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https://www.visitbillings.com/visit/143/Amend-Park

REPORT OF GEOTECHNICAL INVESTIGATION

AMEND PARK TURF FIELD
BOZEMAN, MONTANA

CLIENT
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JOB NO. B19-001-001

FEBRUARY 2019

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GEOTECHNICAL REPORT
AMEND PARK TURF FIELD
BILLINGS, MONTANA

1.0 EXECUTIVE SUMMARY

The geotechnical investigation for the proposed artificial turf field to be built within Amend Park in Billings, Montana, encountered surficial sandy lean clay overlying clayey sand and sandy silt soils to depths of at least 10.6 feet. The native soils do not pose a considerable engineering risk to the planned construction; however, they are considered relatively loose and prone to settlement. In our experience, similar turf systems can be adversely impacted by differential settlements and often require snow removal equipment and maintenance equipment which could cause some rutting. Thus, an additional gravel base and separation geotextile beneath the turf system would be advantageous to improve long-term performance. The native soils were at or slightly below the optimum moisture content at the time of our investigation. Thus, compaction of the native soils should be possible depending on the time of construction. During the early spring elevated moisture contents associated with recent snow melt may preclude proper compaction and would warrant modification to the recommendations provided.

2.0 INTRODUCTION

2.1 Purpose and Scope

This report presents the results of our geotechnical study for the proposed artificial turf field to be located within Amend Park on the north side of King Avenue East in Billings, Montana. The purpose of the geotechnical study is to determine the general surface and subsurface conditions at the proposed site and to develop geotechnical engineering recommendations for the subgrade preparation beneath the field. This report describes the field work and laboratory analyses conducted for this project, the surface and subsurface conditions encountered, and presents our recommendations for the proposed turf field.

Our field work included excavating four test pits around the perimeter of the planned turf field. Samples were obtained from the test pits and returned to our Great Falls laboratory for testing. Laboratory testing was performed on selected soil samples to determine engineering properties of the subsurface materials. The information obtained during our field investigations and laboratory analyses was used to develop recommendations for the subgrade preparation beneath the artificial turf system.

This study is in accordance with the proposal submitted by Mr. Ahren Hastings, PE of our firm dated October 17, 2018. Our work was authorized to proceed by Ms. Lisa Rosauer, CFB of Fieldturf by her signed acceptance of our proposal.

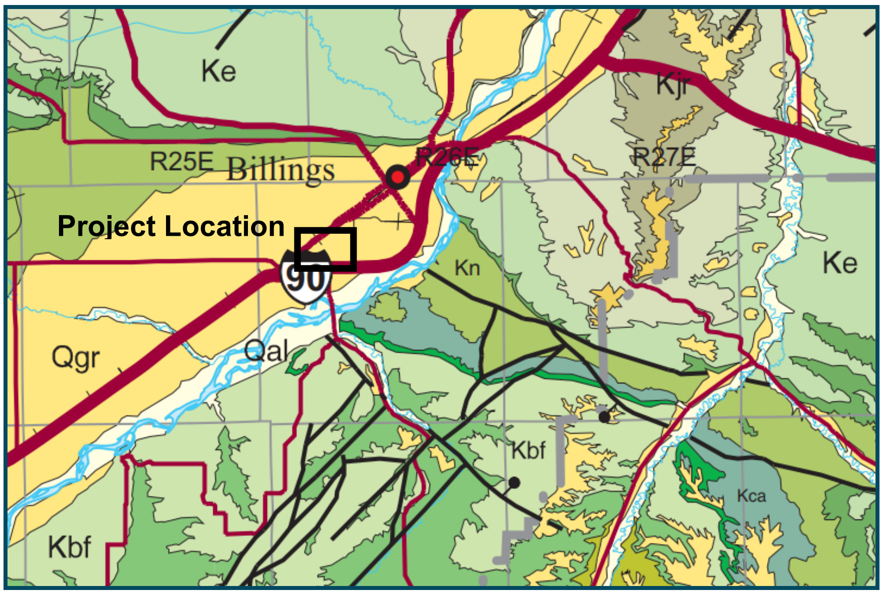
2.2 Project Description

It is our understanding that the project includes the construction of a new artificial turf field being approximately 420 feet by 290 feet in plan. The field is to be located on the north side of King Avenue East in Amend Park. The site is located north and east of the existing parking lots.

3.0 SITE CONDITIONS

3.1 Geology and Physiography

The site is geologically characterized as consisting of alluvium comprised mainly of valley fill which consists of silt, sand, and gravel. A water well log for the irrigation well within Amend Park that was drilled for the City of Billings in July 1995 indicates approximately 20 feet of surficial clay, sand, and silt material underlain by water bearing sand and gravel. This log also indicates a static water level of approximately 17 feet. A copy of this water well log has been included in the appendix for your reference.



Geologic Map of Montana, Edition 1.0 (2007)
Montana Bureau of Mines & Geology

3.2 Surface Conditions

The proposed project site is located within Amend Park on the north side of King Avenue East in Billings, Montana. The project site currently consists of sod fields utilized for various sporting activities and park events. The topography is considered nearly level.

3.3 Subsurface Conditions

3.3.1 Soils

The subsurface soil conditions appear to be relatively consistent based on our exploratory excavations and soil sampling. In general, the subsurface soil conditions encountered within the test pits consist of intermixed deposits of clayey sand, sandy lean clay, and sandy silt. All the materials appear to be a nearly even split between fine-graded sand and fines (silt and clay); however, some variations in the materials plasticity was observed. Similar subsurface conditions extend to a depth of at least 10.6 feet, the maximum depth investigated. The three materials encountered are visually very similar and they may not be distinguishable from one another during excavation. Breaks between materials types were estimated based on variations in moisture content, plasticity, and other parameters measured in the laboratory.

The subsurface soils are described in detail on the enclosed test pit logs and are summarized below. The stratification lines shown on the logs represent approximate boundaries between soil types and the actual in situ transition may be gradual vertically or discontinuous laterally.

All of the samples collected from this investigation appeared relatively similar but some slight variations in the material plasticity were noted. The southern end of the project appears to be more clay dominant with clayey sand and sandy lean clay being the major strata. To the north, surficial sandy lean clays are underlain by sandy silt. All these materials are considered relatively loose based on the ease of excavation and the apparent density of the material. Three samples of the materials contained no gravel, between 44 and 55 percent sand, and between 45 and 56 percent fines (clay and silt). The majority of the sand from each sample is considered fine sand with particle diameters being smaller than 0.09 mm. Two samples classifying as either sandy lean clay or clayey sand exhibited liquid limits of 27 to 36 percent and plasticity indices of 17 each. A single sample of sandy silt exhibited a liquid limit of 21 percent and a plasticity index of 20 percent. The natural moisture contents varied from 9 to 18 percent and averaged 12.6 percent.

A bulk sample of the sandy silt obtained from test pit TP-3 was tested in accordance with ASTM D698 to evaluate its compactive properties. This test resulted in a maximum dry density of 111.5 pounds per cubic foot at an optimum moisture of 14.8 percent. The same materials when compacted at its optimum moisture to at least 95 percent of the maximum dry density exhibited a CBR value (in accordance with ASTM D1883) of 9.9 percent. A single undisturbed sample of the sandy silt was obtained from test pit TP-4 using a Shelby tube. This sample exhibited an in-situ dry density of approximately 87.7 pounds per cubic foot; thus, the relative compaction of the in-situ soils is approximately 79 percent based on the laboratory proctor performed on a similar material.

3.3.2 Ground Water

Ground water or signs of free water were not encountered in any of the test pits performed on this project to depths of at least 10.6 feet. An existing well log for an irrigation well within the park indicates ground water to be at depths greater than 17 feet. The presence or absence of observed water may be directly related to the time of the subsurface investigation. Numerous factors contribute to seasonal ground water occurrences and fluctuations, and the evaluation of such factors is beyond the scope of this report.

4.0 ENGINEERING ANALYSIS

4.1 Introduction

The native soils do not pose a considerable engineering risk to the planned construction; however, they are considered relatively loose and could realize some settlement and rutting associated with vehicles for snow removal and other maintenance activities. Proper compaction of the native subgrade combined with a limited thickness of base course gravel should be adequate to provide a reasonable level of performance during typical maintenance activities.

4.2 Site Grading and Excavations

The ground surface at the proposed site is considered very level and is currently utilized a sod surfaced soccer fields in the existing park. Based on our field work, sandy lean clay, clayey sand, and sandy silt which are all visually very similar will be anticipated across the project site. Based on the test pits, ground water is not anticipated to be encountered based on the limited depth of excavation expected for this project.

4.3 Soil Shrink-Swell

Based on the plasticity data collected from laboratory tests, the site soils are considered only marginally expansive and are not anticipated to have any significant impact to the proposed construction. During previous projects involving turf applications, the use of the Vertical Potential Rise (VPR) calculation method was referenced. This approach, which utilizes an empirically based methodology to calculate a potential rise of the subgrade soils based on the soil liquid limit, plasticity index, and natural moisture content, was also utilized as part of our analysis. The VPR calculation predicted potential vertical movements on the order of 0.5 to 0.6-inch. It is our understanding that conventional turf construction can generally accommodate VPR values of up to one inch; thus, no additional subgrade improvements are required based on the expansive properties of the site soils

4.4 Frost Heave & Snow Removal

Frost penetration depth in the Billings area is typically 36 inches below finish grade as specified in the design criteria for new foundation within the City of Billings. The native soils are considered to of high to very high frost susceptibility and are classified as F3 or F4 soils in accordance with the Federal Highway Administration (FHWA) classification system. While the native soils are considered frost susceptible, the relatively low in-situ moisture contents and the depth of ground water reduce the risk of frost related movements. Proper storm water management practices will be critical in eliminating potential subsurface moisture beneath the turf system which can exacerbate potential frost heave.

Turf systems utilized throughout Montana will require snow removal activities throughout the intended period of use. We understand that Fieldturf typically restricts vehicle use on the turf surfacing to those which limit contact pressures to less than 70 pounds per square inch (psi), which is a pressure typical of most small to midsize trucks. Thus, the turf system will function in some ways as a light traffic, low frequency roadway and needs to be designed to resist rutting or deflection of the subgrade which would hinder the performance of the turf system. In order to support the typically allowable snow removal equipment, a base layer of gravel is warranted beneath the turf section to help distribute wheel loads to the subgrade and control potential rutting. The anticipated turf section is to include approximately four inches of drain rock. This material is expected to be open-graded and thus is not considered structural and should not be included in the required depth of base gravel. Our analyses indicate that an additional compacted base course gravel thickness of at least 12 inches is warranted over the compacted subgrade to achieve suitable performance levels based on the anticipated snow removal and maintenance vehicle use. This gravel thickness beneath the turf section is suitable for the anticipated tire pressures which we understand are limited to 70 psi based on the Fieldturf Warranty documents. If tire contact pressures are anticipated to exceed this 70 psi requirement, a thicker gravel section may be warranted, and we should be consulted to reevaluate our recommendations.

4.5 Geotextiles

A separation fabric should be placed between the fine-grained subgrade and the required gravel course to prevent the migration of fines and the potential loss of aggregate into the subgrade during high moisture periods. Prior to geotextile installation, the native soils should be moisture conditioned and compacted to further improve the turf performance. A minimum compaction requirement has been specified in the recommendations section of this report.

4.6 Percolation Rate

Field percolation tests were not included as part of our scope of work for this project. However, based on the results of the laboratory testing performed on samples of the native soils, we have estimated the percolation rate for the various materials based on their gradational properties. The value of K_{sat}, the saturated permeability, was calculated based on the gradation properties for the three samples tested in our laboratory. Based on the results of laboratory testing, the on site soils are theoretically capable of realizing permeabilities on the order of 2.7 to 4.4 inches per hour.

The values provided above are completely theoretical based on the gradational properties of the materials; thus, they must be corrected to account for site variability and other factors. The total correction factor to be applied to the estimated infiltration rate for the native soils was determined to be 0.12, and this value is the product of the site variability factor of 0.33, the test methodology factor of 0.40, and the influent control factor of 0.9. A maximum infiltration rate of 0.4 inches per hour is appropriate for the native soils in the absence of site-specific infiltration testing at the planned subgrade elevation.

5.0 RECOMMENDATIONS

5.1 Site Grading and Excavations

1. All topsoil and organic material should be removed from the proposed construction limits and all areas which will receive site grading fill material. For planning purposes, a limited stripping thickness of four to six inches should be adequate to remove the existing organic material. Thicker stripping depths may be warranted in localized areas and should be determined once actual stripping operations are performed.

2. All fill should be non-expansive and free of organics and debris. All fill should be placed in uniform lifts not exceeding 8 inches in thickness for fine-grained soils and not exceeding 12 inches for granular soils. All materials compacted using hand compaction methods or small walk-behind units should utilize a maximum lift thickness of 6 inches to ensure adequate compaction throughout the lift. All fill and backfill shall be compacted to the following percentages of the maximum dry density determined by a standard proctor test which is outlined by ASTM D698 or equivalent (e.g. ASTM D4253-D4254).

   a) Subgrade Beneath Structural Fill.. 98%
   b) Structural Fill Beneath Turf Section.. 98%
   c) General Site Grading Fill.. 95%

3. Imported structural fill should be non-expansive, free of organics and debris, and conform to the material requirements outlined in Section 02235 of the Montana Public Works Standard Specifications (MPWSS). All gradations outlined in this standard are acceptable for use on this project; however, conventional proctor methods (outlined in ASTM D698) shall not be used for any materials containing less than 70 percent passing the ¾-inch sieve. Conventional proctor methods are not suitable for these types of materials, and the field compaction value must be determined using a relative density test outlined in ASTM D4253-4254.

4. A non-woven separation geotextile is recommended between the prepared subgrade and the required structural fill to prevent the upward migration of fines or loss of aggregate into the subgrade. A Mirafi 180N or equivalent geotextile is appropriate.

5. For conventional turf construction and use, the turf system should overlie a minimum thickness of 12 inches of compacted structural fill (Item 3) which is separated from the prepared subgrade by a suitable geotextile (Item 4). This thickness of structural fill is intended to accommodate tire contact pressures of up to 70 psi during snow removal and other maintenance activities. If vehicles which apply higher contract pressures are anticipated to be utilized on the field, we must be consulted to determine if additional subgrade improvement is warranted.

The use of finer-graded materials, such as a ¾-inch minus, complying with Item 3 above should be considered as this material is leveled more readily and will provide easier control of the grade directly beneath the turf section.

6. Subsurface drain beneath the field and perimeter drains are recommended at the subgrade elevation around the field perimeter to remove surface infiltration. Drains should discharge directly to the site storm water system.

   Design of storm water systems should utilize an assumed infiltration rate of 0.4 inches per hour or less for the native soils unless site specific infiltration tests are performed.

7. It is the responsibility of the Contractor to provide safe working conditions in connection with underground excavations. Temporary construction excavations greater than four feet in depth, which workers will enter, will be governed by OSHA guidelines given in 29 CFR, Part 1926. For planning purposes, subsoils encountered in the test pits are considered Type C. The soil conditions on site can change due to changes in soils moisture or disturbances to the site prior to construction. Thus, the contractor is responsible to provide an OSHA knowledgeable individual during all excavation activities to regularly assess the soil conditions and ensure that all necessary safety precautions are implemented and followed.

5.2 <u>Continuing Services</u>

Three additional elements of geotechnical engineering service are important to the successful completion of this project.

8. Consultation between the geotechnical engineer and the design professionals during the design phases is highly recommended. This is important to ensure that the intentions of our recommendations are incorporated into the design, and that any changes in the design concept consider the geotechnical limitations dictated by the on-site subsurface soil and ground water conditions.

9. Observation, monitoring, and testing during construction is required to document the successful completion of all earthwork and foundation phases. A geotechnical engineer from our firm should be retained to observe the excavation, earthwork, and foundation phases of the work to determine that subsurface conditions are compatible with those used in the analysis and design.

10. During site grading, placement of all fill and backfill should be observed and tested to confirm that the specified density has been achieved. We recommend that the Owner maintain control of the construction quality control by retaining the services of an experienced construction materials testing laboratory. We are available to

provide construction inspection services as well as materials testing of compacted soils and the placement of Portland cement concrete. In the absence of project specific testing frequencies, TD&H recommends the following minimum testing frequencies be used:

Compaction Testing	
Beneath Turf Surfacing	1 Test per 1,000 Square Feet per Lift
Concrete Testing	
Structural Concrete†	1 Test per 50 CY per Day
Non-Structural Concrete	1 Test per 100 CY per Day (MPWSS Requirement)

† Structural concrete includes all foundations, retaining walls, and other load bearing elements
CY = Cubic Yards

6.0 SUMMARY OF FIELD AND LABORATORY STUDIES

6.1 Field Explorations

The field exploration program was conducted on February 4, 2019. A total of four test pits were excavated to depths ranging from 7.9 to 10.6 feet at the approximate locations shown on Figure 1 to observe subsurface soil and ground water conditions. The test pits were excavated by Earth Surgeons using a Volvo ECR 58D mini-excavator. The subsurface exploration and sampling methods used are indicated on the attached test pits logs. The test pits were logged by Mr. Ahren Hastings, PE of TD&H Engineering. The location of the test pits was estimated by Mr. Hastings in the field based on their proximity to existing surface features.

Composite grab samples of the subsurface materials were taken at varying intervals and at discrete changes in subsurface strata. A sample was also obtained by pushing a 3-inch I.D., thin-walled Shelby tube sampler into the subsoils. Logs of all test pits which include soil descriptions and sample depths are presented on the Figures 2 through 5.

Ground water was not encountered in any of the test pits performed. Soil samples and excavation spoils appeared moist and did not contain visible free water. Surfaces of excavation equipment also did not indicate any presence of free water or elevated soil moisture.

6.2 Laboratory Testing

Samples obtained during the field exploration were returned to our materials laboratory where they were observed and visually classified in general accordance with ASTM D2487, which is based on the Unified Soil Classification System. Representative samples were selected for testing to determine the engineering and physical properties of the soils in general accordance with ASTM or other approved procedures.

Tests Conducted:	To determine:
Natural Moisture Content	Representative moisture content of soil at the time of sampling.
Grain-Size Distribution	Particle size distribution of soil constituents describing the percentages of clay/silt, sand and gravel.
Atterberg Limits	A method of describing the effect of varying water content on the consistency and behavior of fine-grained soils.
Natural Dry Density	Dry unit weight of samples, representative of in-place conditions.
UU Shear Strength (Field)	The undrained, unconfined shear strength (s_u) of cohesive soils as determined in the field by either a pocket penetrometer or a hand torvane.

Moisture-Density Relationship	A relationship describing the effect of varying moisture content and the resulting dry unit weight at a given compactive effort. Provides the optimum moisture content and the maximum dry unit weight. Also called a Proctor Curve.
California Bearing Ratio	The measure of a subgrade's or granular base's ability to resist deformation due to penetration during a saturated condition. Used to assist in pavement thickness designs.

The laboratory testing program for this project consisted of 8 moisture-visual analyses, 3 sieve (grain-size distribution) analyses, and 3 Atterberg Limits analyses. The results of the water content analyses are presented on the test pits logs, Figures 2 through 5. The grain-size distribution curves and Atterberg limits are presented on Figures 6 through 11. In addition, one proctor (moisture-density) test, one California Bearing Ratio test, and one natural dry density test were performed. The results of these tests are shown on Figures 12 through 14. Unconfined compressive strengths (q_u) were determined in the field using a pocket penetrometer. The results are shown on the test pit logs at the depths the samples were tested.

7.0 LIMITATIONS

This report has been prepared in accordance with generally accepted geotechnical engineering practices in this area for use by the client for design purposes. The findings, analyses, and recommendations contained in this report reflect our professional opinion regarding potential impacts the subsurface conditions may have on the proposed project and are based on site conditions encountered. Our analysis assumes that the results of the exploratory borings are representative of the subsurface conditions throughout the site, that is, that the subsurface conditions everywhere are not significantly different from those disclosed by the subsurface study. Unanticipated soil conditions are commonly encountered and cannot be fully determined by a limited number of soil borings and laboratory analyses. Such unexpected conditions frequently require that some additional expenditures be made to obtain a properly constructed project. Therefore, some contingency fund is recommended to accommodate such potential extra costs.

The recommendations contained within this report are based on the subsurface conditions observed in the borings and are subject to change pending observation of the actual subsurface conditions encountered during construction. TD&H cannot assume responsibility or liability for the recommendations provided if we are not provided the opportunity to perform limited construction inspection and confirm the engineering assumptions made during our analysis. A representative of TD&H should be retained to observe all construction activities associated with subgrade preparation, foundations, and other geotechnical aspects of the project to ensure the conditions encountered are consistent with our assumptions. Unforeseen conditions or undisclosed changes to the project parameters or site conditions may warrant modification to the project recommendations.

Long delays between the geotechnical investigation and the start of construction increase the potential for changes to the site and subsurface conditions which could impact the applicability of the recommendations provided. If site conditions have changed because of natural causes or construction operations at or adjacent to the site, TD&H should be retained to review the contents of this report to determine the applicability of the conclusions and recommendations provide considering the time lapse or changed conditions.

Misinterpretation of the geotechnical information by other design team members is possible and can result in costly issues during construction and with the final product. We strongly advise that TD&H be retained to review those portions of the plans and specifications which pertain to earthwork and foundations to determine if they are consistent with our recommendations and to suggest necessary modifications as warranted. In addition, TD&H should be involved throughout the construction process to observe construction, particularly the placement and compaction of all fill, preparation of all foundations, and all other geotechnical aspects. Retaining the geotechnical engineer who prepared your geotechnical report to provide construction observation is the most effective method of managing the risks associated with unanticipated conditions.

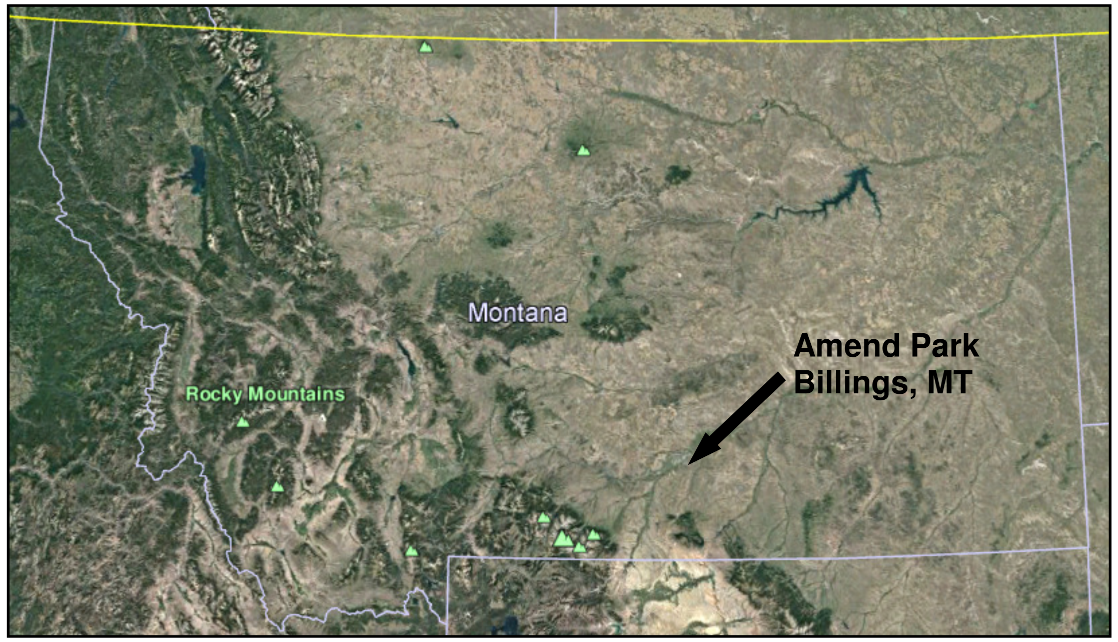
This report was prepared for the exclusive use of the owner and architect and/or engineer in the design of the subject facility. It should be made available to prospective contractors and/or the contractor for information on factual data only and not as a warranty of subsurface conditions such as those interpreted from the boring logs and presented in discussions of subsurface conditions included in this report.

Prepared by:

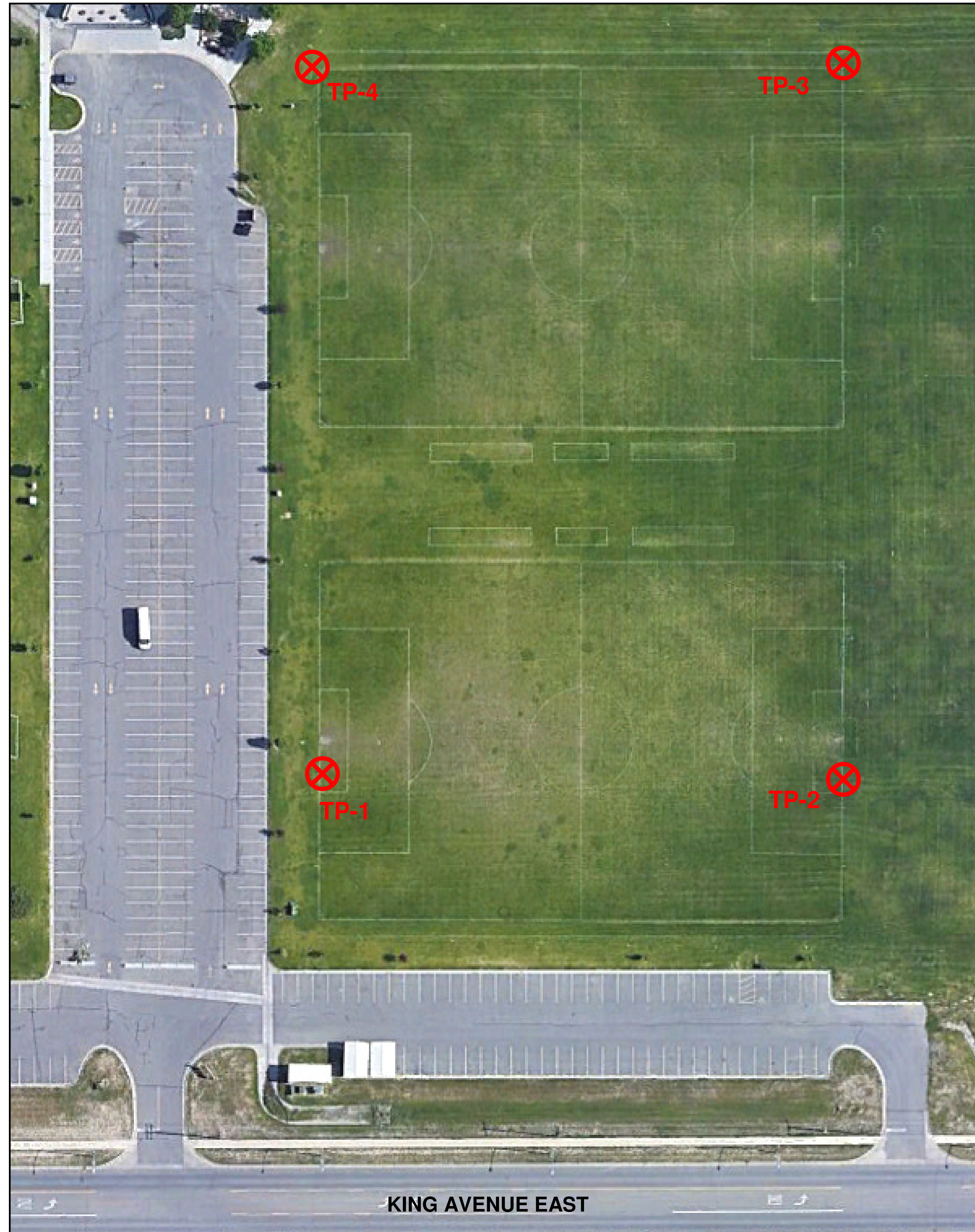
Craig Nadeau *PE*
Geotechnical Manager
TD&H ENGINEERING

Reviewed by:

Ahren Hastings *PE*
Geotechnical Engineer
TD&H ENGINEERING



VICINITY MAP



NOTE: TEST PIT LOCATIONS ARE APPROXIMATE BASED ON PROXIMITY TO EXISTING SURFACE FEATURES.

REV	DATE	REVISION

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DRAWN BY:
DESIGNED BY:
QUALITY CHECK:
DATE:
JOB NO.
FIELDBOOK

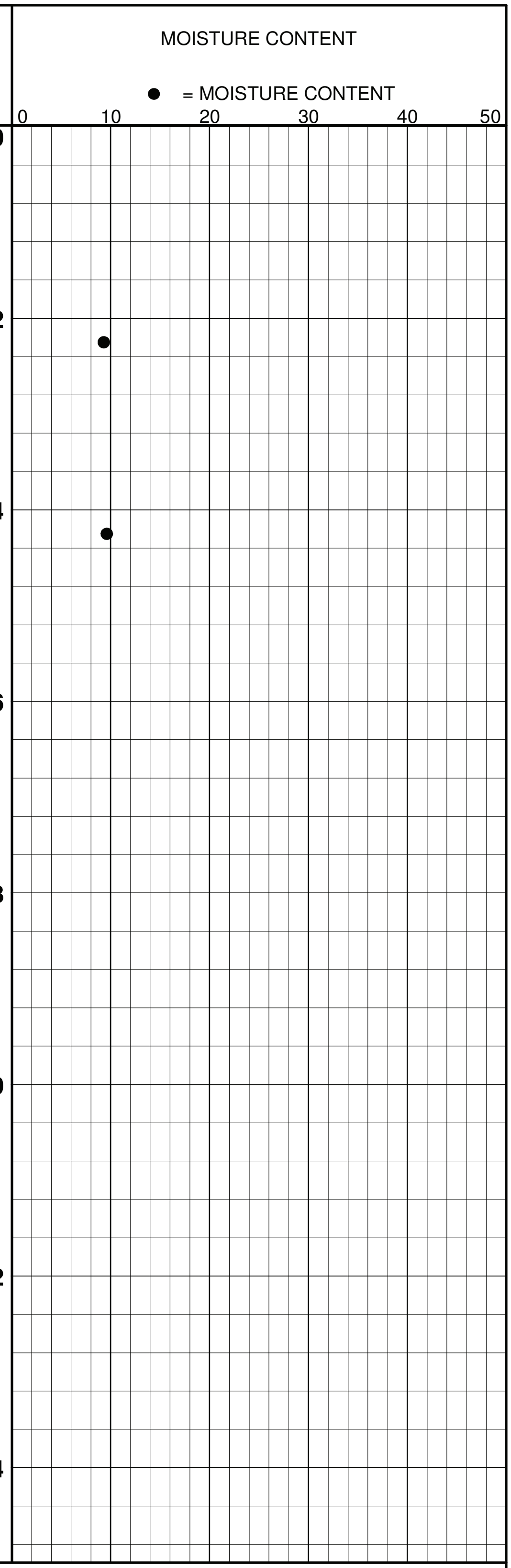
AMEND PARK TURF FIELD
BILLINGS, MONTANA

TEST PIT LOCATION MAP

.DWG

FIGURE 1

GRAPHIC LOG	SURFACE: Sod SURFACE ELEVATION: Not Measured SOIL DESCRIPTION	DEPTH (FT)	GROUND WATER	SAMPLE	DEPTH (FT)
	TOPSOIL: Clayey SAND, appears medium dense, brown, frozen, organics	0.5			0
	Clayey SAND, appears loose, brown, slighlty moist to moist, high fines content			G	2
	qu = 2.5 tsf			G	4
		8.1			8
	Bottom of Test Pit	Ground water not encoun-tered			



LEGEND

● Field Moisture content

▼ Groundwater Level

Grab/composite sample

Atterberg Limits

Plastic Limit

In-Situ Water Content

Liquid Limit

Plasticity Index

GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF TEST PIT TP-1

Amend Park Turf Field
Billings, Montana

Logged by: Ahren Hastings, PE

Excavated by: Earth Surgeons
Volvo ECR 58D

February 4, 2019 B19-001

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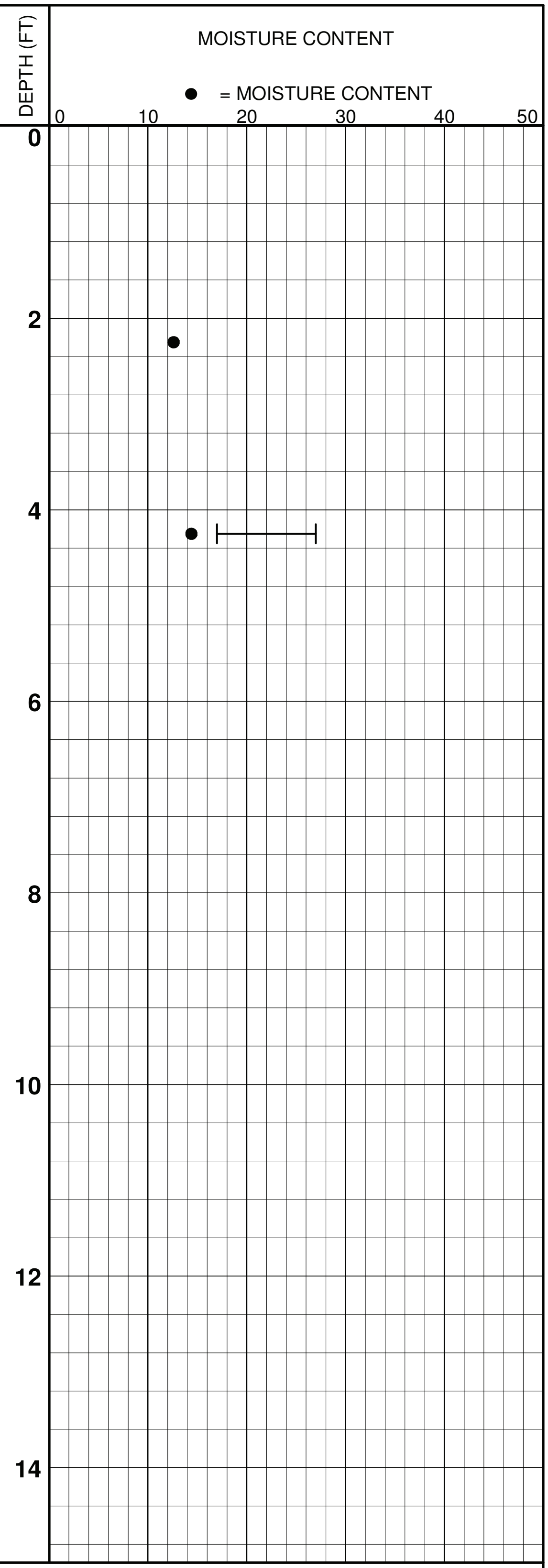
SPOKANE WASHINGTON
LEWISTON IDAHO

Figure No. 2

Sheet 1 of 1

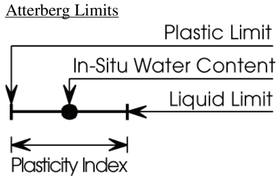
GRAPHIC LOG	SURFACE: Sod SURFACE ELEVATION: Not Measured SOIL DESCRIPTION	DEPTH (FT)	GROUND WATER	SAMPLE
	TOPSOIL: Sandy Lean CLAY, appears firm, brown, frozen, organics	0.3		
	Sandy Lean CLAY, appears firm, brown, moist, high sand content	3.0		G
	Clayey SAND, appears loose, brown, moist, high clay content qu = 3.5 tsf	7.9		G
	Bottom of Test Pit		Ground water not encoun-tered	



LEGEND

- ● Field Moisture content
- ▼ Groundwater Level
- Grab/composite sample

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF TEST PIT TP-2

Amend Park Turf Field
Billings, Montana

Logged by: Ahren Hastings, PE

Excavated by: Earth Surgeons
Volvo ECR 58D

February 4, 2019 B19-001

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Figure No. 3

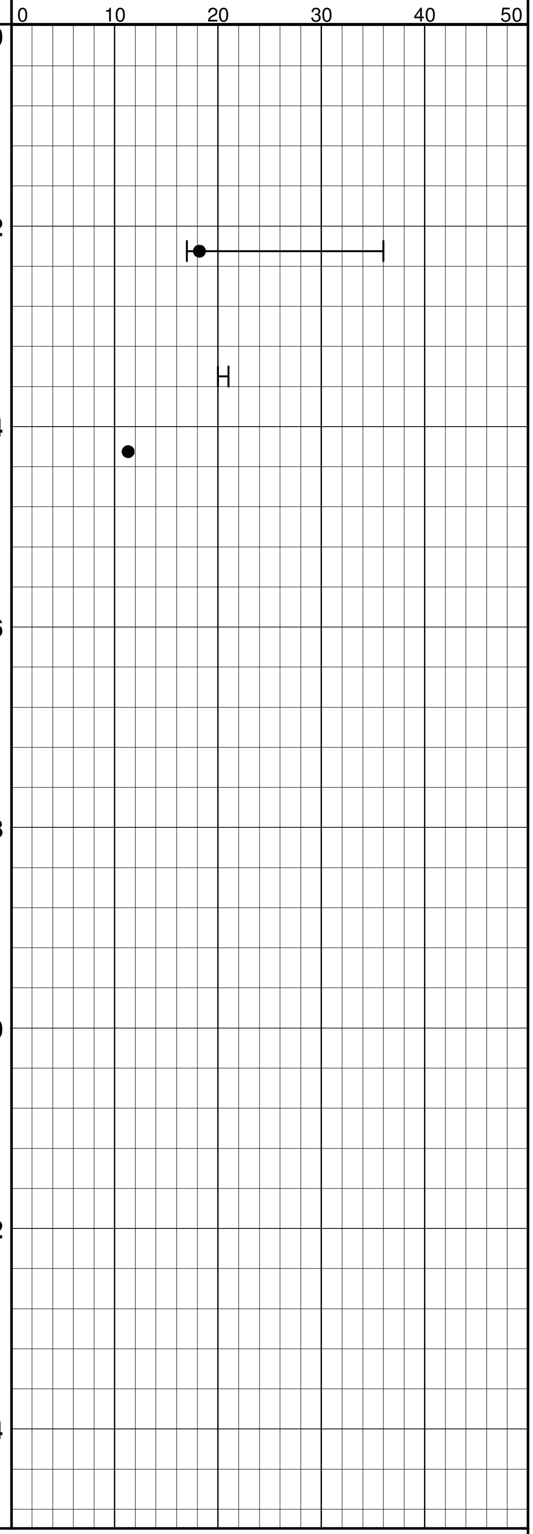
Sheet 1 of 1

SURFACE: Sod
SURFACE ELEVATION: Not Measured

GRAPHIC LOG	SOIL DESCRIPTION	DEPTH (FT) / GROUND WATER	SAMPLE
	TOPSOIL: Sandy Lean CLAY, appears firm, brown, frozen, organics	0.4	
	Sandy Lean CLAY, appears firm, brown, moist	3.0	G
	Sandy SILT, appears loose, brown, moist, high sand content See Figures 7, 11, 12, & 13 for laboratory test results on bulk sample	10.6	G G
	Bottom of Test Pit	Ground water not encountered	

MOISTURE CONTENT

● = MOISTURE CONTENT



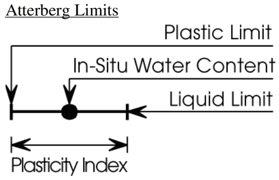
LEGEND

● Field Moisture content

▼ Groundwater Level

Grab/composite sample

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF TEST PIT TP-3

Amend Park Turf Field
Billings, Montana

Logged by: Ahren Hastings, PE

Excavated by: Earth Surgeons
Volvo ECR 58D

February 4, 2019 B19-001

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SPOKANE WASHINGTON
LEWISTON IDAHO

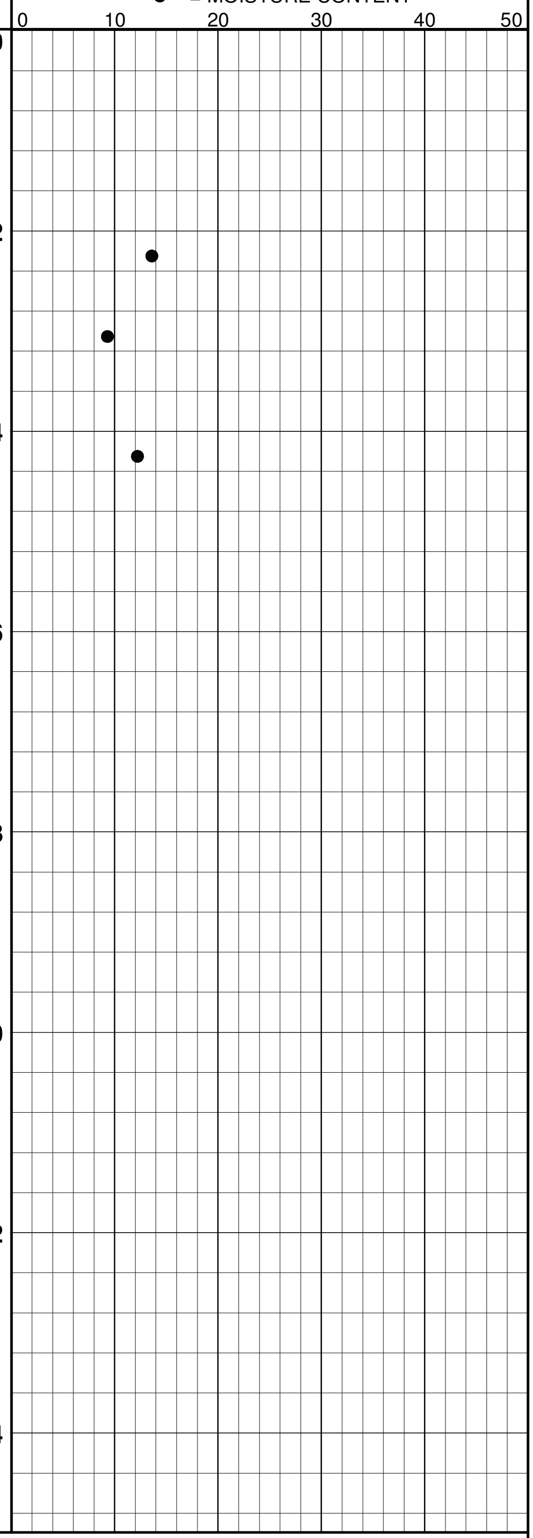
Figure No. 4

Sheet 1 of 1

GRAPHIC LOG	SURFACE: Sod SURFACE ELEVATION: Not Measured SOIL DESCRIPTION	DEPTH (FT) / GROUND WATER	SAMPLE	DEPTH (FT)
	TOPSOIL: Sandy Lean CLAY, appears firm, brown, frozen, organics	0.4		0
	Sandy Lean CLAY, appears firm, brown, frozen, organics, high sand content	1.5		
	Sandy SILT, appears loose, brown, moist, high sand content - Wet Density = 95.8 pcf, Dry Density = 87.7 pcf, Relative Compaction = 79%	8.2	G T G	2 4 6 8
	Bottom of Test Pit	Ground water not encoun- tered		10 12 14

MOISTURE CONTENT

● = MOISTURE CONTENT



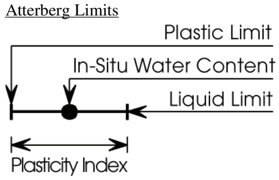
LEGEND

● Field Moisture content

▼ Groundwater Level

Grab/composite sample

Atterberg Limits



GNP = Granular and Nonplastic

Note: The stratification lines represent approximate boundaries between soil types. Actual boundaries may be gradual or transitional.

LOG OF TEST PIT TP-4

Amend Park Turf Field
Billings, Montana

Logged by: Ahren Hastings, PE

Excavated by: Earth Surgeons
Volvo ECR 58D

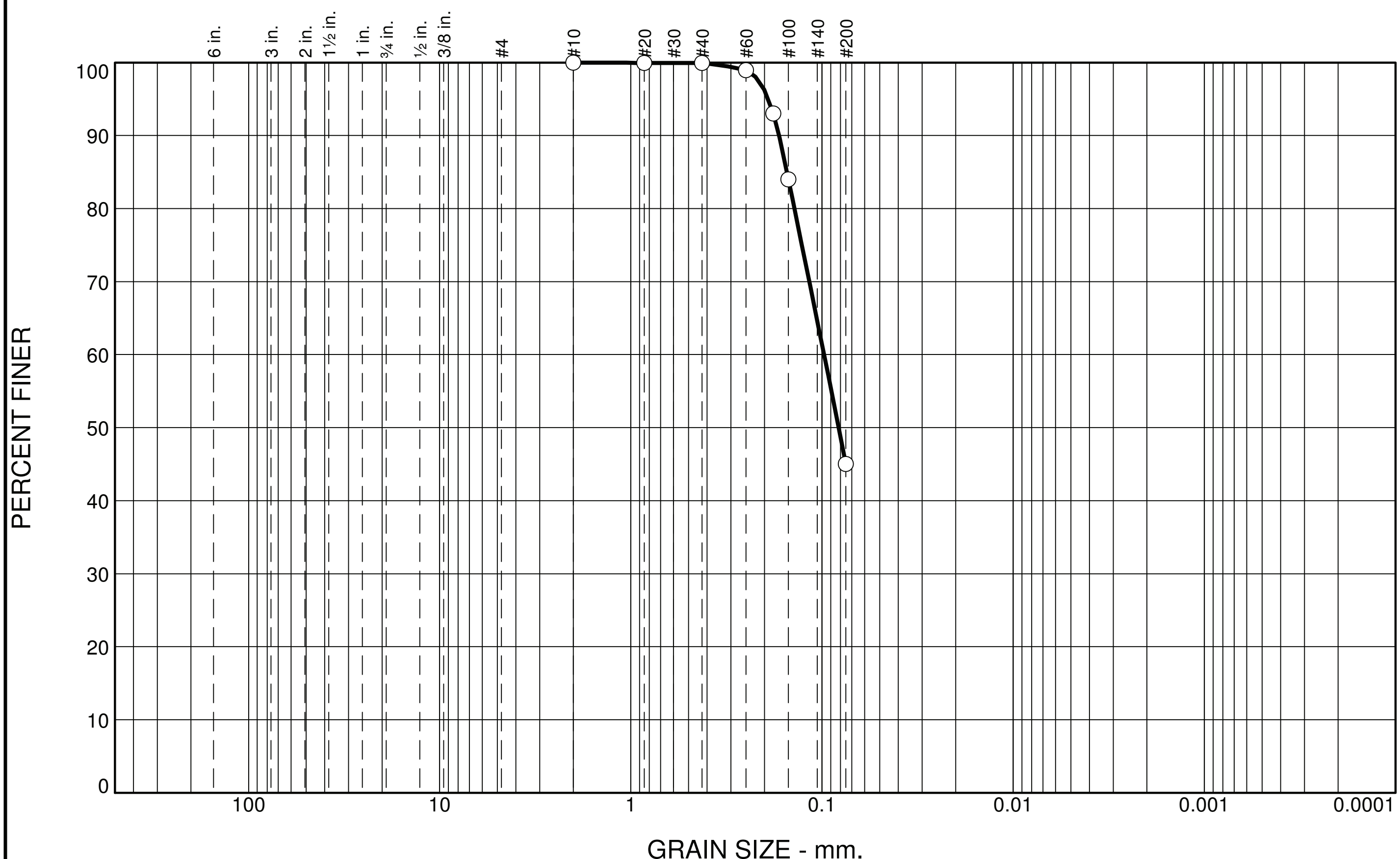
February 4, 2019 — B19-001

TD&H THOMAS, DEAN & HOSKINS, INC. ENGINEERING CONSULTANTS
GREAT FALLS–BOZEMAN–KALISPELL–HELENA MONTANA
SPOKANE WASHINGTON
LEWISTON IDAHO

Figure No. 5

Sheet 1 of 1

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.1	54.9	45.0	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	100.0		
#40	99.9		
#60	99.0		
#80	93.0		
#100	84.0		
#200	45.0		

* (no specification provided)

Soil Description

Clayey SAND

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.1680 D_{85}= 0.1528 D_{60}= 0.0977
D_{50}= 0.0819 D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= SC AASHTO=

Remarks

Report No. A-18973-206

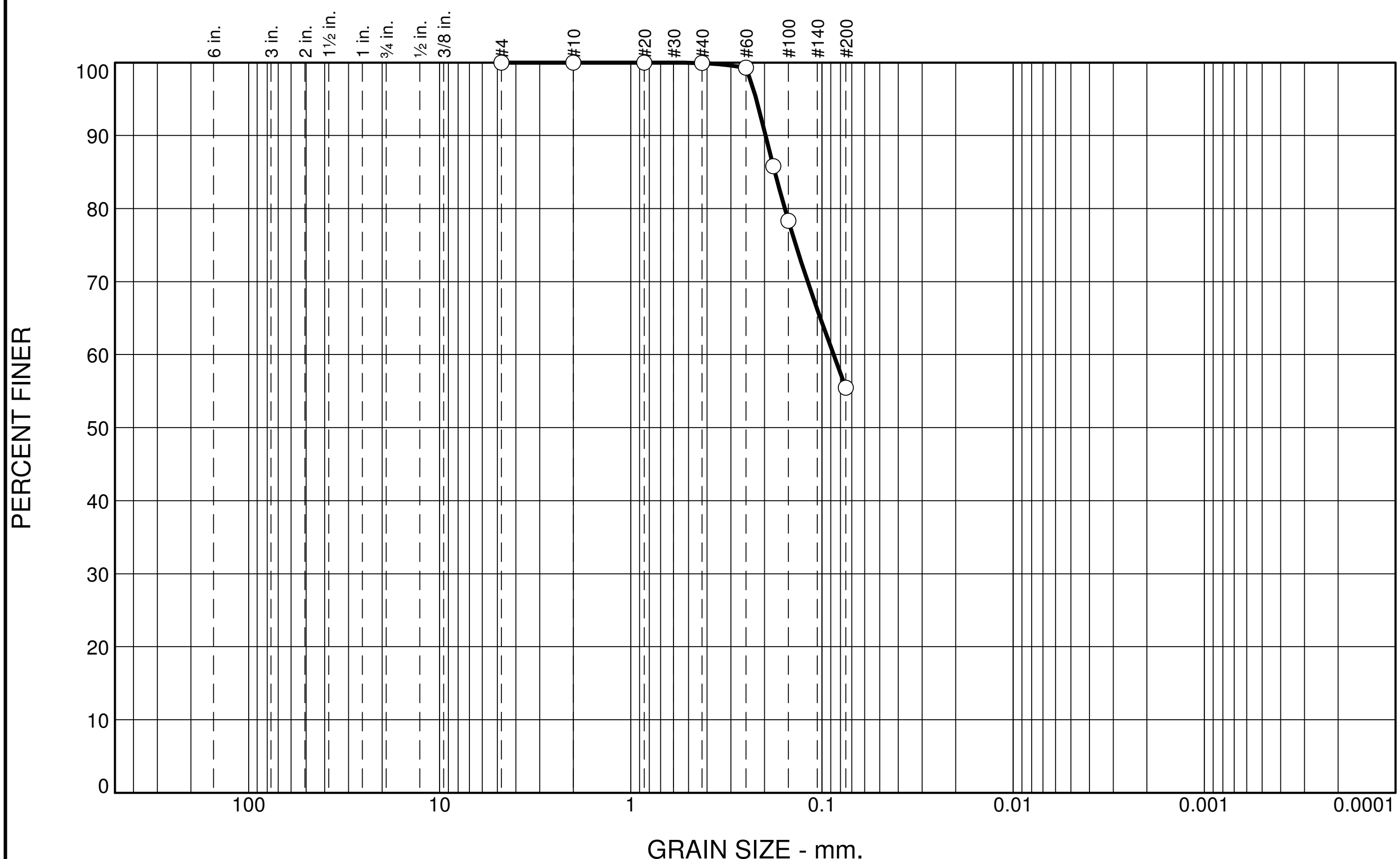
Location: TP-1
Sample Number: A-18973 **Depth:** 2.0 ft **Date:** 2-19-2019

TD&H Engineering
Thomas, Dean & Hoskins, Inc.
Engineering Consultants

Client: Fieldturf
Project: Amend Park Turf Field
Billings, Montana
Project No: B19-001 **Figure** 6

Tested By: JS **Checked By:** ______

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.1	44.4	55.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#4	100.0		
#10	100.0		
#20	100.0		
#40	99.9		
#60	99.3		
#80	85.8		
#100	78.3		
#200	55.5		

* (no specification provided)

Soil Description

Sandy SILT

Atterberg Limits

PL= 20 LL= 21 PI= 1

Coefficients

D_{90}= 0.1972 D_{85}= 0.1767 D_{60}= 0.0871
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= ML AASHTO= A-4(0)

Remarks

Report No. A-18981-206

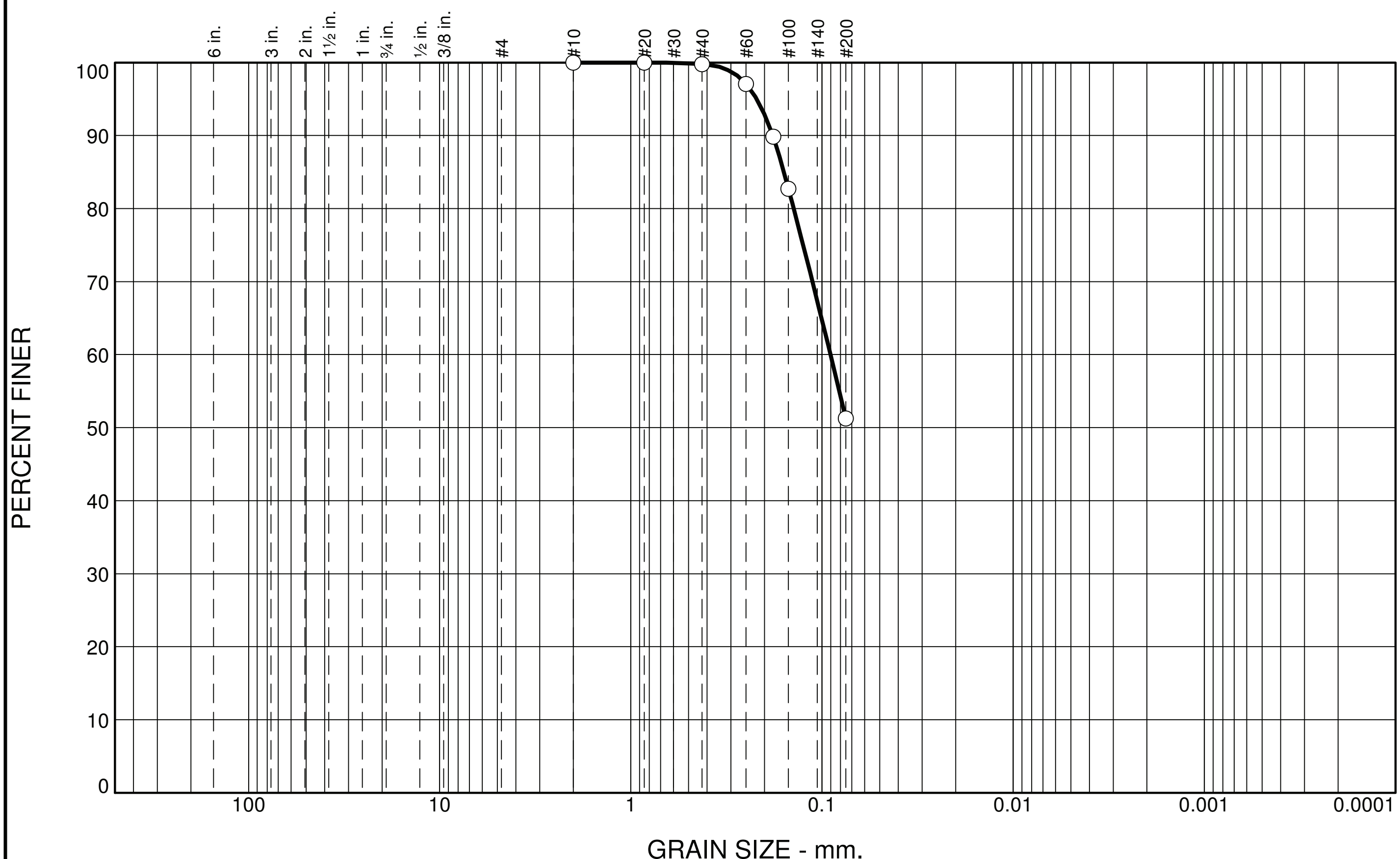
Location: TP-3
Sample Number: A-18981 **Depth:** 3.0 - 4.0 ft **Date:** 2-14-2019

TD&H Engineering
Thomas, Dean & Hoskins, Inc.
Engineering Consultants

Client: Fieldturf
Project: Amend Park Turf Field
Billings, Montana
Project No: B19-001 **Figure** 7

Tested By: WJC **Checked By:** ________________

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	0.0	0.0	0.2	48.5	51.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
#10	100.0		
#20	100.0		
#40	99.8		
#60	97.1		
#80	89.8		
#100	82.7		
#200	51.3		

* (no specification provided)

Soil Description

Sandy SILT

Atterberg Limits

PL= LL= PI=

Coefficients

D_{90}= 0.1810 D_{85}= 0.1585 D_{60}= 0.0904
D_{50}= D_{30}= D_{15}=
D_{10}= C_u= C_c=

Classification

USCS= ML AASHTO=

Remarks

Report No. A-18980-206

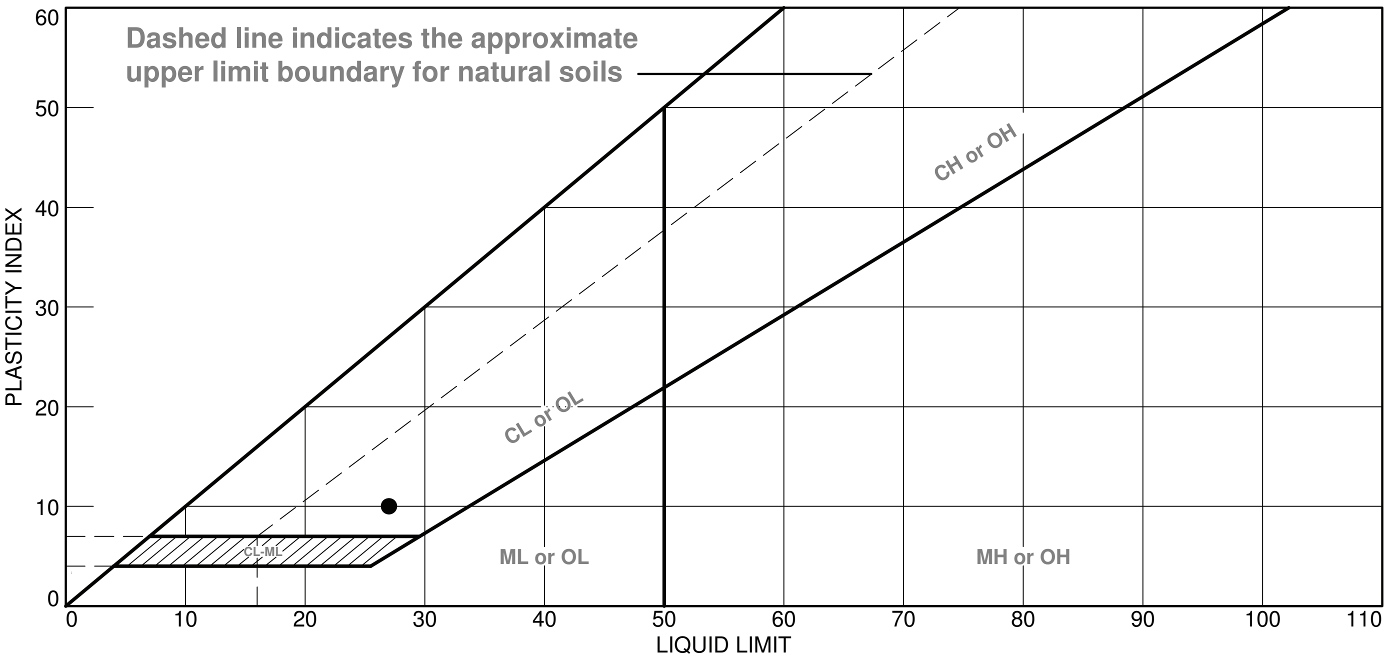
Location: TP-4
Sample Number: A-18980 **Depth:** 4.0 ft **Date:** 2-19-2019

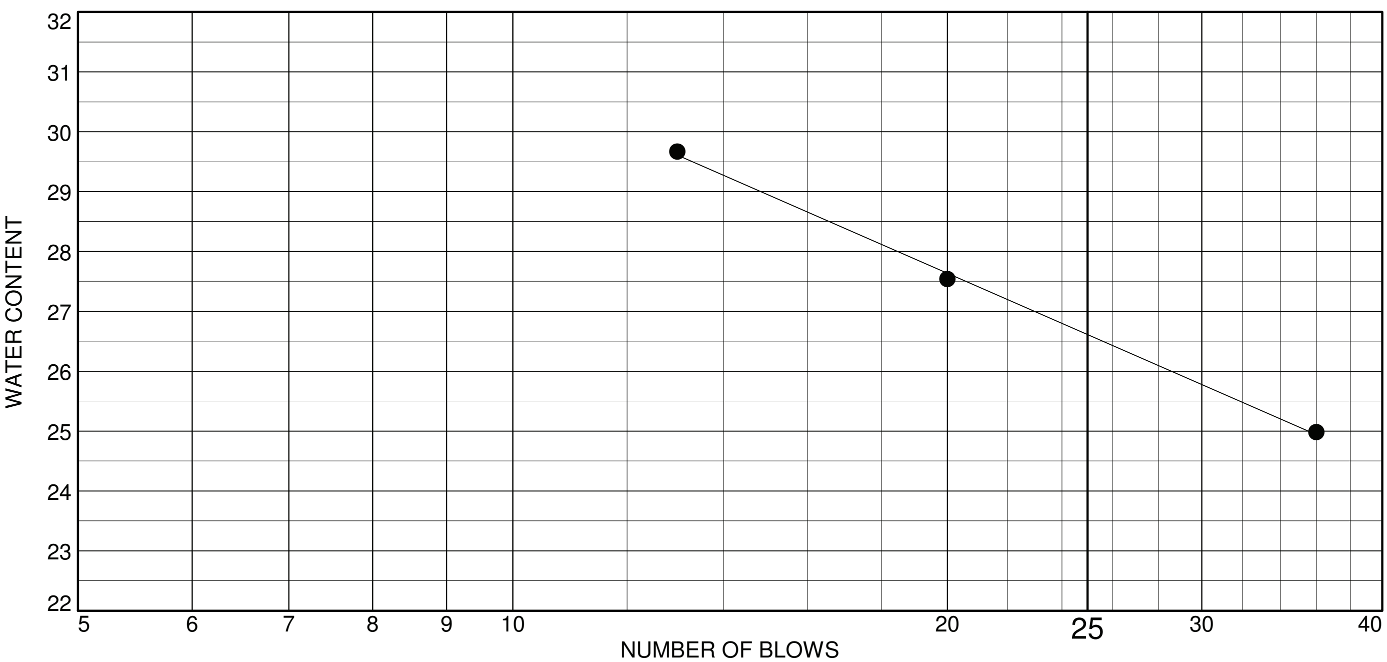
TD&H Engineering
Thomas, Dean & Hoskins, Inc.
Engineering Consultants

Client: Fieldturf
Project: Amend Park Turf Field
Billings, Montana
Project No: B19-001 **Figure** 8

Tested By: JS **Checked By:** ______

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Clayey SAND	27	17	10			SC

Project No. B19-001 **Client:** Fieldturf

Project: Amend Park Turf Field

Billings, Montana

Location: TP-2

Sample Number: A-18976 **Depth:** 4.0 ft

TD&H Engineering Thomas, Dean & Hoskins, Inc. Engineering Consultants

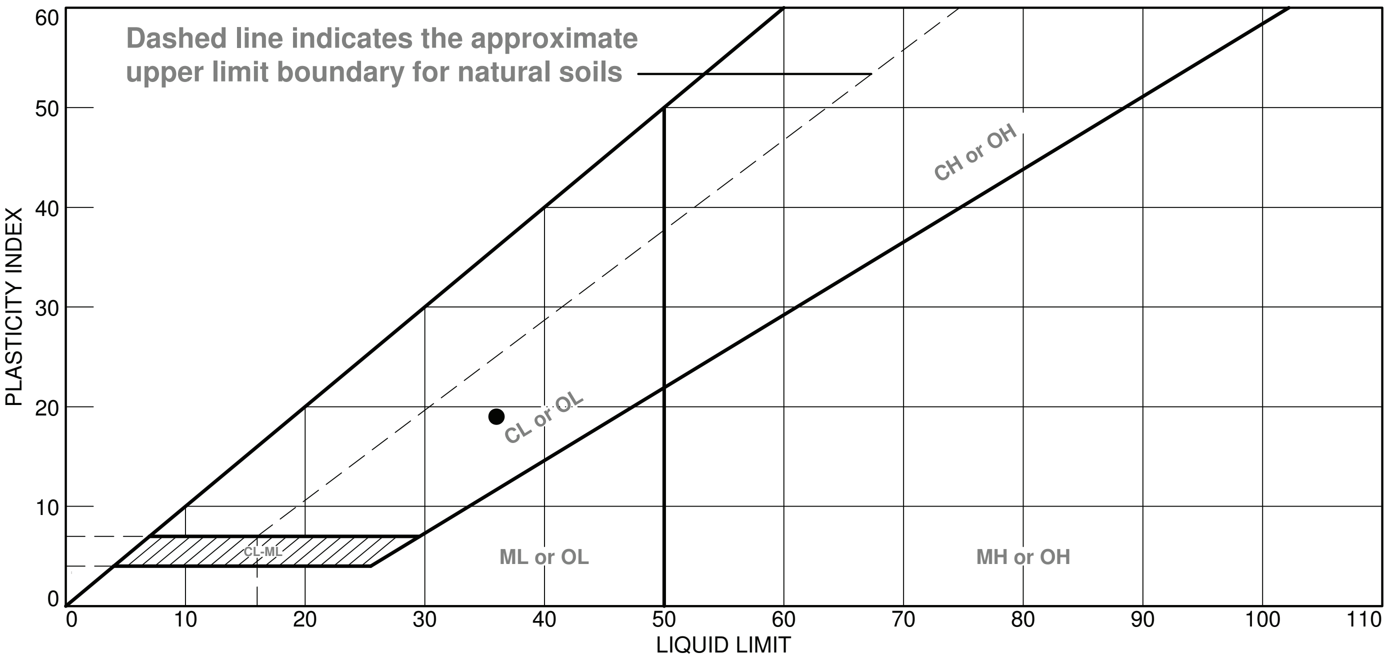
Remarks:

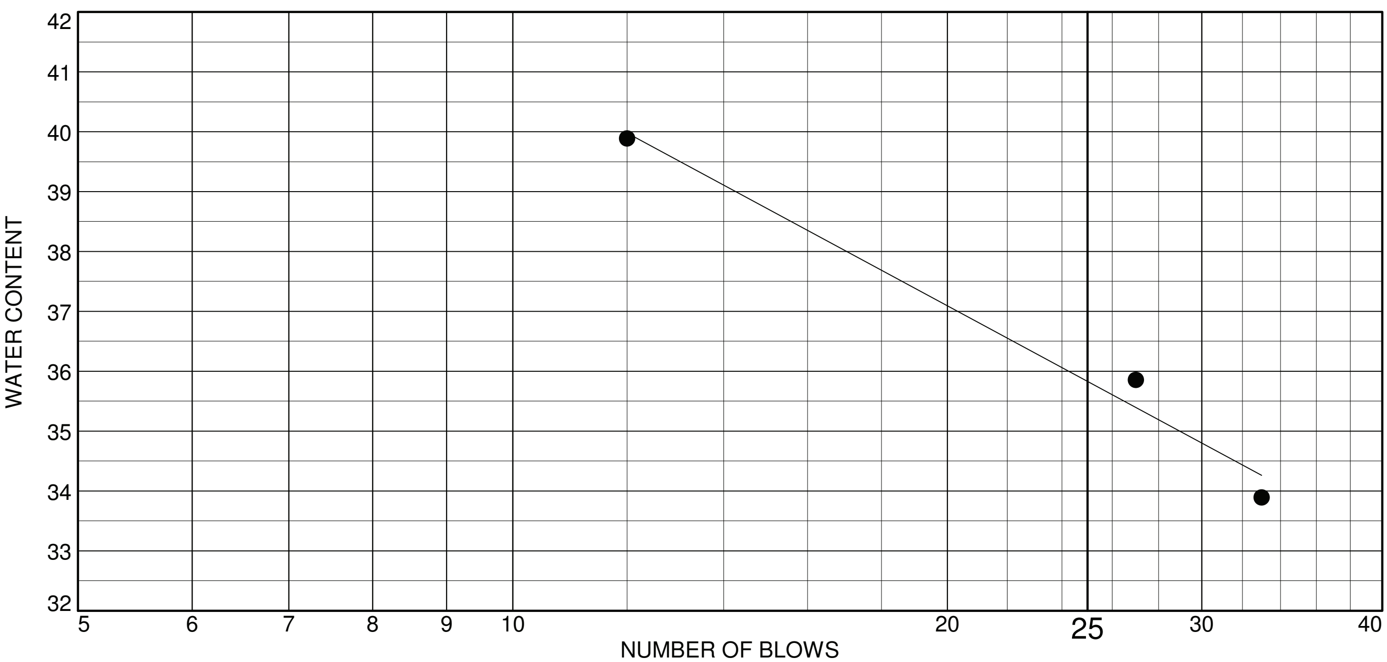
● Report No. A-18976-207
Date: 2-19-2019

Figure 9

Tested By: JS **Checked By:**

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Sandy Lean CLAY	36	17	19			CL

Project No. B19-001 **Client:** Fieldturf

Project: Amend Park Turf Field

Billings, Montana

Location: TP-3

Sample Number: A-18977 **Depth:** 2.0 ft

TD&H Engineering

Thomas, Dean & Hoskins, Inc.
Engineering Consultants

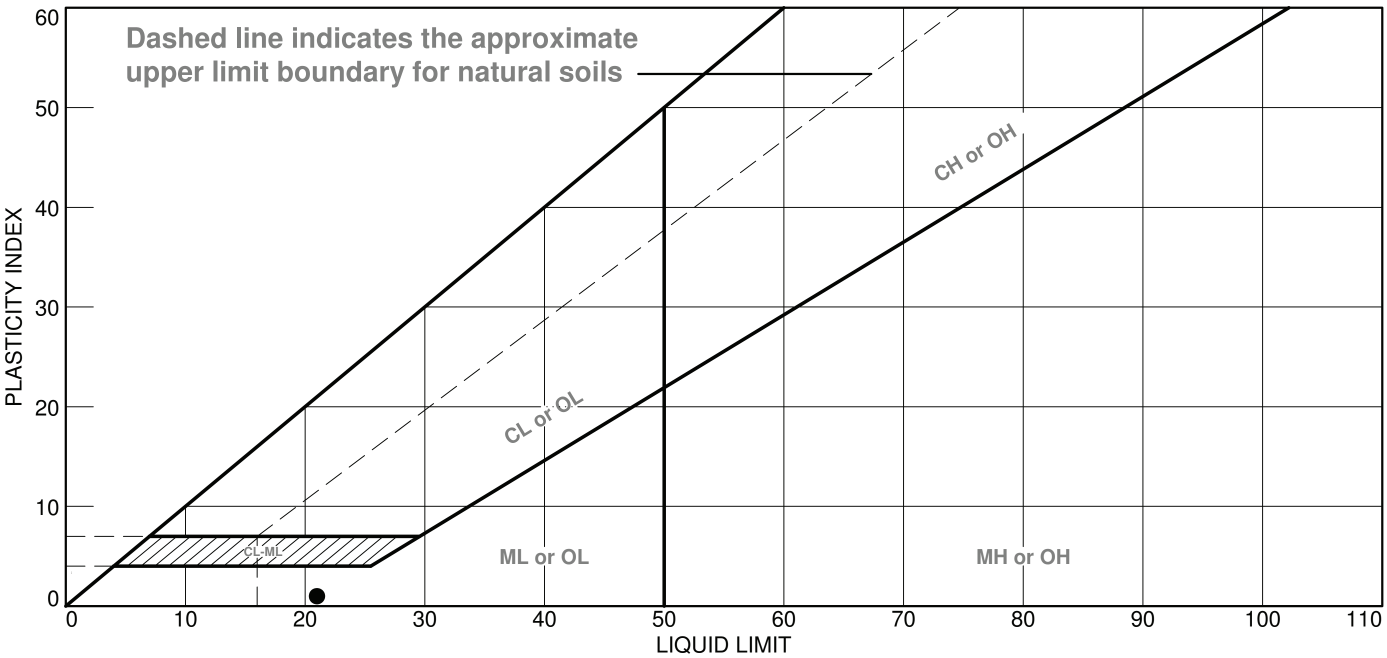
Remarks:

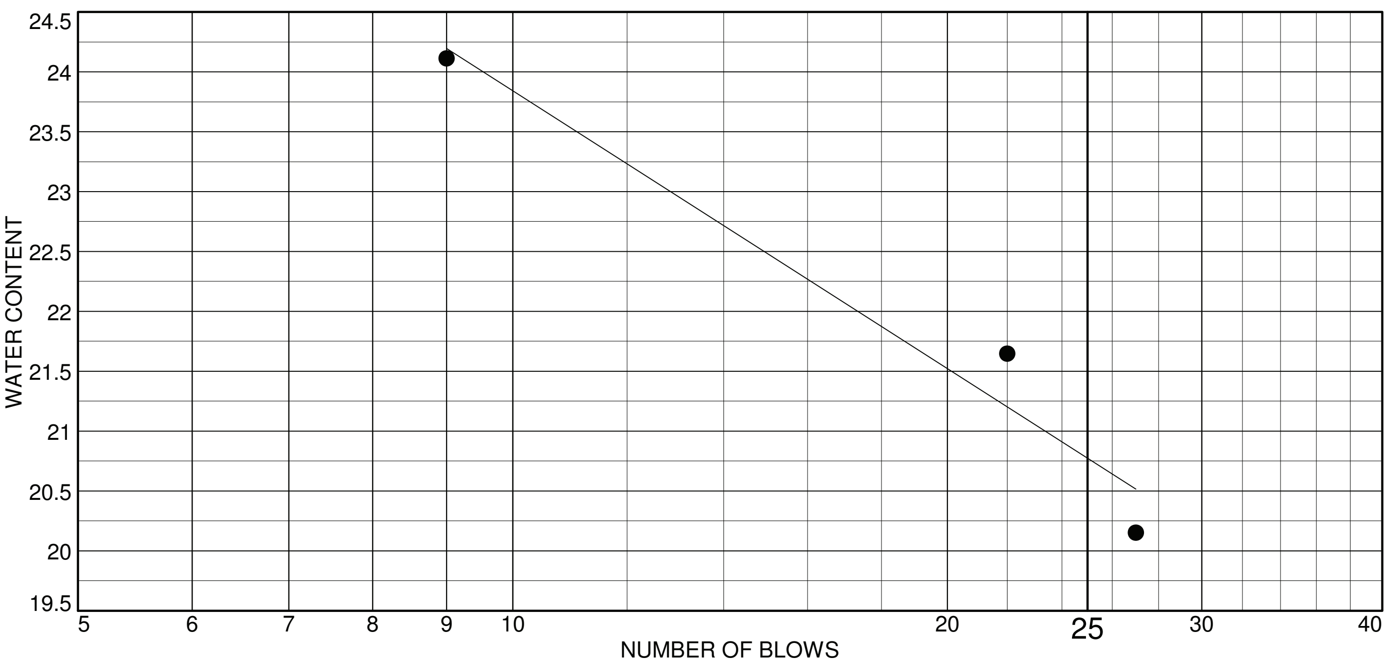
● Report No. A-18977-207
Date: 2-19-2019

Figure 10

Tested By: JS **Checked By:**

LIQUID AND PLASTIC LIMITS TEST REPORT





	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Sandy SILT	21	20	1	99.9	55.5	ML

Project No. B19-001 **Client:** Fieldturf

Project: Amend Park Turf Field

Billings, Montana

Location: TP-3

Sample Number: A-18981 **Depth:** 3.0 - 4.0 ft

TD&H Engineering

Thomas, Dean & Hoskins, Inc.
Engineering Consultants

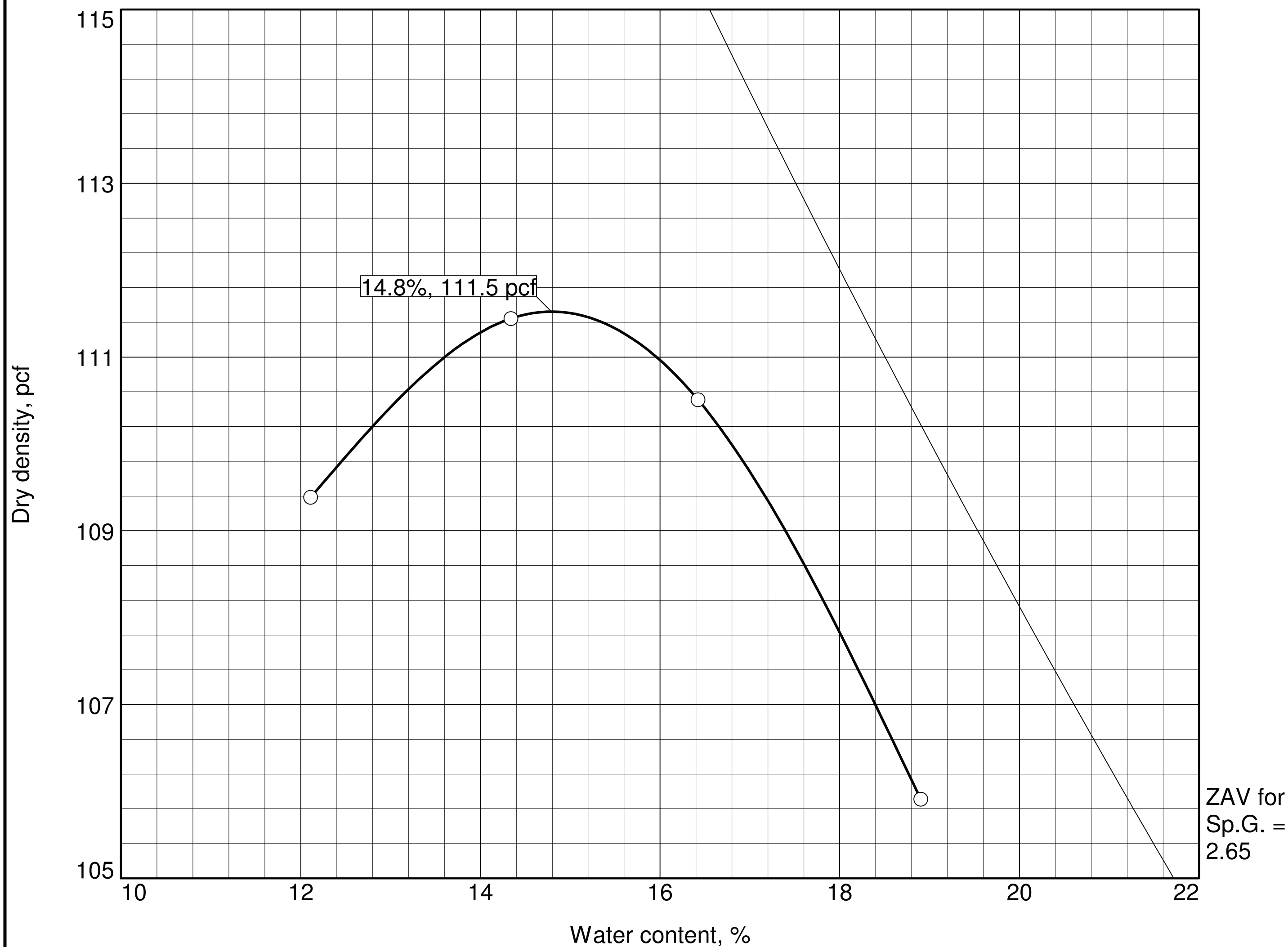
Remarks:

● Report No. A-18981-207
Date: 2-15-2019

Figure 11

Tested By: JS **Checked By:**

Moisture-Density Test Report



Test specification: ASTM D 698-12 Method A Standard

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > #4	% < No.200
	USCS	AASHTO						
3.0 - 4.0 ft	ML	A-4(0)		2.65	21	1	0.0	55.5

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 111.5 pcf Optimum moisture = 14.8 %	Sandy SILT

Project No. B19-001 **Client:** Fieldturf
Project: Amend Park Turf Field
Billings, Montana
○ **Location:** TP-3 **Sample Number:** A-18981

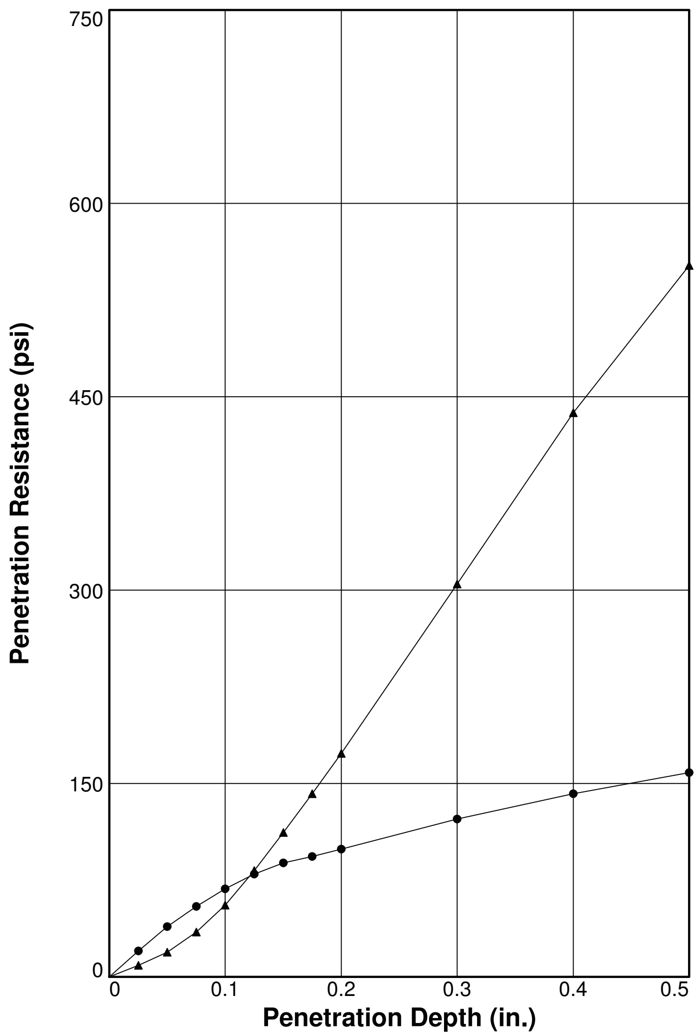
TD&H Engineering — Thomas, Dean & Hoskins, Inc. Engineering Consultants

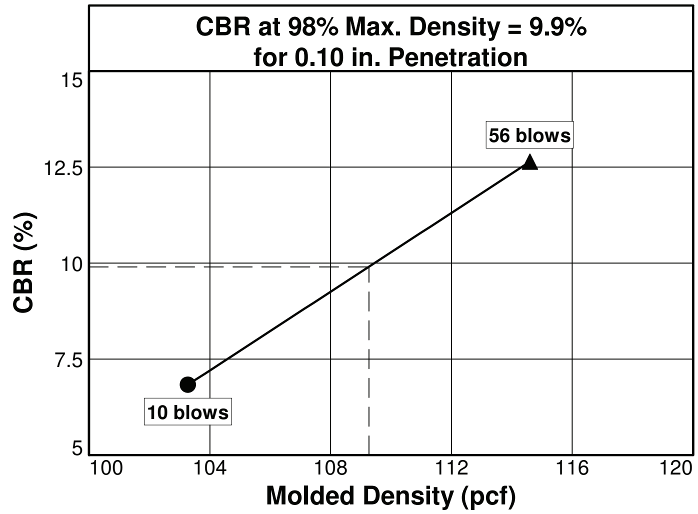
Remarks:
Report No. A-18981-204
Date: 2-14-2019

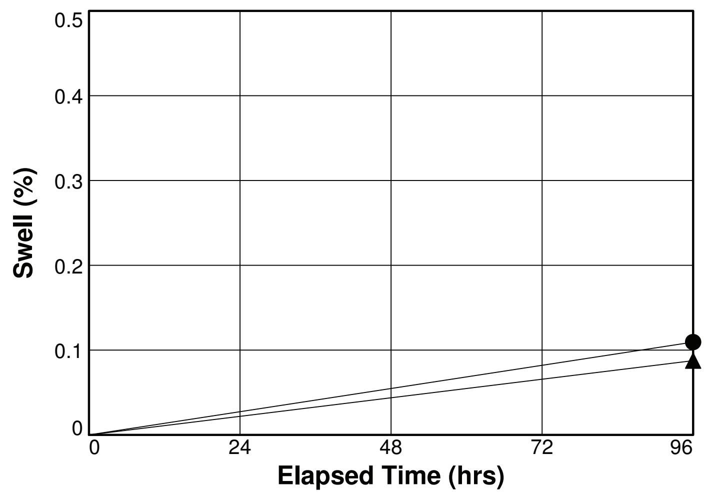
Figure 12

Tested By: WJC **Checked By:** ____________

BEARING RATIO TEST REPORT
ASTM D 1883-07







	Molded			Soaked			CBR (%)		Linearity Correction (in.)	Surcharge (lbs.)	Max. Swell (%)
	Density (pcf)	Percent of Max. Dens.	Moisture (%)	Density (pcf)	Percent of Max. Dens.	Moisture (%)	0.10 in.	0.20 in.			
1 ○	103.3	92.6	13.9	103.2	92.5	19.1	6.8	6.6	0.000	10	0.1
2 △	114.6	102.8	13.9	114.5	102.7	14.9	12.6	17.0	0.062	10	0.1
3 □											

Material Description	USCS	Max. Dens. (pcf)	Optimum Moisture (%)	LL	PI
Sandy SILT	ML	111.5	14.8	21	1

Project No: B19-001

Project: Amend Park Turf Field Billings, Montana

Location: TP-3

Sample Number: A-18981 **Depth:** 3.0 - 4.0 ft

Date: 2-14-2019

Test Description/Remarks:

ASTM D698 with 6-inch Mold
96-hour soak prior to testing

Report No. A-18981-210
Date: 2-22-2019

TD&H Engineering
Thomas, Dean & Hoskins, Inc.
Engineering Consultants

Figure 13

Report of Soil Unit Weight (SOP- 213)

Thomas, Dean, & Hoskins
1800 River Drive North
Great Falls, Montana 59401

Client:	**Fieldturf**	**Report Number:**	A-18982-213
Address:	903 N Opdyke Rd, Suite A1	**Report Date:**	2/20/2019
	Auburn Hills, MI 48326	**Project:**	Amend Park Turf
		Project Number:	B19-001-001
Attn:	**Ms. Lisa Rosauer**	**Test Method:**	ASTM D-2950, D-3017
		Technician:	CRN
		Test Date:	2/15/2019
		Sample Interval:	TP-4 (2.0 - 4.0 ft)

Sample #	Location	Diameter (in.)	Height (in.)	Volume (ft^3)	Container #	Container Weight	Wet Soil & Container (g)	Dry Soil & Container (g)	% Moisture	Wet Density, lbs/ ft^3	Dry Density,lbs / ft^3
A-18982	TP-4 (2.0 - 4.0 ft)	2.875	15.813	0.059	X	656.9	3133.2	2922.1	9.3	95.8	87.7

Deviations From Test Methods: ______________________

Figure: 14

Remarks: ______________________

Peter Klevberg, P.E.
Laboratory Manager

MONTANA WELL LOG REPORT

This well log reports the activities of a licensed Montana well driller, serves as the official record of work done within the borehole and casing, and describes the amount of water encountered. This report is compiled electronically from the contents of the Ground Water Information Center (GWIC) database for this site. Acquiring water rights is the well owner's responsibility and is NOT accomplished by the filing of this report.

Other Options

Return to menu
Plot this site in State Library Digital Atlas
Plot this site in Google Maps
View scanned well log (7/21/2006 1:50:09 PM)

Site Name: CITY OF BILLINGS
GWIC Id: 151383
DNRC Water Right: 93009

Section 1: Well Owner(s)

1) CITY OF BILLINGS*HINK MIKE (MAIL)
PO BOX 1178 BILLINGS
N/A N/A N/A [07/06/1995]

Section 2: Location

Township	Range	Section	Quarter Sections
01S	26E	8	SW¼ SE¼

County	Geocode
YELLOWSTONE	

Latitude	Longitude	Geomethod	Datum
45.757158	-108.543495	TRS-SEC	NAD83

Ground Surface Altitude	Ground Surface Method	Datum	Date

Addition	Block	Lot
AMEND PARK		

Section 3: Proposed Use of Water

IRRIGATION (1)

Section 4: Type of Work

Drilling Method: ROTARY
Status: NEW WELL

Section 5: Well Completion Date

Date well completed: Thursday, July 06, 1995

Section 6: Well Construction Details

There are no borehole dimensions assigned to this well.

Casing

From	To	Diameter	Wall Thickness	Pressure Rating	Joint	Type
-2	38.1	8				STEEL

Completion (Perf/Screen)

From	To	Diameter	# of Openings	Size of Openings	Description
31	38.1	8			SCREEN

Annular Space (Seal/Grout/Packer)

From	To	Description	Cont. Fed?
0	19	BENTONITE	

Section 7: Well Test Data

Total Depth: 42
Static Water Level: 17.16
Water Temperature:

Air Test *

125 gpm with drill stem set at _ feet for 8 hours.
Time of recovery _ hours.
Recovery water level _ feet.
Pumping water level 25.1 feet.

** During the well test the discharge rate shall be as uniform as possible. This rate may or may not be the sustainable yield of the well. Sustainable yield does not include the reservoir of the well casing.*

Section 8: Remarks

Section 9: Well Log

Geologic Source

111TRRC - TERRACE DEPOSITS (HOLOCENE)

From	To	Description
0	2	TOPSOIL
2	20	CLAY W/ SANDS SILTS
20	42	SAND GRAVEL 39-42' PURE SAND SHALE

Driller Certification

All work performed and reported in this well log is in compliance with the Montana well construction standards. This report is true to the best of my knowledge.

Name:	
Company:	PRO PUMP & EQUIPMENT INC
License No:	WWC-532
Date Completed:	7/6/1995

TD&H Engineering Consultants
Great Falls, Kalispell, Bozeman, MT
Spokane, WA; Lewiston, ID, Watford City, ND

SOIL CLASSIFICATION AND SAMPLING TERMINOLOGY FOR ENGINEERING PURPOSES

STANDARD PENETRATION TEST (ASTM D1586)

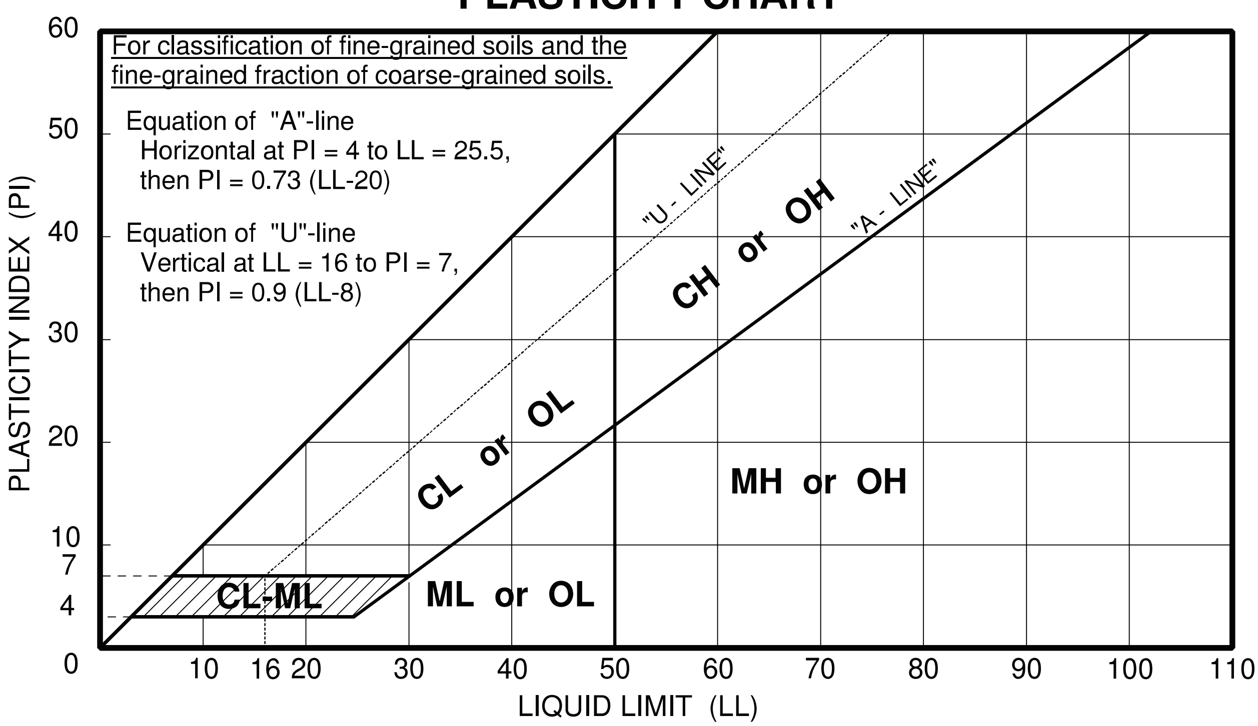
RELATIVE DENSITY*		RELATIVE CONSISTENCY*	
Granular, Noncohesive (Gravels, Sands, & Silts)	Standard Penetration Test (blows/foot)	Fine-Grained, Cohesive (Clays)	Standard Penetration Test (blows/foot)
Very Loose	0-4	Very Soft	0-2
Loose	5-10	Soft	3-4
Medium Dense	11-30	Firm	5-8
Dense	31-50	Stiff	9-15
Very Dense	+50	Very Stiff	15-30
		Hard	+30

* Based on Sampler-Hammer Ratio of 8.929 E-06 ft/lbf and 4.185 E-05 ft^2/lbf for granular and cohesive soils, respectively (Terzaghi)

PARTICLE SIZE RANGE

Sieve Openings (Inches)					Standard Sieve Sizes		
12"	3"	3/4"	No.4	No.10	No.40	No.200	<No.200
BOULDERS	COBBLES	GRAVELS		SANDS			SILTS & CLAYS
		Coarse	Fine	Coarse	Medium	Fine	(Distinguished By Atterberg Limits)

PLASTICITY CHART



GW - Well-graded GRAVEL
GP - Poorly-graded GRAVEL
GM - Silty GRAVEL
GC - Clayey GRAVEL

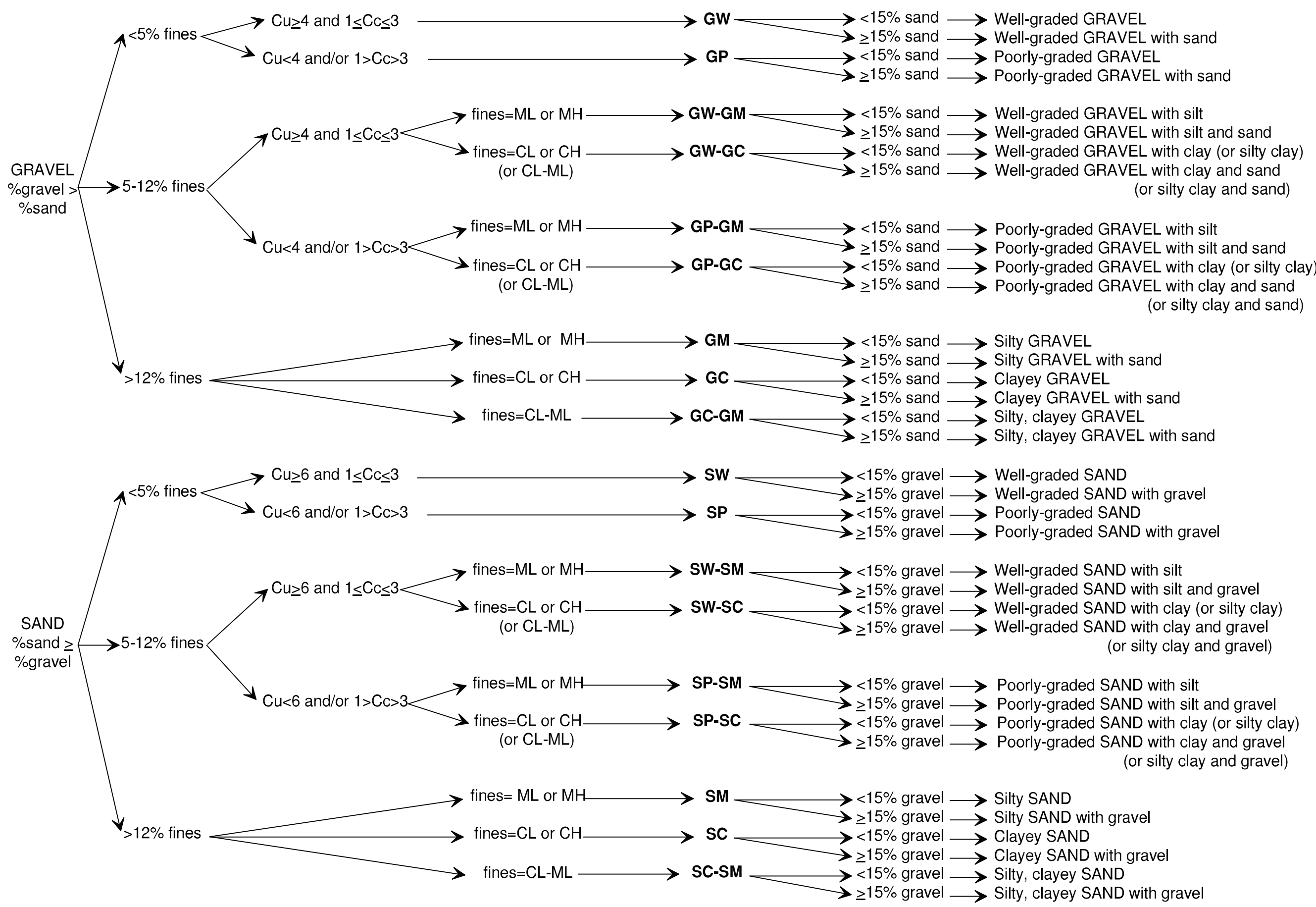
SW - Well-graded SAND
SP - Poorly-graded SAND
SM - Silty SAND
SC - Clayey SAND

CL - Lean CLAY
ML - SILT
OL - Organic SILT/CLAY
CH - Fat CLAY
MH - Elastic SILT
OH - Organic SILT/CLAY

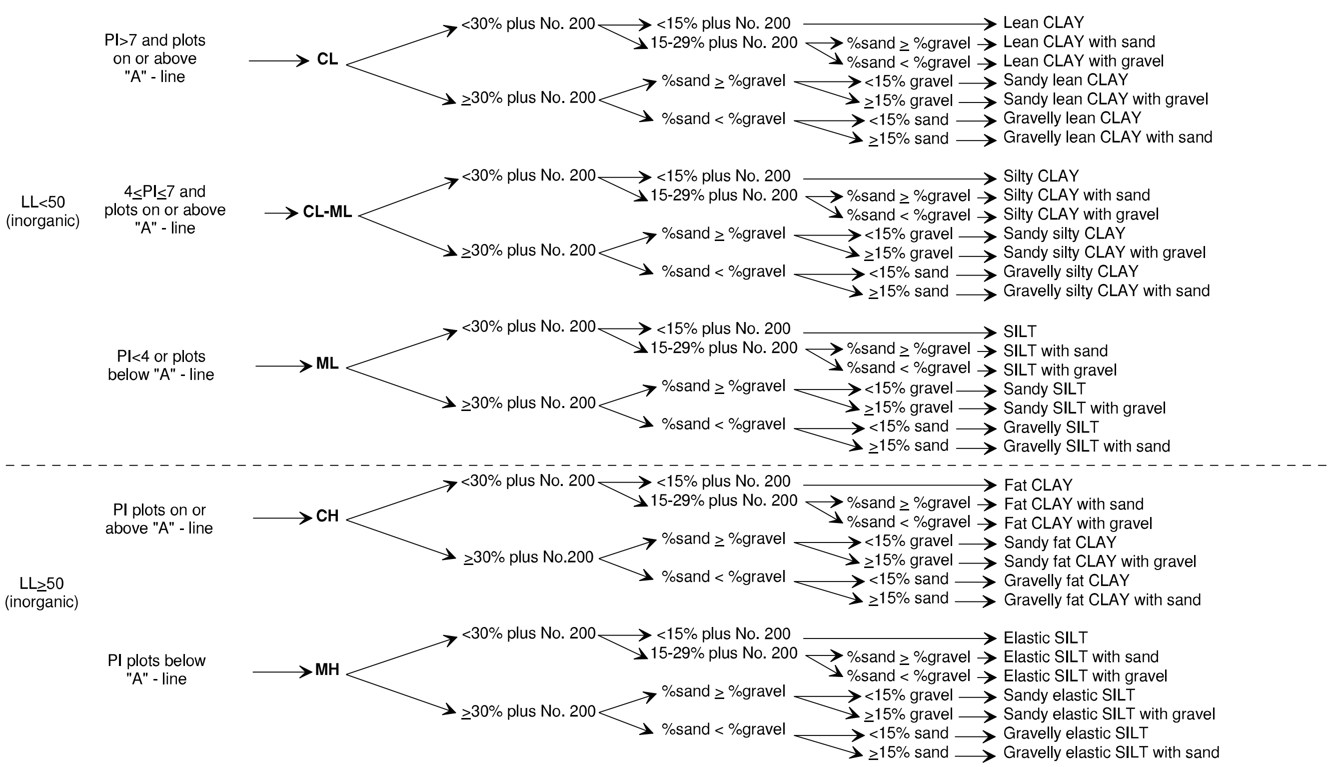
TD&H Engineering Consultants

Great Falls, Kalispell, Bozeman, MT
Spokane, WA; Lewiston, ID, Watford City, ND

ASTM D2487 CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES



Flow Chart For Classifying Coarse-Grained Soils (More Than 50 % Retained On The No. 200 Sieve)



Flow Chart For Classifying Fine-Grained Soils (50 % Or More Passes The No. 200 Sieve)

03/98