City of Imperial

Public Library Expansion Engineering Services

Request for Proposal

Released: February 5, 2015

<u>Important Dates</u>

Pre-RFP Meeting:	**2/12/15**
Proposal Due:	**2/19/15**

City of Imperial
Planning and Development Department
Building and Safety Division
420 South Imperial Avenue
Imperial, CA 92251
Phone: (760)355-1152
Fax: (760)355-4718

I. Overview

The City of Imperial is requesting proposals from qualified, interested Designers to provide Engineering Services for the 4,700 square feet wood structure building expansion and renovation of the Imperial Public Library located at 200 West 9th street. Services being requested include engineering foundation and structural plans, and calculations to assist the City in the expansion and renovation process as per Exhibit A below. The Plans will include future improvements based on current requirements, needs, concerns and cost effectiveness.

The design will offer a prescription for facility improvements designed to meet expectations and recommendations of City staff as well as best library practices generally. The growth is in the space library's customer's use in their individual and collective pursuits, the space needed for the staff to work efficiently, and the space the building needs to be more enjoyable and functional environment. The design can also be modified to meet changes in expectations and resources.

II. Scope of Work

In preparing a response to this Request of Proposal (RFP), the Consultant shall address the following specific components that should be included in the scope of work.

Task No. 1: Pre-RFP Meeting/Site Visit

A Pre-RFP meeting will be conducted at 10:00 am February 12, 2015 at City hall 420 S. Imperial. Ave. followed by an onsite visit to verify the specific details. The site visit shall be for the inspection and verification purposes.

Task No. 2: Schematic Design Phase

Meet with City staff to review preliminary plan design project documents, project goals, and clarify responsibility of each party. The construction documents and calculations must address existing conditions and shall incorporate the City of Imperial Preliminary design (Exhibit A).

The Designer shall incorporate the recommended following:

- The recommended structural system.
- Seismic parameters and recommendations in the Geotechnical Investigation Report (Provided).
- Project specific building code design criteria and loads.
- Identification of potential structural materials, systems and equipment, and their criteria and quality standards.
- Investigating of availability and suitability of alternative structural materials system.

Task No. 3: Final Design

Provide Engineering structural plans, foundation and calculation that incorporates all Architectural elements provided by the City (Exhibit A), and detail complete construction features necessary to support the new facility.

The documents and plans must consider and meet all Municipal, State of California and Federal building codes and regulations.

Task No. 4: Final Report

The Design Engineer shall prepare a final report. The report shall include, without limitation, findings and recommendations for future expansion and current needs, which shall be presented in a single comprehensive document which, should include findings generated as part of other tasks described herein. The Designer shall include plan exhibits and hard copies as part of the report.

III. Proposal Content

Proposal responses must adhere to the requirements outlined in this section. The original proposal and each subsequent copy must be submitted on paper, properly bound, appropriately tabbed and labeled in the following order:

1. **Introduction:** Provide a cover letter and introduction including the name and address of the organization with the name, address, telephone and fax numbers, and e-mail address of the contact person who will be authorized to make representations for the organization. A one- to two-page Executive Summary shall be provided with an overview of the proposal, its highlights, and the approach to successfully completing this project.

2. **Scope of Work and Schedule:** Discuss your approach of each task outlined in Section I and II above with a breakdown of costs and schedule.

   Provide additional service fees that include the review, approval and/or design of the electrical and mechanical systems, energy calculations (Title 24) and any supplementary documents needed for this project.

3. **Qualifications and Personnel:** Describe the firm's resources, experience and capabilities as follows:

   a. Provide an outline of the firm's background, qualifications, and ability to perform the scope of services required.

   b. Provide a list and/or organizational chart to identify the person(s) who will be primarily responsible for contact with the City.

c. Identify all key project personnel, their relationship to the project, relevant qualifications and experience, and their level of effort toward completing all needed tasks. Include a description of specific projects similar to this request and the specific tasks performed by the project personnel.

d. Provide a brief outline of the firm's current workload, staffing and ability to meet the schedule and deadlines described in this RFP.

4. **References:** Identify at least five (3) successfully completed projects of a similar nature, preferably with direct involvement of municipal governments in California. Each project listed shall include the name of the agency, project manager, phone number, and description of work performed. Consulting projects currently underway may also be submitted for consideration.

5. **Additional Data:** Proposals may include any other information the Consultant deems essential to the evaluation of the qualifications and proposal statements. This section will be limited to five (5) pages.

IV. Proposal Submittal

To be considered, please submit three (3) copies of your proposal by February 19, 2015 to:

Othon Mora
Building and Safety Division
City of Imperial
420 South Imperial Avenue
Imperial, CA 92251

All proposals shall be submitted in sealed envelope(s) and shall be clearly marked:

"SEALED PROPOSAL FOR PUBLIC LIBRARY EXPANSION DOES NOT OPEN WITH REGULAR MAIL."

Proposals received after the due date and time will be returned unopened. Faxed proposals will not be accepted. Hand carried proposal will be accepted before the response due date during normal business hours.

Questions regarding this Request for Proposal may be directed to Othon Mora, City of Imperial Building and Safety Division, 420 South Imperial Avenue, Imperial, CA 92251 or via email at omora@cityofimperial.org. All questions should be submitted in writing and all prospective consultants will receive copies of the questions and responses.

V. Review and Selection Procedure

An evaluation committee by the City Council will review each proposal. The following evaluation criteria will be used in selecting a Consultant:

1. Experience with similar efforts.
2. Commitment of Senior Staff to the Project.
3. Relevant qualifications of key personnel.
4. Familiarity with needs of a municipal/governmental entity.
5. Ability to provide a local presence during the process.
6. Proposed schedule and ability to meet applicable deadlines.
7. Overall responsiveness to this RFP.

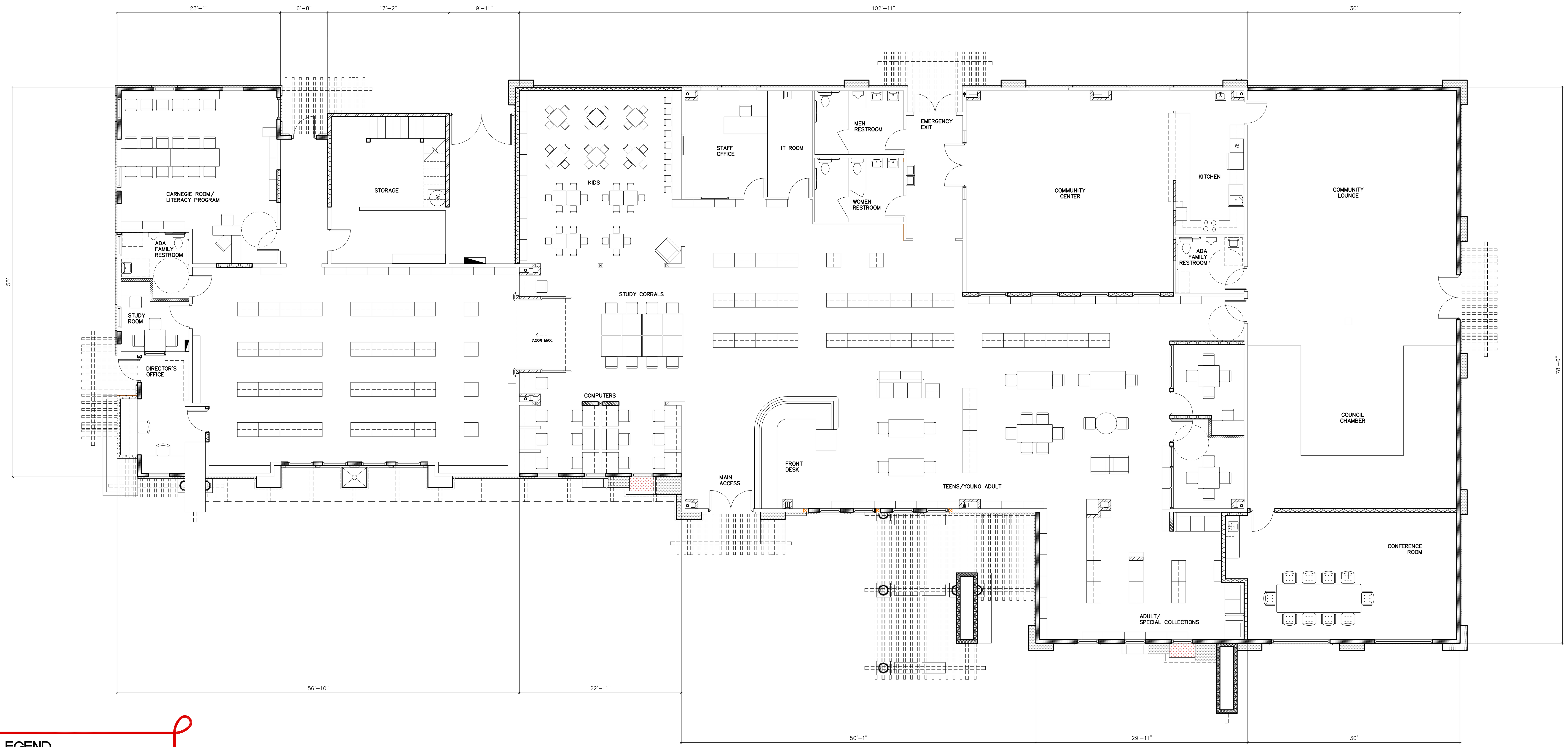
After reviewing all submissions, the selection team may request to meet with its top candidates. The City of Imperial reserves the right to reject any or all proposals for any reason. Minor irregularities of the proposal may be waived at the discretion of the City.

Please note that the ability of the Consultant to complete the overall project within the anticipated completion period will be considered in the selection process. The lowest cost proposal will not necessarily be selected.

This RFP is not intended and should not be construed to commit the City of Imperial to contract with any proposer. All costs incurred in connection with responding to this RFP will be borne by the proposer.

After proposals are opened, all responses and documents submitted in conjunction with this RFP become public documents available for review by the public.

EXHIBIT A



FLOOR PLAN

SCALE: 1/8" = 1'

WALL LEGEND

SYMBOL	DESCRIPTION
	NEW 2x6 WOOD FRAMING WALL @ 16" O.C W/1/2" DRYWALL ONE SIDE (INTERIOR) AND 1/2" DENSGLASS OTHER SIDE (EXTERIOR), R-13 RECYCLED COTTON SOUND PROOF INSULATION.
	NEW 2x6 WOOD FRAMING WALL @ 16" O.C W/1/2" DRYWALL ONE SIDE (INTERIOR) AND 1/2" DENSGLASS OTHER SIDE + STUCCO FINISH (EXTERIOR), R-13 RECYCLED COTTON SOUND PROOF INSULATION.
	NEW 2x6 WOOD FRAMIMG WALL (PARTITION WALL) @ 16" O.C W/1/2" DRYWALL EACH SIDE. EXTEND WALL 6" BEYOND TOP OF SUSPENDED CEILING HEIGHT.
	NEW 2x6 WOOD FRAMIMG WALL (PARTITION WALL) @ 16" O.C W/1/2" DRYWALL EACH SIDE, R-13 RECYCLED COTTON SOUND PROOF INSULATION. EXTEND WALL 6" BEYOND TOP OF SUSPENDED CEILING HEIGHT.
	2x6 WOOD FRAMING WALL @ 16" O.C W/ 3/8" PLYWOOD SHEATHING + STUCCO FINISH AT ONE SIDE ONLY (EXTERIOR).
	NEW 2x4 WOOD FRAMING WALL (PARTITION WALL) @ 16" O.C W/1/2" DRYWALL EA. SIDE, R-13 RECYCLED COTTON SOUND PROOF INSULATION. EXTEND WALL 6" BEYOND TOP OF SUSPENDED CEILING HEIGHT.
	NEW 2x4 WOOD FRAMING WALL (PARTITION WALL) @ 16" O.C W/1/2" DRYWALL EA. EXTEND 6" BEYOND TOP OF SUSPENDED CEILING HEIGHT.
	EXPANDED POLYSTYRENE (EPS) INSULATION + STUCCO FINISH.
	EXISTING WOOD WALL TO REMAIN.

City of Imperial California

REVISIONS

NO.	DESCRIPTION:	DATE:	BY:
△			
△			
△			

BY:

DATE:

XXXXXX

R.C.E. NO. XXXXX

SEAL:

A1

LIBRARY EXPANSION PROJECT

FLOOR PLAN

IN THE CITY OF IMPERIAL, CALIFORNIA

DATE: 02/05/15

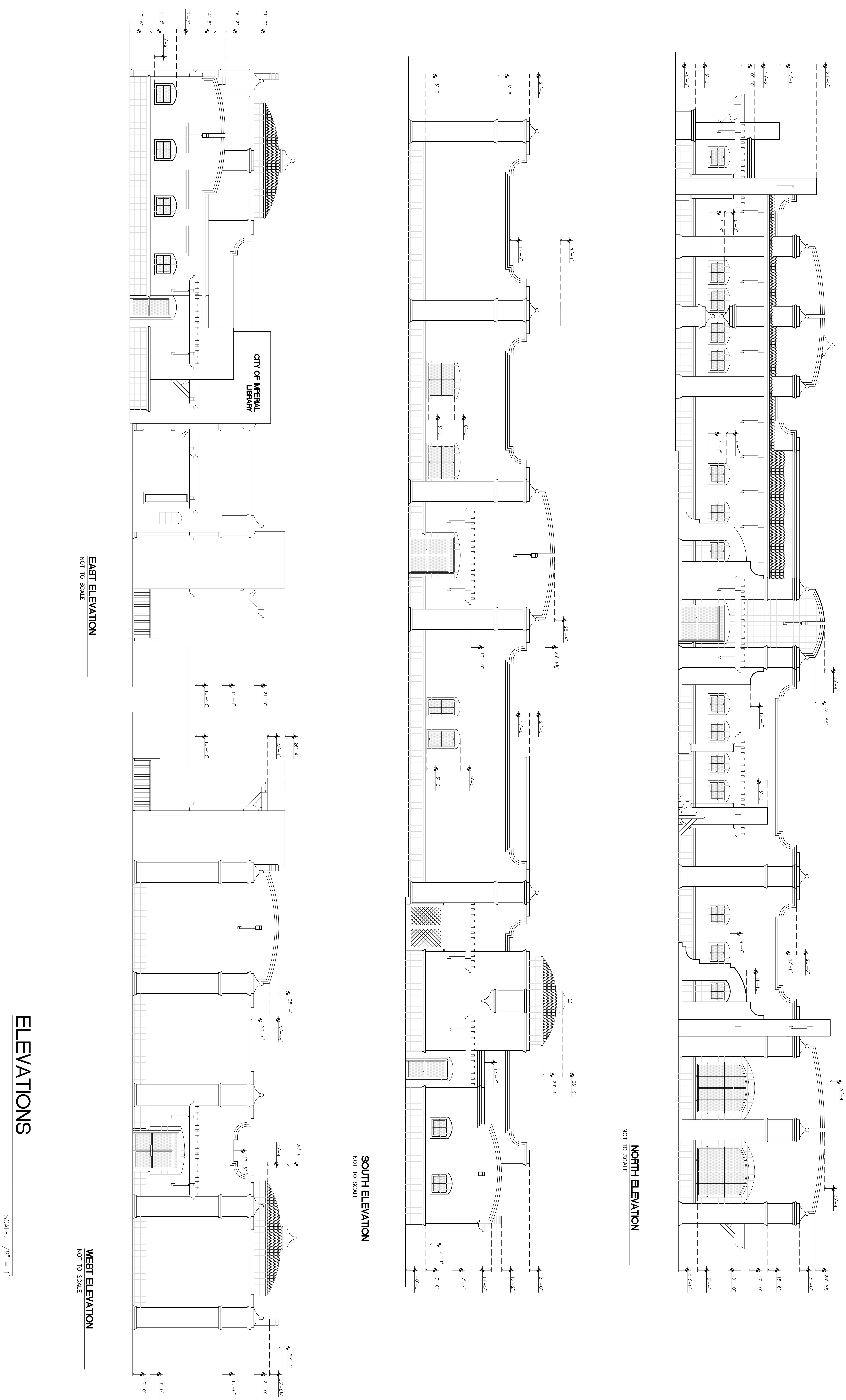
SHEET: 1

OF: 1

DWN. BY: A.A.

REV. BY: O.M.

APP. BY: X.X.



City of Imperial California

REVISIONS			
NO.	DESCRIPTION:	DATE:	BY:
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BY:

DATE:

XXXXXX

R.C.E. NO. XXXXX

SEAL:

A2

LIBRARY EXPANSION PROJECT

ELEVATIONS

IN THE CITY OF IMPERIAL, CALIFORNIA

DATE: 02/05/15

SHEET: 1

OF: 1

DWN. BY: A.A.

REV. BY: O.M.

APP. BY: X.X.

Geotechnical Report – 2014 Update

Imperial Library
200 West 9th Street
Imperial, California

Prepared for:

City of Imperial
420 S. Imperial Avenue
Imperial, CA 92251

Prepared by:

LANDMARK
Geo-Engineers and Geologists

Landmark Consultants, Inc.
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El Centro, CA 92243
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November 2014

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November 17, 2014

Mr. Othon Mora
City of Imperial
420 S. Imperial Avenue
Imperial, CA 92251

Geotechnical Investigation Report – 2014 Update
Imperial Public Library Expansion
200 West 9th Street
Imperial, California
LCI Report No. LE14210

Dear Mr. Mora:

Landmark Consultants, Inc. is providing this geotechnical report update to Geotechnical Report prepared by Southland Geotechnical in 2002 for the proposed expansion of the Imperial Public Library located at 200 West 9th Street in Imperial, California. The project is proposed to consist of a 5,290 square foot addition of the west side of the existing library. The update addresses changes made due to the adoption of the 2013 California Building Code (CBC) and geotechnical engineering standards of practice in Imperial County.

This update report presents selected elements of our findings and professional opinions only. It does not present all details that may be needed for the proper application of our findings and professional opinions. Our findings, professional opinions, and application options are best related through reading the full Geotechnical Report Update, and with the active participation of the engineer of record who developed them during design and construction of the project. A copy of the 2002 Geotechnical Report (SGI Report No. S02280, dated November 20, 2002) is attached as Appendix C.

Seismic Parameters

Seismic Risk: The project site is located in the seismically active Imperial Valley of southern California with numerous mapped faults of the San Andreas Fault System traversing the region. The San Andreas Fault System is comprised of the San Andreas, San Jacinto, and Elsinore Fault Zones in southern California. The Imperial Fault represents a transition from the more continuous San Andreas Fault to a more nearly echelon pattern characteristic of the faults under the Gulf of California (USGS 1990).

We have performed a computer-aided search of known faults or seismic zones that lie within a 62 mile (100 kilometer) radius of the project site as provided in Table 1. A fault map illustrating known active faults relative to the site is presented on Figure 1, *Regional Fault Map*. A legend for the regional fault map is presented on Figure 2. The criterion for fault classification adopted by the California Geological Survey defines Earthquake Fault Zones along active or potentially active faults. An active fault is one that has ruptured during Holocene time (roughly within the last 11,000 years). A fault that has ruptured during the last 1.8 million years (Quaternary time), but has not been proven by direct evidence to have not moved within Holocene time is considered to be potentially active. A fault that has not moved during both Pleistocene and Holocene time (that is no movement within the last 1.8 million years) is considered to be inactive. Review of the current Alquist-Priolo Earthquake Fault Zone maps (CGS, 2000a) indicates that the nearest mapped Earthquake Fault Zones are the Superstition Hills fault located 2.5 miles west of the project site and the Imperial fault located approximately 3.0 miles east of the project site.

Site Acceleration: The project site is considered likely to be subjected to moderate to strong ground motion from earthquakes in the region. Ground motions are dependent primarily on the earthquake magnitude and distance to the seismogenic (rupture) zone. Accelerations also are dependent upon attenuation by rock and soil deposits, direction of rupture and type of fault; therefore, ground motions may vary considerably in the same general area.

CBC General Ground Motion Parameters: The 2013 CBC general ground motion parameters are based on the Risk-Targeted Maximum Considered Earthquake (MCE_R). The U.S. Geological Survey "U.S. Seismic Design Maps Web Application" (USGS, 2013) was used to obtain the site coefficients and adjusted maximum considered earthquake spectral response acceleration parameters. The site soils have been classified as Site Class D (stiff soil profile).

Design spectral response acceleration parameters are defined as the earthquake ground motions that are two-thirds (2/3) of the corresponding MCE_R ground motions. Design earthquake ground motion parameters are provided in Table 2. A Risk Category II was determined using Table 1604.5 and the Seismic Design Category is D since S_1 is less than 0.75.

The Maximum Considered Earthquake Geometric Mean (MCE_G) peak ground acceleration (PGA_M) value was determined from the "U.S. Seismic Design Maps Web Application" (USGS, 2013) for liquefaction and seismic settlement analysis in accordance with 2013 CBC Section 1803.5.12 and CGS Note 48 ($PGA_M = F_{PGA}$*PGA). A PGA_M value of 0.69g is used for liquefaction settlement analysis.

Subsurface Soil and Groundwater

Subsurface soils encountered during the field exploration conducted for Southland's 2002 Geotechnical Report consist of dominantly stiff to very stiff clays with some interbedded silt layers. A sandy silt layer was encountered at a depth of 8 to 13 feet in the western portion of the site. The findings of the geotechnical study indicate that the native surface clays exhibit high swell potential (Expansion Index, EI = 109) that will either require replacement of the upper clays with sands or require foundations and slabs-on-grade designed to resist expansive soil heave (CBC Section 1808). For building additions, replacement of clays with non-expansive granular fill is the preferred alternative to mitigate potential movement between old and new foundations.

Groundwater is typically encountered at a depth of 8 to 10 feet in the vicinity of the project site.

Liquefaction Potential

Evaluation of liquefaction potential at the site indicates that interbedded layers of sandy silt at a depth between 8 to 14 feet and clayey silt from 29 to 34 feet are susceptible to liquefaction induced settlement. Based on empirical relationships, total induced settlements are estimated to be about 1¼ inches should liquefaction occur (see Appendix C).

Mitigation: Means to mitigate liquefaction damage include grade-beam reinforced foundations that can withstand some differential movement or tilting, but may not protect fracturing of buried utilities. The differential settlement caused by liquefaction is estimated at approximately ¾ inch. Due to the depth of potentially liquefiable layers, the existing library building and new addition should move similarly.

Site Preparation

All trash, construction debris, concrete slabs, old pavement, landfill, and buried obstructions such as old foundations and utility lines exposed during rough grading should be traced to the limits of the foreign material by the grading contractor and removed under our supervision. Any excavations resulting from site clearing should be sloped to a bowl shape to the lowest depth of disturbance and backfilled under the observation of the geotechnical engineer's representative.

Building Pad Preparation: The exposed surface soil within the building pad/foundation area should be removed to 3 feet below the building pad elevation or existing natural surface grade (whichever is lower) extending five feet beyond all exterior wall/column lines (including concreted areas adjacent to the building).

A "saw-tooth" excavation should be utilized along the existing foundation to prevent undermining of the existing footings.

Exposed subgrade should be fine graded to a uniform surface and proof-rolled to detect any unstable areas. ***The native soil should not be used in the building support pad.***

An engineered building support pad consisting of 3.0 feet of granular soil placed in maximum 8-inch lifts (loose), compacted to a minimum of 90% of ASTM D1557 maximum density at 2% below to 4% above optimum moisture, should be placed below the bottom of all structural slabs and 2 feet of granular soil below site hardscape areas.

Non-expansive granular soil shall meet the USCS classifications of SM, SP-SM, or SW-SM with a maximum rock size of 1.5 inches and 5 to 35% passing the No. 200. The geotechnical engineer should approve imported fill soil sources before hauling material to the site. Imported granular fill should be placed in lifts no greater than 8 inches in loose thickness and compacted to a minimum of 90% of ASTM D1557 maximum dry density at optimum moisture ±2%.

Foundations and Settlements

Shallow spread footings are suitable to support the library expansion provided they are structurally tied with grade-beams to continuous perimeter wall footings to resist differential movement associated with liquefiable soils at depth. Exterior footings shall be extended to a minimum depth of 18 inches below building pad grade. The foundations may be designed using an allowable soil bearing pressure of 2,000 psf for compacted engineered granular fill. The allowable soil pressure may be increased by 20% for each foot of embedment depth in excess of 18 inches and by one-third for short term loads induced by winds or seismic events. The maximum allowable soil pressure at increased embedment depths shall not exceed 3,000 psf.

<u>Grade-beam Reinforced Foundations</u>: Grade-beam reinforced foundations may be used to mitigate potential liquefaction induced settlement. Slab stiffening should not exceed 25 feet on center.

All footings should be embedded a minimum of 18 inches below the building support pad or lowest adjacent final grade, whichever is deeper. Continuous wall footings should have a minimum width of 18 inches. Spread footings should have a minimum dimension of 24 inches and should be structurally tied to perimeter footings or grade beams. Concrete reinforcement and sizing for all footings should be determined by the structural engineer.

Slabs-On-Grade

Structural Concrete: Structural concrete slabs are those slabs (foundations) that underlie structures or patio covers (shades). These slabs shall be a minimum of 4 inches thick when placed on the granular engineered fill. Concrete floor slabs shall be monolithically placed with the footings (no cold joints).

American Concrete Institute (ACI) guidelines (ACI 302.1R-7 Chapter 3, Section 3.2.3) provide recommendations regarding the use of moisture barriers beneath concrete slabs. The concrete floor slabs should be underlain by a 10-mil polyethylene vapor retarder that works as a capillary break to reduce moisture migration into the slab section. The vapor retarder should be properly lapped and continuously sealed and extend a minimum of 12 inches into the footing excavations. The vapor retarder should be covered by 2 inches of clean sand (Sand Equivalent SE>30.

Concrete slabs may be placed without a sand cover directly over a 15-mil vapor retarder (Stego-Wrap or equivalent), provided that the concrete mix uses a low-water cement ratio and concrete curing methods are employed to compensate for release of bleed water through the top of the slab.

For areas with moisture sensitive flooring materials, the concrete slab should be placed directly on a 15-mil vapor retarder constructed in accordance with ASTM E1643 and E1745.

Non-structural Concrete: All non-structural independent flatwork (sidewalks and uncovered patios) shall be a minimum of 4 inches thick and should be placed on a minimum of 24 inches of concrete sand or aggregate base, dowelled to the perimeter foundations where adjacent to the building to prevent separation and sloped 2% (sidewalks) or 1 to 2% (patios) away from the building. Patio slabs with shade structures shall have a 12-inch deep perimeter footing and shall have interior grade beams at 15 feet on center. The minimum slope for patio slabs is 1% and the slope for sidewalks should be 2%. Isolated planters within the granular fill are not recommended.

Concrete Mixes and Corrosivity

Selected chemical analyses for corrosivity were conducted on bulk samples of the near surface soil from the project site in 2002. The native soils were found to have severe levels of sulfate ion concentration (4,280 to 5,820 ppm). Sulfate ions in high concentrations can attack the cementitious material in concrete, causing weakening of the cement matrix and eventual deterioration by raveling.

The native soil has severe to very severe levels of chloride ion concentration (760 to 3,310 ppm). Chloride ions can cause corrosion of reinforcing steel, anchor bolts and other buried metallic conduits. There are no special concrete mixes required for foundations and hardscape placed on 2 to 3 feet of imported granular soils.

A minimum of 4.0 inches of cover should be provided at all embedded steel building components should reinforced concrete be placed within native clay soils. Epoxy coatings (ASTM D3963 – 1 mil minimum thickness) may be used to protect anchor bolts with less than 4 inches of concrete cover. Resistivity determinations on the soil indicate very severe potential for metal loss because of electrochemical corrosion processes.

No water piping is allowed under the concrete foundations. Water supply piping must come to the sidewall of the footing, with the riser placed outside of the footing area. All copper water piping risers (within 18 inches of native clay ground surface) shall be wrapped with two 15 mil layers of plumbers tape.

A minimum of 6.0 sacks per cubic yard of concrete (4,500 psi) of Type V Portland Cement with a maximum water/cement ratio of 0.45 (by weight) should be used for concrete placed in contact with native soil on this project (sitework including sidewalks, patios, and foundations). Admixtures may be required to allow placement of this low water/cement ratio concrete.

Closure

We appreciate the opportunity to provide our findings and professional opinions regarding geotechnical conditions at the site. If you have any questions or comments regarding our findings, please call our office at (760) 370-3000.

Respectfully Submitted,
Landmark Consultants, Inc.

PROFESSIONAL GEOLOGIST STEVEN K. WILLIAMS CERTIFIED ENGINEERING GEOLOGIST CEG 2261 STATE OF CALIFORNIA

Steven K. Williams, PG, CEG
Senior Engineering Geologist

Jeffrey O. Lyon, PE
President

REGISTERED PROFESSIONAL ENGINEER JEFFREY O. LYON No. 31921 EXPIRES 12-31-14 CIVIL STATE OF CALIFORNIA

Table 1
Summary of Characteristics of Closest Known Active Faults

Fault Name	Approximate Distance (miles)	Approximate Distance (km)	Maximum Moment Magnitude (Mw)	Fault Length (km)	Slip Rate (mm/yr)
Superstition Hills	2.5	4.0	6.6	23 ± 2	4 ± 2
Imperial	3.1	4.9	7	62 ± 6	20 ± 5
Brawley *	5.6	9.0			
Superstition Mountain	7.2	11.4	6.6	24 ± 2	5 ± 3
Rico *	10.2	16.4			
Unnamed 1*	12.8	20.4			
Unnamed 2*	13.1	20.9			
Yuha*	14.8	23.6			
Shell Beds	16.4	26.3			
Yuha Well *	16.5	26.4			
Painted Gorge Wash*	19.5	31.3			
Laguna Salada	19.7	31.5	7	67 ± 7	3.5 ± 1.5
Vista de Anza*	19.7	31.6			
Elmore Ranch	20.3	32.5	6.6	29 ± 3	1 ± 0.5
Borrego (Mexico)*	20.8	33.3			
Ocotillo*	23.8	38.1			
Cerro Prieto *	24.7	39.4			
Pescadores (Mexico)*	26.4	42.3			
San Jacinto - Borrego	26.9	43.0	6.6	29 ± 3	4 ± 2
Elsinore - Coyote Mountain	27.0	43.2	6.8	39 ± 4	4 ± 2
Cucapah (Mexico)*	27.8	44.5			
San Andreas - Coachella	35.8	57.3	7.2	96 ± 10	25 ± 5

* Note: Faults not included in CGS database.

Table 2
2013 California Building Code (CBC) and ASCE 7-10 Seismic Parameters

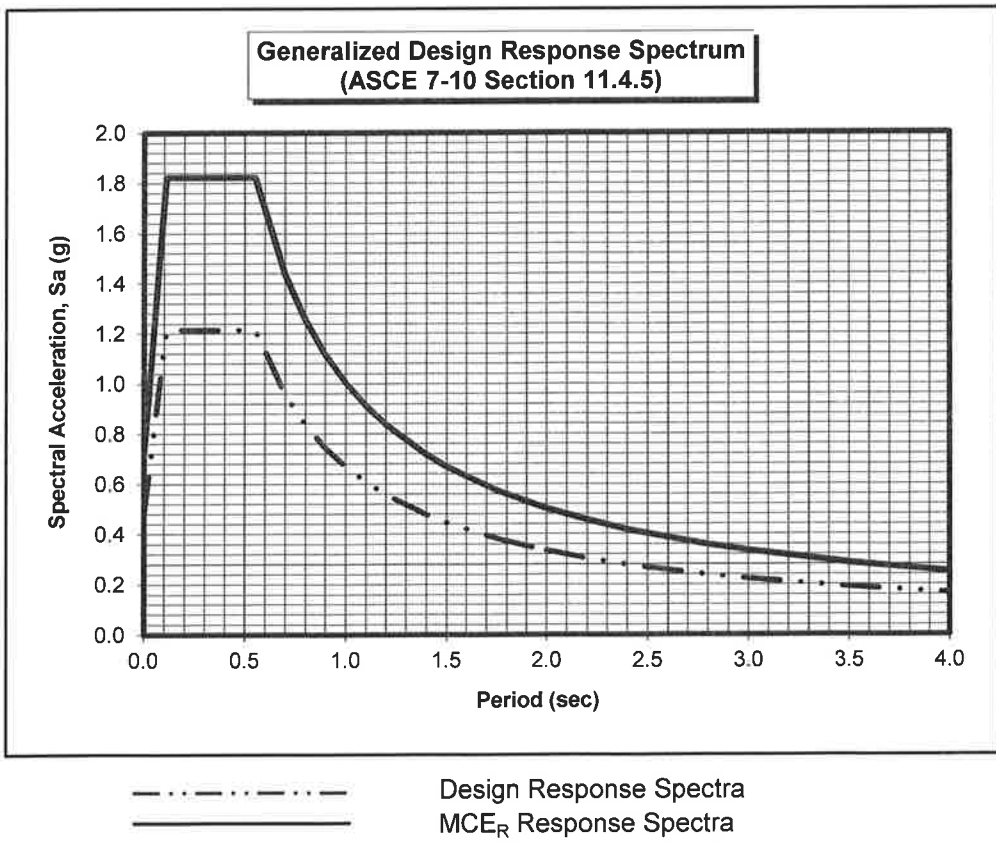
		CBC Reference
Site Class:	**D**	Table 20.3-1
Latitude:	32.8483 N	
Longitude:	-115.5717 W	
Risk Category:	II	
Seismic Design Category:	D	

Maximum Considered Earthquake (MCE) Ground Motion

Mapped MCE_R Short Period Spectral Response	S_s	1.823 g	Figure 1613.3.1(1)	
Mapped MCE_R 1 second Spectral Response	S_1	0.669 g	Figure 1613.3.1(2)	
Short Period (0.2 s) Site Coefficient	F_a	1.00	Table 1613.3.3(1)	
Long Period (1.0 s) Site Coefficient	F_v	1.50	Table 1613.3.3(2)	
MCE_R Spectral Response Acceleration Parameter (0.2 s)	S_{MS}	1.823 g	$= F_a * S_s$	Equation 16-37
MCE_R Spectral Response Acceleration Parameter (1.0 s)	S_{M1}	1.004 g	$= F_v * S_1$	Equation 16-38

Design Earthquake Ground Motion

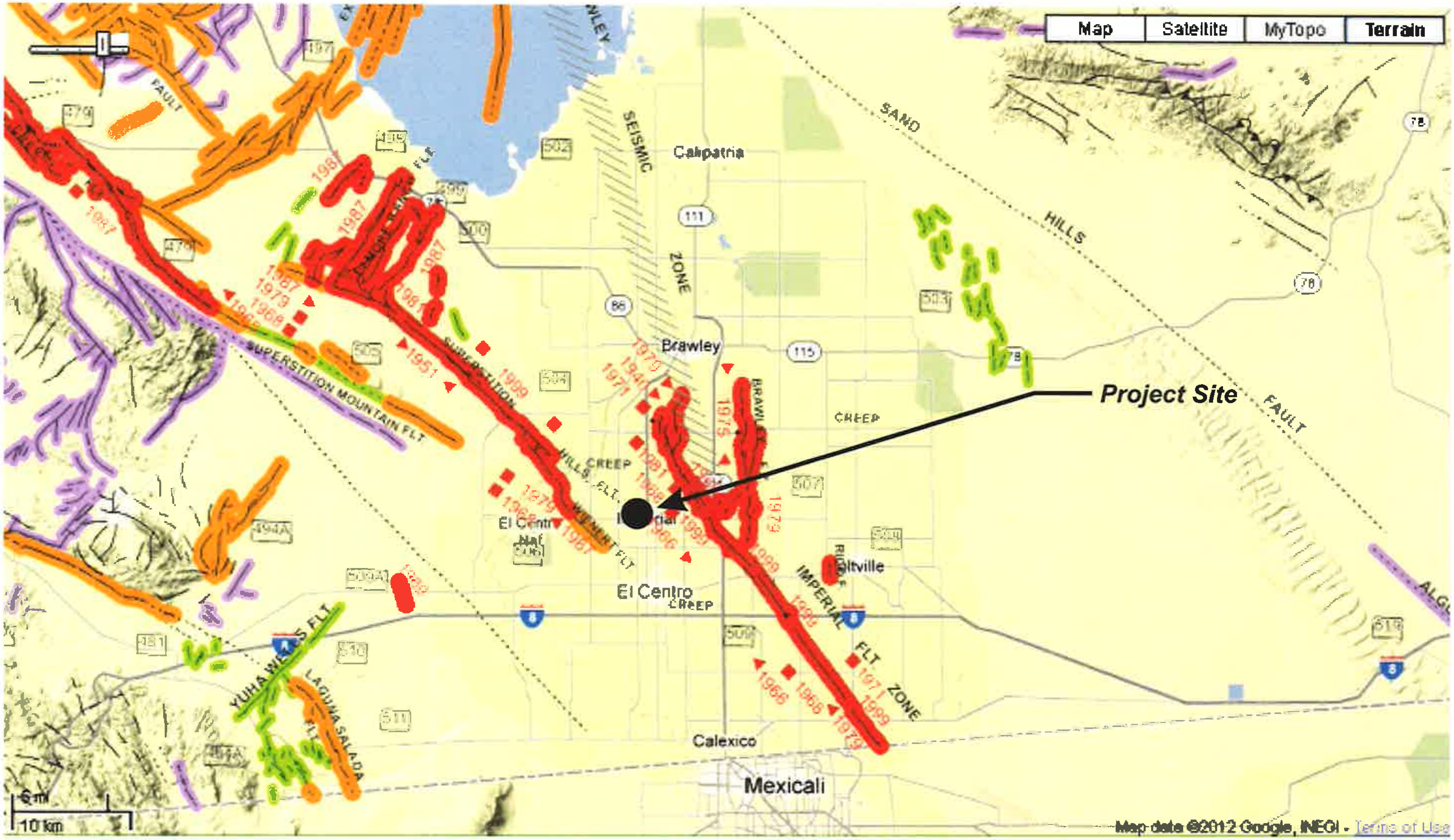
Design Spectral Response Acceleration Parameter (0.2 s)	S_{DS}	1.215 g	$= 2/3*S_{MS}$	Equation 16-39
Design Spectral Response Acceleration Parameter (1.0 s)	S_{D1}	0.669 g	$= 2/3*S_{M1}$	Equation 16-40
	T_L	8.00 sec		ASCE Figure 22-12
	T_O	0.11 sec	$=0.2*S_{D1}/S_{DS}$	
	T_S	0.55 sec	$=S_{D1}/S_{DS}$	
Peak Ground Acceleration	PGA_M	0.69 g		ASCE Equation 11.8-1



Period T (sec)	Sa (g)	MCE_R Sa (g)
0.00	0.49	0.73
0.11	1.22	1.82
0.55	1.22	1.82
0.70	0.96	1.43
0.80	0.84	1.25
0.90	0.74	1.12
1.00	0.67	1.00
1.10	0.61	0.91
1.20	0.56	0.84
1.20	0.56	0.84
1.40	0.48	0.72
1.50	0.45	0.67
1.75	0.38	0.57
2.00	0.33	0.50
2.20	0.30	0.46
2.40	0.28	0.42
2.60	0.26	0.39
2.80	0.24	0.36
3.00	0.22	0.33
3.50	0.19	0.29
4.00	0.17	0.25

Source: California Geological Survey 2010 Fault Activity Map of California
http://www.quake.ca.gov/gmaps/FAM/faultactivitymap.html#

LANDMARK Geo-Engineers and Geologists Project No.: LE14210	Regional Fault Map	Figure 1



Source: California Geological Survey 2010 Fault Activity Map of California
http://www.quake.ca.gov/gmaps/FAM/faultactivitymap.html#

LANDMARK Geo-Engineers and Geologists Project No.: LE14210	Map of Local Faults	Figure 2

EXPLANATION

Fault traces on land are indicated by solid lines where well located, by dashed lines where approximately located or inferred, and by dotted lines where concealed by younger rocks or by lakes or bays. Fault traces are queried where continuation or existence is uncertain. Concealed faults in the Great Valley are based on maps of selected subsurface horizons, so locations shown are approximate and may indicate structural trend only. All offshore faults based on seismic reflection profile records are shown as solid lines where well defined, dashed where inferred, queried where uncertain.

FAULT CLASSIFICATION COLOR CODE
(Indicating Recency of Movement)

Fault along which historic (last 200 years) displacement has occurred and is associated with one or more of the following:

(a) a recorded earthquake with surface rupture. (Also included are some well-defined surface breaks caused by ground shaking during earthquakes, e.g. extensive ground breakage, not on the White Wolf fault, caused by the Arvin-Tehachapi earthquake of 1952). The date of the associated earthquake is indicated. Where repeated surface ruptures on the same fault have occurred, only the date of the latest movement may be indicated, especially if earlier reports are not well documented as to location of ground breaks.

(b) fault creep slippage - slow ground displacement usually without accompanying earthquakes.

(c) displaced survey lines.

A triangle to the right or left of the date indicates termination point of observed surface displacement. Solid red triangle indicates known location of rupture termination point. Open black triangle indicates uncertain or estimated location of rupture termination point.

Date bracketed by triangles indicates local fault break.

No triangle by date indicates an intermediate point along fault break.

Fault that exhibits fault creep slippage. Hachures indicate linear extent of fault creep. Annotation (creep with leader) indicates representative locations where fault creep has been observed and recorded.

Square on fault indicates where fault creep slippage has occured that has been triggered by an earthquake on some other fault. Date of causative earthquake indicated. Squares to right and left of date indicate terminal points between which triggered creep slippage has occurred (creep either continuous or intermittent between these end points).

Holocene fault displacement (during past 11,700 years) without historic record. Geomorphic evidence for Holocene faulting includes sag ponds, scarps showing little erosion, or the following features in Holocene age deposits: offset stream courses, linear scarps, shutter ridges, and triangular faceted spurs. Recency of faulting offshore is based on the interpreted age of the youngest strata displaced by faulting.

Late Quaternary fault displacement (during past 700,000 years). Geomorphic evidence similar to that described for Holocene faults except features are less distinct. Faulting may be younger, but lack of younger overlying deposits precludes more accurate age classification.

Quaternary fault (age undifferentiated). Most faults of this category show evidence of displacement sometime during the past 1.6 million years; possible exceptions are faults which displace rocks of undifferentiated Plio-Pleistocene age. Unnumbered Quaternary faults were based on Fault Map of California, 1975. See Bulletin 201, Appendix D for source data.

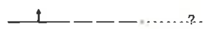
Pre-Quaternary fault (older that 1.6 million years) or fault without recognized Quaternary displacement. Some faults are shown in this category because the source of mapping used was of reconnaissnce nature, or was not done with the object of dating fault displacements. Faults in this category are not necessarily inactive.

LANDMARK Geo-Engineers and Geologists **Project No.: LE14210**	**Fault Map Legend**	**Figure 3a**

ADDITIONAL FAULT SYMBOLS

Bar and ball on downthrown side (relative or apparent).

Arrows along fault indicate relative or apparent direction of lateral movement.



Arrow on fault indicates direction of dip.

Low angle fault (barbs on upper plate). Fault surface generally dips less than 45° but locally may have been subsequently steepened. On offshore faults, barbs simply indicate a reverse fault regardless of steepness of dip.

OTHER SYMBOLS

Numbers refer to annotations listed in the appendices of the accompanying report. Annotations include fault name, age of fault displacement, and pertinent references including Earthquake Fault Zone maps where a fault has been zoned by the Alquist-Priolo Earthquake Fault Zoning Act. This Act requires the State Geologist to delineate zones to encompass faults with Holocene displacement.

Structural discontinuity (offshore) separating differing Neogene structural domains. May indicate discontinuities between basement rocks.

Brawley Seismic Zone, a linear zone of seismicity locally up to 10 km wide associated with the releasing step between the Imperial and San Andreas faults.

Geologic Time Scale			Years Before Present (Approx.)	Fault Symbol	Recency of Movement	DESCRIPTION: ON LAND	DESCRIPTION: OFFSHORE
Quaternary	Late Quaternary	Historic				Displacement during historic time (e.g. San Andreas fault 1906). Includes areas of known fault creep.	
Quaternary	Late Quaternary	Holocene	200			Displacement during Holocene time.	Fault offsets seafloor sediments or strata of Holocene age.
Quaternary	Late Quaternary	Pleistocene	11,700			Faults showing evidence of displacement during late Quaternary time.	Fault cuts strata of Late Pleistocene age.
Quaternary	Early Quaternary	Pleistocene	700,000			Undivided Quaternary faults - most faults in this category show evidence of displacement during the last 1,600,000 years; possible exceptions are faults which displace rocks of undifferentiated Plio-Pleistocene age.	Fault cuts strata of Quaternary age.
Pre-Quaternary			1,600,000* – 4.5 billion (Age of Earth)			Faults without recognized Quaternary displacement or showing evidence of no displacement during Quaternary time. Not necessarily inactive.	Fault cuts strata of Pliocene or older age.

* Quaternary now recognized as extending to 2.6 Ma (Walker and Geissman, 2009). Quaternary faults in this map were established using the previous 1.6 Ma criterion.

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Fault Map Legend

Figure 3b

APPENDIX A

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Project No.: LE14210

Vicinity Map

Plate A-1

LANDMARK
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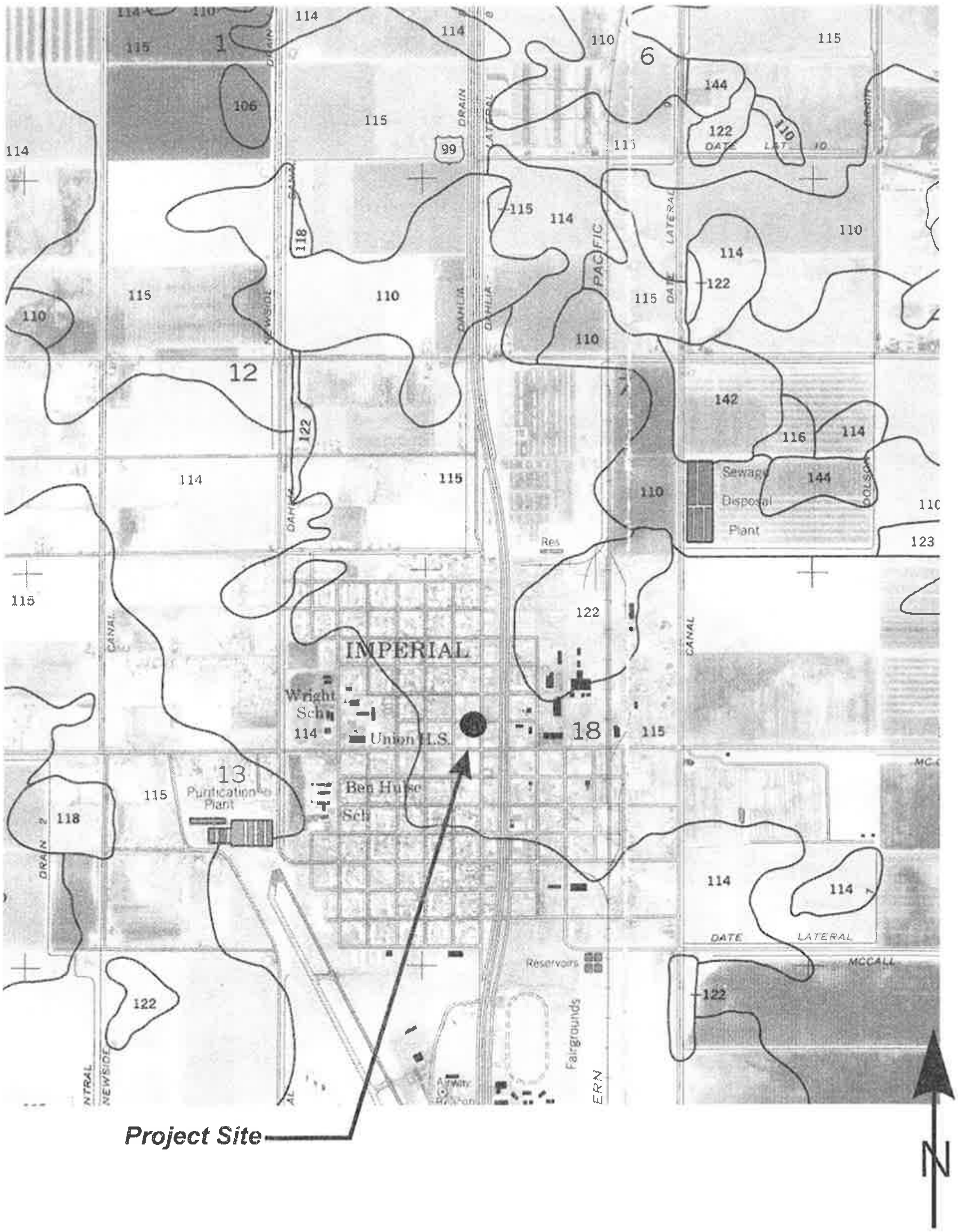
Project No.: LE14210

Site Map

Plate
A-2



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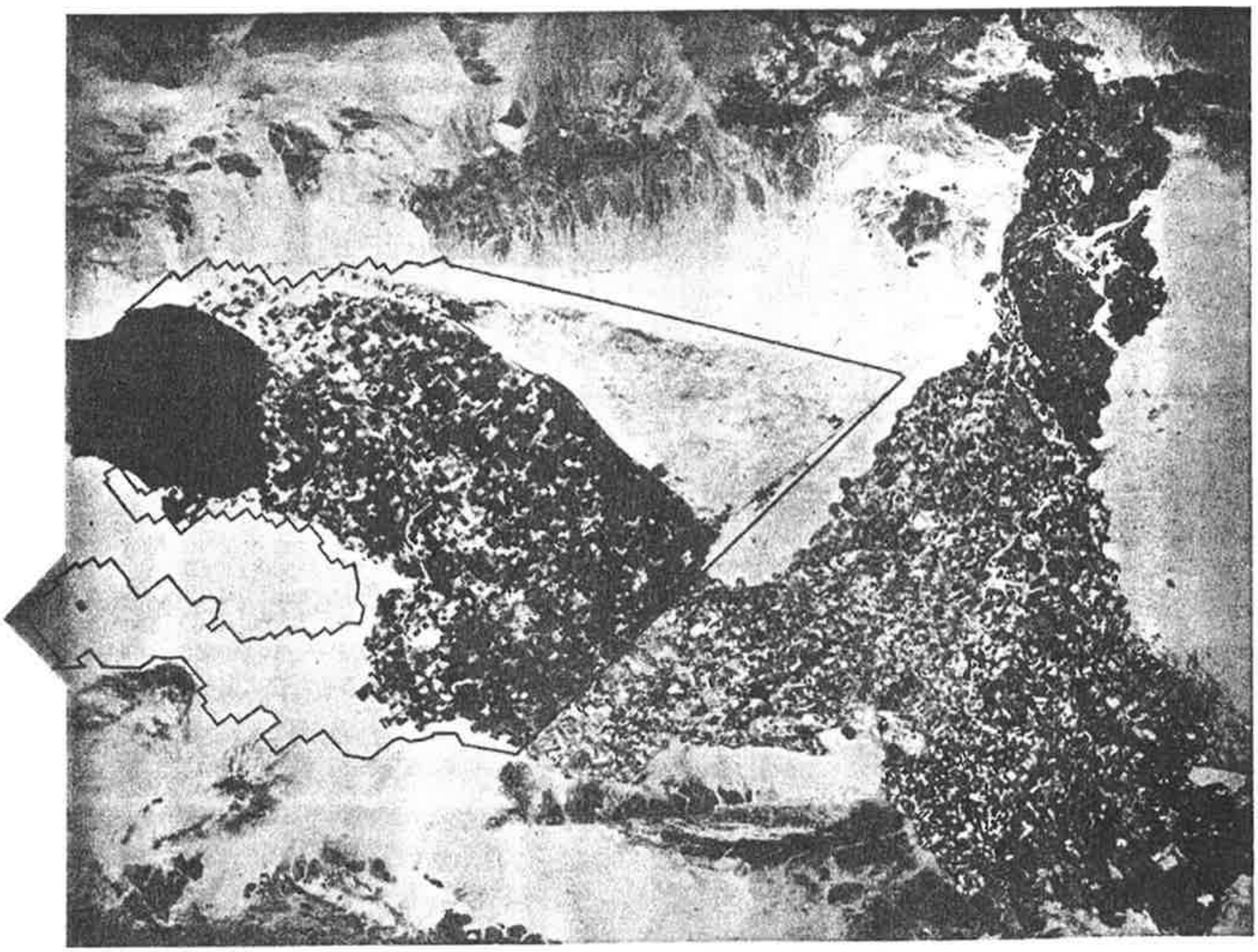
Soil Survey Map

Plate A-3

Soil Survey of

IMPERIAL COUNTY
CALIFORNIA
IMPERIAL VALLEY AREA



United States Department of Agriculture Soil Conservation Service

in cooperation with

University of California Agricultural Experiment Station

and

Imperial Irrigation District

TABLE 11.--ENGINEERING INDEX PROPERTIES

[The symbol > means more than. Absence of an entry indicates that data were not estimated]

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments > 3 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				Pct					Pct	
100----------------- Antho	0-13	Loamy fine sand	SM	A-2	0	100	100	75-85	10-30	---	NP
	13-60	Sandy loam, fine sandy loam.	SM	A-2, A-4	0	90-100	75-95	50-60	15-40	---	NP
101*:											
Antho--------------	0-8	Loamy fine sand	SM	A-2	0	100	100	75-85	10-30	---	NP
	8-60	Sandy loam, fine sandy loam.	SM	A-2, A-4	0	90-100	75-95	50-60	15-40	---	NP
Superstition-------	0-6	Fine sand--------	SM	A-2	0	100	95-100	70-85	15-25	---	NP
	6-60	Loamy fine sand, fine sand, sand.	SM	A-2	0	100	95-100	70-85	15-25	---	NP
102*. Badland											
103----------------- Carsitas	0-10	Gravelly sand---	SP, SP-SM	A-1, A-2	0-5	60-90	50-85	30-55	0-10	---	NP
	10-60	Gravelly sand, gravelly coarse sand, sand.	SP, SP-SM	A-1	0-5	60-90	50-85	25-50	0-10	---	NP
104* Fluvaquents											
105----------------- Glenbar	0-13	Clay loam--------	CL	A-6	0	100	100	90-100	70-95	35-45	15-30
	13-60	Clay loam, silty clay loam.	CL	A-6	0	100	100	90-100	70-95	35-45	15-30
106----------------- Glenbar	0-13	Clay loam--------	CL	A-6, A-7	0	100	100	90-100	70-95	35-45	15-25
	13-60	Clay loam, silty clay loam.	CL	A-6, A-7	0	100	100	90-100	70-95	35-45	15-25
107*---------------- Glenbar	0-13	Loam-------------	ML, CL-ML, CL	A-4	0	100	100	100	70-80	20-30	NP-10
	13-60	Clay loam, silty clay loam.	CL	A-6, A-7	0	100	100	95-100	75-95	35-45	15-30
108----------------- Holtville	0-14	Loam-------------	ML	A-4	0	100	100	85-100	55-95	25-35	NP-10
	14-22	Clay, silty clay	CL, CH	A-7	0	100	100	95-100	85-95	40-65	20-35
	22-60	Silt loam, very fine sandy loam.	ML	A-4	0	100	100	95-100	65-85	25-35	NP-10
109----------------- Holtville	0-17	Silty clay-------	CL, CH	A-7	0	100	100	95-100	85-95	40-65	20-35
	17-24	Clay, silty clay	CL, CH	A-7	0	100	100	95-100	85-95	40-65	20-35
	24-35	Silt loam, very fine sandy loam.	ML	A-4	0	100	100	95-100	65-85	25-35	NP-10
	35-60	Loamy very fine sand, loamy fine sand.	SM, ML	A-2, A-4	0	100	100	75-100	20-55	---	NP
110----------------- Holtville	0-17	Silty clay-------	CH, CL	A-7	0	100	100	95-100	85-95	40-65	20-35
	17-24	Clay, silty clay	CH, CL	A-7	0	100	100	95-100	85-95	40-65	20-35
	24-35	Silt loam, very fine sandy loam.	ML	A-4	0	100	100	95-100	55-85	25-35	NP-10
	35-60	Loamy very fine sand, loamy fine sand.	SM, ML	A-2, A-4	0	100	100	75-100	20-55	---	NP

See footnote at end of table.

TABLE 11.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Frag- ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
111*:											
Holtville----------	0-10	Silty clay loam	CL, CH	A-7	0	100	100	95-100	85-95	40-65	20-35
	10-22	Clay, silty clay	CL, CH	A-7	0	100	100	95-100	85-95	40-65	20-35
	22-60	Silt loam, very fine sandy loam.	ML	A-4	0	100	100	95-100	65-85	25-35	NP-10
Imperial----------	0-12	Silty clay loam	CL	A-7	0	100	100	100	85-95	40-50	10-20
	12-60	Silty clay loam, silty clay, clay.	CH	A-7	0	100	100	100	85-95	50-70	25-45
112---------------- Imperial	0-12	Silty clay------	CH	A-7	0	100	100	100	85-95	50-70	25-45
	12-60	Silty clay loam, silty clay, clay.	CH	A-7	0	100	100	100	85-95	50-70	25-45
113---------------- Imperial	0-12	Silty clay------	CH	A-7	0	100	100	100	85-95	50-70	25-45
	12-60	Silty clay, clay, silty clay loam.	CH	A-7	0	100	100	100	85-95	50-70	25-45
114---------------- Imperial	0-12	Silty clay------	CH	A-7	0	100	100	100	85-95	50-70	25-45
	12-60	Silty clay loam, silty clay, clay.	CH	A-7	0	100	100	100	85-95	50-70	25-45
115*:											
Imperial----------	0-12	Silty clay loam	CL	A-7	0	100	100	100	85-95	40-50	10-20
	12-60	Silty clay loam, silty clay, clay.	CH	A-7	0	100	100	100	85-95	50-70	25-45
Glenbar-----------	0-13	Silty clay loam	CL	A-6, A-7	0	100	100	90-100	70-95	35-45	15-25
	13-60	Clay loam, silty clay loam.	CL	A-6, A-7	0	100	100	90-100	70-95	35-45	15-25
116*:											
Imperial----------	0-13	Silty clay loam	CL	A-7	0	100	100	100	85-95	40-50	10-20
	13-60	Silty clay loam, silty clay, clay.	CH	A-7	0	100	100	100	85-95	50-70	25-45
Glenbar-----------	0-13	Silty clay loam	CL	A-6, A-7	0	100	100	90-100	70-95	35-45	15-25
	13-60	Clay loam, silty clay loam.	CL	A-6	0	100	100	90-100	70-95	35-45	15-30
117, 118----------- Indio	0-12	Loam------------	ML	A-4	0	95-100	95-100	85-100	75-90	20-30	NP-5
	12-72	Stratified loamy very fine sand to silt loam.	ML	A-4	0	95-100	95-100	85-100	75-90	20-30	NP-5
119*:											
Indio-------------	0-12	Loam------------	ML	A-4	0	95-100	95-100	85-100	75-90	20-30	NP-5
	12-72	Stratified loamy very fine sand to silt loam.	ML	A-4	0	95-100	95-100	85-100	75-90	20-30	NP-5
Vint--------------	0-10	Loamy fine sand	SM	A-2	0	95-100	95-100	70-80	25-35	---	NP
	10-60	Loamy sand, loamy fine sand.	SM	A-2	0	95-100	95-100	70-80	20-30	---	NP
120*--------------- Laveen	0-12	Loam------------	ML, CL-ML	A-4	0	100	95-100	75-85	55-65	20-30	NP-10
	12-60	Loam, very fine sandy loam.	ML, CL-ML	A-4	0	95-100	85-95	70-80	55-65	15-25	NP-10

See footnote at end of table.

TABLE 11.--ENGINEERING INDEX PROPERTIES--Continued

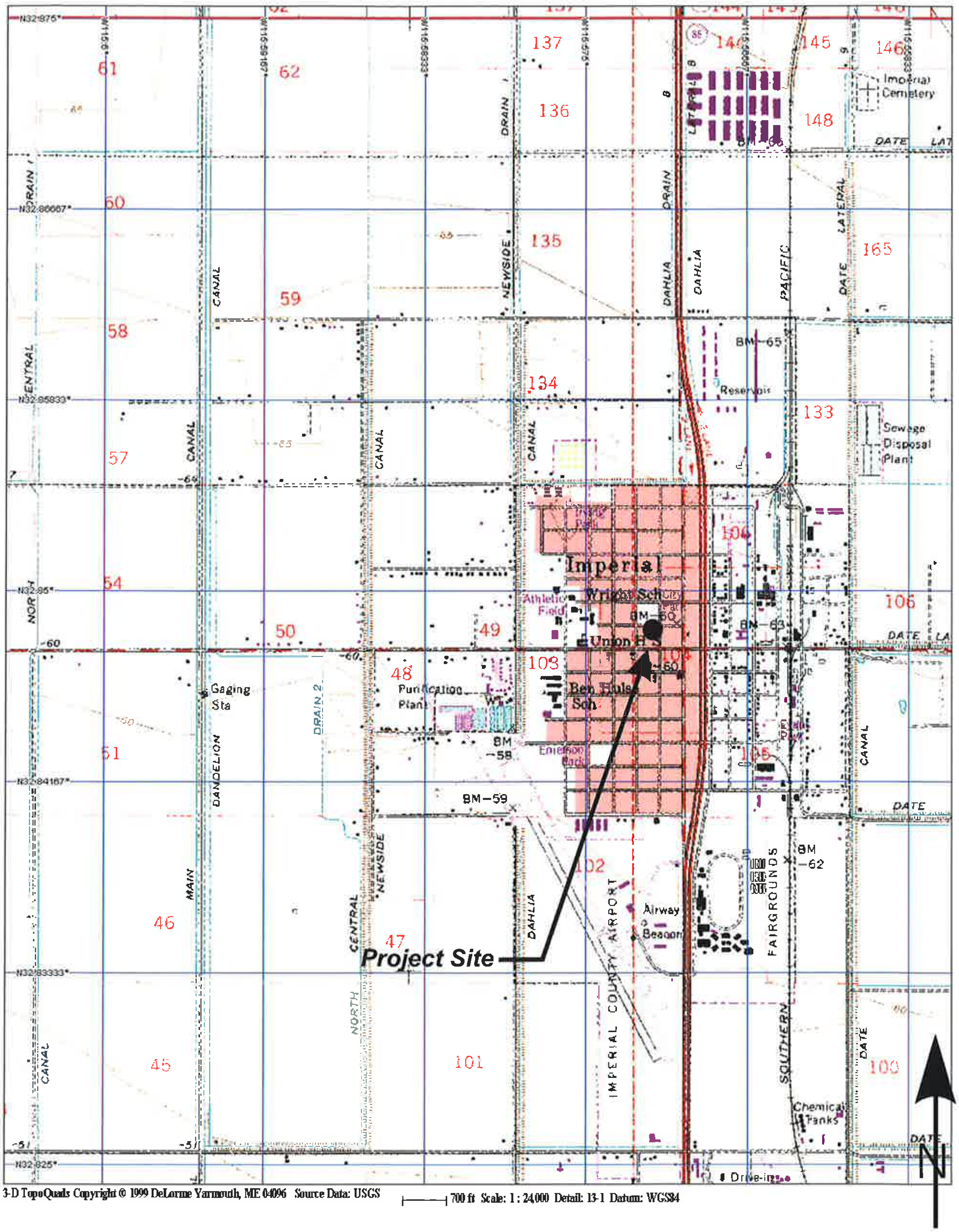
Soil name and map symbol	Depth	USDA texture	Classification		Frag-ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas-ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
121----------------- Meloland	0-12	Fine sand--------	SM, SP-SM	A-2, A-3	0	95-100	90-100	75-100	5-30	---	NP
	12-26	Stratified loamy fine sand to silt loam.	ML	A-4	0	100	100	90-100	50-65	25-35	NP-10
	26-71	Clay, silty clay, silty clay loam.	CL, CH	A-7	0	100	100	95-100	85-95	40-65	20-40
122----------------- Meloland	0-12	Very fine sandy loam.	ML	A-4	0	95-100	95-100	95-100	55-85	25-35	NP-10
	12-26	Stratified loamy fine sand to silt loam.	ML	A-4	0	100	100	90-100	50-70	25-35	NP-10
	26-71	Clay, silty clay, silty clay loam.	CH, CL	A-7	0	100	100	95-100	85-95	40-65	20-40
123*: Meloland-----------	0-12	Loam-------------	ML	A-4	0	95-100	95-100	95-100	55-85	25-35	NP-10
	12-26	Stratified loamy fine sand to silt loam.	ML	A-4	0	100	100	90-100	50-70	25-35	NP-10
	26-38	Clay, silty clay, silty clay loam.	CH, CL	A-7	0	100	100	95-100	85-95	40-65	20-40
	38-60	Stratified silt loam to loamy fine sand.	SM, ML	A-4	0	100	100	75-100	35-55	25-35	NP-10
Holtville----------	0-12	Loam-------------	ML	A-4	0	100	100	85-100	55-95	25-35	NP-10
	12-24	Clay, silty clay	CH, CL	A-7	0	100	100	95-100	85-95	40-65	20-35
	24-36	Silt loam, very fine sandy loam.	ML	A-4	0	100	100	95-100	55-85	25-35	NP-10
	36-60	Loamy very fine sand, loamy fine sand.	SM, ML	A-2, A-4	0	100	100	75-100	20-55	---	NP
124, 125----------- Niland	0-23	Gravelly sand----	SM, SP-SM	A-2, A-3	0	90-100	70-95	50-65	5-25	---	NP
	23-60	Silty clay, clay, clay loam.	CL, CH	A-7	0	100	100	85-100	80-95	40-65	20-40
126----------------- Niland	0-23	Fine sand--------	SM, SP-SM	A-2, A-3	0	90-100	90-100	50-65	5-25	---	NP
	23-60	Silty clay-------	CL, CH	A-7	0	100	100	85-100	80-95	40-65	20-40
127----------------- Niland	0-23	Loamy fine sand	SM	A-2	0	90-100	90-100	50-65	15-30	---	NP
	23-60	Silty clay-------	CL, CH	A-7	0	100	100	85-100	80-95	40-65	20-40
128*: Niland-------------	0-23	Gravelly sand----	SM, SP-SM	A-2, A-3	0	90-100	70-95	50-65	5-25	---	NP
	23-60	Silty clay, clay, clay loam.	CL, CH	A-7	0	100	100	85-100	80-100	40-65	20-40
Imperial-----------	0-12	Silty clay-------	CH	A-7	0	100	100	100	85-95	50-70	25-45
	12-60	Silty clay loam, silty clay, clay.	CH	A-7	0	100	100	100	85-95	50-70	25-45
129*: Pits											
130, 131----------- Rositas	0-27	Sand-------------	SP-SM	A-3, A-1, A-2	0	100	80-100	40-70	5-15	---	NP
	27-60	Sand, fine sand, loamy sand.	SM, SP-SM	A-3, A-2, A-1	0	100	80-100	40-85	5-30	---	NP

See footnote at end of table.

TABLE 11.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments > 3 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				Pct					Pct	
132, 133, 134, 135-- Rositas	0-9	Fine sand	SM	A-3, A-2	0	100	80-100	50-80	10-25	---	NP
	9-60	Sand, fine sand, loamy sand.	SM, SP-SM	A-3, A-2, A-1	0	100	80-100	40-85	5-30	---	NP
136-- Rositas	0-4	Loamy fine sand	SM	A-1, A-2	0	100	80-100	40-85	10-35	---	NP
	4-60	Sand, fine sand, loamy sand.	SM, SP-SM	A-3, A-2, A-1	0	100	80-100	40-85	5-30	---	NP
137-- Rositas	0-12	Silt loam	ML	A-4	0	100	100	90-100	70-90	20-30	NP-5
	12-60	Sand, fine sand, loamy sand.	SM, SP-SM	A-3, A-2, A-1	0	100	80-100	40-85	5-30	---	NP
138*:											
Rositas	0-4	Loamy fine sand	SM	A-1, A-2	0	100	80-100	40-85	10-35	---	NP
	4-60	Sand, fine sand, loamy sand.	SM, SP-SM	A-3, A-2, A-1	0	100	80-100	40-85	5-30	---	NP
Superstition	0-6	Loamy fine sand	SM	A-2	0	100	95-100	70-85	15-25	---	NP
	6-60	Loamy fine sand, fine sand, sand.	SM	A-2	0	100	95-100	70-85	15-25	---	NP
139-- Superstition	0-6	Loamy fine sand	SM	A-2	0	100	95-100	70-85	15-25	---	NP
	6-60	Loamy fine sand, fine sand, sand.	SM	A-2	0	100	95-100	70-85	15-25	---	NP
140*:											
Torriorthents											
Rock outcrop											
141*:											
Torriorthents											
Orthids											
142-- Vint	0-10	Loamy very fine sand.	SM, ML	A-4	0	100	100	85-95	40-65	15-25	NP-5
	10-60	Loamy fine sand	SM	A-2	0	95-100	95-100	70-80	20-30	---	NP
143-- Vint	0-12	Fine sandy loam	ML, CL-ML, SM, SM-SC	A-4	0	100	100	75-85	45-55	15-25	NP-5
	12-60	Loamy sand, loamy fine sand.	SM	A-2	0	95-100	95-100	70-80	20-30	---	NP
144*:											
Vint	0-10	Very fine sandy loam.	SM, ML	A-4	0	100	100	85-95	40-65	15-25	NP-5
	10-40	Loamy fine sand	SM	A-2	0	95-100	95-100	70-80	20-30	---	NP
	40-60	Silty clay	CL, CH	A-7	0	100	100	95-100	85-95	40-65	20-35
Indio	0-12	Very fine sandy loam.	ML	A-4	0	95-100	95-100	85-100	75-90	20-30	NP-5
	12-40	Stratified loamy very fine sand to silt loam.	ML	A-4	0	95-100	95-100	85-100	75-90	20-30	NP-5
	40-72	Silty clay	CL, CH	A-7	0	100	100	95-100	85-95	40-65	20-35

* See description of the map unit for composition and behavior characteristics of the map unit.

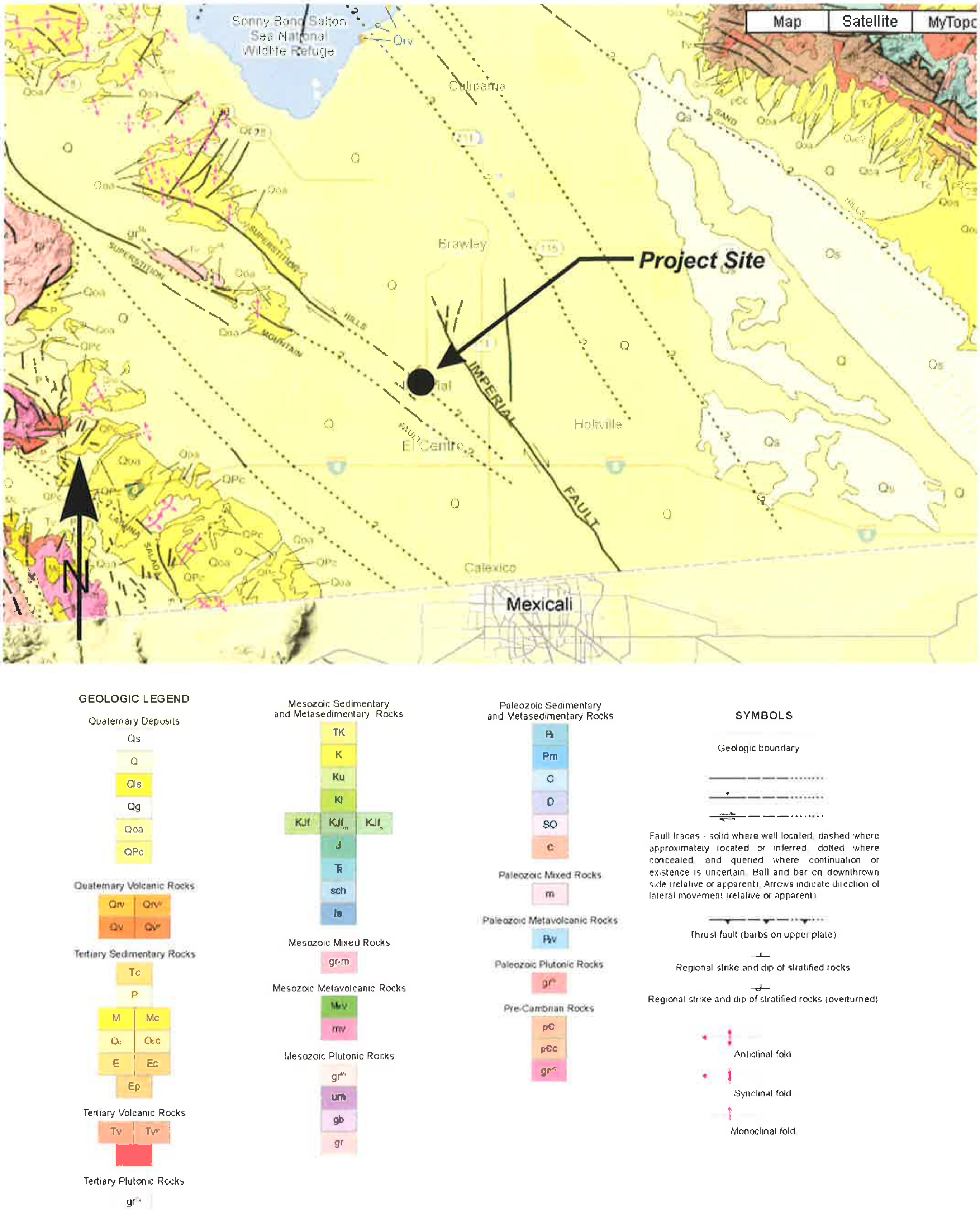


LANDMARK
Geo-Engineers and Geologists

Project No.: LE14210

Topographic Map

Plate A-4



LANDMARK Geo-Engineers and Geologists **Project No.: LE14210**	**Regional Geologic Map**	**Plate A-5**

APPENDIX B

CLIENT: City of Imperial
PROJECT: Imperial Public Library Addition
LOCATION: See Site and Exploration Plan

METHOD OF DRILLING: CME 55 W/ Autohammer
DATE OBSERVED 10/30/02
LOGGED BY: KN

LOG OF BORING B-1

SHEET 1 OF 1

DEPTH (FEET)	CLASSIFICATION	SAMPLE TYPE	BLOWS/ FOOT	POCKET PEN. (TSF)	DESCRIPTION OF MATERIAL SURFACE ELEV. +/-	MOISTURE CONTENT (%)	DRY UNIT WT. (PCF)	UNCONFINED COMPRESSION (TSF)	LIQUID LIMIT	PLASTICITY INDEX	PASSING # 200
		●									
			11	2.0	SILTY CLAY (CL): Dark brown, very stiff, moist.	24	99.8		49	36	
5											
			16	2.25	SILTY CLAY (CL): Dark brown, very stiff, moist.						
10											
			11	3.0	moist/saturated						
15											
			7	4.0	hard						
20											
25											
30											
35											
40											

End of Boring @ 19.0 feet; Groundwater Encountered @ 12.0 feet

**Blow counts not corrected for overburden pressure, sampler size, or increase drive energy for automatic hammers

Project No: S02280

SOUTHLAND GEOTECHNICAL

Plate B-1

CLIENT: City of Imperial
PROJECT: Imperial Public Library Addition
LOCATION: See Site and Exploration Plan

METHOD OF DRILLING: CME 55 W/ Autohammer
DATE OBSERVED 10/30/02
LOGGED BY: KN

LOG OF BORING B-2

SHEET 1 OF 1

DEPTH (FEET)	CLASSIFICATION	SAMPLE TYPE	BLOWS/ FOOT	POCKET PEN. (TSF)	DESCRIPTION OF MATERIAL SURFACE ELEV. +/-	MOISTURE CONTENT (%)	DRY UNIT WT. (PCF)	UNCONFINED COMPRESSION (TSF)	LIQUID LIMIT	PLASTICITY INDEX	PASSING # 200
					SILTY CLAY (CL): Brown, damp/moist.				44	30	
5			6	0.5	CLAYEY SILT (ML): Brown, soft, wet.						
10			12		SANDY SILT (ML): Dark brown, soft, moist/saturated, fine grained.						85
15			13	0.5	SANDY SILTY CLAY (CL): Dark brown, soft, moist/ saturated.						
20			8	3.5	very stiff						
25			9								
30			12		CLAYEY SILT (ML): Dark brown, medium dense, moist/ saturated, fine grained.						98
35			8	1.5 0.75	SILTY CLAY (CL): Brown, soft/stiff, moist/saturated.						
40			13	1.5	thin interbeds of silt						
					End of Boring @ 41.5 feet; Groundwater Encountered @ 12.0 feet **Blow counts not corrected for overburden pressure, sampler size, or increase drive energy for automatic hammers						

Project No:
S02280

SOUTHLAND GEOTECHNICAL

Plate B-2

Liquefaction Evaluation and Settlement Calculation

Project Name: Imperial Library Expansion Update
Project No.: LE14210
Location: B-2

Maximum Credible Earthquake	7	
Design Ground Motion	0.69	g
Total Unit Weight,	115	pcf
Water Unit Weight,	62.4	pcf
Depth to Groundwater	8	ft
Hammer Effenciency	85	
Required Factor of Safety	1.3	

Boring Data						Sampling Corrections							Corrected	Fines	SPT Clean	Cyclical	Cyclical	Factor	Volumetric	Induced
Depth		Blow Counts		Liquefiable	Overburden	Sampler	SPT	Energy	Borehole	Rod	Liner	Overburden	SPT	Content	Sands	Resistance	Stress	of	Strain (%)	Subsidence
(ft)	(m)	SPT	Mod. Cal.	Soil (0 / 1)	Pressure	Diameter	N_m	C_E	C_B	C_R	C_L	C_N	$(N_1)_{60}$	%	$(N_1)_{60CS}$	$CRR_{M7.5}$	CSR	Safety		(inch)
6	1.83	6		0	690	1	6	1.42	1.0	0.75	1	1.70	11	95	18	0.194	0.443	Non-Liq.	0.00	0.00
11	3.35	12		1	1078	1	12	1.42	1.0	0.80	1	1.40	19	85	28	0.340	0.514	0.79	1.06	0.64
16	4.88	13		0	1341	1	13	1.42	1.0	0.85	1	1.26	20	95	29	0.360	0.595	0.72	0.00	0.00
21	6.40	8		0	1604	1	8	1.42	1.0	0.95	1	1.15	12	95	20	0.214	0.644	0.40	0.00	0.00
26	7.92	9		0	1867	1	9	1.42	1.0	0.95	1	1.06	13	95	20	0.222	0.674	0.39	0.00	0.00
31	9.45	12		1	2130	1	12	1.42	1.0	0.95	1	1.00	16	98	24	0.272	0.687	0.47	1.28	0.77
36	10.97	8		0	2393	1	8	1.42	1.0	1.00	1	0.94	11	98	18	0.192	0.686	0.33	0.00	0.00
41	12.50	13		0	2656	1	13	1.42	1.0	1.00	1	0.89	16	98	25	0.278	0.670	0.50	0.00	0.00
	0.00			1	0	0.67	0	1.42	1.0	#N/A	1	#DIV/0!	#N/A	2.9	#N/A	#N/A	#DIV/0!	#N/A	#N/A	
	0.00			1	0	0.67	0	1.42	1.0	#N/A	1	#DIV/0!	#N/A	2.3	#N/A	#N/A	#DIV/0!	#N/A	#N/A	
	0.00			1	0	0.67	0	1.42	1.0	#N/A	1	#DIV/0!	#N/A	7.8	#N/A	#N/A	#DIV/0!	#N/A	#N/A	
	0.00			1	0	0.67	0	1.42	1.0	#N/A	1	#DIV/0!	#N/A	74	#N/A	#N/A	#DIV/0!	#N/A	#N/A	
	0.00			0	0	0.67	0	1.42	1.0	#N/A	1	#DIV/0!	#N/A	95	#N/A	#N/A	#DIV/0!	#N/A	0.00	
	0.00			0	0	0.67	0	1.42	1.0	#N/A	1	#DIV/0!	#N/A	95	#N/A	#N/A	#DIV/0!	#N/A	0.00	

Based on *Proceeding of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils*, Technical Report NCEER-97-0022, December 31, 1997.

Total Settlement **1.40**

Corrections to SPT (Modified from Skempton, 1986) as listed by Robertson and Wride.

Factor	Equipment Variable	Term	Correction
Overburden Pressure		C_N	$(P_a/\sigma_{VO})^{0.5}$ C_N<=2
Energy Ratio	Donut Hammer Safety Hammer Automatic-trip Donut type Hammer	C_E	0.5 to 1.0 0.7 to 1.2 0.8 to 1.3
Borehole Diameter	2.6 inch to 6 inch 6 inch 8 inch	C_B	1 1.05 1.15
Rod Length	10 feet to 13 feet 13 feet to 19.8 ft. 19.8 ft. to 33 ft. 33 ft. to 98 ft. > 98 ft.	C_R	0.75 0.85 0.95 1 <1.0
Sampling Method	Standard Sampler Sampler without liners	C_L	1 1.1 to 1.3

APPENDIX C

Geotechnical Report

Imperial Public Library Expansion

Imperial, California

Prepared for:

City of Imperial
420 S. Imperial Avenue
Imperial, CA 92251

Prepared by:

Southland Geotechnical, Inc.
780 N. 4th Street
El Centro, CA 92243
(760) 370-3000

November 2002

November 20, 2002

City of Imperial
420 S. Imperial Avenue
Imperial, CA 92251

Attn: Mr. Fred Fontaine

Geotechnical Investigation
Imperial Public Library Expansion
200 West 9th Street
Imperial, California
SGI Report No. S02280

Dear Mr. Fontaine:

This geotechnical report is provided for design and construction of the proposed expansion to the Imperial Public Library in Imperial, California. Our geotechnical investigation was conducted in response to your request for our services. The enclosed report describes our soil engineering investigation and presents our professional opinions regarding geotechnical conditions at the site to be considered in the design and construction of the project.

This executive summary presents ***selected*** elements of our findings and recommendations only. It ***does not*** present crucial details needed for the proper application of our findings and recommendations. Our findings, recommendations, and application options are related ***only through reading the full report***, and are best evaluated with the active participation of the engineer of record who developed them.

The findings of this study indicate the site is underlain by clays of high expansion that will require foundations and slabs-on-grade designed to resist expansive soil conditions (UBC Section 1815 and 1816). The UBC design method requires grade-beam stiffening of floor slabs at a maximum spacing of 17 feet on center, grade-beam stiffened post-tensioned slabs or flat-plate structural slabs. Design and construction of site improvements (concrete flatwork, curbs, patios, etc.) should include provisions to mitigate clay soil movement.

The soil is highly corrosive to metals and contains sufficient sulfates and chlorides to require special concrete mixes (4,500 psi with a 0.45 maximum water cement ratio) and protection of embedded steel components when concrete is placed in contact with native soil.

Evaluation of liquefaction potential at the site indicates that a 5-foot thick layer of Sandy Silt at a depth of 8 feet may liquefy under seismically induced groundshaking potentially resulting in an estimated ¾-inch of deep seated settlement. Structural designs should anticipate some differential settlement. Typically, structural flat plate mats, grade-beam reinforced foundations, and stiffened post-tensioned foundations supporting loads typical to lightly loaded structures will limit settlements to acceptable levels.

We did not encounter soil conditions that would preclude development of the site for its intended use provided the recommendations contained in this report are implemented in the design and construction of this project.

We appreciate the opportunity to provide our findings and professional opinions regarding geotechnical conditions at the site. If you have any questions or comments regarding our findings, please call our office at (760) 370-3000.

Respectfully Submitted,
Southland Geotechnical, Inc.

Steven K. Williams, CEG
Project Engineering Geologist

Jeffrey O. Lyon, PE
Principal Engineer

Distribution:
Client (4)

TABLE OF CONTENTS

Section 1
INTRODUCTION

1.1 Project Description

This report presents the findings of our geotechnical investigation for the proposed expansion to the Imperial Public Library located in Imperial, California (See Vicinity Map, Plate A-1). The proposed development will consist of a 5,290 square foot (s.f.) addition to the west side of the existing library. A site plan for the proposed development was provided by the City of Imperial prior to site exploration.

The structure is planned to consist of wood frame construction. Expected footing loads at exterior bearing walls are estimated at 1 to 5 kips per lineal foot. Expected column loads range from 10 to 25 kips. If structural loads exceed those stated above, we should be notified so we may evaluate their impact on foundation settlement and bearing capacity. Site development will include building pad preparation, underground utility installation, and concrete sidewalk placement.

1.2 Purpose and Scope of Work

The purpose of this geotechnical study was to investigate the upper 40 feet of subsurface soil at selected locations within the site for physical/engineering properties. From the subsequent field and laboratory data, professional opinions were developed and are provided in this report regarding geotechnical conditions at this site and the effect on design and construction. The scope of our services consisted of the following:

- Field exploration and in-situ testing of the site soils at selected locations and depths.
- Laboratory testing for physical properties of selected samples.
- A review of the available literature and publications pertaining to local geology, faulting, and seismicity.
- Engineering analysis and evaluation of the data collected.
- Preparation of this report presenting our findings, professional opinions, and recommendations for the geotechnical aspects of project design and construction.

This report addresses the following geotechnical issues:

- Subsurface soil and groundwater conditions
- Site geology, regional faulting and seismicity, near source factors, and site seismic accelerations
- Liquefaction potential and its mitigation
- Expansive soil and methods of mitigation
- Aggressive soil conditions to metals and concrete

Professional opinions with regard to the above issues are presented for the following:

- Site grading and earthwork
- Building pad and foundation subgrade preparation
- Allowable soil bearing pressures and expected settlements
- Concrete slabs-on-grade
- Excavation conditions and buried utility installations
- Mitigation of the potential effects of salt concentrations in native soil to concrete mixes and steel reinforcement
- Seismic design parameters

Our scope of work for this report did not include an evaluation of the site for the presence of environmentally hazardous materials or conditions.

1.3 Authorization

Mr. Fred Fontaine, Administrator of the Imperial Public Library, provided authorization by written agreement to proceed with our work on October 9, 2002. We conducted our work according to our written proposal dated September 6, 2002.

Section 2
METHODS OF INVESTIGATION

2.1 Field Exploration

Subsurface exploration was performed on October 30, 2002 using 2R Drilling of Ontario, California to advance two (2) borings to depths of 20 to 40 feet below existing ground surface. The borings were made with a truck-mounted, CME 55 drill rig using 8-inch diameter, hollow-stem, continuous-flight augers. The approximate boring locations were established in the field and plotted on the site map by sighting to discernable site features. The boring locations are shown on the Site and Exploration Plan (Plate A-2).

A staff geologist observed the drilling operations and maintained a log of the soil encountered and sampling depths, visually classified the soil encountered during drilling in accordance with the Unified Soil Classification System, and obtained drive tube and bulk samples of the subsurface materials at selected intervals. The drill rig was equipped with a CME automatic hammer for conducting Standard Penetration Tests (SPT) in accordance with ASTM D1586. Relatively undisturbed soil samples were retrieved using a 2-inch outside diameter (OD) split-spoon sampler or a 3-inch OD Modified California Split-Barrel (ring) sampler. The samples were obtained by driving the sampler ahead of the auger tip at selected depths. The number of blows (N values) of a 140-lb. hammer falling 30 inches to drive the sampler 18 inches into undisturbed soil were recorded in 6-inch increments. Blow counts reported on the boring logs represent the field blow counts. No corrections have been applied for overburden pressure, automatic hammer drive energy, drill rod lengths, liners, and sampler diameter. Pocket penetrometer readings were also obtained to evaluate the stiffness of cohesive soils retrieved from sampler barrels.

After logging and sampling the soil encountered, the exploratory borings were backfilled with the excavated material. The backfill was loosely placed and was not compacted to the requirements specified for engineered fill.

The stratification lines shown on the subsurface logs represent the approximate boundaries between the various strata. However, the transition from one stratum to another may be gradual over some range of depth. The subsurface logs are presented on Plates B-1 and B-2 in Appendix B. A key to the log symbols is presented on Plate B-3.

2.2 Laboratory Testing

Laboratory tests were conducted on selected bulk and relatively undisturbed soil samples to aid in classification and evaluation of selected engineering properties. The tests were conducted in general conformance to the procedures of the American Society for Testing and Materials (ASTM) or other standardized methods as referenced below. Our laboratory testing program consisted of the following tests:

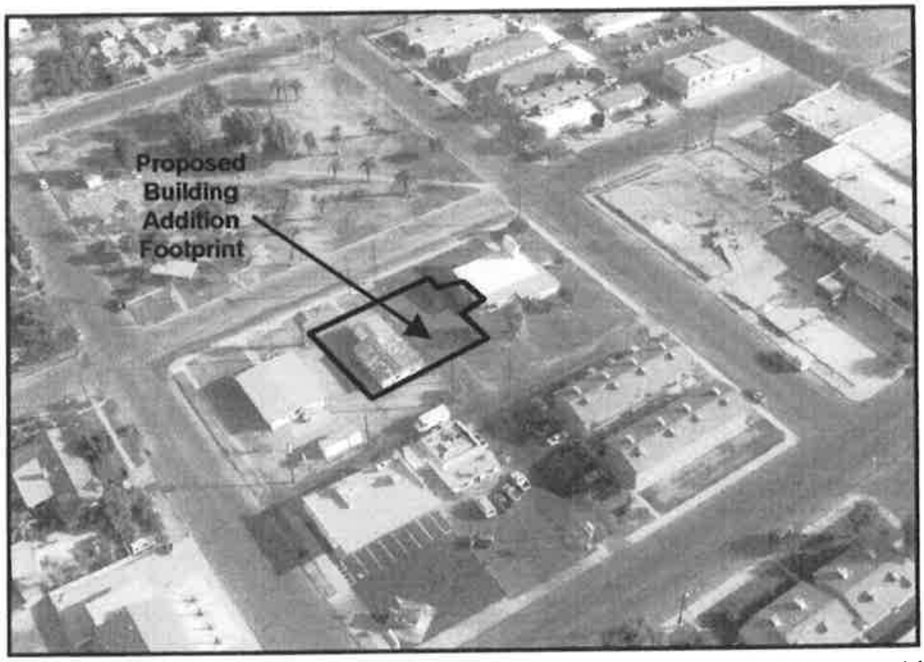
- Plasticity Index (ASTM D4318) – used for soil classification, soil strength estimates (friction), and expansive soil design criteria
- Particle Size Analyses (ASTM D422) – used for liquefaction evaluation
- Unit Dry Densities (ASTM D2937) and Moisture Contents (ASTM D2216) – used for insitu soil parameters
- Expansion Index (Swell) Test (UBC 18-2 and ASTM D4829) – used for evaluating relative expansion classification.
- Chemical Analyses (soluble sulfates & chlorides, pH, and resistivity) (Caltrans Methods) – used for concrete mix evaluations and corrosion protection requirements.

The laboratory test results are presented on the subsurface logs and on Plates C-1 through C-4 in Appendix C.

Section 3
DISCUSSION

3.1 Site Conditions

The project site is located at the southwest corner of 9th Street and "H" Street in Imperial, California. The existing library is located on the east side of the site. A grass lawn surrounds the library. The proposed library addition will be located on the west side of the existing library. This area is partially covered with grass. The proposed building footprint will cross an unpaved alley. A power line runs along the west side of the alley which will need to be re-routed prior to construction of the library. West of the alley are two small single story buildings which will be razed prior to construction.



Adjacent properties are flat-lying and approximately the same elevation with this site. The site is bounded on the north by 9th Street and the east by "H" Street. An apartment complex is located south of the existing library and small businesses are located to the southwest.

The project site lies at an elevation of approximately 60 feet below mean sea level (MSL) (El. 940 local datum) in the Imperial Valley region of the California low desert. The surrounding properties lie on terrain which is flat (planar), part of a large agricultural valley, which was previously an ancient lake bed covered with fresh water to an elevation of ±43 feet above MSL. Annual rainfall in this arid region is less than 4 inches per year with four months of average summertime temperatures above 100 °F. Winter temperatures are mild, seldom reaching freezing.

3.2 Geologic Setting

The project site is located in the Imperial Valley portion of the Salton Trough physiographic province. The Salton Trough is a geologic structural depression resulting from large scale regional faulting. The trough is bounded on the northeast by the San Andreas Fault and Chocolate Mountains and the southwest by the Peninsular Range and faults of the San Jacinto Fault Zone. The Salton Trough represents the northward extension of the Gulf of California, containing both marine and non-marine sediments since the Miocene Epoch. Tectonic activity that formed the trough continues at a high rate as evidenced by deformed young sedimentary deposits and high levels of seismicity. Figure 1 shows the location of the site in relation to regional faults and physiographic features.

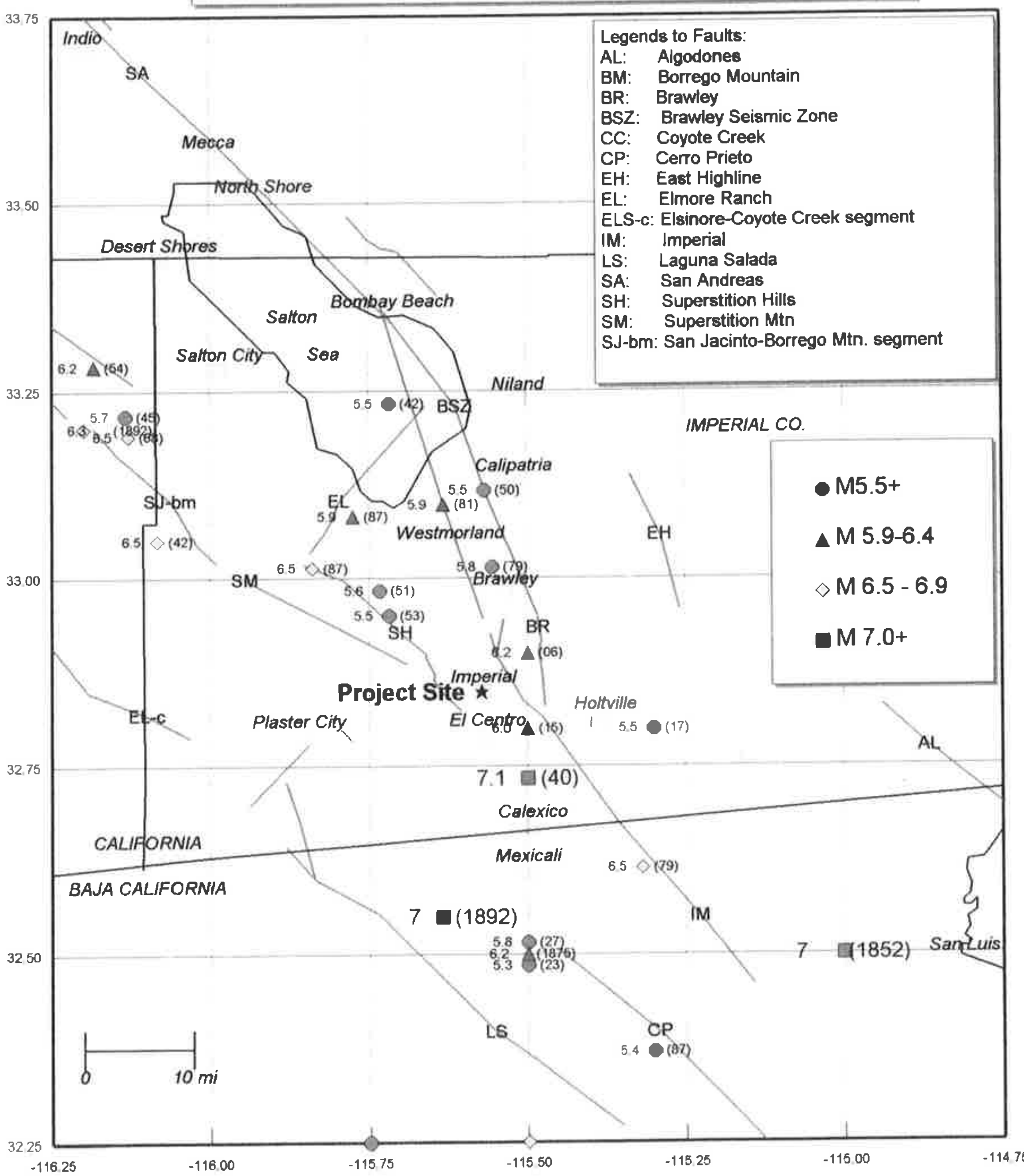
The Imperial Valley is directly underlain by lacustrine deposits, which consist of interbedded lenticular and tabular silt, sand, and clay. The Late Pleistocene to Holocene lake deposits are probably less than 100 feet thick and derived from periodic flooding of the Colorado River which intermittently formed Lake Cahuilla. Older deposits consist of Miocene to Pleistocene non-marine and marine sediments deposited during intrusions of the Gulf of California. Basement rock consisting of Mesozoic granite and Paleozoic metamorphic rocks are estimated to exist at depths between 15,000 - 20,000 feet.

3.3 Seismicity and Faulting

Faulting and Seismic Sources: We have performed a computer-aided search of known faults or seismic zones that lie within a 62 mile (100 kilometers) radius of the project site as shown on Figure 1 and Table 1. The search identifies known faults within this distance and computes the anticipated maximum probable and maximum credible ground accelerations at the site based on the maximum probable and credible earthquakes expected on each of the faults and the distance from the fault to the site. The Maximum Magnitude Earthquake (Mmax) listed was taken from published geologic information available for each fault (CDMG OFR 96-08 and Jennings, 1994).

Seismic Risk: The project site is located in the seismically active Imperial Valley of southern California, and is considered likely to be subjected to moderate to strong ground motion from earthquakes in the region. The proposed site structures should be designed in accordance with the Uniform Building Code for near source factors derived from a "Design Basis Earthquake" (DBE).

MAP OF REGIONAL FAULTS AND SEISMICITY



Faults and Seismic Zones from Jennings (1994), Earthquakes modified from Ellsworth (1990) catalog.

Figure 1. Map of Regional Faults and Seismicity

Table 2
FAULT PARAMETERS & DETERMINISTIC
ESTIMATES OF PEAK GROUND ACCELERATION (PGA)

Fault Name or Seismic Zone	Distance (mi) & Direction from Site	Fault Type		Fault Length (km)	Maximum Magnitude Mmax (Mw)	Avg Slip Rate (mm/yr)	Avg Return Period (yrs)	Date of Last Rupture (year)	Largest Historic Event >5.5M	(year)	Est. Site PGA (g)
Reference Notes: (1)		(2)	(3)	(2)	(4)	(3)	(3)	(3)	(5)		(6)
Imperial Valley Faults											
Imperial	2.9 NE	A	B	62	**7.0**	20	79	1979	7.0	1940	**0.47**
Brawley	5.6 E	B	B	14	**7.0**	20	---	1979	5.8	1979	**0.35**
Brawley Seismic Zone	6.7 N	B	B	42	**6.4**	25	24		5.9	1981	**0.23**
East Highline Canal	20 ENE	C	C	22	**6.3**	1	774				**0.10**
Cerro Prieto	25 SSE	A	B	116	**7.2**	34	50	1980	7.1	1934	**0.14**
San Jacinto Fault System											
- Superstition Hills	2.5 SW	B	A	22	**6.6**	4	250	1987	6.5	1987	**0.39**
- Superstition Mtn.	7.2 WNW	B	A	23	**6.6**	5	500	1440 +/-			**0.24**
- Elmore Ranch	20 NW	B	A	29	**6.6**	1	225	1987	5.9	1987	**0.12**
- Borrego Mtn	27 WNW	B	A	29	**6.6**	4	175		6.5	1942	**0.09**
- Anza Segment	43 NW	A	A	90	**7.2**	12	250	1918	6.8	1918	**0.09**
- Coyote Creek	46 WNW	B	A	40	**6.8**	4	175	1968	6.5	1968	**0.07**
- Hot Spgs-Buck Ridge	58 NW	B	A	70	**6.5**	2	354		6.3	1937	**0.05**
- Whole Zone	7.2 WNW	A	A	245	**7.5**	---	---				**0.39**
Elsinore Fault System											
- Laguna Salada	20 WSW	B	B	67	**7.0**	3.5	336		7.0	1891	**0.14**
- Coyote Segment	27 W	B	A	38	**6.8**	4	625				**0.10**
- Julian Segment	50 W	A	A	75	**7.1**	5	340				**0.07**
- Earthquake Valley	52 WNW	B	A	20	**6.5**	2	351				**0.05**
- Whole Zone	27 W	A	A	250	**7.5**	---	---				**0.15**
San Andreas Fault System											
- Coachella Valley	36 NNW	A	A	95	**7.4**	25	220	1690+/-	6.5	1948	**0.11**
- Whole S. Calif. Zone	36 NNW	A	A	458	**7.9**	---	---	1857	7.8	1857	**0.15**
Algodones	37 E	C	C	74	**7.0**	0.1	20,000				**0.09**

Notes:

1. Jennings (1994) and CDMG (1996)
2. CDMG (1996), where Type A faults -- slip rate >5 mm/yr and well constrained paleoseismic data
   Type B faults -- all other faults.
3. WGCEP (1995)
4. CDMG (1996) based on Wells & Coppersmith (1994)
5. Ellsworth Catalog in USGS PP 1515 (1990) and USBR (1976), Mw = moment magnitude,
6. The deterministic estimates of the Site PGA are based on the attenuation relationship of:
   Boore, Joyner, Fumal (1997)

The DBE is defined as the motion having a 10 percent probability of being exceeded in 50 years. The DBE generally corresponds to the Mmax magnitude discussed here.

Seismic Hazards.

▸ **Groundshaking.** The primary seismic hazard at the project site is the potential for strong groundshaking during earthquakes along the Imperial, Brawley, and Superstition Hills Faults. A further discussion of groundshaking follows in Section 3.4.

▸ **Surface Rupture.** The project site does not lie within a State of California, Alquist-Priolo Earthquake Fault Zone. Surface fault rupture is considered to be unlikely at the project site because of the well-delineated fault lines through the Imperial Valley as shown on USGS and CDMG maps. However, because of the high tectonic activity and deep alluvium of the region, we cannot preclude the potential for surface rupture on undiscovered or new faults that may underlie the site.

▸ **Liquefaction.** Liquefaction is a potential design consideration because of underlying saturated sandy substrata. The potential for liquefaction at the site is discussed in more detail in Section 3.7.

Other Secondary Hazards.

▸ **Landsliding.** The hazard of landsliding is unlikely due to the regional planar topography. No ancient landslides are shown on geologic maps of the region and no indications of landslides were observed during our site investigation.

▸ **Volcanic hazards.** The site is not located in proximity to any known volcanically active area and the risk of volcanic hazards is considered very low.

▸ **Tsunamis, sieches, and flooding.** The site does not lie near any large bodies of water, so the threat of tsunami, sieches, or other seismically-induced flooding is unlikely.

▸ **Expansive soil.** In general, much of the near surface soil in the Imperial Valley consist of silty clays and clays which are moderate to highly expansive. The expansive soil conditions are discussed in more detail in Section 3.5.

3.4 Site Acceleration and UBC Seismic Coefficients

Site Acceleration: Horizontal peak ground acceleration (PGA) from maximum probable earthquakes on regional faults has been estimated and are included in Table 1. Ground motions are dependent primarily on the earthquake magnitude and distance to the seismogenic (rupture) zone. Accelerations also are dependent upon attenuation by rock and soil deposits, direction of rupture and type of fault; therefore, ground motions may vary considerably in the same general area.

We have used the computer program FRISKSP (Blake, 2000) to provide a probabilistic estimate of the site PGA using the attenuation relationship of Boore, Joyner, and Fumal (1997) Soil (310). The PGA estimate for the project site having a 10% probability of occurrence in 50 years (return period of 475 years) is **0.74g**.

UBC Seismic Coefficients: The UBC seismic coefficients are roughly based on an earthquake ground motion that has a 10% probability of occurrence in 50 years (475 year return period). The following table lists seismic and site coefficients (near source factors) determined by Chapter 16 of the 1997 Uniform Building Code (UBC). ***This site lies within4.1 km of a Type B fault and 4.6 km of a Type A fault overlying S_D (stiff) soil.***

UBC Seismic Coefficients for Chapter 16 Seismic Provisions

UBC Code Edition	Soil Profile Type	Seismic Source Type	Distance to Critical Source	Near Source Factors		Seismic Coefficients	
				Na	Nv	Ca	Cv
1997	S_D (stiff soil)	A	< 4.6 km	1.24	1.65	0.55	1.06
1997	S_D (stiff soil)	B	< 4.1 km	1.09	1.32	0.48	0.84
Ref. Table	16-J	16-U	---	16-S	16-T	16-Q	16-R

3.5 Subsurface Soil

Subsurface soils encountered during the field exploration conducted on October 30, 2002 consist of dominantly stiff to very stiff clays with some interbedded silt layers. A sandy silt layer was encountered at a depth of 8 to 13 feet in the western portion of the site. The subsurface logs (Plates B-1 and B-2) depict the stratigraphic relationships of the various soil types.

The native surface clays exhibit high swell potential (Expansion Index (EI) = 109) when tested according to Uniform Building Code Standard 18-2 methods. The clay is expansive when wetted and can shrink with moisture loss (drying). Development of building foundations, concrete flatwork, and asphaltic concrete pavements should include provisions for mitigating potential swelling forces and reduction in soil strength, which can occur from saturation of the soil. Causes for soil saturation include landscape irrigation, broken utility lines, or capillary rise in moisture upon sealing the ground surface to evaporation. Moisture losses can occur with lack of landscape watering, close proximity of structures to downslopes and root system moisture extraction from deep rooted shrubs and trees placed near the foundations. Typical measures used locally to remediate expansive soil include:

- replacement of silt/clay with non-expansive sands or silts,
- treatment of silt/clay with lime to mitigate the shrink/swell forces of the clay soils when sulfate content of the soils is generally less than 7,500 ppm,
- capping silt/clay soil with a non-expansive sand layer of sufficient thickness to reduce the effects of soil shrink/swell,
- design of foundations that are resistant to shrink/swell forces of silt/clay soil.

3.6 Groundwater

Groundwater was encountered in the borings at about 12 feet during the time of exploration, but may rise with time to approximately 8 to 10 feet below ground surface at this site. There is uncertainty in the accuracy of short-term water level measurements, particularly in fine-grained soil. Groundwater levels may fluctuate with precipitation, irrigation of adjacent properties, drainage, and site grading. The groundwater level noted should not be interpreted to represent an accurate or permanent condition. Our work scope did not include a groundwater surface mounding study resulting from applied landscape water.

3.7 Liquefaction

Liquefaction occurs when granular soil below the water table is subjected to vibratory motions, such as produced by earthquakes. With strong ground shaking, an increase in pore water pressure develops as the soil tends to reduce in volume. If the increase in pore water pressure is sufficient to reduce the vertical effective stress (suspending the soil particles in water), the soil strength decreases and the soil behaves as a liquid (similar to quicksand). Liquefaction can produce excessive settlement, ground rupture, lateral spreading, or failure of shallow bearing foundations.

Four conditions are generally required for liquefaction to occur:

(1) the soil must be saturated (relatively shallow groundwater);
(2) the soil must be loosely packed (low to medium relative density);
(3) the soil must be relatively cohesionless (not clayey); and
(4) groundshaking of sufficient intensity must occur to function as a trigger mechanism.

All of these conditions exist to some degree at this site.

<u>Methods of Analysis:</u> Liquefaction potential at the project site was evaluated using the 1997 NCEER Liquefaction Workshop methods that are based on the Seed, et. al. 1985 and Robertson and Campanella (1985) methods. The 1997 NCEER methods utilize direct SPT blow counts or CPT cone readings from site exploration and earthquake magnitude/PGA estimates from the seismic hazard analysis. The resistance to liquefaction is plotted on a chart of cyclic shear stress ratio (CSR) versus a corrected blow count $N_{1(60)}$ or Qc_{1N}. A ground acceleration of 0.74g was used in the analysis with an 8-foot groundwater depth.

Liquefaction induced settlements have been estimated using the 1987 Tokimatsu and Seed method. Fines content of liquefiable sands and silt increase the liquefaction resistance in that more cycles of ground motions are required to fully develop pore pressures. The SPT blow counts were adjusted to an equivalent clean sand blow count, $N_{1(60)}$ prior to calculating settlements using Robertson and Wride (1997) adjustments. A computed factor of safety less than 1.0 indicates a liquefiable condition.

The soil encountered at the points of exploration included saturated silts and silty sands that could liquefy during a UBC Design Basis Earthquake (7M – 0.74g) for a 10% risk in 50 years. Liquefaction can occur within a 5-foot thick silty sand layer at a depth of 8 to 13 feet below ground surface. The likely triggering mechanism for liquefaction appears to be strong groundshaking associated with the rupture of the Imperial Fault and Superstition Hills Fault.

Liquefaction Effects: Based on empirical relationships, total induced settlements, should liquefaction occur are estimated to be about ¾-inch. Differential settlement could be estimated to be about 1.5 inch across a building area. Based on research from Ishihara (1985) and Youd (1995) ground rupture or sand boil formation is possible because of the relatively thin overlying unliquefiable soil. The relatively high fines content (>80%) within the potentially liquefiable layer will probably reduce pore water movement significantly, thereby stalling development of a "quick" soil condition.

Mitigation: Ground improvement methods are available to mitigate liquefaction such vibro-compaction, vibro-replacement, stone columns, compaction grouting, or deep dynamic compaction. Some other means to mitigate liquefaction damage include either a deep foundation system, rigid mat foundations and grade-beam reinforced foundations that can withstand some differential movement or tilting, but may not protect fracturing of buried utilities.

Because of the potential for differential settlement upon liquefaction, the designer should consider the structures be either founded on:

1) Densify the potentially liquefiable sand/silt layers at 8 to 13 feet depth by use of vibro-compaction, vibro-replacement, compaction grouting, or deep dynamic compaction.
2) foundations that use grade-beam footings to tie floor slabs and isolated columns to continuous footings (conventional or post-tensioned).
3) structural flat-plate mats, either conventionally reinforced or tied with post-tensioned tendons.

These alternatives reduce the potential effects of liquefaction-induced settlements by making the structures more able to withstand differential settlement.

Section 4
RECOMMENDATIONS

4.1 Site Preparation

Clearing and Grubbing: All surface improvements (existing buildings and power line), debris or vegetation including grass, trees, and weeds on the site at the time of construction should be removed from the construction area. Root balls should be completely excavated. Organic strippings should be hauled from the site and not used as fill. Any trash, construction debris, concrete slabs, old pavement, landfill, and buried obstructions such as old foundations and utility lines exposed during rough grading should be traced to the limits of the foreign material by the grading contractor and removed under our supervision. Any excavations resulting from site clearing should be dish-shaped to the lowest depth of disturbance and backfilled under observation by the geotechnical engineer's representative with compacted fill as described below.

Building Pad Preparation: The exposed surface soil within the building pad/foundation areas should be removed to 30 inches below the building pad elevation or existing grade (whichever is lower) for five feet beyond all exterior wall/column lines (including adjacent concreted areas). The bottom 6 inches of the excavation should be scarified, uniformly moisture conditioned to 5 to 10% above optimum moisture content and recompacted to 85 to 90% of the maximum density determined in accordance with ASTM D1557 methods. The native soil is suitable for use as engineered fill provided it is free from concentrations of organic matter or other deleterious material. The fill soil should be uniformly moisture conditioned by discing and watering to the limits specified above, placed in maximum 8-inch lifts (loose), and compacted to the limits specified above. Clay soil should not be compacted greater than 90% relative compaction because highly compacted soil will result in increased swelling.

If foundation designs are to be utilized which do not include provisions for expansive soil, an engineered building support pad consisting of 3.0 feet of granular soil or lime treated soil, placed in maximum 8-inch lifts (loose), compacted to a minimum of 90% of ASTM D1557 maximum density at 2% below to 4% above optimum moisture, should be placed below the bottom of the slab. Imported fill soil should be non-expansive, granular soil meeting the USCS classifications of SM, SP-SM, or SW-SM with a maximum rock size of 3 inches. The geotechnical engineer should approve imported fill soil sources before hauling material to the site.

In areas other than the building pad which are to receive area concrete slabs, the ground surface should be presaturated to a minimum depth of 24 inches and then scarified to 8 inches, moisture conditioned to a minimum of 5% over optimum, and recompacted to 83-87% of ASTM D1557 maximum density just prior to concrete placement.

Trench Backfill: On-site soil free of debris, vegetation, and other deleterious matter may be suitable for use as utility trench backfill, but may be difficult to uniformly maintain at specified moistures and compact to the specified densities. Granular material is often more cost effective for backfill of utility trenches. Backfill soil within roadways should be placed in layers not more that 6 inches in thickness and mechanically compacted to a minimum of 87% of the ASTM D1557 maximum dry density except for the top 12 inches of the trench which shall be compacted to at least 90%. Native backfill should only be placed and compacted after encapsulating buried pipes with suitable bedding and pipe envelope material. Pipe envelope/bedding should either be clean sand (Sand Equivalent SE>30) or crushed rock when encountering groundwater. A geotextile filter fabric (Mirafi 140N or equivalent) should be used to encapsulate the crushed rock to reduce the potential for in-washing of fines into the gravel void space. Precautions should be taken in the compaction of the backfill to avoid damage to the pipes and structures.

Moisture Control and Drainage: The moisture condition of the building pad should be maintained during trenching and utility installation until concrete is placed or should be rewetted before initiating delayed construction. If soil drying is noted, a 2 to 3 inch depth of water may be used in the bottom of footings to restore footing subgrade moisture and reduce potential edge lift.

Adequate site drainage is essential to future performance of the project. Infiltration of excess irrigation water and stormwaters can adversely affect the performance of the subsurface soil at the site. Positive drainage should be maintained away from all structures (5% for 5 feet minimum across unpaved areas) to prevent ponding and subsequent saturation of the native clay soil. Gutters and downspouts may be considered as a means to convey water away from foundations. If landscape irrigation is allowed next to the building, drip irrigation systems or lined planter boxes should be used. The subgrade soil should be maintained in a moist, but not saturated state, and not allowed to dry out. Drainage should be maintained without ponding.

Observation and Density Testing: All site preparation and fill placement should be continuously observed and tested by a representative of a qualified geotechnical engineering firm. Full-time observation services during the excavation and scarification process is necessary to detect undesirable materials or conditions and soft areas that may be encountered in the construction area. The geotechnical firm that provides observation and testing during construction shall assume the responsibility of "*geotechnical engineer of record*" and, as such, shall perform additional tests and investigation as necessary to satisfy themselves as to the site conditions and the recommendations for site development.

4.2 Foundations and Settlements

Shallow spread footings and continuous wall footings are suitable to support the building provided they are structurally tied with grade-beams to resist differential movement associated with liquefiable and expansive soils. Footings shall be founded on a layer of properly prepared and compacted soil as described in Section 4.1. The foundations may be designed using an allowable soil bearing pressure of 1,500 psf for compacted native clay soil and 2,000 psf when foundations are supported on imported sands (extending a minimum of 1.0 feet below footings). The allowable soil pressure may be increased by 20% for each foot of embedment depth in excess of 18 inches and by one-third for short term loads induced by winds or seismic events. The maximum allowable soil pressure at increased embedment depths shall not exceed 3,000 psf (clays).

Flat Plate Structural Mats: Flat plate structural mats may be used to mitigate expansive soils at the project site. The structural mat shall have a double mat of steel (minimum No. 4's @ 12" O.C. each way – top and bottom) and a minimum thickness of 12 inches. Mat edges shall have a minimum edge footing of 12 inches width and 18 inches depth (below the building pad surface). Mats may be designed by UBC Section 1815 (Div. III) methods using an Effective Plasticity Index (PI) of 30.

Structural mats may be designed for a modulus of subgrade reaction (Ks) of 100 pci when placed on compacted clay or a subgrade modulus of 300 pci when placed on 3.0 feet of granular fill. Mats shall overlay 2 inches of sand and a 10-mil vapor barrier. The building support pad shall be moisture conditioned and recompacted as specified in Section 4.1 of this report.

Grade-beam Reinforced Foundations: Specific soil data for structures with grade-beam reinforced foundations placed on the native clays (without a minimum of 3.0 feet of underlying granular fill or lime treated soil placed over native clays) are presented below in accordance with the design method given in UBC Chapter 18 (1997) - Division III, Section 1815:

- Weighted Plasticity Index (PI) = 36
- Slope Coefficient (C_s) = 1.0
- Strength Coefficient (C_o) = 0.8
- Climatic Rating (C_w) = 15
- Effective PI = 29
- 1-C Value = 0.16
- Maximum Grade-beam Spacing = 17 feet

Post-tensioned Slabs: If post-tensioned slabs are considered for this project, the following soil criteria shall be used in the Post Tensioning Institute (PTI) designs:

Edge Moisture Variation, e_m	Center Lift: 5.5 ft. Edge Lift: 3.0 ft.
Depth to Constant Suction:	5.0 ft.
Constant Suction (pF):	3.6
Differential Swell, Y_m	Center Lift: 2.2 in. Edge Lift: 0.8 in.
Estimated Differential Settlement (swell):	0.5 in.
Bearing Capacity:	1,500 psf

Clamping devices and end anchors for post-tensioned tendons are susceptible to corrosion from aggressive soil and landscape water conditions. Therefore, a minimum concrete cover of 4.0 inches and epoxy coatings should be specified for the tendon ends with a positive bonding agent used with polymer modified cementitious material to patch the recessed anchor cup. A complete encapsulation system intended for corrosive environments is a suggested protection method for post-tensioning cables and anchoring/clamping devices.

Foundations placed on a minimum of 3.0 feet of non-expansive granular soil or lime treated soil are not required to meet the provisions of UBC Section 1815.

All exterior and interior foundations should be embedded a minimum of 18 inches below the building support pad or lowest adjacent final grade, whichever is deeper. Interior footings may be 12 inches deep. Continuous wall footings should have a minimum width of 12 inches. Spread footings should have a minimum width of 24 inches and should not be structurally isolated. Recommended concrete reinforcement and sizing for all footings should be provided by the structural engineer.

Resistance to horizontal loads will be developed by passive earth pressure on the sides of footings and frictional resistance developed along the bases of footings and concrete slabs. Passive resistance to lateral earth pressure may be calculated using an equivalent fluid pressure of 250 pcf (300 pcf for sands) to resist lateral loadings. The top one foot of embedment should not be considered in computing passive resistance unless the adjacent area is confined by a slab or pavement. An allowable friction coefficient of 0.25 (0.35 for sands) may also be used at the base of the footings to resist lateral loading.

Foundation movement under the estimated loadings and static site conditions are estimated to not exceed ¾-inch with differential movement of about two-thirds of total movement for the loading assumptions stated above when the subgrade preparation guidelines given above are followed. Seismically induced liquefaction settlement may be on the order of ¾-inch.

4.3 Slabs-On-Grade

Concrete slabs and flatwork placed over native clay soil should be designed in accordance with Chapter 18, Division III of the 1997 UBC (using a Effective Plasticity Index of 30) and shall be a minimum of 5 inches thick due to expansive soil conditions. No special requirements exist for slabs placed on 3.0 feet of granular fill or lime treated soil. Concrete floor slabs shall be monolithically placed with the foundations unless placed on 3.0 feet of granular fill or lime treated soil. The concrete slabs should be underlain by a minimum of 4 inches of clean sand (Sand Equivalent SE>30) or aggregate base or may be placed directly on the 3.0-foot thick granular fill pad (if used) that has been moistened to approximately optimum moisture just before the concrete placement. A 10-mil visqueen vapor barrier, properly lapped and sealed with a 2-inch sand cover and extended a minimum of 12 inches into the footing, should be placed as a capillary break to prevent moisture migration into the slab section.

Concrete slab and flatwork reinforcement should consist of chaired rebar slab reinforcement (minimum of No. 4 bars at 18-inch centers, both horizontal directions) placed at slab mid-height to resist potential swell forces and cracking. Slab thickness and steel reinforcement are minimums only and should be verified by the structural engineer/designer knowing the actual project loadings. All steel components of the foundation system should be protected from corrosion by maintaining a 4-inch minimum concrete cover of densely consolidated concrete at footings (by use of a vibrator). The construction joint between the foundation and any mowstrips/sidewalks placed adjacent to foundations should be sealed with a polyurethane based non-hardening sealant to prevent moisture migration between the joint. Epoxy coated embedded steel components or permanent waterproofing membranes placed at the exterior footing sidewall may also be used to mitigate the corrosion potential of concrete placed in contact with native soil.

Control joints should be provided in all concrete slabs-on-grade at a maximum spacing (in feet) of 2 to 3 times the slab thickness (in inches) as recommended by American Concrete Institute (ACI) guidelines. All joints should form approximately square patterns to reduce randomly oriented contraction cracks. Contraction joints in the slabs should be tooled at the time of the pour or sawcut (¼ of slab depth) within 6 to 8 hours of concrete placement. Construction (cold) joints in foundations and area flatwork should either be thickened butt-joints with dowels or a thickened keyed-joint designed to resist vertical deflection at the joint. All joints in flatwork should be sealed to prevent moisture, vermin, or foreign material intrusion. Precautions should be taken to prevent curling of slabs in this arid desert region (refer to ACI guidelines).

All independent flatwork (sidewalks, patios) should be placed on a minimum of 4 inches of concrete sand or aggregate base, dowelled to the perimeter foundations where adjacent to the building and sloped 2% or more away from the building. A minimum of 24 inches of moisture conditioned (5% minimum above optimum) and 8 inches of compacted subgrade (83 to 87%) and a 10-mil (minimum) polyethylene separation sheet should underlie the flatwork (except sidewalks). All flatwork should be jointed in square patterns and at irregularities in shape at a maximum spacing of 10 feet or the least width of the sidewalk.

4.4 Concrete Mixes and Corrosivity

Selected chemical analyses for corrosivity were conducted on bulk samples of the near surface soil from the project site (Plate C-3). The native soil was found to have severe to very severe sulfate ion concentration (4,000 to 6,000 ppm). Sulfate ions in high concentrations can attack the cementitious material in concrete, causing weakening of the cement matrix and eventual deterioration by raveling. The Uniform Building Code recommends that increased quantities of Type II Portland Cement be used at a low water/cement ratio when concrete is subjected to moderate sulfate concentrations. Type V Portland Cement and/or Type II/V cement with 25% flyash replacement is recommended when the concrete is subjected to soil with severe sulfate concentration.

A minimum of 6.25 sacks per cubic yard of concrete (4,500 psi) of Type V Portland Cement with a maximum water/cement ratio of 0.45 (by weight) should be used for concrete placed in contact with native soil on this project (sitework in parking/landscape areas, sidewalks, driveways, patios, and foundations). Admixtures may be required to allow placement of this low water/cement ratio concrete.

There are no special requirements for concrete mixes when foundations are placed on 3.0 feet of low sulfate content granular fill.

The native soil has very severe chloride ion concentrations (700 to 3,300 ppm). Chloride ions can cause corrosion of reinforcing steel, anchor bolts and other buried metallic conduits. Resistivity determinations on the soil indicate severe potential for metal loss because of electrochemical corrosion processes. Mitigation of the corrosion of steel can be achieved by using steel pipes coated with epoxy corrosion inhibitors, asphaltic and epoxy coatings, cathodic protection or by encapsulating the portion of the pipe lying above groundwater with a minimum of 4 inches of densely consolidated concrete. ***No metallic pipes or conduits should be placed below foundations.***

Foundation designs shall provide a minimum concrete cover of four (4) inches around steel reinforcing or embedded components (anchor bolts, hold-downs, etc.) exposed to native soil or landscape water (to 18 inches above grade). If the 4-inch concrete edge distance cannot be achieved, all embedded steel components (anchor bolts, hold-downs, etc.) shall be epoxy dipped for corrosion protection or a permanent waterproofing membrane shall be placed along the exterior face of the exterior footings.

Additionally, the concrete should be thoroughly vibrated at footings during placement to decrease the permeability of the concrete. ***Copper water piping (except for trap primers) should not be placed under floor slabs.*** The trap primer pipe shall be completely encapsulated in a PVC sleeve and Type K copper should be utilized if polyethylene tubing cannot be used.

4.5 Excavations

All site excavations should conform to CalOSHA requirements for Type B soil. The contractor is solely responsible for the safety of workers entering trenches. Temporary excavations with depths of 4 feet or less may cut nearly vertical for short duration. Excavations below 8 feet will require shoring or slope inclinations in conformance to CAL/OSHA regulations for Type C soil. Surcharge loads of stockpiled soil or construction materials should be set back from the top of the slope a minimum distance equal to the height of the slope. All permanent slopes should not be steeper than 3:1 to reduce wind and rain erosion. Protected slopes with ground cover may be as steep as 2:1. However, maintenance with motorized equipment may not be possible at this inclination.

4.6 Seismic Design

This site is located in the seismically active southern California area and the site structures are subject to strong ground shaking due to potential fault movements along the Brawley, Superstition Hills, and Imperial Faults. Engineered design and earthquake-resistant construction are the common solutions to increase safety and development of seismic areas. Designs should comply with the latest edition of the UBC for Seismic Zone 4 using the seismic coefficients given in Section 3.4 of this report. ***This site lies within 4.6 km of a Type A fault overlying S_D (stiff) soil.***

Section 5
LIMITATIONS AND ADDITIONAL SERVICES

5.1 Limitations

The recommendations and conclusions within this report are based on current information regarding the proposed expansion of the Imperial Public Library located in Imperial, California. The conclusions and recommendations of this report are invalid if:

- Structural loads change from those stated or the structures are relocated.
- The Additional Services section of this report is not followed.
- This report is used for adjacent or other property.
- Changes of grade or groundwater occur between the issuance of this report and construction other than those anticipated in this report.
- Any other change that materially alters the project from that proposed at the time this report was prepared.

We have based our findings and recommendations in this report are based on selected points of field exploration, geologic literature, laboratory testing, and our understanding of the proposed project. Our analysis of data and recommendations presented herein are based on the assumption that soil conditions do not vary significantly from those found at specific exploratory locations. Variations in soil conditions can exist between and beyond the exploration points or groundwater elevations may change. If detected, these conditions may require additional studies, consultation, and possible design revisions.

This report was prepared according to the generally accepted *geotechnical engineering standards of practice* that existed in Imperial County at the time the report was prepared. No express or implied warranties are made in connection with our services. This report should be considered invalid for periods after two years from the report date without a review of the validity of the findings and recommendations by our firm, because of potential changes in the Geotechnical Engineering Standards of Practice.

The client has responsibility to see that all parties to the project including, designer, contractor, and subcontractor are made aware of this entire report. The use of information contained in this report for bidding purposes should be done at the contractor's option and risk.

5.2 Additional Services

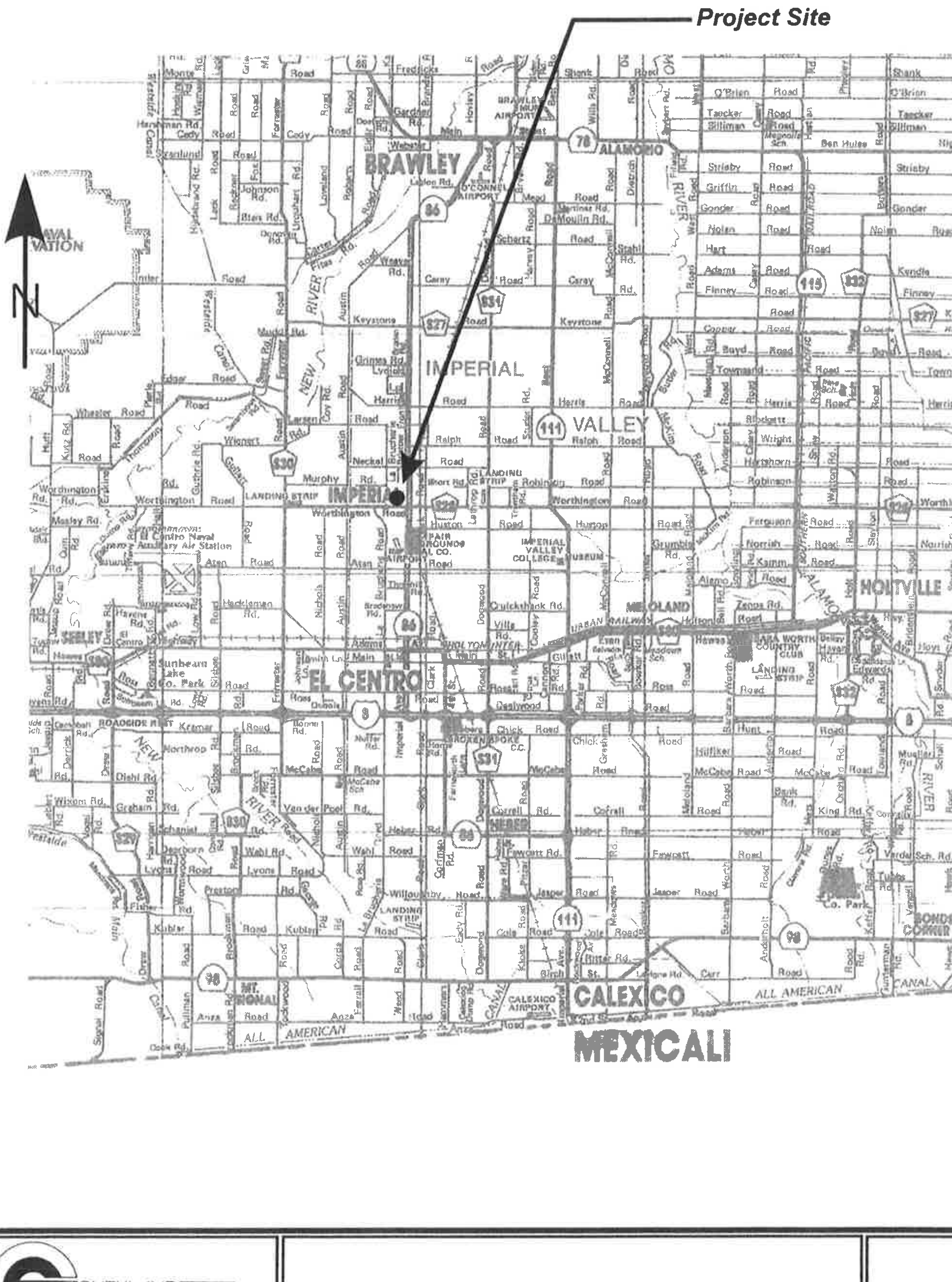
We recommend that Southland Geotechnical, Inc. be retained as the geotechnical consultant to provide the tests and observations services during construction. If Southland Geotechnical does not provide such services then *the geotechnical engineering firm providing such tests and observations shall become the geotechnical engineer of record and assume responsibility for the project.*

The recommendations presented in this report are based on the assumption that:

- Consultation during development of design and construction documents to check that the geotechnical recommendations are appropriate for the proposed project and that the geotechnical recommendations are properly interpreted and incorporated into the documents.
- Southland Geotechnical will have the opportunity to review and comment on the plans and specifications for the project prior to the issuance of such for bidding.
- Continuous observation, inspection, and testing by the geotechnical consultant of record during site clearing, grading, excavation, placement of fills, building pad and subgrade preparation, and backfilling of utility trenches.
- Observation of foundation excavations and reinforcing steel before concrete placement.
- Other consultation as necessary during design and construction.

We emphasize our review of the project plans and specifications to check for compatibility with our recommendations and conclusions. Additional information concerning the scope and cost of these services can be obtained from our office.

APPENDIX A



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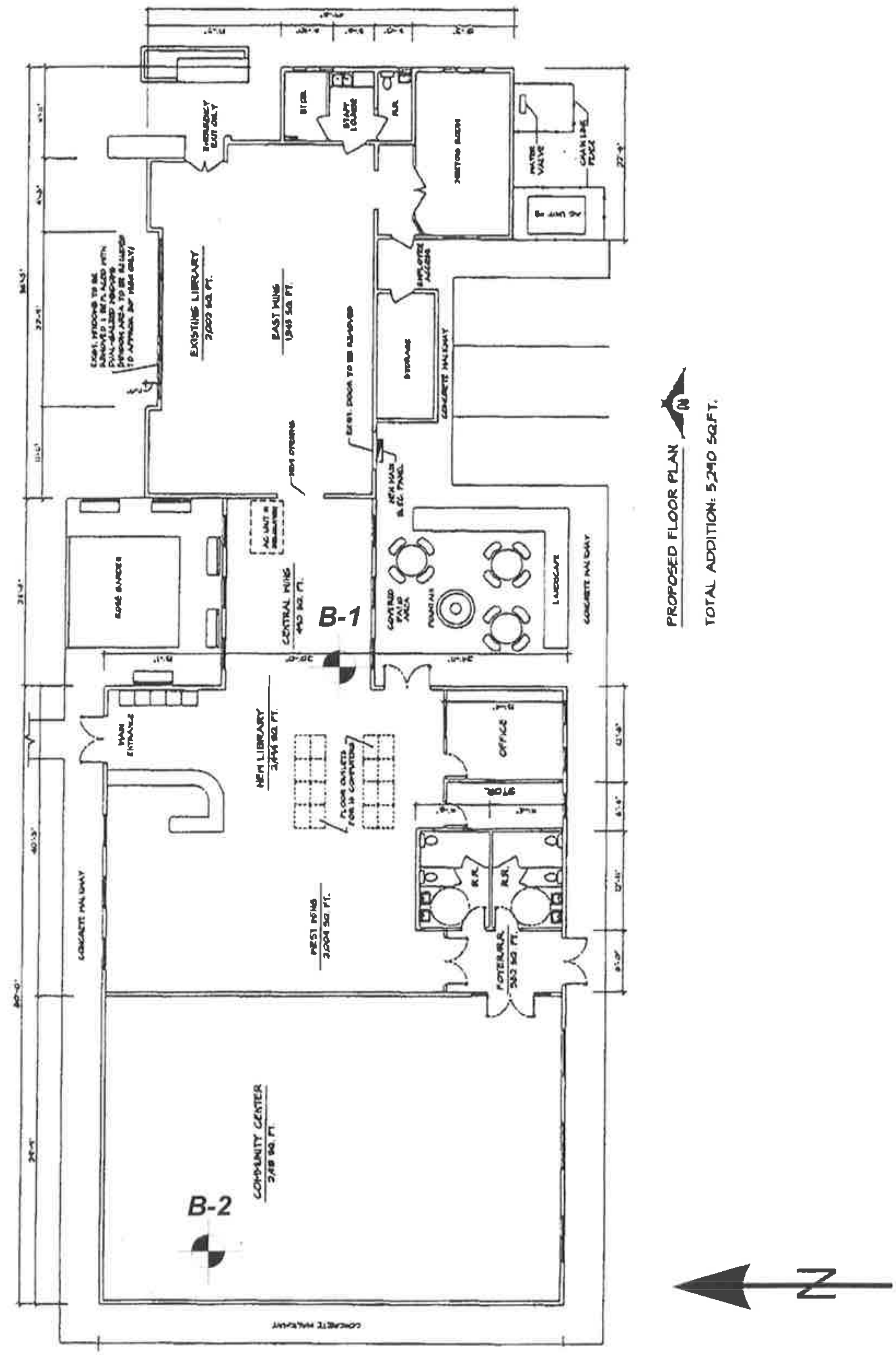
Project No.: S02280

Vicinity Map

Plate A-1

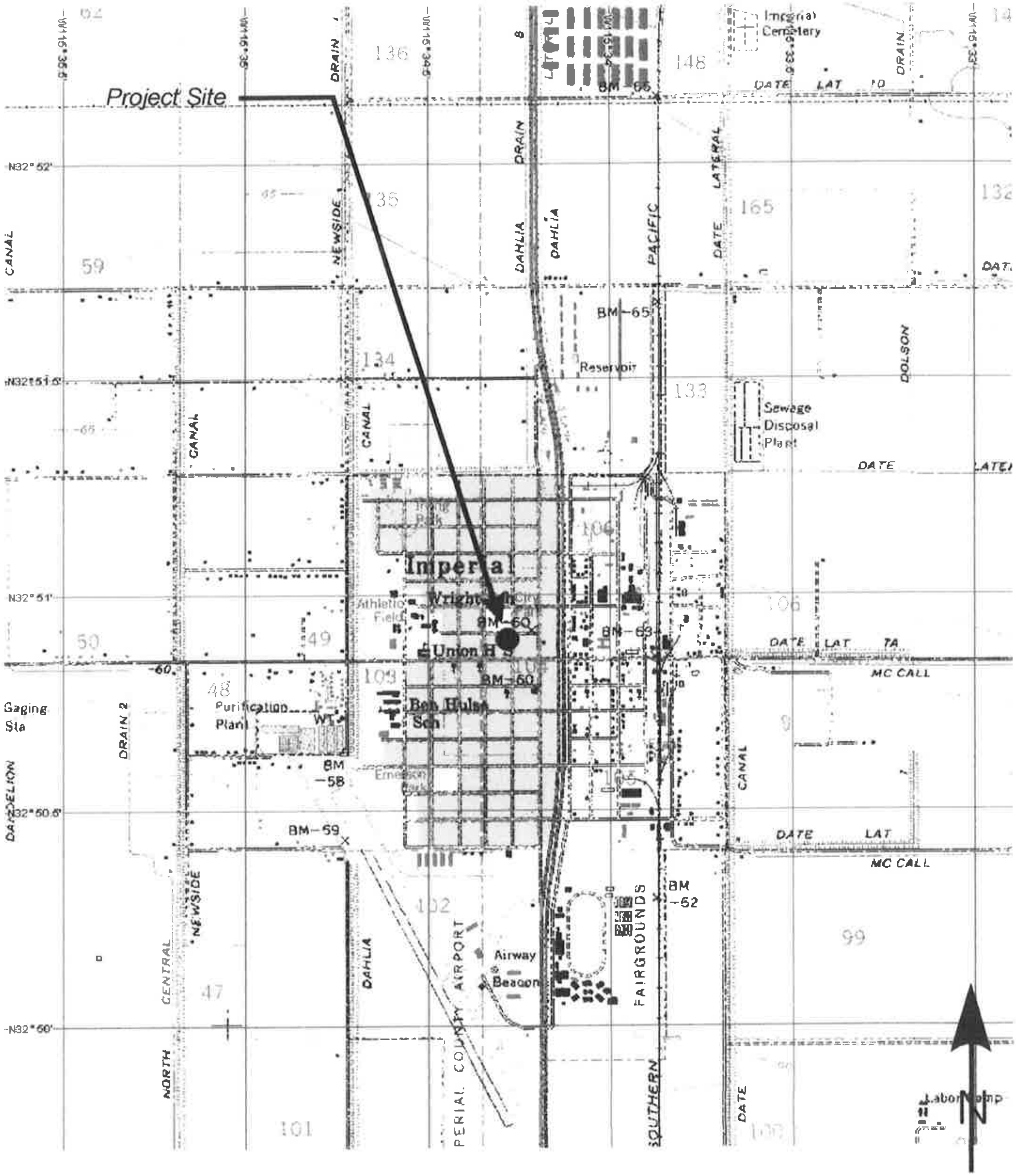


SOUTHLAND GEOTECHNICAL

Project No.: S02280

Site and Exploration Plan

Plate A-2



Project No.: S02280

Topographic Map

Plate A-3

APPENDIX B

CLIENT: City of Imperial
PROJECT: Imperial Public Library Addition
LOCATION: See Site and Exploration Plan

METHOD OF DRILLING: CME 55 W/ Autohammer
DATE OBSERVED 10/30/02
LOGGED BY: KN

LOG OF BORING B-1

SHEET 1 OF 1

DEPTH (FEET)	CLASSIFICATION	SAMPLE TYPE	BLOWS/ FOOT	POCKET PEN. (TSF)	DESCRIPTION OF MATERIAL SURFACE ELEV. +/-	MOISTURE CONTENT (%)	DRY UNIT WT. (PCF)	UNCONFINED COMPRESSION (TSF)	LIQUID LIMIT	PLASTICITY INDEX	PASSING # 200
			11	2.0	SILTY CLAY (CL): Dark brown, very stiff, moist.	24	99.8		49	36	
5											
			16	2.25	SILTY CLAY (CL): Dark brown, very stiff, moist.						
10											
			11	3.0	moist/saturated						
15											
			7	4.0	hard						
20											
25											
30											
35											
40											

End of Boring @ 19.0 feet; Groundwater Encountered @ 12.0 feet
**Blow counts not corrected for overburden pressure, sampler size, or increase drive energy for automatic hammers

Project No:
S02280

SOUTHLAND GEOTECHNICAL

Plate
B-1

CLIENT: City of Imperial
PROJECT: Imperial Public Library Addition
LOCATION: See Site and Exploration Plan

METHOD OF DRILLING: CME 55 W/ Autohammer
DATE OBSERVED 10/30/02
LOGGED BY: KN

LOG OF BORING B-2

SHEET 1 OF 1

DEPTH (FEET)	CLASSIFICATION	SAMPLE TYPE	BLOWS/ FOOT	POCKET PEN. (TSF)	DESCRIPTION OF MATERIAL SURFACE ELEV. +/-	MOISTURE CONTENT (%)	DRY UNIT WT. (PCF)	UNCONFINED COMPRESSION (TSF)	LIQUID LIMIT	PLASTICITY INDEX	PASSING # 200
					SILTY CLAY (CL): Brown, damp/moist.				44	30	
5			6	0.5	CLAYEY SILT (ML): Brown, soft, wet.						
10			12		SANDY SILT (ML): Dark brown, soft, moist/saturated, fine grained.						85
15			13	0.5	SANDY SILTY CLAY (CL): Dark brown, soft, moist/ saturated.						
20			8	3.5	very stiff						
25			9								
30			12		CLAYEY SILT (ML): Dark brown, medium dense, moist/ saturated, fine grained.						98
35			8	1.5 0.75	SILTY CLAY (CL): Brown, soft/stiff, moist/saturated.						
40			13	1.5	thin interbeds of silt						

End of Boring @ 41.5 feet; Groundwater Encountered @ 12.0 feet
**Blow counts not corrected for overburden pressure, sampler size, or increase drive energy for automatic hammers

Project No: S02280

SOUTHLAND GEOTECHNICAL

Plate B-2

DEFINITION OF TERMS

PRIMARY DIVISIONS			SYMBOLS	SECONDARY DIVISIONS
Coarse grained soils More than half of material is larger than No. 200 sieve	Gravels More than half of coarse fraction is larger than No. 4 sieve	Clean gravels (less than 5% fines)	GW	Well graded gravels, gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels, or gravel-sand mixtures, little or no fines
		Gravel with fines	GM	Silty gravels, gravel-sand-silt mixtures, non-plastic fines
			GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines
	Sands More than half of coarse fraction is smaller than No. 4 sieve	Clean sands (less than 5% fines)	SW	Well graded sands, gravelly sands, little or no fines
			SP	Poorly graded sands or gravelly sands, little or no fines
		Sands with fines	SM	Silty sands, sand-silt mixtures, non-plastic fines
			SC	Clayey sands, sand-clay mixtures, plastic fines
Fine grained soils More than half of material is smaller than No. 200 sieve	Silts and clays Liquid limit is less than 50%		ML	Inorganic silts, clayey silts with slight plasticity
			CL	Inorganic clays of low to medium plasticity, gravely, sandy, or lean clays
			OL	Organic silts and organic clays of low plasticity
	Silts and clays Liquid limit is more than 50%		MH	Inorganic silts, micaceous or diatomaceous silty soils, elastic silts
			CH	Inorganic clays of high plasticity, fat clays
			OH	Organic clays of medium to high plasticity, organic silts
Highly organic soils			PT	Peat and other highly organic soils

GRAIN SIZES

Silts and Clays	Sand			Gravel		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		

200 4 10 4 3/4" 3" 12"

US Standard Series Sieve — Clear Square Openings

Sands, Gravels, etc.	Blows/ft. *
Very Loose	0-4
Loose	4-10
Medium Dense	10-30
Dense	30-50
Very Dense	Over 50

Clays & Plastic Silts	Strength **	Blows/ft. *
Very Soft	0-0.25	0-2
Soft	0.25-0.5	2-4
Firm	0.5-1.0	4-8
Stiff	1.0-2.0	8-16
Very Stiff	2.0-4.0	16-32
Hard	Over 4.0	Over 32

* Number of blows of 140 lb. hammer falling 30 inches to drive a 2 inch O.D. (1 3/8 in. I.D.) split spoon (ASTM D1586).

** Unconfined compressive strength in tons/s.f. as determined by laboratory testing or approximated by the Standard Penetration Test (ASTM D1586), Pocket Penetrometer, Torvane, or visual observation.

Type of Samples:

Ring Sample — Standard Penetration Test — Shelby Tube — Bulk (Bag) Sample

Drilling Notes:

1. Sampling and Blow Counts
   - Ring Sampler - Number of blows per foot of a 140 lb. hammer falling 30 inches.
   - Standard Penetration Test - Number of blows per foot.
   - Shelby Tube - Three (3) inch nominal diameter tube hydraulically pushed.
2. P. P. = Pocket Penetrometer (tons/s.f.).
3. NR = No recovery.
4. GWT ▼ = Ground Water Table observed @ specified time.

SOUTHLAND GEOTECHNICAL

Project No: S02280

Key to Logs

Plate B-3

APPENDIX C

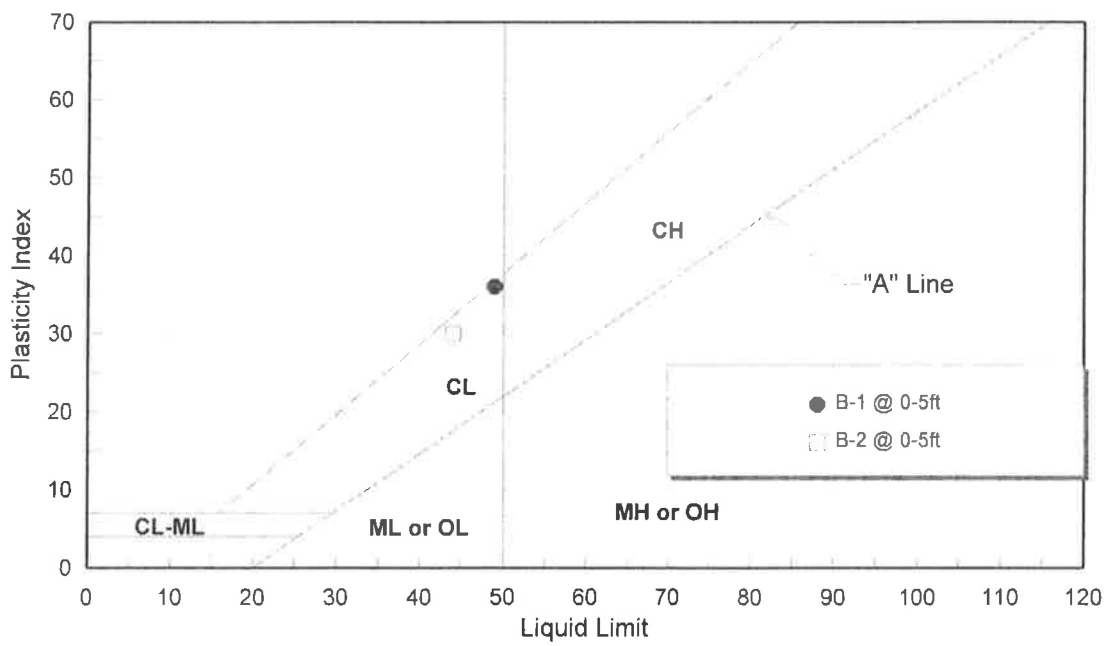
SOUTHLAND GEOTECHNICAL

CLIENT: City of Imperial
PROJECT: Imperial Public Library Expansion
JOB NO: S02280
DATE: 11/19/02

ATTERBERG LIMITS (ASTM D4318)

Sample Location	Sample Depth (ft)	Liquid Limit (LL)	Plastic Limit (PL)	Plasticity Index (PI)	USCS Classif-ation
B-1	0-5	49	13	36	CL
B-2	0-5	44	14	30	CL

PLASTICITY CHART



SOUTHLAND GEOTECHNICAL

Project No: S02280

Atterberg Limits Test Results

Plate C-1

SOUTHLAND GEOTECHNICAL

CLIENT: City of Imperial
PROJECT: Imperial Public Library Expansion
JOB NO: S02280
DATE: 11/19/02

EXPANSION INDEX TEST (UBC 29-2 & ASTM D4829)

Sample Location & Depth (ft)	Initial Moisture (%)	Compacted Dry Density (pcf)	Final Moisture (%)	Volumetric Swell (%)	Expansion Index (EI)	Expansive Potential
B-1 1-5 ft.	13.2	98.6	33.5	10.9	**109**	High

UBC CLASSIFICATION

0-20	Very Low
20-50	Low
50-90	Medium
90-130	High
130+	Very High

Note: * The measured EI have been adjusted to the estimated EI at 50% saturation in accordance with Section 10.1.2 of ASTM D4829.

SOUTHLAND GEOTECHNICAL

Project No: S02280

Expansion Index Test Results

Plate C-2

SOUTHLAND GEOTECHNICAL

CLIENT: City of Imperial
PROJECT: Imperial Public Library Expansion
JOB NO: S02280
DATE: 11/19/02

CHEMICAL ANALYSES

Boring:	B-1	B-2	CalTrans Method
Sample Depth, ft:	1-5	1-5	
pH:	7.0	6.6	643
Electrical Conductivity (mmhos):	4.2	3.2	424
Resistivity (ohm-cm):	260	125	643
Chloride (Cl), ppm:	3,310	760	422
Sulfate (SO4), ppm:	4,280	5,820	417

General Guidelines for Soil Corrosivity

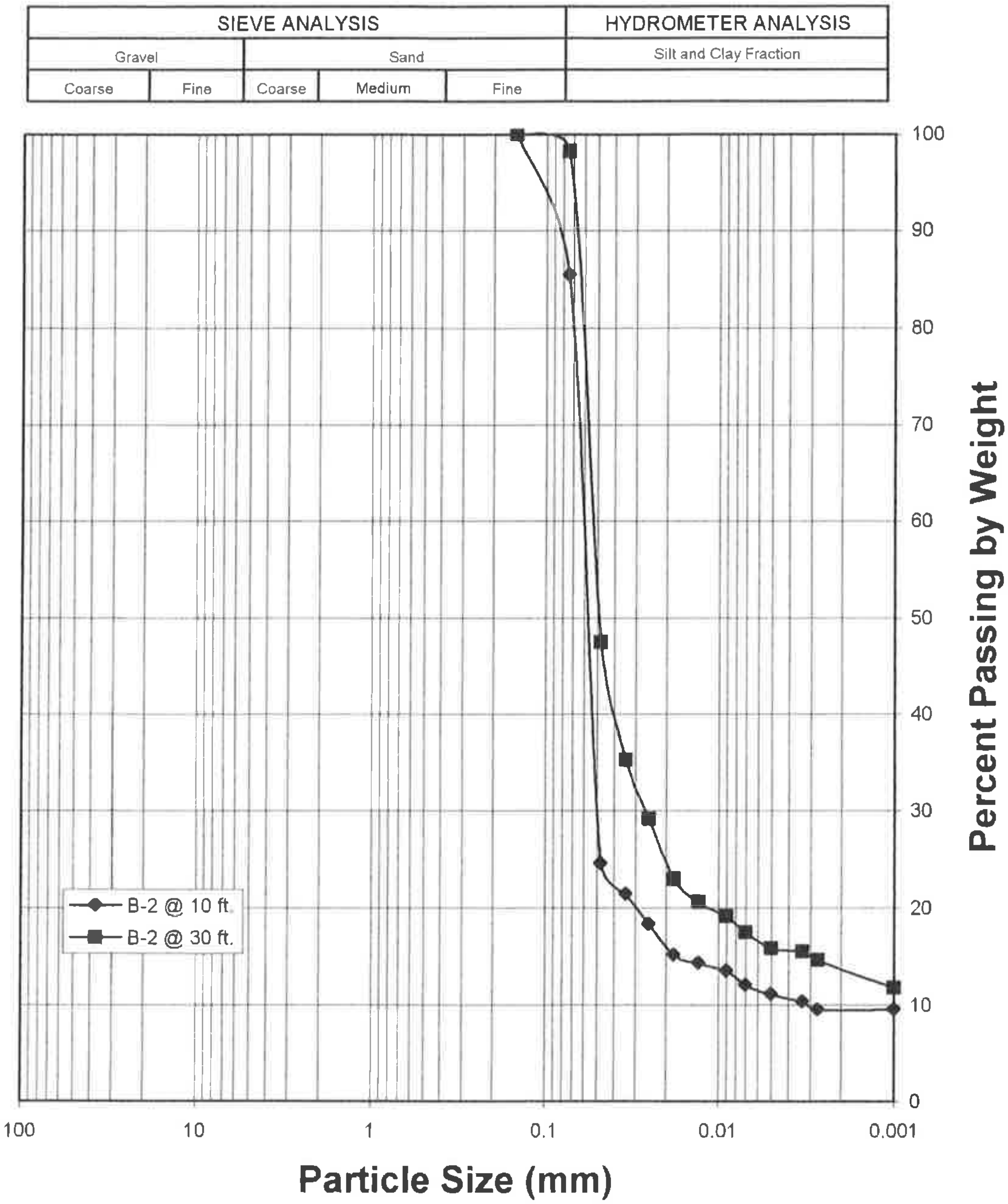
Material Affected	Chemical Agent	Amount in Soil (ppm)	Degree of Corrosivity
Concrete	Soluble Sulfates	0 -1000	Low
		1000 - 2000	Moderate
		2000 - 5000	Severe
		> 5000	Very Severe
Normal Grade Steel	Soluble Chlorides	0 - 200	Low
		200 - 700	Moderate
		700 - 1500	Severe
		> 1500	Very Severe
Normal Grade Steel	Resistivity	1-1000	Very Severe
		1000-2000	Severe
		2000-10,000	Moderate
		10,000+	Low

SOUTHLAND GEOTECHNICAL

Project No: **S02280**

Selected Chemical Analyses Results

Plate C-3



SOUTHLAND GEOTECHNICAL

Project No.: S02280

Grain Size Analysis

Plate C-4

APPENDIX D

REFERENCES

Arango I., 1996, Magnitude Scaling Factors for Soil Liquefaction Evaluations: ASCE Geotechnical Journal, Vol. 122, No. 11.

Bartlett, Steven F. and Youd, T. Leslie, 1995, Empirical Prediction of Liquefaction-Induced Lateral Spread: ASCE Geotechnical Journal, Vol. 121, No. 4.

Blake, T. F., 2000, FRISKSP - A computer program for the probabilistic estimation of seismic hazard using faults as earthquake sources.

Bolt, B. A., 1974, Duration of Strong Motion: Proceedings 5th World Conference on Earthquake Engineering, Rome, Italy, June 1974.

Boore, D. M., Joyner, W. B., and Fumal, T. E., 1994, Estimation of response spectra and peak accelerations from western North American earthquakes: U.S. Geological Survey Open File Reports 94-127 and 93-509.

Boore, D. M., Joyner, W. B., and Fumal, T. E., 1997, Empirical Near-Source Attenuation Relationships for Horizontal and Vertical Components of Peak Ground Acceleration, Peak Ground Velocity, and Pseudo-Absolute Acceleration Response Spectra: Seismological Research Letters, Vol. 68, No. 1, p. 154-179.

Building Seismic Safety Council (BSSC), 1991, NEHRP recommended provisions for the development of seismic regulations of new buildings, Parts 1, 2 and Maps: FEMA 222, January 1992

California Division of Mines and Geology (CDMG), 1996, California Fault Parameters: available at http://www.consrv.ca.gov/dmg/shezp/fltindex.html.

Ellsworth, W. L., 1990, Earthquake History, 1769-1989 in: The San Andreas Fault System, California: U.S. Geological Survey Professional Paper 1515, 283 p.

International Conference of Building Officials (ICBO), 1994, Uniform Building Code, 1994 Edition.

International Conference of Building Officials (ICBO), 1997, Uniform Building Code, 1997 Edition.

Ishihara, K. (1985), Stability of natural deposits during earthquakes, Proc. 11th Int. Conf. On Soil Mech. And Found. Engrg., Vol. 1, A. A. Balkema, Rotterdam, The Netherlands, 321-376.

Jennings, C. W., 1994, Fault activity map of California and Adjacent Areas: California Division of Mines and Geology, DMG Geologic Map No. 6.

Jones, L. and Hauksson, E., 1994, Review of potential earthquake sources in Southern California: Applied Technology Council, Proceedings of ATC 35-1.

Joyner, W. B. and Boore, D. M., 1988, Measurements, characterization, and prediction of strong ground motion: ASCE Geotechnical Special Pub. No. 20.

Maley, R. P. and Etheredge, E. C., 1981, Strong motion data from the Westmorland, California earthquake of April 26, 1981: U.S. Geological Survey Open File Report 81-1149, 18 p.

Morton, P. K., 1977, Geology and mineral resources of Imperial County, California: California Division of Mines and Geology, County Report No. 7, 104 p.

Mualchin, L. and Jones, A. L., 1992, Peak acceleration from maximum credible earthquakes in California (Rock and Stiff Soil Sites): California Division of Mines and Geology, DMG Open File Report 92-01.

Naeim, F. and Anderson, J. C., 1993, Classification and evaluation of earthquake records for design: Earthquake Engineering Research Institute, NEHRP Report.

National Research Council, Committee of Earthquake Engineering, 1985, Liquefaction of Soils during Earthquakes: National Academy Press, Washington, D.C.

Porcella, R. L., Matthiesen, R. B., and Maley, R. P., 1982, Strong-motion data recorded in the United States: U.S. Geological Survey Professional Paper 1254, p. 289-318.

Porcella, R., Etheredge, E., Maley, R., and Switzer, J., 1987, Strong motion data from the Superstition Hills earthquake of November 24, 1987: U.S. Geological Survey Open File Report 87-672, 56 p.

Robertson, P. K. and Wride, C. E., 1996, Cyclic Liquefaction and its Evaluation based on the SPT and CPT, Proceeding of the NCEER Workshop on Evaluation of Liquefaction Resistance of Soils, NCEER Technical Report 97-0022, p. 41-88.

Seed, Harry B., Idriss, I. M., and Arango I., 1983, Evaluation of liquefaction potential using field performance data: ASCE Geotechnical Journal, Vol. 109, No. 3.

Seed, Harry B., et al, 1985, Influence of SPT Procedures in Soil Liquefaction Resistance Evaluations: ASCE Geotechnical Journal, Vol. 113, No. 8.

Sharp, R. V., 1982, Tectonic setting of the Imperial Valley region: U.S. Geological Survey Professional Paper 1254, p. 5-14.

Sharp, R. V., 1989, Personal communication, USGS, Menlo Park, CA.

Structural Engineers Association of California (SEAOC), 1990, Recommended lateral force requirements and commentary.

Sylvester, A. G., 1979, Earthquake damage in Imperial Valley, California May 18, 1940, as reported by T. A. Clark: Bulletin of the Seismological Society of America, v. 69, no. 2, p. 547-568.

Tokimatsu, K. and Seed H. B., 1987, Evaluation of settlements in sands due to earthquake shaking: ASCE Geotechnical Journal, v. 113, no. 8.

U.S. Geological Survey (USGS), 1982, The Imperial Valley California Earthquake of October 15, 1979: Professional Paper 1254, 451 p.

U.S. Geological Survey (USGS), 1990, The San Andreas Fault System, California, Professional Paper 1515.

U.S. Geological Survey (USGS), 1996, National Seismic Hazard Maps: available at http://gldage.cr.usgs.gov

Wallace, R. E., 1990, The San Andreas Fault System, California: U.S. Geological Survey Professional Paper 1515, 283 p.

Working Group on California Earthquake Probabilities (WGCEP), 1988, Probabilities of large earthquakes occurring in California on the San Andreas Fault: U.S. Geological Survey Open-File Report 88-398.

Working Group on California Earthquake Probabilities (WGCEP), 1992, Future seismic hazards in southern California, Phase I Report: California Division of Mines and Geology.

Working Group on California Earthquake Probabilities (WGCEP), 1995, Seismic hazards in southern California, Probable Earthquakes, 1994-2014, Phase II Report: Southern California Earthquake Center.

Youd, T. Leslie and Garris, C. T., 1995, Liquefaction induced ground surface disruption: ASCE Geotechnical Journal, Vol. 121, No. 11.

Youd, T. L. et. al., 2001, Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils: Journal of Geotechnical and Geoenvironmental Engineering, Vol. 127, No. 10, p. 817-833.

Zimmerman, R. P., 1981, Soil survey of Imperial County, California, Imperial Valley Area: U.S. Dept. of Agriculture Soil Conservation Service, 112 p.