Hanson Ponds Russian River Floodplain Restoration Project

30% Basis of Design Report
February 2, 2021

Endangered Habitats Conservancy,
California Coastal Conservancy, and
Resources Legacy Fund

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1. INTRODUCTION

1.1 Background

The primary purpose of the Hanson Russian River Floodplain Restoration Project (HFRP) is to re-establish functional riparian floodplain and thereby enhance the Russian River's native ecosystems. The project will restore seasonal wetland floodplain ecotones, floodplain connectivity, and the riparian corridor, providing valuable habitat for fish and wildlife. Floodplain restoration increases the floodplain volume, which improves groundwater recharge and water quality. Typically, heavily vegetated floodplains reduce Russian River streamflow velocities and peak flood water surface elevations in the project area. Development of the project to date is documented in the *Hanson Russian River Ponds Floodplain Restoration: Feasibility Study and Conceptual Design* (Feasibility Study, EHC 2016).

The project area as defined in the Feasibility Study consists of the primary 358-acre Hanson Aggregates parcel and other privately owned parcels. The Hanson Aggregates parcels are comprised of four remnant gravel mining ponds on the east bank of the Russian River. The other privately owned parcels located in the project area are tabulated in subsequent sections of this report.

As described in the Feasibility Study, every major drainage in the Russian River watershed has been significantly modified for land development and/or flood control purposes. Gravel mining ponds excavated in the leveed and disconnected floodplains comprise over 800 acres of floodplain through the Middle Reach of the Russian River. 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 Russian River watershed today. The region-wide loss of seasonally inundated floodplains and elimination of associated seasonal and perennial off-channel habitat features have contributed significantly to the decline of Russian River salmonid populations. Available floodplain habitat for Coho Salmon (*Oncorhynchus kisutch*) and Steelhead (*O. mykiss*) is reported to be at an historical low.

Compounding the loss of floodplain habitat, the mining ponds function as biological sinks for native juvenile fish stranded after high flow events. Non-native predatory fish species thrive in the calm, warm waters of the gravel ponds, and eat the trapped native fish. The gravel ponds also promote biogeochemical processes that cycle and accumulate metals and nutrients (e.g., mercury and phosphorous) which raise water quality concerns. Further compounding these detrimental ecological impacts, the levees and infrastructure associated with these deep gravel ponds are unstable and costly to maintain.

The current post-mining Hanson Ponds are typical of the reclamation strategy permitted under the California Surface Mining and Reclamation Act (SMARA). For off-channel mining operations, reclamation plans typically utilize levees to maintain separation from the main river channel and adjacent ponds on the historical floodplain. Separation from the main stem Russian River was required during mine operation to protect water quality. Suspended sediment concentration (turbidity) is typically high in reclamation ponds. If mobilized, the turbid water can significantly degrade water quality and can have long-term detrimental impacts to federally-listed salmonids –

native Coho Salmon, Chinook Salmon (*O. tshawytscha*), and Steelhead. The project proposes to eliminate the ponds and associated riverbank revetment and internal mine drainage infrastructure. As a result, existing mine closure plans will be amended to reflect infrastructure removal in lieu of in-place stabilization and maintenance.

The project seeks to improve ecological outcomes beyond reclamation site closure requirements under SMARA. If successful, the project will help guide similar efforts elsewhere along the Russian River. In order to restore the Russian River floodplain the project proposes to fill the reclamation ponds and remove internal levees, roads and mining infrastructure. The floodplain will be reconfigured to re-establish the natural floodplain topography, and remove the western revetment. The project will enhance connectivity between the river and floodplain restoring riverine processes to benefit a variety of native aquatic and terrestrial species.

The Feasibility Study confirmed overall project feasibility, and garnered support from local stakeholders, including natural resource and regulatory agencies. The Feasibility Study compared conceptual design alternatives, arriving at a preferred alternative (Scenario II-E) to integrate mine closure with floodplain restoration. The project design fills the four mining ponds by redistributing on-site soils. Via grading and revegetation, it restores a broad seasonally inundated river floodplain, and retains public access via a high eastern riverbank terrace.

Removing the riverbank levee will restore the natural seasonal connection between the river and its floodplain. This earthwork, the re-establishment of native vegetation communities and dynamic geomorphic processes will facilitate the establishment of habitats that meet the life history requirements and promote the genetic diversity of federally-listed anadromous fish species. Other at-risk species that will likely benefit from the restoration are native Russian River Tule Perch (*Hysterocarpus traskii pomo*), Western Pond Turtle (*Actinemys 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 design incorporates floodplain channels intended to enhance river floodplain connectivity, support floodplain conveyance and flood recession, and promote natural fluvial processes. Floodplain grading and revegetation provides seasonally appropriate hydraulic connections and will support habitat for multiple life history stages of juvenile salmonids. The integration of the off-channel habitats, seasonally inundated floodplain wetlands and native riparian vegetation communities will begin to reverse the losses of critical ecosystem functions now widespread in the Russian River Basin. The project will 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. Additionally, the project includes public access amenities consistent with the floodplain restoration that will incorporate recreational opportunities designed by Sonoma County Parks including parking, day uses, boat launch, and campground facilities.

1.2 Location

The HFRP is located within the Middle Reach of the Russian River, west of the Town of Windsor, Sonoma County, California (see Appendix A, Figure 1 – Project Location). The HFRP site is on the east bank of the Russian River, between the confluences of Dry Creek (north) and Mark West Creek (south). The four ponds are located within the 358-acre Hanson Aggregates parcels. See Appendix

A, Figure 2 – Project Area for additional parcels and ownerships bisected by the project. Access to the site is via Eastside Road.

1.3 Project Partners and Stakeholders

Project partners actively engaged in the HFRP include the property owner, Hanson Aggregates Mid-Pacific, Inc., the Endangered Habitats Conservancy, California State Coastal Conservancy, National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS), Permit Sonoma, Sonoma County Regional Parks, Town of Windsor, Sonoma Water, and Russian River Keeper. NOAA scientists led the development of the Feasibility Study, and were supported by U.S. Geological Survey (USGS) hydraulic engineers. Restoration design review, permitting guidance and grant funding is currently provided by the California Department of Fish and Wildlife (CDFW).

The development of the Feasibility Study was also supported by a Scientific Working Group including top scientists from diverse disciplines. Scientists were engaged to define and reconcile science-based restoration goals and objectives, review design alternatives considered in the Feasibility Study, and inform the preferred design alternative. Work completed by the Scientific Working Group and project partners was reviewed by a peer review panel of leading scientists with expertise in riverine and fisheries restoration. These contributions have been integrated into the 30% design.

A Partners Planning Group was developed for the project to keep resource agencies and conservation organization partners informed, solicit technical guidance and design review, and assist with outreach. A partial list of stakeholders includes adjacent and nearby landowners, Sonoma County Farm Bureau, Lytton Tribe, West Side Association to Save Agriculture (WASA), 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. During development of the Feasibility Study, 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.

2. PROJECT GOALS AND OBJECTIVES

The overarching goal of the project is to restore floodplain habitat at the HFRP site by re-creating a hydrologically and ecologically functional floodplain, enhancing the natural river ecosystem and addressing the needs of listed fish species and other wildlife. In addition, the HFRP site will provide the opportunity to establish high quality public access along the Russian River. The design goals also include:

- Achieving both long-term, self-maintaining process-based riverine functions and rapid re-establishment of salmonid and native riparian habitat;
- Successfully transitioning land uses and property ownership control;
- Establishment of public access and recreational amenities identified by Sonoma County Parks; and

- Protecting, and, to the extent feasible enhancing Russian River ground water sources supplying local and regional Sonoma County residents via the Town of Windsor Wells, located upstream of the project area, and Sonoma County Water Agency wells located downstream of the project area.

The overarching goal is further supported by specific goals and objectives developed in the Feasibility Study related to restoring floodplain habitat and natural processes beyond the minimal goals required under SMARA. Goals and objectives specific to geomorphology, floodplain inundation, fisheries, aquifer restoration, water quality, vegetation, and public amenities (access), are summarized below. The goals from the Feasibility Study have been updated and/or refined in project objectives derived from the groundwater analysis, riparian revegetation design, and geotechnical investigation.

2.1 Floodplain Restoration Goals and Objectives

Goals and objectives as described below originated from the Feasibility Study and have been slightly refined based on the findings from this 30% design effort.

2.1.1 Geomorphic Goals

Goal 1. Arrest or reverse the ongoing trend of channel incision and resulting revetment scour and bank failure. Maintain channel bed elevations and riverbank stability in the project area. Specific objectives include:

1. Restore river/floodplain interaction to increase dissipation of flood energy and deposit sediment in the project reach.

2. Reduce hydraulic forces driving scour along the existing and restored river banks for flows up to the 100-year flood anticipated in design.

Goal 2. Restore sediment deposition, sorting, and habitat-forming fluvial processes. Specific objectives include:

1. Restore sediment deposition and sorting processes to increase river channel bed heterogeneity and create pool riffle morphology.

2. Re-establish naturally sloping banks and gradients on the restored floodplain that support re-establishment of geomorphic dynamic equilibrium during 5-year and greater flood flows.

3. Restore fluvial processes forming a seasonally active macro-scale floodplain channel diversity, including alluvial bar channel networks across at least 50% of the annually inundated floodplain.

2.1.2 Flood Elevation Goal

Goal 3. Do not increase, and potentially reduce, flood elevations in the project area. Specific objectives include:

1. Increase floodplain floodwater conveyance across of the restored floodplain for 5-year and greater floods.

2. Decrease flood elevations within the project area by an average of 1-3 feet for a 5-year flood event.

2.1.3 Fisheries Goals

Goal 4. Eliminate the altered landscape and resulting altered hydraulic conditions and ecology that support the persistence of non-native fish and riparian species. Specific objectives include:

1. Fill the reclamation pits to restored floodplain elevations to eliminate warm water fisheries habitat.
2. Re-establish seasonally inundated floodplain elevations and native plant communities and minimize the potential for dominance of non-native invasive exotic species (e.g., *Arundo* and *Ludwigia* spp.) on the restored floodplain.

Goal 5. Increase the populations of native salmonids. Specific objectives include:

1. Restore dynamic geomorphic processes needed to establish spawning gravel deposits that will support salmonid spawning in the adjacent river channel.

2. Restore and maximize project area productivity and carrying capacity so that juvenile Steelhead, Chinook and Coho Salmon attain minimum threshold sizes for marine survival. Specific objectives for each species are summarized below.

Chinook Salmon objectives:

1. Increase main channel spawning habitat area and quality.

2. 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. Restore 80 acres of highly productive seasonally inundated floodplain wetland and backwater alcove-type habitats under normal hydrologic conditions to provide rapid growth opportunities for rearing juveniles.

Coho Salmon objectives:

1. 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. Restore 80 acres of highly productive seasonally inundated floodplain wetland and backwater alcove-type habitats under normal hydrologic conditions to provide flood refuge and diverse winter rearing habitat for Coho parr annually migrating from basin-wide over-summering habitats to enhanced winter and spring growth opportunities.

Steelhead objectives:

1. Increase main channel and off-channel winter/spring edgewater habitat by at least 60 acres during normal hydrologic conditions.

2. Increase summer and winter rearing habitat capacity and productivity in the project area.

Other aquatic riparian 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.

2.1.4 Aquifer Restoration Goal

Goal 6. Improve groundwater quality and quantity. Specific objectives include:

1. Fill existing ponds below the summer water table with porous native sand and gravel utilizing methods that minimize the potential for mobilization of pond sediments.

2. Increase groundwater recharge by restoring floodplain connectivity and flooding over at least 100 acres for a minimum of 100 days under average hydrologic conditions, and 100 acres for a minimum of 50 days under drier than average hydrologic conditions.

2.1.5 Water Quality Goals

Goal 7. Improve surface water quality conditions within the project area and downstream. Reduce the transformation of harmful nutrients (phosphorus) and metals (mercury) in the water column and sediments. Reduce localized warming of Russian River summertime water temperatures by eliminating the reclamation ponds as a source of warm subsurface flows, and increasing the seasonally saturated aquifer area. Specific objectives for water quality constituents are detailed below.

Nutrient and Metal Objective:

1. Eliminate toxic “hotspots”, i.e., methylmercury and phosphorus accumulation and production, within the project area by filling the ponds; and increasing perennial river flow through the site.

Sediment Objective:

1. Restore deposition of fine sand and spawning gravel by increasing flood flow routing onto a minimum of 200 acres of floodplain in average hydrological conditions.

Temperature Objectives:

1. Decrease or eliminate deep summer ponded water to minimize thermal stratification of the water column.

2. Reduce or eliminate deep persistent quiescent pools, and the associated summer water surface area exposed to ambient air and solar heating to minimize warming of river water temperatures in the project area and downstream.

2.1.6 Vegetation Community Goals

Goal 8. Restore and enhance riparian floodplain native species along a natural gradient from aquatic streambed, emergent marsh, seasonal wet meadow and woodland wetland, to upland mature seral stage forest communities. Re-establish a complex and diverse floodplain ecosystem which is resilient to disturbance and provides floodplain ecosystem benefits and habitat for native fish and wildlife species. Specific objectives include:

1. Within 5 years following conclusion of construction, establish a minimum 50 acres of native riparian vegetation communities consisting of a gradient from aquatic streambed to seasonal wet meadows under average hydrologic conditions.

2. Within 10 years following conclusion of construction, establish a minimum of 200 acres of native riparian vegetation zones consisting of a gradient from aquatic streambed, to emergent marsh, to scrub-shrub forest wetland, to upland riparian forest under average hydrologic conditions.

3. Increase native riparian forest in uplands to a minimum 125 acres under average hydrologic conditions.

2.1.7 Public Amenities Goal

Goal 9. Accommodate potential public access and recreation facilities in the grading plan. The specific objective is to create site spaces that can be developed concurrent with floodplain restoration or at a later time for an upland perimeter multiuse trail within as much of the eastern HFRP area boundary as feasible, ingress and egress routes for parks vehicles, a pad for a low-intensity campground, and a pad for parking area and non-motorized boat access to the river.

2.2 Purpose and Need

The primary purpose of the 30% design phase was to conduct additional studies to further evaluate the current floodplain design developed by the Scientific Working Group for alignment with previously stated goals and objectives, and evaluate construction constraints. The purpose of this report is to consolidate existing information, summarize the findings of the recently completed studies. The report provides supplemental information advancing the project design, and supports developing the project description and information needs for CEQA and revision to reclamation plans, including:

- Groundwater hydrogeology and water quality protection measures;
- Riparian habitat and revegetation design;
- Geotechnical investigation and construction design considerations for slope stability consolidation and settlement;
- Assessment of potential biological impacts to special status species;
- Public Access approach; and
- Anticipated construction means and methods, identifying the rate, duration, seasonality and need for sequencing and phasing work.

Findings from these additional studies are summarized in Section 6 – Findings from 30% Design Investigations.

3. OPPORTUNITIES AND CONSTRAINTS

3.1 Opportunities

3.1.1 Fisheries Benefits

The project design would restore more than 300 acres of seasonal floodplain in a manner which promotes native vegetation and ecological complexity. The HFRP proposes to backfill the ponds, thus eliminating sources of warm water and the continued generation of methylmercury. The HFRP retains surficial soils and incorporates revegetation with native species to minimize the time required to establish seasonal wetland vegetation communities, which when inundated provide salmonid foraging and rearing habitat. Floodplain elevation targets support seasonal hydroperiods required to enhance salmonid habitat (food sources and shelter) when inundated. The restored floodplain will support large areas of seasonal wet meadow dominated by sod-forming plant species such as sedges (*Carex* spp.), spikerush (*Eleocharis* spp*.),* grasses, and herbs. These conditions also discourage the establishment of invasive aquatic plants, such as water primrose species (*Ludwigia* spp.), likely to hinder development of diverse floodplain food sources and shelter needed for salmonid recovery.

The design provides salmonid winter rearing habitat across a broad, seasonally inundated system of channels and floodplain. Flood energy dissipates across shallows, forming low velocity habitat that is food rich, and comprises a large area with complex cover. This seasonally-wet meadow habitat is favored by listed Steelhead, Coho Salmon, and Chinook Salmon because such habitat:

- Provides essential winter rearing habitat that supports fry and juvenile growth so that juveniles can reach larger threshold sizes for improved marine survival;
- Provides high-quality winter floodplain foraging habitat with important prey for juvenile salmonids (e.g., dipterans and zooplankton prey);
- Reduces the likelihood of predation by non-native fish and American Bullfrogs (*Lithobates catesbeianus*); and
- Reduces fish stranding potential.

Potential fisheries benefit also exists in the opportunity to restore dynamic geomorphic processes that support the deposition of spawning gravel within floodplain channels and/or the adjoining Russian River. Currently spawning habitat in this reach of the river is limited by channel and substrate conditions. Russian River incision resulting from watershed development and floodplain encroachment has concentrated river flows, increased flow velocities and depths, and reduced transient sediment storage, all of which has resulted in a coarsening of the alluvial gravel bed. Floodplain restoration increases the potential for deposition of transient alluvial deposition, and the associated sorting of gravels required to form spawning deposits in the HFRP area.

3.1.2 Opportunities for Riparian Species Benefits

The HFRP ameliorates local floodplain impacts associated with mine operations. Currently, the ponds and surrounding compacted floodplain terrace adversely impact riparian ecosystem functions. They support non-native predatory fish and invasive non-native vegetation, provide substantially reduce woody riparian vegetation cover, and degrade Russian River water quality by elevating water temperatures, accumulating toxic levels of methylmercury, and amassing nutrients (i.e., creating eutrophic conditions; EHC 2016). Floodplain restoration measures re-establish grades and vegetation communities intended to support seasonal floodplain inundation and native riparian species. Equally important, the HFRP restores floodplain connectivity and physical processes (inundation, disturbance, sedimentation, and scour) critical to sustaining riparian functions, and providing habitat diversity in normal and extreme wet and dry periods. Floodplain restoration also mitigates the forces driving Russian River incisions and bank scour both within the HFRP area and for a short distance upstream.

After filling the ponds, the floodplain grading is intended to support, dynamic floodplain processes. A shallow floodplain template will direct floodplain conveyance and flow recession paths to reduce the potential for fish stranding, mainstem channel capture and east bank scour. Following this reconnection of river to floodplain, alluvial processes will drive channel development, sinuosity and sediment deposition on the active floodplain. Reliance on alluvial processes in floodplain restoration retains disturbance forces that provide and maintain ecological diversity. Within the restored floodplain, alluvial bars, riparian stands, and large wood structures will be designed in subsequent phases to provide post-construction floodplain flow diversity, hydraulic, and vegetative shelter during peak flow events. Both floodplain topography and these nascent features serve as a locust for accumulation of wrack and finer alluvial graves suitable for spawning. Floodplain grading and revegetation will promote sod-forming plant species such as sedges, spikerush, grasses, and herbs.

Restoration measures also discourage the establishment and dominance of invasive species observed throughout the Middle Reach of the Russian River. Invasive plants are major stressors on ecosystem processes, habitats, and native species that are the focus the HFRP. Because the HFRP will disturb the entire site, there is a valuable opportunity to restore a topsoil relatively free of invasive plant propagules. Achievement of this objective combined with restoration of suitable substrate and hydrologic conditions will facilitate natural succession of the target habitats and inhibit invasive plant establishment. To realize this opportunity, invasive plant management measures are incorporated in soils preparation, handling, stockpile, and grading plans.

3.1.3 Opportunities for Wildlife Benefits

Floodplain restoration provides benefits for wildlife in the riparian corridor. Food sources, expansion of riparian habitat and connectivity all increase in association with floodplain restoration. In general, the HFRP assumes that wildlife benefit from floodplains dominated by native riparian species. Wildlife benefit is maximized by restoring native plant communities and natural gradients from streambed and seasonally-wet meadow, through scrub shrub/riparian forest to mature upland riparian forest. To avoid construction derived impacts, the HFRP incorporates species specific impact minimization measures. These measures described as constraints in the following section, include requirements identified by local, state, and federal natural resources protection regulations.

3.1.4 Community Benefits

Floodplain restoration provides the broad array of community benefits summarized below.

Enhance Community Flood Resiliency

Floodplains naturally attenuate flood peaks by providing available area for flood storage and conveyance. Floodplain restoration reduces river flow velocities, promotes river and floodplain deposition, and decreases channel incision and bank erosion rates.

Improves Water Quality

Floodplains provide natural filtration that attenuates organic nutrients benefiting both surface and ground water quality. Filling the ponds eliminates sources of methylmercury, turbidity, and high temperatures.

Improves Water Supply

Floodplains increase the groundwater recharge capacity by expanding the recharge area available. In the dry season, when the Russian River is gaining from tributary sources, channel thalweg dictates ground water surface elevations in the coarse alluvium. As a result, to the extent that the HFRP abates or reduces channel incision, it adds saturated aquifer thickness which contributes to recovery of groundwater supply. This increases climate resilience across the riparian corridor, decreasing seasonal groundwater recession and dry season river temperatures critical to sustaining aquatic species.

Expands Recreational Use and River Access

Pursuant to proposed recreational use plans provided by Sonoma County, the property will be a Sonoma County riverfront park, including day use parking, boat launch, and campground facilities.

Removes Obsolete Infrastructure

The HFRP proposes to remove remnant infrastructure including interior weirs, culverts, and interior levees. Banks adjoining the Russian River and upper floodplain terrace will be graded to more stable natural alluvial slopes and revegetated.

Sequesters Carbon

Seasonally-wet grassland, such as those restored on the HFRP floodplain, is estimated to support a carbon sequestration rate of 40-60 carbon per unit area per year (g $C/m^{-2}yr^{-1}$). Thus, the HFRP’s 300-acre floodplain, once mature, will provide a passive carbon offset of 50-75 tons Carbon/year.

3.2 Constraints

3.2.1 Regulatory Constraints

Regulatory requirements, potential mitigation requirements, and specific permit conditions could pose significant constraints on construction and therefore impact construction costs. Typical regulatory requirements may not be directly applicable or desirable for the HFRP. Regulatory requirements regarding control of water, stormwater, turbidity thresholds, and monitoring should be considered, and discussed with resource and regulatory stakeholders. As the project proceeds and permit conditions that address specific concerns or regulatory requirements are identified, additional mitigation measures will be integrated in the design.

Construction Disturbance

Prior to cessation of mining in 2002, gravel mining occurred year-round. Grading and construction disturbances associated with mine closure and floodplain restoration are comparable in nature to mining operations. Furthermore, time is of the essence in restoring suitable habitat for a variety of species including state and federally-listed salmonids. The groundwater assessment recommends a multi-year approach to filling the ponds, to reduce the source area for potential contaminant mobilization when filling ponds below the water table. Earthwork above the water table, could be completed during winter months, and would be subject to agency approval and appropriate grading, turbid water, and sediment mobilization control measures.

Mine Closure and Reclamation Plan

SMARA, regulated by the State since its inception in 1975, requires approved reclamation (mine closure) plans that detail the re-establishment of stable grades, abatement of potentially adverse water quality impacts, and removal of obsolete infrastructure. Decommissioning and reclamation of the gravel mines with floodplain restoration provides a regulatory opportunity to meet SMARA mine closure requirements for pit, infrastructure, and site stabilization. The HFRP stabilizes the remnant gravel pits via filling, and removes the riverfront revetments, internal levees and drainage infrastructure which would otherwise be subject to SMARA requirements. The HFRP also incorporates low gradient (5 horizontal–to-1 vertical) or lower slopes where the active floodplain meets the eastern valley terrace, where park facilities and river access points will be established to support floodplain restoration and recreational uses.

As a result, the mine closure via floodplain restoration can be considered self-mitigating pursuant to local, state, and federal regulations. Riparian corridor and floodplain restoration actions (fine grading, revegetation, aquatic habitat enhancement measures) are incorporated, by association with the floodplain restoration plan. The opportunity for public/park lands conversion can be realized after mine closure requirements are met.

Mine closure and reclamation via floodplain restoration re-establishes naturally dynamic geomorphic process on the floodplain. This language may appear to conflict with SMARA requirements to stabilize the site prior to certification for closure. Physically these concepts do not conflict. Filling the ponds and grading the site to elevations suitable for floodplain restoration re-establishes natural gradients on the floodplain. These natural gradients are typically low and meet SMARA requirements for stability. Where the banks rise to elevations associated with mid- and high- riparian grades, proposed grading complies with geotechnical criteria for slope stability.

Riparian Impact Mitigation/Balancing

Project construction would impact existing open waters and wetlands supported by the four ponds. While low quality and undesirable habitats, they are still regulated under the Clean Water Act and may require mitigation. However, because the design results in expansion of wetland, riparian, floodplain, and other desirable habitats, the HFRP is likely to be self-mitigating overall. See Section 7.2 – Proposed Habitats for additional information on conversion to post-project habitat types.

Construction Disturbance and Impact Mitigation Measures

Activities associated with implementation of the proposed project (e.g., vegetation removal using heavy equipment, mass grading, noise and vibrations caused by heavy equipment, and the presence of workers) may have the potential to adversely affect sensitive wildlife species and may, therefore, be subject to various state and/or federal regulatory requirements. Potentially affected species and associated avoidance, minimization, and/or mitigation measures are discussed in more detail in Section 5.8 – Biological Conditions.

3.2.1 Environmental Constraints

Proximity to Groundwater

Vegetation communities depend on both rainfall and connectivity to shallow groundwater. The depth to groundwater is a controlling factor in determining the composition of floodplain plant communities. Willow (*Salix* spp.) and cottonwood (*Populous fremontii*) depend on perennial, shallow groundwater for their water supply, whereas plant species typical of mixed riparian forest and valley oak riparian habitats tolerate drier conditions. See Section 7.1.2 – Riparian Floodplain Corridor Restoration for discussion on how groundwater constraints have been factored into design recommendations.

Preliminary assessment of groundwater impacts associated with pit reclamation and floodplain restoration (LSCE 2021) describes regional gradients as predominantly north to south (away from the Windsor well field), and seasonally fluctuate east and west as the Russian River feeds or receives subsurface inflows. Construction activities during the dry season, when Russian River flows are lowest and groundwater flows toward the river are most prevalent, pose the greatest potential for off-site impacts. Proposed construction phasing minimizes the potential for pond fill to displace water from the ponds and drive the poor-quality pit water toward the Russian River.

Floodplain Accretion Rates

Natural accretion of sediments is expected to occur on the restored floodplain. The rate of accretion varies spatially and temporally, and is not expected to be uniform year after year. The project design establishes a template for floodplain evolution, and relies on natural depositional processes for floodplain aggradation.

Qualitatively, geomorphic principals and USGS numerical modeling indicate that the highest aggradation rates will occur near Russian River confluences, and until site grades approach equilibrium, coarse sediment deposition (bed load transport) will attenuate rapidly with distance downstream. The expansive floodplain area and the predominance of coarse alluvial gravels will result in aggradation in the mainstem Russian River around newly established floodplain confluences. Within the HFRP site coarse alluvium deposits will form lobes (deltas) expanding into the site over time. High rate fine (suspended) sediment deposition will be more broadly distributed across the site(s). Rapid aggradation of fines is anticipated for several years due to recent fires.

Additional study is required to characterize sediment accretion rates to help inform the final design. More information is also needed to characterize the role of fire-born sediments relative to vegetation and fisheries.

Invasive Plant Species

Establishment of hydrologic conditions that support target habitat of seasonally inundated floodplains are critical to project success in providing foraging and rearing habitat for salmonids. To reduce the risk of invasive aquatic and emergent species (e.g., *Ludwigia* spp.) dominance on the restored floodplain, the designs should minimize the extent of HFRP area that is perennially inundated and saturated. See Section 7.1.2 – Riparian Floodplain Corridor Restoration for discussion on how avoidance of groundwater conditions preferable to invasive species has been factored into design recommendations.

Forest Habitat

Project construction will remove the most of the existing walnut-dominated riparian forest. This relatively young (e.g., approximately 5–6 decades) riparian stand established on human-made levees currently provide moderate to high riparian and wildlife functions and is a regulated habitat. The design maintains existing mature stands to the extent feasible; however, trees will not be preserved at the expense of the HFRP's over-arching process-based restoration objectives.

Re-establishment of riparian stands on the floodplain is constrained by the HFRP's large floodplain area and the costs associated with active revegetation. The design relies on natural recruitment as the primary strategy for establishment of native woody obligate riparian habitat on the restored floodplain. Willow and cottonwood depend on perennial, shallow groundwater for their water supply; whereas plant species typical of mixed riparian forest and valley oak riparian habitats tolerate drier conditions.

On the terrace adjoining the active floodplain, upland habitat within a new Sonoma County river park will be actively planted to maximize wildlife habitat and structural diversity of the restored habitats. The primary strategy for establishment of native valley oak woodland on slopes and upland areas is planting nursery-grown stock, and maintaining plant establishment for three to five years via irrigation, weed control, and browse protection. As on the floodplain, upland soil conditions require that designs support both target habitat establishment and minimize the potential for invasive weed dominance. Where favorable soils are scarce, the rate of natural recruitment of willow, cottonwood, and mulefat (*Baccharis salicifolia*) can be increased at low cost via harvest and installation of cuttings in strategic locations.

Seasonally-Wet Meadow Restoration

The composition of self-forming riparian floodplain habitats is constrained by water supply rations. Regulated base-flows and Mirabel Dam operations influence the depth to late summer groundwater in the HFRP area, and in turn, the minimum suitable elevation for floodplain grading. Where funding permits, restoration of seasonally-wet meadow requires heavy seeding by a native annual and perennial forb pioneer "cover crop" to inhibit weed colonization and dominance. Seeding should include translocation of vegetative propagules (sod fragments, plugs, etc.) of native clonal perennial ground cover where native plants may not readily colonize the site on their own. To overcome this constraint, stands of native wet meadow species (e.g., willows, sedges, rushes, and grasses) could potentially be salvaged, stored, and/or grown and transplanted on the graded floodplain.

Surface and Groundwater Resources

Earthwork associated with filling the Hanson Ponds has the potential to impact water quality in the Russian River and the Town of Windsor production wells, as evaluated by Luhdorff & Scalmanini Consulting Engineers (LSCE; 2021). LSCE (2021) concludes that the Sonoma Water's Wholer Collection Wells were located significantly downstream of the HFRP area such that water quality would not be impacted.

Potential impacts to the Russian River and Town of Windsor production wells were comparatively assessed using two different construction scenarios: one construction season and three construction seasons. The LSCE study concludes that a phased approach to construction would result in reduced potential increases to methylmercury, temperature, and turbidity mobilization, when compared to single season construction (LSCE 2021).

Conservative estimates of potential water quality impacts to the Town of Windsor production wells over one construction season vs. three construction seasons were identical since the potential impacts to the wells are only possible from two ponds (Piombo and Mariani Ponds -two of the four ponds; LSCE 2021).

Water quality standards include the RWQCB Environmental Screening Levels for methylmercury and the Low Threat Discharge Permit for water temperature. Projected increases in methylmercury in both the Russian River and the Town of Windsor wells do not exceed allowable thresholds (LSCE 2021).

Available standards for turbidity are 5 Nephelometric Turbidity Units (NTU) for drinking water (wells) and a 5 NTU increase in receiving waters (when background concentration is less than 25 NTU). The high-end conservative estimate for one construction season exceeds the 5 NTU increase standard for the Russian River; the three-year estimate does not exceed allowable standards in the Russian River. The increased turbidity estimates for the Town of Windsor production wells are within the drinking water standard (LSCE 2021). Following the short-term construction impacts period, the HFRP is expected to improve water quality into the future and make the reach more resilient to impact events, such as high turbidity runoff periods.

3.2.2 Construction Constraints

Cut and Fill Balance

Proposed grading is constrained by the practical requirement to balance cut and fill on site to avoid additional costs, impact and time required for importing additional material. If cost were not a constraint, additional fill would be preferred to achieve design goals. As such, the capacity to raise the floodplain elevations is constrained by available fill. This is a primary constraint identified in the 30% floodplain design because targeted vegetation communities require seasonal inundation, and so does suppression of invasive non-native vegetation. Summer groundwater elevations are consistent as dictated by summer base flows and the Mirabel Dam, and range from 45 feet-NAVD88 at the northern end of the HFRP area, to 42 feet-NAVD88 at the southern HFRP area boundary (LSCE 2020). As a result, minimum floodplain elevations one foot above the seasonal low groundwater elevation are critical to successful restoration of seasonally saturated floodplain wetlands targeted to provide habitat for salmonids.

Geotechnical Constraints

Geotechnical conditions in the coarse alluvial gravels that dominate site conditions pose constraints in both construction and design. Design and construction implementation planning requires considering varying rates of work and site stability (safety) criteria dependent on the proximity to groundwater. Consistent with operational and reclamation plans, grading and work on stable slopes ranges from >6H:1V to 2H:1V within and above the water table respectively. Similarly, the equipment deployed for construction varies with distance from the water table. Scrapers, excavators and dump trucks are feasible within three feet of the water table. Earthwork within the ponds, at and below the water table, requires swamp dozers, dredging equipment, and draglines.

Compaction and consolidation also require careful consideration given the large volumes of material manipulated, and that design objectives and costs preclude use of traditional methods of work in dry conditions compacting fill in lifts. Earthwork designs and estimated costs reflect geotechnical studies (Appendix D).

The geotechnical constraints inform construction methods, site grading and cost estimates in the 30% design. Differential settlement poses the most significant challenges in design in light of limited fill availability; expected invasive plant dominance where floodplain elevations dip to within 1-2 feet of the water table; and the need to avoid low ponded areas without connection to the main-stem river where juvenile salmonids could be stranded when floodwaters recede. To promote consolidation and settlement in the first season, ponds are proposed to be filled and surcharged with several feet of material above target finish grades. In the second season, finished grading across the floodplain would occur to remove excess fill from the surcharged area.

4. OWNERSHIP, LAND USE, AND OPERATIONS

4.1 Operational History

According to the 1982 reclamation plan, the Windsor Quarry began operations at Piombo Pond in the late 1940s, mining sand and gravel at a rate of 50,000 to 250,000 cubic yards annually (Sonoma County 1982). Dates of initial operation for the other three ponds are not available. Reclamation efforts commenced in the Middle Reach in the late 1980s. By 1975, the Richardson Pit, the first to be excavated in the HFRP area was complete. The reclamation plan for Richardson Pond was filed in 1995. Reclamation activities presumably commenced thereafter and were reported to span through 2004 (Kaiser Sand and Gravel 1995).

During their period of operation, the mining pits were inundated by flood waters from the Russian River. There is documentation that the ponds were overtopped in the 1995 flood, resulting in breaches in the levee separating the ponds from the Russian River (Kaiser Sand and Gravel 1995). Subsequent analysis conducted in 1998 compared flood elevations resulting from the period of record at available from the USGS at the time (1977 -1998, 22 years) and estimated the Vimark Pit was inundated approximately once per year as a result of Russian River flood waters (Halligan 1998). A separate hydraulic analysis of the Vimark Pit was also completed in the same year, concluding the Vimark Pit was inundated between a 2-year and 5-year recurrence interval (Murray et al. 1998). Both Halligan (1998) and Murray et al. (1998) noted the potential for the inundated pit to trap salmonids and evaluated alternatives to raise the levee elevation surrounding the pit to reduce the risk of entrapment.

As noted in reclamation plans and associated CEQA documents, other environmental impacts resulting from quarry operations, such as dust, noise, and traffic, were confined to the quarry sites (e.g., Kaiser Sand and Gravel 1995, Sonoma County 1982). The potential for mining operations to adversely impact groundwater and riverine water quality with regard to methylmercury and other water quality constituents of concern was recognized prior to 1990.

In 2009, Hanson Aggregates initiated plans to complete the last remaining mine reclamation obligations at the HFRP area. As noted in the Feasibility Study, the reclamation plans were developed two decades ago and presented a significant risk to threatened and endangered species associated with the Russian River. At the urging of the U.S. Army Corps of Engineers (USACE), the Sonoma County Permit and Management Department, and the NMFS, discussions with Hanson Aggregates identified regulatory issues and concerns related to implementation of the previously approved reclamation plan features that were no longer biologically acceptable and had questions about being geotechnically stable. The HFRP described herein was thus developed to, in part, remedy or address these identified concerns.

Instead of pursuing the traditional approach to mine closure and reclamation, the HFRP proposes to instead repurpose the floodplain currently occupied by the mining ponds for restoration purposes. Such an approach would directly address concerns previously expressed by resource agencies with regulatory authority, avoiding or reducing risk to salmonids, water quality, and the Russian River corridor overall. Moreover, pursuing a reclamation approach that focuses on floodplain connectivity and habitat restoration across the HFRP area would result in ecological outcomes above and beyond what would otherwise result from a traditional reclamation approach. Through collaboration with the landowner, Permit Sonoma, resource agencies, and numerous other partners and stakeholders, this approach to mine reclamation is both possible and exemplary for future projects with similar circumstances.

4.2 Mine Closure, Levee Repair, and Maintenance

The SMARA, administered by the California Department of Conservation Division of Mine Reclamation (DMR) 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.

The four retired ponds are covered by three reclamation plans. The Mariani and Piombo pits fall under the same plan, while Richardson and Vimark pits have individual reclamation plans for compliance with SMARA regulations. All three reclamation plans identify wildlife habitat and open space as the subsequent beneficial land use approved by Permit Sonoma, the local land use authority 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 throughout the Middle Reach has continued to incise since it was channelized in the 1950s, although the localized deep dredge ponds have partially recovered in depth. During flood events, the earthen revetments isolating ponds from the river during low flow are subject to strong seepage forces and bank erosion even before high flows overtop them. In addition, overtopping and levee breaching events in the winter months became more frequent than originally anticipated due to limitations of previous flood mapping and hydrologic studies, ongoing watershed development, channel incision 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 occurred. The current status of reclamation activities of each pond each pond is described below.

4.2.1 Status of Reclamation Activities

The status of reclamation activities varies for each of the Hanson Ponds. The 30% design incorporates existing topography, grading, and infrastructure associated with the reclamation status of all four Hanson Ponds and is summarized below.

Piombo Pond

The Piombo and Mariani ponds are covered by one reclamation plan (PLP97-0096). Mining is complete and final slopes have been graded, capped with topsoil, and planted on south and west sides. The Piombo plant site was dismantled and stockpiles removed in 2005. Some final grading and reseeding remains to be completed.

Mariani Pond

Mining is complete at this pond. Initial slope grading, topsoil replenishment, and revegetation are approximately 60% complete. The most recent grading and hydroseeding work was completed in 2007. According to the 2019 Financial Assurance Estimate for the Mariani Pond, disturbed areas still requiring reclamation include approximately five acres and includes the removal of a pipe and construction of a weir where the Mariani and Piombo ponds meet at their southern end. The weir was redesigned and modified in 2004 and indications of erosion exist on the earthen embankment between Piombo and Mariani. However, Hanson Aggregates, Endangered Habitats Conservancy (EHC), and Permit Sonoma are working to develop a minor reclamation plan amendment for the Mariani and Piombo Pits Reclamation Plan such that the hardened weir is not required, and alternative site configurations that meet the performance standards of the Reclamation Plan and Use Permit conditions under PLP97-0096 are acceptable for reclamation.

Richardson Pond

Mining was completed prior to the adoption of SMARA in 1975 and, as of December 2020, the pond is considered fully reclaimed by Permit Sonoma and DMR. 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 Game (now CDFW) determined the habitat value of the existing vegetation to be significant. Approximately 70% of the perimeter was left undisturbed at the recommendation of the CDFW. Some grading and revegetation work occurred along the west side and the north west sides of the pit in 2006. At that time, substantial work remained 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.

Vimark Pond

Mining is complete. All initial reclamation grading, topsoil replenishment, and revegetation and weir construction was complete in 2005. The site has been monitored since and has remained stable since site reclamation was signed-off.

4.3 Land Use and Current Ownership

Land use in the HFRP area is dominated by the four former gravel ponds managed by Hanson Aggregates. The HFRP area is privately owned by a variety of landowners, including the Hanson Aggregates. Mapped on the 30% design plans (Sheet G-101), landowners within the established grading limit are summarized by assessor parcel number (APN) in Table 4.1. Additional APNs adjacent to but outside the HFRP boundary are under the ownership of Syar Industries, Inc., Ledbetter Farms, Inc., Town of Windsor, Windsor Water District, and Ferrari Carano Vineyard & Winery, LLC.

4.3.1 Land Use, Zoning, and Williamson Act Designations

The land use designation within the project boundary is Land Intensive Agricultural (LIA) (Sonoma County 2020). Zoning designations within the project boundary include combining districts for LIA, Floodway, Mineral Resources, Riparian Corridor, and Valley Oak Habitat (Sonoma County 2020). Within the Riparian Corridor combining district, stream maintenance, and restoration carried out by Sonoma Water is an allowable use (Sonoma County 2020).

Within the HFRP boundary, agricultural areas (e.g., vineyards) located between the ponds and Eastside Road are considered prime agricultural land and enrolled in Williamson Act contracts (Sonoma County 2020).

4.3.2 Easements and Right of Ways

Existing easements are summarized in Table 4.2. See 30% Design Plans (Sheet G103 – Existing Conditions) for easement locations.

Table 4.1 Land Ownership by Assessor Parcel Number within the Grading or Staging Limits

Assessor Parcel Number	Landowner
066-290-042-000	Passalacqua, Thomas R TR
066-290-043-000	Passalacqua, Thomas R TR
066-290-044-000	Caplan River Vineyard II
110-120-030-000	G3 Enterprises
110-120-028-000	Syar Industries Inc
110-120-022-000	Syar Industries Inc
110-120-023-000	Syar Industries Inc
110-110-018-000	Syar Industries Inc
110-110-020-000	Syar Industries Inc
110-160-011-000	Estate Vineyards LLC
110-160-016-000	Estate Vineyards LLC
066-290-050-000	Hanson Aggregates Mid-Pacific, Inc.
066-290-049-000	Hanson Aggregates Mid-Pacific, Inc.
066-290-052-000	Hanson Aggregates Mid-Pacific, Inc.
066-300-027-000	Hanson Aggregates Mid-Pacific, Inc.
066-300-049-000	Hanson Aggregates Mid-Pacific, Inc.
066-300-011-000	Hanson Aggregates Mid-Pacific, Inc.
110-110-106-000	Hanson Aggregates Mid-Pacific, Inc.
110-110-015-000	Hanson Aggregates Mid-Pacific, Inc.
110-120-021-000	Hanson Aggregates Mid-Pacific, Inc.
110-120-020-000	Hanson Aggregates Mid-Pacific, Inc.
110-170-014	Rochioli Enterprises LP[1]
[1] Parcel not bisected by grading. Parcel may be needed for temporary construction access.	

Table 4.2 Summary of Existing Easements

Easement	Location
30-foot access and utility easement to Vimark Pond	Between Eastside Road and Vimark Pond
Agricultural purpose easement	Between Eastside Road and Richardson Pond
Agricultural access easement	Off Eastside Road, between Richardson Pond and Piombo Pond
Water access and utility easement	Richardson Pond
Open space easement to County of Sonoma	Covers Vimark Pond, APN 066-290-049
Waterline and surface right of way to the Windsor Water District	Northeast corner of project boundary, east of Mariani Pond.

4.4 Future Ownership

Future ownership for the HFRP area remains undetermined. EHC proposes to own the property through restoration construction, then transfer to Sonoma County Regional Parks (Regional Parks) for long term ownership and management. Regional Parks has prepared a conceptual plan for the future public amenities, which include a trail network with beach access, camp sites, and a boat launch. Sonoma County Parks may secure use of the area by easement or by outright ownership; this remains to be determined. EHC holds an option to purchase, which expires June 30, 2021. Fee transfer from Hanson to EHC is to occur upon reclamation plan sign-off. EHC will hold fee title until completion of site restoration, after which, property transfer to the Sonoma Parks is anticipated.

4.5 Water Rights

The California Department of Water Resources' (DWR) eWRIMS GIS water rights mapping tool was queried for water rights within the HFRP boundary (Table 4.3, DWR 2020). The allowed period of use and quantity of withdrawal and/or storage vary by water right. Numerous additional water rights are located north of the HFRP boundary near the Russian River and near the west bank of the Russian River, opposite the HFRP.

Table 4.3 Summary of Existing Water Rights

Water Right	Point of Diversion	Water Right Type[1]	Diversion Information[2]
A030391	Vimark Pond	Permitted	200 acre-feet
A025363	Vimark Pond	Adjudicated	500 gallons/day direct; 0.4 acre-feet
A013097	Vimark Pond	Adjudicated	1,000 gallons/day
A024892A	Vimark Pond	Permitted	12,8 cfs; 195 acre-feet
A024892B	Vimark Pond	Adjudicated	12.25 cfs
A014747	Russian River east of Richardson Pond	Licensed	1.75 cfs
A023639	Russian River east of Richardson Pond	Licensed	0.451 cfs; 37 acre-feet
S015459	Richardson Pond	Claimed	0.278 cfs, 166 acre-feet
A024891	West of Piombo Pond	Licensed	0.2 cfs; 36 acre-feet
A013267	Northwest corner of HFRP boundary	Licensed	0.43 cfs

[1] Inactive and revoked water rights not listed.

[2] Available information varies by each water right. Water volume (acre-feet) is allocated annually.

Abbreviations: cubic feet per second (cfs)

5. EXISTING CONDITIONS

5.1 Site Topography and Bathymetry

To support assessment of the HFRP area and design development, topography and bathymetry data was compiled from LiDAR, pond bathymetry, riverine bathymetric survey (e.g., RTK-GPS) and conducted and provided by NOAA and USGS.

5.1.1 Middle Reach Russian River Topography and Bathymetry

Riverine topography shows an incised channel and over-steepened banks. The river is separated from the floodplain by constructed levees surrounding the ponds and a riparian berm adjacent to the channel. The river bed in the Middle Reach of the Russian River has continued to incise since it was channelized in the 1950s, although the localized deep dredge ponds have partially recovered in depth.

Gravel removal has included periodic bar skimming which in recent times has been approved by the regulatory agencies. Topographic analysis of historical maps indicates the channel thalweg is progressively deepening, and bank erosion due to the collapse of high steep banks, is increasing in frequency. In the HFRP area, only a narrow earthen levee approximately 200 feet wide separates the river channel from the ponds. The eastern riverbank revetment is comprised primarily of trees and steep bank. Less than 1,000 linear feet of the bank, adjoining the Richardson Pond, is currently reinforced to provide added stability where overbank floodwaters currently return to the main river channel. .

The existing riparian berm serves as a revetment, maintaining separation between the river and the four floodplain ponds. The berm is composed of compacted native material and mature riparian trees (predominantly walnut). Established parallel to the channel, the elevation of the riparian berm varies but is approximately 24 to 26 feet higher than the adjoining channel thalweg. Riparian berms commonly occur in managed river corridors where minimum flows are sustained through summer, and peak floods driving disturbance are attenuated by dams.

Riverbank erosion is ongoing adjoining the HFRP area. Stabilization/maintenance of the banks is required to maintain separation between the ponds and the river channel. Re-connecting a seasonally inundated floodplain will abate channel incision in the HFRP reach, and reduce risks associated with bank failure, levee breaching, and discharge of pond water and sediments.

5.1.2 Hanson Ponds Topography and Bathymetry

The HFRP area encompasses four ponds, Mariani, Piombo, Richardson and Vimark, ranging in size from approximately 20 to 84 acres. Key bathymetry attributes for each of the four ponds are summarized in Table 5.1. Ponds and surrounding levees and surfaces range in elevation from approximately 20 feet to 30 feet.

Table 5.1 Existing Dimension of the Hanson Ponds (From EHC 2016)

Pond	Ave. Depth (feet)	Max Depth (feet)	Lowest Pond Bottom Elevation (feet NAVD88)	Adjacent Approximate River Thalweg Elevation (feet NAVD88)	Measured Area (acres)
Mariani	13.4	38.2	6.34	43	19.6
Piombo	21.2	35.3	9.36	43	19.8
Richardson	17.3	37.1	14.65	41	83.8
Vimark	17.8	42.7	-0.5	40	25.1

5.2 Site Geology and Geotechnical Assessment

Multiple sub-surface soil borings have been completed at the HFRP area to support past pit mining activities and recent restoration planning. Prior studies are described in the most recent geotechnical investigation report completed by Miller Pacific Engineering Group (MPEG 2020) and provided in Appendix D. This geotechnical investigation supplements previous subsurface conditions exploration and provides geotechnical recommendations for design and construction. Geologic mapping incorporated into the geotechnical investigation notes the HFRP area is underlain by relatively young alluvial deposits consisting of unconsolidated and interbedded sands, gravels, silts, and clays. The alluvium is underlain by older fluvial gravel, silt, sand and clay (MPEG 2020). The nearest known active faults are the Rodgers Creek, Healdsburg, and Maacama Fault which are located roughly 3.7 miles northeast, 4.0 miles north, and 7.6 miles east of the site, respectively (MPEG 2020).

In general, subsurface soil conditions in the upper 10 feet to 15 feet consist of layers of medium stiff clay and silt and medium dense silty sand. Soils below 10 to 15 feet are generally comprised of more sands and gravels. The riparian berm along the river and undisturbed native soils consist of primarily dense sand and gravel layers (MPEG 2020). Borings were installed to a depths of 10-12 feet below ground surface. Bedrock was not encountered during these geotechnical investigations (MPEG 2020).

5.3 Levees, Drainage and Flood Control Infrastructure

During flood events, the earthen levees isolating ponds from the river during low flow are subject to strong subsurface seepage forces and bank erosion even before high flows overtop the levee. The levees vary in elevation by pond. The levee between Mariani Pond and Piombo Pond is the highest, ranging from approximately 78 feet to 83 feet. The levee between Richard Pond and Vimark Pond ranges between approximately 79 feet and 81 feet. The levee between Piombo Pond and Richardson Pond varies from a high elevation of approximately 79 feet to a low elevation of approximately 64 feet, while the levee between Mariani Pond and Richardson Pond varies from approximately 71.5 feet to 77 feet.

The crest of the levee slopes gently (approximately 2%) toward the river draining runoff away from the ponds. The pond-ward slopes of the levees range from approximately 2 horizontal distance(H): 1 vertical distance(V) to 3H:1V. As documented in the revised Mariani Pit Reclamation Plan, a 200-foot long overflow weir (elevation 70.6 ft) separates Mariani Pond from Piombo Pond. Three riprapped spillways are also located on the HFRP area.

The riverfront revetment which runs parallel to the Russian River was constructed to isolate the floodplain from the river so that gravel could be extracted. A reinforced section of the revetment was constructed to mitigate scour driven by flood waters draining from the floodplain adjoining the Richardson Pit. Drainage from the floodplain to the outside of a river meander at this location creates a relatively steep bank along the east side of the Russian River (MPEG 2020). Erosion on toe of the slope on the river side of the levee has been documented since 1995 (MPEG 2020). The revetment is several thousand feet long. Though the exact location of the north and south ends are undefined (MPEG 2020). The levee crest elevation varies from 78 feet to 84 feet. The east side toe elevation varies from 60 feet to 62 feet, and the west side toe elevation is at the riverbed elevation, approximately 44 feet. Side slope elevations are largely 1H:1V and nearly vertical (MPEG 2020).

5.4 Hydrology

Streamflow regimes in the Middle Reach of the Russian River results from natural hydrologic conditions, unregulated tributary inflow, and reservoir releases from Lake Mendocino via the Coyote Valley Dam, and Lake Sonoma via the Warm Springs Dam on Dry Creek. Upstream of the Coyote Valley Dam, 160,000 acre-feet (typical) of the Eel River water is diverted into the Russian River basin via the Potter Valley Project (PVP). The PVP conveys Eel River waters into Lake Mendocino. Dry Creek headwaters are captured by the Warm Springs Dam (constructed in 1982) forming the 380,000 acre-feet of Lake Sonoma reservoir. Both dams are operated by the Corps of Engineers, which utilize the Forecast Information Reservoir Operations (FIRO) reservoir management ruleset (storage curve) triggers flood control releases to the Russian River.

Hydrology data is available via USGS gaging station 1146400 - Russian River near Healdsburg, CA and includes a period of record from 1987 through present. A large tributary (Dry Creek) contributes additional flow to the Russian River upstream of the HFRP area, inclusive of flow releases from Lake Sonoma. Thus, tributary contributions from Dry Creek are best captured via USGS 11465200 – Dry Creek near Geyserville, CA.

Managed streamflows are regulated by the SWRCB Order Number D1610 and the federal Endangered Species Act (ESA) via the 2008 NMFS Biological Opinion. D1610 authorizes SCWA to divert 75,000 acre-feet annually, and was developed prior to the listings of salmon and Steelhead under the ESA. The order delineates specific flow minimums for different water year types. The 2008 NMFS Biological Opinion covering Sonoma Water and USACE 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.

5.4.1 Summer and Fall Base Flows

In the Middle Reach of the Russian River, D1610 requires a minimum summer flow (May-September) of 125 cubic feet per second (cfs) in normal water years, 85 cfs in dry years, and 35 cfs in critically dry years. However, due to natural unregulated flows, Sonoma Water cannot reduce river flows significantly until late June or early July in most water years.

Biologists with the NMFS concluded that D1610 flow regimes in the Russian River and Dry Creek during the summer are too high for young Coho Salmon and Steelhead. 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. Under extreme drought conditions in 2020, Russian River minimum flows above and below the Dry Creek confluence fell to 50cfs and 60 cfs, respectively. Dry year flow requirements continue to be re-evaluated in an effort to balance conflicting interest of water user and stream habitat.

5.4.2 Winter and Spring Base Flows and Design Storms

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 did not result in changes to the winter and spring base flow regime, as previously established under D1610.

The Scientific Working Group's sediment transport model was used to evaluate design alternatives and select the preferred alternative. The model was calibrated to predict floodplain inundation, river hydraulics, sediment transport metrics, and erosion and deposition. Nine discharges were evaluated, ranging from 883 cfs to 50,280 cfs. Results were used to evaluate changes in hydraulic and sediment transport capacity, and build an understanding regarding how the interactions of flow and topography might drive ecology in floodplain restoration. Sediment transport modeling methods and results are available in Appendix G of the Feasibility Study (EHC 2016).

Recurrence intervals resulting from available data from USGS 1146400 – Russian River near Healdsburg are summarized in Table 5.2, as computed by StreamStats (2020). These return periods do not incorporate streamflow from Dry Creek, located upstream of the Hanson Ponds. StreamStats has not computed peak flood intervals for USGS 11465350 – Dry Creek Near Mouth Near Healdsburg.

Table 5.2 Peak Flood Discharges for USGS 1146400 – Russian River near Healdsburg, CA (StreamStats 2020).

Return Period	Discharge (cfs)
Mean annual event	21,500
2-year peak flood	35,600
5-year peak flood	53,000
10-year peak flood	63,600
25-year peak flood	75,800
50-year peak flood	84,000
100-year peak flood	91,700

5.4.3 Inflatable Dam Operations

Sonoma Water operates the Mirabel Dam located just downstream of the Wohler Bridge on the Russian River, near Forestville (approximately 3.5 miles downstream of the HFRP site). The inflatable rubber dam is normally raised in the spring or early summer when water demands increase, during low flow conditions. The dam crest elevation is approximately 42 feet feet-NAVD88 and creates a backwater condition to recharge Sonoma Water's well fields. The backwater effects of the dam propagate upstream in dry summer months, and sustain groundwater elevations in the HFRP area during low flow conditions.

Permanent fish ladders provide fish passage when the rubber dam is raised. Sonoma Water routinely deflates the rubber dam when Russian River flows reach 2,000 cfs or above in order to prevent damage to the rubber dam from the high flows. When completely deflated, the rubber dam rests flat on the bottom of the Russian River.

5.4.4 Flood Hydrology

The HFRP area is entirely located with the Federal Emergency Management Agency (FEMA) 100-year floodplain and predominately located within the mapped regulated FEMA floodway (FEMA 2020, see Figure 3 – FEMA 100-year Floodplain). The 100-year discharge for USGS 11464000 is 97,100 cfs (StreamStats 2020). The highest peak flow on record (1987 – present) for USGS 1146400 was recorded on January 9, 1995 at 73,000 cfs.

Floodplain inundation from upstream of the HFRP area also contribute to flood hydrology at the Hanson Ponds. During flood events exceeding the 5-year recurrence, floodplain flow enters the HFRP area across Fontana Road and flow overland into the Mariani and Piambo ponds, and then to and by the Richardson Pond before returning to the Russian River (Figure 1). Indicators of sheet and rill erosion are present throughout the HFRP area from floodplain flood flows most notably the earthen berm separating the Mariani and Piombo ponds and the channel connecting the Piombo and Richardson ponds to the river.

Figure 1. Hanson Ponds inundated from Russian River Floodplain Flow on January 11, 2017, which experienced a peak flow of 42,500 cfs at USGS 11464000 - Russian River near Healdsburg, CA combined with a peak flow of 2,200 cfs from USGS 11465200 Dry Creek near Geyserville, CA for a total of 44,700 cfs (Approx. 4-Year Recurrence). Photo provided by Brian Cluer.

5.4.5 Future Streamflows

As a result of relicensing of the Potter Valley Project, future managed streamflows in the Middle Reach of the Russian River may differ from the existing streamflow regime[1]. The scenarios evaluated a range of conditions from full decommissioning of the Potter Valley Project, including the diversion tunnel from Lake Pillsbury, which would eliminate all inflows from the Eel River watershed. Scenarios also considered modifying Potter Valley Project operations to maintain diversions to the Russian River (e.g., increasing diversions during winter peak flows and decreasing diversions during low flow periods), and revising the FIRO flood control curve in Lake Mendocino to increase storage, among others (Sonoma Water et al. 2020).

While no decisions have yet been made, decommissioning or relicensing of the Potter Valley Project, an ongoing and lengthy process, will very likely alter Russian River flow regimes within a

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[1] Modeling completed by the Potter Valley Project Huffman Ad-Hoc Committee Water Supply Working Group, with participation from Sonoma Water, NMFS, and the Round Valley Indian Tribe, included five scenarios, some of which considered climate change effects (Sonoma Water et. al 2020). Modeling included evaluation of future streamflows at the Russian River near Healdsburg, upstream of the Hanson Ponds site.

period of approximately 10 to 20 years. Results of modeled scenarios predict decreases in minimum weekly streamflows at the Russian River at Healdsburg by as much as 13% with reductions in water year storage volumes by as much as 7%. If the Potter Valley Project is entirely decommissioned, during dry and extremely dry conditions (exceedances of 75% and above), minimum streamflow conditions in the 2008 NMFS Biological Opinion would not be met and streamflows could approach 0 cfs (Sonoma Water et al. 2020). However, the Two-Basin Solution Partnership lead by California Trout, Sonoma Water, and the Round Valley Indian Tribe, is working to develop a solution that retains streamflow minimums in the Russian River. Under such a scenario, minimum streamflows near the HFRP would still be likely to decrease during some low flow periods. Decreases would be greater during drier hydrologic conditions and could range from 50 cfs to as low as 10 cfs (Sonoma Water et al. 2020).

5.5 Water Quality

5.5.1 Middle Reach Russian River Water Quality

Water quality in the Middle Reach is adversely impacted by warmed water inputs during summer as the expansive gravel ponds seep into the river. The abandoned gravel ponds also create biogeochemical processes that convert naturally occurring mercury into highly toxic and bioavailable methylmercury, and accumulate phosphorous and other detrimental nutrients.

Water Temperature

Water temperatures below 23 degrees Celsius (°C) are vital for salmonid survival, growth, egg incubation, and migration cues. The USGS formerly collected water temperature data at the nearest gage (USGS 1146400 Russian River near Healdsburg, CA) but discontinued data collection at the end of the 2002 water year. The NMFS 2008 Biological Opinion Reasonable and Prudent Alternative (RPA) does not include water temperature requirements (e.g., thresholds to avoid water temperatures that could be lethal to salmonids).

Turbidity and Water Quality

Prior to the implementation of the RPA in the NMFS 2008 Biological Opinion, turbid dam releases from Lake Mendocino, upstream of Hanson Ponds, were considered detrimental to downstream fisheries resources (NMFS 2008). With improved management, turbidity resulting from dam releases has improved. Water quality sampling for methylmercury in the Russian River resulted in approximately 0.09 nanogram per liter (ng/L) under summer conditions (LSCE 2020).

5.5.2 Hanson Pond Water Quality

Water Temperature

NMFS developed temperature profiles for each of the four ponds. Surface temperatures of all ponds were 24°C and above, with the highest temperature recorded as 29.1°C in the Mariani Pond. Bottom temperatures at depths of 25 to 30 feet were between 11 and 12°C 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°C, and surface temperature uniformly at 25°C, thus with an average difference of only 4°C 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 10 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.

Dissolved Oxygen

NMFS also developed Dissolved Oxygen (DO) profiles for the four ponds. 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 milligrams per liter (mg/L) in the top five 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 depths of 25 or 30 feet 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.

5.5.3 Contamination Sampling

As summarized in the Feasibility Study, soil, sediment, and water sampling were conducted for the Russian River from Alexander Valley to the Wohler Bridge and the Hanson Ponds. Sampled constituents included California Administrative Manual (CAM) metals, total mercury, organochlorine pesticides and Polychlorinated biphenyls (PCBs), organophosphorus pesticides, total extractable petroleum hydrocarbons (TPH), polcyclic aromatic hydrocarbons (PAH), nutrients, chlorophyll-a, and methylmercury. This suite of detected metals was found in the Hanson Ponds and thus indicated a natural source of background minerals bound to suspended fine clay sediments. The highest total mercury level in river sediments was found in the Russian River at the Jimtown Bridge in the Alexander Valley, 18 river miles above the HFRP site (the most upriver site sampled). Organochlorine pesticides and PCBs were not detected in Russian River benthic sediment or bank soils.

The methylmercury concentrations in the three ponds adjacent to the river (Piombo, Richardson, and Vimark) range from 0.2 to 7.97 ng/L, and the Mariani Pond has a concentration of 15.3 ng/L (LSCE 2021). Methylmercury 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 (3.0 ng/L) (ECF 2016).

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 river and Hanson Pond 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 background concentrations of heavy metal for sediments in the watershed.

These preliminary data provide evidence that elevated levels of mercury and methylmercury are highly variable throughout the Russian River watershed. The higher methylmercury concentrations observed in the Hanson Ponds compared to the Russian River are primarily due the accumulation of river-born suspended (fine) sediments in the ponds which contribute to high rates of organic matter and fine clay particle (carrying mercury and phosphorus) 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) which stimulate increased microbial activity all support conditions necessary to drive methylmercury production.

5.6 Groundwater Conditions

Groundwater resources at Hanson Ponds have been assessed through numerous previous studies. To support 30% design, LSCE assessed groundwater and surface water impacts related to the HFRP (LSCE 2021). As described in the study, the western edge of three of the four Hanson Ponds are located between 200 and 800 feet from the current low flow river channel; thus, the Russian River surface waters are separated from the Hanson Ponds , except during flood events. Ground water is separated by a lateral thickness of aquifer materials ranging from 200 to 800 feet. The western edge of Mariani Pond is located further from the river at distances of 1,000 to 1,650 feet (LSCE 2021). Groundwater study results indicate potential for movement of water from the ponds to the river (when the river level is lower than pond surface elevations).

5.6.1 Elevation, Gradient, and Seasonal Variation

Elevation and Gradient

Groundwater elevations at the Hanson Ponds range from about 63 feet at the eastern margin of the HFRP area (just east of the Hanson Ponds) at the upstream end of the HFRP area to 45 feet at the Russian River at the downstream end of the HFRP area. This equates to a groundwater gradient of about 0.003. However, the groundwater gradient along the Russian River is significantly less at 0.0005 based on a drop from 48 to 45 feet from the upstream to downstream ends of the Hanson Ponds property (LSCE 2021).

During the geotechnical investigation, groundwater was not encountered in shallow borings (less than 10 feet in depth) but was encountered in some of the deeper reference borings. As part of the geotechnical study, groundwater was resultantly determined to be 18 feet to 28 feet below ground surface and likely corresponds with water levels in the Russian River and Hanson Ponds (MPEG 2020).

Groundwater flow directions tend to be a combination of flow from the eastern margins (east to west) and north to south flow from upstream to downstream along the river (i.e., towards the southwest across the ponds). The groundwater gradient driving flow through Richardson Pond is approximately 0.001. The groundwater gradient through Piombo Pond is more difficult to quantify due to flattening of the local gradient from Town of Windsor production well pumping. However, an overall groundwater elevation decline of about one foot between points upgradient and downgradient of Piombo Pond indicates a net gradient of about 0.0003 (LSCE 2021).

Seasonal Variation

Review of earlier groundwater data indicates seasonal groundwater level fluctuations generally ranged up to 10 feet, with seasonal highs instantaneously corresponding to high river flows (PES Environmental 2003 cited in LSCE 2021). Synthesis of data from the past decade found groundwater elevations fluctuate seasonally due to annual hydrologic variation in connected surface waters and production well pumping. Review of available data spanning July 2009 to October 2019 indicate a fairly consistent seasonal low of about 42 feet. Overall, February/March 2020 on-site groundwater elevations ranged from 43.83 feet to approximately 46.35 feet, and late May 2020 groundwater elevations ranged from 42.39 feet to 44.92 feet (LSCE 2021).

5.6.2 Groundwater Water Quality

Evaluation of groundwater water quality focused on methylmercury, turbidity, total dissolved solids (TDS), and nutrients (LSCE 2021). Groundwater water quality data were sourced from production wells managed by the Town of Windsor and Sonoma Water (see Section 5.6.4 below). Additional groundwater water quality data was sourced from the USGS, sourced from the broader study area, and on-site monitoring wells.

Sonoma Water Wells

Water quality samples obtained from downstream Sonoma Water wells in October and November 2008 reported TDS ranging from 149 to 161 mg/L, DO ranging from 2.7 to 7.9 mg/L, oxidation-reduction potential (ORP) ranging from 125 to 220 millivolts (mV), temperatures ranging from 17.0 to 18.7°C, and pH ranging from 6.6 to 7.1. Similar data from downstream Sonoma Water Syar monitoring wells reported TDS ranging from 140 to 190 mg/L, DO ranging from 2.2 to 7.5 mg/L, temperature for March 2008 samples ranging from 13.7 to 15.5°C and for September 2008 samples from 22.2 to 25.7°C, and pH generally ranging from 7.1 to 7.7. Available data for these wells did not report testing for total mercury or methylmercury (LSCE 2021).

USGS Monitoring Data

Water quality data from the USGS online Groundwater Ambient Monitoring and Assessment Program spanned the broader study area and included data for TDS, sulfate, nitrate, mercury, and total organic carbon (TOC). Data reported TDS ranging from about 130 to 365 mg/L, sulfate from 3 to 55 mg/L for almost all wells (with a majority of readings below 25 mg/L), nitrate (as N) for virtually all wells below 5 mg/L, TOC from 0 to 11 mg/L (with most readings below 4 mg/L), and total mercury at 1 ug/L or less (LSCE 2021).

Town of Windsor and On-site Monitoring Wells

Most recently, on-site groundwater data collection occurred in 2020 at seven monitoring wells (five existing wells and two new wells). Due to the proximity to the HFRP area, one of the Town of Windsor wells was sampled concurrently. Four of the five existing monitoring wells are located between the ponds and the river, and had TDS ranging from 114 to 207 mg/L, temperature ranging from 18.9 to 21.5°C, and pH ranging from 7.14 to 7.33. The two new monitoring wells had TDS ranging from 112 to 215 mg/L, DO ranging from 1.4 to 3.0 mg/L, temperature from 17.5 to 22.3°C, and pH ranging from 6.95 to 7.08. Total mercury was less than 0.2 ug/L and methylmercury was less than 0.05 ng/L. One existing monitoring well further away from the river (P-3) had notably higher TDS at 431 mg/L (LSCE 2021).

Additional Town of Windsor production well (Well 8 and Well 10) groundwater quality data spanning 2008 through 2020 sampling events indicate TDS ranging from 180 to 220 mg/L for Well 8 and from 170 to 200 mg/L for Well 10. Sulfate concentrations ranged from 11 to 17 mg/L for Well 8 and 11 to 15 mg/L for Well 10. Lab turbidity data for Well 8 ranged from 0.15 to 2.7 NTU, and from 0.75 to 1.8 NTU for Well 10. Comparison of lab turbidity data for Town of Windsor production wells to stream turbidity indicates slightly greater than one order of magnitude reduction in turbidity reaching the wells from the river for river discharge turbidity levels (LSCE 2021)

5.6.3 Comparison to Historical Water Table Elevations and Gradients

LSCE (2021) considered previous groundwater data collected at the Hanson Ponds in 2003 by PES Environmental. This prior data analysis considered by LSCE (2021) indicates that the primary source of groundwater recharge in the area is Russian River surface water infiltration, quarry pond infiltration, and infiltration of precipitation. According to earlier analysis, prior to the development of the sand and gravel quarries and water diversions, groundwater at the Hanson Ponds generally flowed toward the river and discharged as underflow during much of the year (i.e., gaining river conditions). Findings generally indicated water levels in quarry ponds were higher than groundwater levels in the adjacent aquifer and river levels; thus, water flowed from the ponds to the river (PES Environmental cited in LSCE 2021).

In addition, during periods of groundwater levels decline, often during the summer and fall, surface water from the Russian River may recharge the alluvial aquifer (i.e., losing river condition) in areas outside of the influence of quarry ponds and the local direction of groundwater flow is away from the river. During high river stages (seasonal or as a result of controlled surface water releases to the river), and in areas of significant groundwater pumping near the river (e.g., in the vicinity of the Town of Windsor production wells), surface water from the Russian River may also recharge the alluvial aquifer (PES Environmental Cited in LSCE 2021).

5.6.4 Connectivity with Water Supply Wells

The Hanson 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. The Town of Windsor has five vertical production wells located adjacent to the Russian River about 500 feet east of the current low flow river channel. Piombo and Mariani Ponds are located approximately 1,000 to 1,300 feet from Town of Windsor production wells at their nearest points (LSCE 2021). Sonoma Water also manages water supply wells. The nearest collector well to the HFRP area is located approximately 2.3 miles downstream of the southern end of Vimark Pond. The Mirabel Dam is about 3.5 miles downstream of Vimark Pond (LSCE 2021). Sonoma Water's Wohler Collection Wells are located approximately 2.5 to 3.0 river miles downstream of Vimark Pond (LSCE 2021).

5.6.5 Recharge and Discharge Area

The recharge (or inflow) components of the water budget for the HFRP area include estimated rainfall plus irrigation water percolation of approximately 12 inches/year, rainfall directly on the Hanson Ponds estimated at an average annual 41 inches/year, regional groundwater flow from the north and east, and river seepage under losing stream conditions (LSCE 2021). The discharge components of the water budget for the HFRP area include evaporation from pond surfaces, discharge to the river, groundwater flow off-site to the south, and pumping (LSCE 2021).

Reaches of the Russian River adjacent to the Town of Windsor production wells and Sonoma Water pumping wells were generally characterized as losing (discharging) stream reaches, whereas the area in between (Hanson Ponds property and immediately south of Hanson Ponds) was characterized as seasonally variable gaining and losing (recharging and discharging) river reach conditions.

5.7 Geomorphic Conditions

5.7.1 Watershed History

An analysis conducted by the San Francisco Estuary Institute (SFEI) indicates the Middle Reach Russian River migrated laterally across the alluvial valley floodplain prior to be encumbered by levees infrastructure. Large sandbars, side channels, and numerous sloughs were common fluvial features. The riparian corridor was documented to be more than half a mile wide. The riparian corridor was densely vegetated, while active channel bars, frequently mobilized, were sparsely vegetated. Riparian vegetation types included willow thickets, cottonwood forests, large valley oaks (*Quercus lobata*), an understory of brush and briers, and marsh vegetation (EHC 2016, Appendix B).

Early settlers, whose primary interest was agriculture, modified the Russian River channel and its tributaries with fluvial engineering, concentrating and directing flood flows to excavate straighter and deeper drainage channels. In the location of today’s Riverfront Regional Park, the channel was dredged and straightened, severing three large-amplitude channel meanders winding around expansive point bar formations. Levees and gravel mining haul roads were also constructed.

In the 1950s, the Middle Reach channel was 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. 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 developed floodplain immediately adjacent to the river channel because a deeper channel with a larger cross-sectional area conveys larger floods. Large floods (e.g., 1940) would have inundated the HFRP area and surrounding vicinity. 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 (upstream of the Hanson Ponds) and extended downstream to Riverfront Regional Park.

Flood control efforts were advanced with the building of two USACE flood control dams upstream in the watershed: Coyote Valley Dam on the East Fork of the Russian River (1959), and 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.

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.

The HFRP is 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 and its alluvial sediment supply could, over time or in a single large event, avulse and be captured by the excavated ponds, abandoning the now active channel.

As channel incision continues, 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 are challenged to address bank erosion and collapse, continually threatening property and cropland. 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 and intervention, the current channel configuration is considered unstable and unsustainable.

Kaiser Sand and Gravel began mining the gravel terraces on the approximately 358-acre Hanson Aggregate 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. Reclamation of the Hanson Ponds is covered by the Windsor Master Reclamation Plan and there are three reclamation plans covering the four ponds. Reclamation is complete for the Vimark and Richardson ponds, and EHC and Hanson are working with Permit Sonoma and reclamation plan amendments that will be compatible with the restoration plan.

5.7.2 River Corridor Trajectory

The major Russian River valleys are substantially modified for flood control, agriculture, and gravel mining. These modifications transformed relatively shallow river 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 the high-capacity Russian River channel. Thus, only the strongest storms generate sufficient stream flow to inundate the historical floodplain. The widespread 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 a series of topographic maps 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. The consequence of reduced sinuosity, resulting in a shortened river length, is greater channel slope.

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.

5.7.3 Summary of Sediment Characteristics

Ponds

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. 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 reflects multiple annual inundation of the ponds by the river during storm events containing high concentrations of suspended fine silt and clay and potential contributions from wash water during mining operations. 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.

Uplands

Analysis of sediment sampling of the uplands of the HFRP 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.

Middle Reach Riverine Sediments and Grain Size Distribution

Analysis of the Middle Reach gravel bar samples, with the tight cluster of grain sizes, and uniform sizes throughout the reach indicates that little sorting of materials occurs when bed mobilization occurs. Channel sediment sampling conducted by NMFS resulted in a Russian River grain size distribution ranging from 0.0059 inches (0.15 millimeters ([mm]) to 4.13 inches (105 mm). The 16th percentile ranged from 0.31-0.79 inches (0.8-2 mm), the 50th percentile ranged from 0.16-0.79 inches (4-20 mm), and the 84th percentile ranged from 0.39-0.79 inches (10-20 mm), with the exception of the location at bar #3 which had an 84th percentile greater than 5.04 inches (128 mm; EHC 2016, Appendix G).

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 (EHC 2016, Appendix G), and the model was tested for sediment size sensitivity by conducting some runs using the finest measured sediment size to simulate the greatest model response.

5.7.4 Middle Reach Russian River Sediment Transport, Yield, and Floodplain Deposition

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, 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.

The evidence of approximately 6.6 feet 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, 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, likely approaching a new equilibrium but at unknown elevation.

5.7.5 Implications of Future Pond Existence

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 provide abundant dissolved organic carbon for anaerobic bacteria. River hydrology delivers fine clays and attached phosphorous, mercury, and other metals to the ponds 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. Continuation of methylmercury generation into the future is anticipated within the ponds. 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 negatively impact the local aquifer and 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.

5.8 Biological Conditions

In addition to biological evaluations included in EHC 2016, a USGS nine-quadrangle search was completed for the HFRP. To avoid the potential for construction-related impacts to special status species with a moderate or high likelihood to occur, avoidance and minimization measures were developed (Avocet 2020). These measures are available in Appendix C.

5.8.1 Vegetation Communities and Habitat

Existing plant communities were mapped by H.T. Harvey and Associates (2020). The area between the ponds and the adjoining reach of the Russian River was mapped as a Walnut-Dominated Riparian Forest, the largest of the mapped vegetation types. The levees surrounding the ponds were predominantly mapped as Coyote Brush Scrub with islands of Fremont Cottonwood Forest. Smaller areas of Smartweed-cocklebur Patches, Valley Oak Woodland, and Water Primrose Wetland (invasive, non-native) were also mapped (H.T. Harvey 2020).

The plant communities at the HFRP site have been significantly altered historically by agriculture, then gravel mining at the site. 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, 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 and young oaks (*Quercus spp.).* Invasive Himalayan blackberry (*Rubus armeniacus* and/or *R. 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.).

Special Status Plants

Special status plant species with a moderate or high likelihood to occur at or near the HFRP are summarized in Table 5.3. To ensure construction-related impacts would be less than significant, avoidance and minimization measures for these species are included in Appendix C.

Table 5.3 Special Status Plants

Species	Likelihood to Occur
Baker’s navarretia (*Navarretia leucocephala*)	Moderate potential
many-flowered navarretia (*Navarretia leucocephala ssp. plieantha)*	Moderate potential
Burke's goldfields (*Lasthenia burkei*)	Moderate potential
Marsh scorzonella (*Microseris paludosa)*	Moderate potential
congested-headed hayfield tarplant (*Hemizonia congesta ssp. congesta*)	Moderate Potential
short-leaved evax (*Hesperevax sparsiflora var. brevifolia*)	Moderate Potential
Sebastopol meadowfoam (*Limnanthes vinculans*)	Moderate Potential

Invasive Plant Species

Invasive plants are major stressors on the ecosystem processes, habitats, and species that are the focus of restoring the Hanson Ponds (H.T. Harvey 2020). Predominant upland and aquatic invasive plant species present are smartweed-cocklebur patches and water primrose (H.T. Harvey 2019). Smartweed-cocklebur patches are located along the western edge of the Richardson Pond levee. Water primrose was mapped along the edges of all four ponds (H.T. Harvey 2019). Giant reed and Himalayan blackberry are also present (H.T. Harvey 2020).

5.8.2 Fisheries

Special Status Salmonids

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:

- Endangered Central California Coast (CCC) Coho Salmon ESU. The Russian River watershed continues to experience a substantial decline in Coho Salmon abundance.
- Threatened California Coastal (CC) Chinook Salmon ESU. Since 2000, Sonoma Water has maintained a video camera for counting Russian River adult CC Chinook Salmon returns at its Mirabel diversion facilities below Wohler Bridge in the Lower Russian River. Counts are variable and range from a low of 1,125 fish in 2008 to a high of 6,713 fish in 2012. Counts subsequently declined in 2014 to 1,432 fish.
- Threatened Central California Coast Steelhead DPS. The Warm Springs Fish Hatchery at Lake Somona manages hatchery-stock Steelhead and has tracked adult returns since 1980.

Fish Habitat

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. 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 quiescent rearing 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 duration droughts as well.

Remnant off-channel features still evident in the 1933 and 1942 maps, 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 are at a historical low point.

Non-Native and Predatory Fish Assemblage in the Middle Reach Ponds

Furthermore, the ponds themselves provide ideal habitat for warm water non-native and/or predatory fish such as Largemouth Bass (*Micropterus salmoides*) that prey on federally-listed juvenile salmonids and native amphibian species. Fish assemblage results in the ponds identified Largemouth Bass, Bluegill (*Lepomis macrochirus*), Common Carp (*Cyprinus carpio*), Red Ear Sunfish (*Lepomis microlophus*), Golden Shiner (*Notemigonus crysoleucas*), Brown Bullheads (*Ameiurus nebulosus*), Northern Pikeminnows (*Ptychocheilus oregonensis*), and Black Crappie (*Pomoxis nigromaculatus*). Largemouth Bass were found to be the most abundant of observed fish in the ponds. Restoration of the Hanson Ponds could result in the inadvertent release of these species into the Russian River, increasing predatory pressure on special status salmonids.

5.8.3 Special Status Wildlife

Special status wildlife species with a moderate or high likelihood to occur at or near the HFRP include are summarized in Table 5.4. Related avoidance and minimization measures for these species are included in Appendix C.

Table 5.4 Special Status Wildlife

Species	Likelihood to Occur
Mammals	
Townsend’s big-eared bat (*Corynorhinus townsendii*)	High Potential
Hoary Bat (*Lasiurus cinereus*)	Moderate Potential
Fringed Myotis (*Myotis thysanodes*)	High Potential
Pallid Bat (*Antrozous pallidus*)	Moderate Potential
Western Red Bat (*Lasiurus blossevillii*)	Moderate Potential
American Badger (*Taxidea taxus*)	Moderate Potential
Birds	
Double-crested Cormorant (*Phalacrocorax auritus*)	High Potential
Great Egret (*Ardea alba)*	High Potential
Great Blue Heron (*Ardea herodias*)	High Potential
Snowy Egret (*Egretta thula*)	Moderate Potential

Species	Likelihood to Occur
Black-crowned Night Heron (*Nycticorax nycticorax*)	Moderate Potential
Osprey (*Pandion haliaetus*)	High Potential
Cooper's Hawk (*Accipiter cooperii*)	High Potential
Sharp-shinned Hawk (*Acccipiter striatus)*	Moderate Potential
Golden Eagle (*Aquila chrysaetos*)	Moderate Potential
Swainson's Hawk (*Buteo swainsoni)*	Moderate Potential
White-tailed Kite (*Elanus leucurus)*	High Potential
Bald Eagle (*Haliaeetus leucocephalus*)	High Potential
American Peregrine Falcon (*Falco peregrinus anatum*)	High Potential
California Gull *(Larus californicus*)	High Potential
Vaux's swift (*Chaetura vauxi*)	Moderate Potential
Olive-sided Flycatcher (*Contopus cooperi*)	Moderate Potential
Willow Flycatcher (*Empidonax trailii*)	Moderate Potential
Loggerhead Shrike (*Lanius ludovicianus*)	Moderate Potential
Purple Martin (*Progne subis*)	Moderate Potential
Oak Titmouse (*Baeolophus inornatus*)	High Potential
Grasshopper Sparrow (*Ammodramus savanarum*)	Moderate Potential
Yellow-breasted Chat (I*cteria virens*)	Moderate Potential
Yellow Warbler (*Setophaga petechial*)	High Potential
Reptiles	
Western Pond Turtle (*Emys marmorata*)	High Potential
Amphibians	
California Tiger Salamander (*Ambystoma californiense*)	Moderate Potential
California Giant Salamander (*Dicamptodon ensatus*)	Moderate Potential
Red-bellied Newt (*Taricha rivularis*)	Moderate Potential
California red-legged frog (*Rana draytonii*)	Moderate Potential
Foothill Yellow-legged Frog (*Rana boylii*)	Moderate Potential
Invertebrates	
California Fairy Shrimp (*Linderiella occidentalis)*	Moderate Potential
California freshwater Shrimp (Syncaris pacifica)	Moderate Potential

5.8.4 Jurisdictional Wetlands and Waters

Jurisdictional wetlands and waters were considered by H.T. Harvey and Associates (2019) and are reported below.

Jurisdictional Wetlands and Waters of the United States

Approximately 160 acres of the HFRP area may meet the physical criteria and regulatory definition of Waters of the United States under Sections 404 of the Clean Water Act, administered by the USACE. These areas include all four ponds, a drainage that connects the Piombo Pond to the river, a drainage that connects the Richardson Pond to the river, the river side of the levee (below the ordinary high water mark), and a seasonal wetland in the northwest corner of the HFRP area.

Jurisdictional Wetlands and Waters of the State

Approximately 259 acres of the HFRP area may be subject to regulation under the Porter-Cologne Water Quality Control Act administered by the RWQCB under Section 401 of the Clean Water Act as regulated waters and/or wetlands. These areas exceed the boundaries of potential waters of the United States to encompass the canopy of trees that are rooted on the river side of the levee and on the slopes of the ponds.

California Department of Fish and Wildlife Jurisdiction

Approximately 329 acres of the HFRP area may be subject to regulation under Section 1600 of the California Fish and Game Code administered by the CDFW. The HFRP lies completely within 100-year floodplain acreage includes all areas within the 100-year floodplain.

5.9 Parks and Public Lands

Currently, public access is not allowed on the HFRP area. The HFRP area and surrounding parcels, including parcels on the opposite bank of the Russian River, are privately owned by mining interests, vineyards and wineries, and other private landowners. Public access is limited to float-through boat traffic only, with boating access points located upstream and downstream of the HFRP site. However, Russian Riverkeeper who is providing site security, has noted extensive trespassing on the property. See Section 7.3 for an overview of project elements related to public access improvements.

6. FINDINGS FROM 30% DESIGN ASSESSMENTS AND INVESTIGATIONS

In order to meet the project goals articulated above, key findings from this current design phase result from the recommendations of the groundwater assessment, 30% revegetation design, and geotechnical investigation, all completed in 2020. These recommendations build upon the listed goals and objectives previously established in the Feasibility Study.

The technical studies undertaken enhance the understanding of existing conditions, address implications for construction, and identify measures to avoid potential environmental impacts and best meet the HFRP's ecological goals and objectives. Extensive hydraulic and sediment transport modeling was previously completed to evaluate and aide in selection of the preferred design alternative, as documented in the Feasibility Study. Additional hydraulic modeling and fluvial geomorphic design has not been completed as part of the current design phase. The 30% civil and revegetation designs documented herein are predicated on existing hydraulic modeling and grading design completed to date and presented in the Feasibility Study for the selected alternative. The conclusions section of this report outlines the recommended next steps to finalize the hydraulic modeling. See Appendix G of the Feasibility Study for additional information on existing hydraulic modeling completed for the HFRP.

The key findings from each of the studies are summarized below.

6.1.1 Groundwater Assessment

The groundwater assessment completed by LSCE (2021) identified seasonal low groundwater elevations, regional and site groundwater gradients, and the capacity for transport off-site and to the Russian River. It will not be feasible to dewater the ponds prior to construction and fill placement, as is typically preferred. Soil substrate porosity will require fill placement into the ponds while they remain watered. Key findings that influence final design and construction sequencing are summarized below:

- Filling the ponds has the potential to drive transport of contaminants from the ponds to water supply wells and the Russian River when the ponds are backfilled during construction. The pace of construction (pond filling) influences local groundwater gradients, and in turn the capacity for transport and dilution of turbidity, methylmercury, and other water quality constituents of concern. The groundwater assessment analyzed backfilling the ponds in a single construction season and over multiple construction seasons relative to impacts from nearby wells and the ability of the Russian River to assimilate water quality constituents that would be displaced from the ponds as they are filled during construction. As a key conclusion, the groundwater assessment recommended phasing construction over multiple years and monitoring groundwater during construction. Phasing construction would allow for a gradual blend through sub-surface lateral flow between the ponds and the Russian River, reducing potential construction-related impacts to the riverine environment and groundwater wells. Alternatively, pond backfilling operations during winter and early spring months may reduce the rate and concentrations of key constituents migrating to the river. Mass grading operations are generally not permitted during winter months; however, given the reversed gradient that can occur during winter months (groundwater flow gradient from the river towards the ponds), this option could be considered in future planning and consultation with regulatory agencies.
- The relationship between minimum summer groundwater elevation and floodplain grading (i.e., the maximum depth to groundwater) is a critical factor in determining the floodplain vegetation communities supported, and in turn, revegetation design. A summary of how the low seasonal groundwater elevation defined in the groundwater assessment was utilized to inform the revegetation design is described below.

6.1.2 30% Revegetation Design

The revegetation designs prepared by H.T. Harvey and Associates (H.T. Harvey 2020) target the creation of floodplains at an elevation that will support seasonal wet meadow to maximize fisheries benefits. Seasonal inundation is recommended to avoid perennial inundation and minimize establishment of invasive aquatic plants, such as water primrose that would preclude establishment of floodplain habitat that support salmonid populations and could further degrade downstream habitat (H.T. Harvey 2020). Based on predicted summer low groundwater elevations, the floodplain elevation would need to be increased approximately one foot above design elevations proposed in the Feasibility Study to re-establish seasonal wet meadow and targeted plant communities. Elevating the floodplain approximately one foot could be achieved by balancing on-site cut and fills and is further detailed in Section 7 – Proposed Project. Alternatively, the design team proposed further analysis to determine if the rate of natural accretion of sediments on the floodplain could also achieve the desired floodplain elevation and preclude dominance by invasive emergent aquatic species in a timely manner.

6.1.3 Geotechnical Investigation

The geotechnical investigation completed by the MPEG (2020) evaluated site conditions, recommended measures to maintain slope stability and safety in construction, and estimated the extent and rate of consolidation and settlement expected with proposed grading. The depth of the ponds and target floodplain elevations vary significantly across the site. As fill depths increase, so does expected consolidation. Placement of fill in compacted lifts, as is typically recommended to minimize differential settlement, is not feasible when fill is placed below the waterline in the ponds. The cost and time required for compaction also limits the extent of the HFRP area that can be engineered to be stable via compaction. Differential consolidation and settlement on the order of three to five feet or more is anticipated in some deeper fill areas. Unanticipated settlement of three to five feet could result in post-construction floodplain elevation that do not support the desired seasonal wetland habitat, and would increase the risk of Russian River avulsion (channel jumping to a new location).

For excavation of on-site soil placed as compacted fill (85 to 90% relative compaction) outside of ponds and above water, MPEG (2020) estimated net results volume change of 0 to 10% shrinkage. For excavation of on-site soil placed as loose dumped fill into ponds, bulking volume change of 20 to 40% “fluff” was estimated (MPEG 2020). During and following placement of fill in the ponds, compression and consolidation of the fill is expected to occur. The amount of compression (settlement) will range based on the soil type and load (depth of fill). MPEG (2020) estimated roughly 10% compression at shallow depths (less than 10 feet) and roughly 30% compression at depths of 30 to 40 feet.

To accommodate anticipated settlement, MPEG (2020) recommends a phased filling of the ponds. Initial fill would be placed several feet above the desired finished floodplain elevation to surcharge the deep fills. Finished grading would be completed the following year. This is further described in Section 8.

6.1.4 Special Status Species Assessment

A USGS nine-quadrangle search was completed for the HFRP area to identify special status species which may be affected during implementation (Appendix C, Avocet 2020). To avoid the potential for construction-related impacts to special status species with a moderate or high likelihood to occur, avoidance and minimization measures were developed (Avocet 2020). These measures were integrated into the construction approach to avoid any potential undesired biological impacts. While this current design effort has further advanced the understanding of project feasibility in preparation for CEQA, additional design analyses are necessary, and these next steps have been listed in the conclusion section of this report.

6.1.1 Public Access

Since the development of the Feasibility Study, a more specific design concept for public access components has been developed by Sonoma Parks (Appendix G). The planned amenities are described in Section 7.3 and remain consistent with the Feasibility Study floodplain design.

6.1.1 30% Design Plans

As previously described, the 30% design plans are based on the Feasibility Study grading design and represent a compilation of the information summarized above. The plans are referenced throughout this report and located in Appendix F.

7. PROPOSED PROJECT

7.1 Overview of Project Elements

The project design would re-grade on-site earth materials to create a new functional floodplain across the 358-acre HFRP area. The process-based design would improve the functions and values of the Russian River floodplain geomorphically and ecologically. By restoring the floodplain, the design would promote habitat-forming fluvial processes, such as sediment deposition and sorting, to increase floodplain complexity benefiting native salmonid populations. Project elements, as described in this section, reflect the Feasibility Study design and are shown on the 30% design plans, 30% revegetation design, and the public access and park vision concept (see Appendix E, Appendix F, and Appendix G).

7.1.1 Description of Project Limits

The HFRP boundary extends to the eastern limit of the Hanson Aggregate's property, Fontana Road to the north, and the southern boundary of the Vimark Pond to the South (Figure 2). The western HFRP boundary consists primarily of the Russian River channel. Within the HFRP boundary, grading limits encompass the riparian corridor between the Russian River and the four ponds, the four ponds, and levees surrounding each pond. The grading limit includes the four ponds and the riparian corridor between the ponds and the Russian River. Agricultural properties located east of the four ponds are excluded from the grading limits (see Appendix F – 30% Design Plans, sheet G-103). Site access for construction ingress and egress would be achieved via Eastside Road in two locations – near Mariani Pond and Richardson Pond. Pending discussions with landowners, temporary internal haul roads may be developed outside the grading limits but within the HFRP boundary, through agricultural properties east of the pond.

One temporary staging area would be established for each of the three proposed construction phases. The Phase 1 temporary staging area would be located northeast of Vimark Pond; the Phase 2 temporary staging area would be located northeast of Richardson Pond; and the Phase 3 temporary staging area would be located northeast of Mariani Pond (see Appendix F – 30% Design Plans, sheet G-104).

Beyond the HFRP boundary, the area of influence includes the Russian River upstream and downstream of the HFRP area. Restoring river bed sediment deposition processes would occur gradually and without predicted adverse consequences for channel stability upstream or downstream from the HFRP. Implementation of the design would not increase the flood elevation; all model runs as documented in the Feasibility Study showed a decrease in water surface elevations at all modeled streamflows, extending upstream a limited distance. The mainstem channel immediately upstream and downstream of the HFRP area could experience some geomorphic adjustment. Modeling predicts that gravel will deposit in the upstream area of the HFRP where the river flows onto the new floodplain, be re-worked by subsequent flows, and potentially form a large, clean gravel deposit. The HFRP also aims to improve surface water quality downstream of the HFRP area.

7.1.2 Riparian Floodplain Corridor Restoration

Topographic and riparian design elements include: (1) filling the four ponds and re-grading the HFRP area to restore a broad floodplain, (2) constructing channel analogs with perennial alcoves connected to existing deep river pools, (3) constructing a 25 acre-feet water supply pond (Jackson Pond) at the northeast corner of Richardson Pond, and (4) revegetation. In addition, some existing infrastructure would remain in place and other infrastructure would be removed during construction.

Floodplain Restoration

As the four ponds are filled, the restored floodplain would be graded at a maximum slope of 5:1to match grades in the upstream and downstream terrain. In the upstream to downstream direction, slope across the broad floodplain would primarily vary from 0.3 to 0.1% parallel the thalweg of the adjoining Russian River (see Appendix F – 30% Design Plans, Sheet C-201). An elevated riparian terrace (riparian levee) along the bank of the Russian River would largely remain, although it would be lowered in some locations, predominantly at the upper end of the HFRP area, to improve floodplain connectivity. Grading along the riparian terrace would result in some loss of existing walnut-dominated riparian forest, while creating a net increase in overall riparian forested area.

Existing levees surrounding the ponds would be lowered and tied into the floodplain. As an exception, the levees to the east of Vimark, Richardson, and Mariani ponds would remain, although grading would change the western slope. The lowered active floodplain surface would be located between the riverine terrace and the eastern levee, creating an overland flow path between the two higher elevation surfaces (see Appendix F – 30% Design Plans, sheets C-301 and C-302).

The final floodplain elevation is essential to the revegetation strategy, as it ties into the seasonal low groundwater elevation to achieve desired plant communities. The anticipated seasonal low groundwater elevation varies from approximately 42 to 45 feet, from south to north, respectfully. In order to achieve the targeted seasonal wet meadow habitat that would maximize fisheries benefits, avoiding perennial inundation, the current floodplain bench elevation would need to be elevated approximately one foot from the Feasibility Study design elevations. There are challenges to address this, with limited quantities of on-site material to balance cut and fill volumes, and settlement of fill areas that will occur as outlined in the geotechnical investigations. Strategies to achieve the desired base floodplain elevation to support the desired vegetation communities utilizes both available on-site material and also depends on post-construction passive sediment accretion. Moving forward, both strategies need to be considered. The two strategies are not necessarily mutually exclusive and could be applied in tandem across different portions of the floodplain to achieve the desired final floodplain elevated.

> **Grading-based Strategy.** Site grading will be developed to increase the base level of floodplain one foot to provide needed freeboard above the groundwater table. This may be a phased approach in the deep pond areas where settlement is expected to occur. In the pond areas additional material may be placed the first year to surcharge the material and help expedite the settlement. During the second year, the surcharged pond area can be

graded to the final design elevations. To achieve this, modified perimeter grading would rebalance cut and fill and address overland flow paths onto the HFRP area. In addition to the site grading using available material to balance cut and fill quantities, passive sediment accretion is expected to occur.

Passive Sediment Accretion Strategy. An assessment of the rates of passive sediment accretion that could be expected in the short- and long-term post-construction time horizons would be needed to determine the amount and timing of aggradation that could be expected. The assessment needs to consider the timeframe needed to passively accrete sediment and potential tradeoffs with respect to finish design grades, expected settlement, and invasive vegetation management. This approach balances available on-site materials, settlement of fill areas, and future accretion of sediments on the floodplain.

The final design would include fine grading, topographic variation across the large restored floodplain surface, large wood placement, and large wood habitat structures for floodplain enhancement. Final floodplain topography would be design to provide topographic, hydraulic and ecological diversity. Large riparian trees lost to accommodate grading could be repurposed on-site as large wood for habitat purposes. Public Access amenities would be compatible with floodplain restoration design.

Floodplain Channels

Approximately 4,850 feet of floodplain channel would be constructed within the regraded broad floodplain surface (see Appendix F – 30% Design Plans, Sheet C-101). The two channels provide off-channel habitat targeted by the HFRP's fisheries objectives as described in Section 2.1.3. The lower limit of the upstream channel would intersect the mainstem Russian River near the middle of the HFRP area at approximately Station 55+00 (R), and the downstream channel's confluence with the Russian River is further downstream, near Station 30+00 (R).

In normal and low flow conditions, the two channels have direct mainstem connectivity at the downstream end only and would be inundated backwater. Flow inputs from the upstream end would be limited to hyporheic flow, seasonal groundwater connectivity, and high flows that result in floodplain activation. Compared to a typical side channel, the channel area is relatively large to concentrate floodplain conveyance and promote natural formation of alluvial micro-topography. These channel templates have an approximate width of 100 feet, and slope gently to depths of between five and ten feet. During larger bed-mobilizing flows, natural processes will shape evolving geomorphic features such as channel width, meander wavelength, bar configuration, and small islands. The final design of the channel analog would include perennial alcoves that could provide habitat connectivity to existing deep river pools and would specify wood placement.

Water Supply Pond

A 25 acre-feet water supply pond (or equivalent well) would be constructed in the northeast corner of Richardson Pond to support adjacent agricultural uses and maintain existing water rights. In the 30% design, the western and eastern edge of the water supply pond would have side slopes of approximately 16% and 30%, respectively. The pond would be approximately 425 feet width with a depth of roughly 15 feet. Additional refinements to the pond geometry, or conversion to a well may be required to minimize seismic and Division of Safety of Dams (DSOD) jurisdictional requirements.

On-Site Infrastructure

Existing on-site infrastructure includes culverts, wells, piping, and pond-related drainage structures. On-site infrastructure that conflicts with the design or would no longer be necessary as a result of pond filling would be removed. Infrastructure to be removed includes:

- An abandoned water pipe at the southeast corner of Piombo Pond;
- The riprap spillways at the southwest corner of Piombo Pond, north edge of Richardson Pond, and the eastern edge of Richardson Pond (rip rap would be salvaged for re-use); and
- The concrete spillway south of Mariani Pond.

Existing on-site infrastructure to remain in place, and potentially be modified includes:

- A drainage ditch and associated culverts along Fontana Road;
- A well on the eastern edge of Mariani Pond; and
- An existing irrigation diversion (pump) at the northeast corner of Richardson Pond.

7.2 Proposed Habitats

As part of the 30% revegetation design (see Appendix E), existing habitats are mapped and compared with anticipated future habitats. Table 7.1 presents a summary of existing and proposed habitat types. These acreages include only areas below the 100-year floodplain.

Under existing conditions, and with the exception of the riparian corridor, habitats are low functioning and support invasive fish and aquatic plant species. Existing habitats are largely disassociated with floodplain function and the riverine ecosystem. Following construction, restored habitats would better provide for native species and integrate with floodplain function and adjacent riverine habitat.

As a result of project implementation, three acres of low-quality aquatic backwater pool and channel habitat associated with the ponds and supportive of predatory non-native fish species and invasive water primrose would be restored to ten acres of riverine aquatic backwater pool and channel habitat via the channel analog features. Decreases in disturbed shrub/grassland habitat would balance with significant increases of seasonal wet meadow habitat. Existing poor-quality freshwater marsh habitat associated with the mining ponds would decrease as a result of project implementation, resulting in five acres of restored, functioning freshwater marsh following construction. The 135-acre open water footprint of the ponds would largely balance into increases of seasonal wet meadow and riparian forest habitats. Riparian forest habitat would increase from 112 acres to 135 acres (22-acre increase), while seasonal wet meadow would increase from four acres to 150 acres (146-acre increase). The footprint of riparian scrub habitat would remain unchanged at 42 acres. The resulting five acres of open water habitat is attributable to the water supply pond. The nine-acre increase in developed areas results from some of the public access enhancements, specifically planned parking areas.

Table 7.1 Existing and proposed habitat types (H.T. Harvey 2020)

Regulated Habitat Type	Existing Area (Acres)	Restored Area (Acres)	Change in Habitat (Acres)
Aquatic backwater pool and channel	3[1]	10	7
Disturbed shrub/grassland/developed	48	11	-37
Freshwater marsh	14	5	-9
Open water	135	5	-130
Riparian forest	112	134	22
Riparian scrub	42	42	0
Seasonal wet meadow	4	150	146
Total	**357[2]**	**357**	**0**

Notes:

[1] Existing aquatic backwater pool and channel habitat is associated with the ponds only and is not riverine habitat.

[2] Total project acres differ slightly from the overall project area of 358 acres, as only the footprint within the 100-year FEMA floodplain was considered during analysis.

7.3 Proposed Public Access Amenities

Following construction, public access amenities would be developed as part of a new Sonoma County River Park and River Trail facility with multiple public access points of entry. See Appendix G – Draft Hanson River Park and River Trail Design. The public access design would be integrated into the overall project design to ensure compatibility with planned restoration elements, final grading, and revegetation.

Planned public access features include seasonal camping sites and a non-vehicular boat portage trail near the northwest (upstream) corner of the HFRP area. A multi-use pathway/bikeway would align with Fontana Road and the eastern levee, extending to the downstream, southwest corner of the HFRP area. The multi-use pathway/bikeway would meet fire safe road standards. A seasonal riparian trail would link to the multi-use pathway/bikeway at both ends to create a loop. The seasonal trail would meander through the restored riparian corridor.

Access for maintenance and emergency vehicles would be incorporated into the design. Three parking areas are proposed – one at the camping sites, a second in the northeast HFRP corner off Fontana Road, and a third just north of the new water supply pond, accessed via Eastside Road. Parking areas would be Americans with Disabilities Act (ADA) accessible. All parking areas would be day use only unless associated with the seasonal camping sites. Double stall flood-proof pump-out restrooms would be located at parking areas. Gates would be installed at points of entry to regulate public access as needed (e.g., seasonal use or daytime only use).

7.4 Anticipated Long-Term Evolution of the HFRP Area

As designed and described in the Feasibility Study, the HFRP will restore connectivity between the mainstem Russian River and an expansive floodplain. Within the reconnected floodplain, two incipient channel features will be constructed to focus flood conveyance, and provide perennially backwatered, low-flow off-channel habitat. Given the depositional setting of the restored floodplain and the existing alluvial river system, the HFRP area is expected to be dynamic and self-evolving into the long-term future. Projections of long-term evolution require further evaluation via hydraulic and sediment transport modeling, and are recommended for incorporation into the 65% and 100% design iterations (see Section 13.2.2 – 65% Design Considerations).

7.4.1 Channel Evolution

Following construction, the channel features are expected to evolve in dynamic equilibrium in response to hydrologic conditions and sediment supply. The channels will be constructed as broad shallow features with a deeper low flow channel. Narrowing, widening and sinuosity is expected to evolve as the channels mature as an integrated part of the evolving revegetated riparian floodplain landscape. Deposition is expected to dominate channel evolution initially, with interior features, bar and pool complexes evolving from the upstream end as sediments prograde into the system during high flow events. Geomorphic processes, including local bed mobility and sorting, burial, scour and translocation of riparian vegetation, formation and movement of bar features will evolve over time as flood energy reworks the post-construction grading on the alluvial floodplain. Sediment deposition and thus bar formation is expected during high flow events. The channel features consolidate floodplain flows, and concentrate geomorphic processes within the forming floodplain channel complex. The floodplain system will be self-forming, and self-maintaining, with the expansive channels providing adequate room for lateral and longitudinal channel migration.

The floodplain channel template focuses flood flows and recession, providing fish-friendly hydraulic flow structure on the floodplain post-construction. Maintenance or repair is not anticipated. A mosaic of streambed and floodplain habitat is anticipated, with form dependent on sediment supply and flood energy. Post-construction, the floodplain template is likely to form a braded anastomosing channel complex providing abundant found source and shelter for aquatic and riparian species.

7.4.2 Mainstem Russian River Evolution and Expected Geomorphic Adjustment

Lowering and removal of the riparian berm and removal of existing levees surrounding the four ponds will re-establish connectivity between the mainstem channel and adjacent, restored floodplain. The mainstem channel through the HFRP area is expected to adjust as a result, resulting in improved riverine function and salmonid habitat quantity and quality over a range of streamflows. The HFRP seeks to restore an integrated alluvial river floodplain complex consistent with Russian River channel form prior to watershed development. Increased, sinuosity and dynamic form and alignment all correlate with increased channel and riparian complexity which benefit both salmonids and wildlife.

Mainstem capture onto the restored floodplain during a high flow event is possible and would result in increased sinuosity lateral migration of the Russian River. It is recommended that hydraulic modeling for the future 65% design iteration more thoroughly evaluate the potential for mainstem channel integration and potential implications for recreational access (e.g., incompatibility with planned public access enhancements) and neighboring properties and land uses).

Modeling completed as part of the Feasibility Study predicted geomorphic change following construction, including response in the Russian River and evolution of the restored floodplain for selected design flows. Results show the areas of greatest post-construction bed change would be the upstream floodplain inlet where a delta form is predicted, and the adjacent river channel where deposition is predicted. At the floodplain inlet, deposition of a delta between six and seven feet thick during simulated peak flows is predicted to be followed by a similar scale channel formation during flood recession. The predicted grain sizes transported by a 2-year to 5-year event were less than one inch and suitable for spawning. Resulting prolonged floodplain inundation would further support spawning habitat.

Upstream from the floodplain inlet, 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. The model predicts a decrease in sediment transport and deposition in the main river channel adjacent to the floodplain. The main river channel would likely be predominantly depositional but would continue to alternate between deposition and transport until a new equilibrium is reached between streamflow and sediment transport on the floodplain.

Under existing conditions, the Russian River is actively incising, and transports a relatively high suspended sediment concentration. Mobile suspended sediment size plots predict that deposition of suspended sediment varying from fine sand to silt would likely occur over the floodplain. Creating a deposition zone where riparian vegetation is becoming established would result in many environmental benefits in the reach and downstream. Restoring floodplain depositional processes is one of the goals of the HFRP, leading to improved downstream water quality, valuable habitat-building substrate, and increased channel complexity.

Modeling completed to date indicates the current trend of progressive scour of the river bed and banks adjacent to the floodplain would be 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. Velocities in the current river channel would be reduced significantly, which in turn would significantly increase the potential for alluvial gravel deposition, and the value of spawning habitat and winter, spring and summer rearing and recruitment habitat of the existing river channel.

7.4.3 Floodplain Evolution

The restored floodplain is expected to be predominantly depositional, although local scour and fill would be expected in some locations (e.g., upstream end of the HFRP area). The restored floodplain supports natural sediment and nutrient depositional processes in ecologically desirable locations. A deposition zone for suspended Russian River sediment will improve water quality downstream from the HFRP 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 HFRP.

Following winter/spring high flow events and associated sediment sorting/deposition and vegetation establishment, floodplain topography would adjust over time, increasing in variability. During the future 65% design iteration, hydraulic analysis is recommended to assess expected floodplain hydrodynamics to maximize the degree to which the floodplain (or portions thereof) is expected to inundate to provide vital salmonid habitat at target life stages and refine surface elevations as needed to ensure inundations goals are achieved. In addition to floodplain channels, additional backwater or high flow secondary channels may naturally form as permanent or transient features.

7.4.4 Large Wood

Large wood would be incorporated into floodplain and potentially the mainstem channel design during construction. Over time, large wood and/or large wood habitat structures are expected to evolve, and function as a locust for the accumulation of wrack and retention of naturally born large wood. Depending on the final design and bed mobility around installed large wood, large wood may mobilize and migrate downstream during high flow events. Large wood designed as key pieces cultivate sediment capture and bar formation, increasing channel complexity. Following completion of initial construction, long-term large wood maintenance or augmentation may be recommended as an adaptive management measures to accelerate development ecologically complex floodplain habitat.

7.4.5 Riparian and Upland Vegetation Evolution

The proposed restored floodplain and associated uplands will support a large and diverse gradient of native flora and fauna, and will be monitored and adaptively managed towards a goal of self-sustainability. Following restoration, floodplain vegetation is expected to be predominantly seasonally-wet meadow as a result of the target seasonal low groundwater relationships. Riparian trees will naturally regenerate in floodplain bars and along mainstem channel and floodplain channel margins, and geomorphically interact with channel and floodplain project elements and provide salmonid habitat, cover, and food sources. With the expansive and geomorphically dynamic floodplain activated, the width and species diversity of the riparian corridor will expand across the floodplain. This is a significant benefit when compared to linear stands in pre-project conditions. Both upland and floodplain vegetation are expected to be self-maintaining. As a permit condition, vegetation monitoring is likely to be required for a period of five years to ensure survivability. If upland survivability is poor, some replanting or maintenance may be required to achieve compliance. Following the permit compliance window, no long-term vegetation maintenance would occur.

Construction and revegetation methods will be designed to minimize the potential for invasive species by promoting conditions favorable to desired native species and effectively eradicating weed sources and invasive species during implementation. However, invasive species may inevitably establish across the HFRP site to varying degrees. Long-term maintenance and removal of invasive species would occur as part of adaptive management to the extent practical and subject to available funding and resources.

7.4.1 Anticipated Changes in Salmonid Habitat

As described in the Feasibility Study, salmonid habitat for rearing juveniles is predicted to increase by more than an order of magnitude. Spawning gravel deposits are anticipated to form around the upstream entry to the floodplain, and in the existing and restored floodplain channels where current annual floods scour gravel deposits.

As a result of post-construction variability of floodplain elevations and bar features (mainstem and within the floodplain channels), increases in habitat availability are expected during all streamflow conditions to benefit all life stages for Chinook Salmon, Coho Salmon, and Steelhead. Hydraulic modeling is recommended during the 65% design iteration to confirm constructed floodplain elevations appropriately correspond with key streamflows and target life stages.

Given the restored floodplain and the mainstem channel are expected to be dynamic and self-maintaining, increases in salmonid habitat are also expected to persist through time. During high flow conditions, newly available floodplain and off-channel habitats will greatly increase the amount of refugia habitat available to juvenile salmonids. Lower streamflow velocities in the mainstem would reduce the risk of red scour, and increased availability of spawning habitat would reduce the risk of red superimposition.

8. PROJECT CONSTRUCTION

8.1 Earthwork Volumes and Site Grading

One of the primary design criteria described in the Feasibility Study was to balance on-site cut and fills and eliminate the costly expense of importing soil from a currently undefined source. The Feasibility Study reported a total cut volume of approximately 4,700,000 cubic yards with an equivalent fill volume, and it was implied that the unit volume of cut material would be equivalent to a unit volume of placed fill material. Based on the geotechnical investigation (MPEG 2020), this assumption remains an overall achievable criteria. However, due to the large amount of earthwork, volumes associated with the HFRP, anticipated volumetric change (bulking and shrinkage) during excavations, and backfill, the final design will need to be further refined, specifically as it relates to target floodplain elevations and settlement in the deep pond fills. This is further discussed below along with preliminary findings from MPEG (2020).

8.1.1 Clearing and Grubbing

Clearing and grubbing would occur prior to excavation and pond filling. Existing vegetation would be salvaged for on-site replanting to the extent practical and in support of the revegetation plan. Existing vegetation that cannot be salvaged or is not needed for revegetation efforts would be buried in the ponds or chipped for on-site mulch. Areas reserved for vegetation salvage would be identified during future phases of design. Similarly, areas of existing riparian vegetation to be protected during clearing and grubbing, control of weed sources and burial of invasive plant materials would also be identified during future phases of design.

8.1.2 Excavation

Based on subsurface explorations, site excavations will likely encounter medium stiff to stiff clays and loose to medium dense silts and sands in the upper 10 to 15 feet. The levee adjacent the Russian River and the native undisturbed soil are primarily medium dense to dense sands and alluvial gravels.

The methods of excavation will vary based on proximity of the cut to the final fill location and groundwater elevation. Excavations of soil to within about two to three feet above the groundwater will likely be completed with traditional grading equipment (scrapers, dozers, and excavators). Excavation of soil from a few feet above to a few feet below the groundwater level will likely be accomplished with excavators working from higher elevation, excavating soil to planned grades, and loading into trucks from above, at higher elevations. Additionally, low ground-impact dozers (e.g., swamp dozers) could be used to excavate and push soil down to and slightly below the groundwater level. Draglines could also be used for excavation within this zone.

8.1.3 Fill Placement and Compaction

Most of the excavated material will be placed directly into the ponds, however some will also be used to re-contour the floodplain banks. The fill placement approach for these two locations will require different placement methods and compaction efforts. Of the total placed fill volume, approximately 15% will be placed outside the ponds to re-contour the floodplain banks and 85% placed within the ponds.

Filling of the ponds will likely be completed by dozing material in from the edges, dumped from draglines, dumped by trucks or a conveyor belt system supported on a barge. Below-water fill will be loose and settle during placement using swamp dozers or draglines. Above the water table, traditional equipment will be used. The elevation of the fill will need to be several feet above the design grade during placement. The surface would then be cut down to planned grades following a period of consolidation. Care should be taken to not over compact the finish floodplain surface to promote revegetation and sorting of floodplain surface materials. Surficial floodplain fill placement under these placement methods should correspond with relative compaction between 70 to 80%.

Fill for placement in the re-contoured floodplain banks should be moisture conditioned and placed loosely with horizontal lifts limited to 12-inch thickness and compacted to at least 85% relative compaction. As with pond fill, care should be taken to not over compact the finish graded surface to promote revegetation. Fill and compaction of park facilities will require traditional geotechnical stabilization criteria to minimize long term maintenance.

8.1.4 Volumetric Changes with Excavation and Backfill

As described above, the Feasibility Study established the design criteria to achieve a net balance of on-site cut and fill. The variability in soil type, loading (thickness of fill) and degree of compaction all influence the volumetric change and ability to achieve an on-site net balance. MPEG (2020) provided preliminary estimates of bulking and shrinkage below, however as a next phase of analyses recommended a laboratory testing program that would include compaction curves, bulking under water, and consolidation tests to refine estimates of grading quantities. Below are preliminary estimates which support a net balance for the current Feasibility Study design.

For excavation of on-site soil placed as compacted fill (85 to 90% relative compaction) to re-contour the floodplain banks outside of ponds and above the groundwater, an estimated volume change of 0 to 10% shrinkage is anticipated. This indicates a cut:fill ratio ranging from 1:1 to 1.10:1. In short, the compacted fill areas could require up to 10% more cut volume to achieve the equivalent fill volume. As described above, of the total placed project fill volume, approximately 15% will be placed outside the pond to re-contour the floodplain banks, which is small relative to the remaining 85% that will be used to fill the ponds, as described below.

For excavation of on-site soil placed as loose dumped fill into ponds, the estimated bulking volume change of 20 to 40% “fluff” or “expansion” can be expected. Once fill heights exceed the water table elevation, compression and consolidation of the fill will occur. The amount of compression (settlement) will range based on the soil type, saturated thickness, and load (depth of fill). Approximately 10% compression at shallow depths (less than 10 feet) and roughly 30% compression at depths of 30 to 40 feet can be anticipated. These preliminary ranges generally indicate the density of the placed fill in the pond will be initially less than the in-situ density of the excavated soils. Time required for post construction consolidation to occur varies with soil type. For clean sands and gravels, the consolidation will occur relatively fast with rough estimates of several months to a couple of years. To accelerate consolidation and avoid long-term floodplain settlement uncertainty, surcharging the pond areas with several feet of additional fill above planned grades for a minimum of 6 months and a dry season is recommended to accelerate post-construction settlement, and result in final grades closer to the desired plan elevations. Based on the above information and unlike the compacted fill to re-contour the floodplain banks, the pond fill areas could require less cut volume to achieve the equivalent fill volume. As noted above, an additional laboratory testing program is recommended to further refine the volumetric changes. The current use of a 1:1 (cut:fill) ratio for fill placed above water and some net bulking of fill placed below the water level remains appropriately conservative for the 30% design effort.

8.1.1 Soil Segregation

To support revegetation, soil segregation during construction would be required to ensure topsoil is compatible with the final revegetation plan. As recommended in the 30% revegetation design (see Appendix E – 30% Revegetation Design), the grading plan should be crafted to create soil conditions well-suited for establishment of the target vegetated habitats both on the floodplain and slopes (H.T. Harvey 2020).

Achieving desired soil conditions increases the likelihood of target habitat establishment and reduces the potential for invasive weed dominance and associated vegetation maintenance costs. Desired final soil conditions vary throughout the HFRP area. Riparian habitat requires a contiguous vertical profile of well-drained coarse sediments with low compaction, from the surface to the shallow groundwater table (H.T. Harvey 2020). In contrast, wet meadow habitat on floodplains requires finer textured top soils within topographic depressions (H.T. Harvey 2020).

In soil segregation, the finer grained soils are segregated for reuse in the upper lightly compacted fills along the re-contoured floodplain banks with the balance of the material placed as backfill in the ponds. Segregation of top soil would need to be considered in next phase of design (see Section 13 – Next Steps).

8.2 Invasive Plant Removal and Burial During Grading

Invasive plant propagules (seed and viable meristematic tissue) will be removed during grading. The existing terrestrial topsoil in many locations likely has a substantial weed seed bank in the upper portion of the soil profile (e.g., upper 1-2 inches) (H.T. Harvey 2020). Earthwork/clearing and grubbing will be designed to remove and bury the existing weed seed bank at least several feet below the design grade.

Following revegetation design recommendations from H.T. Harvey (2020), heavy equipment, such as bulldozers or excavators, will be used to mechanically remove invasive plant infestations from the HFRP area. Eradication of perennial or woody species (e.g., giant reed and Himalayan blackberry) using this technique may be difficult because deep rhizomes and root fragments must be removed from the soil to prevent resprout. Invasive plant material excavated from uplands will be buried in the bottom of the ponds. Existing invasive aquatic vegetation in the ponds (e.g., water primrose) should also be buried on-site well below the design grades.

After grading is complete, invasive plants will be actively managed throughout the HFRP area to allow native riparian and wetland vegetation to establish and exclude colonizing invasive plant species. An invasive plant management plan will be developed and implemented to prevent the introduction and spread of invasive plants, effectively track existing infestations, detect new infestations early, and provide effective control measures.

8.3 Revegetation

The revegetation strategy is based on a restored floodplain surface designed to support hydrologic and geomorphic processes that facilitate the natural colonization of wind- and water-dispersed native riparian-wetland obligate plant species, combined with active (direct planting) upland revegetation (see Appendix E – 30% Revegetation Designs; H.T. Harvey 2020).

Vegetation growth quickly enhances biological productivity of fish prey species, and interacts 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 to evolve and improve habitat quality for native fish and wildlife.

Revegetation requires implementation of a variety of methods, specific to revegetation zones and target habitats, summarized in Table 7.1. In addition to passive floodplain colonization, revegetation methods recommended include seeding, sod translocation sprigging, cutting, live wood transplants, and direct planting of container stock. Existing riparian vegetation would be preserved to minimize potential impacts to the extent feasible.

Table 7.1 Revegetation Methods by Zones and Target Habitats (From H.T. Harvey 2020)

Revegetation Method	Revegetation Zone – Target Habitat					
	Floodplain Seasonal Wet Meadow	Floodplain Aquatic Backwater Pool and Channel	Floodplain Freshwater Marsh	Lower Slope Riparian Scrub	Mid-Slope Riparian Forest	Upper Slope Riparian Forest
Seeding of herbaceous wetland species	x	x	x	x		
Seeding of herbaceous upland species					x	x
Seeding of acorns and California buckeye					x	x
Sod (rootmat) translocation	x		x			
Vegetative sprigging	x		x			
Cuttings				x		
Livewood transplants				x		
Livewood transplants					x	x
Container plants					x	x

8.3.1 On-site Sod Farm

To support revegetation, stands of native wet meadow species currently would be salvaged and amplified at an on-site sod farm to increase the amount of native wet meadow sod that can be used during revegetation (H.T. Harvey 2020). The on-site sod farm would be located on graded benches at the final construction phase area (Mariani Pond) where groundwater and irrigation are available. The sod fragments would be transplanted from the sod farm onto the floodplain seasonal wet meadow and freshwater marsh revegetation zones. Salvaged material would be harvested in fall and transplanted and grown at the on-site sod farm. After one or two growing seasons, sod would be harvested from the sod farm and planted across the floodplain surface during each construction phase (see Section 8.4 for a description of construction phasing; H.T. Harvey 2020). Additional planting of sod blocks may also be undertaken in adaptive management

8.3.2 Floodplain Revegetation

The revegetation strategy is based on a restored floodplain surface designed to support hydrologic and geomorphic processes that facilitate the natural colonization of wind- and water-dispersed native riparian-wetland obligate plant species (see Appendix E – 30% Revegetation Designs; H.T. Harvey 2020). Due to the large surface area of the floodplain and associated costs of active revegetation, the recommended primary strategy for establishment of native woody obligate riparian habitat on the restored floodplain is passive, natural recruitment (H.T. Harvey 2020). As discussed above, the HFRP's floodplain elevation would be raised by approximately one foot to better support passive colonization of target floodplain habitats (e.g., a mosaic of willow/cottonwood riparian and wet meadow habitats). 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 saturated, low-flow channels, and floodplain backwater area at the downstream confluence. By restoring floodplain connectivity and reducing the depth to groundwater, the proposed grading would establish high-quality wetland and riparian habitats that are dominated by locally appropriate, native species (H.T. Harvey 2020).

As described in the revegetation design, the rate of natural recruitment of willow, cottonwood, and mulefat could be increased at low cost via harvest and installation of cuttings in strategic locations (H.T. Harvey 2020). If feasible, stands of native wet meadow species (e.g., willows, sedges, rushes, and grasses) would be salvaged, stored, and transplanted on the graded floodplain using heavy equipment. Successful establishment can be increased by transplanting large intact clumps of plant material that is matched with appropriate topographic positions and depths to groundwater. In addition to transplanting, heavy equipment can be used to spread and partially bury rhizome masses of wet meadow species in the constructed backwaters of the floodplain (H.T. Harvey 2020).

Herbaceous vegetation can be established by drill seeding or hydroseeding, depending upon the location within the HFRP area. The relatively flat floodplain and gentler bank slopes would be conducive to use of a seed drill where soils and not gravels are present. Hydroseeding would be applied to any slopes that are 5H:1V or steeper (H.T. Harvey 2020).

Revegetation species that may not readily colonize the site on their own could be actively revegetated to accelerate riparian habitat establishment. Restored emergent/seasonal wet meadows in constructed floodplain backwaters could support hardstem and California bulrush (*Schoenoplectus [acutus, californicus]*) marshes, pale spike rush (*Eleocharis macrostachya*) marshes, dense sedge (*Carex densa*) marshes, Baltic and Mexican rush (*Juncus arcticus [var. balticus, mexicanus*]) marshes, valley sedge (*Carex barbarae*) beds, and meadow barley (*Hordeum brachyantherum*) patches. The surrounding scrub shrub/riparian forest wetland could support white alder (*Alnus rhombifolia*) groves, sandbar willow thickets, red willow thickets, mulefat thickets, cottonwood forest, and box elder (*Acer negundo*) forest (H.T. Harvey 2020).

8.3.3 Upland Revegetation

The primary strategy for establishment of native valley oak woodland on slopes and upland areas should be active planting of nursery grown stock and 3-5 years of plant establishment maintenance (e.g., irrigation, weed control, browse protection). A variety of native trees and shrubs that currently occur on and near the HFRP area should be established. The valley oak woodland habitat should be designed to provide sufficient buffer to protect the floodplain riparian and wetland habitats from the surrounding agriculture and urban development (Semlitsch and Bodie 2003 cited in H.T. Harvey 2020). The locations where each plant species could be established would be based on the predicted post-construction soil texture, plant-available soil moisture, and water availability. To maintain local genetic diversity and integrity, all propagules (seeds, cuttings, and root masses) should originate from the HFRP area or similar sites within the Russian River watershed and from locations with soils, elevations, and hydrology that is similar to the HFRP area. A nursery contract would need to be established at least 12 months prior to the time of container plant installation to allow sufficient time to collect propagules and ensure they have sufficient growing time in the nursery prior to installation. All propagules should be sourced from healthy plant material to reduce the potential for the spread of plant pathogens such as *Phytophthora* species. Container stock should be sourced from nursery stock grown in accordance with established *Phytophthora* prevention best management practices (BMPs) to prevent the introduction of infested plant material and soil at the HFRP area. The California Oak Mortality Task Force provides a set of applicable guidelines to minimize *Phytophthora* pathogens in restoration nurseries and projects (Working Group for Phytophthoras in Native Habitats 2016a and 2016b cited in H.T. Harvey 2020).

The upland slope habitat would be actively restored by planting and maintaining (for a 3-5 year establishment period) native riparian woodland tree, shrub, and herbaceous species. Restored upland slope habitat could support valley oak woodland and coast live oak woodland, which could include Oregon ash (*Fraxinus latifolia*) groves, California buckeye (*Aesculus californica*) groves, blue elderberry (*Sambucus cerulea*) patches, coyote brush scrub, and California rose (*Rosa californica*) patches.

8.4 Construction Sequencing and Phasing

As a result of recommendations from the geotechnical (MPEG 2020) and groundwater assessments (LSCE 2021), the project would be constructed using a phased approach. The pace of construction will be constrained by soils saturation and pond water management and lateral transmissivity with the Russian River. Phasing construction would allow for a gradual blend through sub-surface lateral flow between the ponds and the Russian River, reducing potential construction-related impacts to the riverine environment and Town of Windsor groundwater wells. Phasing construction will also be used to accommodate anticipated water quality requirements relative to the downstream zone of dilution for turbidity, methylmercury, and other water quality constituents of concern, avoiding potential impacts. Construction would be segmented into phases spanning at least four years of construction. Each year of construction is assumed to span 120 days during the dry season. A longer, or year-round, construction season may be feasible given the history of year-round mining operations on the HFRP site. Opportunity for year-round work should be investigated in subsequent design phases and follow-on agency consultation. Each partially completed phase would be subject to overwinter flood flows. Hydraulic modeling of the proposed phases to assess the stability of partially completed phases, and the feasibility of wet season work would need to be completed as part of the 65% design. It is most likely, that construction would start at the downstream end of the HFRP area, working toward the upstream end. However, the sequence will be subject to the results of the aforementioned hydraulic modeling. Each year, one pond would be backfilled and surcharged with several feet of fill to accelerate settlement. The following year, any surcharged material above the finished floodplain grade would be removed, if needed. Some double handling may be required to remove any excess material, placing it in a final location. Final grading would be completed, including grading to the margin of the Russian River.

Table 7.2 shows one scenario starting on the downstream end and progressing upstream. This scenario would start with backfilling Vimark Pond in Phase 1. During the following year, Phase 2 construction would complete finish grading and revegetation at Vimark Pond and backfill Richardson Pond. During Phase 3, finish grading and revegetation at Richardson Pond would be completed, following by initial filling of Piombo Pond and Mariani Pond. During the final year of construction, finish grading and revegetation would occur at Piombo Pond and Mariani Pond. Following completion of Phase 1, this approach would be revisited and production rates would be altered as deemed appropriate. The final construction phasing will be based on follow-on hydraulic modeling and considerations to minimize impacts to Town of Windsor water supply wells and Russian River water quality.

Volumes for each phase of construction are summarized in Table 7.3. Volumes assume an in situ density equivalent to placed density. Cut and fill balances for each phase as well as the project overall. Off-site disposal of excavated material or on-site importation of additional fill would not be necessary.

Table 7.2 Construction sequence scenario from down- to upstream.

Phase	Description	Year 0	Year 1	Year 2	Year 3	Year 4
0	Reclamation Plan stabilization between Piombo and Mariani ponds	▨				
1	Vegetation removal/salvage Vimark Pond; set-up on-site plant propagation		▨			
1	Backfill Vimark Pond		▨			
1	Finish grading; Vimark Pond revegetation			▨		
2	Vegetation removal/salvage Richardson Pond			▨		
2	Backfill Richardson Pond			▨		
2	Finish grading; Richardson Pond revegetation				▨	
3	Vegetation removal/salvage for Piombo and Mariani ponds				▨	
3	Backfill Piombo and Mariani ponds				▨	
3	Finish grading; Piombo and Mariani ponds revegetation					▨

Table 7.3 Approximate Earthwork Volumes (Assumed In situ Density Equivalent to Placed Density)

Phase	Zone	Cut Cubic Yards	Fill Cubic Yards
1	Vimark Pond	1,300,000	1,300,000
2	Richardson Pond	1,800,000	1,800,000
3	Piombo Pond and Mariani Pond	1,600,000	1,600,000
Total		**4,700,000**	**4,700,000**

8.5 Construction Considerations and BMPs

8.5.1 Sensitive Species Impact Avoidance and Minimization

As part of the special status species assessment, Appendix C identifies special status species that may occur in the HFRP area. It also includes recommended avoidance and mitigation measures to protect sensitive species from potential impacts associated with construction. Potential impacts identified pertain to the project in general and are not specific to the project alternatives. Mitigation measures and BMPs listed are conceptual and likely need to be modified and expanded as the design is developed and additional analysis is conducted. Avoidance and minimization measures would be refined during the HFRP's CEQA and permitting phase (see Section 11). Mitigation measures would be developed and integrated into the project for any potential impacts that could be considered significant.

- **Special Status Plants.** Potential measures to protect special status plants would include pre-construction surveys. Seed collection would be recommended for any special status plants that could not be avoided.

- **Special Status Amphibians and Reptiles.** Pre-construction surveys are also recommended for special status amphibians and reptiles. If encountered, relocation of special status amphibians and reptiles to suitable habitat would occur as directed by CDFW.

- **Special Status Birds, Raptors, and Bats.** Pre-construction surveys for special status birds, raptors, and bats are recommended. Active bird nests or bat colonies/roosts would be buffered in coordination with qualified biologists and CDFW staff. Removal of vegetation during the non-nesting season would be completed to the greatest extent practical.

- **Special Status American Badgers**. Pre-construction surveys are recommended for American Badgers (*Taxidea taxus*). Active burrows would be buffered in coordination with qualified biologists and CDFW staff.

- **Special Status Salmonids**. Riverine in-channel work would be limited to the regulated in-water work period. While unlikely, salmonids could be assumed present in the ponds. Measures to protect salmonids would be further refined through project permitting and consultation with NMFS under Section 7 of the ESA. The HFRP will also need to be permitted by the CDFW under the California Endangered Species Act (CESA) for salmonids.

8.5.1 Dewatering and Aquatic Species Relocation

As detailed in Appendix C – Special Status Species Assessment, if dewatering is required for any work areas, pump inlets will be screened, and coffer dams or barrier nets would be placed to block off the area. Any native fish remaining inside the coffer dams or barriers would be carefully removed by a qualified biologist.

Initial relocation and isolation measures for special status fish is anticipated during grading operations juxtaposed to the active river channel. To minimize potentially adverse effects to aquatic organisms, all translocation/removal of fishes would be conducted by qualified fisheries biologists. Any fish that cannot be herded by seines from the work areas and must be physically handled would be immediately released in suitable habitat away from the work area, with comparable habitat and water quality conditions. Immediately following completion of in-channel work, any cofferdams or block nets would be removed allowing free fish passage through the HFRP area during the remainder of the construction period.

8.5.2 Water Management

Given the pond bottoms are below the river thalweg and regional seasonal low groundwater levels, dewatering of the ponds by pumping down during backfilling is not feasible. As previously described, although the dominant groundwater gradients are north to south, filling the ponds creates a potential gradient for lateral sub-surface flow towards the Russian River during backfilling operations. If lateral sub-surface flow towards the Russian River is less than LSCE (2021) estimated pond fill rates, some pumping of pond water may be necessary to avoid elevating pond water levels that could slow construction efficiency and/or alter groundwater gradients. Pumped pond water could be discharged to an adjoining pond, or infiltrated into an upland site or restored floodplain. Pumping directly to the Russian River will likely not be feasible do to the anticipated elevated turbidity in the pond water relative to the receiving Russian River. Any direct or in-direct (lateral sub-surface) discharge of pond water into the Russian River would require compliance with the North Coast Regional Water Quality Control Board (NCRWQCB) 401 water quality certification, which would include turbidity limits and/or an established zone of dilution (see Section 10.2 – Anticipated Regulatory Permits). Recommended BMPs to reduce potential water quality impacts to groundwater and receiving surface waters are described below.

- Conduct surface and groundwater monitoring during construction and adjust BMPs described below to maintain compliance with regulatory permits and avoid off-site impacts. At a minimum, this would include groundwater monitoring in the existing well between the Piombo Pond and Town of Windsor wells per LSCE (2021) and anticipated surface water monitoring in the Russian River per the 401 water quality certification.
- During backfilling of the Piombo and Mariani ponds, monitor pond levels to avoid potential rise from displacement and alteration to the groundwater gradient towards the Town of Windsor wells and pump pond water as needed to maintain levels during backfilling. Depending upon the construction sequencing of other phases, the pumped pond water could be discharged to the Richardson pond or infiltrated across the restored floodplain.
- Install turbidity curtains in the ponds during initial pond filling activities to minimize potential for migration of higher turbidity pond water to the Russian River and Town of Windsor production wells. The optimum placement of the turbidity curtains would be on the west side of Vimark, Richardson and Mariani ponds, and on the west and north sides of Piombo Pond. If turbidity curtains are installed, filling would start on the eastern or southeastern sides of the ponds to maximize the distance turbid pond water has to migrate within the ponds to reach the edges of each pond nearest the sensitive receptors (i.e., Russian River and Town of Windsor production wells; LSCE 2021).
- Alternatively, without use of turbidity curtains, filling the ponds could start on the western side of each pond closest to the Russian River and northern side of Piombo Pond closest to the Town of Windsor wells, thereby resulting in the initial addition of a greater thickness of sediments between the remaining pond area, the Russian River, and Town of Windsor production wells to provide greater filtration and travel times through sediments before reaching groundwater resources (LSCE 2021).
- Coordinate with the Town of Windsor to shift well field pumping to the three northernmost wells (Wells 9, 10, and 11) during filling of Mariani and Piombo ponds. This would shift the pumping depression as far away from the ponds as possible and decrease the potential for flow from the ponds toward the wells.

As described by LSCE (2021), construction during winter months would be subject to gaining water table conditions (i.e., sub-surface flow from the Russian River towards the ponds). Thus, wet season operations could reduce potential for impacts to the receiving Russian River, however overall water levels would likely be higher relative to summer conditions. The contractor awarded the construction contract will need to develop a water management plan describing their means and methods of managing on-site water consistent with the measures described above and project permits.

8.5.3 Erosion and Sediment Control BMPs

The HFRP will fall under the National Pollutant Discharge Elimination System (NPDES) storm water requirements for construction activities as more than one acre will be disturbed. Therefore, a Stormwater Pollution Prevention Plan (SWPPP) will likely be required and implemented in accordance with NPDES requirements and Permit Sonoma requirements for grading and environmental protection. The SWPPP and project design should be developed concurrently so as to develop an overall project approach that can minimize vegetation disturbance and minimize the erosion potential and need for costly BMPs during construction. The final plans should include an erosion and sediment control sheet(s), which are then referenced and added to in the SWPPP. The erosion and sediment control sheet(s) would then convey the overall erosion and sediment control strategy and would be beneficial for various agencies reviewing the project, such as the 401 water quality certification from the NCRWQCB. The final design and accompanying SWPPP will detail the location and maintenance of erosion and sediment control BMPs. Common BMPs that may be applicable to the planned work include:

- **Erosion Control BMPs:** seeding, straw mulching, geotextiles, plastic covering (during temporary material storage only), erosion control blankets and mats, and wood mulching.
- **Sediment Control BMPs**: silt fencing, fiber rolls, sediment basins, silt curtains, and check dams.
- **Tracking Control BMPs**: stabilized construction entrance/exit and stabilized construction roadway and haul routes.
- **Good Housekeeping BMPs:** solid waste facilities, sanitary facilities for workers, and designated fueling and maintenance areas away from the channel.

9. CONSTRUCTION COST

9.1 Opinion of Probable Cost (OPC)

An opinion of probable cost (OPC) was developed for the project based on the 30% design plans and quantities, and can be used for planning and budgeting purposes. The OPC is available in Appendix H. The OPC consists of a combination of estimated labor, equipment and materials necessary to implement the current design. An estimating contingency was included in the OPC to account for material and construction cost volatility and uncertainties given the early planning phases of the HFRP. OPC unit costs are based on recent bid results of similar projects and the basis of professional experience. Construction costs associated with river restoration projects are difficult to estimate given the unique nature of work and lack of applicable industry standard construction estimating resources, such as RSMeans data. Site conditions such as a high groundwater and the presence of endangered species increase construction costs. The risks associated with working in these environments are much higher relative to typical construction projects. Project construction costs are subject to variations in contractor bidding, labor rates, material costs and availability, permitting conditions, site accessibility, general economic pressures, and other unforeseen costs associated with a project in the current planning level. Given these potential variations, GHD makes no warranty, express or implied, that actual project costs will not vary from the provided OPC.

The total project cost is extremely sensitive to the unit cost for excavation and placement of fill. The unit cost reported, was based on bid results from similar earthwork projects and discussions with colleagues. Water management and other environmental protection measures are difficult to develop costs for at this project stage. The permitting, design, and construction requirements associated with these elements will have potentially large impacts on actual bid results. The list below provides items that were not included in the OPC, but should be considered and included as part of the overall project budget.

- CEQA, Permit application preparation and agency consultation;
- Public outreach;
- Entitlements, Construction Easements and Outstanding Reclamation Obligations;
- Final Design and Engineering;
- Bidding assistance;
- Construction management services;
- Biological and cultural resource monitoring; and
- Long-term management and maintenance.

As the design and regulatory approval processes evolves the costs associated with the above items will be better understood and should be considered for project planning budget purposes.

10. ADAPTIVE MANAGEMENT FRAMEWORK AND MONITORING

Given the large scale of the project, the variety of habitats and hydrologic conditions, the high initial disturbance to the ecosystem, interactions with former land uses (gravel and sand mining), adjacency to groundwater wells, and typical level of uncertainty associated with the evolution of ecosystem restoration projects, the HFRP will benefit from an adaptive management program. Adaptive management is a systematic and iterative process that provides for feedback between monitoring and management actions. The feedback mechanism is engaged when monitoring data are analyzed, and the results are utilized to adjust project operations in a manner that optimizes the achievement of project goals.

Adaptive management assumes that a level of uncertainty with respect to the range of potential changes associated with restoration activities. Adaptive management is essentially a process by which scientifically driven, hypothesis-based decisions are brought forward in a management plan context, and information gained through plan implementation is then used to refine and improve the original decisions, in a positive feedback loop.

Adaptive management employs a structured approach, yet it is also a flexible tool that can adjust to a dynamic environment and an evolving project. Adaptive management can thereby keep a project ‘on track’ toward meeting its goals and objectives, despite the variability inherent in dynamic, natural systems over spatial and temporal scales. Adaptive management assists managers in responding to unanticipated changes in the various components of a project such as hydrology, sedimentation, target habitat development, or changes in the species' response along a restoration trajectory (NRC 2004).

The adaptive management framework is driven by the project goals and objectives together with the regulatory permit requirements. The process includes identification of initial monitoring activities proposed to evaluate project progress towards meeting the goals and objectives, establishment of triggers or thresholds that would initiate a management response and predicted ranges of potential adaptive management actions. If adaptive management monitoring determines that a trigger has been "activated," three possible response pathways result:

- Determine that more data is required and continue (or modify) monitoring;
- Identify and implement a remedial action; or
- Modify project goals and objectives (this option would *only* be considered as a last resort and upon careful consideration by and consensus of project participants).

Monitoring is a key component of the adaptive management framework. The development of baseline data allows triggers, even if rudimentary, to be developed which are integrated into the overall environmental monitoring program. If triggers are exceeded, potential impacts can be reviewed and the flexible mitigation plan can be adapted to limit the observed impacts. While all steps of the adaptive management schematic presented above may not be relevant to the HFRP, the importance of initiating a monitoring plan as part the implementation is important and will likely be requested by the regulatory agencies.

Under an adaptive management framework, there may be multiple management action options when a particular trigger or threshold is activated, depending on a variety of factors such as how far the project is from achieving a specific goal, whether the situation is an imminent threat to local infrastructure, ecosystem services/functions, or site stability, etc. The adaptive management process would apply to the project as a whole, but management actions can be identified and implemented on individual reaches or sub-reaches, as needed. The process is flexible as it allows for a wide range of management actions but just as importantly it imposes a structured approach as management actions must derive from monitoring results. The adaptive management process also accommodates different physical and temporal scales for management actions.

At a minimum, adaptive management would need to address mandatory compliance monitoring. As the final property owner and/or responsible party has yet to be determined, any adaptive management plan would need to be crafted flexibly as not to unintentionally hinder advancement of implementation planning and construction. The recommended initial step of a future adaptive management framework specific to HFRP is to identify the responsible party. Recommended components of an adaptive management plan for the project would include:

- Adaptive management goals, objectives, and thresholds for action;
- Roles and responsibilities, describing who is responsible for funding, implementing, and reporting adaptive management monitoring and results;

- A detailed monitoring plan for each discipline (e.g., geomorphic response, revegetation success, fish use, etc.), including field and analytical methods as well as thresholds and/or triggers for adaptive management;
- A site plan depicting the location(s) of proposed annual maintenance and/or adaptive management activities, including applicable APNs and property owner names for all proposed work sites and associated construction areas;
- A description of the type(s) of proposed annual adaptive management activities;
- Cross sections, maps, and associated calculations as necessary that accurately depict the proposed annual maintenance/adaptive management work area(s);
- Any necessary biological and botanical surveys needed for approval of annual maintenance/adaptive management activities;
- Site specific revegetation objectives, specific to the timeframe of the adaptive management plan (e.g., 5 to 10 years); and
- A schedule for proposed annual maintenance/adaptive management activities.

Project-specific adaptive management considerations are summarized in Table 9.1. At minimum, project elements link directly to project objectives as detailed in Section 2 – Project Goals and Objectives, in addition to likely regulatory requirements.

Table 9.1 Project-specific adaptive management considerations

Project Element	Evaluated objective
Geomorphic response	• Reversal of mainstem channel incision and geotechnical bank failure • Increased habitat-forming geomorphic processes • Post-construction floodplain elevation and groundwater response successfully support desired vegetation type (seasonal wet meadow)
Flood elevation response	• Flood elevations do not increase and potentially decrease
Fisheries response	• Naturally control non-native salmonid predators • Creation of specific habitat types by life stage and location within the HFRP area (main channel and floodplain)
Aquifer restoration response	• Improve groundwater quality and quantity
Water quality response	• Improve surface water quality conditions within the HFRP area and downstream and reduce the generation and transport of constituents
Vegetation community response	• Restore and enhance natural floodplain vegetation by desired habitat types
Regulatory requirements	• Required revegetation ratios and associated success criteria are achieved • Post-project stormwater obligations and erosion control BMPS are met

11. CEQA AND PERMITTING

The HFRP will require completion of the CEQA and federal, state, and local permits. While anticipated CEQA and permitting pathways are summarized below, pre-application coordination with the CEQA Lead Agency (Sonoma County) and permitting agencies is recommended. Pre-application coordination would best facilitate any design refinements or adjustments to planned construction approaches that may be necessary to ensure regulatory requirements can be fully met. While this strategy does not include consideration of the National Environmental Policy Act (NEPA), receipt of federal funds would trigger NEPA environmental review processes, in addition to CEQA.

11.1 California Environmental Quality Act (CEQA)

This report is not intended to satisfy the requirements of CEQA (Public Resources Code, Div 13, Sec 21000-21177) or the State CEQA Guidelines (California Code of Regulations, Title 14, Sec 15000-15387). However, the HFRP is subject to the requirements of the CEQA. Given the large scale, multi-year nature of the project, combined with potential impacts to water quality, salmonids, and other environmental factors, an Environmental Impact Report (EIR) is anticipated to be the likely CEQA pathway with Sonoma County as lead agency.

In addition to CEQA, permit and consultation requirements from various agencies would also be necessary. These agencies may include, but are not necessarily limited to, those listed below. Where applicable, the type of needed approval is indicated.

11.2 Anticipated Regulatory Permits

11.2.1 U.S. Army Corp of Engineers (USACE)

Work in areas defined as waters of the United States requires permitting through the USACE under Section 404 of the Clean Water Act. While a Nationwide Permit can often be used for small-scale habitat restoration projects, the HFRP will likely require an Individual Permit and development of a 404(b)1 Alternatives Analyses. The USACE will trigger consultation with NMFS and the U.S. Fish and Wildlife Service (UFWS) under Section 7 of the ESA and State Historic Preservation Office (SHPO).

11.2.2 North Coast Regional Water Quality Control Board

Application for the Clean Water Action Section 401 Water Quality Certification will be required for the HFRP. As part of the Section 401 permitting process, coordination with the NCRWQCB is needed to determine the acceptable zone of dilution within the receiving waters (Russian River) during construction to assimilate turbidity as has occurred on similar large-scale riverine restoration projects (e.g., Trinity River and Salt River restoration projects). The HFRP will also require compliance with a construction general stormwater permit and preparation of a SWPPP and associated monitoring and reporting. The potential to implement winter work where feasible, in compliance with the SWPPP, should also be considered during the Section 401 permitting process. On-site BMPs to isolate active areas of work from erosion and vulnerability to winter floodplain events would be necessary.

11.2.3 California Department of Fish and Wildlife (CDFW)

Work would occur within a stream channel where the floodplain grading activities connect to the river triggering the requirement for a Lake and Streambed Alteration Agreement (LSAA or 1600 permit). The CDFW would likely rely on the CEQA document for the HFRP to meet its own CEQA requirement with respect to issuing the permit. Any state listed species that is federally-listed may be addressed through a consistency determination with the ESA; however, any state listed species that is not federally-listed would need to be addressed through the CESA Section 2081. This could require an Incidental Take Permit (ITP), memorandum of understanding (MOU) or safe harbor agreement (SFA). Early consultation with the CDFW is suggested as financial assurance are often required for compliance with section 2081.

11.2.4 National Marine Fisheries Service and U.S. Fish and Wildlife Service

The NMFS and USFWS regulate the federal endangered species list as described by the ESA. Formal consultation with the NMFS would most likely be necessary. A formal Biological Assessment will be needed to support Section 7 ESA consultation.

11.2.5 State Lands Commission

The State Lands Commission owns certain lands and streambeds in the state. However, the HFRP site is located within former land grant lands and due to an historic anomaly is not subject to the jurisdiction of the Commission. However, outreach to the State Lands Commission is recommended to confirm the agency does not have jurisdiction over the HFRP site.

11.2.6 Sonoma County (Permit Sonoma)

The HFRP will require a conditional use permit (CUP), roiling and grading permit issued by Permit Sonoma. The CUP will be issued following the completion of CEQA and the grading permit will be issued upon complete of the final construction plans and prior to construction. Additional longer term permits may be also be sought for adaptive management efforts.

12. PROJECT DELIVERY

This section describes various considerations and options for Project Delivery. Project Delivery is a broad term used to describe the approach and processes used to execute a project. Successful implementation of a project can depend on, among other factors:

- Site control
- Viable contracting approaches
- Time requirements
- Funding
- Environmental considerations
- Review requirements

- Delivery or lead time constraints (i.e., nursery plant propagation)
- Management Resources
- Labor and contractor availability
- Weather

Some of these can be controlled, others can only be accommodated. Evaluation of these factors should be considered as the project planning and design advances and an approach should be developed that best meet the needs of the project owner(s). A Project Delivery Analysis at this early planning phase can:

- Identify the delivery approach that is best aligned with the owner's cost and schedule requirements.
- Develop a design and contracting plan that avoids or eliminates last minute repackaging of the design into unanticipated contract packages, ultimately saving both time and money.
- Define roles and responsibilities and describe how the project will evolve.
- A comprehensive delivery approach developed early in the project should result in smoother overall project delivery by a more efficient and effective project team. Elements of the analysis should include:
    - Identify the project owner's goals and priorities along with applicable implementation factors.
    - Identify potential project constraints and analyze avoidance measures.
    - Determine and evaluate available sources of funding.
    - Develop and analyze alternative bid contracting and packaging strategies.
    - Analyze the project cash flow requirements associated with the alternative schedules.
    - Evaluate the potential risks associated with the alternative project delivery approaches.
    - Recommend a project delivery approach that appears most consistent with the project goals.
    - Determine contracting approach.

12.1 Contracting Approaches

This section describes various contracting approaches that can be considered for the HFRP.

12.1.1 Traditional (Design-Bid-Build)

The traditional project delivery system has a sequential approach to implementation, with complete plans and specifications prepared prior to bidding any part of the work. Following design, the project is bid, a contract is awarded, and construction is started either for the entire project or for a defined portion. For public projects in California, the bid is based solely on cost, though contractors often have to meet minimum qualifications, and the award is made to the lowest responsive, responsible bidder.

Although the design team typically has a role during the construction phase (in confirming that products and methods meet the design intent and requirements of the contract document) and either the owner, the designer, or a third party assists in managing the construction contract, the actual construction is completed by a licensed contractor who assumes responsibility for:

- Procuring required materials;
- Supplying labor;
- Meeting permit and quality control requirements; and
- Delivering a completed project meeting the requirements of the contract documents in accordance with the schedule.

With limitations as described in the contract documents, the contractor is responsible for scheduling and sequencing activities and assumes the risks of site safety, productivity, and quality control.

Advantages to the traditional delivery model include broad familiarity with the method and extensive experience with contract terms and the relationships between project participants. Many public agencies and funders require this contracting model due to the transparency of the relationships, clear delineation of responsibilities, and the ability to complete a thorough review of the design prior to the start of construction.

A disadvantage to the common design-bid-build method with construction awarded to the lowest bidder is that sometimes a bidder is low because they are not experienced enough to accurately estimate the cost to complete the project in accordance with the stipulated permit and quality requirements. Other times a bidder may undervalue work with the intent to make up the difference between their bid and the actual cost through change orders.

Although bidders are typically required to submit their qualifications as part of their bid proposal, public agencies are reluctant to make a determination that a low bidder is not qualified both due to the threat of legal action on the part of the low bidder which could delay the project and due to the higher cost of the next bidder. One mechanism to minimize this challenge is to prequalify contractors and only accept bids from contractors who have met standards for safety and successful performance on similar projects. Prequalifying contractors limits the number of contractors eligible to compete, but may actually improve competition because the bidders are assured, before they invest the time and money in preparing a bid, that inexperienced contractors have been excluded.

12.1.2 Turnkey (Design-Build)

The Design Build Institute of America (DBIA) Design-Build Manual of Practice defines design-build (DB) as “a method of project delivery in which the owner executes a single contract with one entity (design-builder) to provide architectural/engineering services and construction services.” Turnkey contracts are usually based on a preliminary design package prepared by the owner and the owner's consultant.

The DB team can be selected either on a negotiated basis (primarily for private projects) or through a competitive process. The team's responsibilities typically include:

- Professional engineering responsibility, similar to the traditional design consultant contract;
- Procurement responsibility;
- Broad performance responsibilities pertaining to the constructed project;
- Permitting responsibilities (environmental, building department, construction, etc.);
- Construction responsibility – schedule compliance (often with liquidated damages), subcontracting, safety, checkout, start-up, turnover, licenses and other construction related metrics; and
- Extensive range of commercial responsibilities.

For a negotiated DB project, the DB team is typically selected on a qualifications basis, tasked with completing initial design on a lump-sum basis (to a 50-65% level), and then either a lump sum or an amount referred to as a Guaranteed Maximum Price (GMP) is negotiated to complete the design and construct the project. If a GMP is negotiated, the work is completed on a cost plus mark-up basis, typically with provision that any savings from completion under the GMP are shared by the owner and the DB team, while costs over the GMP will be paid by the owner without mark-up.

For a competitively bid DB project, prospective bidders will first be asked to submit a Statement of Qualifications (SOQ) on the basis of general project requirements. The owner will "short list" eligible bidders (typically 3 or 4) who are then invited to offer proposals for the design and construction. A Request for Proposal (RFP) outlining the project requirements is issued by the owner, typically including initial design documents, and qualified bidders submit proposals for both preparing the full design and constructing the project as a fixed, lump sum bid. The project technical requirements in the RFP may be described in great detail or be very brief, allowing the design-builder great latitude in the design. Proposal submittal requirements are generally detailed in the RFP. A typical project of this type is likely to include:

- Preparation of a preliminary design based upon the RFP requirements.
- Preparation and submittal of a technical and cost proposal for the project including:
    - Engineering and design;
    - Permitting;
    - Construction and procurement of equipment;
    - Engineering Services during construction (SDC);
    - A fixed lump-sum cost for completion of all of the above; and
    - Any changes to the scope of the project will be handled by change orders.

Regardless of the procurement method, the owner will either need to have the staff resources to manage the process or hire an owner's representative to assist in assuring that the DB team meets the contractual obligations and delivers a product meeting the owner's standards for quality.

DB can offer advantages to the owner, including a single point of responsibility for the entire project, sometimes a shorter overall project schedule, and competitive pricing. Disadvantages can include reduced flexibility to cost-effectively make changes subsequent to completion of the preliminary design package and risks inherent with compressing the schedule by beginning construction on some elements prior to completing design of others.

12.1.3 Construction Management at Risk (CMAR or CM/GC)

This system, adopted and promoted by many large general contracting firms, is similar in many ways to the traditional system, in that the construction manager (CM) acts as a general contractor during construction. That is, the CM holds the risk of subletting the construction work to trade subcontractors and guaranteeing completion of the project for a fixed, negotiated price following completion of the design. However, in this scenario, the CM also provides advisory professional management assistance to the owner prior to construction, offering schedule, budget, and constructability advice during the project planning phase. Thus, instead of a traditional general contractor, the owner deals with a hybrid construction manager/general contractor (CM/GC).

In addition to providing the owner with the benefit of pre-construction services which may result in advantageous changes to the project, the construction management-at-risk (CMAR) scenario offers the opportunity to begin construction prior to completion of the design. The CM/GC can bid and subcontract portions of the work at any time, often while design of unrelated portions is still not complete. In this circumstance, the CM/GC and owner negotiate a GMP based on a partially completed design, which includes the CM/GC's estimate of the cost for the remaining design features. Furthermore, CMAR may allow performance specifications or reduced specifications to be used, since the CM/GC's input can lead to early agreement on preferred materials, equipment types and other project features.

The primary disadvantages cited in the CMAR system involve the contractual relationship among the design team, CM/GC and owner once construction begins. Once construction is underway, the CM/GC converts from a professional advisory role of the construction manager to the contractual role of the general contractor. At that time, tensions over construction quality, the completeness of the design, and impacts to schedule and budget can arise. Interests and stake holding can become similar to the traditional design-bid-build system, and adversarial relationships may result. While the fixed GMP is supposed to address the remaining unfinished aspects of the design, this can in fact increase disputes over assumptions of what remaining design features could have been anticipated at the time of the negotiated bid.

One mitigating approach to this problem is for the CM/GC to share with the owner its subcontractor bids, to ensure openness in the process. The CM/GC may further assume risk by taking some responsibility for design errors discovered during construction, if it was involved in the review of the design prior to establishing the GMP. In addition, arrangements can be made regarding risk-sharing and profit sharing if there are over-runs or under-runs in the GMP.

An owner wishing to use the CMAR approach can realize many benefits. Chief among them is the opportunity to incorporate a contractor's perspective and input to planning and design decisions and the ability to "fast-track" early components of construction prior to full completion of design. However, since a commitment is made to a contractor earlier in the process, a premium is placed on the proper selection of the CM/GC to provide the best value to the owner. The owner needs to have a sophisticated management team to assure that the project is delivered with the quality required and to protect against unanticipated costs that could be associated with risks not clearly assigned in the contract documents.

Self Performance

Some owners have the staff to design and/or construct projects using in-house resources. To take on a larger than typical project, short-term staff may be added for either or both the design and construction phase of the work. If the owner does not already have the infrastructure in place to manage as well as implement the work, the time and effort to hire and train staff may not be cost effective for an individual project. The competitiveness of the marketplace often translates to efficiencies that are hard to obtain without the entrepreneurial spirit found in and financial incentives available to private businesses.

Design Implications

One key detail determined by the contracting approach is the corresponding design approach. How a project is to be procured clearly influences how it is to be designed; these two approaches must be regarded in tandem. If the design approach associated with a specific procurement approach cannot be effectively implemented, then the procurement approach should not be proposed.

Time Requirements

Time requirements are critical to the selection of the project delivery approach. Time considerations need to be carefully evaluated to ensure that they are realistic and take into consideration the time constraints imposed by the owner, regulators, and other project participants. Factors affecting the time required to implement the project include, but are not limited to, the following:

- Sequence of construction
- Market conditions (e.g., labor, trade, and contractor availability)
- Weather
- Site logistics (e.g., work hours, access, egress, staging, laydown)
- Materials of construction
- Site conditions (e.g., soil types, groundwater, topography, wetlands, vegetation)
- Startup requirements
- Regulatory reviews and approvals
- Contract procurement process
- Permitting
- Public sensitivity and awareness

Funding

The availability of funds for design and construction is an important factor in selecting the project delivery approach. Cash flow projections based on schedule alternatives verify that the availability of funding and the project schedule coincide, thereby providing a smooth progression of work. In some instances, fund constraints or availability may stipulate a particular delivery approach.

Environmental Considerations

Construction methods must be evaluated in the context of environmental constraints. For example, the HFRP will be subject to seasonality constraints associated with sensitive species, instream work windows, erosion/sediment control and other necessary BMPs to avoid and/or otherwise minimize environment impacts during construction. These aspects must be considered in the delivery approach to the project.

Review Requirements

Depending on the number of reviewers, whether reviewers work in parallel or in series, the level of detail, and the expertise and workload of the specific reviewers, the document review process can become quite extensive and time consuming. When possible, the benefit of quality assurance reviews should be balanced with the associated costs (both time and budget). Collaboration may expedite the review process and prevent costly project delays.

Labor and Contractor Availability

Unemployment rates and local construction availability will influence the availability of labor, particularly in a location distant from major employment centers. Availability of labor will influence how quickly a project can be completed (may not be able to cost-effectively apply enough staff time to complete a project on an aggressive schedule), and the cost of a project (if labor needs to be brought in from outside the area, costs will increase). Even if labor is available, the project also needs firms capable of taking on the management and financial obligations of the schedule. A scarcity of qualified contractors will have the same effect as a shortage of workers with the appropriate skills.

Weather

Local weather conditions and the length of the construction season must be considered in developing viable schedules for the project.

12.2 Construction and Resource Market Trends

The construction market in Sonoma County has remained strong during the pandemic period of 2020. Conditions for the next five years are expected to continue a pattern of moderate growth as remote work opportunities expand and working professionals migrate away from urban centers. Shortages in the construction trades will likely continue, but long-term restoration projects in supportive locations will continue to attract qualified firms and personnel.

12.3 Construction Funding

The current planning and preliminary design phases of the HFRP have been funded through state and local funding sources. Future design, CEQA and permitting phases are anticipated to be funded through a combination of local, state and/or federal funding sources. Construction funding has not yet been secured, however local, v and federal sources will likely be targeted through various grant programs and multiple sources will be necessary. The public funding sources will require construction contractor procurement through a traditional design-bid-build approach. Should public funding sources not be sufficient, an alternative is to engage with an environmental equity firm that would implement the project through an anticipated DB approach then upon completion “sell” the restored habitat area for environmental mitigation credits. These arrangements could become complex with regards to current and future landownership and use.

12.4 Alternative Bid Contracting and Packaging Strategies

The simplest project delivery method for a project of this size is sometimes to prepare a complete set of Contract Documents and hire a single contractor (sole-provider) to complete the work, including the revegetation efforts. Coordination between various project elements (earthwork and revegetation) is the responsibility of the Contractor, minimizing the need for Owner representative involvement in sequencing and prioritizing. Materials and procedures are likely to be consistent throughout the project, bringing economies of scale and potentially reducing cost. Drawbacks to the single contractor approach, however, can be significant. Few qualified local contractors can take on the financial responsibilities of a project with this construction cost. Competition would be limited to those with adequate bonding capacity and the expertise necessary to complete a complex project of this size. Whether local contractors would be given the opportunity to provide services as subcontractors would be up to the discretion of the sole-provider. Another disadvantage to the sole-provider approach for the project is that final design documents and right-of-ways must be available for the entire project before any construction begins. If the project is bid and constructed in phases, design and any remaining site control (right-of-ways) can be completed for portions of the project in time for construction and other portions postponed. This phased approach may also better align with obtaining public funding over time. Unless the current design funding for the entire project was accelerated, construction of the project as one package could be challenging.

If the project is not a single construction package, criteria for developing efficient packages must be established. Unless a mechanism is available for an alternative delivery approach, the project will likely have public financing and use a traditional design-bid-build project delivery method. Prequalifying the prime contractor and landscape contractor (if separate) is recommended.

13. CONCLUSIONS AND NEXT STEPS

13.1 Conclusions

The key findings from this current design phase further support achievement of project goals, including re-creating a functional floodplain, enhancing the natural river ecosystem, addressing the needs of listed fish species, and expanding public access opportunities along the Russian River, among others. Key outcomes of this design phase include:

- Identification of the need to increase the floodplain elevation by one foot in future phases of design to support desired revegetation outcomes, as it relates to seasonal low groundwater elevation, results in the targeted habitat community (seasonal wet meadow).
- Identification of the need to characterize anticipated floodplain accretion rates, and the implications for vegetation establishment and expansion on the restored floodplain. This

need is heightened by the recent fires in the watershed, and the expected increase in sediment supply to the system.

- Development of a phased approach to construction spanning multiple years to address anticipated sediment settlement of fill in each pond and avoid undesirable water quality impacts in the Russian River and adjacent wells.
- Coordination with regulatory agencies to discuss opportunities for year-round construction, consistent with historic gravel mining operations.
- Identification of possible construction methods for earthwork and grading, revegetation and invasive plant removal, and other special considerations.
- Inclusion of the public amenity design concepts and identification of the need to further integrate the public amenities design into the restoration design.
- Comparison of existing habitat types with anticipated post-project habitat types to better describe expected transitions in habitat types.
- Identification of special status species with likelihood to occur at the Hanson Ponds and associated avoidance and minimization measures that would inform mitigation measures potentially required under CEQA.
- Completion of a planning level OPC.

By working cooperatively with project partners and continuing to pursue an ecologically-based alternative to traditional mine reclamation, restoration of the 358-acre HFRP property would restore natural riverine process to benefit Coho Salmon, Chinook Salmon, Steelhead, and other aquatic and terrestrial species.

13.2 Next Steps

The recommended next steps to advance the HFRP are outlined below.

13.2.1 Consolidation of Project Goals and Objectives

The project goals and objectives defined in the Feasibility Study and refined in Section 2 of this report appear achievable and all support restoration of natural riverine processes to benefit Coho Salmon, Chinook Salmon, Steelhead and other aquatic species while being compatible with Sonoma County’s public access vision. These goals will be used in the development of an adaptive management plan and integrated in the CEQA document. Consideration for consolidating similar goals with corresponding redundant objectives should be considered for brevity purposes. Long-term monitoring implications as part of the adaptive management plan and compensatory mitigation obligations should also be considered in any further refinement of the goals and objectives.

13.2.1 Environmental Compliance Considerations – Pre-Application Consultation

Prior to advancement of the 65% design, it is recommended that partners confirm project elements and the phased construction approach with project partners and regulatory agencies. Initiation of pre-application coordination with agencies to confirm the anticipated permitting approach could influence construction phase, technique, and cost. Pre-application coordination with the NCRWQB regarding an allowable zone of dilution within the Russian River during construction is recommended. Pre-application with the USACE and the NCRWQB should address if a formal wetland jurisdictional determination (wetland delineation) would be required, beyond existing effort to document wetland extent in the H.T. Harvey (2020) report. Completion of a Biological Assessment and consultation with NMFS under Section 7 of the ESA is also anticipated and recommended prior to initiation of formal Section 7 consultation, and specifically regarding pond dewatering and advance fish relocation.

Federal funding would trigger NEPA environmental review. While environmental and biological work completed for the project to address special status biological resources by Avocet (2020) is sufficient for the purposes of CEQA, the NEPA lead agency may require a more robust biological analysis (e.g., Biological Resources Evaluation), which could dually serve as a Biological Assessment for the project.

13.2.1 CEQA Preparation

As previously described, the project will require completion of CEQA. Prior to releasing the Notice of Preparation (NOP) any remaining studies shall be identified by the Lead Agency and completed as necessary. Finalization of the project description and circulation amongst the project partners is also recommended.

13.2.2 65% Design Considerations

The 65% design would further refine the project's fluvial geomorphic and hydraulic design and further assess geotechnical considerations. The 65% design would also need to identify and proceed with the desired floodplain option (Strategy 1 – Grading vs. Strategy 2 – Passive Sediment Accretion), as discussion in Section 7.1.2 – Riparian Corridor and Floodplain Restoration.

In addition, the public access design would be further integrated into the restoration design to align project components, clearly delineate the footprint of public access design elements, and define impact limits. The habitat conversion analyses do not currently reflect all public access amenities. The 65% design would also address site control and entitlements by confirming permanent and temporary access roads. Design elements and supporting analysis anticipated for the 65% design are outlined below.

Fluvial Geomorphic and Hydraulic Design Refinements

1. Advance the hydraulic modelling to evaluate floodplain inundation and sedimentation to determine habitat specifications (structure, compositions, diversity, and location).
2. Hydraulic modelling to evaluate anticipated evolution of the floodplain channels over a range of anticipated streamflows (e.g., confirm sufficient high flow scour to maintain features from the upstream end and avoid deposition at the downstream end), as well as potential capture of the mainstem into the restored floodplain.
3. Incorporate fine grading, large wood structure and riparian canopy installations to accelerate recovery of ecological functions into up-gradient and near-bank areas.
4. Complete hydraulic modelling for each construction phase to confirm each phase is stable and can withstand winter overland flow paths from vineyards to floodplain.
5. Complete floodplain accretion assessment to determine range of potential accretion rates.

6. Advance the floodplain grading to accommodate revegetation design goals with respect to seasonal low groundwater elevations and integrate features that promote desired geomorphic function and habitat complexity, i.e., LWD structures, etc.
7. Coordinate hydraulic modelling efforts with Syar Industries' restoration efforts.

Geotechnical Refinements

1. Conduct additional laboratory analyses to confirm bulking volume and expected settlement rates.
2. Develop a soils segregation plan for topsoil reuse as part of the grading design.

Revegetation Design

As the grading design advances, additional refinements to the revegetation design will also be necessary. To promote vegetation communities and composition that maximizes habitat values for salmonids, opportunistic floodplain restoration design should:

1. Delineate and stockpile surficial soils suitable for floodplain vegetation, and reuse these soils in finish grading of floodplain areas where active revegetation will be undertaken.

2. Designate where large wood will be retained and reused floodplain features, which will increase flow and topographic diversity on the inundated floodplain, and serve as a catalyst for the periodic storage and release of wrack.

3. Establish floodplain elevations (or elevated terraces if available fill is limited) which support near equilibrium sedimentation processes, and reduce the likelihood that burial depth limit vegetation establishment.

4. Develop specific details for on-site plant and seed-stock cultivation, and designate areas which can be seeded, planted and farmed to produce native plant stock.

5. Specify methods to control invasive plant material excavated from uplands and invasive aquatic vegetation in the ponds via burial in the bottom of the ponds.

Public Access Amenities

1. Advance design of public access amenities in collaboration with Sonoma County.

13.2.3 Funding Considerations

To fully fund the HFRP, as estimated in the OPC (Appendix H), the funding strategy detailed in the Feasibility Study should be revisited and updated. The phased approach to construction may benefit the funding approach, allowing each phase to be funded independent from other phases.

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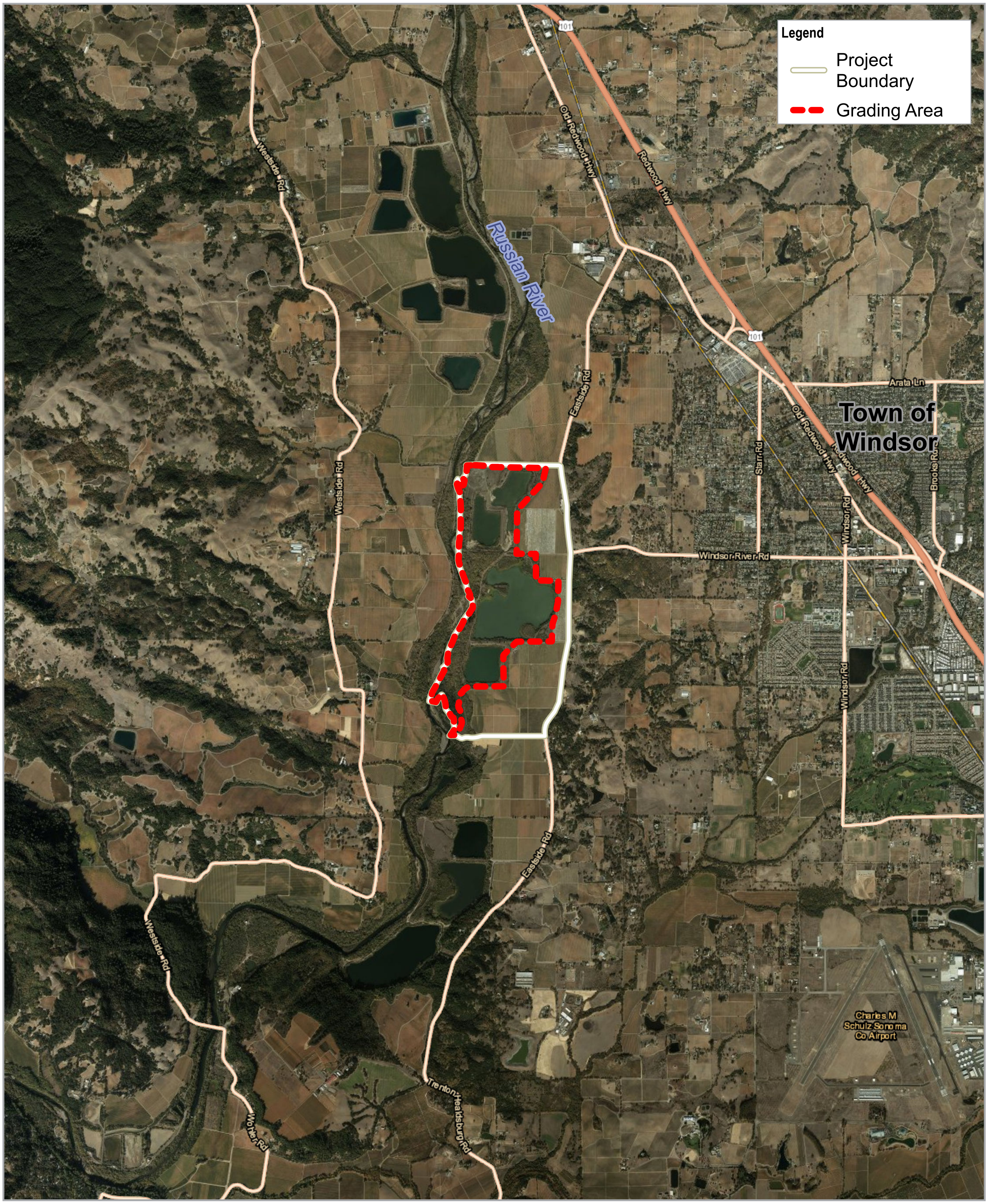
Appendices

Appendix A
Figures



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Grid: NAD 1983 StatePlane California II FIPS 0402 Feet

Hanson Russian River Floodplain Restoration Project
Basis for 30% Design Report

Project No. **11195953**
Revision No. **1**
Date **Nov 2020**

Project Location

FIGURE 1

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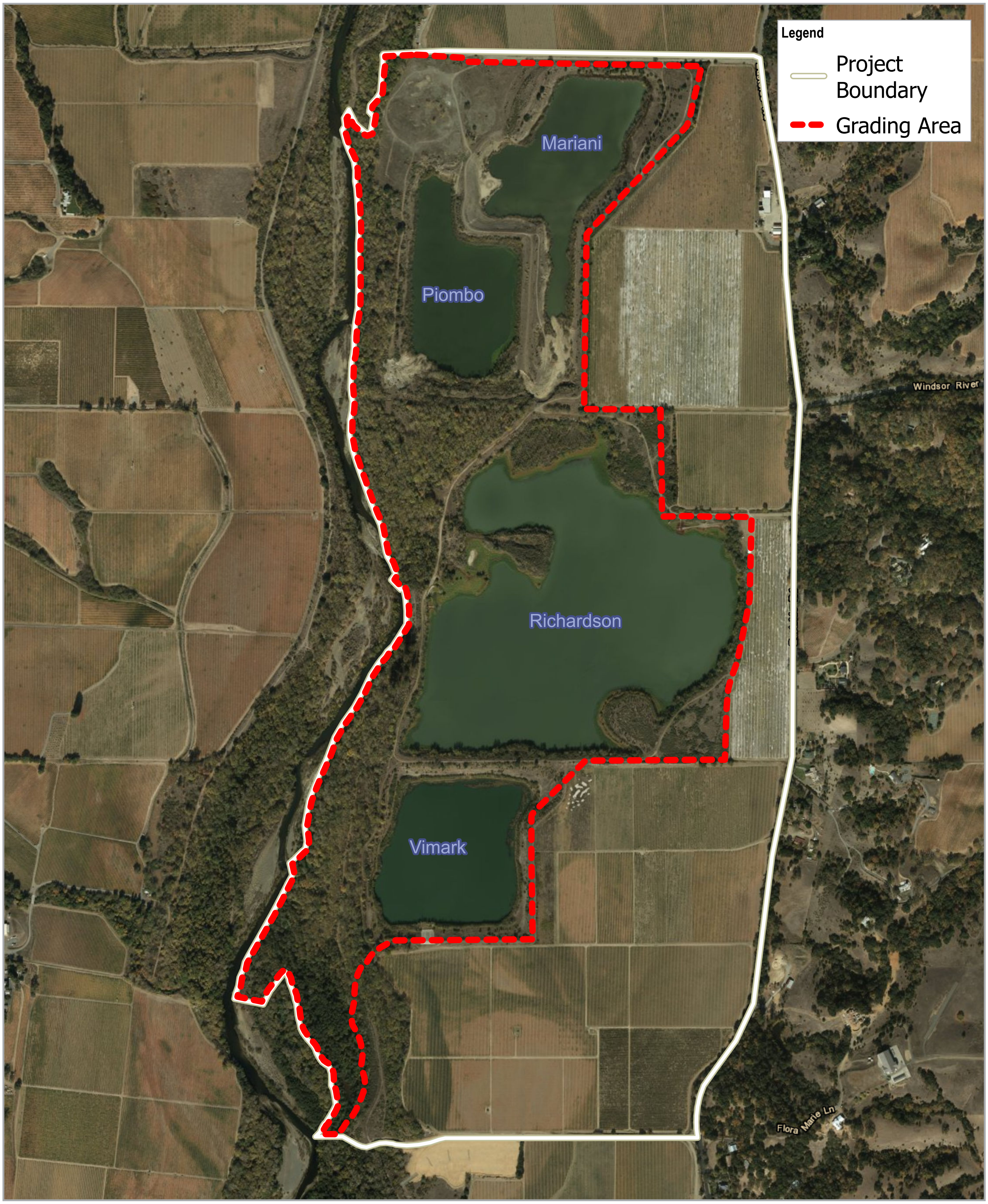
Data source: World_Transportation: Esri, HERE, Garmin, (c) OpenStreetMap contributors; World Imagery (Clarity): Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community. Created by: jlopez4



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Feet

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Map Projection: Lambert Conformal Conic
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Grid: NAD 1983 StatePlane California II FIPS 0402 Feet

GHD

Hanson Russian River Floodplain Restoration Project
Basis for 30% Design Report

Project No.	**11195953**
Revision No.	**-**
Date	**Nov 2020**

Project Area

FIGURE 2

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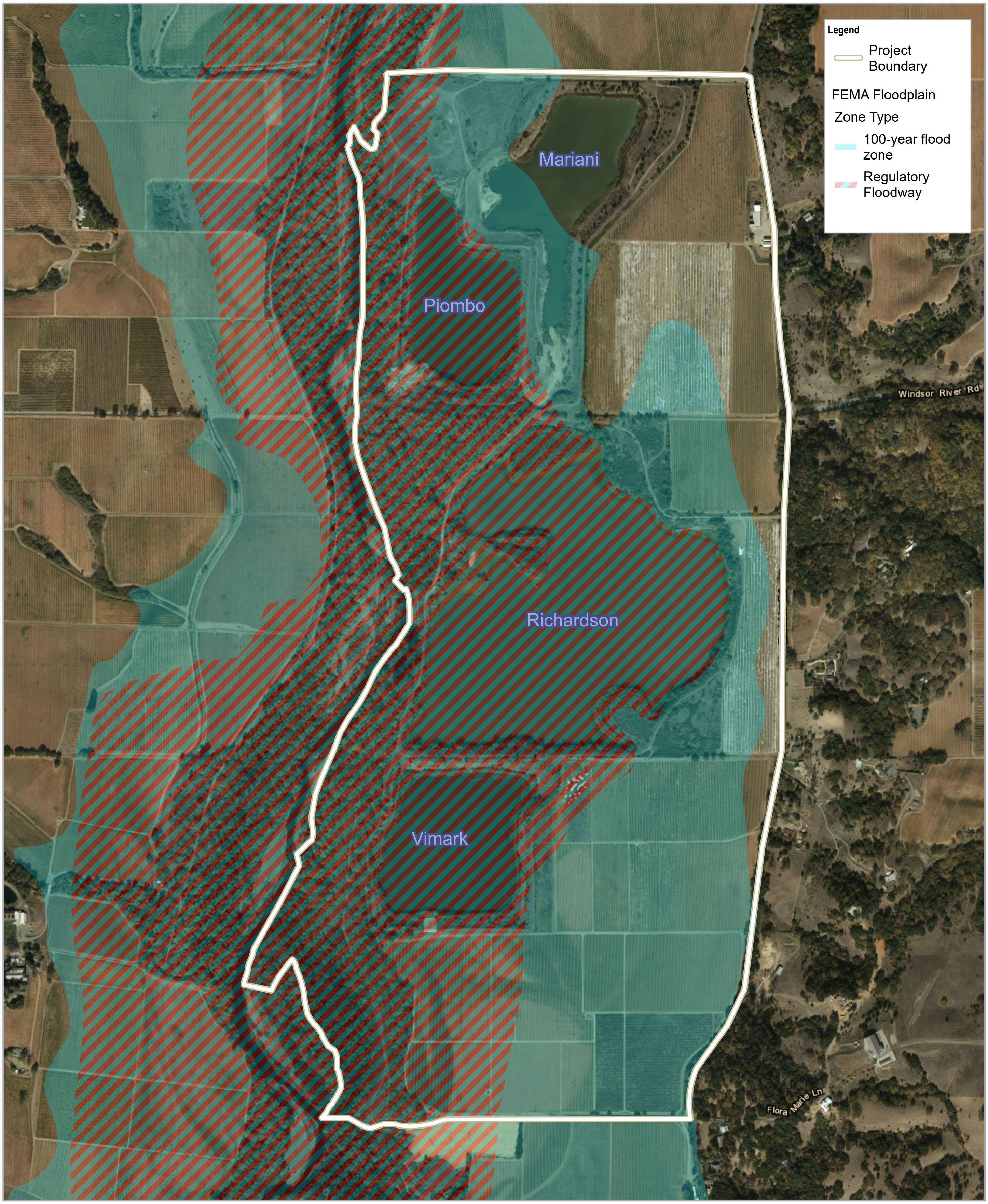

Paper Size ANSI A

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Feet

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Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane California II FIPS 0402 Feet

Hanson Russian River Floodplain Restoration Project

Basis for 30% Design Report

FEMA

Project No. **11195953**
Revision No. **-**
Date **Nov 2020**

FIGURE 3

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Appendix B
Groundwater Assessment

Appendix C
Special Status Species Assessment

Table 1: Special-Status Species with High or Moderate Potential to Occur

Wildlife Species	Status	Likelihood to Occur	Notes
Mammals			
Townsend's big-eared bat (Corynorhinus townsendii)	CDFW:SSC BLM-Sensitive IUCN-LC	High Potential	Proximate CNDDB records. Likely transient, possible roosting habitat.
Hoary Bat (*Lasiurus cinereus*)	IUCN-LC; WBWG-M	Moderate Potential	Records of this species from the project vicinity. (iNaturalist 2019). Likely to occur as transient during migration.
Fringed Myotis (*Myotis thysanodes*)	BLM-S IUCN-LC USFS-S WBWG-H	High Potential	There are records from the county (CNDDB 2019). Allowing large dead snags to stand will benefit this species.
Pallid Bat (*Antrozous pallidus*)	BLM-S CDFW-SSC IUCN-LC USFS-S WBWG-H	Moderate Potential	Apprpriate habitat iis present at the site and there are Sonoma records from the County (Naturalist 2019, CNDDB). Bole cavities of oaks will benefit this species.
Western Red Bat (*Lasiurus blossevillii*)	CDFW-SSC IUCN-LC WBWG-H	Moderate Potential	The requisite habitat for this species (intact riparian) is present at the project site. There are records from the County (iNaturalist 2019)
American Badger (*Taxidea taxus*)	CDFW-SSC IUCN-LC	Moderate Potential	There is a recent record of this species from the project vicinity (CNDDB 2019). Suitable habitat for the species is present immediately adjacent to the site and transients are likely.
Birds			
Double-crested Cormorant (*Phalacrocorax auritus*)	CDFW-WL IUCN-LC	High Potential	There are nesting records from the project vicinity and requisite foraging habitat is present (SCBBA). Observed on site (ARA 2018)
Great Egret (*Ardea alba*)	CDFW-WL IUCN-LC	High Potential	Nesting colony at nearby at Kaiser Gravel (Kelly et al.) and foraging habitat on-site. Observed on site (ARA 2018)

Great Blue Heron (*Ardea herodias*)	CDFW-SSC IUCN-LC	High Potential	Nesting confirmed on-site (ARA 2018) and colony at nearby Riverfront Park (Kelly et al.). Foraging habitat on-site.
Snowy Egret (Egretta thula)	IUCN-LC	Moderate Potential	Foraging habitat on-site and potential nesting habitat along mainstem of Russian River. Closest known nesting colony along Santa Rosa Creek (SCBBA).
Black-crowned night Heron	IUCN-LC	Moderate Potential	Foraging habitat on-site and potential nesting habitat along mainstem of Russian River. Closest known nesting colony along Santa Rosa Creek (SCBBA).
Osprey (*Pandion haliaetus*)	CDF-S CDFW-WL IUCN-LC	High Potential	Nesting confirmed on-site (ARA 2018). Numerous records of this species from the project area (SCBBA, eBird).
Cooper's Hawk (*Accipiter cooperii*)	CDFW-WL IUCN-LC	High Potential	Nests in vicinity of site (SCBBA; iNaturalist)
Sharp-shinned Hawk (*Acccipiter striatus)*	CDFW-WL IUCN-LC	Moderate Potential	Nesting record from "Windsor area" (SCBBA). Likely transient during winter and migration.
Golden Eagle (*Aquila chrysaetos*)	BLM-S CDF-S CDFW-FP CDFW-WL IUCN-LC USFWS:BCC	Moderate Potential	Nesting records east of Healdsburg (SCBBA). Large hunting territories and numerous eBird reports suggest likely occurrence at site.
Swainson's Hawk (*Buteo swainsoni)*	ST BLM S; IUCN:LC USFWS:BCC	Moderate Potential	Nests along the Napa River at Oakville (ARA) and expanding its range northward. Numerous regional records (eBird). Likely to occur as transient or foraging.
White-tailed Kite (*Elanus leucurus)*	BLM:S CDFW:FP IUCN:LC	High Potential	Nests in vicinity (SCBBA). Open woodlands and bottomlands offer preferred nesting areas. Episodic occurrence likely.

Bald Eagle (*Haliaeetus leucocephalus*)	SE FD BLM-S; CDF-S; CDFW-FP IUCN-LC; USFS-S; USFWS:BCC	High Potential	Numerous records from the project area (including individuals foraging around the mainstem Russian River) and paired individuals at Riverfront Park suggest likely local nesting (eBird 2020).
American Peregrine Falcon (*Falco peregrinus anatum*)	FD SD. CDF-S CDFW-FP USFWS-BBC	High Potential	Increasing population, wide-ranging foraging habit, and nesting in Sonoma County (SCBBA). Observed on site (ARA 2018)
California Gull *(Larus californicus*)	CDFW-WL IUCN-LC	High Potential	Attracted to large bodies of quiescent water. Likely to occur in winter when habitat available.
Vaux's swift (*Chaetura vauxi*)	CDFW-SSC IUCN-LC	Moderate Potential	There are records of this species from the project vicinity and the requisite foraging and roosting habitat for this species is present at the project site.
Olive-sided Flycatcher (*Contopus cooperi*)	CDFW-SSC IUCN-NT NABCI-YWL USFWS-BBC	Moderate Potential	Most likely to occur as a transient during migratory periods.
Willow Flycatcher (*Empidonax traili*i)	SE IUCN-SSC USFWS-BCC	Moderate Potential	Observed on-site as a transient (ARA).
Loggerhead Shrike	CDFW-SSC IUCN-LC USFWS-BCC	Moderate Potential	Declining in Sonoma county (and regionally), however known nesting "from Healdsburg south to Petaluma" (SCBBA) suggests likely nesting in vicinity of project site.
Purple Martin (*Progne subis*)	CDFW-SSC IUCN-LC	Moderate Potential	There are records of this species from the project area (eBird). Observed on-site (ARA), most likely foraging during migration.
Oak Titmouse	IUCN-LC NABCI-YWL USFWS-BCC	High Potential	Nest in area (SCBBA). Confirmed nesting on site (ARA 2018)
Grasshopper Sparrow (*Ammodramus savanarum*)	CDFW-SSC IUCN-LC	Moderate Potential	This species is a known breeder from grassland habitat near the project site (SCBBA).

Yellow-breasted Chat (*Icteria virens*)	CDFW-SSC IUCN-LC	Moderate Potential	Nests in dense thickets associated with the Russian River in vicinity of project site. (Riverfront Park-eBird 2019)
Yellow Warbler (*Setophaga petechial*)	CDFW-SSC USFWS-BBC	High Potential	Nest in the vicinity (Riverfront Park-eBird). Riparian thickets along the adjacent Russian river provide excellent habitat. Observed on site (ARA 2018)
Reptiles			
Western Pond Turtle (*Emys marmorata*)	BLM-S CDFW-SSC IUCN- VU USFS-S	High Potential	Status and distribution in the Russian River system not well-understood, although there are records along its length (CNDDB 2020). Presence should be assumed and surveyed for prior to construction.
Amphibians			
California Tiger Salamander (*Ambystoma californiense*)	FE SE CDFW:WL IUCN-VU	Moderate Potential	Project lies 2.5 km NW of the CTS Management Area boundaries and approximately 9.0 km NW of the closest CNDDB occurrence at “Alton Lane” (USFWS 2016). Larval emigration and annual adult spawning migration reportedly extends as far as 1.6 km (Stebbins and McGinnis 2012), therefore the project site is likely beyond potential range of the CTS. (But see note below)**
California Giant Salamander (*Dicamptodon ensatus*)	CDFW-SSC IUCN-NT	Moderate Potential	This species has been detected in the vicinity of the site and habitat is present.

Red-bellied Newt (*Taricha rivularis*)	CDFW-SSC IUCN-LC	Moderate Potential	Range extends southward into central Sonoma County; occurs in the Russian River (Stebbins and McGinnis 2012). CNDDB record 4.0 m. ESE of site. Habitat available.
California red-legged frog (*Rana draytonii*)	FT CDFW-SSC IUCN-VU	Moderate Potential	The site is within the Recovery Unit Boundary and the Santa Rosa plateau is identified as "currently occupied" and "potential for reestablishment" USFWS 2002).
Foothill Yellow-legged Frog (*Rana boylii*)	SE BLM-S CDFW-SSC IUCN-NT USFS-S	Moderate Potential	CNDDB indicates that suitable habitat for the species is present (gravel bars, large cobbles, etc.). CNDDB record from Mark West Creek, <4 m. SE of site
Fish			
Russian River tule perch (*Hysterocarpus traskii pomo*)	AFS-V CDFW-SSC	Moderate Potential	Subspecies confined to the Russian River and its tributaries, Sonoma and Mendocino Cos. (CNDDB)
Steelhead – central California coast DPS (*Oncorhynchus mykiss irideus*)	FT AFS-T	High Potential	Recorded at Turtle Crk., tributary of Russian River, <0.5 mi W of project site. (CNDDB)
Steelhead – northern California DPS (*Oncorhynchus mykiss irideus*)	FT AFS-T	High Potential	Records along mainstem of Russian River and main tributaries (CNDDB)
Chinook Salmon – California coastal ESU (*Oncorhynchus tshawytscha*)	FT AFS-T	Moderate Potential	This species is present throughout the Russian River watershed (CNDDB) and suitable habitat may be present within the project area.
Invertebrates			

California Fairy Shrimp (*Linderiella occidentalis)*	IUCN:NT	Moderate Potential	In the Santa Rosa Vernal Pool Region (as identified by Keeler-Wolf *et. al*.1998), the California fairy shrimp is known from the vicinity of the cities of Healdsburg, Santa Rosa, and Sebastopol in Sonoma Co. CNDDB record (near Windsor)
California freshwater Shrimp (Syncaris pacifica)	FE, SE	Moderate Potential	Range extends to "Tributary streams in the lower Russian River drainage." (USFWS 2020)
Plants			
Baker's navarretia (Navarretia leucocephala)	CNPS 1B.1	Moderate potential	Records from the Santa Rosa Plain (CNDDB). Wetlands, meadows, vernal pools.
Many-flowered navarretia (Navarretia leucocephala ssp. plieantha	FE SE CNPS 1B.2	Moderate potential	Several records from the Santa Rosa Plain (CNDDB, Calflora)
Burke's goldfields (*Lasthenia burkei*)	FE SE CNPS 1B.1	Moderate potential	Several records from the Santa Rosa Plain (CNDDB, Calflora). Habitat present: freshwater, wetlands, meadows
Marsh scorzonella (*Microseris paludosa)*	CNPS: 1B.2	Moderate potential	Several records from the Santa Rosa Plain (CNDDB, Calflora).
congested-headed hayfield tarplant (*Hemizonia congesta ssp. congesta*)	1B.2	Moderate Potential	Occurs in the Santa Rosa plain (CNDDB)
short-leaved evax (*Hesperevax sparsiflora var. brevifolia*)	1B.2 BLM-S	Moderate Potential	Coll. S of Healdsburg 1897 (Calflora)
Sonoma sunshine *(Blennosperma bakeri)*	FE SE CNPS 1B.1	Moderate Potential	Freshwater wetlands; CNDDB records in Healdsburg Quad. Site is within the "core area" of the Recovery Plan (USFWS 2016)
Burke's goldfields (*Lasthenia burkei*)	FE SE CNPS 1B.1	Moderate Potential	Historic CNDDB record for Healdsburg quad near site. Site is within the "core area" of the Recovery Plan (USFWS 2016)

Sebastopol meadowfoam (*Limnanthes vinculans*)	FE SE CNPS 1B.1	Moderate Potential	CNDDB record for Healdsburg quad near site. Site is within the "management area" of the Recovery Plan (USFWS 2016)

STATUS CODES

- AFS-V American Fisheries Society "vulnerable"
- AFS-T American Fisheries Society "threatened"
- BLM-S Bureau of Land Management "sensitive"
- CDF-S California Department of Forestry and Fire Protection (CDF) Sensitive
- CDFW Species of Special Concern (SSC)
- CDFW Fully Protected
- CDFW Fully Protected (FP)
- CDFW-WL Watch list
- CNPS-California Native Plant Society (
- FE Federally listed as endangered
- FT Federally listed as threatened
- FD Federally delisted
- FC Federal candidate species (former Category 1 candidates)
- IUCN-LC International Union for Conservation of Nature "Least Concern"
- IUCN-NT International Union for Conservation of Nature "Near Threatened"
- NABCI-YWL North American Bird Conservation Initiative Yellow Watch List
- SE State listed as endangered
- ST State listed as threatened
- SD State delisted
- USFWS-BCC U.S. Fish and Wildlife Service Birds of Conservation Concern
- USFS-S United States Forest Service (USFS) Sensitive
- WBWG-Western Bat Working Group: Medium Priority (M); High priority (H)

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**Regarding California Tiger Salamander: In 2004 the California tiger salamander was federally listed as Threatened statewide. The Santa Barbara County and Sonoma County Distinct Vertebrate Population Segments (DPS), formerly listed as Endangered, were reclassified to Threatened. On 20050819 U.S. District court vacated the down-listing of the Sonoma and Santa Barbara populations from Endangered to Threatened. Therefore, the Sonoma & Santa Barbara populations were once again listed as Endangered. https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=109405&inline

Table 2: Federal Species Avoidance and Minimization Measures

Species	Federal Status	Governing Guidance Document
Sonoma sunshine *(*Blennosperma bakeri*)*	FE, SE CNPS 1B.1	• USFWS. 1991. Endangered and Threatened Wildlife and Plants; Determination of Endangered Status for Three Plants, Blennosperma bakeri (Sonoma Sunshine or Baker's Stickyseed), Lasthenia burkei (Burke's Goldfields), and Limnanthes vinculans (Sebastopol Meadowfoam). Federal Register 56(231):61173-61182. • USFWS. 2016. Recovery Plan for the Santa Rosa Plain: *Blennosperma bakeri* (Sonoma sunshine)*; Lasthenia burkei* (Burke's goldfields)*; Limnanthes vinculans* (Sebastopol meadowfoam); California Tiger Salamander Sonoma County Distinct Population Segment (*Ambystoma californiense*). U.S. Fish and Wildlife Service, Pacific Southwest Region, Sacramento, California. vi + 128 pp. • Center for Plant Conservation 1991 • USFWS 2020. Conservation Banks Serving Sonoma County, California.

Burke's goldfields (*Lasthenia burke*)	FE SE; CNPS 1B.1	• USFWS. 1991. Endangered and Threatened Wildlife and Plants; Determination of Endangered Status for Three Plants, Blennosperma bakeri (Sonoma Sunshine or Baker's Stickyseed), Lasthenia burkei (Burke's Goldfields), and Limnanthes vinculans (Sebastopol Meadowfoam). Federal Register 56(231):61173-61182. • USFWS. 2016. Recovery Plan for the Santa Rosa Plain: *Blennosperma bakeri* (Sonoma sunshine)*;* *Lasthenia burkei* (Burke’s goldfields)*; Limnanthes vinculans* (Sebastopol meadowfoam); California Tiger Salamander Sonoma County Distinct Population Segment (*Ambystoma californiense*). U.S. Fish and Wildlife Service, Pacific Southwest Region, Sacramento, California. vi + 128 pp. • USFWS 2020. Conservation Banks Serving Sonoma County, California. • Center for Plant Conservation 1991

Sebastopol meadowfoam (*Limnanthes vinculans*)	FE SE CNPS 1B.1	• USFWS. 1991. Endangered and Threatened Wildlife and Plants; Determination of Endangered Status for Three Plants, Blennosperma bakeri (Sonoma Sunshine or Baker's Stickyseed), Lasthenia burkei (Burke's Goldfields), and Limnanthes vinculans (Sebastopol Meadowfoam). Federal Register 56(231):61173-61182. • USFWS. 2016. Recovery Plan for the Santa Rosa Plain: *Blennosperma bakeri* (Sonoma sunshine)*;* *Lasthenia burkei* (Burke's goldfields)*;* *Limnanthes vinculans* (Sebastopol meadowfoam); California Tiger Salamander Sonoma County Distinct Population Segment (*Ambystoma californiense*). U.S. Fish and Wildlife Service, Pacific Southwest Region, Sacramento, California. vi + 128 pp. • USFWS 2020. Conservation Banks Serving Sonoma County, California. • Center for Plant Conservation 1991
Many-flowered navarretia *(Navarretia leucocephala ssp. plieantha*)	FE SE CNPS 1B.2	• USFWS. 1997. Endangered and Threatened Wildlife and Plants; Endangered Status for Four Plants from Vernal Pools and Mesic Areas in Northern California. Federal Register, vol. 62, no. 117. 33029-33038**.** • USFWS 2005. Recovery Plan for Vernal Pool Ecosystems of California and Southern Oregon. • https://www.fws.gov/oregonfwo/documents/RecoveryPlans/Vernal_Pool_Fairy_Shrimp_RP.pdf • Paterson et al. 1994. • Conservation Banks Serving Sonoma County, California (USFWS 2020) • Center for Plant Conservation 1991
California Freshwater shrimp (*Syncaris pacifica)*	FE	• USFWS. 1988. Federal Register 53(210):43884-43889 • USFWS. 1998. Recovery Plan. https://ecos.fws.gov/docs/recovery_plan/980731a.pdf

California Red-legged Frog (*Rana draytonii*)	FT	• USFWS Biological Opinion, June 18, 2014 (FF08ESMF00-2014-F-0389) • USFWS Recovery Plan https://www.fws.gov/arcata/es/amphibians/crlf/documents/020528.pdf • USFWS Biological Opinion, June 18, 2014 (FF08ESMF00-2014-F-0389); • Mitigation Measure BIO-2: Conservation Measures to Protect Special-Status Amphibians and Reptiles
California Tiger Salamander (*Ambystoma californiense*) Sonoma Co. DPS	FE SE	• USFWS. 2005. Federal Register 70(239):74137-74163 • USFWS. 2016. Recovery Plan for the Santa Rosa Plain: *Blennosperma bakeri* (Sonoma sunshine)*;* *Lasthenia burkei* (Burke's goldfields)*; Limnanthes vinculans* (Sebastopol meadowfoam); California Tiger Salamander Sonoma County Distinct Population Segment (*Ambystoma californiense*). U.S. Fish and Wildlife Service, Pacific Southwest Region, Sacramento, California. vi + 128 pp. • USFWS 2020. Conservation Banks Serving Sonoma County, California
Steelhead – central California coast DPS (*Oncorhynchus mykiss irideus*)	FT	• NMFS Biological Opinion, May 9, 2016 (WCR-2016-4406); • Mitigation Measure BIO-5: Conservation Measures to Protect Salmonids • CDFW Habitat and Restoration Act of 2014. https://wildlife.ca.gov/Conservation/Environmental-Review/HRE-Act

Coho Salmon – California coastal ESU (*Oncorhynchus* kisutch)	FT	• NMFS Biological Opinion, August 27, 2015 (WCR-2015-2716); • Mitigation Measure BIO-5: Conservation Measures to Protect Salmonids • Federal Register 64 FR 24061, May 5, 1999, as amended at 69 FR 18803, Apr. 9, 2004 • CDFW Habitat and Restoration Act of 2014. https://wildlife.ca.gov/Conservation/Environmental-Review/HRE-Act

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USFWS. 2020. Conservation Banks Serving Sonoma county, California. https://www.fws.gov/sacramento/es/Conservation-Banking/Banks/Sonoma/

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State listed species or CDFW Species of Special Concern that have moderate to high potential to occur within the project site will be protected through appropriate minimization or avoidance measures.
The table below summarizes the minimization or avoidance measures for state special status species, which are provided in detail in Appendix B.

Table 3: Special Status State Species: Avoidance and Minimization Measures

Species	State Status	Governing Guidance Document, or Minimization or Avoidance Measure
Townsend's Big-eared Bat (*Corynorhinus townsendii*)	CDFW-SSC	• Mitigation Measure BIO-3: Conservation Measures to Protect Nesting, Migratory Birds, Raptor and Bat Species
Pallid Bat (*Antrozous pallidus*)	CDFW-SSC	• Mitigation Measure BIO-3: Conservation Measures to Protect Nesting, Migratory Birds, Raptor and Bat Species
Western Red Bat (*Lasiurus blossevillii*)	CDFW-SSC	• Mitigation Measure BIO-3: Conservation Measures to Protect Nesting, Migratory Birds, Raptor and Bat Species
American Badger (*Taxidea taxus*)	CDFW-SSC	• Mitigation Measure BIO-4: Conservation Measures to Protect the American Badger
Great Blue Heron (*Ardea herodias*)	CDFW-SSC	• Mitigation Measure BIO-3: Conservation Measures to Protect Nesting, Migratory Birds, Raptor and Bat Species • RHJV 2004. http://www.prbo.org/calpif/pdfs/riparian.v-2.pdf.
Grasshopper Sparrow (*Ammodramus savanarum*)	CDFW-SSC	• Mitigation Measure BIO-3: Conservation Measures to Protect Nesting, Migratory Birds, Raptor and Bat Species
Golden Eagle (*Aquila chrysaetos*)	CDFW Fully Protected (FP)	• Mitigation Measure BIO-3: Conservation Measures to Protect Nesting, Migratory Birds, Raptor and Bat Species
Vaux's swift (*Chaetura vauxi*)	CDFW-SSC	• Mitigation Measure BIO-3: Conservation Measures to Protect Nesting, Migratory Birds, Raptor and Bat Species
Olive-sided Flycatcher (*Contopus cooperi*)	CDFW-SSC	• Mitigation Measure BIO-3: Conservation Measures to Protect Nesting, Migratory Birds, Raptor and Bat Species
White-tailed Kite (*Elanus leucurus*)	CDFW-FP	Mitigation Measure BIO-3: Conservation Measures to Protect Nesting, Migratory Birds, Raptor and Bat Species

American Peregrine Falcon (*Falco peregrinus anatum*)	CDFW-FP	• Mitigation Measure BIO-3: Conservation Measures to Protect Nesting, Migratory Birds, Raptor and Bat Species
Bald Eagle (*Haliaeetus leucocephalus*)	SE CDFW-FP	• Mitigation Measure BIO-3: Conservation Measures to Protect Nesting, Migratory Birds, Raptor and Bat Species
Purple Martin *(Progne subis*)	CDFW-SSC	• Mitigation Measure BIO-3: Conduct Bat and Bird Surveys for Protected Avian Species
Yellow Warbler (*Setophaga petechial*)	CDFW-SSC	• Mitigation Measure BIO-3: Conservation Measures to Protect Nesting, Migratory Birds, Raptor and Bat Species • RHJV 2004. http://www.prbo.org/calpif/pdfs/riparian.v-2.pdf.
Western Pond Turtle (*Emys marmorata*)	CDFW-SSC	• Mitigation Measure BIO-2: Conservation Measures to Protect Special-Status Amphibians and Reptiles •
California Giant Salamander (*Dicamptodon ensatus*)	CDFW-SSC	• Mitigation Measure BIO-2: Conservation Measures to Protect Special-Status Amphibians and Reptiles
Foothill Yellow-legged Frog (*Rana boylii*)	SE CDFW-SSC	• Mitigation Measure BIO-2: Conservation Measures to Protect Special-Status Amphibians and Reptiles
Red-bellied Newt (*Taricha rivularis*)	CDFW-SSC	• Mitigation Measure BIO-2: Conservation Measures to Protect Special-Status Amphibians and Reptiles

Supplemental References

Bald and Golden Eagle Protection Act (BGEPA). 1940. 16 United States Code (USC) § 668-668d. Bald Eagle Protection Act of 1940, June 8, 1940, Chapter 278, § 2, 54 Statute (Stat.) 251; Expanded to include the related species of the golden eagle October 24, 1962, Public Law (P.L.) 87-884, 76 Stat. 1246. As amended: October 23, 1972, P.L. 92-535, § 2, 86 Stat. 1065; Nov. 8, 1978, P.L. 95-616, § 9, 92 Stat. 3114.

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U.S. Fish and Wildlife Service (USFWS). 2010. Considerations for Avian and Bat Protection Plans. USFWS White Paper. 11 pp.

U.S. Fish and Wildlife Service (USFWS). 2020. Conservation Banks Serving Sonoma County, California https://www.fws.gov/sacramento/es/Conservation-Banking/Banks/Sonoma/

Mitigation Measure	Implementation Responsibility	Monitoring/ Reporting Responsibility	Timing
BIO-1: Avoidance and Protection Measures for Special-status Plants The Project will implement the following avoidance and protection measures for special-status plants which are listed in Table 1 of the Hanson Wetland Implementation and Monitoring Plan to a less than significant level and includes: 1. Seasonally appropriate pre-construction surveys will occur prior to construction within the planned area of disturbance (project footprint), during the appropriate blooming time (spring or summer) for the target species. Impacts to special-status annual plants will be avoided to the extent feasible. If these plants occur within the project footprint, and permanent impacts cannot be avoided, they will be conserved through re-seeding (by a qualified botanist) into suitable habitat in the immediate project area. Seed will be collected in the late summer or early fall the year before construction when seeds from each target species are mature. Seed will be stored and spread post-project construction in available suitable habitat, near areas where impacts have occurred. Conservation banking may also be investigated (USFWS 2016). 2. If pre-construction surveys determine that other special-status species are present within the project footprint, these plants will also be avoided to the extent feasible, and if not feasible, they will be conserved by measures appropriate for the individual species. Conservation measures may include plant relocation, seed collection, and/or nursery plant propagation. (see Endnote) 3. Pre-construction surveys will also be performed within the planned area of disturbance, less than seven days prior to ground disturbance within habitat appropriate for the special-status plant species listed in the Implementation and Monitoring Plan. At this time any newly identified impacts to special-status plant species within the planned area of disturbance that cannot be feasibly avoided will be quantified and mapped. In the event that mature seed is available for any of the special-status plant species listed in Appendix E, Table 1 present within the project disturbance area and plants cannot be feasibly avoided, the seed will be collected, stored, and spread post construction and as described in this mitigation measure. All special-status plant species found at this time within the planned area of disturbance will be flagged for avoidance during construction. 4. Any plants that could not be feasibly avoided and that will be impacted will be mapped, and the number of individuals documented prior to construction. The approximate quantity of seed collected from these plants and the dates the seed was collected and spread will also be reported. 5. Any seed mixes or other vegetative material used for re-vegetation of disturbed sites will consist of locally adapted native plant materials to the extent practicable.	Project lead	Project lead	Prior to construction (surveys)

BIO-2: Conservation Measures to Protect Special-Status Amphibians and Reptiles Mitigation Measure BIO-2 is included to reduce any potential impacts to special-status amphibians and special-status reptiles listed in Appendix E, Table 1 of the Implementation and Monitoring Plan to a less than significant level and includes: 1. If work is required that would impact known or potential breeding habitat for the California Red-legged Frog, a federally threatened species, or if any individual animals are encountered, then a qualified biologist would manage any encounters with the species or its habitat in accordance with the USFWS Nine-county Programmatic Biological Opinion (2014). All conservation measures in the PBO, including but not limited to the following, will be complied with: A Service-approved biologist(s) will be onsite during all activities that may result in take of the California red-legged. The qualifications of the biologist(s) will be submitted to the Service for review and written approval at least 30 calendar days prior to the date earthmoving is initiated at the project site. The biologist will keep a copy of the biological opinion and the appendage in their possession when onsite. Prior to the date of initial ground disturbance, a pre-construction survey for the CRLF will be conducted by a Service-approved biologist at the project site. The survey will consist of walking the project limits and the project footprint to ascertain the possible presence of the species. The Service-approved biologist will investigate all potential areas that could be used by the CRLF for feeding, breeding, sheltering, movement, and other essential behaviors. This includes an adequate examination of mammal burrows, such as ground squirrels or gophers. If any adults, subadults, juveniles, tadpoles, or eggs are found, the Service-approved biologist will contact the Service to determine if moving any individuals is appropriate. In making this determination the Service will consider if an appropriate relocation site exists. Only Service-approved biologists will capture, handle, and monitor the CRLF. 2. If work is required that would impact known or potential breeding habitat for the Foothill Yellow-legged Frog, CA Giant Salamander, Red-bellied Newt, California Tiger Salamander, or Northwestern Pond Turtle, then a qualified biologist would conduct preconstruction surveys within 24 hours prior to start of construction to identify and relocate, subject to CDFW approval, any encountered species. (See Northwestern Pond Turtle species account) 3. Prior to construction, a qualified biologist will conduct training sessions to familiarize all construction personnel and supervisors with identification of the following: California Red-legged Frog, Foothill Yellow-legged Frogs, California Giant Salamander, California Tiger Salamander, Red-bellied Newt, and Northwestern Pond Turtle. Additionally, information regarding habitat, general provisions and protections afforded to these species, measures implemented to protect the species, and a review of the project boundaries will be conveyed. This training would also be provided to construction supervisors and staff within 30 days of the arrival of any new worker during the course of implementation of the project.	Project lead	Project lead	Prior to construction (surveys)

Mitigation Measure BIO-3: Conservation Measures to Protect Nesting, Migratory Birds, Raptor and Bat Species Mitigation Measure BIO-3 is included to reduce any potential impacts to special-status migratory bird and bat species listed in Section 2.3.1 of the Implementation and Monitoring Plan to a less than significant level and includes: 1. The Project Manager shall ensure that seasonal avoidance of the February 15 – August 15 nesting season will be utilized when feasible, to avoid impacts to native bird species protected under the Migratory Bird Treaty Act that may be present within the project footprint or adjacent area during construction. Clearing of shrubs or other vegetation, if necessary for construction or maintenance, will be conducted during the fall and/or winter months from August 16 to February 14, outside of the active nesting season. If vegetation removal or ground disturbance cannot be confined to work during the non-breeding season, the Project Manager will have a qualified biologist conduct preconstruction surveys within the vicinity of the impact area, to check for nesting activity of native birds and to evaluate the site for presence of raptors and special-status bird species. The biologist will conduct a minimum of one day preconstruction survey within the 7-day period prior to vegetation removal and ground-disturbing activities. If ground disturbance and vegetation removal work lapses for seven days or longer during the breeding season, a qualified biologist shall conduct a supplemental avian preconstruction survey before project work is reinitiated. 2. If active nests are detected within the construction footprint or within 500 feet of construction activities, the biologist will flag habitat segments that are supporting breeding, and the Project Manager will not begin construction activities inside the avian buffers until the young have fledged. If nests are documented outside of the construction (disturbance) footprint, but within 500 feet of the construction area, buffers will be implemented as needed. In general, the buffer size for common species would be determined on a case-by-case basis in consultation with the CDFW. The buffer size for sensitive species would be 300 feet, and the buffer size for raptors would be 500 feet, if deemed appropriate in coordination with the CDFW. 3. Buffer sizes will take into account factors such as (1) noise levels and human disturbance activity at the construction site at the time of the survey and the noise and disturbance expected during the construction activity; (2) distance and amount of vegetation or other screening between the construction site and the nest; and (3) sensitivity of individual nesting species and behaviors of the nesting birds. The survey results will be reported to the CDFW prior to the commencement of construction activities. 4. A bat survey will be conducted during the spring, summer, or fall prior to construction, and any areas where oaks or potential roosting sites may be disturbed. Surveys will be conducted by a qualified biologist and will include at a minimum a visual inspection of the riparian corridor and any large trees with cavities or loose bark. If bats are located, an attempt will be made to identify the species either	Project lead	Project lead	Prior to construction (surveys)

visually or acoustically. If the presence of a bat maternity colony or roost is confirmed, no activity generating significant noise will occur within 300 feet of the roost from April 1 through August 15 or until young have dispersed.			
Mitigation Measure BIO-4: Conservation Measures to Protect the American Badger. Mitigation Measure BIO-4 is included to reduce any potential impacts to the American Badger as listed in Appendix E, Table 1 of the Implementation and Monitoring Plan to a less than significant level and includes: 1. The construction impact area and a 2,640-foot (0.5 mile) buffer area around each construction impact area will be surveyed seven days before the start of construction for any ground burrows indicative of American Badgers. 2. If any burrows suggestive of American Badger are found, they will be avoided by a 100-foot buffer.	Project lead	Project lead	Prior to construction (surveys)
Mitigation Measure BIO-5: Conservation Measures to Protect Salmonids Mitigation Measure BIO-5 is included to reduce any potential impacts to ESA-listed and other special-status fishes as listed in Appendix E, Table 1 of the Implementation and Monitoring Plan to a less than significant level and includes: 1. Prior to complete dewatering of any in-channel work areas, coffer dams or barrier nets shall be placed to block off the area. Any fish remaining inside the coffer dams or barriers will be carefully removed by a qualified biologist. In order to minimize potentially adverse effects to aquatic organisms, all translocation/removal of fishes will be conducted by qualified fisheries biologists. Any fish that cannot be herded by seines from the work areas and must be physically handled will be immediately released in suitable habitat away from the action area, with comparable habitat and water quality conditions. Immediately following completion of in-channel work, any cofferdams or block nets will be removed allowing free fish passage through the project area during the remainder of the construction period. 2. To protect the most vulnerable life stages of sensitive fish species that occur within the action area, all in-channel work will be restricted to the regulated in-water work period. This seasonal work window correlates to the period of the year when sensitive fish species are least likely to occur in the action area. 3. Prior to hydrological modification of existing ponds and backwaters, “escape routes,” that is channels or sloughs, will be constructed to allow movement of fish out of the area to be modified and into safe refugial habitats.	Project lead	Project lead	Prior to construction (surveys)

Supplemental references

Center for Plant Conservation. 1991. Genetic Sampling Guidelines for Conservation Collections of Endangered Plants. Pages 225-238 *in* D. A. Falk

U.S. Fish and Wildlife Service. 2016. Recovery Plan for the Santa Rosa Plain: *Blennosperma bakeri* (Sonoma sunshine)*; Lasthenia burkei* (Burke's goldfields)*; Limnanthes vinculans* (Sebastopol meadowfoam); California Tiger Salamander Sonoma County Distinct Population Segment (*Ambystoma californiense*). U.S. Fish and Wildlife Service, Pacific Southwest Region, Sacramento, California. vi + 128 pp.

Endnotes:

Seed collections for each plant taxon should be representative of both population- and species-level genetic diversity; seeds should be collected from multiple plants at each occurrence. Seed collection guidelines published by the Center for Plant Conservation (1991) should be followed. Seed collection should be conducted with caution to ensure that donor populations are not adversely affected by the collection. No more than 5 percent of the reproductive output should be removed from donor populations. Store seeds at two storage facilities certified by the Center for Plant Conservation. Seeds should be collected every 5 years to ensure that seeds in storage are viable. Permits will be required for collecting federally-listed plant seed on federal lands. (USFWS 2016, p93)

Appendix D
Geotechnical Investigation

MPEG
MILLER PACIFIC
ENGINEERING GROUP

GEOTECHNICAL INVESTIGATION
HANSON QUARRY POND RESTORATION PROJECT
9651 EASTSIDE ROAD
WINDSOR, CALIFORNIA

November 10, 2020

Job No. 1206.183 (Rev 1)

Prepared for:
Hanson Quarry
c/o GHD
718 3rd Street
Eureka, California 95501

Attn: Mr. Jeremy Svehia

CERTIFICATION

This document is an instrument of service, prepared by or under the direction of the undersigned professionals, in accordance with the current ordinary standard of care. The service specifically excludes the investigation of polychlorinated byphenols, radon, asbestos or any other hazardous materials. The document is for the sole use of the client and consultants on this project. No other use is authorized. If the project changes, or more than two years have passed since issuance of this report, the findings and recommendations must be updated.

MILLER PACIFIC ENGINEERING GROUP	REVIEWED BY:
REGISTERED PROFESSIONAL ENGINEER NATHAN G. KLEMIN C83411 Exp. 3/31/21 CIVIL STATE OF CALIFORNIA	REGISTERED PROFESSIONAL ENGINEER SCOTT A. STEPHENS 2398 Exp. 6/30/21 GEOTECHNICAL STATE OF CALIFORNIA
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GEOTECHNICAL INVESTIGATION
HANSON QUARRY POND RESTORATION PROJECT
9651 EASTSIDE ROAD
WINDSOR, CALIFORNIA

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GEOTECHNICAL INVESTIGATION
HANSON QUARRY POND RESTORATION PROJECT
9651 EASTSIDE ROAD
WINDSOR, CALIFORNIA

1.0 INTRODUCTION

This report presents the results of our Geotechnical Investigation for the planned Hanson Quarry Pond Restoration project. As shown on Figure 1, the project site is located along the Russian River at 9651 Eastside Road, just west of the town of Windsor, California.

Our work was performed in accordance with GHD's Purchase Order No. 38004086 dated September 18, 2019. The purpose of our investigation was to explore subsurface conditions and to develop geotechnical criteria for permitting, design and construction during the restoration of the pond. The scope of our services includes:

- Review of available, published geologic mapping and geotechnical background information from our files, and any geologic/geotechnical background information supplied by you.
- Coordinate with Underground Service Alert (USA) to mark underground utilities in areas where we plan to conduct subsurface exploration.
- Subsurface exploration consisting of one day of exploratory borings. We completed four borings that extended approximately 10-feet below the ground surface.
- Evaluation of relevant geologic hazards including seismic shaking, liquefaction, settlement, and other hazards.
- Preparing preliminary geotechnical recommendations and design criteria related to, site grading, and other geotechnical-related items.
- Preparing a Geotechnical Investigation report which summarizes the subsurface exploration, evaluation of relevant geologic hazards, and geotechnical recommendations and design criteria.

This report completes our geotechnical services for the project. Subsequent phases of work typically include supplemental consultation with the design team, geotechnical plan review of project plans, and observation and testing of geotechnical-related work items during construction. These services have not been authorized.

2.0 PROJECT DESCRIPTION

The project site is located at 9651 Eastside Road in Windsor, California, west of the intersection of Windsor River Road and Eastside Road. The property encompasses several assessor parcels. The property formerly served as an aggregate quarry facility and quarry operations have been discontinued for several years. During previous site development, a levee was constructed near the southwest end of property, likely to mitigate flooding of the Richardson Pit from the Russian River. The existing levee creates a relatively steep bank along the east side of the Russian River and directly west of the Richardson Quarry Pit, approximately 2,000 feet north of Richardson Road. The main objective of the project is to quarry reclamation that involves site grading to restore the natural flood plain. A site plan showing the existing conditions with the project site and our boring locations is presented on Figure 2.

3.0 SITE CONDITIONS

3.1 Regional Geology

The project site is located within the Coast Ranges geomorphic province of California. It is typified by generally northwest-trending ridges and intervening valleys that formed as a result of movement along a group of northwest-trending fault systems, including the San Andreas Fault. Bedrock geology within the San Francisco Bay Area is dominated by sedimentary, igneous, and metamorphic rocks of the Jurassic-Cretaceous age Franciscan Complex. Most of Franciscan rock types are composed of sandstone and pervasively sheared shale. It also includes less common rocks such as chert, serpentinite, basalt, greenstone, and exotic low- to high-grade metamorphic rocks, including phyllite, schist, and eclogite.

Geologic mapping (Wagner and Bortugno, 1982) indicates that the project site is underlain by relatively young alluvial deposits consisting of unconsolidated and interbedded sands, gravels, silts, and clays. The alluvium is underlain by older fluvial gravel, silt, sand and clay. A regional geologic map is provided on Figure 3.

3.2 Seismicity

The project site is located within the seismically active San Francisco Bay Area and will therefore experience the effects of future earthquakes. Earthquakes are the product of the build-up and sudden release of strain along a “fault” or zone of weakness in the earth's crust. Stored energy may be released as soon as it is generated, or it may be accumulated and stored for long periods of time. Individual releases may be so small that they are detected only by sensitive instruments, or they may be violent enough to cause destruction over vast areas.

Faults are seldom single cracks in the earth's crust but are typically composed of localized shear zones which link together to form larger fault zones. Within the Bay Area, faults are concentrated along the San Andreas Fault zone. The movement between rock formations along either side of a fault may be horizontal, vertical, or a combination, and is radiated outward in the form of energy waves. The amplitude and frequency of earthquake ground motions partially depends on the material through which it is moving. The earthquake force is transmitted through hard rock in short, rapid vibrations, while this energy becomes a long, high-amplitude motion when moving through soft ground materials, such as Bay Mud.

3.2.1 Regional Active Faults

An “active” fault is one that shows displacement within the last 11,000 years (i.e., Holocene) and has a reported average slip rate greater than 0.1 mm per year. The California Division of Mines and Geology has mapped various active and inactive faults in the region. These faults are shown in relation to the project site on the attached Active Fault Map, Figure 4. The nearest known active faults are the Rodgers Creek, Healdsburg, and Maacama Faults which are located roughly 6.0 kilometers northeast, 6.5 kilometers north, and 12.2 kilometers east of the site, respectively.

3.2.2 Historic Fault Activity

Numerous earthquakes have occurred in the region within historic times. Earthquakes (magnitude 2.0 and greater) that have occurred in the San Francisco Bay Area since 1985 have been plotted on a map shown on Figure 5.

3.2.3 Probability of Future Earthquakes

The site will likely experience moderate to strong ground shaking from future earthquakes originating on any of several active faults in the San Francisco Bay region. The historical records do not directly indicate either the maximum credible earthquake or the probability of such a future event. To evaluate earthquake probabilities in California, the USGS has assembled a group of researchers into the "Working Group on California Earthquake Probabilities" (USGS 2003, 2008, 2013) to estimate the probabilities of earthquakes on active faults. These studies have been published cooperatively by the USGS, CGS, and Southern California Earthquake Center (SCEC) as the Uniform California Earthquake Rupture Forecast, Versions 1, 2, and 3. In these studies, potential seismic sources were analyzed considering fault geometry, geologic slip rates, geodetic strain rates, historic activity, micro-seismicity, and other factors to arrive at estimates of earthquakes of various magnitudes on a variety of faults in California.

Conclusions from the most recent UCERF3 and USGS indicate the highest probability of an earthquake with a magnitude greater than 6.7 originating on any of the active faults in the San Francisco Bay region by 2043 is assigned to the Hayward/Rodgers Creek Fault system. The Rodgers Creek Fault is located approximately 6.0 kilometers (3.7 miles) northeast of the site and is assigned a probability of 33 percent. Additional studies by the USGS regarding the probability of large earthquakes in the Bay Area are ongoing. These current evaluations include data from additional active faults and updated geological data.

3.3 Site History

As previously discussed, the project site was formerly used as part of quarry operations. We reviewed seven aerial photographs of the project area provided by Pacific Aerial Survey. We reviewed aerial photographs that span over a 32-year period from April 1968 to April 2000. Quarry operations were visible in the 1968 photo, but the embankment was not clearly visible. The vegetation and water flow path within the riverbed vary within the aerial photos. Comparison of the 1993 and 1995 photos show a significant loss of vegetation and erosion at the toe of the slope on the river side of the levee as well as loss of vegetation and possible sloughing on the quarry side. Continued erosion is visible between the 1995 and 2000 photographs.

3.4 Surface Conditions

The project site encompasses an approximately 356-acre parcel located just west of the Town of Windsor between Eastside Road and the Russian River. Extensive site grading, excavation, and removal of aggregate material during quarry operations have resulted in the formation of several quarry pits present at the site, with the largest pit (Richardson Pit) located toward the south end of the property. During site development, a levee was constructed to provide separation between the river and adjacent quarry pit during flooding events. The existing levee embankment is sited between the Russian River (to the west) and Richardson Pit (to the east). The levee alignment roughly parallels the river. The exact location of the north and south end of the constructed embankment and its total length are unclear. It appears the embankment is several thousand feet long. An unpaved access road exists around the perimeter of Richardson Pit and parallels the east side of the levee. The levee crest elevation varies from approximately +78 feet to +84 feet. The toe of the east side of the embankment exists along the adjacent access road and elevations vary from approximately +60 feet to +62 feet, and the toe of the west side of the embankment is at the current riverbed elevation of roughly +44.

The side slopes of the levee embankment are very steep (on the order of 1:1 to nearly vertical in localized areas) and frequent scarps from erosion and sloughing are visible on both sides of the levee, with the most extensive scaring visible on the west side along the river cut bank. In the improvement area, the west side slope is sparsely vegetated with shrubs and small trees with relatively denser vegetation observed along the east side slopes. Vegetation and tree cover become denser progressing north and south of the eroded cut bank.

The existing quarry pits are generally filled with water and have depths of approximately 30 to 60-feet. The surrounding areas are relatively level with access roads around the existing ponds. Dense vegetation is present throughout the project site and along the pond embankments. The areas beyond the project site are planted with vineyards.

3.5 Field Exploration and Laboratory Testing

We explored subsurface conditions near the proposed improvements on January 8, 2020 with four borings at the approximate locations shown on Figure 2. The borings were excavated using track mounted drilling equipment with 4-inch solid flight augers to a maximum depth of 11.5 feet below the ground surface. A Soil Classification Chart is shown on Figure A-1. The boring logs are presented on Figures A-2 through A-5 of Appendix A.

Laboratory testing of selected soil samples from the exploratory borings included moisture content, dry density, unconfined compressive strength, direct shear, sieve analyses, percent of particles passing a number 200 sieve, plasticity index, and compaction curve testing. The results of the moisture content, dry density, unconfined compression testing, and percent of particles passing a number 200 sieve are presented on the boring logs. The direct shear, sieve analysis, plasticity index, and compaction curve test results are presented on Figures A-6 through A-11. The laboratory testing program is discussed in greater detail in Appendix A.

We previously explored a damaged portion of the existing levee near the Richardson Quarry Pit in September 2008. Boring Logs and associated lab testing results are presented on Figures A-12 through A-19 in Appendix A.

3.6 References Subsurface Exploration

Previous explorations at or near the site conducted by RGH (1995 and 1996) included soil borings at the approximate locations shown on Figure 2. The borings extended between 20- and 50-feet below the ground surface. Reference subsurface logs and relevant laboratory data are provided in Appendix B.

3.7 Subsurface Soil Conditions

The interpreted subsurface conditions along with the previously explored conditions encountered are generally consistent with the mapped geologic conditions at the site (Clahan, 2003). Based on our subsurface exploration and reference data, the site is generally underlain by variable fill and alluvial deposits. Within previous fill areas from quarry operations, the upper 10 to 15 feet are layers of medium stiff, clay and silt and medium dense, silty sand. The levee along the river, and undisturbed native alluvial soils are primarily dense sand and gravel layers. Bedrock was not encountered.

3.8 Groundwater

Groundwater was not encountered in our relatively shallow borings in January of 2020. However, groundwater was encountered in some of the deeper reference borings. Reference borings indicate groundwater between about 18- and 28-feet below the ground surface. We expect that groundwater will likely correspond with water levels in the adjacent Russian River and ponds (elevation +40 to +50).

4.0 GEOLOGIC HAZARDS

This section summarizes our review of commonly considered geologic hazards and discusses their potential impacts on the planned improvements. The primary geologic hazards which could affect the proposed development include strong seismic ground shaking, liquefaction, lateral spreading, seismic densification, slope instability, erosion and settlement. Other geologic hazards are judged less than significant regarding the proposed project. Geologic hazards, potential impacts and mitigation measures are discussed in further detail in the following sections.

4.1 Fault Surface Rupture

Under the Alquist-Priolo Earthquake Fault Zoning Act, the California Division of Mines and Geology (now known as the California Geological Survey) produced 1:24,000 scale maps showing known active and potentially active faults and defining zones within which special fault studies are required. The nearest known active fault to the site is the Rodgers Creek Fault located approximately 6.0 kilometers to the northeast. The site is not located within an Alquist-Priolo Special Studies Zone. We therefore judge the potential for fault surface rupture in the project site to be low.

Evaluation: Less than significant. No mitigation measures are required.

4.2 Seismic Shaking

The site will likely experience seismic ground shaking similar to other areas in the seismically active Bay Area. The intensity of ground shaking will depend on the characteristics of the causative fault, distance from the fault, the earthquake magnitude and duration, and site-specific geologic conditions. Estimates of peak ground accelerations are based on either deterministic or probabilistic methods.

Deterministic methods use empirical attenuation relations that provide approximate estimates of median peak ground accelerations. A summary of the active faults that could most significantly affect the planning area, their maximum credible magnitude, closest distance to the center of the planning area, probable peak ground accelerations, and 84th percentile peak ground accelerations are summarized in Table 1. The calculated accelerations should only be considered as reasonable estimates. Many factors (e.g., soil conditions, orientation to the fault, etc.) can influence the actual ground surface accelerations.

Table 1 – Deterministic Peak Ground Accelerations for Active Faults

Fault	Moment Magnitude for Characteristic Earthquake	Closest Estimated Distance (km)	Median Peak Ground Acceleration (g)	84% Peak Ground Acceleration (g)
Rodgers Creek	7.3	6.0	0.41	0.68
Healdsburg	6.4	6.5	0.33	0.56
Maacama	7.4	12.2	0.31	0.52
San Andreas	8.0	27.6	0.24	0.41
Chianti	6.4	20.2	0.15	0.27

Reference: Abrahamson, Silva & Kamai (2014), Boore, Stewart, Seyhan & Atkinson (2014), Campbell & Bozorgnia (2014), and Chiou & Youngs (2014) NGA models using V_{s30} = 270 m/s.

Probabilistic Seismic Hazard Analysis analyzes all possible earthquake scenarios while incorporating the probability of each individual event to occur. The probability is determined in the form of the recurrence interval, which is the average time for a specific earthquake acceleration to be exceeded. The design earthquake is not solely dependent on the fault with the closest distance to the site and/or the largest magnitude, but rather the probability of given seismic events occurring on both known and unknown faults.

We calculated the peak ground acceleration for two separate probabilistic conditions; the 2 percent chance of exceedance in 50 years (2,475-year statistical return period) and the 10 percent chance of exceedance in 50 years (475-year statistical return period). The peak ground acceleration values were calculated utilizing the USGS Unified Hazard Tool (USGS, 2018). The results of the probabilistic analyses are presented below in Table 2.

Table 2 – Probabilistic Peak Ground Accelerations for Active Faults

Probability of Exceedance	Statistical Return Period	Magnitude	Peak Ground Acceleration (g)
2% in 50 years	2,475 years	7.2	0.82
10% in 50 years	475 years	7.1	0.49

Reference: USGS Unified Hazard Tool accessed on January 24, 2020.

Ground shaking can result in structural failure and collapse of structures or cause non-structural building elements (such as light fixtures, shelves, cornices, etc.) to fall, presenting a hazard to building occupants and contents. Compliance with provisions of the most recent version of the California Building Code (2019 CBC) should result in structures that do not collapse in an earthquake. Damage may still occur and hazards associated with falling objects or non-structural building elements will remain.

The potential for strong seismic shaking at the project site is high. Due to their proximity and historic rates of activity, the Healdsburg, Rodgers Creek, Maacama, and San Andreas Faults present the highest potential for severe ground shaking. The significant adverse impact associated with strong seismic shaking is potential damage to structures and improvements.

Evaluation: *Less than significant with mitigation.*
Minimum mitigation recommendations include designing any new structures in accordance with the provisions of the 2019 California Building Code or subsequent codes in effect when final design occurs. Preliminary seismic design coefficients are presented in Section 5.1 of this report.

4.3 <u>Liquefaction and Related Effects</u>

Liquefaction refers to the sudden, temporary loss of soil strength during strong ground shaking. The strength loss occurs as a result of the build-up of excess pore water pressures and subsequent reduction of effective stress. While liquefaction most commonly occurs in saturated, loose, granular deposits, recent studies indicate that it can also occur in materials with relatively high fines content provided the fines exhibit lower plasticity.

The effects of liquefaction can vary from cyclic softening resulting in limited strain potential to flow failure which cause large settlements and lateral ground movements. Lateral spreading refers to a specific type of liquefaction-induced ground failure characterized primarily by horizontal displacement of surficial soil layers due to liquefaction of a subsurface granular layer (Youd, 1995). Lateral spreads generally move down gentle slopes or slip toward a free face such as an incised river channel.

As shown on Figure 6, regional mapping of seismic hazard zones indicates the site lies within a zone of high to very high liquefaction potential. Subsurface exploration indicates the presence of loose granular materials that may be prone to liquefaction during strong seismic shaking. Many of these layers are present in the upper 20-feet of soils. Liquefaction analysis indicates that liquefaction settlements maybe on the order of 3- to 6-inches, using a PGA_M of 0.80 g and groundwater located approximately 5-feet from the existing ground surface surrounding the ponds.

Additionally, soils placed in the existing ponds will likely be loose and uncompacted, considering they will likely be dumped or pushed into the water filled ponds. These soils would probably be susceptible to liquefaction and would result in vertical settlements. Seismic induced settlements on the order of several feet are likely in the filled pond areas following a strong seismic event.

The amount of lateral spreading will largely depend on the differences in elevation between the quarry restoration area and the riverbed. Higher elevation difference will result in higher amounts of lateral spreading. In general, several feet of lateral spreading should be anticipated. Therefore, we judge the potential for lateral spreading and adjustment of finished grades at the project site is moderate to high.

Evaluation: *Significant unavoidable hazard. Differential seismic induced settlement at transitions from cut to deep fill areas should be expected. Finished elevations within the project site should take into account the potential for future liquefaction due to strong seismic shaking. Additional soils may be needed following a seismic event to restore grades. The amount of seismic induced settlement and lateral spreading can be reduced by dynamic compaction (i.e., vibratory stone columns) of the placed pond fills. The cost for densification is expected to be significant. Following a strong seismic event, any roadways or levees within the project area should be inspected for damage and to develop any needed repair plans.*

4.4 Settlement

Significant settlement can occur when new loads are placed over soft, compressible clays or loose granular soils. While these soil conditions exist in some of the project areas, much of the pond embankments and the existing levee will be removed as part of the project. These soils will then be placed into the existing ponds to restore the original ground surface. This fill material will consolidate under the overburden fill load. The amount of settlement is difficult to predict since it depends of the fill material type and thickness. Sands and gravels should have less settlement and should occur quicker compacted to clayey soils. For rough planning purposes, several feet of compression / consolidation settlement should be anticipated. We judge the risk of vertical settlement is low in cut areas and high in the filled pond areas.

Evaluation: *Significant hazard. Mitigation of this hazard could involve deep dynamic compaction or grouting that is likely not economically feasible for the project. Surcharging the filled pond areas with several feet of additional soil above planned grades and allowing several months for settlement to occur would reduce post-construction settlements. Differential settlement should be expected at transitions from cut to deep fill areas. Finished elevations within the project site should take into account this potential settlement.*

If the range of bulking and shrinkage estimates provided in Section 5.1.4 need to be narrowed or a higher confidence in estimates is desired, additional laboratory testing should be performed on the borrow area soils to be used to fill the ponds to better estimate bulking volume, expected settlement amounts and time rates.

4.5 Seismic Densification

Seismic ground shaking can induce settlement in unsaturated, loose, granular soils. Settlement occurs as the loose soil particles rearrange into a denser configuration when subjected to seismic ground shaking. Varying degrees of settlement can occur throughout new fill areas. Soils above the groundwater level may be prone to densification during strong seismic shaking. Therefore, the risk of seismic densification impacting the project is generally low.

Evaluation: Less than significant. Mitigation measures are similar to liquefaction settlement but to a lesser extent.

4.6 Expansive Soils

Soil expansion occurs when clay particles interact with water causing seasonal volume changes in the soil matrix. The clay soil swells when saturated and then contracts when dried. This phenomenon generally decreases in magnitude with increasing confinement pressures at increasing depths. These volume changes may damage lightly loaded foundations, concrete slabs, pavements, retaining walls and other improvements. Expansive soils also cause soil creep on sloping ground.

Near surface soils along the existing levees include medium plasticity silts and clays with a moderate expansive potential. However, the project does not include any new structural improvements, therefore the risk of damage due to expansive soils is low.

Evaluation: Less than significant. No mitigation measures are required.

4.7 Erosion

Sandy soils on moderately steep slopes or clayey soils on steep slopes are susceptible to erosion when exposed to concentrated surface water flow. The potential for erosion is increased when established vegetation is disturbed or removed during normal construction activity.

The proposed project includes demolition of existing levees for use as pond backfill to restore the original ground surface. The proximity of the Russian River to the project site and potential for flooding does create an erosion hazard. However, slopes within the project are expected to be relatively flat. Considering the Russian River is a hydraulically dynamic environment, erosion is considered to be a significant geologic hazard.

Evaluation: Less than significant with mitigation. Since natural erosion and sedimentation are expected for the project, no significant mitigation measures are required. Where low flow velocities are anticipated, use of more fine-grained materials near the finished ground surface and/or providing vegetation will reduce erosion potential where desired. Where higher flow velocities are anticipated, riprap should be used to protect against erosion.

4.8 Flooding

The project site is located at about elevation +10 to +85 feet and is mapped as being within a 100-year flood zone (ABAG, 2019), as shown on Figure 7. However, the site is intended to restore former flood plains along the Russian River. Therefore, large scale flooding is not considered a significant adverse hazard.

Evaluation: Less than significant with mitigation. The project Civil Engineer should design site grading and flow paths in consideration of localized flooding associated with maximum credible rainfall events.

4.9 Tsunami and Seiche

Seiche and tsunamis are short duration, earthquake-generated water waves in large enclosed bodies of water and the open ocean, respectively. The extent and severity of a seiche or tsunami would be dependent upon ground motions and fault offset from nearby active faults. The site is not located near a large body of water. Therefore, the likelihood of inundation by seiche or tsunami is low.

Evaluation: Less than significant. No mitigation measures are required.

4.10 Slope Instability/Landslides

The majority of the project site around the existing ponds is relatively level. The existing levee along the Russian River has been subject to slope instability in the past due to over-steepened slopes from erosion during high flows in the river. As part of the project, the pond embankments and the existing levee are to be graded and reduced in height, reducing the risk of slope instability. Therefore, we judge the risk of damage to new improvements due to slope instability/landsliding is currently high but would be low after planned grading.

Evaluation: Less than significant. No special engineering measures are required.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the results of our investigation, we conclude the site conditions are suitable for the proposed improvements. The primary geotechnical considerations for the project will include site grading in the water filled pond areas and estimating cut and fill soil volumes with consideration of soil fluff / shrinkage. As discussed, the geologic hazards significant differential settlement is expected between cut and fill areas. Additional discussion and preliminary conclusions and recommendations addressing these, and other considerations are presented in the following sections.

5.1 Site Grading

Site grading and earthwork should be performed in accordance with the recommendations and criteria outlined in the following sections.

5.1.1 Site Preparation

Clear pavements, old foundations, utilities, over-sized debris, and organic material from areas to be graded. Debris, rocks larger than six inches, and vegetation are not suitable for structural fill and should be removed from the site or buried in landscape areas.

Where fills or other structural improvements are planned, the subgrade surface should be scarified to a depth of 8 inches, moisture conditioned to above the optimum moisture content, and compacted to at least 90 percent relative compaction. Relative compaction refers to the in-place dry density of soil expressed as a percentage of the maximum dry density, as determined by ASTM D1557. Subgrade preparation should extend a minimum of 5 feet beyond the planned building envelope in all directions. The subgrade should be firm and unyielding when proof-rolled with heavy, rubber-tired construction equipment. If soft, wet or otherwise unsuitable materials are encountered at subgrade elevation during construction, we can provide supplemental recommendations to address the specific condition.

5.1.2 Excavations

Based on our subsurface exploration, site excavations will likely encounter medium stiff to stiff clays and loose to medium dense silts and sands in the upper 10 to 15 feet. The levee adjacent the Russian River and the native undisturbed soil are primarily medium dense to dense sands and gravels. Groundwater should be anticipated below a depth of 10-feet but may be shallower during wet months. The medium stiff clay and loose to medium dense sands should be classified as Cal-OSHA Type C soil.

Temporary support of excavations will be required to ensure the safety of workers and to reduce the potential for failure of the excavation sidewalls and damage to surrounding improvements. Excavation stability and the structural design of temporary shoring should be made the sole responsibility of the Contractor. For excavation deeper than 5 feet, the design of temporary dewatering systems should be made the sole responsibility of the Contractor.

Excavations of soil to within about 2 to 3 feet above the groundwater will likely be able to be completed with traditional grading equipment (scrapers, dozers and excavators). We anticipate scrapers on a circular haul route would be the quickest and most efficient way to excavate and haul material above the groundwater level.

Excavation of soil from a few feet above to a few feet below the groundwater level can be accomplished with excavators working from higher elevation, excavating soil to planned grades, loading into trucks and backing their way out using higher grades for support. Additionally, a swamp dozer could be used to excavate and push soil down to and slightly below the groundwater level. Drag lines can also be used for excavation within this zone.

Excavation more than a couple feet below the below the groundwater level is probably best suited for removed by use of a dragline or dredging equipment to achieve the proper excavation depth.

5.1.3 Fill Materials, Placement and Compaction

Structural fill materials should consist of non-expansive materials that are free of organic matter, have a Liquid Limit of less than 40 (ASTM D 4318), a Plasticity Index of less than 20 (ASTM D 4318), and a minimum R-value of 20 (California Test 301). The fill material should contain no more than 50 percent of particles passing a No. 200 sieve and should have a maximum particle size of 4 inches. A majority of onsite soils are suitable for use as structural fill.

Most of the anticipated grading will not be structural fill, therefore organic material can be mixed with the fill if some minor settlement from decomposition is acceptable.

Where fills are placed above water level, materials should be moisture conditioned to near the optimum moisture content prior to compaction. Properly moisture conditioned fill materials should subsequently be placed in loose, horizontal lifts and uniformly compacted. For landscape fill, lift thickness should limited to 12 inches lift thickness and compacted to at least 85 percent relative compaction. General fill for levees, roadways, parking areas or building pads should limited to 12 inches lift thickness and compacted to at least 90 percent relative compaction. In pavement areas, the upper 12 inches of fill should be compacted to at least 95 percent relative compaction. The maximum dry density and optimum moisture content of fill materials should be determined in accordance with ASTM D1557.

To fill the ponds, fill material will likely be dozed in from the edges, dumped from drag lines or pumped in from dredging. Fill placement under these placement methods should correspond with relative compaction between 70 to 80 percent. Since the below-water fill will be loose and settle during placement, we expect the elevation of the fill will need to be several feet above the water level during grading, and then the surface cut down to planned grades using swamp dozers.

The rate at which grading can occur will be defined by site access restrictions (haul routes) and the Contractor’s available manpower and equipment. We recommend consultation with a grading contractor to establish an estimate on cubic yards per day that can be moved. For rough planning, assuming 10 scrapers with a 20 yards per scraper capacity and a 15-minute round trip haul route, can move approximately 800 yards per hour.

Recommended maximum slope inclinations vary depending on cut and relative compaction of the fill. For cut areas or fill areas with greater than 85% relative compaction, the maximum recommended slope inclinations is 3:1 (horizontal:vertical). For the loose pond fill with low relative compaction, recommended maximum slope inclinations is 6:1 or flatter if feasible.

5.1.4 Bulking and Shrinkage

We understand bulking, shrinkage and compression / consolidation estimates are desired. However, these estimates are highly variable based on soil type, loading (thickness of fill) and degree of compaction. Some very rough estimates are presented below. A laboratory testing program include compaction curves, bulking under water, and consolidation tests are highly recommended to refine estimates of grading quantities.

For excavation of on-site soil placed as compacted fill (85 to 90% relative compaction) outside of ponds and above water, we estimated net results volume change of 0 to 10% shrinkage.

For excavation of on-site soil placed as loose dumped fill into ponds, we estimated a bulking volume change of 20 to 40% “fluff”. During and following placement of fill in the ponds, we expected compression and consolidation of the fill to occur. The amount of compression (settlement) will range based on the soil type and load (depth of fill). We expect roughly 10% compression at shallow depths (less than 10 feet) and roughly 30% compression at depths of 30 to 40 feet.

The time it takes for post construction compression and consolidation to occur varies with soil type. For clean sands and gravels, the compression will occur relatively fast with rough estimates of several months to a couple of years. For sandy clays and clayey sand, we estimate settlement will take 5 to 10 years. Predominately clayey soils can take several decades for consolidation to be completed.

As previously noted, surcharging the pond areas with several feet of additional fill above planned grades will significantly reduce post construction settlement. We recommended allowing the surcharge to stay in place a minimum of 6 months. Monitoring settlement with survey points is recommended to track rate of settlement over time.

5.2 Flexible Pavement Design

We understand that new asphalt pavements may be placed to provide access around the project site after grading is completed. Typically, asphalt pavement sections are designed utilizing two variables, the R-Value (a measure of the subgrade resistance) and the Traffic Index (a measure of the amount of daily traffic). Based on experience with similar subgrade materials, an R-Value of 15 is appropriate for the site. We have calculated theoretical pavement sections for the project site in accordance with Caltrans procedures for flexible pavement design utilizing the values described above and various Traffic Index (T.I.) values. The resulting supplemental pavement sections are presented in Table 3 below. Once final grading is performed, pavement sections may need to be adjusted to reflect the subgrade conditions at finished grade.

Table 3 – Asphalt Pavement Sections

Traffic Index (T.I.)	Asphalt Thickness (in.)	Baserock Thickness (in.)
4.0	2.5	7.0
5.0	3.0	8.0
6.0	3.5	11.0

The aggregate baserock should conform to Caltrans Class 2 Aggregate Baserock (Class 2 AB) outlined in Section 26 of the Caltrans Standard Specifications. The Class 2 AB shall be placed in layers on a properly prepared and firm and unyielding subgrade as described in the previously discussed grading recommendations. The Class 2 AB should be compacted to at least 95% relative compaction. Additionally, the Class 2 AB section should be firm and unyielding under heavy construction equipment.

6.0 SUPPLEMENTAL GEOTECHNICAL SERVICES

Following review and consideration of this report, we should consult with the project team regarding the “preferred” grading plan. Supplemental exploration and laboratory testing will be needed once project details are better defined. We should provide consultation throughout the design process on geotechnical-related items. As project plans near completion, we should review them to ensure that the intent of our recommendations has been sufficiently incorporated.

During construction, we should be present intermittently to observe and test the geotechnical portions of the work. The purpose of our observation and testing is to confirm that site conditions are as anticipated, to adjust our recommendations and design criteria if needed, and to confirm that the Contractor’s work is performed in accordance with the project plans and specifications.

7.0 LIMITATIONS

We believe this report has been prepared in accordance with generally accepted geotechnical engineering practices in the San Francisco Bay Area at the time the report was prepared. This report has been prepared for the exclusive use of GHD and/or their assignees specifically for this project. No other warranty, expressed or implied, is made. Our evaluations and recommendations are based on the data obtained during our subsurface exploration program and our experience with soils in this geographic area.

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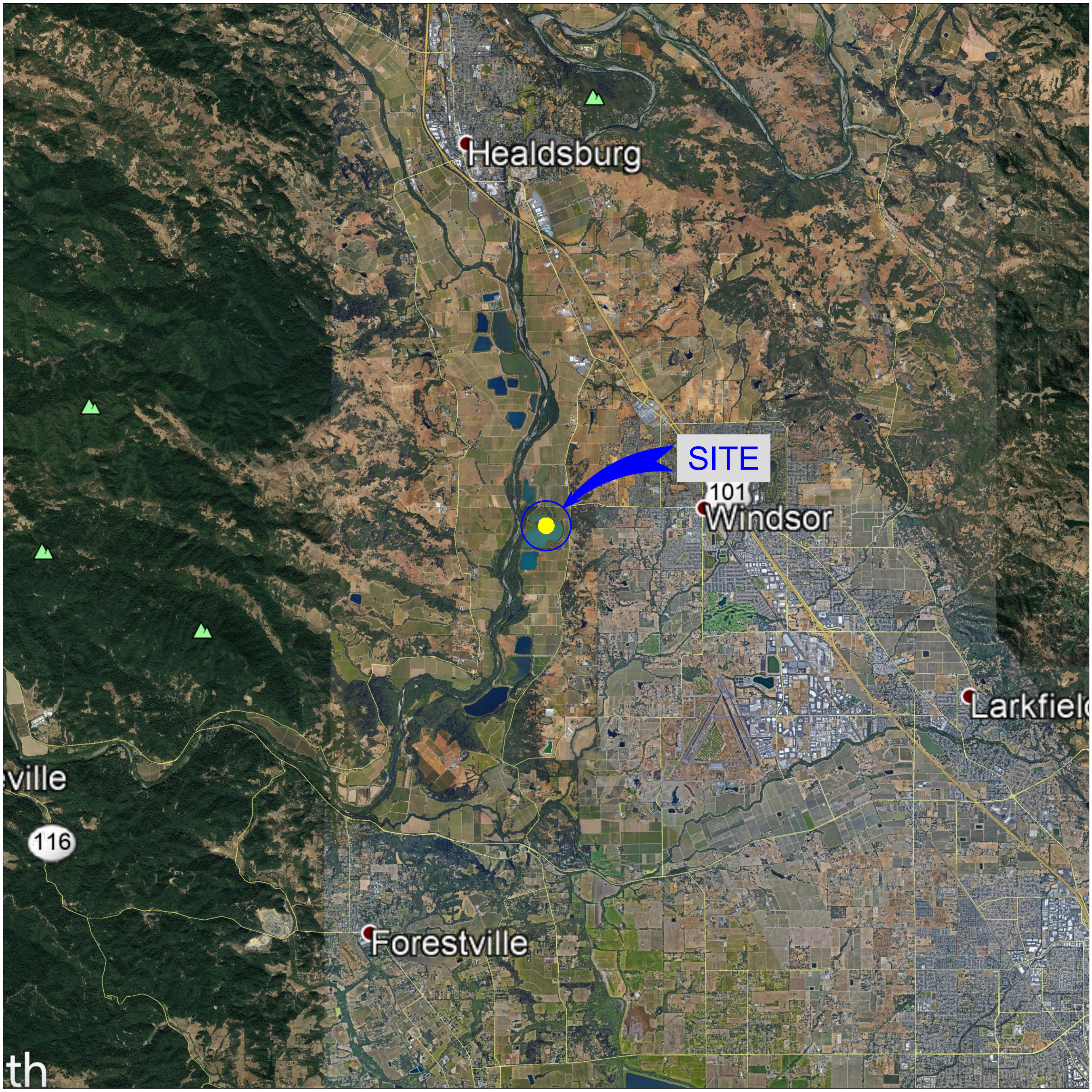

SITE COORDINATES
LAT. 38.5451°
LON. -122.8543°

SITE LOCATION

N.T.S.

REFERENCE: Google Earth, 2020

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FILENAME: 1206.183 Figures.dwg

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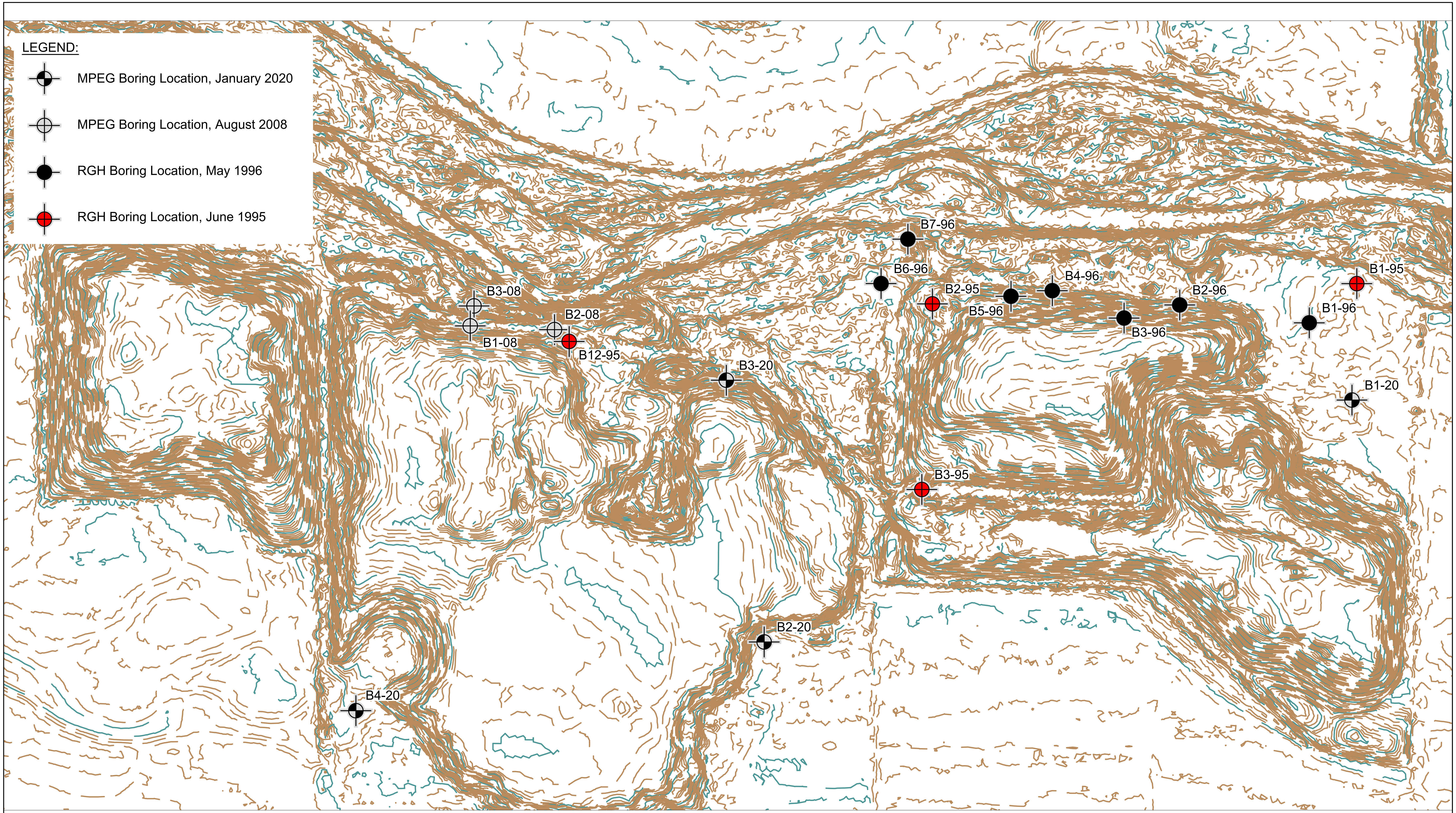
SITE LOCATION MAP

Hanson Quarry Restoration
Windsor, California

Project No. 1206.183 Date: 2/7/2020

Drawn NGK
Checked

1
FIGURE



REFERENCE: Topo provided by GHD

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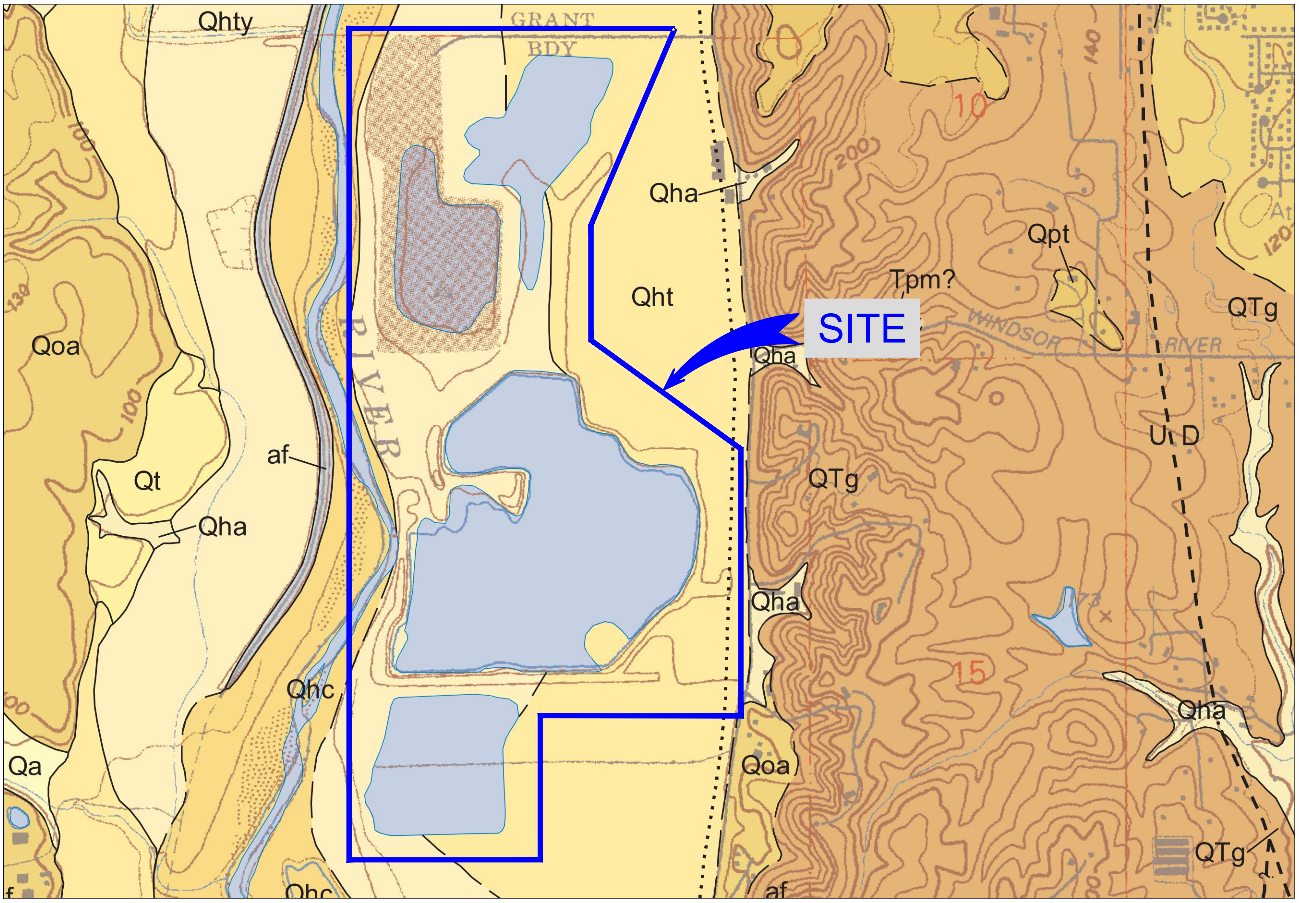
SITE PLAN

Hanson Quarry Restoration
Windsor, California

Project No. 1206.183 Date: 8/3/2016

Designed SAS
Drawn NGK
Checked SAS

2
FIGURE



REGIONAL GEOLOGIC MAP

NORTH

LEGEND:

af	**Artificial Fill -** May be engineered and/or non-engineered; includes levees, dams, and embankments constructed to impound water.
Qhc	**Stream Channel Deposits (modern to latest Holocene) -** Fluvial deposits within active, natural stream channels composed of loose sand, silt, and gravel.
Qhty	**Stream Terrace Deposits (modern to latest Holocene) -** Stream terrace desposits of sand, silt, gravel, and minor clay.
Qht	**Stream Terrace Deposits (Holocene) -** Sand, gravel, silt, and minor clay deposited in overbank and point-bar settings along streams.
Qoa	**Older Alluvial Deposits, undivided (early to late Pleistocene) -** Uplifted or deeply dissected older alluvium, fan, and terrace deposits.
QTg	**Unnamed Fluvial Deposits (early Pleistocene to Pliocene) -** Light-brown to yellow-brown, weakly consolidated gravel, tuffaceous sand, silt, clay, and reworked tuff.

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REGIONAL GEOLOGIC MAP

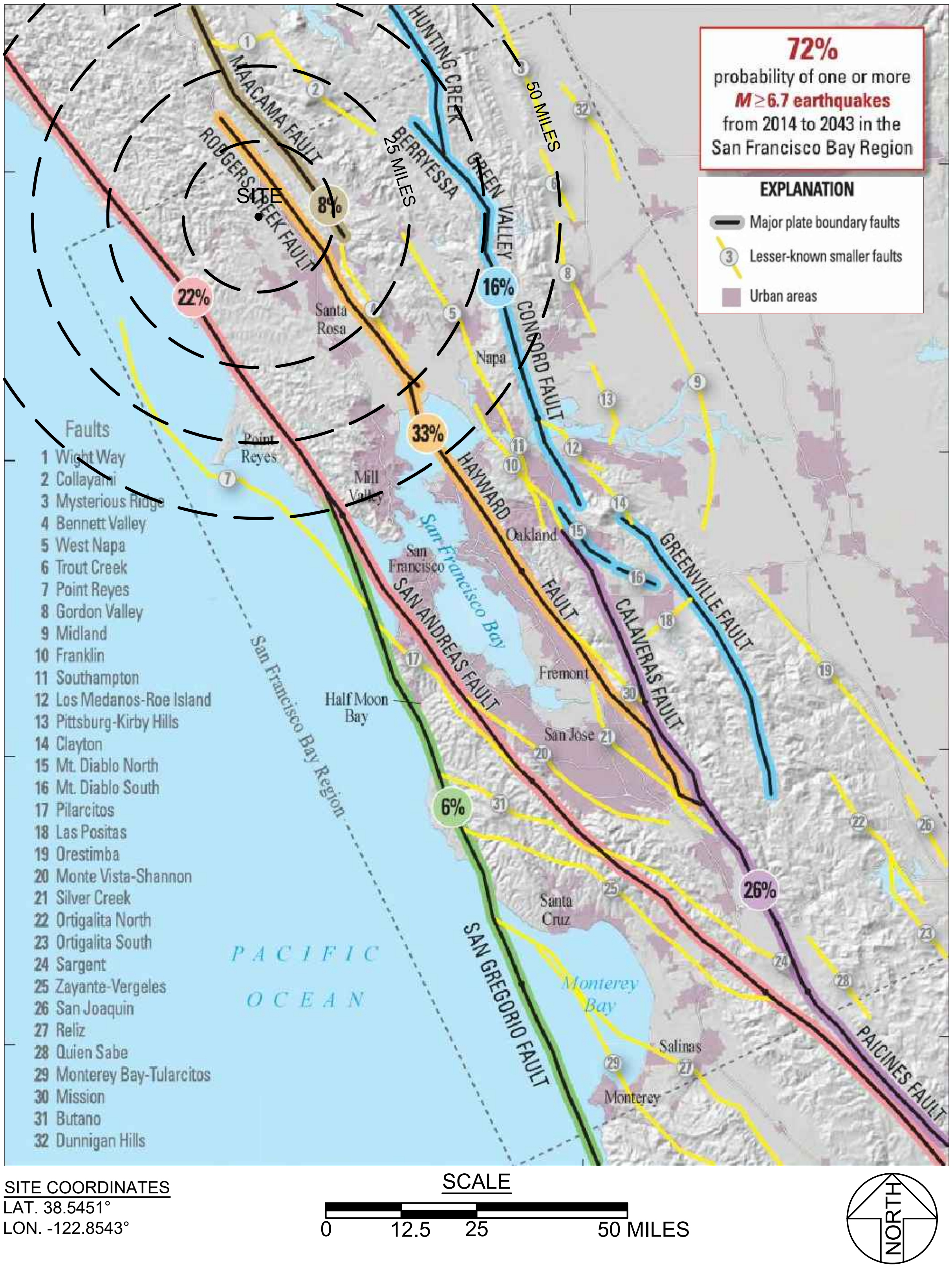
Hanson Quarry Restoration
Windsor, California

Project No. 1206.183

Date: 2/7/2020

Drawn NGK
Checked

3
FIGURE



SITE COORDINATES
LAT. 38.5451°
LON. -122.8543°

DATA SOURCE:
1) U.S. Geological Survey, U.S. Department of the Interior, "Earthquake Outlook for the San Francisco Bay Region 2014-2043", Map of Known Active Faults in the San Francisco Bay Region, Fact Sheet 2016-3020, Revised August 2016 (ver. 1.1).

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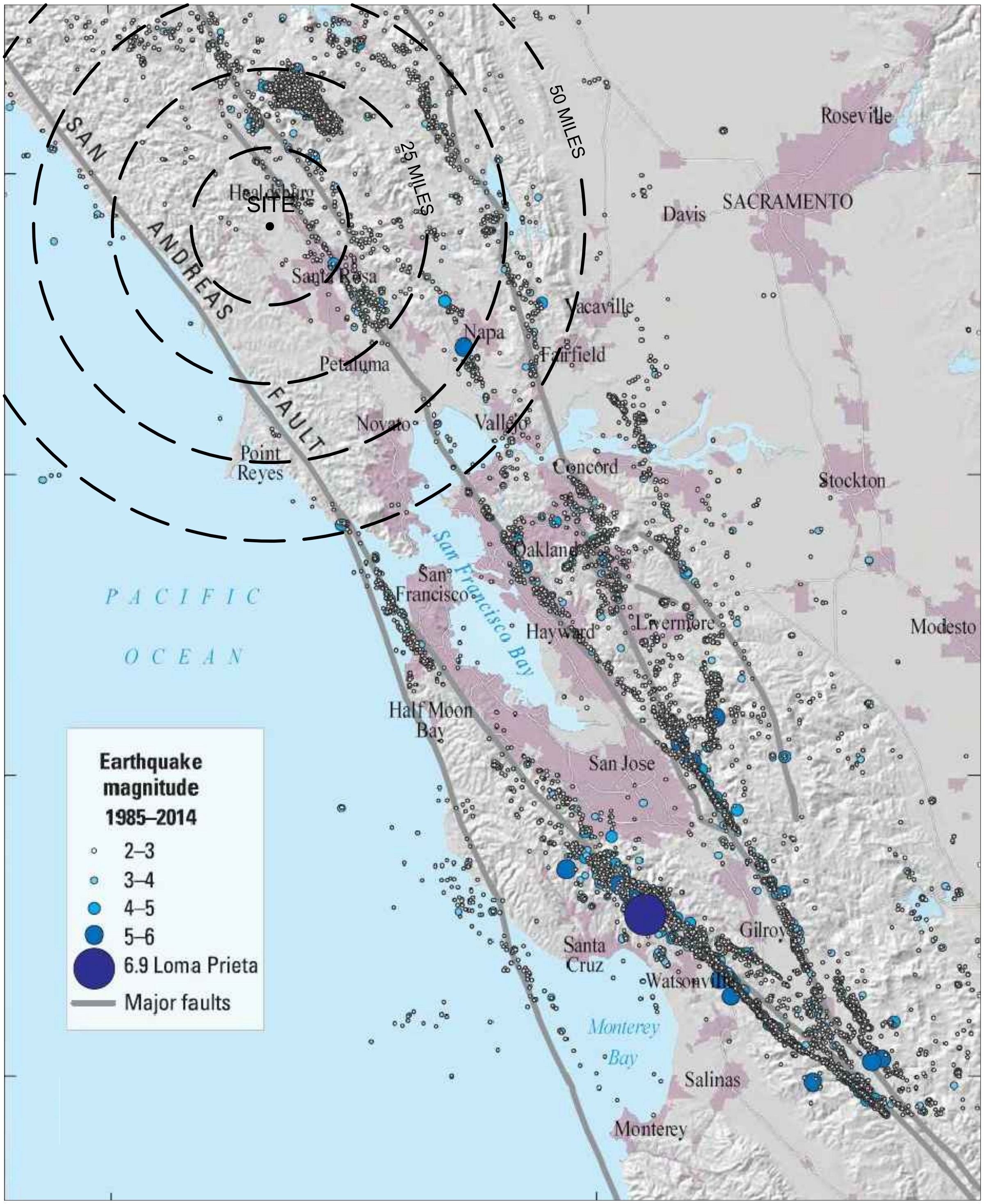
ACTIVE FAULT MAP

Hanson Quarry Restoration
Windsor, California

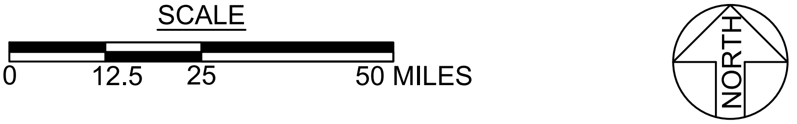
Project No. 1206.183
Date: 2/7/2020

Drawn NGK
Checked

4
FIGURE



SITE COORDINATES
LAT. 38.5451°
LON. -122.8543°



DATA SOURCE:

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HISTORIC FAULT ACTIVITY MAP

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Windsor, California

Project No. 1206.183
Date: 2/7/2020

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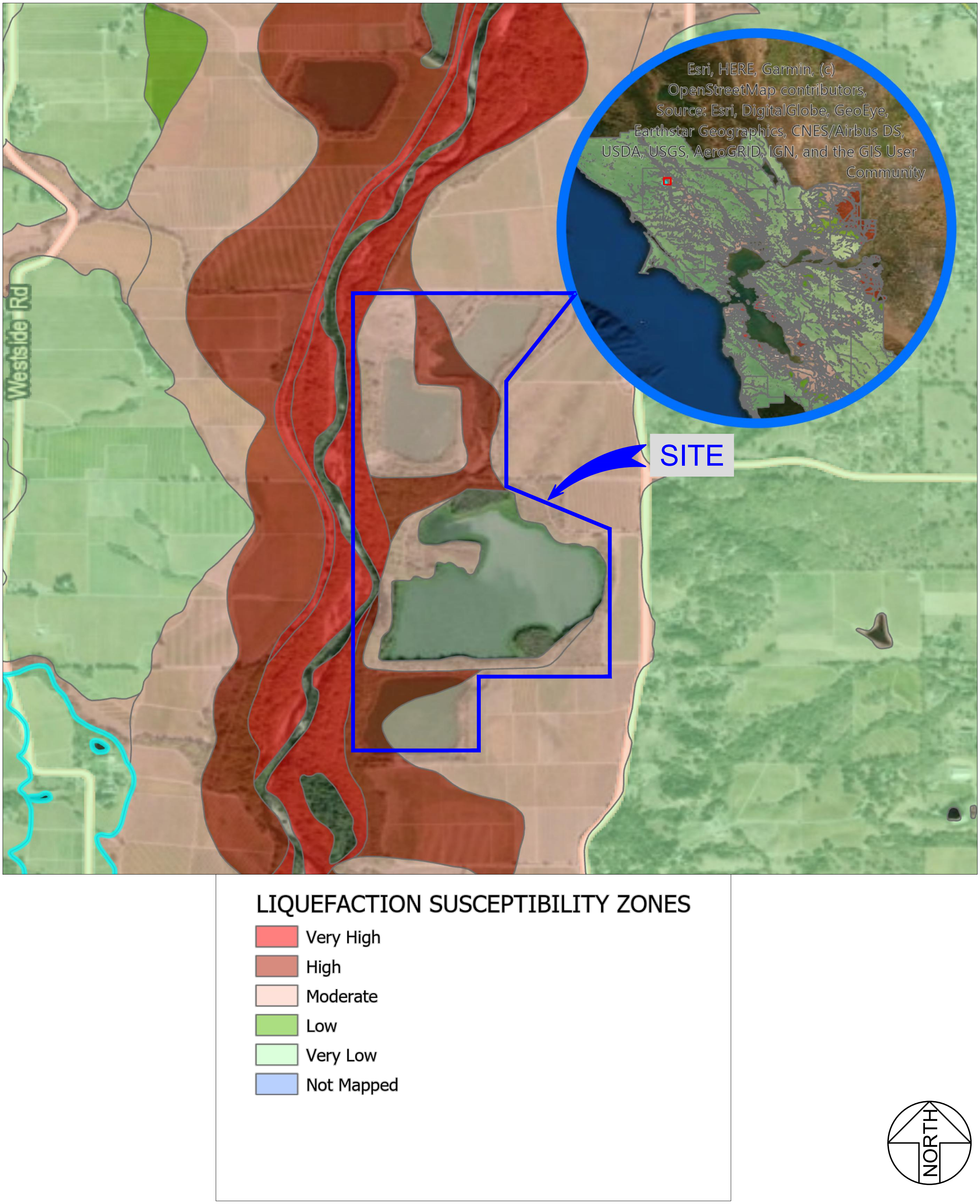
5
FIGURE



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LIQUEFACTION SUSCEPTIBILITY MAP

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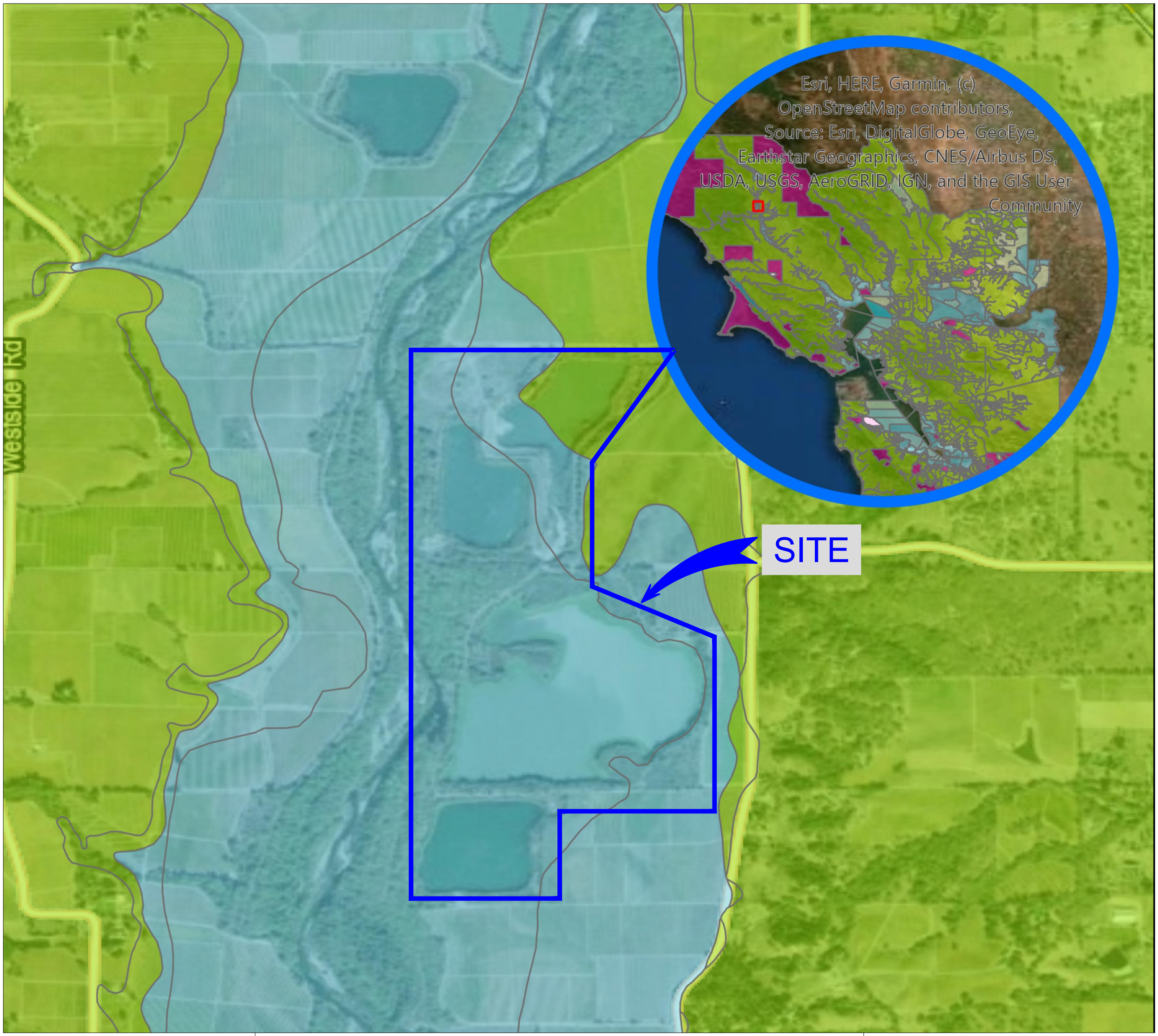
6
FIGURE



FLOOD INSURANCE RATE MAP ZONES

- 🟩 A - 100-YEAR FLOOD ZONE, NO BFE
- 🟫 A99 - PROTECTED FROM 100-YEAR FLOOD BY LEVEES
- 🟦 AE - 100-YEAR FLOOD ZONE, BFE DETERMINED
- 🟩 AH - 100-YEAR FLOOD ZONE, BFE DETERMINED
- 🟦 AO - BASE FLOODPLAIN
- 🟪 AREA NOT INCLUDED
- 🟪 D - UNDETERMINED
- ☐ OPEN WATER
- 🟦 V - 100-YEAR COASTAL FLOOD ZONE, NO BFE
- 🟦 VE - 100-YEAR COASTAL FLOOD ZONE, BFE DETERMINED
- 🟩 X - AREA OF MINIMAL FLOOD HAZARD

NORTH

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FEMA FLOOD INSURANCE RATE MAP

Hanson Quarry Restoration
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Project No. 1206.183 Date: 2/7/2020

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7
FIGURE

APPENDIX A
SUBSURFACE EXPLORATION AND LABORATORY TESTING

1.0 Soil and Rock Classification Systems

We have classified soil and rock materials for engineering purposes in general conformance with ASTM Standard D 2488, "Field Identification and Description of Soils (Visual-Manual Procedure)" and the Unified Soil Classification System. These systems enable Geotechnical Engineers to correlate soil stratigraphy and compare physical soil properties. The soil classification system and symbols used for the borings and in discussions throughout this report are briefly explained on Figure A-1, Soil Classification Chart.

2.0 Exploratory Borings and Sampling

We explored subsurface conditions at the site on January 8, 2020 with four exploratory borings excavated at the locations shown on Figure 2. The purpose of the borings was to supplement previous data to evaluate subsurface soil type and properties, examine the materials encountered and obtain representative samples for laboratory testing. The borings were excavated using a track-mounted portable drilling equipment with 4-inch solid flight augers. The exploration was done under the technical supervision of our Field Engineer who examined and logged the soil and rock materials encountered and obtained samples for laboratory testing. Boring Logs are presented on Figures A-2 through A-5.

Three exploratory borings were previously excavated on July 24, 2008, at the approximate locations shown on Figure 2. The borings were excavated using a truck-mounted Mobile B-53 drill with 6-inch solid flight augers. These boring logs are presented on Figure A-12 through A-19.

3.0 Laboratory Testing

We conducted laboratory tests on selected intact samples to verify field identifications and to evaluate engineering properties. The following laboratory tests were conducted in accordance with the ASTM standard test method cited:

- Laboratory Determination of Water (Moisture Content) of Soil, Rock, and Soil-Aggregate Mixtures, ASTM D 2216;
- Density of Soil in Place by the Drive-Cylinder Method, ASTM D 2937;
- Unconfined Compressive Strength of Cohesive Soil, ASTM D 216;
- Direct Shear of Soils, ASTM D 3080;
- Percent Material Finer than the No. 200 Sieve, ASTM D2248;
- Particle Size Analysis, ASTM D 6913 and D 1140;
- Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of Soils, ASTM D 4318; and
- Compaction Characteristics of Soil, Modified Proctor, ASTM D1557.

The moisture content, dry density, and unconfined compressive strength results are shown on the exploratory Boring Logs. Results of our direct shear testing are presented on Figures A-6 and A-7. Results of our sieve analysis testing are presented on Figures A-8 and A-9. Results of our plasticity index testing and compaction curve testing are presented on Figures A-10 and A-11, respectively. The exploratory boring logs, description of soils encountered, and the laboratory test data reflect conditions only at the location of the boring at the time they were excavated or retrieved. Conditions may differ at other locations and may change with the passage of time due to a variety of causes including natural weathering, climate and changes in surface and subsurface drainage.

MAJOR DIVISIONS		SYMBOL	DESCRIPTION
COARSE GRAINED SOILS over 50% sand and gravel	CLEAN GRAVEL	GW	Well-graded gravels or gravel-sand mixtures, little or no fines
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines
	GRAVEL with fines	GM	Silty gravels, gravel-sand-silt mixtures
		GC	Clayey gravels, gravel-sand-clay mixtures
	CLEAN SAND	SW	Well-graded sands or gravelly sands, little or no fines
		SP	Poorly-graded sands or gravelly sands, little or no fines
	SAND with fines	SM	Silty sands, sand-silt mixtures
		SC	Clayey sands, sand-clay mixtures
FINE GRAINED SOILS over 50% silt and clay	SILT AND CLAY liquid limit <50%	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
		CL	Inorganic clays of low to medium plasticity, gravely clays, sandy clays, silty clays, lean clays
		OL	Organic silts and organic silt-clays of low plasticity
	SILT AND CLAY liquid limit >50%	MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic clays of medium to high plasticity
HIGHLY ORGANIC SOILS		PT	Peat, muck, and other highly organic soils
ROCK			Undifferentiated as to type or composition

KEY TO BORING AND TEST PIT SYMBOLS

CLASSIFICATION TESTS

PI	PLASTICITY INDEX
LL	LIQUID LIMIT
SA	SIEVE ANALYSIS
HYD	HYDROMETER ANALYSIS
P200	PERCENT PASSING NO. 200 SIEVE
P4	PERCENT PASSING NO. 4 SIEVE

SAMPLER TYPE

■	MODIFIED CALIFORNIA	⊠	HAND SAMPLER
▯	STANDARD PENETRATION TEST	⊠	ROCK CORE
▨	THIN-WALLED / FIXED PISTON	X	DISTURBED OR BULK SAMPLE

NOTE: Test boring and test pit logs are an interpretation of conditions encountered at the excavation location during the time of exploration. Subsurface rock, soil or water conditions may vary in different locations within the project site and with the passage of time. Boundaries between differing soil or rock descriptions are approximate and may indicate a gradual transition.

STRENGTH TESTS

UC	LABORATORY UNCONFINED COMPRESSION
TXCU	CONSOLIDATED UNDRAINED TRIAXIAL
TXUU	UNCONSOLIDATED UNDRAINED TRIAXIAL
	UC, CU, UU = 1/2 Deviator Stress
DS (2.0)	DRAINED DIRECT SHEAR (NORMAL PRESSURE, ksf)

SAMPLER DRIVING RESISTANCE

Modified California and Standard Penetration Test samplers are driven 18 inches with a 140-pound hammer falling 30 inches per blow. Blows for the initial 6-inch drive seat the sampler. Blows for the final 12-inch drive are recorded onto the logs. Sampler refusal is defined as 50 blows during a 6-inch drive. Examples of blow records are as follows:

25	sampler driven 12 inches with 25 blows after initial 6-inch drive
85/7"	sampler driven 7 inches with 85 blows after initial 6-inch drive
50/3"	sampler driven 3 inches with 50 blows during initial 6-inch drive or beginning of final 12-inch drive

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SOIL CLASSIFICATION CHART

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Project No. 1206.183
Date: 2/7/2020

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A-1
FIGURE

BORING 1-20

EQUIPMENT: Track-Mounted Drill Rig with 4.0-inch Solid Flight Auger
DATE: 1/8/2020
ELEVATION: 78 - feet*
*REFERENCE: Topo by GHD

DEPTH meters: 0, 1, 2, 3, 4, 5, 6
DEPTH feet: 0, 5, 10, 15, 20

SAMPLE / SYMBOL (4) / DESCRIPTION	BLOWS / FOOT (1)	DRY UNIT WEIGHT pcf (2)	MOISTURE CONTENT (%)	SHEAR STRENGTH psf (3)	OTHER TEST DATA	OTHER TEST DATA
SAND and Gravel with Silt (SW-SM) Medium brown, moist, dense, fine to coarse grained sand, ~40% subangular to subrounded gravel, ~10% low plasticity silt.	93	133	4.5			
Silty SAND with Gravel (SM) Medium brown, moist, very loose, fine to medium grained sand, ~35-40% low plasticity silt, occasional coarse gravel.	6	88	18.6		SA	
	6	99	19.4	DS		
Grades with ~10-15% low plasticity silt.	11	87	13.3		P200 10.7%	
Boring terminated at 11.5 feet. No groundwater encountered during exploration.						

∇ Water level encountered during drilling
▼ Water level measured after drilling

NOTES:
(1) UNCORRECTED FIELD BLOW COUNTS
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(4) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

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BORING LOG

Hanson Quarry Restoration
Windsor, California

Project No. 1206.183
Date: 2/7/2020

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A-2
FIGURE

BORING 2-20

EQUIPMENT: Track-Mounted Drill Rig with
4.0-inch Solid Flight Auger
DATE: 1/8/2020
ELEVATION: 75 - feet*
*REFERENCE: Topo by GHD

DEPTH (meters / feet): 0 – 0; 1; 5; 2; 3 10; 4; 15; 5; 6 20

SAMPLE	SYMBOL (4)		BLOWS / FOOT (1)	DRY UNIT WEIGHT pcf (2)	MOISTURE CONTENT (%)	SHEAR STRENGTH psf (3)	OTHER TEST DATA	OTHER TEST DATA
■	▨	CLAY and SILT with Sand (CL) Medium brown, moist, medium stiff, medium plasticity clay and silt, ~5-15% fine to medium grained sand.	9	94	25.8		SA	
■	▨		11	96	26.6	UC 775		PI:15 LL:38
■	▨		11	97	26.3		P200 91.6%	
■	▨		11	96	28.1			
		Boring terminated at 11.5 feet. No groundwater encountered during exploration.						

▽ Water level encountered during drilling
▼ Water level measured after drilling

NOTES:
(1) UNCORRECTED FIELD BLOW COUNTS
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(4) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

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BORING LOG

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Project No. 1206.183 Date: 2/7/2020

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A-3
FIGURE

BORING 3-20

EQUIPMENT: Track-Mounted Drill Rig with
4.0-inch Solid Flight Auger
DATE: 1/8/2020
ELEVATION: 78 - feet*
*REFERENCE: Topo by GHD

DEPTH meters feet	SAMPLE	SYMBOL (4)		BLOWS / FOOT (1)	DRY UNIT WEIGHT pcf (2)	MOISTURE CONTENT (%)	SHEAR STRENGTH psf (3)	OTHER TEST DATA	OTHER TEST DATA
0 – 0	■	▨	Sandy CLAY (CL) Dark brown, moist, stiff, medium plasticity silt and clay, ~25-35% fine grained sand, trace gravel.	20	114	14.8			PI:10 LL:30
5	■	▨	Grades very stiff.	34	113	10.5		P200 64.3%	
	■	▨	Grades blue gray and brown, ~10-15% gravel.	51	115	11.8		SA	
3 10	■	▨	Grades stiff.	18	110	16.1	DS		
			Boring terminated at 11.5 feet. No groundwater encountered during exploration.						

Depth scale: meters 0, 1, 2, 3, 4, 5, 6; feet 0, 5, 10, 15, 20

▽ Water level encountered during drilling
▼ Water level measured after drilling

NOTES: (1) UNCORRECTED FIELD BLOW COUNTS
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(4) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

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BORING LOG

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Project No. 1206.183 Date: 2/7/2020

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A-4
FIGURE

BORING 4-20

EQUIPMENT: Track-Mounted Drill Rig with
4.0-inch Solid Flight Auger
DATE: 1/8/2020
ELEVATION: 80 - feet*
*REFERENCE: Topo by GHD

DEPTH meters	DEPTH feet	SAMPLE	SYMBOL (4)		BLOWS / FOOT (1)	DRY UNIT WEIGHT pcf (2)	MOISTURE CONTENT (%)	SHEAR STRENGTH psf (3)	OTHER TEST DATA	OTHER TEST DATA
0	0			Sandy SILT (ML) Medium brown, moist, medium stiff, low to medium plasticity silt, ~45-50% fine grained sand.						
		■			11	103	15.9		SA	
1										
	5	■		Grades with ~30-35% fine grained sand.	11	95	25.5	UC 425	SA	
2										
		■			9	98	16.4			
				Grades with ~15-20% fine grained sand.						
3	10									
		■			13	97	23.4		SA	
				Boring terminated at 11.5 feet. No groundwater encountered during exploration.						
4										
	15									
5										
6	20									

▽ Water level encountered during drilling
▼ Water level measured after drilling

NOTES: (1) UNCORRECTED FIELD BLOW COUNTS
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(4) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

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BORING LOG

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Project No. 1206.183
Date: 2/7/2020

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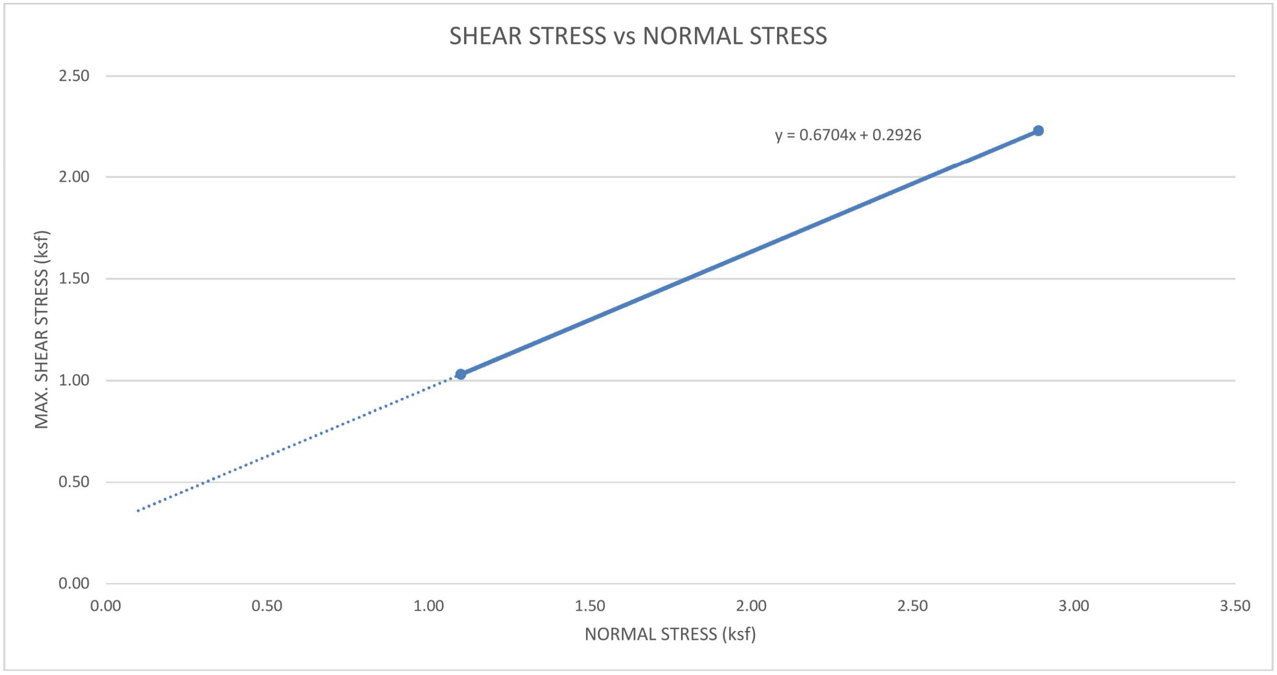
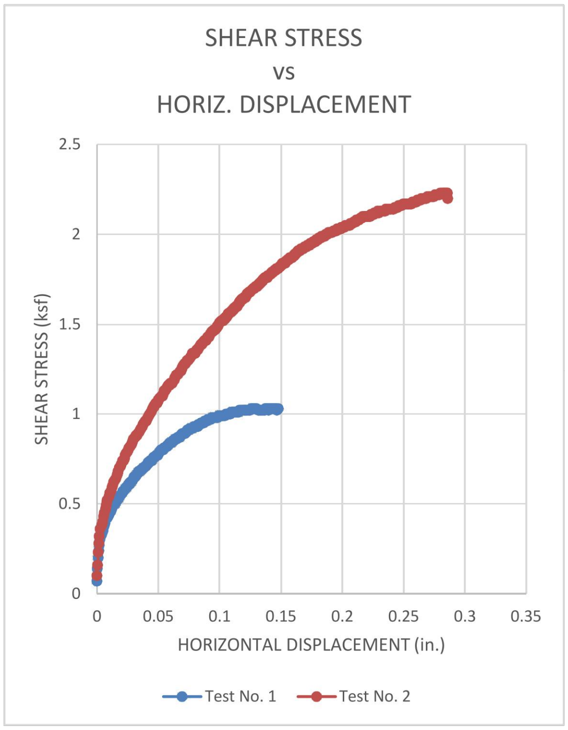
A-5
FIGURE

DIRECT SHEAR TEST REPORT
ASTM D 3080

Job Name: GHD - Hanson Quarry
Tested By: NGK
Job Number: 1206.183
Date: 1/17/2020





Sample ID: B1-20 @ 8.0'
Soil Classification: SAND with Gravel (SP)
Soil Color: Medium Brown

	Test No.		
Variable	**1**	**2**	**3**
Height (in.)	1.05	1.05	
Diameter (in.)	2.41	2.41	
Wet Weight (g)	154.9	143.6	
Wet Density (pcf)	123.2	114.2	#DIV/0!
Moisture Content	19.4%	19.4%	
Dry Density (pcf)	103.2	95.7	#DIV/0!
Shear Rate (in./min.)	0.008	0.008	
Normal Stress (ksf)	1.10	2.89	
Max. Shear Stress (ksf)	1.03	2.23	

Results:

ϕ' (degrees):	**33.8**
c' (psf):	**300**

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DIRECT SHEAR TEST RESULTS

Hanson Quarry Restoration
Windsor, California

Project No. 1206.183 Date: 2/7/2020

Drawn MMT
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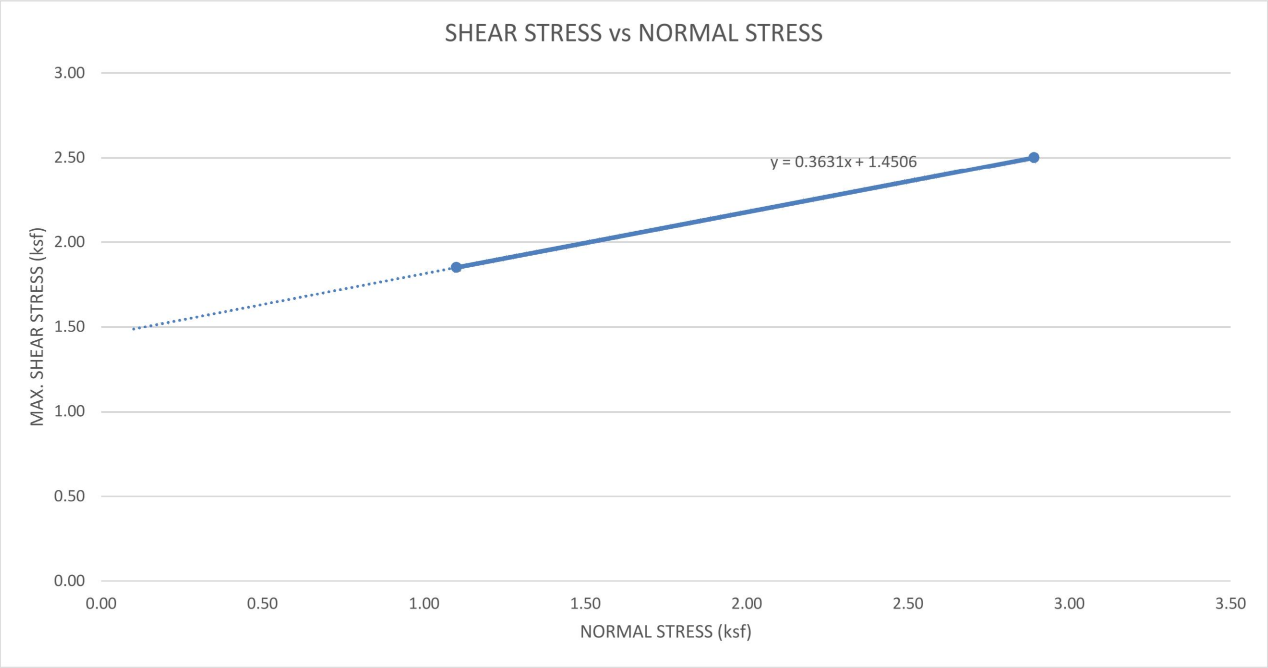
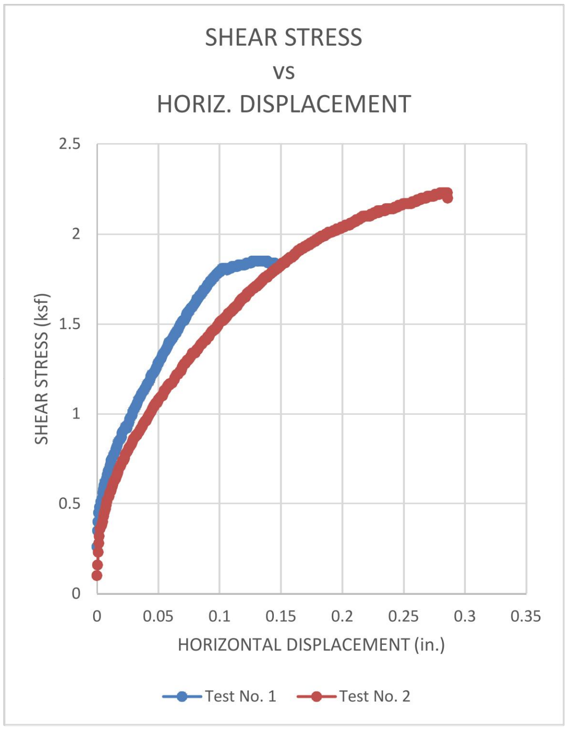
A-6
FIGURE

DIRECT SHEAR TEST REPORT
ASTM D 3080

Job Name: GHD - Hanson Quarry | **Tested By:** NGK

Job Number: 1206.183 | **Date:** 1/17/2020





Sample ID: B3-20 @ 11.0'

Soil Classification: SILT with Sand (ML)

Soil Color: Medium Brown

	Test No.		
Variable	**1**	**2**	**3**
Height (in.)	1.05	1.05	
Diameter (in.)	2.41	2.41	
Wet Weight (g)	154.9	143.6	
Wet Density (pcf)	123.2	114.2	#DIV/0!
Moisture Content	16.1%	19.4%	
Dry Density (pcf)	106.1	95.7	#DIV/0!
Shear Rate (in./min.)	0.008	0.008	
Normal Stress (ksf)	1.10	2.89	
Max. Shear Stress (ksf)	1.85	2.50	

Results:

ϕ' (degrees):	**20.0**
c' (psf):	**1450**

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DIRECT SHEAR TEST RESULTS

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A-7
FIGURE

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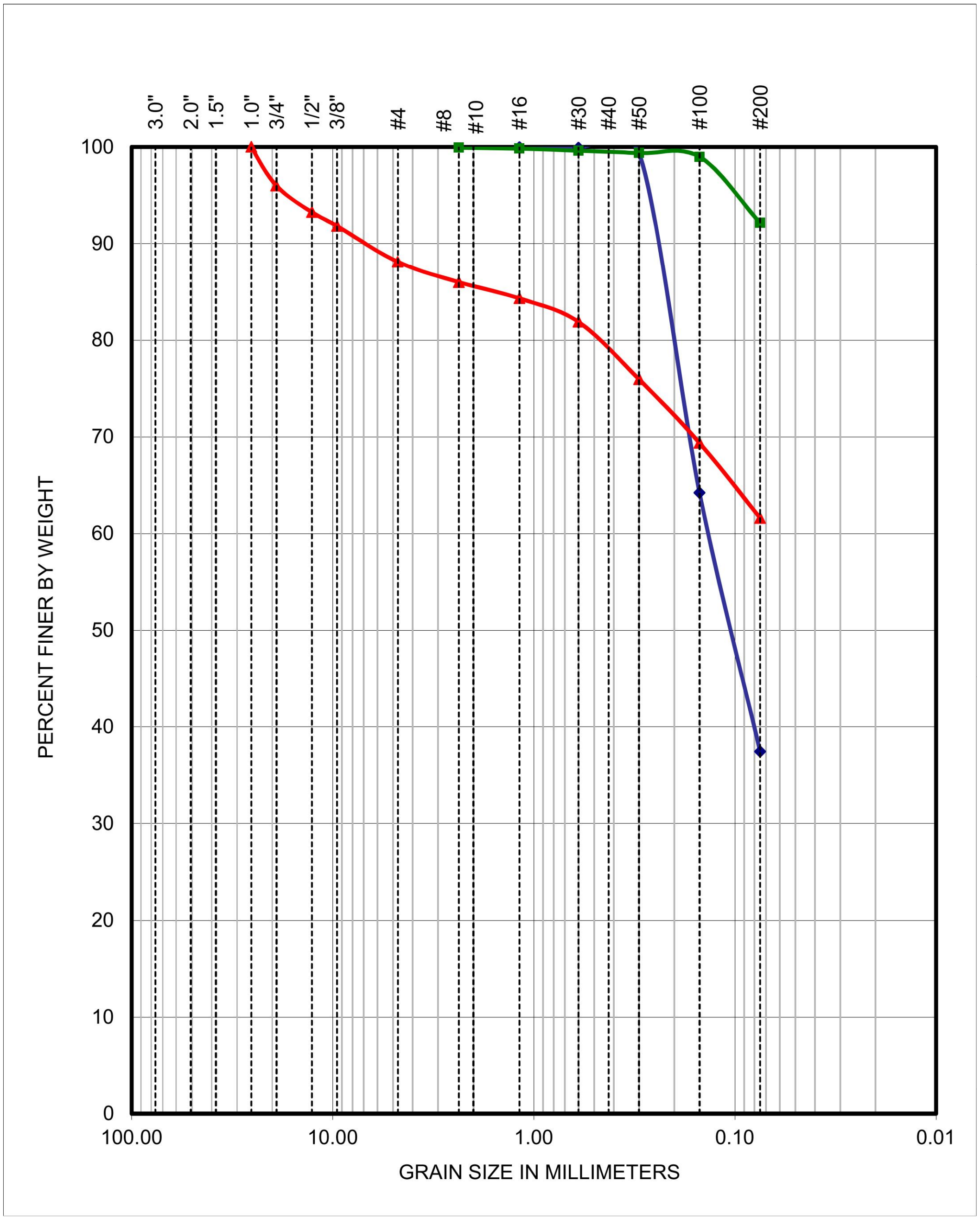
PARTICLE SIZE ANALYSIS - ASTM D 6913 & ASTM D 1140



SYMBOL	SAMPLE SOURCE	CLASSIFICATION
—◆—	B1-20 @ 5'	Silty SAND (SM)
—■—	B2-20 @ 2'	CLAY with Sand (CL)
—▲—	B3-20 @ 8'	Sandy CLAY (CL)

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SIEVE ANALYSIS TEST RESULTS

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Project No. 1206.183 Date: 2/7/2020

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A-8
FIGURE

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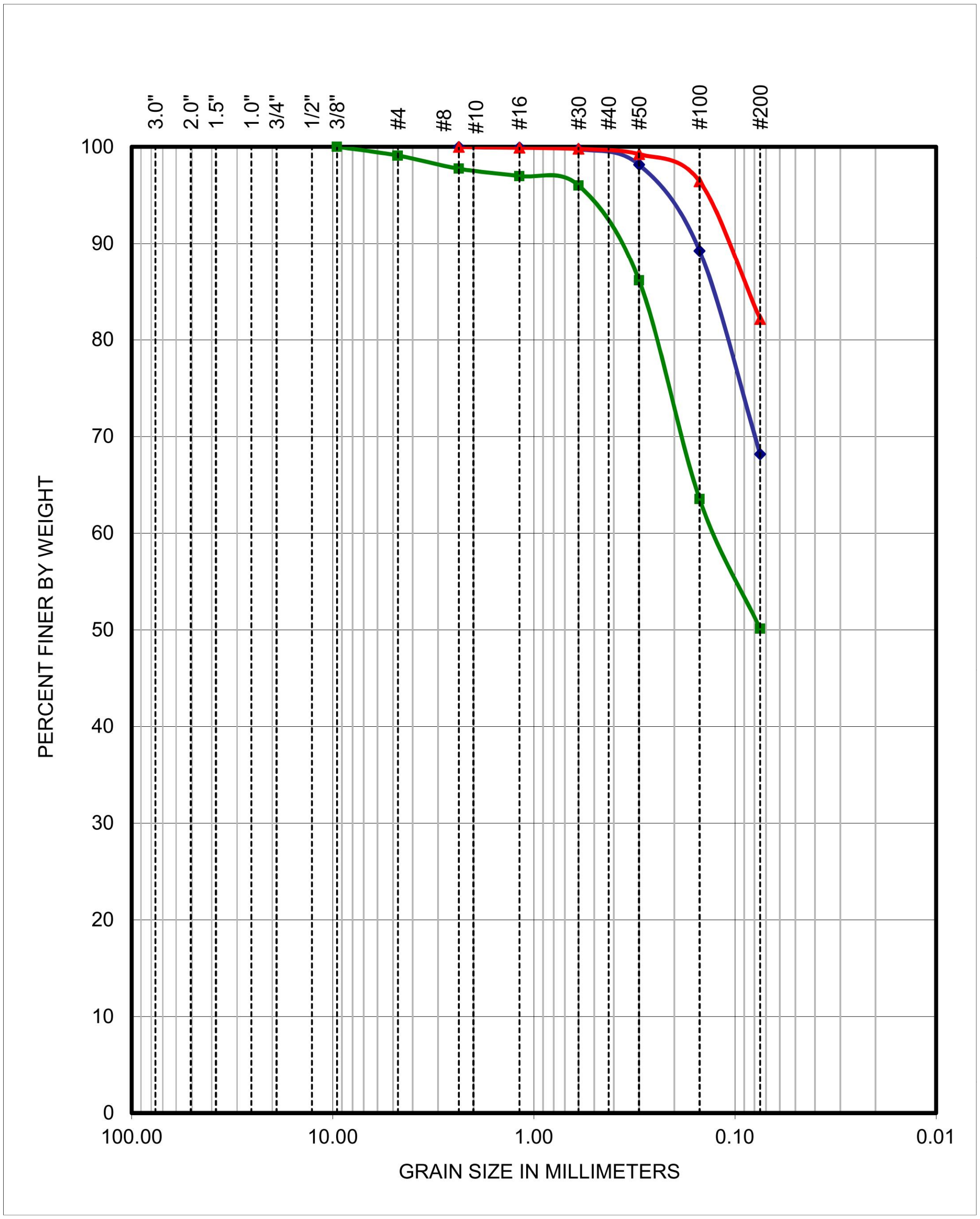
PARTICLE SIZE ANALYSIS - ASTM D 6913 & ASTM D 1140



SYMBOL	SAMPLE SOURCE	CLASSIFICATION
◆	B4-20 @ 5'	Sandy SILT (ML)
■	B4-20 @ 2'	Sandy SILT (ML)
▲	B4-20 @ 11'	SILT with Sand (ML)

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SIEVE ANALYSIS TEST RESULTS

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Project No. 1206.183
Date: 2/7/2020

A-9
FIGURE

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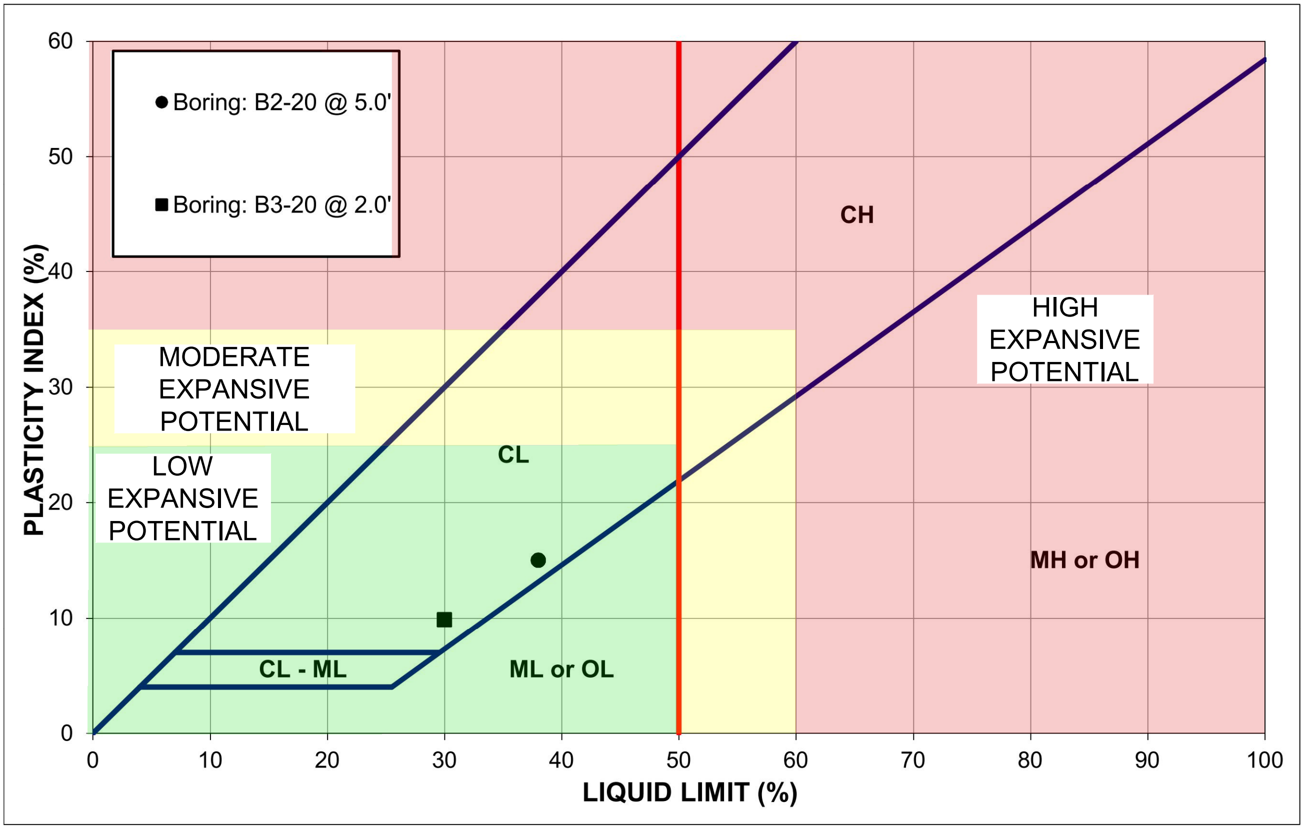
ATTERBERG LIMITS TEST (ASTM D 4318)



Sample	Classification	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
Boring: B2-20 @ 5.0'	CLAY (CL) Medium brown	38	23	15
Boring: B3-20 @ 2.0'	Sandy CLAY (CL) Dark brown	30	20	10

PI = 0-3: Non-Plastic
PI = 3-15: Slightly Plastic
PI = 15-30: Medium Plasticity
PI = >30: High Plasticity

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PLASTICITY INDEX TEST RESULTS

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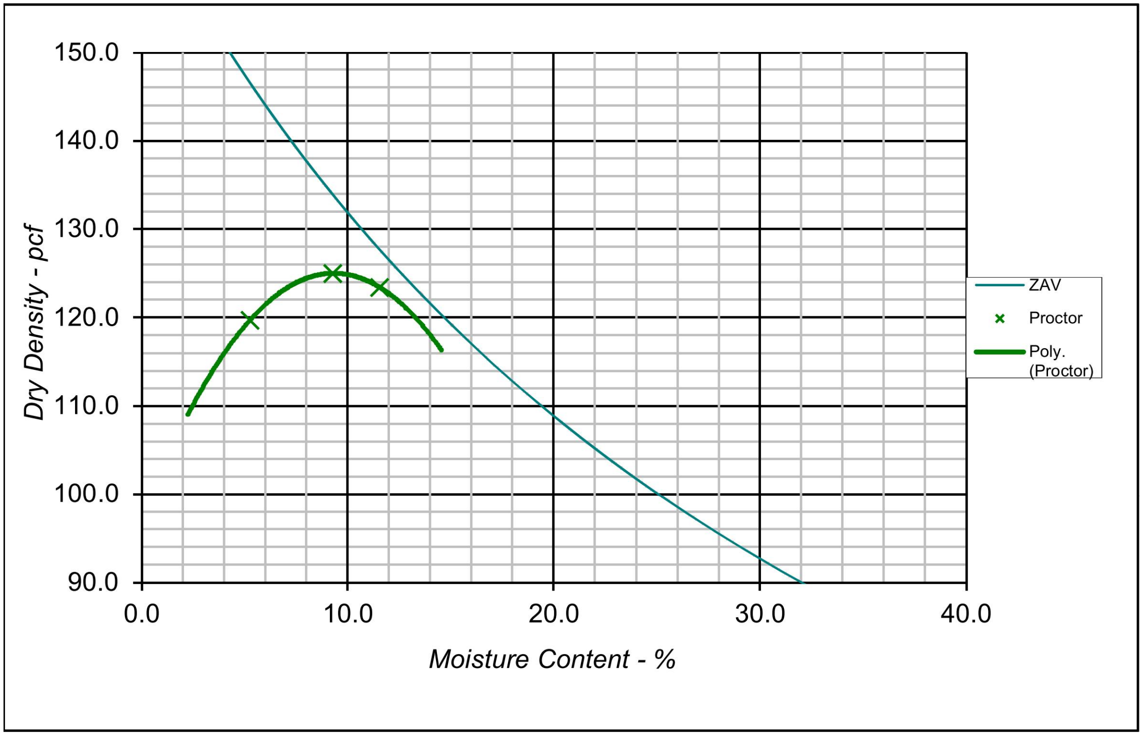
A-10
FIGURE

Miller Pacific Engineering Group

Laboratory Compaction Test

Project Name	Project No.	Date	Technician	Specific Gravity G_S
Hanson Quarry	1206.183	1/16/2020	JMO	2.68

Soil Type	Soil Description	Source
CL	Sandy CLAY with Gravel Dark brown	Native Borings B1-20 through B4-20 Composite



Series	1 (-6)	2 (-8)	3 (-10)	4	5	6
Mold+Wet Soil (g)	9.864	9.818	9.464			
Mold (g)	5.274	5.264	5.264			
Wet Soil (g)	4.590	4.554	4.200			
*Factor	0.0662	0.0662	0.0662			
Wet Density (pcf)	137.70	136.62	126.00			
Pan No.	B	D	I			
Pan+Wet Soil (g)	621.1	661.4	722.6			
Pan+Dry Soil (g)	567.5	613.9	691.7			
Moisture Loss (g)	53.6	47.5	30.9			
Pan Tare (g)	103.2	102.4	103.1			
Dry Soil (g)	464.3	511.5	588.6			
Moisture Content	11.5	9.3	5.2			
Dry Density (pcf)	123.4	125.0	119.7			
Dry Density (kN/m2)	19.4	19.6	18.8			

Max.Dry Density = 125.0 pcf

Opt.Moist.Content = 10.0 %

* For weight of wet soil in grams and volume = 1/30 cu.ft.

ASTM D-1557 (10 lb hammer - 5 lifts - 25 blows)

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COMPACTION CURVE RESULTS

Hanson Quarry Restoration
Windsor, California

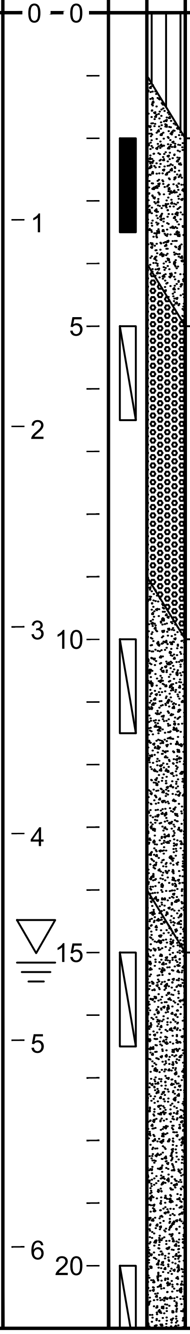
Project No. 1206.183 Date: 2/7/2020

Drawn MMT
Checked

A-11
FIGURE

BORING 1-08

EQUIPMENT: Mobile B53 with 7-inch Hollow Stem Augers
DATE: 7/24/08
ELEVATION: 59-Feet*
*REFERENCE: Site Plan by Chang Associates, 2008



OTHER TEST DATA	% PASSING NO. 200	UNDRAINED SHEAR STRENGTH psf (1)	BLOWS PER FOOT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT pcf (2)	
						CLAYEY SILT (ML) light brown, dry, medium stiff, medium plasticity, occasional rounded gravel (Alluvium)
			18	2.5	116	SAND WITH GRAVEL (SP) brown, moist, loose, poorly graded medium to coarse grained sand, rounded gravel (Alluvium)
	6.0% P200		17	3.2		SAND WITH SILT/CLAY AND GRAVEL (SW-SM/SC) brown, moist, medium dense, well graded fine to coarse grained sand, rounded gravel (Alluvium)
	6.5% P200		12	5.3		SAND WITH SILT/CLAY AND GRAVEL (SP-SM/SC) brown, moist, loose to medium dense, poorly graded medium to coarse grained sand, rounded gravel (Alluvium)
	2.3% P200		20	8.7		SAND WITH GRAVEL (SP) brown, saturated, medium dense, poorly graded medium to coarse grained sand, rounded gravel (Alluvium)

NOTES: (1) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

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ENGINEERING GROUP

FILE: 1063.03 BL.dwg

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BORING LOG

Hanson Windsor Quarry
Levee Improvements
Windsor, California

Project No. 1063.03 Date: 8/11/08

Designed
Drawn RCA
Checked

A-12
FIGURE

BORING 1-08
(CONTINUED)

OTHER TEST DATA	% PASSING NO. 200	UNDRAINED SHEAR STRENGTH psf (1)	BLOWS PER FOOT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT pcf (2)	DEPTH meters	DEPTH feet	SAMPLE	SYMBOL (3)	
							20			SAND WITH GRAVEL (SP) brown, saturated, medium dense, poorly graded medium to coarse grained sand, rounded gravel (Alluvium)
	1.5% P200		21	11.9						
						7				
							25			
	3.0% P200									
						8				
	59.4% P200		20	12.6						SANDY CLAY (CH) brown, very wet, stiff, medium to high plasticity clay, fine to coarse grained sand (Alluvium)
										SAND (SP) brown, saturated, dense, poorly graded medium to coarse grained sand (Alluvium)
						9				
							30			
	2.1% P200			20.5						
	6.3% P200		42	9.2						SAND WITH SILT/CLAY AND GRAVEL (SW-SM/SC) brown, saturated, dense, medium to high plasticity clay, well graded fine to coarse grained sand, rounded gravel (Alluvium)
						10				
							35			no sample recovery
						11				
			41							
						12				
							40			

NOTES: (1) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

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Hanson Windsor Quarry
Levee Improvements
Windsor, California

Project No. 1063.03 Date: 8/11/08

Designed
Drawn RCA
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A-13
FIGURE

BORING 1-08
(CONTINUED)

OTHER TEST DATA	% PASSING NO. 200	UNDRAINED SHEAR STRENGTH psf (1)	BLOWS PER FOOT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT pcf (2)	DEPTH meters	DEPTH feet	SAMPLE	SYMBOL (3)	
							40			SAND WITH SILT/CLAY AND GRAVEL (SW-SM/SC) brown, saturated, dense, medium to high plasticity clay, well graded fine to coarse grained sand, rounded grave (Alluvium)
						13				
	3.3% P200 3.8% P200		45	16.9		14	45			SAND WITH GRAVEL (SP) brown, saturated, dense, fine to coarse grained sand, rounded gravels (Alluvium)
						15				
	3.7% P200		15	8.7			50			
										CLAY (CL/CH) brown, saturated, stiff, medium plasticity (Alluvium)
						16				Bottom of boring at 51.5 feet Groundwater observed at 15 feet immediately after drilling
						17	55			
						18				
							60			

NOTES: (1) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
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Hanson Windsor Quarry
Levee Improvements
Windsor, California

Project No. 1063.03 Date: 8/11/08

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Drawn RCA
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A-14
FIGURE

BORING 2-08

EQUIPMENT: Mobile B53 with 7-inch Hollow Stem Augers
DATE: 7/24/08
ELEVATION: 59-Feet*
*REFERENCE: Site Plan by Chang Associates, 2008

OTHER TEST DATA	% PASSING NO. 200	UNDRAINED SHEAR STRENGTH psf (1)	BLOWS PER FOOT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT pcf (2)	DEPTH meters	DEPTH feet	SAMPLE	SYMBOL (3)	
						0	0			CLAYEY SILT (ML) brown, dry, medium stiff, medium plasticity (Alluvium)
			26	14.2	102	1				
							5			SAND WITH SILT/CLAY AND GRAVEL (SW-SM/SC) brown, moist, medium dense, well graded fine to coarse grained sand, rounded gravel (Alluvium)
			38			2				
										CLAYEY SILT (ML) brown, moist, stiff, medium plasticity (Alluvium)
				21.7	105					
	6.1% P200		24	7.0		3	10			SAND WITH SILT/CLAY AND GRAVEL (SW-SM/SC) brown, moist, medium dense, well graded fine to coarse grained sand, rounded gravel (Alluvium)
						4				
							15			SAND WITH GRAVEL (SW) brown, saturated, medium dense, well graded fine to coarse grained sand, rounded gravel (Alluvium)
	2.8% P200		24	6.0		5				
	1.3% P200		43	10.1		6	20			

NOTES: (1) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

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BORING LOG

Hanson Windsor Quarry
Levee Improvements
Windsor, California

Project No. 1063.03 Date: 8/11/08

Designed
Drawn RCA
Checked

A-15
FIGURE

OTHER TEST DATA	% PASSING NO. 200	UNDRAINED SHEAR STRENGTH psf (1)	BLOWS PER FOOT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT pcf (2)	DEPTH meters	DEPTH feet	SAMPLE	SYMBOL (3)	BORING 2-08 (CONTINUED)
							20	■		SAND WITH GRAVEL (SW) brown, saturated, medium dense, well graded fine to coarse grained sand, rounded gravel (Alluvium)
						7				
							25			
	2.6% P200		18	8.1		8		▨		
										CLAYEY SAND (SC) brown, saturated, dense, fine grained sand, high plasticity clay (Alluvium)
						9				
	32.1% P200		33	26.4			30	▨		
										Bottom of boring at 31 feet Groundwater observed at 16.5 feet immediately after drilling
						10				
						11	35			
						12				
							40			

NOTES: (1) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
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Project No. 1063.03 Date: 8/11/08

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A-16
FIGURE

BORING 3-08

EQUIPMENT: Portable Hydraulic Rig with 4-inch Solid Augers
DATE: 7/24/08
ELEVATION: 82-Feet*
*REFERENCE: Site Plan by Chang Associates, 2008

OTHER TEST DATA	% PASSING NO. 200	UNDRAINED SHEAR STRENGTH psf (1)	BLOWS PER FOOT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT pcf (2)	DEPTH meters	DEPTH feet	SAMPLE	SYMBOL (3)	
						0	0			SILTY SAND WITH GRAVEL (SM) mottled light brown and light gray, dry to slightly moist, medium dense, fine to coarse grained sand, subangular to subround gravels, low plasticity silt (Fill)
						1		X		SAND WITH GRAVEL (SW) mottled light brown and light gray, moist, medium dense, well graded fine to coarse grained sand, rounded gravels (Fill) caving soil
							5			
				4.7		2		X		GRAVEL WITH SILT/CLAY AND SAND (GW-GM/GC) mottled red, brown, and light gray, moist, medium dense, well graded fine to coarse grained sand, rounded gravels (Fill) caving soil
	5.1% P200			5.0				X		
	1.1% P200					3	10	X		GRAVEL (GW) mottled light gray and red, moist, loose to medium dense, well graded rounded gravel (Fill)
										GRAVEL WITH SILT/CLAY AND SAND (GW-GM/GC) mottled red, brown, and light gray, moist, medium dense, well graded rounded gravels, fine to coarse grained sand (Fill)
	11.3% P200			8.8		4		X		
							15			SILTY/CLAYEY SAND WITH GRAVEL (SM) mottled light brown, gray, and red, moist, medium dense, fine to coarse grained sand, low plasticity silt/clay rounded gravel (Fill)
	12.3% P200		31	7.0	122	5				
			22							
	10.2% P200			5.6		6	20	X		

NOTES: (1) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
(3) GRAPHIC SYMBOLS ARE ILLUSTRATIVE ONLY

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Windsor, California

Project No. 1063.03 Date: 8/11/08

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A-17
FIGURE

BORING 3-08
(CONTINUED)

OTHER TEST DATA	% PASSING NO. 200	UNDRAINED SHEAR STRENGTH psf (1)	BLOWS PER FOOT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT pcf (2)	DEPTH meters	DEPTH feet	SAMPLE	SYMBOL (3)	
							20			**SILTY/CLAYEY SAND WITH GRAVEL (SM)** mottled light brown, gray, and red, moist, medium dense, fine to coarse grained sand, low plasticity silt/clay rounded gravel (Fill)
						7				caving soil
							25			
						8				
	3.0% P200			2.7				X		**GRAVEL (GP)** gray-brown, very moist, loose to medium dense gravel, poorly graded rounded gravel (Fill)
						9				caving soil
	8.6% P200			6.9			30	X		**GRAVEL WITH SILT/CLAY AND SAND (GW-GM/GC)** gray-brown, very moist, loose to medium dense, well graded rounded gravel, fine to coarse grained sand, low plasticity silt (Fill)
						10				
										caving soil
	4.3% P200					11	35	X		**GRAVEL (GP)** gray-brown, wet, loose to medium dense gravel, poorly graded rounded gravel, trace fine to coarse grained sand (Alluvium)
	5.8% P200			5.5				X		
						12				caving soil
	2.3% P200						40	X		

NOTES: (1) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
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Windsor, California

Project No. 1063.03 Date: 8/11/08

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A-18
FIGURE

BORING 3-08
(CONTINUED)

OTHER TEST DATA	% PASSING NO. 200	UNDRAINED SHEAR STRENGTH psf (1)	BLOWS PER FOOT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT pcf (2)	DEPTH meters	DEPTH feet	SAMPLE	SYMBOL (3)	
							40			GRAVEL (GP) gray-brown, wet, loose to medium dense gravel, poorly graded rounded gravel, trace fine to coarse grained sand (Alluvium)
	6.9% P200			5.9				X		
						13				
										caving soil
	7.9% P200			4.9			45	X		GRAVEL WITH SILT/CLAY AND SAND (GP-GM/GC) gray-brown, wet, loose to medium dense, poorly graded rounded gravel, fine to coarse grained sand, low plasticity silt (Alluvium)
						14				
										caving soil
	12.7% P200			7.5				X		SILTY/CLAYEY GRAVEL WITH SAND (GM/GC) gray-brown, wet, loose to medium dense, rounded gravel, fine to coarse grained sand, low plasticity silt (Alluvium)
						15				
							50			
										caving soil
										Bottom of boring at 51 feet No groundwater observed during drilling
						16				
							55			
						17				
						18				
							60			

NOTES: (1) METRIC EQUIVALENT STRENGTH (kPa) = 0.0479 x STRENGTH (psf)
(2) METRIC EQUIVALENT DRY UNIT WEIGHT kN/m^3 = 0.1571 x DRY UNIT WEIGHT (pcf)
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BORING LOG

Hanson Windsor Quarry
Levee Improvements
Windsor, California

Project No. 1063.03 Date: 8/11/08

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A-19
FIGURE

APPENDIX B
REFERENCE SUBSURFACE EXPLORATION

RGH Geotechnical and Environmental Consultants

LOG OF BORING B1

Page 1 of 2

OTHER LABORATORY TESTS	DRY DENSITY (pcf)	MOISTURE (%)	BLOWS/ FOOT*	DEPTH (ft)	SAMPLES	SYMBOLS	MATERIALS DESCRIPTION
							GRAY-BROWN SILTY SAND (SM) very dense, moist; with occasional small gravel
			100+		☒		
			100+		☒		*Wet at 4 feet*
				5			
			31		☒		*Dense at 8 feet*
							GRAY-BROWN SANDY GRAVEL (GP) medium dense, wet
				10			
			21		☒		
				15			*Dense from 15 feet*
			38		☒		
				20			
			39		☒		
			57	25	☒		*Very dense at 25 feet*
				30			

PROJECT Piombo Pond – Kaiser Property

LOCATION Windsor, California

JOB NUMBER 1102.01.01.1

LOGGED BY KSG

DRILL RIG Rotary Wash

DRILLING COMPANY RNL

DATE DRILLED 05/02/96

SURFACE ELEVATION** 75.0 Feet

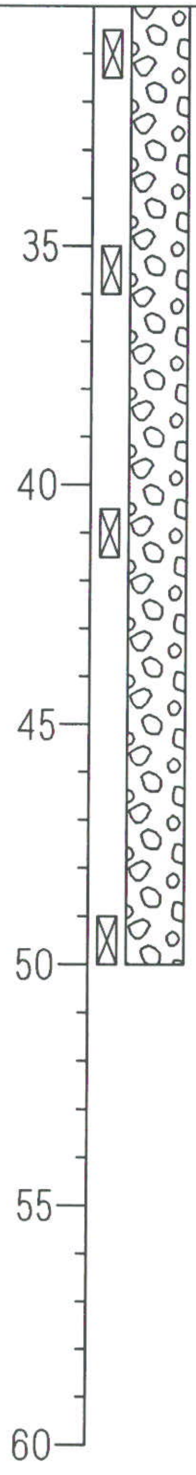
TOTAL DEPTH OF HOLE 50.0 Feet

APPROVED BY

PLATE 3

LOG OF BORING B1

Page 2 of 2



OTHER LABORATORY TESTS	DRY DENSITY (pcf)	MOISTURE (%)	BLOWS/ FOOT*	DEPTH (ft)	SAMPLES	SYMBOLS	MATERIALS DESCRIPTION
			33				*Sandy, dense at 30 feet* Saturated from 30 feet
			36				
			55				*Very dense at 40 feet*
			59				

*BLOW COUNTS – Converted to Equivalent Standard Penetration Blow Counts

**ELEVATION – Topographic Map of Windsor Properties for Kaiser Sand & Gravel by Towill, Inc, March 29, 1989

PROJECT Piombo Pond – Kaiser Property
LOCATION Windsor, California
JOB NUMBER 1102.01.01.1
LOGGED BY KSG
DRILL RIG Rotary Wash

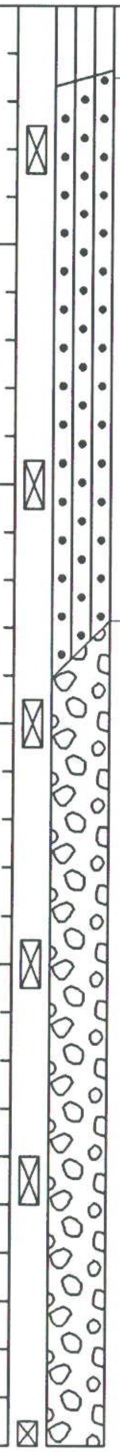
DRILLING COMPANY RNL
DATE DRILLED 05/02/96
SURFACE ELEVATION** 75.0 Feet
TOTAL DEPTH OF HOLE 50.0 Feet
APPROVED BY

PLATE
3A

RGH Geotechnical and Environmental Consultants

LOG OF BORING B2

Page 1 of 2



OTHER LABORATORY TESTS	DRY DENSITY (pcf)	MOISTURE (%)	BLOWS/ FOOT*	DEPTH (ft)	SAMPLES	MATERIALS DESCRIPTION
						LIGHT BROWN SANDY SILT (ML) stiff, dry;
						GRAY-BROWN SILTY SAND (SM) dense, moist; with occasional small gravel
			38		☒	
				5		
			19	10	☒	*Medium dense, wet at 9 feet; with thin (± 3") intermittent lenses of Sandy Silt* *Increasing gravels from 10 feet*
						GRAY-BROWN SANDY GRAVEL (GP) dense, wet
			29	15	☒	
			51	20	☒	*Very dense, wet at 19 feet*
			100+	25	☒	*Very dense at 24 feet* Saturated from 24 feet
			91	30	☒	

PROJECT Piombo Pond – Kaiser Property

LOCATION Windsor, California

JOB NUMBER 1102.01.01.1

LOGGED BY KSG

DRILL RIG Rotary Wash

DRILLING COMPANY RNL

DATE DRILLED 05/06/96

SURFACE ELEVATION** 78.0 Feet

TOTAL DEPTH OF HOLE 50.0 Feet

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PLATE
4

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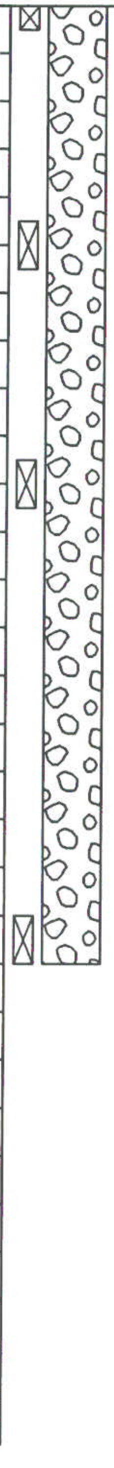
LOG OF BORING B2

Page 2 of 2

OTHER LABORATORY TESTS	DRY DENSITY (pcf)	MOISTURE (%)	BLOWS/ FOOT*	DEPTH (ft)	MATERIALS DESCRIPTION
					Very dense, slightly Silty at 30 feet
			48	35	*Dense at 35 feet*
			84	40	*Very dense at 40 feet*
				45	
			100+	50	
				55	
				60	



*BLOW COUNTS – Converted to Equivalent Standard Penetration Blow Counts
**ELEVATION – Topographic Map of Windsor Properties for Kaiser Sand & Gravel by Towill, Inc., March 29, 1989

PROJECT Piombo Pond – Kaiser Property
LOCATION Windsor, California
JOB NUMBER 1102.01.01.1
LOGGED BY KSG
DRILL RIG Rotary Wash

DRILLING COMPANY RNL
DATE DRILLED 05/06/96
SURFACE ELEVATION** 78.0 Feet
TOTAL DEPTH OF HOLE 50.0 Feet
APPROVED BY

PLATE
4A

RGH Geotechnical and Environmental Consultants

LOG OF BORING B3

Page 1 of 2

OTHER LABORATORY TESTS	DRY DENSITY (pcf)	MOISTURE (%)	BLOWS/ FOOT*	DEPTH (ft)	SAMPLES	SYMBOLS	MATERIALS DESCRIPTION
							LIGHT BROWN SANDY SILT (ML) hard, moist;
			29		☒		
							LIGHT BROWN SILTY SAND (SM) loose, moist;
			7	5	☒		
			--		■		
			5	10	☒		
			10		☒		
							GRAY SAND (SP) medium dense, wet; with occasional small gravels
							LIGHT BROWN SILTY SAND (SM) medium dense, wet;
			9	15	☒		
			21	20	☒		GRAY-BROWN GRAVELLY SAND (SP) medium dense, wet;
			22	25	☒		*Increasing gravels, saturated from 25 feet*
							GRAY-BROWN SANDY GRAVEL (GP) very dense, wet;
			66	30	☒		

PROJECT Piombo Pond - Kaiser Property
LOCATION Windsor, California
JOB NUMBER 1102.01.01.1
LOGGED BY KSG
DRILL RIG Rotary Wash

DRILLING COMPANY RNL
DATE DRILLED 05/06/96
SURFACE ELEVATION** 89.0 Feet
TOTAL DEPTH OF HOLE 50.5 Feet
APPROVED BY

PLATE
5

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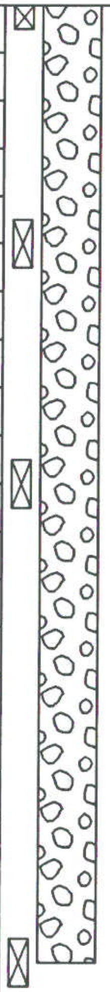
LOG OF BORING B3

Page 2 of 2

OTHER LABORATORY TESTS	DRY DENSITY (pcf)	MOISTURE (%)	BLOWS/ FOOT*	DEPTH (ft)	MATERIALS DESCRIPTION
			49	35	*Dense at 35 feet*
					Large gravels from 36 feet
			36	40	
				45	
			82	50	*Very dense at 50 feet*
				55	
				60	



*BLOW COUNTS – Converted to Equivalent Standard Penetration Blow Counts
**ELEVATION – Topographic Map of Windsor Properties for Kaiser Sand & Gravel by Towill, Inc., March 29, 1989

PROJECT Piombo Pond – Kaiser Property
LOCATION Windsor, California
JOB NUMBER 1102.01.01.1
LOGGED BY KSG
DRILL RIG Rotary Wash

DRILLING COMPANY RNL
DATE DRILLED 05/06/96
SURFACE ELEVATION** 89.0 Feet
TOTAL DEPTH OF HOLE 50.5 Feet
APPROVED BY

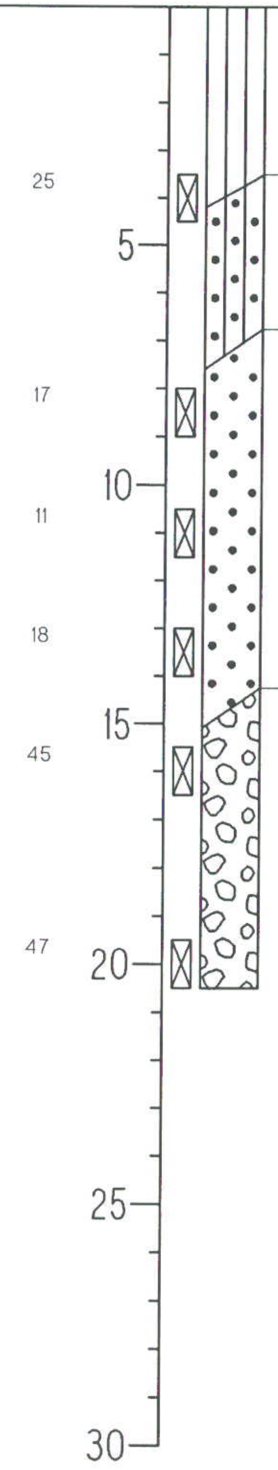
PLATE
5A

RGH Geotechnical and Environmental Consultants

LOG OF BORING B4

Page 1 of 1

OTHER LABORATORY TESTS	DRY DENSITY (pcf)	MOISTURE (%)	BLOWS/ FOOT*	DEPTH (ft)	SAMPLES	SYMBOLS	MATERIALS DESCRIPTION



LIGHT GRAY SANDY SILT (ML)
hard, moist;

LIGHT BROWN SILTY SAND (SM)
medium dense, moist;

GRAY-BROWN SAND (SP)
medium dense, moist

GRAY-BROWN SANDY GRAVEL (GP)
dense, wet;

No Free Water Encountered

*BLOW COUNTS – Converted to Equivalent Standard Penetration Blow Counts
**ELEVATION – Topographic Map of Windsor Properties for Kaiser Sand & Gravel by Towill, Inc., March 29, 1989

PROJECT Piombo Pond – Kaiser Property
LOCATION Windsor, California
JOB NUMBER 1102.01.01.1
LOGGED BY KSG
DRILL RIG 8" Hollow-Stem Auger

DRILLING COMPANY RNL
DATE DRILLED 05/07/96
SURFACE ELEVATION** 78.0 Feet
TOTAL DEPTH OF HOLE 20.5 Feet
APPROVED BY

PLATE
6

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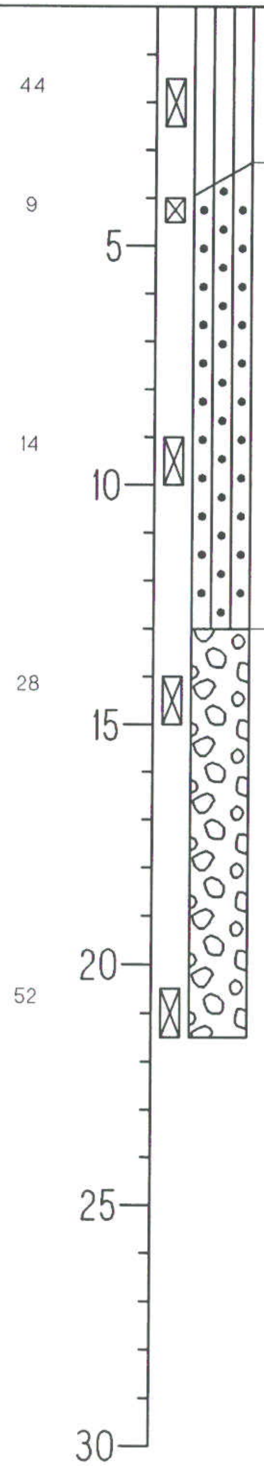
LOG OF BORING B5

Page 1 of 1

OTHER LABORATORY TESTS	DRY DENSITY (pcf)	MOISTURE (%)	BLOWS/ FOOT*	DEPTH (ft)	SAMPLES	SYMBOLS	MATERIALS DESCRIPTION



LIGHT BROWN SANDY SILT (ML)
hard, wet; with occasional
small gravels

LIGHT BROWN SILTY SAND (SM)
medium dense, wet;

With occasional clean sand lenses

GRAY-BROWN SANDY GRAVEL (GP)
dense, wet;

Large gravels at 16 feet; hard to drill from 16 feet to bottom of hole

No Free Water Encountered

*BLOW COUNTS – Converted to Equivalent Standard Penetration Blow Counts

**ELEVATION – Topographic Map of Windsor Properties for Kaiser Sand & Gravel by Towill, Inc., March 29, 1989

PROJECT Piombo Pond – Kaiser Property
LOCATION Windsor, California
JOB NUMBER 1102.01.01.1
LOGGED BY KSG
DRILL RIG Rotary Wash

DRILLING COMPANY RNL
DATE DRILLED 05/02/96
SURFACE ELEVATION** 77.0 Feet
TOTAL DEPTH OF HOLE 21.5 Feet
APPROVED BY

PLATE
7

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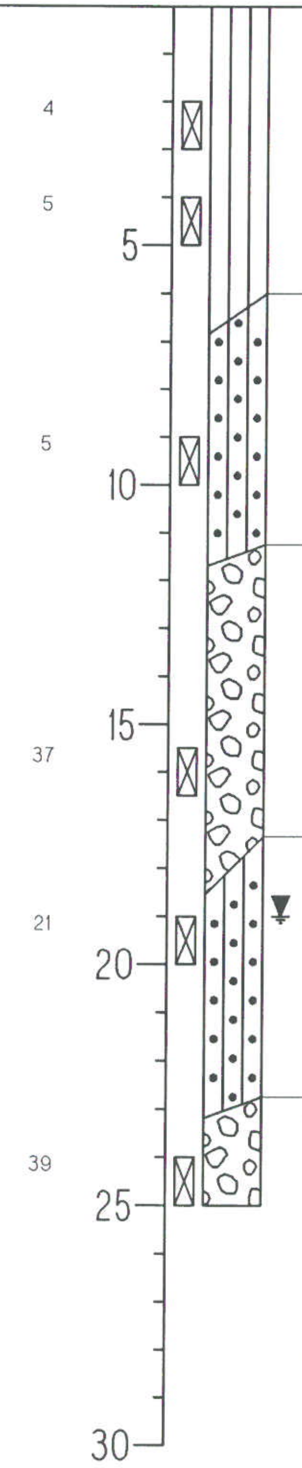
LOG OF BORING B6

Page 1 of 1

OTHER LABORATORY TESTS	DRY DENSITY (pcf)	MOISTURE (%)	BLOWS/ FOOT*	DEPTH (ft)	SAMPLES	SYMBOLS	MATERIALS DESCRIPTION



LIGHT BROWN SANDY SILT (ML)
medium dense, wet;

LIGHT BROWN SILTY SAND (SM)
loose, moist to wet;

GRAY-BROWN SANDY SILTY GRAVEL (GP-GM)
dense, moist;

BROWN SILTY SAND (SM)
medium dense, saturated;

▼ Water Level: 5/30/96

GRAY-BROWN SANDY GRAVEL (GP)
dense, saturated;

*BLOW COUNTS - Converted to Equivalent
Standard Penetration Blow Counts
**ELEVATION - Topographic Map of Windsor Properties for
Kaiser Sand & Gravel by Towill, Inc., March 29, 1989

PROJECT Piombo Pond - Kaiser Property
LOCATION Windsor, California
JOB NUMBER 1102.01.01.1
LOGGED BY KSG
DRILL RIG 8-inch Hollow Stem Auger

DRILLING COMPANY RNL
DATE DRILLED 05/30/96
SURFACE ELEVATION** 72.0 Feet
TOTAL DEPTH OF HOLE 25.0 Feet
APPROVED BY

PLATE
8

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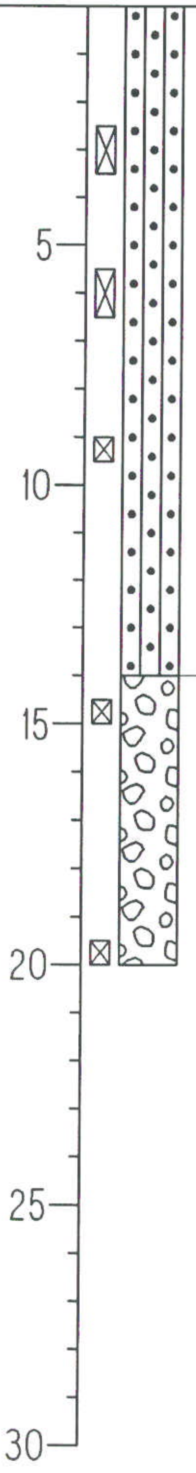
LOG OF BORING B7

Page 1 of 1

OTHER LABORATORY TESTS	DRY DENSITY (pcf)	MOISTURE (%)	BLOWS/ FOOT*	DEPTH (ft)	SAMPLES	SYMBOLS	MATERIALS DESCRIPTION
							LIGHT BROWN SILTY SAND (SM) medium dense, saturated;
			14		☒		
			15				
			6	5	☒		*Loose, moist at 5 feet, with lenses of clean, fine sand*
			6		☒		
				10			*Medium dense at 12 feet*
			20	15	☒		GRAY-BROWN SANDY GRAVEL (GP) medium dense, saturated;
			33	20	☒		*Dense at 19 feet*



*BLOW COUNTS – Converted to Equivalent Standard Penetration Blow Counts

**ELEVATION – Topographic Map of Windsor Properties for Kaiser Sand & Gravel by Towill, Inc., March 29, 1989

PROJECT Piombo Pond – Kaiser Property
LOCATION Windsor, California
JOB NUMBER 1102.01.01.1
LOGGED BY KSG
DRILL RIG 8-inch Hollow Stem Auger

DRILLING COMPANY RNL
DATE DRILLED 05/30/96
SURFACE ELEVATION** 67.0 Feet
TOTAL DEPTH OF HOLE 20.0 Feet
APPROVED BY

PLATE
9

MAJOR DIVISIONS					TYPICAL NAMES
COARSE GRAINED SOILS More Than Half Is Larger Than #200 Sieve	GRAVELS More Than Half Coarse Fraction Is larger Than No. 4 Sieve Size	Clean Gravels With Little or No Fines	GW		Well Graded Gravels, Gravel - Sand Mixtures
			GP		Poorly Graded Gravels, Gravel - Sand Mixtures
		Gravels With Over 12% Fines	GM		Silty Gravels, Poorly Graded Gravel - Silt - Silt Mixtures
			GC		Clayey Gravels, Poorly Graded Gravel - Sand - Clay Mixtures
	SANDS More Than Half Coarse Fraction Is Smaller Than No. 4 Sieve Size	Clean Sands With Little or No Fines	SW		Well Graded Sands, Gravelly Sands
			SP		Poorly Graded Sands, Gravelly Sands
		Sands With Over 12% Fines	SM		Silty Sands, Poorly Graded Sand - Silt Mixtures
			SC		Clayey Sands, Poorly Graded Sand - Clay Mixtures
FINE GRAINED SOILS More Than Half Is Smaller Than #200 Sieve	SILTS AND CLAYS Liquid Limit Less Than 50		ML		Inorganic Silts and Very Fine Sands, Rock Flour, Silty or Clayey Fine Sands, or Clayey Silts with Slight Plasticity
			CL		Inorganic Clays of Low to Medium Plasticity, Gravelly Clays, Sandy Clays, Silty Clays, Lean Clays
			OL		Organic Clays and Organic Silty Clays of Low Plasticity
	SILTS AND CLAYS Liquid Limit Greater Than 50		MH		Organic Silts, Micaceous or Diatomacious Fine Sandy or Silty Soils, Elastic Silts
			CH		Inorganic Clays of High Plasticity, Fat Clays
			OH		Organic Clays of Medium to High Plasticity, Organic Silts
HIGHLY ORGANIC SOILS			Pt		Peat and Other Highly Organic Soils

UNIFIED SOIL CLASSIFICATION SYSTEM

Consol	-	Consolidation
LL	-	Liquid Limit (In %)
PL	-	Plastic Limit (In %)
PI	-	Plastic Index
G_s	-	Specific Gravity
SA	-	Sieve Analysis
■		"Undisturbed" Sample
☒		Bulk or Disturbed Sample
◪		Standard Penetration Test
☐		Sample Attempt With No Recovery

	Shear Strength, psf	Confining Pressure, psf	
Tx	320	(2600)	Unconsolidated Undrained Triaxial
Tx CU	320	(2600)	Consolidated Undrained Triaxial
DS	2750	(2000)	Consolidated Drained Direct Shear
FVS	470		Field Vane Shear
UC	2000		Unconfined Compression
LVS	700		Laboratory Vane Shear

SS - Shrink Swell
EXP - Expansion
P - Permeability

Note: All strength tests on 2.8" or 2.4" diameter sample unless otherwise indicated.

KEY TO TEST DATA

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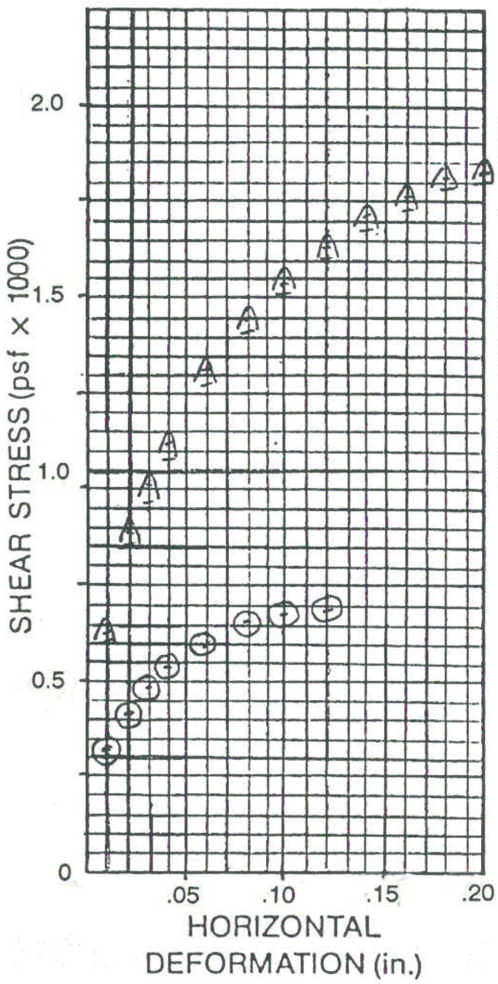
Job No: 1102.01.01.1
Appr:
Drwn: kab
Date: July 1996

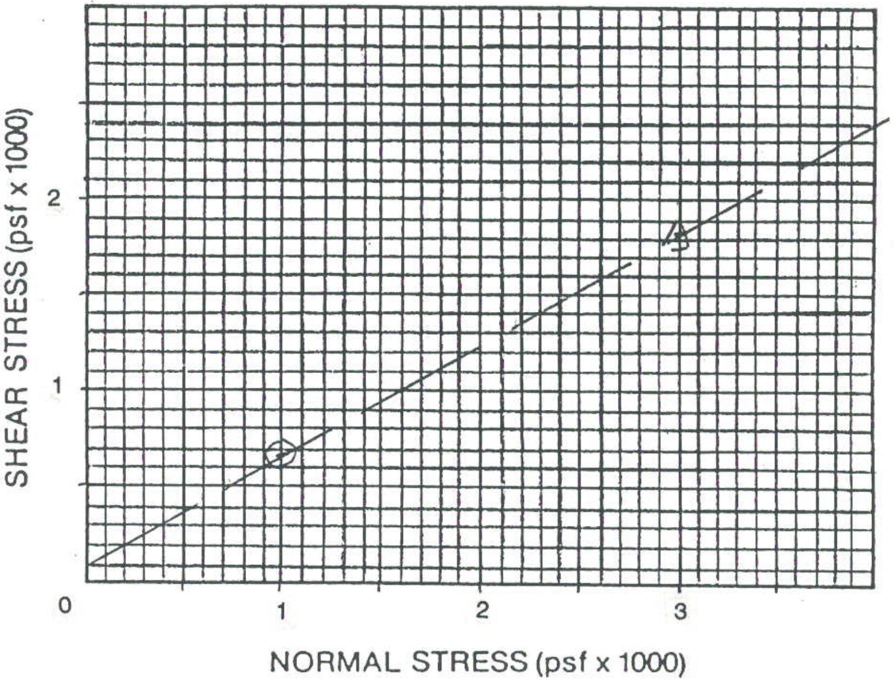
SOIL CLASSIFICATION CHART AND KEY TO TEST DATA

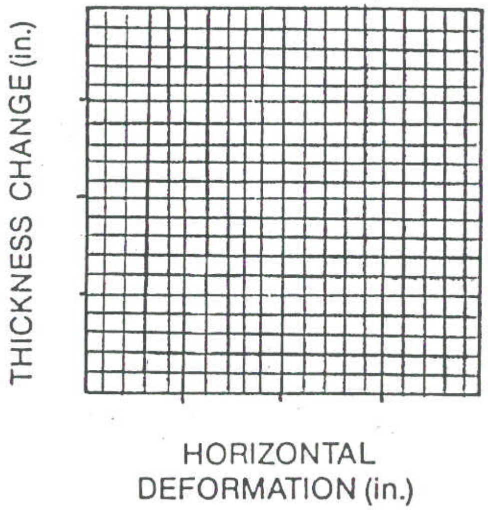
KAISER PROPERTY
PIOMBO POND
Windsor, California

PLATE
10

Reference: ASTM D 3080







$\phi' =$ 30°

$C' =$ 100 psf

Test Type: Consolidated/Drained   Controlled: Deflection

PHYSICAL CONDITIONS		TEST NO.		
		A	B	C
INITIAL	Height (in.)	1.00	1.00	
	Water Content (%)	11.5	12.5	
	Void Ratio	--	--	
	Saturation (%)	--	--	
	Dry Density (pcf)	86.8	84.4	
BEFORE TEST	Time for 50%	< 2	< 2	
	Time for 95%	--	--	
	Void Ratio	--	--	
	Dry Density (pcf)	88.1	89.8	
FINAL	Water Content (%)	30.2	29.6	
	Void Ratio	--	--	
	Saturation (%)	100	100	
Normal Stress (psf)		1000	3000	
Maximum Shear (psf)		690	1810	
Time to Failure (min.)		16	26	
Sample Source: B-3 @ 6.25'				
Classification: Brown Silty Fine Sand (SP-SM)				G_s

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Job No: 1102.01.01.1

Appr: JMB

Drwn: kab

Date: July 1996

DIRECT SHEAR TEST DATA
KAISER PROPERTY
PIOMBO POND
Windsor, California

PLATE
11

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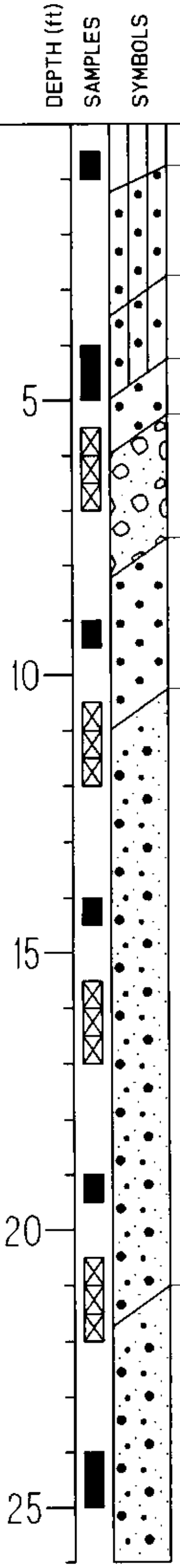
LOG OF BORING B1

Page 1 of 2

OTHER LABORATORY TESTS	DRY DENSITY (pcf)	MOISTURE (%)	BLOWS/ FOOT*
	--	3.7	40
	95	13.3	--
	109	5.7	11
Particle Size (See Plate 16)	--	--	36
	--	3.7	10
% Passing 200 = 6.3	--	--	21
% Passing 200 = 6.4	106	4.2	23
Particle Size (See Plate 17)	--	--	22
	110	5.2	24
	--	--	35
	--	--	37
	100	8.8	



MATERIALS DESCRIPTION

GRAY-BROWN SANDY SILT (ML)
medium stiff, wet; (Recent Silt Deposit)

GRAY-BROWN SILTY SAND (SM)
dense, wet; with small gravel (Fill)

BROWN SILTY SAND (SM)
medium dense, moist;

GRAY SAND (SP)
medium dense, moist; medium grained

GRAY SANDY GRAVEL (GW-GM)
dense, moist;

GRAY SAND (SP)
medium dense, moist; medium grained

GRAY GRAVELLY SAND (SW-SM)
dense, moist

With lenses of slightly Silty Sand; increasing moisture content below 14-feet

With lenses of coarse Sand (SP)

GRAY GRAVELLY SAND (SW-SM)
dense, wet; medium size gravel

Free Water on Gravel Surface

PROJECT Kaiser Property
LOCATION Eastside Road, Windsor, California
JOB NUMBER 1102.01-00-1
LOGGED BY JBH
DRILL RIG 8-inch Hollow Stem Auger

DRILLING COMPANY RNL
DATE DRILLED 06/15/95
SURFACE ELEVATION** 74.0 Feet
TOTAL DEPTH OF HOLE 40.5 Feet
APPROVED BY

PLATE 3A

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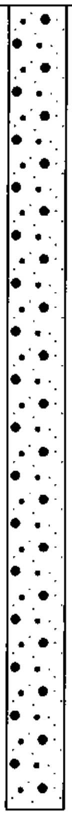
Consultants

LOG OF BORING B1

Page 2 of 2

OTHER LABORATORY TESTS	DRY DENSITY (pcf)	MOISTURE (%)	BLOWS/ FOOT*	DEPTH (ft)	SAMPLES	MATERIALS DESCRIPTION
% Passing 200 = 1.7	--	--	44		■	
						Free Water on Gravel Surface
				31		
						▼ *Becoming saturated below 33-feet* Free Water in Sampler: Water Level 06/15/95
% Passing 200 = 2.9	130	7.4	30		■	
				36		
Particle Size (See Plate 18)	--	--	34		☒	
						With lenses of Gravelly Sand
				41		
				46		
				51		



*BLOW COUNTS - Converted to Equivalent Standard Penetration Blow Counts
**ELEVATION - Contour lines shown on Topographic Map by Hogan, Schoch & Associates dated April 1995

PROJECT Kaiser Property
LOCATION Eastside Road, Windsor, California
JOB NUMBER 1102.01-00-1
LOGGED BY JBH
DRILL RIG 8-inch Hollow Stem Auger
DRILLING COMPANY RNL
DATE DRILLED 06/15/95
SURFACE ELEVATION** 74.0 Feet
TOTAL DEPTH OF HOLE 40.5 Feet
APPROVED BY

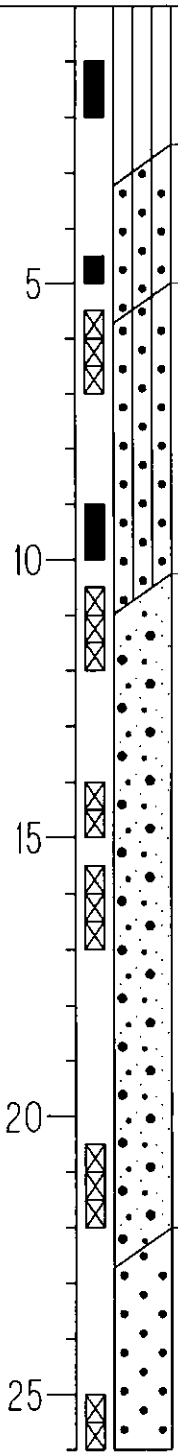
PLATE
3B

RGH Geotechnical and Environmental Consultants

LOG OF BORING B2

Page 1 of 2

OTHER LABORATORY TESTS	DRY DENSITY (pcf)	MOISTURE (%)	BLOWS/ FOOT*
	--	6.3	26
	106	13.0	--
	111	12.5	12
	--	--	8
Direct Shear (See Plate 28)	--	--	8
	91	11.5	19
Particle Size (See Plate 19)	--	--	23
	--	--	30
	--	--	20
	--	--	26
Particle Size (See Plate 20)	--	--	17



MATERIALS DESCRIPTION

BROWN SANDY SILT (ML)
very stiff, moist; (Fill)

Becoming wet below 1.5-feet

BROWN SILTY SAND (SM)
medium dense, wet; (Fill)

BROWN SILTY SAND (SM)
loose, moist;

GRAY-BROWN GRAVELLY SAND (SW)
medium dense, wet; with small gravel, medium sand with lenses of dense Sandy Gravel and medium coarse Sand

GRAY SAND (SP)
medium dense, wet;

PROJECT Kaiser Property
LOCATION Eastside Road, Windsor, California
JOB NUMBER 1102.01-00-1
LOGGED BY JBH
DRILL RIG 8-inch Hollow Stem Auger

DRILLING COMPANY RNL
DATE DRILLED 06/15/95
SURFACE ELEVATION** 75.0 Feet
TOTAL DEPTH OF HOLE 50.0 Feet
APPROVED BY

PLATE
4A

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LOG OF BORING B2

Page 2 of 2

OTHER LABORATORY TESTS	DRY DENSITY (pcf)	MOISTURE (%)	BLOWS/ FOOT*	DEPTH (ft)	SAMPLES	SYMBOLS	MATERIALS DESCRIPTION
							GRAY GRAVELLY SAND (SP-SM) ▼ dense, saturated; with small gravel, medium Sand Water Level: 06/15/95
% Passing 200 = 3.4	--	--	28		☒		
				31			
	--	--	48		☒		
				36			
							With lenses of dense Sand (SP)
	--	--	35		☒		
				41			
Particle Size (See Plate 21)	--	--	72		☒		*With lenses of very dense Silty Gravelly Sand*
				46			
					☒		
				51			

*BLOW COUNTS - Converted to Equivalent Standard Penetration Blow Counts
**ELEVATION - Contour lines shown on Topographic Map by Hogan, Schoch & Associates dated April 1995

PROJECT Kaiser Property
LOCATION Eastside Road, Windsor, California
JOB NUMBER 1102.01-00-1
LOGGED BY JBH
DRILL RIG 8-inch Hollow Stem Auger

DRILLING COMPANY RNL
DATE DRILLED 06/15/95
SURFACE ELEVATION** 75.0 Feet
TOTAL DEPTH OF HOLE 50.0 Feet
APPROVED BY

PLATE
4B

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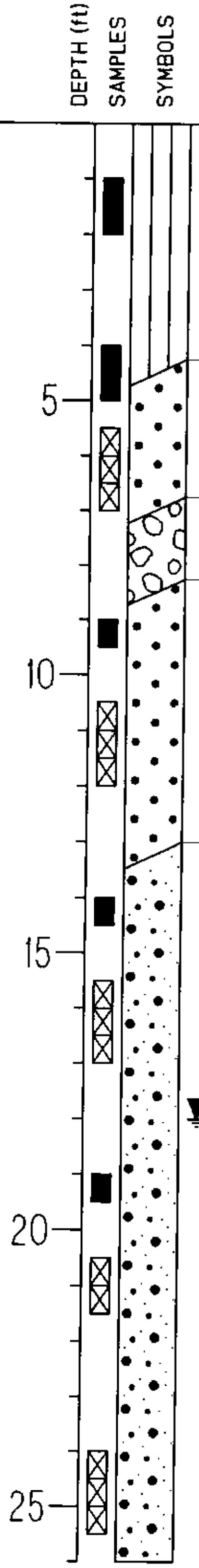
LOG OF BORING B3

Page 1 of 2

OTHER LABORATORY TESTS	DRY DENSITY (pcf)	MOISTURE (%)	BLOWS/ FOOT*	MATERIALS DESCRIPTION
				BROWN SANDY SILT (ML) very stiff, wet; with small gravel
	107	17.1	20	
	85	27.0	12	
	98	17.9		GRAY-BROWN SAND (SP-SM) medium dense, wet;
% Passing 200 = 13.6 UC 300	--	--	23	
				GRAY SANDY GRAVEL (GP) dense, wet;
				GRAY GRAVELLY SAND (SP-SM) medium dense, wet;
	116	3.0	18	
Particle Size (See Plate 22)	--	--	15	
				With lenses of Sandy Gravel; small gravel, medium dense
				GRAY GRAVELLY SAND (SW-SM)
	119	2.3	20	
Particle Size (See Plate 23)	--	--	32	
				Water Level: 06/16/95 Saturated below 18-feet
	129	4.4	24	
Particle Size (See Plate 24)	--	--	27	*With lenses of sandy gravel*
	--	--	39	



PROJECT Kaiser Property

LOCATION Eastside Road, Windsor, California

JOB NUMBER 1102.01-00-1

LOGGED BY JBH

DRILL RIG 8-inch Hollow Stem Auger

DRILLING COMPANY RNL

DATE DRILLED 06/16/95

SURFACE ELEVATION** 65.0 Feet

TOTAL DEPTH OF HOLE 30.5 Feet

APPROVED BY

PLATE

5A

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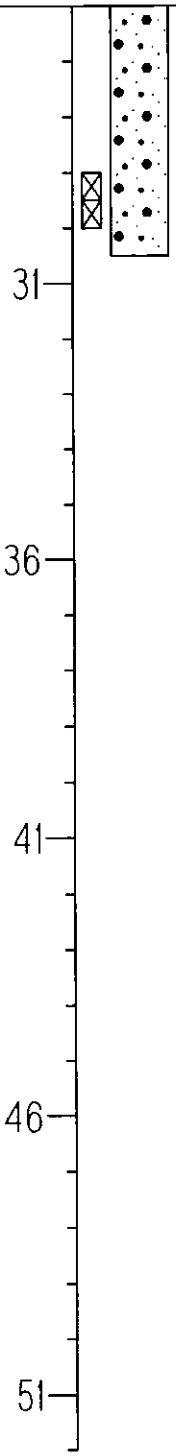
LOG OF BORING B3

Page 2 of 2

OTHER LABORATORY TESTS	DRY DENSITY (pcf)	MOISTURE (%)	BLOWS/ FOOT*	DEPTH (ft)	SAMPLES	SYMBOLS	MATERIALS DESCRIPTION
	--	--	47		☒		



*BLOW COUNTS - Converted to Equivalent Standard Penetration Blow Counts

**ELEVATION - Contour lines shown on Topographic Map by Hogan, Schoch & Associates dated April 1995

PROJECT Kaiser Property

LOCATION Eastside Road, Windsor, California

JOB NUMBER 1102.01-00-1

LOGGED BY JBH

DRILL RIG 8-inch Hollow Stem Auger

DRILLING COMPANY RNL

DATE DRILLED 06/16/95

SURFACE ELEVATION** 65.0 Feet

TOTAL DEPTH OF HOLE 30.5 Feet

APPROVED BY

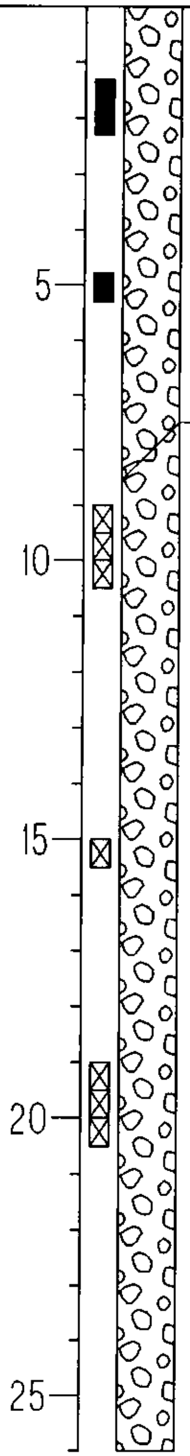
PLATE

5B

LOG OF BORING B12

Page 1 of 2

OTHER LABORATORY TESTS	DRY DENSITY (pcf)	MOISTURE (%)	BLOWS/ FOOT*
	--	--	20
	--	--	21
	--	--	10
	--	--	14
	--	--	22



MATERIALS DESCRIPTION

BROWN SANDY GRAVEL (GP)
medium dense, moist;

Wet at 5-feet

GRAY-BROWN SILTY SANDY GRAVEL (GP-GM)
medium dense, wet;

Becoming Silty Sand at 8-feet

PROJECT Kaiser Property
LOCATION Eastside Road, Windsor, California
JOB NUMBER 1102.01-00-1
LOGGED BY KSG
DRILL RIG 8-inch HA

DRILLING COMPANY RNL
DATE DRILLED 06/26/95
SURFACE ELEVATION** Feet
TOTAL DEPTH OF HOLE 45.5 Feet
APPROVED BY

PLATE 14A

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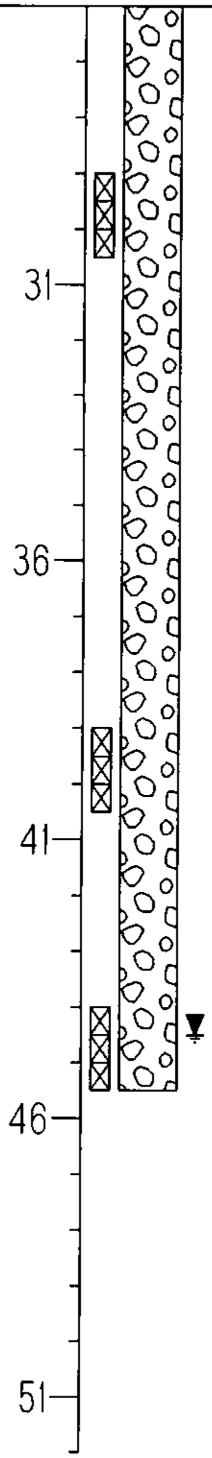
LOG OF BORING B12

Page 2 of 2



OTHER LABORATORY TESTS	DRY DENSITY (pcf)	MOISTURE (%)	BLOWS/ FOOT*	DEPTH (ft)	SAMPLES	SYMBOLS	MATERIALS DESCRIPTION
	--	--	42		☒		*Dense at 29-feet*
	--	--	12		☒		*Medium dense, saturated at 39-feet*
	--	--	39		☒		Water Level: 06/23/95

*BLOW COUNTS - Converted to Equivalent Standard Penetration Blow Counts

**ELEVATION - Contour lines shown on Topographic Map by Hogan, Schoch & Associates dated April 1995

PROJECT Kaiser Property

LOCATION Eastside Road, Windsor, California

JOB NUMBER 1102.01-00-1

LOGGED BY KSG

DRILL RIG 8-inch HA

DRILLING COMPANY RNL

DATE DRILLED 06/26/95

SURFACE ELEVATION** Feet

TOTAL DEPTH OF HOLE 45.5 Feet

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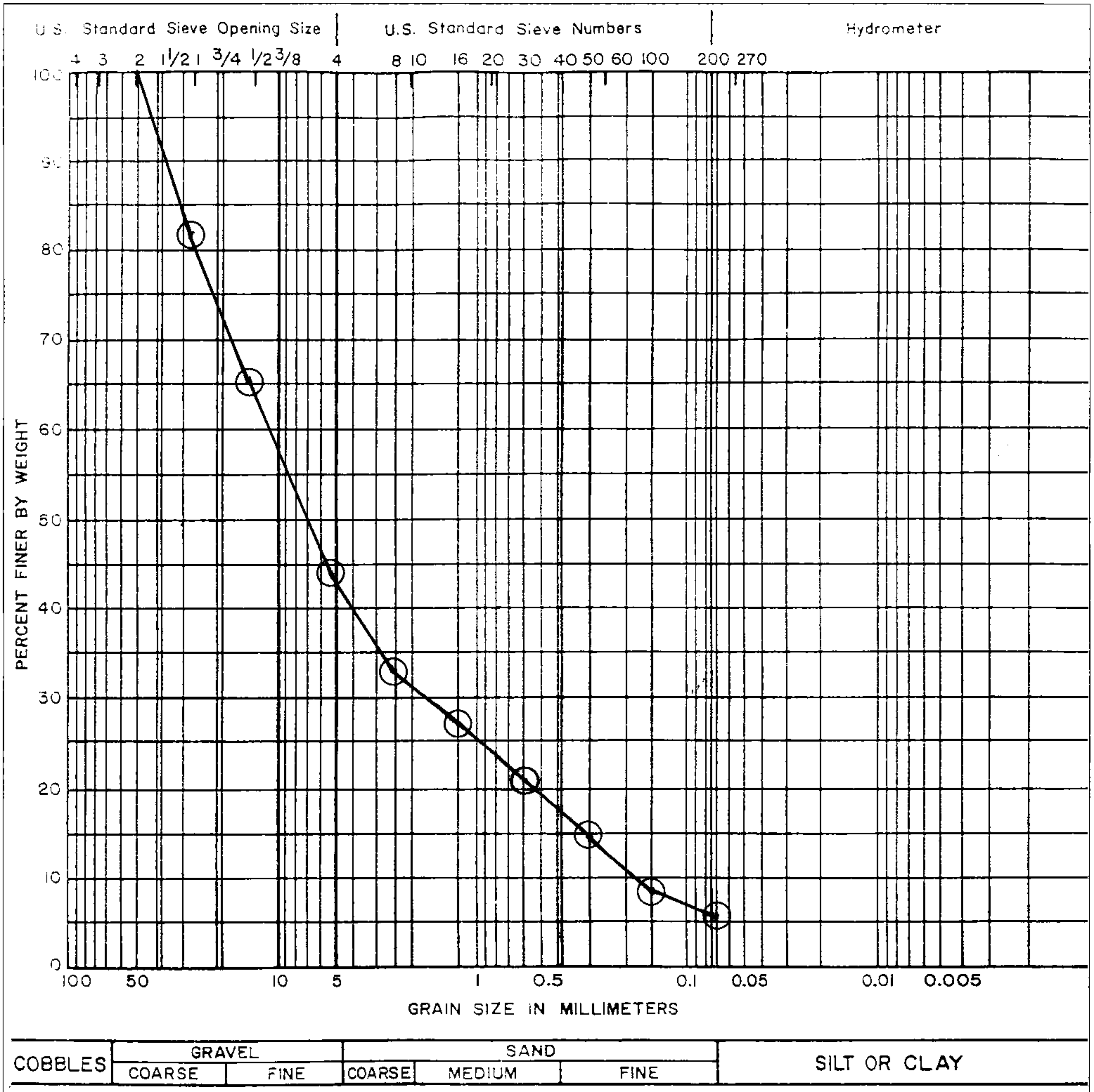
PLATE
14B



Symbol	Sample Source	Classification
⊙	B-1 @ 5.5'	GRAY SANDY GRAVEL (GW-GM)

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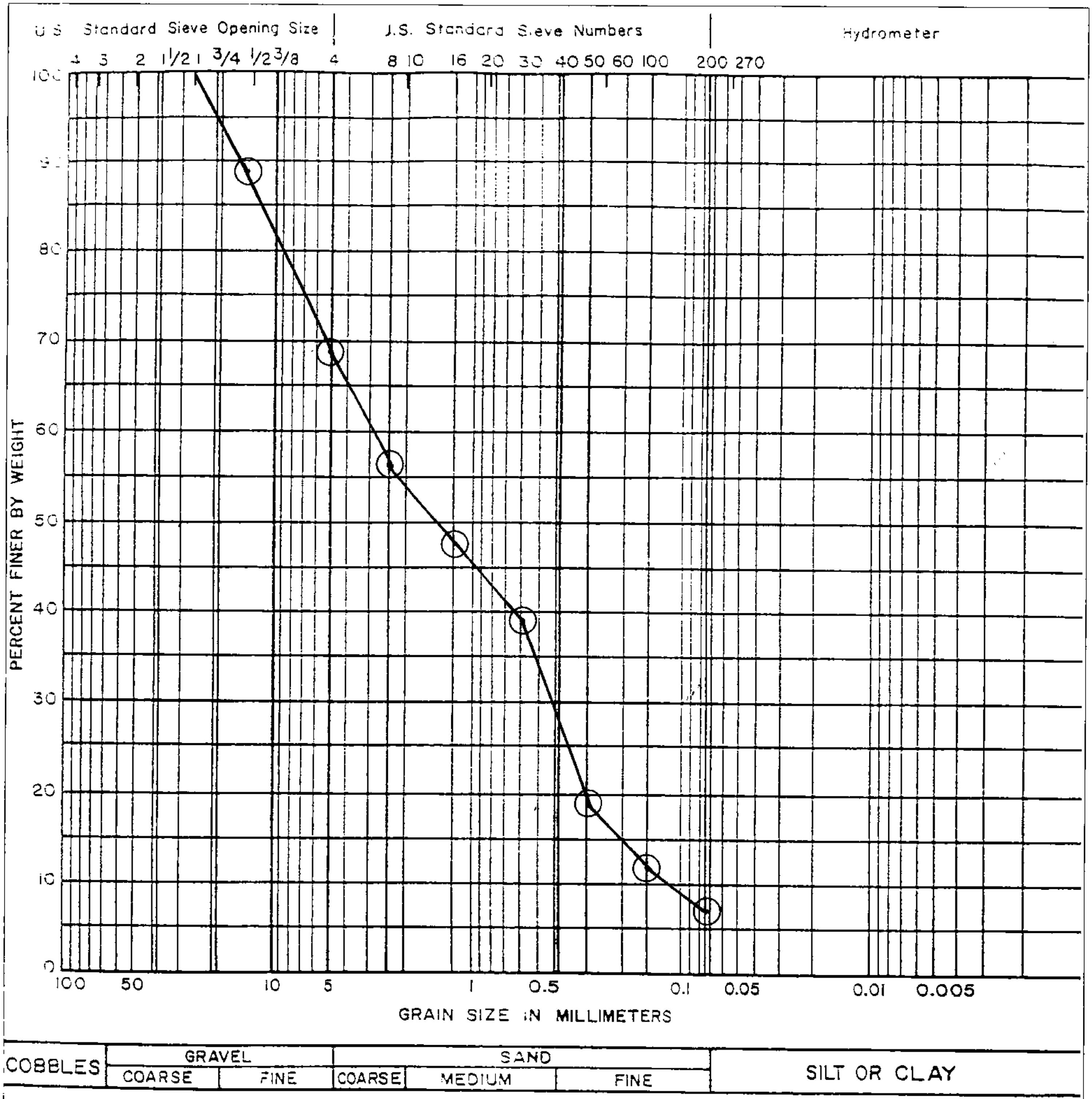
Appr:
Drwn: kab
Date: August 1995

PARTICLE SIZE ANALYSIS
KAISER PROPERTY
Windsor, California

PLATE
16



Symbol	Sample Source	Classification
⊙	B-1 @ 15.5'	GRAY GRAVELLY SAND (SW-SM)

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Job No: 1102.01-01-1

Appr:

Drwn: kab

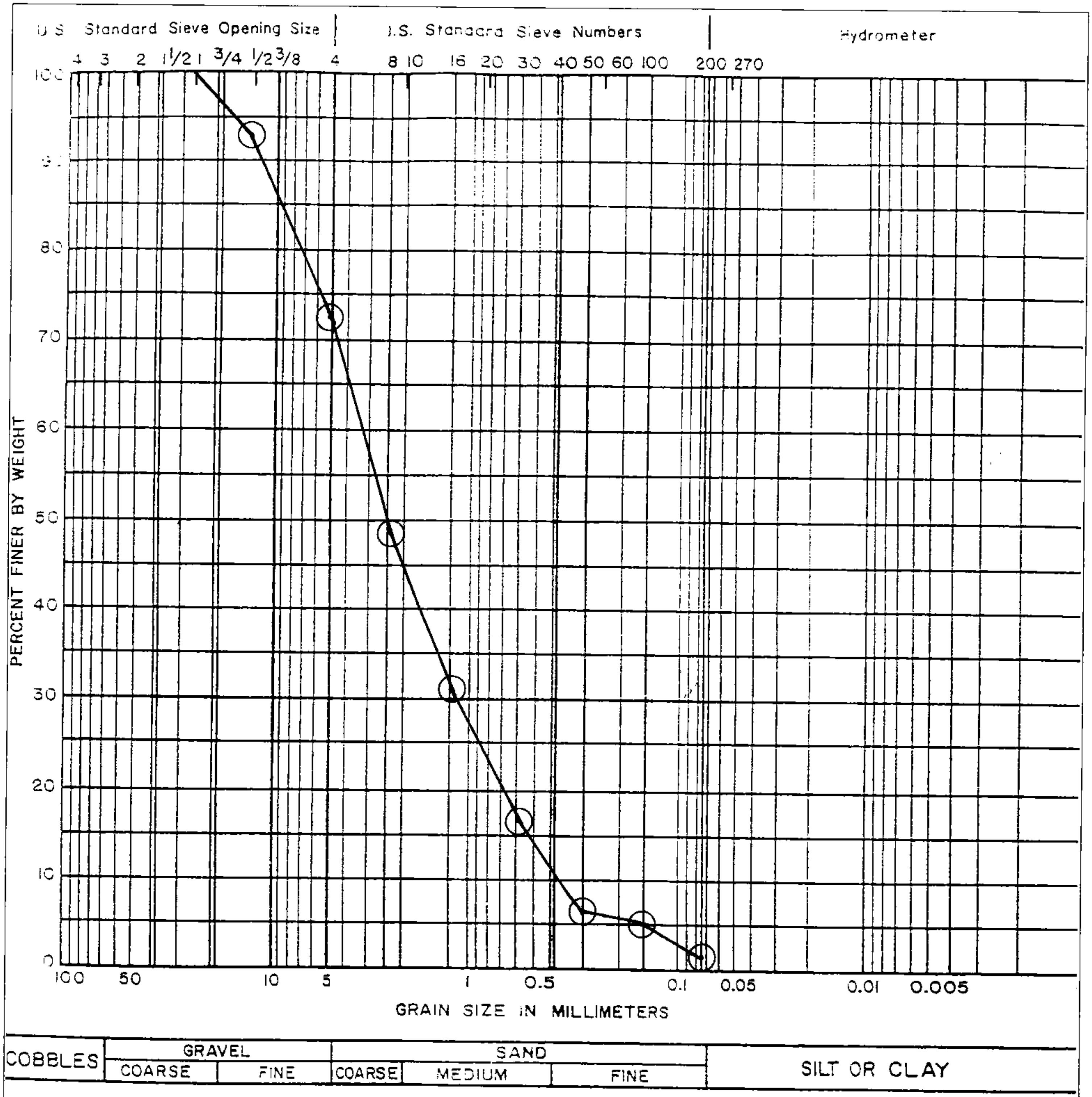
Date: August 1995

PARTICLE SIZE ANALYSIS

KAISER PROPERTY

Windsor, California

PLATE
17



Symbol	Sample Source	Classification
⊙	B-1 @ 39.0'	GRAY GRAVELLY SAND (SW-SM)

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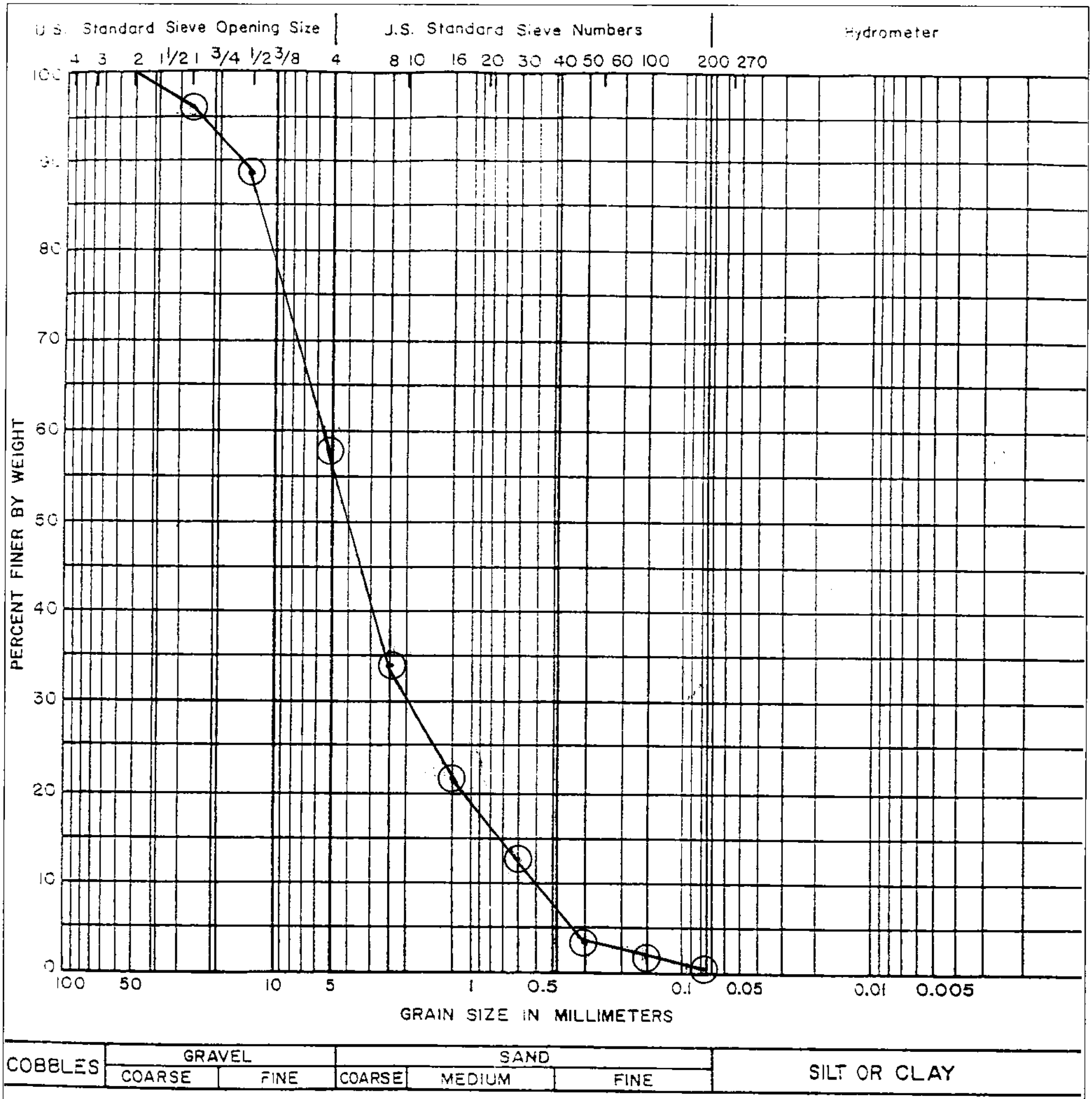
Date: August 1995

PARTICLE SIZE ANALYSIS
KAISER PROPERTY
Windsor, California

PLATE
18



Symbol	Sample Source	Classification
⊙	B-2 @ 14.0'	GRAY GRAVELLY SAND (SW)

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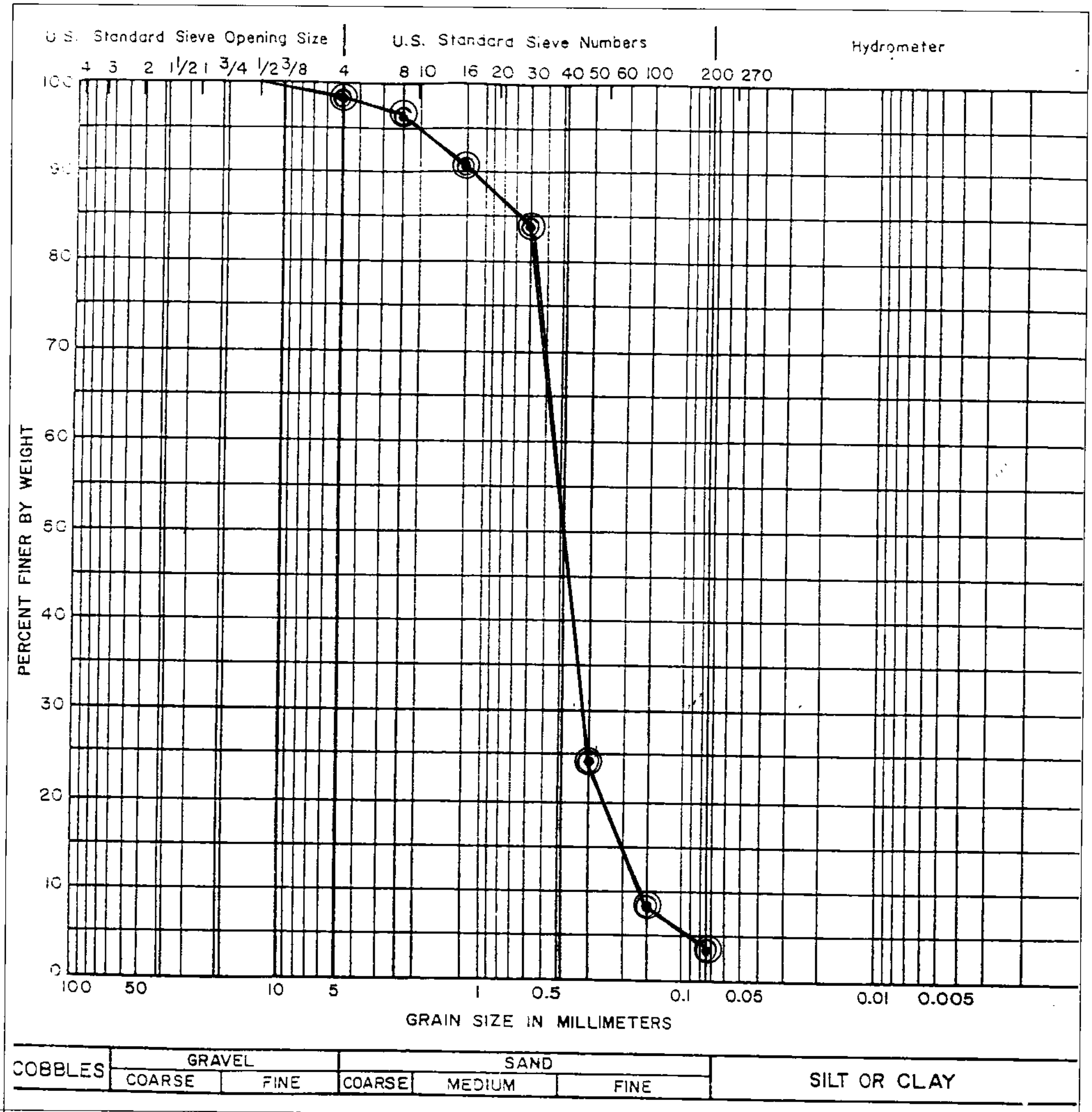
Appr:
Drwn: kab
Date: August 1995

PARTICLE SIZE ANALYSIS
KAISER PROPERTY
Windsor, California

PLATE
19



Symbol	Sample Source	Classification
⊙	B-2 @ 25.0'	GRAY SAND (SP)

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Job No: 1102.01-01-1

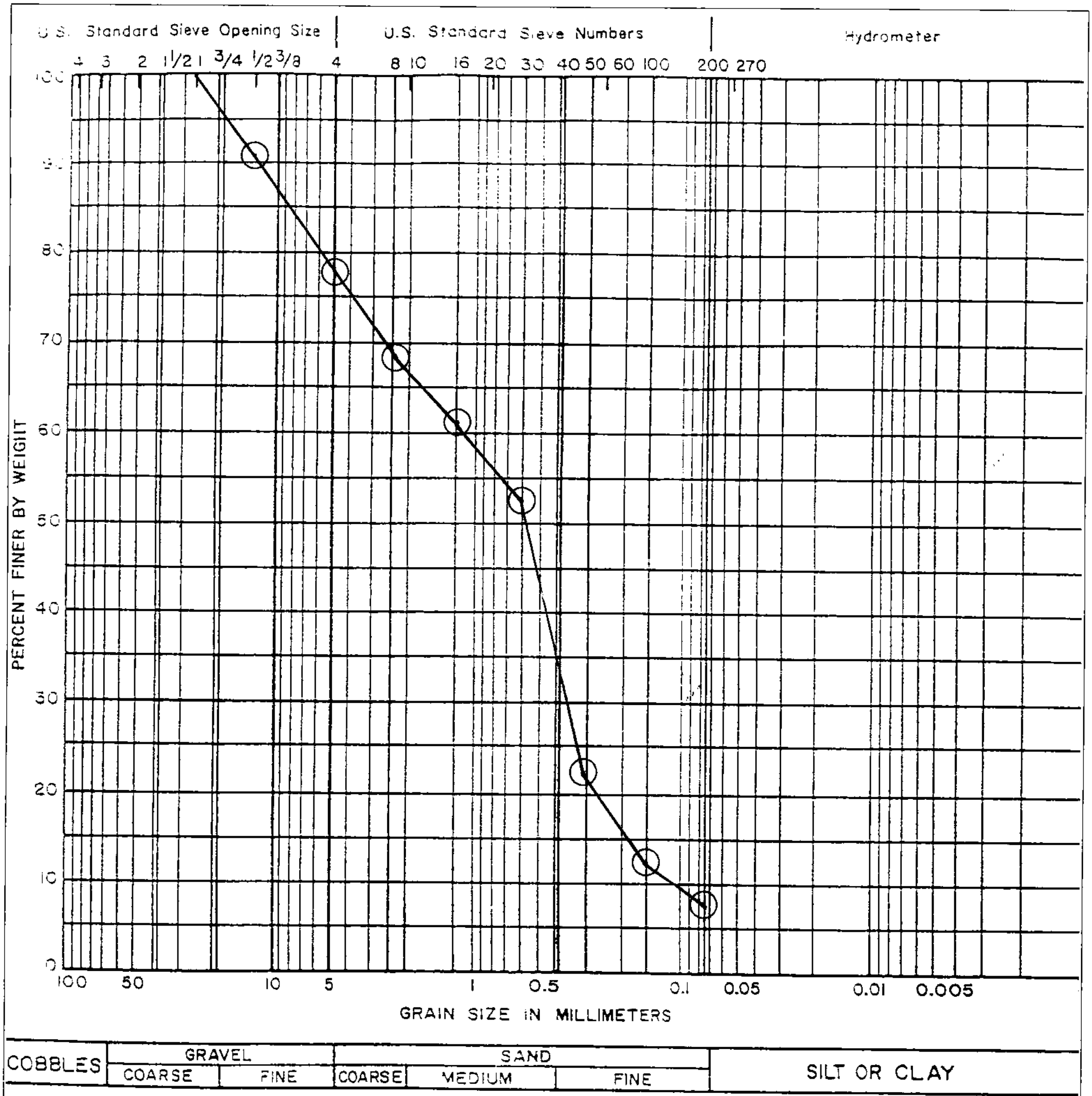
Appr:

Drwn: kab

Date: August 1995

PARTICLE SIZE ANALYSIS
KAISER PROPERTY
Windsor, California

PLATE
20



Symbol	Sample Source	Classification
⊙	B-2 @ 45.0'	GRAY GRAVELLY SAND (SP-SM)

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Job No: 1102.01-01-1
Appr:
Drwn: kab
Date: August 1995

PARTICLE SIZE ANALYSIS
KAISER PROPERTY
Windsor, California

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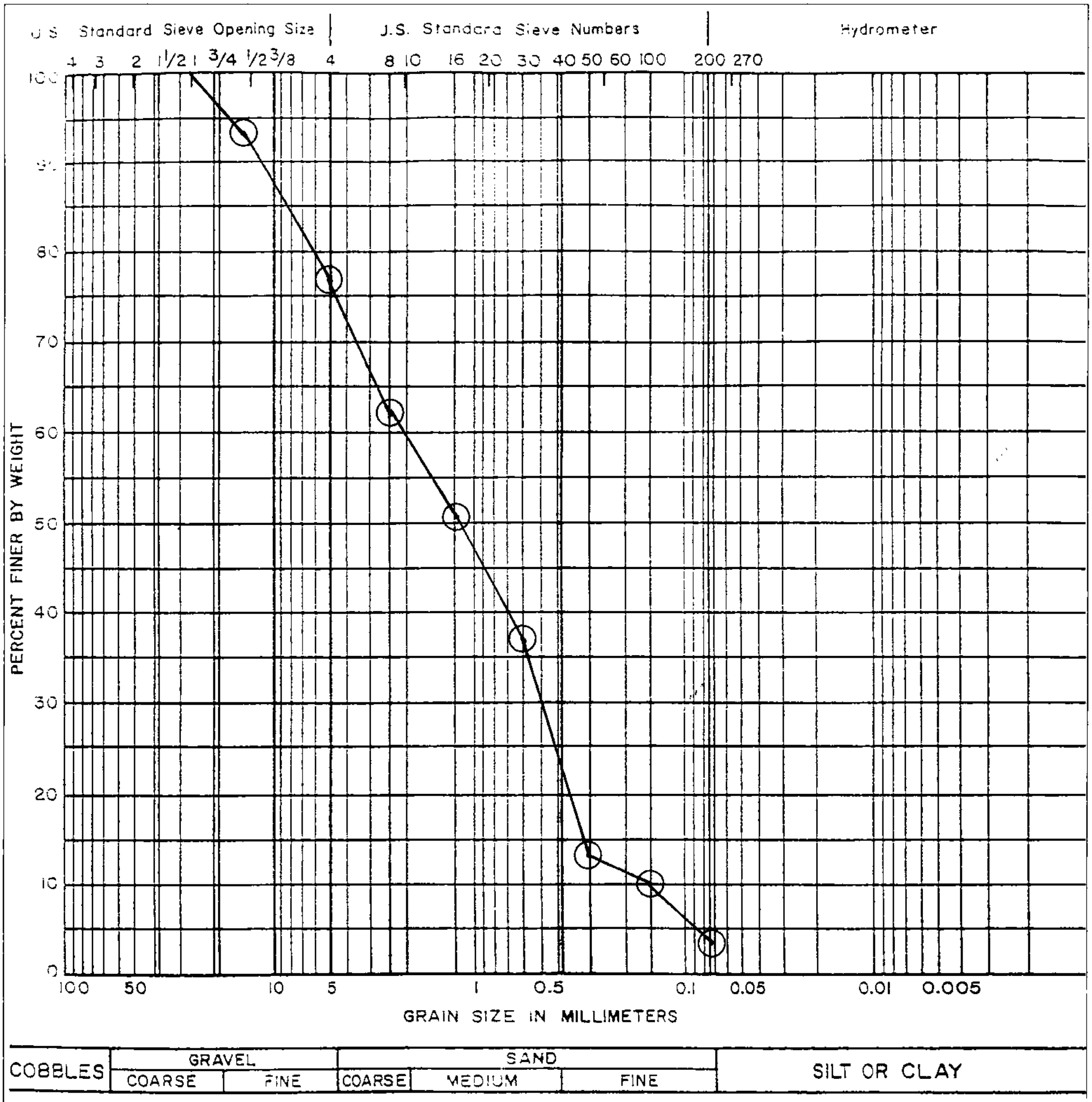


Symbol	Sample Source	Classification
⊙	B-3 @ 10.5'	GRAY GRAVELLY SAND (SP-SM)

R G H

Geotechnical and
Environmental
Consultants

Job No: 1102.01-01-1

Appr:

Drwn: kab

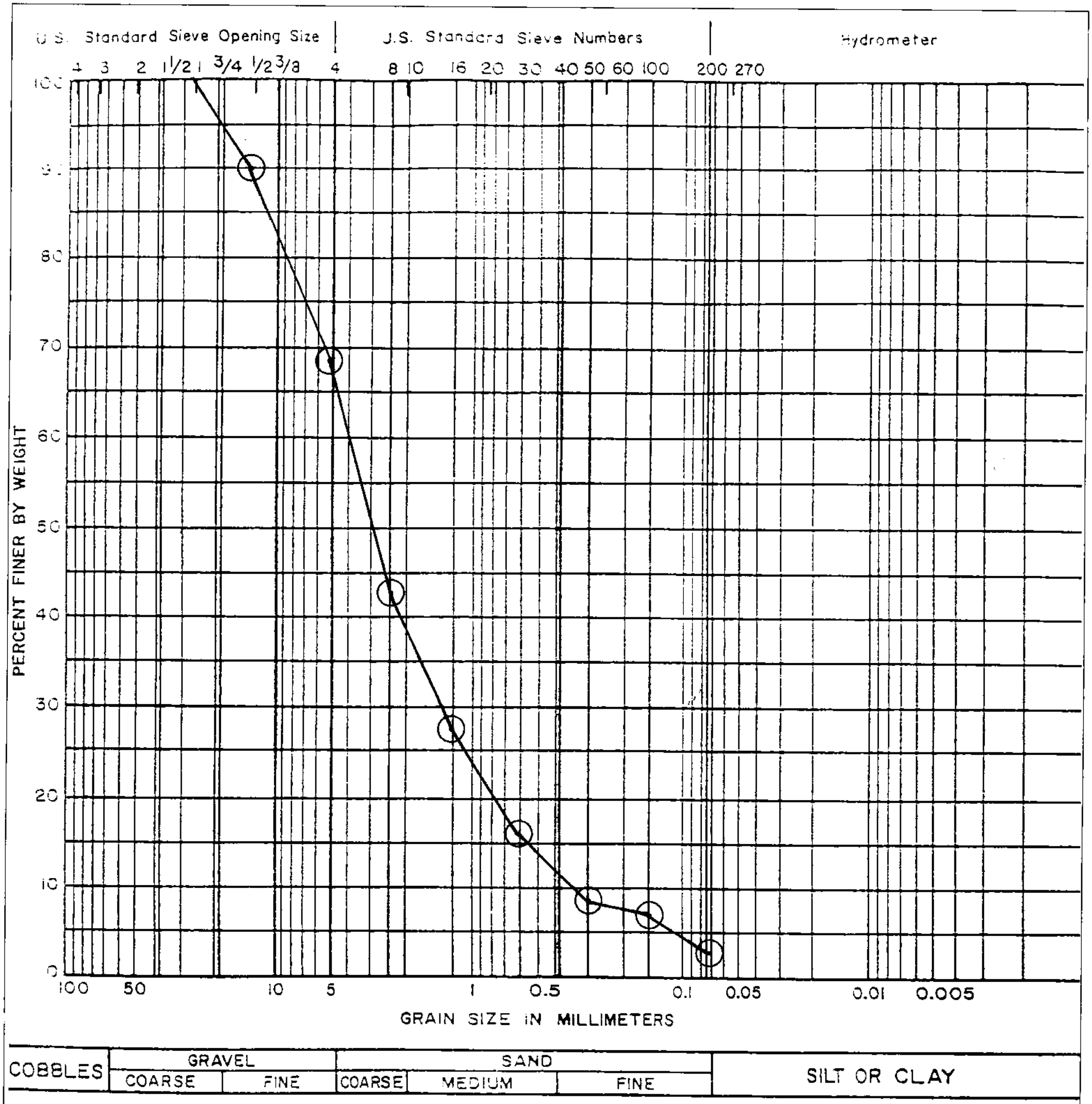
Date: August 1995

PARTICLE SIZE ANALYSIS

KAISER PROPERTY

Windsor, California

PLATE
22



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Geotechnical and
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Consultants

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Appr:

Drwn: kab

Date: August 1995

PARTICLE SIZE ANALYSIS
KAISER PROPERTY
Windsor, California

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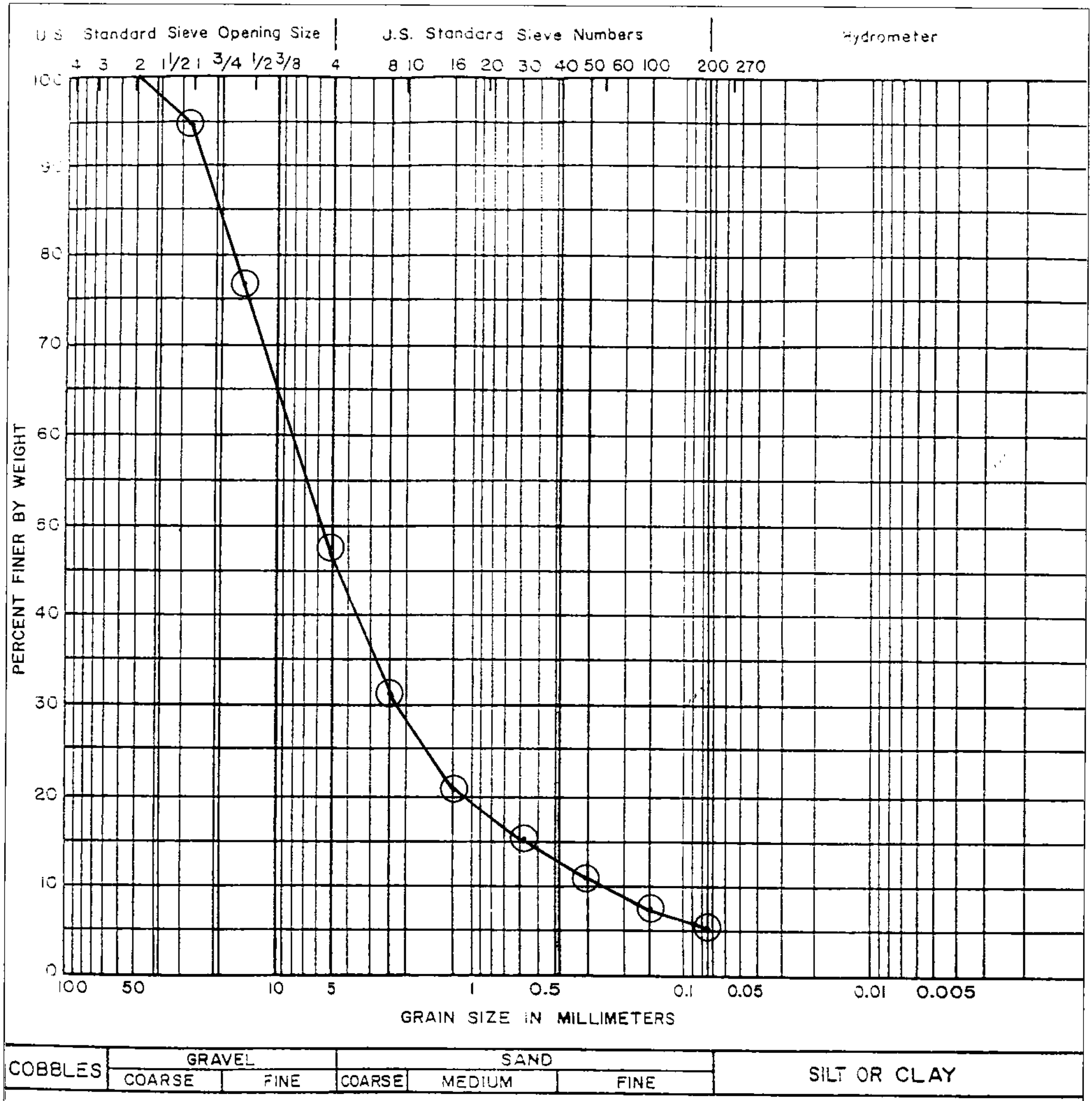

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Environmental
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Job No: 1102.01-01-1
Appr:
Drwn: kab
Date: August 1995

PARTICLE SIZE ANALYSIS
KAISER PROPERTY
Windsor, California

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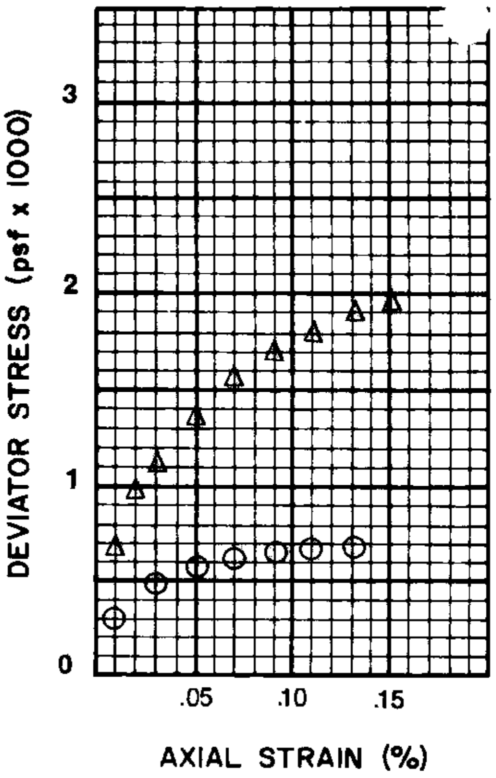
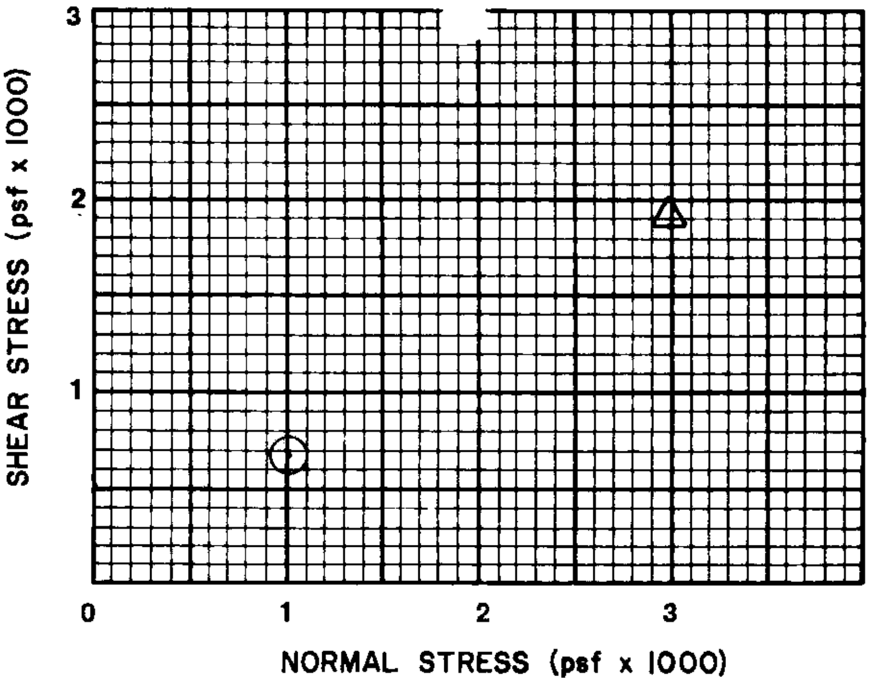
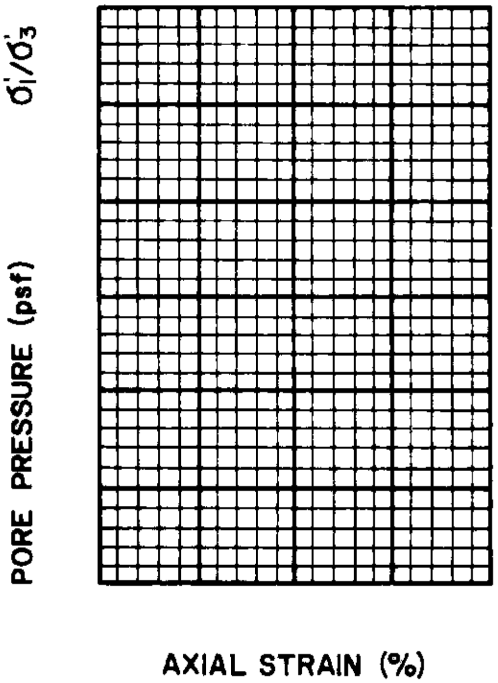




Test Type:____________________Controlled:________

Saturation Method:____________________Gs________



Test No.		A ○	B △	C
Initial	Diameter (in.)	1.00	1.00	
	Height (in.)			
	Moisture Content	15.3 %	23.6 %	%
	Void Ratio			
	Saturation	%	%	%
	Dry Density (pcf)	86.0	83.2	
Before Test	Moisture Content	%	%	%
	Void Ratio			
	Saturation	100 %	100 %	%
	Pressure (psf)			
Final	Moisture Content	27.5 %	28.5 %	%
	Void Ratio			
σ_1 Major Prin. Stress (psf)		1000	3000	
σ_3 Minor Prin. Stress (psf)		690	1940	
Time to Failure (min.)		11	19	

Sample Source: B-2 @ 9.0'

Classification: MOTTLED BROWN SAND (SP)
- very fine grained

Ø = 33.0
C = 0

R G H

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Job No: 1102.01-01-1
Appr:
Drwn: kab
Date: August 1995

DIRECT SHEAR TEST DATA

KAISER PROPERTY

Windsor, California

PLATE
28

Appendix E

30% Revegetation Designs

H. T. HARVEY & ASSOCIATES
Ecological Consultants
50 years of field notes, exploration, and excellence

Hanson Russian River Ponds Floodplain Restoration: 30% Revegetation Design

Project 4353-01

Prepared for:

Endangered Habitats Conservancy
San Diego, CA

Prepared by:

H. T. Harvey & Associates

November 2020

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Section 1.0 Introduction

1.1 Report Purpose and Project Goals

This report provides H. T. Harvey & Associates' (H. T. Harvey's) 30% design and rough order-of-magnitude cost estimate for the revegetation of the Hanson Russian River Ponds Floodplain Restoration Project (project) in Sonoma County, California. The report also addresses fish ecology design elements as they relate to revegetation. This 30% design takes into consideration existing conditions at the project site and the project's feasibility study and conceptual design (EHC 2016). The 356-acre project site is located next to the Russian River, approximately 1 mile west of Windsor, Sonoma County, California (Figure 1). Channel excavation, straightening, and levee construction have caused the river to become incised and disconnected from its historical floodplain. The project site consists of a well vegetated levee that disconnects the river from a broad floodplain and four retired gravel ponds located on the floodplain (from north to south: Mariani, Piombo, Richardson, and Vimark) (Figure 2). The ponds impact riparian ecosystem functions in numerous ways. They support nonnative predatory fish; lack spawning gravel habitat for native fish; substantially reduce seasonal wetland and woody riparian vegetation cover; and degrade water quality in the river ecosystem by elevating water temperatures, accumulating toxic levels of methylmercury, and producing and amassing inorganic plant nutrients (i.e., creating eutrophic conditions) (EHC 2016).

The primary goal of the project is to re-establish a stable, seasonal river-floodplain interface and restore essential ecological processes and functions that sustain off-channel aquatic, wetland, riparian, and upland habitats that are crucial for recovery of listed steelhead (*Oncorhynchus mykiss*), coho salmon (*Oncorhynchus kisutch*), and Chinook salmon (*Oncorhynchus tshawytscha*) (EHC 2016). This goal will be accomplished by mass grading to restore natural floodplain form and function, combined with thoughtful topsoil preparation and native habitat revegetation. Mass grading will remove the levee, fill the ponds, and restore floodplain connectivity with the Russian River. The project's conceptual design outlines specific restoration goals and objectives concerning geomorphology, hydrology, fish, aquafers, water quality, vegetation, and public amenities (EHC 2016). This 30% revegetation design and cost estimate addresses the project's vegetation community and fish ecology goals and will serve as a basis for design decisions made by the Endangered Habitats Conservancy to be incorporated into the project's subsequent 60% design.

H. T. Harvey's restoration and fish ecologists conducted reconnaissance-level surveys to assess ecological restoration opportunities and constraints. We then collaborated closely with GHD's engineers and with coastal ecologist/botanist Peter Baye, PhD, to advise GHD on the floodplain grading design and to develop the basis for this 30% revegetation design. Our findings were presented in two technical memoranda, which characterize existing biotic habitat conditions, identify restoration opportunities and constraints, and outline design criteria for floodplain wetland and riparian habitat restoration (H. T. Harvey & Associates 2019, 2020; Baye 2020a, 2020b) (Appendices A, B, and C).

Our findings included recommendations for target floodplain riparian habitat types and recommendations for the design of site grading and topsoil management conducive to support establishment of the target habitats necessary to achieve the project's vegetation community and fish ecology habitat goals.

1.2 Design Goals for Vegetation Community and Fish Ecology Elements

Target habitats and distributions described in this 30% revegetation design report (Section 2) are targeted to achieve the project's vegetation community and fish ecology goals. The project's vegetation community goal is to restore and enhance a complex, diverse, and resilient floodplain-riparian ecosystem, composed of native plant species which will provide habitat for native fish and wildlife. The goal includes restoration of a diverse habitat mosaic distributed across restored gradients of topography, geomorphology, and hydrology from aquatic bed (submerged and floating aquatic vegetation) to emergent marsh, seasonal wet meadow, riparian scrub, riparian forest, and upland riparian (EHC 2016). Below we provide the rationale for our recommendation to maximize seasonal wet meadow on the floodplain and minimize aquatic habitat and emergent marsh. Based on riparian habitat compositions typical of the region, what is currently growing on the site, and the current grading plan, numerous riparian zones and habitats could be established throughout the project site. Their distribution and species composition will be governed by hydrologic, geomorphic, and biotic factors and their interactions, including flooding depth and duration, groundwater depth during the dry season, rates of sediment deposition and erosion, substrate composition, seed source proximity and dispersal, plant competition, and herbivory.

The project's fish ecology goals are to:

(1) control nonnative fish populations that prey on salmonids by eliminating the floodplain ponds that support the persistence of nonnative fishes under the existing condition; and

(2) increase the populations of native salmonids by restoring spawning gravel deposits and maximizing project area productivity and carrying capacity for juvenile salmonids (EHC 2016).

Models predict that suitable spawning habitat could be formed at the upper floodplain inlet (EHC 2016); spawning habitat in this reach of the river under current conditions is limited, in part due to high velocities and depths, and therefore high sediment transport resulting in gravel coarsening. Models indicate that a delta should form at the restored floodplain inlet resulting in cycles of gravel deposition during passing floods that should be of appropriate grain size, velocity and depth to support salmonid spawning (EHC 2016). However, the amount and consistency of spawning habitat restoration is uncertain; whether the habitat will support spawning for all salmonids is also not known. Chinook salmon require larger spawning gravel and habitat patch sizes than coho salmon or steelhead (Kondolf 2000). Therefore, the grading design should consider design elements such as inlet channel width and gradient, or potential roughness elements, which would promote spawning habitat creation (Roni et al. 2008).

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Figure 1. Vicinity Map

Hanson Russian River Ponds Floodplain Restoration:
30% Revegetation Design (4353-01)
November 2020

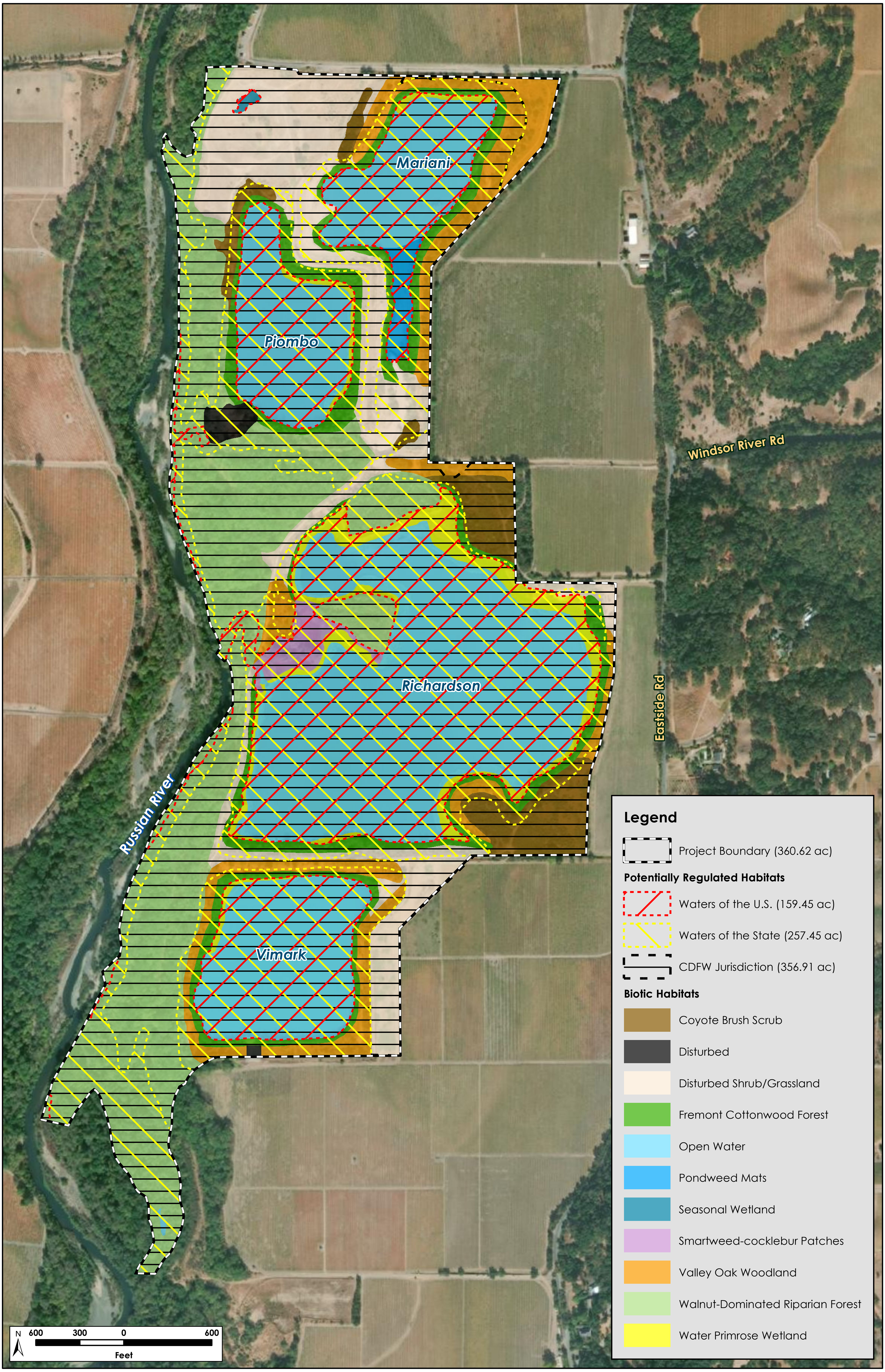

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Figure 2. Project Site and Existing Biotic and Regulated Habitats
Hanson Russian River Ponds Floodplain Restoration: 30% Design (4353-01)
November 2020

To maximize juvenile salmonid productivity and carrying capacity, seasonal wet meadow habitat should be targeted throughout the project's floodplain. Conversely, aquatic (perennial open water channels) and associated emergent marsh habitats should be kept to the minimum necessary to provide suitable conditions for salmonid ingress and egress (Appendix B). Compared to perennial marsh, seasonal wet meadow floodplain habitat is likely favored by steelhead, coho salmon, and Chinook salmon because such habitat:

- provides high-quality winter floodplain foraging habitat with important prey for juvenile salmonids (e.g., dipterans and zooplankton prey),
- precludes reproduction by predatory American bullfrogs (*Lithobates catesbeianus*),
- precludes nonnative fish habitat and thereby reduces the likelihood of predation by nonnative fish, and
- reduces fish stranding potential (Feyrer et al. 2004, Feyrer et al. 2006, Henning et al. 2006, Jeffres et al. 2008, Bellmore et al. 2013, DWR and DFG 2016).

The grading design should also minimize the likelihood of stranding of juvenile salmonids on the floodplain. Design grades on the restored floodplain should minimize depressions (of substantial surface area/depth) without connection to the mainstem, where juveniles could become stranded when flood waters recede.

1.3 Floodplain Target Habitat Design Assumptions

GHD provided H. T. Harvey with the estimated post-construction hydroperiod and dry season groundwater depths that would be generated by the proposed conceptual grading plan presented in the project's feasibility study (EHC 2016). The predicted post-construction hydroperiod/groundwater conditions, indicate that long-duration flooding would occur in winter and shallow, perennial inundation (i.e., ~1–2 feet deep) would occur across the floodplain throughout the growing season (i.e., spring and summer); perennial summer inundation would be due to the presence of a high groundwater table (EHC 2016, Luhdorff & Scalmanini 2020). These abiotic conditions would likely support establishment of tall emergent freshwater marsh across the entire floodplain dominated by plant species such as tules (*Schoenoplectus* spp.) and cattails (*Typha* spp.). Perennial freshwater marsh is not preferred by listed steelhead, coho salmon, and Chinook salmon for the reasons listed above. Moreover, creation of perennial freshwater marsh hydrology is also likely to facilitate early establishment by invasive, nonnative water primrose species (*Ludwigia* spp.) from abundant upstream propagule source populations; invasive primroses would substantially reduce onsite floodplain habitat functions and contribute propagules to downstream suitable habitat, potentially degrading downstream habitat. Therefore, to achieve the project's primary goal, the floodplain elevation should be raised above that shown in the project's feasibility study to allow winter flooding, spring drawdown, and summer groundwater approximately 1 foot below the floodplain surface. These abiotic conditions would support large areas of seasonal wet meadow. These conditions would also discourage the establishment of invasive aquatic plants, such as water primrose species. The rationale behind this floodplain target habitat recommendation is further elaborated in Appendix B.

The grading plan approach seeks an onsite cut-fill balance to avoid the substantial expense of soil import. The floodplain elevations could be raised, while retaining a cut-fill balance, by steepening the landward fill slopes relative to the feasibility study concept and utilizing the additional material to fill the floodplain to higher elevations. If modifying the conceptual grading plan to raise the floodplain elevation is not feasible, the project's primary goal could still be achieved if fine sediment accumulates on the floodplain surface. This deposition would raise the floodplain elevation to create abiotic conditions that favor the establishment of seasonal wet meadow. However, fine sediment deposition rates would need to be relatively rapid (e.g., 1 decade to reach seasonal wet meadow elevations) in order to reduce the negative effects of perennial freshwater marsh creation. Moreover, these rates have not been estimated and such estimation has substantial uncertainty. Therefore, this 30% revegetation design assumes that the grading plan will be modified to achieve target floodplain elevations to support seasonal wet meadow habitat.

Section 2.0 Target Habitats and Distribution

2.1 Overview

The target habitats for revegetation are seasonal wet meadow, aquatic backwater pool and channel, freshwater marsh, riparian scrub, riparian forest, and upland riparian forest. Figure 3 shows the conceptual distributions of revegetation zones (target habitats) overlaid onto the EHC 2016 (GHD's draft 30%) grading plan. Figure 4 shows a typical cross-section of the proposed target habitat distribution. The proposed distribution of target habitats will restore a broad (approximately 1,700–2,500-feet wide), contiguous wetland-riparian corridor.

The following subsections provide brief descriptions of the distribution and surface area of proposed target habitats for revegetation. The acreage estimates are for planning purposes; however, the restored floodplain ecosystem will be purposefully designed to be geomorphically dynamic over time as it responds to the natural dynamism of the Russian River fluvial system. Vegetation succession and distribution will naturally respond to these geomorphic changes. Lists of plant species proposed for revegetation are provided in Section 3.5.

Table 1 presents a summary of existing and proposed habitat types that may be subject to regulation under Section 1600 of the California Fish and Game Code administered by the California Department of Fish and Wildlife. These acreages include all areas below the 100-year floodplain (Figure 3). The approximate footprint of the 100-year floodplain on the project site (357 acres) was derived from County of Sonoma (2018), and is approximately 4 acres smaller than the project boundary.

Table 1. Summary of Existing and Proposed Regulated Habitats

Regulated Habitat Type	Existing Area (acres)	Restored Area (acres)	Delta (acres)
Aquatic backwater pool and channel[1]	3	10	7
Disturbed shrub/grassland	46	0	-46
Disturbed/developed	2	11	9
Freshwater marsh[2]	14	5	-9
Open water	135	5	-130
Riparian forest[3]	112	134	22
Riparian scrub[4]	42	42	0
Seasonal wet meadow[5]	4	150	146
Total	**357**	**357**	**0**

Note: Values have been rounded to the nearest acre; totals are subject to rounding error.

[1] Includes existing pondweed mats.

[2] Includes water primrose wetlands.

[3] Includes existing walnut-dominated riparian forest and valley oak woodland.

[4] Includes existing coyote brush scrub and Fremont cottonwood forest.

[5] Includes existing seasonal wetland and smartweed-cocklebur patches.

2.2 Seasonal Wet Meadow

Approximately 150 acres of seasonal wet meadow will be restored on the floodplain which will be set at a design grade that will result in ephemeral winter flooding, spring drawdown, and a summer groundwater table at approximately 1.0 foot below ground surface. In addition, sediment deposition and erosion rates should average less than 0.3-foot per year to sustain this habitat type. Examples of the dominant seasonal wet meadow plant species include sticktight (*Bidens frondosa*), valley sedge (*Carex barbarae*), tall cyperus (*Cyperus eragrostis*), spike rush (*Eleocharis macrostachya*), slender willow herb (*Epilobium ciliatum*), and Baltic rush (*Juncus balticus*). This plant community will perform best in fine textured soils (e.g., clayey silt, silty clay, and silty sand). The proposed seasonal wet meadow habitat is designed to maximize juvenile salmonid productivity and carrying capacity at the project site.

2.3 Aquatic Backwater Pool and Channel

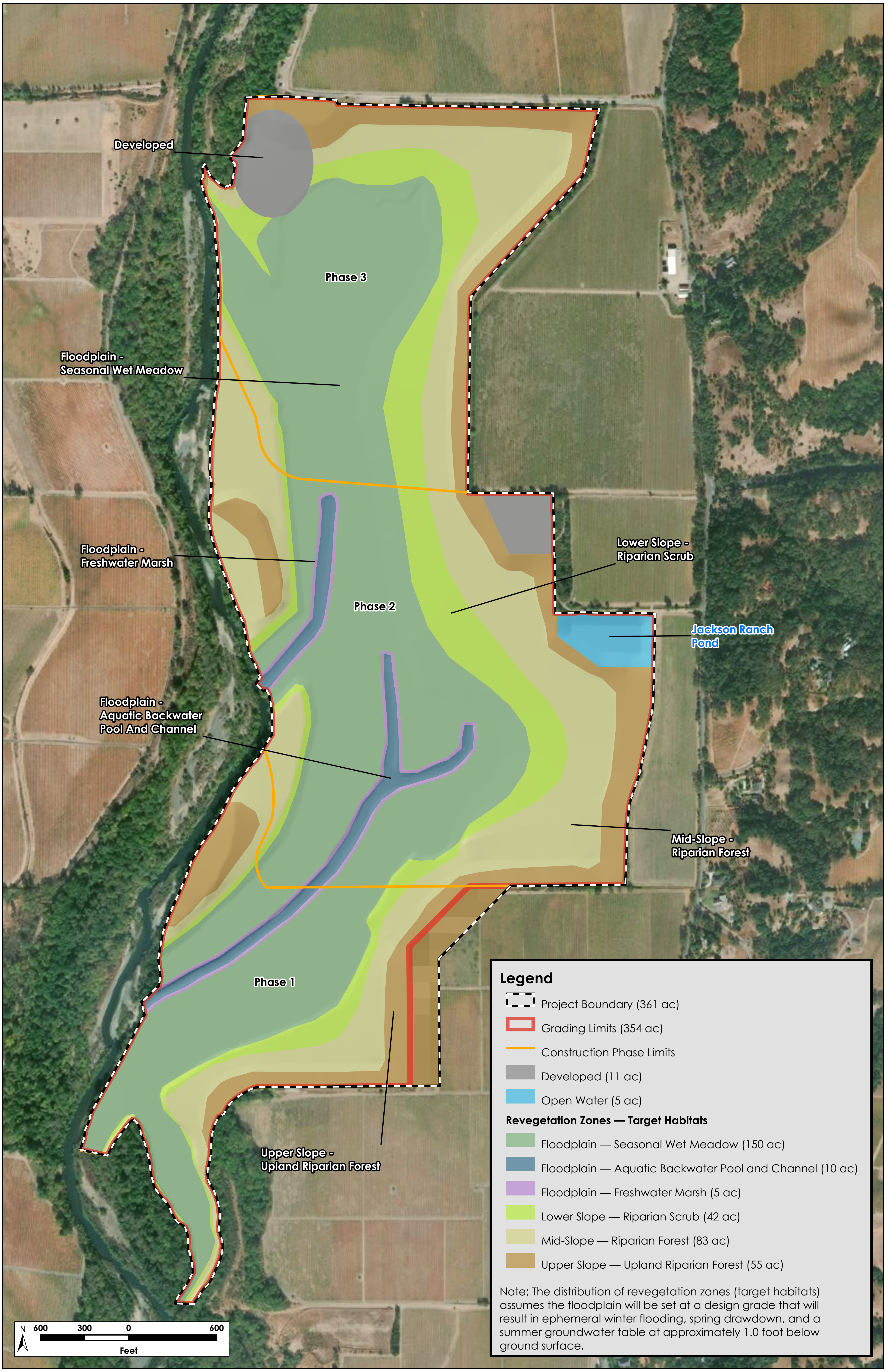
Approximately 10 acres of aquatic backwater pool and channel habitat will be restored on the floodplain where water depths are anticipated to range 3–4 feet during summer due to the backwater channel's interception of the shallow summer groundwater table. The proposed aquatic backwater pool and channel habitat is designed to provide perennial aquatic channel dominated by open water. The aquatic channels will provide obvious ingress for migrating salmonids accessing backwater pools and floodplain habitat for foraging, and provide obvious egress for salmonids to return to the river channel as floods recede.

2.4 Freshwater Marsh

Approximately 5 acres of perennial emergent freshwater marsh will be restored on the floodplain between seasonal wet meadow and aquatic backwater pools and channels where spring submergence following ephemeral winter floods is 3 feet or less and summer groundwater maintains perennial saturation to the soil surface. In addition, sediment deposition and erosion rates should average less than 0.3 foot per year to sustain this habitat type. Freshwater marsh will be dominated by native plant species such as river bulrush (*Bolboschoenus fluviatilis*), hardstem bulrush (*Schoenoplectus acutus*) California bulrush (*Schoenoplectus californicus*), small fruited bulrush (*Scirpus microcarpus*), and broadleaf cattail (*Typha latifolia*). Target plant species prefer substrates composed of fine textured soils (e.g., clayey silt and silty clay). The proposed freshwater marsh is designed to contribute to riparian zone and habitat patch type diversity, and contribute to the vegetation community gradient from aquatic bed to seasonal wet meadow, scrub-shrub forest wetland, and upland riparian forest.

2.5 Riparian Scrub

Approximately 42 acres of riparian scrub will be restored on the lower slope surrounding the floodplain in areas subjected to ephemeral winter floods, rapid drawdown, and summer groundwater approximately 3–9 feet below ground surface. In addition, sediment deposition and erosion rates should average less than 1 foot per year to sustain this habitat type. Riparian scrub will be dominated by native woody plant species such as Fremont



Note: The distribution of revegetation zones (target habitats) assumes the floodplain will be set at a design grade that will result in ephemeral winter flooding, spring drawdown, and a summer groundwater table at approximately 1.0 foot below ground surface.

N:\Projects4300\4353-01\Reports\Fig 1 30 percent Reveg Design\Fig 3 Plan View Layout of Reveg Zones and Target Habitats Copy2.aprx

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Figure 3. Plan View Layout of Revegetation Zones and Target Habitats
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November 2020

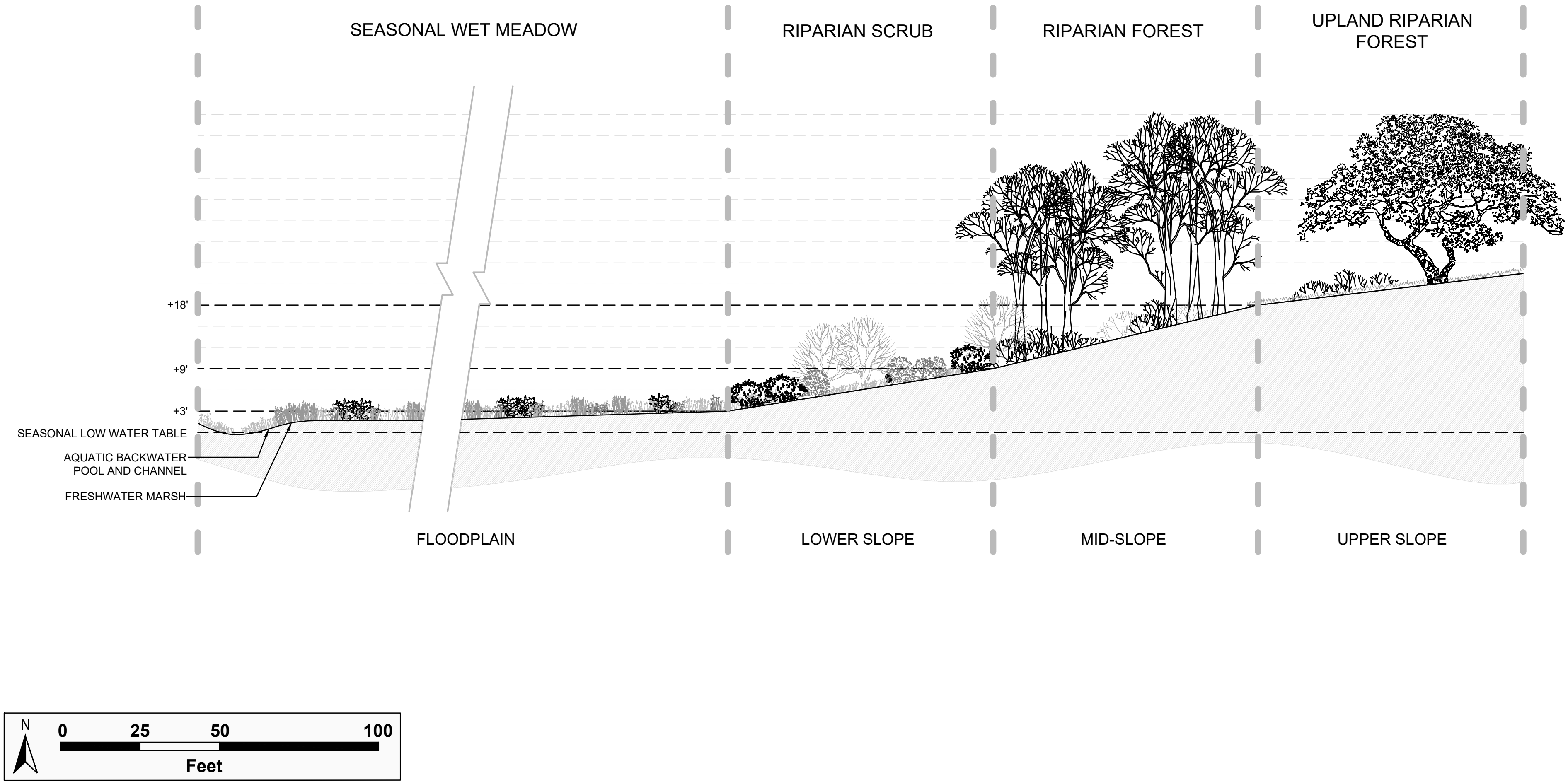

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Figure 4: Floodplain Restoration Conceptual Section

Hanson Russian River Floodplain Restoration (4353-01)
November 2020

cottonwood (*Populus fremontii*), narrowleaf willow (*Salix exigua*), red willow (*Salix laevigata*), and arroyo willow (*Salix lasiolepis*). Target plant species prefer coarser textured soils relative to wetlands (e.g., silt, sandy silt, silty sand, and gravel). Riparian scrub will provide shaded riverine aquatic habitat and structure along the margins of the floodplain and provide a transitional habitat between seasonal wet meadow and riparian forest. Riparian scrub could also be established on floodplain undulations or mounds to increase habitat complexity and heterogeneity, which may benefit salmonids; however, its extent should be limited in favor of maximizing seasonal wet meadow habitat for reasons discussed in Section 1.2.

2.6 Riparian Forest

Approximately 83 acres of riparian forest will be restored on the mid-slope in areas subjected to ephemeral winter floods, rapid drawdown, and summer groundwater approximately 9–18 feet below ground surface. These areas should experience little or no sediment deposition and erosion to support this target habitat. Riparian forest will be dominated by native woody plant species such as box elder (*Acer negundo*), Oregon ash (*Fraxinus latifolia*), Northern California black walnut (*Juglans hindsii*), Fremont cottonwood, valley oak (*Quercus lobata*), California wild rose (*Rosa californica*), California blackberry (*Rubus ursinus*), red willow, and arroyo willow. Target plant species prefer soils similar to riparian scrub (e.g., silt, sandy silt, silty sand, and gravel). Riparian forest will provide wildlife habitat, slope stability, shade, and woody and organic debris that support aquatic food webs. Riparian forest will also provide a buffer to protect the floodplain riparian and wetland habitats from the surrounding agriculture and urban development (Semlitsch and Bodie 2003).

2.7 Upland Riparian Forest

Approximately 55 acres of upland riparian forest will be restored on the upper slope. Hydrologic conditions will be characterized by ephemeral winter floods, rapid drawdown, summer groundwater 18 feet or more below ground surface, and little or no sediment deposition and erosion. The dominant species in upland riparian forest will include valley oak, coast live oak (*Quercus agrifolia*), Northern California black walnut, blue elderberry (*Sambucus nigra*), California bay laurel (*Umbellularia californica*), and California buckeye (*Aesculus californica*). Target plant species prefer substrates composed of silt to loam, to clay loam. Upland riparian forest will provide functions and values similar to riparian forest.

Section 3.0 Revegetation Basis of Design and Methods

3.1 Overview

Due to the large scale of earthwork required, the project will be implemented in phases over multiple construction seasons. Construction work related to revegetation will include grading and topsoil preparation, invasive plant removal/burial during earthwork, revegetation, and incorporation of habitat features. These aspects of the project are discussed below.

3.2 Phasing

Grading and revegetation will be implemented in three phases over a 3-year period. Phase 1 activities will be performed the first year of construction on approximately 85 acres and include filling the Vimark pond, Phase 2 activities will be performed the second year of construction on approximately 163 acres and include filling the Richardson pond, and Phase 3 activities will be performed the third year of construction on approximately 106 acres and include filling the Piombo and Mariani ponds (Figure 3). The construction season is expected to be June 15 to October 15 during each year.

3.3 Grading and Topsoil Preparation

The project's grading plan should be crafted to create soil conditions well-suited for establishment of the target habitats both on the floodplain and slopes in the root zones of target plant species. This is a key aspect of the design to increase the likelihood of target habitat establishment and reduce the potential for invasive weed dominance and associated vegetation maintenance costs. For example, riparian scrub habitat requires a contiguous vertical profile of well-drained sediments with low compaction, from the surface to the shallow groundwater table. In contrast, seasonal wet meadow habitat on floodplains tends to occur in finer textured topsoils in the upper 1–2 feet of the soil profile at the design grade. Upland riparian forest vegetation favors loams and is not dependent upon access to perennial groundwater and the primary rooting zone is within the upper 3–4 feet. Therefore, soils suitable for the rooting zones of the various habitat types should be salvaged from onsite and stockpiled onsite prior to the mass grading work that will remove the levee and fill the ponds. Following mass grading, salvaged soils should then be placed to design grade elevations to create suitable rooting media for the various habitat types.

The design of soil conditions tailored to the target habitats will require close collaboration between a soils restoration ecologist and the project engineer. A soils restoration ecologist should carefully review existing soils information, determine if additional field soils investigation is needed, prepare a conceptual soils preparation plan, and collaborate with the project engineer to integrate soils preparation processes into the grading plan.

3.4 Invasive Plant Removal/Burial during Grading

Invasive plants are major stressors on the ecosystem processes, habitats, and species that are the focus the project. Because the project will excavate and/or fill the entire site, there is a valuable opportunity during the earthwork process to restore a topsoil substrate that is relatively free of invasive plant propagules (e.g., seed and viable meristematic tissue). Achievement of this objective combined with restoration of suitable soil/hydrologic conditions, will facilitate natural succession of the target habitats and inhibit invasive plant establishment. Therefore, invasive plant management measures should be incorporated into the soils preparation plan and earthwork design. Heavy equipment, such as bulldozers or excavators, could be used to mechanically remove infestations from the project site; however, eradication of perennial or woody species (e.g., giant reed [*Arundo donax*] and Himalayan blackberry [*Rubus armeniacus*]) using this technique is difficult because deep rhizomes and root fragments must be removed from the soil to prevent resprout (DiTomaso et al. 2013). Invasive plant material excavated from uplands should be buried in the bottom of the ponds. Existing invasive aquatic vegetation in the ponds (e.g., water primrose) should also be buried onsite well below the design grades.

The existing terrestrial topsoil in many locations likely has a substantial weed seed bank in the upper portion of the soil profile (e.g., upper 1–2 inches). Earthwork/clearing and grubbing should be designed to remove and bury the existing weed seed bank at least several feet below the design grade.

After grading is complete, invasive plants should be actively managed throughout the project site to allow native riparian and wetland vegetation to establish and exclude colonizing invasive plant species. An invasive plant management plan should be developed and implemented to prevent the introduction and spread of invasive plants, effectively track existing infestations, detect new infestations early, and provide effective control measures. Invasive plant management would not only reduce stressors to the project, but it is also essential to prevent the spread of invasive plants onto adjacent lands and the resultant habitat degradation associated with invasive plant infestations in those areas. Factors related to each infestation's location, density, extent, and proximity to sensitive biological resources will dictate management parameters and inform the choice of appropriate control methods.

3.5 Revegetation

The restored floodplain surface will be designed to establish the physical conditions (hydrology, topography and topsoil) to support the target habitat mosaic presented above. The restored fluvial hydrologic and geomorphic processes on the floodplain will facilitate the natural colonization of wind- and water-dispersed riparian-wetland plant species. The restored topsoil will initially be largely free of invasive plant propagules. However, invasive plant propagules will rapidly disperse to the site and have the potential to inhibit native plant establishment, degrade habitat quality, and compromise attainment of the project goals even if the abiotic template is properly set. Therefore, the revegetation strategy is to install native vegetation propagules in large quantities across the large-scale graded landscape to increase the rate of primary succession in favor of the target native plant communities to preempt substantial colonization and dominance by invasive weeds.

The project will implement standard revegetation methods such as direct seeding and installation of cuttings and container plants. It will also implement progressive, process-based revegetation methods developed by Dr. Peter Baye that mimic natural systems and facilitate native wetland and riparian vegetation colonization and establishment, including sod (rootmat) fragment translocation, vegetative sprigging, and livewood transplants (Baye 2020b, Appendix C). Table 2 lists the revegetation methods that would be used in each revegetation zone to restore the target habitats. Prior to construction, existing stands of native wet meadow and riparian species at the site will be mapped to understand the distribution and abundance of potential propagule sources and inform the implementation of these revegetation strategies. The revegetation methods will be used during Phase 1 of project construction and may be modified during subsequent construction phases depending on their relative success. In addition, supplemental revegetation in future years could be done to fill in areas that lack sufficient canopy and to introduce later successional riparian species.

Table 2. Revegetation Methods by Zone and Target Habitats

	Revegetation Zone—Target Habitats					
Revegetation Method	**Floodplain Seasonal Wet Meadow**	**Floodplain Aquatic Backwater Pool and Channel**	**Floodplain Freshwater Marsh**	**Lower Slope Riparian Scrub**	**Mid-Slope Riparian Forest**	**Upper Slope Upland Riparian Forest**
Seeding of herbaceous wetland species	X	X	X	X		
Seeding of herbaceous upland species					X	X
Seeding of acorns and California buckeye					X	X
Sod (rootmat) translocation[1]	X		X			
Vegetative sprigging[1]	X		X			
Cuttings				X		
Livewood transplants[1]				X	X	X
Container plants					X	X

[1] Restoration methods proposed and developed by Baye (2020b), Appendix C.

3.5.1 Seeding

All soil surfaces disturbed by earthwork will be drill seeded or hydroseeded with native herbaceous species from Central or Northern California ecotypes. Drill seeding is generally more effective than hydroseeding in soil and slope conditions conducive to drill seeding. The relatively flat floodplain and gentler bank slopes would be conducive to use of a seed drill where soils and not gravels are present, and hydroseeding would be best for any slopes that are 5H:1V or steeper. Two seed mixes will be applied at the site. One will be applied in more mesic (wetter) locations, such as the floodplain and lower slopes, and contain primarily wetland herbaceous plant species. The second seed mix will be used for more xeric (drier) areas, such as mid- and upper slopes, and upland areas, and contain primarily upland herbaceous species. Table 3 provides preliminary list of herbaceous species for the mesic and xeric seed mixes. In addition to herbaceous species, several native woody species will be established from seed on approximately 10–15% of the riparian forest and upland riparian forest revegetation zones, including coast live oak, black oak (*Quercus kelloggii*), valley oak, and California buckeye.

Table 3. Plant Species Palettes for Seeding Wetland and Riparian Habitats

Scientific Name	Common Name
Floodplain and Lower Slope Wetland Herbaceous Species Seed Mix	
Artemisia douglasiana	California mugwort
Bidens frondosa	Sticktight
Carex barbarae	Valley sedge
Cyperus eragrostis	Tall cyperus
Eleocharis macrostachya	Spike rush
Elymus triticoides	Beardless wild rye
Epilobium ciliatum	Slender willow herb
Hordeum brachyantherum	Meadow barley
Juncus balticus	Baltic rush
Persicaria punctata	Dotted smartweed
Mid- and Upper Slope Upland Herbaceous Species Seed Mix	
Amsinckia intermedia	Common fiddleneck
Amsinckia menziesii	Fiddleneck
Clarkia gracilis ssp. *sonomensis*	Sonoma clarkia
Elymus glaucus	Blue wildrye
Epilobium brachycarpum	Willow herb
Hemizonia congesta ssp. *leucocephala*	Hayfield tarweed
Hemizonia congesta ssp. *lutescens*	Hayfield tarweed
Lupinus bicolor	Bicolored lupine
Madia elegans	Common madia
Madia sativa	Coastal tarweed
Melica californica	California melic
Stipa pulchra	Purple needle grass

Note: Species list developed by Baye (2020b), Appendix C.

3.5.2 Sod (Rootmat) Translocation

Stands of native wet meadow species currently growing at the site will be salvaged and amplified at an onsite sod farm to increase the amount of native wet meadow sod that can be used for revegetation. The onsite sod farm will be located on graded benches at the Mariani pond where groundwater and irrigation are available. The sod fragments will be transplanted from the sod farm onto the floodplain seasonal wet meadow and freshwater marsh revegetation zones (Figure 3). Establishment success will be increased by transplanting large clumps of plant material on topographic positions with appropriate depths to groundwater (Steed and DeWald 2003). Salvaged material will be harvested in fall, and transplanted and grown on at the onsite sod farm. After one or two growing seasons, sod will be harvested from the sod farm and planted across the floodplain surface during each construction phase. At each planting location, a shallow, approximately 6 inches deep by 12-inch-diameter planting hole will be excavated, the soil will be loosened, and 12-inch diameter sod transplants will be placed and lightly compacted to ensure good soil contact. While we understand that larger sod transplants (e.g., 2–3 feet wide) would likely have a higher rate of vegetative spread, we have elected to go with 12-inch diameter sod transplants due to the substantial increase in cost associated with larger sod transplants at the large scale of this floodplain revegetation effort. Given the importance of rapid wet meadow establishment to achievement of the project's fish and vegetation community goals, a substantial portion of the floodplain should be actively revegetated with sod transplants (at least 50% of the floodplain area should be planted on 5–10-foot centers).

The sod farm will be sized to produce enough material to plant 12-inch-diameter sod transplants on 5–15-foot centers during each of the floodplain mass grading phases. This revegetation strategy will require substantial onsite mapping and ground-truthing of available sod sources and further development of the sod farm process during the detailed design phase. If sufficient quantities of sod are not available on the project site, additional material could be acquired from adjacent lands in the watershed or alternative methods could be used to establish seasonal wet meadow (e.g., vegetative sprigging or plugs). A preliminary list of species that could be established by sod translocation is provided in Table 4.

Table 4. Plant Species Palette for Sod Translocation and Vegetative Sprigging to Restore Seasonal Wet Meadow and Freshwater Marsh Habitats

Scientific Name	Common Name
Artemisia douglasiana	California mugwort
Bolboschoenus fluviatilis	River bulrush
Carex barbarae	Valley sedge
Eleocharis macrostachya	Spike rush
Elymus triticoides	Beardless wild rye
Euthamia occidentalis	Western goldenrod
Juncus balticus	Wire rush
Schoenoplectus acutus	Hardstem bulrush
Schoenoplectus californicus	California bulrush
Scirpus microcarpus	Small fruited bulrush

3.5.3 Vegetative Sprigging

Herbaceous perennial plant species that reproduce vegetatively, including species listed in Table 4, will be established by planting sprigs. A sprig is defined here as a small section (2–4-inch long) cut from vegetatively reproductive stolons, rhizomes, and root crowns sourced from dormant plants. Sprigs will be sourced from materials used for sod translocation; broadcast across a small portion (e.g., 10%) of the floodplain revegetation zones (Figure 3); covered with a thin topsoil layer (~1 inch) to reduce desiccation; and lightly compacted to ensure good soil contact. We anticipate that this method will be relatively costly compared to sod translocation due to the necessity to spread a topsoil layer over the sprigs. Therefore, we recommend use of this method in a smaller surface area of the floodplain, relative to sod translocation, as an experimental comparison with sod translocation. Alternatively, sprigging could be deleted as a methodology, and the surface area of floodplain coverage by sod translocation could be increased.

3.5.4 Cuttings

Fremont cottonwood and willow cuttings harvested from existing stands on site, or from as close to the project site as possible, will be installed on portions of the lower slope revegetation zone to restore riparian scrub habitat (Figures 3 and 4). Cuttings will be harvested and installed in January or February while the plants are completely dormant and after rainfall and/or flood flows have saturated the soils. Cuttings will be planted on approximately 10–12-foot centers. Harvest and installation of cuttings is a relatively low cost revegetation method. Therefore, this method will be employed within a substantial proportion of the riparian scrub habitat (e.g., at least 50%).

3.5.5 Livewood Transplants

Native riparian trees and shrubs of stump- and root-sprouting species will be excavated or grubbed from existing stands on site and shallowly buried/planted on portions of the lower, mid-, and upper slope revegetation zones to restore riparian scrub, riparian forest, and upland riparian forest. The trees and shrubs will be harvested from onsite while they are dormant and their branches will be heavily pruned to increase root growth. The trees and shrubs will be installed on 16–20 foot centers. They will be prioritized for the lower and mid-slope revegetation zones where water availability will be greater than, and the need for supplemental irrigation will be less than, the upper slope revegetation zone. Table 5 provides a preliminary list of tree and shrub species that may be used as livewood transplants within each revegetation zone. We anticipate that this method will be relatively costly to construct and that source material will be somewhat limited onsite. However, this method has the advantage of providing for rapid plant establishment on the drier mid- to upper slopes without the cost of irrigation. Therefore, we recommend that this method be used in a relatively small proportion of the riparian restoration areas (~10% of each riparian revegetation zone).

Table 5. Livewood Transplant Species Palette for Riparian Scrub, Riparian Forest, and Upland Riparian Forest

		Revegetation Zone—Target Habitats		
Scientific Name	**Common Name**	**Lower Slope Riparian Scrub**	**Mid-Slope Riparian Forest**	**Upper Slope Upland Riparian Forest**
Acer negundo	Box elder		X	
Aesculus californicus	California buckeye		X	X
Alnus rhombifolia	White alder	X		

		Revegetation Zone—Target Habitats		
Scientific Name	**Common Name**	**Lower Slope Riparian Scrub**	**Mid-Slope Riparian Forest**	**Upper Slope Upland Riparian Forest**
Arbutus menziesii	Pacific madrone		X	X
Calycanthus occidentalis	Spicebush		X	
Cornus sericea	American dogwood		X	
Populus fremontii	Fremont cottonwood	X	X	
Quercus agrifolia	Coast live oak			X
Rhododendron occidentale	Western azalea		X	
Salix exigua	Narrowleaf willow	X		
Salix laevigata	Red willow	X	X	
Salix lasiolepis	Arroyo willow	X	X	
Umbellularia californica	California bay		X	X
Vitis californica	California grape		X	

Note: species list developed by Baye (2020b), Appendix C.

3.5.6 Container Plants

To supplement a potential deficit of onsite livewood plant material, nursery-grown container trees and shrubs will be installed on portions of the mid- and upper slope revegetation zones to restore riparian forest and upland riparian forest. Species found lower on floodplains in dense riparian forests, such as Fremont cottonwood, willows (only in lower portion of mid-slope), Oregon ash, and California blackberry, will be planted in the mid-slope revegetation zone (Figures 3 and 4). Species more commonly found on drier and higher floodplains, such as oaks, box elder, and blue elderberry, will be planted on the upper slope. On average, trees will be planted on 16–20-foot centers, and shrubs will be planted on 8–12-foot centers. Table 6 provides a preliminary list of species that may be used as container plants within the mid- and upper slope revegetation zone. Percent composition and species-specific spacing will be determined at a later, more detailed design phase. This method is relatively costly, compared to direct installation of cuttings (stakes). However, use of container plants is recommended as a primary method for the mid- and upper slopes (riparian forest and upland riparian forest) because the summer groundwater table will likely be too deep in most of the mid- and upper slope zones for establishment of species that can be readily established via direct cuttings (e.g. willows). At least 10–20% of the mid- and upper slope zones should be revegetated with container plants. The low percentage is driven solely by the relatively high cost to actively revegetate the entire mid- to upper slope with container plants. If ample funding is available, we recommend increasing the percent coverage of these zone with container plantings.

Table 6. Container Plant Species Palette for Riparian Forest and Upland Riparian Forest

Scientific Name	Common Name
Acer negundo	Box elder
Aesculus californica	California buckeye
Baccharis pilularis	Coyote brush
Fraxinus latifolia	Oregon ash
Juglans hindsii	Northern California black walnut
Populus fremontii	Fremont cottonwood
Quercus agrifolia	Coast live oak
Quercus kelloggii	Black oak
Quercus lobata	Valley oak
Rosa californica	California wild rose
Rubus ursinus	California blackberry
Salix laevigata	Red willow
Salix lasiolepis	Arroyo willow
Sambucus nigra	Blue elderberry
Umbellularia californica	California bay laurel

3.5.7 Plant Procurement

To maintain local genetic diversity and integrity and provide seed well adapted to local site conditions, all seed for the herbaceous species seed mixes should originate from Northern California counties, preferably from Sonoma County, or from neighboring counties. Seed will be tested by the seed supplier for percent purity, percent germination, number of pure live seeds per pound, and weed content. All plant propagules for use as sprigs, sod fragments, livewood transplants, cuttings, and container stock, California buckeye seeds and oak acorns will be collected on site or in the Russian River watershed from locations with soils, elevations, and hydrology that are similar to the project site. If an adequate number of plant propagules are unavailable to collect from within the project site or Russian River watershed, then they will be obtained from areas in Sonoma County or neighboring counties that exhibit environmental conditions similar to those found at the project site.

A nursery contract will need to be established at least 12 months prior to the time of container plant installation for each phase of construction to allow sufficient time to collect propagules and ensure they have sufficient growing time in the nursery prior to installation at the mitigation site. Nursery inspections will be conducted by a qualified restoration ecologist to ensure propagules will be ready for installation and to make any necessary species substitutions (e.g., if the nursery is unable to successfully propagate certain species).

To the extent feasible, all propagules will be sourced from healthy plant material to reduce the potential for the spread of plant pathogens such as *Phytophthora* species. Container stock will be grown in accordance with established *Phytophthora* prevention best management practices (BMPs) to prevent the introduction of infested plant material and soil at the mitigation sites. The California Oak Mortality Task Force provides a set of applicable guidelines to minimize *Phytophthora* pathogens in restoration nurseries and restoration projects (Working Group for Phytophthoras in Native Habitats 2016a, 2016b).

3.6 Incorporation of Habitat Features

Habitat features, such as large woody debris, standing snags, and boulders could be incorporated into the design. These physical structures provide habitat complexity for aquatic macroinvertebrates and fish (Roni et al. 2008), shelter for amphibians, and roosting habitat for birds. Large wood structures could be constructed from woody material salvaged during mass grading where feasible. Coarse woody debris piles could be strategically placed on bank slopes and upland areas to improve habitat values and long-term soil development.

3.7 Conceptual Vegetation Maintenance Plan

The project will excavate and/or fill the entire site thereby generating a large acreage of disturbed, unvegetated topsoil that will be vulnerable to rapid colonization by invasive plant species. Invasive plant propagules will rapidly disperse to the site from adjacent populations and have the potential to rapidly colonize and inhibit native plant establishment, degrade habitat quality, and compromise attainment of the project's vegetation community and fish ecology goals. Vegetation maintenance will be integral to facilitating primary succession in favor of the target native plant communities to preempt substantial colonization and dominance by invasive weeds. Therefore, a vegetation maintenance plan will be developed and implemented to ensure the highest likelihood of successful habitat establishment. Each phase of the project site will be maintained by a qualified restoration site maintenance contractor for 3–5 years following installation (plant establishment period). Because the project will be implemented in three phases over a 3-year period, vegetation maintenance will occur for up to 7 years at the site. Maintenance needs may include dead plant replacement, irrigation, weed control, plant protection, and debris removal. However, the proposed revegetation and maintenance will be designed so that minimal and infrequent maintenance will be required in the long-term. Monitoring data collected by a restoration ecologist will be used to evaluate and provide feedback to guide maintenance and help ensure that the site achieves the project's vegetation community goal. All maintenance activities will be conducted in accordance with established *Phytophthora* prevention BMPs to minimize risk of introducing *Phytophthora* at the project site. The California Oak Mortality Task Force provides a detailed set of applicable guidelines (Working Group for Phytophthoras in Native Habitats 2016b).

3.7.1 Dead Plant Replacement

If recommended by the monitoring ecologist, dead plants will be replaced at the end of each of the first two growing seasons following plant installation. Those species that are well adapted to the project site and have demonstrated high health and vigor will generally be used to replace dead plants in each revegetation zone.

3.7.2 Irrigation

Irrigation should not be required to establish the target vegetation in the floodplain and lower slope revegetation zones assuming that vegetation is installed during the wet season and that summer groundwater is in accordance with predictions for these habitats provided in Section 2. However, we recommend that supplemental irrigation (during the first 3 growing seasons) be provided to facilitate establishment of woody seedlings from nursery grown container stock (and acorns, buckeye seed) in the mid-slope (riparian forest) and upper slope (upland riparian forest) revegetation zones. We recommend irrigation in these zones due to the projected depth to the seasonal groundwater table (approximately 9–18 or more feet), and because we anticipate there will not be a sufficient amount of livewood available to adequately revegetate these zones. The irrigation method will be determined in future design phases, and may include a combination of irrigation systems and hand watering.

3.7.3 Invasive Plant Control

Invasive plants can significantly impair the quality of restored habitats at the project site, and immediately surrounding upland areas, and therefore will need to be monitored and controlled. A monitoring biologist will determine whether weed control is needed. In general, weeds that are considered to be "noxious" by the California Department of Food and Agriculture's Integrated Pest Control Branch (CDFA 2020), or are rated "high" by the California Invasive Plant Council (Cal-IPC 2020), should be controlled. Other weed species should be controlled if the monitoring biologist determines that they threaten the success of the restored habitats. A detailed weed control plan will be developed in future design phases. The weed control plan will emphasize manual control methods where feasible and cost-effective and minimize use of herbicide.

3.7.4 Plant Protection

Measures will be taken to protect native woody plant species and, to a lesser extent, native herbaceous plant species that establish through natural recruitment. At a minimum, these species will be identified and flagged prior to and during maintenance activities so that maintenance activities do not damage natural recruits. Plant protection cages are not proposed because animal browse is not expected to be severe and the quantity of cages would substantially increase revegetation cost. If herbivory significantly impedes restoration success, plant protection cages will be installed and maintained in good working order (upright and secure) on susceptible species.

3.7.5 Trash and Debris Removal

Trash and other unnatural debris will be removed from the project site during scheduled maintenance visits. All removed material will be disposed of properly.

3.7.6 Schedule

The restoration plantings will need to be maintained up to four times per month during the growing season (March to October) and approximately once per month from November to February during the 3–5-year plant establishment period for each phase of construction.

Section 4.0 Rough Order of Magnitude Revegetation Cost Estimate

The following is H. T. Harvey's rough order of magnitude cost estimate for revegetation based upon this 30% design report. The range of cost provided is commensurate with the conceptual level of design at this point in the design process. The 30% revegetation design calls for revegetation of approximately 345 acres of wetland-riparian habitat (Figure 3). Our opinion of the probable revegetation cost is \$3.5–7.0 million (~\$10–20K/acre). This estimate is on the very low end of typical per acre riparian habitat revegetation costs due to assumed economy of scale for this large-scale project, cost-saving revegetation methods described above, and the assumption that only 30–60% of the site would be actively revegetated with vegetative propagules (i.e., wetland sod transplants, cuttings, container plants, acorns/buckeye seed, and livewood transplants). However, given the likelihood of intense and rapid weed invasion pressure following earthwork/soil disturbance and hydroseeding (or drill seeding), the project team should strive to actively revegetate (with vegetative propagules) as much of the site as possible given funding availability.

This estimate includes hydroseeding (or drill seeding) the entire site, plant salvage, propagation and installation, irrigation system installation (for the mid-slope and upper slope zones), and 3 years of post-construction vegetation maintenance during each phase, or a total of 7 years. This estimate does not include the cost of earthwork activities related to revegetation such as invasive plant removal during clearing and grubbing, topsoil salvage/reuse, or incorporation of fish habitat features (e.g., large wood structures).

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Appendix A. Existing Biotic Habitat Conditions and Ecological Restoration Opportunities and Constraints

H. T. HARVEY & ASSOCIATES
Ecological Consultants

Memorandum

Project 4180-01

February 13, 2019

To: Michael Bowen, Program Manager, California Coastal Conservancy
Nancy Schaefer, Land Conservation Services, Consultant to Endangered Habitats Conservancy

From: Max Busnardo, M.S., Principal, Restoration Ecologist
Max Busnardo

Subject: **Hanson Russian River Floodplain Restoration—Existing Biotic Habitat Conditions and Ecological Restoration Opportunities and Constraints**

Introduction and Purpose

This memorandum conveys the results of H. T. Harvey & Associates' (H. T. Harvey) ecological restoration opportunities and constraints assessment for the Hanson Russian River Floodplain Restoration Project (project). The purpose of the assessment was to characterize existing biotic habitat conditions and identify constraints and opportunities that will affect restoration design and permitting for the project. In accordance with our scope of work, this assessment is focused on biotic and regulated habitats, invasive plants, and salmonids.

The 356-acre project site is located next to the Russian River, approximately 1 mile west of Windsor, Sonoma County, California. Channel excavation, straightening, and levee construction have caused the river to become deeply incised and disconnected from its historical floodplain. The project site consists of a well vegetated levee, a broad floodplain disconnected from the river by the levee, and four retired gravel ponds (from north to south: Mariani, Piombo, Richardson, and Vimark). The ponds impact riparian ecosystem functions in numerous ways including the following. They support nonnative predatory fish, lack spawning gravel habitat for native fish, substantially reduce woody riparian vegetation cover, and degrade water quality in the river ecosystem by elevating water temperatures, accumulating toxic levels of methylmercury, and amassing nutrients (i.e., creating eutrophic conditions) (Endangered Habitats Conservancy [EHC] 2016). Unstable banks and levees separate the ponds from the river. The primary goal of the project is to re-establish a stable seasonal river-floodplain interface and restore essential ecological processes and functions that sustain off-channel aquatic, wetland, riparian, and upland habitats that are crucial for recovery of listed steelhead (*Oncorhynchus mykiss*), Coho (*Oncorhynchus kisutch*), and Chinook salmon (*Oncorhynchus tshawytscha*) (EHC 2016). This goal will be accomplished by mass grading to remove the levee, fill the ponds, and restore floodplain connectivity with the Russian River.

Existing Biotic Habitat Conditions and Constraints to Restoration Design

Methods

On November 15 and 16, 2018, H. T. Harvey's restoration ecologists Charles McClain, M.S., and Max Busnardo, M.S., and fish ecologist Sharon Kramer, Ph.D., conducted a reconnaissance-level field survey at the project site to characterize existing biotic and fish habitats and gather information to facilitate identification of riparian and wetland restoration opportunities and constraints. The restoration ecologists recorded the dominant plant species and mapped the spatial distribution of biotic habitats, with a focus on sensitive and regulated habitats (e.g., riparian, wetland, and aquatic). Vegetation alliances were characterized using nomenclature from *A Manual of California Vegetation* (Sawyer et al. 2009). Because the survey was conducted during winter, when most riparian and wetland plant species have senesced and gone dormant, the results of rare plant surveys conducted on May 5 and August 30, 2018, were used to help determine species composition within each biotic habitat (Gerwein 2018). In addition to mapping biotic habitats, the restoration ecologists mapped the point locations of substantial patches of invasive plant species that could pose a constraint to the restoration of native riparian and wetland habitats; however, our scope did not include thorough mapping of all invasive plant patches. For the purpose of the study, we define invasive plants species as species with a moderate or high invasiveness rating by the California Invasive Plant Council, or species that in our professional judgement pose a risk to achievement of the project's habitat goals.

H. T. Harvey's restoration ecologists also conducted a reconnaissance-level survey of the project site for wetlands and other waters potentially subject to regulation under Section 404 of the Clean Water Act (CWA) as administered by the U.S. Army Corps of Engineers (USACE). A formal wetland delineation was not conducted. They estimated the approximate extent of waters of the state and riparian habitat that may be subject to regulation by the Regional Water Quality Control Board (RWQCB) under Section 401 of the CWA and the Porter-Cologne Water Quality Control Act. The ecologists also evaluated the rough extent of riparian habitat that is likely subject to regulation under Section 1600 of the California Fish and Game Code, as administered by the California Department of Fish and Wildlife (CDFW). Although a formal delineation of potentially regulated habitats was not performed during the reconnaissance-level site visit, the approximate extents of these areas are shown in Figure 1.

The results of the surveys are summarized below.

Biotic Habitats

Eight vegetation alliances were identified on the project site. Figure 1 shows their extent and the distribution of other land cover types present (disturbed, disturbed shrub/grassland, open water, and stratified deep water). Each vegetation alliance is described below.

Coyote brush scrub. Coyote brush (*Baccharis pilularis*) scrub is common on stream sides and terraces with sandy to clay soils (Sawyer et al. 2009). At the project site, coyote brush scrub is located on the upland terrace east of Piombo and Mariana and northeast and southwest of Richardson. Coyote brush is dominant in the shrub canopy, which ranges from sparse to dense, and the tree canopy is absent. The herbaceous layer is variable, consisting of nonnative annual grass and forbs.

Fremont cottonwood forest. Fremont cottonwood (*Populus fremontii*) forest is common on floodplains along low-gradient rivers and in valleys with a dependable shallow groundwater supply (Sawyer et al. 2009). At the project site, Fremont cottonwood forest occurs along the toe of the banks surrounding each pond. Fremont cottonwood is dominant in the tree canopy, which is continuous to open. The shrub layer varies from dense to open in structure, and is dominated by arroyo willow (*Salix lasiolepis*), sandbar willow (*Salix exigua*), and red willow (*Salix laevigata*). Most of the Fremont cottonwood forest at the project site was planted after the ponds were constructed and is of a relatively young age (approximately 10–20 years) (McEnhill pers. comm. 2018).

Pondweed mats. Pondweed (*Potamogeton* spp.) mats are common in seasonally or permanently flooded freshwater ponds and lakes, and provide forage for waterfowl (Sawyer et al. 2009). At the project site, pondweed mats form a homogenous layer at or below the water surface on the southern portion of the Mariani pond. Pondweed is a perennial aquatic herb. Native and nonnative pondweed species occur in Sonoma County; however, pondweed at the project site has not been identified to species (Gerwein 2018).

Sandbar willow thickets. Sandbar willow thickets are common on temporarily flooded floodplains along rivers and streams (Sawyer et al. 2009). At the project site, they occur on a gravel bar at the southern end of the site. Sandbar willow is the dominant species in the shrub canopy, which is intermittent to continuous, and arroyo willow is also present. The herbaceous layer is sparse and consists primarily of nonnative herbs.

Smartweed-cocklebur patches. Smartweed-cocklebur (*Polygonum lapathifolium-Xanthium strumarium*) patches are common in marshes, regularly-disturbed vernally wet ponds, fields, and stream terraces on clay-rich or silty soils (Sawyer et al. 2009). At the project site, they occur on the east side of the Richardson pond. Rough cocklebur is dominant in the herbaceous layer and forms dense, continuous patches. Tree and shrub layers are absent.

Valley oak woodland. Valley oak (*Quercus lobata*) woodland is common in valley bottoms on seasonally saturated alluvial soils that may intermittently flood (Sawyer et al. 2009). At the project site, it occurs north and east of the Mariana pond; north, west, and southeast of the Richardson pond; and along nearly the entire perimeter of the Vimark pond. Valley oak is dominant in the tree canopy, which is open to continuous, and occurs with coast live oak (*Quercus agrifolia*) and Hinds' walnut (*Juglans hindsii* and hybrids). Coyote brush is dominant in the open to intermittent shrub layer. The herbaceous layer is grassy, dominated by nonnative annual grasses and forbs with occasional stands of purple needle grass (*Stipa pulchra*). Most of the valley oak woodland at the project site was planted after the ponds were constructed and is of a relatively young age (approximately 10–20 years) (McEnhill pers. comm. 2018). Further investigation is required during the permitting phase of the project to determine if the planted areas are permit-driven mitigation sites.

Walnut-dominated riparian forest (Hinds' walnut and related stands). Walnut-dominated riparian forest is common along intermittently flooded riparian corridors, floodplains, streambanks and terraces with alluvial soils

(Sawyer et al. 2009). Naturalized populations of Hinds' walnut, such as the ones that occur on the project site, are thought to have hybridized with other black walnut taxa that were introduced to northern California for horticultural purposes (Kirk 2003). Walnut-dominated riparian forest is the most common vegetation alliance on the project site; it occurs as an expansive and variable forest across the levee and floodplain between the ponds and the Russian River. The community is dominated by Hinds' walnut and several other tree species, with red willow and box elder (*Acer negundo*) being the most common. The tree canopy is relatively continuous. The shrub layer varies from dense to open in structure, and was dominated by native species including poison oak (*Toxicodendron diversilobum*), blue elderberry (*Sambucus nigra* ssp. *caerulea*), common snowberry (*Symphoricarpos albus*), California blackberry (*Rubus ursinus*), and California rose (*Rosa californica*). Giant reed (*Arundo donax*) and Himalayan blackberry (*Rubus armeniacus*), both invasive species, are patchily distributed in the understory. Vines are common, including California grape (*Vitis californica*), California manroot (*Marah fabacea*), and California pipevine (*Aristolochia californica*). The herb layer is sparse in most areas and is dominated by nonnative grasses and herbs (e.g., Bermuda grass [*Cynodon dactylon*], common periwinkle [*Vinca minor*], black mustard [*Brassica nigra*] and radish [*Raphanus sativa*]). Stands of native valley sedge (*Carex barbarae*) are dense and expansive in a few areas

Water primrose wetlands. Water primrose wetlands occur on permanently and seasonally flooded freshwater habitats with still water or on ground surfaces after water levels have dropped (Sawyer et al. 2009). At the project site, they occur along the north edge of Mariani pond, on the east edge of Piombo pond, along nearly the entire perimeter of Richardson pond, and on the northwest edge of Vimark pond. Six petal water primrose (*Ludwigia hexapetala*) is dominant as an invasive, nonnative emergent or floating perennial herb; it forms dense, continuous mats.

Potentially Regulated Habitats

Waters of the United States

Approximately 160 acres of the project site may meet the physical criteria and regulatory definition of "waters of the United States (jurisdictional waters)" under Sections 404 of the CWA as administered by the USACE. These areas include all four ponds, a drainage that connects the Piombo pond to the river, a drainage that connects the Richardson pond to the river, the river side of the levee (below the ordinary high water mark), and a seasonal wetland in the northwest corner of the project site.

Waters of the State

Approximately 259 acres of the project site may be subject to regulation under the Porter-Cologne Water Quality Control Act administered by the RWQCB. These areas exceed the boundaries of potential waters of the United States to encompass the canopy of trees that are rooted on the river side of the levee and on the slopes of the ponds.

California Department of Fish and Wildlife Jurisdiction

Approximately 329 acres of the project site may be subject to regulation under Section 1600 of the California Fish and Game Code administered by CDFW. This acreage includes all areas below the 100-year floodplain. We derived the approximate footprint of the 100-year floodplain on the project site from the following source: County of Sonoma (2018).

Invasive Plants

Five invasive plant species are prominent on the project site and pose substantial constraints to establishment of the target native-dominated riparian and wetland habitats: giant reed, six petal water primrose, Himalayan blackberry, scarlet wisteria (*Sesbania punicea*), and common periwinkle (Table 1) (Figure 2). The giant reed stands are predominantly located in the walnut-dominated riparian forest. Six petal water primrose almost completely surrounds the Richardson pond, and also occurs along the perimeters of the other three ponds. Himalayan blackberry and common periwinkle are common in the walnut-dominated riparian forest. Himalayan blackberry is also frequent along the eastern boundary of the project site in Fremont cottonwood forest and valley oak woodland. Scarlet wisteria is abundant along the northern waterline of the Richardson pond, and occurs as scattered populations along the remainder of the pond's perimeter.

Other invasive plant species occur as relatively small stands or scattered individuals on the project site and not all of these species were mapped during our field work. They include poison hemlock (*Conium maculatum*), stinkwort (*Dittrichia graveolens*), blue gum (*Eucalyptus globulus*), sweet fennel (*Foeniculum vulgare*), black mustard, and radish.

Table 1. Invasive Plant Species

Common Name	Scientific Name	Growth Form	Cal-IPC Rating[1]
Blue gum	*Eucalyptus globulus*	Tree	Limited
Common periwinkle	*Vinca minor*	Perennial herb	None
Giant reed	*Arundo donax*	Perennial grass	High
Himalayan blackberry	*Rubus armeniacus*	Shrub	High
Poison hemlock	*Conium maculatum*	Perennial herb	Moderate
Scarlet wisteria	*Sesbania punicea*	Shrub	High
Six petal water primrose	*Ludwigia hexapetala*	Perennial herb	High
Stinkwort	*Dittrichia graveolens*	Annual herb	Moderate
Sweet fennel	*Foeniculum vulgare*	Perennial herb	High

[1] Cal-IPC = California Invasive Plant Council. Cal-IPC ratings refer to the level of negative ecological impact presented by the species. See Cal-IPC (2018) for additional details on these ratings and for management recommendations.

Overview of Target Biotic Habitats

The vegetation community goal in the project's feasibility study and conceptual design is to restore native-dominated riparian habitats by restoring the natural plant community gradient from emergent/seasonal wet meadow and scrub shrub/riparian forest wetland, to mature seral stage upland riparian forest (EHC 2016). Based on habitat compositions typical of the region and what is currently growing on the site, numerous vegetation alliances could be established to increase ecological functions and overall habitat complexity (e.g., number of co-dominant species and plant layers, degree of overlap among plant layers, and variety and interspersion of plant zones). Vegetation alliances that could be established on the restored floodplain and upland slope habitats are summarized below.

Restored Floodplain Habitats

The project's goals and design are intended to 1) decrease or remove habitat for nonnative salmonid predator populations, and 2) promote habitat conditions that support native salmonid populations and improve floodplain riparian habitat quality and quantity. Removal of existing ponded habitat will eliminate habitat for nonnative predators of juvenile salmonids. On the Russian River, a lack of floodplain habitat hydrologically connected to the river's low flow channel limits salmonid populations (EHC 2016). Floodplain habitat provides essential salmonid winter rearing habitat that supports fry and rearing juvenile growth, so that juveniles can reach larger threshold sizes for improved marine survival. Optimum winter rearing habitat includes broad, off-channel floodplains where flood energy is dissipated into low velocity habitat that is warmed by being shallow, is food rich, and comprises a large area with complex cover.

The restored floodplain surface will be designed to support hydrologic and geomorphic processes that facilitate the natural colonization of wind- and water-dispersed native riparian-wetland obligate plant species. These species and other native plants that may not readily colonize the site on their own could be actively revegetated to accelerate riparian habitat establishment. Restored emergent/seasonal wet meadows in constructed floodplain backwaters could support hardstem and California bulrush (*Schoenoplectus* [*acutus, californicus*]) marshes, pale spike rush (*Eleocharis macrostachya*) marshes, dense sedge (*Carex densa*) marshes, Baltic and Mexican rush (*Juncus arcticus* [var. *balticus, mexicanus*]) marshes, valley sedge (*Carex barbarae*) beds, and meadow barley (*Hordeum brachyantherum*) patches. The surrounding scrub shrub/riparian forest wetland could support white alder (*Alnus rhombifolia*) groves, sandbar willow thickets, red willow thickets, mulefat (*Baccharis salicifolia*) thickets, Fremont cottonwood forest, and box elder forest.

Restored Upland Slope Habitat

The upland slope habitat would be actively restored by planting and maintaining (for a 3–5 year establishment period) native riparian woodland tree, shrub, and herbaceous species. Restored upland slope habitat could support valley oak woodland and coast live oak woodland, which could include Oregon ash (*Fraxinus latifolia*) groves, California buckeye (*Aesculus californica*) groves, blue elderberry patches, coyote brush scrub, and California rose patches.

Ecological Restoration Design Considerations to Achieve Target Habitats

The purpose of this section is to identify key ecological design considerations to attain the desired habitats and maximize ecosystem benefits and habitat for native fish and wildlife species. Achievement of the below design considerations will require close collaboration on the design team to successfully integrate the disciplines of hydrology and engineering with restoration ecology, soil science, fish/wildlife ecology, and landscape architecture.

Biotic Resource Avoidance and Minimization

Reduce or Minimize Impacts on Riparian Forest. The current conceptual grading plan for the preferred alternative (Scenario II-E) balances the volume of cut-and-fill on the project site to reduce the cost of earthwork; import of large volumes of soil to fill the ponds would dramatically increase costs. However, the current preferred concept would remove the vast majority of walnut-dominated riparian forest. While this riparian forest is relatively young (e.g., ~5–6 decades) and established on a human-made levee, it nonetheless provides moderate to high riparian and wildlife functions and is a regulated habitat. Therefore, we recommend that the team explore design modifications to achieve a cut-fill balance while preserving a greater proportion of this habitat type along the river. For example, the grading design could be modified to reduce the slope angle on the east side of the project site, thereby reducing the volume of cut/fill and preserving some high quality riparian forest habitat along the river. For larger trees that cannot be preserved or transplanted, their trunks and branches should be harvested to create coarse woody debris piles on the floodplains and banks, assuming this reuse would not pose flood hazards downstream.

Minimize Impacts on Sensitive Wildlife. Activities associated with implementation of the proposed project (e.g., vegetation removal using heavy equipment, mass grading, noise and vibrations caused by heavy equipment, and the presence of workers) may have the potential to adversely affect sensitive wildlife species and may, therefore, be subject to various California or federal regulations and their requirements. Appropriate minimization and avoidance measures (e.g., observation of seasonal work restriction windows, establishment of protective "no entry" buffers around sensitive resources, on-site biological monitors) should be taken to minimize impacts on sensitive wildlife.

Our understanding is that Avocet Research Associates is on the consultant team to provide design guidance on sensitive wildlife issues.

Salmonid Habitat Considerations

One of the project goals for salmonid habitat includes an objective to restore spawning gravel deposits that will support salmonid spawning in the adjacent river channel, within 1 year. Models predict that suitable spawning habitat could be formed at the upper floodplain inlet (EHC 2016); spawning habitat in this reach of the river under current conditions is limited, in part due to high velocities and depths, and therefore high sediment transport resulting in gravel coarsening. Models indicate the floodplain inlet should form a delta, resulting in cycles of deposition and sediment reworking during passing floods that should be of appropriate grain size, velocity and depth to support salmonid spawning (EHC 2016). However, the amount and consistency of spawning habitat is uncertain; whether the habitat will support spawning for all salmonids is not known. Chinook salmon require larger spawning gravel and habitat patch sizes than coho salmon or steelhead (Kondolf 2000), so design considerations should factor in inlet channel width and gradient, or potential roughness elements, that would promote spawning habitat creation (Roni et al. 2008).

Design considerations should also minimize the likelihood of stranding of juvenile salmonids on the floodplain. Grading the floodplain should minimize low ponded areas without connection to the mainstem, where juveniles could become stranded when flood waters recede.

Floodplain Design Grades and Groundwater Hydrology

Willow and cottonwood depend on perennial, shallow groundwater for their water supply; whereas plant species typical of mixed riparian forest and valley oak riparian habitats tolerate drier conditions (Table 2). Therefore, the design team should assess the approximate depth to late summer groundwater across the project site. The project's restoration ecologist and design engineer should then utilize the groundwater depth information to refine the floodplain design grades to further support hydrologic and geomorphic processes that favor passive colonization of target floodplain habitats (e.g., a mosaic of willow/cottonwood riparian and wet meadow habitats).

Table 2. Hydrologic and Soil/Substrate Tolerances of Riparian Habitats

Habitat	Depth to Groundwater	Annual Flooding Duration	Flood Frequency	Soil Texture
Willow scrub	5–10 feet	20–50%	Each year	Gravel to sandy loam
Cottonwood riparian forest	5–20 feet	5–20%	1–3 years	Sand to sandy loam
Mixed riparian forest	20 feet or more[1]	0.1–5%	3–5 years	Sandy loam to silt
Valley oak riparian	20 feet or more[1]	0.1%	>5 years	Silt to clay loam

Source: TNC 1998, Griggs 2009

[1] Species typical of mixed riparian forest and valley oak riparian habitats do not require a water table (Griggs 2009)

Soil/Substrate Suitability for Establishment of Target Habitats

The project's grading plan should be crafted to create soil conditions well-suited for establishment of the target habitats both on the floodplain and slopes. This is a key aspect of the design to increase the likelihood of target habitat establishment and reduce the potential for invasive weed dominance and associated vegetation maintenance costs. For example, willow/cottonwood riparian habitat requires a contiguous vertical profile of well-drained coarse sediments with low compaction, from the surface to the shallow groundwater table (Table 2). In contrast, wet meadow habitat on floodplains tends to occur in finer textured topsoils within topographic depressions. The design of soil conditions tailored to the target habitats will require close collaboration between a soils restoration ecologist and the project engineer. A soils restoration ecologist should carefully review existing soils information, determine if additional field soils investigation is needed, prepare a conceptual soils preparation plan, and collaborate with the project engineer to integrate soils preparation processes into the grading plan.

Invasive Plant Management

Invasive plants are major stressors on ecosystem processes, habitats, and species that are the focus the project. Because the project will excavate and/or fill the entire site, there is a valuable opportunity during the earthwork process to restore a topsoil substrate that is relatively free of invasive plant propagules. Achievement of this objective combined with restoration of suitable soil/hydrologic conditions, will facilitate natural succession of the target habitats and inhibit invasive plant establishment. Therefore, invasive plant management measures could be incorporated into the conceptual soils preparation plan and earthwork design. Heavy equipment, such as bulldozers or backhoes, could be used to mechanically remove infestations from the project site; however, eradication of perennial or woody species (e.g., giant reed and Himalayan blackberry) using this technique is difficult because deep rhizomes and root fragments must be removed from the soil to prevent resprout (DiTomaso et al. 2013). Invasive plant material excavated from uplands should be placed and buried in the bottom of the ponds and existing invasive aquatic vegetation in the ponds (e.g., six petal water primrose) should be buried.

After mass grading is complete, invasive plants should be actively managed throughout the project site to allow native riparian and wetland vegetation to establish and exclude colonizing invasive plant species. A invasive plant management plan should be developed and implemented to prevent the introduction and spread of invasive plants, effectively track existing infestations, detect new infestations early, and provided effective control measures. Invasive plant management would not only reduce stressors to the project, but it is also essential to prevent the spread of invasive plants onto adjacent lands and the resultant habitat degradation associated with invasive plant infestations in those areas. Contributing factors related to each infestation's location, density, extent, and proximity to sensitive biological resources will dictate management parameters and inform the choice of appropriate control methods.

Revegetation

By restoring floodplain connectivity and reducing the depth to groundwater, the proposed grading will provide an excellent opportunity to establish high-quality wetland and riparian habitats that are dominated by locally-appropriate, native species. The revegetation approach should involve establishing native tree, shrub, and herbaceous species to maximize fish and wildlife habitat values and the structural diversity of the restored habitats.

Due to the large surface area of the floodplain and associated costs of active revegetation, the primary strategy for establishment of native woody obligate riparian habitat on the restored floodplain should be passive, natural recruitment. As stated above, this strategy requires creating suitable abiotic floodplain conditions that facilitate rapid natural recruitment of wind- and water-dispersed native riparian-wetland obligate species (Table 2). The rate of natural recruitment of willow, cottonwood, and mulefat could be increased at low cost via harvest and installation of cuttings in strategic locations. Stands of native wet meadow species (e.g., willows, sedges, rushes, and grasses) could potentially be salvaged, stored, and transplanted on the graded floodplain using heavy equipment. Successful establishment would be increased by transplanting large intact clumps of plant material that is matched with appropriate topographic positions and depths to groundwater (Steed and DeWald 2003). In addition to transplanting, the design should consider cost effective methods that utilize heavy equipment to spread and partially bury rhizome masses of wet meadow species in the constructed backwaters of the floodplain. Existing stands of native wet meadow species should be mapped before construction to inform the implementation of these revegetation strategies. Herbaceous vegetation could be actively established by drill seeding or hydroseeding depending upon the specific area. Drill seeding is generally more effective than hydroseeding in soil and slope conditions conducive to drill seeding. The relatively flat floodplain and gentler bank slopes would be conducive to use of a seed drill where soils and not gravels are present, and hydroseeding would be best for any slopes that are 5H:1V or steeper.

The primary strategy for establishment of native valley oak woodland on slopes and upland areas should be active planting of nursery grown stock and 3–5 years of plant establishment maintenance (e.g., irrigation, weed control, browse protection). A variety of native trees and shrubs that currently occur on and near the project site could be established. The valley oak woodland habitat should be designed to provide sufficient buffer to protect the floodplain riparian and wetland habitats from the surrounding agriculture and urban development (Semlitsch and Bodie 2003). The locations where each plant species could be established would be based on the predicted post-construction soil texture, plant-available soil moisture, and water availability. To maintain local genetic diversity and integrity, all propagules (seeds, cuttings, and root masses) should originate from the project site or similar sites within the Russian River watershed and from locations with soils, elevations, and hydrology that is similar to the project site. A nursery contract would need to be established at least 12 months prior to the time of container plant installation to allow sufficient time to collect propagules and ensure they have sufficient growing time in the nursery prior to installation. All propagules should be sourced from healthy plant material to reduce the potential for the spread of plant pathogens such as *Phytophthora* species. Container stock should be sourced from nursery stock grown in accordance with established *Phytophthora* prevention best management practices to prevent the introduction of infested plant material and soil at the project site. The California Oak Mortality Task Force provides a set of applicable guidelines to minimize *Phytophthora* pathogens in restoration nurseries and projects (Working Group for Phytophthoras in Native Habitats 2016a, 2016b).

Lastly, habitat features, such as large boulders, woody debris, and standing snags, could be incorporated into the design. These physical structures provide habitat complexity for aquatic macroinvertebrates and fish (Roni et al. 2008), shelter for amphibians, and roosting habitat for birds. Coarse woody debris piles could be strategically placed on bank slopes and upland areas to improve habitat values, long-term soil development, and the overall aesthetics of the restored habitat.

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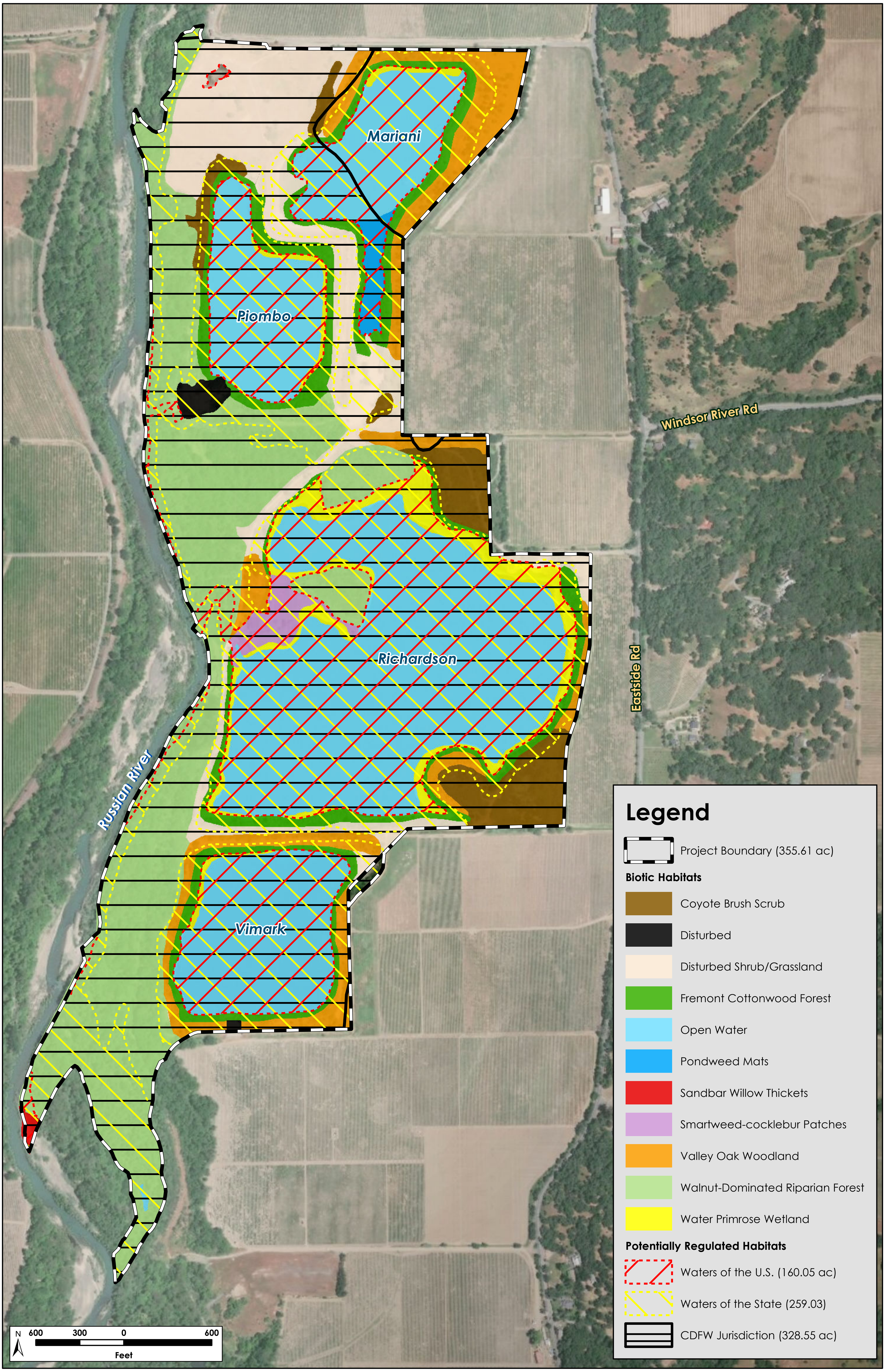

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Figure 1. Biotic/Regulated Habitats
Hanson Russian River Floodplain Restoration, Ecological Design Services
Ecological Restoration Opportunities and Constraints (4180-01)
February 2019

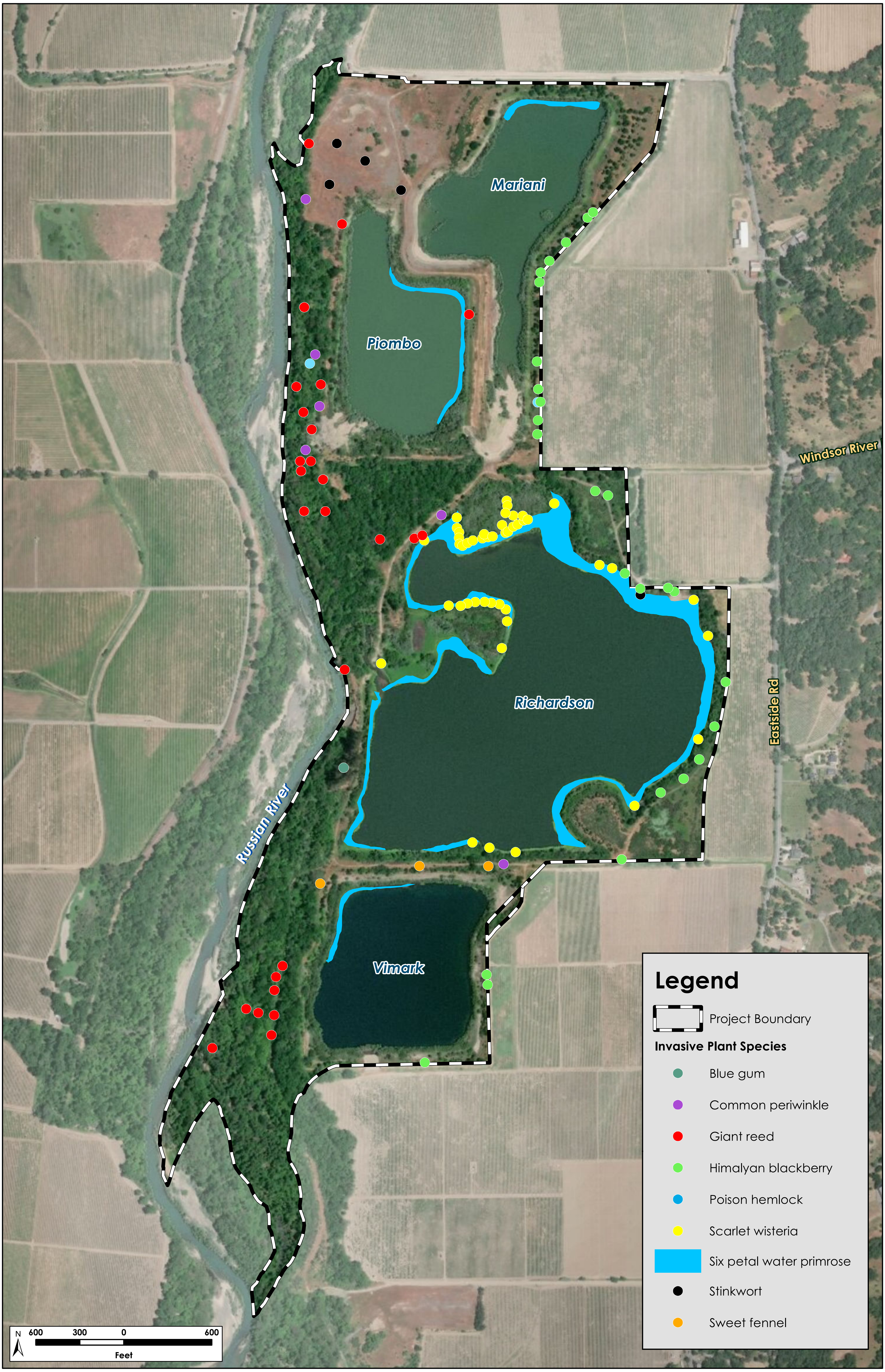

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Figure 2. Invasive Plant Species

Hanson Russian River Floodplain Restoration, Ecological Design Services
Ecological Restoration Opportunities and Constraints (4180-01)
February 2019

Appendix B. Floodplain Design Elevations and Predicted Biotic Habitats

H. T. HARVEY & ASSOCIATES
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Memorandum

Project 4353-01

June 2, 2020

To: **Jeremy Svehla, Project Manager, GHD**

Cc: **Michael Bowen, Program Manager, California Coastal Conservancy**
Nancy Schaefer, Land Conservation Services, Consultant to Endangered Habitats Conservancy

From: **Max Busnardo, M.S., Principal, Restoration Ecologist and Sharon Kramer, Ph.D., Principal, Fish Ecologist**

Subject: **Hanson Russian River Floodplain Restoration—Floodplain Design Elevations and Predicted Biotic Habitats**

This memorandum summarizes the results of a collaborative ecological assessment completed by Peter Baye, Ph.D., and H. T. Harvey & Associates (fish ecologist, Sharon Kramer, Ph.D.; restoration ecologists, Max Busnardo, M.S.; and Charles McClain, M.S.) of the current conceptual grading plan for the Hanson Russian River Floodplain Restoration Project (project) in Sonoma County, California. The purpose of our assessment was to qualitatively predict the type and successional trajectory of biotic habitat type(s) that would likely establish on the restored floodplain on the basis of the project's current conceptual grading plan and existing hydrologic, geotechnical, and ecological studies (EHC 2016, H. T. Harvey & Associates 2019, LSCE 2020, and MPEG 2020). The current conceptual grading plan is based on the project's Feasibility Study (EHC 2016). We understand that the primary goal of the project is to re-establish a stable, seasonal river-floodplain interface and restore ecological processes that sustain off-channel aquatic, wetland, and riparian habitats crucial for recovery of listed steelhead (*Oncorhynchus mykiss*), coho salmon (*Oncorhynchus kisutch*), and Chinook salmon (*Oncorhynchus tshawytscha*) (EHC 2016).

GHD provided both measured wet season and predicted dry season depths to groundwater, as well as predicted surface water elevations for various flood return intervals relative to the conceptual grading plan ground surface elevations. After review of the grading plan and GHD's hydroperiod/groundwater predictions, we conclude that the current grading plan would likely result in long-duration flooding in winter and shallow, perennial inundation (i.e., ~1–2 feet deep) across the floodplain throughout the growing season (i.e., spring and summer) due to the presence of a high groundwater table. These abiotic conditions would support establishment of tall emergent freshwater marsh across the entire floodplain dominated by plant species such as tules (*Schoenoplectus* spp.) and cattails (*Typha* spp.). Perennial freshwater marsh is not preferred by listed steelhead, coho salmon, and Chinook salmon because it creates unfavorably warm water temperatures, lacks important prey for juveniles, and provides habitat for predators, such as nonnative American bullfrogs (*Lithobates catesbeianus*) and nonnative fish (Feyrer et al. 2006, Jeffres et al. 2008, Sather et al. 2009, Bottom et al. 2011, Corline et al. 2017). Moreover, creation of perennial freshwater marsh hydrology is also likely to facilitate early establishment by invasive, nonnative water primrose species (*Ludwigia* spp.); invasive primroses would substantially reduce onsite floodplain habitat functions and contribute propagules to downstream suitable habitat, potentially degrading downstream habitat.

Based on the current literature, we recommend that seasonal wet meadow habitat should be targeted on the project's floodplain in lieu of perennial marsh primarily to achieve the project's salmonid goals and secondarily to avoid the site's invasion by water primrose species. Compared to perennial marsh, seasonal wet meadow floodplain habitat is likely favored by listed steelhead, coho salmon, and Chinook salmon because such habitat:

- provides high-quality winter floodplain foraging habitat with important prey for juvenile salmonids (e.g., dipterans and zooplankton prey),
- precludes reproduction by American bullfrogs,
- reduces the likelihood of predation by nonnative fish, and
- reduces fish stranding potential (Feyrer et al. 2004, Feyrer et al. 2006, Henning et al. 2006, Jeffres et al. 2008, Bellmore et al. 2013, DWR and DFG 2016).

Therefore, to achieve the project's primary goal, the floodplain elevation should be raised to allow winter flooding, spring drawdown, and summer groundwater approximately 1 foot below the floodplain surface. These abiotic conditions would support large areas of seasonal wet meadow dominated by sod-forming plant species such as sedges (*Carex* spp.), spikerush (*Eleocharis* spp.), grasses, and herbs. These conditions would also discourage the establishment of invasive aquatic plants, such as water primrose species. We understand that the grading plan approach seeks an onsite cut-fill balance to avoid the substantial expense of soil import. It would seem that the floodplain elevations could be raised, while retaining a cut-fill balance, by steepening the landward fill slopes (e.g., to 3H:1V) and utilizing the additional material to fill the floodplain to higher elevations. In our opinion, this approach constitutes a use of cut material that better serves the project's ecological goals compared to the current grading plan.

If modifying the conceptual grading plan to raise the floodplain elevation is not feasible, the project's primary goal could still be achieved if fine sediment accumulates on the floodplain surface. This deposition would raise the floodplain elevation to create abiotic conditions that favor the establishment of seasonal wet meadow. However, fine sediment deposition rates would need to be relatively rapid (e.g., 1 decade to reach wet meadow elevations) in order to reduce the negative effects of freshwater marsh creation, these rates have not been estimated, and such estimation has substantial uncertainty. Therefore, we recommend modifying the grading plan to raise the floodplain elevation. If the grading plan is modified, efforts should be made to minimize impacts (i.e., removal) on the existing riparian forest, which provides high-quality habitat for wildlife and is subject to regulation under Section 1600 et al. of the California Fish and Game Code.

A detailed assessment of the floodplain grading design and predicted biotic habitats prepared by Baye (2020) is provided as an attachment.

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Attachment: Hanson Ponds Floodplain Restoration Memorandum

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MEMORANDUM

To: Max Busnardo, Principal, Restoration Ecologist mbusnardo@harveyecology.com
Charles McClain, M.S., Senior Ecologist, cmcclain@harveyecology.com
Subject: Hanson Ponds floodplain restoration (GHD/Endangered Habitats Conservancy); ecological design & objectives for floodplain wetland habitats supporting ephemeral flood foraging by juvenile salmonids
Date: May 22, 2020

This memorandum assesses floodplain wetland functional types for the Hanson Ponds grading plan, considered in terms of seasonally variable juvenile salmonid habitat rearing habitat conducive to rapid growth (Central Valley model of transient overbank flood events; Sommer et al. 2001, 2005; Henning et al. 2006, Jeffres and Moyle 2008), related to seasonal and perennial wetland hydrology, substrate, sediment deposition rates and patterns, and vegetation types. The overall purpose of this assessment is to assist HTH in developing consensus interdisciplinary ecological recommendations for the grading plan for Hanson Ponds, as we discussed in our conference call of May 13, 2020. Wetland hydrology and vegetation (dynamic habitat structure) are considered primarily in terms of plant functional groups, vegetation structure, species composition, related to groundwater depth (dry season), and depth and duration of surface flooding (wet season flood events and drawdown), in backwater floodplain depositional environments.

DISCUSSION

The underlying design question is how to optimize distribution of available fill volumes and substrate types in the grading plan, to achieve the best long-term floodplain rearing habit structure and function for juvenile salmonid rearing. Part of this design question hinges on long-term fine sediment deposition gradients and rates of sedimentation, relative to initial (graded) floodplain elevations. The preliminary grading plan would result in large areas of perennial freshwater marsh, with permanent groundwater at or near the ground surface during the growing season, and long duration of relatively deep submergence (over 30 cm) during the winter flood season, and prolonged drawdown during the growing season. Long-hydroperiod freshwater marsh would remain highly vulnerable to rapid invasion by non-native water-primrose species (*Ludwigia* spp.) which occur as permanent, abundant source populations in upstream reaches of the Russian River, as well as on site.

As we discussed, the long-term geomorphic and ecological evolution of the floodplain and its vegetation depends in part on the long-term rate of fine sediment deposition. Of all data gaps, this one is arguably one of the most important influences on professional judgment for setting the initial elevation range of the graded floodplain above relatively permanent summer groundwater levels. Gradual, low annual long-term average rates of fine sediment deposition (on the order of 1-10 mm/yr) would likely drive wetland succession from long-hydroperiod (spring-summer flooded, late drawdown or permanently flooded) freshwater tall emergent marsh (tule, cattail dominants), to short-hydroperiod, early summer drawdown regimes supporting transition from freshwater marsh to wet meadow (sparse tule, cattail, bulrush marsh transition to prevalent sedge-rush meadow and forb) and willow thickets, but only after a very long period of sedimentation (many decades). In contrast, frequent, relatively rapid pulses of high-magnitude fine sediment deposition (circa 50-100 mm events), or high average long-term gradual fine sediment deposition rates (on the order of 10-50 mm/yr) would likely accelerate marsh to meadow succession over extensive areas within a few decades. Currently, we have very little data or analysis available to support assumptions about long-term fine sediment deposition rates, and their consequences for floodplain wetland vegetation types and ecological functions.

There are significant potential ecological differences between floodplain freshwater marsh and wet meadow wetlands, with respect to juvenile salmonid rearing habitat, wildlife habitat, and plant community diversity. Freshwater marsh with long hydroperiods and high maximum submergence depths during the growing season support few dominant and strongly colonial tall emergent plant species with high submergence tolerance (tules, *Schoenoplectus acutus* and *S. californicu*s; cattails, *Typha latifolia, T. domingensis*, and non-native *T. angustifolia*). During early stages of colonization and establishment in early succession, floodplain freshwater marsh areas with long hydroperiods (over all submergence depth ranges) are likely to become dominated by invasive *Ludwigia* spp. (floating aquatic water-primroses) from upstream Russian River propagule rain (seeds and fragment deposition during flood events). *Lugwigia* invasions resulting in rapid dominance are likely to significantly inhibit rates of succession, reduce native species diversity during succession, and increase invasion pressures on downstream fluvial wetlands. They are also a high risk for increasing local populations of non-native predatory fish and bullfrogs. Once invasive *Ludwigia* spp. establish dominance over large acreages, the feasibility of subsequent control is likely to be low, and costs and impacts would be high. Some resistance to local invasion may be increased by early establishment of high-density stands of river bulrush (*Bolboschoenus fluviatalis*; source populations in Laguna de Santa Rosa), but there is probably no cost-effective available control for large-scale rapid pre-emption of invasive *Ludwigia* in disturbed, early succession freshwater perennial marsh. Long-term succession to higher (short hydroperiod) wet meadow or other seasonal wetlands may be the only pathway to escape *Ludwigia* invasion, but its time requirement (dependent on sedimentation rate) is largely unknown.

The off-channel perennial submersed floodplain wetland pool habitats of Pacific Northwest streams (Bellmore *et al*. 2012, 2013) may have limited or no analogs in the warm, relatively summer-arid floodplain wetlands of Windsor vicinity reaches of the Russian River. This hypothesis is based on the contrasts in local invasive aquatic vegetation and predatory fish species.

In contrast, floodplain areas with relatively higher elevation above summer groundwater elevation range, and short winter-spring hydroperiods (Mar-April drawdown or earlier) are likely to develop wet meadow wetland vegetation, or rapid succession between pioneer freshwater marsh and wet meadow. Wet meadows in the lower Russian River are dominated by more native (and non-native) plant species, and a higher proportion of native clonal (creeping, sod-forming) sedge, bulrush, rush, spikerush, grass, and broadleaf forb species that resist invasion by non-native species. Wet meadows are generally seasonal wetlands that alternate between drained or dry soils in summer, and saturated to flooded soils in late fall, winter, and spring. The invertebrate communities of seasonal wetlands fluctuate significantly over the year: terrestrial soil insects grow in summer, and are subject to recurrent flooding in winter. Seasonal aquatic invertebrate and zooplankton populations alternate between resting or dormant dry-season life-history stages and wet-season flood "blooms" of juvenile salmonid prey items, including dipteran larvae (particularly midges), and aquatic crustaceans including cladocerans (water-fleas) ostracods, and copepods (see Table 1 below). Seasonal wet meadows (and pools or swales within them that draw down in summer) support a high diversity of terrestrial wildlife species, including small mammals, ground-nesting birds, wading birds, and native amphibians (including Sierran chorus frogs and California red-legged frogs). Their seasonal hydrology restricts reproduction by non-native bullfrogs. Fish stranding potential of seasonal wet meadows can be modified by aligning floodplain topography with continuously sloping swales that connect to open alcoves at downstream ends of the floodplain connected to the main channel zone, providing fish access to instream habitats during drawdown.

Sharon Kramer's email (May 1, 2020) highlighted the following points about juvenile salmonids and floodplain seasonal wetlands, contrasted with floating or submerged aquatic vegetation (perennial aquatic/freshwater marsh):

1. If it gets too warm [during floodplain submergence events] juveniles will likely leave.
2. Seasonally flooded vegetation was found to provide dipterans and zooplankton, important prey items for juvenile salmonids that promote Chinook salmon growth rates
3. Best habitat conditions are seasonally inundated vegetation that doesn't strand fish (e.g., there are good channel connections) but that inundates long enough for dipterans and zooplankton prey to increase in abundance (weeks)
4. Aquatic vegetation appears to promote habitat for non-native potential predator fish species, such as cyprinids and centrarchids (Feyrer et al. 2006).

RECOMMENDATIONS FOR ALTERNATIVES

Given the uncertainty of long-term floodplain fine sediment accretion rates, and the overall higher confidence of better salmonid rearing habitat and overall biological diversity of floodplains provided by a prevalence of seasonal wet meadow over freshwater marsh, grading alternatives that spread available suitable fill volume to raise floodplain elevation gradients to near or above the threshold of summer groundwater emergence would be a priority for the next stage of ecological engineering. The higher the initial elevation range above summer groundwater, the shorter the successional pathway (time) to accretion-driven succession to wet meadow and willow scrub, and the lower the exposure to highly invasion-prone disturbed early succession freshwater marsh. Elevation gradients can include swales or channels dominated by freshwater marsh of limited extent, within a matrix of ecotonal freshwater marsh and wet meadow, to provide vegetation structure diversity of local zones of tall emergent tules and cattails, rather than an extensive, relatively homogeneous landscape of tule-cattail marsh with pervasive water-primrose. Higher initial graded platforms for floodplain accretion over significant areas (pioneer succession on seasonal wetland elevation gradients) would be advantageous if grading costs and fill supply are feasible. This approach would involve, as we discussed, reallocation of fill from steeper upland border slopes, to at least portions of the graded floodplain platform. However, if new analysis of long-term fine sediment accretion rates in the floodplain indicate likely rapid accretion within the first decade after grading/restoration activities, less reallocation of fill from upland-riparian slopes to the floodplain platform may be needed to achieve comparable target wet meadow/willow scrub habitats within the next one or two decades. As a working hypothesis, I assume willow and cottonwood seedlings are likely to spontaneously colonize silty to sandy surface substrates; clayey-silt flats, poorly drained, are likely to select for more (prolonged) anoxia-tolerant herbaceous seasonal wetland assemblages. Open wet meadow conditions (high surface area of herbaceous shoot canopy, high productivity of labile organic matter) among patches of willow scrub or floodplain forest are favorable for rapid phytoplankton growth during floodplain submergence events, and trophic support for zooplankton that in turn support juvenile salmonid growth.

Restoration of wet meadow from initial substrate elevations above summer groundwater levels would likely require heavy seeding by a native annual and perennial forb pioneer “cover crop” to stabilize sediments rapidly and inhibit colonization and dominance by wetland weeds, to accompany translocation of vegetative propagules (sod fragments, plugs, etc.) of dominant native clonal perennial graminoids and forbs. Of the species identified in Table 2 below, I recommend smartweeds (*Persicaria* spp.), beggar-ticks (*Bidens frondosa*), and nut-sedges (*Cyperus eragrostis* and similar spp.) as superior native pioneer colonizer and competitors that would not interfere with establishment of target native clonal perennials. Cultivation of “sod farms” of native sedges, rushes, wildrye, spikerush, etc. at shallow-emergent terraced margins of existing Hanson Ponds (phased alternative) would potentially supplement salvage of native remnant stands during (minimized) grading in riparian zones.

If large areas of floodplain graded to or below mean summer groundwater levels are included in the next stage of grading plan modifications, they would need to be “mitigated” by more intensive active revegetation (rather than passive colonization) by translocation of high densities of large vegetative propagules of mature *Bolboschoenus fluviatalis, Schoenoplectus* spp, and *Typha* spp., to restrict rapid spread and dominance of invasive *Ludwigia* spp and other aquatic weeds.

Reference	Study site floodplain hydrology	Study site floodplain vegetation	RR floodplain equivalents	Juvenile salmonid prey and fish growth response
Jeffres & *al*. 2008	- annual ephemeral pond (Upper Pond) - alternating perennial/seasonal pond (Lower Pond) - ephemeral flooded terrestrial herbaceous vegetation dry late summer (FP Veg)	Annual grasses and forbs (unspecified; presumed ruderal), including *Xanthium* (cocklebur); interspersed with young oak, willow and cottonwood Cosumnes River	Early succession alluvial grassland and forbs (*Persicaria, Epilobium, Erythranthe,Dysphania*, willow & cottonwood, dogwood, black walnut; perennial and annual (non-native and native).	Majority gut contents from herbaceous floodplain = benthic macroinvertebrates, larval fish, and zooplankton. Majority gut contents flooded ponds = zooplankton. Important vegetative structure for primary and secondary production
Corline &	Yolo Bypass	High shoot density	Disturbed early	**Cladocerans** were the

al. 2017	cultivated croplands (rice), variable post-harvest treatments including fallow (weed), dry summer	rice stubble & weeds (surface area remnant winter vegetation) Zooplankton colonize from both allochthonous (flood-delivered) and autochthonous (desiccation-resistant diaspores, rapid flood colonization & growth) sources.	succession fine sediment (unstable, successional, herbaceous grass & forb, annual-dominated)	most abundant **zooplankton** (*Daphnia* & associated genera). Dominant soil-emergent invertebrates were ostracods and cyclopoid copepods. gut contents of Chinook Salmon in agricultural floodplain 85% daphniids -- had some of the highest growth rates recorded for Chinook Salmon in the Central Valley Studies of juvenile Chinook Salmon (50–218 mm FL) in other lentic water bodies found that salmon selectively fed on large *Daphnia* spp.
Johnson & al. 2009	Lower Columbia River:	willows (Salix spp.) most frequent; creeping spikerush (*Eleocharis*), horsetail (*Equisetum* spp.), rice cutgrass (Leersia), marsh seedbox (Ludwigia), water milfoil (Myriophyllum spp.), reed canary grass (Phalaris arundinacea – fine sediment (muds)	Perennial emergent to seasonal marsh and wet meadow, willow groves (*Alisma triviale, Eleocharis macrostachya, Equisetum* spp., *Glyceria spp., Hordeum brachyantherum, Leymus triticoides, L Xgouldii, Paspalum distichum, Sparganium, Scirpus microcarpus, Persicaria* spp.)	Regardless of sampling month or site of capture, the diets of juvenile Chinook salmon and coho are generally dominated by aquatic insects (**Diptera, mostly Chironomidae** (non-biting midges) and **Ceratopogonidae** (biting midges). In later months, as chironomids declined, terrestrial insects became important constituents of the diet.

Table 1. Seasonal and perennial floodplain wetland types and juvenile salmonid prey production, with study site descriptions (literature review) and Russian River local equivalent native plant community elements (this memorandum)

Hydrologic regime (submergence, depth to groundwater, seasonality)	Substrate	Deposition/erosion regime	Target native species assemblage
Winter flood, spring drawdown (emergence), summer groundwater < 30 cm BGS – emergent moist to dry summer [landform/vegetation: **floodplain seasonal**	Clayey silt Silty clay Silty sand Organic flood debris Root/rhizome peat & shoot litter mat	1-10 mm/yr average (magnitude) Maximum 10-20 cm/extreme event	***Artemisia douglasiana*** ***Bidens frondosa*** ***Carex barbarae*** ***Cyperus eragrostis*** ***Eleocharis macrostachya*** ***Epilobium ciliatum*** ***Juncus arcticus*** *Euthamia occidentalis*

marsh to wet meadow] Preferable for ephemeral winter floodplain foraging by salmonids (invertebrate production)			*Helenium spp.* *Helianthus californicus* *Juncus phaeocephalus* *Juncus xiphoides* ***Leymus (Elymus) triticoides*** *Persicaria amphibia* ***Persicara lapathifolia*** ***Persicaria punctata*** *Symphyotrichum chilense* *S. lentum*
Perennial saturation to (summer groundwater 0-1 cm BGS) to 30 cm submergence through growing season, infrequent fall emergence **Perennial emergent marsh** [landform/vegetation: **floodplain freshwater emergent marsh - shallow**]	Clayey silt Silty clay Organic flood debris Root/rhizome peat & shoot litter mat	1-10 mm/yr average (magnitude) Maximum 10-20 cm/extreme event (best estimate)	***Bolboschoenus fluviatalis*** ***Scirpus microcarpus*** ***Schoenoplectus acutus*** *Sparganium eurycarpum* *Typha domingensis* ***Typha latifolia***
Perennial saturation to (summer groundwater 0-1 cm BGS) to 100 cm submergence through growing season, infrequent fall emergence [landform/vegetation: **floodplain freshwater emergent marsh – deep]**	Clayey silt Silty clay Muck (fine particulate organic) Root/rhizome peat & shoot litter mat	1-5 mm/yr average (magnitude) Maximum 10 cm/extreme event (best estimate)	***Schoenoplectus acutus*** ***S. californicus*** ***Typha domingensis*** ***Typha latifolia***
Winter flood ephemeral; rapid post-flood emergence, drainage Primary succession [landform/vegetation: **sand-gravel bar & levee riparian woodland]**	Silt Sandy silt Silty sand, gravel & organic flood debris	1-30 cm/yr average (magnitude) Maximum 60 cm/extreme event (best estimate; local observation 2018)	*Salix exigua* *Salix laevigata* *Salix lasiolepis* *Populus fremontii* *Rubus ursinus* *[understory: shade-tolerant wet meadow spp., esp. Carex]*
Winter flood ephemeral; rapid post-flood emergence, drainage late succession [landform/vegetation: **sand-gravel bar & levee riparian woodland]**	Silt Sandy silt Silty sand, gravel & organic flood debris	0.1-1 cm/yr average Maximum 10 cm/extreme event (best estimate)	*Acer negundo* *Fraxinus oregona* *Juglans hindsii* *Populus fremontii* *Quercus lobata* *Sambucus nigra*

Table 2. Preliminary characterization of hydrology, substrate, sedimentation, and native species assemblages (including target composition for the project) of Russian River floodplain wetland vegetation,

Windsor to Laguna de Santa Rosa (based on field observations and floristic data; California Consortium of Herbaria, Calflora, and Sonoma County Flora (Best et al. 1996).

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Appendix C. Riparian Revegetation Models, Methods, and Materials

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MEMORANDUM

To: Max Busnardo, Principal, Restoration Ecologist mbusnardo@harveyecology.com
Charles McClain, M.S., Senior Ecologist, cmcclain@harveyecology.com
Subject: Hanson Ponds floodplain restoration (GHD/Endangered Habitats Conservancy); riparian revegetation models, methods and materials
Date: August 4, 2020

1.0 Introduction

This memorandum describes methods and materials for revegetation of the Hanson Pond floodplain restoration project, and the basis for its conceptual design, aligned with ecosystem process-based restoration. Quantified estimates of materials and costs are not included in the conceptual revegetation at this level.

2.0. Typology, composition, distribution, and abundance of riparian and upland vegetation types of the floodplain-hillslope landscape. The following typology is provided as a project-specific framework for revegetation activities in distinct ecohydrogeomorphic zones or landscape units. The vegetation and riparian classification scheme is partly based on traditional Munz-Ornduff and Holland-Keil California vegetation classifications, and a basic California riparian classification (Johnson *et al.* 1981)

2.1. **Floodplain vegetation**. Off-channel, backwater, bar, bank, and alluvial flat riparian vegetation, predominantly low-energy depositional wetland and wetland ecotone (transition zone) environments within floodplain; silt to clay with more narrowly distributed sand in high flow distributary channels or splays within floodplain.

- **(Aquatic) backwater pool and channel**: ponded perennial aquatic habitat, dominated by open water with floating or submersed vascular vegetation, minor freshwater emergent marsh. Hydrology: saturated to flooded throughout the growing season, up to 3-4 ft water depth during summer. Substrate: organic muck and clayey silt or clay. Vegetation: native and non-native floating aquatic vegetation (FAV), submerged aquatic vegetation (SAV), and tall emergent freshwater marsh patches.
- **Freshwater marsh**: dominant cover of extensive freshwater marsh; minor pool or open water inclusions or none. Hydrology: saturated to shallow submerged during growing season, 0-1 ft (infrequently 2 ft) depth (perennial freshwater marsh), or frequent drawdown to moist drained or dry surface substrate in fall (seasonal freshwater marsh) in upper 0.5-1.0 ft. Substrate: fine silty sand grading to silt or clay. Vegetation: dominant cover of obligate emergent perennial wetland plants: tule, cattail, bulrush, sedge, rush, spikerush, wetland grass species, and

broadleaf herbaceous emergent marsh (smartweed, water-plantain). The extent of this wetland vegetation type in the project is currently uncertain, while floodplain design grades, settlement rates, and sediment accretion rates are being reviewed. To minimize risks of unmanageable wetland non-native species invasions, the initial extent of freshwater marsh should be minimized unless very high rates of sedimentation are determined to be likely within 5 years after construction.

- **Seasonal wet meadow**: dominant cover wetland grassland and forb (herbaceous broadleaf) vegetation; sedge, rush, grass, and perennial forb species tolerant of seasonal saturation or inundation, and periodic summer drainage to mesic or dry substrate in the root zone. Hydrology: winter-spring saturation and shallow flooding, summer drainage to mesic or dry conditions in upper 1-2 ft of soil profile/root zone. Substrate: fine silt to clay. The extent of this wetland vegetation type in the project is currently uncertain, while floodplain design grades, settlement rates, and sediment accretion rates are being reviewed. To optimize ecological performance of the project for supporting juvenile salmonid growth, and minimize the risk of unmanageable non-native species invasions, the extent of this vegetation type and elevation range should be maximized.

- **Riparian wetland scrub**: dominant cover of flood-tolerant and burial-tolerant shrubs and small trees. Hydrology: brief flooding, prolonged saturation in winter-spring, and shallow drainage to mesic soil in summer. Substrate: sand to silt. Vegetation: mostly willow and California blackberry thickets and poison-oak with variable ground layer (including shade-tolerant wet meadow species assemblages).

- **Riparian wetland woodland**: dominant cover of riparian trees with variable understory of lianas, scrub, or shade-tolerant wet meadow assemblages. Hydrology: brief flooding, prolonged saturation in winter-spring, and shallow drainage to mesic soil in summer. Substrate: sand to silt.

2.2. Terrestrial riparian and upland vegetation. Hillslope soils or artificial fill in non-wetland soils bordering but above extreme high flood levels (floodplain-terrestrial ecotone) but either influenced indirectly by shallow groundwater (riparian mesic woodland), or draining upland slopes towards the floodplain (upland woodland and savannah), with ecological connectivity to the floodplain from seed dispersal, wildlife movement, drainage, sediment and nutrient transport.

- **Riparian mesic woodland or forest**: dominant cover of riparian trees with grassland or scrub understory. Hydrology: shallow groundwater, but no significant soil saturation near the surface (upper 1-2 ft).

- **Upland woodland and savannah**: terrestrial hillslope trees varying from continuous canopy groves (woodland) to scattered trees in grassland (savannah). Hydrology: deep groundwater (gen >10 ft). Substrate: soil profile over weathered regolith parent material (stony to gravelly clay loams, sandy clay loams). Vegetation: coast live oak, black oak, madrone, buckeye, bay laurel (mixed evergreen forest, oak woodland) and valley oak (oak savannah).

3.0. Riparian ecological succession models for Windsor-Healdsburg Russian River floodplains.

3.1. Summary of riparian succession and geomorphic evolution models. The process-based revegetation strategy for the floodplain is adapted from three primary sources: (a) a local riparian succession process model developed empirically for nearby Dry Creek riparian vegetation of channel banks and bars (McBride and Strahan 1984 a,b); a recent general global ecogeomorphic model for vegetation-sediment interactions based on literature review of floodplain evolution and succession influenced by livewood and large woody debris (Corenblit *et al*. 2009, Francis 2007, Francis et al. 2008, Gurnell et al. 2012, Opperman et al. 2008, Montgomery and Abbe 2006); and (c) local investigations of the channel banks, bars, and narrow floodplains adjacent to and upstream of the project site to Healdsburg and Cloverdale (P. Baye, unpublished observations).

- **Dry Creek riparian successional model (McBride and Strahan 1984)** The McBride-Strahan riparian succession model was developed for gravel and sand bars and banks of Dry Creek, the closest riparian vegetation study site known. Their study site differs from the low-energy fine-grained depositional floodplain of the project site, since it was developed for high energy confined channelized flow zones with coarser gravel-sand bars and banks subject to winter erosional scour. Key woody riparian species, and some relevant key seasonal riparian ecological processes are summarized below:
    - High recruitment and survival of willow and wetland forb plant seedlings on sheltered gradually sloped coarser bars and finer-grained swales and “lagoons” with shallow groundwater.
    - Rapid willow seedling-sapling transitions during the growing season (1 m/3 mo) where depth to groundwater mid-summer is < 20 cm.
    - Cottonwood (*Populus fremontii*) seedling recruitment and survival on coarser gravel and sand with summer groundwater depths over 1 m. Poor cottonwood growth and survival in areas of prolonged saturation or flooding.
    - Mulefat (*Baccharis salicifolia* and *B. glutinosa*) recruitment and survival occurred at higher, coarser bars.
    - Most woody plant mortality was associated with unstable substrate and high flow erosional scour in channel-bar systems (infrequent in low-energy backwater floodplain environments)
    - Sediment trapping was correlated with vegetation density and distance from sediment sources or upstream bar ends, with sediment fining patterns downstream.

No reports of large willow fragment (livewood) deposition or regeneration in gravel-sand bar systems were included in McBride and Strahan studies, nor was herbaceous ground layer vegetation of floodplains analyzed.

- **Floodplain “island” ecogeomorphic evolution model** (multiple authors). Deposition of live and dead large wood (livewood, large woody debris, and logjams including both) provides localized major structural roughness elements to streams and floodplains. These become nuclei of alluvium deposition, sediment sorting and sheltering that establish centers of pioneer vegetation recruitment and expansion, with positive feedbacks on vertical and lateral sediment accretion lowland valley and floodplain landscapes (Corenblit *et al*. 2009, Francis 2007, Gurnell *et al.* 2012, Collins *et al*. 2012, Opperman *et al.* 2008, Montgomery and Abbe 2006). These sedimentation-woody debris/livewood-vegetation feedbacks are a key driver of riparian biological diversity (Francis *et al.* 2008). Livewood refers to flood transport and deposition of living large whole trees and rootwads with strong vegetative regeneration (sprouting ability) after partial or full burial in alluvium. The ecogeomorphic effects of livewood, and sheltering and anchoring effects of their co-occurrence in logjams of large woody debris, provide structural nuclei for riparian floodplain accretion patterns and vegetation succession, resulting in self-enlarging floodplain "islands" that trap vegetative propagules, seeds, sediment, and coarse flood debris. Heterogeneity of topography, drainage, flow paths (energy), sediment texture, deposition rates, and vegetation in the floodplain would likely be enhanced by artificial logjam-linked floodplain island patterns and processes.

- In California stream and riparian restoration, installation of large woody debris or livewood is often limited to banks and beds of channels for purposes of high-energy instream salmonid habitat enhancement. Riparian deforestation, leveeing, and agriculture of the Russian River floodplain upstream of the site, however, is likely to limit recruitment of both large woody debris and large sprouting cottonwood and willow livewood after floodplain restoration at the project site. Logjam placement of live and dead large wood in emerging floodplains undergoing primary succession and island-patterned geomorphic evolution is perhaps unprecedented in this region. The low-energy backwater environment of the project site, and potential high sediment delivery of extreme floods on the Russian River, suggesst high potential utility of embedding artificial logjams of live willows and cottonwoods (high vegetative regeneration capacity and burial tolerance) and dead large woody debris, to establish deposition centers (structural roughness elements at island heads), topographic gradients, sediment texture gradients (fining downstream) and sheltering gradients as a framework for patterning floodplain revegetation activities.

- **Local upstream riparian vegetation propagule rain and pioneer bar wetland margins**. Floods deliver viable vegetative propagules and seeds of both native and non-native invasive species (Donaldson 1997). The leveed banks of the Russian River contain heavy loads of both invasive non-native weeds (*Arundo donax, Lepidium latifolium, Ludwigia* spp.) as well as agricultural weeds of the reclaimed floodplains, in addition to abundant native riparian vegetation propagules like willow seeds. The disturbed wetland margins of flooded bars and backwater swales of the channel upstream of the project site, through Windsor, Healdsburg, to Cloverdale, are likely to provide a very mixed and abundant assemblage of noxious weeds to passive, pioneer floodplain succession, but only an impoverished, homogenized (low diversity and abundance) of strong pioneer native species such as *Salix* and *Persicaria* spp. The extent of upstream floodplain vegetation propagule supply areas is small because of historical agricultural reclamation of floodplains. Passive recruitment alone is likely to result in overabundance of a few native pioneer plant species, and excessive abundance of noxious or naturalized non-native riparian species, based on observed colonization of floodplain-equivalent shorelines in the bed and banks upstream of the site.

3.2. Synthesis and application of riparian succession models to revegetation design. The riparian succession models suggest that a smooth, low graded floodplain basis would promote relatively homogeneous, fine-grained alluvial deposits colonized by perennial marsh vegetation and willows, with a high proportion of wetland weeds from upstream sources. Incorporation of oversize woody propagules - livewood (willow, cottonwood – sprouting tree species) embedded in artificial logjams within the graded floodplain – would establish nuclei for sediment deposition gradients that would likely accelerate heterogeneous patterns of floodplain "island" succession. If the final grading plan for the floodplain is relatively low in elevation (less than 1 ft above average summer groundwater elevation) floodplain island succession could be further catalyzed by grading small raised terraces or mounds approximately 2 ft above summer groundwater elevation as a matrix for embedding artificial livewood/LWD logjams. Locally elevated, logjam-roughened incipient floodplain islands may be platforms for translocation of wet meadow sods or riparian scrub livewood species other than willow, if the floodplain matrix is graded to, or settles out to, excessively low and homogeneous freshwater marsh.

4.0. Pioneer riparian vegetation establishment processes and related artificial methods.

Natural processes of pioneer riparian vegetation colonization and establishment (primary or secondary succession) applicable to low-gradient reaches of California streams (including floodplains and braided channel/bar complexes) include:

- *Seedling colonization of alluvium*. Pioneer seedling establishment from seed dispersal on bare accreted alluvium.
- *Lateral clonal spread from established populations adjacent to deposited alluviu*m. Alluvium deposited adjacent to established clonal populations is directly colonized by vegetative spread.
- *Vertical clonal spread: regeneration from burial by alluvium (sod/rootmat or individual plant*). Buried rhizomes or leafy shoots emerge from shallow burial and develop nodal or adventitious roots below the raised, accreted floodplain surface.
- *Fragmentation: vegetative fragment dispersal and regeneration in deposited alluvium:* bank erosion severs fragments of rhizomes, corms, and rooting branches during winter dormancy, and deposits them near the surface of flood alluvium, where they regenerate and establish plants or clonal populations.
- *Sod (rootmat) fragment dispersal and regeneration in alluvium*: bank erosion by undermining and shearing severs fragments of rhizomatous semi-buoyant root-mats (sods) of floodplain wet meadow and transports them to depositional zones of bars and floodplains.
- *"Livewood" colonization*: Whole woody plant flood dispersal, deposition, and re-establishment. Toppled trees with sprouting ability (especially willow and cottonwood, but also other species) erode out of banks during floods, and are transported to bars or floodplains where they lodge and are partially or fully buried. They sprout and regenerate new clonal sibling tree rows along the bole, or clusters of trees at the trunk/rootwad. Moderate sediment burial of sprouting riparian tree species is associated with size-dependent low mortality. Higher mortality of relatively deep burial in smaller trees (saplings) is offset by compensatory growth rates of low-density resprouts (Kui and Stella 2016).
- *Floodplain island recruitment*: dynamic complex ecogeomorphic units of sedimentation and vegetative colonization, based on process feedback between trapping of sediment, debris, and

propagules, and increased roughness and substrate elevation; serial vegetative spread and raised floodplain island progradation.

Each of these natural pioneer riparian colonization processes of floodplains has an actual or potential corresponding "nature-based" revegetation technique. Riparian revegetation methods in general vary in the degree to which they have been tested in practical applications in the western United States, and in Central California coast riparian environments in particular.

- *Direct seeding*. Riparian vegetation establishment (revegetation) methods for western states generally recommend a limited role or avoidance of primary reliance on direct seeding riparian vegetation restoration for dominant pioneer vegetation establishment, because of high mortality and unpredictability of recruitment in naturally highly disturbed depositional or erosional environments (Densmore *et al.* 2000, Hoag *et al*. 2008, Sheley *et al*. 2008). Seeding of important riparian pioneer or gap-colonizing species that naturally establish exclusively from seed, and produce copious seed, may be suitable for broadcast seeding in alluvium if they are dispersal-limited or propagule-limited. Native annual *Persicaria, Epilobium, Cyperus, Bidens* species, which are likely to be dispersal-limited, may be suitable for limited direct seeding of founder populations.

- *Vegetative sprigging*. Vegetative sprigging refers to artificial planting of buried rhizome clusters or rhizome fragments, perennial crowns, shoot clusters with attached buds and substrate-detached roots, or similar vegetative divisions (clonal fragment regeneration units). Sprigging generally has higher survivorship than seedling establishment because initial plant size and reserves are initially large, enabling them to accelerate growth and tolerate more disturbance or physiological stress than small seedlings. Sprigging of dormant vegetative divisions is highly suitable for riparian herbaceous perennial species that commonly spread from fragmentation. Sprigging is similar to plugging, the transplanting of rooted vegetative divisions embedded in soil (plugs). Plugs can range from "wildings" (Hoag 2000, Densmore *et al.* 2000, Sheley *et al*. 2008, Steed and deWald 2003) slender divisions of sod harvested from wild or cultivated open-field vegetation; see below) or tubular container-grown nursery stock.

- *Sod (rootmat) fragment translocation*. Sod translocation ("sodding") is a method establishment of herbaceous clonal perennials in riparian vegetation and wet prairies (Hoag 2008, Sheley et al. 2008, Fraser and Kindscher 2001, Densmore *et al.* 2000), as well as perennial pastures. Dormant (fall-winter) sod pieces ranging from the size of small plugs, plugs the size of a spade blade (manual harvest) or sod mat fragments 40-90 cm in diameter or more, lifted by mechanical equipment such as mall excavators or hydraulic tree spades (Densmore *et al.* 2000, Hoag 2001, Fraser and Kindscher 2001). Clonal integration, and large size of plants with stored reserves and well-established roots embedded in substrate, make sod mat translocation one of the most resilient methods of transplanting clonal perennial herbaceous and woody plants. Dormant sod mats of *Carex, Euthamia, Artemisia, Leymus, Juncus, Eleocharis, Bolboschoenus, Schoenoplectus* spp. are highly feasible and efficient for translocation of "instant pioneer colonies" with high vigor and survivorship in disturbed conditions. Sod-forming perennial sedge and other graminoid species are likely to form swards with high resistance to wetland weed invasions (Perry *et al*. 2006) when pioneer colonies coalesce. The cost per unit of vegetation colonies established with high survivorship from sod translocation (or large plugs from field-collected sources), is likely to be significantly lower than nursery-grown container stock. Sod fragments are also well-suited to incorporation within livewood-logjam complexes with high expected sediment accretion rates.

Sod transplant densities would be adjusted to the area needed to be revegetated, and the supply capacity. Lateral clonal spread rates in pioneer floodplain conditions (allowing for weed competition in gaps) vary among species, but may be expected the range of 0.5-1.5 ft/yr during the first and second year after restoration is initiated. While small-scale restoration sites would aim for sod densities up to 50% cover, reasonable densities of large sod fragments acting as founder populations on a site several hundred acres in size would be on 5-15 ft centers or more. Closer spacing would be appropriate for concentrated areas of transplanting, such as floodplain islands.

- *Livewood transplants*. (Hoag 2003, Densmore et al. 2000). Whole small dormant trees of stump-sprouting species can be excavated or grubbed from banks, and translocated to receptor site where they are shallowly buried or lodged in alluvium. Livewood translocation is viable only during dormancy, or approach to dormancy in fall. Most shoot mass (branches and limbs) are heavily pruned before translocation to increase root:shoot ratio. Larger trees can be toppled (pushed) with grading equipment, or cabled and pulled to uproot the rootwad. Living dormant bucked log segments of willow boles can also be used as smaller livewood units. Native riparian stump-sprouting shrubs and lianas that are well-suited for livewood placement include California grape (*Vitis californica*), creek dogwood (*Cornus sericea*), ash-leaved maple (*Acer negundo*), western azalea (*Rhododendron occidentale*), and western spicebush (*Calycanthus occidentalis*). Livewood methods are likely to have very high survivorship because plant size (stored reserves, buds) is large and physiological stress of transplanting is avoided during dormancy.

  Upland tree adaptation of riparian livewood methods is also possible with stump-sprouting woodland tree species in the sapling stage. Heavy top-pruning or stump-pruning (coppicing) coast live oak saplings (*Quercus agrifolia*, up to ca. 10 cm diameter) in late winter, while soil is moist but before shoot bud break, can prepare excavated stump-rootwads for direct transplanting and stump-sprouting. Heavy pruning and transplanting in cool, moist late winter weather minimizes evapotranspiration stress that is the primary cause of mortality. Recompacting root/soil masses is also essential for transplanting cut-stump oaks. Other stump-sprouting upland trees include buckeye (*Aesculus californicus*) and California bay-laurel or pepperwood (*Umbellularia californica*). These can likely be salvaged as dormant saplings transplanted in late fall on site, avoiding risks of introducing off-site plant pathogens.

Dormant transplanting of sprigs, plugs, sod mat divisions, livewood, and coppiced tree sapling stumps is performed like dormant bare-root tree or shrub transplanting. Roots and root masses must be kept protected from desiccation due to exposure to sun or dry air during storage and handling. Transplants must be recompacted to maximized surface contact with the moist substrate, with air pockets minimized. Large sod mats of burial-tolerant floodplain species should be set below the original relative depth below surface and shallowly buried (0.25 ft) to protect buds and shoots from exposure to stress or disturbance. Alternatively, fully dormant small sod fragments can be shallowly tilled into the topsoil layer of the graded floodplain during dormancy in late fall, or they can be incorporated in the final surface grading of topsoil (bulk translocation in earthmoving instead of transplanting) Tilling or grading sod fragments must be followed by recompaction with rollers to avoid desiccation or gaps in root/soil contacts.

Native annual cover crops to stabilize surface soils and compete with invasive species on bare substrate are probably precluded by initial high disturbance (surface flows and wind-waves causing erosion and accretion during flood events) of the newly graded floodplain surface. If native annual cover crops are needed for specific graded floodplain areas, broadcast seeding and surface compaction of the following pioneer species, at an aggregate seed density of approximately 200 seeds/square yard, is recommended: *Bidens frondosa, Cyperus eragrostis, Epilobium ciliatum, Persicara lapathifolia, and Persicaria punctata*.

5.0. Production and harvest of propagation materials on site.

Most native clonal perennial plant species of the floodplain may be required in quantities exceeding typical capacity of native plant nursery container production (and project budgets for propagation). Mass production of wet meadow floodplain species can be performed by the similar agricultural methods used for turfgrass production or perennial pasture of sod-forming species (sod-farming), applied to native clonal sedge, grass, and forb species. Wild-source salvaged divisions or plugs from the project site can be harvested in fall and transplanted to disced, mulched (composted wood chip) silty loams soils, and irrigated with water pumped from the ponds. Locations of on-site native seasonal wetland sod farms could include graded, disced flat areas of suitable silty or clay loam substrate (not compacted stony clay loam or hardpans) bordering the ponds, or weed buffer strips along the roadsides of vineyards bordering the site, if available. Two growing seasons of plugs/divisions planted in fall (October-November) on 1 ft centers, with mulching and irrigation during the growing season (March-October) should yield relatively firm young sods of vigorous rhizome mats. The following dominant pioneer colonizing species are suitable to be grown as farmed native perennial sods with irrigation: Artemisia douglasiana, *Carex barbarae, Juncus balticus, Euthamia occidentalis, Leymus (Elymus) triticoides, L. Xgouldii, Symphyotrichum chilense*.

If freshwater wetland plants are needed for mass production (depending on area and relative elevation of the final floodplain grading plan), they can be directly transplanted to shallow basins excavated below the depth of the summer groundwater table, and planted with wild-salvaged vegetative propagules of *Alisma triviale, Bolboschoenus fluviatalis, Schoenoplectus acutus, S. californicus, and Scirpus microcarpus*. Excavated basins (depth slightly above summer groundwater table, < 0.5 ft) can also be used for seed crop production of native annual cover crops (*Bidens frondosa, Cyperus eragrostis, Epilobium ciliatum, Persicara lapathifolia, and Persicaria punctata*) harvested in bulk by either repeated seed-beating/threshing during seed production, or hay harvest during mid-late seed production stages.

Upland grassland propagules can also be cultivated by open-field farming methods for bulk harvest of seeds, corms (“bulbs”) corm, taproots/crowns, and seed-rich soil inoculum, and vegetative transplants. The same mulched, cultivated row production used for rhizomatous perennial plants can be adapted to production of upland grassland inoculum. Labor-intensive harvest of individual species seed and corms can be substituted with bulk production and fall (dry soil) harvest of the composted wood chips and upper topsoil layers in which annual seed are dispersed locally, and in which corms proliferate. Weed management prior to bulk harvest of soil-mulch inoculum is an essential requirement to minimize inevitable spread of agrestal and wildland weeds present at the site. The inoculum (scraped, harvested mulch and upper soil, removed to depth of observed corm production) is spread and compacted over the final grade of upland soils supporting restored hillslope grassland, oak savannah, or mixed evergreen forest in primary succession stages. Outstanding local native pioneer colonizing annual forbs (needed in high seed density for interference with weeds) include summer annual tarweeds (*Hemizonia congesta ssp. lutescens, H. congesta* ssp. *leucocephala, Madia sativa, M. elegan*s), winter annuals (*Amsinckia menziesii, A. intermedia, Lupinus bicolor, Clarkia gracilis* ssp. *sonomensis,* all locally present along Eastside Road), and weedy summer annuals like *Epilobium brachyantherum*. Dominant corms include *Dichelostemma* spp. and *Tritelea laxa*. Strongly colonial local native hillslope grassland perennials include *Perideridia kelloggii*, *Stipa pulchra*, *Melica californica, Elymus glaucus*, *Agrostis hallii*, and *A. pallens*, all of which would be suitable for cultivation and direct transplanting, or (in part) mass translocation with soil-mulch inoculum during late fall dormancy. Deep taprooted grassland species such as *Wyethia glabra, W. helenoides*, and *W. angustifolia*, though important to establish as abundant populations in upland grasslands, would require direct seeding or transplanting during later successional stages.

6. Irrigation and irrigation alternatives for post-transplant maintenance.

Seasonally flooded riparian areas are highly unlikely to benefit from supplemental irrigation if transplanting and translocation of vegetative stock and sod are performed during dormancy in late fall, before the rainfall and flood season. Rainfall, flooding, and rising groundwater are likely to provide ample moisture to first-year plantings even in relatively dry years. In case of extreme winter droughts during the first year after revegetation, overhead high-pressure jet irrigation systems (mounted on wheeled platforms) used for irrigation and manure slurry fertilizer application in lowland pastures can be applied as an emergency contingency.

Irrigation systems for restoration plantings in extensive, irregular areas of varied upland topography (hillslope grassland, oak woodland) are problematic. Overhead irrigation is indiscriminate, and provides competitive advantage to weeds in upland grasslands of dry Mediterranean climates. Drip irrigation systems are probably feasible only for small areas of relatively dense, regular plantings, because of high infrastructure and labor costs of installation that are not commensurate with the very short-term potential needs for supplemental moisture supplied to native species in restoration plantings. Drip irrigation also imposes risks of soil moisture refugia (invertebrate oases and soft live root production) that attract burrowing mammals, and thus injury risk to sapling roots.

An alternative to irrigation of upland woody plantings is use of temporary brush shelters to reduce evapotranspiration (exposure of transplants to wind and sun). Cut brush cone-shaped shelters can be placed over young tree and shrub saplings that are adequately pruned to adjust root:shoot ratio to favor early root development. Unlike plastic shelters, brush shelters (cut coyote brush) disintegrate within a year, in pace with sapling establishment.

7. **Riparian woodland and scrub**.

Riparian woodland and scrub revegetation would occur in transitional areas if relatively infrequent, shallow flooding in winter and mesic soil with shallow groundwater 1-2 ft or more below ground surface. Riparian woodlands would initially support a seasonal wet meadow/prostrate shrub ground layer vegetation between widely spaced (10-20 ft) transplants of either livewood, stump/rootwad transplants, or container-grown stock trees and shrubs. The ground layer vegetation would be dominated by two species that persist in partial to full understory shade in mature canopy conditions: basket sedge (*Carex barbarae*) and California blackberry (*Rubus ursinus*). Less shade-tolerant ground layer vegetation may be initially established, but should be expected to diminish during succession.

8. **Species diversity and targeted species reintroductions in post-pioneer succession stages.**

The primary aim of revegetation is to establish the matrix of dominant species to support essential ecological processes during early succession stages of floodplain evolution, and to establish a weed-resistant, diverse native pioneer vegetation in uplands. Many native species that are highly desirable or necessary for proper final native plant community diversity in upland and riparian vegetation, but not all can be established in pioneer succession stages. After stabilization and establishment of pioneer vegetation, local habitats suitable for targeted founder populations can be assessed, and species-specific reintroductions can be expediently implemented. Recommended riparian reintroductions of relatively infrequent, slow-dispersing or dispersal-limited seasonal wet meadow and species include: *Apocynum cannabinum* and *A. androsaemifolium* (dogbane), *Helianthus californicus* (California sunflower). *Aristolochia californica* (pipevine) would be suitable for reintroduction after riparian scrub and tree canopies begin to close and develop discrete gaps.

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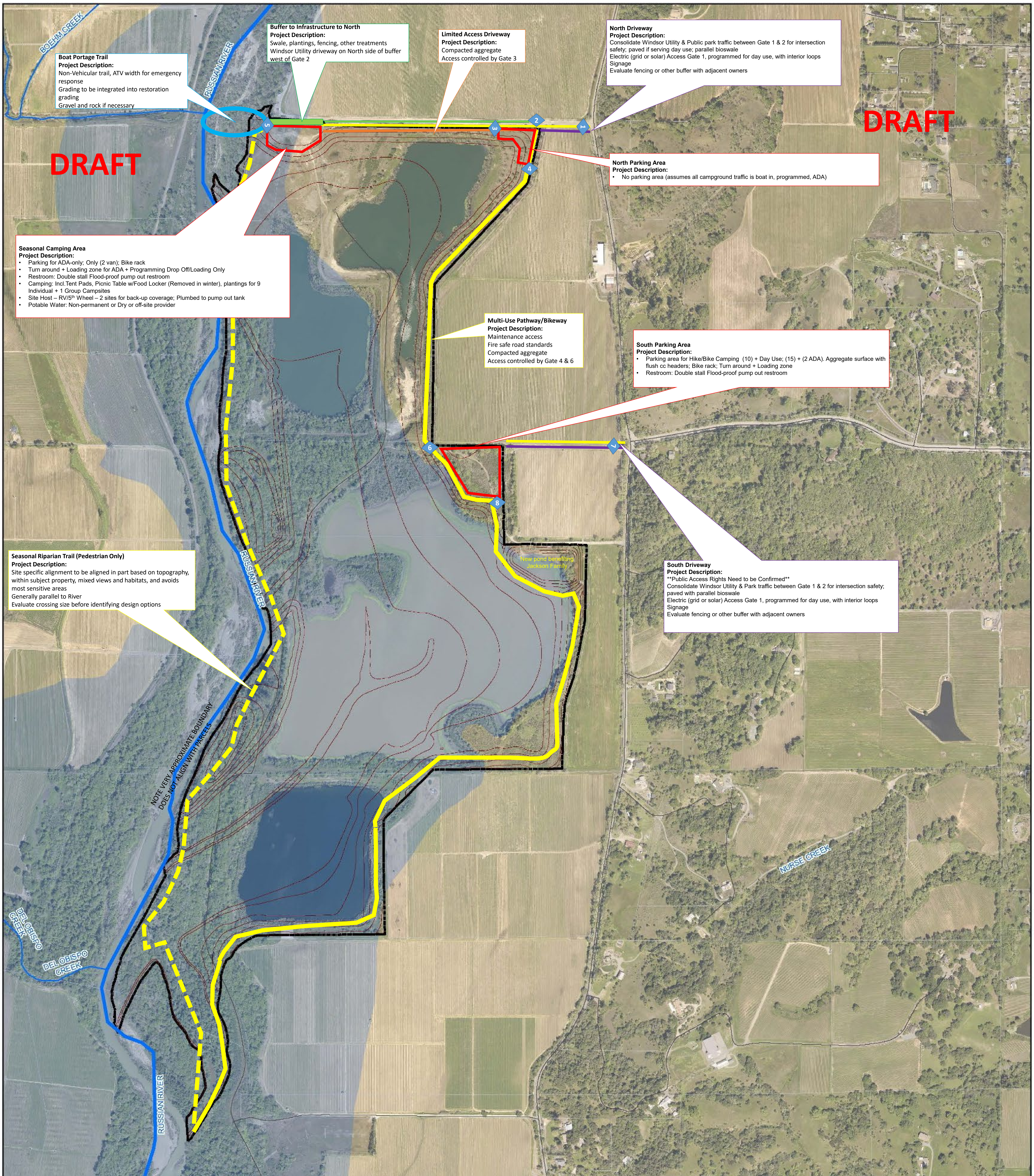
Appendix F
30% Design Plan

Appendix G
Draft Hanson River Park and Trail Design



Boat Portage Trail
Project Description:
Non-Vehicular trail, ATV width for emergency response
Grading to be integrated into restoration grading
Gravel and rock if necessary

Buffer to Infrastructure to North
Project Description:
Swale, plantings, fencing, other treatments
Windsor Utility driveway on North side of buffer west of Gate 2

Limited Access Driveway
Project Description:
Compacted aggregate
Access controlled by Gate 3

North Driveway
Project Description:
Consolidate Windsor Utility & Public park traffic between Gate 1 & 2 for intersection safety; paved if serving day use; parallel bioswale
Electric (grid or solar) Access Gate 1, programmed for day use, with interior loops
Signage
Evaluate fencing or other buffer with adjacent owners

North Parking Area
Project Description:
- No parking area (assumes all campground traffic is boat in, programmed, ADA)

Seasonal Camping Area
Project Description:
- Parking for ADA-only; Only (2 van); Bike rack
- Turn around + Loading zone for ADA + Programming Drop Off/Loading Only
- Restroom: Double stall Flood-proof pump out restroom
- Camping: Incl.Tent Pads, Picnic Table w/Food Locker (Removed in winter), plantings for 9 Individual + 1 Group Campsites
- Site Host – RV/5th Wheel – 2 sites for back-up coverage; Plumbed to pump out tank
- Potable Water: Non-permanent or Dry or off-site provider

Multi-Use Pathway/Bikeway
Project Description:
Maintenance access
Fire safe road standards
Compacted aggregate
Access controlled by Gate 4 & 6

South Parking Area
Project Description:
- Parking area for Hike/Bike Camping (10) + Day Use; (15) + (2 ADA). Aggregate surface with flush cc headers; Bike rack; Turn around + Loading zone
- Restroom: Double stall Flood-proof pump out restroom

Seasonal Riparian Trail (Pedestrian Only)
Project Description:
Site specific alignment to be aligned in part based on topography, within subject property, mixed views and habitats, and avoids most sensitive areas
Generally parallel to River
Evaluate crossing size before identifying design options

South Driveway
Project Description:
Public Access Rights Need to be Confirmed
Consolidate Windsor Utility & Park traffic between Gate 1 & 2 for intersection safety; paved with parallel bioswale
Electric (grid or solar) Access Gate 1, programmed for day use, with interior loops
Signage
Evaluate fencing or other buffer with adjacent owners

Hanson Public Access and Park Vision
Sonoma County Regional Parks

DRAFT 10/5/2020

Appendix H
Opinion of Probable Cost

Hanson Ponds Russian River Floodplain Restoration Project: 30% Design

Planning Level Opinion of Probable Construction Cost

December 2020

No.	*Item Description*	*Quantity*	*Unit*	*Unit Cost*	*Cost*	*Cost +30% Contingency*
1	Mobilization and Demobilization (Estimated Approx. 4% of Subtotal)	1	LS	$ 1,500,000	$ 1,500,000	$ 1,950,000
2	Water Management, Dust/Erosion Control, and Env. Protection	1	LS	$ 5,000,000	$ 5,000,000	$ 6,500,000
3	Construction Survey Staking	1	LS	$ 500,000	$ 500,000	$ 650,000
4	Clearing, Grubbing, Mulching/Salvage Vegetation	160	AC	$ 20,000	$ 3,200,000	$ 4,160,000
5	Excavation, Hauling and Backfill	4,700,000	CY	$ 4	$ 18,800,000	$ 24,440,000
6	Habitat Elements (LWD/Boulder Stuctures)	1	LS	$ 3,000,000	$ 3,000,000	$ 3,900,000
7	Re-vegetation (H.T. Harvey Estimate $3.5M - $7M)	1	LS	$ 5,000,000	$ 5,000,000	$ 6,500,000
	TOTAL PLANNING LEVEL OPINION OF PROBABLE CONSTRUCTION COST RANGE:				**$ 37,000,000**	**$ 48,100,000**

NOTE: This opinion reflects probable construction costs obtainable for the project location on the date this estimate was prepared. Due to inflation of labor, material and equipment costs and nature of contruction cost volitility, prices may vary.

about GHD

GHD is one of the world's leading professional services companies operating in the global markets of water, energy and resources, environment, property and buildings, and transportation. We provide engineering, environmental, and construction services to private and public sector clients.

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