Huddleston-Berry
Engineering & Testing, LLC

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April 27, 2015
Project#[redacted]

Chronos Homes
163 South Ash Street
Fruita, Colorado 81521

Attention: Mr. Cody Davis

Subject: Geotechnical Investigation
1390 Horseshoe Drive
Fruita, Colorado

Dear Mr. Davis,

This letter presents the results of a geotechnical investigation conducted by Huddleston-Berry Engineering & Testing, LLC (HBET) at 1390 Horseshoe Drive in Fruita, Colorado. The site location is shown on Figure 1. The proposed construction is anticipated to consist of a single-family residence. The scope of our investigation included evaluating the subsurface conditions at the site to aid in developing foundation recommendations for the proposed construction.

Site Conditions

At the time of the investigation, the site was generally open. The site lies on a small hill with slight to moderate slopes down to the north, south, and west. Vegetation consisted primarily of weeds. The site was bordered to the north and east by a shared driveway, to the west by Horseshoe Drive, and to the south by an existing residence.

Subsurface Investigation

The subsurface investigation included three test pits as shown on Figure 2 – Site Plan. The test pits were excavated to depths of between 5.0 and 5.5 feet below the existing ground surface. Typed test pit logs are included in Appendix A.

As shown on the logs, the subsurface conditions at the site were slightly variable. Test Pit TP-1, conducted in the northern portion of the site, encountered 1.0 foot of topsoil materials above brown to gray, dry, soft, highly to completely weathered shale bedrock to the bottom of the excavation. Groundwater was not encountered in TP-1 at the time of the investigation.

EXHIBIT [redacted]
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Test Pits TP-2 and TP-3, conducted in the southern portion of the site, encountered 1.0 foot of topsoil materials above brown to gray, dry, loose to medium dense sandy gravel soils to depths of between 2.0 and 3.0 feet. Below the gravels, brown to gray, dry, soft, highly weathered shale bedrock extended to the bottoms of the excavations. Groundwater was not encountered in TP-2 or TP-3 at the time of the investigation.

Foundation Recommendations

As discussed previously, shale bedrock was encountered in the subsurface at this site. Based upon our experience with the Mancos shale in the vicinity of the site, the shale is anticipated to be slightly to moderately expansive. In general, deep foundations such as micro piles will provide the most protection against heave related movements; however, for this type of construction deep foundations are usually cost prohibitive. Shallow foundations will not provide as much protection against heave related movements; however, properly constructed they can help to reduce the risk of excessive differential movements. The recommended foundation alternatives are discussed in the following sections.

Micro Pile Foundation

For a micro pile foundation, it is recommended that micro piles have a minimum length of 30 feet. In order to reduce or eliminate uplift friction in the shallow bedrock, the upper 20 feet of the piles should be sleeved or cased. However, if subsurface moisture conditions differ than those encountered during the subsurface investigation, the sleeved or cased zone may be need to be increased as directed by the engineer. An allowable skin friction value of 1,500 psf may be used for the shale bedrock below the sleeved or cased zone. To ensure friction capacity, pile load testing is strongly recommended. Grout used in the bond zone of the micro piles should have a minimum 28 day compressive strength of 3,000 psi. Due to the presence of shallow groundwater, injection grouting may be necessary.

In general, micro piles should be installed with a center-to-center spacing of greater than 3 feet. However, to the extent practical, smaller numbers of longer micro piles should be used in lieu of larger numbers of shorter piles. The longer the piles and larger the loads on the piles, the lower the risk of movement. A minimum 6-inch void should be provided below the grade beams to concentrate loadings on the piles. The void forms should also extend above the micro piles such that only the reinforcement bar contacts the grade beam.

Spread Footing Type Foundation

The recommended spread footing type foundations alternatives include spread footings, voided spread footings, and isolated pads and grade beams. However, as discussed previously, the shale bedrock is expansive. Therefore, to help limit the potential for excessive differential movements, it is recommended that the foundations be constructed above a minimum of 48-inches of structural fill above competent shale bedrock.

The native gravel soils, exclusive of topsoil, are suitable for reuse as structural fill. Due to the potential for expansion of the native materials, the native shale bedrock materials are not suitable for reuse as structural fill. Imported structural fill should consist of a granular, non-expansive, non-free draining material such as crusher fines, pit-run with high fines content, or CDOT Class 6 base course. However, if pit-run is used for structural fill, a minimum of six inches of crusher fines or Class 6 base course should be placed on top of the pit-run to prevent large point stresses on the bottoms of the footings due to large particles in the pit-run.

Prior to placement of structural fill, it is recommended that the bottom of the foundation excavation in bedrock be proof rolled to identify any soft or weak materials. Soft or weak materials should be removed and replaced with structural fill. Due to the potential for expansion, no moisture should be added to the subgrade. Structural fill should extend laterally beyond the edges of the foundation a distance equal to the thickness of structural fill. Structural fill should be moisture conditioned, placed in maximum 8-inch loose lifts, and compacted to a minimum of 95% of the standard Proctor maximum dry density for fine grained soils and modified Proctor maximum dry density for coarse grained soils, within 0 to -2% of the optimum moisture content as determined in accordance with ASTM D698 and D1557C, respectively. Pit-run materials should be proof rolled to the Engineer's satisfaction.

For structural fill consisting of the native gravels or imported granular materials and foundation building pad preparation as recommended, a maximum allowable bearing capacity of 2,500 psf may be used. However, a minimum dead load pressure of 750 psf is recommended. Where the minimum dead load is not achievable, such as for interior foundations, the dead load should be maximized to the extent practical. For structural fill consisting of the native gravels, pit-run, crusher fines, or base course, a subgrade modulus of 250 pci may be used. Footings subject to frost should be at least 24-inches below the finished grade.

Structural Ribbed Slab Foundation

Ribbed structural slabs are designed to behave in rigid manner such that the slabs do not bend as a result of expansion or collapse of the subgrade soils below the slabs. Instead, the entire slab moves together, thus minimizing structural distress (cracking, etc.). The rib spacing, depth, etc. necessary to provide rigidity of the slab should be determined by the structural engineer.

For ribbed slabs, it is recommended that structural fill extend a minimum of 12-inches beyond the depth of the ribs. Depending upon the type of structural fill used, it may be possible to cut into the structural fill and earth form the ribs. Subgrade preparation, structural fill materials, and structural fill placement should be in accordance with the previous section of this report.

Water Soluble Sulfates

Water soluble sulfates were observed in the shale bedrock. Therefore, at a minimum, Type I-II sulfate resistant cement is recommended for construction at this site.

Lateral Earth Pressures

Any stemwalls, grade beams, or retaining walls should be designed to resist lateral earth pressures. For backfill consisting of imported granular, non-free draining, non-expansive material, we recommend that the walls be designed for an equivalent fluid unit weight of 65 pcf in areas where no surcharge loads are present. Lateral earth pressures should be increased as necessary to reflect any surcharge loading behind the walls. The native shale bedrock should not be used as backfill.

Non-Structural Floor Slab and Exterior Flatwork Recommendations

As mentioned above, expansive shale bedrock is present at the site. Due to the fact that slabs-on-grade do not generate sufficient loads to resist heave, differential movement of slabs-on-grade should be anticipated. However, to help limit the magnitude of movement, it is recommended that non-structural floor slabs be constructed above a minimum of 24-inches of structural will with subgrade preparation and fill placement in accordance with the *Foundation Recommendations* section of this report. It is recommended that exterior slabs-on-grade be constructed above a minimum of 12-inches of structural fill.

Slabs-on-grade should not be tied into or otherwise connected to the foundations in any manner. In addition, where a floor slab is used, interior, non-bearing partitions should include a slip-joint or framing void which permits a minimum of 2-inches of vertical movement.

Drainage Recommendations

Grading and drainage are ***critical*** to the performance of the foundations and slabs-on-grade. Where grading and drainage permit moisture to infiltrate around the structure and down to the shale bedrock, significant structural movement is likely. As a result, grading around the structure should be designed to carry precipitation and runoff away from the structure. It is recommended that the finished ground surface drop at least twelve inches within the first ten feet away from the structure. Downspouts should empty beyond the backfill zone. It is also recommended that landscaping within ten feet of the structures include primarily desert plants with low water requirements. In addition, it is recommended that automatic irrigation within ten feet of foundations be minimized or controlled with automatic shut off valves.

Subsurface downspout drains should be carefully constructed using solid PVC pipe. Dry wells should not be used.

As discussed previously, shallow groundwater was not encountered at the site. However, a perimeter foundation drain is recommended. In general, the perimeter foundation drain should consist of prefabricated drain materials or perforated pipe and gravel systems with the flowline of the drain at the bottom of the foundation (at the highest point). The perimeter drain should slope at a minimum of 1.5% to daylight or to a sump. In addition, the gravel or other prefabricated drainage materials should extend along basement walls to within 36-inches of the finished ground surface. An impermeable membrane is also recommended at the base of the drain to limit the potential for moisture to infiltrate into the subsurface below the foundations.

General Notes

The recommendations included above are based upon the results of the subsurface investigation and on our local experience. These conclusions and recommendations are valid only for the proposed construction.

As discussed previously, the subsurface conditions at the site were observed to be slightly variable. However, the precise nature and extent of any subsurface variability may not become evident until construction. Therefore, it is recommended that HBET be retained to provide oversight during construction.

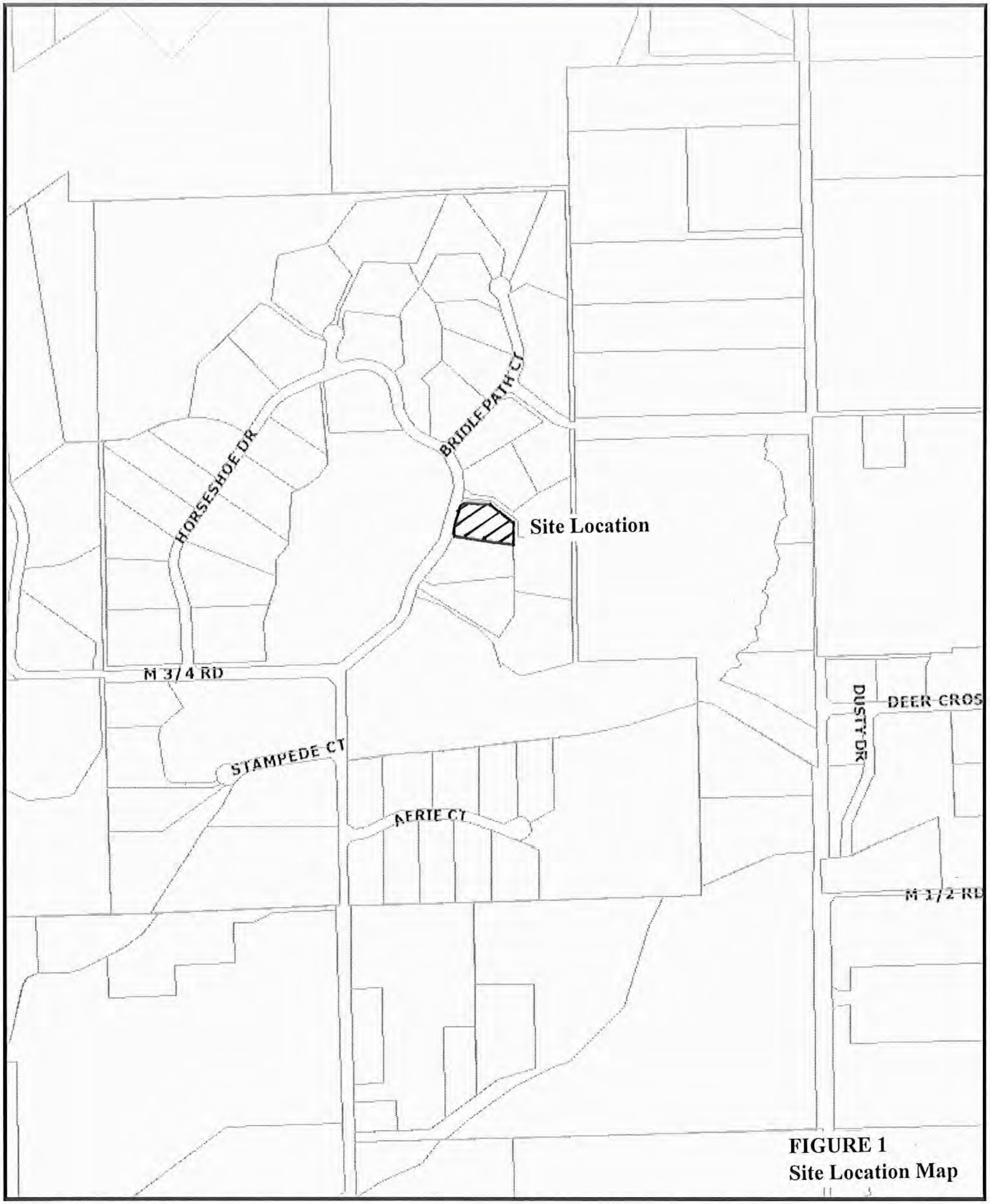
It is important to note that the recommendations herein are intended to reduce, but not eliminate, the potential for structural movement as a result of swelling of the native shale bedrock. While the foundation recommendations above are consistent with generally accepted engineering practices in areas of swelling soils and/or bedrock, HBET cannot predict long-term changes in subsurface moisture conditions and/or the precise magnitude or extent of swelling or swelling pressures. ***Where subsurface moisture conditions change significantly over time due to poor grading and drainage, irrigation leak, utility leak, groundwater fluctuations, or other cause, significant structural movements are possible***.

We are pleased to be of service to your project. Please contact us if you have any questions or comments regarding the contents of this report.

Respectfully Submitted:
Huddleston-Berry Engineering and Testing, LLC

Michael A. Berry, P.E.
Vice President of Engineering

FIGURES



Mesa County Map

The Geographic Information System (GIS) and its components are designed as a source of reference for answering inquiries, for planning and for modeling. GIS is not intended or does not replace legal description information in the chain of title and other information contained in official government records such as the County Clerk and Recorders office or the courts. In addition, the representations of location in this GIS cannot be substitute for actual legal surveys.
The information contained herein is believed accurate and suitable for the limited uses, and subject to the limitations, set forth above. Mesa County makes no warranty as to the accuracy or suitability of any information contained herein. Users assume all risk and responsibility for any and all damages, including consequential damages, which may flow from the user's use of this information.

0 0.05 0.1 0.2 mi
0 0.075 0.15 0.3 km

Print Date: April 27, 2015

Mesa County, Colorado
GIS/IT Department
gis.mesacounty.us

[redacted]

City of Grand Junction

N

0 0.0125 0.025 Miles

Printed: 4/23/2015

1 inch = 48 feet

City of Grand Junction Colorado Geographic Information System

CB 000184

APPENDIX A
Typed Test Pit Logs

Huddleston-Berry Engineering & Testing, LLC
640 White Avenue, Unit B
Grand Junction, CO 81501
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TEST PIT NUMBER TP-1

CLIENT Chronos Homes
PROJECT NAME 1390 Horseshoe Dr
PROJECT NUMBER [redacted]
PROJECT LOCATION Fruita, Co
DATE STARTED 3/19/15 COMPLETED 3/19/15
GROUND ELEVATION
TEST PIT SIZE
EXCAVATION CONTRACTOR Client
GROUND WATER LEVELS:
EXCAVATION METHOD
AT TIME OF EXCAVATION Dry
LOGGED BY CM CHECKED BY MAB
AT END OF EXCAVATION Dry
NOTES
AFTER EXCAVATION ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
0.0		Silty SAND with Organics (TOPSOIL), brown, moist										
		SHALE, brown to gray, dry, soft, completely to highly weathered										
2.5												
			1									
5.0		Bottom of test pit at 5.0 feet.										

[redacted]

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TEST PIT NUMBER TP-2

CLIENT Chronos Homes
PROJECT NAME 1390 Horseshoe Dr
PROJECT NUMBER [redacted]
PROJECT LOCATION Fruita, Co
DATE STARTED 3/19/15 COMPLETED 3/19/15
GROUND ELEVATION TEST PIT SIZE
EXCAVATION CONTRACTOR Client
GROUND WATER LEVELS:
EXCAVATION METHOD
AT TIME OF EXCAVATION Dry
LOGGED BY CM CHECKED BY MAB
AT END OF EXCAVATION Dry
NOTES
AFTER EXCAVATION ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
0.0		Gravely Silty SAND with Organics (TOPSOIL), brown, moist										
		Sandy GRAVEL (gw), brown, dry, loose to medium dense										
2.5		SHALE, brown to gray, dry, soft, highly weathered										
5.0												
		Bottom of test pit at 5.5 feet.										

[redacted]

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TEST PIT NUMBER TP-3

CLIENT Chronos Homes
PROJECT NAME 1390 Horseshoe Dr
PROJECT NUMBER [redacted]
PROJECT LOCATION Fruita, Co
DATE STARTED 3/19/15 COMPLETED 3/19/15
GROUND ELEVATION
TEST PIT SIZE
EXCAVATION CONTRACTOR Client
GROUND WATER LEVELS:
EXCAVATION METHOD
AT TIME OF EXCAVATION Dry
LOGGED BY CM CHECKED BY MAB
AT END OF EXCAVATION Dry
NOTES
AFTER EXCAVATION ---

DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	POCKET PEN. (tsf)	DRY UNIT WT. (pcf)	MOISTURE CONTENT (%)	ATTERBERG LIMITS: LIQUID LIMIT	ATTERBERG LIMITS: PLASTIC LIMIT	ATTERBERG LIMITS: PLASTICITY INDEX	FINES CONTENT (%)
0.0		Sandy GRAVEL with Organics (TOPSOIL), brown, moist										
		Sandy GRAVEL with Cobbles (gw), brown to gray, dry, loose										
2.5												
		SHALE, brown to gray, dry, soft, highly weathered										
5.0												
		Bottom of test pit at 5.5 feet.										

[redacted]