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SOIL, GEOLOGY, AND GEOLOGIC HAZARD STUDY
STERLING RANCH PHASE 2
AND STERLING RANCH FILING NO. 3
EL PASO COUNTY, COLORADO

Prepared for

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Respectfully Submitted,

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1.0 SUMMARY

Project Location:

The project lies in portions of the SW ¼ Section 33, Township 12 South, Range 65 West and a portion of the NW ¼ of the NW ¼ of Section 4 and the NE ¼ of the NE ¼ of Section 5, Township 13 South, Range 65 West of the 6th Principal Meridian. The site is located east of Vollmer Road and north of Woodmen Road, along proposed Sterling Ranch Road, north of proposed Marksheffel Road in El Paso County, Colorado.

Project Description:

Total acreage involved in the project is approximately 107.5 acres. The proposed development is to consist of single-family residential development with a school site proposed at the northeast corner. The development will be serviced by Woodmen Hills Metropolitan District.

Scope of Report:

The report presents the results of our geologic investigation and treatment of engineering geologic hazard study. This report presents the results of our geologic reconnaissance, a review of available maps, aerial photographs and our conclusions with respect to the impacts of the geologic conditions on development.

Land Use and Engineering Geology:

The site was found to be suitable for development. Geologic conditions will impose some constraints on development. These include areas of artificial fill, potentially expansive soils, hydrocompaction, potentially unstable slopes, a floodplain, and seasonal and potentially seasonal shallow groundwater areas. Artificial fill is associated with recent grading and fill stockpiles. Hydrocompaction is associated with wind-blown sand deposits. Areas of seasonal and potentially seasonal shallow groundwater occur in a drainage in the western portion of the site and in southern areas of the site. The floodplain and adjacent potentially unstable slopes are associated with Sand Creek along the eastern boundary of the site and will be avoided by development. Shallow bedrock will also be encountered on portions of the site. Site conditions will be discussed in greater detail in this report. All recommendations are subject to the limitations discussed in the report.

2.0 GENERAL SITE CONDITIONS AND PROJECT DESCRIPTION

The project lies in portions of the SW ¼ Section 33, Township 12 South, Range 65 West and a portion of the NW ¼ of the NW ¼ of Section 4 and the NE ¼ of the NE ¼ of Section 5, Township 13 South, Range 65 West of the 6th Principal Meridian. The site is located east of Vollmer Road and north of Woodmen Road, along proposed Sterling Ranch Road, north of proposed Marksheffel Road in El Paso County, Colorado. The location of the site is shown on the Vicinity Map, Figure 1.

The topography of the site is generally gently sloping to the south with a minor drainage along the western portion of the site, which flows in a southerly direction. Sand Creek exists along the eastern boundary of the site and flows in a southerly direction. An existing detention pond exists in the southern portion of the site. The area of the site is indicated on the USGS Map, Figure 2. Previous site uses have included aggregate extraction as a part of the Pioneer Sand Quarry. Existing sand and gravel quarries lie to the southeast of the site. The vegetation on site consists of low field grasses, weeds with areas where vegetation has been removed.

Total acreage involved in the proposed development is approximately 107.5 acres. The proposed development is to consist of single-family residential development with a school site proposed at the southeast portion of the site. The development is to be serviced by Woodmen Hills Metropolitan District. The overall site plan for the entire Sterling Ranch Development, including the subject site, is presented in Figure 3. The development plan for Sterling Ranch Phase 2 and Sterling Ranch Filing No. 3 is presented in Figure 4. Site photographs, taken on January 8, 2020, are included in Appendix A. The approximate locations and directions of the photographs are indicated on Figure 4. The proposed grading is indicated on Figure 4.

3.0 SCOPE OF THE REPORT

The scope of this report will include the following:

- A geologic analysis of the site utilizing published geologic data, and subsurface soils information.
- Detailed site-specific mapping of major geographic and geologic features.
- Identification of geologic hazards and impacts on the proposed development.
- Recommended mitigation of geologic hazards where they affect development.

4.0 FIELD INVESTIGATION

Our field investigation consisted of the preparation of a geologic map of bedrock features and significant surficial deposits. The Natural Resources Conservation Service (Reference 1), previously the Soil Conservation Service (Reference 2) survey was reviewed to evaluate the site.

The positions of mappable units within the subject property are shown on the Geologic Map. Our mapping procedures involved field reconnaissance, measurements and interpretation. The same mapping procedures have also been utilized to produce the Engineering Geology Map which identifies pertinent geologic conditions affecting development.

Additionally, four (4) test borings were drilled by Entech Engineering, Inc. as a part of this investigation. The borings were drilled with a power-driven continuous flight auger drill rig to 20 feet. Samples were obtained during drilling using the Standard Penetration Test, ASTM D-1586, utilizing a 2-inch O.D. Split Barrel Sampler and a California Sampler. Results of the penetration tests are shown on the drilling logs to the right of the sampling point. The location of the test borings is shown on the Test Boring Location Plan, Figure 4. The drilling logs are included in Appendix B.

Laboratory testing was performed to classify and determine the soils engineering characteristic. Laboratory tests included moisture content, ASTM D-2216, grain size analysis, ASTM D-422, and Atterberg Limits, ASTM D-4318. Swell tests included FHA Swell Testing and Swell/Consolidation Testing, ASTM D-4546. Results of the laboratory testing are included in Appendix C. A Summary of Laboratory Test Results is presented in Table 1.

Geologic Hazard Studies were previously performed by Entech Engineering, Inc. for the entire Sterling Ranch development, October 31, 2006 (Reference 3) and January 20, 2009 (Reference 4). Two of the test borings from the previous investigations was located on the subject site (Test Boring Nos. 2 and 41). The locations of the test borings are indicated on Figure 4. The Test Boring Logs and Laboratory Test Results are included in Appendix D. Information from these reports was used in evaluating the site.

5.0 SOIL, GEOLOGY AND ENGINEERING GEOLOGY

5.1 General Geology

Physiographically, the site lies in the western portion of the Great Plains Physiographic Province. Approximately 10 miles to the west is a major structural feature known as Rampart Range Fault. This fault marks the boundary between the Great Plains Physiographic Province and the Southern Rocky Mountain Province. The site exists within the southern edge of a large structural feature known as the Denver Basin. Bedrock in the area tends to be gently dipping in a northeasterly direction (Reference 5). The rocks in the area of the site are sedimentary in nature, and typically Tertiary to Cretaceous in age. The bedrock underlying the site itself is the Dawson Formation. Overlying the Dawson Formation are unconsolidated deposits of artificial fill, residual, eolian and alluvial soils. The site's stratigraphy will be discussed in more detail in Section 5.3.

5.2 Soil Survey

The Natural Resources Conservation Service (Reference 1), previously the Soil Conservation Service (Reference 2) has mapped three soil types on the site (Figure 5). In general, the soils consist of loamy sand. Soils are described as follows:

Soil Type	Description
9	Blakeland complex, 1-9% slopes: Dark grayish brown to brown loamy sand. Permeability is rapid. Erosion hazard is moderate. Good potential for home sites except in swale areas where high water table is possible and hazard of flooding.
19	Columbine gravelly sandy loam, 0-3% slopes: Grayish brown gravelly sandy loam. Permeability is very rapid. Erosion hazard is slight to moderate. Hazard of flooding in areas of floodplains.
71	Pring coarse sandy loam, 3-8% slopes: Dark grayish brown to brown coarse sandy loam. Permeability is rapid. Erosion hazard is moderate. Good potential for home sites.

Complete descriptions of the soils are presented in Appendix E (Reference 2). The soils have generally been described to have rapid to very rapid permeabilities. Limitations to development are varied on the different soil types and include frost action potential. The hazard of flooding exists in some areas, particularly several areas in Soil Type 9. Soil Type 9 is mapped in the drainage area along the western edge and southern portions of the site. Possible hazards with soil erosion are present on the site. The erosion potential can be controlled with vegetation. The soils have been described to have moderate erosion hazards.

5.3 Site Stratigraphy

The Falcon NW Quadrangle Geologic Map showing the site is presented in Figure 6 (Reference 6). The Geology Map prepared for the site is presented in Figure 7. Five mappable units were identified on this site, which are described as follows:

- **Qaf** **Artificial Fill of Quaternary Age:** These are man-made fill deposits associated with site grading and fill stockpiles. Other areas of fill may be encountered that are not indicated on the map.

- **Qal** **Recent Alluvium of Quaternary Age:** These are recent stream deposits that have been deposited in the drainage along the western boundary and southern portions of the site and in the Sand Creek Drainage. These materials consist of silty to clayey sands and sandy clays. Some of these alluviums may contain highly organic soils.

- **Qb** **Broadway Alluvium of Pleistocene Age:** These materials consist of stream terrace deposits. The Broadway Alluvium typically consists of silty to clayey gravelly sands. This deposit is usually highly stratified and may contain lenses of silt, clay or cobbles.

- **Qes** **Eolian Sand of Quaternary Age:** These deposits are fine to medium grained soil deposited on the site by the action of the prevailing winds from the west and northeast. They typically occur as large dune deposits or narrow ridges. These soil types are typically tan to brown in color and tend to have very uniform or well-sorted gradation. These materials tend to have a relatively high permeability and low density.

- **Tkd** **Dawson Formation of Tertiary to Cretaceous Age:** The Dawson formation typically consists of arkosic sandstone with interbedded fine-grained sandstone, siltstone and claystone. Overlying this formation is a variable layer of residual and/or colluvium soils. The residual soils were derived from the in-situ weathering of the bedrock materials on-site. The colluvium soils have been transported by the action of sheetwash and gravity. These soils consisted of silty to clayey sands and sandy clays.

The soils listed above were mapped from site-specific mapping of the site, the *Geologic Map of the Falcon NW Quadrangle* by Madole, 2003 (Reference 6), the *Reconnaissance Geologic Map of Colorado Springs and Vicinity, Colorado* by Scott and Wobus in 1973 (Reference 7), and *the Geologic Map of the Colorado Springs-Castle Rock Area Front Range Urban Corridor, Colorado*, by Trimble and Machette, 1979 (Reference 8). The test borings from the subsurface investigation by Entech Engineering, Inc. were also used in evaluating the site.

5.4 Soil Conditions

Four soil and rock types were encountered in the test borings drilled on the site: Type 1: slightly silty to silty sand (SM-SW, SM), Type 2: sandy clay (CL), Type 3: silty to clayey sandstone bedrock (SM, SC), and Type 4: sandy claystone bedrock (CL). Each material type was classified using the results of the laboratory testing and the Unified Soil Classification System (USCS). The bedrock encountered in the borings was classified as soil in that the upper bedrock zone could be penetrated using conventional soil drilling and sampling techniques.

Soil Type 1 was classified as a slightly silty to silty sand (SM-SW, SM). The sand was encountered in all of the test borings at the existing ground surface and extending to depths ranging from 3 to 14 feet bgs. Standard Penetration Testing on the sand resulted in N-Values of 10 to 29 bpf, indicating medium dense states. Water content and grain size testing resulted in a water contents of 2 to 13 percent with approximately 6 to 35 percent of the soil size particles passing the No 200 severe. Atterberg limits testing resulted in non-plastic results.

Soil Type 2 classified as a sandy clay (CL). The clay was encountered in Test Boring No.4 at a depth of 3 feet and extending to 8 feet below ground surface (bgs). Standard Penetration Testing on the clay resulted in a N-value of 47 blows per foot (bpf), indicating very stiff consistencies. Water content and grain size testing resulted in a water content of 11 percent with approximately 76 percent of the soil size particles passing the No. 200 sieve. Swell/Consolidation Testing resulted in a volume change of 2.0 percent, indicating low to moderate expansion potential.

Soil Type 3 was classified as silty to clayey sandstone bedrock (SM, SC). The sandstone was encountered in three of the test borings drilled as a part of this investigation at depths of approximately 4 to 8 feet bgs and extending to depths of 18 feet the termination of the borings (20 feet). Standard Penetration Testing on the sandstone resulted in N-values of 34 to greater than 50 bpf indicating dense to very dense states. Water content and grain size testing resulted in water contents of 7 to 16 percent with approximately 25 percent of the soil size particles passing the No. 200 sieve. Atterberg limits testing on the sandstone indicated non-plastic results.

Soil Type 4 was classified as a sandy claystone bedrock (CL). The claystone was encountered in two of the test borings drilled as a part of this investigation at 14 to 18 feet and extending to the termination of the borings (20 feet). Standard Penetration Testing on the claystone resulted in N-values of 41 to greater than 50 bpf, indicating very stiff to hard consistencies. Water content and grain size testing resulted in water contents of 10 to 13 percent with approximately 68 percent of the soil size particles passing the No. 200 Sieve. Atterberg limits testing resulted in a liquid limit of 32 and a plastic index of 12. Swell/Consolidation Testing of the claystone resulted in a consolidation of 0.4 percent, indicating low consolidation potential. Moderately to highly expansive claystone has been encountered in the area.

Test Boring logs are included in Appendix B. A Summary of the Laboratory Test Results for each of the soil and rock types is summarized in Table 1 and included in Appendix C. The Test Boring Log and Laboratory Test Results from previous investigations (Reference 3) is included in Appendix D.

5.5 Groundwater

Groundwater was encountered at depths of 7 and 8.5 feet in two of the test borings subsequent to drilling. Groundwater was not encountered in the other two borings which were drill to 20 feet. Groundwater was encountered at 9 and 11 feet in the Test Boring Nos. 2 and 41, drilled as a part of the previous investigation (Reference 3, Appendix D). Groundwater depths are summarized in Table 2. It should be noted that these water levels are from previous investigations. Fluctuations in the groundwater conditions may occur due to conditions such as variations in rainfall, precipitation infiltration and development of nearby areas. Areas of seasonal and potentially seasonal shallow groundwater have been identified on the site. These areas will be discussed in the following sections.

6.0 ENGINEERING GEOLOGY - IDENTIFICATION AND MITIGATION OF GEOLOGIC HAZARDS

As mentioned previously, detailed mapping has been performed on this site to produce an Engineering Geology Map (Figure 7). This map shows the location of various geologic conditions of which the developers and planners should be cognizant during the planning, design and construction stages of the project. The hazards identified on this site include artificial fill, hydrocompaction, potentially expansive soils, and seasonal and potentially seasonal shallow groundwater areas and a floodplain east of the site. The following hazards have been addressed:

Expansive Soils

Expansive soils were encountered in some of the test borings drilled on-site and as a part of the previous investigation (References 3 and 4). The site is classified in areas of low to moderate swell potential according to the *Map of Potentially Swelling Soil and Rock in the Front Range Urban Corridor, Colorado* by Hart, 1974 (Reference 9); however, highly expansive clays and claystone are typically encountered in the area. These areas are sporadic; therefore, none have been indicated on the map. Expansive clays and claystone, if encountered, can cause differential movement in the structure foundation.

Mitigation: Mitigation of expansive soils will require special foundation design. Overexcavation and replacement with non-expansive soils at a minimum 95 percent of its maximum Modified Proctor Dry Density, ASTM D-1557 is a suitable mitigation which is common in the area. Drilled piers are another option that is used in areas where highly expansive soils are encountered. Typical minimum pier depths are on the order of 25 feet or more and require penetration into the bedrock material a minimum of 4 to 6 feet, depending upon building loads. Floor slabs on expansive soils should be expected to experience movement. Overexcavation and replacement has been successful in minimizing slab movements. The use of structural floors can be considered for basement construction on highly expansive clays. Final recommendations should be determined after additional investigation of each building site.

Subsidence Area

Based on a review of a Subsidence Investigation Report for the Colorado Springs area by Dames and Moore, 1985 (Reference 10) and the mining report for the Colorado Springs coalfield (Reference 11), the site is not undermined. The closest underground mines in the area are 6 miles to the southwest and the site is not mapped within any potential subsidence zones.

Slope Stability and Landslide Hazard

The majority of the slopes on-site are gently sloping and do not exhibit any past or potential unstable slopes or landslides. Some of the steeper slopes along Sand Creek east of the site have been identified as potentially unstable slopes. The mitigation recommendation for these areas is as follows:

Potentially Unstable Slopes

Some of the steep slopes along the Sand Creek drainage have been identified as potentially unstable. Considerable care must be exercised in these areas not to create a condition which would tend to activate instability.

Mitigation: According to the grading plan shown on Figure 7, the majority of these areas are to be regraded. Building should be avoided on any remaining potentially unstable slopes unless stabilized. A setback of 20 feet from the crest of these slopes is recommended unless stabilized. Stabilization could involve regrading to slope angles no steeper than 3:1 or the use of engineer-designed retaining walls, tiebacks, or buttresses. Where retaining walls are not used, erosion protection may be necessary to prevent undercutting by the creek during periods of high water. It is our understanding the project will include drainage improvements and the construction of a regional trail along the Sand Creek drainage and stabilization of the slopes will be a part of the improvements. Specific slope stabilization recommendations are beyond the scope of this report.

Based on the prepared development plan it appears the potentially instable slopes can be regraded or avoided. These areas are minor and there is sufficient distance for proposed setbacks for any remaining slopes.

Debris Fans

Based on-site observations, debris fans were not observed in this area.

Groundwater and Floodplain Areas

Areas within the drainage swale along the western portions of the site have been identified as seasonal and potentially seasonal shallow groundwater areas. According to the development plan, Figure 7, surface waters in this drainage are to be collected and piped along the western boundary to a detention pond south of the site. The Sand Creek drainage lies east of the site and has been mapped as a floodplain zone according to the FEMA Map No. 08041CO533G, Figure 8 (Reference 12). The site does not lie within the floodplain zone as indicated in Figure 8. Finished floor levels must be a minimum of one floor above the floodplain level. Exact floodplain locations by drainage studies are beyond the scope of this report. Much of the western portions of the site have been mapped as seasonal and potentially seasonal shallow groundwater due to the drainage swale, although, shallow groundwater could be encountered adjacent to these areas during periods of high moisture. These areas are discussed as follows:

Seasonal Shallow Groundwater: In these areas, we would anticipate the potential for periodically high subsurface moisture conditions and possible frost heave potential, depending on the soil conditions. These areas are located within the drainage swale along the western portions of the site. According to the grading plan, these areas are to be regraded and surface drainage will be collected and piped along the western boundary of the site to a detention pond south of the site. Areas of shallow groundwater may exhibit unstable subgrade conditions in terms of bearing support of construction equipment during overlot grading. Lots immediately adjacent to drainage may also experience higher subsurface moisture conditions during periods of higher flows.

Mitigation: In these locations, foundations subject to severe frost heave potential should penetrate sufficient depth so as to discourage the formation of ice lenses beneath foundations. At this location and elevation, a foundation depth for frost protection of 30 inches is recommended. In areas where high subsurface moisture conditions are anticipated periodically, a subsurface perimeter drain will be necessary to help prevent the intrusion of water into areas located below grade. A typical perimeter drain detail is presented in Figure 9. Structures should not block drainages. Swales should be created to intercept surface runoff and carry it safely around and away from structures.

Potentially Seasonal Shallow Groundwater: Shallow groundwater was encountered and observed along the drainage in the western portion of the site, particularly west of the drainage following precipitation events. Groundwater depths encountered in the test borings drilled on site are summarized in Table 2. Drainage from north of the site appears to back up west of the site during periods of high runoff. According to the proposed grading plan, the drainage from the north of the site is to be collected and piped alone the eastern boundary of the site to a detention pond southeast of the site. Additionally, much of the area is to be filled, further raising the area above groundwater levels. Foundations should be kept as high as possible. Areas may experience higher groundwater levels during period of higher precipitation where water can flow through permeable sands on top of less permeable bedrock materials. Subsurface perimeter drains may be necessary to prevent the intrusion of water into areas below grade. Typical drain details are presented in Figure 9. Where shallow groundwater is encountered, underslab drains or interceptor drains may be necessary. Typical drain details are presented in Figure 10 and 11. Specific recommendations should be made after additional investigation and site grading has been completed.

Artificial Fill

Areas of artificial fill were observed in areas of the site. The majority of these areas are associated with recent grading and fill stockpiling.

Mitigation: It is anticipated the fill piles will be removed prior to construction. In the areas of site grading, fill records should be obtained to determine if the fill was placed in a controlled manner. Where uncontrolled fill is encountered beneath foundations, mitigation will be necessary. Mitigation typically involves removal and recompaction at a minimum of 95 percent of its maximum Modified Proctor Dry Density, ASTM D-1557. Any new fill added to the site should be placed on native or controlled fill soils, compacted as recommended above.

Hydrocompaction

Areas in which hydrocompaction have been identified are acceptable as building sites. In areas identified for this hazard classification, however, we anticipate a potential for settlement movements upon saturation of these surficial soils. The low density, uniform grain sized, windblown sand deposits are particularly susceptible to this type of phenomenon. Additionally, loose or collapsible soils may be encountered on this site.

Mitigation: The potential for settlement movement is directly related to saturation of the soils below the foundation areas. Therefore, good surface and subsurface drainage is extremely critical in these areas in order to minimize the potential for saturation of these soils. The ground surface around all permanent structures should be positively sloped away from the structure to all points, and water must not be allowed to stand or pond anywhere on the site. We recommend that the ground surface within 10 feet of the structures be sloped away with a minimum gradient of five percent. If this is not possible on the upslope side of the structures, then a well-defined swale should be created to intercept the surface water and carry it quickly and safely around and away from the structures. Roof drains should be made to discharge well away from the structures and into areas of positive drainage. Where several structures are involved, the overall drainage design should be such that water directed away from one structure is not directed against an adjacent building. Planting and watering in the immediate vicinity of the structures, as well as general lawn irrigation, should be minimized.

Areas of loose or collapsible soils may also be encountered in these areas. Should loose or collapsible soils be encountered beneath foundations, removal and recompaction of the upper 2 to 3 feet with thorough moisture conditioning at a minimum of 95 percent of its maximum Modified Proctor Dry Density, ASTM D-1557 will be necessary. Specific recommendations should be made after additional investigation of each building site.

Faults

The closest fault is the Rampart Range Fault, located approximately 10 miles to the west. No faults are mapped on the site itself. Previously, Colorado was mapped entirely within Seismic Zone 1, a very low seismic risk. Additionally, the International Residential Code (IRC), 2003, currently places this area in Design Category B, also a low seismic risk. According to a report by the Colorado Geological Survey by Kirkman and Rogers, 1981, (Reference 13) this area should be designed for Zone 2 due to more recent data on the potential for movement in this area, and any resultant earthquakes.

Dipping Bedrock

The bedrock underlying the site is the Dawson Formation of Tertiary to Cretaceous Age. The bedrock in this area is gently dipping a northeasterly direction according to the *Geologic Structure Map of the Pueblo 1x2 Quadrangle, South-Central Colorado* (1978) (Reference 5).

The bedrock encountered in the test borings did not exhibit steeply dipping characteristics; therefore, mitigation is not necessary.

Radioactivity

Radon levels for the Colorado Geologic Survey in the Open-File have reported the area, Report No. 91-4 (Reference 14). Radon levels ranging from 0 to 20 pci/l have been measured in the area. Only two readings have been taken in the area. One reading was between 4 and 10 pci/l and the other was less than 4 pci/l. The minimal information from this report is not sufficient to determine if radon levels are higher for this site. An occurrence of radioactive minerals has been identified 4 miles northwest of the site (Reference 15). This occurrence is associated with a limonite deposit in the Dawson Formation. The radioactivity hazard was researched by CTL/Thompson, Inc. for Wolf Ranch, west of the site (Reference 16). It was determined that the area lies within a zone that may have small deposits of low intensity radioactivity. No known occurrences exist on the site, however, radon gas originating in the bedrock underlying the site could migrate up into the upper soil profile.

Mitigation: The potential exists for radon gas to build up in areas of the site. Build-ups of radon gas can be mitigated by providing increased ventilation of basements and crawlspaces and sealing of joints. Specific requirements for mitigation should be based on-site specific testing after the site is constructed.

7.0 EROSION CONTROL

The soil types observed on the site are mildly to moderately susceptible to wind erosion, and moderately to highly susceptible to water erosion. A minor wind erosion and dust problem may be created for a short time during and immediately after construction. Should the problem be considered severe enough during this time, watering of the cut areas or the use of chemical palliative may be required to control dust. However, once construction has been completed, and vegetation reestablished, the potential for wind erosion should be considerably reduced.

With regard to water erosion, loosely compacted soils will be the most susceptible to water erosion, residually weathered soils and weathered bedrock materials become increasingly less susceptible to water erosion. For the typical soils observed on-site, allowable velocities or unvegetated and unlined earth channels would be on the order of 3 to 4 feet/second, depending upon the sediment load carried by the water. Permissible velocities may be increased through the use of vegetation to something on the order of 4 to 7 feet/second, depending upon the type of vegetation established. Should the anticipated velocities exceed these values, some form of channel lining material may be required to reduce erosion potential. These might consist of some of the synthetic channel lining materials on the market or conventional riprap.

In cases where ditch-lining materials are still insufficient to control erosion, small check dams or sediment traps may be required. The check dams will serve to reduce flow velocities, as well as provide small traps for containing sediment. The determination of the amount, location and placement of ditch linings, check dams and of the special erosion control features should be performed by or in conjunction with the drainage engineer who is more familiar with the flow quantities and velocities.

Cut and fill slope areas will be subjected primarily to sheetwash and rill erosion. Unchecked rill erosion can eventually lead to concentrated flows of water and gully erosion. The best means to combat this type of erosion is, where possible, the adequate re-vegetation of cut and fill slopes. Cut and fill slopes having gradients more than three (3) horizontal to one (1) vertical become increasingly more difficult to re-vegetate successfully. Therefore, recommendations pertaining to the vegetation of the cut and fill slopes may require input from a qualified landscape architect and/or the Soil Conservation Service.

8.0 ECONOMIC MINERAL RESOURCES

Some of the sandy materials on-site could be considered a low-grade sand resource. According to the *El Paso County Aggregate Resource Evaluation Map* (Reference 7), portions of the site are mapped as upland and floodplain deposits. According to the *Atlas of Sand, Gravel and Quarry Aggregate Resources, Colorado Front Range Counties* distributed by the Colorado Geological Survey (Reference 18), portions of the site are mapped as U3 – Upland deposits: sand, and V3: valley fill deposits: sand. According to the *Evaluation of Mineral and Mineral Fuel Potential* (Reference 19), tracts in the area of the site have been mapped as "Good" for industrial minerals. Quarries exist on the site and in the area of the site for sand and gravel, particularly in the Eolian Sand and Alluvial deposits. Based on the depth of bedrock encountered in the test borings, it appears the majority of the thicker deposits have been excavated from the site.

According to *the Evaluation of Mineral and Mineral Fuel Potential of El Paso County State Mineral Lands* (Reference 19), the tracts in the area of the site have been mapped as "Poor" for coal resources and "Little or no Potential" metallic mineral resources.

The site has been mapped as "Fair" for oil and gas resources (Reference 19). No oil or gas fields have been discovered in the area of the site. The sedimentary rocks in the area lack the essential elements for oil or gas.

9.0 RELEVANCE OF GEOLOGIC AND SITE CONDITIONS TO LAND USE PLANNING

The existing geologic and geotechnical conditions at the site will likely impose some constraints on the proposed development and construction. Avoidance or regrading can mitigate many hazards such as areas of potentially unstable slopes, seasonal and potentially seasonal shallow groundwater. Other constraints identified on the site such as expansive soils, hydrocompaction and artificial fill, can be mitigated through proper engineering design and construction. The floodplain in Sand Creek east of the site will be avoided.

The majority of the soils at typical foundation depths consist of sands, sandstone and claystone. Areas of shallow bedrock will be encountered on the site. Shallow sandstone will have higher bearing capacities. Excavation of the harder sandstone or claystone bedrock may be more difficult in some areas than others. Difficult excavation is anticipated in areas of shallow bedrock, particularly sandstone. Overlot grading and excavation for utility trenches and foundations will be affected by shallow bedrock. The use of track-mounted equipment will likely be required.

Expansive soils may be encountered in areas of this site. The expansive soils encountered in the test borings drilled on-site are sporadic; therefore, none have been indicated on the maps. Expansive soils, if encountered, will require special foundation design and/or overexcavation and replacement with non-expansive soil compacted to a minimum of 95 percent of the maximum dry density as determined by the Modified Proctor Test (ASTM D-1557). Other options include drilled piers.

Areas of hydrocompaction have been identified on this site where there is the potential for settlement movements upon saturation of the surficial soils. Good surface and subsurface drainage is critical in these areas and the ground surface should be positively sloped away from structures at all points. Roof drains should be made to discharge well away from structures and planting and watering in the immediate vicinity of structures should be minimized.

Areas of seasonal and potentially seasonal shallow groundwater have been mapped in the drainage area along the western boundary of the site. This area will be regraded and drainage piped to the south, however, structures immediately adjacent to the drainage area may experience higher water levels during periods of high moisture. Additionally, shallow groundwater was encountered west of the site after precipitation events due to runoff from the north that backed up in permeable sands overlying the bedrock. According to the grading plan the drainage area is to be filled and regraded and drainage from the north collected and piped to a detention pond south of the site. All soft or organic soils should be removed prior to fill placement. Unstable soils may be encountered where excavations approach the groundwater level. Shallow groundwater areas may also affect utility installation. Geo-grids or shotrock may be necessary to stabilize excavations. Foundations in or adjacent to seasonal or potentially seasonal shallow groundwater areas may require drains to control seepage within the foundation zone. A typical drain details are presented in Figures 9 through 11. Additional investigation is recommended after the storm sewer is installed and grading plans are completed to evaluate groundwater conditions.

The floodplain areas of the Sand Creek drainage exist east of the site. According to the development plan, the lots are proposed well outside the floodplain zone. The site is not mapped in any floodplains as indication of the Floodplain Map, Figure 8. Finished floor elevations must be a minimum of one foot above the floodplain level. Specific floodplain locations and drainage studies are beyond the scope of this report.

Potentially unstable slopes exist along Sand Creek east of the site. According to the grading plan the majority of these areas are to be regraded. A minimum building setback of 20 feet is recommended from the crest of any remaining potentially unstable slopes unless site-specific investigation or slope stability analysis is performed. Another option is to stabilize the slopes. Potentially unstable slopes can be typically mitigated by regrading to angles no steeper than 3 horizontal to 1 vertical or by construction of engineer-designed retaining walls. Erosion protection may be necessary along these slopes to prevent erosion by the creek. It is our understanding there will be drainage improvements that will incorporate slope stabilization and the construction of a regional trail corridor along the Sand Creek drainage.

In summary, development of the site can be achieved if the items discussed above are mitigated. These items can be mitigated through proper design and construction or by avoidance. Specific recommendations should be made after additional investigation prior to construction.

10.0 CLOSURE

It is our opinion that the existing geologic engineering and geologic conditions will impose some constraints on development and construction of the site. The geologic hazards identified on the site can either be avoided by development or satisfactorily mitigated through proper engineering design and construction practices.

It should be pointed out that because of the nature of data obtained by random sampling of such variable and non-homogeneous materials as soil and rock, it is important that we be informed of any differences observed between surface and subsurface conditions encountered in construction and those assumed in the body of this report. Discrepancies should be reported to Entech Engineering, Inc. soon after they are discovered so that the evaluation and recommendations presented can be reviewed and revised if necessary. Planning and design personnel should be made familiar with the contents of this report. In addition to lot investigations, additional subsurface soil investigation is recommended after the storm sewer is installed to evaluate groundwater conditions.

This report has been prepared for Morley – Bentley Investments, LLC for application to the proposed project in accordance with generally accepted geologic soil and engineering practices. No other warranty expressed or implied is made.

We trust this report has provided you with all the information you required. Should you require additional information, please do not hesitate to contact Entech Engineering, Inc.

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TABLES

TABLE 1

SUMMARY OF LABORATORY TEST RESULTS

CLIENT MORLEY-BENTLEY INVEST.
PROJECT STERLING RANCH, P2, F3
JOB NO. 191089

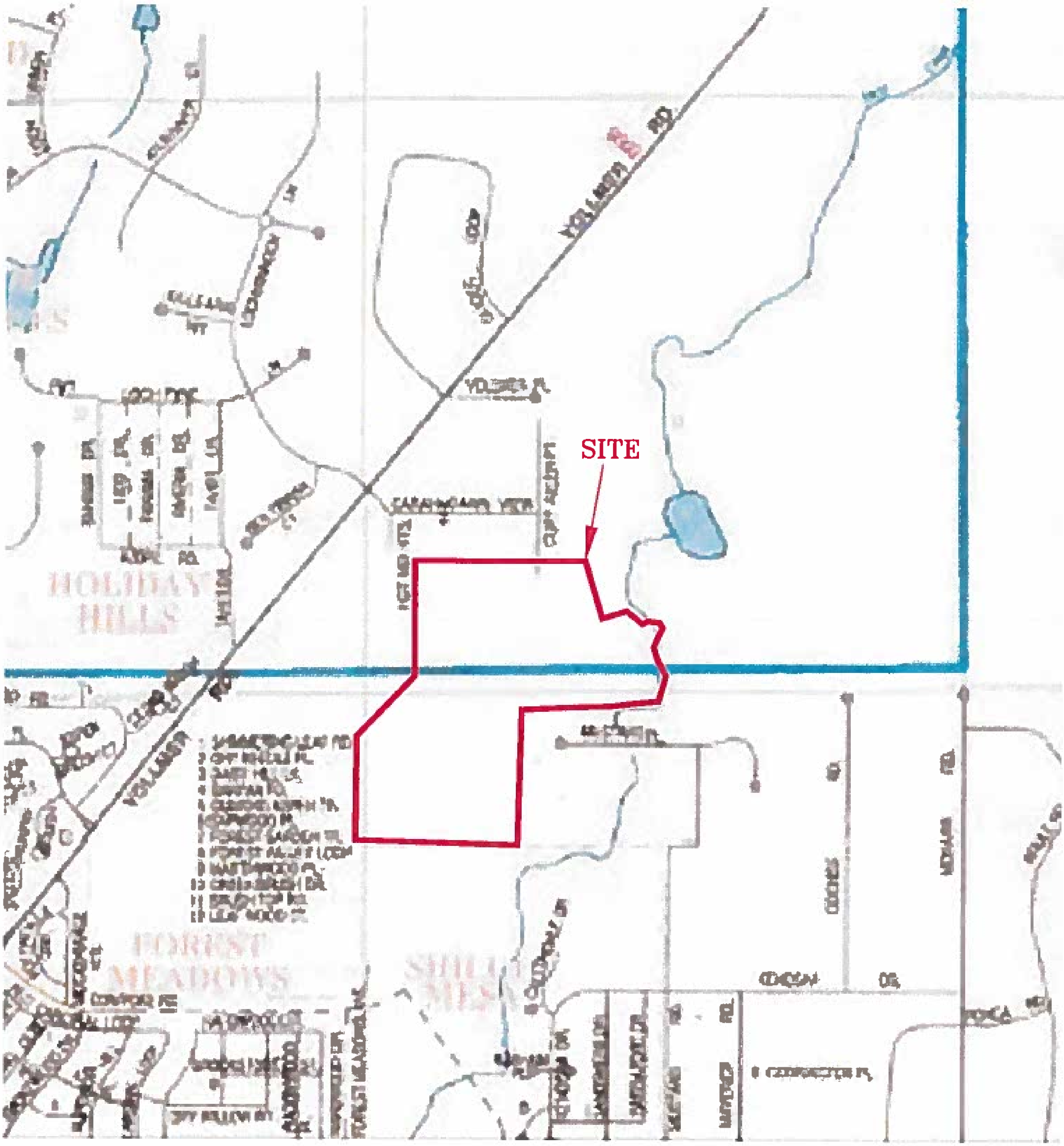
SOIL TYPE	TEST BORING NO.	DEPTH (FT)	WATER (%)	DRY DENSITY (PCF)	PASSING NO. 200 SIEVE (%)	LIQUID LIMIT (%)	PLASTIC INDEX (%)	SULFATE (WT %)	FHA SWELL (PSF)	SWELL/ CONSOL (%)	UNIFIED CLASSIFICATION	SOIL DESCRIPTION
1	1	2-3			6.4	NV	NP	<0.01			SM-SW	SAND, SLIGHTLY SILTY
1	2	5			8.7						SM-SW	SAND, SLIGHTLY SILTY
1	3	10			35.3	NV	NP	<0.01			SM	SAND, SILTY
1	4	2-3			17.8						SM	SAND, SILTY
2	4	5	12.5	113.2	75.9					2.0	CL	CLAY, SANDY
3	2	10			25.1	NV	NP	<0.01			SM	SANDSTONE, SILTY
4	3	20	6.4	120.6	62.7	32	12	<0.01		-0.4	CL	CLAYSTONE, SANDY

Table 2: Summary of Depth of Groundwater and Bedrock

Test Boring Number	Depth of Groundwater (ft.)	Depth to Bedrock (ft.)
1	>20	4*
2	7	7
3	9.5	14
4	>20	8
From Job No. 82556		
2	11	4*
41	9	6

* Weathered Bedrock

FIGURES



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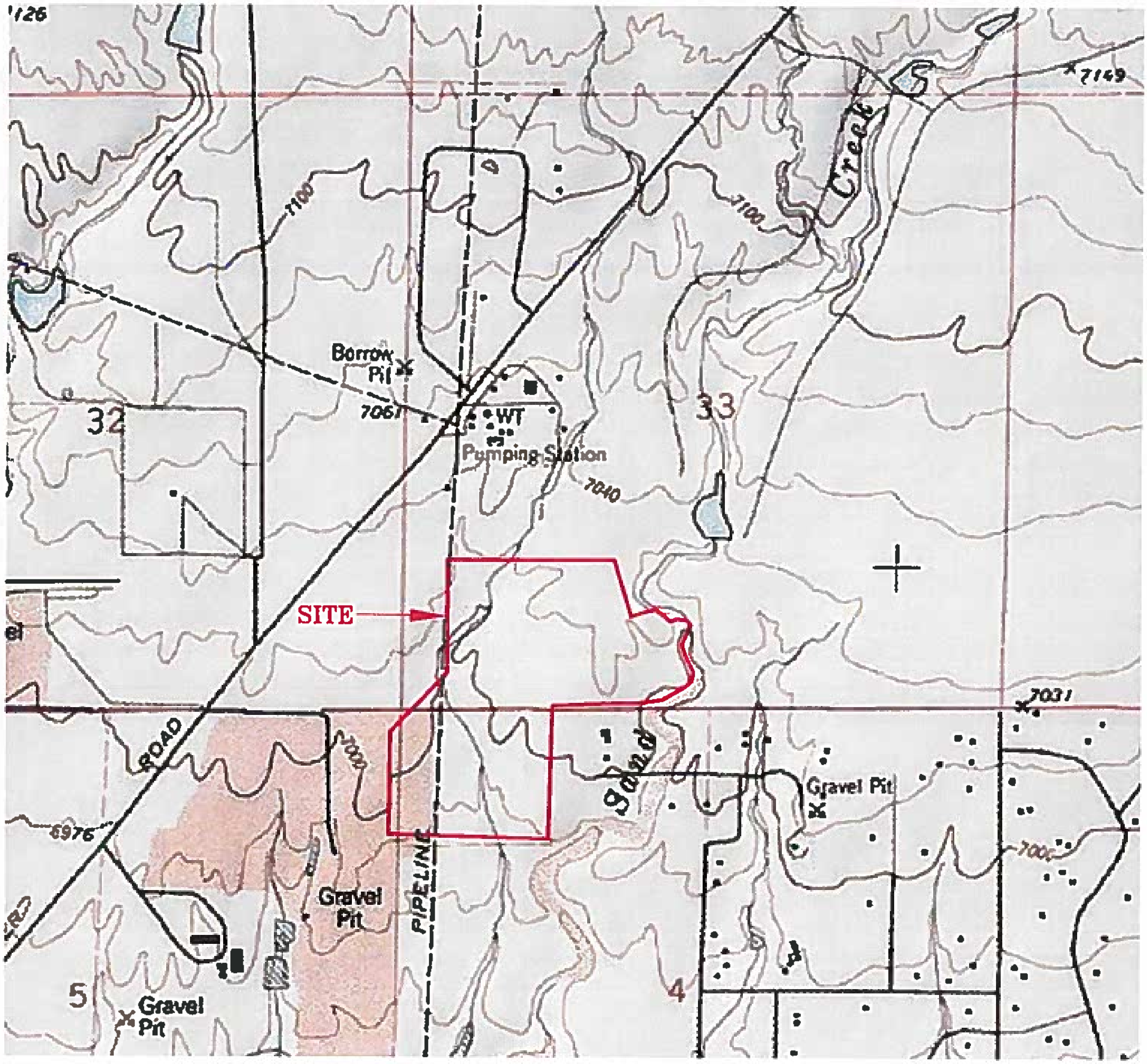
COLORADO SPRINGS, CO. 80907 (719) 531-5599

Vicinity Map
Sterling Ranch Phase 2 & F3
El Paso County, CO.
For: Morley-Bentley Investments, LLC

DRAWN:	DATE:	CHECKED:	DATE:
JAC	8/15/19		6/4/20

JOB NO.: 191089

FIG NO.: 1



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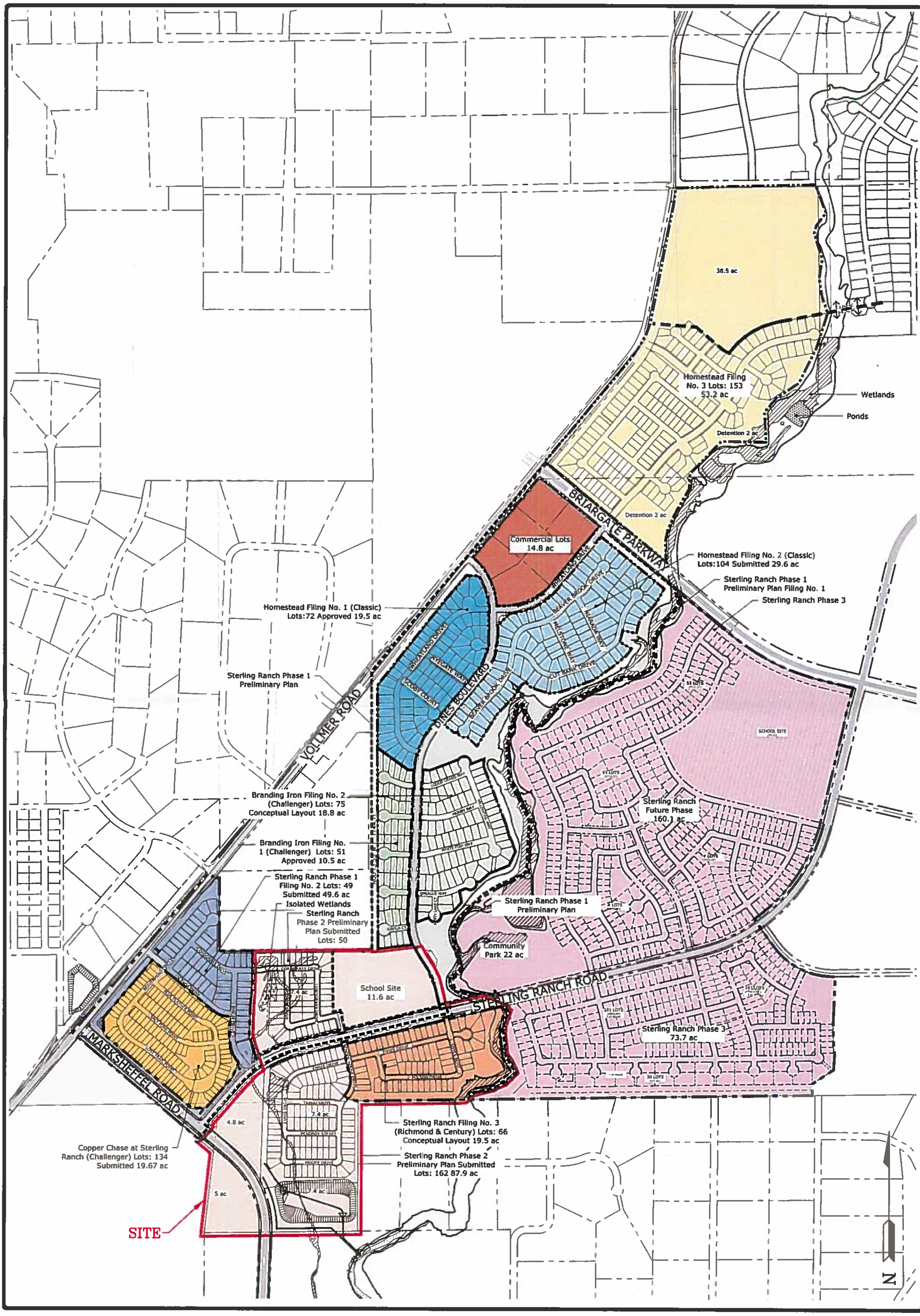
USGS Map
Sterling Ranch Phase 2 & F3
El Paso County, CO.
For: Morley-Bentley Investments, LLC

DRAWN:	DATE:	CHECKED:	DATE:
JAC	8/15/19		4/4/21

JOB NO.: 191089

FIG NO.: 2



DRAWN	JAC
CHECKED	
DATE	06/05/20
SCALE	AS SHOWN
JOB NO.	191089
FIGURE NO.	3

OVERALL SITE PLAN
STERLING RANCH PHASE 2 & F3
EL PASO, COLORADO
FOR: MORLEY-BENTLY INVESTMENTS

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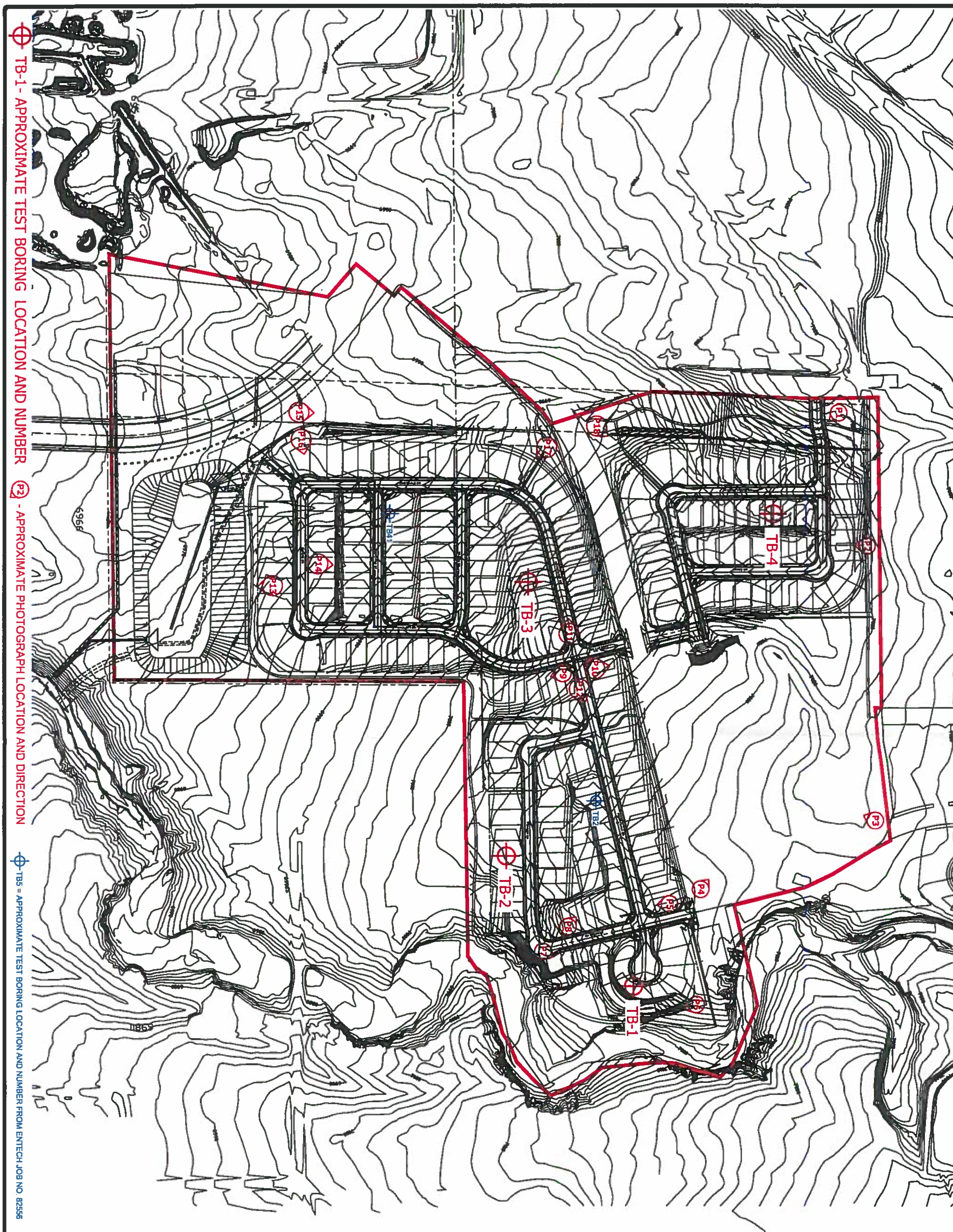
REVISION BY



TEST BORING LOCATION MAP
STERLING RANCH PHASE 2 & F3
EL PASO, COLORADO
FOR: MORLEY-BENTLY INVESTMENTS

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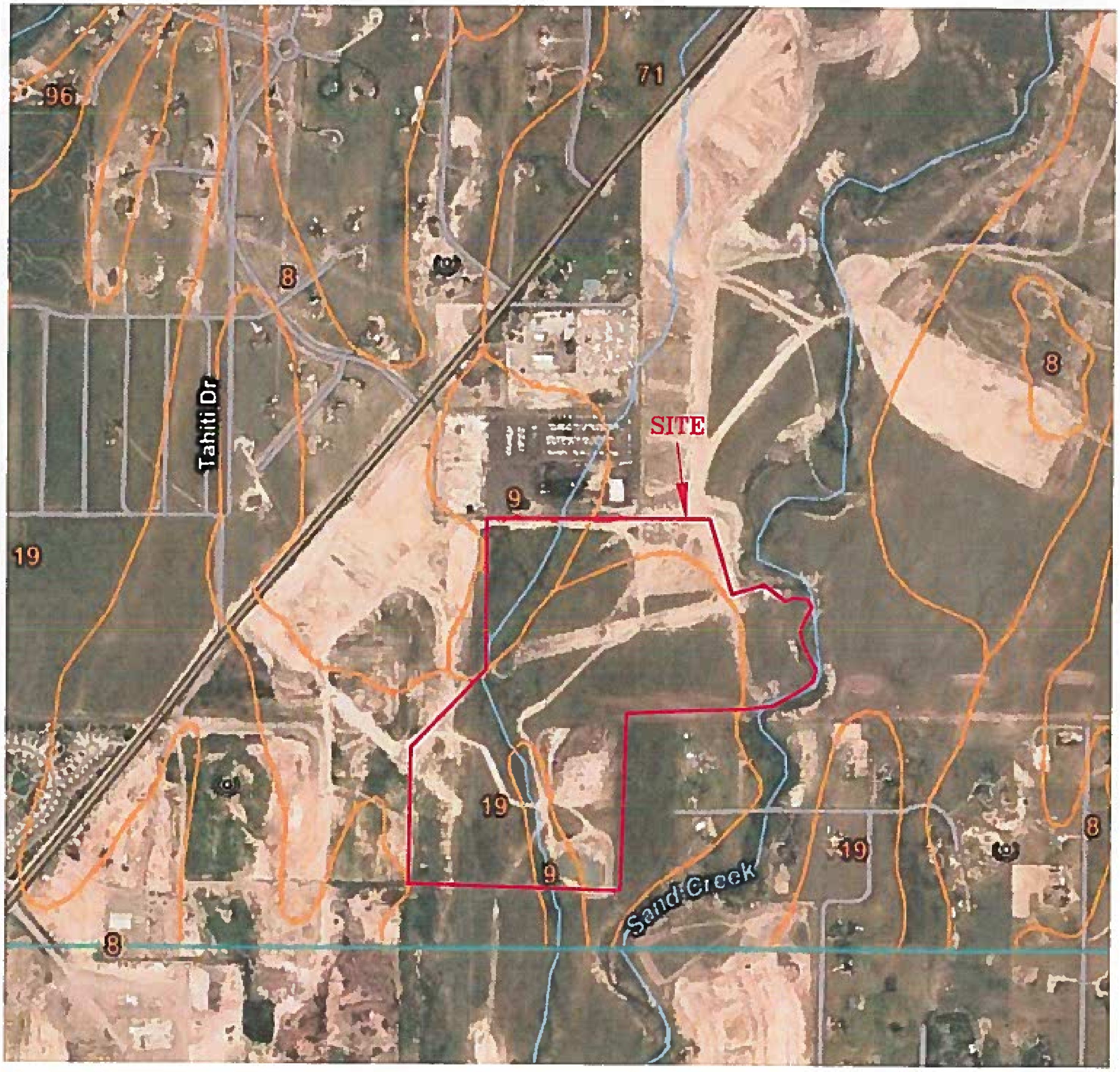
DRAWN	JAC
CHECKED	KAR
DATE	08/15/19
SCALE	AS SHOWN
JOB NO.	191080
FIGURE NO.	4

REVISION	BY



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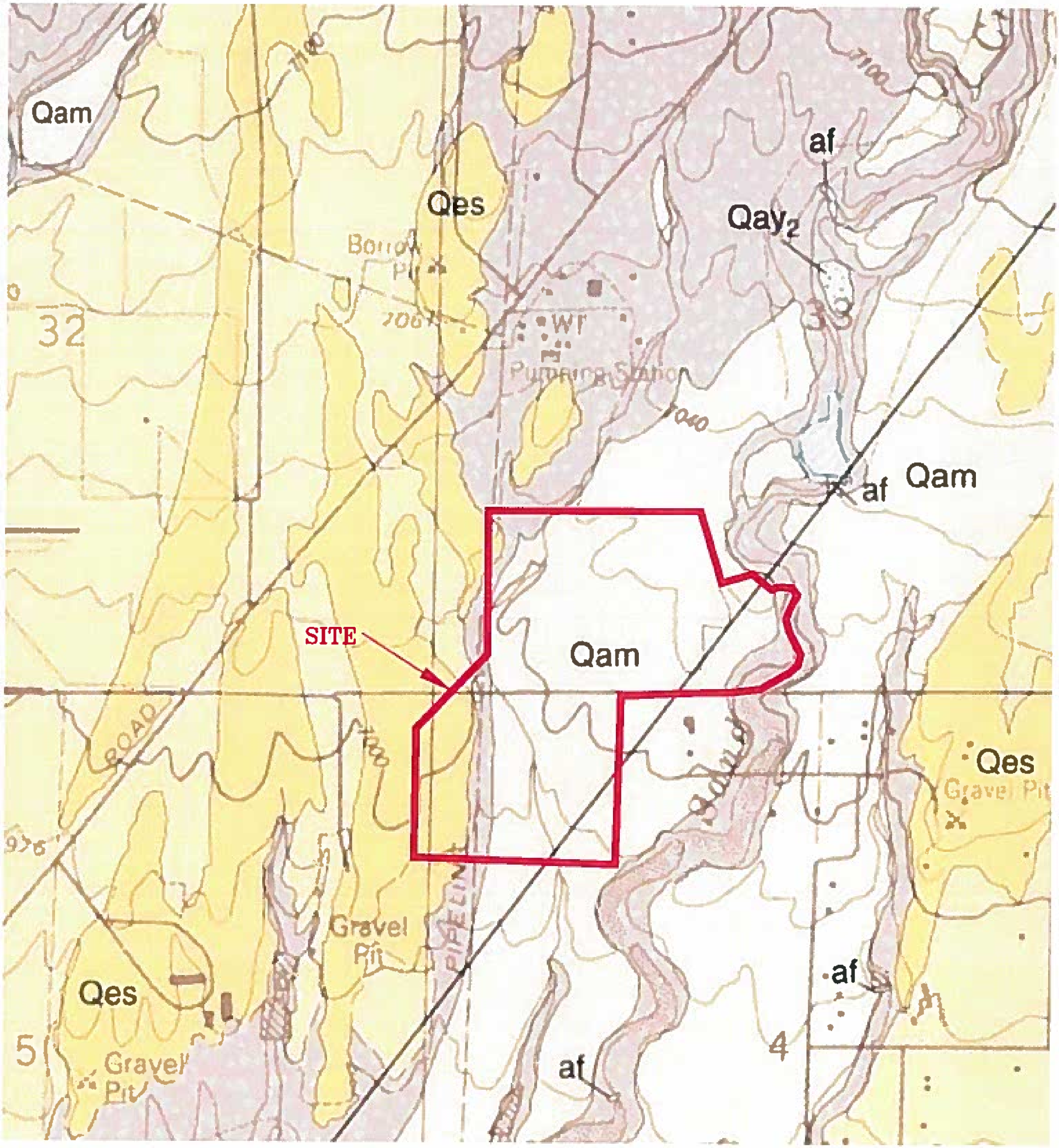
Soil Survey Map
Sterling Ranch Phase 2 & F3
El Paso County, CO.
For: Morley-Bentley Investments, LLC

DRAWN:	DATE:	CHECKED:	DATE:
JAC	8/15/19		6/4/20

JOB NO.: 191089

FIG NO.: 5



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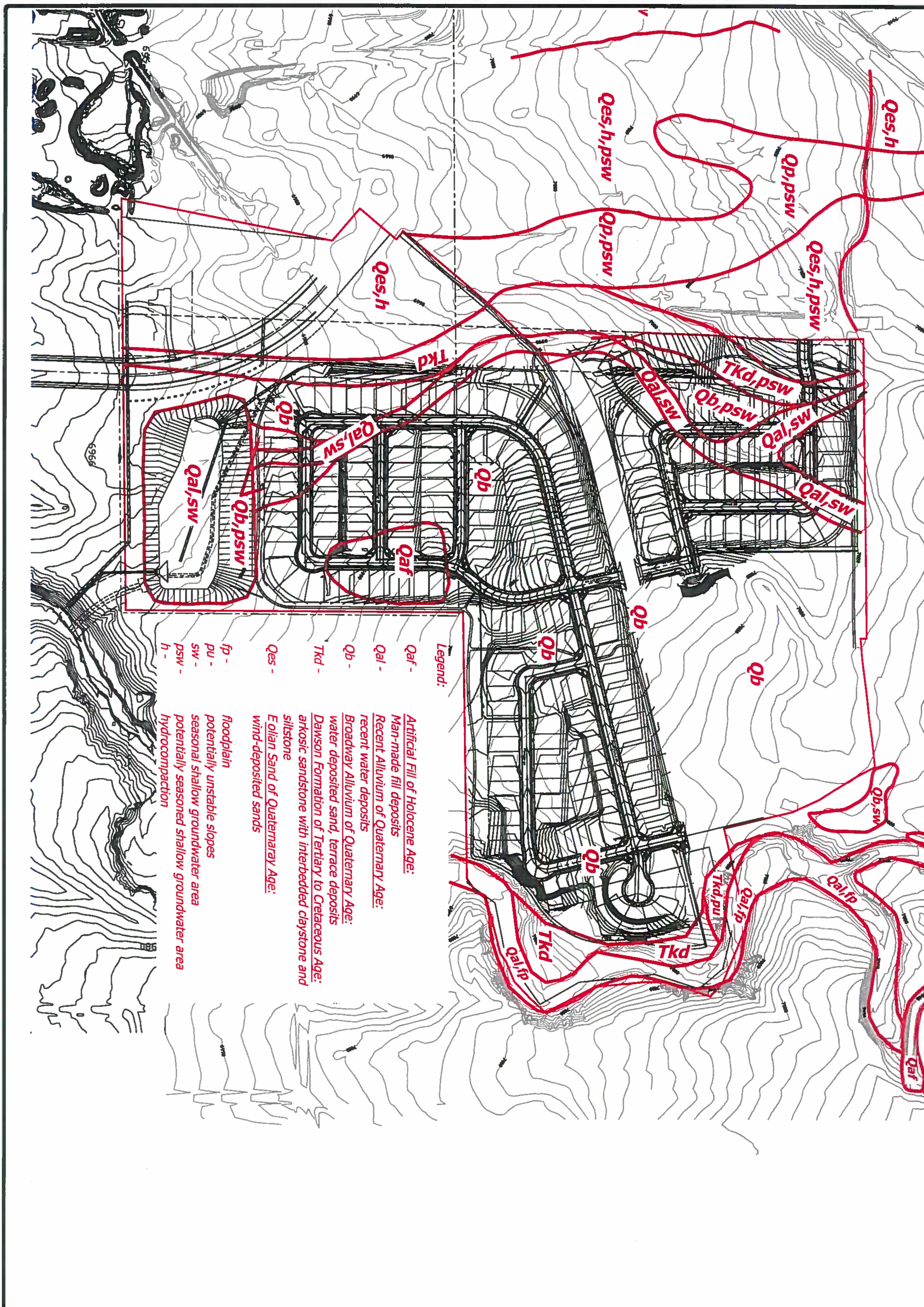
Falcon NW Quadrangle Geology Map
Sterling Ranch Phase 2 & F3
El Paso County, CO.
For: Morley-Bentley Investments, LLC

DRAWN:	DATE:	CHECKED:	DATE:
JAC	8/15/19		6/4/20

JOB NO.: 191089

FIG NO.: 6



DRAWN JAC
CHECKED BC
DATE 08/05/20
SCALE 1" = 300'
JOB NO. 191080
FIGURE NO. 7

GEOLOGY/ENGINEERING GEOLOGY MAP
STERLING RANCH PHASE 2 & F3
EL PASO, COLORADO
FOR: MORLEY-BENTLY INVESTMENTS

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505 ELKTON DRIVE
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LEGEND

SPECIAL FLOOD HAZARD AREAS INUNDATED BY 100-YEAR FLOOD

ZONE A No base flood elevations determined.

ZONE AE Base flood elevations determined.

ZONE AH Flood depths of 1 to 3 feet (usually areas of ponding); base flood elevations determined.

ZONE AO Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.

ZONE A99 To be protected from 100-year flood by Federal flood protection system under construction; no base elevations determined.

ZONE V Coastal flood with velocity hazard (wave action); no base flood elevations determined.

ZONE VE Coastal flood with velocity hazard (wave action); base flood elevations determined.

FLOODWAY AREAS IN ZONE AE

OTHER FLOOD AREAS

ZONE X Areas of 500-year flood; areas of 100-year flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 100-year flood.

OTHER AREAS

ZONE X Areas determined to be outside 500-year floodplain.

ZONE D Areas in which flood hazards are undetermined.

UNDEVELOPED COASTAL BARRIERS

Identified 1983 | Identified 1990 | Otherwise Protected Areas

Coastal barrier areas are normally located within or adjacent to Special Flood Hazard Areas.

Flood Boundary

Floodway Boundary

Zone D Boundary

Boundary Dividing Special Flood Hazard Zones, and Boundary Dividing Areas of Different Coastal Base Flood Elevations Within Special Flood Hazard Zones.

~~~513~~~ Base Flood Elevation Line; Elevation in Feet. See Map Index for Elevation Datum.

(D)——(D) Cross Section Line

(EL 987) Base Flood Elevation in Feet Where Uniform Within Zone. See Map Index for Elevation Datum.

RM7 × Elevation Reference Mark

• M2 River Mile

97°07'30", 32°22'30" Horizontal Coordinates Based on North American Datum of 1927 (NAD 27) Projection.

REVISION	BY

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Floodplain Map
Sterling Ranch Phase 2 & F3
El Paso County, CO.
For: Morley-Bentley Invests, LLC

DRAWN	JAC
CHECKED	
DATE	8/15/19
SCALE	AS SHOWN
JOB NO.	191089
FIGURE No.	8
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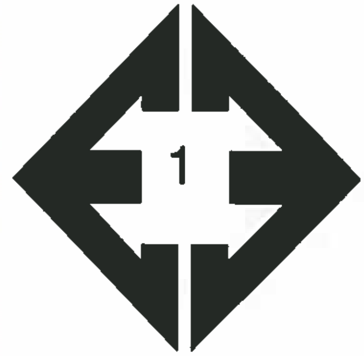
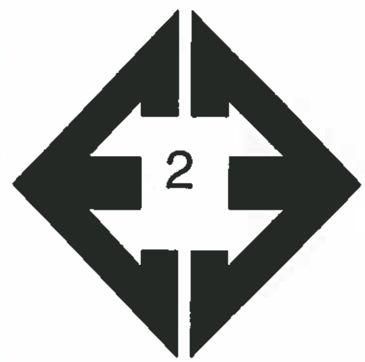
APPENDIX A: Site Photographs



Looking southeast from the northwestern portion of the site.

January 8, 2020



Looking south from the northern portion of the site.

January 8, 2020

3

Looking southwest from the northeast portion of the site.

January 8, 2020

4

Looking northwest from the eastern portion of the site.

January 8, 2020

5

Looking southwest from the eastern portion of the site.

January 8, 2020

6

Looking south along Sand Creek from the northeastern portion of the site.

January 8, 2020

7

Looking northeast along Sand Creek from the southeast portion of the site.

January 8, 2020

8

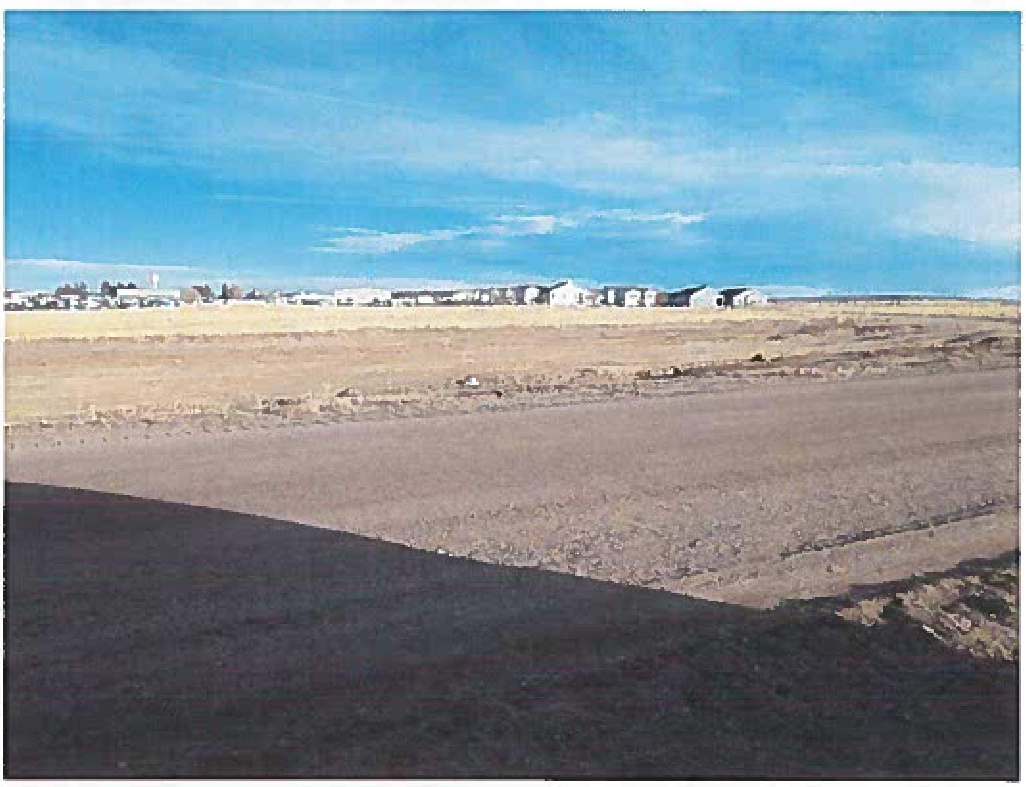
Looking northwest from the southeastern portion of the site.

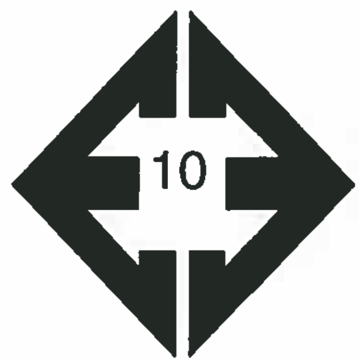
January 8, 2020

9

Looking south from the central portion of the site.

January 8, 2020





10

Looking north from the central portion of the site.

January 8, 2020

11

Looking west from the central portion of the site.

January 8, 2020

12

Looking east from the central portion of the site.

January 8, 2020

13

Looking south toward detention pond from the southern portion of the site.

January 8, 2020

14

Looking north from the southern portion of the site.

January 8, 2020

15

Looking north from the southwestern portion of the site.

January 8, 2020

16

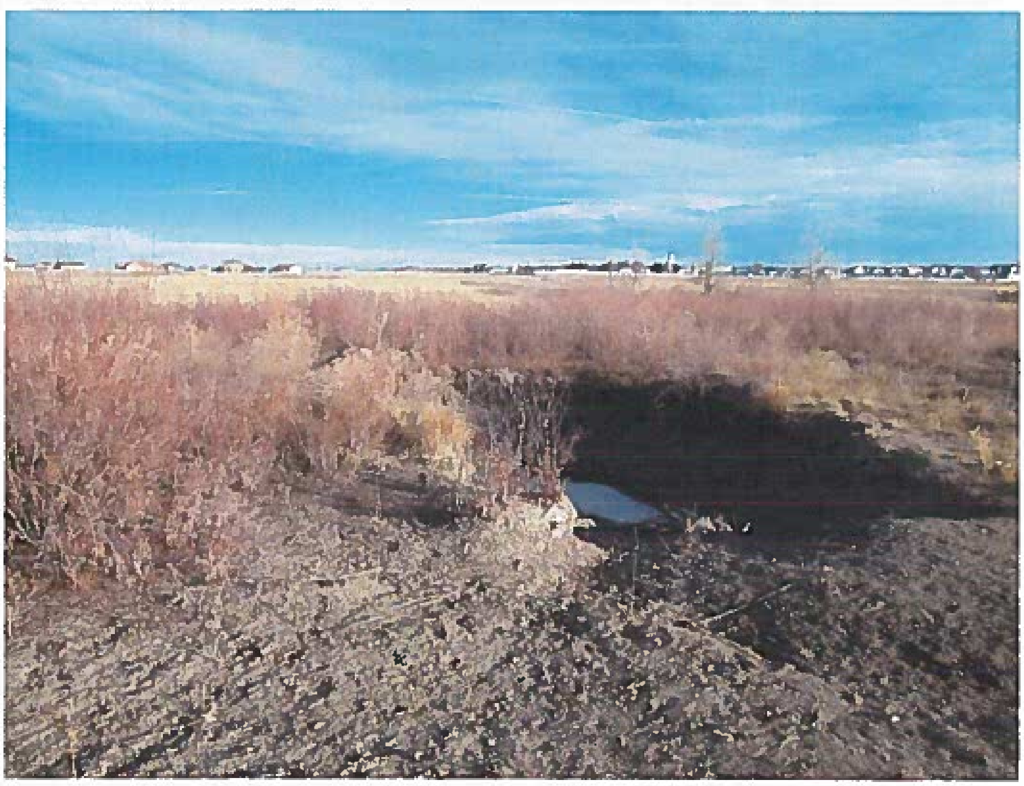
Looking east from the southwestern portion of the site.

January 8, 2020

17

Looking southeast from the western portion of the site.

January 8, 2020



18

Looking northeast from the western portion of the site.

January 8, 2020

APPENDIX B: Test Boring Logs

TEST BORING NO. 1

DATE DRILLED 7/12/2019
Job # 191089

REMARKS: DRY TO 20', 7/12/19

Description	Depth (ft)	Blows per foot	Watercontent %	Soil Type
SAND, SLIGHTLY SILTY, FINE TO COARSE GRAINED, TAN, MEDIUM DENSE, DRY		17	2.2	1
WEATHERED SANDSTONE, SILTY, CLAYEY, FINE TO COARSE GRAINED, GRAY BROWN, DENSE, MOIST	5	34	8.9	3
SANDSTONE, SILTY, FINE TO COARSE GRAINED, TAN, VERY DENSE, MOIST	10	50/6"	9.0	3
	15	50/5"	7.1	3
	20	50/5"	12.6	3

TEST BORING NO. 2

DATE DRILLED 7/12/2019
CLIENT MORLEY-BENTLEY INVEST.
LOCATION STERLING RANCH, P2, F3

REMARKS: WATER @ 7', 8/7/19

Description	Depth (ft)	Blows per foot	Watercontent %	Soil Type
SAND, SLIGHTLY SILTY, FINE TO COARSE GRAINED, TAN, MEDIUM DENSE, MOIST		16	3.7	1
	5	15	8.2	1
SANDSTONE, SILTY, FINE TO COARSE GRAINED, TAN, VERY DENSE, MOIST	10	50/8"	15.7	3
	15	50/7"	14.1	3
	20	50/4"	8.5	3

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TEST BORING LOG

DRAWN: DATE: CHECKED: L DATE: 8/9/19

JOB NO.: 191089
FIG NO.: B-1

TEST BORING NO. 3
DATE DRILLED 7/12/2019
Job # 191089

REMARKS

WATER @ 9.5', 8/7/19

Description	Depth (ft)	Samples	Blows per foot	Watercontent %	Soil Type
SAND, SILTY, FINE TO COARSE GRAINED, TAN, MEDIUM DENSE, MOIST		■	19	3.8	1
	5	■	17	7.1	1
	10	■	29	13.4	1
WEATHERED TO FORMATIONAL CLAYSTONE, SANDY, GRAY BROWN, VERY STIFF TO HARD, MOIST	15	■	41	10.0	4
	20	■	50/8"	11.3	4

TEST BORING NO. 4
DATE DRILLED 7/12/2019
CLIENT MORLEY-BENTLEY INVEST.
LOCATION STERLING RANCH, P2, F3

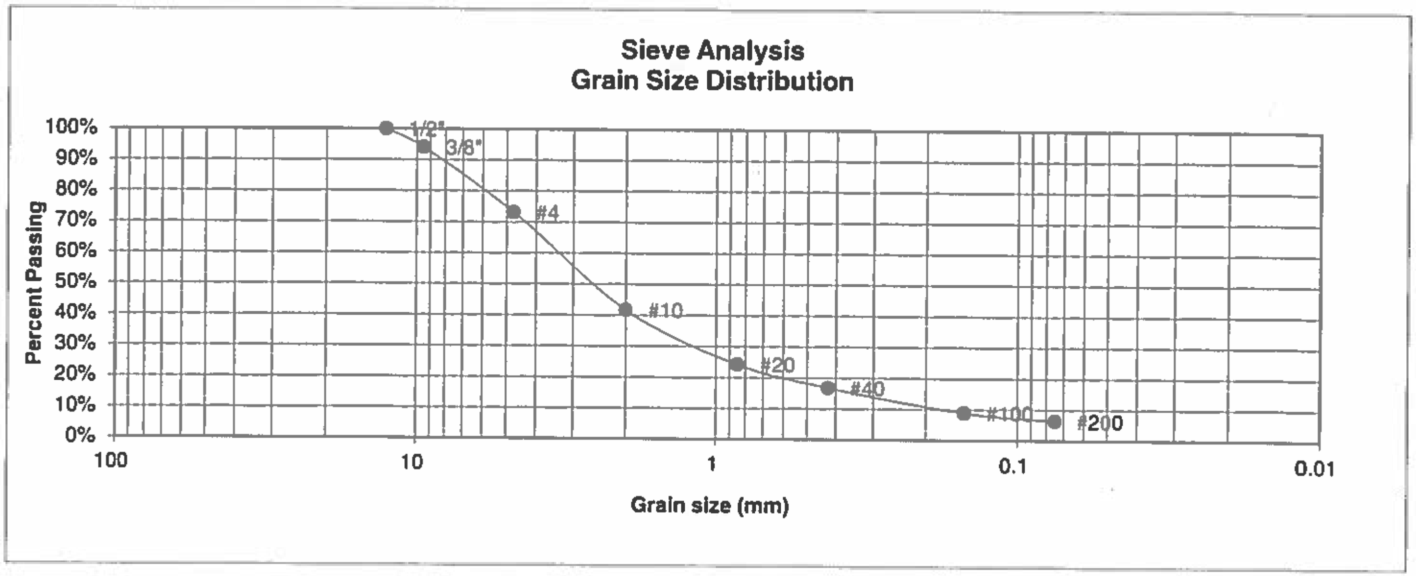
REMARKS

DRY TO 19', 8/7/19

Description	Depth (ft)	Samples	Blows per foot	Watercontent %	Soil Type
SAND, SILTY, FINE TO COARSE GRAINED, BROWN, MEDIUM DENSE, DRY		■	10	1.6	1
CLAY, SANDY, GRAY BROWN, VERY STIFF, MOIST	5	■	47	11.1	2
SANDSTONE, SILTY, FINE TO COARSE GRAINED, TAN, VERY DENSE, MOIST	10	■	50/6"	10.9	3
	15	■	50/7"	12.3	3
CLAYSTONE, SANDY, GRAY BROWN, HARD, MOIST	20	■	50/5"	11.8	4

APPENDIX C: Laboratory Test Results

UNIFIED CLASSIFICATION	SM-SW	CLIENT	MORLEY-BENTLEY INVEST.
SOIL TYPE #	1	PROJECT	STERLING RANCH, P2, F3
TEST BORING #	1	JOB NO.	191089
DEPTH (FT)	2-3	TEST BY	BL



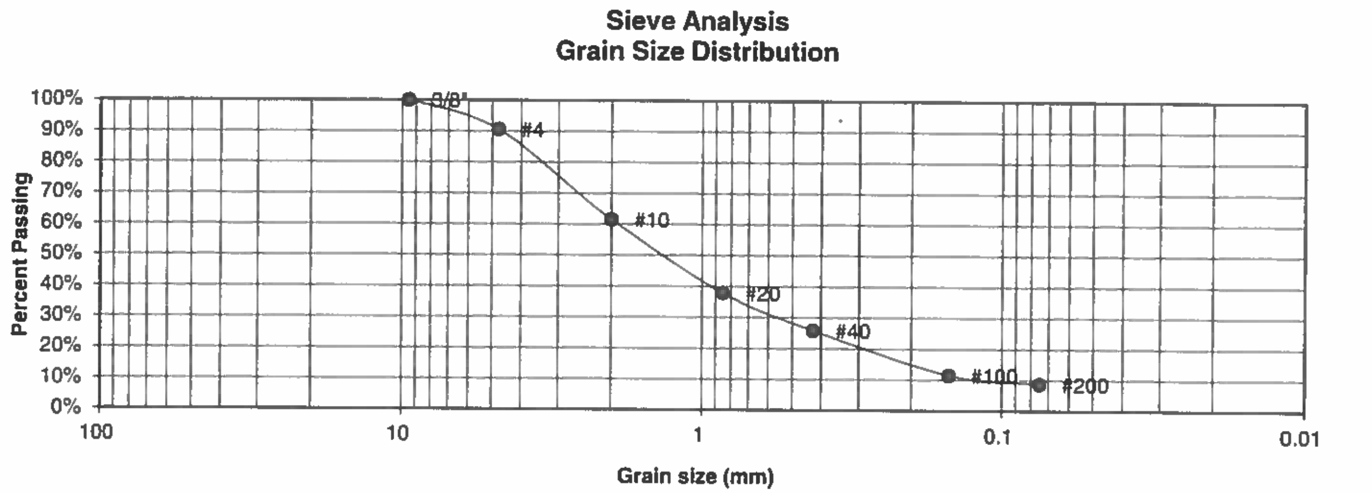
U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	100.0%
3/8"	94.1%
4	73.2%
10	41.7%
20	24.3%
40	16.8%
100	8.9%
200	6.4%

Atterberg
Limits

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

Swell
Moisture at start
Moisture at finish
Moisture increase
Initial dry density (pcf)
Swell (psf)

UNIFIED CLASSIFICATION	SM-SW	CLIENT	MORLEY-BENTLEY INVEST.
SOIL TYPE #	1	PROJECT	STERLING RANCH, P2, F3
TEST BORING #	2	JOB NO.	191089
DEPTH (FT)	5	TEST BY	BL

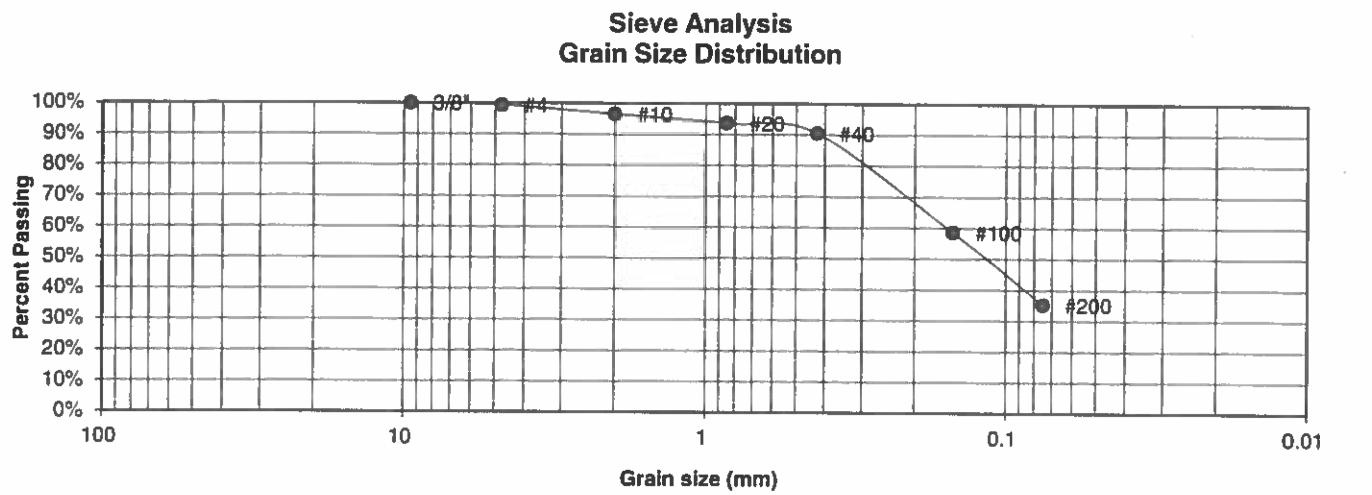


U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	90.5%
10	61.5%
20	37.8%
40	25.8%
100	11.5%
200	8.7%

Atterberg
Limits
Plastic Limit
Liquid Limit
Plastic Index

Swell
Moisture at start
Moisture at finish
Moisture increase
Initial dry density (pcf)
Swell (psf)

UNIFIED CLASSIFICATION	SM	CLIENT	MORLEY-BENTLEY INVEST.
SOIL TYPE #	1	PROJECT	STERLING RANCH, P2, F3
TEST BORING #	3	JOB NO.	191089
DEPTH (FT)	10	TEST BY	BL



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	99.3%
10	96.6%
20	93.6%
40	90.4%
100	58.6%
200	35.3%

Atterberg Limits

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

Swell

Moisture at start
Moisture at finish
Moisture increase
Initial dry density (pcf)
Swell (psf)

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COLORADO SPRINGS, COLORADO 80907

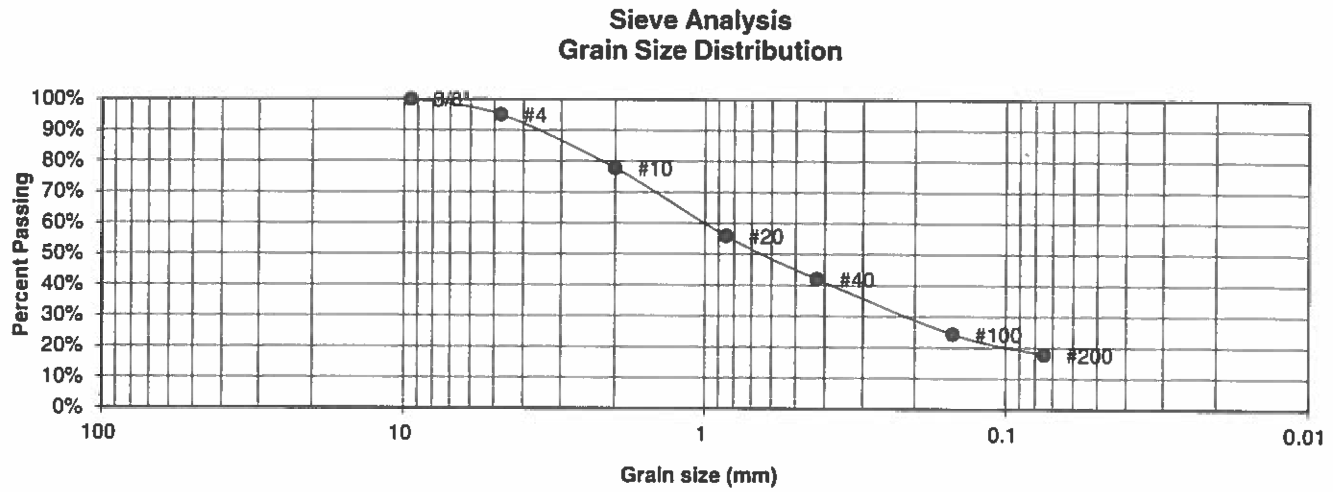
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		[signature]	8/9/19

JOB NO.: 191089

FIG NO.: C-3

UNIFIED CLASSIFICATION	SM	CLIENT	MORLEY-BENTLEY INVEST.
SOIL TYPE #	1	PROJECT	STERLING RANCH, P2, F3
TEST BORING #	4	JOB NO.	191089
DEPTH (FT)	2-3	TEST BY	BL



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	100.0%
4	95.0%
10	77.8%
20	55.9%
40	42.0%
100	24.3%
200	17.8%

Atterberg
Limits
Plastic Limit
Liquid Limit
Plastic Index

Swell
Moisture at start
Moisture at finish
Moisture increase
Initial dry density (pcf)
Swell (psf)

ENTECH ENGINEERING, INC.
505 ELKTON DRIVE
COLORADO SPRINGS, COLORADO 80907

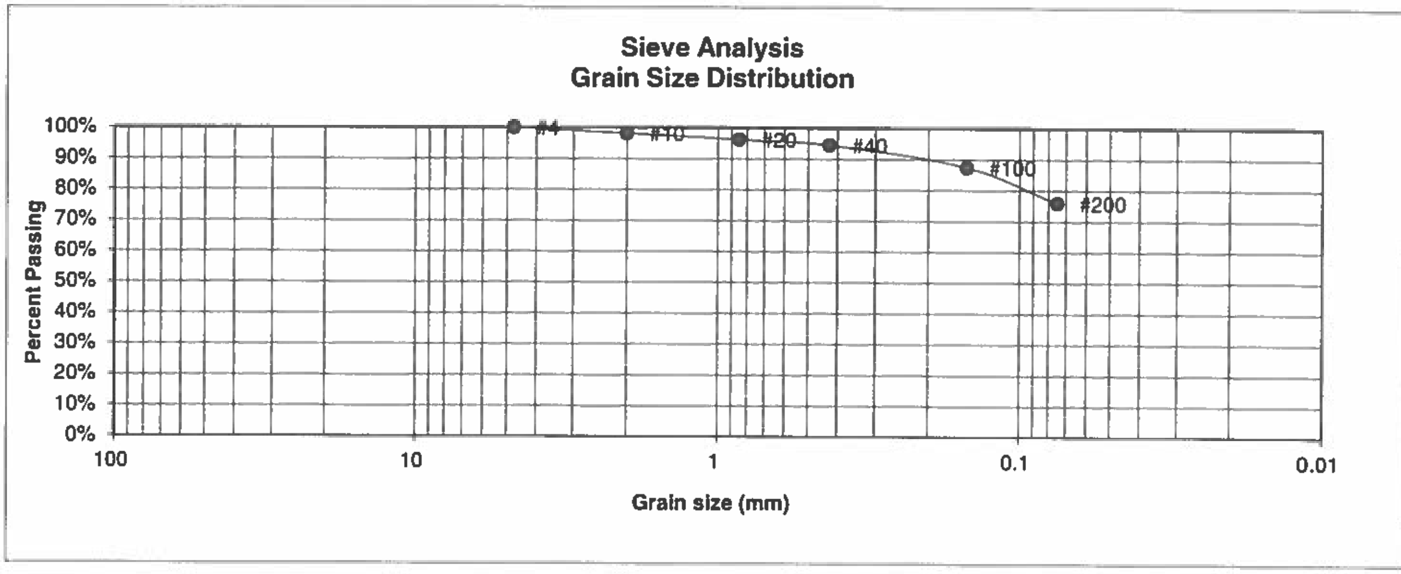
LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED: h	DATE: 8/9/19

JOB NO.: 191089

FIG NO.: C-4

UNIFIED CLASSIFICATION	CL	CLIENT	MORLEY-BENTLEY INVEST.
SOIL TYPE #	2	PROJECT	STERLING RANCH, P2, F3
TEST BORING #	4	JOB NO.	191089
DEPTH (FT)	5	TEST BY	BL



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	100.0%
10	98.3%
20	96.3%
40	94.5%
100	87.5%
200	75.9%

Atterberg Limits
Plastic Limit
Liquid Limit
Plastic Index

Swell
Moisture at start
Moisture at finish
Moisture increase
Initial dry density (pcf)
Swell (psf)

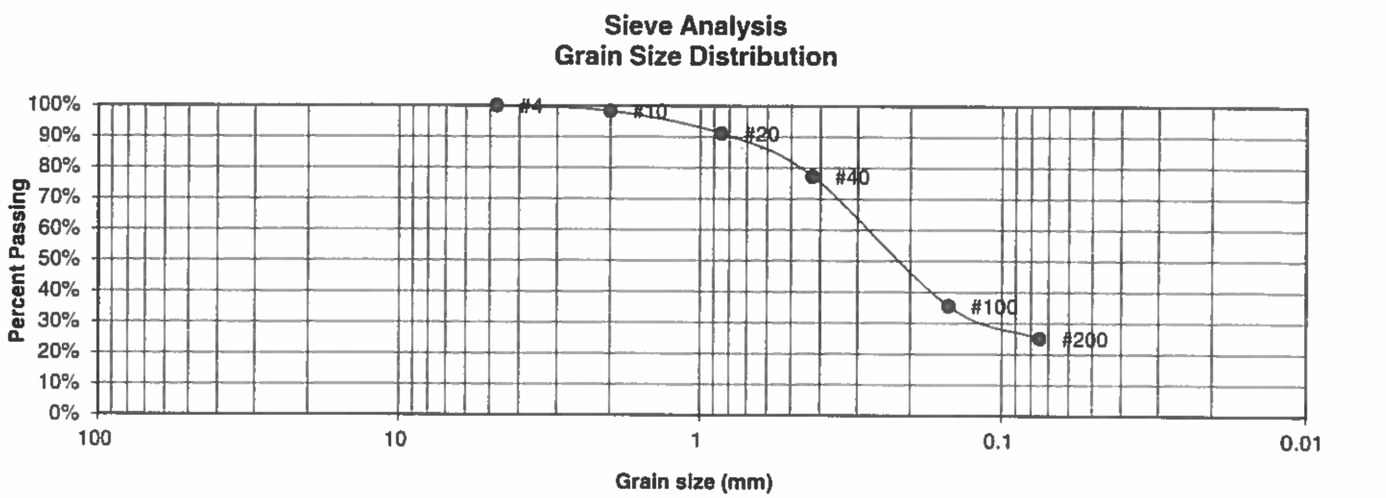
ENTECH ENGINEERING, INC.
505 ELKTON DRIVE
COLORADO SPRINGS, COLORADO 80907

LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED: ㄣ	DATE: 8/9/19

JOB NO.: 191089
FIG NO.: C-5

UNIFIED CLASSIFICATION	SM	CLIENT	MORLEY-BENTLEY INVEST.
SOIL TYPE #	3	PROJECT	STERLING RANCH, P2, F3
TEST BORING #	2	JOB NO.	191089
DEPTH (FT)	10	TEST BY	BL



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	100.0%
10	98.3%
20	91.1%
40	77.3%
100	35.6%
200	25.1%

Atterberg Limits

Plastic Limit	NP
Liquid Limit	NV
Plastic Index	NP

Swell

Moisture at start
Moisture at finish
Moisture increase
Initial dry density (pcf)
Swell (psf)

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505 ELKTON DRIVE
COLORADO SPRINGS, COLORADO 80907

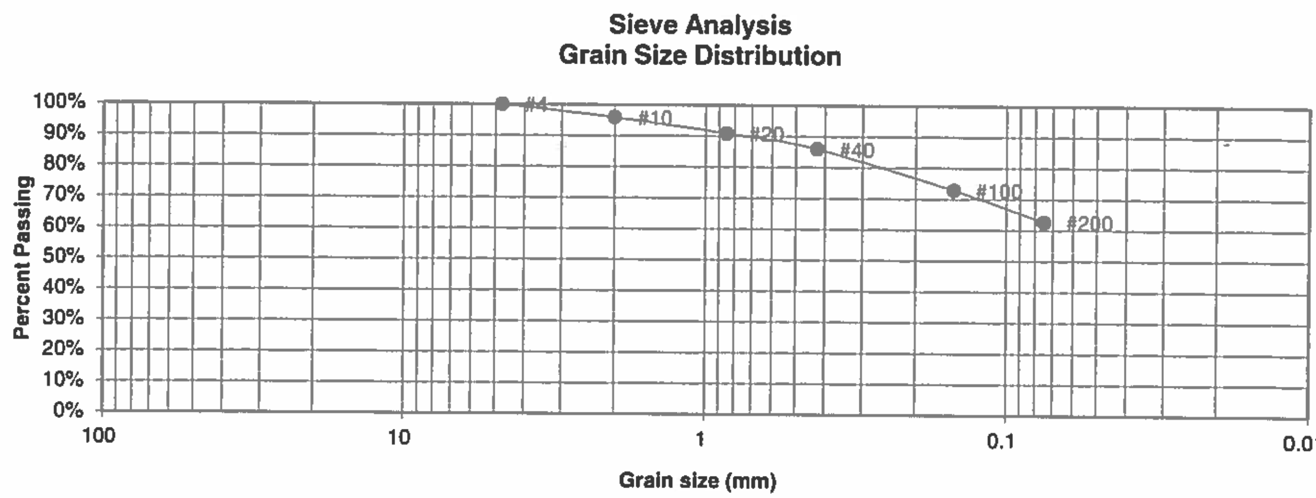
LABORATORY TEST RESULTS

DRAWN: | DATE: | CHECKED: L | DATE: 8/9/19

JOB NO.: 191089

FIG NO.: C-6

UNIFIED CLASSIFICATION	CL	CLIENT	MORLEY-BENTLEY INVEST.
SOIL TYPE #	4	PROJECT	STERLING RANCH, P2, F3
TEST BORING #	3	JOB NO.	191089
DEPTH (FT)	20	TEST BY	BL



U.S. Sieve #	Percent Finer
3"	
1 1/2"	
3/4"	
1/2"	
3/8"	
4	100.0%
10	95.9%
20	90.9%
40	86.0%
100	72.8%
200	62.7%

Atterberg Limits

Plastic Limit	20
Liquid Limit	32
Plastic Index	12

Swell

Moisture at start
Moisture at finish
Moisture increase
Initial dry density (pcf)
Swell (psf)

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COLORADO SPRINGS, COLORADO 80907

LABORATORY TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE:
		[signature]	8/9/19

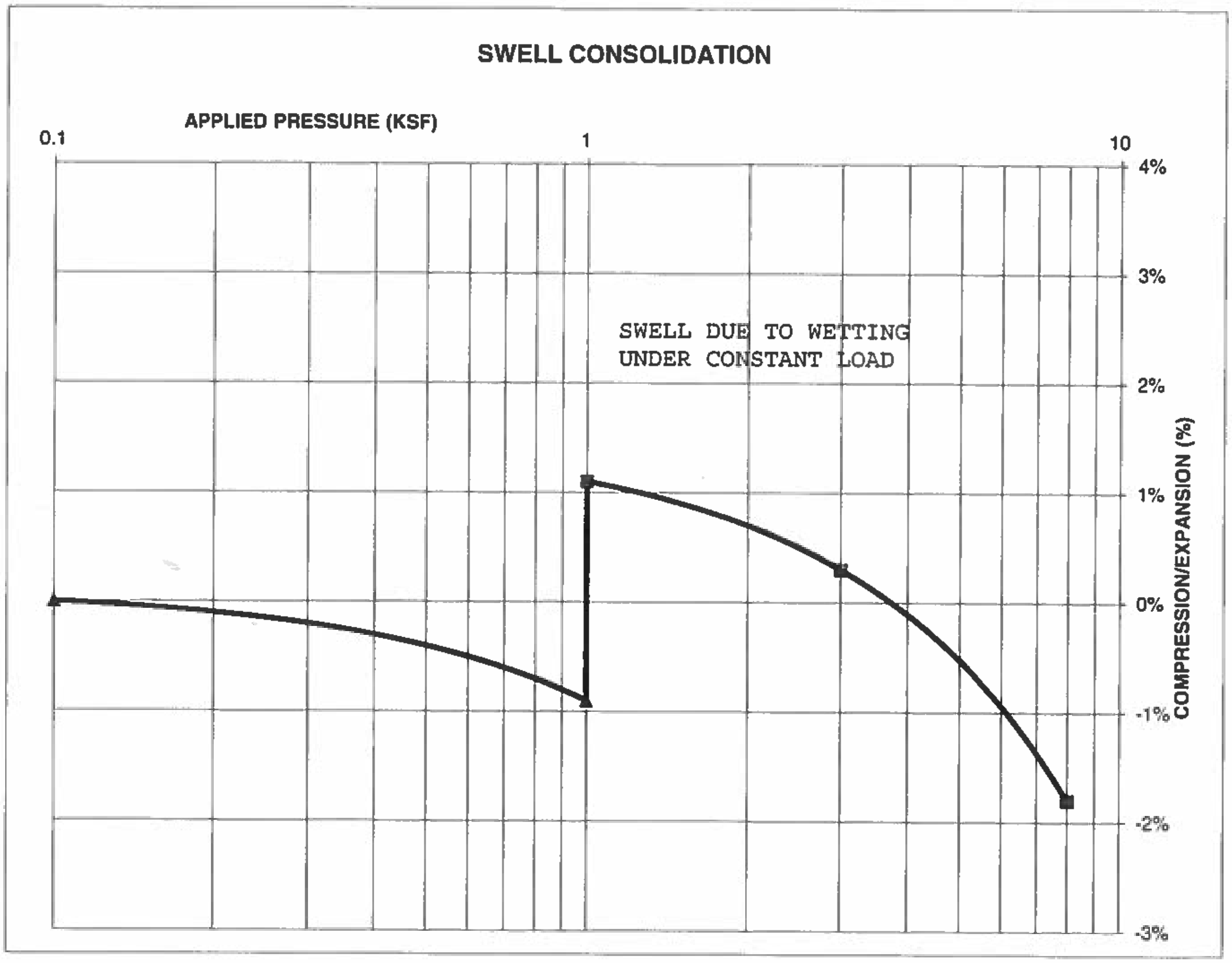
JOB NO.: 191089

FIG NO.: C-7

CONSOLIDATION TEST RESULTS

TEST BORING #	4	DEPTH(ft)	5
DESCRIPTION	CL	SOIL TYPE	2
NATURAL UNIT DRY WEIGHT (PCF)			113
NATURAL MOISTURE CONTENT			12.5%
SWELL/CONSOLIDATION (%)			2.0%

JOB NO. 191089
CLIENT MORLEY-BENTLEY INVEST.
PROJECT STERLING RANCH, P2, F3



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SWELL CONSOLIDATION
TEST RESULTS

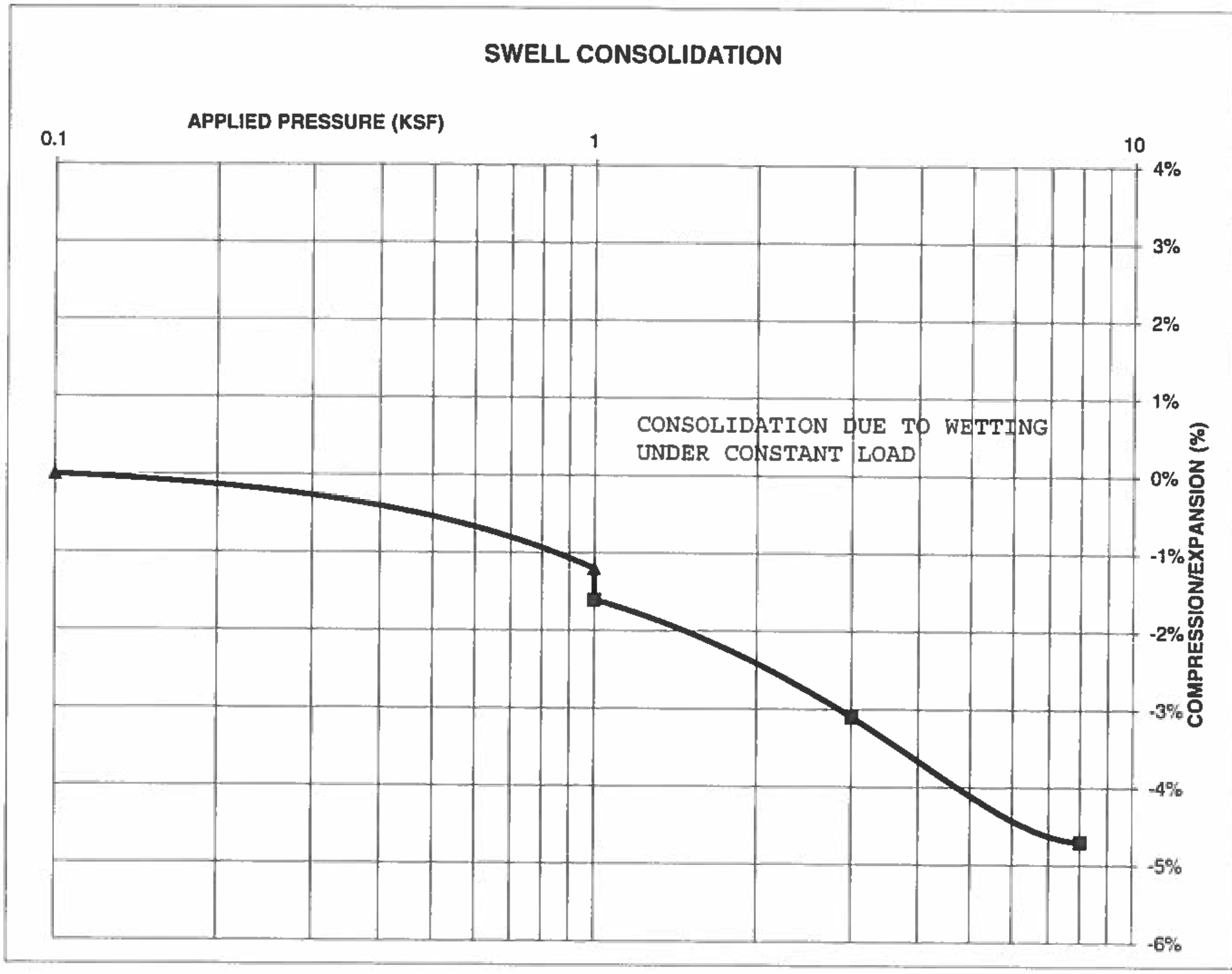
DRAWN:	DATE:	CHECKED:	DATE: 8/9/19

JOB NO.: 191089
FIG NO.: C-8

CONSOLIDATION TEST RESULTS

TEST BORING #	3	DEPTH(ft)	20
DESCRIPTION	CL	SOIL TYPE	4
NATURAL UNIT DRY WEIGHT (PCF)			121
NATURAL MOISTURE CONTENT			6.4%
SWELL/CONSOLIDATION (%)			-0.4%

JOB NO. 191089
CLIENT MORLEY-BENTLEY INVEST.
PROJECT STERLING RANCH, P2, F3



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COLORADO SPRINGS, COLORADO 80907

SWELL CONSOLIDATION
TEST RESULTS

DRAWN:	DATE:	CHECKED:	DATE: 8/9/19

JOB NO.: 191089
FIG NO.: C-9

CLIENT	MORLEY-BENTLEY INVEST.	JOB NO.	191089
PROJECT	STERLING RANCH, P2, F3	DATE	8/5/2019
LOCATION	STERLING RANCH, P2, F3	TEST BY	BL

BORING NUMBER	DEPTH, (ft)	SOIL TYPE NUMBER	UNIFIED CLASSIFICATION	WATER SOLUBLE SULFATE, (wt%)
TB-1	2-3	1	SM-SW	<0.01
TB-2	10	3	SM	<0.01
TB-3	10	1	SM	<0.01
TB-3	20	4	CL	<0.01

QC BLANK PASS

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LABORATORY TEST SULFATE RESULTS

DRAWN: DATE: CHECKED: [signature] DATE: 8/9/19

JOB NO.: 191089

FIG NO.: C-10

APPENDIX D: Test Boring Logs and Laboratory Test Results from Entech Job No. 82556

TEST BORING NO. 1
DATE DRILLED 8/23/2006
Job # 82556

REMARKS

WATER @ 6', 8/25/06

Description	Depth (ft)	Samples	Blows per foot	Watercontent %	Soil Type
SAND, SILTY, TAN					1
CLAYSTONE, SANDY, GRAY BROWN, HARD, MOIST		■	50	12.1	4
	5	■	50/6"	11.2	4
	10	■	50/7"	13.1	4
	15	■	50/5"	9.8	4
	20				

TEST BORING NO. 2
DATE DRILLED 8/23/2006
CLIENT MORLEY BENTLEY
LOCATION STERLING RANCH

REMARKS

WATER @ 11', 8/25/06

Description	Depth (ft)	Samples	Blows per foot	Watercontent %	Soil Type
SAND, SILTY, FINE TO COARSE GRAINED, DARK BROWN TO BROWN, MEDIUM DENSE, MOIST		■	12	2.0	1
WEATHERED CLAYSTONE, SANDY, GRAY, VERY STIFF, MOIST	5	■	30	13.3	4
SANDSTONE, CLAYEY, FINE TO COARSE GRAINED, LIGHT BROWN, VERY DENSE, MOIST TO VERY MOIST	10	■	50/6"	11.1	3
	15	■	50/5"	18.9	3
	20				

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COLORADO SPRINGS, CO. 80907 (719) 531-5599

TEST BORING LOG

DRAWN:	DATE:	CHECKED:	DATE:
		KAH	9/5/06

JOB NO.: 82556
FIG NO.: D-1

TEST BORING NO. 41
DATE DRILLED 8/23/2006
Job # 82556

REMARKS

WATER @ 9', 8/25/06

Description	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
SAND, SLIGHTLY SILTY, FINE TO COARSE GRAINED, BROWN, MEDIUM DENSE, MOIST				25	10.4	1
SAND, VERY CLAYEY, VERY SILTY, FINE TO COARSE GRAINED, GRAY, MEDIUM DENSE, MOIST	5			29	10.9	1
				*	12.4	4
CLAYSTONE, SANDY, LIGHT GRAY						
SANDSTONE, SILTY, FINE TO COARSE GRAINED, LIGHT GRAY, VERY DENSE, VERY MOIST	10			50/7"	11.3	3
	15			50/7"	11.7	3
	20					

* - BULK SAMPLE TAKEN

TEST BORING NO. 42
DATE DRILLED 8/23/2006
CLIENT MORLEY BENTLEY
LOCATION STERLING RANCH

REMARKS

WATER @ 12', 8/28/06

Description	Depth (ft)	Symbol	Samples	Blows per foot	Watercontent %	Soil Type
SAND, SLIGHTLY SILTY, FINE TO COARSE GRAINED, BROWN TO TAN, MEDIUM DENSE, MOIST				18	4.6	1
	5			25	2.9	1
SANDSTONE, SILTY, FINE TO COARSE GRAINED, LIGHT GRAY, VERY DENSE, MOIST	10			50/5"	11.4	4
	15			50/5"	5.0	4
	20					

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TEST BORING LOG

DRAWN:	DATE:	CHECKED:	DATE:
		[illegible]	9/5/06

JOB NO.: 82556

FIG NO.: D-2

TABLE 1

SUMMARY OF LABORATORY TEST RESULTS

CLIENT MORLEY BENTLEY
PROJECT STERLING RANCH
JOB NO. 82556

SOIL TYPE	TEST BORING NO.	DEPTH (FT)	WATER (%)	DRY DENSITY (PCF)	PASSING NO. 200 SIEVE (%)	LIQUID LIMIT (%)	PLASTIC INDEX (%)	SULFATE (WT %)	FHA SWELL (PSF)	SWELL/ CONSOL (%)	UNIFIED CLASSIFICATION	SOIL DESCRIPTION
1	4	2-5			10.0	NV	NP	<0.01			SM-SW	SAND, SLIGHTLY SILTY
1	9	5			22.4						SM	SAND, SILTY
1	12	5			8.6						SM-SW	SAND, SLIGHTLY SILTY
1	17	2-3			11.7						SM-SP	SAND, SLIGHTLY SILTY
1	19	5			15.9						SM	SAND, SILTY
1	20	10			10.7						SM-SW	SAND, SLIGHTLY SILTY
1	25	2-5			8.4						SM-SW	SAND, SLIGHTLY SILTY
1	26	5			17.3						SM	SAND, SILTY
1	41	5			44.1	23	7		574		SC-SM	SAND, VERY CLAYEY-SILTY
1	42	2-3			7.4						SM-SW	SAND, SLIGHTLY SILTY
1	44	5-10			5.7						SM-SW	SAND, SLIGHTLY SILTY
2	7	5	5.6	98.0		29	13			-2.3	CL	CLAY, SANDY
2	13	2-3			54.6				455		CL	CLAY, VERY SANDY
2	21	7						0.10	4179		CL	CLAY, SANDY
2	23	7							1085		CL	CLAY, SANDY
2	27	9							2300		CL	CLAY, SANDY
2	31	5	27.9	95.4	64.2	40	25			1.8	CL	CLAY, SANDY
2	34	2-5			51.6	27	13				CL	CLAY, VERY SANDY
3	5	15	10.4	118.6		24	11			-0.1	SC	SANDSTONE, CLAYEY
3	8	15-20			14.8			0.01			SM	SANDSTONE, SILTY
3	11	10			17.1						SM	SANDSTONE, SILTY
3	13	10			36.0						SM	SANDSTONE, SILTY
3	14	5			20.4						SM	SANDSTONE, SILTY
3	18	15							456		SM	SANDSTONE, SILTY
3	22	5	23.3	100.7	21.1	NV	NP			0.0	SM	SANDSTONE, SILTY
3	28	5-10			17.8						SM	SANDSTONE, SILTY
3	29	7							485		SC	SANDSTONE, CLAYEY
3	30	10			9.1						SM-SW	SANDSTONE, SLIGHTLY SILTY
3	33	5			14.4						SM	SANDSTONE, SILTY
3	35	15			11.1						SM-SW	SANDSTONE, SLIGHTLY SILTY
3	36	2-5			18.7				1014		SC	SANDSTONE, CLAYEY

APPENDIX E: Soil Survey Descriptions

9—Blakeland complex, 1 to 9 percent slopes. This complex is on uplands, mostly in the Falcon area. The average annual precipitation is about 15 inches, the average annual air temperature is about 47 degrees F, and the frost-free period is about 135 days.

This complex is about 60 percent Blakeland loamy sand, about 30 percent Fluvaquentic Haplaquolls, and 10 percent other soils.

Included with these soils in mapping are areas of Columbine gravelly sandy loam, 0 to 3 percent slopes, Ellicott loamy coarse sand, 0 to 5 percent slopes, and Ustic Torrifluvents, loamy.

The Blakeland soil is in the more sloping areas. It is deep and somewhat excessively drained. It formed in sandy alluvium and eolian material derived from arkosic sedimentary rock. Typically, the surface layer is dark grayish brown loamy sand about 11 inches thick. The substratum, to a depth of 27 inches, is brown loamy sand; it grades to pale brown sand that extends to a depth of 60 inches or more.

Permeability of the Blakeland soil is rapid. The effective rooting depth is more than 60 inches. The available water capacity is moderate to low. Surface runoff is slow, and the hazard of erosion is moderate.

The Fluvaquentic Haplaquolls are in swale areas. They are deep, poorly drained soils. They formed in alluvium derived from arkosic sedimentary rock. Typically, the surface layer is brown. The texture is variable throughout. The water table is at a depth of 0 to 3 feet.

The Blakeland soil is well suited to deep-rooted grasses. Native vegetation is dominantly western wheatgrass, side-oats grama, and needleandthread. Rangeland vegetation on the Fluvaquentic Haplaquolls is dominantly tall grasses, including sand bluestem, switchgrass, prairie cordgrass, little bluestem, and sand reedgrass. Cattails and bulrushes are common in the swampy areas.

Proper range management is needed to prevent excess removal of plant cover from these soils. It is also needed to maintain the productive grasses. Interseeding improves the existing vegetation. Deferment of grazing during the growing season increases plant vigor and soil stability, and it helps to maintain and improve range condition. Proper location of livestock watering facilities helps to control grazing of animals.

Windbreaks and environmental plantings are fairly well suited to these soils. Blowing sand and low available water capacity are the main limitations to the establishment of trees and shrubs. The soils are so loose that trees need to be planted in shallow furrows and plant cover needs to be maintained between the rows. Supplemental irrigation may be needed to insure survival. Trees that are best suited and have good survival are Rocky Mountain juniper, eastern redcedar, ponderosa pine, and Siberian elm. Shrubs that are best suited are skunkbush sumac, lilac, and Siberian peashrub.

The Blakeland soil is well suited to wildlife habitat. It is best suited to habitat for openland and rangeland wildlife. Rangeland wildlife, such as pronghorn antelope, can be encouraged by developing livestock watering facilities, properly managing livestock grazing, and reseeding range where needed. Wetland wildlife can be attracted to the Fluvaquentic Haplaquolls and the wetland habitat can be enhanced by several means. Shallow water developments can be created by digging or by blasting potholes to create open-water areas. Fencing to control livestock grazing is beneficial, and it allows wetland plants such as cattails, reed canarygrass, and rushes to grow. Control of unplanned burning and prevention of drainage that would remove water from the wetlands are good practices. Openland wildlife use the vegetation on these soils for nesting and escape cover. These shallow marsh areas are especially important for winter cover if natural vegetation is allowed to grow.

The Blakeland soil has good potential for homesites, roads, and streets. It needs to be protected from erosion when vegetation has been removed from building sites. The Fluvaquentic Haplaquolls have poor potential for homesites. Their main limitations for this use are the high water table and the hazard of flooding. Capability subclass VIe.

ENTECH ENGINEERING, INC.

SCS SOIL DESCRIPTION

Drawn	Date	Checked	Date
		Cr	6/5/20

Job No. 191089

Fig. No. E-1

19—Columbine gravelly sandy loam, 0 to 3 percent slopes. This deep, well drained to excessively drained soil formed in coarse textured material on alluvial terraces and fans and on flood plains. Elevation ranges from 6,500 to 7,300 feet. The average annual precipitation is about 15 inches, the average annual air temperature is about 47 degrees F, and the average frost-free period is about 135 days.

Typically, the surface layer is grayish brown gravelly sandy loam about 14 inches thick. The underlying material is light yellowish brown very gravelly loamy sand.

Included with this soil in mapping are small areas of Stapleton sandy loam, 3 to 8 percent slopes; Blendon sandy loam, 0 to 3 percent slopes; Louviers silty clay loam, 3 to 18 percent slopes; and Fluvaquentic Haplaquolls, nearly level. In places the parent arkose beds of sandstone or shale are at a depth of 0 to 40 inches.

Permeability of this Columbine soil is very rapid. Effective rooting depth is 60 inches or more. Available water capacity is low to moderate. Surface runoff is slow, and the hazard of erosion is slight to moderate.

This soil is used mainly for grazing livestock and for wildlife habitat. It is also used for homesites.

Native vegetation is mainly western wheatgrass, sideoats grama, needleandthread, and little bluestem. The main shrub is true mountainmahogany.

Proper location of livestock watering facilities helps to control grazing.

Windbreaks and environmental plantings are fairly well suited to this soil. Blowing sand and low available water capacity are the principal limitations to the establishment of trees and shrubs. The soil is so loose that trees need to be planted in the rows. Supplemental irrigation may be needed to insure survival. Trees that are best suited and have good survival are Rocky Mountain juniper, eastern redcedar, ponderosa pine, and Siberian elm. Shrubs that are best suited are skunkbush sumac, lilac, and Siberian peashrub.

Rangeland wildlife, such as pronghorn antelope, cottontail, coyote, and scaled quail, is best adapted to life on this droughty soil. Forage production is typically loam, and proper livestock grazing management is necessary if wildlife and livestock share the range. Livestock watering developments are also important and are used by various wildlife species.

The main limitation of this soil for urban development is a hazard of flooding in some areas. Care must be taken when locating septic tank absorption fields because of possible pollution as a result of the very rapid permeability of this soil. Capability subclass VIe.

ENTECH ENGINEERING, INC.

SCS SOIL DESRIPTION

Drawn	Date	Checked	Date
		[initials]	6/5/20

Job No. 191089

Fig. No. E-2

71—Pring coarse sandy loam, 3 to 8 percent slopes. This deep, noncalcareous, well drained soil formed in sandy sediment derived from arkosic sedimentary rock on valley side slopes and on uplands. Elevation ranges from 6,800 to 7,600 feet. The average annual precipitation is about 17 inches, the average annual air temperature is about 43 degrees F, and the average frost-free period is about 120 days.

Typically, the surface layer is dark grayish brown coarse sandy loam about 4 inches thick. The substratum is dark grayish brown coarse sandy loam about 10 inches thick over pale brown gravelly sandy loam that extends to a depth of 60 inches or more.

Included with this soil in mapping are small areas of Alamosa loam, 1 to 8 percent slopes, along drainageways; Cruckton sandy loam, 1 to 9 percent slopes; Peyton sandy loam, 1 to 5 percent slopes; Peyton sandy loam, 5 to 9 percent slopes; and Tomah-Crowfoot loamy sands, 3 to 8 percent slopes. In some places arkose beds of sandstone and shale are at a depth of 0 to 40 inches.

Permeability of this Pring soil is rapid. Effective rooting depth is 60 inches or more. Available water capacity is moderate. Surface runoff is medium, and the hazard of erosion is moderate.

Almost all areas of this soil are used as rangeland. Some areas previously cultivated have been reseeded to grass. This soil is also used for wildlife habitat and homesites.

This soil is well suited to the production of native vegetation suitable for grazing by cattle and sheep. Rangeland vegetation is mainly mountain muhly, little bluestem, needleandthread, Parry oatgrass, and junegrass.

Deferment of grazing in spring helps to maintain vigor and production of the cool-season bunchgrasses. Fencing and properly locating livestock watering facilities help to control grazing.

Windbreaks and environmental plantings generally are suited to this soil. The hazard of soil blowing is the main limitation to the establishment of trees and shrubs. This limitation can be overcome by cultivating only in the tree rows and leaving a strip of vegetation between the rows. Supplemental irrigation may be needed when planting and during dry periods. Trees that are best suited and have good survival are Rocky Mountain juniper, eastern redcedar, ponderosa pine, Siberian elm, Russian-olive, and hackberry. Shrubs that are best suited are skunkbush sumac, lilac, and Siberian peashrub.

This soil is suited to habitat for openland and rangeland wildlife. Rangeland wildlife, such as pronghorn antelope, can be encouraged by developing livestock watering facilities, properly managing livestock grazing, and reseeding range where needed.

This soil is well suited for use as homesites. Erosion control practices are needed to control soil blowing and water erosion on construction sites where the ground cover has been removed. Capability subclass IVe.

ENTECH ENGINEERING, INC.

SCS SOIL DESCRIPTION

Drawn	Date	Checked	Date
			6/5/20

Job No. 191089

Fig. No. E-3