

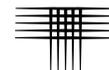
**SOILS AND FOUNDATION INVESTIGATION  
AND GEOLOGIC HAZARDS EVALUATION  
19580 FOUR WINDS WAY  
WOODMOOR, COLORADO**

Prepared for:

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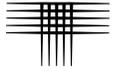
CTL|T Project No. CS19360-120

March 16, 2021



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REFERENCES

EXHIBIT A – SURFACE DRAINAGE, IRRIGATION AND MAINTENANCE

EXHIBIT B – BACKFILL COMPACTION ALTERNATIVES

FIG. 1 – LOCATION OF EXPLORATORY BORINGS

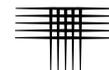
FIG. 2 – SURFICIAL GEOLOGIC CONDITIONS

FIG. 3 – EXTERIOR FOUNDATION WALL DRAIN DETAIL

APPENDIX A – SUMMARY LOGS OF EXPLORATORY BORINGS

APPENDIX B – LABORATORY TEST RESULTS

TABLE B-1: SUMMARY OF LABORATORY TESTING



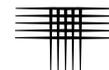
## SCOPE

This report presents the results of our Soils and Foundation Investigation and Geologic Hazards Evaluation for a proposed single-family residence to be constructed at 19580 Four Winds Way in Woodmoor, Colorado (Fig. 1). The purpose of our investigation was to evaluate the subsurface conditions in order to provide geotechnical design and construction recommendations for the proposed residence and to evaluate the lot for the occurrence of geologic hazards that may impact development of the site. The scope of our services was described in our proposal (CTL|T Proposal No. CS-21-0032) dated February 26, 2021.

The report was prepared based on conditions interpreted from field reconnaissance of the site, conditions found in our exploratory borings, results of laboratory tests, engineering analysis, and our experience. It includes our opinions and recommendations for design criteria and construction details for foundations and floor systems, slabs-on-grade, and drainage precautions. The report was prepared for the exclusive use of The Maynard Company in design and construction of a single-family residence on the referenced lot. Other types of construction may require revision of this report and the recommended design criteria. A brief summary of our conclusions and recommendations follows. Detailed design criteria are presented within the report.

## SUMMARY

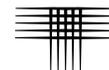
1. We did not identify geologic hazards that we believe preclude development of the property for construction of the planned single-family residence. The presence of shallow, very hard bedrock, as well as the regional issues of radioactivity and seismicity, are conditions that may affect the proposed development. These conditions can be mitigated with engineering design and construction methods commonly employed in the area.
2. Subsurface conditions encountered in our borings consisted of less than one foot of clayey sand overlying sandstone bedrock to the maximum depths explored of up to 30 feet.



3. At the time of drilling, groundwater was not encountered in the two borings completed at the site. The borings were again found to be dry when water levels were checked 20 days following completion of drilling operations. Groundwater elevations will vary with seasonal precipitation and landscaping irrigation.
4. The proposed residence may be constructed with a spread footing foundation underlain by the natural sand soils, bedrock, or new, fill. Design and construction criteria for the foundation are presented in the report.
5. Our analysis indicates the risk of poor slab-on-grade performance (movement and damage) at the basement level or slab-on-grade level, depending on type of construction of the planned residence is low.
6. Surface drainage should be designed, constructed, and maintained to provide rapid removal of surface runoff away from the proposed residence. Conservative irrigation practices should be followed to avoid excessive wetting.
7. The design and construction criteria for the foundation and floor system alternatives in this report were compiled with the expectation that all other recommendations presented related to surface and subsurface drainage, landscaping irrigation, backfill compaction, etc. will be incorporated into the project and that homeowners will maintain the structure, use prudent irrigation practices, and maintain surface drainage. It is critical that all recommendations in this report are followed.

## **SITE CONDITIONS**

The investigated site (Lot 168) is located in the Top O' the Moor II subdivision and addressed as 19580 Four Winds Way, Woodmoor, Colorado (Fig. 1). Developed single-family lots are present surrounding the lot in all directions with open space located to the north of the lot. The lot planned for development is situated in an area identified as having sandstone outcroppings and located near a regional high point. The lot is located in a locally elevated area with a low-lying area crossing the lot in a north to south direction. The low-lying area is surrounded on the north, east, and west by sandstone outcroppings. Elevations across the lot vary by about 30 feet and are defined by topographic mapping as between approx-



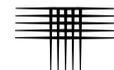
imately 7,430 and 7,395 feet above mean sea level. Overall, the lot is about 20 to 30 feet higher than the street at the proposed driveway. Generally, the lot slopes downward and toward the south. Adjacent lots to the east slope toward the east and adjacent lots to the west slope toward the south. (see Fig. 1). Vegetative cover across the site includes weeds, grasses, scrub oak and young to mature pine.

## **PROPOSED CONSTRUCTION**

Preliminary plans and discussions with the client indicate the proposed residence will be a wood-frame, ranch-style structure constructed with a walk-out basement level, walking out toward the south into the lower lying portion of the lot. Our understanding of the planned construction is that the building footprint will be located within a low-lying area of the lot that is planned to receive import fill to establish a building pad. The residence will have an attached garage. Foundation loads are expected to vary between 1,000 and 3,000 pounds per lineal foot of foundation wall, with individual column loads of 25 kips or less. Typically, excavations of 5 to 7 feet are required for basement construction. If structurally supported basement floors are used, the excavations could be about 2 feet deeper. Final grading and landscaping may result in slightly greater depth of backfill. Specific grading plans were not available at the time of our investigation. We should be provided copies of the grading and site plans for our review when they become available.

## **INVESTIGATION**

Two exploratory borings were drilled on the lot to investigate subsurface conditions near the proposed residence footprint. The borings were advanced to depths of 25 and 30 feet using 4-inch diameter, continuous-flight, solid-stem auger and a track-mounted drill rig. A track mounted drill rig was required to reach the planned footprint with no current driveway cuts in place. Our field representative observed drilling, logged the conditions encountered in the borings, and obtained



samples. Graphical logs of the borings, including results of field penetration resistance tests and some laboratory test data, are presented in the Summary Logs of Exploratory Borings in Appendix A.

Soil samples obtained during drilling were returned to our laboratory and visually classified. Laboratory testing was then assigned to representative samples and included moisture content, sieve analysis, and water-soluble sulfate content tests. Results of the laboratory tests are presented in Appendix B and are summarized in Table B-1.

## **SUBSURFACE CONDITIONS**

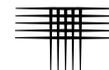
Subsurface conditions encountered in our borings consisted of less than one foot of natural, clayey sand underlain by sandstone bedrock to the maximum depth explored of 30 feet below the existing ground surface. Some of the pertinent engineering characteristics of the subsoils and bedrock encountered and groundwater conditions are described in more detail in the following paragraphs.

### **Natural Sand**

Natural, clayey sand was encountered in both of the borings at the ground surface. The sands extended to depths of less than about one foot below the ground surface. Our experience indicates the sand is non-expansive when wetted.

### **Bedrock**

Silty sandstone bedrock was encountered in the two borings drilled at the site. The bedrock was judged to be very hard, based on field resistance penetration testing. Two samples of the bedrock cuttings were tested in our laboratory contained 25 to 30 percent silt and clay sized particles (passing the -200 sieve). Cemented layers of sandstone were encountered during the drilling operation.



## **Groundwater**

At the time of drilling, groundwater was not encountered in the two borings. The borings were again found to be dry when water levels were rechecked 20 days after the completion of drilling. Groundwater elevations can vary with seasonal precipitation and landscaping irrigation.

## **SITE GEOLOGY**

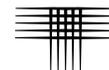
The geology of the site was evaluated through the review of published geologic maps, field reconnaissance, and our exploratory borings drilled in the vicinity of the proposed residence footprint. Information from these sources was used to produce our interpretation of site geology, as shown in Fig. 2. A list of references is included at the end of this report. Mapping by Jon P. Thorson and Richard F. Modale indicate the site is mapped as TKda<sub>5</sub> – Dawson Formation.

Dawson Formation (Map Unit “TKda<sub>5</sub>”): The area mapped as underlain by sandstone bedrock of the Dawson Formation. The deposit exhibits sandstone with rare interbeds of thin to very thin claystone lenses. The formation is estimated to be about 500 feet thick.

The surficial deposits encountered at the site consisted of a thin layer of natural clayey sand underlain by sandstone bedrock to the maximum depth explored of 30 feet. Robinson and Associates mapped the site as cTkda, indicating the site has colluvium underlain by Dawson Sandstone. Our interpretation of the geologic conditions at the site is presented in Fig. 2.

## **POTENTIAL GEOLOGIC HAZARDS AND ENGINEERING CONSTRAINTS**

We did not identify geologic hazards that we believe preclude construction of the proposed residence on the site. The identified conditions that may pose hazards or constraints to development very hard bedrock and erosion. Regional



geologic conditions that could impact the site include seismicity and radioactivity. We believe each of these conditions can be mitigated with engineering design and construction methods commonly employed in this area. These conditions are discussed in greater detail in the sections that follow.

Our interpretation of the engineering conditions is presented in Fig. 2. The engineering geology classification system shown in Fig. 2 is adapted from the classification system of Robinson, 1977, as described below.

Map Unit "2A" depicts stable alluvium, colluvium, and bedrock on gentle to moderate slopes (5% to 12%).

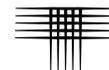
Map Unit "3A" depicts stable alluvium, colluvium, and bedrock on moderately steep slopes (12% to 24%).

## **Erosion**

The site contains surficial sandy soils that are susceptible to the effects of wind and water erosion. Concentrated water flow can result in erosion. The surficial soils are relatively stable and resistant to wind erosion where vegetation is established. Disturbance of the vegetative cover and long-term exposure to the erosive power of wind and water increases the potential for erosion. Maintaining vegetative cover and providing engineered surface drainage will reduce the potential for erosion from wind and water.

## **Economic Minerals**

We found no evidence that the site contains sand and gravel that could be economically mined. Energy fuels such as coal, uranium, oil and gas are not present in economic quantities in the formations below this site. Therefore, it is doubtful the site has been undermined.

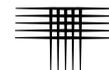


## **Radon and Radioactivity**

We believe no unusual hazard exists from naturally occurring sources of radioactivity on this site. However, the materials found in our borings can be associated with the production of radon gas and concentrations in excess of EPA guidelines can occur. Radon tends to collect in below-grade, residential areas due to limited outside air exchange and interior ventilation. Passive and active mitigation procedures are commonly employed in this region to effectively reduce the buildup of radon gas. Measures that can be taken after a structure is enclosed during construction include installing a blower connected to the foundation drain (if present) and sealing the joints and cracks in concrete floors and foundation walls. If the occurrence of radon is a concern, we recommend the structure be tested after it is enclosed and mitigation systems installed to reduce the risk. The EPA provides guidance for radon mitigation.

The site lies near to the contact between the Denver Formation and the overlying Dawson Formation, and rocks containing naturally occurring uranium have been recognized in areas several miles to the northeast. For these reasons, low-level gamma radiation levels were measured in the cuttings from our exploratory borings using a LUDLUM Micro R Meter (Model 19). The meter provides readings of low-level gamma radiation in terms of micro R/Hr (micro Roentgens per hour). Readings on the drill cuttings were about 20 to 22 micro R/Hr.

The “background” level of low-level gamma radiation in the state generally ranges from 15 to 20 micro R/Hr with the level of concern being established at about twice background. This would imply remediation should be performed for materials which exceed about 30 to 40 micro R/Hr at this site. Our readings were lower than the action level.



## **Flooding**

Information presented on the “Flood Insurance Rate Map” (FIRM), Map No. 08041C0277G, effective date December 7, 2018, indicates the lot is located outside of areas mapped as prone to surface flooding. The project Civil Engineer will determine the flood potential and design appropriate surface drainage.

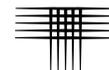
## **Seismicity**

This area, like most of central Colorado, is subject to a degree of seismic activity. Geologic evidence has been interpreted to indicate that movement along some Front Range faults has occurred during the last two million years (Quaternary). This includes the Rampart Range Fault, which is located about four miles west of the site. We believe the soils on the property classify as Site Class C (very dense soil and soft rock profile) according to the 2015 International Building Code (2015 IBC).

## **SITE GRADING**

The lot contains a narrow valley, and we understand it will receive fill to establish a building pad for the new residence. A walkout basement is planned and will walkout toward the south, in the area of the lower lying portion of the lot. The surficial soils at the site are generally shallow and are underlain by very hard sandstone bedrock at less than one foot, as identified in our borings. We believe significant excavation into the sandstone may be difficult. Minor excavations into the sandstone can probably be accomplished with conventional, heavy-duty excavation equipment using rock teeth and rock buckets.

Based on our discussions with the client, we understand the portion of the lot to be occupied by the residence is to receive fill of various thicknesses to establish a building pad. Based on topography and our understanding of the proposed construction, we anticipate areas to receive new fill may contain up to about 10 feet of fill in the lowest lying areas for foundation construction.

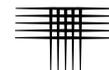


Vegetation and organic materials should be removed from the ground surface at the site. Organic soils should be wasted in landscaped areas. If insufficient landscaped areas are planned, topsoil can be mixed with clean fill soils at a ratio of 15:1 (fill:topsoil) and placed as fill.

We typically recommend the ground surface in areas to receive fill be scarified, moisture conditioned, and compacted to provide a firm base. Shallow excavation on this site is expected to expose sandstone bedrock at shallow depths. Where sandstone is exposed, it should be roughened with the excavator bucket prior to the placement of fill. Sloped ground surfaces to receive fill such as the exposed bedrock should be benched prior to receiving new fill.

The properties of the fill will affect the performance of the foundation and slabs-on-grade. We anticipate the fill will consist primarily of import soils. Import soils should ideally consist of granular materials with 100 percent passing the 2-inch sieve and contain 30 percent passing the No. 200 sieve. The import soils should exhibit low plasticity with a Liquid Limit of less than 30 and a Plasticity Index of less than 15. A sample of the import soils should be submitted to our laboratory for properties testing prior to importing to the site. Granular grading fill should be placed in thin (8 inches or less), loose lifts, moisture conditioned to within 2 percent of optimum and compacted to at least 92 percent of maximum modified Proctor dry density (ASTM D 1557). Placement and compaction of the grading fill should be observed and tested by our representative during construction.

We recommend the contractor become familiar with applicable local, state, and federal safety regulations, including the current Occupational Safety and Health Administration (OSHA) Excavation and Trench Safety Standards, to determine appropriate excavation slopes. We anticipate the near-surface granular soils will classify as Type C materials. We anticipate the bedrock will classify as Type B material. Temporary excavations in Type C materials and Type B require a maxi-



mum slope inclination of 1.5:1 and 1:1, respectively (horizontal to vertical), unless the excavation is shored or braced. If groundwater seepage occurs, flatter slopes will likely be required. Stockpiles and equipment should not be placed within a horizontal distance equal to one-half the excavation depth, from the edge of the excavation.

Permanent cut and fill slopes should be stable at a slope ratio of 3:1 (horizontal: vertical) or flatter if not retained or reinforced. Use of flatter slopes (4:1) is preferred to reduce erosion from run-off. Seeding and revegetation can also be used to reduce erosion.

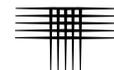
## **FOUNDATIONS**

Based on our understanding of the planned construction and our investigation, we anticipate new foundations will be underlain by new, import fill materials. A spread footing foundation underlain by new, densely compacted fill is considered appropriate for construction of the proposed residence. Foundations underlain by both sandstone bedrock and new fill will likely experience differential settlement, resulting in damages to new foundations and finishing products. We recommend new foundations be separated from the bedrock by at least 2 feet using new fill materials, or be entirely underlain by the sandstone using tall walls, if necessary.

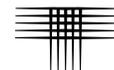
Design criteria for the spread footing foundation developed from analysis of field and laboratory data and our experience are presented below. The builder and structural engineer should also consider design and construction details established by the structural warrantor (if any) that may impose additional design and installation requirements.

### **Spread Footings**

1. Footings should be underlain by new, import soils that have been moisture conditioned and densely placed or bedrock as discussed previously.



2. Footings can be designed for a maximum allowable soil pressure of 3,000 psf.
3. If soft or loose, natural soils are exposed in the excavations, they should be removed or moisture conditioned and compacted as discussed in the Site Grading Section of this report prior to placing concrete.
4. Footings should have a minimum width of at least 16 inches. Foundations for isolated columns should have minimum dimensions of 18 inches by 18 inches. Larger sizes may be required, depending on the loads and structural system used.
5. Foundation walls should be well reinforced, top and bottom. We recommend reinforcement sufficient to span an unsupported distance of at least 10 feet. Reinforcement should be designed by the structural engineer considering the effects of large openings and lateral loads on wall performance.
6. Foundations should be designed considering 1-inch of total settlement. Differential settlement of 1/2-inch should be expected.
7. Exterior footings must be protected from frost action per local building codes. Normally, 30 inches of frost cover are provided in this area.
8. The completed foundation excavations should be observed by a representative of our firm prior to placing the forms to verify subsurface conditions are as anticipated from our borings. The placement and compaction of below-footing fill should be observed and tested by our representative during construction.
9. Proper surface drainage around the residence and between lots is critical to control wetting. The foundation drain and utility service trenches should be braced or installed away from the footings to reduce the risk of undermining the footings and backfill should be compacted. Sump pit and sewer service excavations should avoid undermining the footings or compromising the soil support below and adjacent to footings. The voids around the sump pit excavation should be backfilled with squeegee or "flow fill" to reduce settlements.



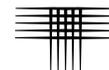
## **SLAB PERFORMANCE RISK**

Laboratory test results, subsoil profiles, and our experience with residence construction and performance were used to provide an evaluation of basement slab performance risk. Slab performance risk evaluation is an engineering judgment that is used as a predictor of the general magnitude of potential slab-on-grade movement and the risk of poor slab-on-grade performance. In our opinion, a low risk of poor slab performance will exist for floor slabs underlain by new, granular import fill materials that have been properly moisture conditioned and densely compacted as previously specified.

## **FLOOR SYSTEMS AND SLABS-ON-GRADE**

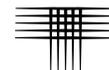
### **Basement Floor Systems and Slabs-On-Grade**

We understand a full depth, walk out basement is planned on the investigated lot. We believe a low risk of poor slab performance will exist for floor slabs underlain by new, import fill materials that have been moisture conditioned and densely placed as previously specified. Our experience indicates basement slab performance has generally been satisfactory on low risk sites. The builder may use a slab-on-grade floor for basement construction on this lot. More heavily loaded foundation walls underlain by granular soils can settle relative to lightly loaded slab-on-grade floors. The settlement can result in cosmetic cracking of drywall partitions in stairwells and in finished basements. We recommend slab-on-grade floors be separated from exterior walls and interior bearing members with joints that allow for independent vertical movements of the slab relative to the foundation. Slab bearing partitions should be minimized. Where such partitions are necessary, a slip joint (or float) allowing at least 2 inches of free vertical slab movement should be provided to reduce the risk of cracking the drywall. Doorways should also be designed to allow vertical movement of slabs. To limit damage in the event of movement, sheetrock should not extend to the floor.



Underslab plumbing should be avoided as much as possible. If underslab plumbing is necessary, service lines should be pressure tested for leaks during construction and be provided with flexible couplings. Any utility lines that penetrate the slab should be isolated from the slab with joints to allow for free vertical movement. Gas and water lines leading to slab-supported appliances should be constructed with flexibility. Heating and air conditioning systems constructed on the slab should be provided with flexible connections capable of at least 2 inches of vertical movement so that slab movement is not transmitted to the ductwork.

The 2015 International Residential Code (IRC R506) states that a 4-inch base course layer consisting of clean, graded sand, gravel, crushed stone, or crushed blast furnace slag shall be placed beneath below-grade floors (unless the underlying soils are free-draining), along with a vapor retarder. The near-surface, granular soils found on this site are comparatively free-draining; however, we understand import materials are to be used and the properties of the import materials will have an impact on this. The IRC states that the vapor retarder can be omitted where approved by the building official. The merits of installation of a vapor retarder below floor slabs depend on the sensitivity of floor coverings and building use to moisture. A properly installed vapor retarder is more beneficial below concrete slab-on-grade floors where floor coverings, painted floor surfaces, or products stored on the floor will be sensitive to moisture. The vapor retarder is most effective when concrete is placed directly on top of it, rather than placing a sand or gravel leveling course between the vapor retarder and the floor slab. Placement of concrete on the vapor retarder may increase the risk of shrinkage cracking and curling. Use of concrete with reduced shrinkage characteristics including minimized water content, maximized coarse aggregate content, and reasonably low slump will reduce the risk of shrinkage cracking and curling. Considerations and recommendations for the installation of vapor retarders below concrete slabs are outlined in Section 3.2.3 of the 2006 American Concrete Institute (ACI) Committee 302, "Guide for Concrete Floor and Slab Construction (ACI 302.R-96)".

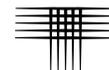


Frequent control joints should be provided in the floor slabs to reduce the effects of curling and to help control shrinkage cracking. Panels that are approximately square generally perform better than rectangular areas. We suggest an additional joint about 3 feet away from and parallel to foundation walls.

### **Porches, Decks and Patios**

Porches or decks with overhanging roofs, or that are otherwise integral with the residence such that differential foundation movement cannot be tolerated, should be constructed with the same foundation type as the house. Isolated piers or pads may be installed beneath a roof overhang provided the slab is independent of the foundation elements. Patio or porch roof columns may be positioned on the slab, directly above the foundation system, provided the slab is structural and supported by the foundation system. Porch or patio slabs should be constructed to reduce the likelihood that backfill settlement will affect the slab. One approach (for smaller porches located over basement backfill zones) is to construct the porch as a structurally supported slab that is independent of the underlying backfill. Non-structural porches, patio slabs, and other exterior flatwork should be isolated from the foundation. Movements of slabs should not be transmitted to the foundation. Wooden decks are more flexible and more easily adjusted in the event of movement.

Deck foundations should be designed by a structural engineer. For simple decks that are not integral with the residence and can tolerate some movement, the use of short piers or footing pads bottomed at least 36 inches below grade can be considered, as long as they are located outside foundation wall backfill areas. Deck foundations should be bottomed below foundation wall backfill to reduce risk of settlement; longer (8 to 10 feet or more) deck piers may be necessary to provide adequate support. The inner edge of the deck may be constructed on haunches or steel angles bolted to the foundation walls and detailed such that movement of the deck foundation will not cause distress to the residence. We suggest use of adjustable bracket-type connections or other details between foun-



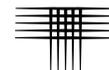
dations and deck posts so the posts can be trimmed or adjusted if movement occurs. We are not aware of planned porches, decks, or patios to be constructed adjacent to the slopes. If plans should include construction near the slopes, we should be contacted to review the plans to determine if special provisions are required.

### **Garage Floors and Exterior Flatwork**

Garage slabs, driveways, and sidewalks are normally constructed as slabs-on-grade. Performance of conventional slabs-on-grade is erratic. Various properties of the soils and environmental conditions influence magnitude of settlement and other performance characteristics. Increases in the moisture content in the underlying soils can result in settlement and possible cracking of slabs-on-grade. Backfill below slabs should be moisture conditioned and compacted to reduce settlement, as discussed in BACKFILL COMPACTION. The driveway and exterior slabs founded on backfill may settle and crack if the backfill is not properly moisture treated and compacted.

### **BELOW-GRADE WALLS**

Basement and/or foundation walls and grade beams that extend below grade should be designed to resist lateral earth pressures where backfill is not present to about the same extent on both sides of the wall. Many factors affect the value of the design lateral earth pressure. These factors include, but are not limited to, the wall type, backfill compaction and composition, slope and drainage of the backfill, and the rigidity of the wall against rotation and deflection. For a very rigid wall where negligible or very little deflection will occur, an “at-rest” lateral earth pressure should be used in design. For walls that can deflect or rotate 0.5 to 1 percent of the wall height (depending upon the backfill types), lower “active” lateral earth pressures are appropriate. Our experience indicates basement walls can deflect or rotate slightly under normal design loads, and that this deflection



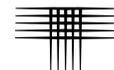
typically does not affect the structural integrity of the walls. Thus, the earth pressure on the walls will likely be between the “active” and “at-rest” conditions.

If the on-site sands are used as backfill and the backfill is not saturated, we recommend design of basement walls at this site using an equivalent fluid density of at least 50 pcf. This value assumes deflection; some minor cracking of walls may occur. If very little wall deflection is desired, a higher design value is appropriate. The structural engineer should also consider site-specific grade restrictions and the effects of large openings on the behavior of the walls.

## **BACKFILL COMPACTION**

Settlement of foundation wall and utility trench backfill can cause damage to concrete flatwork and/or result in poor drainage conditions. Compaction of backfill can reduce settlement. Attempts to compact backfill near foundations to a high degree can cause damage to foundation walls and window wells and may increase lateral pressures on the foundation walls. The potential for cracking of the foundation wall can vary widely based on many factors including the degree of compaction achieved, the weight and type of compaction equipment utilized, the structural design of the wall, the strength of the concrete at the time of backfill compaction, and the presence of temporary or permanent bracing.

Proper moisture conditioning of backfill is as important as compaction, because settlement commonly occurs in response to wetting. The addition of water complicates the backfill process, especially during cold weather. Frozen soils are considered unsuitable for use as backfill because excessive settlement can result when the frozen materials thaw. Exhibit B describes four alternative methods to place, moisture condition, and compact backfill along with a range of possible settlements, and advantages and disadvantages of each approach, all based on our experience. These are just a few of the possible techniques and represent a range for your evaluation. We recommend Alternatives C or D if you wish to control potential settlement.

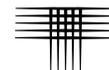


Precautions should be taken when backfilling against a basement wall. Temporary bracing of comparatively long, straight sections of foundation walls should be used to limit damage to walls during the compaction process. Waiting at least seven days (or longer during cold weather months) after the walls are placed to allow the concrete to gain strength can also reduce the risk of damage. Compaction of fill placed beneath and next to window wells, counterforts, and grade beams may be difficult to achieve without damaging these building elements. Proper moisture conditioning of the fill prior to placement in these areas will help reduce potential settlement.

Ideally, drainage swales should not be located over the backfill zone (including excavation ramps), as this can increase the amount of water infiltration into the backfill and cause excessive settlement. Swales should be designed to be a minimum of at least 5 feet from the foundation to help reduce water infiltration. Irrigated vegetation, sump pump discharge pipes, sprinkler valve boxes, and roof downspout terminations should also be at least 5 feet from the foundation. Drainage features such as downspouts or others should not direct water on the steeper slopes at the site, rather water should be directed to other locations at the site.

## **SUBSURFACE DRAINS AND SURFACE DRAINAGE**

Water from surface irrigation of lawns and landscaping frequently flows through relatively permeable backfill placed adjacent to a residence, and collects on the surface of less permeable soils occurring at the bottom of basement or foundation excavations. This process can cause wet or moist basement conditions after construction. To reduce the likelihood water pressure will develop outside foundation walls and the risk of accumulation of water at the basement level, we recommend provision of a foundation drain around the entire basement perimeter. The provision of a drain will not eliminate slab movement or prevent moist conditions in crawl spaces. The drain should consist of a 4-inch diameter, perforated or slotted pipe encased in free-draining gravel. The drain should lead to a positive



gravity outlet away from steep slopes at the site, such as a subdrain located beneath the sewer, or to a sump where water can be removed by pumping. Sump pumps must be maintained by the homeowners. A typical foundation drain detail for basement construction is presented in Fig. 3.

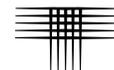
Our experience indicates moist conditions can develop in non-basement crawl space areas, resulting in isolated instances of damp soils, musty smells and, in rare cases, standing water. These crawl space areas should be well ventilated, depending on the use of a vapor retarder/barrier and the floor material selected. Some builders install drain systems around non-basement crawl space areas as a precaution; we regard these installations as optional. If no basement is planned, a drain should be installed in the crawl space. We can provide recommendations for crawl space drain systems, if desired.

Proper design, construction, and maintenance of surface drainage are critical to the satisfactory performance of foundations, slabs-on-grade, and other improvements. Landscaping and irrigation practices will also affect performance. Exhibit A contains our recommendations for surface drainage, irrigation, and maintenance.

## **CONCRETE**

Concrete in contact with soil can be subject to sulfate attack. We measured the water-soluble sulfate concentration in one sample from this site at less than 0.1 percent. For this level of sulfate concentration, ACI 332-08 *Code Requirements for Residential Concrete* indicates there are no special requirements for sulfate resistance.

Superficial damage may occur to the exposed surfaces of highly permeable concrete, even though sulfate levels are relatively low. To control this risk and to resist freeze-thaw deterioration, the water-to-cementitious materials ratio should not exceed 0.50 for concrete in contact with soils that are likely to stay moist due



to surface drainage or high water tables. Concrete should be air entrained where exposed to freeze/thaw conditions. We recommend all foundation walls and grade beams in contact with the subsoils (including the inside and outside faces of garage and crawl space grade beams) be damp-proofed.

## **EXCAVATIONS**

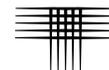
Excavations made at this site, including those for foundations and utilities, may be governed by local, state, or federal guidelines or regulations. Subcontractors should be familiar with these regulations and take whatever precautions they deem necessary to comply with the requirements and thereby protect the safety of their employees and that of the general public.

## **CONSTRUCTION OBSERVATIONS**

We recommend that CTL | Thompson, Inc. provide construction observation services to allow us the opportunity to verify whether soil conditions are consistent with those found during this investigation. If others perform these observations, they must accept responsibility to judge whether the recommendations in this report remain appropriate.

## **GEOTECHNICAL RISK**

The concept of risk is an important aspect with any geotechnical evaluation primarily because the methods used to develop geotechnical recommendations do not comprise an exact science. We never have complete knowledge of subsurface conditions. Our analysis must be tempered with engineering judgment and experience. Therefore, the recommendations presented in any geotechnical evaluation should not be considered risk-free. Our recommendations represent our judgment of those measures that are necessary to increase the chances that the structure will perform satisfactorily. It is critical that all recommendations in this report are followed during design and construction. The homeowner must assume responsi-



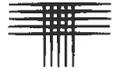
bility for maintaining the structure and use appropriate practices regarding drainage and landscaping. Improvements performed by homeowners after construction, such as finishing a basement or construction of additions, retaining walls, decks, patios, landscaping and exterior flatwork, should be completed in accordance with the recommendations in this report and may require additional soil investigation and consultation.

## **LIMITATIONS**

This report has been prepared for the exclusive use of The Maynard Company for the purpose of providing geotechnical design and construction criteria for the proposed residence located at 19580 Four Winds Way in Woodmoor, Colorado. The information, conclusions, and recommendations presented herein are based on consideration of many factors including, but not limited to, the type of structure proposed, the geologic setting, and the subsurface conditions encountered. The conclusions and recommendations contained in the report are not valid for use by others. Standards of practice evolve in the area of geotechnical engineering. The recommendations provided are appropriate for about three years. If the proposed residence is not constructed within about three years, we should be contacted to determine if we should update this report. Plans were not available at the time of our investigation. We should be provided copies of the grading and site plans for our review when they become available.

Two borings were drilled on the investigated lot (Lot 168) to obtain a reasonably accurate indication of foundation soil conditions. Variations in the subsoil conditions not indicated by our borings are possible. A representative of our firm should observe the foundation excavations to verify the exposed subsoils are as anticipated. Our representative should also test the compaction of below-footing backfill during construction.

We believe this investigation was conducted with that level of skill and care ordinarily used by geotechnical engineers practicing under similar conditions. No



warranty, express or implied, is made. If we can be of further service in discussing the contents of this report or in the analysis of the influence of subsoil conditions on design of the structures, please call.

Very truly yours,

CTL|THOMPSON, INC.

Patrick Foley, EIT  
Staff Engineer

PF:TAM:cw

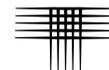
(2 copies sent)

Via e-mail: [terminalangler@swissmail.org](mailto:terminalangler@swissmail.org)

Reviewed by:

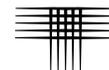
Timothy A. Mitchell, P.E.  
Associate Engineer





## REFERENCES

1. Colorado Geological Survey (1991). Results of the 1987-88 EPA Supported Radon Study in Colorado, with a Discussion on Geology, Colorado Geological Survey Open File Report 91-4.
2. Dames & Moore, April 1985, Colorado Springs Subsidence Investigation, Colorado Division of Mined Land Reclamation.
3. Federal Emergency Management Agency, Flood Insurance Rate Map, Map Number 08041C0277G, Panel 277 of 1300, effective date December 7, 2018.
4. International Residential Code (2012 and 2015 IRC).
5. Kirkham, R. M. & Rogers, W. P. (1981). Earthquake Potential in Colorado. Colorado Geological Survey, Bulletin 43.
6. Robinson and Associates, Inc. (1977). El Paso County, Colorado - Potential Geologic Hazards and Surficial Deposits, Environmental and Engineering Geologic Maps and Tables for Land Use.
7. State of Colorado, Division of Mined Land Reclamation (April 1985). Prepared by Dames and Moore. Colorado Springs Subsidence Investigation.
8. Jon P. Thorson, Richard E. Madole (2003). Geologic Map of the Monument Quadrangle, El Paso County, Colorado, Colorado Geological Survey.



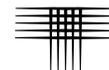
## EXHIBIT A

### SURFACE DRAINAGE, IRRIGATION AND MAINTENANCE

Performance of foundations and concrete flatwork is influenced by the moisture conditions existing within the foundation soils. Surface drainage should be designed to provide rapid runoff of surface water away from the proposed residence. Proper surface drainage and irrigation practices can help control the amount of surface water that penetrates to the foundation level and contributes to settlement or heave of soils and bedrock that support the foundation and slabs-on-grade. Positive drainage away from the foundation and avoidance of irrigation near the foundation also help to avoid excessive wetting of backfill soils, which can lead to increased backfill settlement and possibly to higher lateral earth pressures, due to increased weight and reduced strength of the backfill. CTL | Thompson, Inc. recommends the following precautions. The home buyer should maintain surface drainage and, if an irrigation system is installed, it should substantially conform to these recommendations.

1. Wetting or drying of the open foundation excavation should be avoided.
2. Excessive wetting of foundation soils before, during and after construction can cause softening of fill and foundation soils and result in foundation and slab movements. Proper surface drainage around the residence and between lots is critical to control wetting.
3. The ground surface surrounding the exterior of the residence should be sloped to drain away from the building in all directions. We recommend a minimum constructed slope of at least 12 inches in the first 10 feet (10 percent) in landscaped areas around the residence, where practical. The recommended slope is for the soil surface slope, not the surface of the landscaping rock.

We do not view the recommendation to provide a 10 percent slope away from the foundation as an absolute. It is desirable to create this slope where practical, because we know that backfill will likely settle to some degree. By starting with sufficient slope, positive drainage can be maintained for most settlement conditions. There are many situations around a residence where a 10 percent slope cannot be achieved practically, such as around patios, at inside foundation corners, and between a house and nearby sidewalk. In these areas, we believe it is desirable to establish as much slope as practical and to avoid irrigation. We believe it is acceptable to use a slope on the order of 5 percent perpendicular to the foundation in these limited areas.

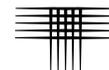


For lots graded to direct drainage from the rear yard to the front, it is difficult to achieve 10 percent slope at the high point behind the house. We believe it is acceptable to use a slope of about 6 inches in the first 10 feet (5 percent) at this location.

Between houses that are separated by a distance of less than 20 feet, the constructed slope should generally be at least 10 percent to the swale used to convey water out of this area. For lots that are graded to drain to the front and back, we believe it is acceptable to install a slope of 5 to 8 percent at the high point (aka “break point”) between houses.

Construction of retaining walls and decks adjacent to a residence should not alter the recommended slopes and surface drainage around the residence. The ground surface under the deck should be compacted and slope away from the residence. A 10-mil plastic sheeting and landscaping rock are recommended above the ground under the decks to reduce water dripping from the deck causing soil erosion and/or forming depressions under the deck. The plastic sheeting should direct water away from the residence. Retaining walls should not flatten the ground surface around the residence and block or impede the surface runoff.

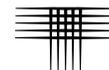
4. Swales used to convey water across yards and between houses should be sloped so that water moves quickly and does not pond for extended periods of time. We suggest minimum slopes of about 2 to 2.5 percent in grassed areas and about 2 percent where landscaping rock or other materials are present. If slopes less than about 2 percent are necessary, concrete-lined channels or plastic pipe should be used. Fence posts, trees, and retaining walls should not impede the runoff in the swale.
5. Backfill around the foundation walls should be moistened and compacted, as discussed previously in the BACKFILL COMPACTION section of the report.
6. Roof downspouts and drains should discharge well beyond the limits of all backfill. Splash blocks and/or extensions should be provided at all downspouts so water discharges onto the ground beyond the backfill. We generally recommend against burial of downspout discharge. Where it is necessary to bury downspout discharge, solid, rigid pipe should be used and it should slope to an open gravity outlet. Downspout extensions, splash blocks and buried outlets must be maintained by the homeowner.



7. The importance of proper homeowner irrigation practices cannot be over-emphasized. Irrigation should be limited to the minimum amount sufficient to maintain vegetation; application of more water will increase likelihood of slab and foundation movements. Landscaping should be carefully designed and maintained to minimize irrigation. Plants placed close to foundation walls should be limited to those with low moisture requirements and utilize only subsurface irrigation such as standard, low-volume drip emitters or in-line drip irrigation. Irrigated grass, irrigation mainlines, above-surface spray heads, rotors, and other above-surface irrigation spray devices should not be located or discharge within 5 feet of the foundation.

Homeowners should periodically check and maintain landscaping and irrigation systems to control introduction of surface water. This maintenance should include, but not be limited to:

- Assure proper ground surface slope (not landscape rock) away from the foundation (yearly).
  - Orient downspout extensions and splash blocks away from the foundation (monthly). Keep downspout tip-ups in the down position.
  - Clean roof gutters (yearly).
  - Check and, if necessary, repair the irrigation system (backflow preventer, sprinkler heads, drip system heads, and pipe) to assure the system components are intact, do not leak, and that spray is directed away from foundations (twice per year).
8. Plastic sheeting should not be placed beneath landscaped areas adjacent to foundation walls or grade beams. Geotextile fabric will inhibit weed growth yet still allow natural evaporation to occur.
  9. The design and construction criteria for foundations and floor system alternatives were compiled with the expectation that all other recommendations presented in this report related to surface and subsurface drainage, landscaping irrigation, backfill compaction, etc. will be incorporated into the project. It is critical that all recommendations in this report are followed.



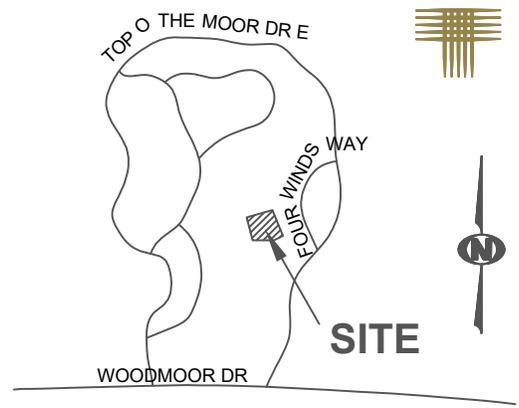
## EXHIBIT B

### EXAMPLE BACKFILL COMPACTION ALTERNATIVES

Alt.	Description	Possible Settlement	Pros (+) / Cons (-)
A	Place in 18 to 24-inch lifts, without moisture conditioning. Compact lift surface to about 85 percent of maximum standard Proctor (ASTM D698) dry density. (Not recommended)	5 to 15 percent of depth (for 8 feet of backfill, 5 to 15 inches)	<ul style="list-style-type: none"><li>+ Fast</li><li>+ Water not required</li><li>- Excessive settlement</li><li>- Highest water penetration</li><li>- Highest probability of warranty repair</li></ul>
B	Moisture condition within 2 percent of optimum, place in 12 to 18-inch lifts. Compact lift surface to about 85 to 90 percent.	5 to 10 percent of depth	<ul style="list-style-type: none"><li>+ Relatively Fast</li><li>- Moderate water penetration</li><li>- Excessive settlement</li><li>- Need for water</li><li>- Warranty repairs probable</li></ul>
C	Moisture condition to within 2 percent of optimum and place in 8 to 12-inch lifts. Compact lift surface to 90 to 95 percent.	2 to 5 percent of depth	<ul style="list-style-type: none"><li>+ Reduced warranty</li><li>+ Reduced water infiltration</li><li>+ Reduced settlement</li><li>- Possible higher lateral pressure</li><li>- Slower</li><li>- Need for water</li><li>- Potential damage to walls</li></ul>
D	Moisture condition and place as in C. Compact lift surface to at least 95 percent.	1 to 2 percent of depth	<ul style="list-style-type: none"><li>+ Reduced warranty</li><li>+ Reduced water infiltration</li><li>+ Lowest comparative settlement</li><li>- Possible higher lateral pressure</li><li>- Slower</li><li>- Need for water</li><li>- Potential damage to walls</li></ul>

**LEGEND:**

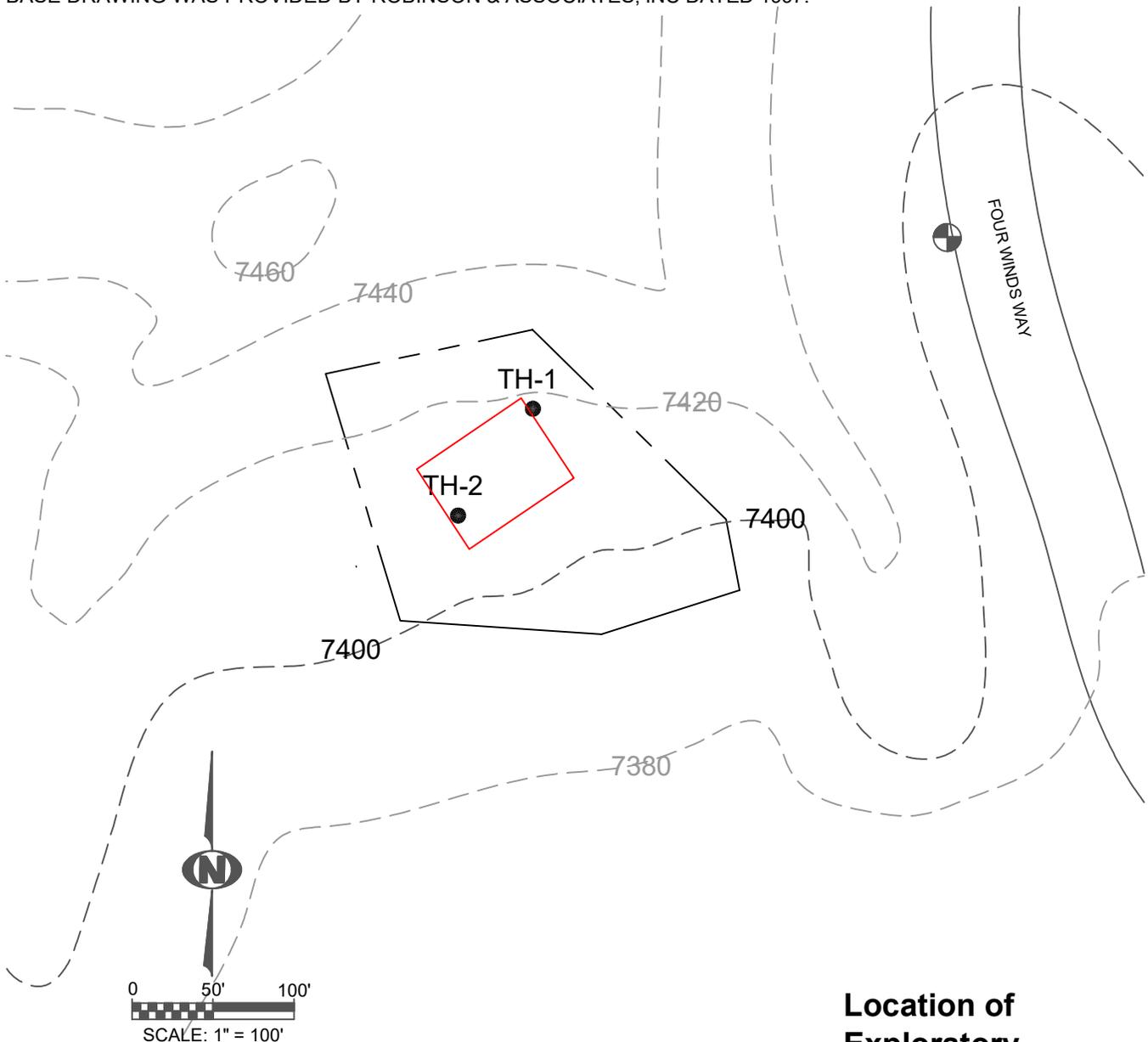
- TH-1**      APPROXIMATE LOCATION OF EXPLORATORY BORING.
- PROJECT BOUNDARY
- LOCATION OF PROPOSED BUILDING FOOTPRINT.
- EXISTING TOPOGRAPHY
- N
 BENCHMARK: THE GROUND SURFACE AT THE TELEPHONE PEDESTAL WAS USED FOR THIS INVESTIGATION AND ASSUMED TO BE ELEV. 100.0.



**VICINITY MAP**

(NOT TO SCALE)

**NOTE:**  
 BASE DRAWING WAS PROVIDED BY ROBINSON & ASSOCIATES, INC DATED 1997.



**LEGEND:**

- TH-1** ● APPROXIMATE LOCATION OF EXPLORATORY BORING.
- PROJECT BOUNDARY
- LOCATION OF PROPOSED BUILDING FOOTPRINT.
- ≡≡≡ EXISTING TOPOGRAPHY

**GEOLOGIC UNITS AND (MODIFIERS)**

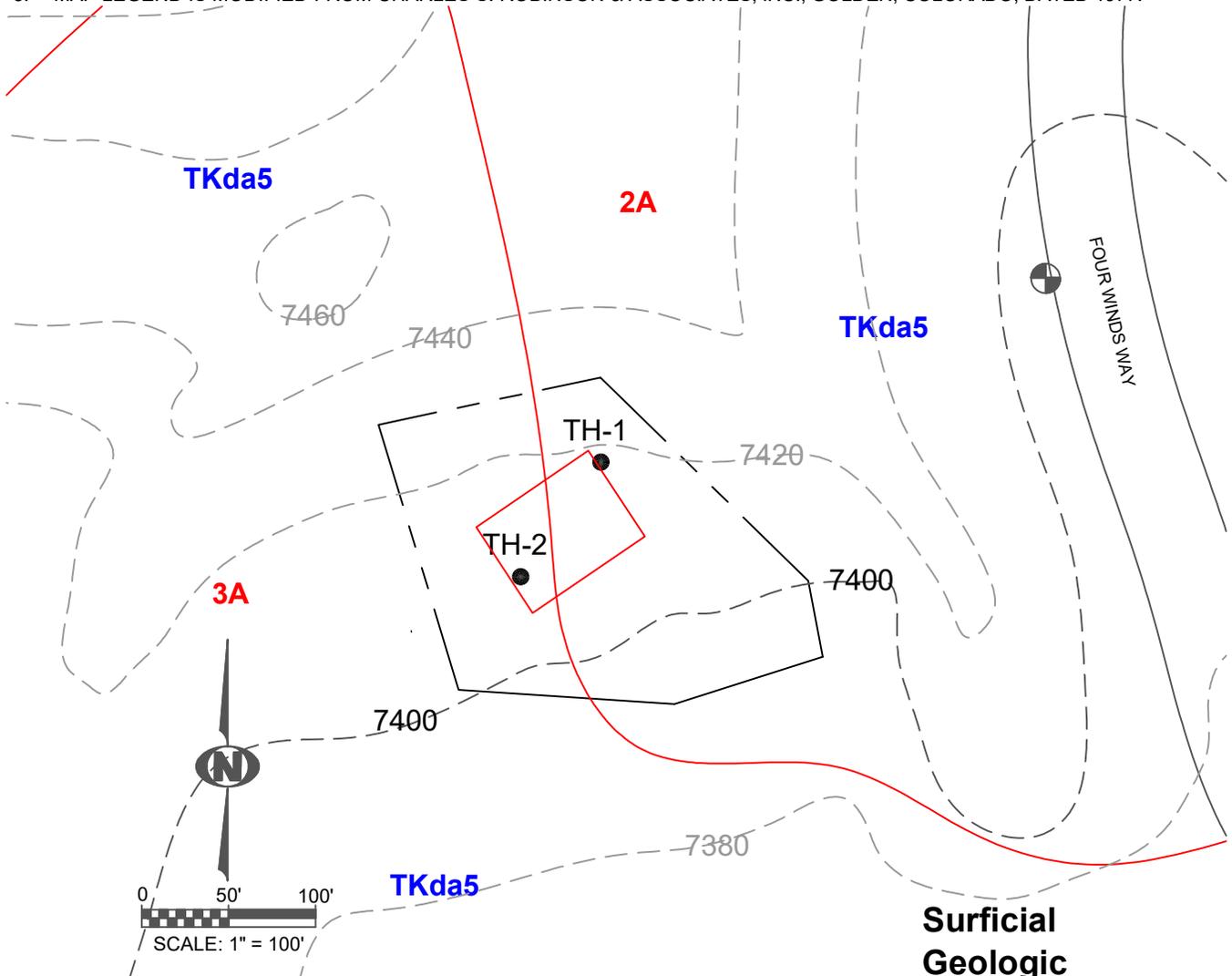
**TKda5** DAWSON FORMATION

**ENGINEERING UNITS AND (MODIFIERS)**

- ~~~~~ ENGINEERING CONTACTS
- 2A** STABLE ALLUVIUM, COLLUVIUM AND BEDROCK ON GENTLE TO MODERATE SLOPES (5%-12%)
- 3A** STABLE ALLUVIUM, COLLUVIUM AND BEDROCK ON MODERATE TO STEEP SLOPES (12%-24%).

**NOTES:**

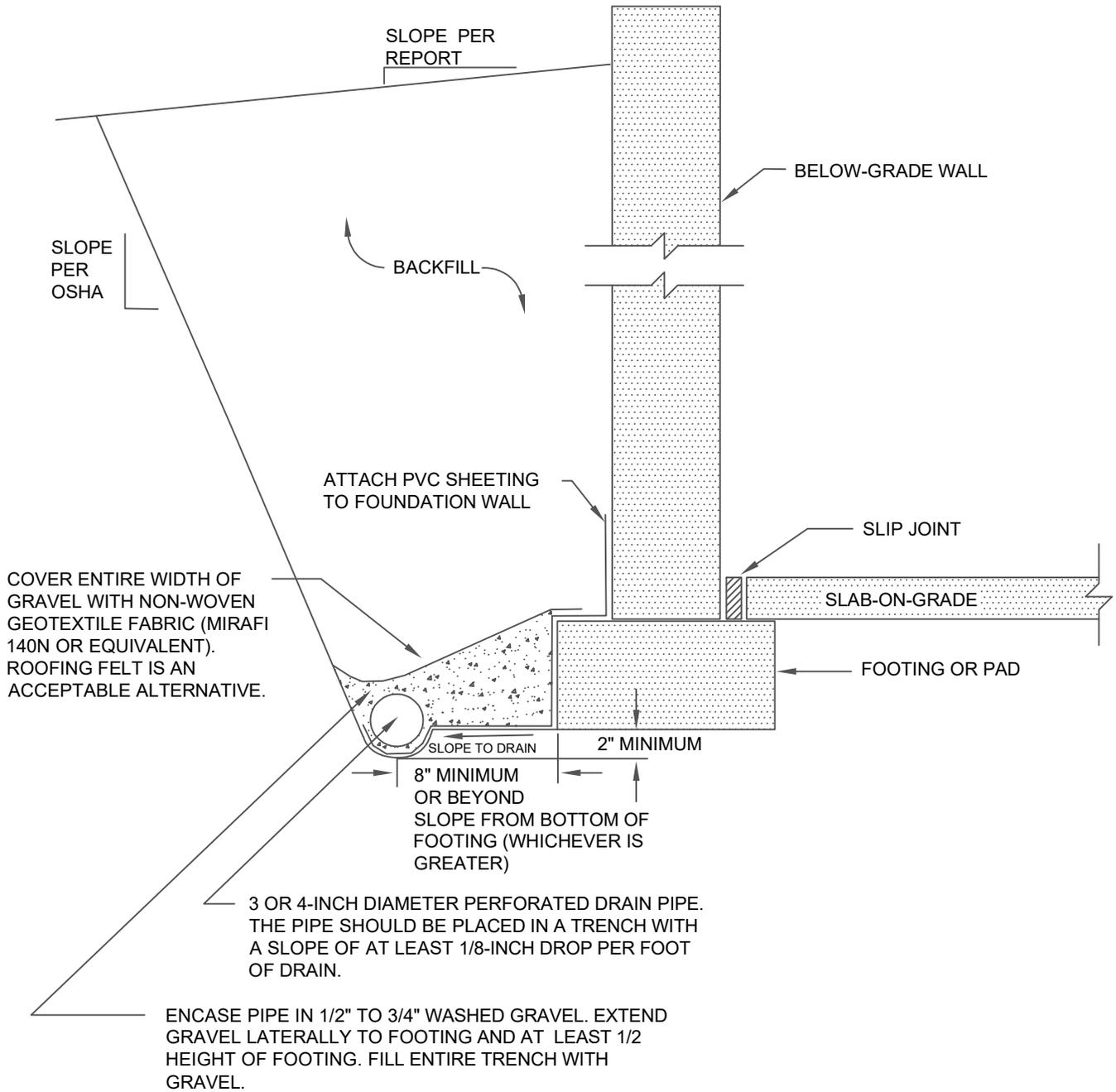
1. BASE DRAWING WAS PROVIDED BY ROBINSON & ASSOCIATES, INC DATED 1997.
2. ALL BOUNDARIES SHOWN SHOULD BE CONSIDERED APPROXIMATE. THEY ARE BASED UPON A SUBJECTIVE INTERPRETATION OF PUBLISHED MAPS, AERIAL PHOTOGRAPHS AND AN INITIAL FIELD RECONNAISSANCE. CHANGES IN THE MAPPED BOUNDARIES SHOWN ARE POSSIBLE AND SHOULD BE EXPECTED WITH MORE DETAILED WORK AND FURTHER INFORMATION. ALL INTERPRETATIONS AND CONDITIONS SHOWN ARE PRELIMINARY AND FOR LAND-USE PLANNING ONLY.
3. MAP LEGEND IS MODIFIED FROM CHARLES S. ROBINSON & ASSOCIATES, INC., GOLDEN, COLORADO, DATED 1977.



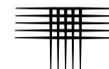
**Surficial  
Geologic  
Conditions**

THE MAYNARD COMPANY  
19580 FOUR WINDS WAY  
CTL/T PROJECT NO. CS19360-120

FIG. 2



NOTE:  
THE BOTTOM OF THE DRAIN SHOULD BE AT LEAST 2 INCHES BELOW BOTTOM OF FOOTING AT THE HIGHEST POINT AND SLOPE DOWNWARD TO A POSITIVE GRAVITY OUTLET OR TO A SUMP WHERE WATER CAN BE REMOVED BY PUMPING.



**APPENDIX A**  
SUMMARY LOGS OF EXPLORATORY BORINGS



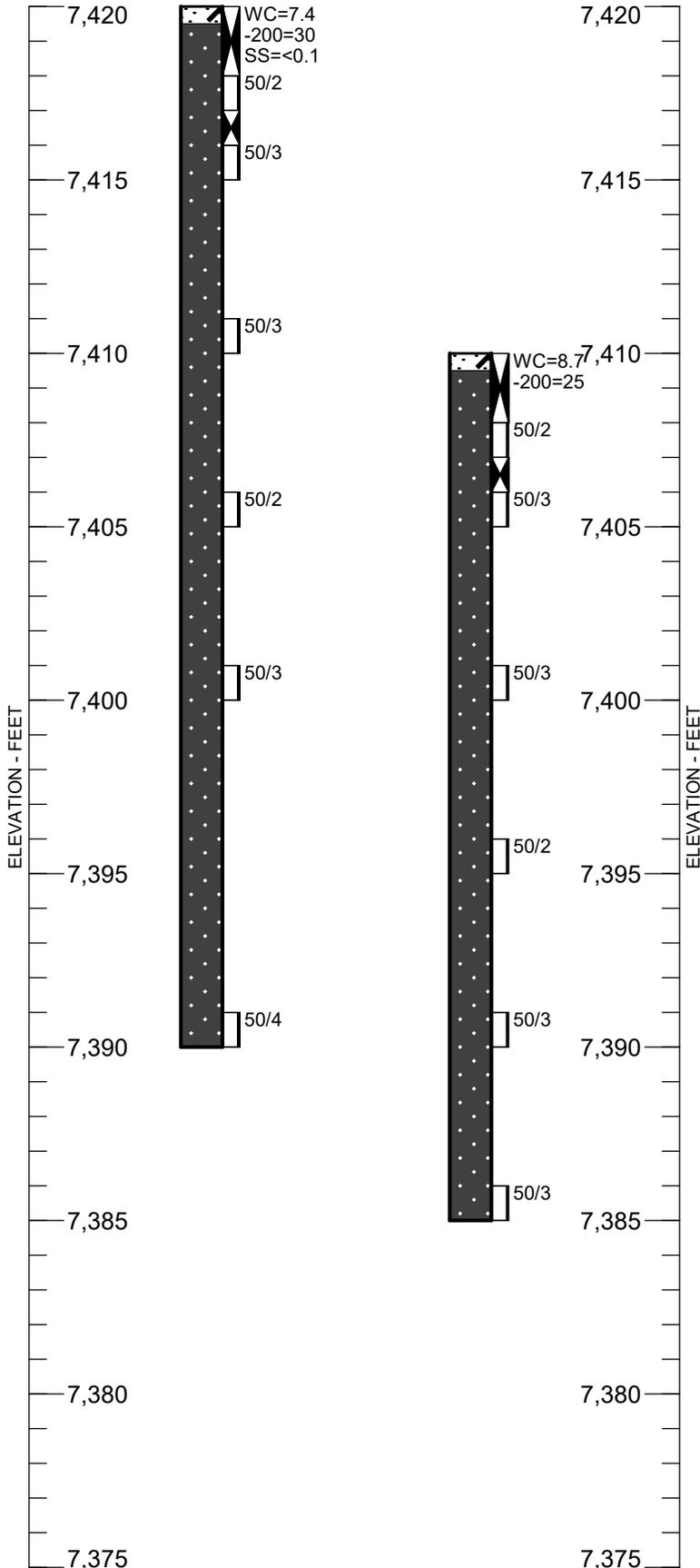
TH - 1

TH - 2

EL. 7420

EL. 7410

**LEGEND:**



SAND, CLAYEY, MOIST, BROWN (SC).



BEDROCK. SANDSTONE, SILTY, VERY HARD, MOIST, LIGHT BROWN TO BROWN.



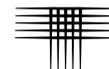
DRIVE SAMPLE. THE SYMBOL 50/2 INDICATES 50 BLOWS OF A 140-POUND HAMMER FALLING 30 INCHES WERE REQUIRED TO DRIVE A 2.5-INCH O.D. SAMPLER 2 INCHES.



INDICATES BULK SAMPLE OBTAINED FROM AUGER CUTTINGS.

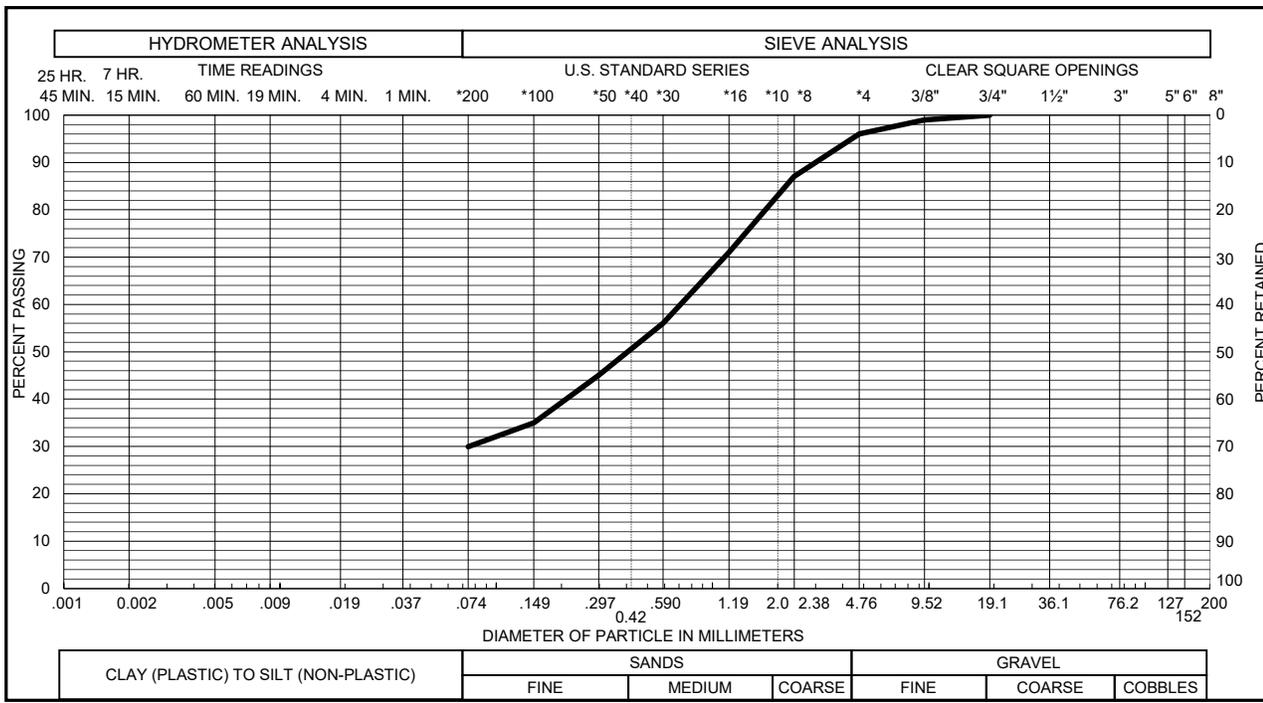
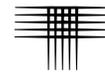
**NOTES:**

1. THE BORINGS WERE DRILLED DECEMBER 28, 2020 USING A 4-INCH DIAMETER, CONTINUOUS-FLIGHT AUGER AND A LIMITED ACCESS, TRACK-MOUNTED DRILL RIG.
2. THESE LOGS ARE SUBJECT TO THE EXPLANATIONS, LIMITATIONS, AND CONCLUSIONS AS CONTAINED IN THIS REPORT.
3. THE BORING ELEVATIONS ARE APPROXIMATE AND WERE ESTIMATED BY PERSONNEL OF CTL | THOMPSON USING A HAND LEVEL AND THE BENCHMARK SHOWN ON FIG. 1.
4. GROUNDWATER WAS NOT ENCOUNTERED IN THE EXPLORATORY BORINGS DURING THIS INVESTIGATION.
5. WC - INDICATES MOISTURE CONTENT. (%)  
 -200 - INDICATES PASSING NO. 200 SIEVE. (%)  
 SS - INDICATES WATER-SOLUBLE SULFATE CONTENT. (%)

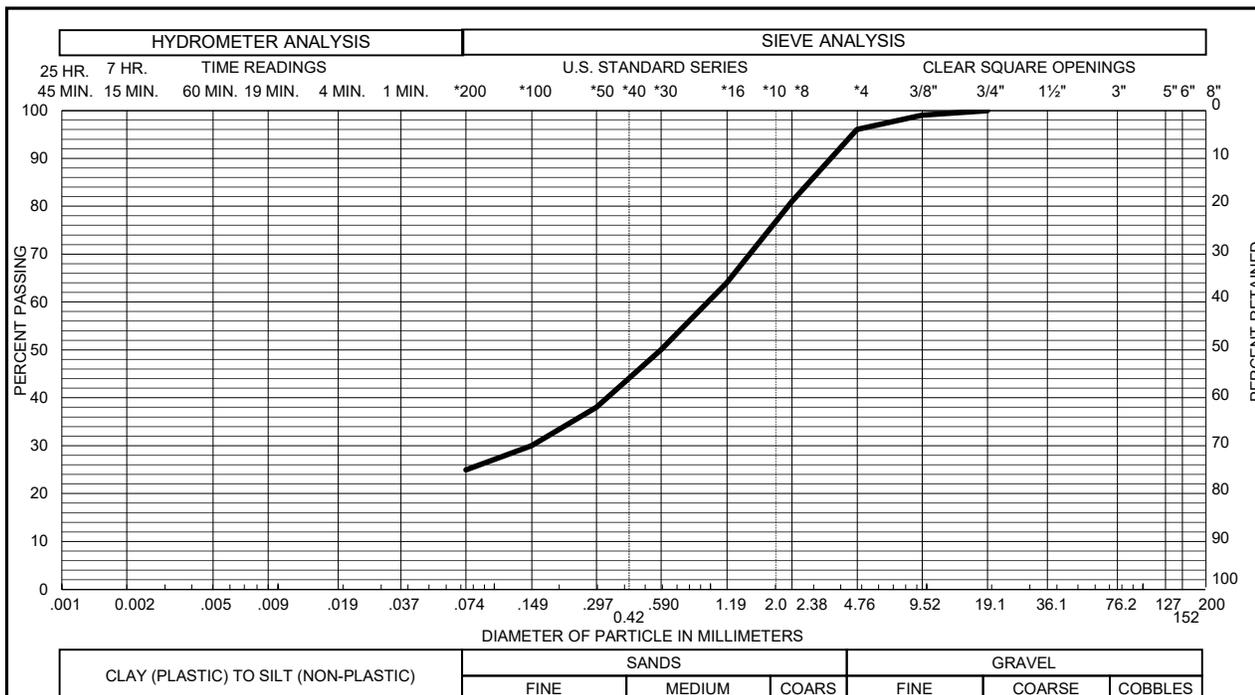


## **APPENDIX B**

### **LABORATORY TEST RESULTS TABLE B-1 – SUMMARY OF LABORATORY TESTING**



Sample of **SANDSTONE, SILTY** GRAVEL 4 % SAND 66 %  
 From TH - 1 AT 0-4 FEET SILT & CLAY 30 % LIQUID LIMIT \_\_\_\_\_ %  
 PLASTICITY INDEX \_\_\_\_\_ %



Sample of **SANDSTONE, SILTY** GRAVEL 4 % SAND 71 %  
 From TH - 2 AT 0-4 FEET SILT & CLAY 25 % LIQUID LIMIT \_\_\_\_\_ %  
 PLASTICITY INDEX \_\_\_\_\_ %

