Young Armos
Habitat Restoration & Incubator Farm Project
Draft Feasibility Analysis Report
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SONOMA COUNTY
AGRICULTURAL PRESERVATION
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1 Introduction

The Sonoma County Agricultural Preservation and Open Space District (District) is proposing to restore seasonal wetland and upland habitat in conjunction with the creation of an incubator farm on the 45-acre Young Armos property on the outskirts of Rohnert Park, Sonoma County. The goal of the restoration is to improve habitat conditions for listed species, including California tiger salamander (CTS; *Ambystoma californiense*) if feasible, within the Santa Rosa Plain while also providing land for new farmers to learn best practices. The goal of the project is also to demonstrate the compatibility of managing land for sensitive species with responsible farming practices. Prunuske Chatham, Inc. (PCI) has been asked by the District to begin the restoration planning process and help support the site plan development.

This report is a summary of an initial habitat restoration feasibility analysis and a background soil study completed by RGH Consultants. The analysis included a background biological review of listed Santa Rosa Plain species and habitat requirements, a topographic survey and analysis, evaluation of the soils and geology on the property, and hydrology and hydraulics analysis of the drainage ditches, fields, and future farm use areas. The primary focus of the evaluation was to determine if sufficient water is available and suitable site characteristics exist to support creation of CTS breeding ponds, although the evaluation also included an assessment of the suitability of the soils for use in plan development of the farm access road, the parking areas, and the future structures. The findings are presented throughout this report along with a conceptual design footprint for the CTS habitat restoration areas based on the results of the biology, hydrology, soils, and topographic analyses. An evaluation of the regulatory compliance needs is also included.

2 Property Description

2.1 Overview

The Young Armos property is located along the northeastern edge of the City of Rohnert Park, east of Highway 101 and immediately west of Snyder Lane in Sonoma County (Figure 1). The 45-acre parcel is located at 4315 Snyder Lane (APN 045-163-045) and is held in fee title by the District. Site elevations range from approximately 103 to 112' above sea level traversing from the west to the east on the property.

The property is essentially flat, with a large wetland depression in the east half near Snyder Lane and numerous wetland depressions on the western half of the property. (See below.) The site is just north of Wilfred Creek, which forms the southern border of the property with the densely urbanized City of Rohnert Park. The long and narrow property is traversed on the east side by Warrington Creek, running roughly north-south across the property. A second channelized drainage ditch located west of Warrington Creek also traverses the property in a north-south direction.

Most of the property has been farmed in the past, and as a result, the property currently has very little natural vegetation remaining. The general habitat type and plant community observed at the site consists mostly of ruderal annual grasslands. A single mature oak tree exists on the west side of the property, and scattered native coyote brush shrubs occur on the southwest portion of the site.

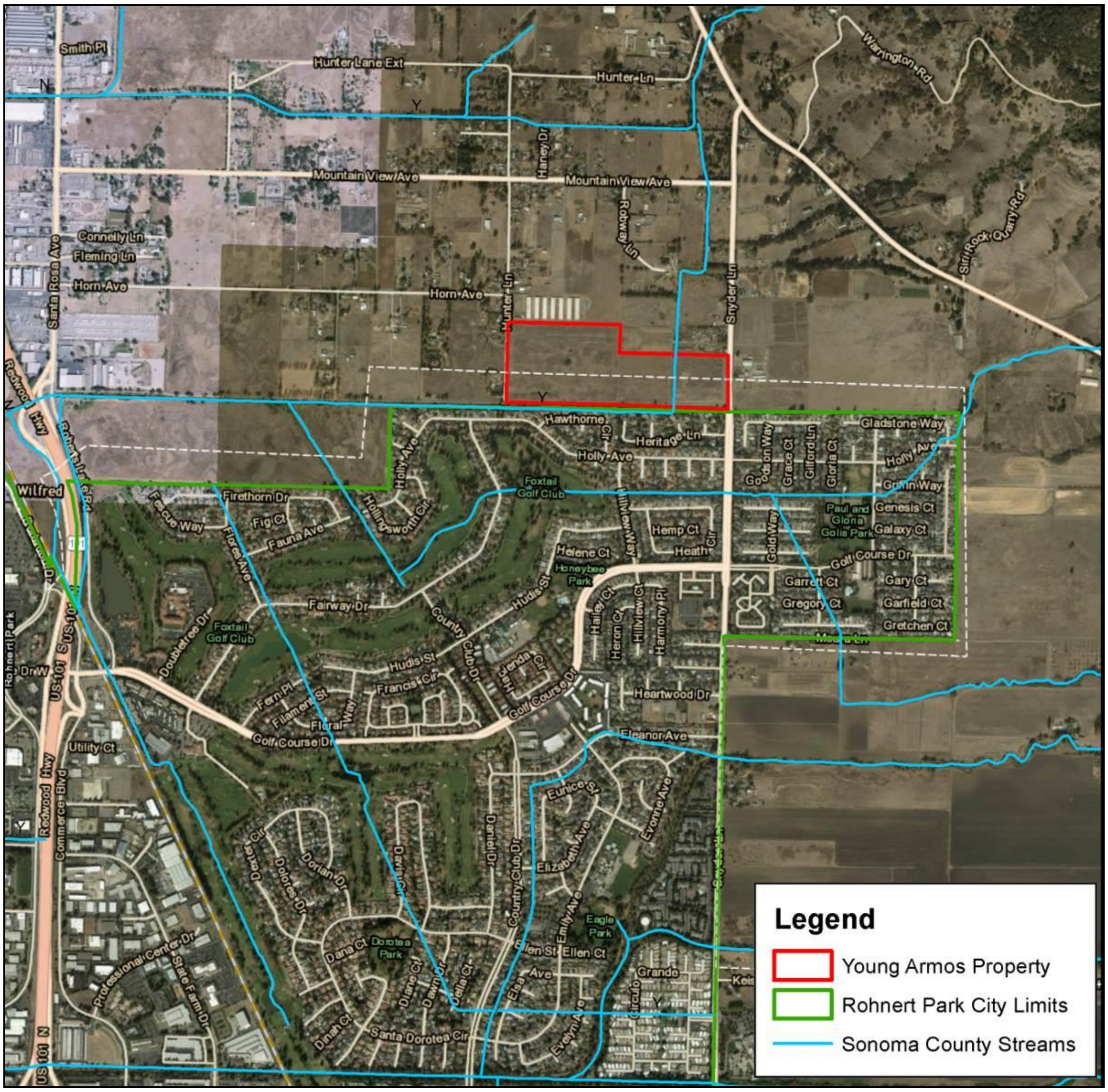

Figure 1. Young Armos property location map.

2.2 Watershed and Hydrology

The property is situated at the southern limits of the Santa Rosa Plain, the low-lying lands of central Sonoma County which extend south and west to the Laguna de Santa Rosa, east to the foothills, and north to the Russian River. As noted above, Warrington Creek and an unnamed drainage channel traverse the property. The drainages on the property have been channelized and show evidence of long-term dredging which likely has been done to reduce flooding (Macmillian 2013). Both channels drain south into Wilfred Creek (aka Wilfred Flood Control Channel). Wilfred Creek flows into the Bellevue-Wilfred Channel on the west side of Highway 101. The Bellevue-Wilfred Channel ultimately drains into the Laguna de Santa Rosa.

The Sonoma County Water Agency (SCWA) owns the Wilfred Flood Control Channel, and they hold an easement on Warrington Creek on two properties north of Young Armos; they manage both channels for flood control purposes (SCWA 2009). Some of the streamflows originating on the western slope of Sonoma Mountain enter Hunter Creek which flows into Warrington Creek and the unnamed drainage channel. Warrington Creek drains approximately 18 acres, and the unnamed channel drains approximately 24 acres, a portion of which includes the Young Armos property. The channels are approximately 2' wide and between 6" to 1' deep.

Four seasonal wetlands are present on the Young Armos property (Macmillian 2013). The areas are shallow depressions or lower areas that become saturated during the wetter times of the year and appear to stay wet during the annual growing season. The seasonal wetlands are dominated by Italian rye grass and curly dock, and they range in size from 0.04 acre to 2.13 acres and cover 3.36 acres on the property (Macmillian 2013). The soils, hydrology, and soils conditions indicate that these seasonal wetlands meet the jurisdictional criteria that make them subject to the U.S. Army Corps of Engineers (Corps) and Regional Water Quality Control Board (RWQCB) jurisdiction. (See Regulatory Compliance below.)

2.3 Surrounding Land Uses

The Young Armos property is bordered by residential development, privately-owned agricultural lands, mixed use parcels, residential, and undeveloped open space. The City of Rohnert Park's Neighborhood H and the Foxtail Golf Club lie to the south of the property across the City's North Rohnert Park Trail and SCWA's Wilfred Flood Control Channel. Parcels surrounding the Young Armos property to the north and east include privately-owned agricultural lands used for farming, pasture, and poultry production. Several large residential properties are located along Hunter Lane west of the property, and further west from the residential parcels is the Horn Avenue Mitigation Bank. The District owns the Oken property further to the east of Snyder Lane.

3 Listed Species & Habitat Design Considerations

The Santa Rosa Plain was once an extensive network of seasonal vernal pools and wetlands intermixed within open grassland and oak savannah habitats. However, urban and rural growth of the Plain over the past one hundred years has greatly diminished the extent of natural habitats. As a result, the Plain supports only remnant populations of several federally listed species that were historically much more widespread and abundant on the Plain. These include, but are not limited to, federally endangered and state threatened California tiger salamander—Sonoma County distinct population segment and federally listed vernal pool plants—Sonoma sunshine (*Blemnosperma bakeri*), Burke's goldfields (*Lasthenia burkei*), and Sebastopol meadowfoam (*Limnanthes vinculans*). All four of these species are part of a regional recovery effort described in U.S. Fish and Wildlife Service's Santa Rosa Plain Conservation Strategy (Conservation Strategy; USFWS 2005) and Draft Recovery Plan for the Santa Rosa Plain (Recovery Plan; USFWS 2014).

The primary objective of PCI's analysis was to evaluate the feasibility of creating viable CTS habitat. However, CTS often occur concurrently with these above-mentioned vernal pool plants. Therefore, the following section provides a brief life history overview and local occurrence information for the four vernal pool species for which habitat restoration could be feasible on the property. Species specific design considerations and establishment information are also described.

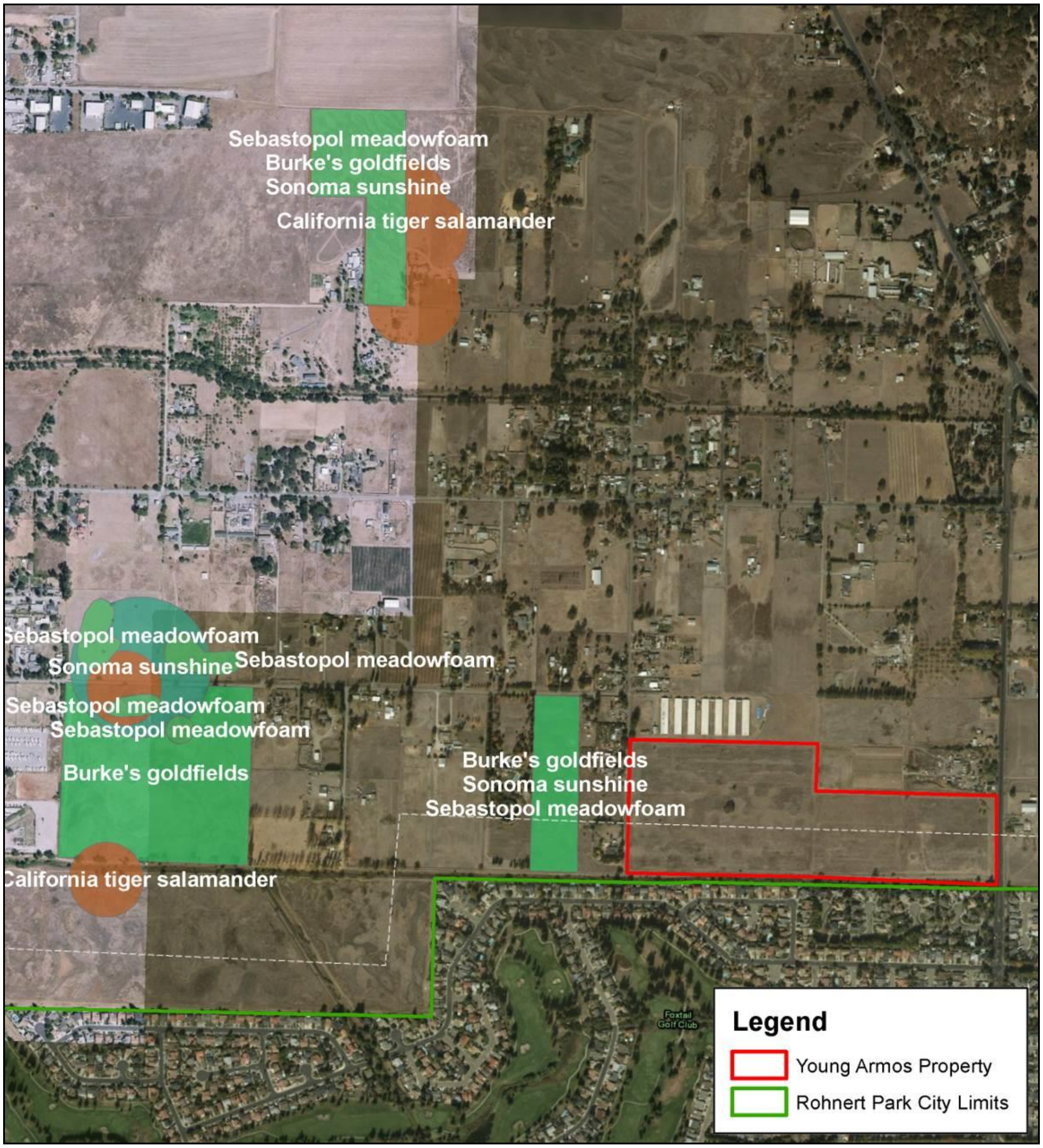

Figure 2. Reported occurrences of Santa Rosa Plain listed species.

(Source: CDFW 2015)

3.1 California Tiger Salamander

Life History Overview

California tiger salamanders spend the majority of their lives underground where they take up residence in primarily small mammal burrows. Adults emerge from underground burrows with the onset of winter rains and migrate to breeding sites. Breeding occurs in ponds and vernal pools, typically between November and January in Sonoma County (Cook et al. 2005). Adults remain at the breeding pools for several days to weeks and then travel back to their upland habitats during or shortly after rain events. All movements occur at night; this along with their underground habits make CTS a particularly elusive species. CTS eggs hatch after approximately 2 weeks. CTS larvae develop in pools over a period of several months. Emergence from pools occurs as early as March or April (Cook et al. 2005). Pools that remain inundated throughout winter and into spring and early summer are vital to aquatic larval development. California tiger salamanders can undertake long-distant migrations. Although the majority of salamanders disperse within 0.5 miles of their breeding sites, some individuals have been documented traveling much further distances—0.75 to 1.3 miles. As a result, CTS require a relatively larger buffer area around breeding pools to support aestivation and movement.

Occurrence Information

Sonoma County's California tiger salamander occurs exclusively in the county and is isolated from all other populations in the state. Historically, their habitat included 100,000 acres within the Plain and Petaluma lowlands. The current range is 18,000 to 20,000 acres of fragmented habitat focused in southwest Santa Rosa and south Cotati (USFWS 2014).

According to the Recovery Plan, the Young Armos property is located within the Horn Hunter Management Area (HHMA); this includes one of four bounded management areas that have been identified as possible areas for CTS restoration (USFWS 2014). The HHMA represents the southern limits of CTS occurrence to the east of Highway 101 and north of Rohnert Park, and CTS are well documented in the area.

In the winter of 2009-2010, CTS pitfall traps were installed at the nearby Horn Avenue Mitigation Bank (less than one mile from the property). During a three-day period, over 100 individuals were captured (Monk 2010). As part of the same survey effort, spring larval surveys were completed and larvae were found in 50% of the pools sampled (Monk 2010). The CNDDB also reports more recent sightings of an adult and juvenile capture in pitfall traps 0.7 miles to the west of the property in 2014 (CDFW 2015).

3.2 California Tiger Salamander: Potential for Establishment and Design Considerations

In assessing the feasibility of creating viable habitat for California tiger salamander on the Young Armos property, PCI reviewed the specific habitat requirements and known design criteria for the species. The following section summarizes the habitat elements necessary for success breeding and aestivation and likelihood of establishment. This information is based on published CTS resource studies, life history information, management recommendations, and an interview with local CTS expert Dave Cook (Cook 2015; Cook et al. 2005 and 2006; Ford et al. 2013; PRMS 2013; USFWS 2005 and 2014). CTS design considerations include:

Inundation Period

- Breeding sites should remain inundated until mid-April to early-May (similar to those successful breeding sites in Sonoma County; Cook 2015). Pools must dry to reduce predation.

Vegetation

- Typical breeding pools are free of emergent vegetation. Optimal breeding pools support 0-5% cover of emergent vegetation and no more than 35%. Higher percentages of emergent vegetation may support more predatory aquatic insects. CTS can do well in pools with minimal or abundant submerged vegetation.

Water Depths and Pool Size

- Both deep and shallow breeding ponds are used by CTS. Deeper ponds stay inundated longer. Deeper areas are needed if the water is clear or unvegetated to avoid predators. Shallow ponds promote faster larval development and metamorphosis, as long as they stay inundated.
- Sloped or benched side slopes can provide habitat complexity as pools begin to dry.
- Minimum water depths required to initiate breeding varies by year, but ranges from approximate 2 to 4' (Cook et al. 2006). Cook describes pools from 7" to just over 3.5' as supporting CTS breeding in Sonoma County, with 3' pools being the most reliably successful, 17" being the average maximum depth for pools that support breeding, and 16-32" being optimal (Cook et al. 2005). Deeper pools are more likely to be occupied in most years.
- Pools should have surface areas on the order or 0.25 acres or more.

Water Quality

- Pools with moderate to high levels of turbidity are more likely to be occupied (median NTU of 33.5). Higher turbidity levels help CTS avoid predation.
- High nutrient levels have been linked to disease and deformation as a result of eutrophication and depleted oxygen levels.
- CTS die-off can occur in pools with pesticide contamination or perhaps other water quality impairments.
- If pools are shallow and unvegetated, turbidity is particularly important.
- See *Livestock Grazing* below.

Mosquito Control

- CTS readily consume mosquito larvae and are an effective means for control. However, if there are any local concerns about the effects of creating CTS ponds and the presence of mosquitos, additional information may be needed.

Livestock Grazing

- Grazing can be an important tool in maintaining minimal levels of emergent vegetation. Livestock presence can increase pond turbidity (good) and raise nutrient levels to support algal food base for CTS.

Non-breeding Habitat

- Grassland and savannah habitats with abundant mammal burrows are needed for aestivation habitat during the non-breeding season. CTS use ground squirrel and pocket gophers burrows. Shrub and forests areas can pose as barriers to movement and reduce burrowing habitat; open habitat areas should be maintained.

Predator Considerations

- CTS are preyed upon by a number of aquatic and terrestrial species. Non-native crayfish and bullfrogs are of particular concern in the Plain. Successful breeding is also not compatible with the presence of fish. The adjacent Wilfred Creek is likely to support crayfish and bullfrogs. Created wetland features should not include direct connections to the channel; an outlet swale is preferred. Crayfish will follow any water source to colonize new habitats. Drying out any created wetlands will reduce bullfrog use.
- Pools should be isolated from fish-bearing/aquatic predator habitats.

Preserve Size

- At a breeding site, a complex of 3 or more pools is needed for CTS persistence each year (all suitable breeding pools are not occupied in all years); 4 to 9 pools are preferred. Single pools are not sustainable. The optimal preserve is 500 acres with three, approximate 100' radius pools distributed linearly.
- A terrestrial habitat buffer of 2,066' around breeding pools is needed to support movement and dispersal.

Establishment

- The Young Armos property is within the range of CTS and within suitable colonization distance from occupied habitat (less than 1.3 miles). Given the large population size of the Horn/Hunter Lane area and long-migration distances this species is capable of, CTS colonization of the property is likely over time.
- Creation of CTS habitat on the property could also facilitate occupancy at the southern edge of their range per the draft Recovery Plan.
- Habitat creation on the property warrants more careful analysis of impediments to movement onto the site (e.g., physical barriers, drainage crossings, road crossing and vehicle mortality).

3.3 Sonoma Sunshine

Biology
Sonoma sunshine occurs in vernal pools, along swales between pools, and seasonally wet grasslands at elevations ranging from 30 to 330' (USFWS 2014). It typically grows in shallow pools (12 to 20") along the upper margins. It is an annual plant in the sunflower family. Sonoma sunshine forms butter-yellow daisy-like flowers which typically bloom in March and April. Plants are typically less than 12" tall. It likely forms a persistent soil seed bank, and therefore, it can remain dormant during years with unfavorable conditions. It typically occurs on Huichica, Wright loam or Clear Lake clay soils, where a clay restricting layer occurs 2-3' below the surface.

Occurrence Information
This species is known only in Sonoma County. It is documented to the west of the Young Armos property, less than 0.1 mile, at the Horn Avenue Mitigation Bank. Plants were last documented and reported to the CNDDB in 2011 when over 1,000 plants were observed (CDFW 2015).

3.4 Burke's Goldfields

Biology
Burke's goldfields grow in vernal pools and swales in grassland and oak woodlands at elevations below 984' (USFWS 2014). The species typically grows in pool bottoms in depths of 10 to 20", with pool surface areas ranging from 20 square feet to a half-acre in size. In Sonoma County, it typically occurs in level or slightly sloping clay, clay loams, and loam soils. It typically occurs on Huichica, Wright loam or Clear Lake clay soils, where a clay restricting layer occurs 2-3' below the surface. It is an annual plant in the sunflower family. Burke's goldfields form yellow daisy-like flowers which bloom from April to June. Plants can range in height from 5 to 24".

Occurrence Information
This species is endemic to the California Coast Range with the core of its range occurring in the Santa Rosa Plain. Like Sonoma sunshine, it is documented to the west of the Young Armos property, less than 0.1 mile, on the Horn Avenue Mitigation Bank. Plants were last documented and reported to the CNDDB in 2011 when over 1,200 plants were observed (CDFW 2015).

3.5 Sebastopol Meadowfoam

Biology
Sebastopol meadowfoam grows in vernal pools and swales, wet meadows, and ditches (USFWS 2014). It typically grows in pools and swales with depths of 6" to 12", but sometimes occurs in pools up to 18 to 20". Shallowly sloped pool margins and the

swales that often connect pools frequently provide good habitat. The typical inundation period where meadowfoam occurs is mid-December through mid-March. In Sonoma County, it typically occurs on Wright loam or Clear Lake clay soils. It is an annual plant in the falsemeadow family. Sebastopol meadowfoam forms weak, decumbent stems up to 12” long and bears white flowers from April to May. Seeds germinate in fall with the first significant rains.

Occurrence Information

Sebastopol meadowfoam is known only in Sonoma and Napa counties. Sebastopol meadowfoam was documented on the Young Armos property in April 2000 (LSA 2001). Fewer than 10 plants were documented in an approximately 22 square foot area at the southwest corner of the property. Sebastopol meadowfoam is also known to occur to the west of the property, less than 0.1 mile, on the Horn Avenue Mitigation Bank. Plants were last documented and reported to the CNDDB in 2011 when over 9,000 plants were observed (CDFW 2015).

3.6 Special-Status Vernal Pool Plant Species: Potential for Establishment and Design Considerations

There appears to be strong potential for establishing Sonoma sunshine and Burke’s goldfields, and for enhancing or re-establishing the Sebastopol meadowfoam population on the Young Armos property given the following site conditions:

- existing pool topography on the Young-Armos site and evidence of additional pools and swales historically
- suitable soil types and potential for suitable hydrology
- known occurrence of Sebastopol meadowfoam on the site. The three species do not always occur together, but they share many habitat requirements and can occur together, especially if pool topography is diverse, with varied microhabitat for different inundation requirements.
- close proximity of the property to recently documented occurrences of all three species at the Horn Avenue Mitigation Bank

If wetlands are created and restored, it is possible, but not likely, that natural colonization could occur from nearby occurrences. These species are thought to be very limited in their typical dispersal range. Mechanisms for dispersal beyond a plant’s immediate pool location may include water flow or transfer by wildlife. Since there is no direct hydrologic connection with existing populations, and extent of wildlife-facilitated dispersal is unknown but probably low, inoculating the site with seed and/or soil from an existing local occurrence has much greater potential for establishing the species on site. Collecting inoculum and seed from an existing occurrence will require regulatory approvals, including incidental take permits from USFWS and CDFW, and permission from a landowner to collect. Careful consideration would be required to evaluate the effects of reintroduction on plant population genetics and to avoid impacts on existing populations.

In addition to meeting the habitat requirements described above, design considerations for supporting the establishment or enhancement of these species include:

Inundation Period

- Inundation regimes for these species vary, but typically, pools are frequently or continuously inundated from early winter through early spring (approximately December through March).

Water Depths and Pool Size

- Shallow pools and/or gently sloped pool and swale margins typically provide the best, and most extensive, habitat for these species. Among the three, Sebastopol meadowfoam can occupy the deepest areas, while Burke's goldfields typically occur in the shallowest, and Sonoma sunshine is intermediate. The complex pool shapes that are characteristic of naturally-occurring vernal pools on the Plain typically provide more of this valuable edge habitat than simple, steep-sided, round-shaped created pools.

Vegetation and Water Quality

- High non-native plant cover and algal mat cover are generally detrimental to these species. These conditions often result from high nutrient levels in soil or runoff, which is often related to past or ongoing adjacent agricultural uses. Preventing inflow of high-nutrient water and removal of high-nutrient soil layers during pool creation or enhancement—where no native seedbank is present—can help support these plants.

Livestock Grazing

- Carefully managed cattle grazing can help reduce non-native annual grass populations, which can compete with these species in a fertile setting like this. Cattle tend to preferentially graze on grasses rather than forbs, if both are readily available. However, grazing must be closely managed; heavy grazing is likely to be detrimental; and grazing would not be recommended until pool vegetation is well-established.

4 Geotechnical Study Summary

RGH Consultants completed a geotechnical study of the Young Armos property which included reviewing selected geologic data pertinent to the site, evaluating subsurface conditions with borings, installation of vibratory wire line piezometers, laboratory testing, and analysis of field and laboratory data. Below is summary of the primary findings of their study. The complete report is provided as an attachment.

In July 2015, a geotechnical reconnaissance survey of the site was conducted and the subsurface conditions were explored by drilling seven borings to depths ranging from 5 to 17’. Undisturbed samples were obtained from the borings to determine the material encountered, soil characteristics, and groundwater conditions.

Published geologic maps indicate the property is underlain by Holocene alluvial fan deposits (Qhf) and alluvial fan deposits, fine facies (Qhff). Qhf comprises alluvial fan sediment deposited by streams emanating from mountain drainages onto alluvial valleys. These deposits are composed of moderately to poorly sorted sand, gravel, silt, and clay. Qhff comprises fine-grained alluvial fan and floodplain overbank deposits on very gently sloping portions of the valley floor. These deposits are composed of predominantly clay with interbedded lenses of coarser alluvium.

The property extends primarily over flat terrain. Natural drainage on the property consists of sheet flow over the ground surface that concentrates in man-made surface drainage elements such as roadside ditches, canals, and natural drainage elements such as swales and creeks.

In general, the ground surface is moderately hard. However, soils in the area that appear hard and strong when dry will typically lose strength rapidly and settle under the loads of fills, foundations, and slabs as their moisture content increases and approaches saturation. This typically occurs because the surface soils are weak, porous, and compressible. The surface soils are disturbed by randomly arrayed shrinkage cracks generally associated with expansive soils. Locally, expansive soils shrink and swell with the weather cycle (see below). The cyclic shrinking and swelling tends to disturb the upper portion of the expansive clay.

Borings and laboratory tests indicate that the portion of the property studied is blanketed by 2 to 3’ of weak, porous, compressible, clayey soils. Porous soils appear hard and strong when dry but become weak and compressible as their moisture content increases towards saturation. These soils exhibit medium plasticity and medium expansion potential, and are disturbed by shrinkage cracks that extend 2 to 3’ below the ground surface. The surface soil is typically underlain by clay with varying amounts of sand with layers of clayey sand to the maximum depth explored (17’).

Permeability rates, the ability of water to move through soil, were also tested. Rates were determined to be very slow (2.83 to 3.333 x 10 (-7) cm/sec). These results indicate that on-site materials would qualify as clay liner for wastewater ponds.

Free groundwater was first detected in two of seven borings at depths ranging from 10 to 11' below the ground surface at the time of drilling. When the holes were backfilled after drilling was completed, the water level had risen to depths ranging from about 8½ to 10'. Fluctuation in the groundwater level typically occurs because of a variation in rainfall intensity, duration, and other factors such as flooding and periodic irrigation. Vibrating wire line piezometers were installed at borings to allow for continuous groundwater depth monitoring over time. The vibrating wire line piezometers are designed to take readings every hour. The first set of readings will be the lowest groundwater that will likely be detected at the site because of the serious lack of rain during the extended drought. The first data download will occur in October.

Soil samples collected on the property were analyzed by Environmental Technical Services (ETS) to determine suitability for farming and current nutrient content. Testing results indicate several problems with the soil (e.g., low nutrient levels, high acidity, excess salinity, high sodium). ETS recommends amendment of the soil with organic fertilizers, conditioners, and organic matter as prescribed in the attached ETS report.

Additional information on the borings, seismic hazards, geotechnical issues, seismic design, grading, site development, and drainage are provided in the attached RGH report.

5 Hydrology

A hydrologic analysis was conducted to determine the quantity of water available from the two channels that pass through the property (West Swale and Warrington Creek), the wetland area near the west of the site, and from future structures and parking areas along the eastern edge of the property (Figure 3). The primary focus of the analysis is to determine if there is sufficient water and suitable site characteristics to support creation of CTS breeding pools based on known habitat requirements.

Figure 3. Watershed map showing watershed delineations (red lines).

Elements of the project design that convey water, including swales, weirs, pipes and gravel lenses will be sized to convey certain peak flows or design storms. These peak flows were determined using the Rational Method as defined in the SCWA's flood control manual (SCWA 1999).

The Rational Method uses the equation: $Q = K * C * I * A$

where: Q = Peak Flow Rate (cubic feet/second)
K = Rainfall Coefficient (unitless)
C = Runoff Coefficient (unitless)
I = Rainfall Intensity (inches/hour)
A = Drainage Area (acres)

The rainfall coefficient, K, is based on mean seasonal precipitation in Santa Rosa. The runoff coefficient, C, is determined using the average ground slope of the project site and a runoff curve for parks and vegetated areas. Rainfall intensity, I, is based on time of concentration for each drainage and statistical rainfall data compiled by the National Oceanic and Atmospheric Administration (NOAA 2015). Peak flow rates were determined for the 1-, 1.5-, 2-, 5-, 10-, and 100-year recurrence interval storms (Table 1).

Table 1. Peak flow rates for each drainage area.

Drainage	k	C	Drainage Area, ac	Peak Flow (cfs) Q_1	$Q_{1.5}$	Q_2	Q_5	Q_{10}	Q_{100}
West Swale	1.1	0.31	24	6.2	6.6	6.9	7.9	8.7	12.2
Warrington Ck	1.1	0.31	18	5.3	5.6	5.8	6.7	7.4	10.4
Wetland Area	1.1	0.31	4.4	1.4	1.5	1.5	1.8	2.0	2.8
Structures/Parking Area	1.1	0.95	0.60	0.69	0.73	0.76	0.87	1.0	1.4

The net volume of water available for pond development was determined using the Soil Conservation Service (SCS) curve number method as described in the NRCS engineering field manual (NRCS 1973). Average monthly net runoff is calculated using aerial rainfall for the site minus losses from interception, infiltration, depression storage, evaporation, and antecedent runoff conditions. These losses are taken into account using the NRCS curve number, CN, which is chosen by defining land cover/quality, and soil type. Because this analysis is investigating monthly cumulative runoff, depression storage is assumed to eventually contribute to runoff in the course of each month and is assumed to be zero. Average monthly precipitation data for Santa Rosa were taken from the California Data Exchange Center (http://cdec.water.ca.gov/) (Table 2).

Table 2. Gross average monthly rainfall data and net average runoff volumes for each site.

				Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
				Gross Average Monthly Rainfall, in											
	HSG	Drainage Area, ac	CN	**1.7**	**3.4**	**5.3**	**6.3**	**4.8**	**3.7**	**2.2**	**0.71**	**0.28**	**0.06**	**0.11**	**0.28**
				Net Average Runoff Volume by Month, ac-ft											
West Swale	C/D	23.7	75	2.1	5.4	9.2	11	8.2	6.1	3.2	0.15	0.0	0.0	0.0	0.0
Warrington	C/D	18.2	76	1.6	4.1	7.0	8.6	6.2	4.6	2.4	0.07	0.0	0.0	0.0	0.0
Wetland Drainage	D	4.4	80	0.45	1.1	1.7	2.1	1.6	1.2	0.63	0.08	0.0	0.0	0.0	0.0
Structures/Parking Area	Paved	0.60	98	0.08	0.17	0.26	0.31	0.24	0.18	0.11	0.03	0.01	0.0	0.0	0.01

Because monthly rainfall data has significant variation from year to year, the actual monthly runoff volumes may vary significantly from the values shown. These runoff volumes are only meant to provide for a feasibility level of design. Weather extremes, which may become more typical with the changing climate, may produce drastically different results. To simulate drier years, the analysis above was repeated using 50% of average rainfall values (Table 3).

Table 3. Net average runoff volumes for drainage area based on 50% average monthly rainfall data.

	HSG	Drainage Area, ac	CN	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
				Gross Monthly Rainfall, in											
				0.86	**1.685**	**2.635**	**3.165**	**2.38**	**1.865**	**1.115**	**0.355**	**0.14**	**0.03**	**0.055**	**0.14**
				Average Net Runoff by Month, in											
West Swale	C/D	23.70	75	0.45	2.1	4.0	5.0	3.5	2.4	0.95	0.0	0.0	0.0	0.0	0.0
Warrington	C/D	18.20	76	0.29	1.5	3.0	3.8	2.6	1.8	0.68	0.0	0.0	0.0	0.0	0.0
Wetland Drainage	D	4.40	80	0.13	0.43	0.78	0.98	0.69	0.50	0.23	0.0	0.0	0.0	0.0	0.0
Structures/Parking Area	Paved	0.60	98	0.04	0.08	0.13	0.16	0.12	0.09	0.05	0.02	0.0	0.0	0.0	0.0

6 Concept Design

The primary objective of this investigation is to evaluate the feasibility of creating viable CTS habitat. CTS specific design considerations are described in Section 3.2. Critical design considerations used to determine feasibility in this phase include:

- Pond inundation period at least until early May, with pools going completely dry by the end of summer.
- Optimal maximum water depths between 16" to 32" with a variety of depths.
- Pond surface area of 0.25 acres or more.
- Pond isolation from other fish-bearing/aquatic predator habitats.
- Pond groupings with 3 or more isolated ponds.

Using these considerations, a concept design was developed to provide a conceptual level "footprint" of potential CTS habitat and wetland restoration areas (Figure 4). The principle core of the concept was to use the layout of the project area and site drainage to create new or enhance existing areas that are suitable for CTS breeding habitat. Additional considerations were taken to incorporate elements of the future development of the site as an incubator farm. The concept design has three main elements:

1. Development of new CTS ponds using existing site hydrology in areas where pond development is feasible.
2. Modification of swales/drainage channels to spread out and route storm water into critical areas for enhancement of existing wetland habitat.
3. Creation of a new pond to function as both a CTS pond as well as stormwater detention for future development of structures and parking areas.

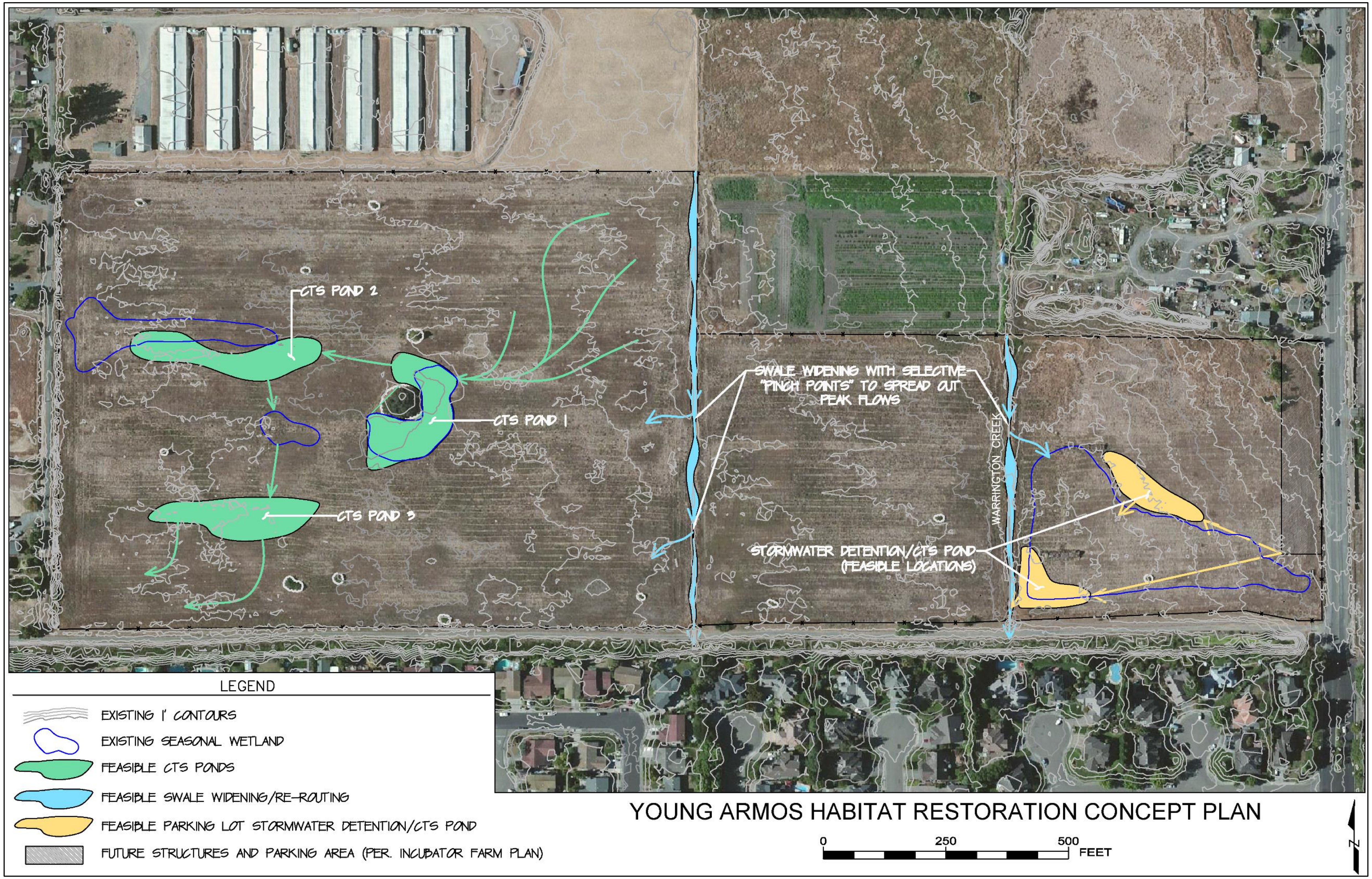

Figure 4. Young Armos concept plan.

6.1 CTS Ponds

A water balance analysis was used to investigate the relationship between inflow, storage, and outflow for a series of potential design ponds. The water balance compares all hydrologic inputs and outputs in a given pond to determine potential storage volumes throughout the year. A typical pond geometry was assumed with 5:1 (horizontal: vertical) side slopes and a flat bottom. The water balance uses the equation:

$$\Delta S = Q_{in} - Q_{out} - GW - ET$$

where:
- ΔS = change in pond storage
- Q_{in} = surface water into pond
- Q_{out} = surface water out of pond
- GW = groundwater interchange
- ET = pond surface evaporation

The surface water into the pond was determined using the watershed area labeled Wetland Area in Figure 3. To account for dryer years, the water supply into the pond was based on 50% average rainfall data. A geotechnical investigation of the site determined that the soil is highly impermeable, see Section 4, Geotechnical Study Summary. Although the site may have high groundwater during the winter that may actually contribute to pond storage, during that time the pond is likely full and the inflow would only contribute to slightly more runoff. This investigation is more concerned with the pond's response during the summer months and as such, groundwater interchange was assumed to be a constant loss of 3.0x10-7cm/sec. Evapotranspiration data was taken from the California Department of Water Resources CIMIS database for Santa Rosa (http://www.cimis.water.ca.gov/). Pond evaporation was assumed to be 70% of evapotranspiration.

The feasibility level concept plan includes a series of three CTS ponds. CTS Pond #1 is located in an existing depression surrounding the large oak tree on the western portion of the property. The existing depression encompasses an approximate area of 0.57 acres. Ponds #2 and #3 are to the west of Pond #1 and were designed with a full pond surface area of 0.5 acres. The maximum depth of these ponds varies from 22" at Pond #1 to 15" at Pond #3. These depths are in the lower vicinity of optimal max water depth for CTS habitat and were set to ensure that the ponds completely dry out by the end of summer. Because the ponds are in a series, the outflow from Pond #1 becomes inflow to Pond #2 and subsequently Pond #3.

Results from the water balance indicate that Pond #1 begins to fill in October, is completely full from December through April, and is empty by August. Pond #2 begins to fill in December, is completely full from January through March, and is empty by August. Pond #3 begins to fill in December, is completely full from February through March, and is empty by July (Figure 5). For further information, see that attached water balance calculations worksheets at the end of this report.

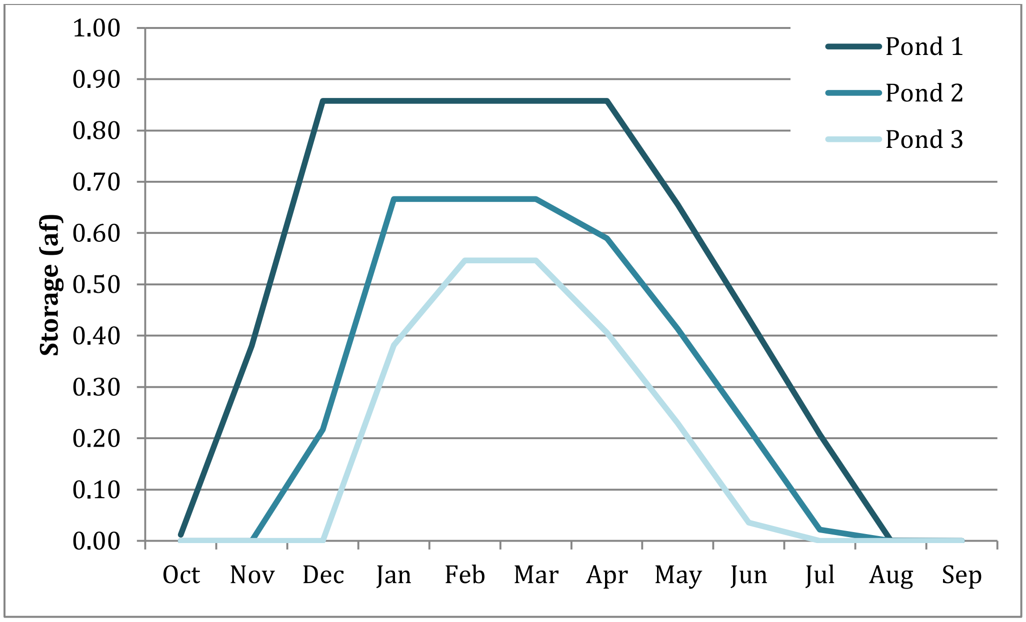

Figure 5. Cumulative storage plots of all three CTS ponds.

Based on this preliminary analysis, creating CTS habitat at the site appears to be feasible. The hydrology analysis indicates that the ponds are very likely to completely fill up during the course of the average winter, and the water balance indicates that the ponds will go dry by the end of summer. However, the timing of when the ponds actually go dry is very sensitive to the amount of rainfall that occurs late in the season. If the site receives heavy rainfall early in the season, but then very little late rainfall, the total rainfall for the year may be close to average, but most of it will have contributed to site run-off. One future adjustment that could be made to ensure the ponds receive adequate volume is to route a portion of the flow from the West Swale into the created wetland areas.

6.2 Swale Widening/Re-routing

The property has two linear channels that route water from north to south through the site. The channels are approximately 2’ wide and between 6” to 1’ deep. A hydraulic analysis was conducted to determine the capacity of these existing channels. Results indicate that both channels are overflowing during storms with return intervals of less than 1 year (Table 4).

Table 4. Existing condition hydraulic results from two channels in project area.

Channel	Longitudinal slope, ft/ft	Manning n	Max Depth, ft	Q, cfs	Return Interval, year	Q at 1-yr RI
Warrington Creek	0.005	0.075	0.7	3.887	<1	5.3
West Swale	0.005	0.075	0.44	2.214	<1	6.2

The limited cross-sectional flow area of these channels makes them essentially conduits that quickly transport the lower peak flows through the site. A possible alternative to the present condition is to widen these channels in order to slow down the lower peak flows and allow for more hydraulic detention on the site. Narrow areas, or "pinch points" with a cross sectional area similar to under existing conditions could be installed at selective locations to help create ponding as well as continue to allow the higher peak flows to access the overbanks (Figure 6).

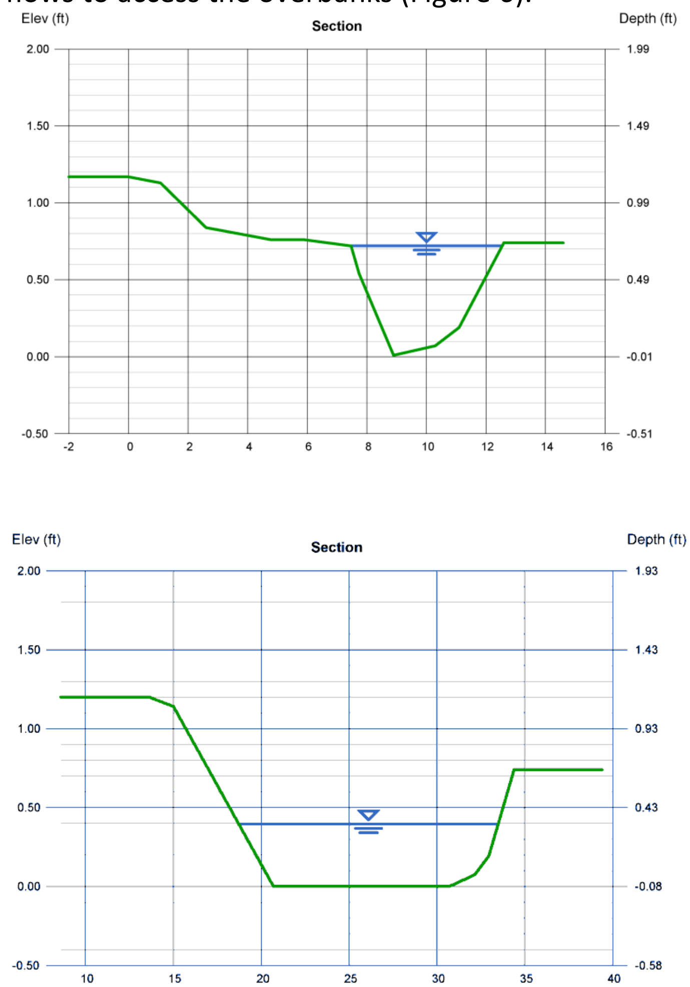

Figure 6. Existing (top) and design condition (bottom) cross sections showing water surface at 4 cfs.

6.3 Parking Lot Stormwater Detention/CTS Pond

Future development of the site as an incubator farm includes a parking area in the southeast corner of the property. New development, retrofit projects, and applicable infrastructure in Sonoma County may be required to follow Low Impact Development (LID) design strategies as outlined in the City of Santa Rosa and County of Sonoma Low Impact Development Technical Design Manual (City of Santa Rosa 2012). Among other requirements, the manual specifies that new development shall not cause any increase in peak flows of receiving waters downstream of the project.

One feasible alternative to prevent an increase in peak flows from the new parking lot is to install a retention/detention basin on the site. This basin could be designed to also function as a CTS pond by excavating a shallow pond below the ground surface that is meant to permanently retain water with additional capacity created above the ground surface to temporarily detain stormflows. A shallow berm could be installed around the pond with a permeable lens designed to allow the detained stormwater to be gradually released (Figure 7).

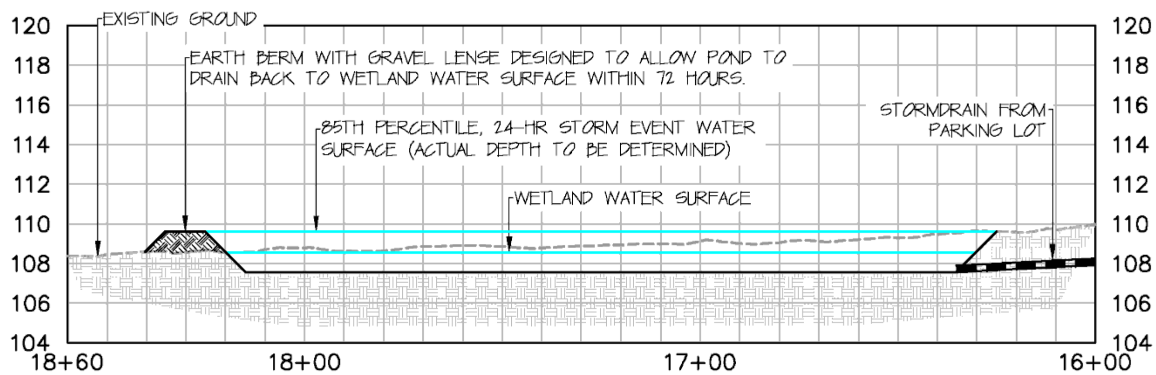

Figure 7. Profile view of detention/retention basin to treat new parking lot stormwater.

A similar water balance as described in the previous section was conducted on the lower portion of this basin. Results indicate that during an average rainfall year, a 17” deep pond with approximate dimensions of 80’x110’ would be completely full from December to April and would dry out by August. Further design is needed to size the embankment height and gravel lens to allow peak flows to be stored in the same basin and gradually released. The location also needs to be considered to minimize the impact on the proposed farm.

6.4 CTS Design Conclusions

Based on PCI's preliminary analysis, creating viable CTS habitat at the Young Armos property appears to be feasible. The site supports:

- Suitable soils to allow for CTS pool creation given the low permeability values
- Sufficient water available to support pools of adequate depth and duration of inundation
- Areas of adequate size to support a number of possible breeding pools
- Areas of upland habitat, however small, to support aestivation habitat
- Nearby source populations that may allow for establishment of CTS over time
- Consistency with the recovering planning goals of supporting CTS in the Hunter Horn area

7 Regulatory Compliance

The Young Armos property is located in an area where there are known occurrences California tiger salamander and listed plants; Sebastopol meadowfoam was documented on the site in 2000. The site supports several areas of potential jurisdictional wetlands (Macmillian 2013). Two drainages also cross the property, Warrington Creek and an unnamed drainage, and Wilfred Creek forms the southern border of the property. The Horn Mitigation Bank, an approved mitigation bank for wetlands and rare plants, is also located to the west of the property (PRMD 2013). The property is located within the US Fish and Wildlife Service's, Santa Rosa Plain Recovery Planning Area, Horn Hunter Management Area (USFWS 2014) and habitat considered critical for CTS and listed plants as identified in the Santa Rosa Plain Conservation Strategy (USFWS 2005).

Based on PCI's preliminary feasibility analysis, there is sufficient water to create viable CTS habitat on the property through enhancement of existing wetlands and creation of new ones. However, development of the site could impact existing jurisdictional wetlands. These restoration actions could support the establishment of both listed plants and California tiger salamander on the site, if they are not already present.

These biological resources are protected by regulations established by state, federal, and local agencies. Regulations are in place to protect native plant communities, aquatic resources, and other vegetation and wildlife resources. The following includes a description of the applicable regulations and the agencies responsible for enforcing the regulations relevant to potential future development and restoration of the Young Armos property.

7.1 U.S. Army Corps of Engineers

Jurisdictional wetlands and other waters of the U.S., including stream channels, are regulated by the U.S. Army Corps of Engineers (Corps) under the provisions of Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. Any disposal of dredged or fill material and structures, as well as work in wetlands or waters, require a permit from the Corps. Habitat enhancement activities could result in alteration of existing wetland areas through excavation, construction of ponds for CTS breeding, construction of berms or other structures, and changes in hydrology of the area. The project could also alter the hydrologic conditions of Warrington Creek, the unnamed drainage, and possibly Wilfred Creek to the south. Restoration work could temporarily impact jurisdictional wetlands. Construction of the farm parking lot may result in the loss of a small area of existing wetland at the south end of the proposed parking area.

The recommended approach for Corps permitting is to submit a Nationwide Permit Preconstruction Notification (PCN) Form for use of NWP #27, Aquatic Habitat Restoration, Establishment, and Enhancement and NWP #33, Temporary Construction, Access, and Dewatering. As part of Section 404 permitting in the Santa Rosa Plain, the Corps will consult with the USFWS on potential impacts to CTS and special-status plants to determine potential temporary impacts and for compliance with the federal Endangered Species Act (ESA). See the USFWS discussion below on the proposed permitting process.

As part of the Corps permit process, the preliminary wetlands assessment completed for the property in 2013 will need verification from the Corps (Macmillian 2013). PCI submitted the delineation to the Corps in July 2015 requesting verification. The project has been assigned to the Holly Costa. PCI is awaiting further communications.

7.2 North Coast Regional Water Quality Control Board

The Federal Clean Water Act, in Section 401, specifies that states must certify that any activity subject to a permit issued by a federal agency, such as the Corps, meets all State water quality standards. This is accomplished by application to the local Regional Water Quality Control Board (RWQCB) for Section 401 certification that requirements have been met. Future development of the property will require consultation with the RWQCB and issuance of a 401 permit if work is proposed in any wetland or other waters of the U.S. The application should be submitted at the same time as the PCN is submitted to the Corps; however, the certification cannot be issued until the Corps issues their approval.

If no federal permits are needed, under Section 13263 of the Porter-Cologne Water Quality Act, the RWQCB is authorized to regulate discharge and fill within waters of the State, wetlands, including isolated features. Through this process the local RWCQB issues a Waste Discharge Requirement (WDR).

7.3 US Fish and Wildlife Service and ESA Compliance

Under the federal Endangered Species Act of 1973 (FESA), the Secretary of the Interior and the Secretary of Commerce have joint authority to list a species as threatened or endangered. Two federal agencies oversee the FESA: the U.S. Fish and Wildlife Service (USFWS), a part of the Department of the Interior, has jurisdiction over plants, wildlife, and resident fish, while NOAA's National Marine Fisheries Service (NOAA Fisheries Service), a part of the Commerce Department, has jurisdiction over anadromous fish and marine fish and mammals. Section 7 of the FESA mandates that all federal agencies consult with USFWS and NOAA Fisheries Service to ensure that federal agency actions do not jeopardize the continued existence of a listed species or destroy or adversely modify critical habitat for listed species.

As noted above, the Corps must consult with USFWS as part of project approval based on the location of the Young Armos property within the Santa Rosa Plain recovery planning area and within habitat considered critical for CTS and listed plants. To support the permit planning process, the Conservation Strategy provides USFWS and California Department of Fish and Wildlife (CDFW) with guidelines for strategies for permitting and mitigating projects within the Santa Rosa Plain. USFWS completed a Programmatic Biological Opinion in 2007 (USFWS 2007). The BO provides a process for consulting with the USFWS regarding compliance with the ESA. The BO was completed by USFWS with the Corps.

The project includes creation of CTS habitat (and potentially habitat for listed plants) and implementation of compatible farming operations to illustrate how conservation activities and farming practices can coexist on the same parcel. Because the project includes both CTS habitat creation and farming activities on the parcel, the establishment of a Safe Harbor Agreement (SHA) is recommended. The SHA would allow the District to manage the property for both species conservation and farming with assurances that no additional or different management activities and/or use restrictions will be imposed by State or federal agencies if the conditions of the SHA are fulfilled. The District is eligible to participate in the SHA program as a non-federal landowner, because use of the property includes creation of potential breeding ponds for CTS and development of farming operations in critical habitat for the species. The management assurances would be provided by USFWS through an Enhancement of Survival Permit issued to the District under the authority of Section 10(a)(1)(A) of the ESA. The Enhancement of Survival Permit authorizes incidental take of species that may result from actions undertaken by the landowner under the SHA.

The SHA application process involves general information gathering (e.g., species information), a baseline assessment of conditions for the property, and identification of conservation efforts to benefit the species and the anticipated future management activities on the entire property. The condition information and the proposed management activities are then used to develop a draft SHA that specifies management actions that will provide a net conservation benefit and identification of monitoring needs. USFWS identifies anticipated incidental take of listed species that might result from the management planned under the SHA, and the District submits an Enhancement of Survival Permit application to USFWS. Once the application and SHA are completed, notification is published in the Federal Register for a 30-day public comment period. During the public comment period, USFWS further evaluates the issues related to issuance of the requested permit. Following a response to any public comments, and after incorporating any appropriate changes, USFWS and the landowner approve and sign the final SHA. Assuming all criteria have been met, USFWS then issues the permit and restoration activities and site development may begin. The Corps will use the SHA and Incidental Take Permit as the consultation necessary to issue a Section 404 permit. The timeline for issuance of the SHA and incidental take permit should occur concurrently with the Section 404/401 permitting process.

Protocol-level surveys for CTS on the property would not likely be required given existing occurrence information from nearby areas; however, this would need to be verified with USFWS. Protocol-level surveys for listed plant may be necessary since Sebastopol meadowfoam has been reported on the property and all three listed species have been reported nearby. Again, this would need to be verified within USFWS.

7.4 California Department of Fish and Wildlife

The California Department of Fish and Game (CDFW) is responsible for managing, conserving, and protecting the state’s biological resources including fish, wildlife, and plants. Under the California Fish and Game Code, CDFW must be notified when work is proposed in a creek, river, or lake in which there is at any time an existing fish or wildlife resource or from which such resources derive benefit. Projects affecting or potentially affecting such resources must obtain a Streambed Alteration Agreement from CDFW and comply with CEQA. Under Section 1602 of the Fish and Game Code, any proposed restoration or development actions within the channels may be subject to a Lake and Streambed Alteration Agreement.

Under sections 3511 (birds), 4700 (mammals), 5050 (reptiles and amphibians), and 5515 (fish) of the California Fish and Game Code, CDFG designates certain animal species as "fully protected." Fully protected species may not be taken or possessed at any time. Future development of the property will require avoidance of fully protected species.

Under the California Endangered Species Act of 1984 (CESA), CDFW is responsible for maintaining a list of endangered and threatened species. Pursuant to the requirements of CESA, an agency reviewing a proposed project within its jurisdiction must determine whether any state-listed as endangered or threatened species may be present in the project area and determine whether the proposed project will have a potentially significant impact on such species. California tiger salamander, Sebastopol meadowfoam, Burke's goldfields, and Sonoma sunshine are all listed as threatened or endangered under CESA and CDFW would need to be consulted.

The California State Safe Harbor Agreement Program Act (SHAPA) requires no further authorizations or approvals if a land owner has a federal SHA authorizing take for a dually listed species, except CDFW will issue a Consistency Determination (CD) to document that the federal SHA is consistent with Fish and Game Code Section 2081. The CD constitutes CDFW's determination that no CESA take authorization is necessary. In order for CDFW to issue a Consistency Determination, the conditions specified in the federal incidental take permit must be consistent with CESA.

7.5 Sonoma County Permits

The project will require acquisition of a Sonoma County Grading and Drainage Permit, and a Hydrology and Hydraulics report is required with the application. A building permit may also be required for development of the facilities.

7.6 Sonoma County Water Agency

The Sonoma County Water Agency owns the Wilfred Flood Control Channel and holds an easement on Warrington Creek on two properties north of Young Armos; they manage both channels for flood control purposes. The project may require coordination with SCWA and possible permits.

7.7 Environmental Quality Acts

The California Environmental Quality Act (CEQA) was passed in 1970 to institute a statewide policy of environmental protection. Projects undertaken, funded, or requiring a permit by a state or local public agency must comply with CEQA. The primary purposes of CEQA are to inform decision-makers and the public about the potential environmental impacts of the proposed activities, identify ways that environmental damage can be avoided or significantly reduced, require changes in projects through the use of alternatives or mitigation measures when feasible, and disclose to the public the reasons why a project was approved if significant environmental effects are determined. Similarly, the National Environmental Policy Act (NEPA) requires federal agencies to integrate environmental values into their decision-making processes by considering the environmental impacts of their proposed actions and reasonable alternatives to those actions. Further development of the property will require compliance with CEQA; issuance of a SHA or a CD by CDFW constitutes a discretionary project; therefore, CEQA compliance will be required. NEPA review is necessary for project activities undertaken, permitted, or funded by a federal agency. For activities requiring a permit from Corps, NEPA review is already complete.

7.8 Permit Timeline

The following is a general timeline for securing permits for the project.

U.S. Army Corps of Engineers:
It is reasonable to assume at least 6 months will be needed to secure a Section 404 permit.

North Coast Regional Water Quality Control Board:
Acquisition of the Section 401 Water Quality Certification will also require approximately 6 months. Process is concurrent with the Corps permitting.

U.S. Fish and Wildlife Service - Safe Harbor Agreement:
Many agreements can be developed within 3-4 months. More complex agreements may take at least 6-18 months, including time for publication in the Federal Register. It is prudent to anticipate the longer timeframes. It depends on a number of factors:

- the specie's and the state of scientific knowledge regarding the species
- size of project
- number of parties to the agreement
- funding available for the Safe Harbor program

U.S. Fish and Wildlife Service - Enhancement of Survival Permit:
Once the Safe Harbor Agreement is secured, then the District can apply for the Enhancement of Survival Permit. It will take at least 3 months.

California Department of Fish and Wildlife:
There is no specific timeframe noted for CDFW to issue a Safe Harbor Consistency analysis. It is safe to assume 3-6 months. The timeframe begins with issuance of the federal Safe Harbor agreement; however, consultation during the federal process is advisable to ensure compliance with CESA.

Sonoma County:
Sonoma County permits will require approximately 3 months.

California Environmental Quality Act:
The project is subject to CEQA. The process for an exemption takes approximately 2 months. An Initial Study and Negative Declaration or Mitigated Negative Declaration required 6-12 months to complete.

8 Next Steps

Based on the conceptual design footprint presented here, PCI will prepare a scope of work for a preliminary concept plan of potential restoration areas and general locations of farm infrastructure (e.g., farm access road, parking, green houses and future permanent structures). The concept plan would include a preliminary grading plan and planning level cost estimate. This next phase should also include coordination with the District and stakeholders (e.g., UC Cooperative Extension) on the development requirements for the farming operation, participation in outreach efforts with neighbors, and initial outreach efforts with the regulatory agencies and permitting strategy development and background document preparation.

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Young Armos Habitat Restoration and Incubator Farm
Feasibility Analysis Report
Report Attachments

- Geotechnical Study Report, SCAPOSD Young-Armos Incubator Farm, Snyder Lane, Rohnert Park, CA by RGH Consultants
- Soil Analysis Report by Environmental Technical Services
- Young Armos – Future Structures Parking Area Detention/CTS Pond Water Balance Calculations
- Young Armos - Multiple Pond Water Balance Calculations

RGH CONSULTANTS

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GEOTECHNICAL STUDY REPORT

SCAPOSD YOUNG-ARMOS INCUBATOR FARM
SNYDER LANE
ROHNERT PARK, CALIFORNIA

Project Number:

1993.41.04.1

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INTRODUCTION

This report presents the results of our geotechnical study for the proposed SCAPOSD Young-Armos Incubator Farm project off Snyder Lane in Rohnert Park, California. The property is located on the western side of Snyder Lane, north of the North Rohnert Park Trail. The L-shaped property is covered with seasonal grasses and weeds and includes multiple wetland areas and scattered trees. The site location is shown on Plate 1, Appendix A.

We understand it is planned to expand and enhance the existing wetlands on the property. Portions of the property may be used for crop land. Long term plans include a tool shed near the western edge of the property with barns and/or other structures along the Snyder Lane (eastern) side of the property. Parking is planned for the eastern portions of the property as well. We assume that the planned structures will be of wood and/or metal framed construction with concrete slab-on-grade floors. Roof loads will be transmitted to the ground by perimeter wall and isolated column footings.

Actual foundation loads are not known at this time. We anticipate the loads will be typical for the light to moderately heavy type of construction planned and that wall loads will range from about ½ to 1½ kips per lineal foot. Grading plans are not available, but we anticipate that the planned grading will be the minimum amount needed to construct level building pads and provide the building sites and paved areas with positive drainage, and could include cuts and fills on the order of 2 to 3 feet.

Utility plans are not available, but we have assumed for this study that the project utilities will extend no deeper than 5 feet below the existing ground surface. If project utilities extend deeper, supplemental exploration may be required to evaluate the soil conditions within and below the utility excavations.

SCOPE

The purpose of our study, as outlined in our Professional Services Agreement dated July 13, 2015, was to generate geotechnical information for the design and construction of the project. Our scope of services included reviewing selected published geologic data pertinent to the site; evaluating subsurface conditions with borings, vibrating wire line piezometers, and laboratory tests; analyzing the field and laboratory data; and presenting this report with the following geotechnical information:

1. A brief description of soil and groundwater conditions observed during our study;

2. A discussion of seismic hazards that may affect the proposed improvements;

3. Seismic design criteria per guidelines in the 2013 California Building Code (CBC); and

4. Specific conclusions and recommendations concerning:

   a. Primary geotechnical engineering concerns and mitigating measures, as applicable;

   b. Site preparation and grading including treatment of weak, porous, compressible and/or expansive surface soils;

c. Alternative foundation types, design criteria and settlement behavior;

d. Support of concrete slabs-on-grade;

e. Preliminary pavement sections based upon our experience with similar projects and soils;

f. Backfilling of utility trenches;

g. Geotechnical engineering drainage improvements; and

h. Supplemental geotechnical engineering services.

STUDY

Site Exploration

We reviewed our previous geotechnical studies in the vicinity and selected geologic references pertinent to the site. The geologic literature reviewed is listed in Appendix B.

On July 17, 2015, we performed a geotechnical reconnaissance of the site and explored the subsurface conditions by drilling seven borings to depths ranging from about 5 to 17 feet. The borings were drilled with a truck-mounted drill rig equipped with 6-inch diameter, solid stem augers at the approximate locations shown on the Exploration Plan, Plate 2. The boring locations were determined approximately by pacing their distance from features shown on the Exploration Plan and should be considered accurate only to the degree implied by the method used. Our geologist located and logged the borings and obtained samples of the materials encountered for visual examination, classification and laboratory testing. Once completed, vibrating wire line piezometers were installed in borings B-1 and B-2.

Relatively undisturbed samples were obtained from the borings at selected intervals by driving a 2.43-inch inside diameter, split spoon sampler, containing 6-inch long brass liners, using a 140-pound hammer dropping approximately 30 inches. The sampler was driven 12 to 18 inches. The blows required to drive each 6-inch increment were recorded and the blows required to drive the last 12 inches, or portion thereof, were converted to equivalent Standard Penetration Test (SPT) blow counts for correlation with empirical data. Disturbed “bulk” samples were also obtained from the borings and placed in a bucket.

The logs of the borings showing the materials encountered, groundwater conditions, converted blow counts and sample depths are presented on Plates 3 through 9. The soils are described in accordance with the Unified Soil Classification System, outlined on Plate 10.

The boring logs show our interpretation of subsurface soil and groundwater conditions on the date and at the locations indicated. Subsurface conditions may vary at other locations and times. Our interpretation is based on visual inspection of soil samples, laboratory test results, and interpretation of drilling and sampling resistance. The location of the soil boundaries should be considered approximate. The transition between soil types may be gradual.

Laboratory Testing

The samples obtained from the borings were transported to our office and re-examined to verify soil classifications, evaluate characteristics and assign tests pertinent to our analysis. Selected samples were laboratory tested to determine their water content, dry density, classification (Atterberg Limits, percent of silt and clay), expansion potential (Expansion Index - EI), unconfined compressive strength, moisture-density relationship and remolded and in-place permeability. Results of the classification, expansion index, unconfined compression strength, compaction and permeability tests are presented on Plates 11 through 19.

SITE CONDITIONS

General

Sonoma County is located within the California Coast Range geomorphic province. This province is a geologically complex and seismically active region characterized by sub-parallel northwest-trending faults, mountain ranges and valleys. The oldest bedrock units are the Jurassic-Cretaceous Franciscan Complex and Great Valley sequence sediments originally deposited in a marine environment. Subsequently, younger rocks such as the Tertiary-age Sonoma Volcanics group, the Plio-Pleistocene-age Clear Lake Volcanics and sedimentary rocks such as the Guinda, Domengine, Petaluma, Wilson Grove, Cache, Huichica and Glen Ellen formations were deposited throughout the province. Extensive folding and thrust faulting during late Cretaceous through early Tertiary geologic time created complex geologic conditions that underlie the highly varied topography of today. In valleys, the bedrock is covered by thick alluvial soils.

Geology

Published geologic maps (Clahan et al., 2003) indicate the property is underlain by Holocene alluvial fan deposits (Qhf) and alluvial fan deposits, fine facies (Qhff). Qhf comprises alluvial fan sediment deposited by streams emanating from mountain drainages onto alluvial valleys. These deposits are composed of moderately to poorly sorted sand, gravel, silt and clay. Qhff comprises fine-grained alluvial fan and floodplain overbank deposits on very gently sloping portions of the valley floor. These deposits are composed of predominantly clay with interbedded lenses of coarser alluvium.

Surface

The property extends primarily over flat terrain. The vegetation consists of seasonal grasses and weeds. The site includes multiple wetland areas and scattered trees.

In general, the ground surface is moderately hard. However, soils in the area that appear hard and strong when dry will typically lose strength rapidly and settle under the loads of fills, foundations and slabs as their moisture content increases and approaches saturation. This typically occurs because the surface soils are weak, porous and compressible. The surface soils are disturbed by randomly arrayed shrinkage cracks generally associated with expansive soils. Locally, expansive soils shrink and swell with the weather cycle. The cyclic shrinking and swelling tends to disturb the upper portion of the expansive clay. This zone is defined hereinafter as the active layer.

Natural drainage consists of sheet flow over the ground surface that concentrates in man-made surface drainage elements such as roadside ditches, canals and gutters, and natural drainage elements such as swales and creeks.

Subsurface

Our borings and laboratory tests indicate that the portion of the site we studied is blanketed by 2 to 3 feet of weak, porous, compressible, clayey soils. Porous soils appear hard and strong when dry but become weak and compressible as their moisture content increases towards saturation. These soils exhibit medium plasticity (LL = 36; PI = 20) and medium expansion potential (EI = 86), and are disturbed by shrinkage cracks that extend 2 to 3 feet below the ground surface. The surface soil is typically underlain by clay with varying amounts of sand with layers of clayey sand to the maximum depth explored (17 feet).

A detailed description of subsurface conditions found in our borings is given on Plates 3 through 9, Appendix A. Based on Table 20.3-1 of American Society of Civil Engineers (ASCE) Standard 7-10, titled “Minimum Design Loads for Buildings and Other Structures” (2010), we have determined a Site Class of D should be used for the site.

Corrosion Potential

Mapping by the Natural Resources Conservation Service (2015) indicates that the corrosion potential of the near surface soil is high for uncoated steel and moderate for concrete. Performing corrosivity tests to verify these values was not part of our requested and/or proposed scope of work. Should the need arise, we would be pleased to provide a proposal to evaluate these characteristics.

Groundwater

Free groundwater was first detected in two of seven borings at depths ranging from 10 to 11 feet below the ground surface at the time of drilling. When the holes were backfilled after drilling was completed, the water level had risen to depths ranging from about 8½ to 10 feet. Fluctuation in the groundwater level typically occurs because of a variation in rainfall intensity, duration and other factors such as flooding and periodic irrigation. Vibrating wire line piezometers were installed in borings B-1 and B-2 to allow for continuous groundwater depth monitoring over time.

DISCUSSION AND CONCLUSIONS

Seismic Hazards

Seismicity

Data presented by the Working Group on California Earthquake Probabilities (2007) estimates the chance of one or more large earthquakes (Magnitude 6.7 or greater) in the San Francisco Bay region within the next 30 years to be approximately 63 percent. Therefore, future seismic shaking should be anticipated at the site. It will be necessary to design and construct the proposed farm project in strict adherence with current standards for earthquake-resistant construction.

Faulting

We did not observe landforms within the area that would indicate the presence of active faults and the site is not within a current Alquist-Priolo Earthquake Fault Zone (Bryant and Hart, 2007). Therefore, we believe the risk of fault rupture at the site is low. However, the site is within an area affected by strong seismic activity. Several northwest-trending Earthquake Fault Zones exist in close proximity to and within several miles of the site (Bortugno, 1982). The shortest distances from the site to the mapped surface expression of these faults are presented in the table below.

ACTIVE FAULT PROXIMITY		
Fault	**Direction**	**Distance-Miles**
San Andreas	SW	18
Healdsburg-Rodgers Creek	NE	2½
West Napa	ENE	16

Liquefaction

Liquefaction is a rapid loss of shear strength experienced in saturated, predominantly granular soils below the groundwater level during strong earthquake ground shaking due to an increase in pore water pressure. The occurrence of this phenomenon is dependent on many complex factors including the intensity and duration of ground shaking, particle size distribution and density of the soil.

Granular soils were encountered at the site below the groundwater table. Therefore, we performed an analysis of the blow count data from our borings using the methods of Seed and Idriss (1982), Seed and others (1985), Youd and Idriss (2001), Idriss and Boulanger (2004) and Idriss and Boulanger (2008). These procedures normalize the blow counts to account for overburden pressure, rod length, hammer energy, and fines (percent of silt and clay) content. Once the blow counts are normalized and adjusted to a clean sand blow count, the cyclic resistance ratio (CRR) for each blow count is then determined using the same procedures referenced above. The CRR is compared to the cyclic stress ratio (CSR) induced by the earthquake. Calculating the CSR requires a peak ground acceleration and design earthquake magnitude.

Peak ground acceleration (PGA) was determined using the methods in the 2013 California Building Code (CBC) and the American Society of Civil Engineers (ASCE) Standard 7-10, titled "Minimum Design Loads for Buildings and Other Structures" (2010). Using the U.S. Seismic Design Maps from the United States Geological Survey (USGS) website (http://geohazards.usgs.gov/designmaps/us/application.php), the site's latitude and longitude of 38.3735°N and 122.6912°W, respectively, and a Site Soil Class of D, the PGA for the site is 0.76g. Using this information, the CSR for a M_M 7.5 earthquake at the site ranges from 0.48 to 0.62. The Rodgers Creek fault is most likely controlling the ground motions at the site. According to Petersen (1996), the Rodgers Creek fault is capable of a M_M 7.0 earthquake. Therefore, the CRR values at the site must be scaled to account for the difference between M_M 7.0 and M_M 7.5. When the scaling factor for magnitude and confining stress corrections presented in Idriss and Boulanger (2004) are applied, the CRR values at the site exceed the CSR values except for a layer of sand with boring B-3. Therefore, we judge that the potential for liquefaction at the site is generally considered low.

There are three potential consequences of liquefaction: bearing capacity failure, lateral spreading toward a free face (e.g. riverbank) and settlement. Bearing capacity failure is sudden and extreme settlement of foundations that typically occurs when the liquefied layer is relatively close (typically within two times the footing width, depending on the loads) to the bottom of the foundation. Because the liquefiable layer is at least 8 feet below the ground surface, we judge that the potential for bearing capacity failure is low.

Lateral spreading can occur where continuous layers of liquefiable soil extend to a free face, such as a creek bank. There are no significant free faces in the vicinity of the site. Therefore, we judge the potential for liquefaction-induced lateral spreading at the site is low.

The third potential consequence of liquefaction is settlement due to densification of the liquefied soils. Potential settlement based on the blow count data and the cyclic stress ratio was calculated using the methods of Ishihara and Yoshimine (1992). For the layer encountered in boring B-3, we calculated total settlement of less than 1-inch. Differential settlement could range up to 1-inch.

Densification

Densification is the settlement of loose, granular soils above the groundwater level due to earthquake shaking. Typically, granular soils that would be susceptible to liquefaction, if saturated, are susceptible to densification if not saturated. As discussed in the "Liquefaction" section, the soils at the site generally have a low potential for liquefaction. Therefore, we judge that there is a low potential for densification to impact structures at the site.

Geotechnical Issues

General

Based on our study, we judge the proposed parking lot, barn, and storage shed can be built as planned, provided the recommendations presented in this report are incorporated into its design and construction. The primary geotechnical concerns during design and construction of the project are:

1. The presence of 2 to 3 feet of highly expansive, weak, porous, compressible, clayey surface soils;

2. The detrimental effects of uncontrolled surface runoff; and

3. The strong ground shaking predicted to impact the site during the life of the project.

Weak, Porous Surface Soils

Weak, porous surface soils, such as those found at the site, appear hard and strong when dry but will lose strength rapidly and settle under the load of fills, foundations, slabs, and pavements as their moisture content increases and approaches saturation. The moisture content of these soils can increase as the result of rainfall, periodic irrigation or when the natural upward migration of water vapor through the soils is impeded by, and condenses under fills, foundations, slabs, and pavements. The detrimental effects of such movements can be reduced by strengthening the soils during grading. This can be achieved by excavating the weak soils and replacing them as properly compacted (engineered) fill.

Expansive Soil - In addition, the surface soils are expansive. Expansive surface soils shrink and swell as they lose and gain moisture throughout the yearly weather cycle. Near the surface, the resulting movements can heave and crack lightly loaded shallow foundations (spread footings) and slabs and pavements. The zone of significant moisture variation (active layer) is dependent on the expansion potential of the soil and the extent of the dry season. In the Rohnert Park area, the active layer is generally considered to range in thickness from about 2 to 3 feet. The detrimental effects of the above-described movements can be reduced by pre-swelling the expansive soils and covering them with a moisture fixing and confining blanket of properly compacted select fill, as subsequently defined. In building areas, the blanket thickness required depends on the expansion potential of the soils and the anticipated performance of the foundations and slabs. In order to effectively reduce foundation and slab heave given the expansion potential of the site's soils, a blanket thickness of 30 inches will be needed. In exterior slab and paved areas, the select fill blanket need only be 12 inches thick.

Foundation and Slab Support - Provided grading is performed as discussed above, satisfactory foundation support can be obtained from spread footings that bottom on the select engineered fill at least 12 inches below pad subgrade. Interior slabs-on-grade can also be supported on the select engineered fill. Drilled piers can be used for foundation support for gates, fences and other structural elements with isolated foundations. The use of drilled pier foundation needs to be reviewed with RGH on a case by case basis.

Exterior Slabs and Pavements

Exterior slabs and pavements will heave and crack as the expansive soils shrink and swell through the yearly weather cycle. Slab and pavement cracking and distress are typically concentrated along edges where moisture content variation is more prevalent within subgrade soils. Slab and pavement performance and the incidence of repair can be reduced, but not eliminated, by covering the pre-swelled expansive soils with at least 12 inches of select fill (see "On-Site Soil Quality" section) prior to constructing the slab or pavement required to carry the anticipated traffic.

Wetland Materials

The wetlands are to be constructed with materials that have a slow infiltration/permeability rate in order to maintain these areas as wetlands. Permeability tests performed on a remolded sample of the near surface clay soils and in-place samples of the native clay soils yielded permeability rates slower than 1×10^{-6} cm/sec. These permeability rates would qualify for use as wastewater pond liner. Therefore, the on-site clay soils within the upper 5 to 8 feet can be used for constructing the wetlands.

On-Site Soil Quality

All fill materials used in the upper 30 inches of the building area and the upper 12 inches of exterior slab and pavement subgrade must be select, as subsequently described in "Recommendations." We anticipate that, with the exception of organic matter and of rocks or lumps larger than 6 inches in diameter, the excavated material will be suitable for re-use as general fill, but will not be suitable for use as select fill unless stabilized with lime.

Select Fill

The select fill can consist of import materials with a low expansion potential or lime stabilized on-site clayey soils. Lime stabilized soils may prevent the growth of landscape vegetation due to the inherent elevated pH level of the soil. The geotechnical engineer must approve the use of on-site soils as select fill during grading.

Settlement

If remedial grading is performed and the spread footings are installed in accordance with the recommendations presented in this report, we estimate that post-construction differential settlements related to consolidation across the building will be about ½ inch.

Surface Drainage

The site will be impacted by surface runoff. Surface runoff typically sheet flows over the ground surface but can be concentrated by the planned site grading, landscaping, and drainage. The surface runoff can pond against structures and cause deeper than normal soil heave and/or seep into the slab rock. Therefore, strict control of surface runoff is necessary to provide long-term satisfactory performance of projects. It will be necessary to divert surface runoff around improvements and provide positive drainage away from structures. This can be achieved by constructing the building pad several inches above the surrounding area and conveying the runoff into man-made drainage elements or natural swales that lead downgradient of the site.

RECOMMENDATIONS

Seismic Design

Seismic design parameters presented below are based on Section 1613 titled "Earthquake Loads" of the 2013 California Building Code (CBC). Based on Table 20.3-1 of American Society of Civil Engineers (ASCE) Standard 7-10, titled "Minimum Design Loads for Buildings and Other Structures" (2010), we have determined a Site Class of D should be used for the site. Using a site latitude and longitude of 38.3735°N and 122.6912°W, respectively, and the U.S. Seismic Design Maps from the United States Geological Survey (USGS) website (http://earthquakes.usgs.gov/designmaps/us/application.php), we recommend that the following seismic design criteria be used for structures at the site.

2013 CBC Seismic Criteria	
Spectral Response Parameter	**Acceleration (g)**
S_S (0.2 second period)	1.979
S_1 (1 second period)	0.804
S_{MS} (0.2 second period)	1.979
S_{M1} (1 second period)	1.206
S_{DS} (0.2 second period)	1.319
S_{D1} (1 second period)	0.804

Grading

Site Preparation

Areas to be developed should be cleared of vegetation and debris. Trees and shrubs that will not be part of the proposed development should be removed and their primary root systems grubbed. Cleared and grubbed material should be removed from the site and disposed of in accordance with County Health Department guidelines. We did not observe septic tanks, leach lines or underground fuel tanks during our study. Any such appurtenances found during grading should be capped and sealed and/or excavated and removed from the site, respectively, in accordance with established guidelines and requirements of the County Health Department. Voids created during clearing should be backfilled with engineered fill as recommended herein.

Stripping

Areas to be graded should be stripped of the upper few inches of soil containing organic matter. Soil containing more than two percent by weight of organic matter should be considered organic. Actual stripping depth should be determined by a representative of the geotechnical engineer in the field at the time of stripping. The strippings should be removed from the site, or if suitable, stockpiled for re-use as topsoil in landscaping.

Excavations

Following initial site preparation, excavation should be performed as planned or recommended herein. Excavations extending below the proposed finished grade should be backfilled with suitable materials compacted to the requirements given below.

Within wetland areas, the disturbed active layer should be excavated in their entirety (about 2 to 3 feet in our borings) to expose clay soils with a moisture content that is at least 4 percent above optimum moisture. In addition, within fill and building areas, the disturbed active layer should be excavated to within 6 inches of their entire depth. Additional excavation should be performed, as necessary, to allow space for the installation of a blanket of select fill, at least 30 inches thick, beneath the building pad subgrade. The excavation of weak, compressible, expansive soils should also extend at least 12 inches below exterior slab and pavement subgrade to allow space for the installation of the select fill blanket discussed in the conclusions section of this report.

The excavation of weak, porous, compressible, expansive surface materials should extend at least 5 feet beyond the outside edge of the exterior footings of the proposed buildings and 3 feet beyond the edge of exterior slabs and pavements and three feet beyond the toe of new fills or the edge of the wetlands. The excavated materials should be stockpiled for later use as compacted fill, or removed from the site, as applicable.

At all times, temporary construction excavations should conform to the regulations of the State of California, Department of Industrial Relations, Division of Industrial Safety or other stricter governing regulations. The stability of temporary cut slopes, such as those constructed during the installation of underground utilities, should be the responsibility of the contractor. Depending on the time of year when grading is performed, and the surface conditions exposed, temporary cut slopes may need to be excavated to 1½:1, or flatter. The tops of the temporary cut slopes should be rounded back to 2:1 in weak soil zones.

Fill Quality

All fill materials should be free of perishable matter and rocks or lumps over 6 inches in diameter, and must be approved by the geotechnical engineer prior to use. The upper 30 inches of fill beneath and within 5 feet of building areas and the upper 12 inches of fill beneath and within 3 feet of exterior slabs and pavement edges should be select fill. We judge the on-site soils are generally suitable for use as general fill but will not be suitable for use as select fill unless they are stabilized with lime. Lime stabilized soils may prevent the growth of landscape vegetation due to the inherent elevated pH level of the soil. The suitability of the on-site soils for use as select fill should be verified during grading.

In addition, fill materials and native soils within the wetland areas should have a low infiltration/permeability rate. Laboratory testing on the on-site clay soils encountered within the upper 5 to 8 feet have permeability that is less than 1×10^{-6} cm/sec. We judge the on-site clay soils will be suitable for use as wetland soils.

Select Fill

Select fill should be free of organic matter, have a low expansion potential, and conform in general to the following requirements:

SIEVE SIZE	PERCENT PASSING (by dry weight)
6 inch	100
4 inch	90 – 100
No. 200	10 – 60

Liquid Limit – 40 Percent Maximum
Plasticity Index – 15 Percent Maximum
R-value – 20 Minimum (pavement areas only)

Expansive on-site soils may be used as select fill if they are stabilized with lime. In general, imported fill, if needed, should be select. Material not conforming to these requirements may be suitable for use as import fill; however, it shall be the contractor's responsibility to demonstrate that the proposed material will perform in an equivalent manner. The geotechnical engineer should approve imported materials prior to use as compacted fill. The grading contractor is responsible for submitting, at least 72 hours (3 days) in advance of its intended use, samples of the proposed import materials for laboratory testing and approval by the soils engineer.

Lime Stabilization

For preliminary planning purposes, we estimate that high calcium lime mixed at a minimum of 5½ percent (dry weight) will stabilize the expansive site soils. This percentage of lime needs to be verified prior to construction with engineering analysis and laboratory Atterberg Limits and/or pH testing using lime from the same source as that planned for use on the project and a sample of the soil to be treated. Laboratory test results and engineering analysis may indicate that a higher percentage of lime is required. The contractor should allow a minimum of 5 business days for the laboratory tests to be completed.

The lime stabilization should be performed in accordance with Section 24 of the Caltrans Standard Specifications except that a curing seal will not be required, provided the moisture content of the lime-stabilized material is maintained at or above optimum moisture content until it is permanently covered with subsequent construction. Lime stabilized materials are generally not suitable for reuse as general fill, select fill or backfill after compaction has taken place.

Fill Placement

The surface exposed by stripping and removal of weak, compressible, expansive surface soils should be scarified to a depth of at least 6 inches, uniformly moisture-conditioned to at least 4 percent above optimum and compacted to at least 90 percent of the maximum dry density of the materials as determined by ASTM Test Method D-1557. In expansive soil areas, moisture conditioning should be sufficient to completely close all shrinkage cracks for their full depth. If grading is performed during the dry season, the shrinkage cracks may extend to a few feet below the surface. Therefore, it may be necessary to excavate a portion of the cracked soils to obtain the proper moisture condition and degree of compaction. Approved fill material should then be spread in thin lifts, uniformly moisture-conditioned to near optimum and properly compacted. All structural fills, including those placed to establish site surface drainage, should be compacted to at least 90 percent relative compaction. Expansive soils used as fill should be moisture-conditioned to at least 4 percent above optimum. Only approved select materials should be used for fill within the upper 30 inches of interior slab subgrades and within the upper 12 inches of exterior slabs and pavement subgrades.

SUMMARY OF COMPACTION RECOMMENDATIONS	
Area	Compaction Recommendation (ASTM D-1557)
Preparation for areas to receive fill	After preparation in accordance with this report, compact upper 6 inches to a minimum of 90 percent relative compaction.
General fill (native or import)	Compact to a minimum of 90 percent relative compaction.
Structural fill beneath buildings, extending outward to 5' beyond building perimeter	Compact to a minimum of 90 percent relative compaction.
Trenches	Compact to a minimum of 90 percent relative compaction. Compact the top 6 inches below vehicle pavement subgrade to a minimum of 95 percent relative compaction.
Pavements, extending outward to 3' beyond edge of pavement	Compact upper 6 inches of subgrade to a minimum of 95 percent relative compaction.
Concrete flatwork and exterior slabs, extending outward to 3' beyond edge of slab	Compact subgrade to a minimum of 90 percent relative compaction. Where subject to vehicle traffic, compact upper 6 inches of subgrade to at least 95 percent relative compaction.
Aggregate Base	Compact aggregate base to at least 95 percent relative compaction.

Permanent Cut and Fill Slopes

In general, cut and fill slopes should be designed and constructed at slope gradients of 2:1 (horizontal to vertical) or flatter, unless otherwise approved by the geotechnical engineer in specified areas.

Wet Weather Grading

Generally, grading is performed more economically during the summer months when on-site soils are usually dry of optimum moisture content. Delays should be anticipated in site grading performed during the rainy season or early spring due to excessive moisture in on-site soils. Special and relatively expensive construction procedures, including dewatering of excavations and importing granular soils, should be anticipated if grading must be completed during the winter and early spring or if localized areas of soft saturated soils are found during grading in the summer and fall.

Open excavations also tend to be more unstable during wet weather as groundwater seeps towards the exposed cut slope. Severe sloughing and occasional slope failures should be anticipated. The occurrence of these events will require extensive clean up and the installation of slope protection measures, thus delaying projects. The general contractor is responsible for the performance, maintenance and repair of temporary cut slopes.

Foundation Support

Spread Footings

Spread footings should be at least 12 inches wide and should bottom on select engineered fill at least 12 inches below pad subgrade. Additional embedment or width may be needed to satisfy code and/or structural requirements.

The bottoms of all footing excavations should be thoroughly cleaned out or wetted and compacted using hand-operated tamping equipment prior to placing steel and concrete. This will remove the soils disturbed during footing excavations, restore their adequate bearing capacity, and reduce post-construction settlements. Footing excavations should not be allowed to dry before placing concrete. If shrinkage cracks appear in soils exposed in the footing excavations, the soil should be thoroughly moistened to close all cracks prior to concrete placement. The moisture condition of the foundation excavations should be checked by the geotechnical engineer no more than 24 hours prior to placing concrete.

Bearing Pressures - Footings installed in accordance with these recommendations may be designed using allowable bearing pressures of 2000, 3000 and 4000 pounds per square foot (psf), for dead loads, dead plus code live loads, and total loads (including wind and seismic), respectively.

Lateral Pressures - The portion of spread footing foundations extending into select engineered fill may impose a passive equivalent fluid pressure and a friction factor of 350 pcf and 0.35, respectively, to resist sliding. Passive pressure should be neglected within the upper 6 inches, unless the soils are confined by concrete slabs or pavements.

Drilled Piers

Drilled, cast-in-place, reinforced concrete piers should be used for foundation support for elements with isolated foundations, such as gates, fences, etc. We should review the use of drilled piers on a case by case basis. Drilled piers should be at least 12 inches in diameter and should extend at least 8 feet below the adjacent ground surface. Larger piers and deeper embedment may be needed to resist the lateral forces imposed by earthquakes per the 2013 California Building Code. Piers should be spaced no closer than 3 pier diameters, center to center.

Skin Friction - The portion of the piers extending below the active layer (3 feet) may be designed using an allowable skin friction of 500 psf for dead load plus long term live loads. This value can be increased by ⅓ for total loads, including downward vertical wind or seismic forces. A skin friction value of 350 psf should be used to resist uplift forces. End bearing should be neglected because of the difficulty of cleaning out small diameter pier holes, and the uncertainty of mobilizing end bearing and skin friction simultaneously.

Lateral Forces - Lateral loads on piers will be resisted by passive pressure on the soil. An equivalent fluid pressure of 300 pcf acting on two pier diameters should be used. Confinement for passive pressure may be assumed from 3 feet below the lowest adjacent finished ground surface.

Pier Drilling - If groundwater is encountered during drilling, it may be necessary to de-water the holes and/or place the concrete by the tremie method. If caving soils are encountered, it may be necessary to case the holes.

Concrete - Concrete mix design and placement should be done in accordance with the current ADSC and/or ACI specifications. Concrete should not be allowed to mushroom at the top of the piers or below the bottom of grade beams.

Slab-On-Grade

Provided grading is performed in accordance with the recommendations presented herein, interior and exterior slabs should be underlain by select engineered fill. Slab-on-grade subgrade should be rolled to produce a dense, uniform surface. The future expansion potential of the subgrade soils should be reduced by thoroughly presoaking the slab subgrade prior to concrete placement. The moisture condition of the subgrade soils should be checked by the geotechnical engineer no more than 24 hours prior to placing the capillary moisture break. The slabs should be underlain with a capillary moisture break consisting of at least 4 inches of clean, free-draining crushed rock or gravel (excluding pea gravel) at least ¼-inch and no larger than ¾-inch in size. Interior slabs subject to vehicular traffic may be underlain by Class 2 aggregate base. The use of Class 2 aggregate base should be reviewed on a case by case basis. Class 2 aggregate base can be used for slab rock under exterior slabs.

Slabs should be designed by the project civil or structural engineer to support the anticipated loads, reduce cracking and provide protection against the infiltration of moisture vapor. A vapor barrier should be placed under all slabs-on-grade that are likely to receive an impermeable floor finish or be used for any purpose where the passage of water vapor through the floor is undesirable. RGH does not practice in the field of moisture vapor transmission evaluation or mitigation. Therefore, we recommend that a qualified person be consulted to evaluate the general and specific moisture vapor transmission paths and any impact on the proposed construction. This person should provide recommendations for mitigation of the potential adverse impact of moisture vapor transmission on various components of the structure as deemed appropriate.

Utility Trenches

The shoring and safety of trench excavations is solely the responsibility of the contractor. Attention is drawn to the State of California Safety Orders dealing with "Excavations and Trenches."

Unless otherwise specified by the County of Sonoma, on-site, inorganic soil may be used as general utility trench backfill. Where utility trenches support pavements, slabs and foundations, trench backfill should consist of aggregate baserock. The baserock should comply with the minimum requirements in Caltrans Standard Specifications, Section 26 for Class 2 Aggregate Base. Trench backfill should be moisture-conditioned as necessary, and placed in horizontal layers not exceeding 8 inches in thickness, before compaction. Each layer should be compacted to at least 90 percent relative compaction as determined by ASTM Test Method D-1557. The top 6 inches of trench backfill below vehicle pavement subgrades should be moisture-conditioned as necessary and compacted to at least 95 percent relative compaction. Jetting or ponding of trench backfill to aid in achieving the recommended degree of compaction should not be attempted.

Pavements

Because of the high expansion potential of the soil at the site and the difficulty in controlling seasonal moisture variation beneath and adjacent to pavement areas, significant cracking may develop in the pavement even if 12-inches of select fill is installed. Increasing the thickness of select fill or installing moisture cutoffs may reduce but not eliminate the potential for cracks to develop. It should be understood that pavements will likely require regular maintenance including crack sealing and the aesthetics may not be desirable. Provided the site grading is performed to remediate expansive soil heave, as recommended herein, the uppermost 12-inches of pavement subgrade soils will be either imported select fill with a minimum R-value of 20 or lime stabilized site soils that generally have an R-value of at least 50. Based on those R-values we recommend the pavement sections listed in the tables below be used.

PAVEMENT SECTIONS WITH IMPORTED SELECT FILL SUBGRADE

TI	ASPHALT CONCRETE (feet)	CLASS 2 AGGREGATE BASE (feet)	IMPORTED SELECT FILL* (feet)
7.0	0.30	1.15	1.0
6.0	0.25	1.05	1.0
5.0	0.20	0.90	1.0

* R-value ≥ 20

PAVEMENT SECTIONS WITH LIME STABILIZED SELECT FILL SUBGRADE			
TI	ASPHALT CONCRETE (feet)	CLASS 2 AGGREGATE BASE (feet)	LIME STABILIZED SELECT FILL* (feet)
7.0	0.35	0.50	1.0
6.0	0.30	0.50	1.0
5.0	0.20	0.50	1.0

* R-value ≥ 50

Pavement thicknesses were computed using Caltrans CalFP v1.1 design software and are based on a pavement life of 20 years. These recommendations are intended to provide support for traffic represented by the indicated Traffic Indices. They are not intended to provide pavement sections for heavy concentrated construction storage or wheel loads such as forklifts, parked truck-trailers and concrete trucks or for post-construction concentrated wheel loads such as self-loading dumpster trucks.

In areas where heavy construction storage and wheel loads are anticipated, the pavements should be designed to support these loads. Support could be provided by increasing pavement sections or by providing reinforced concrete slabs. Alternatively, paving can be deferred until heavy construction storage and wheel loads are no longer present. Loading areas for self-loading dumpster trucks should be provided with reinforced concrete slabs at least 6 inches thick, and reinforced with No. 4 bars at 12-inch centers each way. Alternatively, the asphalt concrete section should be increased to at least 8 inches in these areas.

Prior to placement of aggregate base, the upper 6 inches of the pavement subgrade soils (excluding lime stabilized soils) should be scarified, uniformly moisture-conditioned to near optimum, and compacted to at least 95 percent relative compaction to form a firm, non-yielding surface. Lime stabilized select fill subgrade soils should be compacted as specified in Section 24 of the Caltrans Standard Specifications.

Aggregate base materials should be spread in thin layers, uniformly moisture-conditioned, and compacted to at least 95 percent relative compaction to form a firm, non-yielding surface. The materials and methods used should conform to the requirements of the County of Sonoma and the current edition of the Caltrans Standard Specifications, except that compaction requirements should be based on ASTM Test Method D-1557. Aggregate used for the base course should comply with the minimum requirements specified in Caltrans Standard Specifications, Section 26 for Class 2 Aggregate Base.

Parking Lot Drainage

Water tends to migrate under pavements and collect in the aggregate courses at low areas on parking lot subgrade soils, such as around storm drain inlets and the thread of paved swales leading to inlets. The ponded water will soften subgrade soils and, under repetitive heavy-wheel loads, will induce inordinately high stresses on the subgrade and pavement components that could result in untimely maintenance. Under-pavement drainage can be improved and maintenance reduced by replacing a 12-inch wide strip (extending at least 15 feet on either side of the inlet) of the select subbase layer or subgrade soils with a subdrain consisting of ¾-inch or 1½-inch free-draining Class 1 Permeable Material. The drain rock should be outletted into the storm drain inlet. Storm drain trenches can be made to serve as pavement subdrains. We should be consulted to verify the suitability of storm drain trenches as pavement subdrains in a case-specific basis.

Where pavements will abut landscaped areas, the pavement baserock layer and subgrade soils should be protected against saturation from irrigation and rainwater with a subdrain, similar to that previously discussed. The subdrain should extend to a depth of at least 6 inches below the bottom of the baserock layer. Alternatively, a grouted moisture cut-off that extends 12 inches below the bottom of the baserock layer should be provided below or immediately behind the curb and gutter.

Wet Weather Paving

In general, the pavements should be constructed during the dry season to avoid the saturation of the subgrade and base materials, which often occurs during the wet winter months. If pavements are constructed during the winter, a cost increase relative to drier weather construction should be anticipated. Unstable areas may have to be overexcavated to remove soft soils. The excavations will probably require backfilling with imported crushed (ballast) rock. The geotechnical engineer should be consulted for recommendations at the time of construction.

Geotechnical Drainage

Surface

Surface water should be diverted away from slopes, foundations and edges of pavements. Surface drainage gradients should slope away from building foundations in accordance with the requirements of the CBC or local governing agency. Where a gradient flatter than 2 percent for paved areas and 4 percent for unpaved areas is required to satisfy design constraints, area drains should be installed with spacing no greater than about 20 feet. Roofs should be provided with gutters and the downspouts should be connected to closed (glued Schedule 40 PVC or ABS with SDR of 35 or better) conduits discharging well away from foundations, onto paved areas or into the site's surface drainage system. Roof downspouts and surface drains must be maintained entirely separate from the slab underdrains recommended hereinafter.

Water seepage or the spread of extensive root systems into the soil subgrade of footings, slabs or pavements could cause differential movements and consequent distress in these structural elements. Landscaping should be planned with consideration for these potential problems.

Slab Underdrains

Where interior slab subgrades are less than 6 inches above adjacent exterior grade and where migration of moisture through the slab would be detrimental, such as where floor coverings are planned, slab underdrains should be installed to dispose of surface and/or groundwater that may seep and collect in the slab rock. Slab underdrains should consist of 6-inch wide trenches that extend at least 6 inches below the bottom of the slab rock and slope to drain by gravity. The slab underdrain trenches should be spaced no further than 15 feet, both ways. Additional drain trenches should be installed, as necessary, to drain all isolated under slab areas. Four-inch diameter perforated pipe (SDR 35 or better) sloped to drain to outlets by gravity should be placed in the bottom of the trenches. Slab underdrain trenches should be backfilled to subgrade level with clean, free draining slab rock. An illustration of this system is shown on Plate 20. If slab underdrains are not used, it should be anticipated that water will enter the slab rock, permeate through the concrete slab and ruin floor coverings.

Maintenance

Periodic land maintenance will be required. Surface and subsurface drainage facilities should be checked frequently, and cleaned and maintained as necessary or at least annually. A dense growth of deep-rooted ground cover must be maintained on all slopes to reduce sloughing and erosion. Sloughing and erosion that occurs must be repaired promptly before it can enlarge.

Supplemental Services

Pre-Bid Meeting

It has been our experience that contractors bidding on the project often contact us to discuss the geotechnical aspects. Informal contacts between RGH and an individual contractor could result in incomplete or misinterpreted information being provided to the contractor. Therefore, we recommend a pre-bid meeting be held to answer any questions about the report prior to submittal of bids. If this is not possible, questions or clarifications regarding this report should be directed to the project owner or their designated representative. After consultation with RGH, the project owner or their representative should provide clarifications or additional information to all contractors bidding the job.

Plan and Specifications Review

Coordination between the design team and the geotechnical engineer is recommended to assure that the design is compatible with the soil, geologic and groundwater conditions encountered during our study. RGH Consultants (RGH) recommends that we be retained to review the project plans and specifications to determine if they are consistent with our recommendations. In the event we are not retained to perform this recommended review, we will assume no responsibility for misinterpretation of our recommendations.

Construction Observation and Testing

Prior to construction, a meeting should be held at the site that includes, but is not limited to, the owner or owner’s representative, the general contractor, the grading contractor, the foundation contractor, the underground contractor, any specialty contractors, the project civil engineer, other members of the project design team and RGH. This meeting should serve as a time to discuss and answer questions regarding the recommendations presented herein and to establish the coordination procedure between the contractors and RGH.

In addition, we should be retained to monitor all soils related work during construction, including:

- Site stripping, over-excavation, grading, and compaction of near surface soils;
- Placement of all engineered fill and trench backfill with verification field and laboratory testing;
- Observation of all foundation excavations; and
- Observation of foundation and subdrain installations.

If, during construction, we observe subsurface conditions different from those encountered during the explorations, we should be allowed to amend our recommendations accordingly. If different conditions are observed by others, or appear to be present beneath excavations, RGH should be advised at once so that these conditions may be evaluated and our recommendations reviewed and updated, if warranted. The validity of recommendations made in this report is contingent upon our being notified and retained to review the changed conditions.

If more than 18 months have elapsed between the submission of this report and the start of work at the site, or if conditions have changed because of natural causes or construction operations at, or adjacent to, the site, the recommendations made in this report may no longer be valid or appropriate. In such case, we recommend that we be retained to review this report and verify the applicability of the conclusions and recommendations or modify the same considering the time lapsed or changed conditions. The validity of recommendations made in this report is contingent upon such review.

These supplemental services are performed on an as-requested basis and are in addition to this geotechnical study. We cannot accept responsibility for items that we are not notified to observe or for changed conditions we are not allowed to review.

LIMITATIONS

This report has been prepared by RGH for the exclusive use of Prunuske Chatham, Inc. and their consultants as an aid in the design and construction of the proposed improvements described in this report.

The validity of the recommendations contained in this report depends upon an adequate testing and monitoring program during the construction phase. Unless the construction monitoring and testing program is provided by our firm, we will not be held responsible for compliance with design recommendations presented in this report and other addendum submitted as part of this report.

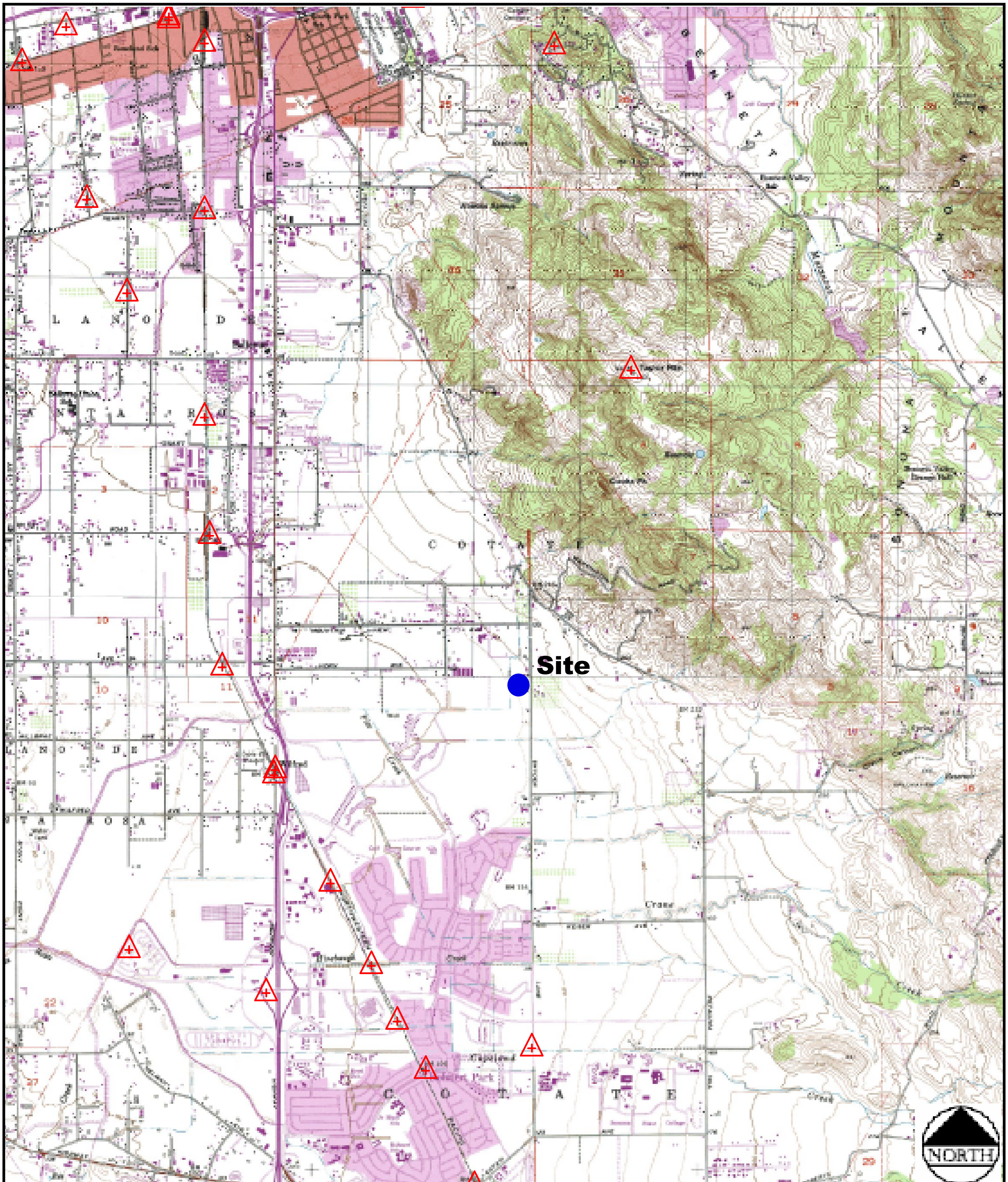
Our services consist of professional opinions and conclusions developed in accordance with generally accepted geotechnical engineering principles and practices. We provide no warranty, either expressed or implied. Our conclusions and recommendations are based on the information provided to us regarding the proposed construction, the results of our field exploration, laboratory testing program, and professional judgment. Verification of our conclusions and recommendations is subject to our review of the project plans and specifications, and our observation of construction.

The borings represent subsurface conditions at the locations and on the date indicated. It is not warranted that they are representative of such conditions elsewhere or at other times. Site conditions and cultural features described in the text of this report are those existing at the time of our field exploration on July 17, 2015, and may not necessarily be the same or comparable at other times.

The scope of our services did not include an environmental assessment or a study of the presence or absence of toxic mold and/or hazardous, toxic or corrosive materials in the soil, surface water, groundwater or air (on, below or around this site), nor did it include an evaluation or study for the presence or absence of wetlands. These studies should be conducted under separate cover, scope and fee and should be provided by a qualified expert in those fields.

APPENDIX A - PLATES

LIST OF PLATES



Reference: Maptech Topoquad, Cotati and Santa Rosa, California Quadrangle

Scale: 1" = 2000'

RGH CONSULTANTS

SITE LOCATION MAP
SCAPOSD Young-Amos Incubator Farm
Snyder Lane
Rohnert Park, California

PLATE 1

Job No: 1993.41.04.1 | Date: Aug 2015

200 0 200 400 feet

N

B-7 Boring Location and Number

Reference: Google Earth

RGH CONSULTANTS		**EXPLORATION PLAN** SCAPOSD Young-Amos Incubator Farm Snyder Lane Rohnert Park, California	PLATE 2
Job No: 1993.41.04.1	Date: Aug 2015		

Date(s) Drilled **August 17, 2015**	Logged By **JNK**	Checked By **EGC**
Drilling Method **Solid Stem Auger**	Drill Bit Size/Type **6 inches**	Total Depth of Borehole **17.0 feet**
Drill Rig Type **Truck-mounted Drill Rig**	Drilling Contractor **Pearson Drilling**	Approximate Surface Elevation **Existing ground surface**
Groundwater Level and Date Measured **8.5 feet**	Sampling Method(s) **Modified California**	Hammer Data **140 lbs., 30 inch drop**

Elevation (feet)	Depth (feet)	Sample Type	Sampling Resistance, blows/ft	Graphic Log	MATERIAL DESCRIPTION	Dry Density (pcf)	Water Content (%)	% <#200 Sieve	PI, %	LL, %	Expansion Index (EI)	UC, psf	REMARKS AND OTHER TESTS
	0				GRAY BROWN SANDY CLAY (CL), stiff, moist, desication cracks, few roots								
			12		GRAY BROWN SANDY CLAY (CL), stiff to very stiff, moist, fine sand			69.5	20	36	86		
			16					68.5	22	46			
	5				GRAY BROWN SANDY CLAY (CL/CH), medium stiff to stiff, moist, fine to coarse sand								
			10										
					9:20 am								
					9:01 am								
					8:53 am								
	10		6										
					GRAY SANDY CLAY (CL), stiff, moist, fine sand								
	15		28		MEDIUM BROWN SILTY GRAVEL W/ SAND (GM), medium dense, wet								
			24		GRAY BROWN SANDY CLAY (CL), very stiff, wet, fine to coarse sand								
					Bottom of boring at 17.0 feet								

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Job No: 1993.41.04.1 | Date: Aug 2015

LOG OF BORING B-1
SCAPOSD Young-Amos Incubator Farm
Snyder Lane
Rohnert Park, California

PLATE
3

Date(s) Drilled **August 17, 2015**	Logged By **JNK**	Checked By **EGC**
Drilling Method **Solid Stem Auger**	Drill Bit Size/Type **6 inches**	Total Depth of Borehole **16.1 feet**
Drill Rig Type **Truck-mounted Drill Rig**	Drilling Contractor **Pearson Drilling**	Approximate Surface Elevation **Existing ground surface**
Groundwater Level and Date Measured **11.0 feet**	Sampling Method(s) **Modified California**	Hammer Data **140 lbs., 30 inch drop**

Elevation (feet)	Depth (feet)	Sample Type	Sampling Resistance, blows/ft	Graphic Log	MATERIAL DESCRIPTION	Dry Density (pcf)	Water Content (%)	% <#200 Sieve	PI, %	LL, %	Expansion Index (EI)	UC, psf	REMARKS AND OTHER TESTS
	0				DARK BROWN SANDY CLAY (CL), stiff, dry, porous w/ roots, few coarse sand								
			12					69.5	20	36	86		
					GRAY BROWN SANDY CLAY (CL), very stiff, moist, fine sand								
			22					56.9					
	5				Increasing sand content at 5.0 feet								
			21										
	10		12										
					10:52 am ▼								
	15		7										
			29/1.5"		SILTY GRAVEL W/ SAND (GM), medium dense, wet, fine to coarse gravel								
					Bottom of boring at 16.0 feet								

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Job No: 1993.41.04.1 | Date: Aug 2015

LOG OF BORING B-2
SCAPOSD Young-Amos Incubator Farm
Snyder Lane
Rohnert Park, California

PLATE **4**

Date(s) Drilled **August 17, 2015**	Logged By **JNK**	Checked By **EGC**
Drilling Method **Solid Stem Auger**	Drill Bit Size/Type **6 inches**	Total Depth of Borehole **11.5**
Drill Rig Type **Truck-mounted Drill Rig**	Drilling Contractor **Pearson Drilling**	Approximate Surface Elevation **Existing ground surface**
Groundwater Level and Date Measured **No free groundwater detected**	Sampling Method(s) **Modified California**	Hammer Data **140 lbs., 30 inch drop**

Elevation (feet)	Depth (feet)	Sample Type	Sampling Resistance, blows/ft	Graphic Log	MATERIAL DESCRIPTION	Dry Density (pcf)	Water Content (%)	% <#200 Sieve	PI, %	LL, %	Expansion Index (EI)	UC, psf	REMARKS AND OTHER TESTS
	0				DARK BROWN SANDY CLAY (CL), stiff, moist, few roots and coarse sand, desication cracks								
			10										
					GRAY BROWN CLAYEY SAND (SC), medium dense to dense, dry to moist, fine to coarse sand, fine gravel								
			37			107	10.3						
	5												
			32			106	14.1						
	10												
			19					12.3					
					Bottom of boring at 11.5 feet								
	15												

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Job No: 1993.41.04.1 | Date: Aug 2015

LOG OF BORING B-3
SCAPOSD Young-Amos Incubator Farm
Snyder Lane
Rohnert Park, California

PLATE
5

Date(s) Drilled **August 17, 2015**	Logged By **JNK**	Checked By **EGC**
Drilling Method **Solid Stem Auger**	Drill Bit Size/Type **6 inches**	Total Depth of Borehole **5.0 feet**
Drill Rig Type **Truck-mounted Drill Rig**	Drilling Contractor **Pearson Drilling**	Approximate Surface Elevation **Existing ground surface**
Groundwater Level and Date Measured **No free groundwater detected**	Sampling Method(s) **Modified California**	Hammer Data **140 lbs., 30 inch drop**

Elevation (feet)	Depth (feet)	Sample Type	Sampling Resistance, blows/ft	Graphic Log	MATERIAL DESCRIPTION	Dry Density (pcf)	Water Content (%)	% <#200 Sieve	PI, %	LL, %	Expansion Index (EI)	UC, psf	REMARKS AND OTHER TESTS
	0				GRAY BROWN SANDY CLAY (CL), stiff, dry, rootlets, porous								
					GRAY BROWN SANDY CLAY (CL), stiff, moist, coarse sand								
	5				Bottom of boring at 5.0 feet								
	10												
	15												

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Job No: 1993.41.04.1 | Date: Aug 2015

LOG OF BORING B-4
SCAPOSD Young-Amos Incubator Farm
Snyder Lane
Rohnert Park, California

Date(s) Drilled	**August 17, 2015**	Logged By	**JNK**	Checked By	**EGC**
Drilling Method	**Solid Stem Auger**	Drill Bit Size/Type	**6 inches**	Total Depth of Borehole	**15.5 feet**
Drill Rig Type	**Truck-mounted Drill Rig**	Drilling Contractor	**Pearson Drilling**	Approximate Surface Elevation	**Existing ground surface**
Groundwater Level and Date Measured	**No free groundwater detected**	Sampling Method(s)	**Modified California**	Hammer Data	**140 lbs., 30 inch drop**

Elevation (feet)	Depth (feet)	Sample Type	Sampling Resistance, blows/ft	Graphic Log	MATERIAL DESCRIPTION	Dry Density (pcf)	Water Content (%)	% <#200 Sieve	PI, %	LL, %	Expansion Index (EI)	UC, psf	REMARKS AND OTHER TESTS
	0				MOTTLED LIGHT AND DARK GRAY SANDY CLAY (CL), stiff to hard, dry, some gravel and coarse sand								
		■	15			108	8.7						
		■	38/9"			100.7	9.3					2689	
	5				GRAY BROWN CLAYEY SAND (SC), dense, moist, fine to coarse sand with some gravel								
		■	37/9"			111	14.1						
					MOTTLED GRAY AND ORANGE SANDY CLAY (CL), stiff to very stiff, moist, some coarse sand								
	10	■	13			93.8	28.8					4336	
	15	■	29										
					Bottom of boring at 15.5								

RGH CONSULTANTS

Job No: 1993.41.04.1 | Date: Aug 2015

LOG OF BORING B-5

SCAPOSD Young-Amos Incubator Farm
Snyder Lane
Rohnert Park, California

PLATE
7

Date(s) Drilled **August 17, 2015**	Logged By **JNK**	Checked By **EGC**
Drilling Method **Solid Stem Auger**	Drill Bit Size/Type **6 inches**	Total Depth of Borehole **10.5 feet**
Drill Rig Type **Truck-mounted Drill Rig**	Drilling Contractor **Pearson Drilling**	Approximate Surface Elevation **Existing ground surface**
Groundwater Level and Date Measured **No free groundwater detected**	Sampling Method(s) **Modified California**	Hammer Data **140 lbs., 30 inch drop**

Elevation (feet)	Depth (feet)	Sample Type	Sampling Resistance, blows/ft	Graphic Log	MATERIAL DESCRIPTION	Dry Density (pcf)	Water Content (%)	% <#200 Sieve	PI, %	LL, %	Expansion Index (EI)	UC, psf	REMARKS AND OTHER TESTS
	0				GRAY BROWN CLAYEY SAND (SC), dense, dry to moist, fine to medium sand								
			40			100	18.4						
	5		15		GRAY BROWN SANDY CLAY (CL), stiff, moist, fine sand	96.9	25.2					4778	
	10		10										
					Bottom of boring at 10.5 feet								
	15												

RGH CONSULTANTS

Job No: 1993.41.04.1 | Date: Aug 2015

LOG OF BORING B-6
SCAPOSD Young-Amos Incubator Farm
Snyder Lane
Rohnert Park, California

PLATE **8**

Date(s) Drilled **August 17, 2015**	Logged By **JNK**	Checked By **EGC**
Drilling Method **Solid Stem Auger**	Drill Bit Size/Type **6 inches**	Total Depth of Borehole **15.5 feet**
Drill Rig Type **Truck-mounted Drill Rig**	Drilling Contractor **Pearson Drilling**	Approximate Surface Elevation **Existing ground surface**
Groundwater Level and Date Measured **No free groundwater detected**	Sampling Method(s) **Modified California**	Hammer Data **140 lbs., 30 inch drop**

Elevation (feet)	Depth (feet)	Sample Type	Sampling Resistance, blows/ft	Graphic Log	MATERIAL DESCRIPTION	Dry Density (pcf)	Water Content (%)	% <#200 Sieve	PI, %	LL, %	Expansion Index (EI)	UC, psf	REMARKS AND OTHER TESTS
	0				DARK BROWN CLAY W/ SAND (CL), very stiff, dry, desication cracks, few roots, coarse sand and gravel								
		■	20			100	12.9						
					BROWN GRAY CLAYEY SAND (SC), dense, most, fine to coarse sand								
		■	30		BROWN GRAY CLAY (CH), stiff, moist	104	16.6						
	5												
		■	12			96.7	23.1					1787	
					BROWN GRAY CLAY (CL), very stiff, most, some coarse sand								
	10	■	16										
	15	■	8										
					Bottom of boring at 15.5								

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Job No: 1993.41.04.1 | Date: Aug 2015

LOG OF BORING B-7

SCAPOSD Young-Amos Incubator Farm
Snyder Lane
Rohnert Park, California

PLATE 9

Elevation (feet)	Depth (feet)	Sample Type	Sampling Resistance, blows/ft	Graphic Log	MATERIAL DESCRIPTION	Dry Density (pcf)	Water Content (%)	% <#200 Sieve	PI, %	LL, %	Expansion Index (EI)	UC, psf	REMARKS AND OTHER TESTS
1	2	3	4	5	6	7	8	9	10	11	12	13	14

COLUMN DESCRIPTIONS

1. Elevation (feet): Elevation (MSL, feet).
2. Depth (feet): Depth in feet below the ground surface.
3. Sample Type: Type of soil sample collected at the depth interval shown.
4. Sampling Resistance, blows/ft: Number of blows to advance driven sampler one foot (or distance shown) beyond seating interval using the hammer identified on the boring log.
5. Graphic Log: Graphic depiction of the subsurface material encountered.
6. MATERIAL DESCRIPTION: Description of material encountered. May include consistency, moisture, color, and other descriptive text.
7. Dry Density (pcf): Dry density, in pcf.
8. Water Content (%): Water content, percent.
9. % <#200 Sieve: % <#200 Sieve
10. PI, %: Plasticity Index, expressed as a water content.
11. LL, %: Liquid Limit, expressed as a water content.
12. Expansion Index (EI): Expansion Index (EI)
13. UC, psf: Unconfined compressive strength, in pounds per square foot.
14. REMARKS AND OTHER TESTS: Comments and observations regarding drilling or sampling made by driller or field personnel.

FIELD AND LABORATORY TEST ABBREVIATIONS

CHEM: Chemical tests to assess corrosivity
COMP: Compaction test
CONS: One-dimensional consolidation test
LL: Liquid Limit, percent
PI: Plasticity Index, percent
SA: Sieve analysis (percent passing No. 200 Sieve)
UC: Unconfined compressive strength test, Qu, in psf
WA: Wash sieve (percent passing No. 200 Sieve)

MATERIAL GRAPHIC SYMBOLS

Fat CLAY, CLAY w/SAND, SANDY CLAY (CH)
Lean CLAY, CLAY w/SAND, SANDY CLAY (CL)
Lean-Fat CLAY, CLAY w/SAND, SANDY CLAY (CL-CH)
Silty GRAVEL (GM)
Clayey SAND (SC)

TYPICAL SAMPLER GRAPHIC SYMBOLS

Auger sampler
Bulk Sample
3-inch-OD California w/ brass rings
CME Sampler
Grab Sample
2.5-inch-OD Modified California w/ brass liners
Pitcher Sample
2-inch-OD unlined split spoon (SPT)
Shelby Tube (Thin-walled, fixed head)

OTHER GRAPHIC SYMBOLS

Water level (at time of drilling, ATD)
Water level (after waiting)
Minor change in material properties within a stratum
Inferred/gradational contact between strata
Queried contact between strata

GENERAL NOTES

1: Soil classifications are based on the Unified Soil Classification System. Descriptions and stratum lines are interpretive, and actual lithologic changes may be gradual. Field descriptions may have been modified to reflect results of lab tests.
2: Descriptions on these logs apply only at the specific boring locations and at the time the borings were advanced. They are not warranted to be representative of subsurface conditions at other locations or times.

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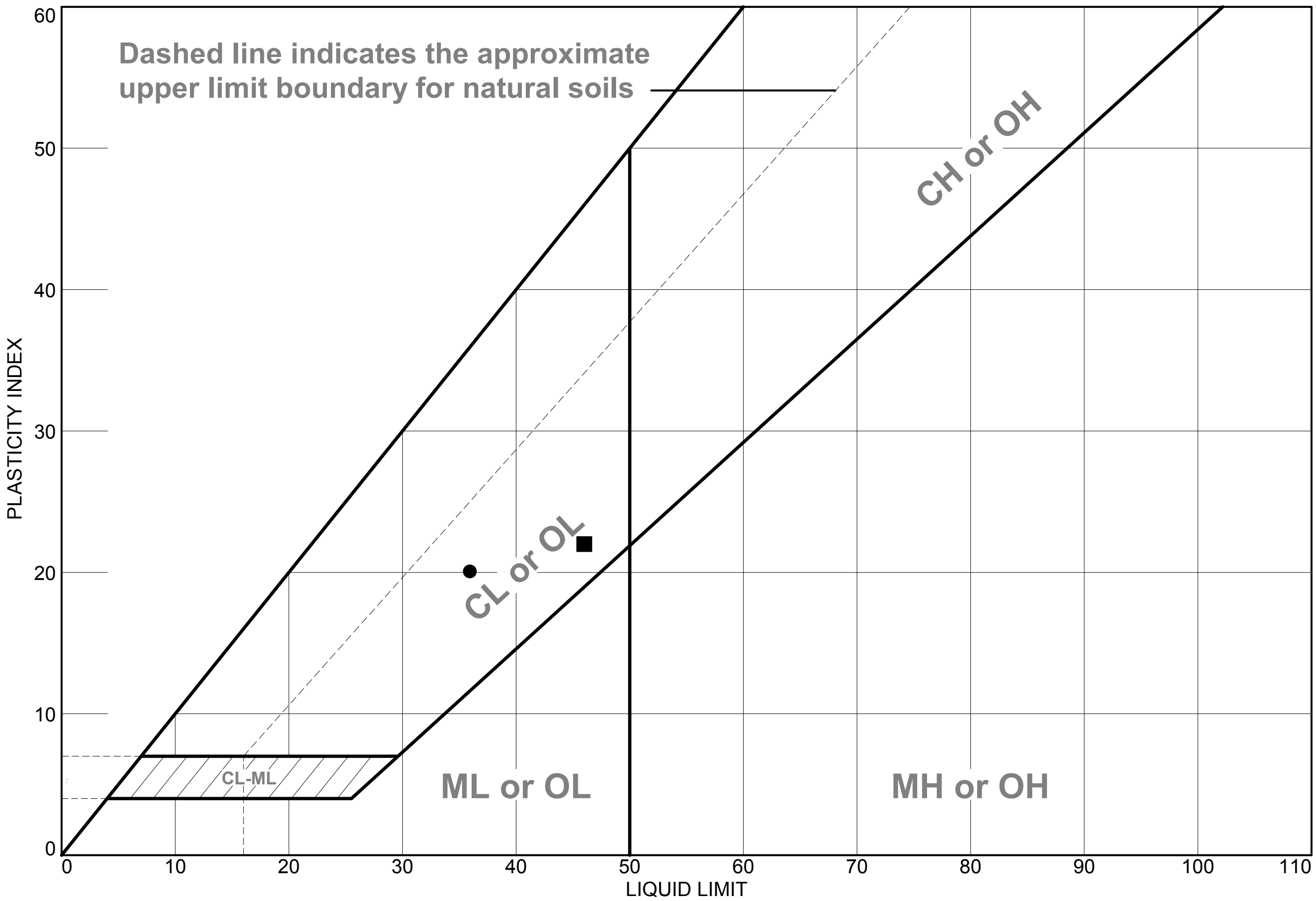
Job No: 1993.41.04.1 | Date: Aug 2015

SOIL CLASSIFICATION AND KEY TO TEST DATA
SCAPOSD Young-Amos Incubator Farm
Snyder Lane
Rohnert Park, California

PLATE **10**

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Brn Sandy Clay (CL)	36	16	20		69.5	CL
■	Brn Sandy Clay (CL)	46	24	22		68.5	CL

Project No. 1993.41.04.1 **Client:** RGH Consultants

Project: SCAPOSD- Young-Amos Incubator Farm

Remarks:
●Expansion Index=86

●**Source of Sample:** B-1, 2 **Depth:** 1.0’-4.0’ **Sample Number:** Bulk

■**Source of Sample:** B-1 **Depth:** 4.0’

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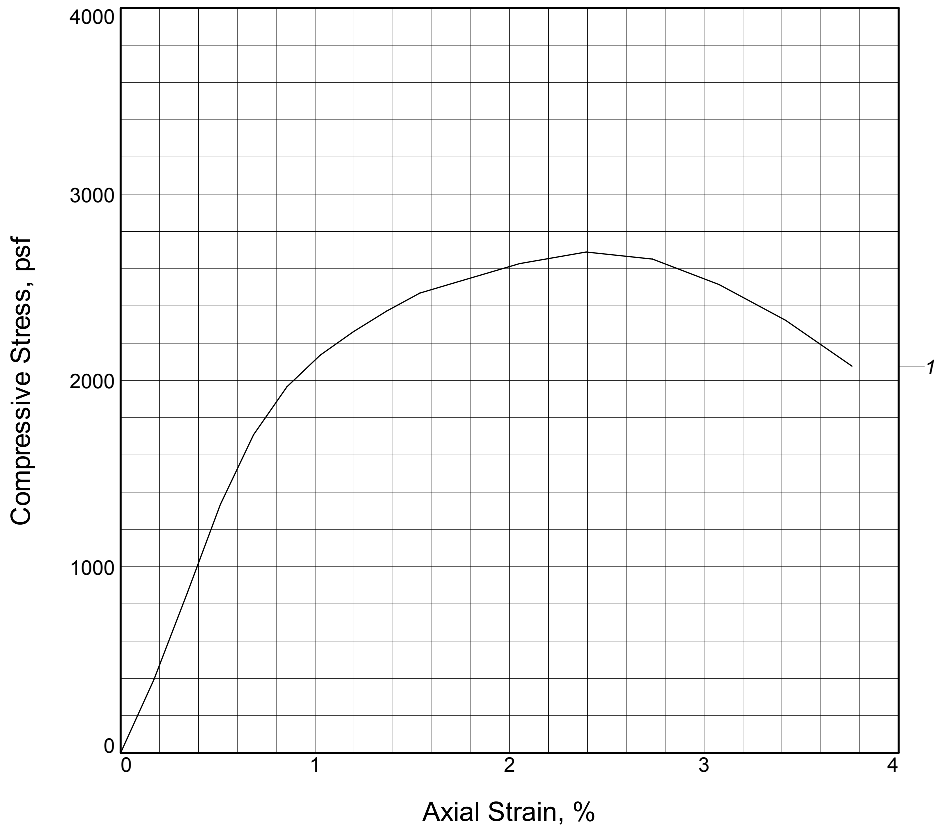
Job No: 1993.41.04.1 | Date: Aug 2015

CLASSIFICATION TEST DATA
SCAPOSD Young-Amos Incubator Farm
Snyder Lane
Rohnert Park, California

PLATE 11

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	2689			
Undrained shear strength, psf	1345			
Failure strain, %	2.4			
Strain rate, in./min.	0.06			
Water content, %	9.3			
Wet density, pcf	110.0			
Dry density, pcf	100.7			
Saturation, %	37.3			
Void ratio	0.6745			
Specimen diameter, in.	2.40			
Specimen height, in.	5.85			
Height/diameter ratio	2.44			

Description: Brn Clayey Sand (SC)

LL =	PL =	PI =	GS= 2.70	Type: Undisturbed

Project No.: 1993.41.04.1

Client: RGH Consultants

Date Sampled: 7/29/15

Remarks:

Project: SCAPOSD- Young-Amos Incubator Farm

Source of Sample: B-5 **Depth:** 4.0’

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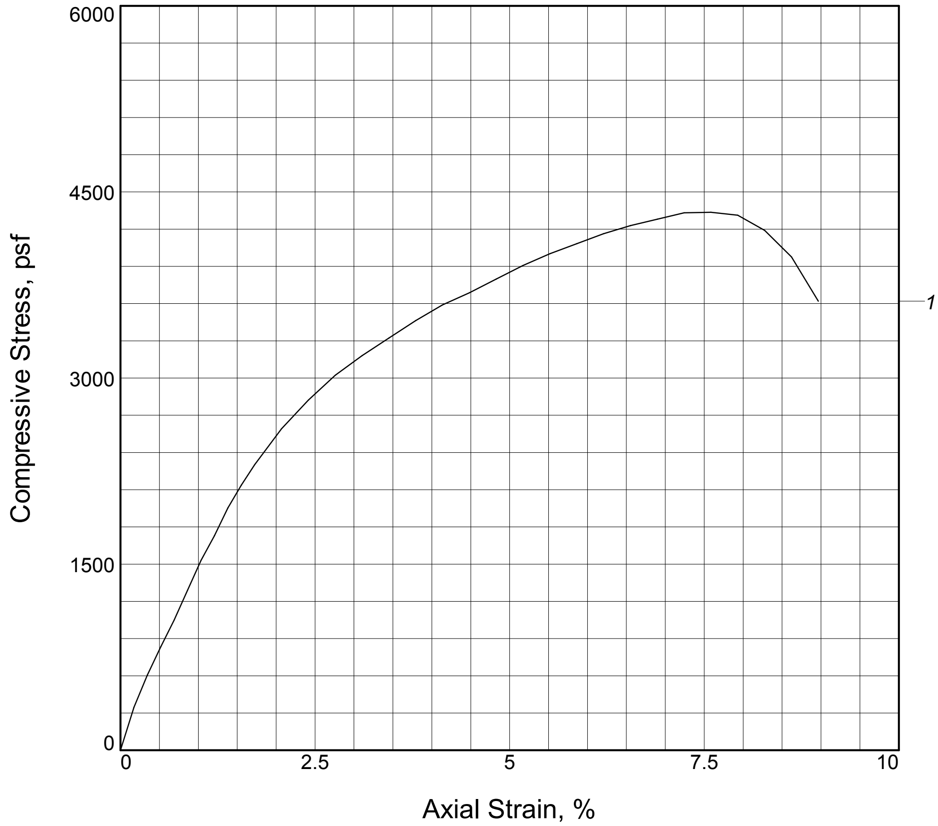
Job No: 1993.41.04.1 | Date: Aug 2015

STRENGTH TEST DATA
SCAPOSD Young-Amos Incubator Farm
Snyder Lane
Rohnert Park, California

PLATE
12

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	4336			
Undrained shear strength, psf	2168			
Failure strain, %	7.6			
Strain rate, in./min.	0.06			
Water content, %	28.8			
Wet density, pcf	120.8			
Dry density, pcf	93.8			
Saturation, %	97.6			
Void ratio	0.7964			
Specimen diameter, in.	2.41			
Specimen height, in.	5.80			
Height/diameter ratio	2.41			

Description: Brn Sandy Clay (CL)

LL =	PL =	PI =	GS= 2.70	Type: Undisturbed

Project No.: 1993.41.04.1

Client: RGH Consultants

Date Sampled: 7/29/15

Remarks:

Project: SCAPOSD- Young-Amos Incubator Farm

Source of Sample: B-5 **Depth:** 10.0’

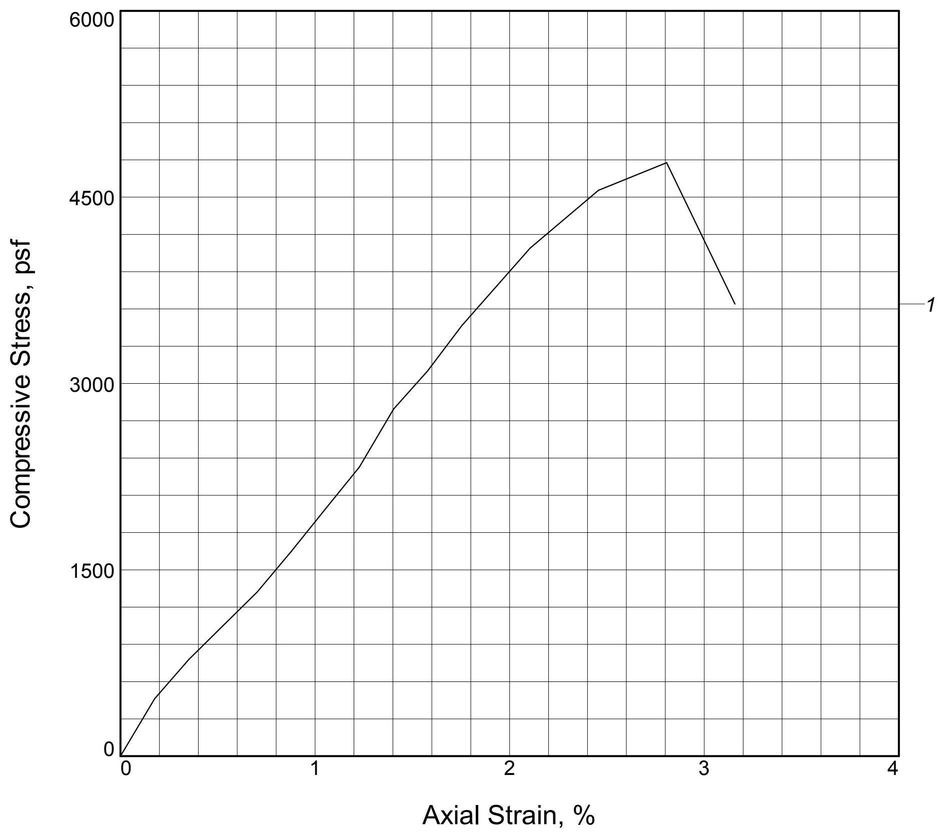
RGH CONSULTANTS

STRENGTH TEST DATA
SCAPOSD Young-Amos Incubator Farm
Snyder Lane
Rohnert Park, California

PLATE 13

Job No: 1993.41.04.1 | Date: Aug 2015

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	4778			
Undrained shear strength, psf	2389			
Failure strain, %	2.8			
Strain rate, in./min.	0.06			
Water content, %	25.2			
Wet density, pcf	121.4			
Dry density, pcf	96.9			
Saturation, %	92.2			
Void ratio	0.7396			
Specimen diameter, in.	2.41			
Specimen height, in.	5.70			
Height/diameter ratio	2.37			

Description: Brn Sandy Clay (CL)

LL =	PL =	PI =	GS= 2.70	Type: Undisturbed

Project No.: 1993.41.04.1

Date Sampled: 7/29/15

Remarks:

Client: RGH Consultants

Project: SCAPOSD- Young-Amos Incubator Farm

Source of Sample: B-6 **Depth:** 5.0’

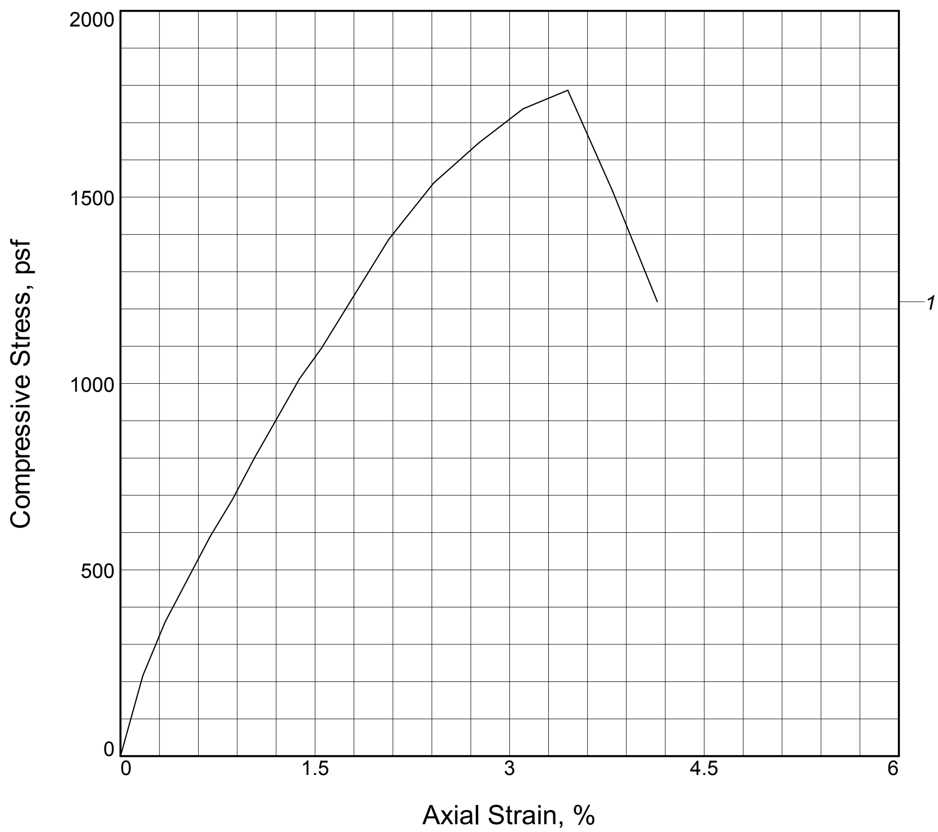
RGH CONSULTANTS

Job No: 1993.41.04.1 | Date: Aug 2015

STRENGTH TEST DATA
SCAPOSD Young-Amos Incubator Farm
Snyder Lane
Rohnert Park, California

PLATE 14

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	1787			
Undrained shear strength, psf	893			
Failure strain, %	3.4			
Strain rate, in./min.	0.06			
Water content, %	23.1			
Wet density, pcf	119.1			
Dry density, pcf	96.7			
Saturation, %	84.0			
Void ratio	0.7429			
Specimen diameter, in.	2.41			
Specimen height, in.	5.80			
Height/diameter ratio	2.41			

Description: Olive Sandy Clay (CL)

LL =	**PL =**	**PI =**	**GS=** 2.70	**Type:** Undisturbed

Project No.: 1993.41.04.1

Client: RGH Consultants

Date Sampled: 7/29/15

Remarks:

Project: SCAPOSD- Young-Amos Incubator Farm

Source of Sample: B-7 **Depth:** 5.5’

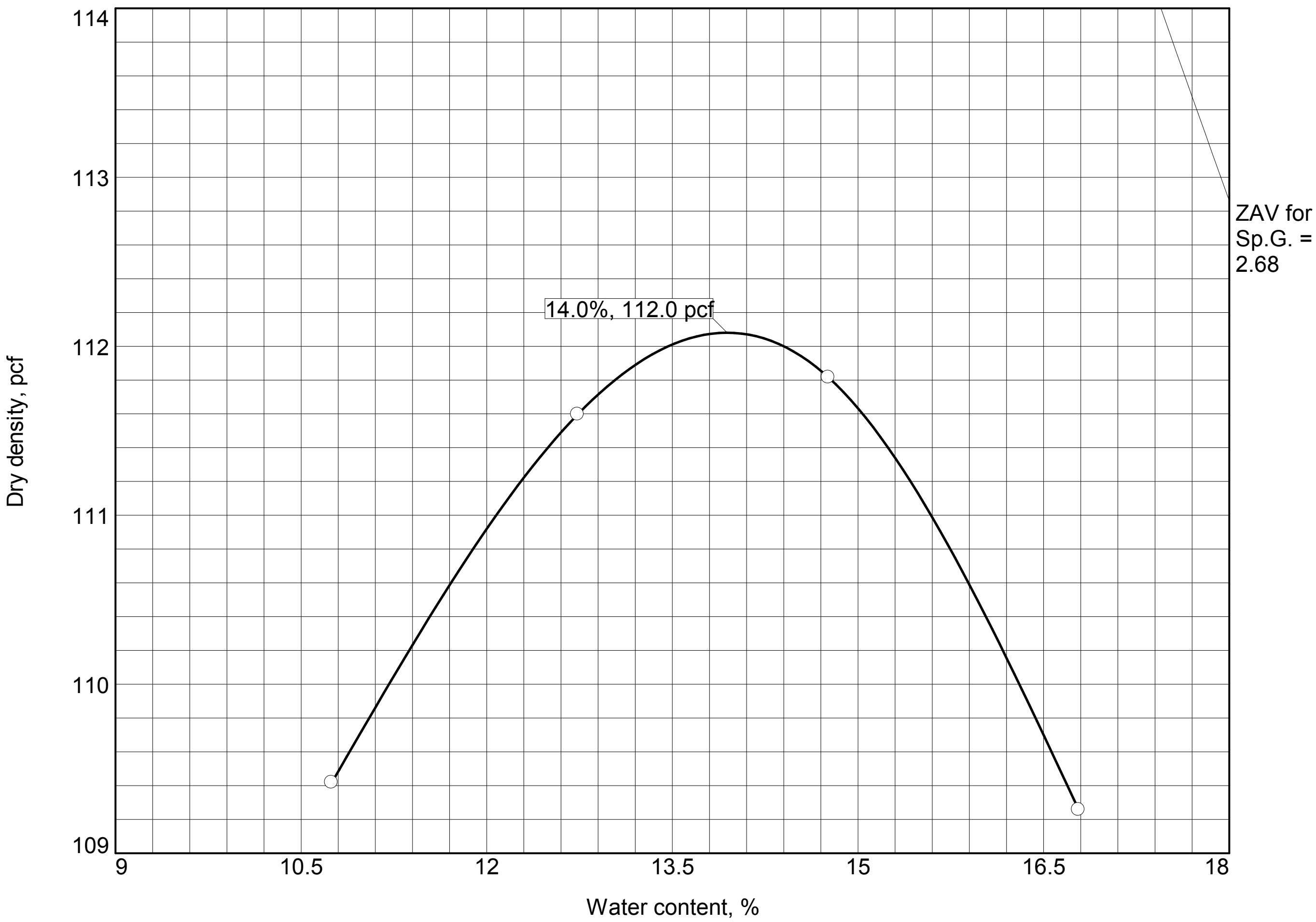
RGH CONSULTANTS

Job No: 1993.41.04.1 | Date: Aug 2015

STRENGTH TEST DATA
SCAPOSD Young-Amos Incubator Farm
Snyder Lane
Rohnert Park, California

PLATE
15

COMPACTION TEST REPORT



Test specification: ASTM D 1557-12 Method B Modified

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/8 in.	% < No.200
	USCS	AASHTO						
1.0'-4.0'	CL				36	20		69.5

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 112.0 pcf Optimum moisture = 14.0 %	Brn Sandy Clay (CL)

Project No. 1993.41.04.1 **Client:** RGH Consultants

Project: SCAPOSD- Young-Amos Incubator Farm

○**Source of Sample:** B-1, 2 **Sample Number:** Bulk

RGH CONSULTANTS

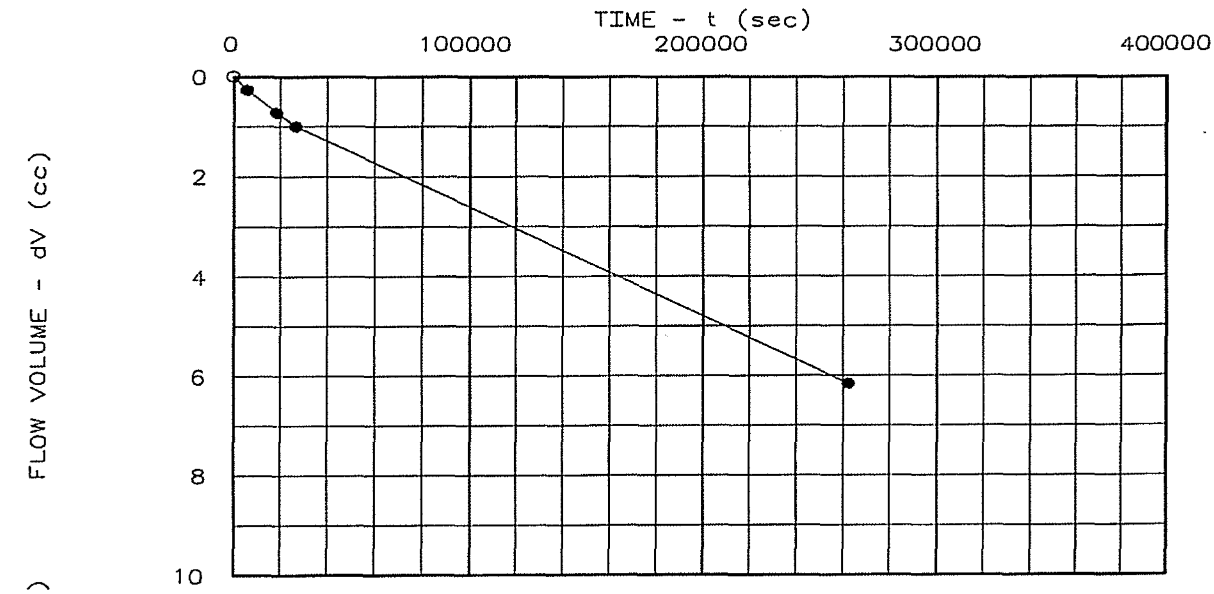
COMPACTION TEST DATA
SCAPOSD Young-Amos Incubator Farm
Snyder Lane
Rohnert Park, California

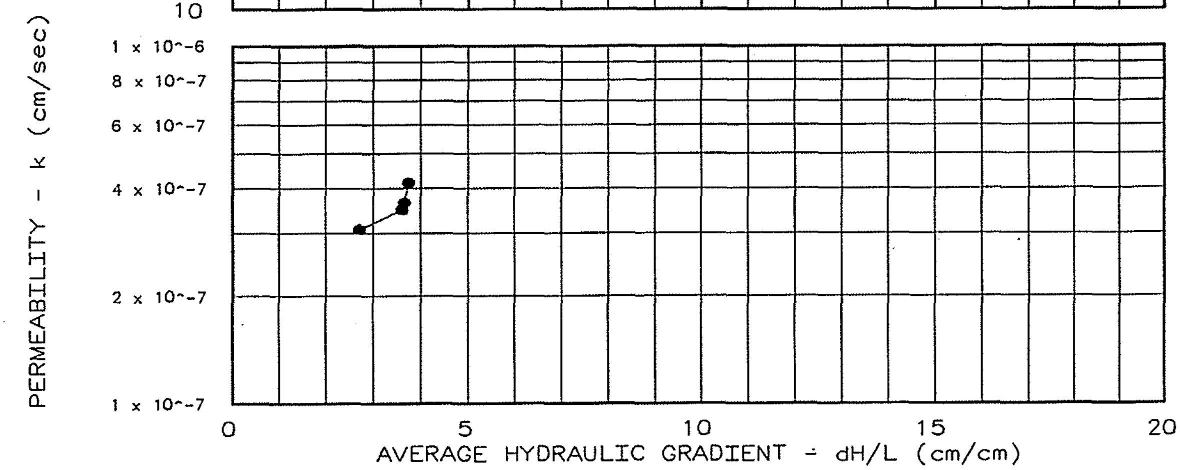
PLATE **16**

Job No: 1993.41.04.1 | Date: Aug 2015

PERMEABILITY TEST REPORT

TEST DATA:			SAMPLE DATA:
Specimen Height (cm): 6.35			Sample Identification: B-1, 2 @ 1.0'-4.0'
Specimen Diameter (cm): 6.17			
Dry Unit Weight (pcf): 100.4			Visual Description: Brn Sandy Clay (CL)
Moisture Before Test (%): 18.3			
Moisture After Test (%): 25.1			Remarks:
Run Number:	1 ●	2 ▲	
Cell Pressure (psi):	56.0		Maximum Dry Density (pcf): 112.0
			Optimum Moisture Content (%): 14.0 ASTM(D1557)
Sat. Pressure (psi):	52.0		
Diff. Head (psi):	0.2		Percent Compaction: 89.7%
			Permeameter type: Flexwall
Perm. (cm/sec):	3.33 x 10^-7		Sample type: Remold





Project: SCAPOSD	Project No.: 1993.41.01
Location: Rohnert Park	File No.:
Date: 7/31/15	Lab No.:
	Tested by: GEF
	Checked by: GEF
	Test: FH - Falling head C

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Job No: 1993.41.04.1 | Date: Aug 2015

PERMEABILITY TEST DATA
SCAPOSD Young-Amos Incubator Farm
Snyder Lane
Rohnert Park, California

PLATE
17

PERMEABILITY TEST REPORT

TEST DATA:
Specimen Height (cm): 8.00
Specimen Diameter (cm): 6.17
Dry Unit Weight (pcf): 81.6
Moisture Before Test (%): 32.0
Moisture After Test (%): 39.4
Run Number: 1 ● 2 ▲
Cell Pressure (psi): 56.0

Sat. Pressure (psi): 52.0
Diff. Head (psi): 0.3

Perm. (cm/sec): 3.00 x 10^-7

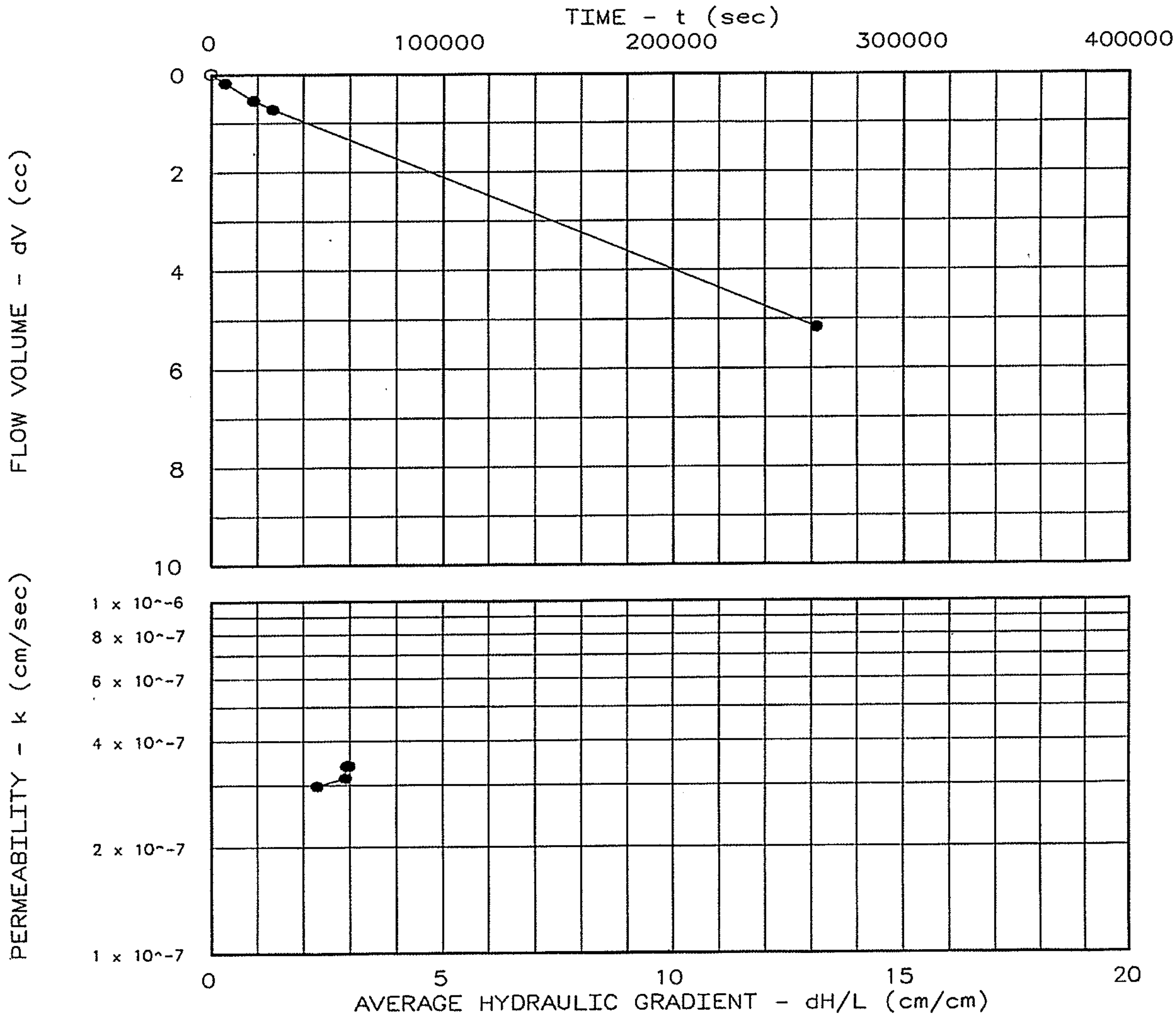
SAMPLE DATA:
Sample Identification: BH-1 @ 4.0'

Visual Description: Brn Sandy Clay (CL)

Remarks:

Maximum Dry Density (pcf):
Optimum Moisture Content (%):

Percent Compaction:
Permeameter type: Flexwall
Sample type: Undisturbed



Project: SCAPOSD
Location: Rohnert Park
Date: 7/31/15

Project No.: 1993.41.1
File No.:
Lab No.:
Tested by: GEG
Checked by: GEF
Test: FH - Falling head C

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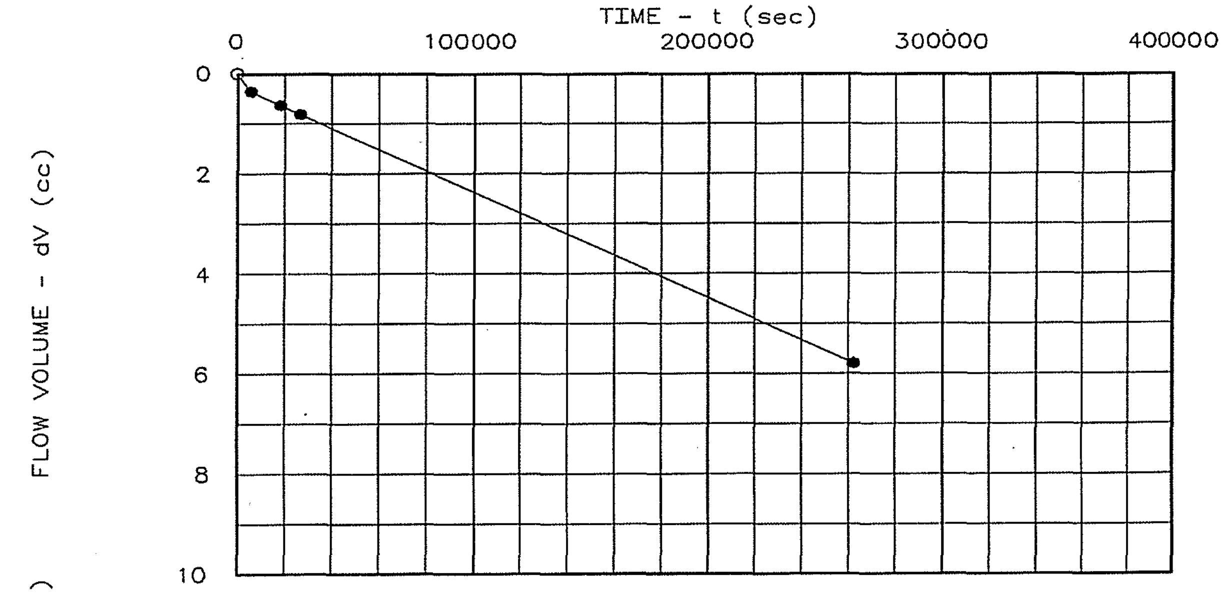
PERMEABILITY TEST DATA
SCAPOSD Young-Amos Incubator Farm
Snyder Lane
Rohnert Park, California

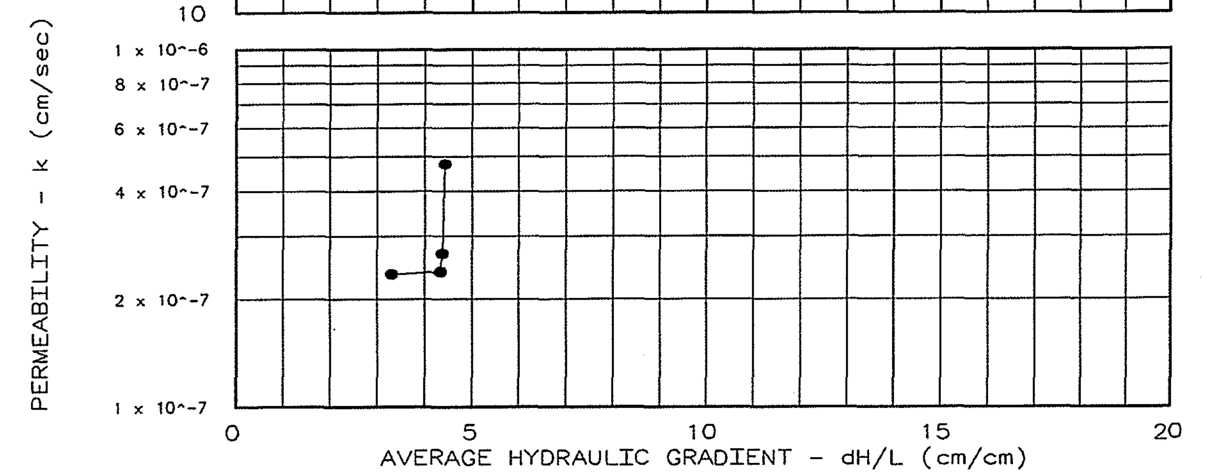
PLATE
18

Job No: 1993.41.04.1 | Date: Aug 2015

PERMEABILITY TEST REPORT

TEST DATA:			SAMPLE DATA:
Specimen Height (cm): 5.33			Sample Identification: B-2 @ 4.0'
Specimen Diameter (cm): 6.17			
Dry Unit Weight (pcf): 102.4			Visual Description: Grey Sandy Clay (CL)
Moisture Before Test (%): 18.6			
Moisture After Test (%): 23.9			Remarks:
Run Number:	1 ●	2 ▲	
Cell Pressure (psi):	56.0		Maximum Dry Density (pcf):
			Optimum Moisture Content (%):
Sat. Pressure (psi):	52.0		
Diff. Head (psi):	0.3		Percent Compaction:
			Permeameter type: Flexwall
Perm. (cm/sec):	2.83 x 10^-7		Sample type: Undisturbed





Project: SCAPOSD	Project No.: 1993.41.01
Location: Rohnert Park	File No.:
Date: 7/31/15	Lab No.:
	Tested by: GEF
	Checked by: GEF
	Test: FH - Falling head C

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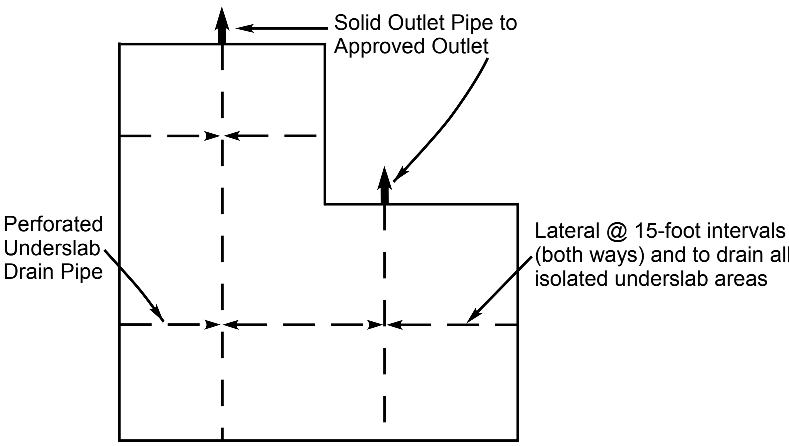
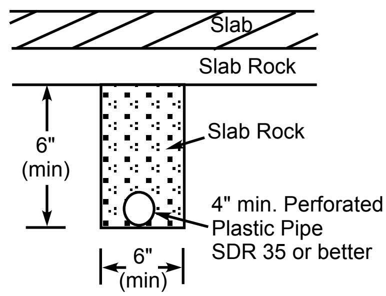
Job No: 1993.41.04.1 | Date: Aug 2015

PERMEABILITY TEST DATA
SCAPOSD Young-Amos Incubator Farm
Snyder Lane
Rohnert Park, California

PLATE
19



TYPICAL UNDERSLAB DRAIN PLAN



SLAB UNDERDRAIN

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Job No: 1993.41.04.1 | Date: Aug 2015

TYPICAL SUBDRAIN DETAILS

SCAPOSD Young-Amos Incubator Farm
Snyder Lane
Rohnert Park, California

PLATE 20

APPENDIX B - REFERENCES

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Youd, T.L., and Idriss, I.M., and 19 others, 2001, Liquefaction Resistance of Soils: summary report from the 1996 NCEER and 1998 NCEER/NSF workshops on evaluation of liquefaction resistance of soils: ASCE Geotechnical and Geoenvironmental Journal, v. 127, no. 10, p. 817-833.

APPENDIX C - DISTRIBUTION

Prunuske Chatham, Inc. (6,0,e)
Attn: Jennifer Michaud
400 Morris Street, Suite G
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jennifer@pcz.com

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Eric G. Chase
RGH Consultants
1305 N.Dutton Avenue
Santa Rosa, CA 95401

September 3, 2015

Dear Eric::

Please find herewith your ag soil report on the bulk soil sample from a Sonoma County Agricultural Preservation & Open Space District location in Sonoma County, Santa Rosa area.

RESULTS
By way of introduction and orientation, there are two graph sheets: one rates the various standard nutrients plus organic matter content (OM); and a second graph rates the various soil condition parameters (e.g. pH, salinity, etc.). The nutrients are the basics comprised of the primaries, N/P/K (nitrogen, phosphorous and potassium), and the secondaries, Ca/Mg (calcium & magnesium); plus there are the minors, S, Zn, Mn, Cu, Fe and B (sulfur, zinc, manganese, copper, iron & boron). As you can see, primary the nutrients (N/P/K) rate adequate (N) to low (P & K). This soil does have a marginal to low secondary (Ca), while the other secondary (Mg) rates fine. Most of the minors rate at least adequate, but S and Zn rate marginal (i.e., not low, but not optimal either); the other minors, including boron, are fine. The OM level is decent for a native soil, but could be improved for vegetables.

The next topic is the soil condition parameters. These are properties of the soil that are just as crucial as nutrient levels and they must be within proper ranges in order for vegetation to do well. These properties include soil reaction (i.e., pH), acidity, alkalinity and salinity. Soil reaction (pH) is moderately acidic being in the mid fives, and buffer index (exchangeable soil acidity) is high, and is a definite concern as a result. Excess carbonate level (soil alkalinity) is very low, which is fine and consistent with the elevated acidity. Total salinity (as soluble salts) is a little high, and sodium (Na) salinity is definitely elevated (being near 300 ppm). The Ca:Mg ratio (@ ~3.2) is fine.

The next item of discussion is the CEC (Cation Exchange Complex) of the soil the results for which are found on the data sheet (second tier, right side under the heading "Actual Percent of Total CEC"). There are several critical nutrient elements shown and underneath each one is listed its optimal range. Three of the five base exchange numbers are out of their optimal ranges, including %Ca, which is quite low; %Na, which is elevated; and %H (i.e., soil acidity) which is high (approaching double its optimal maximum). At <16, total CEC value is fair indicating the soil should have an adequate nutrient holding exchange capacity. The PSA test results indicate this is a loam soil.

CONCLUSIONS
None of the three primaries is deficient, but both P and K are low, and while N is (barely) adequate now, it too should be improved. Calcium is definitely relatively low in this soil as evidenced by its low CEC proportion, despite its otherwise decent ppm level, and a decent Ca:Mg ratio. Thus, the Ca level needs to be improved. The primary reason for Ca being low in the CEC is due to the fact that this soil has too much bound acidity such that this acidity in displacing a significant amount of Ca. It depresses CEC K & Mg as well, but to a lesser extent. However, with %K barely reaching adequate in the CEC, additional K would be prudent. Alkalinity is fine, but both total soil salinity and Na are problematic and must be corrected; the latter is most troublesome. The OM level is not bad, but can and should be improved.

RECOMMENDATIONS
The following amendments, i.e., organic fertilizers, two conditioners and OM, will be needed to correct the various problems with this soil. And there will be a necessary process to correct excess salinity and, especially, elevated Na before standard amending takes place. This will involve some pre-conditioning and leaching.

Use the following amendments for vegetables in this soil:
(1) COTTONSEED MEAL (6/2/1) [requirement: **17** lbs/1000 sqft];
(2) BLOODMEAL (processed blood for N --> 12/0/0) [requirement: **10** lbs/1000 sqft];
(3) BONEMEAL (ground bone for P --> 3/15/0) [requirement: **12** lbs/1000 sqft];
(4) SULFATE of POTASH (natl deposit --> 0/0/50) [requirement: **4** lbs/1000 sqft];
(5) AG LIME ($CaCO_3$ @ >90%) [requirement: **75** lbs/1000 sqft/6"];
(6) OM (humus materials) [requirement: **2.5-3.5** cuyds/1000 sq ft]; plus
(7) Gypsum ($CaSO_4\ 2H_2O$ @ >90%) [requirement: **10** lbs/1000 sqft/6"]; and
(8) Leach – w/ **6"** of good quality irrigation water.

This soil will benefit from addition of both slow release (cottonseed meal) and immediately available (bloodmeal) nitrogen sources. The other critical primary nutrients, P and K, will be supplied by bonemeal and sulfate of potash, the latter of which will also add sulfate sulfur.

Ag lime is listed to accomplish two very important objectives: reduce the excess acidity in this soil which is serious; and increase Ca so that CEC Ca is improved while, at the same time, %H in the CEC is reduced; pH should climb to the 6-6.5 range. Gypsum is listed as an agent to facilitate the reduction of the high sodium level in this soil which would otherwise inhibit good growth of some of the vegetables that would normally be planted. This occurs through release of sulfate from the gypsum molecule which then preferentially combines with Na to help keep it soluble and moving down through the soil profile during leaching.

This soil has a fair amount of native disseminated organics, but definitely would benefit from more organic matter. The optimal range is listed above. A little more could be used, if desire, but probably should not exceed 4.5 cuyds/1000 sqft. The organic matter that is best is humus materials that are high in organic carbon and low in mineral nutrients. There are two very important reasons for using humus materials. First of all, all of the mineral nutrients needed for good growth will be provided by the various organic fertilizing agents listed above. Secondly, composts vary in their nutrient and salts content greatly, and often times can add excess salinity to soils. So it is best to avoid composts in favor of humus materials.

DISCUSSION

Before any amending of this soil is done, it has to have its excess salinity, and especially its high sodium, reduced. This is only accomplished through leaching, although addition of a small amount of conditioner (item #7 above) will facilitate the reduction of sodium. Rip or Pre-till the soil to prepare it for receiving the gypsum and for leaching. Rip down at least 1'-1.5', then spread gypsum at 2-3 times the rate listed above, and then till it into the ripped zone (either 1' or 1.5' - thus @ 2X for 1' or @ 3X for 1.5'). Then begin leaching the soil with good quality irrigation water. Because only about 50% of the leching water is effective, due to runoff and evaporative losses (especially the time of year), the rule of thumb is to double the calculated amount. This means that at least 12" of leach water should be used. The procedure is to set out a graduated container and start overhead watering putting on water and measuring how much is being put out while saturating the soil. Irrigate until water begins to pool and runoff, then stop and allow the soil to drain its excess water. Once excess water has drained, begin watering again until saturation. Keep cycling this way until 12" of water has been put on. This should take a week or two of watering a few times each day. At the end of the process take several samples and submit for Na testing.

After leaching is completed, i.e., Na has been reduced to a safe level, and the soil has dried sufficiently, rake out any debris >1"-2" in size as needed. Afterward, spread all the other various appropriate amendments (i.e., items #1 thru #6 as listed above) at the appropriate rates as listed or described above. Cultivate the entire set into the soil to a depth of 6-8" or so and then the soil is ready for planting. Be sure to water thoroughly after planting, and continue to water liberally for a couple of weeks after planting to facilitate the actions of the other conditioner, i.e., the ag lime, in the processes of re-balancing the CEC, and reducing improving the Ca level. After a couple of weeks of watering liberally each day, drop back to a normal irrigation regime for the garden.

FINAL REMARKS

Be sure to water enough to keep the soil more or less constantly moist (but not necessarily wet) for a couple of weeks post planting as this is very critical for the actions of the conditioner in correcting the various soil imbalances. Use mulching where needed at adequate depth (at least ~2", if practical). Doing the standard amending after leaching is important since leaching will reduce native nutrient content. Ag lime can be put in at the same time as the various nutrients since pH is not extreme. If a composted OM amender is considered, then be sure to obtain data for it and have that data evaluated before utilizing the compost to be sure excess in salinity and specific components toxicity will not occur. Again though, it is best to avoid compost materials since they vary great and since mineral nutrients will be provided by the amending agents listed above. Also, if there will be any fruit trees (or any other trees for that matter) that are to be planted in this soil material, then there is a different process that must be followed after leaching and after initial amending (i.e., right after cultivating the entire set of amendments into the soil). Please consult ETS in that instance. Otherwise, it is assumed typical vegetables are to be planted in this soil.

Please contact me if you have any questions, and best of luck to SCAPOSD with this project.

Sincerely yours,

Greg S. Conrad

Greg S. Conrad, Ph.D.

GSC/kc
enclos.

E T S

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CALCULATED CEC & ITS APP. RELATIONSHIP to SOIL TEXTURE
0-8 -> SAND
8-12 -> LOAMY SAND
12-20 -> SANDY LOAM
20-28 -> LOAM
28-40 -> CLAY LOAM
>40 -> CLAY

		RECEIVED & PROCESSED	DATE of REPORT
CLIENT:	RGH Consultants, 1305 N. Dutton Avenye, Santa Rosa, California	8/26/2015	9/3/2015
ATTN:	Eric G. Chase JOB #: 1993.41.04.1		
JOB:	Sonoma County Agricultural Preservation & Open Space District		
SITE:	Sonoma County, Santa Rosa area		

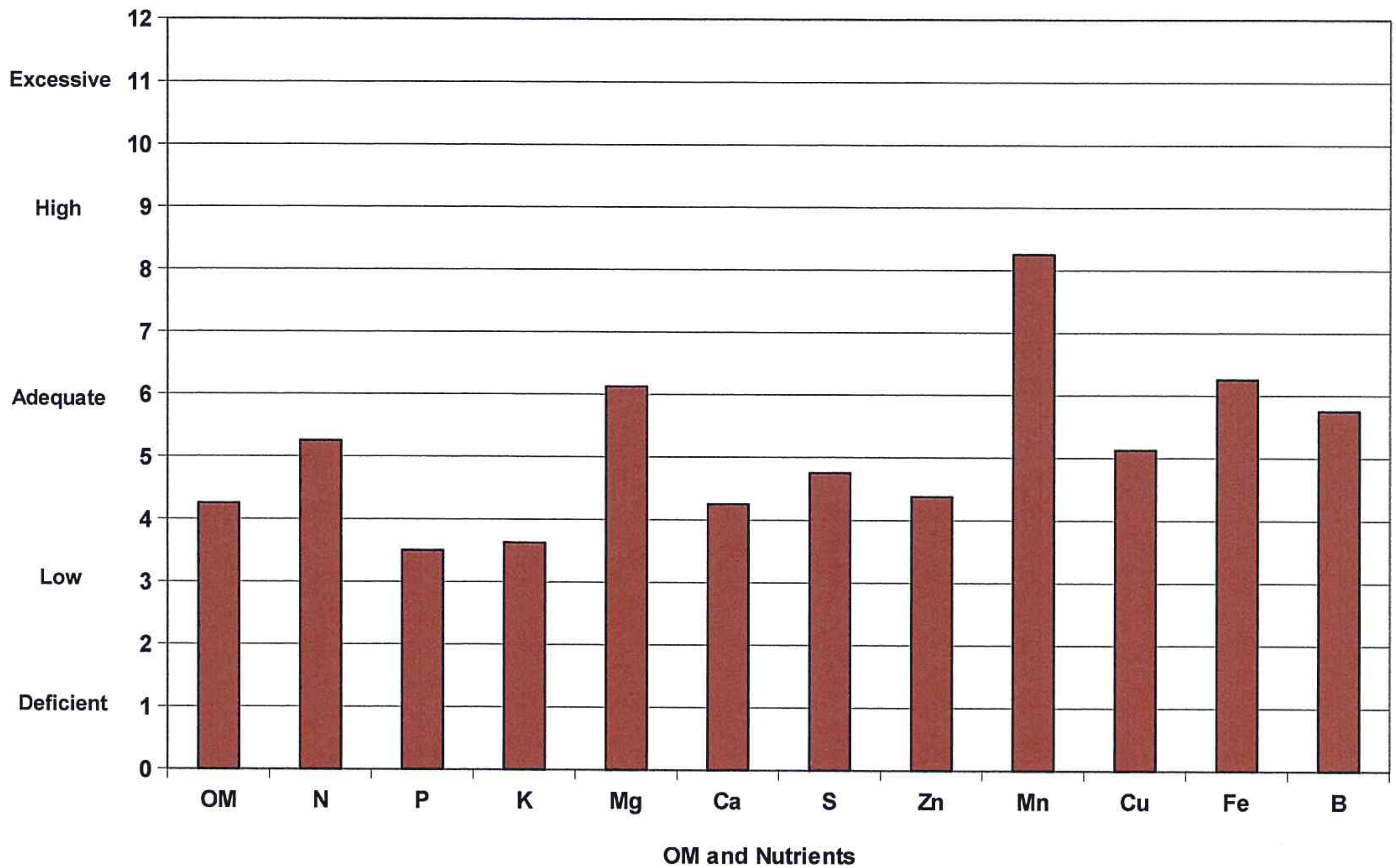
LAB SAMPLE NUMBER	THE SAMPLE ID	AREA &/or TYPE of SAMPLE	PERCENT ORGANIC MATTER	NITRATE N ppm	AMMONIA N ppm	PHOSPHOROUS P ppm	POTASSIUM K ppm	MAGNESIUM Mg ppm	CALCIUM Ca ppm	SULFUR S ppm	SODIUM Na ppm	BORON B ppm
06515-1	SCAPOSD1	Native Soil B-4 Bulk 1-3	**3.3**	**12**	**51**	**35**	**164**	**410**	**1325**	**48**	**272**	**0.8**
								Ca:Mg = 3.23				

ZINC Zn ppm	MANGANESE Mn ppm	COPPER Cu ppm	IRON Fe ppm	SOLUBLE SALTS mmhos/cm	EXCESS CARBONATE (Qual)	SOIL pH/ BUFFER INDEX -log[H+]	%K [2.7-7%]	%Mg [15-25%]	%Ca [60-75%]	%Na [0-5%]	%H [0-15%]	CALC TOTAL CEC
							ACTUAL PERCENT of TOTAL CEC					
1.8	**109.9**	**1.2**	**52.6**	**0.74**	**N**	**5.5 / 6.68**	**2.7**	**21.4**	**42.0**	**7.5**	**26.5**	**15.8**

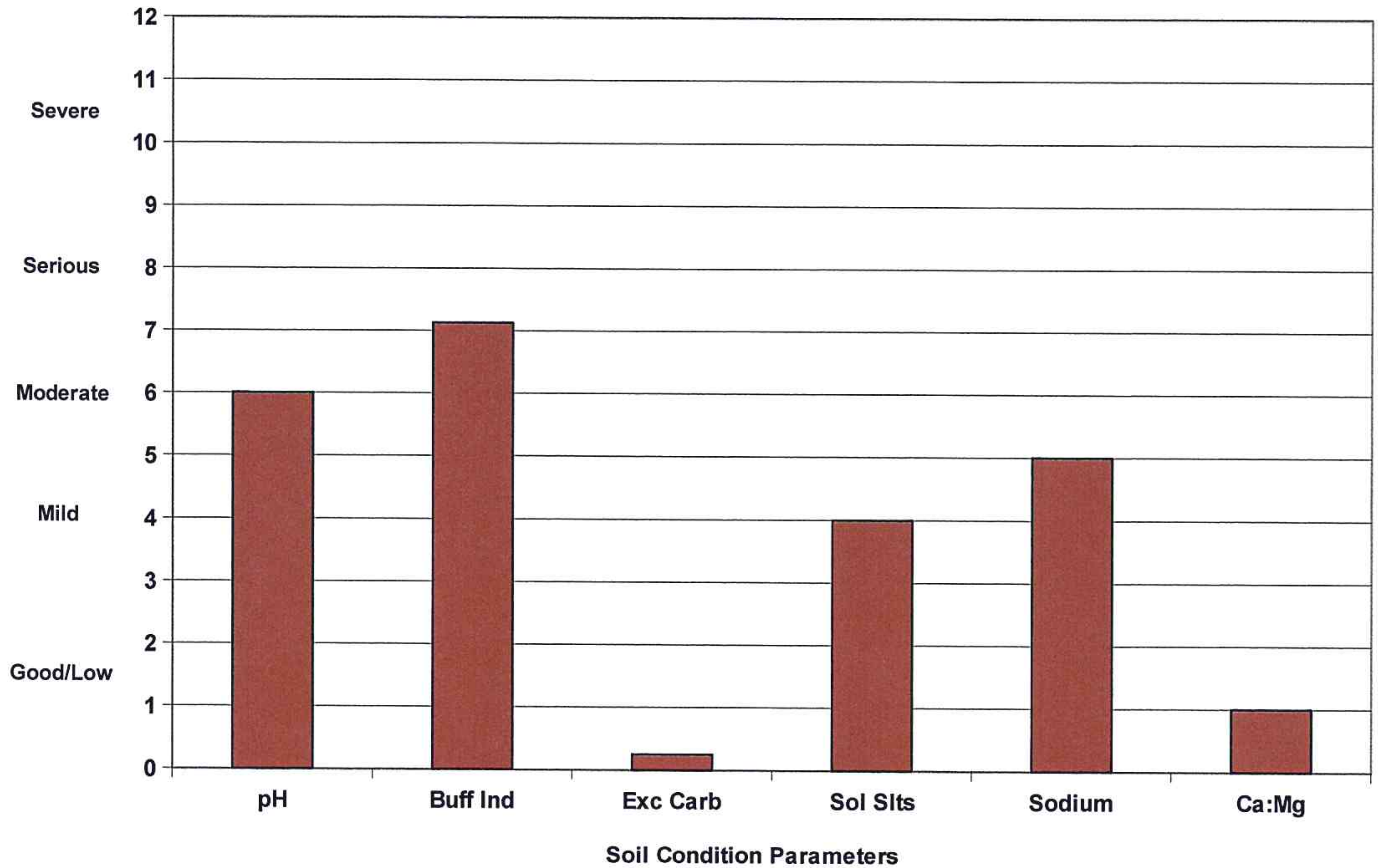
SAMPLE #	SAMPLE ID	SMPL TYPE	P S A TEST			SOIL TEXTURE	USDA CLASSIFICATION
06515-1	SCAPOSD1	Native Soil	**44.0% Sand**	**30.6% Silt**	**25.4% Clay**	**Sandy Mud**	**Loam**
			PERCOLATION/INFILTRATION TEST			RATE CLASSIFICATION	

THE SAMPLE ID	PLANT TYPE	ORG/INORG & CONDITIONERS O = Organics (cuyds/1000 sqft)	I = Inorg	D = Dolomite (lbs/1000)	N	P	K	Mg	S	Fe/Mn	Zn/Cu	B
					SUMMARY of FERTILIZER RECOMMENDATIONS (lbs/1000 sqft)							
SCAPOSD1	Vegetables	**O->3.5**	**I->Y**	**L->75 G->10**	**1.0**	**1.8**	**1.6**	**0.0**	**0.5**	**0 / 0**	**0 / 0**	**0.0**

Graphic Summary of OM and Nutrient Results



Graphic Summary of Soil Condition Parameter Results



Young Armos - Future Structures Parking Area Detention/CTS Pond Water Balance Calculations

Calcs By: LW
Date: 9/10/15

Assuming Average Precipitation

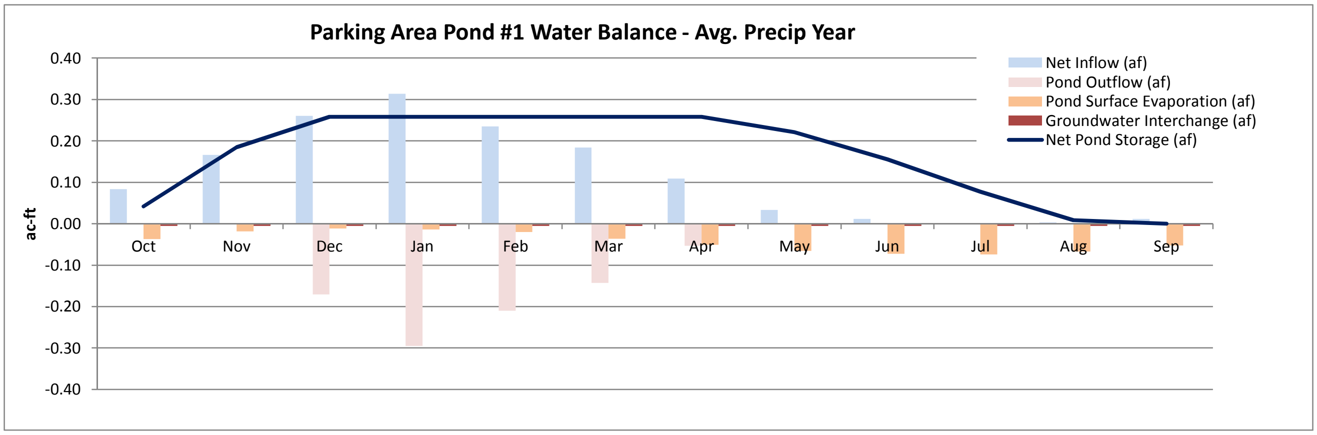
Parking Area Pond Water Balance

Full Pond Surface Area (ac):	0.20
Maximum Depth (in):	17
Pond XS Top Width (ft):	80
Average Depth (in):	15.5
Full Pond Volume (af):	0.26
Pond Length (ft):	109

Design: Create a pond with a gravel lense above some elevation to allow a the 84th percentile storm to fill up above the wetland pond and slowly drain over 72-hrs. Then the residual wetland pond has the dimensions shown here and remains wet until this calculator says it will go dry.

Parking Area Pond Water Balance

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Net Inflow (af)	0.08	0.17	0.26	0.31	0.24	0.18	0.11	0.03	0.01	0.00	0.00	0.01
Groundwater Interchange (af)	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005	-0.005
Pond Surface Evaporation (af)	-0.04	-0.02	-0.01	-0.01	-0.02	-0.04	-0.05	-0.07	-0.07	-0.07	-0.07	-0.05
Delta Monthly Volume (af)	0.04	0.14	0.24	0.29	0.21	0.14	0.05	-0.04	-0.07	-0.08	-0.07	-0.05
Net Pond Storage (af)	0.04	0.18	0.26	0.26	0.26	0.26	0.26	0.22	0.16	0.08	0.01	0.00
Pond Outflow (af)	0.00	0.00	-0.17	-0.29	-0.21	-0.14	-0.05	0.00	0.00	0.00	0.00	0.00
Actual Pond Capacity	16%	72%	100%	100%	100%	100%	100%	86%	60%	30%	3%	0%



Calcs By: LW
Date: 9/10/15

Young Armos - Multiple Pond Water Balance Calculations

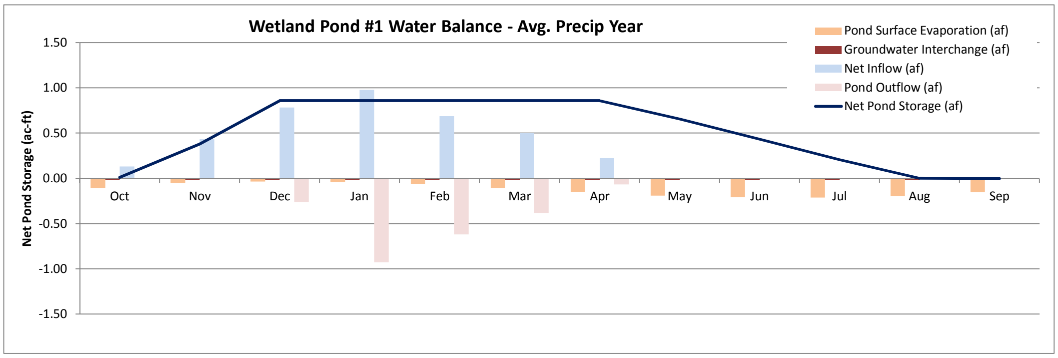
Assuming 50% avg. precipitation

	Pond 1	Pond 2	Pond 3
Full Pond Surface Area (ac):	0.57	0.50	0.50
Pond XS Top Width (ft):	50	50	50
Maximum Depth (in):	22	19	15
Average Depth (in):	18.0	16.0	13.1
Full Pond Volume (af):	0.86	0.67	0.55

Pond #1

Pond 1 Water Balance

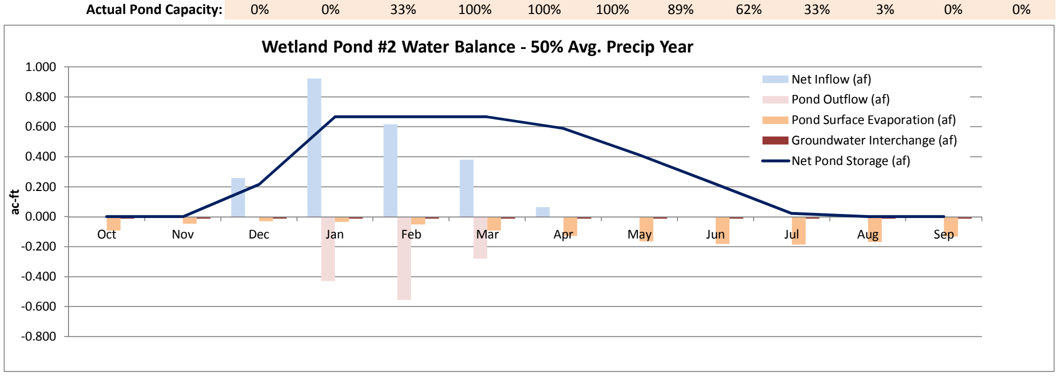
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Net Inflow (af)	0.13	0.43	0.78	0.98	0.69	0.50	0.23	0.00	0.00	0.00	0.00	0.00
Groundwater Interchange (af)	-0.015	-0.015	-0.015	-0.015	-0.015	-0.015	-0.015	-0.015	-0.015	-0.015	-0.015	-0.015
Pond Surface Evaporation (af)	-0.11	-0.05	-0.03	-0.04	-0.06	-0.10	-0.15	-0.19	-0.21	-0.21	-0.19	-0.15
Delta Monthly Volume (af)	0.01	0.37	0.74	0.92	0.62	0.38	0.06	-0.20	-0.22	-0.23	-0.21	-0.16
Net Pond Storage (af)	0.01	0.38	0.86	0.86	0.86	0.86	0.86	0.66	0.43	0.21	0.00	0.00
Pond Outflow (af)	0.00	0.00	-0.26	-0.92	-0.62	-0.38	-0.06	0.00	0.00	0.00	0.00	0.00
Avg. Pond Depth (in):	0.25	7.96	17.97	17.97	17.97	17.97	17.97	13.73	9.07	4.34	0.02	0.00
Max Pond Depth (in):	0.3	9.8	22.0	22.0	22.0	22.0	22.0	16.8	11.1	5.3	0.0	0.0
Actual Pond Capacity (%):	1%	44%	100%	100%	100%	100%	100%	76%	51%	24%	0%	0%



Pond #2

Pond 2 Water Balance

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Net Inflow (af)	0.000	0.000	0.258	0.924	0.617	0.382	0.064	0.000	0.000	0.000	0.000	0.000
Groundwater Interchange (af)	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013
Pond Surface Evaporation (af)	-0.092	-0.045	-0.028	-0.034	-0.050	-0.091	-0.128	-0.164	-0.181	-0.184	-0.167	-0.131
Delta Monthly Volume (af)	-0.105	-0.058	0.217	0.877	0.554	0.278	-0.077	-0.176	-0.194	-0.197	-0.180	-0.143
Net Pond Storage (af)	0.00	0.00	0.22	0.67	0.67	0.67	0.59	0.41	0.22	0.02	0.00	0.00
Pond Outflow (af)	0.000	0.000	0.000	-0.428	-0.554	-0.278	0.000	0.000	0.000	0.000	0.000	0.000
Avg. Pond Depth (in):	0.0	0.0	5.2	16.0	16.0	16.0	14.2	9.9	5.3	0.5	0.0	0.0
Max Pond Depth (in):	0.0	0.0	6.2	19.0	19.0	19.0	16.8	11.8	6.2	0.6	0.0	0.0
Actual Pond Capacity:	0%	0%	33%	100%	100%	100%	89%	62%	33%	3%	0%	0%



Pond #3

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Net Inflow (af)	0.000	0.000	0.000	0.428	0.554	0.278	0.000	0.000	0.000	0.000	0.000	0.000
Groundwater Interchange (af)	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013	-0.013
Pond Surface Evaporation (af)	-0.092	-0.045	-0.028	-0.034	-0.050	-0.091	-0.128	-0.164	-0.181	-0.184	-0.167	-0.131
Delta Monthly Volume (af)	-0.105	-0.058	-0.041	0.382	0.491	0.174	-0.141	-0.176	-0.194	-0.197	-0.180	-0.143
Net Pond Storage (af)	0.00	0.00	0.00	0.38	0.55	0.55	0.41	0.23	0.04	0.00	0.00	0.00
Pond Outflow (af)	0.000	0.000	0.000	0.000	-0.326	-0.174	0.000	0.000	0.000	0.000	0.000	0.000
Avg. Pond Depth (in):	0.0	0.0	0.0	9.2	13.1	13.1	9.7	5.5	0.9	0.0	0.0	0.0
Max Pond Depth (in):	0.0	0.0	0.0	10.5	15.0	15.0	11.1	6.3	1.0	0.0	0.0	0.0
Actual Pond Capacity:	0%	0%	0%	70%	100%	100%	74%	42%	6%	0%	0%	0%