



# WOOD RODGERS

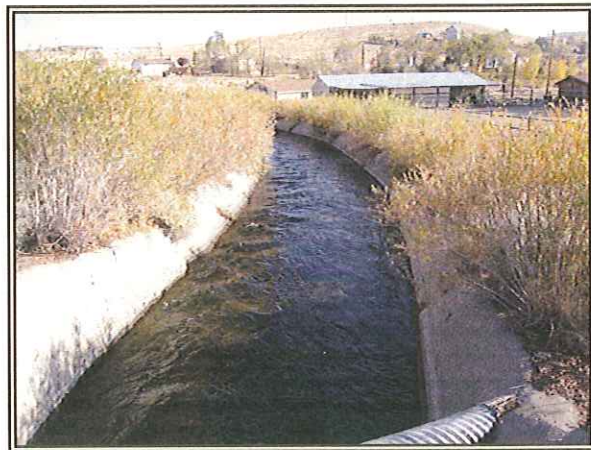
November 4, 2009

Mr. Ron Penrose, PE  
TRUCKEE MEADOWS WATER AUTHORITY  
P.O. Box 30013  
Reno, NV 86520-3013

**RE: HIGHLAND CANAL IMPROVEMENTS  
MESA PARK – TMWA ACCOUNT #01-017**

Dear Mr. Penrose:

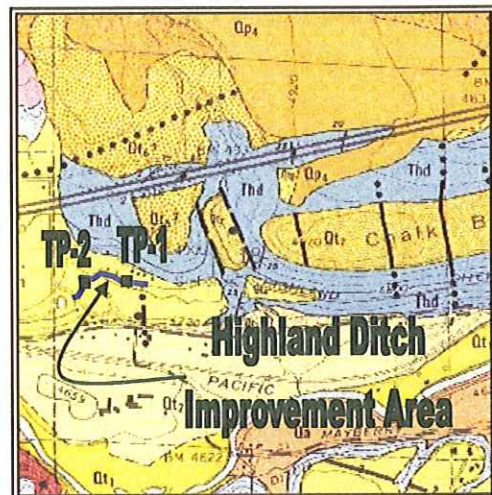
This letter presents the results of our geotechnical investigation for the planned Highland Canal improvements proposed between Mesa Park and Anselmo Drive. It is our understanding the existing canal is to be reconstructed to accommodate increasing the design flow from the current 55 million gallons per day (mgd) to 95 mgd. The existing canal is shown in Figure 1. The canal is typically bordered on both sides with mild slopes extending approximately 2 to 3 feet above top of canal. The slopes and adjacent grades are typically heavily vegetated with willows, brush, and grasses. A maintenance access road parallels the ditch and improvements to this road are also planned as part of the project.



**Figure 1 – Existing Highland Ditch**

Access for our investigation was provided off Mesa Park and Anselmo Drive.

The Highland Ditch is located in an area mapped as Donner Lake Outwash Deposits. This unit is typified by zones of coarse granular deposits containing cobbles and large boulders capped by a strong clay horizon. Our test pits encountered the sandy gravels with cobbles within the western limits (TP-2) of the planned improvements, and the medium to high plastic fines within the eastern limits (TP-1) of the planned improvements. The soils encountered were typically moist, but no free water was encountered in our test pits. Logs of Test Pits, presented with this letter report as Plates A-2a and 2b, discuss the soil types and depths encountered in more detail. The exploration logs represent our interpretation of the subsurface conditions based on our field observations and the indicated laboratory test results. The lines designating the interface between various strata on the test pit records represent the approximate positions of the interface. The actual transition between



**Figure 2 – Geologic Map**

the strata may be gradual or completely irregular. Because of the variation in material properties encountered along the alignment our site preparation and geotechnical recommendations have been prepared to address the more critical condition, i.e. the medium to highly plastic fine grained soils.

In accordance with the 2006 IBC the site is defined as a Site Class D (stiff soil profile) listed in Table 1613.5.2. Based on the average latitude and longitude of the site (39.511 N, -119.899 W), the Site Coefficients  $F_a$  and  $F_v$ , as a function of site class, are 1.0 and 1.5, respectively. A printout of the Spectral Response Accelerations and Design Spectral Response Acceleration Parameters are included in Appendix B of this report (<http://earthquake.usgs.gov/research/hazmaps/design/>).

All vegetation and topsoil should be stripped and grubbed from structural areas and removed from the site or placed in non-structural zones. If strippings are placed in non-structural areas, enough soil should be blended with the organics in order for the material to be adequately moisture conditioned and sufficiently compacted. Where larger brush is encountered, the contractor must demonstrate his ability to blend, moisture condition, and compact the mix prior to allowing placement in nonstructural areas. In addition, the owner's approval must be secured. Because of the limited right-of-way associated with the project, most of the vegetation will likely have to be removed from the project.

Once the existing canal structure has been removed, the exposed subgrade should be excavated to foundation grade beneath planned walls or removed for a depth of at least 6 inches beneath the planned slab-on-grade subgrade to allow for the placement of an aggregate base layer. If minor fills are required to bring subgrade to the design grade, fill meeting the requirements specified in Table 1 shall be used. The exposed soils shall be scarified for a minimum depth of 1 foot and moisture conditioned to at least optimum and compacted to not less than 90 percent of the soils maximum dry density (ASTM D 1557). If soft or pumping subgrade soils are encountered they shall be removed for a depth of 1 foot and replaced with structural fill. The basis for determining 'soft or pumping' shall be if adequate compaction cannot be attained in the layer under consideration. Where exposed subgrade soils exhibit more than 30% of the soil retained on the 3/4 inch sieve, proof-rolling is required to address any loose or disturbed soils. Construction traffic can cause stable soils to begin to pump and due care should be exercised by the contractor.

If structural fill is required, it should meet the requirements established in Table 1. Import structural fill should be qualified and approved before importing.

<b>TABLE 1 - GUIDELINE SPECIFICATION FOR STRUCTURAL FILL</b>	
<b><u>Sieve Size</u></b>	<b><u>Percent by Weight Passing</u></b>
2 Inch	100
3/4 Inch	70 – 100
No. 40	15 – 70
No. 200	20 – 40
<b><u>Maximum Plastic Index</u></b>	
12	

Adjustments to the recommended limits presented in Table 1 can be provided to allow the use of other granular, non-expansive material. Any such adjustments must be made and approved by the geotechnical engineer, in writing, prior to importing fill to the site.

Embankment fills associated with the maintenance access road may be constructed from the on-site soils and do not require structural fill. Embankment fills shall be moisture conditioned to at least optimum and compacted to not less than 90 percent of the soils maximum dry density determined in accordance with ASTM D 1557. The native soils within the western limits of the planned improvements will likely consist of rockfill. Where standard density testing can not be performed, a proof rolling effort consisting of at least five single passes with a minimum 20-ton roller (825 Caterpillar Sheepsfoot compactor, or equivalent) in mass grading, or five complete passes with hand compactors in footing trenches is recommended. This alternate has proven to provide adequate performance as long as all other geotechnical recommendations are closely followed. Monitoring of the proof-rolling program should be provided to establish that no significant increase in measured density is occurring with subsequent passes prior to terminating compaction efforts. The rolling pattern established shall be reported and shall include: number of passes (each way), equipment used, thickness of fill lift, and estimated fraction of the fill passing the  $\frac{3}{4}$ -inch sieve. Density tests and moisture contents should be reported as part of the quality assurance program.

The face of any embankment should be constructed with an inclination of no steeper than 2H:1V. The surface of embankment slopes should be compacted to the same percent compaction as the body of the fill. This may be accomplished by compacting the surface of the embankment as it is constructed or by overbuilding the fill and cutting back to its compacted core. The recommendations presented herein address the structural adequacy of the embankment, and additional considerations may be required to adequately address surface erosion potential.

Concrete slabs-on-grade shall also be underlain by not less than 6 inches of compacted Type 2, Class B aggregate base. Aggregate base shall be compacted to at least 95 percent of the soils' maximum dry density (ASTM D 1557). The adjacent maintenance access road should also be capped by a six inch minimum layer of Type 2, Class B, aggregate base as set for in the Standard Specifications for Public Works Construction. A geomembrane separator is recommended between the embankment soils and base course to help extend the life of the unpaved roadway. US Fabric's US200, or equal, is recommended. Placement and backfill shall be in strict conformance with the manufacturer's recommendations.

Concrete utilized for the project shall be air entrained to between 4  $\frac{1}{2}$  and 6  $\frac{1}{2}$  percent, and shall exhibit a minimum 28 day concrete compressive strength of at least 4,000 pounds per square inch unless a more stringent requirement is specified by the structural engineer or the project documents.

Lateral earth pressures imposed on the canal walls are dependent on the relative rigidity and movement of the structure, soil type, surcharge loading, and moisture conditions behind the wall. Recommended lateral earth pressures are presented in Table 2 – Lateral Earth Pressures. Lateral loads acting on sidewalls may be resisted by passive soil pressure and friction on the bottom of the footing. The recommended coefficient of base friction is 0.4 and has been reduced by a factor of 1.5 on the ultimate soil strength.

TABLE 2 – LATERAL EARTH PRESSURES					
Active Pressure Condition	Level Backslope	2:1 Backslope	3:1 Backslope	Traffic Loading	Passive
Static (psf/f)	37	57	47	240 psf	350
Pseudo-static (psf/f)	48	103	69	240 psf	300
Static w Drain Rock (psf/f)	35	47	40		
Pseudo-static with Drain Rock (psf/f)	45	75	55		

The values presented in Table 2 do not take into account hydrostatic pressures. French drains, a drainage backfill geotextile such as Mirafi 140 N, or a pre-manufactured drain system such as Tensor® DC1200 may be used if hydrostatic pressure buildup is possible. The presented active pressures may be decreased as indicated by the drain rock option in Table 2, if the backfill zone within 1 foot of the wall consists of a granular, free draining, backfill such as Class C drain rock.

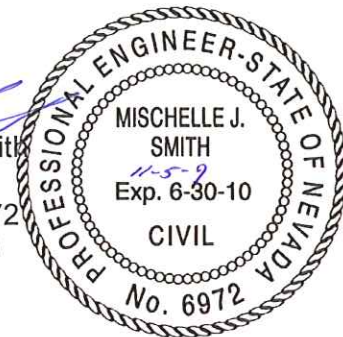
We appreciate the opportunity to provide our services. Please do not hesitate to call if you have any questions or comments.

Sincerely,

**WOOD RODGERS, INC.**

  
 James G. Smith, PE  
 Principal

Mischelle J. Smith  
 Principal  
 RE Number 6972  
 Expires 6-30-10





9475 Double R Boulevard, Reno, NV 89521  
 Phone 775.828.1866 Fax 775.828.1871

**SITE PLAN AND APPROXIMATE  
 EXPLORATION LOCATIONS**

**Geotechnical Investigation  
 HIGHLAND FLUME  
 MESA PARK TO ANSELMO  
 TMWA #01-017**


Project No.: 8040.023  
 Date: 11/02/09

**PLATE  
 A-1**

# LOG OF TEST PIT NO. 1

PROJECT NAME:	HIGHLAND CANAL IMPROVEMENTS
LOCATION:	SEE PLAN
DATE:	10/22/2009

PROJECT NUMBER:	
SURFACE ELEVATION:	SEE PLAN
EXPLORATION EQUIPMENT:	DEERE 310 SG

Depth in Feet	Unified Soil Classification	Graphical Log	Sample	Sample Type	Sample No.	Moisture	Visual Description	Pocket Penetrometer (tsf)	Moisture Content (% of Dry Weight)	Laboratory Tests		
1	ML	FILL				M	0 – 3' FILL – <b>Sandy Silt (ML)</b> – stiff, moist, dark brown					
2												
3	SC					M	3 – 3 ½' <b>Clayey Sand (SC)</b> with Gravel and occasional Cobbles – dense, moist, brown					
4							3 ½ - 8 ½' <b>Sandy Silt (ML)</b> – stiff, moist, brown (45% sand, 54.4% medium plastic fines)					
5												
6	ML					M						
7				B	1A				16.9	A,B		
8												
Bottom of Test Pit at 8½ Feet. No Free Water Encountered												
GROUNDWATER & SOIL MOISTURE				SAMPLE TYPE				LABORATORY TESTS				
□	Depth	Hour	Date	<b>D</b> - DRY				<b>A</b> - Drill Cuttings		<b>B</b> - Bulk Sample	<b>A</b> - Atterberg Limits	
▣	NE		10/22/09	<b>S</b> - SLIGHTLY MOIST				<b>C</b> - CME Sample		<b>R</b> - Rotary Cuttings		<b>B</b> - Grain Size Distribution
▾				<b>M</b> - MOIST				<b>S</b> - 2" O.D. 1.38" I.D. Tube Sample				<b>C</b> - Consolidation
NE- No Free Water Encountered				<b>V</b> - VERY MOIST				<b>U</b> - 3" O.D. 2.42" I.D. Tube Sample		<b>MD</b> - Moisture/Density		
				<b>W</b> - WET				<b>T</b> - 3" O.D. Thin-Walled Shelby Tube		<b>DS</b> - Direct Shear		
 <b>WOOD RODGERS</b>				9475 Double R Boulevard Reno, Nevada 89521 Phone 775.828.1866 Fax 775.828.1871				<b>Plate A-2</b>				


# LOG OF TEST PIT NO. 2

PROJECT NAME:	HIGHLAND CANAL IMPROVEMENTS
LOCATION:	SEE PLAN
DATE:	10/22/2009

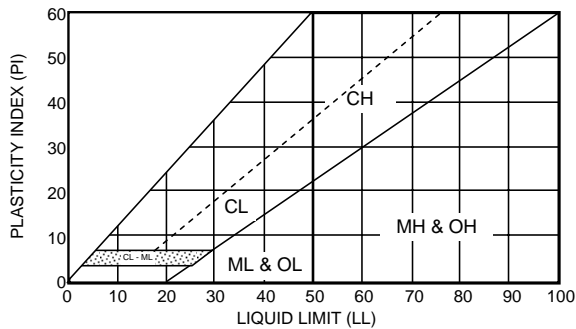
PROJECT NUMBER:	
SURFACE ELEVATION:	SEE PLAN
EXPLORATION EQUIPMENT:	DEERE 310 SG

Depth in Feet	Unified Soil Classification	Graphical Log	Sample	Sample Type	Sample No.	Moisture	Visual Description	Pocket Penetrometer (tsf)	Moisture Content (% of Dry Weight)	Laboratory Tests
0	GP	BASE					0 – 8" <b>Aggregate Base (GP)</b>			
1							8" – 3' <b>FILL – Sandy Gravel (GP)</b> – medium dense, slightly moist, brown			
2	GP	FILL				S				
3							3 – 9' <b>Clayey Sand with Gravel, Cobbles, and small Boulders (GP)</b> – dense, slightly moist, brown (35% gravel, 41% sand, 24.3% medium plastic fines)			
4										
5										
6	GP			B	2A	S		13.8	A,B	
7										
8										
9										
Bottom of Test Pit @ 9 Feet No Free Water Encountered										

GROUNDWATER & SOIL MOISTURE				SAMPLE TYPE		LABORATORY TESTS	
	Depth	Hour	Date	D - DRY	A - Drill Cuttings	B - Bulk Sample	A- Atterberg Limits
∇	NE		10/22/09	S - SLIGHTLY MOIST	C - CME Sample	R - Rotary Cuttings	B- Grain Size Distribution
▼				M - MOIST	S- 2" O.D. 1.38" I.D. Tube Sample		C- Consolidation
NE- No Free Water Encountered				V - VERY MOIST	U- 3" O.D. 2.42 " I.D. Tube Sample		MD- Moisture/Density
				W - WET	T- 3" O.D. Thin-Walled Shelby Tube		DS - Direct Shear

	9475 Double R Boulevard Reno, Nevada 89521 Phone 775.828.1866 Fax 775.828.1871	<div style="border: 2px solid black; padding: 5px; display: inline-block;"> <b>Plate A-2</b> </div>
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MAJOR DIVISION					TYPICAL NAMES
COARSE-GRAINED SOILS MORE THAN HALF IS COARSER THAN NO. 200 SIEVE	GRAVEL MORE THAN HALF COARSE FRACTION IS LARGER THAN NO. 4 SIEVE	CLEAN SANDS WITH LITTLE OR NO FINES		GW	WELL GRADED GRAVELS WITH OR WITHOUT SAND, LITTLE OR NO FINES
		GRAVELS WITH OVER 12% FINES		GP	POORLY GRADED GRAVELS WITH OR WITHOUT SAND, LITTLE OR NO FINES
				GM	SILTY GRAVELS, SILTY GRAVELS WITH SAND
				GC	CLAYEY GRAVELS, CLAYEY GRAVELS WITH SAND
	SAND MORE THAN HALF COARSE FRACTION IS SMALLER THAN NO. 4 SIEVE	CLEAN SANDS WITH LITTLE OR NO FINES		SW	WELL GRADED SANDS WITH OR WITHOUT GRAVEL, LITTLE OR NO FINES
		SANDS WITH OVER 12% FINES		SP	POORLY GRADED SAND WITH OR WITHOUT GRAVEL, LITTLE OR NO FINES
				SM	SILTY SANDS WITH OR WITHOUT GRAVEL
				SC	CLAYEY SANDS WITH OR WITHOUT GRAVEL
FINE-GRAINED SOILS MORE THAN HALF IS FINER THAN NO. 200 SIEVE	SILT AND CLAY  LIQUID LIMIT 50% OR LESS			ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTS WITH SANDS AND GRAVELS
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY CLAYS WITH SANDS AND GRAVELS, LEAN CLAYS
				OL	ORGANIC SILTS OR CLAYS OF LOW PLASTICITY
	SILT AND CLAY  LIQUID LIMIT GREATER THAN 50%			MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOLID, ELASTIC SILTS
				CH	INORGANIC CLAYS OR HIGH PLASTICITY, FAT CLAYS
				OH	ORGANIC SILTS OR CLAYS MEDIUM TO HIGH PLASTICITY
HIGHLY ORGANIC SOILS				Pt	PEAT AND OTHER HIGHLY ORGANIC SOILS



CONSISTENCY		RELATIVE DENSITY	
SILTS & CLAYS	SPT BLOW* COUNTS (N)	SANDS & GRAVELS	SPT BLOW* COUNTS (N)
VERY SOFT	0 - 2	VERY LOOSE	0 - 4
SOFT	3 - 4	LOOSE	5 - 10
MEDIUM STIFF	5 - 8	MEDIUM DENSE	11 - 30
STIFF	9 - 15	DENSE	31 - 50
VERY STIFF	16 - 30	VERY DENSE	50 +
HARD	30 +		

\* The Standard Penetration Resistance (N) in blows per foot is obtained by the ASTM D1585 procedure using 2" O.D., 1 3/8" I.D. samplers.

DESCRIPTION OF ESTIMATED PERCENTAGES OF GRAVEL, SAND, AND FINES	
TRACE	Particles are present but est. < 5%
FEW	5% - 10%
LITTLE	15% - 20%
SOME	30% - 45%
MOSTLY	50% - 100%

NOTE: Percentages are presented within soil description for soil horizon with laboratory tested soil samples.

DEFINITIONS OF SOIL FRACTIONS	
SOIL COMPONENT	PARTICLE SIZE RANGE
COBBLES	ABOVE 3 INCHES
GRAVEL	3 IN. TO NO. 4 SIEVE
COARSE GRAVEL	3 IN. TO 3/4 IN.
FINE GRAVEL	3/4 IN. TO NO. 4 SIEVE
SAND	NO. 4 TO NO. 200
COARSE SAND	NO. 4 TO NO. 10
MEDIUM SAND	NO. 10 TO NO. 40
FINE SAND	NO. 40 TO NO. 200
FINES (SILT OR CLAY)	MINUS NO. 200 SIEVE



**WOOD RODGERS**  
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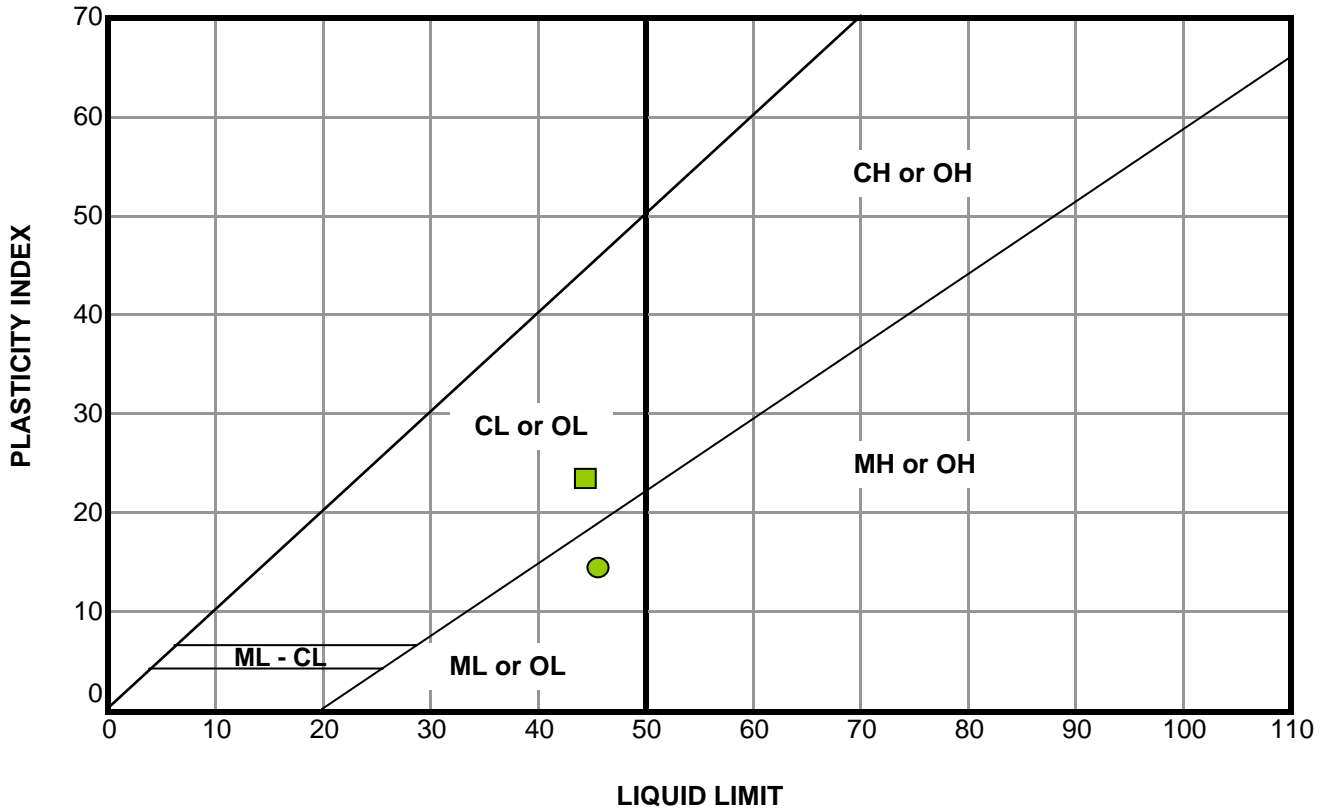
**UNIFIED SOIL  
CLASSIFICATION  
AND  
KEY TO SOIL DESCRIPTIONS**

**Geotechnical Investigation  
HIGHLAND FLUME  
MESA PARK TO ANSELMO  
TMWA #01-017**

Project No.: 8040.023  
Date: 11/02/09

**PLATE  
A-3**

**SUMMARY OF TEST DATA**



**SUMMARY OF TEST DATA**

SYMBOL	LOCATION	DEPTH (FEET)	NATURAL WATER CONTENT	- # 200 (%)	LIQUID LIMIT (%)	PLASTIC LIMIT (%)	PLASTICITY INDEX	USCS
●	TP-1	6 - 8'	16.9	54.4	46	31	15	ML
■	TP-2	4 - 8'	13.8	24.3	44	21	23	SC



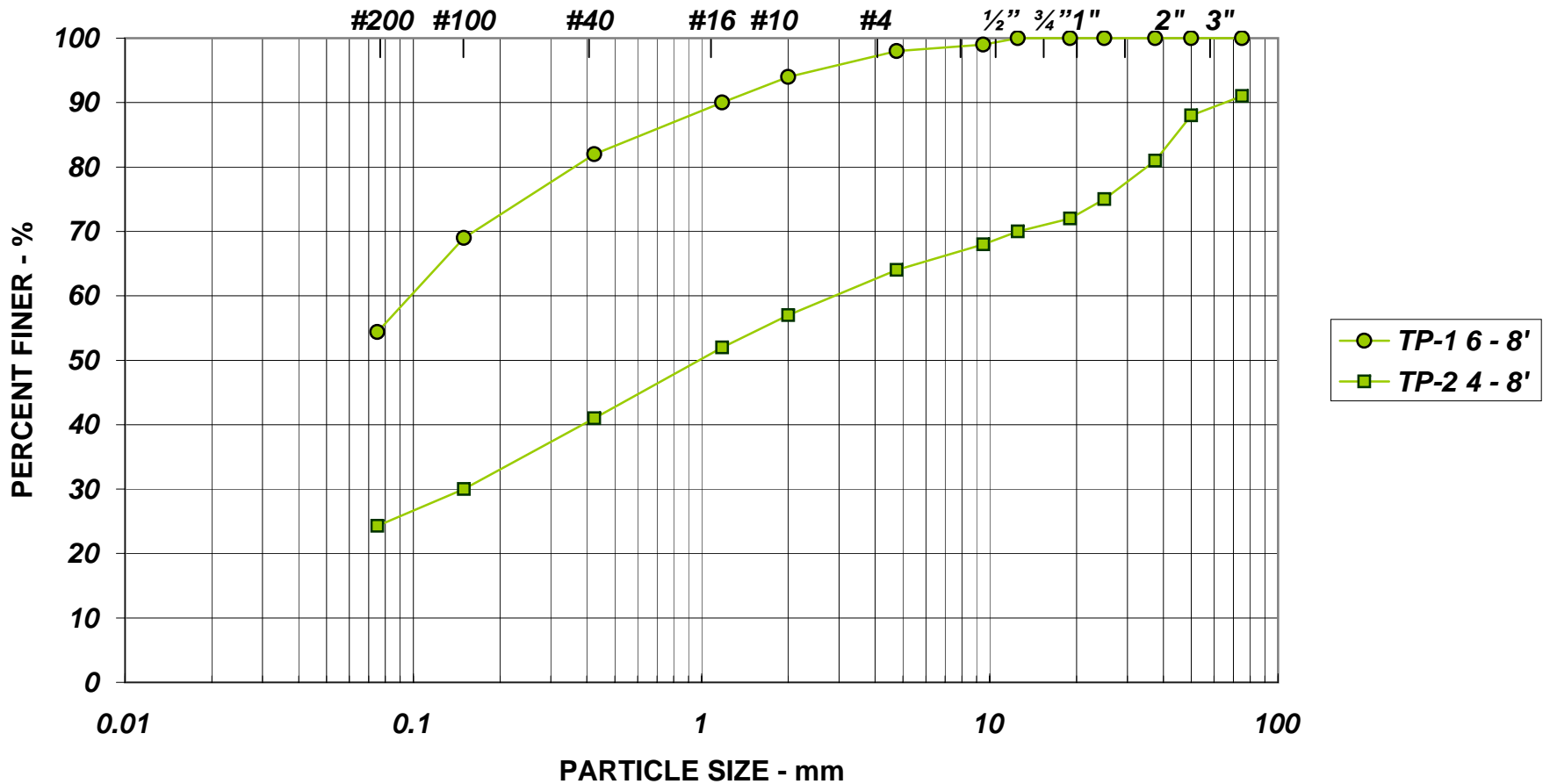
**SUMMARY OF TEST RESULTS**

*Geotechnical Investigation*  
**HIGHLAND FLUME**  
**MESA PARK TO ANSELMO**  
**TMWA #01-017**

Project No.: 8040.023  
 Date: 11/02/09

**PLATE**  
**A-4a**

# PARTICLE SIZE ANALYSES



$\gamma$  - unit weight of soil (pcf)  
 $k_v$  - vertical acceleration in g's  
 $h$  - height of structure  
 $\phi$  - internal friction angle of soil  
 $\psi$  -  $\arctan(k_h/1-k_v)$  = seismic inertia angle  
 $k_h$  - horizontal acceleration in g's  
 $\theta$  - inclination of interface with respect to vertical  
 $\xi$  - soil-structure friction angle

Radians Degrees

120	120
0	0
1	1
0.5582	32.0
0.1500	8.6
0.1500	8.6
0	0
0	0

$\beta$  - inclination of soil surface (upwards from structure is positive)

Backfill Slope		Toe Slope	
0.4640	26.6	0.0000	0

**$K_A$  &  $K_{AE}$**

	Radians	Degrees
$\phi - \psi - \theta$	0.4082	23.4
$\psi + \theta + \xi$	0.1500	8.6
$\phi + \xi$	0.5582	32
$\phi - \psi - \beta$	0.0000	0.0
$\beta - \theta$	0.4640	26.6
$\cos^2(\phi - \psi - \theta)$	0.8424	0.8424
$\cos(\psi)$	0.9888	0.9888
$\cos^2(\theta)$	1	1
$\cos(\psi + \theta + \xi)$	0.9888	0.9888
$\sin(\phi + \xi)$	0.5297	0.5297
$\sin(\phi - \psi - \beta)$	0.0000	0.0000
$\cos(\beta - \theta)$	0.8943	0.8943
$K_A$	0.4709	
$K_A * \gamma$	57	
$K_{AE}$	0.8617	0.8617
$K_{AE} * \gamma$	103	

**$K_P$  &  $K_{PE}$**

	Radians	Degrees
$\phi - \psi + \theta$	0.4082	23.4
$\psi - \theta + \xi$	0.1500	8.6
$\phi - \xi$	0.5582	32.0
$\phi - \psi + \beta$	0.4082	23.4
$\beta - \theta$	0.0000	0
$\cos^2(\phi - \psi + \theta)$	0.8424	0.8424
$\cos(\psi)$	0.9888	0.9888
$\cos^2(\theta)$	1	1
$\cos(\psi - \theta + \xi)$	0.9888	0.9888
$\sin(\phi - \xi)$	0.5297	0.5297
$\sin(\phi - \psi + \beta)$	0.3970	0.3970
$\cos(\beta - \theta)$	1.0000	1.0000
$K_P$	3.2524	
$K_P * \gamma$	390	
$K_{PE}$	2.9675	2.9675
$K_{PE} * \gamma$	356	

\* $k_h$  = 0.5 Peak Ground Acceleration

	2:1	3:1
0.4636	26.6	
0.3805	21.8	
0.3218	18.4	

		Active		Pass	
		2:1	3:1	Level	Level
Clayey Sand	$K_A$	57	47	37	390
	$K_{AE}$	103	69	48	356
Sandy Gravel	$K_A$	48	41	34	500
	$K_{AE}$	87	61	45	460

**DRIVING WEDGE  $P_{AE} = \frac{1}{2} K_{AE} \gamma h^2$**

**RESISTING WEDGE  $K_{PE} = \frac{1}{2} K_{PE} \gamma h^2$**

$P_{AE}$  and  $P_{PE}$  are the combined static and dynamic forces due to the driving and resisting wedges, respectively.

EC 1110-2-6058 Department of The Army - US ACOE



**WOOD RODGERS**  
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**STATIC AND DYNAMIC EARTH PRESSURES  
(MONONOBÉ-OKABE)**

**Geotechnical Investigation  
HIGHLAND FLUME  
MESA PARK TO ANSELMO  
TMWA #01-017**

Project No.: 8040.023  
Date: 11/02/09

**PLATE  
A-1**