Indiana Department of Transportation

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December 17, 1999

ARE
NRG NG
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KDD SWJ
WDR WEH
Route To: 98-417

Mr. Phelps Klika
Chief, Division of Design
Room N-642 - IGCN

Attn: Ms. Joan Staggs
Project Coordinator

Subject: Geotechnical Investigation
Des. No.: 9161365
Project No.: NH-075-3( )
US 231 Roadway Construction (**Phase 3**)
County: Spencer
District: Vincennes

Gentlemen:

An investigation into the existing subsurface conditions for the subject project has been completed and the findings and recommendations are included herein.

The project consists of a new alignment of US 231 from CR 1250 N to SR 162. The limits of the project are from Station 21+250 "A" to Station 27+420 "A". The total length of the project is approximately 6.2 km (3.7 miles).

Twenty-three (23) split spoon borings were drilled for the project during the field investigation. Laboratory tests were performed to identify the soils and to determine their strength and density characteristics. Following the completion of laboratory testing, final boring logs were prepared. Copies of the General Site Plan, Boring Logs, and Laboratory test data are transmitted with this report. Alt & Witzig, soils consultant, did drilling and performed laboratory tests.

The following are some recommendations by the INDOT Geotechnical Section.

ROADWAY

SCOPE:

According to the project plans, US 231 will follow a new alignment. The maximum fill and maximum cut are on the range of 23 m (75') and 16 m (52') respectively.

Findings:

The predominant soils encountered in the borings are Silty Clay Loam, and Silty Loam with a consistency range from very stiff to hard. Other soils encountered were Sand, Loam, and Sandy Loam. These soils had densities ranging from loose to very dense. Silty Clay Loam/Silty Loam is underlain by weathered Shale/Siltstone/Sandstone. Recovery of rock sample and rock qualifying designation [RQD] varies from 23% to 100% and 0% to 90% respectively. Some of the borings were dry at the completion of drilling; however, other borings had groundwater tables ranging from 1.2 m to 7.0 m.

Recommendations:

According to some of the resources available in our office, this alignment passes near some very old coal mines. Although there is no visible signs of soils distress on the project and most of these coal mines might have subsided already, there might be mine subsidence in the far future.

When shale or rock are used for embankment construction, it should be done per Specification Section 203.20 (b).

It is strongly recommended that shale not be used in the strip mine pits where water is standing.

Fills

Station 22+000 to Station 22+300

Fill up to 9 m (30') is proposed in this area. Boring RB-5 drilled in this area had a water table of 7 m (23') after 24 hours. The soils consist of 3 m (10') of loose to medium dense Sandy Loam overlying 2.5 m of medium stiff Silty Loam. The Silty Loam is underlain by Shale. If any very loose or soft soils are encountered, they should be undercut and replaced with compacted "B" Borrow to an elevation 0.6 m (2') above the groundwater level if groundwater is encountered. Otherwise, backfilling should be per Specification Section 203.09.

Due to the amount of fill proposed in this area, some settlement is anticipated. Therefore, settlement stakes are recommended from Station 22+040 to Station 22+280 at 30 m (100') center to center staggered intervals. Final pavement should not be constructed until the settlement is less than or equal to 0.01' for four consecutive weeks. The proposed sideslopes of 3:1 are adequate.

Station 22+770 to Station 22+940

Fill up to 4.5 m (14.5') is proposed in this area. RB-7 drilled in this area was dry after 24 hours. The soils consist of 2 m (6.5') of stiff Silty Loam, overlying 1 m of medium dense Sandy Loam. This stratum is underlain by very stiff to hard Silty Clay Loam. The proposed slopes are 6:1 immediately adjacent to the shoulder, and they become 3:1 for the remainder of the fill. These slopes should be adequate if compacted per Specification Section 203.09.

Station 23+660 to Station 24+560

Fill up to 6 m (19') is proposed in this area. Weathered rock was found at shallow depths in borings RB-10, RB-11 and RB-12 in this area. These borings were found to be dry at the completion as well as 24 hours after drilling. In general, the rock will be found at approximately 3 m depth. A loose Loamy soil was found at the existing grade at Station 24+060. If this soil cannot be compacted, it should be undercut and replaced by compacted "B" Borrow to an elevation 0.6 m (2') above the groundwater table. Otherwise, backfilling should be per specification section 203.09.

Station 24+800 to Station 25+060

Fill up to 11 m (36') is proposed in this area. Boring RB-14 drilled in this area was found to be dry after 24 hours. The soils consist of a 2 m (6.5') thick layer of very stiff Silty Clay, overlying very weathered Siltstone. These soils should be capable of supporting the large fill and no stability or settlement problems are anticipated provided compaction is done per section 203.09. However, flattening the sideslopes from the proposed 2:1 to 3:1 from Station 25+000 to Station 25+020 could be considered.

Station 25+120 to Station 25+400

This area consists of various fill amounts including a very deep fill of 23 m (75.5') in a strip mine pit that the proposed alignment directly crosses. According to the boring logs, the approximate standing lake water depth is 2 m (6.5') at the coal mine strip pit. Very soft Silty Clay Loam, is at the lake bed. This material must be removed. The pit as well as the entire embankment can then be filled with Rock Backfill and properly choked. A Filter Fabric could be placed on top before the pavement is laid.

Alternatively, #53 Crushed Stone could be used, or "B" Borrow could be used to an elevation 0.6 m (2') above the groundwater level. The remaining fill could be completed in accordance with Specification Section 203.09. Dewatering could be needed at this location.

The proposed sideslopes vary from 2:1 to 5:1 in this section. Based on the soils encountered in this area, we feel that these slopes are adequate provided construction of the fill is done per section 203. However, flattening of the 2:1 slopes to 3:1 could be considered if the right of way is available.

Station 25+580 to Station 26+040

This area also consists of various fill amounts including a strip mine pit. The soils encountered are organic Silty Loam and Silty Clay containing rock fragments. This material must be undercut and due to high water table dewatering could be needed. The approximate undercut would be 2 m, at which point, shale will be encountered. The pit as well as the entire embankment can then be filled with Rock Backfill and properly choked. A Filter Fabric could be placed on top before the pavement is laid.

Alternatively, #53 Crushed Stone could be used, or "B" Borrow could be used to an elevation 0.6 m (2') above the groundwater level. The remaining fill could be completed in accordance with Specification Section 203.09.

The fill area north of the strip pit will be placed on soils consisting mainly of hard Silty Clay Loam, overlying Sandstone. RB-18 had a water table depth of 1.2 m (4') 24 hours after drilling. The proposed fill in this area is 11 m (36'). We do not anticipate any settlement or stability problem.

Cuts:

Station 21+250 to Station 21+360

A cut up to 7 m (23') is proposed in this section. The soils consist of Silty Clay Loam underlain by Shale. Based on the observation of the core, Shale is rippable. Boring RB-1 drilled in this area was dry 24 hours after drilling. The proposed 3:1 cutback slopes in this section are adequate.

Station 21+520

In the area of this Station, a hill on the right side of the road is being removed. The proposed cut is up to 7 m (23'). Boring RB-2 drilled in this area had a water table of 2.4 m (7.8') 24 hours after drilling. Most of that excavation will be Silty Loam, rippable Shale, and Sandstone. Based on observation of the core, it is our opinion that the Sandstone may not be rippable. Therefore, other means of excavation such as the use of controlled blasting and/or hydraulic hammers for smaller, more-controlled rock removal will likely be required. The proposed cutback slope of 3:1 is adequate.

Station 21+520 to Station 21+700

A cut up to 9 m is proposed in this section. Boring RB-3 drilled in this area had a water table depth of 1.9 m (6') 24 hours after drilling. All soils can be excavated except Sandstone, which may not be rippable. Therefore, other means of excavation such as the use of controlled blasting and/or hydraulic hammers for smaller, more-controlled rock removal will likely be required. The Sandstone was encountered at a depth of approximately 7.6 m. The 3:1 cutback slopes in this section are adequate.

Station 21+840 to Station 21+940

A cut up to 7 m (23') is proposed in this section. Boring RB-4 drilled in this area was dry 24 hours after drilling. All of the excavation involves Silty Clay Loam. The proposed 3:1 cutback slope in this section is adequate.

Station 22+340 to Station 22+620

A cut up to 10 m is proposed in this section. Boring RB-6, which was drilled in this area had a water table of 2.1 m (7') 24 hours after drilling. The excavation in this area involves about 3 to 5 meters of Silty Loam, then Shale and Shale is rippable in general. Some of the Shale near the proposed grade of the road is rather hard. This could be ripped, but difficulty can be expected. The cutback slopes of 3:1 are adequate.

Station 23+020 to Station 23+620

In this section, a maximum cut of 16 m (52.5') is proposed. RB-8 was dry and RB-9 had a water table of 1.2 m (4') 24 hours after drilling. The cuts in this section, between Station 23+080 and 23+360 contain Silty Clay Loam, and very weathered Siltstone. Excavation should be rather simple. However, from Station 23+360 to Station 23+610, Shale was encountered at a depth of 3 m (10'). Excavation could be accomplished with regular equipment, because this rock is rippable.

EXCAVATION BENEATH 16m CONSIDERED ROCK ?

This Shale was rather massive, and difficulty can be expected. The excavation of 16 m (52.5') near Station 23+460 is the maximum possible excavation in this area. Any further excavation would require blasting, or the use of hydraulic hammers. The cutback slope varies from 2:1 to 3:1. Flattening the 2:1 slopes to 3:1 could be considered, if rock is not encountered within the first 3 m (10').

Station 25+460 to Station 25+540

A maximum cut of 11 m (36') to remove a hill, is proposed in this area. Boring RB-16 drilled in this area was dry 24 hours after drilling. The removal will involve 7 m (23') of very dense Sand, and weathered Shale. This material can be removed rather easily.

The proposed 3:1 cutback slopes are adequate. However, as granular material has been encountered in this cut area, the finished slopes should be encased with nonerodible material suitable for sustaining vegetation.

Station 26+080 to Station 26+240 and Station 26+420 to Station 27+000

A maximum cut of 12 m (39.5') is proposed in this area. Four borings were done in this area, and the 24 hour water tables varied from 1.4 m (4.5') to 7 m (23'). The area generally consists of about 2 m (6.5') of Silty Clay Loam and Silty Loam, overlying Siltstone, Shale, and some thin Sandstone layers. Some of the Sandstone and massive Shale may be difficult to remove, however, they are rippable. The proposed cutback slopes of 2.5:1 to 3:1 are adequate.

Blasting:

Where blasting is necessary, it should only be performed by a qualified contractor with specific experience in this area. Prior to performing any blasting activities on the site, a pre-blast survey for the surrounding area to view the conditions of existing structures if any is recommended. We also recommend that a post-blast survey be performed and compared with those conditions observed earlier. In addition, the contractor should consider the use of perimeter control blasting to provide a smooth rock surface at the periphery of the excavation as well as minimize blast damage.

pH:

Tests show that the pH values of the soils on the project varies from 5.1 to 7.3, therefore corrosion protection measures are not needed.

PAVEMENT DESIGN CONSIDERATIONS

1. The estimated CBR value is 4.0 for 600 mm (24 inch) Special Subgrade Treatment.

2. We recommend 600 mm (24") Special Subgrade Treatment including shoulders and a CBR Value of 4.0 could be used. However, the following alternatives could be used in at grade or cut areas only:

   Alternative 1:
   At grade or in cuts for less permeable soils, where aeration or drying may not be effective, the wet soils may be undercut to a depth of 300 mm (12") and backfilled with #53 Crushed Stone. A CBR value of 4.0 could be used with this option.

   Alternative 2:
   At grade or in cuts if aeration is not practical, a chemical modification of 400 mm (16") depth in-situ soils is recommended. An undistributed quantity of chemical modification should be included in the contract. A CBR value of 4.0 could be used with this option.

3. The natural moisture content of some of the subgrade soils may exceed their optimum moisture content. Therefore, aerating, drying or other means may be necessary to reduce the moisture content to within an acceptable range for compaction. The current specifications require -3 percent of optimum moisture content for Silty Soils.

4. Underdrains are recommended for this project. Outlets with rodent screens should be provided at regular intervals to lead the collected water away from the subgrade. Filter Fabric should be used in conjunction with the underdrains.

5. All of the rock encountered in cut areas shall be overexcavated and at least 150 mm (6") of bedding material should be provided per Specification Section 207.02.

STRUCTURES

One bridge and several smaller drainage structures are proposed for this project. As was discussed at the grade review meeting, the geotechnical investigation for structures will be performed at a later date.

GENERAL RECOMMENDATIONS

1. Proofrolling of the natural ground surface should be specified in accordance with the Standard Specifications, Section 203.26, within all areas where new fill will be placed. Any soft soils encountered during the proofrolling operations, which will not readily compact, should be removed and replaced with "B" Borrow to an elevation 0.6m (2') above the groundwater level, if groundwater is encountered. Otherwise, backfilling should be accomplished in accordance with Section 203.09

2. Where new embankment fill will be placed on or adjacent to existing natural slopes or existing embankment of 4:1 or steeper, benches a minimum of 3 m (10') wide should be cut into the existing natural slope prior to the placement of new fill. These benches should be cut in accordance with Section 203.21 of the Standard Specifications.

3. Where existing ditches will be covered by embankment construction, all soft sediments should be stripped and replaced with "B" Borrow to an elevation 0.6 m (2') above ground water level. If ground water is not encountered during the removal operations, the backfill shall be in accordance with 203.09 of the Standard Specifications.

4. Cohesionless, granular material should not be used in ditches or within 300 mm (12") of the required finished surface of fill slopes. The material required to encase the embankment should be non-erodible material free from clods, debris, and stones and suitable for sustaining vegetation.

General soil strata descriptions and indicated boundaries are based on an engineering interpretation of all available subsurface information by the Geotechnical Section of INDOT and may not necessarily reflect the actual variation in subsurface conditions between borings and samples. Detailed data and field interpretation of conditions encountered in individual borings are shown on the boring logs.

The observed water levels and/or conditions indicated on the boring logs are as recorded at the time of exploration. These water levels and/or conditions may vary considerably, with time, according to the prevailing climate, rainfall or other factors and are otherwise dependent on the duration of, and methods used, in the exploration program.

If you have any questions, please contact us.

Very truly yours,

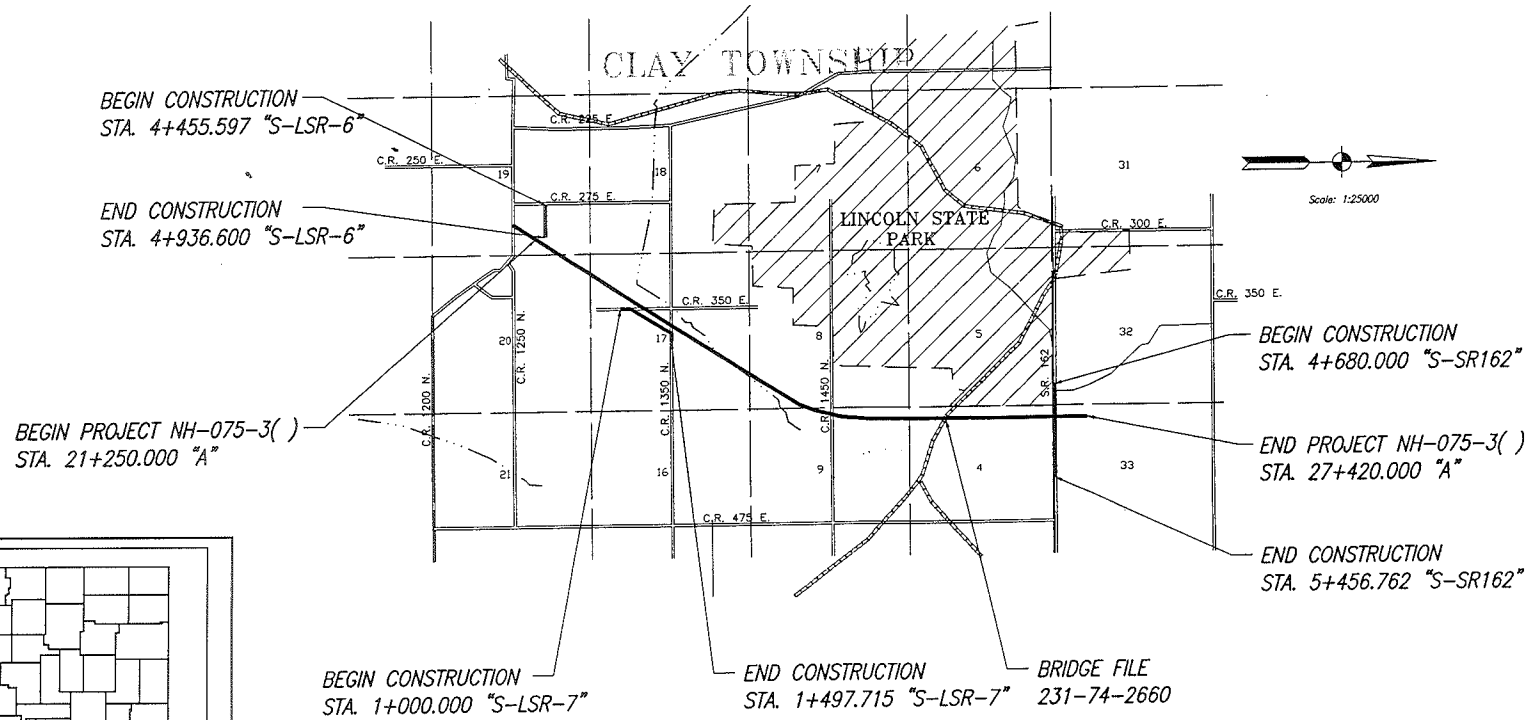
Athar A. Khan, P.E.
Chief Geotechnical Engineer

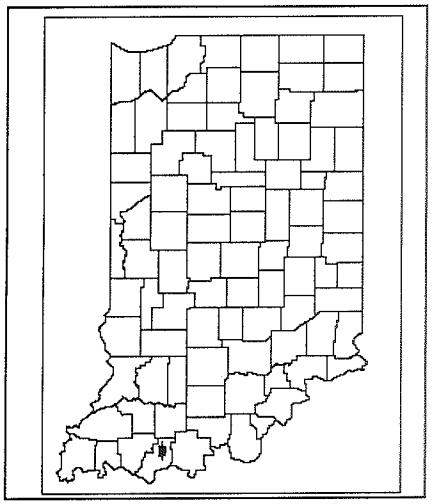
S. S. Hiremath

Somanath S. Hiremath, P.E.
Geotechnical Engineering Group Leader

SSH/JF/nd
cc: United Consulting Engineers & Architects - Attn: Mr. M. Rape - Attachment
Mr. T. Seeman - Attn: Mr. J. Nicholson – Attachment
Mr. J. Russell – Attn: Mr. M. Fowler – Attachment (2)
Mr. C. Miller – Attachment
Mr. J. Schneider - Attachment
Mr. K. Dave – Attachment
File
Attachment
H/Joey/Large Cuts & Fills.doc

General Site Plan





Des. No:	9161365
Project No:	NH-075-3( )
Structure No:	NA
Location:	US 231 realignment (Phase 3)
County:	Spencer

Scale: Not To Scale
Drawn By: JJF
Checked By: SSH

Des No: 9161365
Project No: NH-075-3( )
U.S. 231 Realignment
Spencer County, Indiana
Alt & Witzig File: S9905

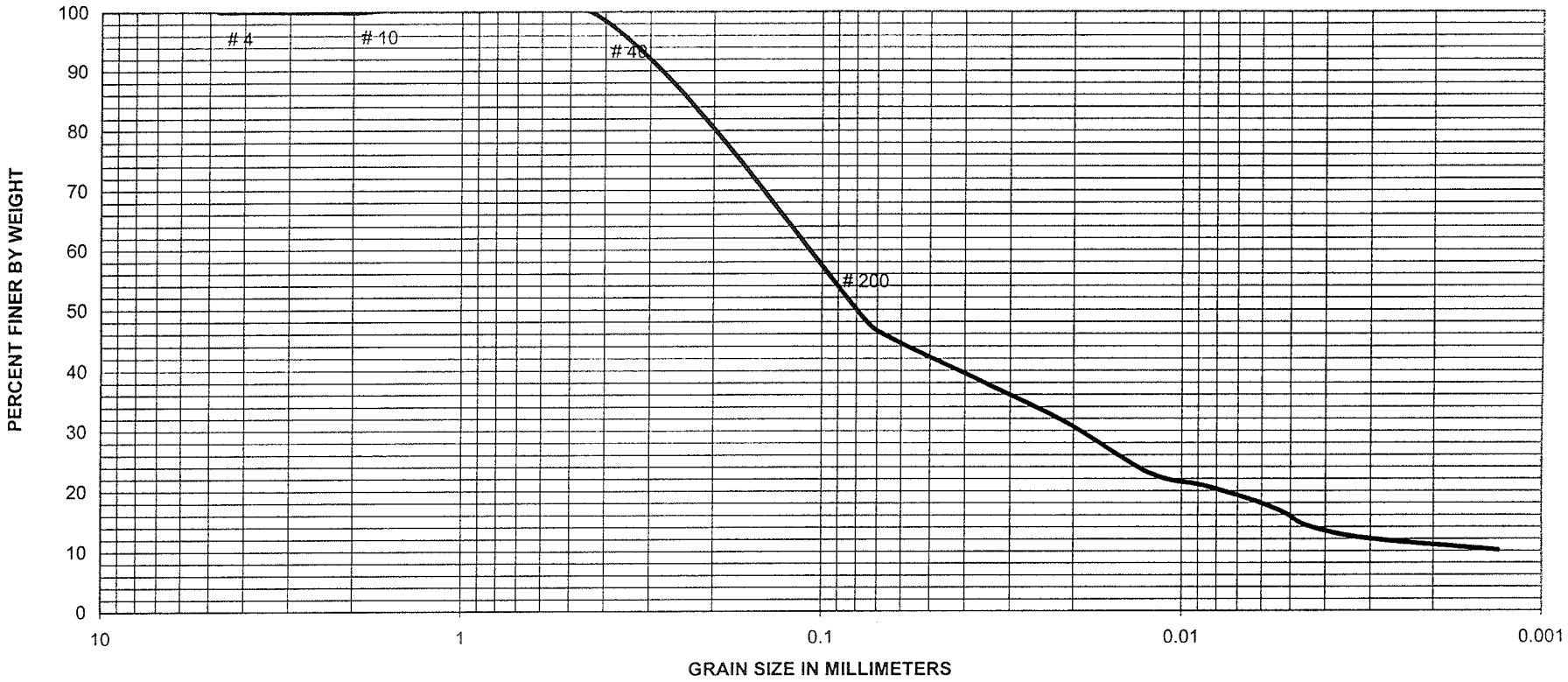
CLASSIFICATION TEST DATA												
Lab No.	Boring # Station	Depth & Sample	Description	% Gravel	*Passing #40 #10-#200 % Sand	#200-.002mm % Silt	0.002mm % Clay	0.001mm % Colloids	LL	PL	PI	AASHTO Classification
1	RB-1 21+260 30.0m RT, A	1.1-1.5m (2ss)	Silty Clay Loam	1	20 *99	57	22	20	24	15	9	A-4(5)
2	RB-05 22+160 15.0m LT, A	1.1-1.5m (2ss)	Sandy Loam	0	57 *100	32	11	10	NP	NP	NP	A-4(0)
3	RB-05 22+160 15.0m LT, A	4.1-4.6m (5ss)	Silty Loam	3	16 *95	62	19	17	30	22	8	A-4(6)
4	RB-07 22+840 15.0m LT, A	2.6-3.0m (4ss)	Silty Clay Loam	2	12 *96	61	25	23	32	20	12	A-6(10)
5	RB-11 22+060 20.0m LT, A	1.1-1.5m (2ss)	Loam	16	25 *76	42	17	15	27	24	3	A-6(0)
6	RB-15 25+500 30.0m LT, A	1.1-1.5 (2ss)	Silty Clay Loam	1	7 *97	70	22	18	30	21	9	A-6(8)
7	RB-16 26+200 20.0m RT, A	4.1-4.6m (5ss)	Sand	1	90 *99	9			NP	NP	NP	A-3(0)

Grain Size Distribution Curve

GRAVEL	SAND	SILT OR CLAY

Boring No.	Sample No.	Elev or Depth	Nat w%	LL	PL	PI	Classification	Project: S9905
RB-01	2 SS	1.1 - 1.5 m	10.1	24	15	9	Silty Clay Loam	Project No.: NH-075-3( ), Des. No.: 9161365
21+260							A-4(5)	U.S. 231 Realignment
Line "A"								Spencer County, Indiana
30.0 m Rt.								Date: 9/99

Grain Size Distribution Curve



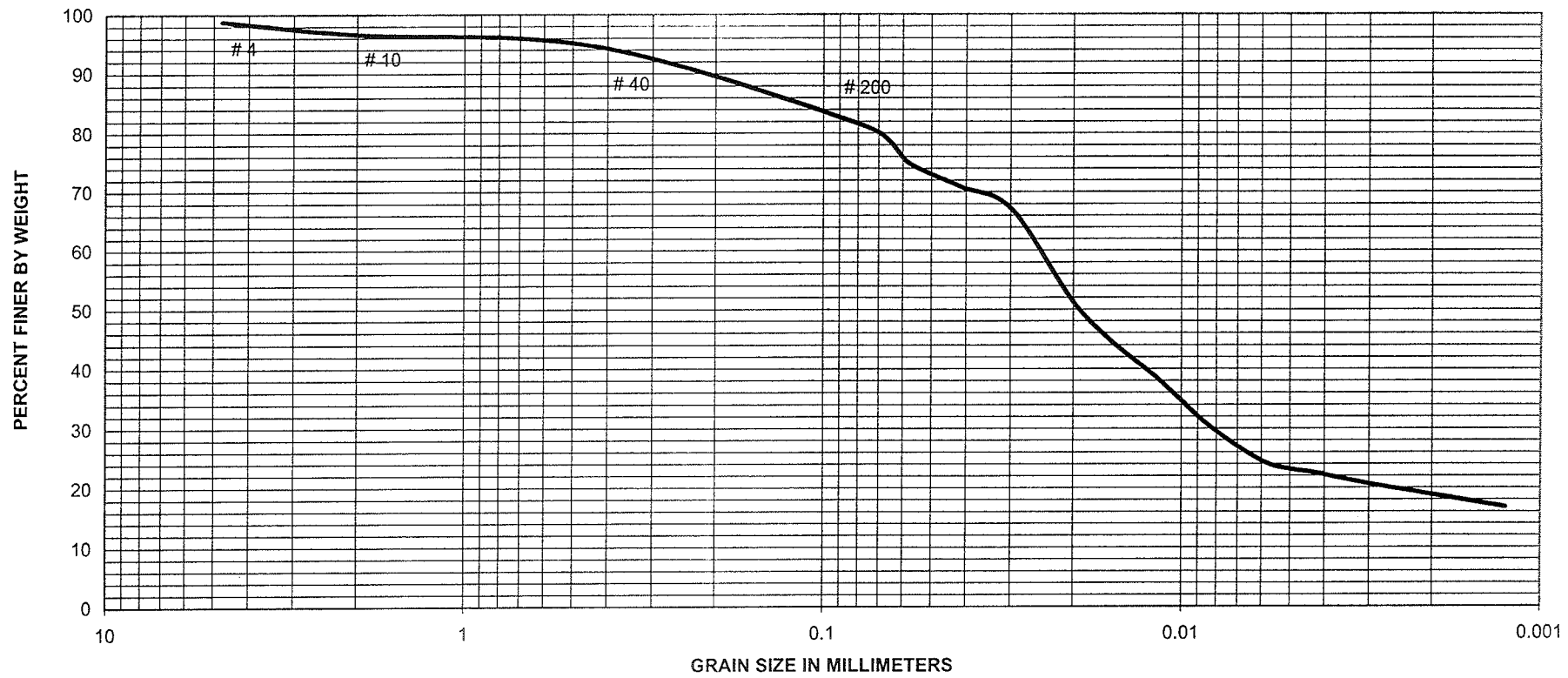
GRAVEL	SAND	SILT OR CLAY

Boring No.	Sample No.	Elev or Depth	Nat w%	LL	PL	PI	Classification
RB-05	2 SS	1.1 - 1.5 m	14.9	NP	NP	NP	Sandy Loam
22+160							A-4(0)
Line "A"							
15.0 m Lt.							

Project: S9905
Project No.: NH-075-3( ), Des. No.: 9161365
U.S. 231 Realignment
Spencer County, Indiana
Date: 9/99

A&W

Grain Size Distribution Curve



GRAVEL	SAND	SILT OR CLAY

Boring No.	Sample No.	Elev or Depth	Nat w%	LL	PL	PI	Classification
RB-05	5 SS	4.1 - 4.6 m	27.8	30	22	8	Silty Loam: A-4(6)
22+160							
Line "A"							
15.0 m Lt.							

Project: S9905

Project No.: NH-075-3( ), Des. No.: 9161365

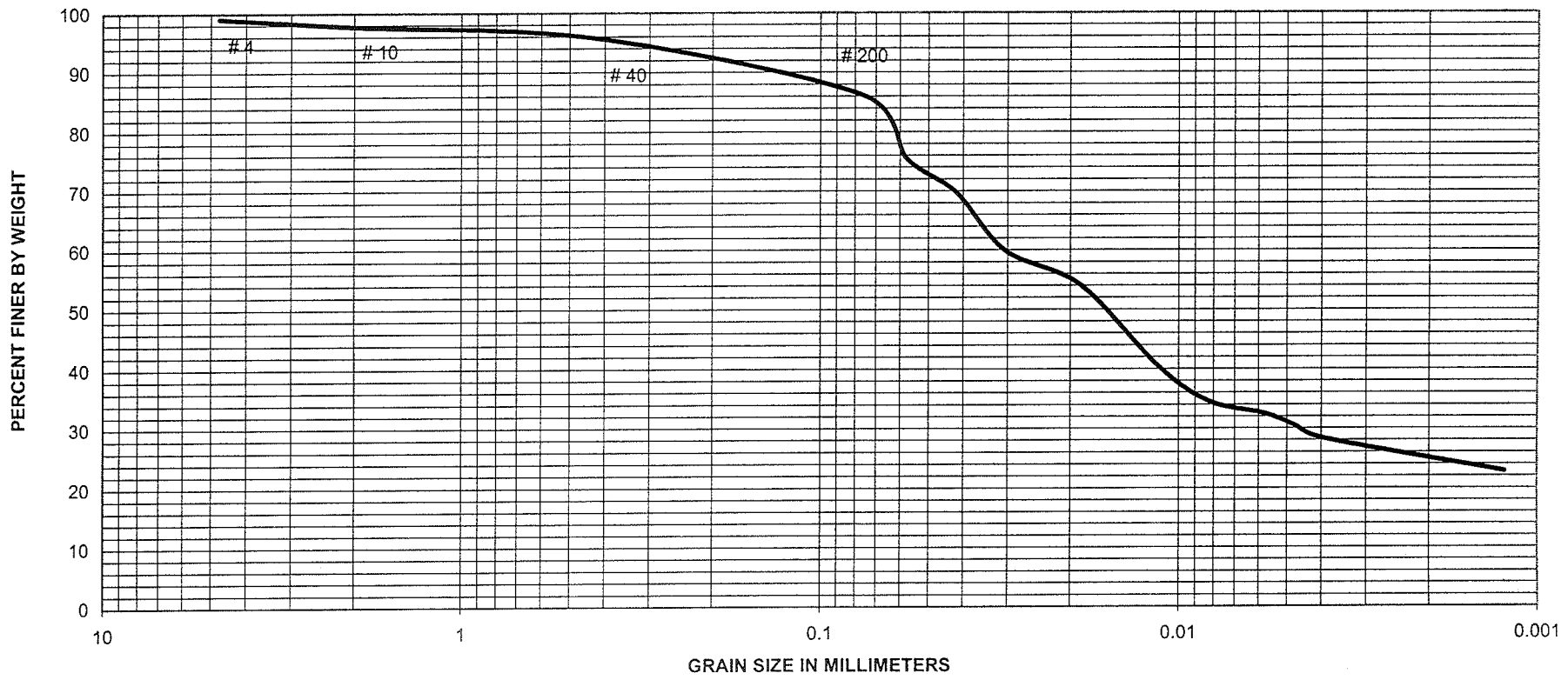
U.S. 231 Realignment

Spencer County, Indiana

Date: 9/99

A&W

Grain Size Distribution Curve



GRAVEL	SAND	SILT OR CLAY

Boring No.	Sample No.	Elev or Depth	Nat w%	LL	PL	PI	Classification
RB-07	4 SS	2.6 - 3.0 m	22.0	32	20	12	Silty Clay Loam
22+840							A-6(10)
Line "A"							
15.0 m Lt.							

Project: S9905

Project No.: NH-075-3( ), Des. No.: 9161365

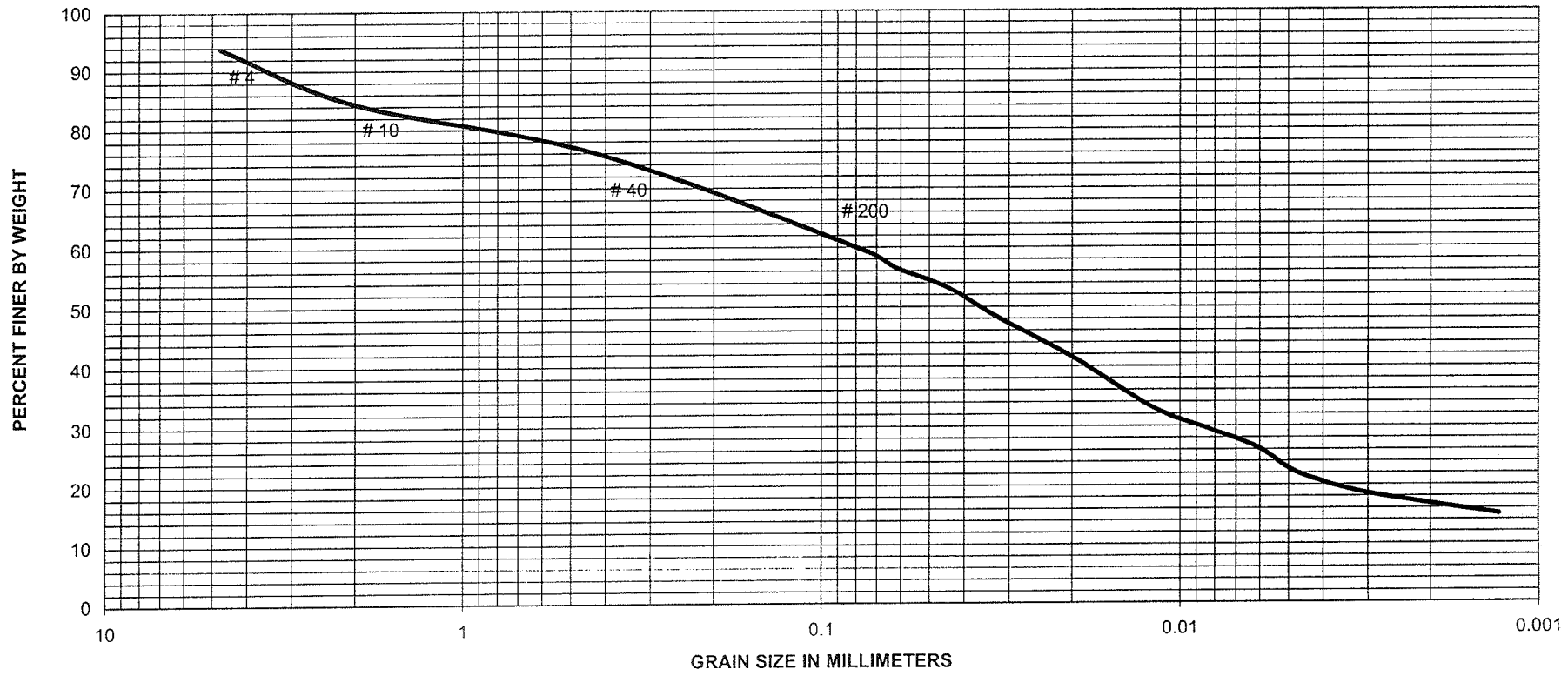
U.S. 231 Realignment

Spencer County, Indiana

Date: 9/99

A&W

Grain Size Distribution Curve

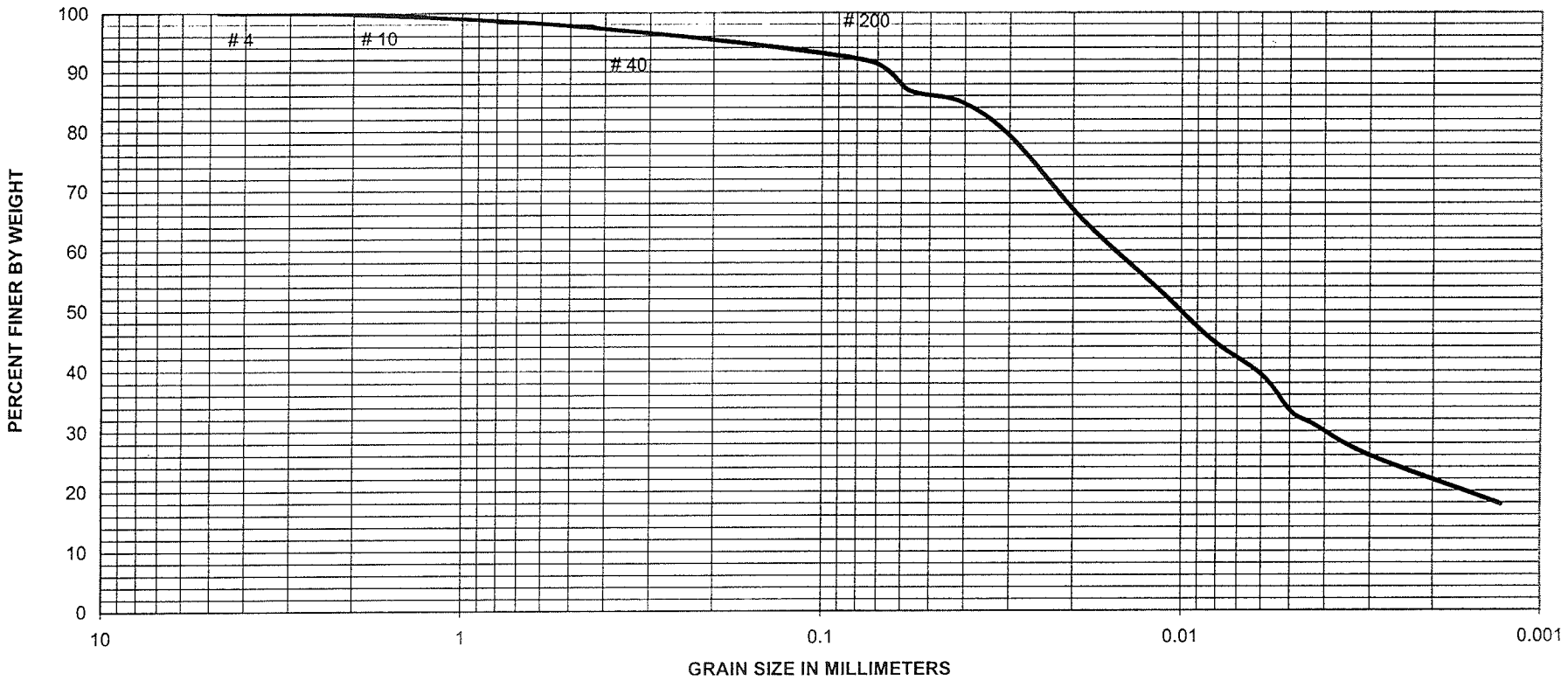


GRAVEL	SAND	SILT OR CLAY

Boring No.	Sample No.	Elev or Depth	Nat w%	LL	PL	PI	Classification
RB-11	2 SS	1.1 - 1.5 m	17.1	27	24	3	Loam: A-6(0)
24+060							
Line "A"							
20.0 m Lt.							

Project: S9905
Project No.: NH-075-3( ), Des. No.: 9161365
U.S. 231 Realignment
Spencer County, Indiana
Date: 10/99

Grain Size Distribution Curve



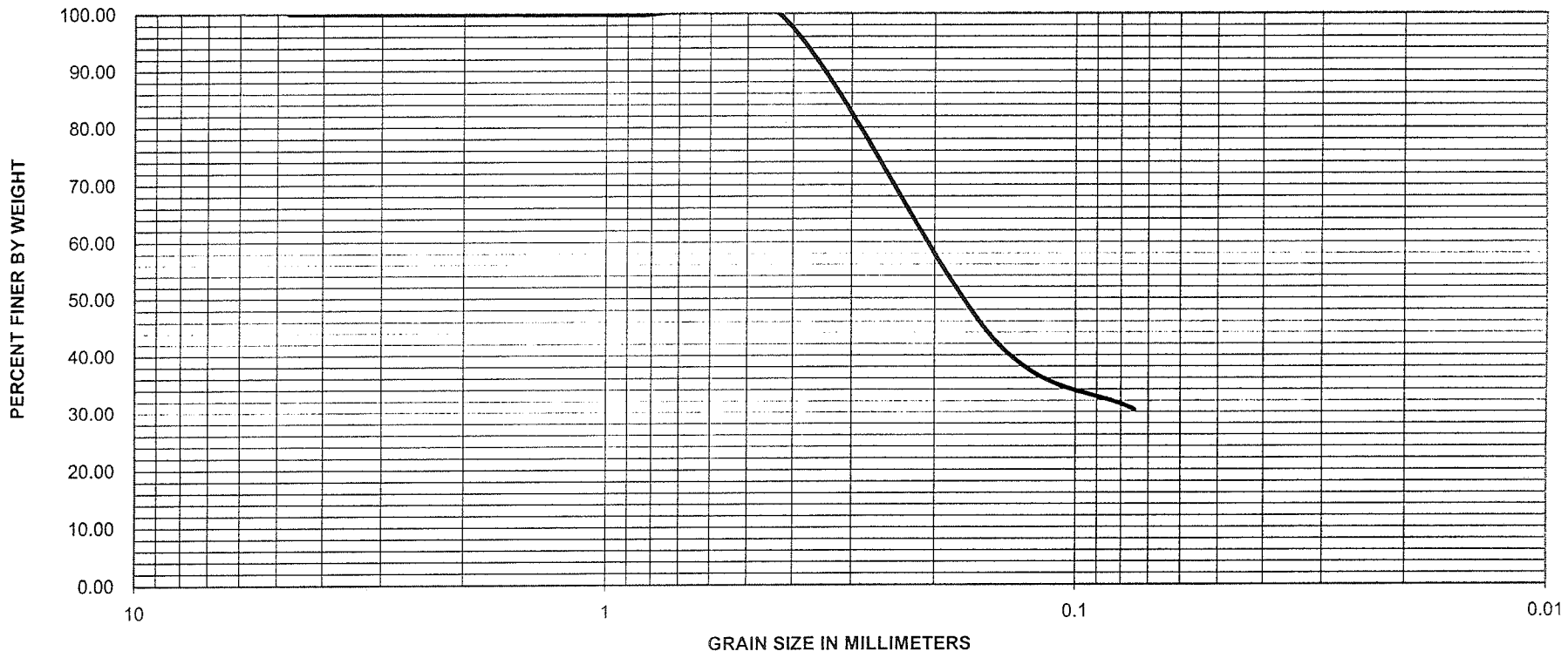
GRAVEL	SAND	SILT OR CLAY

Boring No.	Sample No.	Elev or Depth	Nat w%	LL	PL	PI	Classification
RB-15	4 SS	2.6 - 3.0 m	12.2	30	21	9	Silty Clay Loam:
25+280							A-6(8)
Line "A"							
24.0 m Rt.							

Project: S9905
Project No.: NH-075-3( ), Des. No.: 9161365
U.S. 231 Realignment
Spencer County, Indiana
Date: 10/99

A&W

Grain Size Distribution Curve



GRAVEL	SAND	SILT OR CLAY

Boring No.	Sample No.	Elev or Depth	Nat w%	LL	PL	PI	Classification
RB-16	5SS	4.1 - 4.6m	11.7	NP	NP	NP	Sand: A-3(0)
25+500							
Line "A"							
30.0 m Lt.							

Project No: S9905
Project No.: NH-075-3( ), Des. No.: 9161365
U.S. 231 Realignment
Spencer County, Indiana
Date: 10/99

A&W

Project No: NH-075-3( )
Des No. 9161365
U.S. 231 Realignment
Alt & Witzig File: S9905
Date: 9/99

Boring	*Sample*	*Depth (m)*	*pH*
RB-01	2 SS	1.1 –1.5m	5.1
RB-05	2 SS	1.1 – 1.5m	7.0
RB-05	5 SS	4.1 – 4.6m	7.3
RB-07	4 SS	2.6 – 3.0m	7.0
RB-11	2 SS	1.1 – 1.5m	5.2
RB-15	1 SS	1.1 – 1.5m	7.2
RB-16	2 SS	1.1 –1.5m	7.1

Project No: NH-075-3( )
Des No. 9161365
U.S. 231 Realignment
Alt & Witzig File: S9905
Date: 9/99

Boring	*Sample*	*Moisture*
RB-01	1 SS	13.7
RB-01	2 SS	10.1
RB-01	3 SS	18.5
RB-01	4 SS	11.8
RB-01	5 SS	7.6
RB-01	6 SS	14.0
RB-03	1 SS	13.1
RB-03	2 SS	9.0
RB-03	3 SS	16.3
RB-04	1 SS	12.5
RB-04	2 SS	10.4
RB-04	3 SS	10.1
RB-04	4 SS	7.1
RB-04	5 SS	6.9
RB-04	6 SS	5.9
RB-05	1 SS	18.4
RB-05	2 SS	14.9
RB-05	3 SS	20.9
RB-05	4 SS	20.4
RB-05	5 SS	27.8
RB-05	6 SS	15.1
RB-05	7 SS	14.5

Boring	*Sample*	*Moisture*
RB-06	1 SS	10.8
RB-06	2 SS	12.7
RB-06	3 SS	12.3
RB-06	4 SS	10.1
RB-06	5 SS	7.8
RB-06	6 SS	14.1
RB-07	1 SS	9.5
RB-07	2 SS	11.1
RB-07	3 SS	11.3
RB-07	4 SS	22.0
RB-07	5 SS	23.9
RB-07	6 SS	22.1
RB-08	1 SS	12.5
RB-08	2 SS	14.2
RB-08	3 SS	17.9
RB-08	4 SS	10.3
RB-10	1 SS	12.5
RB-10	2 SS	14.2
RB-10	3 SS	17.9
RB-10	4 SS	10.3
RB-11	1 SS	20.0
RB-11	2 SS	18.9
RB-11	3 SS	10.4

Boring	*Sample*	*Moisture*
RB-12	1 SS	9.0
RB-12	2 SS	11.0
RB-12	3 SS	11.9
RB-12	4 SS	11.1
RB-13	1 SS	11.4
RB-13	2 SS	12.0
RB-14	1 SS	8.7
RB-14	2 SS	13.5
RB-15	1 SS	18.2
RB-19	1 SS	12.4
RB-19	2 SS	18.7
RB-19	3 SS	13.7
RB-20	2 SS	19.8
RB-20	3 SS	19.4
RB-20	4 SS	22.3
RB-22	1 SS	14.9
RB-22	2 SS	18.2
RB-22	3 SS	12.6
RB-23	1 SS	20.5
RB-23	2 SS	12.3
RB-23	3 SS	15.9
RB-23	4 SS	16.8
RB-23	5 SS	14.3
RB-23	6 SS	14.1

LOG OF TEST BORING

Project: U.S. 231 Realignment
Location: Spencer County, Indiana
Client: Indiana Department of Transportation

3405 West 96th Street Indianapolis, Indiana 46268-1194
317-875-7000/317-876-3705(Fax)

Boring No. RB-01
Surface Elevation 144.9
Proj. # NH-075-3( )
AW Proj. # S9905
Sheet 1 of 1

Str. No. N/A | Station 21+260 | Offset 30.0 m Rt | Line "A"
Datum USC & GS | Weather Sunny | Temperature 85 | Inspector M. Rowe

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
1	X	100	8-9-13		Topsoil (Visual)			13.7			
2	X	100	14-25-25		Brown, Dry, Very Stiff to Hard, Silty Clay Loam Test 1 A-4(5) pH = 5.1			10.1	24	15	9
3	X	100	15-10-14					18.5			
4	X	100	32-32-28					11.8			
5	X	100	36-41-50/4"		Brown, Dry, Hard, Silty Clay Loam (Weathered Shale) Test 1 A-4			7.6			
6	X	100	15-21-30	5							
7	X	100	50		Gray, Dry, Weathered Shale (Visual)			14.0			
8	X	100	43-50/3"								
				10	Boring Terminated at 9.1 meters						
				15							
				20							

WATER LEVEL OBSERVATIONS

While Drilling ▽ DRY | Upon Completion of Drilling ▼ DRY
Time After Drilling 24 hrs
Depth to Water ▽ ▼ DRY
Depth to Cave in

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 8/19/99 End 8/20/99 Rig ATV
Driller Loveday Editor M. Rowe
Remarks Boring backfilled with soil cuttings.

LOG OF TEST BORING

Project: U.S. 231 Realignment
Location: Spencer County, Indiana
Client: Indiana Department of Transportation

3405 West 96th Street Indianapolis, Indiana 46268-1194
317-875-7000/317-876-3705(Fax)

Boring No. RB-02
Surface Elevation 148.3
Proj. # NH-075-3( )
AW Proj. # S9905
Sheet 1 of 1

Str. No.	N/A	Station	21+520	Offset	32.0 m Rt	Line	"A"
Datum	USC & GS	Weather	Sunny	Temperature	85	Inspector	M. Rowe

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
1	X	75	12-13-35		Gray, Dry, Hard, Silty Loam Test 3 A-4						
2	X	100	17-27-28								
3	X	100	25-50/3"		Gray, Dry, Hard, Silty Loam (Weathered Shale) Test 3 A-4						
4	X	100	41-50/3"								
5	X	100	48-50/3"	5	Gray, Dry, Weathered Shale (Visual)						
6	X	100	50/1"		Gray, Dry, Weathered Shale (Visual) 6.1 to 6.7 m, Gray Sandstone (Visual) 6.7 to 7.6 m Rock Core No. 1 REC: 97% RQD: 88%						
				10	Gray Sandstone (Visual) Rock Core No. 2 REC: 97% RQD: 68%						
					Boring Terminated at 9.1 meters						
				15							
				20							

WATER LEVEL OBSERVATIONS

While Drilling	▽ DRY	Upon Completion of Drilling	▼ 1.1	
Time After Drilling		24		
Depth to Water	▽	▼ 2.4	▽	▽
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 8/19/99 End 8/19/99 Rig ATV
Driller Loveday Editor M. Rowe
Remarks Boring backfilled with soil cuttings.

LOG OF TEST BORING

Project: U.S. 231 Realignment
Location: Spencer County, Indiana
Client: Indiana Department of Transportation

3405 West 96th Street Indianapolis, Indiana 46268-1194
317-875-7000/317-876-3705(Fax)

Boring No. RB-03
Surface Elevation 150.7
Proj. # NH-075-3( )
AW Proj. # S9905
Sheet 1 of 1

Str. No.	N/A	Station	21+680	Offset	32.0 m Lt	Line	"A"
Datum	USC & GS	Weather	Sunny	Temperature	85	Inspector	M. Rowe

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
1	X	100	10-11-15		Topsoil (Visual)			13.1			
2	X	100	26-46-43		Brown, Dry, Very Stiff to Hard, Silty Clay Loam			9.0			
3	X	100	26-28-50/2		Test 1 A-4			16.3			
4	X	100	50/1"								
5	X	100	50/2"	5	Brown, Dry, Hard, Silty Clay Loam with Shale Fragments						
6	X	100	50/3"		Test 1 A-4						
7	X	100	50/1"		Gray Sandstone (Visual)						
					Rock Core No. 1						
					REC: 97%						
				10	RQD: 80%						
					Gray Sandstone (Visual)						
					Rock Core No. 2						
					REC: 97%						
					RQD: 90%						
					Gray Sandstone (Visual) 10.7 to 11.7 m,						
					Gray Shale (Visual) 11.7 to 12.2m						
					Rock Core No. 3						
					REC: 93%						
					RQD: 85%						
				15	Boring Terminated at 12.2 meters						
				20							

WATER LEVEL OBSERVATIONS

	While Drilling	Upon Completion of Drilling			
Time After Drilling		24			
Depth to Water	▽	▼ 1.9	▽	▽	
Depth to Cave in					

DRY — 1.2

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 8/18/99 End 8/18/99 Rig ATV
Driller Loveday Editor M. Rowe
Remarks Boring backfilled with soil cuttings.

LOG OF TEST BORING

Project: U.S. 231 Realignment
Location: Spencer County, Indiana
Client: Indiana Department of Transportation

3405 West 96th Street Indianapolis, Indiana 46268-1194
317-875-7000/317-876-3705(Fax)

Boring No. RB-04
Surface Elevation 148.8
Proj. # NH-075-3( )
AW Proj. # S9905
Sheet 1 of 1

Str. No. N/A | Station 21+880 | Offset 30.0 m Rt | Line "A"
Datum USC & GS | Weather Sunny | Temperature 85 | Inspector M. Rowe

SAMPLE					DESCRIPTION/CLASSIFICATION and REMARKS	SOIL PROPERTIES					
No.	Type	Rec (%)	N	Depth		qu (qp) (tsf)	ɣ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
1	X	100	13-16-23		Topsoil (Visual)			12.5			
2	X	100	15-24-24		Brown, Dry, Hard, Silty Clay Loam			10.4			
3	X	100	50/4"		Test 1 A-4			10.1			
4	X	100	50/4"					7.1			
5	X	100	50/4"	5				6.9			
6	X	100	50/1"					5.9			
7	X	100	50/1"		Gray, Dry, Weathered Shale (Visual)						
					Gray Sandstone (Visual) Rock Core No. 1 REC: 90% RQD: 66%						
				10	Boring Terminated at 9.1 meters						
				15							
				20							

WATER LEVEL OBSERVATIONS

While Drilling ▽ DRY | Upon Completion of Drilling ▼ DRY
Time After Drilling 24
Depth to Water ▽ ▼ DRY ▽ ▽
Depth to Cave in

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 8/18/99 End 8/18/99 Rig ATV
Driller Loveday Editor M. Rowe
Remarks Boring backfilled with soil cuttings.

LOG OF TEST BORING

Project: U.S. 231 Realignment
Location: Spencer County, Indiana
Client: Indiana Department of Transportation

3405 West 96th Street Indianapolis, Indiana 46268-1194
317-875-7000/317-876-3705(Fax)

Boring No. RB-05
Surface Elevation 131.3
Proj. # NH-075-3( )
AW Proj. # S9905
Sheet 1 of 1

Str. No.	N/A	Station	22+160	Offset	15.0 m Lt	Line	"A"
Datum	USC & GS	Weather	Sunny	Temperature	85	Inspector	M. Rowe

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
1	X	100	4-4-3		Topsoil (Visual)			18.4			
2	X	100	4-4-3		Brown, Dry, Loose to Medium Dense, Sandy Loam Test 2 A-4(0) pH = 7.0			14.9	NP	NP	NP
3	X	100	2-4-4					20.9			
4	X	100	4-5-7					20.4			
5	X	100	2-2-4	5	Brown, Dry, Medium Stiff, Silty Loam Test 3 A-4(6) pH = 7.3			27.8	30	22	8
6	X	100	9-8-10		Gray, Dry, Weathered Shale (Visual)			15.1			
7	X	100	50/4"					14.5			
					Gray Shale (Visual) Rock Core No. 1 REC: 83% RQD: 40						
				10	Boring Terminated at 9.1 meters						
					Note: Shelby Tube Pushed from 1.8 to 2.4m						
				15							
				20							

WATER LEVEL OBSERVATIONS

While Drilling	6.7	Upon Completion of Drilling	6.7	
Time After Drilling		24		
Depth to Water		7.0		
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 8/17/99 End 8/17/99 Rig ATV
Driller Loveday Editor M. Rowe
Remarks Boring backfilled with soil cuttings.

LOG OF TEST BORING

Project: U.S. 231 Realignment
Location: Spencer County, Indiana
Client: Indiana Department of Transportation

3405 West 96th Street Indianapolis, Indiana 46268-1194
317-875-7000/317-876-3705(Fax)

Boring No. RB-06
Surface Elevation 147.6
Proj. # NH-075-3( )
AW Proj. # S9905
Sheet 1 of 1

Str. No.	N/A	Station	22+540	Offset	30.0 m Rt	Line	"A"
Datum	USC & GS	Weather	Sunny	Temperature	85	Inspector	M. Rowe

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Topsoil (Visual)						
1	X	100	4-4-3					10.8			
2	X	100	4-4-3		Brown, Dry, Very Stiff to Hard, Silty Loam Test 3 A-4			12.7			
3	X	100	2-4-4					12.3			
4	X	100	4-5-7					10.1			
5	X	100	2-2-4		Brown, Dry, Hard, Silty Loam with Shale Fragments Test 3 A-4			7.8			
6	X	100	9-8-10	5				14.1			
					Gray Very Weathered Shale (Visual) Rock Core No. 1 REC: 91% RQD: N/A						
				10	Gray Weathered Shale (Visual) 8.4 to 9.6 m, Gray Shale (Visual) 9.6 to 11.4 m. Rock Core No.2 REC: 100% RQD: 73%						
					Gray Shale (Visual) Rock Core No.3 REC: 80% RQD: 66%						
				15	Boring Terminated at 12.2 meters						
				20							

WATER LEVEL OBSERVATIONS

	While Drilling	Upon Completion of Drilling		
Time After Drilling		24		
Depth to Water		2.1		
Depth to Cave in				

DRY

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 8/16/99 End 8/17/99 Rig ATV
Driller Loveday Editor M. Rowe
Remarks Boring backfilled with soil cuttings.

LOG OF TEST BORING

Project: U.S. 231 Realignment
Location: Spencer County, Indiana
Client: Indiana Department of Transportation

3405 West 96th Street Indianapolis, Indiana 46268-1194
317-875-7000/317-876-3705(Fax)

Boring No. RB-07
Surface Elevation 134.3
Proj. # NH-075-3( )
AW Proj. # S9905
Sheet 1 of 1

Str. No. N/A | Station 22+840 | Offset 15.0 m Lt | Line "A"
Datum USC & GS | Weather Sunny | Temperature 85 | Inspector M. Rowe

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Topsoil (Visual)						
1	X	100	7-7-8		Brown, Dry, Stiff, Silty Loam Test 3 A-4			9.5			
2	X	100	6-6-7					11.1			
3	X	100	17-16-14		Brown, Dry, Medium Dense, Sandy Loam Test 2 A-4			11.3			
4	X	100	14-10-15		Brown, Dry, Very Stiff to Hard, Silty Clay Loam Test 4 A-6(10) pH = 7.0			22.0	32	20	12
5	X	100	11-17-21	5				23.9			
6	X	100	25-50/3"		Gray Weathered Shale (Visual)			22.1			
					Boring Terminated at 6.1 meters						
				10							
				15							
				20							

WATER LEVEL OBSERVATIONS

While Drilling ▽ DRY | Upon Completion of Drilling ▼ DRY
Time After Drilling 24
Depth to Water ▽ | ▼ DRY | ▽ | ▽
Depth to Cave in

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 8/16/99 End 8/16/99 Rig ATV
Driller Loveday Editor M. Rowe
Remarks Boring backfilled with soil cuttings.

LOG OF TEST BORING

Project: U.S. 231 Realignment
Location: Spencer County, Indiana
Client: Indiana Department of Transportation

3405 West 96th Street Indianapolis, Indiana 46268-1194
317-875-7000/317-876-3705(Fax)

Boring No. RB-08
Surface Elevation 152.5
Proj. # NH-075-3( )
AW Proj. # S9905
Sheet 1 of 1

Str. No. N/A | Station 23+200 | Offset 30.0 m Rt | Line "A"
Datum USC & GS | Weather Sunny | Temperature 75 | Inspector M. Rowe

SAMPLE					DESCRIPTION/CLASSIFICATION and REMARKS	SOIL PROPERTIES					
No.	Type	Rec (%)	N	Depth		qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
1	X	100	3-2-4		Brown, Dry, Medium Stiff to Very Stiff, Silty Clay Loam Test 4 A-6			12.5			
2	X	100	18-7-6					14.2			
3	X	100	21-10-10					17.9			
4	X	100	23-15-15					10.3			
5	X	100	23-10-13	5							
6	X	100	27-11-13								
7	X	100	25-13-13								
8	X	75	14-8-10								
9	X	100	46-24-21	10	Brown to Gray, Moist, Very Weathered Siltstone (Visual)						
10	X	100	9-49-50/3"								
11	X	100	36-50/4"								
12	X	100	36-50/3"	15							
13	X	10	50/1"								
					Boring Terminated at 16.8 meters						
				20							

WATER LEVEL OBSERVATIONS

While Drilling	DRY	Upon Completion of Drilling	DRY
Time After Drilling		24	
Depth to Water		DRY	
Depth to Cave in			

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 10/7/99 End 10/7/99 Rig ATV
Driller Loveday Editor M. Rowe
Remarks Boring backfilled with soil cuttings.

LOG OF TEST BORING

Project: U.S. 231 Realignment
Location: Spencer County, Indiana
Client: Indiana Department of Transportation

3405 West 96th Street Indianapolis, Indiana 46268-1194
317-875-7000/317-876-3705(Fax)

Boring No. RB-09
Surface Elevation 138.6
Proj. # NH-075-3( )
AW Proj. # S9905
Sheet 1 of 1

Str. No.	N/A	Station	23+460	Offset	34.0 m Lt	Line	"A"
Datum	USC & GS	Weather	Cloudy	Temperature	76	Inspector	M. Rowe

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
1	X	100	6-5-6		Brown, Moist, Stiff to Hard, Silty Clay Loam Test 4 A-6						
2	X	100	4-5-6								
3	X	100	6-28-37								
4	X	100	32-50/3"		Gray Weathered Shale (Visual)						
5	X	100	46-50/3"								
				5	Gray Shale (Visual) Rock Core No. 1 REC: 96% RQD: 83%						
				10	Gray Shale (Visual) Rock Core No. 2 REC: 90% RQD: 85%						
					Gray Shale (Visual), Coal Seam (Visual) from 14.0 to 14.2 m Rock Core No. 3 REC: 100% RQD: 90%						
				15	Gray Shale (Visual) 14.3 to 15.8 m, Brown Sandstone (Visual) 15.8 to 17.4 m Rock Core No. 4 REC: 100% RQD: 88%						
					Brown Sandstone (Visual) Rock Core No. 5 REC: 90% RQD: 80%						
				20	Boring Terminated at 18.2 meters						

WATER LEVEL OBSERVATIONS

While Drilling	DRY	Upon Completion of Drilling	1.0	
Time After Drilling		24		
Depth to Water		1.2		
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 8/25/99 End 8/25/99 Rig ATV
Driller Loveday Editor M. Rowe
Remarks Boring backfilled with soil cuttings.

LOG OF TEST BORING

Project: U.S. 231 Realignment
Location: Spencer County, Indiana
Client: Indiana Department of Transportation

3405 West 96th Street Indianapolis, Indiana 46268-1194
317-875-7000/317-876-3705(Fax)

Boring No. RB-10
Surface Elevation 138.2
Proj. # NH-075-3( )
AW Proj. # S9905
Sheet 1 of 1

Str. No. N/A | Station 23+720 | Offset 20.0 m Lt | Line "A"
Datum USC & GS | Weather Sunny | Temperature 75 | Inspector M. Rowe

SAMPLE					DESCRIPTION/CLASSIFICATION and REMARKS	SOIL PROPERTIES					
No.	Type	Rec (%)	N	Depth		qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
1	X	100	10-9-8		Brown, Dry, Medium Dense to Dense Loam Test 5 A-6			12.5			
2	X	100	10-15-17								
3	X	100	30-20-20		Brown to Gray, Dry, Hard, Silty Clay Loam with Very Weathered Shale Test 1 A-4			14.2			
4	X	100	24-31-44					17.9			
					Gray Sandstone (Visual)			10.3			
				5	Boring Terminated at 3.8 meters						
					Note: Auger refusal at 3.8 meters						
				10							
				15							
				20							

WATER LEVEL OBSERVATIONS

While Drilling ▽ DRY | Upon Completion of Drilling ▼ DRY
Time After Drilling 24
Depth to Water ▽ | ▼ DRY | ▽ | ▽
Depth to Cave in

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 10/5/99 End 10/5/99 Rig ATV
Driller Loveday Editor M. Rowe
Remarks Boring backfilled with soil cuttings.

LOG OF TEST BORING

Project: U.S. 231 Realignment
Location: Spencer County, Indiana
Client: Indiana Department of Transportation

3405 West 96th Street Indianapolis, Indiana 46268-1194
317-875-7000/317-876-3705(Fax)

Boring No. RB-11
Surface Elevation 141.5
Proj. # NH-075-3( )
AW Proj. # S9905
Sheet 1 of 1

Str. No.	N/A	Station	24+060	Offset	20.0 m Lt	Line	"A"
Datum	USC & GS	Weather	Sunny	Temperature	70	Inspector	M. Rowe

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
1	X	100	5-4-6		Brown, Dry, Loose to Very Dense, Loam (Weathered Shale) Test 5 A-6(0) pH = 5.2			20.0			
2	X	100	4-7-11					18.9	27	24	3
3	X	100	8-30-50/3"					10.4			
4	X	100	15-25-22		Gray Sandstone (Visual)						
					Boring Terminated at 3.4 meters						
				5	Note: Auger refusal at 3.4 meters						
				10							
				15							
				20							

WATER LEVEL OBSERVATIONS

While Drilling	DRY	Upon Completion of Drilling	DRY	
Time After Drilling		24		
Depth to Water		DRY		
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 10/5/99 End 10/5/99 Rig ATV
Driller Loveday Editor M. Rowe
Remarks Boring backfilled with soil cuttings.

LOG OF TEST BORING

Project: U.S. 231 Realignment
Location: Spencer County, Indiana
Client: Indiana Department of Transportation

3405 West 96th Street Indianapolis, Indiana 46268-1194
317-875-7000/317-876-3705(Fax)

Boring No. RB-12
Surface Elevation 145.3
Proj. # NH-075-3( )
AW Proj. # S9905
Sheet 1 of 1

Str. No. N/A | Station 24+300 | Offset 25.0 m Rt | Line "A"
Datum USC & GS | Weather Sunny | Temperature 70 | Inspector M. Rowe

SAMPLE					DESCRIPTION/CLASSIFICATION and REMARKS	SOIL PROPERTIES					
No.	Type	Rec (%)	N	Depth		qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
1	X	100	10-16-19		Brown, Dry, Hard, Silty Clay Loam			9.0			
2	X	100	16-22-20		Test 4 A-6			11.0			
3	X	100	27-21-21					11.9			
4	X	100	28-31-35		Gray, Very Weathered Siltstone (Visual)			11.1			
5	X	50	50	5							
6	X	30	50/4"								
					Boring Terminated at 6.1 meters						
				10							
				15							
				20							

WATER LEVEL OBSERVATIONS

While Drilling	DRY	Upon Completion of Drilling	DRY
Time After Drilling		24	
Depth to Water		DRY	
Depth to Cave in			

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 10/5/99 End 10/5/99 Rig ATV
Driller Loveday Editor M. Rowe
Remarks Boring backfilled with soil cuttings.

LOG OF TEST BORING

Project: U.S. 231 Realignment
Location: Spencer County, Indiana
Client: Indiana Department of Transportation

3405 West 96th Street Indianapolis, Indiana 46268-1194
317-875-7000/317-876-3705(Fax)

Boring No. RB-13
Surface Elevation 164.5
Proj. # NH-075-3( )
AW Proj. # S9905
Sheet 1 of 1

Str. No.	N/A	Station	24+680	Offset	30.0 m Lt	Line	"A"
Datum	USC & GS	Weather	Sunny	Temperature	70	Inspector	M. Rowe

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
1	X	100	7-12-14		Brown to Gray, Dry, Very Stiff to Hard, Silty Clay Loam			11.4			
2	X	100	8-28-40		Test 1 A-4			12.0			
3	X	100	34-29-44								
4	X	100	50-32-50/4"								
5	X	10	50/3"	5							
6	X	10	50/3"								
7	X	0	50/0"		auger refusal						
				10	Boring Terminated at 7.6 meters						
				15							
				20							

WATER LEVEL OBSERVATIONS

While Drilling	▽ DRY	Upon Completion of Drilling	▼ DRY	
Time After Drilling		24		
Depth to Water	▽	▼ DRY	▽	▽
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 10/5/99 End 10/5/99 Rig ATV
Driller Loveday Editor M. Rowe
Remarks Boring backfilled with soil cuttings.

LOG OF TEST BORING

Project: U.S. 231 Realignment
Location: Spencer County, Indiana
Client: Indiana Department of Transportation

3405 West 96th Street Indianapolis, Indiana 46268-1194
317-875-7000/317-876-3705(Fax)

Boring No. RB-14
Surface Elevation 155.5
Proj. # NH-075-3( )
AW Proj. # S9905
Sheet 1 of 1

Str. No. N/A | Station 24+940 | Offset 30.0 m Rt | Line "A"
Datum USC & GS | Weather Sunny | Temperature 70 | Inspector M. Rowe

SAMPLE				DESCRIPTION/CLASSIFICATION and REMARKS	SOIL PROPERTIES					
No.	Type	Rec (%)	N	Depth		qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
1	X	100	7-11-15		Brown, Dry, Very Stiff, Silty Clay Loam Test 1 A-4			8.7			
2	X	100	18-12-12								
3	X	100	23-24-30					13.5			
4	X	100	23-42-50/3"		Brown to Gray, Very Weathered Siltstone						
5	X	30	50/4"	5							
					Boring Terminated at 5.3 meters						
					Note: 1. Auger refusal at 5.3 meters						
				10							
				15							
				20							

WATER LEVEL OBSERVATIONS

While Drilling ▽ DRY | Upon Completion of Drilling ▼ DRY
Time After Drilling 24
Depth to Water ▽ | ▼ DRY | ▽ | ▽
Depth to Cave in

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 10/4/99 End 10/4/99 Rig ATV
Driller Loveday Editor M. Rowe
Remarks Boring backfilled with soil cuttings.

LOG OF TEST BORING

Project: U.S. 231 Realignment
Location: Spencer County, Indiana
Client: Indiana Department of Transportation

3405 West 96th Street Indianapolis, Indiana 46268-1194
317-875-7000/317-876-3705(Fax)

Boring No. RB-15
Surface Elevation 148.9
Proj. # NH-075-3( )
AW Proj. # S9905
Sheet 1 of 1

Str. No. N/A | Station 25+280 | Offset 24.0 m Rt | Line "A"
Datum USC & GS | Weather Sunny | Temperature 55 | Inspector M. Rowe

SAMPLE					DESCRIPTION/CLASSIFICATION and REMARKS	SOIL PROPERTIES					
No.	Type	Rec (%)	N	Depth		qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Gray, Moist to Very Moist, Very Soft to Hard, Silty Clay Loam						
1	X	60	1-1-1		Test 6 A-6(8)			18.2	30	21	9
2	X	20	0-0-1		pH = 7.2						
3	X	50	2-6-3								
4	X		50/3"		auger refusal						
				5	Boring Terminated at 4.6 meters						
				10							
				15							
				20							

WATER LEVEL OBSERVATIONS

While Drilling ▽ 1.2 | Upon Completion of Drilling ▼ 1.3
Time After Drilling
Depth to Water
Depth to Cave in

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 10/20/99 End 10/20/99 Rig Skid
Driller Winkler Editor M. Rowe
Remarks Boring backfilled with soil cuttings.

LOG OF TEST BORING

Project: U.S. 231 Realignment
Location: Spencer County, Indiana
Client: Indiana Department of Transportation

3405 West 96th Street Indianapolis, Indiana 46268-1194
317-875-7000/317-876-3705(Fax)

Boring No. RB-16
Surface Elevation 177.7
Proj. # NH-075-3( )
AW Proj. # S9905
Sheet 1 of 1

Str. No.	N/A	Station	25+500	Offset	30.0 m Lt	Line	"A"
Datum	USC & GS	Weather	Sunny	Temperature	70	Inspector	M. Rowe

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
1	X	100	48-50/3"		Brown to Gray, Dry, Very Dense Sand						
2	X	100	16-50/4"		Test 7 A-3(0)				NP	NP	NP
3	X	100	40-50/3"		pH = 7.1						
4	X	100	45-50/3"								
5	X	100	50-50/3"	5							
6	X	50	50/2"								
7	X	100	30-32-50/3"		Gray Weathered Shale (Visual)						
8	X	30	50/3"		Boring Terminated at 8.8 meters						
				10							
				15							
				20							

WATER LEVEL OBSERVATIONS

While Drilling	DRY	Upon Completion of Drilling	DRY	
Time After Drilling		24		
Depth to Water		DRY		
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 10/5/99 End 10/5/99 Rig ATV
Driller Loveday Editor M. Rowe
Remarks Boring backfilled with soil cuttings.

LOG OF TEST BORING

Project: U.S. 231 Realignment
Location: Spencer County, Indiana
Client: Indiana Department of Transportation

3405 West 96th Street Indianapolis, Indiana 46268-1194
317-875-7000/317-876-3705(Fax)

Boring No. RB-17
Surface Elevation 155.2
Proj. # NH-075-3( )
AW Proj. # S9905
Sheet 1 of 1

Str. No.	N/A	Station	25+740	Offset	15.0 m Rt	Line	"A"
Datum	USC & GS	Weather	Sunny	Temperature	55	Inspector	M. Rowe

SAMPLE					DESCRIPTION/CLASSIFICATION and REMARKS	SOIL PROPERTIES					
No.	Type	Rec (%)	N	Depth		qu (qp) (tsf)	ɣ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Water						
					Dark Brown, Organic Silty Loam (Visual)						
					Brown, Organic Silty Clay with Rock Fragments (Visual)						
					Rock Core No. 1 REC: 23% RQD: 13%						
				5	Gray Shale (Visual)						
					Rock Core No.2 REC: 93% RQD: 69%						
					Boring Terminated at 6.0 meters Note: Boring Casing						
				10							
				15							
				20							

WATER LEVEL OBSERVATIONS

While Drilling ▽		Upon Completion of Drilling ▼		
Time After Drilling				
Depth to Water	▽	▼	▼	▼
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 10/18/99 End 10/19/99 Rig Barge
Driller Winkler Editor M. Rowe
Remarks Boring backfilled with soil cuttings.

LOG OF TEST BORING

Project: U.S. 231 Realignment
Location: Spencer County, Indiana
Client: Indiana Department of Transportation

3405 West 96th Street Indianapolis, Indiana 46268-1194
317-875-7000/317-876-3705(Fax)

Boring No. RB-18
Surface Elevation 150.4
Proj. # NH-075-3( )
AW Proj. # S9905
Sheet 1 of 1

Str. No.	N/A	Station	25+900	Offset	15.0 m Lt	Line	"A"
Datum	USC & GS	Weather	Sunny	Temperature	81	Inspector	M. Rowe

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
1	X		16-17-17		Brown, Dry, Hard, Silty Clay Loam Test 1 A-4						
2	X	100	8-11-15								
3	X	100	6-11-23								
4	X	100	18-50/3"		Brown, Very Weathered, Sandstone (Visual)						
5	X	100	36-50/3"	5							
6	X	100	50/4"		Gray Limestone (Visual)						
					Gray Shale (Visual)						
					Boring Terminated at 7.3 meters						
				10							
				15							
				20							

WATER LEVEL OBSERVATIONS

While Drilling ▽ DRY
Time After Drilling 24
Depth to Water ▽ ▼ 1.3
Depth to Cave in

Upon Completion of Drilling ▼ 1.2

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 8/31/99 End 8/31/99 Rig ATV
Driller Loveday Editor M. Rowe
Remarks Boring backfilled with soil cuttings

LOG OF TEST BORING

Project: U.S. 231 Realignment
Location: Spencer County, Indiana
Client: Indiana Department of Transportation

3405 West 96th Street Indianapolis, Indiana 46268-1194
317-875-7000/317-876-3705(Fax)

Boring No. RB-19
Surface Elevation 160.4
Proj. # NH-075-3( )
AW Proj. # S9905
Sheet 1 of 1

Str. No. N/A | Station 26+200 | Offset 20.0 m Rt | Line "A"
Datum USC & GS | Weather Sunny | Temperature 85 | Inspector M. Rowe

SAMPLE					DESCRIPTION/CLASSIFICATION and REMARKS	SOIL PROPERTIES					
No.	Type	Rec (%)	N	Depth		qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
1	X	100	8-16-19		Brown, Dry, Hard, Silty Loam Test 3 A-4			12.4			
2	X	100	10-13-18					18.7			
3	X	100	13-15-19					13.7			
4	X	0	50/0"								
					Brown Weathered Sandstone (Visual) 3.1 to 3.7 m, Brown Very Weathered Shale (Visual) 3.7 to 6.1 m Rock Core No. 1 REC: 57% RQD: 0%						
				5							
					Boring Terminated at 6.1 meters						
				10							
				15							
				20							

WATER LEVEL OBSERVATIONS

While Drilling ▽ DRY | Upon Completion of Drilling ● 0.3
Time After Drilling 24
Depth to Water ▽ ▼ 1.4 ▽ ▽
Depth to Cave in

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 8/24/99 End 8/24/99 Rig ATV
Driller Loveday Editor M. Rowe
Remarks Boring backfilled with soil cuttings.

LOG OF TEST BORING

Project: U.S. 231 Realignment
Location: Spencer County, Indiana
Client: Indiana Department of Transportation

3405 West 96th Street Indianapolis, Indiana 46268-1194
317-875-7000/317-876-3705(Fax)

Boring No. RB-20
Surface Elevation 161.6
Proj. # NH-075-3( )
AW Proj. # S9905
Sheet 1 of 1

Str. No. N/A | Station 26+500 | Offset 30.0 m Rt | Line "A"
Datum USC & GS | Weather Sunny | Temperature 85 | Inspector M. Rowe

SAMPLE					DESCRIPTION/CLASSIFICATION and REMARKS	SOIL PROPERTIES					
No.	Type	Rec (%)	N	Depth		qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
1	X	100	6-5-7		Brown, Moist, Stiff to Very Stiff, Silty Loam Test 3 A-4						
2	X	100	6-5-9					19.8			
3	X	100	6-14-15					19.4			
4	X	100	5-13-43		Brown Siltstone (Visual)			22.3			
					Brown Siltstone (Visual) Rock Core No. 1 REC: 92% RQD: 91%						
				5	Brown Siltstone (Visual) 4.9 to 5.8m, Brown Weathered Sandstone (Visual) 5.8 to 6.4m Rock Core No. 2 REC: 95% RQD: 43%						
					Brown Weathered Sandstone (Visual) 6.4 to 7.3m Gray Weathered Shale (Visual) 7.3 to 7.6m Rock Core No. 3 REC: 94% RQD: 25%						
				10	Boring Terminated at 7.6 meters						
				15							
				20							

WATER LEVEL OBSERVATIONS

While Drilling ▽ DRY | Upon Completion of Drilling ▼ 0.9
Time After Drilling 24
Depth to Water ▽ | ▼ 2.0 | ▽ | ▽
Depth to Cave in

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 8/24/99 End 8/24/99 Rig ATV
Driller Loveday Editor M. Rowe
Remarks Boring backfilled with soil cuttings.

LOG OF TEST BORING

Project: U.S. 231 Realignment
Location: Spencer County, Indiana
Client: Indiana Department of Transportation

3405 West 96th Street Indianapolis, Indiana 46268-1194
317-875-7000/317-876-3705(Fax)

Boring No. RB-21
Surface Elevation 161.8
Proj. # NH-075-3( )
AW Proj. # S9905
Sheet 1 of 1

Str. No. N/A | Station 26+720 | Offset Centerline | Line "A"
Datum USC & GS | Weather Sunny | Temperature 65 | Inspector M. Rowe

SAMPLE					DESCRIPTION/CLASSIFICATION and REMARKS	SOIL PROPERTIES					
No.	Type	Rec (%)	N	Depth		qu (qp) (tsf)	ɣ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
1	X	100	17-26-34		Brown, Dry, Hard, Silty Clay Loam Test 4 A-6						
2	X	100	6-15-17								
3	X	100	14-14-17								
4	X	100	18-19-30		Gray Weathered Siltstone (Visual)						
5	X	0	50/1"								
				5	Gray Weathered Sandstone (Visual) 4.6 to 5.5m, Gray Shale (Visual) 5.5 to 7.6m Rock Core No. 1 REC: 100% RQD: 63%						
				10	Gray Shale (Visual) Rock Core No. 2 REC: 100% RQD: 88%						
					Gray Shale (Visual) Rock Core No. 3 REC: 100% RQD: 91%						
				15	Boring Terminated at 13.7 meters						
				20							

WATER LEVEL OBSERVATIONS

While Drilling	DRY	Upon Completion of Drilling	5.0	
Time After Drilling		24		
Depth to Water		7.0		
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 10/6/99 End 10/6/99 Rig ATV
Driller Loveday Editor M. Rowe
Remarks Boring backfilled with soil cuttings.

LOG OF TEST BORING

Project: U.S. 231 Realignment
Location: Spencer County, Indiana
Client: Indiana Department of Transportation

3405 West 96th Street Indianapolis, Indiana 46268-1194
317-875-7000/317-876-3705(Fax)

Boring No. RB-22
Surface Elevation 151.3
Proj. # NH-075-3( )
AW Proj. # S9905
Sheet 1 of 1

Str. No.	N/A	Station	26+920	Offset	30.0 m Lt.	Line	"A"
Datum	USC & GS	Weather	Sunny	Temperature	85	Inspector	M. Rowe

SAMPLE

No.	Type	Rec (%)	N	Depth
1	X	100	7-8-9	
2	X	100	4-8-11	
3	X	100	8-12-17	
4	X	100	16-23-33	
5	X	100	28-50	5
6	X	100	50/4"	
7	X	100	33-50/4"	
8	X	100	50/2"	10
				15
				20

DESCRIPTION/CLASSIFICATION and REMARKS

Topsoil (Visual)

Brown, Dry, Very Stiff, Silty Loam
Test 3 A-4

Gray, Dry, Hard, Very Weathered Shale (Visual)

Gray Limestone (Visual) 9.1 to 9.8m,
Black Shale (Visual) 9.8 to 9.9m, Gray Sandstone (Visual) 9.9 to 10.7m
Rock Core No. 1
REC: 85%
RQD: 66%

Boring Terminated at 10.7 meters

SOIL PROPERTIES

qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
		14.9			
		18.2			
		12.6			

WATER LEVEL OBSERVATIONS

While Drilling	DRY	Upon Completion of Drilling	3.1	
Time After Drilling		24		
Depth to Water		3.5		
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 8/23/99 End 8/23/99 Rig ATV
Driller Loveday Editor M. Rowe
Remarks Boring backfilled with soil cuttings.

LOG OF TEST BORING

Project: U.S. 231 Realignment
Location: Spencer County, Indiana
Client: Indiana Department of Transportation

3405 West 96th Street Indianapolis, Indiana 46268-1194
317-875-7000/317-876-3705(Fax)

Boring No. RB-23
Surface Elevation 135.8
Proj. # NH-075-3( )
AW Proj. # S9905
Sheet 1 of 1

Str. No.	N/A	Station	27+192	Offset	20.0 m Rt.	Line	"A"
Datum	USC & GS	Weather	Cloudy	Temperature	78	Inspector	M. Rowe

SAMPLE					DESCRIPTION/CLASSIFICATION and REMARKS	SOIL PROPERTIES					
No.	Type	Rec (%)	N	Depth		qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
1	X	80	10-15-20		Brown, Dry, Hard, Silty Loam Test 3 A-4			20.5			
2	X	100	10-15-16					12.3			
3	X	100	13-19-24		Gray, Dry, Hard, Very Weathered Shale (Visual)			15.9			
4	X	100	13-18-25					16.8			
5	X	100	18-32-49	5				14.3			
6	X	100	17-28-33					14.1			
					Boring Terminated at 6.1 meters						
				10							
				15							
				20							

WATER LEVEL OBSERVATIONS

While Drilling	▽ DRY	Upon Completion of Drilling	▼ DRY	
Time After Drilling		24		
Depth to Water	▽	▼ DRY	▽	▽
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 8/24/99 End 8/24/99 Rig ATV
Driller Loveday Editor M. Rowe
Remarks Boring backfilled with soil cuttings.

FILE 98-417

Indiana Department of Transportation

Materials and Tests Division
120 South Shortridge Road P.O. Box 19389
Indianapolis, Indiana 46219-0389
Phone: (317) 232-5280 Fax: (317) 356-9351

November 16, 2001

Mr. Phelps Klika
Chief, Division of Design
Room N-642 - IGCN

Attn: Ms. Hollie Bays
Project Coordinator

Subject: Des. No: 9161365
Addendum
Project No: NH-075-3( )
US 231 Roadway Construction (Phase 3)
County: Spencer
District: Vincennes

Gentlemen:

At the time of the original report, dated December 17, 1999, Spencer County was not considered a seismic area. Subsequently, the Indiana Earthquake Preparedness Committee added several Counties including Spencer County in southwestern Indiana to the list of seismic areas. The purpose of this addendum is to address the sideslopes of Phase 3 with regards to seismic concerns.

Each of the recommendations in our original report of December 17, 1999 are still valid, with the exception of the sideslope recommendations. We have re-analyzed the sideslopes using a peak ground acceleration of 0.1g. This value comes from maps and a computer database provided by USGS, and the use of these maps and computer database was recommended by the Federal Highway Administration, FHWA Publication Number FHWA HI-99-014, NHI Course Number 132039 "Geotechnical Earthquake Engineering". The peak ground accelerations are very specific to the exact latitude and longitude lines for a given location.

Based on the above information and engineering judgment, a slope stability analysis was performed. The following recommendations apply to this project:

1. For all areas where the sideslope height is less than 5.0 m (16.5 feet), sideslopes of 3:1 should be safe.

2. For all areas where the sideslope height is greater than 5.0 m (16.5 feet), sideslopes of 3:1 will not be safe in the event of an earthquake. We therefore recommend that 4:1 sideslopes be provided to ensure the safety of these areas.

Please call us at (317) 232-5280 if you have any questions.

Very Truly Yours,

Steve Morris
for Athar A. Khan, P.E.
Chief Geotechnical Engineer

S. S. Hiremath
Somanath S. Hiremath, P.E.
Geotechnical Engineering Group Leader

SSH/JF
Cc: United Consulting Engineers & Architects – Attn: Mr. M. Rowe
Mr. T. Seeman – Attn: Mr. J. Nicholson
Mr. J. Russell – Attn: Mr. M. Fowler (2)
Mr. D. Cohen
Mr. J. Schneider
Mr. K. Dave
File

H:Joey/Itemization Letters/Short Letter

SUBSURFACE INVESTIGATION & FOUNDATION RECOMMENDATIONS

ADDENDUM I
DES NO: 9161365
PROJECT NO: NH-075-3 ()
SRUCTURE NO: 231-74-844845 & J
US-231 PHASE 3
SPENCER COUNTY, INDIANA

PREPARED BY:
ALT & WITZIG ENGINEERING, INC.
GEOTECHNICAL DIVISION
PROJECT NO: 02IN0005

PREPARED FOR:
INDIANA DEPARTMENT OF TRANSPORTATION
INDIANAPOLIS, INDIANA

MAY 14, 2002

SUMMARY OF RECOMMENDATIONS

ADDENDUM I
DES NO: 9161365
STRUCTURE #: 231-74-844845 & J
PROJECT NO: NH-075-3()
US-231 PHASE 3
SPENCER COUNTY, INDIANA

A subsurface investigation has been performed for the proposed US-231 and SR-162 Intersection Modifications in Spencer County, Indiana. The subsurface investigation encompassed the proposed US-231 bridges over SR-162, four (4) ramps to exit and enter US-231, and the realignment of SR-162.

Our subsurface investigation included reconnaissance of the project site, drilling twenty (20) soil borings, one (1) hand sounding, and ten (10) machine soundings. The natural shallow soils encountered over most of the project site were predominately A-6 Silty Clay and A-4 Clay Loam. These shallow layers were then predominately underlain by bedrock consisting of weathered Shale, Siltstone, and Sandstone.

Subgrade preparation for the new pavement should be in accordance with Section 203.22 of the INDOT Standard Specifications. Some very soft and medium stiff cohesive soils were encountered in soil borings RB-7 and RB-8, Line "NWR", RB-13, Line "SER", and RB-14, Line "NER". Due to the proposed amount of fills, up to 7.2m (23.5'), some settlement is anticipated in these areas. It is recommended that settlement stakes be placed at the locations indicated in the report and settlement stakes be placed in a staggered fashion, one hundred (100) feet (30m) center to center intervals between the stationing presented later in this report. Paving operations should not commence until the rate of settlement is 0.01 feet (3mm) or less per week. In the vicinity of HS-12 (Line "SER", Station 1+170), an existing pond exists. Major difficulties with embankment construction should be anticipated at this section.

As the AADT is greater than 3000 vpd and the subgrade area is greater than 10,000 sq. yds., at grade or in cuts, a Type "A" subgrade treatment is recommended. A CBR value of 2.5 can be used with this option. A twenty-four (24) inch (600mm) subgrade treatment is recommended in fill sections including above structures. A CBR of 2.5 should be used in designing the thickness of the pavement with this option. The subgrade treatment should be constructed under the pavement section including the shoulders.

In cut areas, it is anticipated that some construction difficulties will be encountered due to the shallow rock encountered and water levels on certain parts of the project. As stated later in our report, it may be necessary to blast rock in large cut areas and to provide adequate surface drains where water levels are of concern.

Design plans indicate two (2) three span bridge structures are associated with this phase of the project. The borings drilled for the structures indicated bedrock at a shallow depth. The end bents for these new bridges may be founded on steel H-piles driven to sound bedrock at the minimum elevations shown in Table 1 and Table 2. For design loads of 50 and 70 tons, HP12x53's can be used, and for design load of 90 tons, HP12x74's can be used. If driving of piles is desired after construction of the embankment, then preboring through the fill is recommended.

In accordance with INDOT Standard Specifications, the following report discusses in more detail the recommendations concerning design and construction procedures for earthwork, roadway, subgrade and bridge structures.

Alt & Witzig Engineering, Inc.
4105 West 99th Street • Carmel, Indiana 46032
(317) 875-7000 • Fax (317) 876-3705

Chris Johanchek - Alt & Witzig

May 14, 2002

Indiana Department of Transportation
120 South Shortridge Road
Indianapolis, Indiana 46219
Attn: Mr. Athar A. Khan

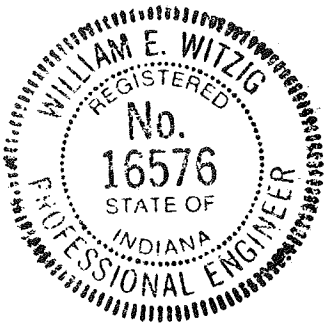
RE: Subsurface Investigation &
Foundation Recommendations
Addendum I
Des. No.: 9161365
Project No: NH-075-3 ()
US-231 Phase 3
Spencer County, Indiana
Alt & Witzig File: 02IN0005

Gentlemen:

In compliance with your request, we have completed a subsurface investigation and evaluation for the above referenced project. It is our pleasure to transmit herewith a copy of the report.

The results of our test borings and laboratory test are presented in the appendix of the report. Our recommendations for the project are presented in the "Discussion and Recommendations" section of the report.

If you have any questions or comments regarding this matter, please contact us at your convenience.



Sincerely,

ALT & WITZIG ENGINEERING, INC.

William E. Witzig

William E. Witzig, P.E.

WEW/bkm

TABLE OF CONTENTS

SUBSURFACE INVESTIGATION

AND

FOUNDATION RECOMMENDATIONS

INTRODUCTION

General

This report presents the results of a geotechnical investigation for the proposed US-231 and SR-162 intersection modifications in Spencer County, Indiana. It is submitted as an addendum to previous reports submitted for the Phase 3 portion of this project. These modifications consist of the realignment of SR-162, constructing two (2) bridge structures over SR-162 and providing access to these roadways by means of ingress-egress ramps. This investigation was conducted for the Indiana Department of Transportation.

Authorization to perform this investigation was in the form of a notice to proceed from Mr. Firooz Zandi and Athar A. Khan of the Indiana Department of Transportation to Alt & Witzig Engineering, Inc.

The scope of this investigation included a review of geological maps of the area, review of geologic and related literature, a reconnaissance of the immediate site, subsurface exploration, field and laboratory testing, and engineering analysis and evaluation of the materials.

The purpose of this foundation investigation was to determine the various soils profile components, the engineering characteristics of the foundation materials and to provide criteria for use be the design engineers in preparing roadway and various structure design.

DESCRIPTION OF SITE

Site Location

The site of the proposed project is southeast of Dale, Indiana. More specifically, the project is located in Sections 4, 5 and 33 of Township 5 South, Range 5 West in Spencer County. The Site Location Map in the Appendix of the report graphically displays the project limits.

Site Topography and Drainage

The site where SR-162 is to be realigned is an existing roadway that consists of relatively flat to gently rolling terrain. The area of the proposed ramps consists of woods, agricultural fields, and residential structures in which the terrain varies from gently sloping to steep hills and ravines. In the vicinity of the proposed bridge structures, the surface consists of the existing SR-162 pavement and adjacent drainage ditches. Drainage patterns are along the roadway and into existing ditches or primarily along the ground surface into natural drainage ditches or creeks.

The surrounding area is a mixture of residential and agricultural development with several overhead and underground utilities. An existing youth camp is also present in the general vicinity.

General Geology

The site of this project lies in the Wabash Lowland Physiographic Unit of the State of Indiana. The geologic map of the Vincennes quadrangle indicates that some of the soils near this project site has been modified by coal stripping.

Bedrock in the project area lies in the Sullivan Lowland Bedrock Physiographic Unit of the State. Anticipated is Shale and Limestone of Mississippian Age.

FIELD INVESTIGATIONS

Scope

Field investigations to determine the engineering characteristics of the foundation materials included a reconnaissance of the project site, drilling borings as shown on the Boring Location Plan, performing standard penetration tests, obtaining soil samples retained in the standard split-spoon sampler, pushing Shelby tubes, and obtaining bag samples for the purpose of CBR testing. Twenty (20) soil borings, one (1) hand sounding, and ten (10) machine soundings were drilled as part of this investigation. Borings were field staked for this investigation by means of "pacing and taping" methods, thus, the accuracy of the boring locations are as accurate as these methods permit.

The field investigation commenced on February 12, 2002, and was completed on April 22, 2002. Due to the difficulties with property owners, extensive time and requirements were necessary before right of entry was granted, therefore causing delays in the field work portion of the project.

The apparent groundwater levels at most boring locations were also determined. In addition to proper backfilling of boring holes, ATV ruts were backfilled, graded, and seeded on certain properties.

Drilling and Sampling Procedures

The soil borings were performed with a drilling rig equipped with a rotary head. Conventional hollow-stem augers were used to advance the holes. Representative samples were obtained employing split-spoon sampling procedures in accordance with ASTM Procedure D-1586.

Rock Coring

Rock coring was performed on several of the structure boring locations. Samples of the bedrock materials were obtained using rock coring procedures in general accordance with AASHTO T 225-83. The equipment used to obtain the cores was a conventional "NX" double tube core barrel system with a diamond cutting bit.

Field Tests and Measurements

Penetration tests. During the sampling procedure, standard penetration tests were performed at regular intervals to obtain the standard penetration value of the soil. The standard penetration value is defined as the number of blows a 140 lb (63.6kg) hammer, falling 30 inches (0.76m), required to advance the split-spoon sampler 12 inches (0.3m) into the soil. The results of the standard penetration tests indicate the relative density and comparative consistency of the soils, and thereby provide a basis for estimating the relative strength and compressibility of the soil profile components.

Water level measurements. Water level observations were made during the borings operations and are noted on the boring logs presented herewith. In relatively impervious soils such as sandy soils, the indicated elevations are considered reliable groundwater levels. In relatively impervious soils, the accurate determination elevation is not possible even after several days of observation.

Ground surface elevation. The elevation of the ground surface shown on the boring logs was determined using the design cross-sections provided by United Consulting Engineers and are presumably accurate to within $\pm$ 1.0 foot (0.3m).

LABORATORY INVESTIGATIONS

In addition to the field investigations, a supplemental laboratory investigation was conducted to ascertain additional pertinent engineering characteristics of the subsurface materials necessary in analyzing the behavior of the proposed roadway. All phases of the laboratory investigation were conducted in general accordance with applicable AASHTO Specifications and INDOT Exhibit "C".

The laboratory testing program included supplementary visual classification on all samples. Atterberg limit tests, unit weight tests, unconfined compression tests, moisture content tests, pH tests, and grain size analyses were performed on selected soil samples. A moisture-density relationship and CBR tests were also performed on a bag sample obtained at boring RB-6.

In addition, due to the softer soils encountered in some of our borings, the compressibility of these soils was determined by performing a consolidation test on an undisturbed sample obtained at boring RB-14.

DISCUSSION AND RECOMMENDATIONS

Project Description

This report presents the finding of the subsurface investigation and resulting geotechnical recommendations for three portions of the US-231 Phase 3 project. The first portion that this report covers is the construction of the north and south bound lanes for US-231 over the existing SR-162. In conjunction with the bridge will be the construction of ramps for accessing both roadways. The last portion covered by this report is the realignment of SR-162.

The north and south bound bridges (Structure #'s 231-74-844845) will consist of three (3) spans. A ramp will be constructed at each quadrant of the SR-162 and US-231 intersection. The approximate stationing of the ramp improvements and road realignments are listed in the chart below.

Line	From Station	To Station
SR-SR162	1+020	2+120
NWR	1+000	1+325
SWR	1+000	1+598
NER	1+000	1+427
SER	1+000	1+521

According to the design plans, fills ranging from eight and one-half (8½) feet (2.6m) to twenty-five (25) feet (7.7m) are proposed on this project. Maximum cuts up to thirty-six (36) feet (10.9m) are also proposed for this project.

Detailed Geotechnical Conditions and Recommendations

State Road 162 (SR-162) Roadway Recommendations

Design plans indicate that SR-162 will consist of regrading the existing topography. Regrading will consist of cuts up to eight and one-half (8½) feet (2.6m) and fill areas up to twenty

(20) feet (6.1m). Borings RB-1 through RB-6 were drilled at various stations along Line "SR-SR162". RB-2 and RB-3, which were drilled in cut areas corresponding to Station 1+250 and Station 1+400, encountered medium stiff to hard Silty Clay to an approximate depth of six (6) feet (1.8m). Underlying the cohesive material was gray weathered Siltstone which extended to the termination depth of our borings. Based on the anticipated amount of cut and depth to bedrock in our borings, bedrock will be encountered during excavation to the roadway subgrade in these areas. Due to the weathered texture of the bedrock, rock in this area should be rippable to the required depth. The water level in RB-2 was at five (5) feet (1.5m). Since the cut depths are below the apparent groundwater level, dewatering may be necessary.

Borings RB-4 to RB-6 were strategically placed in fill areas ranging from eight and one-half (8½) feet (2.6m) to twenty (20) feet (6.1m) in height. In general, the soils encountered in these borings were stiff and very stiff Silty Clay and Clay Loam. These soils were underlain by highly weathered Shale. Twenty-four (24) hour groundwater measurements at boring RB-6 was dry while RB-4 and RB-5 were five (5) feet (1.8m) and seven and one-half (7½) feet (2.3m), respectively. Minimal settlement is anticipated if proper stripping and embankment construction procedures are followed. However, based on the quantity of fill proposed, settlement plates and toe stakes, per Section 204.03, are recommended from Station 1+480 to Station 1+900 at one hundred (100) feet (30m) center to center along the centerline or staggered along the shoulder. Final pavement should not be constructed until the settlement is less than or equal to 0.01 feet (3mm) per seven day week for four consecutive weeks.

Design plans indicate slopes of 3:1 for cutback slope sections and embankment side slopes. No slope stability problems are anticipated if proper construction techniques and the recommendations in this report are followed.

Ramp Recommendations

Four (4) ramps for ingress-egress are proposed at the US-231 and SR-162 intersection. These ramps consist of Lines "NWR", "SWR", "NER", and "SER". Borings and soundings RB-7, RB-8, RB-9, S-10, S-11, HS-12, and RB-13 through RB-15 were drilled for the proposed ramps.

Line "NWR" Borings RB-7 and RB-8, which were drilled at Stations 1+000 and 1+260, respectively, encountered very soft and soft Silty Clay. Underlying these cohesive layers, our borings indicated layers of Coal and Shale. Twenty-four (24) hour water level readings at RB-7 and RB-8 indicated water at five (5) feet (1.5m) and eight (8) inches (0.2m), respectively. These borings were drilled in low lying areas and should be expected to be softer and have higher than normal moisture contents.

Fills in the range of eighteen (18) to twenty (20) feet (5.5m & 6.1m) are proposed in these areas. Due to the soft nature and higher moisture contents of the soils, large settlements which will be detrimental to the pavement are anticipated. Based on a consolidation test performed on similar soils at RB-14, the estimated magnitude of settlement is six and three-tenths (6.3) inches (160mm). Assuming single drainage, our calculations indicate that 50% and 90% of the settlement in this area will occur in sixty-one (61) and two hundred and sixty-one (261) days, respectively.

Since borings RB-7 and RB-8, were performed in low-lying areas, these softer soils are anticipated to be somewhat isolated along this ramp line. Therefore, the following remedial strategies are recommended. If the embankment can be constructed during the initial phases of road construction and time is not a factor, it is recommended to let the foundation soils compress under the embankment until acceptable limits are reached. Settlement plates and toe stakes should be provided between stations 0+980 to 1+100 and 1+200 to 1+290 at one hundred (100) feet (30m) staggered intervals. If desired, the contractor can construct a (2) feet (0.6m) "B" Borrow layer above the existing ground surface and beneath the embankment fill. In doings so, the more permeable "B"

Borrow would further expedite the consolidation of the foundation soils. This granular layer should be constructed between Stations 0+980 to 1+100 and 1+200 to 1+290.

Line "SWR" Borings RB-9 and S-10 were drilled along this alignment at Stations 1+240 and 1+460, respectively. RB-21, which was drilled in the near vicinity during a previous investigation (1999) on Line "A", was also used in providing recommendations for this area. For convenience, a copy of this boring log is provided in the Appendix of this report. Cuts on the order of thirty-six (36) feet (10.9m) are proposed in this area. Based on RB-9, bedrock is anticipated at an approximate depth of seven (7) feet (2.2m). The weathered rock should be rippable in some areas but difficulty can be expected. With blow count of N>50 and the quantity of cut required, blasting may be a more feasible means of excavation. RB-9 also encountered coal at the proposed subgrade elevation. Based on the rock profile, up to seven (7) feet (2.2m) of overexcavation may be necessary to remove the coal.

RB-9 indicated a water level of twenty-five and one-half (25½) feet (7.8m). Dewatering should be anticipated during construction. In addition, subsurface and surface drains should be provided to account for the apparent groundwater.

Areas of minimal fills are also proposed along this line. No problems are anticipated if proper construction techniques in accordance to INDOT Standard Specifications are performed.

Line "NER" Fill up to twenty-three and one-half (23½) feet (7.2m) is expected in this area. Borings RB-14 and RB-15 were drilled at Stations 1+080 and 1+280, respectively. These borings were performed in low lying areas and encountered very soft to stiff Silty Clay and Clay Loam.

Because of the softer soils and large amount of fill proposed, a consolidation test was performed on a relatively undisturbed sample taken between three (3) to five (5) feet (0.9-1.5m) at RB-14. Based on the results of our consolidation test, the estimated magnitude of settlement is approximately five and eight-tenth (5.8) inches (147mm). Assuming single drainage, our

calculations indicate that 50% and 90% of the settlement in this area will occur in thirty-one (31) and one hundred thirty-five (135) days, respectively. Visual inspection of the topography indicates the limits of these softer soils may be quite extensive along this line. It is recommended that the ramp embankment for this line be constructed as early in the earthmoving stages of the project as possible to allow for maximum settlement of the underlying foundation soils. Due to the quantity of fill proposed in this area, settlement plates and toe stakes are recommended at Stations 1+040 to 1+370 at one hundred (100) feet (30m) center to center staggered intervals. Final pavement should not be constructed until the settlement is less than or equal to 0.01 feet (3mm) per seven day week for four consecutive weeks. If desired, the proposed settlement can be expedited in areas of concern by placing a two (2) feet (0.6m) "B" Borrow mat above the existing ground surface.

Due to the softer soils and larger fills in this area, a slope stability analysis was performed at Station 1+080. A 250psf traffic load and 0.1g horizontal acceleration factor for seismic considerations was implemented into our analysis. Using the subsurface profile encountered in boring RB-14 and the proposed cross section at this Station, a 1.2 factor of safety was obtained. Based on these results, constructing the embankment and allowing the foundation soils to compress appears to be a feasible option for construction.

Minimal cuts are proposed on this line. Little difficulty should be anticipated during excavation to the roadway subgrade.

Line "SER" Excavation in this area involves cuts up to twenty-nine and one-half (29½) feet (9m) and fills up to twenty-five (25) feet (7.7m). S-11, HS-12, and RB-13 were performed in this area. RB-21, which was drilled in the near vicinity during a previous investigation on Line "A", was also used in providing recommendations for this area. For convenience, a copy of this boring is provided in the Appendix of the Report.

In the large cut area, S-11 (Station 1+060) encountered "sound" bedrock at an approximate

depth of seven (7) feet (2.1m). Based on quality of rock encountered in RB-21 and the depth to the proposed subgrade, blasting of the rock appears to be the most feasible option for rock removal.

HS-12 (Station 1+170) and RB-13 (Station 1+450) were performed in the fill portions of this line. HS-12 was performed in a pond and indicated water to a depth fifteen (15) feet (4.6m). Between the depths of fifteen (15) feet (4.6m) and twenty-one (21) feet (6.4m), black very soft Silty Loam was encountered. To prevent large settlements, this material should be removed and replaced with a compacted "B" Borrow backfilling in accordance with 211.02 to an elevation at least two (2) feet (0.6m) above the ground water level. The limits of removal are estimated between Stations 1+150 to 1+190. Major bracing and/or shoring will be needed during the removal and replacement in this area. Furthermore, dewatering will be necessary while removal and replacement is occurring. A photograph is provided in the Appendix of the report to better portray the pond area and difficulties surrounding it.

RB-13 encountered very soft (1m thick) to medium stiff Silty Clay underlain by brown and gray weathered Shale. Some settlements are anticipated and therefore should be undercut and replaced with "B" Borrow.

In areas where fill is placed on existing slopes greater than 4:1, benching should occur in accordance to INDOT Specification 203.21. Due to the cut to fill transition nature near Station 1+140, special attention should be applied during benching procedures in this vicinity.

Bridge Structure 231-74-844845 & J

Design plans indicate that two (2), three span bridge structures are to be constructed with this project. The borings drilled for this new structure encountered bedrock at relatively shallow depth. This new bridge may be founded on steel H-Piles driven to competent bedrock. For design loads of 50 and 70 tons, HP12x53's can be used, and for design loads of 90 tons, HP12x74's can be used. The approximate competent bedrock elevations encountered in our borings are shown in

Table 1 and Table 2.

Bent or Pier Number	Boring or Sounding Number	Station	Offset "A"	Ground Surface Elevation (m)	Approximate "Sound" Bedrock Elevation (m)	Depth Below Pile Cap (m)
1	TB-1	27+100	23mLT	141.8	134.8	13.4
1	S-1	27+100	11mLT	141.1	133.5	14.7
2	TB-2	27+116	23mLT	140.1	135.5	6.1
2	S-2	27+116	11mLT	140.0	135.5	6.1
3	TB-3	27+148	26mLT	138.9	133.7	7.1
3	S-3	27+148	11mLT	138.6	134.1	6.7
4	TB-4	27+163	24mLT	138.2	133.6	13.5
4	S-4	27+163	11mLT	138.0	133.1	14.0

Table 1: Summary of Approximate Competent Bedrock Elevations **(Southbound Lane)**

Bent or Pier Number	Boring or Sounding Number	Station	Offset "A"	Existing Ground Surface Elevation (m)	Approximate "Sound" Bedrock Elevation (m)	Depth Below Pile Cap (m)
1	TB-5	27+098	11mRT	140.2	134.4	13.8
1	S-5	27+098	23mRT	139.5	133.4	14.8
2	TB-6	27+114	23mRT	139.2	134.2	7.4
2	S-6	27+114	11mRT	139.7	135.1	6.5
3	TB-7	27+146	11mRT	138.8	132.7	8.1
3	S-7	27+146	23mRT	138.7	132.7	8.1
4	TB-8	27+161	23mRT	137.8	131.8	15.3
4	S-8	27+161	11mRT	137.8	131.8	15.3

Table 2: Summary of Approximate Competent Bedrock Elevations **(Northbound Lane)**

Furthermore, it is then recommended that the piles be driven with an impact hammer to ensure proper seating to at least the approximated sound bedrock elevation noted in Table 1. It will be necessary to use a protective tip (pile tips) to minimize damage to the piles during driving. If driving of piles is desired after construction of the embankment, then preboring through the fill is recommended. Preparation and driving of piles should be in accordance with INDOT Standard Specifications Section 701.09.

The bedrock elevations given in Table 1 and Table 2 are only approximate elevations determined at the exact structure boring and sounding locations and should be used only as a guide.

The final tip elevation should be determined by ultimate load using the methods outlined in section 701.04 of the INDOT Standard Specifications. The tables below lists pile driving parameters.

Bent or Pier	No. 1	No. 2	No. 3	No. 4
Design Load (Tons)	55/70/90	55/70/90	55/70/90	55/70/90
Factor of Safety	2.5	2.5	2.5	2.5
Factored Design Load	137.5/175/225	137.5/175/225	137.5/175/225	137.5/175/225
Friction in Scour Zone (Tons)	N/A	N/A	N/A	N/A
Down Drag Friction	N/A	N/A	N/A	N/A
Ultimate Load (Tons)	137.5/175/225	137.5/175/225	137.5/175/225	137.5/175/225
Testing Method	By Formula, Std. Spec. 701			

Table 3: Parameters for Pile Driving (Northbound & Southbound Structures)

Subgrade Recommendations

Subgrade preparation for the new pavement should be in accordance with Section 207 of the INDOT Standard Specifications. It is recommended that after the subgrade level is established, the exposed subgrade should be proofrolled with an approved roller or other approved equipment. This proofrolling will determine if any pockets of soft unsuitable materials exist beneath the exposed subgrade. If any pockets of unsuitable materials are encountered, they should be removed and replaced with "B" Borrow to an elevation 0.6m above the groundwater level, if groundwater is encountered. Proofrolling should be performed in accordance with Section 203.26 of the INDOT Standard Specifications.

The natural shallow soils encountered over most of the project site were predominately Silty Clay and Clay Loam. The cohesive soils along this project line have very soft to very stiff relative densities and if compacted properly should also provide adequate subgrade.

Based on our laboratory tests, it appears a majority of the cohesive materials are above optimum moisture. Therefore, it is anticipated that these soils will not pass a proofroll and will require disking and aeration prior to subgrade compaction.

It should also be noted in accordance to INDOT Standard Specifications, sections where shale,

shale and soft rock mixtures, or soft rock are encountered, these materials shall be undercut 150mm (6") below the subgrade elevation and replaced with No. 53 aggregate and compacted in accordance with INDOT Standard Specifications. All irregularities and holes shall be graded to provide positive drainage.

Pavement Recommendations

A CBR test was performed on a representative sample obtained from boring RB-6. The results of our lab tests can be found in the appendix of the report. As the AADT is greater than 3000 vpd and the subgrade area is greater than 10,000 sq. yds., at grade or in cuts, a Type "A" subgrade treatment is recommended. Based on lab results and additional soils information INDOT has in the area, INDOT has recommended a CBR value of 2.5 can be used with this option. A twenty-four (24) inch (600mm) subgrade treatment is recommended in fill sections including above structures and a CBR of 2.5 should be used in designing the thickness of the pavement with this option. The subgrade treatment should be constructed under the pavement section including the shoulders.

Foundation Recommendations-General

Stripping

The topography of this project site varies from relatively flat and gentle rolling farm fields to woods with large hills and ravines. With portions of the terrain being wooded, clearing and grubbing will be necessary. This procedure should be performed in accordance with Section 211.03 of the INDOT Standard Specifications.

Any topsoil or loose soils encountered in construction not considered to be suitable subgrade material should be removed during construction. The soft soils encountered should be stripped from the site and replaced with "B" Borrow to an elevation of two (2) feet (0.6m) above the ground water level. If groundwater is not encountered, the backfill shall be in accordance with Section 203.09 of the INDOT Standard Specifications.

Benching

When fills are placed on existing slopes greater than 4:1, it is recommended that benching should be implemented. Benching of natural slopes of 4:1 or steeper should be performed in accordance with Section 203.21 of the INDOT Standard Specifications. For placement of fills, the earthwork contractor must follow proper benching techniques. A minimum of ten (10) feet (3m) wide benches shall be cut into the slopes prior to the placement of embankment fill. Benches should be of sufficient width to accommodate the required compaction equipment. Where ten (10) feet (3.m) wide benches are not feasible for existing embankment sideslopes due to shallow embankment heights; minimum four (4) feet (1.2m) wide benches can be used per Section 203.22 of INDOT Standard Specifications.

Embankment Construction

Design plans indicate fills ranging from eight and one-half (8½) feet (2.6m) to twenty-five (25) feet (7.7m) are proposed on the ramp and SR-162 portions of this project. Before any fill is placed, topsoil or loose soils encountered during earthwork construction not considered to be suitable for subgrade material shall be removed. If groundwater is not encountered, backfill shall be in accordance with Section 203.09 of the INDOT Standard Specifications. If groundwater is encountered, backfilling shall be accomplished utilizing "B" borrow in accordance with 211.02(b) to an elevation at least two (2) feet (0.6m) above the ground water level. After the topsoil or loose material have been removed, proofrolling of the natural ground surface may be performed in accordance with Section 203.26 within proposed fill areas.

It is recommended that all soil embankments be compacted to at least ninety-five (95) percent of their maximum dry density. The moisture content shall be within –2 and +1 percentage points of optimum moisture content. Maximum density and optimum moisture content shall be determined in accordance with AASHTO T 99. If the embankment material is too wet or dry, the

material should be aerated to remove any excess moisture or watered and disked until the moisture content is within the specified range. The placement of embankment material shall be in accordance with Section 203.23 of INDOT Standard Specifications

A moisture-density test was performed on Test 02 (RB-6). Test 02 which classified as a Silty Clay had a maximum dry unit weight and optimum moisture content of 113.2 pcf (17.80kN/m^3) and 16.8%, respectively. Based on laboratory testing, moisture contents of the soils encountered at shallow depths had natural moisture contents that were higher than the optimum moisture contents. It is anticipated to obtain 95% compaction, these soils will require drying by discing and aerating or chemical modification prior to compaction. At this time, sufficient moisture tests should be made to ensure the desired range is obtained. The results of the moisture tests and moisture-density relationships can be found in the Appendix of the report.

Due to the high silt content of some of the soils encountered on this project and their susceptibility to high swell and shrinkage. It is our recommendation that if the soils on this project cannot be proofrolled, they should be undercut and replaced with compacted "B" Borrow per INDOT Specifications.

Because of the limited amount of borrow on the project, it is anticipated that the weathered shale and other weathered rock encountered on the project could be used as fill for the embankments. Filling using shale or weathered rock should follow the guidelines in Section 203.20 of INDOT Standard Specifications.

Due to the large fills on this project and the softer soils encountered in some of the ramp borings, some settlement of the foundation soils and embankment is expected. Estimated settlements of the in-situ soils are provided in the recommendations part of this report.

Over part of the project, embankments will span existing roadbeds. These roadbeds with an existing rigid or flexible type pavement should be dealt with in accordance with Section

203.22.

On a majority of the proposed embankments, the design plans indicate sideslopes of 3:1. Based on the soils encountered in this area, we feel that these slopes are adequate provided construction of the fill is accomplished per Section 203 of INDOT Standard Specifications and the recommendations throughout this report.

Cut Excavation

According to the design plans, cuts up to thirty-six (36) feet (10.9m) are also proposed for this project. The boring logs, which are located in the Appendix of the report, indicate that rock was encountered at shallow depths. Therefore, some difficulty in excavation of cut areas can be expected. It appears from the field investigation that a majority of the rock encountered may be rippable or excavated by conventional means. The earth-moving equipment used to excavate this hard material must be of sufficient size and power and should have a rock bucket and/or ripper bar to remove the rock. In some areas including large cut areas, blasting may be needed to remove the rock and should be in accordance with INDOT Standard Specifications Section 203.15. It should be noted that the nature of the rock on this project is such that the drill rig penetrated to a significant depth before encountering "auger refusal". The borings were advanced by slowly "grinding" through the sandstone, siltstone, limestone, or shale. The depth to the different rock strata noted on the boring logs is based upon field observations made during drilling operations. At several of the boring locations, rock cores were obtained to determine the quality of the rock.

Our drill rig was able to drill into the rock layers, however, conventional construction equipment may encounter difficulties during excavation operations. In general, a material with an N-value of 50 or more might require ripping or jackhammering in order to be excavated. Where large amounts of rock excavation are necessary, blasting may be a more economical method.

Erosion Control

Cohesionless, granular material should not be used in ditches, or within twelve (12) inches (305mm) of the required finished surfaces of fill-slopes. The material required to encase embankments should be non-erodible material free from clods, debris, and stones, and suitable for sustaining vegetation. Seeding and/or sodding of the finished earth slopes should be performed as soon as possible after the construction is completed in order to minimize erosion.

Subsurface Drainage Recommendations

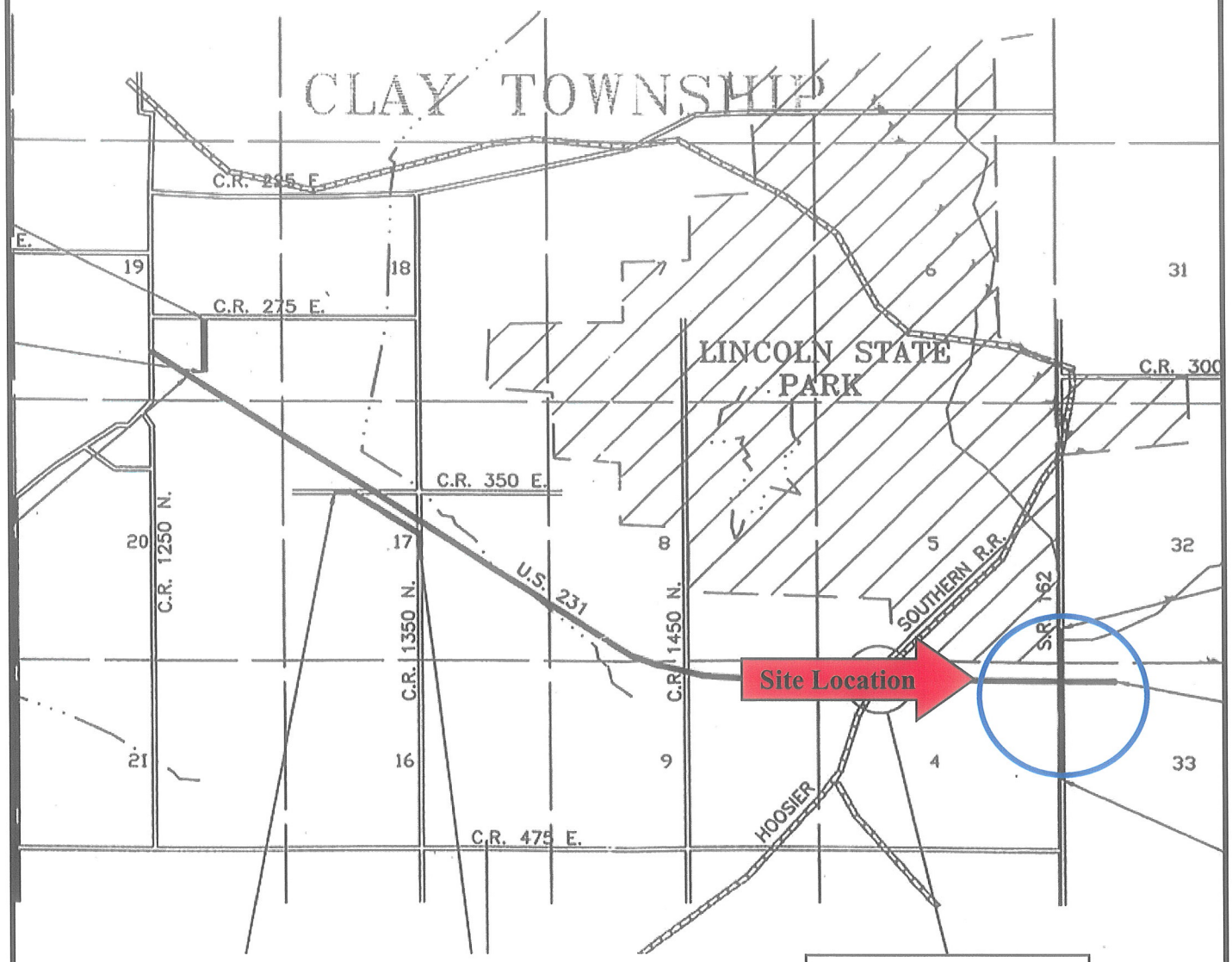
Design plans indicate that subsurface drains and outlets will be placed throughout this project. Due to the high silt content of the foundation soils, it is recommended that filter fabric be utilized in conjunction with the subsurface drain.

Corrosion

Tests performed at varying depths throughout the project indicate pH's of 6.1 to 6.7. Thus, it does appear that corrosion protection for underground facilities such as pipe structures will be necessary.

APPENDIX

SITE LOCATION MAP



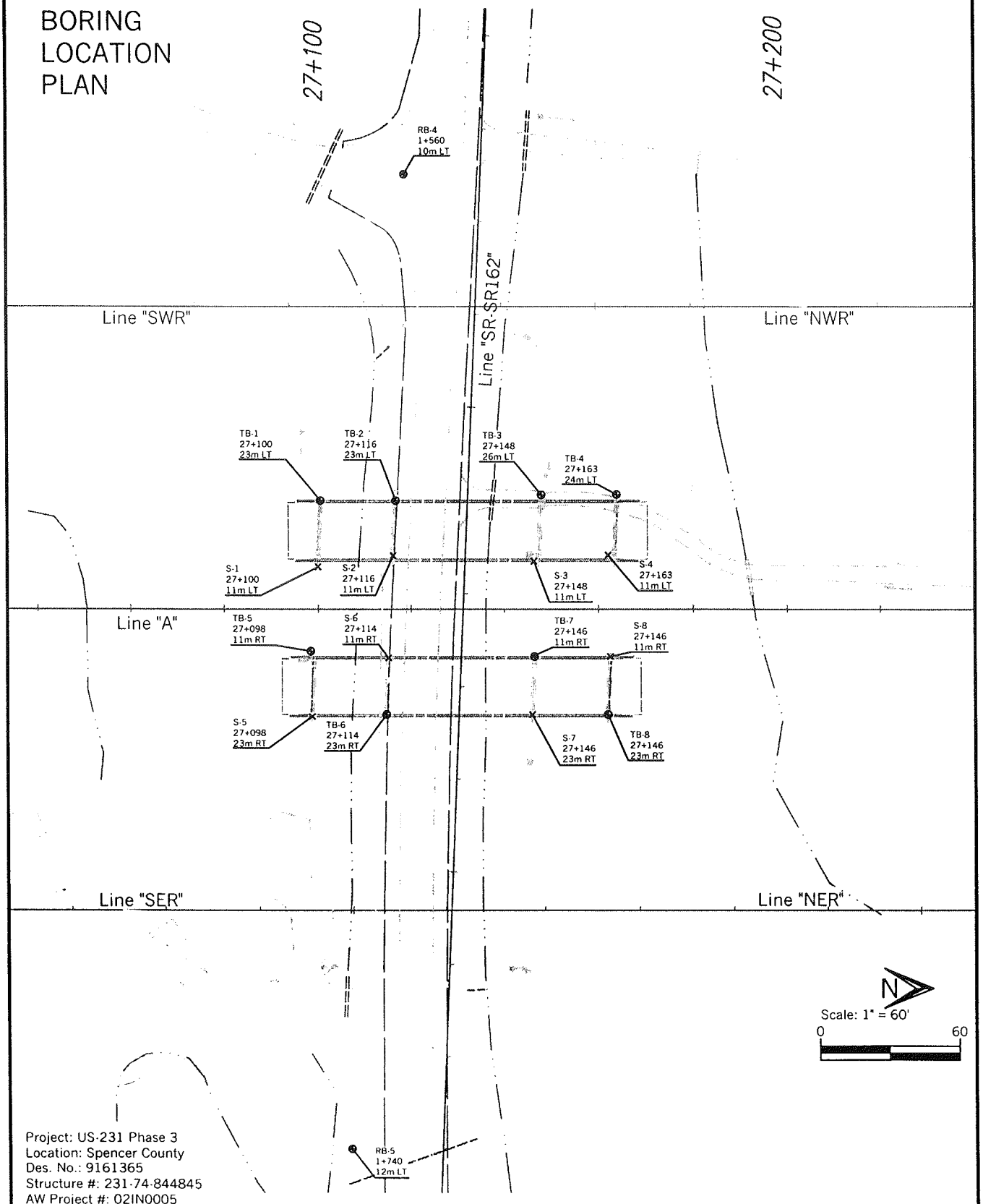
Des. No.: 9161365
STR No.: 231-74-844845
US-231 Phase 3
Spencer County, IN
AW File: 02IN0005

N

Scale: 1:25000

Prepared For: INDOT		**Prepared By:** Alt & Witzig Engineering, Inc.
Project Name: US 231 Phase 3 Spencer County, IN		**Project No:** 02IN0005 / **Date:** 5/02

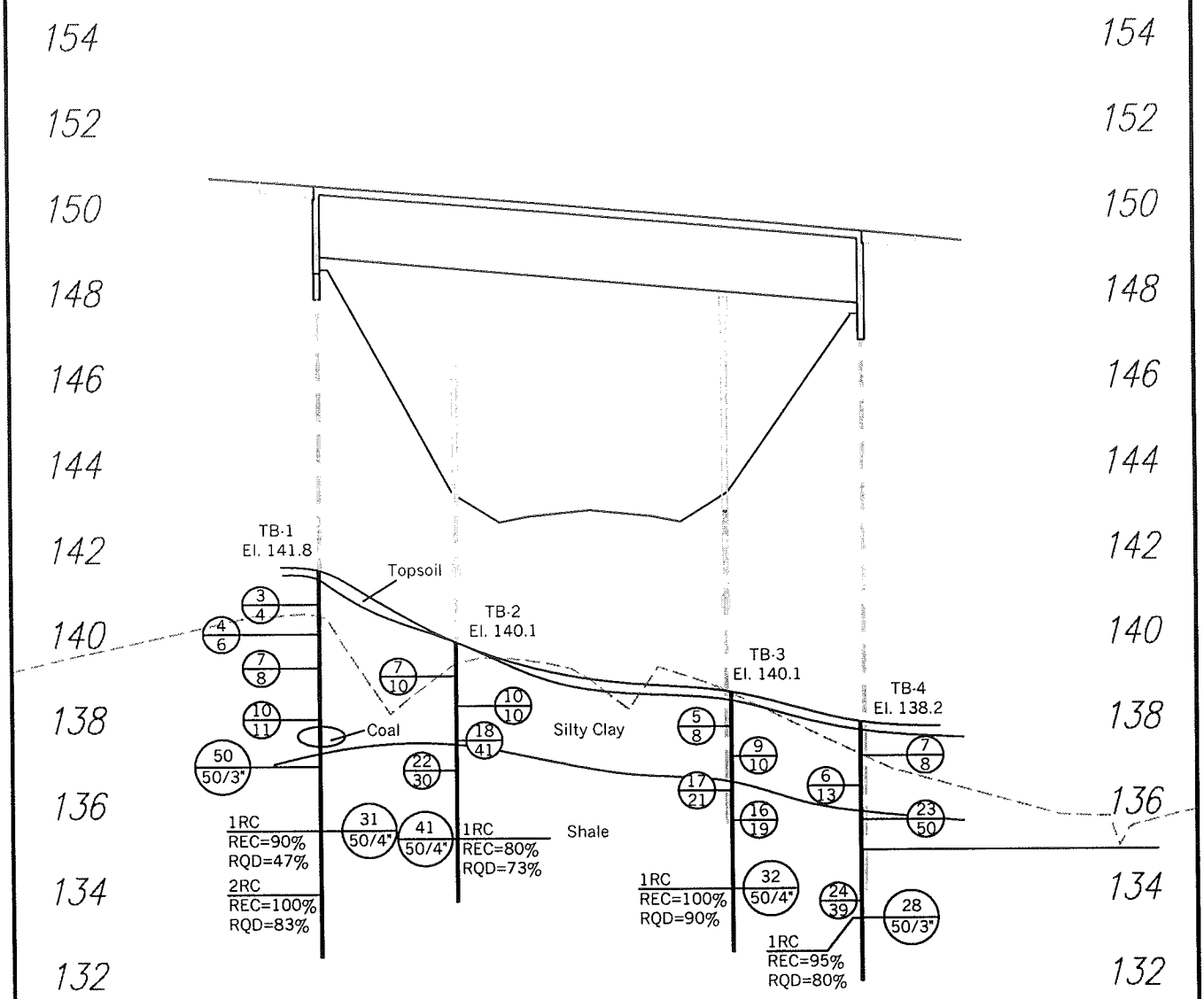
BORING LOCATION PLAN



Project: US-231 Phase 3
Location: Spencer County
Des. No.: 9161365
Structure #: 231-74-844845
AW Project #: 02IN0005

Prepared For: INDOT - Geotechnical Section	AW	Prepared By: Alt & Witzig Engineering, Inc.	
Project Name: US-231 Bridge & SR-162 Road Construction		Project No: 02IN0005	Date: 5/02

GENERALIZED SUBSURFACE PROFILE
Southbound U.S. 231



Project: US-231 Phase 3
Location: Spencer County
Des. No.: 9161365
Structure #: 231-74-844845
AW Project #: 02IN0005

Scale
Horizontal: 1"=60'
Vertical: 1"=4'

Prepared For: INDOT - Geotechnical Section	AW	Prepared By: Alt & Witzig Engineering, Inc.
Project Name: US-231 Bridge & SR-162 Road Construction		Project No: 02IN0005 / Date: 5/02

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. TB-1
Surface Elevation 141.8
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No. 231-74-844845 | Station 27+100 | Offset 23m LT | Line "A"
Datum USC-GS | Weather Sunny | Temperature 75F | Inspector Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Topsoil (Visual)						
1SS	X	30	1-3-4		Brown, Moist, medium stiff, SILTY CLAY Test 02 A-6						
2SS	X	80	3-4-6								
3SS	X	100	4-7-8		Brown, Moist, medium stiff to very stiff, SILTY CLAY with Shale fragments Test 02 A-6						
4SS	X	50	6-10-11								
5SS	X	100	30-50-50/3"								
				5	Gray, weathered SHALE (Visual)						
~~6SS~~	~~X~~	~~80~~	~~31-50/4"~~								
1RC					Rock Core No.1: (6.1m-7.6m) REC=90% RQD=47% Black, Coal (Visual) Gray, SHALE (Visual) Rock Core No.2: (7.6m-9.1m) REC= 100% RQD=83%						
2RC											
				10	Boring Terminated at 9.1m						
				15	Notes: Two attempts on 1SS.						

WATER LEVEL OBSERVATIONS

While Drilling	Dry	Upon Completion of Drilling	Dry
Time After Drilling		24hrs.	
Depth to Water		N/A	
Depth to Cave in			

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 4/16/02 End 4/16/02 Rig ATV
Driller Loveday Editdohnecheck
Remarks Boring backfilled with bentonite chips and soil cuttings. 152mm Dia HSA. Water used to core.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. S-1
Surface Elevation 141.1
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No.	231-74-844845	Station	27+100	Offset	11m LT	Line	"A"
Datum	USC-GS	Weather	Sunny	Temperature	80F	Inspector	Tom Coffey

SAMPLE					DESCRIPTION/CLASSIFICATION and REMARKS	SOIL PROPERTIES					
No.	Type	Rec (%)	N	Depth		qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					See TB-1 for Soil Description						
					Apparent Bedrock encountered at 3.9m						
				5							
					Auger Refusal and Boring Terminated at 7.6m						
				10							

WATER LEVEL OBSERVATIONS

While Drilling N/A
Upon Completion of Drilling Dry
Time After Drilling 24hrs.
Depth to Water 2.5
Depth to Cave in

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 4/18/02 End 4/18/02 Rig ATV
Driller Loveday Editor johnecheck
Remarks Boring backfilled with bentonite chips and soil cuttings. 6" Dia HSA.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. TB-2
Surface Elevation 140.1
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No. 231-74-844845 | Station 27+116 | Offset 23m LT | Line "A"
Datum USC-GS | Weather Sunny | Temperature 50F | Inspector Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
1SS	SS	100	5-7-10		Brown, Moist, very stiff to hard, SILTY CLAY Test 02 A-6						
2SS	SS	90	8-10-10								
3SS	SS	45	8-18-41								
4SS	SS	60	10-22-30		Brown, highly weathered SHALE (Visual)						
5SS	SS	50	17-41-50/4"								
1RC	RC			5	Gray, SHALE (Visual) Rock Core No. 1: (4.6m-6.1m) REC=80% RQD=73%						
				10	Boring Terminated at 6.1m						

WATER LEVEL OBSERVATIONS

While Drilling	Dry	Upon Completion of Drilling	2.1	
Time After Drilling		24hrs.		
Depth to Water		2.1		
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 2/11/02 End 2/11/02 Rig Truck
Driller Schwarzkopf Edit Johnecheck
Remarks Boring backfilled with bentonite chips and soil cuttings. 152mm Dia HSA. Worksite set-up 1. Water used to core.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. S-2
Surface Elevation 140.0
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No.	231-74-844845	Station	27+116	Offset	11m LT	Line	"A"
Datum	USC-GS	Weather	Sunny	Temperature	55F	Inspector	Tom Coffey

SAMPLE					DESCRIPTION/CLASSIFICATION and REMARKS	SOIL PROPERTIES					
No.	Type	Rec (%)	N	Depth		qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					See TB-2 for Soil Description						
					Apparent Bedrock encountered at 2.0m						
				5	Auger Refusal and Boring Terminated at 4.5m						
				10							

WATER LEVEL OBSERVATIONS

While Drilling ○ N/A Upon Completion of Drilling ● Dry
Time After Drilling
Depth to Water ▽
Depth to Cave in

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 2/12/02 End 2/12/02 Rig Truck
Driller Schwarzkopf Editor Johnecheck
Remarks Boring backfilled with bentonite chips and soil cuttings. 6" Dia HSA. Worksite set-up 1.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. TB-3
Surface Elevation 138.9
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No.	231-74-844845	Station	27+148	Offset	26m LT	Line	"A"
Datum	USC-GS	Weather	Sunny	Temperature	50F	Inspector	Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Topsoil (Visual)						
1SS	X	60	5-5-8		Brown, Moist, stiff to hard, SILTY CLAY Test 02 A-6						
2SS	X	70	7-9-10								
3SS	X	100	11-17-21								
4SS	X	70	11-16-19		Brown and Gray, highly weathered SHALE (Visual)						
5SS	X	50	17-32-50/4"								
1RC				5	Gray, SHALE (Visual) Rock Core No. 1: (4.6m-6.1m) REC=100% RQD=90%						
				10	Boring Terminated at 6.1m.						

WATER LEVEL OBSERVATIONS

While Drilling	Dry	Upon Completion of Drilling	Dry	
Time After Drilling		24hrs.		
Depth to Water		N/A		
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 2/12/02 End 2/12/02 Rig Truck
Driller Schwarzkopf Editor Johnecheck
Remarks Boring backfilled with bentonite chips and soil cuttings. 152mm Dia HSA. Worksite set-up 1. Water used to core.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. S-3
Surface Elevation 138.6
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No.	231-74-844845	Station	27+148	Offset	11m LT	Line	"A"
Datum	USC-GS	Weather	Sunny	Temperature	55F	Inspector	Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					See TB-3 for Soil Description						
					Apparent Bedrock encountered at 1.8m						
				5	Auger Refusal and Boring Terminated at 4.5m						
				10							

WATER LEVEL OBSERVATIONS

While Drilling ○ N/A Upon Completion of Drilling ● Dry
Time After Drilling
Depth to Water ▽ ▽ ▽ ▽
Depth to Cave in

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 2/12/02 End Rig Truck
Driller Schwarzkopf Editor Johnecheck
Remarks Boring backfilled with bentonite chips and soil cuttings. 6" Dia HSA.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. TB-4
Surface Elevation 138.2
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No. 231-74-844845 | Station 27+163 | Offset 24m LT | Line "A"
Datum USC-GS | Weather Sunny | Temperature 45F | Inspector Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Topsoil (Visual)						
1SS	X	60	4-7-8		Brown, Moist, stiff to very stiff, SILTY CLAY Test 02 A-6			26.0			
2SS	X	75	5-6-13								
3SS	X	55	11-23-50					14.4			
4SS	X	50	8-24-39		Brown and Gray, highly weathered SHALE (Visual)						
5SS	X	60	5-28-50/3"								
1RC				5	Gray, SHALE (Visual) Rock Core No. 1: (4.6m-6.1m) REC=95% RQD=80%						
				10	Boring Terminated at 6.1m						

WATER LEVEL OBSERVATIONS

While Drilling	Dry	Upon Completion of Drilling	2.9
Time After Drilling		24hrs.	
Depth to Water		5.6	
Depth to Cave in			

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 2/12/02 End 2/12/02 Rig Truck
Driller Schwarzkopf Editor Johnecheck
Remarks Boring backfilled with bentonite chips and soil cuttings. 152mm Dia HSA.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. S-4
Surface Elevation 138.0
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No. 231-74-844845 | Station 27+163 | Offset 11m LT | Line "A"
Datum USC-GS | Weather Sunny | Temperature 45F | Inspector Tom Coffey

SAMPLE					DESCRIPTION/CLASSIFICATION and REMARKS	SOIL PROPERTIES					
No.	Type	Rec (%)	N	Depth		qu (qp) (tsf)	ɣ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					See TB-4 for Soil Description						
					Apparent Bedrock at 1.8m						
				5	Auger Refusal and Boring Terminated at 4.6m						
				10							

WATER LEVEL OBSERVATIONS

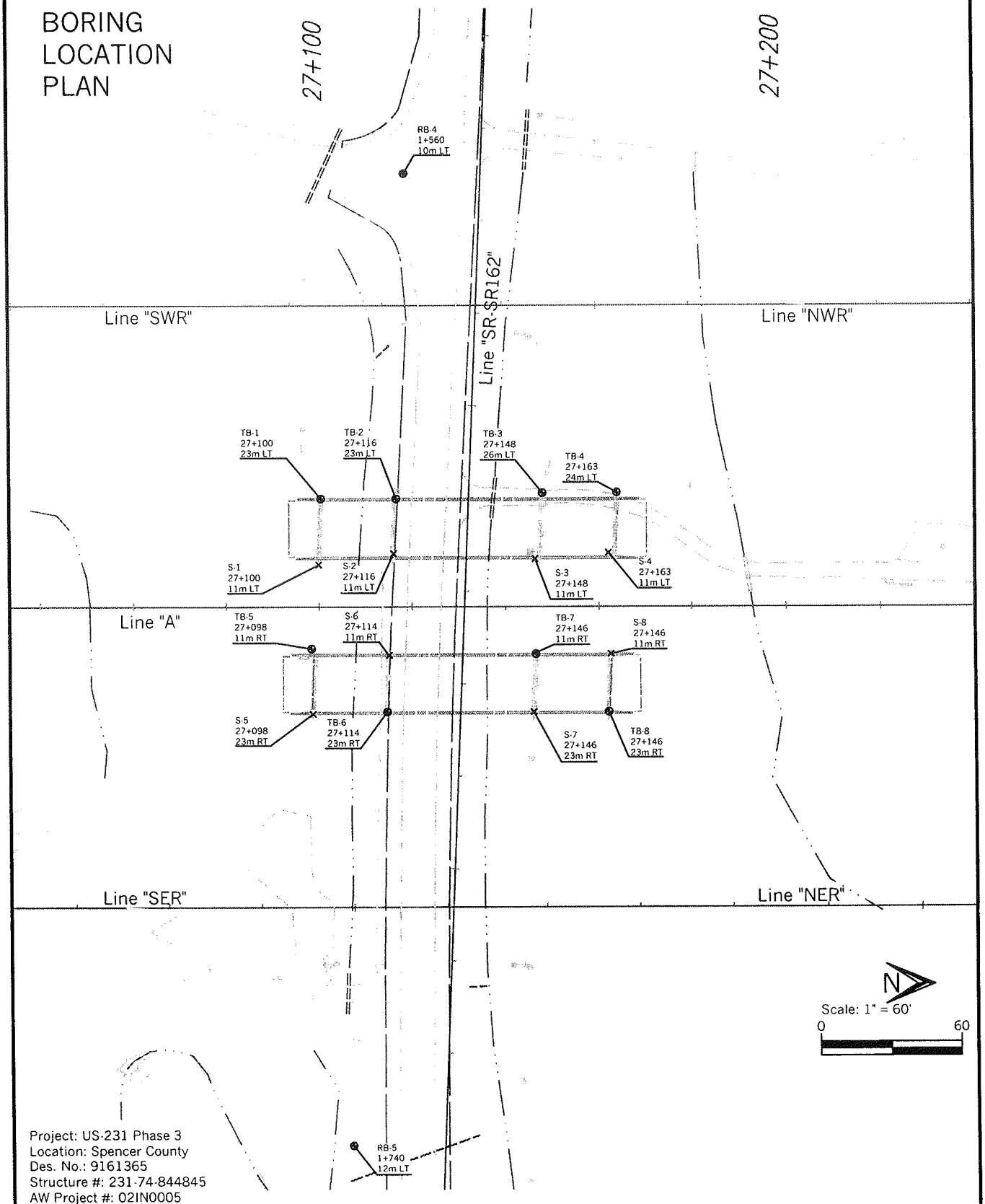
While Drilling ○ Dry — Upon Completion of Drilling ● Dry
Time After Drilling
Depth to Water
Depth to Cave in

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 2/12/02 End 2/12/02 Rig Truck
Driller Schwarzkopf Editd Johnecheck
Remarks Boring backfilled with bentonite chips and soil cuttings. 6" Dia HSA

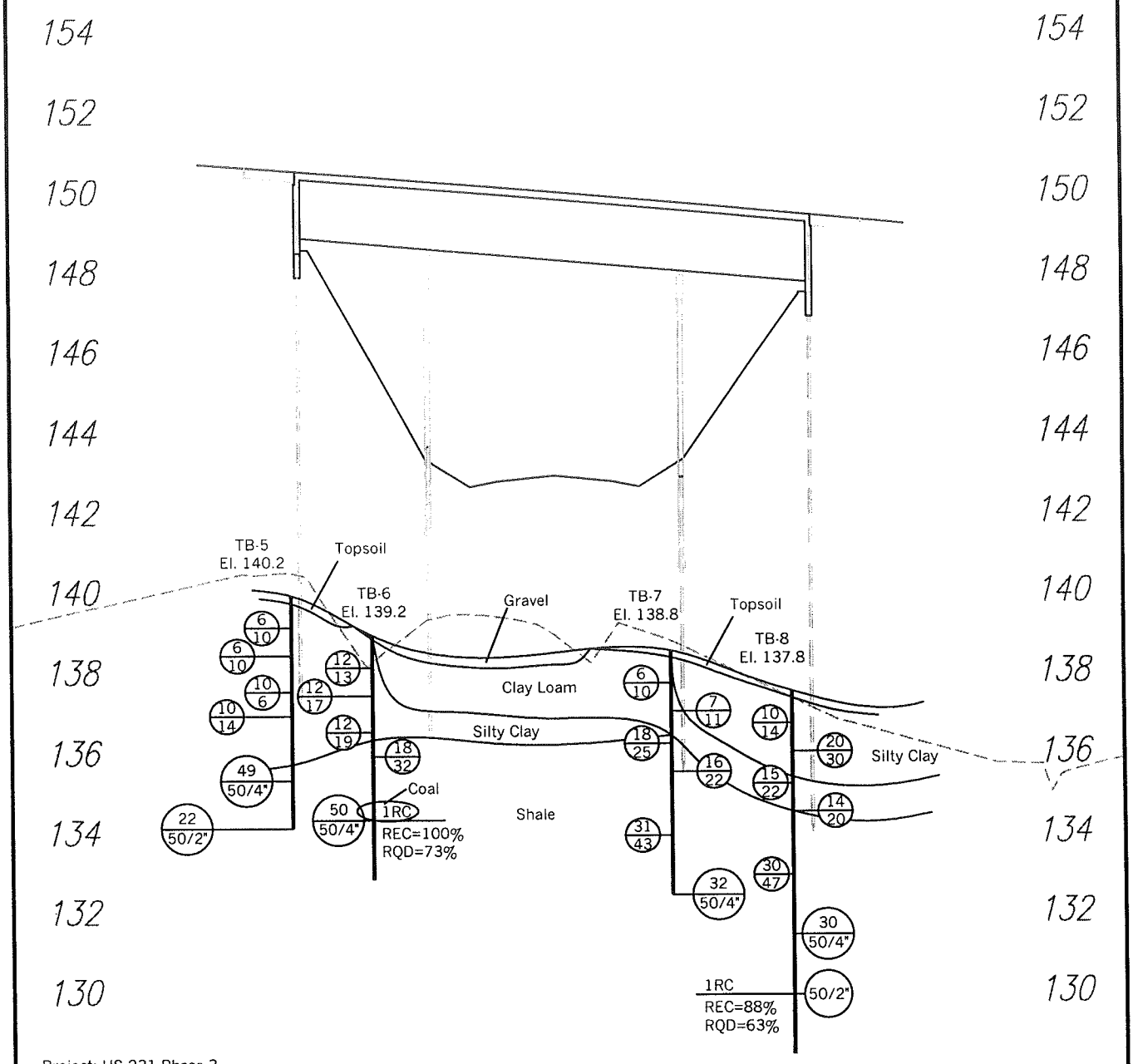
BORING LOCATION PLAN



Project: US-231 Phase 3
Location: Spencer County
Des. No.: 9161365
Structure #: 231-74-844845
AW Project #: 02IN0005

Prepared For: INDOT - Geotechnical Section	AW	Prepared By: Alt & Witzig Engineering, Inc.	
Project Name: US-231 Bridge & SR-162 Road Construction		Project No: 02IN0005	Date: 5/02

GENERALIZED SUBSURFACE PROFILE
Northbound U.S. 231



Project: US-231 Phase 3
Location: Spencer County
Des. No.: 9161365
Structure #: 231-74-844845
AW Project #: 02IN0005

Scale
Horizontal: 1"=60'
Vertical: 1"=4'

Prepared For: INDOT - Geotechnical Section	AW	Prepared By: Alt & Witzig Engineering, Inc.
Project Name: US-231 Bridge & SR-162 Road Construction		Project No: 02IN0005 / Date: 5/02

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. TB-5
Surface Elevation 140.2
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No.	231-74-844845	Station	27+098	Offset	11m RT	Line	"A"
Datum	USC-GS	Weather	Sunny	Temperature	60F	Inspector	Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Topsoil (Visual)						
1SS	X	70	4-6-10		Brown, Moist, very stiff, SILTY CLAY						
					Test 02 A-6						
2SS	X	85	3-6-10								
3SS	X	50	6-10-16								
				▼							
4SS	X	90	6-10-14								
5SS	X	50	21-49-50/4"								
				5	Gray weathered SHALE (Visual)						
6SS	X	50	22-50/2"								
					Auger Refusal and Boring Terminated at 5.8m						
				10							

WATER LEVEL OBSERVATIONS

While Drilling	○ Dry	Upon Completion of Drilling	● Dry	
Time After Drilling		24hrs.		
Depth to Water	▽	▼ 2.5	▼	▽
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 4/22/02 End 4/22/02 Rig ATV
Driller Loveday Editjohnecheck
Remarks Boring backfilled with bentonite chips and soil cuttings. 152mm Dia HSA.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. S-5
Surface Elevation 139.5
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No. 231-74-844845 | Station 27+098 | Offset 23m RT | Line "A"
Datum USC-GS | Weather Sunny | Temperature 80F | Inspector Tom Coffey

SAMPLE					DESCRIPTION/CLASSIFICATION and REMARKS	SOIL PROPERTIES					
No.	Type	Rec (%)	N	Depth		qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					See TB-5 for Soil Description						
					Apparent Bedrock encountered at 4.0m						
				5							
					Auger Refusal and Boring Terminated at 6.1m						
				10							

WATER LEVEL OBSERVATIONS

While Drilling	▽ N/A	Upon Completion of Drilling	● Dry	
Time After Drilling		24hrs.		
Depth to Water	▽	▼ 1.4	▽	▽
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 4/18/02 End 4/18/02 Rig ATV
Driller Loveday Editdphnecheck
Remarks Boring backfilled with bentonite chips and soil cuttings. 6" Dia HSA.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. TB-6
Surface Elevation 139.2
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No. 231-74-844845 | Station 27+114 | Offset 23m RT | Line "A"
Datum USC-GS | Weather Sunny | Temperature 40F | Inspector Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Brown, Slighty Moist, GRAVEL (Visual)						
1SS	X	55	10-12-13		Brown, Moist, very stiff, CLAY LOAM Test 01 A-4(2)			15.4	22	16	6
2SS	X	45	9-12-17								
3SS	X	50	7-12-19		Brown, Moist, hard, SILTY CLAY Test 02 A-6			14.1			
4SS	X	70	8-18-32		Brown and Gray highly weathered SHALE (VISUAL)						
5SS	X	60	5-50-50/4"		Black, COAL (Visual)						
1RC				5	Gray, SHALE (Visual) Rock Core No. 1: (4.6-6.1m) REC=100% RQD=73%						
				10	Boring Terminated at 6.1m.						

WATER LEVEL OBSERVATIONS

While Drilling	Dry	Upon Completion of Drilling	3.7	
Time After Drilling		24hrs.		
Depth to Water		2.3		
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 2/11/02 End 2/11/02 Rig Truck
Driller Schwarzkopf Editor Johnecheck
Remarks Boring backfilled with bentonite chips and soil cuttings. 152mm Dia HSA. Worksite set-up 1. Water used to core.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. S-6
Surface Elevation 139.7
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No. 231-74-844845 | Station 27+114 | Offset 11m RT | Line "A"
Datum USC-GS | Weather Sunny | Temperature 55F | Inspector Tom Coffey

SAMPLE					DESCRIPTION/CLASSIFICATION and REMARKS	SOIL PROPERTIES					
No.	Type	Rec (%)	N	Depth		qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					See TB-6 for Soil Description						
					Apparent Bedrock encountered at 2.0m						
				5	Auger Refusal and Boring Terminated at 4.6m						
				10							

WATER LEVEL OBSERVATIONS

While Drilling ▽ N/A | Upon Completion of Drilling ▼ Dry
Time After Drilling
Depth to Water
Depth to Cave in

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 2/12/02 End 2/12/02 Rig Truck
Driller Schwarzkopf Editor Johnecheck
Remarks Boring backfilled with bentonite chips and soil cuttings. 6" Dia HSA. Worksite set-up 1.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. TB-7
Surface Elevation 138.8
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No. 231-74-844845 | Station 27+146 | Offset 11m RT | Line "A"
Datum USC-GS | Weather Sunny | Temperature 80F | Inspector Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Topsoil (Visual)						
1SS	X	50	2-6-10		Brown, Moist, very stiff, SILTY CLAY Test 02 A-6						
2SS	X	55	6-7-11								
3SS	X	40	6-18-25		Brown, Moist, very stiff, CLAY LOAM Test 01 A-4						
4SS	X	45	10-16-22		Brown and Gray, highly weathered SHALE (Visual)						
5SS	X	60	16-31-43	5	Gray, slightly weathered SHALE (Visual)						
6SS	X	60	8-32-50/4"		Auger Refusal and Boring Terminated at 6.1m.						
				10	Notes: Two attempts on 3SS.						

WATER LEVEL OBSERVATIONS

While Drilling	▽ Dry	Upon Completion of Drilling	▼ Dry	
Time After Drilling		24hrs.		
Depth to Water	▽	▼ Dry	▽	▽
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 4/19/02 End 4/19/02 Rig ATV
Driller Loveday Editjohnecheck
Remarks Boring backfilled with bentonite chips and soil cuttings. 152mm Dia HSA.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. S-7
Surface Elevation 138.7
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No. 231-74-844845 | Station 27+146 | Offset 23m RT | Line "A"
Datum USC-GS | Weather Sunny | Temperature 80F | Inspector Tom Coffey

SAMPLE					DESCRIPTION/CLASSIFICATION and REMARKS	SOIL PROPERTIES					
No.	Type	Rec (%)	N	Depth		qu (qp) (tsf)	ɣ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					See TB-7 for Soil Description						
					Apparent Bedrock encountered at 2.2m						
				5							
					Auger Refusal and Boring Terminated at 9.1m						
				10							

WATER LEVEL OBSERVATIONS

While Drilling	N/A	Upon Completion of Drilling	Dry
Time After Drilling		24hrs.	
Depth to Water		5.8	
Depth to Cave in			

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 4/18/02 End Rig ATV
Driller Loveday Editdohnecheck
Remarks Boring backfilled with bentonite chips and soil cuttings. 6" Dia HSA.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. TB-8
Surface Elevation 137.8
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No. 231-74-844845 | Station 27+161 | Offset 23m RT | Line "A"
Datum USC-GS | Weather Sunny | Temperature 75F | Inspector Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Topsoil (Visual)						
1SS	X	100	6-10-14		Brown, Moist, very stiff, SILTY CLAY Test 02 A-6						
2SS	X	100	5-20-30								
3SS	X	100	11-15-22		Brown, Moist, hard, CLAY LOAM Test 01 A-4						
4SS	X	100	12-14-20								
5SS	X	100	20-30-47	5	Brown, highly weathered SHALE (Visual)						
6SS	X	100	30-50/4"		Gray, SHALE (Visual)						
7SS	X	100	50/2"								
1RC					Auger Refusal at 7.6m feet Gray, SHALE (Visual) Rock Core No. 1: (7.6-9.1m feet) REC=88% RQD=63%						
				10	Boring Terminated at 9.1m.						

WATER LEVEL OBSERVATIONS

While Drilling	Dry	Upon Completion of Drilling	4.7
Time After Drilling		24hrs.	
Depth to Water		N/A	
Depth to Cave in			

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 4/18/02 End 4/18/02 Rig ATV
Driller Loveday Edit dohnecheck
Remarks Boring backfilled with bentonite chips and soil cuttings. 152mm Dia HSA. Water used to core.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. S-8
Surface Elevation 137.8
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No.	231-74-844845	Station	27+161	Offset	11m RT	Line	"A"
Datum	USC-GS	Weather	Sunny	Temperature	80F	Inspector	Tom Coffey

SAMPLE					DESCRIPTION/CLASSIFICATION and REMARKS	SOIL PROPERTIES					
No.	Type	Rec (%)	N	Depth		qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					See TB-8 for Soil Description						
					Apparent Bedrock encountered at 2.3m						
				5							
					Auger Refusal and Boring Terminated at 9.1m						
				10							

WATER LEVEL OBSERVATIONS

While Drilling	N/A	Upon Completion of Drilling	Dry	
Time After Drilling		24hrs.		
Depth to Water		1.5		
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 4/18/02 End 4/18/02 Rig ATV
Driller Loveday Editd ohnecheck
Remarks Boring backfilled with bentonite chips and soil cuttings. 6" Dia HSA. .5 excess access time.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. RB-1
Surface Elevation 137.3
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No.	N/A	Station	1+100	Offset	8m RT	Line	"SR-SR162"
Datum	USC-GS	Weather	Sunny	Temperature	50F	Inspector	Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Asphalt (0.1m) (Visual)						
1SS	X	100	12-9-8		Stone (0.2m) (Visual)						
					Brown, Moist, very stiff to stiff SILTY CLAY						
2SS	X	50	3-5-6		Test 02 A-6			19.3			
3SS	X	45	4-13-21		Brown, weathered SANDSTONE (Visual)						
				5	Boring Terminated at 2.3m.						
				10							

WATER LEVEL OBSERVATIONS

While Drilling	Dry	Upon Completion of Drilling	Dry	
Time After Drilling		24hrs.		
Depth to Water		0.9		
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 2/12/02 End 2/12/02 Rig Truck
Driller Schwarzkopf Editor Johnecheck
Remarks Boring backfilled with soil cuttings. 152mm Dia HSA. Worksite setup-1. Asphalt patched.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. RB-2
Surface Elevation 142.1
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No. N/A | Station 1+250 | Offset 2m LT | Line "SR-SR162"
Datum USC-GS | Weather Sunny | Temperature 50F | Inspector Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Gray, Stone (Visual)						
1SS	X	40	2-3-6		Brown, Moist, medium stiff to very stiff, SILTY CLAY						
					Test 02 A-6						
2SS	X	50	2-6-13	▼				17.4			
3SS	X	50	10-21-42		Gray, weathered SILTSTONE (Visual)						
4SS	X	50	10-30-50/4"	5	Boring Terminated at 3.0m.						
					Notes: Two attempts on 1SS.						
				10							

WATER LEVEL OBSERVATIONS

While Drilling	Dry	Upon Completion of Drilling	Dry
Time After Drilling		24hrs.	
Depth to Water		1.5	
Depth to Cave in			

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 2/12/02 End 2/12/02 Rig Truck
Driller Schwarzkopf Editor
Remarks Boring backfilled with soil cuttings. 152mm Dia HSA. Worksite set-up 1.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. RB-3
Surface Elevation 144.9
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No. N/A | Station 1+400 | Offset 12m RT | Line "SR-SR162"
Datum USC-GS | Weather Sunny | Temperature 50F | Inspector Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Gray, STONE (Visual)						
1SS	X	55	5-7-10		Brown, Moist, very stiff to hard, SILTY CLAY Test 02 A-6						
2SS	X	45	12-13-19					18.1			
3SS	X	50	6-23-55		Brown, weathered SILTSTONE (Visual)						
4SS	X	60	15-50/4"								
				5	Boring Terminated at 3.0m.						
				10							

WATER LEVEL OBSERVATIONS

While Drilling ▽ Dry | Upon Completion of Drilling ▼ Dry
Time After Drilling
Depth to Water
Depth to Cave in

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 2/12/02 End 2/12/02 Rig Truck
Driller Schwarzkopf Editor Johnecheck
Remarks Boring backfilled with soil cuttings. 152mm Dia HSA. Worksite set-up 1.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. RB-4
Surface Elevation 139.6
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No.	N/A	Station	1+560	Offset	10m LT	Line	"SR-SR162"
Datum	USC-GS	Weather	Sunny	Temperature	60F	Inspector	Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Topsoil (Visual)						
1SS	X	80	4-5-6		Brown, Very Moist, stiff, SILTY CLAY Test 02 A-6			21.8			
2SS	X	45	1-2-11					15.7			
3SS	X	60	7-16-18		Brown, highy weathered SHALE (Visual)						
4SS	X	45	5-12-18								
				5	Boring Terminated at 3.0m.						
				10							

WATER LEVEL OBSERVATIONS

While Drilling	Dry	Upon Completion of Drilling	Dry
Time After Drilling		24hrs.	
Depth to Water		1.8	
Depth to Cave in			

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 4/22/02 End 4/22/02 Rig ATV
Driller Loveday Editd ohnecheck
Remarks Boring backfilled with soil cuttings. 152mm Dia HSA.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. RB-5
Surface Elevation 136.4
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No.	N/A	Station	1+740	Offset	12m LT	Line	"SR-SR162"
Datum	USC-GS	Weather	Sunny	Temperature	81F	Inspector	Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Topsoil (Visual)						
1SS			5-9-12		Brown, Moist, very stiff, CLAY LOAM Test 01 A-4			18.5			
2SS			4-7-9					18.2			
3SS			6-10-12								
4SS			6-7-10					18.2			
5SS			15-27-36		Brown, slightly weathered SHALE (Visual)						
				5	Boring Terminated at 4.6m						
				10							

WATER LEVEL OBSERVATIONS

	While Drilling	Upon Completion of Drilling		
Time After Drilling		24hrs.		
Depth to Water		2.3		
Depth to Cave in				
	Dry	Dry		

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 4/18/02 End 4/18/02 Rig ATV
Driller Loveday Edit dohnecheck
Remarks Boring backfilled with bentonite chips and soil cuttings. 152mm Dia HSA.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. RB-6
Surface Elevation 140.0
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No. N/A | Station 1+900 | Offset 10m RT | Line "SR-SR162"
Datum USC-GS | Weather Cloudy | Temperature 50F | Inspector Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Brown, Moist, very stiff to stiff, SILTY CLAY						
1SS	X	100	11-13-16		Test 02 A-6(12)			17.9	33	20	13
2SS	X	30	6-7-8					17.4			
3SS	X	50	21-29-33		Brown, highly weathered SHALE (Visual)						
					Boring Terminated at 2.3m.						
				5	Notes: Two attempts on 2SS. Bag Sample obtained at 0.3m1.5m.						
				10							

WATER LEVEL OBSERVATIONS

While Drilling	Dry	Upon Completion of Drilling	Dry
Time After Drilling		24hrs.	
Depth to Water		Dry	
Depth to Cave in			

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 2/12/02 End 2/12/02 Rig Truck
Driller Schwarzkopf Editor Johnecheck
Remarks Boring backfilled with soil cuttings. 152mm Dia HSA. Worksite set-up 1.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. RB-7
Surface Elevation 136.1
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No. N/A | Station 1+000 | Offset CL | Line "NWR"
Datum USC-GS | Weather Cloudy | Temperature 65F | Inspector Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Brown, Very Moist, very soft, SILTY CLAY						
1SS	X	80	3-2-1		Test 02 A-6			30.6			
2SS	X	60	1-1-2	▼			92.9	29.5			
3SS	X	50	1-1-1					29.5			
4SS	X	100	2-3-50/2"								
				●	Black, COAL with intermittent layers of Shale (Visual)						
5SS	X	100	31-50/3"								
					Gray, slightly weathered SHALE (Visual)						
					Boring Terminated at 4.6m.						
				5							
					Notes: Tube pushed at 0.9m-1.5m.						
				10							

WATER LEVEL OBSERVATIONS

While Drilling	Dry	Upon Completion of Drilling	3.6
Time After Drilling		24hrs.	
Depth to Water		1.5	
Depth to Cave in			

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 4/17/02 End 4/17/02 Rig ATV
Driller Loveday Editdohnecheck
Remarks Boring backfilled with bentonite chips and soil cuttings. 152mm Dia HSA.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. RB-8
Surface Elevation 137.8
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No. N/A | Station 1+260 | Offset CL | Line "NWR
Datum USC-GS | Weather Sunny | Temperature 80F | Inspector Tom Coffey

SAMPLE					DESCRIPTION/CLASSIFICATION and REMARKS	SOIL PROPERTIES					
No.	Type	Rec (%)	N	Depth		qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
				▼	Topsoil (Visual)						
1SS	X		1-2-3		Brown, Very Moist, soft, SILTY CLAY Test 02 A-6			30.4			
2SS	X		1-1-4					28.5			
3SS	X		6-18-26		Brown, highly weathered SHALE (Visual)						
4SS	X		7-18-26								
5SS	X		10-50/3"		Gray, SHALE (Visual)						
				5	Boring Terminated at 4.5m.						
				10							

WATER LEVEL OBSERVATIONS

While Drilling	▽ Dry	Upon Completion of Drilling	● Dry	
Time After Drilling		24hrs.		
Depth to Water	▽	▼ 0.2	▽	▽
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 4/17/02 End 4/17/02 Rig Truck
Driller Loveday Editdohnecheck
Remarks Boring backfilled with bentonite chips and soil cuttings. 152mm Dia HSA. 2hr. excess access time

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. RB-9
Surface Elevation 146.0
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No.	N/A	Station	1+240	Offset	10m LT	Line	"SWR"
Datum	USC-GS	Weather	Sunny	Temperature	75F	Inspector	Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Topsoil (Visual)						
1SS	X	75	1-2-2		Brown, Moist, soft to very stiff, SILTY CLAY Test 02 A-6			29.2			
2SS	X	100	5-5-8					18.2			
3SS	X	100	4-9-14								
4SS	X	100	3-12-22		Brown, highly weathered SHALE (Visual)						
5SS	X	100	14-50/4"								
				5	Brown, weathered SHALE (Visual)						
6SS	X	50	4-5-5		Brown, Wet, medium stiff, LOAM with a trace of Coal Deposits (Visual)						
7SS	X	100	8-50/3"					42.5			
					Gray, LIMESTONE (Visual)						
					Black, COAL (Visual)						
8SS	X	40	21-50/5"								
					Gray, SHALE (Visual)						
9SS	X	90	49-50/4"								
				10	Boring Terminated at 9.1m.						

WATER LEVEL OBSERVATIONS

While Drilling	Dry	Upon Completion of Drilling	Dry
Time After Drilling		24hrs.	
Depth to Water		7.8	
Depth to Cave in			

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 4/16/02 End 4/16/02 Rig ATV
Driller Loveday Edit dohnecheck
Remarks Boring backfilled with bentonite chips and soil cuttings. 152mm Dia HSA.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. S-10
Surface Elevation 163.4
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No.	N/A	Station	1+460	Offset	CL	Line	"SWR"
Datum	USC-GS	Weather	Sunny	Temperature	80F	Inspector	Tom Coffey

SAMPLE					DESCRIPTION/CLASSIFICATION and REMARKS	SOIL PROPERTIES					
No.	Type	Rec (%)	N	Depth		qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					See RB-21 for Soil Description and Rock Core Information						
				5	Auger Refusal and Boring Terminated at 3.7m Notes: RB-21 was performed for Report dated 1999.						
				10							

WATER LEVEL OBSERVATIONS

While Drilling	N/A	Upon Completion of Drilling	Dry	
Time After Drilling		24hrs.		
Depth to Water		Dry		
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 4/18/02 End 4/18/02 Rig ATV
Driller Loveday Editjohnecheck
Remarks Boring backfilled with bentonite chips and soil cuttings. 6" Dia HSA.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. S-11
Surface Elevation 162.0
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No.	N/A	Station	1+060	Offset	5m LT	Line	"SER"
Datum	USC-GS	Weather	Sunny	Temperature	80F	Inspector	Tom Coffey

SAMPLE					DESCRIPTION/CLASSIFICATION and REMARKS	SOIL PROPERTIES					
No.	Type	Rec (%)	N	Depth		qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					See RB-21 for Soil Description and Rock Core Information						
					Auger Refusal and Boring Terminated at 2.1m						
				5	Notes: RB-21 was performed for Report dated 1999						
				10							

WATER LEVEL OBSERVATIONS

While Drilling	Dry	Upon Completion of Drilling	Dry	
Time After Drilling		24hrs.		
Depth to Water		0.3		
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 4/18/02 End 4/18/02 Rig ATV
Driller Loveday Editjohnecheck
Remarks Boring backfilled with bentonite chips and soil cuttings. 6" Dia HSA.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. HS-12
Surface Elevation 145.0
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No.	N/A	Station	1+170	Offset	CL	Line	"SER"
Datum	USC-GS	Weather	Sunny	Temperature	55F	Inspector	Tom Coffey

SAMPLE					DESCRIPTION/CLASSIFICATION and REMARKS	SOIL PROPERTIES					
No.	Type	Rec (%)	N	Depth		qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Water (Visual)						
				5	Black, very soft, SILTY LOAM (Visual)						
					Boring Terminated at 6.4m, Apparent Firm Material						
				10							

WATER LEVEL OBSERVATIONS

While Drilling	▽ 0.0	Upon Completion of Drilling	● 0.0	
Time After Drilling				
Depth to Water	▽	▼	▼	▼
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 3/4/02 End 3/4/02 Rig Truck
Driller Sanders Edit Johnecheck
Remarks

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. RB-13
Surface Elevation 139.0
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No. N/A | Station 1+450 | Offset CL | Line "SER"
Datum USC-GS | Weather Sunny | Temperature 75F | Inspector Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Topsoil (Visual)						
1SS	X	60	1-1-2		Brown, Moist, very soft to medium stiff, SILTY CLAY Test 02 A-6		90.5	24.9			
2SS	X	100	2-4-4					24.9			
3SS	X	100	3-4-10								
4SS	X	100	4-17-26		Brown and Gray, weathered SHALE (Visual)						
				5	Boring Terminated at 3.0m. Notes: Tube pushed at 0.3m-0.9m						
				10							

WATER LEVEL OBSERVATIONS

While Drilling	Dry	Upon Completion of Drilling	Dry	
Time After Drilling		24hrs.		
Depth to Water		1.5		
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 4/16/02 End 4/16/02 Rig ATV
Driller Loveday Editjohnecheck
Remarks Boring backfilled with soil cuttings. 152mm Dia HSA.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. RB-14
Surface Elevation 134.5
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No. N/A | Station 1+080 | Offset CL | Line "NER"
Datum USC-GS | Weather Sunny | Temperature 80F | Inspector Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Topsoil (Visual)						
1SS	X	45	2-3-4		Brown, Very Moist, medium stiff to very soft, SILTY CLAY			27.5			
					Test 02 A-6						
2SS	X	40	1-1-2	▼			94.9	27.1			
3SS	X	20	4-5-10					23.4			
					Brown, Moist, stiff to hard, CLAY LOAM						
					Test 01 A-4						
4SS	X	80	30-50/2"								
					Black, COAL (Visual)						
					Gray, slightly weathered SHALE (Visual)						
5SS	X	75	4-41-50/2								
				5	Boring Terminated at 4.6m.						
					Notes: Pushed tube at 0.9m-1.5m Two Attempts on 3SS.						
				10							

WATER LEVEL OBSERVATIONS

While Drilling	Dry	Upon Completion of Drilling	Dry
Time After Drilling		24hrs.	
Depth to Water		1.5	
Depth to Cave in			

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 4/18/02 End 4/18/02 Rig ATV
Driller Loveday Edit dohnecheck
Remarks Boring backfilled with bentonite chips and soil cuttings. 152mm Dia HSA.

LOG OF TEST BORING

Project: US-231 Phase 3
Location: Spencer County
Client: INDOT-Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. RB-15
Surface Elevation 135.8
Proj. # NH-75-3 ( )
AW Proj. # 02IN0005
Sheet 1 of 1

Str. No. N/A | Station 1+280 | Offset CL | Line "NER"
Datum USC-GS | Weather Cloudy | Temperature 68F | Inspector Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Topsoil (Visual)						
1SS	X	80	2-4-4		Brown, Moist, medium stiff to very stiff, SILTY CLAY			19.1			
2SS	X	50	5-9-11	▼	Test 02 A-6		103.4	22.0			
3SS	X	100	5-9-10								
4SS	X	100	5-5-7		Brown, Moist, stiff, CLAY LOAM			23.4			
					Test 01 A-4						
					Brown, LIMESTONE (Visual)						
5SS	X		50/3"		Boring Terminated at 4.2m.						
				5							
				10							

WATER LEVEL OBSERVATIONS

While Drilling	Dry	Upon Completion of Drilling	Dry	
Time After Drilling		24hrs		
Depth to Water		1.5		
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 4/17/02 End 4/17/02 Rig ATV
Driller Loveday Editdohnecheck
Remarks Boring backfilled with bentonite chips and soil cuttings. 152mm Dia HSA.

LOG OF TEST BORING

Project: U.S. 231 Realignment
Location: Spencer County, Indiana
Client: Indiana Department of Transportation

3405 West 96th Street Indianapolis, Indiana 46268-1194
317-875-7000/317-876-3705(Fax)

Boring No. RB-21
Surface Elevation 161.8
Proj. # NH-075-3( )
AW Proj. # S9905
Sheet 1 of 1

Str. No. N/A | Station 26+720 | Offset Centerline | Line "A"
Datum USC & GS | Weather Sunny | Temperature 65 | Inspector M. Rowe

SAMPLE					DESCRIPTION/CLASSIFICATION and REMARKS	SOIL PROPERTIES					
No.	Type	Rec (%)	N	Depth		qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
1	X	100	17-26-34		Brown, Dry, Hard, Silty Clay Loam Test 4 A-6						
2	X	100	6-15-17								
3	X	100	14-14-17								
4	X	100	18-19-30		Gray Weathered Siltstone (Visual)						
5	X	0	50/1"								
				5	Gray Weathered Sandstone (Visual) 4.6 to 5.5m, Gray Shale (Visual) 5.5 to 7.6m Rock Core No. 1 REC: 100% RQD: 63%						
				10	Gray Shale (Visual) Rock Core No. 2 REC: 100% RQD: 88%						
					Gray Shale (Visual) Rock Core No. 3 REC: 100% RQD: 91%						
				15	Boring Terminated at 13.7 meters						
				20							

WATER LEVEL OBSERVATIONS

While Drilling ▽ DRY | Upon Completion of Drilling ● 5.0
Time After Drilling 24
Depth to Water ▽ ▼ 7.0
Depth to Cave in

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 10/6/99 End 10/6/99 Rig ATV
Driller Loveday Editor M. Rowe
Remarks Boring backfilled with soil cuttings.

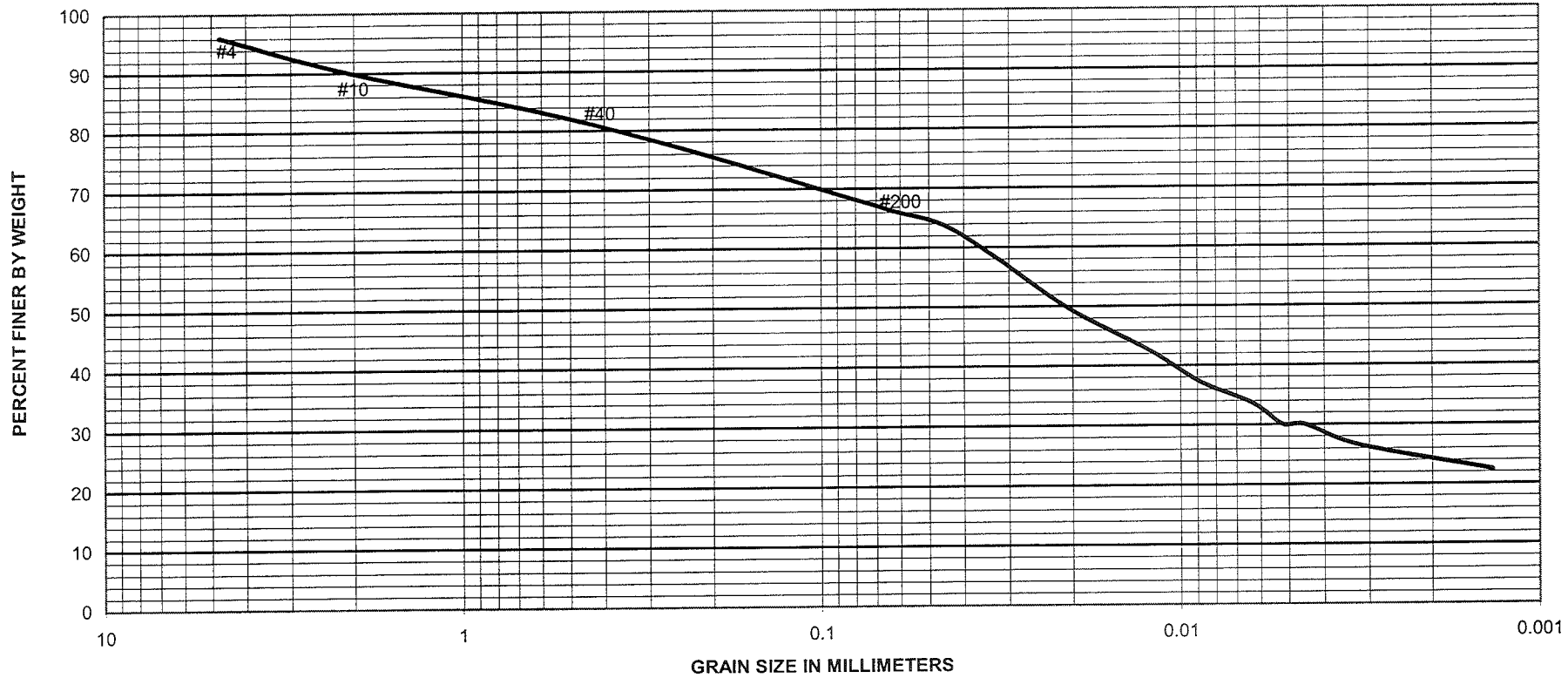
US-231 Phase 3
Des. No.: 9161365
Project No: NH-075-3
Structure No: 231-74-844845
Alt & Witzig File: 02IN0005

CLASSIFICATION TEST DATA SUMMARY

Test No.	Boring # Station Offset Line	Sample & Depth	Description	Passing #10	Passing #40	> #10 % Gravel	#10-#200 % Sand	#200-.002mm % Silt	0.002mm % Clay	0.001mm % Colloids	LL	PL	PI	AASHTO Classification
01	TB-6 27+114 23mRT "A"	1 SS (1.0 – 2.5 ft) (0.3 – 0.8 m)	Clay Loam	90	81	10	22	44	24	22	22	16	6	A-4(2)
02	RB-6 1+900 10mRT "S-SR162"	1 BS (1.0 – 5.0ft) (0.3 – 1.5m)	Silty Clay	99	97	1	8	59	32	31	33	20	13	A-6(12)

SS - Split Spoon --- BS – Bag Sample

Grain Size Distribution Curve



GRAVEL	SAND	SILT OR CLAY
	#10	#200

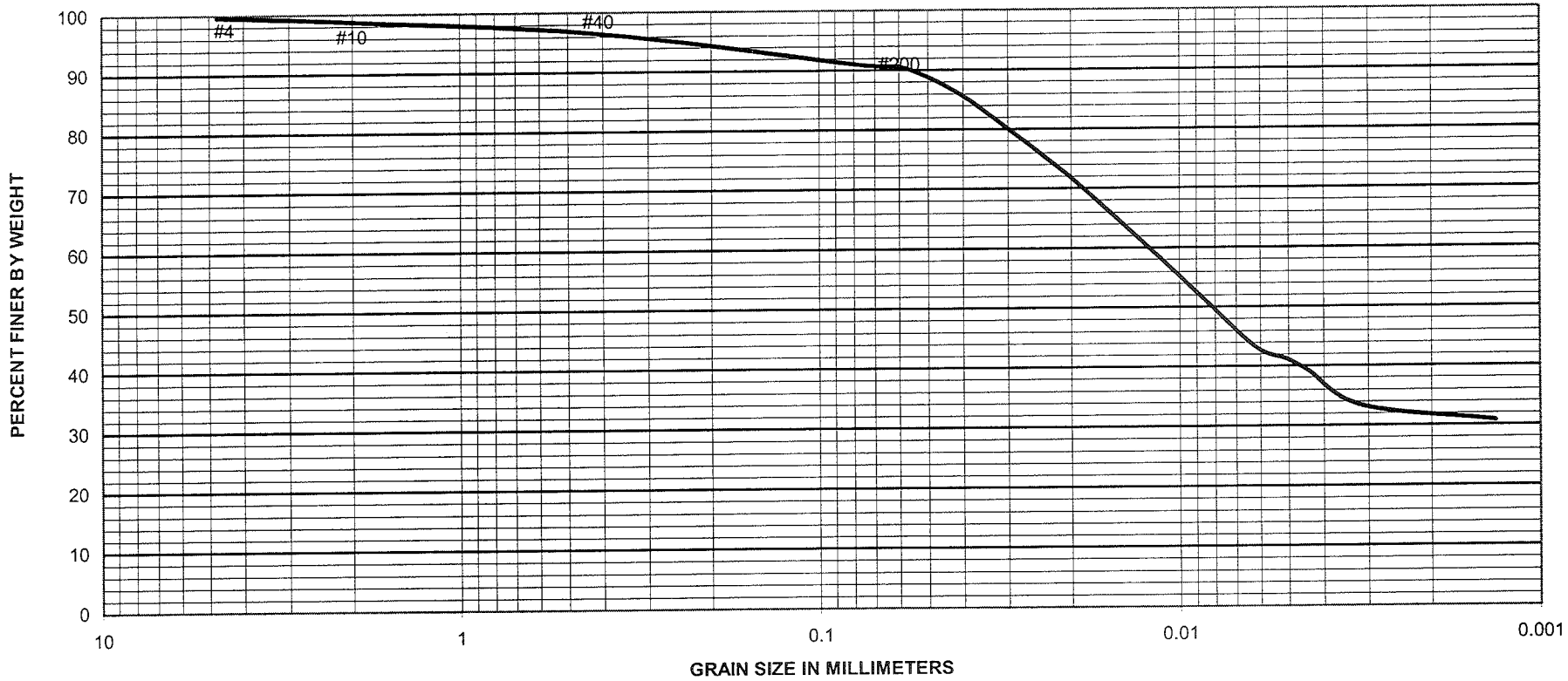
Boring No.	Sample No.	Elev or Depth	Nat w%	LL	PL	Pi	Classification
TB-6	1SS	1.0 -2.5 ft	15.4	22	16	6	Clay Loam
27+114		(0.3 - 0.8 m)					A-4(2)
23mRT							
"A"							

Project: US-231 Phase 3 - 02IN0005
Des. No.: 9161365 - Project #: NH-075-3
Structure #: 231-74-844845
Spencer County, Indiana
Date: 4/02

A&W

#1

Grain Size Distribution Curve



GRAVEL	SAND	SILT OR CLAY
	#10	#200

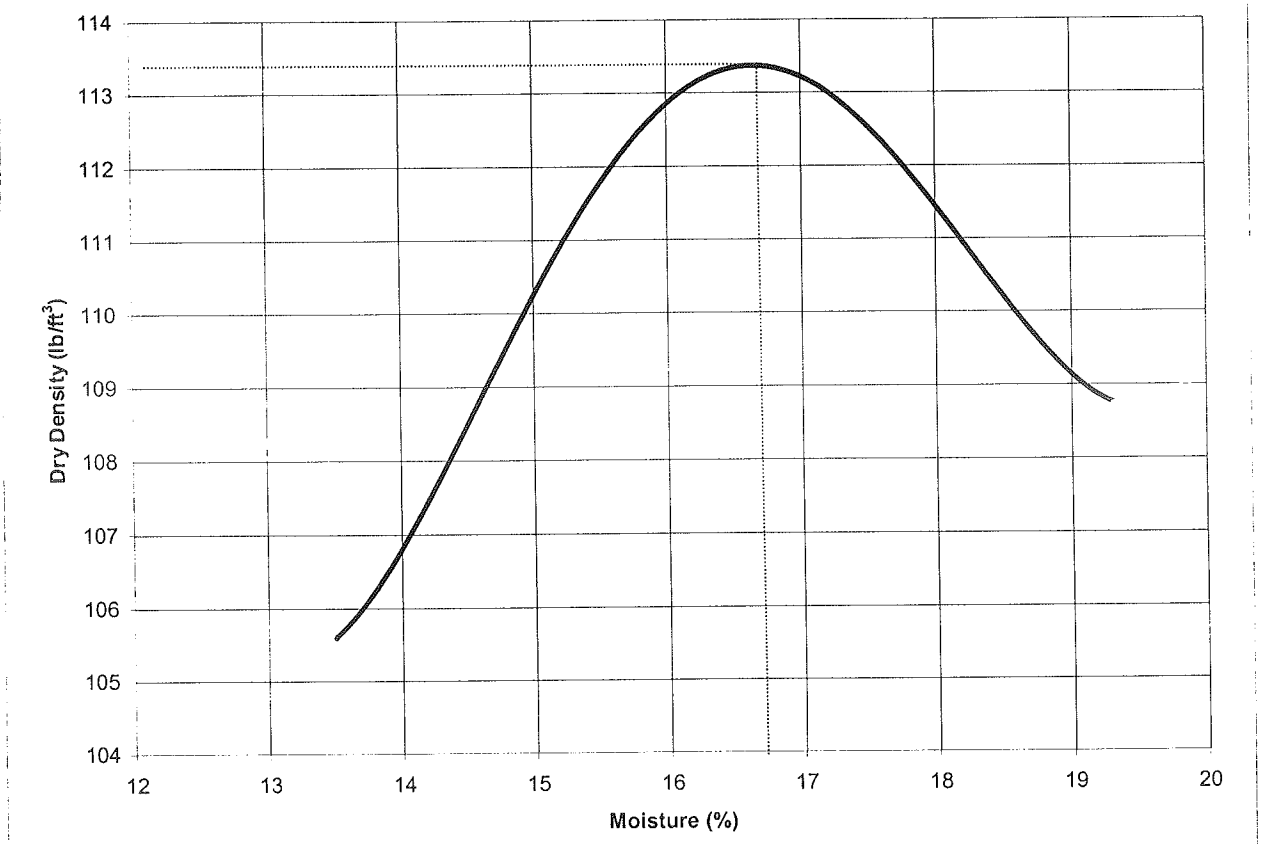
Boring No.	Sample No.	Elev or Depth	Nat w%	LL	PL	PI	Classification
RB-6	1 BS	1.0 - 5.0 ft	17.6	33	20	13	Silty Clay
1+900		(0.3 - 1.5 m)					A-6 (12)
10mRT							
"S-SR162"							

Project: US-231 Phase 3 - 02IN0005
Des. No.: 9161365 - Project #: NH-075-3()
Structure #: 231-74-844845
Spencer County, Indiana
Date: 4/02

A&W

#2

Moisture Density Relationship



Sample Location RB-6, Station 1+900, 10mRT, Line "S-SR162"

Depth 1.0 - 5.0 ft. (0.3 - 1.5m)

Sample Bag Sample - Test 02 - Silty Clay - A-6 (12)

Test Method Standard Proctor

Maximum Dry Unit Weight 113.2 (17.80 kN/m^3) (lb/ft^3)

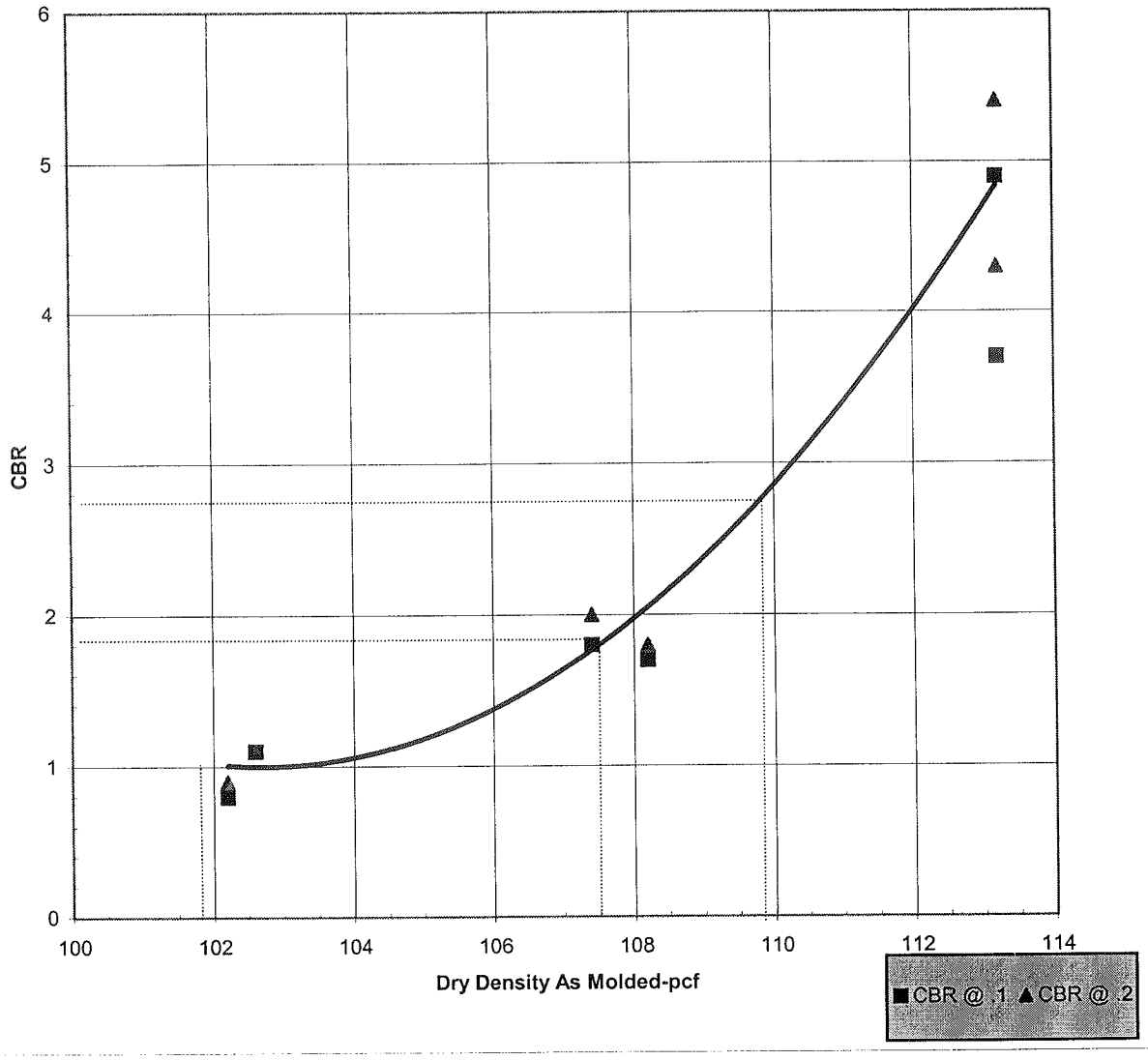
Optimum Moisture 16.8 (%)

PREPARED FOR: INDOT Indianapolis, Indiana	A&W	PREPARED BY: Alt & Witzig Engineering, Inc. Indianapolis, Indiana
PROJECT NAME: US-231 Bridge & SR-162 Reconstruction Spencer County, Indiana		PROJECT NO.: 02IN0005 / DATE: 4/02

SUMMARY OF CBR TEST RESULTS

SUMMARY OF RB-6									
Sample Number	**Dry Denisty (lb/ft^3)**	**MC (%) Molded**	**% of Maximum Dry Density**	**Blows/Layer**	**Surcharge Load (lbs)**	**MC After Soaking(%)**	**% Swell**	**CBR @ 0.1**	**CBR @ 0.2**
1	102.6	16.8	90.6	25	25	28.1	2.7	1.1	1.1
2	102.2	16.8	90.3	25	25	23.2	2.6	0.8	0.9
3	107.4	16.8	94.9	35	25	21.3	2.4	1.8	2.0
4	108.2	16.8	95.6	35	25	22.0	2.3	1.7	1.8
5	113.2	16.8	100.0	60	25	20.1	1.7	3.7	4.3
6	113.2	16.8	100.0	60	25	19.7	1.3	4.9	5.4

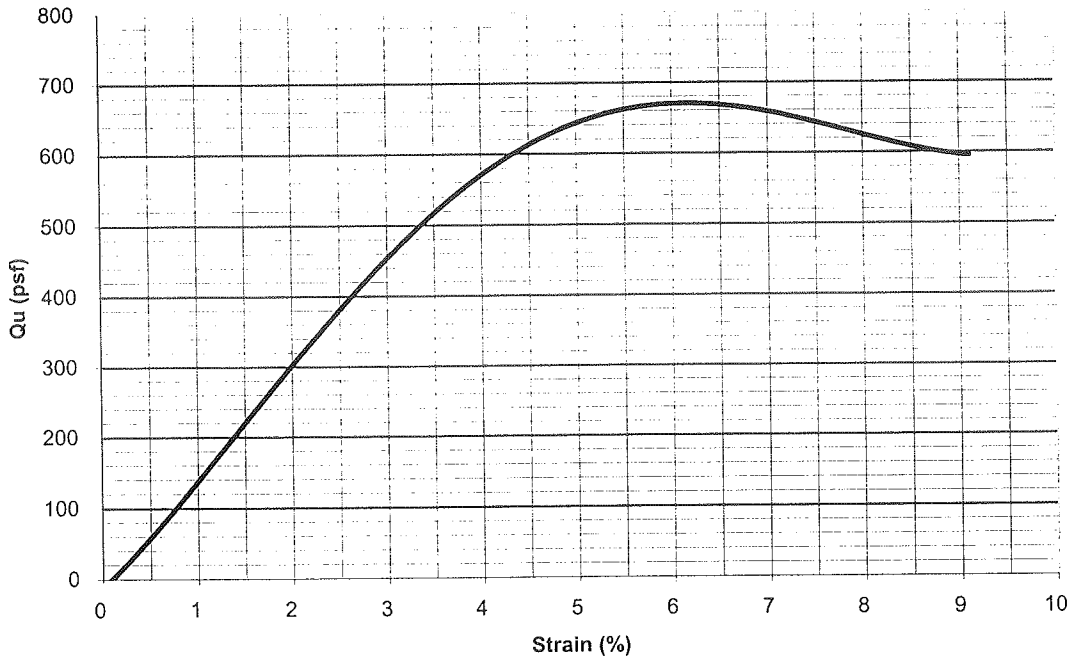
Dry Density vs CBR



Sample Location RB-6, Station 1+900, 10mRT, Line "S-SR162"
Depth 1.0 - 5.0 ft. (0.3 - 1.5m)
Material Description Bag Sample - Test 02 - Silty Clay A-6(12)
Test Method AASHTO T-99
CBR @ 93% 1.0 (101.9 pcf)
CBR @ 95% 1.8 (107.5 pcf)
CBR @ 97% 2.8 (109.8 pcf)

PREPARED FOR: INDOT Indianapolis, Indiana	A&W	PREPARED BY: Alt & Witzig Engineering, Inc. Carmel, Indiana	
PROJECT NAME: US 231 Phase 3 Proj #: NH-075 (), Des #: 9161365 Spencer County, Indiana		PROJECT NO.: 02IN0005	DATE: 4/02

Unconfined Compression Test

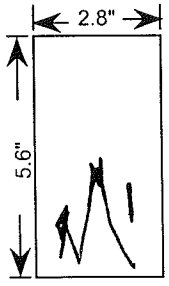


Sample Location RB-7

Depth 3.0 - 5.0 ft Moisture Content: 29.4 (%)

Strain Rate 2% min. Dry Unit Weight: 92.8 (pcf)

FAILURE SKETCH



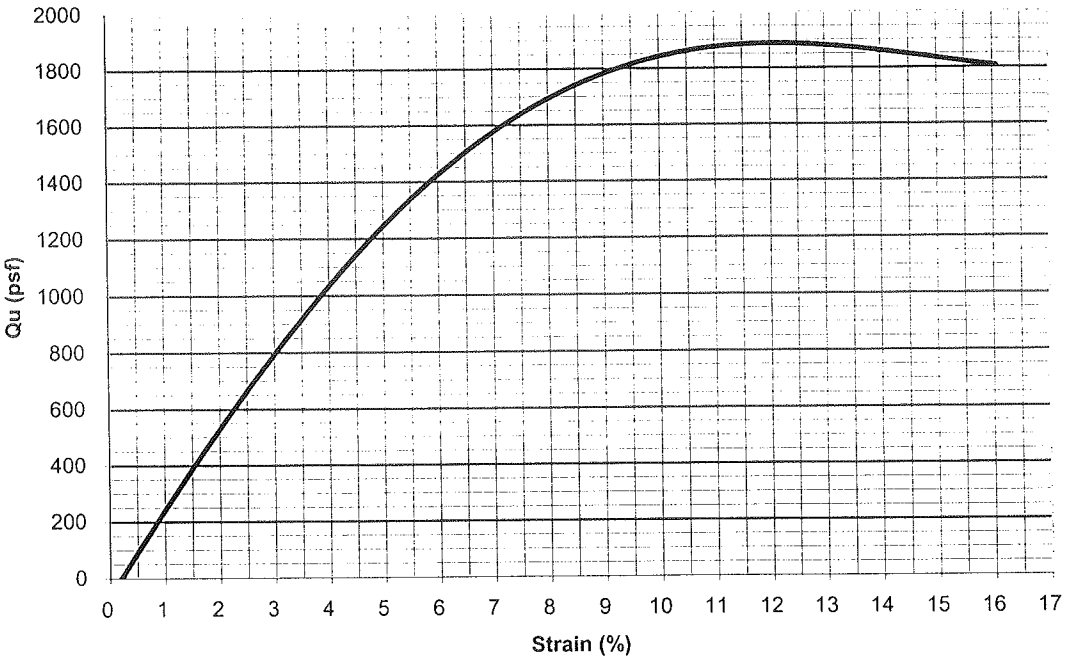
Soil Description Brown Silty Clay

Unconfined Compressive Strength (psf) 675

Failure Strain (%) 6.1

PREPARED FOR: INDOT-Geotechnical Division		PREPARED BY: Alt & Witzig Engineering, Inc. Carmel, Indiana	
PROJECT NAME: U.S. 231 Bridge & S.R. 162 Road Construction Warrick County, Indiana		PROJECT NO.: 02IN0005	DATE: 4/02

Unconfined Compression Test

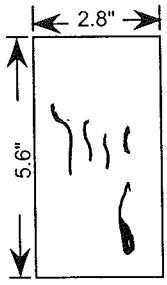


Sample Location RB-13

Depth 1.0 - 3.0 ft Moisture Content: 26.9 (%)

Strain Rate 2% min. Dry Unit Weight: 90.5 (pcf)

FAILURE SKETCH



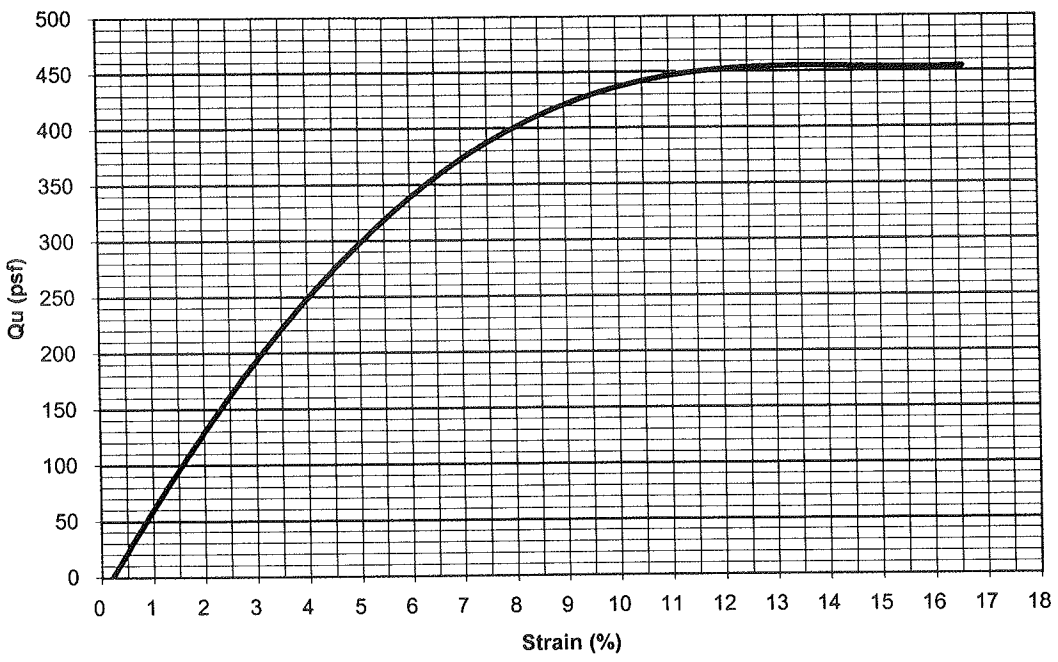
Soil Description Brown Silty Clay

Unconfined Compressive Strength (psf) 1900

Failure Strain (%) 12.0

PREPARED FOR: INDOT-Geotechnical Division		PREPARED BY: Alt & Witzig Engineering, Inc. Carmel, Indiana	
PROJECT NAME: U.S. 231 Bridge & S.R. 162 Road Construction Warrick County, Indiana		PROJECT NO.: 02IN0005	DATE: 4/02

Unconfined Compression Test

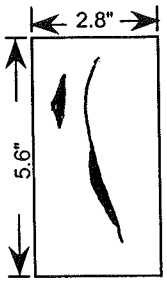


Sample Location RB-14

Depth 3.0 - 5.0 ft Moisture Content: 26.6 (%)

Strain Rate 2% min. Dry Unit Weight: 94.9 (pcf)

FAILURE SKETCH

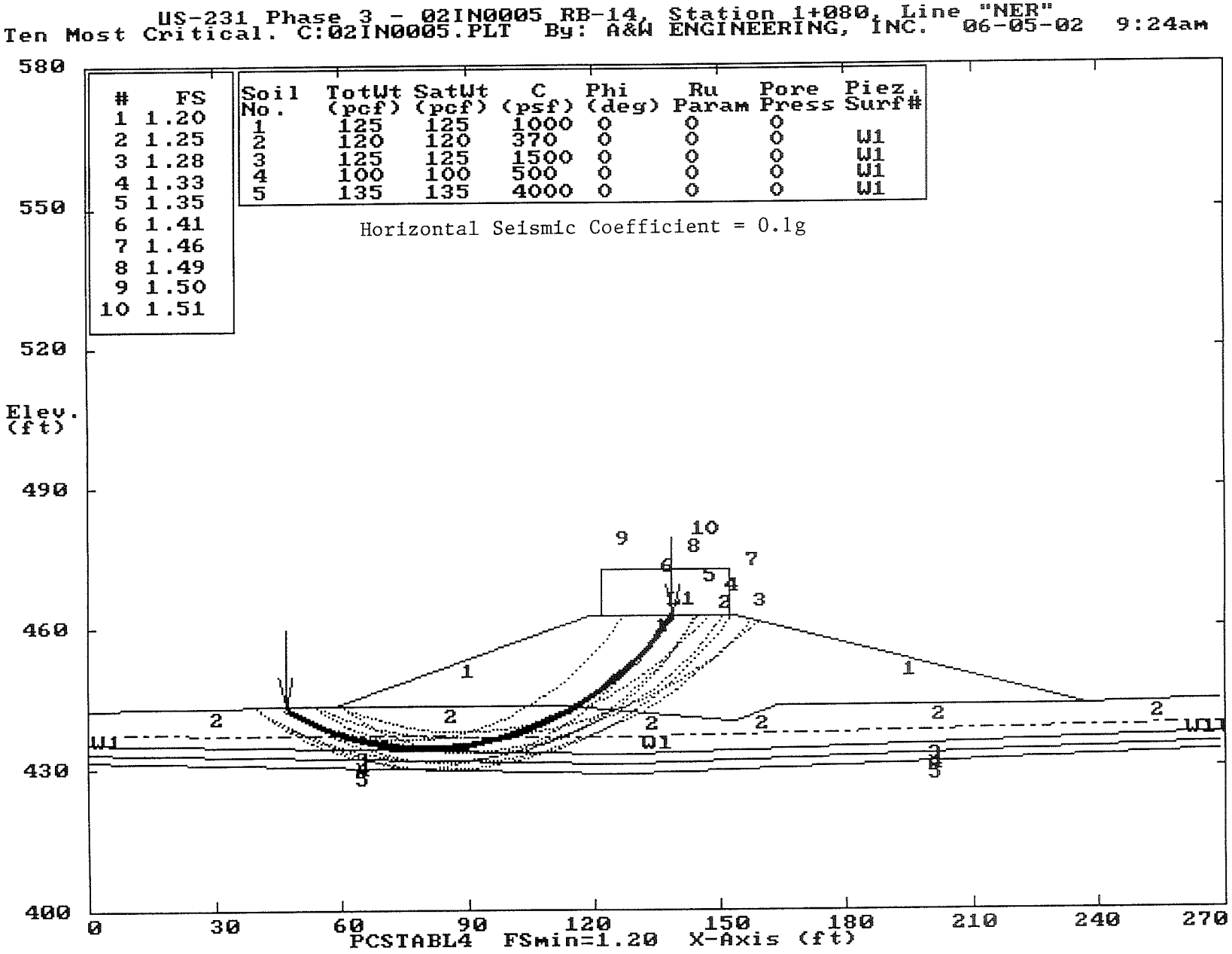


Soil Description Brown Silty Clay

Unconfined Compressive Strength (psf) 460

Failure Strain (%) 13.5

PREPARED FOR: INDOT-Geotechnical Division	A&W	PREPARED BY: Alt & Witzig Engineering, Inc. Carmel, Indiana	
PROJECT NAME: U.S. 231 Bridge & S.R. 162 Road Construction Warrick County, Indiana		PROJECT NO.: 02IN0005	DATE: 4/02



Slope Stability Analysis at Station 1+080, Line "NER" utilizing RB-14

Magnitude of Settlement

@ RB-7

Assume: Stress Distribution Negligible

$P_o = 120.3\ pcf\ (4.4ft) = 529.3\ psf = .26\ tsf$
$\Delta P = 125\ pcf\ (20ft) = 2500\ psf = 1.25\ tsf$
$P_c = .21\ tsf$ from Consolidation Graph

$OCR = \frac{.26}{.21} = 1.2 \Rightarrow$ Say N.C. $\Rightarrow$

$$S = \frac{C_c H}{1+e_o} \log \frac{P_o + \Delta P}{P_o} = \frac{.139(8.8 \times 12)}{1+.79} \log \frac{.26+1.25}{.26} = \underline{6.3"}$$

@ RB-14

Assume: Ignore Clay Loam Layer

$P_o = 120.6\ pcf\ (3.5ft) = 422.1\ psf = .21\ tsf$

$\Delta p = 125\ pcf\ (23.5ft) = 2937.5\ psf = 1.47\ tsf$

$P_c = .21\ tsf$ from Consolidation Graph

$OCR = \frac{.21}{.21} = 1$ so N.C.

$$S = \frac{C_c H}{1+e_o} \log \frac{P_o + \Delta P}{P_o} = \frac{.139(6.9 \times 12)}{1+.79} \log \frac{.21+1.47}{.21} = \underline{5.8"}$$

Time Rate of Settlement

@ RB-7

Stress = 1.25
Stress Range = 1.0 to 2.0 tsf
Range of C_v = .00034 in^2/s to .00067 in^2/s
C_v Used = .00042 in^2/s

Assume: 1) 1-Way Drainage
2) Homogeneous Conditions
3) Time of Consolidation (t) = $\frac{T H^2}{C_v}$ where $T_{90} = 0.848$, $T_{50} = 0.197$

Time for 90% of Settlement:

$T_{90} = 0.848$
$H = 8.8\,ft$
$C_v = .00042\ in^2/s$

$$t_{90} = \frac{0.848(8.8 \times 12)^2}{.00042\ in^2/s} = 22515127\ sec. \left(\frac{1\ hr}{3600\ s}\right)\left(\frac{1\ day}{24\ hr}\right)$$

$$\approx \underline{261\ days}$$

For 50% of Settlement:

$$t_{50} = \frac{.197(8.8 \times 12)^2}{.00042\ in^2/s} = 5230518s \left(\frac{1}{3600}\right)\left(\frac{1}{24}\right)$$

$$\approx 61\ days$$

@ RB-14

Assume: 1) 1-Way Drainage
2) Homogeneous Conditions
3) $(t) = \frac{TH^2}{C_v}$ where $T_{90} = .848$, $T_{50} = .197$

Stress = 1.47 tsf
C_v Used: .00050 in^2/s
$H = 6.9\,ft$

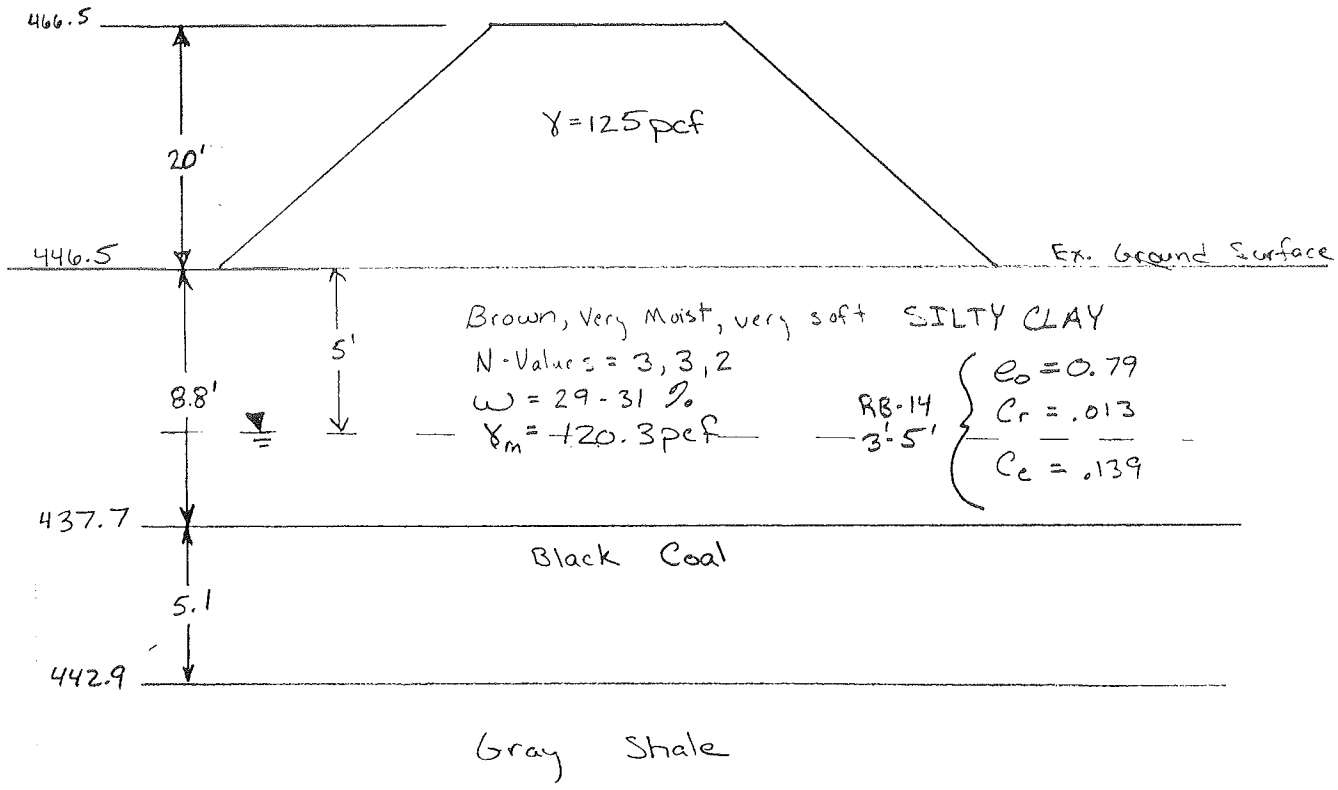
Time for 90% of Settlement:

$$t_{90} = \frac{.848(6.9 \times 12)^2}{.00050\ in^2/s} = 11627505s \left(\frac{1}{3600s}\right)\left(\frac{1}{24}\right) = \underline{135\ days}$$

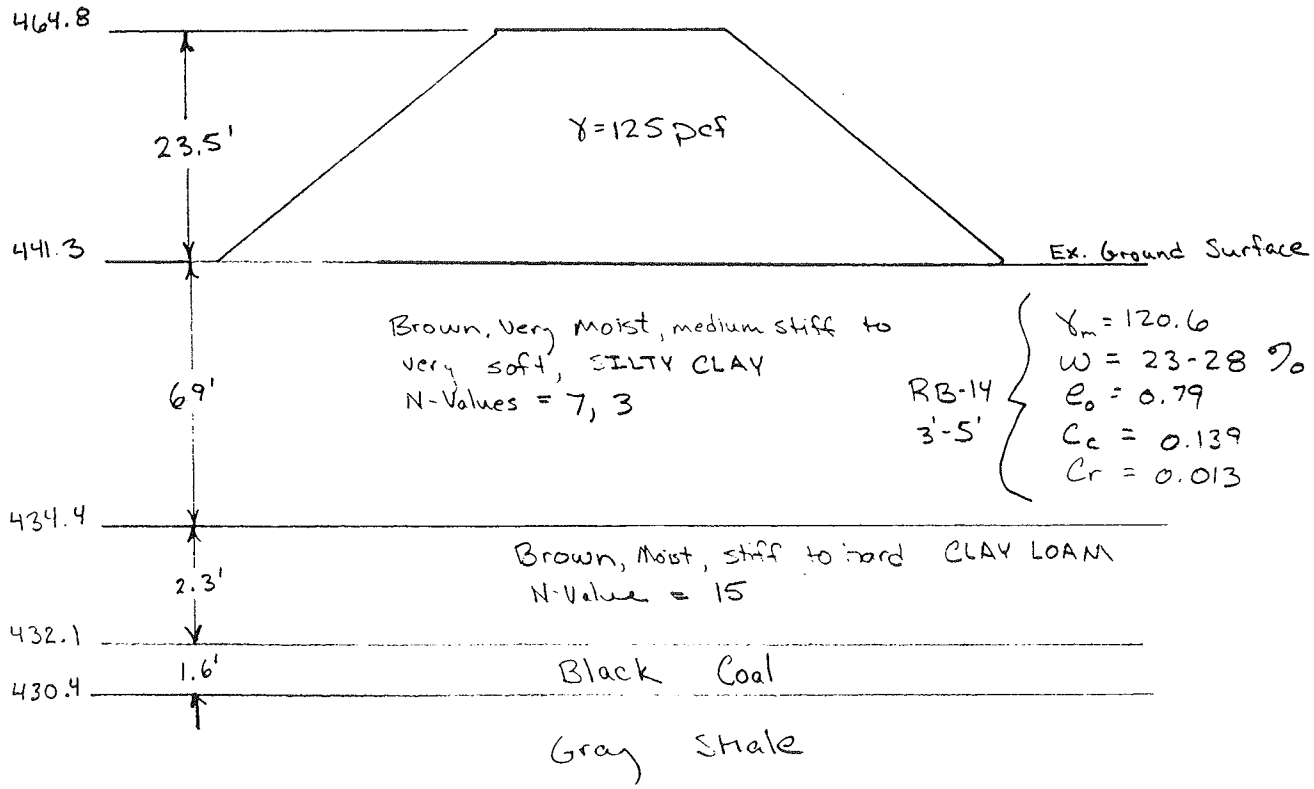
$$t_{50} = \frac{.197(6.9 \times 12)^2}{.00050\ in^2/s} = 2701201s \left(\frac{1}{3600}\right)\left(\frac{1}{24}\right) = \underline{31\ days}$$

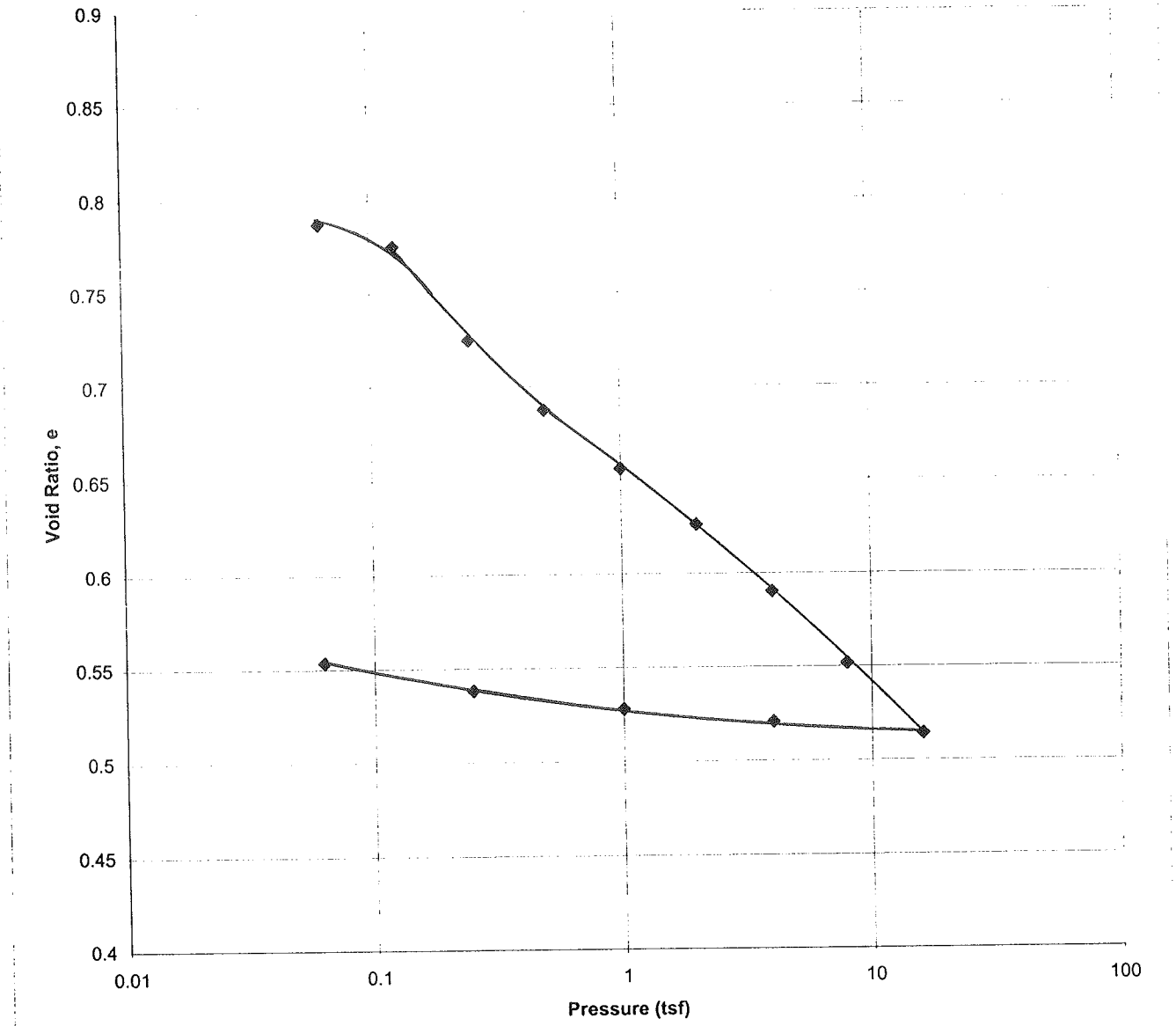
Settlement Analysis Cross Section

Station 1+000, RB-7, Line "NWR"



Station 1+080, RB-14, Line "NER"





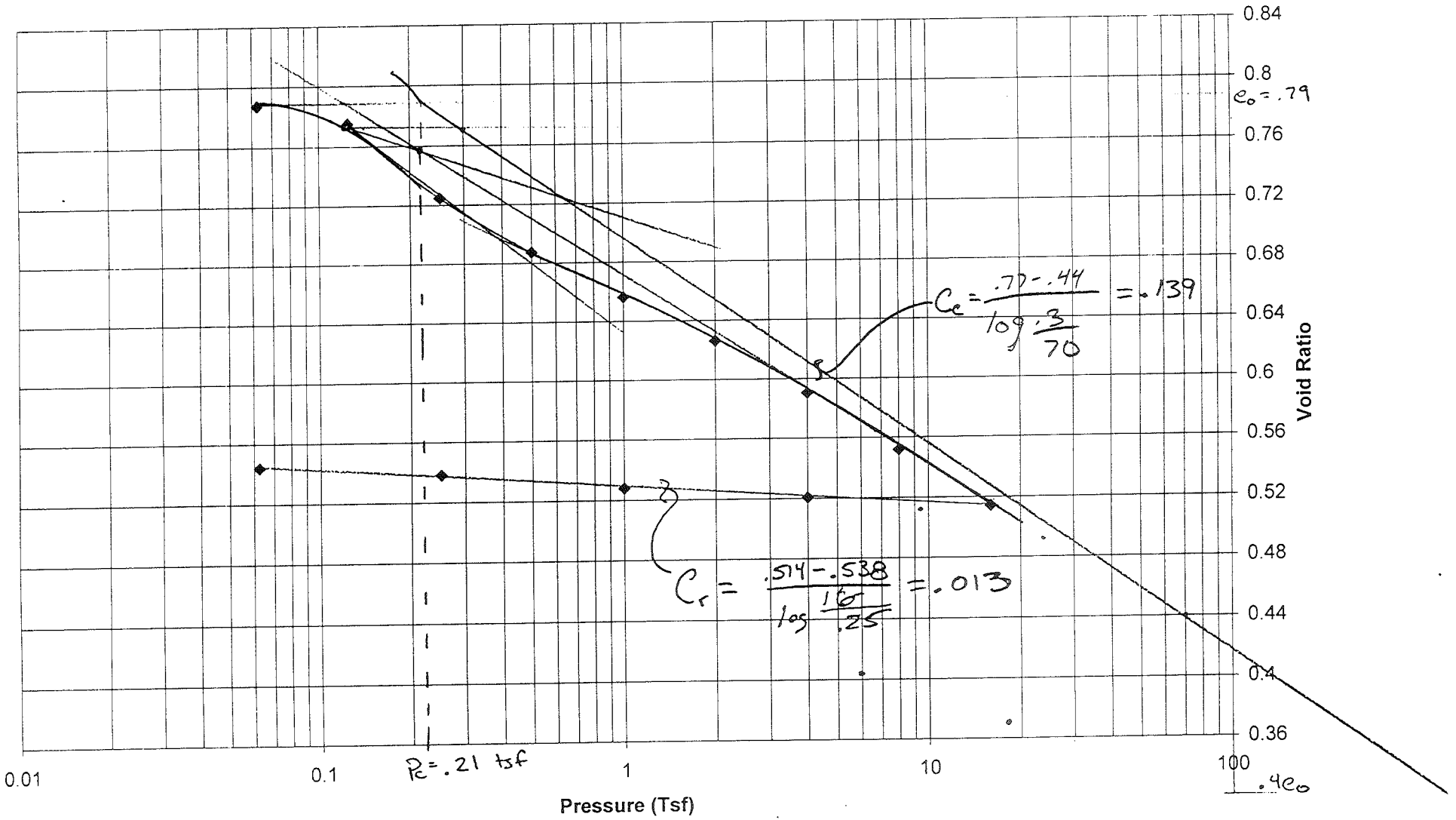
Moisture Content (%):	Initial 27.5	Final 20.5	Cc (lab):	0.128
Saturation (%):	Initial 91.2	Final 100.0	Cc (field):	0.139
Dry Density(pcf):	Initial 92.3	Final 106.0	Cr:	.013
Void Ratio:	Initial 0.79	Final 0.54		

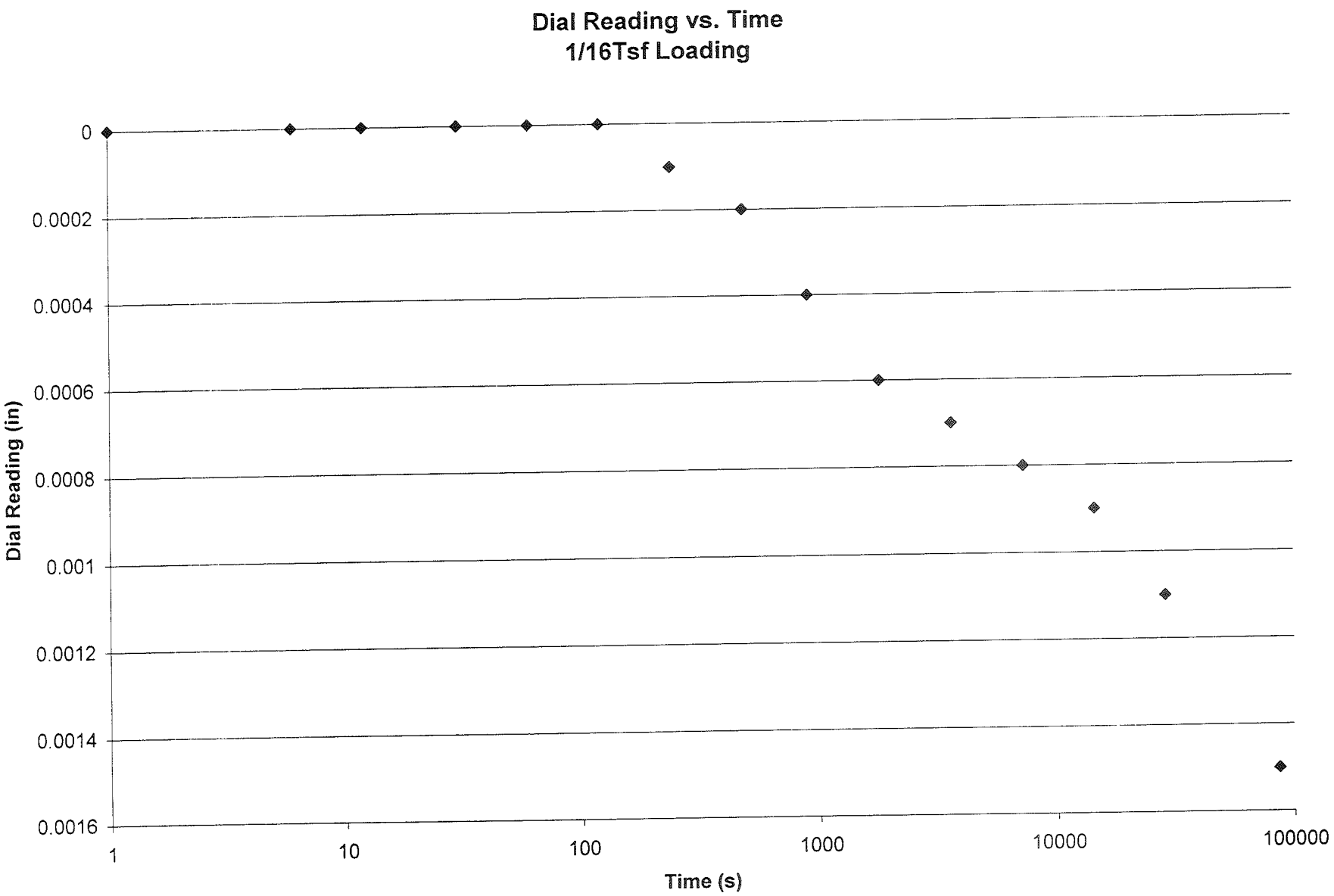
Gs: 2.62 Pc: 0.21 tsf Overburden: 0.21 tsf

Boring: RB-14 Depth: 3.0-5.0ft. Station: 1+080 Offset: CL Line: "NER"

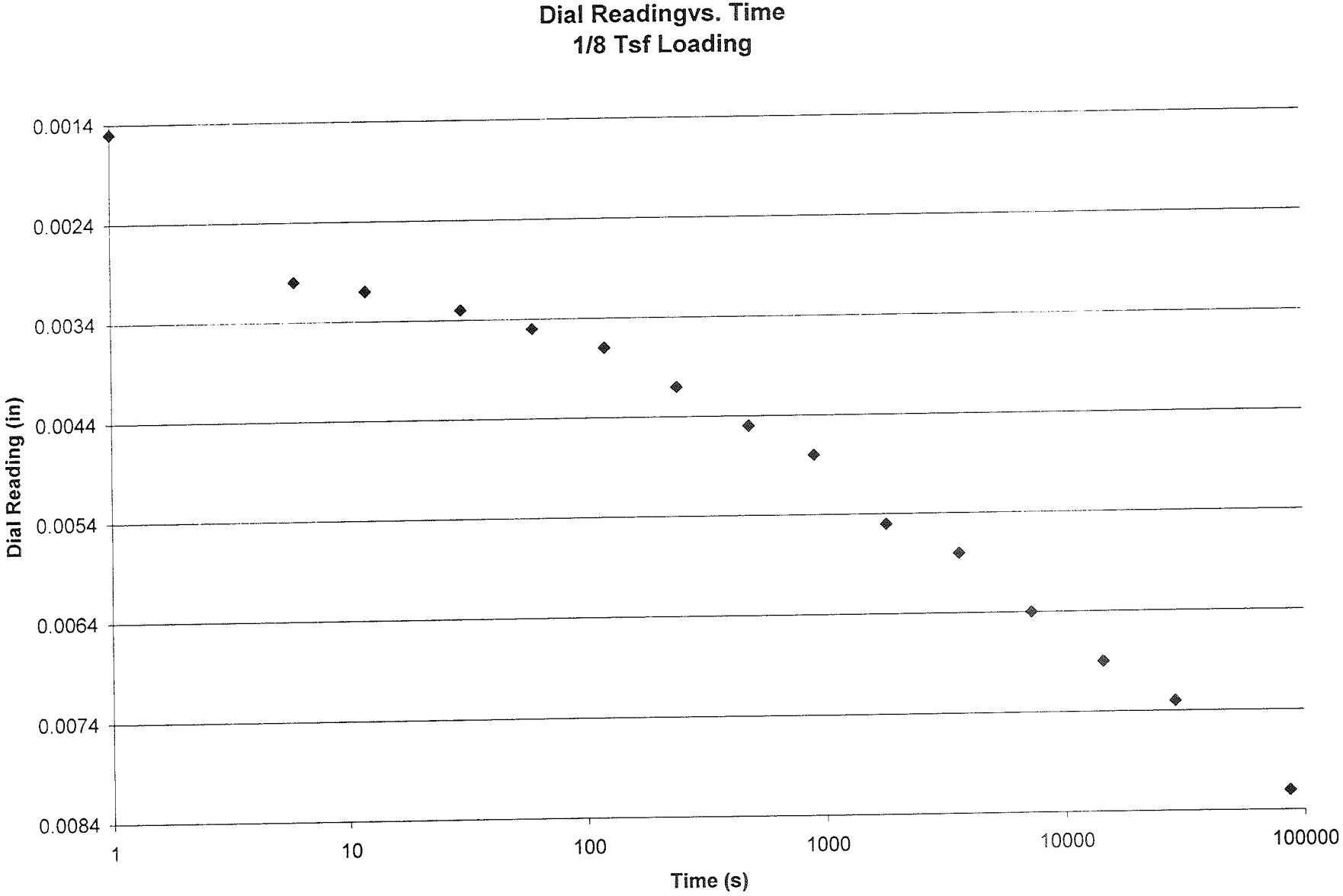
PREPARED FOR: INDOT Materials and Testing Division		PREPARED BY: Alt & Witzig Engineering, Inc. Indianapolis, Indiana	
PROJECT NAME: US-231 Phase 3 Spencer County, IN	A W	PROJECT NO.: 02IN0005	DATE: 5/02

Void Ratio vs. Pressure

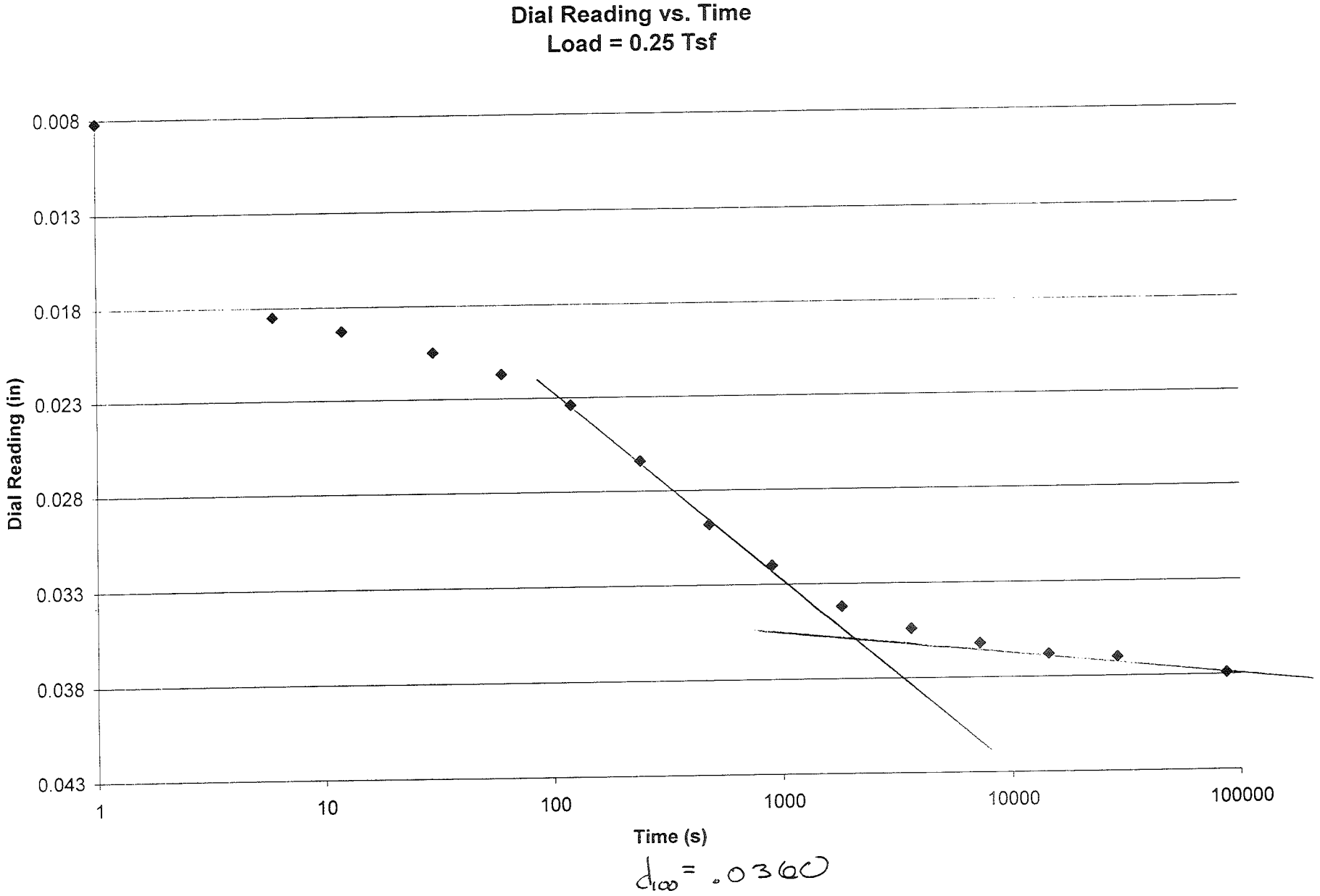



Dial Reading vs. Time
1/16Tsf Loading
Dial Reading (in)
0
0.0002
0.0004
0.0006
0.0008
0.001
0.0012
0.0014
0.0016
1
10
100
1000
10000
100000
Time (s)

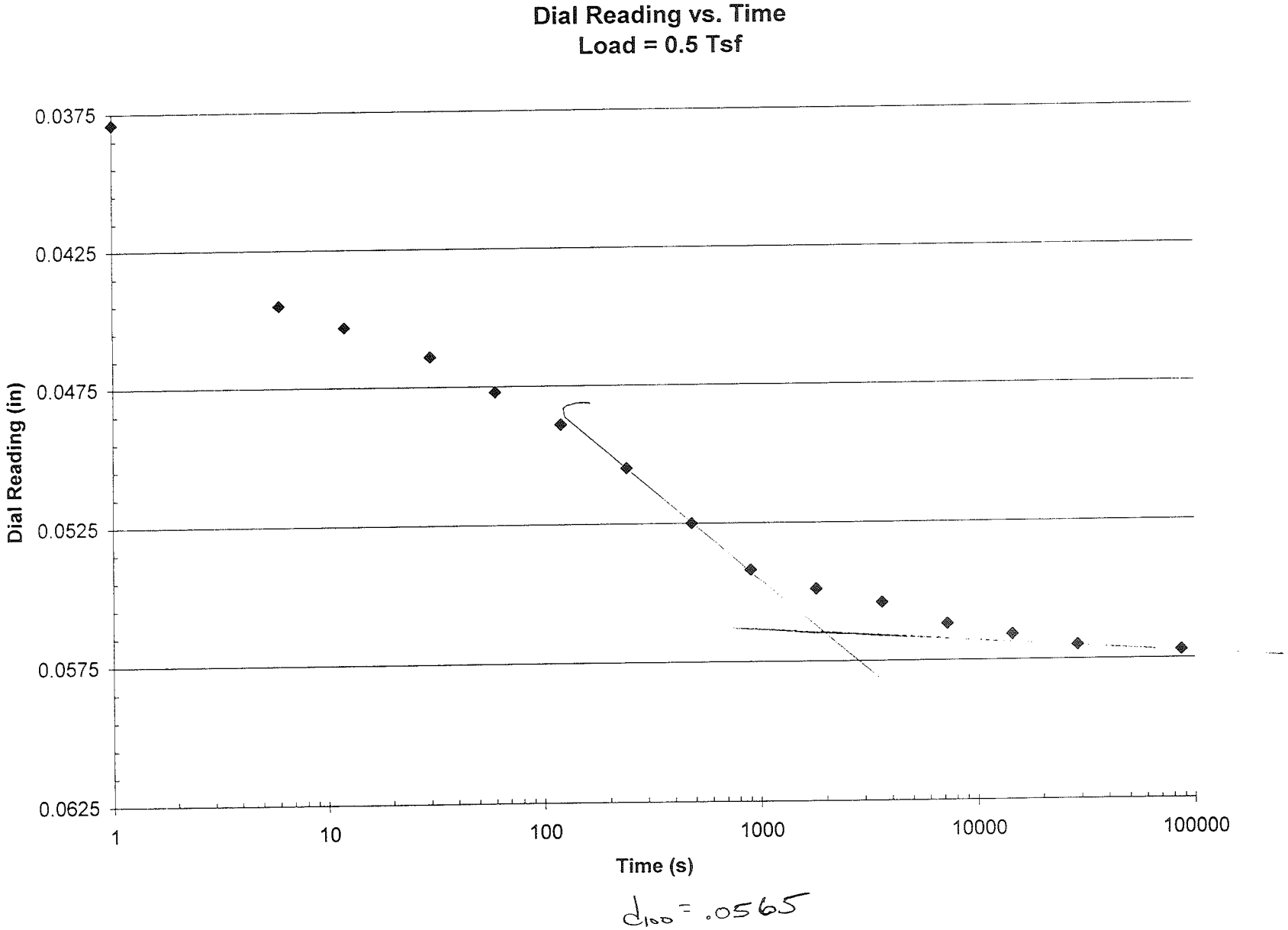
$d_{100} = .0015$


Dial Readingvs. Time
1/8 Tsf Loading
Dial Reading (in)
0.0014
0.0024
0.0034
0.0044
0.0054
0.0064
0.0074
0.0084
1
10
100
1000
10000
100000
Time (s)

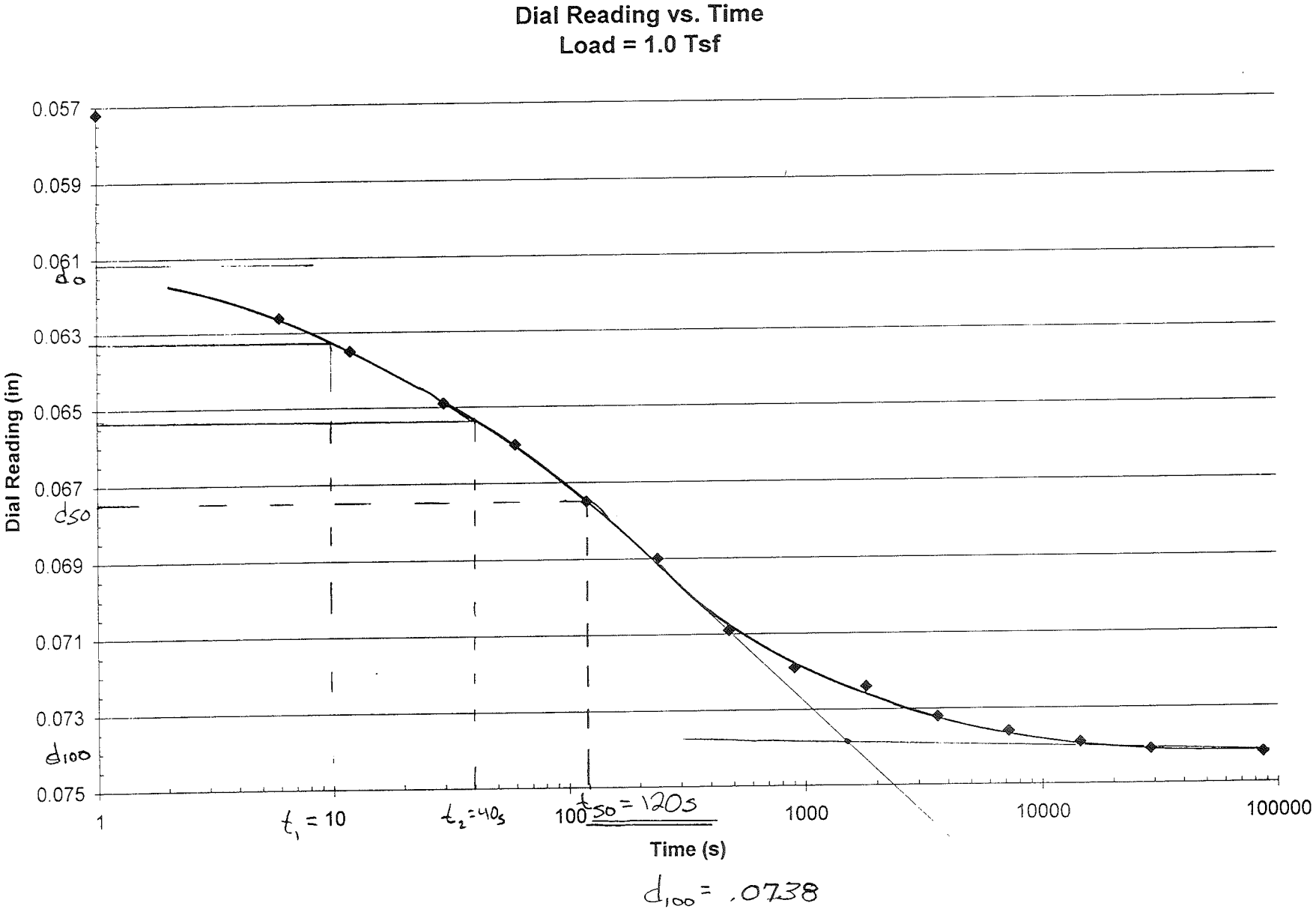
$d_{100} = .0082$


Dial Reading vs. Time
Load = 0.25 Tsf
Dial Reading (in)
0.008
0.013
0.018
0.023
0.028
0.033
0.038
0.043
1
10
100
1000
10000
100000
Time (s)

$d_{100} = .0360$

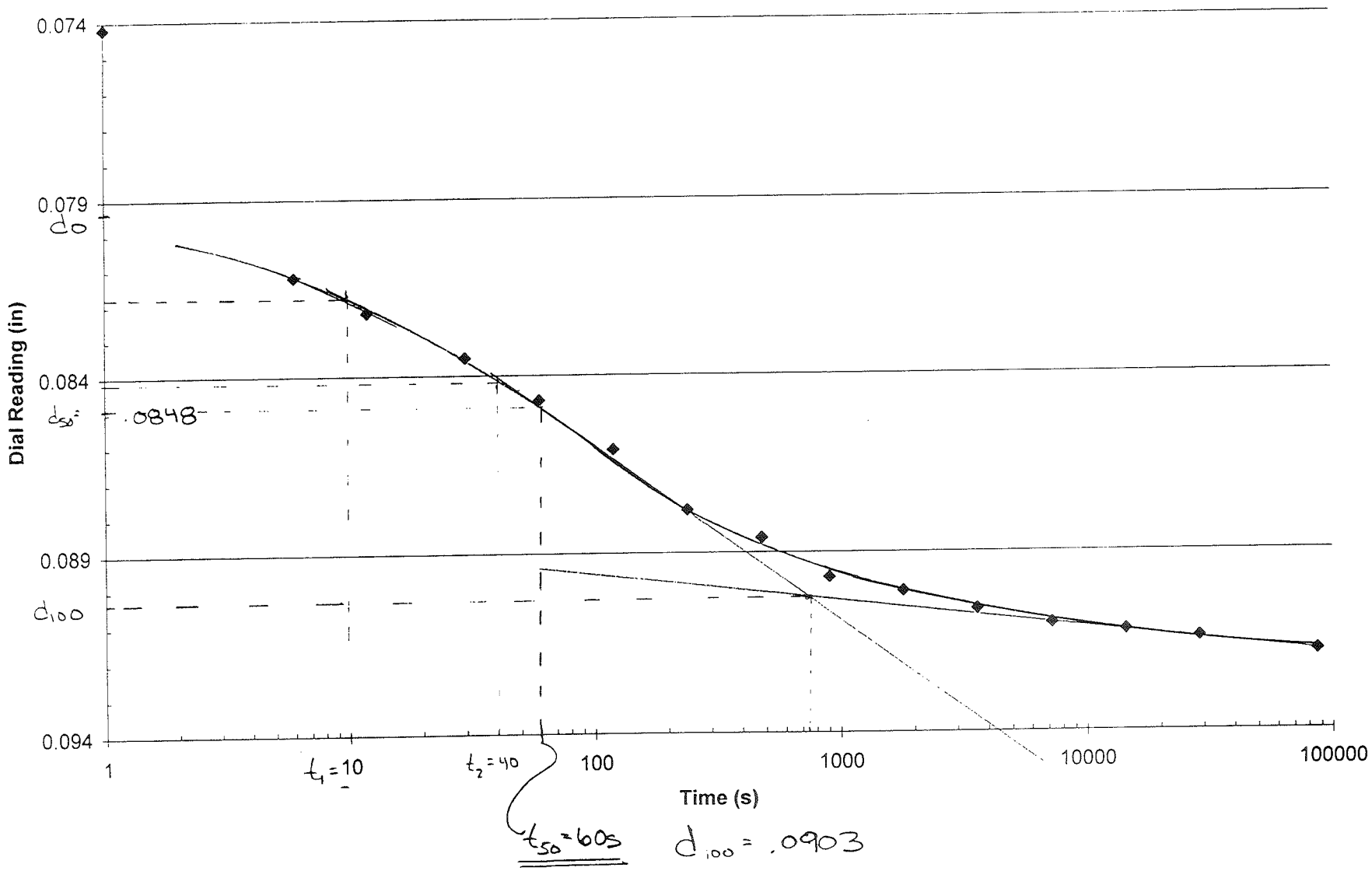

Dial Reading vs. Time
Load = 0.5 Tsf
0.0375
0.0425
0.0475
0.0525
0.0575
0.0625
Dial Reading (in)
1
10
100
1000
10000
100000
Time (s)

$d_{100} = .0565$

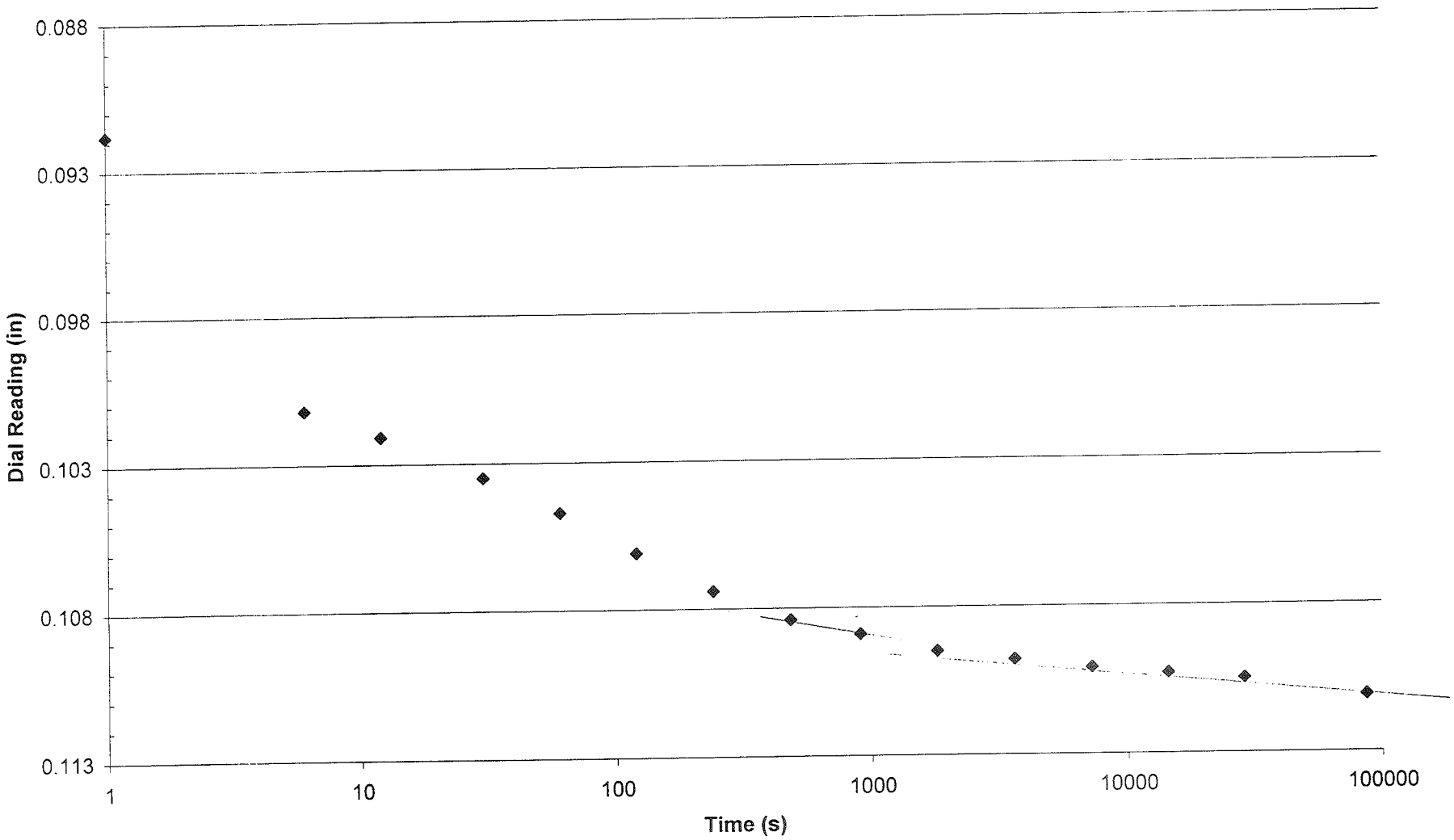

Dial Reading vs. Time
Load = 1.0 Tsf
Dial Reading (in)
0.057
0.059
0.061
0.063
0.065
0.067
0.069
0.071
0.073
0.075
d0
d50
d100
1
t1 = 10
t2 = 40s
100
t50 = 120s
1000
10000
100000
Time (s)

$d_{100} = .0738$

Dial Reading vs. Time
Load = 2.0 Tsf

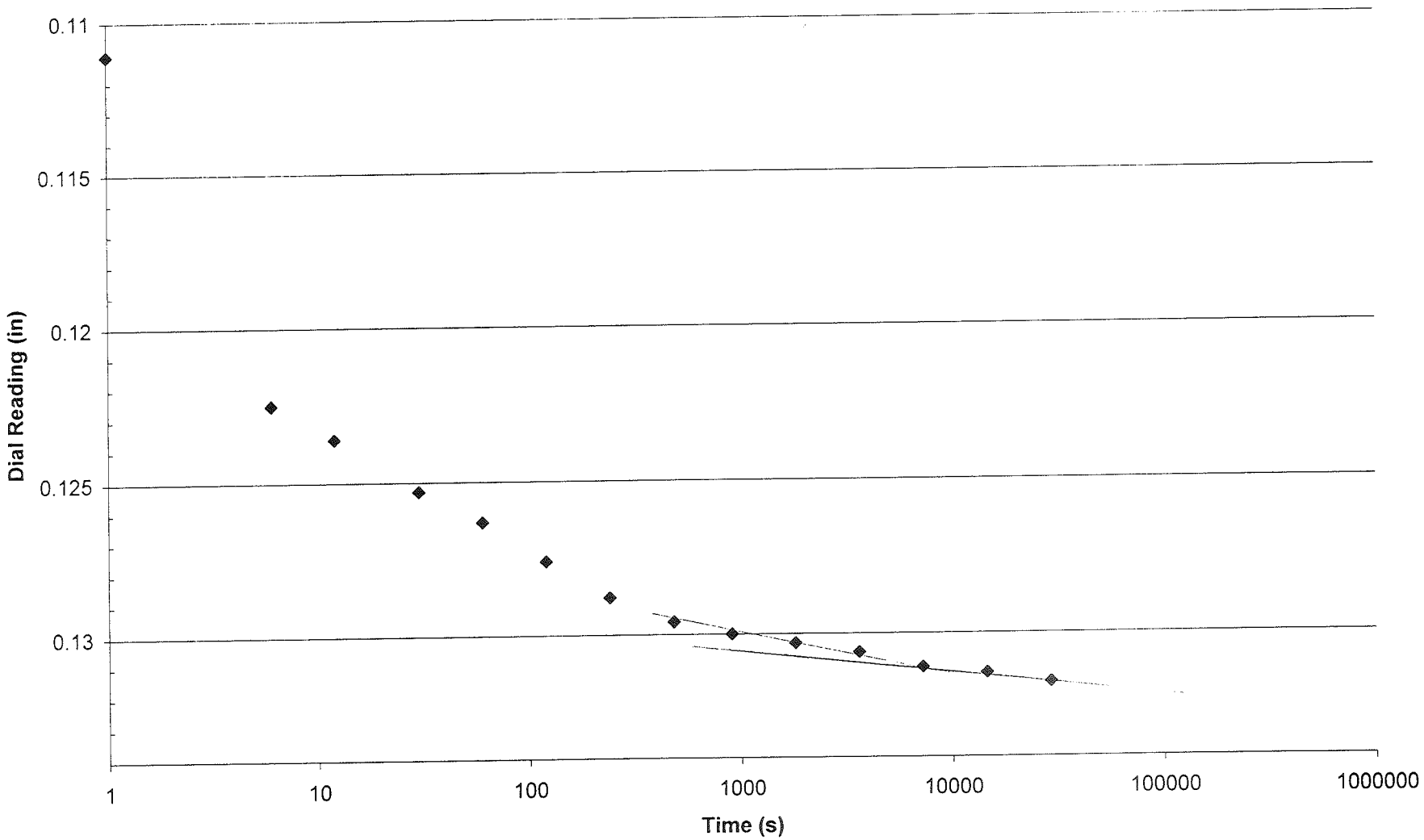


Dial Reading vs. Time
Load = 4.0 Tsf



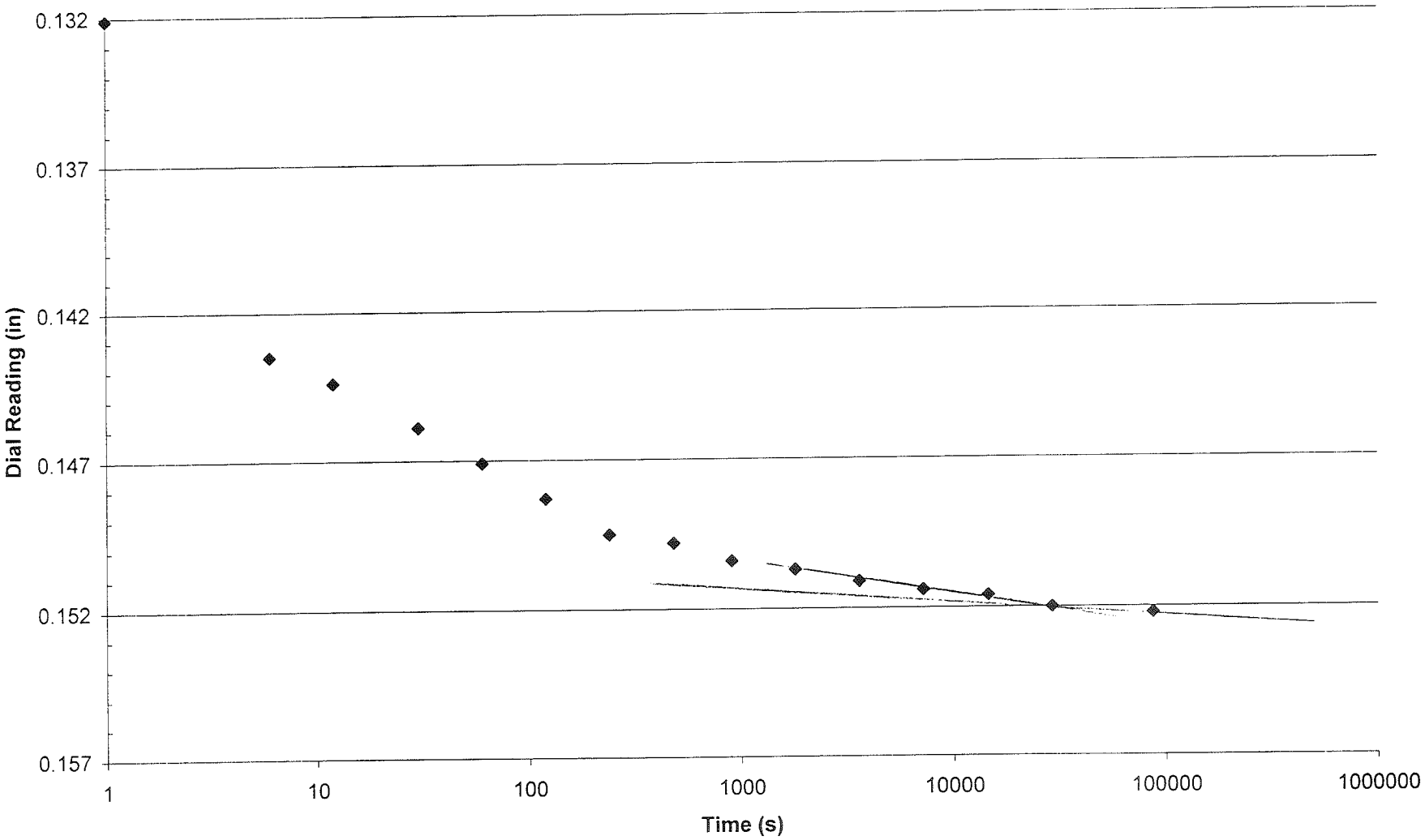
$D_{100} = .1100$

Dial Reading vs. Time
Load = 8.0 Tsf



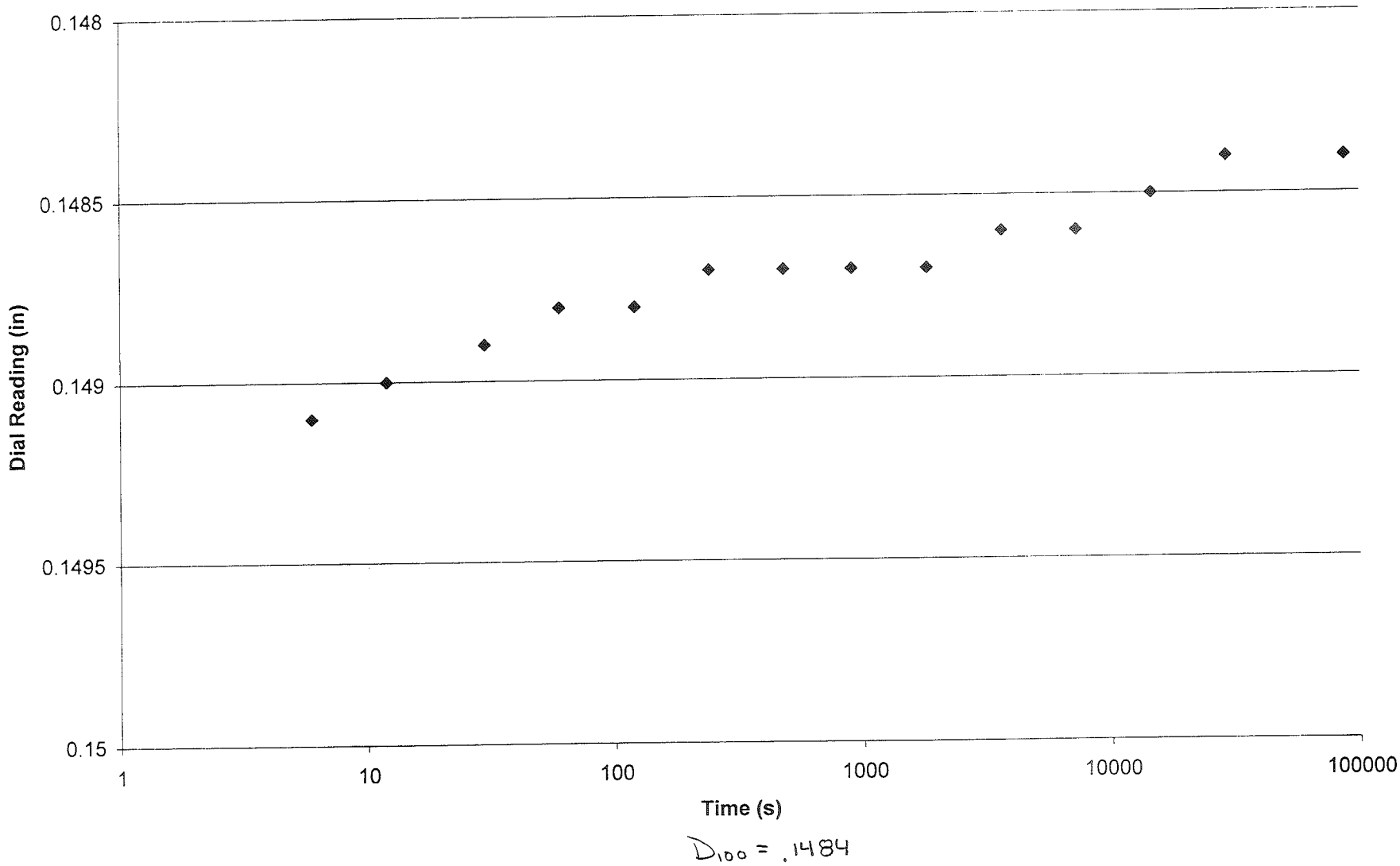
$D_{100} = .1313$

Dial Reading vs. Time
16 Tsf Loading

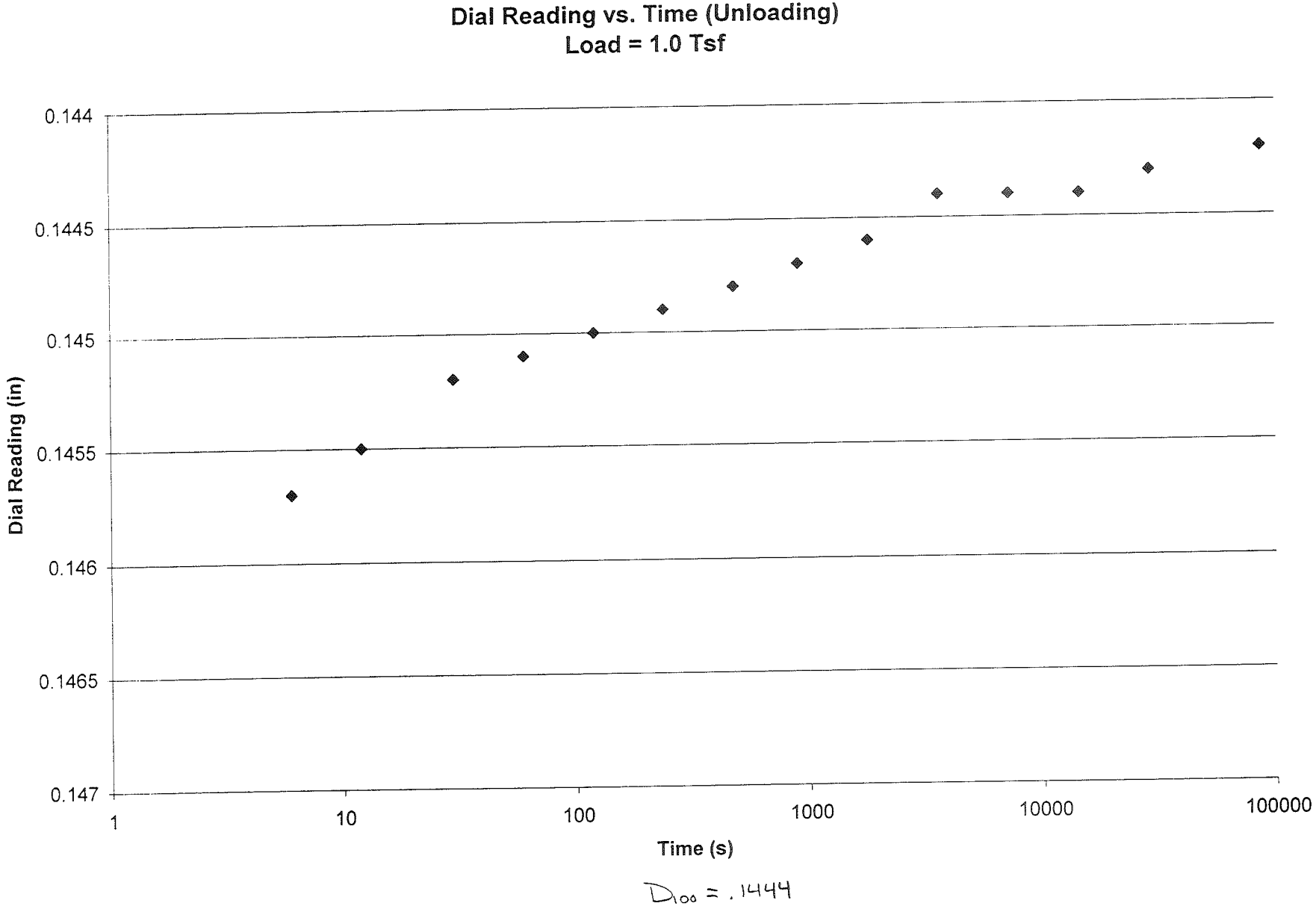


$D_{100} = .1520$

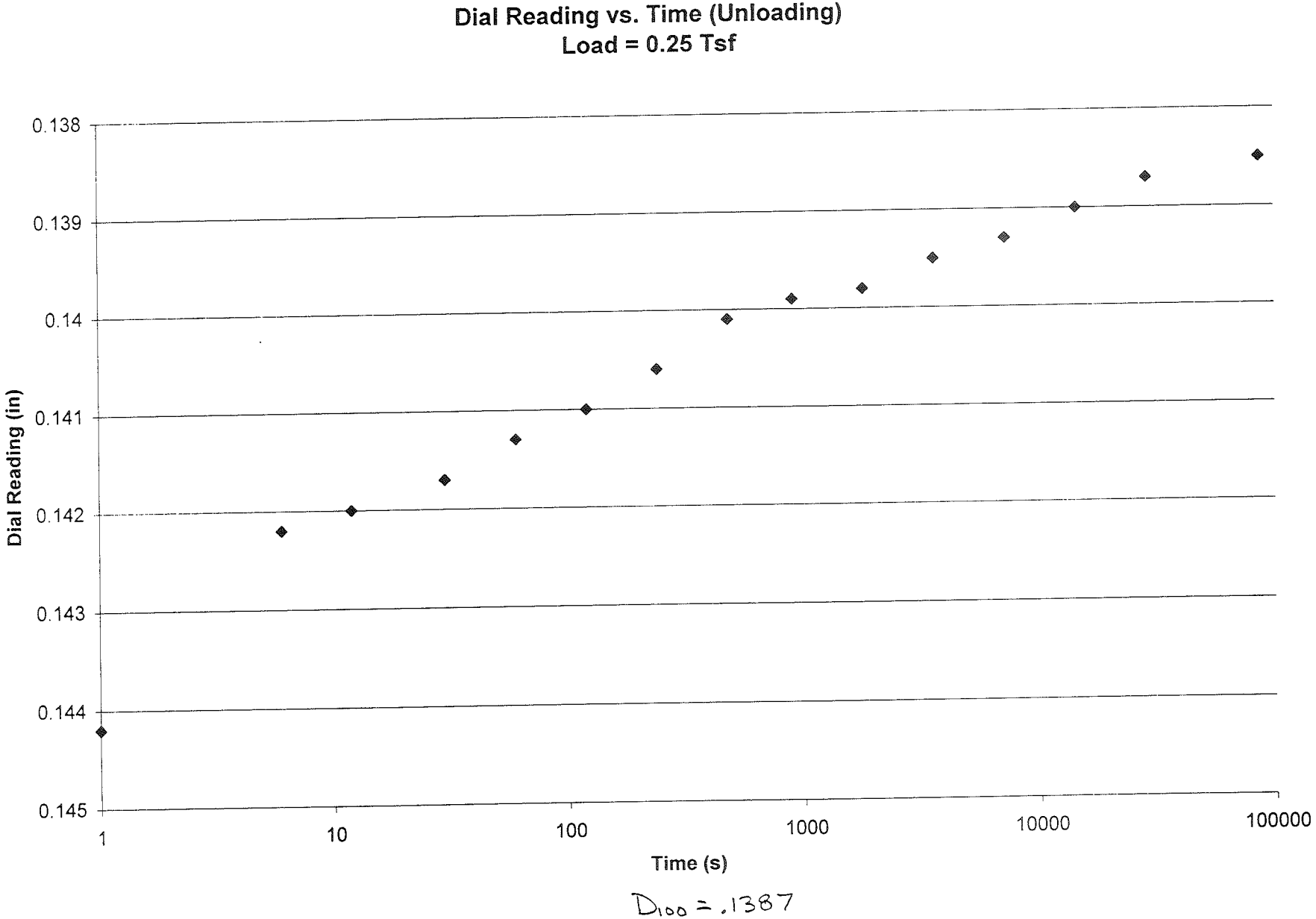
Dial Reading vs. Time
4.0 Tsf Unloading



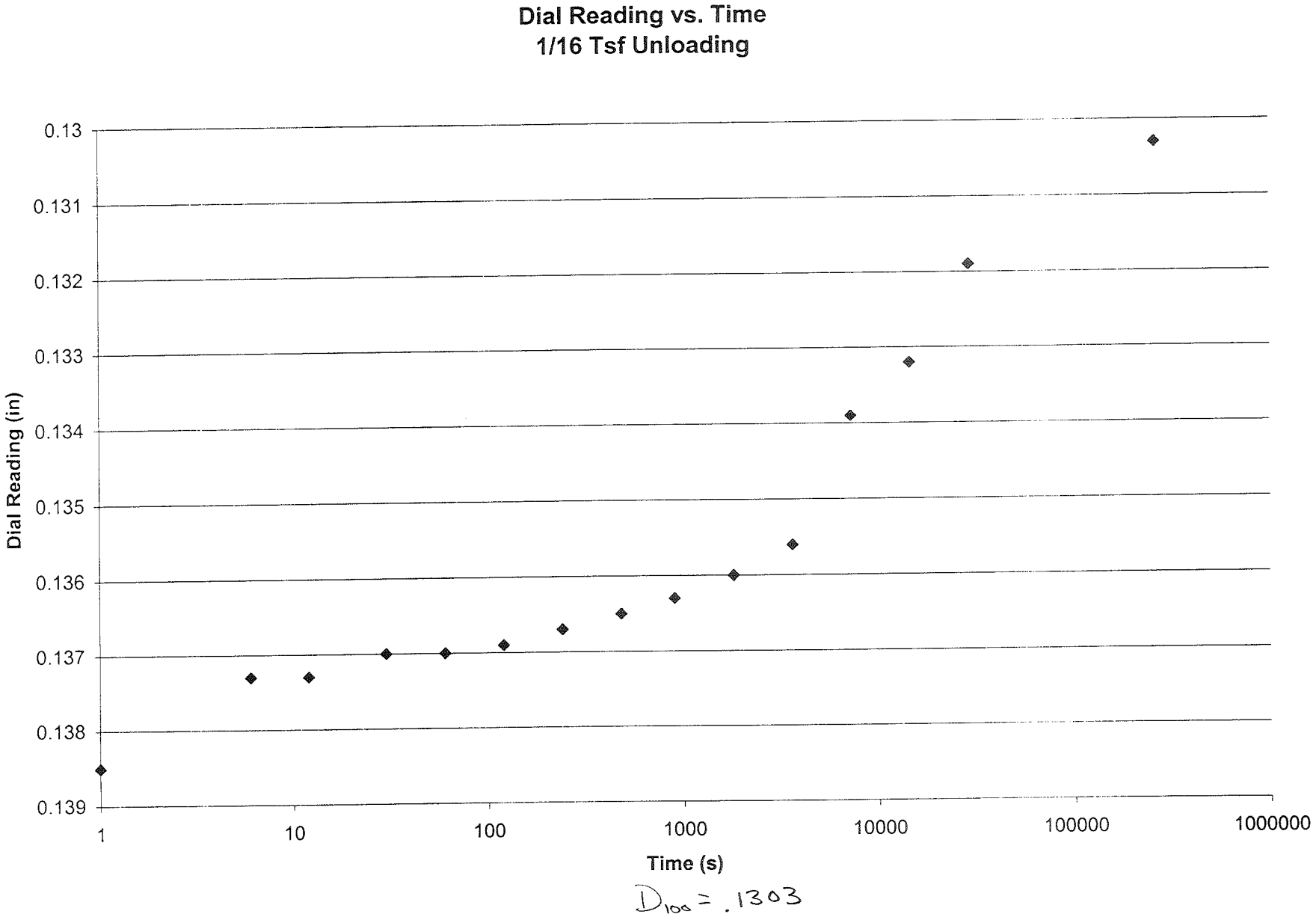
$D_{100} = .1484$


Dial Reading vs. Time (Unloading)
Load = 1.0 Tsf
0.144
0.1445
0.145
0.1455
0.146
0.1465
0.147
Dial Reading (in)
1
10
100
1000
10000
100000
Time (s)

$D_{100} = .1444$


Dial Reading vs. Time (Unloading)
Load = 0.25 Tsf
Dial Reading (in)
0.138
0.139
0.14
0.141
0.142
0.143
0.144
0.145
1
10
100
1000
10000
100000
Time (s)

$D_{100} = .1387$


Dial Reading vs. Time
1/16 Tsf Unloading
Dial Reading (in)
0.13
0.131
0.132
0.133
0.134
0.135
0.136
0.137
0.138
0.139
1
10
100
1000
10000
100000
1000000
Time (s)

$D_{100} = .1303$

MOISTURE CONTENT SUMMARY
U.S. 231 BRIDGE & S.R. 162 ROAD INVESTIGATION
02IN0005

Boring	*Sample*	*Depth (ft)*	*Depth (m)*	*Moisture (%)*
RB-1	1SS	1.0-2.5	1.3-0.8	10.9
RB-1	2SS	3.5-5.0	1.1-1.5	19.3
RB-2	2SS	3.5-5.0	1.1-1.5	17.4
RB-3	2SS	3.5-5.0	1.1-1.5	18.1
RB-4	1SS	1.0-2.5	0.3-0.8	21.8
RB-4	2SS	3.5-5.0	1.1-1.5	15.7
RB-5	1SS	1.0-2.5	0.3-0.8	18.5
RB-5	2SS	3.5-5.0	1.1-1.5	18.2
RB-5	4SS	8.5-10.0	2.6-3.0	18.2
RB-6	1 SS	1.0-2.5	0.3-0.8	17.9
RB-6	2SS	3.5-5.0	1.1-1.5	17.4
RB-7	1SS	1.0-2.5	0.3-0.8	30.6
RB-7	2SS	3.5-5.0	1.1-1.5	29.5
RB-7	3SS	6.0-7.5	1.8-2.3	29.5
RB-8	1SS	1.0-2.5	0.3-0.8	30.4
RB-8	2SS	3.5-5.0	1.1-1.5	28.5
RB-9	1SS	1.0-2.5	0.3-0.8	29.2
RB-9	2SS	3.5-5.0	1.1-1.5	18.2
RB-9	6SS	17.0-18.5	5.2-6.0	42.5
RB-13	1SS	1.0-2.5	0.3-0.8	24.9
RB-13	2SS	3.5-5.0	1.1-1.5	24.9
RB-14	1SS	1.0-2.5	0.3-0.8	27.5
RB-14	2SS	3.5-5.0	1.1-1.5	27.1
RB-14	4SS	8.5-10.0	2.6-3.0	23.4
RB-15	1SS	1.0-2.5	0.3-0.8	19.1
RB-15	2SS	3.5-5.0	1.1-1.5	22.0
RB-15	4SS	8.5-10.0	2.6-3.0	23.4
TB-4	1SS	1.0-2.5	0.3-0.8	26.0
TB-4	3SS	6.0-7.5	1.8-2.3	14.4

MOISTURE CONTENT SUMMARY
U.S. 231 BRIDGE & S.R. 162 ROAD INVESTIGATION
02IN0005

Boring	*Sample*	*Depth (ft)*	*Depth (m)*	*Moisture (%)*
RB-15	2SS	3.5-5.0	1.1-1.5	22.0
RB-15	4SS	8.5-10.0	2.6-3.0	23.4

PH SUMMARY
US-231 Phase 3

Boring	*Sample*	*Depth (ft)*	*Depth (m)*	*pH*
TB-6	1 SS	1.0 – 2.5	0.3 – 0.8	6.7
RB-6	1 BS	1.0 - 5.0	0.3 – 1.5	6.1

Photograph # 1	Description: Looking at pond from west to east.	
Project #:02IN0005	Project Name: US-231 Phase 3	Date: 4/02

GENERAL NOTES

SAMPLE IDENTIFICATION

The AASHTO T-88 Soil Classification System is used to identify the soils unless otherwise noted.

SOIL PROPERTY SYMBOLS

N: Standard "N" penetration: Blows per foot of a 140-pound hammer falling 30 inches on a 2 inch O.D. split-spoon

Qu: Unconfined Compressive Strength, TSF

γ: Natural Dry Density, PCF

Mc: Water content, %

LL: Liquid Limit, %

PL: Plastic Limit, %

PI: Plasticity Index, %

: Apparent groundwater level at time noted while drilling

: Apparent groundwater level at time noted upon completion of drilling

: Apparent groundwater level at time noted 24 hours after completion of drilling

DRILLING AND SAMPLING SYMBOLS

SS: Split-spoon - 1 3/8" I.D., 2" O.D., except where noted
ST: Shelby-tube - 3" O.D., except where noted
RC: Rock Core, 2" O.D., Except Where Noted
AU: Auger sample
DB: Diamond bit
CB: Carbide bit
WS: Washed Sample

RELATIVE DENSITY AND CONSISTENCY CLASSIFICATION

TERM (NON-COHESIVE SOILS)	BLOWS PER FOOT
Very loose	0 - 5
Loose	6 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very dense	51 or more

TERM (COHESIVE SOILS	BLOWS PER FOOT
Very soft	0 - 3
Soft	4 - 5
Medium	6 - 10
Stiff	11 -15
Very stiff	16 - 30
Hard	31 or more

Indiana Department of Transportation

Materials and Tests Division
120 South Shortridge Road P.O. Box 19389
Indianapolis, Indiana 46219-0389
Phone: (317) 232-5280 Fax: (317) 356-9351

KDD SWJ
WDR WEH
Route To: 98-417
ARE ARE BWC BWC
BSS BSS NRG NG
JEC JEC KGG

These revisions will result in some additional Survey.
ARE

March 21, 2002

Mr. Phelps Klika
Chief, Division of Design
Room N-642-IGCN

Attn: Ms. Christine Baynes
Project Coordinator

Subject: Addendum -2
Des. No: 9161365
Project No: NH-075-3 ( )
US 231 – Phase 3
County: Spencer
District: Vincennes

Gentlemen:

This is addendum #2 to the Geotechnical Report for the subject project dated December 17, 1999. After addendum #1 dated November 16, 2001 in which we recommended 4:1 sideslopes for this project, it was brought to our attention by Mr. Thomas Seeman that right of way problems were making it difficult to use 4:1 sideslopes. He requested our office to perform further review to determine if these sideslopes could be reduced in certain areas to reduce right of way purchase for this project.

Subsequently, a detailed slope stability analysis was performed on several slopes throughout this project to determine the minimum slope is to meet the required factor of safety with seismic considerations.

The following are our recommendations:

1. Station 22+080 to Station 22+180

This section contains some of the weakest soils of phase 3 of the project. Marginal Silty Loam and loose Sandy Loam soils were encountered. Furthermore, the depth to bedrock varies from 6 m (20 feet) to 7.5 m (25 feet). The proposed highway embankment in this area reaches heights up to 9 m (30 feet). We recommend that **3.3:1** Slopes should be used for this 100 m (328 feet) area ranging from Station 22+080 to Station 22+180. **The 3.3:1 slopes should be used for both sides of the road.**

2. *Station 25+290 to Station 25+340*

In the area of the strip pit near Station 25+280, some massive fills with slopes up to 24 m (80 feet) in height exist. In many of these areas to both the north and south sides of the strip pit, the natural ground is very rugged. **The soils encountered south of the strip pit should be safe at 3:1.** However, some of the soils expected to the **north** side of the strip pit are not suitable to support such high sideslopes at 3:1. **Therefore, we recommend that sideslopes of 3.4:1 should be used from Station 25+290 to Station 25+340 on the right side of the road. On the other hand, the left side of the road is stable at 3:1.**

3. *Other Areas of this Project*

With the exception of the two areas listed above, the rest of the sideslopes on this project should be safe at 3:1. While this addendum # 2 supersedes our previous slope stability recommendations in addendum #1 dated November 16, 2001, all of the recommendations in the report dated December 17, 1999 are still valid with the exception of the new required slopes as per the above recommendations in this letter.

Please call us at (317) 610-7251 if you have any further questions.

Very Truly Yours,

Steve Morris
for Athar A. Khan, P.E.
Chief Geotechnical Engineer

S. S. Hiremath
Somanath S. Hiremath, P.E.
Geotechnical Engineering Group Leader

SSH/JF
cc: United Consulting Engineers & Architects – Attn: Mr. M. Rowe
Janssen & Spaans – Attn: Ms. M. Effinger
Mr. T. Seeman – Attn: Mr. J. Nicholson
Mr. J. Russell – Attn: Mr. M. Fowler
Mr. D. Cohen
Mr. J. Schneider
File
Attachment

Indiana Department of Transportation

Materials and Tests Division

120 South Shortridge Road P. O. Box 19389
Indianapolis, Indiana 46219-0389
Phone: (317) 610-7251 Fax: (317) 356-9351

October 31, 2005

Mr. Gerard Mroczka
Chief, Division of Design
Room N-642 - IGCN

Attn: Ms. Kimberly Peters
Project Coordinator

Subject: Addendum 3
Des. No.: 9161365
Project No.: NH-075-3(018)
US 231 – Phase 3, Retaining Wall on SR 162 S-line
County: Spencer
District: Vincennes

Gentlemen:

This addendum is due to a change in scope for the above mentioned project. The new scope mainly involves the construction of a Conventional Retaining Wall on SR 162 for Right of Way limitations. The approximate location of the wall is from Station 1+319 to Station 1+388, offset about 33 feet (10 meters) to the left of Line "S-SR162". The maximum height of the wall is approximately 10.2 feet (3.1 meters).

Soils data from three borings (RW-1 to RW-3) was used for Engineering analysis for this wall. Copies of the Boring Logs and Laboratory Test Data are transmitted with this report.

The following are some recommendations by the INDOT Geotechnical Section.

Findings:

The borings show that the soils at the footing elevation (141.5 m to 142.0 m) primarily consist of medium stiff to stiff Silty Clay Loam (A-7-6). The borings were all dry at the completion of drilling. However, they all caved and the cave-in depth varies from 4.5 feet (1.37 m) to 6.1 feet (1.86 m).

Recommendations:

1. Prior to construction of the Retaining Wall, all topsoil and wet or soft surface soils should be stripped from the site within construction limits. Any very soft, soft, and very loose soils encountered which cannot be compacted should be undercut to at least two feet depth, and replaced with compacted "B" Borrow. Proofrolling of the natural ground surface should then be performed in accordance with the Standard Specifications, in the area where new fill for the Retaining Wall will be placed.

2. In evaluating the design for a Conventional Retaining Wall, the external and internal stability should be analyzed. For external stability, the following four standard modes of failure are typically addressed.

   a). Overturning (minimum factor of safety FS > 2.0).
   b). Sliding (minimum factor of safety FS > 1.5).
   c). Bearing Capacity (minimum factor of safety FS > 3.0)
   d). Global Stability (FS > 1.2)

   All of the factors of safety listed above were found to be adequate provided that the above recommendations are satisfied. However, based on the dimensions of the wall as supplied in the plans, the wall is likely to have eccentricity problems. We therefore recommend that the dimensions of the wall be adjusted as follows. First of all, we recommend a thicker stem, it should be 1 foot (300 mm wide) instead of the 8 inches (200 mm) shown on the plans. Also, we feel that the total width of the footing should be six feet (1800 mm) instead of the 5 feet (1500 mm) as shown on the plans. The extra foot should be added to the toe ideally, it would make a two foot (600 mm) toe.

3. Our analyses which determined this wall to be safe are based on the dimensional adjustments given in the above recommendation. If any alternate dimensional adjustments are considered, our section should be contacted to re-analyze the external stability. The bearing capacity analysis was performed. We recommend a maximum allowable bearing capacity of 3000 psf based on the bottom of the footing elevation varying from 141.5 m to 142.0 m.

4. None of the borings show groundwater tables after 24 at the completion of drilling. However, all of the borings did cave at shallow depths and this is often reflective of a varying groundwater table. Since groundwater levels fluctuate seasonally and with rainfall variations, dewatering could be needed.

GENERAL

General soil strata descriptions and indicated boundaries are based on an engineering interpretation of all available subsurface information by the Geotechnical Section of INDOT and may not necessarily reflect the actual variation in subsurface conditions between borings and samples. Detailed data and field interpretation of conditions encountered in individual borings are shown on the boring logs.

The observed water levels and/or conditions indicated on the boring logs are as recorded at the time of exploration. These water levels and/or conditions may vary considerably, with time, according to the prevailing climate, rainfall or other factors and are otherwise dependent on the duration of, and methods used, in the exploration program.

If you have any questions, please contact us.

Very truly yours,

Athar A. Khan, P.E.
Chief Geotechnical Engineer

Somanath S. Hiremath, P.E.
Geotechnical Engineering Group Leader

Prepared by: Joey Franzino
SSH/JF
cc: United Consulting – Attn: Mr. K. Fowerbaugh - Attachments
Janssen & Spaans – Attn: Mr. H. Patel - Attachments
Mr. J. Wright - Attn: Mr. M. Bari - Attachments
Mr. S. Sarvis - Attn: Mr. M. Fowler - Attachments (2)
Mr. D. Cohen - Attachments
Ms. J. Somers - Attachments
File
H/JoeyReports//Conventional Retaining Wall

INDOT BORING LOG

ROUTE #: SR 162 | COUNTY : Spencer | BORING NO.: RW-1

PROJECT TYPE: Retaining Walls | SHEET 1 OF 1

LOCATION : US 231 - Phase III (S- Line) | DATE STARTED : 02-10-05

DES NO. : 9161365 | PROJECT NO.: NH-075-3(018) | DATE COMPLETED : 02-10-05

BORING ELEVATION	: 143.50	BORING METHOD	: HSA	HAMMER	: AUTO
STATION	: 1+32	RIG TYPE	: TRUCK MOBILE	DRILLER/INSP	: DT/JL
OFFSET	: 2.00 mL	CASING DIA.	: 8 mm	TEMPERATURE	: -1.1 °C
LINE	: "S-SR 162"	CORE SIZE	:	WEATHER	: CLOUDY
DEPTH	: 3.26 m				

GROUNDWATER: ▽ Encountered at DRY ▼ At completion DRY ▼ N/A After 🖂 Caved in at 1.68 m

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	SAMPLE NUMBER	SPT per 15cm	% RECOVERY	MOISTURE CONTENT	UNCONF. COMP., ksf	ATTERBERG LIMITS LL	PL	PI	REMARKS
143.20		GRAVEL (visual). 0.30									
	0.5		SS 1	3 6 5	60						
	1.0										
	1.5		SS 2	4 4 7	70						
		Gray, slightly moist, stiff to hard, SILTY CLAY LOAM with Shale seams A-7-6 #05-496.									
	2.0		SS 3	14 26 47	100						
	2.5										
	3.0		SS 4	16 27 62	100						
140.27		3.23									
140.24		Brown, dry, very weathered, LIMESTONE (visual) 3.26	SS 5	50/.03	10						
	3.5	Bottom of Boring at 3.26 m									
	4.0										
	4.5										
	5.0										
	5.5										
	6.0										

INDOT BORING LOG

ROUTE #: SR 162 | COUNTY : Spencer | BORING NO.: **RW-2**

PROJECT TYPE: Retaining Walls | SHEET 1 OF 1

LOCATION : US 231 - Phase III (S- Line) | DATE STARTED : 02-10-05

DES NO. : 9161365 | PROJECT NO.: NH-075-3(018) | DATE COMPLETED : 02-10-05

BORING ELEVATION	: 144.80	BORING METHOD	: HSA	HAMMER	: AUTO
STATION	: 1+35	RIG TYPE	: TRUCK MOBILE	DRILLER/INSP	: DT/JL
OFFSET	: 3.00 mL	CASING DIA.	: 8 mm	TEMPERATURE	: -1.1 °C
LINE	: "S-SR 162"	CORE SIZE	:	WEATHER	: CLOUDY
DEPTH	: 4.15 m				

GROUNDWATER: ▽ Encountered at DRY ▼ At completion DRY ▼ N/A After ▩ Caved in at 1.37 m

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	SAMPLE NUMBER	SPT per 15cm	% RECOVERY	MOISTURE CONTENT	UNCONF. COMP., ksf	ATTERBERG LIMITS LL	PL	PI	REMARKS
144.50		GRAVEL (visual). 0.30									
	0.5		SS 1	7 9 8	80						
	1.0										
	1.5	Gray, slightly moist, very stiff to stiff, SILTY CLAY LOAM with Shale seams A-7-6 #05-496.	SS 2	3 4 4	70						
	2.0		SS 3	3 5 7	80	19	4.71				
142.21	2.5	2.59									
	3.0		SS 4	19 26 53	100						
	3.5	Brown, dry, very weathered, SANDY SHALE (visual).									
	4.0										
140.65		4.15	SS 5	50/.1	5						
		Bottom of Boring at 4.15 m									
	4.5										
	5.0										
	5.5										
	6.0										

INDOT BORING LOG

ROUTE #: SR 162 | COUNTY : Spencer | BORING NO.: **RW-3**

PROJECT TYPE: Retaining Walls | SHEET 1 OF 1

LOCATION : US 231 - Phase III (S- Line) | DATE STARTED : 02-09-05

DES NO. : 9161365 | PROJECT NO.: NH-075-3(018) | DATE COMPLETED : 02-09-05

BORING ELEVATION	: 144.40	BORING METHOD	: HSA	HAMMER	: AUTO
STATION	: 1+380	RIG TYPE	: TRUCK MOBILE	DRILLER/INSP	: DT/JL
OFFSET	: 3.00 mL	CASING DIA.	: 8 mm	TEMPERATURE	: 4.4 °C
LINE	: "S-SR 162"	CORE SIZE	:	WEATHER	: CLOUDY
DEPTH	: 4.97 m				

GROUNDWATER: ▽ Encountered at 4.11 m ▼ At completion DRY ▼ N/A After ▩ Caved in at 1.86 m

STRATUM ELEVATION	SAMPLE DEPTH	SOIL/MATERIAL DESCRIPTION	SAMPLE NUMBER	SPT per 15cm	% RECOVERY	MOISTURE CONTENT	UNCONF. COMP., ksf	ATTERBERG LIMITS LL	PL	PI	REMARKS
144.10	0.0	GRAVEL (visual). 0.30									
	0.5		SS 1	3 4 5	90	22		42	21	21	
	1.0										
	1.5		SS 2	2 4 5	70						
	2.0	Gray, slightly moist, medium stiff to hard, SILTY CLAY LOAM with Shale seams TEST A-7-6(23) #05-496.	SS 3	6 8 13	100						
	2.5										
	3.0		SS 4	17 32 44	100						
141.05	3.5	3.35									
	4.0	Brown, wet, very soft, CLAY A-7-6(41) #05-504.	SS 5	0 0 1	60	64		67	29	38	
139.68	4.5	4.72									
139.43	5.0	Gray, dry, very weathered, SHALE (visual). 4.97	SS 6	18 50/.24	30						
		Bottom of Boring at 4.97 m									
	5.5										
	6.0										

INDOT BORING LOG 9161365.GPJ IN_DOT1.GDT 10/26/05

10/14/05

DES NO. 9161365

SUMMARY OF SPECIAL LABORATORY TEST RESULTS

DES. NO. 9161365
PROJECT NO. NH-075-3 (018)
STRUCTURE NO. NA
COUNTY SPENCER

LABORATORY NUMBER	PART	BORING NUMBER	SAMPLE NUMBER	DEPTH	NATURAL WATER CONTENT (%)	pH VALUE	LOI (%)	CA & MG (%)	NATURAL WET DENSITY (pcf)	NATURAL DRY DENSITY (pcf)	MAX DRY DENSITY (pcf)	OPT. MOIST (%)	CBR @93%	CBR @97%	COHESION (Qu/2) (psf)
057079200496		RW-3	SS 1 T	1.0-2.5	22.4	6.3									
057079200504		RW-3	SS 5 T	13.5-15.0	63.7	7.0									
057079200511		RW-2	SS 3 T	6.0-7.5	18.6				128.6	108.4					2271

10/14/05

SUMMARY OF CLASSIFICATION TEST RESULTS

DES. NO. 9161365
PROJECT NO. NH-075-3 (018)
STRUCTURE NO. NA
COUNTY SPENCER

LABORATORY NUMBER	PART	BORING NUMBER	STATION	OFFSET LINE	SAMPLE NUMBER	SAMPLE DEPTH	TEXTURAL/ UNIFIED	AASHTO	NO. 10	NO. 40	NO. 200	GRAVEL 76.2 - 2.00 mm	SAND 2.00- 0.074 mm	SILT 0.074- 0.002 mm	CLAY BELOW 0.002 mm	BELOW 0.001 mm	LL	PL	PI
057079200496		RW-3	1+380	3m LT S-SR162	SS 1 T	1.0-2.5	SILTY CLAY LOAM	A-7-6(23)	100.0	100.0	98.6	0.0	1.4	71.8	26.8	25.0	42.2	20.5	21.7
057079200504		RW-3	1+380	3m LT S-SR162	SS 5 T	13.5-15.0	CLAY	A-7-6(41)	100.0	99.5	91.6	0.0	8.4	41.6	50.0	42.3	67.2	29.1	38.1

DES NO: 9300400

STRUCTURE #: 231-74-2660

PROJECT NO: NH-075-3()

US-231 PHASE III STRUCTURES

SPENCER COUNTY, INDIANA

A & W PROJECT NO: 01-0113-9

PREPARED FOR

INDIANA DEPARTMENT OF TRANSPORTATION

INDIANAPOLIS, INDIANA

JANUARY 2, 2002

SUMMARY OF RECOMMENDATIONS

DES NO: 9300400
STRUCTURE #: 231-74-2660
PROJECT NO: NH-075-3()
US-231 PHASE III STRUCTURES
SPENCER COUNTY, INDIANA

A foundation investigation has been performed for the proposed structures on Phase III of the US-231 new road construction in Spencer County, Indiana. Design plans indicate two (2) bridge structures and two (2) large culvert structures are associated with this phase of the project. In conjunction with the two (2), one (1) span bridge structures, a MSE Wall is proposed at each end bent location.

Bridge Structure 231-74-2660

The borings drilled for this structure indicated the following approximate bedrock elevations:

Bent Number	Boring or Sounding Number	Station	Offset "A"	Ground Surface Elevation (m)	Approximate Bedrock Elevation (m)	Depth Below Pile Cap (m)
1	TB-4	25+927	23mRT	151.3	148.8	9.7
1	TB-5	25+940	3mLT	150.3	146.3	12.2
1	S-5	25+954	23mRT	150.3	146.7	11.8
2	S-6	25+948	23mLT	151.2	148.8	9.3
2	TB-6	25+960	3mRT	151.2	148.5	9.6
2	TB-7	25+975	23mLT	150.4	148.0	10.1

Table 1: Summary of Approximate Bedrock Elevations

The end bents for this new bridge may be founded on steel H-piles driven to sound bedrock at approximate elevations shown in Table 1. Due to the relatively shallow bedrock encountered, a pile driven to the desired ultimate capacity may not be able to laterally support itself. Therefore, prior to MSE Wall construction, it is recommended to predrill through the shallow rock a minimum of ten (10) feet (3m) to provide temporary lateral support and proper seating. Alternatively, if driving piles after MSE Wall construction is desired, sleeves should be implemented at the pile locations. After the embankment is constructed, it is recommended that the piles be driven at the sleeve location with an impact hammer to ensure proper seating at the approximate bedrock elevation noted in Table 1.

Two MSE Walls are proposed at each end bent location. As long as the reinforcement strips at each end bent are 1.0H or greater, adequate factors of safety against overturning, sliding, bearing capacity and global stability will be obtained. H refers to the height of the MSE Wall. The recommended length of these strips is also assuming the material five (5) feet (1.5m) below the reinforced area is removed and replaced with "B" Borrow.

Design plans indicate two (2) large drainage structures are to be constructed with this phase of the project. Recommendations and concerns regarding placement of these structures are discussed more thoroughly in the main portion of this report.

Alt & Witzig Engineering, Inc.
4105 West 99th Street • Carmel, Indiana 46032
(317) 875-7000 • Fax (317) 876-3705

January 2, 2002

Indiana Department of Transportation
120 South Shortridge Road
P.O. Box 19389
Indianapolis, Indiana 46219-0389
ATTN: Mr. Athar A. Kahn

RE: RE: Subsurface Investigation
and Recommendations
Des No: 9300400
Project No: NH-075-3()
US-231 Structures, Phase III
Spencer County, Indiana
Alt & Witzig File: 01-0113-9

Gentlemen:

In compliance with your request, we have completed seven (7) soil borings and two (2) soundings at the above referenced site. It is our pleasure to transmit herewith a copy of the report.

Purpose and Procedures

This report presents the results of a geotechnical investigation and evaluation for the US-231 Phase III proposed structures. Roadway recommendations for this phase of the US-231 project have previously been released. Design plans indicate two (2), one (1) span bridge structures and two (2) large culvert structures are associated with this phase of the project. In conjunction with the one (1) span bridge structures, a MSE Wall is proposed at each end bent location. This investigation was conducted for the Indiana Department of Transportation.

The purpose of this foundation investigation was to determine the various soils profile components, the engineering characteristics of the foundation materials and to provide criteria for use be the design engineers in preparing the structures design.

The field investigations to determine the engineering characteristics of the foundation materials included a reconnaissance of the project site, drilling borings as shown on the soil profile drawings, performing standard penetration tests and obtaining soil samples retained in shelby tubes and the standard split-spoon sampler. The borings stationing and offsets are noted on the boring logs. The apparent groundwater level and the ground surface elevation at the boring locations were also determined. The field investigation was started on May 3, 2001, and completed on August 21, 2001.

The soil borings were performed with a drilling rig equipped with a rotary head. Conventional hollow-stem augers were used to advance the holes. Representative samples were obtained employing split-spoon sampling procedures in accordance with ASTM Procedure D-1586. After auger refusal was encountered some of the borings were advanced using rock coring equipment and representative rock samples were obtained from an NX rock core barrel.

During the sampling procedure, standard penetration tests were performed at regular intervals to obtain the standard penetration value of the soil. The standard penetration value is defined as the number of blows a 140 lb hammer, falling 30 inches, required to advance the split-spoon sampler 12 inches into the soil. The results of the standard penetration tests indicate the relative density and comparative consistency of the soils, and thereby provide a basis for estimating the relative strength and compressibility of the soil profile components.

In addition to the field investigations, a supplemental laboratory investigation was conducted to ascertain additional pertinent engineering characteristics of the subsurface materials necessary in analyzing the behavior of the proposed roadway. All phases of the laboratory investigation were conducted in general accordance with applicable AASHTO Specifications and INDOT Exhibit "C".

The laboratory testing program included supplementary visual classification on all samples. Atterberg limit tests, moisture content tests, pH tests, and grain size analyses were performed on selected soil samples. A consolidation test was also performed on a relatively undisturbed sample from soil boring TB-1A.

Bridge Structure 231-74-2660

Design plans indicate that two (2), one (1) span bridge structures are to be constructed with this project. The borings drilled for this new structure encountered bedrock at relatively shallow depth. The end bents for this new bridge may be founded on steel H-piles driven to competent bedrock. The approximate bedrock elevations encountered in our borings are shown in Table 1.

Bent Number	Boring or Sounding Number	Station	Offset "A"	Ground Surface Elevation (m)	Approximate Bedrock Elevation (m)	Depth Below Pile Cap (m)
1	TB-4	25+927	23mRT	151.3	148.8	9.7
1	TB-5	25+940	3mLT	150.3	146.3	12.2
1	S-5	25+954	23mRT	150.3	146.7	11.8
2	S-6	25+948	23mLT	151.2	148.8	9.3
2	TB-6	25+960	3mRT	151.2	148.5	9.6
2	TB-7	25+975	23mLT	150.4	148.0	10.1

Table 1: Summary of Approximate Bedrock Elevations

Due to the relatively shallow bedrock encountered, a pile driven to the desired ultimate capacity before MSE Wall construction may not be able to laterally support itself. Therefore, prior to MSE Wall construction, it is recommended to predrill through the shallow rock a minimum of ten (10) feet (3m) to provide temporary lateral support and proper seating. Alternatively, if driving piles after MSE Wall construction is desired, sleeves should be implemented at the pile locations during embankment construction so that no damage to the MSE Wall will occur. After the MSE Wall is constructed, it is recommended that the piles be driven at these cased locations with an impact hammer to ensure proper seating at the approximate bedrock elevation noted in Table 1. It will be necessary to use a protective tip (pile tips) to minimize damage to the piles during driving. Preparation and driving of piles should be in accordance with INDOT Standard Specifications Section 701.09.

Soil boring TB-4 encountered coal between the depths of two and one-half (2½) to six (6) feet (0.8-1.8m). Pile tips should be driven through the coal stratum and seated in the bedrock below.

The bedrock elevations given above are only approximate elevations determined at the exact structure boring and sounding locations and should be used only as a guide. The preliminary elevations are presented only as a guideline, the final tip elevation should be determined by ultimate load using the methods outlined in section 701.04 of the INDOT Standard Specifications. The tables below lists pile driving parameters.

Bent or Pier	No. 1	No. 2
Design Load (Tons)	55/70/90	55/70/90
Factor of Safety	2.5	2.5
Factored Design Load	137.5/175/225	137.5/175/225
Friction in Scour Zone (Tons)	N/A	N/A
Down Drag Friction	N/A	N/A
Ultimate Load (Tons)	137.5/175/225	137.5/175/225
Testing Method	By Formula, Std. Spec. 701	

Table 2: Parameters for Pile Driving

MSE Wall Recommendations

As indicated by the design plans, two (2) MSE Retaining Walls are proposed at the end bents of the bridge structure. These MSE Walls run parallel to the railroad track and are approximately one hundred thirty (130) feet (40m) in length. External stability analyses of the

proposed retaining walls were performed at the most critical section, which also corresponds to the highest section of the wall, 29'(8.9m). A traffic surcharge load of 250 psf was used in the design calculations. Since the highest section of the wall is beneath the bridge abutment, the soil load above the top of the wall was also factored into the design analysis. According to the design plans, the bridge abutment extends approximately five (5) feet (1.5m) above the top of the MSE Wall at all these locations. However, it is assumed the lateral earth pressure on the abutment itself will be resisted by either tie backs or lateral pile resistance. **When MSE plans are finalized, it is recommended that the Geotechnical Consultant be provided with a set of plans to verify the recommendations made in this report.**

To meet required factors of safety for sliding of all the walls, it is recommended that five (5') feet (1.5m) be undercut beneath the wall and its strip foundation and replaced with "B" Borrow. Thus, ultimately requiring considerably less strip length and structural backfill. **The MSE Walls at the south and north abutments should have adequate factors of safety against overturning, sliding, bearing capacity, and global stability if minimum strip lengths of 1.0H are utilized.** The letter H refers to the height of the MSE Wall. For the design of the foundation pad, a net allowable bearing pressure of 4000 psf can be used. The calculations of our analysis are presented in the Appendix of the report.

Based on the recommendations given in this report and the slope stability analysis performed at the critical wall section, we feel that the MSE retaining walls will have adequate global stability. A sliding block and a rotational analysis was performed on the South MSE Wall as well as on the North MSE Wall. A seismic horizontal acceleration factor of 0.10g and a 250psf surcharge load was factored into our stability analysis. Our calculations indicate critical factors of safety of 1.24 and 1.23 on the north and south wall, respectively, were achieved. The graphical and numerical results of our analysis can be found in the Appendix of our report.

Prior to construction of the walls, all topsoil and wet or soft surface soils should be stripped from the site within construction limits. Proofrolling of the exposed subsurface should be performed in accordance with Section 203.26 in the area where new fill for the walls will be placed. Any soft, loose or unstable soils encountered during proofrolling operations, which will not readily compact, should be removed and replaced in accordance with Section 203.09. It is recommended that the base of the wall/backfill area be compacted to a minimum density of 95 percent of maximum dry density as determined by AASHTO T-99.

Evaluation of the internal stability of the walls against three standard modes of failure should be addressed by the design engineer. These include pullout of the strips, tensile overstress for the strip and wall/strip connection, and corrosion of the steel reinforcement strip. The backfill for these structures are to be of structural "B" Borrow as outlined in INDOT Standard Specifications. Soil parameters used for the backfill in the internal stability analysis are assumed to be $\phi = 34°$, $c = 0$, and unit weight (γ) = 125pcf. Behind the reinforced soil mass, additional "B" Borrow backfill should be placed. This material should rise from the heel of the MSE wall on a 1:1 slope. Any loose sand exposed in the foundation excavation should be compacted with a heavy vibrating roller before construction of the MSE wall. Careful consideration when compacting and

placing the backfill should be given in order to minimize the increase in lateral earth pressure Furthermore, tracked construction equipment should not be operated directly on the strips. A minimum backfill thickness of six (6) inches (150mm) is required prior to operation of tracked vehicles over the strips. Turning of tracked vehicles should be kept to a minimum to prevent tracks from displacing the backfill and damaging the strips. Rubber-tired equipment may pass over the reinforcement at slow speed, less than 5mph. Sudden braking and sharp turning should be avoided. The MSE Wall construction should be done per INDOT Special Provision which is attached to the Appendix of the report.

Where high water tables are indicated on the boring logs, sump pumps or other means of dewatering will be necessary to maintain a dry excavation. It should be noted the above design values are assuming proper drainage is occurring. Therefore, during construction of the retaining walls, it is recommended that a permanent subsurface drainage system be installed at or near the base of the retaining wall. It is important that the drainage system be protected by some form of filter to prevent fines from clogging the pipe.

Due to the relatively shallow bedrock encountered, a pile driven to the desired ultimate capacity before MSE Wall construction may not be able to laterally support itself. Therefore, prior to MSE Wall construction, it is recommended to predrill through the shallow rock a minimum of ten (10) feet (3m) to provide temporary lateral support and proper seating. Alternatively, if driving piles after MSE Wall construction is desired, sleeves should be implemented at the pile locations during embankment construction so that no damage to the MSE Wall will occur. After the MSE Wall is constructed, it is recommended that the piles be driven at these cased locations with an impact hammer to ensure proper seating at the approximate bedrock elevation noted in Table 1.

Drainage Structures

Two large drainage structures are proposed in this phase of the project. In general, it is recommended that any unsuitable material beneath these structures be undercut to suitable material and replaced with "B" Borrow for Structural Backfill. Prior to placement of fill, it is recommended that the foundation soils be compacted with a heavy vibratory roller. The following table summarizes the drainage structures on this project and states placement recommendations.

Drainage Structure Summary				
Type of Structure	**Boring(s)**	**Station**	**Offset**	**Recommended Procedure**
Box Culvert 4200mm x 1500mm R.C. Box Culvert (#50)	TB-1 TB-1A TB-2	22+090 22+120 22+158	59mRT 3mRT 55mLT	Remove 3'-6'(1-2m) of unsuitable material below estimated invert elevations of 130.3 & 129.6 and replace with compacted "B" Borrow for Structural Backfill.
2305mm x 1465mm Smooth Deformed Pipe or 3240mm x 2140mm CDP (#95)	RB-7	22+840	15mLT	Undercut to invert elevations 133.2 & 134.0 & adhere to the recommendations in the report.

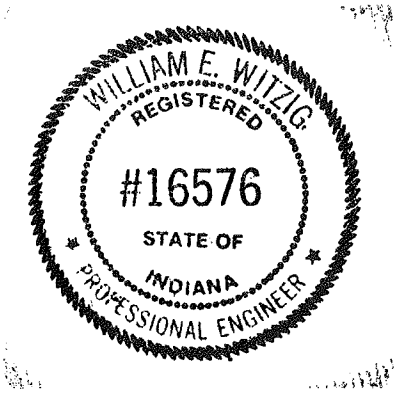
Table 3: Drainage Structure Recommendations

Due to the difficulty with the property owner, no structure boring was performed for Structure #95 at Station 22+887. Instead, the closest boring to this vicinity, RB-7, was used for the basis of our recommendations. RB-7 was drilled during the previous roadway phase of this project. For convenience, a copy of the boring log is included in the Appendix of the report.

Approximately twenty-nine (29) feet (8.9m) of fill is proposed at Station 22+120. The INDOT Geotechnical Section has performed a settlement analysis for the roadway in this area and has estimated that two (2) inches (51mm) of settlement will occur.

According to our boring logs, the groundwater level at the proposed structure locations was relatively high. Therefore, some difficulty managing the water during construction should be anticipated. Due to the depth of excavation proposed and types of soils encountered, it may be necessary to use some form of retaining system during construction. At the site of the proposed structures, the current terrain consists of relatively small creek beds. To control the flow of water at the time of construction, a cofferdam or some form of rerouting may be necessary.

Often, because of design and construction details which occur on a project, questions arise concerning the soil conditions. If we can give further service in these matters, please contact us at your convenience.



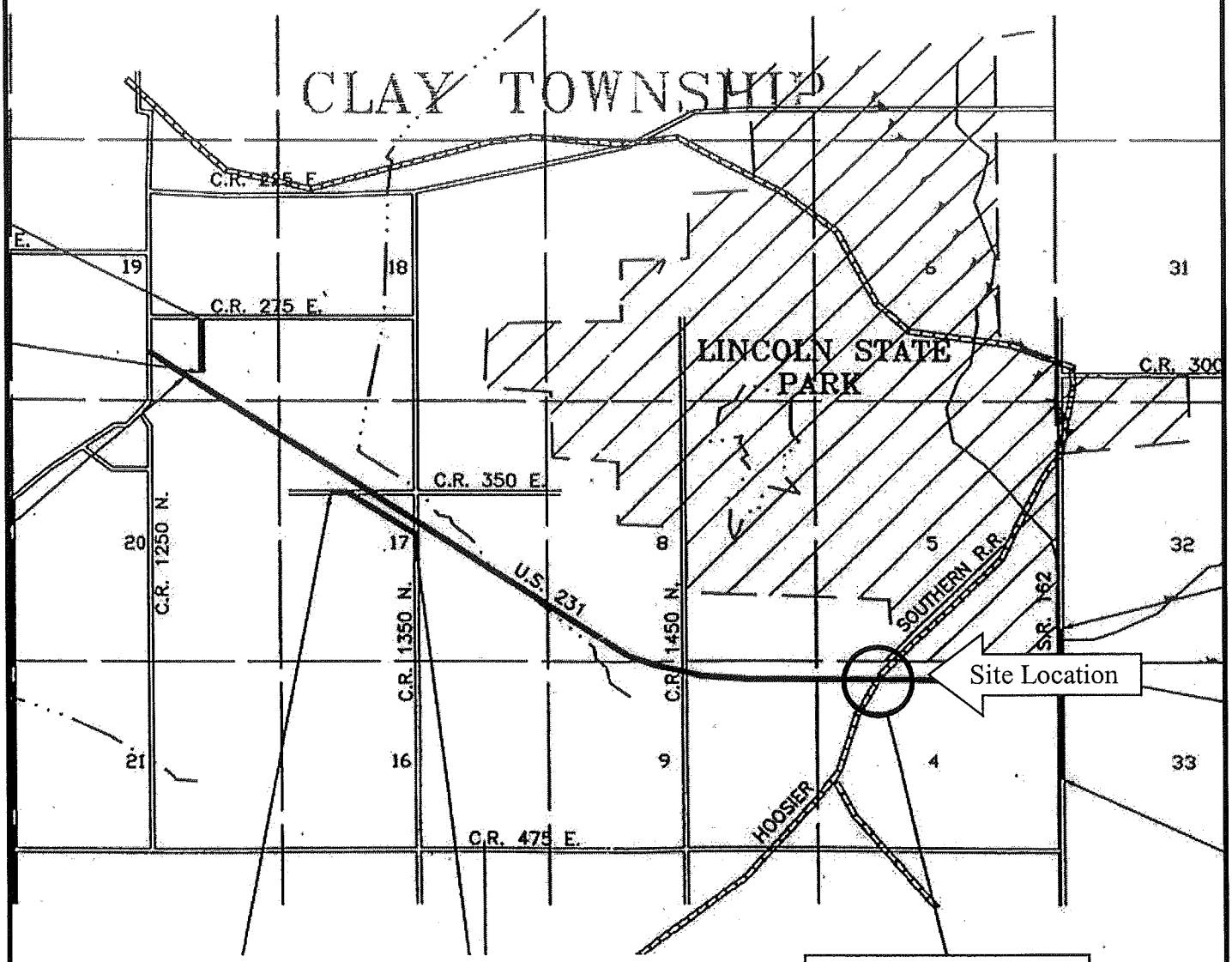
Very truly yours,

ALT & WITZIG ENGINEERING, INC.

William E. Witzig, P.E.

Appendix

SITE LOCATION MAP



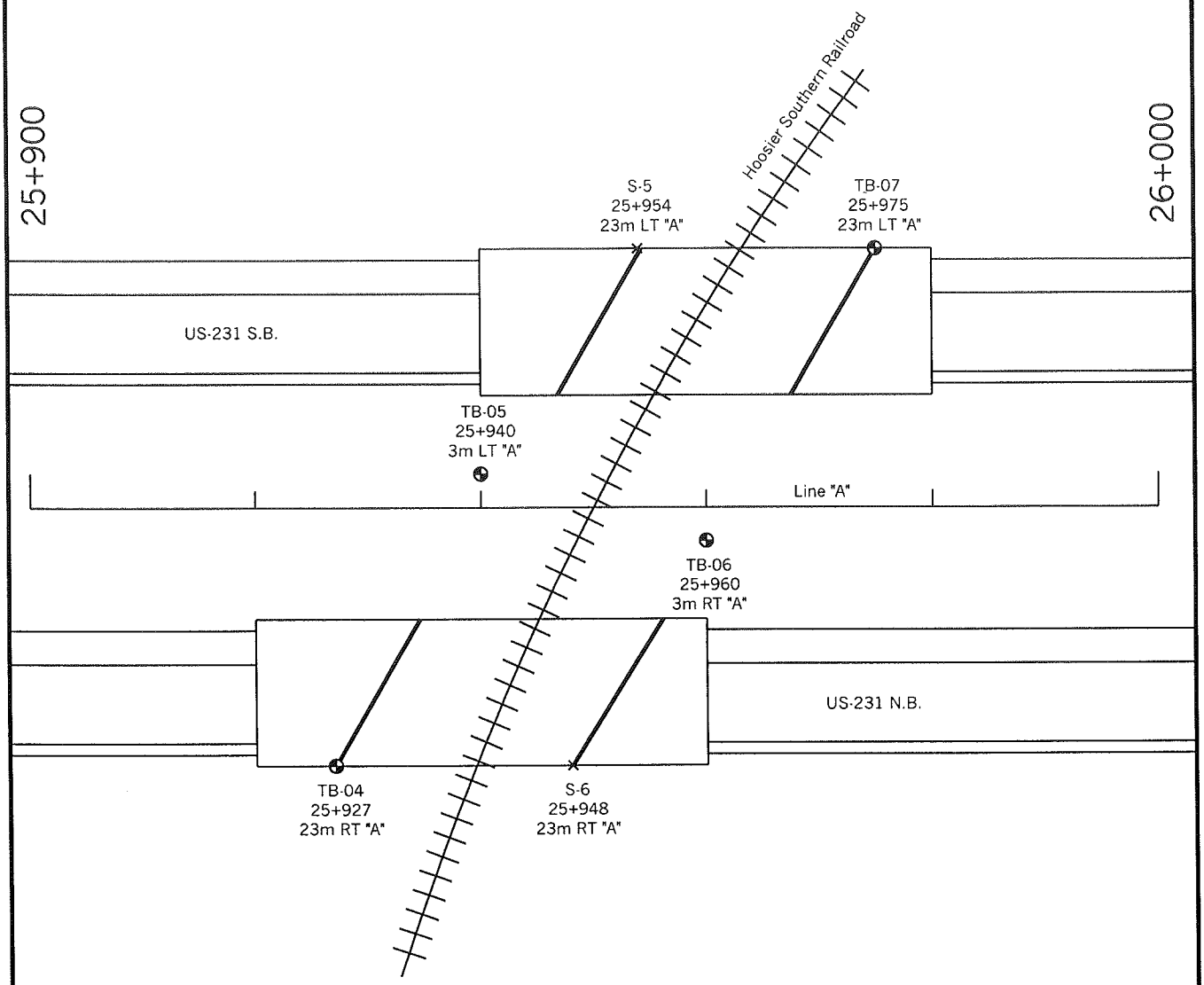
Des. No.: 9161365
STR.(231)74-2660
US-231 Structures
Spencer County, IN
AW File: 01-0113-9

N

Scale: 1:25000

Prepared For: INDOT		**Prepared By:** Alt & Witzig Engineering, Inc.	
Project Name: US 231 Structures		**Project No:** 01-0113-9	**Date:** 1/02

BORING LOCATION PLAN



N

Scale: 1" = 50'

0 50

01-0113-9

Des. No.: 9161365
STR.(231)74-5660
US-231 Structures
Spencer County, IN
AW File: 01-0113-9

PREPARED FOR: INDOT		PREPARED BY: Alt & Witzig Engineering, Inc.
PROJECT NAME: US 231 Structures		PROJECT NO.: 01-0113-9 / DATE: 1/02

LOG OF TEST BORING

Project: US-231 Structure
Location: Spencer County, IN
Client: INDOT Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. TB-01
Surface Elevation 131.8
Proj. # NH-075-3 ( )
AW Proj. # S0901
Sheet 1 of 1

Str. No.	50	Station	22+090	Offset	59m RT	Line	"A"
Datum	USC-GS	Weather	Sunny	Temperature	75F	Inspector	Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Topsoil (Visual)						
1SS	X	100	2-2-1		Brown, Very Moist, very soft to medium stiff, CLAY Test 01 A-4(0)			21.9	23	20	3
2SS	X	100	1-3-4								
3SS	X	100	1-1-1		Brown, Very Moist, very soft, SILTY LOAM Test 02 A-4(0)		95.0	27.5	21	18	3
4SS	X	100	1-1-5								
					Brown mottled Gray, Wet, medium stiff, SANDY LOAM and GRAVEL Test 03 A-2-6						
~~5SS~~ 1RC	~~X~~	~~40~~ 83	~~13-50/3"~~	5	Auger Refusal at 4.2m Gray, Dry, LIMESTONE (Visual) Rock Core No. 1 (4.2-5.9m) REC: 83% RQD: 75% Gray, Dry, weathered SHALE (Visual) Soft layer at 5.4-5.7m						
					Boring Terminated at 5.9m						
				10	Notes: Shelby tube pushed from 1.5 to 2.1m						

WATER LEVEL OBSERVATIONS

While Drilling	2.7	Upon Completion of Drilling	1.5
Time After Drilling		24hrs	
Depth to Water		1.2	
Depth to Cave in			

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 5/3/01 End 5/3/01 Rig ATV
Driller Copeland Editor E.Felix
Remarks Backfilled with soil cuttings and slurry mix. 152mm Dia. HSA.

LOG OF TEST BORING

Project: US-231 Structure
Location: Spencer County, IN
Client: INDOT Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. TB-1A
Surface Elevation 131.2
Proj. # NH-075-3 ( )
AW Proj. # S0901
Sheet 1 of 1

Str. No.	50	Station	22+120	Offset	3m RT	Line	"A"
Datum	USC-GS	Weather	Sunny	Temperature	80F	Inspector	Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Topsoil (Visual)						
1SS		100	4-5-2		Brown, Moist, medium stiff to soft, CLAY Test 01 A-4						
2SS		100	2-2-2								
3SS		100	1-2-2		Brown, Moist, soft SILTY LOAM Test 02 A-4						
4SS		100	3-3-5		Brown, Moist, medium stiff, CLAY LOAM Test 05 A-4(1)		96.8	19.7	24	19	5
5SS		100	1-1-2		Gray, Moist, very soft, SILTY CLAY LOAM Test 04 A-4						
				5	Gray, Moist, weathered, LIMESTONE (Visual)						
6SS 1RC		20 97	50/2"		Auger Refusal at 5.7m Gray, Dry, LIMESTONE (Visual) Dark Gray, Dry, weathered SHALE (Visual) Rock Core No. 1 (5.7-7.2m) REC= 97% RQD= 40%						
2RC		92			Rock Core No. 2 (7.2-8.7m) REC= 92% RQD= 20% Soft layer between 6.8-7.0m.						
				10	Boring terminated at 8.7m Notes: Pushed Shelby tube from 2.1-2.7m						

WATER LEVEL OBSERVATIONS

	While Drilling	Upon Completion of Drilling		
Time After Drilling		24hrs		
Depth to Water		N/A		
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 5/7/01 End 5/7/01 Rig ATV
Driller Copeland Editor E.Felix
Remarks Boring backfilled with soil cuttings and slurry mix. 152mm Dia. HSA.

LOG OF TEST BORING

Project: US-231 Structure
Location: Spencer County, IN
Client: INDOT Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. TB-02
Surface Elevation 129.8
Proj. # NH-075-3 ( )
AW Proj. # S0901
Sheet 1 of 1

Str. No. 50 | Station 22+158 | Offset 55m LT | Line "A"
Datum USC-GS | Weather Sunny | Temperature 75F | Inspector Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Topsoil (Visual)						
1SS	X	100	4-3-3		Brown, Moist, medium stiff to very soft, CLAY Test 01 A-4			24.4			
2SS	X	100	2-1-2								
3SS	X	100	1-7-7								
4SS	X	100	2-9-7		Brown, Moist, stiff to very stiff, SANDY LOAM and GRAVEL Test 03 A-2-6(0)			16.4	37	23	14
5SS	X	100	1-2-3	5	Gray, Moist, soft, SILTY CLAY LOAM Test 04 A-4(3)			23.7	26	22	4
6SS	X	100	2-4-6		Brown, Wet, loose fine, SAND (Visual)						
7SS	X	40	4-37-50/4"		Dark Gray, Dry, very weathered SHALE (Visual)						
				10	Auger Refusal and Boring terminated at 7.6m						

WATER LEVEL OBSERVATIONS

While Drilling	▽ 2.3	Upon Completion of Drilling	● 1.9	
Time After Drilling		24hrs		
Depth to Water	▽	▼ 1.7	▽	▽
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 5/3/01 End 5/3/01 Rig ATV
Driller Copeland Editor E.Felix
Remarks Boring backfilled with soil cuttings and slurry mix. 152mm Dia HSA.

LOG OF TEST BORING

Project: U.S. 231 Realignment
Location: Spencer County, Indiana
Client: Indiana Department of Transportation

3405 West 96th Street Indianapolis, Indiana 46268-1194
317-875-7000/317-876-3705(Fax)

Boring No. RB-07
Surface Elevation 134.3
Proj. # NH-075-3( )
AW Proj. # S9905
Sheet 1 of 1

Str. No.	N/A	Station	22+840	Offset	15.0 m Lt	Line	"A"
Datum	USC & GS	Weather	Sunny	Temperature	85	Inspector	M. Rowe

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
1	X	100	7-7-8		Topsoil (Visual)						
					Brown, Dry, Stiff, Silty Loam			9.5			
2	X	100	6-6-7		*Test 3 A-4			11.1			
3	X	100	17-16-14		Brown, Dry, Very Stiff to Hard, Silty Clay Loam			11.3			
4	X	100	14-10-15		*Test 4 A-6(10)			22.0	32	20	12
					pH = 7.0						
5	X	100	11-17-21					23.9			
				5							
6	X	100	25-50/3"					22.1			
					Gray Weathered Shale (Visual)						
					Boring Terminated at 6.1 meters						
					*Test data from roadway report						
				10							
				15							
				20							

WATER LEVEL OBSERVATIONS

While Drilling	▽ DRY	Upon Completion of Drilling	▼ DRY	
Time After Drilling		24		
Depth to Water	▽	▼ DRY	▽	▽
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 8/16/99 End 8/16/99 Rig ATV
Driller Loveday Editor M. Rowe
Remarks Boring backfilled with soil cuttings.

LOG OF TEST BORING

Project: US-231 Structure
Location: Spencer County, IN
Client: INDOT Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. TB-04
Surface Elevation 151.3
Proj. # NH-075-3 ( )
AW Proj. # S0901
Sheet 1 of 1

Str. No. 231-74-2660 | Station 25+927 | Offset 23m RT | Line "A"
Datum USC-GS | Weather Sunny | Temperature 75F | Inspector Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
1SS		100	3-18-24		Brown, Moist, hard, CLAY LOAM Test 05 A-4						
2SS		100	8-42-36		Black, Dry, weathered COAL (Visual)						
3SS		100	17-21-32		Gray, Dry, weathered SILTSTONE (Visual)						
4SS		40	10-32-50/4"								
5SS		40	10-40-50/4"								
6SS		30	20-50/3"	5	Auger Refusal at 5.7m Gray, Dry, LIMESTONE (Visual)						
1RC		95			Dark Gray, Dry, SHALE (Visual) (with intermittent weathering) Rock Core No. 1 (5.7-7.2m) REC= 95% RQD= 63%						
				10	Boring terminated at 7.2						

WATER LEVEL OBSERVATIONS

While Drilling	Dry	Upon Completion of Drilling	1.2	
Time After Drilling		24hrs		
Depth to Water				
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 5/18/01 End 5/18/01 Rig ATV
Driller Copeland Editor E.Felix
Remarks Boring backfilled with soil cuttings and slurry mix. 152mm Dia. HSA. Water used to core.

LOG OF TEST BORING

Project: US-231 Structure
Location: Spencer County, IN
Client: INDOT Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. TB-05
Surface Elevation 150.3
Proj. # NH-075-3 ( )
AW Proj. # S0901
Sheet 1 of 1

Str. No. 231-74-2660 | Station 25+940 | Offset 3m LT | Line "A"
Datum USC-GS | Weather Sunny | Temperature 75F | Inspector Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Topsoil (Visual)						
1SS	X	100	3-5-5		Brown, Moist, medium stiff, SILTY LOAM Test 02 A-4			21.6			
2SS	X	100	6-10-14		Brown, Moist, very stiff to hard, SILTY CLAY LOAM Test 04 A-4						
3SS	X	100	17-32-36					25.9			
4SS	X	40	25-50-50/4"								
					Brown, Moist, hard, SILTY LOAM Test 02 A-4						
5SS	X	30	45-50/3"		Dark Gray, Dry, very weathered SHALE (Visual)						
				5							
6SS	X	20	50/2"		Auger Refusal and Boring terminated at 5.7m						
				10							

WATER LEVEL OBSERVATIONS

While Drilling	▽ Dry	Upon Completion of Drilling	▼ Dry	
Time After Drilling		24hrs		
Depth to Water	▽	▼ 1.1	▽	▽
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 5/18/01 End 5/18/01 Rig ATV
Driller Copeland Editor E.Felix
Remarks Boring backfilled with soil cuttings and slurry mix. 152mm Dia. HSA.

LOG OF TEST BORING

Project: US-231 Structure
Location: Spencer County, IN
Client: INDOT Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. TB-06
Surface Elevation 151.2m
Proj. # NH-075-3 ( )
AW Proj. # S0901
Sheet 1 of 1

Str. No. 231-74-2660 | Station 25+960 | Offset 3m RT | Line "A"
Datum USC-GS | Weather Sunny | Temperature 75F | Inspector Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Topsoil (Visual)						
1SS	X	100	4-5-5		Brown, Moist, medium stiff to very stiff, SILTY LOAM Test 02 A-4						
2SS	X	100	5-8-8								
3SS	X	100	4-6-7					20.3			
4SS	X	40	5-32-50/4"								
					Brown mottled Gray, Dry, weathered SANDSTONE (Visual)						
5SS	X	20	36-50/2"		Gray, Dry, very weathered SHALE (Visual)						
					Auger Refusal and Boring terminated at 4.3m						
				5							
				10							

WATER LEVEL OBSERVATIONS

While Drilling	Dry	Upon Completion of Drilling	Dry	
Time After Drilling		5hrs		
Depth to Water		3.2		
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 5/3/01 End 5/3/01 Rig ATV
Driller Copeland Editor E.Felix
Remarks Boring backfilled with soil cuttings and slurry mix. 152mm Dia. HSA.

LOG OF TEST BORING

Project: US-231 Structure
Location: Spencer County, IN
Client: INDOT Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. TB-07
Surface Elevation 150.4
Proj. # NH-075-3 ( )
AW Proj. # S0901
Sheet 1 of 1

Str. No. 231-74-2660 | Station 25+975 | Offset 23m LT | Line "A"
Datum USC-GS | Weather Sunny | Temperature 75F | Inspector Tom Coffey

SAMPLE No.	Type	Rec (%)	N	Depth	DESCRIPTION/CLASSIFICATION and REMARKS	qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					Topsoil (Visual)						
1SS	X	100	6-11-13		Brown, Moist, very stiff to hard, CLAY LOAM Test 06 A-4(4)						
2SS	X	100	8-9-9					21.2	31	23	8
3SS	X	30	6-50/3"								
4SS	X	40	12-50/4"		Brown, Dry, very weathered SHALE (Visual)						
5SS	X	30	30-50/3"								
1RC		77		5	Auger Refusal at 4.4m Gray, Dry, slightly weathered SHALE (Visual) Rock Core No. 1 (4.4-5.9m) REC= 77% RQD= 71% Rock Core No. 2 (5.9-7.4m) REC= 82% RQD= 72%						
2RC		82									
				10	Boring terminated at 7.4m						

WATER LEVEL OBSERVATIONS

While Drilling	Dry	Upon Completion of Drilling	Dry	
Time After Drilling		24hrs		
Depth to Water		1.8		
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 5/3/01 End 5/3/01 Rig ATV
Driller Copeland Editor E.Felix
Remarks Boring backfilled with soil cuttings and slurry mix. 152mm Dia. HSA.

LOG OF TEST BORING

Project: US-231 Structure
Location: Spencer County, IN
Client: INDOT Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. S-5
Surface Elevation 150.3
Proj. # NH-075-3 ( )
AW Proj. # S0901
Sheet 1 of 1

Str. No. N/A | Station 25+954 | Offset 23m LT | Line "A"
Datum USC-GS | Weather Sunny | Temperature 85F | Inspector Tom Coffey

SAMPLE					DESCRIPTION/CLASSIFICATION and REMARKS	SOIL PROPERTIES					
No.	Type	Rec (%)	N	Depth		qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					See TB-7 for Soil Description						
				5	Gray, Dry, Weathered SHALE (Visual)						
				10	Auger Refusal and Boring Terminated at 5.5m						

WATER LEVEL OBSERVATIONS

While Drilling	Dry	Upon Completion of Drilling	Dry
Time After Drilling		24hrs.	
Depth to Water		N/A	
Depth to Cave in			

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 8/21/01 End 8/21/01 Rig ATV
Driller Copeland Editor E.Felix
Remarks Backfilled apon completion of drilling with slurry mix and soil cuttings. 152mm Dia. HSA.

LOG OF TEST BORING

Project: US-231 Structure
Location: Spencer County, IN
Client: INDOT Des. No.: 9161365

4105 West 99th Street Carmel, Indiana 46032
317-875-7040/317-870-0314(Fax)

Boring No. S-6
Surface Elevation 151.2
Proj. # NH-075-3 ( )
AW Proj. # S0901
Sheet 1 of 1

Str. No.	N/A	Station	25+948	Offset	23m RT	Line	"A"
Datum	USC-GS	Weather	Sunny	Temperature	85F	Inspector	Tom Coffey

SAMPLE					DESCRIPTION/CLASSIFICATION and REMARKS	SOIL PROPERTIES					
No.	Type	Rec (%)	N	Depth		qu (qp) (tsf)	γ (pcf)	W (%)	LL (%)	PL (%)	PI (%)
					See TB-6 for Soil Description						
					Brown, Dry, Weathered SANDSTONE						
				5	Gray, Dry, Weathered SHALE						
					Auger Refusal and Boring Terminated at 6.7m						
				10							

WATER LEVEL OBSERVATIONS

While Drilling	Dry	Upon Completion of Drilling	Dry	
Time After Drilling		24hrs.		
Depth to Water		N/A		
Depth to Cave in				

The stratification lines represent the approximate boundary between soil types and the transition may be gradual.

GENERAL NOTES

Start 8/21/01 End 8/21/01 Rig ATV
Driller Copeland Editor E.Felix
Remarks Backfilled apon completion of drilling with slurry mix and soil cuttings. 152mm Dia. HSA.

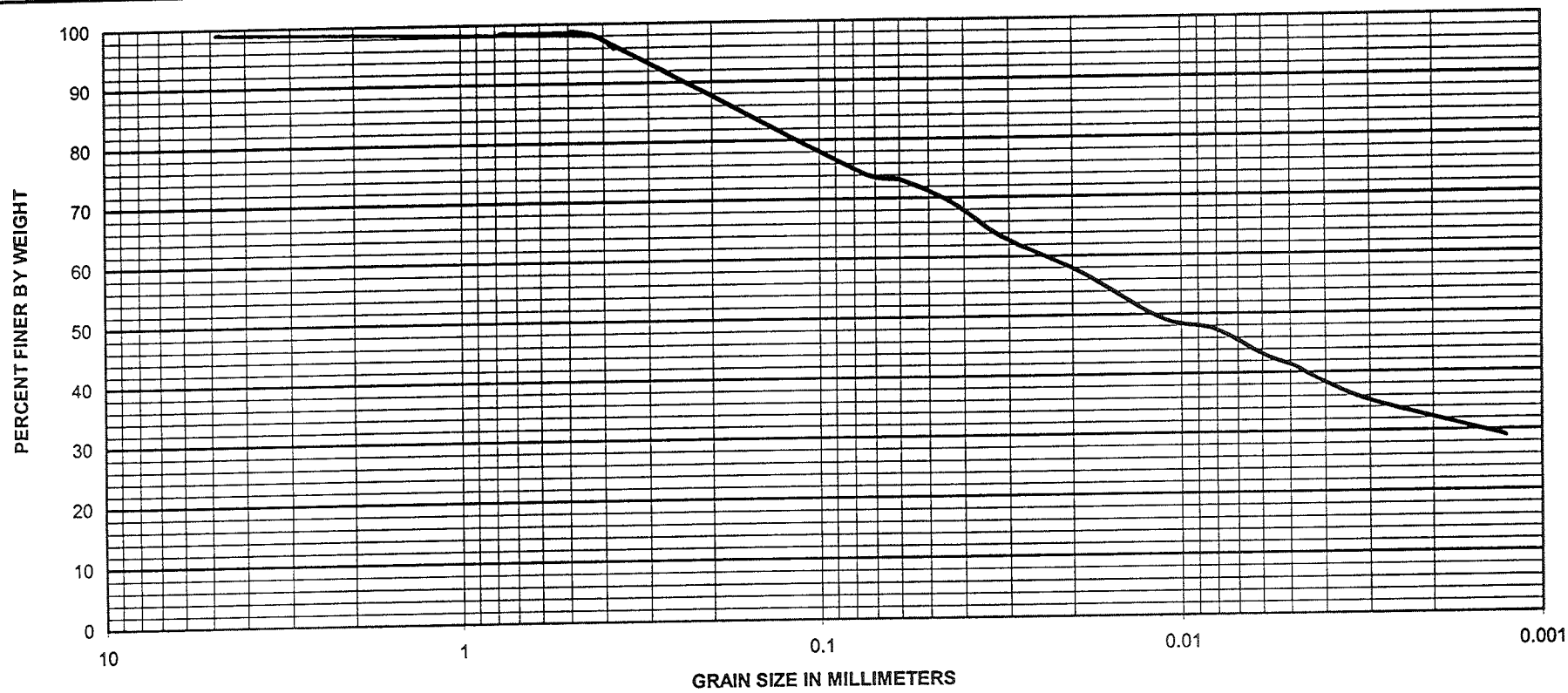
Des No: 9101565
US-231 in Spencer County, Indiana
Alt & Witzig File: S0901

CLASSIFICATION TEST DATA

Test No.	Boring # Station	Sample & Depth	Description	% Gravel	*Passing #40 #10-#200 % Sand	#200-.002mm % Silt	0.002mm % Clay	0.001mm % Colloids	LL	PL	PI	AASHTO Classification
01	TB-1 22+090 Line A, 59mRT	1 SS (0.3 – 0.8m)	Clay	1	*98 25	42	32	29	23	20	3	A-4(0)
02	TB-1 22+090 Line A, 59mRT	3 SS (1.8 – 2.3m)	Silty Loam	2	*98 26	53	19	16	21	18	3	A-4(0)
03	TB-2 22+158 Line A, 55mLT	4 SS (2.6 – 3.0m)	Sandy Loam and Gravel	43	*47 27	17	13	11	37	23	14	A-2-6(0)
04	TB-2 22+158 Line A, 55mLT	5 SS (4.1 – 4.6m)	Silty Clay Loam	0	6	74	20	19	26	22	4	A-4(3)
05	TB-1A 22+120 Line A, 3mRT	4 SS (2.6 – 3.0m)	Clay Loam	3	*92 36	40	21	20	24	19	5	A-4(1)
06	TB-7 25+975 Line A, 23mLT	2 SS (1.1 – 1.5m)	Clay Loam	15	*80 19	39	27	24	31	23	8	A-4(4)

BS - Bag Sample
SS - Split Spoon

Grain Size Distribution Curve



GRAVEL	SAND	SILT OR CLAY
	#10	#200

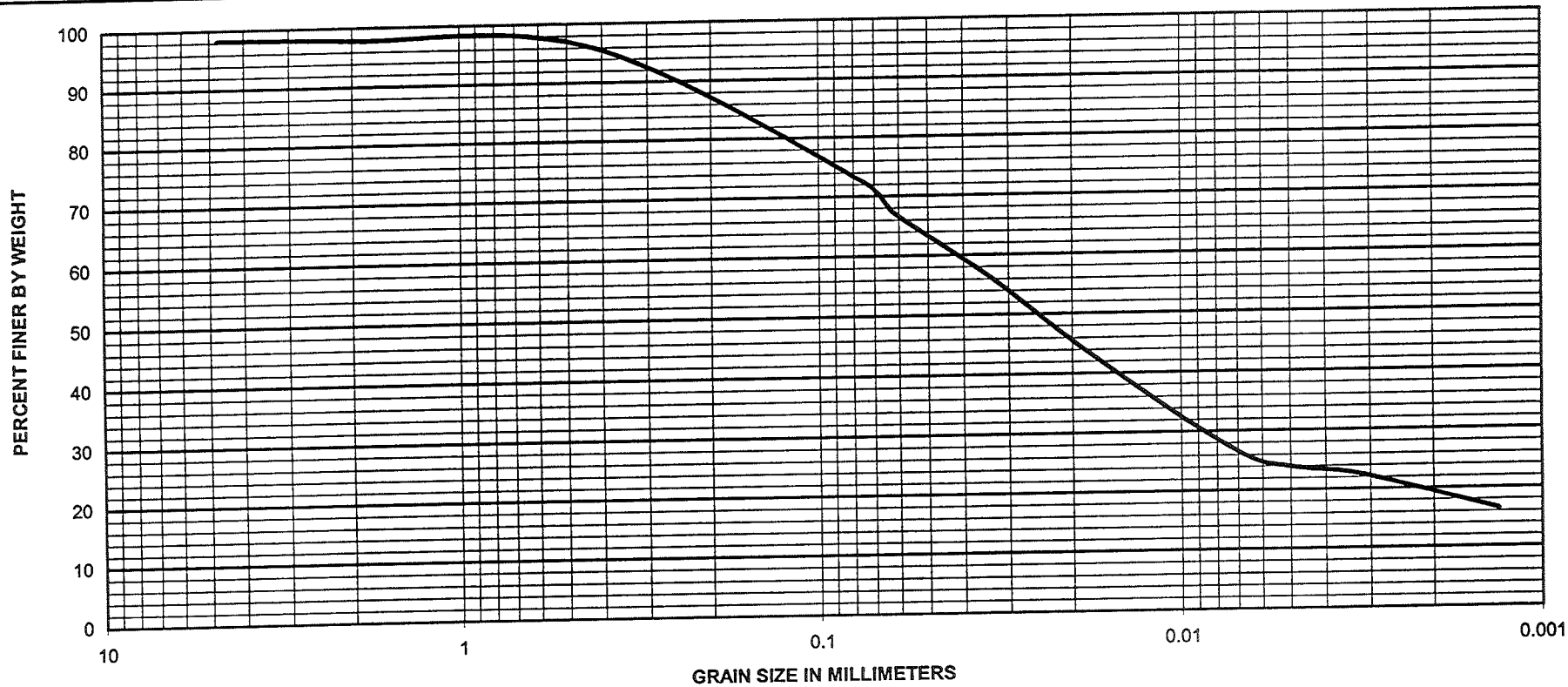
Boring No.	Sample No.	Elev or Depth	Nat w%	LL	PL	PI	Classification
TB-1	1 SS	0.3 - 0.8m	21.9	23	20	3	Clay
22+090		(1.0 - 2.5 ft)					A-4(0)
59mRT							
Line "A"							

Project: S0901
Des. No.: 9161365 - Project #: NH-075-3 ()
US 231 Structures
Spencer County, Indiana
Date: 7/01

A&W

#1

Grain Size Distribution Curve



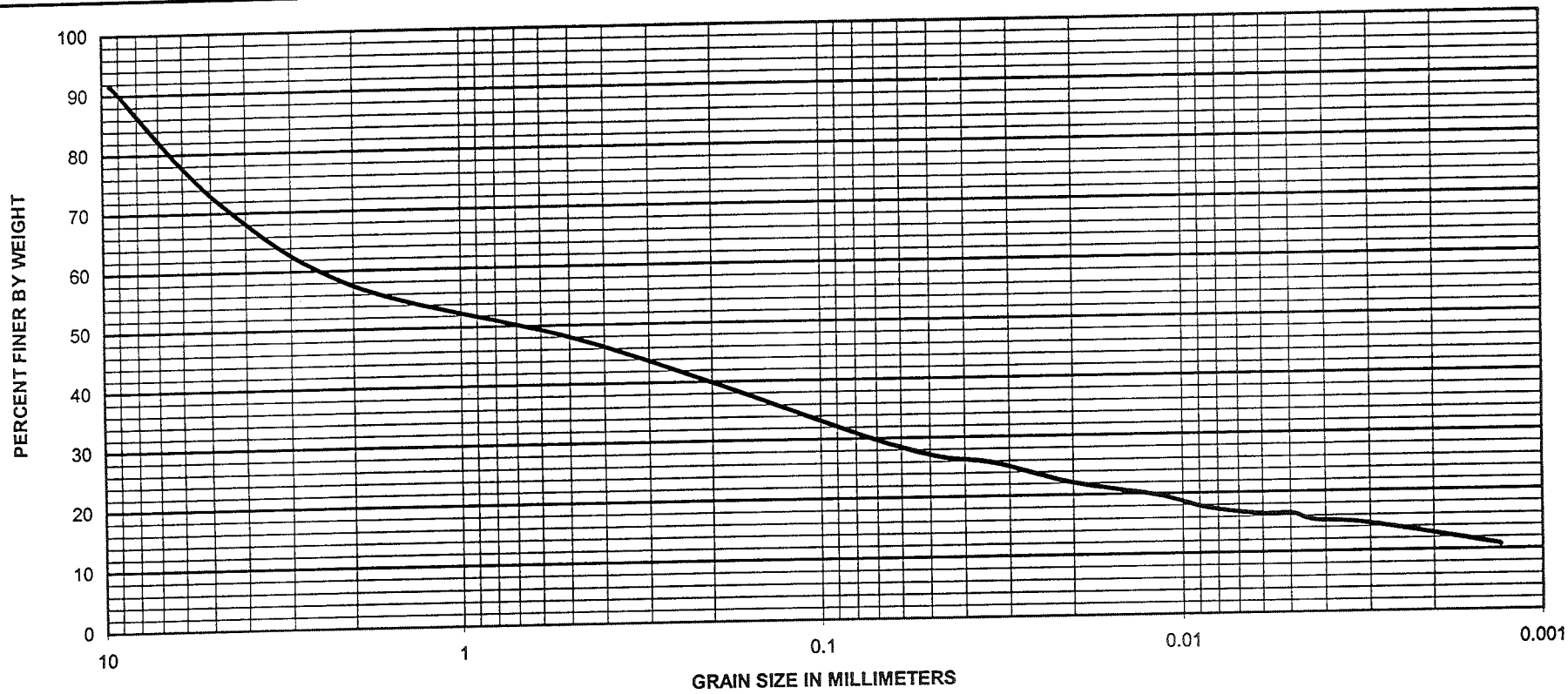
Boring No.	Sample No.	Elev or Depth	Nat W%	LL	PL	PI	Classification
TB-1	3 SS	1.8 - 2.3m	27.5	21	18	3	Silty Loam
22+090		(6.0 - 7.5ft)					A-4 (0)
59mRT							
Line "A"							

Project: S0901
Des No: 9161365, Project No: NH-075-3 ()
US-231 Structures
Spencer County, Indiana
Date: 7/01

A&W

#2

Grain Size Distribution Curve



GRAVEL	SAND	SILT OR CLAY
	#10	#200

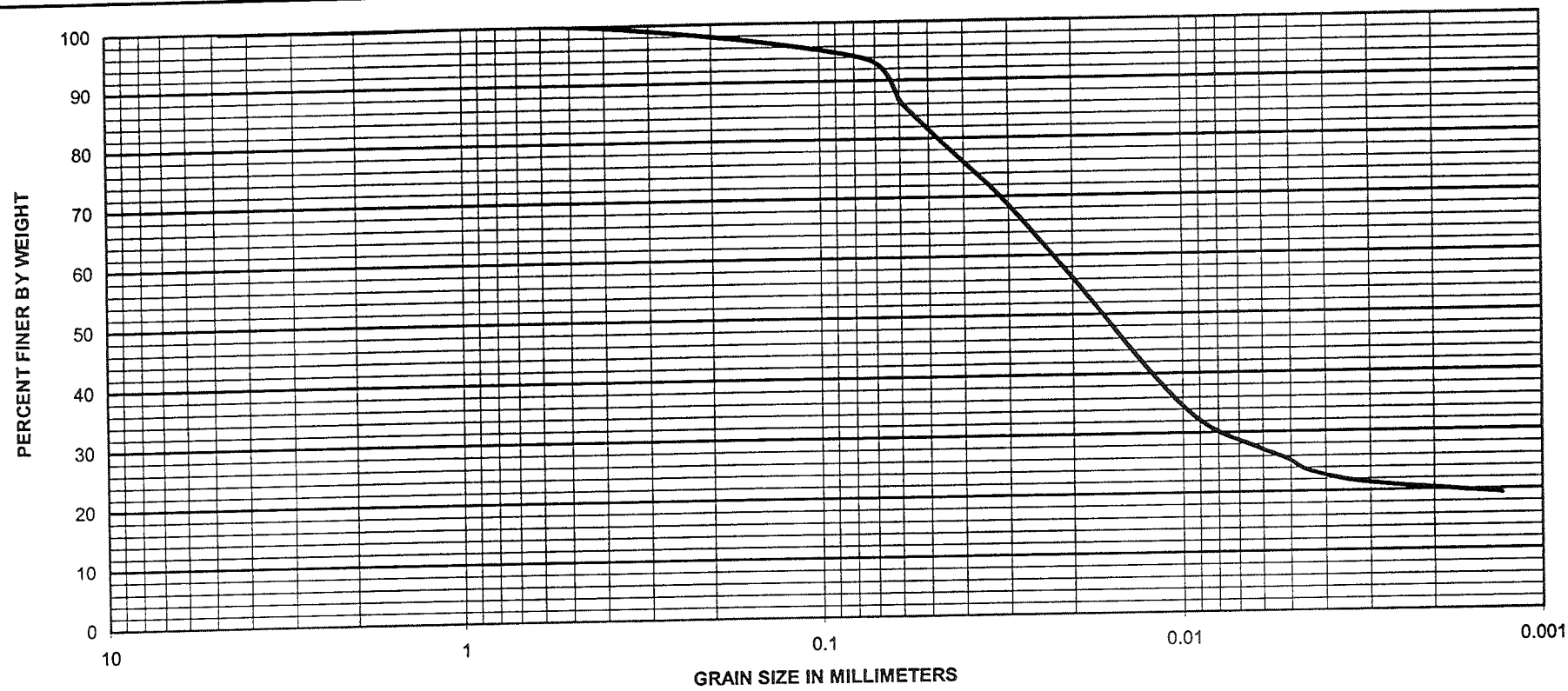
Boring No.	Sample No.	Elev or Depth	Nat w%	LL	PL	PI	Classification
TB-2	4 SS	2.6 - 3.0m	16.4	37	23	14	Sandy Loam and Gravel
22+158		(8.5 - 10.0ft)					A-2-6 (0)
55mLT							
Line "A"							

Project: S0901
Des. No.: 9161365 - Project #: NH-075-3 ()
US 231 Structures
Spencer County, Indiana
Date: 7/01

A&W

#3

Grain Size Distribution Curve



GRAVEL	SAND	SILT OR CLAY
	#10	#200

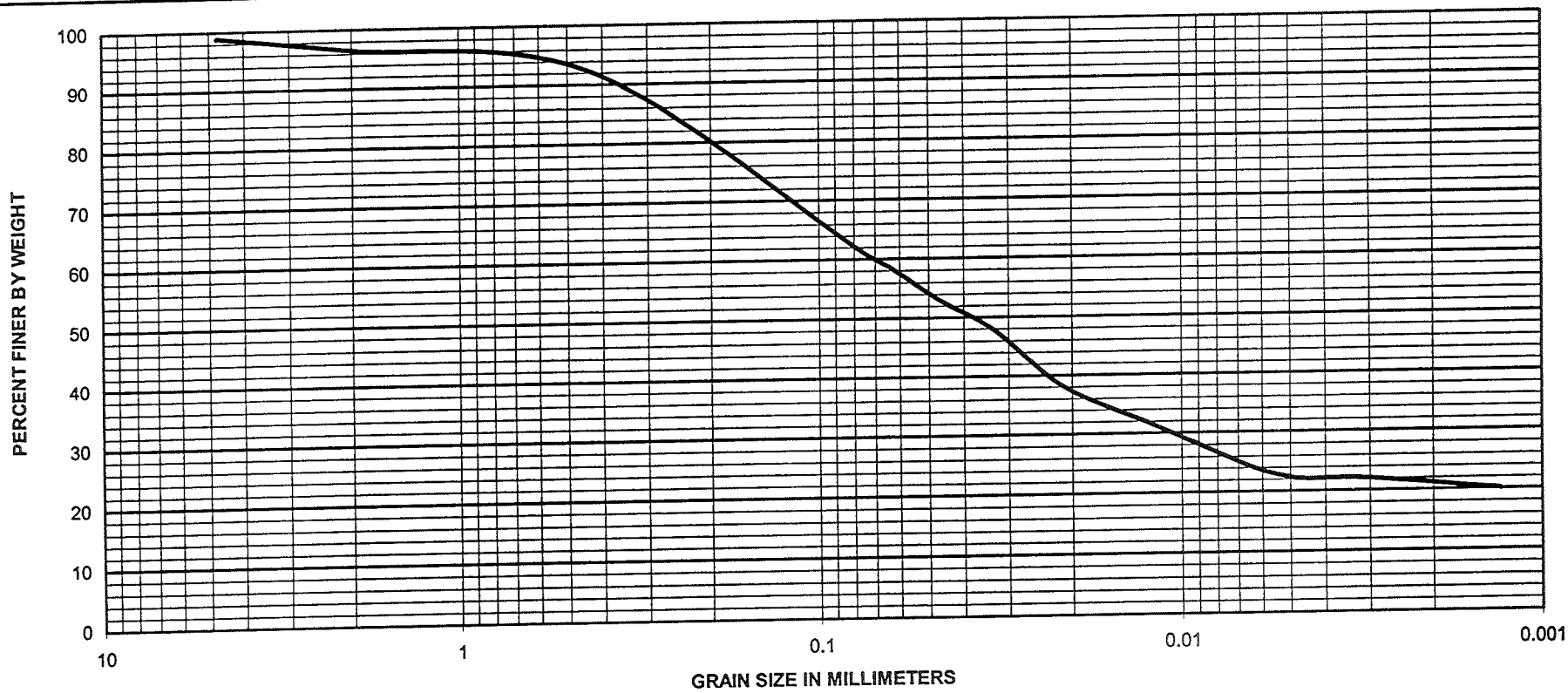
Boring No.	Sample No.	Elev or Depth	Nat w%	LL	PL	PI	Classification
TB-2	5 SS	4.1 - 4.6m	23.7	26	22	4	Silty Clay Loam
22+158		(13.5-15.0ft)					A-4(3)
55mLT							
Line "A"							

Project: S0901
Des. No.: 9161365 - Project #: NH-075-3 ()
US-231 Structures
Spemcer County, Indiana
Date: 7/01

A&W

#4

Grain Size Distribution Curve



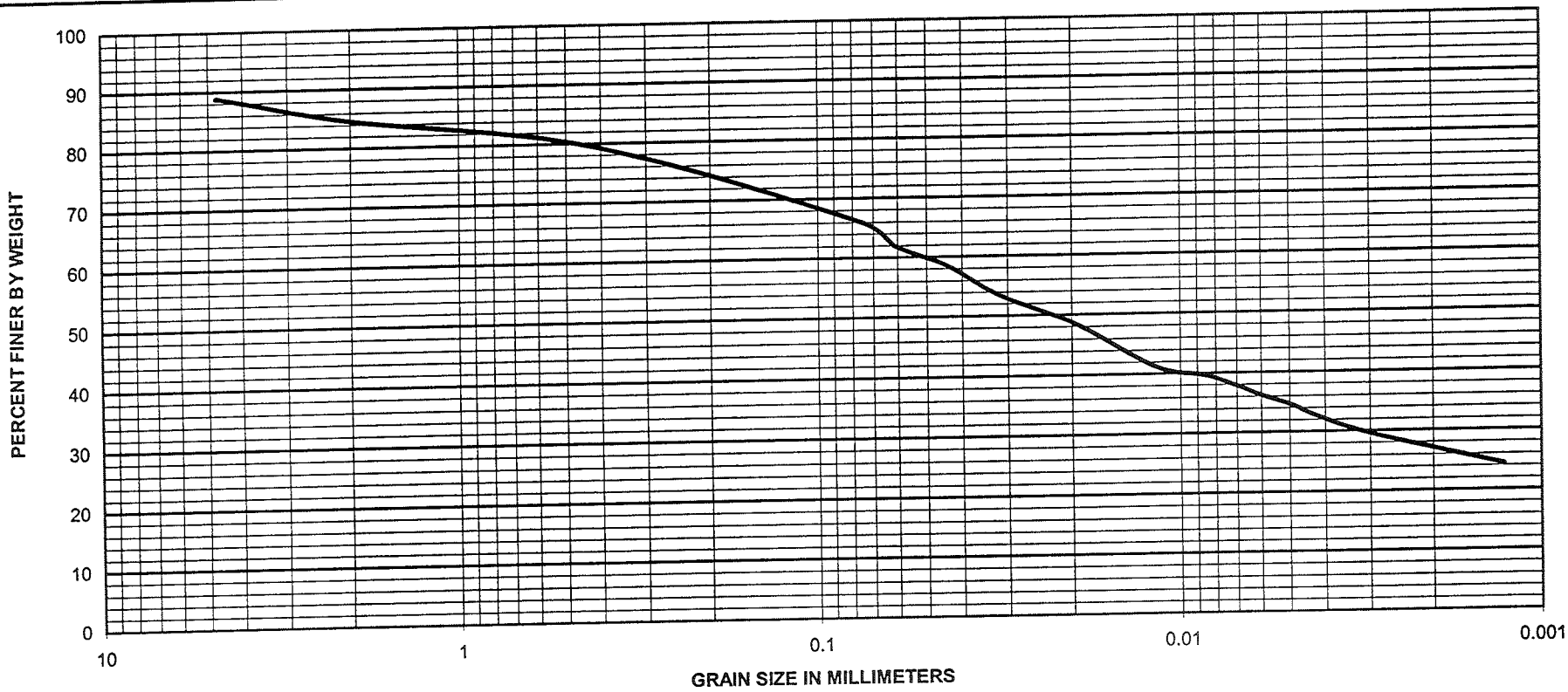
GRAVEL	SAND	SILT OR CLAY
	#10	#200

Boring No.	Sample No.	Elev or Depth	Nat w%	LL	PL	PI	Classification
TB-1A	4 SS	2.6 - 3.0 m	19.7	24	19	4	Clay Loam
22+120		(8.5 - 10.0ft)					A-4(1)
3mRT							
Line "A"							

Project: S0901
Des. No.: 9161365 - Project #: NH-075-3 ()
US-231 Structures
Spencer County, Indiana
Date: 7/01

A&W

Grain Size Distribution Curve



Boring No.	Sample No.	Elev or Depth	Nat w%	LL	PL	PI	Classification
TB-7	2 SS	1.1- 1.5m	18.1	31	23	8	Clay Loam
25+975		(3.5 - 5.0ft)					A-4(4)
23mLT							
Line "A"							

Project: S0901
Des. No.: 9161365 - Project #: NH-075-3 ()
US-231 Structures
Spencer County, Indiana
Date: 7/01

A&W

#6

MOISTURE CONTENT SUMMARY

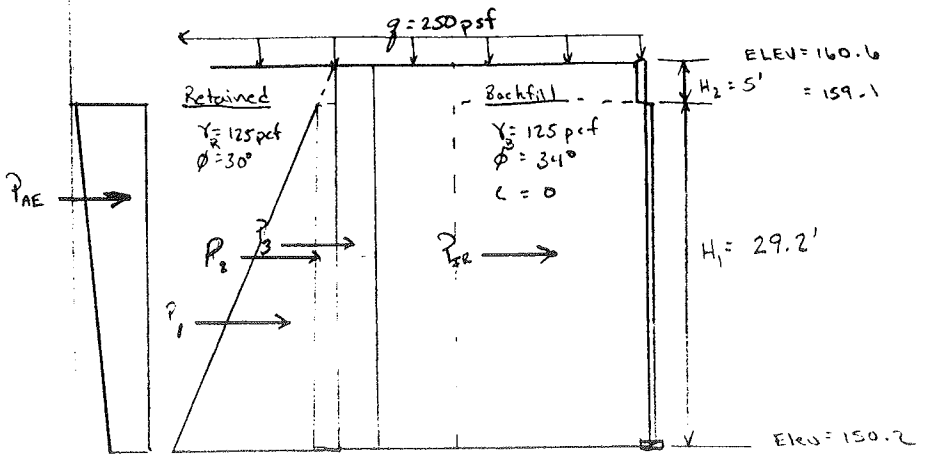
S0901

Boring	*Sample*	*Depth (ft)*	*Depth (m)*	*Moisture Content*
TB-1	1 SS	1.0-2.5	0.3-0.8	21.9
	3SS	6.0-7.5	1.8-2.3	27.5
TB-1A	4SS	8.5-10.0	2.6-3.0	19.7
TB-2	1SS	1.0-2.5	0.3-0.8	24.4
	4SS	8.5-10.0	2.6-3.0	16.4
	5SS	13.5-15.0	4.1-4.6	23.7
TB-5	1SS	1.0-2.5	0.3-0.8	21.6
	3SS	6.0-7.5	1.8-2.3	25.9
TB-6	3SS	6.0-7.5	1.8-2.3	20.3
TB-7	2SS	3.5-5.0	1.1-1.5	21.2

pH Summary
US-231 in Spencer County

Boring	*Sample*	*Depth (m)*	*pH*
TB-1	1 SS	0.3 – 0.8	5.4
TB-1	3 SS	1.8 – 2.3	6.7
TB-2	4 SS	2.6 – 3.0	6.0
TB-2	5 SS	4.1 – 4.6	5.4
TB-1A	4 SS	2.6 – 3.0	6.8
TB-7	2 SS	1.1 – 1.5	6.4

TB-4 & TB-5 MSE Wall Analysis Station 25+943, EB-1



Foundation
γ_F = 125 pcf
c = 2500 psf
φ = 0

Assume

1) Lateral Force from soil above top of wall is resisted by either tie backs into the abutments or lateral pile resistance.

2) Horizontal Earthquake Acceleration Factor = 1.0 = A

Find Ka: $K_a = \tan^2(45 - \phi/2) = \tan^2(45 - 30/2) = 0.33$

Find P_a: $P_a = P_3 + P_2 + P_1 = K_a q_o (H_1 + H_2) + K_a(\gamma_R) H_2 H_1 + \frac{1}{2} K_a \gamma_R H_1^2$

$P_a = .33(250\text{psf})(29.2+5) + 0.33(125)(29.2)(5) + \frac{1}{2}(.33)(125)(29.2)^2$

(2821.5 + 6022.5 + 17585.7)

$= \underline{26429.7 \text{ lb/ft}}$

Find z resultant: $z = \dfrac{P_1\left(\frac{H_1}{3}\right) + P_2\left(\frac{H_1}{2}\right) + P_3\left(\frac{(H_1+H_2)}{2}\right)}{P_a}$

$z = \dfrac{17585.7\left(\frac{29.2}{3}\right) + 6022.5\left(\frac{29.2}{2}\right) + 2821.5\left(\frac{34.2}{2}\right)}{26429.7} = \underline{11.63'}$

Lateral Forces due to Earthquake

Find A_m: $A_m = (1.45 - A)A = (1.45 - 1)1 = \underline{0.45}$

Find $P_{AE} = 0.375 A_m \gamma_R H_1^2 = .375(.45)(125 \text{ pcf})(29.2)^2 = \underline{17985.4 \text{ lb/ft}}$

P_{AE} is located @ $0.6 H_1 = .6(29.2) = \underline{17.5'}$

Find $P_{IR} = 0.5 A_m \gamma_B H_1^2 = .5(.45)(125)(29.2)^2 = \underline{23980.5 \text{ lb/ft}}$ @ $H_1/2 = 14.6'$

Lateral Earth Pressures	Distance From Base
P_a = 26430 lb/ft	11.63'
P_{AE} = 8993 lb/ft	17.5'
P_{IR} = 23980 lb/ft	14.6'

Use 50% in Calculations

Factor of Safety Against Sliding

Earthquake

$$F.S_{(sliding)} = \frac{\sum P_{resisting}}{\sum P_{driving}} = \frac{W_1 \tan\phi + B C_a}{P_D}$$ (Neglect $B C_a$)

Assume
- Neglect Surcharge
- $C_a = 1200$ psf
- $\phi = 30°$

$$P_D = P_a + P_{AE} + P_{IR} = 26430 + 8993 + 23980 = \underline{59,403} \text{ lb/ft}$$

Try reinforcement strip $0.7H = 0.7(29.2') = 20.44$ Use $L = 20'$

$$W_1 = \gamma_R (H_1 + H_2)(L) = 125 \text{ pcf}(29.2+5)(20) = \underline{85,500} \text{ lb/ft}$$

1) Assume undercut 1.5m and replace with retained backfill $\phi = 30°$.

$$F.S. = \frac{W_1 \tan\phi_1}{P_D} = \frac{85500 \tan 30°}{59403} = 0.83 < .75(1.5) = 1.12$$ so ab good

Try $0.9H = 0.9(29.2) = 26.28'$, Use $L = 26'$

$$W_1 = 125(29.2+5)(26) = 111,150 \text{ lb/ft}$$

$$F.S. = \frac{111150 \tan 30°}{59403} = 1.08 < 1.12$$ so No Good

Try $1.0H \simeq 1.0(29.2) = 29.2$ Use $L = 29'$

$$W_1 = 125(29.2+5)(29) = 123,975 \text{ lb/ft}$$

$$F.S. = \frac{123975 \tan 30°}{59403} = 1.20 > .75(1.5) = 1.12$$ so o.k.

* Undercut 1.5m and replace with "B" Borrow, $\phi = 30°$
* Use 1.0H length strips where H is the height of the MSE Wall

Long-Term Conditions

$P_D = P_a = 26,430$ lb/ft
$W_1 = 123,975$ lb/ft

$$F.S. = \frac{123,975 (\tan 30°)}{26,430} = 2.71 > 1.5$$ so o.k.

MSE Wall Analysis Station 25+943, EB-1

Factor of Safety Against Bearing Capacity Failure

Foundation: $c = 2500$ psf $N_c = 5.53$
$\gamma = 125$ pcf $N_\gamma = 1$
$\phi = 0$
Neglect surcharge

Earthquake:

$$Q_{ult} = cN_c = 2500\text{psf}(5.53) = 13{,}825 \text{ psf}$$

Find eccentricity: $e = \frac{L}{2} - \frac{\Sigma M_R - \Sigma M_O}{\Sigma V}$

$$e = \frac{29}{2} - \left(\frac{29(125)(34.2)\left(\frac{29}{2}\right) - (26430(11.63) + 8993(17.5) + 23980(14.6))}{29(125)(34.2)}\right)$$

(1,797,637.5)

$e = 6.6'$ from front of wall

For Earthquake Analysis: $e < \frac{L}{3} = \frac{29}{3} = 9.67$ so O.K

$$\sigma_V = \frac{\gamma(H_1+H_2)L + q_0 L}{B} = \frac{125(34.2)(29) + 250\text{psf}(29)}{29 - 2(6.6)} = 8{,}305.4 \text{ psf}$$

$$\text{F.S.} = \frac{Q_{ult}}{\sigma_V} = \frac{13825}{8{,}305.4} = 1.66 \geq .75(2.0) = 1.5 \text{ so O.K.}$$

* Use 1.0H Long Reinforcement Strips

Long Term Conditions:

$Q_{ult} = 13{,}825$ psf

Find eccentricity: $e = \frac{29}{2} - \left(\frac{29(125)(34.2)\left(\frac{29}{2}\right) - (26430(11.63))}{29(125)(34.2)}\right) = 2.5'$

$e < \frac{L}{6e} = \frac{29}{6} = 4.8'$ so O.K.

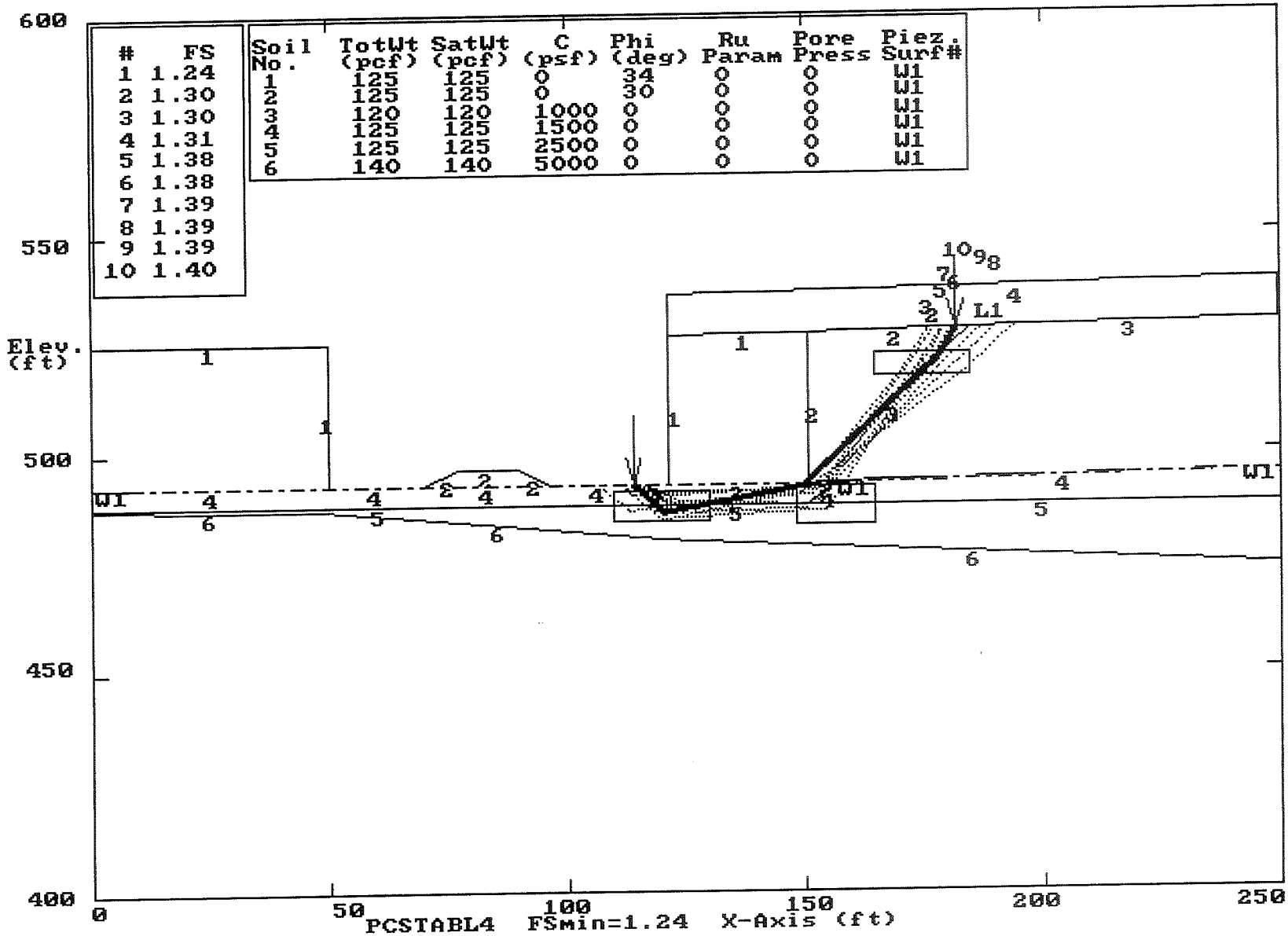
$$\sigma_V = \frac{125(34.2)(29) + 250(29)}{29 - (2)(2.5)} = 5467.7 \text{ psf}$$

$$\text{F.S.} = \frac{Q_{ult}}{\sigma_V} = \frac{13825}{5467.7} = 2.5 > 2 \text{ so O.K.}$$

US-231 Spencer County - MSE Walls Station 25+943 @ End Bent #1, TB-5
Ten Most Critical. C:01139DD.PLT By: A&W ENGINEERING, INC. 12-27-01 2:18pm

#	FS
1	1.24
2	1.30
3	1.30
4	1.31
5	1.38
6	1.38
7	1.39
8	1.39
9	1.39
10	1.40

Soil No.	TotWt (pcf)	SatWt (pcf)	C (psf)	Phi (deg)	Ru Param	Pore Press	Piez. Surf#
1	125	125	0	34	0	0	W1
2	125	125	0	30	0	0	W1
3	120	120	1000	0	0	0	W1
4	125	125	1500	0	0	0	W1
5	125	125	2500	0	0	0	W1
6	140	140	5000	0	0	0	W1



PCSTABL4 FSmin=1.24 X-Axis (ft)

** PCSTABL4 **

by
Purdue University

--Slope Stability Analysis--
Simplified Janbu Method of Slices
or Simplified Bishop Method

Run Date:	12-27-01
Time of Run:	2:18pm
Run By:	A&W ENGINEERING, INC.
Input Data Filename:	C:01139DD
Output Filename:	C:01139DD.OUT
Plotted Output Filename:	C:01139DD.PLT

PROBLEM DESCRIPTION US-231 Spencer County - MSE Walls
Station 25+943 @ End Bent #1

BOUNDARY COORDINATES
NOTE: User defined origin was specified.
Add 00.00 to X values and 400.00 to Y values listed.

12 Top Boundaries
27 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	125.60	50.00	125.60	1
2	50.00	125.60	50.10	92.80	1
3	50.10	92.80	70.00	92.80	4
4	70.00	92.80	77.00	96.70	2
5	77.00	96.70	90.00	96.70	2
6	90.00	96.70	97.00	92.80	2
7	97.00	92.80	116.50	92.80	4
8	116.50	92.80	121.60	92.80	2
9	121.60	92.80	121.70	126.90	1
10	121.70	126.90	150.80	127.60	1
11	150.80	127.60	184.90	128.20	2
12	184.90	128.20	250.00	129.60	3
13	.00	92.80	50.10	92.80	4
14	70.00	92.80	97.00	92.80	4
15	121.60	92.80	150.70	92.80	2
16	150.70	92.80	150.80	127.60	2
17	150.70	92.80	184.90	128.20	3
18	150.70	92.80	156.70	93.00	2
19	156.70	93.00	250.00	95.00	4
20	116.50	92.80	121.60	88.00	4

21	150.70	88.00	156.70	93.00	4
22	.00	88.00	121.60	88.00	5
23	121.60	88.00	150.70	88.00	5
24	150.70	88.00	250.00	88.00	5
25	.00	87.50	50.00	87.20	6
26	50.00	87.20	121.70	80.00	6
27	121.70	80.00	250.00	73.40	6

ISOTROPIC SOIL PARAMETERS

6 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	125.0	125.0	.0	34.0	.00	.0	1
2	125.0	125.0	.0	30.0	.00	.0	1
3	120.0	120.0	1000.0	.0	.00	.0	1
4	125.0	125.0	1500.0	.0	.00	.0	1
5	125.0	125.0	2500.0	.0	.00	.0	1
6	140.0	140.0	5000.0	.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 3 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	.00	92.80
2	156.70	92.80
3	250.00	95.00

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (lb/sqft)	Deflection (deg)
1	121.70	250.00	250.0	.0

NOTE - Intensity Is Specified As A Uniformly Distributed Force Acting On A Horizontally Projected Surface.

A Horizontal Earthquake Loading Coefficient Of .100 Has Been Assigned

A Vertical Earthquake Loading Coefficient Of .000 Has Been Assigned

Cavitation Pressure = .0 psf

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Sliding Block Surfaces, Has Been Specified.

The Active And Passive Portions Of The Sliding Surfaces Are Generated According To The Rankine Theory.

50 Trial Surfaces Have Been Generated.

3 Boxes Specified For Generation Of Central Block Base

Length Of Line Segments For Active And Passive Portions Of Sliding Block Is 5.0

Box No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Height (ft)
1	110.00	88.00	130.00	88.00	7.00
2	148.00	88.00	165.00	88.00	9.00
3	165.10	120.00	185.00	120.00	5.00

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 8 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)

1	114.04	92.80
2	115.30	91.54
3	118.84	88.00
4	120.43	86.40
5	149.62	92.18
6	178.03	121.39
7	180.53	125.72
8	181.93	128.15

*** 1.241 ***

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	114.31	92.80
2	117.21	89.90
3	153.12	92.39
4	173.27	121.31
5	175.77	125.64
6	177.16	128.06

*** 1.296 ***

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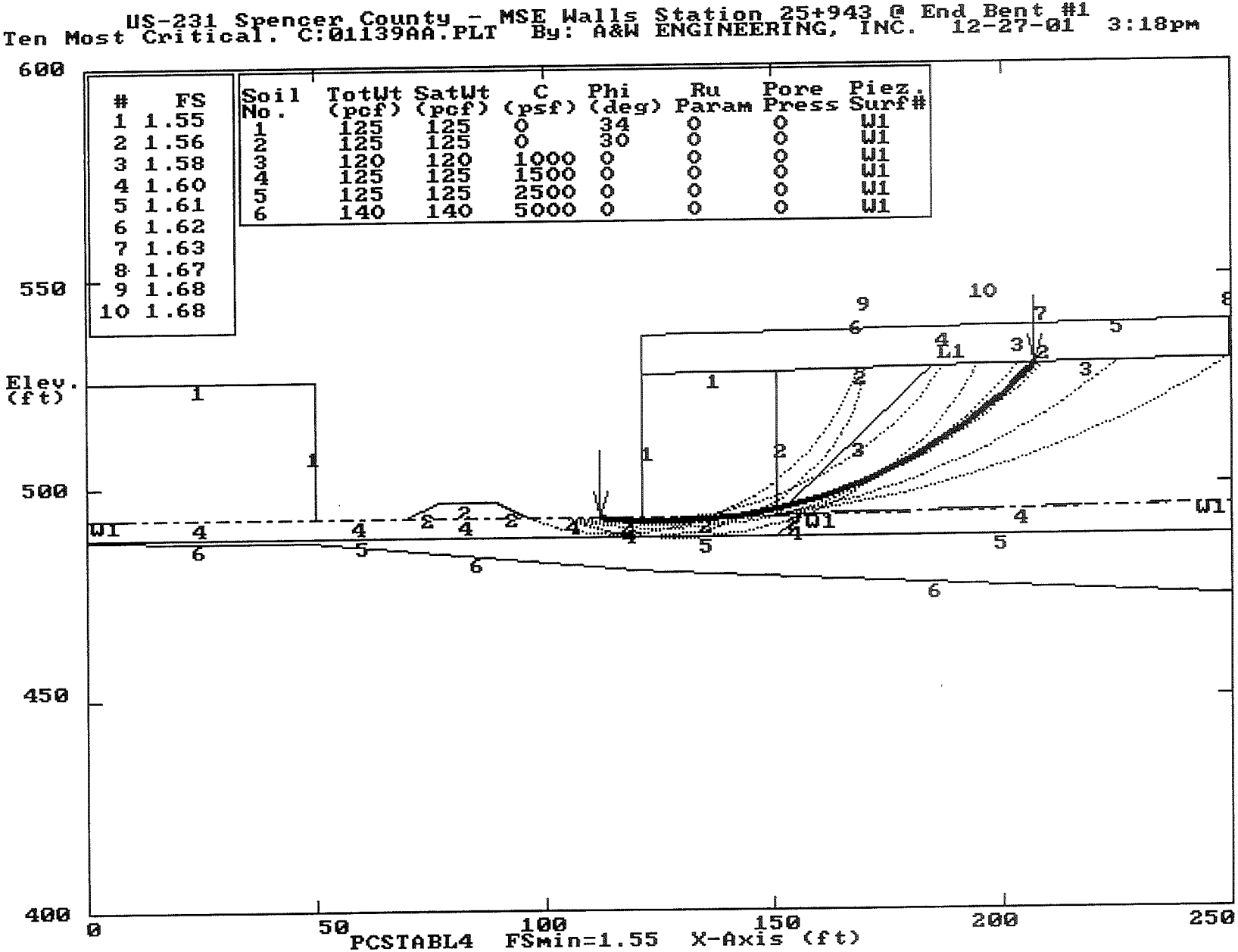
Failure Surface Specified By 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	114.61	92.80
2	115.16	92.48
3	119.49	89.98
4	122.93	88.00
5	125.01	85.91
6	149.33	90.89
7	170.92	119.21
8	173.42	123.54
9	175.92	127.87
10	176.02	128.04

*** 1.301 ***

Failure Surface Specified By 9 Coordinate Points


US-231 Spencer County - MSE Walls Station 25+943 @ End Bent #1
Ten Most Critical. C:01139AA.PLT By: A&W ENGINEERING, INC. 12-27-01 3:18pm
FS
1 1.55
2 1.56
3 1.58
4 1.60
5 1.61
6 1.62
7 1.63
8 1.67
9 1.68
10 1.68
Soil No. | TotWt (pcf) | SatWt (pcf) | C (psf) | Phi (deg) | Ru Param | Pore Press | Piez. Surf#
1 | 125 | 125 | 0 | 34 | 0 | 0 | W1
2 | 125 | 125 | 0 | 30 | 0 | 0 | W1
3 | 120 | 120 | 1000 | 0 | 0 | 0 | W1
4 | 125 | 125 | 1500 | 0 | 0 | 0 | W1
5 | 125 | 125 | 2500 | 0 | 0 | 0 | W1
6 | 140 | 140 | 5000 | 0 | 0 | 0 | W1
Elev. (ft)
600
550
500
450
400
0
50
100
150
200
250
W1
L1
PCSTABL4 FSmin=1.55 X-Axis (ft)

** PCSTABL4 **

by
Purdue University

--Slope Stability Analysis--
Simplified Janbu Method of Slices
or Simplified Bishop Method

Run Date:	12-27-01
Time of Run:	3:18pm
Run By:	A&W ENGINEERING, INC.
Input Data Filename:	C:01139AA
Output Filename:	C:01139AA.OUT
Plotted Output Filename:	C:01139AA.PLT

PROBLEM DESCRIPTION US-231 Spencer County - MSE Walls
Station 25+943 @ End Bent #1

BOUNDARY COORDINATES
NOTE: User defined origin was specified.
Add 00.00 to X values and 400.00 to Y values listed.

12 Top Boundaries
27 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	125.60	50.00	125.60	1
2	50.00	125.60	50.10	92.80	1
3	50.10	92.80	70.00	92.80	4
4	70.00	92.80	77.00	96.70	2
5	77.00	96.70	90.00	96.70	2
6	90.00	96.70	97.00	92.80	2
7	97.00	92.80	116.50	92.80	4
8	116.50	92.80	121.60	92.80	2
9	121.60	92.80	121.70	126.90	1
10	121.70	126.90	150.80	127.60	1
11	150.80	127.60	184.90	128.20	2
12	184.90	128.20	250.00	129.60	3
13	.00	92.80	50.10	92.80	4
14	70.00	92.80	97.00	92.80	4
15	121.60	92.80	150.70	92.80	2
16	150.70	92.80	150.80	127.60	2
17	150.70	92.80	184.90	128.20	3
18	150.70	92.80	156.70	93.00	2
19	156.70	93.00	250.00	95.00	4
20	116.50	92.80	121.60	88.00	4

21	150.70	88.00	156.70	93.00	4
22	.00	88.00	121.60	88.00	5
23	121.60	88.00	150.70	88.00	5
24	150.70	88.00	250.00	88.00	5
25	.00	87.50	50.00	87.20	6
26	50.00	87.20	121.70	80.00	6
27	121.70	80.00	250.00	73.40	6

ISOTROPIC SOIL PARAMETERS

6 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	125.0	125.0	.0	34.0	.00	.0	1
2	125.0	125.0	.0	30.0	.00	.0	1
3	120.0	120.0	1000.0	.0	.00	.0	1
4	125.0	125.0	1500.0	.0	.00	.0	1
5	125.0	125.0	2500.0	.0	.00	.0	1
6	140.0	140.0	5000.0	.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 3 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	.00	92.80
2	156.70	92.80
3	250.00	95.00

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (lb/sqft)	Deflection (deg)
1	121.70	250.00	250.0	.0

NOTE - Intensity Is Specified As A Uniformly Distributed Force Acting On A Horizontally Projected Surface.

A Horizontal Earthquake Loading Coefficient Of .100 Has Been Assigned

A Vertical Earthquake Loading Coefficient Of .000 Has Been Assigned

Cavitation Pressure = .0 psf

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

300 Trial Surfaces Have Been Generated.

30 Surfaces Initiate From Each Of 10 Points Equally Spaced Along The Ground Surface Between X = 50.10 ft.
and X = 120.00 ft.

Each Surface Terminates Between X = 150.00 ft.
and X = 250.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = .00 ft.

5.00 ft. Line Segments Define Each Trial Failure Surface.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 23 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	112.23	92.80
2	117.20	92.21

3	122.19	91.85
4	127.18	91.73
5	132.18	91.85
6	137.17	92.21
7	142.14	92.80
8	147.07	93.63
9	151.95	94.69
10	156.78	95.99
11	161.55	97.51
12	166.23	99.25
13	170.83	101.22
14	175.33	103.40
15	179.72	105.79
16	183.99	108.39
17	188.13	111.19
18	192.14	114.18
19	196.00	117.36
20	199.70	120.72
21	203.24	124.25
22	206.61	127.95
23	207.21	128.68

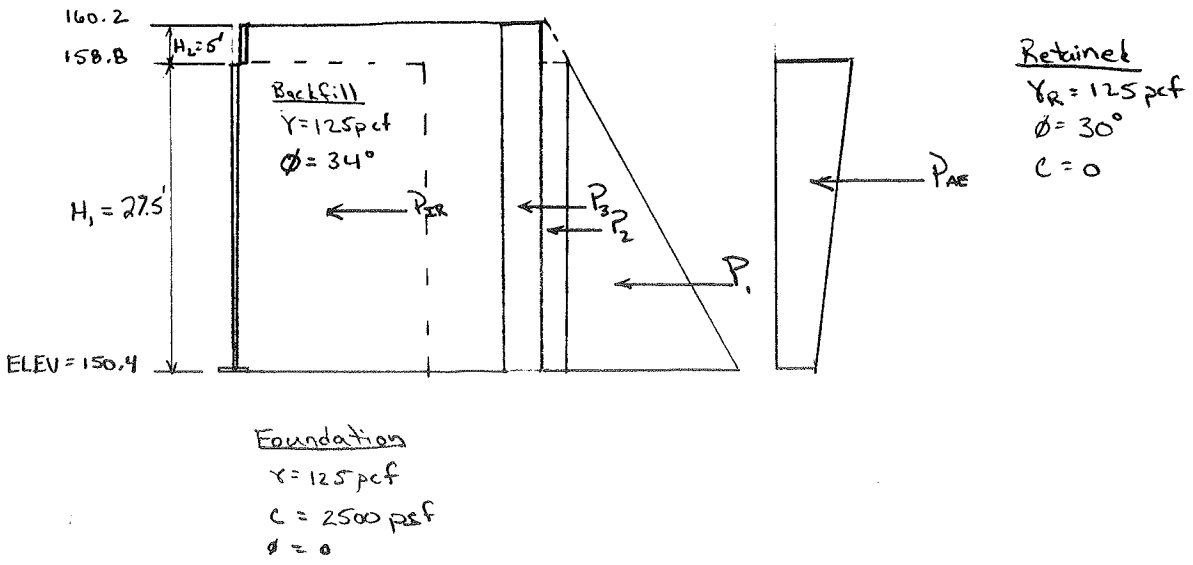
Circle Center At X = 127.2 ; Y = 197.0 and Radius, 105.2

*** 1.551 ***

Failure Surface Specified By 23 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	112.23	92.80
2	117.20	92.25
3	122.19	91.93
4	127.19	91.83
5	132.19	91.96
6	137.18	92.32
7	142.14	92.90
8	147.08	93.71
9	151.97	94.73
10	156.81	95.98
11	161.59	97.45
12	166.30	99.13
13	170.93	101.02
14	175.47	103.12
15	179.91	105.42
16	184.24	107.92
17	188.45	110.61
18	192.54	113.49
19	196.49	116.55
20	200.30	119.79
21	203.96	123.20
22	207.46	126.77
23	209.22	128.72

TB-6 & TB-7 MSE Wall Analysis Station 25+962, EB-2



Find k_a: $k_a = \tan^2(45 - \phi/2) = \tan^2(45 - 30/2) = \underline{0.33}$

Find P_a: $P_a = P_1 + P_2 + P_3 = \frac{1}{2} k_a \gamma_R H_1^2 + k_a \gamma_R H_1 H_2 + k_a q_o (H_1 + H_2)$

$P_a = .5(.33)(125pcf)(27.5ft)^2 + 0.33(125pcf)(27.5')(5') + 0.33(250psf)(32.5ft)$

(15,597.7) (5671.9) (2681.2)

$= \underline{23950.8 \text{ lb/ft}}$

Find $\bar{z}$ resultant: $\bar{z} = \dfrac{P_1(\frac{H_1}{3}) + P_2(\frac{H_1}{2}) + P_3(\frac{H_1+H_2}{2})}{P_a}$

$= \dfrac{15597.7(\frac{27.5}{3}) + 5671.9(\frac{27.5}{2}) + 2681.2(\frac{32.5}{2})}{23950.8} = \underline{11.0 \text{ ft}}$

Find A_m: $A_m = (1.45 - A)A = (1.45 - 1)1 = \underline{0.45}$

Find $P_{AE} = 0.375 A_m \gamma_R H_1^2 = 0.375(.45)(125)(27.5)^2 = 15952.1$ lb/ft

Use 50% in Design = $\underline{7976 \text{ lb/ft}}$

P_{AE} is located @ $0.6H_1 = 0.6(27.5) = \underline{16.5'}$

Find $P_{IR} = 0.5 A_m \gamma_B H_1^2 = 0.5(.45)(125)(27.5)^2 = 21269.5$ lb/ft

Lateral Earth Pressure	Distance From Base
P_a = 23951 lb/ft	11.0 ft
P_{AE} = 7976 lb/ft	16.5 ft
P_{IR} = 21270 lb/ft	13.75 ft

Factor of Safety Against Sliding

$$F.S._{(sliding)} = \frac{\Sigma P_{resisting}}{\Sigma P_{Driving}} = \frac{W_1 \tan\phi + \cancel{BC_a}\ \text{Neglect}}{P_a + P_{AE} + P_{IR}}$$

Earthquake

Undercut beneath reinforcement strips and replace with Retained Fill $\phi = 30°$

Try reinforcement strips of $0.7H = 0.7(27.5) = 19.25$ use $L = 19'$

$$W_1 = \gamma_B L (H_1 + H_2) = 125pcf(19ft)(27.5 + 5.0ft) = 77,187.5 lb/ft$$

$$F.S. = \frac{77187.5 \tan 30°}{(23951 + 7976 + 21270)} = 0.84 < 1.5(.75) = 1.12 \text{ so No Good}$$

Try $0.9H = 0.9(27.5) = 24.75$ use $L = 25'$

$$W_1 = 125(25)(27.5 + 5) = 101562.5 lb/ft$$

$$F.S. = \frac{101562.5 \tan 30°}{53,197} = 1.10 < 1.12 \text{ so No Good}$$

$$F.S. = \frac{113,750 \tan 38}{(23951 + 7976 + 21270)} = 1.23 > .75(1.5) = 1.12 \text{ so o.k.}$$

* Undercut 1.5m and replace with Retained Fill, $\phi = 30°$,
* Use 1.0H length strips where H is the height of the MSE wall.

Long Term Conditions

$W_1 = 113,750 lb/ft$

$P_D = P_a = 23951 lb/ft$

$$F.S. = \frac{113,750 \tan 30°}{23951} = 2.74 > 1.5 \text{ so o.k.}$$

Factor of Safety Against Bearing Capacity Failure

Foundation

$c = 2500$ psf $\quad N_c = 5.53$

$\gamma = 125$ pcf $\quad N_\gamma = 1.0$

$\phi = 0$

Neglect Surcharge

$$Q_{ULT} = cN_c = 2500\,psf(5.53) = 13,825$$

Earthquake:

Find eccentricity: $e = \frac{L}{2} - \frac{\Sigma M_R - \Sigma M_O}{\Sigma V}$

$$e = \frac{28}{2} - \left(\frac{28(125)(32.5)(\frac{28}{2}) - (23951(11) + 7976(16.5) + 21270(13.75))}{125(28)(32.5)}\right)$$

(1,592,500 and 687,527.5)

$e = 6.04 < \frac{L}{3} = \frac{28}{3} = 9.33$ so o.k.

$$\sigma_v = \frac{125(28)(32.5) + 250(28)}{28 - 2(6.04)} = 7584.8\ psf$$

$$F.S. = \frac{Q_{ULT}}{\sigma_v} = \frac{13825}{7584.8} = 1.8 > .75(2.0) = 1.5 \quad \text{so o.k}$$

* Use 1.0H Length Reinforcement strips

Long-Term Conditions:

$Q_{ULT} = 13,825$ psf

$$e = \frac{28}{2} - \left(\frac{28(125)(32.5)(\frac{28}{2}) - 23951(11)}{125(28)(32.5)}\right) = 2.32'$$

$e < \frac{L}{6a} = \frac{28}{6a} = 4.67$ so o.k.

$$\sigma_v = \frac{125(28)(32.5) + 250(28)}{28 - 2(2.32)} = 5169.1\ psf$$

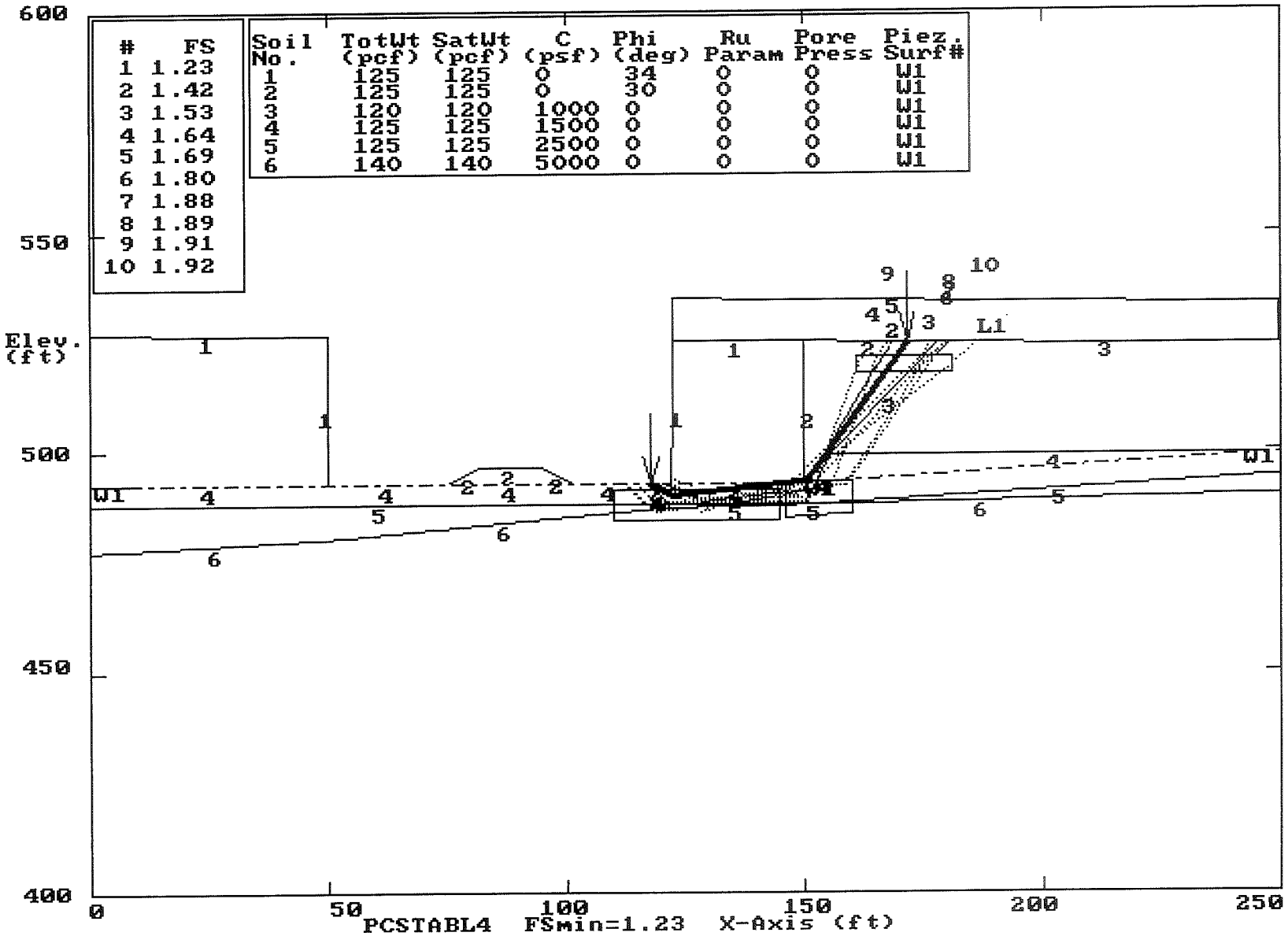
$$F.S. = \frac{13825}{5169.1} = 2.67 > 2 \text{ so o.k.}$$

US-231 Spencer County Station 25+962 - End Bent #2

Ten Most Critical. C:01139CC.PLT By: A&W ENGINEERING, INC. 12-27-01 3:08pm

#	FS
1	1.23
2	1.42
3	1.53
4	1.64
5	1.69
6	1.80
7	1.88
8	1.89
9	1.91
10	1.92

Soil No.	TotWt (pcf)	SatWt (pcf)	C (psf)	Phi (deg)	Ru Param	Pore Press	Piez. Surf#
1	125	125	0	34	0	0	W1
2	125	125	0	30	0	0	W1
3	120	120	1000	0	0	0	W1
4	125	125	1500	0	0	0	W1
5	125	125	2500	0	0	0	W1
6	140	140	5000	0	0	0	W1



PCSTABL4 FSmin=1.23 X-Axis (ft)

** PCSTABL4 **

by
Purdue University

--Slope Stability Analysis--
Simplified Janbu Method of Slices
or Simplified Bishop Method

Run Date:	12-27-01
Time of Run:	3:09pm
Run By:	A&W ENGINEERING, INC.
Input Data Filename:	C:01139CC
Output Filename:	C:01139CC.OUT
Plotted Output Filename:	C:01139CC.PLT

PROBLEM DESCRIPTION US-231 Spencer County
Station 25+962 - End Bent #2

BOUNDARY COORDINATES
NOTE: User defined origin was specified.
Add 00.00 to X values and 400.00 to Y values listed.

12 Top Boundaries
27 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	127.60	50.00	126.90	1
2	50.00	126.90	50.10	92.80	1
3	50.10	92.80	75.00	92.80	4
4	75.00	92.80	82.00	96.70	2
5	82.00	96.70	95.00	96.70	2
6	95.00	96.70	102.00	92.80	2
7	102.00	92.80	117.00	92.80	4
8	117.00	92.80	122.00	92.80	2
9	122.00	92.80	122.10	125.60	1
10	122.10	125.60	150.10	125.30	1
11	150.10	125.30	178.00	125.00	2
12	178.00	125.00	250.00	124.50	3
13	.00	92.80	50.10	92.80	4
14	75.00	92.80	102.00	92.80	4
15	122.00	92.80	150.00	92.80	2
16	150.00	92.80	150.10	125.30	2
17	117.00	92.80	122.00	88.00	4
18	150.00	88.00	155.60	99.30	4
19	155.60	99.30	178.00	125.00	3
20	155.60	99.30	250.00	99.30	4

21	.00	88.00	122.00	88.00	5
22	122.00	88.00	150.00	88.00	5
23	150.00	88.00	155.60	88.00	5
24	155.60	88.00	250.00	94.00	5
25	.00	77.20	50.00	80.00	6
26	50.00	80.00	122.00	87.20	6
27	122.00	87.20	250.00	90.00	6

ISOTROPIC SOIL PARAMETERS

6 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	125.0	125.0	.0	34.0	.00	.0	1
2	125.0	125.0	.0	30.0	.00	.0	1
3	120.0	120.0	1000.0	.0	.00	.0	1
4	125.0	125.0	1500.0	.0	.00	.0	1
5	125.0	125.0	2500.0	.0	.00	.0	1
6	140.0	140.0	5000.0	.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 3 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	.00	92.80
2	150.00	92.80
3	250.00	99.30

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (lb/sqft)	Deflection (deg)
1	122.10	250.00	250.0	.0

NOTE - Intensity Is Specified As A Uniformly Distributed Force Acting On A Horizontally Projected Surface.

A Horizontal Earthquake Loading Coefficient Of .100 Has Been Assigned

A Vertical Earthquake Loading Coefficient Of .000 Has Been Assigned

Cavitation Pressure = .0 psf

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Sliding Block Surfaces, Has Been Specified.

The Active And Passive Portions Of The Sliding Surfaces Are Generated According To The Rankine Theory.

30 Trial Surfaces Have Been Generated.

3 Boxes Specified For Generation Of Central Block Base

Length Of Line Segments For Active And Passive Portions Of Sliding Block Is 5.0

Box No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Height (ft)
1	110.00	88.00	145.00	88.00	7.00
2	146.00	89.00	160.00	89.50	8.00
3	161.00	120.00	181.00	120.00	4.00

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 6 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)

1	117.59	92.80
2	118.29	92.40
3	122.62	89.90
4	150.22	93.05
5	169.21	121.05
6	171.53	125.07

*** 1.234 ***

Failure Surface Specified By 8 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	112.41	92.80
2	113.68	91.54
3	117.21	88.00
4	118.04	87.18
5	150.36	92.57
6	164.71	118.62
7	167.21	122.95
8	168.46	125.10

*** 1.415 ***

Failure Surface Specified By 8 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	118.35	92.80
2	122.33	90.50
3	126.66	88.00
4	127.34	87.32
5	128.26	86.40
6	147.34	92.77
7	173.99	121.11
8	176.25	125.02

*** 1.530 ***

Failure Surface Specified By 7 Coordinate Points

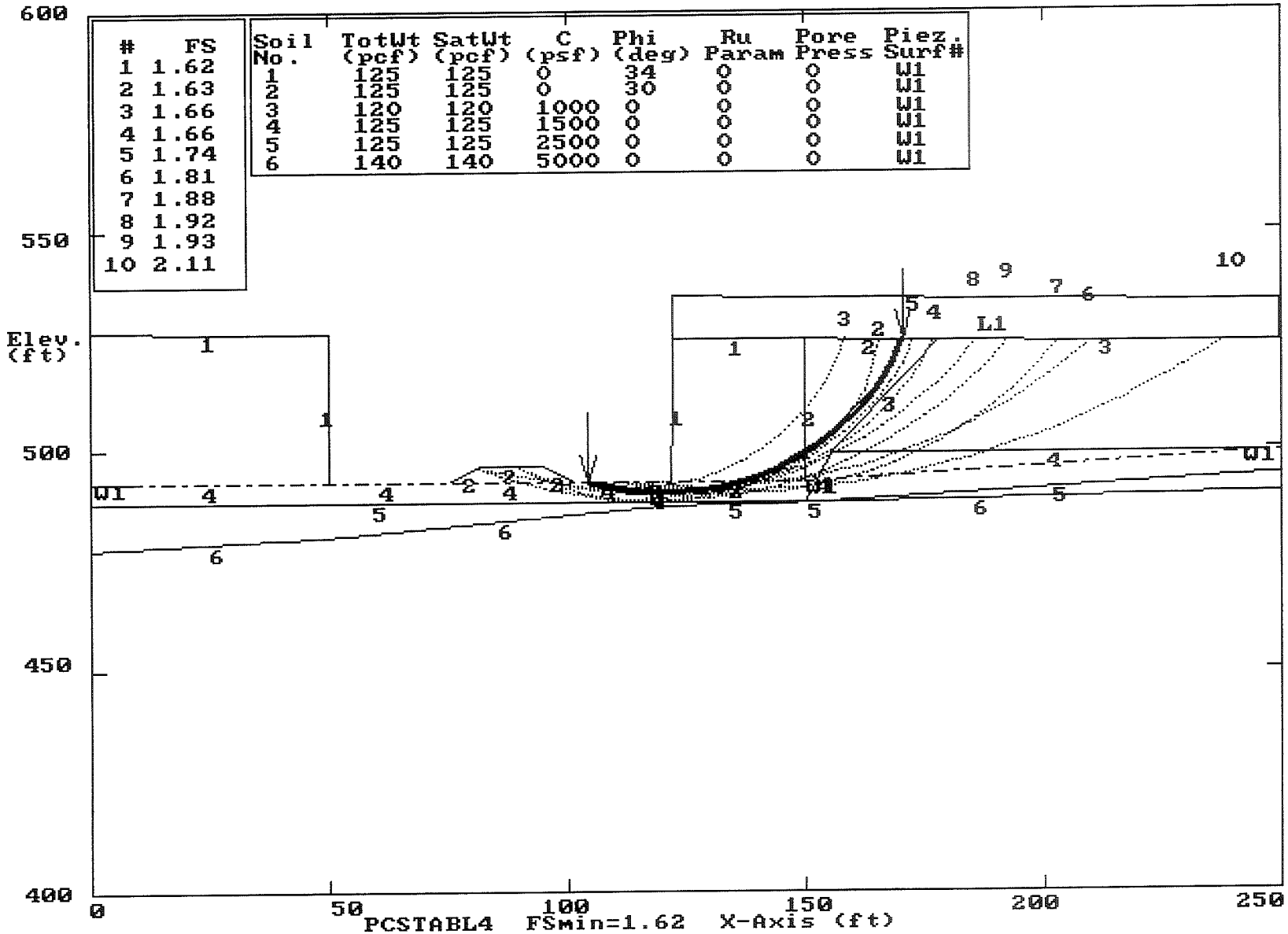
Point No.	X-Surf (ft)	Y-Surf (ft)

US-231 Spencer County Station 25+962 - End Bent #2

Ten Most Critical. C:01139BB.PLT By: A&W ENGINEERING, INC. 12-27-01 3:34pm

#	FS
1	1.62
2	1.63
3	1.66
4	1.66
5	1.74
6	1.81
7	1.88
8	1.92
9	1.93
10	2.11

Soil No.	TotWt (pcf)	SatWt (pcf)	C (psf)	Phi (deg)	Ru Param	Pore Press	Piez. Surf#
1	125	125	0	34	0	0	W1
2	125	125	0	30	0	0	W1
3	120	120	1000	0	0	0	W1
4	125	125	1500	0	0	0	W1
5	125	125	2500	0	0	0	W1
6	140	140	5000	0	0	0	W1



PCSTABL4 FSmin=1.62 X-Axis (ft)

** PCSTABL4 **

by
Purdue University

--Slope Stability Analysis--
Simplified Janbu Method of Slices
or Simplified Bishop Method

Run Date:	12-27-01
Time of Run:	3:34pm
Run By:	A&W ENGINEERING, INC.
Input Data Filename:	C:01139BB
Output Filename:	C:01139BB.OUT
Plotted Output Filename:	C:01139BB.PLT

PROBLEM DESCRIPTION US-231 Spencer County
Station 25+962 - End Bent #2

BOUNDARY COORDINATES
NOTE: User defined origin was specified.
Add 00.00 to X values and 400.00 to Y values listed.

12 Top Boundaries
27 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	.00	127.60	50.00	126.90	1
2	50.00	126.90	50.10	92.80	1
3	50.10	92.80	75.00	92.80	4
4	75.00	92.80	82.00	96.70	2
5	82.00	96.70	95.00	96.70	2
6	95.00	96.70	102.00	92.80	2
7	102.00	92.80	117.00	92.80	4
8	117.00	92.80	122.00	92.80	2
9	122.00	92.80	122.10	125.60	1
10	122.10	125.60	150.10	125.30	1
11	150.10	125.30	178.00	125.00	2
12	178.00	125.00	250.00	124.50	3
13	.00	92.80	50.10	92.80	4
14	75.00	92.80	102.00	92.80	4
15	122.00	92.80	150.00	92.80	2
16	150.00	92.80	150.10	125.30	2
17	117.00	92.80	122.00	88.00	4
18	150.00	88.00	155.60	99.30	4
19	155.60	99.30	178.00	125.00	3
20	155.60	99.30	250.00	99.30	4

21	.00	88.00	122.00	88.00	5
22	122.00	88.00	150.00	88.00	5
23	150.00	88.00	155.60	88.00	5
24	155.60	88.00	250.00	94.00	5
25	.00	77.20	50.00	80.00	6
26	50.00	80.00	122.00	87.20	6
27	122.00	87.20	250.00	90.00	6

ISOTROPIC SOIL PARAMETERS

6 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	125.0	125.0	.0	34.0	.00	.0	1
2	125.0	125.0	.0	30.0	.00	.0	1
3	120.0	120.0	1000.0	.0	.00	.0	1
4	125.0	125.0	1500.0	.0	.00	.0	1
5	125.0	125.0	2500.0	.0	.00	.0	1
6	140.0	140.0	5000.0	.0	.00	.0	1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 3 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	.00	92.80
2	150.00	92.80
3	250.00	99.30

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (lb/sqft)	Deflection (deg)
1	122.10	250.00	250.0	.0

NOTE - Intensity Is Specified As A Uniformly Distributed
Force Acting On A Horizontally Projected Surface.

A Horizontal Earthquake Loading Coefficient
Of .100 Has Been Assigned

A Vertical Earthquake Loading Coefficient
Of .000 Has Been Assigned

Cavitation Pressure = .0 psf

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

100 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 10 Points Equally Spaced
Along The Ground Surface Between X = 50.10 ft.
and X = 120.00 ft.

Each Surface Terminates Between X = 150.20 ft.
and X = 250.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation
At Which A Surface Extends Is Y = .00 ft.

5.00 ft. Line Segments Define Each Trial Failure Surface.

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Bishop Method * *

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	104.47	92.80
2	109.30	91.50

3	114.23	90.66
4	119.21	90.29
5	124.21	90.39
6	129.18	90.96
7	134.07	91.99
8	138.84	93.48
9	143.46	95.41
10	147.87	97.77
11	152.04	100.53
12	155.93	103.66
13	159.51	107.16
14	162.74	110.97
15	165.61	115.07
16	168.07	119.42
17	170.12	123.98
18	170.49	125.08

Circle Center At X = 120.7 ; Y = 143.4 and Radius, 53.1

*** 1.618 ***

Failure Surface Specified By 16 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	112.23	92.80
2	117.01	91.34
3	121.94	90.48
4	126.94	90.26
5	131.92	90.66
6	136.81	91.69
7	141.54	93.33
8	146.02	95.55
9	150.18	98.31
10	153.97	101.58
11	157.31	105.29
12	160.16	109.40
13	162.48	113.84
14	164.21	118.53
15	165.34	123.40
16	165.52	125.13

Circle Center At X = 126.2 ; Y = 129.9 and Radius, 39.7

*** 1.626 ***

Failure Surface Specified By 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	88.93	96.70
2	93.44	94.54
3	98.15	92.86
4	103.01	91.67
5	107.96	91.00
6	112.96	90.83
7	117.95	91.19
8	122.87	92.05
9	127.68	93.42
10	132.32	95.28
11	136.75	97.60
12	140.91	100.38
13	144.77	103.56
14	148.27	107.13
15	151.39	111.04
16	154.09	115.25
17	156.33	119.71
18	158.11	124.39
19	158.33	125.21

Circle Center At X = 112.0 ; Y = 139.2 and Radius, 48.4

*** 1.655 ***

Failure Surface Specified By 17 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	112.23	92.80
2	117.13	91.80
3	122.10	91.25
4	127.10	91.14
5	132.09	91.49
6	137.03	92.28
7	141.87	93.50
8	146.59	95.16
9	151.14	97.24
10	155.48	99.72
11	159.59	102.57
12	163.42	105.79
13	166.94	109.33
14	170.14	113.18
15	172.98	117.29
16	175.43	121.65
17	176.95	125.01

Circle Center At X = 125.8 ; Y = 146.8 and Radius, 55.6

*** 1.660 ***

Failure Surface Specified By 22 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	88.93	96.70
2	93.33	94.33
3	97.92	92.34
4	102.66	90.75
5	107.52	89.58
6	112.47	88.83
7	117.46	88.50
8	122.46	88.61
9	127.43	89.14
10	132.34	90.10
11	137.14	91.48
12	141.81	93.26
13	146.31	95.44
14	150.61	97.99
15	154.67	100.91
16	158.47	104.16
17	161.97	107.73
18	165.16	111.58
19	168.00	115.69
20	170.48	120.04
21	172.58	124.58
22	172.75	125.06

Circle Center At X = 118.7 ; Y = 146.7 and Radius, 58.2

*** 1.744 ***

Failure Surface Specified By 23 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	112.23	92.80
2	117.20	92.18
3	122.18	91.78
4	127.18	91.60
5	132.18	91.63
6	137.17	91.88
7	142.15	92.34
8	147.10	93.01
9	152.02	93.90
10	156.90	95.00
11	161.73	96.31
12	166.49	97.83

MECHANICALLY STABILIZED EARTH RETAINING WALLS

The Standard Specifications are revised as follows:

SECTION 105, AFTER LINE 48, INSERT AS FOLLOWS:

When constructing a mechanically stabilized earth retaining wall, the Contractor shall perform the necessary work to verify that the foundation is at the correct elevation, that the wall is constructed to the correct alignment, and that the work is in accordance with the specified tolerances. The checking of alignments and tolerances shall include verifying that the plumbness of the face panels is in accordance with 731.10 over the entire height of the wall. Alignment shall be checked at each layer of panels after the backfill behind the panels has been compacted, and the results shall be recorded.

SECTION 731, BEGIN LINE 1, INSERT AS FOLLOWS:

SECTION 731 - MECHANICALLY STABILIZED EARTH RETAINING WALLS

731.01 Description. *This work shall consist of furnishing materials and placement of mechanically stabilized earth walls constructed in accordance 105.03.*

731.02 General Design Requirements. *The mechanically stabilized earth wall shall consist of a non-structural leveling pad, concrete face panels, and ground reinforcement elements mechanically connected to each panel. Ground reinforcement shall have sufficient strength, frictional resistance, and quantity as required by design.*

The approved proprietary mechanically stabilized earth retaining walls are Reinforced Earth by the Reinforced Earth Company, Retained Earth by the V.S.L. Corporation, and Hilfiker Soil Embankment Wall Systems by Hilfiker Texas Corporation. The quantities shown in the Schedule of Pay Items will be the same for all mechanically stabilized earth wall systems. The proposed mechanically stabilized earth wall system shall not be indicated when preparing the bid. All mechanically stabilized earth walls shall be built in accordance with the approved plans and panel shop drawings for one of the approved mechanically stabilized earth retaining wall systems, based on the requirements herein. The recommendations of the wall system suppliers shall not override the minimum performance requirements shown herein. Other systems offered by the approved supplier shall not be submitted.

If the wall manufacturer needs additional information to complete the design, the Contractor shall be responsible for obtaining such information.

All appurtenances behind, in front of, under, mounted upon, or passing through the wall such as drainage structures, utilities, or other appurtenances shown on the plans shall be accounted for in the stability design of the wall.

The mechanically stabilized earth wall design shall follow the general dimensions of the wall envelope shown on the plans. The plans will locate the leveling pad at or below the theoretical leveling pad. The top of the face panel shall be at or above the top of the panel elevation shown on the plans.

Where coping or barrier is utilized, the wall face panel shall extend up into the coping or barrier a minimum of 50 mm (2 in.). The top of the face panels may be level or sloped to meet the top of the face panel line noted. Cast-in-place concrete will not be an acceptable replacement for panel areas noted by the wall envelope.

Where walls or wall sections intersect with an included angle of 130 degrees or less, a vertical corner element separate from the standard panel face shall abut and interact with the opposing standard panels. The corner element shall have ground reinforcement connected specifically to that panel and shall be designed to preclude lateral spread of the intersecting panels.

The face panels shall be designed to accommodate differential settlement of 1 m in 100 m (1 ft in 100 ft). Where shown on the plans, slip joints to accommodate excessive or differential settlement shall be included.

731.03 Design Criteria. *The design by the proprietary manufacturer shall consider the internal and the external stability of the wall mass including the bearing pressure, overturning, sliding, and stability of temporary construction slopes. The design shall be in accordance with the Design, Construction, and Commentary divisions of the AASHTO Standard Specifications for Highway Bridges, unless specified otherwise herein. The analysis of settlement, bearing capacity, and overall slope stability will be the responsibility of the Department.*

The theoretical failure plane within the soil mass shall be analyzed so that the soil stabilizing component extends sufficiently beyond the failure plane to stabilize the material. External loads which affect the internal stability such as those applied through piling, bridge footings, traffic, and slope surcharge, shall be accounted for in the design. The size of all structural elements shall be determined such that the design load stresses do not exceed the allowable stresses found in the AASHTO Standard Specifications for Highway Bridges, unless otherwise shown on the plans.

The maximum allowable yield stress for reinforcement shall be 450 MPa (65,000 psi).

The maximum standard panel size shall be 3 m^2 (32 sq ft).

The ϕ angle for the internal design of the volume shall be assumed to be 34 degrees. Before construction begins, the B borrow for structure backfill selected shall be subject to approval to show accordance with this frictional requirement. Test compliance with the requirement shall be the responsibility of the Contractor. The wall supplier shall be furnished a copy of the testing results for the backfill. The friction angle of the foundation soils shall be assumed to be 30 degrees. The ϕ angle of the backfill behind the mechanically stabilized earth mass shall be assumed to be 30 degrees. Granular fill will not be necessary for the embankment.

The wall shall be defined by the wall envelope shown on the plans. For design purposes, the height of wall H shall be measured from the theoretical top of the leveling pad to the top of the wall. For a level surcharge situation, the top of the wall shall be measured to the top of the coping or to the gutter line of the traffic barrier. The top of the wall shall be the theoretical top of the face panels only when a coping or barrier is not used. For an abutment face, the design height H shall be defined as the height measured from the top of the leveling pad to the top of the roadway surface. For a wall with a sloping surcharge the top of the wall shall be measured at a point 0.3H back from the face where the design height is H' and the actual wall height is H.

For aesthetic considerations and to make differential settlement unnoticeable, the panels shall be erected such that the horizontal site line is discontinuous at every other panel. This shall be accomplished by starting erection with the lower panel level of each wall by alternating full height and half height panels. Panels above the lowest level shall be of a standard size except as required to top out the wall to be in accordance with the plan elevations.

The connections of the ground reinforcing steel to the panels shall be in two elevations for standard panels. The connections shall not be more than 750 mm (30 in.) apart vertically. To prevent out-of-plane rotation, standard face panels shall be connected to ground reinforcement on at least 3 different points in 2 different planes. However, preapproved systems utilizing a horizontal stabilizing leg to prevent rotation shall only require ground reinforcement attachments in one plane. Partial panels shall have 3 different connection points, but only one plane shall be attached to ground reinforcement. Panels which are located at the top of the wall shall not be attached to the coping or the traffic barrier.

The ground reinforcement shall be the same length from the bottom to the top of each wall section whether bar mats, grids, or strips are used. Differing ground reinforcement elements shall be clearly marked for ease of construction. This element may be used individually or in a prefabricated grouping. The minimum length of the ground reinforcement shall be 2.5 m (8 ft) or 0.7H for a wall without sloping surcharges, 0.7H' for a wall with sloping surcharges, or in accordance with the AASHTO Standard Specifications for Highway Bridges for an abutment on a spread footing.

The ground reinforcement for the mechanically stabilized earth volume shall be sized using the lesser of the allowable forces for each specific connection and each specific reinforcing element. The connection's allowable force shall be taken as 2/3 of the connection test load at the allowable pullout deformation limit of 13 mm (1/2 in.) or one half of the ultimate load, whichever is less.

The ground reinforcement length shall be as required for internal design or as shown on the plans. The length shall exceed the minimum noted as required for design consideration. One hundred percent of the ground reinforcement which is designed and placed in the reinforced earth volume shall extend to and shall be connected to the face panels.

For mats, grids, or strip steel, the minimum zinc coating thickness shall be 0.64 L/m² (2 oz/sq ft). Such thickness shall be assumed to be 86 μm for purpose of calculation of reduced structural section.

The actual applied bearing pressures under the stabilized mass for each reinforcement length shall be clearly indicated on the shop drawings and shall be equal to or less than the maximum allowable soil pressure shown on the plans. Passive pressure in front of the wall mass will be assumed to be zero for design purposes.

731.04 Submittals. The Contractor shall submit one copy of the design computations for approval. If the computations are computer generated, one sample set of hand calculations, for one wall location, shall also be submitted. The Contractor shall then submit 8 sets of design drawings for approval after the design computations are approved and before beginning construction.

(a) The design drawings shall include all details, dimensions, quantities and cross-sections necessary to construct the wall and shall include but shall not be limited to the following:

1. A plan and elevation sheet or sheets for each wall

2. An elevation view of the wall which shall include the elevation at the top of the wall at all horizontal and vertical break points at least every 15 m (50 ft) along the face of the wall, all steps in the leveling pads, the designation as to the type of panel, the length of soil reinforcing systems, the distance along the face of the wall to where changes in length of the soil reinforcing systems occur, and an indication of the original and final ground lines and maximum bearing pressures

3. A plan view of the wall that indicates the offsets from the construction centerline to the face of the wall at all changes in horizontal alignment. A plan view and elevation view which detail the placing position and connection of all steel ground reinforcing elements in areas where piling, utility, or other structures are near the wall.

4. A typical cross section or cross sections showing elevation relationship between ground conditions and proposed grades

5. All general notes required for constructing the wall

6. All horizontal and vertical curve data affecting the wall

7. A listing of the summary of quantities on the elevation sheet for each wall

(b) *All panel details shall show all dimensions necessary to construct the element, all reinforcing steel in the element, and the location of soil reinforcing system devices embedded in the panels.*

(c) *Clearly indicated details for construction of walls around drainage facilities.*

(d) *All details of the architectural treatment.*

(e) *The details for diverting strips or mesh around obstructions such as piles, catch basins, and other utilities shall be submitted for approval.*

(f) *The details for each connection between the concrete panel and the mesh or strip.*

If the work is on a Department-maintained route, the Department will check the shop drawings. A consultant, if utilized, or the Department, if a consultant is not utilized, will check the design calculations and design drawings.

If the work is not on a Department-maintained route, the appropriate local public agency will check the shop drawings, design calculations, and detail drawings.

MATERIALS

731.05 Materials. *The Contractor shall make arrangements to purchase the materials described herein, including concrete face panels, retaining strips or mesh, tie strips, fasteners, joint materials, and all necessary incidentals, from an approved mechanically stabilized earth wall system manufacturer. The Contractor shall make arrangements with the Chief of the Division of Materials and Tests for all required offsite testing. Materials not in accordance with the requirements herein shall not be used without written approval.*

Materials shall be in accordance with the following:

Coarse Aggregate, Size No. 23	*904.01*
Concrete Admixtures	*912.03*
Fine Aggregate	*904.01*
Fine Aggregate, Class A, Size No. 91 or 8	*904.03*
Fly Ash	*901.02*
Portland Cement	*901.01(b)*
Reinforcing Steel	*910.01*
Water	*913.01*

(a) Concrete Face Panels. *Concrete shall be in accordance with the applicable requirements of 702. Concrete shall have a compressive strength at 28 days in accordance with 731.05(a)7.*

Retarding agents, accelerating agents, or additives containing chloride shall not be used without approval. Air-entraining and slump requirements shall be in accordance with 702.05.

Ground reinforcement connecting hardware and rebar lifting devices shall be set in place and secured prior to beginning casting, in accordance with the dimensions and tolerances shown on the plans.

*1. **Testing and Inspection.** Acceptability of the panels will be determined on the basis of compressive strength tests and visual inspection. The panels shall be considered acceptable regardless of curing age when compressive test results indicate that the compressive strength is in accordance with 28-day requirements. Panels utilizing type I or II cement shall be considered acceptable for placement in the wall when 7-day initial strengths exceed 85 percent of the 28-day requirements. Panels utilizing type III cement shall be considered acceptable for placement in the wall prior to 28 days only when compressive strength test results indicate that the strength exceeds the 28-day requirements.*

*2. **Casting.** The panels shall be cast on a flat area, with the front face of the form at the bottom, and the back face at the upper part. Tie strip guides shall be set on the rear face. The concrete in each unit shall be placed without interruption and shall be consolidated by the use of an approved vibrator, supplemented by such hand tamping as may be necessary to force the concrete into the corners of the forms and prevent the formation of stone pockets of cleavage planes. Clear form oil of one manufacture shall be used throughout the casting operation.*

*3. **Curing.** The panels shall be cured for a sufficient length of time such that the concrete develops the specified compressive strength. A production lot which is not in accordance with the Compressive Strength requirements will be rejected.*

*4. **Removal of Forms.** The forms shall remain in place until they may be removed without damage to the unit.*

*5. **Concrete Finish.** Unless otherwise shown on the plans or specified elsewhere herein, the concrete surface for the front panel face shall have a surface finish produced from contact with the form. The rear face of the panel shall be roughly screeded to eliminate open pockets of aggregate and surface distortions in excess of 6 mm (¼ in.).*

*6. **Tolerances.** All panels shall be manufactured within the tolerances as follows:*

*a. **Panel Dimensions.** Lateral position of tie strips shall be within 25 mm (1 in.). All other dimensions shall be within 5 mm (3/16 in.).*

*b. **Panel Squareness.** Squareness, as determined by the difference between the 2 diagonals, shall not exceed 13 mm (½ in.).*

*c. **Panel Surface Finish.** Surface defects on smooth formed surfaces measured on a length of 1.5 m (5 ft) shall not exceed 3 mm (1/8 in.). Surface defects on textured finished surfaces measured on a length of 1.5 m (5 ft) shall not exceed 5 mm (5/16 in.).*

*7. **Compressive Strength.** Acceptance of the concrete panels with respect to compressive strength will be determined on the basis of production lots. A production lot will be defined as a group of panels which is represented by a single compressive strength sample and shall consist of either 40 panels or a single day's production, whichever is less.*

During the production of the concrete panels, the Department will randomly sample the concrete in accordance with AASHTO T 141. A single compressive strength sample, consisting of a minimum of 4 cylinders, shall be randomly selected for each production lot.

Cylinders for compressive strength tests shall be prepared in accordance with AASHTO T 23 on specimens of 150 mm x 300 mm (6 in. x 12 in.). For each compressive strength sample, a minimum of 2 cylinders will be cured in the same manner as the panels and tested at approximately 7 days. The average compressive strength of these cylinders, when tested in accordance with AASHTO T 22, will provide a test result which will determine the initial strength of the concrete. In addition, 2 cylinders will be cured in accordance with AASHTO T 23 and tested at 28 days. The average compressive strength of these 2 cylinders, when tested in accordance with AASHTO T 22, will provide a compressive strength test result which will determine the compressive strength of the production lot.

If the initial strength test results indicate a compressive strength in excess of 27,500 kPa (4,000 psi), then these results will be utilized as the compressive strength test results for that production lot. The requirement for testing at 28 days will be waived for that particular production lot.

Acceptance of a production lot will be made if the compressive strength test result is greater than or equal to 27,500 kPa (4,000 psi). If the compressive strength test result is less than 27,500 kPa (4,000 psi), the manufacturer will be permitted to retest the production lot. Such retest shall be made on 4 cores taken from the panels within the production lot. Cores shall be obtained and tested in accordance with AASHTO T 24. The panels to be retested will be selected by the Department. The retest shall be done in the presence of the Department and with no additional payment.

*8. **Rejection.** Units shall be subject to rejection due to failure to be in accordance with the requirements specified above. In addition, the following defects may be sufficient cause for rejection:*

a. Defects which indicate imperfect molding

b. Defects which indicate honeycombed or open texture concrete

c. Defects in the physical characteristics of the concrete, such as broken or chipped concrete, or color variations or dunnage marks on the front face due to excessive form oil or other reasons.

The Engineer will determine whether spalled, honeycombed, chipped, or otherwise defective concrete shall be repaired or be cause for rejection. Repair of concrete, if permitted, shall be done in a satisfactory manner. Repair to concrete surfaces which are to be exposed to view after completion of construction shall be subject to approval.

9. Marking. The date of manufacture, the production lot number, and the place mark shall be clearly scribed on the rear face of each panel.

10. Handling, Storage, and Shipping. All panels shall be handled, stored, and shipped so as to eliminate the danger of chipping, cracks, fractures, and excessive bending stresses. Panels in storage shall be supported on firm blocking located immediately adjacent to tie strips to avoid bending the tie strips.

(b) Concrete Leveling Pad. *Concrete for the leveling pad shall be Class A and shall be in accordance with the applicable requirements of 702.*

(c) Concrete Coping. *Concrete for the coping shall be class A and shall be in accordance with the applicable requirements of 702. Reinforcing steel in the coping shall be in accordance with the applicable requirements of 703. The coping or traffic barrier may be either precast or cast in place.*

(d) Reinforcing Mesh, Clevis Connector, and Connector Bar. *The reinforcing grid shall be shop fabricated of cold drawn steel wire in accordance with ASTM A 82 and shall be welded into the finished mesh fabric in accordance with ASTM A 185. Galvanization shall be in accordance with ASTM A 123.*

Clevis connectors, if used, shall be attached to the alignment templates using the bars provided with the forms. The vertical and horizontal alignment of the connectors shall be +3 mm (+1/8 in.). The holes inside the loops shall be free of all concrete and debris, loose or otherwise.

The clevis connector shall be fabricated of cold drawn steel wire in accordance with ASTM A 82 and welded in accordance with ASTM A 884. Loops shall be galvanized in accordance with ASTM A 153 Class B-3 or ASTM A 123.

The connector bar, if used, shall be fabricated of cold drawn steel wire in accordance with ASTM A 884 and galvanized in accordance with ASTM A 123.

(e) Ground Reinforcement. *The ground reinforcement may be a deformed steel strip or a welded wire grid. The grid or strip used shall be consistent with that used in the pullout test and shall be consistent throughout the project.*

The grid shall consist of not less than 2 longitudinal wires, perpendicular to the wall, welded to equally spaced cross ribs capable of developing passive pressure with the fill. The deformed strip shall be of constant width. The strip thickness shall vary only from the standard underformed section to the standard deformed section as required to produce the pullout resistance.

Longitudinal and transverse wires shall be of the same diameter.

The face panel edges shall be configured to conceal the joints. All horizontal and vertical joints shall be covered with a joint cover to prevent backfill leakage while passing water.

Reinforcing strips shall be hot rolled from bars to the required shape and dimensions. Their physical and mechanical properties shall be in accordance with ASTM A 572M Grade 450 (A 572 Grade 65). Tie strips shall be shop fabricated with hot rolled steel in accordance with the minimum requirements of ASTM A 709M Grade 345 (A 570 Grade 50). Galvanization for reinforcing strips and tie strips shall be in accordance with ASTM A 123. All reinforcing strips and tie strips shall be inspected to ensure that they are true to size and free from defects which may impair their strength and durability.

*(f) **Reinforcing Steel.** Mill certificates for reinforcing steel as shown on the plans shall be furnished for approval. All reinforcing steel shall be in accordance with ASTM A 709M Grade 400 (A 615 Grade 60).*

*(g) **Fasteners.** Fasteners shall consist of 13 mm (½ in.) diameter, hexagonal cap screw bolts and nuts, which shall be galvanized and in accordance with ASTM A 325M (A 325).*

*(h) **Alignment Pins.** The rods used to align the face panels during construction shall be 19 mm (3/4 in.) diameter, 300 mm (12 in.) long. The rods shall be either mild steel, polyvinyl chloride, or fiberglass. A sample shall be submitted prior to use to the Division of Materials and Tests.*

*(i) **Joint Materials.** Bearing pads shall be rubber, neoprene, polyvinyl chloride, or polyethylene, and of the type and grade recommended by the supplier of the mechanically stabilized earth wall materials.*

The joint cover shall be either a non-woven needle punch polyester geotextile or a woven monofilament polypropylene. The joint cover shall be attached to the rear face of the panels with a suitable adhesive.

Horizontal and vertical joints shall be provided between adjacent face panels to prevent concrete-to-concrete contact and chipping when differential settlement occurs. The horizontal and vertical joints shall contain compression blocks, pins, or other approved means as recommended by the manufacturer to provide a uniform joint. Panels without an uninterrupted verical joint shall have a minimum joint thickness of 19 mm (3/4 in.).

*(j) **Backfill Material.** All backfill material used in the mechanically stabilized earth wall structure volume, as shown on the plans, shall be B borrow for structure backfill in accordance with 211. In addition to the requirements of 211, the backfill material shall have a minimum resistivity of 3000 Ω cm at 100 percent saturation when tested in accordance with AASHTO T 288. The pH of the backfill material shall be in the range of 5 to 10 as determined in accordance with AASHTO T 289. The maximum soluble salt content of the reinforced backfill material shall not exceed 100 ppm chlorides and 200 ppm sulfates as determined in accordance with AASHTO T 291 and AASHTO T 290, respectively. If the minimum resistivity exceeds 5000 Ω cm at 100 percent saturation, the requirement of testing for chlorides and sulfates may be waived.*

The Contractor shall furnish a type A certification in accordance with 916 for the reinforced backfill materials. One copy of all test results performed by the Contractor, which are necessary to ensure compliance with the specifications, shall also be furnished. Backfill which is not in accordance with this specification shall not be used without the written consent of both the Engineer and the wall supplier.

CONSTRUCTION REQUIREMENTS

***731.06 General Requirements.** The wall supplier shall provide technical instruction, shall provide guidance in pre-construction activities including the preconstruction conference, and shall provide on-site technical assistance to the Contractor during construction. All instructions from the supplier shall be closely followed by the Contractor, unless otherwise directed in writing.*

731.07 Blank.

***731.08 Foundation Preparation.** The foundation for the structure shall be graded level for a width equal to or exceeding the length of the reinforcing strips or as shown on the plans. Prior to wall construction, the foundation, if not in rock, shall be compacted as directed. The base of the wall excavation shall be proofrolled with a heavy vibratory roller. If unsuitable foundation material is encountered, it shall be removed and replaced with well compacted B borrow.*

At each foundation level, an unreinforced concrete leveling pad shall be provided as shown on the plans. The leveling pad shall be cured a minimum of 12 h before placement of concrete face panels.

***731.09 Retaining Wall Excavation.** This work shall consist of the excavation of material whose removal is necessary for the construction of the mechanically stabilized earth walls in accordance with the plans, the requirements herein, or as directed. Excavation shall include the construction and subsequent removal of all necessary bracing, shoring, sheeting; and cribbing and all pumping, bailing, and draining.*

Prior to starting excavation operations at the wall site, all necessary clearing and grubbing at the site shall have been performed in accordance with 201.03. The Contractor shall clear and grub the area for the excavation in accordance with the limits shown on the plans. All timber, stumps, and debris shall be disposed of in accordance with 201.04 or 201.05.

The Contractor shall notify the Engineer a sufficient time before beginning the excavation so that measurements may be taken of the undisturbed ground.

Where necessary for safety, the excavation shall be shored or braced in accordance with State and local safety standards. Excavation and related work shall be performed such that no portion of the wall is endangered by subsequent operations.

Where excavation for the wall is adjacent to a traveled way, the method for shoring, sheeting, or bracing the excavation opening shall have been approved before beginning the excavation. The Contractor shall submit 5 copies of drawings in accordance with 206.09 showing details of the proposed method of excavation protection.

After the excavation for each wall location has been performed, the Contractor shall notify the Engineer. No concrete leveling pad shall be placed until the Engineer has approved the depth of the excavation and the character of the foundation material and has given permission to proceed.

All sheeting and bracing shall be removed as the random backfilling progresses.

All material for random backfill shall be subject to approval and shall be free from large or frozen lumps, wood, or other undesirable material. All backfill shall be compacted in accordance with 203.

***731.10 Wall Erection.** Concrete face panels shall be placed vertically with the aid of a light crane. For erection, panels shall be handled by means of a lifting device set into the upper edge of the panels. Panels shall be placed in successive horizontal lifts in the sequence shown on the plans as backfill placement proceeds. As backfill material is placed behind the panels, the panels shall be maintained in vertical position by means of temporary wooden wedges placed in the joint at the junction of the 2 adjacent panels on the external side of the wall. External bracing will be required for the initial lift.*

Panels accidentally placed in contact with the earth or covered by standing water shall have face discoloration removed by means of a chemical wash. Panels shall be stored on blocking to avoid touching the ground or being covered by standing water.

Plumbness, vertical tolerances, and horizontal alignment tolerances shall not exceed 20 mm (3/4 in.) when measured with a 3 m (10 ft) straightedge. The maximum allowable offset in panel joints shall be 20 mm (3/4 in.). The overall plumbness from top to bottom to the wall shall not exceed 12 mm per 3 m (½ in. per 10 ft) of wall height.

Reinforcing strips shall be placed normal to the face of the wall, unless otherwise shown on the plans or as directed. Prior to placement of the reinforcing strips, backfill shall be compacted in accordance with the Backfill Placement requirements below.

731.11 Backfill Placement. *Backfill placement shall closely follow erection of each course of panels. Backfill shall be placed so as to avoid damage or disturbance to the wall materials or misalignment of the concrete face panels. Wall materials which become damaged or disturbed during backfill placement shall be either removed and replaced or corrected as directed. All misalignment or distortion of the concrete face panels due to placement of backfill outside the limits described herein shall be corrected as directed.*

The work shall also include B borrow backfilling above a theoretical 1:1 slope behind the ground reinforcement in accordance with the details shown on the plans and the disposal of surplus of unsuitable excavated materials as permitted.

B borrow for structure backfill shall be compacted to 95 percent of the maximum dry density in accordance with 203.23.

The moisture content of the backfill material prior to and during compaction shall be uniformly distributed throughout each layer. Backfill material shall have a placement moisture content between optimum and -3 of the Optimum Moisture Content. Backfill material with a placement moisture content in excess of the Optimum Moisture Content shall be removed and reworked until the moisture content is uniformly acceptable through the entire lift.

The maximum loose lift thickness shall not exceed 200 mm (8 in.) except that lifts 0.9 m (3 ft) from the wall or closer shall not exceed 125 mm (5 in.) in loose thickness. This lift thickness shall be decreased if necessary, to obtain the specified density.

Compaction within 0.9 m (3 ft) of the back face of the concrete face panels shall be achieved by means of a minimum of 3 passes with a lightweight mechanical tamper, roller, or vibratory system.

At the end of each day's operation, the last level of backfill shall be sloped away from the concrete face panels. In addition, surface runoff from adjacent areas shall not be permitted to enter the wall construction site.

Cutting or altering of the basic structural section of either the strip or grid at the site will be prohibited, unless the cutting is preplanned and detailed on the approved design drawings. Cutting shall only be considered if adequate additional steel is provided to produce the required ground reinforcement strength shown in the approved calculations. If the grid or strip is shortened in the field, the cut ends shall be covered with a galvanized paint or Bitumastic 50 coal tar to prevent corrosion of the metal.

731.12 Method of Measurement. Concrete face panels and wall erection will be measured by the square meter (square foot) of wall surface area. Cast-in-place concrete for the leveling pad will be measured by the meter (linear foot). B borrow for structure backfill will be measured in accordance with 211.09.

The pay quantities for concrete face panels, wall erection, and concrete leveling pad will not be measured on the basis of the details shown on the plans as prepared by the mechanically stabilized earth wall company. Such pay quantities will be based on the neat line limits of the wall envelope shown on the plans. No field measurements will be made. The wall envelope limits will be considered to be the vertical distance from the top of the leveling pad to the top of the coping, and the horizontal distance from the beginning to the end of the leveling pad.

731.13 Stockpiled Concrete Face Panels. Partial payment will be made for panels stockpiled on the project site or at the Contractor's approved storage location. Such partial payment will be the delivered cost of the wall panels, as verified by invoices which include freight charges. Such invoices shall be furnished by the Contractor. The payment will not exceed 75 percent of the contract unit price for concrete face panels. Prior to authorizing partial payment, verification will be obtained that all required inspection has been made and that the panels are acceptable. Stockpiled ground reinforcement will not be paid for separately.

731.14 Basis of Payment. Concrete face panels and wall erection will be paid for at the contract unit price per square meter (square foot). The concrete leveling pad, complete and in place, will be paid for at the contract unit price per meter (linear foot) for leveling pad. B borrow for structure backfill will be paid for at the contract unit price per cubic meter (cubic yard) in accordance with 211.10.

Payment will be made under:

Pay Item	*Metric Pay Unit Symbol (English Pay Unit Symbol)*
B Borrow for Structure Backfill	*m3 (CYS)*
Face Panels, Concrete	*m2 (SFT)*
Leveling Pad, Concrete	*m (LFT)*
Wall Erection	*m2 (SFT)*

The costs of all mechanically stabilized earth wall materials including concrete face panels, reinforcing strips, tie strips, fasteners, joint materials, coping, repair or replacement of face panels damaged or removed due to backfill placement, and incidentals shall be included in the cost of concrete face panels. The costs of all labor and materials required to prepare the wall foundation, place the reinforcing strips, and erect the concrete face panels shall be included in the cost of wall erection. Excavation will not be paid for separately. The cost of all excavation required shall be included in the costs of other pay items.

GENERAL NOTES

SAMPLE IDENTIFICATION

The AASHTO T-88 Soil Classification System is used to identify the soils unless otherwise noted.

SOIL PROPERTY SYMBOLS

N: Standard "N" penetration: Blows per foot of a 140-pound hammer falling 30 inches on a 2 inch O.D. split-spoon

Qu: Unconfined Compressive Strength, TSF

γ: Natural Dry Density, PCF

Mc: Water content, %

LL: Liquid Limit, %

PL: Plastic Limit, %

PI: Plasticity Index, %

$\underline{\nabla}$: Apparent groundwater level at time noted while drilling

$\underline{\blacktriangledown}$: Apparent groundwater level at time noted upon completion of drilling

$\underline{\blacktriangledown}$: Apparent groundwater level at time noted 24 hours after completion of drilling

DRILLING AND SAMPLING SYMBOLS

SS: Split-spoon - 1 3/8" I.D., 2" O.D., except where noted
ST: Shelby-tube - 3" O.D., except where noted
RC: Rock Core, 2" O.D., Except Where Noted
AU: Auger sample
DB: Diamond bit
CB: Carbide bit
WS: Washed Sample

RELATIVE DENSITY AND CONSISTENCY CLASSIFICATION

TERM (NON-COHESIVE SOILS)	BLOWS PER FOOT
Very loose	0 - 5
Loose	6 - 10
Medium Dense	11 - 30
Dense	31 - 50
Very dense	51 or more

TERM (COHESIVE SOILS	BLOWS PER FOOT
Very soft	0 - 3
Soft	4 - 5
Medium	6 - 10
Stiff	11 -15
Very stiff	16 - 30
Hard	31 or more

Indiana Department of Transportation

Materials and Tests Division

120 South Shortridge Road P. O. Box 19389
Indianapolis, Indiana 46219-0389
Phone: (317) 610-7251 Fax: (317) 356-9351

September 16, 2004

United Consulting
1625 N. Post Road
Indianapolis, IN 46219-1995

KDD ✓ SWJ
WEH
9-9-4/7
ARE ARE
CRP CRP
JEC JEC

Attention: Mr. Michael Rowe

Subject: Des. No.: 9161365
Project No: NH-075-3 (018)
US 231 – Phase 3
County: Spencer
District: Vincennes

Gentlemen:

Our office was contacted by Mr. Ben Swain and Mr. Michael Rowe of United Consulting with regards to a few questions about excavation for the subject project. At a meeting on September 2, 2004, we were asked the following questions. The first question was how to estimate for bidding purposes, the amount of Rock excavation versus Soil excavation. Our standard practice on a project of this magnitude with varying Rock elevations, is to estimate the total excavation and label it all as "Unclassified Excavation".

The second question to us was in regard to the reuse of excavated fill material. According to Mr. Marston Fowler, Construction Engineer of the Vincennes District, a special note should be put on the plans and in the contract documents stating the following: "All Coal, Muck, and other unsuitable materials excavated in cut should not be reused as fill, and this material should be completely removed from the project site". The Shale should be reusable as fill, provided INDOT Requirements regarding the reuse of Shale as fill should be followed. It should not be the responsibility of the Geotechnical Section, nor the responsibility of the Design Consultant to estimate the reuse of fill material. However, the INDOT Geotechnical Engineering Section can be called upon during Construction to assist in evaluating the reuse of the cut material for fill.

If you have any questions, please contact us at (317) 610-7251.

Very Truly Yours,

S. S. Hiremath

Somanath Hiremath
Geotechnical Engineering Group Leader

Joey Franzino

Joey Franzino
Geotechnical Engineer

Prepared by: Joey Franzino
SSH/JF
cc: Mr. M. Fowler – Construction Engineer of the Vincennes District
File
H/Joey/Itemizationletters/shortletter.doc

Indiana Department of Transportation

Materials and Tests Division
120 South Shortridge Road P.O. Box 19389
Indianapolis, Indiana 46219-0389
Phone: (317) 232-5280 Fax: (317) 356-9351

KDD SWJ
WDR WEH
Route To: 98-417
ARE ARE
NRG NG

Memorandum
June 1, 2001

TO: Mr. Tom Seeman
INDOT Design Group Manager

Thru: Somanath Hiremath SSH
Geotechnical Engineering Group Leader

From: Joey Franzino JF
Geotechnical Engineer

RECEIVED
JUN 04 2001
UNITED CONSULTING ENGINEERS, INC.

Re:
Des No:	9161365
Project No:	NH-075-3 ( )
Location:	US 231 - Phase 3
County:	Spencer
District:	Vincennes

Recently, our office was contacted by United Consulting, with a request for us to analyze the settlement in the area of Station 22+040 to Station 22+280. We have analyzed the settlement, and the following are our findings:

1. The estimated total settlement is 2 inches (50 mm).
2. The estimated time for 50% of the settlement to take place is 1 month. The estimated time for 90% of the settlement to take place is 4 months.

Please note that our original recommendations regarding settlement for this section of roadway still apply. These recommendations can be found in our original report dated December 17, 1999.

Please contact our office at (317) 232-5280 if we can be of any further assistance on this project.

SSH/JF

Cc: United Consulting Engineers – Attn: Mr. N. Grady

H:JOEY/itemization letters/memo