IGES®

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March 29, 2012

Chad Husband Construction Inc.
c/o Mr. Richard Marshall
875 South Chestnut Street
Salt Lake City, Utah 84104

IGES Project No. 01289-004

Geotechnical Investigation
Westinghouse Monopole
10000 West 900 South
South Ogden, Utah

Mr. Marshall:

As requested, Intermountain GeoEnvironmental Services, Inc. (IGES) has conducted a geotechnical investigation for the proposed new Century Link monopole (cell tower) to be constructed at the Westinghouse facility at 10000 West 900 South in South Ogden, Utah (See Figure A-1).

Our understanding of the project is based on the *Slab Foundation Layout* by Valmont Microflect, dated February 1, 2012, and other information provided by the Client. We understand that a 100-foot tall monopole will be constructed at Westinghouse's Western Zirconium facility located west of South Ogden, Utah. The new monopole will be, in effect, a cell tower to accommodate internet access. Based on the plans provided, we understand that a conventional mat foundation is planned. The plans indicate that the mat foundation will have a maximum footprint of 14 ft.x14 ft.; the bottom of the mat is shown as approximately 3.5 feet below grade (2-ft. thick slab with 1.5 ft. burial). According to the structural plans provided the foundation elements will be subjected to a vertical load of about 7.8 kips, a base moment 374 kip-ft, and a base shear of 5.5 kips (factored loads). We understand that the referenced plans are preliminary, subject to revision based on the results of this geotechnical investigation.

Subsurface Conditions

As a part of this investigation, subsurface soil conditions were explored by drilling two hollow-stem auger borings to a maximum depth of 20 feet below the existing surface. The approximate location of the borings is depicted on the *Geotechnical Map*, Figure A-2 in Appendix A. Subsurface soil conditions as encountered in the borings were logged at the time of our investigation by a member of our technical staff and are presented on the enclosed boring logs, Figures A-3 and A-4, in Appendix A. A *Key to Soil Symbols and Terminology* is presented on Figure A-5.

The borings were advanced with the aid of a CME75 truck-mounted drill rig. Relatively 'undisturbed' samples were obtained using a 2.5-inch I.D. Dames & Moore ring split spoon sampler. Bulk soil samples were also obtained using a Standard Penetration Test (SPT) split-spoon sampler. The soils observed in the explorations were logged and classified in general accordance with the *Unified Soil Classification System* (USCS). Classifications for the individual soil units are shown on the attached boring logs (Figures A-3 and A-4). The subsurface conditions encountered during our subsurface exploration are discussed below.

Earth Materials: The site is currently overlain by approximately 3 inches of asphalt and between 12 and 16 inches of road base. To a depth of about 15 feet, the pavement section is underlain by medium stiff Silty CLAY (CL-ML) and Lean CLAY (CL) with sand, grading to fine-grained Silty, Clayey SAND (SC-SM). Although much of the soil in the upper 15 feet classifies as granular (SC-SM), the fines fraction (silt, clay) is expected to dominate the soil's behavioral (engineering) characteristics. Below 15 feet, we encountered granular soils that generally classified as either Silty SAND (SM) or Clayey SAND (SC). The sandy soils and clay below 10 feet were generally blue-gray in color, suggesting an anaerobic depositional environment (i.e., undisturbed native soils). Fill soils were not identified; however, we cannot preclude the possible presence of undocumented fill.

Groundwater: Groundwater was encountered at a depth of 11 feet below surface grade (surface of the asphalt). Since our subsurface exploration is limited it is not possible to ascertain whether the water observed is a locally perched groundwater condition or the regional piezometric groundwater surface; however, based on our experience in the area, the groundwater level observed is probably representative of the regional groundwater level. Due to the season of our investigation (late winter), groundwater levels are expected to be near their seasonal average. It is our experience that during snowmelt, runoff, irrigation on surrounding properties, high precipitation events, and other activities, the groundwater level can rise several feet. Fluctuations in the groundwater level should be expected over time.

Strength of Earth Materials: A representative sample of the clayey soils encountered was tested to evaluate the inherent strength properties of site soils. An unconsolidated-undrained (UU) test (ASTM D2850) was completed on a relatively 'undisturbed' sample retrieved from a depth of 10 feet. The test indicated the sample tested had an undrained shear strength (S_u) of approximately 2,500 psf (about half of the deviator stress at failure). The results of the UU test are presented in Appendix B.

Compressible Soils: A consolidation test (ASTM D2435) was performed on a relatively 'undisturbed' sample of native clay soil. The result of the test suggests that the native clay soils are highly over-consolidated (OCR~6.5), suggesting that moderate foundation loads (up to about 2,000 psf) would result in minor consolidation settlement (i.e., applied loads would not exceed the estimated pre-consolidation stress). The results of the consolidation tests are presented in Appendix B.

Faulting and Seismicity

There are no known active faults that are mapped under the site (Black et al., 2003). The closest mapped active fault is the East Great Salt Lake Fault Zone (EGSLFZ), a series of east-dipping normal faults located approximately 17 km west of the site. Much of the EGSLFZ is located within the Great Salt Lake; as such, the location and displacement of the fault zone is largely based on seismic reflection data (Hecker, 1993). The EGSLFZ is estimated to have an average slip rate of about 0.3-0.5mm/year. Although poorly understood, the EGSLFZ has been assigned a characteristic moment magnitude of 7.1 by the USGS (Promontory segment).

The site is located approximately 24 km west of the main trace of the Brigham City segment of the Wasatch Fault Zone (WFZ) (Black et al. 2003). The WFZ is a series of normal faults that marks the eastern boundary of the Intermountain Seismic Belt (ISB) through northern and central Utah. The WFZ is comprised of five major north-south trending segments that extend southward from Brigham City to Nephi. The Brigham City segment is reported to be active and thought to have a mean return period of ~1,300 years (Black et al., 2003). Analyses of ground shaking hazard along the Wasatch Front suggests that the WFZ is the single greatest contributor to the seismic hazard in the Salt Lake City region.

Seismic hazard maps depicting probabilistic ground motions and spectral response have been developed for the United States by the U.S. Geological Survey as part of NEHRP/NSHMP (Frankel et al, 1996). These maps have been incorporated into both *NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures* (FEMA, 1997) and the *International Building Code* (IBC) (International Code Council, 2009). Spectral responses for the Maximum Considered Earthquake (MCE) are shown in the following table. These values generally correspond to a two percent probability of exceedance in 50 years (2PE50) for a "firm rock" site. To account for site effects, site coefficients which vary with the magnitude of spectral acceleration are used. Based on our field exploration, it is our opinion that this location is best described as a Site Class D. The spectral accelerations are calculated based on the site's approximate central latitude and longitude of 41.2607˚ and -112.2313˚ respectively. Based on IBC, the site coefficients are F_a=1.165 and F_v= 1.741. From this procedure the peak ground acceleration (PGA) is estimated to be 0.391g. The MCE PGA and design response spectrum are presented in Appendix C on Figure C-1.

MCE Seismic Response Spectrum Spectral Acceleration Values for IBC Site Class D [a]	
Site Location: Latitude = 41.2607 N Longitude = -112.2313 W	**Site Class D Site Coefficients: Fa = 1.165 Fv = 1.741**
Spectral Period (sec)	**Response Spectrum Spectral Acceleration (g)**
0.2	0.838xFa =**0.976**
1.0	0.330xFv = **0.574**
[a] IBC 1615.1.3 recommends scaling the MCE values by 2/3 to obtain the design spectral response acceleration values.	

Other Geologic Hazards

Geologic hazards can be defined as naturally occurring geologic conditions or processes that could present a danger to human life and property. These hazards must be considered before development of critical facilities at the site. There are several hazards in addition to seismicity and faulting that may be present at a site, and which should be considered in the design of habitable structures and other critical infrastructure. The hazards considered for this site include shallow groundwater and liquefaction.

Liquefaction: Certain areas within the Intermountain region possess a potential for liquefaction during seismic events. Liquefaction is a phenomenon whereby loose, saturated, granular soil deposits lose a significant portion of their shear strength due to excess pore water pressure buildup resulting from dynamic loading, such as that caused by an earthquake. Among other effects, liquefaction can result in densification of such deposits causing settlements of overlying layers after an earthquake as excess pore water pressures are dissipated. The primary factors affecting liquefaction potential of a soil deposit are: (1) level and duration of seismic ground motions; (2) soil type and consistency; and (3) depth to groundwater.

The tower site is underlain by at least 10 feet of clay, which is generally considered not susceptible to liquefaction. In addition, the tower will have a relatively small footprint (14’x14’ or less). As such, the potential for surface manifestation of liquefaction (sand boils, differential settlement) is considered low.

Shallow Groundwater: At the project site groundwater was encountered at approximately 11 feet below existing site grade (surface of asphalt). Due to the season of our investigation we anticipate that these levels are at or near their seasonal average. The site is located within close proximity to The Great Salt Lake. Typical yearly fluctuations of the groundwater elevation could be on the order of 2-3 feet, depending on seasonal runoff and precipitation and changes in the elevation of the lake. In addition, local groundwater could be influenced by heavy watering of nearby agriculture.

RECOMMENDATIONS

Subgrade Preparation

In consideration of the presence of potentially compressive clays and the relatively high moment applied at the base of the foundation, we recommend the foundation be underlain by a minimum of 18 inches of structural fill. The structural fill should extend a minimum of two feet beyond the foundation. Structural fill should consist of an A-1-a granular material or an approved equivalent, and should be placed and compacted in accordance with the recommendations contained in this letter-report.

Structural Fill and Compaction

All fill placed for the support of the tower foundation should consist of structural fill. Structural fill should be substantially free of vegetation and debris, and have a maximum particle size of 3 inches in diameter. Structural fill should consist of imported A-1-a material. Material not meeting A-1-a specifications may be allowed (such as road base), subject to review and approval by IGES.

All structural fill should be placed in maximum 6-inch loose lifts if compacted by small hand-operated compaction equipment, maximum 8-inch loose lifts if compacted by light-duty rollers, and maximum 10-inch loose lifts if compacted by heavy duty compaction equipment that is capable of efficiently compacting the entire thickness of the lift. Additional lift thickness may be allowed by IGES provided the Contractor can demonstrate sufficient compaction can be achieved with the equipment in use. Soils in compacted fills beneath the tower footing should be compacted to at least 95 percent of the *maximum dry density* as determined by ASTM D-1557. The moisture content should be at or slightly above the *optimum moisture content* for all structural fill. Any imported or locally borrowed fill materials should be approved by IGES prior to use.

Prior to placing any fill, the excavation should be observed by IGES to confirm that unsuitable materials have been removed. Where particularly soft, wet, compressible, or otherwise deleterious earth materials are identified, such materials should be removed prior to placement of structural fill. However, maximum over-excavation need not exceed 3½ feet below the bottom of the foundation.

Foundation Design

Based on the presence of potentially compressive clays and a potentially high moment applied at the base of the foundation, we recommend that the footing for the proposed tower be founded on a minimum of 18 inches of structural fill. All fill beneath the foundations should consist of structural fill and should be placed and compacted in accordance with our recommendations contained in the previous sections of this letter.

A conventional foundation, with maximum footprint of 14’x14’, constructed on a minimum of 18 inches of structural fill, may be proportioned utilizing a maximum net allowable bearing pressure of **3,400 pounds per square foot (psf)** and a *Modulus of Subgrade Reaction* of **200 psi/inch**. The net allowable bearing value presented above are for dead load plus live load conditions. For *transient* wind or seismic loads, the net allowable bearing can be increased by one-third (1/3) (<u>note</u>: for some tower structures, wind loads may not be considered transient – applicability should be determined by the Structural Engineer). The Structural Engineer should also verify that the net allowable bearing pressure presented herein is sufficient to resist non-uniformly distributed bearing pressures resulting from anticipated eccentric loads.

Lateral forces imposed upon conventional foundations due to wind or seismic forces may be resisted by the development of passive earth pressures and frictional resistance between the base of the footing and the supporting soils. In determining the frictional resistance against concrete, a coefficient of friction of 0.50 for granular structural fill should be used. For passive resistance, a lateral pressure coefficient (K_p) of 2.4 should be used (or an equivalent fluid density of 285 pcf). If passive resistance is calculated in conjunction with frictional resistance, the passive resistance should be reduced by ½.

All foundations **exposed to the full effects of frost** should be established at a minimum depth of 30 inches below the lowest adjacent final grade.

Settlement: Static settlement of a properly designed and constructed conventional foundation, founded as described above, are anticipated to be on the order of 1 inch or less. Differential settlement is expected to be less than 1/8 inch.

Soil Corrosion Potential

To evaluate the corrosion potential of concrete in contact with onsite native soil a representative soil sample was tested in our soils laboratory for soluble sulfate content. Laboratory test results indicate that the sample tested had a sulfate content of 84 ppm. Based on this result, the onsite native soils are expected to exhibit a low potential for sulfate attack to concrete. We anticipate that conventional Type I/II cement may be used for all concrete in contact with site soils.

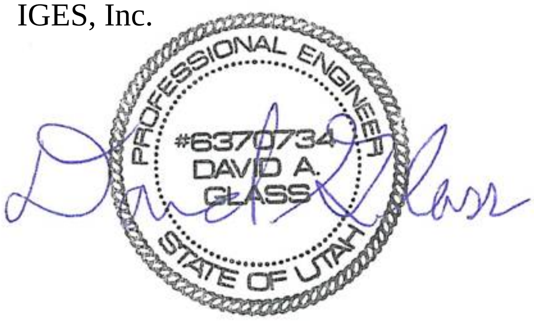
To evaluate the corrosion potential of ferrous metal in contact with onsite native soil, a representative soil sample was tested in our soils laboratory for soil resistivity (AASHTO T288), chloride content, and pH. The tests indicated that the onsite soil tested has minimum soil resistivity of 256 OHM-cm, a chloride content of 1,250 ppm, and a pH value of 7.7. Based on these results, the onsite native soil is considered severely corrosive to ferrous metal. Consideration should be given to retaining the services of a qualified corrosion engineer to provide an assessment of any metal that may be in contact with native soils.

CLOSURE

As with any geotechnical project of this nature, variations in subsurface conditions, both laterally and vertically, may exist that may not be discovered until actual construction. If subsurface conditions encountered during construction differ from those described in the above and used to develop our designs, IGES must be notified immediately in order to evaluate any changed conditions and their potential impacts on our designs. The designs developed and discussed in this document and the attached drawing and specifications were developed to meet the minimum standard of care for similar projects designed and constructed in the local area at the time which they were prepared. No other warrantee or guarantee, express or implied, is made. Recommendations made in this document are subject to change if revisions are made to the current project as planned.

We appreciate the opportunity to be of service on this project. Should you have any questions regarding the report or wish to discuss additional services, please contact the undersigned at your convenience (801) 748-4044.

Sincerely,
IGES, Inc.



David A. Glass, P.E.
Senior Geotechnical Engineer

Reviewed by:

Kent A. Hartley, P.E.
Principal

Attachments:

References

Appendix A	Figure A-1 – Site Vicinity Map Figure A-2 – Geotechnical Map Figures A-3, A-4 – Boring Logs Figure A-5 – Key to Soil Symbols and Terminology
Appendix B	Summary of Laboratory Test Results
Appendix C	Figure C-1 – MCE PGA Design Response Spectra

References

Black, B.D., Hecker, S., Hylland, M.D., Christenson, G.E., and McDonald G.N., 2003, Quaternary Fault and Fold Database and Map of Utah: Utah geological Survey Map 193DM.

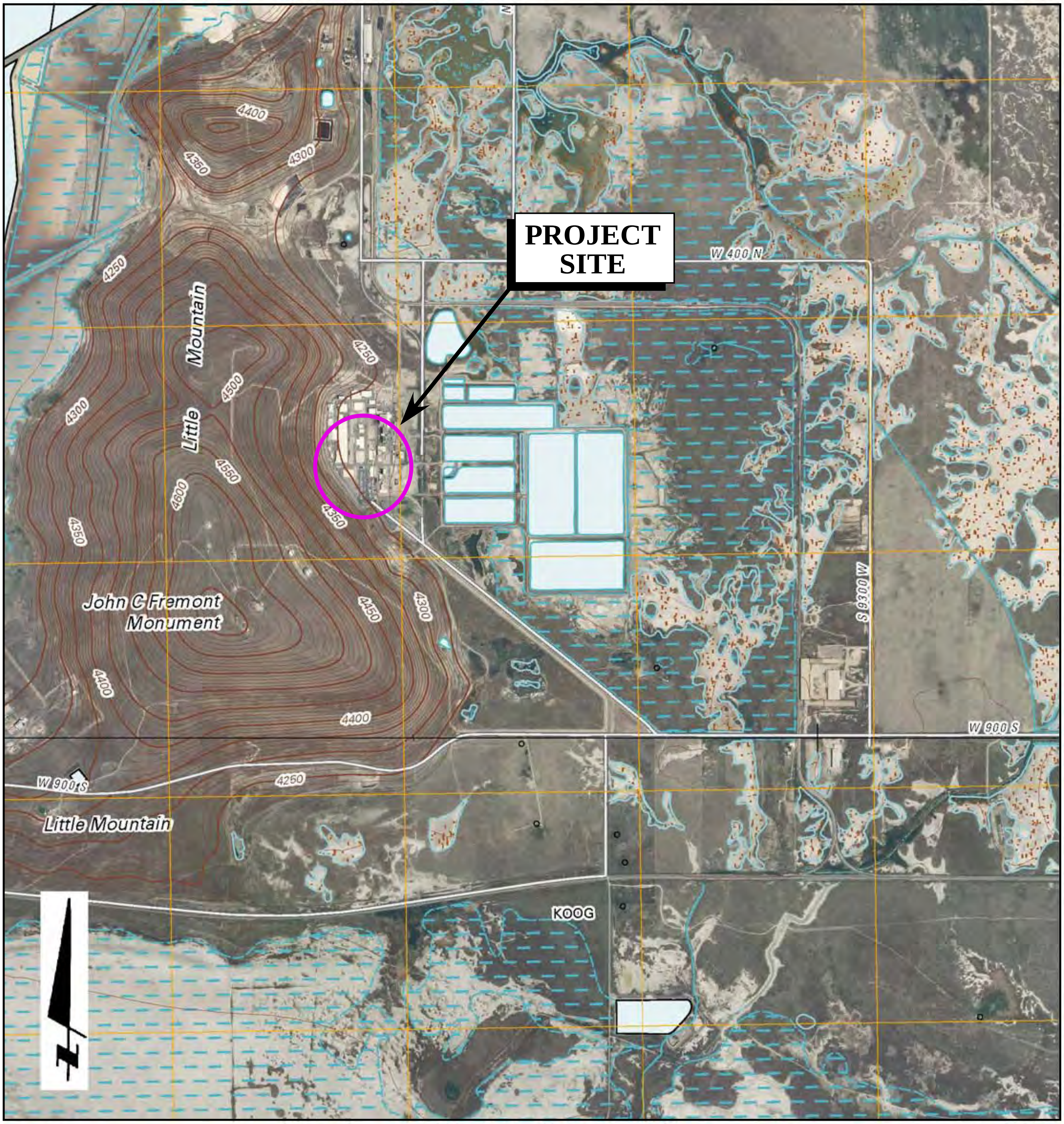
Federal Emergency Management Agency [FEMA], 1997, *NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures*, FEMA 302, Washington, D.C.

Frankel, A., Mueller, C., Barnard, T., Perkins, D., Leyendecker, E.V., Dickman, N., Hanson, S., and Hopper, M., 1996, *National Seismic-hazard Maps: Documentation*, U.S. Geological Survey Open-File Report 96-532, June.

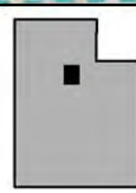
Hecker, S., 1993, Quaternary Tectonics of Utah with Emphasis on Earthquake-Hazard Characterization: Utah Geological Survey Bulletin 127, 157p.

International Building Code [IBC], 2009, International Code Council, Inc.

APPENDIX A



BASE MAPS:
USGS *Plain City* and *Ogden Bay* 7.5-Minute Quadrangle Topographic Maps (2011)



MAP LOCATION

0' 1000' 2000'
SCALE 1:24,000

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Geotechnical Investigation
Westinghouse Monopole
10000 West 900 South
Ogden, Utah

SITE VICINITY MAP

Figure

A-1

SCALE: 1 in. = 40 ft.

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Geotechnical Investigation
Westinghouse Monopole
10000 West 900 South
Ogden, Utah

GEOTECHNICAL MAP

Figure

A-2

DATE	
STARTED:	3/12/12
COMPLETED:	3/12/12
BACKFILLED:	3/12/12

Geotechnical Investigation
Husband/Westinghouse Monopole
Western Zirconium Facility
Ogden Utah
IGES Project Number: 01289-004

IGES Rep: DAG
Rig Type: CME 75
Boring Type: HSA

BORING NO: **B-1**

Sheet 1 of 1

LOCATION

LATITUDE | LONGITUDE | ELEVATION (above m.s.l) feet

Moisture Content and Atterberg Limits: Plastic Limit, Moisture Content, Liquid Limit (10 20 30 40 50 60 70 80 90)

DEPTH (FEET)	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	N	Water Level	Dry Density(pcf)	Moisture Content (%)	Percent minus 200	Liquid Limit	Plasticity Index
0		@ 0'ASPHALT, 3 inches asphalt underlain by ~12 inches road base							
2½	CL-ML	@ 2½' Silty CLAY, medium stiff, low plasticity, moist, dark brown, homogenous, possible trace organic material (topsoil)	17 6 4						
5	SC-SM	@ 5' Silty, Clayey SAND, medium dense, very fine-grained, low plasticity fines, moist, dark brown, homogenous	7 6 9			14	42	24	7
7½		@ 7½' No Recovery	18 11 6						
10	SC-SM	@ 10' Silty, Clayey SAND, medium dense, fine-grained, low-plasticity fines, moist, blue-gray with abundant iron staining	5 6 8	▼		19	40	23	5
15	SC	@ 15' Clayey SAND, medium dense, fine-grained, wet, blue-gray, rock in shoe, some angular rock fragments, low plasticity fines, grades to sandy clay	17 50/4"						
20	SM	@ 20' Silty SAND, medium dense, fine- to medium-grained, trace gravel, wet, moderate brown, non-plastic fines, 1-in. clay lens	10 17 12						

Total depth 21½ feet
Groundwater at 11 feet

Bottom of Boring @ 21.5 Feet

N - OBSERVED BLOW COUNT PER 6 INCHES

SAMPLE TYPE
- 2" O.D./1.38" I.D. Split Spoon Sampler
- 3.25" O.D./2.42" I.D. 'U' Sampler
- 3" O.D. Thin-Walled Shelby Sampler
- Grab Sample
- Modified California Sampler
- Sample from Auger Cuttings

BORING LOG

NOTES:

WATER LEVEL
▼ - MEASURED ▽ - ESTIMATED

Figure A - 3

DATE	
STARTED:	3/12/12
COMPLETED:	3/12/12
BACKFILLED:	3/12/12

Geotechnical Investigation
Husband/Westinghouse Monopole
Western Zirconium Facility
Ogden Utah
IGES Project Number: 01289-004

IGES Rep: DAG
Rig Type: CME 75
Boring Type: HSA

BORING NO: **B-2**
Sheet 1 of 1

LOCATION: LATITUDE | LONGITUDE | ELEVATION (above m.s.l) feet

DEPTH (FEET)	UNIFIED SOIL CLASSIFICATION	MATERIAL DESCRIPTION	N	Water Level	Dry Density(pcf)	Moisture Content (%)	Percent minus 200	Liquid Limit	Plasticity Index
0		@ 0' ASPHALT, 3 in. asphalt over ~16 inches road base							
4		@ 4' refusal (both Shelby and D&M)							
5	CL-ML	@ 5' Silty CLAY, stiff, low plasticity, trace gravel, moist, moderate brown	300psf						
8		@ 8' No Recovery							
10	CL-ML	@ 10' Silty CLAY, very stiff, low plasticity, moist, mottled brown/blue-gray, about 6-in. lens of blue-gray clayey sand w/fine gravel, grades to Silty, Clayey SAND (SC-SM)	9 28 19	▼	119.4	12		26	7
13	SM	@ 13' Silty SAND, medium dense, coarse, non-plastic fines, blue-gray, wet, about 20% subrounded gravel to ½ inch	9 16 20						

Total depth 13½ feet
Groundwater at 11 feet

Bottom of Boring @ 13.5 Feet

Moisture Content and Atterberg Limits: Plastic Limit, Moisture Content, Liquid Limit (10 20 30 40 50 60 70 80 90)

N - OBSERVED BLOW COUNT PER 6 INCHES

SAMPLE TYPE
- 2" O.D./1.38" I.D. Split Spoon Sampler
- 3.25" O.D./2.42" I.D. 'U' Sampler
- 3" O.D. Thin-Walled Shelby Sampler
- Grab Sample
- Modified California Sampler
- Sample from Auger Cuttings

BORING LOG

NOTES:

WATER LEVEL
▼ - MEASURED ▽ - ESTIMATED

Figure A - 4

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UNIFIED SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			USCS SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS (More than half of material is larger than the #200 sieve)	GRAVELS (More than half of coarse fraction is larger than the #4 sieve)	CLEAN GRAVELS WITH LITTLE OR NO FINES	GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES
			GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES WITH LITTLE OR NO FINES
		GRAVELS WITH OVER 12% FINES	GM	SILTY GRAVELS, GRAVEL-SILT-SAND MIXTURES
			GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
	SANDS (More than half of coarse fraction is smaller than the #4 sieve)	CLEAN SANDS WITH LITTLE OR NO FINES	SW	WELL-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES
			SP	POORLY-GRADED SANDS, SAND-GRAVEL MIXTURES WITH LITTLE OR NO FINES
		SANDS WITH OVER 12% FINES	SM	SILTY SANDS, SAND-GRAVEL-SILT MIXTURES
			SC	CLAYEY SANDS SAND-GRAVEL-CLAY MIXTURES
FINE GRAINED SOILS (More than half of material is smaller than the #200 sieve)	SILTS AND CLAYS (Liquid limit less than 50)		ML	INORGANIC SILTS & VERY FINE SANDS, SILTY OR CLAYEY FINE SANDS, CLAYEY SILTS WITH SLIGHT PLASTICITY
			CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
			OL	ORGANIC SILTS & ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS (Liquid limit greater than 50)		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILT
			CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
			OH	ORGANIC CLAYS & ORGANIC SILTS OF MEDIUM-TO-HIGH PLASTICITY
HIGHLY ORGANIC SOILS			PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

LOG KEY SYMBOLS

BORING SAMPLE LOCATION

TEST-PIT SAMPLE LOCATION

WATER LEVEL (level after completion)

WATER LEVEL (level where first encountered)

CEMENTATION

DESCRIPTION	DESCRIPTION
WEAKELY	CRUMBLES OR BREAKS WITH HANDLING OR SLIGHT FINGER PRESSURE
MODERATELY	CRUMBLES OR BREAKS WITH CONSIDERABLE FINGER PRESSURE
STRONGLY	WILL NOT CRUMBLE OR BREAK WITH FINGER PRESSURE

OTHER TESTS KEY

C	CONSOLIDATION	SA	SIEVE ANALYSIS
AL	ATTERBERG LIMITS	DS	DIRECT SHEAR
UC	UNCONFINED COMPRESSION	T	TRIAXIAL
S	SOLUBILITY	R	RESISTIVITY
O	ORGANIC CONTENT	RV	R-VALUE
CBR	CALIFORNIA BEARING RATIO	SU	SOLUBLE SULFATES
COMP	MOISTURE/DENSITY RELATIONSHIP	PM	PERMEABILITY
CI	CALIFORNIA IMPACT	-200	% FINER THAN #200
COL	COLLAPSE POTENTIAL	Gs	SPECIFIC GRAVITY
SS	SHRINK SWELL	SL	SWELL LOAD

MODIFIERS

DESCRIPTION	%
TRACE	<5
SOME	5 - 12
WITH	>12

MOISTURE CONTENT

DESCRIPTION	FIELD TEST
DRY	ABSENCE OF MOISTURE, DUSTY, DRY TO THE TOUCH
MOIST	DAMP BUT NO VISIBLE WATER
WET	VISIBLE FREE WATER, USUALLY SOIL BELOW WATER TABLE

STRATIFICATION

DESCRIPTION	THICKNESS
SEAM	1/16 - 1/2"
LAYER	1/2 - 12"

DESCRIPTION	THICKNESS
OCCASIONAL	ONE OR LESS PER FOOT OF THICKNESS
FREQUENT	MORE THAN ONE PER FOOT OF THICKNESS

GENERAL NOTES

1. Lines separating strata on the logs represent approximate boundaries only. Actual transitions may be gradual.
2. No warranty is provided as to the continuity of soil conditions between individual sample locations.
3. Logs represent general soil conditions observed at the point of exploration on the date indicated.
4. In general, Unified Soil Classification designations presented on the logs were evaluated by visual methods only. Therefore, actual designations (based on laboratory tests) may vary.

APPARENT / RELATIVE DENSITY - COARSE-GRAINED SOIL

APPARENT DENSITY	SPT (blows/ft)	MODIFIED CA. SAMPLER (blows/ft)	CALIFORNIA SAMPLER (blows/ft)	RELATIVE DENSITY (%)	FIELD TEST
VERY LOOSE	<4	<4	<5	0 - 15	EASILY PENETRATED WITH 1/2-INCH REINFORCING ROD PUSHED BY HAND
LOOSE	4 - 10	5 - 12	5 - 15	15 - 35	DIFFICULT TO PENETRATE WITH 1/2-INCH REINFORCING ROD PUSHED BY HAND
MEDIUM DENSE	10 - 30	12 - 35	15 - 40	35 - 65	EASILY PENETRATED A FOOT WITH 1/2-INCH REINFORCING ROD DRIVEN WITH 5-LB HAMMER
DENSE	30 - 50	35 - 60	40 - 70	65 - 85	DIFFICULT TO PENETRATED A FOOT WITH 1/2-INCH REINFORCING ROD DRIVEN WITH 5-LB HAMMER
VERY DENSE	>50	>60	>70	85 - 100	PENETRATED ONLY A FEW INCHES WITH 1/2-INCH REINFORCING ROD DRIVEN WITH 5-LB HAMMER

CONSISTENCY - FINE-GRAINED SOIL

CONSISTENCY	SPT (blows/ft)	TORVANE UNTRAINED SHEAR STRENGTH (tsf)	POCKET PENETROMETER UNCONFINED COMPRESSIVE STRENGTH (tsf)	FIELD TEST
VERY SOFT	<2	<0.125	<0.25	EASILY PENETRATED SEVERAL INCHES BY THUMB. EXUDES BETWEEN THUMB AND FINGERS WHEN SQUEEZED BY HAND.
SOFT	2 - 4	0.125 - 0.25	0.25 - 0.5	EASILY PENETRATED ONE INCH BY THUMB. MOLDED BY LIGHT FINGER PRESSURE.
MEDIUM STIFF	4 - 8	0.25 - 0.5	0.5 - 1.0	PENETRATED OVER 1/2 INCH BY THUMB WITH MODERATE EFFORT. MOLDED BY STRONG FINGER PRESSURE.
STIFF	8 - 15	0.5 - 1.0	1.0 - 2.0	INDENTED ABOUT 1/2 INCH BY THUMB BUT PENETRATED ONLY WITH GREAT EFFORT.
VERY STIFF	15 - 30	1.0 - 2.0	2.0 - 4.0	READILY INDENTED BY THUMBNAIL.
HARD	>30	>2.0	>4.0	INDENTED WITH DIFFICULTY BY THUMBNAIL.

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Key to Soil Symbols and Terminology

Figure A-5

IGES, Inc. Project No.:01289-004

APPENDIX B

Moisture Content and Unit Weight of Soil

(In General Accordance with ASTM D2937 and D2216)

Project: **Husband/Western Zirconium**
No: **01289-004**
Location: Western Zirconium Plant, Ogden
Date: 3/22/2012
By: BRR

Sample Info.	Boring No.	B-1	B-1						
	Sample:								
	Depth:	5'	10'						
Unit Weight Info.	Sample height, H (in)								
	Sample diameter, D (in)								
	Sample volume, V (ft^3)								
	Wt. rings + wet soil (g)								
	Wt. rings/tare (g)								
	Moist soil, Ws (g)								
	Moist unit wt., γ_m (pcf)								
Moisture	Wet soil + tare (g)	437.20	581.20						
	Dry soil + tare (g)	399.13	508.22						
	Tare (g)	122.63	122.08						
Moisture Content, w (%)		**13.8**	**18.9**						
Dry Unit Wt., γ_d (pcf)									

Entered by:___________

Reviewed:___________

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

IGES

Project: **Husband/Western Zirconium**
No: **01289-004**
Location: Western Zirconium Plant, Ogden
Date: 3/23/2012
By: BRR

Boring No.: **B-1**
Sample:
Depth: **5'**
Description: Brown silty clay

Preparation method: Air Dry
Liquid limit test method: Multipoint

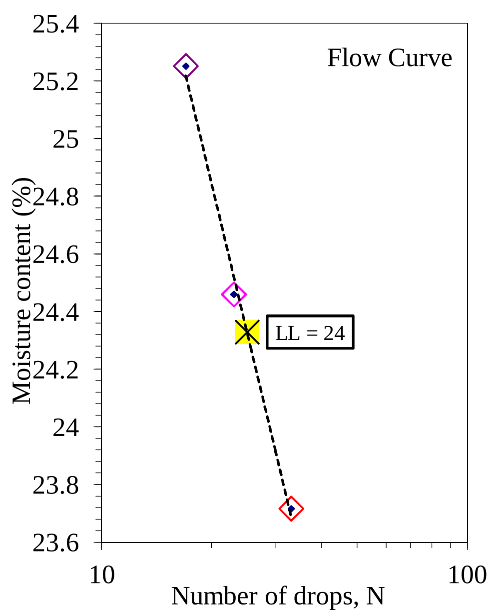
Plastic Limit

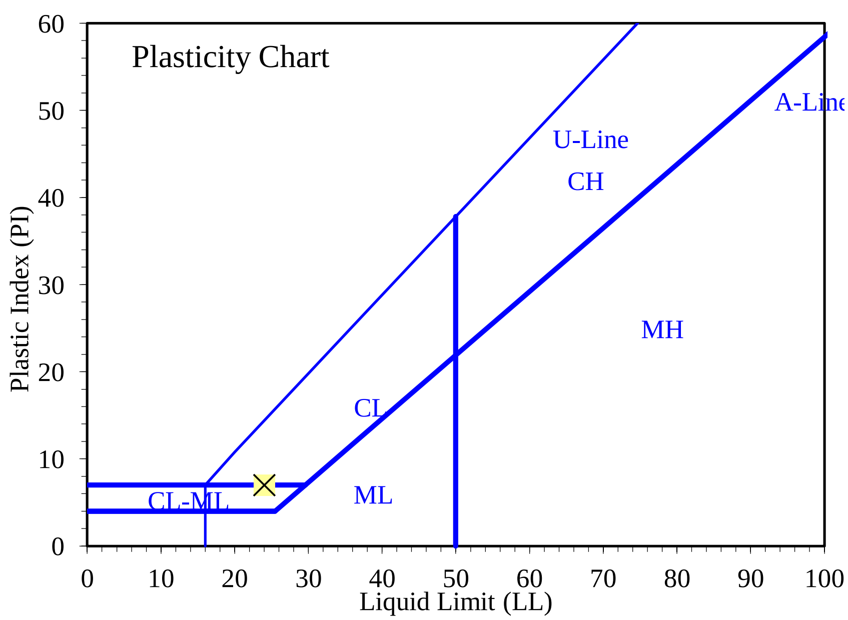
Determination No	1	2				
Wet Soil + Tare (g)	29.90	29.42				
Dry Soil + Tare (g)	28.71	28.28				
Moisture Loss (g)	1.19	1.14				
Tare (g)	21.49	21.39				
Dry Soil (g)	7.22	6.89				
Moisture Content, w (%)	16.48	16.55				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	33	23	17			
Wet Soil + Tare (g)	33.48	34.14	35.14			
Dry Soil + Tare (g)	31.17	31.65	32.38			
Moisture Loss (g)	2.31	2.49	2.76			
Tare (g)	21.43	21.47	21.45			
Dry Soil (g)	9.74	10.18	10.93			
Moisture Content, w (%)	23.72	24.46	25.25			
One-Point LL (%)		24				

Liquid Limit, LL (%)	**24**
Plastic Limit, PL (%)	**17**
Plasticity Index, PI (%)	**7**





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Reviewed:____________

Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: **Husband/Western Zirconium**
No: **01289-004**
Location: Western Zirconium Plant, Ogden
Date: 3/23/2012
By: BRR

Boring No.: **B-1**
Sample:
Depth: **10'**
Description: Brown silty clay

Preparation method: Air Dry
Liquid limit test method: Multipoint

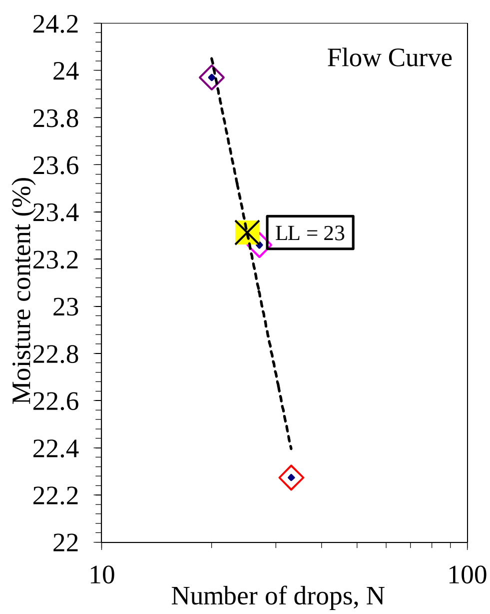
Plastic Limit

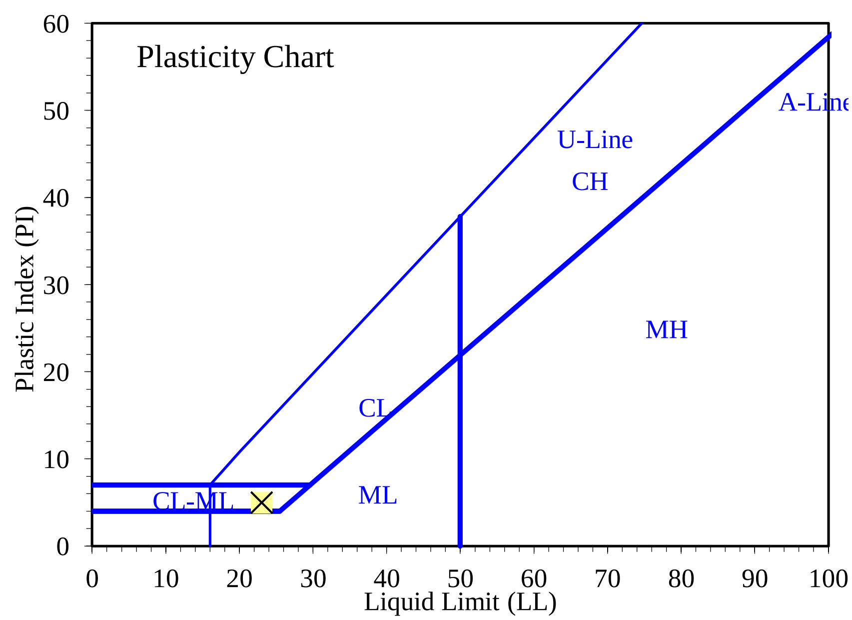
Determination No	1	2				
Wet Soil + Tare (g)	29.32	28.00				
Dry Soil + Tare (g)	28.03	26.99				
Moisture Loss (g)	1.29	1.01				
Tare (g)	21.10	21.42				
Dry Soil (g)	6.93	5.57				
Moisture Content, w (%)	18.61	18.13				

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	33	27	20			
Wet Soil + Tare (g)	34.41	33.60	33.07			
Dry Soil + Tare (g)	32.04	31.26	30.80			
Moisture Loss (g)	2.37	2.34	2.27			
Tare (g)	21.40	21.20	21.33			
Dry Soil (g)	10.64	10.06	9.47			
Moisture Content, w (%)	22.27	23.26	23.97			
One-Point LL (%)		23	23			

Liquid Limit, LL (%)	**23**
Plastic Limit, PL (%)	**18**
Plasticity Index, PI (%)	**5**





Entered by:____________
Reviewed:____________

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Liquid Limit, Plastic Limit, and Plasticity Index of Soils

(ASTM D4318)

Project: **Husband/Western Zirconium**
No: **01289-004**
Location: Western Zirconium Plant, Ogden
Date: 3/23/2012
By: BRR

Boring No.: **B-2**
Sample:
Depth: **10'**
Description: Grey/brown silty clay

Preparation method: Air Dry
Liquid limit test method: Multipoint

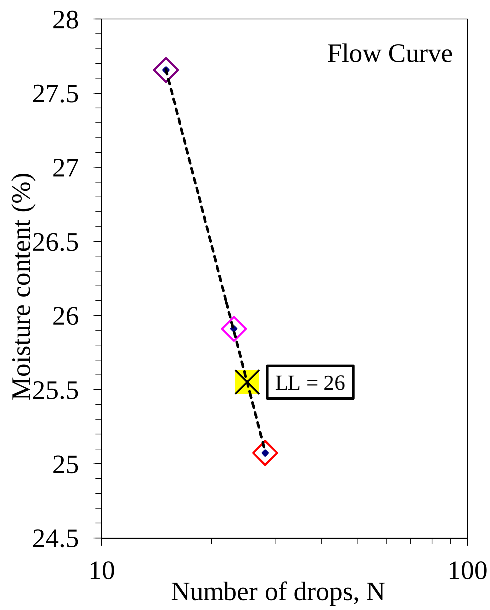
Plastic Limit

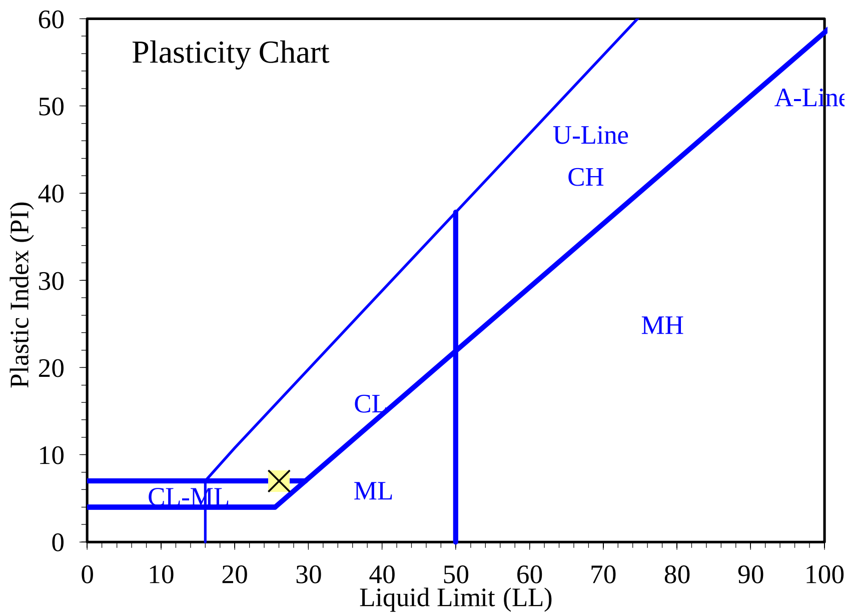
Determination No	1	2			
Wet Soil + Tare (g)	30.28	27.89			
Dry Soil + Tare (g)	28.88	26.85			
Moisture Loss (g)	1.40	1.04			
Tare (g)	21.43	21.32			
Dry Soil (g)	7.45	5.53			
Moisture Content, w (%)	18.79	18.81			

Liquid Limit

Determination No	1	2	3			
Number of Drops, N	28	23	15			
Wet Soil + Tare (g)	33.49	34.12	31.35			
Dry Soil + Tare (g)	30.96	31.49	29.19			
Moisture Loss (g)	2.53	2.63	2.16			
Tare (g)	20.87	21.34	21.38			
Dry Soil (g)	10.09	10.15	7.81			
Moisture Content, w (%)	25.07	25.91	27.66			
One-Point LL (%)	25	26				

Liquid Limit, LL (%)	**26**
Plastic Limit, PL (%)	**19**
Plasticity Index, PI (%)	**7**





Entered by:____________
Reviewed:____________

Amount of Material in Soil Finer than the No. 200 (75μm) Sieve

(ASTM D1140)

IGES

Project: **Husband/Western Zirconium**
No: **01289-004**
Location: Western Zirconium Plant, Ogden
Date: 3/22/2012
By: BRR

Sample Info.	Boring No.	B-1	B-1						
	Sample								
	Depth	5'	10'						
	Split	No	No						
	Split Sieve*								
	Moist total sample wt. (g)	314.57	459.12						
	Moist coarse fraction (g)								
	Moist split fraction + tare (g)								
	Split fraction tare (g)								
	Dry split fraction (g)								
	Dry retained No. 200 + tare (g)	282.47	353.90						
	Wash tare (g)	122.63	122.08						
	No. 200 Dry wt. retained (g)	159.84	231.82						
	Split sieve* Dry wt. retained (g)								
	Dry total sample wt. (g)	276.50	386.14						
Coarse Fraction	Moist soil + tare (g)								
	Dry soil + tare (g)								
	Tare (g)								
	Moisture content (%)								
Split Fraction	Moist soil + tare (g)	437.20	581.20						
	Dry soil + tare (g)	399.13	508.22						
	Tare (g)	122.63	122.08						
	Moisture content (%)	13.77	18.90						
	Percent passing split sieve* (%)								
	Percent passing No. 200 sieve (%)	**42.2**	**40.0**						

Entered by:___________

Reviewed:___________

One-Dimensional Consolidation Properties of Soils

(ASTM D2435)

IGES

Project: **Husband/Western Zirconium**
No: **01289-004**
Location: Western Zirconium Plant, Ogden
Date: 3/26/2012
By: BRR

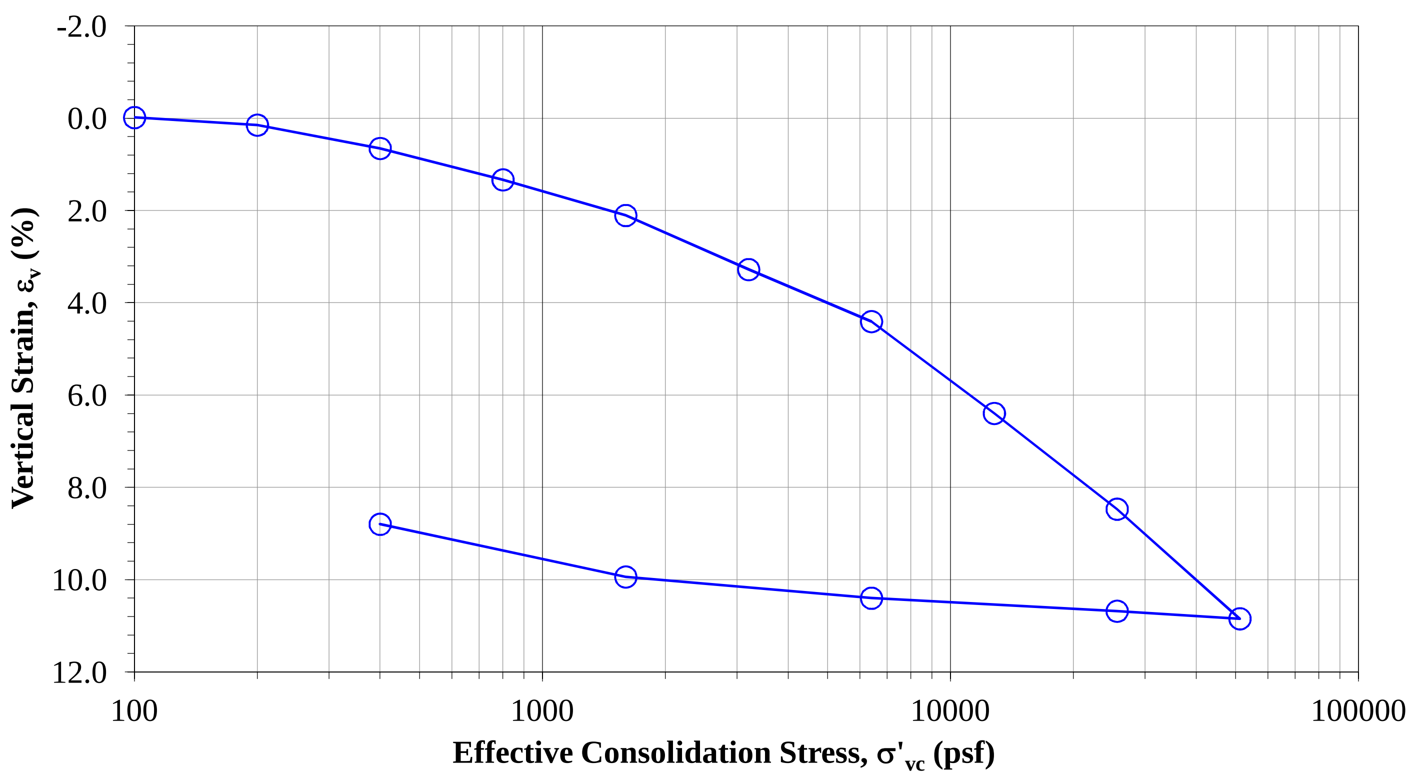
Boring No.: **B-2**
Sample:
Depth: **10'**
Sample Description: Brown clay
Engineering Classification: Not requested
Sample type: Undisturbed-trimmed from ring

Consolidometer No.:	1	
Test method:	A	
Inundation stress (psf), timing:	Seating	Beginning
Specific gravity, G_s	2.65	Assumed

	Initial (o)	Final (f)
Sample height, H (in.)	0.674	0.6147
Sample diameter, D (in.)	2.416	2.416
Wt. rings + wet soil (g)	150.90	149.17
Wt. rings/tare (g)	42.26	42.26
Moist unit wt., γ_m (pcf)	133.9	144.5
Wet soil + tare (g)	541.35	
Dry soil + tare (g)	497.69	
Tare (g)	140.15	
Moisture content, w (%)	12.2	10.4
Dry unit wt., γ_d (pcf)	119.4	130.9
Saturation	0.84	1.00

*Note: c_v, c_c, c_r, and σ_p' to be determined by Geotechnical Engineer.

Stress (psf)	Dial (in.)	1-D ε_v (%)	H_c (in.)	e
Seating	0.1539	0.00	0.6740	0.386
100	0.1538	-0.01	0.6741	0.386
200	0.1549	0.15	0.6730	0.384
400	0.1583	0.65	0.6696	0.377
800	0.1629	1.34	0.6650	0.367
1600	0.1681	2.11	0.6598	0.357
3200	0.1760	3.28	0.6519	0.340
6400	0.1836	4.41	0.6443	0.325
12800	0.1970	6.39	0.6309	0.297
25600	0.2110	8.47	0.6169	0.269
51200	0.2270	10.85	0.6009	0.236
25600	0.2259	10.68	0.6020	0.238
6400	0.2240	10.40	0.6039	0.242
1600	0.2209	9.94	0.6070	0.248
400	0.2132	8.80	0.6147	0.264



Comments: Specimen swelled upon inundation and at the 100 psf loading.

Entered: ________
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Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils

(ASTM D2850)

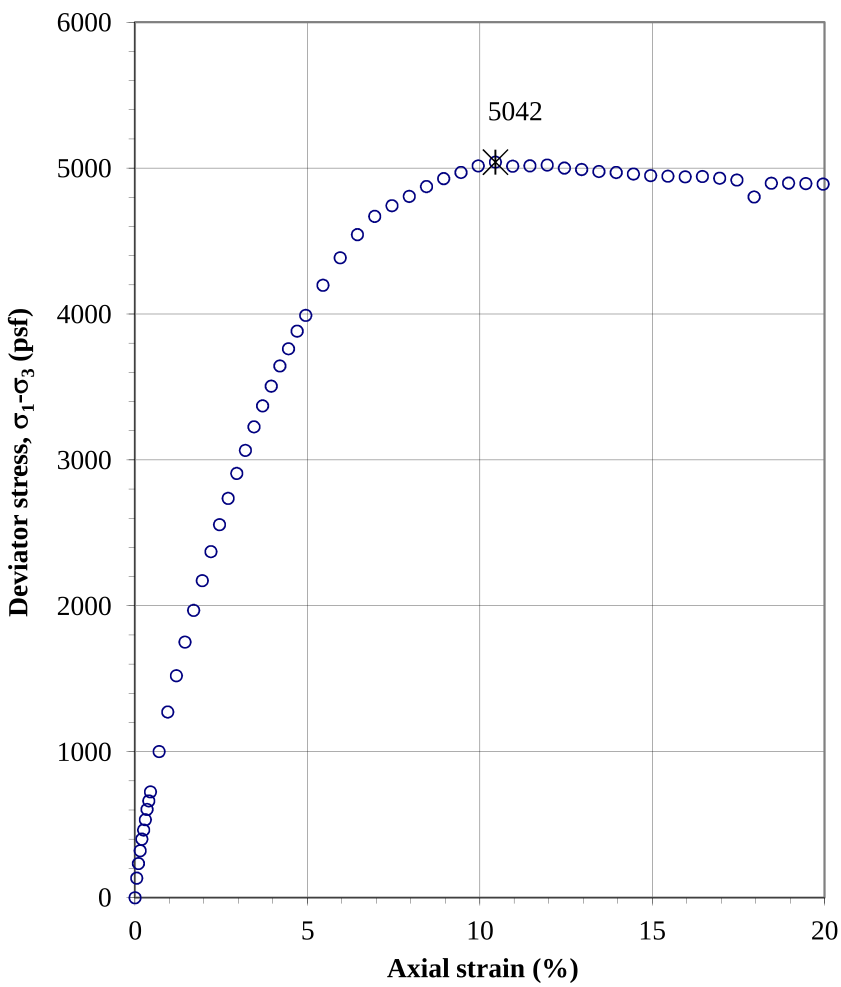
Project: Husband/Western Zirconium
No: 01289-004
Location: Western Zirconium Plant, Ogden
Date: 3/21/2012
By: NB

Boring No.: B-2
Sample:
Depth: 10'
Sample Description: Brown clay with gravel
Sample type: Undisturbed

Sample height, H (in.)	4.977
Sample diameter, D (in.)	2.412
Sample volume, V (ft^3)	0.0132
Wt. rings + wet soil (g)	836.82
Wt. rings/tare (g)	0.00
Moist soil, Ws (g)	836.82
Moist unit wt., γ_m (pcf)	140.2
Dry unit wt., γ_d (pcf)	**124.9**

Wet soil + tare (g)	541.35
Dry soil + tare (g)	497.69
Tare (g)	140.15
Moisture content, w (%)	**12.2**
Confining stress, σ_3 (psf)	1200
Shear rate (in/min)	0.0149
Strain at failure, ε_f (%)	10.45
Deviator stress at failure, $(\sigma_1-\sigma_3)_f$ (psf)	5042
Shear stress at failure, $q_f = (\sigma_1-\sigma_3)_f/2$ (psf)	2521

Axial Strain (%)	σ_d $\sigma_1-\sigma_3$ (psf)	Q 1/2 σ_d (psf)
0.00	0.0	0.0
0.05	134.2	67.1
0.10	234.6	117.3
0.15	322.3	161.2
0.20	401.6	200.8
0.25	464.1	232.0
0.30	534.8	267.4
0.35	605.4	302.7
0.40	663.5	331.7
0.45	725.6	362.8
0.70	1002.0	501.0
0.95	1272.9	636.4
1.20	1521.6	760.8
1.45	1752.4	876.2
1.70	1969.7	984.8
1.95	2173.4	1086.7
2.20	2371.9	1185.9
2.45	2557.2	1278.6
2.70	2737.3	1368.6
2.95	2908.4	1454.2
3.20	3066.2	1533.1
3.45	3227.3	1613.6
3.70	3371.3	1685.6
3.95	3506.4	1753.2
4.20	3644.8	1822.4
4.45	3762.4	1881.2
4.70	3883.2	1941.6
4.95	3991.5	1995.7
5.45	4198.0	2099.0
5.95	4386.3	2193.1
6.45	4544.8	2272.4
6.95	4670.1	2335.0
7.45	4743.1	2371.5
7.95	4807.2	2403.6
8.45	4874.3	2437.1
8.95	4928.8	2464.4
9.45	4970.9	2485.4
9.95	5016.0	2508.0
10.45	5041.6	2520.8
10.95	5014.0	2507.0
11.45	5016.3	2508.1
11.95	5021.7	2510.8
12.45	5001.1	2500.5
12.95	4991.3	2495.6
13.45	4977.5	2488.7
13.95	4970.8	2485.4
14.45	4960.3	2480.1
14.95	4949.4	2474.7
15.45	4945.4	2472.7
15.95	4941.0	2470.5
16.45	4943.5	2471.7
16.95	4931.5	2465.7
17.45	4919.2	2459.6
17.95	4803.3	2401.6
18.45	4897.4	2448.7
18.95	4898.0	2449.0
19.45	4894.8	2447.4
19.95	4891.2	2445.6
20.45	4897.3	2448.6



Entered by:___________

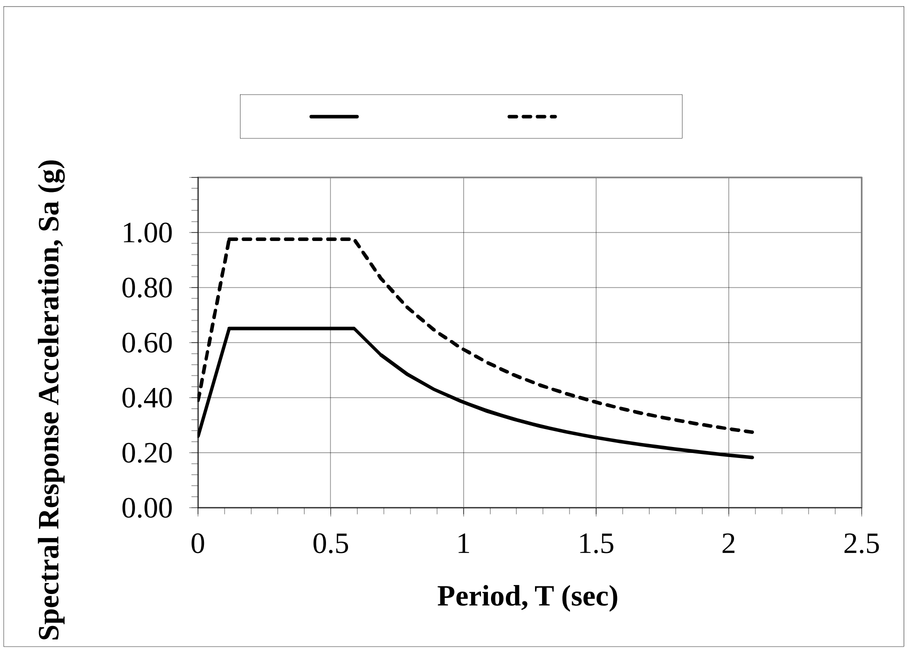
Reviewed:___________

APPENDIX C

SITE GROUND MOTION [IBC SECTION 1613]

Project:	**Husband/Westinghouse**	**Number:**	**01289-004**
Latitude =	**41.2607**	**Date:**	**3/15/12**
Logitude =	**-112.2313**	**By:**	**DAG**

Ss =	0.838 (g)	The mapped spectral accleration for short periods		[1613.5]
S_1 =	0.330 (g)	The mapped spectral accleration for a 1-second period		
Site Class =	D	Table 16.13.5.2		
Fa =	1.16	Table 1613.5.3(1)		
Fv =	1.74	Table 1613.5.3(2)		
S_{MS} =	0.976	S_{MS} = Fa*Ss	*The maximum considered E.Q. spectral resonse accelerations	
S_{M1} =	0.574	S_{M1} = Fv*S_1	for short and 1-second periods [1613.5.3]	
MCE/PGA =	**0.390**	**0.4*S_{MS} [In accordance with 1802.2.7]**		
S_{DS} =	0.651	S_{DS} = 2/3*S_{MS}	*The design spectral response acceleration	
S_{D1} =	0.383	S_{D1} = 2/3*S_{M1}	at short and 1-second periods	
T_0 =	0.118	T_0 = 0.2*S_{D1}/S_{DS}		
T_s =	0.588	T_s = S_{D1}/S_{DS}		
ΔT =	0.1	Time step for diagram		



T (sec)	Sa (g)	Sa (MCE) (g)
0	0.26	0.39
0.12	0.65	0.98
0.59	0.65	0.98
0.69	0.56	0.83
0.79	0.49	0.73
0.89	0.43	0.65
0.99	0.39	0.58
1.09	0.35	0.53
1.19	0.32	0.48
1.29	0.30	0.45
1.39	0.28	0.41
1.49	0.26	0.39
1.59	0.24	0.36
1.69	0.23	0.34
1.79	0.21	0.32
1.89	0.20	0.30
1.99	0.19	0.29
2.09	0.18	0.27

Figure C-1