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November 14, 2007

Robert Miller, P.E.
Project Manager
CH2M Hill Ltd.
1001 Lakeside Avenue
990 North Point Tower
Cleveland, Ohio 44114

Re: **Bearing Capacity and Settlement Evaluation**
(Culvert at STA. 609+50)
SCI-823-0.00 Portsmouth Bypass
DLZ Job No.: 0121-3070.03
Document # 0094

Dear Mr. Miller:

This letter presents the findings of preliminary evaluations of the proposed culvert at Station 609+50 on the above-referenced project. The findings of other culvert and embankment evaluations will be submitted in separate documents.

It is our understanding that a new culvert will be constructed at Station 609+50 for the above referenced project. The culvert will be a 10 ft × 5 ft box culvert in accordance with ODOT specifications. Preliminary plans indicate the flow line of the culvert ranges from approximately 9 to 6 feet below existing grade. The inlet and outlet of the culvert will be supported by headwalls flush with the face of the pipe at both ends. At the time of preparing this letter no further information was available regarding the proposed culvert.

It should be noted that the results of this preliminary evaluation are based upon the findings of two culvert borings (C-120 and C-121) located along the proposed alignment of the culvert. The borings were advanced to depths ranging between 26.3 and 32.5 feet below the ground surface. Logs of the borings, a plan and profile drawing showing the approximate locations of the borings, a legend of the boring log terminology and general information regarding the drilling procedures are attached. The surveyed ground elevations at the boring locations are reported on the logs.

Exploration Findings

Borings C-120 and C-121 were located near the outlet and inlet of the proposed culvert and encountered 8.0 and 15.5 feet, respectively, of cohesive soil (A4b, A-6a, A-6b) underlain by granular soil (A-1-b, A-2-6) over sandstone and shale bedrock. The consistency of the soil

ranged from stiff to hard but was predominantly hard. The bedrock was generally slightly weathered and slightly to severely fractured.

Bearing Capacity and Settlement Evaluation

The preliminary plans indicate that the invert elevations at the inlet and outlet of the proposed culvert are 531.00 and 530.00, respectively. The bottoms of the headwall footings were assumed to be 4 feet below the invert elevations to place them below the frost zone and prevent scour of the headwall (Ohio BDM Section 200). Based on the results of the borings, the footings will bear in stiff to very stiff silt and clay (A-6a) or very loose gravel with sand (A-1-b). Footings bearing in the native soil may be designed based on an allowable bearing capacity of 1,000 pounds per square foot (psf). Since the proposed culvert is located in an area where proposed grade is essentially the same as existing, post construction settlement of the culvert is expected to be negligible.

It should be noted that boring C-121 encountered very loose, wet, granular soil at the proposed bearing elevation. These materials may be unstable under construction activities and will likely require dewatering and/or overexcavation and replacement to allow construction of the headwall footing.

We appreciate having the opportunity to be of service to you on this project. Please do not hesitate to call if you have any questions concerning our preliminary findings.

Respectfully submitted,

DLZ OHIO, INC.

Wael Alkasawneh, P.E.
Geotechnical Engineer

Bryan Wilson, P.E.
Senior Geotechnical Engineer

Encl: As noted.

cc: Andy Wolpert (CH2M Hill Ltd.), File

GENERAL INFORMATION
DRILLING PROCEDURES AND LOGS OF BORINGS

Drilling and sampling were conducted in accordance with procedures generally recognized and accepted as standardized methods of investigation of subsurface conditions concerning geotechnical engineering considerations. Borings were drilled with either a truck-mounted or ATV-mounted drill rig.

Drive split-barrel sampling was performed in 1.5 foot increments at intervals not exceeding 5 feet. In the event the sampler encountered resistance to penetration of 6 inches or less after 50 blows of the drop hammer, the sampling increment was discontinued. Standard penetration data were recorded and one or more representative samples were preserved from each sampling increment.

In borings where rock was cored, NXM or NQ size diamond coring tools were used.

In the laboratory all samples were visually classified by a soils engineer. Moisture contents of representative fine-grained soil samples were determined. A limited number of samples, considered representative of foundation materials present, were selected for performance of grain-size analyses and plasticity characteristics tests. The results of these tests are shown on the boring logs.

The boring logs included in the Appendix have been prepared on the basis of the field record of drilling and sampling, and the results of the laboratory examination and testing of samples. Stratification lines on the boring logs indicating changes in soil stratigraphy represent depths of changes approximated by the driller, by sampling effort and recovery, and by laboratory test results. Actual depths to changes may differ somewhat from the estimated depths, or transitions may occur gradually and not be sharply defined. The boring logs presented in this report therefore contain both factual and interpretative information and are not an exact copy of the field log.

Although it is considered that the borings have disclosed information generally representative of site conditions, it should be expected that between borings conditions may occur which are not precisely represented by any one of the borings. Soil deposition processes and natural geologic forces are such that soil and rock types and conditions may change in short vertical intervals and horizontal distances.

Soil/rock samples will be stored at our laboratory for a period of six months. After this period of time, they will be discarded, unless notified to the contrary by the client.

LEGEND - BORING LOG TERMINOLOGY

Explanation of each column, progressing from left to right

1. Depth (in feet) - refers to distance below the ground surface.

2. Elevation (in feet) - is referenced to mean sea level, unless otherwise noted.

3. Standard Penetration (N) - the number of blows required to drive a 2-inch O.D., 1-3/8 inch I.D., split-barrel sampler, using a 140-pound hammer with a 30-inch free fall. The blows are recorded in 6-inch drive increments. Standard penetration resistance is determined from the total number of blows required for one foot of penetration by summing the second and third 6-inch increments of an 18-inch drive.

   50/n - indicates number of blows (50) to drive a split-barrel sampler a certain number of inches (n) other than the normal 6-inch increment.

4. The length of the sampler drive is indicated graphically by horizontal lines across the "Standard Penetration" and "Recovery" columns.

5. Sample recovery from each drive is indicated numerically in the column headed "Recovery".

6. The drive sample location is designated by the heavy vertical bar in the "Sample No., Drive" column.

7. The length of hydraulically pressed "Undisturbed" samples is indicated graphically by horizontal lines across the "Press" column.

8. Sample numbers are designated consecutively, increasing in depth.

9. Soil Description

   a. The following terms are used to describe the relative compactness and consistency of soils:

Granular Soils - Compactness

Terms	Blows/Foot Standard Penetration
Very Loose	0 - 4
Loose	4 - 10
Medium Dense	10 - 30
Dense	30 - 50
Very Dense	over 50

Cohesive Soils - Consistency

Term	Unconfined Compression tons/sq.ft.	Blows/Foot Standard Penetration	Hand Manipulation
Very Soft	less than 0.25	below 2	Easily penetrated by fist
Soft	0.25 - 0.50	2 - 4	Easily penetrated by thumb
Medium Stiff	0.50 - 1.00	4 - 8	Penetrated by thumb w/ moderate effort
Stiff	1.0 - 2.0	8 - 15	Readily indented by thumb but not penetrated
Very Stiff	2.0 - 4.0	15 - 30	Readily indented by thumb nail
Hard	over 4.0	over 30	Indented with difficulty by thumb nail

   b. Color - If a soil is a uniform color throughout, the term is single, modified by such adjective as light and dark. If the predominant color is shaded by a secondary color, the secondary color precedes the primary color. If two major and distinct colors are swirled throughout the soil, the colors are modified by the term "mottled".

   c. Texture is based on the ODOT Classification System. Soil particle size definitions are as follows:

Description	Size	Description	Size
Boulders	Larger than 8"	Sand-Coarse	2.00 mm. to 0.42 mm.
Cobbles	8" to 3"	-Fine	0.42 mm. to 0.074 mm.
Gravel-Coarse	3" to 3/4"	Silt	0.074 mm. to 0.005 mm.
-Fine	3/4" to 2.00" mm.	Clay	Smaller than 0.005 mm.

   d. The main soil component is listed first. The minor components are listed in order of decreasing percentage of particle size.

e. Modifiers to main soil descriptions are indicated as a percentage by weight of particle sizes.

trace	- 0 to 10%
little	- 10 to 20%
some	- 20 to 35%
"and"	- 35 to 50%

f. The moisture content of cohesive soils (silts and clays) is expressed relative to plastic properties.

Term	Relative Moisture or Appearance
Dry	Powdery
Damp	Moisture content slightly below plastic limit
Moist	Moisture content above plastic limit, but below liquid limit
Wet	Moisture content above liquid limit

g. Moisture content of cohesionless soils (sands and gravels) is described as follows:

Term	Relative Moisture or Appearance
Dry	No moisture present
Damp	Internal moisture, but none to little surface moisture
Moist	Free water on surface
Wet	Voids filled with free water

10. Rock hardness and rock quality description.

a. The following terms are used to describe the relative hardness of the bedrock.

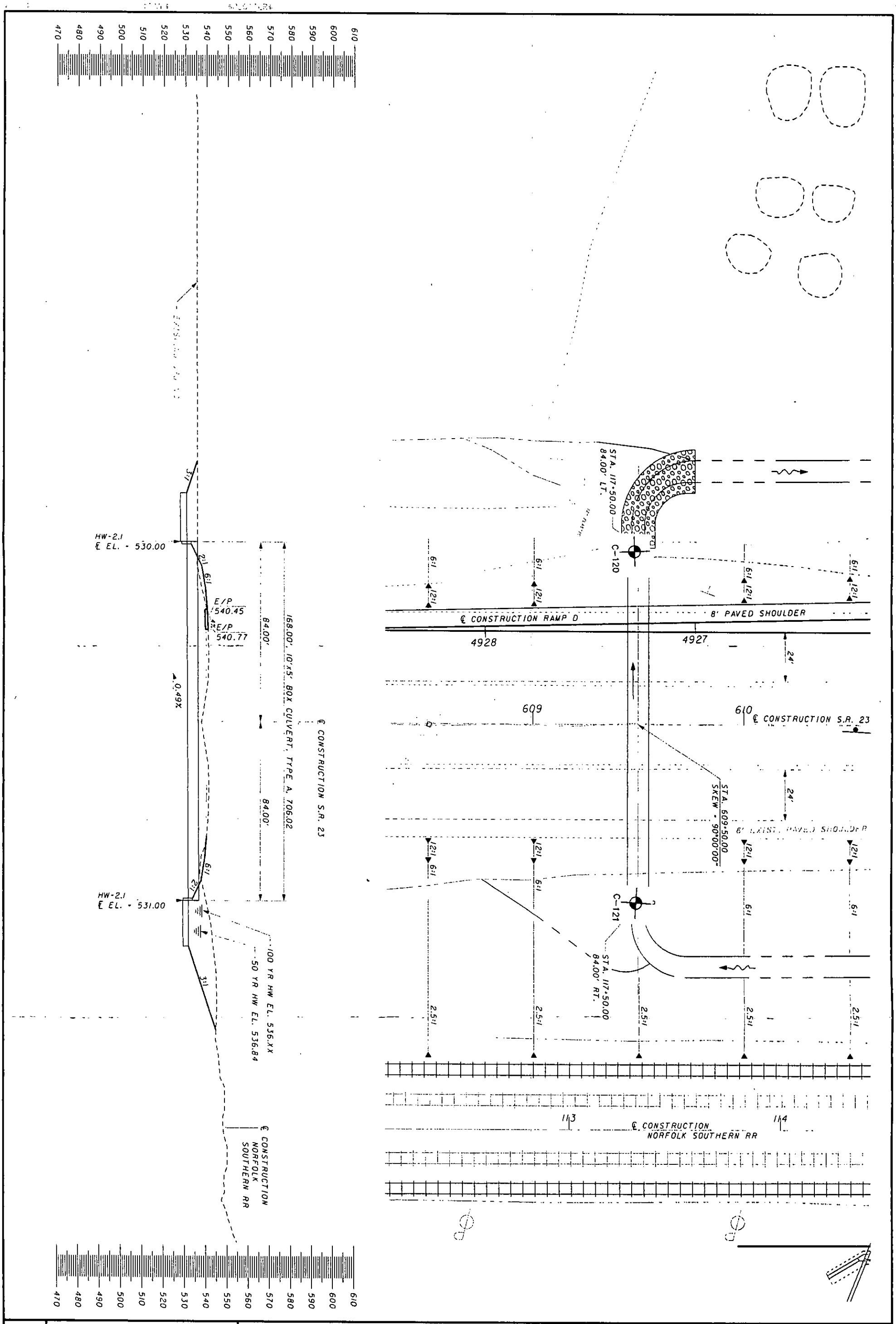
Term	Description
Very Soft	Difficult to indent with thumb nails; resembles hard soil but has rock structure
Soft	Resists indentation with thumb nail but can be abraded and pierced to a shallow depth by a pencil point.
Medium Hard	Resists pencil point, but can be scratched with a knife blade.
Hard	Can be deformed or broken by light to moderate hammer blows.
Very Hard	Can be broken only by heavy blows, and in some rocks, by repeated hammer blows.

b. Rock Quality Designation, RQD - This value is expressed in percent and is an indirect measure of rock soundness. It is obtained by summing the total length of all core pieces which are at least four inches long, and then dividing this sum by the total length of the core run.

11. Gradation - when tests are performed, the percentage of each particle size is listed in the appropriate column (defined in Item 9c).

12. When a test is performed to determine the natural moisture content, liquid limit moisture content, or plastic limit moisture content, the moisture content is indicated graphically.

13. The standard penetration (N) value in blows per foot is indicated graphically.



SCI-823-10.13	**CULVERT DETAIL** **US 23 STA. 609+50.00**	CTS ADW	HORIZONTAL SCALE IN FEET

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring C-120 | Location: Sta. 609+46.0, 74.4 ft. LT of US 23 CL | Date Drilled: 08/01/07

WATER OBSERVATIONS: Water seepage at: 18.5'-27.0'
Water level at completion: 18.2' (Includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay
0	536.1												
0.3	535.8						Topsoil - 4"						
		10 11 11	16	1		4.5+	Hard brown SILTY CLAY (A-6b), little silt, trace fine to coarse sand; damp.						
3.0	533.1												
		2 3 4	14	2		1.0	Stiff to very stiff mottled brown and gray SILT AND CLAY (A-6a), trace to little fine to coarse sand, trace gravel; moist.	1	6	--	7	53	34
5		2 2 3	15	3	ST1	1.5							
		3 4 5	18	4		1.75		0	0	--	1	58	41
10		3 4 6	18	5	ST2	2.5							
		3 4 6	18	6		1.5		1	2	--	3	60	34
15													
15.5	520.6				ST3								
		2 2 2	16	7			Loose to medium dense brown GRAVEL WITH SAND (A-1-b), trace silty clay; moist.						
		2 2 4	11	8			@ 18.5', becomes wet.	40	41	--	10	9	
20		2 4 12	12	9			@ 20.0', added water to reduce sand heave.						
		7 7 7	12	10									
25													
27.0	509.1	6 20 50/3	15	11A									
27.5	508.6			11B			Severely weathered brown SANDSTONE.						
		Core 60"	Rec 60"	RQD 61%	R-1		Medium hard gray SANDSTONE; very fine to fine grained. @ 27.8'-28.0',28.5'-28.7', high angle fractures.						
30													

STANDARD PENETRATION (N)
Natural Moisture Content, % - ●
PL ⊢ LL
Blows per foot - ○
10 20 30 40

Non-Plastic

50+

FILE: 0121-3070-03 [11/14/2007 10:24 AM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring C-120 | Location: Sta. 609+46.0, 74.4 ft. LT of US 23 CL | Date Drilled: 08/01/07

WATER OBSERVATIONS: Water seepage at: 18.5'-27.0'
Water level at completion: 18.2' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ⊢—⊣ LL Blows per foot - ○ 10 20 30 40
30	506.1						Medium hard gray SANDSTONE; very fine to fine grained, slightly weathered, argillaceous, micaceous, thinly bedded, moderately fractured, with typical low angle clay-filled fractures.							
32.5	503.6						Bottom of Boring - 32.5'							
35														
40														
45														
50														
55														
60														

FILE: 0121-3070-03 [11/8/2007 10:28 AM]

DLZ OHIO INC. * 6121 HUNTLEY ROAD, COLUMBUS, OHIO 43229 * (614)888-0040

Client: TranSystems, Inc. | Project: SCI-823-0.00 | Job No. 0121-3070.03

LOG OF: Boring C-121 | Location: Sta. 609+50.3, 73.7 ft. RT of US 23 CL | Date Drilled: 07/30/07

WATER OBSERVATIONS: Water seepage at: 6.0'-14.0'
Water level at completion: 12.0' (includes drilling water)

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No. Drive	Sample No. Press / Core	Hand Penetrometer (tsf) / * Point-Load Strength (psi)	DESCRIPTION	GRADATION % Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	STANDARD PENETRATION (N) / Natural Moisture Content, % / Blows per foot
0	537.7													
0.5	537.2						Topsoil - 6"							
		4 4 5	14	1		4.5+	Hard brown SILT (A-4b), little to some clay, little fine to coarse sand, trace gravel; damp to moist.							
		3 3 2	18	2		1.0	@ 3.5'-7.5', medium stiff to stiff, mottled brown and gray.	1	7	--	11	55	26	
5		1 3 4	18	3	ST1	1.0								
8.0	529.7				ST2									
		WOH 2 1	18	4			Very loose brown GRAVEL WITH SAND, SILT, AND CLAY (A-2-6); moist.	21	23	--	26	11	19	
10														
10.5	527.2	WOH 1 1	18	5			Very loose brown and gray GRAVEL WITH SAND (A-1-b), little silt; wet. @ 12.5', added water to reduce sand heave.	22	46	--	16	16		Non-Plastic
14.5	523.2	4 39 31	12	6A 6B										
15							Severely weathered brown SANDSTONE; very fine to fine grained, argillaceous, micaceous.							70
16.0	521.7	7 4 7	10	7			Severely weathered brown and gray SHALE; micaceous. @ 18.5'-20.0', dark gray, carbonaceous.							
		3 4 7	12	8										
20														
21.3	516.4	50/3		9										
21.6	516.1						Medium hard dark gray SHALE; moderately weathered, carbonaceous, thinly laminated, slightly fractured.							50+
		Core 60"	Rec 60"	RQD 64%	R-1		Medium hard gray SANDSTONE; moderately weathered, argillaceous, pyritic, thinly bedded, moderately fractured, with typical low angle fractures.							
25														
26.3	511.4						Bottom of Boring - 26.3'							
30														

FILE: 0121-3070-0J [11/8/2007 10:28 AM]

DLZ

CLIENT	CH2M Hill	JOB NUMBER	0121-3070-03
PROJECT	Portsmouth Bypass	SHEET NO.	1 OF 1
SUBJECT	Culvert at Station 609+50	COMP. BY	BEW DATE 11/13/07
	Bearing Capacity Analysis	CHECKED BY	DATE

Base analysis on results of boring C-121

qu =	0	tsf
c =	0	psf
ϕ =	28	degrees
Assume B =	3.5	ft
Assume γ =	120	pcf
Factor of Safety (FS) =	3	(ODOT BDM 202.2.3.1)

For cohesionless foundation soil:

Meyerhof's Method

$q_u = S_c*c*N_c+q*N_q+0.5\gamma*B*N_\gamma*S_\gamma$

$q = \gamma*D$

S_γ = 1

$N\gamma$ = 11.20 for ϕ equal to 28 degrees

Nq = 11.20 for ϕ equal to 28 degrees

$q_a = q_u/FS$ = 1021

Use $q_a <$ 1000 psf