



August 16, 2007

Michael D. Weeks, P.E., P.S.  
TranSystems Corporation  
5747 Perimeter Drive, Suite 240  
Dublin, OH 43017

Re: **Bearing Capacity and Settlement Evaluation**  
**(Culvert at STA. 600+75)**  
SCI-823-0.00 Portsmouth Bypass  
DLZ Job No.: 0121-3070.03  
Document #0077

Dear Mr. Weeks:

This letter presents the findings of the preliminary evaluation of the proposed culvert and embankment at Station 600+75 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 600+75 for the above referenced project. The culvert will be a 72-inch Type A conduit in accordance with ODOT Item 707.03 (Structural Plate Corrugated Steel Structures). Preliminary plans indicate the flow line of the culvert ranges from approximately 0 to 8 feet below existing grade. It is therefore anticipated that the culvert will be constructed in accordance with ODOT CMS Item 603.05 Method B. The maximum cover over the culvert at this location is approximately 81 feet. The inlet and outlet of the culvert will be supported by headwalls flush with the face of the pipe at each end. At the time of preparing this letter no further information was available regarding the culvert.

It should be noted that the results of this evaluation are based upon the findings of three borings (C-82 through C-84) located along the proposed alignment of the culvert. The borings were advanced to depths ranging between 15 and 18 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**

The borings encountered 8 to 11 feet of soil overlying siltstone and sandstone bedrock. The soil consisted mainly of medium dense silt (A-4b), sandy silt (A-4a) and gravel with sand and silt (A-2-4). The underlying sandstone and siltstone bedrock was soft to medium hard, weathered and fractured to varying degrees, but generally improved in quality with depth.

Michael D. Weeks, P.E., P.S.  
August 16, 2007  
Page 2

### **Bearing Capacity Evaluation**

The preliminary plans indicate that the invert elevations at the inlet and outlet of the proposed culvert are 821.75 and 802.79, 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, footings at this depth will bear in stiff silt or medium dense sandy silt. Footings bearing in these materials may be designed based on allowable bearing capacity of up to 2,500 pounds per square foot (psf).

### **Settlement Evaluation**

Soil parameters for use in the settlement calculations were estimated using correlations with moisture content and Atterberg limits. Settlement below the centerline of the embankment was evaluated using the maximum cover of the embankment (approximately 81 feet) as the surcharge load and using the soil profile encountered in boring C-82.

The settlement analysis indicated that the soil below the embankment will yield a total settlement of 2.6 inches. The analysis indicated that 80% of the consolidation settlement (2.1 inches) will occur within one month after application of the embankment load (essentially during construction for an embankment this size) while the time required to achieve the total consolidation settlement (2.6 inches) will be approximately 4 months. Secondary compression of the foundation soils beneath the embankment is estimated to produce approximately 0.6 inches of additional settlement over a period of a few years after construction.

Settlement at the ends of the culvert, due to the embankment loading, is expected to be insignificant. Based on the preceding information, and including the secondary consolidation estimate, differential settlement between the center of the embankment and the inlet and outlet of the culvert is expected to be approximately 3.2 inches. The settlement analyses are attached.



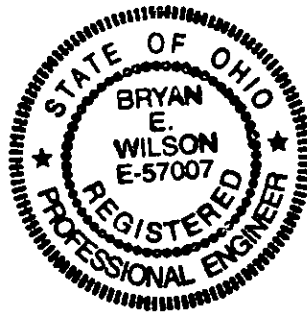
Michael D. Weeks, P.E., P.S.  
August 16, 2007  
Page 3

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: J. Greg Brown, P.E. (TranSystems Corporation), 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

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

### Cohesive Soils - Consistency

<u>Term</u>	<u>Unconfined Compression tons/sq.ft.</u>	<u>Blows/Foot Standard Penetration</u>	<u>Hand Manipulation</u>
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:

<u>Description</u>	<u>Size</u>	<u>Description</u>	<u>Size</u>
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.

<u>Term</u>	<u>Relative Moisture or Appearance</u>
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:

<u>Term</u>	<u>Relative Moisture or Appearance</u>
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.

<u>Term</u>	<u>Description</u>
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.

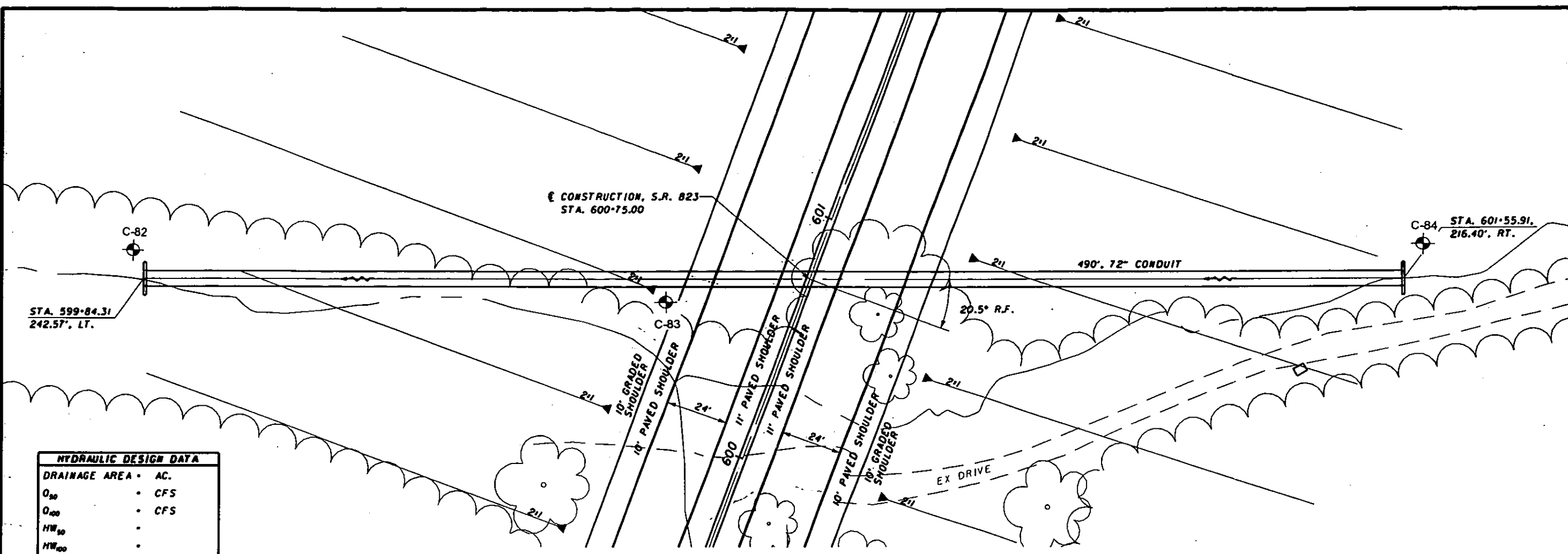


HORIZONTAL SCALE IN FEET

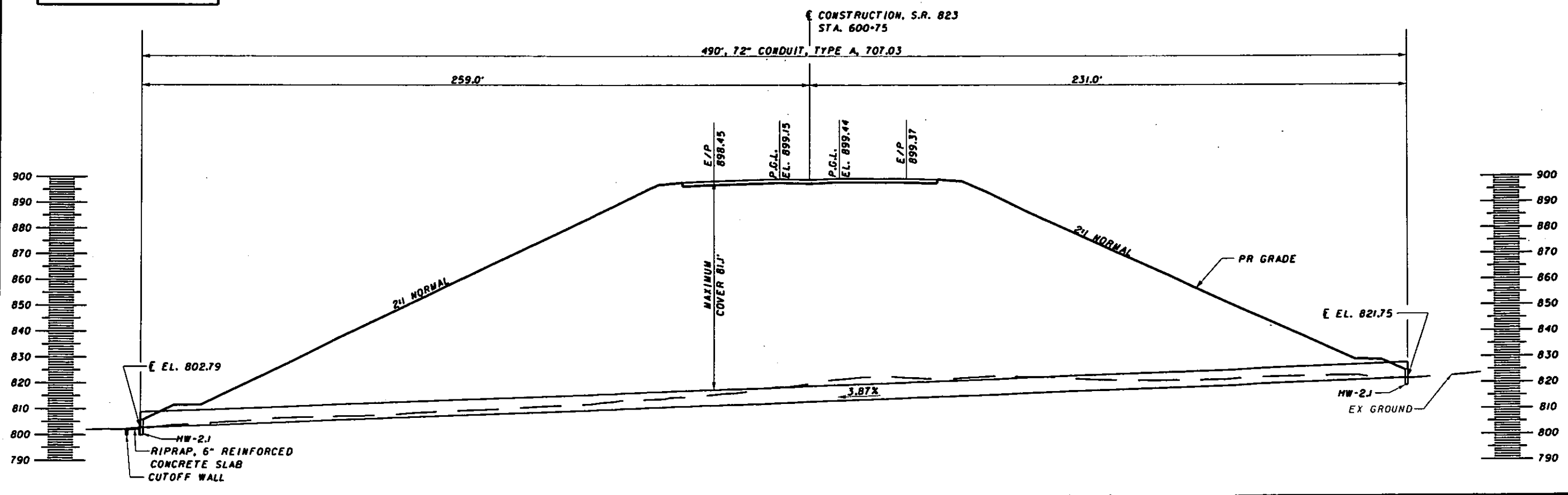
CHECKED MDC  
DESIGNED HJS

CULVERT DETAIL  
S.R. 823 STA. 600+75

SCI-823-10.31



HYDRAULIC DESIGN DATA	
DRAINAGE AREA	AC.
$O_{50}$	CFS
$O_{100}$	CFS
$HW_{50}$	
$HW_{100}$	
$V_{50}$	FPS
$V_{100}$	FPS



Client: TranSystems, Inc.

Project: SCI-823-0.00

Job No. 0121-3070.03

**LOG OF: Boring C-82**

Location: Sta. 599+93.7, 241.4 ft. LT of SR 823 CL

Date Drilled: 01/25/07

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No.		Hand Penetro-meter (tsf)	WATER OBSERVATIONS: Water seepage at: 5.0'-6.0' Water level at completion: None (prior to coring) 7.5' (inside hollowstem augers)	GRADATION						STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ————— LL Blows per foot - ○ 10 20 30 40						
				Drive	Press / Core			% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay							
0.3	803.9																			
	803.6						Topsoil - 4"													
		1			1		Very loose dark brown SANDY SILT (A-4a); organic; moist.													
		2	9																	
3.0	800.9						Soft brown SANDY SILT (A-4a), some gravel, little clay; contains sandstone fragments; damp to moist.	23	14	-	6	41	16							
		2			2	0.5														
		3	18																	
5																				
		5			3	-	Stiff to very stiff brown SILT (A-4b), little clay, little gravel; contains sandstone fragments; damp to moist.	16	7	-	6	55	16							
6.0	797.9																			
		7																		
		7	18																	
		10			4	--														
		14																		
		24	4																	
10																				
		15			5		Severely weathered grayish brown SANDSTONE, argillaceous.													
11.0	792.9																			
		47																		
		50/4	16																	
13.0	790.9						Medium hard gray SILTSTONE; slightly to moderately weathered, arenaceous, micaceous, argillaceous, very thinly bedded, slightly fractured.													
15		Core 60"	Rec 60"		RQD 93%	R1														
18.0	785.9						Bottom of Boring - 18.0'													
20																				
25																				
30																				



Client: TranSystems, Inc.

Project: SCI-823-0.00

Job No. 0121-3070.03

LOG OF: Boring C-83

Location: Sta. 600+49.4, 45.8 ft. LT of SR 823 CL

Date Drilled: 01/25/07 to 01/25/07

Depth (ft)	Elev. (ft)	Blows per 6"	Recovery (in)	Sample No.		Hand Penetro-meter (tsf)	WATER OBSERVATIONS: Water seepage at: 5.0'-6.0' Water level at completion: None (prior to coring) 4.9' (inside hollowstem augers)	GRADATION						STANDARD PENETRATION (N) Natural Moisture Content, % - ● PL ————— LL Blows per foot - ○ 10 20 30 40
				Drive	Press / Core			% Aggregate	% C. Sand	% M. Sand	% F. Sand	% Silt	% Clay	
0	811.8						DESCRIPTION  Topsoil - 6" Very loose dark brown SANDY SILT (A-4a); organic; moist.  Medium stiff brown SILT (A-4b), little clay, little gravel; contains sandstone fragments; moist.  Medium dense to dense brown GRAVEL WITH SAND AND SILT (A-2-4), trace clay; contains sandstone fragments; damp to moist.  Soft gray SILTSTONE interbedded with SANDSTONE; very fine to fine grained, highly weathered, micaceous, argillaceous, thinly bedded, slightly to moderately fractured. @ 11.2'-11.7', qu = 920 psi.							
0.5	811.3			1		0.75								
3.0	808.8			2				16	10	-	5	51	18	
5.5	806.3			3				51	11	-	7	24	7	
10.0	801.8			4										
15.0	796.8													
							Bottom of Boring - 15.0'							





CLIENT TranSystems Inc.  
PROJECT Portsmouth Bypass  
SUBJECT Culvert at Station 600+75  
Bearing Capacity Analysis

JOB NUMBER 0121-3070-03  
SHEET NO. 1 OF 2  
COMP. BY BEW DATE 8/16/2007  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

Base analysis on results of boring C-82.

Assume  $q_u = 1.5$  tsf for stiff cohesive material

$c = 1500$  psf

Factor of Safety (FS) = 3 (ODOT BDM 202.2.3.1)

For cohesive foundation soil:

**Meyerhof's Method**

$q_u = S_c * c * N_c + q * N_q$        $q = \gamma * D$       Can be neglected since footing depth is less than 5 ft

Since footing Dimensions are not known assume  $S_c = 1.0$ . For  $\phi = 0$ , use  $N_c = 5.14$  and  $N_q = 1$

$q_a = q_u / FS = 2570$  psf

Use  $q_a < 2570$  psf



CLIENT TranSystems Inc.  
PROJECT Portsmouth Bypass  
SUBJECT Culvert at Station 600+75  
Bearing Capacity Analysis

JOB NUMBER 0121-3070-03  
SHEET NO. 2 OF 2  
COMP. BY BEW DATE 8/16/2007  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

Base analysis on results of boring C-84.

$$q_u = 0 \text{ tsf}$$

$$c = 0 \text{ psf}$$

$$\phi = 34 \text{ degrees}$$

$$\text{Assume } B = 2.5 \text{ ft}$$

$$\text{Assume } \gamma = 120 \text{ pcf}$$

$$\text{Factor of Safety (FS)} = 3 \text{ (ODOT BDM 202.2.3.1)}$$

For cohesionless foundation soil:

**Meyerhof's Method**

$$q_u = S_c * c * N_c + q * N_q + 0.5 * \gamma * B * N_\gamma * S_\gamma \quad \text{Conservatively use buoyant unit weight in calculation.}$$

$$q = \gamma * D$$

$$S_\gamma = 1$$

$$N_\gamma = 31.10 \text{ for } \phi \text{ equal to } 34 \text{ degrees}$$

$$N_q = 30.30 \text{ for } \phi \text{ equal to } 34 \text{ degrees}$$

$$q_a = q_u / \text{FS} = 2492$$

Use  $q_a < 2500 \text{ psf}$



Client TranSystems Inc.  
 Project Portsmouth Bypass  
 Item Culvert at STA. 600+75

JOB NUMBER 0121-3070.03  
 SHEET NO. 1 OF 4  
 COMP. BY WMA DATE 8/10/2007  
 CHECKED BY BEW DATE 8/18/2007

**Calculations Data**

Boring	Sample	w	PL	LL	PI	Cc <sup>1</sup>	Cr <sup>2</sup>	e <sub>s</sub> <sup>3</sup>	
C-82	2	18	18	25	7	0.09	0.032	0.9797	
C-82	3	21	21	27	6	0.08	0.034	0.9861	
C-83	2	21	18	25	7	0.09	0.032	0.9838	
C-83	3	15	20	25	5	0.07	0.032	0.9804	
C-84	2	18	20	28	8	0.11	0.036	0.9768	
						Average	0.09	0.033	0.9814
						Maximum	0.11	0.036	0.9861

1) Cc=PI/74  
 2) Cr=0.000463xLLxGs  
 3) Based on CR below

Boring	Sample	LL	C <sub>v</sub> *(ft <sup>2</sup> /day)	C <sub>v</sub> *(ft <sup>2</sup> /sec)	
C-82	2	25	0.86	1.11E-05	
C-82	3	27	0.77	8.88E-06	
C-83	2	25	0.96	1.11E-05	
C-83	3	25	0.96	1.11E-05	
C-84	2	28	0.88	8.01E-06	
			Minimum	0.69	8.01E-06
			Average	0.87	1.00E-05
			Maximum	0.96	1.11E-05

\*C<sub>v</sub>(ft<sup>2</sup>/day) = 9343.5\*LL<sup>-2</sup>(-2.8542) (Kulhawy and Mayne- 1990)

**Typical Values**  
 Source: Holtz and Kovacs (1981)/ Terzaghi, Peck and Mesri (1985)

Soil	C <sub>v</sub> /C <sub>c</sub>
Organic Silts	0.035-0.06
Amorphous and Fibrous Peat	0.035-0.085
Organic Clays and Silts	0.04-0.06
Granular Soils	0.01-0.03
Shale and mudstones	0.02-0.04
Silty Clay	0.03-0.06
Peat	0.05-0.07

**Correlation Values-Source: Lamb and Whitman (1969)**

w%	CR=(C <sub>v</sub> /1+e <sub>s</sub> )
9.983	2.389
11.785	2.547
14.487	3.016
17.099	3.825
19.816	4.892
25.352	6.931
28.328	8.079
34.174	10.369
42.400	13.490
51.139	16.388
79.829	23.326
152.740	33.469
341.288	46.114
501.494	52.174

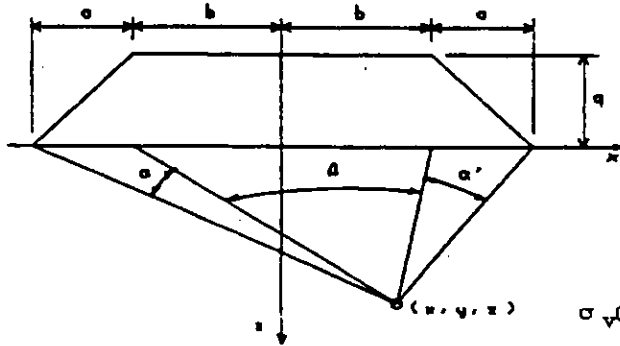
Correlation: CR=4E-09w<sup>4</sup> + 5E-06w<sup>3</sup> - 0.0021w<sup>2</sup> + 0.4695w - 3.1337  
 R<sup>2</sup>=0.9992

Boring	Sample	w	PL	LL	PI	LI	Consolidation*
C-82	2	18	18	25	7	0.00	Overconsolidated
C-82	3	21	21	27	6	0.00	Overconsolidated
C-83	2	21	18	25	7	0.43	Overconsolidated
C-83	3	15	20	25	5	-1.00	Overconsolidated
C-84	2	18	20	28	8	-0.25	Overconsolidated

\*Overconsolidated when LI<0.7  
 Ref: Soils and Foundations Workshop Reference Manual- NHI-00-045 (p. 6.11)

## SETTLEMENT ANALYSIS - EMBANKMENT

### Embankment Informaiton:



Groundwater Table: D= 23.0 ft  
 Embankment Height: H = 81 ft  
 Fill Unit Weight:  $\gamma_{emb} = 120$  pcf  $q = 9,720$  psf  
 Width of Slope: a = 186  
 Top half-width of Emb: b = 59  
 Distance from CL: x = 0  
 Output Range: z = 0 to 49 ft

\*See Data output Attached

$$\sigma_v(z) := \left( \frac{q}{\pi a} \right) (a \cdot (\alpha(z) + \beta(z) + \alpha'(z)) + b \cdot (\alpha(z) + \alpha'(z)) + x \cdot (\alpha(z) - \alpha'(z)))$$

$$\beta(z) := \text{atan} \left[ \frac{(b-x)}{z} \right] + \text{atan} \left[ \frac{(b+x)}{z} \right]$$

$$\alpha'(z) := \text{atan} \left[ \frac{(a+b-x)}{z} \right] - \text{atan} \left[ \frac{(b-x)}{z} \right]$$

$$\alpha(z) := \text{atan} \left[ \frac{(a+b+x)}{z} \right] - \text{atan} \left[ \frac{(b+x)}{z} \right]$$

Reference: US Army Corps of Engineers EM 1110-1-1904 "Settlement Analysis", Table C-1

### Cohesionless

### Soil Properties:

Settlement is calculated at mid-point of layer

No.	Bot. of Layer	Soil Type	$\gamma_{soil}$ (pcf)	$\sigma'_c$ (psf)	$\sigma'_o$ (psf)	$\Delta\sigma_z$ (psf)	$\sigma'_r$ (psf)	Soils			
								C'	C <sub>r</sub>	C <sub>c</sub>	e <sub>o</sub>
1	11.0 ft	Silt/ Sandy Silt	120	10,500	660	9,720	10,380	0.0	0.03	0.09	0.980
2	0.0		0	0				0.0	0.00	0.00	0.000
3	0.0		0	0				0.0	0.00	0.00	0.000
4	0.0		0	0							
5	0.0		0	0							
6	0.0		0	0							
7	0.0		0	0							
8	0.0		0	0							
9	0.0		0	0							
10	0.0		0	0							

Reference: Geotechnical Engineering Principles and Practices; Coduto, 1999

### Overconsolidated Soils - Case I ( $\sigma'_o < \sigma'_c$ ) Eqn:11.24

$$(\delta_c)_{ult} = \sum \frac{C_r}{1+e_0} H \log \left( \frac{\sigma'_f}{\sigma'_o} \right)$$

### Overconsolidated Soils - Case II ( $\sigma'_o < \sigma'_c < \sigma'_c$ ) Eqn:11.25

$$(\delta_c)_{ult} = \sum \left[ \frac{C_r}{1+e_0} H \log \left( \frac{\sigma'_c}{\sigma'_o} \right) + \frac{C_c}{1+e_0} H \log \left( \frac{\sigma'_f}{\sigma'_c} \right) \right]$$

### Normally Consolidated Soils ( $\sigma'_o = \sigma'_c$ ) Eqn: 11.23

$$(\delta_c)_{ult} = \sum \frac{C_c}{1+e_0} H \log \left( \frac{\sigma'_f}{\sigma'_o} \right)$$

### Cohesionless Soils ( $\sigma'_o = \sigma'_c$ )

$$(\delta_c)_{ult} = \sum \frac{1}{C'} H \log \left( \frac{\sigma'_f}{\sigma'_o} \right)$$

### No. Settlement:

### Total Settlement

1 0.219 ft

**0.219 ft**

2

3

4

5

**2.6 in**

6

7

8

9

10



SUBJECT

Client TranSystems, Inc.

JOB NUMBER 0121-3007.03

Project SCI-823-0.00

SHEET NO. 3 OF 4

Item Culvert at STA.600+75

COMP. BY WMA DATE 08/10/07

Based on C-82

CHECKED BY BEW DATE 08/16/07

### TIME RATE SETTLEMENT

Coefficient of consolidation ( $c_v$ ) = 8.0E-06 ft<sup>2</sup>/s

Assumed Life Time = 5 yrs

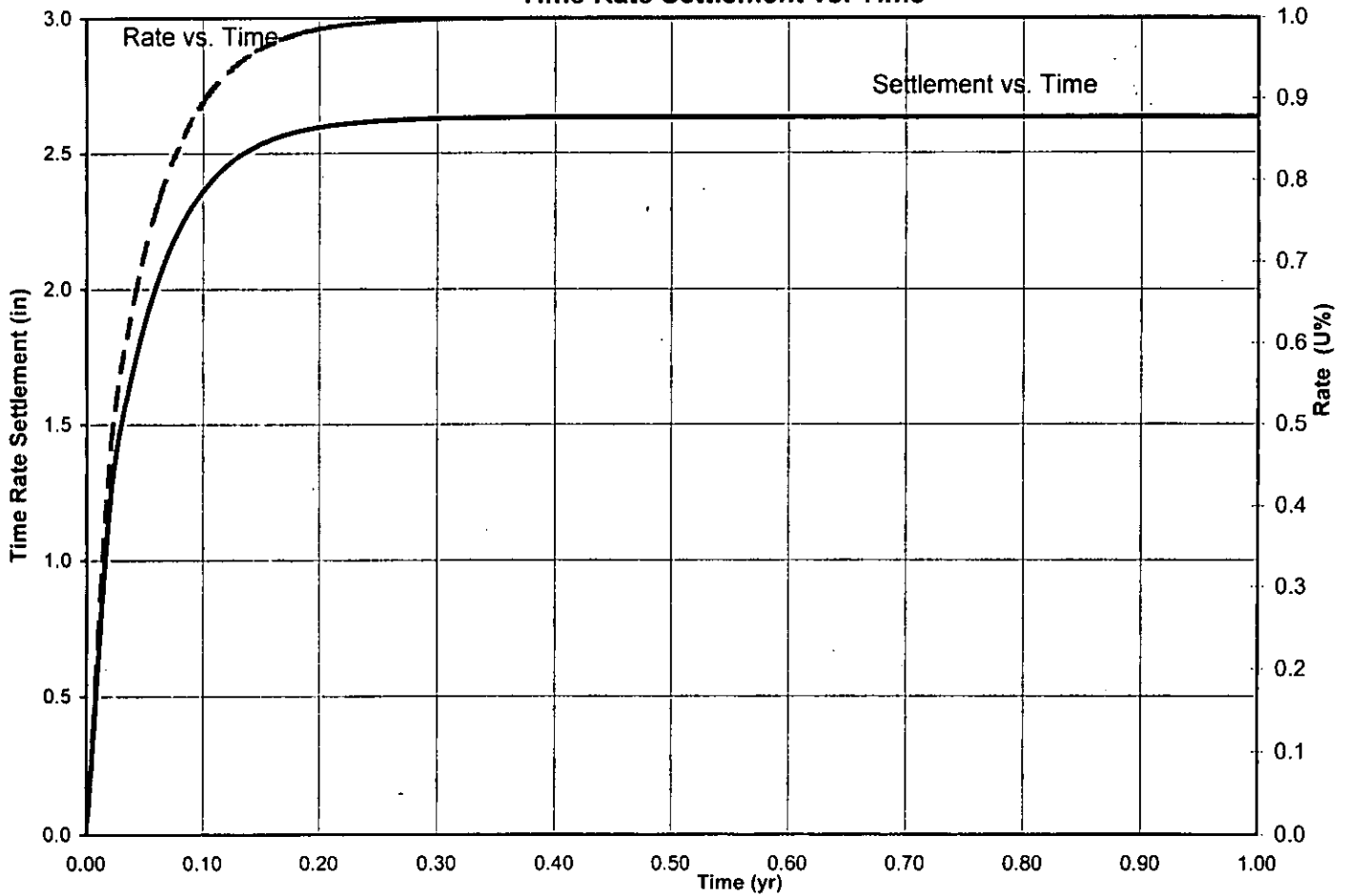
Drainage Path Condition = 1 (0 for single drainage; 1 for double drainage)

Thickness of Layer = 11.0 ft

Maximum Time Rate Settlement = 2.6 inches

Settlement at (U% =80%) = 2.11 inches      23 days after the end of construction

Time Rate Settlement vs. Time





SUBJECT

Client TranSystems Inc.

JOB NUMBER 0121-3007.03

Project Portsmouth Bypass

SHEET NO. 4 OF 4

Item Culvert at STA. 600+75

COMP. BY WMA DATE 08/10/07

Based on boring C-82

CHECKED BY BEW DATE 08/16/07

### SECONDARY SETTLEMENT ANALYSIS - EMBANKMENT

Thickness (H) 11 ft  
 $c_v = 8.01E-06$  ft<sup>2</sup>/s  
 T= 2.71 (assuming U=0.999)  
 $t_p = 0.3$  yrs

Time to end of primary consolidation ( $t_p$ ) = 0.3 yrs

No.	Soil	H(ft)	w(%)	$C_a$	S(inch)
1	Silt and Clay	11	21	0.0047	0.6
2					
3					

Total Secondary Settlement = 0.6 inches

Secondary Settlement\*

$$(\delta_{secondary}) = C_a H$$

$$t_p = \frac{T \cdot H^2}{c_v} \text{ Assume } U = 0.999$$

\* Ref: Soils and Foundations Workshop Reference Manual- NHI-00-045 (p. 6.14)