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Report
Soil Investigation
Wright Greenhouses
6095 Bodega Avenue
Petaluma, California

Prepared for
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INTRODUCTION

This report presents the results of our soil investigation for the proposed new greenhouses to be constructed at 6095 Bodega Avenue in Petaluma, California. We understand that two or three greenhouse structures are planned to be located in a gently sloping area in the southern portion of your property. The combined building area of the greenhouses would be about 10,000 square feet. The proposed greenhouses will be one-story, metal-frame, light-duty structures with concrete slab-on-grade floors. Minor cuts and fills are planned to create level building areas.

The object of our investigation, as stated in our proposal dated May 2, 2017, was to review selected, geologic references in our files, explore subsurface conditions, measure depth to groundwater, if encountered, and determine physical properties of the soils encountered. We then performed engineering analyses to develop conclusions and recommendations concerning:

1. Proximity of the site to active faults.
2. Site preparation and grading.
3. Foundation support and design criteria.
4. Support of concrete slab-on-grade floors
5. Soil engineering drainage.
6. Supplemental soil engineering services.

WORK PERFORMED

We reviewed selected, geologic information including:

1. "Geology for Planning in Sonoma County," Special Report 120, California Division of Mines and Geology, 1980.

2. "Geologic Map of the Cotati 7.5' Quadrangle, Sonoma County, California: A Digital Database," by M. T. Mascorro & E. W. Ford, California Geological Survey, 2003.

3. Liquefaction Susceptibility Map, United States Geological Survey (USGS), 2006, accessed July 24, 2017 from the Association of Bay Area Governments website: http://gis.abag.ca.gov/website/Hazards/?hlyr=liqSusceptibility.

On May 18, 2017, we were at the site to observe surface features and explore subsurface conditions to the extent of four test pits at the approximate locations indicated on Plate 1. The pits were excavated to depths of about 4 to 6½ feet with backhoe equipment. Our project engineer located the pits, observed the excavations, logged the conditions encountered and obtained a few samples for minor laboratory classification testing. Logs of the pits showing the soil conditions encountered are presented on Plate 2. The soils are classified in accordance with the Unified Soil Classification System explained on Plate 3.

The test pit locations shown on Plate 1 were determined by visually estimating from existing surface features. The locations should be considered no more accurate than implied by the methods used to establish the data. At the completion of the exploration, the pits were backfilled with the excavated soils, but without compaction.

SURFACE AND SUBSURFACE CONDITIONS

The project site is a roughly rectangular lot approximately 7 acres in size located about 6 miles northwest of downtown Petaluma, California. The site is accessed from Bodega Avenue via Ramen Road. The proposed greenhouses will be located in the gently sloping southern portion of the property. At this location, the ground surface slopes downward toward the northwest and west at a gradient that averages about ten horizontal to one vertical (10:1). At the time of our exploration, the ground surface consisted of a tall growth of grass and weeds. Large eucalyptus trees are located near the northeastern extent of the proposed greenhouses. A small debris pile was also present near the southwest corner of the proposed building area.

The test pits indicate that the area explored is generally underlain by layers of natural sandy and clayey soils overlying highly weathered bedrock materials. Silty sands with abundant root fibers were encountered at the ground surface in all of the test pits and extending to depths of about 2 to 3 feet. The upper silty sands were relatively weak and porous from prior decomposition of organic materials. The sands exhibit a low expansion potential. That is, the materials would tend to undergo low strength and volume changes with seasonal variation in moisture content. Layers of stiff sandy clay of moderate expansion potential and medium dense clayey sand were encountered underlying the topsoils and extending to depths of about 3 to 5 feet.

All of the test pits bottomed in deeply weathered sandstone bedrock materials of the Wilson Grove Formation. At the shallow depth explored, the bedrock materials were observed to be more soil-like in strength and consistency. However, the bedrock materials generally became firmer and more rock-like with depth.

Groundwater was not encountered during our exploration. Groundwater conditions and seepage levels can vary seasonally and could rise and fall several feet annually. Determination of precise depth to groundwater, extent of seasonal water level fluctuations and existence of perched groundwater conditions is beyond the scope of this investigation.

CONCLUSIONS

Based on our field exploration, laboratory tests and engineering analyses, we conclude that, from a geotechnical engineering standpoint, the site can be used for the proposed greenhouse construction. The most significant soil engineering factor that must be considered during design and construction is the presence of weak, compressible upper soils.

Weak, compressible soils can undergo considerable strength loss and settlement when loaded in a saturated condition. Where evaporation is inhibited by footings, slabs or fill, eventual saturation of the underlying soils can occur. Therefore, for spread footing and slab-on-grade support, we conclude that it will be necessary to remove and replace the weak, compressible upper soils as properly compacted fill.

Total and/or differential settlement and resultant distress to structures can occur in areas underlain by significant differential thicknesses of fill, or in areas that transition from cut to fill. To provide more uniform support and reduce the risk of distress, we conclude that it will be necessary to verify that all slab-on-grade floor areas are underlain with a sufficient thickness of properly compacted fill, even those located in areas of planned cut. Differential fill thicknesses should also be limited to help control differential settlement, as subsequently recommended.

For site preparation and building foundation design and installation in accordance with our recommendations, we judge that total settlements would be about 1-inch, or less. Post-construction settlements should be about 1/2-inch, or less.

SEISMIC DESIGN

The geologic maps reviewed did not indicate the presence of active faults at the site, and the parcel is not located within a presently designated Alquist-Priolo Earthquake Fault Zone. Therefore, we judge that there is little risk of fault-related ground rupture at the site during earthquakes. In a seismically active region such as Northern California, there is always some possibility for future faulting at any site. However, historical occurrences of surface faulting have generally closely followed the trace of the more recently active faults. The closest faults generally considered active are the Rodgers Creek fault zone located approximately 9 miles to the northeast and the San Andreas fault zone located approximately 11 miles to the southwest.

Strong ground shaking will occur during earthquakes. The intensity at the site will depend on the distance to the earthquake epicenter, depth and magnitude of the shock and the response characteristics of the materials beneath the site. Because of the proximity of active faults in the region and the potential for strong ground shaking, it will be necessary to design and construct the project in strict accordance with current standards for earthquake-resistant construction.

We have determined the seismic ground motion values in accordance with procedures outlined in Section 1613 of the 2016 California Building Code (CBC). Mapped acceleration parameters, S_S and S_1, were obtained by inputting approximate site coordinates (latitude and longitude) into earthquake ground motion software developed by the United States Geological Survey. Based on our review of available geologic maps and knowledge of the subsurface conditions, we judge that the site can be classified as Site Class C, as described in Table 20.3-1 of the American Society of Civil Engineers/Structural Engineering Institute (ASCE/SEI) Standard ASCE/SEI 7-10. Using corresponding values of site coefficients for Site Class C and procedures outlined in the CBC, the mapped acceleration parameters were adjusted to yield the design spectral response acceleration parameters S_{DS} and S_{D1}. The following earthquake design data summarize the results of the procedures outlined above.

2016 CBC Ground Motion Parameters

Site Class	C
Mapped Spectral Response Accelerations:	
S_S	1.500 g
S_1	0.600 g
Design Spectral Response Accelerations:	
S_{DS}	1.000 g
S_{D1}	0.520 g

RECOMMENDATIONS

Site Grading

Areas to be developed should be cleared of debris, brush, grass and vegetation, where encountered. Designated trees and their root systems should be removed within planned improvement areas. The resultant voids should be backfilled with compacted soil, as subsequently described. The building areas then should be stripped of the upper soils containing abundant root growth and organic matter. We anticipate that the depth of stripping will average about 3 inches. The strippings should be removed from the site, be stockpiled for reuse as topsoil or be mixed with at least five parts of soil and used as fill at least 10 feet away from the structures, walkways or paved areas.

Wells, septic tanks, leach fields or other voids encountered or generated during site preparation and grading should be removed, filled with compacted soil or compacted granular material, or be capped with concrete, as determined by the appropriate regulatory agency or the soil engineer.

Once stripping has been completed, excavations can be performed as necessary. Within building areas, all weak, compressible upper soils should be removed (overexcavated) for their full depth prior to fill placement. The overexavation should occur within the building areas and extending to at least 5 feet beyond their perimeter, and to at least 3 feet beyond any adjacent exterior concrete slab areas (i.e. building envelopes). Based on the test pits, we anticipate overexcavation depths to remove the weak upper soils would be about 2½ to 3 feet below the existing ground surface, but could be deeper if deeper weak, compressible soils are encountered. The depth of overexcavation should also be adjusted, as needed, to provide space for at least 12 inches of properly compacted fill of low expansion potential below footings and floor slabs.

The surfaces exposed by excavation should be prepared by scarifying to a depth of at least 6 inches, moisture conditioning to near optimum and compacting to at least 90 percent relative compaction.[1] Approved fill material then should be spread in 8-inch-thick loose lifts, similarly moisture conditioned, and compacted to at least 90 percent relative compaction. Fill material should be free of organic matter and rocks or hard fragments larger than 4 inches in diameter. We anticipate that, with the exception of organic matter and oversize rocks or hard fragments larger than 4 inches in size, the excavated materials will be suitable for reuse as fill. Imported fill, if necessary, should also be nonexpansive and have a Plasticity Index of 15 or less.

To reduce the risk of total and/or differential settlement, we recommend that differential fill thickness under the building foundations or floor slabs be limited to 6 feet, or less. This may result in the need for overexcavation within planned cut or minor fill areas and refilling with compacted fill. The indicated variation in fill thickness could be increased with increased compaction of the fills. We can provide specific recommendations, if desired. We recommend contract documents contain provisions to cover the costs for additional overexcavation and fill placement to reduce differential fills, if needed.

The test pits were backfilled with the excavated materials, but the soils were not well compacted. Therefore, the backfilled pits constitute local deep zones of highly compressible materials. Where encountered within planned improvement areas, the backfill should be removed for its entire depth and replaced as properly compacted fill.

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1 Relative compaction refers to the in-place dry density of fill expressed as a percentage of maximum dry density of the same material determined in accordance with the American Society for Testing and Materials (ASTM) Standard ASTM D 1557 laboratory compaction test procedure. Optimum moisture content refers to the moisture content at maximum dry density.

Finished cut and fill slopes should be trimmed to expose firm materials and should not be steeper than 2:1. Slopes over 3 feet high should be planted with fast-growing, deep-rooted ground cover to help reduce sloughing and erosion. Jute mesh or other erosion-retarding medium should be considered until the vegetation is fully established, especially through the first winter.

Foundation Support

Spread footings can be used for foundation support of the proposed greenhouses. Provided site grading is performed as recommended above, spread footings should be underlain by at least 12 inches of properly compacted fill of low expansion potential. Spread footings should be at least 12 inches wide and be bottomed at least 18 inches below lowest adjacent pad grade.

Spread footings can be designed to impose dead plus code live load and total design load (including wind or seismic forces) bearing pressures of 2,000 and 3,000 pounds per square foot (psf), respectively.

Resistance to lateral loads can be obtained from passive earth pressures and soil friction. We recommend the following criteria for design:

Passive Earth Pressure	=	300 pounds per cubic foot (pcf) equivalent fluid, neglect the upper 1 foot (unless confined by pavement or slab)
Soil Friction Factor	=	0.30

Slab-On-Grade

Slabs should be at least 4 inches thick and be reinforced with bars to reduce cracking. Actual slab thickness and reinforcing should be determined by the structural design engineer based on anticipated use and performance. Floor slabs should be underlain with a capillary moisture break and cushion layer consisting of at least 4 inches of free-draining gravel or crushed rock (i.e. slab rock). The gravel or crushed rock should be at least 1/4-inch and no larger than 3/4-inch in size. Prior to placing the reinforcing or slab rock, the subgrade soils should be thoroughly moistened and be smooth, firm and uniform. Slab subgrade should not be allowed to dry prior to concrete placement.

Provided the site is prepared as recommended above, slab-on-grade floors should be underlain by at least 12 inches properly compacted fill of low expansion potential. We judge that exterior concrete flatwork can be supported directly on properly prepared existing upper soils, provided the slabs are allowed to float and some minor settlement and resultant distress are acceptable. Slabs not underlain by compacted fill should be carefully separated from adjacent foundations. Felt paper, expansion joint material or other positive, low friction separators should be used.

Moisture vapor will condense on the underside of slabs. Where migration of moisture vapor through the slabs would be detrimental, a 10-mil minimum vapor retarder should be provided between the supporting base material and the slab. Two inches of moist, clean sand could be placed on top of the membrane to aid in curing and to help provide puncture protection. However, the actual use of sand should be determined by the architect or design engineer. The use of a less permeable and stronger membrane should be considered if sand is not placed for puncture protection or where the flooring manufacturer requires a vapor barrier. Concrete design and curing specifications should recognize the potential adverse affects associated with placement of concrete directly on the membrane.

Geotechnical Drainage

Ponding water will cause softening of the site soils and would be detrimental to foundations. It is important that areas adjacent to the structures be sloped to drain away from foundations. We recommend that good, positive surface drainage away from the structures consisting of at least 1/2-inch per foot extending at least 4 feet out be provided. It should be recognized that fences, walkways, patio slabs, lawns, planters, etc. could impede water flow and promote surface soil saturation and seepage into underslab areas. The roofs should be provided with gutters, and the downspouts should discharge on to paved areas, splash blocks draining at least 30 inches away from foundations or be connected to nonperforated pipelines that discharge into planned storm drain facilities.

To provide an outlet for water that may accumulate in the underslab rock, plastic pipes could be embedded in the grade below the slab-on-grade floors. The underslab subdrain systems, if used, should be configured to drain each bay created by interior and/or perimeter foundations. The underslab subdrain systems, if installed, should be connected to nonperforated outlet pipes that extend through or beneath the perimeter foundations to suitable discharge points. A typical cross-section of our recommended underslab subdrain is shown on Plate 4. We can provide additional consultation concerning the configuration and location of the underslab subdrain systems during final design once foundation plans have been prepared, if desired. Roof downspouts and surface drains must be maintained entirely separate from underslab subdrains.

Supplemental Services

We should review final grading and foundation plans for conformance with the intent of our recommendations. We should observe site grading and footing excavations to verify that suitable bearing materials are encountered and to modify our recommendations, if warranted. Field and laboratory tests should be performed to ascertain that the recommended moisture content and degree of compaction are being attained. Concrete placement and reinforcing should be checked as stipulated on the project plans or as required by the Building Department. It is our understanding that approval from the Building Department must be obtained prior to the placement of concrete in foundation elements.

LIMITATIONS

We have performed the investigation and prepared this report in accordance with generally accepted standards of the soil engineering profession. No warranty, either express or implied, is given. It should be understood that our services were limited to the scope of work outlined above and specifically excluded other services including, but not limited to, an evaluation or analysis of soil chemistry, corrosion potential, mold, and soil and/or groundwater contamination.

Subsurface conditions are complex and may differ from those indicated by surface features or encountered at the test pit locations. Therefore, variations in subsurface conditions not indicated on the log could be encountered.

If the project is revised or if conditions different from those described in this report are encountered during construction, we should be notified immediately so that we can take timely action to modify our recommendations, if warranted.

Supplemental services as recommended herein are performed on an as-requested basis. We can accept no responsibility for items we are not notified to check or for use or interpretation by others of the information contained herein. Such services are in addition to this soil investigation and are charged for on an hourly basis in accordance with our Standard Schedule of Charges.

Site conditions and standards of practice change. Therefore, we should be notified to update this report if construction is not performed within 24 months.

LIST OF PLATES

DISTRIBUTION

Copies Submitted: 5

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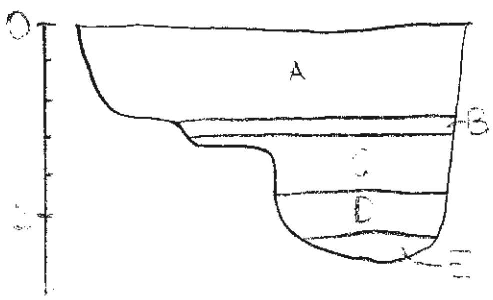
JM/JKR:nay/ra//Job No. 1055.1.1

SITE VICINITY MAP

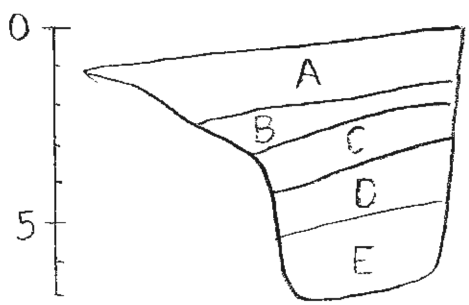
REESE & ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS	Job No: 1055.1.1 Date: 07-26-17 Appr:	**TEST PIT LOCATION PLAN AND SITE VICINITY MAP** **WRIGHT GREENHOUSES** **PETALUMA, CALIFORNIA**	**PLATE** **1**

Scale: 1" = 5'
(Horizontal and Vertical)

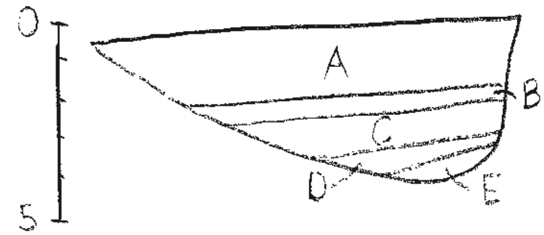
Log of Test Pit 1



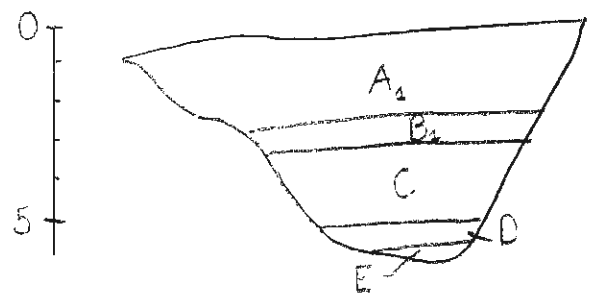
Log of Test Pit 2



Log of Test Pit 3



Log of Test Pit 4



Soil Descriptions

A = GRAY-BROWN SILTY FINE SAND (SM), loose, dry to moist, porous, with abundant root fibers and occasional roots up to 3 inches (Topsoil)

A_1 = dark brown in color

B = YELLOW-BROWN SILTY VERY FINE SAND (SP-SM), loose, moist, porous

B_1 = dark brown in color

C = YELLOW-BROWN VERY SANDY CLAY (CL), stiff, wet, slightly plastic

D = GRAY-BROWN CLAYEY SAND (SC), medium dense, wet

E = MOTTLED ORANGE AND GRAY SANDSTONE OF THE WILSON GROVE FORMATION, deeply weathered, soft, plastic

REESE & ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS	Job No: 1055.1.1 Date: 07-26-17 Appr:	**LOG OF TEST PITS 1 THROUGH 4** **WRIGHT GREENHOUSES** **PETALUMA, CALIFORNIA**	**PLATE** **2**

UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS				TYPICAL NAMES
COARSE GRAINED SOILS MORE THAN HALF IS LARGER THAN No. 200 SIEVE	GRAVEL MORE THAN HALF OF COARSE FRACTION IS LARGER THAN No. 4 SIEVE SIZE	CLEAN GRAVEL WITH LESS THAN 5% FINES	GW	WELL GRADED GRAVEL, GRAVEL-SAND MIXTURE
			GP	POORLY GRADED GRAVEL, GRAVEL-SAND MIXTURE
		GRAVEL WITH OVER 12% FINES	GM	SILTY GRAVEL, GRAVEL-SAND-SILT MIXTURE
			GC	CLAYEY GRAVEL, GRAVEL-SAND-CLAY MIXTURE
	SAND MORE THAN HALF OF COARSE FRACTION IS SMALLER THAN No. 4 SIEVE SIZE	CLEAN SAND WITH LESS THAN 5% FINES	SW	WELL GRADED SAND, GRAVELLY SAND
			SP	POORLY GRADED SAND, GRAVELLY SAND
		SAND WITH OVER 12% FINES	SM	SILTY SAND, GRAVEL-SAND-SILT MIXTURE
			SC	CLAYEY SAND, GRAVEL-SAND-CLAY MIXTURE
FINE GRAINED SOILS MORE THAN HALF IS SMALLER THAN No. 200 SIEVE	SILT AND CLAY LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILT, ROCK FLOUR, SANDY OR CLAYEY SILT WITH LOW PLASTICITY
			CL	INORGANIC CLAY OF LOW TO MEDIUM PLASTICITY, GRAVELLY, SANDY, OR SILTY CLAY (LEAN)
			OL	ORGANIC CLAY AND ORGANIC SILTY CLAY OF LOW PLASTICITY
	SILT AND CLAY LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILT, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOIL, ELASTIC SILT
			CH	INORGANIC CLAY OF HIGH PLASTICITY, GRAVELLY, SANDY OR SILTY CLAY (FAT)
			OH	ORGANIC CLAY OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT AND OTHER HIGHLY ORGANIC SOILS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

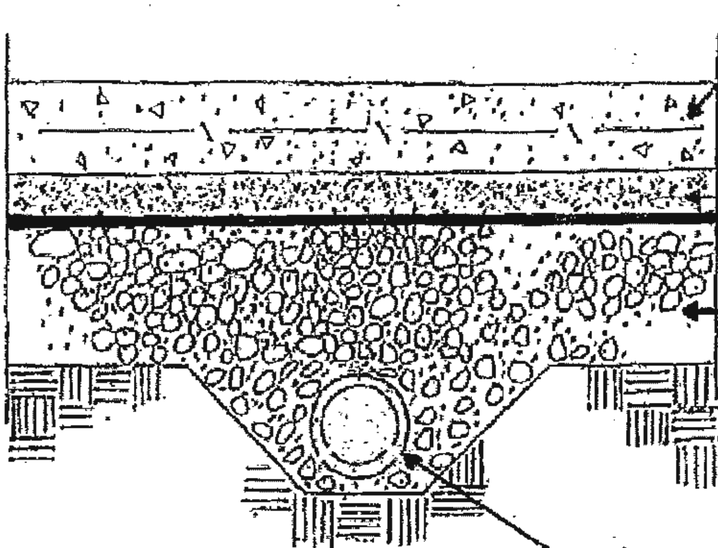
KEY TO TEST DATA

				Shear Strength, psf	Confining Pressure, psf
EI	– Expansion Index	TxUU	– Unconsolidated Undrained Triaxial	320	(2600)
Consol	– Consolidation	TxCU	– Consolidated Undrained Triaxial	320	(2600)
LL	– Liquid Limit (in %)	DSCD	– Consolidated Drained Direct Shear	2750	(2000)
PL	– Plastic Limit (in %)	FVS	– Field Vane Shear	470	
PI	– Plasticity Index	LVS	– Laboratory Vane Shear	700	
SA	– Sieve Analysis	UC	– Unconfined Compression	2000	*
G_S	– Specific Gravity	UC(P)	– Laboratory Penetrometer	700	*
■	"Undisturbed" Sample				
□	Bulk Sample				

Notes: (1) All strength tests on 2.8" or 2.4" diameter samples unless otherwise indicated.

* Compressive Strength

REESE & ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS	Job No: 1055.1.1 Date: 7-28-17 Appr: [signature]	SOIL CLASSIFICATION CHART AND KEY TO TEST DATA WRIGHT GREENHOUSES PETALUMA, CALIFORNIA	PLATE 3



REESE & ASSOCIATES CONSULTING GEOTECHNICAL ENGINEERS	Job No: 1055.1.1 Date: 07-28-17 Appr: Jm	**TYPICAL CROSS SECTION** **UNDERSLAB SUBDRAIN** **WRIGHT GREENHOUSES** **PETALUMA, CALIFORNIA**	**PLATE** **4**