



Project No. 41377A-01

July 9, 2013

Acumen Engineering Company
P.O. Box 3497
Truckee, California 96161

Attention: Bill Quesnel

Reference: *Truckee Tahoe Airport District Facilities Maintenance Master Plan*
10356 Truckee Airport Road
Truckee, California

Subject: *Geotechnical Engineering and Building Foundation Review Report*

This letter presents the results of our geotechnical engineering and building foundation review report for the Truckee Tahoe Airport District Facilities Maintenance Master Plan (FMMP) in Truckee, California. The purpose of the FMMP is to help identify short and long term maintenance needs for the existing structures located at the airport. In particular, concerns have been raised as to the cause of foundation settlement and/or concrete slab movement within structures located at the airport. The purpose of our services was to evaluate surface and subsurface conditions at buildings using existing information throughout the airport complex to help develop a maintenance plan and associated capital costs for repairs of existing structures at the airport facility. We previously prepared a draft report dated April 26, 2013 that was submitted to the Truckee Tahoe Airport District (TTAD) for review and comment. This final report incorporates comments received from TTAD on our draft report.

Our scope of services included review of available plans and previous geotechnical engineering reports prepared by Holdrege & Kull and other consultants at the site, a surface reconnaissance to observe building foundations, floors and surrounding pavements, and geotechnical engineering analysis to develop professional opinions concerning the cause of the movement, future performance of foundations and pavements; and recommendations for repairs, as needed.

Site and Project Description

The Truckee Tahoe Airport (TTA) is located at the northeast end of Truckee Tahoe Airport Road, north of Highway 267, and southeast of downtown Truckee, California (Figure 1). The airport facility contains twenty six structures and two main runways used for airport and business purposes (Figure 2). Structures at the site include

modular buildings, hangars, a maintenance building, garage, warehouse, fuel farm, and a main administration building. There are a total of 26 buildings listed on the Airport Facilities Plan, shown as Figure 2. Much of the ground surface surrounding the existing buildings is covered with asphalt pavement.

Differential vertical movement has occurred between the asphalt concrete pavements surrounding the buildings and the interior concrete slab-on-grade floors and building foundations. There has also been some vertical movement between the building foundations and the interior slab-on-grade floors. Some of the hangar buildings have asphalt concrete interiors and some have Portland cement concrete "floors".

Literature Review

To help evaluate geology in the site area, the following maps and literature were reviewed:

- *Geologic Map of the North Lake Tahoe-Donner Pass Region, Northern Sierra Nevada, California*, by Arthur G. Sylvester, W.S. Wise, J. T. Hastings, and L.A. Moyer, California Geological Survey in cooperation with the University of California at Santa Barbara, 2012.
- *Geologic Map of the Lake Tahoe Basin, California and Nevada*, by G.J. Saucedo, California Geological Survey, 2005.
- *Pleistocene History of the Truckee Area, North of Lake Tahoe, California*, by Peter W. Birkeland, Stanford University Ph.D. Thesis, 1962.

The geologic maps indicate that the site is underlain by glacial outwash deposits of Quaternary age (less than approximately 1.6 million years before the present). The glacial outwash deposits generally consist of silt, sand, cobbles, and boulders that locally contain clay soil.

Previous Site Investigations and Building Plans

The following reports were reviewed as part of our site assessment:

- *Geotechnical Investigation, Truckee/Tahoe Airport, H & I-Row Hangars & Access Road, Truckee, California*, dated September 29, 1997, prepared by Agra Earth & Environmental, Inc. (Agra 1997a).
- *Geotechnical Investigation, Reconstruction of the Main & South Airport Aprons, Access Road and South Apron Extension, Truckee/Tahoe Airport, Truckee*,

California, dated November 18, 1998, prepared by Agra Earth & Environmental, Inc. (Agra 1998a).

- *Geotechnical Investigation, Pavement Reconstruction at Hangar Rows C and D, Truckee/Tahoe Airport, Truckee, California*, dated May 28, 1998, prepared by Agra Earth & Environmental, Inc. (Agra 1998b).
- *Geotechnical Investigation, Pavement Reconstruction at Hangar Row A, Truckee/Tahoe Airport, Truckee, California*, dated February 14, 2001, prepared by Agra Earth & Environmental, Inc. (Agra 2003).
- *Geotechnical Investigation, Pavement Reconstruction at Hangar Rows B and C and D and F, Truckee/Tahoe Airport, Truckee, California*, dated June 14, 1999, prepared by AMEC Earth & Environmental, Inc. (AMEC 2001).
- *Geotechnical Exploration Report, Proposed Airport Improvements and Pavement Reconstruction of Overrun Area, Runway 28, Truckee Tahoe Airport, Truckee, California*, dated February 12, 2003, prepared by AMEC Earth & Environmental, Inc. (AMEC 2003).
- *Geotechnical Engineering Report for Proposed Truckee Tahoe Airport, Terminal/Administration Building, Truckee, California*, dated December 29, 2009, prepared by Holdrege & Kull (H&K 2009).
- *Geotechnical Investigation, Truckee Tahoe Airport, Hangars "G" and "H", Truckee, California*, dated December 4, 1989, prepared by Kleinfelder (Kleinfelder 1989).
- *Geotechnical Investigation Report, Proposed Maintenance Building, Truckee Tahoe Airport, Truckee, California*, dated October 17, 1991, prepared by Kleinfelder (Kleinfelder 1991).
- *Geotechnical Investigation Report, Proposed Above Ground Storage Tanks, Truckee Tahoe Airport, Truckee, California*, dated May 27, 1994, prepared by Kleinfelder (Kleinfelder 1994).
- *Geotechnical Investigation, Runway 10/28 and Hangar Rows J & K, Truckee Tahoe Airport, Truckee, California*, dated December 20, 2007, prepared by Stantec Consulting, Inc. (Stantec 2007).

Each of the investigations listed above involved completing subsurface exploration for improvement projects at the airport. Subsurface conditions encountered during these investigations generally consisted of loose to very dense granular soil consisting of silty

sand with gravel (SM), clayey sand with gravel (SC), silty gravel (GM), and poorly graded sand (SP). Stiff to hard sandy silt (ML) was reported in near-surface soil near Buildings 8, 14, 15 (Hangar Rows A, G, and H, respectively) of low plasticity. Approximately 6.5 feet of existing fill was reported near Buildings 12 and 13 (Hangar Rows E and F). The existing fill was reported as medium dense to dense clayey sand with varying amounts of gravel, cobbles, and boulders. Approximately 3 feet of fill containing wood debris was reported near Building 15 (Hangar Row H). Groundwater was not encountered during the previous investigations completed at the site. A summary of the findings of the reports listed above is included in Table 1 of Appendix A. It is possible that additional reports pertaining to subsurface conditions at the site may exist but were not readily available for review at the time of our assessment.

To help evaluate existing foundation types at site structures, we reviewed available plans of some of the facility buildings. A brief listing of plans we reviewed is included in Table 1 (Appendix A) of this letter report. It should be noted that the plans we reviewed may not represent actual as-built drawings.

Surface Reconnaissance and Building Evaluation

Based on the results of our surface reconnaissance and plan review, the airport structures are supported on conventional shallow spread footings with continuous perimeter foundations or isolated shallow piers. The hangar structures have concrete or asphalt concrete floors and do not appear to be heated. Although there is differential movement of up to about 2 inches between the floors and foundation, we did not observe obvious signs of significant foundation settlement during our reconnaissance. The roof lines on hangars appear straight and level and the structures do not appear to be racked or titled. In nearly all cases, the floor is raised in relation to the foundation. A site plan showing the airport facility and structure layout is included as Figure 2, Site Plan. Photographs collected during our reconnaissance are attached as Appendix B.

Conclusions and Recommendations

This report addresses geotechnical engineering issues pertaining to buildings and other structures at the airport. The same soils may perform differently under pavements than structures. We understand that subgrade soil under pavements along runways and aprons have been previously over excavated due to instability. Geotechnical engineering recommendations should be provided for specific projects involving structures and/or pavements. Additional subsurface investigations should be completed in the future to evaluate building specific design and construction for new projects at the airport facility.

Based on our research of geologic literature and available geotechnical engineering reports prepared by H&K and others, it appears that the airports structures are

predominantly underlain by medium dense to very dense silty sand (SM) with varying amounts of gravel, cobbles, and boulders. This soil profile is non-plastic and is not highly prone to expansion or settlement when loaded.

There is a high potential for seasonal saturation of near-surface soil in foundation and pavement areas. Near-surface and perched groundwater likely results in frost heave of floors and pavements. The underlying soil conditions should provide suitable support for the structures at the airport. The differential movement between foundations and pavements (including interior floors) is likely due to frost heave. It does not appear there is significant foundation settlement or swell from expansive soils. We do not anticipate the need for remedial measures for existing buildings.

We recommend that well-drained subgrade soil and pavements be designed and constructed for new projects at the airport facility to help reduce frost heave. Final elevations should be planned so that drainage is directed away from all foundations and pavements. Ponding of surface water should not be allowed near pavements or structures. Infiltration of roof or pavement runoff should not be allowed near structures. Paved areas should be sloped away from structures and drainage gradients should be maintained to carry all surface water to a properly designed infiltration or detention basin.

To reduce the potential for moisture intrusion and adverse effects of near-surface water, drains beneath slab-on-grade foundations and pavement sections should be considered for future projects at the airport. The drains should be constructed such that they direct water away from the foundation towards a properly designed infiltration or detention basin.

Limitations

Our professional services were performed consistent with the generally accepted geotechnical engineering principles and practices employed in the site area at the time the report was prepared. No warranty, express or implied, is intended.

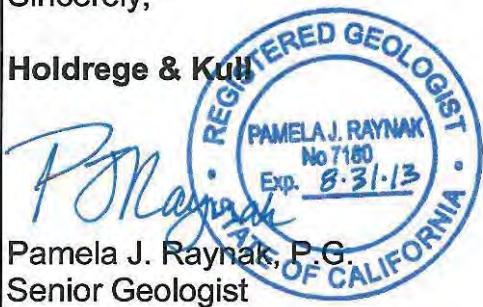
Our services were performed consistent with our agreement with our client. We are not responsible for the impacts of changes in environmental standards, practices or regulations subsequent to performance of our services. We do not warrant the accuracy of information supplied by others, or the use of segregated portions of this report. This report is solely for the use of our client. Reliance on this report by a third party is at the risk of that party.

Closing

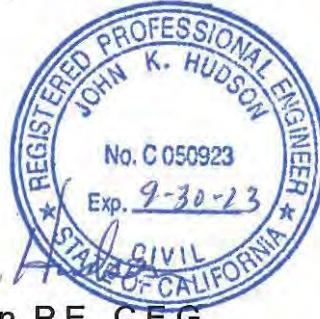
We appreciate the opportunity to provide our services for this project. Please contact the undersigned if you have any questions regarding this report.

Sincerely,

Holdrege & Kull



Pamela J. Raynak, P.G.
Senior Geologist



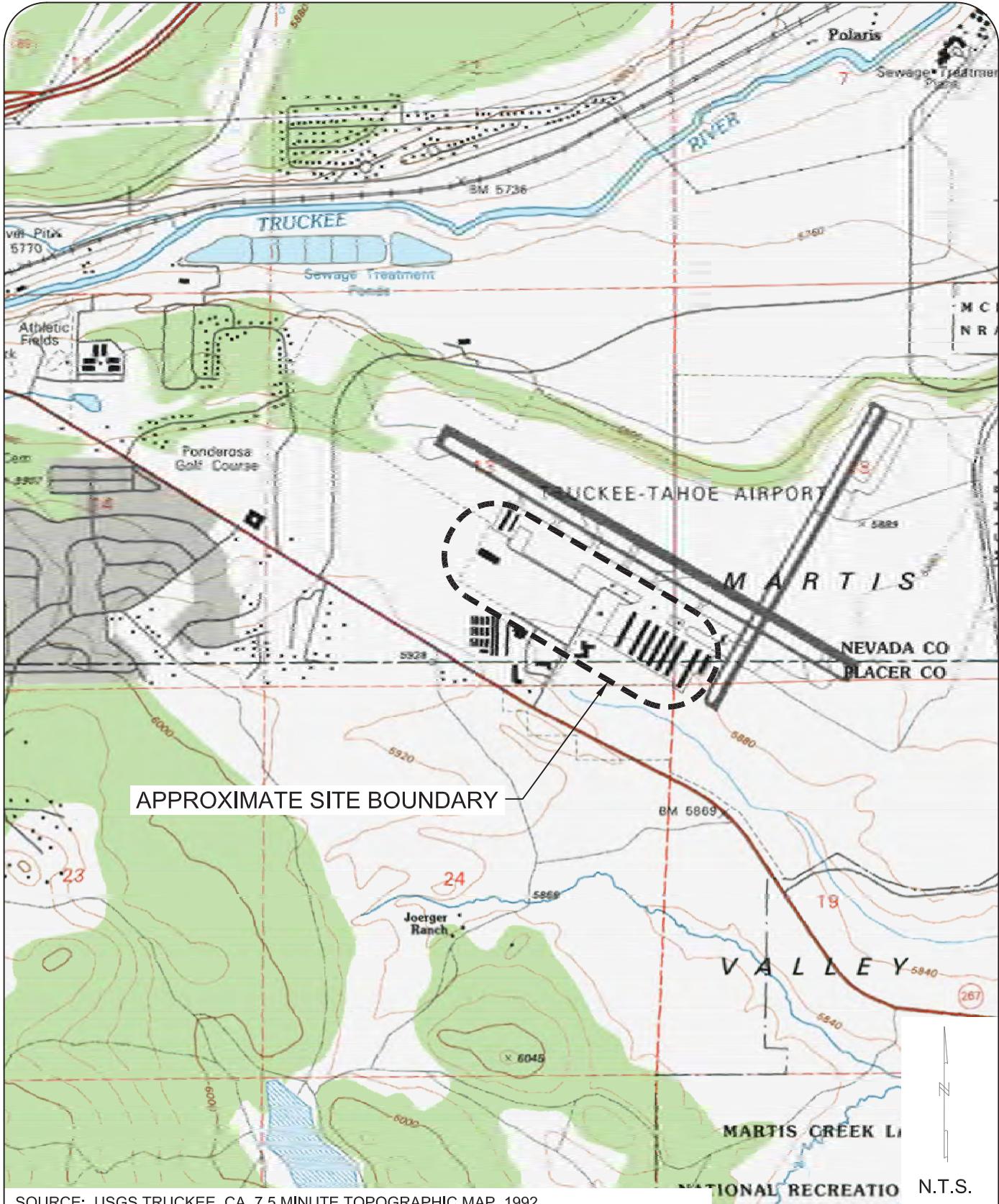
John K. Hudson, P.E., C.E.G.
Principal

Attachments: Figure 1, Site Vicinity Map
 Figure 2, Site Plan
 Appendix A, Table 1, Existing Buildings and Previous Investigations
 Appendix B, Site Photographs

Copies: 3 to Bill Quesnel, Acumen Engineering Company

FIGURES

- Figure 1 Site Vicinity Map**
Figure 2 Site Plan



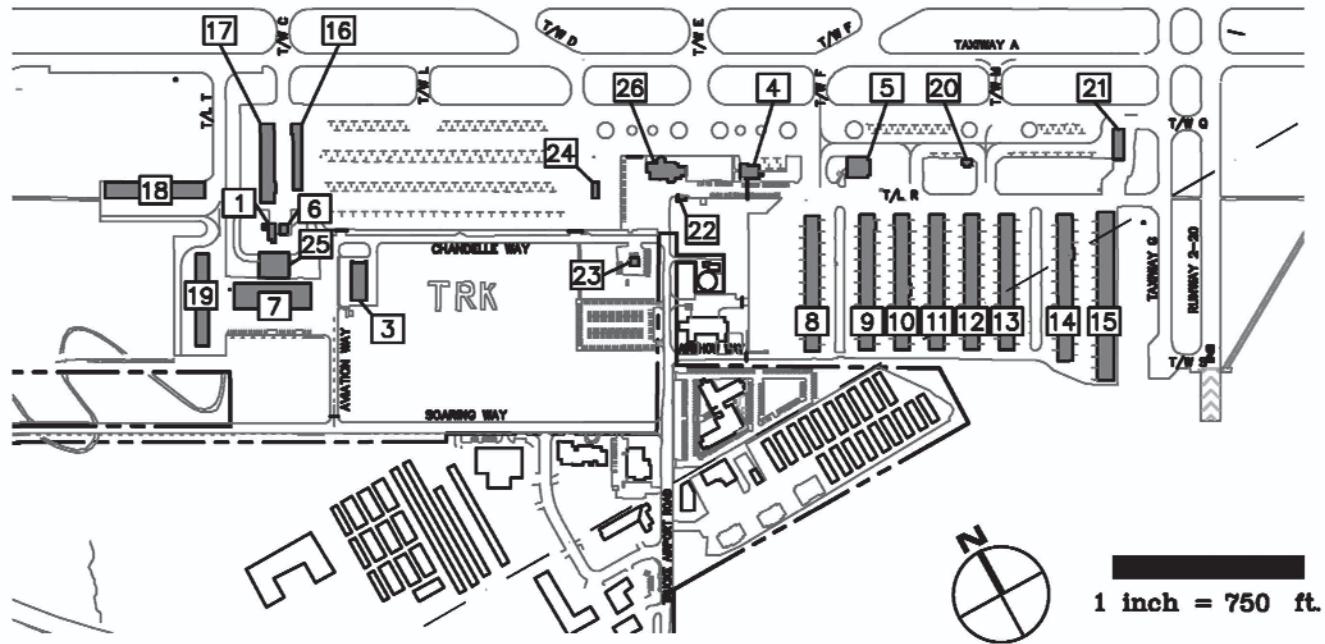
SOURCE: USGS TRUCKEE, CA, 7.5 MINUTE TOPOGRAPHIC MAP, 1992.

N.T.S.

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SITE VICINITY MAP
TTAD FACILITIES MAINTENANCE
MASTER PLAN
TRUCKEE, CALIFORNIA

PROJECT NO.: 41377A-01
DATE: JULY 2013
FIGURE NO.: 1



Number	Facility	Year Built	Square Feet	Construction Type
1	West Side Modular	1991 ±	1,728	Wood Frame
2	Accounting Modular	2003	400	Wood Frame
3	Maintenance Building	1998	9,352	Metal
4	Hangar 2	1966 ±	3,126	Metal
5	Hangar 1	1963 ±	7,500	Metal
6	Garage	1991	1,140	Metal
7	Warehouse	1974	30,000	Metal
8	Hangar Row A	1984	29,680	Metal
9	Hangar Row B	1977	29,680	Metal
10	Hangar Row C	1976	29,680	Metal
11	Hangar Row D	1981	29,680	Metal
12	Hangar Row E	1981	29,680	Metal
13	Hangar Row F	1987	29,680	Metal
14	Hangar Row G	1988	32,200	Metal
15	Hangar Row H	1991	42,250	Metal
16	Hangar Row J	1970	8,840	Metal
17	Hangar Row K	1981	16,740	Metal
18	Hangar Row L	2005	24,304	Metal
19	Hangar Row M	2005	18,514	Metal
20	Phoenix Hangar	1985?	1,000	Metal
21	EAA	1963?	5,043	Metal & wood
22	Generator Building	1990	260	Metal
23	Auto Rental Building	1978?	570	Wood Frame
24	Self Serve Tank	1999		Steel tank
25	Fuel Farm	1996		Steel tanks & canopy
26	Admin Building	2012	11,556	Steel, wood, concrete

MODIFIED TTAD AIRPORT FACILITIES DRAWING PREPARED BY ACUMEN ENGINEERING COMPANY DATED FEBRUARY 4, 2013.

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SITE PLAN
TTAD FACILITIES MAINTENANCE
MASTER PLAN
TRUCKEE, CALIFORNIA

PROJECT NO.: 41377A-01

DATE: JULY 2013

FIGURE NO.: 2

APPENDIX A

**Table 1, Existing Buildings and Previous
Investigations**

Table 1
Truckee Tahoe Airport Facilities Master Plan
Existing Buildings and Previous Investigations

Building No	Building Name	Year Built	Construction Type	Foundation Type	Previous Investigation	Subsurface Soil Conditions	Plans	Comments
1	West Side	1991	Wood ± (Modular)	RW PF (o)	NA		NA	
2	Accounting	2003				Building to be surplus		
3	Maintenance	1998	Metal	SOG (o)	Test Pits TP-1 and TP-2 (Kleinfielder 1991) ¹ Boring T5 (AMEC 2003)	Loose ML to 1.5 feet, dense SM to GM to 4.5 feet. SC with gravel, cobbles, and boulders to 3.25 feet	SOG PF (1997)	Low plasticity
4	Hangar 1 (designated as Sierra Aero)	1963	Metal ±	SOG IP (o)	¹ B-9 (Agra 1998a)	Dense to very dense SC with gravel to 6.5 feet	SOG PF with circular interior columns (1965)	Low plasticity Possible settlement of pier on south side. Soil on west side higher than slab

Table continued on following page.

Table 1 - Continued
 Truckee Tahoe Airport Facilities Master Plan
 Existing Buildings and Previous Investigations

Building No	Building Name	Year Built	Construction Type	Foundation Type	Previous Investigation	Subsurface Soil Conditions	Plans	Comments
5	Hangar 2 (designated as Hangar 1 in field)	1966 ±	Metal	SOG IP (o) Possible PF?	NA	NA	NA	Minor cracking in slab. No significant vertical offset.
6	Garage	1991	Metal		NA		SOG PF (1992)	Low plasticity
7	Warehouse	1974	Metal	SOG IP (o)	¹ Boring SWE1 (AMEC 2003)	Loose to dense SC with gravel and cobbles to 5.5 feet	SOG IP (square) (1973)	Low plasticity Boulders ???
8	Hangar Row A	1984	Metal	SOG PF (o)	Agra (1997)	Stiff to hard ML, GM, and SC with gravel to 5 feet over medium dense to very dense SM with gravel to 9 feet	SOG PF (1986)	Low to medium plasticity
9	Hangar Row B	1977	Metal	SOG IP (round) with AC floor (o)	Borings B-1 through B-4 Agra (1999)	Loose to very dense SM and SC with gravel to 6.5 feet	SOG PF (1975)	Low plasticity Spalling at pier and door buckling.
10	Hangar Row C	1976	Metal	SOG IP (o)	Borings B-1 through B-4 Agra (1999)	Loose to very dense SM and SC with gravel to 6.5 feet	NA	1 to 1.5 inch vertical difference between slab and footing.
					Boring B-14 (Agra 1998b)	Medium dense SC with gravel to 6.5 feet		

Table continued on following page.

Table 1 - Continued
 Truckee Tahoe Airport Facilities Master Plan
 Existing Buildings and Previous Investigations

Building No	Building Name	Year Built	Construction Type	Foundation Type	Previous Investigation	Subsurface Soil Conditions	Plans	Comments
11	Hangar Row D	1981	Metal	IP with AC floor (o)	Boring B-15 (Agra 1998b)	Medium dense to dense SC with gravel to 6.5 feet	NA	Low plasticity
12	Hangar Row E	1981	Metal	SOG IP with AC floor (o)	Boring B-5 (Agra 1999)	Medium dense to dense SM with gravel and some cobbles to 6.5 feet	NA	Low plasticity
					Boring B-16 (Agra 1997a)	Medium dense to dense SC (FILL) to 6.5 feet		
13	Hangar Row F	1987	Metal	SOG IP (o)	Boring B-5 (Agra 1999)	Medium dense to dense SM with gravel and some cobbles to 6.5 feet	SOG PF (1986)	Low plasticity
					Boring B-16 (Agra 1997a)	Medium dense to dense SC (FILL) to 6.5 feet		Minor slab heave.
14	Hangar Row G	1988	Metal	SOG IP? Possible PF? with AC floor (o)	TPs-2, -3, -4, -5 (Kleinfelder 1989)	Hard ML and dense SM 4 to 8 feet	SOG PF (1990)	Low plasticity
								Minor to mod. Slab cracking.

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Table 1 - Continued
 Truckee Tahoe Airport Facilities Master Plan
 Existing Buildings and Previous Investigations

Building No	Building Name	Year Built	Construction Type	Foundation Type	Previous Investigation	Subsurface Soil Conditions	Plans	Comments
15	Hangar Row H	1991	Metal	SOG IP? (o)	TPs-1, -6, -7, -8, -9 (Kleinfelder 1989)	Hard ML and dense SM 3 to 8 feet	SOG PF (1990)	Low plasticity Minor slab cracking. Water staining on cracks in slab. Concentric cracking.
				Borings B-1 and B-2 (Agra 1997a)		Medium dense to dense GM to SM with gravel and cobbles to 4.5 feet		
					Test Pits TP-1 and TP-2 (Agra 1997a)	GM to SM to 3 feet SC to GC 3 to 8 feet SM to SP 8 to 10 feet - boulders		Upper 3 feet fill with pieces of wood
16	Hangar Row J	1970	Metal	SOG PF and IP with AC floor (o)	¹ B-7 (Agra 1998a) B-17 and B-18 (Stantec 2007)	Medium dense SM with gravel to 6.5 feet	NA	Low plasticity
					¹ B-19 and B-20 (Stantec 2007)	Medium dense SM with gravel and cobbles to 2.5 and 4 feet		Severe spalling where slab is exposed outside of building.
17	Hangar Row K	1981	Metal	IP (circular) with AC floor (o)	B-15 and B-16 (Stantec 2007)	Medium dense SM with gravel to 4 feet	NA	Low plasticity Cracking and settlement at pier. AC patching. Minor to mod. Slab cracking.

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Holdrege & Kull

Table 1 - Continued
 Truckee Tahoe Airport Facilities Master Plan
 Existing Buildings and Previous Investigations

Building No	Building Name	Year Built	Construction Type	Foundation Type	Previous Investigation	Subsurface Soil Conditions	Plans	Comments
18	Hangar Row L	2005	Metal	SOG IP (o)	Borings NHF3, 4, 5, 14 (AMEC 2003)	Loose to dense SC to SM to GC with gravel and cobbles to 6.5 feet	NA	Low to medium plasticity
19	Hangar Row M	2005	Metal	SOG IP (o)	Borings NHF8 and 9 (AMEC 2003)	Loose to dense SM to SC with gravel to 2 feet 2 – 4.75 feet medium dense SM-GM with cobbles	NA	Low plasticity Minor slab cracking and water staining on cracks.
20	Phoenix Hangar	1985?	Metal	SOG (o)	¹ B-2 (Agra 1998a)	Dense SM with gravel to 6.5 feet	SOG PF (1982)	Low plasticity Minor to mod. Slab cracking. Door does not entirely close.
21	EAA	1963?	Metal & Wood	SOG IP (o) Possible PF?	¹ B-1 (Agra 1998a)	Medium dense to dense SC to 6.5 feet	SOG IP (1966)	Low plasticity Slight buckling on door. Pier settlement.
22	Generator	1990	Metal	SOG (o)	¹ B-8 (Agra 1998a)	Dense to very dense SC with gravel to 6.5 feet	NA	Low plasticity Minor to mod. Slab cracking. Soil higher than slab at south side.

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Table 1 - Continued
 Truckee Tahoe Airport Facilities Master Plan
 Existing Buildings and Previous Investigations

Building No	Building Name	Year Built	Construction Type	Foundation Type	Previous Investigation	Subsurface Soil Conditions	Plans	Comments
23	Auto Rental	1978?	Wood	RW partial PF and IP (o)	¹ Boring T3 (AMEC 2003)	Medium dense SC-SM to 4 feet Medium dense SC-SM 4 to 25.75 feet	NA	Low plasticity
24	Self-Serve Tank	1999	Steel tank	SOG (o)	¹ B-14 and B-15 (Agra 1998a)	Medium dense to dense SC with gravel to 4 and 6.5 feet	NA	Low plasticity Poor perimeter drainage.
25	Fuel Farm	1996	Steel tanks & canopy	NA	Test Pits TP-1 and TP-2 (Kleinfelder 1994)	Loose to medium dense SM to 1.75 feet, dense GM and GP to 7 feet.	NA	Low plasticity
26	Administration	2012	Steel, wood, concrete	SOG PF (o)	¹ B-4, B-8, and B-13 (Agra 1998a)	Loose to medium dense SM to SC with gravel and cobbles to 4 and 6.5 feet	SOG PF (2010)	Low plasticity
					B-1 through B-6 (H&K 2009)	Medium dense to very dense SM with gravel and SP-SM to 21.5 feet		Slight AC heaving at north side of building. Scattered boulders up to 1.5 feet in diam.

NOTES:

¹ Location of subsurface exploration is nearby. All others were part of building specific studies and located within and/or adjacent to building footprints.

AC Asphalt concrete
 IP Isolated pier
 PF Perimeter foundation
 RW Raised wood
 SOG Slab-on-grade

Table continued on following page.

NA	Not available
(o)	Observed in field.
(p)	Reviewed on plans.
SM	Silty Sand
SC	Clayey Sand
ML	Sandy Silt
GM	Silty Gravel
SP	Poorly Graded Sand

- Agra (1997a) *Geotechnical Investigation, Truckee/Tahoe Airport, H & I-Row Hangars & Access Road, Truckee, California*, dated September 29, 1997, prepared by Agra Earth & Environmental, Inc.
- Agra (1997b) Geotechnical Investigation Report for New Warehouse Facility at the Truckee Tahoe Airport (AGRA Project No. 7-417-000130) – could not locate report.
- Agra (1998a) *Geotechnical Investigation, Reconstruction of the Main & South Airport Aprons, Access Road and South Apron Extension, Truckee/Tahoe Airport, Truckee, California*, dated November 18, 1998, prepared by Agra Earth & Environmental, Inc.
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Kleinfelder (1991)	<i>Geotechnical Investigation Report, Proposed Maintenance Building, Truckee Tahoe Airport, Truckee, California,</i> dated October 17, 1991, prepared by Kleinfelder.
Kleinfelder (1994)	<i>Geotechnical Investigation Report, Proposed Above Ground Storage Tanks, Truckee Tahoe Airport, Truckee, California,</i> dated May 27, 1994, prepared by Kleinfelder.
SHB Agra (1993)	Geotechnical Investigation Report for Truckee/Tahoe Airport Improvement Project (SHB Project No. E93-8190) – could not locate report.
Stantec (2007)	<i>Geotechnical Investigation, Runway 10/28 and Hangar Rows J & K, Truckee Tahoe Airport, Truckee, California,</i> dated December 20, 2007, prepared by Stantec Consulting, Inc.

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APPENDIX B **Site Photographs**



Photo #1: Heaving along expansion joint inside Hangar F (Building 13).

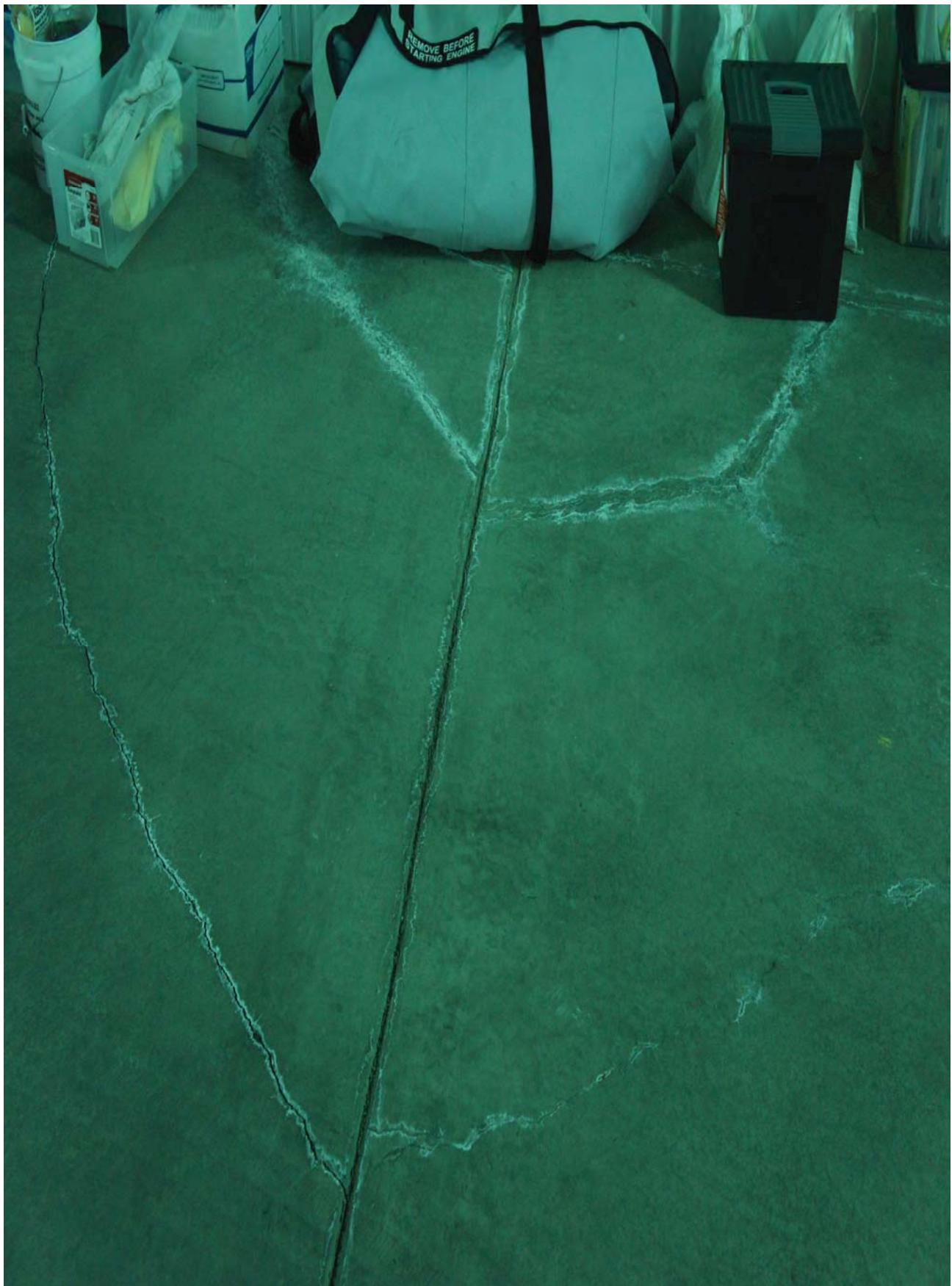


Photo #2: Cracking and moisture staining in slab in Hangar H (Building 15).

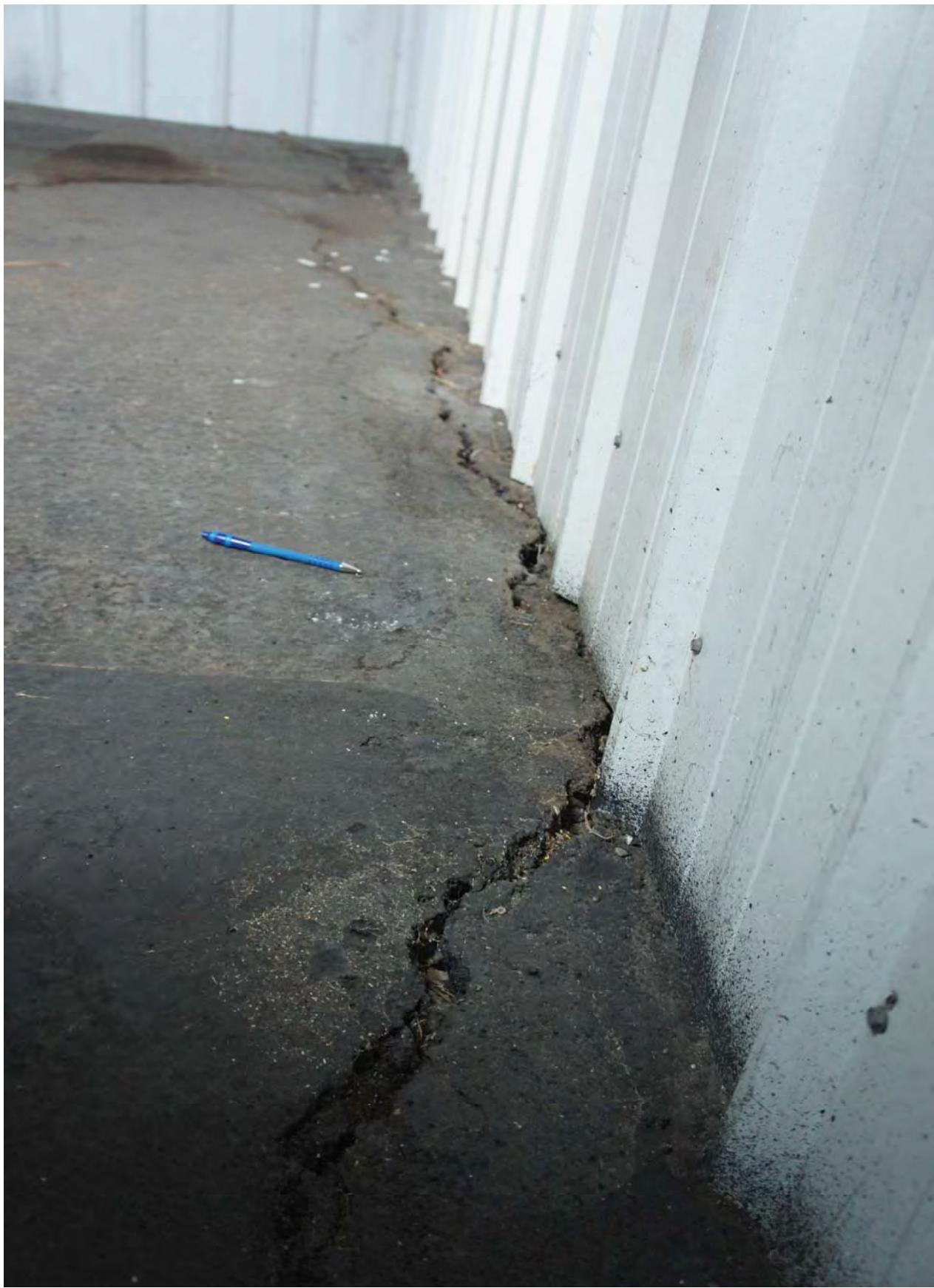


Photo #3: Cracks in asphalt concrete floor inside Hangar K (Building 17). AC is at or above the metal siding level.



Photo #4: Perimeter footing at the EAA structure (Building 21).



Photo #5: Subgrade soil higher than foundation at generator (Building 22).