GEOTECHNICAL INVESTIGATION

FOR

PROPOSED INDUSTRIAL SITE READINESS – KALLA LOT

BESSEMER, MICHIGAN

JULY 15, 2020

CEC PROJECT NO. GD-200149

COLEMAN ENGINEERING COMPANY

CIVIL ENGINEERING • ENVIRONMENTAL ENGINEERING
GEOTECHNICAL ENGINEERING • SURVEYING

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Prepared By:

COLEMAN ENGINEERING COMPANY
200 E. Ayer Street
Ironwood, MI 49938

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CIVIL ENGINEERING • ENVIRONMENTAL ENGINEERING • GEOTECHNICAL ENGINEERING • SURVEYING
200 EAST AYER STREET • IRONWOOD, MI 49938 • PHONE: 906-932-5048

July 15, 2020

Ms. Charly Loper, City Manager
City of Bessemer
411 S. Sophie Street
Bessemer, MI 49911

Re: Geotechnical Investigation
Proposed Industrial Site Readiness – Kalla Lot
Bessemer, Michigan

Dear Ms. Loper:

Coleman Engineering Company (CEC) has completed the geotechnical investigation for the above referenced project. Enclosed are two (2) copies of a Geotechnical Report that includes a summary of the field and laboratory activities associated with the investigation.

We appreciate the opportunity to serve you. If you have any questions about our report, please feel free to call me in our Ironwood office at (906) 932-5048.

Sincerely,

COLEMAN ENGINEERING COMPANY

Garth C. Stengard, P.E.
Geotechnical Engineering Manager

GCS/ks

Enclosure

CEC Project No. GD-200149

TABLE OF CONTENTS

		PAGE #
I.	INTRODUCTION	1
II.	FIELD PROCEDURES	1
III.	LABORATORY PROCEDURES	1
IV.	SITE CONDITIONS	2
V.	ANALYSIS AND RECOMMENDATIONS	2
	Site Preparation and Grading	2
	Shallow Foundations	4
	Floor Slabs	4
	Pavement Areas	4
	Lateral Loads	5
	Underground Utility Construction	6
	Exterior Concrete Flatwork	7
	Inspection and Testing	7
	Construction Considerations	8
VI.	LIMITATIONS OF SUBSURFACE EXPLORATION	9

APPENDIX

APPENDIX A. LOCATION MAPS
- Project Location Map
- Boring Location Maps

APPENDIX B. CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES
(UNIFIED SOIL CLASSIFICATION SYSTEM)

APPENDIX C. SOIL EXPLORATION-GENERAL NOTES AND LEGEND

APPENDIX D. BORING LOGS

I. INTRODUCTION

The City of Bessemer is investigating their industrial areas for new building sites. This investigation covers recommendations for the Kalla Lot. The site is located in the northwest quadrant of Eli Avenue and Kalla Road in Bessemer, Michigan. Industrial buildings are typically one to two story, slab-on-grade structures. Wall and column loads were not known at the time of the report. The purpose of this report is to document the results of the field investigation and to provide recommendations/guidance for soil bearing capacity, settlement mitigation, groundwater management, pavement design, earthwork quality assurance/control (QA/QC) and other geotechnical considerations.

II. FIELD PROCEDURES

The site was evaluated with a total of three (3) soil borings designated as B-10 through B-12. The borings were advanced with a Diedrich D-120 all-terrain mounted drill unit present at the site on June 19, 2020. Drilling was completed using 4 ¼-inch I.D. hollow-stem augers (HSA).

The HSA act as continuously-advancing steel casing that prevents the borehole walls from collapsing in above the depths to be tested/sampled. Sampling tools are lowered inside the augers for testing into undisturbed soils ahead of the tip of the augers.

Drilling and field sampling of soils were performed in accordance with American Society for Testing and Materials (ASTM) D-1586, "Penetration Test and Split Barrel Sampling of Soils" with a 2-inch O.D. split spoon. Twenty-one (21) such samples were obtained.

A field log was prepared for each boring during exploration, which contained the work method, standard penetration test (SPT) data, samples recovered and the indication of the presence of various soil types. The field logs were submitted to Coleman Engineering Company's (CEC) laboratory along with the soil samples for evaluation of the subsurface information and preparation of the final boring logs.

The boring locations were selected by the City of Bessemer and established in the field by the CEC drill crew. Ground surface elevations at the boring locations were provided by the CEC Survey Crew. The general project location and boring location maps are presented in Appendix A.

III. LABORATORY PROCEDURES

All field soil samples collected were visually classified in accordance with ASTM D-2488,

"Description and Identification of Soils (Visual-Manual Procedure)." Because of the relative uniformity and density of the subsurface conditions encountered and extensive past experience with local subsurface conditions, additional laboratory testing was deemed unnecessary.

The final logs contain both factual and interpretive information. It should be emphasized that the recommendations are based only on the final boring logs. On the final logs, horizontal lines designating the interface between differing materials encountered represent approximate boundaries. The transition between soil strata is typically gradual.

IV. SITE CONDITIONS

The site is sloping downward to northeast with corresponding elevations at the boring locations ranging from +1448.51 to 1452.65.

The borings encountered interbedded layers of glacial sandy silt (ML), silty sand (SM) and poorly graded sand (SP) to the maximum depths explored. The native soils were generally in a very loose to medium dense condition. For a more detailed soil description see the individual soil boring logs in Appendix D.

Measureable groundwater was encountered in the borings at depths ranging from about 6.0 to 6.5 feet below the existing ground surface corresponding to elevations +1442.51 and 1445.45. The groundwater levels may fluctuate several feet seasonally, owing to rainfall, snowmelt, surface runoff, and other factors.

V. ANALYSIS AND RECOMMENDATIONS

Our analysis and recommendations related to the geotechnical aspects of the proposed project include:

Site Preparation and Grading

We recommend that topsoil and any deleterious materials be stripped/excavated from within the building footprint, building appurtenances, sidewalks, pavements and utilities to a lateral distance equal to the depth of removal (1 foot horizontal to 1 foot vertical) and replaced with engineered fill as defined below.

Excavations deeper than about 6.0 feet at this site will encounter groundwater. It is anticipated that groundwater will flow unpredictably into excavations at this depth. Any excavation that is

anticipated to intersect the water table will require dewatering.

Dewatering will likely need to be accomplished with a combination of a perimeter dewatering system or deep well system. Dewatering operations will need to be sufficient to allow fill placement and foundation construction activities to take place in dry conditions. Dewatering should lower the groundwater surface to at least 2 feet below the bottom of all excavations to avoid upward flow gradients that could destabilize the base of the excavation and so that any required engineered fill placement can take place in "dry" conditions.

Dewatering systems are typically installed in the field by contractors using "trial and error" methods. The contractor may need to adjust the system a number of times until finding a combination of pump size and well spacing best matched to the local conditions. In any case, prospective contractors will need to evaluate dewatering methods and discharge permitting appropriate to this project for themselves. Dewatering operations will need to be maintained 24 hours a day, 7 days a week, until all construction activities taking place below the groundwater surface are complete. Dewatering activities may require discharge permitting.

All subgrades exposed after stripping/excavation should be evaluated by a geotechnical engineer or person under the direction of a geotechnical engineer. The evaluation should include shallow hand auger borings and/or dynamic cone penetrometer tests to determine if the native subgrade soils are similar to those encountered in the soil borings and suitable for support of fill and structure loads. All native subgrade exposed after stripping/excavation should be compacted to a minimum of ninety percent (90%) of modified Proctor (ASTM D-1557) maximum dry density prior to any backfilling or placing foundations.

Excavation equipment operating on an exposed subgrade that is within 12 inches of the groundwater table may cause significant disturbance to bearing conditions of the soil. Therefore, we recommend that all excavation/stripping be accomplished using a tracked backhoe. All construction traffic needs to be eliminated from traveling across the exposed subgrade until foundations have been constructed and the interior foundation walls have been backfilled.

Engineered fill should consist of sand and/or gravel with less than about ten percent (10%) by weight of fines passing the No. 200 sieve with a maximum rock size of about 4 inches. A soil meeting Michigan Department of Transportation (MDOT) specifications for Class II or IIA sand would be acceptable for use as engineered fill. Fill shall be placed in lifts not exceeding about 12 inches in loose thickness compacted to a minimum of ninety-five percent (95%) of modified Proctor (ASTM D-1557) maximum dry density. The on-site poorly graded sand (SP) may be acceptable for use as engineered fill pending the results of laboratory testing.

Shallow Foundations

We recommend that any proposed buildings at this site be supported on conventional spread footings supported on native sand and/or compacted engineered fill. Foundations so supported can be proportioned for a net allowable soil bearing pressure of up to 2,000 pounds per square foot. The net allowable soil bearing pressure refers to that pressure in excess of the final overburden pressure. The recommended net allowable bearing pressure can be increased by one-third for short-term transient type live loadings. For the recommended design soil bearing pressure, we estimate a total settlement of less than ¾ inch. Differential settlement is expected to approach fifty to seventy-five percent (50 to 75%) of the total settlement for similarly sized structures and loads.

All perimeter footings should extend to a minimum depth of 42 inches or below frost depth, as defined by local building codes/practice. Interior footings in heated areas can be located immediately below the floor slab. All continuous wall footings should have a minimum width of 16 inches. An adequate thickness of insulation is recommended on the inside face of all footing/foundation walls exposed to cold weather. All isolated exterior footings should extend a minimum depth of 60 inches or below frost depth, as defined by local building codes/practice.

Floor Slabs

As with the footings, earth supported interior floors are recommended to be constructed on native soil or engineered fill. We recommend that the base of the slab be separated from the subgrade with an appropriate vapor barrier (Visqueen or similar). If the structure cannot accommodate curling or shrinkage of the floor, industry standards often recommend burying the vapor barrier beneath a minimum of 4 inches of free draining sand. However, we would caution that this practice risks trapping water between the slab and vapor barrier. We recommend contacting the floor covering manufacturer for placement of vapor barrier. If required, earth supported floor slabs can be designed using a modulus of subgrade reaction of 225 pounds per square inch per inch (pci) of deflection.

Pavement Areas

We recommend that any deleterious materials be stripped/excavated from beneath the proposed pavement area as defined in the “Site Preparation” section. Excavation should extend to a depth to accommodate the pavement section defined below. Where fill is required, we recommend it be compacted to at least ninety-five percent (95%) modified Proctor density (ASTM D-1557). Any natural soils within 2 feet of top of subgrade should be scarified to a depth of at least 6 inches

before placing fill or pavements and then surface compacted. This is intended to disrupt any near surface seams of saturated sands, which could later result in weak spots or frost boils in the subgrade.

If there are areas which cannot be compacted, we recommend that the unstable materials be subexcavated to a depth of at least 2 feet and be replaced by materials which can be compacted. Ideally, the fill should be similar to the existing soils. Subsequent fill should be similarly moistened and compacted.

Prior to placing fill, we advise "proof-rolling" the subgrade with a rubber-tire roller or heavy truck. The rolling should be observed by a geotechnical engineer or a field technician under the direction of a geotechnical engineer. Soft or spongy areas should be sub-cut, replaced and compacted as directed. The surface of the subgrade should be graded so as not to create low areas where water will collect.

Flexible Bituminous Pavement

For the assumptions of a firm subgrade and light traffic volumes, we recommend a pavement section of 3 inches of MDOT bituminous concrete surface course and 8 inches of MDOT 22A aggregate base course for car and light truck areas. For heavy truck areas, we recommend increasing the bituminous concrete thickness to 4 inches. The aggregate base course should be compacted to ninety-five percent (95%) modified Proctor density; the bituminous concrete should be compacted to ninety-two percent (92%) Theoretical Maximum Density. Density tests should be conducted to confirm that these densities are achieved.

Rigid Concrete Pavement

For concrete pavements, we recommend a minimum pavement section of six inches of reinforced Portland cement concrete and eight inches of MDOT Class IIA sand for uniform load support. The sand base should be compacted to ninety-five percent (95%) modified Proctor density. Density tests should be conducted to confirm that these densities are achieved.

Paved areas should be inspected frequently, particularly in the fall, and cracks sealed as soon as possible.

<u>Lateral Loads</u>

We recommend using the following equivalent fluid pressures and a triangular-shaped pressure distribution for the design of any walls resisting lateral loads from soil backfill:

WALL TYPE	EQUIVALENT ACTIVE FLUID PRESSURE	EQUIVALENT PASSIVE FLUID PRESSURE
Restrained at top	60 pcf	300 pcf
Free to rotate at top	40 pcf	300 pcf

Backfill within 5 lateral feet of the back of the walls should consist of MDOT Class II Sand. The backfill should be compacted to at least ninety-five percent (95%) of modified Proctor maximum dry density. Relatively light manually-propelled compactors should be used within five (5) feet of walls. Compactors used beyond five (5) feet should be limited in weight to 3,000 lbs.

A minimum 4-inch diameter perforated flexible drainage pipe (ADS green stripe or similar) should be located behind, parallel to, the wall, above the water table. The pipe should be embedded in washed concrete aggregate wrapped with filter fabric (Mirafi 140N or similar). The pipe should be routed to gravity discharge away from any structure.

External loads on the back of walls have not been taken into account in our recommendations. Surcharge loads imposed by vehicle parking, construction equipment and material storage should be considered during structural design.

Underground Utility Construction

Soil types encountered during utility installation will likely be native sand. Based on the borings, the native sands encountered at depth are generally suitable for utility support provided the excavations are adequately dewatered. If over-excavation is required, we recommend that the unsuitable soils be removed a lateral distance equal to the depth of removal (1 foot horizontal to 1 foot vertical) below the utility line and replaced with engineered fill. In the event that unstable soils are encountered, it may be necessary to undercut these soils 1 to 3 feet (depth to be determined by field observation) and replace them with engineered fill as outlined in the site preparation and grading section in order to provide a stable work surface. Engineered fill below utility lines should be compacted to a minimum of ninety percent (90%) modified Proctor density (ASTM D-1557).

All trench backfill above utility lines should be compacted to a minimum of ninety percent (90%) of modified Proctor maximum dry density. Trench backfill should be placed in lifts not exceeding about 12 inches in loose thickness. Excavated soils are recommended for trench backfill above the pipe bedding material if they are at or can be brought, with reasonable effort, to the moisture content optimum for compaction as defined by the modified Proctor test (ASTM D-1557). Also, the

excavated soils shall be free of chunks of frozen soil, organics, cobbles and boulders larger than about 4 inches and other deleterious materials. If this is not the case, we recommend that all excavations be backfilled with a soil recommended by a geotechnical engineer familiar with site subsurface conditions. Backfill to at least 12 inches above the pipe crown (pipe bedding) should consist of MDOT Class II sand.

Trench spoil, heavy equipment and any type of vibrating machinery should not be permitted within a lateral distance from the top of the trench/excavation equal to 0.5 times the depth of the trench/excavation.

Caving of trench sidewalls and soils at the site should be expected to occur at any depth and without warning. All utility trenches should be cut back or braced as required to provide safe trench working conditions. Trench safety is the responsibility of the utility contractor.

Exterior Concrete Flatwork

We recommend that exterior concrete flatwork be supported on a minimum of 12 inches of engineered backfill as defined in the "Site Preparation and Grading" section compacted to a minimum of ninety-five percent (95%) of modified Proctor maximum dry density.

We recommend that concrete entrance stoops be supported on frost-depth footings to prevent frost heave from negatively impacting door operation. Walkways leading to the entrance flatwork, as well as other exterior concrete flatwork, should be supported on a minimum of 12 inches of engineered fill placed over a firm subgrade. Exterior flatwork should be pitched to drain away from the building.

Inspection and Testing

A qualified testing laboratory should be retained throughout the course of earthwork operations for testing and documentation of compliance with the recommendations of this report and related project specifications. As a guide, the following compaction testing schedule is recommended:

Area or Material To Be Tested	**Recommended Minimum Testing Frequency**
Native Subgrades	1 test per 2,500 sq. ft.
Engineered Fill	1 test per 2,500 sq. ft. per lift
Wall Footings	1 test per 25 lineal feet
Utility Trenches	1 test per 50 lineal feet per lift

Construction Considerations

We anticipate that the sidewalls of excavations to depths greater than 4 feet below surrounding grades will cave to 1 vertical to 1.5 horizontal or flatter. Excavation spoil, heavy equipment and any type of vibrating machinery should not be permitted within a lateral distance from the top of the excavation to 0.5 times the depth of the excavation. Excavation safety is the excavation contractor's responsibility.

Dewatering systems are typically installed in the field by contractors using “trial and error” methods. The contractor may need to adjust the system a number of times until finding a combination of pump size and well spacing best matched to the local conditions. In any case, prospective contractors will need to evaluate dewatering methods appropriate to this project for themselves.

Excavation equipment operating on an exposed subgrade that is within 12 inches of the groundwater may cause significant disturbance to bearing conditions of the soil. Therefore, we recommend that all excavation be accomplished using a tracked backhoe. All construction traffic needs to be eliminated from traveling across the exposed subgrade until foundations have been constructed and the interior foundation walls have been backfilled. Footing excavations should be performed with a smooth bucket excavator to minimize disturbance to excavation bottoms.

During construction, adequate provision should be made for proper drainage, so as to prevent erosion and possible damage to this site and adjacent property. Temporary cut slopes during construction above the water table should not exceed about 2:1 (horizontal:vertical). Post-construction finished slopes above the water table should not exceed about 3:1 (horizontal:vertical).

VI. LIMITATIONS OF SUBSURFACE EXPLORATION

Services performed by Coleman Engineering Company as part of this investigation have been conducted in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering profession currently practicing under similar conditions. No other warranty, expressed or implied, is made.

Subsurface conditions between borings will probably vary from those encountered at the locations where borings have been made. The data, interpretations and recommendations contained herein are based solely on the information obtained from the three (3) soil borings completed for this study.

The conclusions and recommendations contained in this report are based on the assumption that the materials encountered in the borings represent the site conditions. If any unforeseen difficulties or unusual conditions are encountered, Coleman Engineering Company should be contacted immediately in order to make supplemental recommendations.

This report completes our present assignment for this project. As the design nears completion, we recommend that you consult with us on unanticipated problems or questions regarding the design and/or review of any plans or specifications. The work assignments for the above services are subject to your prior approval and authorization.

OUR CONCLUSIONS AND RECOMMENDATIONS ARE PREDICATED ON OBSERVATION AND TESTING OF THE EXCAVATION AND FOUNDATION PREPARATIONS BY QUALIFIED PERSONNEL. IT WOULD BE LOGICAL FOR COLEMAN ENGINEERING COMPANY TO PROVIDE THAT SERVICE, SINCE WE ARE BEST ABLE TO DETERMINE IF THE CONDITIONS ENCOUNTERED MATCH THOSE USED IN OUR ANALYSES, TO DETERMINE IF MODIFICATIONS OF OUR RECOMMENDATIONS ARE NEEDED AND TO MAKE SUCH MODIFICATIONS OF OUR RECOMMENDATIONS AS MAY BE NECESSARY. MODIFICATIONS OF OUR RECOMMENDATIONS BY OTHERS RELIEVES US OF RESPONSIBILITY FOR THEM.

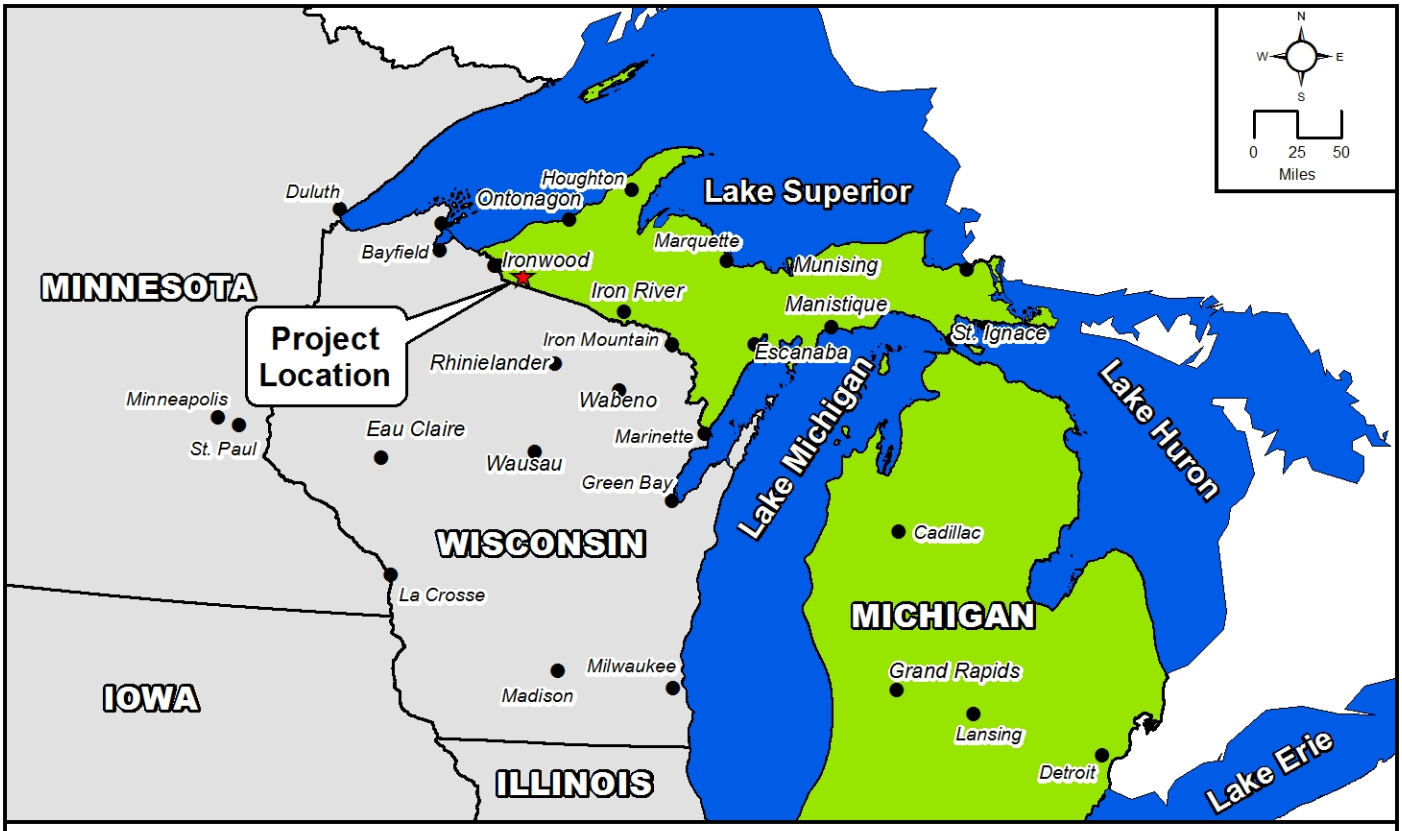
This report has been completed by Garth C. Stengard, a registered engineer in the State of Michigan.

Garth C. Stengard, P.E.
Geotechnical Engineer
Registration #: 6201050531

APPENDIX A

PROJECT LOCATION MAPS

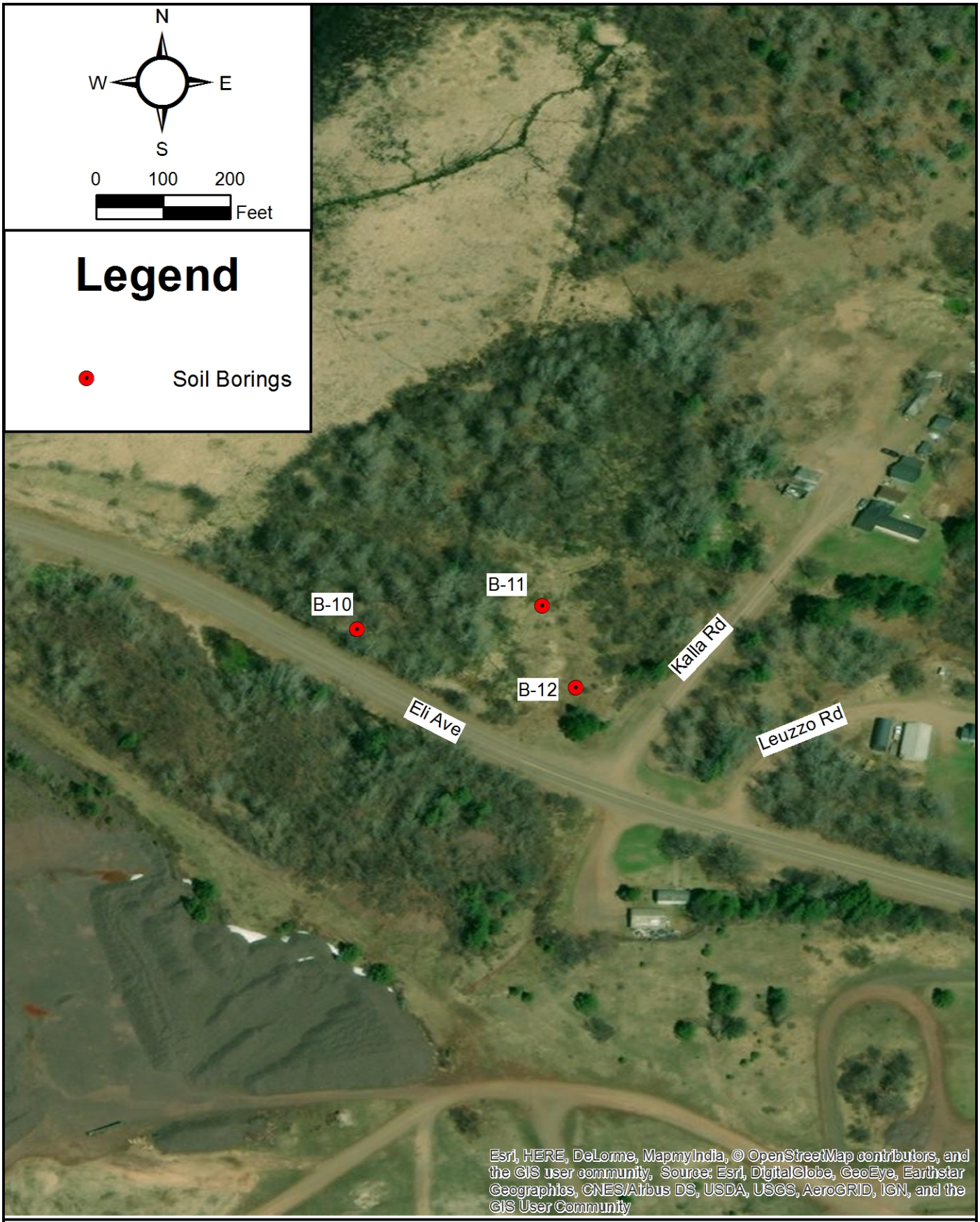
- Project Location Map
- Boring Location Maps



PROJECT LOCATION MAP

SITE LOCATION MAP

Coleman Engineering Company Iron Mountain • Ironwood • Negaunee • Green Bay www.coleman-engineering.com	City of Bessemer Industrial Site Readiness Bessemer, Michigan	Project No: 200149	GIS File: WIW_WIQ.mxd
		Map Date: 7/1/20	Figure No: Fig 1



SOIL BORING LOCATION MAP

Coleman Engineering Company Iron Mountain • Ironwood • Negaunee • Green Bay www.coleman-engineering.com	City of Bessemer Industrial Site Readiness Bessemer, Michigan	Project No: 200149	GIS File: BORELOC.mxd
		Map Date: 7/1/20	Figure No: Fig 3

APPENDIX B

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES
(UNIFIED SOIL CLASSIFICATION SYSTEM)

COLEMAN ENGINEERING COMPANY

635 Circle Drive
Iron Mountain, Michigan 49801

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES
ASTM Designation: D-2487 – 83
(Based on Unified Soil Classification System)

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification	
				Group Symbol	Group Name[B]
Coarse-Grained Soils More than 50 % retained on No. 200 sieve	Gravels More than 50 % of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5 % fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$ [E]	GW	Well-graded gravel [F]
			$Cu < 4$ and/or $1 > Cc > 3$[E]	GP	Poorly graded gravel[F]
		Gravels with Fines more than 12 % fines[C]	Fines classify as ML or MH	GM	Silty gravel[F.G.H.]
			Fines classify as CL or CH	GC	Clayey gravel[F.G.H.]
	Sands 50 % or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5 % fines[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]	SW	Well-graded sand
			$Cu < 6$ and/or $1 > Cc > 3$[E]	SP	Poorly graded sand [I]
		Sands with Fines More than 12 % fines[D]	Fines classify as ML or MH	SM	Silty sand[G.H.J.]
			Fines classify as CL or CH	SC	Clayey sand[G.H.I.]
Fine-Grained Soils 50 % or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	Pl > 7 and plots on or above "A" line[J]	CL	Lean clay[K.L.M.]
			Pl < 4 or plots below "A" line[J]	ML	Silt[K.L.M.]
		organic	$\frac{\text{Liquid limit – oven dried}}{\text{Liquid limit – not dried}} < 0.75$	OL	Organic clay[K.L.M.N.] / Organic silt[K.L.M.O.]
	Silts and Clays Liquid limit 50 or more	inorganic	Pl plots on or above "A" line	CH	Fat clay[K.L.M.]
			Pl plots below "A" line	MH	Elastic silt[K.L.M.]
		organic	$\frac{\text{Liquid limit – oven dried}}{\text{Liquid limit – not dried}} < 0.75$	OH	Organic clay[K.L.M.P.] / Organic silt[K.L.M.Q.]
Highly organic soils	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12 % fines require dual symbols:
GW-GM well-graded gravel with silt
GW-GC well-graded gravel with clay
GP-GM poorly graded gravel with silt
GP-GC poorly graded gravel with clay

[D] Sands with 5 to 12 % fines require dual symbols:
SW-SM well-graded sand with silt
SW-SC well-graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10} \quad \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soils contains $\geq$ 15 % sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains $\geq$ 15 % gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29 % plus No. 200, add "with sand" or "with gravel", whichever is predominant.

[L] If soil contains $\geq$ 30 % plus No. 200, predominantly sand, add "sandy" to group name.

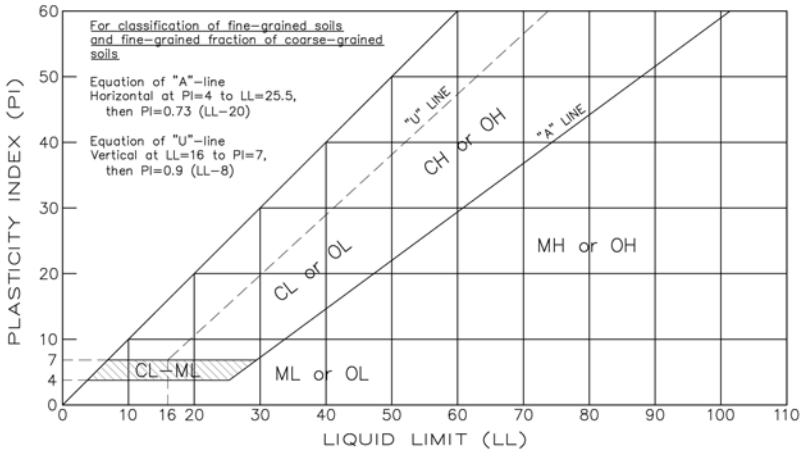
[M] If soil contains $\geq$ 30 % plus No. 200, predominately gravel, add "gravelly" to group name.

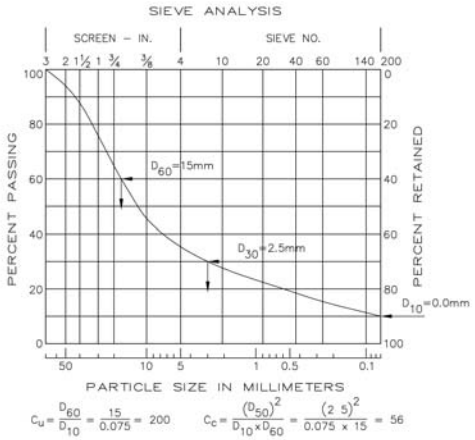
[N] Pl $\geq$ 4 and plots on or above "A" line.

[O] Pl < 4 or plots below "A" line.

[P] Pl plots on or above "A" line.

[Q] Pl plots below "A" line.





APPENDIX C

SOIL EXPLORATION-GENERAL NOTES AND LEGEND

SOIL EXPLORATION
GENERAL NOTES AND LEGEND

COLEMAN ENGINEERING COMPANY
635 CIRCLE DRIVE - IRON MOUNTAIN, MICHIGAN 49801 (906) 774-3440
200 EAST AYER STREET - IRONWOOD, MICHIGAN 49938 (906) 932-5048

DESCRIPTIVE SOIL CLASSIFICATION
ASTM D2487 / 2488

GRAINSIZE TERMINOLOGY

Soil Fraction	Particle Size	U.S. Standard Sieve Size
Boulders	Larger than 12"	Larger than 12"
Cobbles	3" to 12"	3" to 12"
Gravel: Coarse	3/4" to 3"	3/4" to 3"
Fine	4.75mm to 3/4"	#4 to 3/4"
Sand: Coarse	2.00mm to 4.75mm	#10 to #4
Medium	0.42mm to 2.00mm	#40 to #10
Fine	0.075mm to 0.42mm	#200 to #40
Silt	0.005mm to 0.075mm	Smaller than #200
Clay	Smaller than 0.005mm	Smaller than #200

GENERAL TERMINOLOGY

Physical Characteristics
Color, moisture, grain shape, fineness, etc.
Major Constituents
Clay, silt, sand, gravel
Structure
Laminated, varved, fibrous, stratified, cemented, fissured, etc.
Geologic Origin
Glacial, alluvial, eolian, residual, etc.

RELATIVE DENSITY

Term	"N" Value
Very Loose	0–4 BPF
Loose	5–10 BPF
Medium Dense	11–30 BPF
Dense	31–50 BPF
Very Dense	Over 50 BPF

RELATIVE PROPORTIONS OF COHESIONLESS SOILS

Proportional Terms	Defining Range By Percentages of Weight
Trace	0%–5%
With	5%–12%
–Y	12%–50%

CONSISTENCY

Term	"N"–value	qa (tsf)
Very Soft	0–1 BPF	0.0 to 0.25
Soft	1–4 BPF	0.25 to 0.50
Medium	5–8 BPF	0.50 to 1.0
Stiff	8–16 BPF	1.0 to 2.0
Very Stiff	17–31 BPF	2.0 to 4.0
Hard	Over 32 BPF	Over 4.0

ORGANIC CONTENT BY COMBUSTION METHOD

Soil Description	Loss on Ignition
Non–Organic	Less than 4%
Organic Silt / Clay	4% – 12%
Sedimentary Peat	12% – 50%
Fibrous and Woody Peat	More than 50%

PLASTICITY

Term	Plastic Index
None to Slight	0–4
Slight	5–7
Medium	8–22
High to Very High	Over 22

The penetration resistance, N–value, is the summation of the number of blows required to effect two successive 6" penetrations of the 2" split–barrel sampler or blows per foot (BPF). The sampler is typically driven 18" with a 140 lb. weight falling 30" and is seated to a depth of 6" before commencing the standard penetration test. When driven 24" the "N" is the sum of the blow of the second and third 6" increment.

SYMBOLS
DRILLING AND SAMPLING

RB – Roller Bit
RC – Rock Coring
RQD – Rock Quality Designator
CW – Clear Water
DM – Drilling Mud
HSA – Hollow Stem Auger
SSA – Solid Stem Auger
HA – Hand Auger
SPT – Standard Penetration Test
2SS – 2" Diameter Split–Barrel Sample
3SS – 3" Diameter Split–Barrel Sample
2ST – 2" Diameter Shelby Tube Sample
3ST – 3" Diameter Shelby Tube Sample
PS – 3" Diameter Piston Tube Sample
AS – Auger Sample
WS – Wash Sample
NR – No Recovery
VS – Vane Shear Test
T – Torvane Shear Test
BS – Bag Sample
GS – Grab Sample
q_a – Penetrometer Reading, tsf
q_u – Unconfined Strength, tsf

LABORATORY TEST

W – Moisture Content, %
LL – Liquid Limit, %
PL – Plastic Limit, %
SL – Shrinkage Limit, %
LI – Loss on Ignition, %
DD – Dry Density, psf

WATER LEVEL MEASUREMENT

▽ Water Level During Drilling
▼ Water Level After Drilling
▼ Water Level at Time Shown 1
▼ Water Level at Time Shown 2
▼ Water Level at Time Shown 3
▼ Water Level at Time Shown 4
NW – No Water Encountered
BCR – Before Casing Removal
ACR – After Casing Removal

NOTE: Water level measurements shown on the boring logs represent conditions at the time indicated and may not reflect static levels, especially in cohesive soils.

Revised 6/8/12

APPENDIX D

BORING LOGS

COLEMAN ENGINEERING COMPANY
635 CIRCLE DRIVE
IRON MOUNTAIN, MICHIGAN 49801
Telephone: (906)-774-3440 Fax: (906)-774-7776

JOB NO.: 200149.GPJ

PROJECT: Industrial Site Readiness — BORING NO.: B-10

CLIENT: City of Bessemer — 1 OF 2

BORING LOCATION: Kalla Lot - 46.468798656° N, -90.075366730 (See soil boring location drawing) — ELEV.: 1452.65 +/-

RIG TYPE: Diedrich D-120 ATV — DRILL CREW: C. Reidner / W. Lake

DRILLING METHOD: 4-1/4" Hollow Stem Auger — BORING DEPTH: 21.5

DATE STARTED: 6/19/20 — DATE COMPLETED: 6/19/20 — REVIEWED BY: D. Edlebeck — DATE: 7/10/20

HOLE CLOSURE: Soil Cuttings

SAMPLE NUMBER	SPT VALUES BLOWS/6"(N)	RECOVERY	LEGEND	DEPTH (FT)	SOIL DESCRIPTION	WATER TABLE	ELEV. (FT)	COMMENTS	TEST RESULTS: +4 -4 -200	MOISTURE CONTENT (%)	LL PL	T (tsf)	q_a (tsf) q_u (tsf)
1	2-6-3 (9)	1.2		0	(SM) SILTY SAND, brown, fine, with gravel, from 0.0' to ± 2.0', moist, loose		1452.7	4-1/4" Hollow Stem Auger 2" SPT Sampling 140# wt., 30" drop Auto Hammer					
				1									
				2									
2	4-5-5 (10)	1.2		3									
				4									
				5	...trace clay from ± 4.5' to ± 7.0', medium dense		1447.7						
3	5-8-5 (13)	1.0		6		▼		Driller's note: Samples wet 6.0' to 21.5'					
				7									
4	2-1-2 (3)	1.0		8	...wet, very loose								
				9									
					(Glacial Outwash) ± 9.5'								
				10	(SP) POORLY GRADED SAND, brown, fine to medium, some silt, wet, loose		1442.7						
5	2-2-3 (5)	1.2		11									
				12									
				13									
				14									
				15	...fine		1437.7						
6	3-3-4 (7)	1.0		16									
				17									
				18									
				19									
				20			1432.7						

-AS-Auger Sample
-BS-Bag Sample
-RC-Rock-Core
-MC-Macrocore
-PS-Piston Tube
-2SS-2" Split Spoon
-3SS-3" Split Spoon
-2ST-2" Shelby Tube
-3ST-3" Shelby Tube

▽ while drilling 6.0
▼ after drilling 6.0
▼ after hours

BORING NO.: B-10

COLEMAN ENGINEERING COMPANY
635 CIRCLE DRIVE
IRON MOUNTAIN, MICHIGAN 49801
Telephone: (906)-774-3440 Fax: (906)-774-7776

JOB NO.: 200149.GPJ

PROJECT: Industrial Site Readiness — BORING NO.: B-10

CLIENT: City of Bessemer — 2 OF 2

BORING LOCATION: Kalla Lot - 46.468798656° N, -90.075366730 (See soil boring location drawing) — ELEV.: 1452.65 +/-

RIG TYPE: Diedrich D-120 ATV — DRILL CREW: C. Reidner / W. Lake

DRILLING METHOD: 4-1/4" Hollow Stem Auger — BORING DEPTH: 21.5

DATE STARTED: 6/19/20 — DATE COMPLETED: 6/19/20 — REVIEWED BY: D. Edlebeck — DATE: 7/10/20

HOLE CLOSURE: Soil Cuttings

SAMPLE NUMBER	SAMPLE SPT VALUES BLOWS/6"(N)	SAMPLE RECOVERY	SAMPLE LEGEND	DEPTH (FT)	SOIL DESCRIPTION	WATER TABLE	ELEV. (FT)	COMMENTS	TEST RESULTS +4 -4 -200	TEST RESULTS MOISTURE CONTENT (%)	TEST RESULTS LL PL	TEST RESULTS T (tsf)	TEST RESULTS q_a (tsf) q_u (tsf)
7	5-8-6 (14)	1.2		20	(SP) POORLY GRADED SAND, brown, fine, with gravel, some silt, wet, medium dense		1432.7						
				21	(Glacial Outwash) 21.5'								
				22	End of Boring								
				23									
				24									
				25			1427.7						
				26									
				27									
				28									
				29									
				30			1422.7						
				31									
				32									
				33									
				34									
				35			1417.7						
				36									
				37									
				38									
				39									
				40			1412.7						

-AS-Auger Sample
-BS-Bag Sample
-RC-Rock-Core
-MC-Macrocore
-PS-Piston Tube
-2SS-2" Split Spoon
-3SS-3" Split Spoon
-2ST-2" Shelby Tube
-3ST-3" Shelby Tube

▽ while drilling 6.0
▼ after drilling 6.0
▼ after hours

BORING NO.: B-10

COLEMAN ENGINEERING COMPANY
635 CIRCLE DRIVE
IRON MOUNTAIN, MICHIGAN 49801
Telephone: (906)-774-3440 Fax: (906)-774-7776

JOB NO.: 200149.GPJ

PROJECT: Industrial Site Readiness — BORING NO.: B-11

CLIENT: City of Bessemer — 1 OF 2

BORING LOCATION: Kalla Lot - 46.468895900° N, -90.074608707 (See soil boring location drawing) — ELEV.: 1448.51 +/-

RIG TYPE: Diedrich D-120 ATV — DRILL CREW: C. Reidner / W. Lake

DRILLING METHOD: 4-1/4" Hollow Stem Auger — BORING DEPTH: 21.5

DATE STARTED: 6/19/20 — DATE COMPLETED: 6/19/20 — REVIEWED BY: D. Edlebeck — DATE: 7/10/20

HOLE CLOSURE: Soil Cuttings

SAMPLE NUMBER	SPT VALUES BLOWS/6"(N)	RECOVERY	LEGEND	DEPTH (FT)	SOIL DESCRIPTION	WATER TABLE	ELEV. (FT)	COMMENTS	TEST RESULTS: +4 -4 -200	MOISTURE CONTENT (%)	LL PL	T (tsf)	q_a (tsf) q_u (tsf)
1	1-2-2 (4)	1.0		0	TOPSOIL 0.2'		1448.5	4-1/4" Hollow Stem Auger 2" SPT Sampling 140# wt., 30" drop Auto Hammer					
				1	(ML) SANDY SILT, brown, non-plastic, moist, very loose								
				2									
2	3-4-3 (7)	1.5		3	...slightly plastic, loose								
				4									
3	2-2-2 (4)	1.5		5	...moderately plastic, wet, very loose		1443.5						
				6		▼		Driller's note: Samples wet 6.0' to 21.5'					
				7	(Glacial Outwash) ± 7.0' (SM) SILTY SAND, brown, fine, wet, loose								
4	3-3-4 (7)	1.5		8									
				9									
5	WOH/1'-1 (-)	1.5		10	...fine to medium, very loose		1438.5						
				11									
				12									
				13	(Glacial Outwash) ± 13.0' (SP) POORLY GRADED SAND, brown, fine to medium, some silt, wet, loose								
				14									
6	2-2-3 (5)	1.5		15			1433.5						
				16									
				17									
				18	(Glacial Outwash) ± 18.0' (SM) SILTY SAND WITH GRAVEL, brown, fine to coarse, wet, medium dense								
				19									
				20			1428.5						

-AS-Auger Sample
-BS-Bag Sample
-RC-Rock-Core
-MC-Macrocore
-PS-Piston Tube
-2SS-2" Split Spoon
-3SS-3" Split Spoon
-2ST-2" Shelby Tube
-3ST-3" Shelby Tube

▽ while drilling 6.0
▼ after drilling 6.0
▼ after hours

BORING NO.: B-11

COLEMAN ENGINEERING COMPANY
635 CIRCLE DRIVE
IRON MOUNTAIN, MICHIGAN 49801
Telephone: (906)-774-3440 Fax: (906)-774-7776

JOB NO.: 200149.GPJ

PROJECT: Industrial Site Readiness — BORING NO.: B-11

CLIENT: City of Bessemer — 2 OF 2

BORING LOCATION: Kalla Lot - 46.468895900° N, -90.074608707 (See soil boring location drawing) — ELEV.: 1448.51 +/-

RIG TYPE: Diedrich D-120 ATV — DRILL CREW: C. Reidner / W. Lake

DRILLING METHOD: 4-1/4" Hollow Stem Auger — BORING DEPTH: 21.5

DATE STARTED: 6/19/20 — DATE COMPLETED: 6/19/20 — REVIEWED BY: D. Edlebeck — DATE: 7/10/20

HOLE CLOSURE: Soil Cuttings

SAMPLE NUMBER	SAMPLE SPT VALUES BLOWS/6"(N)	SAMPLE RECOVERY	SAMPLE LEGEND	DEPTH (FT)	SOIL DESCRIPTION	WATER TABLE	ELEV. (FT)	COMMENTS	TEST RESULTS +4 -4 -200	TEST RESULTS MOISTURE CONTENT (%)	TEST RESULTS LL PL	TEST RESULTS T (tsf)	TEST RESULTS q_a (tsf) q_u (tsf)
7	6-11-12 (23)	1.2		20	(SM) SILTY SAND WITH GRAVEL, brown, fine to coarse, wet, medium dense		1428.5						
				21	(Glacial Outwash) 21.5'								
				22	End of Boring								
				23									
				24									
				25			1423.5						
				26									
				27									
				28									
				29									
				30			1418.5						
				31									
				32									
				33									
				34									
				35			1413.5						
				36									
				37									
				38									
				39									
				40			1408.5						

-AS-Auger Sample
-BS-Bag Sample
-RC-Rock-Core
-MC-Macrocore
-PS-Piston Tube
-2SS-2" Split Spoon
-3SS-3" Split Spoon
-2ST-2" Shelby Tube
-3ST-3" Shelby Tube

▽ while drilling 6.0
▼ after drilling 6.0
▼ after hours

BORING NO.: B-11

COLEMAN ENGINEERING COMPANY
635 CIRCLE DRIVE
IRON MOUNTAIN, MICHIGAN 49801
Telephone: (906)-774-3440 Fax: (906)-774-7776

JOB NO.: 200149.GPJ

PROJECT: Industrial Site Readiness — BORING NO.: B-12

CLIENT: City of Bessemer — 1 OF 2

BORING LOCATION: Kalla Lot - 46.468561711° N, -90.074472712 (See soil boring location drawing) — ELEV.: 1451.95 +/-

RIG TYPE: Diedrich D-120 ATV — DRILL CREW: C. Reidner / W. Lake

DRILLING METHOD: 4-1/4" Hollow Stem Auger — BORING DEPTH: 21.5

DATE STARTED: 6/19/20 — DATE COMPLETED: 6/19/20 — REVIEWED BY: D. Edlebeck — DATE: 7/10/20

HOLE CLOSURE: Soil Cuttings

SAMPLE NUMBER	SPT VALUES BLOWS/6"(N)	RECOVERY	LEGEND	DEPTH (FT)	SOIL DESCRIPTION	WATER TABLE	ELEV. (FT)	COMMENTS	TEST RESULTS: +4 -4 -200	MOISTURE CONTENT (%)	LL PL	T (tsf)	q_a (tsf) q_u (tsf)
1	3-4-1 (5)	0.5		0	(SM) SILTY SAND, brown, fine, moist, loose		1452.0	4-1/4" Hollow Stem Auger 2" SPT Sampling 140# wt., 30" drop Auto Hammer					
				1									
				2	...with gravel from ± 2.0' to ± 4.5'								
2	5-5-5 (10)	1.0		3									
				4									
3	3-7-7 (14)	1.5		5	...wet, medium dense		1447.0						
				6		▼							
				7	(Glacial Outwash) ± 7.0' (SP) POORLY GRADED SAND, brown, fine to medium, some silt, wet, loose			Driller's note: Samples wet 6.5' to 21.5'					
4	1-3-5 (8)	1.0		8									
				9	(Glacial Outwash) ± 9.5'								
				10	(SM) SILTY SAND, brown, fine, wet, loose		1442.0						
5	2-3-4 (7)	1.5		11									
				12									
				13	(Glacial Outwash) ± 13.5'								
				14	(GM) SILTY GRAVEL WITH SAND, brown, fine to coarse, rounded to subangular, wet, medium dense								
				15			1437.0						
6	6-13-17 (30)	1.5		16									
				17									
				18	(Glacial Outwash) ± 18.0' (SP) POORLY GRADED SAND, brown, fine to medium, trace silt, wet, medium dense								
				19									
				20			1432.0						

-AS-Auger Sample
-BS-Bag Sample
-RC-Rock-Core
-MC-Macrocore
-PS-Piston Tube
-2SS-2" Split Spoon
-3SS-3" Split Spoon
-2ST-2" Shelby Tube
-3ST-3" Shelby Tube

▽ while drilling 6.5
▼ after drilling 6.5
▼ after hours

BORING NO.: B-12

COLEMAN ENGINEERING COMPANY
635 CIRCLE DRIVE
IRON MOUNTAIN, MICHIGAN 49801
Telephone: (906)-774-3440 Fax: (906)-774-7776

JOB NO.: 200149.GPJ

PROJECT: Industrial Site Readiness — BORING NO.: B-12

CLIENT: City of Bessemer — 2 OF 2

BORING LOCATION: Kalla Lot - 46.468561711° N, -90.074472712 (See soil boring location drawing) — ELEV.: 1451.95 +/-

RIG TYPE: Diedrich D-120 ATV — DRILL CREW: C. Reidner / W. Lake

DRILLING METHOD: 4-1/4" Hollow Stem Auger — BORING DEPTH: 21.5

DATE STARTED: 6/19/20 — DATE COMPLETED: 6/19/20 — REVIEWED BY: D. Edlebeck — DATE: 7/10/20

HOLE CLOSURE: Soil Cuttings

SAMPLE NUMBER	SAMPLE SPT VALUES BLOWS/6"(N)	SAMPLE RECOVERY	SAMPLE LEGEND	DEPTH (FT)	SOIL DESCRIPTION	WATER TABLE	ELEV. (FT)	COMMENTS	TEST RESULTS +4 -4 -200	TEST RESULTS MOISTURE CONTENT (%)	TEST RESULTS LL PL	TEST RESULTS T (tsf)	TEST RESULTS q_a (tsf) q_u (tsf)
7	6-11-12 (23)	1.5		20	(SP) POORLY GRADED SAND, brown, fine to medium, trace silt, wet, medium dense		1432.0						
				21	(Glacial Outwash) 21.5'								
				22	End of Boring								
				23									
				24									
				25			1427.0						
				26									
				27									
				28									
				29									
				30			1422.0						
				31									
				32									
				33									
				34									
				35			1417.0						
				36									
				37									
				38									
				39									
				40			1412.0						

▌-AS-Auger Sample ▣-MC-Macrocore ▨-3SS-3" Split Spoon
B -BS-Bag Sample P -PS-Piston Tube ◪-2ST-2" Shelby Tube
▌-RC-Rock-Core ▩-2SS-2" Split Spoon ◩-3ST-3" Shelby Tube

▽ while drilling 6.5 ▼ after hours
▼ after drilling 6.5

BORING NO.: B-12