Hanson Russian River Ponds Floodplain Restoration: Feasibility Study and Conceptual Design

November 2016

Funding provided by

California State Coastal Conservancy

and

Sonoma County Permit and Resource Management Department

The mission of the Endangered Habitats Conservancy is to acquire, manage, monitor and maintain land in California for habitat protection and restoration, agricultural preservation, and other conservation purposes. Incorporated in 2005, EHC currently manages 4,000 acres of conserved open space lands. www.ehleague.org/index.html

NOAA Fisheries is responsible for the stewardship of the nation's ocean resources and their habitat. We provide vital services for the nation: productive and sustainable fisheries, safe sources of seafood, the recovery and conservation of protected resources, and healthy ecosystems—all backed by sound science and an ecosystem-based approach to management. www.nmfs.noaa.gov/

The Coastal Conservancy acts with others to preserve, protect, and restore the resources of the California coast, ocean, and the San Francisco Bay Area. Our vision is of a beautiful, restored, and accessible coastline, ocean and San Francisco Bay Area. http://scc.ca.gov/

Our mission is to serve the people of Sonoma County by providing a customer-focused process for the orderly development of real property, balanced with resource stewardship under the general policy direction of the Board of Supervisors and to develop and maintain standards that protect the health and safety of the public. http://sonomacounty.ca.gov/Permit-and-Resource-Management/

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Executive Summary

Sonoma County's Russian River valleys are well known for their scenic beauty, surrounding rolling hills, oak woodlands, extensive vineyards, and fine wines. Less well known is that many of these valleys have channelized streams and levees, and retired gravel mining ponds along the river banks, a legacy of open pit aggregate mining. The Middle Reach Valley of the Russian River, where the Hanson Russian River Ponds Floodplain Restoration Project is located (Figure A), has approximately 800 acres of these gravel ponds (Figure B). The ponds are separated from the river by an unstable levee system preventing the river from connecting with the floodplain, thus eliminating ecologically critical off-channel slow shallow water floodplain habitats. Historically the broad alluvial valley habitats provided critical nursery, rearing, and refuge habitat for juvenile steelhead, coho and Chinook salmon – all federal Endangered Species Act listed species. The historical floodplain also afforded critical habitat for other sensitive native wildlife species such as western pond turtle, foothill yellow-legged frog, migrating songbirds and waterfowl.

Analysis of current versus historical conditions shows that the geomorphic and ecological attributes of the eight-mile Russian River Middle Reach Valley are degraded to historic lows.

The 358-acre Hanson property, located just west of the Sonoma County town of Windsor, includes four retired gravel ponds (Figure C) providing an opportunity to address the extensive ecological losses within the reach. With the support of the property owner, Hanson Aggregates Mid-Pacific, Inc., the Endangered Habitats Conservancy, NOAA Fisheries, Sonoma County Permit and Resource Management Department, California State Coastal Conservancy, and U.S. Geological Survey completed this feasibility study evaluating ecological restoration alternatives for the Hanson property.

The feasibility study identified a restoration alternative that achieves **the primary project goal** of re-establishing a stable seasonal river-floodplain interface. This re-connection will begin to unwind and restore essential ecological attributes and habitat-forming processes to the Russian River ecosystem and address a primary project objective of contributing to the recovery of listed steelhead, coho, and Chinook salmon. Additional project objectives met by the identified restoration alternative include:

- establishing science-based standards and strategies for similar river restoration projects;
- promoting and demonstrating the use of the state Surface Mining and Reclamation Act (SMARA) to achieve ecosystem restoration; and,
- accommodating public access for recreation, environmental education, and wildlife observation.

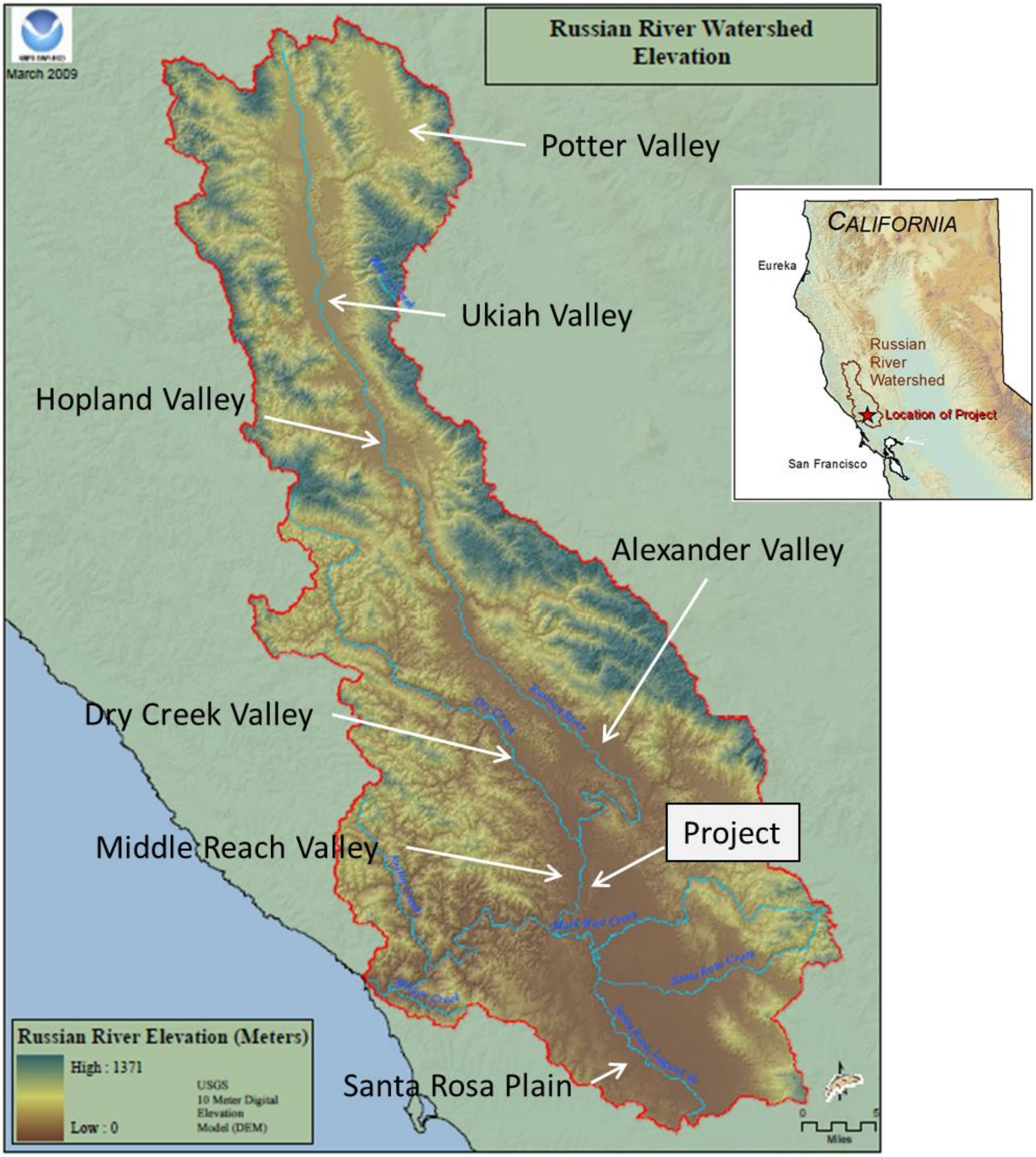

Figure A. The alluvial valleys of the Russian River watershed. The Hanson Russian River Ponds Floodplain Restoration Project is in the Middle Reach Valley just west of the town of Windsor in Sonoma County.

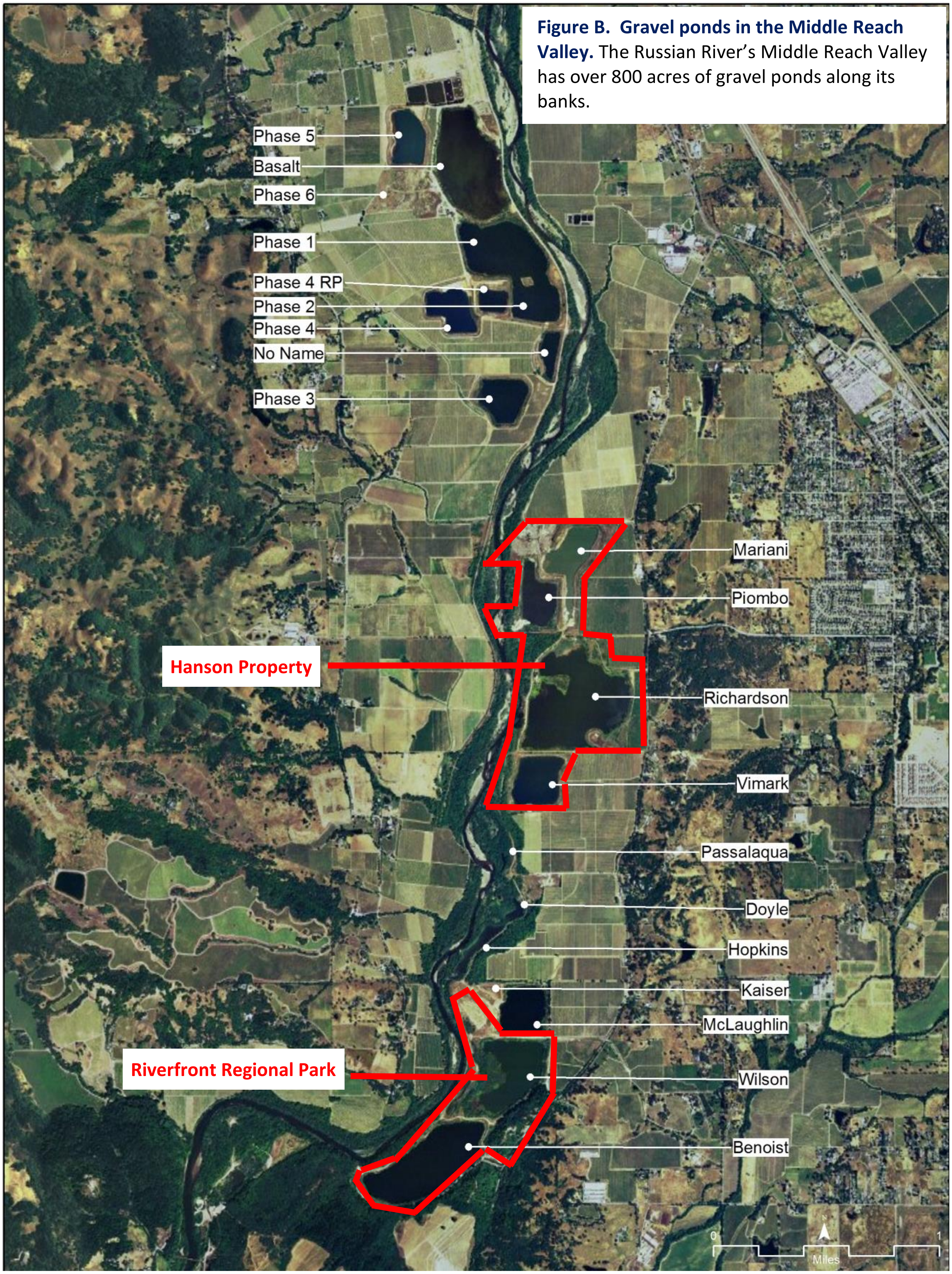

Figure B. Gravel ponds in the Middle Reach Valley. The Russian River's Middle Reach Valley has over 800 acres of gravel ponds along its banks.

The Russian River Middle Reach of the Past

A 2014 historical ecology study by the San Francisco Estuary Institute indicates the Middle Reach alluvial floodplain and riparian forests were seasonally inundated by winter river flows that provided abundant off-channel shallow water floodplain habitats rich in food resources for fish and wildlife. The floodplain was a dynamic matrix of landscape features including meandering channels, tributary sloughs, spring-fed blind channels, oxbow lakes, seasonal wetlands, marshes, and extensive riparian forest. The river channel was relatively shallow and winter inundations spread across a large area, making these seasonal flood events a time of enhanced and highly productive fish habitat. The feasibility study examined restoration strategies that would recover those lost physical properties and ecological functions, and addressed other compromised hydro-geomorphic conditions such as increased flooding, ongoing channel incision, bank instability, and water quality issues.

The Russian River Middle Reach Today

Analysis of current versus historical conditions shows that the geomorphic and ecological attributes of the eight-mile Russian River Middle Reach Valley are degraded to historic lows. Channel straightening, dredging, and levee building during the 1950s and 60s left the river bed deeply incised and isolated from the floodplain during all but the largest storm events. Subsequent decades of floodplain encroachment for aggregate mining and various land uses further diminished the ecological value of the reach, and the river continues to incise. Not surprisingly, the incised channel and over-steepened banks and levees separating the river from the floodplain and terrace gravel mining ponds are geotechnically unstable requiring frequent, expensive, and difficult to permit repairs.

Although the river has perennial flow, current conditions provide poor habitat for salmonids and other native fish. Even though the Russian River is historically one of California's largest gravel bed rivers, the Middle Reach river channel today has essentially no suitable spawning gravel habitat for salmonids. During high flow events, the leveed and straightened channel provides little refuge from the artificially high water velocities and scant suitable refuge or rearing habitat. Furthermore, the ponds themselves provide ideal habitat for warm water non-native fish such as largemouth bass that prey on federally-listed juvenile salmonids and native amphibian species.

Water quality in the Middle Reach is impacted by fine sediment during winter runoff events, and there are no remaining sediment deposition zones in the valley except during extreme flood events. In summer months, nutrient rich and artificially warmed water flows subsurface from the ponds into the river affecting downstream water temperature and quality. The deep, stratified ponds also promote biogeochemical processes that convert naturally occurring mercury into highly toxic methylmercury, and accumulate and cycle nutrients resulting in eutrophic conditions in the bottom of the ponds. This is a significant issue as the gravel ponds sit atop the relatively small and shallow alluvial aquifer that is the drinking water source for 600,000 residents in Sonoma and Marin Counties.

Feasibility Study Outreach and Engagement

The feasibility study plan involved extensive outreach to stakeholders including agricultural interests, conservation groups, and adjacent landowners. Led by then-Sonoma County Supervisor Mike McGuire, several scoping meetings were held with resource and regulatory agencies, and local conservation organizations. The scoping meetings focused on long-standing concerns about the existing reclamation plans for the Hanson property, the feasibility study work plan, feasibility study goals and objectives, and ideas for developing an ecologically superior restoration plan for the property.

This advisory group became the Partners Planning Group offering input at key junctures during the development of the feasibility study. A Management Team, consisting of Endangered Habitats Conservancy (EHC), NOAA Fisheries, Sonoma County Permit and Resource Management Department (PRMD) and the California State Coastal Conservancy (SCC), also convened the Scientific Working Group (SWG), a multidisciplinary panel of 30 technical experts, and the smaller Peer Review Panel. The SWG reviewed the modeling methodology and evaluated results for several restoration scenarios, ultimately identifying the restoration alternative that best achieved the SWG-identified project goals and objectives. The Peer Review Panel provided guidance to the Management Team and SWG in developing project goals, objectives, alternatives analyzed, and feasibility study report conclusions.

Key Feasibility Study Findings

> ***Research indicates restored off-channel and wetland habitat complexes may support fish population densities as much as five times greater and growth rates up to six times higher than main channel habitats for coho salmon and other salmonid species endemic to the Russian River Basin.***
> ***(Swales and Levings 1989; Sommer et al. 2001, Hiner et al. 2009; Morley et al. 2005; Limm and Marcheti 2009; Peterson 1982).***

The feasibility study employed an analytical framework guided by the restoration goals and objectives to explore a range of restoration alternatives. The development of the study was also guided by a review of relevant scientific literature. The literature search helped identify feasible restoration priorities, information gaps, necessary additional field data, and direct existing data compilation. A key component of the feasibility study was the contribution from the U.S. Geological Survey Geomorphology and Sediment Transport Laboratory of Golden, Colorado. The lab used state-of-the-art multidimensional surface-water and sediment transport /landscape evolution modeling of the eight-mile Middle Reach channel to evaluate the performance of restoration alternatives. Figure D illustrates the consensus restoration alternative that best achieves the geomorphic and ecological restoration goals and objectives of the project.

The feasibility study determined that the preferred alternative is feasible and accomplishes the following project goals and objectives:

1. **Significantly increase salmonid habitat** by an order of magnitude including spawning gravels and shallow off-channel calm water, winter and spring nursery, rearing, and refuge habitat for salmonids.

2. **Make a significant contribution to recovery** of the federal- and state-listed Central California Coho salmon population, and federal-listed California Coastal Chinook salmon, and Central California Coast steelhead populations, and provide population level benefits for multiple federally- or state-listed Species of Special Concern.

3. **Significantly reduce production of non-native fish populations** that prey on native fish species by eliminating the warm water habitats favored by the predators.

4. **Halt ongoing river bed degradation and scour** by significantly reducing Middle Reach river flood elevations and water velocities, thus minimizing the erosive scour potential which has resulted in ongoing channel bed incision and destabilization of banks during high flow events.

5. **Improve onsite and downstream water quality** by eliminating the artificial open water ponds that seep warm water into the river, and by restoring annual seasonal floodplain sediment deposition to the reach.

6. **Stimulate ecosystem productivity** by restoring the natural seasonal floodplain pulse-flow dynamics of the valley, and increase aquifer recharge by restoring extensive annual floodplain inundation for significant durations in the winter and spring.

7. **Enhance overall ecosystem function** by restoring connectivity between the river channel and off-channel floodplain shallow water habitats, and seasonal aquatic ecotone interactions with riparian and upland habitats.

8. **Promote recovery of native flora and fauna** by restoring the natural seasonal variability of floodplain and river channel habitat complexity, and natural seasonal heterogeneity and connections of off-channel aquatic habitats under which native species have evolved and flourished.

9. **Restore the structure and function of the riparian corridor** by restoring the landforms and physical processes necessary for supporting a natural riparian vegetation progression from aquatic beds to mature seral stage upland riparian forests.

10. **Lower water surface elevations** in the study area by approximately 1 meter for all flood flows including the 100-year flood event.

11. **Present an ecologically superior, feasible, and exemplary alternative to typical SMARA reclamation plans**, thus providing a science-based rationale to promote the use of SMARA to accomplish ecological restoration goals.

12. **Provide recreational and environmental education opportunities** compatible with ecosystem restoration.

Figure C. The current configuration of the Hanson Russian River Ponds. The Hanson property consists of four ponds totaling 358 acres.
Photo by Brian Cluer, NOAA Fisheries.

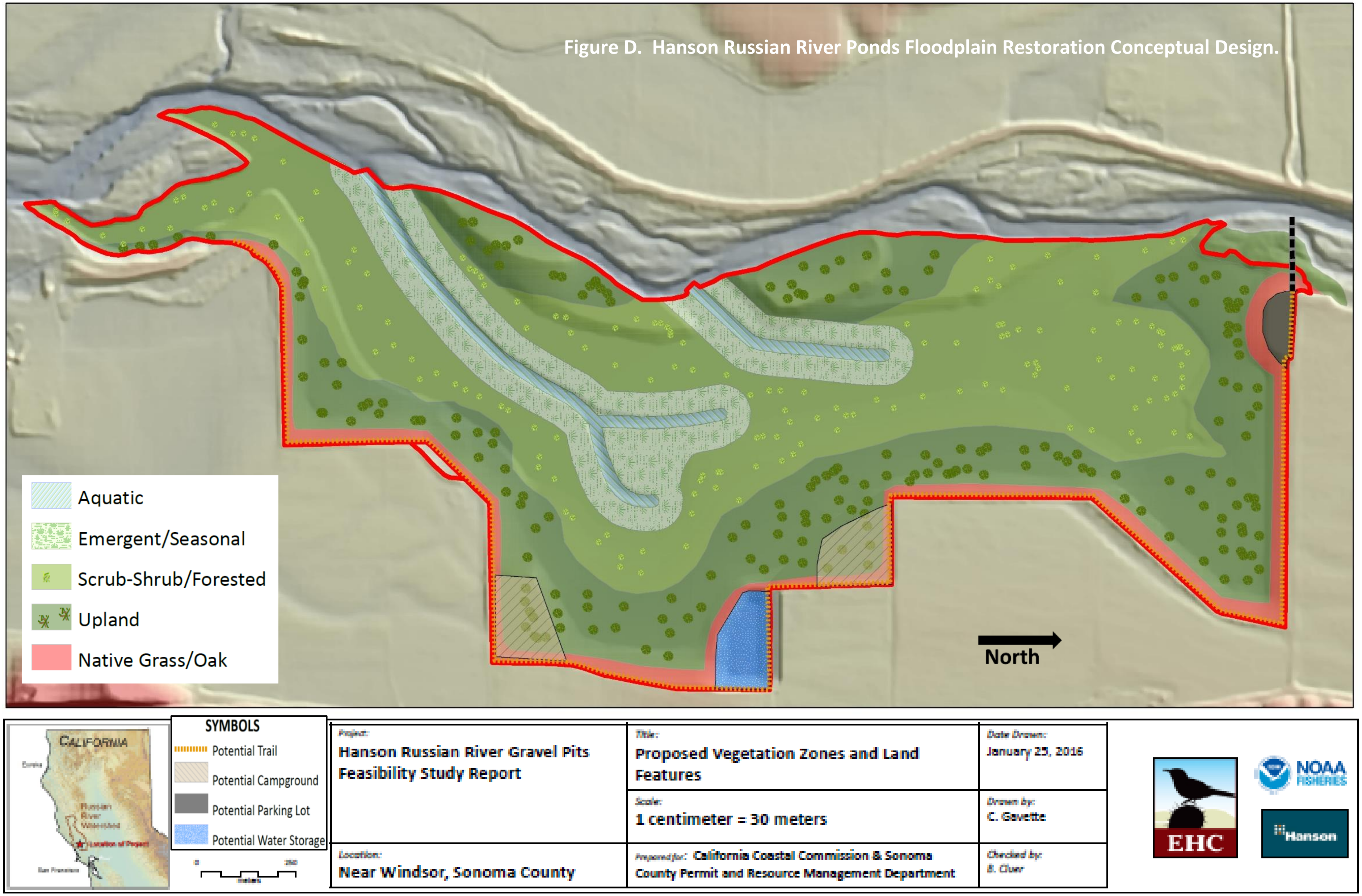
Figure D. Hanson Russian River Ponds Floodplain Restoration Conceptual Design.
Aquatic
Emergent/Seasonal
Scrub-Shrub/Forested
Upland
Native Grass/Oak
North
California
SYMBOLS
Potential Trail
Potential Campground
Potential Parking Lot
Potential Water Storage
Project:
Hanson Russian River Gravel Pits Feasibility Study Report
Title:
Proposed Vegetation Zones and Land Features
Date Drawn:
January 25, 2016
Scale:
1 centimeter = 30 meters
Drawn by:
C. Gavette
Location:
Near Windsor, Sonoma County
Prepared for: California Coastal Commission & Sonoma County Permit and Resource Management Department
Checked by:
B. Cluer
EHC
NOAA FISHERIES
Hanson

Next Steps

Next steps toward the implementation of the preferred restoration scenario include:

- Secure approval from Sonoma County Permit and Resource Management Department and California Department of Conservation Office of Mine Reclamation for an amended reclamation plan that facilitates the initiation of the preferred ecological restoration alternative.

- Complete CEQA/NEPA review (Mitigated Negative Declaration or Environmental Impact Report), including impact analysis, detailed design and engineering plans.

- Concurrently, develop the implementation budget and funding strategy that includes a monitoring and adaptive management plan.

- Secure funding for construction of preferred ecological restoration alternative.

- Secure no cost fee title transfer of the property from Hanson to Endangered Habitats Conservancy.

- Complete engineering and design of the preferred restoration alternative and construct an ecologically superior restoration plan over one or two construction seasons.

- Once restoration is complete, transfer property for long-term management and operation to an appropriate partner. Sonoma County Regional Parks has expressed interest in accepting the property to establish a campground, trails, and kayak launch to expand public access to the Russian River.

CHAPTER

1 Introduction

In 2009, Hanson Aggregates Mid-Pacific, Inc. initiated plans to complete the last remaining mine reclamation obligations at their gravel mine property located in the lower Russian River Middle Reach just west of the town of Windsor in Sonoma County, California (Figure 1.1). At the urging of the Army Corps of Engineers, the Sonoma County Permit and Management Department, National Marine Fisheries Service and Hanson Aggregates discussed issues and concerns related to implementation of the approved reclamation plan features that were no longer biologically acceptable and had never been geotechnically stable. As an outcome of these discussions, Hanson Aggregates sought an alternative to the reclamation plans and turned to Endangered Habitats Conservancy for assistance.

Thus began the Hanson Ponds Russian River Floodplain Restoration Project feasibility study initiated in 2012 with a $340,000 grant from the California State Coastal Conservancy (SCC) to Endangered Habitats Conservancy (EHC) to collaborate with Sonoma County Permit and Management Department (PRMD) and NOAA's National Marine Fisheries Service (NMFS). The Coastal Conservancy grant was augmented with $60,000 from Sonoma County, $20,000 from the California Wildlife Foundation, and $15,000 from NMFS for an historical ecology study, and numerous hours dedicated by their scientists.

The purpose of the feasibility study was to evaluate options to re-integrate the Russian River with the adjacent floodplain on the 358-acre Hanson Aggregates Mid-Pacific, Inc. property (Hanson property). The restoration goal is to maximize ecological services to benefit threatened and endangered species. In contrast, the existing reclamation plans approved two decades ago represent a significant risk to threatened and endangered species associated with the Russian River.

The Hanson property is comprised of four ponds on the east bank of the Russian River (Figure 1.2). The post-mining ponds are typical of the reclamation strategy employed under the California Surface Mining and Reclamation Act (SMARA). For off-channel mining operations, reclamation plans usually require a levee revetment to maintain a separation from the main river channel and adjacent ponds on the historical floodplain. These revetment strategies are frequently unsustainable, costly to maintain, can significantly degrade water quality, and can have long-term detrimental impacts to federally-listed salmonid species including coho and Chinook salmon, and steelhead

However, emerging research posits that re-establishing an ecologically functional floodplain within the footprint of the remnant ponds could significantly reduce or eliminate negative impacts and provide substantial positive outcomes, particularly for native fish populations (Cluer *et al.* 2009). The feasibility study was designed to test this restoration hypothesis and offer a better option than the approved reclamation plan.

Prior to the approval of the SCC grant, PRMD, NMFS, SCC and EHC - the Management Team - held scoping meetings, led by then-Sonoma County Supervisor Mike McGuire, with resource and regulatory agencies and conservation organizations. The meetings focused on long-standing concerns about the impacts of the currently approved site reclamation plans, the feasibility study work plan, potential feasibility study goals and objectives, and ideas for developing an ecologically superior restoration plan for the property. This group became the Partners Planning Group advising the feasibility study.

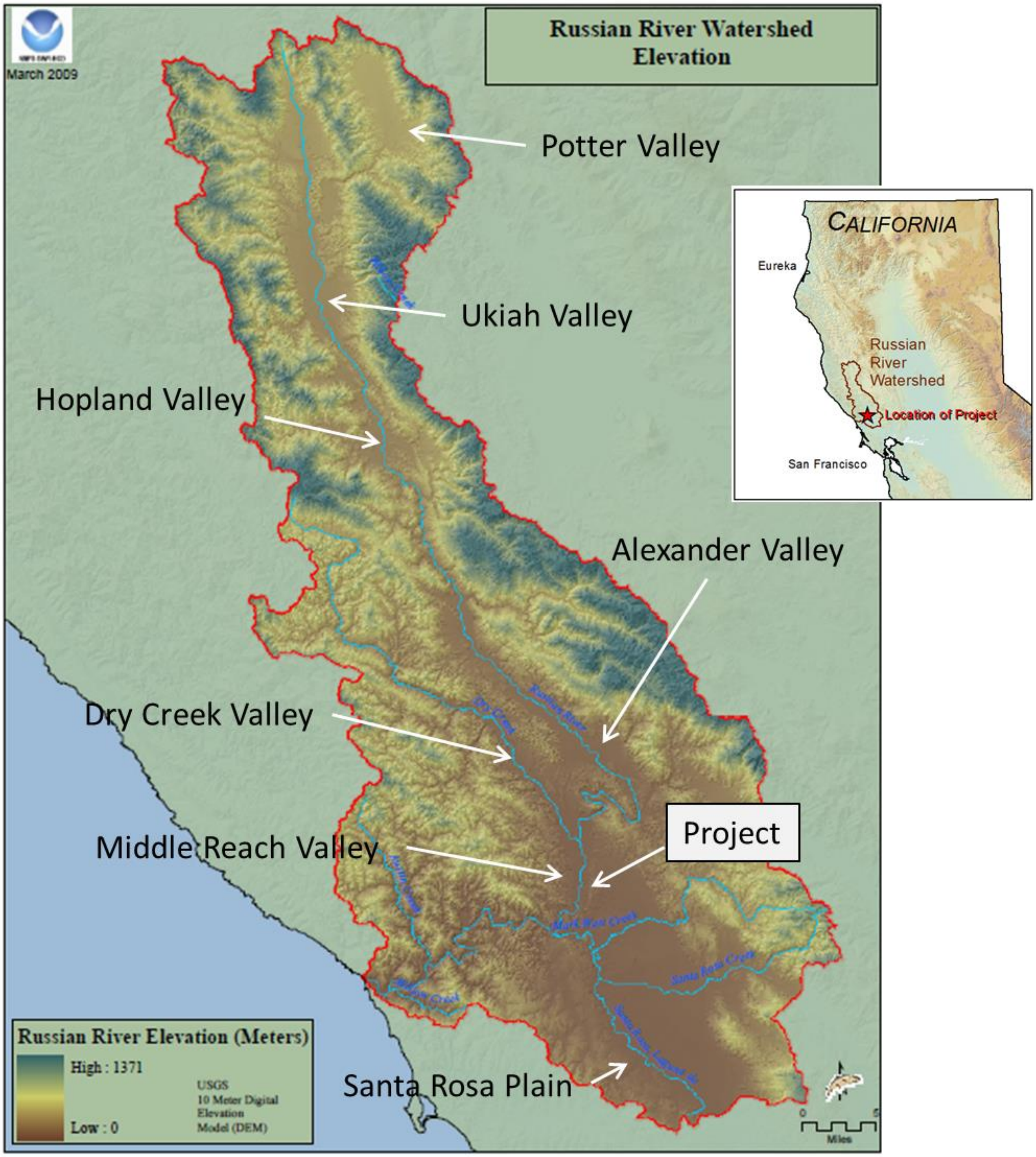

Figure 1.1. The Russian River watershed and Hanson property location map. The Hanson property is located in the lower Middle Reach of the Russian River watershed. The map also shows the major alluvial valleys of the watershed.

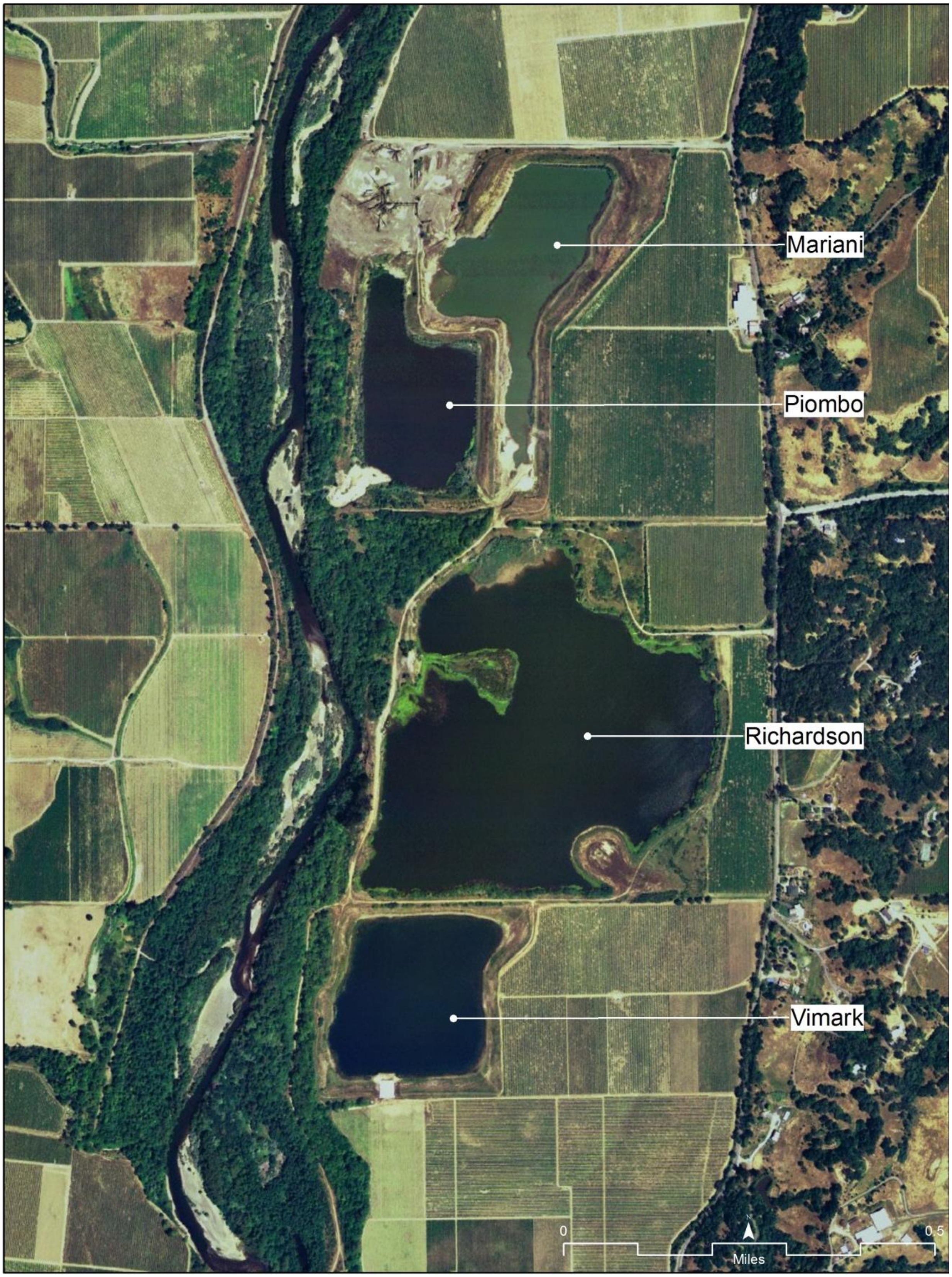

Figure 1.2. The Hanson Russian River Ponds. The 358-acre Hanson property, located on the east bank of the river, includes four ponds – Mariani, Piombo, Richardson and Vimark – and each has different reclamation obligations. The reclamation plan for the Vimark pond has been completed and signed off in compliance with SMARA regulations.

The grants allowed the Management Team to convene the Partners Planning Group, Scientific Working Group (SWG), Peer Review Panel, and other stakeholders (participants listed in Chapter 2). All groups offered guidance for the feasibility study plan and restoration goals and objectives. The SWG also reviewed the study methodology, modeling results for several restoration scenarios, and ultimately identified the restoration alternative that best achieves identified goals and objectives. The SWG was composed of local and national experts in habitat restoration planning, water quality, fisheries, fluvial geomorphology, sediment transport, hydrology, plant ecology, and landscape-level floodplain habitat restoration. The Peer Review Panel provided scientific oversight to the SWG and encompassed similar expertise.

The feasibility study plan employed an analytical framework driven by the identified restoration goals and objectives. The plan was also informed by a review of relevant scientific literature to establish restoration priorities, identify information gaps, and direct existing data compilation and the field collection of additional data necessary for analyses. A key element of the study was the contribution of the US Geological Survey Geomorphology and Sediment Transport Laboratory of Golden, Colorado, using state-of-the-art multidimensional surface-water and sediment transport /landscape evolution modeling to evaluate the performance of restoration alternatives.

1.1 The Problem: Loss of Historical Floodplains

Every major alluvial valley in the Russian River watershed has been significantly hydromodified for land development and flood control purposes (see Appendix A: Russian River Watershed Assessment). Gravel mining ponds excavated in the leveed and disconnected floodplains dot many of the alluvial valleys totaling over 800 acres in Sonoma County's Middle Reach Valley alone (Figure 1.3). Functional floodplains (i.e., seasonal and frequently inundated areas of floodways and off-channel habitats within alluvial valleys), once abundant, have become rare geomorphic features in the modern day Russian River watershed. The catchment-wide loss of seasonally inundated floodplains, and elimination of associated seasonal and perennial off-channel habitat features has likely contributed significantly to the decline of Russian River salmonid populations, currently considered to be at unprecedented low abundance for coho salmon and steelhead (Williams *et al.* 2011).

Literature review confirms the freshwater stages of the salmonid lifecycle benefit significantly from access to off-channel floodplain habitats and refuge. Restoring functional floodplain significantly increases recruitment rates of fry to salmonid populations (Sellheim *et al.* 2015). The more optimal growth and survival conditions for rearing juveniles in floodplain habitats (compared to main river channels) results in the

The Importance of Healthy Floodplains to Pacific Salmon and Steelhead, NOAA Fisheries Fact Sheet, Spring 2014

There is a direct relationship between loss of floodplain function and trends in declining salmon runs. In particular, altering the natural processes that allow habitat to form and recover from disturbances such as floods, landslides, and droughts has the following detrimental effects on salmon habitat:

- Loss of side channels, sloughs, and other in-channel and off-channel rearing and refuge habitats;
- Increased flow velocity during flood events;
- Increased severity and frequency of peak and low flows;
- Reduced subsurface flows and groundwater contributions to the river;
- Simplified habitat due to loss of complex form, large woody debris and terrestrial food sources; and
- Reduced shade that helps to regulate water temperatures.

production of much larger smolts (Grosholz and Gallo 2006, Bellmore *et al.* 2013, Jeffres *et al.* 2008, Sommer 2001, Lister *et al. 1997).*

Smolt size at ocean entry is strongly correlated with marine survival rates (Hayes *et al.* 2008). Thus, large-scale floodplain habitat restoration is documented as an effective means to increase numbers of adult salmonids returning to freshwater to spawn (Lindsey *et al.* 2015).

NMFS's Southwest Fisheries Science Center conducted an assessment of the Intrinsic Potential [1]of Russian River Basin salmonid habitat using valley width, slope, and discharge, and assigned the highest Intrinsic Potential habitat rating to the Middle Reach Valley in Sonoma County (Bjorkstedt *et al.* 2005). Locations where the difference between current ecological status and Intrinsic Potential are greatest indicate areas of highest restoration potential. This potential habitat value for native cold water fish species has been severely compromised due to the hydromodification of the Middle Reach Valley. The hydromodifications have left a straightened, incised, and leveed channel—with former floodplain only connected to the river during the largest hydrologic events, most recently in 2006.

Compounding the loss of floodplain habitat, the ponds become biological sinks for native juvenile fish carried into the ponds during high flows multiple times each winter as fish seek refuge from high velocity flows in the main channel. Once the high flows subside, the fish become isolated in the disconnected ponds. Non-native fish species that thrive in the calm, warm waters of the gravel ponds likely prey on the trapped native fish. Reduced water quality is another area of concern because the post-mining "reclaimed" ponds promote fluvial and biogeochemical processes that cycle and accumulate metals and nutrients (e.g., mercury and phosphorous). Further compounding these detrimental ecological impacts, gravel ponds adjacent to rivers create long-term geomorphic liabilities as they are unstable, difficult to access, and costly to maintain.

1.2 The Opportunity

Emerging new research confirms that the location of river terrace gravel mining ponds potentially offer valuable ecosystem and fisheries restoration opportunities (Kondolf *et al*. 2002; Norman 1998). In 2009, NMFS and Syar Industries, a Russian River gravel mining operator, co-sponsored a symposium to explore reclamation alternatives. The symposium report, *Ecological Opportunities for Gravel Pit Reclamation on the Russian River* (Cluer *et al.* 2009*),* concludes that re-connecting Russian River terrace mining ponds to the river channel to create off-channel habitat offers the potential to significantly improve watershed-wide ecosystem services and the production and ultimate abundance of federally-listed steelhead, and coho and Chinook salmon populations. The report also notes that the approach may improve river channel stability, flood control, water quality, aquifer restoration, and that further study is merited.

Supporting the feasibility study was a 2014 historical ecology reconnaissance study of the Middle Reach Valley by the San Francisco Estuary Institute (see Appendix B: SFEI Historical Ecology Report) that compiled maps and photos from the early 1900's, as well as surveyors' notes with landscape descriptions from the mid-1800s that offer important glimpses of former ecosystem attributes. Prior to the era of development, a broadly meandering, relatively shallow river channel flanked by sand and gravel bars, often up to 1000' wide, characterized the Middle Reach Valley ecosystem. Within that larger and more dynamic river corridor was a rich array of tributary and high-flow channel sloughs,

[1] Intrinsic potential (IP) provides an estimate of relative habitat potential inferred from attributes of channel size (based on estimated mean annual flow), channel gradient, and the valley-width index (the ratio of channel to valley width) as inferred from a DEM.

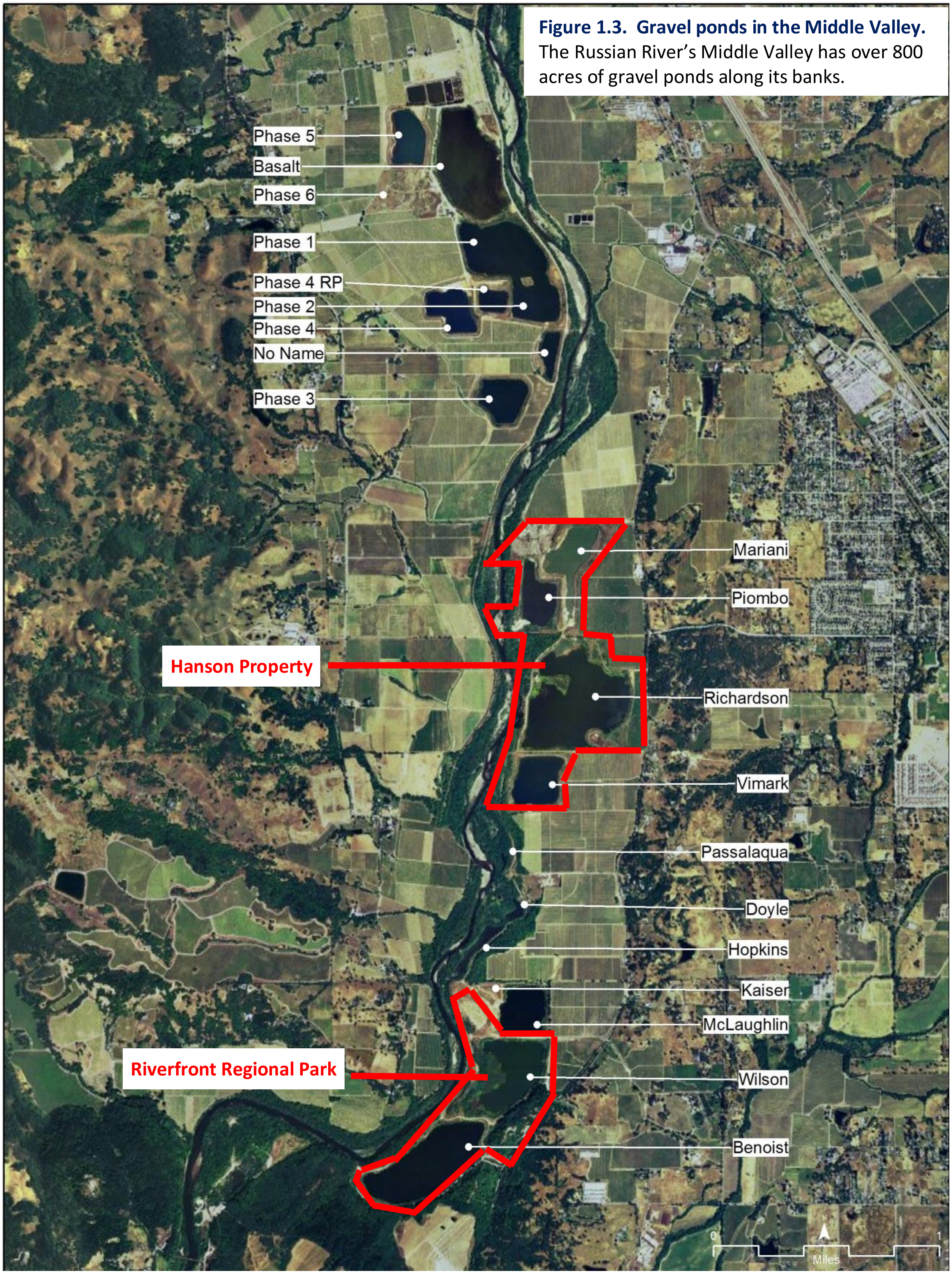

Figure 1.3. Gravel ponds in the Middle Valley. The Russian River's Middle Valley has over 800 acres of gravel ponds along its banks.

seasonally connected ponds (oxbow lakes formed by cut-off channels), and perennial sloughs comprising extensive and diverse off-channel habitats. These shallow edgewater habitats afforded refuge from floods and predators, areas for recruitment of fry, and opportunities for rapid growth for juvenile salmonids in winter and spring. In the summer, some of the blind channel features were deep enough to connect to the groundwater table, likely providing thermal refuge and rearing habitat for native cold water fish species.

The Hanson property is an excellent candidate for the exploration of alternatives to the reclamation plan, focusing on ecological process-based floodplain restoration. Such restoration strategies have the potential to begin reversing habitat losses in the Russian River watershed by re-establishing and re-integrating hydrologic, fluvial, and vegetative processes into an ecologically dynamic floodplain landscape. The feasibility study presents an opportunity to develop science-based standards for similar landscape-level river restoration projects in California and the Northwest, and demonstrate how this new approach to aggregate mining could achieve ecosystem restoration as its "reclamation" end product. The feasibility study also provides an opportunity to gather and analyze scientific information to assist the many academic and governmental institutions interested in refining and updating SMARA to include ecosystem restoration as an end use of former mining sites.

1.3 Reclamation of Hanson Ponds: Evolving Strategies

The California Surface Mining and Reclamation Act (SMARA), administered by the California Department of Conservation Office of Mine Reclamation with local agency permitting authority, requires mine operators to prepare and implement a post-mining reclamation plan ensuring future beneficial uses. SMARA reclamation does not typically mean restoration to ecologically functional landscapes, rather SMARA focuses on stabilizing the property for a subsequent land use, which may include commercial, agricultural, or residential uses.

In the case of the Hanson gravel ponds, each pond has a separate reclamation plan identifying wildlife habitat and open space as the subsequent beneficial land use approved by Sonoma County PRMD, the local land use and lead agency for SMARA. These reclamation plans have been amended several times. The original Hanson reclamation plans allowed the Russian River to flow into the ponds and deposit sediment that would naturally refill them. This approach was reversed in the 1980s when Russian River reclamation plans were changed to maintain a separation between the river and ponds amid concerns that linking ponds to the river could cause streambed capture (also known as "pit capture") thus inducing downstream channel instability. The isolated ponds filled with low permeability fines however had potential to negatively impact groundwater flows by "plugging" aquifers with fine sediments, to entrap native salmonids, and create warm water nurseries for invasive predator species thereby increasing predation on salmonids in the river.

While many of the concerns associated with the early reclamation plans remain today, maintaining separation between the ponds and the river has proven to be more challenging than anticipated. The river bed in the Middle Valley Reach has continued to incise since it was channelized in the 1950s, although the localized deep dredge pits have partially recovered in depth. During flood events, the earthen berms isolating ponds from the river during low flow are subject to strong subsurface seepage forces and bank erosion even before high flows overtop the berm. In addition, overtopping and levee breaching events in the winter months became more frequent than originally anticipated due to inaccuracies in flood mapping and hydrologic studies, high rates of vegetation growth driven by artificially high summer flows, and minimal to no bank and channel maintenance.

In an effort to reduce these impacts, Sonoma County initiated a different approach in the 1990s. To improve pond and levee stability, the construction of relatively low elevation erosion-resistant rock weirs between adjacent ponds and between the ponds and the river were incorporated into reclamation plans. The purpose of the weirs was to equilibrate water levels during flood events, specifically before levee overtopping occurs. The current Hanson property reclamation plans that incorporate this weir strategy are included as an alternative analyzed in the feasibility study.

As new research and experience highlights the problems with maintaining a separation between the gravel ponds and the river, the project feasibility analysis identified strategies to directly address that challenge. Consequently, f the feasibility study had a two-fold task: identifying a restoration scenario consistent with a geomorphologically stable amended reclamation plan while achieving the biological and hydrological restoration objectives of seasonally connecting the river to the floodplain

1.4 Project Purpose, Feasibility Study Goals and Objectives

The Management Team, in consultation with the Partners Planning Group, Scientific Working Group, and other stakeholders, developed the project purpose and feasibility study goals and objectives.

1.4.1 Project purpose. The primary purpose of the Hanson Ponds Russian River Floodplain Restoration Project is to recreate a functional floodplain and enhance the natural Russian River ecosystem, to restore ecosystem services, and address the needs of listed fish species. Establishing a natural seasonal connection between the river and its floodplain facilitates the establishment of habitats that meet the life history requirements and promote the genetic diversity of federally-listed anadromous fish species – native coho and Chinook salmon and steelhead (*Oncorhynchus* spp.). Other at-risk species that will likely benefit from the restoration are native Russian River tule perch (*Hysterocarpus traski*), western pond turtle (*Clemmys marmorata*), foothill yellow-legged frog (*Rana boylii*), migrating waterfowl and songbirds, and other avian, botanic, aquatic and herpetological floodplain and riparian-dependent native species.

The creation of seasonally appropriate hydraulic connections to the river will provide natural ingress and egress for freshwater migrations of multiple life history stages of juvenile salmonids. The integration of the off-channel habitats, seasonal wetlands and riparian landscapes will begin to reverse the losses of critical ecosystem functions now widespread in the Russian River Basin. Literature review indicates these types of restored off-channel and wetland habitat complexes may support fish population densities as high as five times greater, and growth rates up to six times higher than main channel habitats for coho salmon and other salmonid species endemic to the Russian River Basin (Swales and Levings 1989; Sommer *et al.* 2001, Hiner *et al.* 2009; Morley *et al.* 2005; Limm and Marcheti 2009; Peterson 1982).

Additionally, the project is intended to provide numerous ecological services including water quality enhancement, aquifer restoration, nutrient and fine sediment processing, flood control, and provision of habitat for native flora and fauna as an integral component of the greater Russian River ecosystem.

Secondary, but also important project purposes are:

- Establish science-based standards for similar landscape-level river restoration projects in California and the Pacific Northwest.
- Provide a rationale and working example for SMARA regulations to promote more robust ecological restoration of former aggregate mining sites.
- Provide public access facilities that give users the opportunity to enjoy the Russian River without impacting the resource values of the restoration concept.

1.4.2 Feasibility study goals: The primary feasibility study goal is to assess restoration alternatives and develop a preferred scenario from several terrain model concepts. The highest-ranking scenario maximizes and integrates natural physical and biotic processes into a landscape-level ecosystem restoration strategy providing critical seasonal habitat for multiple life stages of ESA-listed salmonids by re-establishing a connection between the Russian River and its floodplain. The goal envisions a self-sustaining terrain that evolves over time, providing a shifting mosaic of riverine and floodplain habitats.

While not a focus of the feasibility study, public access concepts were developed in coordination with Sonoma County Regional Parks staff and are incorporated into the project conceptual design. Proposed public amenities include regional trail linkages, campground facilities, and possibly a launch and takeout site for non-motorized personal watercraft. County Parks has identified the project as an ideal opportunity to increase access to the river, provide another link in a proposed Russian River trail, and implement environmental education programs. All public access and use facilities ultimately incorporated into the project design will avoid and/or minimize impacts on fish and wildlife habitats and floodplain environmental services.

1.4.1 Feasibility study objectives: The objectives of the feasibility study are to address key issues that must be resolved or mitigated if the project is to be successfully implemented. These issues are:

1. Evaluate the benefits and risks to the population dynamics of ESA-listed *Oncorhynchus* species resulting from increased access to new off-channel floodplain habitats, including changes in predator-prey interactions of the Russian River resulting from connecting a floodplain to the river versus connecting the ponds to one another and the river.
2. Document the current status of nutrient and metals cycling and identify viable strategies for assessing and remediating potential mercury methylation issues at the project site.
3. Analyze current conditions and how changes in river hydraulics and project site geomorphology of alternative restoration scenarios will affect fine sediment processing, water quality, and temperature dynamics affecting the project area and downstream.
4. Evaluate the surface and groundwater interactions resulting from floodplain restoration including the potential for increasing groundwater/aquifer recharge and the potential impact on Sonoma County Water Agency facilities downstream, the adjacent Town of Windsor well field to the north, other adjoining land uses, seasonal water table levels and well use.
5. Model how changes in river hydraulics resulting from re-establishing a floodplain will affect flood stage elevations at the project site and flood frequency throughout the eight miles of the Middle Reach Valley.
6. Evaluate how the alternatives impact river hydraulics, sediment transport deposition and processing, channel stability, and erosion throughout the eight miles of the Middle Reach Valley.

1.5 Project Design Considerations

Consultation with the Partners Planning Group, Scientific Working Group and Peer Review Panel identified the following design considerations as essential to achieving the project purpose described above.

1. Maintain or improve upstream and downstream channel stability to avoid "pit capture."
2. Maintain or improve bank stability for adjacent landowners.

3. Maintain or improve water quality at the Hanson site and downstream. Water quality characteristics include temperature, dissolved oxygen, turbidity, metals, nutrients, organochlorines, and total dissolved carbon.
4. Maintain or improve flood conditions at the Hanson site and downstream, including flood stage elevations and flood frequency.
5. Reduce non-native fish habitat and warm water temperature to avoid predation of federally-listed salmonids.
6. Avoid stranding of federally-listed salmonids by improving native fish egress from Hanson property.

1.6 Feasibility Study Conclusions

The conclusion of the feasibility study as described in the following chapters indicates that re-establishing a seasonal connection between the Russian River and the Hanson property is feasible and that the enhanced floodplain function would produce numerous ecological benefits while eliminating the negative impacts of existing conditions. Analysis of potential “fatal flaw” impacts have been included in this study and found to be eliminated or fully mitigated by the preferred restoration scenario.

1.7 Feasibility Study Report Purpose

The purpose of this report is three-fold:

1. Present existing ecological conditions and evaluate potential environmental outcomes of the current reclamation plan.
2. Describe the methodology, project goals and objectives, constraints, scenario selection, modeling results, and conclusions of the SWG and Management Team of the feasibility of an alternative-to-the-reclamation-plan restoration scenario.
3. Present the preferred restoration scenario and anticipated environmental outcomes.

The report also lays the foundation for the next steps of engineered designs, environmental review, permitting, and securing implementation funding.

This report details the approach and methodology used to assess the feasibility of several restoration scenarios (Chapter 2); describes the data compilation and collection (Chapter 3); offers an overview of the Russian River land use history and documents current conditions in the watershed (Chapter 4); summarizes the results of the literature review (Chapter 5) and lists the restoration goals and objectives (Chapter 6). Chapters 7 and 8 examine the development, modeling and analysis employed to identify a feasible restoration alternative detailed in Chapter 9. Chapter 10 presents conceptual design plans for the most feasible restoration alternative. Project constraints and next steps to move the concept plan to implementation are detailed in Chapter 11.

Figure 1.4. Gravel ponds along the Russian River Middle Reach. Looking north, the ponds in the foreground are part of Sonoma County Regional Parks Riverfront Regional Park, Hanson gravel ponds are in the center of the photo, and Syar Industries ponds are visible in the upper left. *Photo by Brian Cluer, PhD, NOAA's National Marine Fisheries Service.*

CHAPTER

2 Approach and Methodology

Restoration planning and implementation are grounded in understanding the causes of habitat degradation, the scale at which the problem must be addressed, and constraints on restoration opportunities (Skidmore *et al.* 2013). Effective river restoration projects require planning that includes (Beechie *et al*. 2008):

1. Setting clear goals for restoration activities.
2. Choosing a project prioritization approach that is consistent with the goals.
3. Using watershed assessments to identify restoration actions necessary to meet the goals.
4. Prioritizing proposed actions based on assessment results.

Based on this approach, and in consultation with restoration experts and stakeholders participating on the Partners Planning Group and Scientific Working Group, the Management Team formulated a study plan with clear goals and objectives (Chapter 1, Section 1.4). Existing constraints were identified with assistance from these same groups, while the Scientific Working Group offered extensive input on the methodology and data needed for modeling existing and potential restoration conditions, and criteria for evaluating the model results. The study plan is outlined below and described in more detail in the following chapters.

2.1 Establish project structure to ensure engagement of key stakeholders and scientific expertise

The project structure was designed to afford feedback and oversight from a diverse group of scientists, resource agency and conservation organization representatives, landowners and other stakeholders. Each group contributed to the development of the project goal and feasibility study goals and objectives. The organizational structure is illustrated in Figure 2.1, which also depicts the roles and relationship of each group to one another.

Management Team: The primary role of the Management Team is day-to-day project oversight and developing the project structure, approach, methodology for review and input by Partners Planning Group, Scientific Working Group, and Peer Review Panel.

Management Team

Jennifer Barrett, Sonoma County Permit & Resource Management Department
Michael Beck, Endangered Habitats Conservancy
Michael Bowen, California State Coastal Conservancy
Brian Cluer, Ph.D., NOAA's National Marine Fisheries Service
Melanie Harrison-Okoro, Ph.D., NOAA's National Marine Fisheries Service
Amy Lyle, Sonoma County Permit & Resource Management Department
John McKeon, NOAA's National Marine Fisheries Service
Nancy Schaefer, Endangered Habitats Conservancy consultant
Chris Seppeler, Sonoma County Permit & Resource Management Department

Figure 2.1. Project structure for the Hanson Ponds Russian River Floodplain Restoration Feasibility Study.

Partners Planning Group: The purpose of this group is to keep key resource agency and conservation organization partners informed, solicit their input and guidance, and assist with outreach.

Partners Planning Group

Toni Bertolero, Town of Windsor
Carlo Bongio, Redwood Empire Trout Unlimited
Marc Bommersbach, Westside Association to Save Agriculture
Karen Gaffney, Sonoma County Agricultural Preservation & Open Space District
Caryl Hart, Sonoma County Regional Parks
Kara Heckert, Sonoma Resource Conservation District
Brian Hines, Redwood Empire Trout Unlimited
Jay Jasperse, Sonoma County Water Agency
Rick Jorgenson, Redwood Empire Trout Unlimited
Don McEnhill, Russian Riverkeeper
Mike McGuire, Sonoma County Supervisor, District 4
Doug Lipton, Russian Riverkeeper
Adam McKannay, California Department of Fish & Wildlife
Patrick Rutten, NOAA National Marine Fisheries Service
Ken Tam, Sonoma County Regional Parks
Bob Torre, Russian River Wild Steelhead Society
Leslie Vivian, Redwood Empire Trout Unlimited
Ryan Watanabe, California Department of Fish & Wildlife

Scientific Working Group: The role of this group was essential for the success of the feasibility study. Top scientists from diverse disciplines were engaged to define and reconcile science-based restoration goals and objectives, review and advise modifications to terrain models and corresponding USGS model results to assist with the identification of the restoration scenario that best meets the restoration goals.

Scientific Working Group

Brian Bair, US Forest Service, Watershed Restoration Team Leader
Peter Baye, **Ph.D**., Consulting Scientist, Botanist, Coastal Ecologist
Steve Butkus, North Coast Regional Water Quality Control Board, Environmental Engineer
Greg Carr, Sonoma County Planner (retired)
Wayne Chang, MS, PE, Chang Consultants, Civil Engineer
Joseph Dillon, NOAA's National Marine Fisheries Service, Water Quality Specialist
Michael Donahue, NOAA's National Marine Fisheries Service, technical intern
Tom Gardali, Point Blue Conservation Science, Avian Ecologist
Gregory Guensch, Sonoma County Water Agency, Water Resource Engineer, Geomorphologist
Joshua Goodwin, Office of Mine Reclamation, Department of Conservation
Robin Grossinger, San Francisco Estuary Institute, Historical Ecologist
Melanie Harrison-Okoro, **Ph.D**., NOAA's National Marine Fisheries Service, Biogeochemical Expert
Sean Hayes, **Ph.D.**, NOAA's National Marine Fisheries Service, Southwest Fisheries Science Center, Fisheries Ecologist
Beth Hendrickson, Office of Mine Reclamation, Department of Conservation
Jacob Katz, Ph.D., CalTrout, Fisheries Biologist
Peter Kiffney, Ph.D., NOAA Northwest Fisheries Science Center, Fisheries Ecologist
John Klochak, US Fish and Wildlife Service, Fisheries Biologist
Neil Lassiter, Sonoma County Water Agency, Hydrologist & Geomorphologist
Dave Manning, Sonoma County Water Agency, Environmental Resources Manager
Richard McDonald, US Geological Survey, Geomorphology & Sediment Transport Laboratory, Hydrologist & Modeling Expert
Adam McKannay, California Department of Fish & Wildlife, Fisheries Biologist
Jonathan Nelson, Ph.D., US Geological Survey, Geomorphology & Sediment Transport Laboratory, Hydrologist & Modeling Expert
Don Seymour, Sonoma County Water Agency, Principal Engineer
Mark Strudley, Ph.D., NOAA National Weather Service, Hydrologist and Fluvial Geomorphologist
Marcus Trotta, Sonoma County Water Agency, Hydrogeologist
Richard Wantuck, NOAA's National Marine Fisheries, Supervisor, Engineering Branch
Gus Yates, Todd Engineers, Hydrologist

Peer Review Panel

Tim Beechie, Ph.D., NOAA's National Marine Fisheries Service, Northwest Fisheries Science Center, Fisheries Ecologist, Geomorphologist
Blair Greimann, Ph.D., US Bureau of Reclamation, Civil Engineering, Sediment Transport
Joseph Kiernan, Ph.D., NOAA's National Marine Fisheries Service, Southwest Fisheries Science Center, Fisheries Ecologist
Michael Pollock, Ph.D., NOAA's National Marine Fisheries Service, Northwest Fisheries Science Center, Ecosystem Analyst, Fluvial Geomorphologist

Peer Review Panel. The Peer Review Panel performed the essential function of reviewing the methodology, restoration goals and objectives, modeling results, and justification for the selected restoration scenario.

2.2 Conduct stakeholder outreach

Several meetings were held with the Partners Planning Group to describe the project, feasibility study, receive input on the approach, methodology, goals and objectives and outreach plan, and to provide periodic updates. In addition to the Partners Planning Group, the Sonoma Resource Conservation District and Russian Riverkeeper were engaged to assist with outreach to the broader community of business, agriculture and the general public. The Sonoma Resource Conservation District led the outreach efforts to the agricultural community and those living near the Hanson project site. Russian Riverkeeper met with its supporters, local and state legislators, and provided outreach to the general public through river trips and articles in local newspapers.

A partial listing of stakeholders includes adjacent and nearby landowners, Sonoma County Farm Bureau, Lytton Tribe, West Side Association to Save Agriculture (WASA), Farm Bureau, Dry Creek Valley Association, Ducks Unlimited, Madrone Audubon Society, Redwood Chapter of the Sierra Club, Russian River Watershed Council, and Russian River Property Owners Association.

2.3 Complete literature review

A literature review and summary was conducted by Brian Cluer, Ph.D., and John McKeon with additional assistance from colleagues Joel Casagrande and Joe Hueblein, all with NMFS. The review focused on scientific journal articles that document benefits to salmonids related to landscape-level river restoration projects that either created new off-channel floodplain habitat, or connected former gravel mining ponds to restore off-channel habitat conditions. The literature review built on and added to an earlier literature review completed by NMFS for the 2009 Symposium. California specific literature is richest in the area of Central Valley floodplains seasonally connected to adjacent rivers. Chapter 5 presents a summary of the literature review results.

2.4 Compile existing and collect new data

Most of this task involved collecting new data that was essential for inputs to the USGS landscape evolution model since very little existed at the appropriate resolution. The Management team collected new and collated topographic and bathymetric data sets of the entire floodplain for eight miles of the Middle Reach Valley and the Hanson ponds. Soil, sediment, and water samples were collected from the Hanson property and the Middle Reach Valley channel and banks to analyze for potential contaminants under the Phase II testing described below.

The soil and sediment samples were also evaluated for grain size distribution and stratigraphy. Extensive in situ water quality monitoring was carried out to develop dissolved oxygen and temperature profiles of the Hanson ponds to document physical and biogeochemical processes; and fisheries surveys characterized the fish assemblage of Middle Reach ponds.

Chapter 3 presents a comprehensive overview of the data collection process and analyses.

2.5 Complete Phase I and II Environmental Site Assessments

EHC contracted with Geotechnical and Environmental Solutions, Inc. (EEI) to conduct a Phase I Environmental Site Assessment and modified Phase II testing for the Hanson property to evaluate soil and water quality and determine if there were any hazardous materials issues on the site. The Phase I ESA was performed in conformance with the American Society for Testing and Materials (ASTM) *Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process*, Designation E1527-05.

In the Phase II ESA, EEI collected soil, sediment and water samples from the Hanson property that were submitted for laboratory analysis to evaluate potential impacts from historical mining and agricultural land uses on and adjacent to the property. Chapter 3 describes the sampling process, locations, and analyses for specific constituents completed under this task. The Phase I and II ESA reports can be found in Appendix E.

2.6 Complete watershed assessment for the Russian River

As recommended by Beechie *et al.* 2008, a watershed assessment was completed for the Russian River by Brian Cluer, Ph.D., Fluvial Geomorphologist, and John McKeon, Biologist, both with NMFS. The watershed assessment (Appendix A) begins in the north with the Hopland and Ukiah Valleys and ends with the estuary where the river meets the Pacific Ocean. The assessment covers pre-development processes and conditions, salmonid life history stage, current processes and conditions, and restoration opportunities. The assessment was used to help identify restoration goals and objectives.

2.7 Engage Scientific Working Group and Peer Review Panel

The Scientific Working Group (SWG) was engaged at three key stages of the study. The first meeting was held in March 2013 to review the results of the physical and biological data compilation, identify appropriate scientific processes and analyses to evaluate current conditions, confirm draft project goals and objectives, and review alternative terrain scenarios for river-landscape interaction. Additionally the SWG identified methods to optimize ecosystem functions and services, developed evaluation criteria for restoration scenarios, and provided input on specific project goals and objectives described in Chapter 6.

The Peer Review Panel (PRP) met for the first time in September 2013. The SWG met a second time in September 2013 along with the PRP to review initial Stage I sediment and flow modeling results for current conditions and several simple terrain scenarios and provided direction for development of a more refined restoration scenario for the Stage II round of USGS modeling. The SWG and PRP were engaged as a group and individually via web-based teleconferences, emails, and phone calls by the Management Team from October 2014 through February 2015 as additional modeling runs yielded results.

2.8 Complete Stage I modeling for preliminary floodplain elevations

Stage I consisted of modeling five digital terrain models representing a range of floodplain elevations. USGS scientists Jonathan Nelson, Ph.D., and Richard McDonald with the Geomorphology and Sediment Transport Laboratory were engaged to complete modeling runs to determine important habitat metrics of flow velocity, depths and sediment transport rates associated with existing conditions and the restoration terrain scenarios. The International River Interface Cooperative or iRIC software was used to model responses to discharge variation at the project site and the eight miles of the Russian River Middle Reach to evaluate the time variations of sediment transport rates when subjected to varying annual hydrographs. Model boundary conditions for iRIC were constructed from floodplain topography and vegetation roughness from LiDAR, river and pond bathymetry, water surface elevations, synoptic water surface elevations, and calibration drag (roughness). The terrain models included both existing conditions (reclamation alternatives) and the preliminary floodplain scenarios.

Model output for each floodplain elevation was assessed by the SWG and PRP fusing numerous parameters such as flood hydraulics, geomorphic changes, fish habitat and others that indicate how well each alternative met the restoration goals and objectives. The full list of restoration goals and objectives are in Chapter 6. Detailed descriptions of the floodplain models and the application of the full range of parameters are presented in Chapter 7.

After reviewing the Stage I model results, the SWG and PRP recommended design refinements to the conceptual terrain to meet the restoration goals and objectives and optimize ecosystem function within the site constraints. These refinements were incorporated in the Stage II modeling.

2.9 Complete Stage II modeling to refine terrain model and characterize the best restoration concept

Working with the SWG and PRP through multiple web-ex conferences and phone calls, terrain model options were reviewed as refinements were made to optimize ecological performance within the site constraints. This iterative process zeroed in on the final terrain scenario, which was selected for best achieving the restoration goals and objectives.

Using the final refined terrain scenario, the USGS then ran the iRIC model over a range of flow conditions and examined not only two-dimensional hydraulics, as done for the Stage I modeling, but sediment transport and reach responses of the river to a new floodplain connection. A detailed description of the terrain models, final model run, and results are provided in Chapters 8 – 10 and Appendix G: Physical Evaluation of the Restoration Alternatives.

During the terrain optimization process, consultations were also held with Sonoma County PRMD, Sonoma County Regional Parks, Russian Riverkeeper, Sonoma County Water Agency, the City of Windsor and other stakeholders. At this point topographic accommodations for possible future access and recreation were included in the final terrain model.

2.10 Develop the restoration design concept

The feasibility study results guided the development of alternative restoration scenarios and the preferred restoration scenario. The preferred restoration scenario was used to develop a more detailed concept plan. Chapter 9 compares the restoration scenarios and quantifies how each performs against the restoration goals and objectives and project constraints established by the Partners Planning Group, Scientific Working Group and Peer Review Panel.

CHAPTER

3 Data Compilation and Collection

Execution of the feasibility study required the collection of significant new data. The USGS landscape evolution modeling required hydraulic, sediment transport, and topography data for the entire Middle Reach Valley. The topographic data for the entire study reach of eight miles was necessary to create a high resolution digital terrain model to run the USGS model, develop alternative restoration scenarios, and comparative analyses of geomorphic and ecologic function between restoration scenarios and existing conditions. Additional inputs necessary for study design modeling and analysis of existing conditions required sampling and characterization of soils, sediment, and water from the Hanson Ponds, levees, surrounding uplands, and the bed and banks of the Russian River channel for the eight mile study reach.

To evaluate the potential for hazardous materials on the Hanson property, Phase I and II environmental site assessments collected soil, sediment, and water samples for laboratory analysis from these same locations. NMFS collected sediment, soil, and water samples from the same locations in the river channel and banks to allow comparison of onsite contaminants with background levels.

Lastly, NMFS, along with other agency partners, conducted four surveys in two ponds in order to characterize fish assemblages. Table 3.1 summarizes the data collected.

3.1 Topographic data collection

To create the detailed digital terrain model for the Middle Reach Valley (between the Healdsburg Highway 101 Bridge and the Wohler Bridge), topographic data was collected. Several data sources were used for topographic and bathymetric data, the focus of the initial phase of data collection.

3.1.1 Surface topography - LiDAR. In 2012, Sonoma County Permitting and Resource Management Department (PRMD) hired GeoDigital, Inc. to fly LiDAR for the Middle Reach Valley on October 20-21 as shown in Figure 3.1. The point density was eight points per square meter having accuracies of 9.25 cm vertical RMSE which is typical of federal flood studies and general environmental mapping. GeoDigital processed the raw LiDAR data to produce spatially explicit data layers including:

- Classified LiDAR point cloud (ASPRS Class Codes) in LAS 1.2
- Non-vegetation
- Ground
- Low vegetation
- High vegetation
- DEM, 0.5 m resolution, in ArcGIS format
- 1 foot contours in SHP format

Table 3.1. Summary of data compilation and collection.

Data	Source
Topography	
Middle Reach Valley topography, LiDAR Survey	GeoDigital, Inc., NMFS
Hanson Ponds bathymetry	Affiliated Researchers, Inc.
Middle Reach River bathymetry	Affiliated Researchers, Inc., USGS-NMFS
Syar Ponds bathymetry	Syar Industries, Yolano Engineers
Soil and Sediment Sampling	
Particle size sampling and laboratory analysis	NMFS
Hanson Pond sediment core sampling	Affiliated Researchers, Inc., EEI, Inc.
River bed sediment and bank soil sampling	Affiliated Researchers, Inc., NMFS
Hanson Pond soil and sediment sampling analyses for nutrients, metals, organics	Sunstar Laboratories, Inc.
River bed, and bank soil and sediment samples analyses for nutrients, metals, organics	Alpha Analytical Laboratories, LLC
Water Sampling	
Hanson Ponds dissolved oxygen profiles	Affiliated Researchers, Inc., NMFS
Hanson Ponds temperature profiles	Affiliated Researchers, Inc., NMFS
Hanson Ponds water quality sampling for nutrients, metals, organics, chlorophyll-A	EEI, Inc., Affiliated Researchers, Inc., NMFS
Russian River water quality sampling for nutrients, metals, organics	Affiliated Researchers, Inc., NMFS
Analyses of Hanson Ponds water quality samples	Weck Laboratories, Inc.
Analyses of Russian River water quality samples	Alpha Analytical Laboratories, LLC
Fish Surveys	
Fish assemblage surveys and characterization of gravel pond fish populations	NMFS, California Department of Fish and Wildlife, Sonoma County Water Agency
Hydrology and Hydraulics	
Russian River discharge records, at Healdsburg	USGS gage #11464000
Dry Creek discharge records, near mouth and near Geyserville	USGS gages # 11465350 and 11465200
Water surface elevations for a range of river flows	NMFS and USGS

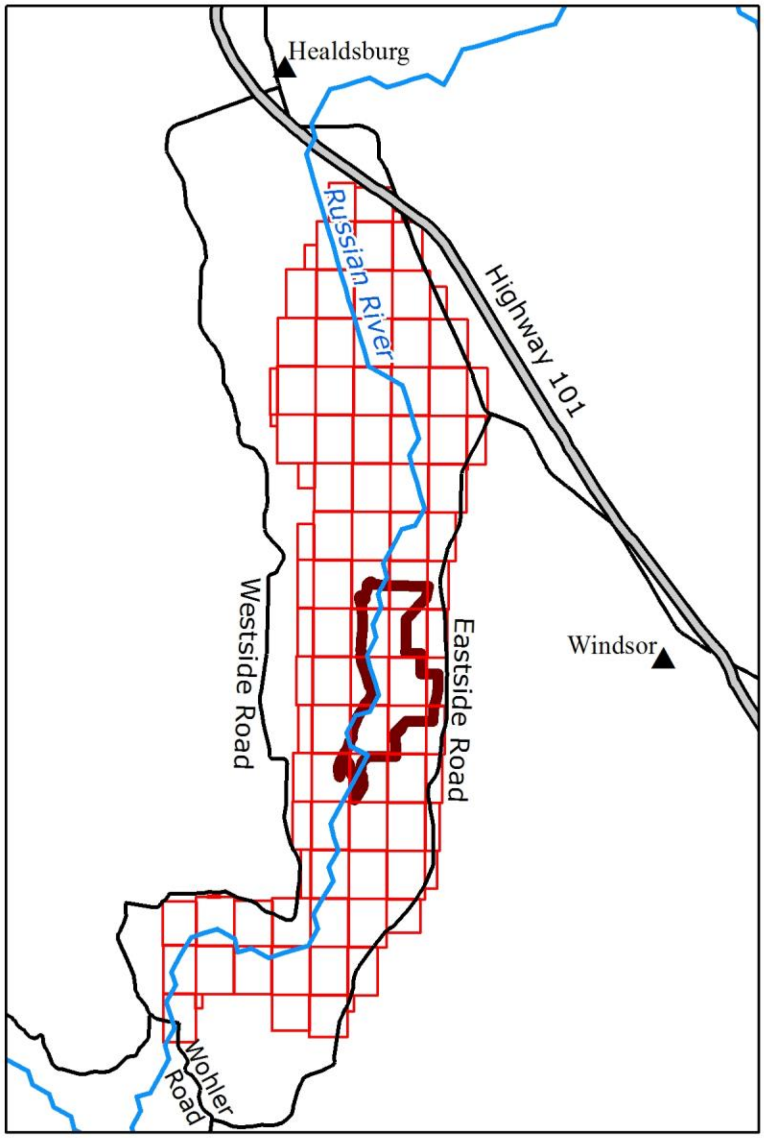

Figure 3.1. **LiDAR coverage (red grid).** With funding from Sonoma County, GeoDigital, Inc. flew LiDAR for the Middle Reach Valley extending from the Healdsburg Highway 101 Bridge south to the Wohler Bridge. The project site is outlined by the bold red line.

3.2 Bathymetric data collection

Bathymetric data was collected for the Hanson ponds and the eight-mile Russian River channel in the Middle Reach Valley between the Healdsburg Highway 101 Bridge and the Wohler Bridge. Syar Industries, Inc. provided the Management Team with new bathymetric data collected for their ponds on the west side of the river below the mouth of Dry Creek.

3.2.1 Hanson ponds bathymetry. In August 2012, consulting firm Affiliated Researchers, Inc., established eight hill-top bench marks on the Hanson site for future survey needs. These benchmarks were established with NGS OPUS techniques using RTK-GPS equipment and monumented with plastic caps on 2’ lengths of 3/8” rebar. Affiliated Researchers also mapped the Hanson ponds with single and multi-beam echo sounder integrated with sub-meter accurate RTK-GPS positioning equipment, producing a grid of bathymetric elevation data of the inundated ponds. The location of the water's edge of the ponds was mapped using sub-meter accurate RTK-GPS at approximately 200' spacing around the perimeter of each pond. Affiliated Researchers provided the following data and services:

- single-beam bathymetric surveys of each of the four ponds
- side-scan survey of the Richardson Pond
- multi-beam survey of the Richardson Pond
- 8 survey monuments
- GPS location of the pond perimeters
- water surface elevation for the Hanson ponds
- water surface elevations of the adjacent Russian River channel
- GPS locations of soil, sediment, and water samples from the ponds and river
- GPS locations of dissolved oxygen and temperature profiles of the Hanson ponds

3.2.2 Syar ponds bathymetry. In May 2012, Syar Industries' contractor, Yolano Engineers, conducted bathymetric surveys of their gravel ponds located upriver and on the opposite (west) side of the river from the Hanson site, and provided the data to NMFS for integration with the LiDAR coverage. The Syar ponds were mapped with a single beam echo sounder integrated with sub-meter accurate RTK-GPS positioning equipment. The survey produced a grid of elevation data for the bathymetry and water surface elevations of Syar ponds.

3.2.3 Russian River Middle Reach bathymetry. River bathymetry data was collected in two phases. During the first phase on January 9 and 10, 2013, Affiliated Researchers collected river bathymetry with a single-beam echo sounder and RTK-GPS along the eight-mile Middle Reach Valley from a shallow draft aluminum boat. Approximately 140,000 centimeter accurate river bathymetry points were compiled from the data. The river's water surface elevation (WSE) data were collected simultaneously with each point of the river bed topographic data. The simultaneous collection of WSE and bathymetry data facilitated verification and calibration of the hydraulic model over the entire Middle Reach Valley. Three hundred and nine water's edge shoreline positions and corresponding water surface elevations were also mapped using the RTK-GPS.

River flows during the early January 2013 bathymetric survey were descending from a flood peak of approximately 27,000 cfs in late December (Figure 3.3). During Affiliated Researchers' survey, flow rates varied gradually from 1,850 to 1,650 cfs. A water level staff plate was installed at the river access point approximately mid-way along the reach to track changes in water elevation and discharge. The water surface elevation was manually recorded several times per day, surveyed with RTK-GPS twice per day, and an acoustic Doppler current profiler (ADCP) measured discharges several times per day over the course of the bathymetric survey.

After the first phase of river data collection, the US Geological Survey (USGS) developed an initial hydraulic model using Affiliated Researchers' river bathymetry data. This initial model highlighted areas where additional channel topographic data was needed, thus requiring a second phase of data collection. Additional data was needed for the steep, well-vegetated banks with robust woody vegetation overhanging the river on both banks characteristic of the Middle Reach Valley channel shape. The survey boats are generally unable to penetrate the bank vegetation at higher flows and the GPS signal is often lost in the overhanging vegetation.

From February 19 to 24, 2013, Paul Kinzel from USGS in Golden, Colorado, joined Dr. Brian Cluer of NMFS to collect additional river bathymetry. An RTK-GPS system was set up on the benchmarks previously established by Affiliated Researchers and a single-beam echo sounder was attached to NMFS's River Cat to conduct the additional survey work. Several hundred-thousand additional bathymetry points and water surface elevations were recorded along the eight miles of the Middle Reach Valley. Daily transmission of additional data to, and feedback from the USGS modeling team in Colorado served to focus next-day survey efforts. With an additional five days of data collected during this period, the USGS modeling team reported they had adequate bathymetric coverage to build a calibrated hydraulic model.

The February 2013 river bathymetry surveys found that a mound of river bed material forms in the channel center that was not present during the January bathymetry surveys. That mid-channel mound, approximately 2 m in height, is apparently mobilized during flood flows and reforms late on the declining limb of the hydrograph as flow recedes. The Russian River hydrograph during the period of the two bathymetry surveys is shown in Figure 3.2.

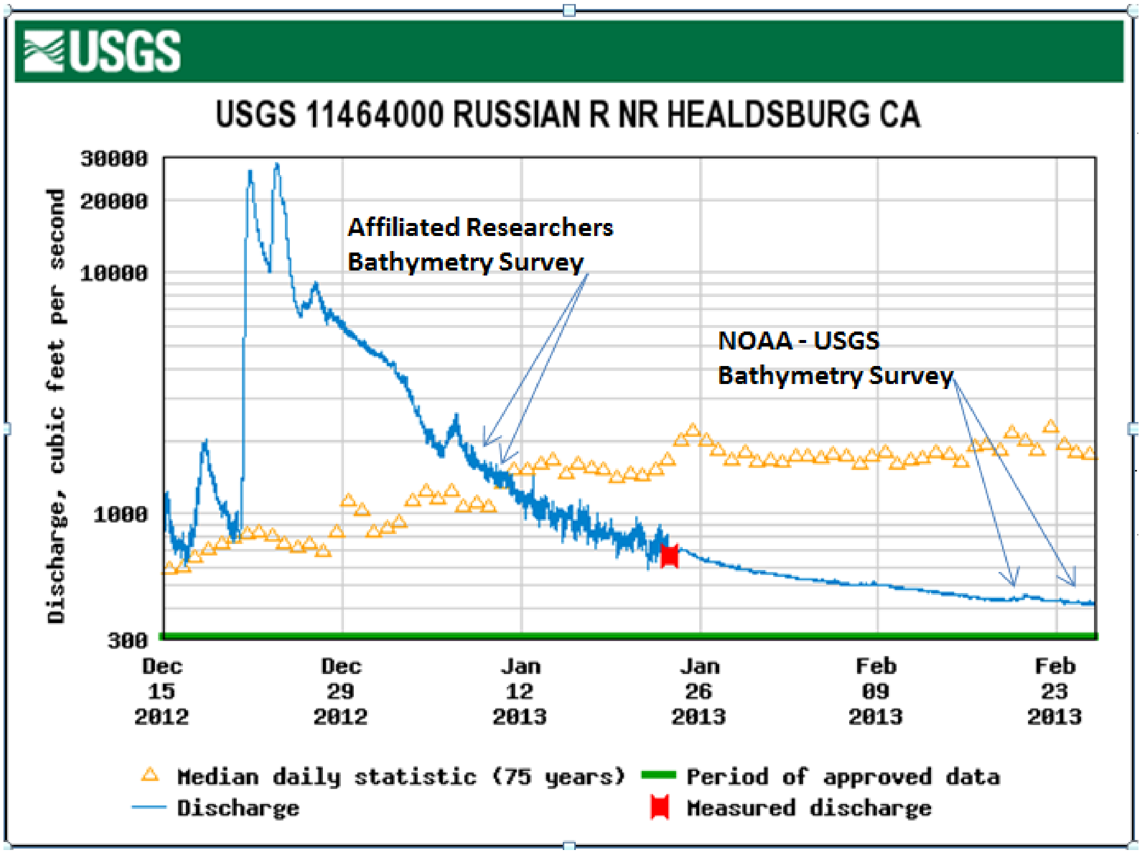

Figure 3.2. Russian River hydrograph during the bathymetry surveys.

3.3 Creating the digital terrain model

Using the topographic and bathymetric data, the NMFS GIS lab in Santa Rosa created a detailed digital terrain model for the Middle Reach floodplain extending between the Healdsburg Highway 101 Bridge and the Wohler Bridge, and from Eastside Road to Westside Road representing existing topography for the approximately 18 square kilometer study reach. The four sources of bathymetric data – Affiliated

Researchers' river and Hanson ponds data, USGS/NMFS river data, and Syar Industries pond data - were merged with the Bare-Earth processed LiDAR data using ARC GIS software to create this digital terrain model (DTM) (Figure 3.3). This existing conditions DTM was the starting point for analyzing current conditions, modeling alternative restoration configurations, and as the base layer input for USGS hydraulic and sediment transport modeling of proposed restoration scenarios to be evaluated for water depths, velocities, and sediment transport characteristics.

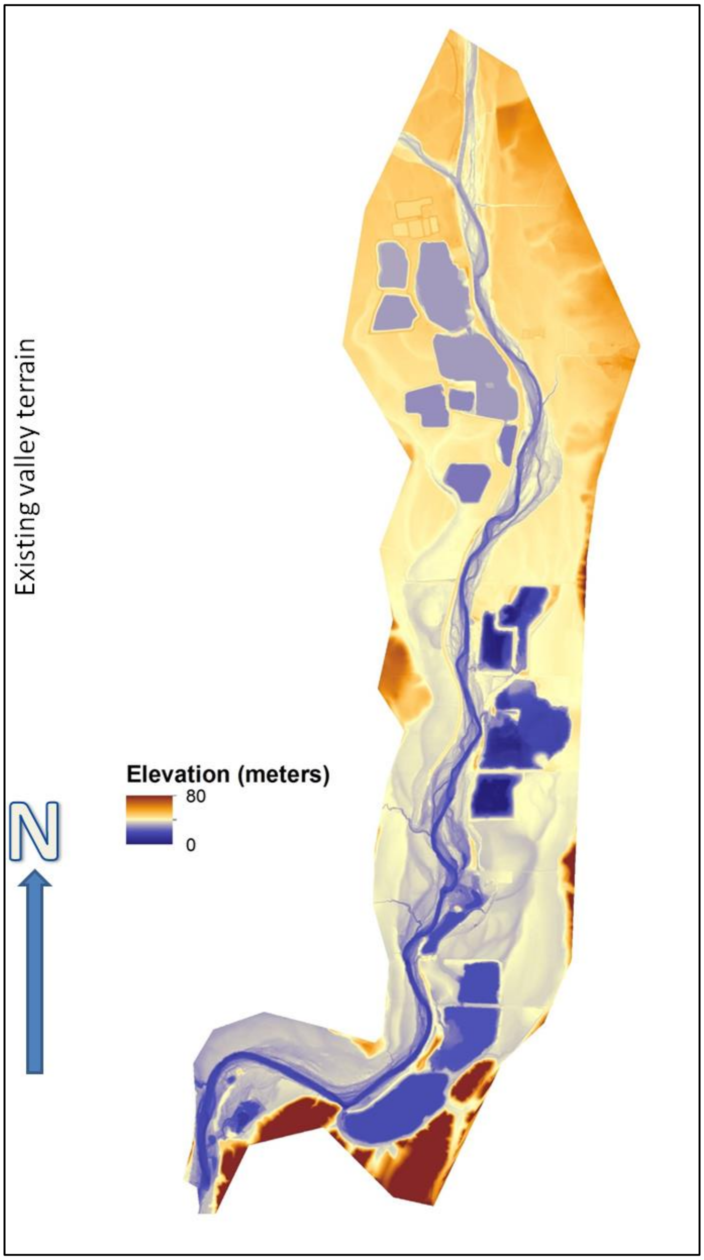

Figure 3.3. Russian River Middle Reach digital terrain model. The digital terrain model of the Russian River Middle Reach floodplain was generated from the combined LiDAR-derived surface topography and the bathymetric data for the river, Hanson, and Syar ponds. The three large ponds at the southern end of the reach are within the Sonoma County Riverfront Park for which bathymetric data was not available. They are thus depicted in the terrain model as flat surfaces at the water surface elevations present during the LiDAR survey.

3.4 Soil and sediment sampling for grain size distribution and fill characterization

Soil and sediment sampling was done in the Middle Reach study area, the Hanson property, and the Russian River channel. There were two data needs for carrying out the sampling: 1) to characterize sediment and soils texture, depth, and stratigraphy as key inputs for USGS modeling efforts, and 2) to test for hazardous materials (Phase II environmental site assessment).

The characterization of particle grain size distributions is a key input for the USGS sediment transport model for both the Hanson property and in the river channel. Consequently, soil and sediment samples were taken from both locations. The material at the Hanson property proposed for re-contouring the ponds for restoration was also characterized. The collection and analysis of these samples is described in the following sections.

3.4.2 Hanson property soil sampling for grain size distribution. From August 1 to 3, 2012, NMFS staff directed a small excavator operator to dig soil profile trenches at 15 locations and 30 test pits around the Hanson site ponds for a total of 45 samples (Figure 3.4) and to build access ramps to each of the four Hanson ponds for launching Affiliated Researchers vessels. The site is highly disturbed from the mining operation and from constructed levees between the river and the ponds, and levees between the ponds. Consequently, soil stratigraphy was not observed at most locations, which allowed aggregating multiple samples taken from each trench and test pit. Collected bulk samples from each location were stored in one gallon canvas sample bags for later laboratory analysis of soil particle grain size distributions. Sampling locations were documented by Affiliated Researchers using RTK-GPS equipment. The five grab samples collected by EEI for chemical and contaminant laboratory analysis by Sunstar Laboratories Inc. as described below in section 3.5.1 were collected from a subset of these trench and test pit sampling locations.

3.4.3 Russian River channel sediment sampling for grain size distribution. On December 19, 2012, NMFS collected bulk sediment samples weighing approximately 70 pounds each from nine gravel bars distributed throughout the eight-mile study reach (Figure 3.6). The samples were processed using a combination of field and laboratory sieving techniques. Particles greater than 1.5 inches were hand measured in the field along their intermediate axis. Particles from 1.5 inches to 3/8 inch were field sieved, and particles less than 1/2 inch were laboratory sieved. During field sieving, all materials landing on each sieve (1.5”, 0.75” and 0.5 “) were field weighed and all particles less than 0.5 inches were bagged and transported to a laboratory for further sieving. The results of the field and laboratory analyses were combined to produce grain size distributions ranging from 0.15 mm to 105 mm.

3.4.4 Laboratory analysis of particle grain size distributions. A sediment size analysis laboratory was made available to NMFS by Bohan and Cannelis Austin Creek Ready Mix. Bulk samples from the Hanson site trenches and test pits along with the samples collected from 9 gravel bars of the Russian river were processed in this lab. A stack of nine ASTM gradation sieves ranging from 0.15 mm opening to 4.75 mm opening were used with a mechanical shaker to create particle grain-size distributions for each discrete sample. Particles smaller than 0.15 mm (silt/clay) were not further analyzed. Particle grain size distribution analyses results are presented in Chapter 4.

Figure 3.4. Terrestrial sediment sampling locations around the Hanson ponds. Trench and test pit locations for 45 samples for Hanson site grain size distribution and soil stratigraphy characterization.

3.4.5 Hanson ponds sediment coring for sediment texture, depth, and stratigraphy. During the July 20 to August 1, 2012 field mobilization, Affiliated Researchers collected 25 Vibracore samples for evaluating the texture, depth, and stratigraphy of accumulated sediment at the locations shown in Figure 3.6. The nine benthic sediment samples used for laboratory analysis for contaminants described below (Section 3.5.3) were taken from a subset of these 25 Vibracore samples. The samples provided data to map the depths, composition, texture, and stratigraphy of sediments that have accumulated in the pond bottoms since the mining operations excavated each pond down to a clay-pan aquatard layer. The depths of accumulated sediments, their texture, composition, and stratigraphy of layers provides important information for discerning current ecologic conditions and the physical and biological processes affecting the ponds water quality dynamics currently and in the future. Vibracore sediment samples were collected in 3-inch diameter polycarbonate tubes, lowered through the center of a 20-foot pontoon boat to the bottom of the respective pond and driven to the point of refusal up to a maximum of 96 inches using a Rossfelter Vibracore driver. Refusal before 96" depth is interpreted as the depth of a hard layer or coarse sediment.

3.4.6 Analysis of Hanson ponds sediment cores. On August 14, 2012, NMFS staff examined the Vibracore samples to characterize particle grain size (clay/sand/gravel) composition (organic/inorganic), and the depths and pattern of the stratified layers. Results are discussed in Chapter 4. GPS locations of the 25 Vibracore samples and descriptions of particle size, texture, composition and stratigraphy of the sediments of each core collected are contained in Appendix E.

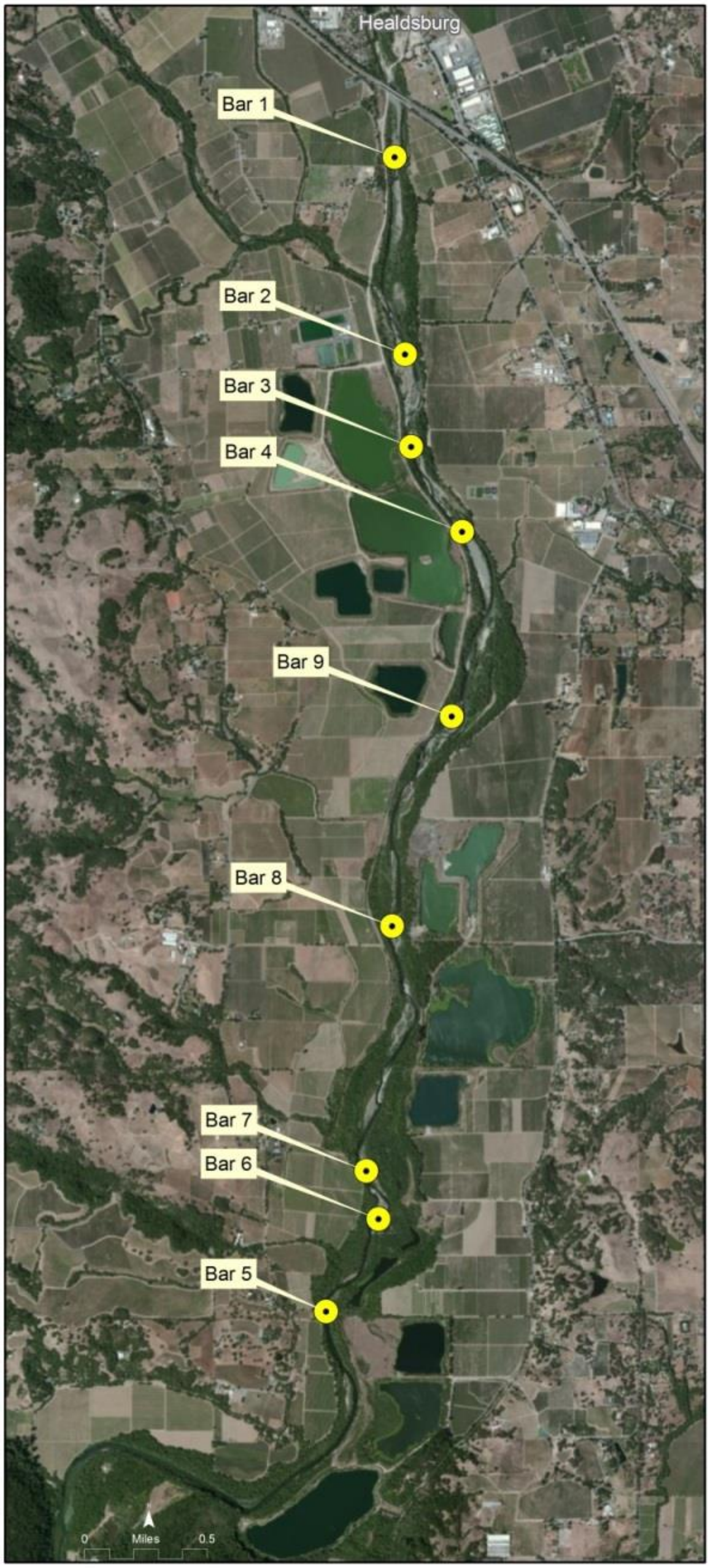

Figure 3.5. Russian River channel sediment sample locations. Bulk sediment sample sites from bars distributed throughout the study reach. The Hanson ponds are adjacent to Bar 8 in this figure.

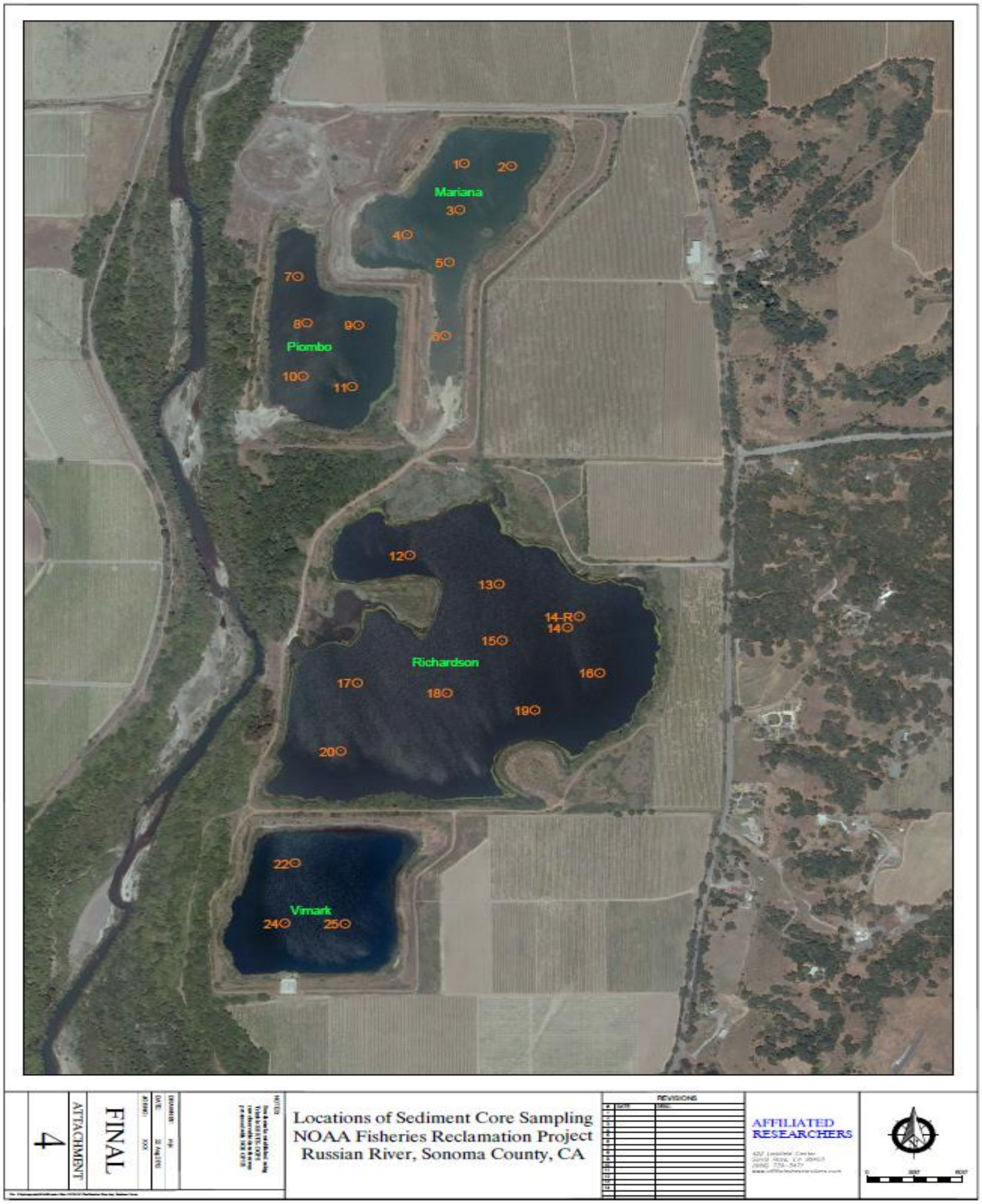

Figure 3.6. Hanson pond locations for sediment and soil samples. Map illustrating the location of the 25 Vibracore sediment samples taken at the Hanson property by Affiliated Researchers, Inc., to evaluate sediment depth, composition, texture, and stratigraphy.

3.5 Soil and sediment sampling for contaminants

Soil and sediment sampling was done for both the Hanson property and the Russian River channel. Endangered Habitats Conservancy commissioned Geotechnical and Environmental Solutions EEI, Inc. (EEI), to conduct a modified Phase I for the Hanson property that included Phase II soil and water sampling for laboratory analysis. Sampling was conducted to evaluate potential impacts from historical mining and agricultural activities on and adjacent to the property, for comparison with background levels of the Russian River channel, and to identify potential geochemical drivers of conditions basin-wide. NMFS and Affiliated Researchers carried out concurrent soil and sediment sampling of the Russian River and Russian River channel.

The North Coast Regional Water Quality Control Board (Regional Board) was consulted to determine the distribution of sampling sites, the list of contaminants of concern, and the suite of laboratory tests that should be performed to discern the presence or absence of these compounds. The laboratory analyses conducted on soil and sediment samples were:

- Extractable Petroleum Hydrocarbons by 8015C
- Metals (16) by EPA 6010B
- Total mercury by Cold Vapor Extraction EPA 7470/7471
- Organochlorine Pesticides by EPA Method 8081A
- Organophosphorus Pesticides by EPA Method 8141A
- Polynuclear Aromatic Compounds by GC/MS with Selected Ion Monitoring

Reported soil and sediment concentrations were compared to California Human Health Screening Levels (CHHSLs) for Soil-Residential Land Use values (Cal-EPA, 2005). The CHHLs are concentrations of 18 hazardous chemicals that are used to estimate and compare reported concentrations in soil or soil gas to identify potential risk to human health. Where CHHL values were not available (and for the water samples), San Francisco Bay Regional Water Quality Environmental Screening Levels (ESL) for either shallow soil (residential) or groundwater (potential drinking water resource) was used (SFBRWQCB 2008).

The ESLs are concentrations of chemicals of concern commonly found during soil and groundwater investigations which can be used to estimate and compare reported concentrations to risk to human health and the environment. Typically, the use of ESL in evaluating water samples is preferred over the California Maximum Contaminant Levels (MCLs). The ESL calculations are generally more conservative by one or more degrees of magnitude.

The laboratory analyses results for all the samples are summarized in Chapter 4 and the complete Phase I and II environmental site assessment reports and laboratory results are in Appendix E.

3.5.1 Hanson ponds sediment and soil sampling (Phase II testing). On July 30, 31, and August 1, 2012, EEI conducted soil and sediment sampling in the vicinity of the former plant operations area, various spoils areas, and within the four ponds on the Hanson property, collecting a total of 14 soil/sediment samples. Figure 3.7 depicts the sample locations for this investigation.

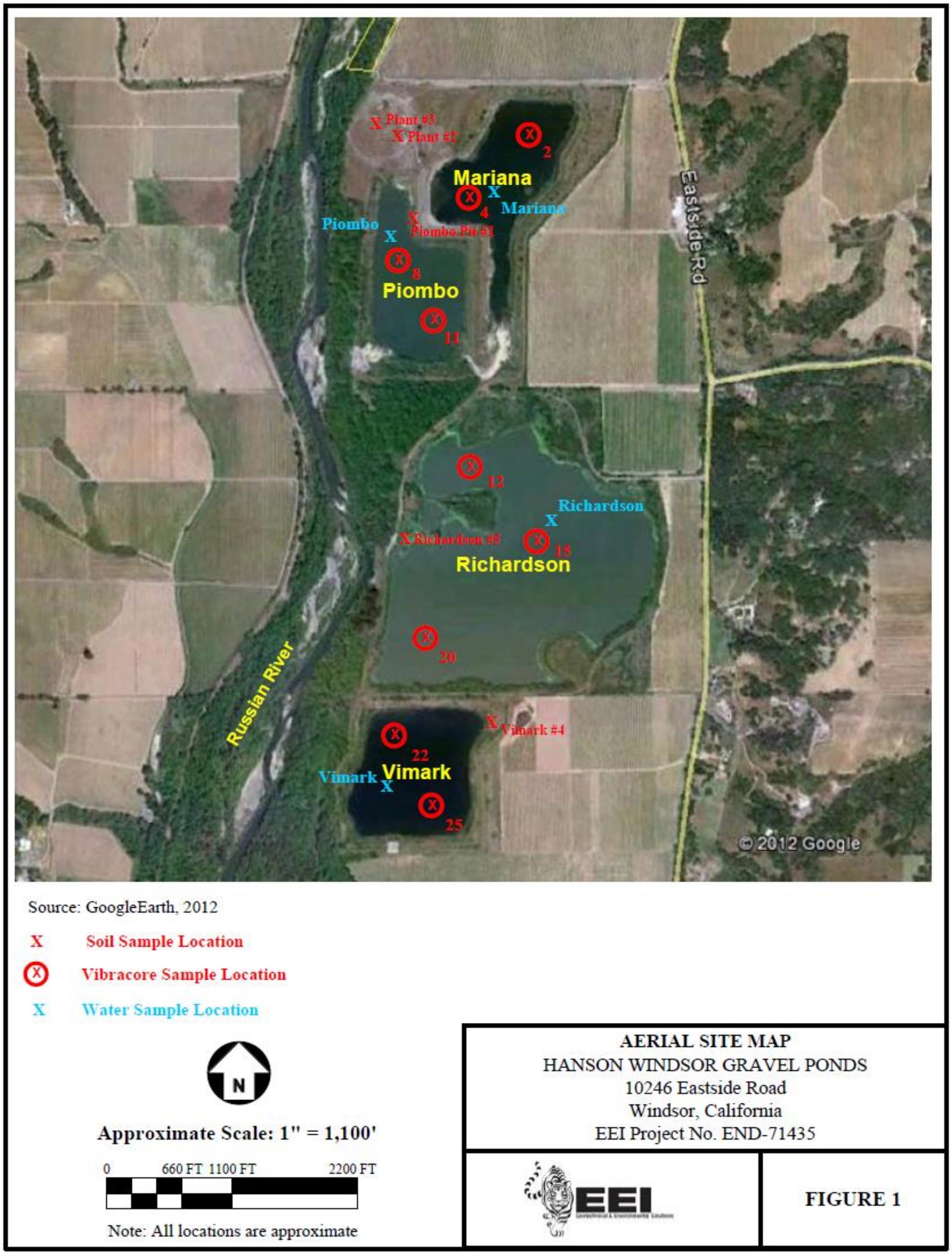

Figure 3.7. Location of Hanson ponds soil and sediment samples for contaminants. Map illustrating the location of the fourteen soil/sediment samples and four water samples taken for Phase II testing at the Hanson property by EEI, Inc. with assistance from Affiliated Researchers, Inc.

The Hanson property soil and sediment sampling included:

- two grab samples in the former plant operations area located in the northwest corner of the property north of the Piombo pond
- one grab sample each from the spoils areas/berms adjacent to the Piombo, Richardson, and Vimark ponds
- nine Vibracore sediment samples from the bottom of the ponds, including two each from the Mariani, Piombo, and Vimark ponds, and three from the Richardson Pond (with assistance from Affiliated Researchers and NMFS)

Grab soil samples were collected, at depths ranging from 0.5 to 2 feet below ground surface in laboratory-supplied 4-ounce glass jars and sealed with Teflon-lined plastic lids. The grab samples were taken from a subset of the strategically located trenches excavated around the site to characterize soil stratigraphy and texture of the uplands surrounding the ponds, described above in Section 3.4.2.

3.5.2 Phase II laboratory analysis of Hanson property sediment and soil samples. The 14 soil/sediment core samples were submitted for laboratory analysis to Sunstar Laboratories, Inc., for analysis of organochlorine pesticides (EPA 8081), organophosphorous pesticides (EPA 8141), Title 22 heavy metals (EPA 6010B/7400), polycyclic aromatic hydrocarbons (PAH, EPA 8270 SIM), and total extractable petroleum hydrocarbons (EPA 8015M).

3.5.3 Russian River soil and sediment sampling for contaminants. In January 2013, NMFS collected in-stream benthic sediment and bank soil samples from four locations: Alexander Valley Bridge, Wohler Bridge and the channel adjacent to the Syar and Hanson ponds (Figure 3.8). Four in-stream benthic sediment samples were collected in quiescent backwater areas within the river channel at 10-20 cm below the sediment surface using a Wildco Petite Stainless Steel Ponar Sampler (sample area 152mm x 152 mm or 6” x 6”) washed with a standard brand of phosphate-free laboratory detergent, such as Luminox and thoroughly rinsed with distilled water between samples. Four bank soils samples were taken from newly-deposited areas approximately 1-2 meters above the water surface on the left bank of the Russian River. Samples were transferred to laboratory-supplied 4-ounce glass jars and sealed with Teflon-lined plastic lids and stored in a chilled cooler.

3.5.4 Laboratory analysis of sediment and soil samples from the Russian River channel. A total of eight samples were delivered under chain-of-custody documentation to Alpha Analytical Laboratories, LLC in Ukiah, California for analyses to be conducted for the same compounds sampled for in the Hanson Ponds soil/sediment samples.

3.6 Water sampling for contaminants

Water samples were also taken from the Hanson ponds and the Russian River during the sampling described in the previous sections for contaminant testing. The following section discusses the methodology for collecting the water samples.

As with the soil sampling, EEI worked with Affiliated Researchers to gather water samples from the Hanson Ponds, while NMFS, also working with Affiliated Researchers, collected subsurface water samples from near the sediments of the Russian River using a Van Dorn bottle. Samples were poured directly into appropriate lab-supplied containers, labeled, and placed in a chilled cooler, pending delivery to a California-certified laboratory under chain-of-custody documentation. The water samples were tested for the same suite of contaminants as the soil and sediment samples recommended by

North Coast Regional Water Quality Control Board staff (Section 3.4) along with their additional recommendations for laboratory analyses of water samples for total Phosphorous (TP), total Nitrogen (TN), chlorophyl-*a*, and methyl mercury (MeHg). Laboratory analyses performed on collected samples were as follows:

- Chlorinated Pesticides and/or PCBs
- Conventional Chemistry/Physical Parameters by APHA/EPA/ASTM Methods
- Hydrocarbons by EPA 8015B
- Metals - Low Level by 1600 Series Methods
- Metals (Aqueous) by EPA 6000/7000 Series Methods
- Organophosphorus Pesticides by EPA Method 8141A
- Volatile Organic Compounds by EPA Method 8260B
- Methyl mercury by EPA Method 1630

Sampling locations, which were recommended by the Water Board staff are depicted in Figure 3.8 for the Hanson ponds, and in Figure 3.8 for the Russian River.

3.6.1 Hanson ponds water sampling for contaminants. During the soil and sediment sampling conducted on August 1, 2012, EEI, with assistance from Affiliated Researchers, collected water samples from the four ponds on the Hanson property. Figure 3.7 depicts the sample locations for this investigation which included: one grab sample each from the Mariani, Piombo, Richardson, and Vimark ponds, collected at depths ranging from 1 to 5 feet above the bottom of the water column, as measured using sonar bathymetry.

Vimark and Richardson pond grab water samples were collected during Vibracore sediment sampling by decanting water trapped at the top of the 3-inch diameter polycarbonate tubes after core retrieval. For the Mariani and Piombo Ponds, the samples were collected using a Van Dorn bottle lowered by cable from the side of a small skiff. In both cases, the water collected was either decanted or poured directly into appropriate containers, labeled, and placed in a chilled cooler, pending delivery to a California-certified laboratory under chain-of-custody documentation.

3.6.2 Laboratory analysis of Hanson Ponds water quality samples. A total of four water samples, one from each pond were collected and submitted for laboratory analysis during this phase of investigation. Water samples were submitted to Weck Laboratories, Inc., in Industry, California, under chain-of-custody documentation for analysis of Organochlorine Pesticides (EPA 8081), Organophosphate Pesticides (EPA 8141), CAM-17 Metals (i.e., includes total arsenic, lead, mercury, etc., by EPA 6010B/7400), Methyl Mercury (EPA 1630), Total Extractable Petroleum Hydrocarbons (EPA 8015M), and Volatile Organic Compounds (EPA 8260). The results are discussed in Chapter 4. Complete lab results of sample analyses are contained in Appendix E.

3.6.3 Russian River water sampling for contaminants. During the January 2013 river sediment sampling, NMFS staff also collected in-stream water samples at the four locations shown on Figure 3.8. Four grab samples were taken in the thalweg of the Russian River, collected at a depth of approximately 30-40 cm below the water surface in the Van Dorn bottle supplied by Affiliated Researchers. Samples were poured directly into appropriate containers, labeled, and placed in a chilled cooler. The Van Dorn bottle was washed and rinsed with distilled water before and between samples.

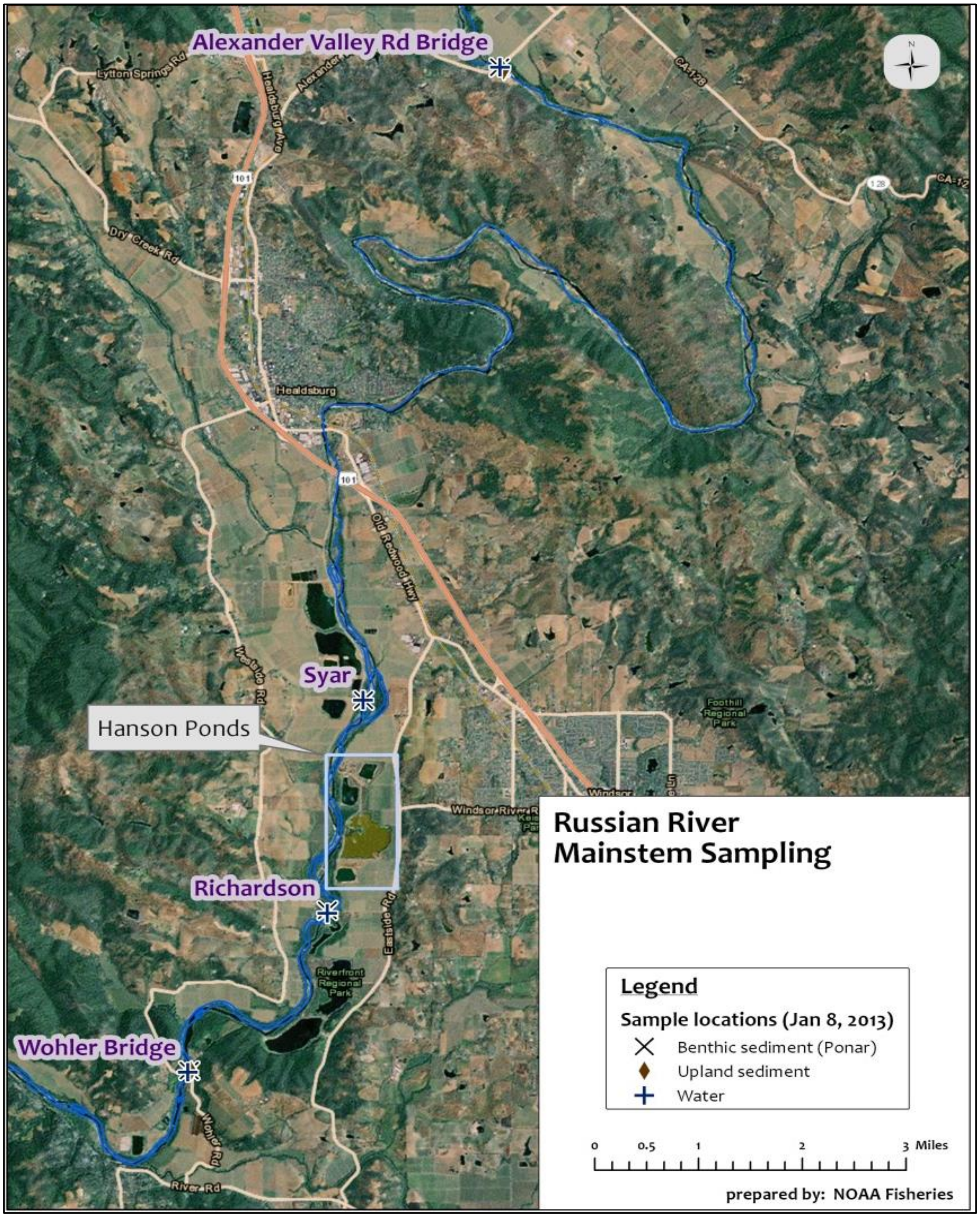

Figure 3.8. Soil, sediment and water quality sample locations in the Russian River channel. Map illustrating the location of the four soil/sediment samples and four water samples from the Russian River channel collected by NMFS with assistance from Affiliated Researchers.

3.6.4 Laboratory analysis of Russian River water quality samples. Russian River water samples were delivered to Alpha Analytical Laboratories, LLC, in Ukiah, California under chain-of-custody documentation. Sample analyses performed were the same as for the Hanson ponds WQ laboratory analyses listed above. Results are discussed in Chapter 4. Complete laboratory results of water sample analyses are contained in Appendix E.

3.7 Hanson ponds temperature and dissolved oxygen profiles, and water clarity data collection

To evaluate existing conditions, summer water column temperature and dissolved oxygen (DO) profiles were developed for each of the four Hanson Ponds by NMFS between July 30 and August 1, and on September 6, 2012. To document water column water quality profiles, NMFS used YSI Model 85 and model Pro2030 water quality meters, both equipped with 20 meter monitoring-probe cables. The cables were marked in one-foot increments, and a three ounce lead weight was attached just above the probe. A minimum of eight profiles were measured in each pond, using a grid pattern to obtain profiles distributed in all areas of each pond. Profile measurements were taken at the surface and at 5 foot depth increments from Affiliated Researchers' Vibracore pontoon boat and bathymetry surveying vessels. Affiliated Researchers recorded the GPS coordinates of the profile locations.

The two YSI meters were calibrated for DO each day prior to use, using the standard methods recommended by the manufacturer. A Secchi disc was used to measure visual water clarity in all the ponds.

Results from the water quality, dissolved oxygen and water clarity measurements are discussed in Chapter 4. Appendix E presents results of all the water column profiles and water clarity measurements for each pond.

3.8 Characterization of fish assemblages of the Middle Reach ponds

NMFS engaged in four sampling investigations to characterize the assemblage of fish in Middle Reach ponds. Investigations were conducted in collaboration with the California Department of Fish and Wildlife (CDFW), NMFS's Southwest Fisheries Science Center, and Sonoma County Water Agency (SCWA). One sampling investigation focused on the Hanson property Richardson pond to identify species present, and three sampling efforts focused on the small Hopkins pond located just downstream from the Hanson property.

The Hopkins pond was selected for more intensive surveys for two reasons: 1) because its relatively small size of 11 acres allowed for comprehensive data collection and generation of a population estimate for the predominant species, largemouth bass (*Micropterus salmoides*); and 2) it is an older pond excavated in the 1970s, and is thus likely representative of how existing conditions of the Hanson ponds will evolve in the future sans restoration. Results are discussed in Chapter 4.

3.9 Middle Reach hydrology and hydraulics

3.9.1 Compiling discharge records. The upstream extent of the project reach is located approximately two miles downstream from the Russian River/Dry Creek confluence. Both Dry Creek and the mainstem Russian River are gaged by the USGS above, and in close proximity to, the confluence, and very little runoff enters the mainstem between the confluence and the upstream end of the project. Project reach inflow discharge records were developed by combining flow data from Dry Creek and the mainstem Russian River, using the Russian River near Healdsburg gage (11464000) and both the Dry Creek near Mouth near Healdsburg (11465350) and Dry Creek near Geyserville (11465200) gages during a continuously overlapping period of record between 1981 and 2013.

3.9.2 Water surface elevations. Water surface elevations over a wide range of flows, at several mainstem channel locations throughout the study reach, were needed to develop local stage-discharge relationships and to calibrate the USGS hydraulic model. Six locations were selected based on hydraulic considerations including local constriction points, and access. NMFS installed the USGS's loggers. The autonomous water level loggers were surveyed into the project geographic network by Affiliated Researchers. Data records were downloaded after significant storm events and the data were delivered to USGS for processing.

CHAPTER

4 Russian River Watershed Land Use History, Existing Conditions, and Field Investigations

This chapter is divided into four main sections with each addressing key issues. Section 4.1 describes historical and current land uses that have resulted in the existing conditions, and the mining and reclamation history of the Hanson gravel ponds. Section 4.2 describes existing conditions and physical processes affecting aquatic habitat. The results of the feasibility study field investigations detailed in Chapter 3 are presented and discussed in Section 4.3. Section 4.4 describes the results of fish assemblage sampling.

4.1 Watershed land use history

4.1.1 Watershed description

The 110-mile long Russian River mainstem contains five major alluvial valleys. From the northern headwaters in Mendocino County to the estuary in Sonoma County, the valleys are Ukiah, Hopland, Alexander, Middle Reach, and Santa Rosa Plain/Laguna de Santa Rosa (Figure 4.1.1).

The geology of the Russian River catchment is predominated by accreted sea floor sediment and uplifted volcanic deposits that are highly faulted and thermally altered (Bailey *et al.* 1964; Hart *et al.* 1983). According to the USDA Natural Resource Conservation Service (1972), the watershed has relatively high erosion rates. The regional Mediterranean climate of generally wet winters and very dry summers is punctuated by the El Niño storm cycle, often producing flood events during the wet season on approximately a 4- to 5-year frequency.

Numerous parallel faults across the region result in patterns of valleys and ranges that are overlain by the natural drainage network. Each of the alluvial valleys has a geologic constriction at their southern downstream outlet that produces backwater hydraulic conditions during flood events that, over geologic time have left the valleys filled with alluvium (river-derived deposits of silt to gravel) ranging from 30 to 100 feet deep. The most frequent and deepest flooding occurs in the downstream end of the valleys near the outlet areas. The combination of climate and geology result in relatively high watershed sediment loads, particularly during El Niño storm events, and relative quiescence during the longer time periods between larger El Niño driven storms. Historically, this was the dominant geomorphic process that created the sediment deposition zones and resulting aquatic habitat patterns found in the valleys.

4.1.2 Watershed assessment

As described in Chapter 2, a watershed assessment is the first step in restoration planning and project development (Beechie *et al.* 2008), as clear problem definition is essential (Skidmore *et al.* 2013). A watershed assessment for the Russian River evaluated the physical processes that form and maintain habitat for each physiographic section of the watershed in order to understand the potential significance of floodplain restoration at the Hanson property. The assessment, included in its entirety in Appendix B, is the framework for comprehending the extent of watershed modifications and resulting impacts on aquatic habitats and salmonid populations.

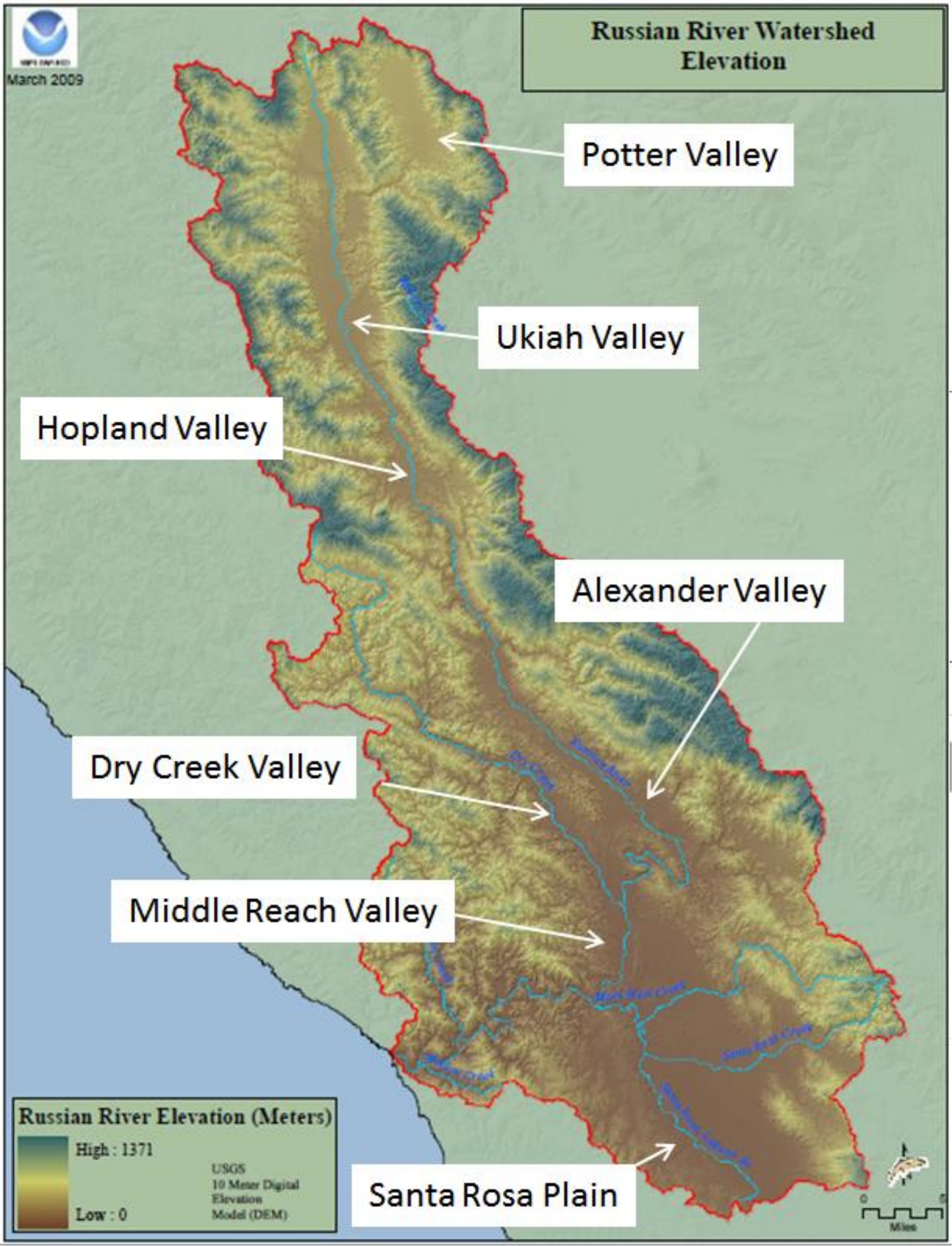

Figure 4.1.1 The Russian River Watershed showing major streams and alluvial valleys. From north to south the valleys are Potter, the Ukiah, Hopland, Alexander, Dry Creek, and Middle Reach Valleys, and the Santa Rosa Plain/Laguna de Santa Rosa.

The results of this watershed assessment underscore two significant findings:

1. Every major alluvial valley and associated former floodplains have been significantly impacted by various flood control measures. Development has effectively eliminated the major floodplain associated aquatic habitats from the ecosystem, with a few small exceptions representing the remaining strongholds for salmonids - the Atascadero Creek/Green Valley wetland, and Willow Creek with a formerly altered floodplain that has been passively restored to wetland habitat.

2. The major remaining floodplain wetlands - Laguna de Santa Rosa and the Russian River estuary remain only partly functional. For the estuary, this is due to water levels maintained through mechanical breaching below the floodplain elevation, and in the case of the Laguna de Santa Rosa floodplain, channelization has diminished its ecological functions. The Laguna can be sizable in winter, but use by salmonids is poorly understood.

The significance of floodplain habitat for salmonid populations has become clearer as results of rearing trials and various experiments and studies have been published in peer-reviewed journals (Grosholz and Gallo 2006, Bellmore *et al.* 2013, Jeffres *et al.* 2008, Sommer 2001, Lister *et al.* 1997, Lindsey *et al.* 2015, Katz *et al.* 2013). To gain a better understanding of former ecosystem attributes within the Middle Reach Valley, NMFS funded an historical ecology study carried out by the San Francisco Estuary Institute (SFEI). The restoration of lost or diminished ecosystem attributes identified in the SFEI study were incorporated into goals and objectives used to evaluate restoration alternatives considered in this feasibility study.

4.1.3 Historical ecology of the Middle Reach

As noted above, San Francisco Estuary Institute was engaged to complete a reconnaissance-level historical ecology study of the pre-European Middle Reach Valley and channel conditions (SFEI 2014, Appendix B). SFEI located and compiled maps and photos from the early 1900s, and surveyor’s notes from the mid-1800s. This information, coupled with landscape descriptions from that era, provide important documentation of former ecosystem attributes.

Prior to development of the Middle Reach Valley, the landscape was characterized by a broadly meandering, relatively shallow river channel flanked by sand and gravel bars often 1,000’ wide. Within that large, dynamically changing landscape was a rich array of seasonally important aquatic habitats including tributary and high flow channels, sloughs, and seasonally connected ponds and wetlands. The seasonal ponds (oxbow lakes formed from abandoned river channels) and a few deep perennial sloughs provided complex hydrologic structure within an extensive, dynamic, biologically complex, and likely highly productive floodplain. Floodplain inundation is the principal force determining productivity and biotic interactions in river–floodplain systems (Junk *et al.* 1989; Bayley 1991 and 1995) (Figure 4.1.2).

Owing to their complex topography and relative proximity to the main river channel, these features likely provided extensive calm edgewater habitats in winter and spring, offering native species refuge from floods and predators as well as rich feeding areas. These former floodplains, annually integrated into the river system would have functioned as “nurseries” by providing habitat for fry recruitment and a wealth of opportunities for rapid growth of juveniles. In summer, some of the blind channel features, such as those labeled as sloughs, were probably sufficiently deep and well-connected to a cold water aquifer to provide thermal refuge for native fish species dependent on cold water habitats.

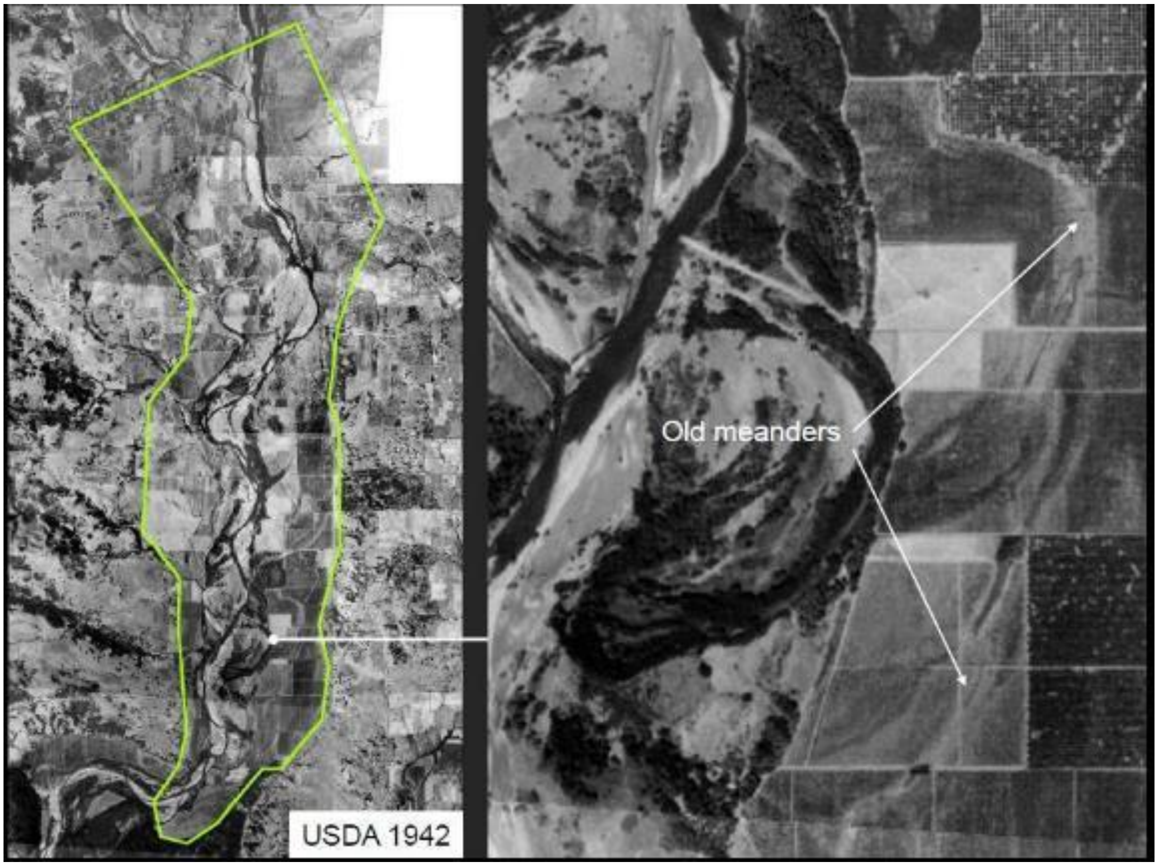

Figure 4.1.2. Historical ecology of the Middle Reach Valley of the Russian River. The San Francisco Estuary Institute completed an historical ecology reconnaissance of the Middle Reach Valley. The photos illustrate the greater sinuosity of the river and the cutoff oxbows (meanders) that probably provided calm edgewater habitats in winter and spring offering refuge and feeding areas for salmonids.

Each of the Russian River alluvial valleys and their floodplains likely possessed many of the habitat attributes revealed by the SFEI study for the Middle Reach Valley, because the geomorphic processes and conditions are comparable.

4.1.4 History of development and land use changes in the Middle Reach

Early settlers, whose primary interest was agriculture, had been modifying the Russian River channel and its tributaries with fluvial engineering, concentrating and directing flood flows to excavate straighter and deeper drainage channels for a century prior to the first precision topography map (1933) and aerial photography (1942) of the valley. Historical valley forest land was cleared of conifers and hardwoods for livestock grazing (Ornduff 1974). A redwood sawmill operated at the mouth of Mark West Creek from 1820 to 1840 to serve the demand for building materials in the region (SFEI 2014); while hardwoods from the North Coastal Forest plant community were turned into charcoal to fuel the frontier's energy demands. Today, hardwoods are sparse, and only a remnant stand of redwoods survives on the valley floor at Riverfront Regional Park.

Although the Middle Reach Valley was already well into agricultural production with associated drainage and irrigation practices by 1950, the advent of earth-moving machinery following World War II triggered an unprecedented period of river channel and valley modification. The aerial photograph in Figure 4.1.3 from the mid-1950s looking upstream from the approximate location of today's Riverfront Regional Park documents a recently dredged straight channel that severed three large-amplitude channel meanders winding around expansive point bar formations. Also evident in that photo are levees and gravel mining haul roads under construction.

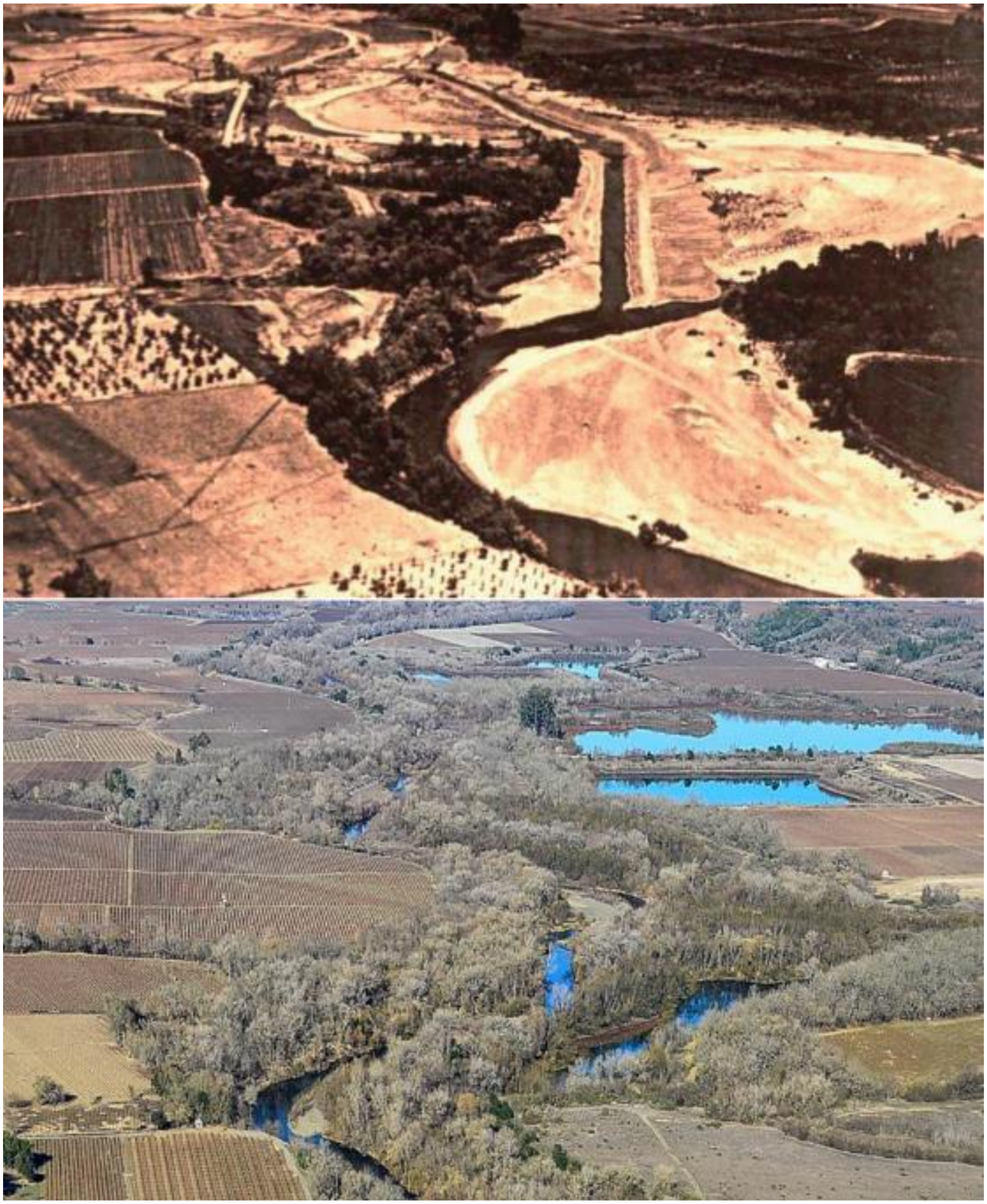

Figure 4.1.3. Changes in the Middle Reach of the Russian River. The upper photo shows the Middle Reach in the mid-1950s (Press Democrat), and the lower photo is the same area in December 2013. The wide meanders were dredged, replacing the sinuous channel with a straightened alignment and then the gravel bars were mined. The channel was dredged 50-60 feet deep which drove incision along with its shorter and steeper path. Once incised, agriculture encroached tightly on the river banks, which have levees along most of the length of the Middle Reach channel. *Photo by Brian Cluer, NMFS.*

In the 1950s, local county leaders asked the US Army Corps of Engineers to develop a flood control project for the Middle Reach. The Corps declined due to an unfavorable cost/benefit analysis. However, the Corps subsequently granted permits to a local company to dredge and isolate the channel in exchange for the right to sell the aggregate. From that precedent-setting action to the present, the Middle Reach channel has been converted to an incised, straightened, and levee constrained flood conveyance channel managed by periodic gravel bar mining and frequent bank repair projects.

The former valley floodplain was thus isolated from all but the largest floods. This river management approach has degraded ecosystem function on many levels as illuminated by this feasibility study. Additionally, systemic hydrologic degradation resulting from the disconnected floodplain contributes to increased flood levels downstream.

The primary goal of channelization of the Middle Reach was to reduce inundation of the floodplain immediately adjacent to the river channel because a deeper channel conveys larger floods. In the Middle Reach, channel straightening was coupled with dredging as deep as 50-60 feet for several years. Channel mining was concentrated near the Dry Creek confluence and extended downstream to Riverfront Regional Park. Evidence of these activities is apparent in the sequence of Middle Reach maps in Figure 4.1.4.

Flood control efforts were further advanced with the building of two Army Corps of Engineers flood control dams upstream in the watershed, Coyote Valley Dam on the East Fork of the Russian River (1959), Warm Springs Dam on Dry Creek (1983). These projects reduce flood peaks over a range of moderate flooding events. Agricultural expansion and channel encroachment increased significantly following completion of the dams and subsequent further channel incision. Former frequently inundated floodplains were converted into farmed terraces that now flood infrequently, and the floodplain acreage has been reduced from approximately 3,300 acres in 1942, to 800 acres by 2005 (Figure 4.1.5).

Along with the loss of floodplain acreage was the loss of complex, biodiverse, and dynamic floodplain associated habitats such as side channels, abandoned oxbows, depressions, seasonal wetlands, and tributary sloughs. These features are evident even on the relatively coarse (compared to modern standards) 1933 topographic map in Figure 4.1.4, which was made 100 years after settlement and when hydromodification was first initiated in the valley.

Once the floodplain was isolated from the river channel, gravel pit mining began on the terraces, which by 1990 was the primary source of aggregate production in the region. Since then, over a dozen deep, steep-sided ponds have been excavated adjacent to the river channel, now covering more than 800 acres of former floodplain in the Middle Reach Valley. Figure 4.1.6 shows the locations and names attributed to the ponds and their proximity to the Russian River channel.

Mining interests recognize that under existing conditions, alternate bars of sand and gravel slowly accumulate in the main channel. In response to reduced flood conveyance capacity of the channel, periodic bar skimming has become the river channel management strategy. However, topographic analysis of historical maps indicates the channel thalweg is progressively deepening (Figure 4.2.2), and bank erosion, or more accurately described as the collapse of high steep banks, is common. In most

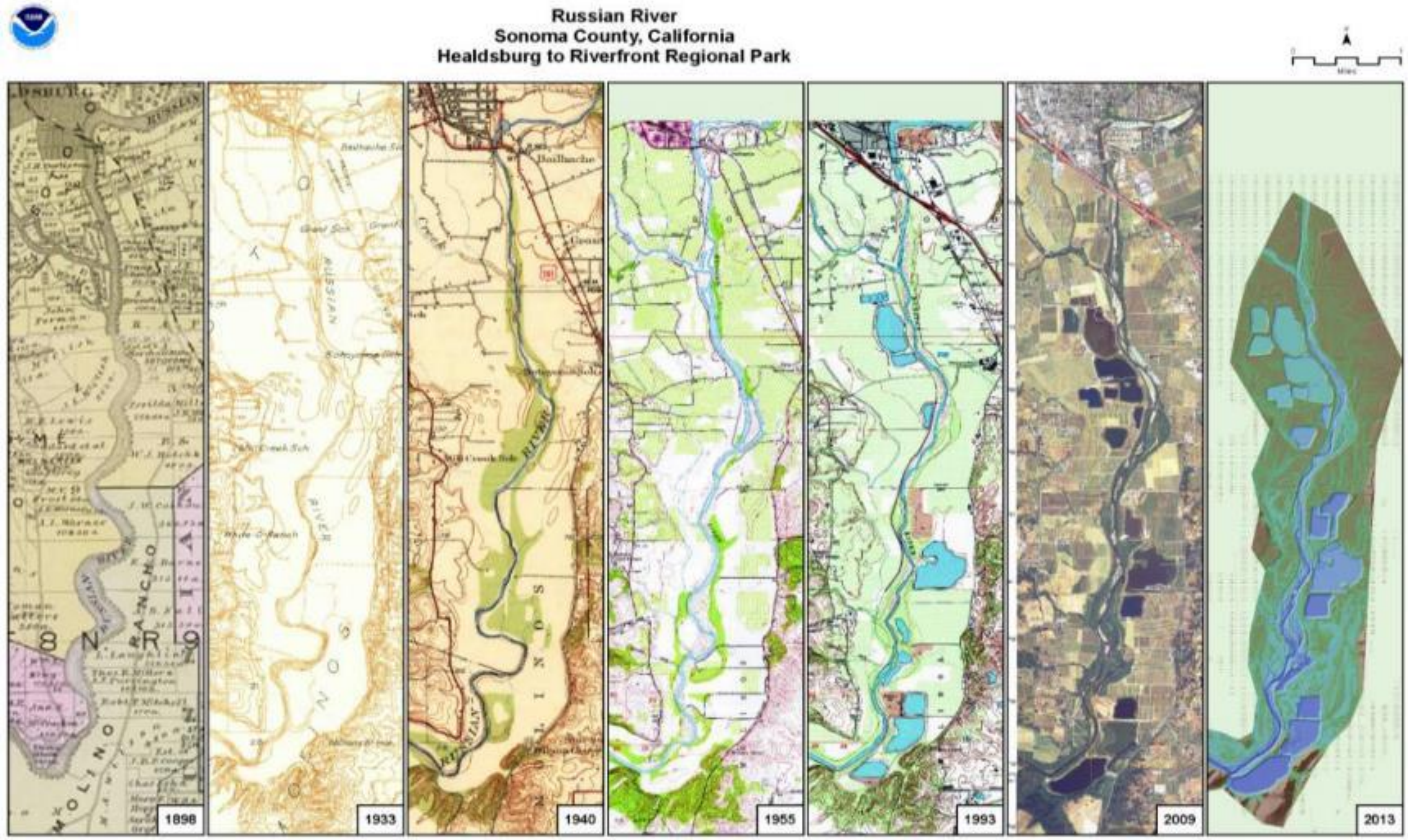

Figure 4.1.4. Topographic map series of the Middle Reach. This series of maps for the Middle Reach from 1898 to 2013 shows the tremendous changes to the Russian River channel and floodplain resulting from channel straightening, levee construction, gravel mining, and lastly agricultural encroachment post dam building.

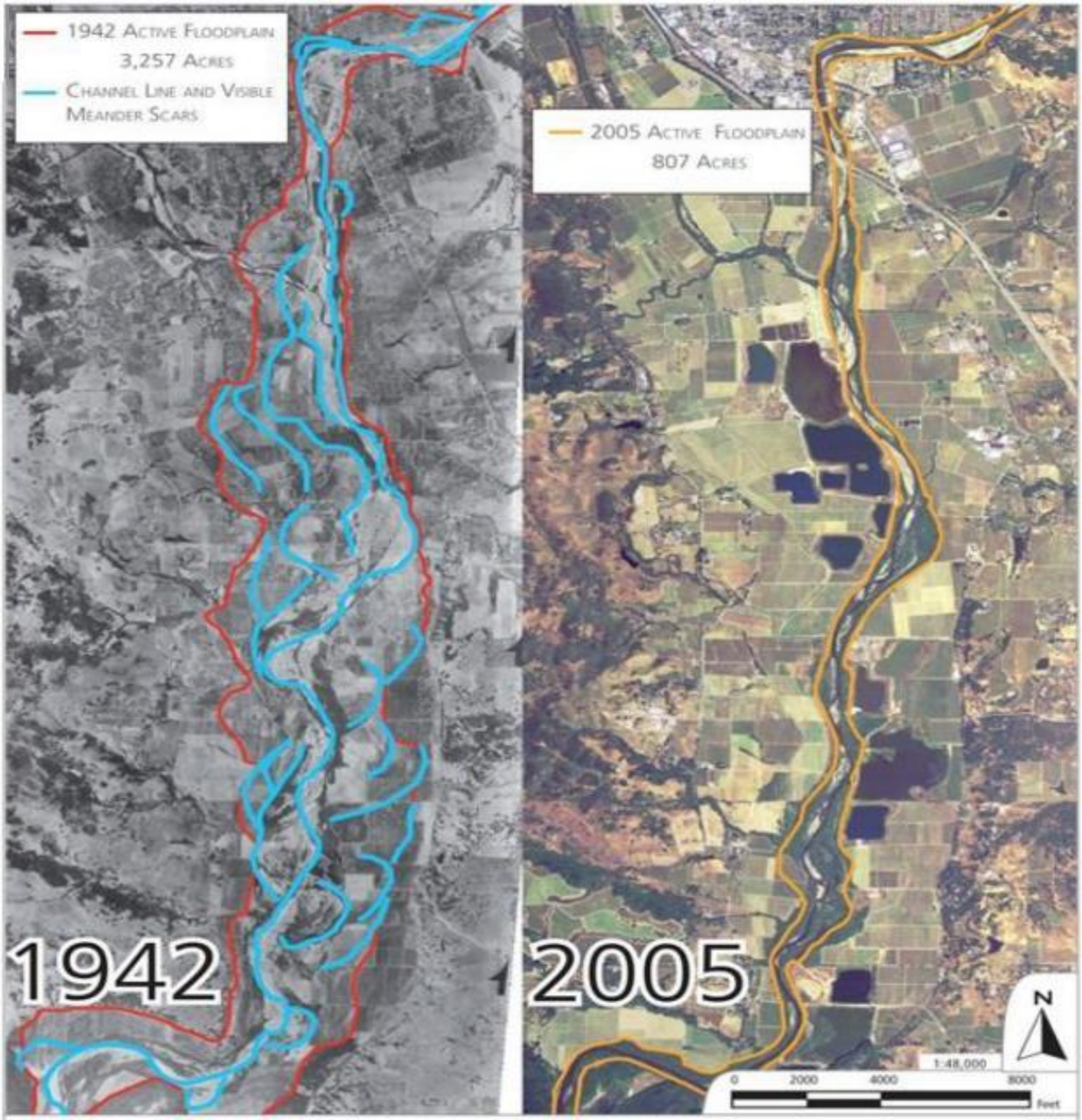

Figure 4.1.5. Reduction of the Middle Reach alluvial floodplain by 75% since 1942. The active channel area in 1942 and 2005 is outlined in red and yellow lines, respectively, showing a reduction in acreage from ~3,300 to 800 acres. Channel scars and potential off-channel winter/spring habitats are outlined in blue in the 1942 photo. *(Source: Mitchell Swanson)*

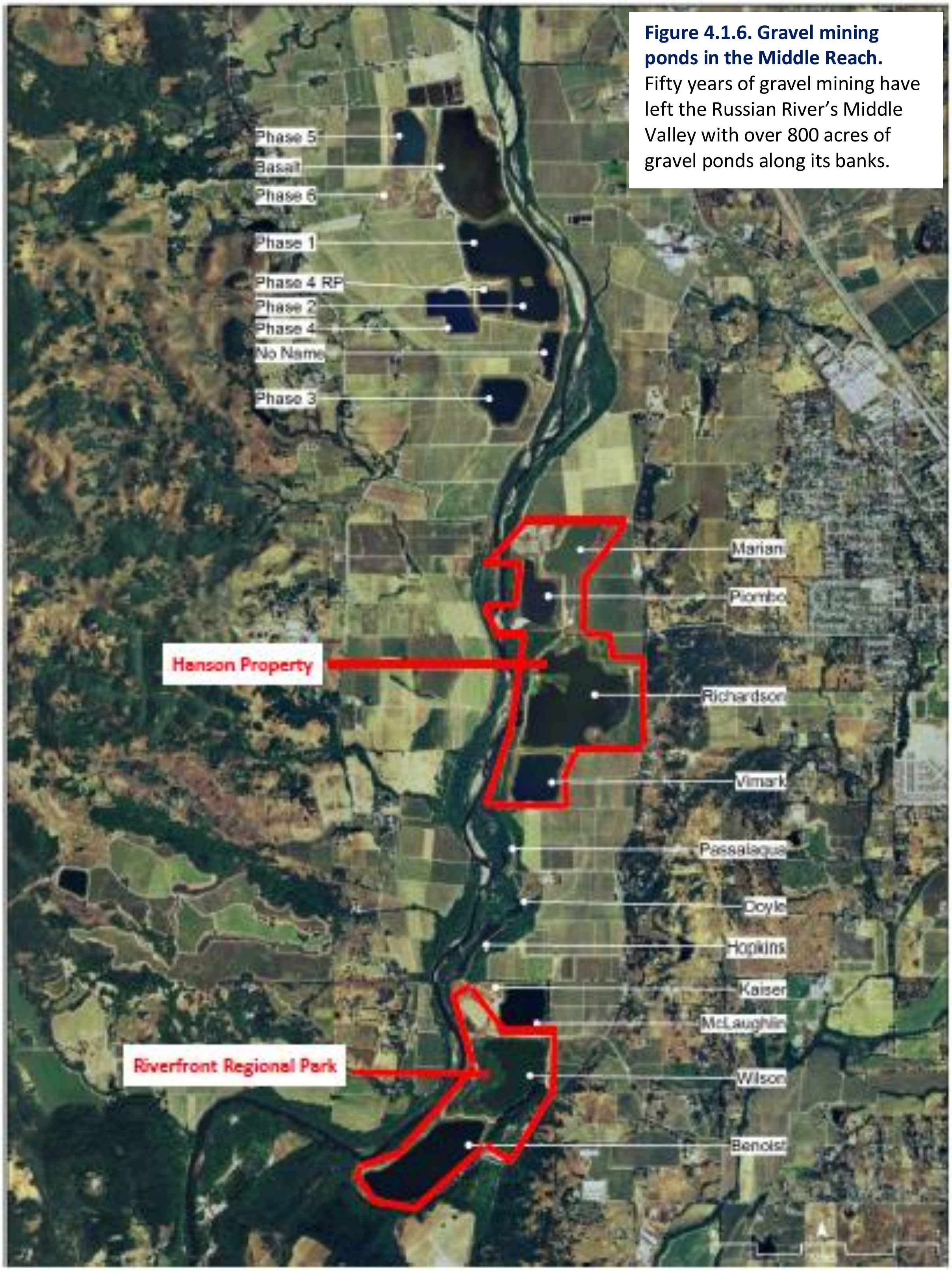

Figure 4.1.6. Gravel mining ponds in the Middle Reach. Fifty years of gravel mining have left the Russian River's Middle Valley with over 800 acres of gravel ponds along its banks.

cases, only a narrow earthen berm normally at least 200 feet wide separates the river channel from the ponds. These berms are typically not reinforced levees.

The Hanson ponds are located within the former active river meander zones where lateral erosion and channel migrations would occur under unconstrained conditions. Under existing conditions, in-stream gravel mining, vegetation removal and levee maintenance are required to reduce channel aggradation, levee breaching, and overtopping events. Without expensive channel maintenance and continuing bank repairs, the river will likely, over time or in a single large event, return to its former wider and shallower form and incorporating the gravel ponds into the active channel.

As a result, the banks and infrastructure alongside the channel repeatedly require very expensive repairs, and in any given year, there are one or more bank repair projects in the Middle Reach. Private and public landowners along the reach fight a continual and shifting battle, with bank erosion and collapse continually threatening property and cropland (Figure 4.2.5). The current river channel alignment is moderately stable over short timeframes (<10 years), but its maintenance is expensive and ongoing. Without continuing public and private expenditures, the current channel configuration is unsustainable.

The standard reclamation approach for floodplain ponds has been to attempt isolation of the gravel ponds from the river. As noted above, this has proven to require frequent and expensive bank stabilization repairs because physically, the current setting of steep high banks and frequent periodic high energy flood events confined within the incised channel is inherently unstable.

4.1.5 Hanson Russian River ponds: Mining and reclamation history and status

Kaiser Sand and Gravel began mining the gravel terraces on the approximately 358-acre Hanson property in the early 1960s although records indicate that mining began sometime in the 1940s. Hanson Aggregates Mid-Pacific, Inc., purchased the property from Kaiser in 1999 and continued mining until 2002. Since that time, Hanson has completed many, but not all, of the obligations of the reclamation plans due to a lack of consensus on the optimal strategy.

4.1.5.1 Mining and reclamation history. Approximately 15 years after Kaiser began mining operations at the site, the California Surface Mining and Reclamation Act (SMARA) was signed into law requiring all mine operators to prepare reclamation plans for review and approval. The State Office of Mine Reclamation (OMR) oversees SMARA implementation while local government agencies function as the lead for permitting. The core regulatory objective of reclamation plans is to ensure that mined properties are stabilized and restored to a useful alternative purpose once mining is concluded. Acceptable final land uses range from housing and retail development to agriculture and open space. Economics, land use, and zoning considerations have historically driven post-reclamation land uses.

In accordance with SMARA, the Sonoma County Permit and Resource Management Department (PRMD) approved permits and reclamation plans in the 1990s for two river terrace gravel mining operations along the Middle Reach of the Russian River: Syar Industries and Kaiser Sand and Gravel (now the Hanson property). In March 1996, Sonoma County approved two reclamation plans (Permit # 91-981 and 95-1037) for the Kaiser (Hanson) site.

In 1998, litigation changed the regulatory landscape for terrace pond mining permitting under SMARA. Initiated by environmentalists, the litigation (ultimately appealed to the U.S. Supreme Court who declined to hear the case) clarified that gravel mining ponds adjacent to the Russian River were jurisdictional waters of the US. This determination mandated US Army Corps of Engineers (Corps) review and approval of mining permits and reclamation plans through its Clean Water Act (CWA) authority.

Another layer of review was added in 2005-2006 when Russian River coho and Chinook salmon, and steelhead were listed under the federal Endangered Species Act (ESA). The listings required the Corps to conduct ESA Section 7 consultation with NMFS for potential adverse impacts on listed species and designated critical habitat when reviewing and approving mining permits and reclamation plans under Section 404 of the CWA.

In 2007, PRMD, NMFS, the Corps, California Department of Fish and Wildlife, and the North Coast Regional Water Quality Control Board initiated in depth discussions with mine operators about the implications of this regulatory framework. These discussions led to the 2009 symposium, ***Exploring Ideas and Research for Reclaiming Old Gravel Pits Adjacent to the Russian River and Assessing Ecological Opportunities for Wetlands and Fisheries,*** hosted by NMFS and Syar Industries*.* Invited participants were resource and regulatory agency staff, leading experts from NOAA's Fisheries Science Centers, and academics in the fields of fluvial geomorphology, salmonid population dynamics, floodplain ecology, and seasonal water quality dynamics. Consensus symposium conclusions suggested that re-establishing a seasonal hydraulic connection between the Russian River and its floodplain offered the potential to significantly improve watershed-wide ecosystem services, and production and ultimate abundance of ESA-listed Russian River salmonid populations. Additional potential benefits included improved river channel stability, flood control, water quality, and aquifer restoration. The symposium report concluded that these issue areas merited further study.

In light of the symposium conclusions and a growing body of research on historical hydromodification and loss of off-channel habitat of the Middle Reach Valley, and on the value of functional floodplains to viable salmonid populations, this feasibility study analyzed a river/floodplain reconnection strategy for the Hanson reclamation plan.

4.1.5.2 Hanson property reclamation status. Reclamation of the Hanson Ponds is covered by the Windsor Master Reclamation Plan and each pond has a separate reclamation plan. Each year Hanson is required to submit a Financial Assurances Estimate for each pond detailing the remaining reclamation tasks and associated implementation costs. The southernmost pond, Vimark, is the only pond with a completed reclamation plan, signed off by Sonoma County PRMD and California Office of Mining Reclamation (OMR) in September 2013.

The reclamation of the other three ponds, Richardson, Piombo, and Mariani, are not yet completed. The reclamation plan status is summarized by Sonoma County PRMD as follows:

- **Piombo (south portion) (Permit # 91-981).** Mining completed and final slopes graded, re-soiled and planted on south and west sides. The weir on the southwestern boundary between the pond and the river was redesigned and modified in 2004. Reclamation of north and west side is to commence once weir connection to Mariani is installed. However, in response to recent NMFS recommendations, applicant is weighing possibility of submitting a reclamation plan revision request to eliminate need for weir and connect pits to the river.
- **Piombo (plant site) (Permit # 95-1037).** Mining completed and plant site was dismantled and stockpiles removed in 2005. Some final grading and reseeding remains to be completed.

- **Mariani (Permit # 94-126)**. Mining is completed. Initial slope grading, re-soiling and revegetation are approximately 60% completed. Last grading and hydroseeding work was done in 2007. Remaining grading and revegetation work will be carried out once weir between Piombo and Mariani is either 1) installed or 2) eliminated through a formal application to revise the reclamation plan to keep the pits connected to the river. Operator is considering whether or not to apply for a reclamation plan revision to eliminate weir requirement.
- **Richardson/Argonaut (Permit # 95-089)**. Mining was completed on this vested site prior to the adoption of SMARA in 1975. Though existing banks were steeper than required on later reclamation plans, the reclamation plan approval allowed existing banks to remain as is to protect existing voluntary vegetation where the California Department of Fish and Wildlife determined the habitat value of the existing vegetation to be significant. Approximately 70% of the perimeter was left undisturbed at the recommendation of Fish and Wildlife. Some grading and revegetation work was done along the west side and the north west sides of the pit in 2006 but substantial work remains to install revetment to control lateral bank erosion from the river, carry out grading to elevate road and retain overflow along the west side of the pit adjacent to the river. Operator was pursuing development of an engineered revetted levee along the west side to address lateral erosion of the separation levee, but has not committed, and is now considering applying for a revised reclamation plan.
- **Vimark (Permit # 96-096).** Mining is completed. All initial reclamation grading, re-soiling and revegetation and weir construction was completed in 2005. Site has been monitored since and has remained stable. Reclamation is complete.

Implementing the remaining reclamation obligations, specifically the weir between Mariani and Piombo, the repair of revetment between Richardson and the river, and grading requirements - would be costly and in conflict with the emerging restoration strategy outlined in this feasibility study. Consequently, it will be necessary to amend the reclamation plans to insure consistency with a comprehensive floodplain restoration strategy.

In 2010, Hanson requested EHC's assistance with the reclamation impasse and to pursue a conservation strategy. Hanson and EHC have a signed option agreement that will transfer the property to EHC at no cost once a feasible reclamation plan amendment has been approved.

4.2 Existing conditions

As noted previously, all of the major Russian River valleys are substantially hydromodified for flood control, agriculture, and gravel mining. These modifications transformed relatively shallow channels with hydraulically connected floodplains into deepened high-capacity flood channels and disconnected floodplains where intensive agriculture is the dominant land use. The valleys and historical floodplains still flood during very wet winter conditions because the downstream geologic controls have not been modified. However, all frequent flows of moderate storm events that formerly went over bank and inundated floodplains are now confined in flood control channels. Thus, only the strongest storms generate sufficient stream flow to inundate the historical floodplain. The widespread hydro-modifications and local channel changes have resulted in almost no functional wetland, side channel or off-channel habitats remaining, very little seasonally connected floodplain or annually inundated floodway, and a deeper and steeper channel with high velocities that transports sediment very efficiently.

Comparative analysis using the series of topographic maps in Figure 4.1.4 shows that the sinuosity of the river's channel (ratio of stream length over valley length) has been reduced from approximately 1.3 overall in 1933 (locally the sinuosity was over 2.0 in the downstream third of the Valley) to nearly 1.0, which is straight (Figure 4.2.1). The consequence of reduced sinuosity, resulting in a shortened river length, is greater channel slope.

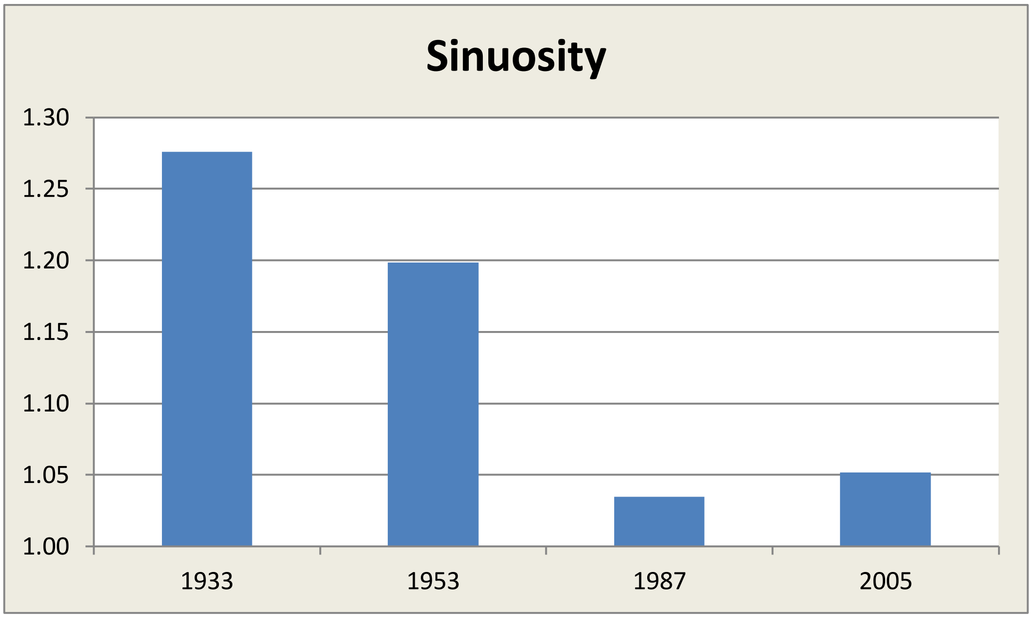

Figure 4.2.1. Changes in sinuosity of the Russian River Middle Reach. The slope of the river has been increased by cutting off its meanders and straightening its path. This is quantified by a metric called sinuosity, which is the ratio of river channel length to valley length.

As channel slope increased, channel depth also increased substantially. Since 1933, the 50 and 60 foot elevation contours that cross the river in the Middle Reach migrated upstream by more than 2,000 feet (Figure 4.2.2). Tributaries became incised in response to river bed lowering at their confluences with the Russian River. A few tributaries were stabilized by engineered features within the levees such as at Storey Creek (Figure 4.2.3), which is now perched 15-20 feet above the Russian River channel bed today. Harvey and Schumm (1987) studied river incision around the world, and their paper documenting incision of the Dry Creek tributary as a geomorphic response to bed lowering of the mainstem channel is a classic example in fluvial geomorphology.

Gravel mining of terraces along the river banks further contributes to the instability of the system. The reclamation plans associated with terrace pit gravel mining permits allow the deep gravel ponds to remain, but require them to be isolated from the river channel to prevent potential "pit capture." Pit capture is the phenomenon whereby a river flowing into and through a deep pond drops its coarse sediment load thus becoming sediment "starved" as it continues downstream, degrading the river bed and banks due to the imbalance of the sediment load.

Experience shows that levees separating the river from the ponds often collapse during floods (Figure 4.2.4) with the river quickly flooding into the pond. However, once the pond equilibrates to the level of the river, flow and velocity rests and there is little interaction with sediment load. Erosion and filling of the pond is limited to the material from the levee. Thus, river bed material mobilized and transported during flood flows is not delivered into the pond with levee breaches, as only the upper half of the levee is breached. At the 2009 Russian River Gravel Pit Symposium, Matt Kondolf of UC Berkeley advised that pit capture was a relatively low risk on the Russian River Middle Reach given the already straight river channel, citing several examples of pit-levee failures that did not trigger a response in the channel. Rather, the upper half of the levees fail into the pond while the pond fills, and after water surface equilibrium between the pond and the river is achieved, no further erosion of the levee or sediment transport into the pond occurs.

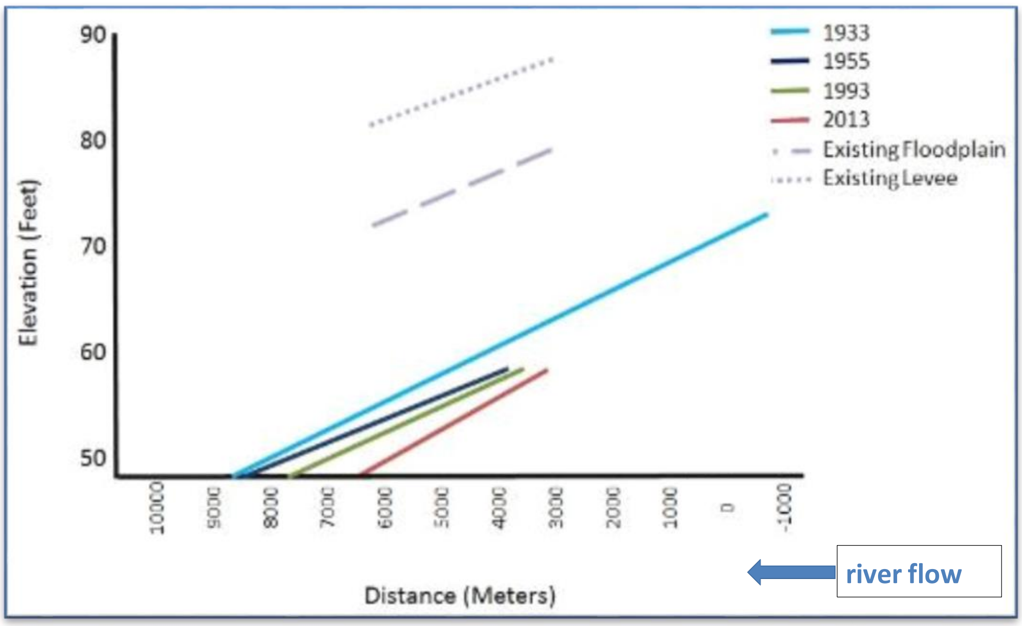

Figure 4.2.2. Channel bed elevation and slope changes over time. Topographic maps and 2013 LiDAR illustrate the progressive lowering of river bed elevations and increasingly steeper slopes with each successive map. As a result, the 50-60 foot elevation contour of the river bed moved upstream by nearly a half-mile between 1933 and 2013. The zero point of the x-axis is the location of Veterans Memorial Beach Dam in Healdsburg.

Nevertheless, although the risk may be low, the consequences of pit capture can be significant. To mitigate the risk, the common practice has been to construct costly engineered low weirs between the river and ponds. In the case of Richardson pond on the Hanson property, the reinforced access road acts as a low weir connection with the Russian River, activated at approximate 3,000 to 4,000 cfs, generates storm flows into the ponds which repeatedly outflank the reinforced road and erode a channel around it requiring nearly annual maintenance and additional rip-rap and concrete (Figure 4.2.6). Estimated costs in 1998 for a proposed engineered weir to resist this type of erosion, avoid pit capture, and to complete reclamation and stabilization of the Syar Industries ponds across the river was $2.9 million (Sonoma County 1998).

Figure 4.2.3. Channel incision at Storey Creek, a tributary in the middle of the study reach. Approximately 20-24 feet of channel incision is evident from the height difference of the concrete stabilized channel bed at the mouth of Storey Creek (upper right) that would have connected with the river bed when constructed. If not for the concrete culvert, this tributary would have incised along with the river, as did Dry Creek and other tributaries to the Russian River channel.

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Figure 4.2.4. Levee washout at Syar ponds. Washout of the levee dividing the river (left) and one of the Syar gravel ponds in 1997.

Figure 4.2.5. Bank erosion in the Middle Reach. A bank erosion repair site along the Middle Reach channel in 2012 - 2013. A Syar mining pond is seen in upper right of the photo. The Hanson ponds, not visible in this photo, are just downstream on river left.

Figure 4.2.6. Connection between Hanson Richardson pond and the Russian River, aerial and ground view in 2012. Water year 2015 was classified as a critically dry year, and yet the December 2014 and February 2015 storms were sufficient to erode a channel around this low weir of the Richardson pond. 2016 storms eroded this connection even further.

4.2.1 Sediment transport in the Middle Reach

Two variables define the simple one-dimensional equations for hydraulic transport of sediment: channel slope and water depth. The modern Middle Reach channel is incised approximately 5-10 feet on average, more in some locations, and has an approximately 10-foot high levee on top of its original bank. As a result, frequently occurring floods attain hydraulic depths several times greater than the same magnitude prior to channel modification. In addition, the meanders were cut off and the channel straightened, so the slope of the channel is about 30% greater over the entire reach. In the downstream 1/3 of the Middle Reach, the sinuosity measure of the channel has been reduced from approximately 2 to 1 (Figure 4.2.1), although the strong backwater effect from the Wohler Narrows at the Valley outlet limits sediment transport during moderate and large floods. With both variables optimized, sediment transport (the product of slope and depth) is now significantly more efficient than in the past, particularly in the upper portion of the Middle Reach channel. Steeper and straighter channels have predictable results: the channel has excavated its own bed, faster at first then slowing as a new equilibrium is approached. The upstream progression of incision of the bed was arrested at the grade control structure built at the rubble dam just below the Veterans Memorial Beach Dam in Healdsburg.

To date, the coarse sediment load to, and transport through, the Middle Reach remains only roughly understood. Ritter and Brown (1971) monitored suspended sediment at a number of stations in the Russian River watershed from 1965 - 1968, information from which coarse sediment dynamics can be inferred. Overall, the watershed sediment supply is reduced by the two dams upstream (together trapping coarse sediment from about 27% of the watershed area), but sediment yield is enhanced by widespread land development (a dense network of roads, past forest clearing, and development), import of Eel River water which has relatively high suspended sediment concentration (Ritter and Brown 1971), and because transport capacity is generally increased everywhere in the watershed as nearly all stream channels have been transformed to optimize flood conveyance goals. Consequently, the Middle Reach channel probably has a relatively high sediment load compared to historical conditions; it certainly has much greater sediment transport capacity.

Fine sediment transport and water quality are affected by Coyote Valley Dam (CVD) and its operations (Ritter and Brown 1971). Eel River diversions from Lake Pillsbury storage into Lake Mendocino are more turbid than Russian River water (Ritter and Brown 1971) and fine sediment accumulation in the Mendocino reservoir over five decades of its operation have progressively increased the duration of turbid water releases from CVD during flood-storage-capacity releases. This is a function of the fact that sediment accumulated on the reservoir bottom is released at the bottom outlet facilities. Consequently, the Russian River turbid water flow period is longer than if the two system dams were not detaining the turbid water, and instead allowing storm flows to pass through the watershed unimpeded. This issue has been identified as potentially affecting salmonid habitat (NMFS 2008), and data collection is ongoing below CVD by the Corps of Engineers.

The dynamics of coarse sediment transport in the Middle Reach channel has also been informed by the bathymetric mapping completed for this feasibility study as described in Chapter 3. Repeat bed mapping in 2013, on the declining limb of a 20,000 cfs storm flow, and again three weeks later, showed widespread scour and refill of approximately two meters of bed material as the channel bed responded to a typical winter storm flow. Because the bed returned approximately to its pre-flow topography and elevation within about three weeks, it is apparent that the basin supply of bed material is sufficient to replace the large quantity of material that was evacuated during the storm flow.

The evidence of approximately two meters of bed scour and refill during common winter storms throughout the study reach indicates there is a significant supply of bed sediment delivered to the reach, but little sorting or accumulation of useful deposits for habitat formation, i.e., the formation of channel pool-riffle morphology for producing suitable grades and accumulations for spawning gravel riffles. Bar deposits are observed to grow in height during overtopping storm flows, especially if they are heavily vegetated (Sonoma County Aggregate Resource Management Monitoring Plan 2010), prompting occasional permits to mine gravel bars. However, sampling for the grain-size distribution analyses of the river bed indicates there is very little sorting of gravels within the reach. In addition, the bed is slowly lowering over time as illustrated in Figure 4.2.2, approaching a new equilibrium.

4.2.2 Hydromodification impacts on habitat

The flood control and land use modifications within the Russian River alluvial valleys have converted former depositional zones into very efficient flood conveyance and sediment transport zones. These accelerated processes combined with the loss of historical deposition zones and floodplain connectivity in the alluvial valleys are counterproductive to processes that form viable habitat for fish and wildlife. The Middle Reach channel is now straight and deep—a condition that accelerates both floods and sediment load movement through the reach. These accelerated processes in turn create a low depositional efficiency with little sediment sorting; the bed sediment varies little spatially, and without the fluvial processes necessary for the formation of pool/riffle channel morphology, well-sorted spawning gravel sites are rare.

Ecologically, the transformation has resulted in a dramatic loss of what was documented in the SFEI historical ecology study to be an area of rich winter feeding and rearing habitat for early and juvenile life stages of native fish and other aquatic wildlife. Also lost were likely abundant aquifer-fed spring channels with associated wetlands and perennial habitats located where the water table intersected old channel features such as meanders and sloughs. These habitats were most likely resilient to the annual dry season and possibly to longer droughts as well.

Remnant off-channel features still evident in the 1933 and 1942 maps (Figure 4.1.4, and Appendix B), even after 100 years of farming and 250 years of livestock grazing, were eliminated in the latter half of the 20th century. The habitat of the reach, which historically was a rich and ecologically productive mosaic of meanders and side-channels of a floodplain-wetland complex hydraulically connected to the river, is now dominated by hydraulically disconnected terraces with deep ponds of non-native plant and fish species, with some remnant riparian forest. In this current state, the ecological functions and values of the Middle Reach have never been lower than they are today.

4.2.3 Hydrology, hydraulics and groundwater

The characteristics of surface water and groundwater flows at the project site play a significant role in seasonal aquatic habitat availability and quality, and thus are central to the potential ecological function of a restored Hanson site. Seasonal surface water flows, timing, duration, and magnitude are also primary inputs to the USGS hydraulic and sediment transport modeling and NOAA's habitat modeling for the eight-mile study reach. Additionally, any project alternative must consider flow prescriptions mandated by State Water board. The following two sections summarize information provided at the initial SWG meeting by Sonoma County Water Agency (SCWA) staff Don Seymour and Marcus Trotta. Section 4.2.3.3 presents the hydrology of the Russian River Basin as developed from USGS Russian River gauge records by SWG member Mark Strudely, Ph.D., of the National Weather Service.

4.2.3.1 Regulated flow regime of the Russian River. The Sonoma County Water Agency maintains three reservoirs in the system: Lake Sonoma and Lake Mendocino in the Russian River watershed, and Lake Pillsbury in the Upper Eel River watershed. Lake Pillsbury requires an inter-basin transfer via the Potter Valley project tunnel (Figure 4.2.7). Water supply is met through managed reservoir releases to the SCWA pumps on the Russian River at the Wohler Bridge/Mirabel facility near the downstream boundary of the Hanson project reach in the Middle Reach Valley.

The magnitudes of flooding in the Russian River Basin are reduced by flood storage in the two Russian River Basin reservoirs, however less than 30% of the total watershed is regulated by reservoir operations. Consequently flood peaks are of smaller magnitude and longer duration for commonly occurring floods. Heavy floods are not regulated by the reservoirs.

Russian River in-river flow minimums are defined in the State Water Resources Control Board Order Number D1610. D1610 authorizes SCWA to divert 75,000 acre feet annually, and was developed prior to the listings of salmon and steelhead under the Endangered Species Act. The order delineates specific flow minimums for different water year types. The 2008 NMFS Biological Opinion covering SCWA and Corps operations on the Russian River also mandates flows, but only regulates late spring through early fall flows and prescribes lower flows than D1610. The Biological Opinion does not address flow modification and flow regulation during late fall, winter and early spring, thus there are no minimum flows prescribed for these periods other than the D1610 minimums.

In the Middle Reach Valley, D1610 requires a minimum summer flow (May-September) of 125 cfs in normal water years, 85 cfs in dry years, and 35 cfs in critically dry years. D1610 requires a winter flow minimum for January through April of 225 cfs in normal water years. During April through June, flows can be regulated as low as 100 cfs.

The NMFS 2008 Biological Opinion prescribes late spring through early fall flows (May 15 through October 15) to be reduced below the D1610 minimum summer flows. However, due to natural unregulated flows, SCWA cannot reduce river flows significantly until late June or early July in most water years (Figures 4.2.8 and 4.2.9).

Figure 4.2.7. Sonoma County Water Agency reservoirs and infrastructure. The system has three reservoirs: Lake Pillsbury in the Eel River watershed, Lake Mendocino on the East Fork Russian River, and Lake Sonoma on Dry Creek. Additional system infrastructure includes the Potter Valley diversion tunnel for diversion of Eel River water to the East Fork Russian above Lake Mendocino, and the Wohler/Mirabel pumping station in the lower river at the lower end of the study reach.

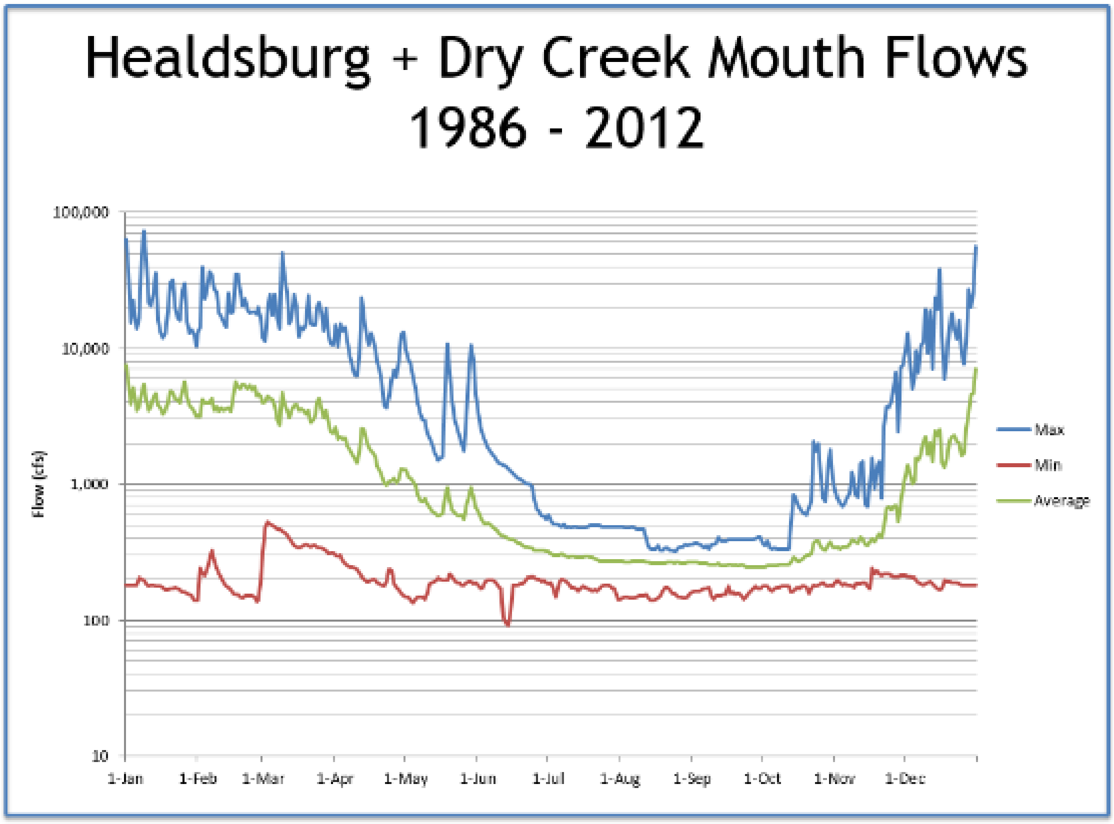


Figure 4.2.8. Annual flows in the Middle Reach and at the Hanson site.

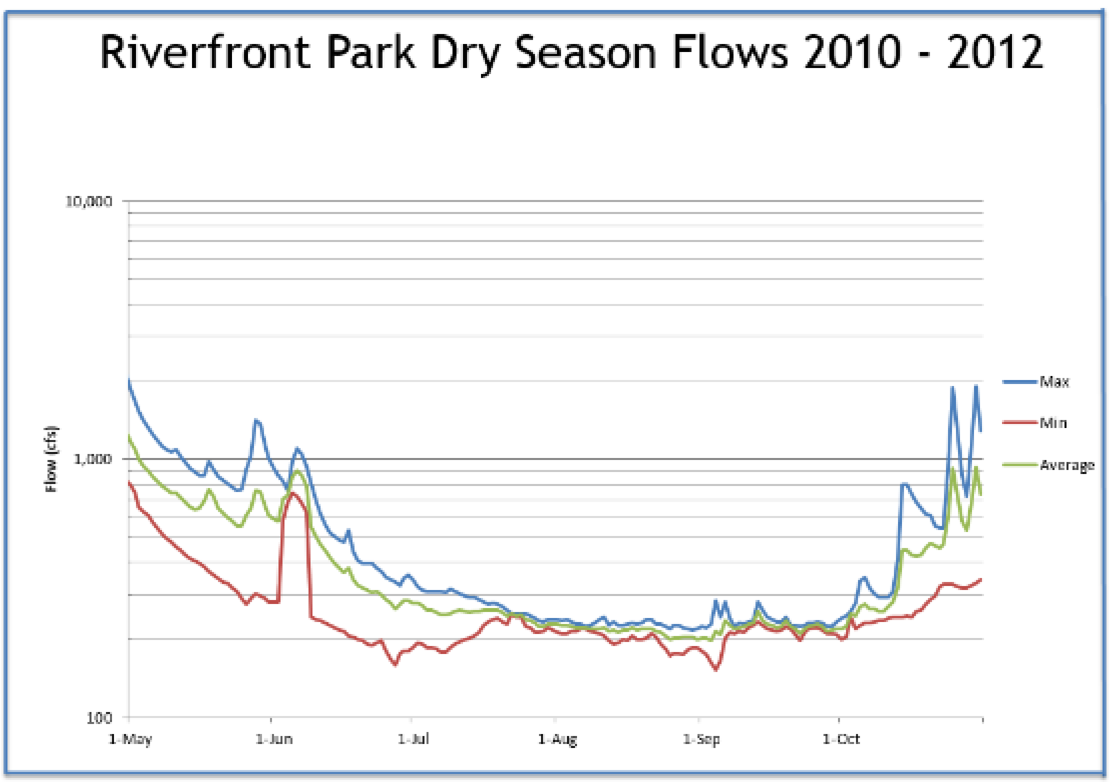


Figure 4.2.9. Recent dry season flows in the Middle Reach and at the Hanson site.

4.2.3.2 Surface water and groundwater Interactions. The Russian River Bank Filtration System of the SCWA pumps at Mirabel and Wohler, south of the Hanson property, are some of the largest such systems in world. Treatment is via natural filtration and only chlorine is added to disinfect for delivery. The system includes 6 collector wells, 7 vertical wells, 5 infiltration ponds, and an inflatable dam. Water is pumped from the unconfined aquifer that is fed by the river from about 60 feet below the river. Alluvium in the Middle Reach Valley is up to 100 feet thick, bounded by Franciscan bedrock on the west and on the east by the Glen Ellen Formation (Figure 4.2.10).

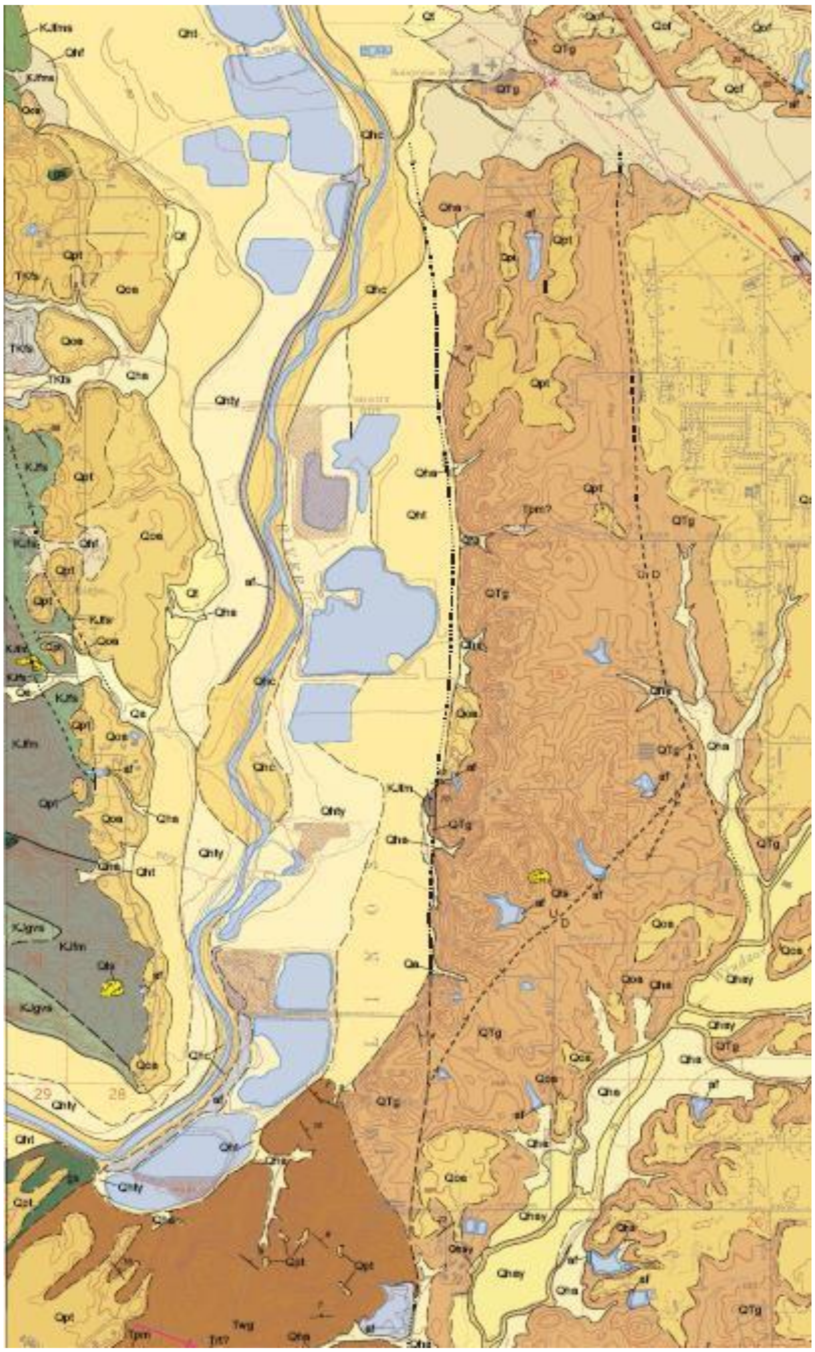
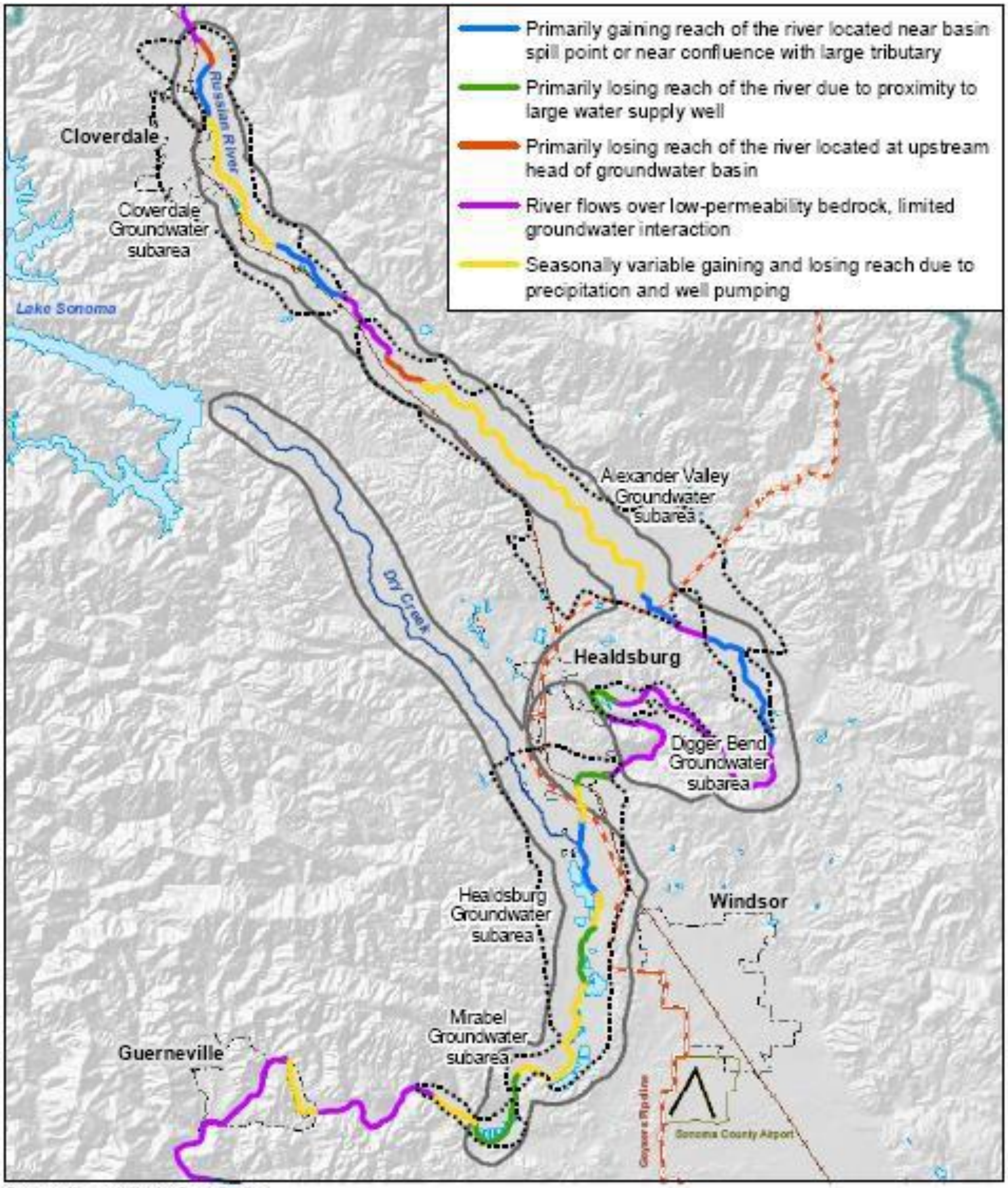


Figure 4.2.10. Geologic map of the Middle Reach Valley. *Source: California Geological Survey.*

SCWA has been studying the groundwater/ surface water interactions using temperature and flow studies, and geophysical monitoring at the Hanson ponds. Studies by PES Environmental, Inc., show warmed groundwater moving from the ponds to the river in summer indicating the groundwater-fed ponds feed the river. Both water level and temperature show a gradient from the Richardson Pond to the river. The Richardson Pond is perched, semi-sealed with clay, and has 10 feet of head above the river water surface elevation in summer. SCWA documented that warm water from the ponds is seeping through the levee to the river during the summer.

SCWA has mapped gaining and losing reaches in the Middle Reach Valley (Figure 4.2.11). Geologically confined reaches have limited groundwater interactions. Alluvial aquifers primarily lose surface flow at upstream ends of basins and are seasonally losing or gaining in the lower end of alluvial valleys. Therefore, the Hanson project study reach gains and loses depending on season. It is generally gaining from Dry Creek inflows and losing from City of Windsor municipal pumping just upstream of the Hanson site, seasonally variable along the Hanson site, then losing to the SCWA pumping at the Mirabel/Wohler site at the downstream end of the reach.

Groundwater inflow at the Hanson site occurs from east and north toward the Richardson Pond, and then to the valley outlet. The sandy gravel Glen Ellen Formation to the east also produces groundwater inflows to the river, which flow through the Hanson Project site (Gus Yates, personal communication, 2013). Surface water is evident year-round in the drainage ditches along Eastside Road just to the east of the project site, indicating the relatively high water table and flow to the project site from the adjacent Glen Ellen Formation that makes up the ridge east of the project site.



Source: Kennedy/Jenks Consultants

Figure 4.2.11. Gaining and losing reaches of the Russian River. *Source: Sonoma County Water Agency.*

4.2.3.3 Project reach hydrology and hydraulics developed for physical and biological analyses.

In order to run the USGS modeling of basic hydraulics, flood inundation depths and duration, sediment transport characteristics, and erosion and deposition patterns, project site and study reach hydrology had to be developed by compiling historical flow records from gaging data. For the initial Stage I comparative analysis of existing conditions versus simple exemplary restoration concepts (Scenarios I-A through I-E, described in Section 7.3, Table 7.1), project reach inflow hydrology was based simplistically on the mean daily flow record of the nearest upstream USGS gaging record, the Russian River near Healdsburg gaging station (11464000). Station 11464000 is approximately 5 miles upstream of the project site. Three separate daily mean annual hydrographs were selected to represent high -, moderate-, and low-flow water year scenarios for simulation: water years 1983, 2008, and 2009, respectively (Figures 4.2.12 A, C, and D).

In the Stage II modeling of the Preferred Scenario (Scenario II-E described in Section 7.7 and Figure 7.3) versus existing conditions, a more exact and detailed hydrology was developed to most accurately simulate the hydrology of the project site and study reach. The hydrology developed for the USGS Stage II hydraulic and sediment transport modeling, and the 2D hydraulic model used for biological analysis of habitat conditions (both described in Chapter 8) included project inflow boundary conditions from both the mainstem Russian River and Dry Creek which enters the Russian River between the USGS Russian River Healdsburg gage and the project site.

The upstream extent of the project site is located approximately two miles downstream of the Russian River/Dry Creek confluence. Both Dry Creek and the mainstem Russian River are gaged by the USGS above, and in proximity to the confluence of Dry Creek. Consequently very little runoff enters the mainstem between the confluence and the upstream end of the project. As such, for Stage II modeling hydrology project reach inflow discharge records were developed by combining flow data from the mainstem Russian River gage near Healdsburg (11464000), and either the Dry Creek near Mouth near Healdsburg (11465350) (low flow) gage or the Dry Creek near Geyserville (11465200) (high flow) gage during a continuously overlapping period of record for the latter two gages between 1981 and 2013. As in Stage I, three separate years of mean daily discharge data was collected from the combined project inflow record to force the 2D hydrodynamic modeling simulations with high-, moderate-, and low-flow annual discharge scenarios. Again, 1983 was chosen as the high-flow year representation (Figure 4.2.12 A) because it is the high flow year of record best simulating the most extreme conditions. 2005 was selected as most representative of an “average” or moderate year (Figure 4.2.12B), and 2009 was again selected to represent the dry or low-flow water year hydrograph (Figure 4.2.12D).

Figure 4.2.12. Project reach hydrology selected for modeling. Water years 1983, 2005, 2008, and 2009 were selected for Stage I and II USGS models runs and habitat modeling to represent a range of possible hydrologic conditions from wet, dry, and average water years

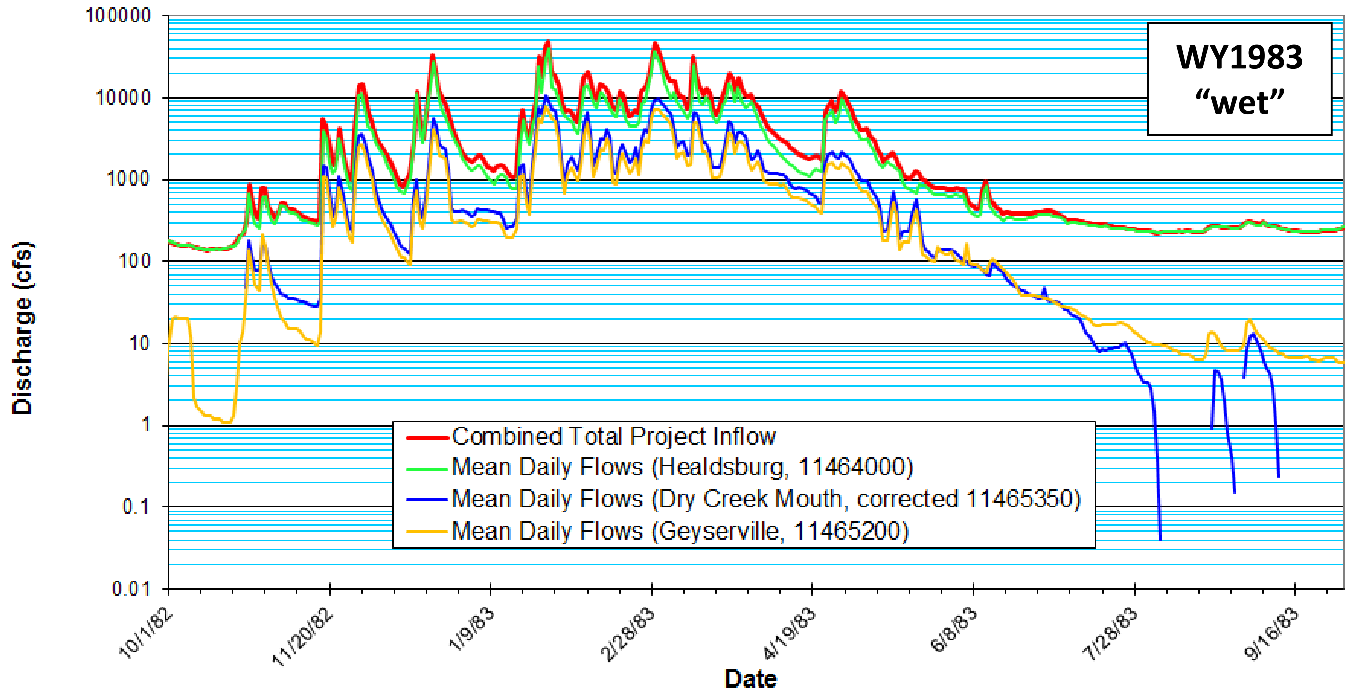


Figure 4.2.12A. 1983 was selected as the wet water year of record to simulate most extreme conditions.

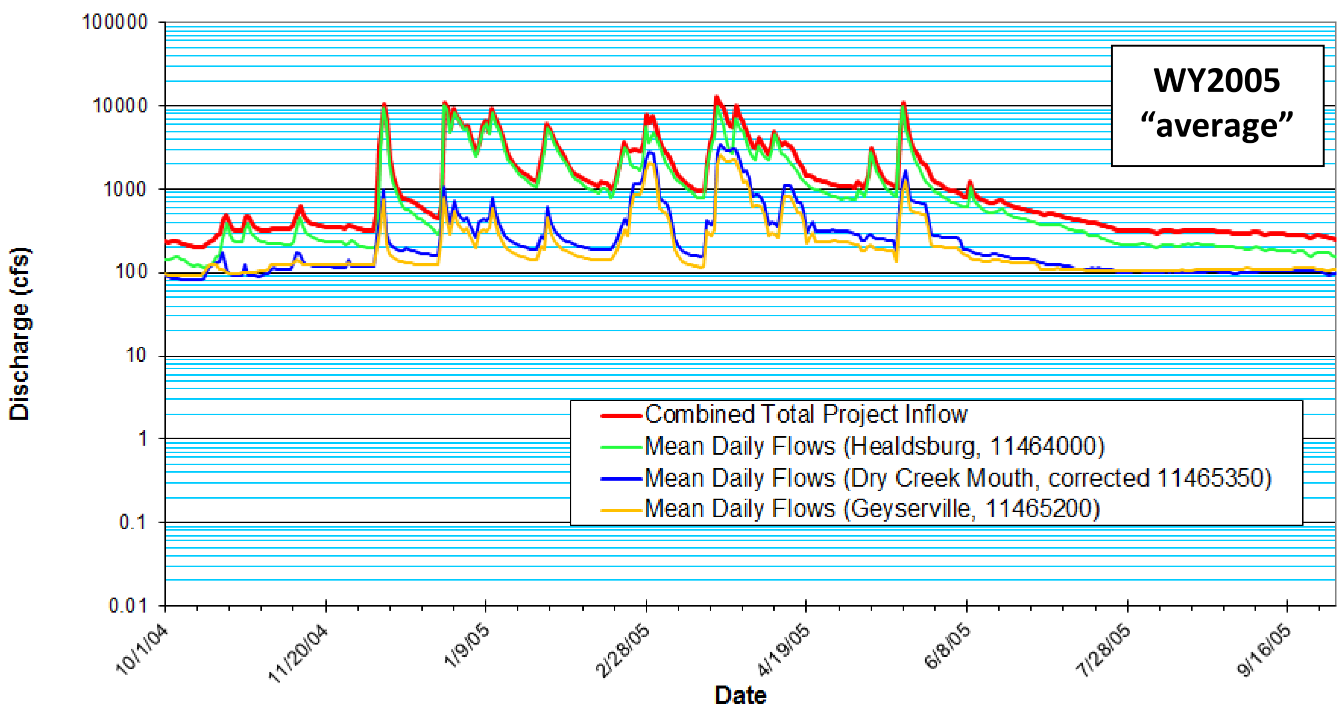


Figure 4.2.12B. 2005 water year with multiple small storm peaks selected as best representing an "average" annual hydrograph for Stage II analysis of hydraulics, sediment transport, and project site habitat conditions.

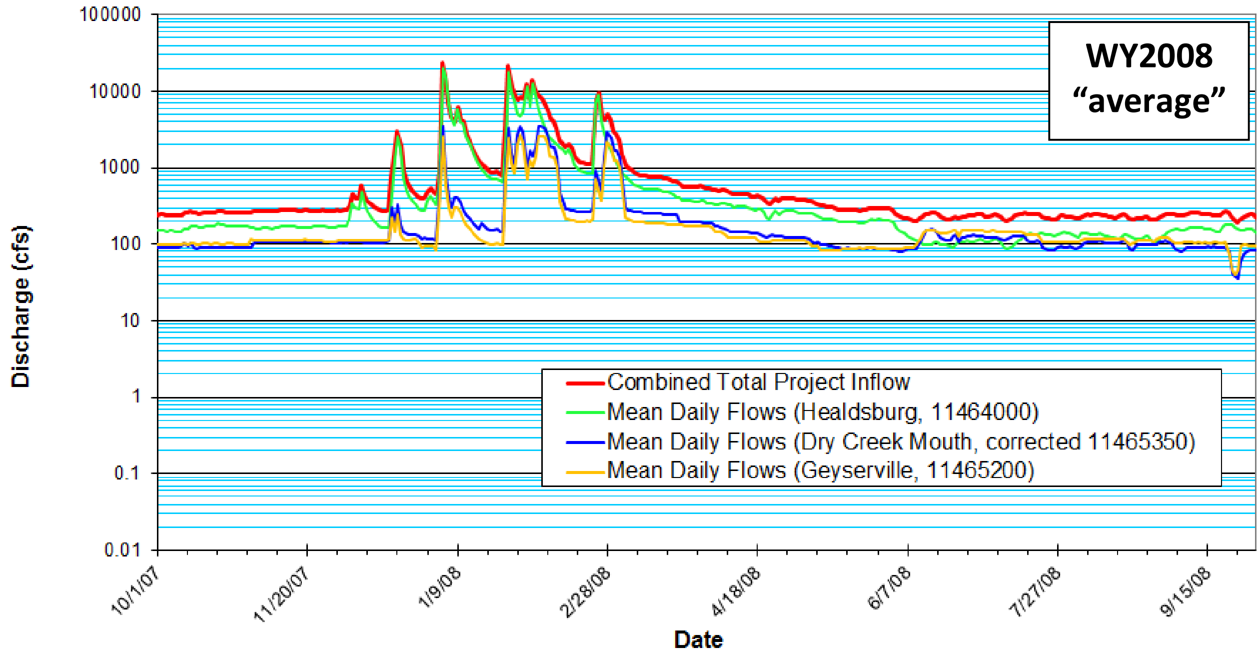


Figure 4.2.12C. 2008 annual hydrograph used to assess hydraulics and sediment transport of Stage 1 Scenarios for an average water year.

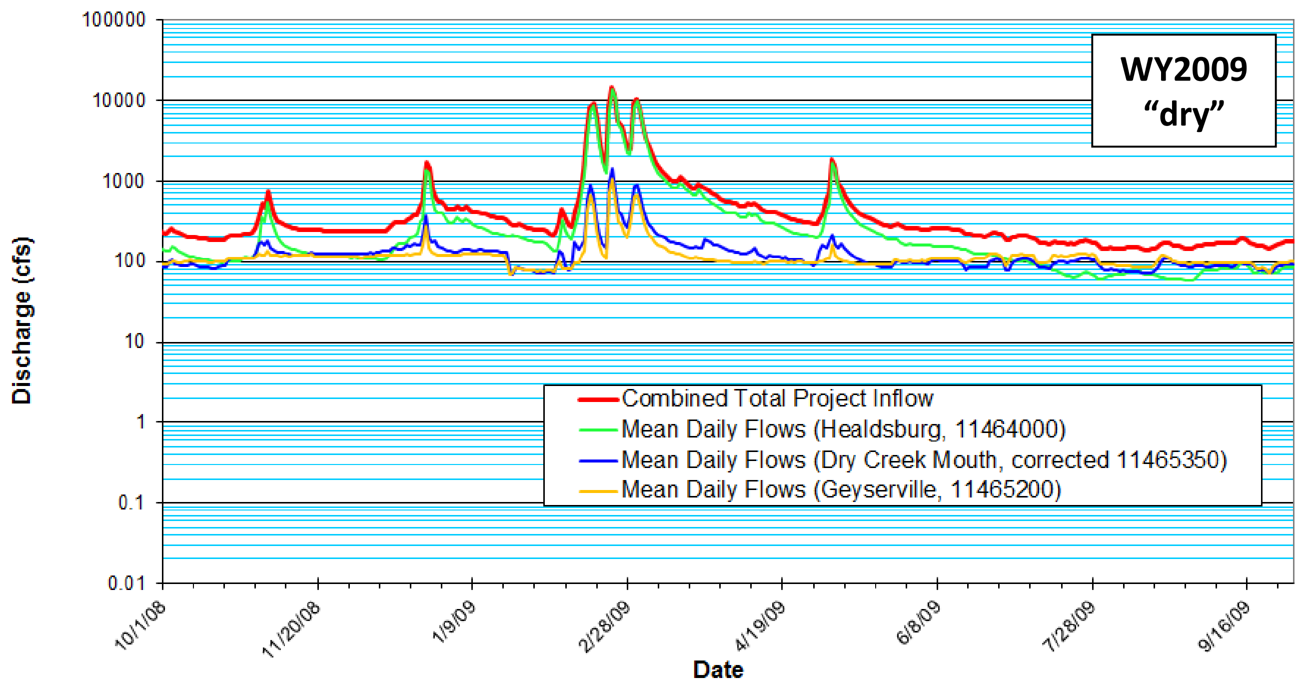


Figure 4.2.12D. 2009 annual hydrograph used to assess hydraulics and sediment transport of dry water years.

During periods of low flow on Dry Creek (<200 cfs at gage 11465350), mean daily discharge at the project site was calculated as the sum of Russian River mainstem gage (11464000) and Dry Creek low flow gage (11465350) mean daily discharges (the record of discharge at Dry Creek near Mouth near Healdsburg gage (114465350) is computed for low flows less than 200 cfs only). For days with a mean daily discharge that exceeded this low flow threshold for Dry Creek, the combined project inflow was calculated by adding the Russian River mainstem gage (11464000) daily discharge to a corrected total mean daily discharge for the Dry Creek basin. The corrected Dry Creek basin discharge is equal to the upstream Dry Creek near Geyserville discharge (11465200) plus an additional runoff volume for the intervening 55 square miles of drainage area between the 'Dry Creek near Healdsburg near Mouth (low flow) gage (11465350) and the Dry Creek near Geyserville (11465200) gages. The additional runoff volume was calculated by multiplying the intervening basin discharge area of 55 mi^2 by the mean daily unit-area discharge of the upstream Dry Creek near Geyserville high flow gage (11465200).

This calculation likely accurately portrays Dry Creek flows to the project site because physiographic, geologic, and vegetation patterns predominantly follow northwest-southeast trending domains that parallel the Dry Creek drainage suggesting that runoff production is fairly consistent longitudinally along Dry Creek. Rainfall rates in the upper watershed, above Lake Sonoma and well above the upstream gage, Dry Creek near Geyserville (11465200), are generally slightly higher than those in the lower watershed. However, Lake Sonoma modulates these differences (Warm Springs Dam and Lake Sonoma constructed in 1984) through reservoir storage and prescribed releases of upper watershed runoff, thus rendering the gaging records at the 'near Geyserville' (11465200) and 'near Mouth near Healdsburg' (11465350) more representative of a spatially-consistent lower watershed unit-area runoff combined with controlled reservoir release. This provides validity to the unit-area computational surrogate for total Dry Creek inflow as described above.

Flow hydraulics (water surface elevation) were recorded over a range of flow conditions using Onset HOBO water level loggers stationed at six locations between the upstream and downstream boundaries of the study reach. Equipment losses and failures limited the results to four locations recording during high flows in December 2012 and January 2013, and one logger recorded low flow conditions between December 2012 and August 2013. The use of water surface records for hydraulic model calibration is explained in Appendix G, the USGS report.

4.2.4 Biogeochemistry

Land use practices are the primary driver of water and sediment quality and quantity in the Russian River basin. Gravel mining has left ponds along the riverbanks that refill with fines carrying mercury (Hg) and other metals from natural background geologic supply during turbid storm flows. Agricultural activities in the basin deliver nitrogen (N), phosphorous (P), and sulfur (S) to the river.

Much of the Russian River is subject to Total Maximum Daily Load (TMDL) numeric standards as described below and illustrated in Figure 4.2.13:

1. Reservoir Mercury TMDLs for Lake Sonoma, Lake Mendocino and Lake Pillsbury.
2. Nutrients, dissolved oxygen and temperature TMDL in the Laguna de Santa Rosa.
3. Bacteria TMDL for the lower Russian River.
4. Silt and sediment TMDL for Russian River Watershed.

Water resource agencies must manage point and non-point sources of pollution to reduce human and environmental impacts. For the feasibility study, the North Coast Regional Water Quality Control Board and Sonoma County Water Agency were consulted to identify the constituents and processes of most concern for the Hanson project. These are:

1. Toxins that bio-magnify in aquatic food webs (*e.g.*, Hg).
2. Algal blooms and eutrophication that cause seasonal dissolved oxygen crashes.
3. Nutrient cycling redox conditions.

4. Nutrient and temperature inputs to the river contributing to toxic blue green algae blooms.
5. Dissolved organic carbon which could alter natural water purification processes.

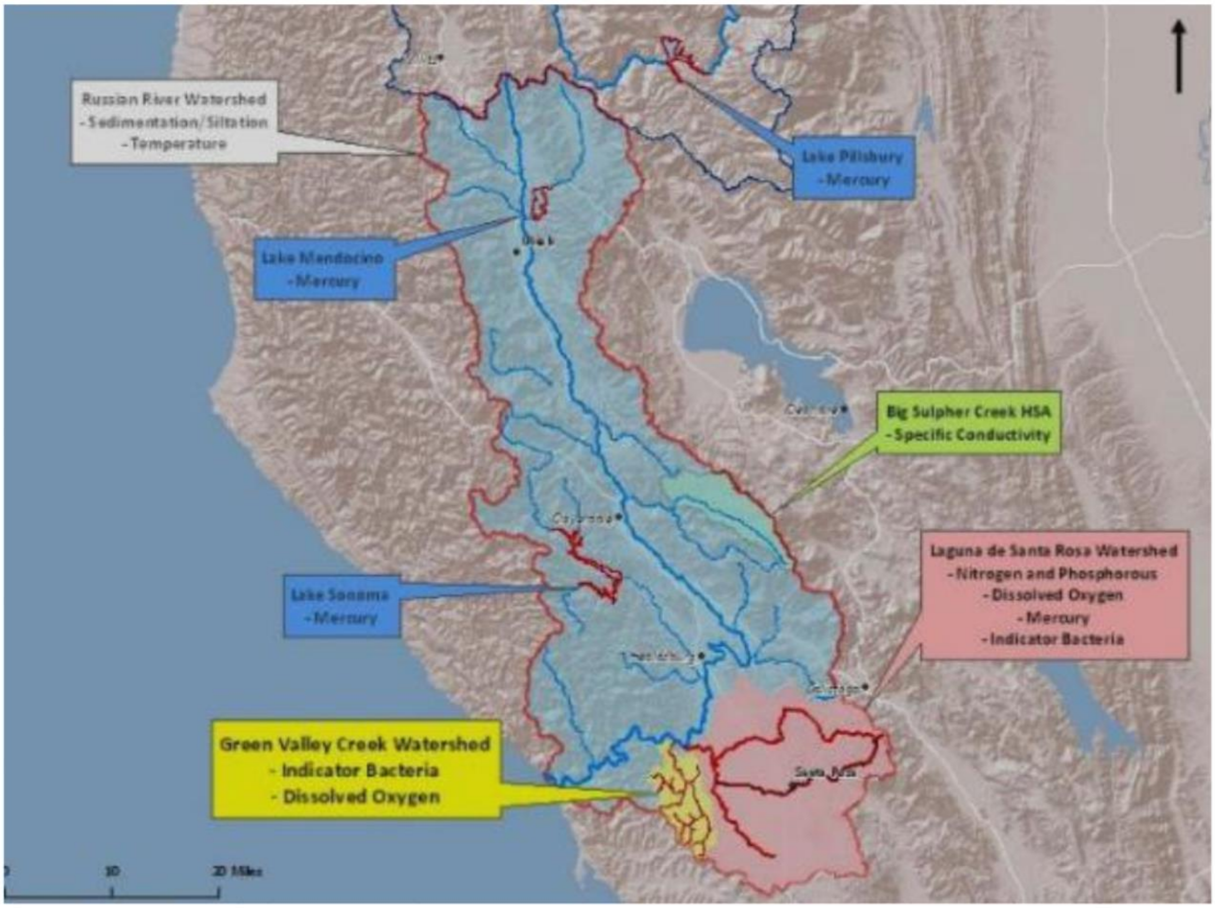


Figure 4.2.13. Map of the Russian River Watershed Total Maximum Daily Loads (TMDLs). *Source: North Coast Regional Water Quality Control Board.*

4.2.4.1 Key drivers and controllers of biogeochemical processes. Biogeochemical processes operate at two scales, locally and watershed-wide. At the watershed scale, urban runoff delivers polycyclic aromatic hydrocarbons (PAHs) from the watershed. For example, as discussed below in Section 4.3 Field Investigation Results, diesel was found in all sediment sampled from the Alexander Valley to Wohler Narrows, including the ponds. Hydrology and water management of the system's three storage reservoirs regulate the rate and supply of constituents and their dilution rate.

Biogeochemical and physical processes in the Hanson ponds include cycling of metals (for example, Hg), nutrient cycling (P), and thermal and dissolved oxygen (DO) stratification discussed further in Section 4.3*,* and illustrated in Figure 4.2.14.

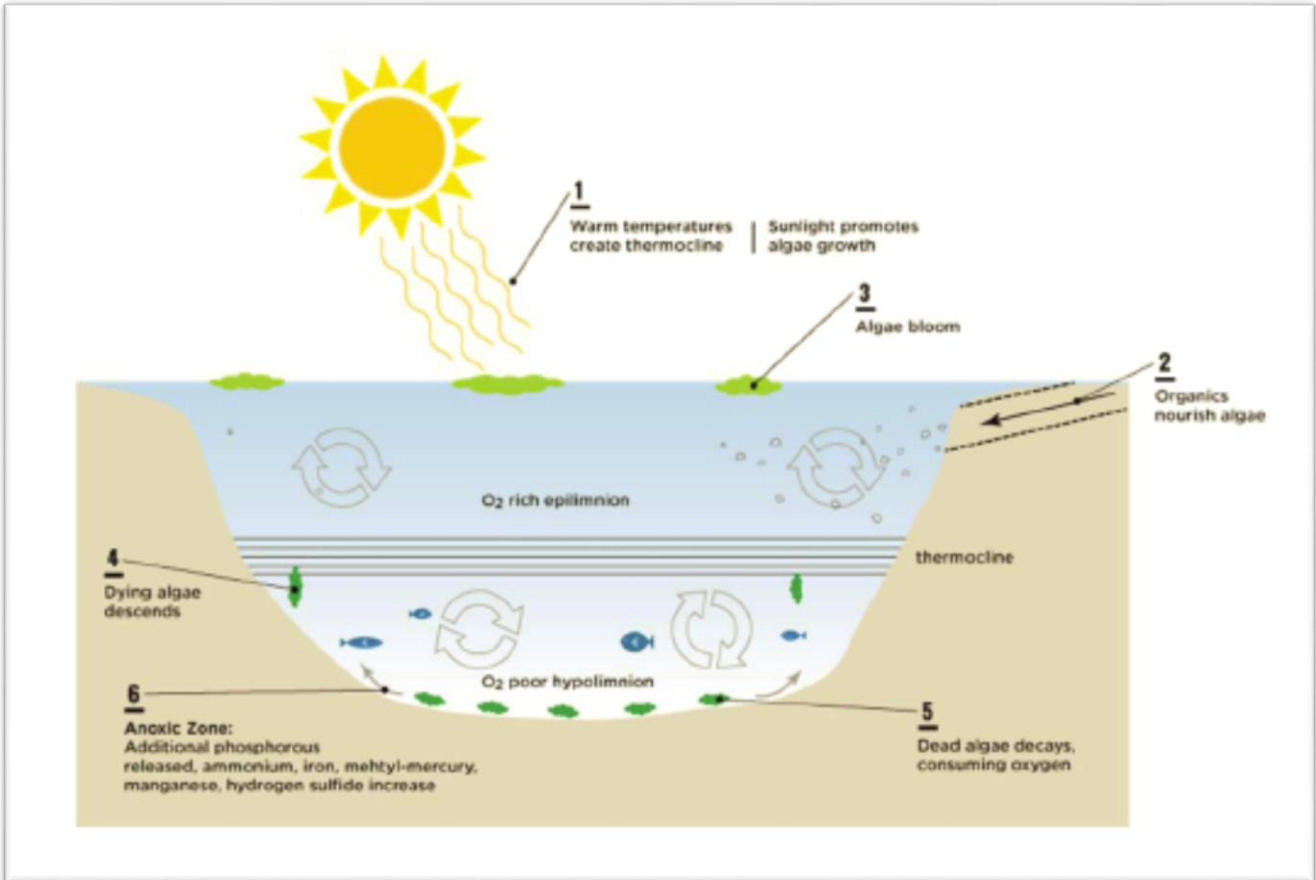


Figure 4.2.14. Thermal stratification of the ponds. Thermal stratification creates the redox conditions for anaerobic decay of cyclic algal blooms, cycling of nutrients (P) and metals (Hg), and hydrogen sulfide production.

Key drivers of biogeochemical processes at the Hanson Ponds include basin hydrodynamics, seasonal thermal stratification of the deep ponds, and sediment and water properties. Key controllers of internal biogeochemical processes at the Hanson Ponds include: availability of P, Hg, Fe, S, and dissolved organic carbon; the anaerobic microbial community, and redox conditions (Figures 4.2.15 and 4.2.16).

Stakeholders and the North Coast Regional Board identified the methylation of mercury in thermally stratified ponds and the potential for accumulating up the food chain as a significant concern. Mineral mercury (Hg) delivered by river hydrology is methylated by anaerobic bacteria (*e.g*., *Disulferans disulferans*) in the anaerobic conditions driven by thermal stratification -- resulting in methyl-mercury and hydrogen sulfide production. The methylation rate by bacteria is governed by the amount of fuel for bacteria determined by concentration of dissolved organic carbon resulting from anaerobic decay of plant material (algae/phytoplankton). Phosphorous from decaying algae under anaerobic conditions is re-mineralized, allowing repeating cyclic algal blooms. Availability of sulfate in the system doubles the rate of the methyl-mercury production.

4.2.4.2 Summary of biogeochemistry. As described in Section 4.2.3.2 Surface and Groundwater Interactions, significant groundwater from both the Russian River aquifer and the Glen Ellen formation flow through the ponds and into the river. Consequently, the biogeochemical processes of the ponds are affecting water temperature and water quality with delivery of warmed water, nutrients, and metals to the Russian River.

River hydrology delivers the constituents, river flows control the rate and form of delivery; and hydro-modification and flow management moderate the detention and release of fines and pollutants, reduce connectivity to floodplains, and prevent floodplain deposition. As a result, constituents are available to the river over a wide range of flow conditions, including low flows because deposition of fines and contaminants occurs in the channel (even at low flows) rather than on floodplains. The key drivers and controllers, and the internal processes that influence water quality in the Middle Reach ponds and in the Russian River downstream are described in Figures 4.2.15 and 4.2.16.

- ❑ Methyl-mercury production
    - ❑ Availability of Hg(II)
    - ❑ Microbial community
    - ❑ Sulfate concentrations
    - ❑ Carbon availability
    - ❑ Optimal redox condition (anaerobic conditions)
- ❑ Physical
    - ❑ Hydrodynamics (i.e., connectivity) semi-isolated
    - ❑ Pond stratification
    - ❑ Pond structure
    - ❑ Sediment properties
        - ❑ Clay and fine grain sediments

- ❑ Phosphorus mineralization
    - ❑ Availability of P
    - ❑ Vegetation
    - ❑ Al and Fe
    - ❑ Optimal redox condition (anaerobic conditions)
    - ❑ Periphyton community
- ❑ Physical
    - ❑ Hydrodynamics
    - ❑ Pond stratification
    - ❑ Pond structure
    - ❑ Sediment properties
        - ❑ Clay and fine grain sediments

Figure 4.2.15. Key drivers and controllers of water quality processes at the Hanson ponds.

- ❑ Essential, such as **Carbon (C)**, Nitrogen (N) and **Phosphorous (P)**
    - ❑ Decomposition (C) by anaerobic microbial bacteria and microorganisms
    - ❑ Phosphorus mineralization
        - ❑ Release of P occluded to sediments under Al and Fe reduction.
- ❑ Trace, such as Iron (Fe), **Sulfur (S)**
    - ❑ Reduction of Fe and S by anaerobic bacteria
- ❑ Toxic, such as Mercury (Hg),
    - ❑ Methylation of inorganic Hg(II) to methyl-mercury (McHg)

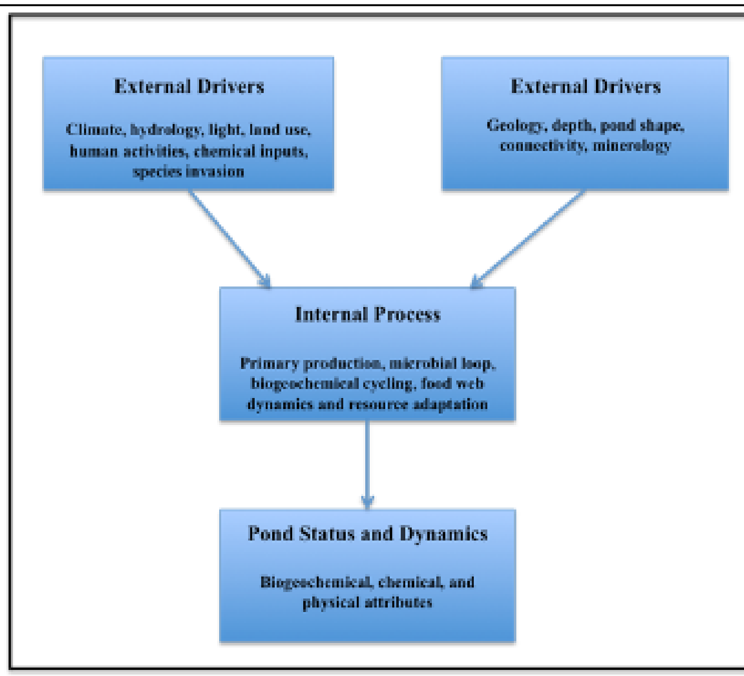


Figure 4.2.16. Important internal biogeochemical processes that influence water quality in the Hanson Ponds.

4.2.5 Status of salmonid populations and critical habitat in the Russian River Basin

The Middle Reach of the Russian River basin is formally recognized as critical habitat for two federally-listed evolutionarily significant units (ESUs) and one distinct population segment (DPS) of salmonid species. These species are:

1. Endangered Central California Coast coho salmon (*Oncorhynchus kisutch*) ESU, listing determination June 28, 2005 (70 FR 37160), critical habitat designation May 5, 1999 (64 FR 24049).
2. Threatened California Coastal Chinook salmon (*O. tshawytscha*) ESU, listing determination June 28, 2005 (70 FR 37160), critical habitat designation September 2, 2005 (70 FR 52488).
3. Threatened Central California Coast steelhead (*O. mykiss*) DPS, listing determination January 5, 2006 (71 FR 834), critical habitat designation September 2, 2005 (70 FR 52488).

The current status and populations of each of these species in the Russian River are described in the following sections.

4.2.5.1 Central California Coast Coho Salmon ESU and Russian River status. Historically, the Central California Coast coho salmon evolutionarily significant unit (CCC coho ESU) comprised approximately 77 populations[1]. Most of these were likely dependent populations that relied upon immigration from nearby populations to ensure their long-term persistence, but 12 have been classified as independent populations, *i.e.*, populations with a high likelihood of persisting for 100+ years even absent the influence of strays from neighboring populations (Bjorkstedt *et al.* 2005, Spence *et al.* 2008). Most extant CCC coho ESU populations are struggling with low abundance, range constriction, fragmentation, and loss of genetic diversity. Brown *et al.* (1994) estimated that annual spawning numbers of coho salmon in California ranged between 200,000 and 500,000 fish in the 1940s, which declined to about 100,000 fish by the 1960s, followed by a further decline to about 31,000 fish by 1991. Within the CCC coho ESU an estimated spawning population of approximately 56,100 coho salmon in the mid-1960s had declined to approximately 6,180 wild and naturalized spawners by the late 1980s-1991 period (Brown *et al.* 1994). The lowest abundance is thought to have occurred in 2009, with an estimate of only 500 spawning adults within the CCC coho ESU (Figure 4.2.17), with some rebound in the population having occurred since then (Spence in press). Recent and previous status reviews indicate that the CCC coho ESU population is likely continuing to decline in number and has experienced acute range restriction and fragmentation (Good *et al.* 2005, Spence and Williams 2011).

Adams *et al*. 1999 found that in the mid-1990s, coho were present in 51% of the streams (98 of 191) where they were historically present, and documented coho in an additional 23 streams within the CCC coho ESU with no historical records. Subsequent and more thorough research by Spence *et al.* 2005 found 310 streams within the CCC coho ESU that were documented to have historically supported coho salmon. The research also found 26 streams where evidence suggests a strong likelihood of historical coho occurrence, but where first-hand field documentation was lacking. Thus range constriction has severely affected the extent, abundance and genetic diversity of the ESU, with only 121 of likely 336 historical coho streams (36%) still supporting remnant coho populations.

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[1] Population as defined by Bjorkstedt *et al.* 2005 and McElhaney *et al.* 2000 as a group of fish of the same species that spawns in a particular locality at a particular season and does not interbreed substantially with fish from any other group. Such fish groups may include more than one stream. These authors use this definition as a starting point from which they define four types of populations (not all of which are mentioned here).

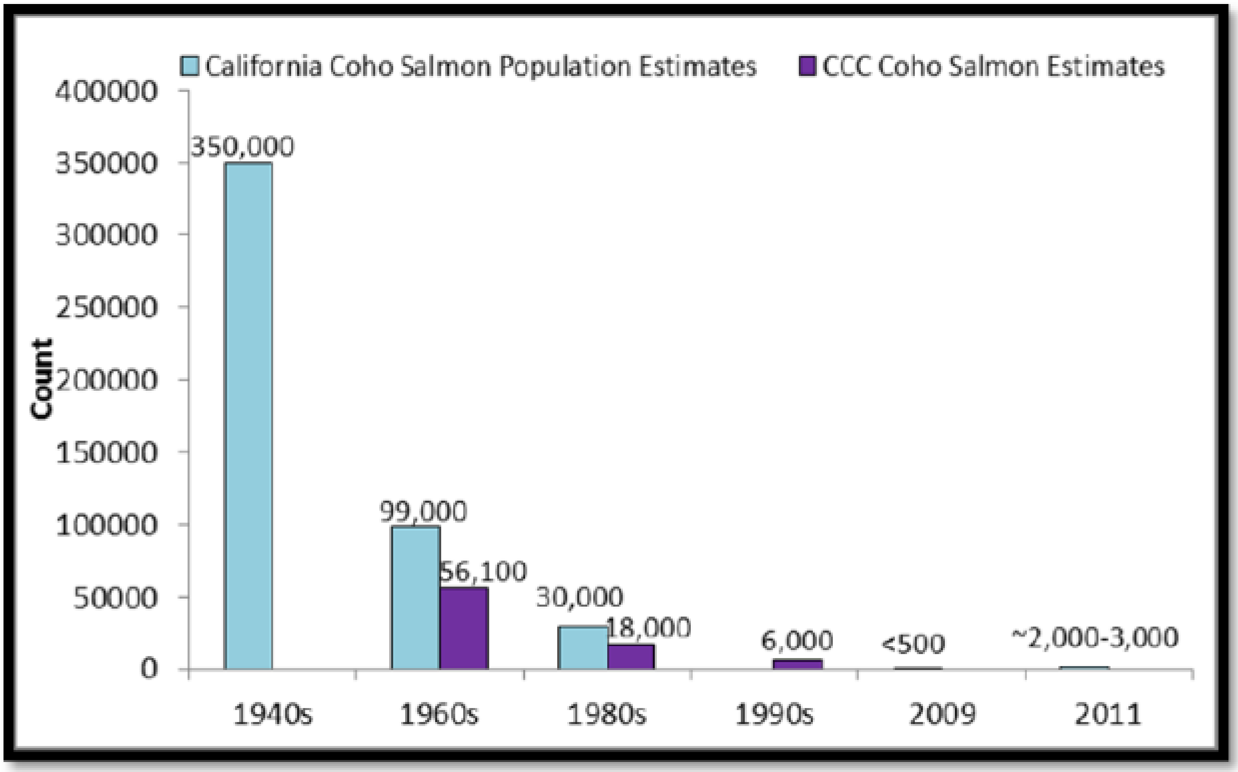


Figure 4.2.17. Decline of California and Central Coast Coho salmon populations in the late 20th century. The Russian River historically had the largest population of the CCC coho ESU. *Source: NMFS Coho Recovery Plan (2012).*

Genetic research in progress at both the NMFS Southwest Fisheries Science Center and UC Davis Bodega Marine Laboratory suggests a reduction in genetic diversity in several populations of the CCC coho ESU (Bjorkstedt *et al.* 2005). The influence of past hatchery production on wild stocks may also have contributed to a diminishment of diversity through inbreeding depression and disease transmission.

Available data from the remaining eight extant independent populations show continuing declines in abundance. Four independent populations that once supported the species overall numbers and geographic distributions have been extirpated, particularly in the southern portion of the ESU. This suggests that populations that historically provided support to dependent populations via immigration have not been able to provide enough immigrants for many dependent populations for several decades. This is evidenced by continued declines in abundance of dependent populations across the ESU (Spence 2016). The near-term viability (10 - 20 years) of many of the extant independent CCC coho ESU populations is of serious concern. These populations may not be large enough to survive additional natural and human caused environmental change.

The most recent published NMFS status report, Spence and Williams (2011), noted that for all available time series, recent population trends have been downward with particularly poor adult returns from 2006 to 2010. In addition, all independent populations are well below low-risk abundance targets, and several are either extinct or below the high-risk depensation thresholds (Spence 2016) that were identified by Spence *et al.* 2008. It appears that none of the five diversity strata defined by Bjorkstedt *et al. (*2005) currently support viable populations based on criteria established by Spence *et al.* (2008). The risk of extinction for the CCC coho ESU appears to have increased since the previous formal review when Good *et al. (*2005) concluded that the ESU was in danger of extinction. The most recent NMFS status review (Spence 2016) states, "We conclude that long-term trends remain predominately downward, but for some populations, the lowest population levels were reached around 2008-2009 and there has been a slight rebound since then. More disconcerting is the continued downward trend for the majority of dependent populations, and the especially dire situation in the Santa Cruz Mountain diversity stratum, where hatchery fish account for almost all returning adults."

The best available updated information on the biological status of this ESU and the threats facing this ESU (Spence and Williams 2011, NMFS 2011a, Spence 2016) indicate that it remains endangered, and its condition is worsening (76 FR 50447). Based on this information, NMFS chose to maintain the endangered listing of CCC coho salmon ESU (76 FR 50477).

In the Russian River Watershed, the substantial decline in coho salmon abundance (Figure 4.2.17) led to the 2001 formation of the Russian River Coho Salmon Captive Broodstock Program (RRCSCBP). Under this program, offspring of wild captive-reared coho salmon are released as juveniles into tributaries within their historical range with the expectation that some of them will rear and return as adults to naturally reproduce. Juvenile coho salmon and coho salmon smolts have been released into several tributaries within the lower Russian River and Dry Creek watersheds.

4.2.5.2 California Coastal Chinook salmon ESU and Russian River status. The California Coastal Chinook salmon evolutionarily significant unit (CC Chinook ESU) historically comprised as many as 32 fall-run populations (Bjorkstedt *et al.* 2005; Spence *et al.* 2008) and six spring-run populations. Many of these populations (about 15) were independent or potentially independent, meaning they historically had a high likelihood of persisting for 100 years or more absent anthropogenic impacts. The remaining populations were probably more dependent upon immigration from nearby independent populations than dependent populations of other salmonids (Bjorkstedt *et al.* 2005).

Data on CC Chinook ESU abundance, both historical and current, are sparse and of varying quality (Bjorkstedt *et al.* 2005; Williams *et al.* 2011). Population-level estimates of historical abundance are scarce for populations in this ESU (Myers *et al.* 1998). In 1965, the California Department of Fish and Game estimated escapement for this ESU at over 76,000. Most were in the Eel River (55,500), with smaller populations in Redwood Creek (5,000), Mad River (5,000), Mattole River (5,000), Russian River (500). and several smaller streams in Humboldt County (Myers *et al.* 1998). Other than the increase in the Russian River and upper Mainstem Eel River populations described below, currently available data from across the ESU indicate abundance is far lower, suggesting an inability to sustain production adequate to maintain the ESU's populations (Williams *et al.* 2016).

CC Chinook populations remain widely distributed throughout much of the ESU. A notable exception is the area between the Mattole and Ten Mile River populations (Mendocino County/Lost Coast area). Also of concern is the small size of populations between Ten Mile River and the Russian River. In the area between the Ten Mile River and Russian River, surveys by CDFW have shown that only small numbers of Chinook are being found in most years in several Mendocino Coast watersheds, including the Ten Mile, Noyo, Big, Navarro, and Garcia rivers (Williams *et al.* 2016). The lack, or low abundance of CC Chinook ESU populations north and south of the Russian River (the Russian River is at the southern end of the species' range) makes it one of the most isolated populations in the ESU. Myers *et al.* (1998) reports no viable populations of Chinook salmon south of the inland Central Valley populations transiting through San Francisco Bay.

Because of their prized status in the sport and commercial fishing industries, CC Chinook salmon have been the subject of many artificial production efforts, including out-of-basin and out-of-ESU stock transfers (Bjorkstedt *et al.* 2005). It is therefore likely that CC Chinook ESU genetic diversity has been significantly adversely affected despite the relatively wide distribution of populations within the ESU. This threat has been ameliorated to an extent in that there are no longer active Chinook hatcheries operating within the ESU. An apparent loss of the spring-run Chinook life history in the Eel River Basin and elsewhere in the ESU also indicates risks to diversity of the ESU (Williams *et al.* 2011).

Data from the 2009 adult CC Chinook ESU return counts and estimates indicated a further decline in returning adults across the range of CC Chinook salmon on the coast of California (Jeffrey Jahn, NMFS, personal communication, 2010). Ocean conditions are suspected as the principal short-term cause because of the wide geographic range of declines (NMFS Southwest Fisheries Science Center 2008). Although subsequent to 2010, some populations appear stable or are increasing (i.e., the Russian River and Upper Mainstem Eel River populations, respectively (Williams *et al.* 2016).

CDFW historically maintained adult CC Chinook counting stations at two locations within the ESU: on the upper Mainstem Eel River at the Van Arsdale egg-taking station at the Potter Valley project diversion facility, and at the Benbow Dam fish ladder on the South Fork Eel River. Only the Van Arsdale facility is still in operation. Upper Mainstem Eel River populations have been affected for most of the 20th century by construction of the Van Arsdale diversion facility in 1908, and the 1922 construction of Lake Pillsbury (Scott Dam) upstream and without a fish ladder. Thus the CDFW counts at Benbow on the South Fork Eel give the best representation of the decline in abundance of CC Chinook through the latter half of the 20th century. In more recent years the Sonoma County Water Agency has maintained a video camera for counting Russian River adult CC Chinook returns at its Mirabel diversion facilities below Wohler Bridge in the Lower Russian River. Figures 4.2.18 - 4.2.20 present data from these three facilities documenting the relative annual abundance of CC Chinook salmon runs at each location.

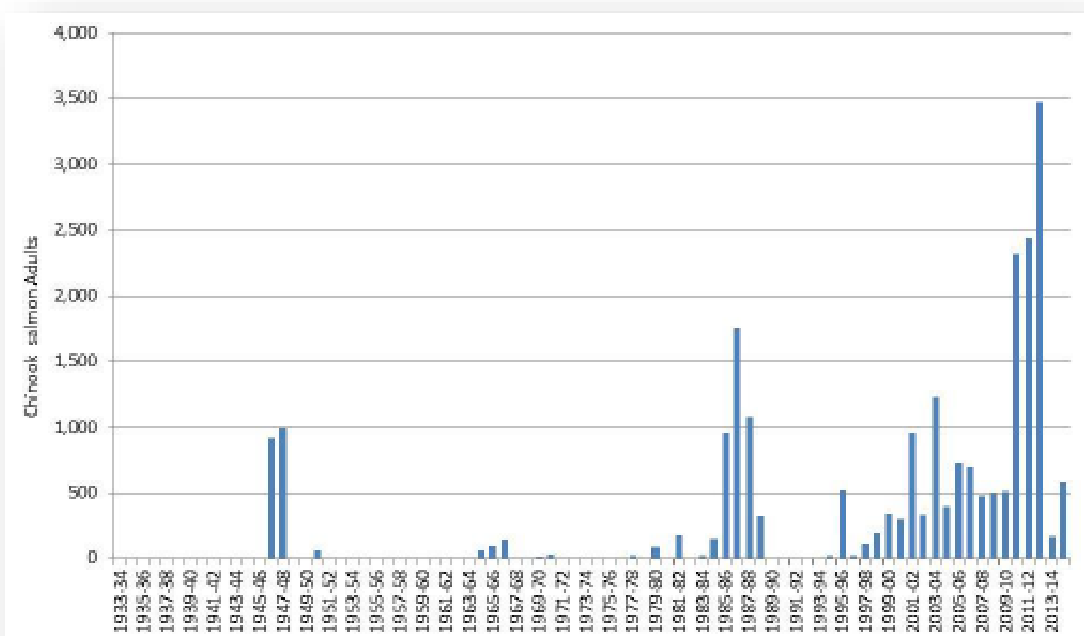


Figure 4.2.18. Adult Chinook salmon returns at Van Arsdale Fisheries Station. Counted at the Van Arsdale Fisheries Station on the Upper Mainstem Eel River, 1933-1934 through 2013-2014. Most recently, adult returns have declined substantially with 168 and 584 adults returning to the station in 2013-14 and 2014-15, respectively. *Source: Coastal Multispecies Recovery Plan Public Draft (NMFS in press).*

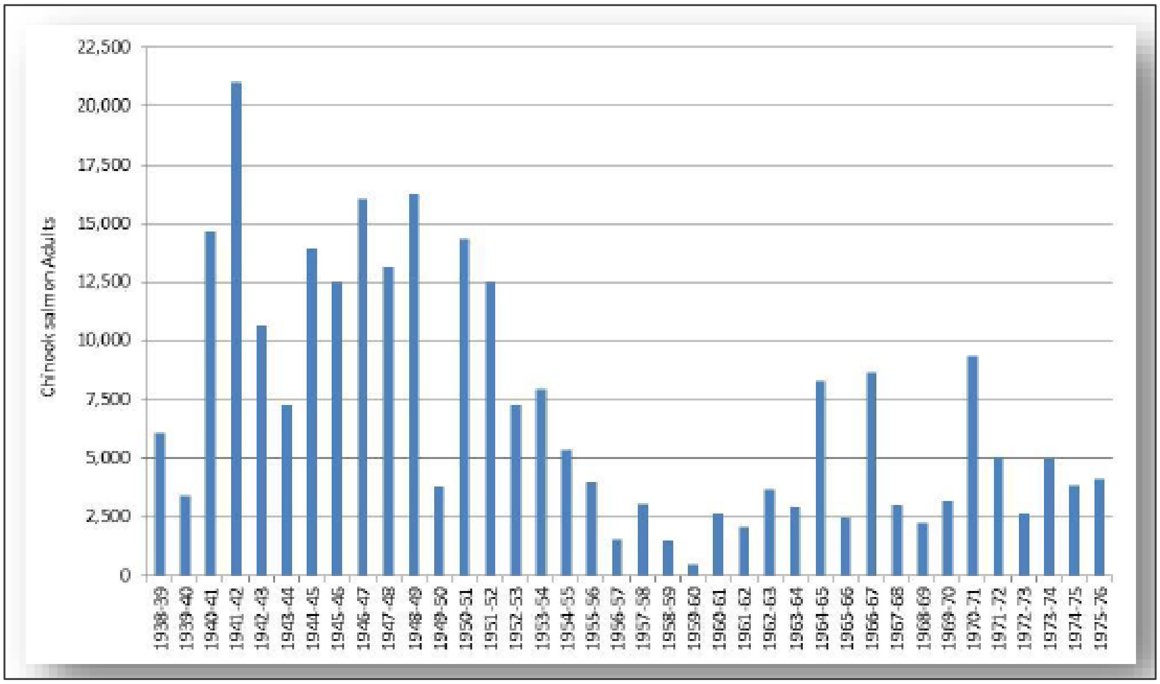


Figure 4.2.19. Adult Chinook salmon returns at Benbow Dam fish ladder. Counts at the Benbow Dam Fish Ladder on the South Fork Eel River best represent the historical decline of CC Chinook, 1938-39 through 1975-76. Counts in 1969-70 and 1970-71 are estimates as the station was closed before the end of the run. *Source: Coastal Multispecies Recovery Plan Public Draft (NMFS in press).*

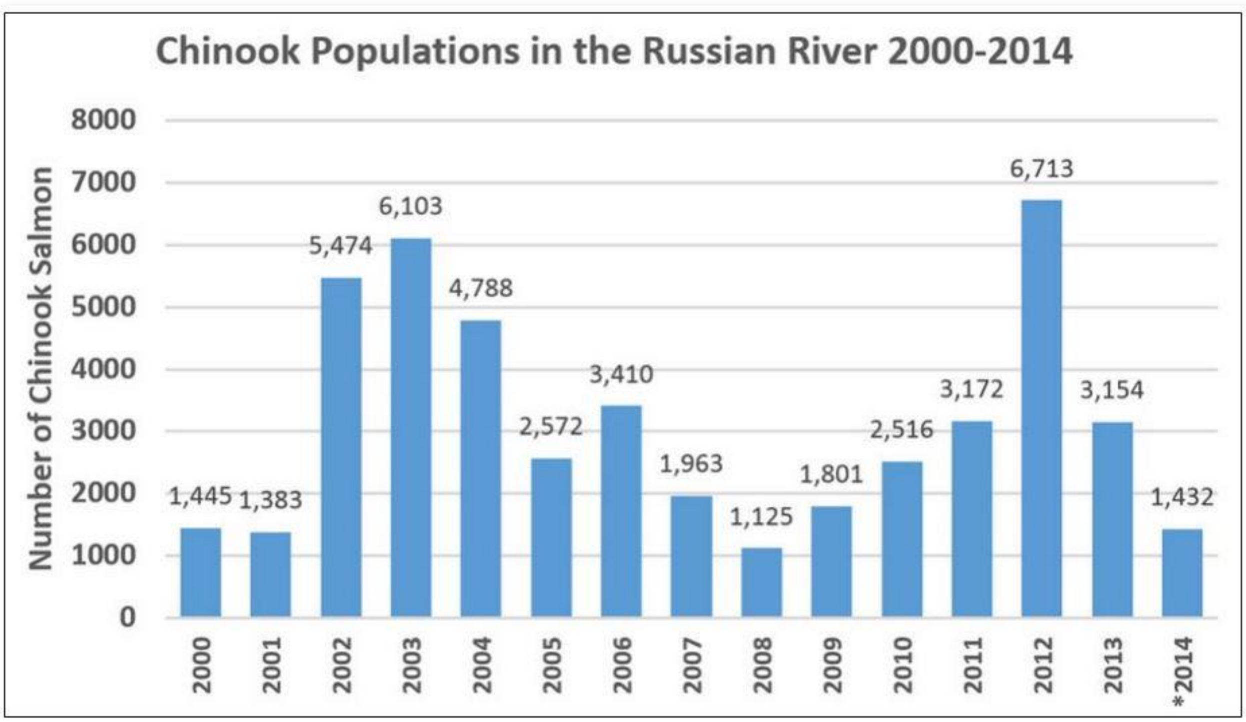


Figure 4.2.20. California Coastal Chinook salmon population counts in the Russian River. This Sonoma County Water Agency graph compares Chinook salmon counts from the Mirabel dam fish ladder video monitoring system for the years 2000-2014. (*denotes count for 2014-2015 winter season. Counts do not include fish spawning below the facility, or fish migrating during high flows when the inflatable dam is not operation).

Using an updated analysis approach, Williams *et al. (*2011) did not find evidence of a substantial change in conditions since the last status review (Good *et al.* 2005). The Williams *et al.* (2011) analysis found that the loss of representation from one diversity stratum, the loss of the spring-run history type in two diversity substrata, and the diminished connectivity between populations in the northern and southern half of the ESU pose a concern regarding viability for this ESU. Based on consideration of this updated information, Williams *et al.* (2011) concluded the extinction risk of the CC Chinook ESU has not changed since the last status review. The 2016 status review update (Williams *et al.* 2016) draws the same conclusion. On August 15, 2011, NMFS affirmed no change to the determination that the CC Chinook salmon ESU is a threatened species, as previously listed (NMFS 2011b, 76 FR 50447).

In the Russian River Watershed, the number of adult CC Chinook salmon returns increased substantially in 2010/2011 compared to 2008/09 and 2009/10 returns (G. Horton, Sonoma County Water Agency, personal communication, 2016). Increases in adult Chinook salmon returns during 2010/2011 were observed in the Central Valley populations as well. The 2012/2013 Chinook salmon returns to the Russian River were counted at the Mirabel fish ladder at 6,696 fish - the highest return of the last dozen years. In 2013/2014 numbers dropped to 3,154 fish counted at Mirabel; and to 1,432 fish in the 2014-2015 season (Figure 4.2.20).

4.2.5.3 Central California Coast steelhead DPS and Russian River status. Historically, approximately 70 populations of steelhead are believed to have existed in the Central California Coast steelhead Distinct Population Segment (CCC steelhead DPS) (Spence *et al.* 2008). Many of these populations (approximately 37) were independent, or potentially independent, meaning they historically had a high likelihood of surviving for 100 or more years absent anthropogenic impacts (Bjorkstedt *et al.* 2005). The remaining populations were dependent upon immigration from nearby CCC steelhead DPS populations to ensure their persistence (McElhaney *et al.* 2000, Bjorkstedt *et al.* 2005).

While historical and current data of abundance are limited, CCC steelhead DPS numbers are substantially reduced from historical levels. A total of 94,000 adult steelhead were estimated to spawn in the rivers of this DPS in the mid-1960s, including 50,000 fish in the Russian River – the largest population within the DPS (Busby *et al.* 1996). Near the end of the 20th century, McEwan (2001) estimated that the wild steelhead population in the Russian River Watershed was between 1,700 and 7,000 fish. Abundance estimates for smaller coastal streams in the DPS indicate low but stable levels, with recent estimates for several streams (Lagunitas, Waddell, Scott, San Vicente, Soquel, and Aptos creeks) of individual run sizes of 500 fish or less (62 FR 43937). However, as noted in Williams *et al.* (2016) data for CCC steelhead populations remains scarce outside of Scott Creek, which is the only long-term dataset and shows a significant decline. Short-term records indicate the low but stable assessment of populations is reasonably accurate; however, it should be noted that there is no population data for any populations outside of the Santa Cruz Mountain stratum, other than hatchery data from the Russian River.

Although available time series datasets are too short for statistically robust analysis, the information available indicates CCC steelhead populations have likely experienced serious declines in abundance, and long-term population trends suggest a negative growth rate (Figure 4.2.21). This would indicate the DPS may not be viable in the long term, and DPS populations that historically provided enough steelhead immigrants to support dependent populations may no longer be able to do so, placing dependent populations at increased risk of extirpation. However, because CCC steelhead have maintained a wide distribution throughout the DPS, roughly approximating the known historical distribution, CCC steelhead likely possess a resilience that could slow their decline relative to other salmonid DPSs or ESUs in worse condition. The 2005 status review concluded that steelhead in the CCC steelhead DPS remain "likely to become endangered in the foreseeable future" (Good *et al.* 2005), a conclusion that was consistent with a previous assessment (Busby *et al.* 1996) and supported by the most recent NMFS Technical Recovery Team work (Spence *et al.* 2008). On January 5, 2006, NMFS issued a final determination that the CCC steelhead DPS is a threatened species, as previously listed (71 FR 834).

Although numbers did not decline further during 2007/08, the 2008/09 adult CCC steelhead return data indicated a significant decline in returning adults across their range (4.2.22). Escapement data from 2009/2010 indicated a slight increase; however, the returns were still well below numbers observed within recent decades (Jeffrey Jahn, NMFS, personal communication, 2010).

In the Russian River, analysis of genetic structure by Bjorkstedt *et al.* (2005) concluded previous among-basin transfers of stock, and local hatchery production in interior populations in the Russian River likely has altered the genetic structure of the Russian River populations. Depending on how "genetic diversity" is quantified, this may or may not constitute a loss of overall diversity. In San Francisco Bay streams, reduced population sizes and fragmentation of habitat has likely led to loss of genetic diversity in these populations. More detailed information on trends in CCC steelhead DPS abundance can be found in the following references: Busby *et al.* 1996, NMFS 1997, Good *et al.* 2005, and Spence *et al.* 2008.

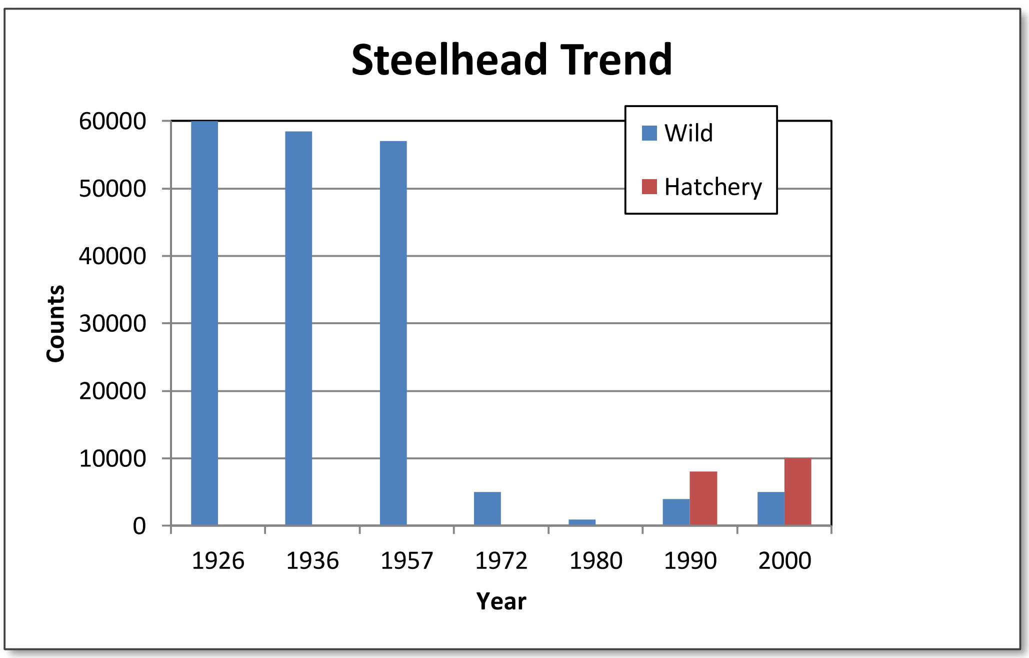


Figure 4.2.21. Russian River steelhead: California Department of Fish and Game early century estimates/counts. 1957-2000 wild fish estimates, and 1980-2000 combined hatchery/wild returns (counts) to Warm Springs Dam (Lake Sonoma) on Dry Creek, and to Coyote Valley Dam (Lake Mendocino) on the East Fork Russian River.

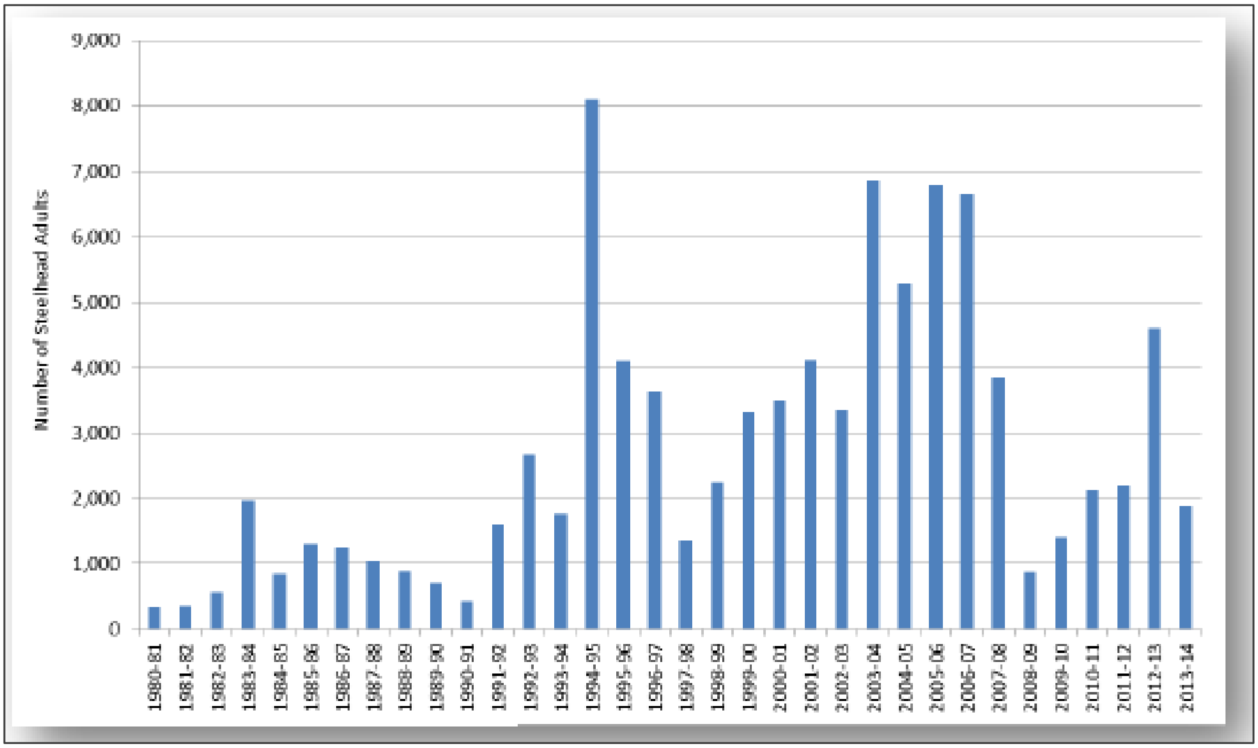


Figure 4.2.22. Adult steelhead returns at Warm Springs Fish Hatchery. Counted at the Warm Springs Fish Hatchery (Lake Sonoma) on Dry Creek, 1980-1981 through 2012-2014. Figure from Coastal Multispecies Recovery Plan Public Draft (NMFS in press)

The most recent published status review by Williams *et al.* (2011) concluded that steelhead in the CCC steelhead DPS remain "likely to become endangered in the foreseeable future." as new information released since Good *et al.* 2005 does not appear to suggest a change in extinction risk. The 2016 status review (Williams *et al.* 2016) reaches the same conclusion. On December 7, 2011, NMFS affirmed no change to the determination that the CCC steelhead DPS is a threatened species, as previously listed (NMFS 2011c, 76 FR 76386).

4.2.5.4 Critical habitat status for CCC steelhead, CC Chinook salmon, and CCC coho salmon.

The quantity and quality of riverine and estuarine habitat for CCC coho salmon, CC Chinook salmon, and CCC steelhead has been degraded from threshold conditions known to support viable salmonid populations. NMFS has determined that a number of human activities have contributed to the loss of critical salmonid habitat including logging, agriculture, mining, urbanization, stream channelization, dams, wetland loss, and water withdrawals (including unscreened diversions for irrigation) (64 FR 24049; 70 FR 37160; 70 FR 52488) [2]. Consequences of these activities include altered stream bank and channel morphology, elevated water temperature, lost spawning and rearing habitat, habitat fragmentation, impaired gravel and wood recruitment from upstream sources, degraded water quality, lost riparian vegetation, and increased erosion from upland areas into streams (Weitkamp *et al.* 1995; Busby *et al.* 1996).

[2] Other factors, such as overfishing and artificial propagation, have also contributed to the current population status of these species. All these human-induced factors have exacerbated the adverse effects of natural environmental variability from such factors as drought and ocean conditions.

Diversion and storage of river and stream flow has dramatically altered the natural hydrologic cycle in many of the streams within the ESUs and DPS. Altered flow regimes can delay or preclude migration, de-water aquatic habitat, disconnect productive wetlands, and/or strand fish in disconnected pools, while unscreened diversions can entrain juvenile fish.

In the Russian River Basin below Cloverdale, the Middle Reach Valley is one of four areas with potential for restoration of significant winter rearing habitat for salmonids. The others are the Laguna de Santa Rosa, the estuary floodplain, and the Dry Creek Valley, all of which have also been highly hydromodified. Restoration by the Sonoma County Water Agency and the Army Corps is ongoing in the Dry Creek Valley downstream of Lake Sonoma with more restoration actions planned. The Dry Creek restoration plan objective is to establish 100,000 square meters of cold, tail-water summer rearing habitat for potentially up to 170,000 coho parr. Habitat suitability analysis conducted by Inter-Fluve, a river restoration consulting firm, concluded that 30 percent of the restored Dry Creek summer rearing habitat will function as winter rearing habitat (Figure 4.2.23). Thus, a completed Dry Creek habitat restoration strategy for coho salmon could result in a significant segment of the summer rearing population seeking winter rearing habitat in downstream floodplains.

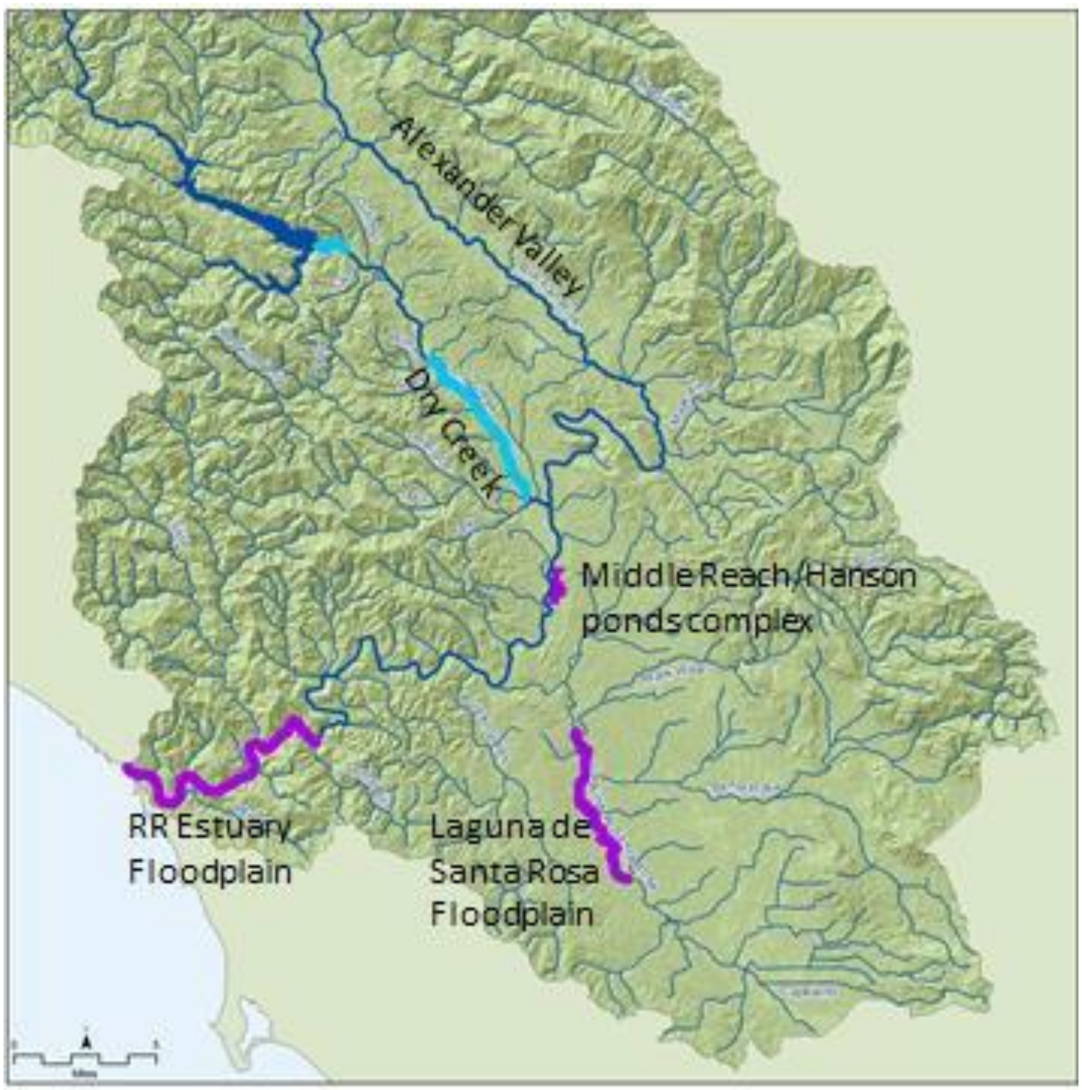


Figure 4.2.23. Potential floodplain restoration areas in the lower Russian River watershed. Areas with potential for significant floodplain rearing habitat restoration highlighted in light blue and purple.

4.2.6 Vegetation types and aquatic habitat restoration potential

4.2.6.1 Russian River watershed vegetation types. The Russian River watershed contains a diversity of plant communities and microclimates ranging from oak woodlands in the foothills surrounding interior valleys to remnant redwood forests on north facing slopes and in the coastal fog belt. However, the quality, extent, and range of vegetation types in the watershed have been impacted over time by the land uses previously described. Figure 4.2.24 denotes vegetation types of the alluvial valleys of the Russian River as cropland (yellow), however the various California floras written by Ornduff, Jepson and Munz describe the original native plant communities of these north coast valleys as mixed evergreen/ deciduous forests of the North Coast BioRegion. This designation is supported by the SFEI Historical Ecology study previously discussed (Appendix B).

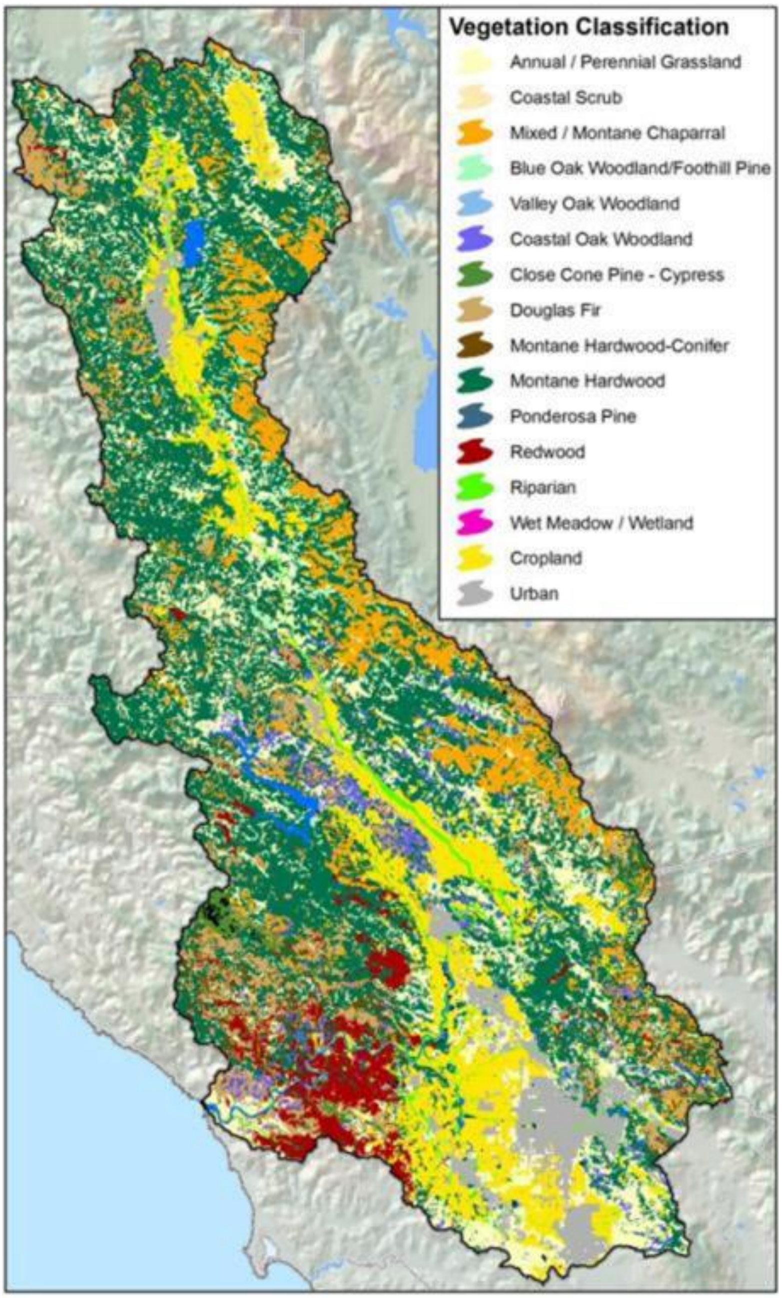


Figure 4.2.24. Plant communities of the Russian River watershed. *Source: North Coast Resource Partnership*

Thirty-plus inches of rain, high groundwater levels and deep alluvial aquifers underlying these valleys also support this historic designation by the published floras of California. Thus the effects of historical land uses include wholesale conversion of native plant communities, *including* the complete loss of redwoods and most other conifers from valley floors and significant loss of natural vegetative aquatic habitat. Invasions of exotic plant species followed hydromodification, altered flood frequency, and suppressed fire regimes. Certain plant species have been locally extirpated in the watershed or are extinct throughout their range (North Coast Resource Partnership). Additional species are considered special-status by California Department of Fish and Wildlife and/or the US Fish and Wildlife Service.

Of particular interest and concern for fisheries restoration are the wholesale loss of floodplain and wetland associated North Coast Forest plant communities including beds of submerged and floating aquatic vegetation (SAV and FAV, respectively), emergent wetlands, and seasonally inundated wet meadows and scrub-shrub forest (woodland wetland) plant communities. Natural analogs of these communities and associated aquatic habitats are now rare or completely eliminated from the Russian River watershed. These plant communities likely once supported quality salmonid habitat with high production of invertebrates, oxygenation of water, and refuge from floods and predation.

The wetland woodlands in the valleys of the Russian River basin likely played an important role in supporting historical salmonid population abundance. Ecological services of riparian communities include canopy shade, leaf litter fall supporting high invertebrate production, flood and predator refuge, LWD and SWD recruitment, and nutrient, fine sediment and carbon sequestration. Live wood in-channel provides far more ecological services than dead wood.

Landforms and riparian vegetation communities are linked and strongly influence each other. The re-establishment of natural landforms, physical processes, and native plant communities is feasible even in highly degraded systems. Foundational to these processes, sod-forming vegetation functions as a key geomorphic agent, accelerating regeneration of surface roughness and vertical accretion through deposition of fines and leaf litter mat building. These characteristics in turn drive invertebrate production. There has been an historical decline of these aquatic habitat forming plant communities in coastal basins of California. Many have been essentially eliminated from our coastal catchment basins.

Due to that decline, little research has been conducted on aquatic vascular plant communities as components of North Coast basins' fisheries habitat. The least studied are the mostly native, SAV and FAV of low velocity or lotic off-channel slough and floodplain features and deep pool margins. Research for contribution of wetland associated plant communities to fisheries habitat productivity is limited to the lower Sacramento River, or the Lower Klamath basin of the Yurok Indian Reservation. Figures 4.2.25 through 4.2.28 are examples of aquatic habitat associated plant communities largely eliminated from the Russian River Basin.

Figure 4.2.25. Emergent wetland plant community of the lower Klamath River Basin. These plant communities are documented to support high densities and growth rates of coho salmon, Chinook salmon, and steelhead, with growth rates and densities of coho salmon up to six times higher than main channel habitats. *Photo by Monica Hiner, Yurok Tribal Fisheries Department.*

Figure 4.2.26. Seasonal wet meadow plant community in the lower Klamath River Basin. Yurok Tribal Fisheries monitoring and documentation shows these plant communities support high densities and rapid growth rates of coho salmon. *Photo by Monica Hiner, Yurok Tribal Fisheries Department.*

Figure 4.2.27. Floating aquatic vegetation plant community of the lower Sacramento River. Predominantly *Potamogeton nodosus*; most common native pondweed. *Photo by Dr. Peter Baye, coastal plant ecologist, Annapolis, California-baye@earthlink.net.*

Figure 4.2.28. Developing woodland wetland plant community along Willow Creek, lower Russian River basin. Restoration of Willow Creek in Sonoma Coast State Park is bringing back this productive plant community. *Photo by Dr. Brian Cluer, NOAA National Marine Fisheries Service.*

4.2.6.2 Vegetation types on the Hanson property. The plant communities at the Hanson property have been significantly altered historically by agriculture, then gravel mining at the site. Figure 4.2.29 illustrates the vegetation types currently found on property. Approximately 149 acres of the site is open water (deep stratified water) with another 80.9 acres of disturbed shrub/grassland dominated by non-native species. Despite the disturbed nature of the site, there are roughly 96 acres of developing riparian forest on the western edge of the property along the river channel.

Riparian forest on the levees and areas between the ponds and river, and on some of the levees between the ponds, is predominated by cottonwood (*Populous fremontii*), California black walnut (*Juglans califonica*), and coyote brush (*Baccharis pilularis*), with dense stands of invasive giant reed (*Arundo donax)* and some *Eucalyptus* spp. Prior reclamation efforts and natural recruitment have created a fringe of native willow species (*Salix* spp.) surrounding all four ponds on the relatively steep levee slopes just above the water surface elevation. Reclamation efforts around two of the four ponds have resulted in the higher elevations of the pond levees to be revegetated with coyote brush (*Baccharis pilularis*) and young oaks (Q*uercus* spp.). Invasive Himalayan blackberry (*Rubus armeniacus* and/or *Rubus discolor*) generally separates the tops of the pond levees from the adjacent vineyards to the south and east. The Richardson pond, as the most frequently inundated of the four ponds, includes a fringe of invasive floating aquatic vegetation, *Ludwigia* spp.

Figure 4.2.29. **Existing vegetation types of the Hanson property.** In spite of mining on the site, the Hanson property has roughly 96 acres of developing to mature riparian forest.

4.3 Field investigation results

4.3.1 Topographic mapping

The feasibility study required a current topographic model of the Middle Reach Valley covering the of the Middle Reach Valley floodplain, the Russian River channel, and the Hanson ponds as detailed in Chapter 3. A combination of technologies was used to obtain current topography in a common geographic data framework. LiDAR was used for surface mapping, bathymetry was used for mapping the river and ponds, and GPS RTK was used for setting common survey controls and mapping shoreline topography. These data combined resulted in a high quality digital terrain model covering the Middle Reach Valley from Highway 101 in the north to Wohler Bridge at the southern end, and from East Side Road to West Side Road (Figure 4.3.1).

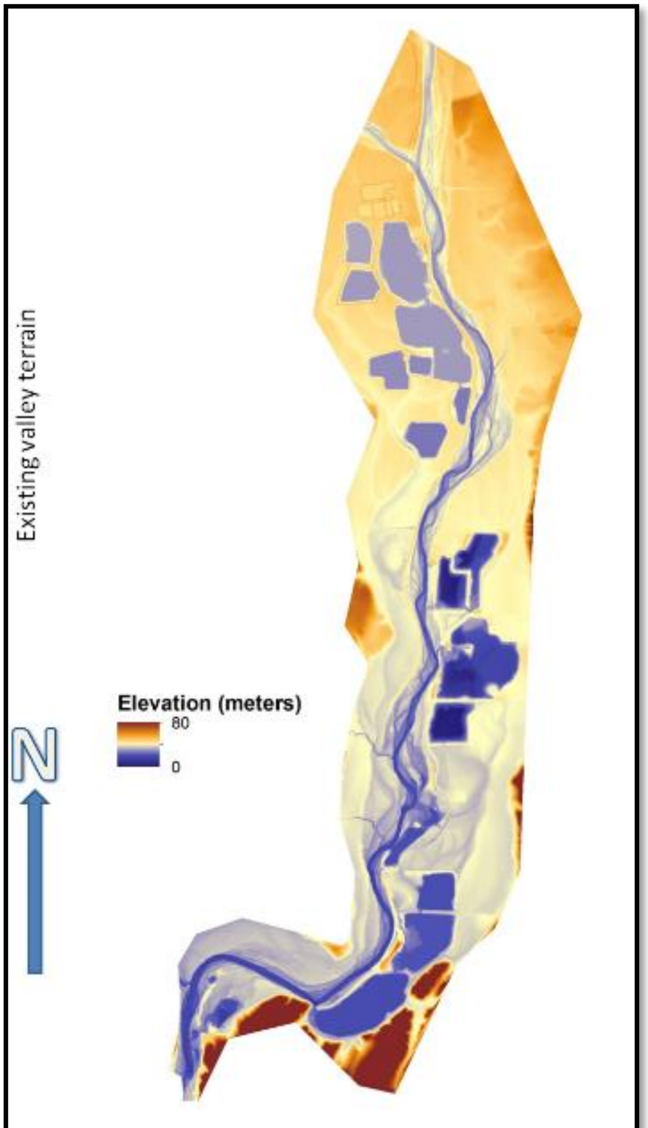


Figure 4.3.1. Middle Reach Valley Digital Terrain Model. The figure includes the entire study reach floodplain area, merged from LiDAR, and bathymetry of the river and ponds. The only features on this map with unconstrained elevations are the County RIverfront Park ponds at the southern end. Note, the colors represent elevations derived from topographic and bathymetric surveys, not depths of aquatic features. Thus, the Riverfront Park pond elevations depicted are of the LiDAR-derived water surface elevations.

4.3.1.1 Bathymetry and dimensions of the Hanson ponds. The Hanson property encompasses four ponds - Mariani, Piombo, Richardson and Vimark - ranging in size from approximately 20 to 84 acres (Table 4.3.1). Affiliated Researchers, Inc., determined that the average pond depths range from 13.4' (Mariani), to 21.2' (Piombo), with a maximum water depth of 42.7' in the Vimark Pond.

Table 4.3.1. Existing dimensions of the Hanson ponds.

Summary of data collected at the four ponds (NAVD88 Geoid 12)						
Pond	Surface Elevation	Measured Volume	Average Depth	Maximum Depth	Lowest Bottom Elevation	Measured Area
Mariana	44.56'	29,427 yds^3	13.4'	38.2'	6.34'	19.6 Acres
Piombo	45.09'	21,106 yds^3	21.2'	35.3'	9.36'	19.8 Acres
Richardson	51.83'	142,414 yds^3	17.3'	37.1'	14.67'	83.8 Acres
Vimark	42.55'	28,320 yds^3	17.8'	42.7'	-0.15'	25.1 Acres

Figures 4.3.1 through 4.3.4 illustrate the current elevation contours of the bottom of the four Hanson ponds as mapped by Affiliated Researchers with RTK-GPS coupled with single or dual beam echo sounders.

Figure 4.3.2. Topographic map of the Hanson Piombo pond showing bottom elevations in feet (NAVD88).

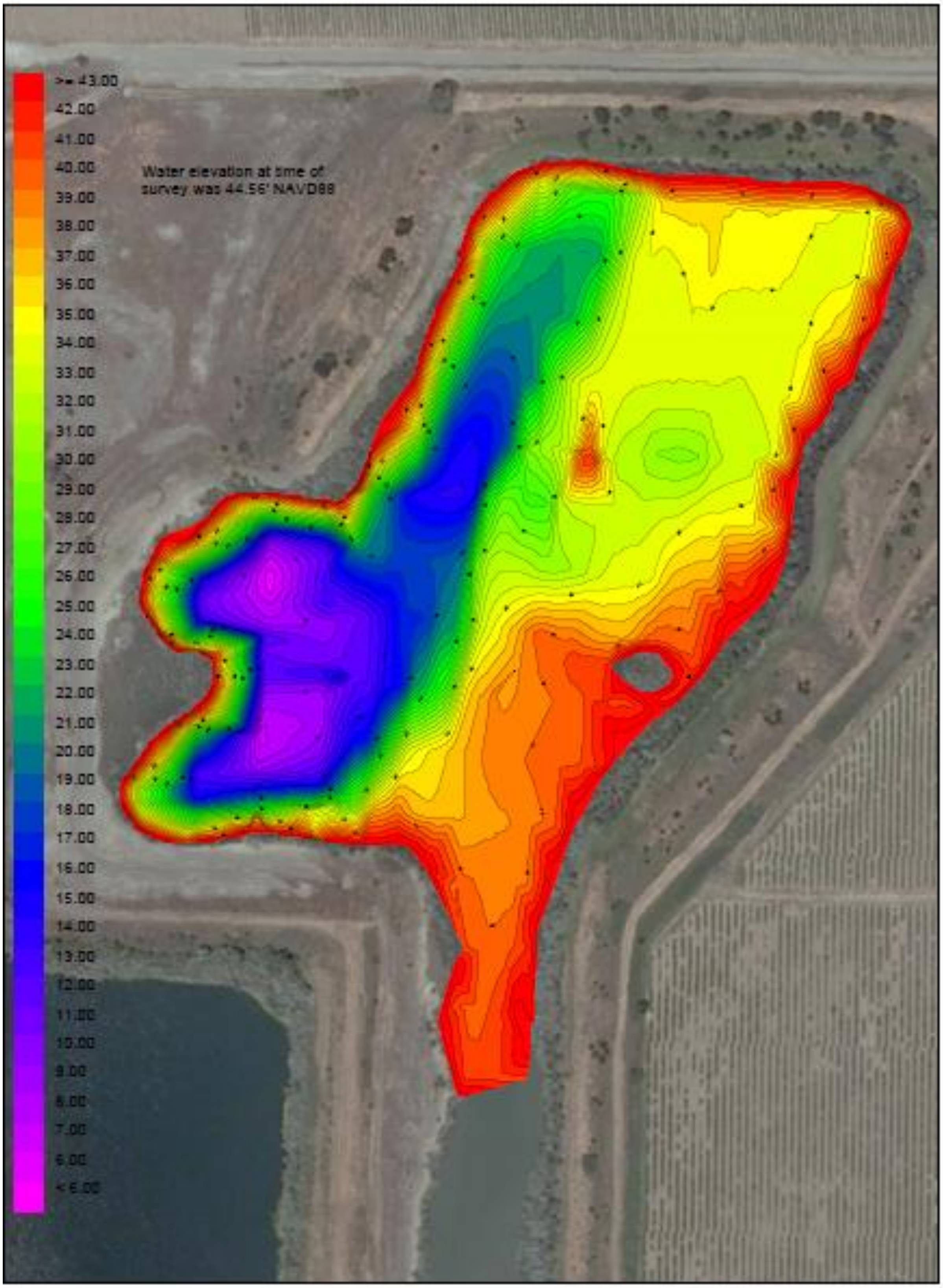


Figure 4.3.3. Topographic map of the Hanson Mariani pond showing bottom elevations in feet (NAVD88).

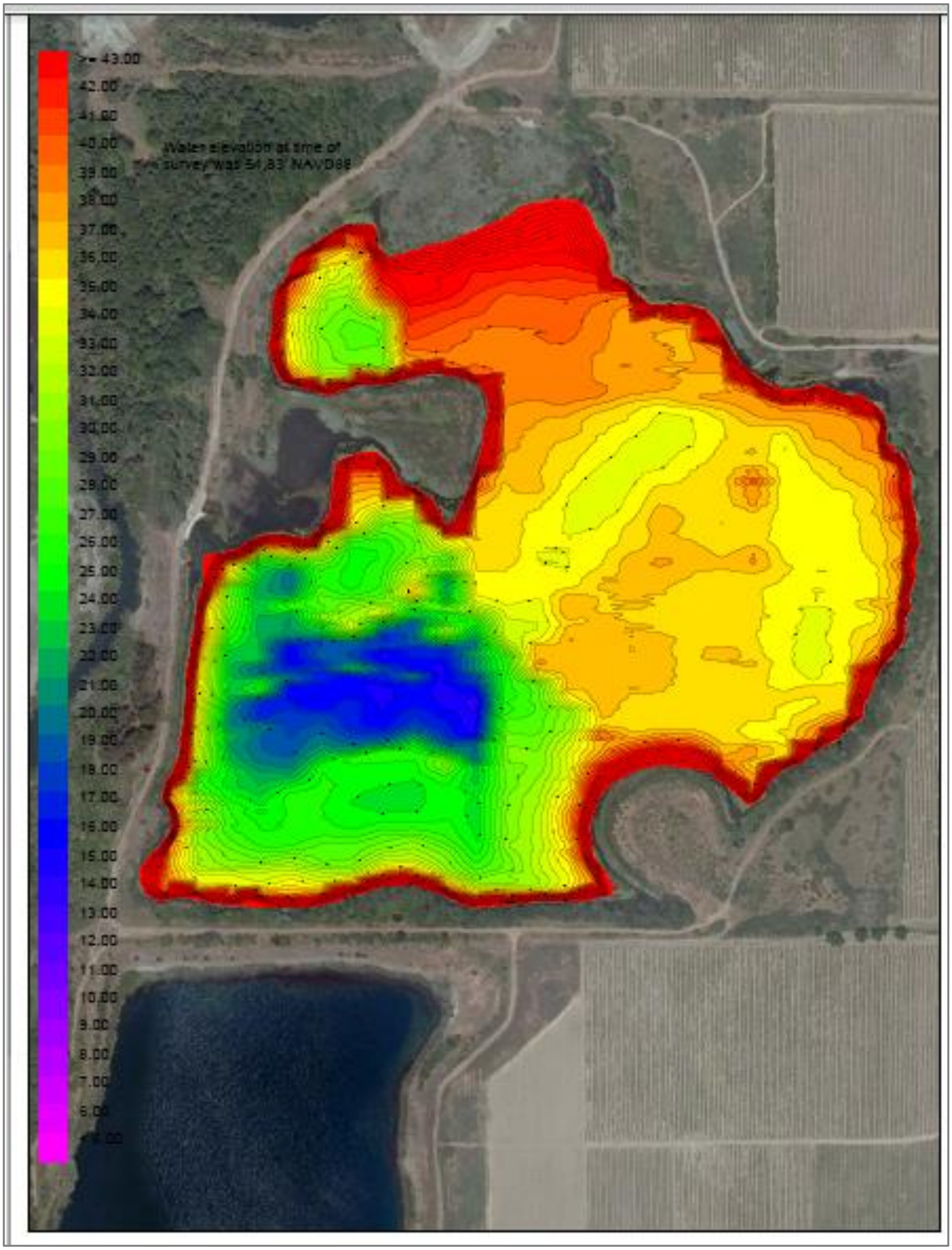


Figure 4.3.4. Topographic map of the Hanson Richardson pond showing bottom elevations in feet (NAVD88).

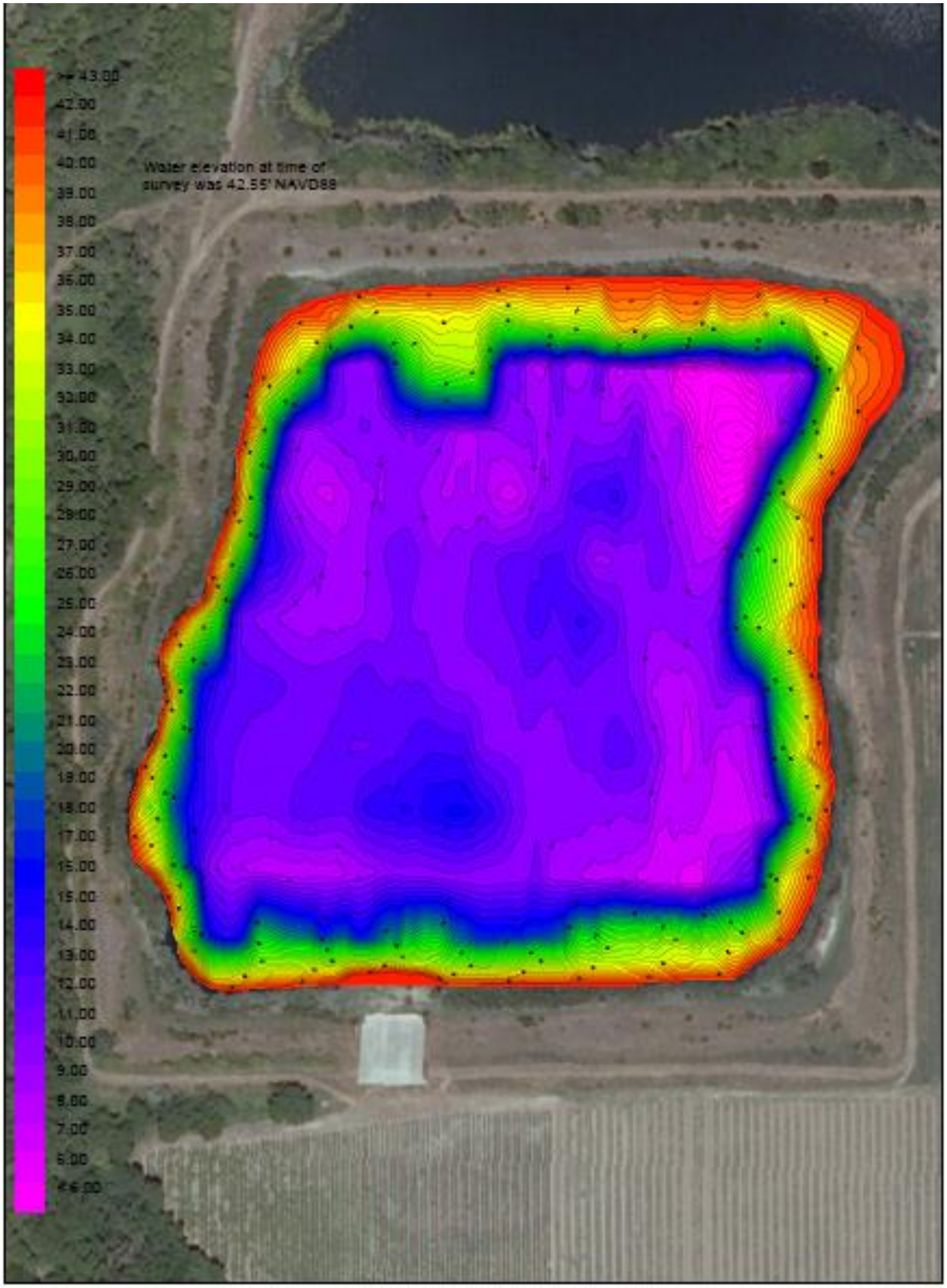


Figure 4.3.5. Topographic map of the Hanson Vimark pond showing bottom elevations in feet (NAVD88).

4.3.1.2 Syar ponds bathymetry. Bathymetry provided by Syar Industries of the ponds upstream and across the river from the Hanson site indicate the Syar ponds have a significantly greater maximum and average depth (Figure 4.3.5). Currently Syar maintains the separation levees above a 20 year storm event, and repairs the levees after failures (as after the 1997 levee breaching event.) Thus the USGS modeling exercises used the water surface elevation of the ponds in the mesh grid of floodplain elevations. Future changes to Syar ponds configuration, such as incorporating backflow and flow through at higher flood elevation will further decrease flood elevations, velocities, and sheer stress applied to river banks of the Middle Reach.

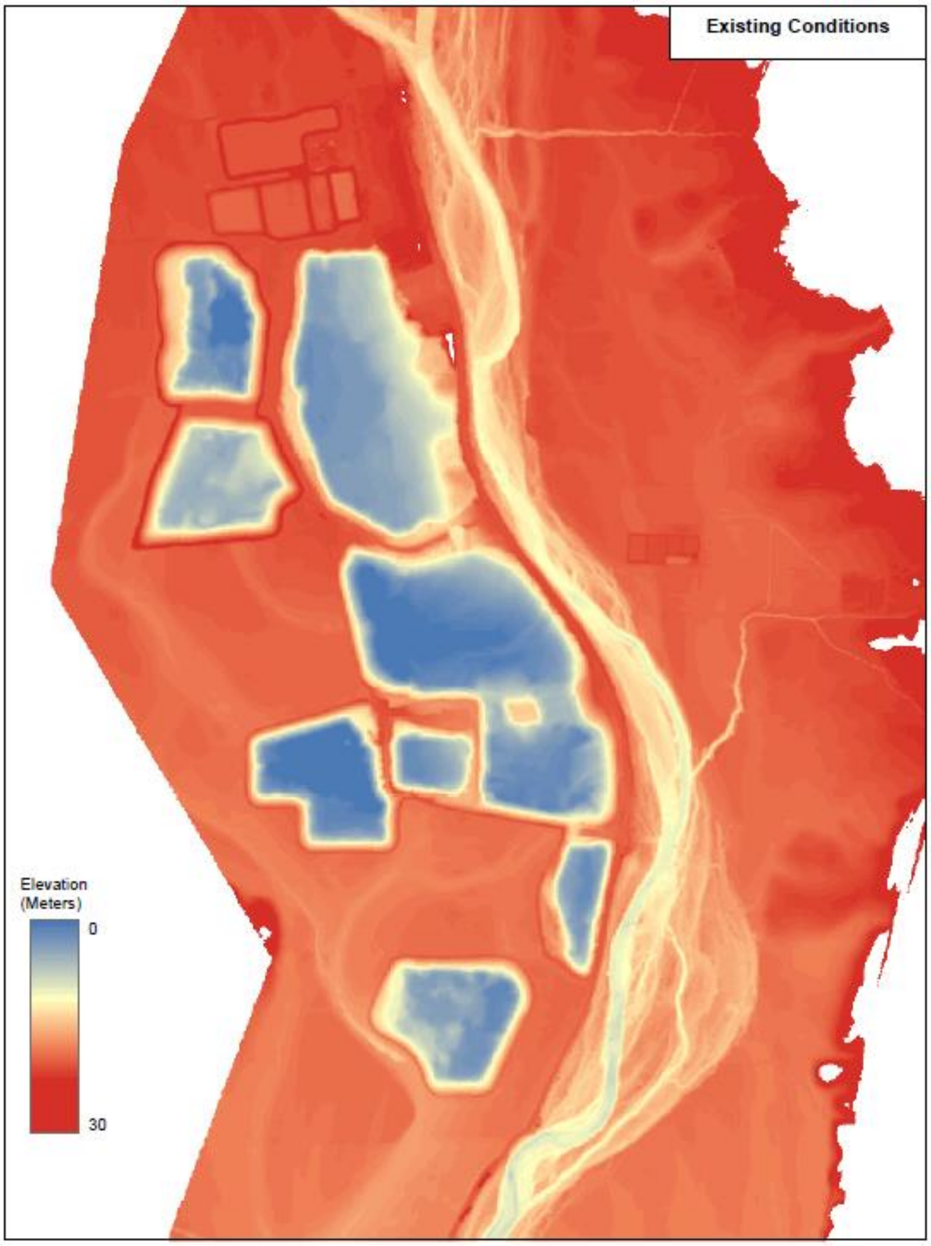


Figure 4.3.6. Topographic map of the Syar ponds showing bottom elevations in meters (NAVD88).

4.3.1.3 River channel bathymetry. Single beam echo-sounding, coupled with RTK-GPS, was operated in two episodes over a total of seven days, provided data coverage of the study reach sufficient to calibrate the hydraulic model (see Appendix G). Figure 4.3.6 is an example of river bathymetry traces by NMFS's River Cat bathymetry surveys. An example of a short stretch of Russian River channel bathymetry integrated with LiDAR developed topography for a model mesh of the entire study reach area is depicted in Figure 4.3.7. Each cell of the mesh has attributes of elevation, roughness elements of grain size, bed forms, vegetation and other larger scale roughness elements.

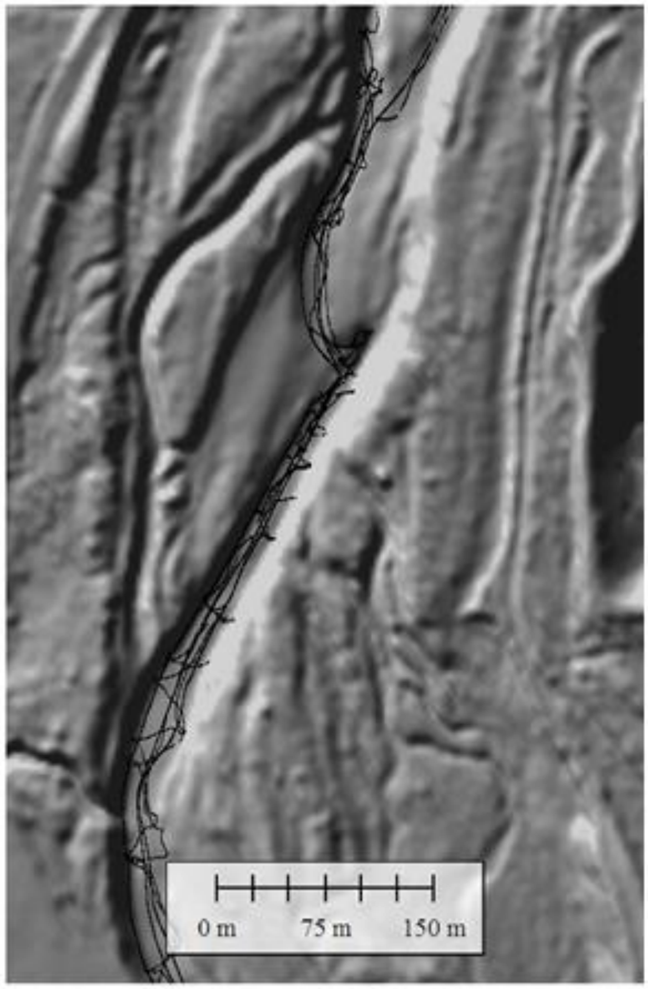


Figure 4.3.7. Bathymetry traces for a short example reach of the river channel in the vicinity of the Richardson pond.

Figure 4.3.8. Example of short section of the river channel bathymetry integrated into grid mesh of LiDAR derived topography of the Middle Reach floodplain.

4.3.1.4 LiDAR of the Middle Reach Valley. Aerial topographic mapping of the Middle Reach Valley using equipment and techniques typical of FEMA floodplain mapping standards was conducted in December 2013 (Figure 4.3.9). Results from the LiDAR survey, processed to remove influences of vegetation, were merged with the results from bathymetric mapping in the Hanson ponds and the Russian River to produce a single digital terrain model of the entire study reach area of the Middle Reach floodplain (Figure 4.3.1).

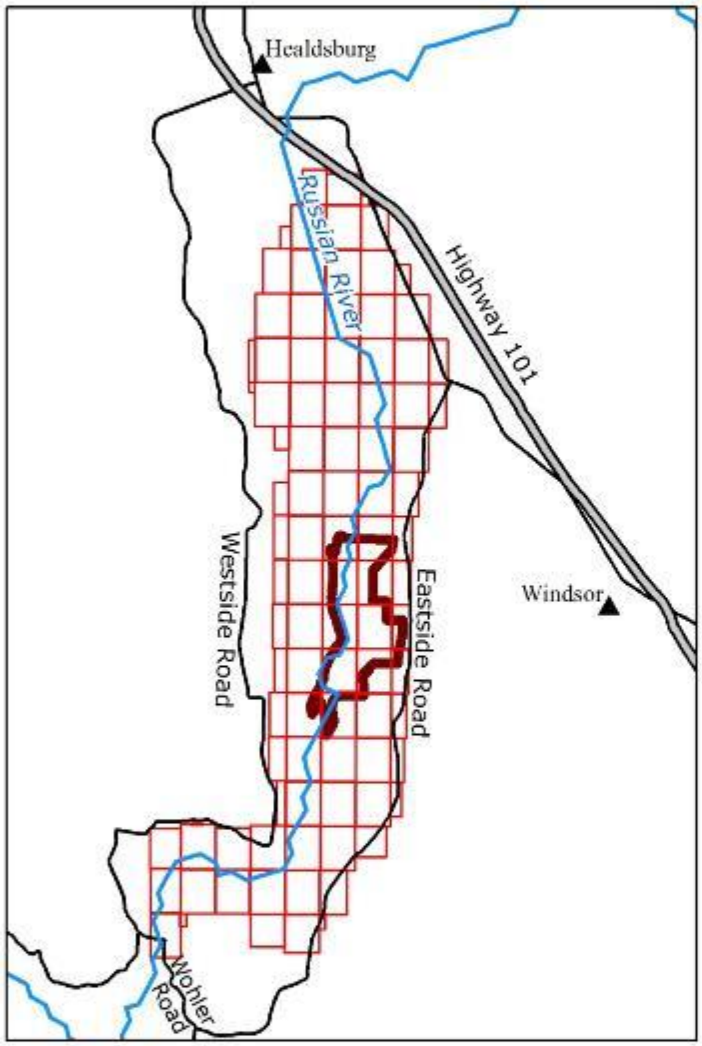


Figure 4.3.9. LiDAR coverage of the Middle Valley with the project area outlined in bold red.

4.3.2 Sediment and water quality characterization

4.3.2.1 Particle size distributions. Sediment sampled in three areas characterizes the materials sizes in the river bars, former floodplain, and bottom layers of the Hanson ponds. The standard Wentworth scale (Figure 4.3.10) is used for reference to particle sizes by their common name and by average diameter.

Name				Size range (mm)	Size range (approx. in)
Very coarse soil		Large boulder	LBo	>630	>24.8031
		Boulder	Bo	200–630	7.8740–24.803
		Cobble	Co	63–200	2.4803–7.8740
Coarse soil	Gravel	Coarse gravel	CGr	20–63	0.78740–2.4803
		Medium gravel	MGr	6.3–20	0.24803–0.78740
		Fine gravel	FGr	2.0–6.3	0.078740–0.24803
	Sand	Coarse sand	CSa	0.63–2.0	0.024803–0.078740
		Medium sand	MSa	0.2–0.63	0.0078740–0.024803
		Fine sand	FSa	0.063–0.2	0.0024803–0.0078740
Fine soil	Silt	Coarse silt	CSi	0.02–0.063	0.00078740–0.0024803
		Medium silt	MSi	0.0063–0.02	0.00024803–0.00078740
		Fine silt	FSi	0.002–0.0063	0.000078740–0.00024803
	Clay		Cl	≤0.002	≤0.000078740

Figure 4.3.10. Wentworth particle size scale. This scale was used to characterize particle sizes. (Wentworth 1922).

4.3.2.2 Terrestrial sediment around the Hanson ponds. On August 1, 2 and 3, 2012, the operator of a small excavator was directed by NMFS staff to dig 15 soil profile trenches and 30 test pits at locations around the Hanson Ponds (Figure 4.3.11). Laboratory results of the grain-size distribution analysis of each sample, or aggregated samples, are presented in Table 4.3.1.

The sediment samples from the uplands around the Hanson ponds are indicative of highly disturbed industrial gravel ponds, roads, levees, and processing areas. Little of the original alluvial stratigraphy remains. Few of the terrestrial samples analyzed were composed of non-porous silt and clay, most were porous sand and gravel. Thus the material onsite and available for filling the ponds will allow for meeting the project's aquifer restoration goal.

Figure 4.3.11. Terrestrial sediment sampling locations around the Hanson ponds. Trench and test pits locations for soil samples were taken from the 45 locations shown below for characterization of the Hanson site levees and upland soils to characterize grain size distribution and stratigraphy. Sampling locations and sample identifiers are referenced in Table 4.3.1.

Table 4.3.2. Terrestrial material sample properties. Cohesive and low porosity materials are indicated in red text. Sample locations are mapped in Figure 4.3.11.

Sample Name	Depth (ft)	d80 (mm)	d50 (mm)	d20 (mm)	Classification
A	0-8	na	na	na	Fine Gravel
B	0-6	na	na	na	Silt-Clay
C	0-11	na	na	na	Fine Sand
D1	0-8	na	na	na	Silt-Clay
E5	6-9	3.00	0.55	0.28	Medium Sand
F1	0-3.5	na	na	na	Fine Gravel
F2(a)	0-3.5	na	na	na	Fine Sand
F2(b)	3.5-7	na	na	na	Silt-Clay
G1(a)	0-3	3.60	0.32	na	Medium Sand
G1(b)	3-9	0.34	0.21	na	Medium Sand
G2	0-7	15.00	5.00	0.65	Fine Gravel
H1	0-7	0.46	0.30	na	Medium Sand
H2(a)	0-5	1.40	0.51	0.35	Medium Sand
H2(b)	5-9	6.00	0.50	0.31	Medium Sand
H3	0-6	12.00	3.75	1.10	Fine Gravel
I1	0-7	20.20	9.00	2.10	Medium Gravel
I2	0-7	20.20	7.00	1.75	Medium Gravel
I3	na	17.00	4.30	0.72	Fine Gravel
J1	0-9	na	na	na	Sandy-Clay
J2(a)	0-7	na	na	na	Sandy-Clay
J2(b)	7-9	8.90	0.59	0.36	Medium Sand
J3	na	10.05	3.50	0.89	Fine Gravel
K1	0-9	na	na	na	Coarse Gravel
K2	na	10.00	2.97	0.68	Fine Gravel
K3(c)	na	18.20	7.00	2.00	Medium Gravel
L1(a)	0-1	3.63	1.58	0.63	Coarse Sand
L1(c)	2-9	0.65	0.49	0.35	Medium Sand
L2(a)	0-2	6.95	0.95	0.44	Coarse Sand
L2(b)	2-8	6.10	1.10	0.45	Coarse Sand
L3	0-9	na	na	na	Fine Sand
M1	0-2	9.60	2.85	0.87	Fine Gravel
N1(a)	0-1	2.13	0.81	0.28	Medium Sand
N1(b)	na	4.50	0.59	0.29	Medium Sand
N2(a)	0-1	10.00	3.10	0.51	Fine Gravel
N2(b)	1-10	1.10	0.45	0.18	Medium Sand
N3	0-9	na	na	na	Coarse Sand
N4	0-9	na	na	na	Fine Gravel

4.3.2.3 Hanson pond sediment core analysis. Chapter 3 describes the methodology used by Affiliated Researchers and EEI to collect 25 sediment cores for texture analysis. Sample locations are illustrated in Figure 4.3.12. Cores were vibrated to refusal, or to the maximum depth of 96". Depth at refusal is interpreted as the depth through the accumulated sediments to a hard layer of clay or coarse sediment. Depths ranged in length between 96" and 21".

NMFS staff characterized particle grain-size, depth of accumulated sediment, and stratigraphy of organic and inorganic layers of the 25 pond sediment core samples taken. Results are presented in Table 4.3.2. The majority of core samples were predominated by clay and silty-clay layers with thin (1-3mm thick) layers of fine sand demarking each layer, and thin black layers of organic matter interspersed .

The stratigraphy of the sediment cores clearly reflects annual inundation of the ponds with highly turbid water during storm events containing high concentrations of suspended fine sand, silt and clay particles (Figure 4.3.13). The slow precipitation of the clay particles from turbid water trapped in the ponds after each storm formed the clay layers of the cores. The thin fine sand layers between clay layers likely reflect the initial flows into the ponds on each storm event when turbulence maintains fine sand in suspension. In the case of the Richardson pond cores the sand layers likely also represent annual influxes of gravel processing residues which were discharged into the pond. The interspersed thin black layers noted in Table 4.3.1 reflect annual summer deposition of organic material from die-off of the cyclic algal blooms fueled throughout the summer by the cycling of phosphorous under the redox conditions of the stratified anaerobic depths of the ponds, as discussed above in the Section 4.2.4.2 Summary of Biogeochemistry.

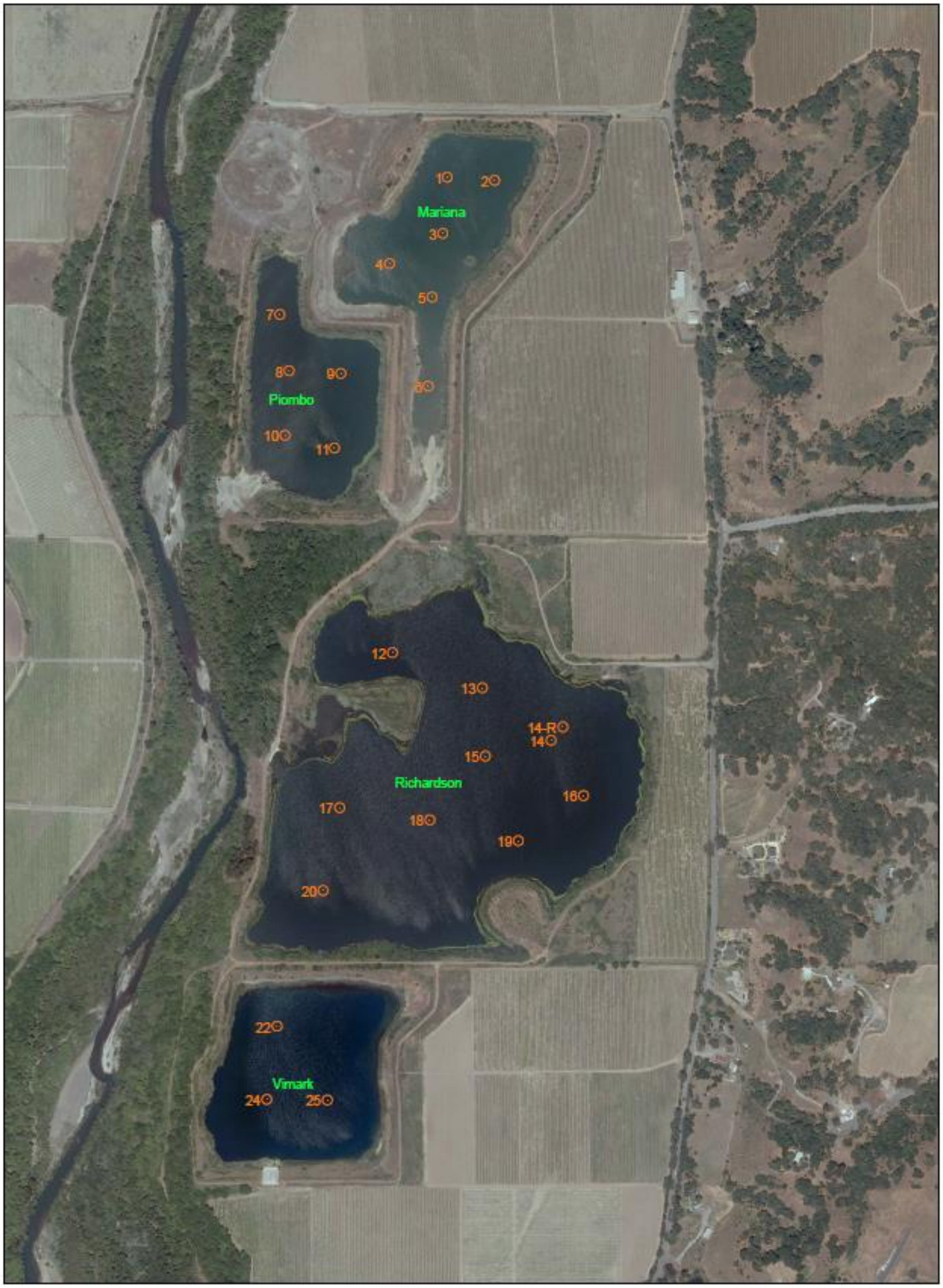


Figure 4.3.12. Hanson pond core sampling locations for both sediment texture and geochemical analyses.

Table 4.3.3. Texture of Hanson pond sediment core samples. Sample locations shown in Figure 4.3.12.

Sample Number	Pond Name	Length/Depth in inches	Textural Description, from bottom to top, in inches
1	Mariani	60	0-8 dark grey clay, 8-15 fine tan sand, 16-29 tan clay, 30-36 grey clay, 37-60 tan to gray clay
2		64	0-7 clean tan sand, 7-10 tan clay, 10-12 sandy tan clay, 12-16 sandy grey clay, 16-17 tan clay, 17-19 clean tan sand, 19-21 tan clay, 21-28 gray clay, 28-35 gray sandy gravel, 35-48 sandy tan clay, 48-64 gray clay
3		48	0-8 clean tan sand, 8-9 tan clay, 9-16 tan to gray clay in many layers, 16-48 indistinct gray clay
4		45	0-13 tan sand, 13-16 layers of tan clay, 16-21 layers of gray clay, 21-30 thick layers of gray clay, 30-45 massive gray clay
5		21	0-5 tan sandy gravel -24mm particle, 5-10 tan to gray layers of clay, 10-21 massive gray clay
6		41	0-14 gray clay, 14-41 gray sandy clay
7	Piombo	93	0-12 tan clay, 12-20 tan to gray clay layers, 20-30 gray clay, 30-31 fine gray sand, 31-93 gray clay and a few dark layers
8		84	0-14 tan sand, 14-19 gray sand, 19-31 tan clay in thin layers, 31-33 gray clay, 33-37 gray sand, 37-84 gray clay
9		53	0-6 gray clay, 6-6.05 tan sand, 6.05-9 gray clay, 9-9.05 light gray clay, 9.05-13 gray clay, 13-16 gray sand, 16-23 gray clay, 23-53 ten layers of gray clay with ten thin black layers
10		90	0-6 tan clay, 6-8 gray clay, 8-20 multiple thin layers of tan to gray clay, 26-30 gray sand, 30-41 gray clay, 41-43 gray sand, 43-90 thin gray clay in layers
11		60	0-8 gray sand, 8-15 gray clay, 15-17 gray sand, 17-21 gray clay, 21-23 gray sand, 23-62 thin gray clay layers
12	Richardson	90	0-5 gray clay, 5-90 tan clay layers 2-4mm thick
13		57	0-20 gray sand and gravel - 24mm particle, 20-31 gray sand, 31-57 soft tan clay
14 R		57	0-17 gray clay, 17-20 gray sand, 20-57 soft gray clay
15		60	0-12 gray clay, 12-15 gray sand, 15-40 gray clay, 40-60 layered tan clay
16		46	0-9 gray clay, 9-26 silty gray gravel, 26-46 soft gray clay
17		46	0-5 gray clay, 5-8 gray sand, 8-21 gray clay, 21-23 gray sand, 23-46 soft gray clay
18		46	0-4 gray sand, 4-46 gray clay in 4" layers with 1" fine sand layers
19		28	0-4 gray sand, 8-46 gray clay
20		46	0-8 gray sand, 8-48 gray clay
22	Vimark	40	0-14 tan sand and gravel, 14-40 soft tan and gray clay in layers 1-3mm thick
24		96	0-96 tan clay in layers 1-3mm thick
25		36	tan sand, 8-36 tan clay in layers 1-3mm thick

Figure 4.3.13. Inundation of the Hanson Richardson pond. The Richardson pond filling with highly turbid silt and clay laden water through a low connection with the Russian River. The low connection is created by the reinforcement access road that acts as a weir and is activated between 3,000 and 4,000 cfs flow in the Russian River, resulting in multiple inundations of the ponds in almost all water years.

4.3.2.4 Riverbed and gravel bars sediment characterization. Locations of nine river bar bulk sediment samples collected are illustrated in Figure 4.3.14. The particle grain sizes of the samples cluster in a relatively tight size range; the median particle diameters range from 4 mm to about 20 mm, all classified as gravel material in the Wentworth scale (Figure 4.3.10). There is likely as much particle size variation across individual bar deposits as there is between bars. Within the Middle Reach channel it is difficult to find sediment patches coarser than those sampled on the bars, although riffles likely have larger materials. However, underestimating the fraction of coarsest materials only tends to make the sediment transport model more responsive than the river may actually be. These river bar sediment sizes were used as inputs to the USGS sediment transport model (Appendix G), and the model was tested for sediment size sensitivity by conducting some runs using the finest measured sediment size to stimulate the greatest model response (see Chapter 8 and Appendix G).

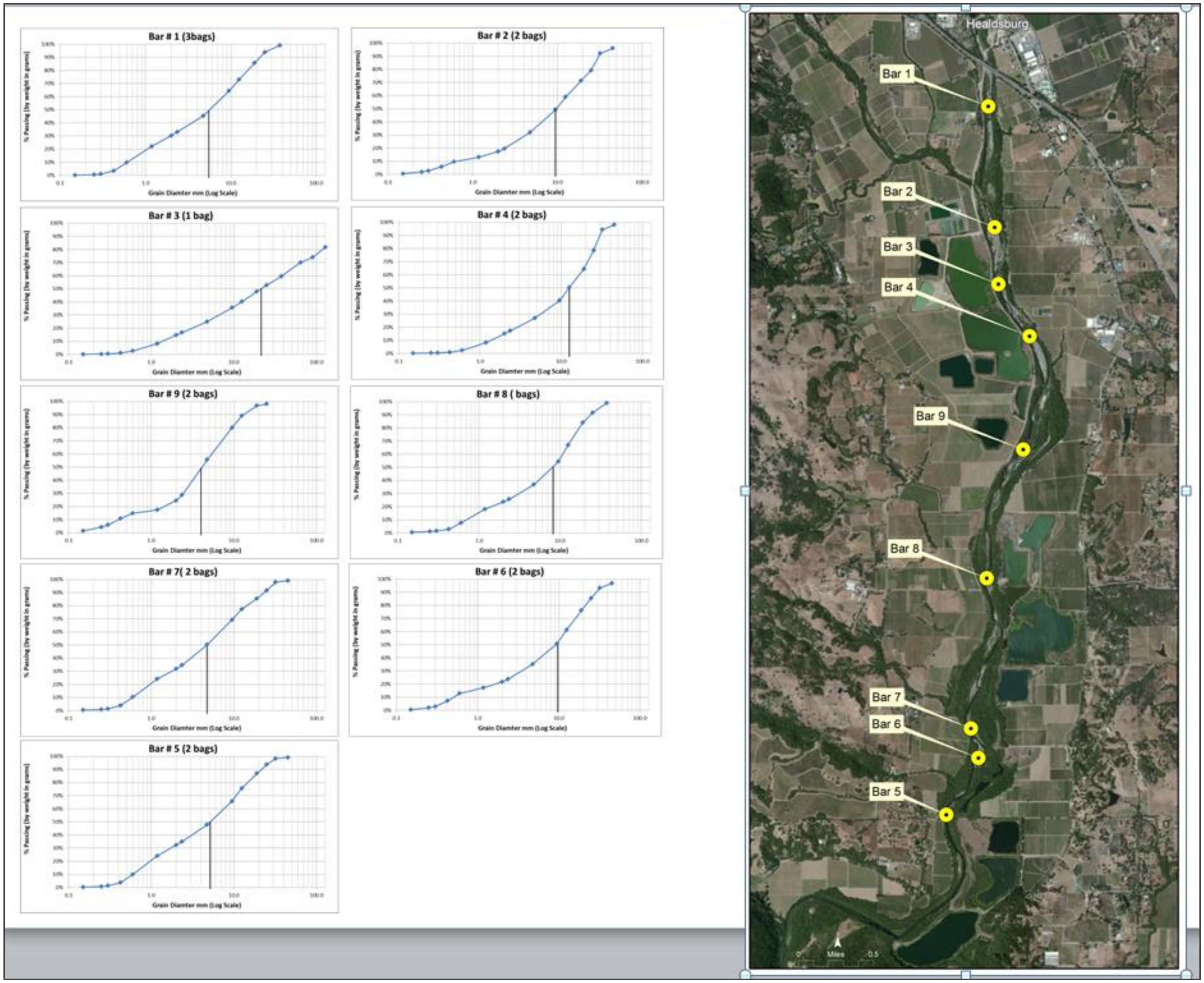


Figure 4.3.14. Map of river deposit sampling sites and graphs of the grain size analysis results.

4.3.2.5 Sediment characteristics summary. The Hanson pond floors are mostly tight to non-porous silt and clay layers interspersed with thin fine sand layers. In a few places the clay is thin as indicated by short core lengths, and at sample #14 in the Richardson pond, the sample came up entirely composed of sandy gravel and was not retained. Vimark pond was the only instance where accumulated sediment depth was greater than the 96-inch maximum depth of the sediment coring equipment.

The stratigraphy of the sediment cores from the ponds clearly reflect multiple annual inundation of the ponds by the river during storm events containing high concentrations of suspended fine silt and clay. The slow precipitation of the silt and clay particles after each storm formed the silt/clay layers of the cores. Cyclic algal blooms are fueled throughout the summer by the cycling of phosphorous under the redox conditions of the stratified anaerobic depths of the ponds, likely causing high dissolved organic carbon concentrations (as discussed previously in Section 4.2.4.2 Summary of Biogeochemistry).

Analysis of sediment sampling of the uplands of the Hanson site around the ponds documented the highly disturbed industrial site retains little of the original alluvial stratigraphy, and is predominantly porous sand and gravel. Few terrestrial sample locations of the uplands are non-porous silt and clay. Thus, the available terrestrial material of the uplands surrounding the ponds available for re-contouring the landscape and filling the ponds is suitable for alluvial aquifer restoration.

Analysis of the Middle Reach gravel bar samples, with the tight cluster of grain sizes, and uniform sizes throughout the reach indicates little sorting of materials occurs when bed mobilization occurs.

4.3.2.6 Laboratory analyses results of sediment and water sampling of the Russian River and Phase I and II Environmental Site Assessments. Soil, sediment, and water sampling was conducted for both the Hanson Ponds and the Russian River from Alexander Valley to the Wohler Bridge aas described in detail in Chapter 3. Working in collaboration with the North Coast Regional Water Quality Control Board, a suite of laboratory analyses was performed for the following constituents and contaminants of concern for either sediment or water quality samples:

- CAM metals
- Total mercury
- Organochlorine pesticides and PCBs
- Organophosphorus pesticides
- Total extractable petroleum hydrocarbons (TPHs)
- Polycyclic aromatic hydrocarbons (PAHs)
- Volatile organic carbons (VOCs)
- Nutrients (TN and TP)
- Chlorophyll-*a*
- Methyl-mercury (MeHg)

A summary of the results and conclusions of sample analyses are described below:

1. Detectable concentrations of methyl-mercury (MeHg) were reported in all Hanson ponds water samples analyzed with concentrations ranging from 0.0002 µg/l to 0.0153 ug/l. MeHg was detected in water at the sediment/water interface of the Piombo and Mariani ponds above residential environmental screening levels (ESL) of 0.003 µg/l.
2. In the Vimark Pond, arsenic was detected in the water at residential ESL of 36 µg/L, and above

the surface water ESL for freshwater habitat of 0.14 μg/l.

3. In the Piombo pond, nickel concentrations were above residential ESL but below the surface water ESL value for freshwater habitats.
4. Elevated phosophorus levels of 12-230 μg/L were detected in the water column of all but Vimark pond.
5. The suite of metals detected in each pond was consistent with those found in the Russian River and is indicative of natural source background minerals carried hydrologically and bound to suspended fine clay sediments.
6. The highest total Hg level in river sediments was found in the Russian River at the Jimtown Bridge in the Alexander Valley, 18 river miles above the Hanson site (the most upriver site sampled).
7. Total Hg concentrations in all the pits were consistent with previous Hg monitoring results found throughout the basin. The Russian River is the source of metal constituents, and the current site configuration of annually flooded ponds, is the cause of accumulation in sediments.

Organochlorine pesticides and PCBs were not detected in Russian River benthic sediment or bank soils. However, these constituents of concern were detected above laboratory reporting limits in the Hanson ponds. Concentrations of TPH as diesel fuel were detected in benthic sediments at all sampling sites, which is evidence of chemicals used for mining and farming in the watershed.

A consistent suite of heavy metals was detected in both the benthic pond sediment and river channel benthic and bank soil samples (arsenic, barium, chromium, cobalt, copper, lead, mercury, nickel, vanadium and zinc). Given the consistency of the constituents and concentrations reported from the river and Hanson Pond samples, it is likely that these concentrations represent the naturally occurring background concentrations of heavy metal for sediments in the watershed.

Concentrations of mercury in the benthic sediment samples from the river range from 0.25 to 1.13 mg/kg, with the highest level found at the Alexander Valley bridge sampling site. This high concentration is most likely due to upstream influence from Lake Mendocino and the chosen sampling location (highly depositional pool area in a backwater eddy sampled on the left bank of the Russian River directly beneath the bridge). It is important to note that one discrete grab sample is not representative of the entire reach. The benthic sediment mercury concentrations were similar to the bank soil concentrations which range from 0.38 to 0.69 mg/kg, and were within the range of values reported from the Hanson ponds sediments (0.11 to 0.55 mg/kg). The values reported are also similar to soil mercury concentrations of 0.17 to 0.56 mg/kg reported by Syar Industries at their ponds upstream from the Hanson ponds. Furthermore, values reported for the bank soils adjacent to Syar ponds, the Hanson Richardson pond, and the Wohler Bridge sites are similar to values reported for Lake Sonoma located in Dry Creek Valley upstream from the Hanson ponds.

Nanogram methyl-mercury levels found in all Russian River water samples (0.0792 ng/l to 0.0943 ng/l) are lower than the microgram levels observed in the Hanson ponds (0.0002 μg/l to 0.0153 μg/l). These differences in concentration in the ponds compared to Russian River are to be expected because the major sites for methyl-mercury production are associated with lake and coastal marine sediments, and wetlands. The higher methyl-mercury concentrations observed in the Hanson ponds compared to the Russian River are primarily due to impoundment conditions within the ponds which contribute to high rates of organic matter and fine clay particle (carrying Hg and P) accumulation, redox conditions (suboxic to anoxic in sediments), temperature and oxygen stratification in the ponds (i.e., low oxygen at greater depths), and higher temperatures during the sampling period (August) stimulate increased microbial activity. These factors create conditions necessary to drive methyl-mercury production. This preliminary data provides evidence that elevated levels of mercury and methyl-mercury are highly variable throughout the Russian River watershed.

4.3.2.7 Summary and discussion of Hanson ponds water quality and clarity measurements.

As described in Chapter 3, NMFS developed temperature and dissolved oxygen (DO) profiles for each of the four Hanson ponds to evaluate existing physical and biogeochemical processes occurring in the summer water column. A minimum of eight GPS-located water quality (WQ) profiles were developed for each pond. The depth to thermocline, and temperature and dissolved oxygen profiles varied spatially within the ponds and between the ponds, likely indicating significant differences in groundwater inflow rates. However, consistent thermal stratification and steep declines of both temperature and dissolved oxygen below the thermocline with increasing depth was evident in the profiles of three of the ponds. A noted exception to this consistent pattern was documented in the Vimark pond. Figure 4.3.15 gives examples of the consistent pattern, and the noted difference in the depth of the thermocline in the Vimark pond. Graphs of all the profiles for each pond are contained in Appendix H.

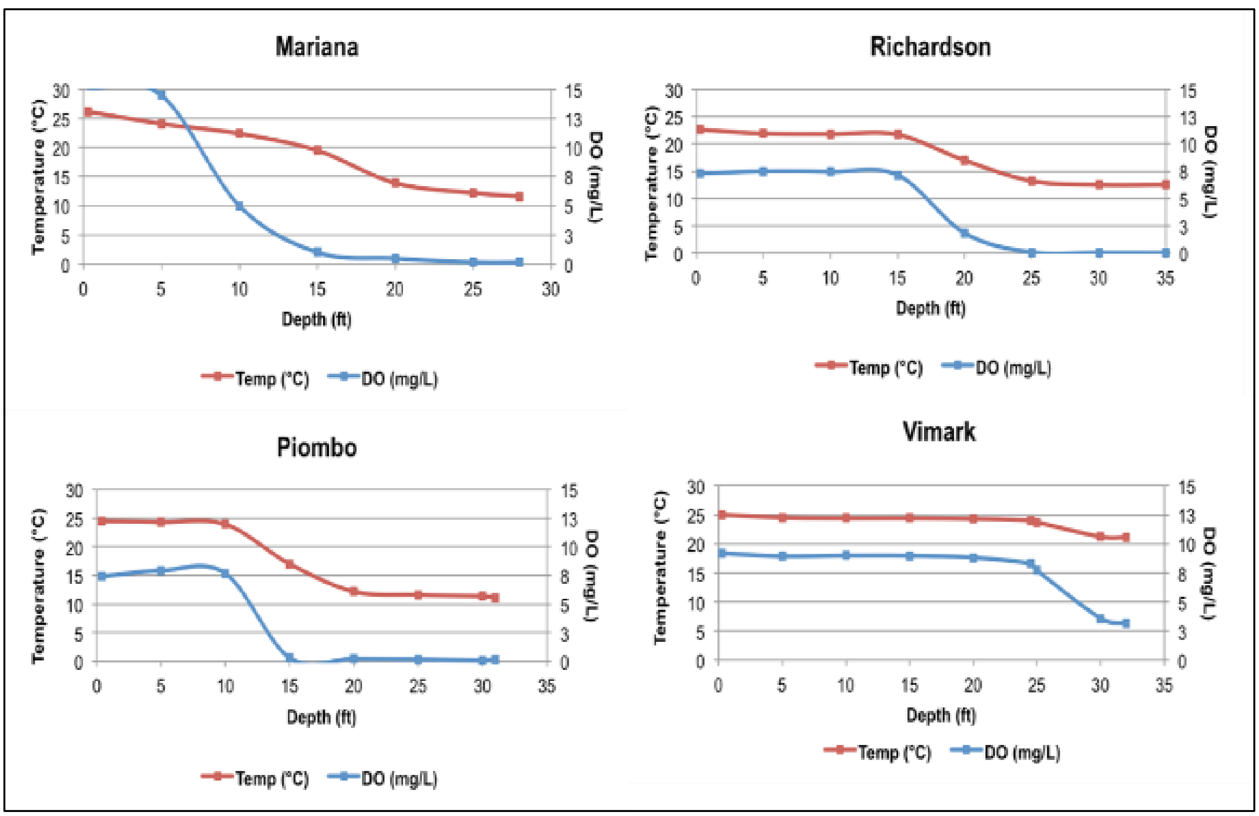


Figure 4.3.15. Temperature and dissolved oxygen stratification in the Hanson ponds. Steep declines in dissolved oxygen occur at approximately 10-15 feet depth and anoxic conditions exist on the pond bottoms, with the exception of the Vimark pond, which may be explained by warm water flow from the Richardson pond into the Vimark pond.

Surface temperatures of all ponds were 24 degrees Celsius and above, with the highest temperature recorded as 29.1 degrees Celsius in the Mariani Pond. Bottom temperatures at depths of 25 to 30 feet were between 11 and 12 degrees Celsius in the Mariani, Piombo and Richardson ponds, indicating a steep temperature gradient from top to bottom. By contrast, the southernmost pond, Vimark did not have a steep temperature gradient, with bottom temperatures at depths of 25 and 30 feet generally above 21 degrees Celsius, and surface temperature uniformly at 25 degrees Celsius, thus with an average difference of only 4 degrees Celsius between top and bottom temperatures. The lack of stratification measured in the Vimark pond may be due to exclusive inflow of warmed surface water from the adjacent up-valley Richardson pond, which has a water surface elevation perched ten feet above the river and the other ponds, likely indicating its lower depths are sealed and thus not providing cold bottom groundwater flow into the Vimark pond.

DO profiles of the Mariani, Piombo, and Richardson ponds showed a distinct stratification of oxygen levels at 10 to 15 feet of depth. Surface DO measurements generally ranged from 9 to 14 mg/l in the top 5 feet, with DO dropping to between 1 and 3 mg/l at depths of 10 to 15 feet. Below 15 foot depths, DO was generally below 0.5 mg/l. At 25 and 30 foot depths or greater, DO was generally between 0.10 and 0.4 mg/l, indicating strongly anaerobic to anoxic conditions at the sediment-water interface. Vimark pond, without thermal stratification, was again an exception lacking marked DO stratification, with DO levels above 8mg/l down to 25 foot depths.

The anaerobic conditions at depth in Mariani, Piombo, and Richardson ponds result in cycling of P (re-mineralization), and methylation of mercury as documented with analyses of water and sediment samples. The cycling of P results in a continuous cycle of algal blooms as demonstrated by the low visibility secchi disk water clarity measurements. The continuous die off and sinking of algal blooms results in a ready and continuous supply of fuel (dissolved organic carbon) for proliferation of anaerobic bacteria species (*e.g*. *Disulferans disulferans*) and resulting methylation of mercury.

DO levels in the Vimark pond, as with the temperature profiles, was not strongly stratified. DO was measured at from 8 to 9 mg/l from the surface down to a depth of 25 feet, with DO dropping to the 2- 3 mg/l range only at 30 foot depths or greater. Although the Vimark Pond water column is not DO stratified, the warm water temperatures from top to bottom of the water column would likely preclude summer rearing of salmonids.

The relatively warm surface layers in approximately the upper 10 to 15 feet of all the ponds during the summer is above juvenile salmonid survival thresholds, and DO at greater than 15 foot depths is below minimum survival thresholds. Thus, summer survival of juvenile salmonids that become entrapped in the ponds during high winter flows is unlikely.

Water clarity was measured with a Secchi disc. In the Mariani, Piombo and Richardson Ponds poor visibility was observed with water clarity ranging from 2.2 to 5.2 feet due to algal blooms in the water column. By contrast, water clarity measured in the Vimark pond was consistently between 20 and 22 feet.

4.3.2.8 Implications for restoration. As they currently exist, the Hanson ponds are filled with nutrient rich water that becomes thermally stratified in summer, with relatively high temperatures in the hyperlimnion and low DO in the colder hypolimnion. These conditions drive the cycling of phosphorous and production of algal blooms which in turn provides abundant dissolved organic carbon for anaerobic bacteria. River hydrology delivers fine clays and attached phosphorous, mercury and other metals to the ponds multiple times annually. The deep ponds allow for settling of significant new accumulation of clays with each storm event. The laboratory analyses confirm methylation of mercury occurs as a result of these physical conditions and biogeochemical processes. The Richardson pond is documented to seep its warmed surface water into the Russian River and its water surface elevation remains higher than the river and other ponds water surface elevations throughout the year.

Given these existing water quality conditions, the Hanson ponds impart negative impacts to the local aquifer and to river surface water quality. Filling the ponds with porous material would likely resolve negative effects of the ponds on river water quality and contribute to increased aquifer recharge in the winter.

4.4 Characterizing the fish assemblage of Middle Reach ponds

Initial stakeholder meetings identified the presumed current assemblage of fish in the Hanson ponds to be of concern due to potential predatory interactions with threatened and endangered salmon and steelhead populations. Thus, characterizing the fish assemblage of the Middle Reach ponds was determined to be an important feasibility study task. Regarding concerns about non-native fish predation on threatened and endangered salmonids, it is generally recognized and documented in the literature that non-native introduced fish species, along with native fish species prey opportunistically on salmonids and seasonally may consume large numbers. However, salmonids supply only a small fraction of the dietary needs of native and non-native predators (Hayes 2015, in Salmonid Restoration Federation Conference, Taboor 2007). Likely more important for population dynamics of salmonids within the Russian River Basin, is the wholesale loss, as described in this study's watershed assessment (Appendix A), of the shallow channel edgewater and off-channel tributary sloughs, oxbows, and blind channels and wetlands of floodplains that provide the habitat necessary to recruit, support, and rear high abundance levels of juvenile salmonids in order to withstand extant predation pressures from both native and non-native species.

4.4.1 Background and purpose

Loss of habitat is identified in ESA listing and Recovery Plan documents as the primary reason California salmonid populations have fallen below 10 percent of historic levels (61 FR 56138, 70 FR 37160, NMFS 2011a, NMFS 2011b). A key concern identified in emerging research and recovery plans is loss of floodplain, wetland, and off-channel habitat. Access to these habitats is now understood to play seasonally critical roles supporting the population dynamics of these species. Hayes (2011) documented complex life history strategies that steelhead have evolved to move between these habitats seasonally providing opportunities to substantially increase growth and survival. Koski (2009), Hiner (2007), Wallace (2015), and Jones (2014) detail similar complex seasonal freshwater migrations by coho salmon enabling rearing juveniles to take advantage of seasonally available habitats providing cold-water refuge in the summer and ecologically highly productive winter/spring habitats of estuarine and riverine wetlands, enabling rapid seasonal growth windows to reach threshold sizes for subsequent marine survival.

The transition from emerging alevins/post emergent fry to open water rearing parr represents the life-stage where adult abundance levels are likely primarily determined (Milner *et al.* 2003). With a meta-data analysis of published studies, Gibson *et al.* (1993) found 57 percent of the variability of adult Atlantic salmon returns could be attributed to survival rates at the earliest life history stage post emergence. Availability of habitat for this transition stage can have orders of magnitude impact on adult abundance levels. Using meta-analysis methods, Bradford (1995) found mean survival rate of eggs to fry of Pacific salmonid species is between 1 to 7 percent under unregulated and unimpaired conditions. Thus, increasing survival rate by a few percentage points at this life-stage can dramatically increase population abundance of subsequent life-stages.

Essential habitat attributes needed for survival of the salmonid early life-history stage are provided in “edgewater” habitat (McMahon 1983), where complex cover and food resources are provided within the protection of emergent and overhanging vegetation, undercut banks, and the tangle of exposed roots in contact with the substrate. These attributes are found in the relatively calm waters of shallow pools along stream margins, tributary sloughs, and seasonal backwater areas. Historically, the majority of edgewater habitat suitable for this earliest life-history stage was found in alluvial valleys where off-channel habitats of abandoned oxbows, braided tributary and river channels, and associated river and tributary wetlands were natural and significant attributes of the alluvial valley floodplain landscape.

These edgewater habitats in the Russian River have been systematically and dramatically reduced during 170 years of agriculture and urban development (Cluer *et al.* 2009). More recent decades of tributary and river channel dredging for aggregate mining and flood control further reduced the extent of suitable edgewater habitats.

Of primary importance in salmonid population dynamics (specifically recruitment to the population), is the function played by availability of suitable habitat during the earliest life history stages after emergence from the spawning gravel. Juxtaposing habitat requirements against historic and present-day land use trends exposes the fundamental challenge to providing seasonally suitable habitat for recruitment of early life-stages to salmonid populations.

Recognizing these trends and obstacles to species recovery, NMFS began exploring the potential for seasonally re-connecting former gravel mining pits to the river channel. The exploration focused on the roughly 800 acres of ground water fed mining ponds in the Russian River alluvial valley between Healdsburg and the Wohler Narrows. Mining activities on these once ecologically dynamic floodplain terraces are concluded, reclamation responsibilities remain.

In 2009, NMFS organized a symposium to explore potential for wetlands and fisheries restoration on retired mining pits on the Russian River. To help establish the ecological profiles of retired mining pits, Dr. Mathias Kondolf, Professor of Environmental Planning and Geography at UC Berkeley, identified three older Middle Reach ponds – Hopkins, Doyle, and Passlaqua - that are seasonally connected to the river. Professor Kondolf’s research showed rapid riparian forest recolonization of these ponds (Cluer *et al.* 2009). The habitat quality and fish assemblage of these older ponds provides perspective of how seasonally reconnected terrace mining pits might impact Russian River native fish populations.

4.4.2 Results of fish investigations of the Hopkins, Doyle, and Passalaqua ponds

NMFS, CDFW and Sonoma County Water Agency (SCWA) surveyed the ponds identified in Dr. Kondolf’s study to assess the evolution and quality of fisheries habitat and fish assemblage on three occasions. Initial reconnaissance by NMFS and CDFW staff on September 23, 2011 indicated only the 11-acre Hopkins pond remained as a significant open water pond. The Doyle and Passalaqua ponds have mostly filled in over the last 40 plus years of annual inundation. Water quality was measured during each field sampling effort. The results of water quality profiles showed similar patterns of thermal stratification and steep declines in temperature and dissolved oxygen with increasing depths below the thermocline as described previously for the Hanson ponds (Section 4.3.2.7).

The water clarity of the Hopkins pond allowed for visual identification of some fish from the surface while kayaking around and across transects of the pond. Juvenile small mouth bass (*Micropterus dolomieu*), crappie (*Pomoxis* sp.), and red-eared sunfish (*Lepomis microlophus*) were observed in the top five feet of the water column, generally near or within the floating masses of *Ludwigia* spp. fringing the pond. A single adult carp (*Cyprinus carpio*) was observed chasing a casted gold spoon. Below the five-foot depth, schools of fusiform shaped fish four to six inches in length were fleetingly observed, particularly near submerged structures. A fish finder mounted on a kayak allowed observation of depths, densities, locations, and size of fish. Fish were noted at all depths throughout the pond, with densities highest near submerged structure in the deeper north end of the pond. The schools of fusiform fish were all noted below the thermocline, below five feet of depth. Large and small fish were noted on sonar throughout the pond, with the larger fish mostly at deeper depths.

Casting a gold spoon resulted in hooking three fish of 5 to 6 inches length. All were reeled to within a meter of the kayak before escaping (barbless hooks required on the Russian River). Two were judged to likely have been largemouth bass juveniles (*Micropterus salmoides*) and one was unidentified.
NMFS and CDFW returned to sample Hopkins pond with seine nets and traps on October 5, 2011. Effective fish sampling with a seine net proved to be difficult due to the 20-40 foot wide fringe of *Ludwigia* sp. floating on the perimeter of the pond. One pull of the seine, with wet suited divers swimming it around the north end of the pond over the deepest central area yielded no catch. A subsequent pull in the shallower south central area of the pond yielded 1 juvenile largemouth bass, 2 red-eared sunfish and 2 bluegill (*Lepomis macrochirus*) (lengths not recorded). A hoop net set along the shore in an area cleared of *Ludwigia* and weighted down to the bottom at 2 meters depth and left overnight from October 5th to the 6th yielded 3 small bluegill (104, 107, and 108 mm FL) and 2 green sunfish (*Lepomis cyanellus*) (157 and 158 mm FL).

On January 10, 2012, NMFS, CDFW and SCWA staff sampled Hopkins pond systematically with an electroshocking boat supplied by the water agency. Two passes were made with the boat around the perimeter of the pond while electrofishing the interior edge of the floating vegetation of *Ludwigia*. Total catch numbers are presented in Figure 4.4.1. Of the nearly 6000 fish captured, a total of only six individual native species were present in the catch. Largemouth bass were by far the largest component of catch both in terms of numbers and biomass. Largemouth bass greater than 75 mm were marked with a maxillary fin clip to carry out a mark-recapture population estimate. A modification of the Petersen mark-and-recapture equation was used to estimate the population of largemouth bass over 75mm FL in the pond at 486 $\pm$ 181 (1 standard deviation), with approximately 68% confidence limits. Scaling up to the size of the 150 acres of open water of the Hanson ponds, it is reasonable to conclude that over time as the Hanson ponds evolve from their current state, the 150 acres of ponds could support a breeding population of largemouth bass numbering in the thousands.

Figure 4.4.1. Electro-fishing results in Hopkins pond. A non-native salmonid predator species, largemouth bass comprised the majority of biomass caught during boat-electrofishing sampling of the Hopkins Pond.

Figure 4.4.2. Hopkins pond. Hopkins Pond within the high flow channel of the Russian River has well-developed riparian vegetation and wide fringe of invasive floating aquatic vegetation. The pond, excavated in the early 1970s, is connected with the Russian River at flows greater than about 800 cfs.

4.4.3 Fish sampling of the Hanson Richardson pond

On January 14 and 15, 2013, NMFS, CDFW, SCWA, and Sonoma State University students sampled Richardson pond, the largest on the Hanson ponds. Launching the heavy SCWA electrofishing boat was deemed infeasible due to soft mud at the potential launch site. A drift boat was then used to set beach seines for pulling into shore to process the catch (Figure 4.4.3). Gill nets were set in various locations around the pond and left overnight but did not capture any fish. Only one of the beach seine locations yielded fish, the largest of which was a largemouth bass. Total species and numbers caught are listed in Figure 4.4.4). Water clarity was less than 6 inches and may have impacted the catch rate of all sampling efforts.

Figure 4.4.3. Drift boat setting a beach seine in the Richardson pond.

Figure 4.4.4. Results from beach seining in the Hanson Richardson pond. A largemouth bass, a non-native predatory species, is shown in the photo.

4.4.4 Fisheries sampling summary

The fish assemblage profile within the project area provides an important reference point in assessing current and future impacts on salmonids and overall river ecosystem function of existing conditions at the Hanson site. The current landform of segregated ponds coupled with the hydrologic regime can support a large population of predatory non-native fish species and invasive non-native plants - but very limited natural edgewater or productive rearing habitat for salmonids. Thus, young salmonids that are carried by high flows into the ponds or seeking refuge from high velocities of the main channel can result in significant numbers becoming trapped in a population sink.

Given the historical loss and scarcity of natural floodplain associated aquatic habitat within the larger river system, biological conditions at the Hanson site could have a disproportionately high influence on critical life stages within the salmonid life cycle, and thus on basin population dynamics and abundance levels. This topic is further discussed in Chapter 8, Section 8.3, Estimating Salmonid Population Benefits.

4.5 Existing conditions summary

Existing ecological conditions of the Russian River Middle Reach Valley have never been worse. Defined by a deeply incised river bed, the ongoing geomorphic process, precipitated by straightening and dredging during the 1950-60's, continue to exacerbate degradation. The deep river bed and steep banks are geotechnically unstable throughout the eight mile Middle Reach. The banks require frequent expensive repairs that are difficult to permit and short-lived. The river, although it has perennial flow, provides poor habitat especially for native fish species. There is no spawning gravel habitat for salmonids even though it is one of California's largest gravel bed rivers. Conversely, it provides very suitable habitat for warm water fish such as bass, which prey on juvenile salmonids.

Water quality in the Middle Reach is deteriorated by warmed water inputs during summer as the expansive gravel ponds leak into the river. The abandoned gravel ponds also create biogeochemical processes that convert naturally occurring mercury into highly toxic and bioavailable methyl mercury, and accumulate phosphorous and other detrimental nutrients. The gravel ponds sit atop the relatively small and shallow alluvial aquifer that is the drinking water source for 600,000 residents in Sonoma and Marin Counties.

CHAPTER

5 Literature Review Summary

5.1 Key findings of literature review

Off-channel habitat use by salmonids was the subject of a literature review conducted by NMFS for the 2009 Symposium Report. That review was updated and expanded in order to assess the Hanson property for salmonid habitat restoration potential. The NMFS literature reviews included studies of off-channel and floodplain habitats used by salmonids in California, Oregon, Washington, and British Columbia. Relevant recent literature from studies in the California Central Valley was included because the region has a climate and fish assemblages similar to the Russian River watershed.

Key findings from the literature review are:

1. Winter rearing habitat is critically important in both recruitment of large numbers of fry to salmonid populations, and in California, the critical period of growth allowing rearing juveniles to reach threshold sizes for marine survival is winter. Optimum winter rearing habitat is off-channel floodplain and other low energy gentle gradient geomorphic settings that are naturally damped for flood events, warmed by being shallow, food rich, and large in area with complex cover.

2. Fish populations of disturbed floodplain, semi-isolated lentic habitats associated with riverine lotic environments (gravel mining ponds adjacent to rivers), are predominated by exotic fish. Salmonids can likely persist on the edges of their physiological tolerance in summer lentic habitat, but become particularly susceptible to predation by non-native introduced piscivores such as largemouth bass that are well-adapted to these semi-isolated pond conditions. (This was verified by fisheries sampling conducted by NMFS and Department of Fish and Wildlife at Hopkins Pond just downstream from the Hanson site. Intensive e-boat sampling of Hopkins Pond and winter beach-seine sampling of the largest project area pond, (Richardson), found both ponds populated almost exclusively by non-native fish species.)

3. In most cases, winter salmonid growth rates in off-channel habitats were shown to be significantly greater than for in-channel winter or summer habitats, and at population densities up to five times higher than in-channel habitats.

4. In California particularly, opportunities for rapid winter growth appear to be key to achieving threshold sizes for marine survival of sea-going smolts. Seasonally inundated floodplains and associated naturally formed off-channel habitats have several advantages for native salmonids over perennial in-channel habitat and semi-isolated deep pond environments:

   - Water depths are typically shallow and relatively warm in winter and within the optimum temperature range for growth of salmonids. These conditions result in high biological productivity and enhanced salmonid growth rates. Wet season river stage increases that spread across a wide area provide shallow productive vegetated habitat not easily accessible by larger predatory fish.

   - Stage changes of riverine systems connected with wide floodplains are substantially muted, thus contributing to aquatic/riparian ecotone of edgewater habitats that are persistent and resilient to stage changes. This in turn fosters higher fry recruitment rates for salmonids. Hydromodification of virtually all floodplain channels within the Russian River Basin for agriculture has largely eliminated the stage resilient edgewater habitats critical for annual cohort recruitment to salmonid populations.

- Many non-native fish (*e.g.*, largemouth bass) cannot successfully spawn in the ephemeral seasonal habitats of floodplains, nor withstand the seasonal displacement by naturally occurring high discharge events.

- Activity levels for some non-native piscivores are low during winter and they are not likely to actively move onto seasonal floodplains. Research by Bailey and Giannico 2009 and Colvin *et al.* 2009 on the Willamette River (Oregon) also suggest exotic introduced fish species are more susceptible to being stranded in ephemeral floodplain habitats than are native species, which have evolved and adapted life histories to the Mediterranean hydrologic cycle. Thus native species of fish are more likely to sense and respond to the environmental cues of rapid water level stage changes typical of Mediterranean climates.

- Studies on the Klamath, Willamette, and Sacramento Rivers, and their tributaries all show superior growth for all salmonids species using non-natal-stream off-channel habitats of sloughs and seasonal wetlands where seasonal inundation creates more abundant, complex, and highly productive habitat.

- California, Oregon, and Washington fish otolith and scale studies show that young of year and yearling salmonids that migrate to downstream non-natal stream habitats attain threshold sizes for marine survival more often than do fish reared in natal streams, and can comprise 80 percent or more of returning adult salmonid populations.

- Narrow floodplain ingress and egress pathways to semi-isolated ponds can greatly concentrate numbers of native fish during seasonal local migrations, and can result in high levels of predation on salmonids by exotic and native fish and avian piscivores.

5.2 Implications for restoration goals

1. **Increase duration of river-floodplain connection.** The Hanson ponds de-stratify in the winter resulting in much higher dissolved oxygen (DO) at depth than in the summer months. Therefore, establishing a perennial or longer seasonal winter/spring connection to the Russian River could be a source of oxygenated water. Moving water could drive mixing. Even without major re-contouring, the ponds could provide marginal off-channel winter habitat for salmonids with a longer duration of hydraulic connection with the river. Any increase/ improvement to habitat complexity is likely to enhance habitat value. However, the combination of large populations of non-native piscivores and narrow connections between the ponds and the river would likely result in high mortality for salmonids (and other native fish) ingressing and egressing the ponds.

2. **Increase floodplain width and channel complexity.** The current leveed channel configuration and semi-isolated off-channel ponds in the project area lack complexity. Biological productivity in these ponds during winter is likely low and salmonids that are able to access these areas at high flows could be highly susceptible to predation and unable to return to the river later in spring. Thus, in its current configuration, the project area probably functions as an “ecological trap” and a sink for native fish populations. Winter salmonid fry recruitment and parr rearing habitat can be created by increasing floodplain width and channel complexity, allowing for a seasonally active island and channel network. Velocities in

the current river channel would be reduced significantly, which in turn would significantly increase the value of spawning habitat and winter, spring and summer rearing and recruitment habitat of the existing river channel.

3. **Modify pond habitat to manage non-natives.** A primary consideration for restoration is the effect of habitat management on both native and non-native fish populations. The existing semi-isolated and near perennial lentic environment of the ponds appears to provide very good rearing and recruitment habitat for largemouth bass that prey on native fish. Largemouth bass habitat suitability and their overall abundance in the project area could be reduced in two ways:

   - Significantly increase flows into the ponds in the winter for displacement purposes, and in spring and early summer to reduce spawning and recruitment success.
   - Minimize perennial pond habitats by replacing the off-channel ponds with seasonally inundated channels and associated ephemeral and perennial groundwater-fed wetlands and cold spring-fed channels.

   Improving native salmonid winter habitat and minimizing largemouth bass habitat could potentially be achieved with the same design elements:

   - Reduce depths in off-channel ponds. Using material available onsite and substantially increasing the river connection and flows to the floodplain would reduce bass habitat and increase winter salmonid rearing and recruitment habitat.
   - Design for seasonally appropriate flow conditions. The physical configuration of the channel and floodplain must be designed to generate seasonally appropriate flow conditions across the project landscape to minimize or eliminate the persistence of the current deep off-channel habitats that favor non-native piscivores.

   These two considerations are probably directly related because the river-floodplain connection and seasonal flow characteristics through the Hanson site will directly influence sediment deposition rates in the ponds or restored floodplain above the summer water table, and the subsequent evolution of hydrologic, geomorphic and biotic processes that create habitat suitable for native versus introduced fish species.

Selected abstracts are on the following pages and a full listing of reviewed literature is in Appendix D.

5.3 Selected abstracts

Publication	Selected Abstract/Summary
Translating Restoration Scenarios Into Habitat Conditions: An Initial Step In Evaluating Recovery Strategies For Chinook Salmon *(Oncorhynchus tshawytscha)*. K.K. Bartz, K.M. Lagueux, M.D. Scheuerell, T. Beechie, M.H. Ruckelshaus, and A.D. Haas. 2006**.** Canadian Journal of Fisheries and Aquatic Sciences, 2006, 63(7): 1578-1595, 10.1139/f06-055.	One of the challenges associated with recovering imperiled species, such as Chinook salmon (*Oncorhynchus tshawytscha*), is identifying a set of actions that will ensure species' persistence. Here we evaluate the effects of alternative land use scenarios on habitat conditions potentially important to Chinook salmon. We first summarize the alternative scenarios as target levels for certain land use characteristics. We then use the target levels to estimate changes in current habitat conditions. The scenarios we explore indicate considerable potential to improve both the quality and quantity of salmon habitat through protection and restoration. Results from this analysis constitute the habitat inputs to a population model linking changes in habitat to salmon population status. By transparently documenting the approach we use to translate land use actions into changes in salmon habitat conditions, we provide decision makers with a clear basis for choosing strategies to recover salmon.
Just add water: sources of *chironomid* drift in a large river floodplain. Benigno, Gina M. and Ted R. Sommer. 2007**.** Hydrobiologia	We examined composition and sources of *chironomid* drift in the Yolo Bypass, the primary floodplain of the Sacramento River. We found that invertebrate drift during winter floodplain inundation is dominated by a single species, the newly identified *chironomid Hydrobaenus saetheri* (Diptera: Chironomidae). In order to determine sources of *chironomids* in the Yolo Bypass, invertebrates were sampled from several potential sources prior to and during initial floodplain inundation. Rehydration of dried floodplain sediments from several locations showed that *H. saetheri* dominated insect emergence from this colonization pathway. By contrast, *H. saetheri* was not a substantial component of inundated floodplain ponds or of tributary inputs to the floodplain. We conclude that the initial pulse of invertebrate abundance in Yolo Bypass floodwaters is dominated by *chironomid* emergence from sediments in multiple regions of the floodplain.

Use of a Restored Central California Floodplain by Larvae of Native and Alien Fishes. Crain, Patrick K., Keith Whitener, and Peter B. Moyle. 2004. American Fisheries Society Symposium 39:125–140.	We sampled larval fish in 1999 and 2001 on a restored floodplain along the lower Cosumnes River, California, from the onset of flooding to when the sites dried or when larval fish became rare. We collected more than 13,000 fish, of which prickly sculpin (*Cottus asper)* made up the majority (73%). Eleven species made up 99% of the catch. Three native fishes (prickly sculpin, Sacramento sucker, and splittail) and two alien species (common carp and bigscale logperch) were associated with higher inundation and cool temperatures of early spring. In contrast, five alien taxa, sunfish *Lepomis spp*., largemouth bass, crappie, golden shiner, and inland silverside, were associated with less inundation and warmer water temperatures. One native species, Sacramento blackfish, was also associated with these conditions. Species did not show strong associations with habitat because of different spawning times of adults and expansion and contraction of flood waters. Most species could be found at all sites throughout flooded habitat, although river and floodplain spawning fishes usually dominated sites closest to levee breaches. Highest species richness was consistently found in two sloughs with permanent water because they both received drainage water from the floodplain and had a complement of resident species. Splittail, a floodplain spawner, was found primarily in association with submerged annual plants. Our results suggest that a natural hydrologic cycle in spring is important for providing flooding and cool temperatures important for many native larval fishes. Alien fishes are favored if low flows and higher temperatures prevail. Restoration of native fish populations that use floodplains for rearing should emphasize early (February–April) flooding followed by rapid draining to prevent alien fishes from becoming abundant.
Evaluation of juvenile Chinook behavior, migration rate and location of mortality in the Stanislaus River through the use of radio tracking. Demko D., C. Gemperle, S. P. Cramer, and A. Phillips. 1998. Prepared for the Tri-dam Project, S.P. Cramer & Associates, Inc. Gresham, Or.	Pilot radio tracking study with juvenile fall-run chinook salmon smolts in the Stanislaus River from May through July 1998, to determine the feasibility of using radio telemetry to monitor juvenile chinook migration, mortality, and possible locations of mortality. Successfully radio-tagged and tracked 36 natural and 10 hatchery chinook subyearlings ranging in length from 101 to 117 mm. Three tagged fish died soon after release and of the remaining 43, only 5 were detected reaching Caswell State Park (distance of 37 miles). Based on the pattern and behavior of repeated tag detections, we estimated that 30 tagged fish (70%) were eaten by predators. However, predation was never directly witnessed and therefore could not be conclusively determined. Detections during mobile surveys revealed locations and habitat characteristics where fish were located. We also detected rapid movement of some tags as we approached, which indicated we were tracking a larger predatory fish that had eaten a tagged salmon. The only location along the river where several tagged fish stopped migrating was the backwater pond habitat at the Oakdale Recreation Area. Of 35 tagged fish released at Orange Blossom Bridge in May, 7 (20 %) halted their migration at the Oakdale Recreation Area. Most of the tagged fish that remained in the ponds at the Oakdale Recreation Area were found in calm, open water atypical of habitat preferred by juvenile chinook. All were classified as having been eaten by predators.

Don Pedro Project. Fisheries Study Report FERC Article 39, Project No. 2299. Appendix 22, Lower Tuolumne River Predation Study Report.EA Engineering, Science, and Technology. 1992. Prepared for the Turlock Irrigation District and the Modesto Irrigation District.	Study to estimate the abundance of predator species in the lower Tuolumne River and to estimate the predation rates of those resident piscivores. Predation of juvenile chinook salmon is a potentially major source of mortality in the Lower Tuolumne River. To estimate bass population abundance, sites were electrofished and "captured" fish were identified and systematically marked for mark-recapture population studies. Several methods of estimating abundance were utilized, and are detailed in the text. Predatory rates were assessed by irrigation of predatory bass stomachs, and subsequent stomach contents identification and analysis. Concurrently-collected water samples were analyzed for turbidity, because turbidity plays a role in the predation efficiency of bass. Population estimates for largemouth bass ranged from 1-139 fish per acre of stream surface (6-758 fish per mile of river shoreline) and from 1-16 fish per acre (2-158 fish per shoreline mile) for smallmouth bass. These ranges are approximates in light of the assumptions used in the population estimation methods. Bass predation rates averaged from zero to 3.62 chinook salmon ingested per day (assuming a slow rate of digestion) or from zero to 5.31 salmon ingested per day (assuming a faster digestion rate).
A Geomorphic Monitoring And Adaptive Assessment Framework To Assess The Effect Of Lowland Floodplain River Restoration On Channel–Floodplain Sediment Continuity. Florsheim, J. L., J. F. Mount and C. R. Constantine. 2006. River Research and Applications 22(3), pages 353–375	Based on results of a case study of floodplain restoration at the lowland Cosumnes River, California, we present a geomorphic monitoring and adaptive assessment framework that addresses the need to inform and utilize scientific knowledge in lowland floodplain river restoration activities. Highlighting hydrogeomorphic processes that lead to habitat creation, we identify a discharge threshold for connectivity and sediment transfer from the channel to the floodplain and integrate discharge magnitude and duration to quantify a threshold to aid determination of when geomorphic monitoring is warranted. Using floodplain sand deposition volume in splay complexes as one indicator of dynamic floodplain habitat, we develop a model to aid prediction of the sand deposition volume as an assessment tool to use to analyze future monitoring data. Because geomorphic processes that form the physical structure of a habitat are dynamic, and because the most successful restoration projects accommodate this fundamental characteristic of ecosystems, monitoring designs must both identify trends and be adapted iteratively so that relevant features continue to be measured. Thus, in this paper, adaptive assessment is defined as the modification of monitoring and analysis methods as a dynamic system evolves following restoration activities. The adaptive monitoring and assessment methods proposed facilitate long-term measurements of channel–floodplain sediment transfer, and changes in sediment storage and morphology unique to lowland river–floodplain interactions and the habitat that these physical processes support. The adaptive assessment framework should be integrated with biological and chemical elements of an interdisciplinary ecosystem monitoring program to answer research hypotheses and to advance restoration science in lowland floodplain river systems.

Ephemeral floodplain habitats provide best growth conditions for juvenile Chinook salmon in a California river. Jeffres, Carson A., Jeff J. Opperman & Peter B. Moyle. 2008.Environ Biol Fish 83:449–458	We reared juvenile Chinook salmon for two consecutive flood seasons within various habitats of the Cosumnes River and its floodplain to compare fish growth in river and floodplain habitats. Fish were placed in enclosures during times when wild salmon would naturally be rearing in floodplain habitats. We found significant differences in growth rates between salmon reared in floodplain and river enclosures. Salmon reared in seasonally inundated habitats with annual terrestrial vegetation experienced higher growth rates than those reared in a perennial pond on the floodplain. Growth of fish in the non-tidal river upstream of the floodplain varied with flow in the river. When flows were high, there was little growth and high mortality, but when the flows were low and clear, the fish grew rapidly. Fish displayed very poor growth in tidally influenced river habitat below the floodplain, a habitat type to which juveniles are commonly displaced during high flow events due to a lack of channel complexity in the main-stem river. Overall, ephemeral floodplain habitats supported higher growth rates for juvenile Chinook salmon than more permanent habitats in either the floodplain or river. Variable responses in both growth and mortality, however, indicate the importance of providing habitat complexity for juvenile salmon in floodplain reaches of streams, so fish can find optimal places for rearing under different flow conditions.
Restoring native fish assemblages to a regulated California stream using the natural flow regime concept. Kiernan, Joseph D., Peter B. Moyle, and Patrick K. Crain. 2012. Ecological Applications 22(5):1472–1482	We examined the response of fishes to establishment of a new flow regime in lower Putah Creek, a regulated stream in California, USA. The new flow regime was designed to mimic the seasonal timing of natural increases and decreases in stream flow. We monitored fish assemblages annually at six sample sites distributed over 30 km of stream for eight years before and nine years after the new flow regime was implemented. Our purpose was to determine whether more natural stream flow patterns would reestablish native fishes and reduce the abundances of alien (nonnative) fishes. At the onset of our study, native fishes were constrained to habitat immediately (1 km) below the diversion dam, and alien species were numerically dominant at all downstream sample sites. Following implementation of the new flow regime, native fishes regained dominance across more than 20 km of lower Putah Creek. We propose that the expansion of native fishes was facilitated by creation of favorable spawning and rearing conditions (e.g., elevated springtime flows), cooler water temperatures, maintenance of lotic (flowing) conditions over the length of the creek, and displacement of alien species by naturally occurring high-discharge events. Importantly, restoration of native fishes was achieved by manipulating stream flows at biologically important times of the year and only required a small increase in the total volume of water delivered downstream (i.e., water that was not diverted for other uses) during most water years. Our results validate that natural flow regimes can be used to effectively manipulate and manage fish assemblages in regulated rivers.

Projecting Cumulative Benefits of Multiple River Restoration Projects: An Example from the Sacramento-San Joaquin River System in California. Kondolf, G. Mathias, Paul L. Angermeier, Kenneth Cummins, Thomas Dunne, Michael Healey, Wim Kimmerer, Peter B. Moyle, Dennis Murphy, Duncan Patten, Steve Railsback, Denise J. Reed, Robert Spies, and Robert Twiss. 2008. Environmental Management 42:933–945.	Drawing on our experience with the CALFED Bay-Delta Ecosystem Restoration Program in California, we consider potential cumulative system-wide benefits of a restoration activity extensively implemented in the region: isolating/filling abandoned floodplain gravel pits captured by rivers to reduce predation of out migrating juvenile salmon by exotic warm-water species inhabiting the pits. We present a simple spreadsheet model to show how different assumptions about gravel pit bathymetry and predator behavior would affect the cumulative benefits of multiple pit-filling and isolation projects, and how these insights could help managers prioritize which pits to fill.
Contrasting patterns of juvenile chinook salmon (Oncorhynchus tshawytschaw) growth, diet, and prey densities in off-channel and main stem habitats on the Sacramento River. Limm, Michael P. and Michael P. Marchetti. 2003. Prepared for: The Nature Conservancy	We utilized otolith microstructure to estimate daily relative growth rates among main channel areas, off-channel ponds, and non-natal seasonal tributaries of the Sacramento River. To examine possible mechanisms leading to growth differences, prey availability, prey preference, and stomach fullness were estimated at each site. We observed wider daily increment widths, higher prey densities, and warmer temperatures in off-channel ponds and non-natal seasonal tributaries in both 2001 and 2002. Chironomidae larve, pupae, and adult diptera were the preferred prey in all habitats. No difference in stomach fullness was found between habitats. In 2001, all habitats had higher temperatures, wider daily increment widths, higher prey densities, and higher stomach fullness than in 2002. Our findings suggest the warmer temperatures and abundant prey in off-channel habitats leads to higher growths rates, which in turn can lead to higher juvenile survival rates.
Population characteristics of juvenile coho salmon (*Oncorhynchus kisutch*) overwintering in riverine ponds. Petersonn, P. 1982. Can. J. Fish. Aquat. Sci. 39: 1303 - 1307.	Survival and growth from immigration to smolt outmigration differed substantially between pond populations of juvenile coho salmon (*Oncorhynchus kisutch*). In Pond 1 (the deeper, less-productive pond) overall survival was 78% but average fish weight increased only 49%. Whereas in Pond 2 (the shallow, more-productive pond) survival was only 28% but average fish weight increased 94%. Diet of resident coho in the early spring was characterized by chironomid larvae and newly emerged adults in Ponds 1 and 2, respectively. Manipulation of pond mophometry may have potential for enhancing coho stocks.

Variation in condition factor and growth in young-of-year fishes in floodplain and riverine habitats of the Cosumnes River, California. Ribeiro, F., P. K. Crain & P. B. Moyle. 2004. Hydrobiologia 527: 77–84	Condition factors and growth rates of post-larval (young-of-year) fishes in a Central California river were compared in order to determine the relative importance of floodplain and riverine habitats for rearing. Sampling took place between April and June of 2001 and 2002 in the lower Cosumnes River and its floodplain. Sacramento splittail showed higher condition and length increment in floodplain habitats than in riverine habitats. Sacramento suckers showed differences in condition between sites, but suckers from the floodplain had lower weight increments than those from the river. The weight increment in Sacramento splittail was not significantly different between habitats. In addition, two alien species, common carp and golden shiner, had similar condition factors and growth rates. This study shows the usefulness of condition factor and growth rate in evaluating the importance of different habitats for early life history stages of fishes.
Floodplain rearing of juvenile chinook salmon: evidence of enhanced growth and survival Sommer, T.R., M.L. Nobriga, W.C. Harrell, W. Batham, and W.J. Kimmerer. 2001. Can. J. Fish. Aquat. Sci. 58: 325–333	In this study, we provide evidence that the Yolo Bypass, the primary floodplain of the lower Sacramento River (California, U.S.A.), provides better rearing and migration habitat for juvenile chinook salmon (Oncorhynchus tshawytscha) than adjacent river channels. During 1998 and 1999, salmon increased in size substantially faster in the seasonally inundated agricultural floodplain than in the river, suggesting better growth rates. Similarly, coded-wire tagged juveniles released in the floodplain were significantly larger at recapture and had higher apparent growth rates than those concurrently released in the river. Improved growth rates in the floodplain were in part a result of significantly higher prey consumption, reflecting greater availability of drift invertebrates. Bioenergetic modeling suggested that feeding success was greater in the floodplain than in the river, despite increased metabolic costs of rearing in the significantly warmer floodplain. Survival indices for coded-wire-tagged groups were somewhat higher for those released in the floodplain than for those released in the river, but the differences were not statistically significant. Growth, survival, feeding success, and prey availability were higher in 1998 than in 1999, a year in which flow was more moderate, indicating that hydrology affects the quality of floodplain rearing habitat. These findings support the predictions of the flood pulse concept and provide new insight into the importance of the floodplain for salmon.

A meander cutoff into a gravel extraction pond, Clackamas River, Oregon. Wampler, P. J., E. F. Schnitzer, D. Cramer, and C. Lidstone. 2006. SME Annual Meeting Mar. 27-Mar.29, 2006, St. Louis, MO	Clackamas River, a large gravel-bed river in northwest Oregon. During major flooding in February 1996, the river cut off a meander and began flowing through a series of gravel pits located on the inside of the meander bend. Erosion by bed lowering, knick point retreat and lateral erosion of upstream river banks occurred quickly. Between 1996 and 2003, the knick point from the meander cutoff has migrated 2,290 m upstream, resulting in increased bed load transport, incision, and local lowering of the water table; 96% of the knick point migration occurred during the first winter following meander cutoff. Connection of the flowing river to the off-channel ponds has had minimal effect on water temperatures in the mainstem Clackamas River. It is likely that this minimal change in temperature will decrease as ponds are isolated from active river flow by gravel bar deposition. Fish netting in spring 2002, suggests that salmonid use of the pond in the spring is minimal. The most abundant native species netted were large-scale sucker and northern pikeminnow. The most abundant non-native species netted was brown bullhead. Early regulation by state and federal agencies did not adequately evaluate potential impacts to the river and the floodplain; nor did it evaluate future impacts related to geomorphic processes and sediment transport. The gravel pit capture at River Island highlights the potential risks of mining in an active secondary channel of a large gravel-bed river. Mining deeper than the depth of the adjacent channel, within the active migration zone, may increase off-site impacts. In locations where multiple gravel excavations are present within the meander zone, a comprehensive reclamation and restoration plan should be developed which provides long-term channel stability within the natural variability of the entire river reach.
The natural control of salmon and trout populations in streams N.J. Milner, J.M. Elliott, J.D. Armstrong, R. Gardiner, J.S. Welton, M. Ladle. 2003. National Salmon and Trout Fisheries Centre, Environment Agency, 29 Newport Road, Cardiff CF24 0TP, UK	This paper reviews current understanding of factors controlling salmonid populations in streams and how this contributes to better fisheries management. Salmonid populations are regulated by density-dependent mortality, typically during the early stages of free-living life after fry emerge from spawning gravels. After the early regulatory phase, mortality is controlled mainly by density-independent factors. The relative contributions of density-dependent and density-independent factors to population variability are outlined, noting the special importance of environmental impacts such as flow and temperature extremes. Stock–recruitment relationships are discussed, with an emphasis on understanding the uncertainties and risks inherent in modeling wild populations. Key subjects for future research are identified. The challenge for science in the future lies in two areas: first, incorporating uncertainties into population modeling and management decision making, and second improving the understanding of processes regulating populations through long term studies.

CHAPTER

6 Restoration Goals and Objectives

In partnership with the Scientific Working Group (SWG), restoration goals and objectives were developed early in the feasibility study planning process. These restoration goals and objectives facilitated the identification of potential restoration scenarios for analysis and served as a template for evaluating the study results. In project development common practice, the terms *goals* and *objectives* are often used interchangeably, but in this document they represent distinctly different concepts.

Goals are outcome statements that define accomplishments. A goal should efficiently express the intent of a project, serving as the fixed vision against which all project elements and alternatives are assessed. Identifying geomorphically and ecologically feasible alternatives typically requires a multi-disciplinary team of scientific specialists. Identifying socially and economically feasible alternatives requires robust representation of diverse stakeholder interests. Goal statements must also acknowledge risks inherent to the project due to scientific uncertainty and natural variability.

While goals articulate a desired end condition, they do not define the actions to be taken. *Objectives* are statements of measurable actions that support completion of a goal within a specified time frame. Hence, objectives are developed to define the actions necessary to achieve a stated goal. Appropriate criteria for developing objectives follow the acronym SMART:[1]

1. **S**pecific – objectives are clear, concise statements that specify what you want to achieve.
2. **M**easurable – objectives use parameters that can be measured before and after project implementation.
3. **A**chievable – objectives are geomorphically and ecologically possible.
4. **R**elevant – objectives are clearly related to and support the project goal.
5. **T**ime-bound – objectives are bound by a specified time frame.

Objectives developed to meet these stated criteria provide a solid foundation and clear link to restoration design, as well as to eventual post-project monitoring. Measurable attributes combined with a specific time frame provide the context for post-project appraisal and, where appropriate, adaptive management. For larger and more complex projects, multiple objectives may overlap or even conflict with one another. Designating primary and secondary objectives is useful in such cases. Secondary objectives should be met only if they do not conflict with primary objectives. In addition, all objectives may not be achieved simultaneously. Prioritizing objectives provides greater clarity to project intent and facilitates development of design criteria, as well as post-project monitoring. As with goals, objectives should not be overly prescriptive. Stating objectives too narrowly closes off possible alternatives for meeting the project goals.

The restoration goals and objectives described below were developed by the Management Team with input from the Partners Planning Group, and vetted with the Scientific Working Group and Peer Review

[1] SMART is a term that is commonly used in project management training, marketing, and business development. Wikipedia (http://www.wikipedia.org/) offers a discussion of the concept and its origins, and states that the term has no clearly documented origin.

Panel. As results from the terrain and hydraulic modeling work began to illuminate the potential of the site, the goals and objectives were reviewed and revised once again.

6.1 Project goal

The overarching goal of the Hanson Russian River Floodplain Restoration Project is to recreate functional floodplain, enhance the natural river ecosystem and address the needs of listed fish species.

Establishing a natural seasonal connection between the river and floodplain facilitates the development of habitats that meet the life history requirements and promote the genetic diversity of federally-listed anadromous fish species - native coho, Chinook and steelhead (*Onchorynchus* spp.). Other species that will benefit from river-floodplain restoration are native Russian River tule perch (*Hysterocarpus traski*), western pond turtle (*Clemmys marmorata*), foothill yellow-legged frog (*Rana boylii*), migrating waterfowl and songbirds, and potentially other avian, botanical, aquatic and herpetological floodplain and riparian-dependent species.

The project is intended to provide a number of ecological services (e.g., improvements in water quality, groundwater recharge, aquifer restoration, nutrient and fine sediment processing, flood control, provision of habitat for native flora and fauna) and function as an integral component of the greater Russian River ecosystem. These ecosystem services are stated as goals with measurable objectives.

6.2 Geomorphic goals

Goal 1. Arrest or reverse the ongoing trend of channel incision and resulting geotechnical bank failure in the study reach. Maintain channel bed elevations and riverbank property stability in the Middle Reach Valley.

Objectives:

1. Within 1 year[2] restore river/floodplain interaction to increase dissipation of flood energy and deposit sediment in the project reach.
2. Within 1 year reduce hydraulic forces applied along the existing river channel banks for the range of flows contained within the existing channel.
3. Within 1 year establish contours on new fluvial property boundaries sufficient to resist erosion during 5-year and greater flood flows.

Goal 2. Restore sediment deposition, sorting, and habitat-forming fluvial processes.

Objectives:

1. Within 1 year restore sediment deposition and sorting processes to increase river channel bed heterogeneity and create pool riffle morphology.
2. Within 1 year restore fluvial processes forming a seasonally active macro-scale island channel network across at least 50% of the annually inundated floodplain.

6.3 Flood elevation goal

Goal 3. Do not increase, and potentially reduce, flood elevations in the study area.

[2] All temporal objectives relate to time elapsed after grading is completed.

Objectives:

1. Within 1 year increase floodwater routing onto 300 acres of floodplain for 5-year and greater floods.
2. Within 1 year decrease flood elevations within the project area by an average of a meter for a 5-year flood event.

6.4 Fisheries goals

Goal 4. Affect natural control of non-native salmonid predator populations by eliminating the altered landscape and resulting altered hydraulic conditions and ecology that support the persistence of non-native fishes.

Objective:

1. Within 1 year eliminate warm water fisheries habitat.

Goal 5. Increase the populations of native salmonids.

Objectives:

1. Within 1 year restore spawning gravel deposits that will support salmonid spawning in the adjacent river channel.
2. Within 5 years restore and maximize project area productivity and carrying capacity so that juvenile steelhead, Chinook and coho salmon attain minimum threshold sizes for marine survival.

Species objectives:

Chinook salmon objectives:

1. Within 2 years increase main channel spawning habitat area and quality.
2. Within 2 years increase main channel and off-channel winter/spring edgewater habitat by an average of 60 acres during normal and dry hydrologic conditions, for cohort recruitment of fry to the rearing population.
3. Within 2 years restore 80 acres of highly productive winter/spring floodplain wetland and slough habitats under normal hydrologic conditions to provide rapid growth opportunities for rearing juveniles.

Coho salmon objectives:

1. Within 2 years increase main channel and off-channel winter/spring edgewater habitat by an average of 60 acres during normal hydrologic conditions for cohort recruitment of fry to the rearing population.
2. Within 2 years restore 80 acres of highly productive winter/spring floodplain wetland and slough habitats under normal hydrologic conditions to provide a substantial increase in flood refuge and high capacity winter rearing habitat for coho parr annually migrating from basin-wide over-summering habitats in search of enhanced winter and spring growth opportunities.

Steelhead objectives:

1. Within 2 years increase main channel and off-channel winter/spring edgewater habitat by at least 60 acres during normal hydrologic conditions.
2. Significantly increase summer and winter rearing habitat capacity and productivity in the Middle Reach Valley (project study reach).

Other aquatic habitat dependent species:

1. Significantly increase spawning, recruitment and rearing habitat capacity for Russian River Tule Perch, foothill yellow-legged frog, and western pond turtle.

6.5 Aquifer restoration goal

Goal 6. Improve groundwater quality and quantity.

Objectives:

1. Fill existing ponds below the summer water table with porous native sand and gravel.
2. Within 1 year increase groundwater recharge by flooding porous area of at least 100 acres for a minimum 100 days under average hydrologic conditions, and 100 acres for a minimum of 50 days under drier than average hydrologic conditions.

6.6 Water quality goals

Goal 7. Improve surface water quality conditions within the project area and downstream. Reduce the transformation of harmful nutrients (P) and metals (mercury) in the water column and sediments. Reduce Russian River summertime water temperatures by reducing warm subsurface flows seeping from the Hanson ponds.

Objectives:

Nutrient and Metal Objective:

1. Within 1 year, eliminate toxic "hotspots", *i.e.*, MeHg and P accumulation and production, within the Hanson project reach by:
   - eliminating the ponds; or
   - substantially filling the ponds and increasing perennial river flow through the site.

Sediment Objective:

1. Within 1 year restore deposition of fine sediment by increasing flood flow routing onto a minimum of 200 acres of floodplain in average hydrological conditions.

Temperature Objectives:

1. Within 1 year decrease or eliminate summer ponded water to minimize thermal stratification of the water column.
2. Within 1 year reduce or eliminate the summer water surface area exposed to ambient air and solar heating to minimize warming of river water temperatures in the project area and downstream.
3. Within 1 year concentrate groundwater flows into small spring-fed channels.

6.7 Vegetation community goals

Goal 8. Restore and enhance natural floodplain native species riparian zones with a gradient from aquatic bed, emergent marsh, seasonal wet meadow and woodland wetland, to upland mature seral stage forest communities comprising a complex and diverse floodplain ecosystem which is resilient to disturbance and provides floodplain ecosystem benefits and habitat for native fish and wildlife species.

Objectives:

1. Within 5 years establish 50 acres of native vegetation consisting of a gradient from aquatic bed (submerged and floating aquatic vegetation) to seasonal and perennial emergent marsh (including seasonal wet meadows), under average hydrologic conditions.
2. Within 10 years establish 200 acres of native riparian vegetation zones consisting of a gradient from aquatic bed, to emergent marsh, to scrub-shrub forest wetland, to upland riparian forest under average hydrologic conditions.
3. Within 15 years increase native upland riparian forest to at least 125 acres under average hydrologic conditions.

6.8 Public amenities goal

Goal 9. Accommodate potential public access and recreation facilities in the grading plan.

Objective:

1. Create site spaces that can be developed concurrent with grading or at a later time for a rim trail around the outer project boundary, a pad for a campground, and a pad for car park and boat access to the river.

CHAPTER

7 Restoration Scenario Modeling: Approach, Methodology and Results

Restoration scenario modeling was carried out in two stages. Stage I utilized GIS terrain modeling to determine the volumes of material available onsite for cut-and-fill scenarios that roughly balance out and achieve major project goals. These Stage I site models were then run through USGS hydraulic modeling in order to identify flow velocities and water surface elevations within a set of given hydrologic regimes (see Chapter 8). Stage II was a more detailed analysis utilizing the hydraulic information obtained in Stage I to create terrain profiles that optimized habitat and ecosystem benefits while meeting the full range of project goals and objectives.

7.1 Developing terrain concepts

A range of topographic (terrain) concepts were explored in Stage I representing several potential re-contouring configurations with floodplain connections to the river. An overriding consideration for feasibility of conceptual models of Stage I was to avoid the importation or exportation of material to or from the site. Substantial quantities of material remain onsite post mining which are available for use in the reclamation/restoration phase. This includes berms around the edges of the ponds, between ponds, and between the river and the ponds. This material was virtually re-contoured in several iterations using ArcGis software, producing a range of digital terrain Stage I concepts.

7.2 Defining floodplain elevations

To define useful floodplain elevations, five initial topographic models with simple broad floodplains at different elevations were developed. These simple models integrated cut and fill volumes to ensure a balance of the onsite materials and were then hydraulically modeled at different floodplain elevations as described in Chapter 8. The initial hydraulic model results were then reviewed for how well each accomplished the restoration goals listed below.

Goal 1. Arrest or reverse the ongoing trend of channel incision and resulting bank failure. Maintain or improve property stability in the Middle Valley.

Goal 2. Restore sediment deposition, sorting, and habitat-forming fluvial processes.

Goal 3. Do not increase, and potentially reduce, flood elevations in the study area.

Goal 4. Affect natural control of non-native salmonid predator populations by eliminating the altered landscape conditions promoting high carrying capacity of non-native introduced species.

Goal 5. Increase the populations of native salmonids.

Goal 6. Improve groundwater quality and quantity.

Goal 7. Improve surface water quality conditions within the project area and downstream. Reduce the transformation of harmful nutrients (P) and metals (total mercury) in the water column and sediments. Reduce Russian River summertime water temperatures by reducing warm subsurface groundwater inputs from the adjacent ponds.

Goal 8. Restore and enhance natural floodplain native species riparian zones with a gradient from aquatic bed, emergent marsh, seasonal wet meadow and woodland wetland, to upland mature seral stage forest communities comprising a complex and diverse floodplain ecosystem which is resilient to disturbance and provides floodplain ecosystem benefits and habitat for native fish and wildlife species.

7.3 Stage 1: Digital terrain modeling

Five Stage I digital terrain models were created with a range of floodplain elevations to explore the hydraulic thresholds for different possible surface elevations and a range of likely flows. The models are described in Table 7.1 and illustrated in Figure 7.1.

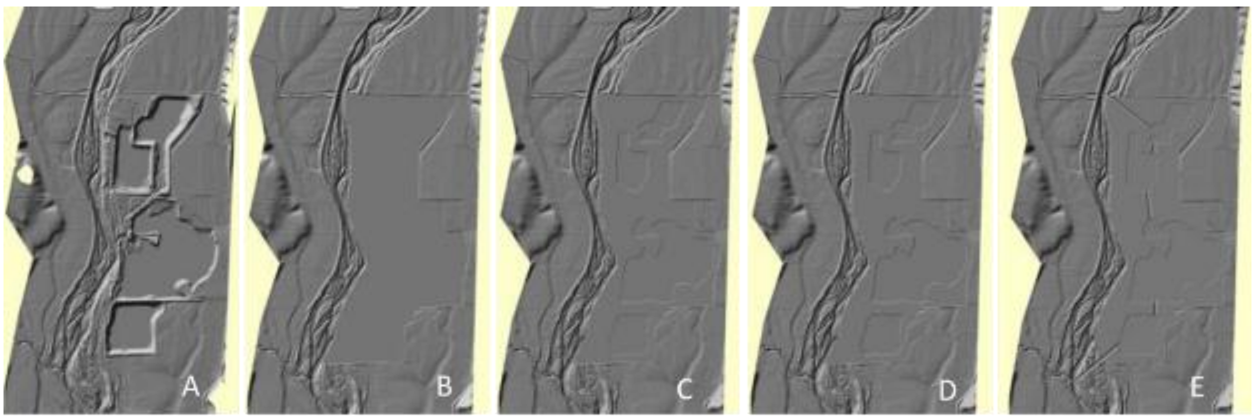


Figure 7.1. Shaded relief maps of the digital terrain models for Stage I-A through D scenarios.

The floodplain inundation flow for the Floodplain Base Level topographic scenario (Scenario I-B above) was found through iterative steady state hydraulic modeling. This process was repeated for each of the initial Stage I topographic scenarios, which resulted in the identification of design flows for floodplain engagement at all of the Stage I floodplain elevations over a range of hydrologic conditions. Hydraulic modeling details and results are presented in Chapter 8 and Appendix G. The results from Stage I hydraulic evaluations are summarized in Table 7.2.

Table 7.1. Digital terrain models developed for evaluation in Stage I of the feasibility study.

Scenario Name	Stage I Digital Terrain Model Descriptions				
	I-A **Existing Topography**	**I-B** **Floodplain Base Level**	**I-C** **Floodplain Base Level + 1 meter**	**I-D** **Floodplain Base Level + 2 meters**	**I-E** **Floodplain Base Level + 2 meters with channels connecting ponds**
Scenario Description	Ponds and river levee remain. Also represents the outcomes from a modified reclamation plan configuration.	• flat floodplain across the site with a downstream gradient matching the river • no east-west slope • elevation 1.4 meters above the river bed • no river levee • no ponds remaining.	• flat floodplain across the site with a downstream gradient matching the river • no east-west slope • elevation 2.4 meters above the river bed • no river levee. • residual pond depths of ~ 1 meter.	• flat floodplain across the site with a downstream gradient matching the river • no east-west slope • elevation 3.4 meters above river bed. • no river levee • residual pond depths of ~ 2.5 meters.	• flat floodplain across the site with a downstream gradient matching the river • no east-west slope • elevation 3.4 meters above river bed. • no river levee • residual pond depths of ~ 2.5 meters. • low flow channels connecting residual ponds and river channel
Modeled by USGS	X	X	X	X	This scenario was refined for Stage II modeling

Table 7.2. Hydraulic modeling results. The table summarizes the number of days of floodplain inundation for the three floodplain elevations of Stage I analysis, during three climatic conditions (water year type) represented by the years 1983 (wet), 2008 (average), and 2009 (dry).

Scenario	Description	Inundation Discharge (m3/s)	Inundation Days		
			1983 (wet)	2008 (avg)	2009 (dry)
I-A	Existing Conditions	na			
I-B	Floodplain Base Level	30	164	48	30
I-C	Floodplain Base Level + 1m	100	99	31	12
I-D	Floodplain Base Level + 2m	190	63	10	8
I-E	Floodplain Base Level + 2m + Interconnecting Channels	42	140	42	21

7.4 Results of Scientific Working Group and Peer Review Panel review

Results from the Stage I floodplain scenario models, hydraulic thresholds, and inundation modeling were vetted with the Scientific Working Group and Peer Review Panel on September 26 and 27, 2013. The participants were asked to evaluate the different terrain concepts against project goals and to suggest design considerations based on the individual hydraulic functioning of each Stage I scenario, that when combined, would produce an ecologically superior terrain concept. These design considerations were incorporated into subsequent model development.

The following recommendations were made:

1. Any residual ponds should not exceed 3 meters in depth during the dry season to minimize mercury methylation processes.
2. The Hanson site should ideally dry out seasonally to prevent warm water fishes from proliferating or salmonids from perishing.
3. Gently sloping broad floodplain surfaces should be created to provide abundant complex and productive rearing and feeding habitat for salmonids over a wide range of river stages.
4. The restoration design should include gentle transition slopes to the surrounding farmlands at approximately 1v:10h.

7.5 Stage II: Developing the superior terrain concept

After consulting with the Scientific Working Group and Peer Review Panel and weighing initial hydraulic elevations and inundation duration of Stage I modeling results with project goals and objectives, a more detailed topographic model was developed. Design criteria included:

1. Balanced cut and fill of onsite material.
2. Grading the entire site within the project boundaries.

3. Provide a gentle slope (1v:10h) from floodplain to farm field elevation around the agricultural perimeter.
4. Slope the floodplain in the down-valley direction parallel to the river slope.
5. Slope floodplain gently from the toe of the agriculture boundary slope to the river (east - west slope of 0.5%) or nearest drain.
6. Contour the inlet and outlet areas to conform to the river channel.
7. Completely fill the ponds with the on-site material so there is no standing water in the drier months.

Zeroing in on an optimal and feasible restoration concept was an iterative process requiring GIS analysis, options vetting with the Scientific Working Group and Peer Review Panel, scrutinizing each alternative for degree of success in meeting restoration goals and objectives, and revising until the most compelling solution emerged. Four additional terrain concepts were developed and are described below and illustrated in Figure 7.2. These four terrain concepts are:

- **Scenario II-A** was a low elevation gently sloping floodplain that completely filled the ponds with gravel. Filled ponds entirely met the water quality and non-native fishery objectives, but Scenario II-A was rejected because the eastern river bank would have been graded to about 1.5 m in height, likely precipitating rapid channel avulsion and a new channel alignment followed by new points of bank erosion before vegetation establishment.
- **Scenario II-B** was a higher floodplain that retained a channel bank 4-5 m high but the balance of cut and fill (material offset) retained residual gravel ponds about 5 m deep, thus failing the water quality and elimination of non-native fish habitats objectives.
- **Scenario II-C** was the result of considering a range of terrain iterations between Scenarios II-A and II-B in order to identify a concept that most closely met the project goals and objectives. Scenario II-C was created with a broad floodplain swale interconnecting the gravel ponds and gentling sloping floodplain on both sides, with a 4-5 m high river bank. In its initial configuration, Scenario II-C retained ~2 m deep residual ponds where some perennial standing water would likely have remained in the pond furthest downstream (Vimark). Although this condition may not have persisted after a few storm events, feedback from the Scientific Working Group and Peer Review Panel in a January 2014 video conference supported revisions to resolve any residual pond depths.
- **Scenario II-D** evolved from Scenario II-C to address the concern about residual standing water. Lowering the expansive floodplain and swale by about 0.2 m allowed for completely filling the gravel ponds while not significantly lowering the river bank.

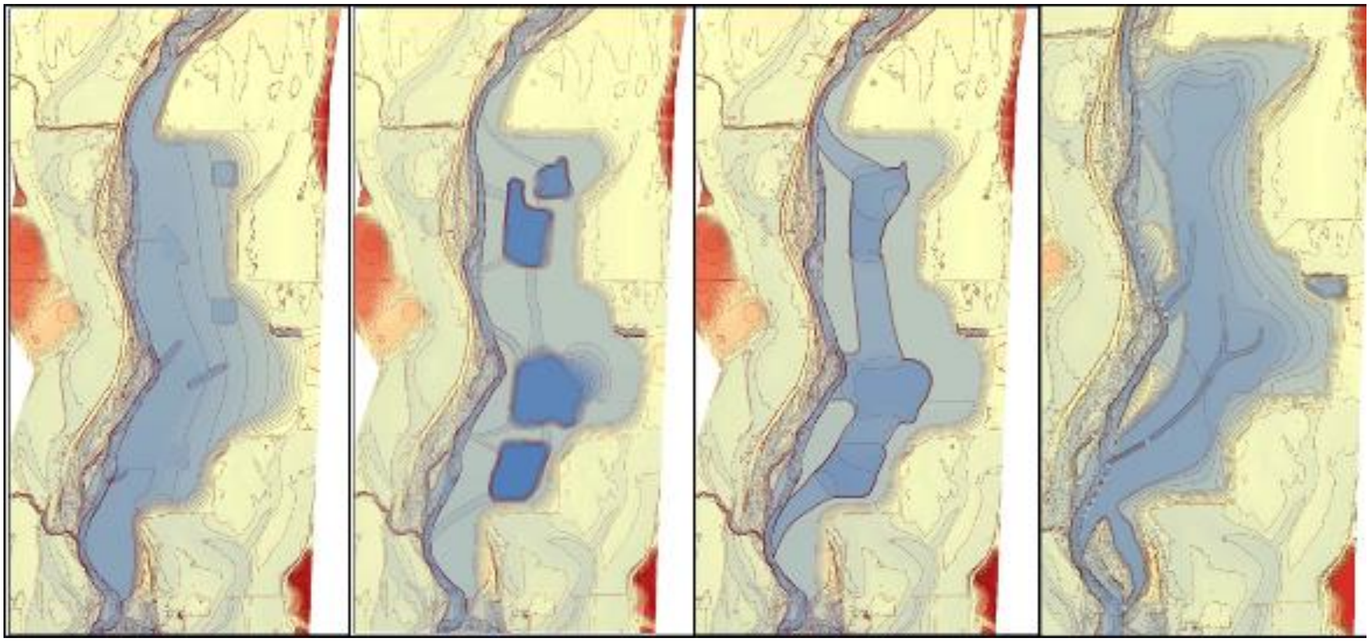


Figure 7.2. Stage II terrain concepts. The panels, left to right, are II-A, II-B, II-C, and II-D as described above.

7.6 Design and construction feasibility review

The Scenario II-D described above was vetted with an additional group of construction experts (Table 7.3) to seek feedback on constructability before advancing the terrain concept to the final phase of USGS modeling and subsequent evaluation. Feedback was supportive, and suggestions were limited to macro scale considerations for vegetation planting approach and possible use of woody debris in the construction.

Table 7.3. Construction review meeting participants. In addition to the project team, the construction review group included outside experts.

Brian Bair	US Forest Service, stream restoration construction leader
Ramon Martin	US Fish and Wildlife Service, floodplain restoration leader
Wayne Chang	Chang Consultants, consulting engineer
Damien Galford	Enviromine, Inc., mining and reclamation consultant
Richard Wantuck	National Marine Fisheries Service, Engineering Branch Chief
Blair Greimann	US Bureau of Reclamation, engineer and sediment expert
Terry Marshall	Hanson Aggregates Mid-Pacific, Inc., landowner representative
Mark Strudley	NOAA, National Weather Service, hydrologist

Terrain design modifications were made to accommodate an existing water right to the adjacent landowner, Jackson Family Wines. A five surface-acre pond at the northeast corner of the Richardson pond has been integrated into modeling for that purpose (Chapter 10, Plan Sheet 8). Other potential public amenities integrated into the Stage II-D terrain model included a kayak launch, parking, trails and campground illustrated in Chapter 10, Plan Sheet # 8. Lesser scale features such as trails were too small to depict in the terrain model but are spatially accommodated around the perimeter of the project.

7.7 Preferred Scenario II-E

Scenario II-E evolved from Scenario II-D following Scientific Working Group suggested refinements and improvements to scenario outcomes. Scenario II-E completely fills the ponds, creates a broad floodplain swale with gentling sloping eastern margin, retains a 4m high eastern river bank, creates two lengthy 'abandoned channel' analogs with perennial groundwater fed alcoves connected to existing deep river channel pools, and feathers into the upstream and downstream terrain at hydraulically appropriate locations for optimum performance (Figure 7.3). Scenario II-E then became the preferred terrain concept carried forward for detailed hydraulic and sediment transport modeling.

Specifically, Scenario II-E is a broad, gently sloping floodplain with an invert that is approximately 1 meter above the current river thalweg. The floodplain slopes gradually and consistently from north to south with an elevation change of 1.5 meters and a gentler east to west slope. It has an overflow divide at its upstream end that is 2 meters above river thalweg, and its downstream end is lower. This configuration floods from the downstream end before flow overtops the upstream inlet. An inlet/outlet is along the mid-length of the project with overflow elevation also 1 meter above river thalweg. The three areas of connection to the river are carefully defined so that the terrain elevation from the project feathers into the existing river banks in gradual and streamlined fashion to minimize potential for erosion and avulsion. Around the farmland boundary there is a gentle slope of 1v:10h gradient. The estimated earth work necessary to construct Scenario II-E is approximately 3.87 x 10^6 m^3 cut and 3.77 x 10^6 m^3 fill. This is an aggressive concept in scale, and it offers the greatest ecological benefits and lowest property risks of any scenario considered including the existing conditions. Habitat modeling discussed in Chapter 8 indicates it accomplishes the stated project goal.

Several options exist for potential small-scale features, including valuable nuances to quickly improve habitat performance that should be thoroughly vetted in the design stage. A preliminary list of design considerations for small-scale features is included in the Conceptual Design Plan Set (Chapter 10).

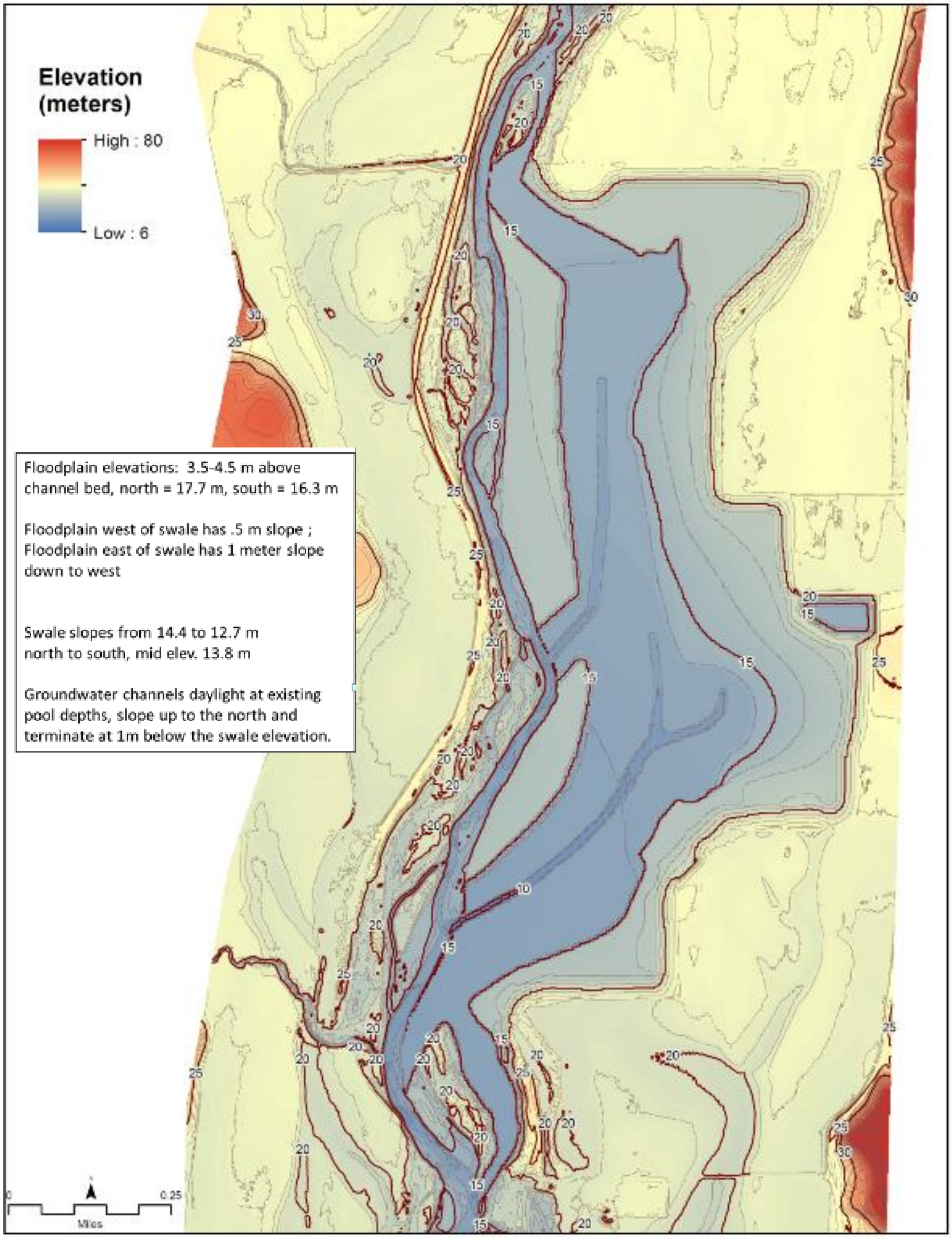


Figure 7.3. Scenario II-E topography. Topographic map of Scenario II-E —the proposed superior approach to floodplain restoration of the Hanson property.

Table 7.4. Descriptions of terrain scenarios developed for consideration in Stage II of the feasibility study. Common attributes for all Stage II scenarios: 1) balanced cut and fill volume, 2) gentle 1v:10h slopes from floodplain to farm fields, 3) floodplain slope in downstream direction parallel to the river slope, 4) east-west floodplain slope from the toe of the 1v:10h slope to the nearest drain at 0.5%, and 5) contour of inlet and outlet areas graded to conform to the existing river channel and banks.

Scenario Name	Stage II Scenario Descriptions				
	II-A **Low elevation gently sloping floodplain**	**II-B** **Higher elevation sloping floodplain**	**II-C** **Broad floodplain swale interconnecting ponds**	**II-D** **Broad lower floodplain swale with no ponds**	**II-E** **Broad floodplain with 'abandoned channel' analogs**
Scenario Description	• floodplain elevation 1.5 meters above river bed • no residual ponds	• floodplain elevation 4-5 meters above river bed • residual ponds ~5 meters deep during summer	• broad floodplain swale sloping from 14.4 to 12.7 meters N-S, interconnecting the residual ponds. • floodplain base elevation 4-5 meters above the river bed • residual ponds ~2.1 meters below swale invert with some perennial standing water	• broad floodplain swale about 0.2 m lower than II-C • floodplain base elevation 4-5 meters above the river bed • no ponds remaining • two drainage channels ~1 meters deep into the broad floodplain swale, daylighting into existing river channel pools, likely to intersect groundwater and be spring-fed.	• modified II-D with 2 lengthy 'abandoned channel' analogs with perennial alcoves connected to existing deep river pools • graded into the upstream and downstream terrain • floodplain base elevation 4-5 meters above river bed • no ponds remaining • 25 acre foot water supply pond (Jackson Pond) at NE corner of Richardson pond • 30' property line setback on N, E and S to allow a trail. • canoe launch & vehicle turn-around near river on NW side • campground pad along E boundary
Modeled by USGS					**X**

CHAPTER

8 Evaluation of the Physical and Biological Responses in Alternative Restoration Scenarios

8.1 Hydraulic and sediment transport modeling summary

EHC contracted with USGS to develop hydraulic and sediment transport computational models for the study reach, specifically to define the existing condition and predict how proposed conditions would perform. A summary of the USGS report follows and the complete report is in Appendix G.

To assess the relative and overall impacts of the scenarios discussed in previous chapters (Chapter 7, Stage I-A through I-D and Stage II-E scenarios), each of the topographic configurations were evaluated over a range of flows. This evaluation was carried out using computational flow modeling tools available in the iRIC public-domain river modeling interface (www.i-ric.org, Nelson *et al.*, in press). Using the iRIC modeling tools (described in more detail in Appendix G), basic hydraulic computations of water-surface elevation, velocity, shear stress, and other hydraulic variables were carried out for the Existing Conditions and a number of alternatives in the reach surrounding the project area. The modeled reach extends from the confluence of Dry Creek (upstream) to the Wohler road bridge (downstream), and Eastside to Westside Roads, for the full range of observed flows. Note that the model reach is slightly shorter than the study reach, which extends to the Healdsburg Highway 101 Bridge.

This methodology allows comparison of the current channel configuration with the proposed alternatives in terms of inundation period and frequency, depth, water velocity, and other hydraulic information that are integral to achieving the project goals and objectives. By integrating this kind of information over the study reach and flow record, critical metrics assessing the impacts of various topographic modifications can be compared to those same metrics for the existing condition or other modification scenarios.

In addition, because the iRIC tools include predictions of sediment mobility, suspension of fines, and the potential evolution of the land surface in response to flow, these methods provide evaluation of sediment transport, stability of current and proposed surfaces, and evaluation of how these surfaces might evolve into the future. This hydraulic and sediment transport information is critically important for understanding the impacts of proposed restoration alternatives on the physical system. Perhaps even more significantly given the goals and objectives of the proposed restoration, this information can also be related to key habitat metrics and biological impacts as discussed in Section 8.3.

This chapter evaluates the physical and biological responses to the floodplain restoration alternatives modeled by USGS. Chapter 9 assesses how well each alternative achieves the project goals and objectives outlined in Chapter 6.

8.2 Evaluation of physical responses to modeled restoration alternatives

Graphical presentations of model output are used to provide both basic factual information for each alternative and comparison between scenarios to the greatest degree possible. The evaluation covers four areas:

1. basic hydraulics
2. flood inundation
3. sediment transport metrics
4. erosion and deposition

These four topics give a good overview of differences between the proposed scenarios in terms of physical characteristics and also lay the groundwork for a deeper discussion about how the interaction of flow with the land surface morphology might drive the ecology for the various scenarios.

Erosion and deposition were evaluated by setting the model to evolve topography in response to a few characteristic winter hydrographs and an assumed equilibrium sediment supply. To guide the evaluation of future potential topographic change, the model was stimulated to produce the greatest topographic change by selecting the most sensitive model parameters for sensitivity analysis, *i.e.,* a 1.0 meter lower downstream boundary water surface elevation, a finer average grain size, and a prolonged flow recession hydrograph, which were used for several final model runs.

For all model runs with a floodplain, water surface elevations decrease at all flows in the project area and some limited distance upstream. Comparative water surface elevations are shown in Figure 8.1 (also see Appendix G, Figure 65) for flows ranging from winter base flow to the 100-year flood. For large and infrequent flood flows including the 100-year flood, flood elevations are reduced within the project area, and the extent of surrounding agricultural lands inundated is reduced with implementation of the floodplain restoration concept, as shown in Figure 8.2 (also see Appendix G, Figure 55).

The current pattern of channel erosion and deposition is focused along the margins of the channel. Bed elevation changes of +/- 2 meters are predicted during normally occurring winter storm flows, shown in Figure 8.3 (also see Appendix G, Figure 86). This model-predicted pattern was observed during repeat bathymetric mapping of the study reach as discussed in Chapter 4. The existing river banks are geotechnically unstable due to their height and steepness, and bank failure is commonly observed during storm flows (Chapter 4). Bank failure is often intensified at localized areas of river bends if erosion of the bank toe locally steepens the bank, and at locations where land drainage saturates the river bank.

For the same model parameters under the Scenario II-E floodplain concept, Figure 8.4 (see also Appendix G, Figure 89), the majority of areas currently cycling +/- 2 meters of erosion and deposition become relatively stable and a new predicted pattern of deposition and reworking of deposits is concentrated in the upstream inlet area of the restored floodplain. The USGS model is not intended to examine geotechnical bank erosion, but the part played by fluvial erosion of steep bank toes in bank erosion overall is predicted to decrease (compare Figures 8.3 and 8.4). The geotechnical drivers of bank failure, bank height, slope, and saturation cycling, are all predicted to decrease with the floodplain concept, however, the USGS team cautions that future bank stability will continue to be uncertain (Appendix G).

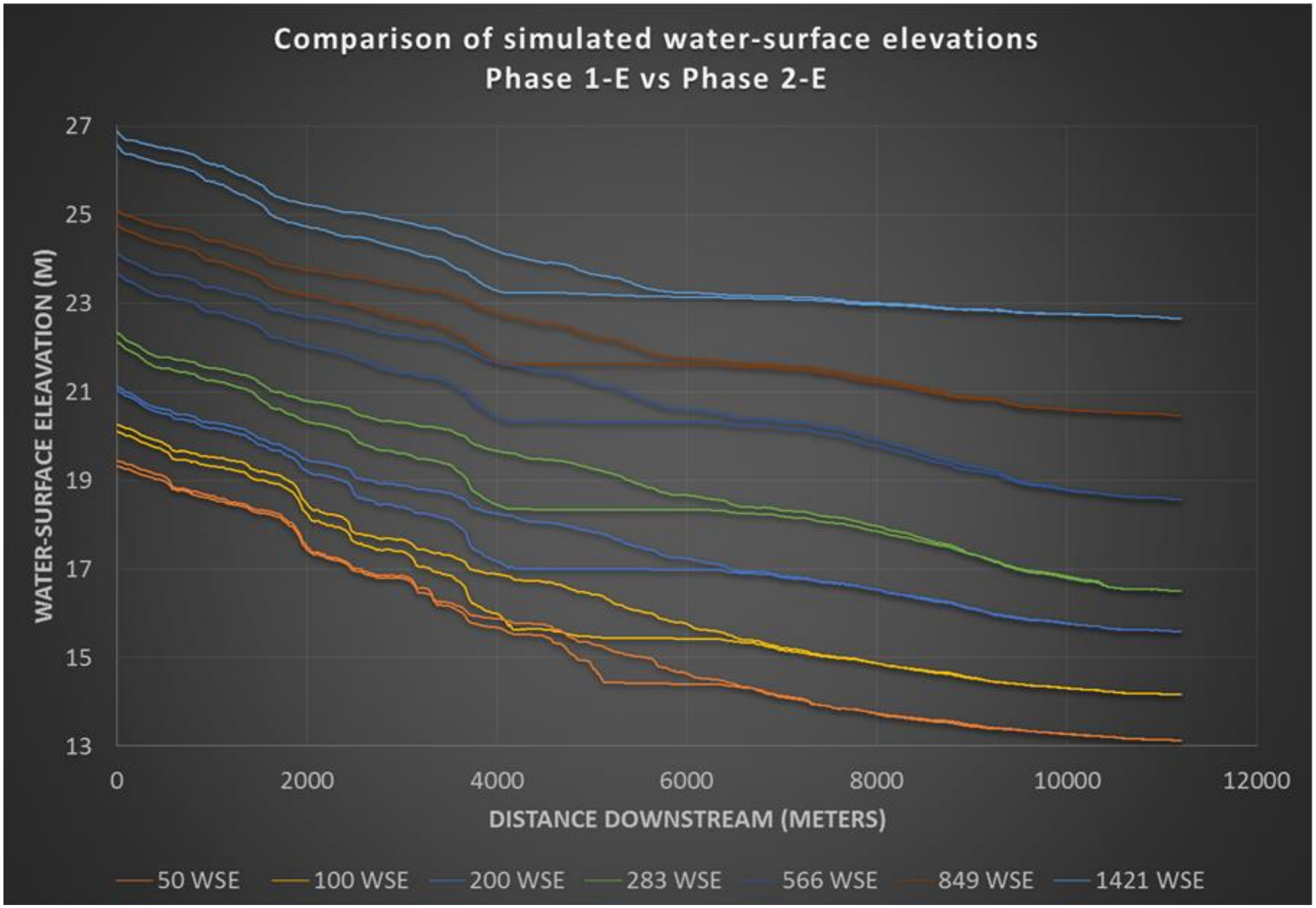


Figure 8.1. Simulated water-surface elevations. With implementation of floodplain restoration, water-surface elevations are reduced for all flows in the project area. This example is a comparison between calibrated Existing Conditions (Stage I-A) and the preferred Scenario II-E floodplain concept (shown as Phase 2-E in figure title), but similar results occur for all floodplain restoration alternatives.

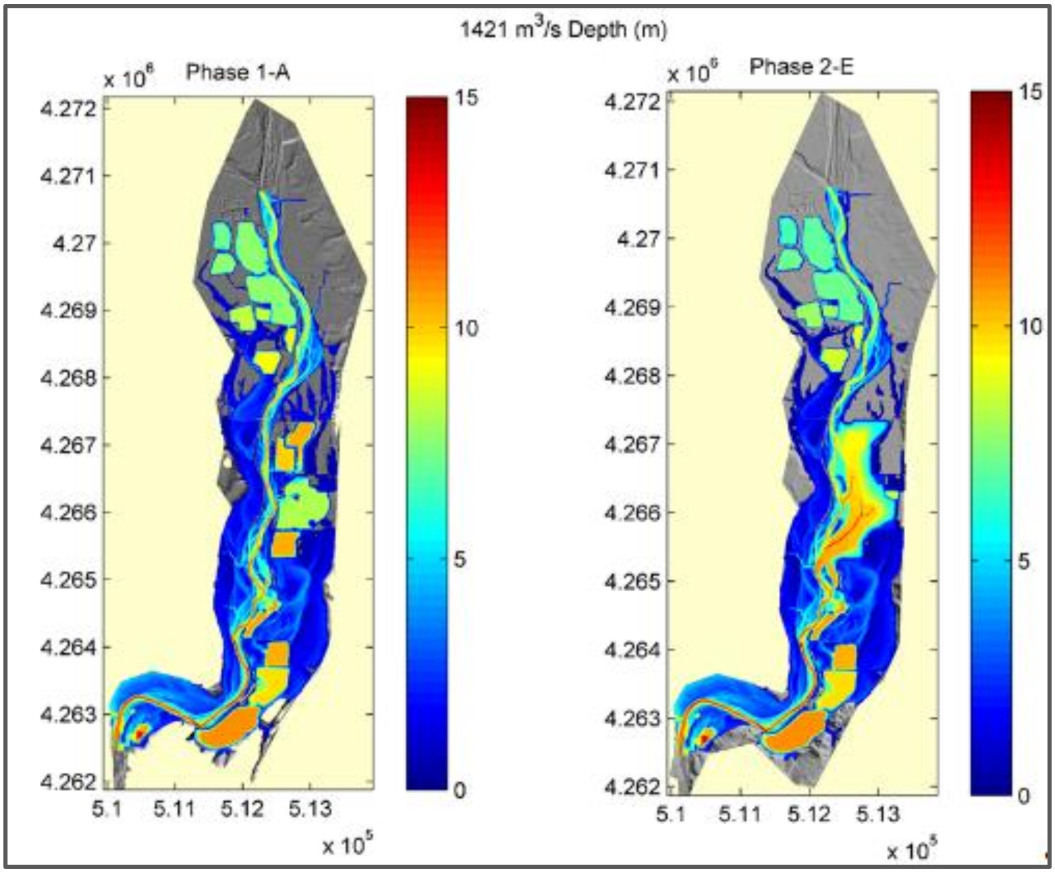
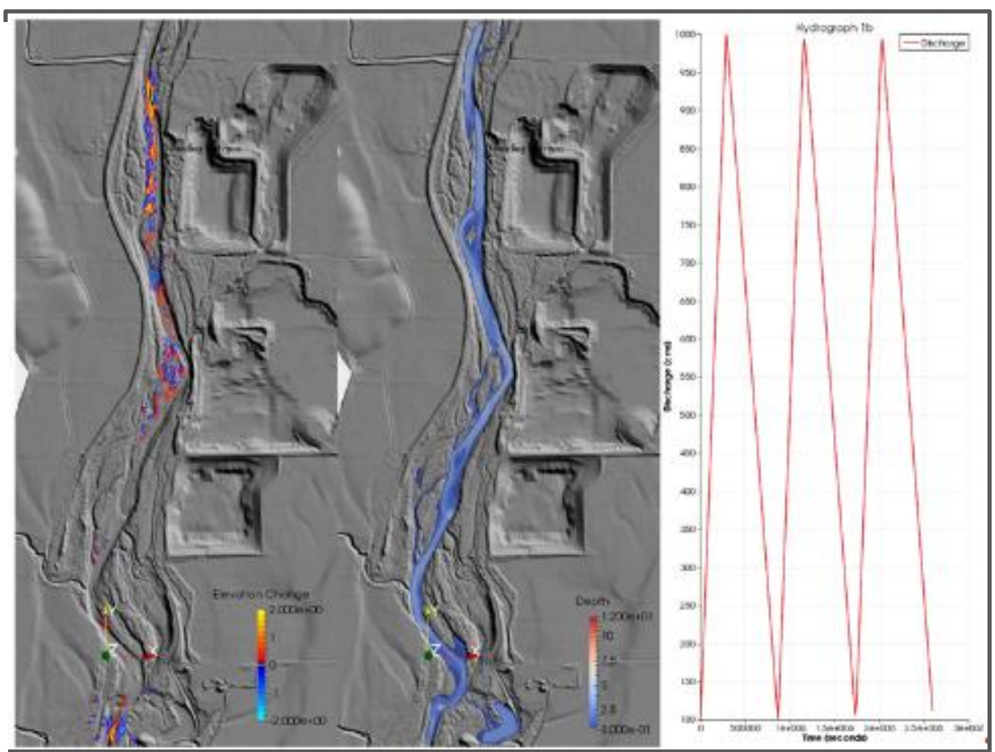


Figure 8.2. Water depth maps for 100-year flood. Water depth maps for the 100-year flood comparing Existing Conditions (Stage I-A) and the floodplain concept Scenario II-E (labeled as Phase 1-A and Phase 2-E in figure).

Figure 8.3. Erosion and deposition patterns for Existing Conditions (Stage 1-A) simulation after three significant floods. Left panel - typical erosion and deposition pattern of the existing conditions model. Resulting predicted elevation changes are focused on the edges of the unvegetated channel. Middle panel – water depth at the end of simulation. Right panel – modeled hydrograph. See Figure 86 in Appendix G for more details.



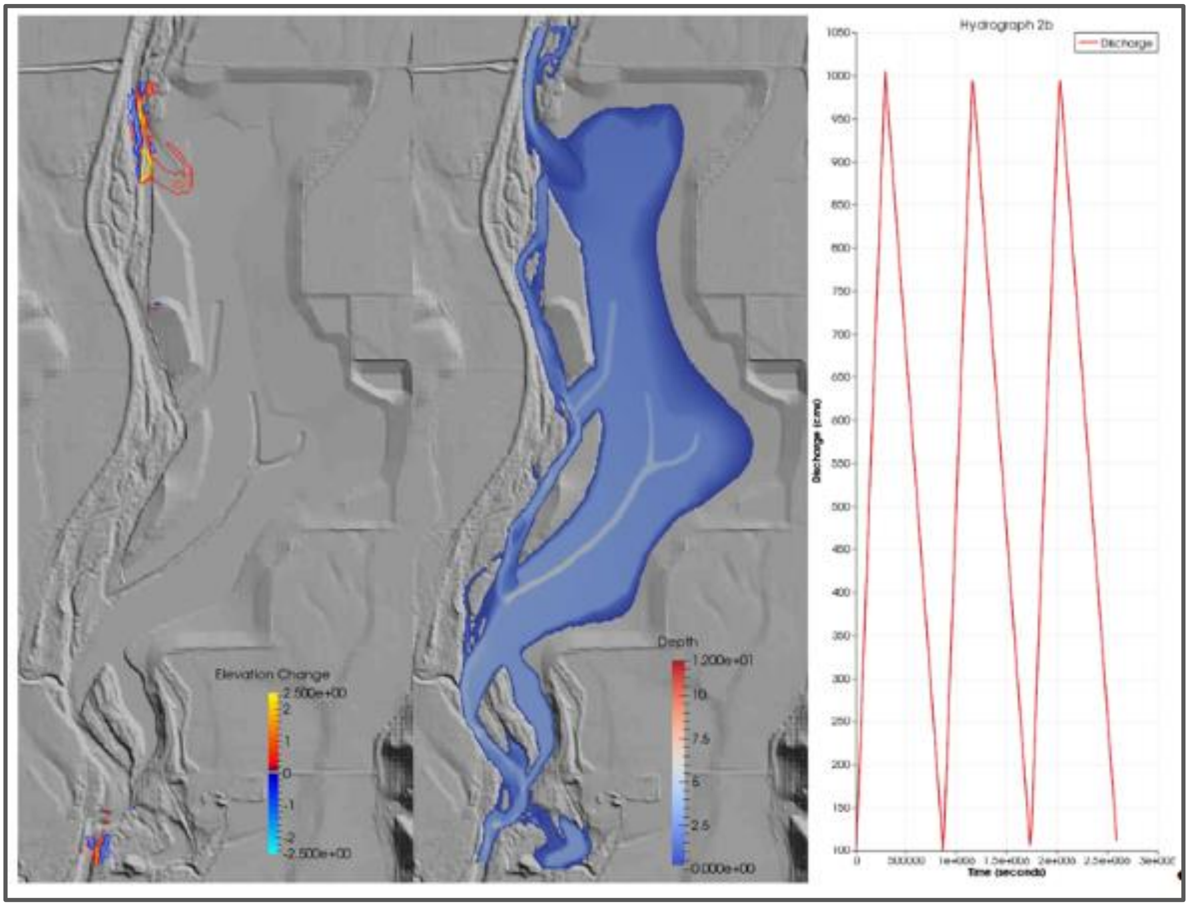


Figure 8.4. Erosion and deposition pattern for floodplain concept Scenario II-E. Using the same model parameters used in the prediction map in Figure 8.3. Left panel - erosion and deposition pattern of the Scenario II-E model. Resulting predicted elevation changes are focused in the upstream floodplain inlet area and the main channel is steady. Middle panel – water depth at the end of simulation. Right panel – modeled hydrograph. See Figure 89 in Appendix G for more details.

Model sensitivity testing for Scenario II-E was accomplished by lowering the downstream boundary, assuming the finest measured sediment size, and using a more sensitive algorithm to force the model to predict where and how the greatest changes may occur for the proposed floodplain condition. The areas of greatest change are the upstream floodplain inlet where a delta form is predicted, and the adjacent river channel where deposition is predicted. The delta is predicted to cycle between erosion and deposition as flood flows rise and fall, Figure 8.5 (see also Appendix G, Figures 90-94). Deposition of a delta up to 2 meters thick during peak flows is predicted to be followed by 2 meters of channel formation during flood recession. This pattern could produce spawning beds because the predicted grain size for the delta form is up to 15-20 mm, and tend to prolong floodplain inundation as a channel reforms in the former inlet deposit.

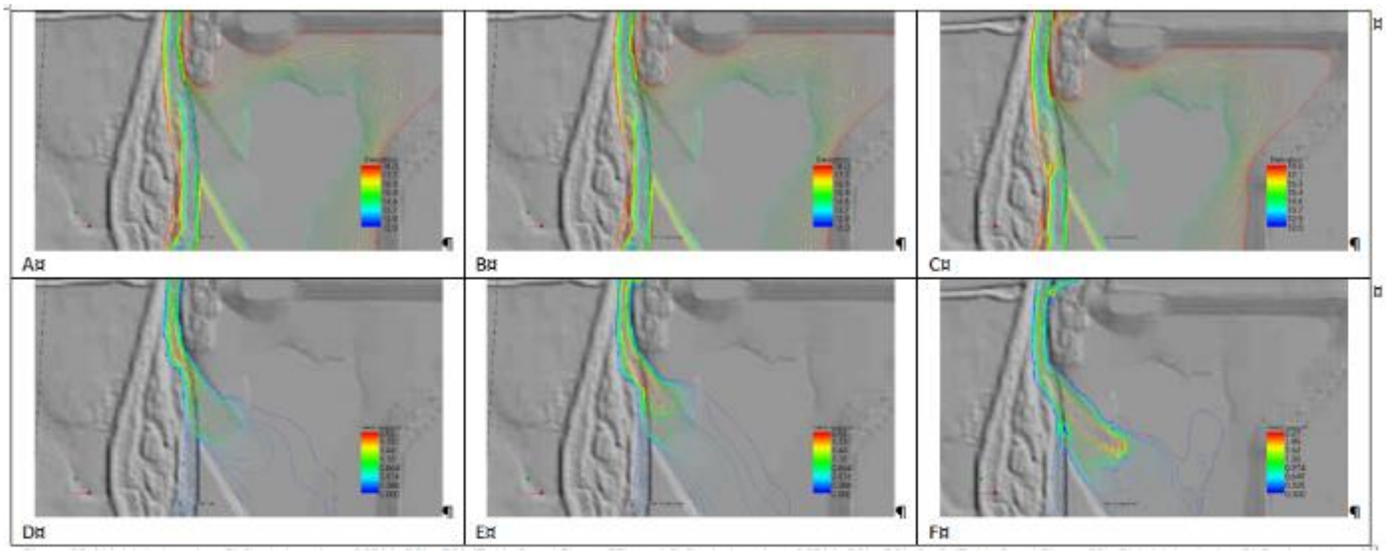


Figure 8.5. Predicted area of greatest topographic change during the modeled flood simulation (see Figure 8.4, right panel). Provoking the model to predict the maximum likely topographic change was done by lowering the downstream boundary, reducing the grain size, and using a more sensitive algorithm. The outcome is displayed in the six panels above, representing the peak of the first flood (A), the end of the first flood (B), the peak of the second flood (C), and so on. The upstream floodplain inlet and adjacent channel are predicted to have the greatest topographic change. A gravel delta will form during floods and a channel will form in the delta deposit as the flood recedes. See Appendix G, Figures 90-94 for more details.

Upstream from the floodplain inlet for approximately 150 meters the model predicts an increase in the maximum mobile size of sediment but negligible bed elevation change, likely resulting in a coarsening of the riffles in this area. For the range of flows that inundate the proposed floodplain, the model predicts a decrease in sediment transport and deposition in the main river channel adjacent to the floodplain, Figure 8.6 (see also Appendix G, Figure 73).

The main river channel will likely alternate between deposition and transport until a new equilibrium is reached with flow and sediment transport on the floodplain.

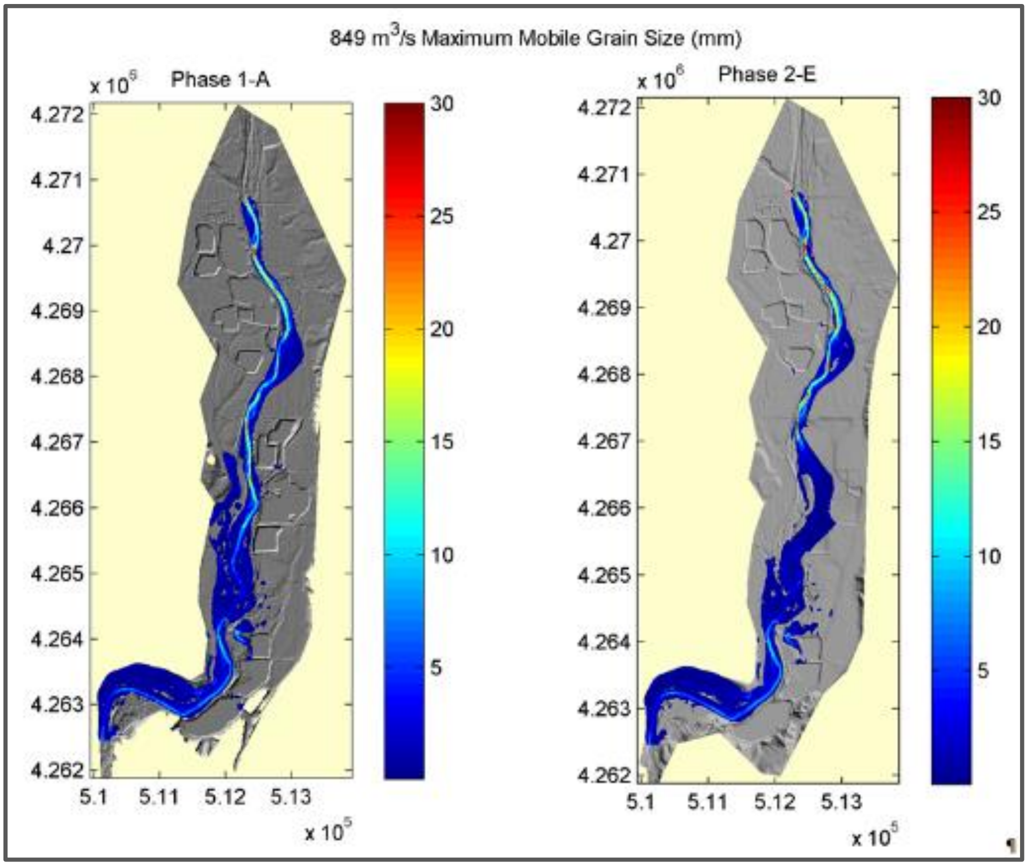


Figure 8.6. Maximum mobile grain size (bedload) comparison between Existing Conditions and floodplain concept Scenario II-E. The greatest differences occur in the channel adjacent to the floodplain and upstream approximately 150 meters. Coarser riffles may form where the mobile grain size increases, and deposition is likely where the mobile grain size decreases. Color scale indicates sediment sizes transported. Existing Conditions shown as Phase 1-A, and Scenario II-E shown as Phase 2-E in Figure. See Appendix G, Figure 73 for more details.

8.2.1 Fine sediment predictions.

The Russian River transports a relatively high suspended sediment concentration (Ritter and Brown 1974) as well as several constituents of concern and nutrients (Chapter 4) during normal and large winter storm flows. Mobile suspended sediment size plots (Figure 8.7; and Appendix G, Figure 73) predict that deposition of suspended sediment varying from fine sand to silt is likely to occur over the floodplain. Creating a deposition zone where a range of constituents can be sequestered, processed, oxidized, and with nutrient uptake, can have many environmental benefits in the reach, and downstream. Restoring floodplain depositional processes is one of the goals of the project, leading to improved downstream water quality and valuable habitat building substrate.

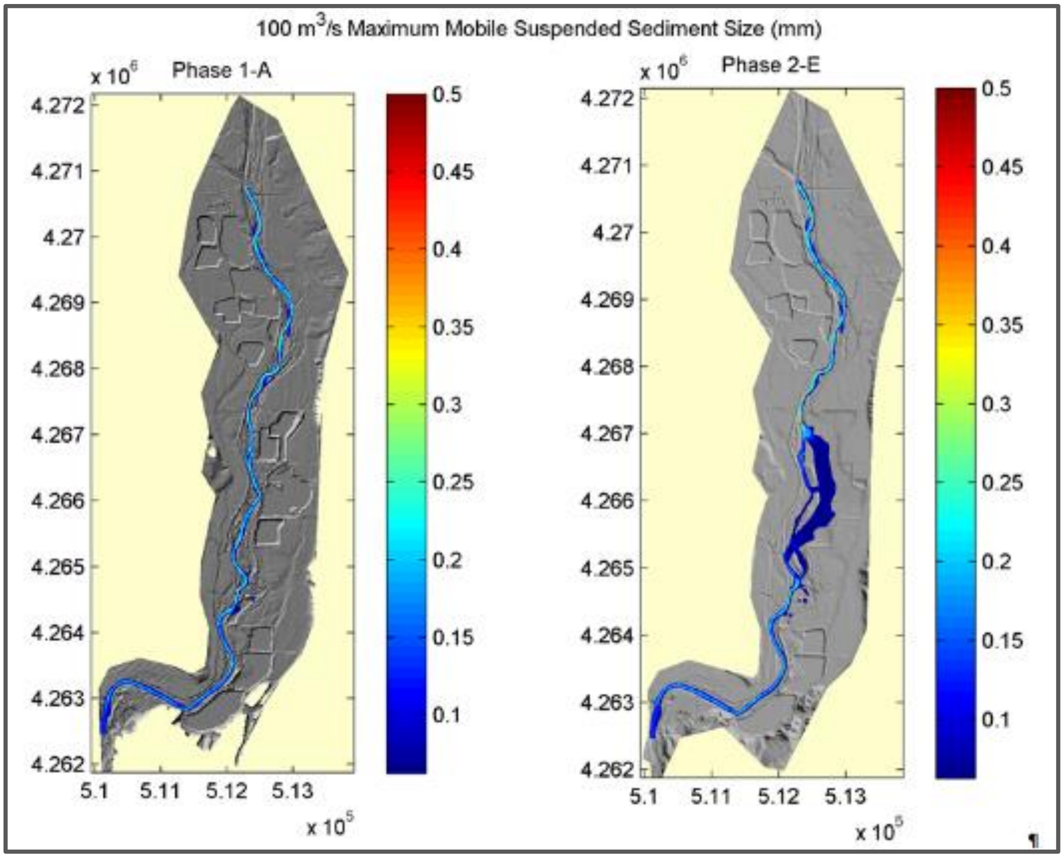


Figure 8.7. Suspended sediment deposition zone for restored floodplain. The proposed floodplain becomes a deposition zone for small suspended sediment (sand and silt) over the entire range of flows examined. This plot is one example. Refer to Appendix G, Figures 75-83 for the complete range of flow conditions. Existing conditions labeled as Phase 1-A and Scenario II-E as Phase 2-E in figure.

8.2.2 Vegetation predictions.

Ideal water table depth and substrate conditions to promote rapid vegetation growth are likely to occur across the floodplain. Exceptions to this overall pattern are the permanently wet, low-lying channels, lower floodplain swale at the downstream outlet, and portions of the delta form where annual erosion is predicted to follow deposition.

Vegetation growth will quickly enhance biological productivity of fish prey species and begin interacting with deposition and erosion processes to create more complex heterogeneous macro geomorphic features. As topographic features evolve in response to vegetation growth, a complex network of successional islands and small channels are expected. This will make the habitat even richer for native fish and wildlife than predicted in the next section.

8.3 Evaluation of biological responses to modeled restoration alternatives

Restoration of highly productive floodplain rearing habitat for juvenile salmonids is a primary goal for the project feasibility study. Thus the USGS model results were analyzed for the key habitat metrics of depth, velocity, and duration of inundation for a range of hydrologic conditions that define productive floodplain rearing conditions for the juvenile life stages of salmonids.

To assess the biological response to the hydraulic model outputs, the outputs were sorted to include the Hanson project area (rather than the entire study reach) and the different model grids were scaled to equivalent area units. As explained in Appendix G, three different model scales were needed to analyze the range of flows depending on the extent of area inundated.

A standardized analysis area was selected based on the extent of the smallest mesh, and the two larger meshes were sorted to exclude output for areas outside the smallest mesh model. The number of elements in the different outputs was multiplied by the representative surface area of each element to derive measures of areas inundated. Extent and duration of inundated area were calculated for each of the 10 modeled steady state discharges, for both Existing Conditions and Scenario II-E.

The feasibility study used two dimensional hydraulic modeling because it is appropriate and required for detailed analysis and comparison of proposed and Existing Conditions. Each element and node in two-dimensional model output has a depth, average velocity, and direction of flow associated with it. Habitat was evaluated in two ways:

1. Measuring wet versus dry areas occurring over a wide range of hydrologic conditions representative of wet, dry, and average water year hydrographs, and
2. Summing the inundated areas with depth and velocity conditions that meet identified key habitat metrics for the most productive juvenile salmonid rearing conditions.

Inundated areas were further sorted using the key habitat metrics recommended by the Scientific Working Group (SWG):

- flow velocity of 35 centimeters per second or less
- water depth of 1 meter or less
- five week floodplain inundation duration

The additional sorting of the inundated area was done to isolate those that met the first two key juvenile rearing criteria listed above. The five week floodplain inundation duration was recommended to provide rapid growth significantly increasing smolt survival rates in the marine environment. The duration of inundation metric is simply a measure of time.

The completed analysis based on these three key metrics of juvenile salmonid rearing habitat resulted in two striking outcomes:

1. There is very little juvenile rearing habitat available under the Existing Conditions scenario and the prediction for the Existing Conditions scenario probably over-estimates benefits to salmonid populations because those model areas meeting the criteria are not clustered in patches that juvenile fish can move to easily as flow and stage change during normal winter storm flows. Instead, suitable habitat nodes under the Existing Conditions scenario are distributed widely throughout the project area, and areas outside of the river channel meeting the criteria (associated with the ponds) likely do not confer substantial benefits to the populations.

2. Juvenile rearing habitat in Scenario II-E is an order of magnitude (an increase of ten-fold) or greater than under Existing Conditions, under all conceivable annual hydrologic conditions.

Figures 8.8 to 8.22 illustrate the habitat evaluations for the Existing Conditions scenario (Stage I-A) and Scenario II-E for dry, average, and wet water years.

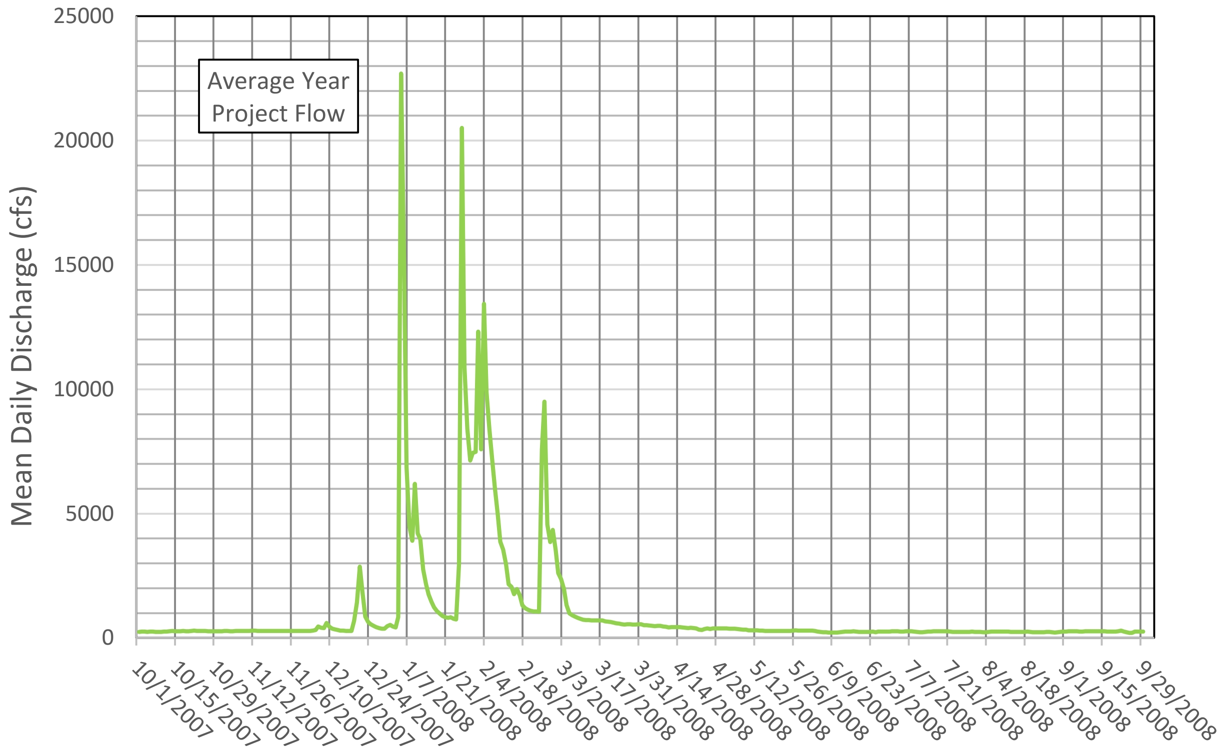


Figure 8.8. Mean daily flow at the project site for an average water year.

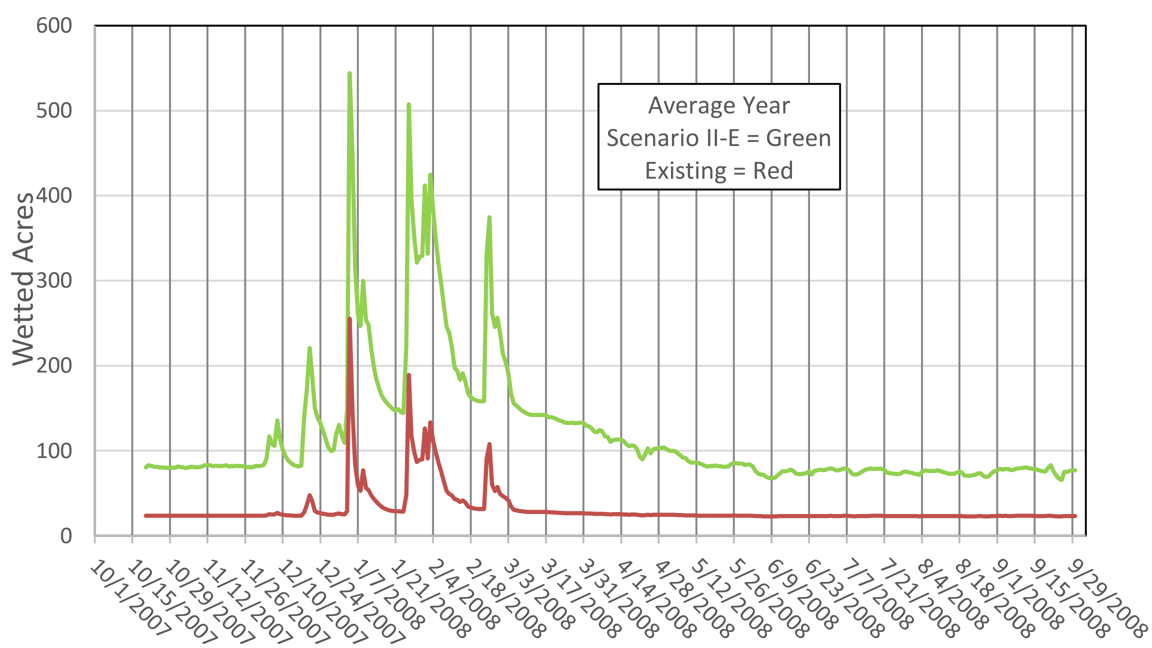


Figure 8.9. Mean daily inundated area over time at the project site for an average water year.

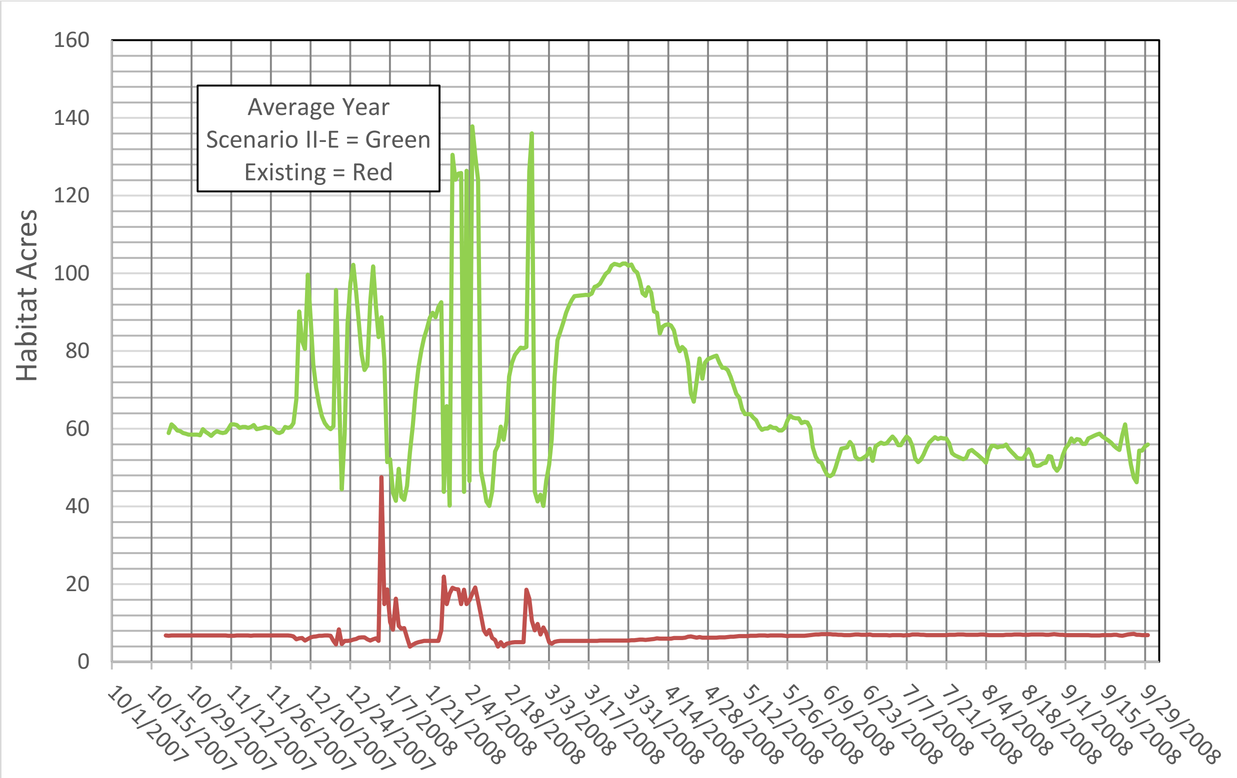


Figure 8.10. Juvenile rearing habitat area over time at the project site for an average water year.

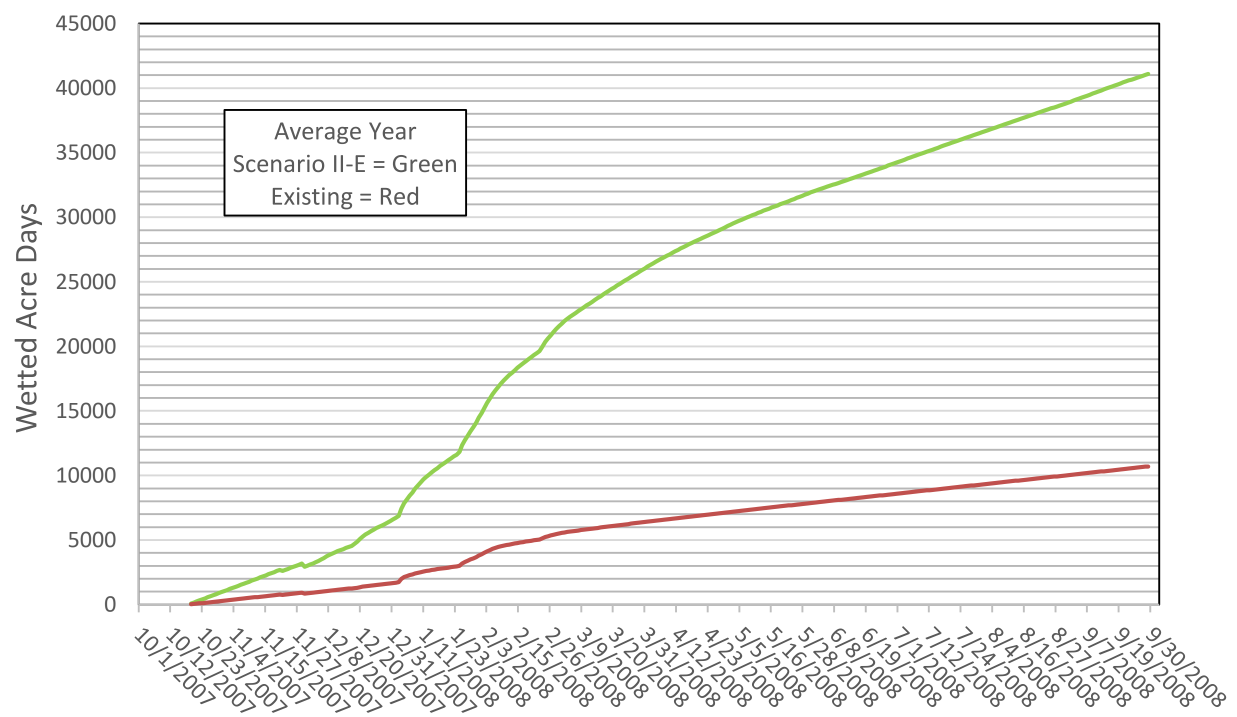


Figure 8.11. Cumulative inundated area at the project site for an average water year.

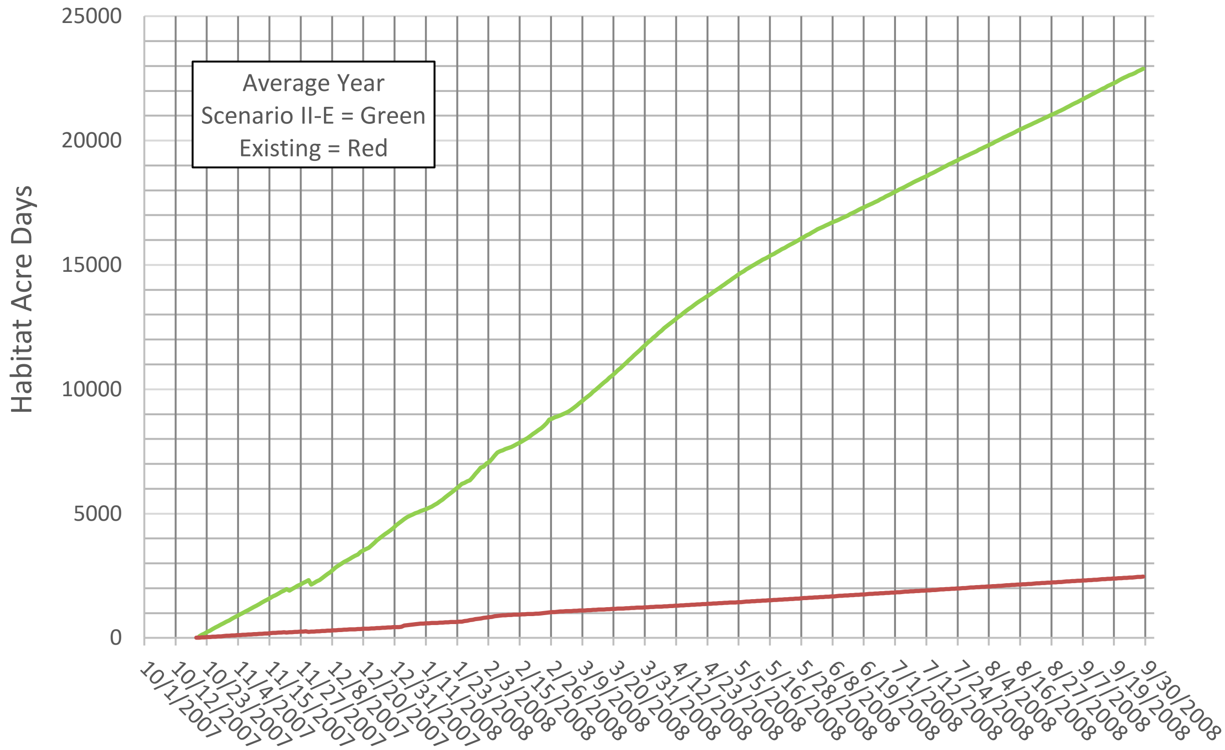


Figure 8.12. Cumulative juvenile rearing habitat at the project site for an average water year.

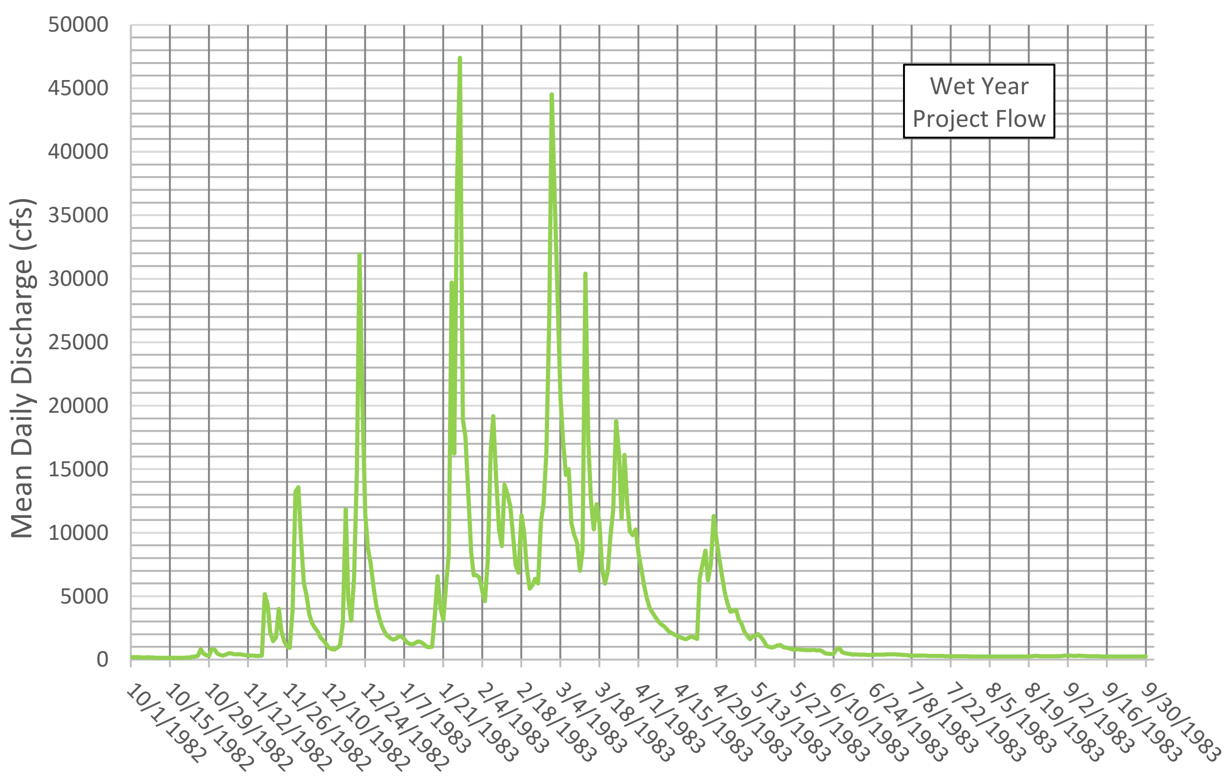


Figure 8.13. Mean daily flow at the project site for a wet water year.

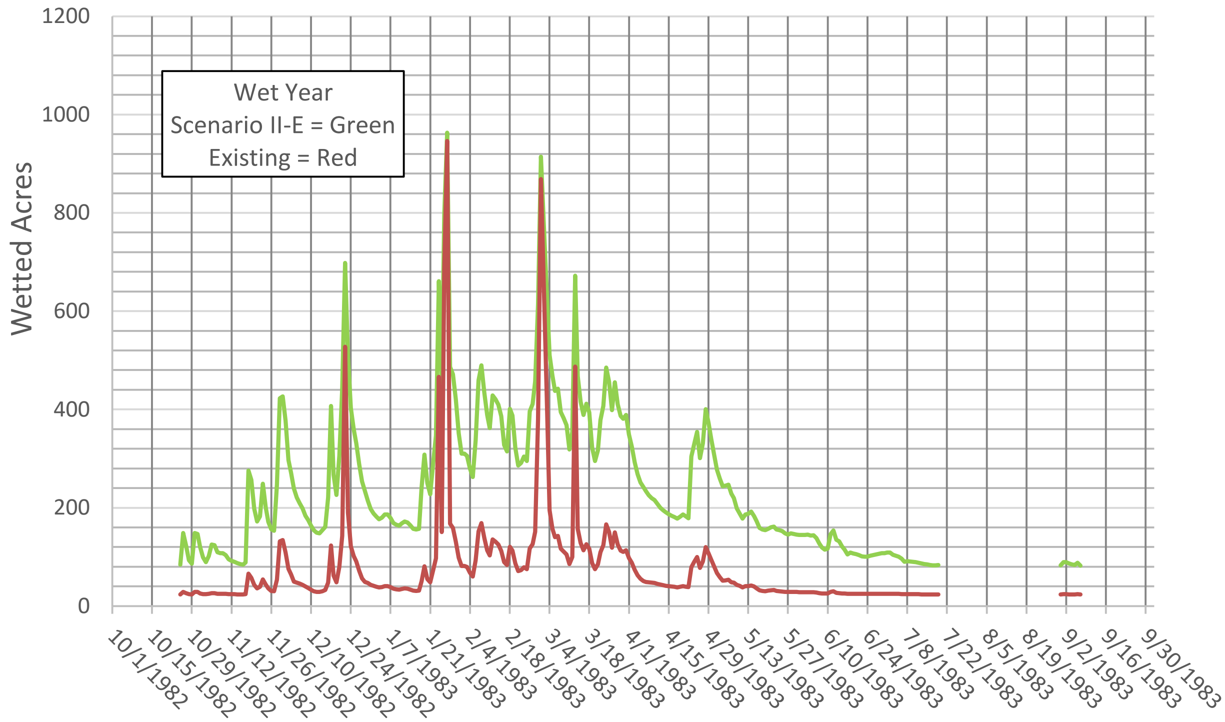


Figure 8.14. Mean daily inundated area at the project site for a wet water year.

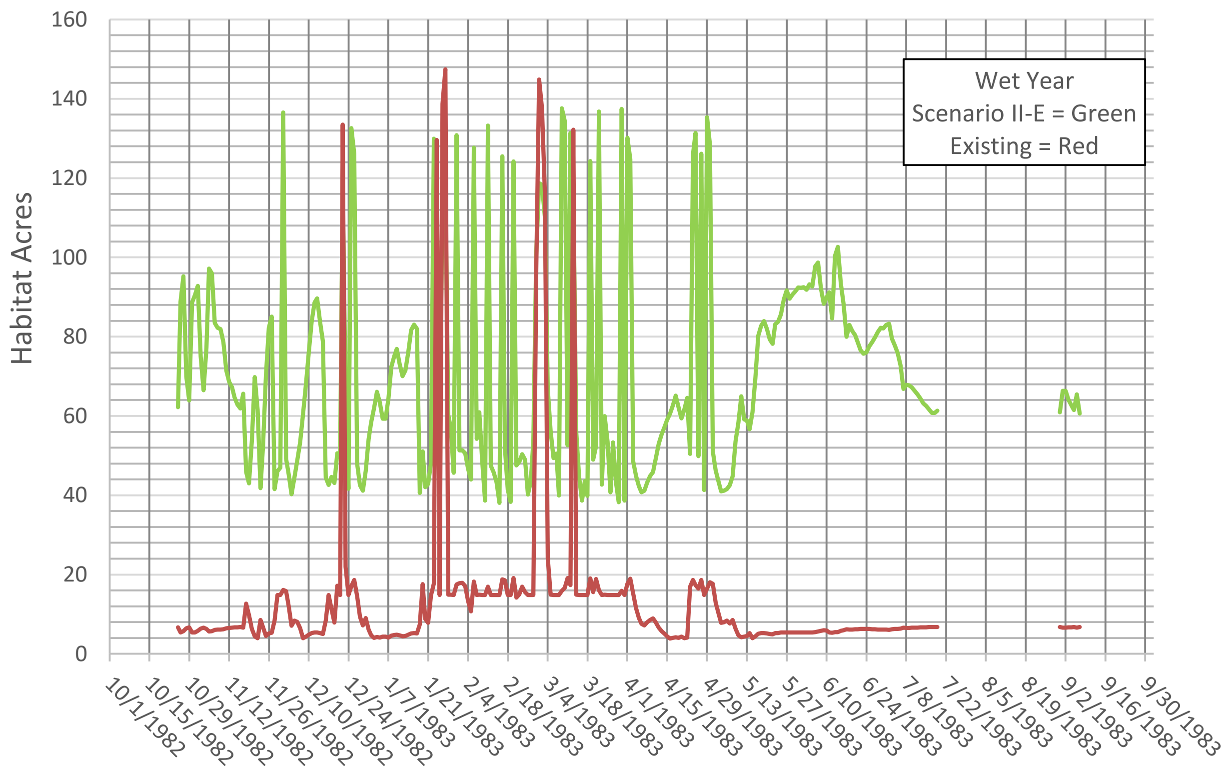


Figure 8.15. Juvenile rearing habitat over time at the project site for a wet water year.

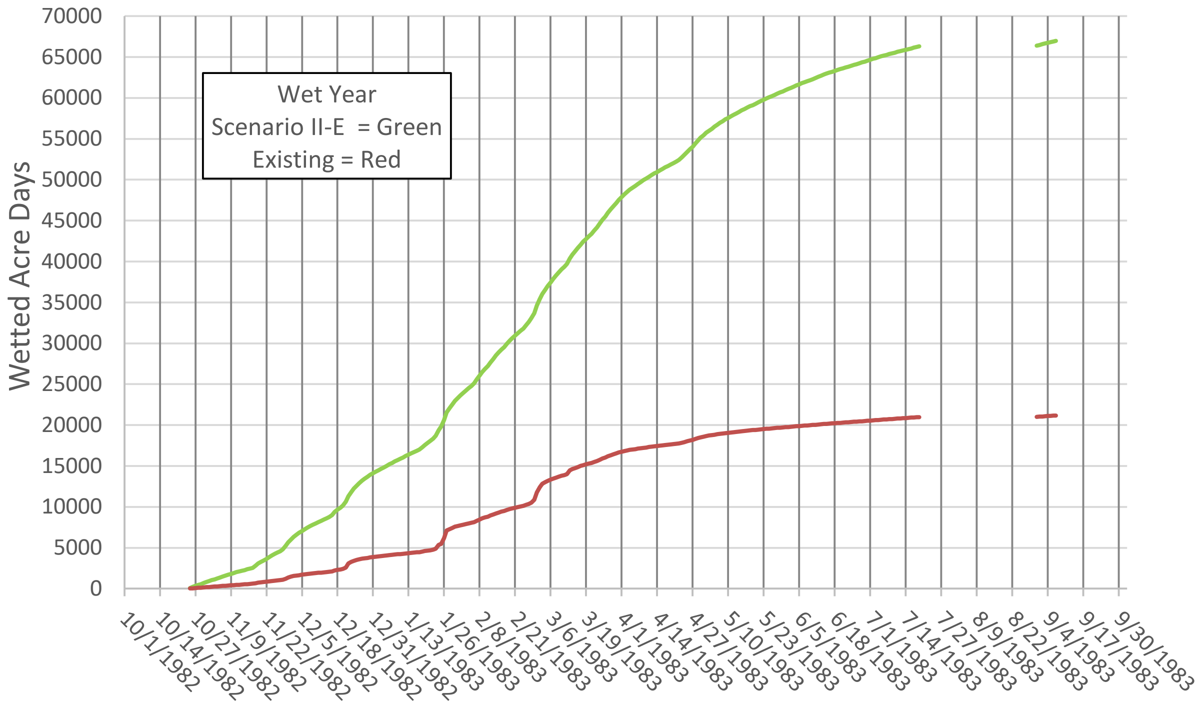


Figure 8.16. Cumulative inundated area over time at the project site for a wet water year.

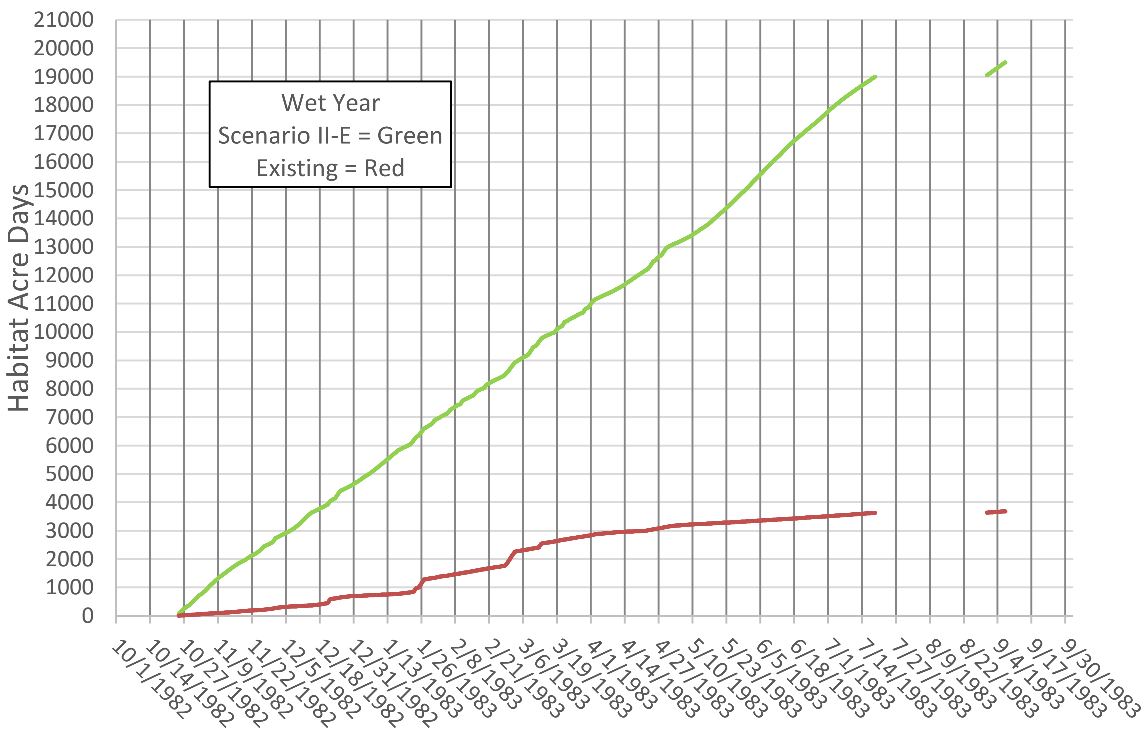


Figure 8.17. Cumulative juvenile rearing habitat area over time at the project site for a wet water year.

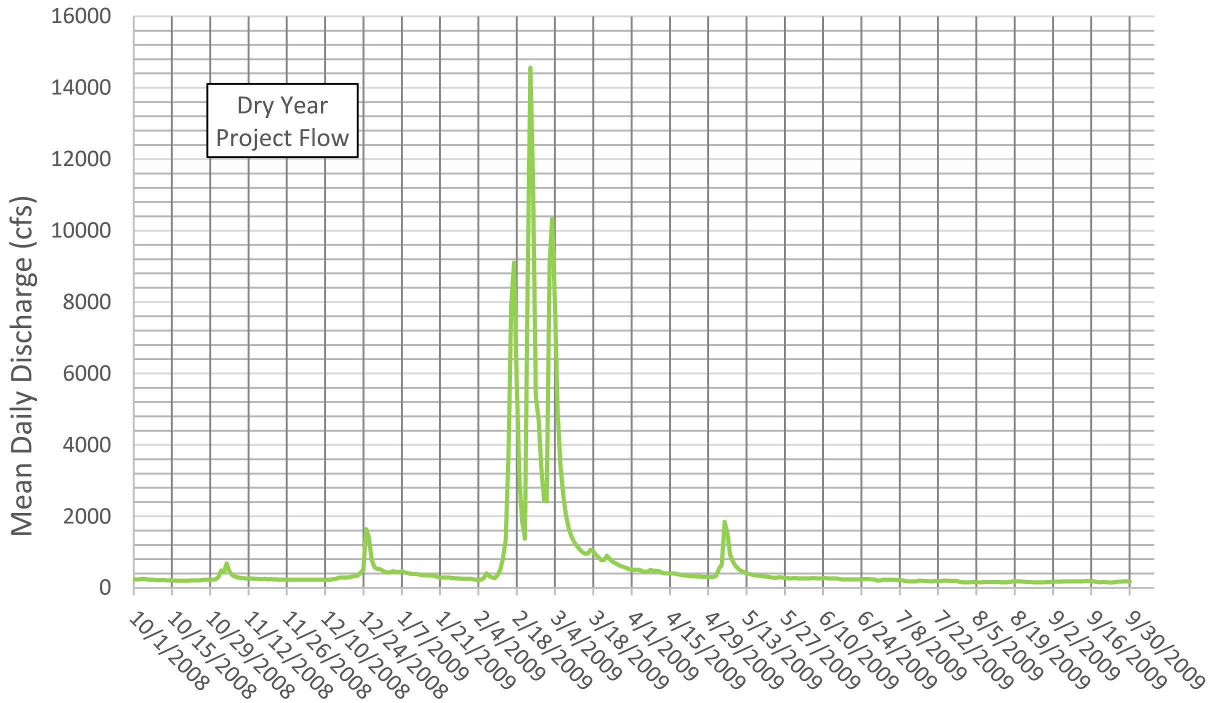


Figure 8.18. Mean daily flow at the project site for a dry water year.

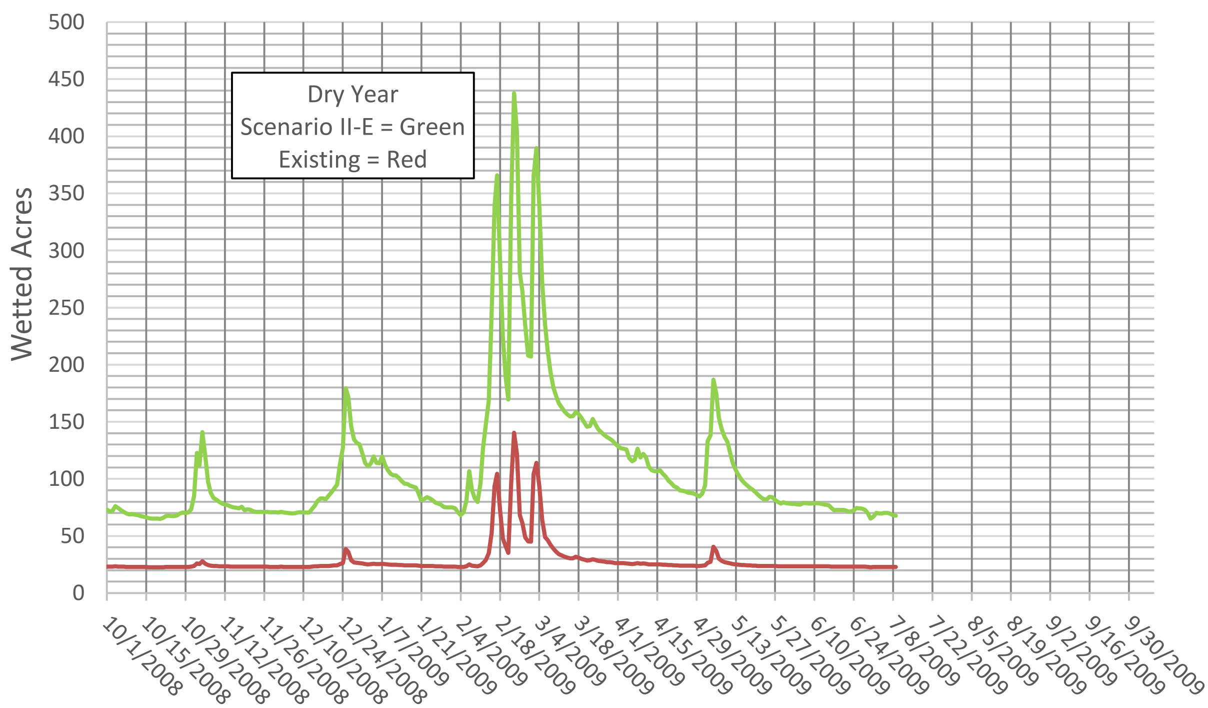


Figure 8.19. Mean daily inundated area over time at the project site for a dry water year.

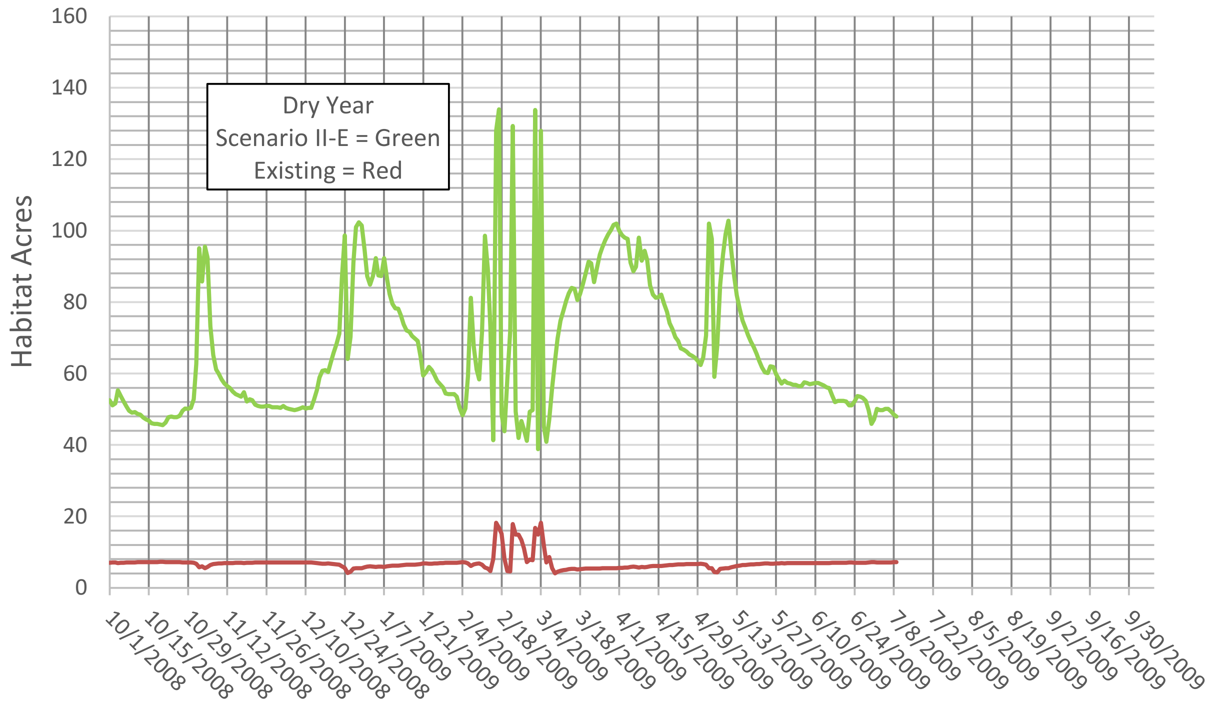


Figure 8.20. Mean daily juvenile habitat area over time at the project site for a dry water year.

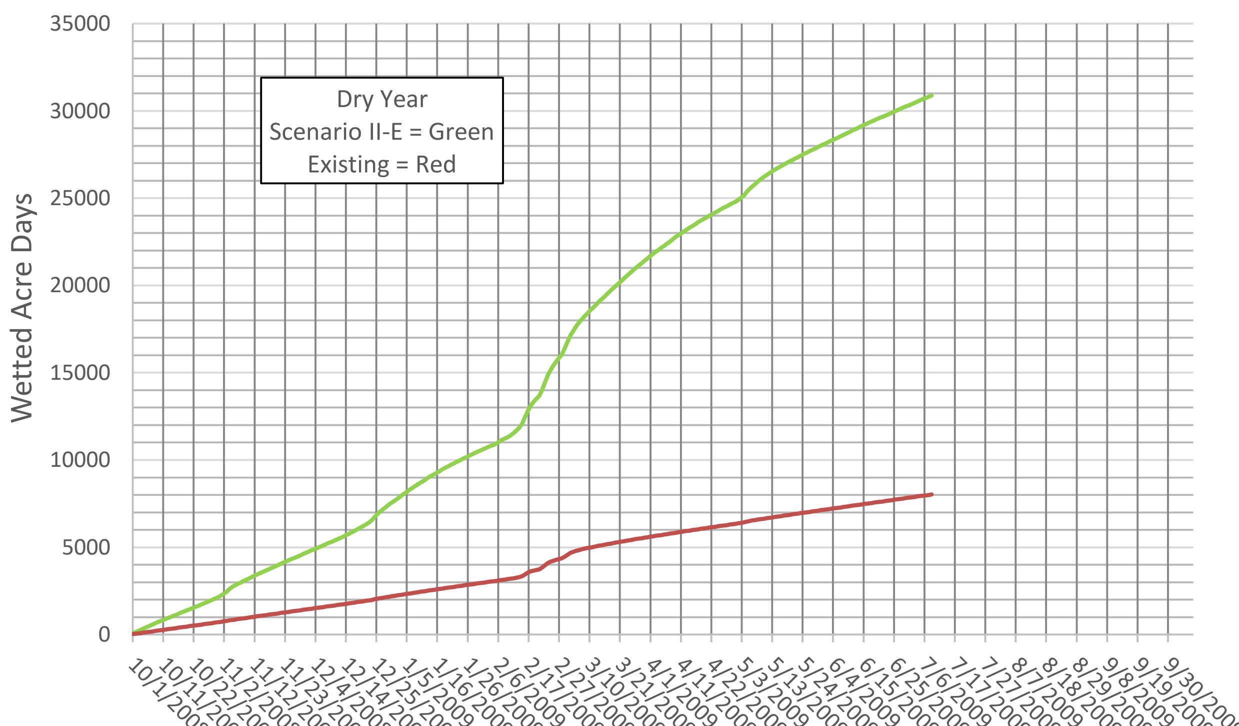


Figure 8.21. Cumulative inundated area over time at the project site for a dry water year.

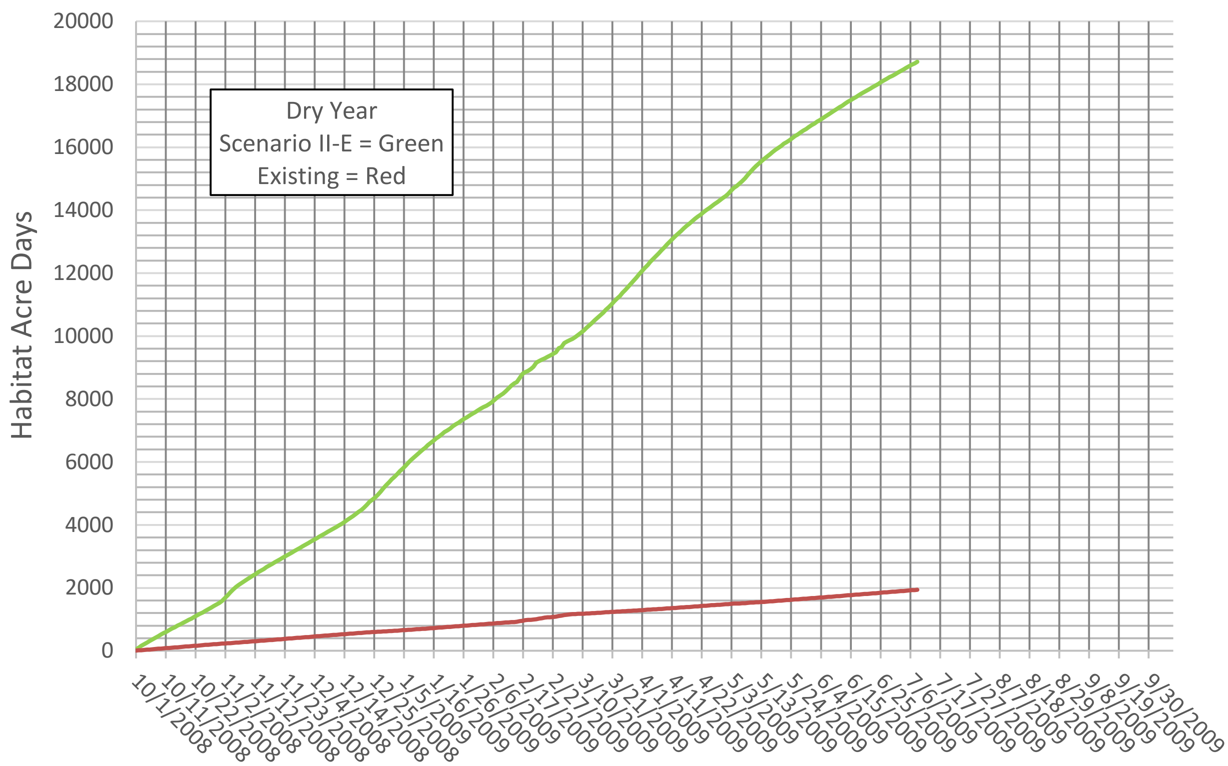


Figure 8.22. Cumulative juvenile habitat area over time at the project site for dry water year.

8.3.1 Evaluating salmonid population benefits. To translate the results of the two dimensional analysis of available habitat into potential annual net benefit accrued to salmonid populations by restoration Scenario II-E versus current conditions, the Cumulative Acre Days model output for an average year was further analyzed using published salmonid rearing densities. An order of magnitude range in rearing density was used for this simplistic mathematical illustration of between 0.1 to 1 fish/m^2.

During the winter/spring rearing season, the average hydrologic condition (represented by the 2007-2008 water year) would have generated a cumulative 1,180 habitat acre days in the existing configuration, and 12,800 acre days in the proposed condition of Scenario II-E (Figure 8.12 above). Over the course of 150 days, from December 20 to the end of May, the daily average habitat area would be 8 acres for the Existing Conditions scenario and 85 acres for Scenario II-E. Assuming a range of fish density from 0.1 to 1 fish per square meter, 3,400 to 34,000 fish could be reared in the Existing Conditions while between 34,530 to 345,300 fish could potentially be reared under Scenario II-E. This same comparison was made for the three representative hydrologic conditions with similar results (Table 8.1) and illustrates how Scenario II-E significantly increases available habitat and the potential productivity of the Hanson property over the Existing Conditions. These calculations are a simple mathematical exercise to illustrate the wide differential in productive potential between existing conditions and Scenario IIE. As a mathematical exercise it is fine to illustrate differences in potential production; however, it is important to acknowledge that these estimates don't account for myriad factors that contribute to juvenile salmonid production including number of spawning adults, spawning success, alevin survival rates, recruitment to the habitat, intra- and inter-species and inter-cohort density dependence, ontogenetic changes, and fundamental constraints on indeterminant growth.

Despite these caveats, the evidence suggests that Scenario II-E will significantly improve overall riverine carrying capacity and the production of juvenile salmonids, especially relative to existing conditions (Figure 8.23).

Table 8.1 Estimated salmonid population for Scenario II-E. Potential salmonid rearing population for three water year types under Existing Conditions versus floodplain Scenario II-E.

	Average Daily Habitat Acres during 150 day rearing period	Potential Range of Salmonid Rearing Population size w/ density range of 0.1 to 1 fish per square meter
Average Water Year		
Scenario II-E	85 acres	34,530 to 345,300 fish
Existing Conditions	8 acres	3400 to 34,000 fish
Wet Water Year (100-yr flood)		
Scenario II-E	74 acres	29,950 to 299,500 fish
Existing Conditions	19 acres	7,700 to 77,000 fish
Dry Water Year		
Scenario II-E	82 acres	33,200 to 332,000 fish
Existing Conditions	7 acres	2830 to 28,300 fish

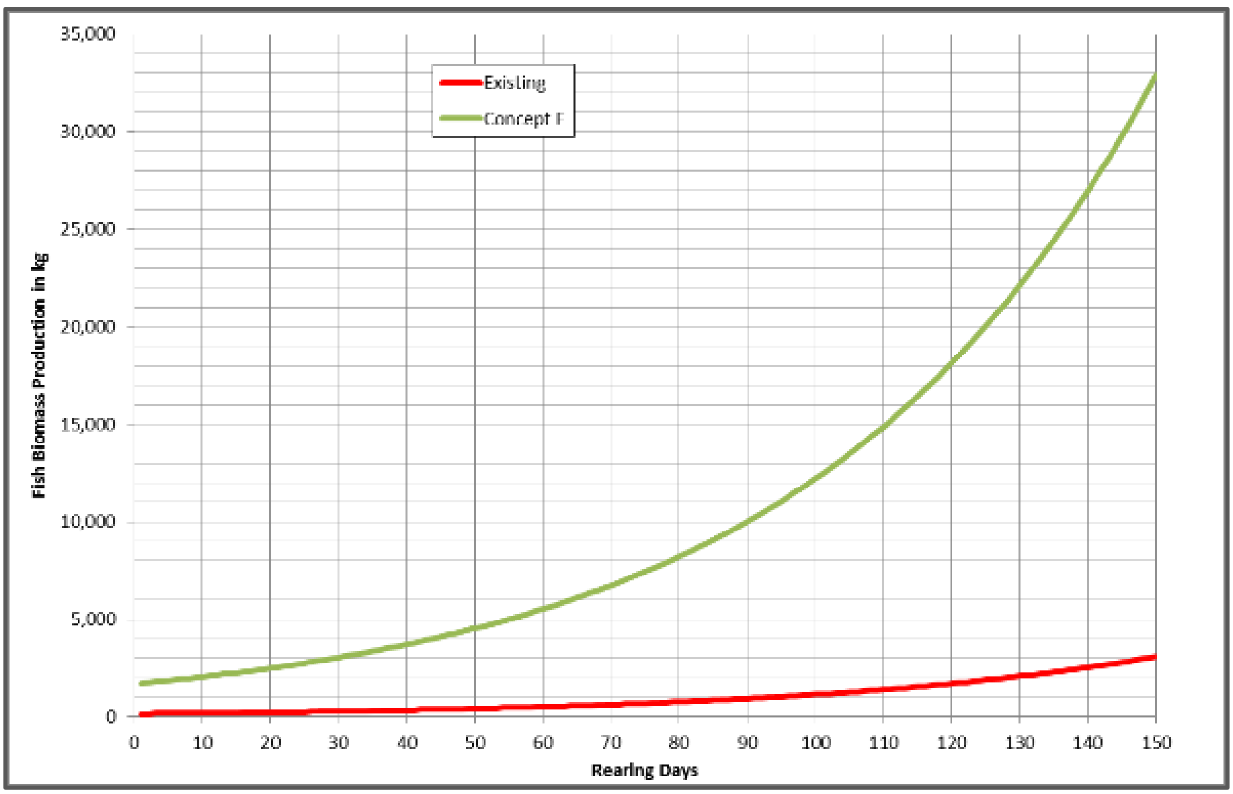


Figure 8.23. Illustration of potential salmonid biomass production in kilograms for Existing Conditions and floodplain concept Scenario II-E. Assumes average water year hydrologic conditions and winter spring rearing from December 20 to the end of May (150 days), starting with fish densities of 1 fish/square meter, and calculated growth rate of 2% per day. The red line represents Existing Conditions and the green line is Scenario II-E.

The relatively rich feeding opportunity that floodplain habitat provides to juvenile salmonid is just as important to population success as increased area for more juvenile habitat. For marine survival of ocean-going salmonid smolts, the two variables most correlated to rates of survival and salmonid population success are the length and condition factor of sea-going smolts (Hayes *et al.* 2008; Evans *et al.* 2014). Because increased survival of larger and better condition smolts is most apparent in years of poor ocean conditions (Evans *et al.* 2014), these factors are the drivers of population resilience. Thus, the increase in length and biomass of juvenile salmonids rearing under the Scenario II-E floodplain conditions would directly contribute to increases in adult abundance, and the populations' resilience to variable climactic conditions in both the freshwater and ocean phases of the salmonid life cycle.

8.3.2 Estimating rearing habitat extent. The two dimensional hydraulic modeling results indicate that greater than an order of magnitude difference exists in suitable juvenile rearing habitat between Scenario II-E and Existing Conditions under nearly all hydrologic conditions. This value difference between the area of juvenile salmonid rearing habitat under Existing Conditions and Scenario II-E is probably much greater than indicated by this analysis of only depth, velocity, and duration of inundation for a number of reasons. First, the rearing habitat in Scenario II-E is mostly contiguous nodes comprising large areas that would be more likely to be encountered and used by rearing juvenile salmonids and easily shifted to and from as the flow/stage changes. In the Existing Conditions model output, the identified nodes meeting the habit criteria are often isolated, discontinuous, and widely distributed. Suitable habitat modeled in Scenario II-E is present in extensive contiguous areas, whereas under Existing Conditions, it is widely dispersed in small patches. The large contiguous areas of Scenario II-E habitat will be more productive and readily accessible to juvenile salmonids in search of suitable rearing habitat, thus easier for juveniles to find, orient in, and locate food in large patches with abundant floodplain vegetation providing both cover from predators, and abundant and varied prey resources.

The current instream cover within the Russian River channel adjacent to the project site is primarily overhanging woody species, essentially rooted above the ordinary high water mark or winter base flow channel. As a result, there is very little instream cover associated with nodes of Existing Conditions in the river channel that meet the habitat screening criteria of the two dimensional habitat modeling.

With establishment of vegetation, new conditions within the footprint of Scenario II-E will be a continuum of submerged aquatic vegetation, emergent aquatic vegetation, seasonally wet meadows, and seasonally inundated scrub-shrub forest wetlands (Chapter 10, Plan Sheet 8). This continuum of plant communities will likely provide a highly productive array of food resources and abundant cover for protection from avian and fish predators at all river stage levels. In contrast, under Existing Conditions, due to the extreme vertical stage change in the incised channel, suitable patches of habitat have no adjoining habitat for fish to occupy with stage changes. Many nodes modeled as suitable habitat in the Existing Conditions channel at lower flows are subject to scour, with adjacent steep walled river banks devoid of vegetation and very little instream cover or flood refuge necessary for suitable juvenile salmonid winter-spring rearing habitat.

Additionally, many of the habitat nodes within the Existing Conditions scenario (Stage I-A) that meet the habitat screening criteria of the two dimensional hydraulic modeling occur around the edges of the ponds when inundated by high river flows. Although these nodes show up as suitable habitat in the modeling output, as noted previously, these areas probably become a population sink rather than benefiting the population. Juvenile salmonids are likely either trapped in inhospitable conditions of the ponds, or flushed downstream during storm flows in the existing condition. However, in Scenario II-E there would be significant habitat available over the entire range of winter/spring flows due to the gentle lateral gradient in the floodplain that also prevents the loss of juveniles downstream. Additionally, perennial connections draining the floodplain to the river allow rearing fish to avoid entrapment.

The two dimensional modeling of habitat acres of Scenario II-E shows a lower number of cumulative acre days for wet years than it does for dry years. While counterintuitive, this conclusion accurately reflects the following data: The 1983 hydrograph modeled as representative for wet years was the wettest year of record for the basin, and substantial flow at this stage occurs on the former (now disconnected) floodplain, so the proportion of nodes confined within the project area meeting the habitat criteria of shallow depths and low velocities actually decreases.

However, future site evolution to an island and channel network resulting from native vegetation growth and associated increased deposition will significantly increase acreage of wet year habitat meeting the velocity and depth criteria over the entire range of hydrologic conditions. This will result in an increase of the extent of productive habitat as the floodplain naturally evolves over time.

8.3.3 Estimating spawning habitat extent. Currently, the project reach and study area lack suitable spawning habitat. The incised and leveed channel bed is too mobile during normal winter storm flows due to increased velocity and depth, and too simple during winter base flows to support fluvial processes of differential sediment size sorting and deposition necessary for spawning riffle development. The model indicates that gravel will deposit in the upstream area of the project where the river flows onto the new floodplain, be re-worked by subsequent flows, and potentially form a large, clean gravel deposit of suitable size clasts (15 -20 mm) for spawning (Figure 8.24, Appendix G, Figure 92). This spawning habitat would be ideally located due to the abundant juvenile rearing habitat immediately downstream in the extensive floodplain. Additionally the decreased depth and velocity of high flows in the river channel as modeled by USGS for Scenario II-E is expected to allow formation of more complex – less homogenous habitat in what is currently a simple straight and habitat poor reach of the Existing Conditions scenario.

8.3.4 Evaluating non-native fish assemblage and salmonid population dynamics. The first objective of the feasibility study as stated in Chapter 1 is to:

> **Feasibility Study Objective 1:** Evaluate the benefits and risks to the population dynamics of ESA-listed *Oncorhynchus* species resulting from increased access to new off-channel floodplain habitats, including changes in predator-prey interactions of the Russian River resulting from connecting a floodplain to the river versus connecting the ponds to one another and the river.

Therefore, in addition to evaluating listed species population level benefits of restoration as discussed in Section 8.3.1 above, Goal 4, a fisheries goal, was developed to evaluate Stage I and Stage II terrain model scenarios ability to*:*

> **Goal 4.** Affect natural control of non-native salmonid predator populations by eliminating the altered landscape and resulting altered hydraulic conditions and ecology that support the persistence of non-native fishes.

As discussed in Chapter 4, Section 4.4, Characterizing the Fish Assemblage of Middle Reach Ponds, comprehensive sampling of the smaller and older Hopkins pond a half mile downriver from the Hanson

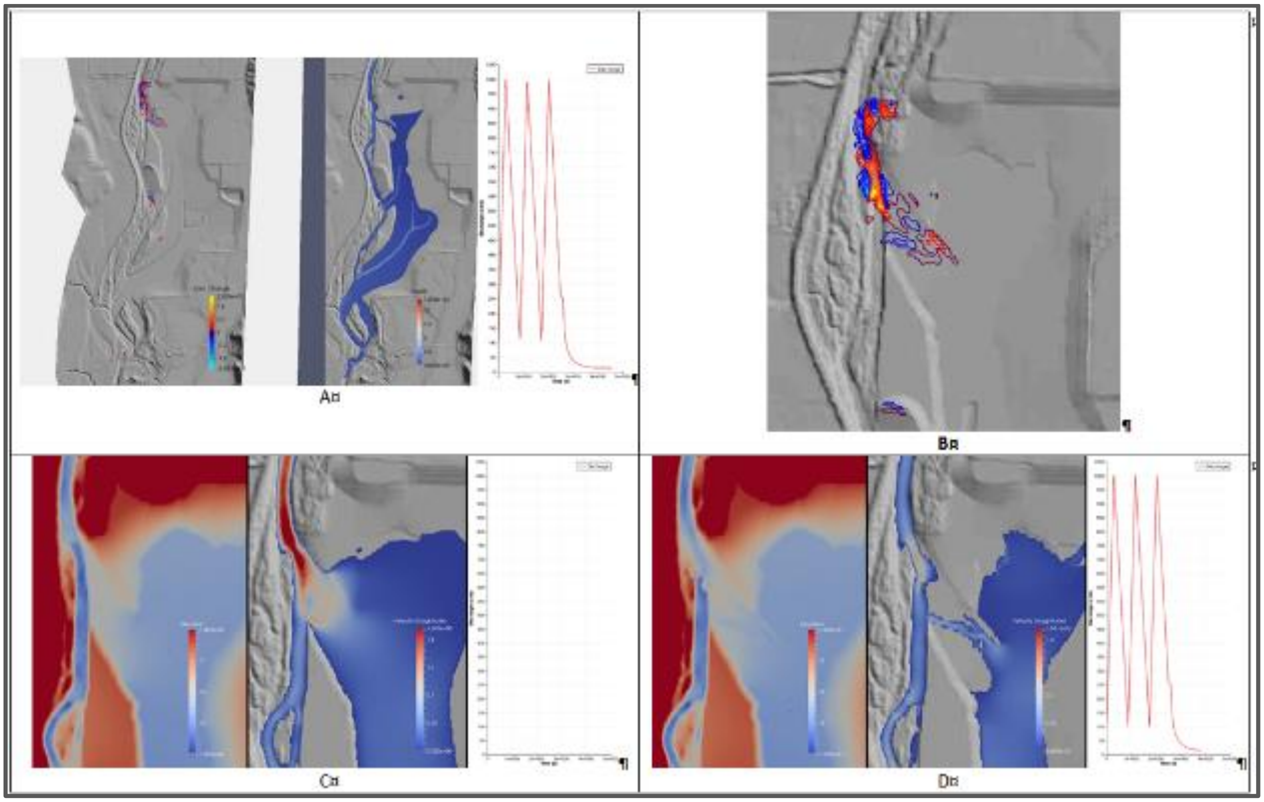


Figure 8.24. Potential evolution of spawning habitat. A gravel delta form is predicted at the upper floodplain inlet that will cycle between deposition and re-working with the passing of normal floods. This area may become suitable spawning habitat, a relatively rare habitat for this reach of river. See Appendix G, Figure 92 for more details.

project area indicates Middle Reach ponds evolve into warm water fisheries habitat that supports flourishing populations of largemouth bass and other non-native species that prey on salmonids. The Hanson ponds probably offer less productive warm water fisheries habitat than the older Hopkins pond because the Hanson ponds are deeper with relatively less shoal habitat, and the invasive aquatic vegetation of *Ludwigia* spp*,* where largemouth bass were documented flourishing in the Hopkins pond, has only just begun to colonize the perimeter of the Richardson pond. However, sampling of the Richardson pond on the Hanson property indicates the same assemblage of fish is present. Thus, the older Hopkins pond is an indication of the evolution trajectory for aquatic habitat in the Hanson ponds under existing, and current SMARA- required reclamation.

The Scientific Working Group made two key recommendations to affect natural control of non-native predator populations:

- Eliminate perennial standing warm water habitat, and
- Increase winter flows through the site to displace non-native species primarily adapted to lentic habitats.

Although the feasibility study cannot quantitatively evaluate predation related population level benefits for listed salmonids, or risk reduction of the Scenario II-E restoration proposal versus allowing Existing Conditions to evolve, Scenario II-E accomplishes both of the recommendation of the SWG for affecting natural control of non-native predator populations. The only perennial water remaining in the study area during summer will be the cold groundwater-fed spring channels, and the upstream floodplain connection with the river will provide annual river flows through the site.

The benefit of reducing predator populations will not be limited to the project site alone, but may also reduce future largemouth bass populations and predation on listed salmonids elsewhere in the watershed. The Sonoma County Water Agency fish sampling equipment installed below the Mirabel inflatable dam each spring has caught as many as 3,600 juvenile largemouth bass in a day (*pers. comm*. Shawn Chase, SCWA 2013). Such a large aggregation of juvenile largemouth bass was probably the result of emigration from an upstream pond, potentially from the Hopkins pond, as it is most frequently connected to the river during the spring.

NMFS conservative population estimate of largemouth bass larger than 75 mm inhabiting the 11 acre Hopkins pond was 481 ± 181 (1 STD). Scaling up to the 150 acres of the combined Hanson ponds indicates that in the future, the project site may be capable of producing a population of thousands of breeding age largemouth bass under the Existing Conditions scenario. Therefore, implementation of the Scenario II-E restoration concept at the Hanson site will significantly reduce the future ability of Middle Reach ponds to seed the river with non-native predators of listed salmonid species.

Regarding concerns about non-native fish predation on salmonids as identified in stakeholder scoping meetings and discussed above: it is generally recognized and documented in the literature that non-native fish prey opportunistically on salmonids and seasonally may consume large numbers. However salmonids supply only a small fraction of the dietary needs of non-native predators (Tabor et al 2007, (Hayes, 2015, in proceedings of the Salmonid Restoration Federation Conference). Likely more important for the salmonid population dynamics within the Russian River Basin is the availability (or lack thereof) of off-channel habitat to recruit, support, and rear high abundance levels of salmonid juveniles to withstand predation pressures from both native and non-native species of multiple classes of predators (Sean Hayes, Southwest Fisheries Science Center, personal communication.

CHAPTER

9 Evaluation of Restoration Alternatives

9.1 Evaluating the restoration alternatives

As described in Chapter 7, potential terrain models were developed iteratively in order to meet the project restoration goals and objectives (Chapter 6). The high level screening tests for iteratively developing the best terrain proposal used the following criteria:

1. Can the grading be achieved with balance in cut and fill using only materials on-site?
2. Will geomorphic adjustment and topographic evolution be gradual and moderated by natural vegetation growth patterns and stabilizing influences?
3. Does it meet project goals and objectives?

Once an optimal terrain concept (Scenario II-E) that best met the goals and objectives was developed, it was evaluated against existing conditions using the analytical approach described in Chapter 8. This approach relied heavily on hydraulic, sediment transport, and habitat modeling. Although the iterations of Stage II terrain scenarios A-D were not explicitly modeled, the performance of each was evaluated against the goals and objectives using relative scale factors and professional judgement. The alternatives are ranked in the following Table 9.1.

Table 9-1. Evaluation of Scenarios. The optimal design concept, Scenario Stage II-E is compared with existing conditions and the precursor terrain concepts II-A through II-D, using the measurable objectives intended to meet project goals and objectives. For each objective a numerical value of 0-3 was assigned for each scenario, where 0 represents absent or objective not met, 1 = partly met, 2 = met but not fully, and 3 = objective is fully met. The scenario scores are tallied and summed at the end of the table. The last column, reference, lists which figure or figures of the report best describe the results that address each objective.

	Stage I Scenario	**Stage II Scenarios**					**Reference**
Rankings: 0 = not met, 1 = partly met, 2 = met but not fully, 3 = fully met							
Modeled by USGS	**X**					**X**	
Scenario Description	**I-A** Existing Topography	**II-A** Low elevation, gently sloping floodplain 1.5 meters above the river bed	**II-B** Higher floodplain base elevation of 4-5 meters above the river bed, residual ponds ~5 meters deep	**II-C** Modified version of II-B with broad floodplain swale interconnecting the ponds with residual depth ~2 meters	**II-D** Modified version of II-C with broad floodplain and swale about 0.2 meters lower than II-C, with no ponds remaining	**II-E** Modified version of II-D with two lengthy 'abandoned channel' analogs with perennial alcoves connected to existing deep river pools, and graded into the upstream and downstream terrain	
Restoration Goals & Objectives							
Geomorphic Goals							
Goal 1. Arrest or reverse the ongoing trend of channel incision and resulting geotechnical bank failure in the study reach. Maintain channel bed elevations and riverbank property stability in the Middle Reach Valley.							
Obj. 1. Within 1 year[3] restore river - floodplain interaction to increase dissipation of flood energy and deposit sediment in the project reach.	0	3	2	3	3	3	Appendix G Figures 71-74
Obj. 2. Within 1 year reduce hydraulic forces applied along the existing river channel banks for the range of flows contained within the existing channel.	0	3	2	3	3	3	Appendix G 67-74

[3] All temporal objectives relate to time after grading is completed.

Table 9-1. Evaluation of Scenarios continued							
	Stage I Scenario	Stage II Scenarios					
Rankings: 0 = not met, 1 = partly met, 2 = met but not fully, 3 = fully met							
Modeled by USGS	X					X	
Scenario	I-A	II-A	II-B	II-C	II-D	II-E	Reference
Geomorphic Goals continued							
Obj. 3. Within 1 year establish contours on new fluvial property boundaries sufficient to resist erosion during 5-year and greater flood flows.	0	3	3	3	3	3	Appendix G, Figures 70-74
Goal 2. Restore sediment deposition, sorting, and habitat-forming fluvial processes.							
Obj 1. Within 1 year restore sediment deposition and sorting processes to increase river channel bed heterogeneity and create pool riffle morphology.	0	1	2	3	3	3	Chapter 8, Figure 8.24
Obj. 2. Within 1 year restore fluvial processes forming a seasonally active macro-scale island channel network across at least 50% of the annually inundated floodplain.	0	3	1	1	3	3	Chapter 8, Figures 8.1 - 8.7
Flood Elevation Goal							
Goal 3. Do not increase, and potentially reduce, flood elevations in the study area.							
Obj. 1. Within 1 year increase floodwater routing onto 300 acres of floodplain for 5-year and greater floods.	0	3	3	3	3	3	Appendix G, Figures 52-54
Obj. 2. Within 1 year decrease flood elevations within the project area by an average of a meter for a 5-year flood event.	0	3	3	3	3	3	Chapter 8, Figure 8.1

Table 9-1. Evaluation of Scenarios continued							
	Stage I Scenario	Stage II Scenarios					
Rankings: 0 = not met, 1 = partly met, 2 = met but not fully, 3 = fully met							
Modeled by USGS	X					X	
Scenario	I-A	II-A	II-B	II-C	II-D	II-E	Reference
Fisheries Goals							
Goal 4. Affect natural control of non-native salmonid predator populations by eliminating the altered landscape and resulting altered hydraulic conditions and ecology that support the persistence of non-native fishes.							
Obj. 1. Within 1 year eliminate warm water fisheries habitat.	0	3	0	0	3	3	Chapter 7, Figure 7.1
Goal 5. Increase the populations of native salmonids.							
Obj. 1. Within 1 year restore spawning gravel deposits that will support salmonid spawning in the adjacent river channel.	0	1	2	2	3	3	Chapter 8, Figure 8.24, Appendix G, Figure 90
Obj. 2. Within 5 years restore and maximize project area productivity and carrying capacity so that juvenile steelhead, Chinook and coho salmon attain minimum threshold sizes for marine survival.	0	2	0	1	2	3	Chapter 8, Figure 8.23
Species Objectives - Chinook Salmon							
Chinook Obj. 1. Within 2 years increase main channel spawning habitat area and quality.	0	1	2	2	3	3	Chapter 8, Figure 8.24, Appendix G, Figure 90
Chinook Obj. 2. Within 2 years increase main-channel and off-channel winter/spring edgewater habitat by an average of 60 acres during normal and dry hydrologic conditions for cohort recruitment of fry to the rearing population.	0	3	1	1	2	3	Chapter 8, Figure 8.9

Table 9-1. Evaluation of Scenarios continued							
	Stage I Scenario	Stage II Scenarios					
Rankings: 0 = not met, 1 = partly met, 2 = met but not fully, 3 = fully met							
Modeled by USGS	X					X	
Scenario	**I-A**	**II-A**	**II-B**	**II-C**	**II-D**	**II-E**	**Reference**
Fisheries Goals continued							
Species Objectives – Chinook Salmon continued							
Chinook Obj. 3. Within 2 years restore 80 acres of highly productive winter/spring floodplain wetland and slough habitats under normal hydrologic conditions to provide rapid growth opportunities for rearing juveniles.	0	2	1	1	2	3	Chapter 8, Figure 8.9
Species Objectives - Coho Salmon							
Coho Obj. 1. Within 2 years increase main channel and off-channel winter/spring edgewater habitat by at least 60 acres during normal hydrologic conditions for cohort recruitment of fry to the rearing population.	0	3	1	1	2	3	Chapter 8, Figure 8.9
Coho Obj. 2. Within 2 years restore 80 acres of highly productive winter/spring floodplain wetland and slough habitats under normal hydrologic conditions to provide a substantial increase in flood refuge and high capacity winter rearing habitat for coho parr annually migrating from basin-wide over-summering habitats in search of rapid winter and spring growth opportunities.	0	2	1	1	2	3	Chapter 8, Figure 8.9

Table 9-1. Evaluation of Scenarios continued							
	Stage I Scenario	Stage II Scenarios					
Rankings: 0 = not met, 1 = partly met, 2 = met but not fully, 3 = fully met							
Modeled by USGS	X					X	
Scenario	**I-A**	**II-A**	**II-B**	**II-C**	**II-D**	**II-E**	**Reference**
Fisheries Goals continued							
Species Objectives - Steelhead							
Steelhead Obj. 1. Within 2 years increase main channel and off-channel winter/spring edgewater habitat by at least 60 acres during normal hydrologic conditions.	0	3	1	1	2	3	Chapter 8, Figure 8.9
Steelhead Obj. 2. Significantly increase summer and winter rearing habitat capacity and productivity in Middle Reach Valley (study reach).	0	1	0	1	2	3	Chapter 8, Figures 8.22 - 8.23
Species Objective - Other aquatic habitat-dependent native species							
Obj. 1. Significantly increase spawning, recruitment and rearing habitat capacity in the Middle Valley for Russian River Tule Perch, foothill yellow-legged frog and western pond turtle.	0	2	1	2	1	3	Appendix G, Figures 47 – 53
Aquifer Restoration Goal							
Goal 6. Improve groundwater quality and quantity.							
Obj. 1. Fill existing ponds below the summer water table with porous native sand and gravel.	0	3	0	1	3	3	Chapter 7, Figure 7.1

Table 9-1. Evaluation of Scenarios continued							
	Stage I Scenario	Stage II Scenarios					
Rankings: 0 = not met, 1 = partly met, 2 = met but not fully, 3 = fully met							
Modeled by USGS	X					X	
Scenario	I-A	II-A	II-B	II-C	II-D	II-E	Reference
Aquifer Restoration Goal continued							
Obj. 2. Within 1 year increase groundwater recharge by flooding porous area of at least 100 acres for a minimum 100 days under average hydrologic conditions, and 100 acres for a minimum of 50 days under drier than average hydrologic conditions.	0	3	1	2	2	3	Chapter 8, Figure 8.8
Water Quality Goals							
Goal 7. Improve surface water quality conditions within the project area and downstream. Reduce the transformation of harmful nutrients (P) and metals (mercury) in the water column and sediments. Reduce Russian River summertime water temperatures by reducing warm subsurface flows seeping from the Hanson ponds.							
Nutrient and Metal Objective							
Obj. 1. Within 1 year eliminate toxic "hotspots", i.e., MeHg and P production, within the Hanson project reach by: • eliminating the ponds, or • substantially filling the ponds and increasing perennial river flow through the site.	0	3	0	1	3	3	Chapter 7, Figure 7.1
Sediment Objective							
Obj. 1. Within 1 year restore deposition of fine sediment by increasing flood flow routing onto a minimum of 200 acres of floodplain in average hydrological conditions.	0	3	1	2	2	3	Chapter 8, Figure 8.8, Appendix G, Figures 52 - 54

Table 9-1. Evaluation of Scenarios continued							
	Stage I Scenario	Stage II Scenarios					
Rankings: 0 = not met, 1 = partly met, 2 = met but not fully, 3 = fully met							
Modeled by USGS	X					X	
Scenario	I-A	II-A	II-B	II-C	II-D	II-E	Reference
Temperature Objectives							
Obj. 1. Within 1 year decrease or eliminate summer ponded water to minimize or eliminate thermal stratification of the water column.	0	3	0	1	3	3	Chapter 7, Figure 7.1
Obj. 2. Within 1 year reduce or eliminate the summer water surface area exposed to ambient air and solar heating to minimize warming of river water temperatures in the project area and downstream.	0	3	1	2	3	3	Chapter 7, Figure 7.1
Obj. 3. Within 1 year concentrate groundwater flows into small spring-fed channels connected to the river.	0	0	0	0	0	3	Chapter 7, Figure 7.1
Vegetation Community Goals							
Goal 8. Restore and enhance natural floodplain native species riparian zones with a gradient from aquatic bed, emergent marsh, seasonal wet meadow and woodland wetland, to upland mature seral stage forest communities comprising a complex and diverse floodplain ecosystem which is resilient to disturbance and provides floodplain ecosystem benefits and habitat for native fish and wildlife species.							
Obj. 1. Within 5 years establish 50 acres of native vegetation consisting of a gradient from aquatic bed (submerged and floating aquatic vegetation) to seasonal and perennial emergent marsh (including seasonal wet meadows), under average hydrologic conditions.	0	2	0	1	2	3	Chapter 10, Figures 10.7-10.8

Table 9-1. Evaluation of Scenarios continued							
	Stage I Scenario	Stage II Scenarios					
Rankings: 0 = not met, 1 = partly met, 2 = met but not fully, 3 = fully met							
Modeled by USGS	X					X	
Scenario	I-A	II-A	II-B	II-C	II-D	II-E	Reference
Vegetation Community Goals continued							
Obj. 2. Within 10 years establish 200 acres of native riparian vegetation zones consisting of a gradient from aquatic bed, to emergent marsh, to scrub-shrub forest wetland, to upland riparian forest under average hydrologic conditions.	0	2	1	1	2	3	Chapter 10, Figure 10.8
Obj. 3. Within 15 years increase native upland riparian forest to at least 125 acres under average hydrologic conditions.	2	1	2	2	2	3	Chapter 10, Figure 10.8
Public Amenities Goal							
Goal 9. Accommodate potential public access and recreation facilities in the grading plan.							
Obj. 1. Create site spaces that can be developed concurrent with grading or at a later time for a rim trail around the outer project boundary, a pad for a campground, and a pad for car park and boat access to the river.						3	Chapter 10, Figure 10.8
SCORE	**2**	**65**	**32**	**45**	**67**	**87**	
% of possible	**2%**	**75%**	**37%**	**52%**	**77%**	**100%**	

9.2 Recommended restoration alternative and associated floodplain restoration benefits

Through direct analysis and comparative evaluation, Scenario II-E clearly out performs the other scenarios while fully meeting restoration goals and objectives. The evaluation exercise also quantifies, contrasts, and highlights the extremely low functions and values of the existing conditions.

This study finds that it is feasible to re-grade on-site earth materials and create a new functional floodplain across the 358-acre former gravel mining site owned by Hanson Aggregates. Improving the functions and values of the Russian River floodplain has benefits geomorphically, ecologically, and culturally. The following benefits, as related to the restoration goals, are anticipated from the implementation of Scenario II-E:

Goal 1. Arrest or reverse the ongoing trend of channel incision and resulting bank failure. Maintain or improve property stability in the Middle Valley.

The proposed floodplain Scenario II-E lowers water surface elevations by approximately 1 meter for all flows including the 100-year event in the Middle Reach Valley. The stream power that currently scours the river bed and banks adjacent to the floodplain project is significantly reduced, which will arrest the particularly intractable problem of ongoing bed degradation characteristic of the existing condition, and thus will improve the geotechnical problem of unstable river banks.

Goal 2. Restore sediment deposition, sorting, and habitat-forming fluvial processes.

The restored floodplain recreates sediment and nutrient depositional processes in ecologically desirable locations. A deposition zone for suspended Russian River sediment will improve water quality downstream from the project for all flows that engage the floodplain. Restoring river bed sediment deposition processes will occur gradually and without predicted adverse consequences for channel stability upstream or downstream from the project.

Goal 3. Do not increase, and potentially reduce, flood elevations in the study area.

The proposed floodplain Scenario II-E lowers water surface elevations in the study area by approximately 1 meter for all flood flows including the 100-year flood event.

Goal 4. Affect natural control of non-native salmonid predator populations by eliminating the altered landscape conditions promoting high carrying capacity of non-native introduced species.

The ponds currently support non-native predatory fish habitat and are a sink for native fish populations when flooded. The proposed project will eliminate the ponds, significantly increase salmonid spawning habitat, and increase by ten-fold the availability of productive off-channel salmonid winter and spring rearing and refuge habitat.

Goal 5. Increase the populations of native salmonids.

Salmonid habitat for rearing juveniles is predicted to increase by more than an order of magnitude. The project site is strategically located just downstream from the Dry Creek spawning tributary. A functioning food-rich, large floodplain relatively close to Dry Creek will provide rearing habitat for all species of native salmonids, and eliminate habitat that now favors warm water fish known to prey on salmonids. Spawning gravel deposits are predicted to form around the upstream entry to the floodplain, and perhaps elsewhere in the existing channel where current annual floods scour gravel deposits.

Goal 6. Improve groundwater quality and quantity.

Aquifer restoration is achieved by filling the ponds with native porous media and eliminating the open surface water. Aquifer recharge will benefit from the annual inundation of a large porous floodplain for extended durations.

Goal 7. Improve surface water quality conditions within the project area and downstream. Reduce the transformation of harmful nutrients (P) and metals (total mercury) in the water column and sediments. Reduce Russian River summertime water temperatures by reducing warm subsurface groundwater inputs from the adjacent ponds.

By filling the existing ponds with porous native alluvium, mercury cycling and bioavailability, and phosphorous cycling and accumulation, along with other harmful nutrients and metals, is effectively eliminated. Also eliminated is the warming of pond surface water that presently seeps into the river in the summer. The warmed water is also nutrient rich, seeping into the river immediately upstream from the region's largest drinking water intakes by Sonoma County Water Agency.

Goal 8. Restore and enhance natural floodplain native species riparian zones with a gradient from aquatic bed, emergent marsh, seasonal wet meadow and woodland wetland, to upland mature seral stage forest communities comprising a complex and diverse floodplain ecosystem which is resilient to disturbance and provides floodplain ecosystem benefits and habitat for native fish and wildlife species.

The proposed restored floodplain and associated uplands will support a large suite of native flora and fauna, and will be monitored and adaptively managed towards a goal of self-sustainability.

Additional benefits are that the proposed restoration scenario has the potential to become a valuable regional park offering river access, and environmental education and recreation opportunities to an area that is currently closed. Lastly, the proposed project will fulfill the goal of presenting an ecologically superior and exemplary alternative to typical SMARA reclamation plans, and strong rationale and impetus to utilize SMARA for ecological restoration purposes.

CHAPTER

10 Recommended Restoration Alternative Conceptual Design

This chapter presents 13 graphics illustrating the project location, boundaries, existing conditions, vegetation types, topography of Scenario II-E, recommended restoration alternative, and several additional plan sheets. These plan sheets and graphics are provided in a separate document to preserve the resolution of the originals.

CHAPTER

11 Feasibility Study Conclusions and Next Steps

The results of the USGS landscape evolution modeling and the expert opinion of the Scientific Working Group and Peer Review Panel support the biological and geomorphological feasibility of the Scenario II-E restoration alternative for the Hanson property.

This scenario will stabilize and restore ecological functions of the site while providing valuable off-channel habitat for juvenile salmonids, other native fish and many other plant and wildlife species. However, project feasibility must also consider regulatory, legal, and financial factors that can determine project viability. These feasibility factors are evaluated in the following sections.

11.1 Regulatory feasibility

The next step toward implementation of the Hanson Russian River Ponds Floodplain Restoration Project is an application to amend the existing reclamation plan for the Mariani, Richardson, and Piombo ponds. Reclamation has been completed for the Vimark pond. Implementation of the existing reclamation plan construction requirements would conflict with the proposed restoration concept. Consequently, the reclamation plan must be amended to facilitate the initiation of the floodplain restoration scenario identified in this feasibility study.

The reclamation plan amendment must, at a minimum, demonstrate stabilization of the site to SMARA standard. It is anticipated that certain revegetation requirements will carry over as reclamation plan obligations. The reclamation plan amendment application will be submitted to the local lead agency Sonoma County Permit and Resource Management Department (PRMD). If PRMD approves the amendment, it will be forwarded to the Department of Conservation Office of Mine Reclamation (OMR) for review and approval. The submission of the amendment application will trigger public review and scoping under the California Environmental Quality Act (CEQA)/National Environmental Quality Act (NEPA)and subsequent approval of the Record of Decision by the Sonoma County Board of Supervisors. lead permitting agency is with final approval from the Office of Mining and Reclamation at the California Department of Conservation.

11.1.1 Reclamation vs. restoration challenges. The project strategy is to replace the existing reclamation plan with a more sustainable and biologically superior restoration plan. However, existing policies, regulations, and practices under the Surface Mining and Reclamation Act (SMARA) create significant challenges to converting a reclamation plan into a restoration plan.

For example, SMARA requires mine operators to carry a surety bond tied to the cost of completing pending reclamation plans. The bond is released when the completed reclamation plan is "signed off" by the responsible local agency and OMR. However, it is difficult to impossible for nonprofit organizations to qualify for surety bonds even for small restorations. Compounding the problem, a more expensive restoration plan will substantially increase the bonding requirement.

It is possible for a reclamation plan to be a pre-cursor or a first phase of a restoration plan. Under such a strategy, once the reclamation plan is implemented and signed off, restoration construction picks up where reclamation ends, greatly reducing bonding requirements. For this approach to work, the restoration strategy must be integrated into the planning and permitting of the initial reclamation plan or a reclamation plan amendment. This is not currently the case at the Hanson site where the configuration of the proposed restoration makes a phased strategy infeasible. If the current reclamation plan is implemented to secure sign off, expensive features in conflict with the restoration would then need to be removed in order to implement the restoration strategy.

In the case of the Hanson project, EHC, NOAA Fisheries, and PRMD are developing a strategy that allows reclamation plan obligations to be met under an amended reclamation plan that facilitates the initiation of the restoration alternative. Once the amended reclamation plan requirements have been met, the restoration alternative will proceed independently from the reclamation process.

A broad range of stakeholders and academic and governmental institutions are interested in examining potential revisions to SMARA that, for appropriate sites, would incorporate ecological restoration as the end use for a reclaimed site. The Hanson feasibility study offers timely and solid scientific data and analyses for advancing that discussion.

11.1.2 Scoping and permitting. The regulatory agencies that will be involved in project permitting are Sonoma County Permit and Resource Management Department, California Office of Mine Reclamation, U.S. Army Corps of Engineers, NOAA's National Marine Fisheries Service, North Coast Regional Water Quality Control Board, and California Department of Fish and Wildlife. At this juncture, it is anticipated that the reclamation plan amendment will not be part of the proposed restoration plan environmental review process. Sonoma County PRMD will determine whether an Environmental Impact Report (EIR) or an expansive Mitigated Negative Declaration is the appropriate document. If an EIR is deemed appropriate, PRMD will initiate public scoping to describe the project and solicit input for CEQA analysis. The CEQA/NEPA document will describe the subsequent restoration strategy implementation and timeline. The document will analyze levels of significance for the entire suite of CEQA parameters. Particular emphasis will be placed on impacts versus costs and benefits to listed species and river channel sustainability.

11.2 Legal feasibility

The Hanson property and restoration project has identified potential legal constraints requiring resolution prior to implementation. The constraints and actions being taken to address the issues are described below.

11.2.1 Adjoining landowners. As Figure 11.1 illustrates, the project encompasses the Hanson property as well as portions of several adjacent properties. To date, members of the Management Team have engaged all of these landowners including Jackson Family Wines, Calplan River Vineyards, Syar Industries, the City of Windsor, Westside Grapes, Ferrari-Carrano Vineyards and Winery, and Thomas Passalacqua to discuss the inclusion of their property in the restoration. No irreconcilable conflicts have been identified. The CEQA/NEPA process will include reconciliation and/or mitigation of any potential impacts to these and other adjacent property owners.

11.2.2 Jackson Family Wines. Jackson Family Wines owns the vineyard adjacent to the Hanson property's eastern boundary and holds access and water rights easements to a portion of the Richardson pond as shown in Figure 11.2. The permanent easements were granted in 2008 and allow Jackson Family Wines to pump water from the Richardson pond for vineyard irrigation and frost protection. In order to maintain the easement rights, the Management Team has come to a tentative understanding with Jackson Family Wines and designed an approximately 5-acre pond to accommodate this continued water use as illustrated in Figure 11.2. The pond has been integrated into the restoration scenarios and does not negatively impact project objectives. An alternative strategy to provide an equivalent amount of water via the installation of wells on the Jackson property is under consideration. The restoration project budget will include the cost of well installations should that option be chosen.

11.2.3 Mariani purchase option. The Mariani family sold their 63-acre ownership to Hanson Aggregates' predecessor, Kaiser Sand and Gravel, in 1985. In the transaction, the family retained the right to re-purchase the property for $1 after the reclamation plan is completed and signed off. The option runs with the land and was assumed when Hanson acquired the property. EHC has discussed options with the Mariani family to reconcile their interest and the ecological restoration of the site.

Figure 11.1. The Hanson Russian River Ponds Floodplain Restoration Project. The Hanson property and the restoration project boundaries are shown in yellow and red, respectively. The restoration project encompasses several ownerships beyond the Hanson property boundaries. The Management Team has initiated discussions with nearly all of these landowners.

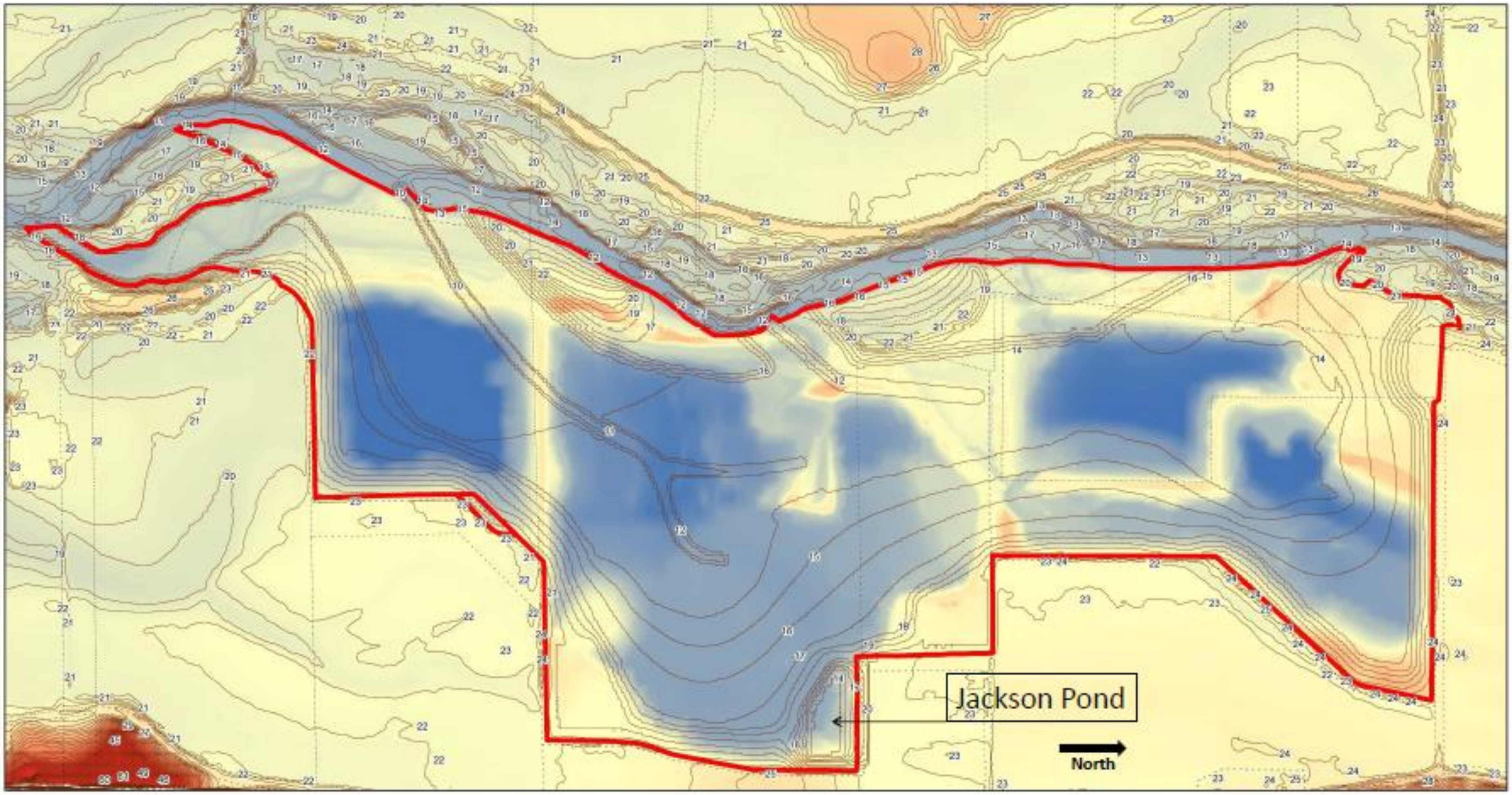


Figure 11.2. The Hanson Russian River Ponds Floodplain Restoration Project – Scenario II-E. Adjacent landowner, Jackson Family Wines, holds access and water rights easements to pump water from the Richardson pond and has a perfected state water right for that diversion point. To accommodate these easements, Scenario II-E includes an approximately five acre pond incorporated into the restoration project proposal as shown above.

11.3 Financial feasibility

Project feasibility includes evaluation of the cost effectiveness of the proposed project and the availability of funding to complete the restoration. Net cost effectiveness must be measured against the costs associated with implementing the existing reclamation plan configuration and maintaining it into the future.

Engineered reclamation strategies such as those currently required on the Hanson property and employed at Riverfront Regional Park downstream, have proven to be inherently unsustainable, requiring expensive repairs and maintenance on a nearly annual basis. In contrast, the value of restored ecosystem services such as improved native fish and wildlife habitats, flood attenuation, water quality benefits, improved groundwater recharge, and climate change resilience must be factored into the cost-benefit analysis.

The following sections estimate project costs and describe proposed sources of CEQA/NEPA review, permitting, engineering design, and construction funding.

11.3.1 Estimated costs. To ascertain more specific project cost estimates for each implementation element, the Management Team will formally prepare and release a Requests for Proposals to qualified firms for the CEQA/NEPA, permitting, design, and construction phases. In the interim, a broad range of $9,000,000 to $17,000,000 has been developed for project implementation costs. The discussion below describes how this range was established.

1. **Land acquisition.** There are no land acquisition costs associated with the Hanson property. EHC holds an option agreement that allows it to purchase the property for $1 when agreement is reached with regulators on the reclamation plan amendment. No costs have yet been identified for the use or acquisition of adjacent lands included in the restoration.
2. **CEQA/NEPA compliance and permitting.** The cost of permitting has not been established but is estimated to be between $500,000 and $700,000.
3. **Final design and engineering.** This cost has not been established.
4. **Construction.** Three initial construction cost estimates have been developed. The firm of Pacific States Environmental Contractors has provided a written budget proposal of $15,073,500 for mobilization, clearing, and grading for Scenario I-D (quantifiably the same as Scenario II-E).[4] Brian Bair, a US Forest Service landscape restoration specialist, and Rand Dericco of Syar Industries, verbally estimated clearing and grading costs at a much lower cost of $4,000,000.
5. **Revegetation and public access facilities.** Ballpark figures for vegetation management and public access facilities development are an additional $3,000,000. The public access facilities are trails, a parking area, and possibly a campground and kayak launch. These amenities have been identified by Sonoma County Regional Parks as integral to their regional parks strategy. The agency has also expressed interest in owning and managing the property once restoration has been completed.

Potential ancillary expenses may include the purchase of property rights or license agreements from adjoining landowners, and the installation of new Jackson Family Wines water wells.

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[4] Pacific States has extensive experience in similar wetland restoration projects including implementation of six sites for the USFWS throughout San Francisco Bay area including the South Bay Salt Ponds Restoration Project (Cargill) (http://pacificstates.net).

Permit compliance, species and ecosystem monitoring programs, and future maintenance costs will be developed and budgeted. An adaptive resource management plan will be designed and integrated with the monitoring programs. Once these post-implementation operations and maintenance costs have been determined, EHC will work with local partners to seek endowment funding for the project prior to transfer to Sonoma County Regional Parks, or another entity, for long term ownership and management.

11.3.2 Potential project funding sources. The Management Team has identified several potential funding sources to take the project through implementation of site grading, revegetation, construction, and monitoring costs of the project. The immediate need is to fund the next level of design and engineering, development of the CEQA/NEPA document, and reclamation plan amendment.

US Army Corps of Engineers. EHC has submitted a Letter of Intent to the US Army Corps of Engineers San Francisco District (Corps) seeking its assistance under the Continuing Authorities Program (CAP; Section 1135) to improve Russian River ecosystem habitat below Coyote Valley Dam. The Corps has determined that this project has strong potential to address identified watershed impacts of previous large Corps-funded Russian River flood control projects and will be consistent with the scope of a project for the Section 1135 CAP program. Once federal interest is determined, the Corps and EHC, as the Non-Federal Sponsor, will execute a Project Management Plan and a Feasibility Cost Sharing Agreement (FCSA) to complete a Detailed Project Report, which is the final product for a Corps feasibility study for Section 1135 CAP projects. Once the FCSA is executed, the project delivery team can initiate the feasibility study phase. This comprehensive Hanson Project feasibility study report is expected to provide extensive and appropriate data and analysis methods to facilitate efficient execution and completion of the Corps feasibility study.

The project FCSA will provide for 50/50 cost sharing of all feasibility phase costs in excess of $100,000 incurred after execution of the FCSA, except for the costs of the Independent Expert Peer Review Panel, if applicable. A Project Partnership Agreement will be executed if the project proceeds to the Design and Implementation phase (i.e., detailed engineering design and construction phase) with costs shared 75% federal and 25% non-federal. EHC, as the Non-Federal Sponsor would be responsible for the costs of land, easements, relocations, rights-of-way, and disposal areas, which are creditable towards the 25% non-federal cost share. Section 1135 also allows credit for certain in-kind contributions, including design coordination, materials, and construction.

The Non-Federal Sponsor, EHC, is responsible for 100% of all costs and obligations related to the operations, maintenance, repairs, rehabilitation, and replacements of the constructed project. The federal limit for construction costs is $10,000,000.

Proposition 1: Water Quality, Supply, and Infrastructure Improvement Act of 2014. In November 2014, voters authorized $7.12 billion in general obligation bonds for state water supply infrastructure projects which included over $600 million for ecosystem and watershed protection and restoration. The California State Coastal Conservancy, California Department of Fish and Wildlife, and the Wildlife Conservation Board have all developed grant programs to distribute their share of these funds. The Hanson restoration project is eligible for funding under all three of these programs, and the Management Team has initiated discussions with these agencies' staff. In June 2016, the Coastal Conservancy approved a $345,000 grant to EHC for the reclamation plan amendment, CEQA/NEPA process and construction design. Sonoma County PRMD is also providing in-kind assistance as a match for the Coastal Conservancy grant. The project may also be eligible for funding under the North Coast Integrated Regional Water Management Plan.

Hanson Aggregates Mid-Pacific, Inc. Hanson has agreed to continue to carry the bonds required under the reclamation plan amendment when the property is transferred to EHC.

11.4 Summary, conclusions and next steps

Due to its size, proximity, and connection to the main stem Russian River, the Hanson property offers a unique opportunity in the Russian River Middle Reach Valley to restore ecosystem functions and critically important floodplain habitat for listed salmonids and other native species. The Hanson Russian River Ponds Floodplain Restoration Feasibility Study has determined that preferred Scenario II-E is feasible and meets all project goals and objectives. Specifically, the project will:

1. **Significantly increase salmonid habitat** by an order of magnitude including spawning gravels and shallow off-channel calm water winter and spring nursery, rearing, and refuge habitat for salmonids.

2. **Make a significant contribution to recovery** of the federally- and state-listed Central California Coho salmon population, and federally-listed California Coastal Chinook salmon, and Central California Coast steelhead populations, and provide population level benefits for multiple federally- or state-listed Species of Special Concern.

3. **Significantly reduce production of non-native fish populations** that prey on native fish species by eliminating the warm water habitats favored by the predators.

4. **Halt ongoing river bed degradation** and scour by significantly reducing Middle Reach river flood elevations and water velocities, thus minimizing the erosive scour potential which has resulted in ongoing channel bed incision and destabilization of banks during high flow events.

5. **Improve onsite and downstream water quality** by eliminating the artificial open water ponds that seep warm water into the river, and by restoring annual seasonal floodplain sediment deposition to the reach.

6. **Stimulate ecosystem productivity** by restoring the natural seasonal floodplain pulse-flow dynamics of the valley, and increase aquifer recharge by restoring extensive annual floodplain inundation for significant durations in the winter and spring.

7. **Enhance overall ecosystem function** by restoring connectivity between the river channel and off-channel floodplain shallow water habitats, and seasonal aquatic ecotone interactions with riparian and upland habitats.

8. **Promote recovery of native flora and fauna** by restoring the natural seasonal variability of floodplain and river channel habitat complexity, and natural seasonal heterogeneity and connections of off-channel aquatic habitats under which native species have evolved and flourished.

9. **Restore the structure and function of the riparian corridor** by restoring the landforms and physical processes necessary for supporting a natural riparian vegetation progression from aquatic beds to mature seral stage upland riparian forests.

10. **Lowers water surface elevations** in the study area by approximately 1 meter for all flood flows including the 100-year flood event.

11. **Present an ecologically superior, feasible, and exemplary alternative to typical SMARA reclamation plans**, thus providing a science-based rationale to promote the use of SMARA to accomplish ecological restoration goals.

12. **Provide recreational and environmental education opportunities** compatible with ecosystem restoration.

Once the draft feasibility study report is approved by the Coastal Conservancy, the final report will be submitted to Sonoma County PRMD, California Office of Mine Reclamation, San Francisco District of the US Army Corps of Engineers, NOAA's National Marine Fisheries Service, California Department of Fish and Wildlife, and other interested agencies. The study will be distributed to the Scientific Working Group, Peer Review Panel, Partners Planning Group, adjacent landowners and other stakeholders. After PRMD determines the appropriate CEQA/NEPA process, a more detailed conceptual design will be prepared, and a Request for Proposals for development of the reclamation plan amendment, CEQA /NEPA restoration plan document will be solicited from qualified consulting firms.

Concurrently, EHC will continue to work with adjacent landowners to reconcile concerns and secure property interests for implementation, solicit additional implementation budget proposals, work with the Corps on the Section 1135 program, and engage with other interested funding agencies.

Literature Cited

Adams PB, Bowers MJ, Fish HE, Laidig TE, and Silberberg KR. April 1999. Historical and current presence-absence of coho salmon (*Oncorhynchus kisutch*) in the Central California Coast Evolutionarily Significant Unit. NMFS Administrative Report SC-99-02. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southwest Fisheries Science Center, Tiburon, California.

Bailey EH, Irwin WP, and Jones DL. 1964. Franciscan and Related Rocks and their Significance in the Geology of Wester California. B183, California Geological Survey.

Bailey P, Giannico G. 2009. Aggregate Mining to Restoration in Willamette River Floodplains. In Ecological Opportunities for Gravel Pit Reclamation on the Russian River. Proceedings of the Russian River Pit Symposium sponsored by NOAA National Marine Fisheries Service and Syar Industries, Santa Rosa, California (Cluer et al. 2009).

Bayley PB. 1991. The flood pulse advantage and the restoration of river floodplain systems. Regulated Rivers: Research and Management, 6:75–86.

Bayley PB. 1995. Understanding large river floodplain ecosystems. Bioscience 45(3):153–158.

Beechie T, Pess G, and Roni P. 2008. Setting river restoration priorities: a review of approaches and a general protocol for identifying and prioritizing actions. N.Am. Jour. Fish. Mngmt 28:891-905.

Bellmore JR, Baxter CV, Martens K, and Connolly PJ. 2013. The floodplain food web mosaic: a study of its importance to salmon and steelhead with implications for their recovery. Ecological Applications 23(1): 189–207.

Bjorkstedt EP, Spence BC, Garza JC, Hankin DG, Fuller D, Jones WE, Smith JJ, and Macedo R. October 2005. An Analysis of Historic Population Structure for Evolutionarily Significant Units of Chinook Salmon, Coho Salmon, and Steelhead in the North-Central California Coast Recovery Domain. NOAA Technical Memorandum. NMFS-SWFSC-382. 210pp.

Blake MC Jr., Graymer RW, and Stamski RE. 2005. Geologic Map and Map Database of Western Sonoma, Northernmost Marin, and Southernmost Mendocino Counties, California. U.S. Geological Survey Miscellaneous Field Studies Map MF-2402.

Bradford MJ. 1995. Comparative review of Pacific salmon survival rates. Canadian Journal of Fisheries and Aquatic Sciences, 52(6): 1327-1338, 10.1139/f95-129. www.nrcresearchpress.com/doi/abs/10.1139/f95-129#.VjlBfUZPIsQ

Brown LR, Moyle PB, and Yoshiyama RM. 1994. Historical decline and current status of coho salmon in California. North American Journal of Fisheries Management 14:237-261.

Busby P, Wainwright TC, Bryant GJ, Lierheimer L, Waples RS, Waknitz FW, and Lagomarsino IV. August 1996. Status review of west coast steelhead from Washington, Idaho, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-27. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

California Department of Fish and Wildlife. 1965. California Fish and Wildlife Plan, Vol. I: Summary. 110p.; Vol. II: Fish and Wildlife Plans, 216.; Vol. III: Supporting Data, 180p.

Cluer B, Swanson M., McKeon J. January 2009. Ecological Opportunities for Gravel Pit Reclamation on the Russian River. Proceedings of the Russian River Pit Symposium sponsored by NOAA National Marine Fisheries Service and Syar Industries, Santa Rosa, California.
Available at: www.russianriverkeeper.drupalgardens.com/media/1726

Colvin R, Giannico GR, Li J, Boyer KL, and Gerth WJ. 2009. Fish Use of Intermittent Watercourses Draining Agricultural Lands in the Upper Willamette River Valley, Oregon. Transactions of the American Fisheries Society 138:1302–1313, 2009 Copyright by the American Fisheries Society 2009. DOI: 10.1577/T08-150.1.

Evans AF, Hostetter NJ, Collis K, Roby DD, Loge FJ. 2014. Relationship between Juvenile Fish Condition and Survival to Adulthood in Steelhead. Transactions of the American Fisheries Society 143:899–909, 2014. American Fisheries Society 2014 ISSN: 0002-8487 print / 1548-8659 online DOI: 10.1080/00028487.2014.901248.

Federal Register 61 FR 56138. October 31, 1996. National Marine Fisheries Service. Final rule: Endangered and threatened species: threatened status for central California coho salmon evolutionarily significant unit (ESU). Federal Register 61:56138-56149. 1996.

Federal Register 62 FR 43937. August 18, 1997. National Marine Fisheries Service. Final Rule: Listing of Several Evolutionary Significant Units of West Coast Steelhead. Federal Register 62:43937-43954.

Federal Register 64 FR 24049. May 5, 1999. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Final Rule and Correction: Designated Critical Habitat; Central California Coast and Southern Oregon/Northern California Coasts Coho Salmon. Federal Register 64:24049-24062.

Federal Register 70 FR 37160. June 28, 2005. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Final Rule: Endangered and Threatened Species: Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs Designation of Critical Habitat for Seven Evolutionarily Significant Units of Pacific Salmon and Steelhead in California. Federal Register, Volume 70 pages 37160-37204.

Federal Register 70 FR 52488. September 2, 2005. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Final critical habitat designations for 19 West Coast salmon and steelhead ESUs. Federal Register 70:52488–52627.

Federal Register 76 FR 50447. August 15, 2011. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service. August 15, 2011. Notice of availability of 5-year reviews: Endangered and Threatened Species; 5-Year Reviews for

5 Evolutionarily Significant 96 Units of Pacific Salmon and 1 Distinct Population Segment of Steelhead in California. Federal Register, 76: 50447-50448.

Gibson JR. and Cutting RE. 1993. Production of juvenile Atlantic salmon, Salmo salar, in natural waters. National Research Council Canada, Canada. Dept. of Fisheries and Oceans. 1993 - Technology & Engineering - 262 pages, 175-177. Can. Spec. Publ. Fish. Aquat. Sci. 1 18.

Good TP, Waples RS, and Adams P (editors). 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Dept. of Commerce, NOAA Tech. Memo. NMFS-NWFSC-66. 597 pp.

Grosholz E and Gallo E. 2006. The influence of flood cycle and fish predation on invertebrate production on a restored California floodplain. Hydrobiologia 568: 91–109.
Hart BW, Bryant WA, and Smith TC. 1983. Summary Report: Fault Evaluation Program, 1981-1982 Area – Northern Coast Ranges Region. OFR83-10, California Geological Survey.

Hart BW, Bryant WA, and Smith TC. 1983. Summary Report: Fault Evaluation Program, 1981-1982 Area – Northern Coast Ranges Region. OFR83-10, California Geological Survey.

Harvey MD, and Schumm SA. 1987. Response of Dry Creek, California, to land use change, gravel mining and dam closure. Erosion and Sedimentation in the Pacific Rim. IAHS Publ. no. 165.

Hayes SA, Bond MH, Hanson CV, Freund EV, Smith JJ, Anderson EC, Ammann AJ, Macfarlane RB. 2008. Steelhead Growth in a Small Central California Watershed: Upstream and Estuarine Rearing Patterns. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Fisheries Ecology Division, Southwest Fisheries Science Center, 110 Shaffer Road, Santa Cruz, California 95060, USA. Transactions of the American Fisheries Society 137:114–128, 2008. DOI: 10.1577/T07-043.1.

Hayes SA. Bond MH, Hanson CV, Jones AW, Ammann AJ. Harding JA. Collins AL,· Perez J, MacFarlane RB. 2011. Down, up, down and "smolting" twice? Seasonal movement patterns by juvenile steelhead (*Oncorhynchus mykiss*) in a coastal watershed with a bar closing estuary. Fisheries Ecology Division, NOAA National Marine Fisheries Service, Southwest Fisheries Science Center, 110 Shaffer Road, Santa Cruz, CA 95060, USA. www.nrcresearchpress.com/doi/abs/10.1139/f2011-062#.Vjk920ZPIsQ.

Hayes SA. 2014. Southwest Fisheries Science Center. Personal communication.

Hayes SA. 2015. Salmonid Federation Restoration Conference.

Healey, MC. 1980. The ecology of juvenile salmon in Georgia Strait, British Columbia, p. 203-229. In W.J. McNeil and D.C. Himsworth (ed.) Salmonid ecosystems of the North Pacific. Oregon State University Press, Corvallis, OR.

Hiner M, Hillemeier D, Silloway S, and Lestelle L. 2009. Juvenile Coho Use of Off-Channel Habitat in the Lower Klamath River. Yurok Tribal Fisheries Program. *In* Proceedings of the American Fisheries Society Annual Conference, Cal-Neva Chapter, Santa Cruz, CA.

Horton G. 2016. Sonoma County Water Agency, personal communication.

Jahn J. 2010. National Marine Fisheries Service fisheries biologist. Personal communication.

Jeffres CA, Opperman JJ, and Moyle PB. 2008. Ephemeral floodplain habitats provide best growth conditions for juvenile Chinook salmon in a California river. Environmental Biology of Fishes 83: 449–458.

Jones, KK, Cornwell TJ, Bottom DL, Campbell LA, and Stein S. 2014. The contribution of estuary-resident life histories to the return of adult *Oncorhynchus kisutch*. *Journal of Fish Biology* (2014), doi:10.1111/jfb.12380, available online at wileyonlinelibrary.com.

Junk WJ, Bayley PB, and Sparks RE. 1989. The flood pulse concept in river floodplain systems. Canadian Special Publication of Fisheries and Aquatic Sciences 106:110–127.

Katz JC, Jeffres L, Conrad T, Sommer N, Corline J, Martinez S, Brumbaugh L, Takata N, Ikemiyagi J, Kiernan J, and Moyle P. 2013. The Experimental Agricultural Floodplain Habitat Investigation at Knaggs Ranch on Yolo Bypass, 2012-2013. Preliminary Report to US Bureau of Reclamation, October 1, 2013. 77pps. Sacramento, CA.

Koski KV. 2009. The fate of coho salmon nomads: the story of an estuarine-rearing strategy promoting resilience. *Ecology and Society* **14**(1): 4. [online] URL: www.ecologyandsociety.org/vol14/iss1/art4/

Limm MP, Marchetti MP. 2009. Juvenile Chinook salmon (*Oncorhynchus tshawytscha*) growth in off-channel and main-channel habitats on the Sacramento River, CA using otolith increment widths. Environmental Biology of Fishes 85:141-151.

Lindsey O, Gidora S, Foy M, and Rosenfeld J. 2015. Watershed-scale effectiveness of floodplain habitat restoration for juvenile coho salmon in the Chilliwack River, British Columbia Canadian Journal of Fisheries and Aquatic Sciences. **72**: 479–490 (2015) dx.doi.org/10.1139/cjfas-2014-0189.

McMahon TE. September 1983. Habitat Suitability Index Models: Coho Salmon: Fish And Wildlife Service Fort Collins Co, Western Energy And Land Use Team. http://handle.dtic.mil/100.2/ADA323350

McElhany P, Rucklelshaus MH, Ford MJ, Wainwright TC, and Bjorkstedt EP. 2000. Viable salmonid populations and the recovery of evolutionarily significant units. NOAA Fisheries Technical Memorandum NMFS-NWFSC-42, Seattle, Washington.

McEwan DR. 2001. Central Valley Steelhead. California Department of Fish and Game, Fish Bulletin 179(1):1-44.

Miller VC. 1972. Soil Survey, Sonoma County, California. United States Department of Agriculture in cooperation with the University of California Agricultural Experiment Station, first issued May 1972, reviewed and reprinted August 1990.

Milner NJ, Elliott JM, Armstrong JD, Gardiner R, Welton JS, Ladle M. 2003. The Natural Control of Salmon and Trout Populations in Streams. National Salmon and Trout Fisheries Centre, Environment Agency, 29 Newport Road, Cardiff CF24 0TP, UK. Fisheries Research 62 (2003) 111–125.

Morley SA, Garcia PS, Bennett T, and Roni P. 2005. Juvenile salmonid (*Oncorhynchus spp.)* use of constructed and natural side channels in Pacific Northwest Rivers. Canadian Journal of Fishery Sciences 62, 2811-2821.

Myers JM, Kope RG, Bryant GJ, Teel D, Lierheimer LJ, Wainwright TC, Grant WS, Waknitz FW, Neely K, Lindley ST, and Waples RS. February 1998. Status review of Chinook salmon from Washington, Idaho, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-35. National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

National Marine Fisheries Service. 2005. An analysis of historical population structure for Evolutionarily Significant Units of Chinook salmon, coho salmon, and steelhead in the North-Central California Coast Recovery Domain.

National Marine Fisheries Service. 2011a. Southern Oregon/ Northern California Coast Recovery Domain 5-year Review: Summary and Evaluation of Southern Oregon/Northern California Coast Coho Salmon ESU. Southwest Region 59 pages.

National Marine Fisheries Service. 2011a. North-Central California Coast Recovery Domain 5-Year Review: Summary and Evaluation of California Coastal Chinook Salmon ESU and Central California Coast Coho Salmon ESU. Southwest Region. 54 pages.

National Marine Fisheries Service. 2011b. North-Central California Coast Recovery Domain 5-Year Review: Summary and Evaluation of California Coastal Chinook Salmon ESU and Central California Coast Coho Salmon ESU. Southwest Region. 67 pages.

National Marine Fisheries Service West Coast Region. Spring 2014. The Importance of Healthy Floodplains to Pacific Salmon & Steelhead. National Marine Fisheries Service West Coast Region website: Floodplains Fact Sheet.

NOAA Technical Memorandum NMFS-NWFSC-112. October 2011. Science Base and Tools for Evaluating Stream Engineering, Management, and Restoration Proposals.

Norman DK. 1998. Reclamation of floodplain sand and gravel pits as off-channel salmon habitat. Olympia, Washington Department of Natural Resources. Washington Geology 26(2/3):21-28.

North Coast Resource Partnership. 2014. North Coast Integrated Regional Water Management Plan.

NRCS. 1972. Soil Survey of Sonoma County. http://www.nrcs.usda.gov/Internet/FSE_MANUSCRIPTS/california/sonomaCA1972/sonomaCA1972.pdf

Ornduff R. 1974. Introduction to California Plant Life. University of California Press. Berkeley and Los Angeles. ISBN 0-520-02735-3. Library of Congress Catalog Number: 73-85793

Peterson NP. 1982. Population characteristics of juvenile coho salmon (*Oncorhynchus kisutch*) overwintering in riverine ponds. Canadian Journal of Fisheries and Aquatic Sciences 39 (9):1303-1307.

Ritter JR, and W.M. Brown. 1971. Turbidity and suspended-sediment transport in the Russian River basin, California. Open-File Report 72-316 prepared by the U.S. Department of the Interior, Geological Survey, Water Resources Division in cooperation with the U.S. Army Corps of Engineers, Menlo Park, California. 100 pages.

San Francisco Estuary Institute. 2014. Middle Reach Russian River; Historical Ecology Reconnaissance. Report to National Marine Fisheries Service, Santa Rosa Office.

San Francisco Bay Joint Venture. 2001. Restoring the Estuary: an Implementation Strategy for the SFBJV. Oakland, CA.

Sellheim KL, Watry CB, Rook B, Zeug SC, Hannon J, Zimmerman J, Dove K, and Merz JE. 2015. Juvenile Salmonid Utilization of Floodplain Rearing Habitat after Gravel Augmentation in a Regulated River. River Research Applications. (2015) Doi: 10.1002/Rra.2876.

Skidmore PB, Thorne CR, Cluer BL, Pess GR, Castro JM, Beechie TJ, and Shea CC. 2011. Science base and tools for evaluating stream engineering, management, and restoration proposals.

Sommer TR, Nobriga ML, Harrel WC, Batham WJ, Kimmerer WJ. 2001. Floodplain rearing of juvenile Chinook salmon: evidence of enhanced growth and survival. Canadian Journal of Fisheries and Aquatic Sciences 58: 325-333.

Sonoma County. 1998. Syar Ponds Reclamation Draft Environmental Impact Report.

Sonoma County. 2010. Aggregate Resources Management Plan, adopted 2010. http://www.sonoma-county.org/prmd/docs/misc/arm_plan.pdf

Spence, BC. North-Central California Coast Recovery Domain. Pages 26 – 47 in Williams, TH, Spence BC, Boughton DA, Johnson RC, Crozier C, Mantua N, O'Farrell M, and Lindley ST. 2016. Viability assessment for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest. 2 February 2016 Report to National Marine Fisheries Service – West Coast Region from Southwest Fisheries Science Center, Fisheries Ecology Division 110 Shaffer Road, Santa Cruz, California 95060.

Spence BC, Bjorkstedt EP, Paddock S, and Nanus L. March 23, 2012. Updates to biological viability criteria for threatened steelhead populations in the North-Central California Coast Recovery Domain. National Marine Fisheries Service. Southwest Fisheries Science Center, Fisheries Ecology Division.

Swales S, Levings CD. 1989. Role of Off-Channel Ponds in the Life Cycle of Coho Salmon (*Oncorhynchus kisutch*) and Other Juvenile Salmonids in the Coldwater River, British Columbia. Published on the web 11 April 2011. Canadian Journal of Fisheries and Aquatic Sciences, 1989, 46(2): 232-242, 10.1139/f89-032.

Tabor RA, Footen BA, Fresh KL, Celedonia MT, Mejia F, Lowand L, Park L. 2007. Smallmouth Bass and Largemouth Bass Predation on Juvenile Chinook Salmon and Other Salmonids in the Lake Washington Basin. North American Journal of Fisheries Management 27:1174-1188, 2007. DOI:10.1577-221.1.

Wallace M, Allen S, Ricker S, Garwood J, and Frimodig A. 2015. Importance of the stream-estuary ecotone to juvenile coho salmon (*Oncorhynchus kisutch*) in Humboldt Bay, California. California Fish and Game 101(4):241-266; 2015. California Department of Fish and Wildlife, Sacramento, USA.

Weitkamp LA, Wainwright TC, Bryant GJ, Milner GB, Teel DJ, Kope RG, and Waples RS. September 1995. Status review of coho salmon from Washington, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-24. United States Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, Washington.

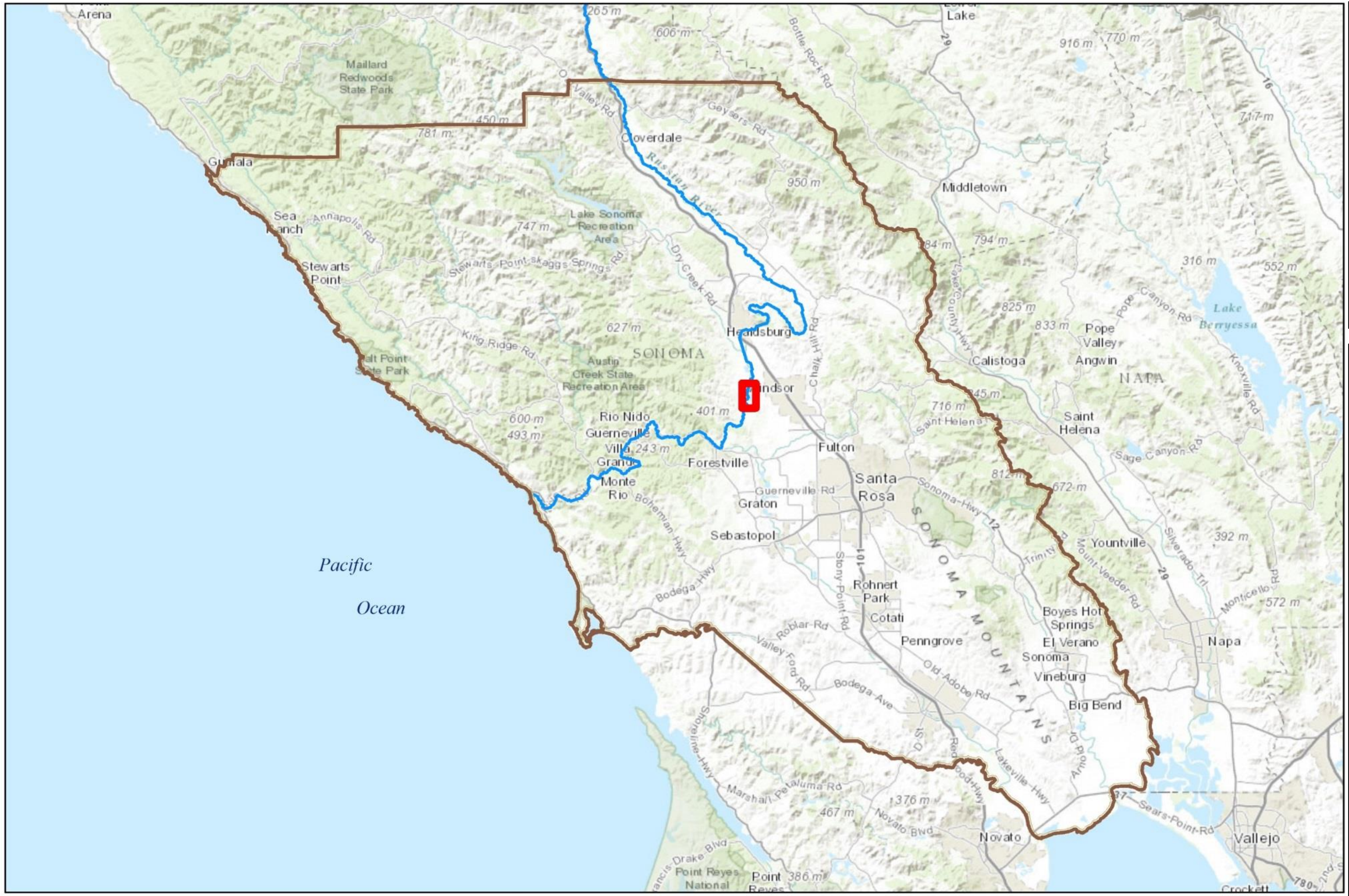
Wentworth CK. 1922. A scale of grade and class terms for clastic sediments", J. Geology V. 30, 377-392.

Western Regional Climate Center. 2013. Cooperative Climatological Data Summaries. http://www.wrcc.dri.edu/climatedata/climsum/.

Williams, TH, Spence BC, Boughton DA, Johnson RC, Crozier C, Mantua N, O'Farrell M, and Lindley ST. 2016. Viability assessment for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest. 2 February 2016 Report to National Marine Fisheries Service – West Coast Region from Southwest Fisheries Science Center, Fisheries Ecology Division 110 Shaffer Road, Santa Cruz, California 95060.

Williams TH, Lindley ST, Spence BC, and Boughton DA. 2011. Status Review Update for Pacific Salmon and Steelhead Listed Under the Endangered Species Act: Southwest. 17 May 2011 – Update to 5 January 2011 report. National Marine Fisheries Service. Southwest Fisheries Science Center. Santa Cruz, California.

Yates G. 2013. Hydrologist. Personal communication.



Conceptual Design – Plan Sheets Hanson Russian River Ponds, Floodplain Restoration Project

Pages:

1. Cover
2. Property Boundaries
3. Existing Land Cover and Property Lines
4. Existing Conditions Topography
5. Existing Conditions and Floodplain Scenario 2-E Topography
6. Scenario 2-E Topography
7. Existing Land Cover and Primary Vegetation Zones
8. Scenario 2-E Proposed Vegetation Zones
9. Generalized Cut and Fill
10. Cut and Fill Volumes
11. Topographic and Hydraulic Cross-sections for flow of 1421 cms
12. Topographic and Hydraulic Profiles
13. Habitat Considerations / Design Notes

Sheet # 1 of 13	*Title:* **Sonoma County and Hanson Project location**	*Date Drawn:* July 13, 2015
Project: **Hanson Russian River Ponds Floodplain Restoration Feasibility Study**	*Scale:*	*Drawn by:* C. Gavette
Location: **Near Windsor, Sonoma County**	*Prepared for:* **California Coastal Conservancy & Sonoma County Permit and Resource Management Department**	*Checked by:*

EHC
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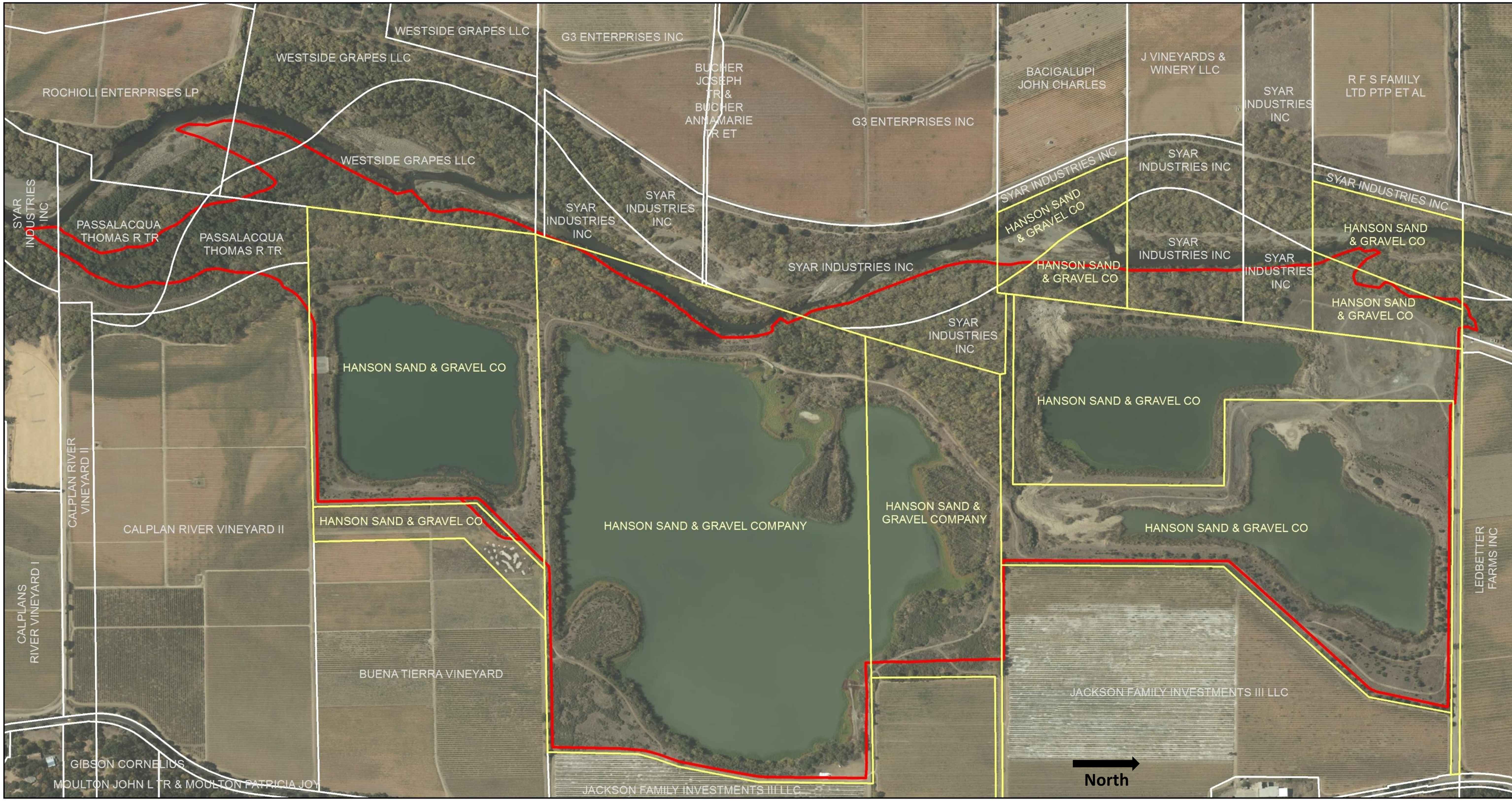
Hanson



Hanson Parcels

White Lines — Parcels

Project Boundary

0 — 250 meters

Sheet # 2 of 13	*Title:* **Property Boundary Map**	*Date Drawn:* July 13, 2015
Project: **Hanson Russian River Ponds Floodplain Restoration Feasibility Study**	*Scale:* **1 centimeter = 65 meters**	*Drawn by:* C. Gavette
Location: **Near Windsor, Sonoma County**	*Prepared for:* **California Coastal Conservancy & Sonoma County Permit and Resource Management Department**	*Checked by:* B. Cluer

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Hanson Parcels

White Lines — Parcels

0 — 250 meters

Sheet # 3 of 13	*Title:* **Existing Land Cover and Hanson Property Lines**	*Date Drawn:* July 13, 2015
Project: **Hanson Russian River Ponds Floodplain Restoration Feasibility Study**	*Scale:* **1 centimeter = 65 meters**	*Drawn by:* C. Gavette
Location: **Near Windsor, Sonoma County**	*Prepared for:* **California Coastal Conservancy & Sonoma County Permit and Resource Management Department**	*Checked by:* B. Cluer

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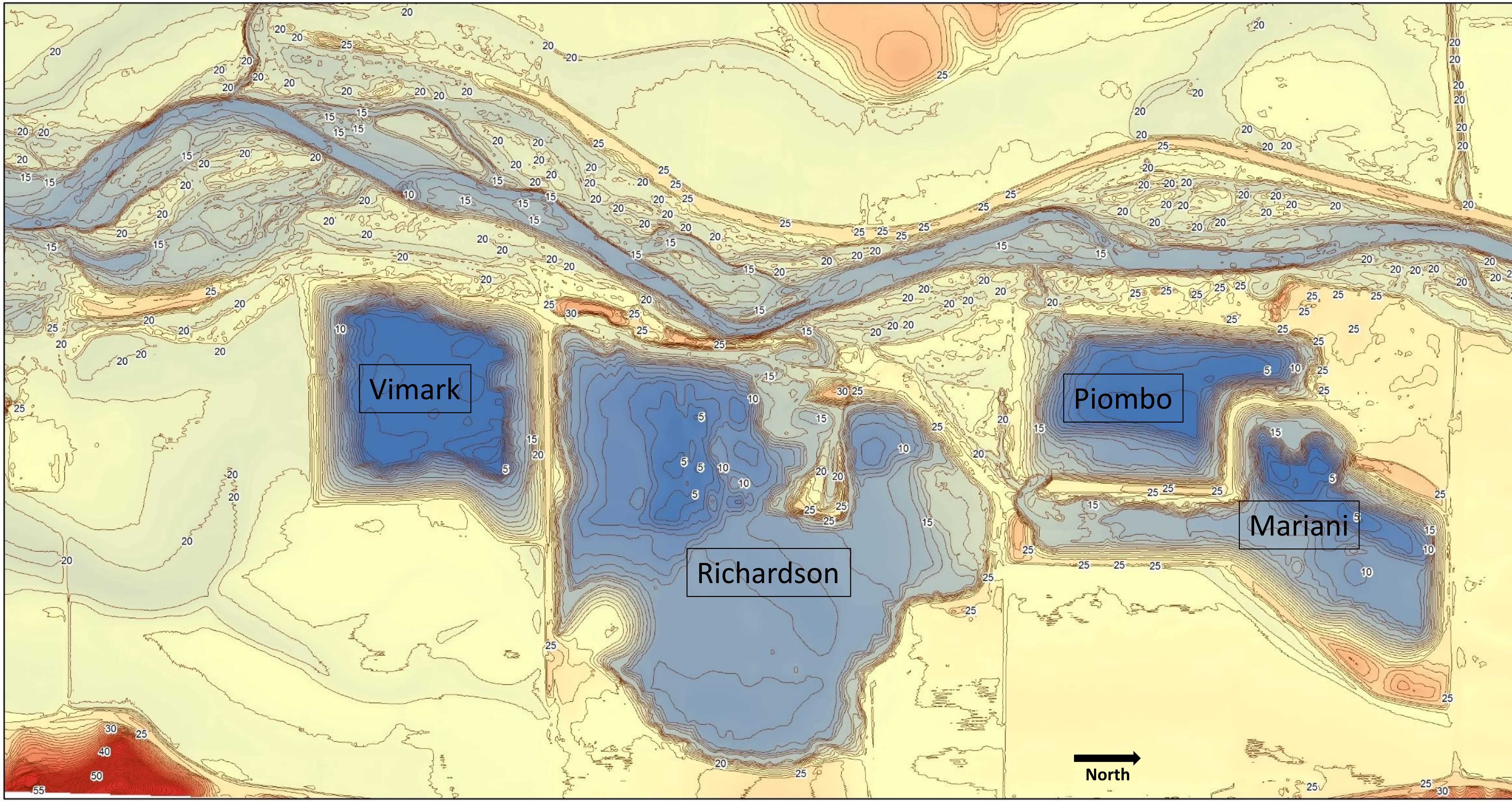

1 Meter Contour

Elevation

80 Meters

0 Meters

0 — 250 meters

Sheet # 4 of 13	*Title:* **Existing Conditions Topography**	*Date Drawn:* July 13, 2015
Project: **Hanson Russian River Ponds Floodplain Restoration Feasibility Study**	*Scale:* **1 centimeter = 65 meters**	*Drawn by:* C. Gavette
Location: **Near Windsor, Sonoma County**	*Prepared for:* **California Coastal Conservancy & Sonoma County Permit and Resource Management Department**	*Checked by:* B. Cluer

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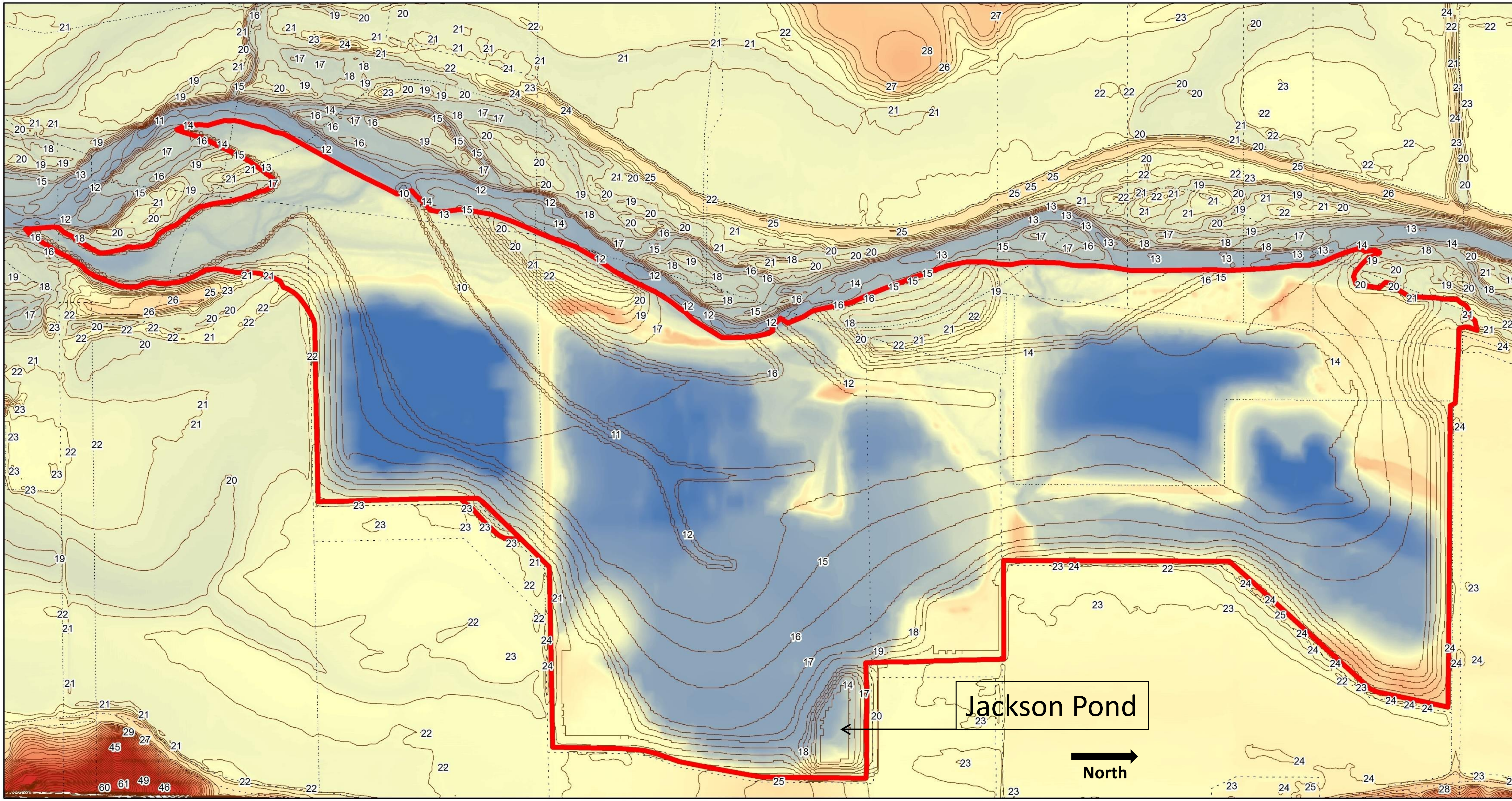

1 Meter Contour

Parcels

Project Boundary

Elevation

80 Meters

0 Meters

0 250 meters

Sheet # 5 of 13	*Title:* **Existing Conditions with Concept E Topography**	*Date Drawn:* July 13, 2015
Project: **Hanson Russian River Ponds Floodplain Restoration Feasibility Study**	*Scale:* **1 centimeter = 65 meters**	*Drawn by:* C. Gavette
Location: **Near Windsor, Sonoma County**	*Prepared for:* **California Coastal Conservancy & Sonoma County Permit and Resource Management Department**	*Checked by:* B. Cluer

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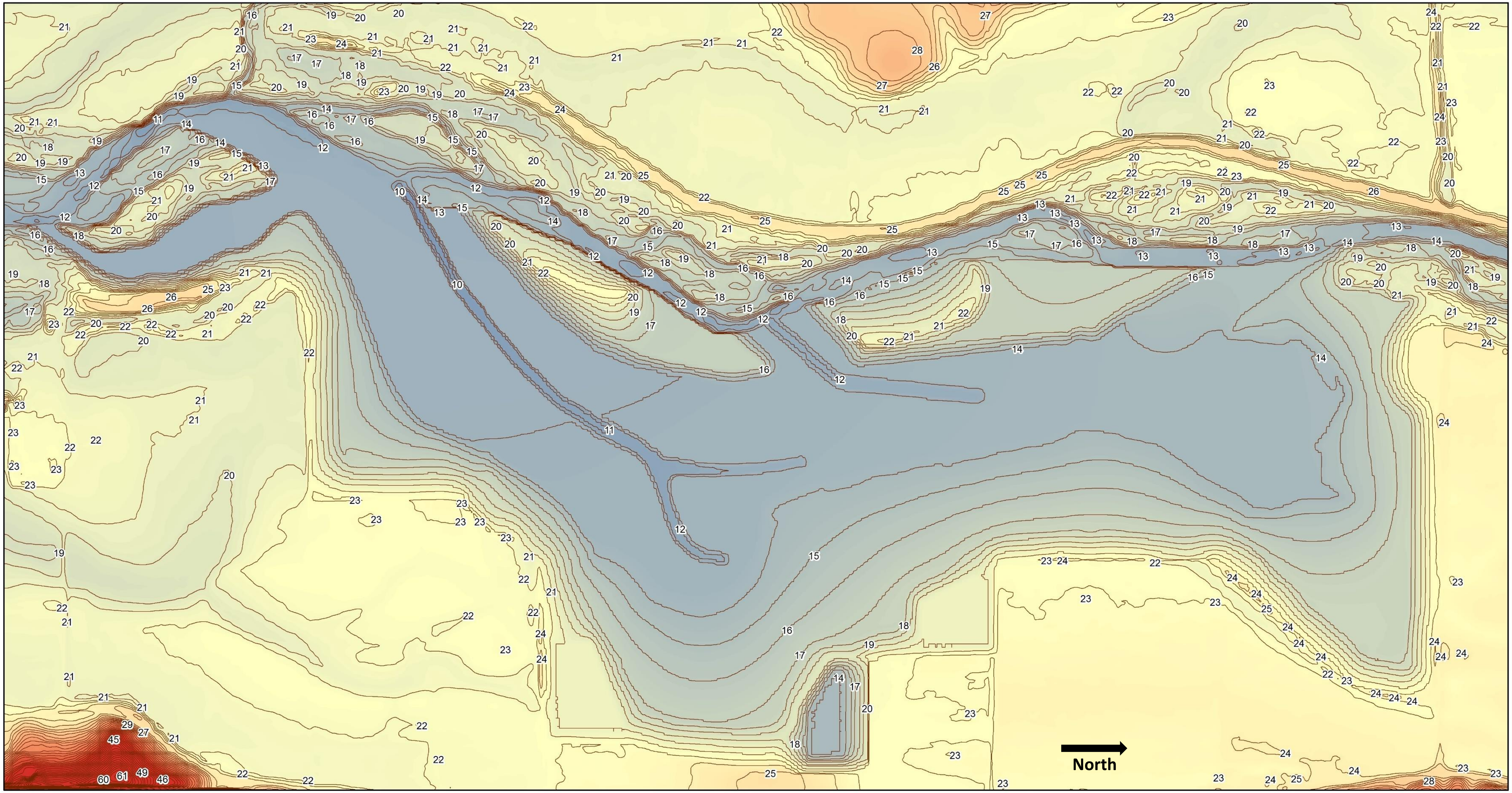

1 Meter Contour

Elevation

80 Meters

0 Meters

0 250
meters

Sheet # 6 of 13	*Title:* **Stage II-E Topography**	*Date Drawn:* July 13, 2015
Project: **Hanson Russian River Ponds Floodplain Restoration Feasibility Study**	*Scale:* **1 centimeter = 65 meters**	*Drawn by:* C. Gavette
Location: **Near Windsor, Sonoma County**	*Prepared for:* **California Coastal Conservancy & Sonoma County Permit and Resource Management Department**	*Checked by:* B. Cluer

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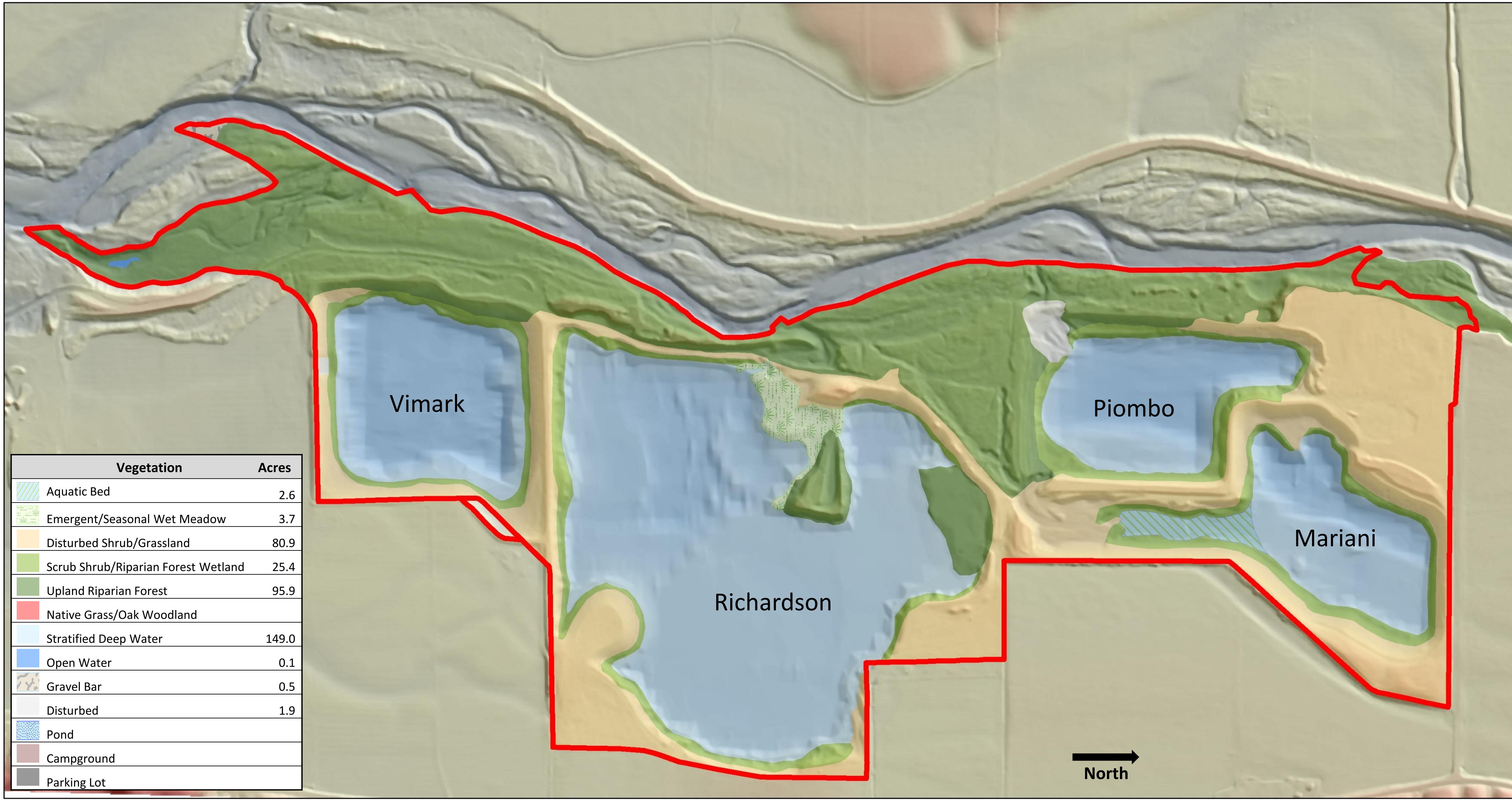

Vegetation	Acres
Aquatic Bed	2.6
Emergent/Seasonal Wet Meadow	3.7
Disturbed Shrub/Grassland	80.9
Scrub Shrub/Riparian Forest Wetland	25.4
Upland Riparian Forest	95.9
Native Grass/Oak Woodland	
Stratified Deep Water	149.0
Open Water	0.1
Gravel Bar	0.5
Disturbed	1.9
Pond	
Campground	
Parking Lot	

Aquatic Bed
Emergent/Seasonal Wet Meadow
Disturbed Shrub/Grassland
Scrub Shrub/Riparian Forest Wetland
Upland Riparian Forest
Stratified Deep Water
Open Water
Gravel Bar
Disturbed

0 250
meters

Sheet # 7 of 13	*Title:* **Existing Land Cover and Primary Vegetation Zones**	*Date Drawn:* July 13, 2015
Project: **Hanson Russian River Ponds Floodplain Restoration Feasibility Study**	*Scale:* **1 centimeter = 65 meters**	*Drawn by:* C. Gavette
Location: **Near Windsor, Sonoma County**	*Prepared for:* **California Coastal Conservancy & Sonoma County Permit and Resource Management Department**	*Checked by:* B. Cluer

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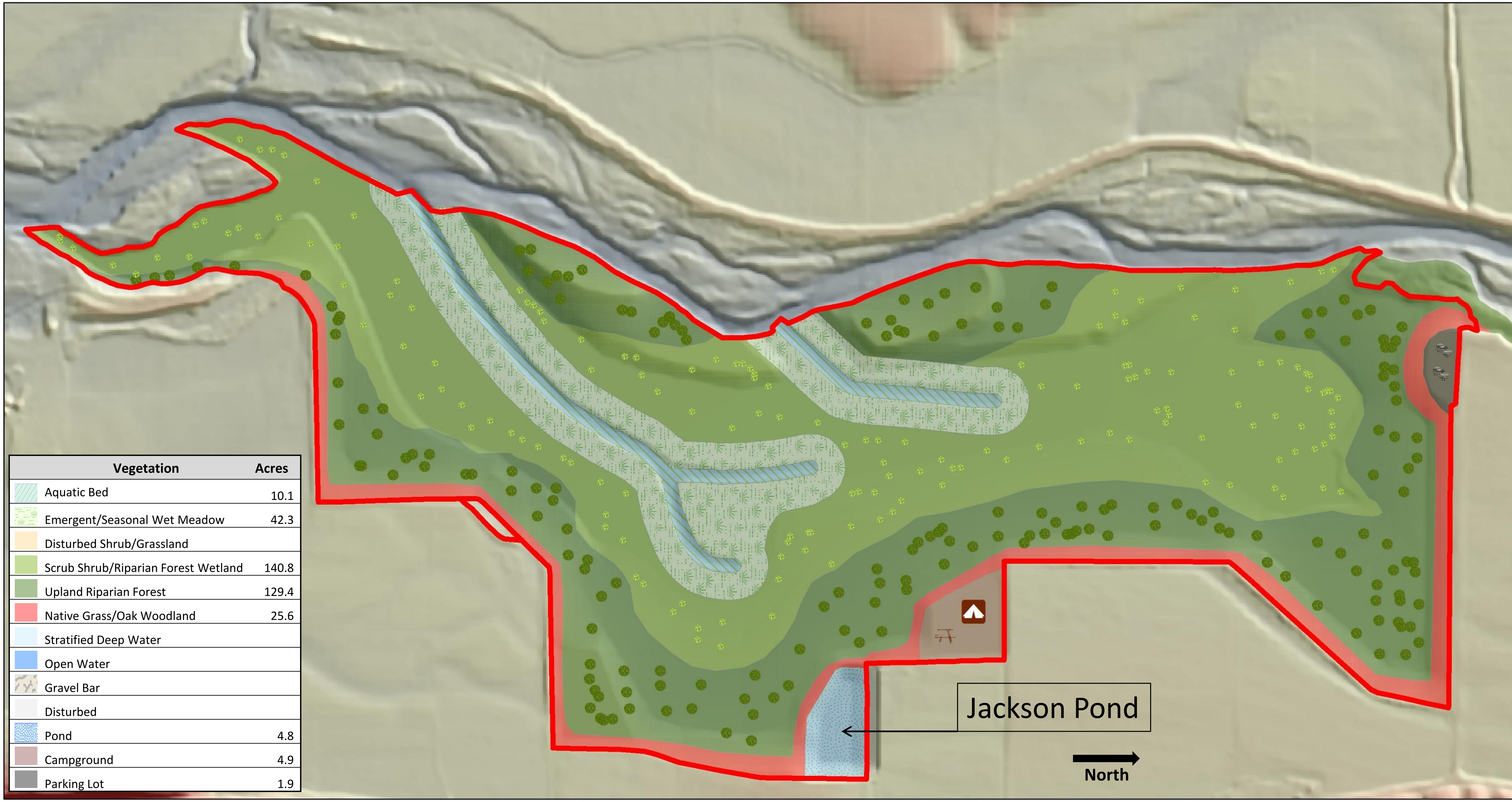

Aquatic Bed
Emergent/Seasonal Wet Meadow
Scrub-Shrub/Forested Seasonal Wetland
Upland Riparian Forest
Native Grass / Oak Woodland
Pond
Campground
Parking Lot

0 250
meters

Sheet # 8 of 13

Title: **Proposed Vegetation Zones and Land Features**

Date Drawn: July 13, 2015

Project: **Hanson Russian River Ponds Floodplain Restoration Feasibility Study**

Scale: **1 centimeter = 65 meters**

Drawn by: C. Gavette

Location: **Near Windsor, Sonoma County**

Prepared for: **California Coastal Conservancy & Sonoma County Permit and Resource Management Department**

Checked by: B. Cluer

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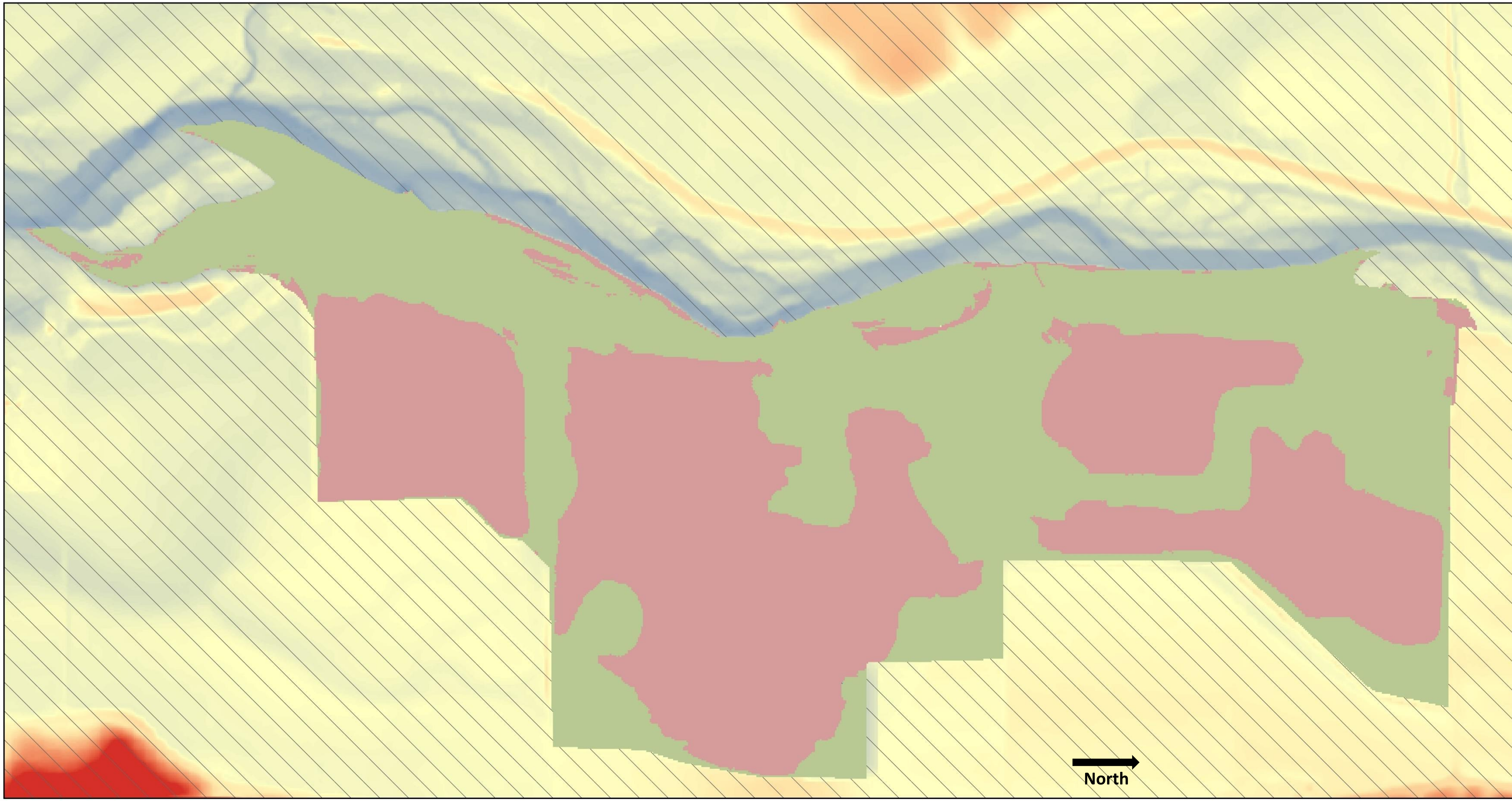


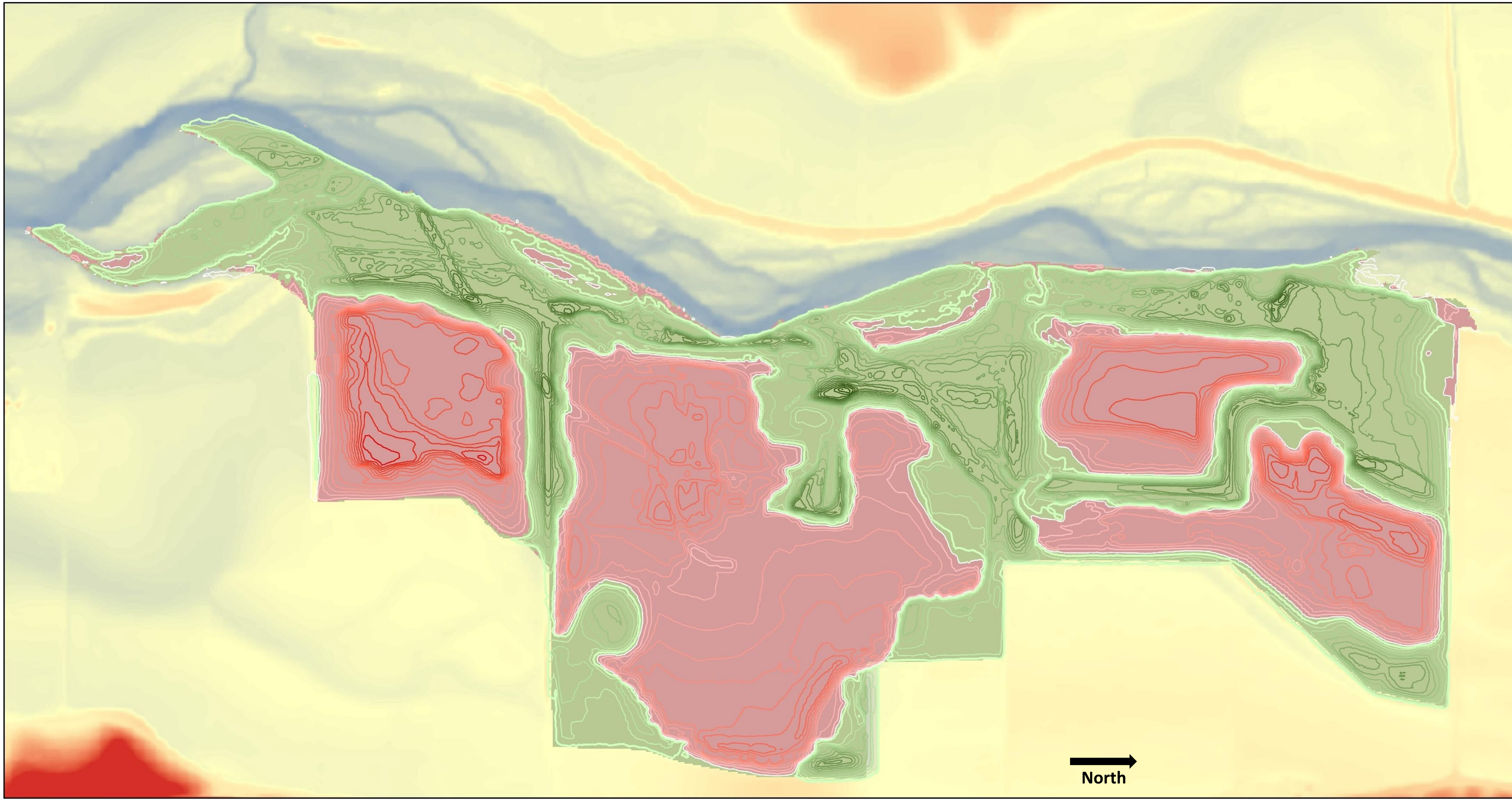
Material Cut / Fill

- Area of Fill
- Unchanged
- Area of Cut

0 250
meters

Sheet # 9 of 13	*Title:* **Generalized Material Cut / Fill** Cut: 3,562,219 m^3 Fill: 3,569,880 m^3	*Date Drawn:* July 13, 2015
Project: **Hanson Russian River Ponds Floodplain Restoration Feasibility Study**	*Scale:* **1 centimeter = 65 meters**	*Drawn by:* C. Gavette
Location: **Near Windsor, Sonoma County**	*Prepared for:* **California Coastal Conservancy & Sonoma County Permit and Resource Management Department**	*Checked by:* B. Cluer

EHC NOAA FISHERIES Hanson



Change Contours

Increase in Elevation — 14 Meters

Decrease in Elevation — -17 Meters

0 — 250 meters

Sheet # 10 of 13	*Title:* **Material Cut / Fill with Change Contours**	*Date Drawn:* July 13, 2015
Project: **Hanson Russian River Ponds Floodplain Restoration Feasibility Study**	*Scale:* **1 centimeter = 65 meters**	*Drawn by:* C. Gavette
Location: **Near Windsor, Sonoma County**	*Prepared for:* **California Coastal Conservancy & Sonoma County Permit and Resource Management Department**	*Checked by:* B. Cluer

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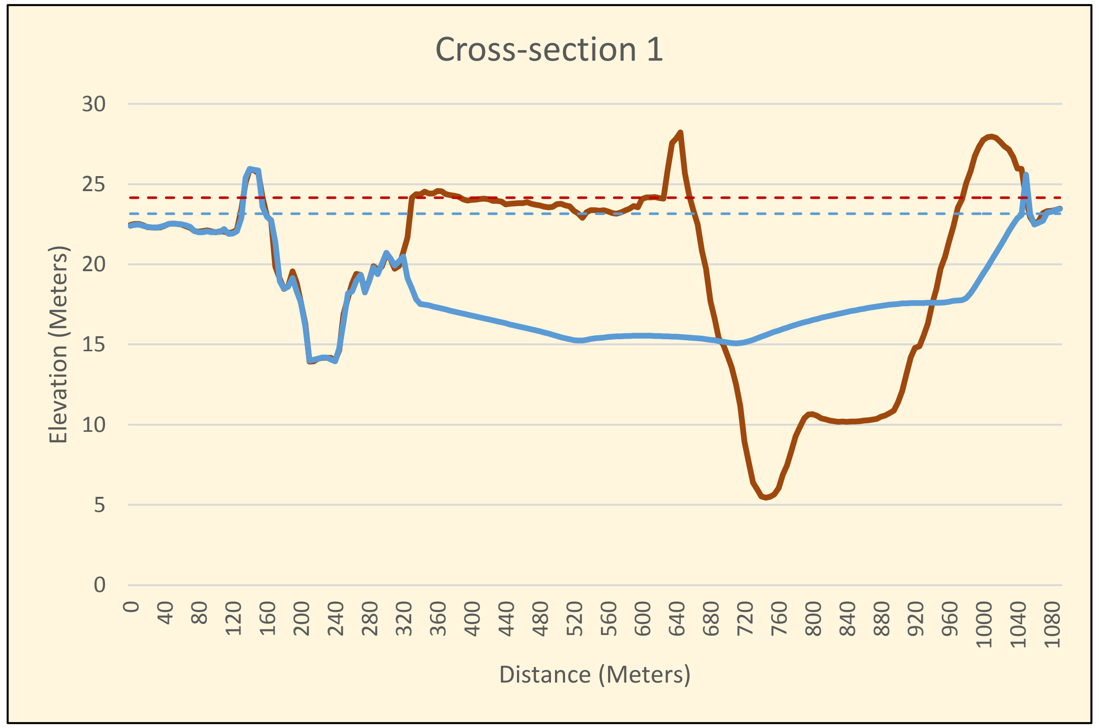
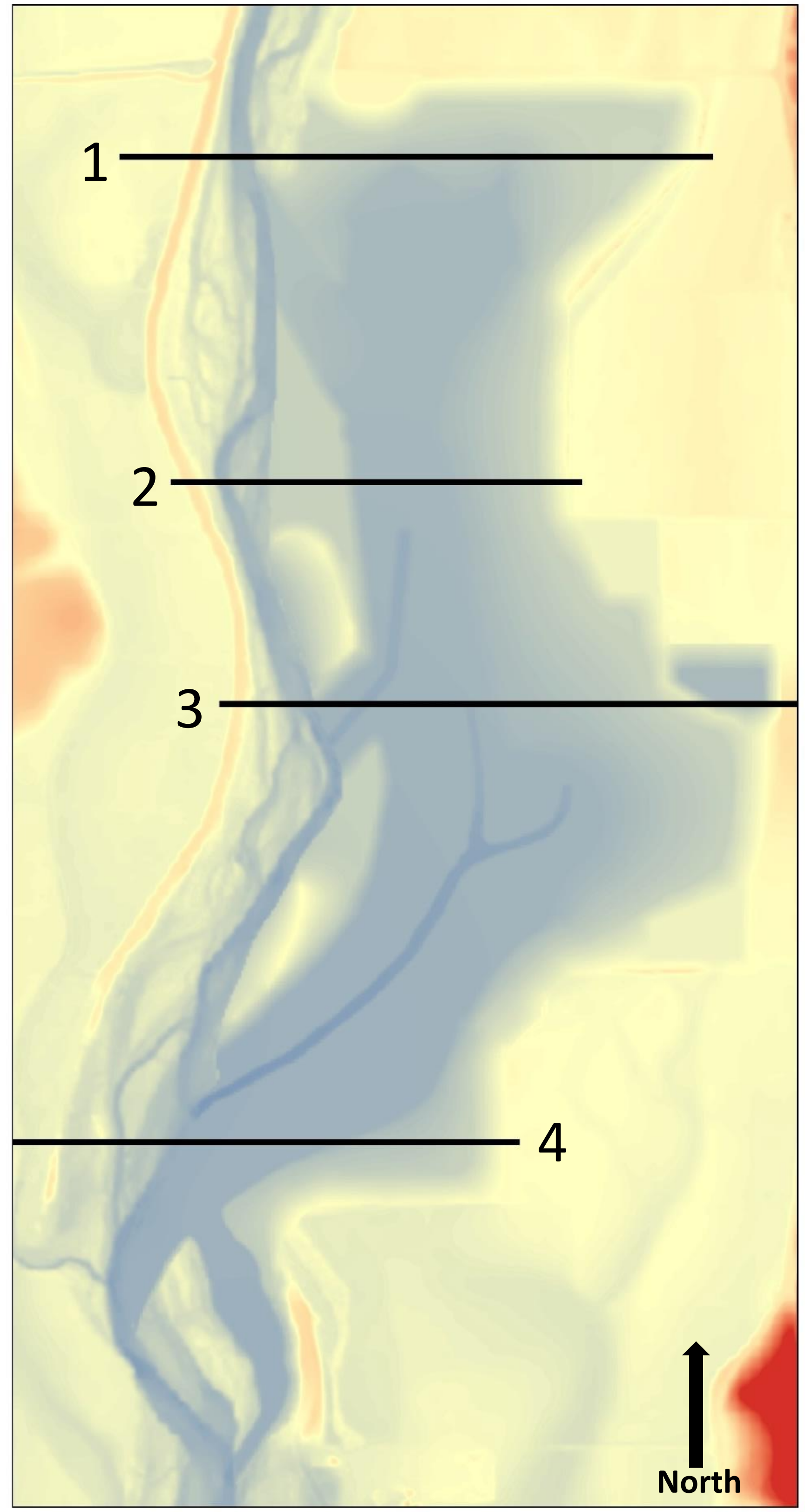
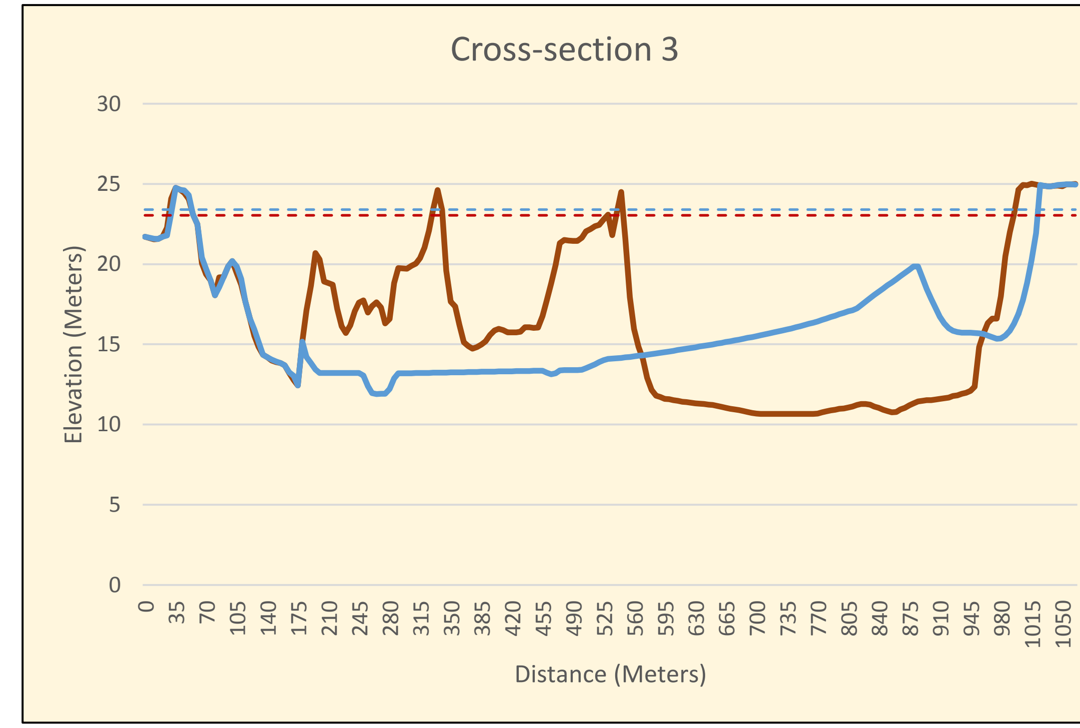
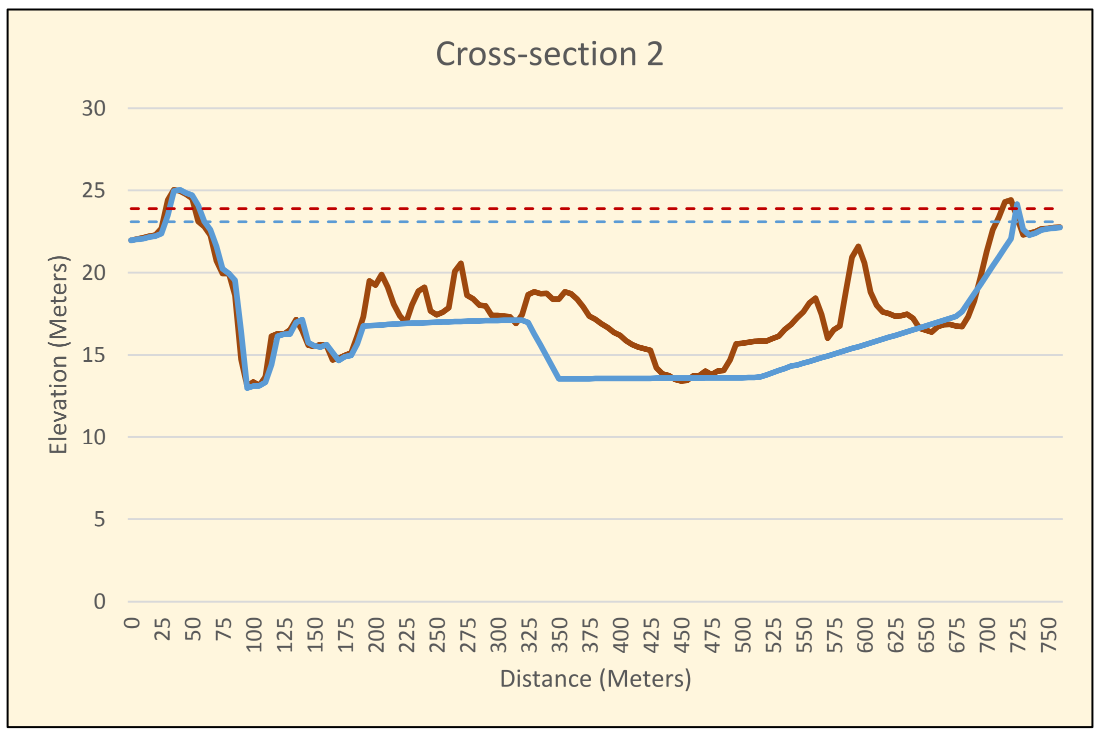
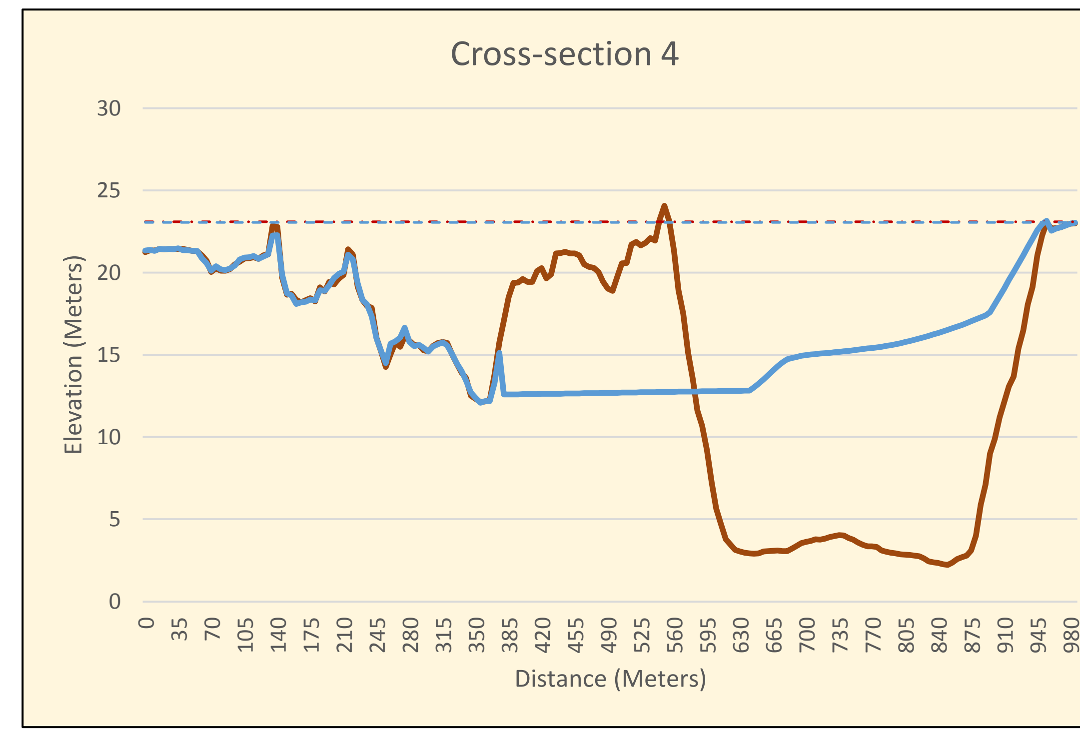






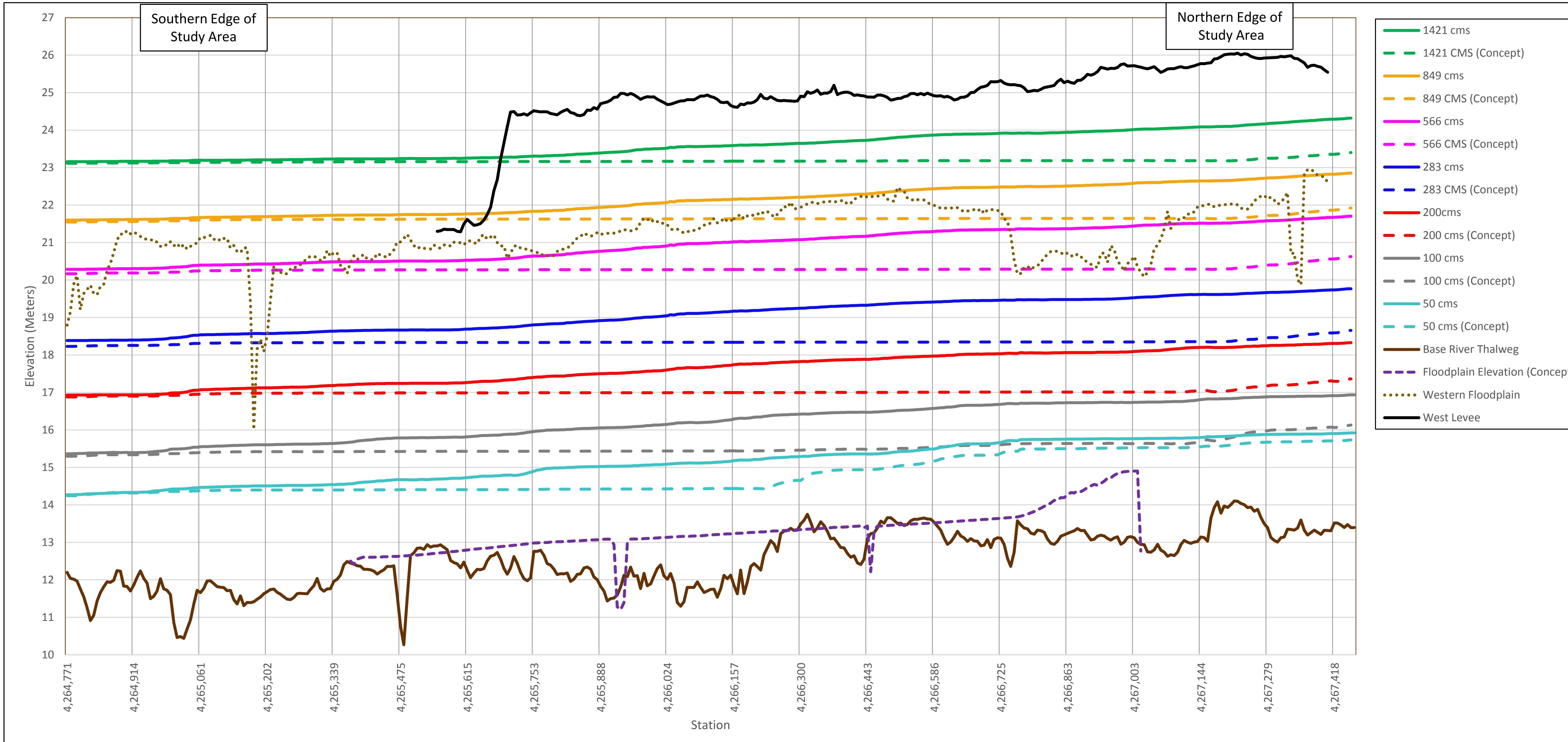




Existing
Concept E
WSE Existing
WSE Concept E

Flow = 1421 cms

Sheet # 11 of 13	*Title:* **Topographic and Hydraulic Cross-sections for 100-year flow 1421 cms**	*Date Drawn:* July 13, 2015
Project: **Hanson Russian River Ponds Floodplain Restoration Feasibility Study**	*Scale:*	*Drawn by:* C. Gavette
Location: **Near Windsor, Sonoma County**	*Prepared for:* **California Coastal Conservancy & Sonoma County Permit and Resource Management Department**	*Checked by:* B. Cluer



Thalweg Profile
Floodplain Profile

Sheet # 12 of 13	*Title:* **Topographic and Hydraulic Profiles for the Project Area**	*Date Drawn:* July 13, 2015
Project: **Hanson Russian River Ponds Floodplain Restoration Feasibility Study**	*Scale:*	*Drawn by:* C. Gavette
Location: **Near Windsor, Sonoma County**	*Prepared for:* **California Coastal Conservancy & Sonoma County Permit and Resource Management Department**	*Checked by:* B. Cluer

Design notes:

1. Sort earth materials, for placing porous fill in ponds, soil on vegetation slopes, gravel in swales for groundwater upwelling, silt-clay for new water storage pond, etc.
2. Macro topographic features graded during construction to immediately improve habitat function.
3. Rim trail incorporated in 1:10 outside slope.
4. Salvage existing vegetation in those zones where grading is within +1 and -1 meter cut/fill of the existing surface.
5. Retain woody debris grubbed from site for incorporation into surfaces and shallow burial habitat features.
6. Willow salvaged and kept alive for incorporating into new banks and macro habitat features such as debris piles, island head, etc.
7. Vegetation management to include control of non-native species, advance planting of desirable natives, particularly aquatic beds.

Sheet # 13 of 13	*Title:* **Habitat Features – Typical & Design Considerations**	*Date Drawn:* Sept 30, 2015
Project: **Hanson Ponds Russian River Floodplain Restoration Feasibility Study**	*Scale:*	*Drawn by:*
Location: **Near Windsor, Sonoma County**	*Prepared for:* **California Coastal Conservancy & Sonoma County Permit and Resource Management Department**	*Checked by:*

APPENDIX A

Russian River Watershed Assessment

A watershed assessment was completed by Brian Cluer and John McKeon of NOAA Fisheries to provide a comprehensive overview of the Russian River watershed. A preliminary discussion of abiotic factors is followed by more specific description of the physical processes and associated salmonid habitat for eight physiographic subregions within the watershed moving north to south – Hopland/Ukiah Valleys, Alexander Valley, Dry Creek, the Middle Valley (Healdsburg to Forestville), Santa Rosa Plain, Laguna de Santa Rosa, Forestville to Jenner, and the Estuary.

B.1 Geology

Accreted terrain made of fine-grained sedimentary, meta-sedimentary, and various volcanic rocks. Highly fractured, highly erodible with low porosity. Multiple semi-parallel active faults and active deep volcanism as evidence by the Geysers Complex in northern Sonoma County.

Faulting and crustal extension creates 'pull-apart' basins that are filled with alluvium and separated by geologic canyon reaches. Valleys are filled with porous alluvium and layered with thick volcanic ash layers (weathered to clay) that are exposed in the bottom of most tributary streams. (Sources: Bailey *et al.* 1964; Hart *et al.* 1983; Blake *et al.* 2005)

B.2 Climate

The Russian River watershed climate is one of the few Mediterranean-type climates in the world and is characterized by high precipitation in winter and early spring, followed by a prolonged intensely dry summer and fall. Inter annual cycles of wet and dry periods are driven by El Nino Southern Oscillation (ENSO) on a roughly 4-5-year periodicity. (Source: Western Regional Climate Center, 2013.)

B.3 Hydrology

Low porosity in the uplands result in a high runoff coefficient. There are vast water-scarce areas around basins with fault/fracture water that is rarely found in abundance. Groundwater of varying depth and volume are found in alluvial aquifers comprised of porous fill layered with thick volcanic ash layers that have weathered to clay. (Source: Miller, 1990.)

B.4 Watershed Development

The California Fur Rush of the mid-1700s extirpated beaver and otter, and the Spanish settlements that began in the late 1700s logged giant fir forests and cleared land for grazing and farming. Products were moved by railroads built in the early 1800s, and land drainage and flood control projects were initiated with the railroads. Currently the basins are highly developed for agriculture, with localized urban centers, and all of the valleys have various flood control schemes. There are two Army Corps of Engineers (COE) flood control and water supply dams in the basin obstructing approximately 30% of the watershed area. Both dams regulate flood flows and increase year-round base flows. The main river channels have been modified for flood control, incised, and then managed for water supply conveyance. Tributaries are also incised and their water supplies have been developed. Groundwater has also been developed resulting in lower elevations, while potential recharge from winter storms has been minimized by drainage and flood control. Much of the watershed has dispersed rural residential and agricultural development, enhancing sediment delivery. Water development, delivery, and use are only nominally regulated.

B.5 Physical Processes and Salmonid Habitat

The following table lists, by major physiographic feature, the hydromodifications that affect the physical processes responsible for creating and maintaining salmonid habitat quality, availability, resiliency, and productivity.

Pre-development Processes and Historic Ecologic Conditions	Salmonid Life History Stage*:* Habitat Association	Current Processes and Conditions	Restoration and Recovery Opportunities
Hopland and Ukiah Valleys			
• Fans at tributaries, depositing coarse sediment, buffering transport downstream.	**Adult Spawning**: Well-sorted gravels. **Emergent Alevin**: Calm edgewater habitats of side channels, sloughs off-channel, and seasonal wetlands provide for high recruitment rates to population. **Parr/Smolt:** Winter rearing, abundant sloughs, side-channel, off-channel and wetland habitats provide opportunities for rapid winter growth.	• Channelized, leveed.	• Restore fan deposition.
• Alluvial valleys, conserving gravel sand and finer sediment, reworked and buffered transfer downstream.	**Adult Spawning:** High quality abundant spawning gravels of naturally forming transverse bars.	• Channelized, leveed, mined, revetted banks. • Deeply incised channels.	Restore valley deposition.
• Resilient to floods and watershed disturbances such as landslides and fire.		• Sensitive to floods, to watershed disturbances. • Bank failure common, land 'loss' constant struggle.	Restore floodplain.
• High water table. • Ephemeral pools connected to water table.	**Fry/Parr:** Summer rearing, temperature refuge.	• Lowered water table, streams losing to water table. • Pools less prominent shortened hydroperiod.	Restore groundwater recharge.
• Seasonally variable flow regime; winter floods, base flow recession, low dry season flows, seasonally dry reaches.	**Fry/Parr:** Adfluvial migrations to seasonal habitats possible in concert with natural timing of environmental cues.	• Lake Mendocino, built in 1958. • River channel managed for flood control and water delivery.	

Pre-development Processes and Historic Ecologic Conditions	Salmonid Life History Stage: Habitat Association	Current Processes and Conditions	Restoration and Recovery Opportunities
• High water quality, clarity restored quickly after storms.	**Fry/Parr/Smolt:** Winter rearing.	• Poor water quality, high turbidity for prolonged periods due to bottom discharge at Coyote Dam. • Prolonged fine sediment load, reducing egg survival.	• Modify dam discharge structure. • Improve sediment management upstream from Coyote Dam. • Restore sediment deposition zones/floodplain.
• Sparse channel vegetation. • Broad gradual sloping gravel bars along channel margins.	**Fry/Parr/Smolt:** Winter and summer rearing.	• Thick invasive riparian vegetation. • Steep sided channel margins.	• Restore sediment deposition zones/floodplain
• Tributaries connected to river. • Scaled down but tributaries exhibit the same set of sediment and hydrologic processes; sediment storage and transfer, ground water recharge. • Prolonged hydro period connections between headwaters and river.	**Adult Spawning**: Abundant and diverse well-sorted gravels and access to most of the watershed. **Emergent Alevin**: Calm edgewater habitats of side channels, sloughs off-channel, and seasonal wetlands provide for high recruitment rates to population. **Parr/Smolt:** Winter rearing, abundant sloughs, side-channel, off-channel and wetland habitats provide opportunities for rapid winter growth. Prolonged time period for migration between headwaters and river and vice-versa.	• Straightened, channelized, incised. • Managed as drainage ditches, expediting flood conveyance and sediment routing. • Tributaries incised or perched 10-20', disconnected from river except during floods. • Shortened hydro period, flashy hydrology.	• Restore tributary channel processes.
• Tributaries with prolonged gradual flow recession.	**Fry/Parr:** Adfluvial migrations to seasonal habitats possible in concert with natural timing of environmental cues.	• Rapid receding flow sensitivity and fish stranding, due to widespread high volume water demand; 'frost protection' for wine grapes. • Tributaries experience prolonged and repeated annual droughts.	• Many options: regulatory, water storage, farm practices, etc. • Improve recharge, flood resilience. • Replace water diversions with storage. • Reduce water withdrawals especially in dry season.

Pre-development Processes and Conditions	Salmonid Life History Stage: Habitat Association	Current Processes and Conditions	Restoration and Recovery Opportunities
Alexander Valley			
• Fan at upstream end, wide active channel meandering reach, island-network wetland at downstream end. • Flood resilient. • Drought resilient.	**Adult Spawning**: Well sorted gravels. **Emergent Alevin**: Calm edgewater habitats of side channels, off-channel sloughs, and seasonal wetlands provide for high recruitment rates to population. **Parr/Smolt:** Winter rearing, abundant sloughs, side-channel, off-channel and wetland habitats provide opportunities for rapid winter growth.	• COE project channelized, narrowed, straightened, moderately incised, high % revetted banks. • Managed for decades as flood control channel. • Recently abandoned project. • Flood sensitive, damage prone.	• Floodplain restoration. • Off channel habitat creation.
• Sediment delivery events deposited in upper reach, reworked and transferred downstream in buffered fashion.		• Sediment routed down valley or through reach. • Nuisance deposition managed by repeat instream mining. • Banks unstable.	• Floodplain restoration. • Strategic / planned retreat.
• High water quality, clarity restored quickly after storms.	**Parr/Smolt:** Winter rearing, opportunities for rapid growth.	• Poor water quality, high turbidity for prolonged periods due to bottom discharge at Coyote Dam. • Prolonged fine sediment load reducing egg survival.	• Modify dam discharge structure. • Improve sediment management upstream from Coyote Dam.
• Productive winter/spring/summer habitat for spawning and rearing.		• Minimized habitat area, less resilient to floods, high sediment delivery.	• Restore 'fan' process. • Floodplain restoration. • Create off-channel habitat.

Pre-development Processes and Conditions	Salmonid Life History Stage: Habitat Association	Current Processes and Conditions	Restoration and Recovery Opportunities
• Ephemeral flow, flood resilient, high water table, perennial pockets with groundwater contact.	**Parr:** Summer temperature refuge	• Perennial flow, flood regulated, lowered water table. • Reservoir released from bottom; prolonged sediment laden flows.	Modify release structure, stabilize upper watershed.
• Sparse channel vegetation.		• Thick non-native invasive riparian vegetation.	Restore flood flows.
• Tributaries connected to river. • Scaled down but same set of sediment and hydrologic processes; sediment storage and transfer, ground water recharge. • Prolonged connections for migration between headwaters and river and vice-versa.	**Adult Spawning**: Well-sorted gravels. **Emergent Alevin**: Calm edgewater habitats of side channels, sloughs off-channel, and seasonal wetlands provide for high recruitment rates to population. **Parr/Smolt:** Winter rearing, abundant sloughs, side-channel, off-channel and wetland habitats provide opportunities for rapid winter growth.	• Straightened, channelized, incised. • Managed as drainage ditches, expediting flood conveyance and sediment routing. • Tributaries perched or incised, disconnected from river except during floods.	Regrade tributaries to connect to current river channel. Restore river channel elevation to reconnect with tributaries.
• Tributaries had prolonged gradual flow recession. • Drought resilient.	**Fry/Parr:** Adfluvial migrations to seasonal habitats possible in concert with natural timing of environmental cues. Summer temperature refuge.	• Rapid receding flow sensitivity and fish stranding due to widespread high volume water demand including 'frost protection' for wine grapes. • Tributaries experience annual droughts.	• Many options; regulatory, storage, farm practices, etc. • Improve recharge, flood resilience. • Replace water diversions with storage.

Pre-development Processes and Conditions	Salmonid Life History Stage: Habitat Association	Current Processes and Conditions	Restoration and Recovery Opportunities
Dry Creek Valley			
• Wide active river belt, braided and meandering network.	**Adult Spawning**: Well sorted gravels. **Emergent Alevin**: Calm edgewater habitats of side channels, off-channel sloughs, and seasonal wetlands provide for high recruitment rates to population. **Parr/Smolt:** Winter rearing, abundant sloughs, side-channel, off-channel and wetland habitats provide opportunities for rapid winter growth.	• Channelized, narrow, straight, incised, levee lined, revetted. • Deeply incised. • Sediment transport maximized, coarse sediment routed to channel. • Unstable banks, sensitive to moderate floods.	• Restore floodplain. • Strategic retreat of encroachment, levees, revetment, infrastructure. Initiate channel evolution to higher value stages.
• Broad floodplain, frequently inundated.	**Eggs and Alevin**: Frequent overbank out of channel flood flows limit in-channel velocities and redd scour that contribute to high egg survival and alevin emergence rates.	• Disconnected floodplain, 20-30' high, rarely inundated.	• Floodplain restoration. • Strategic retreat of encroachment, levees, revetment, infrastructure.
• Sediment storage and transfer processes moderated sediment transport downstream. • Fans stored coarse sediment on valley margins.		• Sediment routing processes deliver everything downstream. • Nuisance deposition managed with instream mining. • Spawning beds unstable.	Initiate channel evolution to higher value stages.
• High water table. • Complex spring-fed off-channel habitats.	**Parr:** Summer rearing, temperature refuge.	• Water table lowered. • Drained, filled, disconnected off-channel habitats.	Create off-channel habitats, directly or by facilitating channel evolution.
Ephemeral flow.	**Fry and parr (survival).** Limited invasive predator populations not adapted to Mediterranean climate hydrologic cycle.	Perennial flow regulated.	• Optimize 'tailwater' fishery. • Create resilient and sustainable habitat.

Pre-development Processes and Conditions	Salmonid Life History Stage*:* Habitat Association	Current Processes and Conditions	Restoration and Recovery Opportunities
Sparse channel vegetation.	**Adults and eggs:** Allow channel meander, and channel incision limited	Thick non-native invasive riparian vegetation.	Restoration of native riparian forest.
Tributaries were drought resilient.	**Parr:** Summer rearing, temperature refuge.	• Tributaries developed; agricultural and rural/residential water development. • Drought experienced annually.	• Improve recharge, flood resilience. • Replace water diversions with off-stream storage and maximize water conservation.
Tributaries had prolonged gradual flow recession.	**Parr:** Summer rearing habitat accessible in synch with natural environmental cues of flow and temperature.	• Rapid receding flow sensitivity and fish stranding, due to widespread high volume water demand; 'frost protection' for wine grapes. • Tributaries experience annual droughts.	• Many options; regulatory, storage, farm practices, etc. • Improve recharge, flood resilience. • Replace water diversions with off-stream storage.
• Tributaries connected to river. • Scaled down but same set of sediment and hydrologic processes, sediment storage and transfer, ground water recharge. • Prolonged connections for migration between headwaters and river and vice-versa.	**Fry/Parr:** Adfluvial migrations to seasonal habitats possible in concert with natural timing of environmental cues.	• Straightened, channelized, incised. • Managed as drainage ditches, expediting flood conveyance and sediment routing. • Tributaries perched or incised, disconnected from river except during floods.	• Restore channelized reaches. • Restore sediment deposition. • Improve infiltration.

Pre-development Processes and Conditions	Salmonid Life History Stage*:* Habitat Association	Current Processes and Conditions	Restoration and Recovery Opportunities
Middle Valley: Healdsburg to Forestville			
• Wide active river belt, meandering and island network at downstream end. • Broad low gradient gravel bars with little vegetation. • Sediment conservation and metering downstream. • Numerous and extensive stable spawning beds and off-channnel rearing sloughs.	**Adult Spawning**: Well sorted gravels with high rates of exchange between surface and hyporeic flows resulting in high egg survival rates and emergence of alevins. **Emergent Alevin**: Calm edgewater of distributary channels, seasonal off-channel and wetlands habitats provided for high survival and recruitment rates of fry to the population. **Fry:** High productivity of food prey result in rapid growth and high survival rates. The result is high carrying capacity of off-channel and wetland habitats. **Parr/Smolt:** Winter/spring rearing in abundant off-channel, side-channel, sloughs, and wetland habitats likely provided abundant opportunities for rapid winter/spring rates of growth and high survival rates.	• Dredged 50’ deep in 1940-50’s. • Channelized, narrow, straight, incised, levee lined, revetted. • Disconnected tributaries perched high above RR main channel. • Steep sided over-elevated and unstable banks, resulting in ongoing expensive, repetitive stabilization projects. • Sediment transport expedited. • Bed sediment mobilized several times per winter with frequent red scour events resulting in low spawning success rates. • Localized nuisance deposition is managed with periodic in-stream mining.	• Restore floodplain. • Strategic retreat of encroachment, levees, revetment, infrastructure.

Pre-development Processes and Conditions	Salmonid Life History Stage*:* Habitat Association	Current Processes and Conditions	Restoration and Recovery Opportunities
• Broad floodplain. • Frequent overbank flooding. • Ground water recharge.	**Eggs and Alevin**: Frequent overbank out of channel flood flows limit in-channel velocities and redd scour, maintain high egg survival and alevin emergence rates. **Adult spawning**: High hyporheic and surface water interaction rate maintains stable DO and temperatures of intergravel flows. **Alevin**: High emergence rates from spawning gravels. **Parr/Smolt:** Winter rearing, abundant off-channel opportunities for rapid winter growth.	• Disconnected floodplain, recharge from channel area only. • Flood capacity non-constant, unsustainable. • Summer dam and water intake facility at downstream end of reach (Wohler). • Floodplain dotted with ~800 acres of gravel ponds.	Floodplain restoration via recontouring used gravel pits at elevation accessible by frequent winter river flows. By restoring some measure of natural meander of the active channel there is high potential to significantly Increase spawning habitat and wetland and off-channel habitat to significantly benefit multiple life history stages and thus synergistically improve population dynamics.
• High water table. • High rate of hyporheic and surface flow interaction. • Abundant cool ground water seeps throughout the channel. • Several substantial sloughs or old oxbow lakes. • Drought resilient summer flows and temperatures.	**Eggs:** High rates of surface and hyporheic flow exchange result in high Dissolved Oxygen levels of hyporheic flows and thus increase survival and emergence rates of alevin, **Parr**: Summer rearing, groundwater flows intersecting river meanders provide high frequency of localized temperature refuge.	• Lowered water table. • Water temperature warmed in summer by Wohler dam impoundment. Old gravel pit ponds contributing to warmer summer river water temperatures via piping of warm surface water of isolated ponds through levees to the river.	Restore off-channel features such as oxbow lakes, sloughs, meander alcoves at elevations appropriate for modern channel.

Pre-development Processes and Conditions	Salmonid Life History Stage: Habitat Association	Current Processes and Conditions	Restoration and Recovery Opportunities
• Complex off-channel habitats. • Flood refuge away from high Velocity flow. • Spring-head tributary channels supplying thermal refuge in summer and flood refuge in winter.	**Alevin:** Flood resilient edgewater of calm off-channel and wetland habitats result in high survival and rates of recruitment to the population. **Parr/ Smolt**: Winter/spring rearing in seasonal expanded off-channel habitats providing abundant opportunities for rapid growth and resulting in high inherent carrying capacity for the population (Intrinsic Potential) Flood refuge. Summer rearing in springhead alcoves and areas of groundwater seeps in the main channel.	• Drained, filled, disconnected off-channel habitats. • Significantly reduced flood refuge.	• Restore off-channel features such as oxbow lakes, sloughs, seasonal wetlands and river channel meander alcoves at elevations appropriate for the modern channel elevation in order to restore historic ecologic conditions and ecosystem processes that create and provide the seasonal niche habitat requirements of multiple life history stages. • Restore floodplain at elevation appropriate for modern channel and regulated winter/spring base flows.
• Wide seasonal flow range, ephemeral reaches.	**Parr:** Provide flow and temperature environmental cues for adfluvial migrations to seasonal habitats.	• Regulated flow range, augmented perennial water delivery to Wohler intake facility.	• Restore seasonal off-channel habitat features that are less driven by perennial water delivery in the channel.
• Sparse vegetation on wide gravel bars.	**Adult spawning:** Non-ossifed by vegetation gravel bars result in more frequent disturbance/turnover resulting in well sorted and clean gravels, higher hyporeic flow rates and surface water interaction.	• Thick invasive riparian vegetation, in narrow strip. Locks channel in place and fossilizes habitat in unproductive steep sided channel.	• Restore riparian, wetland and transitional upland habitats

Pre-development Processes and Conditions	Salmonid Life History Stage: Habitat Association	Current Processes and Conditions	Restoration and Recovery Opportunities
• **Tributaries:** connected to river, same set of sediment conservation and hydrologic processes as main-stem. • Prolonged hydrologic connections for salmonid migration between headwaters and river and vice-versa.	**Parr**: Access to summer temperature refugia in tributaries; and maintenance of flows in the late spring/early summer period through and across alluvial fans at tributary mouths, thus allowing historic migration timing cued by declining flows and temperature increases. **Adult Spawning**: Well sorted gravels. **Emergent Alevin**: Accessible calm edgewater habitats of tributary channels' sloughs and wetlands provide for additional seasonal access to off-channel wetlands resulting in higher recruitment rates to the rearing population. **Parr/Smolt:** Access to tributary winter/spring off channel rearing providing abundant opportunities for rapid winter growth.	• Straightened, channelized, incised. • Managed as drainage ditches, expediting flood conveyance and sediment routing. • Tributaries incised or perched up to 20', disconnected from river except during infrequent floods.	• Re-grade tributaries to connect to current river channel. • Restore river channel elevation to reconnect with tributaries.
• Perennial flow or short dry-season disconnection.	**Parr:** Maintained natural seasonal connections with main channel, in synch with environmental cues for adfluvial upstream and downstream migrations.	• Water development and incision creates a prolonged local drought.	• Replace water diversions with off-stream storage.

Pre-development Processes and Conditions	Salmonid Life History Stage*:* Habitat Association	Current Processes and Conditions	Restoration and Recovery Opportunities
Santa Rosa Plain			
• Floods spread across Santa Rosa Plain.	**Eggs and Alevin:** Frequent overbank, out of channel flood flows limit in-channel velocities and frequency of redd scour, thus maintained high egg survival, and alevin emergence rates.	• Floods routed through constructed or incised channels across Plain, increasing flood flow depths and velocities in tributary channels and expediting the flood pulse, resulting in increased flood elevations in downstream tributary reaches and the Russian River. Increased depths and velocities have increased frequency and depth of bed mobilization/scour leading to progressively further incised channels.	• Enhance infiltration and flood attenuation to improve year round water quality and summer flow resilience. • Remove or revise levees to decrease velocities and depths of flood flows in order to reduce the frequency of redd scour events and increase alevin emergence rates.
• Groundwater recharge maximized across Plain.	**Adult spawning**: High rate of hyporheic and surface water interaction maintains stable dissolved oxygen (DO) and temperatures of intragravel flows. **Alevin**: Resulted in High emergence rates from spawning gravels. **Parr:** Summer rearing: groundwater flows provide high frequency of localized temperature refuge and summer flow resilience.	• Channels deepened several meters, reducing aquifer storage, and thus correspondingly, reducing or eliminating hyporheic intragravel flows. • Groundwater recharge minimized resulting in warmer and lower summer flows	• Enhance infiltration with channels designed for frequent overbank flows and create recharge basins where space is available. • Remove or revise levees to increase floodplain area and duration of inundation.

<table>
<tr><th>Pre-development Processes and Conditions</th><th>Salmonid Life History Stage: Habitat Association</th><th>Current Processes and Conditions</th><th>Restoration and Recovery Opportunities</th></tr>
<tr><td colspan="4">Laguna de Santa Rosa: Designated a Ramsar Wetland of International Importance in 2010. One 1 of 35 designated sites in the US. Large tracts managed by Laguna de Santa Rosa Foundation, but surrounded by large tracts of lower-value agricultural lands that are seasonally flooded. Higher land to the east is used for treated waste-water disposal and recharge.</td></tr>
<tr><td>• Year round broad valley-wide connection of the Laguna to the Russian River through riparian forest network. Father Junipero Serra letter, describes a 1776 summer crossing of the mouth of the Laguna as a ½ mile wide ford.
• Received floods from Russian River, creating vast shallow lake and wetland complex.
• Flood resilient and dampened flood flows to lower Russian River.</td><td>Emergent Alevin: Calm edgewater habitats of distributary channels, ponds, sloughs and extensive wetlands of flood resilient edgewater habitat provided for high recruitment rates of fry to salmonid populations.

Parr/Smolt: Winter/spring and likely summer access to extensive highly productive rearing habitat providing abundant opportunities for rapid winter growth, particularly in the winter and spring periods.</td><td>• Connection moved downstream, lowered, channelized.
• Partially dredged, partially drained, minimal filling.
• Back floods from Russian River in lower reach only, flood pools back up at each road crossing, trapping and storing nutrient loads and contaminants.
• Still has vast flooded area.
• Minimal dampening of Russian River floods.</td><td>• Restore historic connection of a wide riparian forest connection of the Laguna with the Mainstem Russian River Channel.
• Open up road crossings to allow greater transport of nutrient and contaminant loads out of the basin, and increase RR Basin seasonal wetland habitat providing opportunities for rapid winter/spring grow of fry, parr and pre-smolts.</td></tr>
<tr><td>• “Chain of Seven Lakes” has 20-30 foot deep summer pools with high rates of groundwater flow.
• High quality cool water.
• Summer/fall rearing habitat.
• Drought resilient.</td><td>Emergent Alevin: Calm edgewater ecotone habitats of lakes that are resilient to stage and flow changes provide for high emergent alevin survival, thus high recruitment rates of fry to the population.

Parr/Smolt: Winter/spring and summer rearing, with abundant opportunities for rapid winter/spring growth rates. Summer temperature refuge and likely rearing/growth due to groundwater moderated temperatures and abundant prey resources.</td><td>• Sediment routed from tributaries thru alluvial fans, with widespread deposition in the Laguna, especially behind road crossings.
• Water table lowered and ground water inputs to Laguna and tributaries reduced.
• Water warmer & nutrient laden.
• Likely now uninhabitable in summer/fall and not drought resilient. Historic extent of seasonal wetland significantly constrained.</td><td>• Dredge pools at tributary alluvial fans.
• Reduce sediment load, restore historic floodplain processes of sediment deposition and aquifer recharge upstream of the Laguna.
• Enhance summer Laguna flows with tertiary treated wastewater.</td></tr>
</table>

Pre-development Processes and Conditions	Salmonid Life History Stage*:* Habitat Association	Current Processes and Conditions	Restoration and Recovery Opportunities
	Supported multiple salmonids species and multiple life-stages at high abundance levels. Supported boat rental businesses in Sebastopol based on high value summer fishing opportunities.	Salmonid utilization largely unknown and not recognized. Summer water quality considered below salmonid dissolved oxygen and temperature thresholds for survival.	• Designated in Sonoma County General Plan as high priority for conservation and restoration. • Study year round species and life stage specific niche habitat suitability and utilization by salmonids.
Downstream from Laguna/Middle Valley: Forestville to Jenner			
• Floods moderated by thousands of acres of floodplain, perennial and seasonal wetlands in the Laguna, Middle Valley, and Alexander Valley. • Sediment transport and delivery significantly moderated.	**Emergent Alevin, Parr/Smolt**: • Flood refuge. • Flood resilient alevin to fry transition life-stage habitat ensuring stable and high recruitment rates to salmonid populations.. • Extensive highly productive winter rearing habitat providing abundant opportunities for rapid growth in seasonal wetland and off-channel habitats of floodplains	• Floods and sediment expedited to now-populated canyon reach; Guerneville rural/urban area. • Repetitive FEMA flood-loss claims along lower Russian River.	• Floodplain restoration.
• Tributaries were drought resistant. Had perennial flow, or short dry-season disconnection. Some had extensive wetlands (Atascadero, Willow Creek).	**Parr:** Summer temperature refuge and productive rearing habitat of tributaries accessible in synch with environmental cues of seasonal rising water temperatures and flow recession.	• Channelization and water development create a prolonged local seasonal drought. • Wetlands polluted with agricultural processing chemicals.	• Replace water diversions with off-stream storage. • Restore channelized reaches to allow frequent overbank flows.

Pre-development Processes and Conditions	Salmonid Life History Stage: Habitat Association	Current Processes and Conditions	Restoration and Recovery Opportunities
Estuary			
Prolonged summer/ fall perched lagoon condition providing vast acreage of stable, fresh to brackish water inundation of marsh plain. Coastal marine cooled high volume water body	**Emergent Alevin/Fry:** Upper estuary, unbreached is freshwater. Provided extensive calm edgewater, with ecotones resilient to flow and tidal changes resulting in vast acreage of fry recruitment habitat. **Parr/Smolt**: Winter rearing with abundant opportunities for rapid growth due to high estuarine prey abundance, availability. Summer rearing: Opportunities for rapid growth due to high estuarine prey availability with temperatures mediated by conservation of groundwater inflows and coastal zone marine influence mediated air and water temperatures.	• Mechanically breached frequently for decades, to reduce water elevation, as flood defense for a few structures. • Water input warmed at Wohler constriction and at 3 other summer dams upstream.	• Buy out and remove the lowest structures. • Stop mechanical breaching. • Remove upstream summer dams to decrease summer water temperature of Estuary surface

Middle Reach Russian River

Historical Ecology Reconnaissance

San Francisco Estuary Institute

Study Extent

~5.5 miles north-south along Russian River south of Healdsburg (“Middle Reach”)

Background

Study overview:

- Reconnaissance study to provide initial historical ecology perspective and identify future research directions
- Complements broader effort to synthesize historical ecology information for Santa Rosa Plain/Russian River

Study goals:

- Characterize landscape patterns in the Middle Reach prior to major Euro-American modification
- Inform conceptual design of Hanson gravel pits restoration

Why historical ecology?

- Insights derived from an understanding of past landscape patterns and processes can enhance recognition of future restoration potential

Data Collection

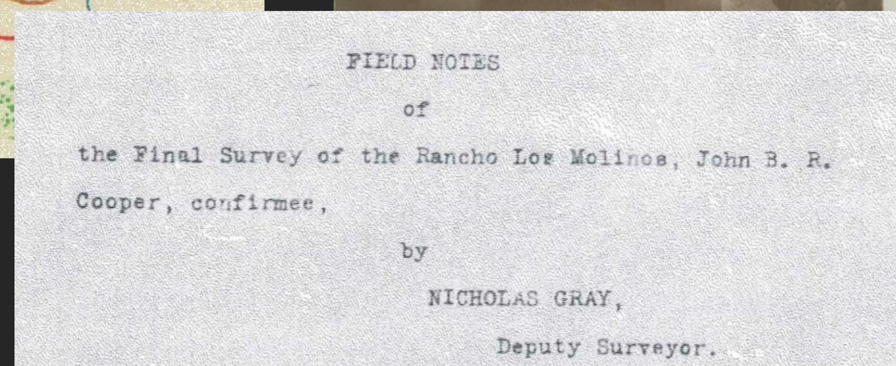
Robert Curtis, Curtis & Assoc. Healdsburg, CA

<u>Archives Visited/Contacted</u>

- The Bancroft Library, UC Berkeley
- Bureau of Land Management
- Curtis & Associates, Inc.
- David Rumsey Map Collection
- Earth Sciences & Map Library, UC Berkeley
- Healdsburg Historical Society
- Laguna de Santa Rosa Foundation
- Library of Congress
- National Oceanographic and Atmospheric Administration
- Sonoma County Library
- Sonoma County Recorder
- Sonoma State University Library
- University of Southern California

Data Compilation and Synthesis

Created orthorectified photomosaic of historical aerial photos



FIELD NOTES

of

the Final Survey of the Rancho Los Molinos, John B. R. Cooper, confirmee,

by

NICHOLAS GRAY,

Deputy Surveyor.

Examined high-priority maps, photos, and textual documents

Research Topics

1. Channel and Floodplain Morphology

2. Vegetation Patterns

3. Hydrology

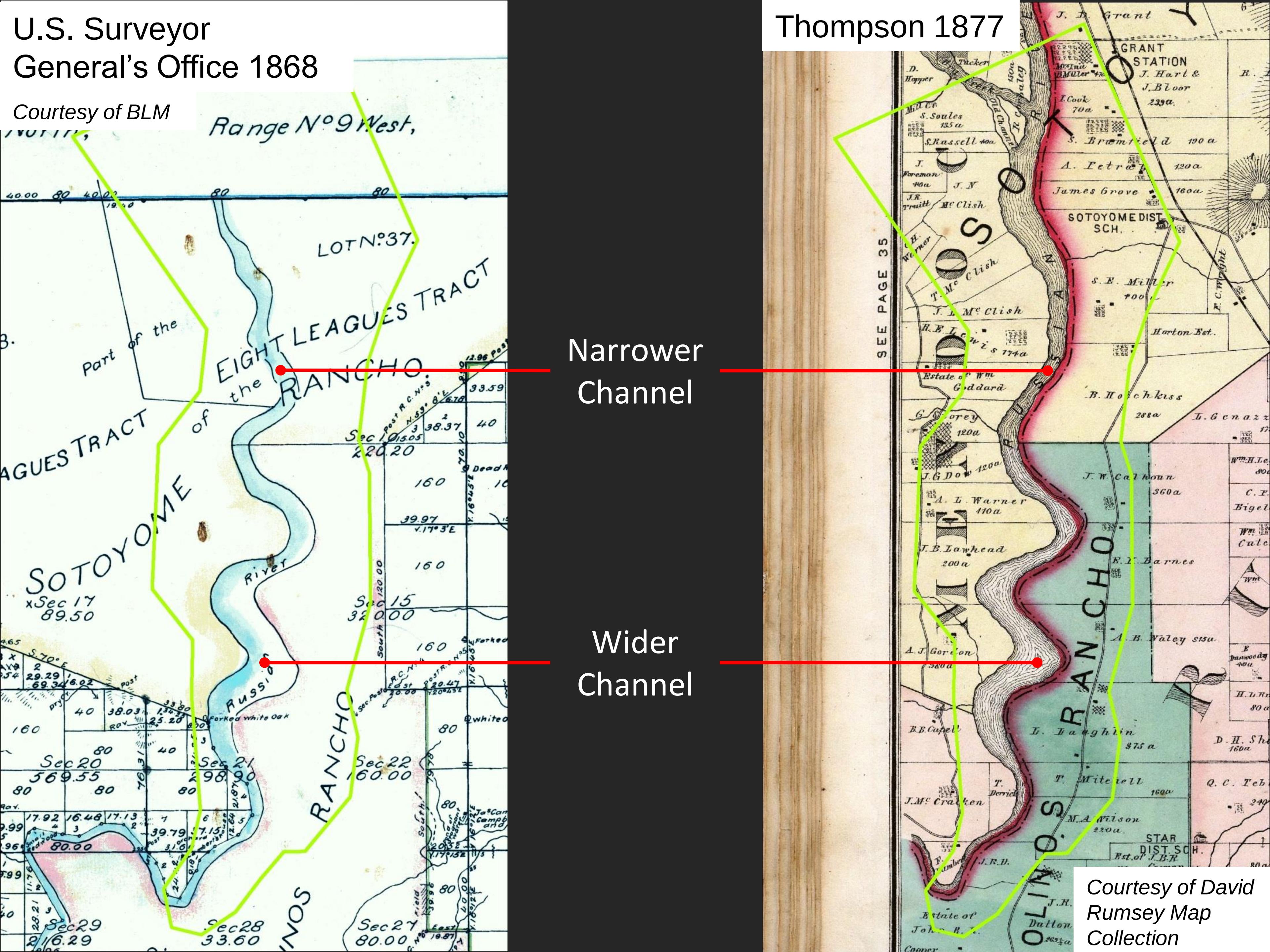
Channel and Floodplain Morphology

Channel and Floodplain Morphology

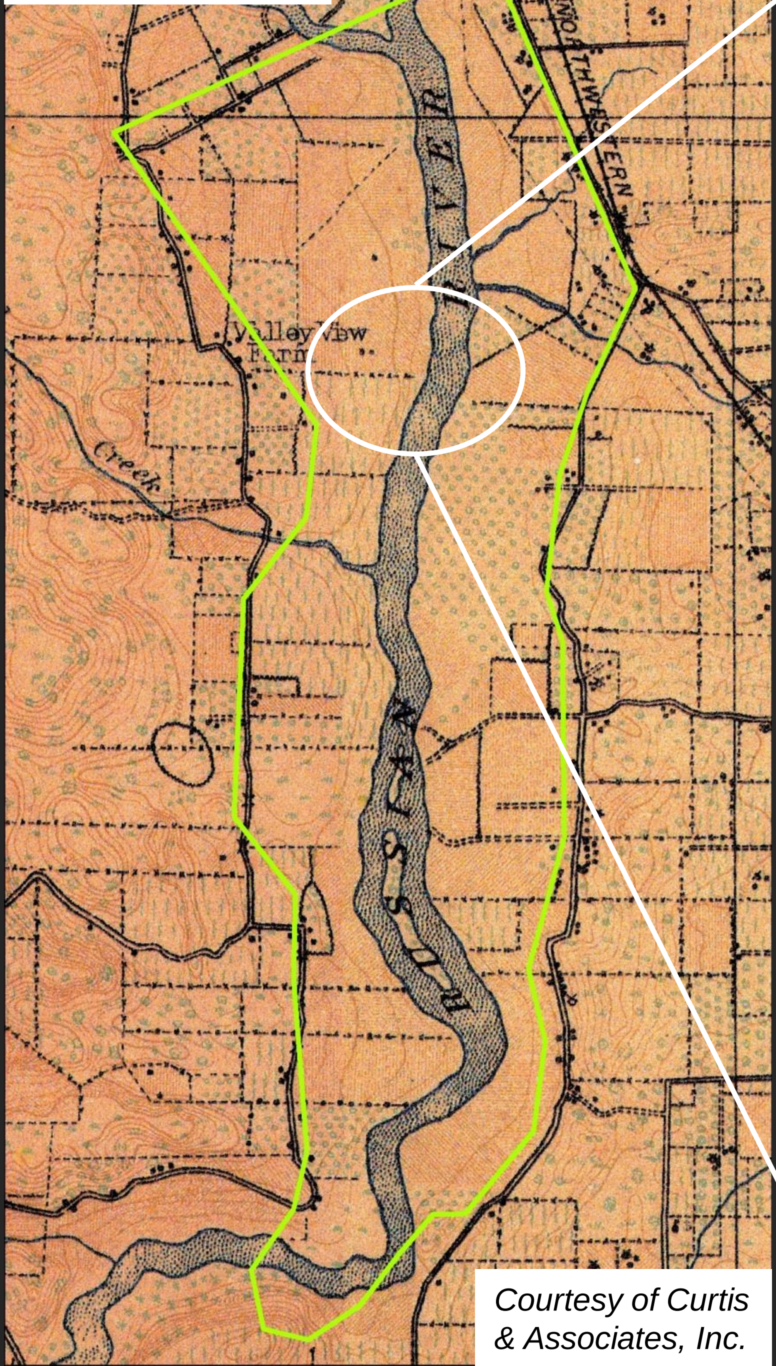
- Channel pattern (sinuosity, width, etc.)
- Side-channels, sloughs, and oxbow lakes
- Sand/gravel bars
- Natural levees

Slides 10-12

- Maps from as early as the mid-19th century consistently show the river as single-threaded, with a straight or meandering channel.
- The width and sinuosity of the channel shown in early maps varies within and between sources (e.g., USACE 1915 shows a straight channel in the same location where larger-scale maps from the same era show more sinuosity).

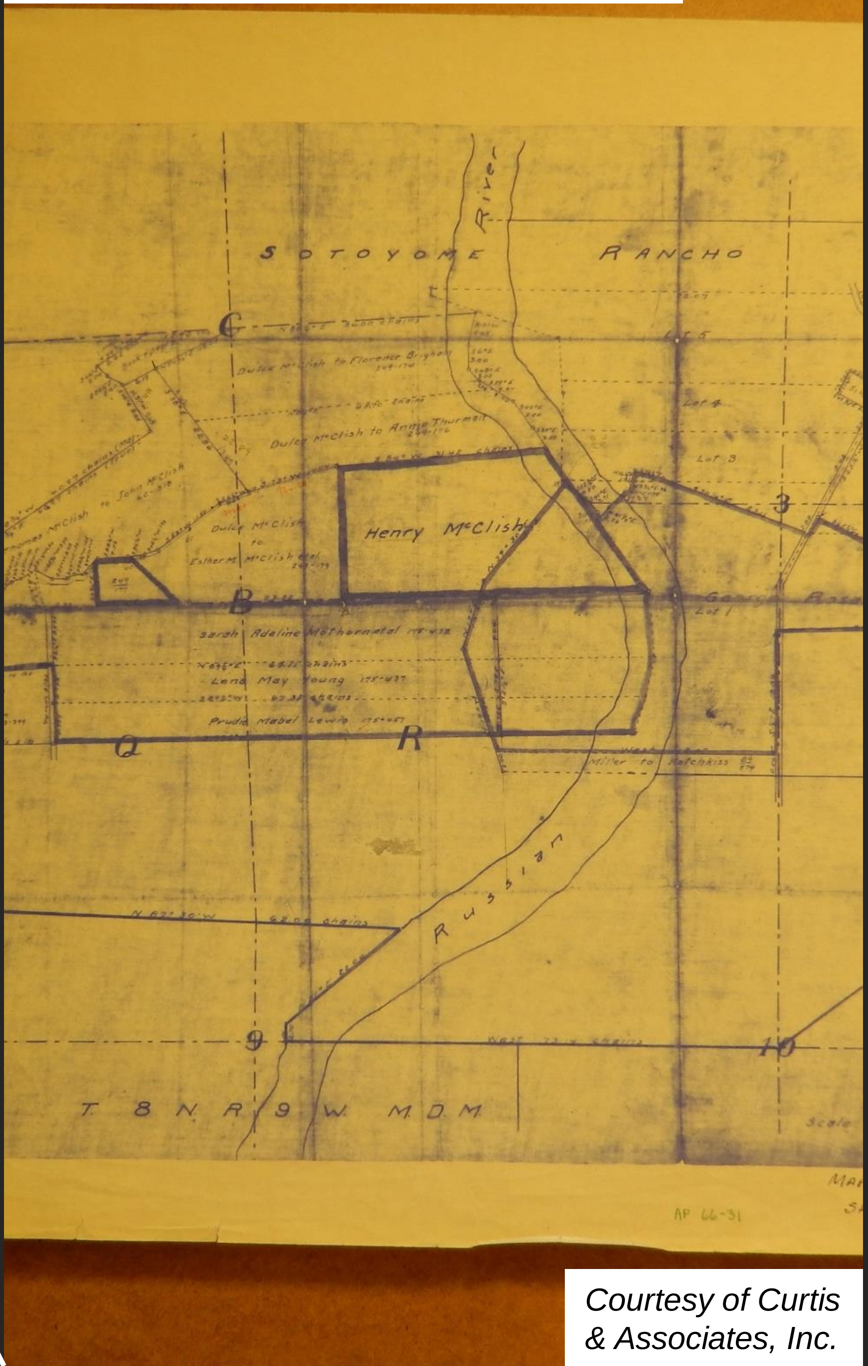

U.S. Surveyor General's Office 1868
Courtesy of BLM
Thompson 1877
Narrower Channel
Wider Channel
Courtesy of David Rumsey Map Collection

USACE 1915



Courtesy of Curtis & Associates, Inc.

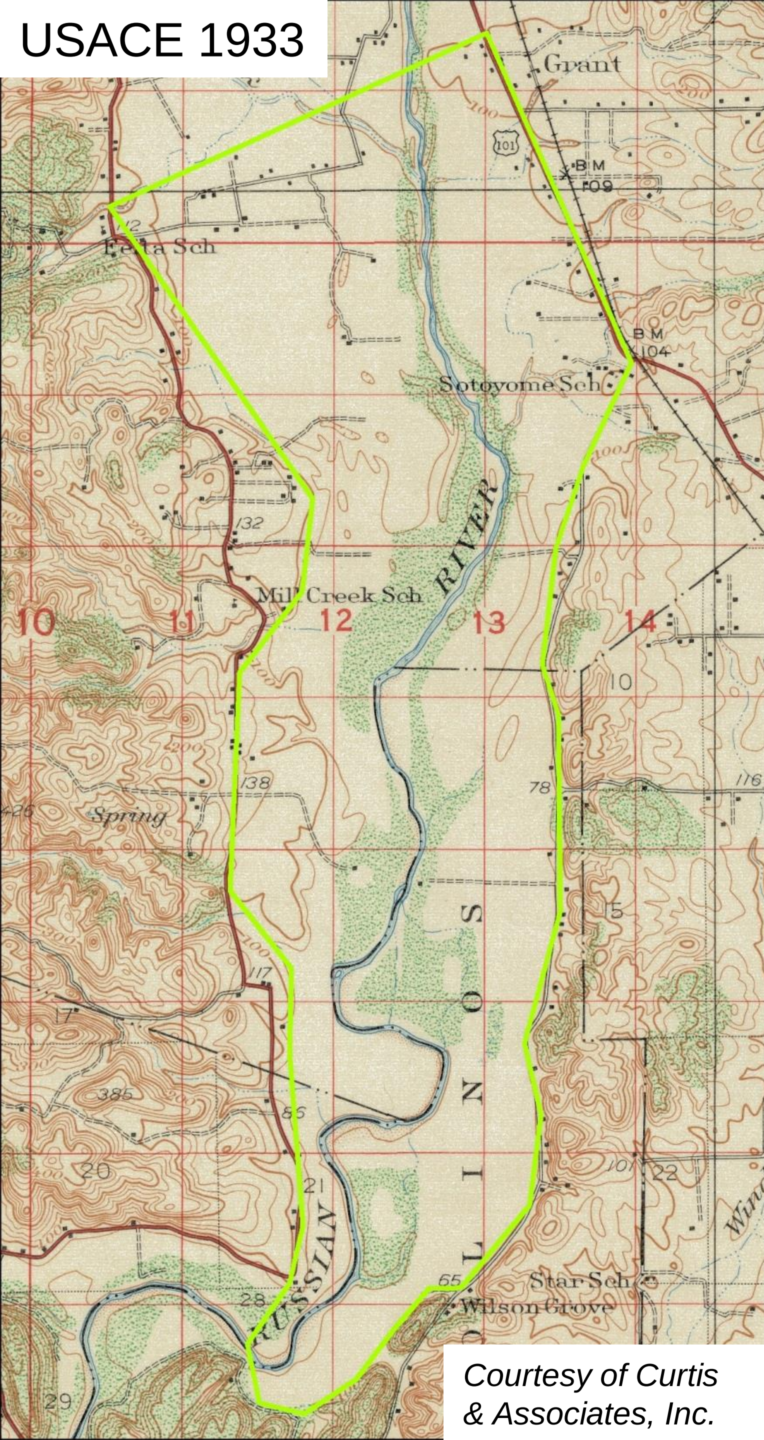
Unknown surveyor ca. 1924



Courtesy of Curtis & Associates, Inc.

Slide 13

- The 1933 topo quad (USACE 1933) and 1942 aerial photos show the channel with a sinuosity of approximately 1.2-1.3. Sinuosity is higher in the southern and central portions of the study area than in the northern portion.
- The 1942 aerial photos show the river with an active width ranging from approximately 600 feet to more than 2,300 feet.



Courtesy of Curtis & Associates, Inc.

Sinuosity = 1.2-1.3

Active width = ~600-2,300 ft

~600 feet

~2,120 feet

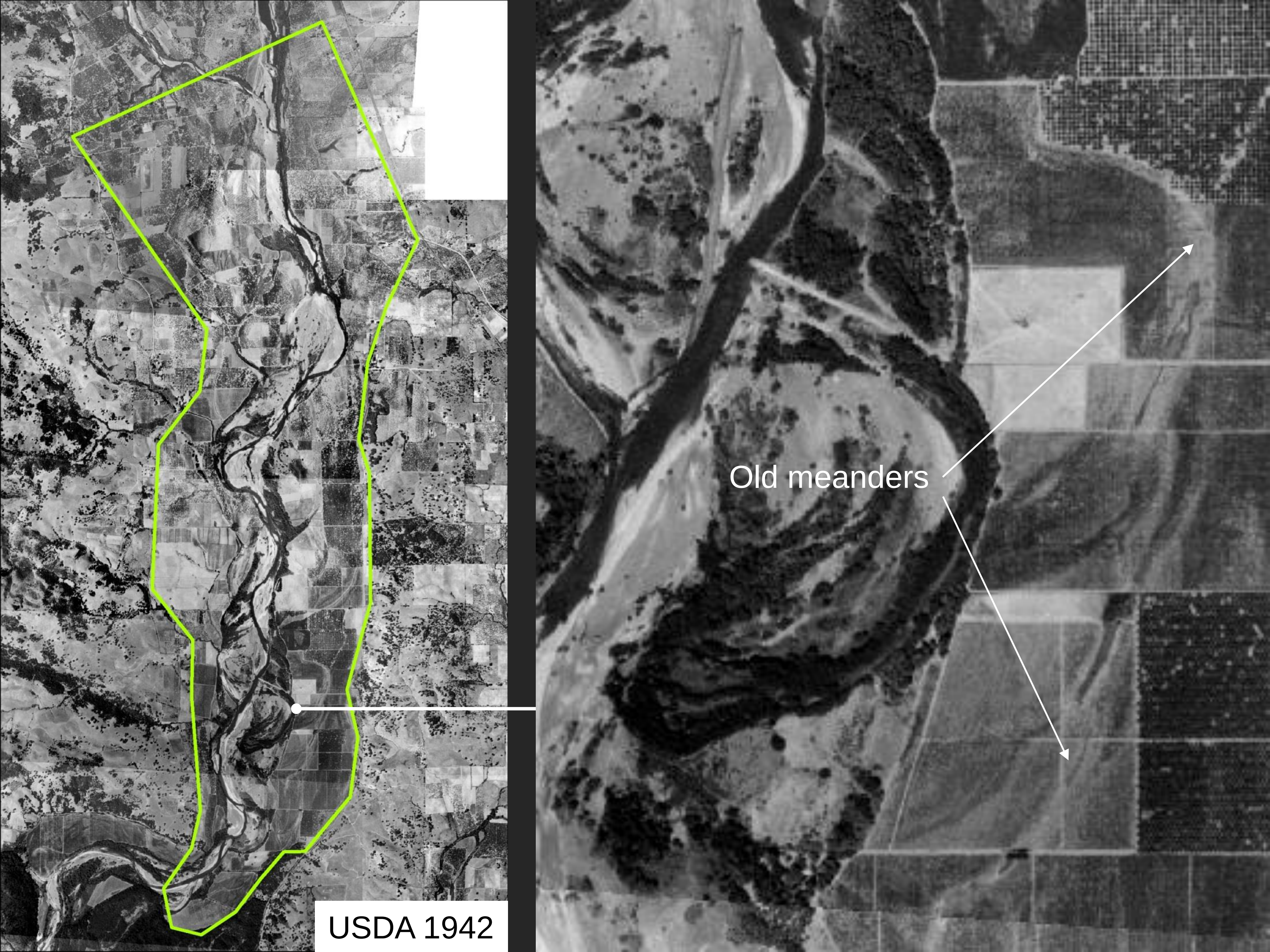
~1,180 feet

~2,300 feet

~690 feet

Slide 15

- Signatures of old meanders indicate that over time the river migrated laterally across a broad floodplain area, especially in the southern and central portions of the study area.


USDA 1942
Old meanders

Slide 17

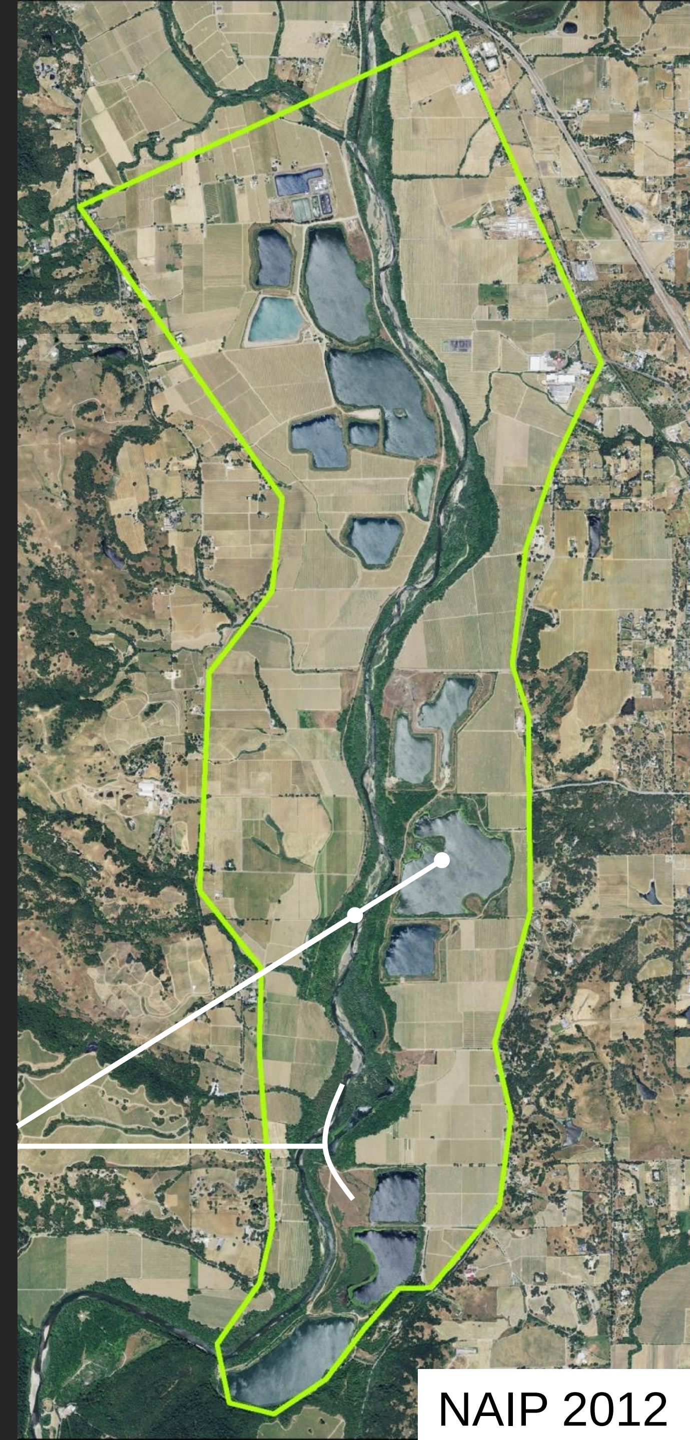
- An undated photograph shows a section of the river near Camp Rose, several miles north of the study area. Note the gently meandering channel and the alternating sandbars on the channel margins. Though the valley was narrower here than in the Middle Reach, the channel morphology depicted in this and other nearby landscape photos may reflect aspects of the morphology that also existed further downstream.


Courtesy of University of
Southern California

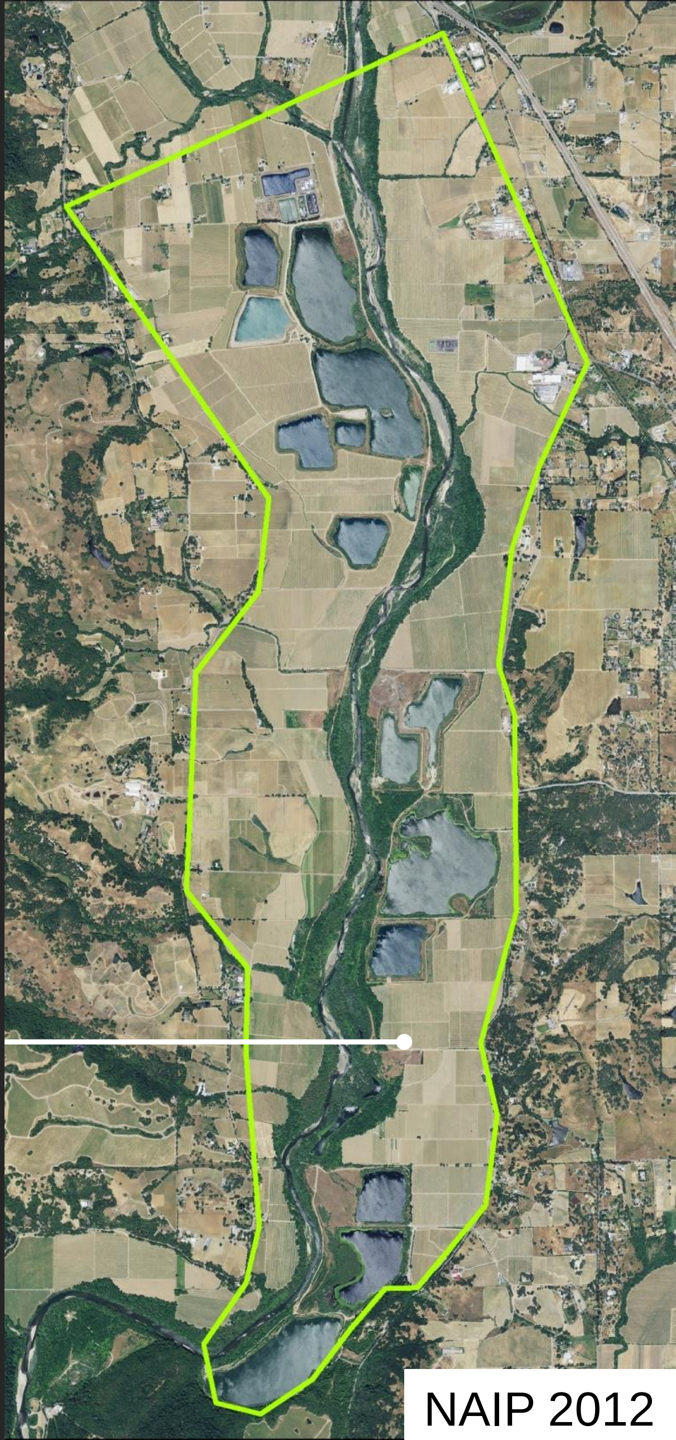
Slides 19-22

- General Land Office survey notes from the 1850s provide early documentation of sandbars throughout much of the Middle Reach.

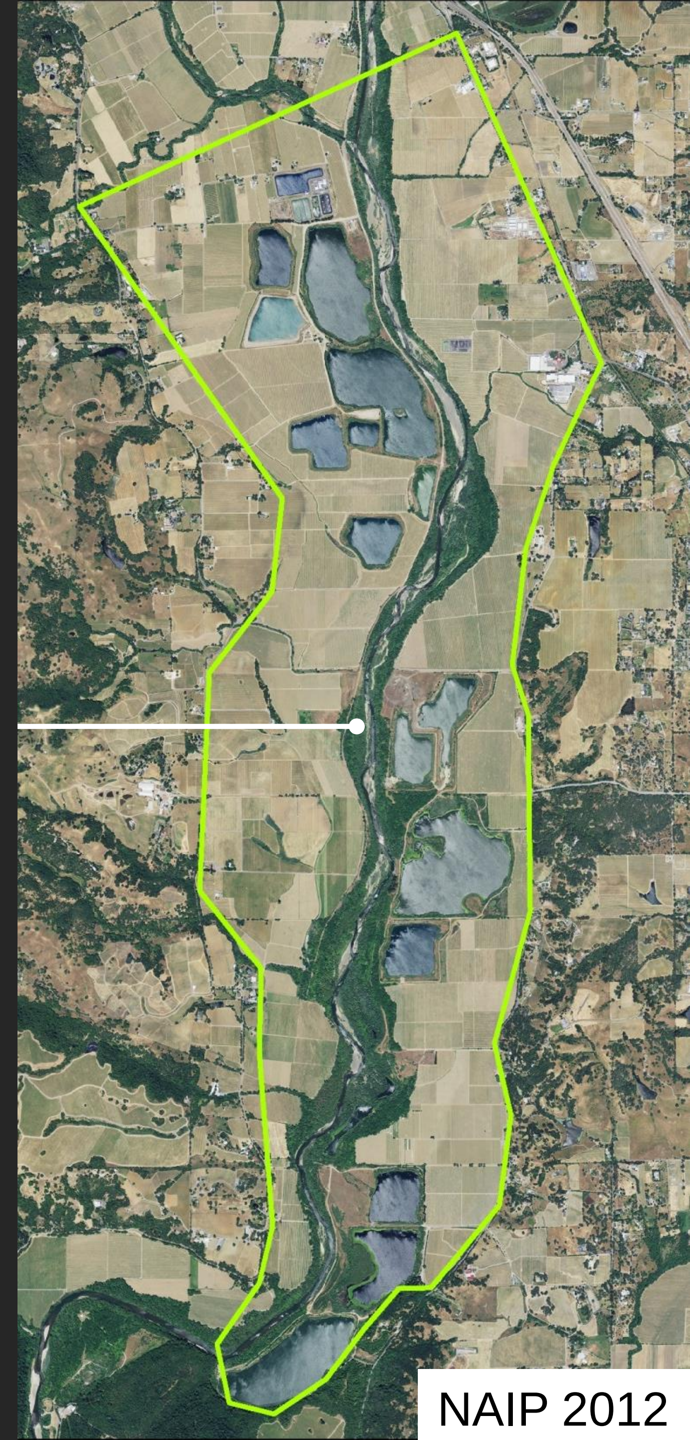
"Along sand bar" (Gray 1857)



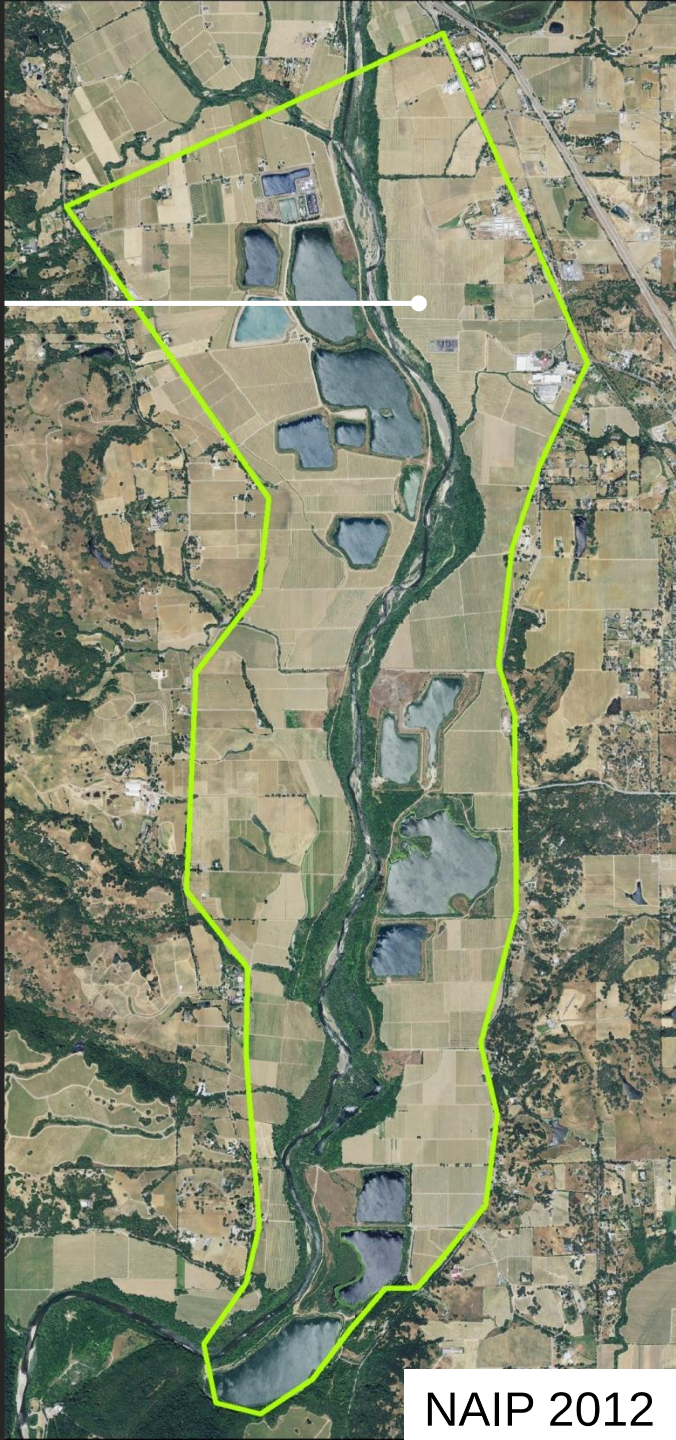
“Leave the sand bar”
(Gray 1857)



“Along a sand bar of great extent” (Gray 1857)



"On sand bar in Russian river" (Whitacre 1853)

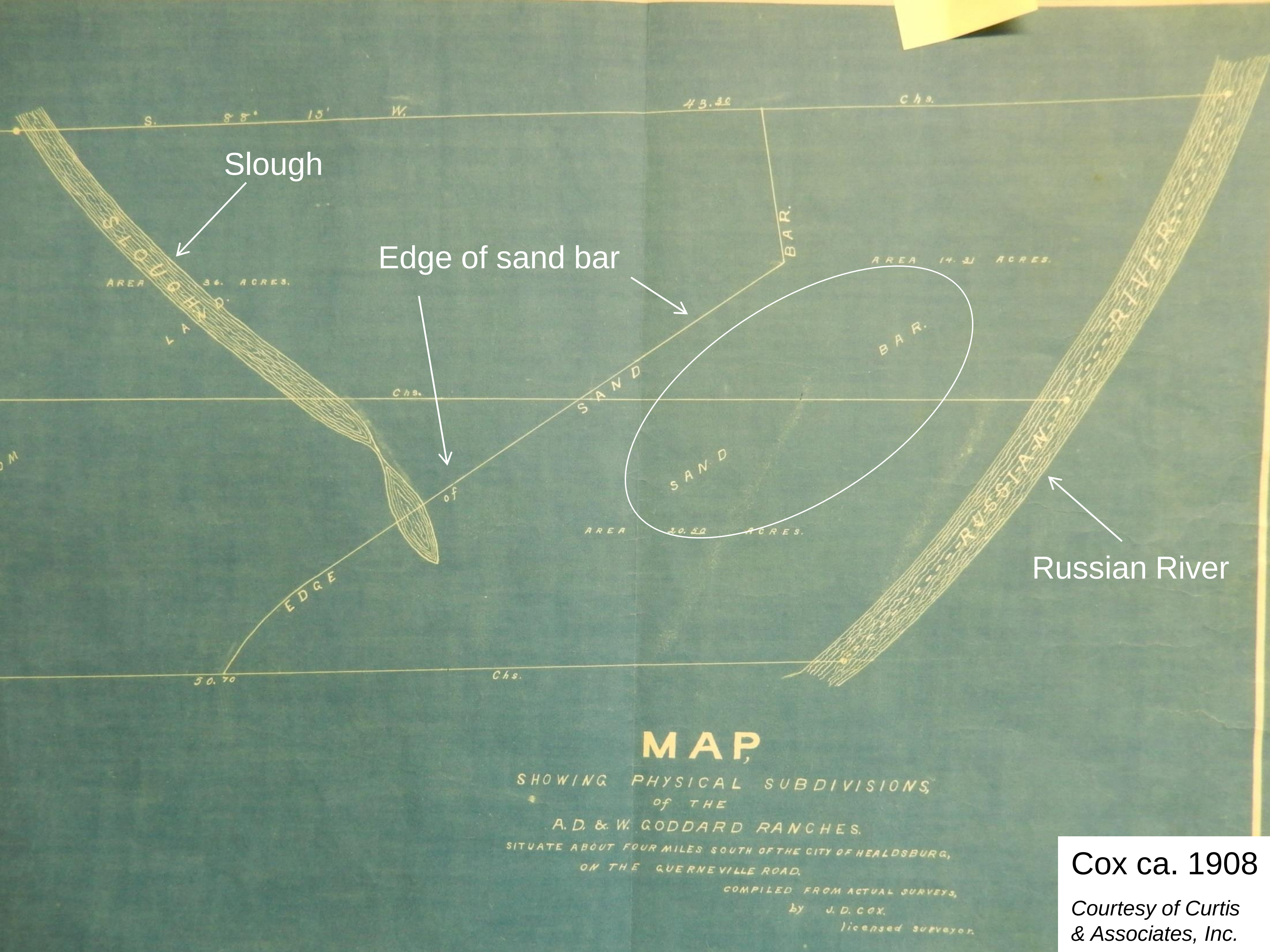


Slides 24-28

- Sandbars are documented in early maps such as Cox ca. 1908, which shows an ~870 ft wide sandbar on the western bank of the river. A slough flowing east across the floodplain terminates on the sandbar. The 1942 aerial photos show a sandbar of approximately the same width (~950 ft) in this location.
- Sandbars are also depicted in early topographic maps (USACE 1933) in the southern portion of the study area.

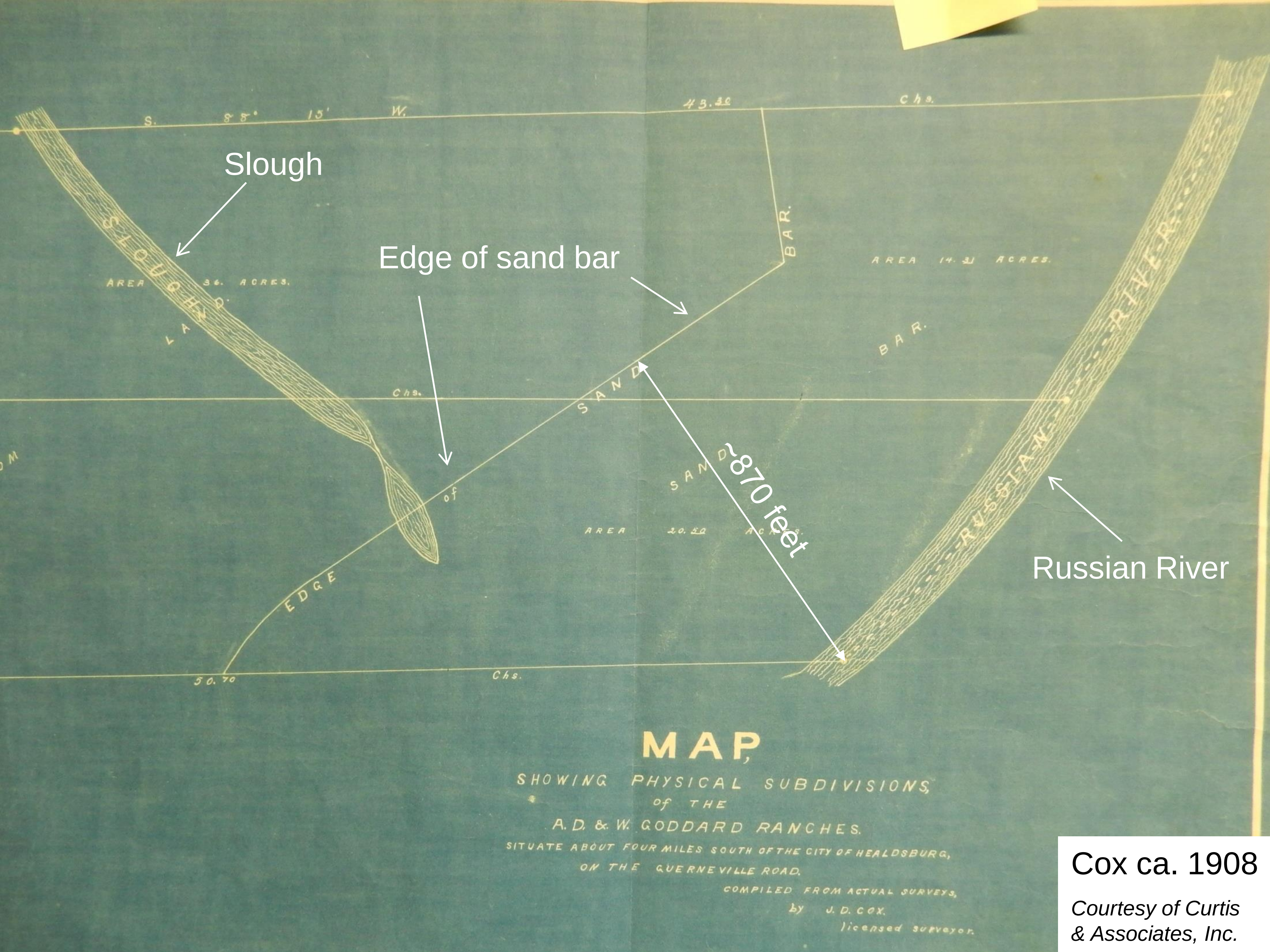
Cox ca. 1908

Courtesy of Curtis & Associates, Inc.



Cox ca. 1908

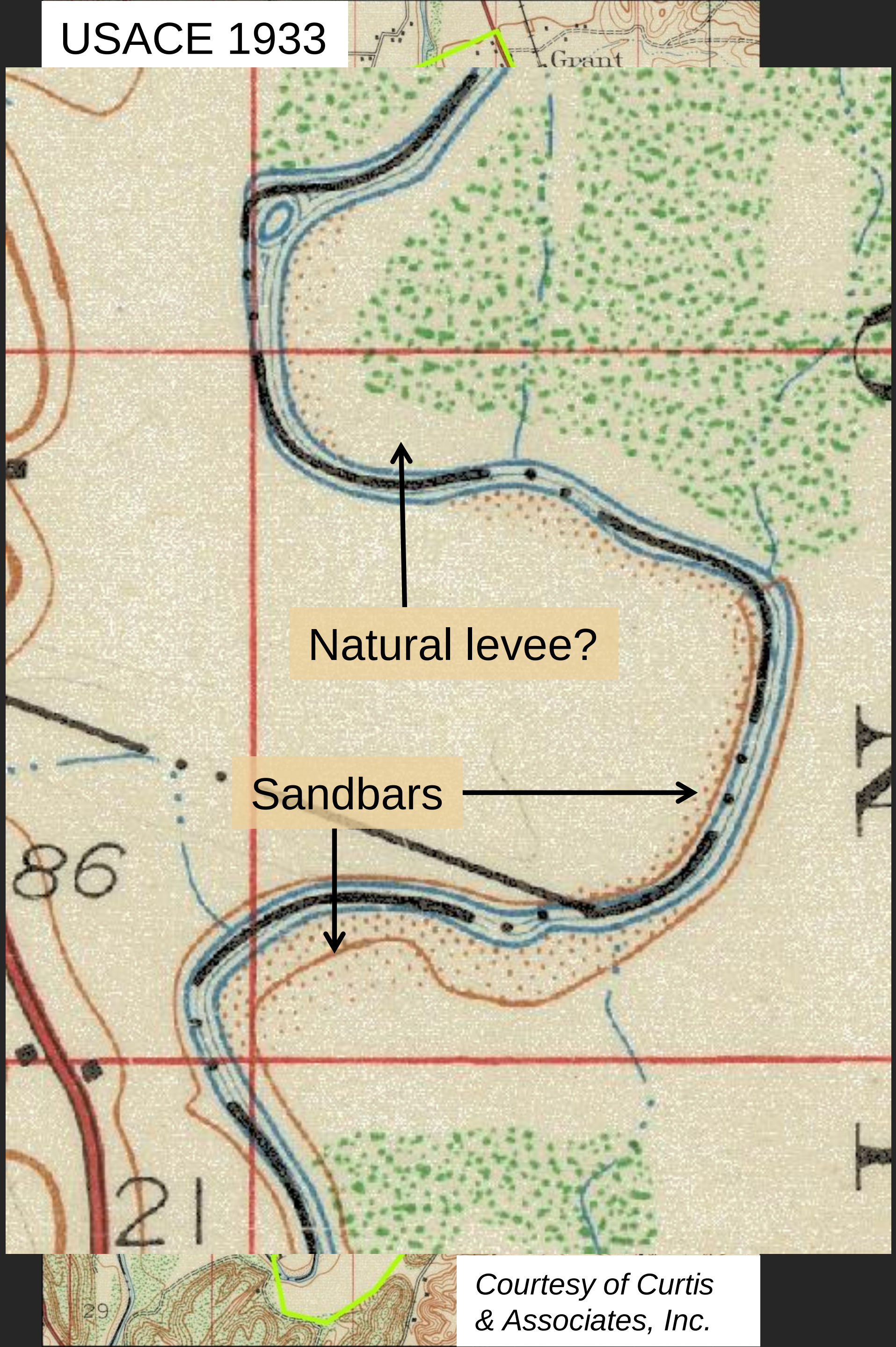
Courtesy of Curtis & Associates, Inc.

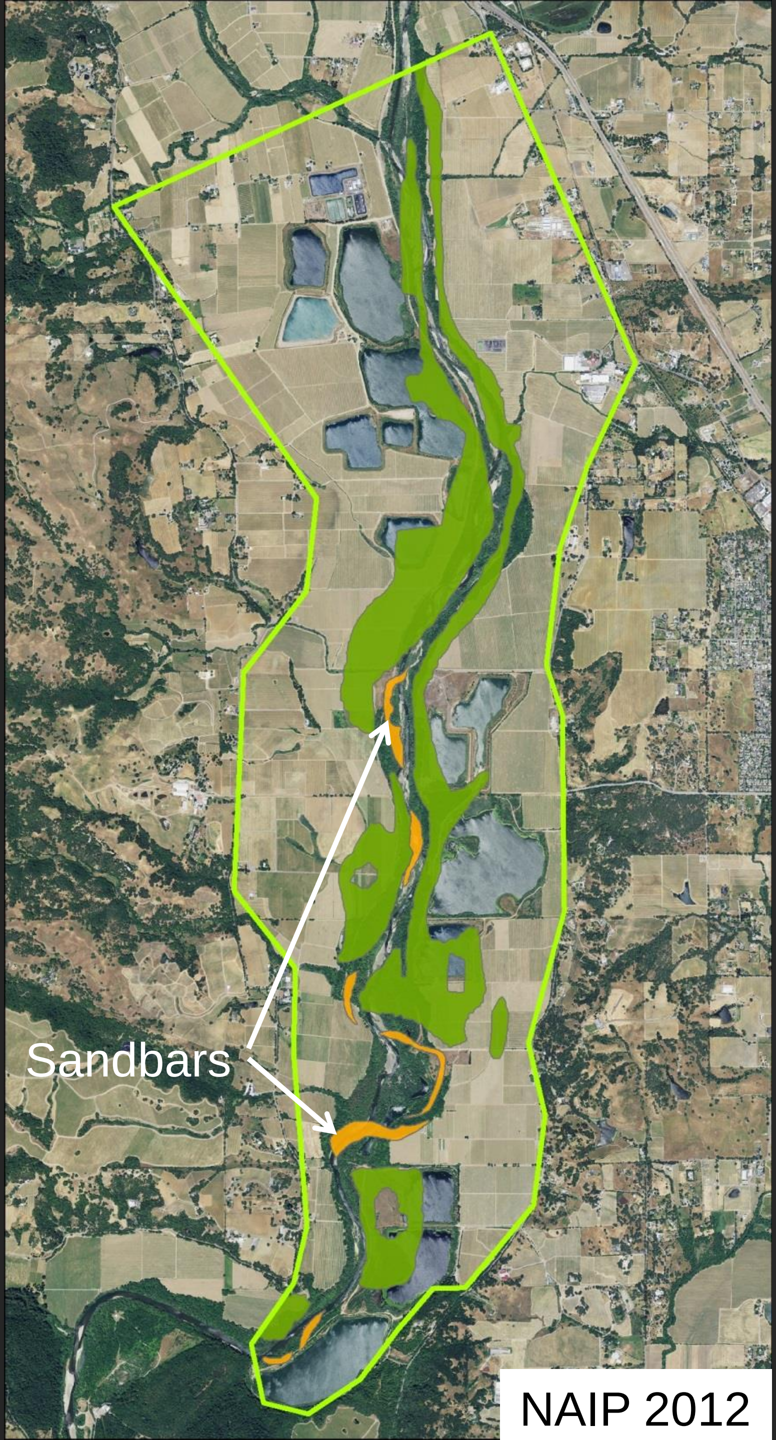


Cox ca. 1908

Courtesy of Curtis & Associates, Inc.

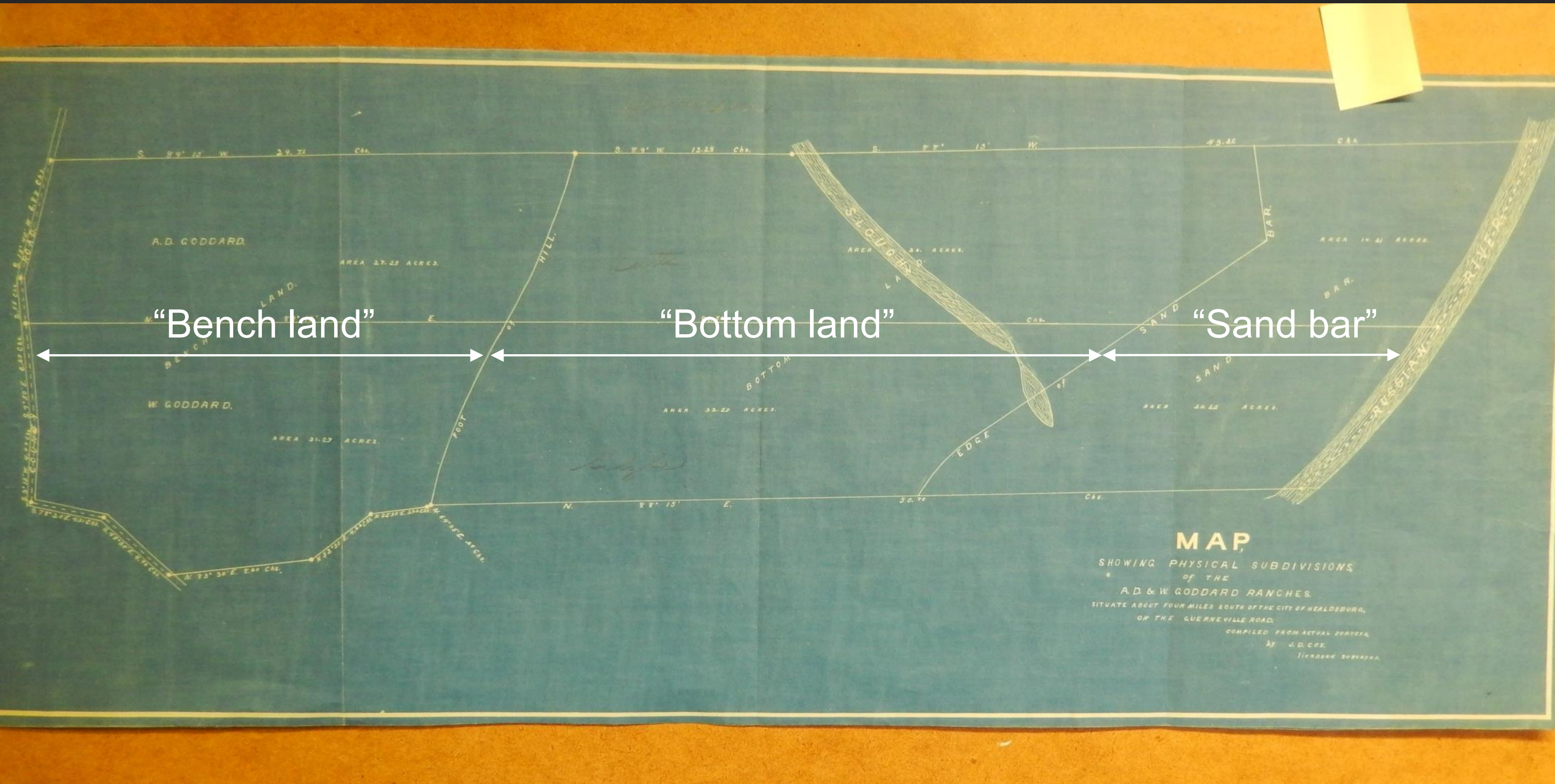

~950 feet
USDA 1942


USACE 1933
Grant
Natural levee?
Sandbars
86
21
29
Courtesy of Curtis & Associates, Inc.


Sandbars
NAIP 2012

Slide 30

- Cox ca. 1908 shows an extensive area of “bottom land,” at least 1,800 ft wide, adjacent to the sandbar, which may correspond to the floodplain along this portion of the river. The bottom land extends to the “foot of hill,” after which the area is labeled as “bench land.”

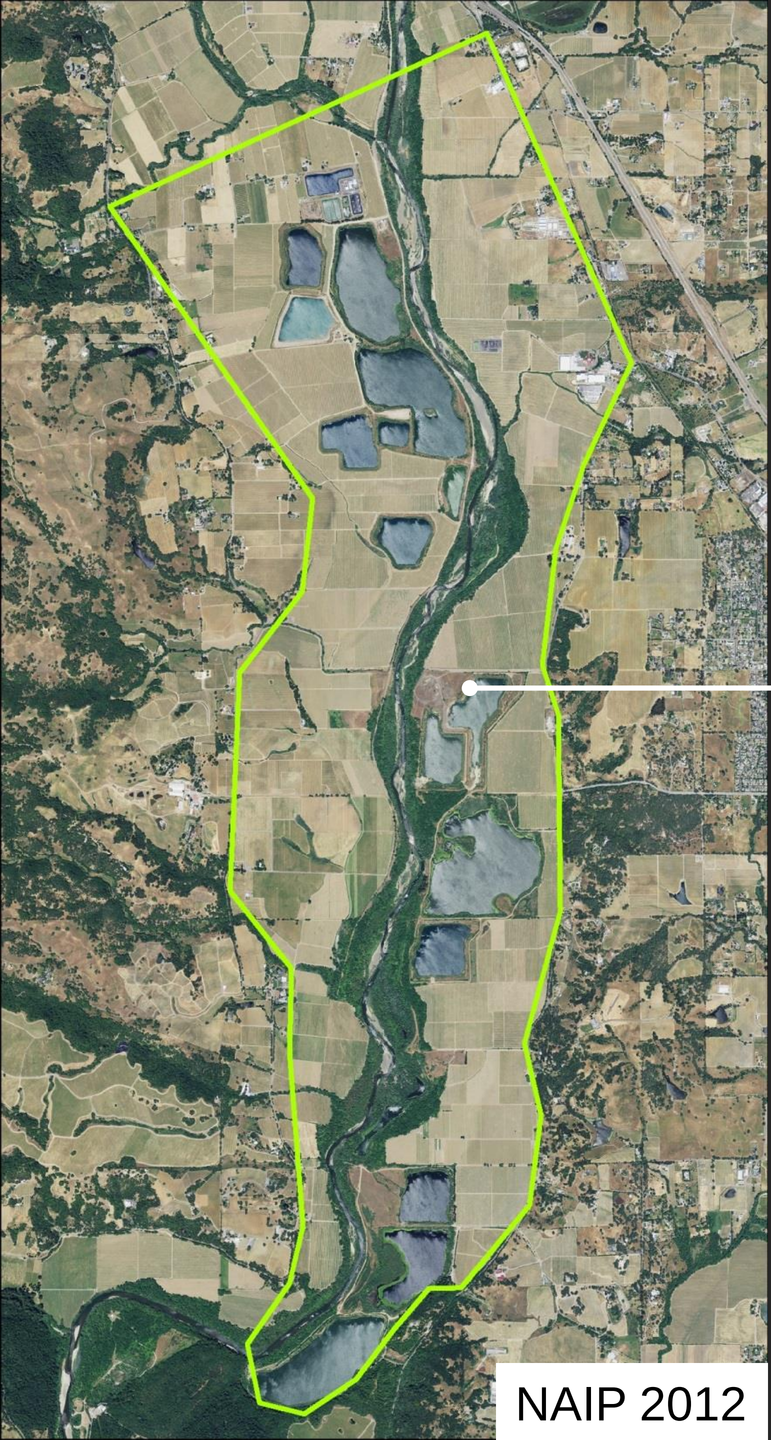


Cox ca. 1908

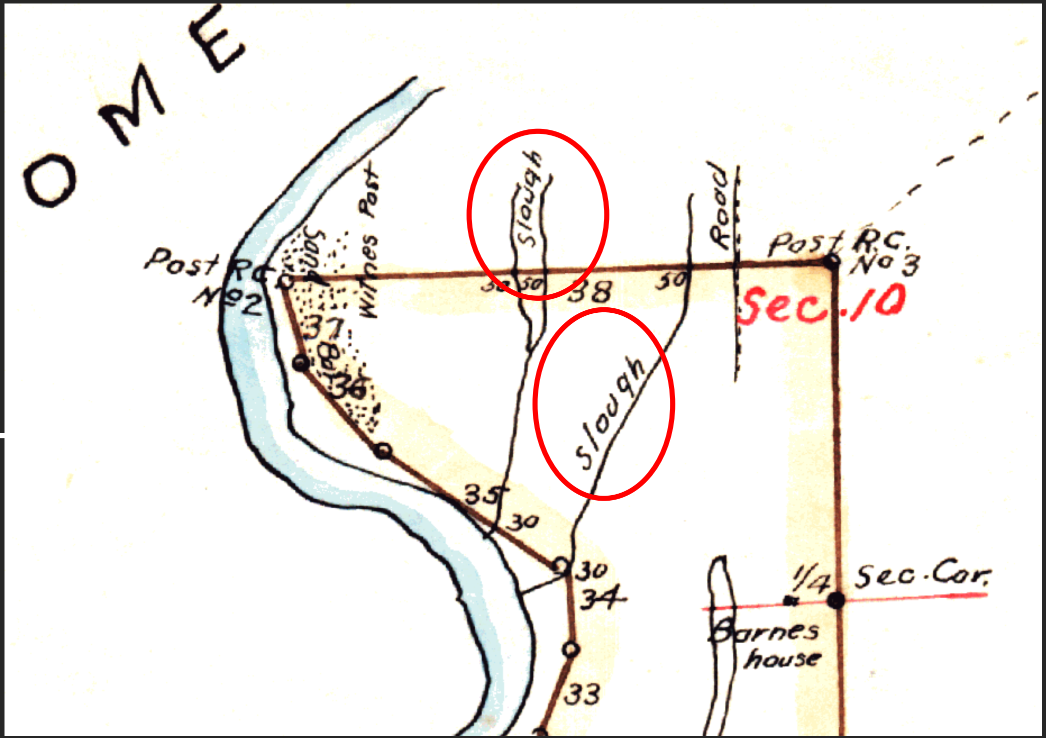
Courtesy of Curtis & Associates, Inc.

Slides 32-36

- In the 1850s GLO surveyors documented numerous sloughs on the river floodplain in the Middle Reach.



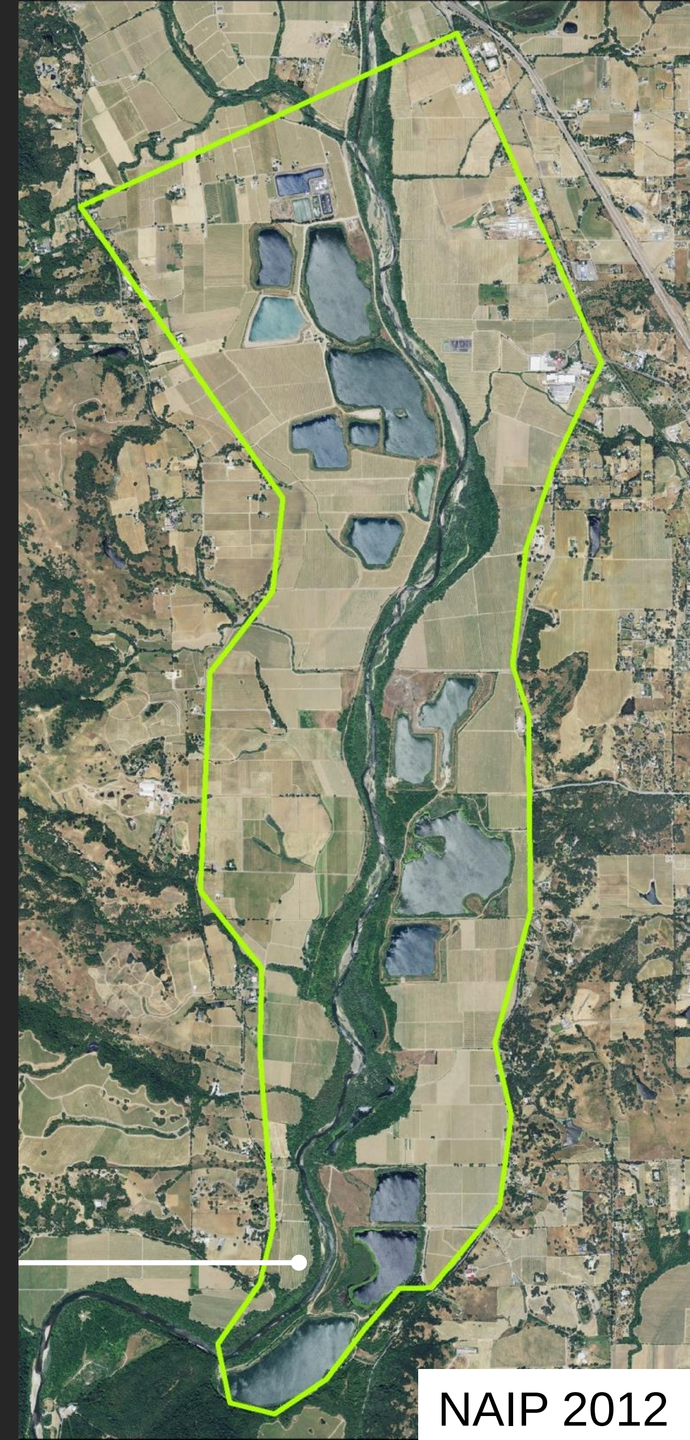
NAIP 2012



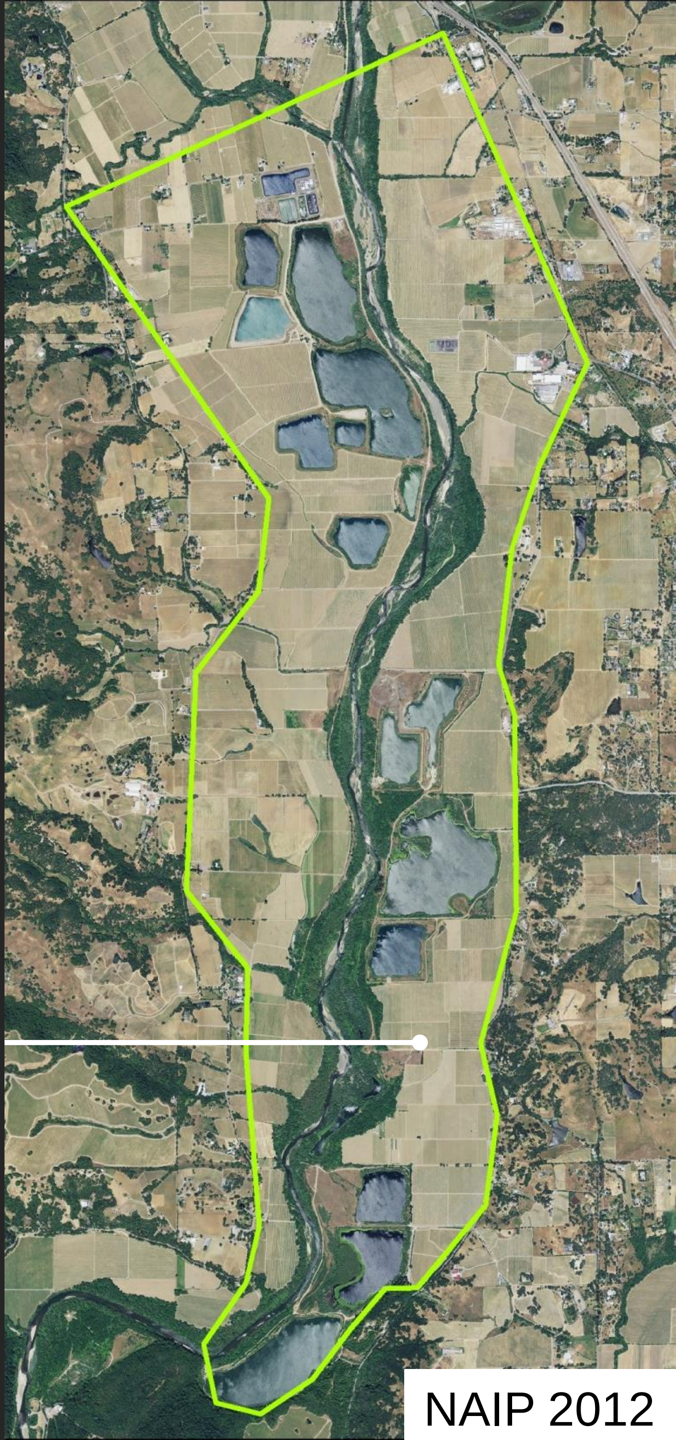
Gray 1857

Courtesy of BLM

“Mouth of a slough 50 links wide” (Gray 1857)

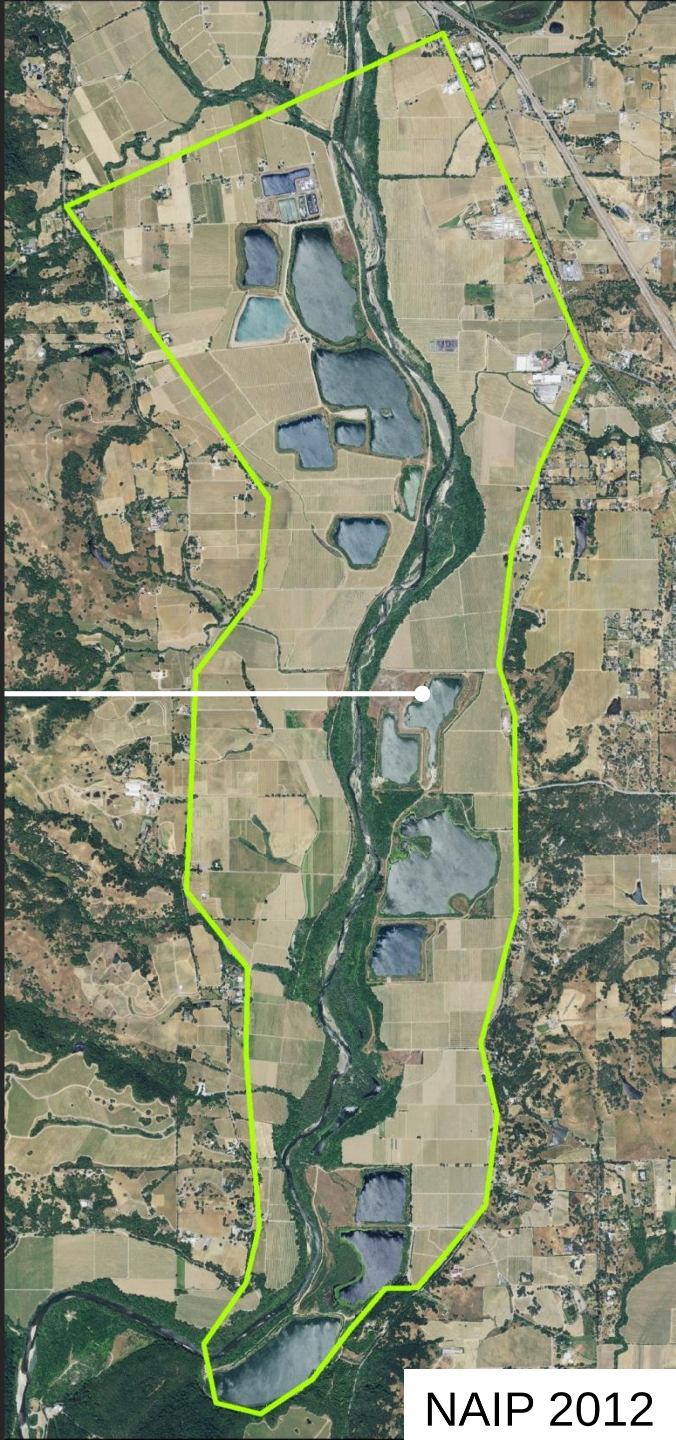


“Offset to the East because of the many sloughs and crooked channel of the river and the great amount of brush and depth of sloughs” (Whitacre 1853)



“Mouth of slough 30 links wide” (Gray 1857)

"Cross a slough 50 links wide, course southwest" (Gray 1857)



Slides 38-43

- The following quote from Whitacre (1853) describes many features of the river corridor and floodplain, including “deep sloughs,” “willow and oak thickets,” and “sand banks.”

“Russian River makes its bend to the west about one mile west from the quarter section corner between sections 28 and 27. The bottom washed by the river is about one half mile wide, full of deep sloughs 10 to 30 ft. deep and from 50 lks. to 150 lks. wide filled with dense willow and oak thickets, briars and vines. The valley which is washed by river not thus covered is sand banks, the river is very crooked” (Whitacre 1853)

“Russian River makes its bend to the west about one mile west from the quarter section corner between sections 28 and 27. The bottom washed by the river is about one half mile wide, full of deep sloughs 10 to 30 ft. deep and from 50 lks. to 150 lks. wide filled with dense willow and oak thickets, briars and vines. The valley which is washed by river not thus covered is sand banks, the river is very crooked” (Whitacre 1853)

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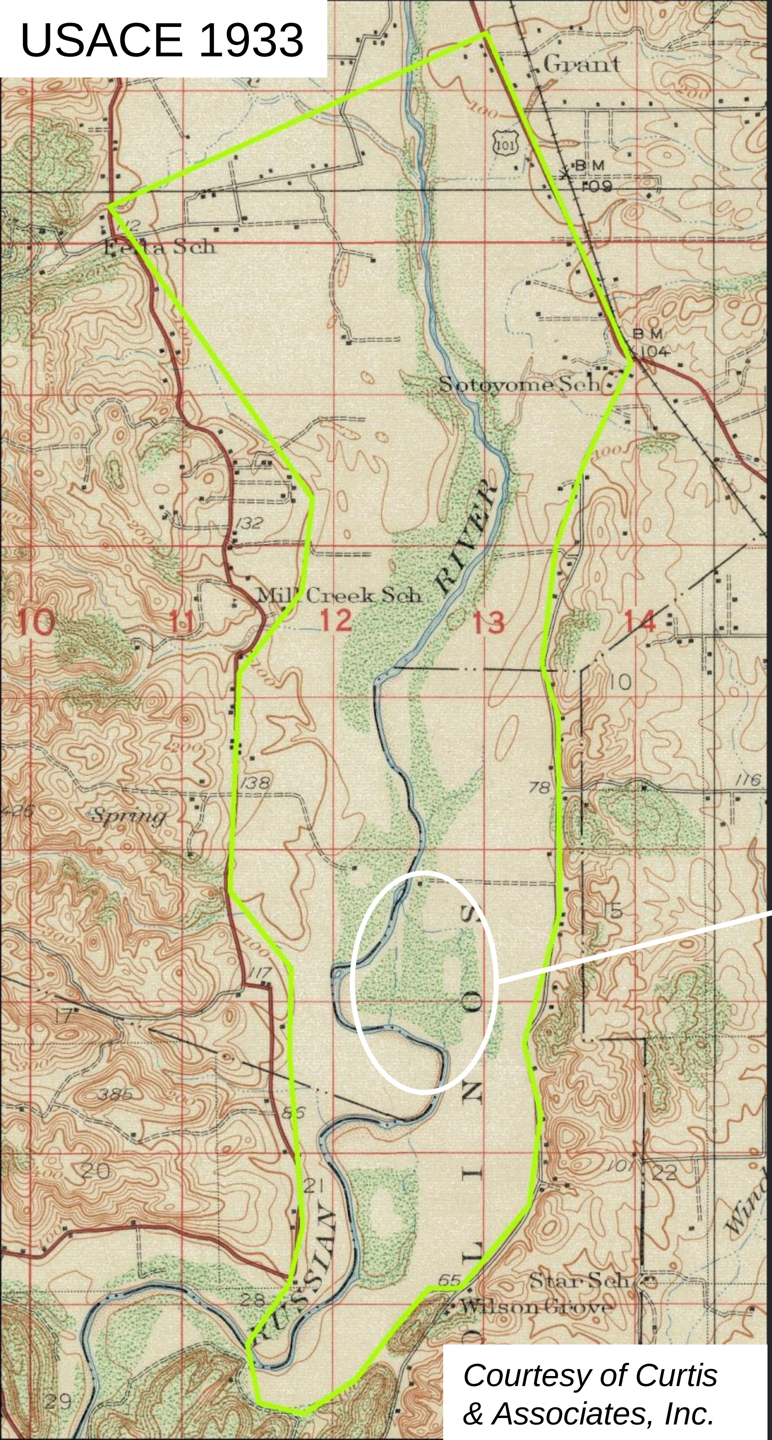
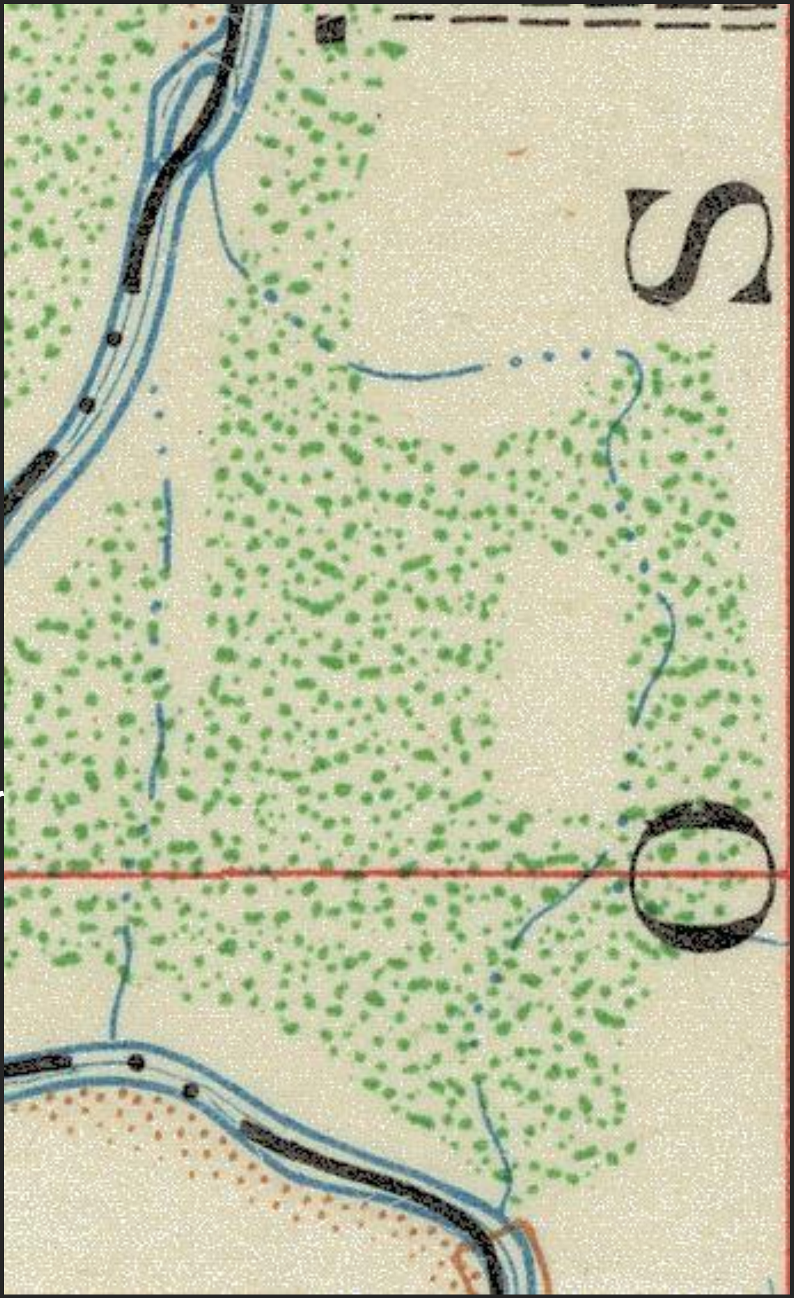
Slide 45

- Numerous sloughs and side-channels are shown in USACE 1933 on the east bank of the river in the southern portion of the study area.

USACE 1933





Courtesy of Curtis & Associates, Inc.

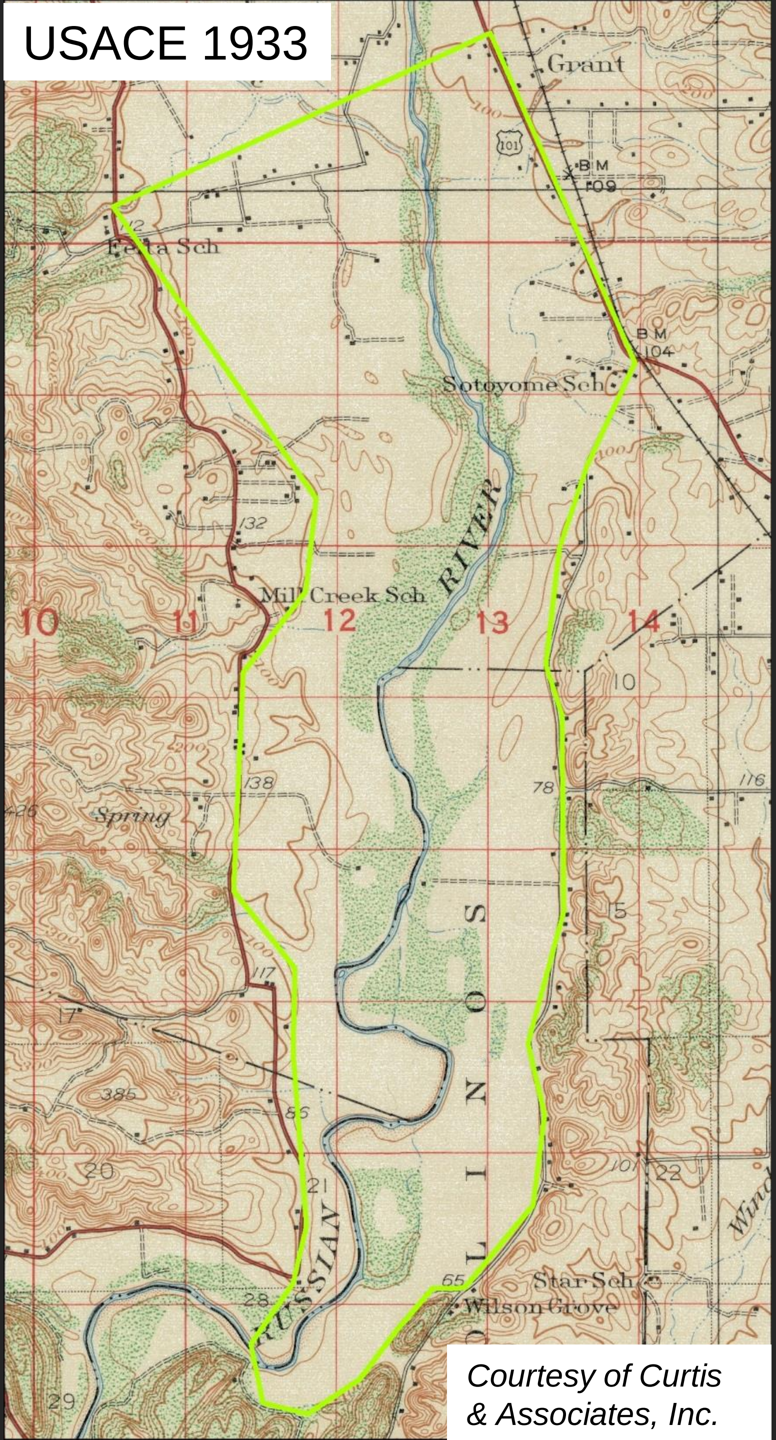
Channel and Floodplain Morphology

- Channel with variable width and sinuosity; average sinuosity in USACE 1933 and USDA 1942 = ~1.2-1.3
- Evidence of lateral channel migration across broad floodplain
- Sloughs, oxbow cut-offs, side channels
- Extensive sand bars with variable width

Vegetation Patterns

Slide 49

- USACE 1933 shows a riparian corridor of “woods or brushwood” extending along almost the entire length of the river in the Middle Reach. The corridor ranges from several hundred feet wide up to 2,800 feet wide.



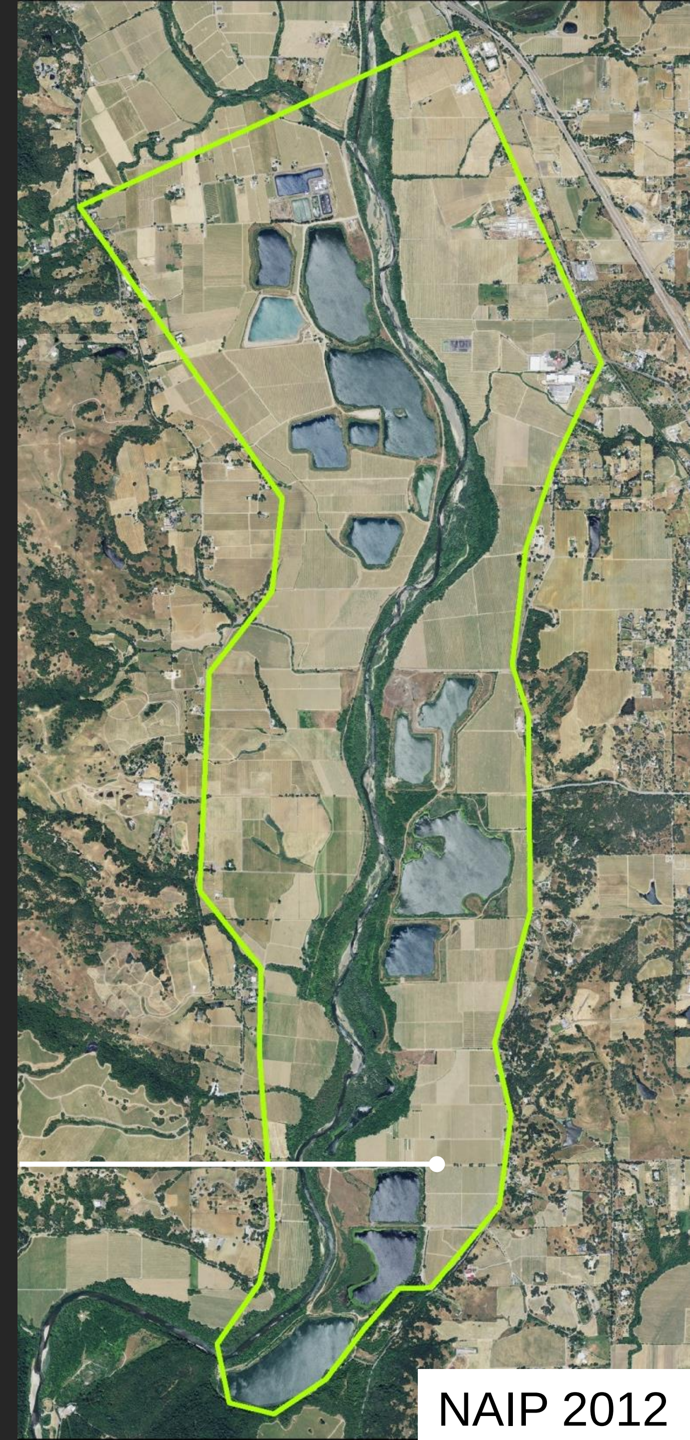
USACE 1933
Grant
Sotoyome Sch
Mill Creek Sch
RIVER
RUSSIAN
Star Sch
Wilson Grove
Courtesy of Curtis & Associates, Inc.

"Woods or brushwood"
~400 feet
~2,800 feet
NAIP 2012

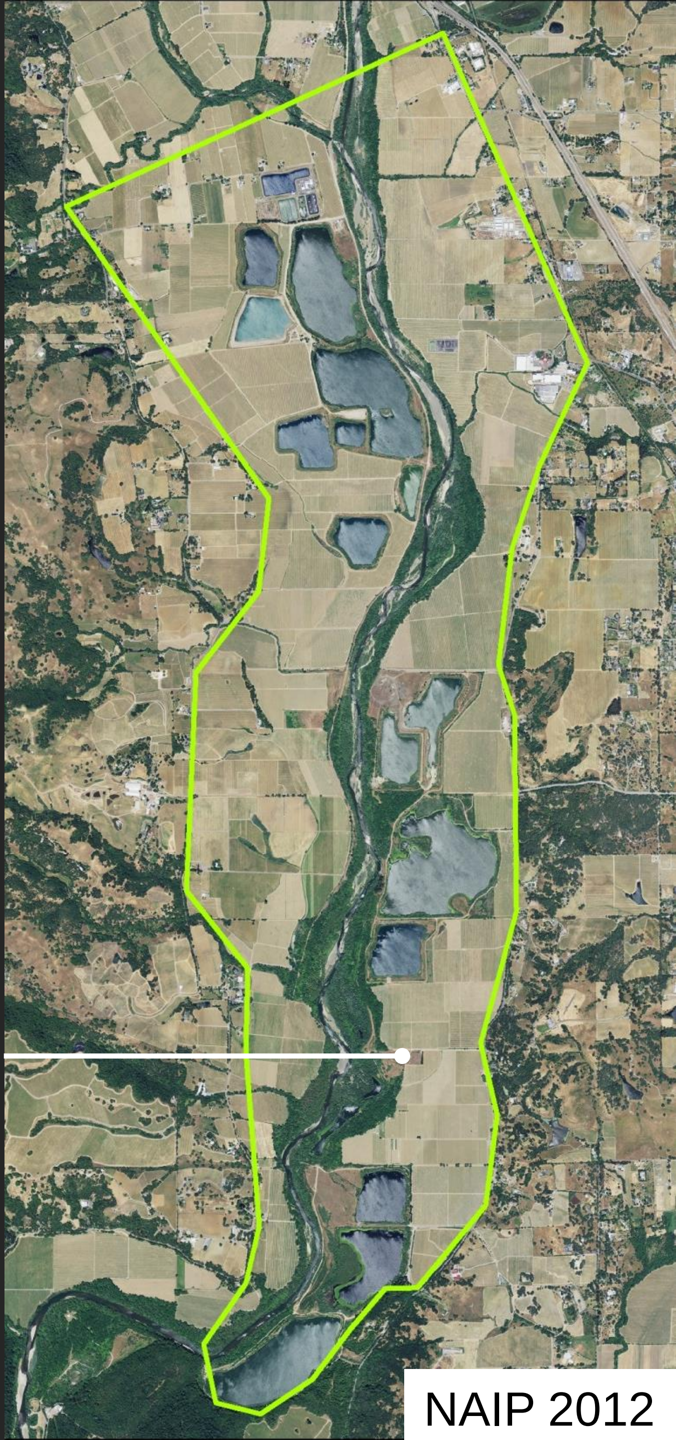
Slides 51-58

- General Land Office surveyors Thomas Whitacre and Nicholas Gray documented a variety of riparian vegetation types within the Middle Reach in the 1850s, both on sand bars and the surrounding floodplain.

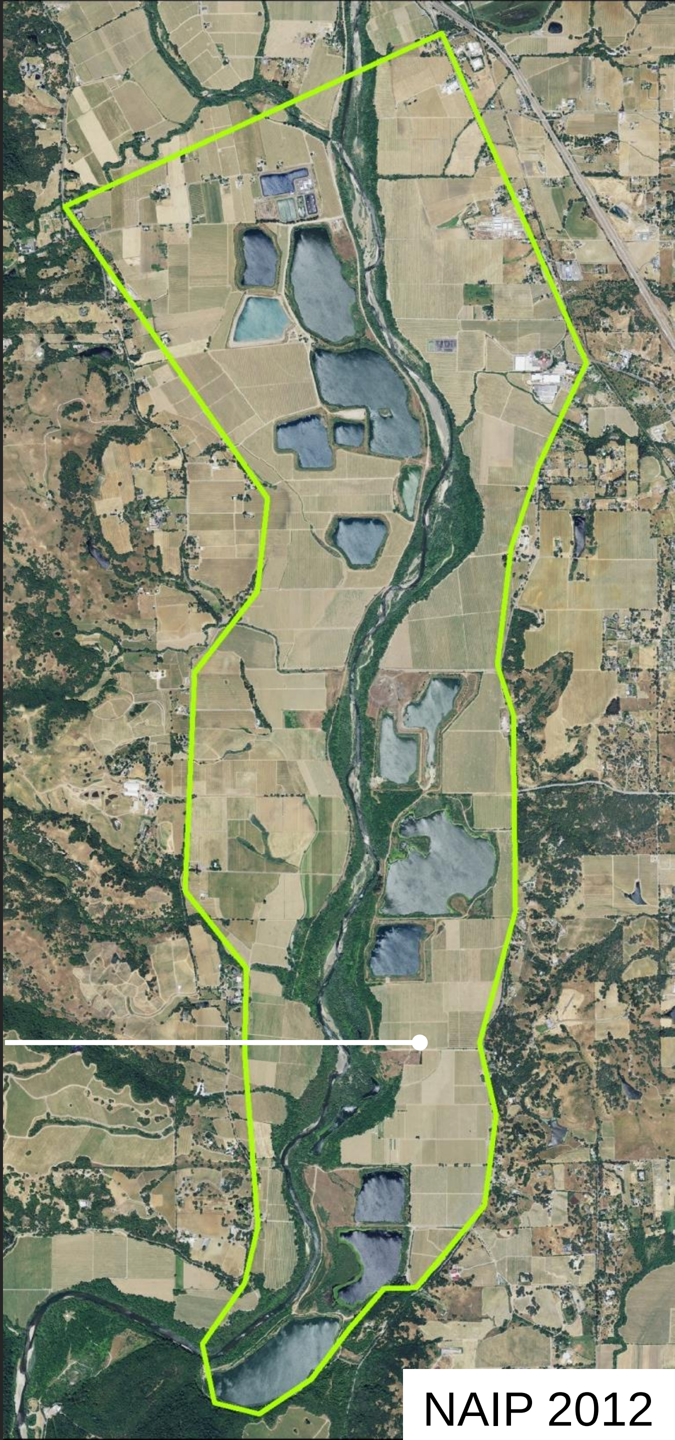
“A white oak 48 in. dia. bears S. 75 1/2 deg E. 37 lks. In willow thicket in edge of slough” (Whitacre 1853)



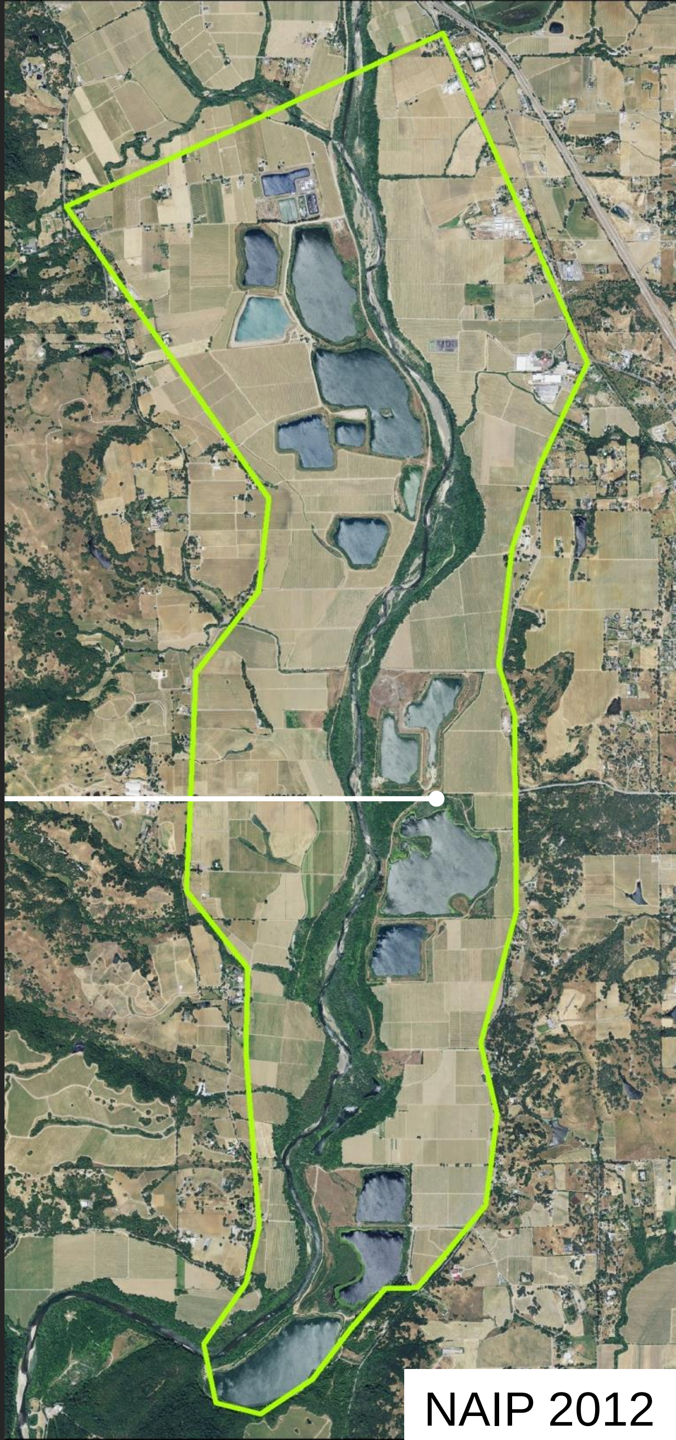
"Leave the sand bar the bank being a little higher, but covered with brush and briers [sic]" (Gray 1857)



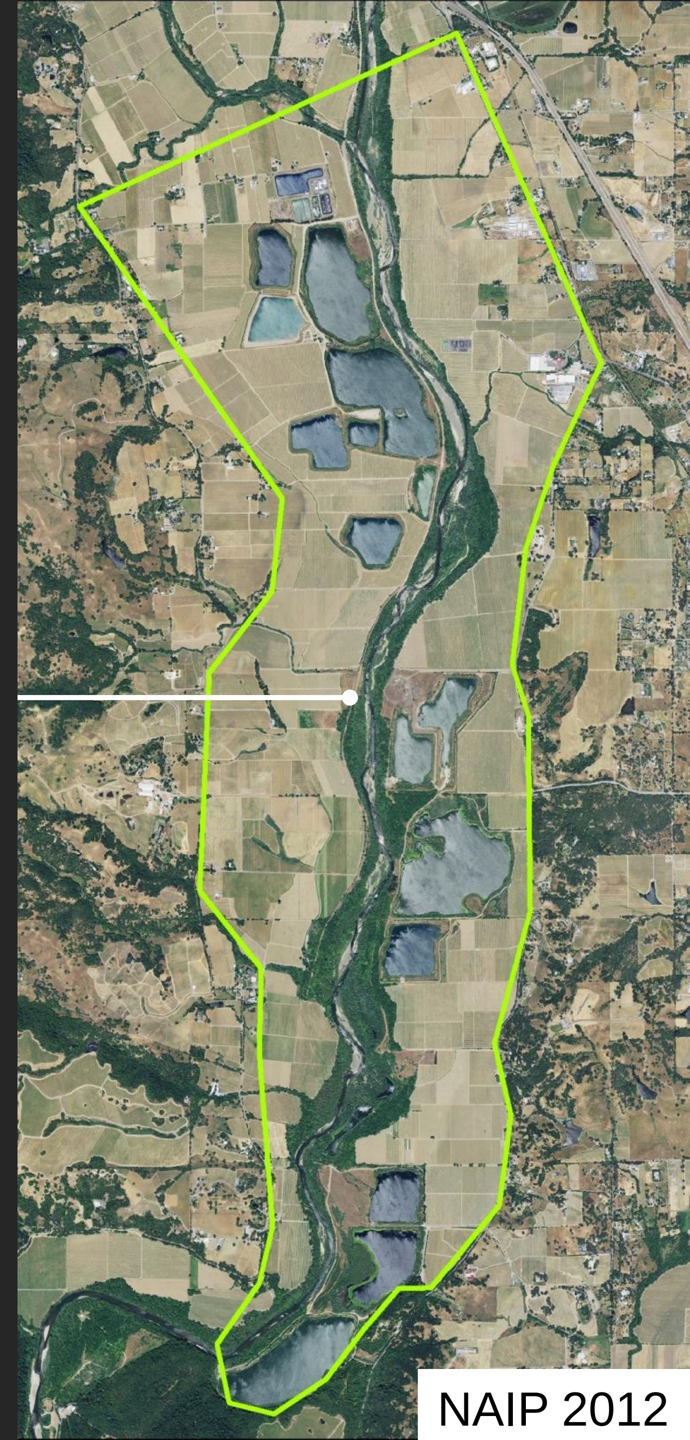
“Great amount of brush and depth of sloughs” (Whitacre 1853)



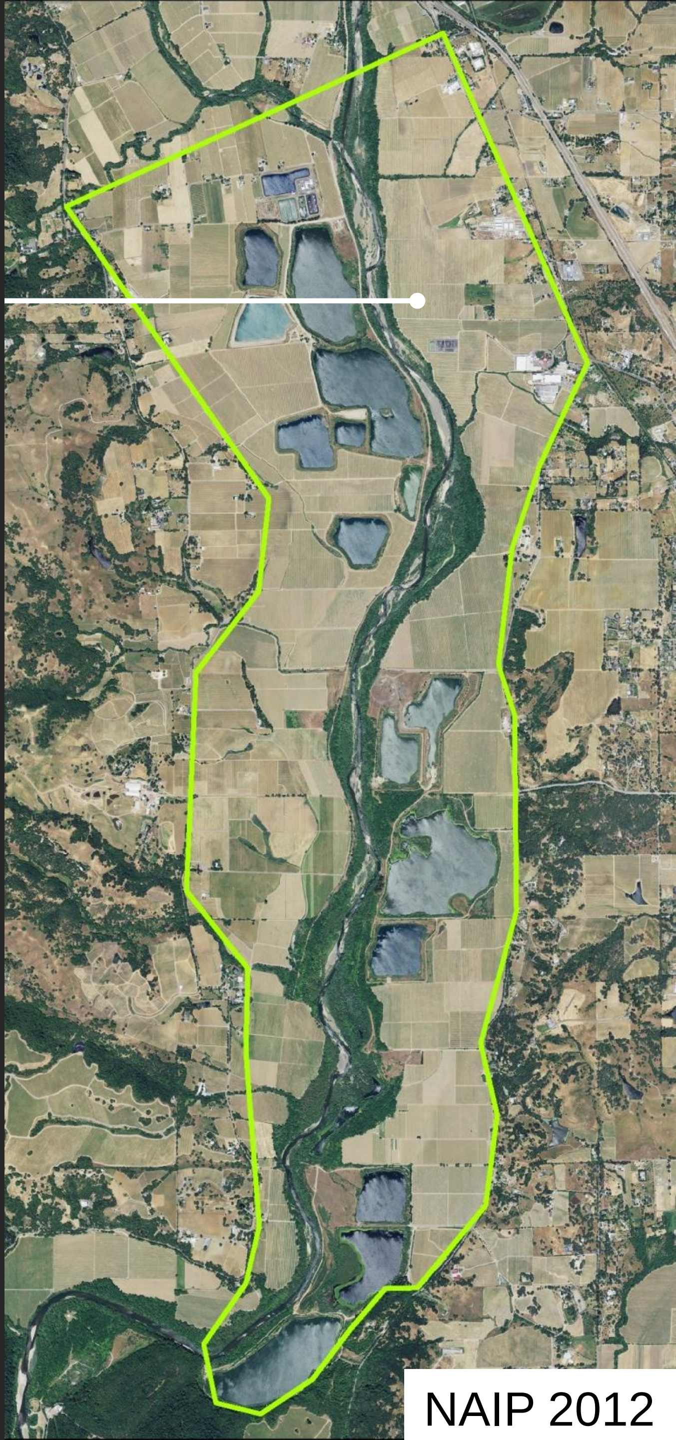
“Brush, briers, cottonwood, willows” (Gray 1857)



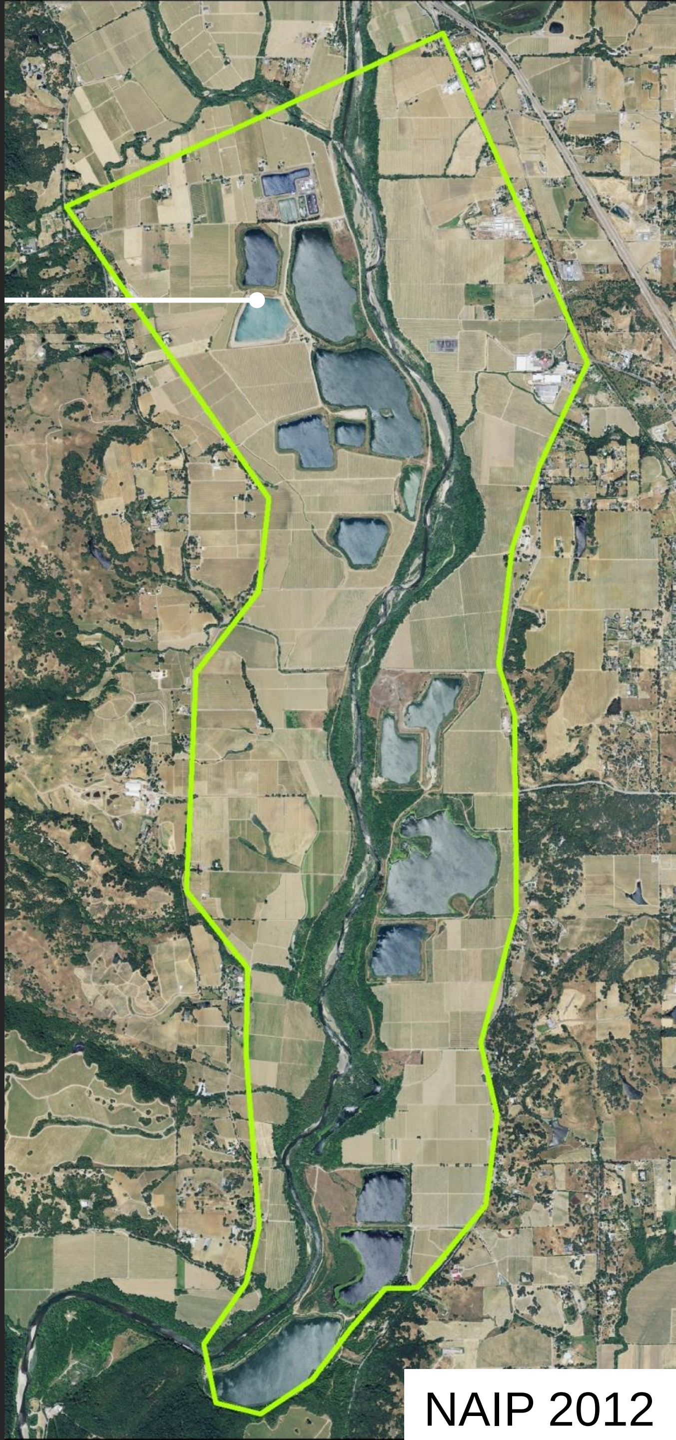
"Cottonwood tree 8 inches diameter" (Gray 1857)



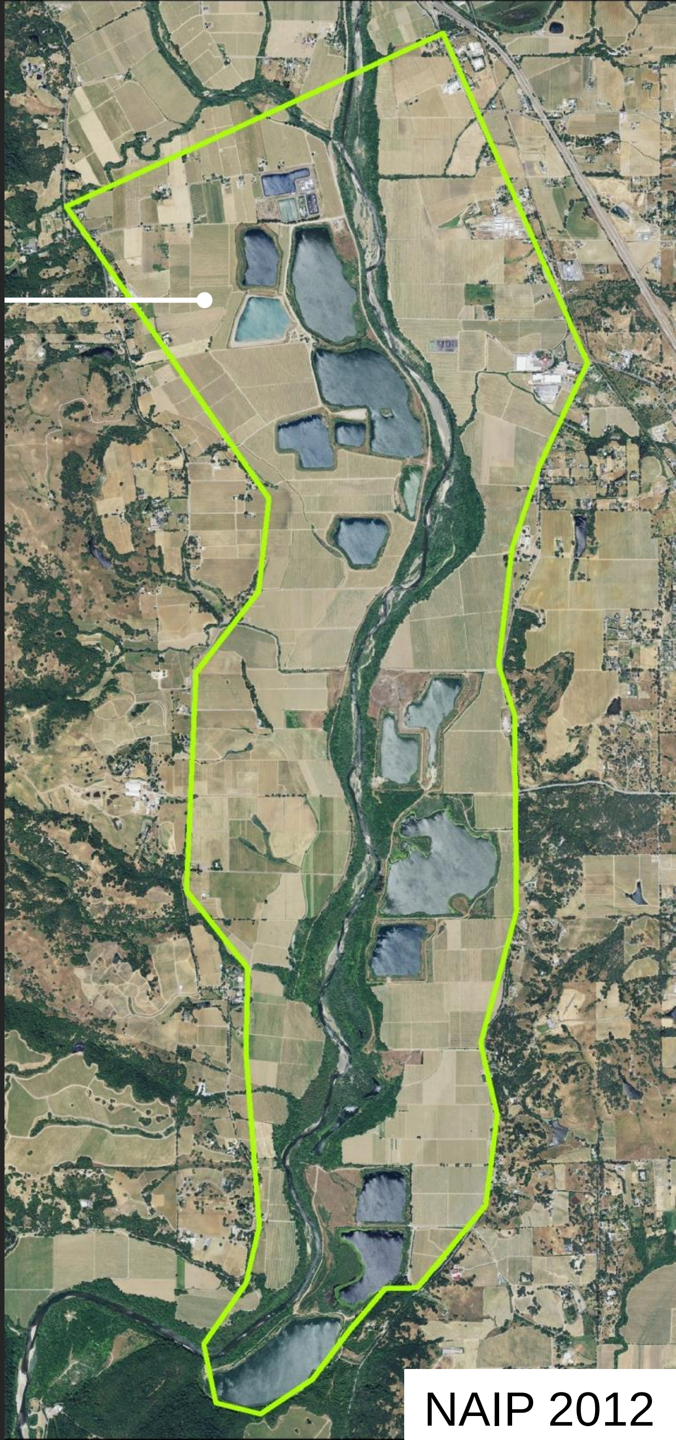
“A willow 8 in. dia… a willow 6 in. dia… On sand bar in Russian river” (Whitacre 1853)



"To lagoon and thicket 50 lks. wide"
(Whitacre 1853)

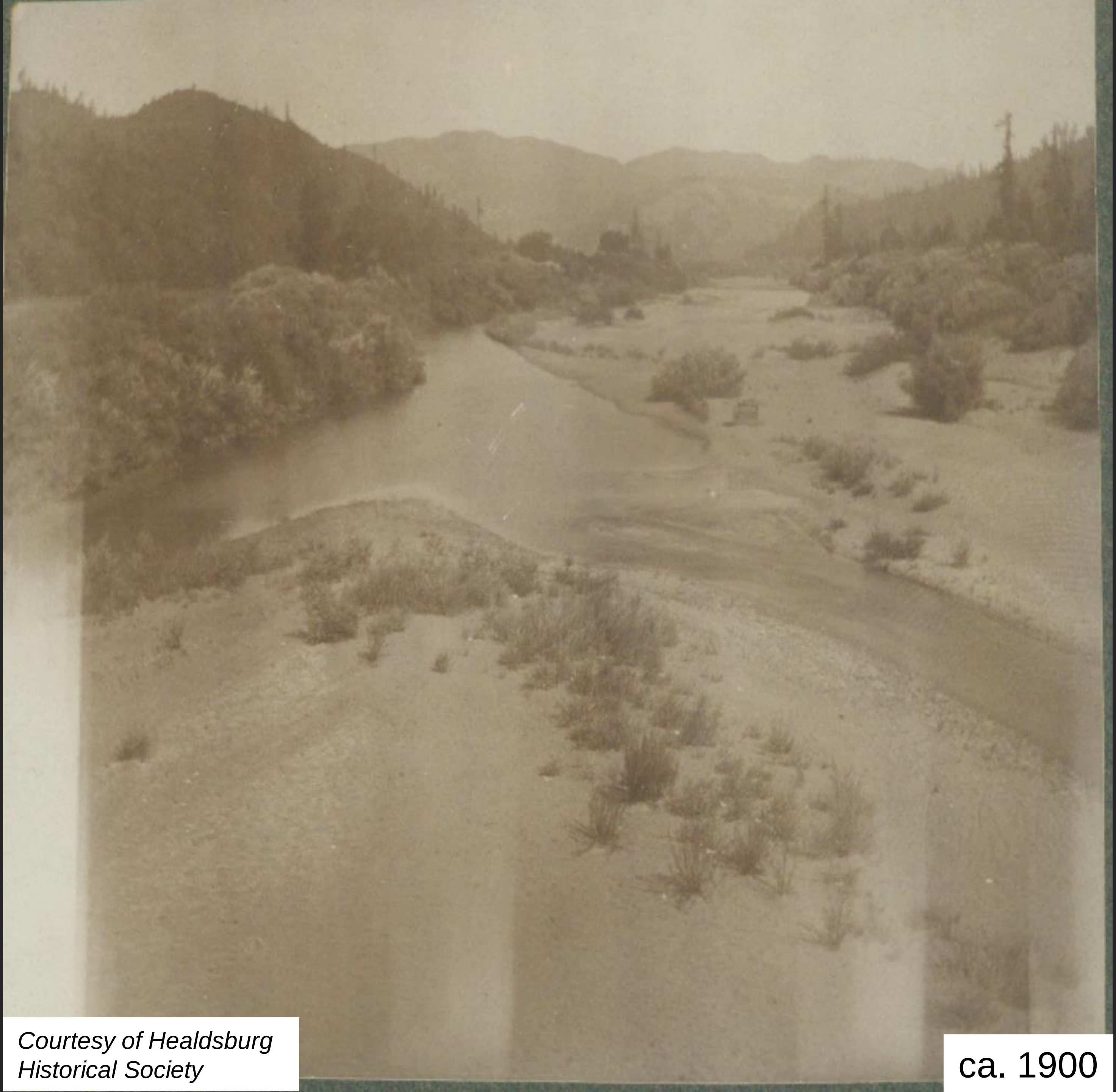


“White oak 40 in. dia… white oak 48 in. dia.” (Whitacre 1853)



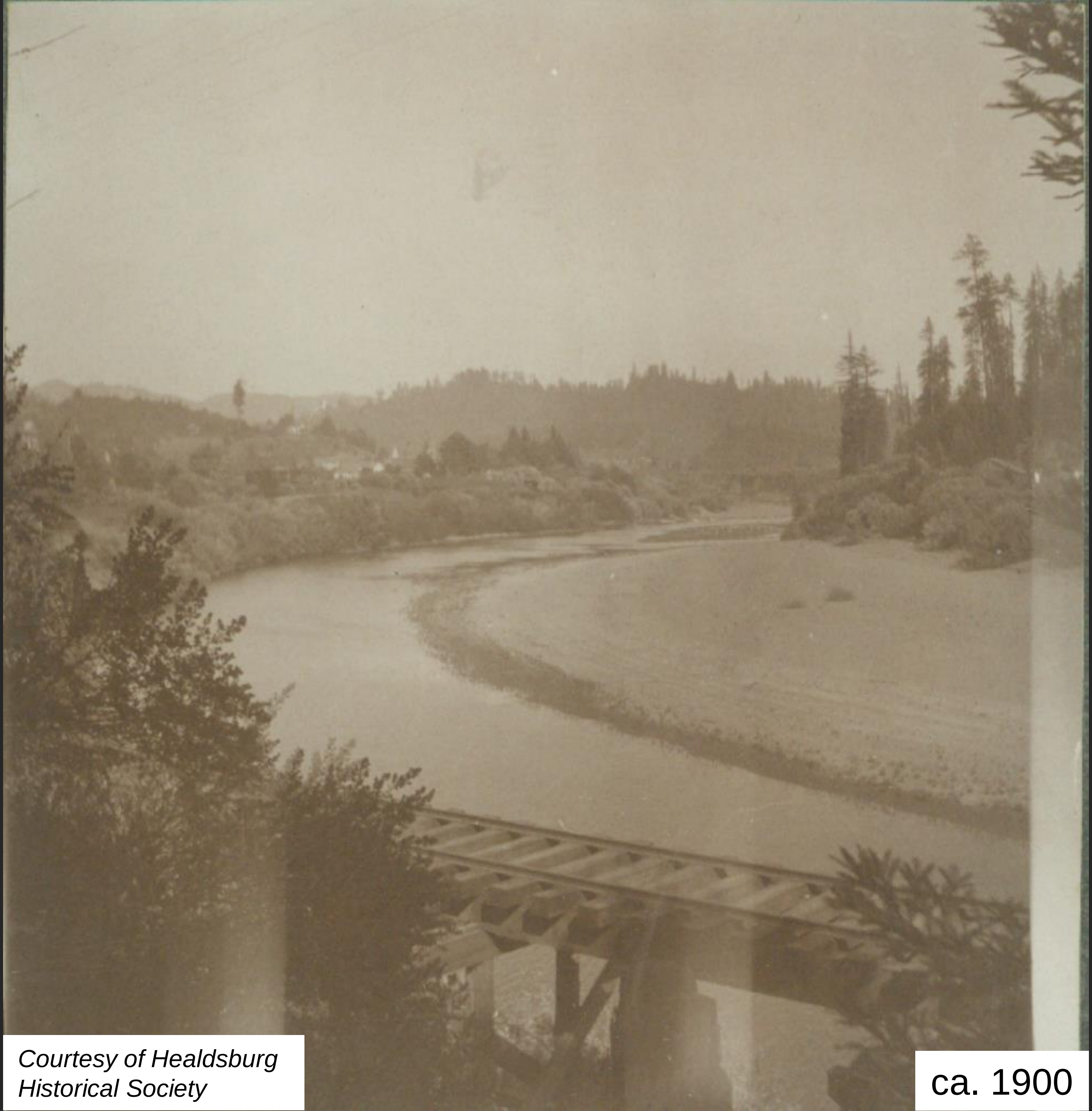
Slides 60-61

- These ca. 1900 photographs show dense riparian vegetation on the floodplain adjacent to the river channel, with sparsely-vegetated bars in the channel.



Courtesy of Healdsburg Historical Society

ca. 1900

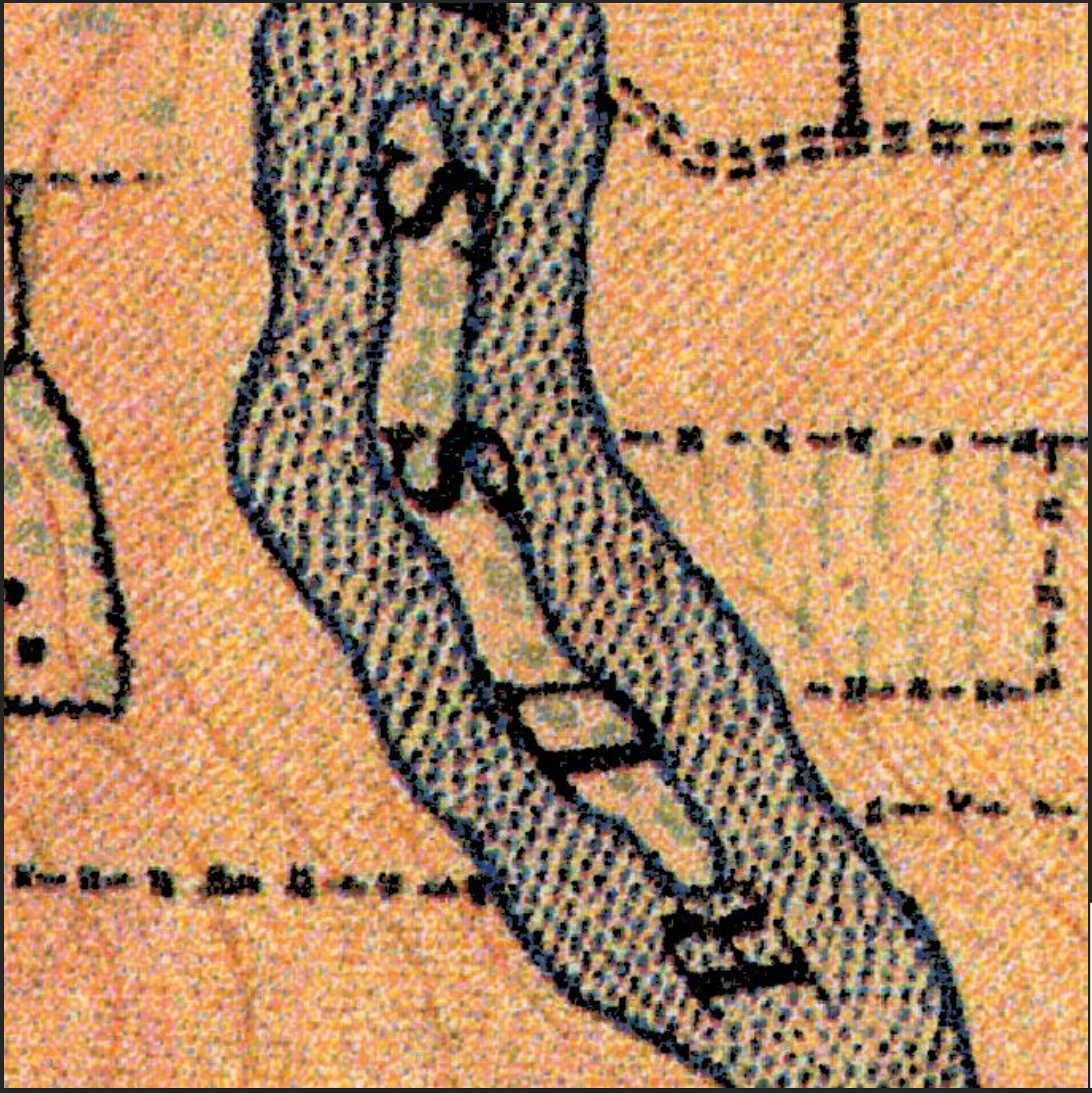


Courtesy of Healdsburg Historical Society

ca. 1900

Slide 63

- USACE 1915 shows trees on a sandbar in the middle of the river.



USACE
1915

Courtesy of Curtis & Associates, Inc.

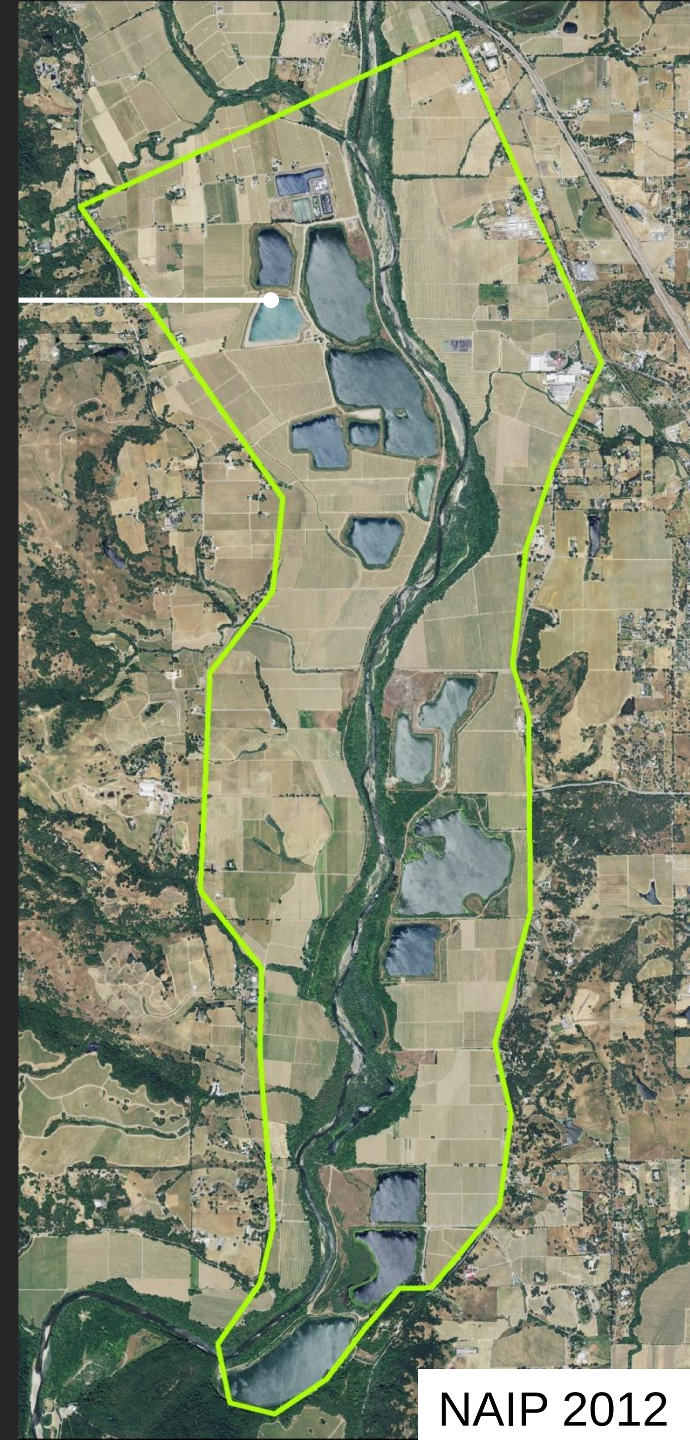
Vegetation patterns in 1942 aerial photos:

- Large unvegetated or sparsely-vegetated bars
- Riparian forest patches generally <300 feet wide, up to 600 feet wide
- Floodplain dominated by agriculture

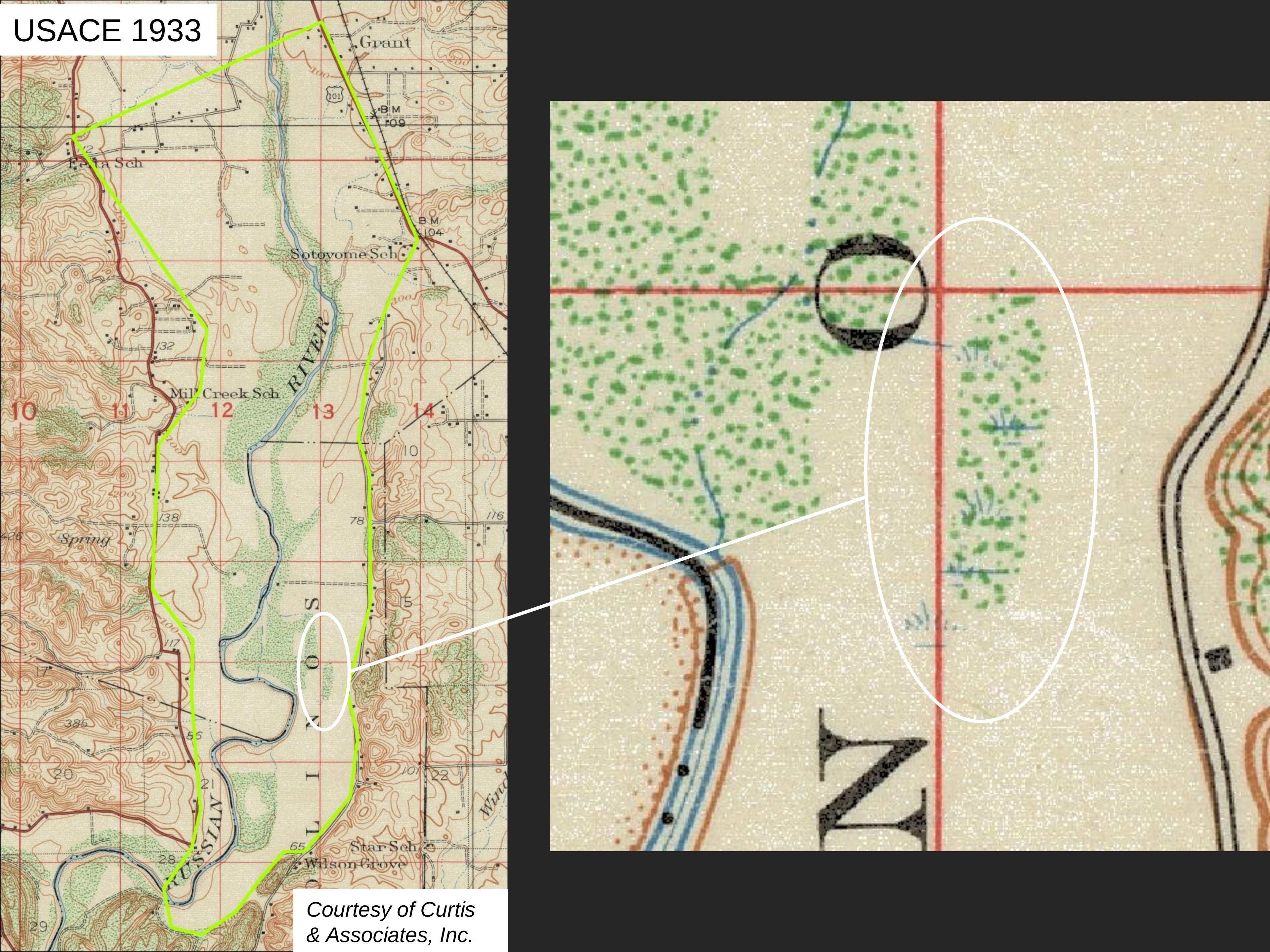
Slides 66-67

- There is evidence for the presence of limited off-channel wetlands historically. Whitacre (1853) noted the presence of a “lagoon and thicket” on the floodplain in the northwestern portion of the study area, while USACE 1933 depicts a small wetland area on the east side of the channel in the southern portion of the study area.

“To lagoon and thicket
50 lks. wide”
(Whitacre 1853)



USACE 1933



Courtesy of Curtis & Associates, Inc.

Vegetation Patterns

- Evidence for a range of riparian environments: willow thickets, willow and cottonwood forest, large valley oaks, understory of brush and briers, marsh vegetation
- Woody riparian corridor up to ~2,800 feet wide in early 20th century
- Loss or expansion of riparian forest in 20th century?

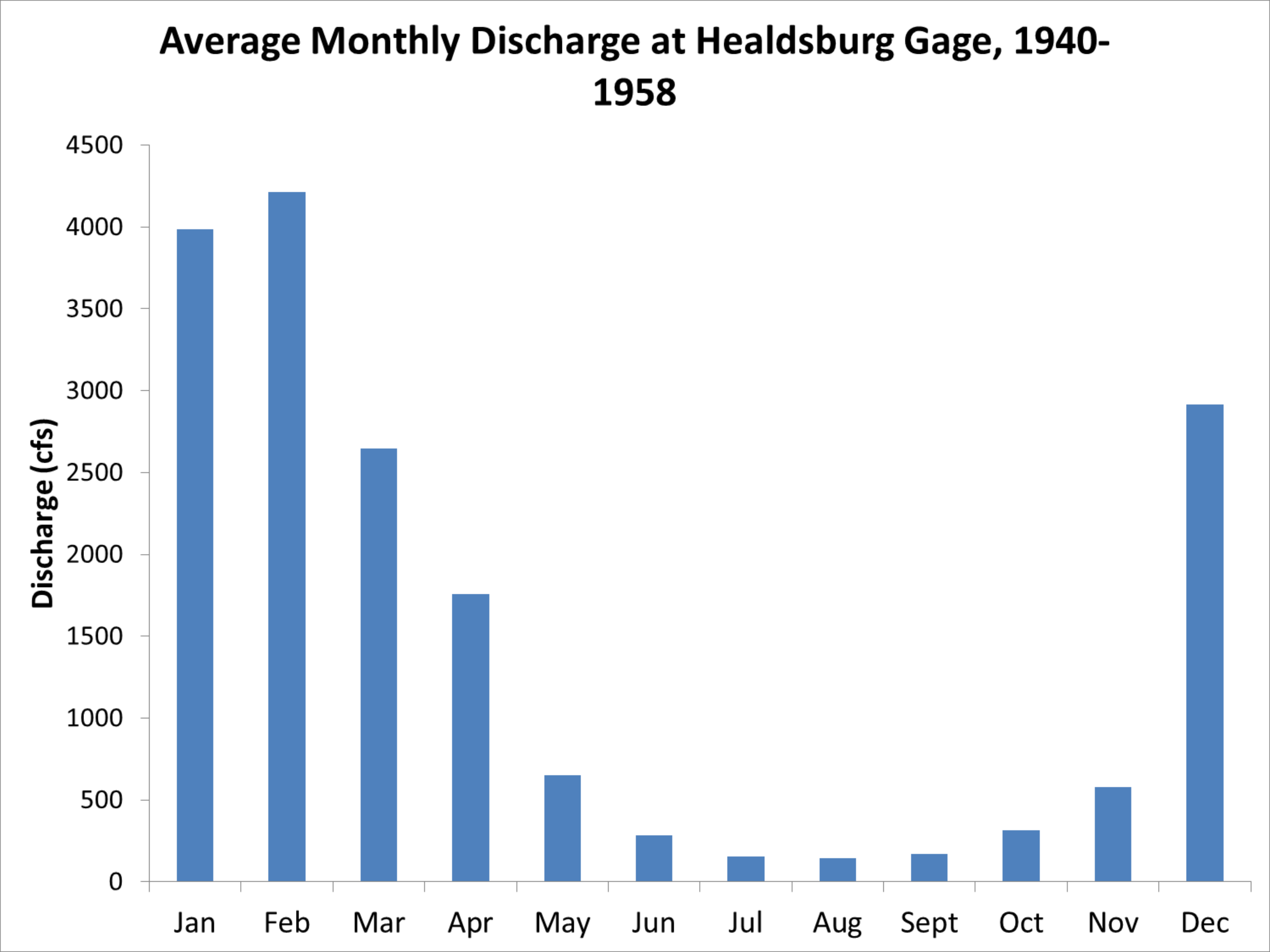
Hydrology

Slides 71-72

- Two contrasting quotes from Frank Marryat – one from August and one from December of 1850 – attest to the pronounced seasonal variability in discharge documented in later instrument measurements.

1850, August: “This is a broad stream, and in the summer months when the water becomes low, it runs sluggishly” (Marryat 1855)

1850, December: “On arriving at Russian River I found the stream much swollen” (Marryat 1855)


Average Monthly Discharge at Healdsburg Gage, 1940-1958
Discharge (cfs)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sept
Oct
Nov
Dec

Slide 74

- Large floods, such as the one shown in this 1940 aerial photo looking south from Healdsburg, inundated much of the study area.

1940

Courtesy of Healdsburg
Historical Society

Next Steps

- Collect and compile additional historical data
- Examine morphology of sand bars, natural levees, and other features
- Analyze rates of channel migration and changes in sinuosity over time
- Further analyze wetland extent
- Gather additional information on historical hydrology and flood events
- Research environmental history (e.g., agriculture, gravel mining, etc.)

APPENDIX D

Literature Reviewed

Bartz KK, Lagueux KM, Scheuerell MD, Beechie T, Ruckelshaus MH, and Haas AD. 2006. **Translating Restoration Scenarios Into Habitat Conditions: An Initial Step in Evaluating Recovery Strategies for Chinook Salmon *(Oncorhynchus tshawytscha)*.** 2006. *Canadian Journal of Fisheries and Aquatic Sciences,* 2006, 63(7): 1578-1595, 10.1139/f06-055.

Bayley P, Klingeman P, Giannico G. 2009**. From Aggregate Mining to Restoration in Willamette Floodplains.** *In* Ecological Opportunities for Gravel Pit Reclamation on the Russian River. 2009 Symposium Report. National Marine Fisheries Service. Habitat Conservation Division. Santa Rosa, California.

Beechie T, Beamer E, and Wasserman L. 1994. **Estimating Coho Salmon Rearing Habitat and Smolt Production Losses in a Large River Basin, and Implications for Habitat Restoration**. North American Journal of Fisheries Management, 14:4, 797-811. To link to this article: http://www.tandfonline.com/doi/abs/10.1577/1548-8675(1994)014%3C0797%3AECSRHA%3E2.3.CO%3B2

Beechie T, Pess G, Roni P and Giannico G. 2008. **Setting River Restoration Priorities: a Review of Approaches and a General Protocol for Identifying and Prioritizing Actions.** North American Journal of Fisheries Management 28:891–905, 2008. DOI: 10.1577/M06-174.1.

Bellmore JR, Baxter CV, Ray AM, Denny L, Tardy K, and Galloway E. 2012. **Assessing the Potential for Salmon Recovery via Floodplain Restoration: A Multitrophic Level Comparison of Dredge-Mined to Reference Segments.** Environmental Management (2012) 49:734–750. DOI 10.1007/s00267-012-9813-x.

Benigno GM and Sommer TR. 2007. **Just Add Water: Sources of Chironomid Drift in a Large River Floodplain.** Hydrobiologia.

Bradford. 1995. **Comparative Review of Pacific Salmon Survival Rates**. Canadian Journal of Fisheries and Aquatic Sciences 52(6):1327-1338.

Crain PK, Whitener K, and Moyle PB. 2004. **Use of a Restored Central California Floodplain by Larvae of Native and Alien Fishes.** American Fisheries Society Symposium 39:125–140.

Cluer B, and Thorne C. 2013. **A Stream Evolution Model Integrating Habitat and Ecosystem Benefits.** River Research and Applications, River Res. Applic. (2013). Published online in Wiley Online Library (wileyonlinelibrary.com) DOI: 10.1002/rra.2631.

Cluer B, Swanson M., McKeon J. January 2009. **Ecological Opportunities for Gravel Pit Reclamation on the Russian River.** Proceedings of the Russian River Pit Symposium sponsored by NOAA National Marine Fisheries Service and Syar Industries, Santa Rosa, California. Available at: www.russianriverkeeper.drupalgardens.com/media/1726

Demko D. 1998. **Evaluation of Juvenile Chinook Behavior, Migration Rate and Location of Mortality in the Stanislaus River through the Use of Radio Tracking.** S.P. Cramer and Associates, Gresham, OR.

Department of Water Resources. 2005. **Fish Passage Improvement: An Element of CALFED's Ecosystem Restoration Program**. Bulletin 250.

EA Engineering, Science, and Technology. 1992. **Don Pedro Project. Fisheries Study Report FERC Article 39, Project No. 2299. Appendix 22, Lower Tuolumne River Predation Study Report**. Prepared for the Turlock Irrigation District and the Modesto Irrigation District.

Ebersole JL, Liss WJ, Polson C, and Frissell CA. 2003. **Thermal Heterogeneity, Stream Channel Morphology, and Salmonid Abundance In Northeastern Oregon Streams.** JCan. J. Fish. Aquat. Sci. **60**: 1266–1280 (2003). DOI: 10.1139/F03-107.

Florsheim JL, Mount JF and Constantine CR. 2006. **A Geomorphic Monitoring and Adaptive Assessment Framework to Assess the Effect of Lowland Floodplain River Restoration on Channel–Floodplain Sediment Continuity.** River Research and Applications 22(3), pages 353–375.

Griggs T. 2009. **California Riparian Habitat Restoration Handbook, Second Edition**, California Riparian Habitat Joint Venture.

Hayes SA, Bond MH, Hanson CV, Freund EV, and Smith JJ. 2008. **Steelhead Growth in a Small Central California Watershed: Upstream and Estuarine Rearing Patterns.** Transactions of the American Fisheries Society 137:114–128, 2008. Copyright by the American Fisheries Society 2008. DOI: 10.1577/T07-043.1.

Hayes SA, Bond MH, Hanson CV, Jones AW, Ammann AJ, Harding JA, Collins AL, Perez J, MacFarlane RB. 2011. **Down, Up, Down and "Smolting" Twice? Seasonal Movement Patterns by Juvenile Steelhead (*Oncorhynchus Mykiss*) in a Coastal Watershed with a Bar Closing Estuary.** *Canadian Journal of Fisheries and Aquatic Sciences,* 2011, 68(8): 1341-1350, 10.1139/f2011-062.

Hiner M, Hillemeier D, Silloway S, and Lestelle L. 2009. **Juvenile Coho Use of Off-Channel Habitat in the Lower Klamath River. Yurok Tribal Fisheries Program.** *In* Proceedings of the American Fisheries Society Annual Conference, Cal-Neva Chapter, Santa Cruz, CA.

Jeffres CA, Opperman JJ, and Moyle PB. 2008. **Ephemeral Floodplain Habitats Provide Best Growth Conditions for Juvenile Chinook Salmon in a California River.** Environ Biol Fish 83:449–458.

J. D. Kiernan, P. B. Moyle, and P. K. Crain. 2012. **Restoring Native Fish Assemblages to a Regulated California Stream Using the Natural Flow Regime Concept.** Ecological Applications, 22(5), pp. 1472–1482.

Kondolf GM, Angermeier PL, Cummins K, Dunne T, Healey M, Kimmerer W, Moyle PB, Murphy D, Patten D, Railsback S, Reed DJ, Spies R, and Twiss R. 2008. **Projecting Cumulative Benefits of Multiple River Restoration Projects: An Example from the Sacramento-San Joaquin River System in California.** Environmental Management (2008) 42:933–945.

Koski KV. 2009. **The Fate of Coho Salmon Nomads: The Story of an Estuarine-Rearing Strategy Promoting Resilience.** Ecology and Society Research, 14(1): 4. Part of a Special Feature on **Pathways to Resilient Salmon Ecosystems** Copyright © 2009 by the author(s). Published under license by the Resilience Alliance: http://www.ecologyandsociety.org/vol14/iss1/art4/.

Limm MP and Marchetti MP. 2003. **Contrasting Patterns of Juvenile Chinook Salmon (*Oncorhynchus tshawytschaw*) Growth, Diet, and Prey Densities in Off-Channel and Main Stem Habitats on the Sacramento River.** Prepared for: The Nature Conservancy.

Lister DB. 1997. **Off-Channel Habitat Rehabilitation.** *In* Watershed Restoration Technical Circular No. 9, Chapter 7. Funded by: Watershed Restoration Program, Ministry of Environment, Lands and Parks and Ministry of Forests, BC. http://www.for.gov.bc.ca/hfd/library/ffip/Lister_DB1997.pdf http://www.env.gov.bc.ca/wld/documents/wrp/wrtc_9.pdf

McBain and Trush. March 1999. **A Summary of the Habitat Restoration Plan for the Lower Tuolumne River Corridor.** Prepared for: The Tuolumne River Technical Advisory Committee.

McBain and Trush and Stillwater Sciences. **2006 Lower Tuolumne River Annual Report,** 2007.

Meade, Jr RJ. 2009. **Recommendations to the Secretary of the Interior: Interim flow releases from Friant Dam for October 1 through November 20, 2009**. Prepared for The Secretary of the Interior and the San Joaquin River Restoration Program Manager.

McMahon TE, September 1983. **Habitat Suitability Index Models: Coho Salmon.** US Fish and Wildlife Service, Fort Collins Co, Western Energy and Land Use Team. http://handle.dtic.mil/100.2/ada323350

Milner J, Elliott JM, Armstrong JD, Gardiner R, Welton JS, and Ladle M. 2003. **The Natural Control of Salmon and Trout Populations in Streams.** NFisheries Research 62 (2003) 111–125. National Salmon and Trout Fisheries Centre, Environment Agency, 29 Newport Road, Cardiff CF24 0TP, UK.

Morley SA, Garcia PS, Bennett T, and Roni P. 2005. **Juvenile salmonid (*Oncorhynchus spp.)* use of constructed and natural side channels in Pacific Northwest Rivers.** Northwest Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, 2725 Montlake Boulevard East, Seattle. Published on the NRC Research Press Web site at http://cjfas.nrc.ca on 3 November 2005.

Opperman JJ and Merenlender AM. 2004. **The Effectiveness of Riparian Restoration for Improving Instream Fish Habitat in Four Hardwood-Dominated California Streams.** North American Journal of Fisheries Management. 24 (3), pp. 822-834. Postprint available at: http://repositories.cdlib.org/postprints/259

Petersonn P. 1982. **Population Characteristics of Juvenile Coho Salmon (*Oncorhynchus Kisutch*) Overwintering In Riverine Ponds**. Can. J. Fish. Aquat. Sci. 39: 1303 - 1307.

Ribeiro F, Crain PK, and Moyle PB. 2004. **Variation in Condition Factor and Growth in Young-of-Year Fishes in Floodplain and Riverine Habitats of the Cosumnes River, California.** Hydrobiologia 527: 77–84.

Sommer TR, Nobriga ML, Harrell WC, Batham W, and Kimmerer WJ. 2001. **Floodplain Rearing of Juvenile Chinook Salmon: Evidence of Enhanced Growth and Survival.** Can. J. Fish. Aquat. Sci. 58: 325–333.

Stillwater Sciences. 2006. **Lower Tuolumne River Predation Assessment**. Prepared for The Tuolumne River Technical Advisory Committee Turlock and Modesto Irrigation Districts USFWS Anadromous Fish Restoration Program California Bay-Delta Authority.

Swales S and Levings CD. 1989. **Role of Off-Channel Ponds in the Life Cycle of Coho Salmon (*Oncorhynchus kisutch*) and Other Juvenile Salmonids in the Coldwater River, British Columbia**. Published on the web 11 April 2011. Canadian Journal of Fisheries and Aquatic Sciences, 1989, 46(2): 232-242, 10.1139/ f89-032.

United States Bureau of Reclamation. November 2003. **Shasta Lake Water Resources Investigation: Potential Ecosystem Restoration Plan Components**. **Chapter VI**, Ecosystem Restoration Opportunities Office Report.

Wampler PJ, Schnitzer EF, Cramer D, and Lidstone C. 2006. **A Meander Cutoff into a Gravel Extraction Pond, Clackamas River, Oregon**. SME Annual Meeting Mar. 27-Mar.29, 2006, St. Louis, MO.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Region
777 Sonoma Ave., Room 325
Santa Rosa, CA 95404-4731

February 20, 2013

In response, refer to:
SWR/F/SWR3:MH

Michael Beck
Endangered Habitats Conservancy
615 La Cresta Boulevard
Crest, California

Subject: Results of Screening Sediment and Water Sampling
Russian River
Windsor Hanson Gravel Pond Project
Windsor, Sonoma County, California

Dear Mr. Beck:

At the request of Endangered Habitats Conservancy (EHC), NOAA's National Marine Fisheries Service (NMFS) has prepared the following report to provide the result of our Sediment/ Soil Screening and Water Quality sampling for the Russian River. The Sonoma County Permit and Resource Management Department (PRMD) funded the analyses. This reports includes a brief site description, project background, scope of the services preformed, a summary of finding, and NMFS conclusions.

BRIEF PROJECT SITE BACKGROUND

The subject property consists of 357.16-acres of privately owned property located along the Russian River, west of Windsor, in Sonoma County, California. EEI Geotechnical & Environmental Solutions, LLC proposed screening sediment and water quality sampling at the Windsor Hanson Gravel ponds to access possible impacts. In August 2012, Affiliated Researchers, LLC (Affiliated) conducted Phase II sampling of the Windsor Hanson Gravel Ponds and EEI provided a report that finalized the sampling activities preformed and the results (see Box 1).

As a result of meetings and email correspondence with the North Coast Regional Water Board concerning Phase II soil and water quality sampling in the Windsor Hanson Gravel ponds, NMFS prepared a draft proposal on November 13, 2013, to collect benthic sediment, bank soil, and water quality samples in the Russian River in four locations: Alexander Valley Bridge (control site), adjacent to Syar Ponds and Windsor Hanson Gravel ponds and Wohler Bridge. The sampling protocol focused on evaluating the potential impacts from historic mining and agriculture activities in the Russian River for constituents that were observed above detection limits in the Windsor Hanson Gravel ponds.

Box 1.0

A brief summary of Phase II sediment and water quality sampling results conducted by Affiliated Researcher, LLC.

In Phase II, sediment and water quality sampling was conducted in the Hanson Ponds (Piombe, Richardson, Vimark and Mariana), to evaluate the potential impacts from historic mining and agriculture activities on an adjacent property.

Results from the Sediment laboratory analysis show no detection above laboratory limits in any soil samples for analysis of Organophosphorous Pesticides (EPA 8141) and Poly Aromatic Hydrocarbons (PAH, EPA 8270 SIM). No concentrations of Total Extractable Petroleum Hydrocarbons (THP) were detected above laboratory reporting limits in any samples analyzed, except for one sediment sample collected from Vimark.

Of the Organochlorine Pesticides (EPA 8081), DDE and DDT were reported in several of the sediments collected, with concentrations ranging from 0.005 mg/kg to 0.036 mg/kg for DDE and 0.0006 mg/kg to 0.008 mg/kg for DDT; no other concentrations of Organochlorine Pesticides were detected.

CAM Metals (EPA 6010B/7400) were detected above laboratory reporting limits for Total Barium, Total Chrominum, Total Cobalt, Total Copper, Total Lead, Total Mercury, Total Nickel, Total Vanadium and Total Zinc. Given the consistency of the reported CAM Metal concentrations between the various sample locations, it is likely that these represent the naturally occurring or "background" mineral concentrations in the local sediments.

Water samples were collected for the same constituents as sediment samples, with the addition of Methyl Mercury (EPA 1630), Volatile Organic Compounds (VOCs) (EPA 8260), Total Nitrogen, Total Phosphorus, and Chlorophyll-A. Results from the analysis show no concentrations of Total Extractable Petroleum Hydrocarbons (TPH), VOCs, Organochlorine Pesticides and Organophosphoruous pesticides.

Detectable concentrations of Methyl Mercury were reported in all samples analyzed, with concentrations ranging from 0.0002 µg/L to 0/0153 µg/L. Concentrations of Arsenic (Richardson, Marina, and Vimark), Barium (all ponds), and Nickel (Piombe) were detected in water quality samples; no other concentrations of Total Metals were detected above laboratory reporting limits.

Concentration of Total Nitrogen and Chlorophyll-A were reported as non-detect. Total Phosphorous was reported above detection limit in all ponds and concentrations range from 12 to 230 µg/L.

SEDIMENT AND SOIL SAMPLING

On January 08, 2013, NMFS staff conducted in stream benthic sediment and bank soil sampling in the Russian River. In stream benthic sediment samples were collected in quiescent, backwater areas within the channel of the Russian River and newly deposited bank soils samples were collected approximately 1- 2 meters from the left bank of the Russian River. Figure 1 depicts the locations of the samples collected during the investigation, which include one in stream benthic grab samples in all four locations sampling sites (Alexander Bridge, Syar ponds, Hanson pond, and Wohler Bridge). A total of four benthic sediment samples were collected from the bottom of the Russian River (n =4).

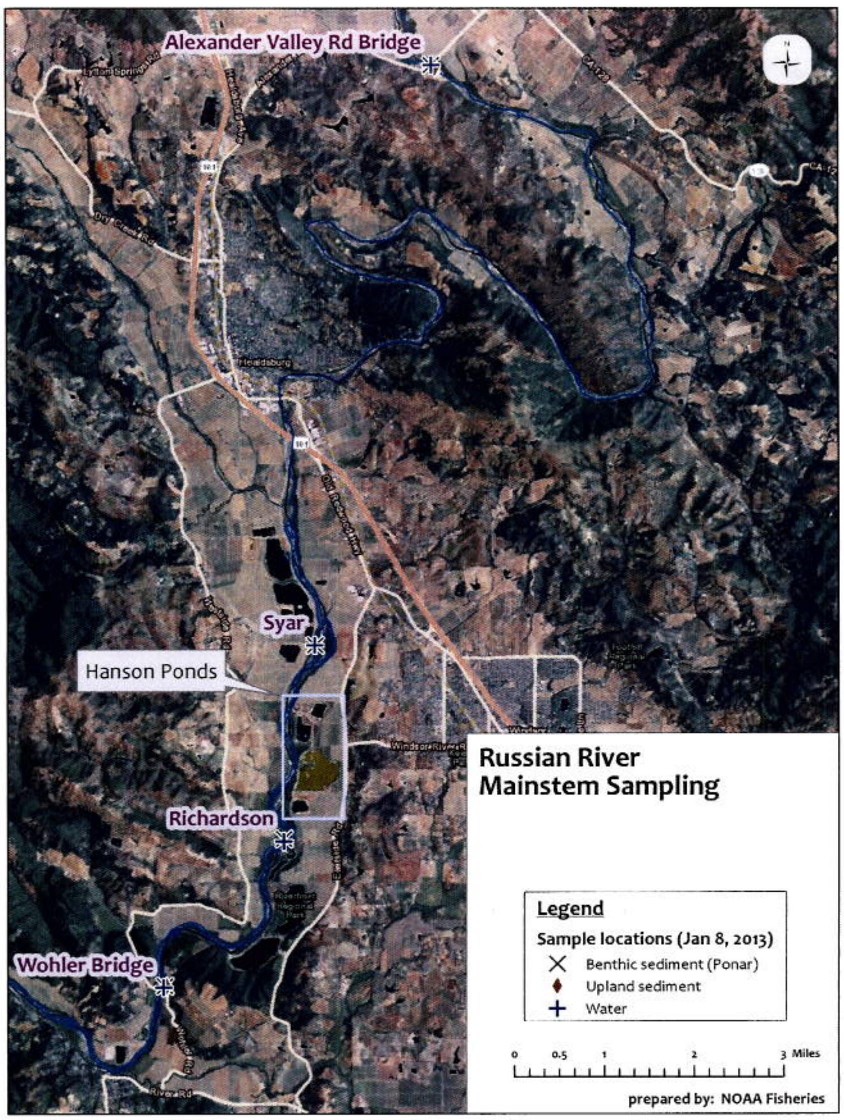


Figure 1. Location of four sampling locations in stream benthic sediment site, upland sediment site and water quality samples in the Russian River Watershed.

Russian River in stream benthic sediment grab samples were collected at depths of approximately 10-20 cm below sediment surface using a Wildco Petite Stainless Steel Ponar Sampler (sample area 152 x 152 mm (6 x 6")) use for sampling benthos sediments in both fresh water and salt water. All benthic sediment and bank soil samples were stored in pre-labeled, 8-ounce glass jars supplied by Alpha-Analytical Laboratories, LLC and sealed with Teflon-lined plastic lids. After collection, all grab samples were placed on ice in a cooler, pending delivery to Alpha-Analytical Laboratories, LLC located in Ukiah, California under chain-of-custody (COC) documentation. A total of 8 samples (4 benthic and 4 bank soils) were submitted for laboratory analysis during this phase of the investigation and sample were reported on a dry weight basis in milligram per kilogram (mg/kg).

Soil texture and type encountered during this investigation consisted of relatively fine-grained silt to gravel sands in the quiescent backwater areas in the channel and silts in the deposited bank soils. No physical evidence of contamination (visible staining or noticeable odor) was observed in any of the sample locations.

Soil Laboratory Analysis and Summary of Results

In stream benthic sediment and bank soil samples were submitted to Alpha Analytical Laboratories, Inc., in Ukiah, California for analysis of Total Extractable Petroleum Hydrocarbons (TPH) (EPA 8015), Organochlorine Pesticides and PCBs (EPA 8081/8082) and Title 22 Heavy Metals (EPA 6000/7000 series methods).

- Concentrations of TPH as diesel were detected above laboratory limits in the benthic sediment samples across all sites and range from 1.6 mg/kg to 2.6 mg/kg. The Hanson Pond site had the lowest concentrations (1.6 mg/kg). Alexander Valley Road Bridge (upstream control site) and Wohler Bridge (furthest downstream site) had TPH concentrations of 1.9 mg/kg, and Syar ponds had the highest concentration of TPH 2.6 mg/kg. No concentration of TPH as motor oil was detected above reporting limits for any of the benthic sediments analyzed, except 2.6 mg/kg in the Syar pond site.

- No concentrations of Organochlorines Pesticides or PCBs were detected above the laboratory limits (i.e., "non-detect) in any of the in stream benthic or bank soil samples analyzed.

- Concentrations of a number of Total Metals were detected above the laboratory reporting limit. The metals in all benthic sediment and bank soils samples were analyzed. The reported metals were consistent in all of the samples and included Arsenic, Barium, Chromium, Cobalt, Copper, Lead, Mercury, Nickel, Vanadium, and Zinc. For reference, the reported concentrations in benthic sediment and bank soils for Total Arsenic range from 3.6 to 41 kg/mg and 3.9 to 5.8 kg/mg, Total Barium 83 to 100 mg/kg and 95 to 110 kg/mg, Total Chromium 47 to 67 mg/kg and 56 to 68 kg/mg, Total Cobalt 11 to 13 mg/kg and 13 to 19 mg/kg, Total Copper 19 to 22 mg/kg and 22-28 mg/kg, Total Lead 2.2 to 5.2 mg/kg and 7.0 to 7.8 mg/kg, Total Mercury 0.25 to 1.13 mg/kg and 0.38 to 0.65 mg/kg, Total Nickel 94 to 110 mg/kg and 100 to 110 mg/kg, Total Vanadium 23 to 31 mg/kg and 26 to 29 mg/kg and Total Zinc 32 to 38 mg/kg and 36 to 44 mg/kg.

Water Sampling

On January 08, 2013, NMFS staff conducted in-stream water sampling in the Russian River. Figure 1 depicts the locations of samples collected during this investigation, which include four grab samples in the thalweg of the Russian River, collected at a depth of approximately 30 to 40 cm below the water surface using EPA's method 1669 "clean hand dirty hands" protocol (EPA, 1996). Water samples were collected and poured directly into pre-labeled sample bottles. For methyl-mercury four samples were collected and poured into specially cleaned, pretested, fluoropolymer or borosilicate bottles (200 mL) using sample handling techniques specially designed for collection of metals at trace levels supplied by Alpha-Analytical Laboratories, LLC. Extreme care was taken to avoid contamination when collecting and analyzing ambient water samples for trace metals. After collection, all grab water samples were placed on ice in a cooler, pending delivery to Alpha-Analytical Laboratories, LLC located in Ukiah, California under chain-of-custody (COC) documentation. A total of 4 water samples were submitted for laboratory analysis during this phase of the investigation and sample were reported in milligrams per liter (mg/L) and nanograms per liter (ng/L).

Water Laboratory Analysis and Summary of Results

Water samples were submitted to Alpha Analytical Laboratories, Inc., in Ukiah, California for analysis of methyl mercury (EPA 1630) and Title 22 Heavy Metals (EPA 6000/7000 series methods).

- Detectable concentrations of methyl mercury (ng/L) were reported above the laboratory reporting limit for all water samples analyzed. The concentrations ranged from 0.0792 to 0.0943 ng/L. The highest concentration of methyl mercury was observed at the Wohler Bridge site (0.0929 ng/L) and Syar pond site (0.0943 ng/L) water grab samples.

- Concentrations of Barium were detected above laboratory reporting limits in all water samples collected and ranged from 0.078 to 0.086 mg/L.

- No other concentrations of heavy metals were detected above the laboratory reporting limits.

Reported soil and sediment concentrations were compared to California Human Health Screening Levels (CHHSLs) for Soil-Residential Land use only values (Cal-EPA, 2005). The CHHLs are concentrations of 18 hazardous chemicals that are used to estimate and compare reported concentrations in soil or soil gas risk to human health. In the case of water samples, or where CHHL values were not available, California Regional Water Control Board (CRWCB) – San Francisco Bay Region, Environmental Screening Levels (ELS) for either shallow soil (residential) or groundwater (potential drinking water resource) was used (CRWQCB, 2008).

The ESLs are concentrations of chemicals of concern commonly found during soil and groundwater investigations, which can be used to estimate and compare reported concentrations to risk to human health and the environment. Typically, the use of ESL in evaluating water samples is preferred over the California Maximum Contaminant Levels (MCL's); the ELS calculations are generally more conservative by one or more degrees of magnitude.

Summary and Conclusion

In the Russian River, organchlorine pesticides and PCB's were not detected in benthic sediment or bank soils; however these constituents of concern were detected above laboratory reporting limits in the Windsor Hanson Gravel Ponds. Concentrations of TPH as diesel fuel were detected across all sites in the benthic sediment, which could indicate evidence of chemicals used for equipment farming purposes.

A consistent suite of heavy metals were detected in the benthic sediment and bank soil samples (arsenic, barium, chromium, cobalt, copper, lead, mercury, nickel, vanadium and zinc). Given the consistency of the constituents and concentrations reported in this sampling effort and the Hanson Gravel Ponds, it is likely that these concentrations represent the naturally occurring background heavy metal characterization in the benthic sediment and bank soils.

Concentrations of mercury reported for this sampling effort in the benthic sediment samples range from 0.25 to 1.3 kg/mg. The approximately 3-fold increase in mercury (1.3 kg/mg) was detected at the Alexander Valley bridge sampling site. This high concentration is most likely due to upstream influence from Lake Mendocino and the chosen sampling location (backwater eddy, highly depositional pool area sampled on the left bank of the Russian River, directly beneath the bridge). It is important to note that one discrete grab sample is not representative of the entire stream reach. The benthic sediment mercury concentrations were similar to the bank soil concentrations which range from 0.38 to 0.69 mg/kg and were within the range of values reported from the Hanson Gravel ponds sediments (0.11-0.55 mg/kg). The values reported are also similar to soil mercury concentrations of 0.17 to 0.56 mg/kg reported by Syar Industries Phase II Reclamation Project located in Healdsburg, California. Furthermore, values reported for the Syar Pond, Richardson Pond, and Wohler Bridge sites are similar to values reported for Lake Sonoma. Lake Sonoma is located 15 miles north of Santa Rosa in Dry Creek Valley, upstream from the Healdsburg Windsor Hanson Gravel pond operation. The USGS (2005) characterized this area as one of the most productive mercury districts in the world.

Our analytical results show that levels of methyl mercury in the Russian River are lower than levels observed in the Windsor Hanson Gravel Ponds. These differences in concentration in the pond compared to Russian River are to be expected. The major sites for methyl mercury production are associated with lake, coastal/estuarine sediments, wetlands and marshes. The higher methyl mercury concentrations observed in the Hanson ponds compared to the Russian River are primarily due to impoundment conditions observed within the ponds which contribute to: high organic matter accumulation, redox conditions (suboxic to anoxic in sediments); temperature and O_2 stratification of the ponds (i.e., low O_2 at greater depths) and higher temperatures during sampling period stimulate increased microbial activity. These factors create the conditions necessary to stimulate methyl mercury production. This preliminary data contributes to evidence that elevated levels of mercury and methyl mercury are highly variable throughout the Russian River watershed.

Limitations

The findings provided were derived in accordance with current standards of practice and no warranty is expressed or implied. Standards of practice are subject to change over time. This report has been prepared for the sole use of Endangered Habitats Conservancy. The site conditions, land use, or other factors may change as a result of man-made influences and additional work may be required.

It is important to note that, this report contains information which may be used in the preparation of the contract specifications; however, the report is not designed as a specification document, and may not contain sufficient information for use without additional assessment. This report may be subject to review by controlling authorities.

Please contact Dr. Melanie Harrison at (707-575-1253) or via email at Melanie.Harrison@noaa.gov, if you have require any additional information.

Sincerely

for Dick Butler
North Central Coast Office Supervisor
Protected Resources Division

Enclosure

Enclosure

alpha
Alpha Analytical Laboratories Inc. e-mail: clientservices@alpha-labs.com
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Satellite Laboratory: 6398 Dougherty Rd., Suite 35, Dublin, CA 94568 • Phone: (925) 828-6226 • Fax: (925) 828-6309

ELAP Certificate Numbers 1551 and 2728

24 January 2013

National Marine Fisheries Service
Attn: Melanie Harrison
777 Sonoma Avenue, Rm 325
Santa Rosa, CA 95409
RE: Russian River sediments and waters
Work Order: 13A0470

Enclosed are the results of analyses for samples received by the laboratory on 01/09/13 21:55. If you have any questions concerning this report, please feel free to contact me.

Sincerely,

Jeanette Popli

Jeanette L. Poplin For David S. Pingatore
Project Manager

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CHEMICAL EXAMINATION REPORT

National Marine Fisheries Service
777 Sonoma Avenue, Rm 325
Santa Rosa, CA 95409
Attn: Melanie Harrison

Report Date: 01/24/13 09:41
Project No: Russian River sediments and waters
Project ID: Russian River sediments and waters

Order Number	Receipt Date/Time	Client Code	Client PO/Reference
13A0470	01/09/2013 21:55	DP NMFS	

ANALYTICAL REPORT FOR SAMPLES

Sample ID	Laboratory ID	Matrix	Date Sampled	Date Received
Alexander Bridge Water	13A0470-01	Water	01/08/13 17:00	01/09/13 21:55
Alexander Bridge Sediment	13A0470-02	Soil	01/08/13 17:15	01/09/13 21:55
Alexander Bridge Bank Soil	13A0470-03	Soil	01/08/13 17:30	01/09/13 21:55
Adj to Richardson Pond Water	13A0470-04	Water	01/08/13 15:40	01/09/13 21:55
Adj to Richardson Pond Sediment	13A0470-05	Soil	01/08/13 15:45	01/09/13 21:55
Adj to Richardson Pond Bank Soil	13A0470-06	Soil	01/08/13 15:47	01/09/13 21:55
Wohler Bridge Water	13A0470-07	Water	01/08/13 15:15	01/09/13 21:55
Wohler Bridge Sediment	13A0470-08	Soil	01/08/13 15:17	01/09/13 21:55
Wohler Bridge Bank Soil	13A0470-09	Soil	01/08/13 15:19	01/09/13 21:55
Syar Water	13A0470-10	Water	01/08/13 16:30	01/09/13 21:55
Syar Sediment	13A0470-11	Soil	01/08/13 16:32	01/09/13 21:55
Syar Bank Soil	13A0470-12	Soil	01/08/13 16:40	01/09/13 21:55

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Bruce Gove
Laboratory Director

1/24/2013

Alpha Analytical Laboratories Inc. e-mail: clientservices@alpha-labs.com
Corporate: 208 Mason St., Ukiah, CA 95482 • Phone: (707) 468-0401 • Fax: (707) 468-5267
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CHEMICAL EXAMINATION REPORT

National Marine Fisheries Service
777 Sonoma Avenue, Rm 325
Santa Rosa, CA 95409
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Project ID: Russian River sediments and waters

Order Number	Receipt Date/Time	Client Code	Client PO/Reference
13A0470	01/09/2013 21:55	DP NMFS	

Alpha Analytical Laboratories, Inc.

	METHOD	BATCH	PREPARED	ANALYZED	DILUTION	RESULT	PQL	NOTE
Alexander Bridge Water (13A0470-01)		**Sample Type: Water**			**Sampled: 01/08/13 17:00**			
Metals by APHA/EPA Methods								
Methyl mercury	EPA 1630	AA31543	01/14/13 14:00	01/15/13 20:03	1	**0.0792 ng/l**	**0.0500**	
Metals by EPA 6000/7000 Series Methods								
Antimony	EPA 6010	AA31121	01/11/13 11:15	01/16/13 12:49	1	ND mg/l	0.020	
Arsenic	EPA 7060	"	"	01/18/13 14:21	"	ND "	0.0020	
Barium	EPA 6010	"	"	01/16/13 12:49	"	**0.086 "**	**0.010**	
Beryllium	"	"	"	"	"	ND "	0.010	
Cadmium	"	"	"	"	"	ND "	0.010	
Chromium	"	"	"	"	"	ND "	0.050	
Cobalt	"	"	"	"	"	ND "	0.020	
Copper	"	"	"	"	"	ND "	0.10	
Lead	"	"	"	"	"	ND "	0.050	
Mercury	EPA 7470	AA31453	01/15/13 07:10	01/16/13 11:42	"	ND "	0.0010	
Molybdenum	EPA 6010	AA31121	01/11/13 11:15	01/16/13 12:49	"	ND "	0.50	
Nickel	"	"	"	"	"	ND "	0.10	
Selenium	EPA 7740	"	"	01/18/13 15:15	"	ND "	0.0050	
Silver	EPA 6010	"	"	01/16/13 12:49	"	ND "	0.010	
Thallium	"	"	"	"	"	ND "	0.40	
Vanadium	"	"	"	"	"	ND "	0.50	
Zinc	"	"	"	"	"	ND "	0.10	
Alexander Bridge Sediment (13A0470-02)		**Sample Type: Soil**			**Sampled: 01/08/13 17:15**			
Metals by EPA 6000/7000 Series Methods								
Antimony	EPA 6010	AA31109	01/11/13 08:57	01/14/13 18:47	1	ND mg/kg	15	
Arsenic	EPA 7060	"	"	01/15/13 15:06	2	**4.1 "**	**4.0**	
Barium	EPA 6010	"	"	01/14/13 18:47	1	**110 "**	**10**	
Beryllium	"	"	"	"	"	ND "	0.75	
Cadmium	"	"	"	"	"	ND "	1.0	
Chromium	"	"	"	"	"	**67 "**	**5.0**	
Cobalt	"	"	"	"	"	**13 "**	**10**	
Copper	"	"	"	"	"	**20 "**	**10**	

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Bruce Gove
Laboratory Director

1/24/2013

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CHEMICAL EXAMINATION REPORT

National Marine Fisheries Service
777 Sonoma Avenue, Rm 325
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13A0470	01/09/2013 21:55	DP NMFS	

Alpha Analytical Laboratories, Inc.

	METHOD	BATCH	PREPARED	ANALYZED	DILUTION	RESULT		PQL	NOTE
Alexander Bridge Sediment (13A0470-02)			**Sample Type: Soil**			**Sampled: 01/08/13 17:15**			
Metals by EPA 6000/7000 Series Methods (cont'd)									
Lead	EPA 6010	"	"	01/14/13 18:47	"	**5.2 "**		**5.0**	
Mercury	EPA 7471	AA31418	01/14/13 14:45	01/15/13 13:35	"	**1.3 "**		**0.20**	
Molybdenum	EPA 6010	AA31109	01/11/13 08:57	01/14/13 18:47	"	ND "		10	
Nickel	"	"	"	"	"	**110 "**		**10**	
Selenium	EPA 7740	"	"	01/16/13 10:27	"	ND "		1.0	
Silver	EPA 6010	"	"	01/14/13 18:47	"	ND "		5.0	
Thallium	"	"	"	"	"	ND "		7.0	
Vanadium	"	"	"	"	"	**31 "**		**5.0**	
Zinc	"	"	"	"	"	**38 "**		**10**	
TPH by EPA/LUFT GC/GCMS Methods									
TPH as Diesel	8015DRO	AA31431	01/14/13 11:57	01/17/13 16:32	1	**1.9 mg/kg**		**1.0**	D-18
TPH as Motor Oil	"	"	"	"	"	ND "		2.0	
Surrogate: Tetratetracontane	"	"	"	"		*85.4 %*	*60-105*		
Organochlorine Pesticides and PCBs by EPA Method 8081/8082									
Aldrin	EPA 8081/8082	AA31527	01/15/13 10:59	01/18/13 00:06	1	ND mg/kg		0.0050	
alpha-BHC	"	"	"	"	"	ND "		0.0050	
beta-BHC	"	"	"	"	"	ND "		0.0050	
delta-BHC	"	"	"	"	"	ND "		0.0050	
gamma-BHC (Lindane)	"	"	"	"	"	ND "		0.0050	
Chlordane (tech)	"	"	"	"	"	ND "		0.20	
4,4´-DDD	"	"	"	"	"	ND "		0.0050	
4,4´-DDE	"	"	"	"	"	ND "		0.0050	
4,4´-DDT	"	"	"	"	"	ND "		0.0050	
Dieldrin	"	"	"	"	"	ND "		0.0050	
Endosulfan I	"	"	"	"	"	ND "		0.0050	
Endosulfan II	"	"	"	"	"	ND "		0.0050	
Endosulfan sulfate	"	"	"	"	"	ND "		0.0050	
Endrin	"	"	"	"	"	ND "		0.0050	
Endrin aldehyde	"	"	"	"	"	ND "		0.0050	

Bruce Gove
Laboratory Director

1/24/2013

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CHEMICAL EXAMINATION REPORT

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13A0470	01/09/2013 21:55	DP NMFS	

Alpha Analytical Laboratories, Inc.

	METHOD	BATCH	PREPARED	ANALYZED	DILUTION	RESULT		PQL	NOTE
Alexander Bridge Sediment (13A0470-02)			**Sample Type: Soil**			**Sampled: 01/08/13 17:15**			
Organochlorine Pesticides and PCBs by EPA Method 8081/8082 (cont'd)									
Heptachlor	EPA 8081/8082	"	"	01/18/13 00:06	"	ND "		0.0050	
Heptachlor epoxide	"	"	"	"	"	ND "		0.0050	
Methoxychlor	"	"	"	"	"	ND "		0.0050	
Toxaphene	"	"	"	"	"	ND "		0.20	
Surrogate: Dibutylchlorendate	"	"	"	"		*91.8 %*	*50-120*		
Alexander Bridge Bank Soil (13A0470-03)			**Sample Type: Soil**			**Sampled: 01/08/13 17:30**			
Metals by EPA 6000/7000 Series Methods									
Antimony	EPA 6010	AA31109	01/11/13 08:57	01/14/13 18:50	1	ND mg/kg		15	
Arsenic	EPA 7060	"	"	01/15/13 15:33	2	**3.9 "**		**2.0**	
Barium	EPA 6010	"	"	01/14/13 18:50	1	**95 "**		**10**	
Beryllium	"	"	"	"	"	ND "		0.75	
Cadmium	"	"	"	"	"	ND "		1.0	
Chromium	"	"	"	"	"	**68 "**		**5.0**	
Cobalt	"	"	"	"	"	**13 "**		**10**	
Copper	"	"	"	"	"	**20 "**		**10**	
Lead	"	"	"	"	"	ND "		5.0	
Mercury	EPA 7471	AA31418	01/14/13 14:45	01/15/13 13:43	"	**0.66 "**		**0.20**	
Molybdenum	EPA 6010	AA31109	01/11/13 08:57	01/14/13 18:50	"	ND "		10	
Nickel	"	"	"	"	"	**110 "**		**10**	
Selenium	EPA 7740	"	"	01/16/13 10:58	"	ND "		1.0	
Silver	EPA 6010	"	"	01/14/13 18:50	"	ND "		5.0	
Thallium	"	"	"	"	"	ND "		7.0	
Vanadium	"	"	"	"	"	**29 "**		**5.0**	
Zinc	"	"	"	"	"	**36 "**		**10**	
Adj to Richardson Pond Water (13A0470-04)			**Sample Type: Water**			**Sampled: 01/08/13 15:40**			
Metals by APHA/EPA Methods									
Methyl mercury	EPA 1630	AA31543	01/14/13 14:00	01/15/13 20:32	1	**0.0896 ng/l**		**0.0500**	

The results in this report apply to the samples analyzed in accordance with the chain of custody document. This analytical report must be reproduced in its entirety.

Bruce Gove
Laboratory Director

1/24/2013

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CHEMICAL EXAMINATION REPORT

National Marine Fisheries Service
777 Sonoma Avenue, Rm 325
Santa Rosa, CA 95409
Attn: Melanie Harrison

Report Date: 01/24/13 09:41
Project No: Russian River sediments and waters
Project ID: Russian River sediments and waters

Order Number	Receipt Date/Time	Client Code	Client PO/Reference
13A0470	01/09/2013 21:55	DP NMFS	

Alpha Analytical Laboratories, Inc.

	METHOD	BATCH	PREPARED	ANALYZED	DILUTION	RESULT	PQL	NOTE
Adj to Richardson Pond Water (13A0470-04)		**Sample Type: Water**			**Sampled: 01/08/13 15:40**			
Metals by EPA 6000/7000 Series Methods								
Antimony	EPA 6010	AA31121	01/11/13 11:15	01/16/13 12:53	1	ND mg/l	0.020	
Arsenic	EPA 7060	"	"	01/18/13 14:26	"	ND "	0.0020	
Barium	EPA 6010	"	"	01/16/13 12:53	"	**0.085 "**	**0.010**	
Beryllium	"	"	"	"	"	ND "	0.010	
Cadmium	"	"	"	"	"	ND "	0.010	
Chromium	"	"	"	"	"	ND "	0.050	
Cobalt	"	"	"	"	"	ND "	0.020	
Copper	"	"	"	"	"	ND "	0.10	
Lead	"	"	"	"	"	ND "	0.050	
Mercury	EPA 7470	AA31453	01/15/13 07:10	01/16/13 11:44	"	ND "	0.0010	
Molybdenum	EPA 6010	AA31121	01/11/13 11:15	01/16/13 12:53	"	ND "	0.50	
Nickel	"	"	"	"	"	ND "	0.10	
Selenium	EPA 7740	"	"	01/18/13 15:21	"	ND "	0.0050	
Silver	EPA 6010	"	"	01/16/13 12:53	"	ND "	0.010	
Thallium	"	"	"	"	"	ND "	0.40	
Vanadium	"	"	"	"	"	ND "	0.50	
Zinc	"	"	"	"	"	ND "	0.10	
Adj to Richardson Pond Sediment (13A0470-05)		**Sample Type: Soil**			**Sampled: 01/08/13 15:45**			
Metals by EPA 6000/7000 Series Methods								
Antimony	EPA 6010	AA31109	01/11/13 08:57	01/14/13 18:54	1	ND mg/kg	15	
Arsenic	EPA 7060	"	"	01/15/13 15:38	2	**4.1 "**	**4.0**	
Barium	EPA 6010	"	"	01/14/13 18:54	1	**100 "**	**10**	
Beryllium	"	"	"	"	"	ND "	0.75	
Cadmium	"	"	"	"	"	ND "	1.0	
Chromium	"	"	"	"	"	**55 "**	**5.0**	
Cobalt	"	"	"	"	"	**12 "**	**10**	
Copper	"	"	"	"	"	**22 "**	**10**	
Lead	"	"	"	"	"	**5.5 "**	**5.0**	
Mercury	EPA 7471	AA31418	01/14/13 14:45	01/15/13 13:45	"	**0.58 "**	**0.20**	
Molybdenum	EPA 6010	AA31109	01/11/13 08:57	01/14/13 18:54	"	ND "	10	

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Project ID: Russian River sediments and waters

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13A0470	01/09/2013 21:55	DP NMFS	

Alpha Analytical Laboratories, Inc.

	METHOD	BATCH	PREPARED	ANALYZED	DILUTION	RESULT		PQL	NOTE
Adj to Richardson Pond Sediment (13A0470-05)			**Sample Type: Soil**			**Sampled: 01/08/13 15:45**			
Metals by EPA 6000/7000 Series Methods (cont'd)									
Nickel	EPA 6010	"	"	01/14/13 18:54	"	**100 "**		**10**	
Selenium	EPA 7740	"	"	01/16/13 11:04	"	ND "		1.0	
Silver	EPA 6010	"	"	01/14/13 18:54	"	ND "		5.0	
Thallium	"	"	"	"	"	ND "		7.0	
Vanadium	"	"	"	"	"	**26 "**		**5.0**	
Zinc	"	"	"	"	"	**36 "**		**10**	
TPH by EPA/LUFT GC/GCMS Methods									
TPH as Diesel	8015DRO	AA31431	01/14/13 11:57	01/17/13 17:07	1	**1.6 mg/kg**		**1.0**	D-18
TPH as Motor Oil	"	"	"	"	"	ND "		2.0	
Surrogate: Tetratetracontane	"	"	"	"		*83.1 %*	*60-105*		
Organochlorine Pesticides and PCBs by EPA Method 8081/8082									**R-06**
Aldrin	EPA 8081/8082	AA31527	01/15/13 10:59	01/18/13 00:41	4	ND mg/kg		0.020	
alpha-BHC	"	"	"	"	"	ND "		0.020	
beta-BHC	"	"	"	"	"	ND "		0.020	
delta-BHC	"	"	"	"	"	ND "		0.020	
gamma-BHC (Lindane)	"	"	"	"	"	ND "		0.020	
Chlordane (tech)	"	"	"	"	"	ND "		0.80	
4,4´-DDD	"	"	"	"	"	ND "		0.020	
4,4´-DDE	"	"	"	"	"	ND "		0.020	
4,4´-DDT	"	"	"	"	"	ND "		0.020	
Dieldrin	"	"	"	"	"	ND "		0.020	
Endosulfan I	"	"	"	"	"	ND "		0.020	
Endosulfan II	"	"	"	"	"	ND "		0.020	
Endosulfan sulfate	"	"	"	"	"	ND "		0.020	
Endrin	"	"	"	"	"	ND "		0.020	
Endrin aldehyde	"	"	"	"	"	ND "		0.020	
Heptachlor	"	"	"	"	"	ND "		0.020	
Heptachlor epoxide	"	"	"	"	"	ND "		0.020	
Methoxychlor	"	"	"	"	"	ND "		0.020	

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13A0470	01/09/2013 21:55	DP NMFS	

Alpha Analytical Laboratories, Inc.

	METHOD	BATCH	PREPARED	ANALYZED	DILUTION	RESULT		PQL	NOTE
Adj to Richardson Pond Sediment (13A0470-05)			**Sample Type: Soil**			**Sampled: 01/08/13 15:45**			
Organochlorine Pesticides and PCBs by EPA Method 8081/8082 (cont'd)									**R-06**
Toxaphene	EPA 8081/8082	"	"	01/18/13 00:41	"	ND "		0.80	
Surrogate: Dibutylchlorendate	"	"	"	"		*87.9 %*	*50-120*		
Adj to Richardson Pond Bank Soil (13A0470-06)			**Sample Type: Soil**			**Sampled: 01/08/13 15:47**			
Metals by EPA 6000/7000 Series Methods									
Antimony	EPA 6010	AA31109	01/14/13 09:26	01/14/13 18:59	1	ND mg/kg		15	
Arsenic	EPA 7060	"	"	01/15/13 15:43	2	**4.9 "**		**4.0**	
Barium	EPA 6010	"	"	01/14/13 18:59	1	**120 "**		**10**	
Beryllium	"	"	"	"	"	ND "		0.75	
Cadmium	"	"	"	"	"	ND "		1.0	
Chromium	"	"	"	"	"	**61 "**		**5.0**	
Cobalt	"	"	"	"	"	**14 "**		**10**	
Copper	"	"	"	"	"	**28 "**		**10**	
Lead	"	"	"	"	"	**7.0 "**		**5.0**	
Mercury	EPA 7471	AA31418	01/14/13 14:45	01/15/13 13:47	"	**0.68 "**		**0.20**	
Molybdenum	EPA 6010	AA31109	01/14/13 09:26	01/14/13 18:59	"	ND "		10	
Nickel	"	"	"	"	"	**120 "**		**10**	
Selenium	EPA 7740	"	"	01/16/13 11:11	"	ND "		1.0	
Silver	EPA 6010	"	"	01/14/13 18:59	"	ND "		5.0	
Thallium	"	"	"	"	"	ND "		7.0	
Vanadium	"	"	"	"	"	**28 "**		**5.0**	
Zinc	"	"	"	"	"	**44 "**		**10**	
Wohler Bridge Water (13A0470-07)			**Sample Type: Water**			**Sampled: 01/08/13 15:15**			
Metals by APHA/EPA Methods									
Methyl mercury	EPA 1630	AA31543	01/14/13 14:00	01/15/13 21:28	1	**0.0929 ng/l**		**0.0500**	

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13A0470	01/09/2013 21:55	DP NMFS	

Alpha Analytical Laboratories, Inc.

	METHOD	BATCH	PREPARED	ANALYZED	DILUTION	RESULT	PQL	NOTE
Wohler Bridge Water (13A0470-07)		**Sample Type: Water**			**Sampled: 01/08/13 15:15**			
Metals by EPA 6000/7000 Series Methods								
Antimony	EPA 6010	AA31121	01/11/13 11:15	01/16/13 12:40	1	ND mg/l	0.020	
Arsenic	EPA 7060	"	"	01/17/13 18:05	"	ND "	0.0020	
Barium	EPA 6010	"	"	01/16/13 12:40	"	**0.085 "**	**0.010**	
Beryllium	"	"	"	"	"	ND "	0.010	
Cadmium	"	"	"	"	"	ND "	0.010	
Chromium	"	"	"	"	"	ND "	0.050	
Cobalt	"	"	"	"	"	ND "	0.020	
Copper	"	"	"	"	"	ND "	0.10	
Lead	"	"	"	"	"	ND "	0.050	
Mercury	EPA 7470	AA32132	01/22/13 07:45	01/23/13 09:57	"	ND "	0.0010	
Molybdenum	EPA 6010	AA31121	01/11/13 11:15	01/16/13 12:40	"	ND "	0.50	
Nickel	"	"	"	"	"	ND "	0.10	
Selenium	EPA 7740	"	"	01/18/13 14:27	"	ND "	0.0050	
Silver	EPA 6010	"	"	01/16/13 12:40	"	ND "	0.010	
Thallium	"	"	"	"	"	ND "	0.40	
Vanadium	"	"	"	"	"	ND "	0.50	
Zinc	"	"	"	"	"	ND "	0.10	
Wohler Bridge Sediment (13A0470-08)		**Sample Type: Soil**			**Sampled: 01/08/13 15:17**			
Metals by EPA 6000/7000 Series Methods								
Antimony	EPA 6010	AA31109	01/14/13 11:26	01/16/13 15:14	1	ND mg/kg	15	
Arsenic	EPA 7060	"	"	01/15/13 15:49	2	**3.6 "**	**2.0**	
Barium	EPA 6010	"	"	01/16/13 15:14	1	**83 "**	**10**	
Beryllium	"	"	"	"	"	ND "	0.75	
Cadmium	"	"	"	"	"	ND "	1.0	
Chromium	"	"	"	"	"	**47 "**	**5.0**	
Cobalt	"	"	"	"	"	ND "	10	
Copper	"	"	"	"	"	**19 "**	**10**	
Lead	"	"	"	"	"	ND "	5.0	
Mercury	EPA 7471	AA31418	01/14/13 14:45	01/15/13 13:53	"	**0.37 "**	**0.20**	
Molybdenum	EPA 6010	AA31109	01/14/13 11:26	01/16/13 15:14	"	ND "	10	

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Alpha Analytical Laboratories, Inc.

	METHOD	BATCH	PREPARED	ANALYZED	DILUTION	RESULT		PQL	NOTE
Wohler Bridge Sediment (13A0470-08)			**Sample Type: Soil**			**Sampled: 01/08/13 15:17**			
Metals by EPA 6000/7000 Series Methods (cont'd)									
Nickel	EPA 6010	"	"	01/16/13 15:14	"	**87 "**		**10**	
Selenium	EPA 7740	"	"	01/16/13 11:30	"	ND "		1.0	
Silver	EPA 6010	"	"	01/16/13 15:14	"	ND "		5.0	
Thallium	"	"	"	"	"	ND "		7.0	
Vanadium	"	"	"	"	"	**23 "**		**5.0**	
Zinc	"	"	"	"	"	**33 "**		**10**	
TPH by EPA/LUFT GC/GCMS Methods									
TPH as Diesel	8015DRO	AA31431	01/14/13 11:57	01/17/13 17:42	1	**1.9 mg/kg**		**1.0**	D-18
TPH as Motor Oil	"	"	"	"	"	ND "		2.0	
Surrogate: Tetratetracontane	"	"	"	"		*88.8 %*	*60-105*		
Organochlorine Pesticides and PCBs by EPA Method 8081/8082									**R-06**
Aldrin	EPA 8081/8082	AA31527	01/15/13 10:59	01/18/13 01:17	4	ND mg/kg		0.020	
alpha-BHC	"	"	"	"	"	ND "		0.020	
beta-BHC	"	"	"	"	"	ND "		0.020	
delta-BHC	"	"	"	"	"	ND "		0.020	
gamma-BHC (Lindane)	"	"	"	"	"	ND "		0.020	
Chlordane (tech)	"	"	"	"	"	ND "		0.80	
4,4′-DDD	"	"	"	"	"	ND "		0.020	
4,4′-DDE	"	"	"	"	"	ND "		0.020	
4,4′-DDT	"	"	"	"	"	ND "		0.020	
Dieldrin	"	"	"	"	"	ND "		0.020	
Endosulfan I	"	"	"	"	"	ND "		0.020	
Endosulfan II	"	"	"	"	"	ND "		0.020	
Endosulfan sulfate	"	"	"	"	"	ND "		0.020	
Endrin	"	"	"	"	"	ND "		0.020	
Endrin aldehyde	"	"	"	"	"	ND "		0.020	
Heptachlor	"	"	"	"	"	ND "		0.020	
Heptachlor epoxide	"	"	"	"	"	ND "		0.020	
Methoxychlor	"	"	"	"	"	ND "		0.020	

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Alpha Analytical Laboratories, Inc.

	METHOD	BATCH	PREPARED	ANALYZED	DILUTION	RESULT		PQL	NOTE
Wohler Bridge Sediment (13A0470-08)			**Sample Type: Soil**			**Sampled: 01/08/13 15:17**			
Organochlorine Pesticides and PCBs by EPA Method 8081/8082 (cont'd)									**R-06**
Toxaphene	EPA 8081/8082	"	"	01/18/13 01:17	"	ND "		0.80	
Surrogate: Dibutylchlorendate	"	"	"	"		*75.6 %*	*50-120*		
Wohler Bridge Bank Soil (13A0470-09)			**Sample Type: Soil**			**Sampled: 01/08/13 15:19**			
Metals by EPA 6000/7000 Series Methods									
Antimony	EPA 6010	AA31109	01/14/13 11:26	01/16/13 15:18	1	ND mg/kg		15	
Arsenic	EPA 7060	"	"	01/15/13 15:54	2	**5.8 "**		**4.0**	
Barium	EPA 6010	"	"	01/16/13 15:18	1	**110 "**		**10**	
Beryllium	"	"	"	"	"	ND "		0.75	
Cadmium	"	"	"	"	"	ND "		1.0	
Chromium	"	"	"	"	"	**57 "**		**5.0**	
Cobalt	"	"	"	"	"	**13 "**		**10**	
Copper	"	"	"	"	"	**27 "**		**10**	
Lead	"	"	"	"	"	**7.8 "**		**5.0**	
Mercury	EPA 7471	AA31418	01/14/13 14:45	01/15/13 13:56	"	**0.38 "**		**0.20**	
Molybdenum	EPA 6010	AA31109	01/14/13 11:26	01/16/13 15:18	"	ND "		10	
Nickel	"	"	"	"	"	**110 "**		**10**	
Selenium	EPA 7740	"	"	01/16/13 11:36	"	ND "		1.0	
Silver	EPA 6010	"	"	01/16/13 15:18	"	ND "		5.0	
Thallium	"	"	"	"	"	ND "		7.0	
Vanadium	"	"	"	"	"	**27 "**		**5.0**	
Zinc	"	"	"	"	"	**41 "**		**10**	
Syar Water (13A0470-10)			**Sample Type: Water**			**Sampled: 01/08/13 16:30**			
Metals by APHA/EPA Methods									
Methyl mercury	EPA 1630	AA31543	01/14/13 14:00	01/15/13 21:37	1	**0.0943 ng/l**		**0.0500**	

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Syar Water (13A0470-10)			**Sample Type: Water**		**Sampled: 01/08/13 16:30**			
Metals by EPA 6000/7000 Series Methods								
Antimony	EPA 6010	AA31121	01/11/13 11:15	01/16/13 12:57	1	ND mg/l	0.020	
Arsenic	EPA 7060	"	"	01/17/13 19:23	"	ND "	0.0020	
Barium	EPA 6010	"	"	01/16/13 12:57	"	**0.078 "**	**0.010**	
Beryllium	"	"	"	"	"	ND "	0.010	
Cadmium	"	"	"	"	"	ND "	0.010	
Chromium	"	"	"	"	"	ND "	0.050	
Cobalt	"	"	"	"	"	ND "	0.020	
Copper	"	"	"	"	"	ND "	0.10	
Lead	"	"	"	"	"	ND "	0.050	
Mercury	EPA 7470	AA31453	01/15/13 07:10	01/16/13 11:51	"	ND "	0.0010	
Molybdenum	EPA 6010	AA31121	01/11/13 11:15	01/16/13 12:57	"	ND "	0.50	
Nickel	"	"	"	"	"	ND "	0.10	
Selenium	EPA 7740	"	"	01/18/13 15:28	"	ND "	0.0050	
Silver	EPA 6010	"	"	01/16/13 12:57	"	ND "	0.010	
Thallium	"	"	"	"	"	ND "	0.40	
Vanadium	"	"	"	"	"	ND "	0.50	
Zinc	"	"	"	"	"	ND "	0.10	
Syar Sediment (13A0470-11)			**Sample Type: Soil**		**Sampled: 01/08/13 16:32**			
Metals by EPA 6000/7000 Series Methods								
Antimony	EPA 6010	AA31109	01/14/13 11:26	01/16/13 15:22	1	ND mg/kg	15	
Arsenic	EPA 7060	"	"	01/15/13 16:10	2	**3.8 "**	**2.0**	
Barium	EPA 6010	"	"	01/16/13 15:22	1	**84 "**	**10**	
Beryllium	"	"	"	"	"	ND "	0.75	
Cadmium	"	"	"	"	"	ND "	1.0	
Chromium	"	"	"	"	"	**54 "**	**5.0**	
Cobalt	"	"	"	"	"	**11 "**	**10**	
Copper	"	"	"	"	"	**19 "**	**10**	
Lead	"	"	"	"	"	ND "	5.0	
Mercury	EPA 7471	AA31418	01/14/13 14:45	01/15/13 13:58	"	**0.25 "**	**0.20**	
Molybdenum	EPA 6010	AA31109	01/14/13 11:26	01/16/13 15:22	"	ND "	10	

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CHEMICAL EXAMINATION REPORT

National Marine Fisheries Service
777 Sonoma Avenue, Rm 325
Santa Rosa, CA 95409
Attn: Melanie Harrison

Report Date: 01/24/13 09:41
Project No: Russian River sediments and waters
Project ID: Russian River sediments and waters

Order Number	Receipt Date/Time	Client Code	Client PO/Reference
13A0470	01/09/2013 21:55	DP NMFS	

Alpha Analytical Laboratories, Inc.

	METHOD	BATCH	PREPARED	ANALYZED	DILUTION	RESULT		PQL	NOTE
Syar Sediment (13A0470-11)			**Sample Type: Soil**			**Sampled: 01/08/13 16:32**			
Metals by EPA 6000/7000 Series Methods (cont'd)									
Nickel	EPA 6010	"	"	01/16/13 15:22	"	**94 "**		**10**	
Selenium	EPA 7740	"	"	01/16/13 11:42	"	ND "		1.0	
Silver	EPA 6010	"	"	01/16/13 15:22	"	ND "		5.0	
Thallium	"	"	"	"	"	ND "		7.0	
Vanadium	"	"	"	"	"	**26 "**		**5.0**	
Zinc	"	"	"	"	"	**32 "**		**10**	
TPH by EPA/LUFT GC/GCMS Methods									
TPH as Diesel	8015DRO	AA31431	01/14/13 11:57	01/17/13 18:17	1	**2.8 mg/kg**		**1.0**	D-18
TPH as Motor Oil	"	"	"	"	"	**2.6 "**		**2.0**	D-17
Surrogate: Tetratetracontane	"	"	"	"		*86.6 %*	*60-105*		
Organochlorine Pesticides and PCBs by EPA Method 8081/8082									**R-06**
Aldrin	EPA 8081/8082	AA31527	01/15/13 10:59	01/18/13 01:52	4	ND mg/kg		0.020	
alpha-BHC	"	"	"	"	"	ND "		0.020	
beta-BHC	"	"	"	"	"	ND "		0.020	
delta-BHC	"	"	"	"	"	ND "		0.020	
gamma-BHC (Lindane)	"	"	"	"	"	ND "		0.020	
Chlordane (tech)	"	"	"	"	"	ND "		0.80	
4,4′-DDD	"	"	"	"	"	ND "		0.020	
4,4′-DDE	"	"	"	"	"	ND "		0.020	
4,4′-DDT	"	"	"	"	"	ND "		0.020	
Dieldrin	"	"	"	"	"	ND "		0.020	
Endosulfan I	"	"	"	"	"	ND "		0.020	
Endosulfan II	"	"	"	"	"	ND "		0.020	
Endosulfan sulfate	"	"	"	"	"	ND "		0.020	
Endrin	"	"	"	"	"	ND "		0.020	
Endrin aldehyde	"	"	"	"	"	ND "		0.020	
Heptachlor	"	"	"	"	"	ND "		0.020	
Heptachlor epoxide	"	"	"	"	"	ND "		0.020	
Methoxychlor	"	"	"	"	"	ND "		0.020	

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Alpha Analytical Laboratories, Inc.

	METHOD	BATCH	PREPARED	ANALYZED	DILUTION	RESULT		PQL	NOTE
Syar Sediment (13A0470-11)			**Sample Type: Soil**			**Sampled: 01/08/13 16:32**			
Organochlorine Pesticides and PCBs by EPA Method 8081/8082 (cont'd)									**R-06**
Toxaphene	EPA 8081/8082	"	"	01/18/13 01:52	"	ND "		0.80	
Surrogate: Dibutylchlorendate	*"*	*"*	*"*	*"*		*79.7 %*	*50-120*		
Syar Bank Soil (13A0470-12)			**Sample Type: Soil**			**Sampled: 01/08/13 16:40**			
Metals by EPA 6000/7000 Series Methods									
Antimony	EPA 6010	AA31109	01/14/13 11:26	01/16/13 15:26	1	ND mg/kg		15	
Arsenic	EPA 7060	"	"	01/15/13 16:16	2	**4.4 "**		**4.0**	
Barium	EPA 6010	"	"	01/16/13 15:26	1	**100 "**		**10**	
Beryllium	"	"	"	"	"	ND "		0.75	
Cadmium	"	"	"	"	"	ND "		1.0	
Chromium	"	"	"	"	"	**56 "**		**5.0**	
Cobalt	"	"	"	"	"	**11 "**		**10**	
Copper	"	"	"	"	"	**22 "**		**10**	
Lead	"	"	"	"	"	**5.5 "**		**5.0**	
Mercury	EPA 7471	AA31418	01/14/13 14:45	01/15/13 14:00	"	**0.69 "**		**0.20**	
Molybdenum	EPA 6010	AA31109	01/14/13 11:26	01/16/13 15:26	"	ND "		10	
Nickel	"	"	"	"	"	**100 "**		**10**	
Selenium	EPA 7740	"	"	01/16/13 11:48	"	ND "		1.0	
Silver	EPA 6010	"	"	01/16/13 15:26	"	ND "		5.0	
Thallium	"	"	"	"	"	ND "		7.0	
Vanadium	"	"	"	"	"	**26 "**		**5.0**	
Zinc	"	"	"	"	"	**37 "**		**10**	

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13A0470	01/09/2013 21:55	DP NMFS	

Metals by APHA/EPA Methods - Quality Control

Analyte(s)	Result	PQL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Flag
Batch AA31543 - EPA 1630										
Blank (AA31543-BLK1)				Prepared: 01/14/13 Analyzed: 01/15/13						
Methyl mercury	ND	0.0500	ng/l							
LCS (AA31543-BS1)				Prepared: 01/14/13 Analyzed: 01/15/13						
Methyl mercury	0.452	0.0500	ng/l	0.500		90.4	67-133			
Matrix Spike (AA31543-MS1)	**Source: 13A0490-02**			Prepared: 01/14/13 Analyzed: 01/15/13						
Methyl mercury	0.490	0.0500	ng/l	0.500	ND	89.5	65-135			
Matrix Spike Dup (AA31543-MSD1)	**Source: 13A0490-02**			Prepared: 01/14/13 Analyzed: 01/15/13						
Methyl mercury	0.446	0.0500	ng/l	0.500	ND	80.7	65-135	9.41	35	

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Metals by EPA 6000/7000 Series Methods - Quality Control

Analyte(s)	Result	PQL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Flag
Batch AA31109 - EPA 3051 Microwave										
Blank (AA31109-BLK1)				Prepared: 01/11/13 Analyzed: 01/14/13						
Antimony	ND	15	mg/kg							
Arsenic	ND	2.0	"							
Barium	ND	10	"							
Beryllium	ND	0.75	"							
Cadmium	ND	1.0	"							
Chromium	ND	5.0	"							
Cobalt	ND	10	"							
Copper	ND	10	"							
Lead	ND	5.0	"							
Molybdenum	ND	10	"							
Nickel	ND	10	"							
Selenium	ND	1.0	"							
Silver	ND	5.0	"							
Thallium	ND	7.0	"							
Vanadium	ND	5.0	"							
Zinc	ND	10	"							
LCS (AA31109-BS1)				Prepared: 01/11/13 Analyzed: 01/14/13						
Antimony	18.7	15	mg/kg	20.0		93.3	85-115			
Arsenic	1.94	1.0	"	2.00		96.8	80-120			
Barium	19.5	10	"	20.0		97.7	85-115			
Beryllium	19.3	0.75	"	20.0		96.3	85-115			
Cadmium	18.5	1.0	"	20.0		92.7	85-115			
Chromium	19.6	5.0	"	20.0		98.0	85-115			
Cobalt	18.9	10	"	20.0		94.4	85-115			
Copper	21.1	10	"	20.6		103	85-115			
Lead	19.3	5.0	"	20.0		96.4	85-115			

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Metals by EPA 6000/7000 Series Methods - Quality Control

Analyte(s)	Result	PQL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Flag
Batch AA31109 - EPA 3051 Microwave										
LCS (AA31109-BS1)				Prepared: 01/11/13 Analyzed: 01/14/13						
Molybdenum	19.5	10	"	20.0		97.3	85-115			
Nickel	19.5	10	"	20.0		97.3	85-115			
Selenium	1.71	1.0	"	2.00		85.6	68-118			
Silver	20.1	5.0	"	20.0		100	78-108			
Thallium	19.1	7.0	"	20.0		95.4	85-115			
Vanadium	19.0	5.0	"	20.0		94.8	85-115			
Zinc	18.8	10	"	20.0		94.2	85-115			
Duplicate (AA31109-DUP1)	Source: 13A0470-02			Prepared: 01/11/13 Analyzed: 01/14/13						
Antimony	ND	15	mg/kg		ND				20	
Arsenic	4.47	4.0	"		4.14			7.55	20	
Barium	115	10	"		106			8.34	20	
Beryllium	0.292	0.75	"		ND				20	
Cadmium	ND	1.0	"		ND				20	
Chromium	71.5	5.0	"		66.9			6.57	20	
Cobalt	12.9	10	"		12.8			0.963	20	
Copper	19.3	10	"		19.9			3.24	20	
Lead	5.36	5.0	"		5.21			2.99	20	
Molybdenum	0.695	10	"		ND				20	
Nickel	108	10	"		113			4.65	20	
Selenium	ND	1.0	"		ND				20	
Silver	ND	5.0	"		ND				20	
Thallium	ND	7.0	"		ND				20	
Vanadium	32.1	5.0	"		30.9			3.72	20	
Zinc	38.1	10	"		37.8			0.883	20	
Matrix Spike (AA31109-MS1)	Source: 13A0470-02			Prepared: 01/11/13 Analyzed: 01/14/13						

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Metals by EPA 6000/7000 Series Methods - Quality Control

Analyte(s)	Result	PQL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Flag
Batch AA31109 - EPA 3051 Microwave										
Matrix Spike (AA31109-MS1)	**Source: 13A0470-02**			Prepared: 01/11/13 Analyzed: 01/14/13						
Antimony	15.5	15	mg/kg	20.0	ND	77.6	70-130			
Arsenic	6.18	4.0	"	2.00	4.14	102	70-130			
Barium	125	10	"	20.0	106	96.8	70-130			
Beryllium	17.7	0.75	"	20.0	ND	87.1	70-130			
Cadmium	16.7	1.0	"	20.0	ND	83.5	70-130			
Chromium	89.5	5.0	"	20.0	66.9	113	70-130			
Cobalt	30.0	10	"	20.0	12.8	86.2	70-130			
Copper	38.6	10	"	20.6	19.9	90.6	70-130			
Lead	22.2	5.0	"	20.0	5.21	84.9	70-130			
Molybdenum	17.4	10	"	20.0	ND	83.6	70-130			
Nickel	132	10	"	20.0	113	92.2	70-130			
Selenium	0.820	1.0	"	2.00	ND	41.0	7-107			
Silver	17.7	5.0	"	20.0	ND	88.4	70-130			
Thallium	17.3	7.0	"	20.0	ND	86.4	70-130			
Vanadium	51.4	5.0	"	20.0	30.9	102	70-130			
Zinc	56.4	10	"	20.0	37.8	93.0	70-130			
Matrix Spike (AA31109-MS2)	**Source: 13A0608-01**			Prepared: 01/16/13 Analyzed: 01/17/13						
Antimony	13.5	15	mg/kg	20.0	ND	67.6	70-130			QM-01, QM-04
Arsenic	5.95	2.0	"	2.00	4.88	53.6	70-130			QM-01
Barium	175	10	"	20.0	170	25.9	70-130			QM-4X
Beryllium	18.5	0.75	"	20.0	ND	91.2	70-130			
Cadmium	16.9	1.0	"	20.0	ND	84.4	70-130			
Chromium	35.4	5.0	"	20.0	12.6	114	70-130			
Cobalt	24.5	10	"	20.0	ND	82.8	70-130			
Copper	42.5	10	"	20.6	20.4	107	70-130			

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Metals by EPA 6000/7000 Series Methods - Quality Control

Analyte(s)	Result	PQL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Flag
Batch AA31109 - EPA 3051 Microwave										
Matrix Spike (AA31109-MS2)	**Source: 13A0608-01**			Prepared: 01/16/13 Analyzed: 01/17/13						
Lead	23.4	5.0	"	20.0	6.17	86.2	70-130			
Molybdenum	16.6	10	"	20.0	ND	77.1	70-130			
Nickel	46.6	10	"	20.0	22.2	122	70-130			
Selenium	1.29	1.0	"	2.00	ND	64.4	7-107			
Silver	17.3	5.0	"	20.0	ND	86.6	70-130			
Thallium	18.4	7.0	"	20.0	ND	92.1	70-130			
Vanadium	52.4	5.0	"	20.0	33.7	93.5	70-130			
Zinc	48.9	10	"	20.0	24.6	121	70-130			
Matrix Spike Dup (AA31109-MSD1)	**Source: 13A0470-02**			Prepared: 01/11/13 Analyzed: 01/14/13						
Antimony	14.9	15	mg/kg	20.0	ND	74.4	70-130	4.26	20	
Arsenic	5.87	4.0	"	2.00	4.14	86.1	70-130	5.26	20	
Barium	131	10	"	20.0	106	124	70-130	4.27	20	
Beryllium	17.8	0.75	"	20.0	ND	87.6	70-130	0.518	20	
Cadmium	17.1	1.0	"	20.0	ND	85.5	70-130	2.43	20	
Chromium	85.3	5.0	"	20.0	66.9	91.7	70-130	4.76	20	
Cobalt	30.0	10	"	20.0	12.8	86.0	70-130	0.137	20	
Copper	39.3	10	"	20.6	19.9	93.9	70-130	1.75	20	
Lead	22.5	5.0	"	20.0	5.21	86.6	70-130	1.50	20	
Molybdenum	17.5	10	"	20.0	ND	84.1	70-130	0.664	20	
Nickel	129	10	"	20.0	113	77.0	70-130	2.34	20	
Selenium	0.966	1.0	"	2.00	ND	48.3	7-107	16.3	20	
Silver	18.2	5.0	"	20.0	ND	90.8	70-130	2.63	20	
Thallium	17.5	7.0	"	20.0	ND	87.5	70-130	1.26	20	
Vanadium	49.3	5.0	"	20.0	30.9	91.9	70-130	4.11	20	
Zinc	55.8	10	"	20.0	37.8	89.8	70-130	1.15	20	

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Metals by EPA 6000/7000 Series Methods - Quality Control

Analyte(s)	Result	PQL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Flag
Batch AA31121 - Metals Digest										
Blank (AA31121-BLK1)				Prepared: 01/11/13 Analyzed: 01/16/13						
Antimony	ND	0.020	mg/l							
Arsenic	ND	0.0020	"							
Barium	ND	0.010	"							
Beryllium	ND	0.010	"							
Cadmium	ND	0.010	"							
Chromium	ND	0.050	"							
Cobalt	ND	0.020	"							
Copper	ND	0.10	"							
Lead	ND	0.050	"							
Molybdenum	ND	0.50	"							
Nickel	ND	0.10	"							
Selenium	ND	0.0050	"							
Silver	ND	0.010	"							
Thallium	ND	0.40	"							
Vanadium	ND	0.50	"							
Zinc	ND	0.10	"							
LCS (AA31121-BS1)				Prepared: 01/11/13 Analyzed: 01/16/13						
Antimony	0.200	0.020	mg/l	0.200		99.8	85-115			
Arsenic	0.0189	0.0020	"	0.0200		94.6	85-115			
Barium	0.199	0.010	"	0.200		99.6	87-124			
Beryllium	0.202	0.010	"	0.200		101	85-115			
Cadmium	0.191	0.010	"	0.200		95.5	85-115			
Chromium	0.203	0.050	"	0.200		101	85-115			
Cobalt	0.192	0.020	"	0.200		95.9	85-115			
Copper	0.215	0.10	"	0.206		104	85-115			
Lead	0.201	0.050	"	0.200		100	85-115			

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CHEMICAL EXAMINATION REPORT

National Marine Fisheries Service
777 Sonoma Avenue, Rm 325
Santa Rosa, CA 95409
Attn: Melanie Harrison

Report Date: 01/24/13 09:41
Project No: Russian River sediments and waters
Project ID: Russian River sediments and waters

Order Number	Receipt Date/Time	Client Code	Client PO/Reference
13A0470	01/09/2013 21:55	DP NMFS	

Metals by EPA 6000/7000 Series Methods - Quality Control

Analyte(s)	Result	PQL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Flag
Batch AA31121 - Metals Digest										
LCS (AA31121-BS1)				Prepared: 01/11/13 Analyzed: 01/16/13						
Molybdenum	0.200	0.50	"	0.200		100	85-115			
Nickel	0.197	0.10	"	0.200		98.6	85-115			
Selenium	0.0211	0.0050	"	0.0200		105	64-120			
Silver	0.200	0.010	"	0.200		99.8	85-115			
Thallium	0.197	0.40	"	0.200		98.7	85-115			
Vanadium	0.192	0.50	"	0.200		95.9	85-115			
Zinc	0.197	0.10	"	0.200		98.7	85-115			
Duplicate (AA31121-DUP1)		Source: 13A0470-07		Prepared: 01/11/13 Analyzed: 01/17/13						
Arsenic	ND	0.0020	mg/l		ND				20	
Selenium	ND	0.0050	"		ND				20	
Matrix Spike (AA31121-MS1)		Source: 13A0470-07		Prepared: 01/11/13 Analyzed: 01/16/13						
Antimony	0.199	0.020	mg/l	0.200	ND	99.3	70-130			
Arsenic	0.0203	0.0020	"	0.0200	ND	96.6	70-130			
Barium	0.273	0.010	"	0.200	0.0853	93.8	70-130			
Beryllium	0.196	0.010	"	0.200	ND	98.1	70-130			
Cadmium	0.183	0.010	"	0.200	ND	91.7	70-130			
Chromium	0.202	0.050	"	0.200	ND	97.0	70-130			
Cobalt	0.187	0.020	"	0.200	ND	92.5	70-130			
Copper	0.230	0.10	"	0.206	ND	108	70-130			
Lead	0.192	0.050	"	0.200	ND	96.2	70-130			
Molybdenum	0.195	0.50	"	0.200	ND	96.3	70-130			
Nickel	0.204	0.10	"	0.200	ND	97.0	70-130			
Selenium	0.0199	0.0050	"	0.0200	ND	99.6	21-132			
Silver	0.195	0.010	"	0.200	ND	97.6	70-130			
Thallium	0.196	0.40	"	0.200	ND	97.8	70-130			

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Metals by EPA 6000/7000 Series Methods - Quality Control

Analyte(s)	Result	PQL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Flag
Batch AA31121 - Metals Digest										
Matrix Spike (AA31121-MS1)	**Source: 13A0470-07**			Prepared: 01/11/13 Analyzed: 01/16/13						
Vanadium	0.186	0.50	"	0.200	ND	90.7	70-130			
Zinc	0.192	0.10	"	0.200	ND	95.9	70-130			
Matrix Spike (AA31121-MS2)	**Source: 13A0512-03**			Prepared: 01/11/13 Analyzed: 01/16/13						
Antimony	0.196	0.020	mg/l	0.200	ND	98.1	70-130			
Arsenic	0.0228	0.0020	"	0.0200	ND	114	70-130			
Barium	0.202	0.010	"	0.200	ND	98.8	70-130			
Beryllium	0.200	0.010	"	0.200	ND	99.8	70-130			
Cadmium	0.189	0.010	"	0.200	ND	94.3	70-130			
Chromium	0.199	0.050	"	0.200	ND	98.8	70-130			
Cobalt	0.192	0.020	"	0.200	ND	96.0	70-130			
Copper	0.239	0.10	"	0.206	ND	110	70-130			
Lead	0.195	0.050	"	0.200	ND	97.5	70-130			
Molybdenum	0.196	0.50	"	0.200	ND	98.1	70-130			
Nickel	0.199	0.10	"	0.200	ND	99.5	70-130			
Selenium	0.0243	0.0050	"	0.0200	ND	121	21-132			
Silver	0.194	0.010	"	0.200	ND	97.2	70-130			
Thallium	0.197	0.40	"	0.200	ND	98.3	70-130			
Vanadium	0.190	0.50	"	0.200	ND	95.2	70-130			
Zinc	0.200	0.10	"	0.200	ND	99.9	70-130			
Matrix Spike Dup (AA31121-MSD1)	**Source: 13A0470-07**			Prepared: 01/11/13 Analyzed: 01/16/13						
Antimony	0.192	0.020	mg/l	0.200	ND	95.8	70-130	3.60	20	
Arsenic	0.0207	0.0020	"	0.0200	ND	98.7	70-130	1.99	20	
Barium	0.270	0.010	"	0.200	0.0853	92.2	70-130	1.11	20	
Beryllium	0.199	0.010	"	0.200	ND	99.3	70-130	1.19	20	
Cadmium	0.181	0.010	"	0.200	ND	90.6	70-130	1.14	20	

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Metals by EPA 6000/7000 Series Methods - Quality Control

Analyte(s)	Result	PQL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Flag
Batch AA31121 - Metals Digest										
Matrix Spike Dup (AA31121-MSD1)	**Source: 13A0470-07**			Prepared: 01/11/13 Analyzed: 01/16/13						
Chromium	0.198	0.050	"	0.200	ND	95.3	70-130	1.69	20	
Cobalt	0.184	0.020	"	0.200	ND	91.4	70-130	1.22	20	
Copper	0.223	0.10	"	0.206	ND	105	70-130	2.89	20	
Lead	0.191	0.050	"	0.200	ND	95.3	70-130	0.925	20	
Molybdenum	0.194	0.50	"	0.200	ND	95.7	70-130	0.531	20	
Nickel	0.198	0.10	"	0.200	ND	93.7	70-130	3.23	20	
Selenium	0.0228	0.0050	"	0.0200	ND	114	21-132	13.4	20	
Silver	0.189	0.010	"	0.200	ND	94.5	70-130	3.27	20	
Thallium	0.195	0.40	"	0.200	ND	97.3	70-130	0.476	20	
Vanadium	0.186	0.50	"	0.200	ND	90.4	70-130	0.351	20	
Zinc	0.189	0.10	"	0.200	ND	94.4	70-130	1.65	20	
Batch AA31418 - EPA 7471A Hg Soil										
Blank (AA31418-BLK1)				Prepared: 01/14/13 Analyzed: 01/15/13						
Mercury	ND	0.20	mg/kg							
LCS (AA31418-BS1)				Prepared: 01/14/13 Analyzed: 01/15/13						
Mercury	0.965	0.20	mg/kg	1.00		96.5	80-120			
Duplicate (AA31418-DUP1)	**Source: 13A0470-02**			Prepared: 01/14/13 Analyzed: 01/15/13						
Mercury	1.36	0.20	mg/kg		1.30			5.26	20	
Matrix Spike (AA31418-MS1)	**Source: 13A0470-02**			Prepared: 01/14/13 Analyzed: 01/15/13						
Mercury	2.43	0.40	mg/kg	1.00	1.30	114	60-140			
Matrix Spike Dup (AA31418-MSD1)	**Source: 13A0470-02**			Prepared: 01/14/13 Analyzed: 01/15/13						
Mercury	2.41	0.40	mg/kg	1.00	1.30	112	60-140	0.826	20	

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Metals by EPA 6000/7000 Series Methods - Quality Control

Analyte(s)	Result	PQL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Flag
Batch AA31453 - EPA 7470A										
Blank (AA31453-BLK1)				Prepared: 01/15/13 Analyzed: 01/16/13						
Mercury	ND	0.0010	mg/l							
LCS (AA31453-BS1)				Prepared: 01/15/13 Analyzed: 01/16/13						
Mercury	0.00277	0.0010	mg/l	0.00250		111	80-120			
Duplicate (AA31453-DUP1)	Source: 13A0356-01			Prepared: 01/15/13 Analyzed: 01/16/13						
Mercury	ND	0.0010	mg/l		ND				20	
Matrix Spike (AA31453-MS1)	Source: 13A0356-01			Prepared: 01/15/13 Analyzed: 01/16/13						
Mercury	0.00233	0.0010	mg/l	0.00250	ND	93.2	60-140			
Matrix Spike Dup (AA31453-MSD1)	Source: 13A0356-01			Prepared: 01/15/13 Analyzed: 01/16/13						
Mercury	0.00239	0.0010	mg/l	0.00250	ND	95.6	60-140	2.54	20	
Batch AA32132 - EPA 7470A										
Blank (AA32132-BLK1)				Prepared: 01/22/13 Analyzed: 01/23/13						
Mercury	ND	0.0010	mg/l							
LCS (AA32132-BS1)				Prepared: 01/22/13 Analyzed: 01/23/13						
Mercury	0.00228	0.0010	mg/l	0.00250		91.2	80-120			
Duplicate (AA32132-DUP1)	Source: 13A0470-07			Prepared: 01/22/13 Analyzed: 01/23/13						
Mercury	ND	0.0010	mg/l		ND				20	
Matrix Spike (AA32132-MS1)	Source: 13A0470-07			Prepared: 01/22/13 Analyzed: 01/23/13						
Mercury	0.00246	0.0010	mg/l	0.00250	ND	98.4	60-140			

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Metals by EPA 6000/7000 Series Methods - Quality Control

Analyte(s)	Result	PQL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Flag
Batch AA32132 - EPA 7470A										
Matrix Spike Dup (AA32132-MSD1)	**Source: 13A0470-07**			Prepared: 01/22/13 Analyzed: 01/23/13						
Mercury	0.00233	0.0010	mg/l	0.00250	ND	93.2	60-140	5.43	20	

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alpha
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TPH by EPA/LUFT GC/GCMS Methods - Quality Control

Analyte(s)	Result	PQL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Flag
Batch AA31431 - CA LUFT - orb shaker										
Blank (AA31431-BLK1)				Prepared: 01/14/13 Analyzed: 01/17/13						
TPH as Diesel	ND	1.0	mg/kg							
TPH as Motor Oil	ND	2.0	"							
Surrogate: Tetratetracontane	*0.915*		"	*1.12*		*81.5*	*60-105*			
LCS (AA31431-BS1)				Prepared: 01/14/13 Analyzed: 01/17/13						
TPH as Diesel	34.8	1.0	mg/kg	41.0		84.8	65-95			
Surrogate: Tetratetracontane	*0.921*		"	*1.12*		*82.1*	*60-105*			
LCS (AA31431-BS2)				Prepared: 01/14/13 Analyzed: 01/17/13						
TPH as Motor Oil	37.8	2.0	mg/kg	42.7		88.4	75-110			
Surrogate: Tetratetracontane	*0.903*		"	*1.12*		*80.4*	*60-105*			
LCS Dup (AA31431-BSD1)				Prepared: 01/14/13 Analyzed: 01/17/13						
TPH as Diesel	33.6	1.0	mg/kg	41.0		81.9	65-95	3.43	25	
Surrogate: Tetratetracontane	*0.724*		"	*1.12*		*64.5*	*60-105*			
LCS Dup (AA31431-BSD2)				Prepared: 01/14/13 Analyzed: 01/17/13						
TPH as Motor Oil	38.6	2.0	mg/kg	42.7		90.3	75-110	2.09	25	
Surrogate: Tetratetracontane	*0.913*		"	*1.12*		*81.3*	*60-105*			
Matrix Spike (AA31431-MS1)	**Source: 13A0470-02**			Prepared: 01/14/13 Analyzed: 01/17/13						
TPH as Diesel	32.3	1.0	mg/kg	41.0	1.89	74.1	65-95			
Surrogate: Tetratetracontane	*0.801*		"	*1.12*		*71.3*	*60-105*			
Matrix Spike Dup (AA31431-MSD1)	**Source: 13A0470-02**			Prepared: 01/14/13 Analyzed: 01/17/13						
TPH as Diesel	35.3	1.0	mg/kg	41.0	1.89	81.6	65-95	9.05	25	

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TPH by EPA/LUFT GC/GCMS Methods - Quality Control

Analyte(s)	Result	PQL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Flag
Batch AA31431 - CA LUFT - orb shaker										
Matrix Spike Dup (AA31431-MSD1)	**Source: 13A0470-02**			Prepared: 01/14/13 Analyzed: 01/17/13						
Surrogate: Tetratetracontane	*0.771*		"	*1.12*		*68.6*	*60-105*			

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Organochlorine Pesticides and PCBs by EPA Method 8081/8082 - Quality Control

Analyte(s)	Result	PQL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Flag
Batch AA31527 - EPA 3540C Soxhlet										
Blank (AA31527-BLK1)				Prepared: 01/15/13 Analyzed: 01/17/13						
Aldrin	ND	0.0050	mg/kg							
alpha-BHC	ND	0.0050	"							
beta-BHC	ND	0.0050	"							
delta-BHC	ND	0.0050	"							
gamma-BHC (Lindane)	ND	0.0050	"							
Chlordane (tech)	ND	0.20	"							
4,4′-DDE	ND	0.0050	"							
4,4′-DDD	ND	0.0050	"							
4,4′-DDT	ND	0.0050	"							
Dieldrin	ND	0.0050	"							
Endosulfan I	ND	0.0050	"							
Endosulfan II	ND	0.0050	"							
Endosulfan sulfate	ND	0.0050	"							
Endrin	ND	0.0050	"							
Endrin aldehyde	ND	0.0050	"							
Heptachlor	ND	0.0050	"							
Heptachlor epoxide	ND	0.0050	"							
Methoxychlor	ND	0.0050	"							
Toxaphene	ND	0.20	"							
Surrogate: Dibutylchlorendate	*0.0339*		"	*0.0392*		*86.5*	*50-120*			
LCS (AA31527-BS1)				Prepared: 01/15/13 Analyzed: 01/17/13						
Aldrin	0.00966	0.0050	mg/kg	0.0120		80.5	30-143			
alpha-BHC	0.00978	0.0050	"	0.0120		81.5	18-155			
beta-BHC	0.0107	0.0050	"	0.0120		89.2	25-190			
delta-BHC	0.0157	0.0050	"	0.0120		130	33-157			

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Organochlorine Pesticides and PCBs by EPA Method 8081/8082 - Quality Control

Analyte(s)	Result	PQL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Flag
Batch AA31527 - EPA 3540C Soxhlet										
LCS (AA31527-BS1)				Prepared: 01/15/13 Analyzed: 01/17/13						
gamma-BHC (Lindane)	0.0102	0.0050	"	0.0120		85.3	33-134			
4,4′-DDE	0.0106	0.0050	"	0.0120		88.6	39-146			
4,4′-DDD	0.0110	0.0050	"	0.0120		91.8	41-139			
4,4′-DDT	0.0111	0.0050	"	0.0120		92.2	42-146			
Dieldrin	0.0101	0.0050	"	0.0120		84.1	39-138			
Endosulfan I	0.0102	0.0050	"	0.0120		85.2	39-146			
Endosulfan II	0.0102	0.0050	"	0.0120		85.2	43-142			
Endosulfan sulfate	0.0103	0.0050	"	0.0120		86.1	45-148			
Endrin	0.0109	0.0050	"	0.0120		90.5	41-164			
Endrin aldehyde	0.00732	0.0050	"	0.0120		61.0	16-166			
Heptachlor	0.00966	0.0050	"	0.0120		80.5	33-148			
Heptachlor epoxide	0.0103	0.0050	"	0.0120		85.9	37-142			
Methoxychlor	0.0127	0.0050	"	0.0120		106	36-148			
Surrogate: Dibutylchlorendate	*0.0289*		"	*0.0392*		*73.8*	*50-120*			
LCS Dup (AA31527-BSD1)				Prepared: 01/15/13 Analyzed: 01/17/13						
Aldrin	0.0103	0.0050	mg/kg	0.0120		85.6	30-143	6.12	30	
alpha-BHC	0.0106	0.0050	"	0.0120		88.4	18-155	8.15	32	
beta-BHC	0.0113	0.0050	"	0.0120		94.5	25-190	5.79	47	
delta-BHC	0.0154	0.0050	"	0.0120		129	33-157	1.35	64	
gamma-BHC (Lindane)	0.0110	0.0050	"	0.0120		91.5	33-134	6.93	30	
4,4′-DDD	0.0123	0.0050	"	0.0120		102	41-139	10.8	43	
4,4′-DDE	0.0114	0.0050	"	0.0120		94.9	39-146	6.93	30	
4,4′-DDT	0.0119	0.0050	"	0.0120		98.8	42-146	6.87	31	
Dieldrin	0.0109	0.0050	"	0.0120		90.6	39-138	7.39	30	
Endosulfan I	0.0109	0.0050	"	0.0120		90.6	39-146	6.13	30	

Bruce Gove
Laboratory Director

1/24/2013

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CHEMICAL EXAMINATION REPORT

National Marine Fisheries Service
777 Sonoma Avenue, Rm 325
Santa Rosa, CA 95409
Attn: Melanie Harrison

Report Date: 01/24/13 09:41
Project No: Russian River sediments and waters
Project ID: Russian River sediments and waters

Order Number	Receipt Date/Time	Client Code	Client PO/Reference
13A0470	01/09/2013 21:55	DP NMFS	

Organochlorine Pesticides and PCBs by EPA Method 8081/8082 - Quality Control

Analyte(s)	Result	PQL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Flag
Batch AA31527 - EPA 3540C Soxhlet										
LCS Dup (AA31527-BSD1)				Prepared: 01/15/13 Analyzed: 01/17/13						
Endosulfan II	0.0108	0.0050	"	0.0120		89.9	43-142	5.44	30	
Endosulfan sulfate	0.0112	0.0050	"	0.0120		93.2	45-148	7.99	30	
Endrin	0.0120	0.0050	"	0.0120		100	41-164	10.1	38	
Endrin aldehyde	0.00704	0.0050	"	0.0120		58.7	16-166	3.92	49	
Heptachlor	0.0105	0.0050	"	0.0120		87.6	33-148	8.42	44	
Heptachlor epoxide	0.0110	0.0050	"	0.0120		91.3	37-142	6.05	34	
Methoxychlor	0.0139	0.0050	"	0.0120		116	36-148	8.92	30	
Surrogate: Dibutylchlorendate	*0.0311*		"	*0.0392*		*79.4*	*50-120*			
Matrix Spike (AA31527-MS1)		**Source: 13A0470-02**		Prepared: 01/15/13 Analyzed: 01/18/13						
Aldrin	0.0111	0.0050	mg/kg	0.0120	ND	92.7	51-122			
alpha-BHC	0.00909	0.0050	"	0.0120	ND	75.7	54-116			
beta-BHC	0.00980	0.0050	"	0.0120	ND	81.7	27-193			
delta-BHC	0.0157	0.0050	"	0.0120	ND	131	64-141			
gamma-BHC (Lindane)	0.00958	0.0050	"	0.0120	ND	79.9	55-121			
4,4′-DDE	0.0123	0.0050	"	0.0120	ND	103	57-128			
4,4′-DDD	0.0124	0.0050	"	0.0120	ND	104	46-144			
4,4′-DDT	0.0136	0.0050	"	0.0120	ND	113	44-154			
Dieldrin	0.0112	0.0050	"	0.0120	ND	93.3	58-124			
Endosulfan I	0.0113	0.0050	"	0.0120	ND	94.4	58-125			
Endosulfan II	0.0112	0.0050	"	0.0120	ND	93.2	51-139			
Endosulfan sulfate	0.0115	0.0050	"	0.0120	ND	96.2	51-138			
Endrin	0.0118	0.0050	"	0.0120	ND	98.7	55-158			
Endrin aldehyde	0.00780	0.0050	"	0.0120	ND	65.0	34-146			
Heptachlor	0.0130	0.0050	"	0.0120	ND	109	42-150			
Heptachlor epoxide	0.0113	0.0050	"	0.0120	ND	94.4	53-120			

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Organochlorine Pesticides and PCBs by EPA Method 8081/8082 - Quality Control

Analyte(s)	Result	PQL	Units	Spike Level	Source Result	%REC	%REC Limits	RPD	RPD Limit	Flag
Batch AA31527 - EPA 3540C Soxhlet										
Matrix Spike (AA31527-MS1)		**Source: 13A0470-02**		Prepared: 01/15/13 Analyzed: 01/18/13						
Methoxychlor	0.0154	0.0050	"	0.0120	ND	128	41-157			
Surrogate: Dibutylchlorendate	*0.0345*		"	*0.0392*		*88.0*	*50-120*			
Matrix Spike Dup (AA31527-MSD1)		**Source: 13A0470-02**		Prepared: 01/15/13 Analyzed: 01/18/13						
Aldrin	0.0105	0.0050	mg/kg	0.0120	ND	87.3	51-122	6.00	30	
alpha-BHC	0.00950	0.0050	"	0.0120	ND	79.2	54-116	4.46	32	
beta-BHC	0.00977	0.0050	"	0.0120	ND	81.4	27-193	0.329	47	
delta-BHC	0.0152	0.0050	"	0.0120	ND	126	64-141	3.17	64	
gamma-BHC (Lindane)	0.0102	0.0050	"	0.0120	ND	84.9	55-121	6.07	22	
4,4´-DDD	0.0135	0.0050	"	0.0120	ND	112	46-144	7.87	43	
4,4´-DDE	0.0120	0.0050	"	0.0120	ND	100	57-128	2.37	22	
4,4´-DDT	0.0133	0.0050	"	0.0120	ND	111	44-154	2.60	31	
Dieldrin	0.0107	0.0050	"	0.0120	ND	89.1	58-124	4.53	30	
Endosulfan I	0.0109	0.0050	"	0.0120	ND	90.6	58-125	4.12	26	
Endosulfan II	0.0102	0.0050	"	0.0120	ND	84.7	51-139	9.60	30	
Endosulfan sulfate	0.0104	0.0050	"	0.0120	ND	86.9	51-138	10.2	29	
Endrin	0.0116	0.0050	"	0.0120	ND	96.2	55-158	2.56	38	
Endrin aldehyde	0.00843	0.0050	"	0.0120	ND	70.3	34-146	7.78	49	
Heptachlor	0.0123	0.0050	"	0.0120	ND	102	42-150	5.77	44	
Heptachlor epoxide	0.0114	0.0050	"	0.0120	ND	95.2	53-120	0.843	34	
Methoxychlor	0.0126	0.0050	"	0.0120	ND	105	41-157	19.5	30	
Surrogate: Dibutylchlorendate	*0.0329*		"	*0.0392*		*83.9*	*50-120*			

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1/24/2013

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CHEMICAL EXAMINATION REPORT

National Marine Fisheries Service
777 Sonoma Avenue, Rm 325
Santa Rosa, CA 95409
Attn: Melanie Harrison

Report Date: 01/24/13 09:41
Project No: Russian River sediments and waters
Project ID: Russian River sediments and waters

Order Number	Receipt Date/Time	Client Code	Client PO/Reference
13A0470	01/09/2013 21:55	DP NMFS	

Notes and Definitions

D-17	The sample chromatographic pattern does not resemble the motor oil standard used for calibration.
D-18	The sample chromatographic pattern does not resemble the diesel standard used for calibration.
QM-01	The spike recovery for this QC sample is outside of established control limits possibly due to a sample matrix interference.
QM-04	High RPD and/or poor percent recovery may reflect sample non-homogeneity.
QM-4X	The spike recovery was outside of QC acceptance limits for the MS and/or MSD due to analyte concentration at 4 times or greater the spike concentration. The QC batch was accepted based on LCS and/or LCSD recoveries within the acceptance limits.
R-06	The Reporting Limits for this analysis have been raised to account for matrix interference.
DET	Analyte DETECTED
ND	Analyte NOT DETECTED at or above the reporting limit
NR	Not Reported
dry	Sample results reported on a dry weight basis
RPD	Relative Percent Difference
PQL	Practical Quantitation Limit

Bruce Gove
Laboratory Director

1/24/2013

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Chain of Custody Record

Lab No. 13A0470

Report to:	Invoice to (if different):	Project Info for Report:
Company: National Marine Fisheries Service	Company: Sonoma Co. Permit & Resource	Project ID: Russian River sediments and waters
Attn: Melanie Harrison	Attn: Amy Lyle	
Address: 777 Sonoma Ave, Rm 325, Santa Rosa CA 95409	Address: 2550 Ventura Ave, Santa Rosa CA 95403	Project No:
Phone/Fax: 707.575.1253 / 707.578.3435	Phone/Fax: 707.565.7389 / 707.565.1103	PO/Reference :
Email Address: melanie.harrison@noaa.gov	Email Address: amy.lyle@sonoma-county.org	

Samplers Signature:

Print:

Signature below authorizes work under terms stated on reverse side.

Sample Identification	Sampled: Date	Sampled: Time	Container: 40ml VOA	Poly	Amber glass	8oz jar	Metal core	Preservative: HCL	HNO3	H2SO4	Other	None	Matrix: Water	Sediment	Soil	Total Number of Containers	CAM 17 metals TTLC water	DU - Methyl Hg	8081 OC Pesticides	CAM 17 metals TTLC soil	TPH - D/MO	handling and disposal	Sample Notes or CDPH Source Numbers
Alexander Bridge water				x	x			x	x				x			2	x	x				x	
Alexander Bridge sediment						x						x		x		2			x	x	x	x	Sample time & Date
Alexander Bridge bank soil						x						x			x	1				x		x	See Attachment
Adj to Richardson Pond water				x	x			x	x				x			2	x	x				x	Per Client SB
Adj to Richardson Pond sediment						x						x		x		2			x	x	x	x	1-15-13
Adj to Richardson Pond bank soil						x						x			x	1				x		x	
Wohler Bridge water				x	x			x	x				x			2	x	x				x	
Wohler Bridge sediment						x						x		x		2			x	x	x	x	
Wohler Bridge bank soil						x						x			x	1				x		x	
(see next page)																							

TAT: 10 days ● ; RUSH: 5 days ○ ; 48 hours ○ ; Other: ___ days ○

Lab Approval Required For Rush TATs

Sample Notes (lab use only): Temperature: 3 deg. C; Shipment Method: ; Custody Seals: Y / N

Relinquished by:	Received by:	Date:	Time:
Melanie W Harrison	F Amaro	1-9-13	13:50
Rivera	[illegible]	1-9-13	2155

CDPH Write On EDT Transmission? ○ Yes ● No

State System Number: ______

If "Y" please enter the Source Number(s) in the column above

CA Geotracker EDF Report? ○ Yes ● No

Global ID: Sampling Company Log Code:

EDF to (Email Address):

Travel and Site Time | Mileage | Misc. Supplies

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Chain of Custody Record

Reports and Invoices will be delivered by email in pdf format

Lab No. 13A0420

Report to:	Invoice to (if different):	Project Info for Report:
Company: National Marine Fisheries Service	Company: Sonoma Co. Permit & Resource	Project ID: Russian River sediments and waters
Attn: Melanie Harrison	Attn: Amy Lyle	
Address: 777 Sonoma Ave, Rm 325, Santa Rosa CA 95409	Address: 2550 Ventura Ave, Santa Rosa CA 95403	Project No:
Phone/Fax: 707.575.1253 / 707.578.3435	Phone/Fax: 707.565.7389 / 707.565.1103	PO/Reference:
Email Address: melanie.harrison@noaa.gov	Email Address: amy.lyle@sonoma-county.org	

Samplers Signature:

Print:

Signature below authorizes work under terms stated on reverse side.

Sample Identification	Sampled: Date	Sampled: Time	Container: 40ml VOA	Poly	Amber glass	8oz jar	Metal core	Preservative: HCL	HNO3	H2SO4	Other	None	Matrix: Water	Sediment	Soil	Total Number of Containers	Analyses Requested: CAM 17 metals TTLC water	DU - Methyl Hg	8081 OC Pesticides	CAM 17 metals TTLC soil	TPH - D/MO	handling and disposal	Sample Notes or CDPH Source Numbers:
Syar water				x	x			x	x				x			2	x	x				x	
Syar sediment						x						x		x		2			x	x	x	x	
Syar bank soil						x						x			x	1				x		x	

TAT: 10 days ● ; RUSH: 5 days ○ ; 48 hours ○ ; Other: ___ days ○

Lab Approval Required For Rush TATs

Sample Notes (lab use only): Temperature: 3 deg. C; Shipment Method: ; Custody Seals: Y / N

Relinquished by:	Received by:	Date:	Time:
Melanie W. H[illegible]	Ray [illegible]	1-9-13	13:50
[illegible]	LAB R. [illegible]	1-9-13	2155

CDPH Write On EDT Transmission? ○ Yes ● No

State System Number: ______

If "Y" please enter the Source Number(s) in the column above

CA Geotracker EDF Report? ○ Yes ● No

Global ID: Sampling Company Log Code:

EDF to (Email Address):

Travel and Site Time | Mileage: | Misc. Supplies:

Site	Date	Time
Alexander Bridge water	1/8/2013	5:00pm
Alexander Bridge sediment	1/8/2013	5:15pm
Alexander Bridge bank soil	1/8/2013	5:30pm
Adjacent to Richardson water	1/8/2013	3:40pm
Adjacent to Richardson pond sediment	1/8/2013	3:45pm
Adjacent to Richardson pond bank soil	1/8/2013	3:47pm
Wohler Bridge water	1/8/2013	3:15pm
Wohler Bridge soil	1/8/2013	3:17pm
Wohler Bridge bank soil	1/8/2013	3:19pm
Syar pond water	1/8/2013	4:30pm
Syar pond sediment	1/8/2013	4:32pm
Syar pond bank soil	1/8/2013	4:40pm