OV Case #2002761
Grading Permit #2202968

Geotechnical Engineering
Construction Inspection
Materials Testing

GEOTECHNICAL ENGINEERING EVALUATION

Naranja Trails, Lots 1-43

Naranja Drive

PATTISON ENGINEERING, LLC
Project Number 20-098

Prepared for: Meritage Homes
July 24, 2020

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July 24, 2020
Project Number 20-098

Meritage Homes
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GEOTECHNICAL ENGINEERING EVALUATION
Naranja Trails, Lots 1-43
Naranja Drive
Oro Valley, Arizona

We have completed the geotechnical evaluation for the Naranja Trails, Lots 1-43 in accordance with our Proposal Number 20-P264 dated July 21, 2020. Our project study results are attached.

In our opinion, the site's subsurface soil and other conditions are suitable for support of the proposed development provided the designers, contractors, and owners follow the report recommendations. Our site evaluation showed silty sands varied gravel content and cobble content.

We are available for consultation during the various design stages. To provide continuity of geotechnical services, we should perform construction observation and testing.

We thank you for selecting PATTISON ENGINEERING, L.L.C. and look forward to being a member of your team on the remainder of this project. If you have any questions about this report, or require additional consultation, please call us.

Sincerely,
PATTISON ENGINEERING, L.L.C.
Geotechnical, Construction Inspection, and Materials Testing Services

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INTRODUCTION

This report presents the results of our geotechnical engineering services for Naranja Trails, Lots 1-43, development to be located near Naranja Drive west of Pusch Ridge Vistas Drive, in Oro Valley, Arizona. The site is in Section 12 of Township 12 South, Range 13 East of the Gila and Salt River Base and Meridian in Oro Valley, Arizona. The Site Plan in the Appendix shows the location of the site.

We obtained information on site soil conditions, performed field and laboratory testing, and geotechnical engineering analyses. This report presents our conclusions and recommendations regarding the engineering properties of the soils encountered and their relationship to the proposed development. Specifically, the report addresses the following information:

- General site and subsurface conditions encountered during our evaluation.
- Recommendations and design criteria for foundation systems, including allowable bearing capacity, lateral earth pressures and estimated settlements.
- Recommendations for support of interior concrete slabs-on-grade
- Recommendations for grading requirements, including site and building area preparation, fill placement, and suitability of existing soils for fill.

The Appendix contains the results of the field explorations and tests and provides a site plan showing the exploration locations.

Project Information

We understand that you will be constructing a new 43 lot subdivision. The subdivision will be divided into single-family residential structures. We assume that the houses will be one- or two-story wood-frame structures with slab-on-grade floors. We expect foundations will be post-tensioned slab/foundation systems. We are also assuming that the structural loads for continuous wall footings and column footings will be about 2 kips per linear foot and 20 kips, respectively.

Evaluation and Testing

To obtain information on the conditions at this site and to determine applicable soil properties, we completed an on-site evaluation. The extent of our evaluation and testing programs is described in the following section.

Field Evaluation

We reviewed the site to obtain information on the general surface conditions. On July 22, 2020, we also observed the excavation of 8 trench pits to approximate depths of about 10 feet below existing site grade. The site plan shows the approximate exploration location. The Appendix contains logs of the subsurface conditions encountered at the explorations.

During the field exploration, the subsurface conditions were described, and the encountered soils were sampled, visually classified and logged. We used the Unified Soil Classification System to classify soils. The soil classification symbols appear on the exploration logs and are briefly described in the Appendix.

Laboratory Evaluation

We performed laboratory analyses on soil samples to aid in material classification and estimate pertinent engineering properties of the on-site soils. We performed the tests in general accordance with applicable ASTM standards. The Appendix contains our laboratory test results.

FINDINGS

Site Conditions

At the time of our exploration, the site was undeveloped native property and supported a growth of native vegetation including cacti, cholla, desert brush, barrel cactus, mesquite and palo verde trees. The terrain is flat to rolling with surface drainage to the south in the form of sheet flow and a wash.

Subsurface Conditions

The soils encountered in our explorations were generally silty sands with varying amounts of gravel and cobbles. Soil moisture contents were relatively low at the time of our field evaluation and no free groundwater was encountered in any of the trenches. The logs in the Appendix show details of the subsurface conditions encountered during the field evaluation.

Conclusions

In our opinion, the site's *natural* subsurface soil and conditions are suitable for support of the proposed development provided the designers, contractors, and owners follow the report recommendations. Our conclusions regarding the soils and planned development are given in the

following discussion. The chloride, sulfate and the laboratory R-value test results for the pavement design were not yet completed. We will provide a revised report once we get those results.

Compressive Properties

Based on our experience with similar soils within this vicinity the on-site soils near shallow foundation level should exhibit low compressibility at existing and increased moisture contents under the loads expected for the construction. We expect that total settlement of the proposed structures, supported as recommended, will be less than 1 inch. Differential settlement should be approximately half of the total settlement provided there is positive drainage and typical local climatic conditions prevail.

Most settlement is expected to occur soon after construction, although additional foundation movements could occur if water from any source infiltrates the underlying soils. Severe overwatering, ponding water, and significant or prolonged leaks that wet soils below several feet can result in adverse differential settlement.

The potential differential movement is a function of the depth and lateral extent of wetting of the supporting soils. It is extremely important, therefore, that precautions be taken in design, construction preparations, and maintenance to *minimize* the potential for moisture increases (from any source) beneath the structures. We suggest that all underground piping within or near the structures be designed with flexible couplings so minor deviations in alignment do not cause damage. Any utility knockouts should be oversized to accommodate differential movements.

Expansive Properties

The existing soils have a relatively low expansive potential. Special preparations or construction details related to swelling pressure or heave are considered unnecessary. The earthwork must be carefully monitored by experienced personnel supervised by a Geotechnical Engineer. The contractor should notify the Geotechnical Engineer if the soil conditions vary significantly from those shown in this report or if there are any questions regarding the type of soil or its condition.

RECOMMENDATIONS

General

All structural elements will experience at least some differential movement and the various components must accommodate this potential. We recommend that you have the Architect, the Structural Engineer, Civil Engineer, Landscape Architect, and all other design team members and contractors read this report and consider our comments. The basis for our comments on foundation and slab design details is primarily our experiences with recurring problems associated with many of these items.

We do not intend to provide recommendations that prevent all undesirable effects resulting from structural movements. We intend to provide reasonable solutions to help control effects the soil may have on the structures.

Post-Tensioned Foundations

A post-tensioned slab foundation system may be used for support of the planned structure. The floor areas of the post-tensioned systems should, however, be supported by at least 4 inches of base course. These structural systems must be designed by a Structural Engineer, who should specify the concrete strength, concrete strength required for post tensioning, required thickness of elements, post-tensioning force, and expected post tensioning cable elongation; we are providing the following parameters needed for the commonly used design methods, especially the Post-Tensioning Institute's methodology (PTI).

According to PTI III methodology, this site would classify as a “stable” soil type. This is defined as having soils not exceeding a plasticity index of 14 and having an expansion potential percent of less than 2.

- Allowable Bearing Capacity: 1000 psf at grade, provided the supporting soils are protected from possible erosion and compacted as recommended
  1600 psf at a depth of 1.0 foot below lowest adjacent grade
  2000 psf at a depth of 1.5 feet below lowest adjacent grade

- Modulus of Subgrade Reaction: 200 pci

- Coefficient of Friction: 1.0 (Coefficient of 0.75 may be used with vapor retarder)

As previously stated, the potential differential movement is a function of the depth and lateral extent of wetting of the supporting soils. It is extremely important, therefore, that precautions be taken in design, construction preparations, and maintenance to *minimize* the potential for moisture increases (from any source) beneath the structures. The above estimates reflect the conditions reasonably expected based on positive drainage and typical local climatic conditions. Significant wetting of the soils below the supporting soil and beyond the above edge moisture distances could result in additional differential vertical movements and superstructure distortions.

Certain designs sometimes incorporate isolated spread foundations. The bearing capacities presented above, for the indicated depths of embedment, may be used for design. A one-third increase in the bearing pressure is allowable for transient wind or seismic loads. The bearing values given are net bearing values so the weight of the concrete in the footings may be ignored. The Structural Engineer should specify the concrete strength, concrete strength required for post-tensioning, required thickness of elements, post-tensioning force, and expected post-tensioning cable elongation.

Foundations adjacent to descending slopes with inclinations less than 1 to 1 should be setback at least 3 feet, horizontally, from the top of the slope. Additionally, an imaginary line extending downward at 45 degrees from a foundation edge should not intersect the slope face.

Although post-tensioning the foundation and slabs will help close some minor cracks that form during hydration, it is still beneficial to properly cure the concrete. The proper curing of concrete, especially for flatwork (slabs), is extremely important in minimizing plastic shrinkage cracks and slab curling. We believe that many slab cracking problems can be mitigated or possibly eliminated by proper curing. We strongly suggest moist-curing slabs for at least a week after placement. Curing promotes more complete hydration of the cement and reduces plastic drying shrinkage, especially near the exposed upper portion of the slab. Alternatively, moist-curing for several days and then applying a liquid membrane curing compound would also be beneficial. Also important are the mix design and quality control during construction.

All concrete placement and curing operations should follow recommendations of the American Concrete Institute manual. Improper curing and excessive slump (water-cement ratio) could cause excessive shrinkage, cracking, or curling of the concrete. Concrete slabs should be allowed to cure adequately before placing vinyl or other moisture-sensitive floor covering. To prevent incomplete

bonding, distortion, and water vapor entrapment, flooring should not be placed until the moisture content of the slab is at or below the manufacturer's requirements.

Important Comments Regarding Post-Tensioned Systems

On the basis of our experience, it appears that many people have a misunderstanding of the performance of post-tensioned systems and the need for ground preparations. The use of a post-tensioned supporting system ***does not*** preclude the need for appropriate ground preparation. If soils capable of volume change underlie any shallow system, there is still the possibility of differential slab/foundation movement and damage. A post-tensioned system can merely lessen the effects of differential movement, especially to the superstructure that it supports. It does this primarily by redistributing stresses because of its higher internal strength (as compared to a conventional unreinforced slab and separate foundations). One cannot expect to design a single, specific post-tensioned system for ***any*** soil and loading situation and have it perform adequately under all conditions. The design should be specific to the site soils and structural loading and good construction practices should be followed.

The need for appropriate soil preparation is not diminished by using a post-tensioned system. In fact, prior to actually tensioning the cables, the system is an *unreinforced* monolithic slab/foundation, deriving all of its support directly from the soil during its critical hydration period. Subgrade preparation, subbase fill construction, base course provisions and compaction, and utility backfill compaction are all important aspects of the construction and should be done in accordance with the geotechnical report and plans.

It is also important to avoid overstressing the planned post-tensioned system (by stacking supplies or by premature construction of the superstructure) prior to gaining appropriate concrete strength and stressing the cables. These service-load-induced stresses can also adversely affect the performance of the system.

To help determine suitable phasing and types of construction activities, we should meet together with you, the structural engineer, and the appropriate subcontractors. Our intention is to help you secure a product that performs as expected.

Seismicity

For structural designs based upon the International Building Code 2018, the soil site class is D. For this location the mapped spectral acceleration of a short period Ss is 0.271g, and for a 1-second period S_1 is 0.077g. The resulting site coefficients Fa and Fv from the IBC Tables 1613.5.3 (1,2) are 1.583 and 2.4, respectively.

Lateral Earth Pressures

For cantilevered or restrained (at-rest case) walls above any free water surface with level backfill and no surcharge loads, the recommended equivalent fluid pressures and coefficients of base friction are presented in the following table.

EARTH PRESSURE STATE	EQUIVALENT FLUID PRESSURE, psf/ft
Active	
Undisturbed Native Soil	32
Granular Backfill	30
Passive	
Undisturbed Native Soil	400
Granular Backfill	450
At-rest (restrained)	
Undisturbed Native Soil	52
Granular Backfill	50
Coefficient of Base Friction = 0.45*	

* For short retaining walls with minimal cover on the outside face, the coefficient of base friction should be reduced to 0.35 when used in conjunction with passive pressure.

We do not expect submerged soil conditions; the lateral earth pressures shown therefore do not include this condition. We should be consulted for additional recommendations if submerged conditions are to be included in the design. Any surcharge from adjacent loading will also increase the lateral pressure and must be added to the above earth pressures.

The contractor should use granular, relatively free-draining soil for retaining wall backfill to reduce the potential for hydrostatic pressure buildup. Retaining walls should be designed with a backdrain that either drains to lower ground or to a sump with a float-activated pump. The level of this drain should be lower than the lowest retained earth behind the wall; the perforations in the drain pipe should be at least 8 inches lower than the top of any interior slabs in front of the wall.

Moderate to high plasticity clay soils should not be used as backfill against retaining structures. Properly place and compact all backfill as recommended in this report. Cobbles, if present, should be removed from the soils placed adjacent to walls so high-intensity point loads do not occur. Avoid nesting of larger particles because voids could form and cause subsidence of the backfill.

Waterproof the exterior face of below-grade walls that are exposed to interior spaces to retard moisture penetration. It is important that all backfill be properly placed and compacted. Mechanically compact all backfill in layers. Water settling or flooding is not acceptable. Care should be taken to avoid damaging the walls when placing the backfill. Backfill should be inspected and tested during placement and compaction, especially if there will be overlying elements supported by the backfill such as foundations, stairs, walls, and planters.

Exterior Features

Exterior slabs-on-grade, exterior architectural features, and utilities may experience some movement due to the volume change of the underlying soils. The potential for movement and resulting distress could be reduced by the following measures:

- Minimizing moisture increases in the soil
- Moisture-density control during placement of soil
- Use of designs which allow vertical movement between the exterior features and adjoining strutural elements
- Placement of effective control joints on relatively close centers
- Allowance for vertical movements in utility connections

Temporary Construction Excavations

Temporary unsurcharged construction excavations should be sloped or shored. Slopes should not be steeper than 1 to 1 (horizontal to vertical) in the natural soil. Slopes may need to be flattened depending on conditions exposed during construction. If there is not enough space for sloped excavations, shoring should be used.

Various shoring systems are possible; their selection and design, however, is beyond the scope of our current evaluation. The design of a retaining system is dependent on the construction method, the sequence of operations, and adjacent construction. The contractor's and designer's responsibilities for design and construction should be clearly defined. Exposed slopes should be kept

moist (but not saturated) during construction. Traffic and surcharge loads should be at least 10 feet from the top of the excavation. All excavations should be completed in accordance with the most recent OSHA requirements.

Slopes and Soil Erodibility

To provide slope stability against mass failure, we recommend that cut and fill slopes less than 7 feet in height have maximum gradients of 1 to 1 (horizontal to vertical). Fill embankments must be properly compacted and, when occurring on natural slopes with inclinations equal to or greater than 5 to 1, constructed on reasonably level cut benches. We recommend that fill slopes be compacted and then cut back or shaped so that proper compaction is obtained. It may not be necessary to overbuild and cut back slopes if the contractor demonstrates that the techniques used result in a properly compacted and prepared slope face. These allowable slope gradients assume proper protection against erosion.

Exposed slopes should be covered as quickly as possible with vegetative or other ground covers such as mulch, jute netting, crushed rock, or rip-rap to avoid unnecessary soil losses. Slopes should be scraped or raked across the slopes (perpendicular to flow), unless they are trackwalked, to aid in providing greater infiltration rates of surface water. If the slopes are shaped by trackwalking, with tracked vehicles, they should be worked up and down as the tread imprints will create grooves parallel to the slope which will aid infiltration rates and trap seeds.

During construction, graded, unprotected areas should retain as much natural vegetation as possible. Vegetation along the perimeters of graded areas should be left intact to control erosion and serve as a sediment trap. Exposed soil areas should be sprinkled with water during construction to reduce transportation of soil by wind. If rains are anticipated during construction, flows over the disturbed areas can be minimized by diverting upslope surface water through use of berms or ditches. Outfall areas associated with detention areas, diversion features, or collection facilities should be provided with energy dissipators such as riprap aprons to reduce surface water velocity.

The following table shows the recommended slope protection for various slope gradients with vertical slope heights of less than 7 feet.

Slope Gradient (horizontal to vertical)	Slope Protection
3:1 or flatter	Revegetate with native species or provide other ground covers such as netting or crushed rock
steeper than 3:1 to 2:1	Rip-rap with filter cloth or cover with mulch, jute, or excelsior netting and then revegetate with native species or provide other ground covers
steeper than 2:1 to 1:1	Grouted or wire-tied rip-rap, asphalt emulsion, or concrete revetments
steeper than 1:1	Stability analysis or retaining wall designed by a structural engineer

Often, unprotected cut and fill slopes are desired for portions of the project. Given the same slope gradients and slope lengths, unprotected slopes can result in about 10 times more soil loss than protected slopes. However, slope gradients and slope lengths are the most critical aspects controlling soil loss since they directly influence the velocity of runoff. If unprotected slopes are used, we suggest they be 5 to 1 (horizontal to vertical) or flatter and at least protected from concentrated upslope drainage. Continuous slope lengths should also be kept relatively short, preferably less than 15 feet. Slope lengths can be reduced by providing frequent intercepting benches or terraces. Areas beneath unprotected slopes may require sediment retention structures to trap eroded soil before it is deposited on undesirable areas. Unprotected slopes should eventually become vegetated and an erosion pavement, resulting from the erosion process, is likely to form across the surface.

Erosional activity, if allowed to form and propagate, will increase soil loss and could cause loss of support to structures, streets and other facilities. Periodic maintenance and prompt repair of erosional features is important to prevent unnecessary soil losses. The effectiveness of erosion control measures should be evaluated subsequent to heavy or prolonged rains. We also recommend an erosional maintenance program be established and implemented.

Surface Drainage

A major cause of soil-related damage to structures in this region is moisture increases in the supporting soil. It is therefore extremely important to provide positive drainage away from the structures, both during construction and throughout their lifes. Infiltration of water into utility or foundation excavations must be prevented.

Waterlines and sewerlines should be carefully tested and inspected for leaks prior to backfilling. Planters and other surface features that could retain water in areas adjacent to the structure should be eliminated or constructed so that accumulated water is discharged onto a positive gradient at least 5 feet from the structures. Roof rainwater, water from cooling unit condensation, and water heater drains should also be discharged onto a positive gradient at least 5 feet from the structure. Trees should not be planted closer to houses than their expected canopy radius at maturity.

In areas where sidewalks or paving do not immediately adjoin the structure, protective slopes should be provided with an outfall of at least 3 percent for at least 5 feet from perimeter walls. Backfill against footings, exterior stemwalls, and in utility and sprinkler line trenches should be well compacted and free of all construction debris to minimize the possibility of moisture infiltration.

Some drainage facilities, such as rock-lined drainage swales, often degrade over time and become inefficient or ineffective. The potential harmful effects of water infiltrating the supporting soils beneath the structures must be made clear to the owners.

Construction Review

The Geotechnical Engineer or his representative ***must*** observe the site preparations and foundation bearing conditions. The purpose of this observations would be to determine if the soils and conditions are similar to those expected for support of the footings. Subgrade preparation and engineered fill construction supporting structural elements is considered *Special Inspection* and must be completed under the *continuous* observation of the Geotechnical Engineer. Any soft, loose or unacceptable soils should be properly compacted and may require supplemental recommendations.

We recommend surveying the finished floor elevation of all slabs-on-grade and maintaining this record. In the event of future movement, this information could be extremely helpful in assessing the conditions and providing remedial measures.

EARTHWORK

General

Our recommendations for foundation and slabs supported on compacted fills or prepared subgrade depend on compliance with the recommendations presented in this section. Observation and testing of earthwork, supervised or performed by a geotechnical engineer, is necessary to assess compliance with these recommendations.

Site Clearing

Strip and remove any existing vegetation, debris, loose or wet soil and other deleterious materials from the building areas and at least 5 feet beyond. Over-excavated areas resulting from removal of unsuitable materials should be backfilled as recommended in this report. All exposed surfaces should be free of mounds and depressions that could prevent uniform compaction.

Excavation

Shallow excavations in the soils we encountered during our evaluation should be possible with conventional equipment. The speed and ease of excavations will depend on the type of grading equipment, the skill of the operators and the structure of the deposit. If more information regarding excavation is desired, we suggest a study using equipment similar to that expected for the actual construction. The information contained in this report is intended for design and preliminary estimating purposes. Contractors reviewing the report must draw their own conclusions regarding the types of equipment and methods required to complete the construction.

Foundation Preparation

Specialized treatment of the existing undisturbed natural soils in foundation areas should be unnecessary. However, proper precautions should be taken to ensure that the foundation excavation bottoms are in undisturbed natural soils and not in disturbed, or loose soil. All disturbed, or loose soil should be removed and foundation excavations must be reviewed by the Geotechnical Engineer or his representative prior to placing reinforcing steel and concrete to determine if the soils and conditions are as expected.

The contractor should construct all subbase fill in a manner resulting in uniform water contents and densities after compaction. All subgrade and subbase fill should be constructed according to the report requirements.

Site preparations must be reviewed by the Geotechnical Engineer or his representative to determine if the soil conditions are as expected. The contractor should notify the Geotechnical Engineer if the conditions vary significantly from those shown in this report or if there are any questions regarding the type of soil or its condition.

Post-Tensioned Foundation System Pad Preparation

The contractor should scarify, moisten or dry as required, and recompact the exposed subgrade soil to a depth of at least 12 inches. Place and compact at least four inches of base course beneath post-tensioned slabs to provide more uniform support and help prevent a damp slab.

The contractor must prepare the subgrade and construct any subbase or engineered fill in a manner resulting in *uniform* water contents and densities after compaction. Place and compact at least four inches of base course beneath interior slabs to provide more uniform support and help prevent a damp slab. The contractor should notify the Geotechnical Engineer if the soil conditions vary significantly from those shown in this report or if there are any questions regarding the type of soil or its condition.

The Geotechnical Engineer or his representative *must* observe the site preparations and foundation excavations. The purpose of this review would be to determine if the soils and conditions are similar to those expected for support of the footings. Any soft, loose or unacceptable soils should be properly compacted and may require additional undercutting.

Vapor Retarder Considerations

If moisture-sensitive floor coverings are used, an impermeable vapor retarder should be considered beneath the floor sections. If used, the vapor retarder should be at least 12-mil polyethylene and placed beneath the underside of the slab as recommended by ACI. Because this positioning doesn’t allow water from placed concrete to bleed from the bottom, we suggest using a low water-cement ratio, appropriate jointing, and good curing techniques to help avoid slab curling issues. Slab curling is a common occurrence in our area because of the often dry, hot, and windy conditions. These conditions, especially if bottom drainage can’t occur, create differential drying from the top and thus the upper part of the slab concrete shrinks at a faster rate.

Utility Trench Backfill

Utility trenches within and beyond the building pad should be made as narrow as possible to reduce the potential for settlement of overlying slabs and other structures. The practice of digging wide trenches for the convenience of plumbers and electricians should be avoided, unless such trenches are carefully backfilled in lifts compacted to 95 percent of Standard Proctor Maximum Dry Density according to ASTM D-698.

Materials

Imported soils and existing granular soils with *low* expansive potentials and all particles passing the 6-inch sieve may be used as fill material for the following areas:

- Foundation areas
- Interior slab areas
- Backfill

Imported soils should conform to the following requirements:

IMPORT SOIL PROPERTIES	
SIEVE SIZE	**PERCENT PASSING, by dry weight**
6"	**100**
No. 4	**50-100**
No. 200	**40 max.**
Maximum Expansive Potential = 1.5%*	
Maximum Soluble Sulfates = 0.10%	

* Measured on a sample compacted to approximately 95 percent of the ASTM D698 maximum dry density at about three percent below optimum water content. The sample is confined under a 100 psf surcharge and submerged.

Aggregate base course below concrete floor slabs should conform to the following requirements:

AGGREGATE BASE COURSE	
SIEVE SIZE	**PERCENT PASSING, by dry weight**
1"	**100**
3/4"	**90 to 100**
1/4"	**45 to 75**
No. 200	**0 to 10**
Plasticity Index = 5 max.	

Placement and Compaction

The contractor should place and compact fill in horizontal lifts, 8 to 10 inches in loose thickness, using equipment and procedures that will produce the recommended moisture contents and densities throughout the lift. When lighter hand-held compaction equipment is used, the loose lift thickness should be 4 to 6 inches.

Materials should be compacted to the following standards. Depending on the actual soils and compaction equipment, compaction moisture contents may need to be changed to avoid or limit soil yielding or pumping.

Imported soils and on-site and with low expansion potential should be compacted within a water content range of 3 percent below to 3 percent above optimum.

Soil Type and Area	Minimum Percent Compaction, ASTM D-698
On-site subgrade soils, on-site soils as subbase fill, and imported soils*	
Below foundations	**95**
Below slabs-on-grade	**95**
Base Course below slabs	**95**
Nonstructural backfill, ***not providing lateral or vertical support of structural elements***	**90**

* Fill 5 feet or more below finished grade should be compacted to at least 100 percent of ASTM D-698.

CLOSURE

Additional Services

Field observation and testing during construction, and reviewing the plans and specifications are integral factors in developing and implementing our conclusions and recommendations. Our involvement during construction is important to observe compliance with the design concepts, specifications, or recommendations, and to allow efficient design changes if the subsurface conditions differ from those anticipated. PATTISON ENGINEERING, L.L.C. offers these services and is the most qualified to determine consistency of field conditions with the data used in our analyses. It is the client's responsibility to make this report available, in its entirety, to all design team members, contractors, and owners.

Limitations

The services we performed for this project include professional opinions and judgments based on the data collected. We performed our professional services using the degree of care and skill ordinarily exercised, under similar circumstances, by reputable geotechnical engineers practicing in southern Arizona. We do not intend to provide recommendations that prevent all undesirable effects resulting from structural movements. We intend to provide reasonable solutions to help control effects the soil may have on the structures. We make no other warranty, expressed or implied.

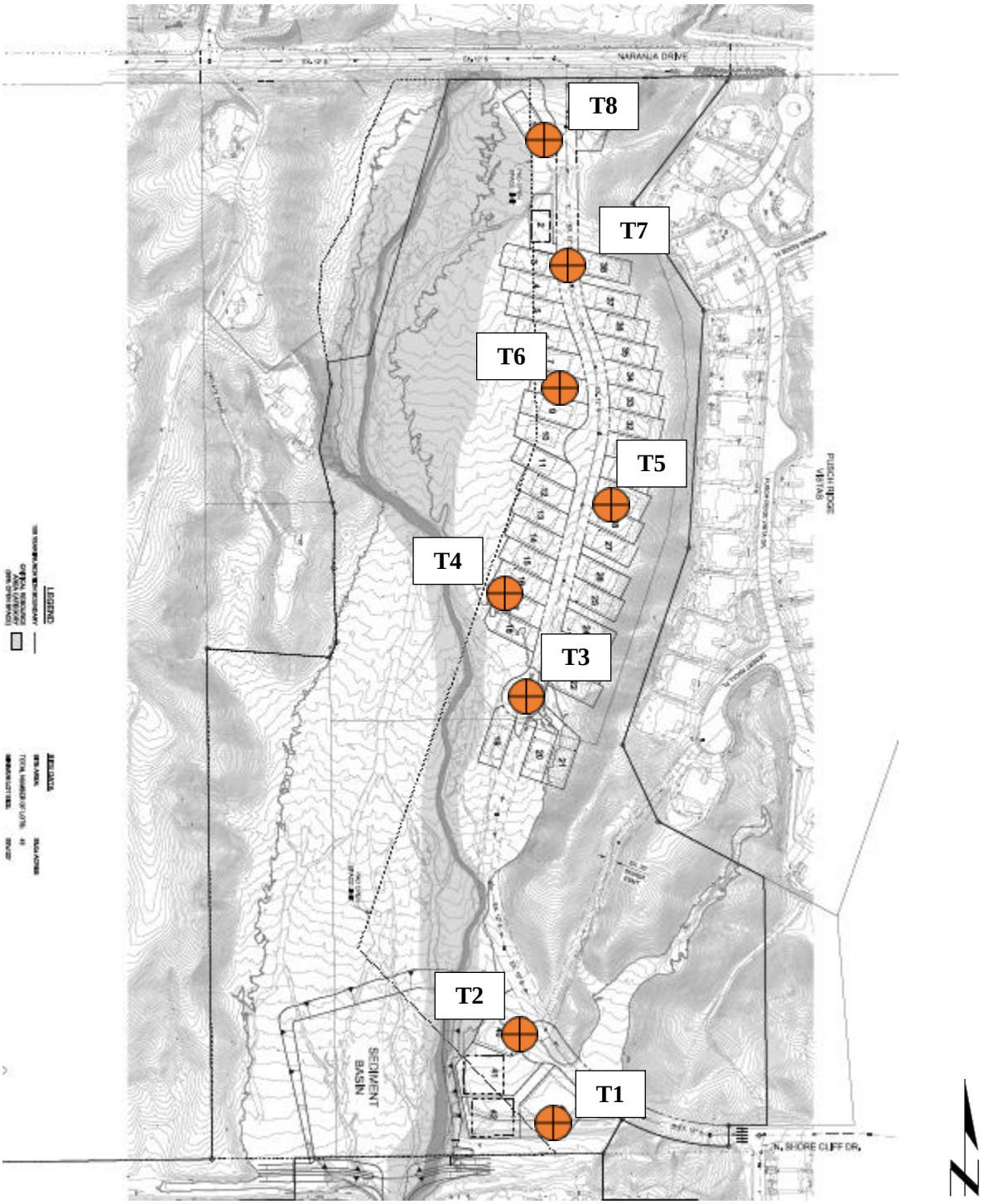
We prepared the report as an aid for the design of the project. This report is not a bidding document and any contractors reviewing it must draw their own conclusions regarding site conditions and specific construction techniques to be used on this project.

Our services did not include any environmental assessment or investigation for the presence or absence of hazardous or toxic materials in the soil, groundwater, or air, on or below or around, this site. All conditions documented or observed are strictly for the information of our client. If environmental information is required, we recommend that an environmental assessment be completed which addresses these concerns.

We based our recommendations on the assumption the soil and groundwater conditions across the site are similar to those encountered at the exploration locations. The extent and nature of subsurface soil and groundwater variations may not be evident until construction. If conditions encountered during construction appear to differ from those described in this report, we should be consulted to assess the impact and provide supplemental recommendations. Our evaluation and report does not include the effects, if any, of underlying geologic hazards or regional groundwater withdrawal and we express no opinion regarding their effects on surface movement.

APPENDIX

Site and Exploration Location Plan



KEY:

T# TRENCH LOCATION

Method of Soil Classification

Major Divisions	Subdivisions	USCS Symbol		Typical Names
Coarse-grained soils (More than 50% retained on No. 200 sieve)	Gravels (More than 50% of coarse fraction retained on No. 4 sieve)	GW	Less than 5% fines*	Well-graded gravels or gravel-sand mixtures, little or no fines
		GP	Less than 5% fines*	Poorly graded gravels or gravelly sands, little or no fines
		GM	More than 12% fines*	Silty gravels, gravel-sand-silt mixtures
		GC	More than 12% fines*	Clayey gravels, gravel-sand-clay mixtures
	Sands (50% or more of coarse fraction passes No. 4 sieve)	SW	Less than 5% fines*	Well-graded sands or gravelly sands, little or no fines
		SP	Less than 5% fines*	Poorly graded sands or gravelly sands, little or no fines
		SM	More than 12% fines*	Silty sands, sand-silt mixtures
		SC	More than 12% fines*	Clayey sands, sand-clay mixtures
Fine-grained soils (50% or more passes the No. 200 sieve)	Silts and Clays (Liquid limit less than 50)	ML	Inorganic soil	Inorganic silts, rock flour, silts of low plasticity
		CL	Inorganic soil	Inorganic clays of low plasticity, gravelly clays, sandy clays, etc.
		OL	Organic soil	Organic silts and organic clays of low plasticity
	Silts and Clays (Liquid limit 50 or more)	MH	Inorganic soil	Inorganic silts, micaceous silts, silts of high plasticity
		CH	Inorganic soil	Inorganic highly plastic clays, fat clays, silty clays, etc.
		OH	Organic soil	Organic silts and organic clays of high plasticity
Peat	Highly Organic	PT		Peat and other highly organic soils

- *Fines* are those soil particles that pass the No. 200 sieve. For gravels and sands with between 5 and 12% fines, use of dual symbols is required (i.e., GW-GM, GW-GC, GP-GM, or GP-GC).

CLASSIFICATION	U.S. Standard Sieve Size
BOULDERS	Above 12”
COBBLES	12” to 3”
GRAVEL	3” to No. 4
Coarse	3” to 3/4”
Fine	3/4” to No. 4
SAND	No. 4 to No. 200
Coarse	No. 4 to No. 10
Medium	No. 10 to No. 40
Fine	No. 40 – No. 200
SILT & CLAY	Below No. 200

Coarse Grained Scale
(50% retained on #200 sieve)

ADJECTIVE	%
trace	0-10
some	10-20
with	20-30
“-y” or “-ey”	30-50

P = poorly graded
W = well graded

P.I.	ADJECTIVE
< 1	non-plastic
1-7	low plasticity
8-25	medium plasticity
> 25	high plasticity

Trench Log Notes

The number shown in **Trench No.** refers to the approximate location of the same number shown on the **Site Plan** as positioned in the field by pacing from property lines and/or existing features.

USCS Code refers to the soil type as defined by the **Unified Soil Classification System.** The soils were visually classified in the field and, where appropriate, classifications were modified by visual examination of samples in the laboratory and by appropriate test.

These notes and boring logs are intended for use in conjunction with the purposes of our services defined in the text. Boring log data should not be construed as part of the construction plans or as defining construction conditions.

Boring logs depict our interpretations of subsurface conditions at the locations and on the date(s) shown. Variations in subsurface conditions and soil characteristics may occur between borings. Groundwater levels may fluctuate due to seasonal variations and other factors.

In general, terms and symbols on the boring logs conform with **"Standard Definitions of Terms and Symbols Relating to Soil and Rock Mechanics"** (ASTM D653).

Laboratory Test Results

TRENCH NO.	DEPTH (FT)	PLASTICITY		% PASSING #200 SIEVE	SOIL CLASSIFICATION
		LL	PI		
T-1	0-5	25	4	8.6	SP-SC
T-2	0-5	17	3	15.5	SM
T-3	0-5	--	NP	5.0	SP-SM
T-5	0-5	18	2	19.1	SM
T-7	0-5	--	NP	10.5	SP-SM
T-8	0-5	--	NP	9.7	SP-SM

EXPANSION PROPERTIES						
TRENCH NO.	DEPTH (FT)	SOIL CLASS	COMPACTED DRY DENSITY (PCF)	MOISTURE CONTENT (%)	SURCHARGE (KSF)	EXPANSION (%)
B-1	0-5	SP-SC	114.0	9.6	0.1	0.04

Notes: Percent expansion measured on a soil sample compacted to approximately 95% of the ASTM D698 at about 3% below optimum moisture content. The sample was confined under a 100-psf surcharge and saturated.

Trench Logs

Project Number 20-098

PATTISON ENGINEERING, LLC

Geotechnical Engineering
Construction Inspection
Materials Testing

TRENCH NUMBER
T-1
SHEET 1 OF 1

Client: Meritage Homes

Project: Naranja Trails, Lots 1-43
Location: Naranja Drive

Location of Boring:
SEE SITE PLAN

Elevation: Datum:
Logged By: IM Date: 7/22/20
Subsurface Conditions or Remarks:

SAMPLE TYPE	BLOWS PER 6"	INCHES DRIVEN/ INCHES RECOV'D	BULLNOSE BLOWS/FT	DEPTH (FEET)	USCS CODE	DESCRIPTION OF SUBSURFACE CONDITIONS	DRY DENSITY (PCF)	MOISTURE (%)
H				0	SP-SC	SAND with clay and gravel, brown, slightly damp, low plasticity		
						cobbles		
				5				
				10		BOTTOM OF TRENCH AT 10 FEET *No Free Water Encountered*		
				15				
				20				
				25				
				30				

Sample Type Key:
SS = Split Spoon
RS = Ring Sample
H = Hand Sample

Excavation Equipment:
Caterpillar 420D

Project Number 20-098

PATTISON ENGINEERING, LLC

Geotechnical Engineering
Construction Inspection
Materials Testing

TRENCH NUMBER
T-2
SHEET 1 OF 1

Client: Meritage Homes

Project: Naranja Trails, Lots 1-43
Location: Naranja Drive

Location of Boring:
SEE SITE PLAN

Elevation: Datum:
Logged By: IM Date: 7/22/20
Subsurface Conditions or Remarks:

SAMPLE TYPE	BLOWS PER 6"	INCHES DRIVEN/ INCHES RECOV'D	BULLNOSE BLOWS/FT	DEPTH (FEET)	USCS CODE	DESCRIPTION OF SUBSURFACE CONDITIONS	DRY DENSITY (PCF)	MOISTURE (%)
H				0	SM	SILTY SAND with gravel, brown, slightly damp, low plasticity		
				5				
				10		BOTTOM OF TRENCH AT 10 FEET *No Free Water Encountered*		
				15				
				20				
				25				
				30				

Sample Type Key:
SS = Split Spoon
RS = Ring Sample
H = Hand Sample

Excavation Equipment:
Caterpilalr 420D

Project Number 20-098

PATTISON ENGINEERING, LLC

Geotechnical Engineering
Construction Inspection
Materials Testing

TRENCH NUMBER
T-3
SHEET 1 OF 1

Client: Meritage Homes

Project: Naranja Trails, Lots 1-43
Location: Naranja Drive

Location of Boring:
SEE SITE PLAN

Elevation: Datum:
Logged By: IM Date: 7/22/20
Subsurface Conditions or Remarks:

SAMPLE TYPE	BLOWS PER 6"	INCHES DRIVEN/ INCHES RECOV'D	BULLNOSE BLOWS/FT	DEPTH (FEET)	USCS CODE	DESCRIPTION OF SUBSURFACE CONDITIONS	DRY DENSITY (PCF)	MOISTURE (%)
H				0	SP-SM	SAND with silt and gravel, brown, slightly damp, non-plastic		
				5		cobbles		
				10		BOTTOM OF TRENCH AT 10 FEET *No Free Water Encountered*		
				15				
				20				
				25				
				30				

Sample Type Key:
SS = Split Spoon
RS = Ring Sample
H = Hand Sample

Excavation Equipment:
Caterpillar 420D

Project Number 20-098

PATTISON ENGINEERING, LLC

Geotechnical Engineering
Construction Inspection
Materials Testing

TRENCH NUMBER
T-4
SHEET 1 OF 1

Client: Meritage Homes

Project: Naranja Trails, Lots 1-43
Location: Naranja Drive

Location of Boring:
SEE SITE PLAN

Elevation: Datum:
Logged By: IM Date: 7/22/20
Subsurface Conditions or Remarks:

SAMPLE TYPE	BLOWS PER 6"	INCHES DRIVEN/ INCHES RECOV'D	BULLNOSE BLOWS/FT	DEPTH (FEET)	USCS CODE	DESCRIPTION OF SUBSURFACE CONDITIONS	DRY DENSITY (PCF)	MOISTURE (%)
				0	SM	SILTY SAND with gravel, brown, slightly damp, low plasticity		
				5		cobbles		
				10		BOTTOM OF TRENCH AT 10 FEET *No Free Water Encountered*		
				15				
				20				
				25				
				30				

Sample Type Key:
SS = Split Spoon
RS = Ring Sample
H = Hand Sample

Excavation Equipment:
Caterpillar 420D

Project Number 20-098

PATTISON ENGINEERING, LLC

Geotechnical Engineering
Construction Inspection
Materials Testing

TRENCH NUMBER
T-5
SHEET 1 OF 1

Client: Meritage Homes

Project: Naranja Trails, Lots 1-43
Location: Naranja Drive

Location of Boring:
SEE SITE PLAN

Elevation: Datum:
Logged By: IM Date: 7/22/20
Subsurface Conditions or Remarks:

SAMPLE TYPE	BLOWS PER 6"	INCHES DRIVEN/ INCHES RECOV'D	BULLNOSE BLOWS/FT	DEPTH (FEET)	USCS CODE	DESCRIPTION OF SUBSURFACE CONDITIONS	DRY DENSITY (PCF)	MOISTURE (%)
H				0	SM	SILTY SAND with gravel, brown, slightly damp, low plasticity		
				5		cobbles		
				10		BOTTOM OF TRENCH AT 10 FEET *No Free Water Encountered*		
				15				
				20				
				25				
				30				

Sample Type Key:
SS = Split Spoon
RS = Ring Sample
H = Hand Sample

Excavation Equipment:
Caterpillar 420D

Project Number 20-098

PATTISON ENGINEERING, LLC

Geotechnical Engineering
Construction Inspection
Materials Testing

TRENCH NUMBER
T-6
SHEET 1 OF 1

Client: Meritage Homes

Project: Naranja Trails, Lots 1-43
Location: Naranja Drive

Location of Boring:
SEE SITE PLAN

Elevation: Datum:
Logged By: IM Date: 7/22/20
Subsurface Conditions or Remarks:

SAMPLE TYPE	BLOWS PER 6"	INCHES DRIVEN/ INCHES RECOV'D	BULLNOSE BLOWS/FT	DEPTH (FEET)	USCS CODE	DESCRIPTION OF SUBSURFACE CONDITIONS	DRY DENSITY (PCF)	MOISTURE (%)
H				0	SP-SM	SAND with silt and gravel, brown, slightly damp, non-plastic		
				5		cobbles		
				10		BOTTOM OF TRENCH AT 10 FEET *No Free Water Encountered*		
				15				
				20				
				25				
				30				

Sample Type Key:
SS = Split Spoon
RS = Ring Sample
H = Hand Sample

Excavation Equipment:
Caterpillar 420D

Project Number 20-098

PATTISON ENGINEERING, LLC

Geotechnical Engineering
Construction Inspection
Materials Testing

TRENCH NUMBER
T-7
SHEET 1 OF 1

Client: Meritage Homes

Project: Naranja Trails, Lots 1-43
Location: Naranja Drive

Location of Boring:
SEE SITE PLAN

Elevation: Datum:
Logged By: IM Date: 7/22/20
Subsurface Conditions or Remarks:

SAMPLE TYPE	BLOWS PER 6"	INCHES DRIVEN/ INCHES RECOV'D	BULLNOSE BLOWS/FT	DEPTH (FEET)	USCS CODE	DESCRIPTION OF SUBSURFACE CONDITIONS	DRY DENSITY (PCF)	MOISTURE (%)
H				0	SP-SM	SAND with silt and gravel, brown, slightly damp, non-plastic		
				5		cobbles		
				10		BOTTOM OF TRENCH AT 10 FEET *No Free Water Encountered*		
				15				
				20				
				25				
				30				

Sample Type Key:
SS = Split Spoon
RS = Ring Sample
H = Hand Sample

Excavation Equipment:
Caterpillar 420D

Project Number 20-098

PATTISON ENGINEERING, LLC

Geotechnical Engineering
Construction Inspection
Materials Testing

TRENCH NUMBER
T-8
SHEET 1 OF 1

Client: Meritage Homes

Project: Naranja Trails, Lots 1-43
Location: Naranja Drive

Location of Boring:
SEE SITE PLAN

Elevation: Datum:
Logged By: IM Date: 7/22/20
Subsurface Conditions or Remarks:

SAMPLE TYPE	BLOWS PER 6"	INCHES DRIVEN/ INCHES RECOV'D	BULLNOSE BLOWS/FT	DEPTH (FEET)	USCS CODE	DESCRIPTION OF SUBSURFACE CONDITIONS	DRY DENSITY (PCF)	MOISTURE (%)
H				0	SP-SM	SAND with silt and gravel, brown, slightly damp, low plasticity		
				5		cobbles		
				10		BOTTOM OF TRENCH AT 10 FEET *No Free Water Encountered*		
				15				
				20				
				25				
				30				

Sample Type Key:
SS = Split Spoon
RS = Ring Sample
H = Hand Sample

Excavation Equipment:
Caterpillar 420D

Geotechnical Engineering - Construction Inspection -Materials Testing
Locally owned and operated since 1993
Pattison Engineering, LLC | Certified SBE/DBE

October 28, 2020
Project Number 20-098

Meritage Homes Construction, Inc.
5326 N. La Cholla Boulevard
Tucson, AZ 85741

RE: ENGINEERING SERVICES
Naranja Trails, Lots 1-43
Naranja Drive
Oro Valley, Arizona

Pattison Engineering prepared a geotechnical engineering evaluation report for this project (Pattison Engineering Project No. 20-098, dated July 24, 2020). We received the results of sulfate and chloride content testing for soil at this site from Turner Laboratories. The laboratory report is attached.

The testing indicated a non-detectable chloride and sulfate content. These results indicate soils with a low corrosion potential with respect to buried reinforced concrete. Commonly available Type I/II portland cement is acceptable for use in concrete at this project site.

All other recommendations provided in the original report remain valid and applicable. Please let us know if you have any questions or require additional information.

Respectfully submitted,
PATTISON ENGINEERING, L.L.C.
Geotechnical, Construction Inspection, and Materials Testing Services

Francisco J. Jacinto, P.E.
Managing Principal

Attachments: Turner Laboratories Report

Copies to: Addressee (1) E-mail

1129 N. Winstel Blvd. • Tucson, AZ 85716
Phone: 520.881.1234 • Fax: 520.881.4919

1129 N. Winstel Blvd. Tucson, Arizona 85716
520.881.1234 | F: 520.881.4919

Geotechnical Engineering - Construction Inspection -Materials Testing
Locally owned and operated since 1993
Pattison Engineering, LLC | Certified SBE/DBE

March 26, 2021

Meritage Homes
5326 N. La Cholla Boulevard
Tucson, AZ 85741

ENGINEERING SERVICES
Naranja Trails, Lots 1-43
Naranja Drive
Oro Valley, Arizona

Project No. 20-098
Supplement No. 1

This report presents the results of the laboratory testing of soil samples obtained from the sediment basin located at the southwest corner of the development. The purpose of these services is to provide information and recommendations regarding the suitability of that soil to be used as import fill material. In addition, we will provide ground compaction shrinkage factors and recommendations for an emergency fire truck access.

On March 23, 2021 five test pits were excavated to approximate depths of 12 feet below the existing site grade. At each test pit location, soils samples were obtained and visually examined and classified. Laboratory testing was performed on the soil samples to aid in material classification of the soils. The soil samples were tested for plasticity and gradation. Testing was performed in general accordance with applicable ASTM methods.

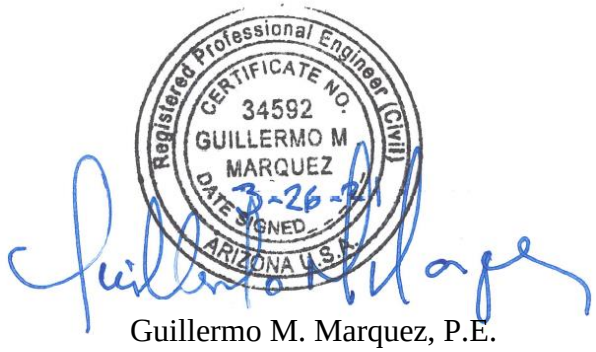
Based on the laboratory tests results, the soils may be used as fill material for foundation, slab, pavement, and backfill areas. These soils should be compacted within a water content range of 3 percent below to 3 percent above optimum. The recommendations are based on the assumption that the conditions of the tested soil sample are similar to the conditions of the soils throughout the sediment basin. If variations are noted during the use of these soils as fill material, Pattison Engineering, LLC should be contacted to reevaluate the recommendations.

We estimate a 5 to 10 percent shrinkage factor from the cutting and filling of native soils on-site. For standard subgrade compaction we expect ground compaction on the order of 1 to 1.5 inches per 12-inches depth of compacted soil.

An emergency access fire truck lane is expected to be constructed between the southern part of the development and the northern part. You may use a 1.5-inch thick layer of asphalt concrete over compacted existing soils for the emergency access lane. The existing soils should be compacted to at least 95% of maximum density as determined by ASTM D-698.

Our services were performed in accordance with generally accepted industry standards and practices by professionals providing similar services in this locality. No other warranty, express, or implied is made. We appreciate being of service to you in this phase of the project. Please contact us if you have any questions regarding this report.

Sincerely,
PATTISON ENGINEERING, L.L.C.
Geotechnical, Construction Inspection, and Materials Testing Services

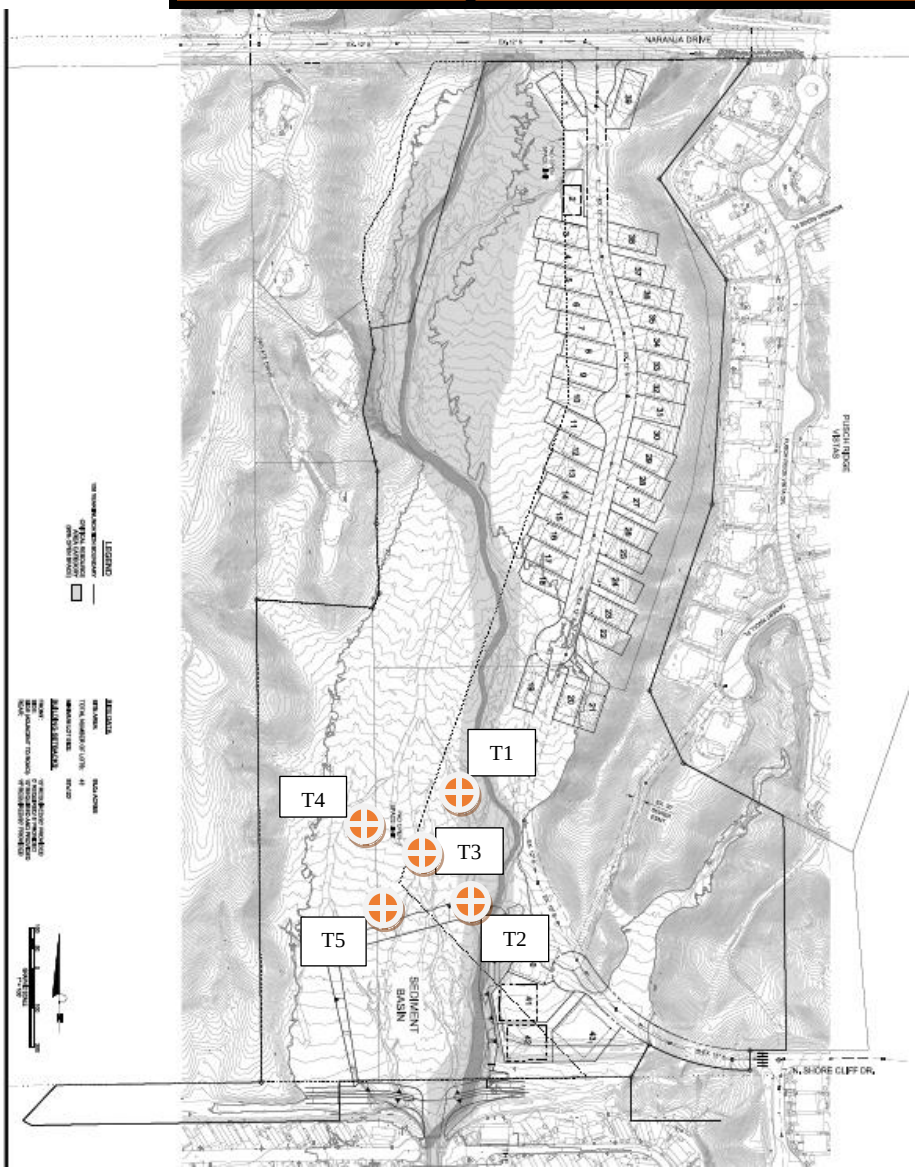


Francisco J. Jacinto, P.E.
Managing Principal

Guillermo M. Marquez, P.E.
Principal

Copies: Addressee (1) email

Site and Exploration Location Plan



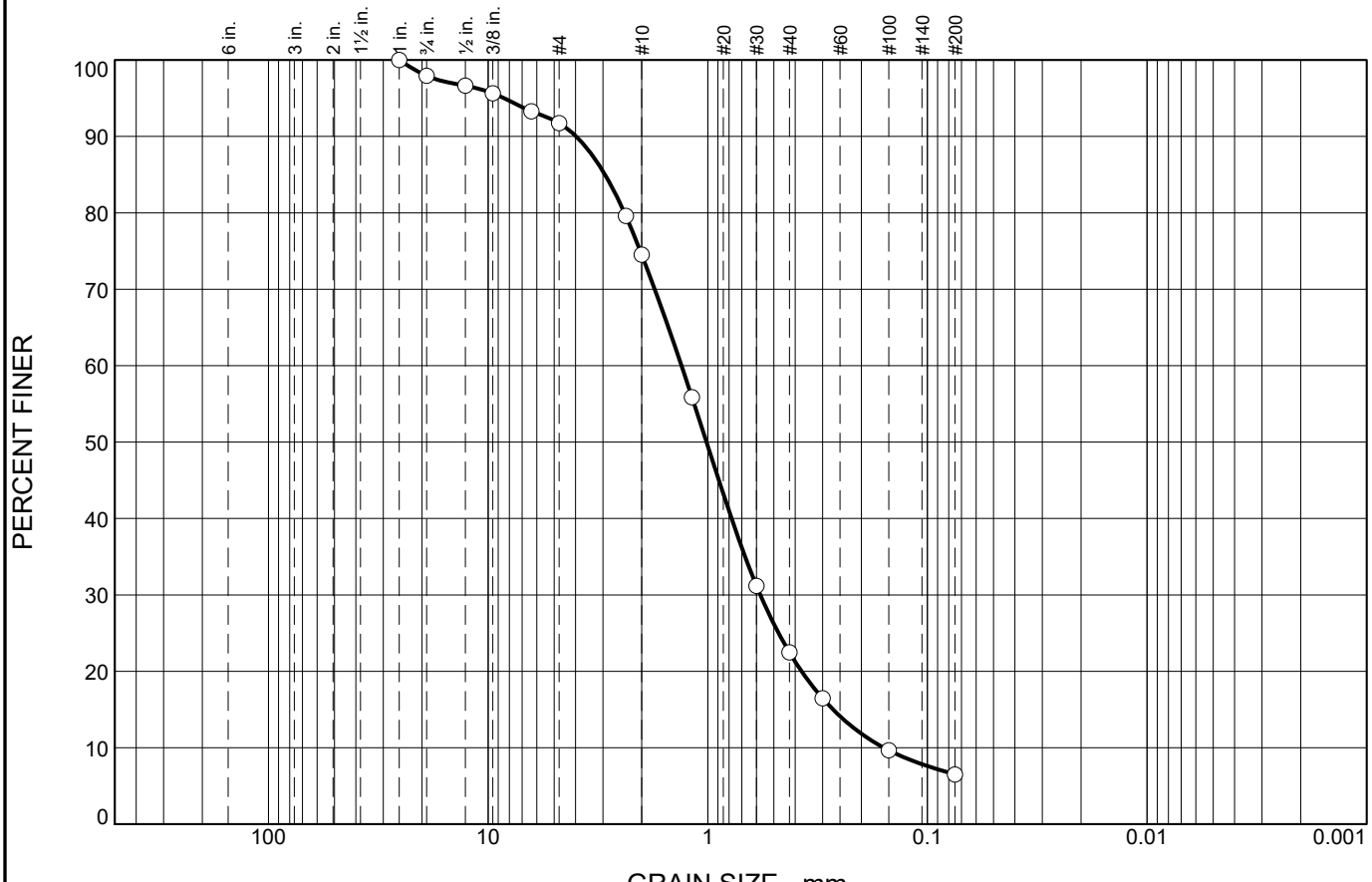
N

NOT TO SCALE

KEY: T# TRENCH LOCATION

Laboratory Test Results

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	2	6	17	53	15	7	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100		
.75"	98		
.5"	97		
.375	96		
.25	93		
#4	92		
#8	80		
#10	75		
#16	56		
#30	31		
#40	22		
#50	16		
#100	10		
#200	6.5		

* (no specification provided)

Material Description

SAND with silt and gravel, brown, slightly damp, non-plastic

Atterberg Limits

PL= LL= PI= NP

Classification

USCS= AASHTO=

Remarks

Source of Sample: T-1 **Depth:** 0

Date:

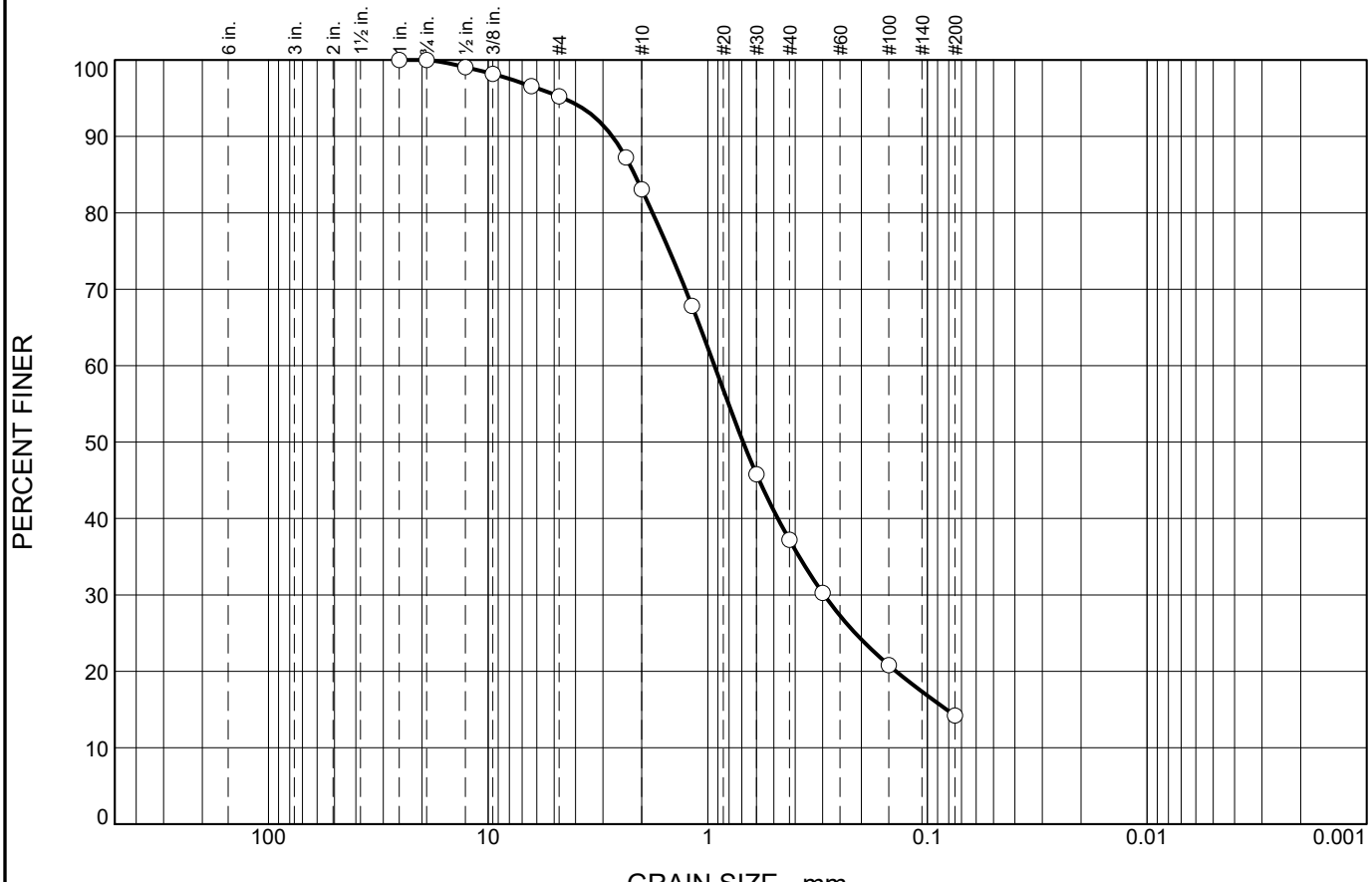
PATTISON ENGINEERING, LLC

Client: Meritage Homes

Project: Naranja Trails, Lots 1-43

Project No: 20-098 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	5	12	46	23	14	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100		
.75"	100		
.5"	99		
.375	98		
.25	97		
#4	95		
#8	87		
#10	83		
#16	68		
#30	46		
#40	37		
#50	30		
#100	21		
#200	14		

* (no specification provided)

Material Description

SAND with gravel, brown, slightly damp, non-plastic

Atterberg Limits

PL= LL= PI=

Classification

USCS= SP AASHTO=

Remarks

Source of Sample: T-2 **Depth:** 0

Date:

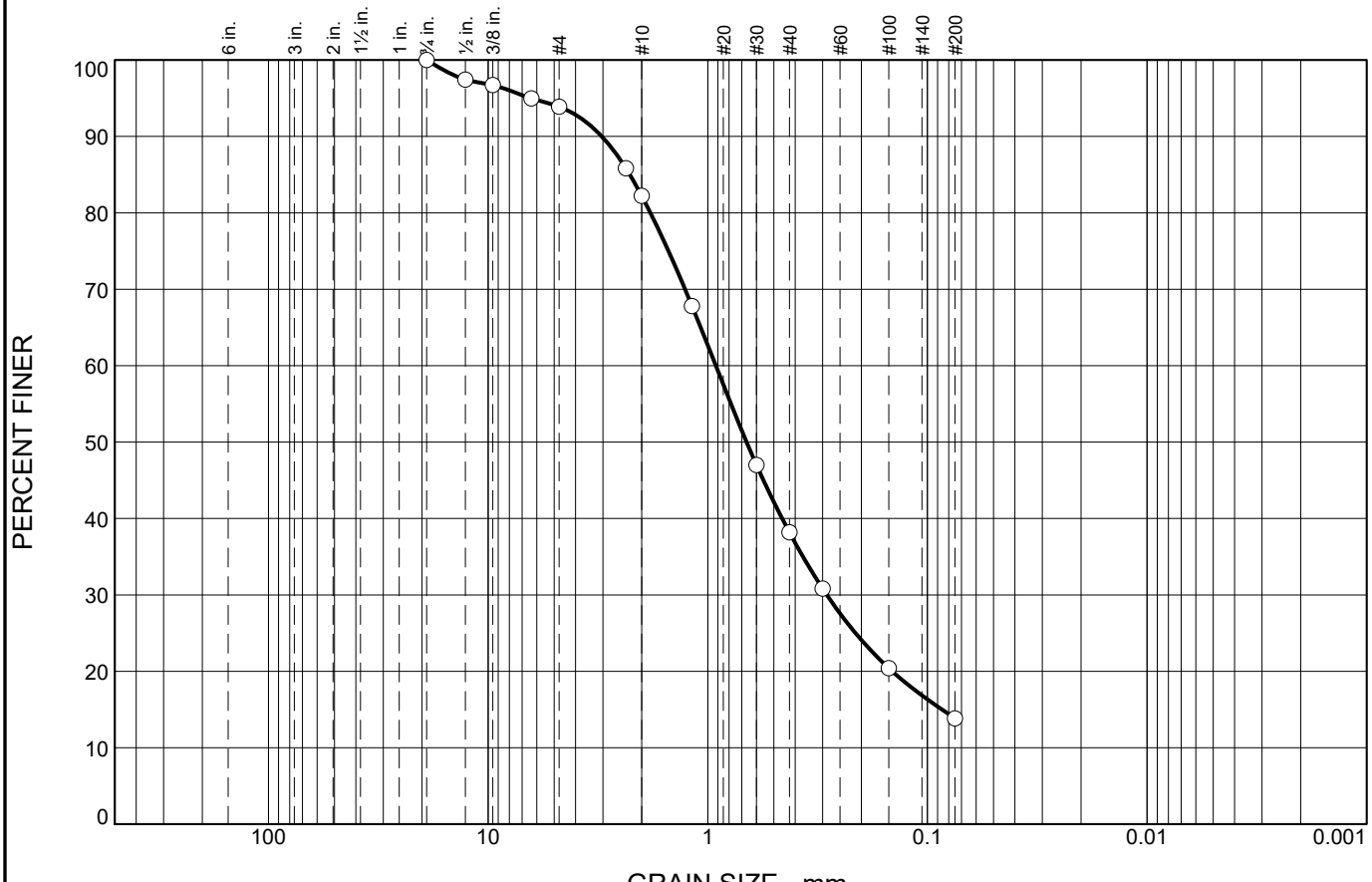
PATTISON ENGINEERING, LLC

Client: Meritage Homes

Project: Naranja Trails, Lots 1-43

Project No: 20-098 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	6	12	44	24	14	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
.75"	100		
.5	97		
.375	97		
.25	95		
#4	94		
#8	86		
#10	82		
#16	68		
#30	47		
#40	38		
#50	31		
#100	20		
#200	14		

* (no specification provided)

Material Description

SILTY SAND with gravel, brown, slightly damp, non-plastic

Atterberg Limits

PL= LL= PI=

Classification

USCS= SM AASHTO=

Remarks

Source of Sample: T-3 **Depth:** 0

Date:

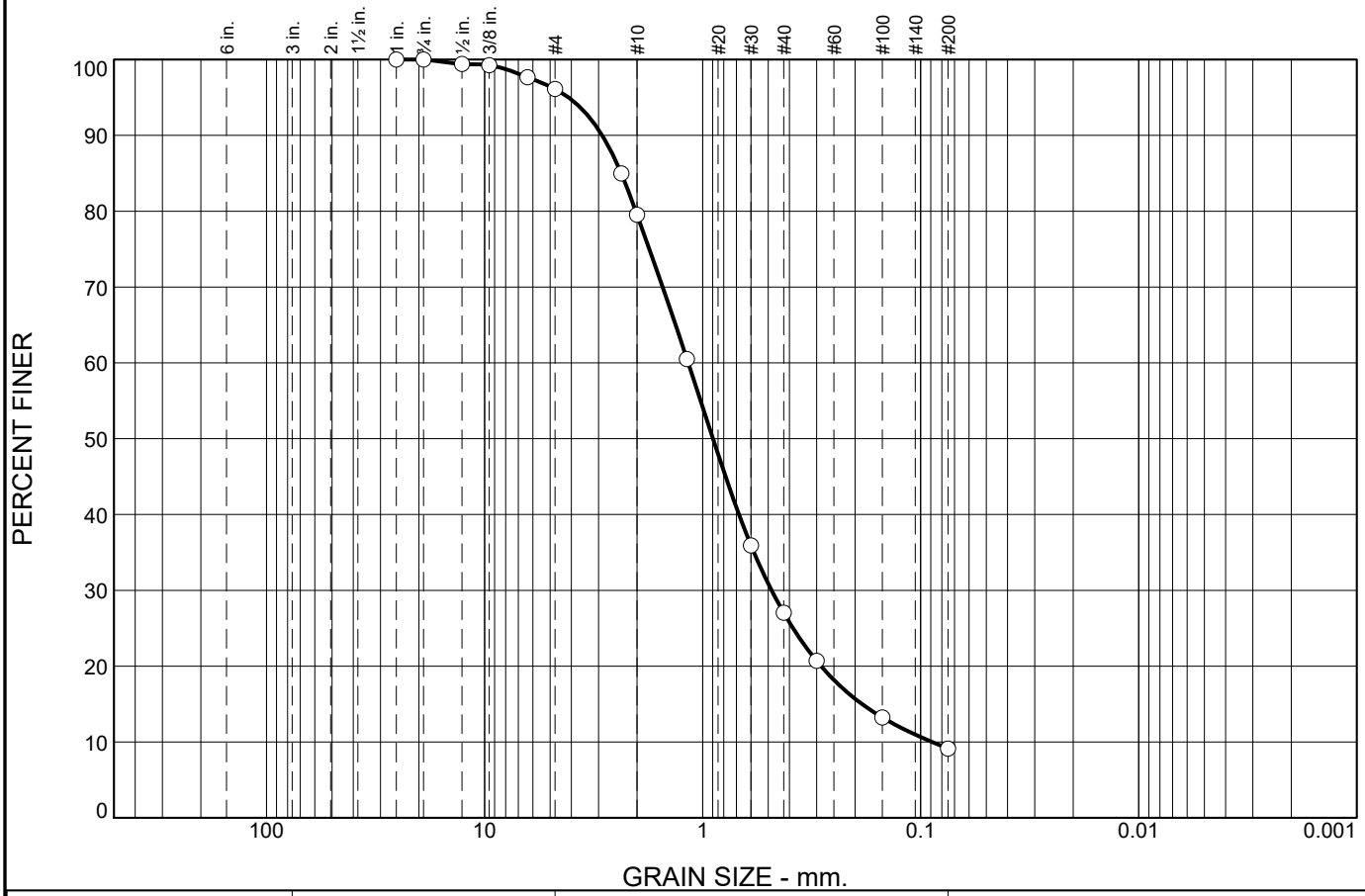
PATTISON ENGINEERING, LLC

Client: Meritage Homes

Project: Naranja Trails, Lots 1-43

Project No: 20-098 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	4	16	53	18	9	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100		
.75"	100		
.5"	99		
.375	99		
.25	98		
#4	96		
#8	85		
#10	80		
#16	61		
#30	36		
#40	27		
#50	21		
#100	13		
#200	9.1		

* (no specification provided)

Material Description

SAND with silt and gravel, brown, slightly damp, non-plastic

Atterberg Limits

PL= LL= PI=

Classification

USCS= SP-SM AASHTO=

Remarks

Source of Sample: T-4 **Depth:** 0

Date:

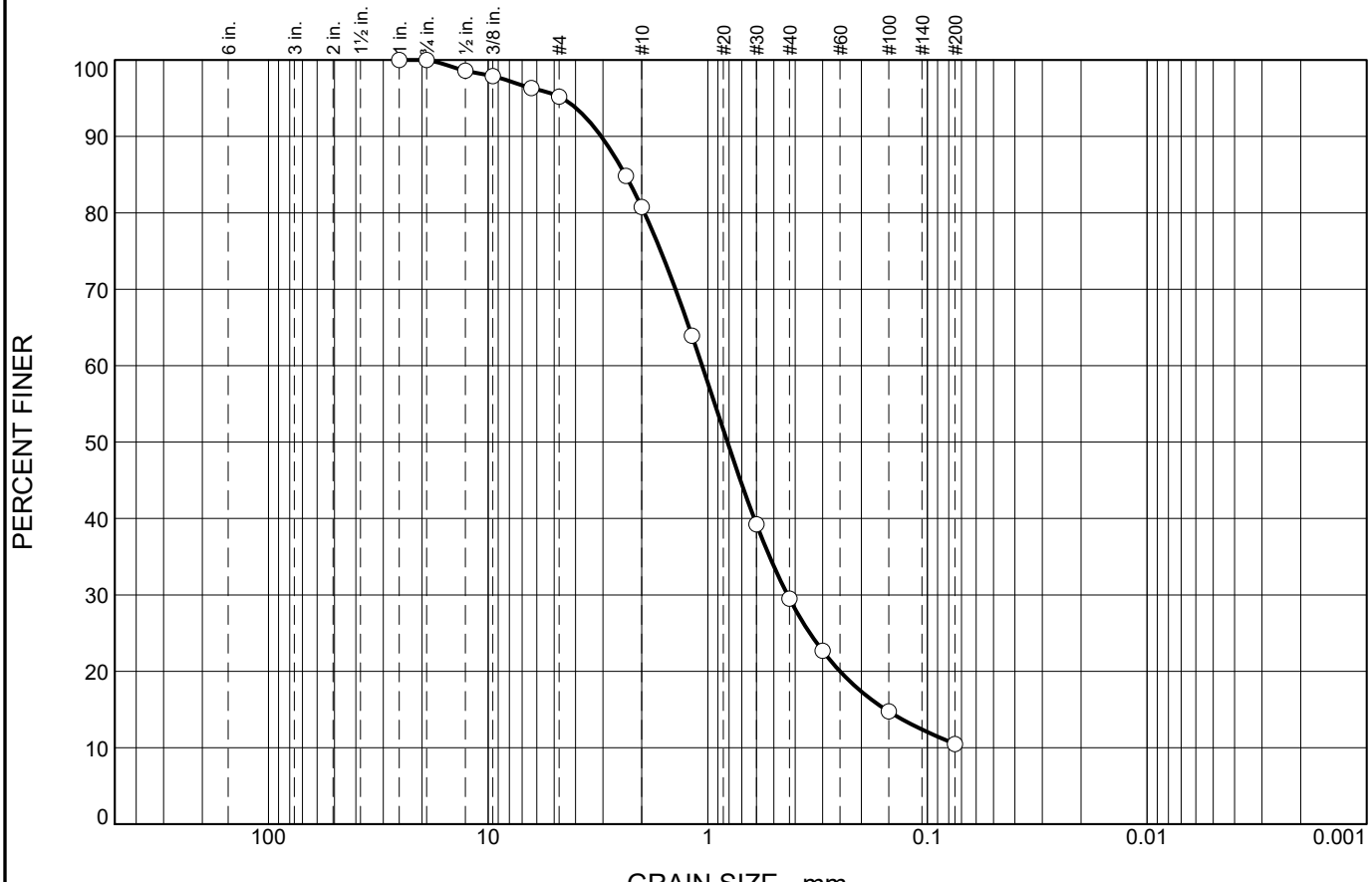
PATTISON ENGINEERING, LLC

Client: Meritage Homes

Project: Naranja Trails, Lots 1-43

Project No: 20-098 **Figure**

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0	0	5	14	51	20	10	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
1"	100		
.75"	100		
.5"	99		
.375	98		
.25	96		
#4	95		
#8	85		
#10	81		
#16	64		
#30	39		
#40	30		
#50	23		
#100	15		
#200	10		

* (no specification provided)

Material Description

SAND with silt and gravel, brown, slightly damp, non-plastic

Atterberg Limits

PL= LL= PI=

Classification

USCS= SP-SM AASHTO=

Remarks

Source of Sample: T-5 **Depth:** 0

Date:

PATTISON ENGINEERING, LLC

Client: Meritage Homes

Project: Naranja Trails, Lots 1-43

Project No: 20-098 **Figure**

Trench Logs

Project Number 20-098

Geotechnical Engineering
Construction Inspection
Materials Testing

TRENCH NUMBER

T-1

SHEET 1 OF 1

Client: Meritage Homes

Project: Naranja Trails, Lots 1-43
Location: Naranja Drive

Location of Boring:
SEE SITE PLAN

Elevation: Datum:
Logged By: IM Date: 3/23/21
Subsurface Conditions or Remarks:

SAMPLE TYPE	BLOWS PER 6"	INCHES DRIVEN/ INCHES RECOV'D	BULLNOSE BLOWS/FT	DEPTH (FEET)	USCS CODE	DESCRIPTION OF SUBSURFACE CONDITIONS	DRY DENSITY (PCF)	MOISTURE (%)
H				0		SAND with silt and gravel, brown, slightly damp, non-plastic		
				5		cobbles		
				10				
						BOTTOM OF TRENCH AT 12 FEET *No Free Water Encountered*		
				15				
				20				
				25				
				30				

Sample Type Key:
SS = Split Spoon
RS = Ring Sample
H = Hand Sample

Excavation Equipment:
Caterpillar 420D

Project Number 20-098

Geotechnical Engineering
Construction Inspection
Materials Testing

TRENCH NUMBER

T-2

SHEET 1 OF 1

Client: Meritage Homes

Project: Naranja Trails, Lots 1-43
Location: Naranja Drive

Location of Boring:
SEE SITE PLAN

Elevation: Datum:
Logged By: IM Date: 3/23/21
Subsurface Conditions or Remarks:

SAMPLE TYPE	BLOWS PER 6"	INCHES DRIVEN/ INCHES RECOV'D	BULLNOSE BLOWS/FT	DEPTH (FEET)	USCS CODE	DESCRIPTION OF SUBSURFACE CONDITIONS	DRY DENSITY (PCF)	MOISTURE (%)
H				0	SP	SAND with gravel, brown, slightly damp, non-plastic		
				5				
				10				
						BOTTOM OF TRENCH AT 12 FEET *No Free Water Encountered*		
				15				
				20				
				25				
				30				

Sample Type Key:
SS = Split Spoon
RS = Ring Sample
H = Hand Sample

Excavation Equipment:
Caterpillar 420D

Project Number 20-098

Geotechnical Engineering
Construction Inspection
Materials Testing

TRENCH NUMBER

T-3

SHEET 1 OF 1

Client: Meritage Homes

Project: Naranja Trails, Lots 1-43
Location: Naranja Drive

Location of Boring:
SEE SITE PLAN

Elevation: Datum:
Logged By: IM Date: 3/23/21
Subsurface Conditions or Remarks:

SAMPLE TYPE	BLOWS PER 6"	INCHES DRIVEN/ INCHES RECOV'D	BULLNOSE BLOWS/FT	DEPTH (FEET)	USCS CODE	DESCRIPTION OF SUBSURFACE CONDITIONS	DRY DENSITY (PCF)	MOISTURE (%)
H				0	SM	SILTY SAND with gravel, brown, slightly damp, non-plastic		
				5				
				10				
						BOTTOM OF TRENCH AT 12 FEET *No Free Water Encountered*		
				15				
				20				
				25				
				30				

Sample Type Key:
SS = Split Spoon
RS = Ring Sample
H = Hand Sample

Excavation Equipment:
Caterpillar 420D

Project Number 20-098

Geotechnical Engineering
Construction Inspection
Materials Testing

TRENCH NUMBER
T-4
SHEET 1 OF 1

Client: Meritage Homes

Project: Naranja Trails, Lots 1-43
Location: Naranja Drive

Location of Boring:
SEE SITE PLAN

Elevation: Datum:
Logged By: IM Date: 3/23/21
Subsurface Conditions or Remarks:

SAMPLE TYPE	BLOWS PER 6"	INCHES DRIVEN/ INCHES RECOV'D	BULLNOSE BLOWS/FT	DEPTH (FEET)	USCS CODE	DESCRIPTION OF SUBSURFACE CONDITIONS	DRY DENSITY (PCF)	MOISTURE (%)
H				0	SP-SM	SAND with silt and gravel, brown, slightly damp, non-plastic		
				5		cobbles		
				10				
						BOTTOM OF TRENCH AT 12 FEET *No Free Water Encountered*		
				15				
				20				
				25				
				30				

Sample Type Key:
SS = Split Spoon
RS = Ring Sample
H = Hand Sample

Excavation Equipment:
Caterpillar 420D

Project Number 20-098

Geotechnical Engineering
Construction Inspection
Materials Testing

TRENCH NUMBER

T-5

SHEET 1 OF 1

Client: Meritage Homes

Project: Naranja Trails, Lots 1-43
Location: Naranja Drive

Location of Boring:
SEE SITE PLAN

Elevation: Datum:
Logged By: IM Date: 3/23/21
Subsurface Conditions or Remarks:

SAMPLE TYPE	BLOWS PER 6"	INCHES DRIVEN/ INCHES RECOV'D	BULLNOSE BLOWS/FT	DEPTH (FEET)	USCS CODE	DESCRIPTION OF SUBSURFACE CONDITIONS	DRY DENSITY (PCF)	MOISTURE (%)
H				0	SP-SM	SAND with silt and gravel, brown, slightly damp, non-plastic		
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Sample Type Key:
SS = Split Spoon
RS = Ring Sample
H = Hand Sample

Excavation Equipment:
Caterpillar 420D

Pattison Engineering LLC

May 3, 2022
Project No. 20-098

Meritage Homes Construction, Inc.
5326 N. La Cholla Boulevard
Tucson, AZ 85741

ENGINEERING SERVICES
Naranja Trails, Lots 1-43 Infiltration Tests
Naranja Drive
Oro Valley, Arizona

Pattison Engineering prepared a geotechnical engineering evaluation report for this project (Pattison Engineering Project No. 20-098, dated July 24, 2020). We are now providing infiltration test results for the two proposed basins that will be located within the development.

The tests were performed in 12-inch-diameter, single-ring infiltrometers with about 1 foot of head, until stabilized rates were obtained. The test results are provided in the following table.

INFILTRATION RESULTS			
Test No.	**Soil Classification**	**Depth, ft**	**Approximate Stabilized Rate of Infiltration, min./in.**
1	Sand with silt	5	4
2	Sand with silt	7	4
3	Sand with silt	7	3

The rates measured at the time of infiltration testing are based on soil conditions at the depth and locations indicated. The actual rates of constructed detention/retention basins may vary significantly because of the following factors: location and depth of basin compared to the infiltration tests conducted at the time of field exploration; type of cover in detention/retention basin bottom (grass, rock, etc.); degree of compaction of the detention/retention basin bottom; placement of fill in the detention/retention basin; and the amount and type of sediment deposited in the basin during storm events. The results do not include any factors of safety or de-rating factors.

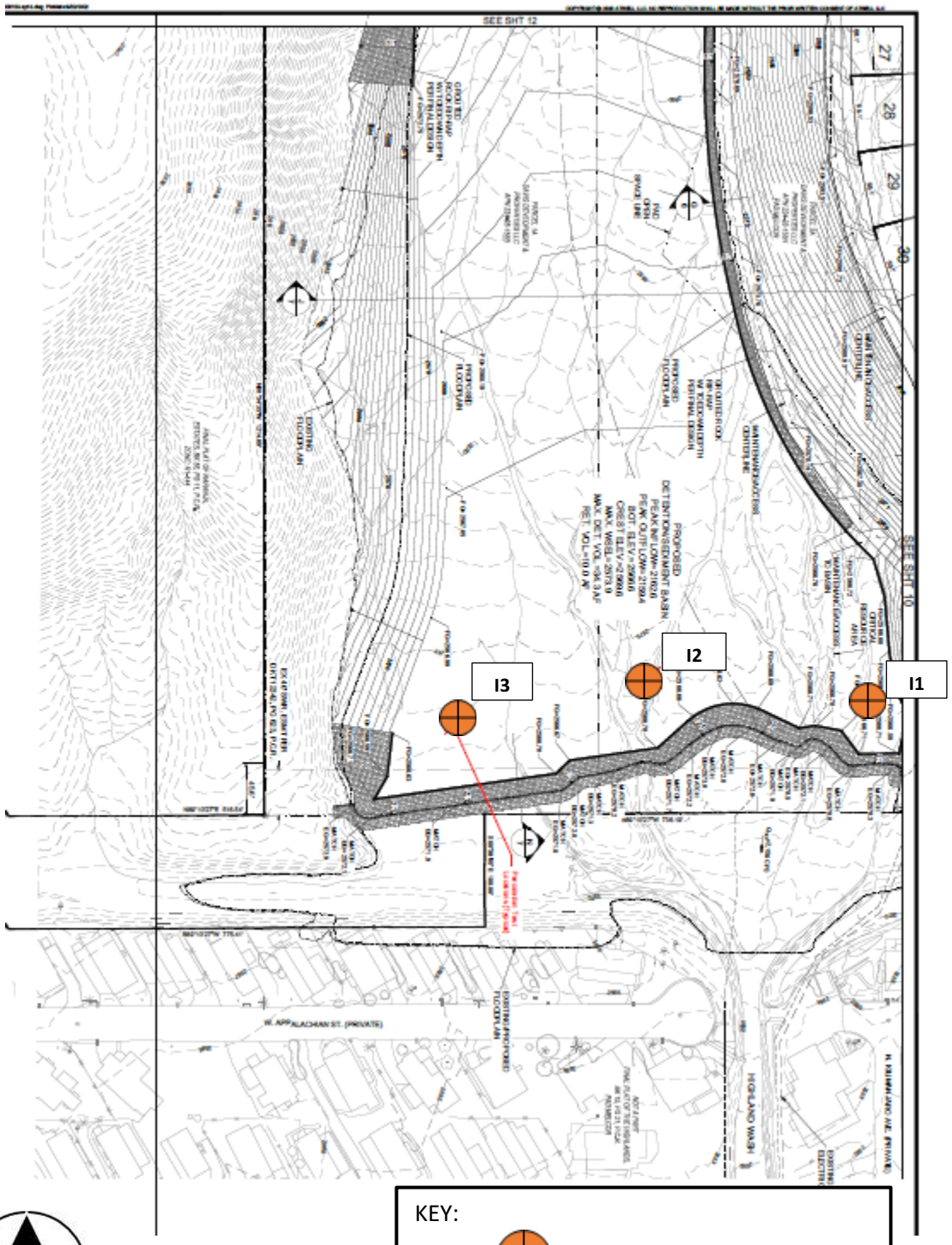
Thank you for selecting PATTISON ENGINEERING, L.L.C. We look forward to being a member of your team on the remainder of this project. If you have any questions about this letter, or require additional consultation, please call us.

Sincerely,
PATTISON ENGINEERING, L.L.C.
Geotechnical, Construction Inspection, and Materials Testing Services

Francisco J. Jacinto, P.E.
Managing Principal

Copies: Addressee (1) email

Site and Exploration Location Plan



November 17, 2022
Project Number 20-098
Addendum No. 2, Revision No. 1

Pattison Engineering LLC

Meritage Homes Construction, Inc.
5326 N. La Cholla Boulevard
Tucson, AZ 85741

RE: Pavement Section Design
Naranja Trails, Lots 1-43
Naranja Drive
Oro Valley, Arizona

Pattison Engineering prepared a geotechnical engineering evaluation report for this project (Pattison Engineering Project No. 20-098, dated July 24, 2020). We are providing the pavement section design for the proposed development.

Flexible Pavement Section

We determined our recommended pavement section in accordance with the "Modifications to the Pima County Roadway Design Manual, adopted April 2016" (MPCRDM, 2016). The following sections provide details of our design.

Determination of Design Weighted R-Value

We determined a Design Weighted R-Value from the soil laboratory data from near-surface soil samples taken from proposed access roadway area within this project site. As required in the MPCRDM, 2016, we determined correlated R-Values based upon the percent passing #200 sieve and plasticity index tests from these samples using the equation: log R-Value at 300 psi =

2.0 – 0.006 (pass 200) – 0.017 (PI).

We further corrected the correlated R-Values (Rc) according to the Pima County correlated R-Value (Rpc) correlation: $Rpc = 0.3(Rc)^{1.2}$. We also had Laboratory Tested R-Value tests performed on all three samples as required in the MPCRDM, 2016.

1129 N. Winstel Blvd. • Tucson, AZ 85716
Phone: 520.881.1234 • Fax: 520.881.4919

The following table is a summary of the soils and laboratory testing:

Sample Location	Depth (ft)	USCS Soil Class	% Minus #200	Plasticity Index	PC Correlated R-Value	Laboratory R-Value[1]
B-2	0-5	SM	15.5	3	48	75
B-3	0-5	SP-SM	5.0	0	62	62
B-7	0-5	SP-SM	10.5	0	57	67

1.Performed by Wood PLC; laboratory data attached.

	PC Correlated R-Values	Laboratory R-Values
Mean	55.7	68.0
Standard Deviation	7.1	6.6
Number of Tests	3	3
Rmean	62.3	

1. $R_{mean} = \frac{NtRt\,\sigma_c^2 + NcRc\sigma_t^2}{Nt\sigma_c^2 + Nc\sigma_t^2}$

Where: Nt = number of actual (laboratory tested) R-Values

Nc = number of correlated R-Values (PC Adjusted Correlated R-Values)

Rt = mean of the actual (laboratory tested) R-Values

Rc = mean of the correlated R-Values (PC Adjusted Correlated R-Values)

σ_t = standard deviation of the actual (laboratory tested) R-Values

σ_c = standard deviation of the correlated R-Values (PC Adjusted Correlated R-Values)

Determination of Resilient Modulus

Using a Seasonal Variation Factor of 1.7 for this area and a Calculated Weighted R-Value of 62.3 we determined a Resilient Modulus (Mr) of 30,495 psi but we used the maximum allowable value of 26,000 psi for the design.

This was determined from the equation:

$$Mr = \frac{1815 + 225(\text{Design R-Value}) + 2.40(\text{Design R-Value})^2}{0.6(\text{Seasonal Variation Factor})^{0.6}}$$

Determination of Design and Construction Control R-Value

We chose a Design and Construction Control R- Value of 62 for this project.

The calculated design R-Value was determined from the Pima County correlated R-Values and Laboratory Tested R-Values as shown in the following table:

Traffic Assumptions

For the local access roadway providing access to the lots we assumed a maximum average daily traffic of 620 vehicles per day (based on 10 trips per day per lot, and the subdivision having a maximum of 62 anticipated lots). Based on Pima County Subdivision Street guidelines for average daily traffic between 500-1000 vehicles per day, a resultant 20-year ESAL of 70,000 may be used for design. We believe this ESAL value is appropriate for this project.

Design Criteria and Determination of Structural Number

We used change in serviceability indices and percent reliabilities appropriate for the range of ADT being evaluated. Per current Pima County guidelines, we used a %Reliability of 80%, a Standard Deviation of 0.35, a Present Serviceability (Po) of 4.0 and Terminal Serviceability (Pt) of 2.4.

Using our design Mr of 26,000 psi, we determined an SN of 1.07 (calculation summary below). The SN was determined through iteration of the pavement design equation, solving for SN as the unknown:

Where: Zr = %Reliability,

So = Standard Deviation,

ΔPSI = serviceability index (Po – Pt),

Mr = Resilient Modulus

W_{18} = 20-year ESAL.

The pavement design equation is below:

$$\log_{10}(W_{18}) = Zr \times So + 9.36 \times \log_{10}(SN+1) - 0.20 + \left[\frac{(\log_{10}) \ \Delta PSI}{4.2-1.5} \right] + 0.40 + \frac{1094}{(SN+1)^{5.19}}$$

$$+ 2.32 \times \log_{10}(Mr) - 8.07$$

Flexible Pavement Design Analysis

Design Criteria

PROJECT DATA

Pavement Designation	Naranja Trails
Design Life (years)	20
Equivalent Axle Loads/Day	**
Total EAL's	70,000
Seasonal Variation Factor	1.7
Reliability	80%
Overall Standard Deviation	0.35

SUBGRADE CONDITIONS

AASHTO Classification	**
% Passing #200 Sieve	**
Plasticity Index	**
Correlated R-Value	62
Resilient Modulus MR (psi)	30,495
Design Modulus (psi)	26,000

SERVICEABILITY

Present (2.5 to 5.0)	4.1
Terminal (1.5 to 4.1)	2.6

LAYER COEFFICIENTS	Structural	Drainage
Asphalt Concrete Surface Course	0.44	N/A
Aggregate Base Course	0.11	1.00
Plant-Mixed Bituminous Base	0.28	1.00

Design Calculations

Target Structural Number SN: **1.20**

Alternative	Recommended Pavement Section Thickness Inches				Total Structural Number	Δ Structural Number
	Asphalt Concrete Surface	Aggregate Base Course	Plant-Mixed Bituminous Base	Total		
A	2.5	4		6.5	1.54	0.34
B				0.0	0.00	-1.20
C				0.0	0.00	-1.20

Pavement Section Recommendations

The interior streets in this subdivision are classified as local streets with less than 500 vehicles per day. Based on 2016, Pima County Subdivision and Development Street Standards, the minimum thickness of asphalt concrete (AC), aggregate base course (ABC), and the minimum structural number (SN) for this project are provided in the table below:

	Local Streets with Less than 500 ADT
Minimum AC Thickness (in.)	2.5
Minimum ABC Thickness (in.)	4
Minimum Design SN	2.5(.44)+ 4(.11)=1.54 > 1.20

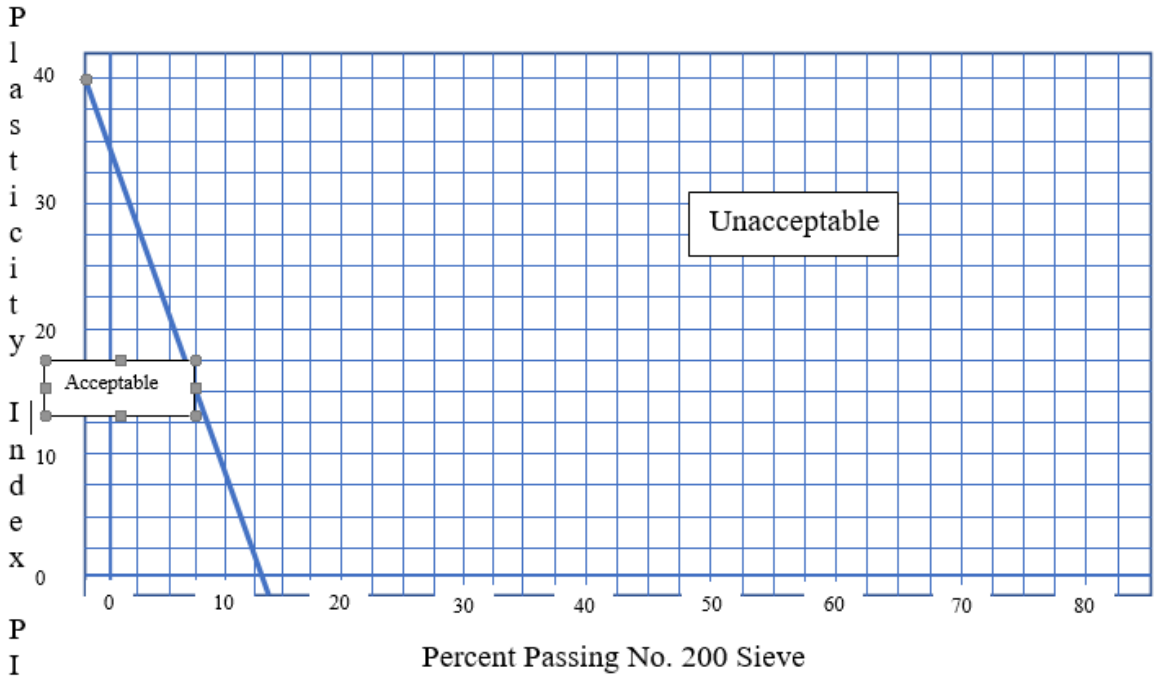
We used surfacing and base coefficients of 0.44 for AC and 0.11 (0.12 times a drainage coefficient of 0.92) for ABC to determine our recommended pavement section. The recommended pavement section is provided in the following table.

PAVEMENT SECTION	ASPHALT CONCRETE, in.	BASE COURSE, in.
Local Streets	2.5	4

We should be consulted for possible supplemental recommendations if additional information showing the amounts and types of traffic becomes available. Bituminous surfacing should be dense-graded, central-plant-mix, asphalt concrete. Base course and asphalt concrete should conform to Pima County specifications.

Subgrade Acceptance Chart

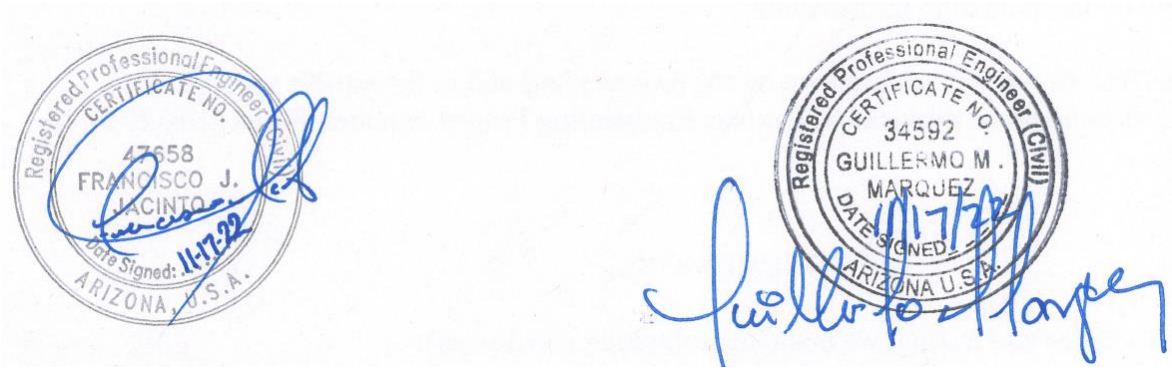
The following subgrade acceptance chart, based on the Construction Control Rpc-Value of 62, may be used for this project:



All other recommendations provided in the original report remain valid and applicable. Please let us know if you have any questions or require additional information.

Respectfully submitted,

PATTISON ENGINEERING, L.L.C.
Geotechnical, Construction Inspection, and Materials Testing Services



Francisco J. Jacinto, P.E.
Managing Principal

Guillermo M. Marquez. P.E.
Principal

Attachments: Wood PLC; laboratory test results

Copies to: Addressee (1) E-mail

October 6, 2023

Meritage Homes Construction, Inc.
5326 N. La Cholla Boulevard
Tucson, Arizona 85718

Slope Stability
Naranja Trails, Lots 39-61
Naranja Drive
Oro Valley, Arizona

Job No. 20-098, Addendum No. 4

As you requested Pattison Engineering, LLC has reviewed the existing slopes behind the proposed building lots 39-61 of the Naranja Trails development. A cursory site visit was made to the site on February 28, 2023. The purpose of our visit was to observe the materials condition of the existing slopes to evaluate their stability. We understand that you are proposing slopes (H:V) of 1:1, 2:1, and 3:1 within this site.

An evaluation of slope stability was conducted for the proposed lots 39-61 and the results are presented in the following table:

Slope Gradient (Horizontal:Vertical)	Vertical Height (Feet)	Factor of Safety
3:1	10	1.8
2:1	7	1.4

Permanent slopes no steeper than 3:1 in the typical silty Sand soil matrix encountered and less than ten feet in vertical height, and for slopes not steeper than 2:1 less than 7 feet in vertical height are recommended. Slopes of 1:1 are not recommended. We are basing our recommendations on the properties of the materials encountered in soil borings previously performed for this site, (Pattison Engineering, LLC, Project Number 20-098 dated July 24, 2020) and the on-site visual observations of materials comprising the slope faces during this visit. Based on our observations the slope faces consisted of sands with silt, gravel, and cobbles. The slopes will require periodic removal of detritus at the base. The dangers of falling rock should be made clear to any residents. Pattison Engineering, LLC has not evaluated the danger of persons or vehicles falling down the slope. Measures to prevent such occurrences must be evaluated by others.

Erosion activity, if allowed to form and propagate, will increase soil loss and could result in loss of support to structures, streets, and other facilities. Periodic maintenance and prompt repair of erosion features is important to prevent soil loss. The effectiveness of erosion control measures should be evaluated after heavy or prolonged rains.

All other recommendations provided in the original report remain applicable. If you have any questions or require additional consultation, please call us.

Sincerely,

PATTISON ENGINEERING, L.L.C.

Geotechnical, Construction Inspection, and Materials Testing Services

Francisco J. Jacinto, P.E.
Managing Principal

Guillermo M Marquez, P.E.
Principal

Copies to: Addressee (1) email