PL202200247
PL2022-247

Westwood

Stormwater Management Plan for

Enclave - 8200 Humboldt, Bloomington, MN

Prepared for:
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Fargo, ND 58102

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Project Number: 0030774.00
Date: 12-08-2021
Revised 01-24-2022

INTRODUCTION

This report summarizes the stormwater management design for the proposed development project west of Humboldt Avenue and east of Irving Avenue South between 82nd Street and 83rd Street in Bloomington.

The proposed development of the 2.75-acre site will include the removal of the existing building and parking lots, construction of a four-story apartment building with below-grade parking, surface parking lot, entrance drives and sidewalks.

The project area includes 2.75 acres (existing office building). The project may also include reconstruction of the public sidewalks along 82nd Street, Irving Avenue South, 83rd Street, and Humboldt Avenue. The total proposed disturbed area is 2.78 acres. The site was modeled in HydroCAD to analyze existing and proposed conditions (Attachments B and C). Atlas 14 rainfall depths for Hennepin County were used in this analysis (Attachment D).

Attachment A shows the drainage areas for existing and proposed conditions within the project area.

REGULATIONS

The proposed project is located within the City of Bloomington, Minnesota, and the Nine Mile Creek Watershed District. The stormwater regulations pertaining to the project are listed below:

- Rate Control – No increase in peak runoff rates going offsite for the 2-, 10-, and 100-year rainfall events.

- Volume Reduction – Retain 1.1 inches of runoff from the site's new and/or fully reconstructed impervious surface.

- Water Quality – Provide at least 60% annual removal efficiency of TP and 90% annual removal efficiency of TSS.

EXISTING SITE AND DRAINAGE CONDITIONS

The existing property is currently developed with one building site west of Humboldt Avenue and east of Irving Avenue South between 82nd Street and 83rd Street. Parking lots exist on the north, west, and south sides of the building. Green space, landscaping, and berms exist between the parking lots and streets.

PROPOSED PROJECT DEVELOPMENT

The proposed development of the 2.75-acre site will include the removal of the existing building and parking lots, construction of a multipe-story apartment building with below-grade parking, surface parking lot, entrance drives and sidewalks. The project may also include reconstruction of the sidewalks along 82nd Street, Irving Avenue South, 83rd Street, and Humboldt Avenue. However, the construction/re-construction areas within the public right-of-way are not included in our analysis or the calculations for the stormwater management design of this project. The project boundary was considered as the property area and a small portion of off-property area that flows onto the site. The area within the project boundary is shown in Table 1.

Table 1: Project Area Information

Project Site	**Existing s.f.**	**Percent**	**Proposed s.f.**	**Percent**
Total Site Project Area	121,113		121,113	
Impervious Area	86,666	(72.5%)	84,814	(70.0%)
Pervious Area	32,892	(27.5%)	36,299	(30.0%)

PROPOSED STORMWATER MANAGEMENT SYSTEM

The proposed project will utilize an underground StormTech stormwater vault for volume reduction, rate control, and water quality. Westwood utilized the HydroCAD computer model for the analysis of stormwater management system at this site and the result of the model are attached (Attachments B and C).

Stormwater runoff from the building, parking lot, and on-site green areas will be routed to the stormwater vault via storm sewer pipes. Sump manhole structures will provide initial pretreatment of discharge to the underground StormTech chambers, with additional sediment removal via the StormTech isolator row system. Water quality performance studies for the StormTech Isolator Row identified TSS removal of 80%. The StormTech system is designed to contain sediment and floatable debris within the isolator row, which can then be removed as need.

The underground system will overflow into the existing public storm sewer network in Humboldt Avenue.

RATE CONTROL

The stormwater management system design was modeled to achieve no net increase in peak discharge rates for the proposed development from pre-development conditions for the 2-year, 10-year and 100-year storm events. The total combined site predevelopment and proposed development peak discharge rates are shown in Table 2.

Table 2: Total Combined Site Peak Discharge Rates

	Pre-development Conditions [cfs]	Proposed Development [cfs]
2-yr Event	7.81	1.05
10-yr Event	12.79	5.65
100-yr Event	24.44	14.44

VOLUME CONTROL

The volume reduction equal to 1.1-inch of runoff from the site's net new and new reconstructed impervious surface is 7,775 c.f.

Stormwater runoff from the building, parking lots, and on-site green space will be directed to the underground vault. The proposed outlet pipe is 1.45 feet above the bottom of the vault chamber. The proposed infiltration volume below the outlet pipe is 8,286 c.f. Using an infiltration rate of 0.45 in/hour, this volume will draw down in less than 48 hours.

WATER QUALITY

Sump manhole structures will provide initial pretreatment of discharge to the underground StormTech chambers, with addition sediment removal via the StormTech isolator row system. Water quality performance studies for the StormTech Isolator Row identified TSS removal of 80%. The StormTech system is designed to contain sediment and floatable debris within the isolator row, which can then be removed as need.

TSS and TP levels will be reduced from existing conditions with volume reduction as noted above, pretreatment via sump manhole structures and sediment capture within the StormTech isolator row.

CONCLUSIONS

The proposed development has been designed to meet the requirements of the City of Bloomington and Nine Mile Creek Watershed District for rate control, volume control and water quality.

ATTACHMENTS

Attachment A - Drainage Area Maps

Sheet 1 – Existing Drainage Areas

Sheet 2 – Proposed Drainage Areas

Attachment B - Existing Conditions HydroCAD Model

Attachment C - Proposed Conditions HydroCAD Model

Attachment D - Atlas 14 depths for Hennepin County

Attachment E - Geotechnical Report, Prepared by AET and dated 02/19/2021

Attachment F - StormTech Removal Efficiency Summary

Attachment A - Drainage Area Maps

Sheet 1 - Existing Drainage Areas

Sheet 2 – Proposed Drainage Areas

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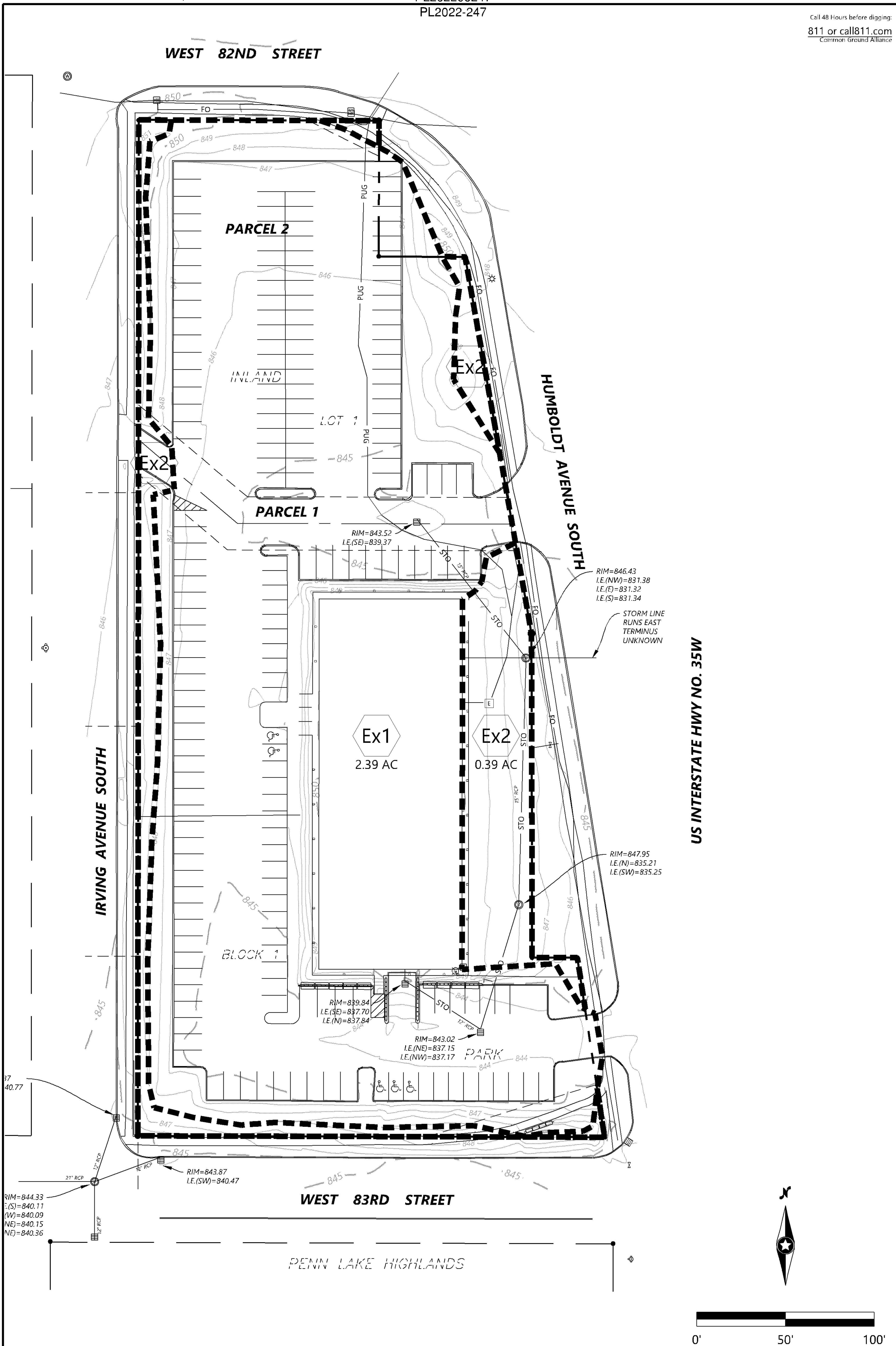

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ENCLAVE DEVELOPMENT 8200 HUMBOLDT

DESIGNED:
CHECKED:
DRAWN:
FIELD CREW:
FIELD WORK DATE:

ENCLAVE DEVELOPMENT
8200 HUMBOLDT

BLOOMINGTON, MN

Westwood

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Westwood Professional Services, Inc.

EXISTING DRAINAGE MAP

PROJECT NUMBER: 0030774.00

SHEET NUMBER:
1 OF 2

DATE: 12/08/2021

PL202200247
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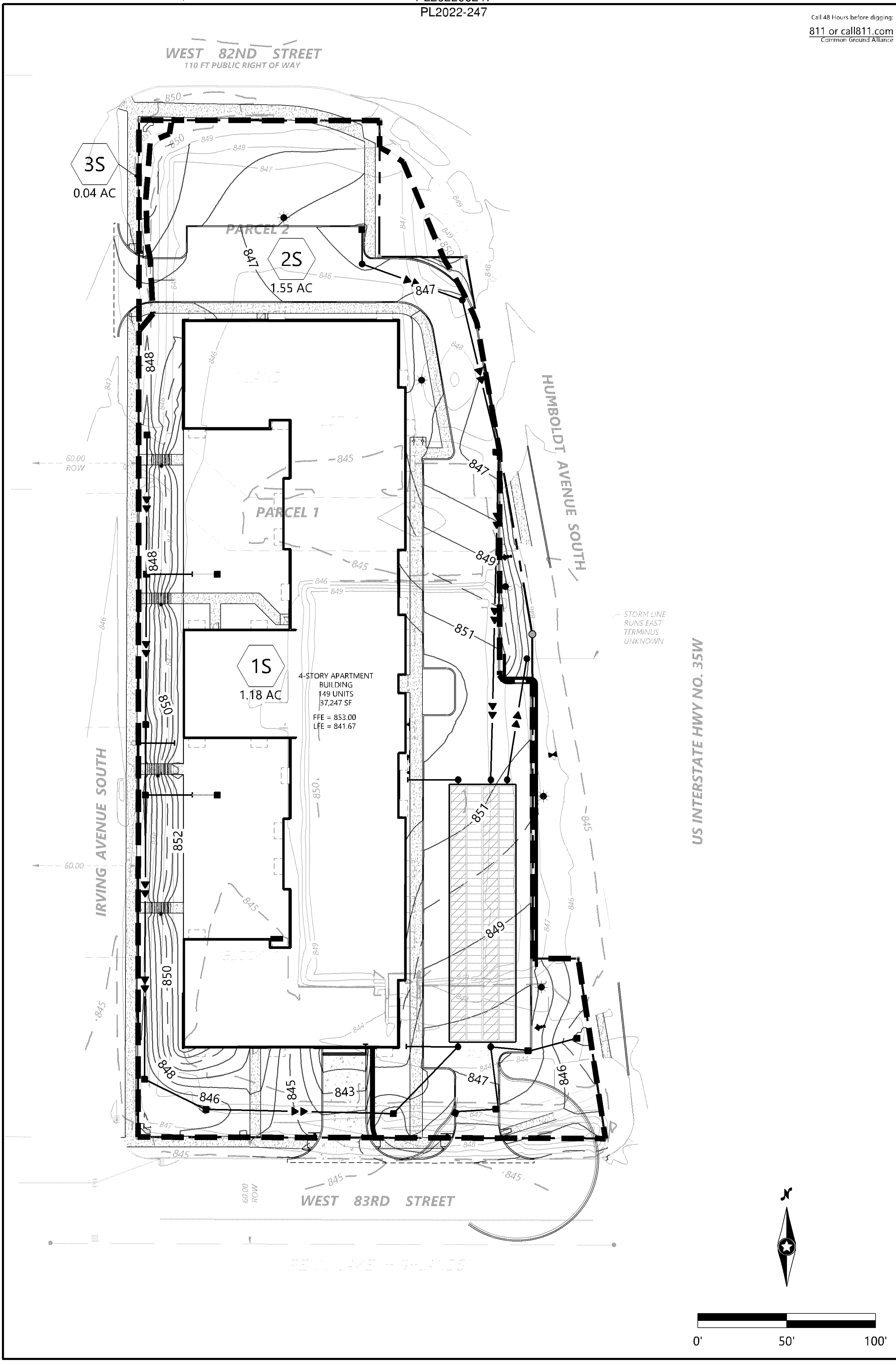

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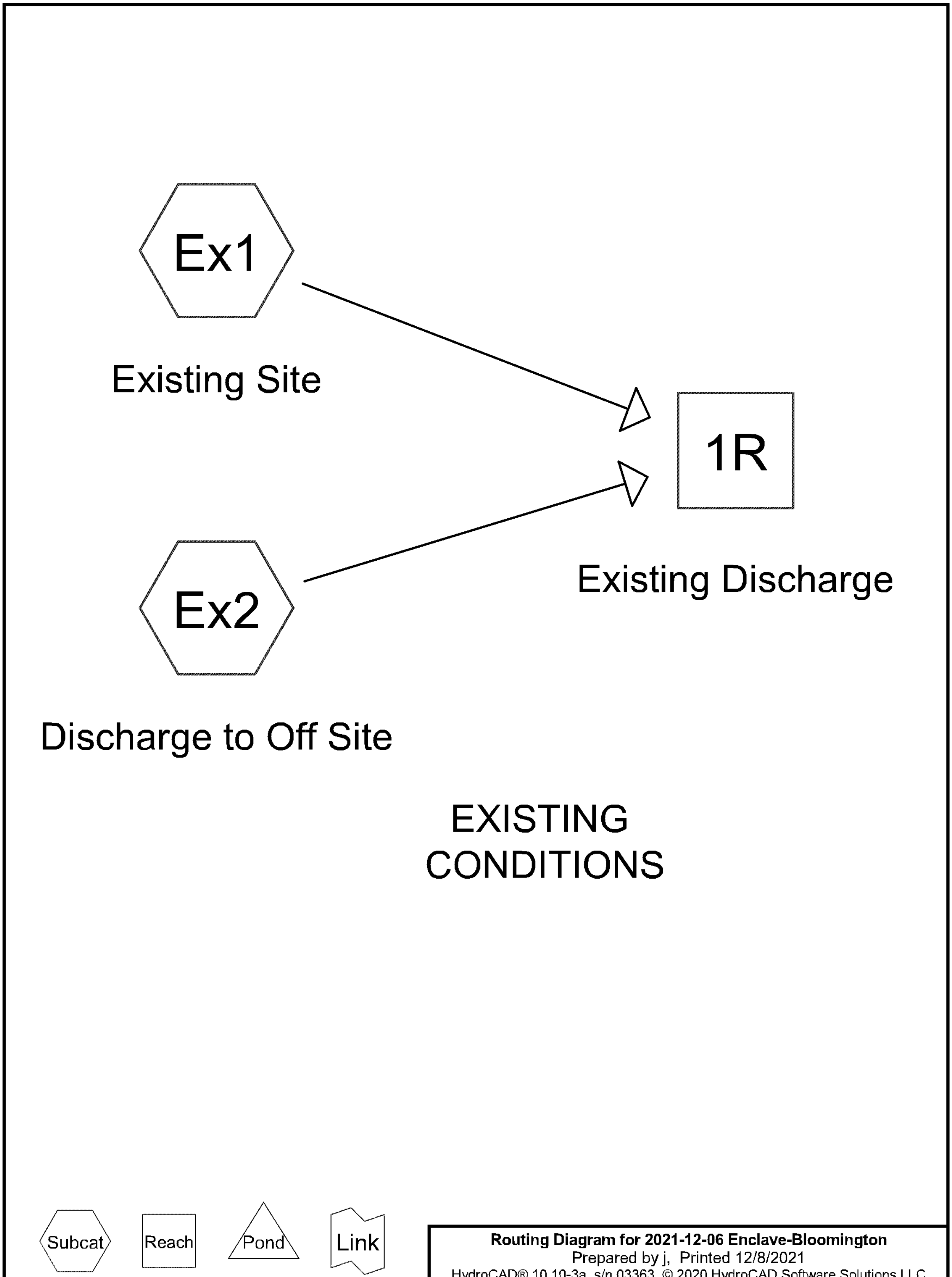
PROPOSED DRAINAGE MAP

PROJECT NUMBER: 0030774.00

SHEET NUMBER:
2 OF 2

DATE: 12/08/2021

Attachment B - Existing Conditions HydroCAD Model



Routing Diagram for 2021-12-06 Enclave-Bloomington
Prepared by j, Printed 12/8/2021
HydroCAD® 10.10-3a s/n 03363 © 2020 HydroCAD Software Solutions LLC

Area Listing (selected nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.755	69	50-75% Grass cover, Fair, HSG B (Ex1, Ex2)
1.975	98	Building and Pavement (Ex1)
0.013	98	Off-site sidewalk area (Ex1)
0.023	69	off-site green area (Ex1)
0.015	98	pavement surfaces (Ex2)
2.780	**90**	**TOTAL AREA**

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment Ex1: Existing Site Runoff Area=104,121 sf 83.16% Impervious Runoff Depth=2.12"
Tc=10.0 min CN=93 Runoff=7.42 cfs 0.422 af

Subcatchment Ex2: Discharge to Off Site Runoff Area=16,992 sf 3.74% Impervious Runoff Depth=0.64"
Tc=7.0 min CN=70 Runoff=0.40 cfs 0.021 af

Reach 1R: Existing Discharge Inflow=7.81 cfs 0.443 af
Outflow=7.81 cfs 0.443 af

Total Runoff Area = 2.780 ac Runoff Volume = 0.443 af Average Runoff Depth = 1.91"
27.99% Pervious = 0.778 ac 72.01% Impervious = 2.002 ac

Summary for Subcatchment Ex1: Existing Site

Runoff = 7.42 cfs @ 12.17 hrs, Volume= 0.422 af, Depth= 2.12"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 2-Year Rainfall=2.86"

	Area (sf)	CN	Description
*	86,030	98	Building and Pavement
	16,536	69	50-75% Grass cover, Fair, HSG B
*	553	98	Off-site sidewalk area
*	1,002	69	off-site green area
	104,121	93	Weighted Average
	17,538		16.84% Pervious Area
	86,583		83.16% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry, Direct**

Summary for Subcatchment Ex2: Discharge to Off Site

Runoff = 0.40 cfs @ 12.16 hrs, Volume= 0.021 af, Depth= 0.64"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 2-Year Rainfall=2.86"

	Area (sf)	CN	Description
*	636	98	pavement surfaces
	16,356	69	50-75% Grass cover, Fair, HSG B
	16,992	70	Weighted Average
	16,356		96.26% Pervious Area
	636		3.74% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.0					**Direct Entry, Direct**

Summary for Reach 1R: Existing Discharge

Inflow Area = 2.780 ac, 72.01% Impervious, Inflow Depth = 1.91" for 2-Year event
Inflow = 7.81 cfs @ 12.17 hrs, Volume= 0.443 af
Outflow = 7.81 cfs @ 12.17 hrs, Volume= 0.443 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment Ex1: Existing Site Runoff Area=104,121 sf 83.16% Impervious Runoff Depth=3.47"
Tc=10.0 min CN=93 Runoff=11.82 cfs 0.692 af

Subcatchment Ex2: Discharge to Off Site Runoff Area=16,992 sf 3.74% Impervious Runoff Depth=1.51"
Tc=7.0 min CN=70 Runoff=1.01 cfs 0.049 af

Reach 1R: Existing Discharge Inflow=12.79 cfs 0.741 af
Outflow=12.79 cfs 0.741 af

Total Runoff Area = 2.780 ac Runoff Volume = 0.741 af Average Runoff Depth = 3.20"
27.99% Pervious = 0.778 ac 72.01% Impervious = 2.002 ac

Summary for Subcatchment Ex1: Existing Site

Runoff = 11.82 cfs @ 12.17 hrs, Volume= 0.692 af, Depth= 3.47"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 10-Year Rainfall=4.26"

	Area (sf)	CN	Description
*	86,030	98	Building and Pavement
	16,536	69	50-75% Grass cover, Fair, HSG B
*	553	98	Off-site sidewalk area
*	1,002	69	off-site green area
	104,121	93	Weighted Average
	17,538		16.84% Pervious Area
	86,583		83.16% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry, Direct**

Summary for Subcatchment Ex2: Discharge to Off Site

Runoff = 1.01 cfs @ 12.15 hrs, Volume= 0.049 af, Depth= 1.51"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 10-Year Rainfall=4.26"

	Area (sf)	CN	Description
*	636	98	pavement surfaces
	16,356	69	50-75% Grass cover, Fair, HSG B
	16,992	70	Weighted Average
	16,356		96.26% Pervious Area
	636		3.74% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.0					**Direct Entry, Direct**

Summary for Reach 1R: Existing Discharge

Inflow Area = 2.780 ac, 72.01% Impervious, Inflow Depth = 3.20" for 10-Year event
Inflow = 12.79 cfs @ 12.17 hrs, Volume= 0.741 af
Outflow = 12.79 cfs @ 12.17 hrs, Volume= 0.741 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment Ex1: Existing Site Runoff Area=104,121 sf 83.16% Impervious Runoff Depth=6.67"
Tc=10.0 min CN=93 Runoff=21.82 cfs 1.328 af

Subcatchment Ex2: Discharge to Off Site Runoff Area=16,992 sf 3.74% Impervious Runoff Depth=4.04"
Tc=7.0 min CN=70 Runoff=2.73 cfs 0.131 af

Reach 1R: Existing Discharge Inflow=24.44 cfs 1.459 af
Outflow=24.44 cfs 1.459 af

Total Runoff Area = 2.780 ac Runoff Volume = 1.459 af Average Runoff Depth = 6.30"
27.99% Pervious = 0.778 ac 72.01% Impervious = 2.002 ac

Summary for Subcatchment Ex1: Existing Site

Runoff = 21.82 cfs @ 12.17 hrs, Volume= 1.328 af, Depth= 6.67"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 100-Year-C Rainfall=7.50"

	Area (sf)	CN	Description
*	86,030	98	Building and Pavement
	16,536	69	50-75% Grass cover, Fair, HSG B
*	553	98	Off-site sidewalk area
*	1,002	69	off-site green area
	104,121	93	Weighted Average
	17,538		16.84% Pervious Area
	86,583		83.16% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry, Direct**

Summary for Subcatchment Ex2: Discharge to Off Site

Runoff = 2.73 cfs @ 12.14 hrs, Volume= 0.131 af, Depth= 4.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 100-Year-C Rainfall=7.50"

	Area (sf)	CN	Description
*	636	98	pavement surfaces
	16,356	69	50-75% Grass cover, Fair, HSG B
	16,992	70	Weighted Average
	16,356		96.26% Pervious Area
	636		3.74% Impervious Area

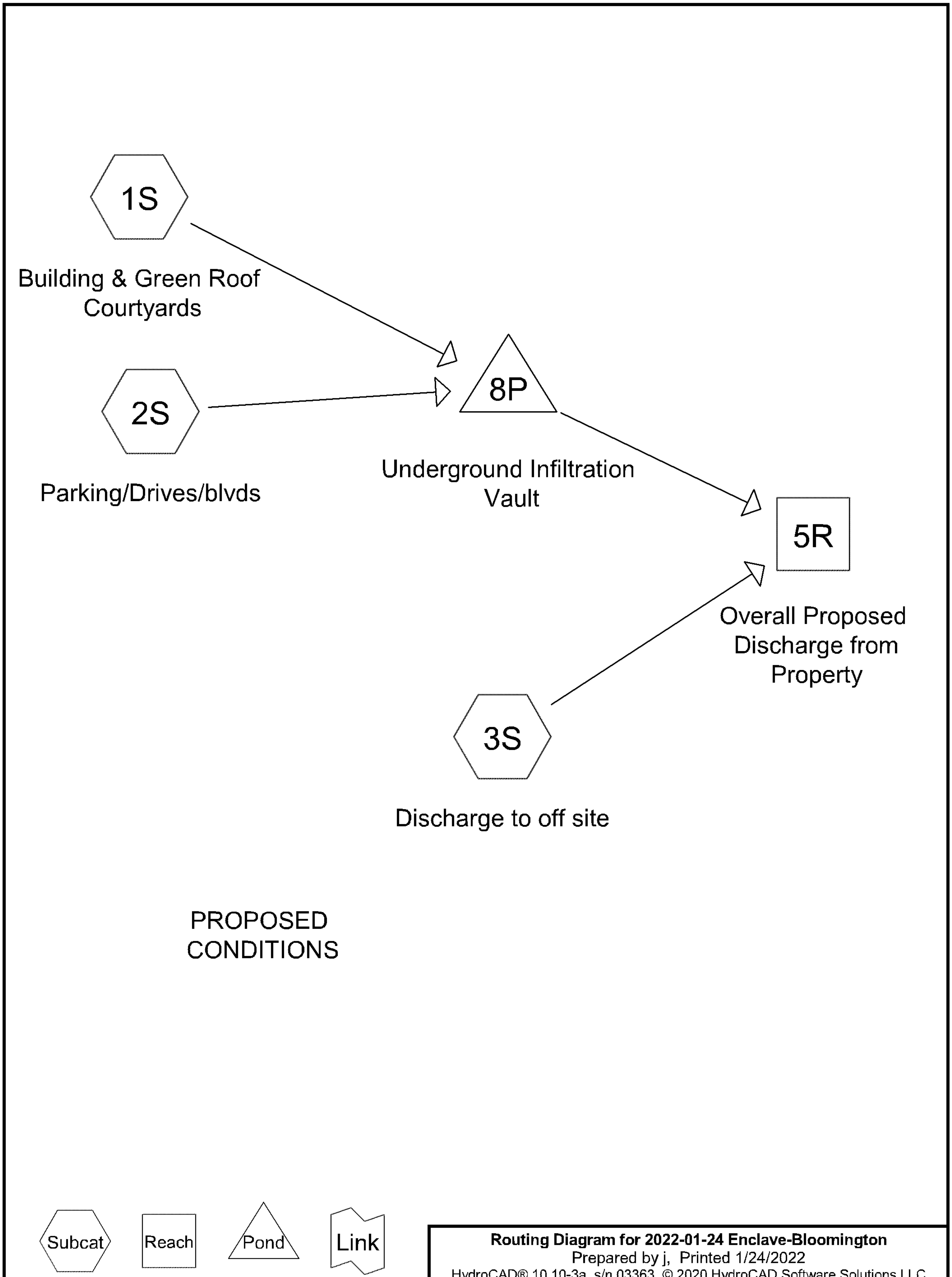
Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.0					**Direct Entry, Direct**

Summary for Reach 1R: Existing Discharge

Inflow Area = 2.780 ac, 72.01% Impervious, Inflow Depth = 6.30" for 100-Year-C event
Inflow = 24.44 cfs @ 12.17 hrs, Volume= 1.459 af
Outflow = 24.44 cfs @ 12.17 hrs, Volume= 1.459 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Attachment C - Proposed Conditions HydroCAD Model w/Stage Storage Summary



Routing Diagram for 2022-01-24 Enclave-Bloomington
Prepared by j, Printed 1/24/2022
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Area Listing (selected nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.618	69	50-75% Grass cover, Fair, HSG B (2S, 3S)
0.215	69	Courtyard Green space (1S)
0.072	98	Courtyard Hardscape (1S)
0.980	98	Paved parking, HSG B (2S)
0.895	98	Roofs, HSG A (1S)
2.780	**89**	**TOTAL AREA**

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Building & Green Roof Runoff Area=51,500 sf 81.80% Impervious Runoff Depth=2.12"
Tc=10.0 min CN=93 Runoff=3.67 cfs 0.209 af

Subcatchment 2S: Parking/Drives/blvds Runoff Area=67,306 sf 63.43% Impervious Runoff Depth=1.62"
Tc=10.0 min CN=87 Runoff=3.78 cfs 0.208 af

Subcatchment 3S: Discharge to off site Runoff Area=2,300 sf 0.00% Impervious Runoff Depth=0.60"
Tc=7.0 min CN=69 Runoff=0.05 cfs 0.003 af

Reach 5R: Overall Proposed Discharge from Property Inflow=1.05 cfs 0.158 af
Outflow=1.05 cfs 0.158 af

Pond 8P: Underground Infiltration Vault Peak Elev=835.90' Storage=10,292 cf Inflow=7.44 cfs 0.417 af
Discarded=0.06 cfs 0.262 af Primary=1.04 cfs 0.155 af Outflow=1.09 cfs 0.417 af

Total Runoff Area = 2.780 ac Runoff Volume = 0.420 af Average Runoff Depth = 1.81"
29.97% Pervious = 0.833 ac 70.03% Impervious = 1.947 ac

Summary for Subcatchment 1S: Building & Green Roof Courtyards

Runoff = 3.67 cfs @ 12.17 hrs, Volume= 0.209 af, Depth= 2.12"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 2-Year Rainfall=2.86"

	Area (sf)	CN	Description
	39,000	98	Roofs, HSG A
*	3,125	98	Courtyard Hardscape
*	9,375	69	Courtyard Green space
	51,500	93	Weighted Average
	9,375		18.20% Pervious Area
	42,125		81.80% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry, direct**

Summary for Subcatchment 2S: Parking/Drives/blvds

Runoff = 3.78 cfs @ 12.18 hrs, Volume= 0.208 af, Depth= 1.62"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 2-Year Rainfall=2.86"

Area (sf)	CN	Description
42,689	98	Paved parking, HSG B
24,617	69	50-75% Grass cover, Fair, HSG B
67,306	87	Weighted Average
24,617		36.57% Pervious Area
42,689		63.43% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry, Direct**

Summary for Subcatchment 3S: Discharge to off site

Runoff = 0.05 cfs @ 12.16 hrs, Volume= 0.003 af, Depth= 0.60"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 2-Year Rainfall=2.86"

Area (sf)	CN	Description
2,300	69	50-75% Grass cover, Fair, HSG B
2,300		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.0					**Direct Entry, Direct**

Summary for Reach 5R: Overall Proposed Discharge from Property

Inflow Area = 2.780 ac, 70.03% Impervious, Inflow Depth = 0.68" for 2-Year event
Inflow = 1.05 cfs @ 12.65 hrs, Volume= 0.158 af
Outflow = 1.05 cfs @ 12.65 hrs, Volume= 0.158 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Summary for Pond 8P: Underground Infiltration Vault

Inflow Area = 2.727 ac, 71.39% Impervious, Inflow Depth = 1.84" for 2-Year event
Inflow = 7.44 cfs @ 12.18 hrs, Volume= 0.417 af
Outflow = 1.09 cfs @ 12.65 hrs, Volume= 0.417 af, Atten= 85%, Lag= 28.6 min
Discarded = 0.06 cfs @ 10.90 hrs, Volume= 0.262 af
Primary = 1.04 cfs @ 12.65 hrs, Volume= 0.155 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 835.90' @ 12.65 hrs Surf.Area= 5,411 sf Storage= 10,292 cf

Plug-Flow detention time= 915.0 min calculated for 0.417 af (100% of inflow)
Center-of-Mass det. time= 916.1 min (1,711.1 - 795.0)

Volume	Invert	Avail.Storage	Storage Description
#1A	833.25'	8,702 cf	**37.58'W x 143.97'L x 6.75'H Field A**
			36,523 cf Overall - 14,768 cf Embedded = 21,754 cf x 40.0% Voids
#2A	834.00'	14,768 cf	**ADS_StormTech MC-4500 +Cap** x 136 Inside #1
			Effective Size= 90.4"W x 60.0"H => 26.46 sf x 4.03'L = 106.5 cf
			Overall Size= 100.0"W x 60.0"H x 4.33'L with 0.31' Overlap
			136 Chambers in 4 Rows
			Cap Storage= +35.7 cf x 2 x 4 rows = 285.6 cf
		23,470 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	835.45'	**18.0" Round Culvert**
			L= 12.0' RCP, square edge headwall, Ke= 0.500
			Inlet / Outlet Invert= 835.45' / 835.21' S= 0.0200 '/' Cc= 0.900
			n= 0.012, Flow Area= 1.77 sf
#2	Discarded	833.25'	**0.450 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.06 cfs @ 10.90 hrs HW=833.32' (Free Discharge)
↑—**2=Exfiltration** (Exfiltration Controls 0.06 cfs)

Primary OutFlow Max=1.04 cfs @ 12.65 hrs HW=835.90' TW=0.00' (Dynamic Tailwater)
↑—**1=Culvert** (Inlet Controls 1.04 cfs @ 2.29 fps)

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Building & Green Roof Runoff Area=51,500 sf 81.80% Impervious Runoff Depth=3.47"
Tc=10.0 min CN=93 Runoff=5.84 cfs 0.342 af

Subcatchment 2S: Parking/Drives/blvds Runoff Area=67,306 sf 63.43% Impervious Runoff Depth=2.88"
Tc=10.0 min CN=87 Runoff=6.62 cfs 0.370 af

Subcatchment 3S: Discharge to off site Runoff Area=2,300 sf 0.00% Impervious Runoff Depth=1.44"
Tc=7.0 min CN=69 Runoff=0.13 cfs 0.006 af

Reach 5R: Overall Proposed Discharge from Property Inflow=5.65 cfs 0.446 af
Outflow=5.65 cfs 0.446 af

Pond 8P: Underground Infiltration Vault Peak Elev=836.74' Storage=13,805 cf Inflow=12.47 cfs 0.713 af
Discarded=0.06 cfs 0.273 af Primary=5.61 cfs 0.440 af Outflow=5.66 cfs 0.713 af

Total Runoff Area = 2.780 ac Runoff Volume = 0.719 af Average Runoff Depth = 3.10"
29.97% Pervious = 0.833 ac 70.03% Impervious = 1.947 ac

Summary for Subcatchment 1S: Building & Green Roof Courtyards

Runoff = 5.84 cfs @ 12.17 hrs, Volume= 0.342 af, Depth= 3.47"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 10-Year Rainfall=4.26"

	Area (sf)	CN	Description
	39,000	98	Roofs, HSG A
*	3,125	98	Courtyard Hardscape
*	9,375	69	Courtyard Green space
	51,500	93	Weighted Average
	9,375		18.20% Pervious Area
	42,125		81.80% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry, direct**

Summary for Subcatchment 2S: Parking/Drives/blvds

Runoff = 6.62 cfs @ 12.17 hrs, Volume= 0.370 af, Depth= 2.88"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 10-Year Rainfall=4.26"

Area (sf)	CN	Description
42,689	98	Paved parking, HSG B
24,617	69	50-75% Grass cover, Fair, HSG B
67,306	87	Weighted Average
24,617		36.57% Pervious Area
42,689		63.43% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry, Direct**

Summary for Subcatchment 3S: Discharge to off site

Runoff = 0.13 cfs @ 12.15 hrs, Volume= 0.006 af, Depth= 1.44"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 10-Year Rainfall=4.26"

Area (sf)	CN	Description
2,300	69	50-75% Grass cover, Fair, HSG B
2,300		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.0					**Direct Entry, Direct**

Summary for Reach 5R: Overall Proposed Discharge from Property

Inflow Area = 2.780 ac, 70.03% Impervious, Inflow Depth = 1.92" for 10-Year event
Inflow = 5.65 cfs @ 12.34 hrs, Volume= 0.446 af
Outflow = 5.65 cfs @ 12.34 hrs, Volume= 0.446 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Summary for Pond 8P: Underground Infiltration Vault

Inflow Area = 2.727 ac, 71.39% Impervious, Inflow Depth = 3.14" for 10-Year event
Inflow = 12.47 cfs @ 12.17 hrs, Volume= 0.713 af
Outflow = 5.66 cfs @ 12.34 hrs, Volume= 0.713 af, Atten= 55%, Lag= 10.2 min
Discarded = 0.06 cfs @ 9.65 hrs, Volume= 0.273 af
Primary = 5.61 cfs @ 12.34 hrs, Volume= 0.440 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 836.74' @ 12.34 hrs Surf.Area= 5,411 sf Storage= 13,805 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 564.2 min (1,348.9 - 784.8)

Volume	Invert	Avail.Storage	Storage Description
#1A	833.25'	8,702 cf	**37.58'W x 143.97'L x 6.75'H Field A**
			36,523 cf Overall - 14,768 cf Embedded = 21,754 cf x 40.0% Voids
#2A	834.00'	14,768 cf	**ADS_StormTech MC-4500 +Cap** x 136 Inside #1
			Effective Size= 90.4"W x 60.0"H => 26.46 sf x 4.03'L = 106.5 cf
			Overall Size= 100.0"W x 60.0"H x 4.33'L with 0.31' Overlap
			136 Chambers in 4 Rows
			Cap Storage= +35.7 cf x 2 x 4 rows = 285.6 cf
		23,470 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	835.45'	**18.0" Round Culvert**
			L= 12.0' RCP, square edge headwall, Ke= 0.500
			Inlet / Outlet Invert= 835.45' / 835.21' S= 0.0200 '/' Cc= 0.900
			n= 0.012, Flow Area= 1.77 sf
#2	Discarded	833.25'	**0.450 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.06 cfs @ 9.65 hrs HW=833.32' (Free Discharge)
↑—**2=Exfiltration** (Exfiltration Controls 0.06 cfs)

Primary OutFlow Max=5.58 cfs @ 12.34 hrs HW=836.73' TW=0.00' (Dynamic Tailwater)
↑—**1=Culvert** (Barrel Controls 5.58 cfs @ 4.67 fps)

Time span=0.00-72.00 hrs, dt=0.05 hrs, 1441 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 1S: Building & Green Roof Runoff Area=51,500 sf 81.80% Impervious Runoff Depth=6.67"
Tc=10.0 min CN=93 Runoff=10.79 cfs 0.657 af

Subcatchment 2S: Parking/Drives/blvds Runoff Area=67,306 sf 63.43% Impervious Runoff Depth=5.96"
Tc=10.0 min CN=87 Runoff=13.23 cfs 0.768 af

Subcatchment 3S: Discharge to off site Runoff Area=2,300 sf 0.00% Impervious Runoff Depth=3.93"
Tc=7.0 min CN=69 Runoff=0.36 cfs 0.017 af

Reach 5R: Overall Proposed Discharge from Property Inflow=14.44 cfs 1.155 af
Outflow=14.44 cfs 1.155 af

Pond 8P: Underground Infiltration Vault Peak Elev=839.02' Storage=21,355 cf Inflow=24.02 cfs 1.425 af
Discarded=0.06 cfs 0.287 af Primary=14.30 cfs 1.138 af Outflow=14.35 cfs 1.425 af

Total Runoff Area = 2.780 ac Runoff Volume = 1.442 af Average Runoff Depth = 6.22"
29.97% Pervious = 0.833 ac 70.03% Impervious = 1.947 ac

Summary for Subcatchment 1S: Building & Green Roof Courtyards

Runoff = 10.79 cfs @ 12.17 hrs, Volume= 0.657 af, Depth= 6.67"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 100-Year-C Rainfall=7.50"

	Area (sf)	CN	Description
	39,000	98	Roofs, HSG A
*	3,125	98	Courtyard Hardscape
*	9,375	69	Courtyard Green space
	51,500	93	Weighted Average
	9,375		18.20% Pervious Area
	42,125		81.80% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry, direct**

Summary for Subcatchment 2S: Parking/Drives/blvds

Runoff = 13.23 cfs @ 12.17 hrs, Volume= 0.768 af, Depth= 5.96"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 100-Year-C Rainfall=7.50"

Area (sf)	CN	Description
42,689	98	Paved parking, HSG B
24,617	69	50-75% Grass cover, Fair, HSG B
67,306	87	Weighted Average
24,617		36.57% Pervious Area
42,689		63.43% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.0					**Direct Entry, Direct**

Summary for Subcatchment 3S: Discharge to off site

Runoff = 0.36 cfs @ 12.14 hrs, Volume= 0.017 af, Depth= 3.93"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
MSE 24-hr 3 100-Year-C Rainfall=7.50"

Area (sf)	CN	Description
2,300	69	50-75% Grass cover, Fair, HSG B
2,300		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.0					**Direct Entry, Direct**

Summary for Reach 5R: Overall Proposed Discharge from Property

Inflow Area = 2.780 ac, 70.03% Impervious, Inflow Depth = 4.99" for 100-Year-C event
Inflow = 14.44 cfs @ 12.29 hrs, Volume= 1.155 af
Outflow = 14.44 cfs @ 12.29 hrs, Volume= 1.155 af, Atten= 0%, Lag= 0.0 min

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs

Summary for Pond 8P: Underground Infiltration Vault

Inflow Area = 2.727 ac, 71.39% Impervious, Inflow Depth = 6.27" for 100-Year-C event
Inflow = 24.02 cfs @ 12.17 hrs, Volume= 1.425 af
Outflow = 14.35 cfs @ 12.29 hrs, Volume= 1.425 af, Atten= 40%, Lag= 7.2 min
Discarded = 0.06 cfs @ 7.15 hrs, Volume= 0.287 af
Primary = 14.30 cfs @ 12.29 hrs, Volume= 1.138 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 839.02' @ 12.29 hrs Surf.Area= 5,411 sf Storage= 21,355 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 305.7 min (1,077.5 - 771.8)

Volume	Invert	Avail.Storage	Storage Description
#1A	833.25'	8,702 cf	**37.58'W x 143.97'L x 6.75'H Field A** 36,523 cf Overall - 14,768 cf Embedded = 21,754 cf x 40.0% Voids
#2A	834.00'	14,768 cf	**ADS_StormTech MC-4500 +Cap** x 136 Inside #1 Effective Size= 90.4"W x 60.0"H => 26.46 sf x 4.03'L = 106.5 cf Overall Size= 100.0"W x 60.0"H x 4.33'L with 0.31' Overlap 136 Chambers in 4 Rows Cap Storage= +35.7 cf x 2 x 4 rows = 285.6 cf
		23,470 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	835.45'	**18.0" Round Culvert** L= 12.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 835.45' / 835.21' S= 0.0200 '/' Cc= 0.900 n= 0.012, Flow Area= 1.77 sf
#2	Discarded	833.25'	**0.450 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.06 cfs @ 7.15 hrs HW=833.32' (Free Discharge)
↑—**2=Exfiltration** (Exfiltration Controls 0.06 cfs)

Primary OutFlow Max=14.24 cfs @ 12.29 hrs HW=839.00' TW=0.00' (Dynamic Tailwater)
↑—**1=Culvert** (Inlet Controls 14.24 cfs @ 8.06 fps)

Stage-Area-Storage for Pond 8P: Underground Infiltration Vault

	Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)	Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)
	833.25	**5,411**	0	838.45	5,411	19,978
	833.35	5,411	216	838.55	5,411	20,250
	833.45	5,411	433	838.65	5,411	20,500
	833.55	5,411	649	838.75	5,411	20,738
	833.65	5,411	866	838.85	5,411	20,971
	833.75	5,411	1,082	838.95	5,411	21,196
	833.85	5,411	1,299	839.05	5,411	21,414
	833.95	5,411	1,515	839.15	5,411	21,630
	834.05	5,411	1,858	839.25	5,411	21,847
	834.15	5,411	2,326	839.35	5,411	22,063
	834.25	5,411	2,792	839.45	5,411	22,280
	834.35	5,411	3,258	839.55	5,411	22,496
	834.45	5,411	3,723	839.65	5,411	22,712
	834.55	5,411	4,186	839.75	5,411	22,929
	834.65	5,411	4,648	839.85	5,411	23,145
	834.75	5,411	5,109	839.95	5,411	**23,362**
	834.85	5,411	5,568			
	834.95	5,411	6,025			
	835.05	5,411	6,481			
	835.15	5,411	6,935			
	835.25	5,411	7,387			
	835.35	5,411	7,838			
Outlet	835.45	5,411	8,286	Volume Provided		
	835.55	5,411	8,732			
	835.65	5,411	9,175			
	835.75	5,411	9,616			
	835.85	5,411	10,055			
	835.95	5,411	10,491			
	836.05	5,411	10,924			
	836.15	5,411	11,354			
	836.25	5,411	11,781			
	836.35	5,411	12,205			
	836.45	5,411	12,626			
	836.55	5,411	13,043			
	836.65	5,411	13,456			
	836.75	5,411	13,866			
	836.85	5,411	14,272			
	836.95	5,411	14,673			
	837.05	5,411	15,070			
	837.15	5,411	15,463			
	837.25	5,411	15,850			
	837.35	5,411	16,233			
	837.45	5,411	16,610			
	837.55	5,411	16,981			
	837.65	5,411	17,346			
	837.75	5,411	17,704			
	837.85	5,411	18,056			
	837.95	5,411	18,400			
	838.05	5,411	18,736			
	838.15	5,411	19,063			
	838.25	5,411	19,380			
	838.35	5,411	19,686			

Attachment D - Atlas 14 depths for Hennepin County

NOAA Atlas 14, Volume 8, Version 2
Location name: Minneapolis, Minnesota, USA*
Latitude: 44.8541°, Longitude: -93.2992°
Elevation: 849.82 ft**
* source: ESRI Maps
** source: USGS

POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Deborah Martin, Sandra Pavlovic, Ishani Roy, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Michael Yekta, Geoffery Bonnin

NOAA, National Weather Service, Silver Spring, Maryland

PF_tabular | PF_graphical | Maps_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.353 (0.285-0.442)	0.420 (0.338-0.526)	0.534 (0.429-0.671)	0.635 (0.507-0.801)	0.781 (0.604-1.03)	0.900 (0.677-1.20)	1.02 (0.743-1.40)	1.16 (0.801-1.63)	1.34 (0.889-1.94)	1.48 (0.956-2.17)
10-min	0.517 (0.417-0.647)	0.614 (0.495-0.770)	0.782 (0.629-0.983)	0.930 (0.742-1.17)	1.14 (0.884-1.51)	1.32 (0.992-1.76)	1.50 (1.09-2.05)	1.69 (1.17-2.38)	1.96 (1.30-2.84)	2.17 (1.40-3.18)
15-min	0.630 (0.509-0.789)	0.749 (0.604-0.939)	0.954 (0.767-1.20)	1.13 (0.905-1.43)	1.40 (1.08-1.84)	1.61 (1.21-2.14)	1.83 (1.33-2.50)	2.06 (1.43-2.90)	2.39 (1.59-3.46)	2.65 (1.71-3.88)
30-min	0.887 (0.716-1.11)	1.06 (0.855-1.33)	1.36 (1.09-1.71)	1.62 (1.30-2.05)	2.00 (1.55-2.64)	2.32 (1.74-3.09)	2.64 (1.92-3.62)	2.99 (2.07-4.21)	3.47 (2.31-5.02)	3.85 (2.48-5.64)
60-min	1.16 (0.934-1.45)	1.38 (1.11-1.73)	1.78 (1.43-2.24)	2.15 (1.72-2.72)	2.72 (2.12-3.62)	3.20 (2.42-4.30)	3.72 (2.71-5.13)	4.29 (2.98-6.07)	5.10 (3.40-7.42)	5.76 (3.71-8.43)
2-hr	1.43 (1.16-1.77)	1.70 (1.38-2.11)	2.20 (1.78-2.74)	2.68 (2.16-3.36)	3.43 (2.71-4.56)	4.09 (3.12-5.47)	4.80 (3.53-6.59)	5.59 (3.93-7.87)	6.73 (4.53-9.73)	7.67 (4.99-11.1)
3-hr	1.60 (1.30-1.97)	1.89 (1.54-2.33)	2.45 (1.99-3.04)	3.01 (2.43-3.75)	3.90 (3.10-5.19)	4.69 (3.61-6.28)	5.57 (4.12-7.63)	6.55 (4.63-9.21)	7.98 (5.41-11.5)	9.17 (5.99-13.3)
6-hr	1.88 (1.55-2.31)	2.21 (1.81-2.71)	2.86 (2.34-3.52)	3.51 (2.86-4.34)	4.58 (3.68-6.07)	5.54 (4.30-7.38)	6.62 (4.94-9.02)	7.83 (5.59-11.0)	9.62 (6.58-13.8)	11.1 (7.33-15.9)
12-hr	2.13 (1.77-2.60)	2.52 (2.08-3.06)	3.24 (2.67-3.96)	3.95 (3.23-4.84)	5.06 (4.07-6.60)	6.04 (4.71-7.93)	7.11 (5.34-9.57)	8.31 (5.97-11.5)	10.1 (6.92-14.2)	11.5 (7.64-16.3)
24-hr	2.49 (2.07-3.00)	2.84 (2.37-3.43)	3.55 (2.94-4.30)	4.24 (3.50-5.17)	5.37 (4.36-6.96)	6.37 (5.01-8.31)	7.49 (5.67-10.0)	8.74 (6.33-12.0)	10.6 (7.35-14.9)	12.1 (8.11-17.1)
2-day	2.89 (2.42-3.45)	3.22 (2.70-3.86)	3.91 (3.27-4.69)	4.60 (3.82-5.55)	5.72 (4.69-7.35)	6.74 (5.35-8.72)	7.87 (6.02-10.4)	9.15 (6.70-12.5)	11.0 (7.75-15.4)	12.6 (8.54-17.7)
3-day	3.15 (2.66-3.76)	3.50 (2.95-4.17)	4.20 (3.52-5.02)	4.90 (4.09-5.88)	6.04 (4.96-7.70)	7.06 (5.63-9.08)	8.21 (6.30-10.8)	9.50 (6.98-12.8)	11.4 (8.04-15.8)	13.0 (8.83-18.1)
4-day	3.36 (2.84-3.99)	3.74 (3.16-4.44)	4.47 (3.77-5.33)	5.20 (4.35-6.22)	6.36 (5.23-8.05)	7.39 (5.90-9.44)	8.53 (6.56-11.2)	9.80 (7.22-13.2)	11.7 (8.25-16.1)	13.2 (9.03-18.3)
7-day	3.87 (3.29-4.56)	4.36 (3.71-5.15)	5.25 (4.45-6.22)	6.06 (5.10-7.21)	7.28 (5.98-9.07)	8.31 (6.65-10.5)	9.42 (7.27-12.2)	10.6 (7.85-14.1)	12.3 (8.75-16.8)	13.7 (9.43-18.9)
10-day	4.36 (3.72-5.12)	4.94 (4.21-5.81)	5.94 (5.05-7.00)	6.81 (5.76-8.06)	8.08 (6.63-9.95)	9.12 (7.30-11.4)	10.2 (7.88-13.1)	11.3 (8.40-14.9)	12.9 (9.21-17.5)	14.2 (9.81-19.5)
20-day	5.93 (5.10-6.91)	6.66 (5.72-7.77)	7.86 (6.73-9.19)	8.86 (7.54-10.4)	10.2 (8.43-12.4)	11.3 (9.10-13.9)	12.4 (9.63-15.6)	13.5 (10.1-17.5)	15.0 (10.7-20.0)	16.1 (11.2-21.9)
30-day	7.33 (6.33-8.49)	8.18 (7.06-9.49)	9.56 (8.22-11.1)	10.7 (9.13-12.5)	12.2 (10.1-14.6)	13.3 (10.8-16.3)	14.4 (11.3-18.1)	15.6 (11.6-20.0)	17.0 (12.2-22.5)	18.1 (12.7-24.4)
45-day	9.14 (7.93-10.5)	10.2 (8.84-11.8)	11.9 (10.2-13.7)	13.2 (11.3-15.3)	14.9 (12.3-17.7)	16.1 (13.1-19.5)	17.3 (13.6-21.5)	18.5 (13.8-23.6)	19.8 (14.3-26.1)	20.8 (14.7-28.0)
60-day	10.7 (9.31-12.3)	12.0 (10.4-13.8)	13.9 (12.1-16.1)	15.5 (13.3-17.9)	17.4 (14.4-20.5)	18.7 (15.2-22.5)	20.0 (15.7-24.7)	21.1 (15.9-26.8)	22.5 (16.3-29.4)	23.4 (16.6-31.4)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

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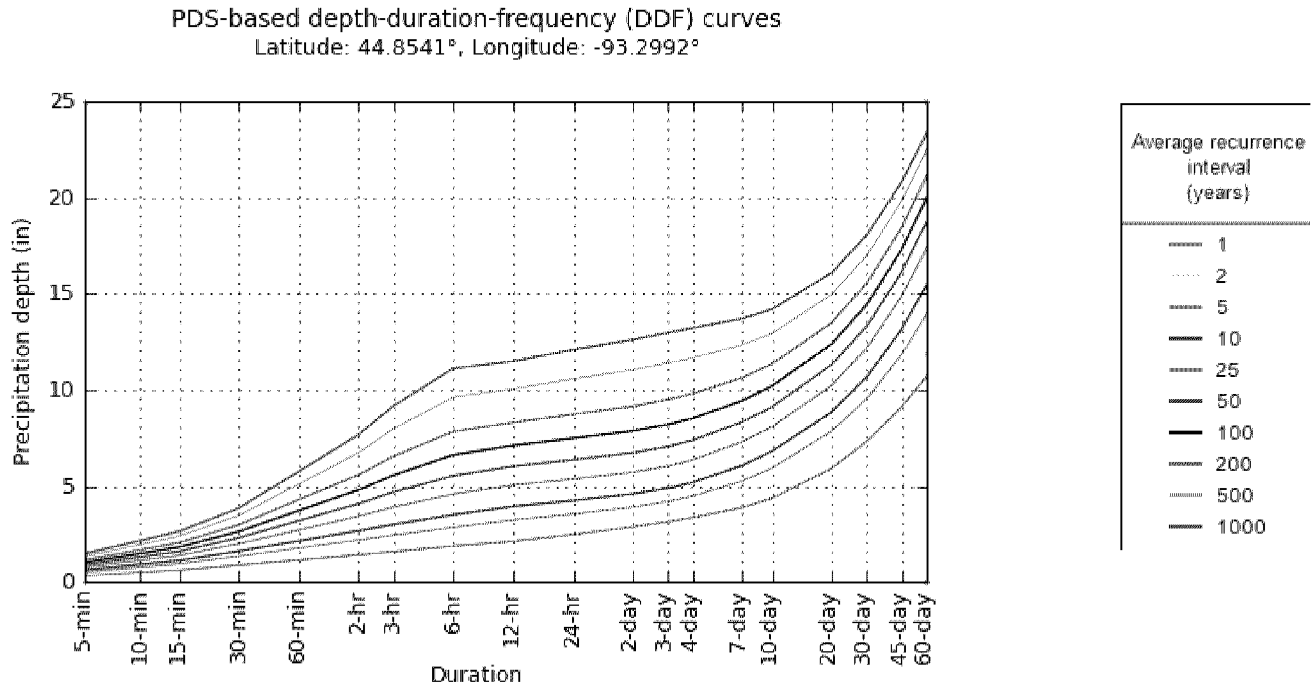
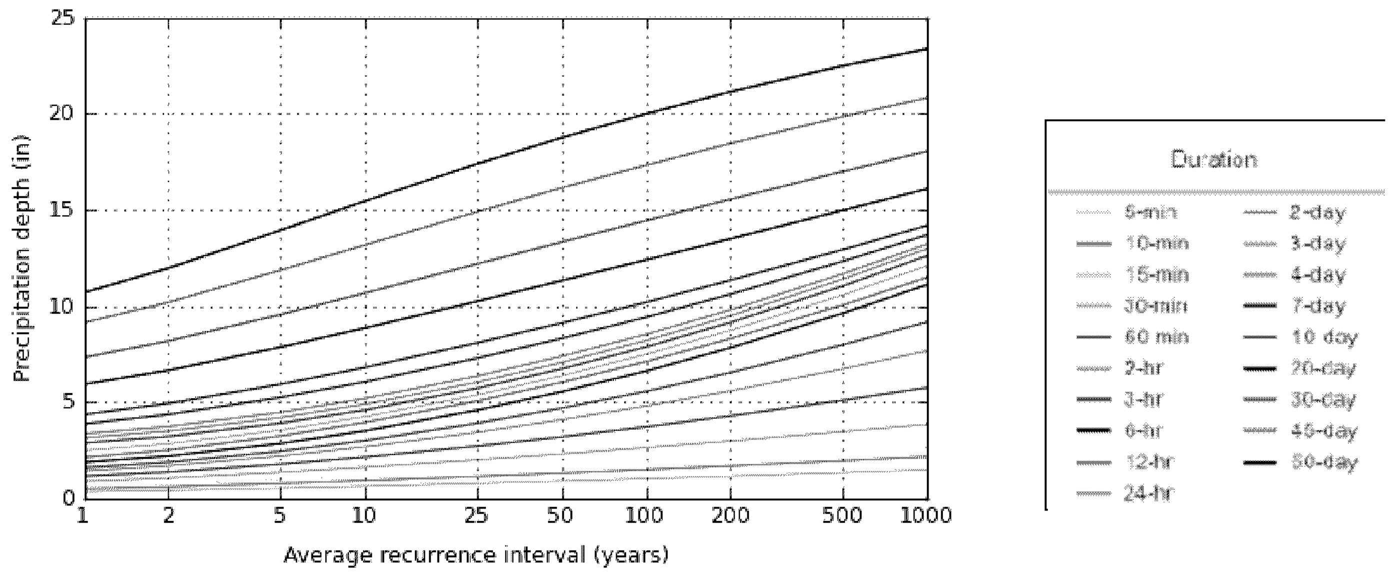
PF graphical

PL2022-247





NOAA Atlas 14, Volume 8, Version 2 Created (GMT): Mon Dec 6 22:51:09 2021

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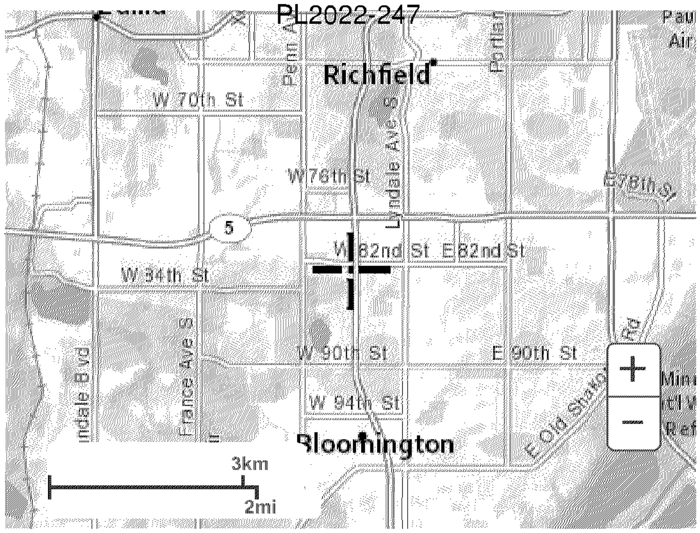
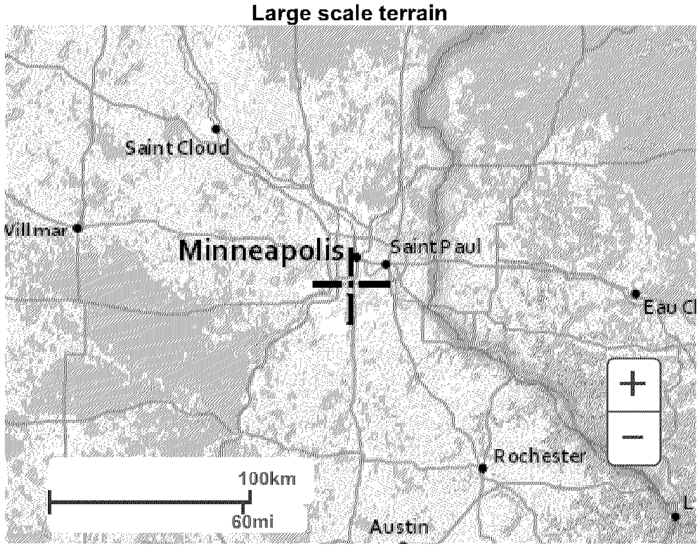
Maps & aerials

Small scale terrain

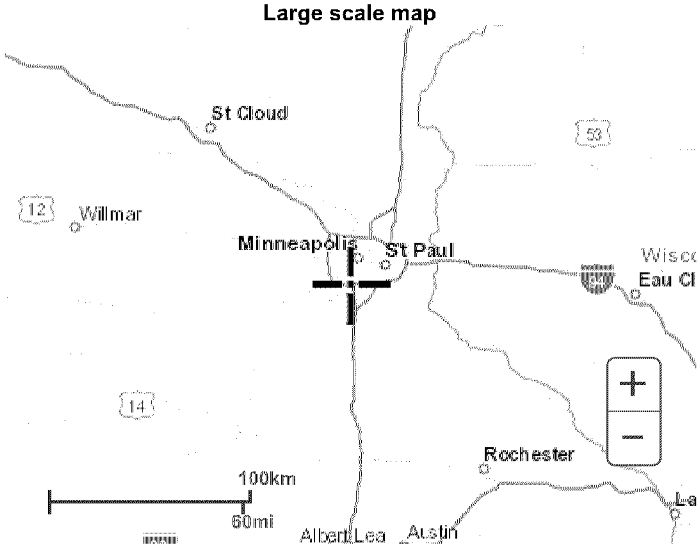
PL2022-247



Large scale terrain



Large scale map



Large scale aerial

PL202200247

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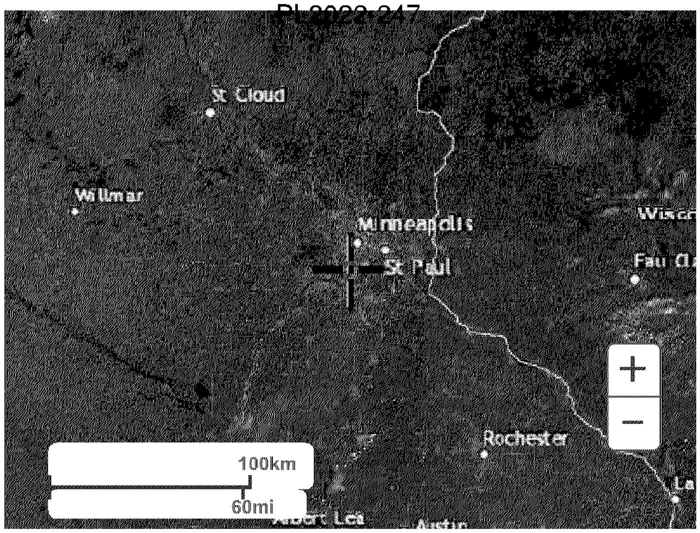

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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

Attachment E - Geotechnical Report, Prepared by AET and dated 10/26/2020

PL202200247
PL2022-247

AMERICAN ENGINEERING TESTING, INC.

CONSULTANTS
- ENVIRONMENTAL
- GEOTECHNICAL
- MATERIALS
- FORENSICS

REPORT OF GEOTECHNICAL EXPLORATION

Humboldt Avenue Apartments

8200 Humboldt Avenue South
Bloomington, Minnesota

AET No. 20-23500

Date:

February 19, 2021

Prepared for:

Enclave Companies
1 2nd Street North, Suite 102
Fargo, North Dakota 58102

www.amengtest.com

AMERICAN ENGINEERING TESTING, INC.

CONSULTANTS
- ENVIRONMENTAL
- GEOTECHNICAL
- MATERIALS
- FORENSICS

February 19, 2021

Enclave Companies
1 2nd Street North, Suite 102
Fargo, North Dakota 58102

Attn: Mr. Brian Bochman – Project Manager

RE: Report of Geotechnical Exploration
Humboldt Avenue Apartments
8200 Humboldt Avenue South
Bloomington, Minnesota
AET Project No. 20-23500

Dear Mr. Bochman:

American Engineering Testing, Inc. (AET) is pleased to present the results of our subsurface exploration program and geotechnical engineering review for your upcoming apartment development project in Bloomington, Minnesota. These services were performed according to our proposal to you dated January 6, 2021 and authorized January 8, 2021.

Please contact us if you have any questions about the report. We can also be contacted for arranging construction observation and testing services.

Sincerely,
American Engineering Testing, Inc.

Mitchell G Nelson

Mitchell Nelson, E.I.T.
Staff Engineer
Phone: (612) 756-3332
mnelson@amengtest.com

SIGNATURE PAGE

Prepared for:

Enclave Companies
1 2nd Street North, Suite 102
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Attn: Mr. Brian Bochman

Prepared by:

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Authored by:

Mitchell Nelson, E.I.T.
Staff Engineer

Reviewed by:

Andrew T. Schmid, P.E.
Principal Engineer

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under Minnesota Statute Section 326.02 to 326.15

Name: Andrew T. Schmid

Date: Feb. 19, 2021 License #: 48982

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1.0 INTRODUCTION

You are proposing to construct a new apartment building in Bloomington, Minnesota. To assist planning and design, you have authorized American Engineering Testing, Inc. (AET) to conduct a subsurface exploration program at the site, conduct soil laboratory testing, and perform a geotechnical engineering review for the project. This report presents the results of the above services and provides our engineering recommendations based on this data.

2.0 SCOPE OF SERVICES

AET's services were performed according to our proposal to you dated January 6, 2021, which you authorized on January 8, 2021. The authorized scope consists of the following:

- Drilling eleven (11) standard penetration test (SPT) borings to various depths totaling 315 linear feet.
- Soil laboratory testing and sample analysis.
- Geotechnical engineering review based on the data and preparation of this report.

These services are intended for geotechnical purposes only. The scope is not intended to explore for the presence or extent of environmental contamination in the soil or groundwater. Samples were collected by Westwood Professional Services at the time of our drilling for an environmental assessment of the area near a buried fuel tank on the west side of the building.

3.0 PROJECT INFORMATION

We understand construction at the project site will include a three-story apartment building with one level of below-grade parking, anticipated to be about 10 feet below the existing site grades. The building is planned to be constructed of below-grade precast concrete with above wood framing. The project site is located at 8200 Humboldt Avenue South in Bloomington, Minnesota, on property identified as Hennepin County Parcel ID 0402724310032. The site currently contains a three-story above-grade commercial building with paved surface parking and access lanes.

While we were able to review a preliminary site layout, dated July 14, 2020, prepared by ESG Architecture & Design, no grading, utility, or structural plans were available for our review during the preparation of this report. We anticipate the design team will set a finished first-floor elevation similar to the existing building. Based on this assumption, our anticipated finished first-floor elevation is 844 feet, with a below-grade parking floor elevation of 834 feet, and a bottom-of-footing elevation of about 832 feet. Based on our experience with previous projects of this type, we estimate the design column loads will be on the order of approximately 325 to 375 kips, and the wall load estimate is approximately 10 to 15 kips per lineal foot. Our foundation design assumptions include a minimum factor of safety of 3 with respect to the ultimate bearing capacity. We assume the structure will be able to tolerate total settlements of up to 1 inch, and differential settlements over a 30-foot distance of up to ½ inch.

The above stated information represents our understanding of the proposed construction. This information is an integral part of our engineering review. It is important that you contact us if there are changes from that described so that we can evaluate whether modifications to our recommendations are appropriate.

4.0 SUBSURFACE EXPLORATION AND TESTING

4.1 Field Exploration Program

The subsurface exploration program conducted for the project consisted of drilling eleven (11) standard penetration test borings at locations determined by AET, approved by Enclave and the design team, to provide a representative characterization of the project site. The logs of the borings and details of the methods used appear in Appendix A. The logs contain information concerning soil layering, soil classification, geologic origins, and moisture condition. A density description or consistency is also noted for the natural soils, which is based on the standard penetration resistance (N-value). The boring locations are shown in Appendix A. The borings were located in the field by AET personnel using a field GPS unit via approximate location coordinates. Surface elevations were measured in the field by AET personnel using a field GPS unit.

4.2 Laboratory Testing

Samples collected in the field were analyzed at the AET lab to provide a more detailed characterization of sample properties. The laboratory test program included moisture content tests on fine-grained soil samples. The test results appear on the individual boring logs in Appendix A, adjacent to the samples upon which they were performed. Additionally, grain size analysis was performed on select granular samples to characterize potential reuse material from onsite excavations. Please review the Gradation Curves in Appendix A for more information.

5.0 SITE CONDITIONS

5.1 Surface Observations

The site is currently occupied by an existing 3-story above-grade office building surrounded by landscaped area and bituminous parking and driveways. The site slopes from west to east and has a ground surface elevation at our boring locations ranging from approximately 834 to 842 feet, with two borings on the eastern edge of the site near Humboldt Avenue near 849 feet. Ground surface elevations at each boring location are provided on the boring logs in Appendix A.

5.2 Subsurface Soils/Geology

The subsurface soil profile is generally characterized by pavement and existing site fill underlain by naturally deposited coarse alluvial sands. The fill layer varied in depth from approximately 2 to 10 feet below the ground surface. Coarse alluvial sand deposits were observed in all borings below the fill to boring terminal depth. Refer to the boring logs in Appendix A for detailed descriptions of the subsurface profile observed at each boring location.

5.3 Groundwater

Groundwater was observed at only one boring location, Boring B-7. During drilling, the field team noted groundwater at a depth of approximately 37 feet, corresponding to an elevation of about 811 feet. The depth indicates that the static groundwater table is located a depth below the anticipated foundation grades. Due to their fast-draining nature, we generally consider groundwater measurements in sand soils to reliably represent the approximate static groundwater levels at the time of drilling. Groundwater levels fluctuate due to varying seasonal and annual rainfall and snow melt amounts, as well as other factors. Additionally, regional groundwater levels can change due to construction events such as alterations in ground cover, surface water runoff control, and structure dewatering systems.

5.4 Review of Soil Properties

5.4.1 Existing Fill and Topsoil

Existing fill or topsoil was observed at the surface of each boring. In paved areas, bituminous pavement and apparent aggregate base material was encountered at the surface. The fill soils encountered in the borings generally consisted of silty sand and clayey sand with trace roots and organic material. Existing fill thicknesses generally ranged from 2 to 5 feet, with occasional fill depths observed of up to 10 feet. The borings indicate that existing fill is not anticipated to be encountered at our assumed foundation subgrade elevations. Silty and clayey sand soils are considered to be relatively slow-draining and are susceptible to frost-heave displacement if exposed to freezing conditions. We judge the silty and clayey sand soils to have low strength and be moderate compressible under the anticipated building loads.

5.4.2 Coarse Alluvium

Naturally deposited coarse alluvial soils were encountered below the existing fill in the borings. Alluvial soils generally consisted of sand (SP) and silty sand (SM). With the exception of Boring B-7, this coarse alluvial layer extended to the termination depth of each boring, indicating the majority of the subsurface profile consists of naturally deposited sand. Boring B-7 encountered glacial till at a depth of approximately 25 feet. The coarse alluvial sands are judged to have moderate strength and low compressibility and are judged to be fast-draining with low susceptibility to freeze-thaw movements. Sample characteristics and observations are provided on the boring logs in Appendix A.The glacial till generally consisted of clayey sand (SC) and is judged to have moderate strength and low compressibility and is judged to be slow-draining and moderately susceptible to freeze-thaw movements.

6.0 RECOMMENDATIONS

The following outlines our exploration and lab testing results, analysis, and recommendations. Site preparation, foundations, and earthwork considerations are presented below.

6.1 Approach Discussion

We anticipate the earthwork team will set a finished floor elevation similar to the existing site grades. Based on our review of the boring logs, naturally deposited coarse alluvial sand is present at the anticipated bottom-of-footing elevation of 832 feet. The existing three-story building will be removed for the new construction. We understand that this structure does not have a lower level. Based on our assumed floor and footing elevations, it is our judgment that the proposed building excavation will extend into the competent naturally deposited soils. If unanticipated fill or soft or unsuitable soils are encountered at foundation grades, corrections will be needed to remove and replace the fill or soft or unsuitable soils with properly placed and compacted granular fill. Because the proposed building includes a below-grade level, we anticipate that soils will need to be exported off-site. As such, we recommend prioritizing silty and clayey soils for export first and reserving the naturally deposited sand removed above footing grades for consideration for reuse to support pavement base materials and backfill walls and foundations. Additionally, the below-grade level will require a larger surface excavation to access the foundation grades.

Depending upon the preliminary site layout and the proximity of the planned foundations to the property boundary a temporary earth retention may be necessary to support construction without disturbing surrounding properties. Underground utilities, floor slabs, pavement sections, retaining walls and surface structures should be supported by natural coarse alluvial deposits or by properly placed and compacted granular fill. If the existing fill soils are to be exported from the site from the general excavation environmental testing will likely be required. Environmental testing may also be required for the export of the naturally deposited soils for acceptance for use on other sites. The testing should follow MPCA guidelines.

6.2 Building Grading and Structural Support

6.2.1 Excavation

To prepare the building area for foundation and slab support, we recommend removing the pavements, topsoil, existing fill, and all existing building elements (including existing utilities that are to be abandoned) in the new building footprint. This would result in excavation depths at the boring locations as shown in Table 1:

Table 1 – Recommended Minimum Excavation Depths

Boring Location	Surface Elevation (ft)	Excavation Depth (ft)	Approximate Excavation Elevation (ft)
B-1	845.8	5 ½	840 ½
B-2	846.0	7	839
B-3	844.8	4 ½	840
B-4	845.4	4 ½	840 ½
B-5	843.8	9 ½	834
B-6	844.9	9 ½	835
B-7	848.7	7	841 ½
B-8	843.8	4 ½	839 ½
B-9	848.1	7	841
B-10	844.1	2	842
B-11	844.3	2	842

**Note: listed values are minimum excavations. In each boring, competent natural soil deposits were observed at foundation grades, so final excavation depths will be governed by the foundation plan.*

The depth/elevations indicated in Table 1 are based on the soil conditions at the specific boring location. Since conditions will vary away from the boring location, it is recommended that AET geotechnical personnel observe and confirm the competency of the soils in the entire excavation bottom prior to new fill or footing placement. Especially because all final excavation depths are determined by the final footing grades, we recommend geotechnical personnel observe excavation bottoms prior to foundation construction to assess the material's composition and consistency with the boring logs.

If excavations extend below foundation grade, the excavation bottom and resultant engineered fill system must be oversized laterally beyond the planned outside edges of the foundations to properly support the loads exerted by that foundation. This excavation/engineered fill lateral extension should at least be equal to the vertical depth of fill needed to attain foundation grade at that location (i.e., 1:1 lateral oversize). While not anticipated based on a review of the boring logs, some deposits of unsuitable material may be present at foundation grades. If encountered, excavation should continue to competent underlying coarse alluvial sand soils with proper lateral oversizing to allow fill placement for a soil correction.

Where they are removed above the recommended excavation depth, on-site sandy soils can be saved for re-use as compacted fill below foundations and floor slabs, and as basement/wall backfill if they meet the material specifications. We recommend prioritizing the coarse alluvial sand deposits to keep and test for re-use and exporting existing fill and topsoil first. Particularly at Borings B-10 and B-11, natural sand deposits were encountered within 2 to 3 feet of the ground surface, indicating that as much as 10 feet of coarse alluvial sand will be removed above assumed foundation grades. Gradation testing indicated relatively clean sand with less than 2% clay and silt in these with 50 to 80 % passing the number 40 sieve.

6.2.2 Fill Placement and Compaction

We recommend surface compacting the exposed subgrade soils prior to foundation construction to provide more uniform support and to densify the soils. The bottom of the excavation should be graded uniformly and compacted with a roller that is appropriate to compact the exposed subgrade soils. Since conditions will vary away from the boring locations, we recommend that AET geotechnical personnel observe and evaluate the suitability of the soils in the excavation bottoms prior to placement of new fill or footing construction.

If fill is needed below foundations or floor slabs (areas of unanticipated fill or unsuitable soft soils and subsequent localized soil corrections, if needed), we recommend using suitable re-placed and recompacted sand or import soils containing no more than 12% of the particles (by weight) finer than the #200 sieve, and no more than 60% of the particles (by weight) passing the #40 sieve. In our opinion, the excavated naturally deposited sands classified as (SP) or (SP-SM) would be suitable to be re-used as fill.

Any fill that is placed within the building pad should be compacted in thin lifts, such that the entire lift achieves a minimum compaction level of 98% of the standard maximum dry unit weight per ASTM: D698 (Standard Proctor test) with moisture contents within 3% of the Standard Proctor optimum moisture. We recommend that fill soils be compacted with vibratory equipment capable of compacting the entire thickness of the fill lift. Loose lift thicknesses should generally not be greater that 8 to 12 inches to appropriately compact layers. If encountered, frozen soils should not be used as fill, and fill should not be placed over frozen soils. Soil removed during excavation, particularly coarse alluvial sands, may be reused as structural fill provided they are properly placed and compacted.

6.2.3 Temporary Earth Retention

We understand the proposed building footprint will be located near the project property boundary in some areas. Based on the anticipated earthwork and below-grade foundation elevations, we expect proximity to the project borders to present a risk to surrounding properties. To make excavations stable and accessible for foundation construction, the edge must be backsloped up to the ground surface at an acceptable slope (typically governed be OSHA earthwork guidelines). Therefore, the area impacted by excavation and earthwork extends laterally away from the edge of the proposed construction. Based on the anticipated depth of the excavation and proximity to the property boundary, we anticipate temporary earth retention will be necessary to stabilize the property boundary. A perimeter temporary earth retention system would maintain the slope of the excavation to allow access to the bottom for continuing earthwork and foundation construction, and would limit the risk of undermining surrounding properties, structures, and roadways. Typical retention systems in the Minneapolis – St Paul area consist of soldier piles and wood lagging.

Temporary earth retention systems are generally designed and installed by specialty contractors. Their design teams may need more detailed geotechnical data (e.g. deeper borings) to propose a design to protect existing footings. While temporary earth retention systems may add budget scope to the project, they will likely be necessary to provide access to working grades for foundation construction. For the temporary earth retention walls, the specialty design-build contractor should be aware of the extensive amount of naturally-deposited sand soils at the site. Design or approval of a temporary earth retention system will involve a review of this report, boring logs, and lab test results from samples collected at the site. Consideration of using a "drill and drop" method to install the soldier piles rather than driving can significantly reduce noise and vibration levels.

6.3 Foundation Design

The previously described building can be supported on conventional spread foundations placed on the natural coarse alluvial sand deposits or on properly placed compacted fill. We recommend perimeter foundations for heated building space is placed such that the bottom is a minimum of 42 inches below exterior grade. We recommend foundations for unheated building space (such as canopy foundations) be extended to a minimum of 60 inches below exterior grade, because deeper frost penetration can occur away from heated areas. All foundation base surfaces should be compacted with a large manual vibrating plate compactor prior foundation placement.

If the footings are placed on competent coarse alluvial sands or on properly compacted granular fill, we recommended that the foundation for the building be designed using a net maximum allowable soil bearing pressure of 4,000 psf. It is our judgment this design pressure will have a factor of safety of at least 3 against localized shear or base failure. We judge that total settlements under this loading should not exceed 1 inch. We also judge that differential settlements of conditions depicted by the borings should not exceed ½ inch.

6.4 Floor Slab Design

It is our judgement that the concrete floor slabs in the new building can be supported on grade by the coarse alluvial sands. Sandy soils placed as fill should meet the guidelines for foundation fill outlined in Section 6.2.2. Assuming the on-grade floor slabs of the building will be supported by these sandy soils, we recommend the slab be designed using a modulus of subgrade reaction (k-value) of 200 pci. If a 4 to 6-inch thick layer of aggregate base (i.e. MnDOT Class 5) is placed immediately below the slab, we recommend a k-value of 225 pci be used for design of the on-grade slabs. Increasing the thickness of the aggregate base layer would further increase the k-value.

The aggregate base layer (if it is placed) should be a crushed material and should be compacted to at least 100% of its standard Proctor maximum dry density or to meet the penetration index criteria for MnDOT Dynamic Cone Penetrometer (DCP) tests. After the aggregate base has been placed, compacted and tested, it is the contractor's responsibility to maintain the base in suitable condition for concrete placement. If the subgrade or aggregate base materials become saturated or contaminated by clayey or silty soils, after testing, it may be rendered unsuitable for concrete placement due to softness and pumping. This action would require remedial action before concrete can be placed.

The use of certain types of flooring on the at-grade level (such as storage rooms, maintenance areas, or elevator lobbies) may require the installation of moisture/vapor membranes below floor slabs. Typically, if moisture sensitive floor coverings like tile or carpet will be used, moisture/vapor membranes are recommended. Recommendations for placement of granular material or plastic membranes beneath on-grade floor slabs are outlines in the attached standard sheet entitled "Floor Slab Moisture/Vapor Protection." A vapor retarder is typically not required below a parking slab. However, on recent projects with underground parking, design teams have specified the use of vapor retarder to allow for the possibility of a future traffic topping. The vapor retarder should be placed directly below the slab.

6.5 Below Grade Walls/Water Control

Based on our understanding of the proposed building design, below grade basement walls will be constructed along the perimeter of the new building. We recommend the backfill placed behind the below-grade walls consist of sands (SP) having no more than 5% of the particles (by weight) finer than the #200 sieve, and no more than 40% of the particles (by weight) finer than the #40 sieve. This type of sand will provide proper drainage. We anticipate portions of the on-site sands will meet these criteria. Gradation tests should be performed during construction on the material that is proposed to be used as wall backfill. The sand should be compacted to 95% of the maximum standard Proctor dry density. Care should be exercised during backfill as over compaction or compacting with large equipment next to the walls could damage the foundation walls or impart excessive lateral pressures.

The zone of sand backfill should extend outward from the wall at least 2 feet from bottom-of-footing grade, and then extend upward and outward from the wall at a 30-degree angle from vertical. Due to the limited size of the site, this wedge of backfill may not be feasible to construct. To minimize the size of the excavation and the volume of backfill, the zone of the free-draining sand backfill could be reduced to a horizontal distance of 3 feet outside the wall, for the height of the wall, against the existing on-site soils. The sand backfill against the basement walls should be covered with approximately 1 foot of low permeability soils (preferably clays) if available and graded to shed away surface water.

Assuming that the basement walls will not be allowed any rotation, we recommend that the at-rest condition be used for design of the walls. For the wall configuration described above, the walls should be designed using an equivalent fluid weight lateral earth pressure of 60 pcf. This is based upon a moist unit weight of 120 psf for the sand backfill and an at-rest earth pressure coefficient of 0.5. Lateral earth pressures will be significantly higher if the backfill soils are not drained and become saturated. This coefficient should also be applied to any surcharges adjacent to the wall. If the alternative backfill method (only a 3-foot wide zone outside the wall) is used, the walls should be designed using an equivalent fluid weight lateral earth pressure of 75 pcf using the at-rest condition. This design pressure can also be used if the onsite fine-grained sands, classified as (SP), are used as backfill in the wedge configuration or in the 3-foot width. These sands will not drain as rapidly as the recommended drainage backfill (which would likely need to be imported or carefully sorted on site) which could result in a higher equivalent earth pressure than the recommended 60 pcf for the drainage fill.

Our recommendations for backfilling the basement walls and other retaining walls (if there are any) appear on the attached standard sheet entitled "Basement/Retaining Wall Backfill and Water Control." To avoid water intrusion issues into the basement, it will be very important that these details be incorporated into the design, and that construction monitoring be performed to assure that proper materials and construction is implemented.

6.6 Underground Utilities and Site Backfilling

We assume that exterior utilities will be constructed at depths of approximately 4 to 8 feet below final grades. The on-site coarse alluvial soils are anticipated to provide adequate support for the new utilities. Any existing fill at the base of the utility trench should be surface compacted and tested for compaction. Backfill for utilities should consist of the on-site inorganic, debris-free, and cobble-free sands. It is important that utility backfill be compacted in thin lifts within a moisture content range that will allow for the soil to be properly densified. Utility backfill should be compacted to at least 95% of its standard Proctor maximum dry density below the upper 3 feet of pavement subgrade, and to 100% in the upper 3 feet of pavement subgrade. If such compaction is not performed, settlement and subsequent damage could occur to utilities and pavements.

Some topsoil and existing site fill contains silty and clayey soils; these materials are considered susceptible to freeze-thaw movements. Consequently, certain design considerations are needed to mitigate their frost effects. If possible, these should not be used on site in the frost zone near or below surface structures. If sidewalks, stoops, or other similar structures are supported by these fine soils and exposed to freezing conditions, seasonal frost-heave displacement and subsequent cracking and damage may occur. All backfill that will support sidewalks, stoops, planters, or similar surface structures should be granular material compacted to at least 95% of the standard Proctor maximum dry density per ASTM: D698. Fill placed in landscaped areas can be compacted to a reduced level of 90%.

6.7 Pavements

6.7.1 Subgrade Preparation

To prepare for pavement support, we recommend excavation include the removal of all surface vegetation, topsoil, and unstable existing fill soils that exist within the upper 3 feet of the subgrade soils (referred to as the critical subgrade zone). Soft and/or unstable clayey, silty, and organic soils should also be removed from within the critical subgrade zone if they are observed during construction. The existing granular fill soils can remain in place if they are in a firm, stable condition. After this excavation, we recommend the exposed soils should be moisture conditioned and recompacted to a minimum of 100% of the standard Proctor maximum dry density (ASTM: D698). Scarifying and compacting the exposed excavation will result in a more uniform subgrade condition. If the scarified soils are more than 3 feet below the pavement subgrade, the compaction can be reduced to 95%.

We expect most soils at the planned pavement subgrade elevations will be coarse alluvial sands or compacted existing granular fill. If soft or unsuitable soils are encountered and removed below pavement subgrades, we recommend re-attaining bottom-of-pavement-base elevations (with reused coarse alluvial sand removed during building pad preparation. If suitable onsite material is not available, select granular borrow may be used. If possible, the sands classified as (SP) should be placed in a uniform layer of about 8 inches in thickness below the aggregate base as a drained sand subbase. Material used in the critical subgrade zone should be placed and compacted at the proper moisture conditions to achieve a stable subgrade, generally within 2% of their respective optimum moisture contents, as determined by the standard Proctor.

6.7.2 Subgrade Stability and Test Roll

Stability within the upper 3 feet of subgrade soil is important for pavement support, construction, and performance. After the subgrade has been prepared and compacted at bottom-of-pavement-base elevation, stability of subgrade soils should be evaluated by test rolling the subgrade with a loaded tandem axle dump truck before placement of the aggregate base layer. We generally recommend testing with a gross vehicle weight of approximately 20 tons. The design team can consider other options for test weight during the subgrade proof roll if a more representative estimate of anticipated traffic loading is available. If primarily (SP) sands are present at subgrade elevation the proof roll test may need to be performed with equipment such as an end loader with a full bucket. There may not be enough "binder" in the subgrade soils to support a tandem axle truck without rutting.

The test roll will help to delineate any unstable soils that will not be acceptable as pavement subgrade soils. These unstable soils should be removed and replaced; or aerated, dried and recompacted back into place as recommended by AET geotechnical personnel. If the sand soils are dry, wetting may be required. After the subgrade soils pass a test roll procedure and general areas of instability have been repaired, the aggregate base can be placed and compacted.

6.7.3 Section Thicknesses

We are presenting pavement designs based on two potential traffic situations: light and heavy duty. The light-duty design refers to parking areas which are intended only for automobiles and passenger truck/ vans. The heavy-duty design is intended for pavements which will experience the heavier truck traffic (9-ton to 10-ton design load). For properly compacted sand or silty sand subgrade, we estimate a design subgrade R-value of 30.

Table 2 – Pavement Thickness Designs

Material	**Section Thickness with Sand Subbase**	
	Light-Duty	**Heavy-Duty**
Bituminous Wear	2	2.5"
Bituminous Non-Wear	2"	2.5"
Crushed Aggregate Base	8"	10"

We recommend consideration of using upgraded oils in the mixes. The typical "B" oil is a softer oil than an "F" oil (upgrade) and in the first year of service the "B" oil mix can rut or shove from wheel turning on hot days. The "F" oil mixes are stiffer and provide increased performance against rutting and shoving. Mixes to consider would be an SPNWB330 for the non-wear and SPWEA340 for the wear (top mix). Both mixes should have "F" oil as the non-wear will be in the top 4 inches of the pavement surface.

6.7.4 Pavement Maintenance

Even if placed and compacted properly on stable subgrade conditions, bituminous pavements typically experience cracking in 1 to 3 years, primarily due to temperature-related expansion and shrinkage. We recommend that a regularly scheduled maintenance program consisting of patching of cracks and local distressed areas be implemented. Seal coating of the pavement surface after 3 to 5 years often helps prolong the pavement life.

6.8 Stormwater

The most commonly observed subsurface material during drilling was coarse alluvial sand. This material is generally conducive to groundwater infiltration. Preliminary site layout plans did not indicate any stormwater management systems, but these features are common for development projects of this size. Design of such systems is generally based on soil properties. Based on the Minnesota Storm Water Manual (MSWM) produced by the Minnesota Pollution Control Agency (MPCA), the infiltration rates for poorly-graded sands, such as those encountered at our boring locations, are estimated to be 0.8 inches per hour. The design infiltration rates are typically intended to represent the long-term infiltration capacity of an infiltration basin or underground gallery. It is not meant to exhibit the capacity of the soils in the natural state. Design rates are often based, in part or in whole, on the least permeable soil horizon within 4 to 5 feet below the bottom of the infiltration device. Different states, watershed districts, and local governing units may have different criteria for assigning design rates based on actual measured rates and/or soil types.

The rates provided by the MSWM are general estimates, and more representative values could be determined by performing in-situ permeability testing using the Double-Ring Infiltrometer (DRI) method if desired. This testing, if performed, should be conducted at or just below the bottom elevations of the proposed infiltration structures/devices. This testing should be used to document that the infiltration rates used by the design engineer are comparable with the in-place soils.

7.0 CONSTRUCTION CONSIDERATIONS

7.1 Potential Difficulties

7.1.1 Runoff Water in Excavation

Water can be expected to collect in the excavation bottom during times of inclement weather or snow melt. To allow observation of the excavation bottom, to reduce the potential for soil disturbance, and to facilitate filling operations, we recommend water be removed from within the excavation during construction. Based on the soils encountered, we anticipate the groundwater can be handled with conventional sump pumping or allowed to infiltrate into the naturally deposited sand soils.

7.1.2 Disturbance of Soils

The on-site soils can be disturbed under construction traffic, especially if the soils are wet. If soils become disturbed, they should be subcut to the underlying undisturbed soils. The subcut soils can then be dried and recompacted back into place, or they should be removed and replaced with drier imported fill.

The onsite sands (SP) could become dry and may need to be wetted and recompacted if disturbed. Designated haul roads with a crushed gravel surface would provide stability for construction traffic.

7.2 Excavation Backsloping

If excavation faces are not retained, the excavations should maintain maximum allowable slopes in accordance with *OSHA Regulations (Standards 29 CFR), Part 1926, Subpart P, "Excavations"* (can be found on www.osha.gov). Even with the required OSHA sloping, water seepage or surface runoff can potentially induce sideslope erosion or sloughing which could require slope maintenance.

7.3 Observation and Testing

The recommendations in this report are based on the subsurface conditions found at our test boring locations. Since the soil conditions can be expected to vary away from the soil boring locations, we recommend on-site observation by a geotechnical engineer/technician during construction to evaluate these potential changes. Soil density testing should also be performed on new fill placed in order to document that project specifications for compaction have been satisfied. Gradation testing and grain-size analysis should be used to asses onsite sand's suitability for reuse during construction.

8.0 ASTM STANDARDS

When we refer to an ASTM Standard in this report, we mean that our services were performed in general accordance with that standard. Compliance with any other standards referenced within the specified standard is neither inferred nor implied.

9.0 LIMITATIONS

Within the limitations of scope, budget, and schedule, we have endeavored to provide our services according to generally accepted geotechnical engineering practices at this time and location. Other than this, no warranty, express or implied, is intended. Important information regarding risk management and proper use of this report is given in Appendix B entitled "Geotechnical Report Limitations and Guidelines for Use."

FLOOR SLAB MOISTURE/VAPOR PROTECTION

Floor slab design relative to moisture/vapor protection should consider the type and location of two elements, a granular layer and a vapor membrane (vapor retarder, water resistant barrier or vapor barrier). In the following sections, the pros and cons of the possible options regarding these elements will be presented, such that you and your specifier can make an engineering decision based on the benefits and costs of the choices.

GRANULAR LAYER

In American Concrete Institute (ACI) 302.1R-04, a "base material" is recommended over the vapor membrane, rather than the conventional clean "sand cushion" material. The base layer should be a minimum of 4 inches (100 mm) thick, trimmable, compactable, granular fill (not sand), a so-called crusher-run material. Usually graded from 1½ inches to 2 inches (38 to 50 mm) down to rock dust is suitable. Following compaction, the surface can be choked off with a fine-grade material. We refer you to ACI 302.1R-04 for additional details regarding the requirements for the base material.

In cases where potential static water levels or significant perched water sources appear near or above the floor slab, an under floor drainage system may be needed wherein a draintile system is placed within a thicker clean sand or gravel layer. Such a system should be properly engineered depending on subgrade soil types and rate/head of water inflow.

VAPOR MEMBRANE

The need for a vapor membrane depends on whether the floor slab will have a vapor sensitive covering, will have vapor sensitive items stored on the slab, or if the space above the slab will be a humidity controlled area. If the project does not have this vapor sensitivity or moisture control need, placement of a vapor membrane may not be necessary. Your decision will then relate to whether to use the ACI base material or a conventional sand cushion layer. However, if any of the above sensitivity issues apply, placement of a vapor membrane is recommended. Some floor covering systems (adhesives and flooring materials) require installation of a vapor membrane to limit the slab moisture content as a condition of their warranty.

VAPOR MEMBRANE/GRANULAR LAYER PLACEMENT

A number of issues should be considered when deciding whether to place the vapor membrane above or below the granular layer. The benefits of placing the slab on a granular layer, with the vapor membrane placed **below** the granular layer, include **reduction** of the following:

- Slab curling during the curing and drying process.
- Time of bleeding, which allows for quicker finishing.
- Vapor membrane puncturing.
- Surface blistering or delamination caused by an extended bleeding period.
- Cracking caused by plastic or drying shrinkage.

The benefits of placing the vapor membrane over the granular layer include the following:

- A lower moisture emission rate is achieved faster.
- Eliminates a potential water reservoir within the granular layer above the membrane.
- Provides a "slip surface", thereby reducing slab restraint and the associated random cracking.

If a membrane is to be used in conjunction with a granular layer, the approach recommended depends on slab usage and the construction schedule. The vapor membrane should be placed above the granular layer when:

- Vapor sensitive floor covering systems are used or vapor sensitive items will be directly placed on the slab.
- The area will be humidity controlled, but the slab will be placed before the building is enclosed and sealed from rain.
- Required by a floor covering manufacturer's system warranty.

The vapor membrane should be placed below the granular layer when:

- Used in humidity controlled areas (without vapor sensitive coverings/stored items), with the roof membrane in place, and the building enclosed to the point where precipitation will not intrude into the slab area. Consideration should be given to slight sloping of the membrane to edges where draintile or other disposal methods can alleviate potential water sources, such as pipe or roof leaks, foundation wall damp proofing failure, fire sprinkler system activation, etc.

There may be cases where membrane placement may have a detrimental effect on the subgrade support system (e.g., expansive soils). In these cases, your decision will need to weigh the cost of subgrade options and the performance risks.

BASEMENT/RETAINING WALL BACKFILL AND WATER CONTROL

DRAINAGE

Below grade basements should include a perimeter backfill drainage system on the exterior side of the wall. The exception may be where basements lie within free draining sands where water will not perch in the backfill. Drainage systems should consist of perforated or slotted PVC drainage pipes located at the bottom of the backfill trench, lower than the interior floor grade. The drain pipe should be surrounded by properly graded filter rock. A geosynthetic "filter fabric" should then envelope the filter rock. The drain pipe should be connected to a suitable means of disposal, such as a sump basket or a gravity outfall. A storm sewer gravity outfall would be preferred over exterior daylighting, as the latter may freeze during winter. For non-building, exterior retaining walls, weep holes at the base of the wall can be substituted for a drain pipe.

BACKFILLING

Prior to backfilling, damp/water proofing should be applied on perimeter basement walls. The backfill materials placed against basement walls will exert lateral loadings. To reduce this loading by allowing for drainage, we recommend using free-draining sands for backfill. The zone of sand backfill should extend outward from the wall at least 2 feet, and then upward and outward from the wall at a 30° or greater angle from vertical. The free-draining sand backfill should contain no more than 40% by weight passing the #40 sieve and no greater than 5% by weight passing the #200 sieve. The sand backfill should be placed in lifts and compacted with portable compaction equipment. This compaction should be to the specified levels if slabs or pavements are placed above. Where slab/pavements are not above, we recommend capping the sand backfill with a layer of clayey soil to minimize surface water infiltration. Positive surface drainage away from the building should also be maintained. If surface capping or positive surface drainage cannot be maintained, then the trench should be filled with more permeable soils, such as the Fine Filter or Coarse Filter Aggregates defined in MnDOT Specification 3149. You should recognize that if the backfill soils are not properly compacted, settlements may occur which may affect surface drainage away from the building.

Backfilling with silty or clayey soil is possible but not preferred. These soils can build-up water which increases lateral pressures and results in wet wall conditions and possible water infiltration into the basement. If you elect to place silty or clayey soils as backfill, we recommend you place a prefabricated drainage composite against the wall which is hydraulically connected to a drainage pipe at the base of the backfill trench. High plasticity clays should be avoided as backfill due to their swelling potential.

LATERAL PRESSURES

Lateral earth pressures on below grade walls vary, depending on backfill soil classification, backfill compaction and slope of the backfill surface. Static or dynamic surcharge loads near the wall will also increase lateral wall pressure. For design, we recommend the following ultimate lateral earth pressure values (given in equivalent fluid pressure values) for a drained soil compacted to 95% of the Standard Proctor density and a level ground surface.

	Equivalent Fluid Density	
Soil Type	**Active (pcf)**	**At-Rest (pcf)**
Sands (SP or SP-SM)	35	60
Silty Sands (SM)	45	65
Fine Grained Soils (SC, CL or ML)	70	90

Basement walls are normally restrained at the top which restricts movement. In this case, the design lateral pressures should be the "at-rest" pressure situation. Retaining walls which are free to rotate or deflect should be designed using the active case. Lateral earth pressures will be significantly higher than that shown if the backfill soils are not drained and become saturated.

FREEZING WEATHER EFFECTS ON BUILDING CONSTRUCTION

GENERAL

Because water expands upon freezing and soils contain water, soils which are allowed to freeze will heave and lose density. Upon thawing, these soils will not regain their original strength and density. The extent of heave and density/strength loss depends on the soil type and moisture condition. Heave is greater in soils with higher percentages of fines (silts/clays). High silt content soils are most susceptible, due to their high capillary rise potential which can create ice lenses. Fine grained soils generally heave about 1/4" to 3/8" for each foot of frost penetration. This can translate to 1" to 2" of total frost heave. This total amount can be significantly greater if ice lensing occurs.

DESIGN CONSIDERATIONS

Clayey and silty soils can be used as perimeter backfill, although the effect of their poor drainage and frost properties should be considered. Basement areas will have special drainage and lateral load requirements which are not discussed here. Frost heave may be critical in doorway areas. Stoops or sidewalks adjacent to doorways could be designed as structural slabs supported on frost footings with void spaces below. With this design, movements may then occur between the structural slab and the adjacent on-grade slabs. Non-frost susceptible sands (with less than 40% by weight passing a #40 sieve and no more than 5% by weight passing a #200 sieve) can be used below such areas. Depending on the function of surrounding areas, the sand layer may need a thickness transition away from the area where movement is critical. With sand placement over slower draining soils, subsurface drainage would be needed for the sand layer. High density extruded polystyrene insulation could be used within the sand to reduce frost penetration, thereby reducing the sand thickness needed. We caution that insulation placed near the surface can increase the potential for ice glazing of the surface.

The possible effects of adfreezing should be considered if clayey or silty soils are used as backfill. Adfreezing occurs when backfill adheres to rough surfaced foundation walls and lifts the wall as it freezes and heaves. This occurrence is most common with masonry block walls, unheated or poorly heated building situations and clay backfill. The potential is also increased where backfill soils are poorly compacted and become saturated. The risk of adfreezing can be decreased by placing a low friction separating layer between the wall and backfill.

Adfreezing can occur on exterior piers (such as deck, fence, or other similar pier footings), even if a smooth surface is provided. This is more likely in poor drainage situations where soils become saturated. Additional footing embedment and/or widened footings below the frost zones (which include tensile reinforcement) can be used to resist uplift forces. Specific designs would require individual analysis.

CONSTRUCTION CONSIDERATIONS

Foundations, slabs and other improvements which may be affected by frost movements should be insulated from frost penetration during freezing weather. If filling takes place during freezing weather, all frozen soils, snow and ice should be stripped from areas to be filled prior to new fill placement. The new fill should not be allowed to freeze during transit, placement or compaction. This should be considered in the project scheduling, budgeting and quantity estimating. It is usually beneficial to perform cold weather earthwork operations in small areas where grade can be attained quickly rather than working larger areas where a greater amount of frost stripping may be needed. If slab subgrade areas freeze, we recommend the subgrade be thawed prior to floor slab placement. The frost action may also require reworking and recompaction of the thawed subgrade.

BITUMINOUS PAVEMENT SUBGRADE PREPARATION AND DESIGN

GENERAL

Bituminous pavements are considered layered "flexible" systems. Dynamic wheel loads transmit high local stresses through the bituminous/base onto the subgrade. Because of this, the upper portion of the subgrade requires high strength/stability to reduce deflection and fatigue of the bituminous/base system. The wheel load intensity dissipates through the subgrade such that the high level of soil stability is usually not needed below about 2 feet to 4 feet (depending on the anticipated traffic and underlying soil conditions). This is the primary reason for specifying a higher level of compaction within the upper subgrade zone versus the lower portion. Moderate compaction is usually desired below the upper critical zone, primarily to avoid settlements/sags of the roadway. However, if the soils present below the upper 3 feet subgrade zone are unstable, attempts to properly compact the upper 3 feet zone to the 100% level may be difficult or not possible. Therefore, control of moisture just below the 3 feet level may be needed to provide a non-yielding base upon which to compact the upper subgrade soils.

Long-term pavement performance is dependent on the soil subgrade drainage and frost characteristics. Poor to moderate draining soils tend to be susceptible to frost heave and subsequent weakening upon thaw. This condition can result in irregular frost movements and "pop-outs," as well as an accelerated softening of the subgrade. Frost problems become more pronounced when the subgrade is layered with soils of varying permeability. In this situation, the free-draining soils provide a pathway and reservoir for water infiltration which exaggerates the movements. The placement of a well-drained sand subbase layer as the top of subgrade can minimize trapped water, smooth frost movements and significantly reduce subgrade softening. In wet, layered and/or poor drainage situations, the long-term performance gain should be significant. If a sand subbase is placed, we recommend it be a "Select Granular Borrow" which meets Mn/DOT Specification 3149.2B2.

PREPARATION

Subgrade preparation should include stripping surficial vegetation and organic soils; where the exposed soils are within the upper "critical" subgrade zone (generally 2 feet deep for "auto only" areas and 3 feet deep for "heavy duty" areas), they should be evaluated for stability. Excavation equipment may make such areas obvious due to deflection and rutting patterns. Final evaluation of soils within the critical subgrade zone should be done by test rolling with heavy rubber-tired construction equipment, such as a loaded dump truck. Soils which rut or deflect 1" or more under the test roll should be corrected by either subcutting or replacement; or by scarification, drying, and recompaction. Reworked soils and new fill should be compacted per the "Specified Density Method" outlined in Mn/DOT Specification 2105.3F1 (a minimum of 100% of Standard Proctor density in the upper 3 feet subgrade zone, and a minimum of 95% below this).

Subgrade preparation scheduling can be an important consideration. Fall and Spring seasons usually have unfavorable weather for soil drying. Stabilizing non-sand subgrades during these seasons may be difficult, and attempts often result in compromising the pavement quality. Where construction scheduling requires subgrade preparation during these times, the use of a sand subbase becomes even more beneficial for constructability reasons.

SUBGRADE DRAINAGE

If a sand subbase layer is used, it should be provided with a means of subsurface drainage to prevent water build-up. This can be in the form of draintile lines which dispose into storm sewer systems, or outlets into ditches. Where sand subbase layers include sufficient sloping and water can migrate to lower areas, draintile lines can be limited to finger drains at the catch basins. Even if a sand layer is not placed, strategically placed draintile lines can aid in improving pavement performance. This would be most important in areas where adjacent non-paved areas slope towards the pavement. Perimeter edge drains can aid in intercepting water which may infiltrate below the pavement.

Appendix A

Geotechnical Field Exploration and Testing
Boring Log Notes
Unified Soil Classification System
Boring Locations
Subsurface Boring Logs
Gradation Curves

Appendix A
Geotechnical Field Exploration and Testing
Report No. 20-23500

A.1 FIELD EXPLORATION

The subsurface conditions at the site were explored by drilling and sampling eleven standard penetration test borings. The locations of the borings appear are provided on the figure preceding the Subsurface Boring Logs in this appendix.

A.2 SAMPLING METHODS

A.2.1 Split-Spoon Samples (SS) - Calibrated to N_{60} Values

Standard penetration (split-spoon) samples were collected in general accordance with ASTM: D1586 with one primary modification. The ASTM test method consists of driving a 2-inch O.D. split-barrel sampler into the in-situ soil with a 140-pound hammer dropped from a height of 30 inches. The sampler is driven a total of 18 inches into the soil. After an initial set of 6 inches, the number of hammer blows to drive the sampler the final 12 inches is known as the standard penetration resistance or N-value. Our method uses a modified hammer weight, which is determined by measuring the system energy using a Pile Driving Analyzer (PDA) and an instrumented rod.

In the past, standard penetration N-value tests were performed using a rope and cathead for the lift and drop system. The energy transferred to the split-spoon sampler was typically limited to about 60% of its potential energy due to the friction inherent in this system. This converted energy then provides what is known as an N_{60} blow count.

The most recent drill rigs incorporate an automatic hammer lift and drop system, which has higher energy efficiency and subsequently results in lower N-values than the traditional N_{60} values. By using the PDA energy measurement equipment, we are able to determine actual energy generated by the drop hammer. With the various hammer systems available, we have found highly variable energies ranging from 55% to over 100%. Therefore, the intent of AET's hammer calibrations is to vary the hammer weight such that hammer energies lie within about 60% to 65% of the theoretical energy of a 140-pound weight falling 30 inches. The current ASTM procedure acknowledges the wide variation in N-values, stating that N-values of 100% or more have been observed. Although we have not yet determined the statistical measurement uncertainty of our calibrated method to date, we can state that the accuracy deviation of the N-values using this method is significantly better than the standard ASTM Method.

A.2.2 Disturbed Samples (DS)/Spin-up Samples (SU)

Sample types described as "DS" or "SU" on the boring logs are disturbed samples, which are taken from the flights of the auger. Because the auger disturbs the samples, possible soil layering and contact depths should be considered approximate.

A.2.3 Sampling Limitations

Unless actually observed in a sample, contacts between soil layers are estimated based on the spacing of samples and the action of drilling tools. Cobbles, boulders, and other large objects generally cannot be recovered from test borings, and they may be present in the ground even if they are not noted on the boring logs.

Determining the thickness of "topsoil" layers is usually limited, due to variations in topsoil definition, sample recovery, and other factors. Visual-manual description often relies on color for determination, and transitioning changes can account for significant variation in thickness judgment. Accordingly, the topsoil thickness presented on the logs should not be the sole basis for calculating topsoil stripping depths and volumes. If more accurate information is needed relating to thickness and topsoil quality definition, alternate methods of sample retrieval and testing should be employed.

A.3 CLASSIFICATION METHODS

Soil descriptions shown on the boring logs are based on the Unified Soil Classification (USC) system. The USC system is described in ASTM: D2487 and D2488. Where laboratory classification tests (sieve analysis or Atterberg Limits) have been performed, accurate classifications per ASTM: D2487 are possible. Otherwise, soil descriptions shown on the boring logs are visual-manual judgments. Charts are attached which provide information on the USC system, the descriptive terminology, and the symbols used on the boring logs.

The boring logs include descriptions of apparent geology. The geologic depositional origin of each soil layer is interpreted primarily by observation of the soil samples, which can be limited. Observations of the surrounding topography, vegetation, and development can sometimes aid this judgment.

A.4 WATER LEVEL MEASUREMENTS

The groundwater level measurements are shown at the bottom of the boring logs. The following information appears under "Water Level Measurements" on the logs:

- Date and Time of measurement
- Sampled Depth: lowest depth of soil sampling at the time of measurement
- Casing Depth: depth to bottom of casing or hollow-stem auger at time of measurement
- Cave-in Depth: depth at which measuring tape stops in the borehole
- Water Level: depth in the borehole where free water is encountered
- Drilling Fluid Level: same as Water Level, except that the liquid in the borehole is drilling fluid

The true location of the water table at the boring locations may be different than the water levels measured in the boreholes. This is possible because there are several factors that can affect the water level measurements in the borehole. Some of these factors include: permeability of each soil layer in profile, presence of perched water, amount of time between water level readings, presence of drilling fluid, weather conditions, and use of borehole casing.

A.5 LABORATORY TEST METHODS

A.5.1 Water Content Tests

Conducted per AET Procedure 01-LAB-010, which is performed in general accordance with ASTM: D2216 and AASHTO: T265.

A.5.2 Sieve Analysis of Soils (thru #200 Sieve)

Conducted per AET Procedure 01-LAB-040, which is performed in general conformance with ASTM: D6913, Method A.

A.6 TEST STANDARD LIMITATIONS

Field and laboratory testing is done in general conformance with the described procedures. Compliance with any other standards referenced within the specified standard is neither inferred nor implied.

A.7 SAMPLE STORAGE

Unless notified to do otherwise, we routinely retain representative samples of the soils recovered from the borings for a period of 30 days.

BORING LOG NOTES

DRILLING AND SAMPLING SYMBOLS

Symbol	Definition
AR:	Sample of material obtained from cuttings blown out the top of the borehole during air rotary procedure.
B, H, N:	Size of flush-joint casing
CAS:	Pipe casing, number indicates nominal diameter in inches
COT:	Clean-out tube
DC:	Drive casing; number indicates diameter in inches
DM:	Drilling mud or bentonite slurry
DR:	Driller (initials)
DS:	Disturbed sample from auger flights
DP:	Direct push drilling; a 2.125 inch OD outer casing with an inner 1½ inch ID plastic tube is driven continuously into the ground.
FA:	Flight auger; number indicates outside diameter in inches
HA:	Hand auger; number indicates outside diameter
HSA:	Hollow stem auger; number indicates inside diameter in inches
LG:	Field logger (initials)
MC:	Column used to describe moisture condition of samples and for the ground water level symbols
N (BPF):	Standard penetration resistance (N-value) in blows per foot (see notes)
NQ:	NQ wireline core barrel
PQ:	PQ wireline core barrel
RDA:	Rotary drilling with compressed air and roller or drag bit.
RDF:	Rotary drilling with drilling fluid and roller or drag bit
REC:	In split-spoon (see notes), direct push and thin-walled tube sampling, the recovered length (in inches) of sample. In rock coring, the length of core recovered (expressed as percent of the total core run). Zero indicates no sample recovered.
SS:	Standard split-spoon sampler (steel; 1.5" is inside diameter; 2" outside diameter); unless indicated otherwise
SU	Spin-up sample from hollow stem auger
TW:	Thin-walled tube; number indicates inside diameter in inches
WASH:	Sample of material obtained by screening returning rotary drilling fluid or by which has collected inside the borehole after “falling” through drilling fluid
WH:	Sampler advanced by static weight of drill rod and hammer
WR:	Sampler advanced by static weight of drill rod
94mm:	94 millimeter wireline core barrel
▼:	Water level directly measured in boring
▽:	Estimated water level based solely on sample appearance

TEST SYMBOLS

Symbol	Definition
CONS:	One-dimensional consolidation test
DEN:	Dry density, pcf
DST:	Direct shear test
E:	Pressuremeter Modulus, tsf
HYD:	Hydrometer analysis
LL:	Liquid Limit, %
LP:	Pressuremeter Limit Pressure, tsf
OC:	Organic Content, %
PERM:	Coefficient of permeability (K) test; F - Field; L - Laboratory
PL:	Plastic Limit, %
q_p:	Pocket Penetrometer strength, tsf (approximate)
q_c:	Static cone bearing pressure, tsf
q_u:	Unconfined compressive strength, psf
R:	Electrical Resistivity, ohm-cms
RQD:	Rock Quality Designation of Rock Core, in percent (aggregate length of core pieces 4" or more in length as a percent of total core run)
SA:	Sieve analysis
TRX:	Triaxial compression test
VSR:	Vane shear strength, remolded (field), psf
VSU:	Vane shear strength, undisturbed (field), psf
WC:	Water content, as percent of dry weight
%-200:	Percent of material finer than #200 sieve

STANDARD PENETRATION TEST NOTES
(Calibrated Hammer Weight)

The standard penetration test consists of driving a split-spoon sampler with a drop hammer (calibrated weight varies to provide N_{60} values) and counting the number of blows applied in each of three 6" increments of penetration. If the sampler is driven less than 18" (usually in highly resistant material), permitted in ASTM: D1586, the blows for each complete 6" increment and for each partial increment is on the boring log. For partial increments, the number of blows is shown to the nearest 0.1' below the slash.

The length of sample recovered, as shown on the “REC” column, may be greater than the distance indicated in the N column. The disparity is because the N-value is recorded below the initial 6" set (unless partial penetration defined in ASTM: D1586 is encountered) whereas the length of sample recovered is for the entire sampler drive (which may even extend more than 18").

UNIFIED SOIL CLASSIFICATION SYSTEM
ASTM Designations: D 2487, D2488

AMERICAN ENGINEERING TESTING, INC.

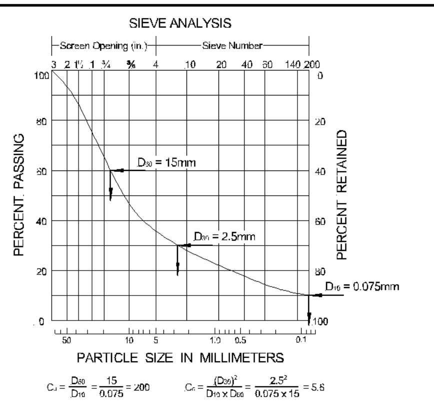
Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Group Symbol	Group Name[B]
Coarse-Grained Soils More than 50% retained on No. 200 sieve	Gravels More than 50% coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]	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[I]
			$Cu < 6$ 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,I]
			Fines classify as CL or CH	SC	Clayey sand[G,H,I]
Fine-Grained Soils 50% or more passes the No. 200 sieve (see Plasticity Chart below)	Silts and Clays Liquid limit less than 50	inorganic	PI>7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI<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	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI 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 soil			Primarily organic matter, dark in color, and organic in odor	PT	Peat[R]

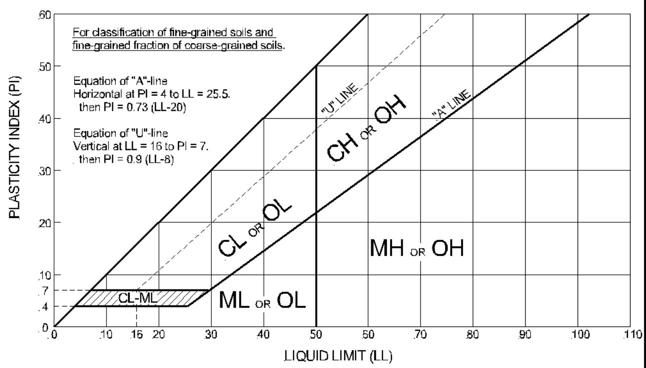
Notes

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

[F]If soil contains ≥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 ≥15% gravel, add "with gravel" to group name.
[J]If Atterberg limits plot is 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 ≥30% plus No. 200, predominantly sand, add "sandy" to group name.
[M]If soil contains ≥30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N]PI≥4 and plots on or above "A" line.
[O]PI<4 or plots below "A" line.
[P]PI plots on or above "A" line.
[Q]PI plots below "A" line.
[R]Fiber Content description shown below.





Plasticity Chart

ADDITIONAL TERMINOLOGY NOTES USED BY AET FOR SOIL IDENTIFICATION AND DESCRIPTION

Grain Size

Term	Particle Size
Boulders	Over 12"
Cobbles	3" to 12"
Gravel	#4 sieve to 3"
Sand	#200 to #4 sieve
Fines (silt & clay)	Pass #200 sieve

Gravel Percentages

Term	Percent
A Little Gravel	3% - 14%
With Gravel	15% - 29%
Gravelly	30% - 50%

Consistency of Plastic Soils

Term	N-Value, BPF
Very Soft	less than 2
Soft	2 - 4
Firm	5 - 8
Stiff	9 - 15
Very Stiff	16 - 30
Hard	Greater than 30

Relative Density of Non-Plastic Soils

Term	N-Value, BPF
Very Loose	0 - 4
Loose	5 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very Dense	Greater than 50

Moisture/Frost Condition (MC Column)

- D (Dry): Absence of moisture, dusty, dry to touch.
- M (Moist): Damp, although free water not visible. Soil may still have a high water content (over "optimum").
- W (Wet/ Waterbearing): Free water visible, intended to describe non-plastic soils. Waterbearing usually relates to sands and sand with silt.
- F (Frozen): Soil frozen

Layering Notes

- Laminations: Layers less than ½" thick of differing material or color.
- Lenses: Pockets or layers greater than ½" thick of differing material or color.

Peat Description

Term	Fiber Content (Visual Estimate)
Fibric Peat:	Greater than 67%
Hemic Peat:	33 – 67%
Sapric Peat:	Less than 33%

Organic Description (if no lab tests)

Soils are described as *organic*, if soil is not peat and is judged to have sufficient organic fines content to influence the Liquid Limit properties. *Slightly organic* used for borderline cases.

Root Inclusions

- With roots: Judged to have sufficient quantity of roots to influence the soil properties.
- Trace roots: Small roots present, but not judged to be in sufficient quantity to significantly affect soil properties.

American Engineering Testing, Inc.		
	PROJECT Humboldt Avenue Apartments	**PREPARED BY** MN
	LOCATION 8200 Humboldt Avenue; Bloomington, Minnesota	**AET NO.** 20-23500
	SUBJECT Soil Boring Locations	**DATE** February 9, 2021

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AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **20-23500**   Log of Boring No. **B-1 (p. 1 of 1)**

Project: **Humboldt Avenue Apartments; Bloomington, MN**

DEPTH IN FEET	Surface Elevation **845.8** MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
	3" Bituminous pavement	FILL									
1	4" FILL, mostly gravel, brown			F							
2	FILL, mostly silty sand, trace roots, a little gravel, brown										
3			11	M	SS	24					
4											
5			11	M	SS	24					
6	SAND, fine grained, light brown, moist, medium dense to loose (SP)	COARSE ALLUVIUM									
7											
8			8	M	SS	20					
9											
10											
11			11	M	SS	19					
12											
13			31	M	SS	20					
14											
15											
16			45	M	SS	24					
	END OF BORING										

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-14½'	**3.25" HSA**	**1/25/21**		**16.5**	**14.5**	**16.5**		**None**

WATER LEVEL MEASUREMENTS

BORING COMPLETED: **1/25/21**

DR: **SG** LG: **SD** Rig: **91C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP 20-23500.GPJ AET+CPT+WELL_20181012_JG.GDT 1/29/21

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AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **20-23500** Log of Boring No. **B-2 (p. 1 of 1)**

Project: **Humboldt Avenue Apartments; Bloomington, MN**

Surface Elevation **846.0**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–0.35	4.25" Bituminous pavement	FILL									
1	FILL, mostly crushed limestone, light brown			F							
2	FILL, mostly silty sand, a little gravel, brown to dark brown										
3			10	M	SS	18					
5			14	M	SS	18					
7	SAND, fine grained, light brown, moist, medium dense (SP)	COARSE ALLUVIUM									
8			13	M	SS	16					
10			11	M	SS	16					
13			14	M	SS	18					
15			15	M	SS	18					
20			18	M	SS	18					
25			21	M	SS	18					
30			22	M	SS	18					
31	**END OF BORING**										

DEPTH:	DRILLING METHOD
0-29½'	**3.25" HSA**

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
1/26/21	**8:28**	**31.0**	**29.5**	**31.0**		**None**

BORING COMPLETED: **1/26/21**

DR: **SG** LG: **SD** Rig: **91C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP 20-23500.GPJ AET+CPT+WELL_20181012_JG.GDT 1/29/21

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AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **20-23500** Log of Boring No. **B-3 (p. 1 of 1)**

Project: **Humboldt Avenue Apartments; Bloomington, MN**

DEPTH IN FEET	Surface Elevation **844.8** MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
	4" Bituminous pavement	FILL									
1	FILL, mostly crushed limestone, light brown			F							
2–4	FILL, mostly silty sand, a little gravel, dark brown		6	M	SS	16					
5–7	SILTY SAND, fine grained, brown, moist, medium dense (SM)	COARSE ALLUVIUM	11	M	SS	18					
7–31	SAND, fine grained, light brown, moist, loose to dense (SP)		13	M	SS	18					
			15	M	SS	18					
			9	M	SS	18					
			13	M	SS	18					
			20	M	SS	18					
			39	M	SS	18					
				M							
			42	M	SS	18					
31	**END OF BORING**										

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-29½'	**3.25" HSA**	**1/26/21**	**9:32**	**31.0**	**29.5**	**31.0**		**None**

WATER LEVEL MEASUREMENTS

BORING COMPLETED: **1/26/21**

DR: **SG** LG: **SD** Rig: **91C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP 20-23500.GPJ AET+CPT+WELL_20181012_JG.GDT 1/29/21

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **20-23500** Log of Boring No. **B-4 (p. 1 of 1)**

Project: **Humboldt Avenue Apartments; Bloomington, MN**

Surface Elevation **845.4**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
	3.5" Bituminous pavement	FILL									
1	6" FILL, mostly crushed limestone, light brown			F							
2	FILL, mostly silty sand, some organic fines, a little gravel, brown to dark brown										
3			6	M	SS	8					
4											
5	SAND, fine grained, light brown, moist, loose to dense (SP)	COARSE ALLUVIUM	8	M	SS	18					
6											
7											
8			12	M	SS	16					
9											
10			7	M	SS	16					
11											
12											
13			7	M	SS	18					
14											
15			8	M	SS	18					
16											
17											
18											
19											
20			31	M	SS	18					
21											
22											
23											
24											
25			22	M	SS	18					
26											
27											
28											
29											
30			49	M	SS	18					
31	**END OF BORING**										

DEPTH: DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-29½' 3.25" HSA							
	1/25/21	**10:58**	**31.0**	**29.5**	**31.0**		**None**
BORING COMPLETED: **1/25/21**							
DR: **SG** LG: **SD** Rig: **91C**							

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP 20-23500.GPJ AET+CPT+WELL_20181012_JG.GDT 1/29/21

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AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **20-23500** Log of Boring No. **B-5 (p. 1 of 1)**

Project: **Humboldt Avenue Apartments; Bloomington, MN**

Surface Elevation **843.8**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–0.25	3" Bituminous pavement	FILL									
1	FILL, mostly crushed limestone, light brown			F							
2–7	FILL, mostly silty and clayey sand, a little gravel, brown		17	M	SS	10					
			8	M	SS	10					
7–9.5	FILL, mostly silty sand with organic fines, black		5	M	SS	8					
9.5–12	SILTY SAND, a little gravel, fine to medium grained, brown (SM)	COARSE ALLUVIUM	9	M	SS	18					
12–31	SAND, fine grained, light brown, moist, loose to dense (SP)		6	M	SS	16					
15			7	M	SS	18					
20			7	M	SS	18					
25			75	M	SS	18					
30			45	M	SS	18					
31	**END OF BORING**										

DEPTH:	DRILLING METHOD
0-29½'	**3.25" HSA**

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
1/26/21	**10:46**	**31.0**	**29.5**	**30.8**		**None**

BORING COMPLETED: **1/26/21**

DR: **SG** LG: **SD** Rig: **91C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP 20-23500.GPJ AET+CPT+WELL_20181012_JG.GDT 1/29/21

AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **20-23500** Log of Boring No. **B-6 (p. 1 of 1)**

Project: **Humboldt Avenue Apartments; Bloomington, MN**

DEPTH IN FEET	Surface Elevation 844.9 MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–1	4.5" Bituminous pavement 4" FILL, mostly crushed limestone, light brown	FILL		F							
3			29	M	SS	14					
5			5	M	SS	10					
7–8	FILL, mostly silty sand, a little gravel, brown		4	M	SS	10					
10	SAND, fine grained, light brown, moist, medium dense (SP)	COARSE ALLUVIUM	13	M	SS	18					
12–13	SILTY SAND, fine grained, brown, moist, loose (SM)		8	M	SS	12					
15	SAND, fine grained, light brown, moist, medium dense to dense (SP)		16	M	SS	12					
20			17	M	SS	14					
25			42	M	SS	18					
30			38	M	SS	18					
31	**END OF BORING**										

DEPTH:	DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-29½'	3.25" HSA	1/25/21	12:18	31.0	29.5	31.0		None

WATER LEVEL MEASUREMENTS

BORING COMPLETED: **1/25/21**

DR: **SG** LG: **SD** Rig: **91C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP 20-23500.GPJ AET+CPT+WELL_20181012_JG.GDT 1/29/21

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AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **20-23500** Log of Boring No. **B-7 (p. 1 of 2)**

Project: **Humboldt Avenue Apartments; Bloomington, MN**

DEPTH IN FEET	Surface Elevation 848.7 MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–4	FILL, mostly silty sand with organic fines, dark brown	FILL	14	F	SS	24					
			3	M	SS	18					
4–7	FILL, mixture of sand and clayey sand, brown		9	M	SS	18					
7–23	SAND, a little gravel, fine to medium grained, brown, moist, very loose to dense (SP)	COARSE ALLUVIUM	3	M	SS	16					
			6	M	SS	18					
			11	M	SS	18					
			12	M	SS	18					
			6	M	SS	18					
			48	M	SS	18					
23–27	CLAYEY SAND, a little gravel, dark brown, very stiff, lens of sand (SC)	TILL	27	M	SS	18					
27–29	SAND, a little gravel, fine to medium grained, brown, moist, medium dense (SP)	COARSE ALLUVIUM	19	M	SS	18					
29–	CLAYEY SAND, a little gravel, brown, loose, lens of sand (SC)	TILL	9	M	SS	18					

DEPTH: DRILLING METHOD	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
0-44½' 3.25" HSA							
	1/27/21	**11:19**	**41.0**	**39.5**	**39.2**		**38.3**
	1/27/21	**11:29**	**41.0**	**39.5**	**38.8**		**37.0**
BORING COMPLETED: **1/27/21**	**1/27/21**	**11:41**	**46.0**	**44.5**	**41.5**		**38.4**
DR: **SG** LG: **SD** Rig: **91C**							

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP 20-23500.GPJ AET+CPT+WELL_20181012_JG.GDT 2/3/21

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AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **20-23500** Log of Boring No. **B-7 (p. 2 of 2)**

Project: **Humboldt Avenue Apartments; Bloomington, MN**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
33–34	SAND, fine grained, light brown, moist, lens of silty sand (SP)	COARSE ALLUVIUM	10	M	SS	18					
34–37	SAND, fine grained, light brown, moist,lens of lean clay (SP)		6	M	SS	16					
37–46	SILTY SAND, a little gravel, fine to medium grained, brown, wet (SM)		7	W	SS	16					
			7	M	SS	18					
			11	W	SS	18					
			6	W	SS	18					
46	**END OF BORING**										

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AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **20-23500** Log of Boring No. **B-8 (p. 1 of 1)**

Project: **Humboldt Avenue Apartments; Bloomington, MN**

DEPTH IN FEET	Surface Elevation 843.8 MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–1	4" Bituminous pavement	FILL									
1	3" FILL, mostly gravelly silty sand, brown			F							
2	FILL, mostly silty sand, brown										
3			13	M	SS	14					
4											
5	SAND, fine grained, light brown, moist,loose to medium dense (SP)	COARSE ALLUVIUM	5	M	SS	12					
6											
7											
8			10	M	SS	16					
9											
10			14	M	SS	18					
11											
12											
13			13	M	SS	10					
14											
15			28	M	SS	14					
16–19											
20			26	M	SS	18					
21–22											
23	SAND WITH SILT, fine grained, light brown, moist, very dense to very dense (SP-SM)										
24											
25			62	M	SS	18					
26–29											
30			48	M	SS	18					
31	**END OF BORING**										

DEPTH:	DRILLING METHOD	WATER LEVEL MEASUREMENTS							NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG
0-29½'	**3.25" HSA**	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL	
		1/25/21		**31.0**	**29.5**	**31.0**		**None**	
BORING COMPLETED: **1/25/21**									
DR: **SG** LG: **SD** Rig: **91C**									

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AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **20-23500** Log of Boring No. **B-9 (p. 1 of 1)**

Project: **Humboldt Avenue Apartments; Bloomington, MN**

Surface Elevation **848.1**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–4	FILL, mostly silty sand with organic fines, trace roots, dark brown	FILL	14	F	SS	4					
			10	M	SS	18					
4–7	FILL, mostly silty sand, brown		7	M	SS	18					
7–9.5	SAND WITH SILT, a little gravel, fine to medium grained, brown, moist, loose (SP-SM)	COARSE ALLUVIUM	10	M	SS	18					
9.5–31	SAND, fine grained, light brown, moist, medium dense, lens of silt at 25' (SP)		11	M	SS	18					
			6	M	SS	16					
			9	M	SS	18					
			10	M	SS	18					
			11	M	SS	18					
			14	M	SS	18					
			17	M	SS	18					
31	**END OF BORING**										

DEPTH:	DRILLING METHOD
0-29½'	**3.25" HSA**

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
1/27/21	**9:28**	**31.0**	**29.5**	**31.0**		**None**

BORING COMPLETED: **1/27/21**

DR: **SG** LG: **SD** Rig: **91C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP 20-23500.GPJ AET+CPT+WELL_20181012_JG.GDT 2/3/21

AMERICAN ENGINEERING TESTING, INC.

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SUBSURFACE BORING LOG

AET No: **20-23500** Log of Boring No. **B-10 (p. 1 of 1)**

Project: **Humboldt Avenue Apartments; Bloomington, MN**

DEPTH IN FEET	Surface Elevation **844.1** MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
	3.5" Bituminous pavement	FILL									
1	FILL, mostly crushed limestone, light brown			F							
2	FILL, mostly silty sand, a little gravel, dark brown	FINE ALLUVIUM	40	M	SS	18					
3-4	SAND, fine grained, light brown, moist, loose to dense (SP)										
5			11	M	SS	18					
8			15	M	SS	18					
10			10	M	SS	18					
13			11	M	SS	18					
15			19	M	SS	18					
20			15	M	SS	18					
25			25	M	SS	18					
30			18	M	SS	18					
31	**END OF BORING**										

DEPTH: DRILLING METHOD		WATER LEVEL MEASUREMENTS							NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG
0-29½'	**3.25" HSA**	DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL	
		1/26/21	**12:55**	**31.0**	**29.5**	**31.0**		**None**	
BORING COMPLETED: **1/26/21**									
DR: **SG** LG: **SD** Rig: **91C**									

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AMERICAN ENGINEERING TESTING, INC.

SUBSURFACE BORING LOG

AET No: **20-23500** Log of Boring No. **B-11 (p. 1 of 1)**

Project: **Humboldt Avenue Apartments; Bloomington, MN**

Surface Elevation **844.3**

DEPTH IN FEET	MATERIAL DESCRIPTION	GEOLOGY	N	MC	SAMPLE TYPE	REC IN.	WC	DEN	LL	PL	%-#200
0–2	FILL, mostly silty sand with organic fines, a little gravel, trace roots, dark brown	FILL		F							
2–31	SAND, fine grained, light brown, moist, loose to dense (SP)	COARSE ALLUVIUM	29	M	SS	16					
			9	M	SS	16					
			14	M	SS	12					
			9	M	SS	18					
			10	M	SS	18					
			14	M	SS	18					
			36	M	SS	18					
			28	M	SS	18					
			28	M	SS	18					
31	**END OF BORING**										

DEPTH:	DRILLING METHOD
0-29½'	**3.25" HSA**

WATER LEVEL MEASUREMENTS

DATE	TIME	SAMPLED DEPTH	CASING DEPTH	CAVE-IN DEPTH	DRILLING FLUID LEVEL	WATER LEVEL
1/26/21	**11:46**	**31.0**	**29.5**	**31.0**		**None**

BORING COMPLETED: **1/26/21**

DR: **SG** LG: **SD** Rig: **91C**

NOTE: REFER TO THE ATTACHED SHEETS FOR AN EXPLANATION OF TERMINOLOGY ON THIS LOG

AET_CORP 20-23500.GPJ AET+CPT+WELL_20181012_JG.GDT 1/29/21

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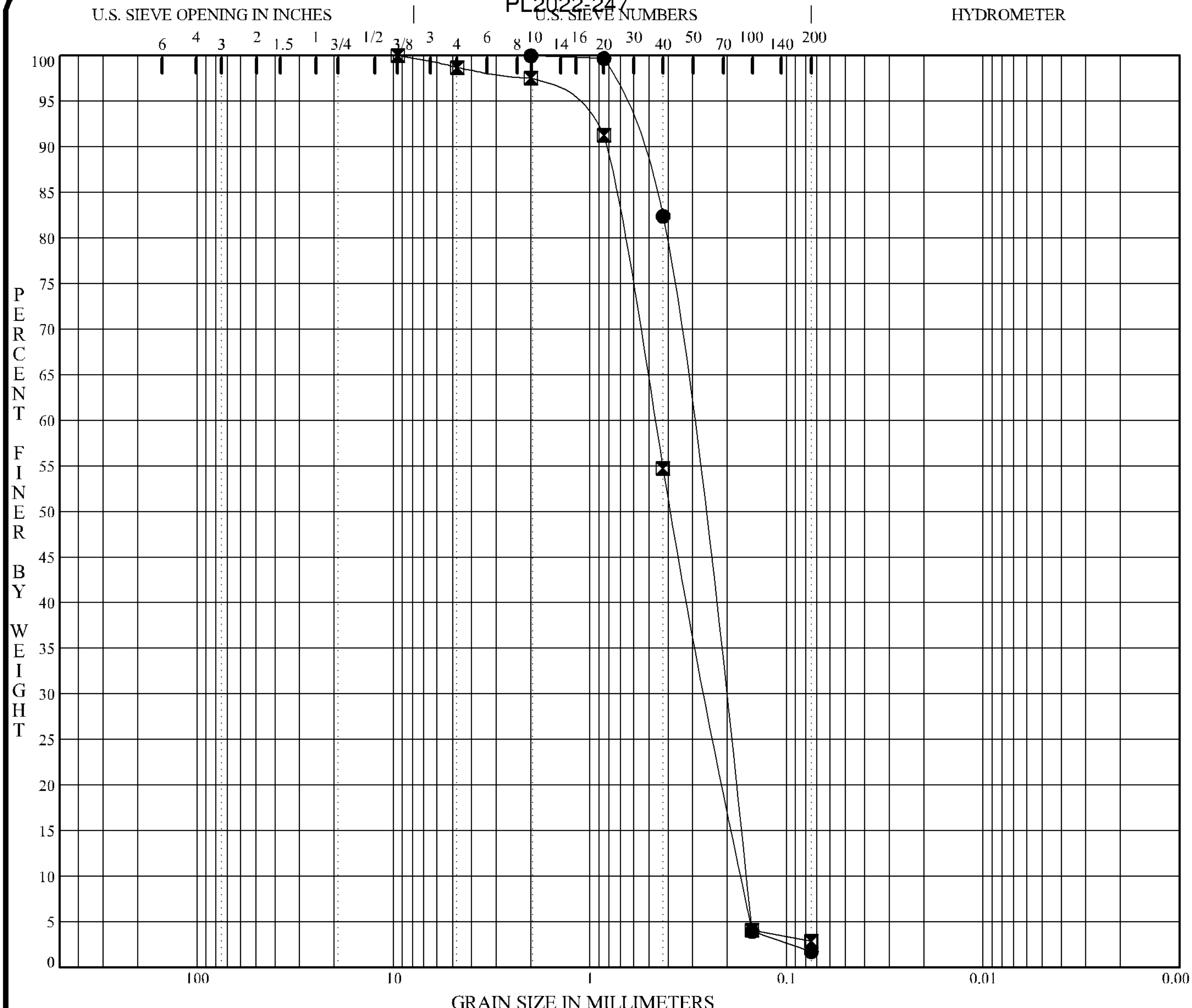

	Specimen Identification		Classification	MC%	LL	PL	PI	Cc	Cu
●	**B-10**	**4.5'**	**POORLY GRADED SAND**	**N/A**	**N/A**	**N/A**	**N/A**	**0.88**	**1.9**
⧗	**B-5**	**19.5'**	**POORLY GRADED SAND**	**N/A**	**N/A**	**N/A**	**N/A**	**0.82**	**2.8**

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	**B-10**	**4.5'**	**2.00**	**0.32**	**0.212**	**0.1626**	**0.0**	**98.3**	**1.7**	
⧗	**B-5**	**19.5'**	**9.50**	**0.47**	**0.256**	**0.1694**	**1.3**	**95.8**	**2.9**	

PROJECT **Humboldt Avenue Apartments; Bloomington, MN**

AET JOB NO. **20-23500**

DATE **1/26/21**

AMERICAN ENGINEERING TESTING, INC.

GRADATION CURVES

Appendix B

Geotechnical Report Limitations and Guidelines for Use

Appendix B
Geotechnical Report Limitations and Guidelines for Use
Report No. 20-23500

B.1 REFERENCE

This appendix provides information to help you manage your risks relating to subsurface problems which are caused by construction delays, cost overruns, claims, and disputes. This information was developed and provided by GBA[1], of which, we are a member firm.

B.2 RISK MANAGEMENT INFORMATION

B.2.1 Understand the Geotechnical Engineering Services Provided for this Report

Geotechnical engineering services typically include the planning, collection, interpretation, and analysis of exploratory data from widely spaced borings and/or test pits. Field data are combined with results from laboratory tests of soil and rock samples obtained from field exploration (if applicable), observations made during site reconnaissance, and historical information to form one or more models of the expected subsurface conditions beneath the site. Local geology and alterations of the site surface and subsurface by previous and proposed construction are also important considerations. Geotechnical engineers apply their engineering training, experience, and judgment to adapt the requirements of the prospective project to the subsurface model(s). Estimates are made of the subsurface conditions that will likely be exposed during construction as well as the expected performance of foundations and other structures being planned and/or affected by construction activities.

The culmination of these geotechnical engineering services is typically a geotechnical engineering report providing the data obtained, a discussion of the subsurface model(s), the engineering and geologic engineering assessments and analyses made, and the recommendations developed to satisfy the given requirements of the project. These reports may be titled investigations, explorations, studies, assessments, or evaluations. Regardless of the title used, the geotechnical engineering report is an engineering interpretation of the subsurface conditions within the context of the project and does not represent a close examination, systematic inquiry, or thorough investigation of all site and subsurface conditions.

B.2.2 Geotechnical Engineering Services are Performed for Specific Purposes, Persons, and Projects, and At Specific Times

Geotechnical engineers structure their services to meet the specific needs, goals, and risk management preferences of their clients. A geotechnical engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared solely for the client.

Likewise, geotechnical engineering services are performed for a specific project and purpose. For example, it is unlikely that a geotechnical engineering study for a refrigerated warehouse will be the same as one prepared for a parking garage; and a few borings drilled during a preliminary study to evaluate site feasibility will not be adequate to develop geotechnical design recommendations for the project.

Do <u>not</u> rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project or purpose;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, the reliability of a geotechnical-engineering report can be affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. If you are the least bit uncertain about the continued reliability of this report, contact your geotechnical engineer before applying the recommendations in it. A minor amount of additional testing or analysis after the passage of time – if any is required at all – could prevent major problems.

1 Geoprofessional Business Association, 1300 Piccard Drive, LL14, Rockville, MD 20850
Telephone: 301/565-2733: www.geoprofessional.org, 2019

B.2.3 Read the Full Report
Costly problems have occurred because those relying on a geotechnical-engineering report did not read the report in its entirety. Do not rely on an executive summary. Do not read selective elements only. Read and refer to the report in full.

B.2.4 You Need to Inform Your Geotechnical Engineer About Change
Your geotechnical engineer considered unique, project-specific factors when developing the scope of study behind this report and developing the confirmation-dependent recommendations the report conveys. Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the elevation, configuration, location, orientation, function or weight of the proposed structure and the desired performance criteria;
- the composition of the design team; or
- project ownership.

As a general rule, always inform your geotechnical engineer of project or site changes – even minor ones – and request an assessment of their impact. The geotechnical engineer who prepared this report cannot accept responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.

B.2.5 Most of the "Findings" Related in This Report Are Professional Opinions
Before construction begins, geotechnical engineers explore a site's subsurface using various sampling and testing procedures. Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing is performed. The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgement to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team through project completion to obtain informed guidance quickly, whenever needed.

B.2.6 This Report's Recommendations Are Confirmation-Dependent
The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, they are not final, because the geotechnical engineer who developed them relied heavily on judgement and opinion to do so. Your geotechnical engineer can finalize the recommendations only after observing actual subsurface conditions exposed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.

B.2.7 This Report Could Be Misinterpreted
Other design professionals' misinterpretation of geotechnical engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a continuing member of the design team, to:

- confer with other design-team members;
- help develop specifications;
- review pertinent elements of other design professionals' plans and specifications; and
- be available whenever geotechnical engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction-phase observations.

B.2.8 Give Constructors a Complete Report and Guidance
Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical engineering report, along with any attachments or appendices, with your contract documents, but be certain to note conspicuously that you've included the material for information purposes only. To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report. Be certain that constructors know they may learn about

specific project requirements, including options selected from the report, only from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to and be sure to allow enough time to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

B.2.9 Read Responsibility Provisions Closely
Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. This happens in part because soil and rock on project sites are typically heterogeneous and not manufactured materials with well-defined engineering properties like steel and concrete. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. Read these provisions closely. Ask questions. Your geotechnical engineer should respond fully and frankly.

B.2.10 Geoenvironmental Concerns Are Not Covered
The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical engineering study. For that reason, a geotechnical engineering report does not usually provide environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. Unanticipated subsurface environmental problems have led to project failures. If you have not obtained your own environmental information about the project site, ask your geotechnical consultant for a recommendation on how to find environmental risk-management guidance.

B.2.11 Obtain Professional Assistance to Deal with Moisture Infiltration and Mold
While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, the engineer's services were not designed, conducted, or intended to prevent migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration. Confront the risk of moisture infiltration by including building-envelope or mold specialists on the design team. Geotechnical engineers are not building-envelope or mold specialists.

Attachment F – StormTech Removal Efficiency Summary

StormTech®
Detention • Retention • Recharge
Subsurface Stormwater Management℠

Isolator Row Testing Summary

Thank you for your interest in the StormTech Isolator Row testing done to date. Below is a summary of the testing that has been completed on the StormTech Isolator Row. The most current testing done by the University of New Hampshire provides the data for 80% removal of TSS. The UNH testing was completed in the field as opposed to a lab test. Any of the referenced reports are available upon request.

- February 23, 2005 - Tennessee Tech University summarized laboratory testing on the Isolator Row in accordance with Maine DEP testing protocol. Tests demonstrated the following:
    - 95% TSS overall removal at 8.1 gpm/sqft for US Silica OK-110 (110 micron).
    - 80% captured on fabric.

- October 20, 2006 - Tennessee Tech University summarized laboratory testing on the Isolator Row in accordance with New Jersey Center for Advanced Technologies (NJCAT) testing protocol. Tests demonstrated the following:
    - 60% TSS Removal at 3.2 gpm/sqft for Sil-Co-Sil 106 with accumulated fines (D_{50} = 10 microns)
    - 66% TSS Removal at 3.2 gpm/sqft for Sil-Co-Sil 106 (D_{50} = 22 microns)
    - 71% TSS Removal at 3.2 gpm/sqft for Sil-Co-Sil 250 (D_{50} = 45 microns)
    - 88% TSS Removal at 1.7 gpm/sqft for Sil-Co-Sil 250 (D_{50} = 45 microns)

- August, 2007 – NJCAT summarized its third party evaluation of the Tennessee Tech test results and produced the "NJCAT Technology Verification Report StormTech Isolator Row". Their verification is summarized as follows:

    - **Claim 1:** A StormTech® SC-740 Isolator™ Row, sized at a treatment rate of no more than 2.5 gpm/ft^2 of bottom area, using two layers of woven geotextile fabric under the base of the system and one layer of non-woven fabric wrapped over the top of the system and a mean event influent concentration of 270 mg/L (range of 139 – 361 mg/L) has been shown to have a TSS removal efficiency (measured as SSC) of at least 60% for SIL-CO-SIL 106, a manufactured silica product with an average particle size of 22 microns, in laboratory studies using simulated stormwater.

    - **Claim 2:** A StormTech® SC-740 Isolator™ Row, sized at a treatment rate of no more than 2.5 gpm/ft^2 of bottom area, using two layers of woven geotextile fabric under the base of the system and one layer of non-woven fabric wrapped over the top of the system and a mean event influent concentration of 318 mg/L (range of 129 – 441 mg/L) has been shown to have a TSS removal efficiency (measured as SSC) of 84% for SIL-CO-SIL

250, a manufactured silica product with an average particle size of 45 microns, in laboratory studies using simulated stormwater.

- **Claim 3:** A StormTech® SC-740 Isolator™ Row, sized at a treatment rate of no more than 6.5 gpm/ft^2 of bottom area, using a single layer of woven geotextile fabric under the base of the system and one layer of non-woven fabric wrapped over the top of the system and a mean event influent concentration of 371 mg/L (range of 116 – 614 mg/L) has been shown to have a TSS removal efficiency (measured as SSC) of greater than 95% for OK-110, a manufactured silica product with an average particle size of 110 microns, in laboratory studies using simulated stormwater.

- June 2008 – The University of New Hampshire Stormwater Center releases the Final Report on Field Verification Testing of the StormTech Isolator Row Treatment Unit. Testing consisted of determining the water quality performance for multiple stormwater pollutants. As of the June report, data was recorded for 17 storm events.

  - TSS median removal efficiency – 80%
  - Petroleum Hydrocarbons median removal efficiency – 90%
  - Zinc median removal efficiency – 53%
  - Phosphorus median removal efficiency – 49%

References:

1. February 23, 2005 Tenn Tech report
2. October 20, 2006 Tenn Tech report
3. August 2007 NJCAT Verification
4. June 2008 UNH report

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StormTech
Detention • Retention • Water Quality
Division of ADS

Summary of Water Quality Performance Studies for the Isolator Row

Introduction

Any stormwater treatment system, ranging from a wet pond to an underground manufactured system requires field testing and an evaluation of the pollutant removal efficiencies. These systems in a network of BMP's can be used to model sediment reduction, phosphorus removal, metal reduction and other constituents. StormTech, a division of Advanced Drainage Systems, Inc. (ADS) has developed the summarized data for pollutant loading inputs into modeling software programs.

The Isolator row has been tested by independent agencies and reports are available. These reports have been provided to the University of MN, St. Anthony Falls Laboratory and evaluated for methodology, oversight, and relevance to Minnesota.*

Data

To aid designers with choosing between different BMP options the MN Stormwater Manual tabulated the current median pollutant removal percentages.

Practice	TSS	TP	PP	DP	TN	Metals	PHC
Biofiltration	85	44	80	20	50	35	80
Constructed Ponds	84	50	91	0	30	70	80
Constructed Wetlands	73	38	69	0	30	70	80
Iron Enhanced Sandfilter	85	77	91	60	35	50	80
Permeable Pavement	74	45	82	0			
Sandfilter	85	50	91	0	35	50	80

Summary of common pollutant removal percentages in MN Stormwater Manual.

TSS=Total Suspended Solids, TP=Total Phosphorus, PP=Particulate Phosphorus, DP=Dissolved Phosphorus, TN=Total Nitrogen, PHC=Petroleum Hydrocarbons

Stormwater Research Center Data

Preamble: ADS has been providing water quality devices which can be routed through a treatment train for infiltration, filtration, and sedimentation. These devices constitute a cost effective and maintainable BMP for urban runoff. These devices and the load removal efficiencies, particulate sizing, and concentrations are available by contacting a local ADS representative.

StormTech chambers feature an "isolator row" to provide water quality treatment of stormwater as it enters the system. The isolator row features a typical StormTech chamber wrapped in woven geotextile fabric. Stormwater first enters the isolator row which traps sediments and pollutants via the filter fabric and then allows stormwater to pass through the fabric in a treated state to the adjacent chambers and stone material via hydrostatic flow. The overall system typically features a 6-inch HDPE perforated under drain line placed along one side of the excavation bottom to provide flow discharge control from the system. Because the excavation for the system is typically unlined, some infiltration of stormwater can be expected if sub-surface soils are conducive to infiltration.

Isolator Row (IR):

The University of New Hampshire Stormwater Research Center conducted field testing of 17 rain events from December 2006—March 2008, encompassing 3 winter seasons. New Hampshire is of similar latitude and climate with similar rain events to Minnesota. Additionally, separate field testing was performed under the direction of the University of North Carolina. Lab testing evaluated sizes for particulates from ranging from 110 microns (OK-110) to 22 microns (Sil-Co-Sil 106). Flow rates ranged from 1.7 gpm/sqft to 3.2 gpm/sqft. Median pollutant removal percentages from field testing are summarized.

Practice	TSS	TP	PP	DP	TN	Metals	PHC
Isolator Row	80	49	89[1]	0	37[2]	76[2]	90

Above data was measured at the University of New Hampshire Stormwater Center, June 2008 report.

1. *Estimated assuming phosphorus concentrated fraction = 55% particulate / 45% dissolved (MIDS Calculator and Pitt, R., Maestre, A., Morquecho, R., Brown, T., Schueler, T., Cappiella, K., and Sturm, P. (2005). Evaluation of NPDES Phase 1 Municipal Stormwater Monitoring Data." University of Alabama and the Center for Watershed Protection).*
2. Charlotte, NC - Cherry Gardens, Charlotte-Mecklenburg Stormwater Services.

* Erickson, A.J. (2017). "Stormwater Master Class: Pollutants, Treatment, Filtration, Inspection, Maintenance and Cost," *Water Quality Forum 1.0. Hosted by ADS. Minneapolis, MN*