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May 11, 2021

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

RE: PRELIMINARY GEOTECHNICAL INVESTIGATION REPORT
BITTERROOT HEIGHTS SUBDIVISION, 3rd FILING
BILLINGS, MONTANA

Dear Mr. Neihart,

We are pleased to present this preliminary geotechnical investigation report for Bitterroot Heights Subdivision, 3rd Filing. The proposed development is located west of Bitterroot Heights Subdivision, 1st and 2nd 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,

GEOSCIENCE, PLLP

Jordan L. Grover, PE
Enc: Report

Greg S. Vick, PG

BITTERROOT HEIGHTS SUBDIVISION, 3rd FILING
PRELIMININARY GEOTECHNICAL INVESTIGATION REPORT
BILLINGS, MONTANA

Prepared for:

Performance Engineering & Consulting
608 North 29th 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 3rd 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-west-central). 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, 3rd 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 1½-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).

Table 2 Lateral Loads γK (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

All sod, topsoil, concrete, uncontrolled man-placed fill and organic soil shall be completely 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, moisture-conditioned 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 ±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 1½ 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 Plastic 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 ±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 weight
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 ±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.

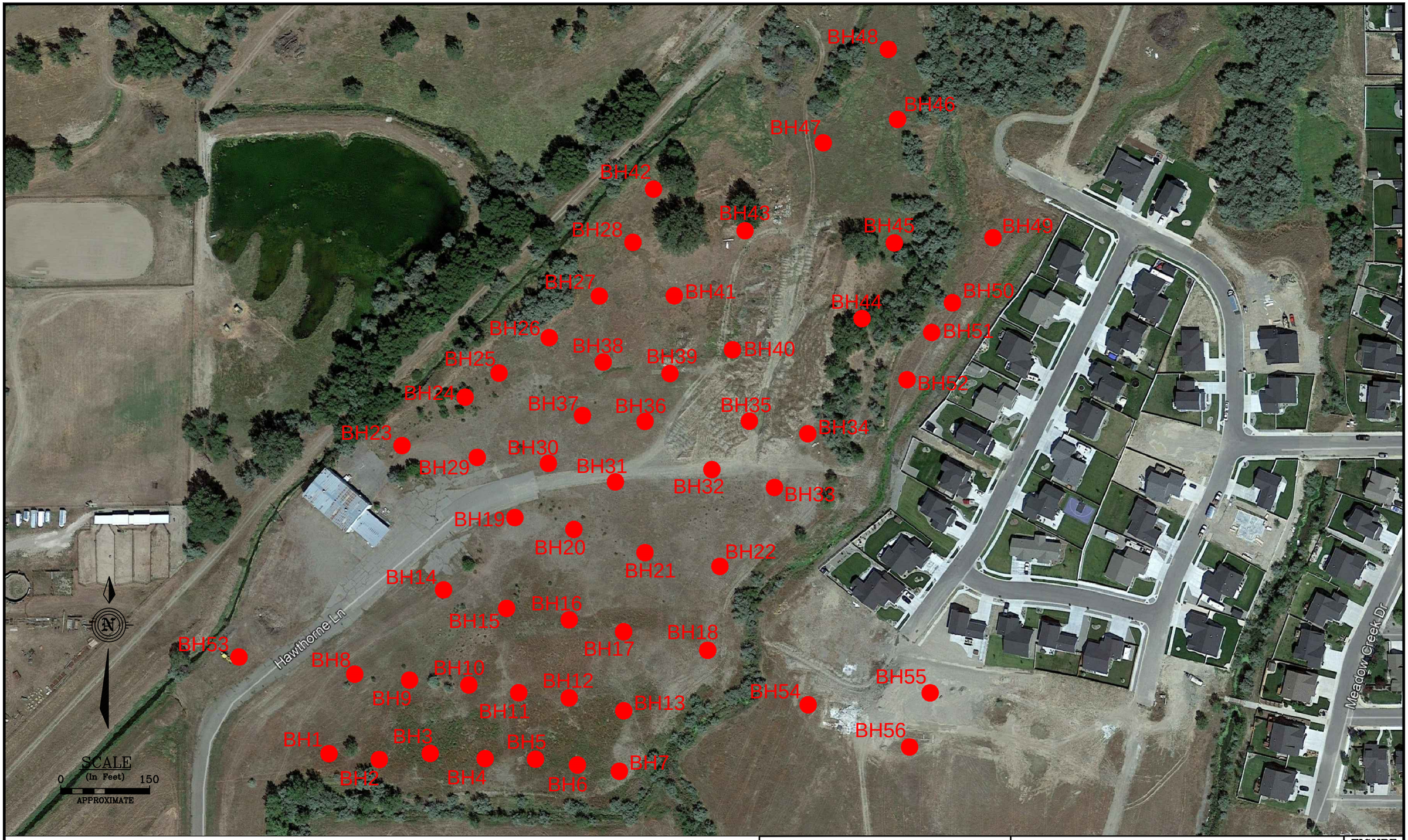
8.0 REFERENCES

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, 3rd Edition, John Wiley and Sons, Inc.

APPENDIX A

Figures



INDICATES APPROXIMATE TEST HOLE LOCATION ADVANCED BY GEOSCIENCE

Preliminary Geotechnical Investigation
Proposed Residential Subdivision
Bitterroot Heights, 3rd Filing
Billings, Montana

SITE AND TEST HOLE LOCATION MAP

FIGURE 1

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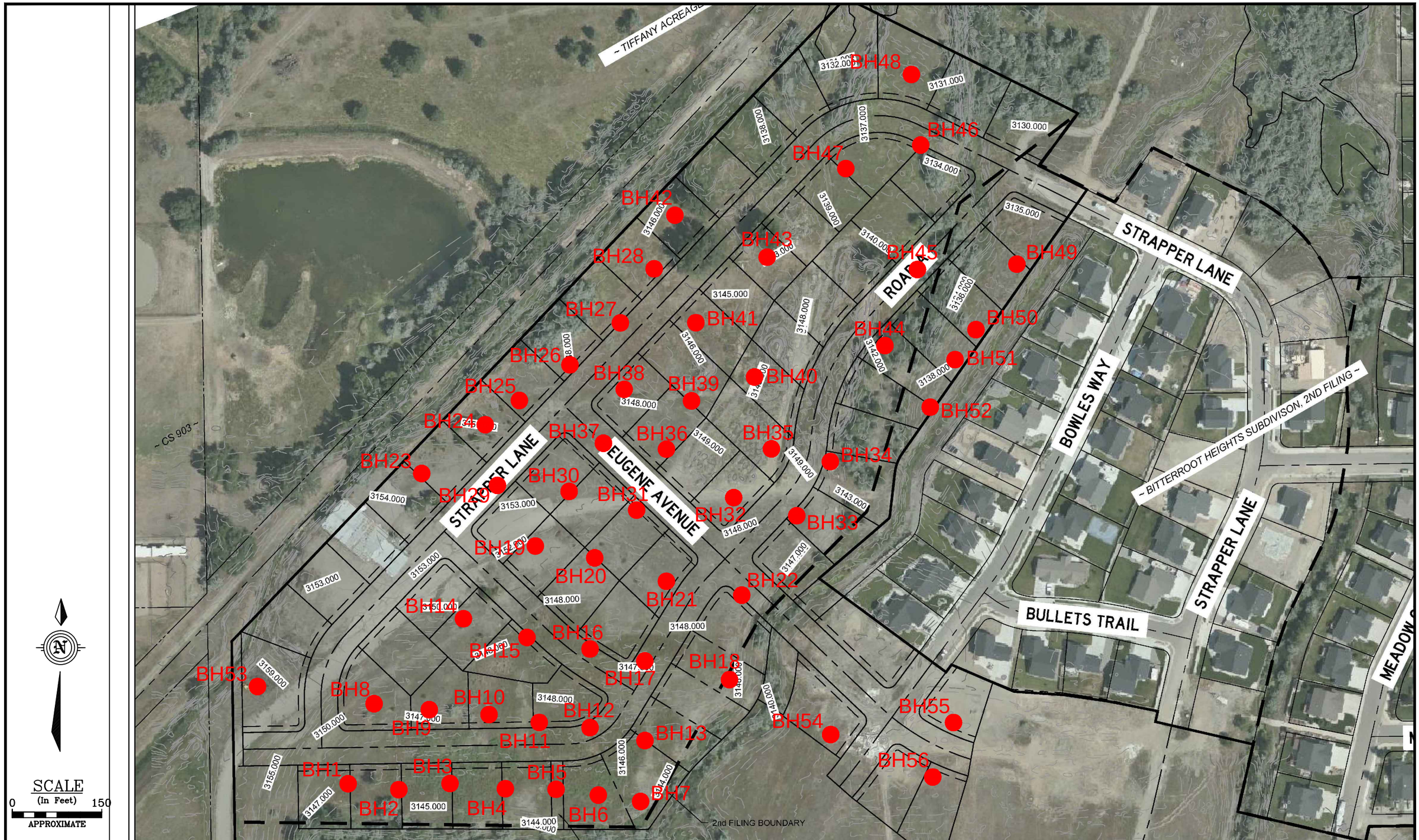
GEOSCIENCE, PLLP



INDICATES APPROXIMATE TEST HOLE LOCATION ADVANCED BY GEOSCIENCE

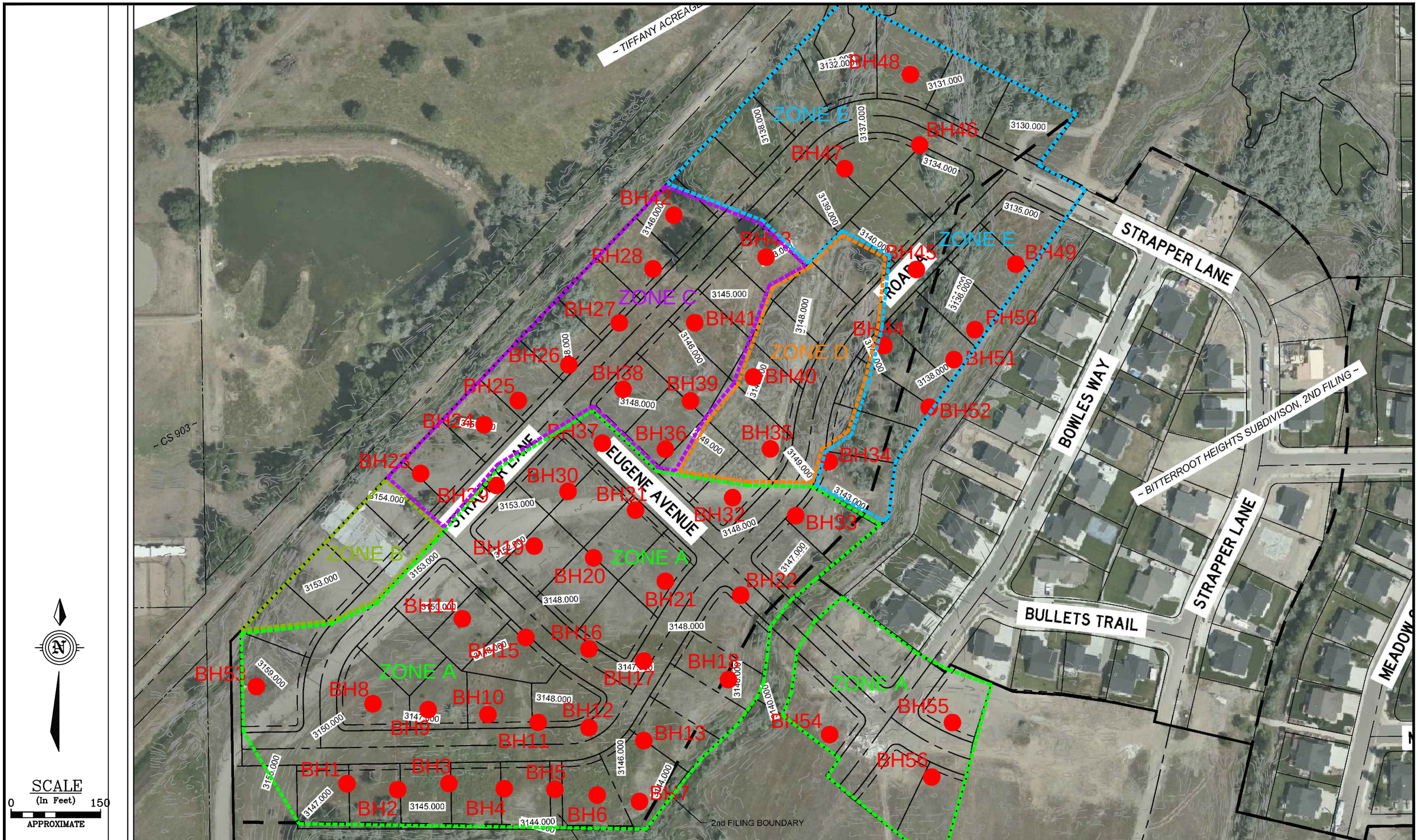
Preliminary Geotechnical Investigation
Proposed Residential Subdivision
Bitterroot Heights, 3rd Filing
Billings, Montana

SUBDIVISION LAYOUT WITH
TEST HOLE LOCATIONS

FIGURE
2

UPDATE TIME:
pec \ res \gt \gsv \B \041421\D:\geoscience\pec\bitterroot heights\Bitterroot Heights Site Map.dwg

GEOSCIENCE, PLLP



INDICATES APPROXIMATE TEST HOLE LOCATION ADVANCED BY GEOSCIENCE

Preliminary Geotechnical Investigation
Proposed Residential Subdivision
Bitterroot Heights, 3rd Filing
Billings, Montana

SUBDIVISION LAYOUT WITH PRELIMINARY RECOMMENDATIONS FOR FOUNDATION SUBGRADE IMPROVEMENTS

FIGURE 3

UPDATE TIME:
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GEOSCIENCE, PLLP

APPENDIX B

Test Hole Logs

SUBSURFACE LOG

TEST HOLE BH1

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings, **STRUCTURE.:** Residential Subdivision
CLIENT: PEC **DATE:** 4/7/2021
LOCATION: See Figures 1 & 2 **ELEVATION:** nm
CONTRACTOR: Geoscience **LOGGED BY:** gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 5 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Clay, Sand & Gravel; brown to dark gray, moist becoming wet at 5 feet, soft/loose, massive, blocks and fragments of asphalt, concrete, sandstone & other debris [Fill]				1 2 3 4 Plastic Limit ⊢—⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
4	▽					
6	6.0 Sandy GRAVEL with Cobble (GP); brown to gray, wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
8	7.5 SHALE; grayish brown, moist, weak, thinly bedded, medium plasticity, moderately weathered [Claggett Formation]					
10	10.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

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SUBSURFACE LOG

TEST HOLE BH2

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings, **STRUCTURE.:** Residential Subdivision
CLIENT: PEC **DATE:** 4/7/2021
LOCATION: See Figures 1 & 2 **ELEVATION:** nm
CONTRACTOR: Geoscience **LOGGED BY:** gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 5 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Clay, Sand & Gravel; brown to dark gray, moist becoming wet at 5 feet, soft/loose, massive, blocks and fragments of asphalt, concrete, sandstone & other debris [Fill]				1 2 3 4 Plastic Limit ⊢——⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
4	4.5 ▽ Sandy GRAVEL with Cobble (GP); brown to gray, wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
6	6.0 SHALE; grayish brown, moist, weak, thinly bedded, medium plasticity, moderately weathered [Claggett Formation]					
8						
10	10.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

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SUBSURFACE LOG

TEST HOLE BH3

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings, **STRUCTURE.:** Residential Subdivision
CLIENT: PEC **DATE:** 4/7/2021
LOCATION: See Figures 1 & 2 **ELEVATION:** nm
CONTRACTOR: Geoscience **LOGGED BY:** gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 5 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Clay, Sand & Gravel; brown to gray, moist becoming wet at 5 feet, soft/loose, massive, blocks and fragments of asphalt, concrete, sandstone & other debris [Fill]				1 2 3 4 Plastic Limit ⊢——⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
3.5						
4	Sandy GRAVEL with Cobble (GP); brown to gray, wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
6	6.0					
8	SHALE; grayish brown, moist, weak, thinly bedded, medium plasticity, moderately weathered [Claggett Formation]					
10	10.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH4

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings, **STRUCTURE.:** Residential Subdivision
CLIENT: PEC **DATE:** 4/7/2021
LOCATION: See Figures 1 & 2 **ELEVATION:** nm
CONTRACTOR: Geoscience **LOGGED BY:** gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 4.5 **AFTER 24 HOURS:** ▼ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Clay, Sand & Gravel; brown to gray, moist becoming wet at 4 feet, soft/loose, massive, concrete, asphalt & other debris [Fill]				1 2 3 4 Plastic Limit ⊢——⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
3.0	Sandy GRAVEL with Cobble (GP); brown to gray, wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
4	▽					
5.5	SHALE; grayish brown, moist, weak, thinly bedded, medium plasticity, moderately weathered [Claggett Formation]					
6						
8						
10	10.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH5

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/7/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 4.5 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Clay, Sand & Gravel; brown to gray, moist becoming wet at 4 feet, soft/loose, massive, some debris [Fill]				1 2 3 4 Plastic Limit ⊢—⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
3.0						
4	Sandy GRAVEL with Cobble (GP); brown to gray, wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
5.5						
6	SHALE; grayish brown, moist, weak, thinly bedded, medium plasticity, moderately weathered [Claggett Formation]					
8						
10	10.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

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SUBSURFACE LOG

TEST HOLE BH6

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings, **STRUCTURE.:** Residential Subdivision
CLIENT: PEC **DATE:** 4/7/2021
LOCATION: See Figures 1 & 2 **ELEVATION:** nm
CONTRACTOR: Geoscience **LOGGED BY:** gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 4.5 **AFTER 24 HOURS:** ▼ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Clay, Sand & Gravel; brown to gray, moist becoming wet at 4 feet, soft/loose, massive, some debris [Fill]				1 2 3 4 Plastic Limit | Liquid Limit; Water Content - ● 10 20 30 40 50; Penetrometer (tsf)- 1 2 3 4	
2						
4	▽4.5 Sandy GRAVEL with Cobble (GP); brown to gray, wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
6						
8	8.0 SHALE; grayish brown, moist, weak, thinly bedded, medium plasticity, moderately weathered [Claggett Formation]					
10	10.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

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SUBSURFACE LOG

TEST HOLE BH7

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings, **STRUCTURE.:** Residential Subdivision
CLIENT: PEC **DATE:** 4/7/2021
LOCATION: See Figures 1 & 2 **ELEVATION:** nm
CONTRACTOR: Geoscience **LOGGED BY:** gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 5 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Clay, Sand & Gravel; brown to gray, moist, soft/ loose, massive, some debris [Fill]				1 2 3 4 Plastic Limit — Liquid Limit; Water Content - ● 10 20 30 40 50; Penetrometer (tsf)- 1 2 3 4	
2	2.0 SAND with some Gravel; brown, moist, very loose, massive [Fill]					
4						
	▽ 5.0 Sandy GRAVEL with Cobble (GP); gray, wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
6	6.0 SHALE; grayish brown, moist, weak, thinly bedded, medium plasticity, moderately weathered [Claggett Formation]					
8						
10	10.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

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BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH8

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings, **STRUCTURE.:** Residential Subdivision
CLIENT: PEC **DATE:** 4/7/2021
LOCATION: See Figures 1 & 2 **ELEVATION:** nm
CONTRACTOR: Geoscience **LOGGED BY:** gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 4 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Clay, Sand & Gravel; brown to gray, moist to wet at 4 feet, soft/loose, massive, some 3/4 " gravel & other debris [Fill]				1 2 3 4 Plastic Limit ⊢—⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
4 ▽						
6	6.0 Sandy GRAVEL with Cobble (GP); gray, wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
	7.5 Pit Walls Collapsing					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

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SUBSURFACE LOG

TEST HOLE BH9

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings, **STRUCTURE.:** Residential Subdivision
CLIENT: PEC **DATE:** 4/7/2021
LOCATION: See Figures 1 & 2 **ELEVATION:** nm
CONTRACTOR: Geoscience **LOGGED BY:** gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 6 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel with Cobble; brown to gray, moist to wet, soft/loose, massive, some clay & asphalt [Fill]				1 2 3 4 Plastic Limit |—| Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
4						
6	▽6.0 Sandy GRAVEL with Cobble (GP); gray, wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
	7.0 SHALE; grayish brown, moist, weak, thinly bedded, medium plasticity, moderately weathered [Claggett Formation]					
8						
10	10.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

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SUBSURFACE LOG

TEST HOLE BH10

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings, **STRUCTURE.:** Residential Subdivision
CLIENT: PEC **DATE:** 4/7/2021
LOCATION: See Figures 1 & 2 **ELEVATION:** nm
CONTRACTOR: Geoscience **LOGGED BY:** gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 5 **AFTER 24 HOURS:** ▼ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel with Cobble; brown to gray, moist to very moist, soft/loose, massive, some clay & debris [Fill]				1 2 3 4 Plastic Limit |—| Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
4						
5.0 ▽	Sandy GRAVEL with Cobble (GP); gray, wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
6	6.0 SHALE; grayish brown, moist, weak, thinly bedded, medium plasticity, moderately weathered [Claggett Formation]					
8						
10	10.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

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SUBSURFACE LOG

TEST HOLE BH11

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings, **STRUCTURE.:** Residential Subdivision
CLIENT: PEC **DATE:** 4/7/2021
LOCATION: See Figures 1 & 2 **ELEVATION:** nm
CONTRACTOR: Geoscience **LOGGED BY:** gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 6 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel with Cobble; brown to gray, moist to very moist, soft/loose, massive, some debris [Fill]				1 2 3 4 Plastic Limit ⊢——⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
4						
5.0	Sandy GRAVEL with Cobble (GP); gray, wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
6 ▽						
7.5	SHALE; grayish brown, moist, weak, thinly bedded, medium plasticity, moderately weathered [Claggett Formation]					
8						
10	10.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

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SUBSURFACE LOG

TEST HOLE BH12

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings, **STRUCTURE.:** Residential Subdivision
CLIENT: PEC **DATE:** 4/7/2021
LOCATION: See Figures 1 & 2 **ELEVATION:** nm
CONTRACTOR: Geoscience **LOGGED BY:** gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 6 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel with Cobble; brown to gray, moist to very moist, soft/loose, massive, some debris [Fill]				1 2 3 4 Plastic Limit |—| Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
4						
5.0	Sandy GRAVEL with Cobble (GP); gray, wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
6 ▽						
8	8.0 SHALE; grayish brown, moist, weak, thinly bedded, medium plasticity, moderately weathered [Claggett Formation]					
10	10.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

GEOSCIENCE, PLLP
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SUBSURFACE LOG

TEST HOLE BH13

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/7/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 5.5 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel with Cobble; brown to gray, moist to wet, loose, massive, some clay & debris [Fill]				1 2 3 4 Plastic Limit ⊢——⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
4						
	5.0					
	Sandy GRAVEL with Cobble (GP); gray, wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
6						
8	8.0					
	SHALE; grayish brown, moist, weak, thinly bedded, medium plasticity, moderately weathered [Claggett Formation]					
10	10.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

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SUBSURFACE LOG

TEST HOLE BH14

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings, **STRUCTURE.:** Residential Subdivision
CLIENT: PEC **DATE:** 4/7/2021
LOCATION: See Figures 1 & 2 **ELEVATION:** nm
CONTRACTOR: Geoscience **LOGGED BY:** gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 5.5 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Clay, Sand & Gravel with Cobble; brown to gray, moist to wet, soft/loose, massive, some debris [Fill]				1 2 3 4 Plastic Limit ⊢—⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
4						
6	6.0 Large concrete block at 6 feet, pit walls collapsing [Fill]					
	7.0 Pit Collapse - Bottom of Pit in Fill					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

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SUBSURFACE LOG

TEST HOLE BH15

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/7/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 6 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel with Cobble; brown to gray, moist to wet, loose, layer of 3/4" gravel, some clay & debris [Fill]				1 2 3 4 Plastic Limit ⊢——⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
3.0	Sandy GRAVEL with Cobble (GP); gray, wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
4						
6 ▽						
8						
8.0	Pit Walls Collapsing					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH16

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/7/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 6 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel with Cobble; brown to gray, moist to wet, loose, massive, some clay & debris [Fill]				1 2 3 4 Plastic Limit ⊢—⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
3.0	Sandy GRAVEL with Cobble (GP); gray, wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
4						
6 ▽						
8						
8.0	Pit Walls Collapsing					

Subsurface Profile Based On Field Observations & Geologic Mapping

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH17

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/7/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 6 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel with Cobble; brown to gray, moist to wet, loose, massive, some clay & debris [Fill]				1 2 3 4 Plastic Limit ⊢—⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
3.5	Sandy GRAVEL with Cobble (GP); gray, wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
4						
6 ▽						
8						
8.0	Pit Walls Collapsing					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH18

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/7/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 6 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel with Cobble; brown to gray, moist to wet, loose, massive, some clay & debris [Fill]				1 2 3 4 Plastic Limit ⊢—⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
3.0	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]					
4						
6 ▽						
7.0	SHALE; grayish brown, moist, weak, thinly bedded, medium plasticity, moderately weathered [Claggett Formation]					
8						
10	10.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH19

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/7/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 7 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel with Cobble; brown to gray, moist to wet, loose, massive, some clay & debris [Fill]				1 2 3 4 Plastic Limit ⊢—⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2	2.0 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]					
4						
6	▽					
8	8.0 Pit Walls Collapsing					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH20

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings, **STRUCTURE.:** Residential Subdivision
CLIENT: PEC **DATE:** 4/7/2021
LOCATION: See Figures 1 & 2 **ELEVATION:** nm
CONTRACTOR: Geoscience **LOGGED BY:** gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 6 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel with Cobble; brown to gray, moist to wet, loose, massive, some clay & debris [Fill]				1 2 3 4 Plastic Limit ⊢—⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2	2.0 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]					
4						
6 ▽						
8						
	9.0 Pit Walls Collapsing					

Subsurface Profile Based On Field Observations & Geologic Mapping

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH21

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/7/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 7 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel with Clay; mostly 3/4" minus road-mix, brown, slightly moist, loose, massive [Fill]				1 2 3 4 Plastic Limit ⊢——⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
3.0	Sand & Gravel with Cobble (GP); brown to gray, slightly moist to wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
4						
6						
▽						
8						
8.0	Pit Walls Collapsing					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH22

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/7/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 7 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel with some clay; mostly pea gravel, brown, slightly moist, very loose, massive [Fill]				1 2 3 4 Plastic Limit ⊢—⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
3.0	Sand & Gravel with Cobble (GP); brown to gray, slightly moist to wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
4						
6						
▽						
8						
8.0	Pit Walls Collapsing					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH23

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings, **STRUCTURE.:** Residential Subdivision
CLIENT: PEC **DATE:** 4/7/2021
LOCATION: See Figures 1 & 2 **ELEVATION:** nm
CONTRACTOR: Geoscience **LOGGED BY:** gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ _____ **AFTER 24 HOURS:** ▼ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Clay, Sand & Gravel; mostly 3/4" minus gravel, brown to dark gray, moist, loose, massive, staining and strong odor [Fill]				1 2 3 4 Plastic Limit |—| Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
4						
5.0	Sand & Gravel with Cobble (GP); brown to gray, moist to very moist, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
6						
8						
8.0	Pit Walls Collapsing					

Subsurface Profile Based On Field Observations & Geologic Mapping

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH24

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/7/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ _____ **AFTER 24 HOURS:** ▼ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel with Clay; brown, slightly moist, loose, massive, some roots and debris [Fill]				1 2 3 4 Plastic Limit ⊢——⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
3.0	Sand & Gravel with Cobble (GP); brown to gray, moist to very moist, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
4						
6						
8						
9.0	Pit Walls Collapsing					

Subsurface Profile Based On Field Observations & Geologic Mapping

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH25

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/7/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 11 **AFTER 24 HOURS:** ▽ **CAVING>** C

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Clay, Sand & Gravel; brown, moist, soft/loose, massive, some roots and debris [Fill]				1 2 3 4 Plastic Limit ⊢—⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
4						
6	6.0 Sandy to Silty CLAY (CL); brown becoming grayish brown, moist becoming very moist, soft, low plasticity, massive, orange and gray mottling [Fill]					
8						
10	10.0 Sandy to Silty CLAY with Fine Gravel; (CL); brown, wet, soft, low plasticity, stratified [Fine-Grained Alluvium] ▽					
12	12.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH26

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/7/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: _____ **AFTER 24 HOURS:** _____ **CAVING>** _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Clay, Sand & Gravel; brown, moist, soft/loose, massive, some roots and debris [Fill]				1 2 3 4 Plastic Limit |—| Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2	2.0 SILT & Fine SAND; brown to light gray, moist becoming very moist, very loose, massive [Fill]					
4						
6						
8						
	9.0 Large Concrete Block [Fill]					
10	10.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH27

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/7/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ _____ **AFTER 24 HOURS:** ▼ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Clay, Sand & Gravel; brown, moist, soft/loose, massive, asphalt, brick & debris [Fill]				1 2 3 4 Plastic Limit |—| Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
4	4.0 Sandy Clay with asphalt, concrete, metal, wood, glass and other debris; moist, very loose, voids [Fill]					
6						
8						
10	10.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH28

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/7/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 9 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand with asphalt, concrete metal, wood, glass, pipe, and other debris; moist, very loose, voids [Fill]				1 2 3 4 Plastic Limit ⊢—⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
4						
6	6.0 SILT & Fine SAND with Clay; light brown, moist becoming very moist, very loose/soft, massive, gray and orange mottling [Fill]					
8						
9	▽ 9.0 Silty CLAY (CL); gray with black organics, very moist to wet, very soft, low plasticity, massive [Buried Alluvium/Old Back Channel Deposits]					
10						
11	11.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH29

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/8/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 8 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel with Clay; mostly 3/4" minus road-mix, brown, slightly moist, loose, massive [Fill]				1 2 3 4 Plastic Limit ⊢——⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
3.0	Sand & Gravel with Cobble (GP); brown to gray, slightly moist to wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
4						
6						
8 ▽						
10						
10.0	SHALE; grayish brown, moist, weak, thinly bedded, medium plasticity, moderately weathered [Claggett Formation]					
12						
12.0						

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH30

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings, **STRUCTURE.:** Residential Subdivision
CLIENT: PEC **DATE:** 4/8/2021
LOCATION: See Figures 1 & 2 **ELEVATION:** nm
CONTRACTOR: Geoscience **LOGGED BY:** gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 8 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel; mostly 3/4" minus road-mix, brown, slightly moist, loose, massive [Fill]				1 2 3 4 Plastic Limit ⊢—⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
4	4.0 Sand & Gravel with Cobble (GP); brown to gray, slightly moist to wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
6						
8	▽					
10						
12	11.0 SHALE; grayish brown, moist, weak, thinly bedded, medium plasticity, moderately weathered [Claggett Formation] 12.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH31

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/8/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 7 **AFTER 24 HOURS:** ▽ **CAVING>** C

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel; mostly 3/4" minus road-mix, brown, slightly moist, loose, massive [Fill]				1 2 3 4 Plastic Limit ⊢—⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2	2.0 Sand & Gravel with Cobble (GP); brown to gray, slightly moist to wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
4						
6						
8						
10	10.0 SHALE; grayish brown, moist, weak, thinly bedded, medium plasticity, moderately weathered [Claggett Formation]					
12	12.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH32

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/8/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 6 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel with Clay; brown, slightly moist, loose, massive [Fill]				1 2 3 4 Plastic Limit ⊢——⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
2.5	Sand & Gravel with Cobble (GP); brown to gray, slightly moist to wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
4						
6 ▽						
8						
9.0	SHALE; grayish brown, moist, weak, thinly bedded, medium plasticity, moderately weathered [Claggett Formation]					
10						
11.0						

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH33

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/8/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 6 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel with Clay; brown, slightly moist, loose, massive [Fill]				1 2 3 4 Plastic Limit ⊢——⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
2.5	Sand & Gravel with Cobble (GP); brown to gray, slightly moist to wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
4						
6 ▽						
8						
8.0	SHALE; grayish brown, moist, weak, thinly bedded, medium plasticity, moderately weathered [Claggett Formation]					
10						
10.0						

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH34

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings, **STRUCTURE.:** Residential Subdivision
CLIENT: PEC **DATE:** 4/8/2021
LOCATION: See Figures 1 & 2 **ELEVATION:** nm
CONTRACTOR: Geoscience **LOGGED BY:** gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 4.5 **AFTER 24 HOURS:** ▼ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel with Clay; brown, slightly moist, loose, massive [Fill]				1 2 3 4 Plastic Limit ⊢—⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
1.5						
2	Sand & Gravel with Cobble (GP); brown to gray, slightly moist to wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
4	▽					
6	6.0					
	SHALE; grayish brown, moist, weak, thinly bedded, medium plasticity, moderately weathered [Claggett Formation]					
8						
10	10.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH35

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/8/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 6.0 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel with Clay; brown, slightly moist, loose, massive [Fill]				1 2 3 4 Plastic Limit ⊢——⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
3.0	Sand & Gravel with Cobble (GP); brown to gray, slightly moist to wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
4						
6 ▽						
8						
8.0	SHALE; grayish brown, moist, weak, thinly bedded, medium plasticity, moderately weathered [Claggett Formation]					
10						
10.0						

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH36

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/8/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 7.5 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel; mostly 3/4" minus road-mix, brown, slightly moist, loose, massive [Fill]				1 2 3 4 Plastic Limit ⊢——⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
3.0	SAND; fine-grained, brown, slightly moist to moist, very loose, massive [Fill]					
4						
6						
7.0	Sand & Gravel with Cobble (GP); brown to gray, moist to wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
8						
9.0	SHALE; grayish brown, moist, weak, thinly bedded, medium plasticity, moderately weathered [Claggett Formation]					
10						
11.0						

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH37

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings, **STRUCTURE.:** Residential Subdivision
CLIENT: PEC **DATE:** 4/8/2021
LOCATION: See Figures 1 & 2 **ELEVATION:** nm
CONTRACTOR: Geoscience **LOGGED BY:** gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 8 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel with Clay; brown, slightly moist, loose, massive [Fill]				1 2 3 4 Plastic Limit ⊢——⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
1.5						
2	Sand & Gravel with Cobble (GP); brown to gray, slightly moist to wet, loose, massive, rounded gravel and cobble to 6"-8" diameter [Coarse-Grained Alluvium/Pit Backfill]					
4						
6						
8 ▽						
9.0						
10	SHALE; grayish brown, moist, weak, thinly bedded, medium plasticity, moderately weathered [Claggett Formation]					
11.0						

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH38

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings, **STRUCTURE.:** Residential Subdivision
CLIENT: PEC **DATE:** 4/8/2021
LOCATION: See Figures 1 & 2 **ELEVATION:** nm
CONTRACTOR: Geoscience **LOGGED BY:** gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 9 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel with Clay; brown, slightly moist, loose, massive [Fill]					
2.0	Clay, Sand & Gravel with Cobble (GC); gray, slightly moist to moist, loose, massive, staining and slight odor [Fill]					
7.0	Silty CLAY (CL); gray with black organics, very moist to wet, very soft, low plasticity, massive [Buried Alluvium/Old Back Channel Deposits]					
9.0 ▽	Sandy SILT (ML); brown, very moist to wet, loose/ soft [Fine-Grained Alluvium]					
11.0	Sand & Gravel with Cobble (GP); brown to gray, wet, loose, massive, rounded gravel and cobble to 6" -8" diameter [Coarse-Grained Alluvium]					
12.0						

TEST RESULTS: 1 2 3 4 — Plastic Limit ⊢—⊣ Liquid Limit; Water Content - ● 10 20 30 40 50; Penetrometer (tsf)- ▨ 1 2 3 4

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

Subsurface Profile Based On Field Observations & Geologic Mapping

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH39

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/8/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 8 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Clay, Sand & Gravel; brown, moist, very loose, massive, concrete, asphalt, metal & debris, voids [Fill]				1 2 3 4 Plastic Limit ⊢—⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
4						
6	6.0 Sandy Clay with Gravel; dark gray, moist, soft, staining and strong odor [Fill]					
8	▽ 8.0 SHALE; gray, very moist to wet, weak, staining and strong odor [Claggett Formation]					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH40

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/8/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 11 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Clay with Sand & Gravel; brown, moist, soft/loose, massive, some roots and debris [Fill]				1 2 3 4 Plastic Limit ⊢——⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
4	4.0 Sandy CLAY (CL); brown, moist, soft, low plasticity, massive [Fill]					
6						
8	8.0 Silty CLAY (CL); gray with black organics, very moist to wet, very soft, low plasticity, massive [Buried Alluvium/Old Back Channel Deposits]					
10	10.0 Sandy to Silty CLAY; (CL); brown, very moist to wet, soft, low plasticity, stratified, orange mottling [Fine-Grained Alluvium] ▽					
12	12.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH41

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/8/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 11 **AFTER 24 HOURS:** ▽ **CAVING>** C

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Clay with Sand, Gravel & Debris; brown, moist, soft/loose, massive, cobbles, concrete, asphalt and wood [Fill]				1 2 3 4 Plastic Limit ⊢—⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
4						
6						
6.5	Clayey to Sandy SILT (ML); brown to gray, moist, soft, laminated [Fill]					
8						
10	10.0					
	Sandy to Silty CLAY; (CL); brown to gray, very moist to wet, very soft, low plasticity, stratified, orange mottling, some black organics [Fine-Grained Alluvium] ▽					
12	12.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH42

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/8/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 11 **AFTER 24 HOURS:** ▽ **CAVING>** C

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Clay with Sand, Gravel & Debris; brown, moist, soft/loose, massive, concrete, asphalt and wood [Fill]				1 2 3 4 Plastic Limit ⊢—⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
4						
5.5	Clayey to Sandy SILT (ML); brown to gray, moist, soft, laminated [Fill]					
6						
8						
9.0	Sandy to Silty CLAY; (CL); brown to gray, very moist to wet, very soft, low plasticity, stratified, orange mottling, some black organics [Fine-Grained Alluvium]					
10						
▽						
12	12.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH43

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/8/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 11 **AFTER 24 HOURS:** ▽ **CAVING>** C

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Clay with Sand, Gravel & Debris; brown, moist, soft/loose, massive, concrete, asphalt, metal and wood [Fill]				1 2 3 4 Plastic Limit ⊢——⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
4						
5.0	Clayey to Sandy SILT (ML); brown to gray, moist, soft, laminated [Fill]					
6						
8						
9.0	Sandy to Silty CLAY; (CL); brown to gray, very moist to wet, very soft, low plasticity, stratified, orange mottling, some black organics [Fine-Grained Alluvium]					
10						
▽						
12						
12.0						

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH44

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings, **STRUCTURE.:** Residential Subdivision
CLIENT: PEC **DATE:** 4/8/2021
LOCATION: See Figures 1 & 2 **ELEVATION:** nm
CONTRACTOR: Geoscience **LOGGED BY:** gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 11 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sandy CLAY (CL); brown, slightly moist, soft, low plasticity, roots and organic material, scattered cobbles [Topsoil/Fill]				1 2 3 4 Plastic Limit ⊢——⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
1.5						
2	Sandy to Silty CLAY (CL); brown to dark grayish brown, slightly moist, medium stiff, low plasticity, massive [Fine-Grained Alluvium]					
4						
6	6.0					
	Sandy to Silty CLAY; (CL); light brown, moist becoming very moist to wet, soft, low plasticity, stratified, orange mottling [Fine-Grained Alluvium]					
8						
10						
	▽					
12	12.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH45

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings, **STRUCTURE.:** Residential Subdivision
CLIENT: PEC **DATE:** 4/8/2021
LOCATION: See Figures 1 & 2 **ELEVATION:** nm
CONTRACTOR: Geoscience **LOGGED BY:** gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 11 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sandy CLAY (CL); brown, slightly moist, soft, low plasticity, roots and organic material, scattered cobbles [Topsoil/Fill]				1 2 3 4 Plastic Limit ⊢——⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2	2.0 Sandy to Silty CLAY (CL); brown to dark grayish brown, slightly moist, medium stiff, low plasticity, massive [Fine-Grained Alluvium]					
4						
6	6.0 Sandy to Silty CLAY; (CL); light brown, moist becoming very moist to wet, soft, low plasticity, stratified, orange mottling [Fine-Grained Alluvium]					
8						
10	▽					
12	12.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH46

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/8/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ _____ **AFTER 24 HOURS:** ▼ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sandy CLAY (CL) with some gravel and cobble; brown, slightly moist, soft, [Fill]				1 2 3 4 Plastic Limit — Liquid Limit; Water Content - ● 10 20 30 40 50; Penetrometer (tsf)- 1 2 3 4	
2						
3.0	Sandy to Silty CLAY (CL); brown, dry to slighly moist, medium stiff, low plasticity, massive, white mottling [Fine-Grained Alluvium]					
4						
6	6.0 Sandy to Silty CLAY; (CL); light brown, moist becoming very moist to wet, soft, low plasticity, stratified, orange mottling [Fine-Grained Alluvium]					
8						
10	10.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH47

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/8/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ _____ **AFTER 24 HOURS:** ▼ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sandy CLAY (CL) with some gravel and cobble; brown, slightly moist, soft, [Fill]				1 2 3 4 Plastic Limit ⊢—⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2	2.0 Sandy to Silty CLAY (CL); brown, dry to slighly moist, medium stiff, low plasticity, massive, white mottling [Fine-Grained Alluvium]					
4						
6	6.0 Sandy to Silty CLAY; (CL); light brown, moist becoming very moist to wet, soft, low plasticity, stratified, orange mottling [Fine-Grained Alluvium]					
8						
10	10.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH48

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings, **STRUCTURE.:** Residential Subdivision
CLIENT: PEC **DATE:** 4/8/2021
LOCATION: See Figures 1 & 2 **ELEVATION:** nm
CONTRACTOR: Geoscience **LOGGED BY:** gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 9 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sandy CLAY (CL); brown, slightly moist, soft, low plasticity, roots and organic material [Topsoil]				1 2 3 4 Plastic Limit ⊢—⊣ Liquid Limit; Water Content - ● 10 20 30 40 50; Penetrometer (tsf)- ▨ 1 2 3 4	
2	2.0 Sandy to Silty CLAY (CL); brown, slighly moist to moist, medium stiff, low plasticity, massive, white mottling [Fine-Grained Alluvium]					
4						
6						
7	7.0 Silty SAND (SM); brown, moist becoming very moist to wet, loose, stratified with clay layers [Fine-Grained Alluvium]					
8						
▽						
10	10.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH49

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/8/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 9 **AFTER 24 HOURS:** ▽ **CAVING>** C

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sandy CLAY (CL) with some gravel and cobble; brown, slightly moist, soft, [Fill]				1 2 3 4 Plastic Limit ⊢—⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2	2.0 Sandy to Silty CLAY (CL); brown, dry to slighly moist, medium stiff, low plasticity, massive, white mottling [Fine-Grained Alluvium]					
4						
6						
7	7.0 Sandy to Silty CLAY; (CL); light brown, moist becoming very moist to wet, soft, low plasticity, stratified, orange mottling [Fine-Grained Alluvium]					
8						
▽						
10	10.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH50

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/8/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 9 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sandy CLAY (CL) with some gravel and cobble; brown, slightly moist, soft, roots [Topsoil/Fill]				1 2 3 4 Plastic Limit ⊢——⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
1.0	Sandy to Silty CLAY (CL); brown, dry to slighly moist, medium stiff, low plasticity, massive, white mottling [Fine-Grained Alluvium]					
2						
4						
6						
7.0	Sandy to Silty CLAY; (CL); light brown, moist becoming very moist to wet, soft, low plasticity, stratified, orange mottling [Fine-Grained Alluvium]					
8						
▽						
10						
10.0						

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH51

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings, **STRUCTURE.:** Residential Subdivision
CLIENT: PEC **DATE:** 4/8/2021
LOCATION: See Figures 1 & 2 **ELEVATION:** nm
CONTRACTOR: Geoscience **LOGGED BY:** gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ _____ **AFTER 24 HOURS:** ▼ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sandy CLAY (CL) with some gravel and cobble; brown, slightly moist, soft, roots [Topsoil/Fill]				1 2 3 4 Plastic Limit — Liquid Limit; Water Content - ● 10 20 30 40 50; Penetrometer (tsf)- 1 2 3 4	
2	2.0 SHALE; grayish brown, slightly moist, weak, thinly bedded, moderately weathered [Claggett Formation]					
4						
6						
8						
10	10.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH52

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/8/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ _____ **AFTER 24 HOURS:** ▼ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sandy CLAY (CL) with some gravel and cobble; brown, slightly moist, soft, roots [Topsoil/Fill]				1 2 3 4 Plastic Limit | Liquid Limit; Water Content - ● 10 20 30 40 50; Penetrometer (tsf)- 1 2 3 4	
1.5						
2	SHALE; grayish brown, slightly moist, weak, thinly bedded, moderately weathered [Claggett Formation]					
4						
6						
8						
10	10.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH53

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/8/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ _____ **AFTER 24 HOURS:** ▼ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sandy CLAY (CL); brown, dry, soft, roots [Topsoil]				1 2 3 4 Plastic Limit ⊢—⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
1.5						
2	Sandy CLAY (CL); light brown, dry, medium stiff, low plasticity, massive [Fine-Grained Alluvium]					
3.0						
4	Sandy GRAVEL with Cobble (GP); brown to gray, dry, medium dense to dense, stratified with sand layers [Coarse-Grained Alluvium]					
6						
8						
10	10.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH54

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings,
STRUCTURE.: Residential Subdivision
CLIENT: PEC
DATE: 4/8/2021
LOCATION: See Figures 1 & 2
ELEVATION: nm
CONTRACTOR: Geoscience
LOGGED BY: gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ _____ **AFTER 24 HOURS:** ▼ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel with Cobble; brown to gray, slighly moist, loose, massive, some asphalt and concrete at surface, large concretion in gravel [Pit Backfill]				1 2 3 4 Plastic Limit ⊢—⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
4	4.0 SHALE; grayish brown, dry to slighly moist, weak, thinly bedded, medium plasticity, moderately weathered [Claggett Formation]					
6						
8						
10	10.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH55

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings, **STRUCTURE.:** Residential Subdivision
CLIENT: PEC **DATE:** 4/8/2021
LOCATION: See Figures 1 & 2 **ELEVATION:** nm
CONTRACTOR: Geoscience **LOGGED BY:** gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ 8 **AFTER 24 HOURS:** ▽ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel with Cobble; brown to gray, slighly moist to wet, loose, massive, some asphalt and concrete at surface [Coarse-Grained Alluvium/Pit Backfill]				1 2 3 4 Plastic Limit ⊢——⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
4						
6						
8 ▽						
	9.0					
10	SHALE; grayish brown, dry to slighly moist, weak, thinly bedded, medium plasticity, moderately weathered [Claggett Formation]					
	11.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA

SUBSURFACE LOG

TEST HOLE BH56

File: BH Logs Date Printed: 5/3/2021

PROJECT: Bitterroot Heights Subdivision, 3rd Filing, Billings, **STRUCTURE.:** Residential Subdivision
CLIENT: PEC **DATE:** 4/8/2021
LOCATION: See Figures 1 & 2 **ELEVATION:** nm
CONTRACTOR: Geoscience **LOGGED BY:** gsv
EQUIPMENT: Excavator
DEPTH TO - WATER> INITIAL: ▽ _____ **AFTER 24 HOURS:** ▼ _____ **CAVING>** C _____

Depth (feet)	Description	Soil Type	Elevation (feet)	Samplers	TEST RESULTS	Monitor Well Installation Details
0	Sand & Gravel with Cobble; brown to gray, slighly moist to moist, loose, massive, some asphalt and concrete at surface, metal & debris [Coarse-Grained Alluvium/Pit Backfill]				1 2 3 4 Plastic Limit ⊢—⊣ Liquid Limit Water Content - ● 10 20 30 40 50 Penetrometer (tsf)- ▨ 1 2 3 4	
2						
4						
6						
7.0	SHALE; grayish brown, dry to slighly moist, weak, thinly bedded, medium plasticity, moderately weathered [Claggett Formation]					
8						
10	10.0					

Subsurface Profile Based On Field Observations & Geologic Mapping

This information pertains only to this boring and should not be interpreted as being indicitive of the site.

GEOSCIENCE, PLLP
BILLINGS, MONTANA