Chelemes Farms Subdivision

Rockery Analysis

PROPERTY LOCATION:
1000 EAST 900 EAST
CLEARFIELD, UTAH

PREPARED FOR:
IVORY HOMES

AUGUST 14, 2008

PREPARED BY:
WILDING ENGINEERING
14721 SOUTH HERITAGE CREST WAY
BLUFFDALE, UTAH 84065

Table of Contents

1. INTRODUCTION

PURPOSE AND SCOPE OF WORK

This report is to present the results of a slope stability analysis for the proposed rock faced cut slopes adjacent a future park near the intersection of 1000 East and 900 East streets in Clearfield, Utah. The purpose of this analysis was to assess the stability of the proposed slope.

The scope of work completed for this analysis included site reconnaissance, data gathering, laboratory work, engineering analysis, and the preparation of this report. All recommendations contained herein are subject to the limitations shown in the "Limitations" section of this report.

PROJECT DESCRIPTION

The project consists of construction of rockeries to facilitate final grade for a park to be constructed in association with the Chelemes Farms Subdivision, in Clearfield, Utah. The rockeries are be constructed according the detail included as plate G-1 in Appendix A. The maximum rockery will consist of three (3) tiers. Each tier will have a maximum exposed height of 6'-0". A 3:1 terrace is proposed between the tiers. The width of the proposed terrace is 6'-0". All faces of rockeries will be laid back at a minimum slope of 1 horizontal to 2 vertical. According to a plan, labeled DRWG. No. 11a, prepared by Great Basin Engineering North, dated 5 September, 2006, the rockery is to be constructed to facilitate grade between a 5 foot sidewalk and a detention pond. The side slopes of the detention pond are to be 3:1. The rockery does not extend laterally into the side slopes of the detention basin.

2. ENGINEERING ANALYSIS

Slope/W software, a module of GeoStudio 2004, was used to perform the slope stability analysis. A sample of the onsite materials was obtained and classified as SP-SM, Poorly Graded Sand with Silt according to the Unified Soils Classification System. No indication of groundwater was observed while collecting this sample. A portion of this sample was remolded to 100% of the maximum dry density and 100% of the natural moisture. The soil strength parameters were integrated into a model of the proposed slope according to the results of direct shear testing (ASTM 3080-04) performed on the aforementioned remolded samples. The date of this testing was August 12, 2008. Parameters used for the soils in this analysis were 94.2 pcf for unit weight, 37.2° and 280 psf, for friction angle and apparent cohesion respectively. See appendix for lab results. In as much as the rockery is to be located adjacent a detention pond, the slope was modeled assuming the pond was completely full to emulate the worst case. A model of the slope using these strength parameters is presented in Figure 1.

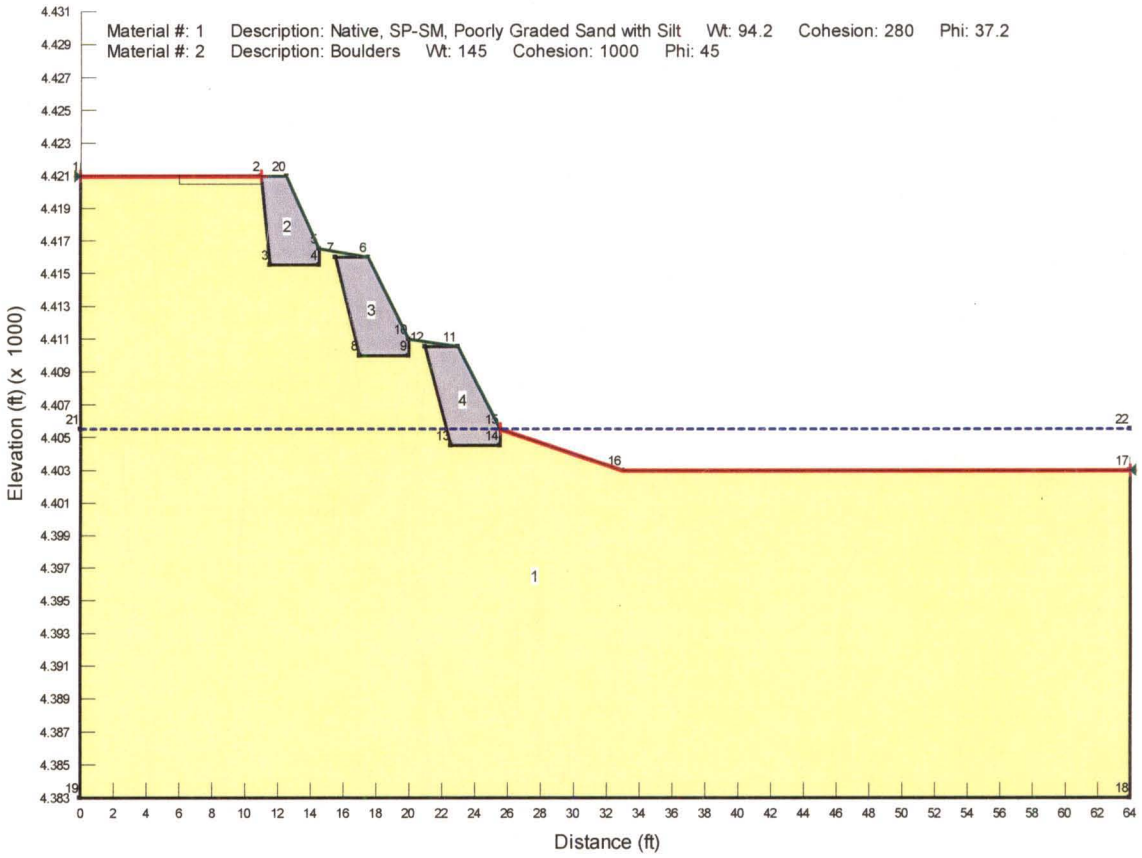


Figure 1 – Slope Model

Region 1 is comprised wholly of Material 1 as indicated in the figure. Regions 2, 3, and 4 are to be comprised of material 2. The piezometric surface is modeled by the blue line.

2.1 STATIC ANALYSIS

An analysis after the Morgenstern-Price Method was specified to determine the factor of safety for this slope. The failure surface entry and exit range was specified as shown in red on Figure 1. The results of the static analysis are presented in Figure 2. The factor of safety for the critical circle was calculated to be 2.2. The critical circle is represented in Dark Green. The center of the potential failure circle is shown in the upper right corner of Figure 2 with its associated calculated factor of safety.

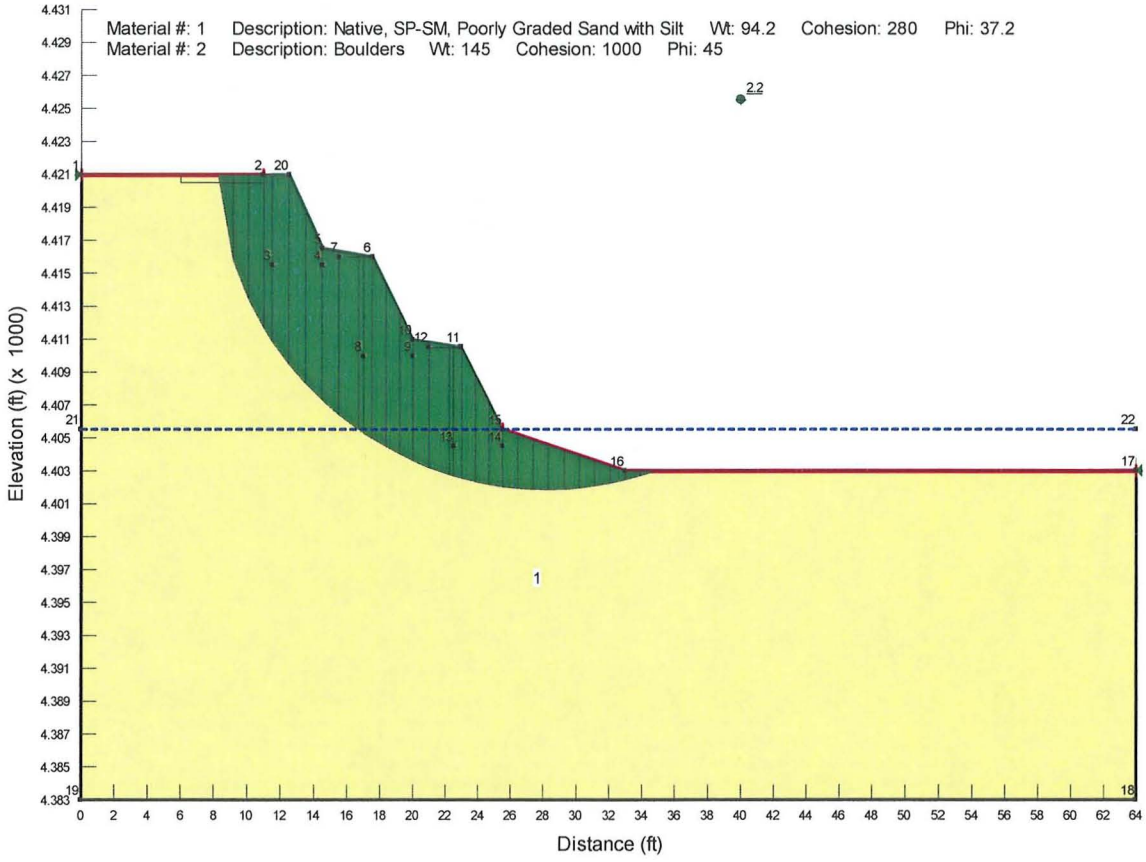


Figure 2 – Static Analysis Results

2.2 PSUEDOSTATIC ANALYSIS

Table 1 - USGS Earthquake Hazards Estimated Values

	10% PE in 50 year	3.5% PE in 50 year	2% PE in 50 year
Peak Ground Acceleration	0.201	0.388	0.0506

The result of the psuedostatic analysis is presented in Figure 3. USGS reports peak ground acceleration (PGA)=0.388g for this site with a 3.5% probability of exceedance in 50 years, see Table 1. A seismic coefficient of ½PGA=0.194g was specified for this analysis. (Hynes-Griffen and Franklin 1984) The factor of safety for the critical circle was calculated to be 1.7. The critical circle is represented in dark green. The center of the potential failure circle is shown in the upper right corner of the figure with its associated calculated factor of safety.

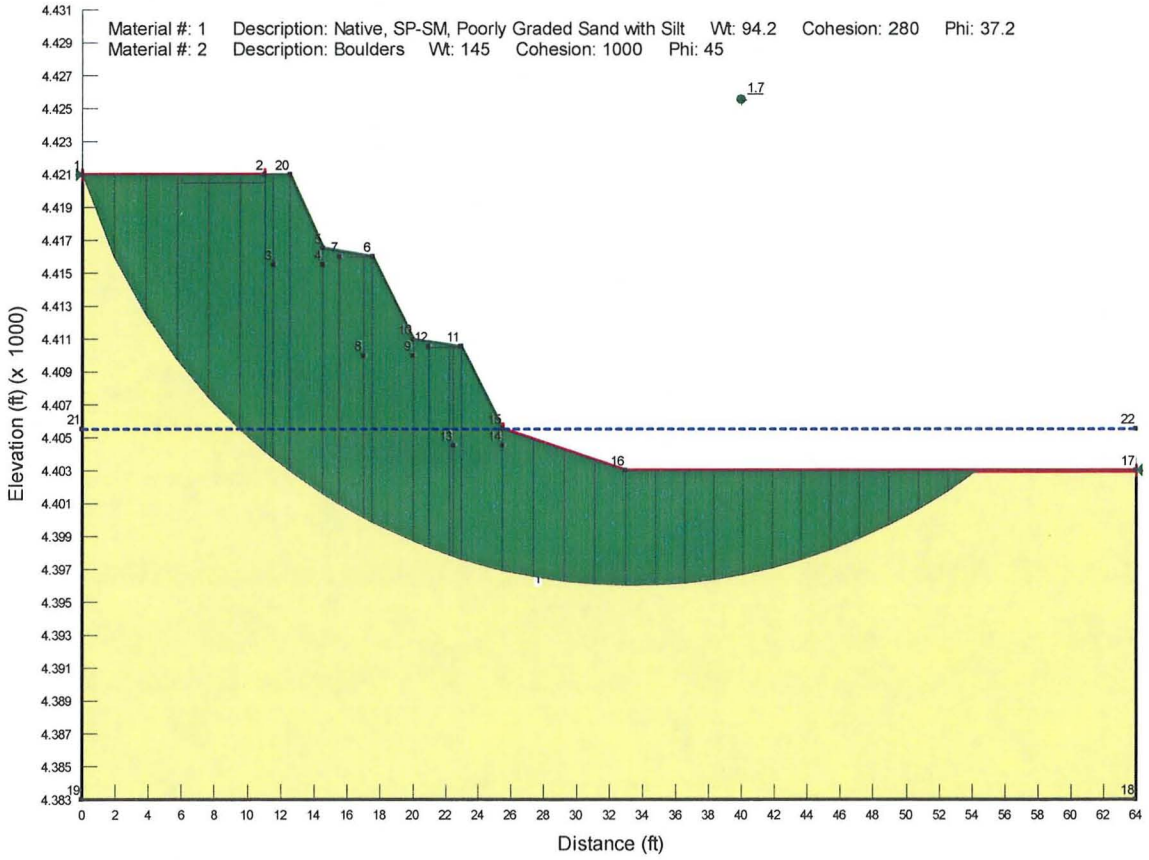


Figure 3 – Psuedostatic Analysis Results

INTERNAL AND EXTERNAL STABILITY ANALYSIS

An analysis of the internal and external stability of each of the tiers was completed utilizing a limit equilibrium approach based loosely upon the recommendations presented in the National Concrete and Masonry Association's Design Manual for Segmental Retaining Walls, Second Edition. Calculations can be found in the appendix. Internal stability calculation was limited to determination of the stone's capacity to resist forces that would cause sliding for each course. External stability calculation was limited to base sliding, overturning, and bearing capacity. All calculated factors of safety exceed those generally accepted for this type of construction. The factors of safety are presented in Table 2.

Table 2 – Calculated Internal and External Factors of Safety

Upper	Factor of Safety Against Base Sliding	FSbs	1.9
	Factor of Safety Against Overturning	FSot	3.4
	Factor of Safety Against Bearing Capacity Failure	FSbc	17.4
	Minimum Factor of Safety Against Internal Shear Failure	FSss	1.8
Middle	Factor of Safety Against Base Sliding	FSbs	1.6
	Factor of Safety Against Overturning	FSot	2.7
	Factor of Safety Against Bearing Capacity Failure	FSbc	19.6
	Minimum Factor of Safety Against Internal Shear Failure	FSss	1.7
Lower	Factor of Safety Against Base Sliding	FSbs	1.6
	Factor of Safety Against Overturning	FSot	3.2
	Factor of Safety Against Bearing Capacity Failure	FSbc	14.1
	Minimum Factor of Safety Against Internal Shear Failure	FSss	1.7

3. RECOMMENDATIONS

If a different material is encountered, the material must be tested and the results shown to meet or exceed the properties of the material tested for this analysis. The swales and drains must be installed as proposed (See design detail plate G-1.) All drainage, including irrigation runoff, must be directed away from the rock faced slope. A properly trained representative of the design engineer shall inspect the construction to ensure their assumptions are adhered to. Inspections of the rock faced slope construction shall be performed according to the schedule provided in this report. Final acceptance of the construction will require certification by the design engineer. The design engineer will not accept nor certify the construction if the inspection schedule is not adhered to.

4. INSPECTION SCHEDULE

The contractor shall be responsible for notifying Wilding Engineering within 2 working days of the events described in the schedule provided to facilitate inspection of the proposed construction. Events that will trigger inspections are presented in the following table.

Table 1 – Inspection Schedule

Inspection Triggering Event	Description
First Course Placement	Engineer shall inspect the placement of the first course of stones. Strict compliance with the design details will be evaluated. Stone embedment, drain rock, and filter fabric placement must comply with the design documents. Contractor shall remove and replace, at their cost, those areas identified not to be in compliance.
Middle Course Placement	Engineer shall inspect the slope upon placement of the middle course of stones. Continued strict compliance with the design details will be evaluated. Batter, height, stone placement, drain rock, and filter fabric placement must comply with the design documents. Contractor shall remove and replace, at their cost, those areas identified not to be in compliance.
Final Course Placement	Engineer shall inspect the slope upon placement of the final course of stones. Strict compliance with the design details will be evaluated. Batter, drain rock, and filter fabric placement must comply with the design documents. Contractor shall remove and replace, at their cost, those areas identified not to be in compliance. Upon approval, engineer will provide a letter certifying compliance with the slope design.

Notes:
1. Where multiple tiers are planned, the Engineer shall inspect each tier as described above as they proceed. The compliance letter will be provided upon completion of the entire rock faced slope.
2. Inspection frequency may be increased at the Engineer's discretion if conditions warrant.

5. CONCLUSION

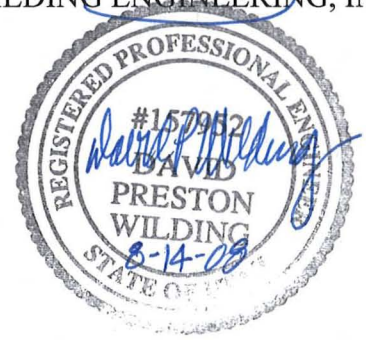
The rockery, as proposed, will be stable under static conditions. In the event of an earthquake the calculated factor of safety will be reduced significantly. Factors of safety were found to be 2.2 and 1.7 for global failure planes in static and psuedostatic conditions, respectively. These factors of safety comply with typically accepted values for this type of construction. It should be noted that some failure, due to ground shaking, raveling of the stones, and erosion may be expected in this type of construction in an earthquake event. Contractor shall be responsible for compliance the inspection schedule as detailed in this report. A certified letter of compliance will be issued upon engineer's approval of the proposed construction.

6. LIMITATIONS AND PROFESSIONAL STATEMENT

The conclusions and recommendations included within this report are based on the parameters determined by lab testing, our understanding of the project and experience with similar construction. Variations in the subsurface conditions may not become evident until additional exploration or excavation is conducted. If the subsurface soil or groundwater conditions are found to be significantly different than that which is described in this report, we should be notified so that we can re-evaluate the design and our recommendations.

We appreciate the opportunity of providing this service for you. If you have any questions concerning this report or require additional information or services feel free to contact us.

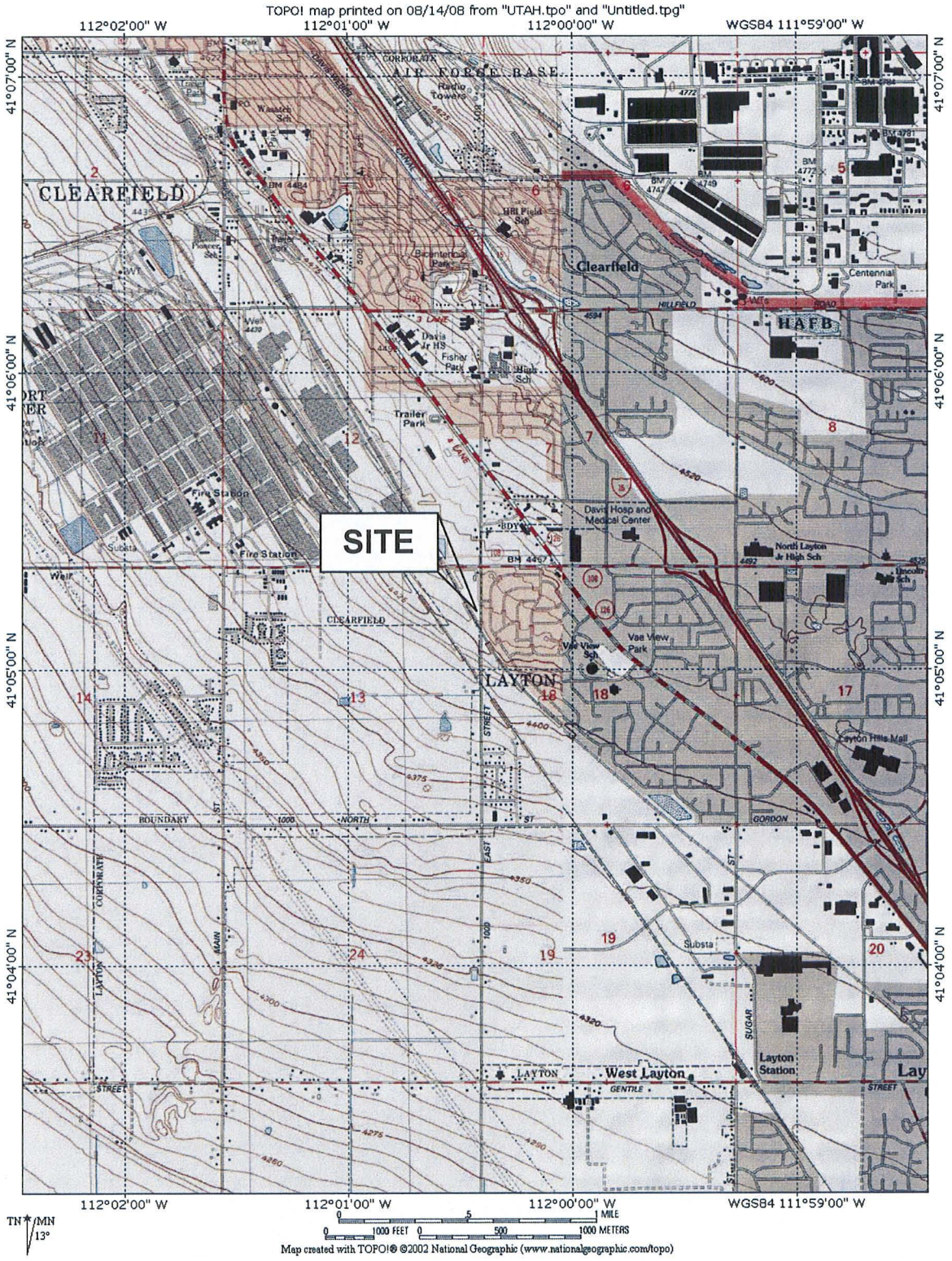
James D. Higgins, PEI
WILDING ENGINEERING, INC.



David P. Wilding, PE, SE
President

APPENDIX

VICINITY MAP

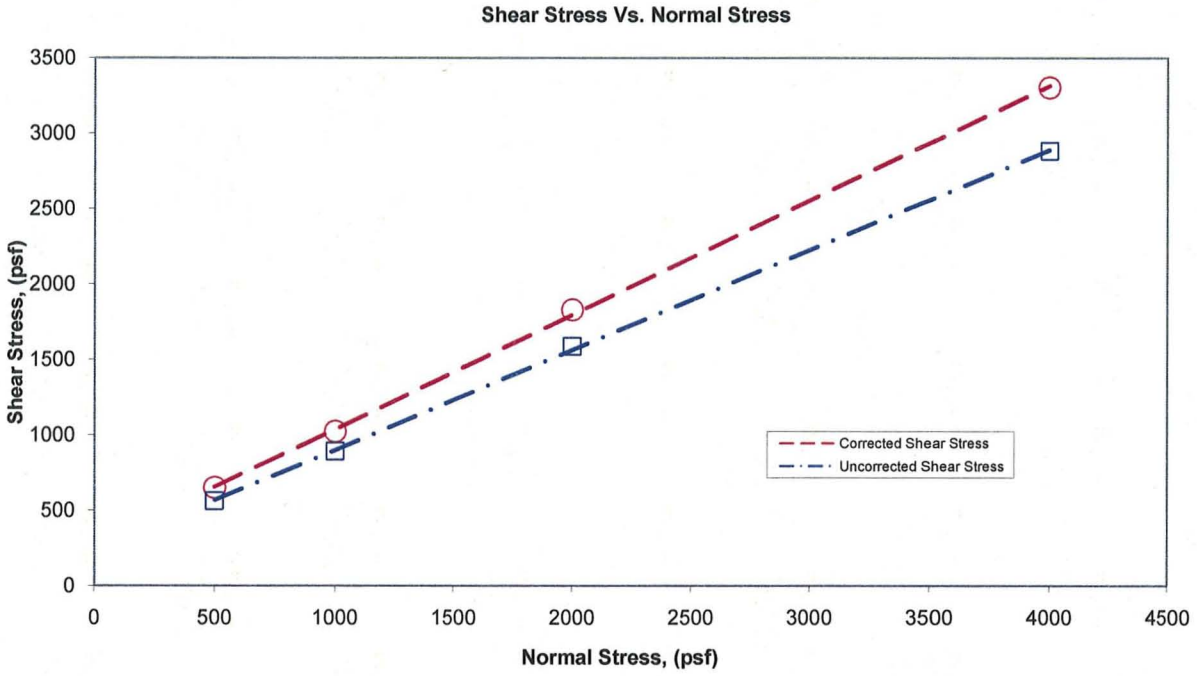


Project: **Ivory Homes, Chelemes Farms** **1000 East and 900 East** **Clearfiled, Utah** Project No: **07133**	Date: August 12 2008 Drawn By: JDH Figure: A-1	WILDING ENGINEERING, INC 14721 SOUTH HERITAGE CREST WAY BLUFFDALE, UTAH 84065 (801)553-8112

Wilding Engineering, Inc.

Consolidated Drained Direct Shear Test (ASTM D3080-04)

Tested By	Jeremy Wright	Date	8/12/08
Computed By	James D. Higgins	Date	8/12/08
Checked By	David Wilding PE	Date	8/12/08



Mohr-Coulomb Stress Envelope			Parameter	Specimen			
				A	B	C	D
Area Corrected	Ø' (deg)	37.2	Initial Water Content (%)	4.0	4.0	4.0	4.0
	C' (psf)	280.0	Final Water Content (%)	28.9	30.7	28.3	28.4
	R^2	0.9996	Dry Density (psf)	90.6	90.6	90.7	89.9
	SSE	N/A	Diameter (in)	2.42			
Area Uncorrected	Ø' (deg)	33.6	Height (in)	1.00			
	C' (psf)	240	Strain Rate (in/min)	0.0080			
	R^2	0.9998	Plastic Index	NP			
	SSE	N/A	Average T_{50} (min)	0.23			

Project:	Ivory Homes, Clearfield	Data Points		
Project Number:	07133	Normal Stress	Corrected Shear Stress	Uncorrected Shear Stress
Test Pit Number:	1			
Sample Number:	L8063	500	650	561
Depth:	1.5	1000	1022	890
Sample Type:	Remolded	2000	1829	1586
Rel. Compaction:	100%	4000	3303	2881
Description:	SP-SM, Poorly Graded Sand with Silt			
Remarks:	Sample remolded to 100% of the insitu density and moisture content			

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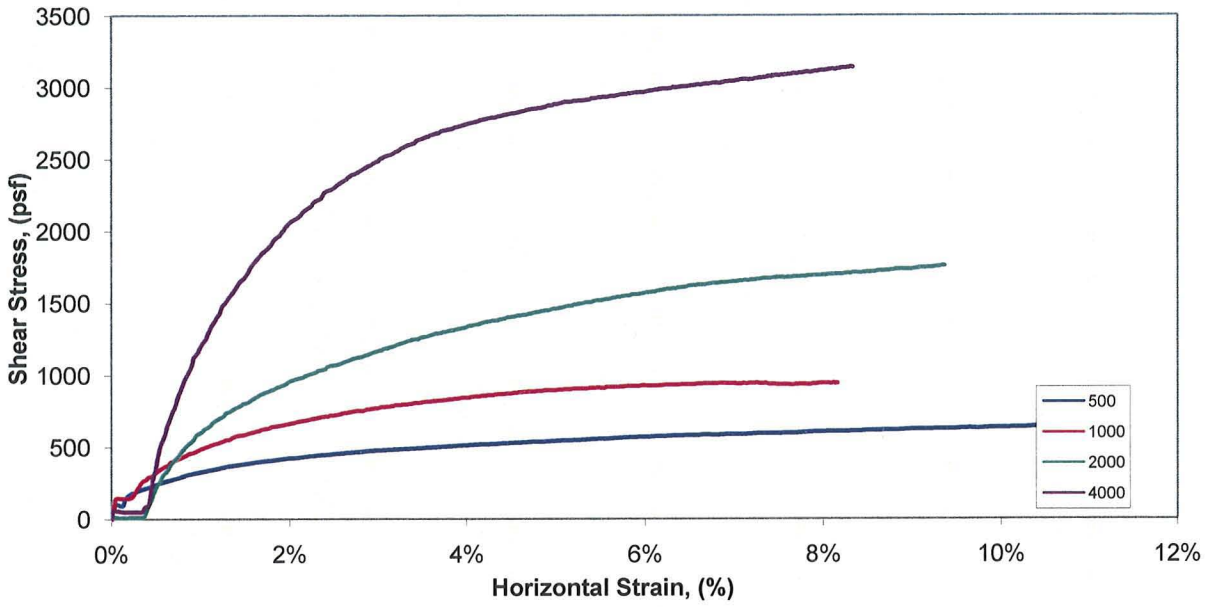
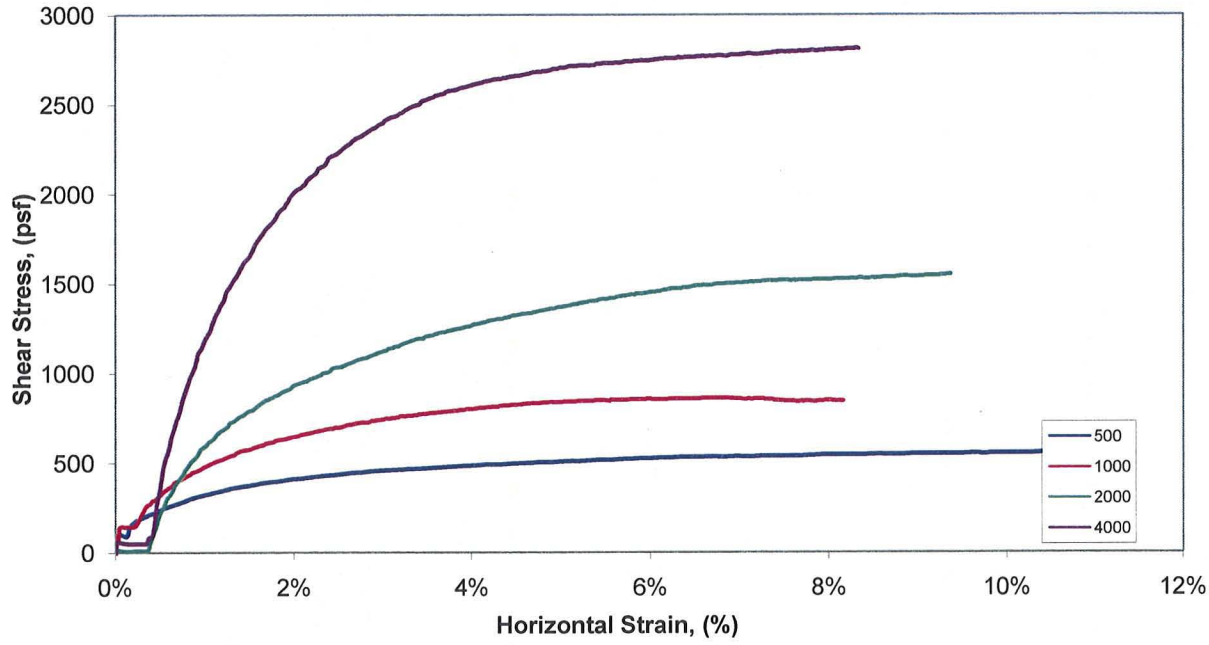
Date	8/12/08

Corrected Shear Stress Vs. Horizontal Strain



Uncorrected Shear Stress Vs. Horizontal Strain



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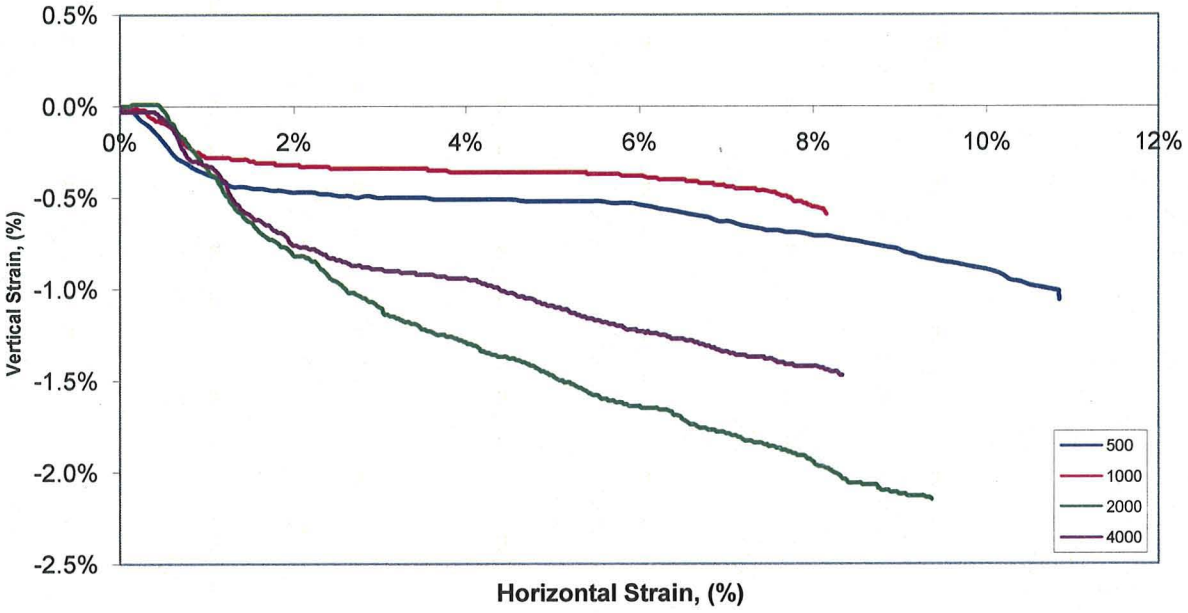
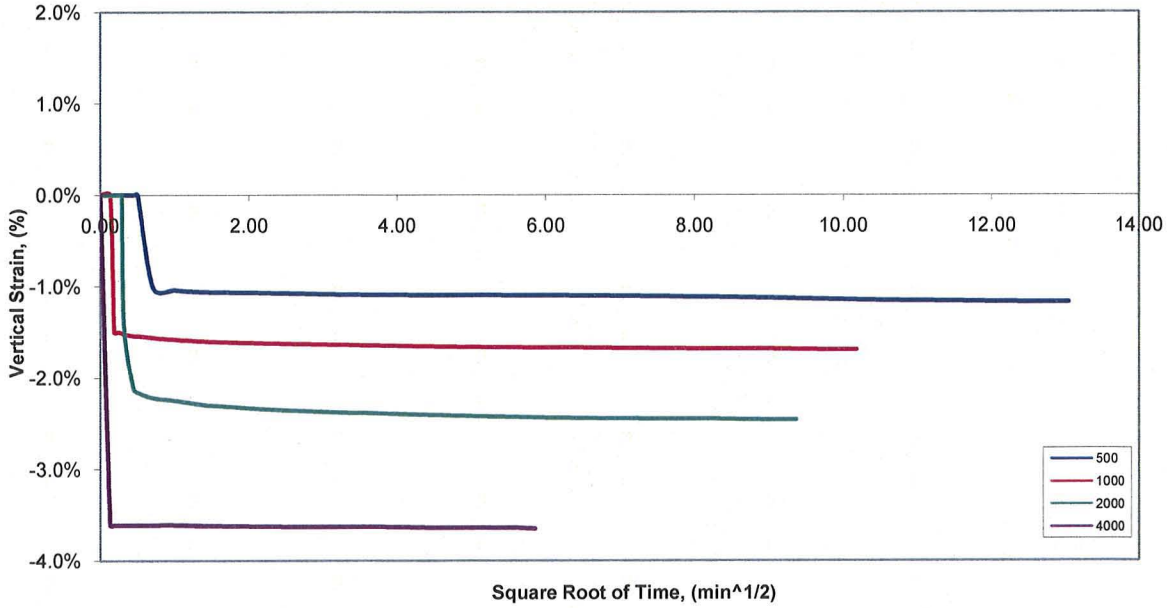
Tested By	Jeremy Wright
Date	8/12/08
Computed By	James D. Higgins
Date	8/12/08
Checked By	David Wilding PE
Date	8/12/08

Vertical Strain Vs. Horizontal Strain



Consolidation Curves



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GRAIN SIZE ANALYSIS-- MECHANICAL

Project: Chelemes Subdivision-Ivory Homes

Sample No: L8063

Location of Project: Clearfield, Utah

Depth of Sample: 2 ft

Location of Sample: Center of slope northeast corner of wall

Date of Testing: July 29, 2008

Description of Soil: SP-SM, Poorly Graded Sand with Silt

Tested by: J. Wright

Soil Sample Size (ASTM D 1140-54)

Wt of wet sample	647.20
Wt of dry sample	626.40

Percent Content

Gravel:	0	
Sand:	90	
Fines:	10	
	100	Total

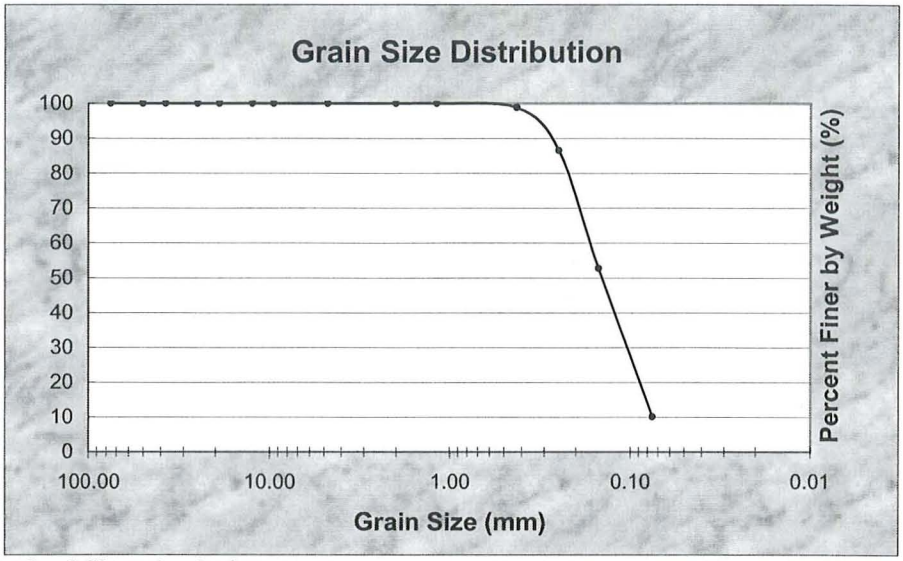

Table - U.S. Standard Sieve Analysis

Sieve No.	Diam. (mm)	Wt retained	% retained	% passing
3.00	75.00		0.0	100.00
2.00	50.00		0.0	100.00
1.50	37.50		0.0	100.00
1.00	25.00		0.0	100.00
0.75	19.000		0.0	100.00
0.50	12.500		0.0	100.00
0.38	9.500		0.0	100.00
4	4.750		0.0	100.00
10	2.000		0.0	100.00
16	1.180		0.0	100.00
40	0.425	7.4	1.2	98.82
60	0.250	84.6	13.5	86.49
100	0.150	296.4	47.3	52.68
200	0.075	563.0	89.9	10.12

NOTE: % passing = 100 - % retained

USCS Classification: **SP-SM, Poorly Graded Sand with Silt**

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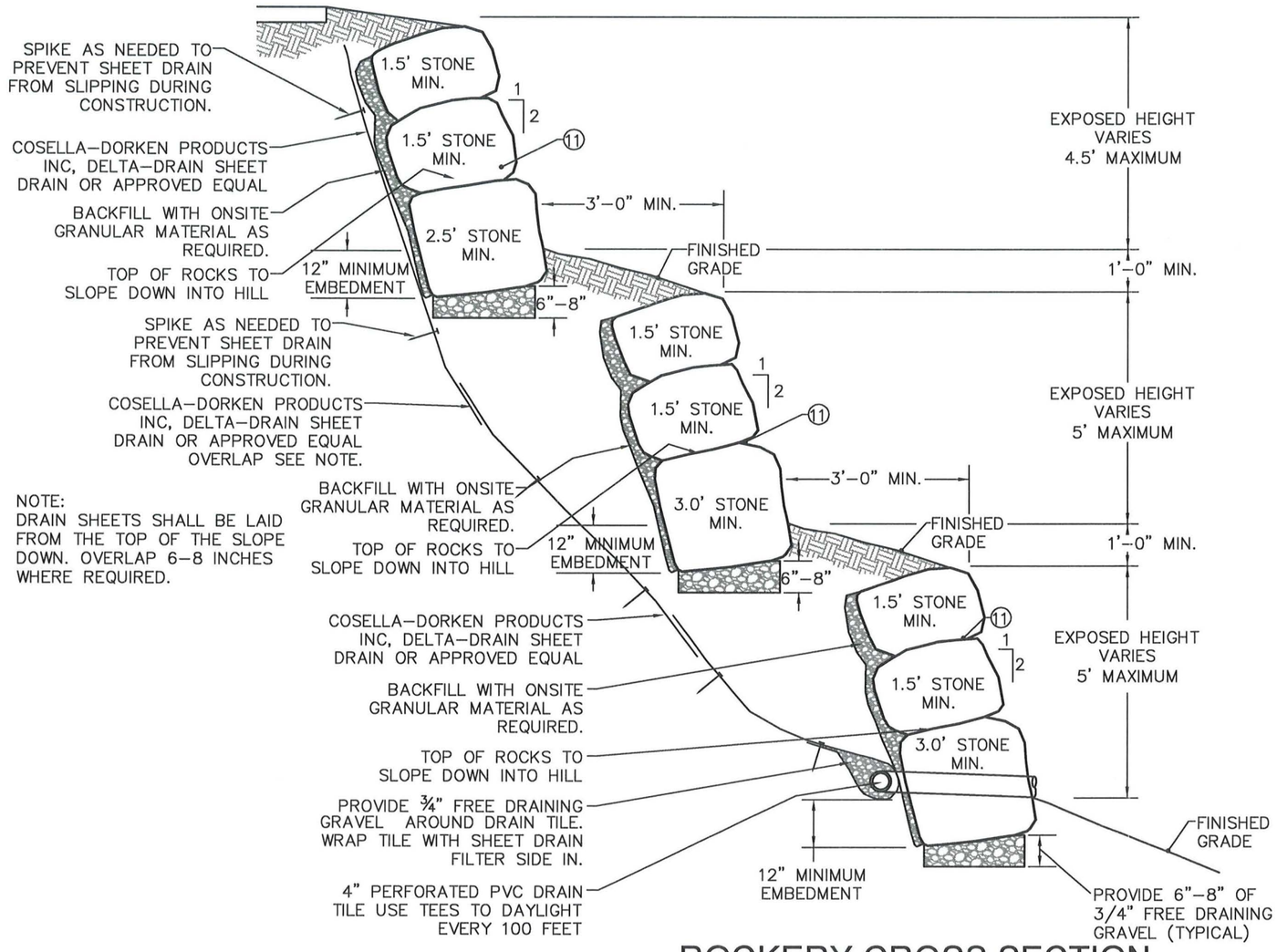
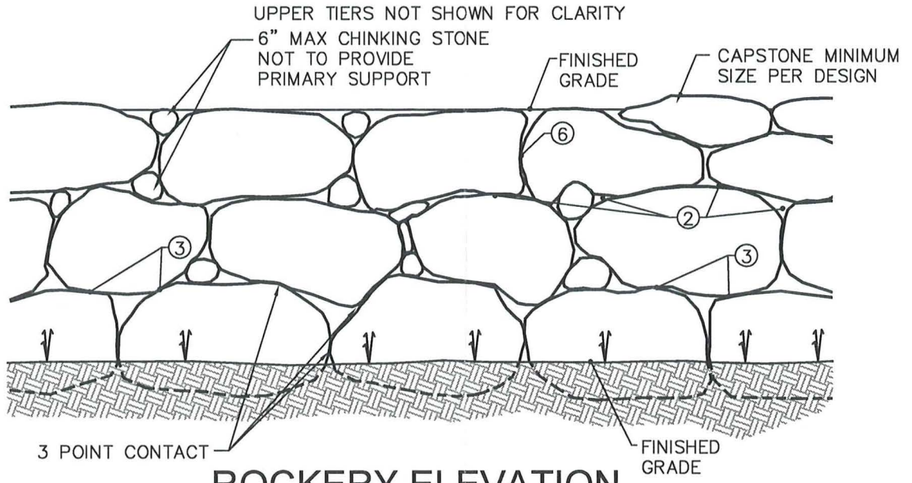
CHELEMES FARMS SUBDIVISION



ROCKERY CROSS SECTION



ROCKERY ELEVATION

NOTES:

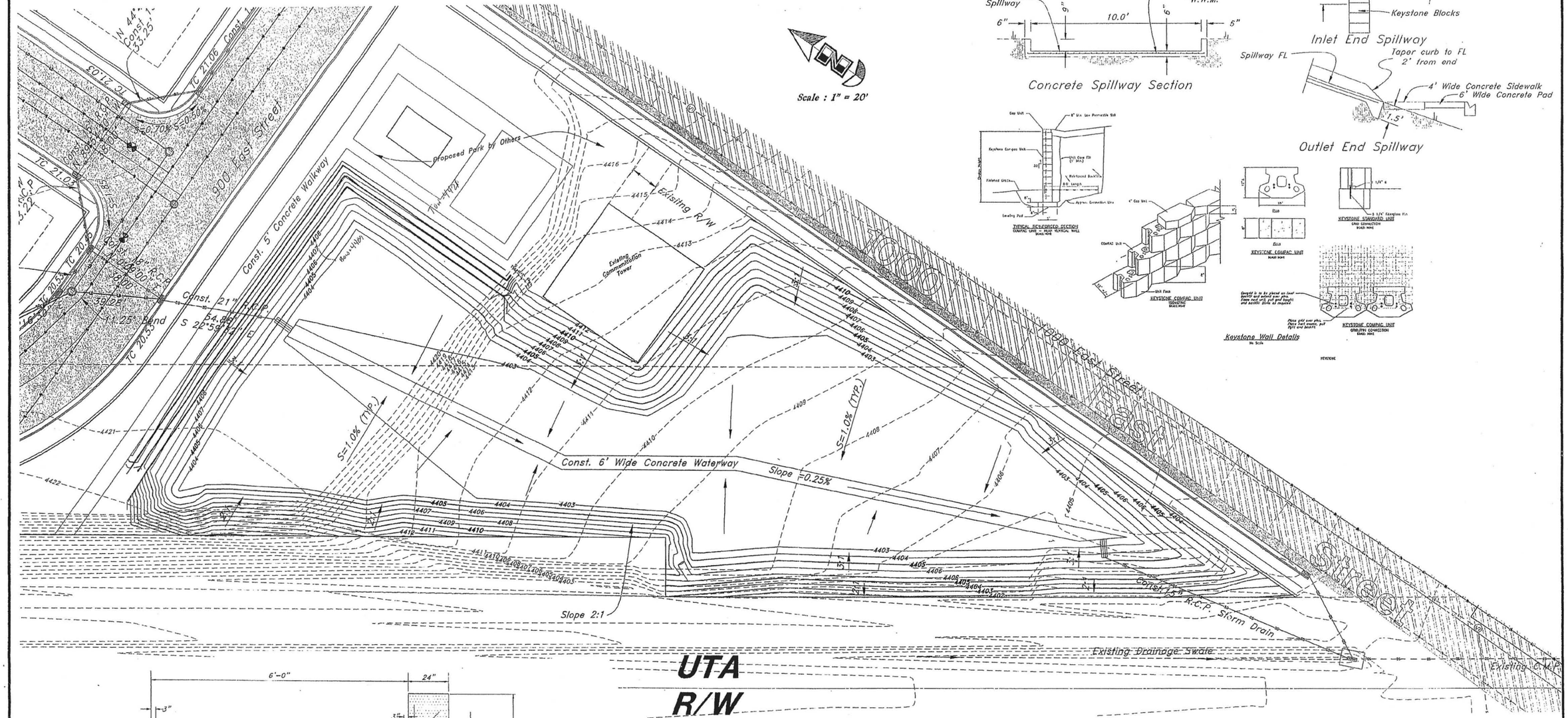
1. ALL CONSTRUCTION SHALL COMPLY WITH THE ASSOCIATION OF ROCKERY CONTRACTORS (ARC) GUIDELINES.
2. ROCKS SHALL BE PLACED SO THAT THERE ARE NO CONTINUOUS JOINT PLANES IN EITHER THE VERTICAL OR LATERAL DIRECTION.
3. WHENEVER POSSIBLE, EACH ROCK SHALL BEAR ON AT LEAST TWO ROCKS BELOW IT.
4. TOP SURFACE OF EACH ROCK IN EACH COURSE SHALL BE SLOPED BACK TOWARD THE SLOPE FACE.
5. BOTTOM ROCK IN EACH TIER SHALL BE KEYED INTO GROUND (BURIED) 1'–0" MINIMUM.
6. ROCK MUST BE ANGULAR AND FITTED TOGETHER TO INTERACT WITH ADJACENT ROCKS. POORLY FITTING, UNSTABLE, OR OTHERWISE MISPLACED STONES SHALL BE REMOVED, ADJUSTED, OR REPLACED AS DIRECTED BY ENGINEER.
7. CONSTRUCTION SHALL REQUIRE "SPECIAL INSPECTION". ENGINEER WILL VISIT SITE TO ENSURE ADHERENCE TO CONSTRUCTION STANDARDS. WALLS ABOVE TEN FEET HIGH OR, THAT ARE TERRACED, WILL REQUIRE SUPERVISION BY ENGINEER. CONTRACTOR TO NOTIFY ENGINEER 48 HOURS MIN. PRIOR TO CONSTRUCTION.
8. CUT SLOPE EXCAVATION IN AREA OF ROCKERY SHALL HAVE A SLOPE OF 1 FOOT HORIZONTAL TO EVERY 2 FEET VERTICAL.
9. A MINIMUM SETBACK OF FOUR (4) FEET FROM BUILDINGS OR STRUCTURES SHALL BE MAINTAINED ABOVE OR BELOW THE ROCKERY.
10. A 12" LAYER OF FREE DRAINING GRAVEL WRAPPED ENTIRELY (BURRITOED) IN A NONWOVEN GEOTEXTILE FILTER FABRIC (MIRAFI 140N, OR APPROVED EQUAL) WITH 4" PERFORATED PVC DRAIN DAYLIGHTED EVERY 100 FEET MAY BE USED AS AN ALTERNATE TO THE SHEET DRAIN SYSTEM.
11. BACKFILL MATERIAL SHALL BE SWEPT FROM SURFACE OF STONES PRIOR TO PLACEMENT OF FOLLOWING STONE COURSES
12. PLACE CHINKING STONES TO PREVENT BACKFILL MATERIALS FROM "LEAKING" THROUGH GAPS IN ROCKERY FACE. CHINKING STONE MAXIMUM SIZE SHALL BE 6". CHINKING STONE SHALL NOT PROVIDE PRIMARY SUPPORT. CHOOSE A BETTER FITTING STONE IF A GAP LARGER THAN 6" EXISTS IN ROCKERY FACE.

REGISTERED PROFESSIONAL ENGINEER
#157952
DAVID PRESTON WILDING
6-14-08
STATE OF UTAH

WILDING ENGINEERING, INC
14721 SOUTH HERITAGE CREST WAY
BLUFFDALE, UTAH 84065
(801)553-8112

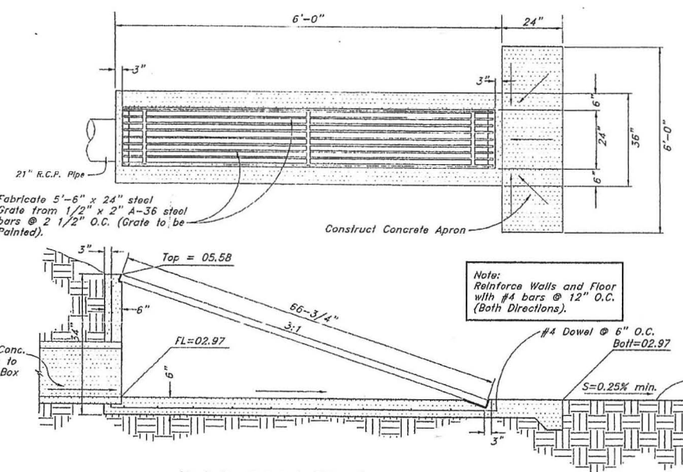
NO.	REVISION	DATE
0	RELEASED TO CLIENT	08/14/08

DRAWING TITLE	ROCKERY CONSTRUCTION DETAIL
PROJECT NAME	IVORY HOMES
LOCATION	1000 EAST AND 900 EAST CLEARFIELD, UTAH
DRAWN	JDH
CHECKED	DPW
FILE NAME:	G:\Data\07133...\dwg\Chelemes – Rock...
DATE	08/14/08
SCALE	NONE
SHEET	G-1

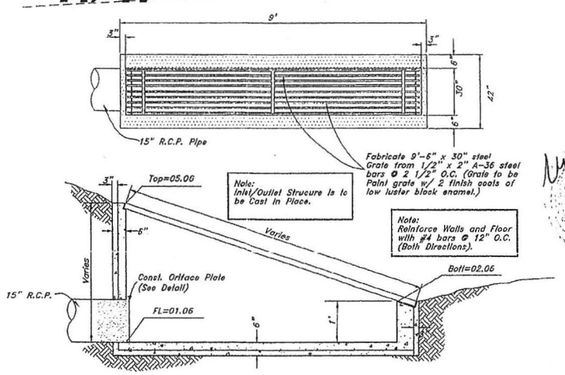


Concrete Spillway Section

Keystone Wall Details

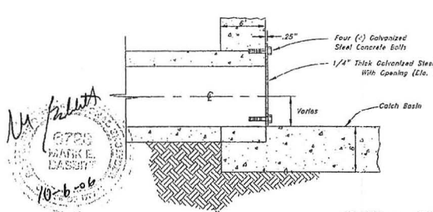


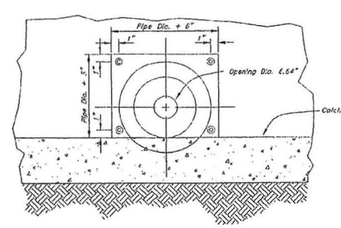
Detail of Inlet Structure



Detail of Outlet Structure

Not to Scale





Orifice Plate Detail

Detention Pond Design

Chelemes Farms

A part of the Northeast 1/4 of Section 13, T4N, R2W, SLB&M, U.S. Survey
Clearfield City, Davis County, Utah

GREAT BASIN ENGINEERING NORTH
CONSULTING ENGINEERS AND SURVEYORS
5746 South 1475 East – Suite 200
Ogden, Utah 84403
P.O. Box 150048, Ogden, Utah 84415
Ogden (801)394-4515 Salt Lake City (801)521-0222 Fax (801)392-7544

SCALE :	1" = 20'	DATE :	5 Sep, 2006	DRWG. NO.
DRAWN :	AH	REVISIONS :	3 Oct, 2006	11a
	05N342-11a			