May 11, 2021

Performance Engineering & Consulting Attn: Mr. Robbie Neihart, P.E. 608 North 29<sup>th</sup> Street Billings, Montana 59101

#### RE: PRELIMINARY GEOTECHNICAL INVESTIGATION REPORT BITTERROOT HEIGHTS SUBDIVISION, 3<sup>rd</sup> FILING BILLINGS, MONTANA

Dear Mr. Neihart,

We are pleased to present this preliminary geotechnical investigation report for Bitterroot Heights Subdivision, 3<sup>rd</sup> Filing. The proposed development is located west of Bitterroot Heights Subdivision, 1<sup>st</sup> and 2<sup>nd</sup> Filing. The report describes site conditions and presents conclusions and recommendations to support design and construction.

As building plans and design elevations are developed, we are available to discuss our recommendations and possible alternatives. If you have any questions about this report, or if we may provide other services, please contact us.

Best Regards,



Jordan L. Grover, PE Enc: Report

Speg S. Vier

Greg S. Vick, PG

## BITTERROOT HEIGHTS SUBDIVISION, 3<sup>rd</sup> FILING PRELIMININARY GEOTECHNICAL INVESTIGATION REPORT BILLINGS, MONTANA

**Prepared for:** 

Performance Engineering & Consulting 608 North 29<sup>th</sup> Street Billings, Montana 59101

**Prepared by:** 

# **GEOSCIENCE**, PLLP

GEOTECHNICAL ENGINEERING & GEOLOGY 2728 GREGORY DRIVE NORTH BILLINGS, MONTANA 59102

May 11, 2021

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### 1.0 SUMMARY

GEOSCIENCE conducted a preliminary geotechnical site investigation for the proposed 3<sup>rd</sup> Filing of Bitterroot Heights Subdivision in Billings, Montana. Approximately 73 new residential lots are planned. Roadways and buried utilities will also be developed. See Figures 1 and 2.

Final lot layout and building envelopes/elevations are unknown at this time. We have assumed single-family residences with foundation loads on the order of 2 kips per lineal foot on perimeter footings are planned. As construction details become available, this office shall review and potentially modify our design assumptions or recommendations.

Historic mining operations at the site include sand and gravel extraction, material screening and washing, heavy equipment use and maintenance, and discarding materials as uncontrolled fill; including soil, washed fines, and organics; and demolition concrete, asphalt, metal, and other materials. Uncontrolled fill with varying amounts of debris and rubbish was encountered in most of the test holes in the south, central, and west portions of the site.

Wash and screening operations were apparently used to separate and process sand and gravel products and remove fine-sand, silt and clay fractions. Uncontrolled fill consisting of soft and loose washed sand, silt, and clay was observed mostly in the west portion of the site. Uncontrolled fill depths across the site generally range from about 2 feet to greater than 10 feet.

Aggregate mining operation methods in the area typically consist of mining/removing sandy gravel with cobble deposits down to the underlying shale bedrock. Shale bedrock was encountered below the uncontrolled fill in numerous test pits, especially in south and central portions of the site. Presumably, the base of the historic gravel pit and extent of mining coincides roughly with the shale bedrock surface.

Mining operations at the site also appear to include groundwater mitigation and seepage control, as evident by swales and drainages crossing the site. Water infiltrating through the permeable sand and gravel deposits and groundwater flow from offsite sources "perches" on the underlying low permeability shale bedrock. The perched groundwater then accumulates or migrates laterally as drainage allows. Modifications, impediments, or failure to maintain the existing drainage features may alter flow paths and cause changes in groundwater elevation across the site. Deep basements are not recommended for the development and owners and contractors shall plan for the potential of shallow, perched groundwater if below-grade habitable-space is considered.

Groundwater was encountered at relatively shallow depths of about 4 to 8 feet across the site during the field investigation in spring of 2021. Soil moisture conditions are expected to fluctuate in response to seasonal precipitation, runoff, snowmelt, and irrigation. Some dewatering may be required for utility installations and placement of structural fill.

Post-mining activities at the site include surface grading and smoothing of the previously mined terrain with un-used "clean" sandy gravel with cobble and also uncontrolled fill with debris. More recently, placement of large quantities of uncontrolled fill in east-central portions of the site on top of the regraded surface are likely the result of nearby construction activity.

It appears further significant site grading is planned as part of the development, particularly in the east-central and north portions of the site. The large uncontrolled fill piles will likely be re-graded and areas of fill are anticipated in east and north portions of the site. Based on our observations cut and fill areas may be on the order of 10 to 15 feet in some areas.

Due to the extensive site modifications from both historic mining operations and proposed cut/fill and regrading, subsurface conditions across the site shall be anticipated to change abruptly over relatively short distances and depths. Foundation subgrade improvement or deep foundations shall be anticipated for all building sites. Figure 3 in Appendix A illustrates anticipated subsurface conditions across the site in generalized Zones A through E that are discussed below:

**Zone A – Regraded and Fill Area (south–south central);** Subsurface conditions generally consist of varying depth (roughly 2 to 8 feet) of uncontrolled fill overlying clean sandy gravel with cobble pit backfill (coarse-grained alluvium) and then shale bedrock at depth. The uncontrolled fill consists of clay, sand, and gravel with varying amounts of dark organic material, asphalt, concrete, sandstone, brick and other debris. The uncontrolled fill is loose/soft and compressible.

**Zone B – Existing Shop Area.** Crews were razing the existing shop structure during our field investigation. Subsurface conditions are unknown and shall be verified. Uncontrolled fill, building debris and potentially deeper buried tanks or sumps may be anticipated in this area.

**Zone C – Demolition Debris and Rubbish with Washed Fine-Grained Sediments (west-westcentral).** Extensive demolition debris including concrete, asphalt, and metal were observed. The debris appear uncontrolled and uncompacted with voids. Zone C also includes subsurface conditions consisting of washed fines including fine-sand, silt and clay from previous sand and gravel processing. The washed fine-grained sediments are very loose or soft and are compressible.

**Zone D** – **Uncontrolled Fill Stockpile Area (east–east central).** Large stockpiles of uncontrolled fill are present and will presumably be used to regrade and fill lower elevations across the east and north portions of the site. The stockpiles are uncontrolled fill containing variable materials. Subsurface conditions below the stockpiles are unknown and shall be verified.

**Zone E – Drainages and Lower Elevations (east and north).** Drainage ways east of the uncontrolled stockpile referenced in Zone D are considerably lower in elevation and appear as possible fill areas on preliminary site plans. It is anticipated 10 feet or more of fill may be placed in these areas. Areas north of the historic gravel pit and north of Strapper Lane appear to consist of in-place, native fine-grained clayey soils of Five-Mile Creek alluvium. The north area is crossed by incised drainages and swales that will possibly be filled with 5 to 10 feet of material to achieve

design grades. After extensive re-grading in these areas, site specific subsurface condition shall be verified prior to foundation construction.

Where uncontrolled fill thicknesses are relatively thin and underlain by sandy gravel with cobble soils, generally, more modest homes with lighter foundations loads and less elaborate foundation geometry have been constructed using over-excavation and replacement with compacted structural fill.

Deep foundations shall be considered where uncontrolled fill thicknesses become extensive or where groundwater elevations prevent over-excavation and replacement in dry conditions. These methods may include driven or drilled piles or piers extending to deeper bearing stratum; and are typically used when the tolerance for foundation movement is more stringent, foundation loads are increased, or the magnitude of the homes are commensurate with more elaborate foundation systems. Typically, deep foundation systems provide the more reliable long-term performance and should be considered as a feasible option.

Based on the owner's acceptable level of risk and desired structural performance, over-excavation and replacement with compacted structural fill may be more economical; however, slab and foundation performance will depend on excavation depth and uncontrolled fill thickness, foundation loading and the owner's ability to control water and maintain existing soil moisture conditions.

Over-excavation and replacement with compacted structural fill may be unfeasible where excavation depths are near groundwater elevations or soils are saturated due to capillary rise (likely depth of 4 to 6 feet). If habitable space below grade is planned, seepage into lower elevations of the home may be expected periodically over the design life of the homes.

Foundation problems in the vicinity of the project are almost without exception related to the introduction of water to soils below footings or slabs or improper treatment and mitigation of uncontrolled fill. Control of water including landscape irrigation, rain gutter downspouts, buried water lines, and surface runoff is critical. Based on our experience, the following critical points regarding foundation construction and water management are emphasized. This report should be passed on to design professionals, building contractors, and future property owners so that they will be alerted to potential hazards discussed herein.

- If soils in the foundation excavations become wet or frozen during construction, the wet or frozen material must be removed. Exposed foundations should be protected against freezing ground conditions.
- Excessive wetting during construction is a common cause of foundation distress. Excavated soils should be placed around the excavation to prevent storm runoff or other surface water from flowing into the excavation during construction.
- Exterior backfills must be compacted and sloped to drain away from structures. Runoff should be discharged away from the proposed and adjacent structures.

• Irrigation is strongly discouraged within 6 feet of the buildings. Over irrigation must be avoided. Underground irrigation systems should be pressure tested when installed and checked periodically for leaks.

This report, including engineering analyses, recommendations, figures, and design details are exclusive to the above referenced site. Under no circumstances shall the figures be separated from the text and used independently. Recommendations in this report are not applicable to other construction sites. This summary shall be considered an overview and does not constitute the entire report.

### 2.0 PROPOSED CONSTRUCTION

The project will consist of developing Bitterroot Heights Subdivision, 3<sup>rd</sup> Filing consisting of 73 new residential lots. Roadways and buried utilities will also be developed.

Final lot layout and building envelopes/elevations are unknown at this time. We have assumed single-family residences with foundation loads on the order of 2 kips per lineal foot on perimeter footings are planned. As construction details become available, this office shall review and potentially modify our design assumptions or recommendations.

The project location is shown on Figures 1, 2 and 3 in Appendix A. At the time of the field investigation, excavation for utilities, roadways, or building foundations had not begun.

### 3.0 INVESTIGATION PROCEDURE

#### **3.1** Field Investigation

Fieldwork consisted of site reconnaissance and observations and advancing 56 test holes. The approximate test hole locations are shown on Figure 1 and 2, in Appendix A. Subsurface logs are attached in Appendix B.

Soil type, thickness, consistency, and relative moisture content were observed and documented by a Professional Engineer and Professional Geologist. Site conditions may be variable and actual soil conditions encountered in the foundation excavations may differ somewhat from those represented on the test hole logs.

### 4.0 SITE CONDITIONS

### 4.1 Soils and Material Properties

Due to the extensive historic and proposed site modifications, including mining and previous and proposed placement of uncontrolled fill, soil conditions shall be anticipated to change over relatively short distances and depths. The soils encountered in the test holes are described below and on the test hole logs in Appendix B.

**Uncontrolled Fill (Various)** consisting of varying fractions of clay, silt, sand and gravel with varying asphalt, concrete, metal and rubbish was encountered across extensive portions of the site. The fill is highly variable and described as brown to dark gray, moist to wet, soft or loose, and massive in texture.

**Sandy Gravel with Cobble (GP)** coarse-grained alluvium/pit backfill was encountered below the uncontrolled fill in the central and south portions of the site. The sandy gravel is described as poorly graded, brown to gray, dry to wet, loose, and contains rounded gravel and cobble to about 6 to 8-inches in diameter.

### 4.2 Bedrock

Shale bedrock presumably of the Claggett Shale Formation was encountered in the test holes, particularly in southern or central portions of the site. Shale bedrock is described as grayish brown, moist, weak, thinly bedded, medium plasticity, and moderately weathered.

### 4.3 Groundwater

Groundwater was encountered at relatively shall depths of about 4 to 8 feet across the site. Soil moisture conditions are expected to fluctuate in response to seasonal precipitation, runoff, snowmelt, and irrigation. Some dewatering may be required for deeper utility installations. Soil moisture conditions are expected to fluctuate in response to seasonal precipitation, runoff, snowmelt, and irrigation.

Mining operations at the site also appear to include groundwater mitigation and seepage control, as evident by swales and drainages crossing the site. Water infiltrating through the permeable sand and gravel deposits and groundwater flow from offsite sources "perches" on the underlying low permeability shale bedrock. The perched groundwater then accumulates or migrates laterally as drainage allows. Modifications, impediments, or failure to maintain the existing drainage features may alter flow paths and cause changes in groundwater elevation across the site. Deep basements are not recommended for the development and owners and contractors shall plan for the potential of shallow, perched groundwater if below-grade habitable-space is considered.

Additionally, concrete slabs block air/soil moisture transfer in arid climates and subsequently increase soil moisture. Adequate precautions are recommended to reduce the potential for seepage into the foundation and subgrade soils. Controlling soil moisture change of soils below structures is considered by some to be the most critical factor affecting foundation performance.

### 4.4 Earthquakes and Seismicity

Yellowstone County and the proposed subdivision are in an area of low seismic activity. No active faults have been identified in the vicinity and historically no major earthquake epicenters have been located in the immediate area. The project site is in Seismic Design Category "A" as specified by the International Residential Code (IRC).

### 5.0 ENGINEERING ANALYSES AND RECOMMENDATIONS

### 5.1 Foundations

Due to the extensive historic and proposed site modifications, including mining and previous and proposed placement of uncontrolled fill, soil conditions shall be anticipated to change over relatively short distances and depths. Foundation subgrade improvement or deep foundations shall be anticipated.

Where uncontrolled fill thicknesses are relatively thin and underlain by sandy gravel with cobble soils, generally, more modest homes with lighter foundations loads and less elaborate foundation geometry have been constructed using over-excavation and replacement with compacted structural fill.

Deep foundations shall be considered where uncontrolled fill thicknesses become extensive or where groundwater elevations prevent over-excavation and replacement in dry conditions. These methods may include driven or drilled piles or piers extending to deeper bearing stratum; and are typically used when the tolerance for foundation movement is more stringent, foundation loads are increased, or the magnitude of the homes are commensurate with more elaborate foundation systems. Typically, deep foundation systems provide the more reliable long-term performance.

Based on the owner's acceptable level of risk and desired structural performance, over-excavation and replacement with compacted structural fill may be more economical; however, slab and foundation performance will depend on excavation depth and uncontrolled fill thickness, foundation loading and the owner's ability to control water and maintain existing soil moisture conditions. Over-excavation and replacement with compacted structural fill may be unfeasible where excavation depths are near groundwater elevations or soils are saturated due to capillary rise (likely depth of 4 to 6 feet). If habitable space below grade is planned, seepage into lower elevations of the home may be expected periodically over the design life of the homes. The flowing table summarizes several foundation alternatives with an associated perceived level of relative risk:

Table 1       Foundation Alternatives and Relative Risk									
Foundation System	Floor System	Relative Risk of Differential Movement							
Standard Footings Constructed on Uncontrolled Fill or Fine-Grained Soils	Slab-On-Grade Over Uncontrolled Fill or Native Fine-Grained Soil	Very High							
Standard Footings Constructed on Compacted Structural Fill	Slab-On-Grade Over Structural Fill	Low to Moderate							
Deep Foundations	Slab-On-Grade Over Compacted Fine-Grained Soil	Low							

Over the life of the structure, minor cracks in the foundation walls, floors, and sheetrock are normal and should not be a cause for concern. Foundation footings should be placed at or below the frost depth recommended by local codes (typically 42 inches). Also, wet or frozen material should be removed from beneath the footings and floor slabs prior to pouring concrete. This office should observe the excavations and exposed subgrade prior to placement of footings or structural fill to verify our assumptions.

### 5.2 Deep Foundations

Deep foundation support systems consisting of driven or drilled elements may be used to support the foundations. Pile or pier foundation elements would support structures directly by embedment into underlying bearing stratum. A structural floor over a crawl space could be supported by the grade beams. Steel reinforced concrete slabs-on-grade placed on approved undisturbed native soil or structural fill may also be used for non-load bearing floors.

A Structural Engineer should determine pile/pier spacing and design grade beam and structural floor reinforcement, in consultation with our Geotechnical Engineer.

### 5.3 Over-Excavation and Engineered Fill

As discussed above, we do not recommend over-excavation and replacement with structural fill unless the owners are willing to accept the risk of some differential movement of the structure and assures to control surface drainage and direct runoff away from foundations. If site grading fill around foundation walls exceed a height of 2 feet, we recommend placing the structure on deep foundations.

Over-excavation and replacement with compacted structural fill may be unfeasible where excavation depths are near groundwater elevations or soils are saturated due to capillary rise (likely depth of 4 to 6 feet). If habitable space below grade is planned, seepage into lower elevations of the home may be expected periodically over the design life of the home.

If selected by the owner and contractor, soils should be over-excavated under footings to a minimum depth of 30 inches (2.5 feet) and to such a depth so as to remove all uncontrolled fill, and at least 30 inches on the outside of the footings. A layer of geogrid such as Tensar TRX 160 or Mirafi BXG 12 should be placed at the interface of the structural fill and native soils. Geogrid should be installed according to the manufacturer's recommendations.

Structural fill may consist of approved imported 1<sup>1</sup>/<sub>2</sub>-inch minus road-mix gravel. Structural fill shall be placed in lifts and compacted to foundation elevation. Construction observation and field density testing are required to verify fill placement and compaction. Site preparation and placement and compaction of structural fill should conform to the recommendations in the Earthworks Section of this report.

### 5.4 Lateral Loads on Basement Walls

Lateral pressures were calculated for active, passive, and at-rest conditions assuming level soil backfill adjacent to the foundation (Bowles, 1996).

γI	Table 2 Lateral Loads K (equivalent fluid pressure)
Static Condition Level Backfill	At Rest - 56 pcf Active - 45 pcf Passive - 290 pcf

#### 5.4.1 Soil Friction Factor

Terzaghi, et al (1996), suggest a maximum value of 30 degrees for the friction angle along a concrete base in granular soils. Accordingly, a friction value of 0.58, which is the tangent of 30 degrees, is suggested. A friction factor of 0.50 is suggested to calculate soil friction for design of retaining walls in contact with any fine-grained soils in the subgrade. The friction value may be combined with the passive pressure to resist horizontal loads.

### 5.5 Earthwork

#### 5.5.1 Site Clearing and Subgrade Preparation

<u>All sod, topsoil, concrete, uncontrolled man-placed fill and organic soil shall be completely</u> removed from the building footprints. All exposed subgrade surfaces should be free of mounds and depressions which could prevent uniform compaction. Structural fill may be required to achieve grade and adequately prepare the area prior to construction. Placement of structural fill shall follow the recommendations below.

Subgrade surfaces beneath the building footprints and slabs shall be scarified, moistureconditioned to near optimum moisture content, and re-compacted to at least 95% of maximum dry density as measured by ASTM D 698. If density tests indicate compaction is not being achieved, fill should be scarified or removed, moisture-conditioned to within  $\pm 2$  percent of optimum moisture content, and re-compacted and re-tested. Field density testing is required.

Fill, footings or slabs should not be placed on frozen or wet subgrade. Organic material should be removed and replaced with structural fill. All excavations shall be inspected by a qualified observer prior to fill or concrete placement. This office is available to inspect excavations. Adequate notice is appreciated.

#### 5.5.2 Excavation

Based on the soil conditions encountered, conventional earthmoving equipment should be capable of excavating site soils. All excavations shall be approved by a qualified observer prior to backfill placement.

All excavations must conform to OSHA *Standards for Excavations*, 29 CFR Part 1926.652 Appendix B to Subpart P. Based on field observations, the soils at the site are classified as Type C using OSHA classification system. Type C soils require excavation slope angles not to exceed  $1\frac{1}{2}$  H: 1 V (horizontal to vertical) for excavations exceeding 5 feet in depth.

#### 5.5.3 Fill Materials

If structural fill from an offsite source is required, it should conform to the following requirements or be approved by the project Geotechnical Engineer. Generally, well-graded 1.5-inch minus road mix materials meet the following specification.

Table 3       Granular Fill Recommendations									
Gradation Percent finer by weight									
3-inch	100								
1 1/2	90-100								
3/4	70-90								
No. 4 Sieve	40-80								
No. 40 Sieve	8-40								
No. 200 Sieve	12 Maximum								
Liquid Limit and Plas	tic Index = Non-plastic								

#### 5.5.4 Fill Placement and Compaction

Structural fill shall be placed in maximum 6-inch loose lifts, moisture-conditioned to near optimum moisture content, and compacted to at least 98% of maximum dry density as measured by ASTM D 698. If density tests taken in the fill indicate compaction is not being achieved, fill should be scarified or removed, moisture-conditioned to within  $\pm 2$  percent of optimum moisture content, and re-compacted and re-tested. No fill should be placed over frozen ground or in a frozen condition. **Density testing requirements are outlined in the table below.** 

Table 4     Minimum Compaction Requirements								
Location or Area	Standard Proctor Density ASTM D 698	Testing Frequency 1 per lift per						
Exterior Slabs and Walkways	95%	3,000 sf.						
Retaining Walls	95%	1,000 sf.						
Trenches in Landscaped Areas	95%	150 sf.						
Trenches Below Pavements or Structures	97%	150 sf.						
Lawn or Unimproved Areas	92%	20,000 sf.						
Structural Fill	98%	1,500 sf.						
Building and Roadway Subgrades	95%	5,000 sf.						

Care should be taken adjacent to "green" foundation concrete. Over compaction adjacent to "green" concrete may lead to foundation damage and cracking. Under no circumstances shall fill be placed using "hydro"-compaction methods. Excessive water may damage foundation elements.

### 5.6 Site Grading and Surface Water Control

Surface water should not be allowed to accumulate and infiltrate the soil near foundations. It must be controlled and directed away from the structures.

Site grading is critical. A simple means of reducing moisture changes is to prevent surface water infiltration by sloping the ground away from the foundation. The recommended minimum slope within 10 feet of the building is 1 inch vertical for 1 foot horizontal. The sloped ground should be initially constructed at a greater slope to account for settlement/consolidation of exterior backfill. Within ten feet of the foundation, the upper 12 to 18 inches of backfill should consist of less permeable, compacted fine-grained soil (silts and clays). The area around the foundation should be inspected regularly by the property owner or manager – particularly after a rainstorm – to determine if proper drainage away from the structure has been maintained.

Changes in site grading by landscapers or property owners have been a persistent and damaging problem. It is the property owner's responsibility to control water and maintain the site to prevent infiltration near foundations. Additionally, it is the property owner's responsibility to maintain rain gutter downspouts and buried sprinklers system conduits.

Roof drainage should include gutters, downspouts, extensions, and splash blocks. The downspouts should discharge at least 6 feet away from foundation walls and beyond any backfill zones.

Sprinklers should not spray closer than 6 feet from foundations and beyond backfill zones. Plantings near foundations should not trap surface runoff. Additionally, sidewalks or low-water consumption groundcover are recommended to further reduce the risk of water infiltration near the foundation walls.

Buried rain gutter discharge pipes are not recommended because of persistent, often undetected, seepage problems caused by clogging, crushing, and adverse grading of the pipes. Similarly, infiltration basins are not recommended adjacent to or upgradient of the structure or adjacent structures. If detention is required by statute, infiltration basins should be located down gradient and at least 30 feet from foundations.

### 5.7 Foundation Drains

Foundation drain requirements should be considered on a site-by-site bases, depending on design location and design elevations.

### 5.8 Interior Slabs-On-Grade

Light duty slabs are typically constructed as thin elements with little or no steel reinforcement. Slabs constructed in this fashion shall be considered walking surfaces, and not structural elements. Non-structural slabs shall be anticipated to crack, warp, and move as the results of many factors. If expectations of slab performance are high, then slabs shall be designed as structural elements. At grade flooring systems and slabs shall consider the potential for subgrade shrink/swell associated with shale bedrock such as encountered at the site. Slab design alternatives may include subgrade improvement by partial over-excavation and replacement with granular fill, subgrade stabilization by cement or lime treatment, or designing the floor system as structural elements.

A structural engineer should design interior slabs based on anticipated loading. Cracking and movement of slabs-on-grade is difficult to control and should be expected to occur with time. Cracking and movement may be the result of many factors such as concrete shrinkage and daily and seasonal variability in temperature and humidity and not necessarily the result of soil activity.

If floor coverings or coatings less permeable than the concrete slab will be used, or if moisture is a concern, we recommend a vapor retarder be placed beneath the slab. Some coverings, coatings or situations may require a vapor *barrier*, i.e., a membrane with a permeance less than 0.3 perms. Flooring installation should be consistent with the flooring manufacturer's recommendations for subsoil and slab construction and moisture testing prior to installation. A durable membrane such as *Stego Wrap* (Stego Industries, LLC) may be used. Such products should be installed according to the manufacture's recommendations.

### 5.9 Exterior Slabs-On-Grade

Exterior concrete flatwork often moves in response to changes in temperature and soil moisture, or freeze/thaw cycles. Over-excavation and re-compaction of 9 inches of subgrade soil may reduce the tendency of the slabs to move. Granular materials placed below slabs should be graded to drain.

Exterior slabs should be separated from foundation elements. Movement of exterior slabs may be transmitted to the foundation walls, resulting in damage. Additionally, exterior columns should not bear on exterior slabs or uncompacted fill to help reduce slab movement being transferred to the structure.

### 5.10 Other Considerations

Footings, slabs, and foundation and retaining walls should be reinforced to resist differential movement. A structural engineer should specify reinforcement.

Water, sewer, and sprinkler lines should be pressure tested before backfilling and periodically after installation.

Type II Portland Cement with maximum water to cement ratio of 0.45 is recommended for all project concrete. All foundations and wall concrete should be designed and reinforced according the recommendations of the project Structural Engineer.

### 5.11 Environmental Services

Environmental services, including but not limited to a Phase I or Phase 2 investigations, evaluation of soil and groundwater quality or petroleum or solvent contaminants, and radon testing are not included in this report and are beyond the scope of this geotechnical investigation.

### 5.12 Winter Construction

**Subgrade soils and fill should be protected against freezing ground conditions.** No concrete or structural fill shall be placed against frozen ground or contain froze materials such as snow or ice. It is the contactor's responsibility to take adequate precautions to prevent damage from frost heave or frozen subgrade. Insulating or warming blankets are recommended to protect subgrade soils when temperatures are near or below freezing.

If winter construction is planned, the contractor shall submit a written plan discussing plans and operating procedures to ensure subgrade and fill materials below buildings, parking areas, and utilities will be prevented from freezing. Earthwork is not recommended during periods of the year when daily temperatures are below freezing or when daily temperatures rise above freezing for only a portion of the workday.

### 5.13 Construction Observations

A representative of this office should observe the foundation excavation and placement and compaction of structural fill recommended in this report. Recommendations in this report are contingent upon our involvement. If any unexpected soils or conditions are revealed during construction, this office should be notified immediately to make necessary modifications.

### 6.0 PAVEMENT DESIGN

Flexible pavement section design criteria are based on test hole observations, field and laboratory testing, and classification of soil types. Design methodologies are consistent with methods suggested in Chapter 4 of the AASHTO Guide for Design of Pavement Structures, 1993.

Surficial soils encountered in the test holes generally consists of sandy lean clay, which typically is poor subgrade materials. California Bearing Ratio (CBR) values are estimated to range from about 2 to 5. These values are considered poor strength for pavement subgrade.

Site soils are typically described as low to moderately plastic clay soils with elevated moisture content. Such soils shall be expected to be moisture sensitive and unstable. Construction traffic and heavy equipment loading will likely exacerbate subgrade instability. When wet or following periods of precipitation, roadway subgrades shall be anticipated to be unstable and may require

over-excavation and stabilization with geogrid and crushed base prior to placement of roadway sections.

The pavement sections were developed based on the following design assumptions and our experience with similar projects and soil conditions. No Equivalent Single Axle Loads (ESAL's) or traffic mix data were provided by the Civil or Traffic Engineer. If the proposed project, traffic loading, or design parameters differ from that assumed, this office shall be notified to re-evaluate our recommendations.

It is assumed a woven geotextile such as Mirafi 315ST will be placed at the interface of the subgrade and aggregate base course. Recommended sections are presented in the following tables:

Table 5     Flexible Pavement and Aggregate Design Options									
Road Surface	Asphalt Concrete Thickness (inches)	Aggregate Base Course (inches)	Total Section Thickness (inches)						
Local Residential	3	12	15						
Collector	4	15	19						

#### 6.1.1 Roadway Site Clearing and Subgrade Preparation

Site preparation should consist of stripping the existing topsoil and fine-grained soils from the proposed roadways and parking areas. All exposed subgrade surfaces should be free of mounds and depressions which could prevent uniform compaction. If man-placed fills or obstructions are encountered during site clearing or grading, such features should be removed and the excavation thoroughly cleaned prior to placement fill.

All exposed soils that will receive crushed aggregate base materials should be scarified to a minimum depth of 9 inches, conditioned to near optimum moisture content, and re-compacted to the requirements in Table 4, above. Recompacted subgrade surfaces shall then be proof-rolled with a loaded tandem-axle haul truck. A representative of this office shall observe and approve proof-rolling.

Areas that are observed to show excessive rutting, pumping, or are otherwise considered unstable during proof-rolling shall be excavated to a depth determined in the field and replaced with compacted gravel. Exceedingly soft or failed areas of subgrade may require placement of a geogrid or woven geotextile in addition to the clean compacted gravel to stabilize the subgrade. Crushed aggregate base may then be placed on the approved subgrade surface.

Subgrade and crushed aggregate base should be graded to drain. Saturation of base materials will substantially reduce the pavement life expectancy. Additionally, a collection system with proper grading should be incorporated into roadway design to collect and convey surface water and prevent ponding.

#### 6.1.2 Roadway Fill Materials

Untreated crushed aggregate base should conform to the following grading requirements or be approved by the project Geotechnical Engineer. The crushed aggregate base course material should not contain more than 20% recycled asphalt pavement (RAP).

Table 6								
Crushed Aggregate Base Specification								
Sieve Size (inch) Percent finer by we								
1-1/2	95-100							
3/4	70-89							
3/8	50-70							
No. 4	35-58							
No. 40	9-30							
No. 200	0-8							
Liquid Limit/Plasticity Index	Non-Plastic							

#### 6.1.3 Roadway Fill Placement and Compaction

Fill material should be moisture-conditioned to near optimum moisture content and compacted to at least 95% of maximum dry density, as measured by ASTM D 698. If density tests taken in the fill indicate compaction is not being achieved, fill should be scarified or removed, moisture-conditioned to within  $\pm 2$  percent of optimum moisture content, and re-compacted and re-tested. No fill should be placed over frozen ground.

Additional work such as over-excavation and replacement with compacted gravel or placement of geogrid/geotextile resulting from poor construction practices, failure to control surface water, or excessive or repeated use of heavy construction equipment are not the responsibility of Owner/Client or GEOSCIENCE. Haul routes and heavy vehicle traffic shall be spread out across the site to help prevent "failed" subgrade areas. It is the contractor's responsibility to maintain site drainage during construction.

#### 6.1.4 High Traffic Areas

In areas subject to heavy repetitive vehicle loading, such as loading/delivery docks, approaches, or dumpster loading pads, a Portland Cement Concrete (PCC) pavement is recommended. The section should consist of a minimum of 8-inches of crushed base and an 8-inch thick PCC pavement.

Portland cement concrete mix design and material specifications should be in accordance with, or equivalent to, requirements of the AASHTO *Guide Specifications for Highway Construction* and the *Standard Specifications for Transportation Materials*.

#### 6.1.5 Hot Mix Bituminous Asphalt

Asphalt concrete should conform to approved mix designs and meet MPW and the City of Billings Modifications for placement and compaction.

### 7.0 LIMITATIONS

The conclusions and recommendations presented in this report assume that site conditions are not substantially different than those exposed by the test holes. If subsurface conditions different from those encountered in the test holes are observed or appear to be present during construction, GEOSCIENCE, PLLP should be advised so that we can review those conditions and reconsider our recommendations where necessary. In addition, we should review any foundation plans for the project to determine if the recommendations presented have been followed.

If there is a substantial lapse of time between submission of this report and the start of work at the site (two years from the date of issuance) and/or conditions have changed due to natural causes or construction operations at or near the site, it is recommended that this report be reviewed to determine the applicability of the conclusions and recommendations.

This report was prepared for use by the client and their representatives. It should be made available to prospective contractors for information on factual data only and not as a warranty of subsurface conditions. This report should be passed on to design professionals, contractors, and future property owners to alert them to the risks associated with water and other hazards.

It is customary for the consultant that provides design recommendations to be retained to provide observation and related services during construction. If GEOSCIENCE, PLLP is not retained to provide continuing services, you agree to hold harmless from all claims, loses, and expenses arising out of any interpretation, clarifications, substitutions, or modifications of our work provided to you or others. If GEOSCIENCE, PLLP is retained to provide observations and related services during construction, our services will not in any way have any right to control the work, stop the job, supervise or coordinate subcontractors, direct the contractor's means, methods, techniques, sequences or procedures of construction, and safety precautions and programs.

This report has been prepared for the exclusive use of our client, as referenced in the cover letter and cover page of this report. All information contained in this report as well as any future written documents, that may address comments or questions regarding this report, constitute the "entire report". GEOSCIENCE, PLLP's opinions, conclusions, and recommendations are based on the entire report. This report may be insufficient for other applications or other clients, other than those described herein. The entire report shall not be transferred to other clients or used for other purposes without the written consent and permission of GEOSCIENCE, PLLP.

Long term monitoring of groundwater levels was not included as part of this scope of services. Groundwater levels may change due to seasonal precipitation, irrigations, changes in land use and other factors. Evaluation of these influences or prediction of future groundwater levels is outside of this scope of services.

These services have been performed in a manner consistent with the level of care and skill ordinarily exercised by members of the profession currently practicing in this area under similar conditions. No warranty is made or implied.

This report, including engineering analyses, recommendations, figures, and design details are exclusive to the above referenced site. Under no circumstances shall the figures be separated from the text and used independently. Recommendations in this report are not applicable to other construction sites.

### 8.0 **REFERENCES**

Bowles, J.E., 1996, Foundation Analysis and Design, 5th Ed.: McGraw-Hill.

Terzaghi, K., Peck, R.B., and Mesri, G., 1996, Soil Mechanics in Engineering Practice, 3<sup>rd</sup> Edition, John Wiley and Sons, Inc.

# **APPENDIX A**

Figures



### **GEOSCIENCE**, PLLP



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### **GEOSCIENCE**, PLLP

# **APPENDIX B**

**Test Hole Logs** 

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en		PROJECT: Bitte	rroot He	ights S	ubd	livision, 3rd Filing,	Billings,	STRUCTURE	Residential Subdivision	
30	<b>BSURFACE LUG</b>	CLIENT: PEC						DATE:	4/7/2021	
		LOCATION: See	Figures	1 & 2				ELEVATION:	nm	
		CONTRACTOR:	Geosci	ence				LOGGED BY	gsv	
	IEST HOLE BHID	EQUIPMENT: E	xcavator							
File: BH Lo	Date Printed: 5/3/2021	DEPTH TO - WA	TER> II	NITIAL	.: -	<u>¥ _ 5</u> <b>AFT</b>	ER 24 HOU	JRS:	CAVING> <u>C</u>	
	·					TEST	RESULTS			
f f f			ii e	t) t)	lers	1 2	3	4	Monitor Well	
)ep (fee	Description		Typ Sol	eva (fee	dma	Plastic Limit		Liquid Limit	Installation	
				Ξ	Š	Water Content - 10 20	• 30 40	50	Details	
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							- <u>2/////</u> 3	4		
	Sand & Gravel with Cobble; brov	vn to gray, moist to	$\times$						—	
ŀ	very moist, soft/loose, massive, s	ome clay & debris				-		·····		
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	Z5 0		$\times$			_				
-	Sandy GRAVEL with Cobble (G	P); gray, wet,								
-	loose, massive, rounded gravel an	d cobble to 6"-8"								
- 6	diameter [Coarse-Grained Alluviu	ım/Pit Backfill]							_	
_	SHALE; grayish brown, moist, w	eak, thinly bedded,								
_	medium plasticity, moderately we	athered [Claggett								
-	Formation					-				
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Sub	bsurface Profile Based On Field	Observations & (	Geologi	ic Map	pii	ng				
SU	BSURFACE LOG	CI IFNT: PEC	110001110	igno o	uoui	vibioli, 214	T hing, Diff.	<u>DAT</u>	F:	4/7/2021
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		LOCATION: See	Figures	1 & 2				ELE	VATION:	nm
		CONTRACTOR:	Geosci	ence				LOG	GED BY:	gsv
	TEST HOLE BH11	EQUIPMENT: E	xcavator						-	0
e: BH Lo	Date Printed: 5/3/2021	DEPTH TO - WA	TER> II	NITIAL	: ¥	6	_ AFTER 2	24 HOURS:	<b>₹</b>	CAVING> <u>C</u>
							TEST RE	SULTS		
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et)	Description		soil /pe	/atic eet)	ple	Plastic I in	nit i		l I imit	Monitor Well Installation
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						10	20 30	40 5	0	
					$\square$	Penetrome	eter (tsf)-			
0	Sand & Gravel with Cobble; brow	vn to gray, moist to			╞		<u> </u>	3 4		
	very moist, soft/loose, massive, s	ome debris [Fill]								
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	5.0		XX							
	Sandy GRAVEL with Cobble (G	P); gray, wet,			[					
	loose, massive, rounded gravel an	d cobble to 6"-8"								
6 🖣	Z diameter [Coarse-Grained Alluvit	im/Pit Backfill]	7		╎┝					
			P							
			•							
	-7.5 SHALE: gravish brown moist w	eak thinly bedded								
8	medium plasticity, moderately we	athered [Claggett			╞					
	Formation]									
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<b>CII</b>		PROJECT: Bitte	rroot He	ights S	ubd	livision, 3rd Filing, B	illings,	STRUCTURE	Residential Subdivision
30	DOURFAUE LUG	CLIENT: PEC		•					4/7/2021
		LOCATION: See	Figures	1&2				ELEVATION	nm
	TEST HOLE BH12	CONTRACTOR:	Geosci	ence				LOGGED BY	':gsv
		EQUIPMENT: E	xcavator	•					
File: BH Lo	Dogs Date Printed: 5/3/2021	DEPTH TO - WA	TER> II	NITIAL	-	<u>₩ 6 AFTEF</u>	R 24 HOL	JRS: ¥	CAVING> <u>C</u>
						TEST R	RESULTS		
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et)	Description		/pe	/atic	ple	Plastic Limit		Liquid Limit	Monitor Well
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						Penetrometer (tsf)-			
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	Sand & Gravel with Cobble; brov	vn to gray, moist to come debris [Fill]	K & X						
	very moist, son loose, massive, s		$\times$						
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	Sandy GRAVEL with Cobble (G	P); gray, wet,				_			-
	diameter [Coarse-Grained Alluvi	um/Pit Backfill]							
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- 8	8.0		•••						_
-	SHALE; grayish brown, moist, w	eak, thinly bedded,							
-	medium plasticity, moderately we	eathered [Claggett							-
-	Formation					-			-
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Sut	osurjace Profile Based On Field	<i>Observations</i> & (	Jeologi	ес мар	pu	ng			
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SU	<b>BSURFACE LOG</b>	CLIENT: PEC	110001110	igno o	aoai	<u>, , , , , , , , , , , , , , , , , , , </u>	T ming, Din	ings, i		4/7/2021
		LOCATION: See	Figures	1&2					ELEVATION:	nm
		CONTRACTOR:	Geosci	ence					LOGGED BY:	gsv
	TEST HOLE BH13	EQUIPMENT: E	xcavator							
le: BH Lo	Date Printed: 5/3/2021	DEPTH TO - WA	TER> II	NITIAL	: ź	<u> </u>		24 HOU	RS:	_ CAVING> _
	*						TEST RE	SULTS		
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eptr set)	Description		soil ype	vatio eet)	ple	Plastic Lim	nit i	↓ L	iauid Limit	Installation
ň "	p		00 <u>F</u> .	Ele (fe	San	Water Cor	ntent - 🔹			Details
						10	20 30	0 40	50	
					H	Penetrome	eter (tsf)-			
0	Sand & Gravel with Cobble; brow	vn to gray, moist to							4	
	wet, loose, massive, some clay &	debris [Fill]			-					
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_	Sandy GRAVEL with Cobble (Gl	P); gray, wet,	?.							
4	loose, massive, rounded gravel an dispector [Coord Chain and Allwrin	d cobble to 6"-8"			-					
6	diameter [Coarse-Grained Alluvit	im/Pit Backfill]	<b>`</b>		╞					
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	medium plasticity, moderately we	eak, thinly bedded, eathered [Claggett			-					
	Formation]	L								
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SU	BSURFACE LOG	PROJECT: <u>Bitterroot</u> ]	Heights S	ubc	livision, 3rd	Filing, Billings,		Residential Subdivisio
		LOCATION: See Figur	res 1 & 2				ELEVATION:	
		CONTRACTOR: Geos	science				LOGGED BY	gsv
	TEST HOLE BH14	EQUIPMENT: Excava	tor					
File: BH Lo	gs Date Printed: 5/3/2021	DEPTH TO - WATER>	> INITIAI	L: -	<u>¥</u> 5.5	_ AFTER 24 HC	)URS: 🐺	CAVING> <u>C</u>
Depth (feet)	Description Clay, Sand & Gravel with Cobble	; brown to gray,	Elevation (feet)	Samplers	1 Plastic Lim Water Cor 10 Penetrome 1	$\begin{array}{c c} \hline TEST RESULT\\ \hline 2 & 3\\ \hline nit & \hline \\ \hline ntent - \bullet \\ \hline 20 & 30 & 4\\ \hline eter (tsf)- \boxed{2} & 3\\ \hline \\ \hline 2 & 3\\ \hline \end{array}$	S 4 Liquid Limit 0 50 222 4	Monitor Well Installation Details
2	moist to wet, soft/loose, massive,	some debris [Fill]	XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX					
4	<u>7</u>		XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX		-			
6	6.0 Large concrete block at 6 feet, pit [Fill] 7.0 Pit Collapse - Bottom of Pit in Fil	walls collapsing			-			
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Sub	surface Profile Based On Field	Observations & Geold	ogic Maj	 ppii	ng	<u>; i</u>		

SUI	BSURFACE LOG	CLIENT: PEC		0		/	<u>U</u> /	- 8	 	TE:	4/7/2021	5101
		LOCATION: See	Figures	1 & 2					_ ELI	EVATION:	nm	
		CONTRACTOR:	Geosci	ence					_ LO	GGED BY:	gsv	_
		EQUIPMENT: E	xcavator									
le: BH Log	gs Date Printed: 5/3/2021	DEPTH TO - WA	TER> II	NITIAL	.: Ę	<u> </u>		R 24 H	OURS	: ¥	_ CAVING> <u>C</u>	_
					╞		TEST	RESUL	TS			
fi ta			— o	tion	ers	1	2	3	4	ļ.	Monitor Well	
Dept (feet	Description		Typ.	levat (feet	ampl	Plastic Li	mit ├──	_	⊢ Liqu	iid Limit	Installation	
				Ξ	ů	Water Co 10	ontent - 20	• 30 4	40	50	Details	
						Penetrom	neter (tsf)	- 7		·		
0	Sand & Gravel with Cobble: brow	in to grave moist to			╞	<u> </u>	2	3	4	<u> </u>		
	wet, loose, layer of 3/4" gravel, so	ome clay & debris										
	[Fill]											
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	Sandy GRAVEL with Cobble (GI loose, massive, rounded gravel an	?); gray, wet, d cobble to 6"-8"										
4	diameter [Coarse-Grained Alluviu	m/Pit Backfill]										
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8	-8.0 Pit Walls Collapsing											
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-	BSURFACE LOG	CLIENT: PEC		0		/	6)		DATE:	4/7/2021
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e: BH Lo	Date Printed: 5/3/2021	DEPTH TO - WA	TER> II	NITIAL	.: <sup>z</sup>	₹6	_ AFTER	24 HOU	RS: ¥	CAVING> <u>C</u>
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					Η	Penetrom	eter (tsf)- 2	3	<sup>∅</sup> 4	
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	wet, loose, massive, some clay &	debris [Fill]	XX			-				
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	Sandy GRAVEL with Cobble (GI	P); gray, wet,	3.			_				
	ioose, massive, rounded gravel an diameter [Coarse-Grained Alluviu	a cobble to 6"-8" m/Pit Backfill]								
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e: BH Lo	Date Printed: 5/3/2021						TEST	RESUL	TS		
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eptn eet)	Description		Soil ype	vatio eet)	nple	Plastic Lin	nit ⊢	Ī	⊢ Liqui	id Limit	Monitor Well Installation
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	wet, loose, massive, some clay &	debris [Fill]				-					
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	3.5 Sandy GRAVEL with Cobble (G)	P) · orav wet	<u> </u>								
4	loose, massive, rounded gravel an	d cobble to 6"-8"			╞						
	diameter [Coarse-Grained Alluviu	um/Pit Backfill]				-					
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8	8.0 Pit Walls Collapsing										
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5U	<b>BSURFACE LOG</b>	CLIENT: PEC							DATE:	4/7/2021
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		CONTRACTOR:	Geosci	ence					LOGGED BY	gsv
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e: BH Lo	Date Printed: 5/3/2021	DEPTH TO - WA	TER> I	NITIAL	-: - <u>-</u>	₹ _ 6	_ AFTER 2	24 HOU	RS: ¥	CAVING> <u>C</u>
							TEST RE	SULTS		
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	wet, loose, massive, some clay &	debris [Fill]				-				
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	Sand & Gravel with Cobble (GP)	; gray, slightly	3							
	moist to wet, loose, massive, rour	ided gravel and	2.1			-				
1	Alluvium/Pit Backfill	Grained								
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	SHALE; grayish brown, moist, w	eak, thinly bedded				-				
	medium plasticity, moderately we	athered [Claggett				-				
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SU	<b>BSURFACE LOG</b>	CLIENT: PEC		igno o	uou			5, Diiii	<u>lgs,</u> C		4/7/2021
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		EQUIPMENT: E	xcavator			_					
e: BH Lo	Date Printed: 5/3/2021	DEPTH TO - WA	TER> I		<u>.: ₹</u>	≩7	AF	TER 24	4 HOUF	RS: ₹	CAVING> <u>C</u>
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E æ				tion t	lers		1 :	2	3	4	Monitor Well
(fee	Description		Typ Sol	leva (fee	amp	Plastic	Limit ⊢ Contont	•	—   L	iquid Limit	Installation Details
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					Н	Penetro	ometer (t	sf)- 🛛			
0	Sand & Gravel with Cobble; brow	n to gray, moist to	X				1 2	2	3	4	
	wet, loose, massive, some clay &	debris [Fill]			╞	-					
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-	Sand & Gravel with Cobble (GP)	gray, slightly	• >		[						
	moist to wet, loose, massive, rour	ded gravel and Grained			[	-					
	Alluvium/Pit Backfill]	S. uniou				-					
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s Date Printed: 5/3/2021		Cavalor							5
Date Printed: 5/5/20211		TER> II	NITIAL	. <u>1</u>	₹6	AFTER 24	HOURS:	<u>¥</u>	CAVING>
		e ii	tion et)	lers	1	TEST RES	ULTS 3 4		Monitor Well
Description		Soi Typ	Eleva (fee	Samp	Plastic Lin Water Cor 10 Penetrome	nit	—   Liquid 40 50	Limit	Installation Details
Sand & Gravel with Cobble; brow wet, loose, massive, some clay &	n to gray, moist to debris [Fill]				-	2	3 4		
2.0 Sand & Gravel with Cobble (GP);	gray, slightly								
moist to wet, loose, massive, round cobble to 6"-8" diameter [Coarse- Alluvium/Pit Backfill]	ded gravel and Grained				-				
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9.0					-				
Pit Walls Collapsing									
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	Sand & Gravel with Cobble; brow wet, loose, massive, some clay & O Sand & Gravel with Cobble (GP); moist to wet, loose, massive, roun cobble to 6"-8" diameter [Coarse- Alluvium/Pit Backfill] 0 Pit Walls Collapsing	Sand & Gravel with Cobble; brown to gray, moist to wet, loose, massive, some clay & debris [Fill] O Sand & Gravel with Cobble (GP); gray, slightly moist to wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill] O O Pit Walls Collapsing	O Sand & Gravel with Cobble; brown to gray, moist to wet, loose, massive, some clay & debris [Fill] O Sand & Gravel with Cobble (GP); gray, slightly moist to wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill] O Pit Walls Collapsing	Sand & Gravel with Cobble; brown to gray, moist to wet, loose, massive, some clay & debris [Fill]	O O Sand & Gravel with Cobble (GP); gray, slightly moist to wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill] O Pit Walls Collapsing	O The Walls Collapsing O O O O O Sand & Gravel with Cobble (GP); gray, slightly moist to wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill] O Pit Walls Collapsing O Pit Walls Collapsing O Pit Walls Collapsing O D D D D D D D D D D D D D	O Sand & Gravel with Cobble; brown to gray, moist to wet, loose, massive, some clay & debris [Fill] O Sand & Gravel with Cobble (GP); gray, slightly moist to wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill] O Pit Walls Collapsing O Pit Walls Collapsing U Urace Perofile Based On Field Observations & Geologic Mapping	O Sand & Gravel with Cobble; brown to gray, moist to wet, loose, massive, some clay & debris [Fill] O Sand & Gravel with Cobble (GP); gray, slightly moist to wet, loose, massive, rounded gravel and coble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill] O Pit Walls Collapsing O Pit Walls Collapsing O U Uterae Profile Brand On Field Observation: & Generatic Manniae	Penetrometer (isf)- E

SU	BSURFACE LOG	CLIENT: PEC	11001110	-Billo 2	uou	1131011, 510	a i iiiig, i	, , , , ,	DATE:	4/7/2021
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	TEST HOLE BH21	CONTRACTOR:	Geosci	ence					_ LOGGED E	<b>BY:</b> gsv
			TER> II	NITIAL	_: <sup>‡</sup>	₹ 7	AFTE	R 24 H	OURS: 🐺	CAVING> <u>C</u>
ile: BH Lo	pgs Date Printed: 5/3/2021		e e	ation et)	olers	1		RESULT 3	S	Monitor Well
(fee	Description		Sc	Eleva (fee	Sam	Plastic Lir Water Co 10 Penetrom	mit ⊢ ntent 20 ⊨eter (tsf)-	30 4	+ Liquid Limit +0 50	Installation Details
0	Sand & Gravel with Clay; mostly mix, brown, slightly moist, loose,	3/4" minus road- massive [Fill]				-	2	3	4	
2						-				
4	-3.0 Sand & Gravel with Cobble (GP); slightly moist to wet, loose, massi and cobble to 6"-8" diameter [Coa Alluvium/Pit Backfill]	; brown to gray, ive, rounded gravel arse-Grained				-				
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8	-8.0 Pit Walls Collapsing									
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SU	<b>BSURFACE LOG</b>	CLIENT: PEC	11001110	ignts 5	uou	1131011, 510	i Fillig, I	mings	, 011 DA	TE:	4/7/2021
		LOCATION: See	Figures	1 & 2					EL	EVATION	nm
	TEST HOLE BH22	CONTRACTOR:	Geosci	ence					LO	GGED BY	gsv
		EQUIPMENT: $\underline{E}$	x cavator		<u> </u>	₹ 7	AFTE	R 24 F	IOURS	: ¥	CAVING> C
le: BH Lo	gs Date Printed: 5/3/2021					,	TEST	RESUL	TS	· ·	
Depth (feet)	Description		Soil Type	levation (feet)	amplers	1 Plastic Lir	 nit	3	4 ⊣ Liqu	iid Limit	Monitor Well Installation Details
				Ш	<i>S</i>		20	30	40	50	Dotano
0					$\mathbb{H}$	Penetrom 1	eter (tsf)- 2	3	4	↓	
0	Sand & Gravel with some clay; m	ostly pea gravel,	$\otimes$								
	brown, slightly moist, very loose,										
						-					
						-					
2											
						-					
	3.0 Sand & Gravel with Cobble (GP)	; brown to gray,				-					
	slightly moist to wet, loose, massi and cobble to 6"-8" diameter [Cos	ve, rounded gravel arse-Grained				-					
4	Alluvium/Pit Backfill]										
						-					
						-					
						-					
6											
						-					
Į	<u>Z</u>					-					
			••			-					
8	-8.0 Pit Walls Collapsing				╞						
	The wans Conapsing					-					
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	911	BSI DEACE I OG	PROJECT: Bitte	rroot He	ights S	ubc	livision, 3rd Fi	iling, Bil	lings,	STRUCTUR	<b>E.:</b> <u>Residential Subdiv</u>	ision
╟	30	DJURFAUL LUG			1 0 0						4/7/2021	
			LOCATION: See	: Figures	1&2					ELEVATION	<b>1:</b> <u>nm</u>	
		TEST HOLE BH23	CONTRACTOR:	Geosci	ence	—				LOGGED B	<b>Y:</b> gsv	
				xcavator			~~	* FTED	24 1101			
	File: BH Lo	Date Printed: 5/3/2021	DEPTH TO - WA	.  EK>    		-: · ==	¥		24 HUU	JRS: ÷		
SICE.	Depth (feet)	Description		Soil Type	Elevation (feet)	Samplers	Plastic Limit Water Conte 10	<u>2</u> → → → → → → → → → → → → → → → → → → →	<u>3</u> <u>3</u> <u>1</u> <u>0</u> <u>40</u>	4 Liquid Limit 50	Monitor Well Installation Details	
	- 0	Clay, Sand & Gravel; mostly 3/4'	' minus gravel,		{		1	2	3	<u>4</u>		
		brown to dark gray, moist, loose, and strong odor [Fill]	massive, staining		( (		-					-
-  -  -	- 2				   							_
	-						-					-
	- 4											-
		-5 0										-
		Sand & Gravel with Cobble (GP) moist to very moist, loose, massiv	; brown to gray, ve, rounded gravel arse-Grained									-
	- 6	Alluvium/Pit Backfill]	1150-Oranieu	<b>)</b>								
							- -					-
	- 8	8.0 Pit Walls Collapsing		•••: <u>*</u>								
<i>r</i> >												-
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	Sub	surface Profile Based On Field	Observations & (	Geolog:	ic Maţ	ppi.	ng					

501	BSURFACE LOG	CLIENT: PEC		8	uou	) -	6,	DAT	E:	4/7/2021
		LOCATION: See	e Figures	1 & 2				ELE'	VATION:	nm
		CONTRACTOR:	Geoscie	ence				LOG	GED BY:	gsv
	IEST HOLE BH24	EQUIPMENT: E	xcavator							
le: BH Lo	gs Date Printed: 5/3/2021	DEPTH TO - WA	TER> IN	ITIAL	: <sup>2</sup>	₽	AFTER 24	HOURS:	¥	CAVING>
							TEST RES	ULTS		
fi fi			— @	t) t	ers	1	2	3 4		Monitor Well
Jept (feet	Description		Typ.	evat (feet	Idma	Plastic Limi	t	— Liquic	d Limit	Installation
-				Ξ	လိ	Water Cont 10	ent - • 20 30	40 50	0	Details
						Penetrome	ter (tsf)-			
0		1.1.1	x x-x x			1	2	3 4		
	loose, massive, some roots and de	slightly moist,				_				
		[]								
						-				
						-				
2										
						-				
	2.0									
ſ	Sand & Gravel with Cobble (GP)	; brown to gray,	• >>							
	moist to very moist, loose, massiv	ve, rounded gravel				-				
4	Alluvium/Pit Backfill]	arse-Grained								
	L		•			-				
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6										
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ŀ	9.0					-				
	Pit Walls Collapsing					-				
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SI		PROJECT: Bitte	erroot He	ights S	ubd	livision, 3rd	Filing, B	Billings,	STRUCTUR	E.: Residential Subdivis	sion
30	JDJUKFACE LUG	CLIENT: PEC		•					DATE:	4/7/2021	
		LOCATION: See	e Figures	1&2					ELEVATION	: nm	
		CONTRACTOR:	Geosci	ence					LOGGED B	<b>Y</b> :gsv	
	TEST HOLE BII25	EQUIPMENT: E	xcavator								
File: BH	Logs Date Printed: 5/3/2021	DEPTH TO - WA	TER> I	NITIAL		<u>¥</u> 11	_ AFTE	R 24 HOI	JRS: 	CAVING>	
	Ĩ						TEST F	RESULTS			
				c	s	1	2	з	1		
t)			e i	atio et)	olen		<u> </u>	 		Monitor Well	
Dep	Description		S ₹	leva (fee	amp	Plastic Lin	nit ⊨		Liquid Limit	Installation Details	
.    ע				ш	Ő	10 vvater	20	<b>3</b> 0 40	50	Dotano	
1						Penetrom	eter (tef)_				
						1	2	3	4		
	Clay, Sand & Gravel; brown, mo	st, soft/loose,									
,  -	massive, some roots and debris [H	Fill]				-					-
											_
			$\boxtimes$			-					-
			KXXX								
a   -						-					-
5			KXX			-					-
			$\bowtie$			_					_
			KXX								
4			$\bigotimes$								
			K K K			-					-
š			$\otimes$								
			$\otimes$			-					-
;  -			$\otimes$								-
	Sandy to Silty CLAY (CL); brow	n becoming									
	grayish brown, moist becoming v	ery moist, soft,	////			-					-
	low plasticity, massive, orange ar	d gray mottling	·/./././			-					_
	[Fill]		///								
			·/////								-
8			////								
3			·////								
7											
						-					-
						-					-
E   - 10	10.0	ravel: (CL):	1.85/.)								
5  -	brown, wet, soft, low plasticity, s	tratified [Fine-	2. 7. 7			-					-
	Grained Alluvium]	L									
	Ŧ		1.50								
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	-12 0		65. <i>[6]</i> .								
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Si Si	ıbsurface Profile Based On Field	Observations &	Geologi	ic Map	pii	ng					

SU	<b>BSURFACE LOG</b>	CLIENT: PEC	erroot He	ights S	ubd	livision, 3rd Filing, Billings,	SIRUCIURE.:	<u>A/7/2021</u>
		LOCATION: Se	e Figures	1 & 2			ELEVATION:	nm
		CONTRACTOR	Geosci	ence			LOGGED BY:	gsv
	TEST HOLE BH26		Excavator				-	
File: BH Lo	ogs Date Printed: 5/3/2021	DEPTH TO - WA	TER> II	NITIAL	.: <sup>2</sup>	₩ AFTER 24 HO	ours:	_ CAVING> <u>C</u>
et)	Description		oil pe	ation et)	plers	TEST RESULTS	S 4	Monitor Well
(fe	Description		Т <sub>У</sub> S	Elev (fe	Sam	Water Content - • 10 20 30 40 Penetrometer (tsf)-		Details
- 0 - -	Clay, Sand & Gravel; brown, moi massive, some roots and debris [F	st, soft/loose, Till]				-	4	-
- 2	-2.0 SILT & Fine SAND: brown to lig	ht gray moist						-
- - -	becoming very moist, very loose,	massive [Fill]						
- 4 - -						-		-
- - 6 -						- · · · · · · · · · · · · · · · · · · ·		
- - 8 -						-		-
- - - 10	Large Concrete Block [Fill]					-		
						-		
								-

SU	BSURFACE LOG	CLIENT: PEC	root He	ights Si	ubdi	vision, 3rd Filing, Billin	DATE	<b>L:</b> <u>Residential Subdivis</u> <u>4/7/2021</u>
		LOCATION: See	Figures	1 & 2				N: nm
		CONTRACTOR:	Geoscie	ence			LOGGED B	Y: gsv
	TEST HOLE BH27	EQUIPMENT: Ex	cavator					
le: BH Lo	Date Printed: 5/3/2021	DEPTH TO - WAT	TER> IN	NITIAL	: ₹	AFTER 24	4 Hours: 🐺	CAVING>
	-					TEST RES	ULTS	
				Ę	δ	1 2	3 4	
et)	Description		oil /pe	/atio eet)	Iple	Plastic Limit ⊢		Monitor Well Installation
ă₩	Description		ωĘ	Ele\ (fe	San	Water Content - •		Details
						10 20 30	40 50	
						Penetrometer (tsf)-		
0	Clay, Sand & Gravel; brown, moi	st, soft/loose,	XXX					
	massive, asphalt, brick & debris [	Fill]			-			
		×	XX		-			
_		le l	XX					
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		×	$\times$		-			
		× ×	$\times$		-			
		F	$\times$		_			
4	4.0							
*	Sandy Clay with asphalt, concrete	, metal, wood,						
	glass and other debris; moist, very	loose, voids [Fill]						
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SU	<b>BSURFACE LOG</b>	CLIENT: PEC		ignts 50	uou	1131011, 514	T ning, Dinniş	DATE:	4/7/2.021
		LOCATION: See	e Figures	1 & 2				ELEVATION:	nm
	TEAT 1161 E B. 166	CONTRACTOR:	Geoscie	ence				LOGGED BY	gsv
	IEST HOLE BH28	EQUIPMENT: E	xcavator		_				
le: BH Lo	gs Date Printed: 5/3/2021	DEPTH TO - WA	TER>	NITIAL	: 4	⊈9	AFTER 24	HOURS: 🐺	
	<u> </u>						TEST RESU	JLTS	
				u	δ	1	2	3 4	
eet)	Description		soil /pe	/atic eet)	ble	Plastic I in	nit I	+ + Higuid Limit	Monitor Well Installation
ă₩	20001194011		0 <u>F</u> .	Elev (fe	San	Water Cor	ntent - •		Details
						10	20 30	40 50	
						Penetrome	eter (tsf)-		
0	Sand with asphalt, concrete metal	, wood, glass,						<del>5 4</del>	
	pipe, and other debris; moist, very	v loose, voids [Fill]							
			KXX (						
					[				
2									
						-			
۱ I									
					[				
6	6.0	1.1 .	KXXX						
	becoming very moist very loose	gnt brown, moist soft, massive grav							
	and orange mottling [Fill]	,							
8									
7	Zo 0								
1	Silty CLAY (CL); gray with black	c organics, very							
	moist to wet, very soft, low plasti	city, massive	HИ						
10	Louried Anuvium/Old Back Chan	mer Deposits]	WИ		╞				
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	11.0								
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SUI	BSURFACE LOG	CLIENT: PEC	11000110	ignito o	uou	111011, 51	iu i iiiig,	Dining	<u>,</u> D	ATE:	4/8/2021
		LOCATION: See	Figures	1 & 2					E	LEVATION:	nm
	TEST HOLE BH29	CONTRACTOR:	Geosci	ence					L(	OGGED BY	:gsv
			TER> II		-: <sup>Ţ</sup>	₹ 8	AFT	ER 24	HOUR	S: <del>¥</del>	CAVING> <u>C</u>
le: BH Lo	gs Date Printed: 5/3/2021						TEST	RESI	JLTS		<u> </u>
_				uo	ខ	1	2		3	4	Monitor Woll
Jepti (feet)	Description		Soil Type	evati (feet)	ample	Plastic Li	imit ⊣		──  Lio	uid Limit	Installation
				Ξ	ŝ	Water Co 10	ontent - 20	• 30	40	50	Details
						Penetron	neter (tsf	;)- 🛛		, L	
0	Sand & Gravel with Clay; mostly	3/4" minus road-	XX			1	2		3	4	
	mix, brown, slightly moist, loose	, massive [Fill]	XX			-					
			$\mathbb{X}$			-					
						-					
2											
						-					
	-3.0	1 .	ex XX		╞	-					
	Sand & Gravel with Cobble (GP) slightly moist to wet, loose, massi	brown to gray, ve, rounded grave				-					
4	and cobble to 6"-8" diameter [Coa Alluvium/Pit Backfill]	arse-Grained									
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8 4	Z										
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10	-10.0										
10	SHALE; grayish brown, moist, w	eak, thinly bedded									
	Formation]	amered [Claggett									
12	12.0										
12	-12.0				[	_					
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SU	<b>BSURFACE LOG</b>	CLIENT: PEC	rroot nei	gnis Si	uba	11111011, 514	гшпg, ы	innigs,	DATE:	4/8/2021
		LOCATION: See	Figures 1	1 & 2					ELEVATION	: nm
	TEST HOLE BH30	CONTRACTOR:	Geoscie	nce					LOGGED BY	: gsv
		EQUIPMENT: E	xcavator TFR> IN	ΙΙΤΙΔΙ	· Ż	<u>∠</u> 8	<b>AFTER</b>	24 HO	URS: ≚	
ile: BH Lo	Date Printed: 5/3/2021				:   _		TEST R		<u></u>	
Depth (feet)	Description		Soil Type	levation (feet)	amplers	1 Plastic Lim	2 nit ⊢	3	4 Liquid Limit	Monitor Well Installation Details
				Ш	S		20	30 40	) 50	Dotano
						Penetrome	eter (tsf)- 2	3	⁄∕⊿ ⊢	
0	Sand & Gravel; mostly 3/4" minu	s road-mix,								
	brown, slightly moist, loose, ma	ssive [riii]				-				
						-				
						-				
2						-				
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						-				
4	4.0 Sand & Gravel with Cobble (GP)	brown to grav.	$\mathbf{x} \mathbf{x} \mathbf{x} \mathbf{x}$							
	slightly moist to wet, loose, mass	ve, rounded gravel				-				
	and cobble to 6"-8" diameter [Coa Alluvium/Pit Backfill]	arse-Grained				-				
	-					-				
6										
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						-				
8 4	7									
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						-				
						-				
10										
10						-				
	-11 0					-				
	SHALE; grayish brown, moist, w	eak, thinly bedded,								
1.2	Formation]	athered [Claggett								
12	12.0	/								
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						•				
Sub	osurface Profile Based On Field	Observations & (	Geologia	c Map	pir	ıg				

5U	BSURFACE LOG	CLIENT: DEC		8			, i iiiig, bii			<u>4/8/2021</u>
		LOCATION: See	Figures	1&2					ELEVATION:	nm
		CONTRACTOR:	Geosci	ence					LOGGED BY:	gsv
	TEST HOLE BH31	EQUIPMENT: E	xcavator							0,
e: BH I o	Date Printed: 5/3/2021	DEPTH TO - WA	TER> I	NITIAL	-: <sup>Į</sup>	<u></u> ¥ _ 7	AFTER	24 HOL	JRS:	CAVING>
<u>c. Dit Lo</u>							TEST RE	SULTS		
				L.	δ	1	2	3	4	
epth eet)	Description		ype	/atic set)	ple	Plastic Lin	nit ⊢		l iquid L imit	Monitor Well Installation
ă ≝	Beechpaen		<sup>0</sup> , ⊢'	Ele (fé	San	Water Co	ntent - •	I		Details
						10	20 30	<u> </u>	50	
					$\vdash$	Penetrom	eter (tsf)- 2			
0	Sand & Gravel; mostly 3/4" minus	s road-mix,								
	brown, slightly moist, loose, mas	sive [Fill]				-				
						-				
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			K XX		[					
2	2.0 Sand & Gravel with Cobble (GP).	brown to grav								
	slightly moist to wet, loose, massi	ve, rounded grave				-				
	and cobble to 6"-8" diameter [Coa	rse-Grained	· • •			-				
	Alluvium/Pit Backfill]					_				
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10	10.0 SHALE: gravish brown moist we	eak thinly bedded								
	medium plasticity, moderately we	athered [Claggett				-				
	Formation]					-				
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12	-12.0-									
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CII	BOUDEACEIOC	PROJECT: Bille	erroot He	ignts 5	uba	ivision, sra r	filing, Billi		CIURE .:	Kesidential Subdivisi
30	DOURFAUE LUG	CLIENT: PEC							:	4/8/2021
		LOCATION: See	Figures	1&2						nm
	TEST HOLE BH32	CONTRACTOR:	Geosci	ence				LOGG	ED BY:	gsv
			TER> II		• 7	Z 6	AFTER 2		L	CAVING>
File: BH Lo	gs Date Printed: 5/3/2021								<u> </u>	
t ç			e =	ition it)	lers	1	2	3 4		Monitor Well
Dep (fee	Description		S dY	leva (fee	amp	Plastic Limit		Liquid I	Limit	Installation Details
				ш	S		20 30	40 50		Botano
					Ц	Penetromet	er (tsf)- 🛛 🛛			
- 0	Sand & Crowal with Class brown	alightly maint	KXXXX		╎╎	1	2	3 4		
	loose, massive [Fill]	slightly moist,				_				
						-				
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- 2										
	-2.5		XX			_				
	Sand & Gravel with Cobble (GP)	; brown to gray,	•?							
	slightly moist to wet, loose, massi	ve, rounded grave	•			-				
	Alluvium/Pit Backfill]	a se-Granieu				-				
- 4			•							
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6 4	<u>Z</u>		•							
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	SHALE; grayish brown, moist, w	eak, thinly bedded	,							
	medium plasticity, moderately we	eathered [Claggett				-				
- 10	Formation									
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SU	BSURFACE LOG							r		4/9/2021
		LOCATION: See	Figures	1 & 2				L		4/8/2021
		CONTRACTOR	Geosci	ence				L	OGGED BY	nesv.
	TEST HOLE BH33	FOUIPMENT: F	x cavator					•		gsv
		DEPTH TO - WA	TER> I	NITIAL	Ţ	₹ 6	AFTER 2	4 HOUF	RS: <del>¥</del>	CAVING> C
e: BH Lo	gs Date Printed: 5/3/2021				П		TEST RE	SULTS		
				_	<u>ر</u>	1	2	2	4	
et)	Description		pe l	atioı et)	plen	Diactia Lim		<u> </u>		Monitor Well
(fe	Description		۲×۵	fe (fe	Sam	Water Cor	nii – – –	L	iquia Limit	Details
				ш		10	20 30	40	50	
						Penetrome	eter (tsf)-		]	
0	Sand & Gravel with Clay: brown	slightly moist	K ARX			1	2	3	4	
	loose, massive [Fill]	singinity monst,				-				
						-				
2										
	-2.5		<b>XX</b>			-				
	Sand & Gravel with Cobble (GP)	brown to gray,				_				
	and cobble to 6"-8" diameter [Cos	ive, rounded grave								
	Alluvium/Pit Backfill]					-				
4					╞					
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8	8.0	cole this last - 1 1 1								
	medium plasticity, moderately we	eathered [Claggett	, 			-				
	Formation]	L 60 ···				-				
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SU	<b>BSURFACE LOG</b>	CI IFNT: PEC	<u></u>	Ignts 5	<u>uba</u>	<u>ivision, siu</u>	<u>t i ning, Dini</u>	<u>ings</u> , (	DATE:	4/8/2021
		LOCATION: Se	e Figures	.1&2				 I	ELEVATION:	nm
		CONTRACTOR	: Geosci	lence				I	LOGGED BY:	gsv
	TEST HOLE BH34	EQUIPMENT: F	Excavator	ι						
e: BH Lo	ogs Date Printed: 5/3/2021	DEPTH TO - WA	ATER> I	NITIAI	<b>_:</b>	<u>₹ 4.5</u>	_ AFTER 2	24 HOU	RS: ¥	
			Ī	Ī	Π			SULTS		
_				ч	S S	1	2	3	4	Manitan Moll
eet)	Description		Soil	vatic eet)	nple	Plastic Lir	mit	—— —— I	_iquid Limit	Installation
יבֿיבֿ				Еle (f	San	Water Co	ntent -			Details
				'		10	20 30	40		
	<u> </u>			['	H	Penetrome	eter (tsf)- ½	<u>///////</u> 3		
0	Sand & Gravel with Clay; brown	, slightly moist,			ļŗ	1				
	loose, massive [Fill]			5	ļţ	ī				
				4	ļļ	F				
	1.5				ļļ	L				
	Sand & Gravel with Cobble (GP)	; brown to gray,	3.	1	ļļ	i				
2	slightly moist to wet, loose, massi	ive, rounded grave		ć	†					
	Alluvium/Pit Backfill]	arse-Grained				ī 👘				
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6	6.0 SUALE: gravish brown moist w	reals thinly bedded	1	1		ī				
	medium plasticity, moderately we	eathered [Claggett	,	-		r i				
	Formation]	-		-	ļļ	F				
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SU	BSURFACE LOG	CLIENT: PEC		igins 5	uba	ivision, sra i	гшпg, ып	ings,		<u>4/8/2021</u>
		LOCATION: See	Figures	1 & 2					ELEVATION:	4/8/2021 nm
		CONTRACTOR:	Geosci	ence					LOGGED BY	gsv
	TEST HOLE BH35	EQUIPMENT: E	xcavator							
e: BH Lo	gs Date Printed: 5/3/2021	DEPTH TO - WA	TER> I	NITIAL	-: <sup>z</sup>	₹6.0	AFTER	24 HOI	JRS: ¥	_ CAVING> _
	<u> </u>						TEST RE	SULTS		
				L.	ø	1	2	3	4	
et)	Description		/pe	/atio ∍et)	ple	Plastic I imi	it ⊢		Liquid Limit	Monitor Well
<u> </u>	Description		l∞⊢	Ele∕ (f€	San	Water Cont	tent - •	I		Details
						10	20 30	<u>4</u> 0	50	
					$\vdash$	Penetromet	ter (tsf)-		▨,⊢	
0	Sand & Gravel with Clay; brown,	slightly moist,	X						4	
	loose, massive [Fill]					-				
						-				
						-				
2										
			$\otimes$			-				
	-3.0		XX							
	Sand & Gravel with Cobble (GP)	; brown to gray,	2							
	slightly moist to wet, loose, massi	ve, rounded grave				-				
4	Alluvium/Pit Backfill]	a se-Grained								
						-				
			7							
			<b>.</b>							
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6 🖣	<u>Z</u>		•							
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8	8.0	1 .1 . 1 . 1 . 1								
	SHALE; grayish brown, moist, w	eak, thinly bedded	· · · · · ·			-				
	Formation]									
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10	-10.0									
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		LOCATION: See	Figures	1&2					5/ El		T/0/2021	
-										EVATION.	nm	
		CONTRACTOR:	Geosci	ence					LC	GGED BY:	gsv	
	TEST HOLE BH36	EQUIPMENT: E	xcavator									
<u>e: BH Log</u>	gsDate Printed: 5/3/2021	DEPTH TO - WA	TER> II	NITIAL	: <u>7</u>	₹ 7.5	AF	TER 24	HOURS	8: 葉	_ CAVING> _	
							TES	T RESU	JLTS			
_				uo	S	1	2	2	3	4	Monitor Woll	ı
eptr eet)	Description		Soil ype	vati eet)	nple	, Plastic Li	mit ⊢		— ∣Liq	uid Limit	Installation	
שב	•		- ~~	Ele (f	Sar	Water Co	ontent -	•	40	50	Details	
						Denetrem			40	50		
						Penetron 1	$\frac{1}{2}$	si)- <u>[//</u> 2	3	4		
"	Sand & Gravel; mostly 3/4" minus	road-mix,										
	brown, slightly moist, loose, mass	ive [Fill]	$\otimes$			-						
						-						
						-						
,												
-												
						-						
ŀ	3.0 SAND: fine-grained brown sligh	tly mojet to mojet				-						
	very loose, massive [Fill]	ay moist to moist,	$\bigotimes$			-						
۱ I			$\times$									
			$\bigotimes$									
			$\otimes$									
			$\otimes$			-						
			$\otimes$			-						
5			$\times$									
			$\bigotimes$			-						
	7.0		$\times$									
	Sand & Gravel with Cobble (GP);	brown to gray,										
Ŧ	moist to wet, loose, massive, rour	ided gravel and				-						
8	Alluvium/Pit Backfill]	Grained										
	-					-						
	-9.0		••••••••••••••••••••••••••••••••••••••			_						
	SHALE; grayish brown, moist, we	ak, thinly bedded,										
	medium plasticity, moderately we	athered [Claggett				-						
10	i ofmation]											
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SU	BSURFACE LOG	CI IENT · PEC		0			8,	<u>ΠΔΤΕ</u> ·	4/8/2021
<u> </u>		LOCATION: See	Figures	1&2					4/8/2021
		CONTRACTOR:	Geosci	ence					: gsv
	TEST HOLE BH37	EQUIPMENT: E	xcavator						5
ila: PU La	Data Brintadi 5/2/2021	DEPTH TO - WA	TER> II	NITIAL	.: ž	<u> </u>	AFTER 2	24 HOURS: 🐺	CAVING>
	gs Date Printed: 5/5/20211	I			Π		TEST RE	SULTS	
				c	ار ار	1		3 1	
et)	Description		pe I	atio et)	bler	Di-stia Lin	·· · ·		Monitor Well
(fe	Description		ŭ≽	(fe	am	Plastic Lin	nit ⊨	——— Liquia Limit	Details
	l			ш	S	<u>10</u>	<u>20</u> <u>30</u>	40 50	
					Ц	Penetrome	eter (tsf)-		
. 0					╎┟	1	2	3 4	
Ŭ	Sand & Gravel with Clay; brown,	slightly moist,	$\sim$						
	l								
ļ	-1 5		$\otimes$		│┟				
-	Sand & Gravel with Cobble (GP);	; brown to gray,	••••						
2	slightly moist to wet, loose, massi	ive, rounded gravel	<b>₩</b> 28						
	and cobble to 6"-8" diameter [Coa	arse-Grained	• • •		-				
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	SHALE; grayish brown, moist, we	eak, thinly bedded,			╎┟				
10	Formation]	amered [Clagged							
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911	Relibeace I OG	PROJECT: Bitte	rroot He	ights S	ubd	livision, 3rd	Filing, Billin		Residential Subdivision
30	BOURFACE LUG	CLIENT: PEC						DATE:	4/8/2021
		LOCATION: See	Figures	1&2				ELEVATION:	
	TEST HOLE BH38	CONTRACTOR:	Geosci	ence				LOGGED BY	gsv
			xcavator						
File: BH Lo	Date Printed: 5/3/2021	DEPTH TO - WA				<u>¥</u> 9	AFIER 24	HOUR5: ¥	
Depth (feet)	Description		Soil Type	Elevation (feet)	amplers	1 Plastic Lim	2 it ├	3 4 → Liquid Limit	Monitor Well Installation Details
						Penetrome	20 30 ter (tsf)-	<u>40 50</u> 	
- 0 -	Sand & Gravel with Clay; brown, loose, massive [Fill]	slightly moist,				-			-
-						-			
- <b>2</b> - -	2.0 Clay, Sand & Gravel with Cobble slightly moist to moist, loose, ma slight odor [Fill]	(GC); gray, ssive, staining and				-			_
- <b>4</b> -						-			-
- - - 6						-			-
- - - 8	7.0 Silty CLAY (CL); gray with blacl moist to wet, very soft, low plasti [Buried Alluvium/Old Back Chan	c organics, very city, massive nel Deposits]				-			-
- 록 	9.0 Sandy SILT (ML); brown, very m soft [Fine-Grained Alluvium]	oist to wet, loose/				-			-
-	-11.0 Sand & Gravel with Cobble (GP) wet, loose, massive, rounded grav 6" -8" diameter [Coarse-Grained	brown to gray, el and cobble to				-			
- 12	12.0		<u></u>			-			-
									-
Sub	osurface Profile Based On Field	Observations & (	Geologi	ic Map	pi	ng			

<b>JU</b>	BSURFACE LOG	CLIENT: PEC		0	uoui	151011, 1	<u>14 I III</u>	ig, Dining		<u>4/8/2021</u>
		LOCATION: See	Figures	1 & 2					ELEVATI	ON: nm
		CONTRACTOR:	Geosci	ence						BY: gsv
	IEST HOLE BH39	EQUIPMENT: E	xcavator							
File: BH Lo	Dgs Date Printed: 5/3/2021	DEPTH TO - WA	TER> II	NITIAL	.: ¥	<u>z</u> 8	AF	TER 24	HOURS: ¥	CAVING> <u>C</u>
epth eet)	Description		soil ype	vation eet)	nplers	Plastic	<u>TE</u> 1 Limit ⊢	2	<u>JLTS</u> 3 4 — → Liquid Limi <sup>-</sup>	- Monitor Well
Ŭ,			» н	Ele (f	San	Water 0 10 Penetro	Content 20 meter (	- • 30 tsf)- 🕅	40 50	Details 
- 0	Clay, Sand & Gravel; brown, moi massive, concrete, asphalt, metal [Fill]	st, very loose, & debris, voids								
- 2										
- 4										
6	-6.0 Sandy Clay with Gravel; dark gra staining and strong odor [Fill]	y, moist, soft,								
<b>8</b>	8.0	walk staining and								
	strong odor [Claggett Formation]	weak, staming and								
										····
										***
										_

5U	BSURFACE LUG	CLIENT: PEC							DATE:	4/8/2021
		LOCATION: See	Figures	1 & 2					ELEVATION:	nm
		CONTRACTOR:	Geosci	ence					LOGGED BY	:gsv
	IEST HOLE BH40	EQUIPMENT: E	xcavator							
e: BH Lo	Date Printed: 5/3/2021	DEPTH TO - WA	TER> II	NITIAL	-: <u>-</u>	<u> </u>	AFTER	24 HO	URS: 	CAVING> <u>C</u>
							TEST R	ESULTS	;	
				Ľ	δ	1	2	3	4	
epun eet)	Description		/pe	/atic	ble	Plastic I im	it ⊢		Liquid Limit	Installation
n ∰	Decemption		<sup>00</sup> ⊢'	Ele (fé	San	Water Con	tent - •	1		Details
						10	20 3	0 40	50	
					$\vdash$	Penetrome	ter (tsf)-			
0	Clay with Sand & Gravel; brown,	moist, soft/loose,	X						4	
	massive, some roots and debris [F	ill]				-				
						-				
2										
			$\bigotimes$			-				
			KXXX							
						-				
1	4.0									
	Sandy CLAY (CL); brown, moist,	soft, low	$\boxtimes$			-				
	plasticity, massive [1 m]		$\otimes$							
			$\boxtimes$			-				
			$\bigotimes$			-				
6			$\boxtimes$							
			$\boxtimes$			-				
			$\bigotimes$							
			$\bigotimes$			-				
			$\boxtimes$			-				
8	-8.0									
	Silty CLAY (CL); gray with black	organics, very								
	[Buried Alluvium/Old Back Chan	nel Deposits]	KI/							
		1	ИV			-				
			КV			-				
10	-10.0									
-	Sandy to Silty CLAY; (CL); brow	n, very moist to	/././.							
-	Fine-Grained Alluvium	orange mottling								
4	/		////			-				
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12	-12.0		<u>././.</u> /.							
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	211		PROJECT: Bitte	erroot He	ights S	ubd	livision,	3rd Filing	, Billings,	STRUCTU	RE.: Residential Subdivisio	m
	JU	DOUNFAUE LUG	CLIENT: PEC								4/8/2021	
			LOCATION: See	Figures	1 & 2					ELEVATIO	<b>N:</b> nm	
			CONTRACTOR:	Geoscie	ence					LOGGED E	BY: gsv	
			EQUIPMENT: E	xcavator								
File	<u>:: BH</u> Lo	Date Printed: 5/3/2021	DEPTH TO - WA	TER> II	NITIAL	.: -	<u>¥</u> 11	AFT	ER 24 HO	URS: 	CAVING>	
								TES	T RESULTS			
					_							
	5			- •	tior t)	lers		1 2	3	4	Monitor Well	
	fee	Description		Typ	eva (fee	dш	Plastic	Limit		Liquid Limit	Installation	
.    `					Ξ	Sa	Water (	Content -	•	50	Details	
									<u> </u>	· <u>50</u>		
						⊢	Penetro	ometer (ts	f)-			
′⊩	0	Clay with Sand Gravel & Debris	brown moist	$\times$						4		_
		soft/loose, massive, cobbles, conc	rete, asphalt and	$\times$								
		wood [Fill]	· 1									
				XXX			_					-
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	0											
		-6.5		<b>XXX</b>			-					-
		Clayey to Sandy SILT (ML); brow	vn to gray, moist,				_					_
		soft, faminated [Fili]										
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il	10	10.0		ĸĸĸ								
24    •		Sandy to Silty CLAY; (CL); brow	n to gray, very	////								
3		moist to wet, very soft, low plasti	city, stratified,									-
	Ţ	Alluvium]	nics [rine-Grained	///			-					-
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<u></u> ¶⊢	12	-12.0		• / •/• /•								
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	C1	Branda Duckla Dan - 1 Or Et 11	Obacmentices 0	Caster	o M -						L	
	SUL	isurjace Frojile Basea On Field	Observations &	Jeologi	с мар	pu	ng					

SU	BSURFACE LOG	CLIENT: PEC		0	uoui		ia i iiii	8,	<u>, 0</u>		4/8/2021
		LOCATION: See	e Figures	1&2					B		: nm
		CONTRACTOR:	Geosci	ence					L	OGGED BY	f:gsv
	TEST HOLE BH42		xcavator								
e: BH Lo	Date Printed: 5/3/2021	DEPTH TO - WA	TER> II	NITIAL	<b>:</b> ¥	11	AF	TER 24	HOUR	S: ₹	CAVING> <u>C</u>
					╽┝		TES	ST RESI	JLTS		
_				uo	S	1		2	3	4	Monitor Well
epu eet)	Description		Soil	vati eet)	롎	Plastic L	_imit ⊢		Li	quid Limit	Installation
שב				Ele (f	Sar	Nater C	ontent -	•	10	50	Details
					.	<u>10</u> Domotros	<u></u>		40	50	
					ΗĽ	enetroi 1	meter (t	si)- 🚧 2	<u>///////</u> 3	4	
U	Clay with Sand, Gravel & Debris	brown, moist,									
	soft/loose, massive, concrete, asp	halt and wood									
	[1]				ŀF						
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2											
			KXX		╞						
	-5.5										
	Clayey to Sandy SILT (ML); brow	wn to gray, moist,									
)	soft, laminated [Fill]										
2											
	9.0										
	moist to wet, very soft, low plastic	city, stratified,	////								
10	orange mottling, some black organ	nics [Fine-Grained									
	Alluvium										
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2	-12.0		<u>. /././</u>								
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SU	BSURFACE LOG	CLIENT: PEC		igino 5	ubui	vision, .	nu r ning	g, Dining	<u>35,</u> 5 D	ATE:	4/8/2021
		LOCATION: Sec	e Figures	1 & 2					E		: nm
		CONTRACTOR:	Geoscie	ence					L	OGGED B	<b>f</b> :gsv
			x cavator			7 11				o. <b>v</b>	
:: BH Lo	gs Date Printed: 5/3/2021	DEPTH TO - WA		NITIAL	.: ¥	<u> </u>				.o: ≢	
(feet)	Description		Soil Type	evation (feet)	amplers	Plastic I	_imit ⊢	2	3 	4 quid Limit	Monitor Well Installation
-				Ξ	Š	Water C	Content - 20	. • 30	40	50	Details
					H	11		<u>2</u>	<u></u>	4	
U	Clay with Sand, Gravel & Debris; soft/loose, massive, concrete, asp	brown, moist, halt, metal and									
	wood [Fill]										
,											
-											
	-5.0 Clayey to Sandy SILT (ML); brow	vn to gray, moist,									
5	soft, laminated [Fill]										
;											
	9.0 Sandy to Silty CLAY; (CL); brow moist to wet very soft low plastic	n to gray, very									
0	orange mottling, some black organ Alluvium]	nics [Fine-Grained									
	7										
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2	-12.0		·/·/·/·/								
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SU	BSURFACE LOG	CLIENT: PEC		0		/	8)		DATE:	4/8/2021
		LOCATION: See	Figures	1 & 2					ELEVATI	ON:
		CONTRACTOR:	Geosci	ence					LOGGED	BY: gsv
	IEST HOLE BH44	EQUIPMENT: E	xcavator							
le: BH Lo	Date Printed: 5/3/2021	DEPTH TO - WA	TER> I	NITIAL	: Ţ	<u>₹ 11</u>	_ AFTE	R 24 H	IOURS:	CAVING> <u>C</u>
							TEST I	RESUL	TS	_
				L L	δ	1	2	3	4	
sptn set)	Description		pe pe	atic et)	ple	Plastic Li	mit 🛏	Î	⊣ Liquid Limit	<ul> <li>Monitor Well</li> <li>Installation</li> </ul>
J, J,	Description		l∞⊢	Ele∕ (fe	San	Water Co	ontent -	•		Details
				_		10	20	30	40 50	_
						Penetrom	neter (tsf)-			
0	Sandy CLAY (CL): brown, slight	ly moist, soft, low	V 1/4 / 4					3	4	-
	plasticity, roots and organic mater	rial, scattered				-				
	cobbles [Topsoil/Fill]									
										111
	-1.5 Sandy to Silty CLAV (CL): heavy	n to dark grovish				-				***
2	brown, slightly moist, medium sti	ff, low plasticity.	\ <i>.//,</i>							
	massive [Fine-Grained Alluvium]	1 J)	×./././			-				
			\ <i>`////</i>			-				
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4			·/////		-					
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			/////			-				
6	6.0									
0	Sandy to Silty CLAY; (CL); light	brown, moist	////							
	becoming very moist to wet, soft,	low plasticity,				-				
	stratified, orange mouning [1 me-c	Stanica Anavianij	·/·///			-				
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SU	<b>BSURFACE LOG</b>	CLIENT: PEC	11001110	Jights 5	uba	<u></u>	<u>i Fillig, Billi</u>	<u></u>	DATE:	4/8/2021
		LOCATION: Ser	e Figures	s 1 <u>&amp; 2</u>				F	ELEVATION:	
		CONTRACTOR:	Geosc	ience				L	OGGED BY:	gsv
	TEST HOLE BH45	EQUIPMENT: F	xcavato	r						
e: BH Lo	Date Printed: 5/3/2021	DEPTH TO - WA	TER> I	NITIAI	L: - <sup>3</sup>	<u>₩ 11</u>	AFTER 2	24 HOUF	₹S: ₩	CAVING> <u></u>
					$\Box'$		TEST RES	SULTS		
	1			5	S S	1 1	2	3	4	
et)	Description		ype	/atic eet)	la	Plastic Li	imit	—	iquid Limit	Monitor vvei Installation
ן <u>י</u> י ר			÷ ۳	∐e ≝	San	Water Co	ontent - •	T		Details
ļ	1			-	1	10	20 30	40	50	
$ \rightarrow $	<u> </u>		<b> </b>	<b> </b>	+'	Penetrom	neter (tsf)-		⊿	
0	Sondy CLAV (CL): brown slight	ty moist soft low		•	'			3	4	
ļ	nlasticity, roots and organic mater	rial. scattered		\$	'	L				
ļ	cobbles [Topsoil/Fill]	10.,		4	'					
ļ	1		14/1/1/	4	'	ļ				
ļ	1			1	'	ļ				
,				1	Ľ					
'	Sandy to Silty CLAY (CL); brow	n to dark grayish	////							
ļ	brown, slightly moist, medium sti	ff, low plasticity,	1.1.1.	4		F i				
ļ	massive [Fine-Grained Alluvium]	1	V././.			4				
ļ	1		\ <i>././</i>	:						
	1		1././.	1	1	f				
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6	6.0		<i>\.</i> /./.j	2	Ľ	L				
	Sandy to Silty CLAY; (CL); light	brown, moist	////			<b>I</b>				
ļ	becoming very moist to wet, soft,	low plasticity,	///	4		<b>I</b>				
ļ	stratified, orange mouring in me	Jraineu Anuvium	\././.j			k				
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<b>5U</b>	BSURFACE LOG	CLIENT: PEC							D	ATE:	4/8/2021	
		LOCATION: Se	e Figures	1 & 2					E		l: nm	
		CONTRACTOR	Geosci	ence					L	OGGED B	Y: gsv	
	TEST HOLE BH46	EQUIPMENT: I	Excavator									
le: BH Lo	Date Printed: 5/3/2021	DEPTH TO - WA	TER> II	NITIAL	: <u></u>	<u>_</u>	AFT	ER 24	HOUR	S:	CAVING>	
<u> </u>							TES	T RESI	JLTS			
				c	s	1	2		з	1		
ef) bth	Description		pe bi	atio et)	pler				<u> </u>	7 	Monitor We	ell
Ţe Į	Description		_∑ S	(fe	am	Plastic L	lmit ⊢	•		quia Limit	Details	n
				ш	S	1 <u>0</u>	2 <u>0</u>	30	4 <u>0</u>	50		
						Penetro	meter (ts	f)- 🗵	////////////////////////////////////	, L		
0		1 1 111	K X X X			1	2		3	4		
	brown slightly moist soft [Fill]	ivel and cobble;										
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	3.0		ľXXX			-						
	Sandy to Silty CLAY (CL); brown	n, dry to slighly	·///			-						
	mottling [Fine-Grained Alluvium]	, massive, white										
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6	-6.0	1										
	becoming very moist to wet, soft.	low plasticity.	////			-						
	stratified, orange mottling [Fine-C	Brained Alluvium]	////									
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SU	BSURFACE LOG	CI IENT: PEC	e1100111e	igino o		1/8/2021						
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		LOCATION: See	e Figures	1&2					ELEVATION:	nm		
		CONTRACTOR	: Geosci	ence					LOGGED BY:	gsv		
	TEST HOLE BH47	EQUIPMENT: I	Excavator	•					_	0		
ile: BH Lo	Date Printed: 5/3/2021	DEPTH TO - WATER> INITIAL: ₩ AFTER 24							)URS: 🐺	_ CAVING> _		
IIE: BH LO	gs Date Printed: 5/5/20211						TEST	RESULT	S			
Depth (feet)	Description		Soil Type	Elevation (feet)	Samplers	1 Plastic Lin Water Con 10	2 nit	3 30 4	4 Liquid Limit 0 <u>5</u> 0	Monitor Well Installation Details		
						Penetrom	eter (tsf)-					
0	Sandy CLAV (CL) with some gra	val and cobble:				<u> </u>	2	3	4			
	brown, slightly moist, soft, [Fill]	ver and coopie,				-						
						-						
						-						
2	2.0											
	Sandy to Silty CLAY (CL); brown moist medium stiff low plasticity	n, dry to slighly		1		-						
	mottling [Fine-Grained Alluvium]			1								
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6	6.0	harry and int				-						
	becoming very moist to wet, soft,	low plasticity,		1		-						
	stratified, orange mottling [Fine-C	Frained Alluvium]				-						
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8			////	1								
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SU	BSURFACE LOG	CLIENT: PEC		: <u>Residential Subdivisio</u> 4/8/2021						
		LOCATION: See	Figures	1&2					ELEVATION:	nm
		CONTRACTOR:	Geosci	ence					LOGGED BY:	gsv
	TEST HOLE BH48	EQUIPMENT: E	xcavator							
e: BH Lo	Date Printed: 5/3/2021	DEPTH TO - WA	TER> I	NITIAL	: 4	₹9	AFTER	24 HOU	RS:	_ CAVING> _
	-						TEST RE	SULTS		
				u	δ	1	2	3	4	
epth eet)	Description		ype /	/atic eet)	ple	Plastic Li	imit ⊢		iquid Limit	Monitor Well Installation
Ğ ¥	Decemption		0, –	Elev (fe	San	Water Co	ontent -			Details
						10	20 30	0 40	50	
						Penetron	neter (tsf)- 2	3		
0	Sandy CLAY (CL); brown, slight	ly moist, soft, low								
	plasticity, roots and organic mater	rial [Topsoil]				-				
						-				
						-				
2	2.0 Sandy to Silty CLAY (CL): brown	n, slighly moist to	////							
	moist, medium stiff, low plasticity	y, massive, white	////			-				
	mottling [Fine-Grained Alluvium]	]	/////			-				
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	7.0		<u> </u>			-				
	moist to wet, loose, stratified with	clay layers [Fine-				-				
8	Grained Alluvium]	, , <sub>L</sub>	1.1.1.1							
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SU	BSURFACE LOG	CLIENT: PEC DATE:									.: <u>Residential Subdivisio</u> 4/8/2021	
		LOCATION: See	e Figures	1 & 2					D E	LEVATION:	nm	
	TEAT US E BUILD	CONTRACTOR	Geoscie	ence					L	OGGED BY	gsv	
	IEST HOLE BH49		excavator									
e: BH Lo	Dgs Date Printed: 5/3/2021	DEPTH TO - WATER> INITIAL: ₩9 AFTER 24 HOURS: ₩										
							TES	T RESL	JLTS			
_				uc	S	1	2		3	4	Manitan Malu	
eet)	Description		Soil ype	vatio eet)	nple	Plastic L	_imit ⊢		—∣ Lio	quid Limit	Installation	
ĽĘ			<sup>00</sup> –	Ele (f	San	Water C	ontent -	•			Details	
						10	20	30	40	50		
					$\square$	Penetro	meter (ts 2	f)- 📈	3	4		
0	Sandy CLAY (CL) with some gra	vel and cobble;							<u> </u>			
	brown, slightly moist, soft, [Fill]					-						
						-						
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	• •											
2	2.0 Sandy to Silty CLAY (CL): brown	n. dry to slighly	///									
	moist, medium stiff, low plasticity	, massive, white				-						
	mottling [Fine-Grained Alluvium]	]				-						
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	Sandy to Silty CLAY; (CL); light	brown, moist	////			-						
	stratified, orange mottling [Fine-C	Frained Alluvium	////									
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		LOCATION: Sec	e Figures	1&2						4/8/2021
		CONTRACTOR:	Geosci	ence					LOGGED B	Y: gsv
	TEST HOLE BH50	EQUIPMENT: F	xcavator							
e BH I o	Data Printad: 5/3/2021	DEPTH TO - WA	TER> II	NITIAL	÷	₹9	AF	TER 24 H	ours:	
<u>c. bii Lo</u>	Date Triffed. 5/3/20211						TES	T RESUL	TS	
				с	β	1	1 2	. 3	4	
spth set)	Description		oil /pe	∕atio ∍et)	plei	Plastic I	imit ⊢	Ť	⊢ Liquid Limit	Monitor Well
Ľ	Description		l ∾ ⊢	Ele∖ (f∈	San	Water C	Content -	•		Details
						10	20	30 4	40 50	
-						Penetro 1	meter (ts 1 2	sf)- ///// 2 3	4	
0	Sandy CLAY (CL) with some gra	vel and cobble;								
	brown, slightly moist, soft, roots [	Topsoil/Fill]	$\times$			-				
	1.0				╞	-				
	Sandy to Silty CLAY (CL); brown	n, dry to slighly	(././././.			-				
<b>,</b>	mottling [Fine-Grained Alluvium]									
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	-7.0 Sandy to Silty CLAY: (CL): light	brown moist				-				
	becoming very moist to wet, soft,	low plasticity,	·/ ·/ ·/·			-				
8	stratified, orange mottling [Fine-C	Frained Alluvium]								
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	SU	BSURFACE LOG	PROJECT: Bitte	erroot He	ights S	ubc	livision, 3rd Filing, Billings,	STRUCTURE.:	Residential Subdivision
╟			LOCATION: See	Figures	1 & 2				4/8/2021
				Geosci	ence				gsv
		TEST HOLE BH51	EQUIPMENT: E	xcavator					5"
	E'1 DU1	D ( D ( 1 5/2/2021	DEPTH TO - WA	TER> I	NITIAL	.: -	¥ AFTER 24 HO	URS: 🐺	
	eth eet)	Description		ioil /pe	/ation eet)	Iplers	TEST RESULTS	4 Liquid Limit	Monitor Well
che site.	(fé De			νr	Elev (fé	San	Water Content - •   10 20 30 40   Penetrometer (tsf)- 2////////////////////////////////////	2	Details
INDICITIVE OF	- U - -	Sandy CLAY (CL) with some gra brown, slightly moist, soft, roots	vel and cobble; Topsoil/Fill]						-
retea as being	- 2	-2.0 SHALE; grayish brown, slightly 1 bedded, moderately weathered [C	noist, weak, thinly laggett Formation]						-
пос ре тисетр	- <b>4</b> -						-		-
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-	Sub	osurface Profile Based On Field	Observations & (	Geologi	ic Map	 opii	ng		

	SU	<b>BSURFACE LOG</b>	PROJECT: Bitte	erroot He	ights S	ubd	livision, 3rd Filing, Billings,	STRUCTURE.:	Residential Subdivision
Ľ			CLIENT: <u>PEC</u>	Figures	1 8 7				4/8/2021
			CONTRACTOR:	Geosci	$\frac{1 \alpha 2}{2}$				
		TEST HOLE BH52	FOUIPMENT: E	x cavator				LOGGED DT.	gsv
			DEPTH TO - WA		NITIAL		¥ AFTER 24 HO	URS: ¥	CAVING> <u>C</u>
	<u>le: BH Lo</u>	gs Date Printed: 5/3/2021				6	TEST RESULTS		
ם אדר פי	Depth (feet)	Description		Soil Type	Elevatior (feet)	Sampler	Image: Plastic Limit Image: Plastic Limit   Water Content - ●   10 20 30 40   Penetrometer (tsf)-	4 Liquid Limit	Monitor Well Installation Details
	0	Sandy CLAY (CL) with some gra brown, slightly moist, soft, roots	vel and cobble; [Topsoil/Fill]				<u>1_2_3</u>	4	-
		-1.5 SHALE; grayish brown, slightly 1	noist, weak, thinly						-
	2	bedded, moderately weathered [C	laggett Formation]				-		-
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	Sub	osurface Profile Based On Field	Observations & (	Geologi	ic Map	opii	ng		

วบ	UBSURFACE LOG							DATE	4/8/2021
		LOCATION: See	Figures 1	& 2				ELEVATION:	nm
		CONTRACTOR:	Geoscier	nce				LOGGED BY:	gsv
	TEST HOLE BH53	EQUIPMENT: E	xcavator						
ile: BH Lo	Date Printed: 5/3/2021	DEPTH TO - WA	TER> IN	ITIAL	: Į	<u></u> AF	TER 24	Hours: 🐺	_ CAVING> _
	-					TE	ST RESI	JLTS	
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et)	Description		oil /pe	∕atio et)	ple	Plastic Limit ⊢	Ŧ		Monitor Well
∎ ∰	Description		°⊢	¶≣ Lev	Sam	Water Content	- •		Details
						10 20	30	40 50	
						Penetrometer (	tsf)- 🕅		
0	Sandy CLAY (CL): brown, dry, s	oft, roots	XXX				2	3 4	
	[Topsoil]	,				-			
	1.5 Sandy CLAV (CL): light begins	try medium stiff				-			
2	low plasticity, massive [Fine-Grai	ned Alluvium							
					[				
	3.0 Sondy GPAVEL with Calible (CI	D). hrown to anot				-			
	dry, medium dense to dense. strat	fied with sand				-			
4	layers [Coarse-Grained Alluvium]	]							
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SU	BSURFACE LOG	CLIENT: PEC		4/8/2021						
		LOCATION: See	Figures	1 & 2					ELEVATION:	nm
		CONTRACTOR:	Geoscie	ence					LOGGED BY:	gsv
	TEST HOLE BH54	EQUIPMENT: E	xcavator							8
DUU	D ( D ( 1 5/2/2021	DEPTH TO - WA	TER> II	NITIAL	. Į	<u>_</u>	AFTER	24 HOU	RS: 🐺	CAVING> _
e: BH Lo	gs Date Printed: 5/3/2021						TEST RI	ESULTS		
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lee (fee	Description		S Typ	leva (fee	amp	Plastic Li	mit	L	_iquid Limit	Installation Details
				ш	ö	Water Co	20 3	0 40	50	Details
						Penetrom	neter (tsf)-	V////////		
0						1	<u>2</u>	3	4	
v	Sand & Gravel with Cobble; brow	vn to gray, slighly	3							
	moist, loose, massive, some asph	alt and concrete at				-				
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2			7, 4			-				
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4	4.0									
	SHALE; grayish brown, dry to sli	ghly moist, weak,								
	weathered [Claggett Formation]	moderately								
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<u>SU</u>	BSURFACE LOG	CLIENT PEC			4/8/2021				
		LOCATION: See	Figures	1 & 2				ELEVATION:	nm
		CONTRACTOR:	Geosci	ence				LOGGED BY:	gsv
	TEST HOLE BH55	EQUIPMENT: E	xcavator						
ile: BH Lc	ogs Date Printed: 5/3/2021	DEPTH TO - WA	TER> II	NITIAL	. <u> </u>	<u> </u>	_ AFTER 24 H	OURS: 	_ CAVING> <u>C</u>
epth eet)	Description		oil 'pe	'ation et)	plers	1 Plastic Lit	TEST RESUL	TS 4 ⊣ Liquid Limit	Monitor Well
(fe	Description		v∑	Elev (fe	Sam	Plastic Lin Water Co 10 Penetrom	ntent - ● 20 30 eter (tsf)-	40 <u>50</u>	Details
- 0	Sand & Gravel with Cobble; brow moist to wet, loose, massive, som concrete at surface [Coarse-Grain- Backfill]	yn to gray, slighly e asphalt and ed Alluvium/Pit				- 1	2 3	4	
- 2					-	-			
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4						-			
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6					-				
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8						-			
	-9.0 SHALE; grayish brown, dry to sli thinly bedded, medium plasticity,	ghly moist, weak, moderately			-	-			
10	weathered [Claggett Formation]					-			
	-11.0					-			
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SU	BSURFACE LOG	CLIENT: PEC			DATE:	4/8/2021				
		LOCATION: See	Figures	1 & 2					ELEVATION:	nm
		CONTRACTOR:	Geosci	ence					LOGGED BY:	gsv
	IEST HOLE BH56		xcavator	<u>:</u>						
e: BH Lo	Date Printed: 5/3/2021	DEPTH TO - WA	.TER> II		-: <sup>-</sup>	र 24 HO	URS: 	_ CAVING> <u>C</u>		
			[]	[]	$\square$		TEST R	ESULTS		
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eet)	Description	,	soil ype	vatic eet)	- Jal	Plastic L	imit ⊢—		Liauid Limit	Monitor vveii Installation
∣≝ڈ		,	<sup>0</sup> ⊢ 1	Ш Ш	San	Water Co	ontent -	, ,		Details
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$\rightarrow$			<b>├</b> ──'	<u> </u> '	$\vdash$	Penetron	neter (tsf)- 2	3		
0	Sand & Gravel with Cobble; brov	wn to gray, slighly		1 '	†	· · · ·				
	moist to moist, loose, massive, so	me asphalt and		<u>ا</u> '		ī				
	concrete at surface, metal & debri Alluvium/Pit Backfill]	s [Coarse-Grained]		! '		F				
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	SHALE; grayish brown, dry to sl	ighly moist, weak,		<u> </u> '		_				
	thinly bedded, medium plasticity,	, moderately	Ē	1 '		-				
8	weathered [Claggett Formation]	,	<u> </u>	'		-				
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