a preliminary estimate. More information is available in the project GIS (scale 1:40,000; 1"~3300'; 1 square inch ~250 acres). See inside front cover for map legend.

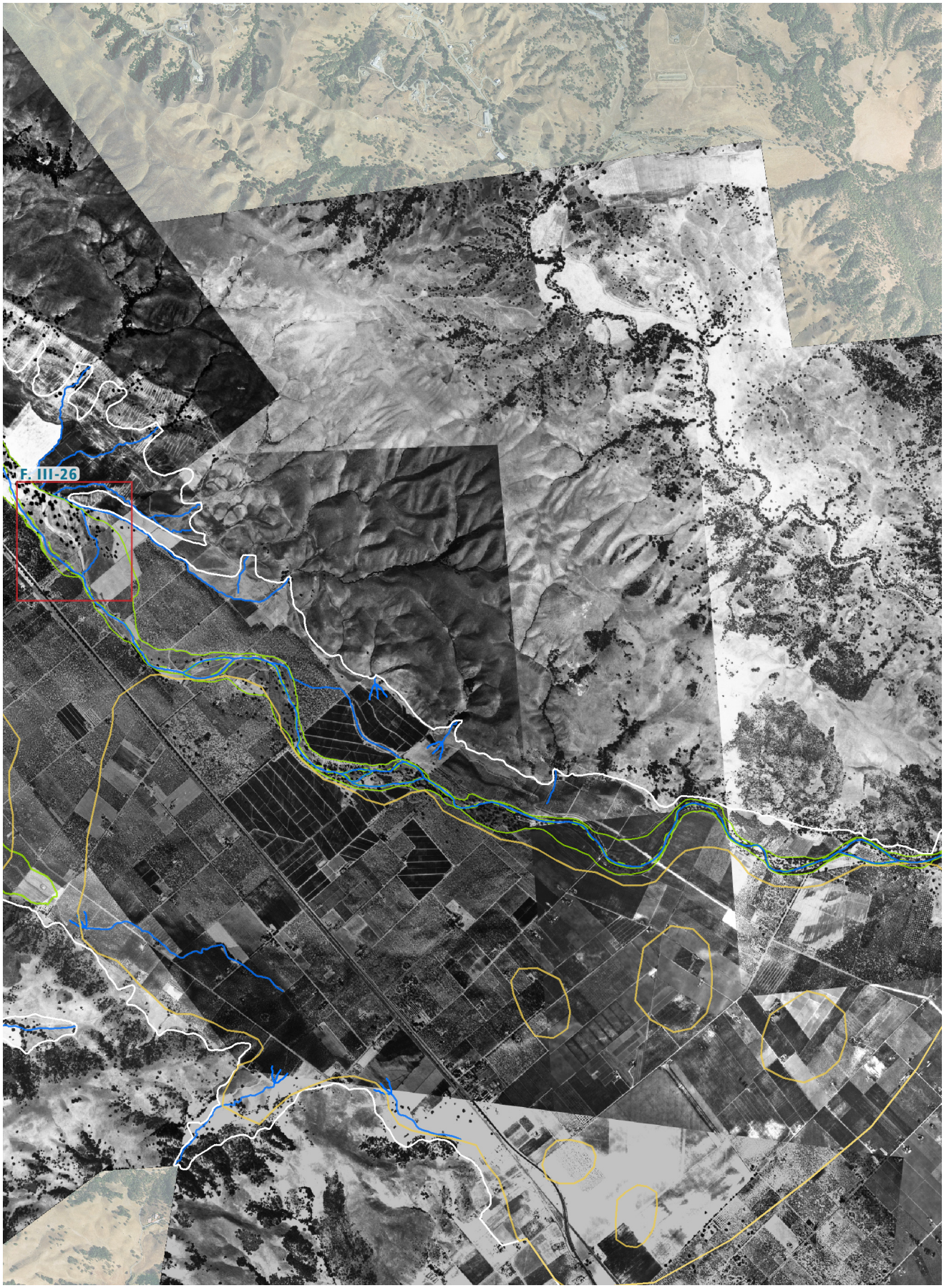
MAP 4B-CA.1800. LANDSCAPE FEATURES DURING INITIAL EURO-AMERICAN SETTLEMENT, CIRCA 1769-1850. Certainty level varies among features; valley oak savanna is a preliminary estimate. More information is available in the project GIS (scale 1:40,000; 1"~3300'; 1 square inch ~250 acres). See inside front cover for map legend.



MAP 4A-1939. PHOTOMOSAIC OF EARLY AERIAL IMAGERY, WITH HISTORICAL LANDSCAPE FEATURES OVERLAY. Historical fluvial features in blue; other features, green; project boundary, white (scale 1:40,000; 1"~3300'; 1 square inch ~250 acres; original photographs courtesy SCVWD, USGS Menlo Park, and UC Santa Cruz, UC Santa Barbara, and UC Berkeley).



MAP 4A-2002. MODERN AERIAL IMAGERY, WITH HISTORICAL LANDSCAPE FEATURES OVERLAY. Historical fluvial features in blue; other features, green; project boundary, white (scale 1:40,000; 1"~3300'; 1 square inch ~250 acres; Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).



MAP 4B-1939. PHOTOMOSAIC OF EARLY AERIAL IMAGERY, WITH HISTORICAL LANDSCAPE FEATURES OVERLAY. Historical fluvial features in blue; other features, green; project boundary, white (scale 1:40,000; 1"~3300'; 1 square inch ~250 acres; original photographs courtesy SCVWD, USGS Menlo Park, and UC Santa Cruz, UC Santa Barbara, and UC Berkeley).

MAP 4B-2002. MODERN AERIAL IMAGERY, WITH HISTORICAL LANDSCAPE FEATURES OVERLAY. Historical fluvial features in blue; other features, green; project boundary, white (scale 1:40,000; 1"~3300' ; 1 square inch ~250 acres; Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

Coyote Valley is shaped by the cone of alluvial sediment spreading downward from the canyon mouth, at the present-day site of Anderson Dam. Currently, Coyote Creek flows to the north, but in previous ages it has flowed south to Monterey Bay. The subtle watershed divide here, crossed in the vicinity of Morgan Hill, is formed purely by the alluvial topography.

A vast valley oak savanna occupied much of Coyote Valley, with small and large "oak openings" (**FIGURE III-24**). Coyote Creek maintained a "wide, gravelly bed" that excluded agriculture from a broad zone (Broek 1932). Steep creeks approached the creek from the hills immediately east of the channel, likely contributing to a high sediment load. On the west side of the Valley, the streams, including Fisher Creek, were discontinuous.

FIGURE III-24. PART OF THE GREAT VALLEY OAK SAVANNA SOUTH OF LAGUNA SECA, CIRCA 1896 (Shortridge 1896, courtesy History San José).

In this reach, Coyote Creek presently exhibits some of its most un-modified morphology and riparian habitat. Examples of sycamore alluvial woodland and open riparian scrub can be found upstream and downstream of Ogier Ponds, representing significant residual habitats (**FIGURES III-25** and **III-26**, see also **FIGURE IV-35**).

At the northern end of the Valley, the adjacent ranges converge into the Coyote Narrows. Laguna Seca, one the most significant freshwater, non-tidal wetland complexes in the region, was located here.

BRAIDED CHANNEL

There is some evidence indicating that Coyote Creek's banks were quite dynamic in this reach, as the main channel moved within the broader channel area. Howe's 1851 (p. 89) survey describes the kinds of dynamic conditions we would expect to observe on braided channels, when he crosses the creek channel between today's Coyote Creek Golf Club and Ogier Ponds:

> 30.30 W. bank of a large creek in wet weather, now entirely dry, bears N. 46 W.
>
> 33.00 E. bank of creek, channel has washed off of one side, and added to the other, so that the channel has been changed for many rods. Width indefinite, say in wet weather 1.50 chains.

Howe's 1851 main channel was about 700 feet to the west of the present-day channel, along the far west bank of the active channel area we have mapped. Prosser (1903) shows

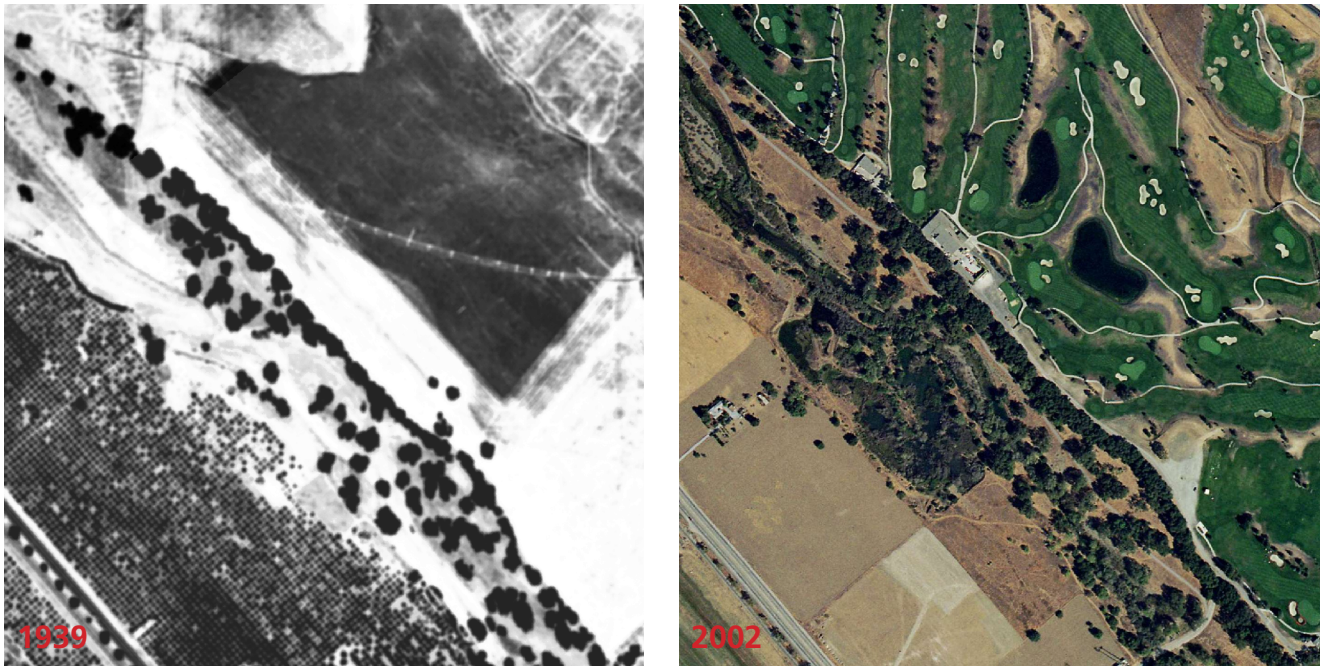


FIGURE III-25. COYOTE CREEK AT THE COYOTE CREEK GOLF CLUB IN 1939 (LEFT) AND 2002 (RIGHT). The 1939 (AAA 1939) image shows several of the common characteristics of the braided Coyote Creek channel historically found from approximately Tully Road to Ogier Ponds/Highway 101 crossing. These include riparian woodland composed of large widely spaced trees; substantial unvegetated, scoured areas; and strands of mixed riparian forest following one of the outer banks. These elements are relatively intact presently, as can be seen in the contemporary image (2002 Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

that the subsequent eastward migration of the main channel took place prior to 1903; the main channel has stayed in position during the 20th century, with the current position closely matching that visible in 1939.

The current channel has perhaps downsized slightly since the 1850s, with a present-day maximum width of 80-90 feet compared to Howe's wet weather estimate of 99 feet (1.5 chains) and a bank-to-bank distance of 178 feet. He also reports crossing a "bayou of creek," corresponding to one of the secondary channels visible in the 1939 aerial image.

LAGUNA SECA

The historical Laguna Seca wetland complex, covering over 1000 acres, was formed by the emergence of Coyote Valley groundwater alongside the Santa Teresa Hills (Clark 1924). Drainage at this northern end of the Coyote Valley was blocked both by the bedrock wall of the Santa Teresa Hills and the natural levee of Coyote Creek — together creating a low spot. Wet meadows, perennial freshwater tule marshes, willow groves, and open water ponds received water from both groundwater discharge and the distributary creeks that are now connected across the valley floor as part of the Fisher Creek watershed.

Crossing the wet meadows at the southern end of the Laguna, near present-day Bailey Ave., Howe (1851: 88) used unusually colorful language for a formal survey, recording "a beautiful valley." He described the wet meadows as "a rich prairie, peculiar to the growth of wild clover" but with "wild geese so numerous that the noise is quite annoying."

The perennial wetlands of Laguna Seca are well-documented in the historical record, particularly by a series of landscape photographs preserved in the Santa Clara Valley Water District vault and taken during its reclamation, in the winter of 1916-1917. Despite earlier irrigation and drainage efforts, the spatial extent of perennial wetland and seasonally flooded area remained consistent between 1847 and 1915-1916 (**FIGURE III-27**).

FIGURE III-26. COYOTE CREEK IMMEDIATELY DOWNSTREAM OF OGIER PONDS IN 1939 (LEFT) AND 2002 (RIGHT). The open riparian and channel pattern visible in 1939 (AAA 1939), which closely matched that described by Howe in 1851, has filled in substantially, probably as a result of decreased winter flows and increased summer flows (2002 Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

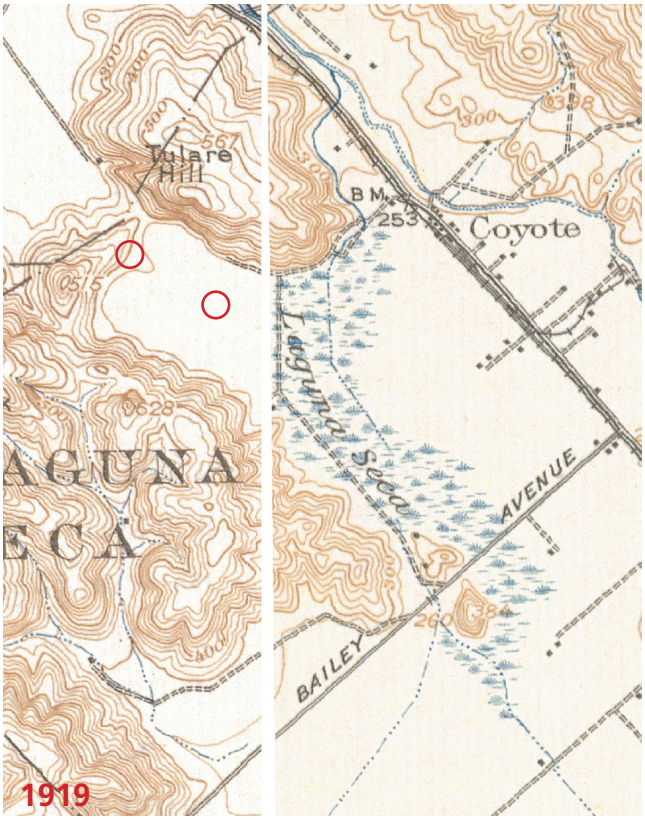
FIGURE III-28 is a panorama taken from the north end of the Laguna, showing a tule marsh with ponds of open water, one of them called "Mallard Pond." Another photograph looks across one pond to the hill on the left, appropriately named Tulare Hill (FIGURE III-29). These pictures and the associated captions (see also FIGURES II-10 and II-11) confirm tule vegetation greater than 10 feet tall and water depths of 4-5 feet.

Despite the construction of an extensive drainage system, groundwater seepage still supports surface water during summer months at the northern end of the historical Laguna (FIGURE III-30). The natural hydrology of the laguna appears substantially intact, despite historical modifications. The site has changed relatively little during the past 85 years (FIGURE III-27, FIGURE IV-34) and would appear to have unusual potential for restoration of a natural wetland mosaic in northern Santa Clara County.

ALVIREZ CANAL

Laguna Seca provided an important natural water source for waterfowl, amphibians, and local human culture. Since Coyote Creek was seasonally dry along most of its length, there were few sources of water for summer irrigation upstream of San Jose. Laguna Seca thus provided a rare source of summer water. Accordingly, it was tapped for agriculture unusually early, by the 1830s. Gravity fed irrigation from the Laguna led to an odd scenario.

It appears that the prevailing topography (sloping towards the Laguna) caused Alvirez, the recipient of the Laguna Seca land grant, to construct an irrigation system carrying water around Tulare Hill and north through Coyote Narrows (and alongside Coyote Creek) to the lower lying lands to the north. Unfortunately this crossed what became the traditional boundary between the Laguna Seca and the Santa Teresa land grants, as well as the natural boundary between Coyote and Santa Clara Valley



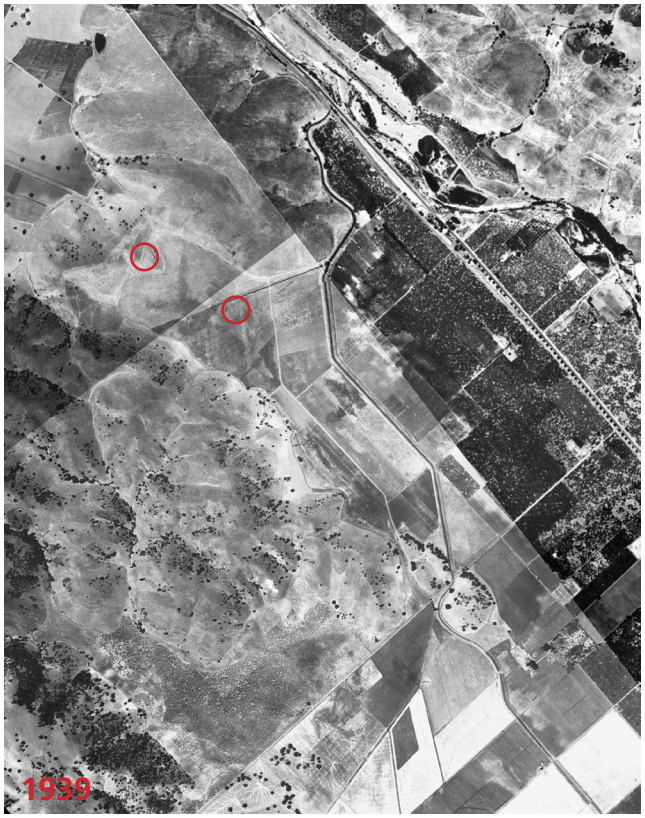


FIGURE III-27. LAGUNA SECA IN 1847, 1915-16, 1939, AND 2002. The 1847 Rancho Laguna Seca *diseño*, by the well-respected surveyor Chester Smith Lyman (e.g. Arbuckle 1986:56), shows perennial wetlands and an open water area, with valley oaks located some distance to the east and south. The outlet channel, probably an extension of Alvirez's canal, has not changed shape much over time, but has received an increasingly greater drainage network. Mottled soil patterns (1939, lower left; AAA 1939) and less agricultural diversification (2002, lower right; Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved) mark the Laguna site after the 1916-17 reclamation. Approximate locations of the following panoramas are indicated with red circles. Lyman 1847, courtesy The Bancroft Library, UC Berkeley; USGS 1919 and 1940 courtesy Santa Clara Valley Water District.

groundwater basins. This early interbasin water transfer led to understandable conflict, which was recorded by the Mexican courts in the 1830s and recapitulated during the land case trials of the 1850s.

The American records document that Alvirez argued in 1834 that he had already occupied the land for over a decade, and was dependent upon the irrigated fields which Bernal now claimed as part of Rancho Santa Teresa:

> "The citizen...now seeks in property the place Santa Teresa whose map comprehends my fields of tillage and canals of water in which I have made my sustenance. Sir this individual who intends to dispoil me of a right which I have acquired in force of sacrifices costly... I swear what is necessary. Monterey, June 5, 1834" (Alvirez 1834).

FIGURE III-28. LAGUNA SECA PANORAMA, DECEMBER 28, 1916. This view from the north end of the Laguna shows wetland vegetation and perennial ponds immediately before draining for agriculture. See **FIGURE III-27** for location. SCVWD Vault 1916: 64-65, courtesy the Santa Clara Valley Water District.

In the 1834 dispute, Alvirez described the significance of the canal "which in fact has produced much benefit, for in the rest of the land solicited there is no irrigated land." At the same time he described the "*ascequia* (canal) of water which I have lately made (leading) from the said *Laguna* (lake) for my cultivations. I petition of you to grant me as far as said *ascequia* extends..." [spelling and parenthetical phrases from the original text].

Because of this construction, his claim was successful. The resulting Rancho shape has been carried through American land tenure and can still be seen on USGS maps as the grant boundary. Apparently the irrigation ditch was later diverted directly into Coyote Creek to help drain Laguna Seca. This early irrigation project appears to be the origin of the present-day reach of Fisher Creek between the Laguna and Coyote Creek.

FIGURE III-29. LAGUNA SECA PANORAMA ACROSS A TULE POND, DECEMBER 20, 1916. "View looking westward from Lagoon showing open water (about 4 1⁄2 ft. deep) with clam-shell working on Ditch advancing through tulles (Sta. D' 22+50) to drain lands." [Original caption text]. See **FIGURE III-27** for location. SCVWD Vault 1916: 58-59, courtesy the Santa Clara Valley Water District.

CONNECTION TO COYOTE CREEK

There is no mention made of an outlet to Coyote Creek during the extensive discussion of Alvirez's canal from the Laguna through the Narrows, which would have come very close to Coyote Creek. The presence of an adjacent natural channel draining to Coyote Creek would have made a diversion alongside the creek particularly difficult. Yet by 1847, Lyman's map does show a connection from Laguna Seca to Coyote Creek. It seems most likely that this was an extension of the early ditch — as a way to begin draining the Laguna. This inferred history would explain why this channel follows the edge of the hill — to maintain elevation — and how it would have been able to cut through the substantial natural levee sloping alongside Coyote here. The expansion of the ditch into the Outlet Canal (now called Fisher Creek), following the edge of the hills, is illustrated in **FIGURE III-31**.

SAUSAL

There also appears to have been a willow grove or thicket at the Narrows, commented on by travelers and perhaps the reason for the splitting of El Camino Real there. Palou (1774 *in* Bolton 1933) encountered a "thick grove" at the Coyote Narrows. This feature may have been part of the *sausal* at the Laguna Seca wetland complex, whose clearing is recorded in the Laguna Seca Reclamation photographs (**FIGURE III-32**; SCVWD Vault 1916-17: 116, 130, 132, 137). The Laguna Seca *sausal* can be generally located based upon the photographs and USGS Morgan Hill Quadrangle (1917).

FIGURE III-30. GROUNDWATER SEEPAGE AT NORTH END OF FORMER LAGUNA SECA.

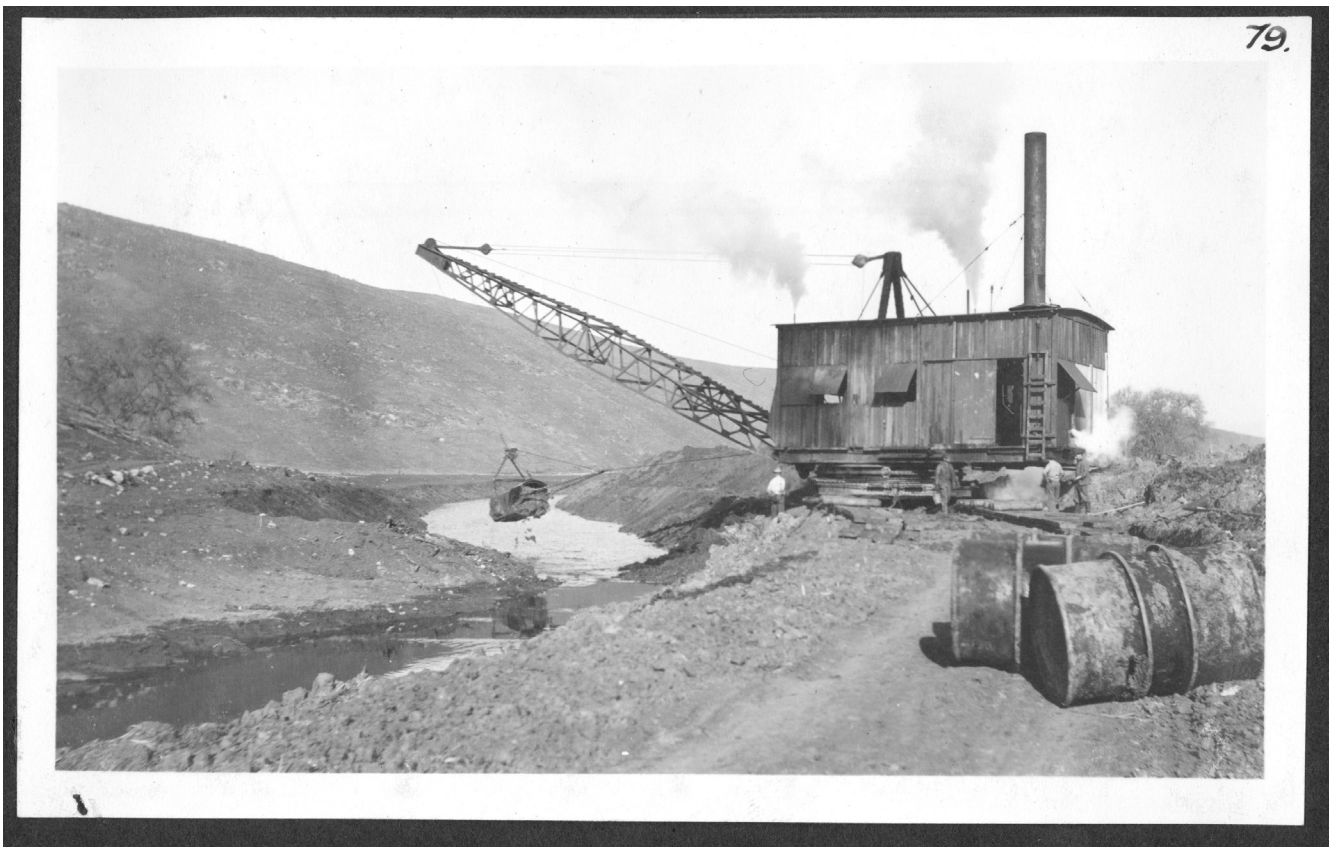


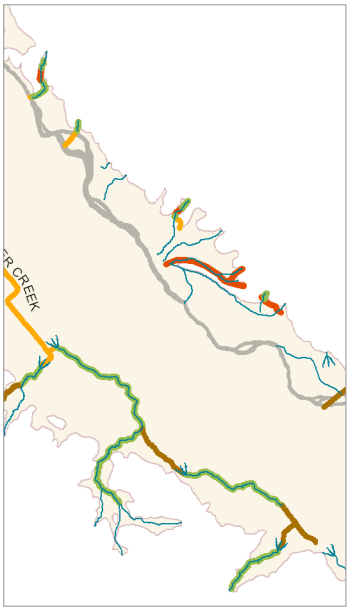
FIGURE III-31. CONSTRUCTION OF THE LAGUNA SECA OUTLET CANAL, FEBRUARY 2, 1917. SCVWD Vault 1917: 79, courtesy the Santa Clara Valley Water District.

FIGURE III-32. LAGUNA SECA WILLOW GROVE, 1917. This image provides a rare photograph of a Santa Clara Valley *sausal*, or willow grove. SCVWD Vault 1917: 115, courtesy the Santa Clara Valley Water District.

PART IV //

LANDSCAPE CHANGE

Part IV assesses how the historical landscape has been transformed into present-day conditions. In the first section, we summarize major events in the land use history of the watershed. Next we describe the trajectories of change in landscape features and associated habitats. In the final section, we discuss some of the implications for watershed restoration and management.



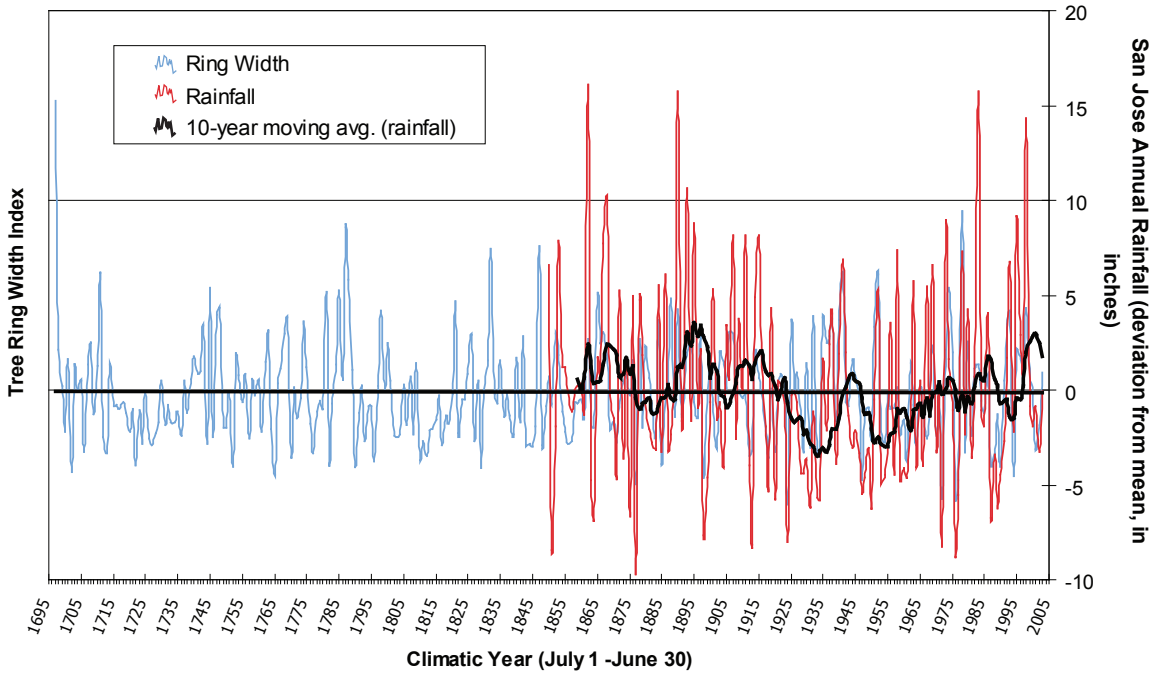


FIGURE IV-1. CLIMATE TIMELINE FOR SANTA CLARA VALLEY. Rainfall data for San Jose, 1874-2004, with 1850-1873 extrapolated based upon San Francisco data, courtesy of Jan Null. Tree ring data from a blue oak near Alum Rock Park (unpublished data provided by David Stahle, University of Arkansas).

LAND USE CHRONOLOGY

The present-day landscape is the product of previous land use events and activities, superimposed upon natural landscape patterns. Climatic variation and catastrophic events also drive landscape change (**FIGURE IV-1**). Understanding landscape change is particularly important in urban watersheds with complex histories of modification, where streams are responding to a combination of recent and historical impacts. This section summarizes the land use history of the Coyote Creek watershed. Several of the major land use trends affecting Coyote Creek are illustrated in **FIGURE IV-2** using a single temporal axis. The following chronology summarizes some of the significant impacts to provide a basis for the discussion of landscape trajectories.

1769: SPANISH EXPEDITIONS ENTER AN OHLONE VALLEY

At the initiation of Euro-American contact, Santa Clara Valley has been intensively managed by a dense indigenous population for at least 5,000 years. While much remains to be learned about the Native management practices (Striplen 2005), the Spanish diaries describe numerous villages, extensive trail networks, and the effects of controlled burns on vegetation patterns and productivity.

1777: MISSION AND PUEBLO ESTABLISHMENT

With the establishment of Mission Santa Clara and Pueblo San Jose, aggressive colonization and widespread disease decimate Native culture. Over the next several decades, Native management of botanical resources declines. Santa Clara Valley changes from a landscape maintained by Natives for specific dietary and utilitarian needs and hunting, to a European-style ranching operation.

~1812: PUEBLO RANCHING ALONG COYOTE CREEK REACHES MODERATE LEVELS

Cattle reported by the Pueblo, which would have grazed in the Coyote Creek watershed, remain rela-

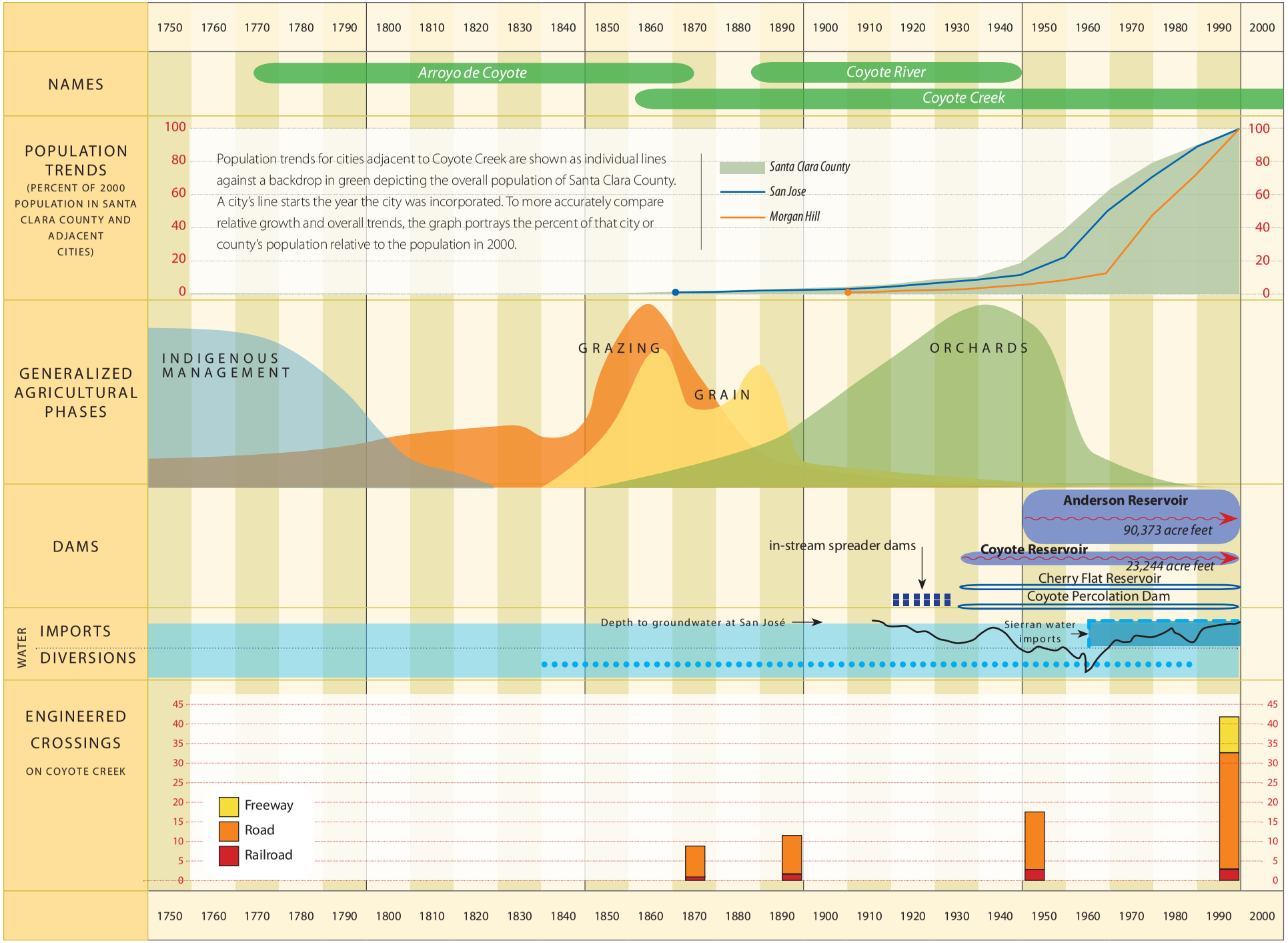


FIGURE IV-2. LAND USE TIMELINE FOR COYOTE CREEK.

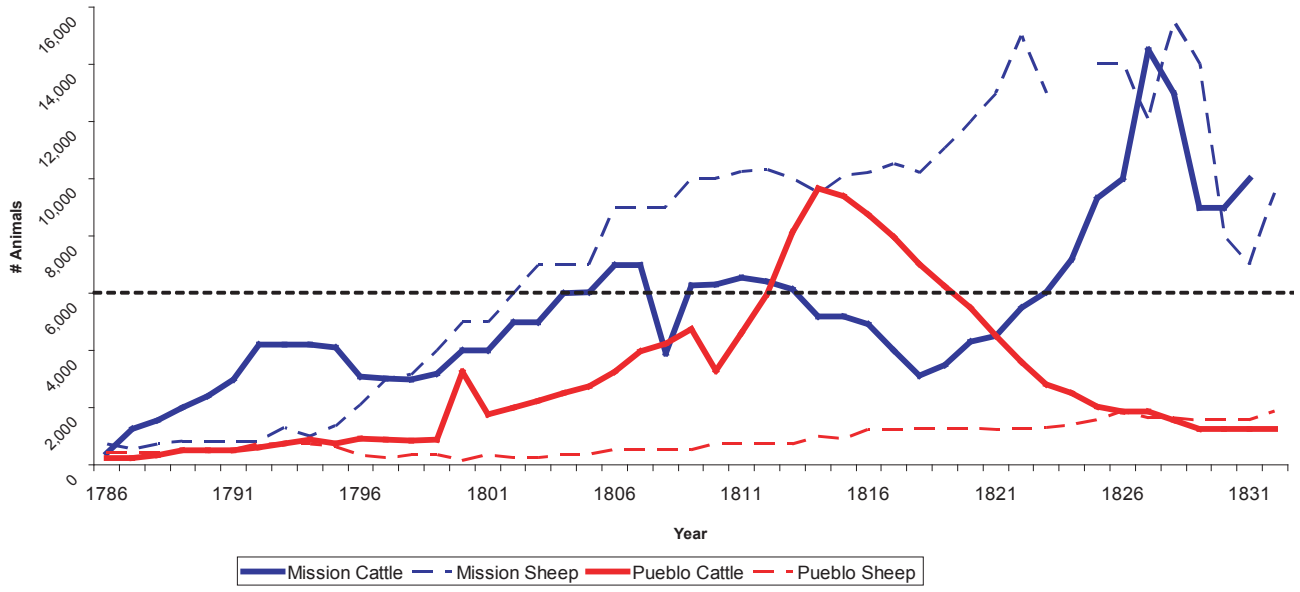


FIGURE IV-3. MISSION ERA STOCKING LEVELS IN THE SANTA CLARA VALLEY. In 1798 Guadalupe River was established as the eastern boundary for the Mission Santa Clara ranch (Friedly 2000: 126), so Pueblo San Jose activities are most relevant to Coyote Creek. While the Mission reported high numbers of sheep, Pueblo ranching seems to have focused primarily on cattle. Numbers increased gradually until about 1810, reached a moderately high level for about a decade, then decreased steadily. The dashed black line indicates what would be a moderate stocking density of one cow in 10 acres (Bancroft 1890), based upon our estimate of the Pueblo's valley floor ranchland. Stocking data from Broek (1932), Jackson and Castillo (1995), and Friedly (2000).

tively low for the first quarter-century of operation. By 1812, Pueblo cattle stocking levels correspond to a moderate density (dashed black line = ~1 cow in 10 acres; Bancroft 1890). Intensity increases, then decreases for the next two decades (**FIGURE IV-3**).

1834: SECULARIZATION OF THE MISSIONS, INTENSIFICATION OF RANCHING

The Mission era ends. Lands held in trust by the church for the native population are instead almost exclusively distributed to prominent Mexican residents, establishing the land grants. Much of the Pueblo lands are also dispersed. Substantial parts of the Valley go unmanaged during the transitional 1830s, but grazing density quickly increases to, at least in places, levels much higher than under the Pueblo and Mission. For example, Chaboya had "about 3000 cattle" in 1835 on less than 10,000 acres of valley floor land of the Yerba Buena Rancho (Pico 1854: 11).

1848: SANTA CLARA VALLEY "MOVES" FROM MEXICO TO THE U.S.

U.S. acquires California in the Treaty of Guadalupe Hidalgo after defeating Mexico in the Mexican-American war.

1849: THE GOLD RUSH MAKES THE VALLEY "CENTRALLY LOCATED"

Previously at the far end of Spanish, Mexican, then American continental interest, Santa Clara Valley is suddenly near the epicenter of mass immigration, financial power, and new markets in the San Francisco Bay Area. Conversion from intensive ranching to intensive agriculture begins.

~1850: ESTABLISHMENT OF DIXON LANDING

Dixon builds warehouses along the tidal reaches of Coyote Creek for hay storage and transport to San Francisco by barge (McArthur and Fuller 1975: 31).

1852: DIVERSION OF PENITENCIA CREEK

A farmer diverts the upper portion Penitencia Creek, which previously flowed in a discontinuous series of channels and wetlands parallel to Coyote Creek at Berryessa Rd., directly into Coyote. This diversion may have been an accident (Loomis 1982: 67), but given its straight course along Berryessa Road, was more likely constructed to reduce flooding and drain the marshy land downstream (Arbuckle 1986: 419).

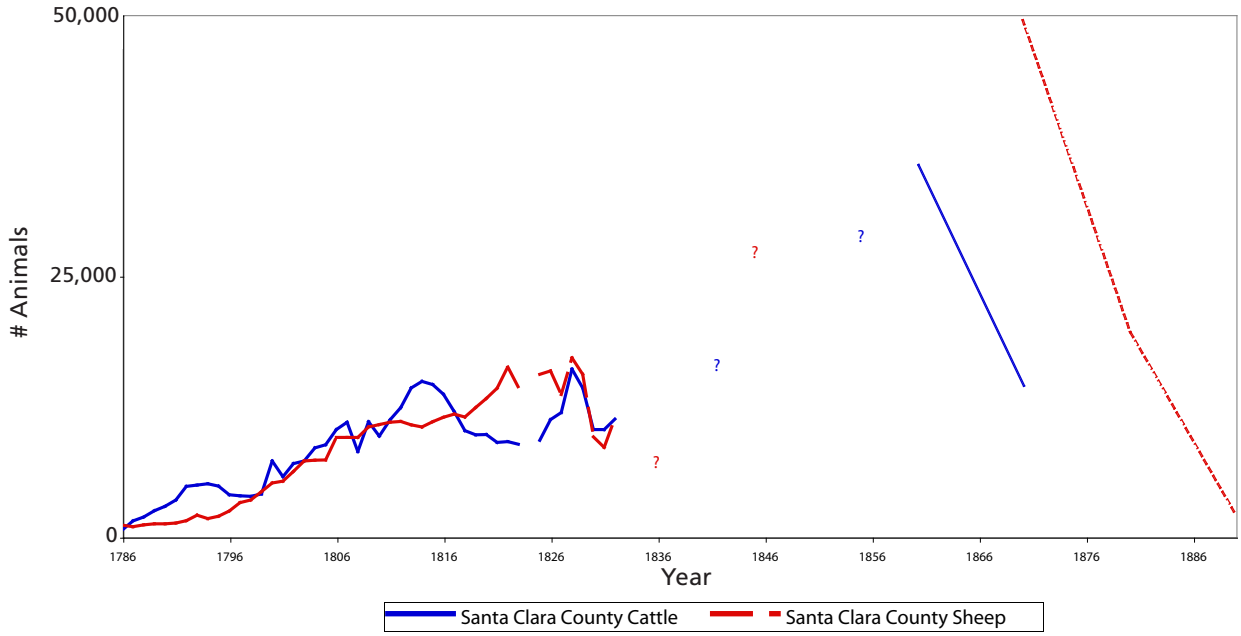


FIGURE IV-4. REPORTED NUMBERS OF CATTLE AND SHEEP IN SANTA CLARA COUNTY, 1786-1896. This graph looks at the entire County, not just Coyote Creek. During the Mission era, stock numbers show an overall increase until the disbanding of the missions in the early 1830s. It is likely that numbers increased substantially during the 1840s, based upon individual rancho reports. Numbers prior to 1834 are the sum of Pueblo San Jose and Mission Santa Clara values; County livestock data from Broek (1932).

1864: VALLEY SHIFTS FROM CATTLE TO WHEAT

Widespread starvation of cattle during severe drought decimates the ranching industry, facilitating the conversion from pasture to farm (**FIGURE IV-4**; Broek 1932: 61-62).

1869: SOUTHERN PACIFIC CROSSING

A branch of the Western Pacific Railroad (now SP) crosses Coyote Creek (at the present-day location, near Oakland Road) — connecting San Jose to Niles, and, through Niles Canyon, the rest of the country (Thompson and West 1876: 12, Unknown ca. 1960).

1870s: THE "BARBAROUS FENCE"

The invention of barbed wire makes fence building economical. New laws make ranchers responsible for cattle damage to crops, hastening the transformation of the open range into divided farms (Broek 1932: 63).

Early 1870s: COYOTE CREEK BREAKOUTS

Coyote Creek jumps its channel in several places downstream of San Jose, causing extensive flooding and damage to agricultural lands, and leading to extensive levee construction upstream of today's Highway 237 (Westdahl and Morse 1896-97).

1872: CALIFORNIA'S FIRST CITY PARK ESTABLISHED ON PENITENCIA CREEK

Springs and surrounding land are protected in Alum Rock Regional Park.

1874: HIGH POINT FOR WHEAT PRODUCTION

Rapid soil depletion and shifting markets lead to the decline of wheat farming, which peaked at an estimated 60,000 acres within the County, and replacement largely by orchards (see **FIGURE IV-2**; Broek 1932: 106).

1897-99: DRY YEARS FOLLOW AGRICULTURAL BOOM

Local agriculture, which expanded and intensified greatly during two decades of relatively high rainfall, begins turning to groundwater pumping and increased creek diversions in response to several drier years (Tibbetts and Kiefer 1921: 56).

1907-1910: SECOND SEQUENCE OF DRY YEARS INITIATES WIDESPREAD GROUNDWATER PUMPING

Dry seasons following a brief wet sequence preclude effective irrigation from stream flow and cause rapid expansion of groundwater use (Tibbetts and Kiefer 1921: 24).

1911: COYOTE CREEK FLOOD

The largest well-documented flood on Coyote Creek causes widespread flooding (Loomis 1986: 63, Duryea et al. 1977, SCVWD n.d.).

~1913: RAILROAD SPUR BUILT TO COYOTE GRAVEL MINE

Large-scale commercial gravel mining has been initiated by this time. Over the next 30 years gravel companies operate between Coyote Narrows and the Ogier Ponds area (**FIGURE IV-5**; Duval pers. comm.; USGS 1917).

1916: END OF RELATIVELY WET QUARTER-CENTURY

A period of relatively high rainfall despite a few dry years during which agriculture intensified, comes to an end (Poland and Ireland 1988: 16-18).

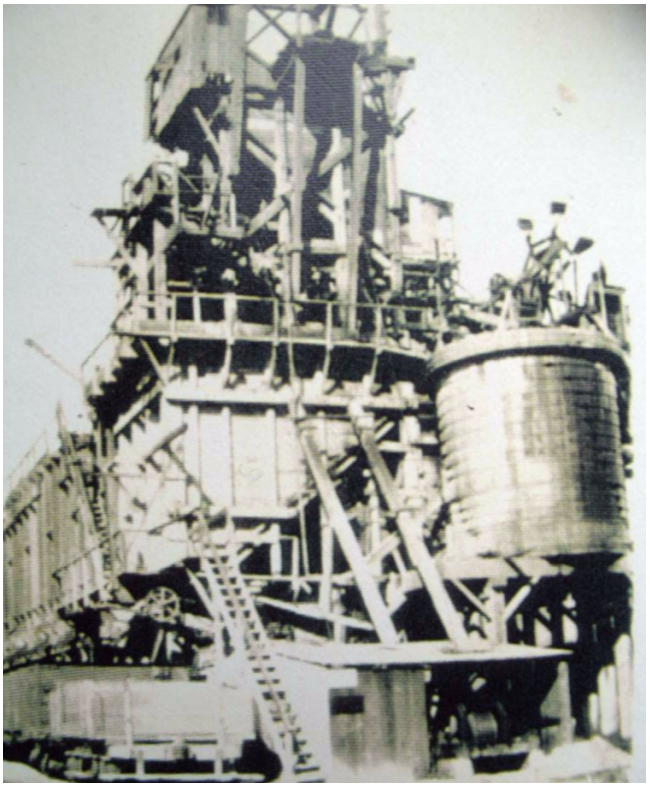


FIGURE IV-5. COYOTE ROCK CRUSHER. The Crusher used gravel from Coyote Creek near Malech Rd. Image by an unknown photographer (Unknown [194-?]); courtesy Charlene Duval, Sourisseau Academy.

1920s: GROUNDWATER RECHARGE EFFORTS BEGIN

As groundwater levels decline following increased pumping and lower rainfall, local farmers form the Valley Water Conservation Association to construct small sack dams on creeks for groundwater replenishment.

1921: SECOND COYOTE CREEK RAILROAD CROSSING

The Western Pacific establishes the second railroad crossing on Coyote Creek, just north of Story Road (construction started in 1917).

1927-1934: DROUGHT

A series of below average rainfall years affects land use locally and throughout the West. While not as extreme locally, the Dust Bowl drought was one of the extreme moisture anomalies of the past 500 years (Fye et al. 2003) and hastened groundwater decline. The Santa Clara Valley Water Conservation District was created.

1930s: GRAVEL PONDS BECOME IN-STREAM DAMS FOR GROUNDWATER RECHARGE

The Santa Clara Valley Water Conservation District develops a percolation area on Coyote Creek, using ponds created by prior gravel extraction, constructing a removable flashboard dam to spread the stream flow over a 60-acre parcel area, which becomes a permanent concrete dam (Coyote Percolation Ponds) within a few years. Metcalf Percolation Pond was first installed in 1935 (McArthur

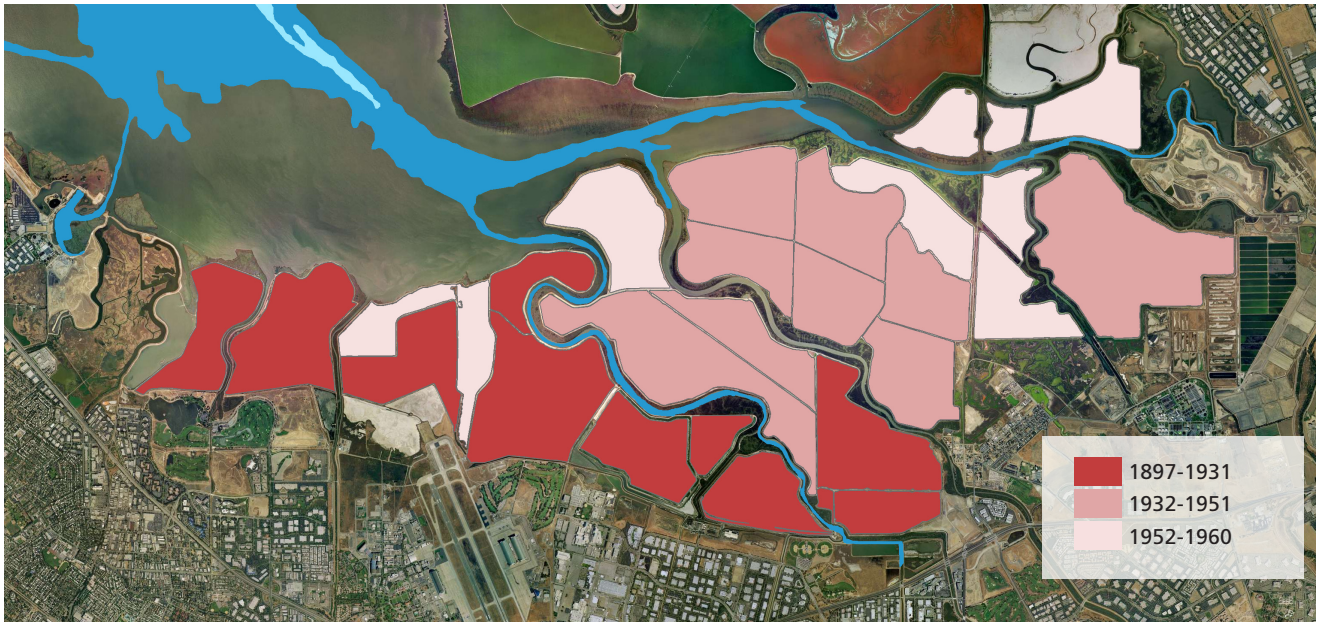


FIGURE IV-6. TIMING OF SALT POND DEVELOPMENT AT THE NORTHERN END OF SANTA CLARA VALLEY. The area at the mouth of Coyote Creek (right side) was one of the last Bayland areas in the region to be diked (2002 Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

1981: 51, Joe Aguilera, SCVWD in Buchan and Randall 2003: G3, G15).

1932: STANDISH DAM INSTALLED

Local farmers construct a seasonal dam on lower Coyote Creek to limit saltwater intrusion during the summer months (Roessler et al. 2001, Buchan and Randall 2003).

1932-1960: CONVERSION OF TIDAL MARSHLAND TO SALT PONDS

Tidal marshland along the tidal reaches of Coyote Creek (to the Mud Slough confluence) is among the last tidal marshland in the entire San Francisco Bay-Delta to be diked (**FIGURE IV-6**; Collins and Grossinger 2004).

1933: LAND SURFACE SUBSIDENCE RECOGNIZED

The US Coast and Geodetic Survey first noticed subsidence near San Jose in 1919, but more complete resurveying of the Valley did not take place until 1933. Poland and Ireland conclude that little or no subsidence and groundwater decrease took place prior to 1915. Land subsidence continues until at least 1967 (Poland and Ireland 1988: 18, Ingebritsen and Jones 2000).

1936: COYOTE CREEK FLOW THROUGH COYOTE VALLEY DIVERTED

Approximately one half mile downstream from Andersen Dam, the Coyote Creek Diversion Dam diverts water into the concrete Coyote Canal to control water table elevation for the benefit of agricultural production. The canal follows the foothills for approximately 6 miles before reintroducing flow below the Narrows (Buchan and Randall 2003).

1936: COYOTE RESERVOIR CREATED

The first major dam and reservoir are constructed in the Coyote watershed, to capture seasonal stream flow for groundwater recharge during summer months (McArthur 1981).

1936: CHERRY FLAT RESERVOIR CREATED

Dam installed on Penitencia Creek (Buchan and Randall 2003).

1950: ANDERSON LAKE CREATED

The second large reservoir on Coyote Creek is constructed, with about four times the capacity of Coyote Reservoir (McArthur 1981).

Circa 1950s: HIGHWAY 101 FOLLOWS COYOTE CREEK

Highway 101 crisscrosses the creek and is constructed partially from gravel extracted from the streambed, creating Ogier Ponds (Buchan and Randall 2003: G15).

1953: SADA COE DONATES LAND FOR HENRY W. COE STATE PARK

The largest state park in Northern California protects a significant portion of the upper watershed (Pine Ridge Association 2005).

1956: WATER TREATMENT PLANT IS CONSTRUCTED AT TIDAL MARSH EDGE

The San Jose-Santa Clara Water Pollution Control Plant becomes a major component of the watershed's tidal interface, discharging treated effluent into sloughs. The plant also maintains an agricultural buffer while surrounding bottomlands are developed.

1960s: COYOTE CREEK PARKWAY INITIATED

San Jose and Santa Clara County begin land acquisitions to buffer Coyote Creek with parkland.

1972: FLOOD CONTROL PROJECT ON MID-COYOTE REACH

Project straightens Coyote Creek between Montague Expressway and Highway 880.

1976-1977: DROUGHT

A relatively brief but intense dry period causes groundwater levels to drop as reservoirs run dry (SCVWD n.d.).

1979: LAND PRESERVATION

The City of San Jose, Santa Clara County, and the SCVWD agree to preserve land along Upper Penitencia Creek.

1983: WIDESPREAD FLOODING

Milpitas, Alviso, and South County areas are flooded. Anderson Reservoir exceeds capacity and spills over into Coyote Creek (SCVWD n.d.).

1987-1992: DROUGHT

Low rainfall years continue until 1993 (SCVWD n.d.).

1996: LOWER COYOTE CREEK FLOOD CONTROL PROJECT

Setback levees protect the Alviso area and provide some floodplain access for the creek downstream of Montague Expressway.

1997: COYOTE ACCIDENTALLY DIVERTS INTO OGIER PONDS

A levee break causes the creek to abandon sections of the historical channel and flow through former gravel ponds (Buchan and Randall 2003: 70).

LANDSCAPE TRAJECTORIES

Landscape change is continual — with or without anthropogenic influences — but variable in rate and type. In most densely populated parts of the world, the rates and types of landscape change during the past two centuries have been very different from those preceding. As a result, we presently inhabit and manage landscapes that are responding to both long-term, natural processes and unusual, intensive, recent land use impacts. Understanding the trajectories established during the past two centuries is essential to predicting future landscape trajectories.

CHANNEL CHANGE: COYOTE CREEK TRIBUTARIES

This section describes changes to the smaller, discontinuous channels of the watershed. Direct changes to Coyote Creek itself are discussed in the following section.

CHANNEL STRAIGHTENING AND LENGTHENING

Channel modifications in many parts of the world have involved the conversion of sinuous, natural channels to straighter, engineered channels. That process is a significant but not dominant impact to the tributaries to Coyote Creek. Quite a few streams have, in fact, been straightened by replacement with artificial channels. These include Lower Penitencia, Arroyo de los Coches, lower Berryessa, and lower Norwood Creeks. Artificial channels replacing historical creeks represent about 16% of the present-day valley floor drainage tributary to Coyote Creek; (**FIGURES IV-7A** and **IV-7B**).

The most dramatic modification, however, has been not the alteration of existing channels but the creation of new ones. Artificial channels serving formerly undrained areas make up almost 50% of the present valley floor drainage network tributary to Coyote. Most of this expansion is the simple extension or lengthening of distributary streams in artificial channels across the lower valley floor, from the former terminus (the point of historical distribution) to the Coyote mainstem.

The proportion of natural versus artificial channel varies significantly by creek (**FIGURE IV-8**), mostly depending how far across the valley floor the channel extended under natural conditions. Many of our present-day creeks are, at least on the valley floor, primarily drainage canals created to remove water. Streams such as Upper Penitencia, Thompson, and Silver are mostly historical creeks. Lower Silver Creek and Miguelita Creek are essentially man-made.

EXPANSION OF THE DRAINAGE NETWORK

The dramatic expansion of drainage networks across the valley floor is one of the most significant Euro-American alterations to the Coyote Creek watershed. Increases in both the absolute density of water courses and in their connectivity have fundamentally altered how fast, how much, and which water and sediment are conveyed from the hills to the Coyote mainstem and the Bay. These basic system modifications affect

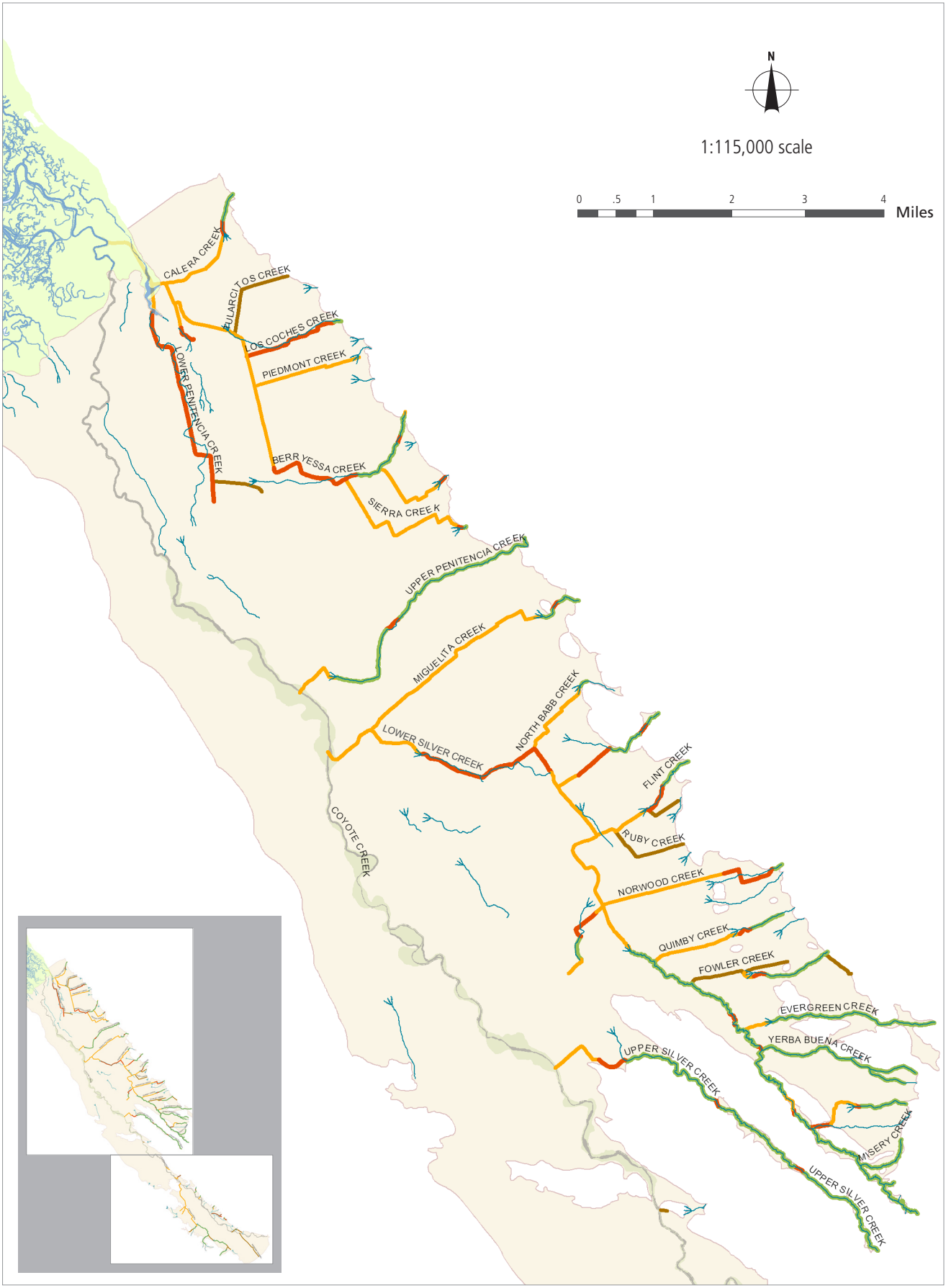
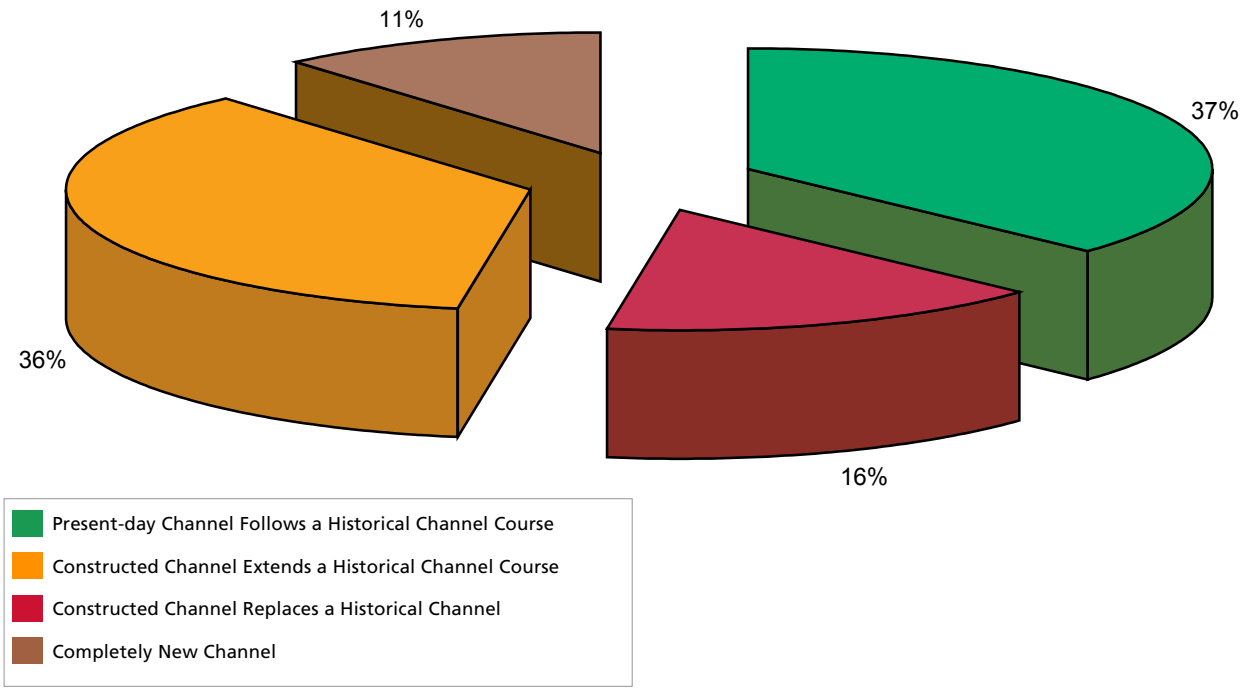


FIGURE IV-7A. EXPANSION OF THE COYOTE CREEK WATERSHED DRAINAGE NETWORK WITH CONSTRUCTED CHANNELS. These maps show both the historical and present-day valley floor creek network. The historical data was developed by SFEI as part of this project. To assess the origin of modern creeks, we compared the historical data to the recently-developed SCVWD GIS. Some very small constructed channel segments may be excluded. See legend on facing page.



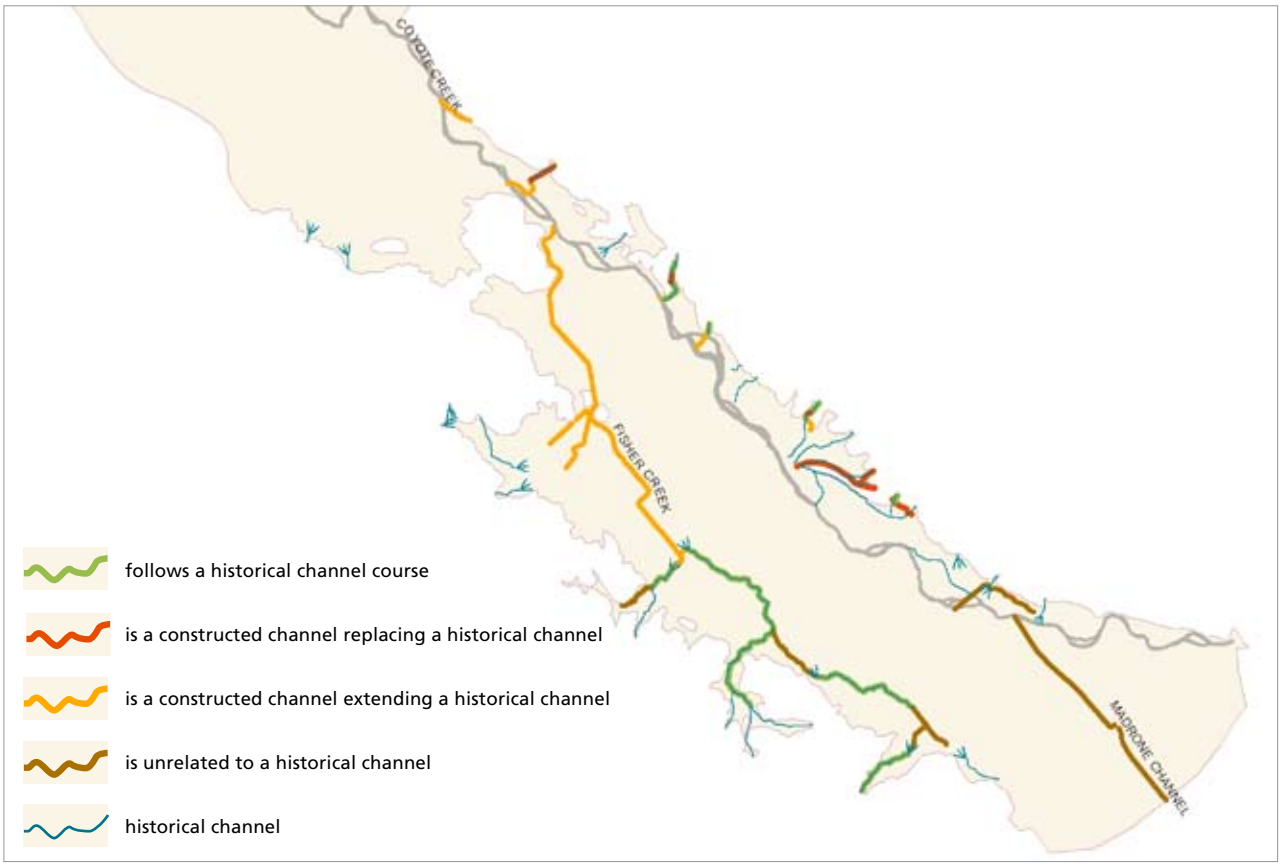


FIGURE IV-7B. ORIGIN OF MODERN CREEKS TRIBUTARY TO COYOTE CREEK (TOP). Nearly two thirds of the tributary drainage network on the valley floor is artificial channel, mostly created to extend discontinuous creeks to the Coyote mainstem.

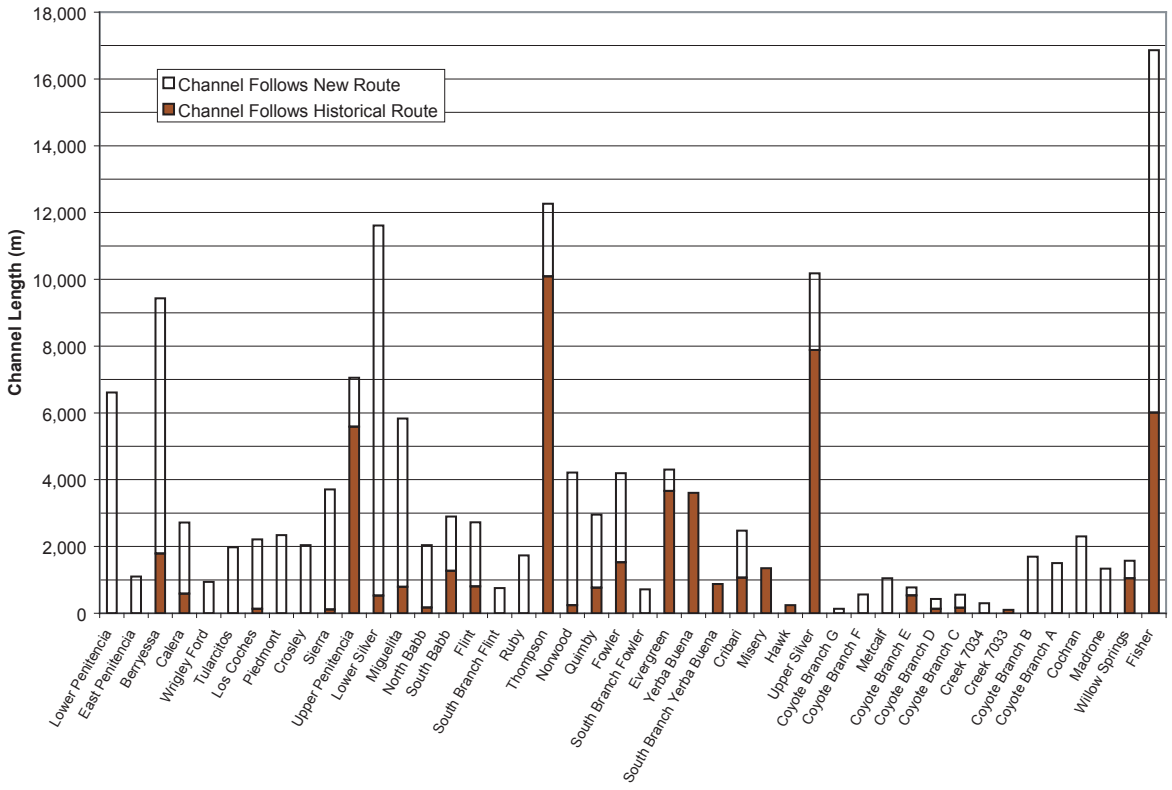


FIGURE IV-8. RELATIVE PROPORTION OF NATURAL VERSUS ARTIFICIAL CHANNEL BY CREEK. This chart considers the valley floor portion of each tributary creek in the Coyote watershed. Some occupy their historical channel across most of the valley floor, while others were mostly created by engineering.

almost every watershed function — from groundwater recharge to the peak and timing of the flood hydrograph, to channel stability. But since many of these modifications took place over a century ago, their continuing effect on current watershed conditions has been largely unrecognized. Understanding early watershed modification is important because it reveals both fundamental alterations to the natural hydrology of the watershed, and also a range of potential opportunities for redesigning watershed drainage in the light of evolving conditions and priorities.

Prior to Euro-American modifications, approximately 105 miles of fluvial channel drained the valley portion of the Coyote Creek watershed. Coyote Creek, by far the longest stream in the Santa Clara Valley, nevertheless accounted for little more than one third of this length, about 39 miles (**TABLE IV-1**). Discontinuous creeks — that is, streams that did not extend continuously from the hills to the Bay or the Coyote mainstem — represented the majority of drainage, 66 miles. (For the purposes of discussion we will also refer to the discontinuous creeks, now mostly tributaries to Coyote, as tributary creeks.) The natural condition of the system maximized the amount of water retained by the basin, both as surface water in the bottomlands and groundwater recharged to aquifers through the alluvial fans.

Since Coyote Creek appears by all evidence to have extended continuously to the Bay under natural conditions, drainage network expansion has taken place exclusively among the other creeks of the watershed. Drainage network increase has occurred in spite of the infilling of about half of the tributary (non-Coyote) creeks that occupied the valley floor. On Lower Penitencia Creek, overflow channels (such as that along lower Coyote Creek), and the lower reaches of many distributary creeks have been infilled.

	HISTORICAL LENGTH (mi.)	HISTORICAL DENSITY (mi./mi.^{2})	MODERN LENGTH (mi.)	MODERN DENSITY (mi./mi.^{2})
[Dis]tributaries	66	0.74	34	0.38
Artificial Channels	0	0	58	0.65
Total (above-ground)	66	0.74	92	1.02
Underground Storm Drains (>24" dia.)	0	0	873	9.74
Total	66	0.74	965	10.8

TABLE IV-1. CHANGES IN THE DENSITY OF DRAINAGE SERVING THE VALLEY FLOOR ALONG COYOTE CREEK. This table presents the total length of natural channel, constructed channel, and large underground storm drains, and calculates the resulting drainage density. Drainage density is calculated both for all aboveground channels and all drainage including storm drains (Area =89.6 mi^2). Because Coyote Creek length has not changed appreciably, these data focus on the tributaries and exclude Coyote Creek(~35 mi.). Storm drain data provided by William Lettis and Associates.

DRAINAGE DENSITY

This loss in historical channel length has been more than compensated by the creation of constructed channels totaling nearly the original length of natural channel. As a result, aboveground drainage density (excluding Coyote Creek) has increased by almost 40% (**TABLE IV-1**).

WATERSHED CONNECTIVITY AND FUNCTIONAL WATERSHED AREA

Increasing connectivity across the valley floor makes the upper watershed more directly linked to the mainstem of Coyote Creek. Prior to modifications, with no direct channel connection to the mainstem, subwatersheds discharged water and sediment to the alluvial fans and bottomlands of the valley floor, where they were largely attenuated before reaching the mainstem.

The process of connecting the upper watershed to the mainstem was initiated early (**FIGURE IV-9**). Originally, with no natural tributaries downstream of Coyote Narrows, Coyote Creek received direct runoff only from the areas above present-day Anderson Reservoir, plus the small eastside tributaries in Coyote Valley. In 1852, the lands above Upper Penitencia Creek were connected directly to Coyote. (Fisher Creek was at least partly extended to Coyote even earlier, but this effort to drain Laguna Seca was apparently unsuccessful.) By 1895, northern tributaries such as Arroyo de los Coches, Calera Creek, and Lower Penitencia Creek had also been connected to the Coyote mainstem. The disconnected watersheds farther south were connected to Coyote Creek by the early 1940s (USACE 1943).

As a result of these efforts to improve valley floor drainage, the directly connected watershed area of Coyote Creek increased by more than 50%. However, simultaneous with the full connection of the upper watershed to Coyote Creek, the construction of Coyote and Anderson Dams in the mid-20th century reduced connectivity. The

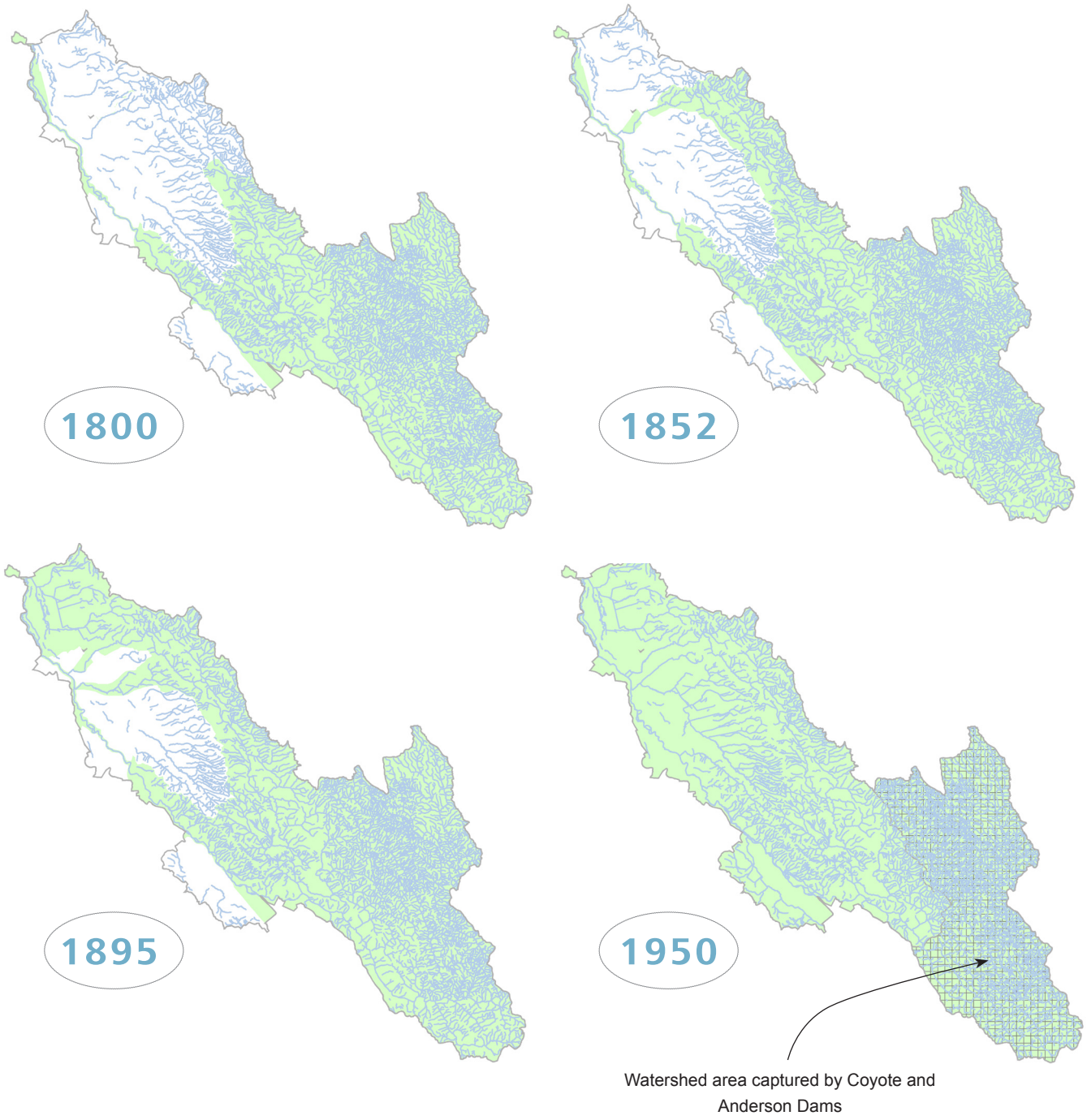


FIGURE IV-9. CHANGES IN FUNCTIONAL WATERSHED AREA. Prior to the expansion of the valley floor drainage network, large parts of the Coyote Creek watershed were not directly connected to the mainstem. The increased channel connectivity expanded the functional watershed area by nearly 60% by the 1940s, before dam construction then reduced watershed connectivity. Now the functional watershed area with regard to sediment transport and flood flow is nearly equivalent to historical, but with a northward shift. (This coarse assessment focuses on the major subwatersheds; smaller areas are not individually considered.)

present area behind these dams, where water and sediment are significantly attenuated from reaching Coyote Creek, is nearly equivalent to that gained from the other subwatersheds. As a result, Coyote Creek's directly connected or functional watershed area has shifted to the north. Because of historical hydromodification, Coyote Creek receives more direct watershed input (e.g. flood flows, sediment) from the subwatersheds immediately to the east (e.g. Silver, Thompson, Norwood, Upper Penitencia). This results in a flashier hydrograph. Farther upstream, the creek receives less direct watershed input.

CONTINUED INCREASE IN VALLEY FLOOR DRAINAGE DENSITY: MODERN "HYDROMODIFICATION"

Channel extension has resulted in the connection of more watershed area to the Bay, either directly or through the Coyote mainstem. Instead of spreading across the valley floor, water from the tributaries is now directly input into the Coyote mainstem. Another type of drainage expansion increases the drainage of the valley floor itself, removing water that falls directly on the alluvial plain. These hydrological features include ditches and storm drains and are designed to drain impervious surfaces in urban areas.

The growth of urban areas has resulted in the massive expansion of drainage network through storm drain construction. On the Coyote Creek valley floor, there are now 873 miles of underground storm drains greater than 24 inches in diameter (see **TABLE IV-1**; data from William Lettis and Associates). For every mile of aboveground channel tributary to Coyote Creek, there are 10 miles of large storm drains underground.

GROUNDWATER RECHARGE EFFECTS

One of the effects of the increased connectivity of upper watersheds to the Bay has been reduced infiltration to groundwater, as water is moved efficiently across the valley floor to prevent flooding. Where many creeks used to spread broadly over the unconfined zone of the Santa Clara Valley Groundwater Subbasin, new channels and storm drains now carry stream flow across the natural recharge areas, reducing natural percolation. We do not know how much natural percolation has been reduced, but it is likely substantial given that "uncontrolled" (unmodulated by management) recharge through creeks still represents approximately 20% of all present-day groundwater recharge (SCVWD 2005). The expansion of the drainage network, and resulting reduction in groundwater recharge, probably contributed to the decline of groundwater levels during the early and mid-20th century.

An indication of the extent to which natural recharge functions have been altered is suggested by the extent of new drainage network constructed directly above the unconfined zone. This portion of the drainage network is designed to rapidly remove surface water that would, in large part, otherwise percolate through these soils to recharge groundwater. Over 25% (~23 miles) of the present-day valley floor channel network tributary to Coyote Creek is new, constructed channel overlying the unconfined zone of the Santa Clara

Valley Subbasin. Even more significantly, 120 miles of large, concrete storm drains (greater than 2 feet in diameter) remove water from the unconfined zone.

The massive extent of constructed drainage within the unconfined zone suggests that there may be potential water supply benefits from strategic drainage redesign. Projects which slow water removal using natural geomorphic features such as swales, floodplains, and natural streambeds in place of concrete beds should be considered for multiple benefits including habitat restoration, flood stage reduction, and groundwater supply.

CHANNEL INCISION

Erosion of channel banks and bed has been recognized as a significant concern on the present-day tributaries to Coyote Creek, because of the effects on both adjacent property and downstream channel conditions. Channel instability is a possible result of channel extension, if constructed channels have established a new gradient and base level where they meet the natural channel (Jordan et al. 2005), potentially propagating upstream downcutting. Increased and flashier runoff from the expanded drainage network would also be expected to cause erosion. Rates and extent of channel incision are clearly highly variable within the watershed, though, even among adjacent streams on the valley floor. For example, we compared an 1854 GLO description of South Babb Creek channel geometry to present-day conditions and found little or no net change over the 150 year period (**FIGURE IV-10**). However, on other Diablo Range tributaries, incision of 5-10 feet or more has been observed in recent decades (Scott Katric, personal communication; Richard McMurtry, personal communication).

Detailed local assessment was beyond the scope of this project, but we were able to identify several sources for long and short-term rates of change in channel geometry. In particular, the field notes of the General Land Office surveys, cross-sectional information from City of San Jose "as-builts," and Santa Clara County historical surveys and bridge-related project field notes are potentially valuable sources of information. Combined with strategic fieldwork, these data should be able to help determine the extent of channel instability and whether observed changes are of recent origin or part of long-term trends.

CHANNEL AGGRADATION

While incision is a concern on the upper alluvial plain, aggradational processes on the lower reaches of tributaries to Coyote Creek are a significant maintenance problem. Hundreds of thousands of cubic yards of sedi-

FIGURE IV-10. CHANNEL FORM AT SOUTH BABB CREEK JUST ABOVE CLAYTON ROAD. Sherman Day described channel geometry at the site in 1854 (p. 509): "deep gully (8 feet deep) 50 links [= 33 ft.] wide." Channel geometry at this site, which has relatively little upstream development, appears to have been highly stable over this period.

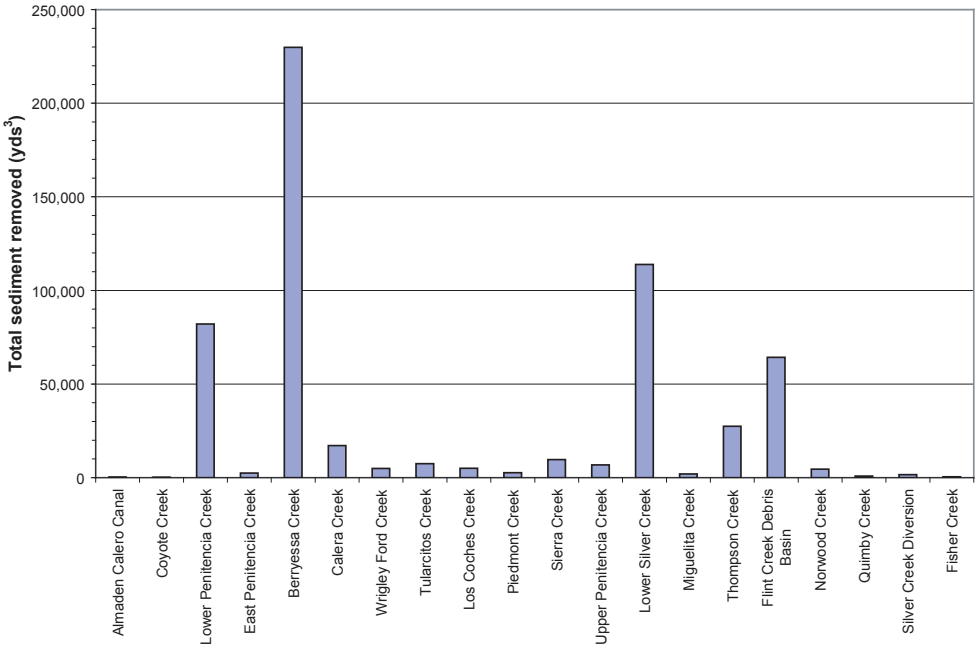


FIGURE IV-11. STREAM SEDIMENT REMOVAL 1977-2004. The extent of maintenance sediment removal varies substantially among Coyote watershed streams. When compared to **FIGURE IV-9**, the major aggradation problems are associated with streams with a high proportion of artificial channel (Lower Penitencia, Berryessa, and Lower Silver Creeks). Sediment data provided by SCVWD.

ment have been removed from these tributaries over the past 25 years, at substantial expense.

As might be expected, stream sediment maintenance removal has been greatest in the stream reaches that were artificially extended across the lower alluvial plain (**FIGURE IV-11**; see also Figure 6-32 in the Baylands Chapter, SCVWD 2005). The streams with the highest amount of total sediment removed — Berryessa Creek and Lower Silver Creek — are almost completely constructed channels extending downstream from the historical distributary point (where aggradation historically precluded a defined channel). In these areas, stream power was naturally insufficient to move watershed sediment across the low-gradient valley bottom. High rates of sediment aggradation on Lower Penitencia Creek, which was, in contrast, a historical stream, are presumably related to increased sediment supply and/or oversized constructed channel dimensions.

CHANNEL CHANGE: COYOTE CREEK

This section describes historical changes to the Coyote Creek channel, including plan form, cross-sectional geometry, active surfaces, and other characteristics. First, we summarize the natural, or pre-modification morphology of the stream. Then we assess specific changes. The extent and character of modification vary substantially by reach and fluvial characteristic. Some attributes of Coyote Creek have experienced dramatic alteration. Other characteristics of the creek, such as plan form, are remarkably unchanged for an urban stream.

PRE-MODIFICATION MORPHOLOGY

Coyote Creek exhibited several distinct geomorphic reaches prior to Euro-American modification (**FIGURE IV-12**). Channel geometry in the tidal reach was controlled primarily by tidal flows, rather than the much smaller fluvial inputs (Atwater et al. 1979). But the freshwater influence did affect channel form through its influence on vegetation. Input from the creek allowed the growth of fresh and brackish channelside vegetation (which can extend lower into the intertidal zone than saltmarsh) resulting in fewer mudflats and narrower, less extensive channel networks (Grossinger 1995). In the tidal reach, Coyote Creek was a distributary system transporting tidal and fluvial water and sediment into and out of a branching network of tidal sloughs.

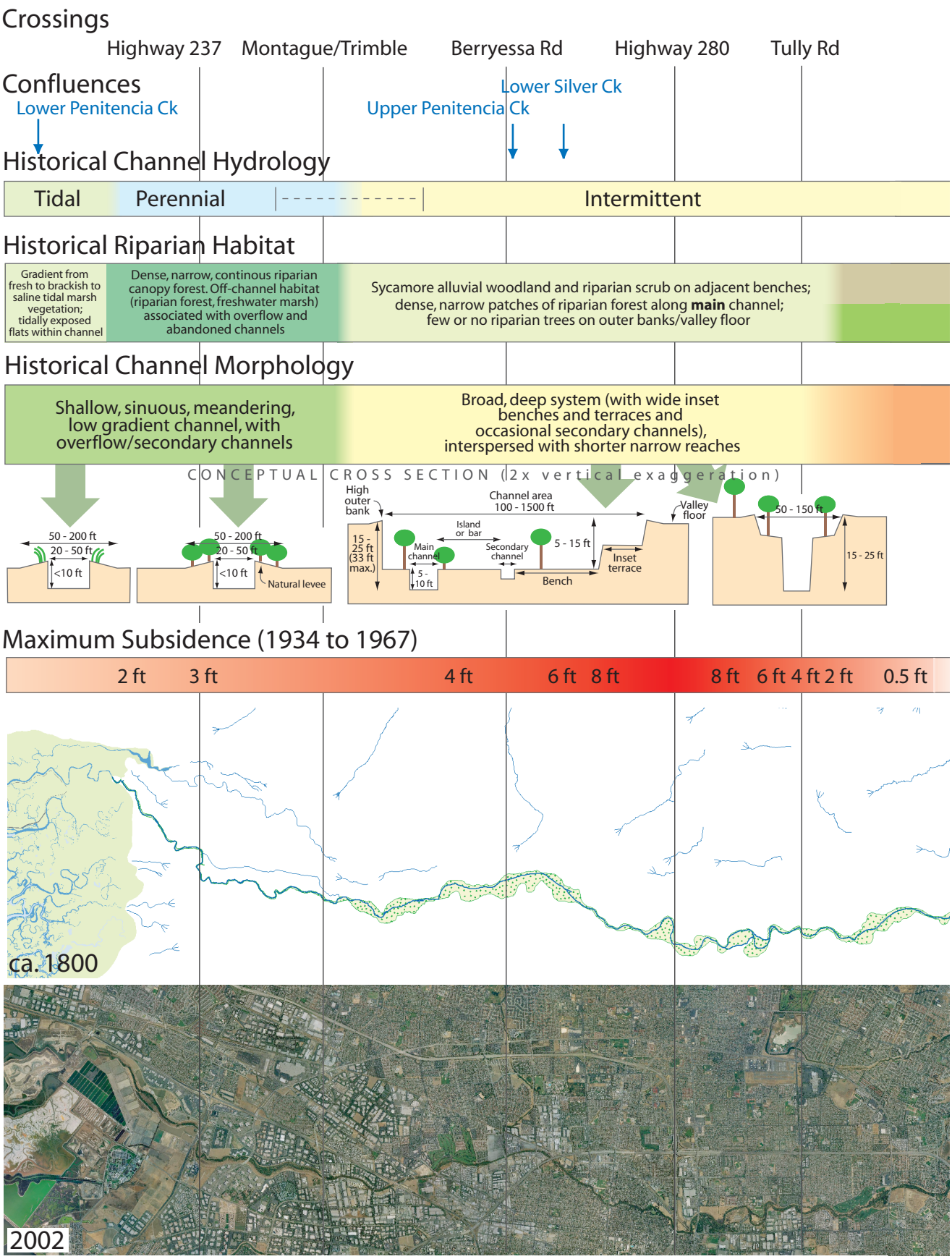
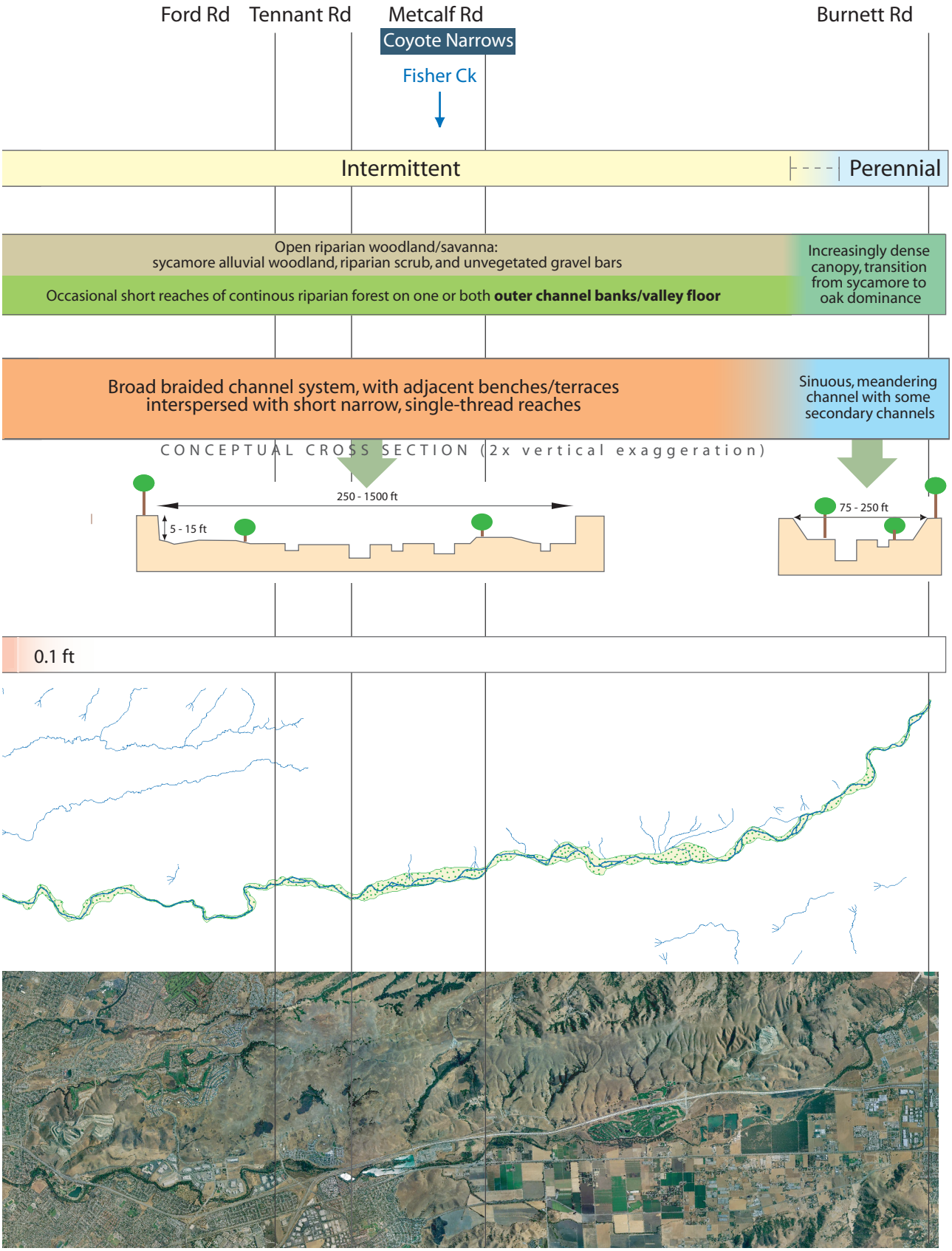


FIGURE IV-12. HISTORICAL MORPHOLOGY, HYDROLOGY, AND HABITAT OF COYOTE CREEK. This diagram shows how key attributes of the creek varied naturally by reach. The close relationships between morphology, habitat, and hydrology indicate how physical and ecological processes are interrelated. Transitions between reaches were gradual and varied through time. Cross-sections are generalized to illustrate reaches based upon historical data (2002 Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).


Ford Rd
Tennant Rd
Metcalf Rd
Coyote Narrows
Fisher Ck
Burnett Rd
Intermittent
Perennial
Open riparian woodland/savanna:
sycamore alluvial woodland, riparian scrub, and unvegetated gravel bars
Occasional short reaches of continous riparian forest on one or both outer channel banks/valley floor
Increasingly dense canopy, transition from sycamore to oak dominance
Broad braided channel system, with adjacent benches/terraces interspersed with short narrow, single-thread reaches
Sinuous, meandering channel with some secondary channels
CONCEPTUAL CROSS SECTION (2x vertical exaggeration)
250 - 1500 ft
5 - 15 ft
75 - 250 ft
0.1 ft

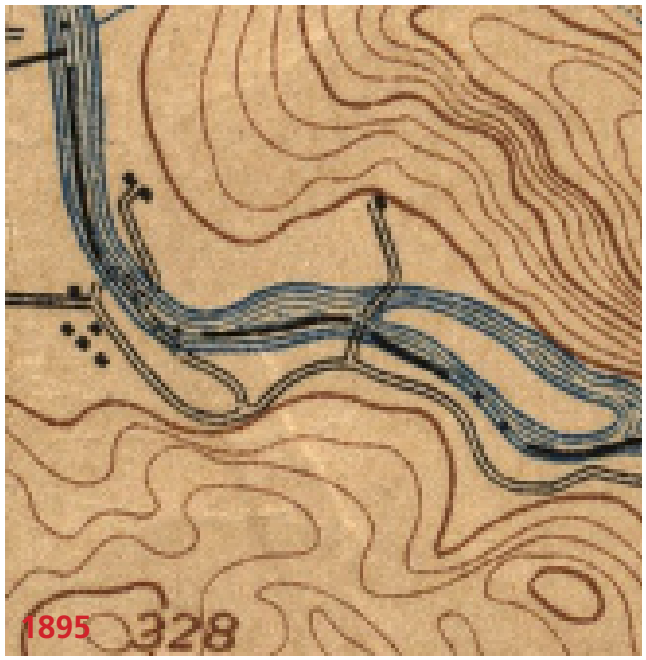
Upstream from tidal influence, Coyote Creek was a relatively shallow, narrow, single thread channel with many of the classic characteristics of a meandering, low-gradient stream. Perennial flow supported dense riparian forest. Channel banks were frequently overtopped during flood events, sending flow broadly across the lower valley floor and through overflow channels. This also deposited fine sediment, contributing to the building and maintenance of natural levees.

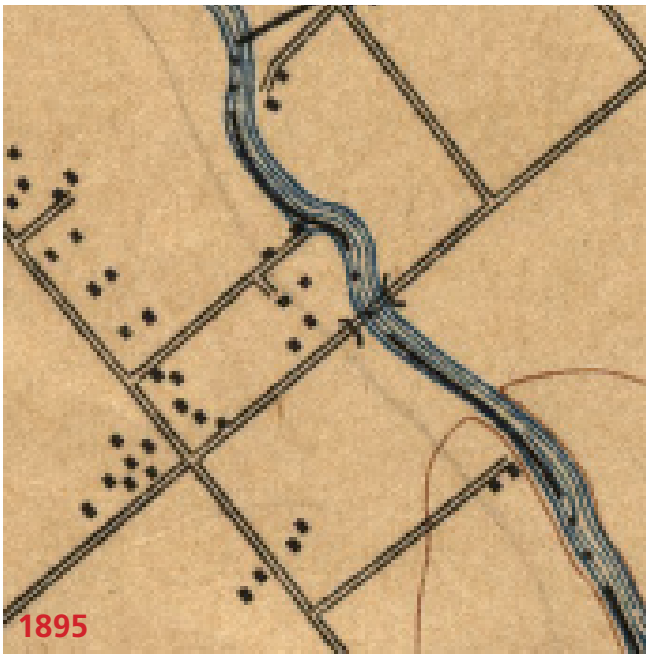
Upstream of present-day Montague Expressway, channel morphology shifted distinctly to the broad, entrenched system that characterized most of Coyote Creek's middle reaches. Here the channel was deeper, with wide adjacent benches inset substantially below the adjacent valley floor. This imposing morphology served as a natural buffer to development immediately along the main channel. Several shorter, narrow reaches without broad benches provided important sites for early crossings (e.g. Southern Pacific Railroad, Oakland Road, Santa Clara Avenue). There were occasional secondary channels and associated bars or islands. The main channel was well-defined but dynamic, with some riparian forest. This entrenchment may reflect Holocene downcutting (or even the draining of the hypothesized Pleistocene Lake San Benito (Jenkins 1973)) before human settlement.

In the vicinity of Tully Road-Capitol Expressway, stream morphology shifted gradually to a wide, braided channel system that continued upstream through most of Coyote Valley. In these reaches, the main channel was less well-defined, comprised of a wide, largely unvegetated area with multiple channels and braid bars. As in the reaches downstream, there were occasional narrow segments with more continuous riparian forest.

While some elevated benches along the braided channel were farmed by 1939, most of the channel area was too gravelly for agriculture. In contrast, the reaches farther downstream supported extensive agriculture within the channel area, presumably on more silty soils. A similar shift is observed in stream substrate today, with small cobble and gravel shifting to silt and sand in the vicinity of Capitol Expressway (Cloak and Buchan 2001: 58). This is also the location in the Valley where unconfined aquifer shifts to confined. The channel area was probably less entrenched than farther downstream, although a 1906 cross-section for one of the intervening narrow reaches indicates that the narrow "nodes" (*sensu* Thorne et al. 2003: 200-201) may have been quite deep (22-23 feet, Herrmann 1905). Another indication of the general shift in morphology above Tully Road is the lack of bridges or crossings upstream of Tully Road. While the six crossings between Trimble and Tully Roads are each shown with distinct bridges in 1895 (USGS San Jose 1899), the upstream crossings are shown as fords without bridges (**FIGURE IV-13**). Fords across the channel bed indicate a less entrenched system, similar to the crossing still in use at the Coyote Creek Golf Club. Additional historical depth data for this reach would be useful to assess bed incision/aggradation.

Braided channel morphology with occasional narrow "nodes" continued upstream through much of Coyote Valley to roughly the present-day Ogier Ponds complex.





The spatial extent of braided channel corresponds closely to the portion of Coyote Creek bordered by steep Diablo Range hills immediately to the east. These small but steep watersheds, which are relatively well-connected to the main channel, may have contributed to the high coarse sediment supply associated with the braided channel pattern (Collison personal communication). The braided reaches appear slightly steeper, albeit not substantially, than downstream reaches — but the longitudinal profile data available for the stream length is likely not sufficiently detailed for this kind of assessment (see **FIGURE IV-19**). Limited historical depth data also suggests a relatively shallow channel. Historical gravel mining and percolation ponds are closely associated with the coarse, permeable bed materials of the braided reaches.

Upstream of Ogier Ponds/Highway 101, braided channel morphology transitioned to a sinuous, meandering channel with common secondary channels. This more thickly wooded reach corresponds largely with perennial flow conditions downstream from the canyon mouth.

CHANNEL STRAIGHTENING AND MEANDER REMOVAL

Along most of the creek (with a few significant exceptions) Coyote Creek's natural plan form has not been substantially straightened by flood control projects. As can be seen in the overlays of the historical landscape map on modern aerial photography in **PART III**, the historical course of the main channel closely matches the present-day channel location in almost all places.

FIGURE IV-13. COYOTE CREEK CROSSINGS IN 1895. As we would expect based upon channel evidence, bridges are commonly shown across the Mid-Coyote reach (lower image, Story Road, note "carrots" on either side of creek indicating a bridge) while fords (indicated by a dashed line) across the channel bed are shown further upstream (upper image, present-day Highway 101 crossing near Cottonwood Lake, USGS [1895]1899, courtesy Earth Science & Map Library, UC Berkeley).

FIGURE IV-14. COYOTE CREEK AT KELLEY PARK, 1939 (LEFT) AND 2002 (RIGHT). Coyote Creek follows a highly sinuous course in this reach. Historical maps (Hermann 1905, Thompson and West 1876) also show secondary channels, which appear to correspond with lines of riparian vegetation distinct from the main channel in 1939 (AAA 1939). By 1939, farms occupy most of the floodplain bench area along the creek; presently, orchard remnants, a parking lot, and several large sycamore trees can be found. A housing development was recently built on the odd peninsula jutting into the creek area at lower middle (2002 Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

There are some significant local changes, however, with the most major alterations associated with the Mid-Coyote reach and gravel mining/percolation ponds in the braided channel reaches. The latter changes are particularly evident in **MAPS 3B-2002** and **4B-2002**. Channel routing through the Ogier Ponds and Coyote Percolation Ponds represents a major alteration in morphology, with many recognized impacts (Buchan and Randall 2003). The SCVWD's 1972 flood control project straightened a mile-long reach of Mid-Coyote Creek, from Montague Expressway to Highway 880, with substantial loss of meanders (see **MAPS 2A-2002**). Along Lower Coyote Creek, meanders have also been removed above and below Highway 237 (see **MAPS 1A-2002**). While the meander immediately south of Highway 237 was removed after 1939, the "S"-bend just north of the highway was removed (or cut off naturally) much earlier, between 1873 and 1897 (see **MAPS 1A-1939**). As a result, this reach would be expected to now be steeper than it was previously, which can cause localized grade adjustments if the reach does not have grade controls (concrete sills, etc).

There remains some uncertainty about alterations to the main channel in the Mid-Coyote reach from Berryessa Road through Watson Park. Here the main channel appears anomalously straight, but sources as early as 1876 show essentially the same course. It is possible that the channel was straightened even earlier, or the alignment may be natural.

APPARENT NATURAL CHANNEL MIGRATION

Interestingly, some of the largest historical changes in the position of Coyote Creek's main channel appear to be the result of natural channel migration.

As discussed in **PART III**, surveyor Howe described dynamic channel conditions in 1851 just south of the Coyote Creek Golf Club, and a 1903 survey confirms lateral migration of about 700 feet. We documented similar changes just downstream of Coyote Narrows based upon GLO notes and Pickwell and Smith (1938). White's reliable 1850 map reveals that a major realignment of the main channel in the mile-long reach surrounding the present-day Highway 280 crossing took place between 1850 and 1876, establishing the current alignment.

Another historical realignment was described just south of this reach at Kelley Park by Ouchi (Ouchi 1983 in Schumm et al. 2000; **FIGURE IV-14**). By comparing USGS quadrangles from 1895 and 1961, he identified a substantial increase in channel sinuousity, which was ascribed to gradient alteration resulting from land subsidence. However, we found that most, if not all, the "new" meanders were, in fact, shown by other early maps (e.g. Thompson and West 1876, McMillan 1904) as primary or secondary channels. These local maps were produced at a more detailed scale than the USGS sources.

It appears that any channel change at this site involved flow-switching (transfer or relocation of the dominant discharge-carrying channel) between primary and secondary channels and, like that observed to the north, took place prior to most land subsidence. Considering these two contiguous reaches together, the interpretation most well supported by historical data is that this highly sinuous reach has been naturally dynamic during historical times.

All of the lateral channel movement observed at the sites discussed above has taken place within the well-defined outer channel banks documented along most of the creek's length. Within this area, the channel appears to have maintained a degree of dynamic equilibrium, with lateral migration contained within the overall channel area of flood-prone benches and terraces.

CHANNEL FILLING

The broad benches along Coyote Creek, particularly those within the original city limits of San Jose (approximately from Berryessa Rd. to Phelan Ave.), served for many decades as a sort of nearby wasteland, providing available space for otherwise undesirable city activities. Local guards turned to "the bed of the Coyote" as the "only safe place to shoot near town" (San Jose Weekly Mercury 1863: 3). These areas were also used as garbage dumps. Gardner et al. (1958: 99) describes how, as late as 1941, these areas were "utilized for grazing, for dumping dirt or building refuse, and as a source of sand and gravel." Since these elevated surfaces of the channel lay 10 or more feet below the adjacent land surface, they provided substantial volume for waste disposal.

Like many early land use activities, the filling of Coyote Creek had been mostly forgotten. For example, present-day Watson Park operated as a city dump for several decades prior to the 1930s and was developed into a city park in the 1960s with no consideration of its prior use (Lynch 2005; **FIGURE IV-15**).

Filling of these benches has had several significant effects. As with Bay fill, Coyote Creek landfill represents a potential source of contaminants to groundwater and, through Coyote Creek, to the Bay. Recent discoveries of elevated levels of lead, arsenic, and other contaminants at Watson Park, where community gardens have been tended for years, has caused substantial community concern and resulted in park closure (Lynch 2005). The City of San Jose is currently assessing contaminant levels and exploring mitigation options (Napp Fukuda, personal communication).

Given the prevalence of wide natural benches along Coyote Creek within the early city limits, it is likely that the Watson Park example is not unique and that other places along the creek received illegal or city-sanctioned dumping. Since historical dump sites represent an important source of some contaminants delivered to the Bay (McKee et al. 2003), landfill along Coyote Creek may represent a significant concern.

Another effect of Coyote Creek landfill was to elevate the level of these channel surfaces, presumably reducing their flood frequency. This is obviously of benefit for certain land uses. But it also suggests an opportunity for "natural flood protection." Floodplain restoration on incised streams often involves excavating new floodplain benches that can be accessed by high flows. In this case, sculpting floodplain benches as part of multi-objective recreational areas could restore them to original elevation and flood capacity.

In fact, most of these former benches still lie substantially below the adjacent valley surface (**FIGURE IV-15**) and many flooded in January 1997 (SCVWD 1997). By reducing channel gradient, subsidence may actually have made flood-prone benches along the Mid-Coyote reach, upstream of the Upper Penitencia Creek confluence, more accessible to high flows than they otherwise would be, and more important for flood protection.

The landfill history may, in some places, provide another incentive for strategic removal of some Coyote Creek landfill. Since areas such as Watson Park still lie within the range of major floods, landfill capping is not a viable option (Fukuda personal communication). In these areas, combining floodplain restoration, increased high flow capacity, and contaminant removal could provide a range of benefits and tap multiple sources of funding.

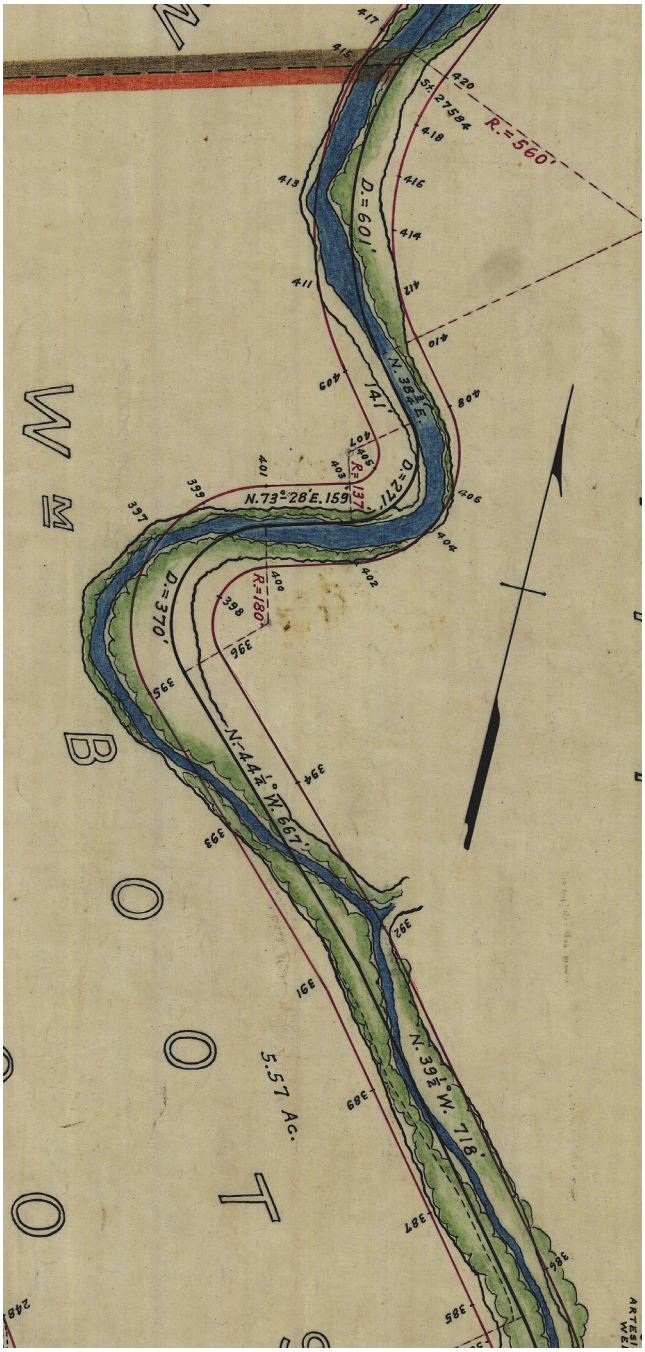
REDUCTION OF CHANNEL AREA

One of the important land use impacts to Coyote Creek has been the encroachment into the broad channel area of parking lots, mobile home parks, commercial buildings, percolation ponds, and other features. Some of this land use involves landfill, but in many other places activity has simply moved into the creek channel area. As early as 1874, Herrmann's Coyote River Survey noted "Bank leveled down and planted in orchard" (Herrmann 1874a) and calculated the area each streamside landowner stood to gain by reclaiming stream benches through the "Proposed Improvements" (**FIGURE IV-16**). Cumulative encroachment of the channel has inevitably reduced overall capacity while placing structures within the range of predictable flooding. An illustration of the reduction of the active channel or riparian area is given in **FIGURE IV-29** and discussed in the section on riparian change.

HIGH FLOW EVENTS AND "BREAKOUTS"

Previous reports have documented flooding along Coyote Creek in the years 1911, 1917, 1931, 1958, 1969, 1982, 1983, and 1997 (WMI 2003: 7-138). Historical data collected in this project indicate flooding also in 1852, 1853, and, likely, 1862. Presumably there were additional flooding events between 1853 and 1911.

FIGURE IV-15. STREAM BENCHES ALONG MID-COYOTE CREEK. Despite filling and grading, these features are still evident along many parts of the creek as distinct "drops" below the adjacent valley floor terrace. Locations are, clockwise from upper left: the Santa Clara Valley Water District's Coyote Creek Outdoor Classroom; private residences on Arroyo Way near William Street Park; Watson Park; Kelley Park; Nordale Ave. near Kelley Park; and private residences on Arroyo Way.



Duryea et al. (1977) speculated that additional floods might have occurred in February 1869; January 19, 1895; and January 14, 1911. Apparently by examining local newspaper accounts corresponding to periods of high rainfall or regionally documented flooding, they evaluated a number of other potential flood events but found "nothing reported in San Jose" for December 1861, January/February 1862, December 1871, November 1885, and November 21, 1900.

A 1927 flood event caused widespread flooding throughout the state and may have also had impacts on Coyote Creek, but does not seem to be noted by these sources. Historical flood accounts for the Valley do, in fact, indicate the heterogeneous and local nature of extreme rainfall events and associated flooding. While most local streams have flooded at times over the past century, flood years vary substantially from stream to stream. Flooding on a given stream is not necessarily matched by flooding on neighboring streams.

On Coyote Creek, high flows during major events caused "breakouts" at specific points along the stream where flood waters overtopped banks. The most well documented area of repeated flooding along Coyote Creek was on its sinuous, shallow lower reaches, below the present-day Southern Pacific railroad crossing, where floods created a massive zone of overflow as Guadalupe, Coyote, and Penitencia merged together and flowed into the marshlands.

In testimony for the land grant case for this area, a local resident described the flooding in 1852 and 1853,

FIGURE IV-16. DETAILED MAP OF LOWER COYOTE CREEK, 1874. Part of Herrmann's 1874 Coyote River Survey, this map shows the main channel and dense, narrow riparian forest along a sinuous channel, immediately downstream of present-day Highway 237. The set of smooth parallel lines illustrates the proposed flood control project, which involved widening the channel and some straightening, while mostly following the general course. For each adjacent landowner, the map indicates the amount of land that stands to be reclaimed by the project (e.g. 5.57 acres are indicated to the right of "Boots") (Herrmann 1874c, courtesy Santa Clara County Surveyors Office).

in response to questioning:

> **Court:** "Were you there during the high water of the winter of 1852 and 1853 and if so did not the Coyote and Guadalupe overflow their banks and run down through the sloughs?"
>
> **Pomeroy:** "I was there and the whole country was overflowed with fresh water" (Pomeroy 1860).

Coyote Creek broke out at several distinct places in this reach, as illustrated in Herrmann's survey two decades later (**FIGURE IV-17**). Just downstream from Trimble Road (present-day Montague Expressway crossing), the creek diverted through the Malovos property and continued west all the way to the Guadalupe River. At the present-day Highway 237 crossing, flow spread both east and west, joining Lower Penitencia Creek and occupying the overflow channels extending northwest into the marshlands.

This event triggered the extensive Coyote River Survey of 1874(c) by County Surveyor Herrmann, as well as consternation about slow County response. The San Jose Mercury reported that:

> "At the junction of the Alviso and Milpitas Road (Highway 237) with the Coyote, the water has backed up and formed a dangerous mudhole, which will long be remembered by all who have had occasion to pass that way. We are glad to be able to state that under the superintendency of the efficient roadmaster Dudley Wells, rocks are being hauled from the hills and a roadbed built across the slough" (Loomis 1986: 29-30).

Herrmann & Herrmann (1876) surveyed a longitudinal profile of the creek below Highway 237, showing that the shallow channel ("slough") had completely filled with sediment and proposed excavation to 4-6 feet depth.

Herrmann's proposed flood control project does not appear to have been constructed as designed, but major levees were constructed along lower Coyote between Highway 237 and Trimble Road before the turn-of-the-century, apparently privately funded:

> "Mr. Malovos secured 260 acres of land, on Coyote Creek in 1870, and at once commenced to improve it. The soil was exceedingly rich and fertile, as it consisted almost entirely of silt deposited by the waters of Coyote Creek, which in winter time formerly spread over the land. Mr. Malovos constructed a levee along the bank of the stream, at great expense, from thirty to forty feet wide at the base, and from ten to fifteen feet in height, for a distance of more than a mile. The work was done most thoroughly, and the levee is safe for all time" (Shortridge 1896: 181).

Malovos understandably had a large incentive, given the breakout route of Coyote Creek through his property shown by Herrmann (1874c) and noted in other maps such as Thompson and West (1876). (Unfortunately, his name was not safe for all time, currently misspelled as Mauvais Lane (USGS 1980) and Malovis Road (CSAA 1998).

In 1897, Westdahl and Morse (1896-97) show continuous levees along both sides of Coyote Creek begin-

FIGURE IV-17. LOWER COYOTE CREEK HISTORICAL OVERFLOW PATTERNS. This map shows the series of "breakouts" along Coyote Creek. Overflow channels extended all the way to Guadalupe River and Lower Penitencia Creek. It also shows the pattern of wide and narrow stream reaches (Herrmann 1874d, courtesy Santa Clara County Surveyors Office).

ning at present-day Highway 237 and extending upstream past the present-day Tasman Drive crossing to about Sycamore Drive (in the area of the Cisco complex). The map ends here, so this flood protection engineering undoubtedly extended some distance farther upstream. Combined with the description of the Malovos levee, the map extends 19th-century levee construction upstream nearly to Trimble Road, that is, almost to the downstream limit of broad channel. In the accompanying descriptive report, Westdahl affirms the extent of early engineering on this reach:

> "To protect the valuable orchards and fields in the low country through which it flows Coyote Creek has been dyked. These dykes rise twenty and more feet above the general level at the Southern limit of the sheet, are broad enough for a road along the top, and are covered with willows and bushes" (Westdahl 1897c: 2-3).

The exact year in which the many breakouts documented by Herrmann (1874c) occurred has not been determined, but examination of newspaper records for the previous several years shows no obvious mention of major flooding. It is possible that the damage was caused by the famous 1862 flood which affected much of California (Charlene Duval personal communication). The lower reach was clearly aggradational and shallow, with substantial sediment supply.

The other important early flood event took place March 7-9, 1911. Local residents were quoted as describing this flood as the largest since 1862, at least on the Guadalupe, and since 1880 on Coyote (Duryea et al. 1977). Accounts of this flood, considered the flood of record on Coyote, describe a similarly broad zone of overflow from Coyote merging with Guadalupe River. The strength of the current is illustrated in a story recounted by Loomis (1986: 63) about the evacuation of a tavern on the Alviso-Milpitas Road west of Milpitas. George Files was forced to evacuate "when the overflow from the Guadalupe River and Coyote Creek began spilling over his polished bar." The boat that rescued him was unable to buck the current and spent the night in Alviso.

Interestingly, while earlier descriptions of Coyote flooding and Herrmann's 1874(c) survey focus exclusively on breakouts downstream of the Southern Pacific Railroad crossing, the 1911 accounts focus farther upstream. Research notes by Duryea et al. (1977), provided by Jim Wang of the SCVWD, report overflowing east of San Jose, the loss of the William Street bridge, and a breakout point at Shallenberger. It is also reported that "water escaped from Coyote through irrigation ditches on Heinlein Place 1 mile south of fill near Coyote Edenvale Hillsdale area."

The Shallenberger breakout point was probably at or near the present-day Brokaw Road crossing. In 1911, Shallenberger Road continued farther north than it does today and joined Brokaw Road (McMillan 1902-1903). The road had been constructed within Coyote's broad active channel area, immediately alongside the main channel, likely on fill. It is not clear if this road segment between Shallenberger and Brokaw was lost due to flooding.

FIGURE IV-18. COYOTE CREEK AT WILLIAM AND OLINDER PARKS IN 1850 (LOWER LEFT), 1939 (UPPER LEFT), AND 2002 (RIGHT). Some evidence of the former main channel course shown by White (1850; courtesy Santa Clara County Surveyors Office) is visible in 1939 (AAA 1939) as less vigorous orchard growth. Martin Park (the triangular green field in the upper right corner of the modern photo) corresponds with the former main channel (2002 Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

It is notable that breakouts were not noted along lower Coyote Creek in 1911. Apparently the levees constructed to protect agricultural land along the narrow, shallow channel below Trimble were successful. At the same time, the tidal reaches were being effectively channelized by the construction of salt ponds (see **FIGURE IV-6**). Reduced flood area along lower Coyote, however, may have increased flood stages upstream. Flooding would also have tended to increase along the broad middle reaches, as benches that previously contained overflow were now reclaimed by fill, orchards, and other land uses. In contrast to the 1911 flooding, in 1888 Foote had authoritatively stated that Coyote Creek's deep and wide channel presented no danger of overflow within the San Jose City limits, (west side of creek approximately from Berryessa Road to Phelan Avenue (see text box at right)). The description of the Edenvale-Hillsdale area flooding also appears associated with early channel modifications including fill and ditches. Additionally, channel scars spreading from the Coyote channel that can be seen in 1939 aerial photography are most prominent in the Shallenberger (Montague Expressway) area, further suggesting upstream migration of flooding effects. Historical flood data and channel morphology also suggest that the large natural flood capacity of the Mid-Coyote reach made flooding of old town San Jose relatively minimal prior to channel modifications.

A present-day potential breakout point of concern is located just upstream of William Street at the Selma Olinder Park (Sibley personal communication, SCVWD 2005).

Horace S. Foote's exceedingly detailed 1888 account of Coyote Creek through San Jose describes channel morphology, lack of flooding, eroding banks composed of coarse sediment, and City-County partnerships for bioengineered stabilization (bold added for emphasis):

> "Coyote River forms the eastern boundary [of San Jose]. **It has a deep, very wide and irregular channel along the city line, and there is no danger of overflow at any place adjoining city territory.** It has been found necessary, however, to protect **its westerly bank, which reaches a height of twenty-two to twenty-five feet**, and consists of a sandy loam, interstratified with sand and fine gravel from the action of the current. This work was done immediately north and south of the crossing of Santa Clara Street, during the years 1875 and 1876, at which time the bank had to be sustained by willow fascine facings and wing-dams, which have ever since remained intact, the willows now forming a dense living barrier, as it were, to further encroachments of the river at these points. The expenditures incurred for this work amounted in the aggregate to the sum of $2,449.70. There was also expended for a somewhat **extensive breakwater embankment, built about one-half mile south of the city** [present-day Kelley Park], during the year 1872, the sum of $3,866.86, this being one-half of its cost, the other half having been paid by the county of Santa Clara. **The embankment was built to avert the danger of overflows from the river at this locality, where its strong current during times of freshets made rapid progress in the destruction of its westerly bank, which consists here also of a sedimentary sandy loam and yields very readily to the undermining and abrading action of flood-waters.** The total cost of river improvement to date has been $44,087.41" (Foote 1888: 160).

Flood-prone conditions here may result in part from the unusually extreme reduction in channel area at the site, where a flood-prone bench historically extended more than 1000 feet to the east (**FIGURE IV-18**). Prior to fill, this reach also likely had a significant secondary channel that meandered all the way to Martin Park (and which was the primary channel circa 1850; White 1850). The secondary channel and large available high flow capacity on the adjacent benches likely reduced historical flooding extent at the site. Now, with more effective flood protection along much of the creek, remnants of these features may provide some of the few remaining conduits for flood flow.

As would be expected, many of the currently flood-prone areas as shown by the 1% Flood Area Map (WMI 2003: 7-135) and SCVWD data are associated with historical channels or wetlands. Projected overflow at the Olinder site would be prevented from returning to the channel by its natural levee and continue into the willow grove and *laguna* area at the downstream end of Upper Penitencia Creek. The flood-prone areas west of Coyote Creek upstream of Highway 280 correspond largely with historical wet meadows, as do areas in Coyote Valley and East San Jose. Most of the areas at flood risk immediately alongside Coyote Creek are developments (or parks) located on Coyote's adjacent benches.

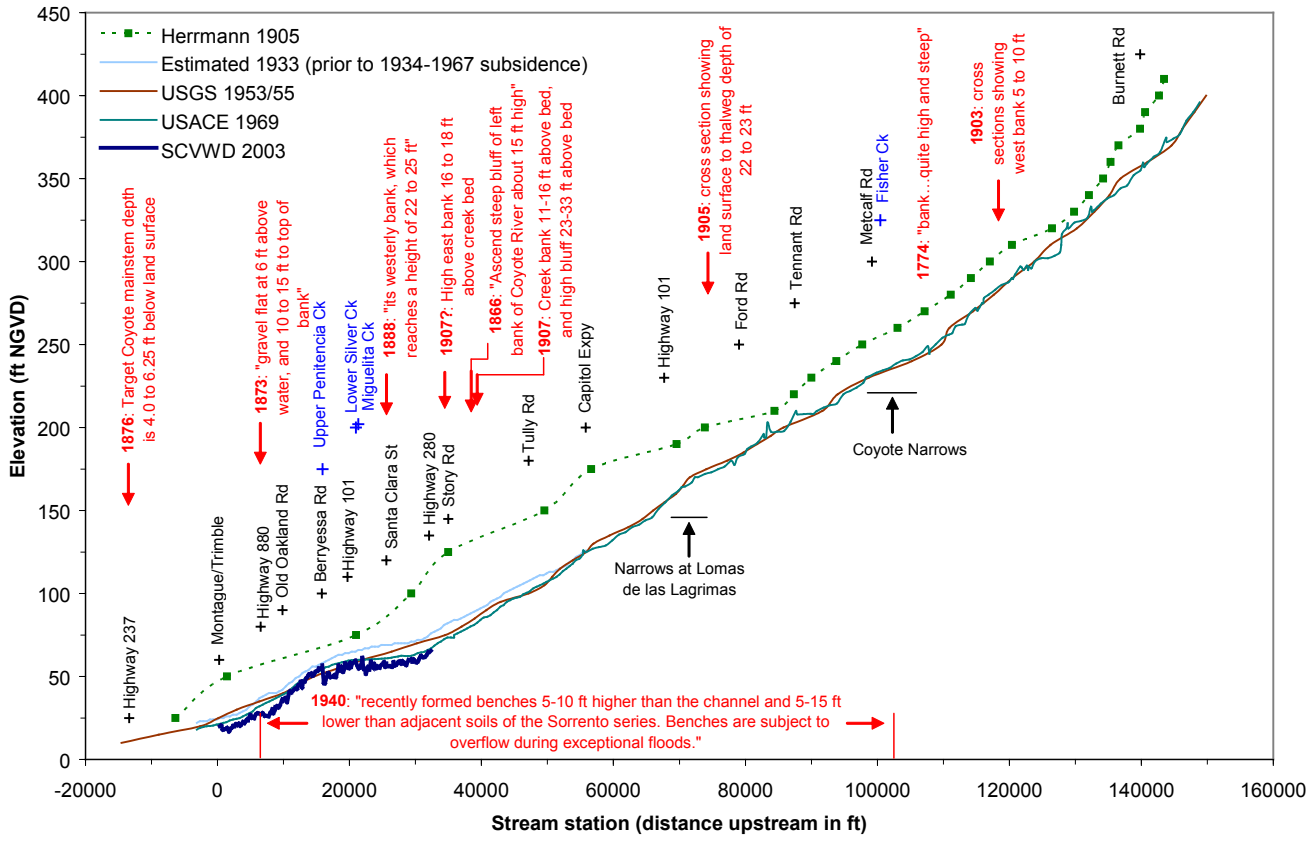


FIGURE IV-19. HISTORICAL AND MODERN LONGITUDINAL PROFILE DATA FOR COYOTE CREEK. See text for details. Comparison to the other data sets indicates that the profile based on Herrmann (1905) is not of comparable accuracy. The Mid-Coyote reach is shown in more detail in **FIGURE II-20**.

VERTICAL CHANGES

Some amount of channel incision could be expected on Coyote Creek in response to the reduction in overall channel area and capacity. The loss of stream sediment to Anderson and Coyote Dams also creates sediment-starved water with a tendency to erode channel banks and bed, although stream power and associated erosive energy have at the same time been reduced by winter flow regulation since 1936 (see **FIGURE IV-27**). Perhaps more importantly, flashier and sediment-depleted peak flows from the now-continuous tributary channels (and associated storm drain networks) may trigger erosion of the Coyote mainstem. Even the increase in riparian tree density, by hardening channel banks, can result in accelerated bed erosion. On the other hand, land surface subsidence in San Jose has created artificially low-gradient reaches that might have a tendency to aggrade rather than incise.

Analysis of change in a stream's longitudinal profile requires both historical information and contemporary data derived from fieldwork. Unfortunately, recent data are only available for the Mid-Coyote reach. We were able to compile several other sources of long profile data, as well as substantial early historical vertical data, but these are of less analytical value until comparable present-day data are developed.

We compiled a longitudinal profile for the entire Coyote Creek valley floor length from the 1969 survey by the US Army Corps of Engineers (US ACE [1969]1970; **FIGURES IV-19** and **IV-20**). We also created a standard longitudinal profile based on contour lines from the current USGS 7.5 minute quadrangles. These data, often the only stream gradient information available for a watershed, have generally not been updated since their original creation. In the case of Coyote Creek, the USGS contour data are truly historical, originating in 1953-1955.

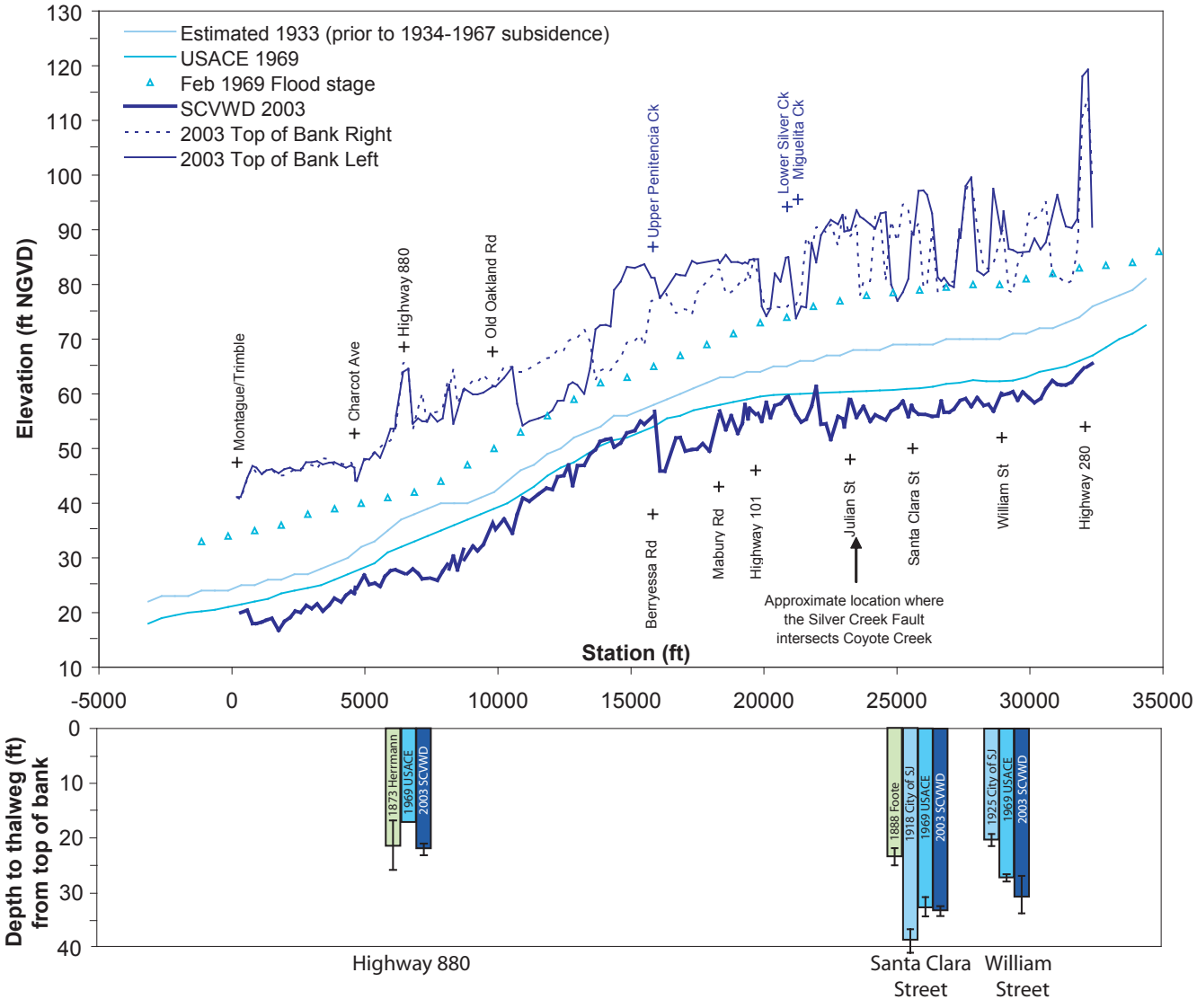


FIGURE IV-20. HISTORICAL AND MODERN LONGITUDINAL PROFILE DATA FOR COYOTE CREEK. See text for details. Since some historical data were not referenced to NGVD (and given changes due to subsidence), we also compiled channel depth data in reference to "top of bank" for this reach (lower part). Error bars on the lower chart indicate the data range (e.g. narrative information such as "22-25 feet" or variability among depths measured from profile).

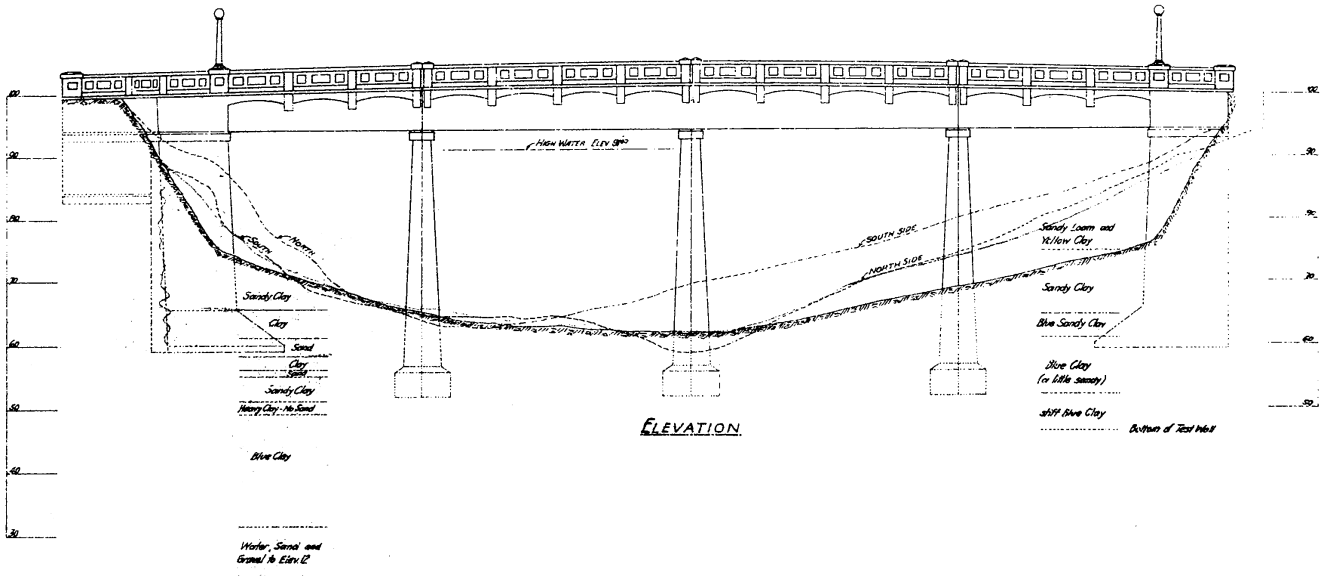


FIGURE IV-21. CONSTRUCTION DIAGRAM FOR THE "SANTA CLARA ST. BRIDGE OVER THE COYOTE RIVER." Courtesy City of San Jose, Department of Public Works (1918).

We also developed a longitudinal profile from the earliest map depicting the full valley floor length of Coyote Creek with fairly detailed contour lines (Hermann 1905). To account for the documented effects of subsidence, we incorporated a profile created by SCVWD staff (provided in hardcopy) to reflect conditions prior to the well-recorded 1934-1967 subsidence. This profile appears to have been created by adjusting a contemporary profile with the subsidence contours created by Poland and Ireland (1988). We made similar adjustments to compensate for subsidence in comparing NGVD-based cross-sections.

We found over a dozen reliable pre-1925 sources of evidence about channel depth, ranging from surveyed cross sections to explicit narrative descriptions. These include an 1863 description of using the creek bed for shooting practice because the "bluff banks effectually prevent any accident from random shots" (from 200 feet distance) and a 1774 explorer's account, as well as a number of late 19th and early 20th-century professional surveys. An example bridge "as-built" providing evidence for historical channel geometry is presented in **FIGURE IV-21**.

This new data set provides evidence along the valley floor length of the creek, although with more information closer to early San Jose (**TABLE IV-2**). These data, including the recent longitudinal data for the Mid-Coyote reach (SCVWD 2003/5), are compiled in **FIGURES IV-19** and **IV-20**. Reconstructed historical cross-sections are presented in **FIGURE IV-22** through **IV-26** in comparison with nearby modern cross-sections.

At present, there are only a few sites where direct comparison is possible. There are also some uncertainties in comparison that could be resolved through fieldwork, namely confirming which channel surface is referred to in bridge as-builts (see William Street example). Based upon these available data, however, we can make some general observations and provide several specific examples. The historical data obtained here provide baseline data for assessing vertical channel change through time more accurately through reoccupation in the field.

Available data at the several sites do suggest that Coyote Creek has generally incised through recorded history. Current low flow channel elevation is consistently lower than or at a similar level to historical elevation.

CREEK	LOCATION	YEAR	EVIDENCE	BED DEPTH	SOURCE
Coyote Creek	immediately downstream of Highway 237	1876 (June)	long profile showing anticipated grade for excavating Coyote Creek following channel breaks. "Old channel" and "waterline" are shown as 1 to 3 feet below land surface. Target depth for "ditch" is just 4-6.25 feet. While the existing depth represents recent aggradation, the shallow target depth is probably indicative of, if not deeper than, prior depth.	<5 feet	Herrmann & Herrmann 1876
Coyote Creek	in the vicinity of Milpitas, probably somewhere downstream of Montague Expressway	circa 1905	two landscape photographs of the same site at different times of year show top of bank~2-3 feet above water surface—water depth likely not more than 3 feet?	5-6 feet?	Hare circa 1905a
Coyote Creek	near Brokaw Road crossing	circa 1880	field notes describe channel geometry in concert with survey: "gravel flat at 6 feet above water" and "10 to 15 feet to top line of bank" [from gravel bar]	16-21 feet	Hermann 1874a
Coyote Creek	just downstream of SP railroad crossing	1874-76	presence of schoolhouse ("Orchard School") in active channel suggests a relatively shallow ("high") inset terrace	NA	Herrmann 1874b, Thompson and West 1876
Coyote Creek	Oakland Road and SP Railroad Crossings	1896	depth cannot be assessed precisely, but bridge piers are fairly high, suggesting top of bank at least 10-15 feet above bed	≥10-15 feet?	Shortridge 1896: 20,174
Coyote Creek	approximately Trimble Road to Coyote Narrows	1940-41	description of benches along Coyote Creek: "The soils occupy small, recently formed "benches" that are generally 5 to 10 feet higher than the channel of Coyote Creek and 5 to 15 lower than the adjacent soils of the Sorrento series"	10-25 feet	Gardner et al. 1958: 99
Coyote Creek	San Jose	1863	"TARGET EXCURSIONS.—The San Jose Zouaves and San Jose Union Guards had their second target practice on Thanksgiving day. The only safe place to shoot near town is in the bed of the Coyote where the bluff banks effectually prevent any accident from random shots"		
Coyote Creek	reaches within the city of San Jose; suggests the vicinity of Santa Clara St.	1888	"Coyote River forms the eastern boundary [of San Jose]. It has a deep, very wide and irregular channel along the city line, and there is no danger of overflow at any place adjoining city territory. It has been found necessary, however, to protect its westerly bank, which reaches a height of twenty-two to twenty-five feet, and consists of a sandy loam, interstratified with sand and fine gravel from the action of the current. This work was done immediately north and south of the crossing of Santa Clara Street, during the years 1875 and 1876..."	22-25 feet	Foote 1888: 160
Coyote Creek	just upstream of Julian St.	1891	Depiction of thousand foot stretch of creek annotated with "Garden Land submerged at high water" (describing bar or terrace between outer line of creek and presumable low flow channel) - a relatively narrow straight reach, perhaps similar to the South 14th St. houses near William Street.		Sanborn 1891: 10
Coyote Creek	Story Road	1907 (?)	500 foot longitudinal profile shows present creek bed 16-18 feet below "High E. Bank" and "Sand Bank" between old and new channels 8 to 10 feet above creek bed.	16-18 feet	Santa Clara County Surveyor 1907 (?)
Coyote Creek	Phelan Ave.	1907	creek "bank" 11-16' feet above bed, and "high bluff" 23-33' feet above bed	22-23	
Coyote Creek	at Needles Drive (just downstream of Phelan)	1866	"Ascend steep bluff of left bank of Coyote River about 15 feet high."	15 feet	Thompson 1866: 166
Coyote Creek	Shady Oaks Park (city; near Silver Valley Road crossing)	1905 (February)	cross-section showing adjacent land elevation (196.7-197.7) and what appears to be a fairly low flow "water level" (175.90); bed elevation may be a little lower (drawing, if to scale, suggests water depth less than 1 foot)	22-23 feet (measured depth to bar surface plus estimated water depth of 1-2 feet)	Herrmann & Bros. 1905
Coyote Creek	South end of Coyote Creek Golf course/ North end of Ogier ponds	1903 (April)	four cross sections along 1000 foot reach; East Bank (may intersect adjacent topography) 14-18 feet above bed, West Bank 5-10 feet	West Bank 5-10 feet	Campbell 1903
Coyote Creek	northern Coyote Valley—the creek approaches El Camino Real in the vicinity of Coyote Creek Golf course	1774 (November 26)	"we came upon a large riverbed, very lined with cottonwoods, sycamores and willows, though without any water; we commenced following along its bank, which was quite high and steep..."		Palou 1774 in Brown 2005: 51-52
Coyote Creek	Gilroy Hot Springs to Anderson Reservoir	1952-53	as part of Master's thesis in geology at UC Berkeley, Frames mapped quaternary terrace gravels alongside Coyote Creek in the canyons above Anderson reservoir ["lower Coyote Creek"]. He notes that: "The Coyote is at present incising these gravels, the present water level being 4 to 6 feet below the terrace level."	4-6 feet	Frames 1955:54

TABLE IV-2. HISTORICAL EVIDENCE FOR CHANNEL DEPTH.

Historical incision may, however, not be as extensive as assumed, because the channel was quite entrenched under natural conditions. Incision over the course of 75-125 years at these sites appears as great as 10 feet in the vicinity of Santa Clara and William Street (**FIGURE IV-22** through **IV-25**) , and negligible farther downstream in the vicinity of Highway 880 (**FIGURE IV-26**). This observation may be explained by the fact that Upper Penitencia Creek provides a substantial present-day sediment source to the lower reaches of the stream.

There does appear to be some consistent incision between 1969 and 2003 at these sites, on the order of 3 feet. Interestingly, this rate of ~1ft/10yrs is similar to the hypothesized long-term rate reported above (roughly 10 feet in 100 years). Comparison of cross-sections from the early 1980s for the Mid-Coyote reach shows a similar trend of approximately 2 feet of incision during 20 years (Sibley personal communication).

Comparison of longitudinal profiles suggests several observations. The profile based on Herrmann (1905), while generally following the modern profiles, does not appear sufficiently accurate for this use. While it shows a pronounced bulge in comparison to the modern profiles, as would be expected given subsequent subsidence, the location is too far upstream (given that subsidence was centered around downtown San Jose).

Even with the correction for subsidence since 1933, the Mid-Coyote reach between Highway 280 and the Upper Penitencia Creek confluence is notably flat. This may be the result of sediment input from Upper Penitencia Creek, which became a tributary to Coyote in 1852. In a stream now starved for upper watershed sediment, Upper Penitencia Creek has likely become an important sediment source for the lower reach. Alternatively, the gradient shift here could be related to the Silver Creek fault.

Given that stream bed erosion has been observed in the vicinity of Santa Clara and William Street since 1888-1925, it is likely that incision would have been even more extreme in the absence of subsidence, which was centered in this vicinity. The stream has been erosive despite a flattening of its gradient and reduced peak flows. Subsidence may have "protected" the reach from even worse incision.

Incision in other parts of the watershed may be more rapid and result from more recent activities. For example, bed erosion in the vicinity of Highway 101 in Coyote Valley has been suggested to result from quarrying activities during the mid-20th century (Reiller personal communication in Buchan and Randall 2003).

HYDROLOGY

This section discusses some of the significant changes affecting the hydrology of the Coyote Creek watershed, including the peak flows, summer flow, and monthly distribution of runoff.

INTERMITTENT VERSUS PERENNIAL FLOW

One of the important questions about the historical hydrology of streams in semiarid California is the

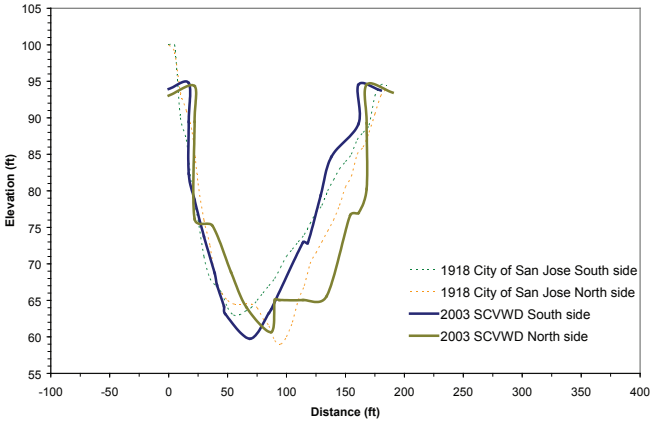


FIGURE IV-22. MEASURED CROSS-SECTIONS AT THE SANTA CLARA STREET BRIDGE. Note the South side cross-sections represent the channel surface on the upstream side of the bridge, while North side cross-sections represent the channel surface on the downstream side. 1918 data from the City of San Jose Department of Public Works. 2003 data from the Santa Clara Valley Water District.

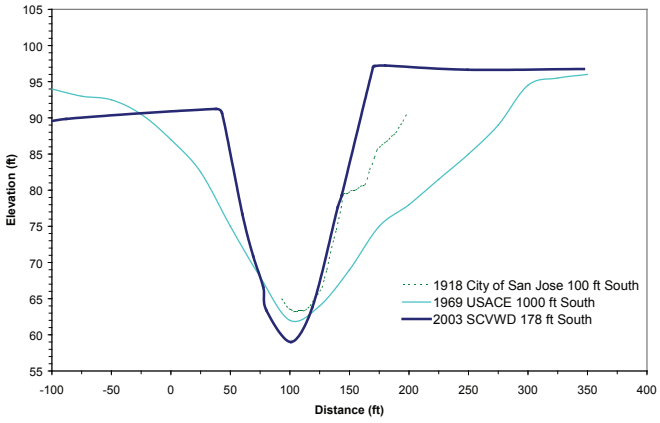


FIGURE IV-23. MEASURED CROSS-SECTIONS TAKEN UPSTREAM FROM THE SANTA CLARA STREET BRIDGE. Note that the three cross-sections represent different locations along the channel length. The 1918 data is from 100 ft south of the bridge (City of San Jose, Department of Public Works, 1918). The 1969 data is from 1000 ft south of the bridge (USACE [1969]1970). The 2003 data is from 178 ft south of the bridge (Santa Clara Valley Water District 2003).

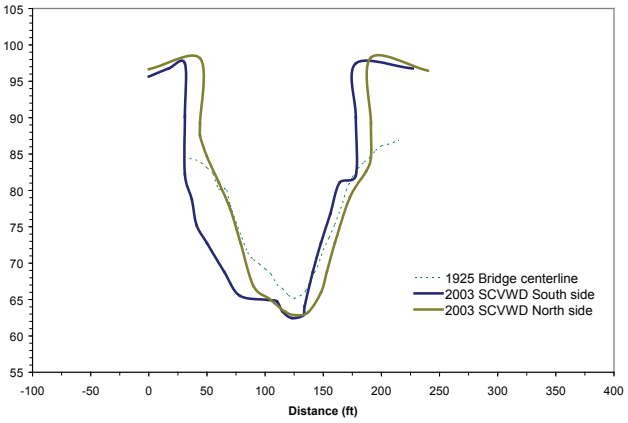


FIGURE IV-24. MEASURED CROSS-SECTIONS AT THE WILLIAM STREET BRIDGE. The 1925 cross-section represents the channel surface at the bridge centerline (City of San Jose, Department of Public Works, 1925). The 2003 South side data represents the channel surface on the upstream side of the bridge, while the 2003 North side data represents the channel surface on the downstream side of the bridge (Santa Clara Valley Water District 2003). We moved the 1925 data down 8 ft to match subsidence shown by Poland and Ireland (1988).

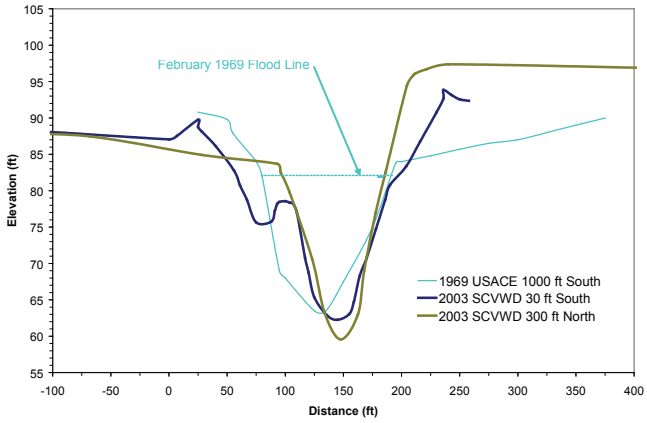


FIGURE IV-25. MEASURED CROSS-SECTIONS TAKEN UPSTREAM FROM THE WILLIAM STREET BRIDGE. Note that the three cross-sections are representing different locations along the channel length. The 1969 data is from 1000 ft south of the bridge, and also shows the flood peak elevation from the February 1969 flood (USACE [1969]1970). The 2003 South side data is from 30 ft upstream of the bridge, and the 2003 North side data is from 300 ft downstream of the bridge (Santa Clara Valley Water District 2003).

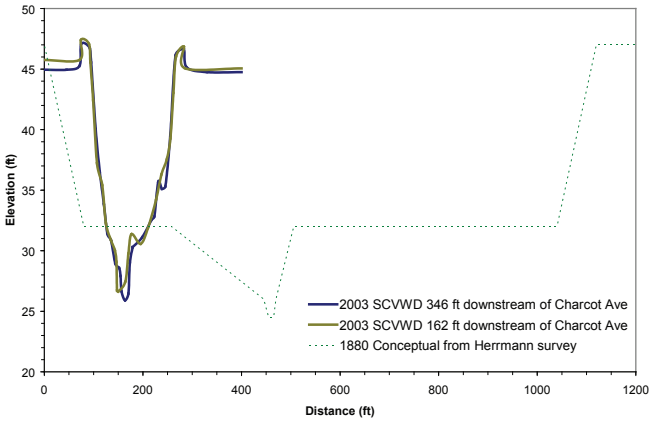


FIGURE IV-26. MEASURED AND CONCEPTUAL CROSS-SECTIONS FROM THE HIGHWAY 880/CHARCOT AVE AREA. Note that the three cross-sections are representing different locations along the channel length. The conceptual cross-section is taken from notes and maps from the circa 1874 survey by Herrmann (Herrmann 1874c). The 2003 data show cross-sections from 346 ft and 162 ft downstream from the Charcot Avenue bridge (Santa Clara Valley Water District 2003).

extent of summertime flow. Given the overall extent of water withdrawal and manipulation for human purposes, a major ecological concern is the maintenance of adequate base flows to support native fish and wildlife species. Relatively large local streams, such as Coyote, are often assumed to have been perennial.

In fact, a wide range of historical evidence confirms that, for most of its length, Coyote Creek was an intermittent stream under natural climatic conditions prior to regulation. As shown in **TABLE IV-3**, evidence for intermittence is reflected through a wide range of years, months, and observers. Accounts of the dry Coyote bed include one of the earliest Spanish explorations in the area and several mid-19th-century travelers' accounts. El Camino Real ran both along and through the creek, so Gold Rush-era visitors coming from the south often commented on stream conditions. An early Mexican map (US District Court 1834) actually incorporates the creek's seasonality into its name ("Arroyo del Coyote *que se seca annualmente*" or "creek that dries annually"), emphasizing this noteworthy condition on the largest stream in the area.

Evidence comes from a wide enough range of years to conclude that these data are not the result of spurious observations during particularly dry years. Intermittent conditions also clearly precede significant anthropogenic groundwater withdrawal. These data also support the finding of very little natural runoff during the months of November and December, as shown by USGS flow data for Coyote Creek near Madrone prior to dam construction, 1907-1935 (**FIGURE IV-27**).

Several explicit narrative descriptions, combined with illustrations of riparian and aquatic habitat, agree that perennial flow conditions on Coyote Creek were historically limited to the lowest reach of the alluvial plain — extending upstream from the tidal reach into the vicinity of present-day Oakland or Berryessa Roads — and the reach immediately downstream from the canyon mouth (present-day Anderson Dam site). Snyder (1905: 329) and Clark (1924: 51) affirm perennial conditions in the lower reach, as would be expected given groundwater emergence and a high water table. Graphic evidence such as willow thickets appearing along the channel in the vicinity of present-day Highway 880 (see **FIGURE II-19**) and evident water in photographs of the Oakland Road-Southern Pacific Railroad (see **FIGURE III-11**) reach also suggest summer flow in the lower reach. On the upper valley floor, early aerial photography shows a clear shift from dense riparian forest to largely unvegetated, gravelly channel between Highway 101 and Ogier Ponds, providing ecological corroboration of the statements by Snyder (1905) and Clark (1924) that summer flow did not extend far from the canyon mouth. Clark (1924: 19) explains the condition of Coyote and other large, episodic, sediment-rich channels of the southern part of the Bay Area: "The channels of Coyote Creek, San Benito River, and Alameda Creek have especially wide gravelly bottoms, which offer opportunity for rapid percolation of their waters into the ground." As a result, of Coyote's 26 mile valley floor length, no more than eight miles (31%) appears to have been perennial.

I= Intermittent; P= Perennial

STREAM(S)	REACH	YEAR	I/P	EVIDENCE	REFERENCE
Coyote Creek	Coyote Valley	1774	I	November 26: "we came to a large river channel, thickly grown with cottonwoods, sycamores, and willows, but without water"	Palou 1774 in Bolton 1930 : 406
Coyote Creek	Ogier Ponds area	1851	I	November 1: "a large creek in wet weather, now entirely dry"	Howe 1851: 89
Coyote Creek	Vicinity of Coyote Narrows (old Monterey Road crossed Coyote Creek at Coyote Narrows)	1849	I	September 1849:: "took the broad highway running southward, up the valley of San Jose. The mountains were barely visible on either side, and the road, perfectly level, now passed over wide reaches of grazing land, now crossed parklike tracts, studded with oaks and sycamores—a charming interchange of scenery. I crossed the dry bed of Coyote Creek several times, and reached Captain Fisher's Ranch as it was growing dusk."	Taylor [1850] 2000: 100-101
Coyote Creek	at The Narrows	1849	I	December 1849: "We then came to a point where the mountain reaches out almost across the valley to meet the mountain on the east side [The Narrows]. Here we found a gravelly creek with but little water, but as soon as we passed this point we saw the valley suddenly widening out."	Manley 1894: 383
Coyote Creek	just downstream of The Narrows	1929-1936	I	"Through most of the year the Coyote channels are dry and surfaced with stream gravel"	Pickwell and Smith 1938
Coyote Creek	between Edenvale and The Narrows	1834	I	Coyote Creek labeled "Arroyo del Coyote que se seca annualmente" [creek which dries annually]	US District Court 1834, 211 N.D., Map D-461
Coyote Creek	from Tully Road to The Narrows	1858	I	October: "It is run dry but during a wet season has an immense body of water flowing in it."	Wallace 1858: 428
Coyote Creek	general description	Summer 1849	I	"the dry bed of a winter stream"	Taylor *in* Carroll 1903: 185
Coyote Creek and other Santa Clara Valley streams	States that the lower fluvial reaches of all creeks, except Coyote, are seasonal. Coyote is mostly seasonal, with perennial reaches just below the canyon mouth and for the lower reach.	1905	I/P	"On the approach of the dry season all the streams of the region [the southern end of the Bay, i.e. Santa Clara Valley streams] rapidly shrink, both in volume and length, only one of them, Coyote Creek, discharging water into the Bay during the entire summer. Much of its bed is dry, however, for part of the year, the water sinking soon after leaving the mountains, and appearing about 2 miles above its mouth."	Snyder 1905: 329
Coyote Creek, Guadalupe River, Stevens Creek, and other Santa Clara Valley streams	Emphasizes that all streams in the Valley are intermittent and specifies some perennial reaches. Explains that lower reaches of streams extending to the Bay are perennial because they intercept the groundwater. Specifies Coyote and Guadalupe downstream of San Jose, and the lower reach of Stevens Creek as well as others, (some of the streams were extended across the valley floor by this time). Also notes that Coyote is perennial a short distance from the mouth of the Canyon (upper gorge).	1924	I/P	"All the streams in Santa Clara Valley are intermittent. Their courses through the valley are usually dry from four to eight months of the year, and occasionally water flows throughout their length for only a few days in the year or perhaps not at all." "Some of the stream channels have been cut down to the normal ground-water level in the lower lands and hence have practically perennial streams in their lower courses. Thus the lower stretches of Coyote Creek, Guadalupe Slough, Stevens Creek, and others carry water except in the very driest seasons. Coyote Creek and Guadalupe Slough may be considered perennial streams from San Jose to the bay. There is usually water flowing at the mouth of the upper gorge of Coyote Creek which disappears almost immediately on reaching the valley, but water reappears in the vicinity of San Jose."	Clark 1924: 51,18-19

TABLE IV-3. HISTORICAL EVIDENCE FOR PERENNIAL AND INTERMITTENT STREAM REACHES

Conditions have reversed today. Most of the stream exhibits perennial flow (Cloak and Buchan 2001). This change has resulted from at least three factors: summer releases from Coyote Reservoir, Anderson Reservoir, and smaller dams; urban runoff, which provides a new source of summer water through 68 storm drains emptying into the creek (Cloak and Buchan 2001); and the increased present-day connectivity of the watershed, which helps deliver urban runoff and shallow groundwater to the Coyote mainstem instead of percolating downward. Environmental improvement efforts have also focused on increasing perennial flow. A Cold Water and Fish Management Zone was recently established by the Fisheries and Aquatic Habitat Collaborative Effort to increase perennial flow below Anderson Dam. The zone largely matches the historically perennial reach, but does appear to extend a mile or more farther downstream. There is also consideration of extending perennial stream flow farther downstream, for the several additional miles through Coyote Valley (FAHCE 2003).

Direct evidence for other creeks in the watershed is less forthcoming, but Mexican-era maps indicate that both Silver and Thompson Creeks were considered "*Arroyo Seco*," indicating that they were seasonally dry. These data affirm the general pattern suggested by Snyder (1905) and Clark (1924), that most creeks were perennial only a short distance from their canyon mouth, at most (**TABLE IV-3**).

It should be noted, however, that intermittent stream reaches, observed to be "dry" or "*seco*" in the summer, can nevertheless maintain subsurface flow and pools with important ecological values. Stream reaches that were historically summer-dry can still become even drier, especially with decreased groundwater levels. In work on a subwatershed of Napa River, Sulphur Creek, we found strong evidence for decreased size and persistence of pools in recent decades, with fewer observed steelhead, even though the stream was historically intermittent (Grossinger et al. 2004). This evidence can often be obtained from interviews with local longtime residents, but because of the time-intensive aspect is most practical at the subwatershed scale.

SEASONAL DISTRIBUTION

The increase in summer flow, and a concurrent reduction in flow during the winter months, can be seen in the dramatically different monthly distribution of runoff before and after the construction of Coyote Reservoir in 1936 (**FIGURE IV-27**). For example, during 1936-1987 summer flow in October was nearly half (43%) the February flow, whereas during the previous three decades (prior to flow regulation), October flow averaged less than 1% of February. These data from the USGS gauging station near Madrone (near the Highway 101 crossing in Coyote Valley) reaffirm naturally intermittent conditions through most of Coyote Valley.

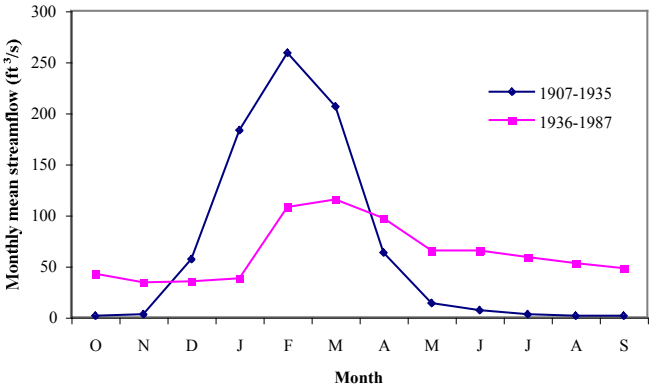


FIGURE IV-27. CHANGE IN MONTHLY RUNOFF DISTRIBUTION FOR COYOTE CREEK. Since the construction of Coyote Dam in 1936, the creek has received reduced winter flows and greatly increased summer flows. Gauge location approx. 1.2 mi. downstream of Anderson Dam and 1 mi. upstream of Highway 101 crossing.

HIGH FLOWS

As is standard in watersheds with significant water reservoirs, peak flows on Coyote Creek have been reduced significantly. For example, while flood flows of 25,000 cfs have been estimated in the past century (1911, Duryea, et al. 1977), the current "planning flood" is 14,500 cfs (Kevin Sibley, personal communication).

RIPARIAN HABITAT

Trends in riparian habitat along the alluvial stream reaches of the Coyote Creek watershed are diverse and spatially heterogeneous. In nearly all places, habitat character and extent has been dynamic under Euro-American management, primarily in response to changes in channel morphology and hydrology.

We observe five general types of change in riparian habitat:

- Complete loss of riparian habitat, where channels have been filled or replaced by artificial channels.
- Reduction in the lateral extent of riparian habitat area along many broad Coyote Creek channel reaches.
- Apparent recovery of narrow riparian forests from historical impacts, with some potential "overgrowth."
- Establishment of riparian tree cover along a few, but not most, engineered channels.
- Conversion of open riparian habitats (e.g. savanna, scrub, gravel bed) to dense forest.

In general, there has been a major expansion in the density of riparian trees in most persisting riparian areas during the second half of the 20th century. This trend, noted by Cloak and Buchan (2001), occurs in a variety of settings. In some places that had dense riparian forest under natural conditions, we may well be observing recovery to more natural habitat structure. But reduced disturbance by high flow events and increased summer stream flow is undoubtedly also causing excessive riparian growth in places. The expansion in riparian growth is particularly noteworthy in the broad riparian areas along Coyote Creek, where significant habitat conversion has taken place.

FIGURE IV-28. RIPARIAN RECOVERY ON LOWER COYOTE CREEK BETWEEN 1939 (LEFT) AND 2002 (RIGHT). Location immediately upstream of Tasman Drive (AAA 1939; 2002 Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

Coyote Creek has been considered to have one of the best-preserved riparian corridors in the region, with much of its riparian corridor "intact" (Cloak and Buchan 2001: 24). Along a significant portion of the creek this is true, and appears to result significantly from recovery in recent decades. On Lower Coyote Creek, where farmers willingly contributed streamside land for the SCVWD's 1996 flood protection project (Fiedler personal communication), there is, in fact, substantially more area dedicated to the stream in places than there was in 1939, and riparian forest has grown accordingly (**FIGURE IV-28**). At the same time, however, 20th-century changes in riparian habitat have greatly altered habitat values along much of the creek. Furthermore, these major ecological changes have not been well recognized because of the lack of historical analysis. As a result, there are a number of ecological functions that could be restored to benefit native species and habitats.

Because there is no existing map of present-day riparian habitat, this assessment must be qualitative. However, recent reports by the Santa Clara Valley Urban Runoff Pollution Prevention Program (Cloak and Buchan 2001, Buchan and Randall 2003) provide extensive and valuable information about present-day conditions. Now that historical riparian habitat patterns have been established, focused assessment to gage current conditions in the context of historical evidence, particularly age and species distribution, would be very useful for documenting trends and resulting management options.

RIPARIAN LOSS

Riparian habitat along the many creeks that have been filled or replaced by artificial channels has been lost. Nearly one quarter (22%) of the historical "tributary" (non-Coyote) streams of the valley floor no longer exist or have been converted to artificial channels. These creeks can be seen in the map of drainage change (see **FIGURES IV-7A** and **IV-7B**) and include a number of the smaller creeks of the watershed as well as some larger ones. Graphic examples are illustrated in **FIGURES II-13** and **II-20**. These smaller, discontinuous creeks may have had naturally sparse tree cover in places, but they were presumably lined by a distinctive herbaceous and shrub riparian plant community. Lower Penitencia Creek supported one of the few low gradient, sinuous,

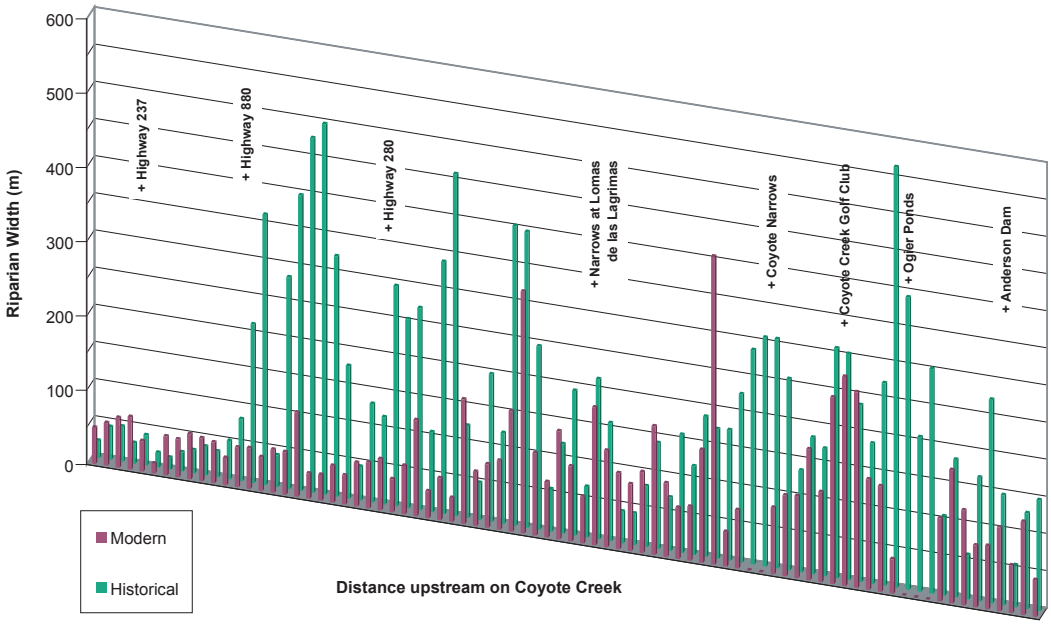


FIGURE IV-29. HISTORICAL CHANGE IN COYOTE CREEK RIPARIAN AREA WIDTH. This graph illustrates the variation between narrow and broad channel reaches along the creek under historical conditions (green bars). Comparison with the modern data (red bars) shows how streamside impacts also vary substantially along the creek. The Coyote Creek Golf Club area shows up as an important reach that has maintained broad riparian function. Reaches immediately above and below, where the channel flows through large ponds, have no effective riparian width and represent restoration opportunities.

dense riparian forests in the watershed — which was removed with conversion to an engineered channel.

Riparian habitat has also been lost along a significant portion of Coyote Creek. The creek's natural form, with a wide gravelly bed and broad benches deeply entrenched below the adjacent valley floor, has been remarkably effective at precluding immediate development, slowing adjacent land use enough to allow conservation of a substantial portion of the channel width. However, gravel ponds, percolation ponds, commercial development, freeway overpasses, city dumps, recreational park features, and housing have nevertheless encroached upon the channel in a number of places, reducing riparian habitat extent. The assessment in previous reports that Coyote Creek's "middle terrace has managed to survive, dominated by cottonwoods, with few remaining oak and sycamore trees" (Cloak and Buchan 2001:24, WMI 2003: 7-139) is substantially accurate in that riparian habitat has survived here more than in most places, but there has been significant reduction and extensive alteration to much of the surviving habitat. There does not appear to have been high terrace (valley floor) riparian forest in the mid-Coyote reach.

To assess this trend in the absence of present-day mapping, we compared the width of Coyote Creek's riparian area as mapped from historical data and present-day data at 2000 foot intervals along the creek (**FIGURE IV-29**). We used a variety of related indicators to define riparian extent, including riparian vegetation and evidence of recent channel scour, gravel deposition, or flooding from historical data and modern aerial photography. For the Mid-Coyote reach, we were able to use a survey of "top-of-bank," which corresponded closely to visible riparian habitat (SCVWD 2003). While this assessment is limited in precision by the lack of field verification, it provides a general illustration of the reduction of active riparian area along the creek. This reduction is most extreme closer to downtown San Jose and in certain Coyote Valley reaches heavily impacted by gravel or percolation ponds. The reaches upstream and downstream of Ogier Ponds stand out as maintaining historical riparian width. Lower Coyote Creek

has maintained or expanded its immediate riparian habitat, although this does not include the reduction in frequently-accessed riparian habitat on former overflow channels, which was lost relatively early.

Conversely, the naturally narrow reaches of Coyote Creek have largely persisted, or recovered. The narrow riparian corridor observed along much of lower and middle Coyote Creek is thus not the result of loss due to urbanization (Buchan and Randall 2003: 46), but in fact reflective of natural condition.

RIPARIAN RECOVERY

Comparative photograph analysis — using both aerial and ground-based images — reveals a number of sites where riparian forest cover along narrow stream reaches has increased. In these places, a sparse corridor of scattered trees and shrubs observed in the late 19th century or first half of the 20th century has become much more dense and continuous tree cover. It is likely that at least some of this riparian expansion represents recovery to more natural conditions after historical impacts from grazing and agriculture, followed by more recent protection from these immediate land use effects. Also, the 1939 aerial photography reflects two decades of unusually low cumulative rainfall — the "Dust Bowl" conditions of the 1920s and 1930s — which may have exacerbated land use effects. Riparian expansion has probably been facilitated by the wetter winters of the last three decades of the 20th century (**FIGURE IV-30**; Poland and Ireland 1988:15-18, Millar and Woolfenden 1999, McKee et al. 2003), but does not appear to be purely a climatic response. For example, in **FIGURE IV-31**, obvious land use-caused gaps in riparian habitat visible in 1939 have filled in substantially since that time. SFEI (2001) observed similar urban riparian recovery during the second half of the 20th century along Wildcat Creek in Contra Costa County. These local examples fit the observation of Leopold (2004: 9) that the return of riparian vegetation helped initiate a "state of healing" on many channels in the western United States beginning in about 1950.

This trend on narrow stream reaches is illustrated in **FIGURE II-20** (right), **FIGURE III-3**, **FIGURE III-10** (left), **FIGURE II-14**, **FIGURE IV-14** and **FIGURE IV-32** (lower middle). Increased streamside land dedicated to riparian habitat since 1939, and associated riparian habitat expansion, can be seen in **FIGURES IV-28** and **IV-31**. **FIGURE IV-32**

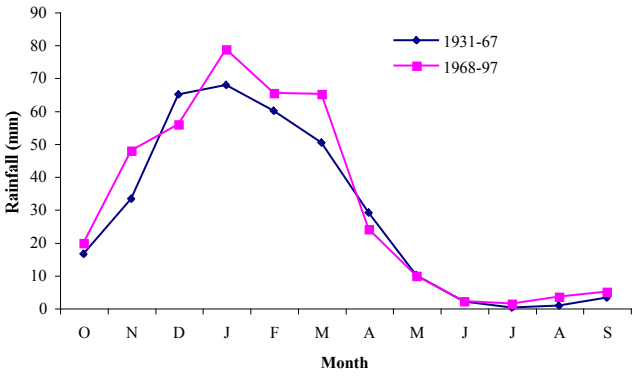


FIGURE IV-30. CHANGE IN MONTHLY RAINFALL DISTRIBUTION FOR SAN JOSE. Average rainfall in the last three decades of the 20th century was greater than the previous decades. Graph from McKee et al. (2003).

FIGURE IV-31. RIPARIAN RECOVERY ON UPPER PENITENCIA CREEK BETWEEN 1939 (LEFT) AND 2002 (RIGHT). The gaps in riparian forest visible in 1939 (AAA 1939), presumably the result of adjacent agricultural practice, have substantially filled in the subsequent years (2002 Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

shows a naturally narrow reach of Coyote Creek along Coyote Road in 1896, 1939, 2002, and 2005 with both aerial and landscape views. Riparian cover has clearly expanded, with mature native tree species, in comparison to the earlier images.

Since riparian habitat is not one of the features mapped precisely by most 19th-century maps, the assessment of pre-modification condition requires some inference and associated uncertainty. Based upon the local history, we would, however, expect to see some reduction in riparian tree cover during the 19th and early 20th centuries — as a result of wood cutting, unregulated grazing along streams and expansion of agriculture adjacent to streams. The impacts of these activities, while likely significant, do not appear to have been extreme. Extensive riparian forest can be seen adjacent to and contemporary with these land use practices throughout this time period — riparian trees were clearly not subject to wholesale clearcuts (see following section).

But many reaches do appear notably sparse in 1939 aerial photography, when compared to 19th-century descriptions, and there are some obvious gaps. So it is probable that the conversion of lands previously used for agriculture, grazing, firewood, and lumber to urban areas has (while having other, negative effects on streams) has effectively buffered the surviving stream reaches from direct impact. Similar "protection" of trees by urban growth has been noted for valley oaks because of reduced seed and seedling predation (Holstein 1999: 56-57).

Given the demonstrable conversion of open riparian habitat to dense cover discussed below, it should be considered to what extent the expansion of riparian cover has been excessive. Increased riparian tree density is a standard response to decreased scour by flows and increased summer water (Kondolf 1996, White & Greer 2006). Cloak and Buchan (2001: ES8) note that expansion of riparian vegetation can result in armored banks, reduced channel width, and channel incision. Excessive tree fall has been reported as a problem in some reaches (Anonymous, pers. comm.), a potential result of riparian overgrowth and incision.

FIGURE IV-32. CHANGES IN COYOTE CREEK RIPARIAN HABITAT ALONG COYOTE ROAD BETWEEN 1896 AND 2005. This set of photographs investigates riparian changes using both aerial and ground-based photographs. As shown in the 1939 photograph (upper left; AAA 1939), the northern half of this reach was broad and characterized by scattered trees. In the southern portion, lines of riparian trees followed a narrow channel, with some gaps. The 1896 photograph of the Swickard property (lower left; from Shortridge 1896, courtesy History San José) appears to have been taken at the point marked on the aerial photographs, looking south along the narrow channel reach. This view also shows gaps in riparian trees. The 2002 (upper right; Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved) and 2005 (lower right) views demonstrate increased riparian cover, and the expansion of dense riparian forest into the former open sycamore woodland habitat to the north.

However, the expansion of riparian trees along narrow channel courses has taken place along not only regulated streams such as Coyote, but also smaller creeks unaffected by dams and, in some cases, largely upstream of urbanization. **FIGURE II-14** shows expansion of riparian cover on unregulated Thompson Creek, while the lower portion of **FIGURE II-20** demonstrates riparian expansion on Quimby Creek clearly unrelated to flow regulation or hydromodification.

In light of the historical data and the functional importance of riparian habitat, some field assessment should be initiated to determine age class distribution and current trajectories of riparian habitat change. Selected sites should be assessed with more detailed sequential aerial photographic analysis and monitored for future change.

RIPARIAN CONVERSION

As discussed above, the observed expansion of riparian tree cover along narrow stream reaches in the watershed appears to be largely a natural adaptive phenomenon, based upon observation of unregulated streams and filling in of riparian gaps during the past 50-75 years. However, along the broad reaches of Coyote Creek, riparian expansion clearly represents the conversion of one type of riparian habitat to another, with a wide range of associated effects.

The development of dense riparian forest in reaches that had relatively little tree cover circa 1939 can be seen especially in **FIGURES II-19**, **III-12**, **III-20**, and **III-26**.

Similar riparian colonization of a constructed channel that replaced a naturally wide, braided channel with the open riparian canopy has been documented over the same general time period on Sulphur Creek in Napa County (Grossinger et al. 2004).

In **FIGURE II-19**, a broad channel area in 1874 supports large willow thickets on the left and several narrow, non-continuous strands of riparian vegetation along the main channel. By 1939, the willow area has been reclaimed for agriculture (apparently with only marginal success) and riparian vegetation is beginning to closely follow the more confined channel. In 2002, the channel has been realigned and fully confined within levees; riparian trees have substantially colonized the altered channel.

As discussed in **PART II**, early aerial photography, mid-19th-century surveys, and extensive descriptive evidence confirm the open character of riparian habitat along the broad reaches of Coyote Creek, from approximately Tully Road to the upstream Highway 101 crossing. In those areas where there was not intensive manipulation, open riparian woodland/savanna conditions persisted through 1939. Most of the riparian conversion has taken place since then.

The expansion of riparian cover is probably mostly due to changes in hydrology, with the added effects of artificial channel confinement in some reaches. Increases in summer flow due to reservoir releases and urban runoff favor expanded riparian growth. Decreased winter high flows reduce disturbance and restrict natural ripar-

ian successional processes, favoring increased riparian recruitment and the persistence of older vegetation. Increased rainfall in the second half of the 20th century also favors the expansion of riparian vegetation.

A shift in dominant riparian tree species supports this interpretation. Historically, sycamores were widely noted along Coyote Creek while cottonwoods were barely mentioned. For example County Surveyor Charles Healy, in his descriptive report for the County to the Surveyor General (1857), writes that

> "The sycamore also grows to a great height along the banks of the creeks. The cotton-wood, willow, and other trees of like species, are found in wet places, and along the small streams."

While the intermittent conditions historically present along Coyote Creek supported sycamores, cottonwoods — previously limited to the few perennially wet reaches — dominate the channel today (Cloak and Buchan 2001: 24). Jepson (1910: 187, 249) notes that the two species occupy almost identical habitats — "the beds or on benches of flood streams" — but that Fremont cottonwood is restricted "almost exclusively [to] the beds or on the banks of ever-flowing streams." A shift from sycamore to cottonwood would be expected effect of the conversion of a semiarid, intermittent stream to perennial flow.

The least amount of riparian conversion has taken place in the historically intermittent reaches in Coyote Valley, north of the upstream Highway 101 crossing, specifically the few reaches that have not been impacted by gravel mining and percolation ponds. The reaches on either side of Ogier Ponds probably represent the closest present-day examples of Coyote Creek's predominant natural character (see **FIGURES III-25**, **III-26**, and **III-35**). The unvegetated gravel bed surfaces and widely spaced riparian trees, with occasional linear strands of dense riparian forest along one bank, are representative of former conditions along much of the creek and have been noted in statewide surveys for such sensitive or noteworthy habitats (see **PART II**).

Enhancement of this reach may be important, given continuing effects of flow regulation and gravel/percolation ponds. The reach is likely sediment starved and its long-term health may be affected by reduced high flows and increased summer flows. Sawyer and Keeler-Wolf (1995: 1) identify "intermittent flooding over broad floodplains and a stable subterranean water table during the dry summer months" as necessary conditions to perpetuate the sycamore alluvial woodland community. Restoration and enhancement goals should be calibrated with an understanding of these natural communities and processes.

Recent assessments of Coyote Creek have noted the challenge of evaluating conditions in the absence of historical analysis (Buchan and Randall 2003: 148). In fact, the historical analysis presented here does help explain the current conditions in new and significant ways. For example, the general decrease in riparian vegetation with upstream extent along Coyote noted by Cloak and Buchan (2001: 62) actually reflects that upstream conditions are closer to the natural, pre-modified state. Decreased canopy cover in Coyote Valley had been speculated to be the result of reduced stream flow caused by upstream water diversion. Accordingly, increased flows and canopy cover have been recommended (Buchan and Randall 2003: 106-

HABITAT	ACREAGE	ESTIMATED ACCURACY
Tidal Flat	1,300	H[1]
Tidal Marshland	10,000	H[1]
Wet Meadow[2]	7,500	H
Saltgrass-Alkali Meadow	4,000	H
Perennial Freshwater Wetlands, incl. Seasonal Lakes	800	M
Perennial Freshwater Ponds	20	M
Willow Groves	400	M
Sycamore Grove	200	M
Valley Oak Savanna	15,000	M
Dry Native Grasslands	29,000	M

[1] Measurement is precise, but boundary of marshland area associated with Coyote Creek could be defined differently. [2] Not including saltgrass-alkali meadows.

TABLE IV-4. ESTIMATED HISTORICAL HABITAT ACREAGES FOR THE COYOTE CREEK STUDY AREA. Areas based upon the GIS map describing the valley floor portion of the Coyote Creek watershed circa 1800. Certainty levels: H,+/-10%; M, +/-50%.

107). In the context of historical data, we might actually consider perennial flows to be a limiting factor to native habitat in this reach. The Coyote Diversion Dam, while having other negative impacts, appears to protect the northern Coyote Valley from excessive summer flows caused by reservoir releases.

This interpretation based upon historical analysis is supported by present-day assessment of fish assemblage. Buchan and Randall (2003: 106) found notably higher fisheries community function in this reach compared to downstream reaches. They hypothesized that the highly native community benefited from fewer pools and common summer dryback, conditions that favor native fish species over non-natives (which are generally less well-adapted to these local conditions). The cessation of diversions to the Coyote Canal since 1998, while generally assumed to have positive effects, should be considered for potentially negative effects on these native fish and riparian communities by increasing summer flow.

WETLAND HABITAT

The extent of native wetland habitats has been reduced in the extreme, primarily as result of increased drainage and urbanization. At the same time, however the bottomlands, where most wetlands were located, have been developed more slowly, because of their poor drainage. Furthermore, clay soils tend to persist (although buried in places). As a result, there are still significant opportunities for wetland restoration associated with some of the less intensively developed areas of the bottomlands. There remains potential to restore some of each of the Valley's native wetland habitat types, including wet meadow, alkali meadow, willow groves, perennial freshwater wetlands and ponds (**TABLES IV-4** and **IV-7**). There is also potential at several noteworthy sites to establish functional mosaics of these habitats, according to the templates described later in this chapter.

NATIVES SPECIES SUPPORT FUNCTIONS

The reconstruction of native habitat types, distribution, and abundance presented in this report provides an important element for prioritizing and designing projects to support native species (Collins and Montgomery 2002). Conservation plans are often hindered by lack of information about historical species distri-

bution to guide the definition of "good habitat" and identification of opportunity zones for restoration. Native habitats, supported by natural hydrogeomorphic processes, often provide a wider range of required species support functions than the more artificial habitats currently available. Identifying "missing" habitat types thus can create previously-unrecognized environmental management opportunities.

This section discusses some of the implications of the historical landscape analysis on native species recovery efforts. It is not intended as an exhaustive assessment of the historical or present status of all species of concern within the watershed. Rather, this section highlights some of the opportunities suggested by the historical analysis. These implications provide a starting point; they should be reviewed, expanded, and adjusted by experienced local ecologists to integrate this information with understanding of present-day populations, non-native species, and other relevant data.

CALIFORNIA RED-LEGGED FROG

The historical landscape mapping may help explain the historical distribution of the California red-legged frog (*Rana aurora draytonii*) in the Santa Clara Valley. At the height of the California frog industry, Santa Clara County was the leading county for supplying red-legged frogs. In 1895, the popularity of red-legged frog legs in San Francisco cuisine drove a Santa Clara harvest of nearly 8000 kg, representing over 40,000 frogs (Jennings and Hayes 1985). However, to date, there has been no direct evidence of the specific habitats from which these large harvests were taken (Jennings personal communication).

The habitat type most widely recognized for red-legged frog harvest in California was the floodplain marshes of the Sacramento and San Joaquin Valleys (Chamberlain 1898 *in* Jennings and Hayes 1985). Santa Clara County, with mostly seasonal streams, did not have broad riverine floodplains with perennial ponds, but did have at least two types of functionally similar habitat. First, the freshwater and slightly brackish tidal marshlands along the Penitencia-Coyote-Guadalupe tidal interface would have provided surface waters likely suitable for breeding. Research at Pescadero Marsh has shown that the species can successfully reproduce with slight saline influences (Jennings personal communication). Secondly, the large freshwater wetland complexes at Laguna Socayre and Laguna Seca likely provided good-quality habitat. Photographs and written descriptions document perennial ponds at Laguna Seca, while Healy (1861) and Schneider (1893) describe similar small perennial water bodies in the Laguna Socayre complex. Surrounded by open grassland habitat, these were likely ideal red-legged frog habitat. Laguna Seca, with its potential for wetland restoration, may provide a significant opportunity for recovery of original habitat for the species.

FISH HABITAT AND ASSEMBLAGES

The restoration and conservation of native fish populations in the Santa Clara Valley is an important natural resource goal. Setting management targets for the restoration of native stream fishes requires an understanding of historical reference conditions. However, there remain

HABITAT	EXAMPLE (S)	PROBABLE FISH ASSEMBLAGE[1]
Fresh and brackish tidal channels	Tidal reaches of Lower Penitencia Creek, Coyote Creek, and artesian sloughs and the tidal marshlands downstream from these freshwater sources	White sturgeon, thicktail chub, Sacramento blackfish, Sacramento splittail, Sacramento sucker, longfin smelt, threespine stickleback, prickly sculpin, Pacific staghorn sculpin, Sacramento perch, tule perch, shiner perch, longjaw mudsucker, starry flounder
Shallow, sinuous, well-wooded perennial lowland stream reaches	Lower Coyote Creek, Lower Penitencia Creek (?)	Pacific lamprey, western brook lamprey, thicktail chub, Sacramento blackfish, hitch, Sacramento splittail, Sacramento pikeminnow, Sacramento sucker, Chinook salmon (?), threespine stickleback, prickly sculpin, tule perch
Well-wooded, perennial stream reaches immediately downstream from the canyon mouth	Coyote Creek immediately below Anderson Dam, Upper Penitencia Creek (?)	Pacific lamprey, thicktail chub, hitch, California roach, Sacramento pikeminnow, Sacramento sucker, Chinook salmon (?), rainbow trout/ steelhead, threespine stickleback, prickly sculpin, Sacramento perch, tule perch,
Distributary streams terminating in seasonally flooded lowland habitats	Upper Penitencia Creek, Berryessa Creek	Rainbow trout/steelhead, Pacific lamprey, California roach, Sacramento sucker, threespine stickleback, prickly sculpin, riffle sculpin (Upper Penitencia Creek only)
Distributary streams terminating in relatively dry habitats a mile or more from a mainstem channel	Calera, Norwood, Babb Creeks	Resident rainbow trout, California roach, threespine stickleback, prickly sculpin
Seasonally-flooded bottomland habitats	Perennial ponds, seasonal lakes, freshwater marshes, and wet meadows throughout the valley floor; Laguna Seca	Thicktail chub, hitch, Sacramento blackfish, Sacramento pikeminnow, Sacramneto sucker, prickly sculpin, Sacramento perch, tule perch
Broad, seasonally dry channel beds with scattered persistent, shaded pools	Coyote Creek from ~Tully Road through Ogier Ponds	Thicktail chub, hitch, California roach, Sacramento blackfish, Sacramento pikeminnow, speckled dace, Sacramento sucker, prickly sculpin, threespine stickleback, Sacramento perch, tule perch
Perennial, shaded upper watershed riverine habitat	Arroyo Aguague, San Felipe Creek	Coho salmon (?), steelhead/rainbow trout, Pacific lamprey, California roach, Sacramento sucker, riffle sculpin

[1] the probable fish assemblages members could occur in any combination, not necessarily all members would be present at any given site.
Leidy et al. 2005a,b; Leidy 2004; Gobalet et al. 2004; Buchan et al. 1999

TABLE IV-5. PROBABLE HISTORICAL HABITAT-FISH RELATIONSHIPS IN THE COYOTE CREEK WATERSHED.

substantial questions about the distribution of fish species under natural conditions and therefore, about which species may be appropriate restoration targets (Leidy et al. 2005a,b, Buchan and Randall 2003).

WHICH SPECIES LIVED WHERE?

The diverse channel morphology and riparian habitat types within the Coyote Creek watershed historically provided habitat for a diverse array of fish species. Specific life history requirements limited each species to a distinct subset of the aquatic habitats within the watershed. The understanding of habitat characteristics developed in this study provides an environmental framework for predicting associated species assemblages. We developed a set of fish habitat relationships based on this information and the strong data set of historical records of fish in the watershed. Such an approach has been used to assess the historical distribution of native fishes in Estuary streams, including Coyote Creek (Leidy et al. 2005a,b, Gobalet et al. 2004, Leidy 2004, Buchan et al. 1999). Native fish assemblages associated with major habitat types in the watershed are summarized in **TABLES IV-5**. Supporting evidence is listed in **APPENDIX 1**.

In the lowest part of the watershed, perennial stream flows created freshwater-influenced tidal conditions similar to (albeit with lesser spatial extent) the northern San Francisco Estuary and Delta, and supporting many of the same fish species. Fresh-to-brackish conditions per-

sisted in and along the tidal channel networks radiating from freshwater sources such as Penitencia Creek, Coyote Creek, and Guadalupe River, as well as the smaller, spring-fed sloughs between Coyote Creek and Guadalupe River. Freshwater tidal conditions also extended upstream along these few creeks that reached the Baylands interface. Thus the lowest reaches of Penitencia Creek, Coyote Creek, and the artesian sloughs also provided estuarine conditions with freshwater influence. These tidally-influenced areas offered shifting patches of habitat influenced by complex seasonal and annual changes in the salinity gradient, as affected by fluvial and spring discharges, tidal cycles, and total watershed outflow.

A number of species have been documented from these tidal freshwater environments on Coyote Creek, including Sacramento splittail, Sacramento perch, tule perch, white sturgeon, thicktail chub (now globally extinct), Sacramento sucker, longfin smelt, juvenile (rearing) and adult (migrating) salmonids, threespine stickleback, prickly sculpin, starry flounder, and staghorn sculpin. **APPENDIX 1** provides these references.

With planned tidal marsh restoration and significant present-day treated wastewater discharges near the mouth of Coyote Creek (and noting the challenges with native fish recovery in the Delta), restoring native brackish tidal marsh habitat and associated fish assemblages in the Coyote Creek delta would be a goal of regional significance.

The Coyote Creek watershed also had a lowland river component not dissimilar in microcosm to Central Valley streams. Downstream of approximately Trimble Road, Coyote Creek and probably Penitencia Creek were shallow, slow-moving perennial streams with mostly continuous riparian canopy (illustrated in **FIGURES III-4** and **III-11**). Lowland non-tidal riverine and brackish-tidal fish species occupied these sinuous, shaded reaches that comprised several miles of habitat. Species likely include Pacific lamprey, western brook lamprey, thicktail chub, Sacramento blackfish, hitch, threespine stickleback, Sacramento splittail, Sacramento pikeminnow, Sacramento sucker, prickly sculpin, Sacramento perch and tule perch. Based upon the habitat conditions, it is possible that Chinook salmon spawned in low-gradient riffle habitats here, although, to date, we have found no specific evidence for that historical use.

Coyote Creek also supported a perennial reach with relatively dense riparian canopy for several miles downstream from the canyon mouth (i.e. downstream of the present-day location of Anderson Dam). Species likely found in this reach include Pacific lamprey, thicktail chub, California roach, Sacramento pikeminnow, Sacramento sucker, rainbow trout, threespine stickleback, prickly sculpin, Sacramento perch, and tule perch. It is possible that this relatively small area may have had some value for Chinook in some years, although there is no specific evidence of this. Perennial, shaded reaches of the upper watershed, such as San Felipe Creek, likely provided high quality habitat for coho salmon and steelhead/rainbow trout.

We would not expect the braided reaches of Coyote

Creek — with intermittent flows and limited riparian cover (illustrated in **FIGURE III-22**), to have provided reliable habitat for salmonids except as a migratory corridor for juvenile and adult fish. However, it is likely that persistent pools of varying depths, partially maintained by zones of shallow groundwater discharge, were found at intervals along the creek (as noted by Day (1854: 514) near the present day Cottonwood Lake). These reaches had occasional dense riparian forest stands, as is affirmed by patches of willows and cottonwoods noted by expeditions in 1774 (Brown 2005: 17), and riparian forest stands visible in early aerial photography. These sites probably constituted important refugia for a distinctive fish assemblage of up to eleven species associated with braided channel streams. As stream reaches dried, fish would likely persist in the deeper, permanent pools. Fish species found within pool refugia may have included thicktail chub, hitch, California roach, Sacramento blackfish, Sacramento pikeminnow, speckled dace, Sacramento sucker, threespine stickleback, prickly sculpin, Sacramento perch, and tule perch (Leidy 2004).

The discontinuous nature of fluvial channels throughout much of the Valley may have precluded access by salmonids to some of the smallest creeks of the watershed during recent climatic regimes. Discontinuous creeks that terminated a mile or more from a mainstem channel or the Bay, with extensive dry land habitats in between, may not have supported consistent salmon or steelhead runs. These include many of the smaller creeks of the Diablo Range (e.g. Calera, Norwood, Babb). However, some of these creeks with suitable headwater habitat may have supported resident populations of rainbow trout that colonized during wetter epochs when fluvial connections to the mainstem channel or Bay may have been stronger.

Another class of streams had discontinuous channel connections to the Bay, but came farther down onto the valley floor. In these cases, the distributary point and the Coyote mainstem channel were separated only by a series of closely connected, occasionally flooded marshes and wet meadows. Streams entering the valley floor relatively close to the Bay, such as Penitencia Creek, Berryessa Creek, and perhaps Arroyo de los Coches, fit this category. The intervening wetland habitats probably provided little barrier to steelhead, which could persist in the upper watershed as resident rainbow trout in years when downstream flooding and ponding did not occur. These streams probably did not provide habitat suitable for coho and Chinook salmon.

In the case of historically discontinuous streams, recent human development of a continuous channel connection likely improved access to some streams for steelhead, Chinook salmon, and possibly coho salmon. For example, it is not unlikely that the 1852 diversion of Penitencia Creek into Coyote Creek while depriving the downstream freshwater wetlands and Lower Penitencia Creek of overflow, established a new corridor for salmon to reach the high-quality habitat on Upper Penitencia Creek. Thompson and Silver Creeks, with 8-10 miles of meadows between their distributaries and the initiation of the continuous Lower Peniten-

cia Creek channel, probably supported only marginal steelhead runs and resident populations of rainbow trout. Smaller tributaries with discontinuous connections to the main channel and Bay likely also supported Pacific lamprey, California roach, Sacramento sucker, threespine stickleback, and prickly sculpin.

With more frequent connection historically between fluvial channels and their floodplains, a distinct fish assemblage would have followed spreading surface waters to forage in the bottomland floodplain habitats. Species such as thicktail chub, hitch, Sacramento blackfish, Sacramento splittail, Sacramento pikeminnow, Sacramento sucker, prickly sculpin, Sacramento perch, and tule perch would have benefited from seasonal access to the freshwater marshes, seasonal lakes, and wet meadows of the valley floor.

Native fishes also undoubtedly used Laguna Seca. The same assemblage described above for large lowland floodplain habitats would also likely have used the aquatic habitats available here at this wetland complex (illustrated in **FIGURES II-11** and **III-29**), especially tule perch, Sacramento perch, thicktail chub, Sacramento splittail, Sacramento blackfish, Sacramento pikeminnow, hitch, and prickly sculpin.

Given their threatened status, the societal focus on salmonid species for conservation actions is well-justified. However, much of the Coyote Creek watershed currently provides suitable habitat for a range of other important native species, and other stream reaches have the potential to be enhanced and restored to benefit native fishes other than salmonids. The habitat requirements for these lowland and estuarine species may be more sustainable restoration targets for much of the Coyote Creek channel than classic perennial, shaded river conditions typically favored by salmonids (that, in many places, may never have existed).

A vision for stream fish in the Coyote Creek watershed based on natural habitat support functions could include: (1) the restoration of brackish tidal sloughs; (2) restoration of several miles of shaded perennial riverine habitat at the top and bottom of the valley floor; and (3) the protection and management of scattered, large, persistent pool refugia with associated riparian forest segments along the remainder of Coyote Creek. Ironically, because of its rerouting into Lower Coyote Creek, Upper Penitencia Creek has probably increased in potential (over the discontinuous historical condition) as a resource for salmon and steelhead, with significant possibilities for improving access to habitat just downstream from the canyon mouth and upstream in the Arroyo Aguague subwatershed.

RESTORATION AND MANAGEMENT IMPLICATIONS

This section summarizes implications of the historical ecology study for restoration and management. First, we describe some of the ways that the historical analysis can be useful to management efforts. Then we briefly note several specific and noteworthy restoration opportunities. The final section summarizes key findings.

WAYS TO USE THE HISTORICAL ECOLOGY STUDY

Historical ecology often represents a new tool for environmental management, which, like any tool, can be misused or misapplied. When applied appropriately, interpretations of historical landscapes can be used in a number of different but related ways to advance environmental stewardship.

ESTABLISHMENT OF HISTORICAL LANDSCAPE CHARACTERISTICS AND REFERENCE CONDITION

This report has established historical landscape characteristics for the water-related features of the Santa Clara Valley draining to Coyote Creek, as well as initial information for some of the dry land features. Historical landscape conditions, when well understood, provide a technical basis for assessing the quality of present-day habitats and setting locally-calibrated restoration targets (National Research Council 1992, Hood and Hinton 2003). Without understanding the physical and ecological characteristics of fluvial features and habitats under relatively natural conditions, restoration has little technical basis. In the absence of a historical landscape perspective, restoration strategies and habitat goals are inevitably based only upon highly disturbed present-day conditions.

In highly modified landscapes like the Santa Clara Valley, a historical ecology study is important to establish reference conditions for monitoring and restoration. For example, the application of environmental indicators by the Santa Clara Valley Urban Runoff Pollution Prevention Program on Coyote Creek was limited by the lack of relatively natural, reference stream reaches downstream of Anderson Dam (Cloak and Buchan 2001). Similarly, a number of other recent studies have recognized the difficulty of interpreting present-day conditions without a well-developed historical data set. Recent reports on Santa Clara Valley streams calling for additional historical information to guide present-day technical assessment and recommendation include Buchan and Randall (2003), SCVURPPP (2003), PWA (2002), and GeoSyntec (2003).

FOUNDATION FOR A WATERSHED RESTORATION PLAN

Developing a picture of local historical conditions, and how they have changed through time, is a key element of creating region or watershed-scale restoration goals and strategies.

Regional historical analyses are increasingly being

developed as foundation data sets for this kind of long-term environmental planning, including efforts for South Florida (McVoy 1996), Puget Sound rivers (Collins et al. 2003), Elkhorn Slough (Van Dyke and Wasson 2005), New England coastal marshes (Bromberg and Bertness 2005), and San Francisco Bay (Goals Project 1999). This historical ecology study establishes a foundation for integrated environmental management of the Coyote Creek watershed, addressing the interrelated processes of habitat creation and maintenance, flood protection, and water supply within a practical, local context.

The historical analysis establishes a framework upon which to set locally specific restoration goals. The identified restoration opportunities and landscape trajectories can now be evaluated in the context of local experience and expertise.

HISTORICAL LANDSCAPES PROVIDE NEW MANAGEMENT OPTIONS

Historical information does not mean that the historical condition is the way it has to be in the future. Historical landscape information provides a reference for interpreting present-day conditions and setting appropriate environmental goals. But it does not, by itself, dictate future scenarios. Changes in culture, land use, and climate mean that the historical landscape cannot be directly translated into the modern. Yet earlier landscapes coexisted with human activity for many centuries and were well-calibrated to local conditions, many of which persist or can be recovered. These landscapes can provide valuable lessons and inspiration for innovative environmental design today.

Living cultures continually incorporate elements of other cultures, including those of the past. Traditions, styles, and techniques of the past are reinterpreted as a source of both cultural innovation and constancy. Landscape history, when well-documented and broadly understood, can serve as a similar source of new ideas for the local landscape. Ecosystem components and management scenarios of the relatively recent past, now often forgotten, provide specific, local examples for present-day environmental challenges. These can come from any era in the local landscape history.

For example, the South Bay salt pond restoration effort is looking to the native-tended *salinas* of the tidal marshlands as natural analogues to the commercial salt ponds. Such features could potentially support some of the important native species now using the modern feature. Similarly, indigenous management of terrestrial fire regimes (with controlled burns) and willow groves (by coppicing), provide present-day stewardship models. Farmers' use of the constructed lower reaches of streams to strategically deliver sediment to the Baylands for reclamation constitutes a late 19th-century model for 21st-century wetlands restoration.

Historical analysis is also useful because it shows things we do not expect. For example, in a few places stream habitats appear to have improved or recovered during the past 75 years. These places should be recognized and studied for lessons that can be applied elsewhere. It is unlikely that we are going to reestablish the disconnected drainage system of the mid-19th century in full, but understanding the impacts of this change on

downstream flood stage, groundwater recharge, sediment management, and channel stability leads us to look for places to strategically reintroduce elements of the natural function.

EXPANDED RESTORATION PALETTE

One of the results of aggressive management efforts of the 19th and 20th centuries has been the general homogenization of habitats (Collins and Montgomery 2002). Within a relatively small geography, Santa Clara Valley streams naturally exhibited a wide range of channel morphology, flow characteristics, riparian habitat, and wetland habitat. Today, much of that diversity has been lost. As a result, the apparent range of restoration alternatives has been reduced and replaced by "one-size-fits-all" models.

By identifying a wide range of native, local habitat types that were naturally present in different physical settings, the historical landscape offers managers an expanded "palette" for environmental restoration. This palette of ecological options often includes habitats – e.g. intermittent channels, sycamore alluvial woodland, alkali meadow – which may be more effectively sustained by current conditions than the previous, generalized targets of the past. It also includes unrecognized options for restoring threatened or endangered species. We can even see that some habitats in the watershed that have been considered artificially impacted (e.g. braided channel, brackish marsh), are actually closer to natural conditions than previously realized.

CONCEPTUAL FRAMEWORK OF LANDSCAPE TYPES

Landscape types provide a simple geographic framework for thinking about the spatial distribution of different watershed functions and the associated constraints and opportunities for environmental management. The framework integrates a range of complex physical and ecological factors – such as stream power, topography, soils, and groundwater interactions – in a relatively easy-to-understand concept. The five landscape types largely explain natural habitat distribution, landscape history, and current issues at a general planning scale, and provide a framework for understanding landscape patterns in more detail.

Some of the management strategies that can be targeted to different landscape types, or the interface between two types, are described in **TABLE IV-6**.

HABITAT REMNANTS

Initial fieldwork to test the historical mapping has revealed a surprising number of native habitat fragments within the watershed. These features, including remnants of the historical valley oak and sycamore groves, alkali meadow, riparian forest, and sycamore alluvial woodland have been sustained despite the surrounding land use changes. These fragments represent an important part of the natural and cultural heritage of the Valley. They also could be important places for habitat preservation and enhancement, as well as models for restoration of these habitats at other sites.

LANDSCAPE	ENVIRONMENTAL MANAGEMENT OPPORTUNITIES/CONSTRAINTS (SELECTED)
BAY	• maintenance of tidal channel capacity • Bay sediment supply • fluvial sediment supply
Interface	• tidal flat loss/development • shorebird habitat
BAYLANDS	• tidal marsh restoration • floodwater storage capacity • waterfowl habitat • endangered salt marsh species habitat • Bay and fluvial sediment supply
Interface	• fresh and brackish tidal marsh restoration • wet meadow and alkali meadow restoration • recovery of "delta" fish species • recovery of rare plant species in tidal marsh-saltgrass-alkali meadow ecotone • high tide refugia for salt marsh harvest mouse • salt water intrusion, sea level rise, and estuarine transgression
BOTTOMLANDS	• palustrine (freshwater, nontidal) wetland restoration • floodwater storage capacity • enhancement of artificial stream channels • excessive sedimentation in artificial channels
Interface	• drainage challenges associated with groundwater emergence • willow grove restoration
ALLUVIAL FANS	• restoration of natural stream channels • erosion/incision of natural stream channels with increased runoff • valley oak savanna preservation and restoration
Interface	• fish access to tributary habitat • excessive sediment storage behind dams • management of water releases for stream functions
HILLS	• hillslope management to decrease runoff, sediment erosion and drainage density increase • sediment and contaminant release from historical/current mining • preservation and restoration of wetland habitat in intermontane valleys

TABLE IV-6. ENVIRONMENTAL MANAGEMENT OPPORTUNITIES AND CONSTRAINTS ASSOCIATED WITH DIFFERENT SANTA CLARA VALLEY LANDSCAPES.

RESTORATION OPPORTUNITIES

HABITAT TEMPLATES

Historical analysis shows that fluvial and wetland habitats in the Coyote Creek watershed occurred in distinctive patterns involving multiple habitat types. We identified several of these habitat "templates." These templates describe the functional arrangement between different habitats and landscapes. They can serve as conceptual models for coordinated, multi-objective restoration planning.

Key elements of each template are described below. At this time a schematic diagram has been developed for the Riparian Tidal template; illustrations of the other templates will be developed as possible.

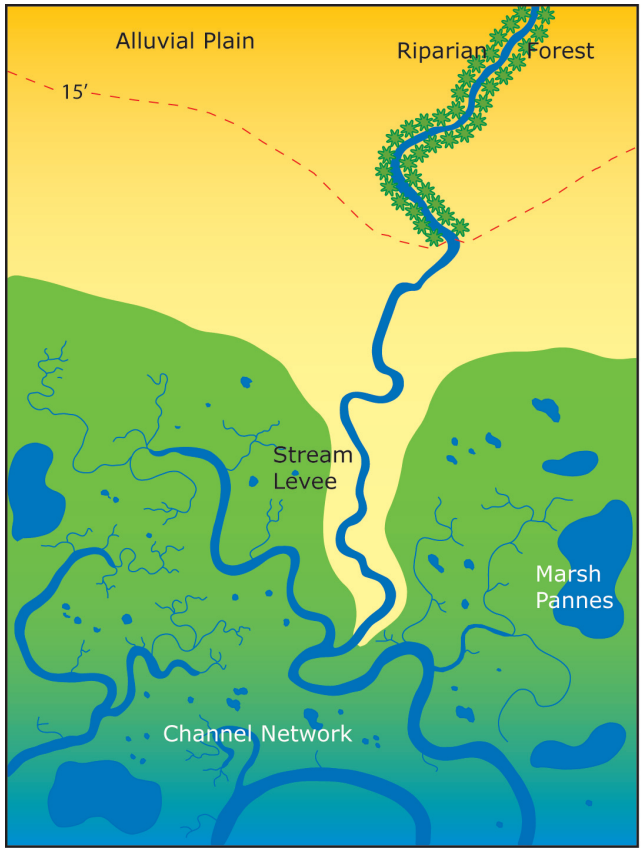


TABLE IV-33. SCHEMATIC DIAGRAM OF THE RIPARIAN TIDAL TEMPLATE.

RIPARIAN TIDAL TEMPLATE (FIGURE IV-33)

- fluvial channel directly joins tidal slough
- natural stream levee extends into tidal marshland along channel
- fresh and brackish tidal marsh extends from fluvial-tidal interface
- tule-lined channels
- tidal channel networks are less dense
- fewer and larger tidal marsh pannes
- dry grassland occupies alluvial fan-baylands interface

ARTESIAN SLOUGH TEMPLATE

- occurs at the baylands-bottomlands interface
- "spring runs" initiate from groundwater discharge in the bottomlands and join tidal sloughs
- may also serve as overflow channels
- fresh and brackish tidal marsh extends from fluvial-tidal interface
- tule-lined channels
- tidal marsh-saltgrass-alkali meadow ecotone

LAGUNA TEMPLATE

- mosaic of temporarily, seasonally, and perennially flooded wetlands
- substantial perennial freshwater wetland: tule marsh
- surrounding wet meadows and alkali meadows
- smaller perennial ponds supplied by groundwater emergence
- possible willow groves at outer margin of perennial wetland
- possible overflow channel but restricted fluvial connection
- distributary creeks contribute surface water directly to wet meadow areas or as groundwater reemergence

FIGURE IV-34. LAGUNA SECA 1919/2005. The area has changed relatively little since the reclamation for agriculture in the early part of the 20th century. Red circle shows location of **FIGURE III-30**. SCVWD Vault 1919: 169, courtesy Santa Clara Valley Water District.

REFERENCE SITES

Comparative, less-disturbed settings can probably be found in other parts of Central California that correspond closely to each of the habitat types historically found in the Coyote watershed. Identification of appropriate reference sites would help provide illustration for a restoration vision that includes habitats that have not been seen locally for some time, yet have significant restoration potential. Information about the characteristics of these sites will be useful for restoration project design and monitoring progress.

POTENTIAL OPPORTUNITIES AT LAGUNA SECA

The historical analysis identifies the Laguna Seca area at the north end of Coyote Valley as a site with unusual, multi-objective wetland restoration potential. The site has changed very little during the past 85 years (**FIGURE IV-34**) and appears to offer opportunities to reestablish significant natural hydrogeomorphic process, with benefits to floodwater attenuation and storage. It also could support a range of native species. Some of these considerations are discussed briefly below in a conceptual manner. Specific site assessments, hydrological modeling, and coordinated planning would be required to determine actual project opportunities.

Under natural conditions, Laguna Seca provided flood attenuation and storage because it could receive and store substantial amounts of water away from the Coyote Creek channel. It remains a topographic low point. The outlet channel, historically constructed for drainage purposes, could be managed or redesigned to reduce

direct drainage to Coyote Creek. The system could provide some of the same flood protection benefits as the Soap Lake Floodplain Preservation Project proposed on the upper Pajaro River (RMC 2005).

The Fisher Creek drainage, which historically terminated in the Laguna Seca wetland complex, represents one of the few opportunities to reestablish a more discontinuous stream system, natural wetland storage capacity, and less flashy flood routing. Reducing the connectivity between Fisher Creek and Coyote Creek would help attenuate high flows before reaching Coyote Creek, provide surface water to Laguna Seca, and allow off-channel sediment retention.

Recharge of the Coyote Valley aquifer has been purposely limited in recent decades because of court-mandated diversion of Coyote Creek into the Coyote Canal. There was concern that summer discharges from the dam would raise groundwater levels to the detriment of local agriculture. However, because the site lies at the lowest portion of the valley, it may be possible to have some groundwater emergence at the site without adversely affecting drainage in the higher-lying parts of Coyote Valley. In fact, surface water can currently be found in the lowest part of the former lake bed during the summer, suggesting that natural hydrology is substantially intact. The bedrock barrier of the Santa Teresa Hills also effectively isolates Laguna Seca from the parts of San Jose to the north.

Reestablishment of the Laguna Seca wetlands is an opportunity to restore a regionally significant wetland mosaic. Large freshwater complexes such as Laguna Seca were not widely distributed in the semiarid Bay Area and opportunities for restoration are even less common. This array of habitats, described in the Laguna Habitat Template above, could support a number of locally important and/or special status species. These potentially include the red-legged frog, tiger salamander, rare plants, and waterfowl. The description of avian use of Laguna Socayre, presented in Part III, probably provides a good illustration of the diverse water birds that historically used Laguna Seca.

Laguna Seca also provides strong conservation benefit because it is contiguous to existing greenbelt. For example, The Silicon Valley Land Conservancy recently acquired portions of the adjacent Tulare Hill for a butterfly habitat preserve (San Jose Mercury News 2005). Wetland conservation and restoration at the site thus has the potential to contribute to an unusually functional preserve, including a mosaic of habitats from upland to lowland, within a relatively small space.

Wetland planning at the Laguna Seca site must be coordinated with adjacent development, emerging as part of the Coyote Valley Specific Plan, to address stormwater quality, recreational benefits, and other issues.

SYCAMORE ALLUVIAL WOODLAND AND STREAM HABITAT DIVERSITY

The open, sycamore-dominated riparian habitat of broad, intermittent streams was celebrated by the naturalist writers of the 19th century — from Sherman Day's "splendid groves of oaks and sycamores" found on Coyote Creek's braided channel, to Mary Carroll's "treasured" *Mentzelia* found in "sandy beds of the dry creeks." Author Bayard Taylor in particular described Coyote Creek's native beauty, lost in the 20th century but not unrecoverable, as a key component of the "dazzling" Santa Clara Valley landscape:

FIGURE IV-35. COYOTE CREEK IMMEDIATELY DOWNSTREAM OF THE COYOTE CREEK GOLF CLUB IN 1939 (LEFT) AND 2002 (RIGHT). Braided channel pattern with riparian scrub and occasional large trees can be seen in both images, but there is more riparian vegetation along the main channel in the recent image (AAA 1939; 2002 Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

> "A valley, ten miles wide, through the center of which winds the dry bed of a winter stream, whose course is marked with groups of giant sycamores, their trunks gleaming like silver through masses of glossy foliage" (Carroll 1903: 185).

One of the implications of the assessment of riparian habitat change is to recognize the value of Sycamore alluvial woodland as a major historical component of Coyote Creek. Given the substantial conversion of the habitat to more dense, cottonwood-dominated riparian habitat, existing remnants gain in significance.

In particular, the Coyote Valley reach from approximately Sycamore Lane to Highway 101 (where not removed by gravel quarrying) has unusually intact sycamore woodland and braided channel habitat (Keeler-Wolf et al. 1996). An important goal may be to preserve and enhance this open riparian habitat (**FIGURE IV-35**), rather than cause conversion to riparian forest. This goal would require maintaining broad, regularly flooded channel beds and would likely necessitate increased high flows, coarse sediment sources, and filling of former gravel ponds.

Target stream habitat for these riparian areas could involve a distinct suite of native species, including fish assemblages associated with braided channels (see Fish Assemblage section, **TABLE IV-5**), a distinct flora including California sycamores and smooth-stem blazing star (*Mentzelia sp.*), and nesting birds such as the lesser nighthawk.

At certain places within these larger reaches, short reaches with dense riparian canopy and persistent summer pools should be identified, preserved, and enhanced.

STREAM FLOW VARIABILITY

One component of stream restoration might involve manipulation of reservoir discharge to more closely mimic natural hydrology. The installation of Coyote and Anderson Reservoirs in the mid-20th century cre-

ated a major and sustained impact on stream processes and habitat. However, the ability to control the timing and quantity of flows from 70% of the watershed does provide an opportunity to manage water releases strategically as part of habitat restoration and management strategies.

Habitat-oriented flow management presently focuses on summer releases to maintain cold water fish assemblages (FAHCE 2003). However, while maintaining minimum flow levels required by native species at appropriate sites, flow management should also consider the importance of flow variation and extremes for physical and ecological processes.

For example, the potential benefits of controlled, yet significant, high flow pulses to maintain or restore downstream habitat quality and improve native fish populations could be considered. Local native species and their habitats evolved with much higher peak flows than are currently observed on Coyote Creek. While extremely high flows must be avoided because of flood risk, managing the timing and frequency of moderately high pulses could have significant geomorphic and ecological benefits (e.g. USGS 2005). The proximity of relatively broad and buffered stream reaches to the Anderson Dam outlet might allow attenuation of a moderately "steep" discharge within the target area. Further study, including assessing sediment availability, would be needed to determine whether higher flows could potentially help reestablish active gravel bars and terraces to promote the continuation of the rare Sycamore alluvial woodland.

Higher flows might help maintain some of the surviving braided channel reaches that currently possess substantial residual value and potential for native fish habitat. Fish distribution studies before and after recent relatively high flows suggest that native fish are better adapted to the short duration, high flow events characteristic of historical conditions than their non-native competitors (Buchan and Randall 2003: 37). Significant, well timed late winter/early spring releases could potentially improve habitat for a range of native fish (Leidy personal communication).

Similarly, native fish tend to be more tolerant of the extreme summer-dry local conditions than most non-natives. Intermittent conditions might actually be an appropriate target for certain stream reaches, as some of the healthiest present-day native fish communities are observed in reaches with summer dryback (Buchan and Randall 2003: 106).

Higher flows could also remove short-lived woody vegetation that has expanded onto the former active channel in some areas since reservoir construction, in the absence of high flows. This might reduce tree fall hazards and trash jams, while increasing channel capacity and fish passage. Higher flows might thereby contribute large woody debris to the channel naturally.

DIVERSE URBAN RESTORATION OPPORTUNITIES

The historical analysis, combined with very preliminary fieldwork, also suggests a number of additional restoration "opportunity zones." These include freshwater

HABITAT	ECOLOGICAL VALUES	GENERAL VALUES	LANDSCAPE POSITION AND FUNCTIONAL REQUIREMENTS	RESTORATION OPPORTUNITIES (SELECTED)
Fresh and Brackish Tidal Marshland	• important component of tidal wetland mosaic • rare estuarine, "Delta" fish • anadromous fish corridor • red-legged frog	• navigable sloughs • public access to tidal channels	Tidal and fluvial water sources at the Baylands-Bottomlands interface.	• Salt ponds A15-23, integrated with fresh water drainage and treated effluent hydrology
Wet Meadow	• seasonal wetland values: rare wetland plants, waterfowl nesting and foraging habitat, tiger salamander	• low intensity agricultural vistas; open space • temporary flood storage	Clay soils with limited drainage, seasonal soil saturation, stream overflow and/or artesian springs, seeps	• Laguna Seca area in Coyote Valley • "buffer lands" of the San Jose-Santa Clara Water Pollution Control Plant
Salt grass-alkali meadow	• wet meadow values • rare alkali- and high marsh-associated plants • high tide refuge for salt marsh harvest mouse • future tidal marsh with sea level rise	• low intensity agricultural vistas; open space • temporary flood storage	Adobe, salt-affected soils with limited drainage, seasonal soil saturation, stream overflow and/or artesian springs, seeps	• Meadow lands at Lake Cunningham Regional Park
Valley Oak Savanna	rare and declining oak habitat	• "signature" habitat of Santa Clara Valley • shade tree • neighborhood stewardship opportunity	Coarse well-drained alluvial soils, access to groundwater via roots (<25 feet?)	• Full savanna habitat in urban parks and open spaces (e.g. Shady Oak Park), higher elevation Diablo Range valleys as potential climate change refugia • Valley oak component in roadsides, medians, yards, fencelines
Willow Grove	migratory and local songbird habitat, amphibians red-legged frog, tiger salamander	• habitat representation • evergreen, aesthetically pleasing	Alluvial fan-bottomland interface or tidal marsh-bottomland interface perennial water source (near surface groundwater, seeks or springs	• Laguna Seca area in Coyote Valley • "buffer lands" of the San Jose-Santa Clara Water Pollution Control Plant
Perennial freshwater marsh and ponds	red-legged frog, tiger salamander, waterfowl	• habitat representation: wetland aesthetics • temporary flood storage	Clay bottomland soils, groundwater emergence	Laguna Seca in Coyote Valley
Sycamore alluvial woodland	• significant, rare California habitat • lesser nighthawks and other birds • unique flora	signature habitat of Coyote Creek	Intermittent, high energy, seasonally flooded gravel substrate (groundwater at depth)	Coyote Creek from ~Sycamore Lane through Highway 101

TABLE IV-7. WATERSHED RESTORATION CONCEPTUAL FRAMEWORK. In addition to riparian and floodplain restoration opportunities, there are "opportunity zones" for restoring a range of other, related watershed components. Many of these habitats are linked to each other through hydrogeomorphic and groundwater processes; restoration of the watershed system should involve each component. Each habitat or watershed component offers distinct ecological/cultural benefits and has specific landscape requirements.

and brackish tidal marsh — which could support rare fish species associated with freshwater deltas — alkali meadows with a range of rare plants, and some of the grand valley oak trees of the alluvial fans. Some of these opportunities for the restoration of native habitats in their appropriate hydrogeomorphic settings are summarized in **TABLE IV-7**.

These habitat restoration opportunities range from sites with the potential to restore significant habitat mosaics following natural "templates" to more distributed opportunities for incremental habitat improvement. For example, while there are only a few possible places to restore a significant component of valley oak savanna, individual valley oak trees might be successfully nurtured at hundreds of sites throughout the Valley. Appropriate requirements could be identified by neighborhood, based upon historical distribution and present-day factors (depth to groundwater, limited summer watering, available space).

Given that most of the remaining valley oaks appear to be relatively old, it will be important to establish subsequent generations at suitable sites with local stewardship. The present-day persistence of many trees does suggest the potential for the continuation and even re-expansion of the Valley's grand oaks within the urban context.

Similarly, the Valley's sycamore trees have shown impressive persistence. The observation of sprouting trees from stumps 6 feet or more in diameter suggests substantial age. Given appropriate conditions, younger California Sycamores could be established alongside the heritage trees found fairly commonly at the edges of neighborhoods along streams. The historic sycamore grove area in San Jose appears to still be supporting sycamores with a range of ages.

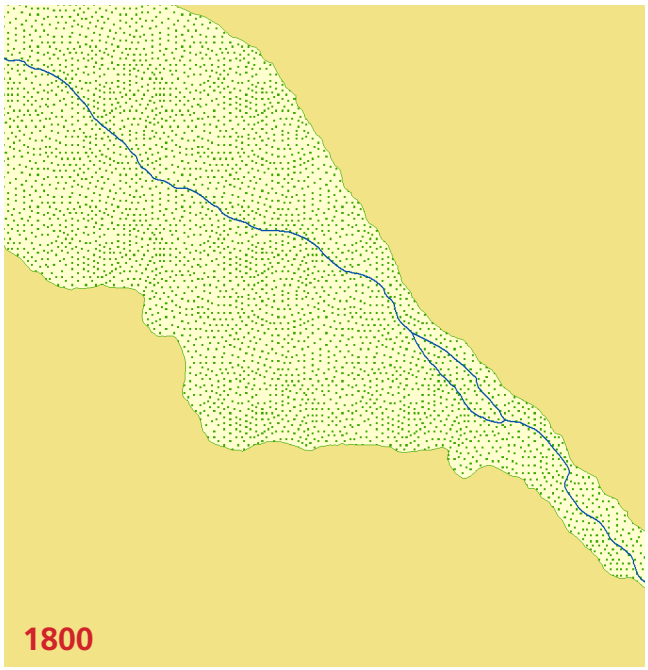


FIGURE IV-36. COYOTE CREEK CHANNEL AT HIGHWAY 880 CROSSING, CIRCA 1800 (LOWER LEFT), 1939 (UPPER LEFT), AND 2002 (RIGHT). The 1800 view identifies naturally broad and narrow channel reaches, which are not easily distinguished in the more recent aerial photography. Naturally wide reaches may have potential for floodplain restoration. For example, the undeveloped area in the center of the 2002 image is a former stream bench that remains flood-prone. Highway 880 runs north-south on the left side of the 2002 image. The *San Jose Mercury News* building can be seen at image bottom, immediately right of the highway. (AAA 1939; 2002 Imagery Copyright 2005 AirPhotoUSA, LLC, All Rights Reserved).

SUMMARY OF KEY FINDINGS

This section provides brief summaries of some of the important products, findings, hypotheses, and management implications.

HISTORICAL ECOLOGY TOOLS

Historical data set. Through this project, thousands of historical documents have been examined for useful environmental data. The resulting project bibliography is a publicly-available tool for addressing future environmental questions in the watershed. This data set also provides a starting point for more detailed reach or sub-watershed investigations.

Georeferenced historical maps. Early maps and photography contain tremendous amounts of information, but are often difficult to use. We have georectified a number of important historical maps for the area, which will be available for convenient comparative use in GIS systems.

Early aerial photomosaic. We developed a composite, georectified image synthesizing over 80 of the earliest aerial photographs for the Coyote Creek valley floor. This data set will be useful for a range of engineering, research, planning and community purposes.

Historical landscape GIS. The GIS map of historical habitats and drainage patterns represents a new data set for restoration planning. Each feature is coded for certainty level, and supporting source materials.

Importance of early historical data for geomorphic assessment. Historical data are often used to determine pre-modification channel form but research efforts are sometimes limited to relatively late and/or coarse sources (e.g. Ouchi 1983 *in* Schumm et al. 2000), resulting in potential misinterpretation of channel processes. Earlier, pre-modification sources used in this project (particularly General Land Office surveys and land grant materials) can provide accurate and detailed baseline data.

The Historical Ecology Study provides a starting point for the development of a detailed vision for recovery and restoration in the Coyote Creek watershed. The Study constitutes the first step in the process of setting realistic, site-specific restoration targets. This "goals-setting" process — integrating the historical findings with modern assessment and local expertise — would produce a template for coordinating diverse restoration and management activities towards a healthy, sustainable watershed.

PRE-MODIFICATION CONDITIONS

Most stream channels did not cross the lower alluvial plain. Nearly 50% of the valley floor water courses draining today to Coyote Creek are constructed channels conveying runoff through areas that previously had no surface drainage. The natural drainage network was highly discontinuous, supporting groundwater recharge on the coarse alluvial fans and wetlands in the valley bottomlands.

Drainage density has increased dramatically. The construction of drainage channels, initially for agricultural drainage, increased the density of drainage to Coyote Creek by about 40%. Creation of the storm drain network during urbanization has resulted in a nearly tenfold increase in drainage density.

The functional watershed area has changed. Coyote Creek receives much more input of water and sediment from the lower part of the watershed than it did historically, when there were no tributaries downstream of Coyote Narrows. This results in a flashier hydrograph and many more sediment sources.

Coyote Creek displayed distinctly different channel morphology and riparian habitat along different reaches. We defined four distinct reaches; historical characteristics substantially explain present-day conditions.

Most of Coyote Creek was intermittent. There were important perennial reaches at the upper and lower ends of the valley and the balance of the mainstem was seasonally dry.

Coyote Creek maintained a regionally unusual broad channel area for much of its length, with interspersed narrow reaches. This pattern affected, and continues to affect, riparian habitat, fish habitat, and even urban transportation patterns.

Coyote Creek was naturally quite deep in the mid-Coyote reach. The system was substantially entrenched, with many broad, inset flood-prone benches.

Coyote Creek above Tully Road had strong braided channel character. Riparian habitat was an open savanna with riparian scrub and large unvegetated areas. Sycamore alluvial woodland was characteristic. There were occasional strands of linear riparian forest on the outer banks of the channel area.

Two major freshwater wetland complexes were found in the Coyote watershed, Laguna Seca and Laguna Socayre. A number of willow groves and other perennial freshwater wetlands provided additional important wetland habitat.

Wet meadows and saltgrass-alkali meadows occupied broad bottomlands. Poor drainage slowed agricultural and commercial development, leaving modern opportunities for both restoration and further urbanization.

Open grassland with valley oak savanna dominated the gently sloping alluvial fans. These were largely converted to orchards, then residential development.

NATURAL FLOOD PROTECTION.

Flood-prone areas have decreased greatly. Successful drainage and flood control projects have increased stream connectivity and decreased stream-floodplain connectivity.

Existing flood-prone benches provide potential flood capacity. In the Mid-Coyote reach, there are many

large, broad stream benches still subject to flooding (FIGURE IV-36). A number of these areas remain in public ownership; some could potentially be designed to support and benefit from occasional flooding.

Strategic stream bench excavation could increase channel capacity and allow restoration of floodplain functions. Many of these areas have been filled, and the main channel has incised, reducing floodplain access. Recovery of even a small percentage of the historical stream floodplain could greatly increase habitat value.

There may be shared benefits with contaminant removal. Historical landfill on the Coyote Creek floodplain benches has become a contaminant concern at Watson Park. Soil removal at this and potentially other sites may be needed to reduce public exposure and prevent contaminant transport downstream to the Bay.

Historical and recent hydromodification has probably contributed to downstream flood potential by increasing connectivity to the Coyote mainstem. Reducing drainage connectivity through off-site storage, swales, and neighborhood-scale infiltration projects will be important especially given predicted climatic changes and increased impervious surfaces.

Laguna Seca and the Fisher Creek drainage network present an opportunity for significant off-site flood peak attenuation. Restoration of the natural hydrogeomorphology of the site could provide flood protection, wetland values, and habitat for a range of species.

Historical drainage patterns and wetland distribution help explain present-day flood-prone areas. Current locations of flooding appear often to be related to significant reduction in channel capacity or to the location of historical wetland complexes. This information may be useful to future flood protection planning.

CHANNEL STABILITY

Channel stability is highly variable within the watershed. We found stream reaches with substantial incision trends and reaches with no discernible change over a 150 year period.

Historical data indicate significant incision in the Mid-Coyote Reach. However, recent incision may not be as great as assumed because the channel was typically 20+ feet deep under historical conditions.

The timing and length of valley floor channel extension may help explain channel stability/instability. The historical data set, combined with field work, could provide a basis for testing this hypothesis, as also suggested by Jordan et al. (2005).

Substantial historical data are available to assess long-term rates of channel erosion. We identified a number of sources that can be integrated with strategic fieldwork to assess how much incision has been taking place where, over what time period.

Major lateral migration of the main channel has taken place during historical times. These changes appear

to have been natural and were confined within the broader channel area defined by the outer banks, suggesting a practical buffer zone for land use planning.

STREAM RESTORATION

This natural bank erosion, also observed recently in Coyote Valley, combined with flood susceptibility, suggests that there is strong rationale for maintaining the broad, historical channel area as a stream buffer. Fortunately, much of the broad creek area has, in fact, been preserved as public space. However, there are numerous conflicting land uses within this area.

Coyote Creek's imposing natural morphology has led to unusually high present-day habitat value and restoration potential. Because of the flood risk on inset benches and braided reaches, much of the creek now lies within city and county parks, making it possible to consider a significant stream restoration vision.

Fresh and brackish tidal marsh gradients could be established at lower Coyote Creek. These should be designed to reestablish natural marshland patterns associated with freshwater influences.

Treated effluent inputs could be used to reestablish brackish tidal sloughs and the "Artesian Slough Habitat Template." Fresh and brackish tidal marsh gradients have been greatly lost within the region (Goals Project 1999).

Could the Coyote Creek delta be restored? A century ago the lower and tidal portions of the creek supported a fish assemblage largely similar to those found in the Sacramento-San Joaquin Delta. Restoration of some of these fish populations could be of regional significance.

While Coyote Creek has escaped major straightening by flood control projects, the channel has been severely modified by large artificial ponded areas. Separating the stream from Ogier Ponds and the Coyote Percolation Ponds would contribute greatly to restoring natural channel form.

Restoration of Coyote Creek at the Ogier Ponds complex would provide an opportunity to restore some of the creek's presently-rare native habitat. Based upon recent historical conditions, stream restoration at Ogier Ponds could consider a broad braided channel supporting Sycamore Alluvial Woodland and related habitats. The pre-modification main channel appears to correspond with the existing riparian forest strand.

RIPARIAN HABITAT RESTORATION

Riparian forest has been lost along some creeks, but also has recovered in places. Urbanization appears to have protected riparian forest from direct encroachment by agriculture and grazing in some cases. There are number of places where the creek now has more room for riparian habitat than it did in 1939.

Incision and excessive vegetation growth are a concern. While riparian habitat appears robust in many places, it should be evaluated to ensure its long-term viability.

Dense riparian forest has expanded into the relatively open native riparian woodland that characterized most of Coyote Creek historically. This riparian habitat conversion is likely due to reduced high flows and increased summer flows.

Preservation, enhancement, and restoration of braided channel habitats and California Sycamore Alluvial Woodland in Coyote Valley could be an important watershed goal. The reach between Sycamore Avenue and Highway 101 includes the best existing examples of the pre-modification habitat along most of Coyote Creek.

FLOW

Strategically modifying regulated flows to more closely mimic natural patterns could have significant benefit to native fishes and habitats. Environmental and groundwater recharge efforts have led to a flattening of the annual monthly distribution of streamflow. Greater variability could be important to stream health.

Controlled high flow releases could have some benefits. Modest but significant pulse flows, particularly with some augmented sediment and gravel supply, could have geomorphic benefit and select for native fishes over non-native species.

Perennial stream flows are not automatically good. The conversion of most of the stream to perennial flow has significantly altered riparian and aquatic habitats.

The braided channel habitats in the vicinity of the Coyote Creek Golf Club have probably maintained their relatively natural character partly because of the Coyote Diversion Canal. This portion of the stream has been excluded from strong summertime flow increases and has not converted to dense riparian forest. Future alterations to the flow regime should consider potential ecological effects within a temporal context.

Historical sites of perennial stream flow and groundwater discharge may be particularly important given future climate uncertainty. These sites, and their dependent native species, are more likely to persist than areas requiring supplemental water, particularly during extended drought and/or limited summer water supply periods.

RESTORATION OF WETLAND HABITATS

Laguna Seca represents a rare opportunity to restore natural hydrogeomorphic wetland functions and a diverse wetland mosaic. Laguna Seca restoration would link to existing buffers and would be regionally significant as a large, natural valley floor wetland.

Substantial historical documentation of Laguna Seca is available to establish natural hydrology and vegetation parameters. Much of this information has been preserved and recently scanned at the Santa Clara Valley Water District archives.

Successful wetland restoration at Laguna Seca could support a wide range of valued species, including rare plants, amphibians, and water birds. Many of these are documented by historical evidence for Laguna Seca and/or Laguna Socayre.

Some saltgrass-alkali meadow currently persists at Lake Cunningham Park. Strategic preservation and enhancement efforts could improve this rare habitat while coexisting with surrounding recreational activities. There may be other opportunities for similar restoration efforts in the vicinity of the historical Laguna Socayre.

Substantial restoration opportunities are also evident in the vicinity of the San Jose-Santa Clara Water Pollution Control Plant, where preservation of local agriculture by the City of San Jose has maintained relatively high habitat potential. Wet meadow and saltgrass-alkali meadows as part of the "Artesian Slough Habitat Template" could potentially be considered in this area.

RESTORATION OF DISTRIBUTED TREES IN PARKS AND NEIGHBORHOODS

Valley oak savanna, the signature habitat of the Santa Clara Valley, could be restored in elements through coordinated local stewardship. The naturally "scattered" distribution of valley oaks means that they can be relatively successfully integrated within the urban framework. Young trees need to be established to maintain this local habitat into the future.

The Valley's grand sycamore trees, found occasionally individually or in groves alongside stream channels, have also persisted to a surprising degree, apparently as descendents of the original trees. These heritage trees could be preserved and regenerated within the urban context.

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GLOSSARY OF TERMS

Aerial Photomosaic: A digital image made from multiple, adjacent, overlapping aerial photograph prints and/or negatives to seamlessly cover a large area.

Alluvial Fan: A body of alluvium whose surface forms a segment of a cone that radiates downslope from the point where the stream emerges from a narrow valley onto a less sloping surface (Grossman et al. 1998).

Alluvial: Deposited by a stream or running water (Bates and Jackson 1984).

Artesian: Pertaining to groundwater under sufficient hydrostatic pressure to rise above the aquifer containing it (Bates and Jackson 1984).

Bottomlands: Low-lying interfluvial flood basins.

Braided Channel: A channel or stream with multiple channels that interweave as a result of repeated bifurcation and convergence of flow around interchannel bars. Generally confined to broad, shallow streams of low sinuousity, high bedload, non-cohesive bank material, and steep gradient (Grossman et al. 1998).

Confined Groundwater: Groundwater that is under sufficient pressure to rise above the level at which it is encountered in a well; it may or may not flow to or above the ground surface. Its upper surface is the bottom of an impermeable bed. (Bates and Jackson 1984).

Distributary Creek: A stream with a discontinuous channel that, in the absence of a defined channel, distributed flow over a broad area; used to distinguish creeks directly tributary to a main stem channel from those that did not historically maintain a defined channel connection.

Entrenched: Entrenchment is defined by the elevation of the current floodplain relative to the elevation of the valley floor. A channel is entrenched when the floodplain is not coincident with the valley floor (Montgomery and MacDonald 2002).

Floodplain: A level area near a river channel, constructed by the river in the present climate and overflowed during moderate flow events (Leopold 1995).

Fluvial: Of or pertaining to rivers; produced by the action of a stream or river (Bates and Jackson 1984).

General Land Office (GLO): Federal agency that carried out the Public Land Survey, resulting in associated historical landscape information.

Georectification: To establish the relationship between page coordinates on a planar map and known real-world coordinates using elevation data to correct for topography. Often used interchangeably with the term 'georeference' (see below).

Georeference: To establish the relationship between page coordinates on a planar map and known real-world coordinates.

Habitat: The specific area or environment in which a particular type of plant or animal lives.

Hydrogeomorphic: Of or pertaining to a synthesis of the geomorphic setting, the water source and its transport, and hydrodynamics.

Hydrology: The branch of physical geography concerned with the behavior of water in the atmosphere, on the surface of the earth and underground. The science dealing with the properties, distribution and circulation of water

Intermittent Stream: A stream that flows only at certain times of the year (Bates and Jackson 1984).

Laguna: Lagoon or small lake (Spanish).

Levee: An artificial or natural embankment built along the margin of a water course or an arm of the sea. Constructed naturally by sediment deposition or artificially to protect land from inundation or to confine streamflow to its channel (Grossman et al. 1998).

Mean Lower Low Water (MLLW): The average height of the lower of the two daily low tide; zero tidal elevation.

Mean Tide Level (MTL): A tidal datum, or reference, which is midway between Mean High Water and Mean Low Water.

Palustrine Wetland: Palustrine wetlands are non-tidal wetlands that received most of their water by direct precipitation or surface runoff.

Perennial Stream: A perennial stream has flowing water year-round during a typical year.

Restoration: The reestablishment of the structure and function of ecosystems. Ecological restoration is the process of returning an ecosystem as closely as possible to appropriate sustainable conditions and functions which are defined based upon an understanding of past, present and predicted future conditions. Implicit in this definition is that ecosystems are naturally dynamic. It is therefore not possible to recreate a historical system exactly. The restoration process reestablishes the general structure, function, dynamic, and self-sustaining behavior of the ecosystem.

Rhizomatous: a plant having long, underground, horizontal stems capable of sprouting new growth.

Riparian Vegetation: Trees or shrubs that directly affect, or are affected by, the surface or subsurface hydrology of a river, stream, canal, ditch, lake, or reservoir.

Roblar: "The place where deciduous oaks grow" (Gudde 1998); commonly refers to groves of valley oaks (Spanish).

Salitroso: Descriptor of salt-affected lands with resulting limited agricultural value; literally, "saltpetrous" (Spanish).

Sausal: Willow grove (Spanish).

Tular: Place of the tules; indicative of perennial freshwater marsh (Spanish).

Unconfined Groundwater: Groundwater that has a free water table, i.e. is not confined under pressure beneath relatively impermeable rocks (Bates and Jackson 1984).

US Coast Survey (USCS): Federal agency established in 1807 to map the nation's shoreline. Produced maps well-recognized for their accuracy dating, in the Bay Area, to the 1850s.

US Department of Agriculture (USDA): Federal agency that has produced soil surveys and, since the 1930s, associated aerial photography of use in historical ecology research.

US Geological Survey (USGS): Federal agency established in 1879. Historical USGS quadrangles of the San Francisco Bay Area date to the late 1800s.

Vernal Pools: Ephemeral wetlands that form in shallow depressions underlain by an impervious, near-surface soil horizon, supporting distinct vernal pool plant and animal species.

HISTORICAL EVIDENCE FOR FISH ASSEMBLAGES IN THE COYOTE CREEK WATERSHED[1]

FAMILY/ SPECIES	ZOO-GEOGRAPHIC TYPE	LIFE HISTORY STATUS	DISTRI-BUTIONAL STATUS	PRIMARY HABITAT OCCURRENCE	NOTABLE EARLY RECORD(S) FROM THE WATERSHED (YEAR) (SOURCE)
PETROMYZONTIDAE/ LAMPREYS *Lampetra tridentata* Pacific lamprey	OBF-SD	M, AND, FWR	P, ?	LLR, MR, HSR	Coyote Creek, Santa Clara Co. (1898) (Snyder 1905)
Lampetra richardsoni western brook lamprey	OBF-SD	FWR	?	LLR, MR	Coyote Creek, Santa Clara Co. (1922) (Hubbs 1924, UMMZ 61003)
ACIPENSERIDAE/ STURGEONS *Acipenser transmontanus* white sturgeon	OBF-SD	M, AND, EST	UR	TER, L/OB	_
CYPRINIDAE/ MINNOWS *Gila crassicauda* thicktail chub	OBF-FD	FWR	EX	LLR, MR, FLP	Coyote Creek, Santa Clara Co. (1898) (Snyder 1905, SU 21031)
Lavinia exilicauda Hitch	OBF-FD	FWR	LC	LLR, MR, FLP	Coyote Creek, Santa Clara Co. (1897) (C. H. Gilbert, CAS 102562/SU2562, CAS104219/ SU 4219)
Lavinia symmetricus California roach	OBF-FD	FWR	LC	MR, HSR	Coyote Creek, Santa Clara Co. (1898) (Snyder 1905)
Orthodon microlepidotus Sacramento blackfish	OBF-FD	FWR	LC	LLR, FLP	Coyote Creek, Santa Clara Co. (1892) (C.H. Gilbert, CAS 111447) Coyote Creek, Santa Clara, Co. (1897, 1898) (C. H. Gilbert, CAS 101199/Snyder 1905) Coyote Creek, Santa Clara Co. (1922) (C. L. Hubbs, UMMZ 63411)
Pogonichthys macrolepidotus Sacramento splittail	OBF-FD	FWR, EST	EX	TER, LLR	Coyote Creek, Santa Clara Co. (1890s) (C.H. Gilbert, CAS 102537) Coyote Creek, Santa Clara Co. (1898) (Snyder 1905)
Ptychocheilus grandis Sacramento pikeminnow	OBF-FD	FWR	P	LLR, MR	Coyote Creek, Santa Clara Co. (1898) (Snyder 1905, CNHM 2574, USNM 75384) Coyote Creek, Santa Clara Co. (1922) (C. L. Hubbs, UMMZ 63410)
Rhinichthys osculus speckled dace	OBF-FD	FWR	EX	MR, HSR	Coyote Creek, Santa Clara Co. (1898) (Snyder 1905, SU 37823, 161721)
CATOSTOMIDAE/ SUCKERS *Catostomus occidentalis* Sacramento sucker	OBF-FD	FWR	W	LLR, MR, HSR, FLP	Coyote Creek, Santa Clara Co. (1898) (Snyder 1905) Coyote Creek, Santa Clara Co. (1922) (C. L. Hubbs, UMMZ 63399, 63400, 63401)
OSMERIDAE/ SMELTS *Spirinchus thaleichthys* longfin smelt	EM	M, AND, EST	P	TER, L/OB	_

[1]**Table provided by Robert A. Leidy, US Environmental Protection Agency, San Francisco.**

FAMILY/ SPECIES	ZOO-GEOGRAPHIC TYPE	LIFE HISTORY STATUS	DISTRI-BUTIONAL STATUS	PRIMARY HABITAT OCCURRENCE	NOTABLE EARLY RECORD(S) FROM THE WATERSHED (YEAR) (SOURCE)
SALMONIDAE/ SALMON AND TROUT *Oncorhynchus kisutch* coho/silver salmon	OBF-SD	M, AND, FWR	EX	MR, HSR	Coyote Creek, Santa Clara Co. (1950s) L. J. Hendricks, Emeritus, San Jose State University, pers. comm., as cited in Smith 1998
Oncorhynchus tshawytscha Chinook salmon	OBF-SD	M, AND, FWR	P, ?	LLR, MR, L/OB	_
Oncorhynchus mykiss resident rainbow trout/ steelhead	OBF-SD	M, AND, FWR	LC	MR, HSR, L/OB	Coyote Creek and San Jose, as "trout" (Hallock 1877) Coyote Creek, near mouth in San Jose and at Gilroy Hot Springs, Santa Clara Co. (1898) (SU 23657, USNM 75314, SCAS 123657, and Snyder 1905)
GASTEROSTEIDAE/ STICKLEBACKS *Gasterosteus aculeatus* threespine stickleback	OBF-SD	M, AND, EST, FWR	W	TER, LLR, MR, HSR, L/OB	San Jose [Coyote Creek] (1858 (Girard 1859, Stanford University 4444[2])
COTTIDAE/ SCULPINS *Cottus asper* prickly sculpin	OBF-SD	AMP, EST, FWR	W	TER, LLR, MR, HSR, L/OB	Coyote Creek, near mouth and San Jose (likely collected 1898) (Snyder 1905)
Cottus gulosus riffle sculpin	OBF-FD	FWR	LC	MR, HSR	Coyote Creek, Santa Clara Co. (1890s-early 1900s) (J. O. Snyder, USNM 75405) Coyote Creek, Santa Clara Co. (1922) (C. L. Hubbs, (UMMZ 63397)
Leptocottus armatus Pacific staghorn sculpin	EM	EST, AMP	LC	TER, LLR, L/OB	_
CENTRARCHIDAE/ SUNFISH *Archoplites interruptus* Sacramento perch	OBF-FD	EST?, FWR	EX	TER, LLR, MR, FLP	Coyote Creek., San Jose (inside City) (1922) (UMMZ 63336) Coyote Creek, "San Jose" (1922) (ANSP 85445) Coyote Creek, between Milpitas and Alviso (1922) (UMMZ 63335)
EMBIOTOCIDAE/ SURFPERCH *Hysterocarpus traskii* tule perch	OBF-SD/FD	EST, FWR	P, ?	TER, LLR, MR, FLP	Coyote Creek, Santa Clara Co. (1895) (Stanford University, 5007) Coyote Creek, Santa Clara Co. (1898) (Snyder 1905)
Cymatogaster aggregata shiner perch	EM	EST	LC	TER, L/OB	_
GOBIIDAE/ GOBIES *Gillichthys mirabilis* longjaw mudsucker	EM	M, EST	P, ?	TER	_
PLEURONECTIDAE/ RIGHTEYE FLOUNDERS *Platichthys stellatus* starry flounder	EM	M, EST	P	TER	_

Zoogeographic type: EM = euryhaline marine; OBF-FD = obligatory freshwater-freshwater dispersant; OBF-SD = obligatory freshwater-saltwater dispersant.
Life history status: M = marine; AND = anadromous; FWR = freshwater resident; EST = estuarine resident; AMP = amphidromous.
Current distributional status: LC = locally common; W = widespread; UR = uncommon/rare; P = present in watershed; EX = extinct in watershed; ? = current status and/or population abundance poorly documented or unknown.
Primary habitat occurrence: TER = tidal estuarine/riverine; LLR large lowland riverine; MR = mid-elevation riverine; HSR = headwater riverine; FLP = floodplain ponds; L/OB = lacustrine/open bay.

Source:
UMMZ = University of Michigan Museum of Vertebrate Zoology
SU = Stanford University Fish Collection (housed California Academy of Sciences, San Francisco)
CAS = California Academy of Sciences, San Francisco
USNM = United States National Museum (Smithsonian)
CNHM - Chicago Natural History Museum
SCAF - Southern California Academy of Sciences
ANSP - Academy of Natural Sciences in Philadelphia










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