

APPROVED

By: RCR Date: 10-6-16

October 6, 2016



City of Fort Collins
Engineering Department



GLH Construction
780 East Garden Drive
Windsor, Colorado 80550

Attn: Mr. Justin Marshall

**Re: Addendum Letter to Geotechnical Engineering Report
Brookfield Second Replat
Fort Collins, Colorado
Northern Colorado Geotech Project No. c218-16**

Based on information provided by Rick Richter with the City of Fort Collins, Northern Lights Drive and Lefever Drive will be designed using an Equivalent Daily Axle Load (EDLA) of 15. Brookfield Drive will use an EDLA of 20.

Pavement Design and Construction

The design of pavements for the project has been based on the procedures outlined in the 1993 Guideline for Design of Pavement Structures by the American Association of State Highway and Transportation Officials (AASHTO).

Traffic criteria was provided by the City of Fort Collins for pavement thickness designs include daily 18-kip equivalent single axle loads (ESAL's) of 15 for Northern Lights and Lefever Drives and 20 for Brookfield Drive.

Local drainage characteristics of proposed pavement areas are considered to vary from fair to good depending upon location on the site. For purposes of this design analysis, fair drainage characteristics are considered to control the design. These characteristics, coupled with the approximate duration of saturated subgrade conditions, results in a design drainage coefficient of 1.0 when applying the AASHTO criteria for design.

For flexible pavement design, a terminal serviceability index of 2.0 was utilized along with an inherent reliability of 75% and a design life of 20 years. Using the correlated design R-value of 20, appropriate ESAL/day, environmental criteria and other factors, the structural numbers (SN) of the pavement sections were determined on the basis of the 1993 ASHTO design equation.

GLH Construction
 Brookfield Second Replat Pavement Design
 Northern Colorado Geotech Project No. c218-16

Traffic Area	Alternative	Recommended Pavement Thicknesses (Inches)				
		Asphalt Concrete Surface	Aggregate Base Course	Plant-Mixed Bituminous Base	Portland Cement Concrete	Total
Northern Lights and Lefever Dr.	A	4	7			11
Brookfield Dr.	A	4½	6			10½

Aggregate base course should consist of a blend of sand and gravel which meets strict specifications for quality and gradation. Use of materials meeting Colorado Department of Transportation (CDOT) Class 5 or 6 specifications is recommended for base course.

Aggregate base course should be placed in lifts not exceeding six inches and should be compacted to a minimum of 95% Standard Proctor Density (ASTM D698).

Based upon the subsurface conditions determined from the geotechnical exploration, subgrade soils exposed during construction are anticipated to be relatively stable. However, the stability of the subgrade may be affected by precipitation, repetitive construction traffic or other factors. If unstable conditions develop, workability may be improved by scarifying and drying. Overexcavation of wet zones and replacement with granular materials may be necessary. Use of lime, fly ash, kiln dust, cement or geotextiles could also be considered as a stabilization technique. Laboratory evaluation is recommended to determine the effect of chemical stabilization on subgrade soils prior to construction. Lightweight excavation equipment may be required to reduce subgrade pumping.

If you have any questions concerning this report or any of our consulting services, please do not hesitate to contact us.

Sincerely,
NORTHERN COLORADO GEOTECH

Prepared by:

Doug Leafgren, P.G.
 President

Reviewed by:

Gary G. Weeks, P.E.
 Vice President

Attachment: DarWin Pavement Design Outputs

Copies to: Addressee (2)
 City of Fort Collins – Rick Richter (2)



2956 29th Street, Unit 21
Greeley, Colorado 80631
Phone: (970) 506-9244
Fax: (970) 506-9242

1993 AASHTO PAVEMENT DESIGN

Client: GLH Construction

Project No. c218-16

Project: Brookfield Second Replat
Northern Lights and Lefever Dr.

Date of Report 10/6/2016

Flexible Structural Design

18-kip ESALs over Initial Performance Period	109,500
Initial Serviceability	4.5
Terminal Serviceability	2.0
Reliability Level	75%
Overall Standard Deviation	0.4
Roadbed Soil Resilient Modulus	4,940
Stage(s) Construction	1
Calculated Design Structural Number	2.50

Specified Layer Design

<u>Layer</u>	<u>Material Description</u>	<u>Struc. Coeff.</u>	<u>Thickness (in)</u>	<u>Calculated Struc Number</u>
1	Asphalt	0.44	4	1.76
2	Base Course	0.11	7	0.77
Total:				2.53



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1993 AASHTO PAVEMENT DESIGN

Client: GLH Construction

Project No. c218-16

Project: Brookfield Second Replat
Brookfield Drive

Date of Report 10/6/2016

Flexible Structural Design

18-kip ESALs over Initial Performance Period	146,000
Initial Serviceability	4.5
Terminal Serviceability	2.0
Reliability Level	75%
Overall Standard Deviation	0.4
Roadbed Soil Resilient Modulus	4,940
Stage(s) Construction	1

Calculated Design Structural Number **2.60**

Specified Layer Design

<u>Layer</u>	<u>Material Description</u>	<u>Struc. Coeff.</u>	<u>Thickness (in)</u>	<u>Calculated Struc Number</u>
1	Asphalt	0.44	4.5	1.98
2	Base Course	0.11	6	0.66
Total:				2.64

GEOTECHNICAL ENGINEERING REPORT

**PAVEMENT SUBGRADE ANALYSIS
BROOKFIELD SECOND REPLAT
FORT COLLINS, COLORADO**

**NORTHERN COLORADO GEOTECH
PROJECT NO. c218-16
OCTOBER 5, 2016**

Prepared for:

**GLH Construction
780 East Garden Drive
Windsor, Colorado 80550
Attn: Mr. Justin Marshall**





2956 29th Street, Unit 21
Greeley, Colorado 80631
Phone: (970) 506-9244
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October 5, 2016

GLH Construction
780 East Garden Drive
Windsor, Colorado 80550

Attn: Mr. Justin Marshall

**Re: Geotechnical Engineering Report
Brookfield Second Replat
Fort Collins, Colorado
Northern Colorado Geotech Project No. c218-16**

Northern Colorado Geotech has completed a geotechnical engineering exploration of the subgrade soils for a portion of Northern Lights Drive in Fort Collins, Colorado.

The subsurface soils at the site consisted of sandy lean clay to depths of 8 feet. The results of our field exploration and laboratory testing indicate that the soils have low expansive potential in accordance with City of Fort Collins standards.

If you have any questions concerning this report or any of our consulting services, please do not hesitate to contact us.

Sincerely,
NORTHERN COLORADO GEOTECH

Prepared by:

Doug Leafgren, P.G.
President

Reviewed by:

Gary G. Weeks, P.E.
Vice President

Copies to: Addressee (2)
City of Fort Collins – Rick Richter (1 – email)

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GEOTECHNICAL ENGINEERING REPORT

PAVEMENT SUBGRADE ANALYSIS BROOKFIELD SECOND REPLAT FORT COLLINS, COLORADO

**NORTHERN COLORADO GEOTECH
PROJECT NO. c218-16
OCTOBER 5, 2016**

SCOPE

This report contains the results of our geotechnical engineering exploration for the pavement design for the Brookfield Second Replat in Fort Collins, Colorado.

This report includes descriptions of, and geotechnical engineering recommendations relative to:

- subsurface soil conditions
- groundwater conditions
- pavement design and construction
- earthwork

The recommendations contained in this report are based upon the results of field and laboratory testing, engineering analyses, and experience with similar soil conditions, structures and our understanding of the proposed project.

SITE CONDITIONS

Soil samples were taken for approximately 1,350 lineal feet of street along Northern Lights Drive, Lefever Drive and Brookfield Drive in Fort Collins, Colorado. The streets have been constructed to approximate subgrade elevation with the wet utilities installed. The borings were drilled within the backfill of the sanitary sewer utility trenches.

PROPOSED CONSTRUCTION

It is our understanding that the roadway will likely be constructed with asphaltic pavement over base course.

SITE EXPLORATION

A total of three test borings were drilled on September 22, 2016. The borings were drilled to approximate depths of 8 feet at the locations shown on the Site Plan, Figure 1. All the borings were advanced with a truck-mounted drilling rig, utilizing 4-inch diameter solid stem augers.

The borings were located in the field by pacing from property lines and/or existing site features. The accuracy of boring locations should only be assumed to the level implied by the methods used.

Lithologic logs of each boring were recorded by an engineering geologist during the drilling operations. At selected intervals, samples of the subsurface materials were taken by driving split-spoon and/or ring samplers. Bulk samples of subsurface materials were also obtained. Standard penetration measurements were recorded while driving a split-spoon and/or ring sampler into the subsurface materials. The standard penetration test is a useful index in estimating the density of the materials encountered.

Groundwater conditions were evaluated in each boring at the time of subsurface exploration.

Laboratory Testing

The samples retrieved during the subsurface exploration were returned to our laboratory for observation by the project manager. The soils were classified in general accordance with the Unified Soil Classification System. At that time, the field descriptions were confirmed or modified and an applicable laboratory testing program was formulated. Boring logs were prepared and are attached with this report.

Laboratory tests were conducted on selected samples and are presented on the boring logs and attached laboratory test sheets. The test results were used for the geotechnical engineering analyses, and the development of foundation and earthwork recommendations.

Selected samples were tested for the following engineering properties:

- Water Content
- Dry Density
- Consolidation
- Compressive Strength
- Atterberg Limits
- Percent Fines
- R-Value
- Expansion

SUBSURFACE CONDITIONS

Soil and Bedrock Conditions

Soils at the site consisted of sandy lean clay (AASHTO A-6) to depths of 8 feet. Summary boring logs are attached with this report.

Groundwater Conditions

Groundwater was not observed in any test boring at the time of field exploration. These observations represent groundwater conditions at the time of the field exploration, and may not be indicative of other times, or at other locations.

Field and Laboratory Test Results

Field test results indicate that the soils vary from medium stiff to very stiff in consistency. Laboratory test results indicate that the clay soil has low expansive potential at its present moisture content (Based on a 150 psf surcharge as required by the City of Fort Collins). The soils exhibited an R-value of 20 and are anticipated to provide fair pavement subgrade support.

DESIGN RECOMMENDATIONS

Pavement Design and Construction

Final pavement design recommendations will be provided in an addendum letter when the City of Fort Collins engineering department provides traffic count data for the streets. The design of pavements for the project will be based on the procedures outlined in the 1993 Guideline for Design of Pavement Structures by the American Association of State Highway and Transportation Officials (AASHTO).

Based upon the subsurface conditions determined from the geotechnical exploration, subgrade soils exposed during construction are anticipated to be relatively stable. The stability of the subgrade may be affected by precipitation, repetitive construction traffic or other factors. If unstable conditions develop, workability may be improved by scarifying and drying. Overexcavation of wet zones and replacement with granular materials may be necessary. Use of lime, fly ash, kiln dust, cement or geotextiles could also be considered as a stabilization technique. Lightweight excavation equipment may be required to reduce subgrade pumping.

General Earthwork

All earthwork on the project should be observed and evaluated by Northern Colorado Geotech.

Site Preparation

If unexpected fills or underground facilities are encountered, such features should be removed and the excavation thoroughly cleaned prior to backfill placement and/or construction.

GLH Construction
Brookfield Second Replat
Northern Colorado Geotech Project No. c218-16

It is anticipated that excavations for the proposed construction can be accomplished with conventional earthmoving equipment.

The individual contractor(s) is responsible for designing and constructing stable, temporary excavations as required to maintain stability of both the excavation sides and bottom. All excavations should be sloped or shored in the interest of safety following local, and federal regulations, including current OSHA excavation and trench safety standards.

Soils encountered at the site should be compacted within a range of 2 percent below to 2 percent above optimum unless modified by the project geotechnical engineer and the City of Fort Collins.

GENERAL COMMENTS

The analysis and recommendations presented in this report are based upon data obtained from borings performed to obtain representative subsurface conditions at the site. Variations in the soil between borings will occur. Northern Colorado Geotech should be present during construction to observe the excavation and construction procedures and confirm or modify our recommendations.

The scope of services for this project does not include either specifically or by implication any environmental assessment of the site.

This report has been prepared in accordance with generally accepted geotechnical engineering practices in this area at this time. No warranties, either express or implied, are intended or made.

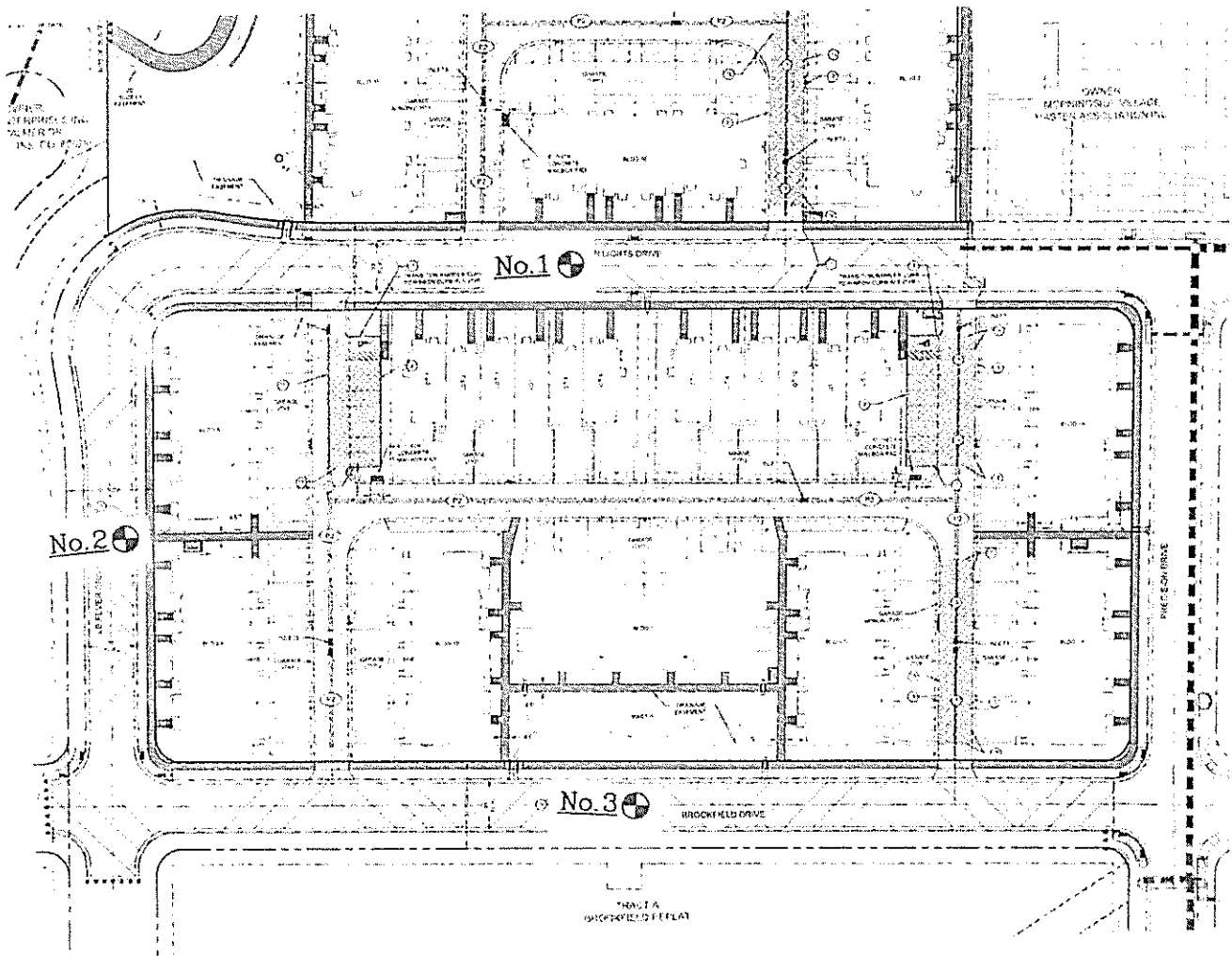


DIAGRAM IS FOR GENERAL LOCATION ONLY.
AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES



BORING LOCATION PLAN
PAVEMENT DESIGN ANALYSIS
NORTHERN LIGHTS DRIVE
FORT COLLINS, COLORADO
FOR GLH CONSTRUCTION



**Northern
Colorado
Geotech**
2956 29th Street, Unit 21
Greeley, Colorado 80631
Phone: (970) 506-9244
Fax: (970) 506-9242

Project No.	c218-16
Scale:	1" = 100'
Date:	10-5-16
Project Mgr:	DML
Figure No.	1

LOG OF BORING No. 1

Sheet 1 of 1

CLIENT GLH Construction	ARCHITECT/ENGINEER									
SITE Northern Lights Drive Fort Collins, Colorado	PROJECT Pavement Design Analysis									
	GRAPHIC LOG	DEPTH (FT.)	SAMPLES				TESTS			
			BLOWS/12" N-VALUE	NUMBER	TYPE	IN. DRIVEN IN. RECOVERED	MOISTURE, %	DRY DENSITY PCF	HAND PENE- TROMETER psf	LIQUID LIMIT PLASTIC INDEX PERCENT FINES
<u>FILL - Sandy Lean Clay (AASHTO A-6)</u> Brown, moist, medium to stiff		14	1	RS	12	10	109	9,000	0.7% Swell	
		12	2	SS	12	12				
		5	3	SS	12	13				
8.0 BOTTOM OF BORING										

WATER LEVEL OBSERVATIONS	 <p style="font-size: small;">2956 29th Street, Unit 21 Greeley, Colorado 80631 Phone: 970-506-9244 Fax: 970-506-9242</p>	STARTED	9/22/16	FINISHED	9/22/16		
WL		None	W.D.	DRILL CO.	Drilling Eng	DRILL RIG	CME-55
				LOGGED BY	TK	APPROVED	DML
Hole Filled in After Boring		NCG PROJECT NO.	c218-16				

218-16.GPJ

LOG OF BORING No. 2

Sheet 1 of 1

CLIENT GLH Construction	ARCHITECT/ENGINEER								
SITE Northern Lights Drive Fort Collins, Colorado	PROJECT Pavement Design Analysis								
GRAPHIC LOG	SAMPLES			TESTS					
	DEPTH (FT.)	BLOWS/12" N-VALUE	NUMBER	TYPE	IN. DRIVEN IN. RECOVERED	MOISTURE, %	DRY DENSITY PCF	HAND PENE- TROMETER psf	LIQUID LIMIT PLASTIC INDEX PERCENT FINES
<u>FILL - Sandy Lean Clay (AASHTO A-6)</u> Brown, moist, medium to stiff		12 24 13 5 4	1 2 3 4	RS GRAB SS SS	12 24 12 12	10 10	118 	6,000 	0.6% Swell 27/11/59
8.0 BOTTOM OF BORING									

WATER LEVEL OBSERVATIONS		
WL	None	W.D.
Hole Filled in After Boring		

**Northern
Colorado
Geotech**

2956 29th Street, Unit 21
Greeley, Colorado 80631
Phone: 970-506-9244
Fax: 970-506-9242

STARTED	9/22/16	FINISHED	9/22/16
DRILL CO.	Drilling Eng	DRILL RIG	CME-55
LOGGED BY	TK	APPROVED	DML
NCG PROJECT NO.	c218-16		

218-16.GPJ

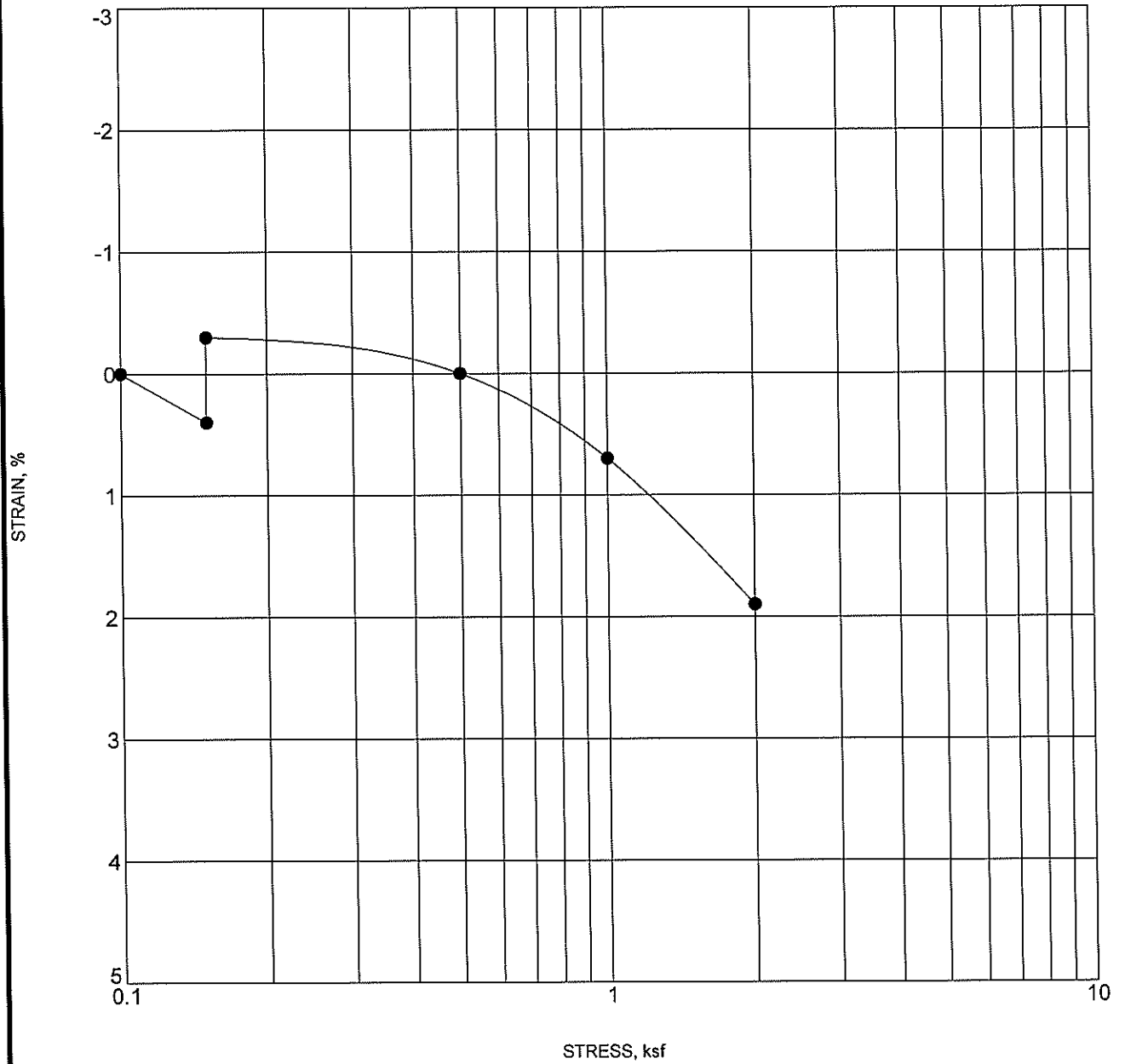
LOG OF BORING No. 3

Sheet 1 of 1

CLIENT GLH Construction		ARCHITECT/ENGINEER								
SITE Northern Lights Drive Fort Collins, Colorado		PROJECT Pavement Design Analysis								
	GRAPHIC LOG	DEPTH (FT.)	SAMPLES				TESTS			
			BLOWS/12" N-VALUE	NUMBER	TYPE	IN. DRIVEN IN. RECOVERED	MOISTURE, %	DRY DENSITY PCF	HAND PENE- TROMETER psf	LIQUID LIMIT PLASTIC INDEX PERCENT FINES
<u>FILL - Sandy Lean Clay (AASHTO A-6)</u> Brown, moist, medium to stiff			11	1	RS	12	11	113	7,500	26/10/52 0.5% Swell
8.0	BOTTOM OF BORING									

WATER LEVEL OBSERVATIONS			Northern Colorado Geotech 2956 29th Street, Unit 21 Greeley, Colorado 80631 Phone: 970-506-9244 Fax: 970-506-9242			STARTED	9/22/16	FINISHED	9/22/16
WL	None	W.D.				DRILL CO.	Drilling Eng	DRILL RIG	CME-55
						LOGGED BY	TK	APPROVED	DML
Hole Filled in After Boring						NCG PROJECT NO.	c218-16		

218-16.GPJ



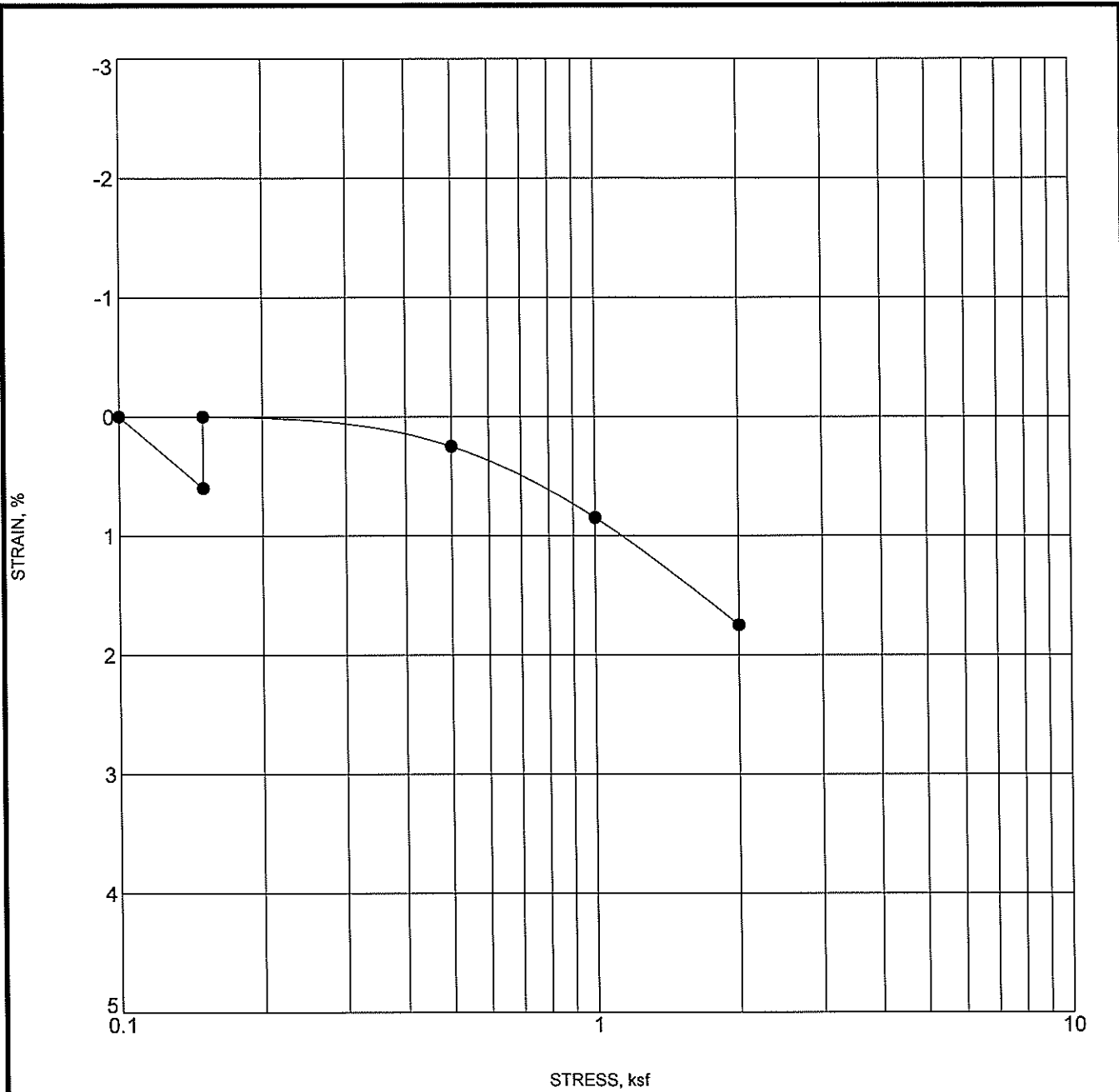
Specimen Identification	Classification	γ_d	MC%
● 1 1.0	FILL - Sandy Lean Clay (AASHTO A-6)	110	10



2956 29th Street, Unit 21
 Greeley, Colorado 80631
 Phone: 970-506-9244
 Fax: 970-506-9242

CONSOLIDATION TEST

Client: GLH Construction Number: c218-16
 Project: Pavement Design Analysis
 Location: Northern Lights Drive



Specimen Identification	Classification	γ_d	MC%
● 2 1.0	FILL - Sandy Lean Clay (AASHTO A-6)	118	10

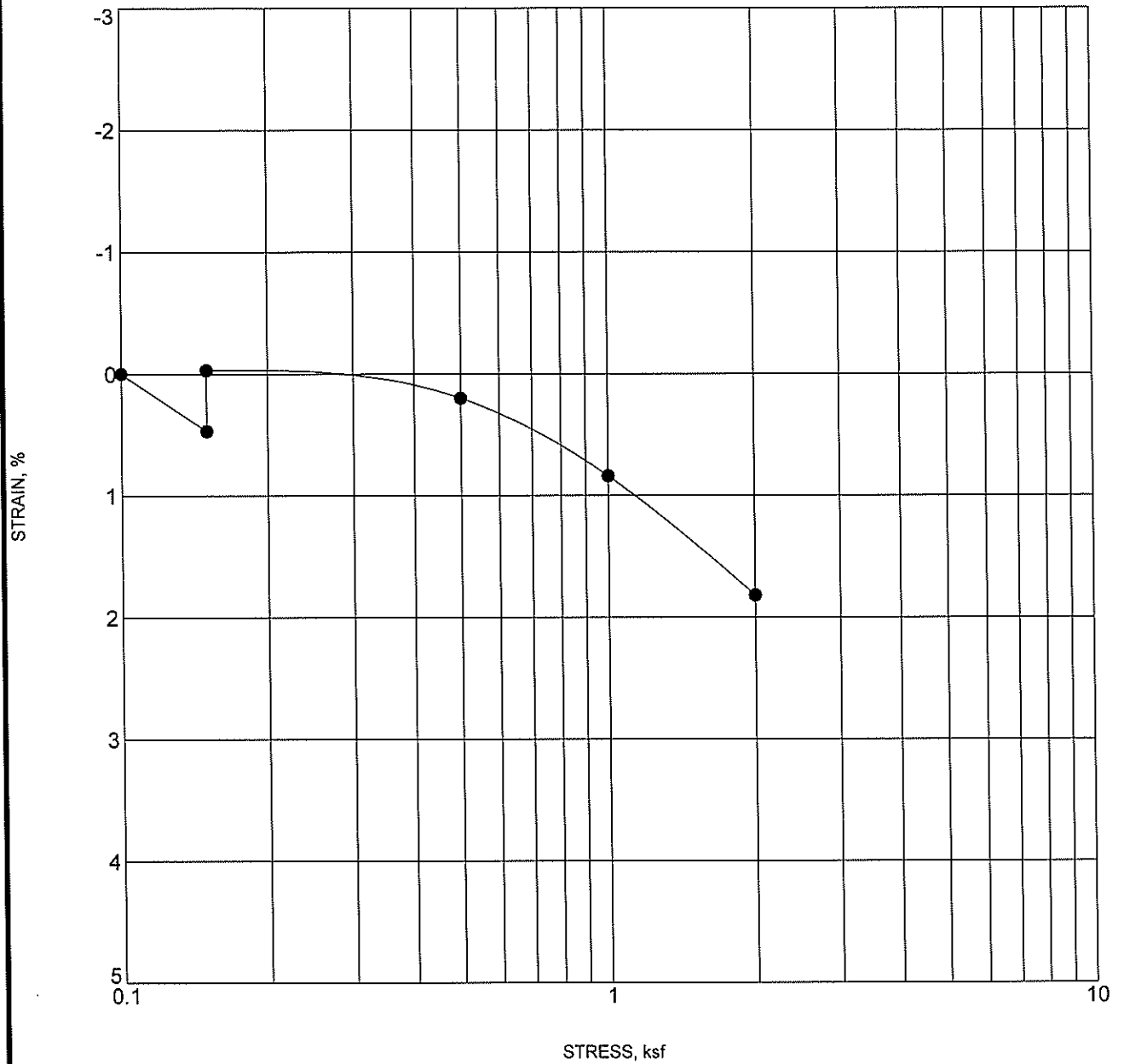
218-16 GPFJ



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CONSOLIDATION TEST

Client: GLH Construction Number: c218-16
 Project: Pavement Design Analysis
 Location: Northern Lights Drive



Specimen Identification	Classification	γ_d	MC%
● 3 1.0	FILL - Sandy Lean Clay (AASHTO A-6)	113	11

218-16.GPJ



2956 29th Street, Unit 21
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 Phone: 970-506-9244
 Fax: 970-506-9242

CONSOLIDATION TEST

Client: GLH Construction Number: c218-16
 Project: Pavement Design Analysis
 Location: Northern Lights Drive

**RESISTANCE R-VALUE & EXPANSION PRESSURE OF
COMPACTED SOIL - ASTM D2844**



PROJECT: Brookfield		PROJECT NO. 1165007A	
LOCATION:		DATE Sep-16	
MATERIAL DESCRIPTION: Sandy Lean Clay (CL)			
SAMPLE LOCATION: Composite Subgrade Sample Boring B-2 @ 0.0' - 4.0'			
LIQUID LIMIT: Not Reported (NR)	PLASTICITY INDEX: NR	%PASSING #200:	NR
R-VALUE LABORATORY TEST RESULTS			
TEST SPECIMEN NO.	1	2	3
COMPACTION PRESSURE (PSI)	125	175	225
DENSITY (PCF)	118.7	119.8	121.3
MOISTURE CONTENT (%)	14.3	13.5	12.2
EXPANSION PRESSURE (PSI)	0.00	0.00	0.00
HORIZONTAL PRESSURE @ 160 PSI	118	111	102
SAMPLE HEIGHT (INCHES)	2.55	2.48	2.50
EXUDATION PRESSURE (PSI)	260.9	363.7	516.7
UNCORRECTED R-VALUE	18.6	22.3	28.6
CORRECTED R-VALUE	18.6	22.3	28.6

R-VALUE @ 300 PSI EXUDATION PRESSURE =	20	RESILIENT MODULUS, PSI =	4,940
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