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June 17, 2019

Ms. Tanowa Troupe, Secretary
Ohio Power Siting Board
Docketing Division
180 East Broad Street, 11th Floor
Columbus, OH 43215

Re: Case Nos. 09-479-EL-BGN, 11-3446-EL-BGA, 16-469-EL-BGA, and 16-2404-EL-BGA
In the Matter of the Application of Hardin Wind Energy LLC for a Certificate of Environmental Compatibility and Public Need for the Hardin Wind Farm.

Phase 3 – Compliance with Condition 24, Case No. 09-479-EL-BGN – Delivery Route Plan

Dear Ms. Troupe:

Hardin Wind Energy LLC ("Applicant") is certified to construct a wind-powered electric generation facility in Hardin County, Ohio, in accordance with the orders issued by the Ohio Power Siting Board ("OPSB") in the above-referenced cases.

The Applicant is currently preparing to begin Phase 3 of the project, which will entail construction of the access roads and turbine foundations that were not included in Phases 1 and 2.

At this time, for purposes of complying with the certificate conditions for Phase 3 of the project, the Applicant is filing the attached: Road Condition Report (Attachment A); Transportation Route Review (Attachment B); and Transportation Plan (Attachment C). These documents are being provided in compliance with Condition 24 of OPSB's March 22, 2010 Order in Case No. 09-479-EL-BGN.

We are available, at your convenience, to answer any questions you may have.

Respectfully submitted,

/s/ *Christine M.T. Pirik*
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cc: Ed Steele
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Attachment A

Hardin County Wind Farm

Road Condition Report

Prepared for
Invenergy, LLC

May 2019

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Minneapolis, MN 55435
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Road Condition Report

May 2019

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Acronyms

Acronym	Description
AASHTO	American Association of State Highway and Transportation Officials
ASTM	American Society for Testing and Materials
CBR	California Bearing Ratio testing
CR	County Road
DCP	Dynamic Cone Penetrometer
EALF	Equivalent Axle Load Factors
ESAL	Equivalent Single Axle Loads
ODOT	Ohio Department of Transportation
TR	Township Road
USGA	United States Geological Survey

1.0 Executive Summary

Several studies were performed for Hardin Wind, a proposed wind power development located in Hardin County, Ohio. Road survey consisting of a video survey, a pavement visual assessment, and identification of areas of concern (See Section 4.0).

The conditions of existing pavement were assessed visually and rated using ASTM Pavement Condition Index (PCI) survey. Roads were divided into sections and each section was inspected with at least two sample units. The existing pavement visual assessments are generally as follows:

- Township Road 92 – very poor (Belmont street) to good.
- County Road 35 – serious to good.
- County Road 110 (West) – good
- Township Road 120 – good
- County Road 130 – fair to good
- County Road 65 – good
- Township Road 90 – satisfactory
- Township Road 105 – fair to good
- County Road 115 – good
- Township Road 85 – satisfactory
- County Road 90 – good
- County Road 95 – satisfactory to good
- Township Road 100 – good
- Township Road 106 – satisfactory
- County Road 106 – satisfactory
- County Road 110 (East) – satisfactory

Soil borings were completed along existing public roads at intervals of approximately 0.25 miles of roadway to a depth of 5 feet. Additionally samples were sent to laboratory for Proctor and California Bearing Ratio testing (CBR) (See Appendix C). The information was used to determine the load capacity of existing roads and improvements required to accommodate any increased traffic by the proposed construction activities (See Section 5.0).

1.1 Recommendations

The results of the capacity study show an acceptable capacity reduction for most roads. Since the reliability level for local rural roads is 80%, and the projects construction traffic will consume less than 20% of the road capacity, there is no need for mitigation measures for those roads.

County Road 95 is the exception and will require mitigation. The proposed mitigations for this roads is to add an asphalt surface course over existing pavement. The required overlay thickness is 1.5 inches for the section between Highway 309 and Township Road 100, and 1.0 inch for the section between Township Road 100 and County Road 110 (See Figure 3 in Appendix A).

2.0 Introduction

Invenergy, LLC (Invenergy) is planning to construct the Hardin County Wind Project, a proposed wind power development located in Hardin County, Ohio. Invenergy has requested a road study and drainage study for the roads indicated in Figure 1 (See Appendix A).

The road study consists of a video survey with identification of areas of concern from visual inspection. It will also include a capacity study to determine the load capacity of the existing roads and improvements required to accommodate any increased traffic by the proposed improvements.

The drainage study consists of site identification of drains, waterways, culverts, and any drainage related structure. The study will review the existing drainage and note any areas of concern near and around the requested roads.

The studies described in this report were performed in phases and represent the road condition at the time of the survey. Phase 1 was completed in November 2016 and included portions of roads near the town of Alger, Phase 2 was completed in December 2016 and included roads near Foraker and roads north of OH-309, Phase 3 was completed in August 2017 and included roads leading to the substation area, and Phase 4 includes the remainder of the roads required for the current wind farm layout.

This report combines all phases and describes the findings from the road and drainage studies including the geotechnical exploration performed for the different sections as part of the capacity study. The following sections provide narrative of the analysis of the conditions of the roads at the time of the survey, and the impact of construction activities to the existing infrastructure. Boring logs, photographs and supporting documents are also provided as part of this report (See Appendix C).

3.0 Project information

The project site is located near the town of Alger, OH. The project consists of construction of wind farm including 60 wind turbines. The vehicles expected for construction activities include fully loaded ready-mix trucks, lowboy semitrailers carrying construction equipment (back hoe excavator, bulldozer, etc.), turbine delivery trucks, crane assembly trucks, and dump trucks for aggregate delivery. Detailed loads are shown in Section 5.0.

The following roads were inspected and analyzed as part of the Hardin Wind project:

1.- Township Road 92 (TR-92) from CR-35 to the intersection with access road to T-12.
2.- County Road 35 (CR-35) from CR-110 to TR-92.
3.- County Road 110 (CR-110) from Highway 235 to the intersection with access road to T-23.
4.- Township Road 120 (TR-120) from Highway 235 the intersection with access road to T-37.
5.- County Road 130 (CR-130) from Highway 235 to the intersection with access road to T-64.
6.- County Road 65 (CR-65) from CR-130 to the intersection with access road to T-52.
7.- Township Road 90 (TR-90) from TR-105 to the intersection with access road to T-114.
8.- Township Road 105 (TR-105) from Highway 309 to the intersection with access road to T-112.
9.- County Road 115 (TR-115) from Highway 309 to the intersection with access road to T-116.
10.- Township Road 85 (TR-85) from Highway 309 to CR-90.
11.- County Road 90 (CR-90) from intersection with access road to T-91 to intersection with access road to T-94.
12.- County Road 95 (CR-95) from Highway 309 to CR-110.
13.- Township Road 100 (TR-100) from CR-95 to the intersection with access road to T-118.
14.- Township Road 106 (TR-106) from CR-89 the intersection with access road to T-106.
15.- County Road 106 (CR-106) from CR-95 to the intersection with access road to T-107.
16.- County Road 110 (CR-110) from the intersection with access road to T-125 to CR-95.

See Appendix A – Figure 2 for analyzed roads.

4.0 Road Study

The conditions of existing pavement were assessed visually and rated using ASTM D 6433 Road and Parking Lots Pavement Condition Index Surveys (See Appendix B). This method divides the pavement into branches that are divided into sections. Each section is then divided into sample units. The units are inspected, and the severity of the distress is assessed visually. The quantity of each distress is estimated to calculate the pavement condition index (PCI). The PCI of the inspected section is determined based on the PCI of the units inspected within the section. Once the PCI of the section is determined, the PCI is used to rate the road using Table 4-1.

In addition to the PCI rating, a video survey was performed for each one of the roads to document the current conditions of the roads. These videos are provided separately and are not part of this report, however, the videos can be used to confirm the distresses described in this document.

Table 4-1 Standard PCI Rating Scale

PCI RANGE	RATING
85 - 100	GOOD
70 - 85	SATISFACTORY
55 - 70	FAIR
40 – 55	POOR
25 – 40	VERY POOR
10 – 25	SERIOUS
0 - 10	FAILED

It is important to note that the PCI does not measure structural capacity, it only provides an objective and rational basis for determining maintenance and repair needs.

Sample units within a section were randomly selected depending on the homogeneity of the pavement section. For roads where more distresses were observed, more sections were selected for measurement. Barr did not find necessary to run a statistical analysis for determining the minimal number of sample units, due to the homogeneity on the number and types of distresses observed.

4.1 Township Road 92

TR-92 was divided into three sections for the inspection. Section 1 from CR-35 to end of Belmont Street (650 ft.), Section 2 from end of Belmont Street to approximately TR-45, and Section 3 from approximately TR-45 to the intersection with access road to turbine 12.

Section 1 was observed in poor condition. The inspected pavement presented several distresses throughout its length such as, alligator cracking, longitudinal and transverse cracking, patching, weathering and raveling, potholes, edge cracking, block cracking, slippage cracking, and bumps and sags. The severity of each distresses observed ranged from low to medium. Figure 4-1 shows examples of these distresses.

Table 4-2 TR-92 Section 1 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	11	SERIOUS
2	36	VERY POOR
3	36	VERY POOR
4	48	VERY POOR

Figure 4-1 TR -92 Section 1

Section 2 was observed with different pavement that the previous sections, newer, homogenous and did not have significant distresses other than slight bleeding towards the center of the road.

Table 4-3 TR-92 Section 2 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	98	GOOD
2	92	GOOD
3	87	GOOD

Figure 4-2 TR -92 Section 2

Section 3 is similar to previous section and observed in newer homogenous condition and did not have significant distresses other than shoulder drop off.

Table 4-4 TR-92 Section 3 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	87	GOOD
2	92	GOOD

Figure 4-3 TR -92 Section 3

4.2 County Road 35

CR-35 was divided in three sections for its assessment. As with TR-92, the portion of the road closest to the town was significantly different to the rest of the road. Section 1 included a portion of S Front Street for the initial 200 feet of road, Section 2 from 200 feet south of TR-92 to TR-100, and Section 3 from TR-11 to CR-110.

Section 1 was observed in poor condition. Several distresses such as alligator and edge cracking, potholes, longitudinal and transversal cracking, and weathering, were observed in this section. See Table 4-5 and Figure 4-4.

Table 4-5 CR-35 Section 1 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	19	SERIOUS
2	39	VERY POOR
3	36	VERY POOR

Figure 4-4 CR-35 Section 1

Section 2 was generally in good condition. Low severity bleeding was observed throughout its length with localized depressions.

Table 4-6 CR-35 Section 2 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	93	GOOD
2	93	GOOD
3	91	GOOD

Figure 4-5 CR-35 Section 2

Section 3 was categorized in fair condition. Distresses like edge cracking, bleeding, shoulder drop-off and longitudinal cracking were observed with low to medium severity, however, two sections of the road presented significant loss of asphalt that were filled with aggregate. Weathering and raveling was also observed around these areas.

Table 4-7 CR-35 Section 3 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	97	GOOD
2	42	POOR
3	91	GOOD
4	22	SERIUS
5	84	SATISFACTORY

Figure 4-6 CR-35 Section 3

Figure 4-7 CR-35 Section 3

4.3 County Road 110

CR-110 was inspected from OH-235 to the intersection with access road to turbine 23 and was generally in good condition. Minimal distresses such as shoulder drop-off, sags and bumps were observed, specifically on the bridge at the intersection with CR-35 and at the irrigation ditch crossings by the Van Deurzen Dairy site. Heavy traffic from harvesting activities was observed coming in and out of the Van Deurzen Dairy site, and travelling east on CR-110 to the adjacent fields. During the site visit no significant distresses were observed in this section of road product of the heavy traffic.

Table 4-8 CR-110 (West) – PCI Summary

SAMPLE UNIT	PCI	RATING
1	97	GOOD
2	97	GOOD

Figure 4-8 CR-110 (West)

4.4 Township Road 120

TR-120 was inspected from the intersection with OH-235 to the intersection with access road to turbine 237 and was observed in good conditions with minimal distresses such as bleeding. Two sample units were selected that are summarized in Table 4-9.

Table 4-9 TR-120 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	97	GOOD
2	97	GOOD

Figure 4-9 TR-120

4.5 County Road 130

CR-130 was inspected from the intersection with OH-235 to the intersection with access road to turbine 64. CR-130 was divided into three sections for the inspection. Section 1 from OH-235 to TR-55 (Scioto River), Section 2 from TR-55 to CR-65, Section 3 from CR-65 to the intersection with access road to turbine 64.

Section 1 conditions were generally good with one fair section due to potholes. Such distresses were mainly classified as low.

Table 4-10 CR-130 Section 1 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	86	GOOD
2	64	FAIR
3	88	GOOD
4	93	GOOD

Figure 4-10 CR-130 Section 1

Section 2 road conditions varied along its length from fair to good with the majority of the distresses at the intersections with other roads, bridges or at farm entrances. Such distresses were mainly classified as low, with few areas where the severity was deemed as medium.

Table 4-11 CR-130 Section 2 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	76	SATISFACTORY
2	89	GOOD
3	87	GOOD
4	72	SATISFACTORY
5	67	FAIR
6	70	SATISFACTORY
7	64	FAIR
8	68	FAIR

Figure 4-11 CR-130 Section 2

Section 3 road was observed generally in good condition. The pavement has minimal distresses such as bleeding. The road differs from previous sections with a width of 17 feet compared to 20 feet. Two sample units were selected within the section.

Table 4-12 CR-130 Section 3 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	90	GOOD
2	93	GOOD

Figure 4-12 CR-130 Section 3

4.6 County Road 65

Approximately 4,530 feet of road were inspected for CR-65, from the intersection with CR-130 to the intersection with the access road of turbine 52. CR-95 was measured at 20-foot wide and was observed in good condition. Low severity distresses such as shoulder drop-off and patching were observed, especially near the intersection with CR-130.

Table 4-13 CR-65 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	87	GOOD
2	87	GOOD
3	86	GOOD

Figure 4-13 CR-65

4.7 Township Road 90

TR-90 was inspected from TR-105 to the intersection with access road to turbine 114. It was observed in satisfactory condition with low severity distresses throughout its length. One of the sample units with a low PCI index due to shoving in the road.

Table 4-14 TR-90 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	FAIR	57
2	SATISFACTORY	70
3	GOOD	87
4	SATISFACTORY	77

Figure 4-14 TR -90

4.8 Township Road 105

TR-105 Was divided in two sections. Section 1 began at the intersection with access road to turbine 112 and ended at the intersection with TR-90. Section 2 from the intersection with TR-90 to the intersection with OH-309.

The rating for Section 1 was found as fair. Even though the general condition of the road was observed to be satisfactory, the sample units analyzed presented several distresses that lowered the rating. Distresses such as utility patching, alligator cracking and longitudinal cracking were observed along culverts that crossed the road. The measurements taken at these areas contributed to the lower rating (See Figure 4-15 and Figure 4-16).

Table 4-15 TR-105 Section 1 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	97	GOOD
2	73	SATISFACTORY
3	52	POOR
4	35	VERY POOR
5	68	FAIR

Figure 4-15 TR-105 Section 1 – Sample 2

Figure 4-16 TR-105 Section 1 – Sample 4

Section 2 had a bituminous surface treatment that appeared to be applied recently. No major distresses to note were observed during the site visit.

Table 4-16 TR-105 Section 2 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	99	GOOD
2	99	GOOD

Figure 4-17 TR-105 Section 2

4.9 County Road 115

CR-115 was inspected from the intersection with access road to turbine 116 to the intersection with OH-309. This road was rated in good conditions due to minimal distresses observed such as bleeding, edge cracking, longitudinal cracking and shoulder drop-off.

Table 4-17 CR-115 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	99	GOOD
2	97	GOOD
3	92	GOOD

Figure 4-18 CR-115

4.10 Township Road 85

TR-85 was inspected from OH-309 to CR-90. The road transitions from a 17 foot road to a 15 foot road approximately 100 feet south of the intersection with OH-309. The road appeared to have been rehabilitated recently and minor distresses were observed, especially near the entrance to the property on the east side of the road and towards the intersection with CR-90. This road was rated satisfactory.

Table 4-18 TR-85 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	80	SATISFACTORY

Figure 4-19 TR-85

4.11 County Road 90

CR-90 was inspected from the intersection with the access road to turbine 91, to the intersection with the access road to turbine 94. The road has a width of 20 feet and appeared to be recently rehabilitated with minor distresses observed.

Table 4-19 CR-90 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	93	GOOD

Figure 4-20 CR-90

4.12 County Road 95

CR-95 was divided in three sections. Section 1 from the intersection with OH-309 to the intersection with TR-100. Section 2 from the intersection with TR-100 to the Scioto River Bridge, and Section 3 from the Scioto River Bridge to the intersection with CR-110.

Sections 1 and 2 were found in satisfactory conditions. They presented low severity distresses throughout their length such as longitudinal and transverse cracking, edge cracking, block cracking, bleeding, polished aggregate, and shoulder drop-offs.

Table 4-20 CR-95 Section 1 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	79	SATISFACTORY
2	81	SATISFACTORY
3	78	SATISFACTORY
4	84	SATISFACTORY
5	85	GOOD

Figure 4-21 CR-95 Section 1

Table 4-21 CR-95 Section 2 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	81	SATISFACTORY
2	86	SATISFACTORY

Section 3 presented similar conditions and distresses but the individual measurements were lower than Sections 1 and 2, thus the higher PCI values in sample units 1 and 3.

Table 4-22 CR-95 Section 3 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	84	GOOD
2	76	SATISFACTORY
3	99	GOOD

Figure 4-22 CR-95 Section 3

4.13 Township Road 100

TR-100 was inspected from CR-95 to the intersection with access road to turbine 118. The section was subject to recent rehabilitation and distresses were not observed at the time of the inspection.

Table 4-23 TR-100 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	99	GOOD
2	99	GOOD

Figure 4-23 TR-100

4.14 Township Road 106

TR-106 is located within the town of Foraker. The road receives heavy traffic from semitrailers coming in and out of the Foraker elevator, located at the corner of TR-106 and CR-89. Distresses with low severity such as shoulder drop-off, alligator cracking, block cracking, longitudinal and transverse cracking were observed.

Table 4-24 TR-106 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	82	SATISFACTORY
2	76	SATISFACTORY
3	70	SATISFACTORY

Figure 4-24 TR-106

4.15 County Road 106

CR-106 was inspected from CR-95 to the intersection with the access road to T-107. This section presented low severity distresses and was observed to be in satisfactory to good condition.

Table 4-25 CR-106 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	77	SATISFACTORY
2	80	SATISFACTORY
3	92	GOOD

Figure 4-25 CR-106

4.16 County Road 110

CR-110 was inspected from the intersection with access road to turbine 125 to CR-95. This portion of CR-110 was divided into two sections for the inspection. Section 1 from intersection with access road to turbine 125 to CR-89, and Section 2 from CR-89 to CR-95.

Section 1 was observed generally in fair condition. Heavier traffic was observed in this section of the road, thus, more distresses were present such as bumps, patching, alligator cracking, bleeding, transversal cracking, edge cracking, etc., however these distresses were low severity.

Table 4-26 CR-110 (East) Section 1 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	67	FAIR
2	58	FAIR
3	77	SATISFACTORY
4	69	FAIR

Figure 4-26 CR-110 (East) Section 1

Section 2 is a portion of the road in an urban area within the town of Foraker and was observed in satisfactory conditions. The distresses observed were shoulder drop-off and edge cracking, as well as a localized depression towards the intersection of CR-95.

Table 4-27 CR-110 (East) Section 2 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	82	SATISFACTORY
2	97	GOOD
3	66	FAIR
4	82	SATISFACTORY

Figure 4-27 CR-110 – (East) Section 2

5.0 Geotechnical Evaluation

Soil borings were completed along existing public roads at intervals of approximately 0.25 miles of roadway. Each soil boring extended to a depth of 5 feet. Soil samples were collected at 2 ½ foot intervals by driving a split spoon sampler.

Other bulk samples were also obtained during drilling. Samples were used for soils characterization and tests. Additionally selected samples were sent to laboratory for Proctor and California Bearing Ratio testing (CBR). Dynamic Cone Penetrometer (DCP) tests were performed parallel to soil borings to determine in situ soil strength and to correlate to other parameters such as CBR values. Further information on the evaluations and results are presented in Appendix C.

6.0 Capacity Study

This section will focus on determining the load capacity of the existing roads and improvements required to accommodate any increased traffic by the proposed construction activities.

6.1 Existing pavement structure

Table 6-1 Existing pavement structure

Road	Average Asphalt Thickness	Average Gravel Thickness
1A - TR 92 – CR 35 to TR 45	13.1	0.0
1B - TR 92 – TR 45 to T12	7.5	7.0
2 - CR 35	12.2	0.0
3 - CR 110 – 235 to T-23	11.6	0.0
4- TR 120	10.3	0.0
5A - CR 130 – Hwy 235 to CR 65	6.5	10.5
5B - CR 130 – CR 65 to T-64	6.0	12.0
6 - CR 65	8.7	8.3
7 - TR 90	7.8	0.0
8 - TR 105	6.1	4.4
9 - CR 115	6.1	6.8
10 - TR 85	7.0	9.0
11 - CR 90	7.8	10.3
12A - CR 95 – Hwy 309 to TR 100	7.6	0.0
12B - CR 95 – TR 100 to CR 110	8.0	0.0
13 - TR 100	6.7	6.0
14 - TR 106	7.8	4.2
15 - CR 106	9.0	9.0
16A - CR 110 – T-125 to CR 89	7.5	8.0
16B - CR 110 – CR 95 to CR 89	7.3	4.8

Asphalt thicknesses at boring locations ranged from 3 to 19 inches and gravel thickness where present ranged from 2.5 to 19 inches with an average of approximately 8 inches. There was no base course underlying the asphalt at several locations (see Appendix C). The average existing pavement structure for each road will be used for the capacity study.

6.2 Subsurface Conditions

Subsurface conditions were determined by borings with the geotechnical evaluation. The resulting boring logs are located in Appendix C. Existing conditions consist of a surficial layer of asphalt sometimes underlain by a base course of either silty sand with gravel, silty gravel, or poorly graded gravel with silt and/or sand followed by native lean to fat clay. There were no base or sub-base courses identified beneath the asphalt for some portions; in these locations the bituminous materials appear to be placed directly on the existing soil/fill materials.

6.3 Roadway analysis

The roadway analysis is based on the AASHTO/ODOT pavement design equations. This pavement design method is based around the concept of serviceability or the ability of pavement to serve traffic.

This empirical equation is widely used and has the following form:

$$\log_{10}(W_{18}) = Z_R \times S_o + 9.36 \times \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left(\frac{\Delta PSI}{4.2-1.5}\right)}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 \times \log_{10}(M_R) - 8.07$$

Where;

	W_{18}	=	number of 18 kip equivalent single axle loads (ESAL)
	Z_R	=	standard normal deviate (function of the design reliability level)
	S_0	=	overall standard deviation (function of overall design uncertainty)
	ΔPSI	=	allowable serviceability loss at end of design life
	M_R	=	subgrade resilient modulus
	SN	=	structural number (a measure of required structural capacity)

6.3.1 Serviceability

The initial serviceability for flexible pavements is 4.5 and the terminal serviceability is 2.5 in accordance to ODOT recommendations. This results in a design serviceability loss of 2.0.

6.3.2 Traffic

For design purposes, truck traffic is converted to loading which is normalized by the concept of an equivalent single axle load (ESAL) of 18,000 lb. (80 kN). The Asphalt Institute's Equivalent Axle Load Factors were used to convert the loads. Table 6-2 shows the conversions.

Table 6-2 Equivalent Axle Load Factors

Aggregate		**EALF**
1.9	tons Aggregate / CY	
20	CY / truck	
12,000	Load on Steer Axle (Single Axle)	0.189
34,000	Load on Drive Axle (Tandem Axle)	1.095
34,000	Load on Trailer Axle (Tandem Axle)	1.095
	ESAL per Aggregate Truck	**2.38**
Concrete		
2.03	tons concrete / CY	
10	CY / truck	
12,000	Load on Steer Axle (Single Axle)	0.189
50,000	Load on Drum Axle (Tandem Axle)	4.86
	ESAL per Concrete Truck	**5.05**
Base Segment		
16,000	Load on Steer Axle (Single Axle)	0.623
54,000	Load on 1st Tridem (Tridem Axle)	1.66
54,000	Load on 2nd Tridem (Tridem Axle)	1.66
54,000	Load on 3rd Tridem (Tridem Axle)	1.66
54,000	Load on 4th Tridem (Tridem Axle)	1.66
	ESAL per Base Segments Truck	**4.98**
Nacelle		
18,000	Load on Steer Axle (Single Axle)	1
40,000	Load on 1st Tridem (Tridem Axle)	0.487
60,000	Load on 2nd Tridem (Tridem Axle)	2.51
60,000	Load on 3rd Tridem (Tridem Axle)	2.51
40,000	Load on 4th Tridem (Tridem Axle)	0.487
	ESAL per Nacelle Truck	**5.51**
Blades/Structures		
12,000	Load on Steer Axle (Single Axle)	0.189
34,000	Load on Drive Axle (Tandem Axle)	1.095
34,000	Load on Trailer Axle (Tandem Axle)	1.095
	ESAL per Blade Truck	**2.38**
Other Vehicles		
12,000	Load on Steer Axle (Single Axle)	0.189
34,000	Load on Drive Axle (Tandem Axle)	1.095
34,000	Load on Trailer Axle (Tandem Axle)	1.095
	ESAL per Other Truck	**2.38**

The total ESAL per turbine are shown on Table 6-3.

Table 6-3 Total ESAL per turbine

Load type	Approx. # of trucks	ESAL per truck	Total ESAL
Aggregate	30	2.38	71.37
Concrete	53	5.05	267.60
Tower	4	4.98	19.92
Nacelle	1	5.51	5.51
Blades	3	2.38	7.14
Other	6	2.38	14.28
		ESAL per turbine	**385.82**

6.3.3 Subgrade Resilient Modulus

ODOT has adopted a standard relationship between modulus of resilience (M_r) and the California bearing ratio (CBR). The units for resilient modulus are pounds per square inch (psi).

$$M_r = 1200 * CBR$$

6.3.4 California Bearing Ratio

The California bearing ratio (CBR) is a value representing a soil's saturated resistance to shearing under a standard load, compared to the resistance of crushed stone subjected to the same load. The CBR results for the site can be found in Appendix C.

ODOT's pavement design procedure uses a statistical reliability factor to account for variability in subgrade stiffness. Because of this, the average CBR is to be used for pavement design thus avoiding unnecessarily thick and wasteful design.

An average CBR @ 95% of standard Proctor density of 2.7 will be used for the evaluation of road capacity (see Appendix C).

6.3.5 Reliability

AASHTO defines reliability as the probability that the load applications a pavement can withstand in reaching a specified minimum serviceability level is not exceeded by the number of load applications that are actually applied to the pavement. ODOT's reliability level for local rural roads is 80%.

6.3.6 Overall Standard Deviation

The overall standard deviation is a measure of the spread of the probability distribution for ESAL vs. Serviceability. ODOT's standard deviation for flexible pavements is 0.49.

6.3.7 AASHTO Drainage Coefficient

The AASHTO pavement design equations attempt to consider the effects of drainage on pavement performance. ODOT's drainage coefficient pavement design is 1.

6.3.8 Structural coefficient

Structural coefficients from ODOT are 0.14 for aggregate base, 0.23 for existing asphalt concrete, and 0.43 for new surface courses.

6.3.9 Structural Number

Existing structural number (SN) is determined by multiplying the existing structure thickness by its structural coefficient. Table 6-4 shows the calculated structural number for the existing road sections.

Table 6-4 Existing Road Structural Number

Road	Asphalt Thickness (in)	Asphalt Structural coefficient	Gravel Thickness (in)	Gravel Structural coefficient	Structural number
1A - TR 92 – CR 35 to TR 45	13.1	0.23	0.0	0.14	3.01
1B - TR 92 – TR 45 to T12	7.5	0.23	7.0	0.14	2.71
2 - CR 35	12.2	0.23	0.0	0.14	2.81
3 - CR 110 – 235 to T-23	11.6	0.23	0.0	0.14	2.67
4- TR 120	10.3	0.23	0.0	0.14	2.37
5A - CR 130 – Hwy 235 to CR 65	6.5	0.23	10.5	0.14	2.97
5B - CR 130 – CR 65 to T-64	6.0	0.23	12.0	0.14	3.06
6 - CR 65	8.7	0.23	8.3	0.14	3.16
7 - TR 90	7.8	0.23	0.0	0.14	1.79
8 - TR 105	6.1	0.23	4.4	0.14	2.02
9 - CR 115	6.1	0.23	6.8	0.14	2.36
10 - TR 85	7.0	0.23	9.0	0.14	2.87
11 - CR 90	7.8	0.23	10.3	0.14	3.24
12A - CR 95 – Hwy 309 to TR 100	7.6	0.23	0.0	0.14	1.75
12B - CR 95 – TR 100 to CR 110	8.0	0.23	0.0	0.14	1.85
13 - TR 100	6.7	0.23	6.0	0.14	2.38
14 - TR 106	7.8	0.23	4.2	0.14	2.38
15 - CR 106	9.0	0.23	9.0	0.14	3.33
16A - CR 110 – T-125 to CR 89	7.5	0.23	8.0	0.14	2.85
16B - CR 110 – CR 95 to CR 89	7.3	0.23	4.8	0.14	2.35

6.4 Analysis and Recommendations

Having all the parameters from the previous section we can calculate the existing pavement capacity using the empirical equation. The result will show the theoretical total number of ESAL the existing pavement is expected to support. Table 6-5 shows the results for existing road capacity.

Table 6-5 Existing Road Capacity

Road	Z_R	S_0	SN	ΔPSI	M_R	W_{18}
1A - TR 92 – CR 35 to TR 45	-0.841	0.49	3.01	2	3240	100667
1B - TR 92 – TR 45 to T12	-0.841	0.49	2.71	2	3240	50801
2 - CR 35	-0.841	0.49	2.81	2	3240	64040
3 - CR 110 – 235 to T-23	-0.841	0.49	2.67	2	3240	46578
4- TR 120	-0.841	0.49	2.37	2	3240	22157
5A - CR 130 – Hwy 235 to CR 65	-0.841	0.49	2.97	2	3240	90872
5B - CR 130 – CR 65 to T-64	-0.841	0.49	3.06	2	3240	111125
6 - CR 65	-0.841	0.49	3.16	2	3240	137372
7 - TR 90	-0.841	0.49	1.79	2	3240	4132
8 - TR 105	-0.841	0.49	2.02	2	3240	8333
9 - CR 115	-0.841	0.49	2.36	2	3240	21357
10 - TR 85	-0.841	0.49	2.87	2	3240	73880
11 - CR 90	-0.841	0.49	3.24	2	3240	159074
12A - CR 95 – Hwy 309 to TR 100	-0.841	0.49	1.75	2	3240	3552
12B - CR 95 – TR 100 to CR 110	-0.841	0.49	1.85	2	3240	4936
13 - TR 100	-0.841	0.49	2.38	2	3240	22862
14 - TR 106	-0.841	0.49	2.38	2	3240	22922
15 - CR 106	-0.841	0.49	3.33	2	3240	191357
16A - CR 110 – T-125 to CR 89	-0.841	0.49	2.85	2	3240	69892
16B - CR 110 – CR 95 to CR 89	-0.841	0.49	2.35	2	3240	21134

The existing road capacity lets us determine the pavement capacity that will be consumed by the projects construction traffic. Table 6-6 shows the pavement capacity and the estimated percentage that will be used by the projects construction traffic.

Table 6-6 Road Analysis Results

Road	Number of Turbines	Section ESAL	Pavement Capacity	% Capacity used
1A - TR 92 – CR 35 to TR 45	3	1157.5	100667	1.15%
1B - TR 92 – TR 45 to T12	1	385.8	50801	0.76%
2 - CR 35	9	3472.4	64040	5.42%
3 - CR 110 – 235 to T-23	21	8102.2	46578	17.39%
4- TR 120	2	771.6	22157	3.48%
5A - CR 130 – Hwy 235 to CR 65	10	3858.2	90872	4.25%
5B - CR 130 – CR 65 to T-64	1	385.8	111125	0.35%
6 - CR 65	4	1543.3	137372	1.12%
7 - TR 90	1	385.8	4132	9.34%
8 - TR 105	4	1543.3	8333	18.52%
9 - CR 115	2	771.6	21357	3.61%
10 - TR 85	2	771.6	73880	1.04%
11 - CR 90	2	771.6	159074	0.49%
12A - CR 95 – Hwy 309 to TR 100	11	4244.0	3552	119.50%
12B - CR 95 – TR 100 to CR 110	9	3472.4	4936	70.34%
13 - TR 100	1	385.8	22862	1.69%
14 - TR 106	5	1929.1	22922	8.42%
15 - CR 106	1	385.8	191357	0.20%
16A - CR 110 – T-125 to CR 89	3	1157.5	69892	1.66%
16B - CR 110 – CR 95 to CR 89	3	1157.5	21134	5.48%

The reliability level for local rural roads is 80%. If the analysis shows the projects construction traffic will consume less than 20% of the road capacity, there is no need for mitigation for the area. The results show no mitigation required for most of the roads analyzed with the exception of CR-95 which will require mitigation.

The analysis and recommendations presented are based on standard pavement design equations using average thicknesses and CBR values. The actual damaged to existing roads can potentially exceed what has been predicted at localized locations.

6.4.1 Proposed Mitigation

The proposed mitigation for these areas is to increase the pavement capacity (W18) by increasing the structural coefficient. This is achieved by adding an asphalt surface course over existing pavement. The new surface course uses a 0.43 structural coefficients in accordance to ODOT.

The capacity is calculated with the new SN varying the surface course thickness until an acceptable capacity reduction is encountered. Table 6-7 shows the new pavement capacity and the required surface

course thickness to achieve a capacity reduction of less than 20%. The minimum surface course used for this analysis was one (1) inch and increments of half (0.5) inch.

Table 6-7 Mitigation Analysis Results

Road	Existing SN	Required Surface Course Thickness (in)	Surface Course SN	New SN	New W18	New % Capacity Used
8A - CR 95 – Hwy 309 to TR 100	1.75	1.5	0.65	2.39	23587	17.99%
8B - CR 95 – TR 100 to CR 110	1.85	1.0	0.43	2.28	17448	19.90%

The location of the roads requiring mitigation and the thickness of the surface course (asphalt overlay) required are provided in Figure 3 (Appendix A).

Appendix A

Figures

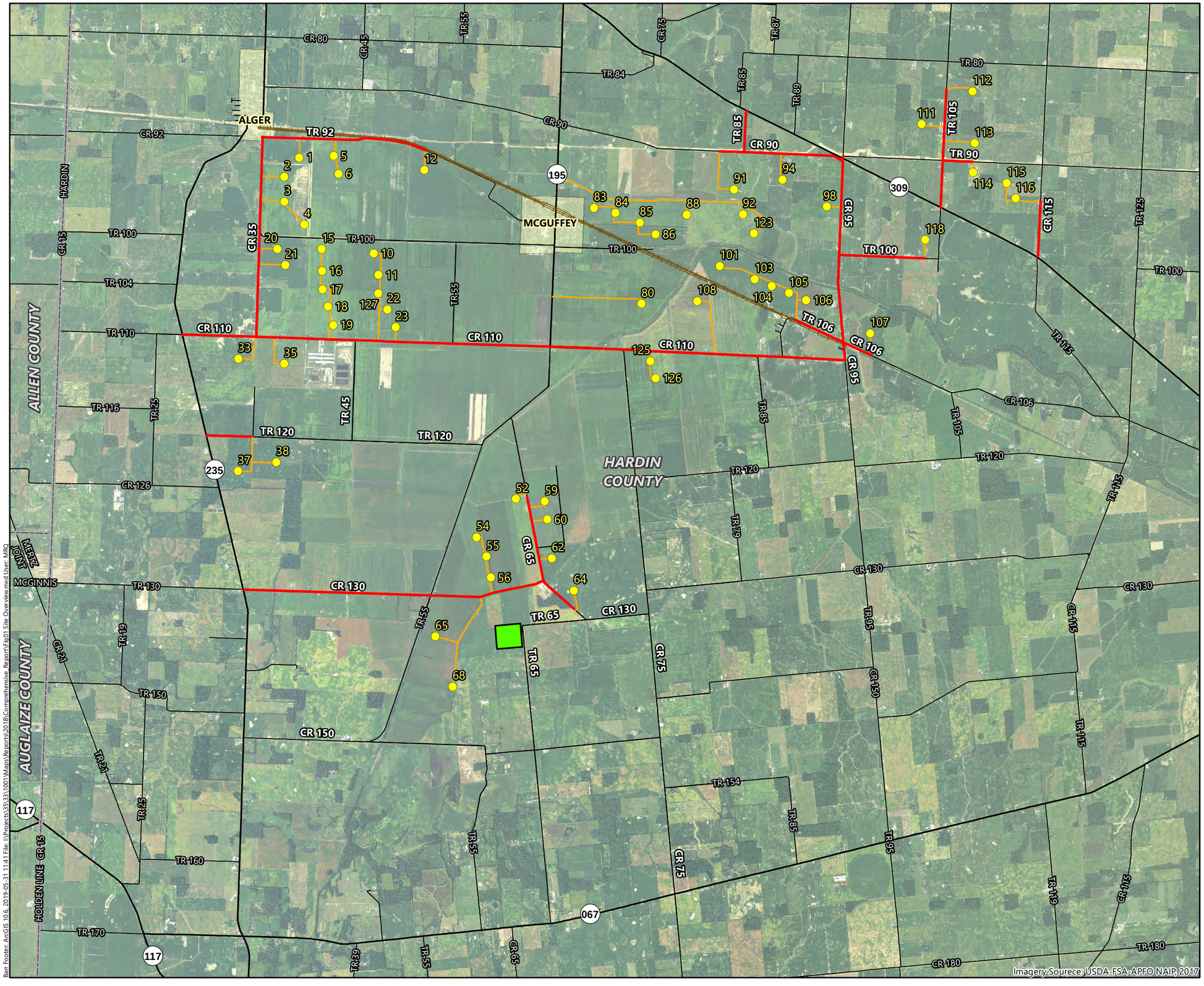
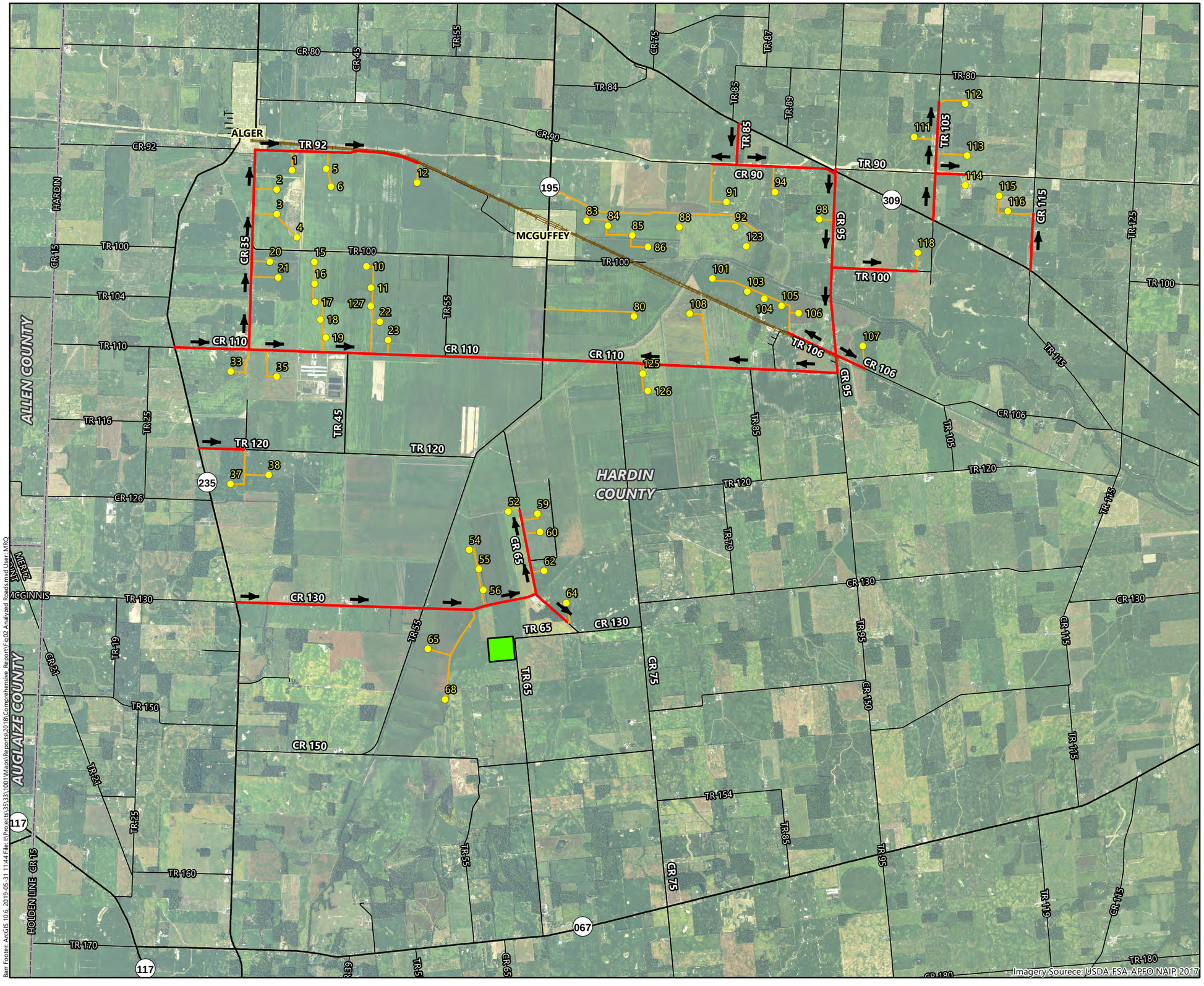


Figure 1

SITE OVERVIEW
Hardin Wind Project
Invenergy LLC
Hardin County, Ohio



Turbine Location
Delivery Route
Access Road
Transportation Route
Substion, POI, and O&M Building Area
City Boundary
County Boundary

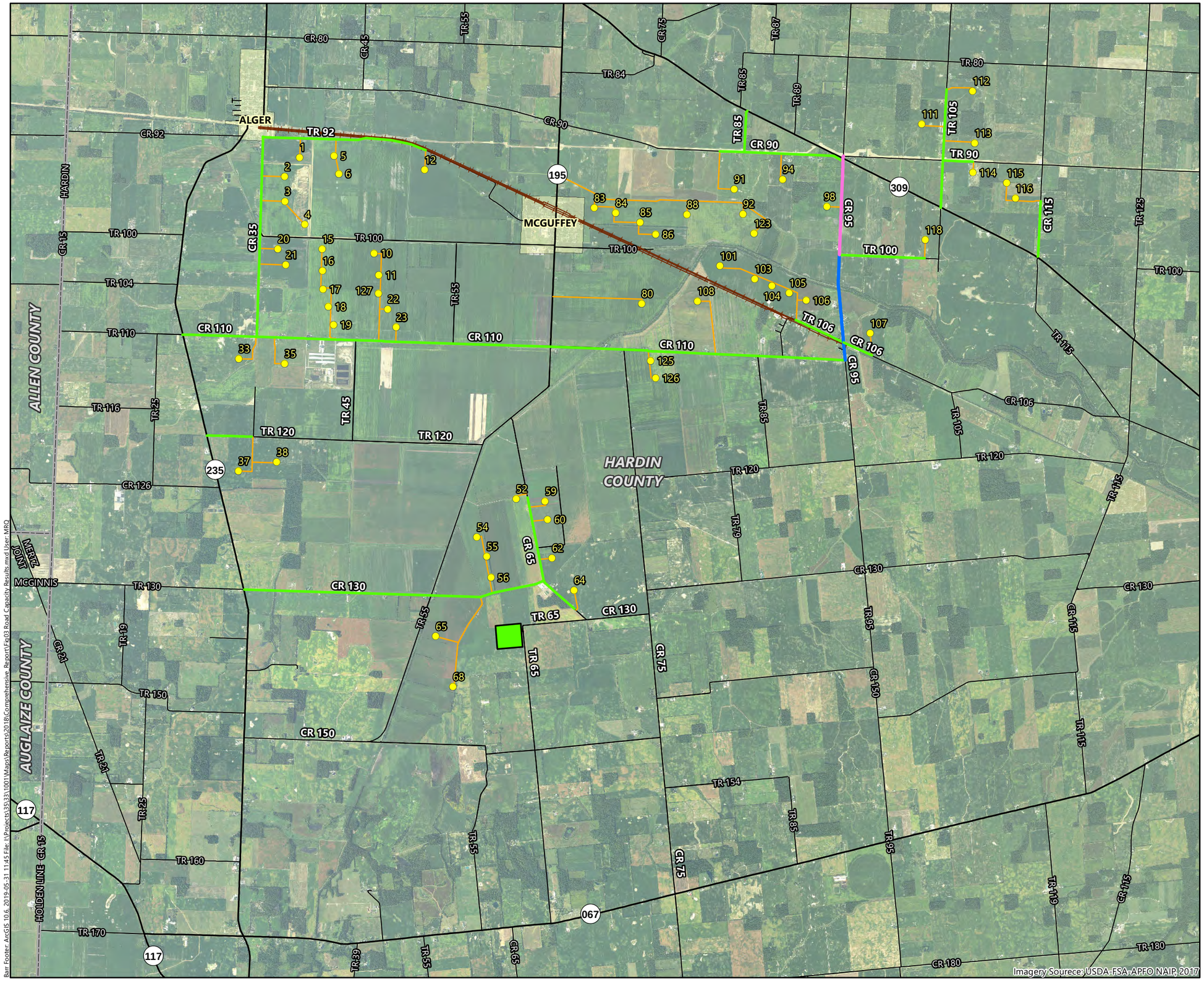
Feet
5,000 0 5,000

Meters
1,600 0 1,600

Figure 2

ANALYZED ROADS
Hardin Wind Project
Invenergy LLC
Hardin County, Ohio

Barr Footer: ArcGIS 10.6, 2019-05-31 11:44 File: N:\Projects\353\31001\Maps\Reports\2018\Comprehensive_Report\Fig02 Analyzed Roads.mxd User: MRQ



Turbine Location
Access Road

Road Capacity Results

Acceptable Road
1 Inch Asphalt Overlay
1.5 Inch Asphalt Overlay
Substion, POI, and O&M Building Area
City Boundary
County Boundary

Feet
5,000 0 5,000

Meters
1,600 0 1,600

Figure 3

ROAD CAPACITY RESULTS
Hardin Wind Project
Invenergy LLC
Hardin County, Ohio

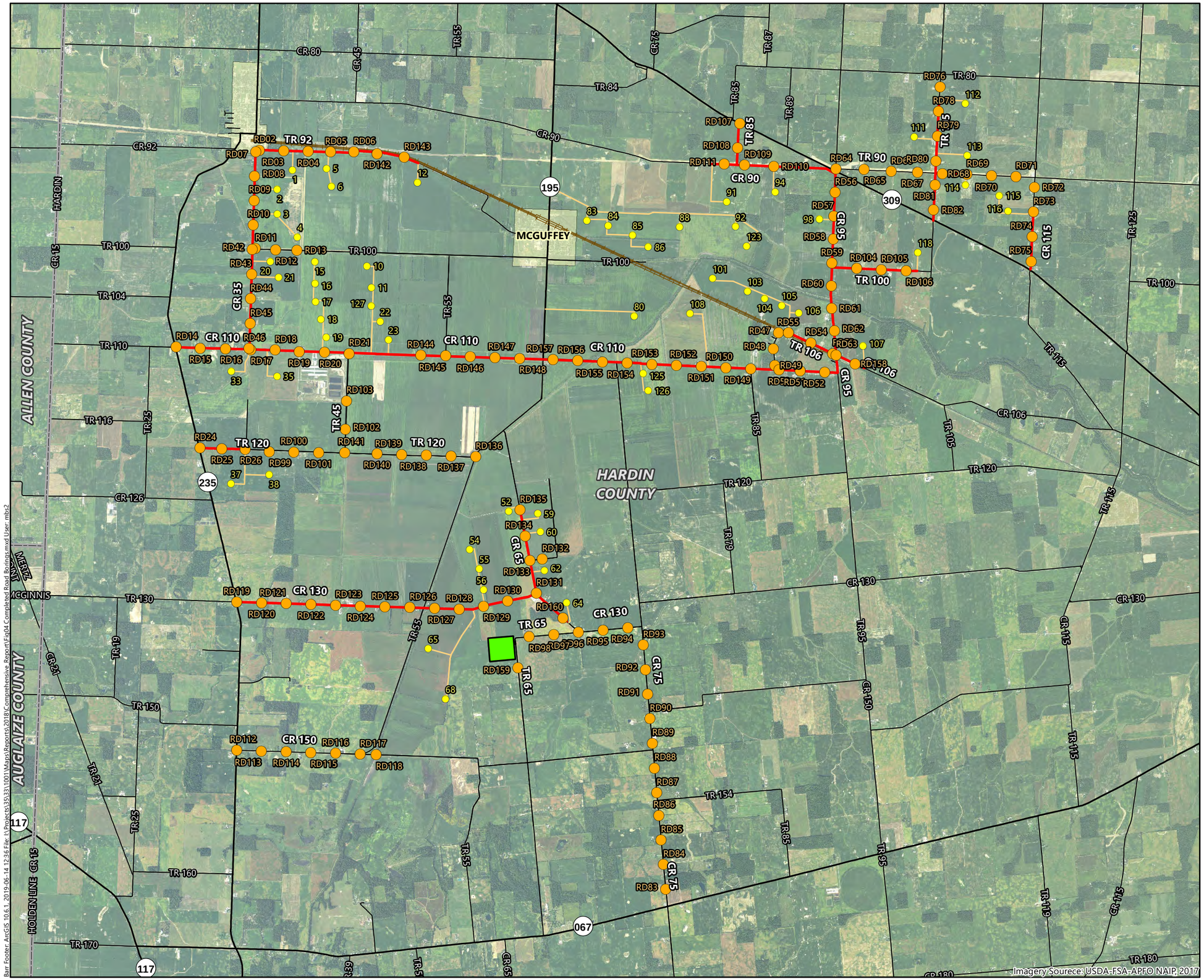


Figure 4

COMPLETED ROAD BORINGS
Hardin Wind Project
Invenergy LLC
Hardin County, Ohio

Appendix B

ASTM D 6433-07

Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys

Designation: D 6433 – 07

Standard Practice for Roads and Parking Lots Pavement Condition Index Surveys[1]

This standard is issued under the fixed designation D 6433; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice covers the determination of roads and parking lots pavement condition through visual surveys using the Pavement Condition Index (PCI) method of quantifying pavement condition.

1.2 The PCI for roads and parking lots was developed by the U.S. Army Corps of Engineers **(1, 2)**.[2] It is further verified and adopted by DOD and APWA.

1.3 The values stated in inch-pound units are to be regarded as the standard. The SI units given in parentheses are for information only.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* Specific precautionary statements are given in Section 6.

2. Terminology

2.1 *Definitions of Terms Specific to This Standard:*

2.1.1 *additional sample*—a sample unit inspected in addition to the random sample units to include nonrepresentative sample units in the determination of the pavement condition. This includes very poor or excellent samples that are not typical of the section and sample units, which contain an unusual distress such as a utility cut. If a sample unit containing an unusual distress is chosen at random it should be counted as an additional sample unit and another random sample unit should be chosen. If every sample unit is surveyed, then there are no additional sample units.

2.1.2 *asphalt concrete (AC) surface*—aggregate mixture with an asphalt cement binder. This term also refers to surfaces constructed of coal tars and natural tars for purposes of this practice.

2.1.3 *pavement branch*—a branch is an identifiable part of the pavement network that is a single entity and has a distinct function. For example, each roadway or parking area is a separate branch.

2.1.4 *pavement condition index (PCI)*—a numerical rating of the pavement condition that ranges from 0 to 100 with 0 being the worst possible condition and 100 being the best possible condition.

2.1.5 *pavement condition rating*—a verbal description of pavement condition as a function of the PCI value that varies from "failed" to "excellent" as shown in Fig. 1.

2.1.6 *pavement distress*—external indicators of pavement deterioration caused by loading, environmental factors, construction deficiencies, or a combination thereof. Typical distresses are cracks, rutting, and weathering of the pavement surface. Distress types and severity levels detailed in Appendix X1 for AC, and Appendix X2 for PCC pavements must be used to obtain an accurate PCI value.

2.1.7 *pavement sample unit*—a subdivision of a pavement section that has a standard size range: 20 contiguous slabs (±8 slabs if the total number of slabs in the section is not evenly divided by 20 or to accommodate specific field condition) for PCC pavement, and 2500 contiguous square feet, ± 1000 ft^2 (225 ± 90 m^2), if the pavement is not evenly divided by 2500 or to accommodate specific field condition, for AC pavement.

2.1.8 *pavement section*—a contiguous pavement area having uniform construction, maintenance, usage history, and condition. A section should have the same traffic volume and load intensity.

2.1.9 *portland cement concrete (PCC) pavement*—aggregate mixture with portland cement binder including nonreinforced and reinforced jointed pavement.

2.1.10 *random sample*—a sample unit of the pavement section selected for inspection by random sampling techniques, such as a random number table or systematic random procedure.

3. Summary of Practice

3.1 The pavement is divided into branches that are divided into sections. Each section is divided into sample units. The type and severity of pavement distress is assessed by visual

[1] This practice is under the jurisdiction of ASTM Committee E17 on Vehicle - Pavement Systems and is the direct responsibility of Subcommittee E17.41 on Pavement Testing, Evaluation, and Management Methods.

Current edition approved Dec. 1, 2007. Published January 2008. Originally approved in 1999. Last previous edition approved in 2003 as D 6433 – 03.

[2] The boldface numbers in parentheses refer to the list of references at the end of this standard.

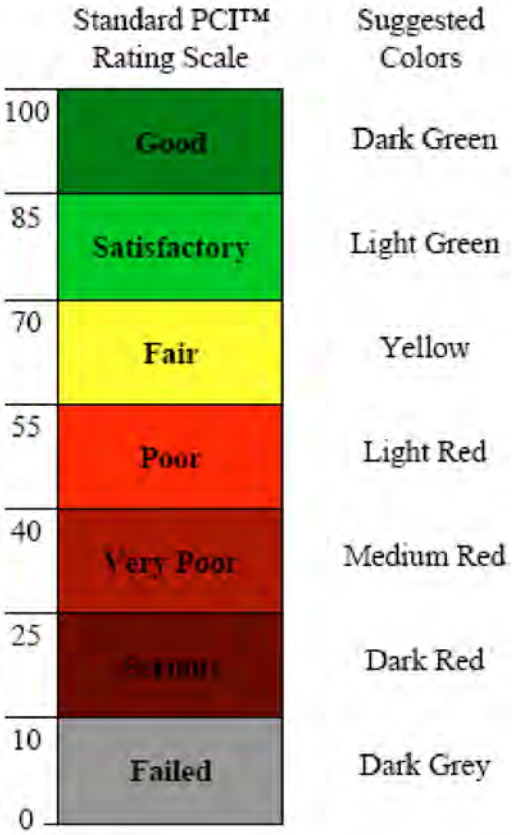


FIG. 1 Pavement Condition Index (PCI), Rating Scale, and Suggested Colors

inspection of the pavement sample units. The quantity of the distress is measured as described in Appendix X1 and Appendix X2. The distress data are used to calculate the PCI for each sample unit. The PCI of the pavement section is determined based on the PCI of the inspected sample units within the section.

4. Significance and Use

4.1 The PCI is a numerical indicator that rates the surface condition of the pavement. The PCI provides a measure of the present condition of the pavement based on the distress observed on the surface of the pavement, which also indicates the structural integrity and surface operational condition (localized roughness and safety). The PCI cannot measure structural capacity nor does it provide direct measurement of skid resistance or roughness. It provides an objective and rational basis for determining maintenance and repair needs and priorities. Continuous monitoring of the PCI is used to establish the rate of pavement deterioration, which permits early identification of major rehabilitation needs. The PCI provides feedback on pavement performance for validation or improvement of current pavement design and maintenance procedures.

5. Apparatus

5.1 *Data Sheets*, or other field recording instruments that record at a minimum the following information: date, location, branch, section, sample unit size, slab number and size, distress types, severity levels, quantities, and names of surveyors. Example data sheets for AC and PCC pavements are shown in Figs. 2 and 3.

5.2 *Hand Odometer Wheel*, that reads to the nearest 0.1 ft (30 mm).

5.3 *Straightedge or String Line*, (AC only), 10 ft (3 m).

5.4 *Scale*, 12 in. (300 mm) that reads to ⅛ in. (3 mm) or better. Additional 12-in. (300 mm) ruler or straightedge is needed to measure faulting in PCC pavements.

5.5 *Layout Plan*, for network to be inspected.

6. Hazards

6.1 Traffic is a hazard as inspectors may walk on the pavement to perform the condition survey.

7. Sampling and Sample Units

7.1 Identify branches of the pavement with different uses such as roadways and parking on the network layout plan.

7.2 Divide each branch into sections based on the pavements design, construction history, traffic, and condition.

7.3 Divide the pavement sections into sample units. If the pavement slabs in PCC have joint spacing greater than 25 ft (8 m) subdivide each slab into imaginary slabs. The imaginary slabs all should be less than or equal to 25 ft (8 m) in length, and the imaginary joints dividing the slabs are assumed to be in perfect condition. This is needed because the deduct values developed for jointed concrete slabs are less than or equal to 25 ft (8 m).

7.4 Individual sample units to be inspected should be marked or identified in a manner to allow inspectors and quality control personnel to easily locate them on the pavement surface. Paint marks along the edge and sketches with locations connected to physical pavement features are acceptable. It is necessary to be able to accurately relocate the sample units to allow verification of current distress data, to examine changes in condition with time of a particular sample unit, and to enable future inspections of the same sample unit if desired.

7.5 Select the sample units to be inspected. The number of sample units to be inspected may vary from the following: all of the sample units in the section, a number of sample units that provides a 95 % confidence level, or a lesser number.

7.5.1 All sample units in the section may be inspected to determine the average PCI of the section. This is usually precluded for routine management purposes by available manpower, funds, and time. Total sampling, however, is desirable for project analysis to help estimate maintenance and repair quantities.

7.5.2 The minimum number of sample units (n) that must be surveyed within a given section to obtain a statistically adequate estimate (95 % confidence) of the PCI of the section

ASPHALT SURFACED ROADS AND PARKING LOTS CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT	SKETCH:
BRANCH _____ SECTION _____ SAMPLE UNIT _____ SURVEYED BY _____ DATE _____ SAMPLE AREA _____	

1. Alligator Cracking	6. Depression	11. Patching & Util Cut Patching	16. Shoving
2. Bleeding	7. Edge Cracking	12. Polished Aggregate	17. Slippage Cracking
3. Block Cracking	8. Jt. Reflection Cracking	13. Potholes	18. Swell
4. Bumps and Sags	9. Lane/Shoulder Drop Off	14. Railroad Crossing	19. Weathering/Raveling
5. Corrugation	10. Long & Trans Cracking	15. Rutting	

DISTRESS SEVERITY	QUANTITY									TOTAL	DENSITY %	DEDUCT VALUE

FIG. 2 Flexible Pavement Condition Survey Data Sheet for Sample Unit

CONCRETE SURFACED ROADS AND PARKING LOTS
CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT

BRANCH_____ SECTION_____ SAMPLE UNIT_____
SURVEYED BY_____ DATE_____ SAMPLE AREA_____

Distress Types

21. Blow up/Buckling
22. Corner Break
23. Divided Slab
24. Durability Crack
25. Faulting
26. Joint Seal
27. Lane/Shoulder
28. Linear Cracking
29. Patching (Large)
30. Patching (Small)
31. Polished Aggregate
32. Popouts
33. Pumping
34. Punchout
35. Railroad Crossing
36. Scaling
37. Shrinkage
38. Spalling Corner
39. Spalling Joint

DIST TYPE	SEV	NO. SLABS	DENSITY %	DEDUCT VALUE

SKETCH:

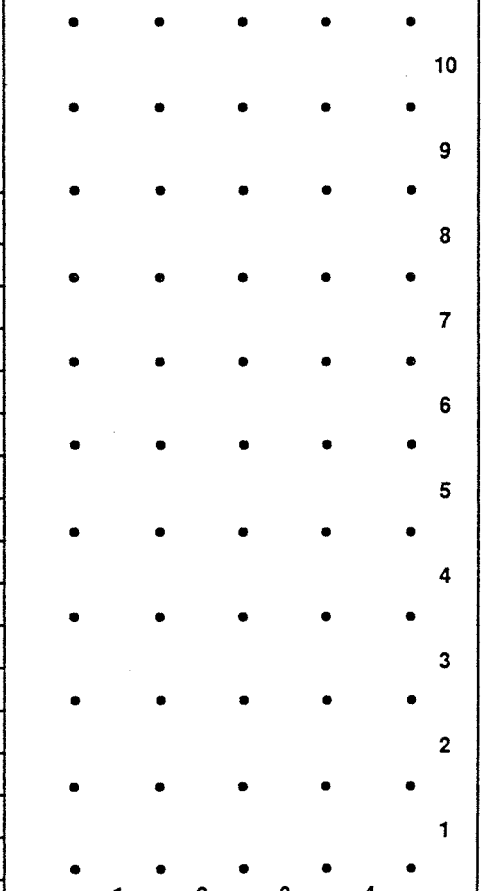


FIG. 3 Joint Rigid Pavement Condition Survey Data Sheet for Sample Unit

is calculated using the following formula and rounding *n* to the next highest whole number (see Eq 1).

$$n = Ns^2/((e^2/4)(N-1) + s^2) \quad (1)$$

where:

e = acceptable error in estimating the section PCI; commonly, $e = \pm 5$ PCI points;

s = standard deviation of the PCI from one sample unit to another within the section. When performing the initial inspection the standard deviation is assumed to be ten for AC pavements and 15 for PCC pavements. This assumption should be checked as described below after PCI values are determined. For subsequent inspections, the standard deviation from the preceding inspection should be used to determine *n*; and,

N = total number of sample units in the section.

7.5.2.1 If obtaining the 95 % confidence level is critical, the adequacy of the number of sample units surveyed must be confirmed. The number of sample units was estimated based on an assumed standard deviation. Calculate the actual standard deviation (s) as follows (see Eq 2):

$$s = (\sum_{i=1}^{n}(PCI_i - PCI_s)^2/(n-1))^{1/2} \quad (2)$$

where:

PCI_i = PCI of surveyed sample units *i*,

PCI_s = PCI of section (mean PCI of surveyed sample units), and

n = total number of sample units surveyed.

7.5.2.2 Calculate the revised minimum number of sample units (Eq 1) to be surveyed using the calculated standard deviation (Eq 2). If the revised number of sample units to be surveyed is greater than the number of sample units already surveyed, select and survey additional random sample units. These sample units should be spaced evenly across the section. Repeat the process of checking the revised number of sample units and surveying additional random sample units until the total number of sample units surveyed equals or exceeds the minimum required sample units (n) in Eq 1, using the actual total sample standard deviation.

7.5.3 Once the number of sample units to be inspected has been determined, compute the spacing interval of the units using systematic random sampling. Samples are spaced equally throughout the section with the first sample selected at random. The spacing interval (i) of the units to be sampled is calculated by the following formula rounded to the next lowest whole number:

$$i = N/n \quad (3)$$

where:
N = total number of sample units in the section, and
n = number of sample units to be inspected.

The first sample unit to be inspected is selected at random from sample units 1 through i. The sample units within a section that are successive increments of the interval i after the first randomly selected unit also are inspected.

7.6 A lessor sampling rate than the above mentioned 95 % confidence level can be used based on the condition survey objective. As an example, one agency uses the following table for selecting the number of sample units to be inspected for other than project analysis:

Given	Survey
1 to 5 sample units	1 sample unit
6 to 10 sample units	2 sample units
11 to 15 sample units	3 sample units
16 to 40 sample units	4 sample units
over 40 sample units	10 %

7.7 Additional sample units only are to be inspected when nonrepresentative distresses are observed as defined in 2.1.1. These sample units are selected by the user.

8. Inspection Procedure

8.1 The definitions and guidelines for quantifying distresses for PCI determination are given in Appendix X1 for AC pavements. Using this test method, inspectors should identify distress types accurately 95 % of the time. Linear measurements should be considered accurate when they are within 10 % if remeasured, and area measurements should be considered accurate when they are within 20 % if remeasured. Distress severities that one determines based on ride quality are considered subjective.

8.2 *Asphalt Concrete (AC) Surfaced Pavement*—Individually inspect each sample unit chosen. Sketch the sample unit, including orientation. Record the branch and section number and the number and type of the sample unit (random or additional). Record the sample unit size measured with the hand odometer. Conduct the distress inspection by walking over the sidewalk/shoulder of the sample unit being surveyed, measuring the quantity of each severity level of every distress type present, and recording the data. Each distress must correspond in type and severity to that described in Appendix X1. The method of measurement is included with each distress description. Repeat this procedure for each sample unit to be inspected. A copy of a Blank Flexible Pavement Condition Survey Data Sheet for Sample Unit is included in Fig. 2.

8.3 *PCC Pavements*—Individually inspect each sample unit chosen. Sketch the sample unit showing the location of the slabs. Record the sample unit size, branch and section number, and number and type of the sample unit (random or additional), the number of slabs in the sample unit and the slab size measured with the hand odometer. Perform the inspection by walking over the sidewalk/shoulder of the sample unit being surveyed and recording all distress existing in the slab along with their severity level. Each distress type and severity must correspond with that described in Appendix X2. Summarize the distress types, their severity levels and the number of slabs in the sample unit containing each type and severity level. Repeat this procedure for each sample unit to be inspected. A copy of a Blank Jointed Rigid Pavement Condition Survey Data Sheet for Sample Unit is included in Fig. 3.

9. Calculation of PCI for Asphalt Concrete (AC) Pavement

9.1 Add up the total quantity of each distress type at each severity level, and record them in the "Total Severities" section. For example, Fig. 4 shows five entries for the Distress Type 1, "Alligator Cracking": 5L, 4L, 4L, 8H, and 6H. The distress at each severity level is summed and entered in the "Total Severity" section as 13 ft^2 (1.2 m^2) of low severity and 14 ft^2 (1.3 m^2) of medium severity. The units for the quantities may be either in square feet (square meters), linear feet (meters), or number of occurrences, depending on the distress type.

9.2 Divide the total quantity of each distress type at each severity level from 9.1 by the total area of the sample unit and multiply by 100 to obtain the percent density of each distress type and severity.

9.3 Determine the deduct value (DV) for each distress type and severity level combination from the distress deduct value curves in Appendix X3.

9.4 Determine the maximum corrected deduct value (CDV). The procedure for determining maximum CDV from individual DVs is identical for both AC and PCC pavement types.

9.5 The following procedure must be used to determine the maximum CDV.

9.5.1 If none or only one individual deduct value is greater than two, the total value is used in place of the maximum CDV in determining the PCI; otherwise, maximum CDV must be determined using the procedure described in 9.5.2-9.5.5.

9.5.2 List the individual deduct values in descending order. For example, in Fig. 4 this will be 25.1, 23.4, 17.9, 11.2, 7.9, 7.5, 6.9, and 5.3.

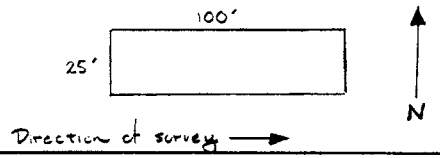
9.5.3 Determine the allowable number of deducts, m, from Fig. 5, or using the following formula (see Eq 4):

$$m = 1 + (9/98)(100–HDV) \leq 10 \quad (4)$$

ASPHALT SURFACED ROADS AND PARKING LOTS
CONDITION SURVEY DATA SHEET
FOR SAMPLE UNIT

BRANCH SPRINGFIELD SECTION 001 SAMPLE UNIT 1
SURVEYED BY KAK DATE 10 Jul 93 SAMPLE AREA 2500 sf

SKETCH:



1. Alligator Cracking
2. Bleeding
3. Block Cracking
4. Bumps and Sags
5. Corrugation
6. Depression
7. Edge Cracking
8. Jt. Reflection Cracking
9. Lane/Shoulder Drop Off
10. Long & Trans Cracking
11. Patching & Util Cut Patching
12. Polished Aggregate
13. Potholes
14. Railroad Crossing
15. Rutting
16. Shoving
17. Slippage Cracking
18. Swell
19. Weathering/Raveling

DISTRESS SEVERITY	QUANTITY									TOTAL	DENSITY %	DEDUCT VALUE
1 L	1×5	1×4	1×4							13	0.52	7.9
1 H	1×8	1×6								14	0.56	23.4
7 L	32	15	18	24	41					130	5.20	7.5
8 M	20	15	35	27	23	10	13			143	5.72	25.1
11 H	3×4	2×5								22	0.88	17.9
13 L	1									1	0.04	11.2
15 L	4	9	8							21	0.84	6.9
19 L	250									250	10.0	5.3

FIG. 4 Example of a Flexible Pavement Condition Survey Data Sheet

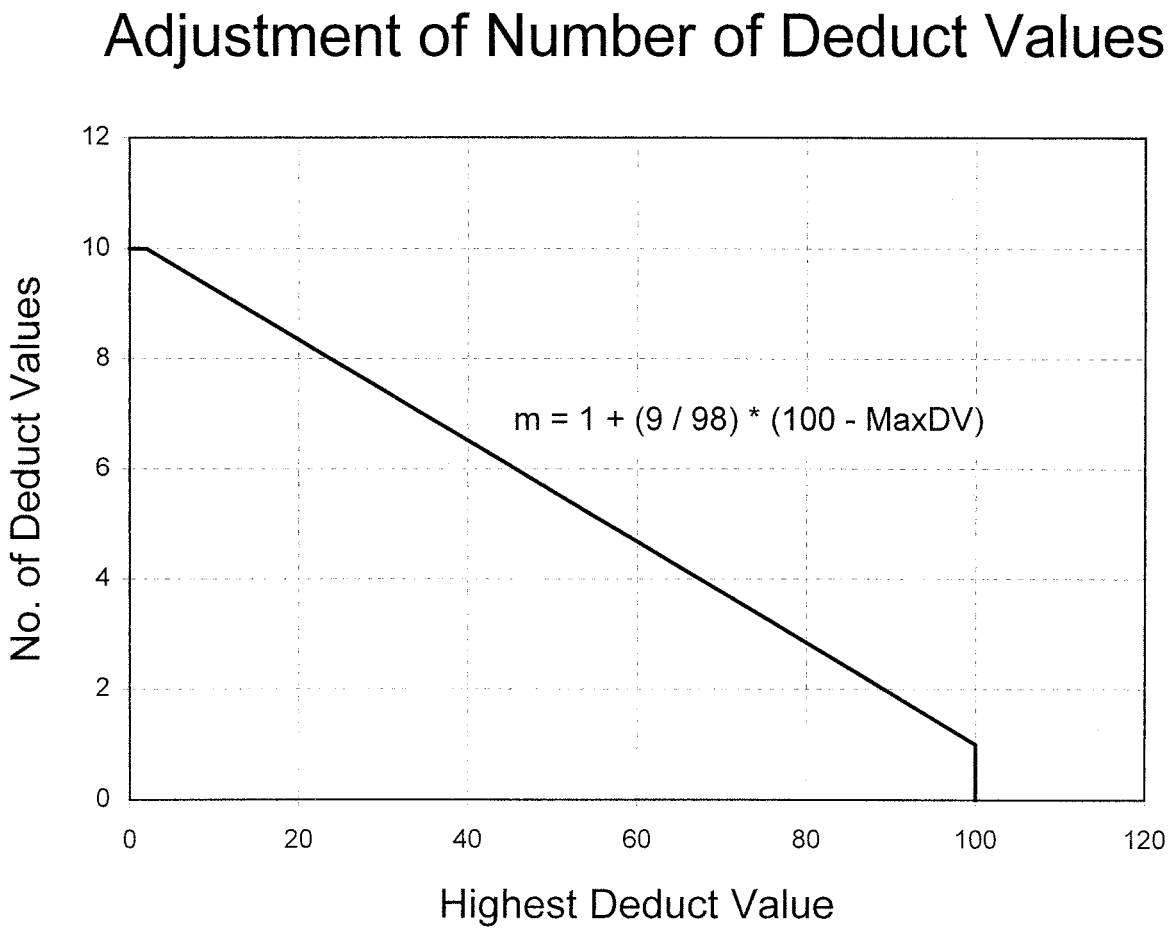


FIG. 5 Adjustment of Number of Deduct Values

where:

m = allowable number of deducts including fractions (must be less than or equal to ten), and

HDV = highest individual deduct value.

(For the example in Fig. 4, $m = 1 + (9/98)(100\text{-}25.1) = 7.9$).

9.5.4 The number of individual deduct values is reduced to the m largest deduct values, including the fractional part. For the example in Fig. 6, the values are 25.1, 23.4, 17.9, 11.2, 7.9, 7.5, 6.9, and 4.8 (the 4.8 is obtained by multiplying 5.3 by (7.9 – 7 = 0.9)). If less than m deduct values are available, all of the deduct values are used.

9.5.5 Determine maximum CDV iteratively, as shown in Fig. 6.

9.5.5.1 Determine total deduct value by summing individual deduct values. The total deduct value is obtained by adding the individual deduct values in 9.5.4, that is, 104.7.

9.5.5.2 Determine q as the number of deducts with a value greater than 2.0. For example, in Fig. 6, $q = 8$.

9.5.5.3 Determine the CDV from total deduct value and q by looking up the appropriate correction curve for AC pavements in Fig. X4.15 in Appendix X3.

9.5.5.4 Reduce the smallest individual deduct value greater than 2.0 to 2.0 and repeat 9.5.5.1-9.5.5.3 until $q = 1$.

9.5.5.5 Maximum CDV is the largest of the CDVs.

9.6 Calculate PCI by subtracting the maximum CDV from 100: PCI = 100-max CDV.

9.7 Fig. 6 shows a summary of PCI calculation for the example AC pavement data in Fig. 4. A blank PCI calculation form is included in Fig. 2.

10. Calculation of PCI for Portland Cement Concrete (PCC) Pavement

10.1 For each unique combination of distress type and severity level, add up the total number of slabs in which they occur. For the example in Fig. 7, there are two slabs containing low-severity corner break (Distress 22L).

10.2 Divide the number of slabs from 10.1 by the total number of slabs in the sample unit and multiply by 100 to obtain the percent density of each distress type and severity combination.

10.3 Determine the deduct values for each distress type severity level combination using the corresponding deduct curve in Appendix X4.

10.4 Determine PCI by following the procedures in 9.5 and 9.6, using the correction curve for PCC pavements (see Fig. X4.20 in Appendix X4) in place of the correction curve for AC pavements.

m = 1 + (9/98) (100 - 25.1) = 7.9 < 8

Use highest 7 deducts and 0.9 of eighth deduct.

0.9 x 5.3 = 4.8

#	Deduct Values										Total	q	CDV
1	25.1	23.4	17.9	11.2	7.9	7.5	6.9	(4.8)			104.7	8	51.0
2	25.1	23.4	17.9	11.2	7.9	7.5	6.9	2			101.9	7	50.0
3	25.1	23.4	17.9	11.2	7.9	7.5	2	2			96.0	6	46.0
4	25.1	23.4	17.9	11.2	7.9	2	2	2			90.5	5	47.0
5	25.1	23.4	17.9	11.2	2	2	2	2			84.6	4	48.0
6	25.1	23.4	17.9	2	2	2	2	2			75.4	3	48.0
7	25.1	23.4	2	2	2	2	2	2			59.5	2	44.0
8	25.1	2	2	2	2	2	2	2			38.1	1	38.0
9													
10													

Max CDV = 51

PCI = 100 - Max CDV = 49

Rating = FAIR

FIG. 6 Calculation of Corrected PCI Value—Flexible Pavement

10.5 Fig. 7 shows a summary of PCI calculation for the example PCC pavement distress data in Fig. 8.

11. Determination of Section PCI

11.1 If all surveyed sample units are selected randomly, then the PCI of the section (PCI_s) is calculated as the area weighted PCI of the randomly surveyed sample units ($\overline{PCI_r}$) using equation 5:

$$PCI_S = \overline{PCI_r} = \frac{\sum_{i=1}^{n} (PCI_{ri} \cdot A_{ri})}{\sum_{i=1}^{n} A_{ri}} \quad (5)$$

CONCRETE SURFACED ROADS AND PARKING LOTS
CONDITION SURVEY DATA SHEET FOR SAMPLE UNIT

BRANCH SECOND SECTION 001 SAMPLE UNIT 1
SURVEYED BY KAK DATE 10 Jul 93 SAMPLE AREA 20 slabs

Distress Types

21. Blow up/Buckling
22. Corner Break
23. Divided Slab
24. Durability Crack
25. Faulting
26. Joint Seal
27. Lane/Shoulder
28. Linear Cracking
29. Patching (Large)
30. Patching (Small)
31. Polished Aggregate
32. Popouts
33. Pumping
34. Punchout
35. Railroad Crossing
36. Scaling
37. Shrinkage
38. Spalling Corner
39. Spalling Joint

DIST TYPE	SEV	NO. SLABS	DENSITY %	DEDUCT VALUE
26	H	—	100	8.0
22	L	3	15	12.6
22	M	1	5	7.7
23	M	3	15	30.5
30	M	4	20	4.4
34	M	2	10	25.1
38	L	6	30	5.8
39	H	1	5	9.0

SKETCH:

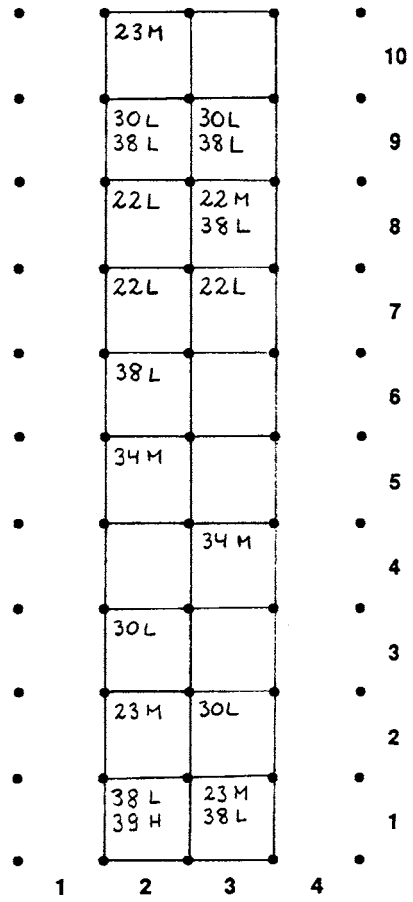


FIG. 7 Example of a Jointed Rigid Pavement Condition Survey Data Sheet

where:

$\overline{PCI}_r$ = area weighted PCI of randomly surveyed sample units,
PCI_{ri} = PCI of random sample unit *i*,
A_{ri} = area of random sample unit *i*,
n = number of random sample units surveyed.

If additional sample units, as defined in 2.1.1, are surveyed, the area weighted PCI of the surveyed additional units ($\overline{PCI}_a$) is calculated using equation 6. The PCI of the pavement section is calculated using equation 7.

$$\overline{PCI_a} = \frac{\sum_{i=1}^{m} (PCI_{ai} \cdot A_{ai})}{\sum_{i=1}^{m} A_{ai}} \quad (6)$$

$$PCI_s = \frac{\overline{PCI_r}(A - \sum_{i=1}^{m} A_{ai}) + \overline{PCI_a}(\sum_{i=1}^{m} A_{ai})}{A} \quad (7)$$

m = 1 + (9/98) (100 - 30.5) = 7.4 < 8

Use highest 7 deducts and 0.4 of eighth deduct.

0.4 x 4.4 = 1.76

#	Deduct Values										Total	q	CDV
1	30.5	25.1	12.6	9.0	8.0	7.7	5.8	1.76			100.5	7	50.0
2	30.5	25.1	12.6	9.0	8.0	7.7	2	1.76			96.7	6	49.5
3	30.5	25.1	12.6	9.0	8.0	2	2	1.76			91.0	5	51.0
4	30.5	25.1	12.6	9.0	2	2	2	1.76			85.0	4	49.0
5	30.5	25.1	12.6	2	2	2	2	1.76			78.0	3	50.0
6	30.5	25.1	2	2	2	2	2	1.76			67.4	2	50.0
7	30.5	2	2	2	2	2	2	1.76			44.3	1	44.3
8													
9													
10													

Max CDV = 51

PCI = 100 - Max CDV = 49

Rating = FAIR

FIG. 8 Calculation of Corrected PCI Value—Jointed Rigid Pavement

$\overline{PCI_a}$ = area weighted PCI of additional sample units,
PCI_{ai} = PCI of additional sample unit *i*,
A_{ai} = area of additional sample unit *i*,
A = area of section,
m = number of additional sample units surveyed, and
PCI_s = area weighted PCI of the pavement section.

11.2 Determine the overall condition rating of the section by using the section PCI and the condition rating scale in Fig. 1.

12. Report

12.1 Develop a summary report for each section. The summary lists section location, size, total number of sample units, the sample units inspected, the PCIs obtained, the average PCI for the section, and the section condition rating.

APPENDIXES

(Nonmandatory Information)

X1. Distress in Asphalt Pavements

X1.1 During the field condition surveys and validation of the PCI, several questions are commonly asked about the identification and measurement of some of the distresses. The answers to these questions for each distress are included under the heading "How to Measure." For convenience, however, the most frequently raised issues are addressed below:

X1.1.1 If alligator cracking and rutting occur in the same area, each is recorded separately at its respective severity level.

X1.1.2 If bleeding is counted, polished aggregate is not counted in the same area.

X1.1.3 Spalling as used herein is the further breaking of pavement or loss of materials around cracks or joints.

X1.1.4 If a crack does not have the same severity level along its entire length, each portion of the crack having a different severity level should be recorded separately. If, however, the different levels of severity in a portion of a crack cannot be easily divided, that portion should be rated at the highest severity level present.

X1.1.5 If any distress, including cracking and potholes, is found in a patched area, it is not recorded; its effect on the patch, however, is considered in determining the severity level of the patch.

X1.1.6 A significant amount of polished aggregate should be present before it is counted.

X1.1.7 A distress is said to be raveled if the area surrounding the distress is broken (sometimes to the extent that pieces are removed).

X1.2 The reader should note that the items above are general issues and do not stand alone as inspection criteria. To properly measure each distress type, the inspector must be familiar with its individual measurement criteria.

X1.3 Nineteen distress types for asphalt-surfaced pavements are listed alphabetically in this manual.

RIDE QUALITY

X1.4 Ride quality must be evaluated in order to establish a severity level for the following distress types:

X1.4.1 Bumps.
X1.4.2 Corrugation.
X1.4.3 Railroad crossings.
X1.4.4 Shoving.
X1.4.5 Swells.

X1.4.6 To determine the effect these distresses have on ride quality, the inspector should drive at the normal operating speed and use the following severity-level definitions of ride quality:

X1.4.6.1 **L**—Low. Vehicle vibrations, for example, from corrugation, are noticeable, but no reduction in speed is necessary for comfort or safety. Individual bumps or settlements, or both, cause the vehicle to bounce slightly, but create little discomfort.

X1.4.6.2 **M**—Medium. Vehicle vibrations are significant and some reduction in speed is necessary for safety and comfort. Individual bumps or settlements, or both, cause the vehicle to bounce significantly, creating some discomfort.

X1.4.6.3 **H**—High. Vehicle vibrations are so excessive that speed must be reduced considerably for safety and comfort. Individual bumps or settlements, or both, cause the vehicle to bounce excessively, creating substantial discomfort, safety hazard, or high potential vehicle damage.

X1.4.7 The inspector should drive at the posted speed in a sedan that is representative of cars typically seen in local traffic. Pavement sections near stop signs should be rated at a deceleration speed appropriate for the intersection.

ALLIGATOR CRACKING (FATIGUE)

X1.5 *Description*—Alligator or fatigue cracking is a series of interconnecting cracks caused by fatigue failure of the asphalt concrete surface under repeated traffic loading. Cracking begins at the bottom of the asphalt surface, or stabilized base, where tensile stress and strain are highest under a wheel load. The cracks propagate to the surface initially as a series of parallel longitudinal cracks. After repeated traffic loading, the cracks connect, forming many sided, sharp-angled pieces that develop a pattern resembling chicken wire or the skin of an alligator. The pieces are generally less than 0.5 m (1.5 ft) on the longest side. Alligator cracking occurs only in areas subjected to repeated traffic loading, such as wheel paths. Pattern-type cracking that occurs over an entire area not subjected to loading is called "block cracking," which is not a load-associated distress.

X1.5.1 *Severity Levels*:

X1.5.1.1 **L**—Fine, longitudinal hairline cracks running parallel to each other with no, or only a few interconnecting cracks. The cracks are not spalled (Fig. X1.1).

FIG. X1.1 Low-Severity Alligator Cracking

X1.5.1.2 **M**—Further development of light alligator cracks into a pattern or network of cracks that may be lightly spalled (Fig. X1.2).

X1.5.1.3 **H**—Network or pattern cracking has progressed so that the pieces are well defined and spalled at the edges. Some of the pieces may rock under traffic (Fig. X1.3).

X1.5.2 *How to Measure*—Alligator cracking is measured in square meters (square feet) of surface area. The major difficulty in measuring this type of distress is that two or three levels of severity often exist within one distressed area. If these portions can be easily distinguished from each other, they should be measured and recorded separately; however, if the different levels of severity cannot be divided easily, the entire area should be rated at the highest severity present. If alligator cracking and rutting occur in the same area, each is recorded separately as its respective severity level.

BLEEDING

X1.6 *Description*—Bleeding is a film of bituminous material on the pavement surface that creates a shiny, glasslike, reflecting surface that usually becomes quite sticky. Bleeding is caused by excessive amounts of asphaltic cement or tars in the mix, excess application of a bituminous sealant, or low air void content, or a combination thereof. It occurs when asphalt fills the voids of the mix during hot weather and then expands onto the pavement surface. Since the bleeding process in not reversible during cold weather, asphalt or tar will accumulate on the surface.

X1.6.1 *Severity Levels*:

X1.6.1.1 **L**—Bleeding only has occurred to a very slight degree and is noticeable only during a few days of the year. Asphalt does not stick to shoes or vehicles (Fig. X1.4).

X1.6.1.2 **M**—Bleeding has occurred to the extent that asphalt sticks to shoes and vehicles during only a few weeks of the year (Fig. X1.5).

X1.6.1.3 **H**—Bleeding has occurred extensively and considerable asphalt sticks to shoes and vehicles during at least several weeks of the year (Fig. X1.6).

X1.6.2 *How to Measure*—Bleeding is measured in square meters (square feet) of surface area. If bleeding is counted, polished aggregate should not be counted.

FIG. X1.2 Medium-Severity Alligator Cracking

FIG. X1.3 High-Severity Alligator Cracking

FIG. X1.4 Low-Severity Bleeding

FIG. X1.5 Medium-Severity Bleeding

BLOCK CRACKING

X1.7 *Description*—Block cracks are interconnected cracks that divide the pavement into approximately rectangular pieces. The blocks may range in size from approximately 0.3 by 0.3 m (1 by 1 ft) to 3 by 3 m (10 by 10 ft). Block cracking is caused mainly by shrinkage of the asphalt concrete and daily

FIG. X1.6 High-Severity Bleeding

temperature cycling, which results in daily stress/strain cycling. It is not load-associated. Block cracking usually indicates that the asphalt has hardened significantly. Block cracking normally occurs over a large portion of the pavement area, but sometimes will occur only in nontraffic areas. This type of distress differs from alligator cracking in that alligator cracks form smaller, many-sided pieces with sharp angles. Also, unlike block, alligator cracks are caused by repeated traffic loadings, and therefore, are found only in traffic areas, that is, wheel paths.

X1.7.1 *Severity Levels*:

X1.7.1.1 **L**—Blocks are defined by low-severity[3] cracks (Fig. X1.7).

X1.7.1.2 **M**—Blocks are defined by medium-severity[3] cracks (Fig. X1.8).

X1.7.1.3 **H**—Blocks are defined by high-severity[3] cracks (Fig. X1.9).

X1.7.2 *How to Measure*—Block cracking is measured in m^2 (ft^2) of surface area. It usually occurs at one severity level in a given pavement section; however, if areas of different severity levels can be distinguished easily from one another, they should be measured and recorded separately.

BUMPS AND SAGS

X1.8 *Description*:

X1.8.1 Bumps are small, localized, upward displacements of the pavement surface. They are different from shoves in that shoves are caused by unstable pavement. Bumps, on the other hand, can be caused by several factors, including:

X1.8.1.1 Buckling or bulging of underlying PCC slabs in AC overlay over PCC pavement.

X1.8.1.2 Frost heave (ice, lens growth).

X1.8.1.3 Infiltration and buildup of material in a crack in combination with traffic loading (sometimes called “tenting”).

X1.8.1.4 Sags are small, abrupt, downward displacements of the pavement surface. If bumps appear in a pattern perpendicular to traffic flow and are spaced at less than 3 m (10 ft), the distress is called corrugation. Distortion and displacement that occur over large areas of the pavement surface, causing large or long dips, or both, in the pavement should be recorded as“ swelling.”

X1.8.2 *Severity Levels*:

X1.8.2.1 **L**—Bump or sag causes low-severity ride quality (Fig. X1.10).

X1.8.2.2 **M**—Bump or sag causes medium-severity ride quality (Fig. X1.11).

X1.8.2.3 **H**—Bump or sag causes high-severity ride quality (Fig. X1.12).

X1.8.3 *How to Measure*—Bumps or sags are measured in linear meters (feet). If the bump occurs in combination with a crack, the crack also is recorded.

[3] See definitions of longitudinal transverse cracking within Appendix X2.10.

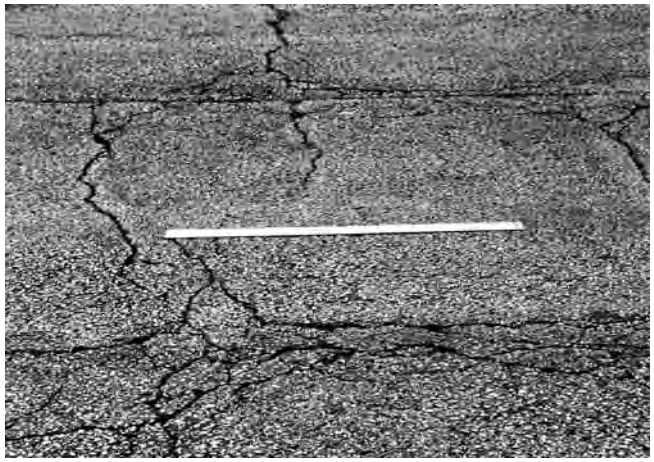


FIG. X1.7 Low-Severity Block Cracking

FIG. X1.8 Medium-Severity Block Cracking

FIG. X1.9 High-Severity Block Cracking

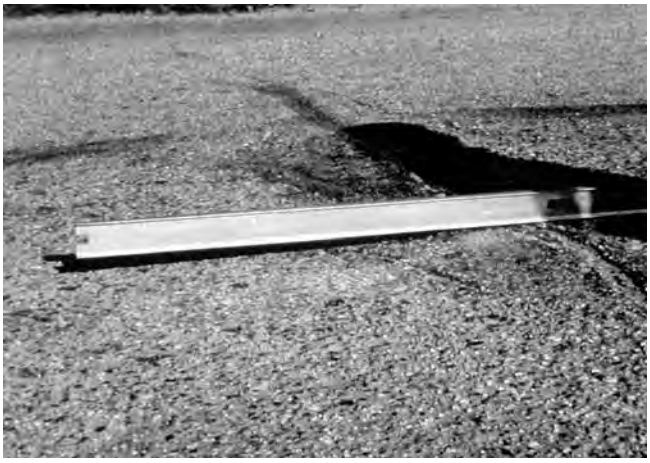


FIG. X1.10 Low-Severity Bumps and Sags

FIG. X1.11 Medium-Severity Bumps and Sags

CORRUGATION

X1.9 *Description*—Corrugation, also known as "washboarding", is a series of closely spaced ridges and valleys (ripples) occurring at fairly regular intervals, usually less than 3 m (10 ft) along the pavement. The ridges are perpendicular to the traffic direction. This type of distress usually is caused by traffic action combined with an unstable pavement surface or base.

FIG. X1.12 High-Severity Bumps and Sags

X1.9.1 *Severity Levels*:

X1.9.1.1 **L**—Corrugation produces low-severity ride quality (Fig. X1.13).

X1.9.1.2 **M**—Corrugation produces medium-severity ride quality (Fig. X1.14).

X1.9.1.3 **H**—Corrugation produces high-severity ride quality (Fig. X1.15).

X1.9.2 *How to Measure*—Corrugation is measured in square meters (square feet) of surface area.

DEPRESSION

X1.10 *Description*—Depressions are localized pavement surface areas with elevations slightly lower than those of the surrounding pavement. In many instances, light depressions are not noticeable until after a rain, when ponding water creates a "birdbath" area; on dry pavement, depressions can be spotted by looking for stains caused by ponding water. Depressions are created by settlement of the foundation soil or are a result of

FIG. X1.13 Low-Severity Corrugation

FIG. X1.14 Medium-Severity Corrugation

FIG. X1.15 High-Severity Corrugation

improper construction. Depressions cause some roughness, and when deep enough or filled with water, can cause hydroplaning.

X1.10.1 *Severity Levels (Maximum Depth of Depression)*:

X1.10.1.1 **L**–13 to 25 mm (½ to 1 in.) (Fig. X1.16).

X1.10.1.2 **M**–25 to 50 mm (1 to 2 in.) (Fig. X1.17).

FIG. X1.16 Low-Severity Depression

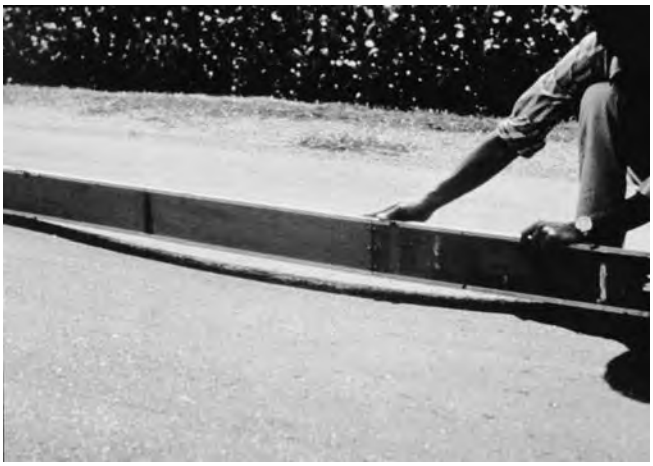


FIG. X1.17 Medium-Severity Depression

X1.10.1.3 **H**—More than 50 mm (2 in.) (Fig. X1.18).

X1.10.2 *How to Measure*—Depressions are measured in square meters (square feet) of surface area.

EDGE CRACKING

X1.11 *Description*—Edge cracks are parallel to and usually within 0.3 to 0.5 m (1 to 1.5 ft) of the outer edge of the pavement. This distress is accelerated by traffic loading and can be caused by frost-weakened base or subgrade near the edge of the pavement. The area between the crack and pavement edge is classified as raveled if it is broken up (sometimes to the extent that pieces are removed).

X1.11.1 *Severity Levels*:

X1.11.1.1 **L**—Low or medium cracking with no breakup or raveling (Fig. X1.19).

X1.11.1.2 **M**—Medium cracks with some breakup and raveling (Fig. X1.20).

X1.11.1.3 **H**—Considerable breakup or raveling along the edge (Fig. X1.21).

X1.11.2 *How to Measure*—Edge cracking is measure in linear meters (feet).

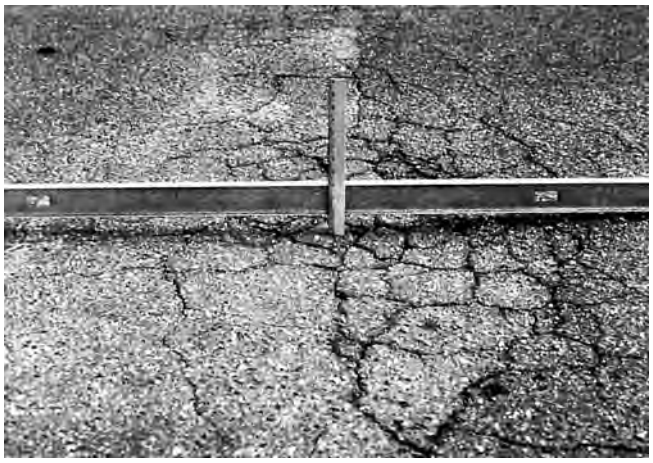


FIG. X1.18 High-Severity Depression

FIG. X1.19 Low-Severity Edge Cracking

FIG. X1.20 Medium-Severity Edge Cracking

FIG. X1.21 High-Severity Edge Cracking

JOINT REFLECTION CRACKING (From Longitudinal and Transverse PCC Slabs)

X1.12 *Description*—This distress occurs only on asphalt-surfaced pavements that have been laid over a PCC slab. It does not include reflection cracks from any other type of base, that is, cement- or lime-stabilized; these cracks are caused mainly by thermal- or moisture-induced movement of the PCC slab beneath the AC surface. This distress is not load-related; however, traffic loading may cause a breakdown of the AC surface near the crack. If the pavement is fragmented along a crack, the crack is said to be spalled. A knowledge of slab dimension beneath the AC surface will help to identify these distresses.

X1.12.1 *Severity Levels*:

X1.12.1.1 **L**—One of the following conditions exists (Fig. X1.22): Nonfilled crack width is less than 10 mm (⅜ in.), or filled crack of any width (filler in satisfactory condition).

X1.12.1.2 **M**—One of the following conditions exists (Fig. X1.23): Nonfilled crack width is greater than or equal to 10 mm (⅜ in.) and less than 75 mm (3 in.); nonfilled crack less than or equal to 75 mm (3 in.) surrounded by light secondary cracking; or, filled crack of any width surrounded by light secondary cracking.

X1.12.1.3 **H**—One of the following conditions exists (Fig. X1.24): Any crack filled or nonfilled surrounded by medium- or high-severity secondary cracking; nonfilled cracks greater than 75 mm (3 in.); or, a crack of any width where approximately 100 mm (4 in.) of pavement around the crack are severely raveled or broken.

X1.12.2 *How to Measure*—Joint reflection cracking is measured in linear meters (feet). The length and severity level of each crack should be identified and recorded separately. For example, a crack that is 15 m (50 ft) long may have 3 m (10 ft) of high severity cracks, which are all recorded separately. If a bump occurs at the reflection crack, it is recorded also.

LANE/SHOULDER DROP-OFF

X1.13 *Description*—Lane/shoulder drop-off is a difference in elevation between the pavement edge and the shoulder. This distress is caused by shoulder erosion, shoulder settlement, or by building up the roadway without adjusting the shoulder level.

X1.13.1 *Severity Levels*:

X1.13.1.1 **L**—The difference in elevation between the pavement edge and shoulder is > 25 mm (1 in.) and< 50 mm (2 in.) (Fig. X1.25).

FIG. X1.22 Low-Severity Joint Reflection Cracking

FIG. X1.23 Medium-Severity Joint Reflection Cracking

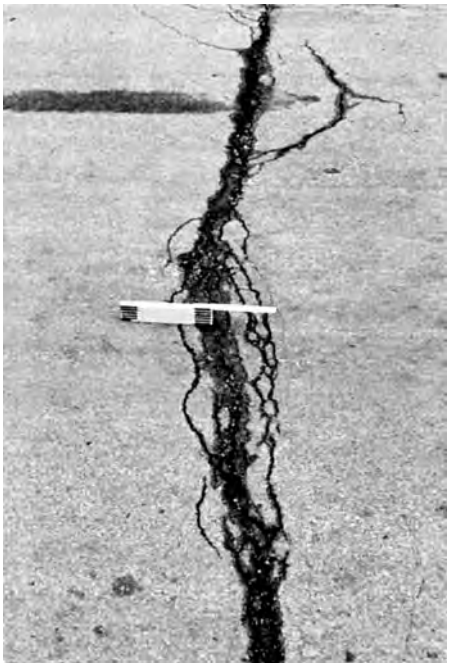


FIG. X1.24 High-Severity Joint Reflection Cracking

X1.13.1.2 **M**—The difference in elevation is > 50 mm (2 in.) and < 100 mm (4 in.) (Fig. X1.26).

X1.13.1.3 **H**—The difference in elevation is > 100 mm (4 in.) (Fig. X1.27).

X1.13.2 *How to Measure*—Lane/shoulder drop-off is measured in linear meters (feet).

LONGITUDINAL AND TRANSVERSE CRACKING (Non-PCC Slab Joint Reflective)

X1.14 *Description*:

FIG. X1.25 Low-Severity Lane/Shoulder Drop-Off

FIG. X1.26 Medium-Severity Lane/Shoulder Drop-Off

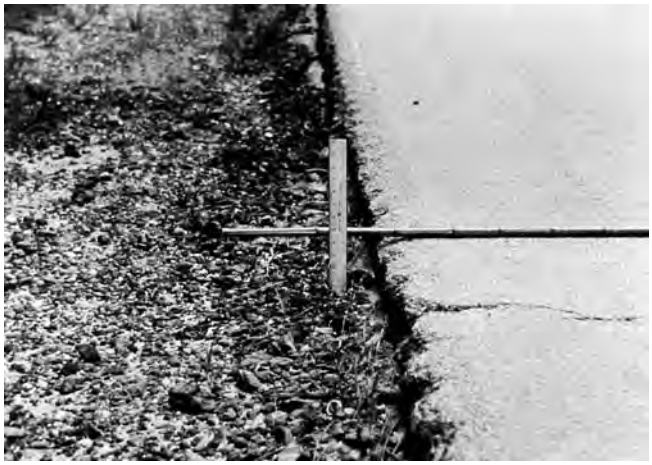


FIG. X1.27 High-Severity Lane/Shoulder Drop-Off

X1.14.1 Longitudinal cracks are parallel to the pavement's centerline or laydown direction. They may be caused by:

X1.14.1.1 A poorly constructed paving lane joint.

X1.14.1.2 Shrinkage of the AC surface due to low temperatures or hardening of the asphalt, or daily temperature cycling, or both.

X1.14.1.3 A reflective crack caused by cracking beneath the surface course, including cracks in PCC slabs, but not PCC joints.

X1.14.1.4 Transverse cracks extend across the pavement at approximately right angles to the pavement centerline or direction of laydown. These types of cracks are not usually load-associated.

X1.14.2 *Severity Levels*:

X1.14.2.1 **L**—One of the following conditions exists (Fig. X1.28): nonfilled crack width is less than 10 mm (⅜ in.), or filled crack of any width (filler in satisfactory condition).

X1.14.2.2 **M**—One of the following conditions exists (Fig. X1.29): nonfilled crack width is greater than or equal to 10 mm and less than 75 mm (⅜ to 3 in.); nonfilled crack is less than or equal to 75 mm (3 in.) surrounded by light and random cracking; or, filled crack is of any width surrounded by light random cracking.

X1.14.2.3 **H**—One of the following conditions exists (Fig. X1.30): any crack filled or nonfilled surrounded by medium- or high-severity random cracking; nonfilled crack greater than 75 m (3 in.); or, a crack of any width where approximately 100 mm (4 in.) of pavement around the crack is severely broken.

X1.14.3 *How to Measure*—Longitudinal and transverse cracks are measured in linear meters (feet). The length and severity of each crack should be recorded. If the crack does not have the same severity level along its entire length, each portion of the crack having a different severity level should be recorded separately.

PATCHING AND UTILITY CUT PATCHING

X1.15 *Description*—A patch is an area of pavement that has been replaced with new material to repair the existing pavement. A patch is considered a defect no matter how well it is performing (a patched area or adjacent area usually does not perform as well as an original pavement section). Generally, some roughness is associated with this distress.

X1.15.1 *Severity Levels*:

X1.15.1.1 **L**—Patch is in good condition and satisfactory. Ride quality is rated as low severity or better (Fig. X1.31).

X1.15.1.2 **M**—Patch is moderately deteriorated, or ride quality is rated as medium severity, or both (Fig. X1.32).

FIG. X1.28 Low-Severity Longitudinal and Transverse Cracking

FIG. X1.29 Medium-Severity Longitudinal and Transverse Cracking

FIG. X1.30 High-Severity Longitudinal and Transverse Cracking

FIG. X1.31 Low-Severity Patching and Utility Cut Patching

X1.15.1.3 **H**—Patch is badly deteriorated, or ride quality is rated as high severity, or both; needs replacement soon (Fig. X1.33).

X1.15.2 *How to Measure*—Patching is rated in ft^2 of surface area; however, if a single patch has areas of differing

FIG. X1.32 Medium-Severity Patching and Utility Cut Patching

FIG. X1.33 High-Severity Patching and Utility Cut Patching

severity, these areas should be measured and recorded separately. For example, a 2.5 m^2 (27.0 ft^2) patch may have 1 m^2 (11 ft^2) of medium severity and 1.5 m^2 (16 ft^2) of low severity. These areas would be recorded separately. Any distress found in a patched area will not be recorded; however, its effect on the patch will be considered when determining the patch's severity level. No other distresses, for example, are recorded within a patch. Even if the patch material is shoving or cracking, the area is rated only as a patch. If a large amount of pavement has been replaced, it should not be recorded as a patch but considered as new pavement, for example, replacement of a complete intersection.

POLISHED AGGREGATE

X1.16 *Description*—This distress is caused by repeated traffic applications. Polished aggregate is present when close examination of a pavement reveals that the portion of aggregate extending above the asphalt is either very small, or there are no rough or angular aggregate particles to provide good skid resistance. When the aggregate in the surface becomes smooth to the touch, adhesion with vehicle tires is considerably reduced. When the portion of aggregate extending above the surface is small, the pavement texture does not significantly contribute to reducing vehicle speed. Polished aggregate should be counted when close examination reveals that the aggregate extending above the asphalt is negligible, and the surface aggregate is smooth to the touch. This type of distress is indicated when the number on a skid resistance test is low or has dropped significantly from a previous rating.

X1.16.1 *Severity Levels*—No degrees of severity are defined; however, the degree of polishing should be clearly evident in the sample unit in that the aggregate surface should be smooth to the touch (Fig. X1.34).

X1.16.2 *How to Measure*—Polished aggregate is measured in square meters (square feet) of surface area. If bleeding is counted, polished aggregate should not be counted.

POTHOLES

X1.17 *Description*—Potholes are small—usually less than 750 mm (30 in.) in diameter—bowl-shaped depressions in the pavement surface. They generally have sharp edges and vertical sides near the top of the hole. When holes are created by high-severity alligator cracking, they should be identified as potholes, not as weathering.

X1.17.1 *Severity Levels*:

X1.17.1.1 The levels of severity for potholes less than 750 mm (30 in.) in diameter are based on both the diameter and the depth of the pothole, according to Table X1.1.

X1.17.1.2 If the pothole is more than 750 mm (30 in.) in diameter, the area should be determined in square feet and divided by 0.5 m^2 (5.5 ft^2) find the equivalent number of holes. If the depth is 25 mm (1 in.) or less, the holes are considered medium-severity. If the depth is more than 25 mm (1 in.), they are considered high-severity (Figs. X1.35-X1.37).

X1.17.2 *How to Measure*—Potholes are measured by counting the number that are low-, medium-, and high-severity and recording them separately.

RAILROAD CROSSING

X1.18 *Description*—Railroad crossing defects are depressions or bumps around, or between tracks, or both.

X1.18.1 *Severity Levels*:

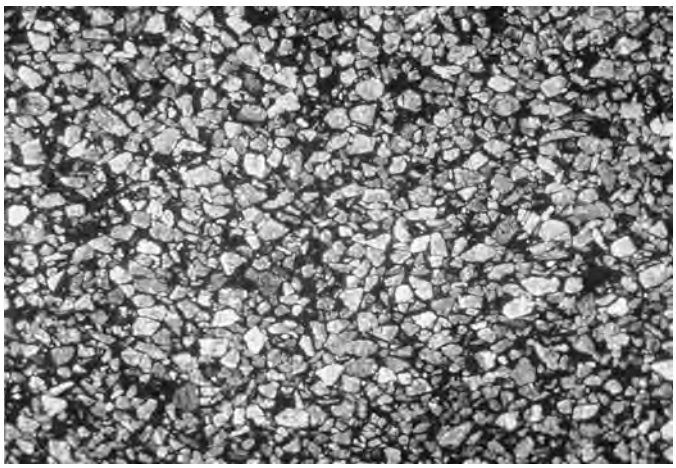


FIG. X1.34 Polished Aggregate

TABLE X1.1 Levels of Severity for Potholes

Maximum Depth of Pothole	Average Diameter (mm) (in.)		
	100 to 200 mm (4 to 8 in.)	200 to 450 mm (8 to 18 in.)	450 to 750 mm (18 to 30 in.)
13 to ≤25 mm (½ to 1 in.)	L	L	M
>25 and ≤50 mm (1 to 2 in.)	L	M	H
>50 mm (2 in.)	M	M	H

FIG. X1.35 Low-Severity Pothole

FIG. X1.36 Medium-Severity Pothole

X1.18.1.1 **L**—Railroad crossing causes low-severity ride quality (Fig. X1.38).

X1.18.1.2 **M**—Railroad crossing causes medium-severity ride quality (Fig. X1.39).

X1.18.1.3 **H**—Railroad crossing causes high-severity ride quality (Fig. X1.40).

X1.18.2 *How to Measure*—The area of the crossing is measured in square meters (square feet) of surface area. If the crossing does not affect ride quality, it should not be counted. Any large bump created by the tracks should be counted as part of the crossing.

FIG. X1.37 High-Severity Pothole

FIG. X1.38 Low-Severity Railroad Crossing

FIG. X1.39 Medium-Severity Railroad Crossing

RUTTING

X1.19 *Description*—A rut is a surface depression in the wheel paths. Pavement uplift may occur along the sides of the rut, but, in many instances, ruts are noticeable only after a

FIG. X1.40 High-Severity Railroad Crossing

FIG. X1.42 Medium-Severity Rutting

rainfall when the paths are filled with water. Rutting stems from a permanent deformation in any of the pavement layers or subgrades, usually caused by consolidated or lateral movement of the materials due to traffic load.

X1.19.1 *Severity Levels (Mean Rut Depth)*:

X1.19.1.1 **L**—6 to 13 mm (¼ to ½ in.) (Fig. X1.41).

X1.19.1.2 **M**—>13 to 25 mm (>½ to 1 in.) (Fig. X1.42).

X1.19.1.3 **H**—>25 mm (>1 in.) (Fig. X1.43).

X1.19.2 *How to Measure*—Rutting is measured in square meters (square feet) of surface area, and its severity is determined by the mean depth of the rut (see X1.19.1.1-X1.19.1.3). The mean rut depth is calculated by laying a straight edge across the rut, measuring its depth, then using measurements taken along the length of the rut to compute its mean depth in millimeters.

FIG. X1.43 High-Severity Rutting

SHOVING

X1.20 *Description*:

X1.20.1 Shoving is a permanent, longitudinal displacement of a localized area of the pavement surface caused by traffic loading. When traffic pushes against the pavement, it produces a short, abrupt wave in the pavement surface. This distress normally occurs only in unstable liquid asphalt mix (cutback or emulsion) pavements.

X1.20.2 Shoves also occur where asphalt pavements abut PCC pavements. The PCC pavements increase in length and push the asphalt pavement, causing the shoving.

X1.20.3 *Severity Levels*:

X1.20.3.1 **L**—Shove causes low-severity ride quality (Fig. X1.44).

X1.20.3.2 **M**—Shove causes medium-severity ride quality (Fig. X1.45).

X1.20.3.3 **H**—Shove causes high-severity ride quality (Fig. X1.46).

X1.20.4 *How to Measure*—Shoves are measured in square meters (feet) of surface area. Shoves occurring in patches are considered in rating the patch, not as a separate distress.

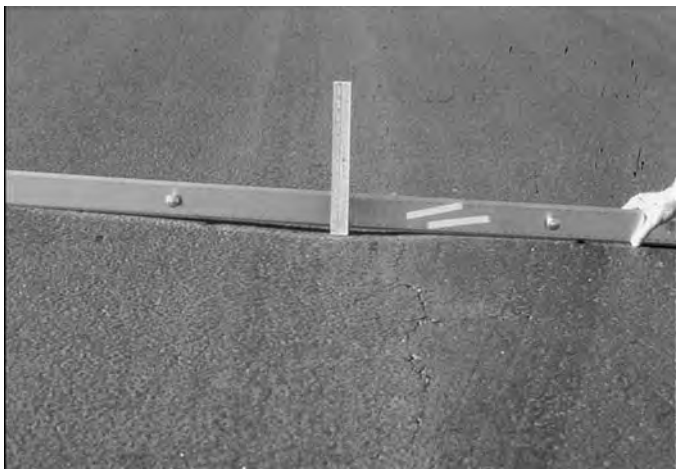


FIG. X1.41 Low-Severity Rutting

SLIPPAGE CRACKING

X1.21 *Description*—Slippage cracks are crescent or half-moon shaped cracks, usually transverse to the direction of travel. They are produced when braking or turning wheels cause the pavement surface to slide or deform. This distress usually occurs in overlaps when there is a poor bond between the surface and the next layer of the pavement structure.

FIG. X1.44 Low-Severity Shoving

FIG. X1.45 Medium-Severity Shoving

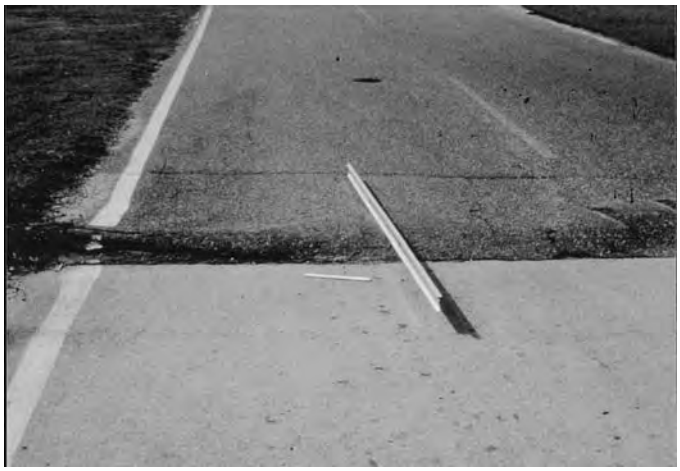


FIG. X1.46 High-Severity Shoving

X1.21.1 *Severity Level*:

X1.21.1.1 **L**—Average crack width is < 10 mm (⅜ in.) (Fig. X1.47).

X1.21.1.2 **M**—One of the following conditions exists (Fig. X1.48): average crack width is ≥ 10 and < 40 mm (≥ ⅜ and< 1-½ in.); or the area around the crack is moderately spalled, or surrounded with secondary cracks.

FIG. X1.47 Low-Severity Slippage Cracking

FIG. X1.48 Medium-Severity Slippage Cracking

X1.21.1.3 **H**—One of the following conditions exists (Fig. X1.49): the average crack width is > 40 mm (1-½ in.) or the area around the crack is broken into easily removed pieces.

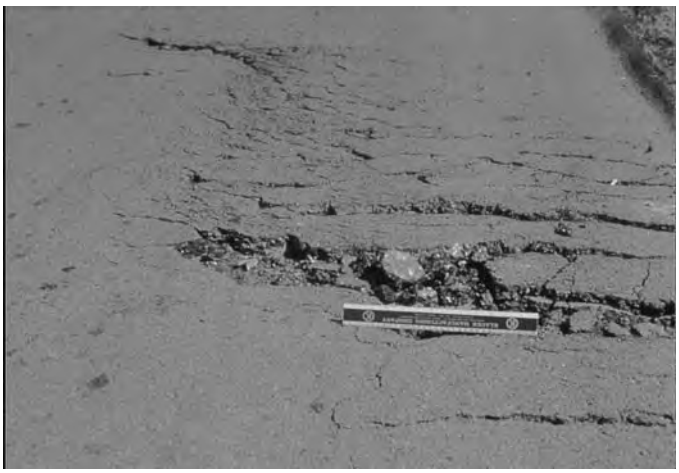


FIG. X1.49 High-Severity Slippage Cracking

X1.21.2 *How to Measure*—The area associated with a given slippage crack is measured in square meters (square feet) and rated according to the highest level of severity in the area.

SWELL

X1.22 *Description*—Swell is characterized by an upward bulge in the pavement's surface, a long, gradual wave more than 3 m (10 ft) long (Fig. X1.50). Swelling can be accompanied by surface cracking. This distress usually is caused by frost action in the subgrade or by swelling soil.

X1.22.1 *Severity Level*:

X1.22.1.1 **L**—Swell causes low-severity ride quality. Low-severity swells are not always easy to see but can be detected by driving at the speed limit over the pavement section. An upward motion will occur at the swell if it is present.

X1.22.1.2 **M**—Swell causes medium-severity ride quality.

X1.22.1.3 **H**—Swell causes high-severity ride quality.

X1.22.2 *How to Measure*—The surface area of the swell is measured in square meters (square feet).

WEATHERING AND RAVELING

X1.23 *Description*—Weathering and raveling are the wearing away of the pavement surface due to a loss of asphalt or tar binder and dislodged aggregate particles. These distresses indicate that either the asphalt binder has hardened appreciably or that a poor-quality mixture is present. In addition, raveling may be caused by certain types of traffic, for example, tracked vehicles. Softening of the surface and dislodging of the aggregates due to oil spillage also are included under raveling.

X1.23.1 *Severity Levels*:

X1.23.1.1 **L**—Aggregate or binder has started to wear away. In some areas, the surface is starting to pit (Fig. X1.51). In the case of oil spillage, the oil stain can be seen, but the surface is hard and cannot be penetrated with a coin.

X1.23.1.2 **M**—Aggregate or binder has worn away. The surface texture is moderately rough and pitted (Fig. X1.52). In the case of oil spillage, the surface is soft and can be penetrated with a coin.

FIG. X1.50 Example Swell. Severity level is based on ride quality criteria.

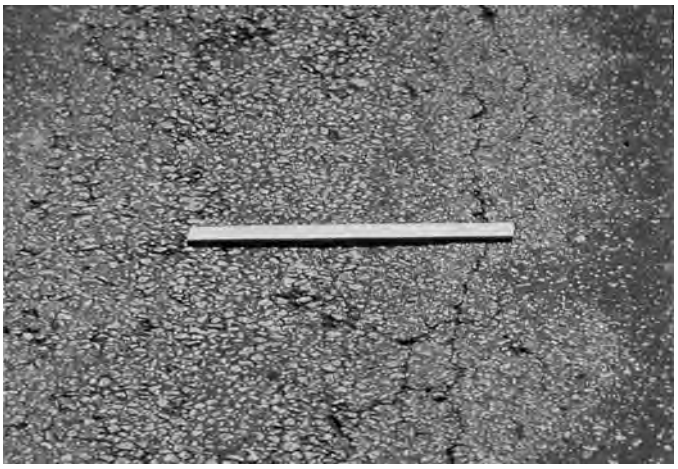


FIG. X1.51 Low-Severity Weathering and Raveling

FIG. X1.52 Medium-Severity Weathering and Raveling

X1.23.1.3 **H**—Aggregate or binder has been worn away considerably. The surface texture is very rough and severely pitted. The pitted areas are less than 10 mm (4 in.) in diameter and less than 13 mm (½ in.) deep (Fig. X1.53); pitted areas larger than this are counted as potholes. In the case of oil

FIG. X1.53 High-Severity Weathering and Raveling

spillage, the asphalt binder has lost its binding effect and the aggregate has become loose.

X1.23.2 *How to Measure*—Weathering and raveling are measured in square meters (square feet) of surface area.

X2. DISTRESS IN JOINTED CONCRETE PAVEMENTS

X2.1 This Appendix lists alphabetically 19 distress types for jointed concrete pavements. Distress definitions apply to both plain and reinforced jointed concrete pavements, with the exception of linear cracking distress, which is defined separately for plain and reinforced jointed concrete.

X2.1.1 During the field condition surveys and validation of the PCI, several questions often are asked about the identification and counted method of some of the distresses. Answers to these questions are included under the heading "How to Count." For convenience, however, the most frequently raised issues are addressed below.

X2.1.1.1 Faulting is counted only at joints. Faulting associated with cracks is not counted separately since it is incorporated into the severity-level definitions of cracks. Crack definitions are also used in defining corner breaks and divided slabs.

X2.1.1.2 Joint seal damage is not counted on a slab-by-slab basis. Instead, a severity level is assigned based on the overall condition of the joint seal in the area.

X2.1.1.3 Cracks in reinforced concrete slabs that are less than ⅛ in. wide are counted as shrinkage cracks. Shrinkage cracks should not be counted to determine if the slab is broken into four or more pieces.

X2.1.1.4 Low-severity scaling, that is, crazing, should only be counted if there is evidence that future scaling is likely to occur.

X2.1.2 The user should note that the items above are general issues and do not stand alone as inspection criteria. To measure each distress type properly, the inspector must be familiar with the individual distress criteria.

X2.2 *Ride Quality*:

X2.2.1 Ride quality must be evaluated in order to establish a severity level for the following distress types:

X2.2.1.1 Blowup/buckling.

X2.2.1.2 Railroad crossings.

X2.2.2 To determine the effect these distresses have on ride quality, the inspector should drive at the normal operating speed and use the following severity-level definitions of ride quality:

X2.2.2.1 **L**—Low. Vehicle vibrations, for example, from corrugation, are noticeable, but no reduction in speed is necessary for comfort or safety, or individual bumps or settlements, or both, cause the vehicle to bounce slightly but create little discomfort.

X2.2.2.2 **M**—Medium. Vehicle vibrations are significant and some reduction in speed is necessary for safety and comfort, or individual bumps or settlements cause the vehicle to bounce significantly, or both, creating some discomfort.

X2.2.2.3 **H**—High. Vehicle vibrations are so excessive that speed must be reduced considerably for safety and comfort, or individual bumps or settlements, or both, cause the vehicle to bounce excessively, creating substantial discomfort, a safety hazard, or high potential vehicle damage, or a combination thereof.

X2.2.3 The inspector should drive at the posted speed in a sedan that is representative of cars typically seen in local traffic. Pavement sections near stop signs should be rated at a deceleration speed appropriate for the intersection.

BLOWUP/BUCKLING

X2.3 *Description*—Blowups or buckles occur in hot weather, usually at a transverse crack or joint that is not wide enough to permit slab expansion. The insufficient width usually is caused by infiltration of incompressible materials into the joint space. When expansion cannot relieve enough pressure, a localized upward movement of the slab edges (buckling) or shattering will occur in the vicinity of the joint. Blowups also can occur at utility cuts and drainage inlets.

X2.3.1 *Severity Levels*:

X2.3.1.1 **L**—Buckling or shattering causes low-severity ride quality (Fig. X2.1).

X2.3.1.2 **M**—Buckling or shattering causes medium-severity ride quality (Fig. X2.2).

X2.3.1.3 **H**—Buckling or shattering causes high-severity ride quality (Fig. X2.3).

X2.3.2 *How to Count*—At a crack, a blowup is counted as being in one slab; however, if the blowup occurs at a joint and affects two slabs, the distress should be recorded as occurring in two slabs. When a blowup renders the pavement impassable, it should be repaired immediately.

CORNER BREAK

X2.4 *Description*—A corner break is a crack that intersects the joints at a distance less than or equal to one-half the slab length on both sides, measured from the corner of the slab. For

FIG. X2.1 Low Severity Blowup/Buckling

FIG. X2.2 Medium Severity Blowup/Buckling

FIG. X2.3 High-Severity Blowup/Buckling

example, a slab measuring 3.5 by 6.0 m (11.5 by 20.0 ft) that has a crack 1.5 m (5 ft) on one side and 3.5 m (11.5 ft) on the other side is not considered a corner break; it is a diagonal crack. However, a crack that intersects 0.5 m (4 ft) on one side and 2.5 m (8 ft) on the other is considered a corner break. A corner break differs from a corner spall in that the crack extends vertically through the entire slab thickness, whereas a corner spall intersects the joint at an angle. Load repetition combined with loss of support and curling stresses usually cause corner breaks.

X2.4.1 *Severity Levels*—

X2.4.1.1 **L**—Break is defined by a low-severity[4] crack. A low severity crack is < 13 mm (½ in.), cracks of any width with satisfactory filler; no faulting. The area between the break and the joints is not cracked or may be lightly cracked (Fig. X2.4).

X2.4.1.2 **M**—Break is defined by a medium-severity[4] crack, or the area between the break and the joints, or both, has a medium crack. A medium severity crack is a nonfilled crack > 13 mm and < 50 mm (>½ in. and < 2 in.), a nonfilled crack < 50 mm (2 in.) with faulting < 10 mm (⅜ in.), or a any filled crack with faulting < 10 mm (⅜ in.) (Fig. X2.5).

X2.4.1.3 **H**—Break is defined by a high-severity[4] crack, or the area between the break and the joints, or both, is highly cracked. A high severity crack is a nonfilled crack >50 mm (2 in.) wide, or any filled or nonfilled crack with faulting >10 mm (⅜ in.) (Fig. X2.6).

X2.4.2 *How to Count*—Distressed slab is recorded as one slab if it:

X2.4.2.1 A single corner break.

X2.4.2.2 More than one break of a particular severity.

X2.4.2.3 Two or more breaks of different severities. For two or more breaks, the highest level of severity should be recorded. For example, a slab containing both low- and medium-severity corner breaks should be counted as one slab with a medium corner break.

FIG. X2.4 Low-Severity Corner Break

FIG. X2.5 Medium-Severity Corner Break

[4] The above crack severity definitions are for nonreinforced slabs. For reinforced slabs, see *linear cracking*.

FIG. X2.6 High-Severity Corner Break

DIVIDED SLAB

X2.5 *Description*—Slab is divided by cracks into four or more pieces due to overloading, or inadequate support, or both. If all pieces or cracks are contained within a corner break, the distress is categorized as a severe corner break.

X2.5.1 *Severity Levels*—Table X2.1 lists severity levels for divided slabs. Examples are shown in Figs. X2.7-X2.9.

X2.5.2 *How to Count*—If the divided slab is medium- or high-severity, no other distress is counted for that slab.

DURABILITY ("D") CRACKING

X2.6 *Description*—"D" cracking is caused by freeze-thaw expansion of the large aggregate, which, over time, gradually breaks down the concrete. This distress usually appears as a pattern of cracks running parallel and close to a joint or linear crack. Since the concrete becomes saturated near joints and cracks, a dark-colored deposit can usually be found around fine" D" cracks. This type of distress may eventually lead to disintegration of the entire slab.

X2.6.1 *Severity Levels*:

X2.6.1.1 *L*—"D" cracks cover less than 15 % of slab area. Most of the cracks are tight, but a few pieces may be loose and or missing (Fig. X2.10).

X2.6.1.2 **M**—One of the following conditions exists (Fig. X2.11): "D" cracks cover less than 15 % of the area and most of the pieces are loose and or missing, or "D" cracks cover more than 15 % of the area. Most of the cracks are tight, but a few pieces may be loose and or missing.

X2.6.1.3 *H*—"D" cracks cover more than 15 % of the area and most of the pieces have come out or could be removed easily (Fig. X2.12).

TABLE X2.1 Levels of Severity for Faulting

Severity Level	Difference of Elevation
L	>3 and <10 mm (>⅛ and <⅜ in.)
M	>10 and <20 mm (>⅜ and <¾ in.)
H	>20 mm (>¾ in.)

FIG. X2.7 Low-Severity Divided Slab

FIG. X2.8 Medium-Severity Divided Slab

FIG. X2.9 High-Severity Divided Slab

X2.6.2 *How to Count*—When the distress is located and rated at one severity, it is counted as one slab. If more than one severity level exists, the slab is counted as having the higher severity distress. For example, if low and medium "D" cracking are on the same slab, the slab is counted as medium-severity cracking only.

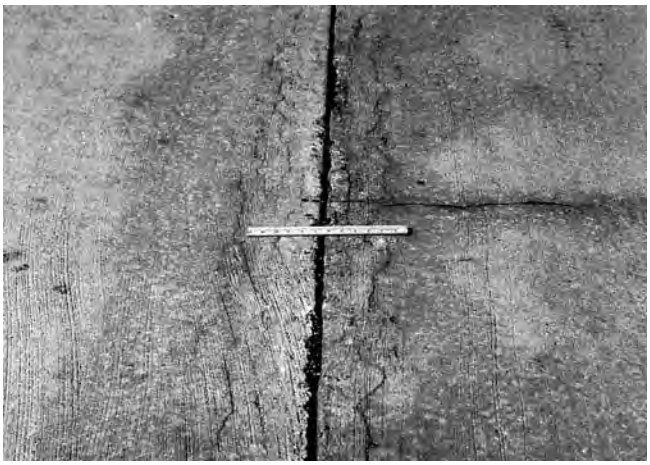


FIG. X2.10 Low-Severity Durability Cracking

FIG. X2.11 Medium-Severity Durability Cracking

FIG. X2.12 High-Severity Durability Cracking

FAULTING

X2.7 *Description*:

X2.7.1 Faulting is the difference in elevation across a joint. Some common causes of faulting are as follows:

X2.7.1.1 Settlement because of soft foundation.

X2.7.1.2 Pumping or eroding of material from under the slab.

X2.7.1.3 Curling of the slab edges due to temperature and moisture changes.

X2.7.2 *Severity Levels*—Severity levels are defined by the difference in elevation across the joint as indicated in Table X2.2. Figs. X2.13-X2.15 show examples of the different severity levels.

X2.7.3 *How to Count*—Faulting across a joint is counted as one slab. Only affected slabs are counted. Faults across a crack are not counted as distress but are considered when defining crack severity.

JOINT SEAL DAMAGE

X2.8 *Description*:

X2.8.1 Joint seal damage is any condition that enables soil or rocks to accumulate in the joints or allows significant water infiltration. Accumulation of incompressible materials prevents the slab from expanding and may result in buckling, shattering, or spalling. A pliable joint filler bonded to the edges of the slabs protects the joints from material accumulation and prevents water from seeping down and softening the foundation supporting the slab. Typical types of joint seal damage are as follows:

X2.8.1.1 Stripping of joint sealant.

X2.8.1.2 Extrusion of joint sealant.

X2.8.1.3 Weed growth.

X2.8.1.4 Hardening of the filler (oxidation).

X2.8.1.5 Loss of bond to the slab edges.

X2.8.1.6 Lack or absence of sealant in the joint.

X2.8.2 *Severity Levels*:

X2.8.2.1 **L**—Joint sealant is in generally good condition throughout section (Fig. X2.16). Sealant is performing well, with only minor damage (see X2.8.1.1-X2.8.1.6). Joint seal damage is at low severity if a few of the joints have sealer, which has debonded from, but is still in contact with, the joint edge. This condition exists if a knife blade can be inserted between sealer and joint face without resistance.

X2.8.2.2 **M**—Joint sealant is in generally fair condition over the entire section, with one or more of the above types of damage occurring to a moderate degree. Sealant needs replacement within two years (Fig. X2.17). Joint seal damage is at medium severity if a few of the joints have any of the following conditions: joint sealer is in place, but water access is possible through visible openings no more than 3 mm (⅛ in.) wide. If a knife blade cannot be inserted easily between sealer and joint face, this condition does not exist; pumping debris are evident at the joint; joint sealer is oxidized and "lifeless" but pliable (like a rope), and generally fills the joint opening; or, vegetation in the joint is obvious but does not obscure the joint opening.

TABLE X2.2 Levels of Severity for Punchouts

Severity of the Majority of Cracks	Number of Pieces		
	2 to 3	4 to 5	>5
L	**L**	**L**	**M**
M	**L**	**M**	**H**
H	**M**	**H**	**H**

FIG. X2.13 Low-Severity Faulting

FIG. X2.14 Medium-Severity Faulting

FIG. X2.15 High-Severity Faulting

FIG. X2.16 Low-Severity Joint Seal Damage

FIG. X2.17 Medium-Severity Joint Seal Damage

FIG. X2.18 High-Severity Joint Seal Damage

X2.8.2.3 **H**—Joint sealant is in generally poor condition over the entire section, with one or more of the above types of damage occurring to a severe degree. Sealant needs immediate replacement (Fig. X2.18). Joint seal damage is at high severity if 10 % or more of the joint sealer exceeds limiting criteria listed above or if 10 % or more of sealer is missing.

X2.8.3 *How to Count*—Joint seal damage is not counted on a slab-by-slab basis but is rated based on the overall condition of the sealant over the entire area.

LANE/SHOULDER DROP-OFF

X2.9 *Description*—Lane/shoulder drop-off is the difference

between the settlement or erosion of the shoulder and the pavement travel-lane edge. The elevation difference can be a safety hazard, and it also can cause increased water infiltration.

X2.9.1 *Severity Levels*:

X2.9.1.1 **L**—The difference between the pavement edge and shoulder is >25 and ≤50 mm (>1 and ≤2 in.) (Fig. X2.19).

X2.9.1.2 **M**—The difference in elevation is >50 and ≤100 mm (>2 and ≤4 in.) (Fig. X2.20).

X2.9.1.3 **H**—The difference in elevation is >100 mm (>4 in.) (Fig. X2.21).

X2.9.2 *How to Count*—The mean lane/shoulder drop-off is computed by averaging the maximum and minimum drop along the slab. Each slab exhibiting distress is measured separately and counted as one slab with the appropriate severity level.

LINEAR CRACKING
(Longitudinal, Transverse, and Diagonal Cracks)

X2.10 *Description*—These cracks, which divide the slab into two or three pieces, usually are caused by a combination of repeated traffic loading, thermal gradient curling, and repeated moisture loading. (Slabs divided into four or more pieces are counted as divided slabs.) Hairline cracks that are only a few feet long and do not extend across the entire slab, are counted as shrinkage cracks.

X2.10.1 *Severity Levels (Nonreinforced Slabs)*:

X2.10.1.1 **L**—Nonfilled[4] cracks ≤ 13 mm (≤ ½ in.) or filled cracks of any width with the filler in satisfactory condition. No faulting exists (Fig. X2.22).

X2.10.1.2 **M**—One of the following conditions exists: nonfilled crack with a width >13 and ≤50 mm (>½ and ≤ 2 in.); nonfilled crack of any width ≤ 50 mm (2 in.) with faulting of <10 mm (⅜ in.), or filled crack of any width with faulting <10 mm (⅜ in.) (Fig. X2.23).

X2.10.1.3 **H**—One of the following conditions exists: nonfilled crack with a width >50 mm (2 in.), or filled or nonfilled crack of any width with faulting >10 mm (⅜ in.) (Fig. X2.24).

X2.10.2 *Reinforced Slabs*:

X2.10.2.1 **L**—Nonfilled cracks ≥ 3 and < 25 mm (≥ ⅛ to < 1 in.) wide; filled crack of any width with the filler in satisfactory condition. No faulting exists.

FIG. X2.19 Low-Severity Lane/Shoulder Drop-Off

FIG. X2.20 Medium-Severity Lane/Shoulder Drop-Off

FIG. X2.21 High-Severity Lane/Shoulder Drop-Off

X2.10.2.2 **M**—One of the following conditions exists: nonfilled cracks with a width ≥ 25 and < 75 mm (≥ 1 and < 3 in.) and no faulting; nonfilled crack of any width ≤ 75 mm (3 in.) with ≤ 10 mm (⅜ in.) of faulting, or filled crack of any width with ≤ 10 mm (⅜ in.) faulting.

X2.10.2.3 **H**—Once of the following conditions exists: nonfilled crack >75 mm (3 in.) wide, or filled or nonfilled crack of any width with faulting >10 mm (⅜ in.).

X2.10.3 *How to Count*—One the severity has been identified, the distress is recorded as one slab. If two medium severity cracks are within one slab, the slab is counted as

FIG. X2.22 Low-Severity Linear Cracking

FIG. X2.23 Medium-Severity Linear Cracking

having one high-severity crack. Slabs divided into four or more pieces are counted as divided slabs. In reinforced slabs, cracks <3 mm (⅛ in.) wide are counted as shrinkage cracks. Slabs longer than 9 m (29.5 ft) are divided into approximately equal length“ slabs” having imaginary joints assumed to be in perfect condition.

PATCHING, LARGE (MORE THAN 0.5 M^2 [5.5 FT^2]) AND UTILITY CUTS

X2.11 *Description*—A patch is an area where the original pavement has been removed and replaced by filler material. A utility cut is a patch that has replaced the original pavement to allow the installation or maintenance of underground utilities. The severity levels of a utility cut are assessed according to the same criteria as large patching.

X2.11.1 *Severity Levels*:

FIG. X2.24 High-Severity Linear Cracking

X2.11.1.1 **L**—Patch is functioning well, with little or no deterioration (Fig. X2.25).

X2.11.1.2 **M**—Patch is moderately deteriorated, or moderate spalling can be seen around the edges, or both. Patch material can be dislodged with considerable effort (Fig. X2.26).

X2.11.1.3 **H**—Patch is badly deteriorated. The extent of the deterioration warrants replacement (Fig. X2.27).

X2.11.2 *How to Count*—If a single slab has one or more patches with the same severity level, it is counted as one slab containing that distress. If a single slab has more than one severity level, it is counted as one slab with the higher severity level.

PATCHING, SMALL (LESS THAN 0.5 M^2 [5.5 FT^2])

X2.12 *Description*—A patch is an area where the original pavement has been removed and replaced by a filler material.

X2.12.1 *Severity Levels*:

X2.12.1.1 **L**—Patch is functioning well with little or no deterioration (Fig. X2.28).

X2.12.1.2 **M**—Patch is moderately deteriorated. Patch material can be dislodged with considerable effort (Fig. X2.29).

FIG. X2.25 Low-Severity Patching, Large and Utility Cuts

FIG. X2.26 Medium-Severity Patching, Large and Utility Cuts

FIG. X2.27 High-Severity Patching, Large and Utility Cuts

FIG. X2.28 Low-Severity Patching, Small

X2.12.1.3 **H**—Patch is badly deteriorated. The extent of deterioration warrants replacement (Fig. X2.30).

X2.12.2 *How to Count*—If a single slab has one or more patches with the same severity level, it is counted as one slab containing that distress. If a single slab has more than one severity level, it is counted as one slab with the higher severity level.

FIG. X2.29 Medium-Severity Patching, Small

FIG. X2.30 High-Severity Patching, Small

POLISHED AGGREGATE

X2.13 *Description*—This distress is caused by repeated traffic applications. Polished aggregate is present when close examination of a pavement reveals that the portion of aggregate extending above the asphalt is either very small, or there are no rough or angular aggregate particles to provide good skid resistance.

X2.13.1 *Severity Levels*—No degrees of severity are defined; however, the degree of polishing should be significant before it is included in the condition survey and rated as a defect (Fig. X2.31).

X2.13.2 *How to Count*—A slab with polished aggregate is counted as one slab.

POPOUTS

X2.14 *Description*—A popout is a small piece of pavement that breaks loose from the surface due to freeze-thaw action, combined with expansive aggregates. Popouts usually range in diameter from approximately 25 to 100 mm (1 to 4 in.) and in depth from 13 to 50 mm (½ to 2 in.).

X2.14.1 *Severity Levels*—No degrees of severity are defined for popouts; however, popouts must be extensive before

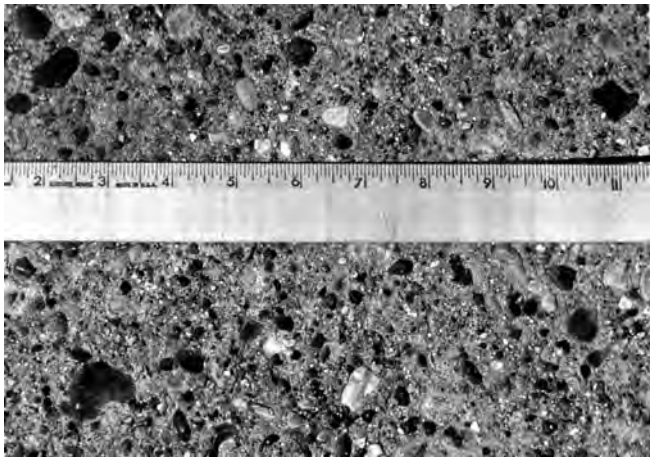


FIG. X2.31 Polished Aggregate

they are counted as a distress. Average popout density must exceed approximately three popouts/m^2 over the entire slab area (Fig. X2.32).

X2.14.2 *How to Count*—The density of the distress must be measured. If there is any doubt that the average is greater than three popouts per square yard, at least three random 1 m^2 (11 ft^2) areas should be checked. When the average is greater than this density, the slab should be counted.

PUMPING

X2.15 *Description*—Pumping is the ejection of material from the slab foundation through joints or cracks. This is caused by deflection of the slab with passing loads. As a load moves across the joint between the slabs, water is first forced under the leading slab, and then forced back under the trailing slab. This action erodes and eventually removes soil particles resulting in progressive loss of pavement support. Pumping can be identified by surface stains and evidence of base or subgrade material on the pavement close to joints or cracks. Pumping near joints is caused by poor joint sealer and indicates loss of support; repeated loading eventually will produce cracks. Pumping also can occur along the slab edge causing loss of support.

FIG. X2.32 Popouts

X2.15.1 *Severity Levels*—No degrees of severity are defined. It is enough to indicate that pumping exists (Fig. X2.33 and Fig. X2.34).

X2.15.2 *How to Count*—One pumping joint between two slabs is counted as two slabs; however, if the remaining joints around the slab are also pumping, one slab is added per additional pumping joint.

PUNCHOUT

X2.16 *Description*—This distress is a localized area of the slab that is broken into pieces. The punchout can take many different shapes and forms, but it is usually defined by a crack and a joint. The distance between the join and the crack or two closely spaced cracks is ≤ 1.5 m (5 ft) wide. This distress is caused by heavy repeated loads, inadequate slab thickness, loss of foundation support, or a localized concrete construction deficiency, for example, honeycombing.

X2.16.1 *Severity Levels*—Table X2.2 lists the severity levels for punchouts, and Figs. X2.35-X2.37 show examples.

X2.16.2 *How to Count*—If a slab contains more than one punchout or a punchout and a crack, it is counted as shattered.

RAILROAD CROSSING

X2.17 *Description*—Railroad crossing distress is characterized by depressions or bumps around the tracks.

X2.17.1 *Severity Levels*:

X2.17.1.1 **L**—Railroad crossing causes low-severity ride quality (Fig. X2.38).

X2.17.1.2 **M**—Railroad crossing causes medium-severity ride quality (Fig. X2.39).

X2.17.1.3 **H**—Railroad crossing causes high-severity ride quality (Fig. X2.40).

FIG. X2.33 Pumping

FIG. X2.34 Pumping

FIG. X2.35 Low-Severity Punchout

X2.17.2 *How to Count*—The number of slabs crossed by the railroad tracks is counted. Any large bump created by the tracks should be counted as part of the crossing.

SCALING, MAP CRACKING, AND CRAZING

X2.18 *Description*—Map cracking or crazing refers to a network of shallow, fine, or hairline cracks that extend only through the upper surface of the concrete. The cracks tend to intersect at angles of 120°. Map cracking or crazing usually is caused by concrete over-finishing and may lead to surface scaling, which is the breakdown of the slab surface to a depth of approximately 6 to 13 mm (¼ to ½ in.). Scaling also may be caused by deicing salts, improper construction, freeze-thaw cycles and poor aggregate. The type of scaling defined here is not caused by "D" cracking. If scaling is caused by "D" cracking, it should be counted under that distress only.

X2.18.1 *Severity Levels*:

FIG. X2.36 Medium-Severity Punchout

FIG. X2.37 High-Severity Punchout

FIG. X2.38 Low-Severity Railroad Crossing

X2.18.1.1 **L**—Crazing or map cracking exists over most of the slab area; the surface is in good condition, with only minor scaling present (Fig. X2.41).

X2.18.1.2 **M**—Slab is scaled but less than 15 % of the slab is affected (Fig. X2.42).

X2.18.1.3 **H**—Slab is scaled over more than 15 % of its area (Fig. X2.43).

FIG. X2.39 Medium-Severity Railroad Crossing

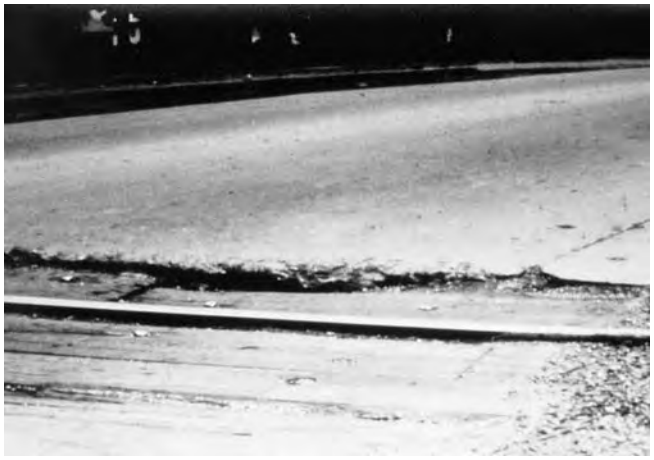


FIG. X2.40 High-Severity Railroad Crossing

FIG. X2.41 Low-Severity Scaling, Map Cracking, and Crazing

X2.18.2 *How to Count*—A scaled slab is counted as one slab. Low-severity crazing only should be counted if the potential for scaling appears to be imminent or a few small pieces come out.

SHRINKAGE CRACKS

X2.19 *Description*—Shrinkage cracks are hairline cracks that usually are less than 2-m long and do not extend across the entire slab. They are formed during the setting and curing of the concrete and usually do not extend through the depth of the slab.

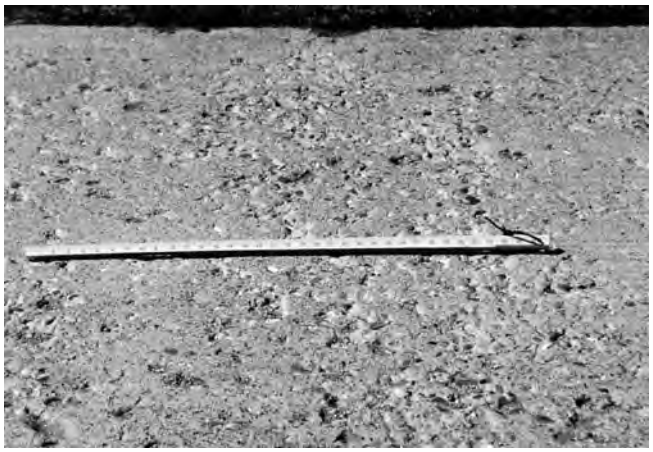


FIG. X2.42 Medium-Severity Scaling, Map Cracking, and Crazing

FIG. X2.43 High-Severity Scaling, Map Cracking, and Crazing

X2.19.1 *Severity Levels*—No degrees of severity are defined. It is enough to indicate that shrinkage cracks are present (Fig. X2.44).

FIG. X2.44 Shrinkage Cracks

X2.19.2 *How to Count*—If any shrinkage cracks exist on a particular slab, the slab is counted as one slab with shrinkage cracks.

SPALLING, CORNER

X2.20 *Description*—Corner spalling is the breakdown of the slab within approximately 0.5 m (1.5 ft) of the corner. A corner spall differs from a corner break in that the spall usually angles downward to intersect the joint, whereas a break extends vertically through the slab corner. Spalls less than 130 mm (5 in.) from the crack to the corner on both sides should not be counted.

X2.20.1 *Severity Levels*—Table X2.3 lists the levels of severity for corner spalling. Figs. X2.45-X2.47 show examples. Corner spalling with an area of less than 650 cm (10 in.^{2}) from the crack to the corner on both sides should not be counted.

X2.20.2 *How to Count*—If one or more corner spalls with the same severity level are in a slab, the slab is counted as one slab with corner spalling. If more than one severity level occurs, it is counted as one slab with the higher severity level.

SPALLING, JOINT

X2.21 *Description*:

X2.21.1 Joint spalling is the breakdown of the slab edges within 0.5 m (1.5 ft) of the joint. A joint spall usually does not extend vertically through the slab, but intersects the joint at an angle. Spalling results from:

X2.21.1.1 Excessive stresses at the joint caused by traffic loading or by infiltration of incompressible materials.

X2.21.1.2 Weak concrete at the joint caused by overworking.

X2.21.1.3 Water accumulation in the joint and freeze-thaw action.

X2.21.2 *Severity Levels*—Table X2.4 and Figs. X2.48-X2.50 show the severity levels of joint spalling. A frayed joint where the concrete has been worn away along the entire joint is rated as low severity.

X2.21.3 *How to Count*—If spall is along the edge of one slab, it is counted as one slab with joint spalling. If spalling is on more than one edge of the same slab, the edge having the highest severity is counted and recorded as one slab. Joint spalling also can occur along the edges of two adjacent slabs. If this is the case, each slab is counted as having joint spalling.

TABLE X2.3 Levels of Severity for Corner Spalling

Depth of Spall	Dimensions of Sides of Spall	
	130 × 130 mm to 300 × 300 mm (5 × 5 in.) to (12 × 12 in.)	300 × 300 mm (>12 × 12 in.)
<25 mm (1 in.)	L	L
>25 to 50 mm (1 to 2 in.)	L	M
>50 mm (2 in.)	M	H

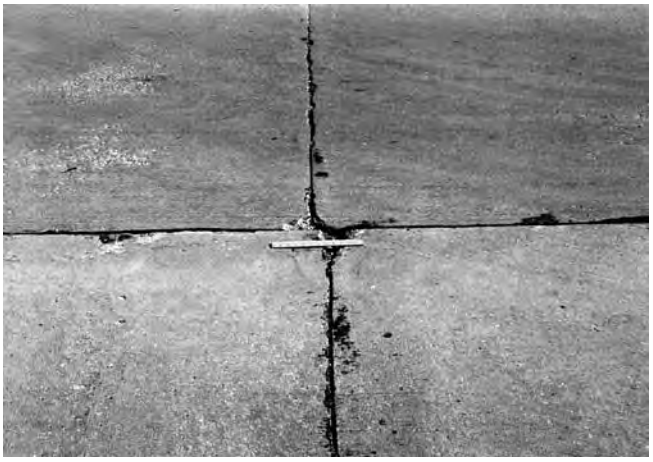


FIG. X2.45 Low-Severity Spalling, Corner

FIG. X2.46 Medium-Severity Spalling, Corner

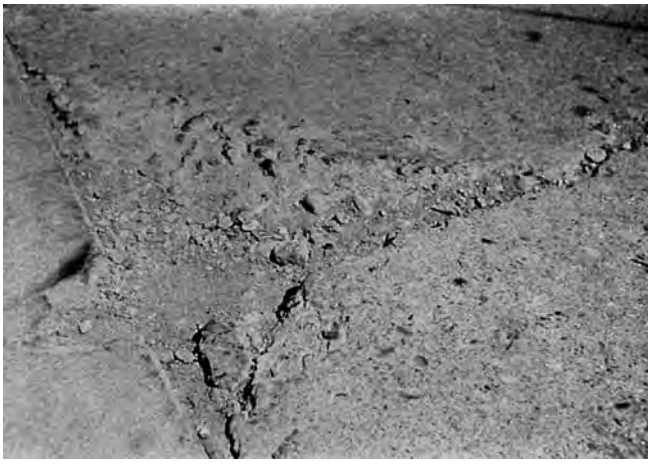


FIG. X2.47 High-Severity Spalling, Corner

TABLE X2.4 Levels of Severity for Joint Spalling

Spall Pieces	Width of Spall	Length of Spall <0.5 m (1.5 ft)	Length of Spall >0.5 m (1.5 ft)
Tight—cannot be removed easily (maybe a few pieces missing.	<100 mm (4 in.)	**L**	**L**
	>100 mm	**L**	**L**
Loose—can be removed and some pieces are missing; if most or all pieces are missing, spall is shallow, less than 25 mm (1 in.).	<100 mm	**L**	**M**
	>100 mm	**L**	**M**
Missing—most or all pieces have been removed.	<100 mm	**L**	**M**
	>100 mm	**M**	**H**

FIG. X2.48 Low-Severity Spalling, Joint

FIG. X2.49 Medium-Severity Spalling, Joint

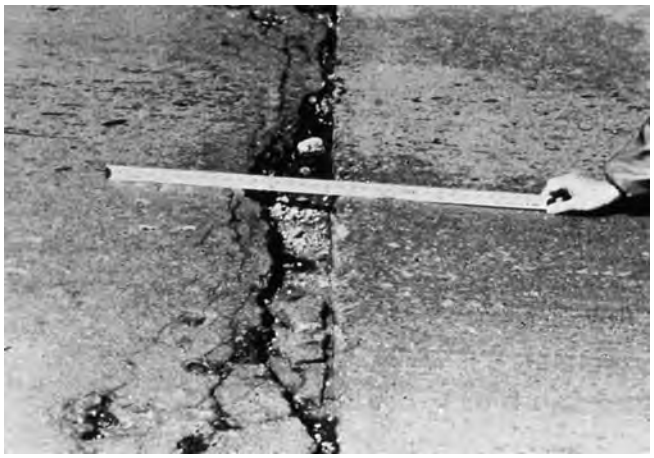


FIG. X2.50 High-Severity Spalling, Joint

X3. DEDUCT VALUE CURVES FOR ASPHALT

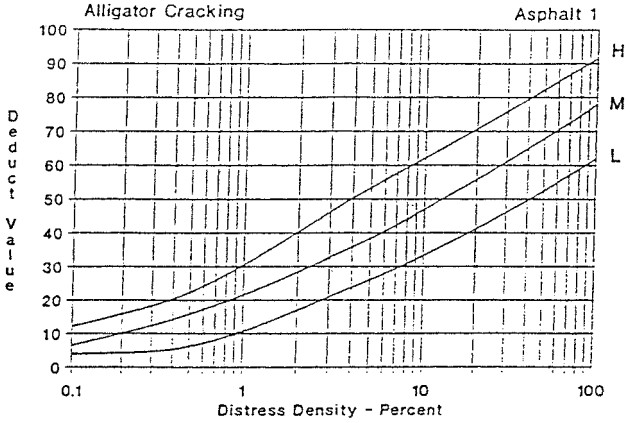


FIG. X3.1 Alligator Cracking

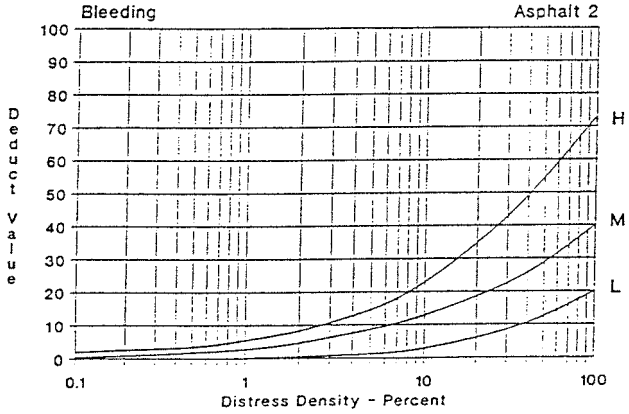


FIG. X3.2 Bleeding

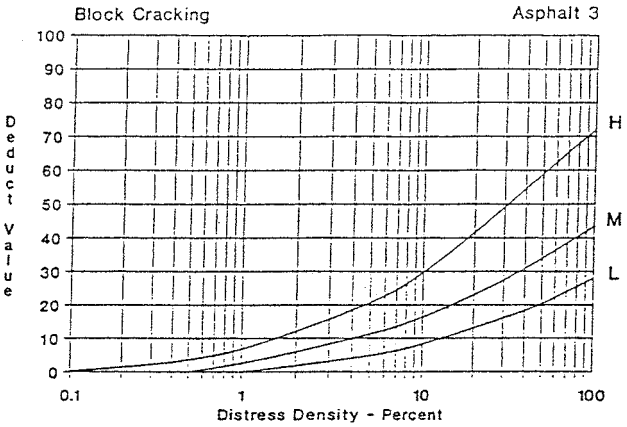


FIG. X3.3 Block Cracking

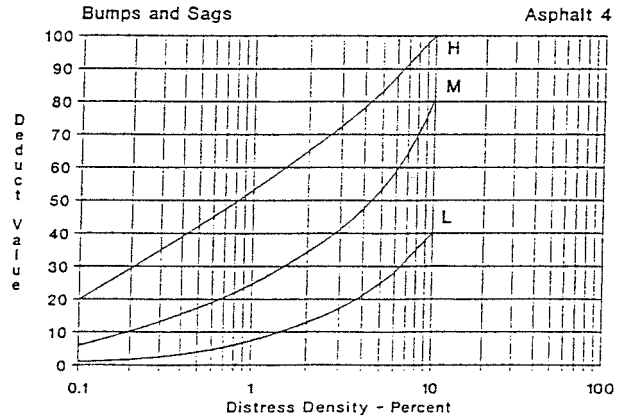


FIG. X3.4 Bumps and Sags

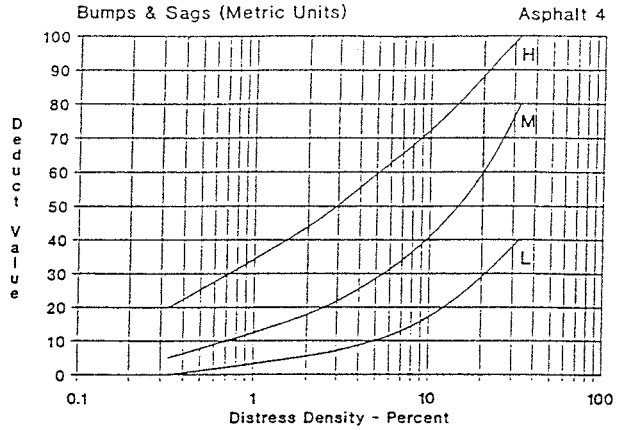


FIG. X3.5 Bumps and Sags (Metric units)

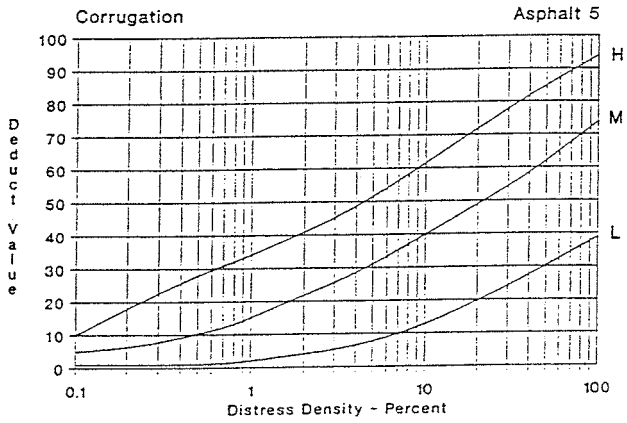


FIG. X3.6 Corrugation

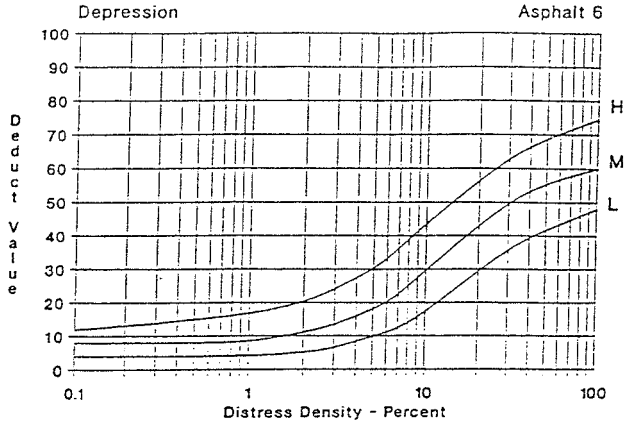


FIG. X3.7 Depression

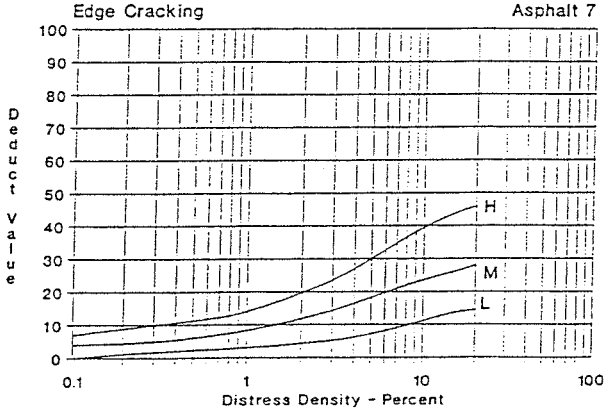


FIG. X3.8 Edge Cracking

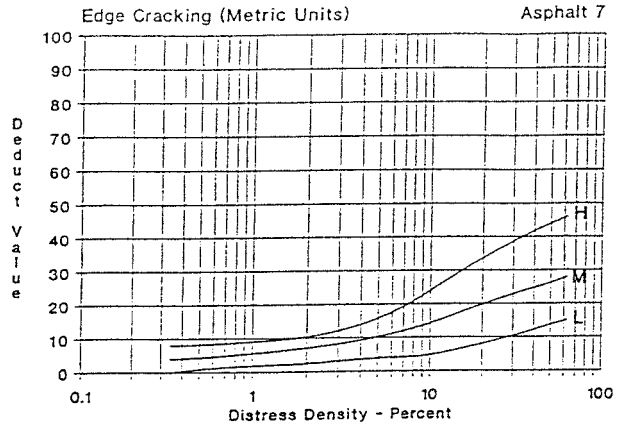


FIG. X3.9 Edge Cracking (metric units)

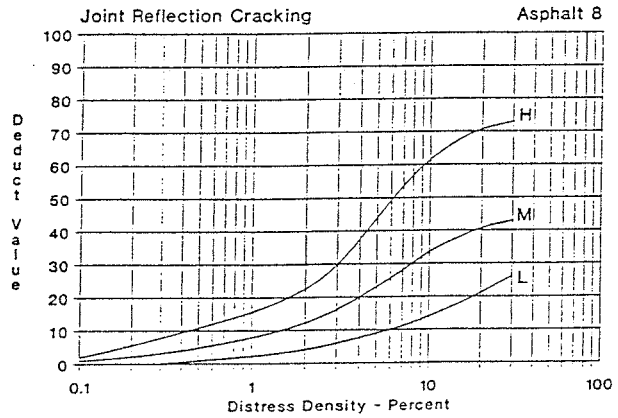


FIG. X3.10 Joint Reflection Cracking

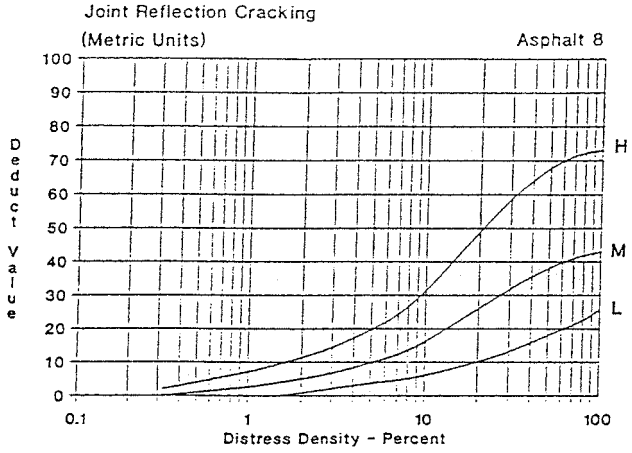


FIG. X3.11 Joint Reflection Cracking (metric units)

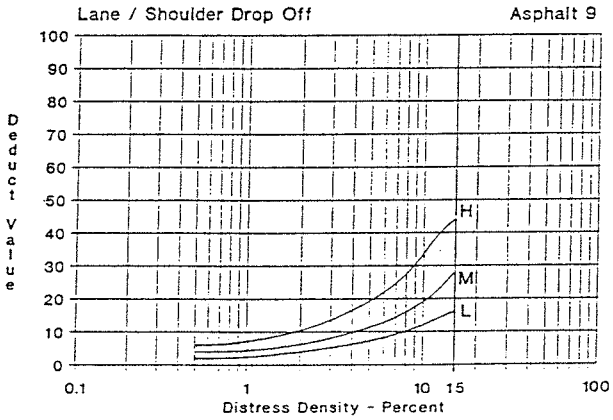


FIG. X3.12 Lane/Shoulder Drop-Off

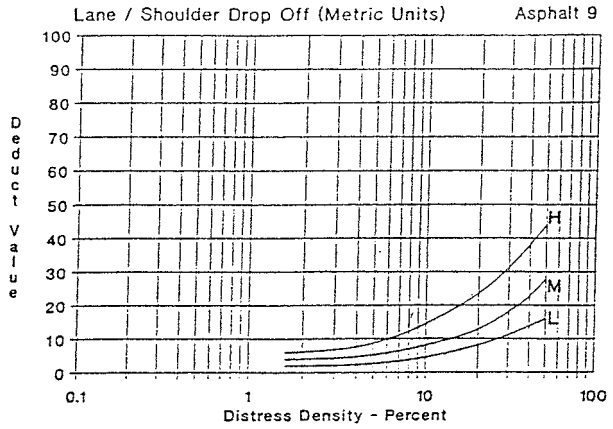


FIG. X3.13 Lane/Shoulder Drop-Off (metric units)

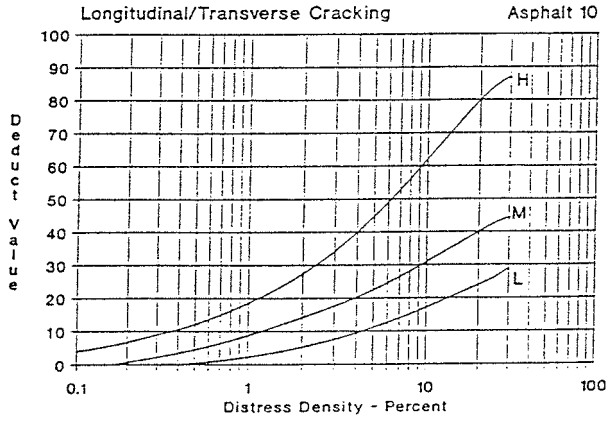


FIG. X3.14 Longitudinal/Transverse Cracking

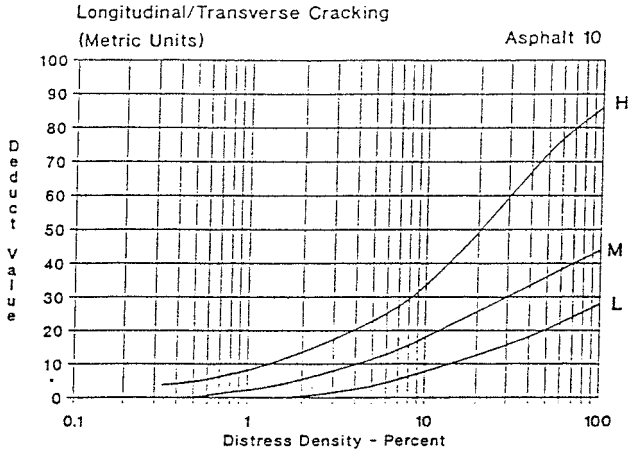


FIG. X3.15 Longitudinal/Transverse Cracking (metric units)

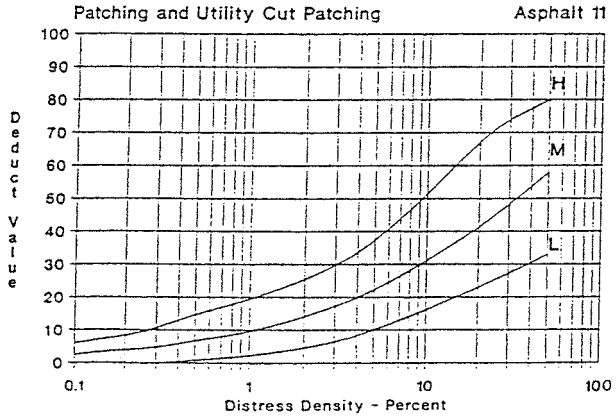


FIG. X3.16 Patching and Utility Cut Patching

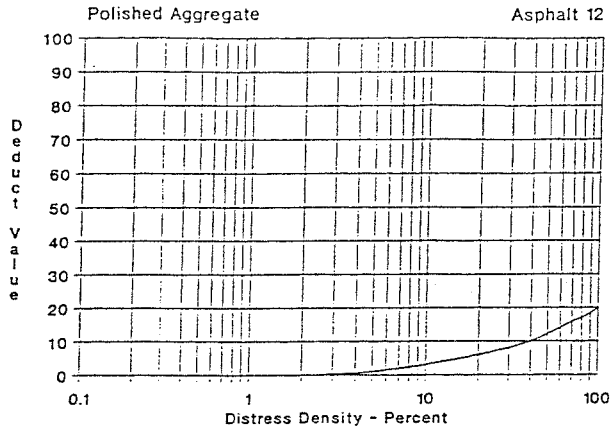


FIG. X3.17 Polished Aggregate

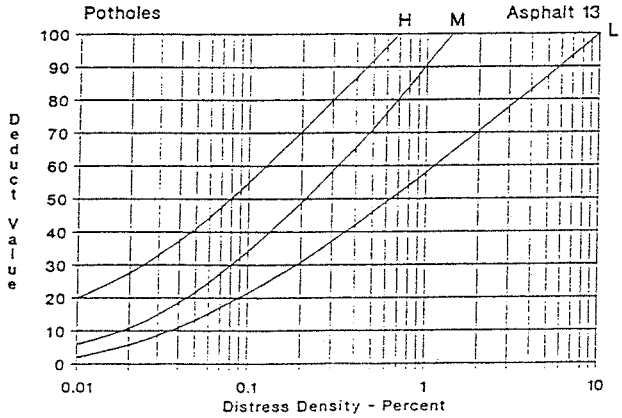


FIG. X3.18 Potholes

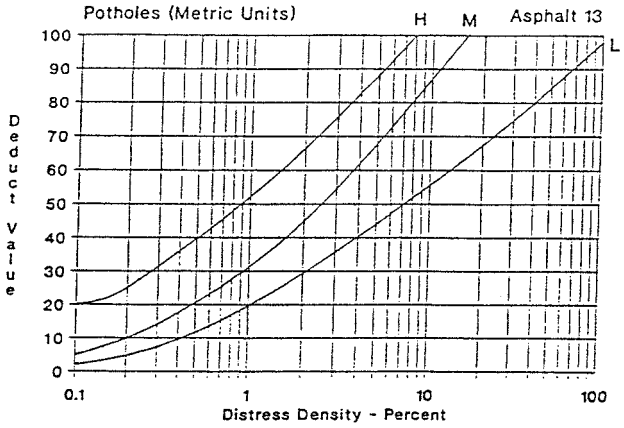


FIG. X3.19 Potholes (metric units)

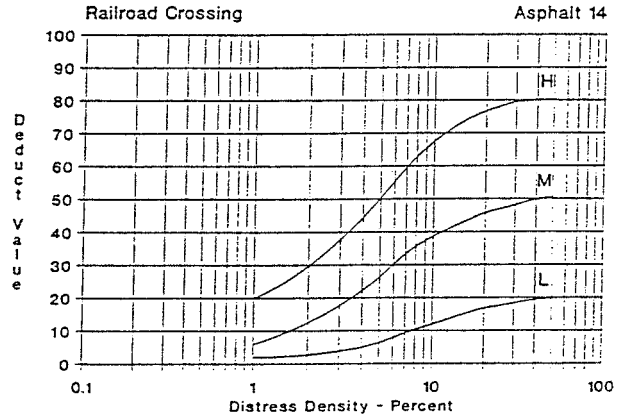


FIG. X3.20 Railroad Crossing

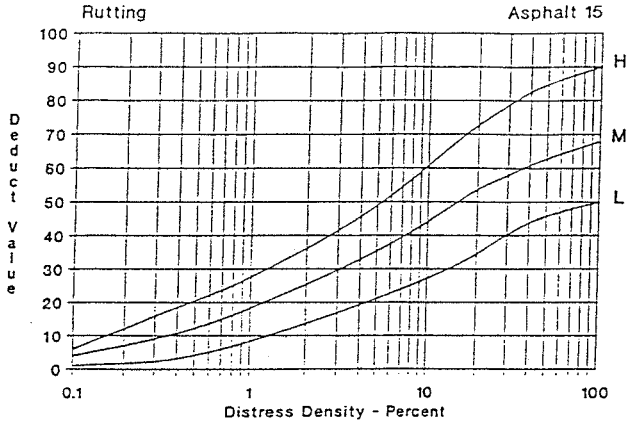


FIG. X3.21 Rutting

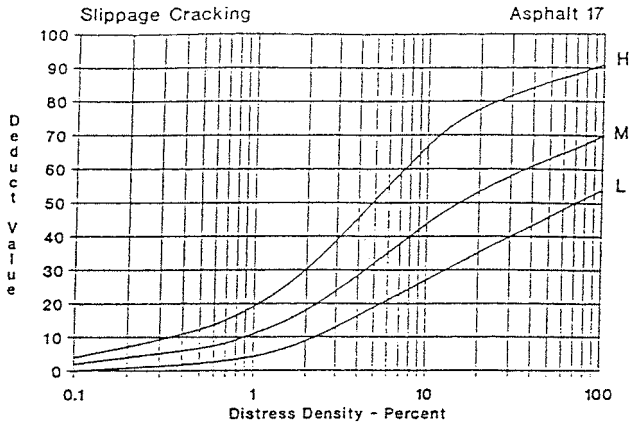


FIG. X3.23 Slippage Cracking

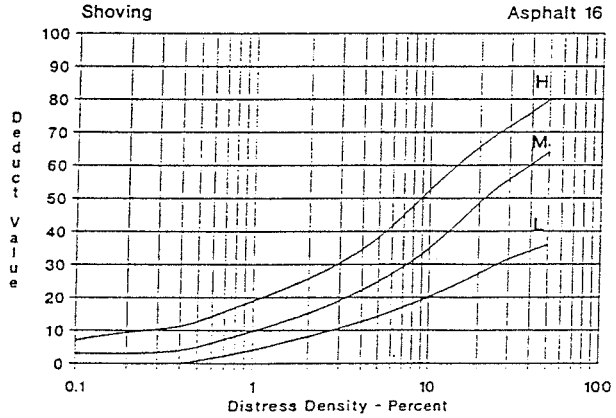


FIG. X3.22 Shoving

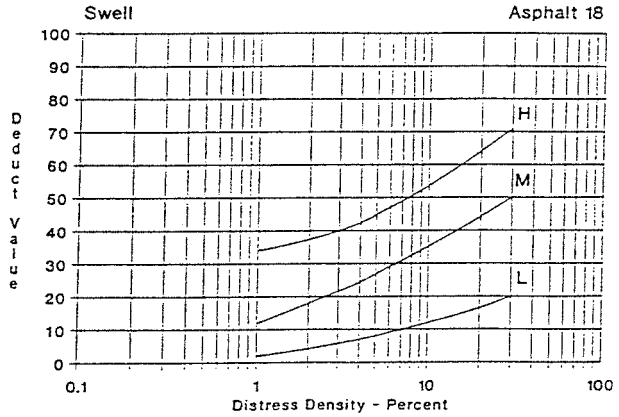


FIG. X3.24 Swell

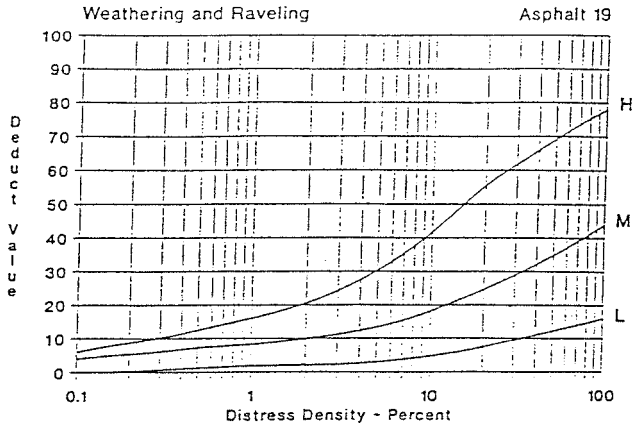


FIG. X3.25 Weathering and Raveling

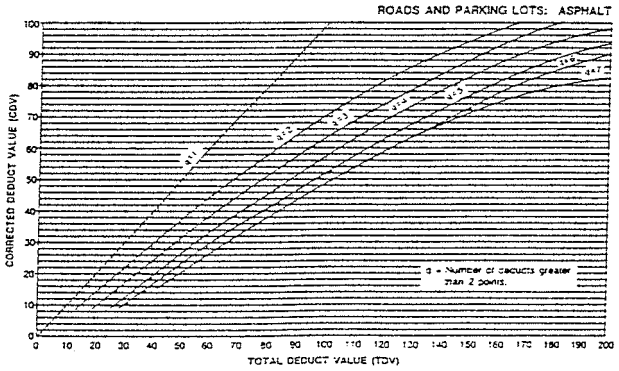


FIG. X3.26 Total Deduct Value

X4. DEDUCT VALUE CURVES FOR CONCRETE

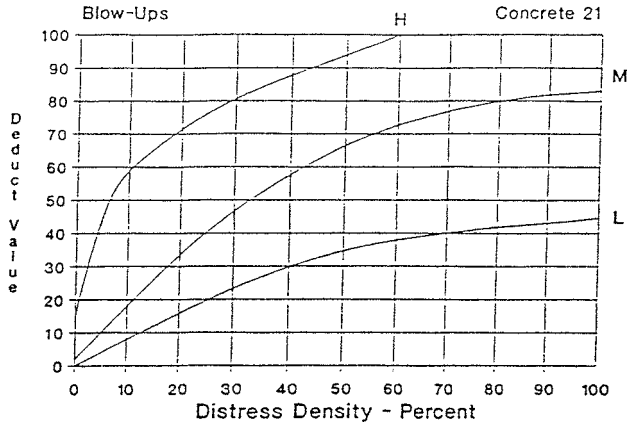


FIG. X4.1 Blowups

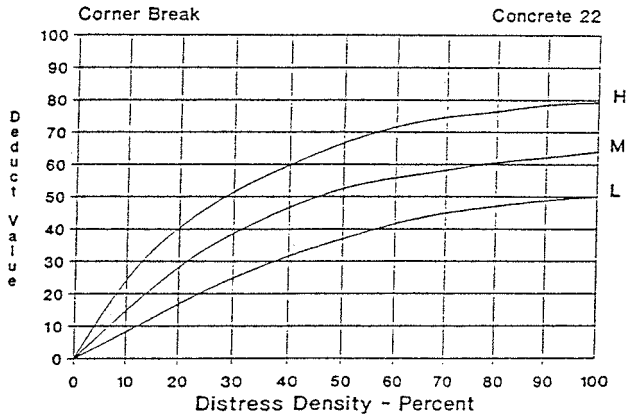


FIG. X4.2 Corner Break

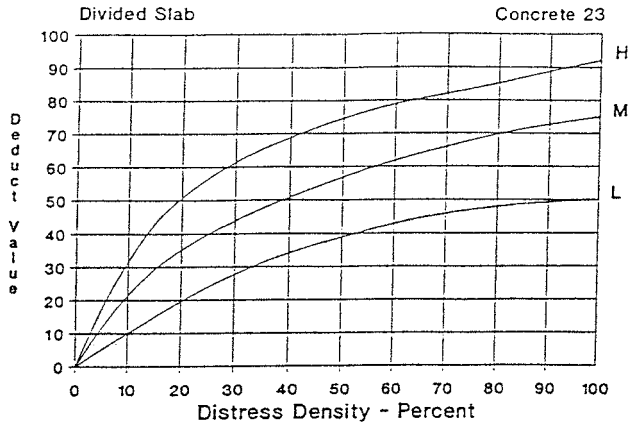


FIG. X4.3 Divided Slab

REFERENCES

(**1**) *PAVER Asphalt Distress Manual*, US Army Construction Engineering Laboratories, TR 97/104, June 1997.

(**2**) *PAVER Asphalt Distress Manual*, US Army Construction Engineering Laboratories, TR 97/105, June 1997.

(**3**) Carey, W.N., Jr. and Irick, P.E., "The Pavement Serviceability-Performance Concept," *HRB Bulletin 250*, 1960.

(**4**) Sayers, M. W., Gillespie, T. D., and Queiroz, C. A. V., "The International Road Roughness Experiment: Establishing Correlation and a Calibration Standard for Measurements," World Bank Technical Paper No. 45, the International Bank for Reconstruction and Development/the World Bank, Washington, DC, 1986.

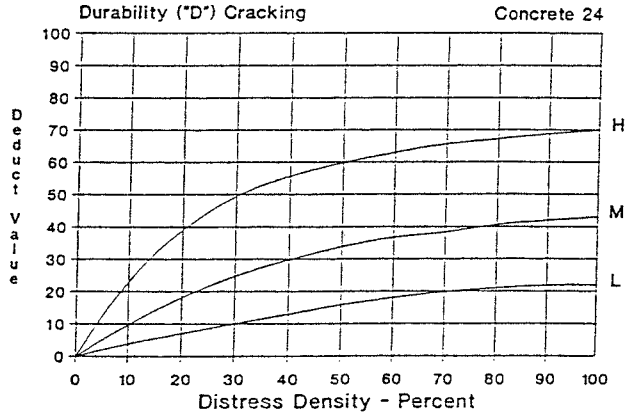


FIG. X4.4 Durability ("D") Cracking

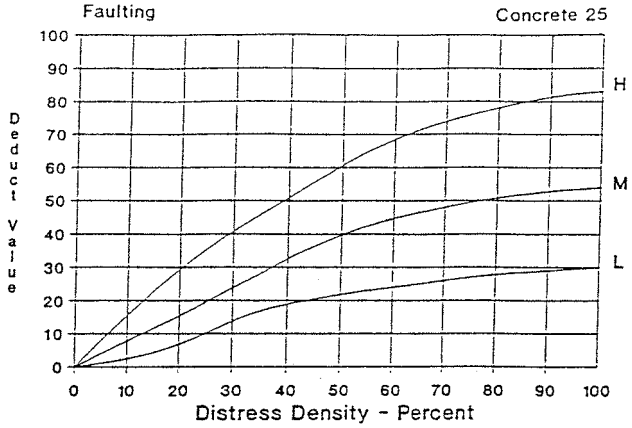


FIG. X4.5 Faulting

Joint Seal Damage Concrete 26

Joint seal damage is not rated by density. The severity of the distress is determined by the sealant's overall condition for a particular sample unit.

The deduct values for the three levels of severity are:

LOW	2 points
MEDIUM	4 points
HIGH	8 points

FIG. X4.6 Rigid Pavement Deduct Values, Distress 26, joint seal damage

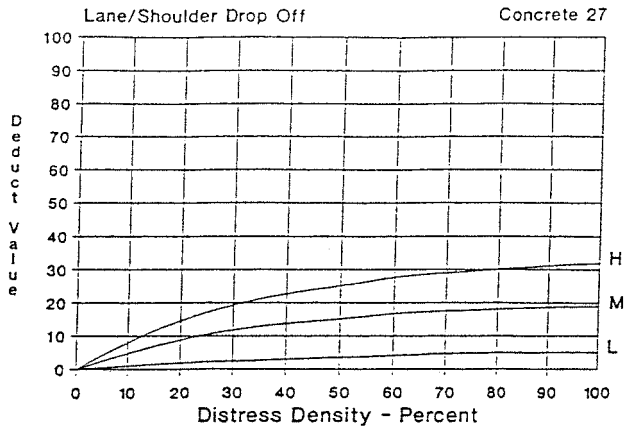


FIG. X4.7 Lane/Shoulder Drop-Off

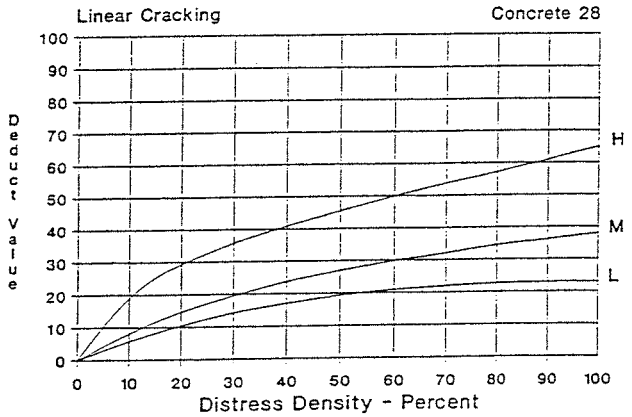


FIG. X4.8 Linear Cracking

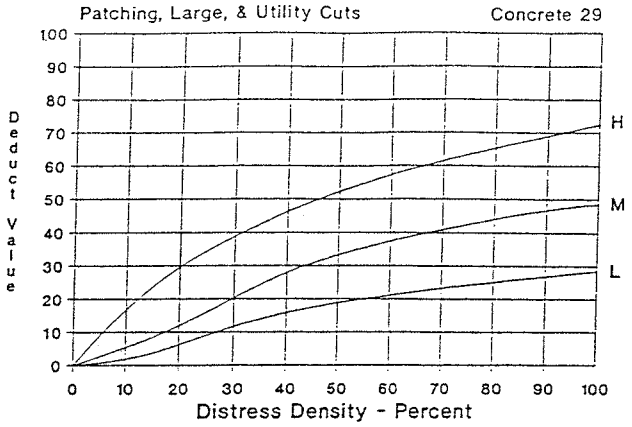


FIG. X4.9 Patching, Large, and Utility Cuts

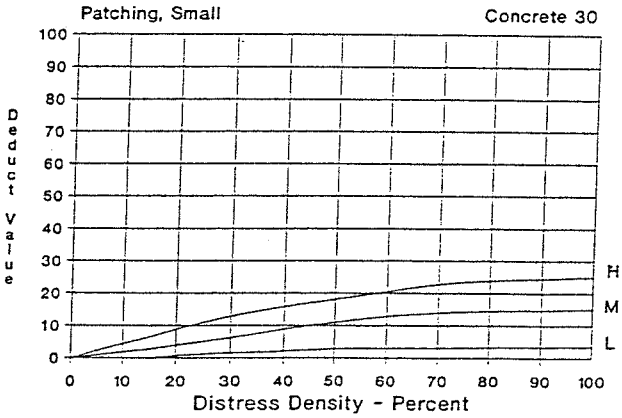


FIG. X4.10 Patching, Small

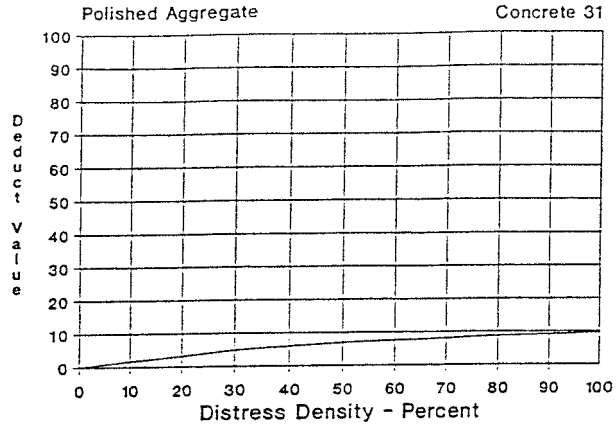


FIG. X4.11 Polished Aggregate

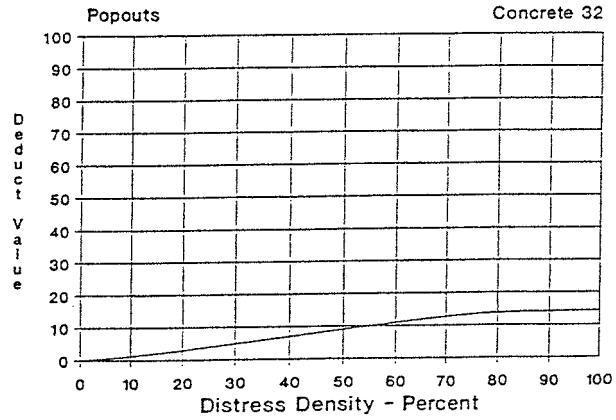


FIG. X4.12 Popouts

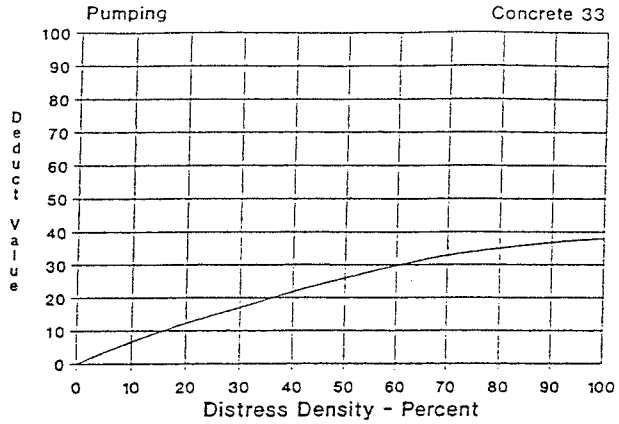


FIG. X4.13 Pumping

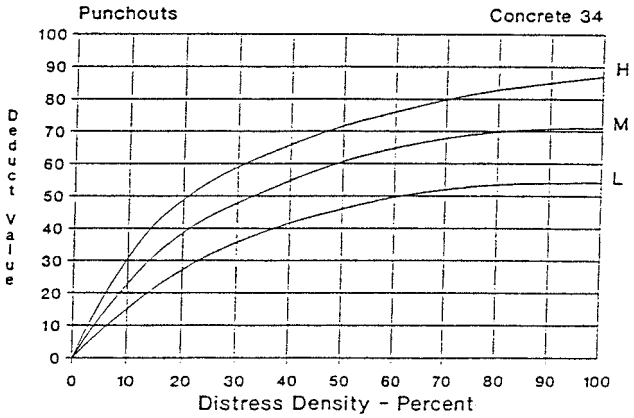


FIG. X4.14 Punchouts

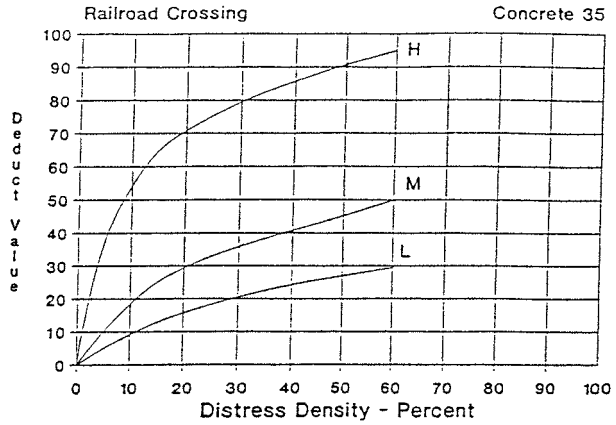


FIG. X4.15 Railroad Crossing

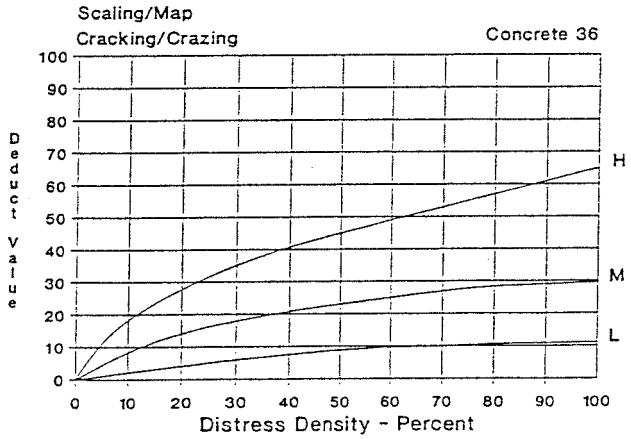


FIG. X4.16 Scaling/Map Cracking/Crazing

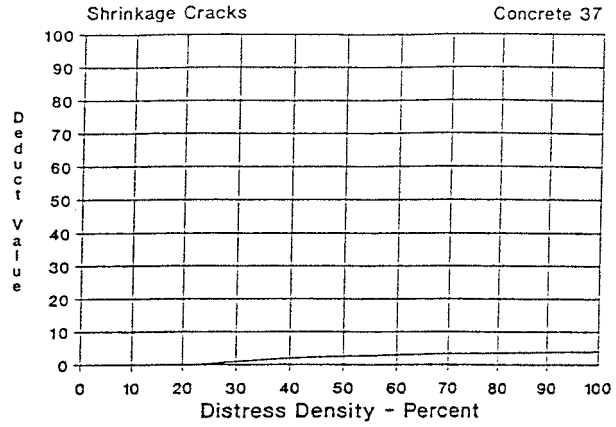


FIG. X4.17 Shrinkage Cracks

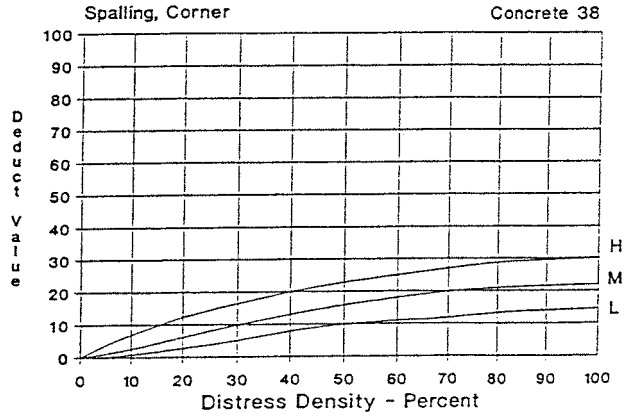


FIG. X4.18 Spalling, Corner

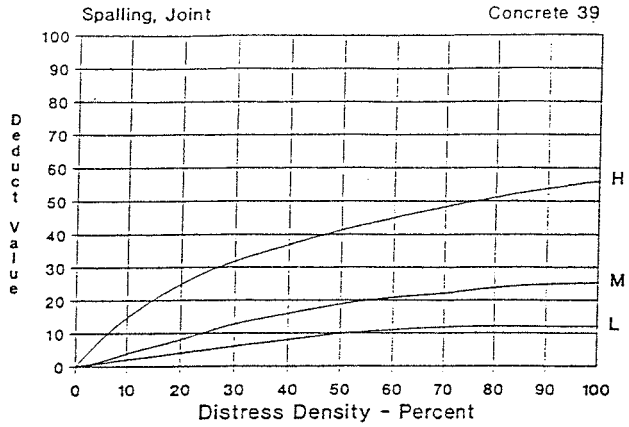
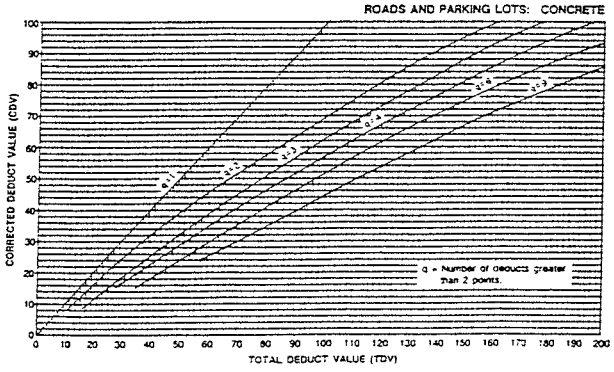


FIG. X4.19 Spalling, Joint



Corrected deduct values for jointed concrete pavement.

FIG. X4.20 Corrected Deduct Values for Jointed Concrete Pavement

Appendix C

Geotechnical Investigation

Geotechnical Investigation – Alger area

1.1 Geotechnical Investigation

Barr Engineering Co. (Barr), under authorization and contract with Invenergy, LLC (Invenergy), has completed a geotechnical investigation of roads around the Hardin Wind Project in Hardin County, Ohio. As part of this geotechnical investigation, Barr completed 23 geotechnical borings along road alignments near the proposed wind turbine location.

This letter report and its attachments provide geotechnical findings from the investigation. Barr previously completed a geotechnical investigation of the overall project area and prepared a comprehensive geotechnical report with recommendations for foundation design of turbines, original substation location, O&M building, overhead collector, and met towers.

1.1.1 Field Work

Under subcontract to Barr, Olsson Associates of Lincoln, Nebraska, completed a 28 shallow borings along existing county road alignments using a truck mounted drill rig to depths of five feet in two mobilizations between September 16th and October 17th, 2016. Standard penetration tests were performed and split-spoon samples were collected at 2.5-ft intervals to a depth of 5 ft. Drilling was advanced using solid-stem augers (SSA).

The coordinates of the borings are included in the Table 1 below and shown on Figure 1 attached.

Table 1 Testing Conditions and Coordinates

Geotechnical Boring ID	UTM NAD83 Z17N		Latitude [deg.]	Longitude [deg.]	Boring	CBR
	Easting [m]	Northing [m]				
RD-02	259954.9	4509774.5	40.70393	-83.84138	X	
RD-03	260351.1	4509766.4	40.70397	-83.83669	X	
RD-04	260747.5	4509750.7	40.70394	-83.83200	X	X
RD-05	261113.5	4509744.9	40.70400	-83.82767	X	
RD-06	261489.3	4509746.6	40.70412	-83.82322	X	
RD-07	259892.2	4509747.8	40.70367	-83.84211	X	
RD-08	259876.7	4509351.7	40.70010	-83.84214	X	
RD-09	259868.8	4508955.5	40.69653	-83.84208	X	
RD-10	259851.8	4508559.3	40.69296	-83.84213	X	
RD-11	259888.1	4508174.9	40.68952	-83.84155	X	
RD-12	260219.0	4508150.8	40.68940	-83.83763	X	X
RD-13	260565.8	4508143.9	40.68943	-83.83353	X	
RD-14	258598.1	4506568.9	40.67469	-83.85619	X	
RD-15	258992.6	4506551.5	40.67465	-83.85152	X	
RD-16	259404.3	4506544.7	40.67471	-83.84665	X	
RD-17	259812.8	4506527.3	40.67467	-83.84181	X	X
RD-18	260210.7	4506520.3	40.67472	-83.83711	X	
RD-19	260602.9	4506494.8	40.67461	-83.83246	X	
RD-20	261015.8	4506482.8	40.67462	-83.82758	X	
RD-21	261415.7	4506464.6	40.67457	-83.82285	X	
RD-24	258987.6	4504926.8	40.66003	-83.85095	X	X
RD-25	259343.0	4504913.7	40.66001	-83.84675	X	
RD-26	259723.8	4504905.9	40.66006	-83.84225	X	

RD-42	259836.8	4508157.4	40.68934	-83.84215	X	
RD-43	259830.0	4507753.1	40.68570	-83.84208	X	
RD-44	259811.8	4507353.9	40.68211	-83.84214	X	
RD-45	259805.0	4506952.0	40.67849	-83.84207	X	
RD-46	259784.2	4506548.3	40.67485	-83.84216	X	

1.1.2 Bulk Soil Sampling

Bulk samples of representative material from the site were collected for the purpose of laboratory testing. A total of four bulk soil samples (5-gallon buckets) were collected across the project site in support of California Bearing Ratio (CBR) testing. Sampling locations were selected to provide representative soil samples across the project area.

1.2 Subsurface Conditions

The results of the geotechnical borings and laboratory tests were compiled to obtain an understanding of the lithology of the study areas.

The typical stratigraphy, as determined from the field data collected at the road boring locations, consists of a surficial layer of asphalt or gravel underlain by primarily lean clay. Silty sand with various amounts of gravel was identified in three of the road borings beneath the asphalt. There were no base or sub-base courses identified beneath the asphalt; the bituminous materials appear to be placed directly on the existing soil/fill materials.

1.2.1 Asphalt

Asphalt was encountered in 26 of the 28 road boring locations. Asphalt thicknesses at boring locations ranged from 6 to 20.5 inches. The average asphalt thickness as approximately 12 inches.

1.2.2 Gravel

Surficial gravel was encountered in five of the 28 road boring locations. It was classified as a poorly graded gravel with sand. The thickness of the surficial gravel ranged from three to five inches.

1.2.3 Lean Clay to Fat Clay

Lean to fat clay was encountered in 27 of the 28 road boring locations in thicknesses ranging from approximately 1.5 feet to 4.7 feet. N-values from Standard Penetration Testing (SPT) conducted in the clays ranged from 4 to 22 blows per foot (bpf) with an average of 10 bpf. These results indicate that the clays typically have consistencies ranging from soft or very stiff.

1.2.4 Silty Sand

Silty sand with various amounts of gravel was encountered in three of the 28 road boring locations in thicknesses ranging from approximately 1.8 feet to 4.1 feet. N-values from SPT's conducted in the silty sand ranged from 7 to 27 blows per foot (bpf) with an average of approximately 14 bpf. These results indicate that the silty sands typically have relative densities ranging from loose to medium dense.

1.3 Groundwater Conditions

No evidence of groundwater was observed during the course of the geotechnical field investigation, however the road borings did not extend greater than 5 feet below existing grade. As a result, groundwater is not anticipated to be a significant factor in the current road construction.

1.4 Shear Strength

1.4.1 Approximate Undrained Shear Strength

The results of the geotechnical investigation indicate that most of roads bear directly on clayey soils with no base or sub-base courses present under the asphalt or gravel.

A number of pocket penetrometer tests were conducted on split spoon samples collected during drilling. The pocket penetrometer values in clay soils at each road boring location ranged from 1.0 tsf to greater than 4.5 tsf. The average results indicated an estimated unconfined compressive strength of 3.0 tons per square foot (tsf), which corresponds to an undrained shear strength of approximately 1,500 psf.

1.4.2 Approximate Drained Shear Strength

Granular soils were encountered in three road borings completed at all proposed turbine locations. The shear strength of these soils was estimated from correlations to SPT results collected at 2.5-foot intervals during sampling in the boreholes. The SPT value can be correlated to the soil friction angle (Das, 2007). The lowest average SPT value obtained for a cohesionless soil interval between a depth of one and five feet was SPT = 7 at road boring RD-19. An SPT value of 7 in silty sand correlates to a friction angle of approximately 30 degrees.

1.5 Laboratory Testing

Laboratory testing was performed on selected samples as described below.

1.5.1 California Bearing Ratio Testing

Design for roads and general working areas is based in part on the strength of the subgrade that can be reasonably achieved. California Bearing Ratio (CBR) tests were completed on soil samples collected from the selected locations across the site to determine the field strength of the subgrade.

A total of four samples of the shallow subgrade soils were collected adjacent to the road borings in the shoulders (Figure 1). The bulk samples were collected from soil immediately topsoil or fill materials, which typically corresponded to a depth of approximately 6 to 20 inches below the surface. The soil samples were prepared to approximate 95 percent of the standard Proctor maximum dry density at the optimum moisture content. The results of the CBR testing are presented in Table 2.

In general, the CBR samples were classified as fat clay with various amount of sand and gravel. Results from the testing conducted on the subgrade samples indicate that CBR values at 0.1 inch of deflection under a surcharge of 50 psf range from 2.0 to 3.6 percent, when compacted to 95 percent of the standard Proctor density at optimum moisture. The results indicate that the soils at the site are fairly consistent in their ability to support roads.

Table 2 CBR Testing Results

Geotechnical Boring ID	USCS	California Bearing Ratio Value (Optimum Moisture Content)*
		95% Compaction
RD-04	CH	2.2
RD-12	CH	3.0
RD-17	CH	3.6
RD-24	CH	2.0

1.6 DCP Field Testing

Dynamic Cone Pentrometer (DCP) tests were completed during investigation as a means of quantifying the subgrade strength of the soils in the road borings.

DCP tests were conducted in accordance with ASTM standard D6951 "Standard Test Method for use of the Dynamic Cone Penetrometer in Shallow Pavement Applications". The DCP was model K-100, manufactured by Kessler Soils Engineering Products, Inc. All tests were conducted utilizing a 17.6 pound hammer.

DCP tests were completed in all 28 road boring locations. The approximate location of each DCP test is provided in Table 3. Each test was conducted to a depth of 12 inches below existing grade. The results of the DCP testing are provided in Table 3.

The DCP rate of penetration can be correlated to California Bearing Ratio (CBR) values for the road subgrade. The following equation shows the relationship between measured DCP values in the field and approximate CBR values.

where:

CBR = California Bearing Ratio

PR = DCP rate of penetration [mm]

Table 3 shows the CBR value obtained at each of the four locations tested. It should be noted that several DCP values were higher than what would be expected given the material encountered in the borings. These locations tend to coincide with borings where silty sand was encountered. Any CBR correlations yielding values above 7 should be treated as anomalous as the DCP may have struck gravel causing an artificially high Dynamic Cone Penetration Index (DPI). Reading higher than 7 are not anticipated with clayey soils. Specifically regarding RD-17, because the CBR samples were collected in the right of way adjacent to the boring rather than in the exact location of the road boring, it is likely that the material tested was not similar to the material the DCP was completed in. Based on the lab results, an average CBR value of 2.7 is recommended for road design based on the results obtained from testing at this time.

Table 3 DCP Testing Results and CBR Correlation

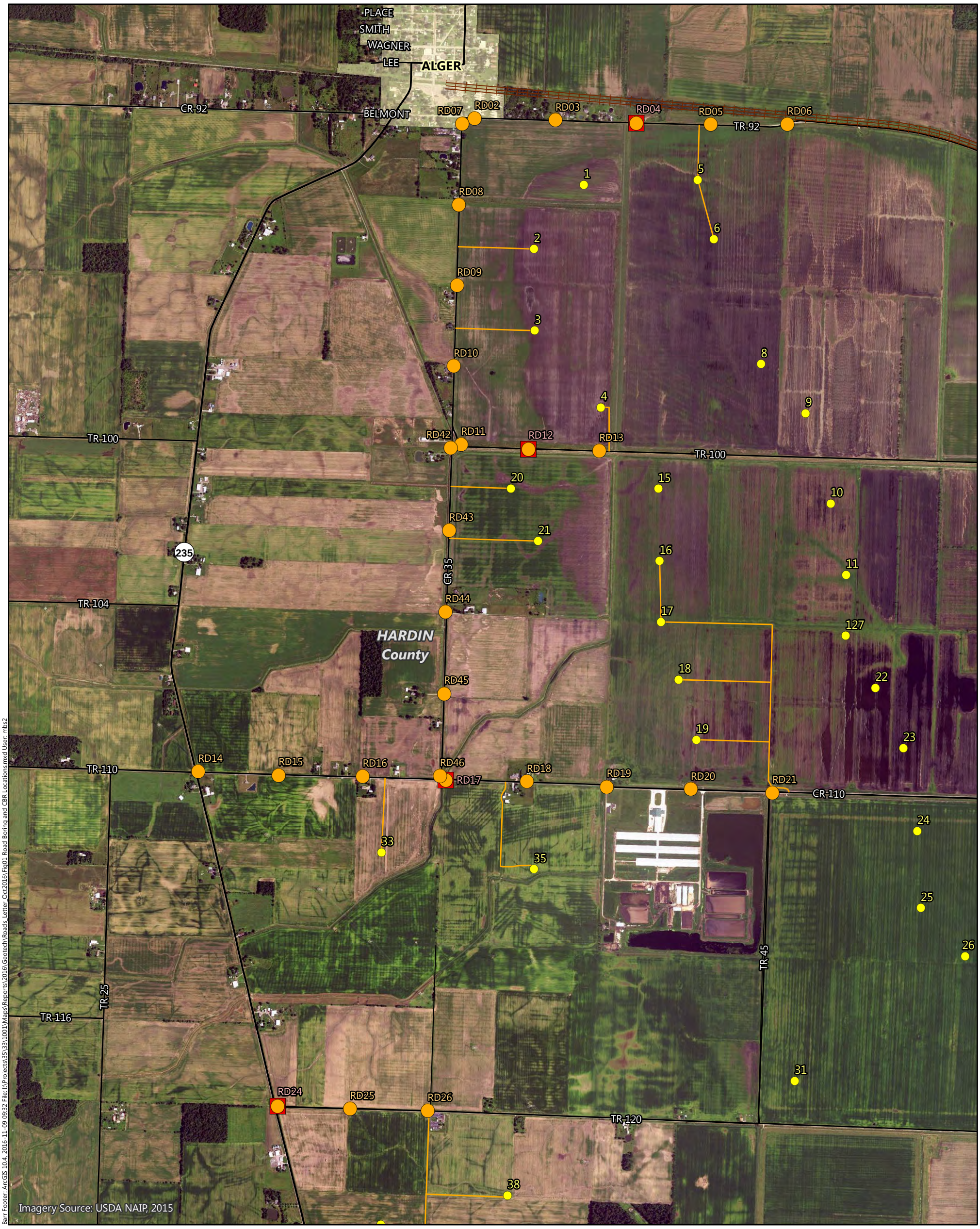
Location ID	Bituminous Thickness (inches)	DCP Blows per Foot	DPI	log (CBR)	Correlated CBR Value	95% Tested CBR Value
RD-02	12.5	7	43.5	0.62	4.2	--
RD-03	12	7	43.5	0.62	4.2	--
RD-04	14.5	7	43.5	0.62	4.2	2.2
RD-05	13.5	7	43.5	0.62	4.2	--
RD-06	19	36	8.5	1.42	26.4	--
RD-07	10.5	7	43.5	0.62	4.2	--
RD-08	10	7	43.5	0.62	4.2	--
RD-09	11	6	50.8	0.55	3.5	--
RD-10	12.5	5	61.0	0.46	2.9	--
RD-11	6	17	17.9	1.06	11.4	--
RD-12	4 (gravel)	6	50.8	0.55	3.5	3.0
RD-13	5 (gravel)	10	30.5	0.80	6.3	--
RD-14	11	9	33.9	0.75	5.6	--
RD-15	11.5	16	19.1	1.03	10.6	--
RD-16	11.5	9	33.9	0.75	5.6	--
RD-17	11.5	41	7.4	1.48	30.5	3.6
RD-18	12	8	38.1	0.69	4.9	--
RD-19	11.5	72	4.2	1.76	57.3	--
RD-20	12	18	16.9	1.08	12.1	--
RD-21	12	12	25.4	0.89	7.7	--
RD-24	8	8	38.1	0.69	4.9	2.0
RD-25	11	11	27.7	0.84	7.0	--
RD-26	12	7	43.5	0.62	4.2	--
RD-42	15	8	38.1	0.69	4.9	--
RD-43	13	7	43.5	0.62	4.2	--
RD-44	13	6	50.8	0.55	3.5	--
RD-45	13	7	43.5	0.62	4.2	--
RD-46	12	6	50.8	0.55	3.5	--

CBR Computations referenced from Salgado, 2003.

Used Kesler DCP (smaller DCP) under asphalt/gravel fill

1. Kessler Soils Engineering Products, Inc., *K-100 Models with quick connect pin User's Manual*, Springfield, Virginia, October 2007.

2. Giroud, J.P. and Han, J. "Design Method for Geogrid-Reinforced Unpaved Roads, II. Calibration and Applications" Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 130(8): 787-797.



- Turbine Location (8/5/2016)
- Road Boring Location
- Road Boring and CBR Location
- Transportation Route
- Access Road

Feet
1,500 0 1,500

Meters
500 0 500

Figure 1

SOIL BORING AND CBR LOCATIONS
Hardin Wind Project
Invenergy LLC
Hardin County, Ohio

California Bearing Ratio ASTM:D1883

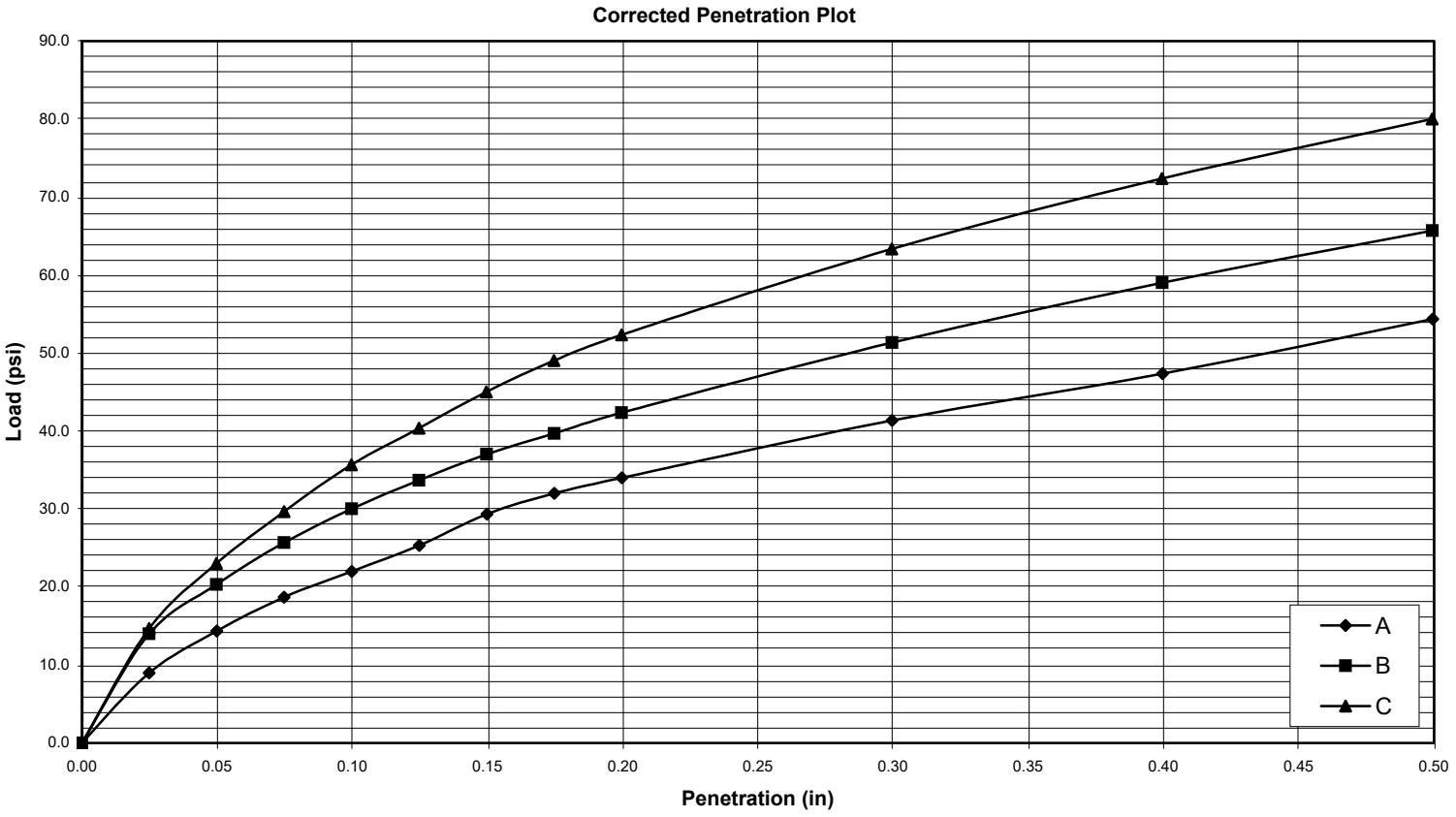
Project:	Hardin Wind	Job:	**10557**
Client:	Barr Engineering Company	Date:	10/5/16

Boring #: RD-04, RD-12, RD-17	Procedural Method:
Sample:	Specimens compacted to approximately 95% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): Type: Bulk	
Location:	
Classification: Fat Clay with a little gravel (CH), Fat Clay with a trace of organic material (CH), Fat Clay (CH)	

Laboratory Moisture-Density Values		Index Properties	
Method:	ASTM:D698 Method B	LL:	Gs:
Maximum Dry Density (PCF):	92.5, 84.3, 98	PL:	Organic Content:
Optimum Water Content:	25.3%, 31.5%, 23.3%	PI:	pH:

Initial Molding Conditions			
Specimen	A	B	C
Compaction Hammer:	5 lb	5 lb	5 lb
Number of Layers:	3	3	3
Blows per Layer:	NA	NA	NA
Initial Moisture Content:	25.3%	31.5%	23.3%
Initial Dry Density (PCF)	87.8	80.4	93.1
Relative Compaction	94.9%	95.4%	94.9%
Soaking Phase			
Days Soaked	4	4	4
Surcharge (psf)	50	50	50
Total Swell (%)	1.6%	1.9%	1.2%
Penetration Phase			
Surcharge (psf)	50	50	50
Corrected CBR Values			
at 0.1 inch (%)	**2.2%**	**3.0%**	**3.6%**
at 0.2 inch (%)	2.3%	2.8%	3.5%
Moisture Content After Penetration			
Top 1" of Specimen:	29.5%	35.1%	25.5%
Average of specimen:	28.4%	33.9%	25.0%

Stress vs. Penetration Graph



9530 James Ave South

SOIL ENGINEERING TESTING, INC.

Bloomington, MN 55431

California Bearing Ratio ASTM:D1883

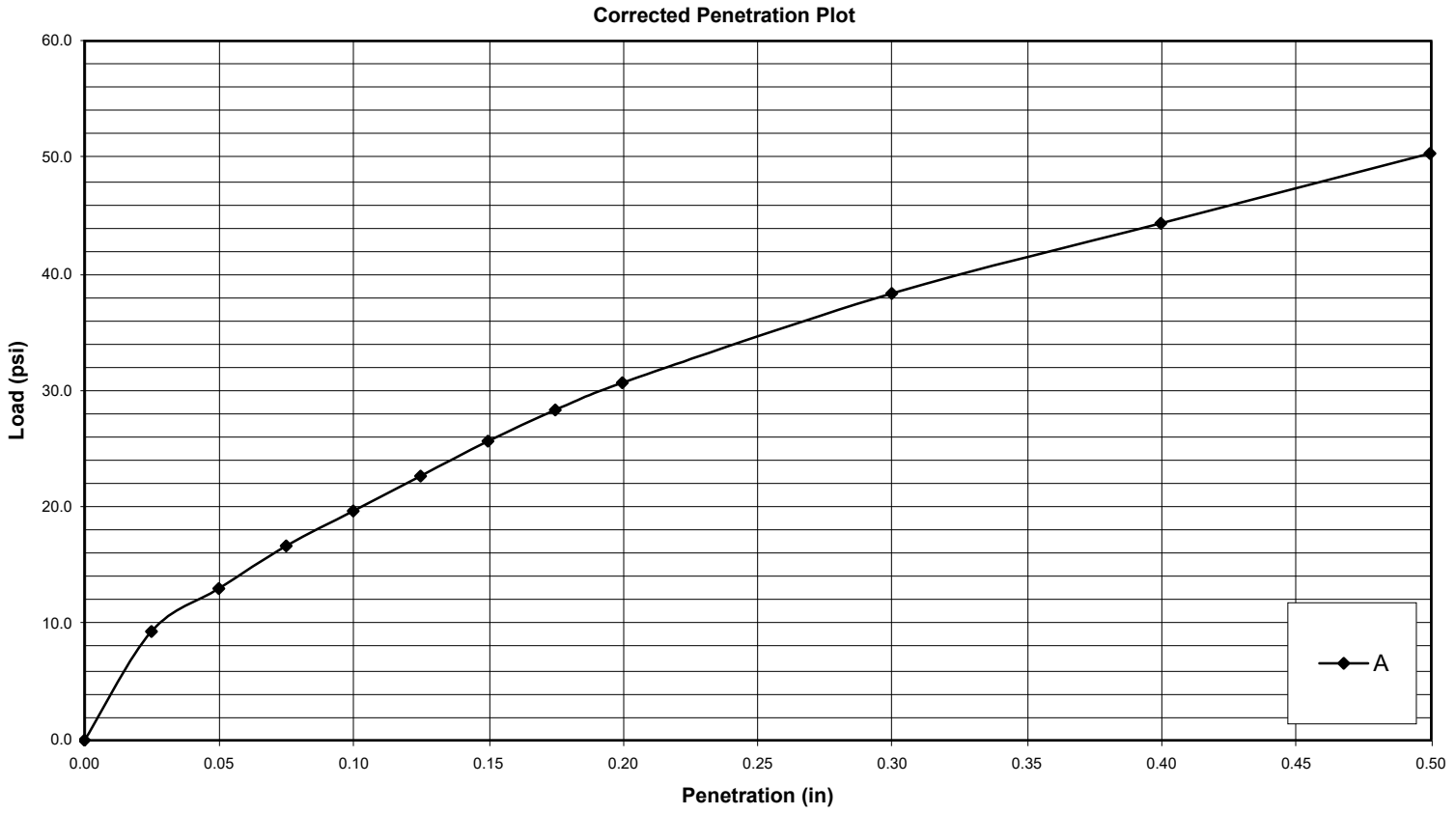
Project:	Hardin Wind	Job:	**10557**
Client:	Barr Engineering Company	Date:	10/5/16

Boring #: RD-24	Procedural Method:
Sample:	Specimens compacted to approximately 95% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): Type: Bulk	
Location:	
Classification: Fat Clay with a little gravel (CH)	

Laboratory Moisture-Density Values		Index Properties	
Method:	ASTM:D698 Method B	LL:	Gs:
Maximum Dry Density (PCF):	91.3	PL:	Organic Content:
Optimum Water Content:	26.7%	PI:	pH:

Initial Molding Conditions			
Specimen	A		
Compaction Hammer:	5 lb		
Number of Layers:	3		
Blows per Layer:	NA		
Initial Moisture Content:	26.7%		
Initial Dry Density (PCF)	86.6		
Relative Compaction	94.9%		
Soaking Phase			
Days Soaked	4		
Surcharge (psf)	50		
Total Swell (%)	2.0%		
Penetration Phase			
Surcharge (psf)	50		
Corrected CBR Values			
at 0.1 inch (%)	**2.0%**		
at 0.2 inch (%)	2.1%		
Moisture Content After Penetration			
Top 1" of Specimen:	32.1%		
Average of specimen:	30.9%		

Stress vs. Penetration Graph



9530 James Ave South

SOIL ENGINEERING TESTING, INC.

Bloomington, MN 55431

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-02

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	
	0.0	ASPHALT: 12.5 inches thick.	
	1.0	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	1.1
	2.5	LEAN TO FAT CLAY (CL/CH): brown to gray; moist; stiff.	2.5
	5.0	Bottom of Boring at 5.0 feet	5.0

Graphic Log | Sample Type & Rec. | STANDARD PENETRATION TEST DATA (N in blows/ft: 10 20 30 40) | WATER CONTENT % (PL, LL; 20 40 60) | SIEVE ANALYSIS (GRAVEL SAND SILT CLAY; FINES; 20 40 60 80)

Physical Properties

WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
				2		
				2		

Completion Depth:	5.0
Date Boring Started:	9/17/16
Date Boring Completed:	9/17/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:239955m, E:4509775m
Datum:	NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): After Drilling Dry; At Time of Drilling Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING RD-03

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	
	0.0	ASPHALT: 12 inches thick.	
	1.0	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	1.0
	3.5	LEAN TO FAT CLAY (CL/CH): brown to gray; moist; stiff.	3.5
	5.0	Bottom of Boring at 5.0 feet	5.0

Graphic Log | Sample Type & Rec.

STANDARD PENETRATION TEST DATA — N in blows/ft (10, 20, 30, 40)

WATER CONTENT % — PL, LL (20, 40, 60)

SIEVE ANALYSIS — GRAVEL, SAND, SILT, CLAY, FINES (20, 40, 60, 80)

Physical Properties

WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
				2.5		
				1.5		

Completion Depth:	5.0
Date Boring Started:	9/17/16
Date Boring Completed:	9/17/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:260352m, E:4509766m
Datum:	NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): After Drilling Dry; At Time of Drilling Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING RD-04

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	
	0.0	ASPHALT: 14.5 inches thick.	
	1.3	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	
	4.0	LEAN TO FAT CLAY (CL/CH): brown to gray; moist; medium stiff.	
	5.0	Bottom of Boring at 5.0 feet	

Graphic Log | Sample Type & Rec. | STANDARD PENETRATION TEST DATA (N in blows/ft: 10 20 30 40) | WATER CONTENT % (PL, LL; 20 40 60) | SIEVE ANALYSIS (GRAVEL SAND SILT CLAY; FINES; 20 40 60 80)

Physical Properties

WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
				3.5		
				1		

Completion Depth: 5.0
Date Boring Started: 9/17/16
Date Boring Completed: 9/17/16
Logged By: ZSM
Drilling Contractor: Olsson Associates
Drilling Method: SSA
Ground Surface Elevation:
Coordinates: UTM 17 N:260747m, E:4509752m
Datum: NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): After Drilling Dry; At Time of Drilling Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING RD-05

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	
	0.0	ASPHALT: 13.5 inches thick.	
	1.3	LEAN TO FAT CLAY (CL/CH): gray; moist; stiff.	1.3
	3.0	LEAN TO FAT CLAY (CL/CH): brown to gray; moist; medium stiff.	3.0
	5.0	Bottom of Boring at 5.0 feet	5.0

Graphic Log | Sample Type & Rec.

STANDARD PENETRATION TEST DATA — N in blows/ft: 10 20 30 40 — 13, 7

WATER CONTENT % — PL, LL: 20 40 60

SIEVE ANALYSIS — GRAVEL SAND SILT CLAY; FINES: 20 40 60 80

Physical Properties

WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
				2.5		

Completion Depth:	5.0
Date Boring Started:	9/17/16
Date Boring Completed:	9/17/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:260113m, E:4709746m
Datum:	NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): After Drilling Dry; At Time of Drilling Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

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LOG OF BORING RD-06

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	
	0.0	ASPHALT: 19 inches thick.	
	1.7	SILTY SAND WITH GRAVEL (SM): fine to coarse grained; brown; moist; medium dense.	
	3.5	LEAN TO FAT CLAY (CL/CH): brown to gray; moist; soft.	
	5.0	Bottom of Boring at 5.0 feet	

Graphic Log | Sample Type & Rec. | STANDARD PENETRATION TEST DATA (N in blows/ft: 10, 20, 30, 40) | WATER CONTENT % (PL, LL; 20, 40, 60) | SIEVE ANALYSIS (GRAVEL, SAND, SILT, CLAY, FINES; 20, 40, 60, 80)

Physical Properties

WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
				0.5		

Completion Depth:	5.0
Date Boring Started:	9/17/16
Date Boring Completed:	9/17/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:261488m, E:4509749m
Datum:	NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): After Drilling Dry; At Time of Drilling Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING RD-07

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

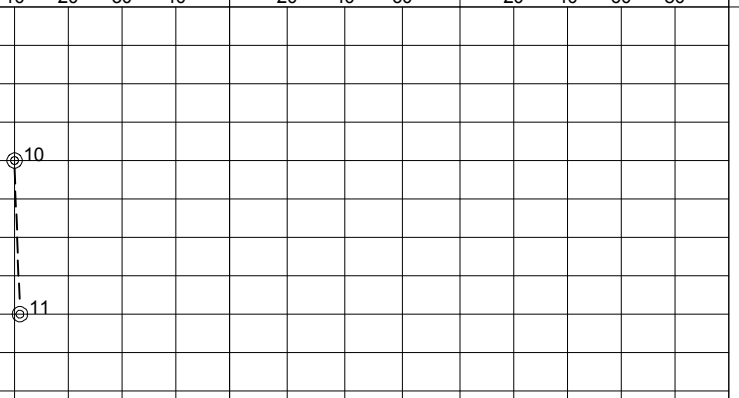
Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	
	0.0	ASPHALT: 10.5 inches thick.	
	0.5		
	1.0	LEAN TO FAT CLAY (CL/CH): gray; moist; stiff.	0.9
	1.5		
	2.0	LEAN TO FAT CLAY (CL/CH): greenish gray; moist; stiff.	2.0
	2.5		
	3.0		
	3.5		
	4.0		
	4.5		
	5.0	Bottom of Boring at 5.0 feet	5.0
	5.5		
	6.0		
	6.5		
	7.0		
	7.5		
	8.0		
	8.5		
	9.0		
	9.5		
	10.0		

Graphic Log | Sample Type & Rec.

STANDARD PENETRATION TEST DATA — N in blows/ft: 10 20 30 40

WATER CONTENT % — PL LL: 20 40 60

SIEVE ANALYSIS — GRAVEL SAND SILT CLAY FINES: 20 40 60 80



Physical Properties	WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
					2		
					2		

Completion Depth:	5.0
Date Boring Started:	9/16/16
Date Boring Completed:	9/16/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:259591m, E:4509747m
Datum:	NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): After Drilling Dry; At Time of Drilling Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

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Minneapolis, MN 55435
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LOG OF BORING RD-08

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	
	0.0	ASPHALT: 10 inches thick.	
	0.9	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	
	3.0	LEAN TO FAT CLAY (CL/CH): gray to brown; moist; stiff.	
	5.0	Bottom of Boring at 5.0 feet	

Graphic Log | Sample Type & Rec. | STANDARD PENETRATION TEST DATA (N in blows/ft: 10 20 30 40) | WATER CONTENT % (PL, LL; 20 40 60) | SIEVE ANALYSIS (GRAVEL SAND SILT CLAY; FINES; 20 40 60 80)

Physical Properties

WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
				2.5		
				2		

Completion Depth:	5.0
Date Boring Started:	9/17/16
Date Boring Completed:	9/17/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:259877m, E:4509351m
Datum:	NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): After Drilling Dry; At Time of Drilling Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING RD-09

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	
	0.0	ASPHALT: 11 inches thick.	
	0.9	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	
	2.0	LEAN TO FAT CLAY (CL/CH): brown to gray; moist; stiff.	
	5.0	Bottom of Boring at 5.0 feet	

Graphic Log; Sample Type & Rec.

STANDARD PENETRATION TEST DATA — N in blows/ft: 10 20 30 40 — 8, 11

WATER CONTENT % — PL, LL: 20 40 60

SIEVE ANALYSIS — GRAVEL SAND SILT CLAY; FINES: 20 40 60 80

Physical Properties

WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
				1.5		
				2		

Completion Depth:	5.0
Date Boring Started:	9/17/16
Date Boring Completed:	9/17/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:259868m, E:4508955m
Datum:	NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): After Drilling Dry; At Time of Drilling Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

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Telephone: 952-832-2600

LOG OF BORING RD-10

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	
	0.0	ASPHALT: 12.5 inches thick.	
	1.0	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	1.1
	3.5	LEAN TO FAT CLAY (CL/CH): greenish gray; moist; stiff.	3.5
	5.0	Bottom of Boring at 5.0 feet	5.0

Graphic Log | Sample Type & Rec. | STANDARD PENETRATION TEST DATA (N in blows/ft: 10 20 30 40; 7; 10) | WATER CONTENT % (PL, LL; 20 40 60) | SIEVE ANALYSIS (GRAVEL SAND SILT CLAY; FINES; 20 40 60 80)

Physical Properties

WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
				1.5		
				1		

Completion Depth: 5.0
Date Boring Started: 9/17/16
Date Boring Completed: 9/17/16
Logged By: ZSM
Drilling Contractor: Olsson Associates
Drilling Method: SSA
Ground Surface Elevation:
Coordinates: UTM 17 N:259851m, E:4508560m
Datum: NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): At Time of Drilling Dry; After Drilling Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING RD-11

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	
	0.0	ASPHALT: 6 inches thick.	
	0.5	LEAN TO FAT CLAY (CL/CH): brown; moist; stiff; trace gravel.	0.5
	3.0	LEAN TO FAT CLAY (CL/CH): brown; moist; stiff.	3.0
	5.0	Bottom of Boring at 5.0 feet	5.0

Graphic Log | Sample Type & Rec.

STANDARD PENETRATION TEST DATA — N in blows/ft (10, 20, 30, 40)

WATER CONTENT % — PL, LL (20, 40, 60)

SIEVE ANALYSIS — GRAVEL, SAND, SILT, CLAY, FINES (20, 40, 60, 80)

Physical Properties

WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
				2		
				2.5		

Completion Depth:	5.0
Date Boring Started:	9/16/16
Date Boring Completed:	9/16/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:259886m, E:4508175m
Datum:	NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): At Time of Drilling Dry; After Drilling Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING RD-12

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	
	0.0	GRAVEL WITH SAND (GP): brown and gray; moist; 6 inches thick; [fill].	0.3
	0.5	LEAN TO FAT CLAY (CL/CH): brown to gray; moist; medium stiff.	
	1.0		
	1.5		
	2.0		
	2.5		
	3.0	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	3.0
	3.5		
	4.0		
	4.5		
	5.0	Bottom of Boring at 5.0 feet	5.0
	5.5		
	6.0		
	6.5		
	7.0		
	7.5		
	8.0		
	8.5		
	9.0		
	9.5		
	10.0		

Graphic Log | Sample Type & Rec.

STANDARD PENETRATION TEST DATA — N in blows/ft: 10 20 30 40; 7; 8

WATER CONTENT % — PL LL; 20 40 60

SIEVE ANALYSIS — GRAVEL SAND SILT CLAY; FINES; 20 40 60 80

Physical Properties

WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
				2.5		
				2.5		

Completion Depth:	5.0
Date Boring Started:	9/16/16
Date Boring Completed:	9/16/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:260219m, E:4508152m
Datum:	NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): At Time of Drilling Dry; After Drilling Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING RD-13

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	Graphic Log	Sample Type & Rec.	STANDARD PENETRATION TEST DATA (N in blows/ft)	WATER CONTENT % (PL, LL)	SIEVE ANALYSIS (GRAVEL, SAND, SILT, CLAY, FINES)	Physical Properties: WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
	0.0	Surface Elev.:												
	0.5	GRAVEL WITH SAND (GP): brown and gray; moist; 5 inches thick; [fill].												
		0.4												
	1.0	LEAN TO FAT CLAY (CL/CH): brown; moist; stiff.												
	1.5													
	2.0				14							2.5		
	2.5	LEAN TO FAT CLAY (CL/CH): gray; moist; stiff.												
		2.5												
	3.0													
	3.5													
	4.0				9							2		
	4.5													
	5.0	Bottom of Boring at 5.0 feet												
		5.0												
	5.5													
	6.0													
	6.5													
	7.0													
	7.5													
	8.0													
	8.5													
	9.0													
	9.5													
	10.0													

Completion Depth:	5.0
Date Boring Started:	9/16/16
Date Boring Completed:	9/16/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:260560m, E:4508144m
Datum:	NAD83

Remarks:

SAMPLE TYPES

Split Spoon

WATER LEVELS (ft)

At Time of Drilling Dry
After Drilling Dry

LEGEND

MC Moisture Content
γ Dry Unit Weight
ϕ Friction Angle
Q_u Unconfined Compression
Q_p Hand Penetrometer UC
Gs Specific Gravity
RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

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Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-14

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	
	0.0	ASPHALT: 11 inches thick.	
	0.9	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	
	3.0	LEAN TO FAT CLAY (CL/CH): brown and gray; moist; stiff.	
	5.0	Bottom of Boring at 5.0 feet	

Graphic Log | Sample Type & Rec. | STANDARD PENETRATION TEST DATA (N in blows/ft: 10 20 30 40; 8; 14) | WATER CONTENT % (PL, LL; 20 40 60) | SIEVE ANALYSIS (GRAVEL SAND SILT CLAY; FINES; 20 40 60 80)

Physical Properties	WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
					3		
					2		

Completion Depth: 5.0
Date Boring Started: 9/16/16
Date Boring Completed: 9/16/16
Logged By: ZSM
Drilling Contractor: Olsson Associates
Drilling Method: SSA
Ground Surface Elevation:
Coordinates: UTM 17 N:258597m, E:4506570m
Datum: NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): At Time of Drilling Dry; After Drilling Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING RD-15

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	
	0.0	ASPHALT: 11.5 inches thick.	
	0.9	LEAN TO FAT CLAY (CL/CH): brown; moist; medium stiff to very stiff.	
	5.0	Bottom of Boring at 5.0 feet	

Graphic Log; Sample Type & Rec.

STANDARD PENETRATION TEST DATA — N in blows/ft: 10 20 30 40; 8; 16

WATER CONTENT % — PL LL; 20 40 60

SIEVE ANALYSIS — GRAVEL SAND SILT CLAY FINES; 20 40 60 80

Physical Properties

WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
				2		
				2		

Completion Depth: 5.0
Date Boring Started: 9/16/16
Date Boring Completed: 9/16/16
Logged By: ZSM
Drilling Contractor: Olsson Associates
Drilling Method: SSA
Ground Surface Elevation:
Coordinates: UTM 17 N:258992m, E:4506558m
Datum: NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): At Time of Drilling Dry; After Drilling Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING RD-16

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	
	0.0	ASPHALT: 11.5 inches thick.	
	0.9	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	
	3.0	LEAN TO FAT CLAY (CL/CH): gray to brown; moist; stiff.	
	5.0	Bottom of Boring at 5.0 feet	

Graphic Log | Sample Type & Rec. | STANDARD PENETRATION TEST DATA (N in blows/ft: 10 20 30 40) | WATER CONTENT % (PL, LL; 20 40 60) | SIEVE ANALYSIS (GRAVEL SAND SILT CLAY; FINES; 20 40 60 80)

Physical Properties

WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
				2		
				1.5		

Completion Depth:	5.0
Date Boring Started:	9/16/16
Date Boring Completed:	9/16/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:259405m, E:4506544m
Datum:	NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): At Time of Drilling Dry; After Drilling Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING RD-17

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	
	0.0	ASPHALT: 11.5 inches thick.	
	0.9	SILTY SAND (SM): fine to coarse grained; brown; moist; loose; [fill].	
	3.0	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	
	5.0	Bottom of Boring at 5.0 feet	

Graphic Log | Sample Type & Rec. | STANDARD PENETRATION TEST DATA (N in blows/ft: 10 20 30 40) | WATER CONTENT % (PL, LL; 20 40 60) | SIEVE ANALYSIS (GRAVEL SAND SILT CLAY; FINES; 20 40 60 80)

Physical Properties

WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
				1		

Completion Depth:	5.0
Date Boring Started:	9/16/16
Date Boring Completed:	9/16/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:259813m, E:4506531m
Datum:	NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): At Time of Drilling Dry; After Drilling Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING RD-18

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	
	0.0	ASPHALT: 12 inches thick.	
	1.0	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	1.0
	2.5	LEAN TO FAT CLAY (CL/CH): brown to gray; moist; stiff.	2.5
	5.0	Bottom of Boring at 5.0 feet	5.0

Graphic Log | Sample Type & Rec. | STANDARD PENETRATION TEST DATA (N in blows/ft: 10 20 30 40; 7; 11) | WATER CONTENT % (PL, LL; 20 40 60) | SIEVE ANALYSIS (GRAVEL SAND SILT CLAY; FINES; 20 40 60 80)

Physical Properties	WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
					2.5		
					3		

Completion Depth:	5.0
Date Boring Started:	9/16/16
Date Boring Completed:	9/16/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:260210m, E:4506521m
Datum:	NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): At Time of Drilling Dry; After Drilling Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING RD-19

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)
	0.0	ASPHALT: 11.5 inches thick.
	0.9	SILTY SAND WITH GRAVEL (SM): fine to coarse grained; brown; moist; loose to medium dense.
	5.0	Bottom of Boring at 5.0 feet

Graphic Log | Sample Type & Rec. | STANDARD PENETRATION TEST DATA (N in blows/ft: 10 20 30 40) | WATER CONTENT % (PL, LL; 20 40 60) | SIEVE ANALYSIS (GRAVEL SAND SILT CLAY; FINES; 20 40 60 80)

Physical Properties

WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %

Completion Depth:	5.0
Date Boring Started:	9/16/16
Date Boring Completed:	9/16/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:260603m, E:4506499m
Datum:	NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): At Time of Drilling Dry; After Drilling Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING RD-20

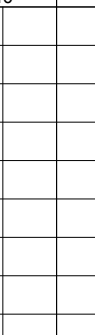
Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	
	0.0	ASPHALT: 12 inches thick.	
	1.0	LEAN TO FAT CLAY (CL/CH): brown; moist; stiff; trace gravel.	1.0
	4.5	LEAN TO FAT CLAY (CL/CH): gray; moist; stiff.	4.5
	5.0	Bottom of Boring at 5.0 feet	5.0

Graphic Log | Sample Type & Rec. | STANDARD PENETRATION TEST DATA (N in blows/ft: 10 20 30 40) | WATER CONTENT % (PL, LL; 20 40 60) | SIEVE ANALYSIS (GRAVEL SAND SILT CLAY; FINES; 20 40 60 80)



Physical Properties

WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
				3.5		
				3		

Completion Depth:	5.0
Date Boring Started:	9/16/16
Date Boring Completed:	9/16/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:260989m, E:4506483m
Datum:	NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): At Time of Drilling Dry; After Drilling Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING RD-21

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	
	0.0	ASPHALT: 12 inches thick.	
	1.0	LEAN TO FAT CLAY (CL/CH): brown; moist; medium stiff; trace gravel.	1.0
	4.5	LEAN TO FAT CLAY (CL/CH): gray; moist; stiff.	4.5
	5.0	Bottom of Boring at 5.0 feet	5.0

Graphic Log | Sample Type & Rec. | STANDARD PENETRATION TEST DATA (N in blows/ft: 10 20 30 40) | WATER CONTENT % (PL, LL; 20 40 60) | SIEVE ANALYSIS (GRAVEL SAND SILT CLAY; FINES; 20 40 60 80)

Physical Properties

WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
				2.5		
				3		

Completion Depth:	5.0
Date Boring Started:	9/16/16
Date Boring Completed:	9/16/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:261399m, E:4506465m
Datum:	NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): At Time of Drilling Dry; After Drilling Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING RD-24

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	
	0.0	ASPHALT: 8 inches thick.	
	0.5		
	0.7	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	
	1.0		
	1.5		
	2.0		
	2.5		
	3.0		3.0
	3.5	LEAN TO FAT CLAY (CL/CH): gray; moist; very stiff; some gravel.	
	4.0		
	4.5		
	5.0	Bottom of Boring at 5.0 feet	5.0
	5.5		
	6.0		
	6.5		
	7.0		
	7.5		
	8.0		
	8.5		
	9.0		
	9.5		
	10.0		

Graphic Log | Sample Type & Rec.

STANDARD PENETRATION TEST DATA — N in blows/ft: 10 20 30 40; 8; 20

WATER CONTENT % — PL LL; 20 40 60

SIEVE ANALYSIS — GRAVEL SAND SILT CLAY; FINES; 20 40 60 80

Physical Properties

WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
				3		
				4.5		

Completion Depth:	5.0
Date Boring Started:	9/16/16
Date Boring Completed:	9/16/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:258987m, E:4504928m
Datum:	NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): At Time of Drilling Dry; After Drilling Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING RD-25

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	
	0.0	ASPHALT: 11 inches thick.	
	0.9	LEAN TO FAT CLAY (CL/CH): brown; moist; medium stiff; trace gravel.	
	3.0	LEAN TO FAT CLAY (CL/CH): brown and gray; moist; very stiff; trace gravel.	
	5.0	Bottom of Boring at 5.0 feet	

Graphic Log | Sample Type & Rec. | STANDARD PENETRATION TEST DATA (N in blows/ft: 10 20 30 40; 8; 22) | WATER CONTENT % (PL, LL; 20 40 60) | SIEVE ANALYSIS (GRAVEL SAND SILT CLAY; FINES; 20 40 60 80)

Physical Properties	WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
					2.5		
					4.5		

Completion Depth: 5.0
Date Boring Started: 9/16/16
Date Boring Completed: 9/16/16
Logged By: ZSM
Drilling Contractor: Olsson Associates
Drilling Method: SSA
Ground Surface Elevation:
Coordinates: UTM 17 N:259342m, E:4504917m
Datum: NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): At Time of Drilling Dry; After Drilling Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING RD-26

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	
	0.0	ASPHALT: 12 inches thick.	
	1.0	LEAN TO FAT CLAY (CL/CH): gray; moist; medium stiff.	1.0
	3.0	LEAN TO FAT CLAY (CL/CH): brown and gray; moist; stiff.	3.0
	5.0	Bottom of Boring at 5.0 feet	5.0

Graphic Log | Sample Type & Rec.

STANDARD PENETRATION TEST DATA — N in blows/ft (10, 20, 30, 40)

WATER CONTENT % — PL, LL (20, 40, 60)

SIEVE ANALYSIS — GRAVEL, SAND, SILT, CLAY, FINES (20, 40, 60, 80)

Physical Properties

WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
				2.5		
				1.5		

Completion Depth:	5.0
Date Boring Started:	9/16/16
Date Boring Completed:	9/16/16
Logged By:	ZSM
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	UTM 17 N:259723m, E:4504907m
Datum:	NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft): At Time of Drilling Dry; After Drilling Dry

LEGEND: MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING RD-42

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)
	0.0	ASPHALT: 15 inches thick.
	1.3	POORLY GRADED GRAVEL WITH SAND (GP): tan to light brown; moist.
	1.4	LEAN TO FAT CLAY (CL/CH): grayish brown to brown; moist; stiff; trace sand and gravel.
	5.5	Bottom of Boring at 5.4 feet

Graphic Log | Sample Type & Rec. | STANDARD PENETRATION TEST DATA (N in blows/ft: 10 20 30 40) | WATER CONTENT % (PL, LL; 20 40 60) | SIEVE ANALYSIS (GRAVEL SAND SILT CLAY; FINES; 20 40 60 80)

Physical Properties

WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %

Completion Depth:	5.4
Date Boring Started:	
Date Boring Completed:	
Logged By:	Carlos
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	
Datum:	NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft)

LEGEND

MC	Moisture Content	Q_u	Unconfined Compression
γ	Dry Unit Weight	Q_p	Hand Penetrometer UC
ϕ	Friction Angle	Gs	Specific Gravity
		RQD	Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

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LOG OF BORING RD-43

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	
	0.0	ASPHALT: 13 inches thick.	
	1.0	POORLY GRADED GRAVEL WITH SAND (GP): tan to light brown; moist.	1.1
	1.5	LEAN TO FAT CLAY (CL/CH): dark brown to gray; moist; stiff; trace sand and gravel.	1.3
	2.0		
	2.5		
	3.0		
	3.5		
	4.0		
	4.5		
	5.0	Bottom of Boring at 5.3 feet	5.3
	5.5		
	6.0		
	6.5		
	7.0		
	7.5		
	8.0		
	8.5		
	9.0		
	9.5		
	10.0		

Graphic Log | Sample Type & Rec.

STANDARD PENETRATION TEST DATA — N in blows/ft: 10 20 30 40 — 10 @ 2.5 ft; 11 @ 4.0 ft

WATER CONTENT % — PL — LL — 20 40 60

SIEVE ANALYSIS — GRAVEL SAND SILT CLAY; FINES — 20 40 60 80

Physical Properties	WC	γ	ϕ	Q_u	Q_p	Gs	RQD
	%	pcf	°	tsf	tsf		%

Completion Depth:	5.3
Date Boring Started:	
Date Boring Completed:	
Logged By:	Carlos
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	
Datum:	NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft)

LEGEND

MC	Moisture Content	Q_u	Unconfined Compression
γ	Dry Unit Weight	Q_p	Hand Penetrometer UC
ϕ	Friction Angle	Gs	Specific Gravity
		RQD	Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

M:\GINT\PROJECTS\35331001 HARDIN COUNTY WIND 2016.GPJ BARRLIBRARY.GLB HORIZONTAL LOG REPORT BARR GEOTECH TEMPLATE.GDT

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-44

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

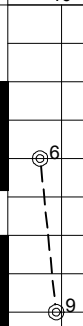
Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	
	0.0	ASPHALT: 13 inches thick.	
	1.1	POORLY GRADED GRAVEL WITH SAND (GP): tan to light brown; moist.	1.1
	1.3	LEAN TO FAT CLAY (CL/CH): dark brown to brown; moist; stiff; trace sand and gravel.	1.3
	5.3	Bottom of Boring at 5.3 feet	5.3

Graphic Log | Sample Type & Rec.

STANDARD PENETRATION TEST DATA — N in blows/ft (10 20 30 40)



WATER CONTENT % — PL LL (20 40 60)

SIEVE ANALYSIS — GRAVEL SAND SILT CLAY FINES (20 40 60 80)

Physical Properties

WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %

Completion Depth:	5.3
Date Boring Started:	
Date Boring Completed:	
Logged By:	Carlos
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	
Datum:	NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft)

LEGEND

MC	Moisture Content	Q_u	Unconfined Compression
γ	Dry Unit Weight	Q_p	Hand Penetrometer UC
ϕ	Friction Angle	Gs	Specific Gravity
		RQD	Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

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Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-45

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	Graphic Log	Sample Type & Rec.	STANDARD PENETRATION TEST DATA (N in blows/ft)	WATER CONTENT %	SIEVE ANALYSIS	Physical Properties
	0.0	ASPHALT: 13 inches thick.						
	1.0	LEAN TO FAT CLAY (CL/CH): dark brown to grayish brown; moist; stiff; trace sand and gravel. 1.1			9, 10			
	5.0	Bottom of Boring at 5.1 feet 5.1						

STANDARD PENETRATION TEST DATA: N in blows/ft — 10 20 30 40

WATER CONTENT %: PL — LL — 20 40 60

SIEVE ANALYSIS: GRAVEL SAND SILT CLAY; FINES — 20 40 60 80

Physical Properties: WC %; γ pcf; ϕ °; Q_u tsf; Q_p tsf; Gs; RQD %

Completion Depth:	5.1
Date Boring Started:	
Date Boring Completed:	
Logged By:	Carlos
Drilling Contractor:	Olsson Associates
Drilling Method:	SSA
Ground Surface Elevation:	
Coordinates:	
Datum:	NAD83

Remarks:

SAMPLE TYPES	WATER LEVELS (ft)	LEGEND
Split Spoon		MC Moisture Content; γ Dry Unit Weight; ϕ Friction Angle; Q_u Unconfined Compression; Q_p Hand Penetrometer UC; Gs Specific Gravity; RQD Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

M:\GINT\PROJECTS\35331001 HARDIN COUNTY WIND 2016.GPJ BARRLIBRARY.GLB HORIZONTAL LOG REPORT BARR GEOTECH TEMPLATE.GDT

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-46

Project: Hardin County Wind Project | Location: Hardin County, Ohio | Client: Invenergy, LLC

Barr Project Number: 35331001

Surface Elev.:

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION (ASTM D2488)	Graphic Log	Sample Type & Rec.	STANDARD PENETRATION TEST DATA (N in blows/ft)	WATER CONTENT % (PL – LL)	SIEVE ANALYSIS (GRAVEL, SAND, SILT, CLAY, FINES)	Physical Properties: WC %	γ pcf	ϕ °	Q_u tsf	Q_p tsf	Gs	RQD %
	0.0	ASPHALT: 12 inches thick.												
	1.0	LEAN TO FAT CLAY (CL/CH): brown; moist; medium stiff; trace sand and gravel.			10, 8									
	5.0	Bottom of Boring at 5.0 feet												

Completion Depth: 5.0
Date Boring Started:
Date Boring Completed:
Logged By: Carlos
Drilling Contractor: Olsson Associates
Drilling Method: SSA
Ground Surface Elevation:
Coordinates:
Datum: NAD83

Remarks:

SAMPLE TYPES: Split Spoon

WATER LEVELS (ft)

LEGEND

MC	Moisture Content	Q_u	Unconfined Compression
γ	Dry Unit Weight	Q_p	Hand Penetrometer UC
ϕ	Friction Angle	Gs	Specific Gravity
		RQD	Rock Quality Designation

The stratification lines represent approximate boundaries. The transition may be gradual.

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Geotechnical Investigation – Foraker area

1.1 Geotechnical Investigation

Barr Engineering Co. (Barr), under authorization and contract with Invenergy, LLC (Invenergy), has completed a geotechnical investigation of roads around the Hardin Wind Project in Hardin County, Ohio. As part of this geotechnical investigation, Barr completed 35 geotechnical borings along road alignments near the proposed wind turbine locations.

This letter report and its attachments provide geotechnical findings from the investigation. Barr previously completed 28 road borings with dynamic cone penetration (DCP) and California bearing ratio (CBR) testing along other travel alignments adjacent to proposed wind turbine locations. A geotechnical investigation of the overall project area and prepared a comprehensive geotechnical report with recommendations for foundation design of turbines, original substation location, O&M building, overhead collector, and met towers.

1.1.1 Field Work

Under subcontract to Barr, TTL Associates, INC of Toledo, Ohio, completed a 35 shallow borings along existing county road alignments using a truck mounted drill rig to depths of approximately five feet in one mobilization between November 16th and 17th, 2016. Standard penetration tests were performed and split-spoon samples were collected at approximately 2-ft intervals to a depth of approximately 5 ft. Drilling was advanced using solid-stem augers (SSA).

The coordinates of the borings are included in the Table 1 below and shown on Figure 1 attached.

Table 1 Testing Conditions and Coordinates

Geotechnical Boring ID	UTM NAD83 Z17N		Latitude [deg.]	Longitude [deg.]	Boring	CBR
	Easting [m]	Northing [m]				
RD-47	268403.4319	4506799.966	40.67957945	-83.7403857	X	
RD-48	268318.5228	4506543.933	40.67725172	-83.7412949	X	
RD-49	268339.59	4506270.925	40.67480099	-83.7409452	X	
RD-50	268410.4847	4506195.139	40.67413895	-83.7400794	X	
RD-51	268751.9301	4506181.553	40.67411246	-83.7360389	X	
RD-52	269153.8898	4506157.843	40.67401167	-83.7312795	X	
RD-53	269281.1811	4506462.284	40.67678678	-83.7298869	X	
RD-54	268927.5277	4506639.041	40.67827835	-83.7341318	X	
RD-55	268563.3968	4506798.961	40.6796153	-83.7384946	X	
RD-56	269322.4737	4509083.902	40.70038891	-83.7303622	X	
RD-57	269300.3226	4508694.78	40.69688121	-83.730481	X	
RD-58	269294.6341	4508326.876	40.69356905	-83.730413	X	
RD-59	269269.9484	4507932.329	40.69001182	-83.7305598	X	
RD-60	269261.1113	4507564.293	40.68669758	-83.730529	X	
RD-61	269266.694	4507201.019	40.68343023	-83.7303295	X	
RD-62	269311.6733	4506833.856	40.6801389	-83.729663	X	
RD-63	269340.7533	4506439.089	40.67659473	-83.7291743	X	X
RD-64	269334.6309	4509469.051	40.70385806	-83.7303601	X	
RD-65	269791.6973	4509461.444	40.7039174	-83.7249529	X	
RD-66	270234.9414	4509425.395	40.70371669	-83.7196987	X	

RD-67	270664.9564	4509415.804	40.70375015	-83.7146106	X	
RD-68	271068.6849	4509391.316	40.70364203	-83.7098279	X	
RD-69	271464.8463	4509380.124	40.70365126	-83.7051394	X	
RD-70	271869.739	4509355.505	40.70354189	-83.7003429	X	
RD-71	272266.4163	4509344.829	40.70355552	-83.6956486	X	X
RD-72	272565.7149	4509169.435	40.70205983	-83.6920459	X	
RD-73	272549.3636	4508767.479	40.69843822	-83.6920936	X	
RD-74	272526.6623	4508365.682	40.69481629	-83.6922163	X	
RD-75	272511.2635	4507963.409	40.69119208	-83.6922525	X	
RD-76	271032.3109	4510803.748	40.71634182	-83.7107737	X	
RD-78	271002.8381	4510403.224	40.71272948	-83.710976	X	
RD-79	270989.1459	4510003.371	40.70912757	-83.7109918	X	
RD-80	270961.6995	4509595.419	40.70544894	-83.7111674	X	
RD-81	270950.1372	4509205.74	40.70193917	-83.7111618	X	
RD-82	270925.6019	4508798.742	40.69826994	-83.7113033	X	

1.1.2 Bulk Soil Sampling

Bulk samples of representative material from the site were collected for the purpose of laboratory testing. A total of two bulk soil samples (5-gallon buckets) were collected across the project site in support of California Bearing Ratio (CBR) testing. Sampling locations were selected to provide representative soil samples across the project area.

1.2 Subsurface Conditions

The results of the geotechnical borings and laboratory tests were compiled to obtain an understanding of the lithology of the study areas.

The typical stratigraphy, as determined from the field data collected at the road boring locations, consists of a surficial layer of asphalt underlain a base course of either silty sand with gravel, silty gravel, or poorly graded gravel with silt underlain by native lean to fat clay.

1.2.1 Asphalt

Asphalt was encountered in all 35 of the road boring locations. Asphalt thicknesses at boring locations ranged from 3 to 10 inches. The average asphalt thickness as approximately 7 inches.

1.2.2 Base Course

Surficial gravel was encountered in five of the 31 road boring locations. It was classified as either silty sand with gravel, silty gravel to silty gravel with sand, or poorly graded gravel with sand and silt. The thickness of the base course ranged from 2.5 to 16 inches with an average of approximately 5.5 inches. There was no base course underlying the asphalt at 4 locations (RD-68, RD-69, RD-70, and RD-71).

1.2.3 Lean Clay to Fat Clay

Lean to fat clay was encountered in all of the 35 road boring locations in thicknesses ranging from approximately 3 feet to 4.7 feet. N-values from Standard Penetration Testing (SPT) conducted in the clays ranged from 4 to 27 blows per foot (bpf) with an average of 10 bpf. These results indicate that the clays typically have consistencies ranging from soft or very stiff.

1.3 Groundwater Conditions

No evidence of groundwater was observed during the course of the geotechnical field investigation, however the road borings did not extend greater than 5 feet below existing grade. As a result, groundwater is not anticipated to be a significant factor in the current road construction.

1.4 Shear Strength

1.4.1 Approximate Undrained Shear Strength

The results of the geotechnical investigation indicate that most of roads bear on a base course. The investigation did show roads bearing directly on clayey soils in four locations with no base or sub-base courses present under the asphalt.

A number of pocket penetrometer tests were conducted on split spoon samples collected during drilling. The pocket penetrometer values in clay soils at each road boring location ranged from 1.25 tsf to greater than 4.5 tsf. The average results indicated an estimated unconfined compressive strength of 3.0 tons per square foot (tsf), which corresponds to an undrained shear strength of approximately 1,500 psf.

1.5 Laboratory Testing

Laboratory testing was performed on selected samples as described below.

1.5.1 California Bearing Ratio Testing

Design for roads and general working areas is based in part on the strength of the subgrade that can be reasonably achieved. California Bearing Ratio (CBR) tests were completed on soil samples collected from the selected locations across the site to determine the field strength of the subgrade.

A total of two samples of the shallow subgrade soils were collected adjacent to the road borings in the shoulders (Figure 1). The bulk samples were collected from soil immediately topsoil or fill materials, which typically corresponded to a depth of approximately 6 to 20 inches below the surface. The soil samples were prepared to approximate 95 percent of the standard Proctor maximum dry density at the optimum moisture content. The results of the CBR testing are presented in Table 2.

In general, the CBR samples were classified as fat clay with various amount of sand and gravel. Results from the testing conducted on the subgrade samples indicate that CBR values at 0.1 inch of deflection under a surcharge of 50 psf range from 2.2 to 5.7 percent, when compacted to 95 percent of the standard Proctor density at optimum moisture. The results indicate that the soils at the site are fairly consistent in their ability to support roads.

Table 2 CBR Testing Results

Geotechnical Boring ID	USCS	California Bearing Ratio Value (Optimum Moisture Content)* 95% Compaction
RD-61	SC	5.7
RD-70	CL/CH	2.2

1.6 DCP Field Testing

Dynamic Cone Pentrometer (DCP) tests were completed during investigation as a means of quantifying the subgrade strength of the soils in the road borings.

DCP tests were conducted in accordance with ASTM standard D6951 "Standard Test Method for use of the Dynamic Cone Penetrometer in Shallow Pavement Applications". The DCP was model K-100, manufactured by Kessler Soils Engineering Products, Inc. All tests were conducted utilizing a 17.6 pound hammer.

DCP tests were completed in all 35 road boring locations. The approximate location of each DCP test is provided in Table 3. Each test was conducted to a depth of approximately 12 inches below existing grade. The results of the DCP testing are provided in Table 3.

The DCP rate of penetration can be correlated to California Bearing Ratio (CBR) values for the road subgrade. The following equation shows the relationship between measured DCP values in the field and approximate CBR values.

where:

CBR = California Bearing Ratio

PR = DCP rate of penetration [mm]

Table 3 shows the CBR value obtained at each of the two locations tested. It should be noted that several DCP values were higher than what would be expected given the material encountered in the borings. These locations tend to coincide with borings where silty sand was encountered. Any CBR correlations yielding values above 7 should be treated as anomalous as the DCP may have struck gravel causing an artificially high Dynamic Cone Penetration Index (DPI). Reading higher than 7 are not anticipated with clayey soils. Based on the lab results, an average CBR value of 2.7 is recommended for road design based on the results obtained from testing at this time.

Table 3 DCP Testing Results and CBR Correlation

Location ID	Bituminous Thickness (inches)	DCP Blows per Foot	DPI	log (CBR)	Correlated CBR Value	95% Tested CBR Value
RD-47	10	18	16.9	1.08	12.1	
RD-48	8	8	38.1	0.69	4.9	
RD-49	10	8	38.1	0.69	4.9	
RD-50	8	32	9.5	1.36	23.1	
RD-51	7	7	43.5	0.62	4.2	
RD-52	7	7	43.5	0.62	4.2	
RD-53	7.5	8	38.1	0.69	4.9	
RD-54	8	9	33.9	0.75	5.6	
RD-55	8	7	43.5	0.62	4.2	
RD-56	6.5	15	20.3	1.00	9.9	
RD-57	6.75	8	38.1	0.69	4.9	

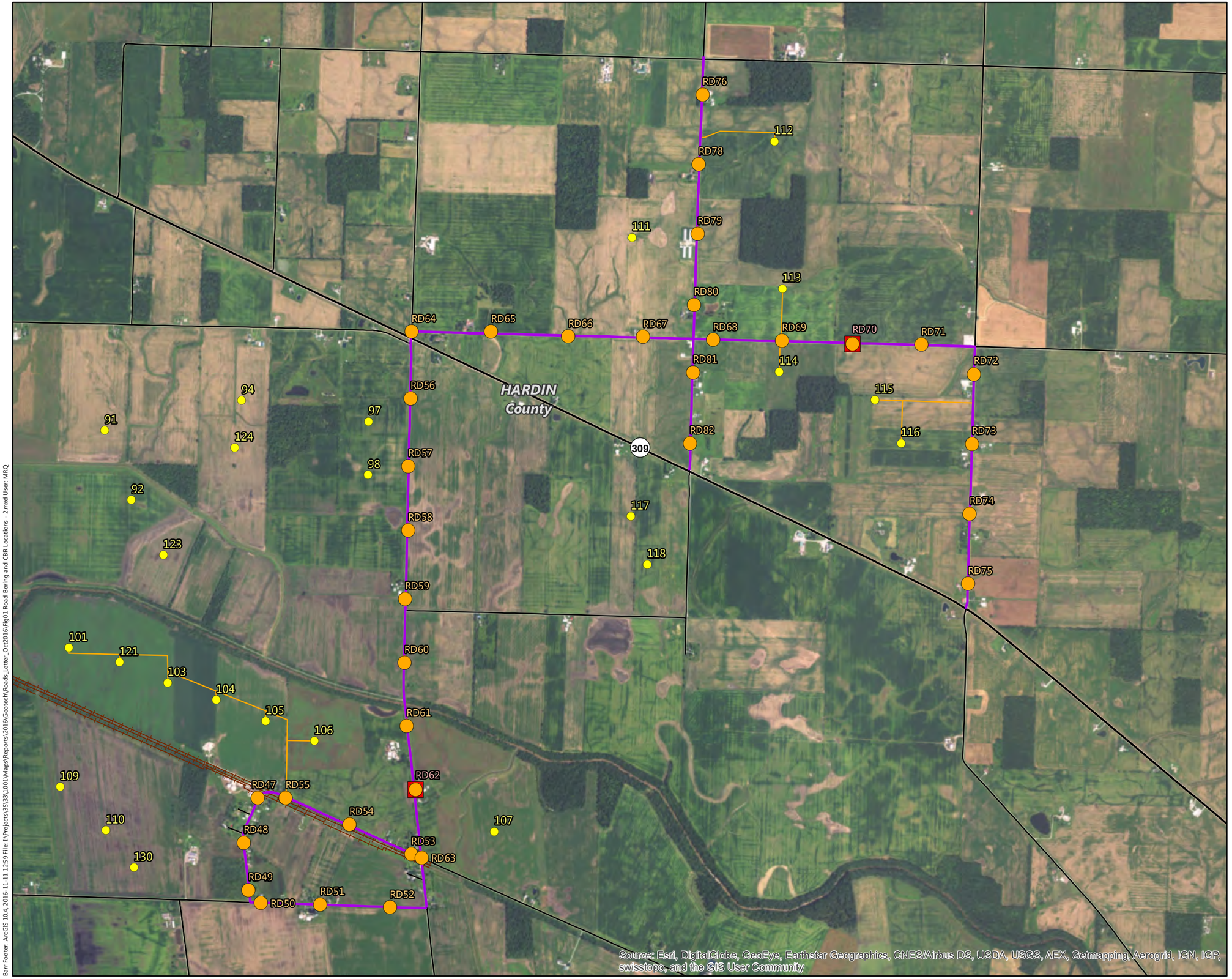
Location ID	Bituminous Thickness (inches)	DCP Blows per Foot	DPI	log (CBR)	Correlated CBR Value	95% Tested CBR Value
RD-58	8	10	30.5	0.80	6.3	
RD-59	8	16	19.1	1.03	10.6	
RD-60	8	6	50.8	0.55	3.5	
RD-61	8	9	33.9	0.75	5.6	5.7
RD-62	8	7	43.5	0.62	4.2	
RD-63	3	17	17.9	1.06	11.4	
RD-64	6	7	43.5	0.62	4.2	
RD-65	6	14	21.8	0.96	9.2	
RD-66	6	7	43.5	0.62	4.2	
RD-67	6	12	25.4	0.89	7.7	
RD-68	7.5	6	50.8	0.55	3.5	
RD-69	8	12	25.4	0.89	7.7	
RD-70	6.5	9	33.9	0.75	5.6	2.2
RD-71	7	6	50.8	0.55	3.5	
RD-72	6.5	11	27.7	0.84	7.0	
RD-73	6	7	43.5	0.62	4.2	
RD-74	6	15	20.3	1.00	9.9	
RD-75	6	9	33.9	0.75	5.6	
RD-76	6	11	27.7	0.84	7.0	
RD-78	6	10	30.5	0.80	6.3	
RD-79	5.75	11	27.7	0.84	7.0	
RD-80	6.5	11	27.7	0.84	7.0	
RD-81	6	9	33.9	0.75	5.6	
RD-82	6	8	38.1	0.69	4.9	

CBR Computations referenced from Salgado, 2003.

Used Kesler DCP (smaller DCP) under asphalt/gravel fill

1. Kessler Soils Engineering Products, Inc., *K-100 Models with quick connect pin User's Manual*, Springfield, Virginia, October 2007.

2. Giroud, J.P. and Han, J. "Design Method for Geogrid-Reinforced Unpaved Roads, II. Calibration and Applications" Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 130(8): 787-797.



Road Boring Location

Road Boring and CBR Location

Turbine Location (8/5/2016)

Access Road

Transportation Route

City Boundary

County Boundary

Feet

1,750 0 1,750

Meters

500 0 500

Figure 1

SOIL BORING AND CBR LOCATIONS

Hardin Wind Project

Invenergy LLC

Hardin County, Ohio

PRELIMINARY California Bearing Ratio ASTM:D1883

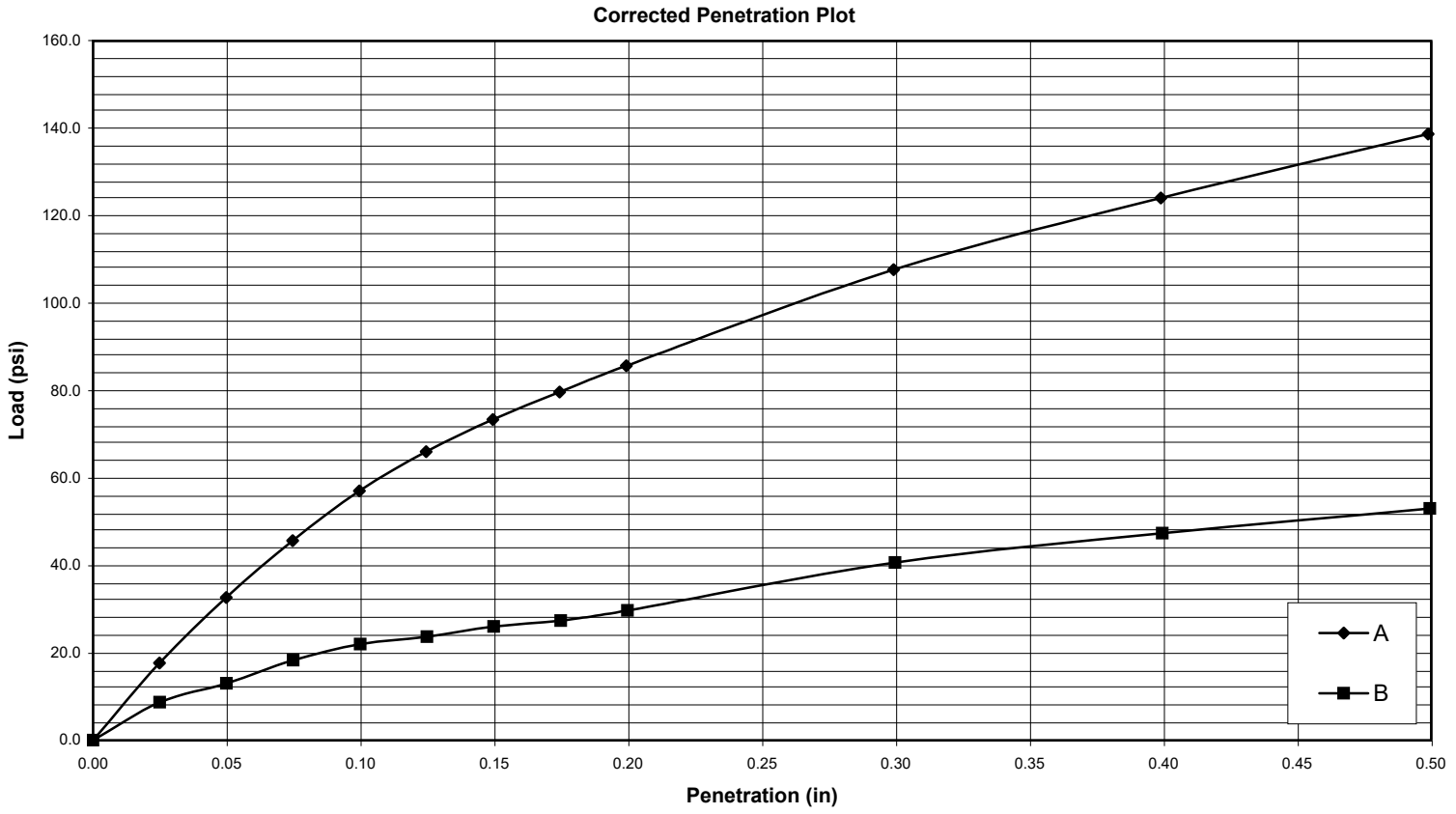
Project:	Hardin Wind	Job:	**10557**
Client:	Barr Engineering Company	Date:	12/6/16

Boring #: RD-61, RD-70	Procedural Method:
Sample:	Specimens compacted to approximately 95% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed. RESULTS ARE PRELIMINARY.
Depth (ft): Type: Bulk	
Location:	
Classification: Clayey Sand with a little gravel (SC), Lean Clay with sand (CL/CH)	

Laboratory Moisture-Density Values		Index Properties	
Method:	ASTM:D698 Method B	LL:	Gs:
Maximum Dry Density (PCF):	124.4, 101.2	PL:	Organic Content:
Optimum Water Content:	10.8%, 21.2%	PI:	pH:

Initial Molding Conditions			
Specimen	A	B	
Compaction Hammer:	5 lb	5 lb	
Number of Layers:	3	3	
Blows per Layer:	NA	NA	
Initial Moisture Content:	10.8%	21.2%	
Initial Dry Density (PCF)	118.1	96.1	
Relative Compaction	94.9%	95.0%	
Soaking Phase			
Days Soaked	4	4	
Surcharge (psf)	50	50	
Total Swell (%)	0.2%	1.6%	
Penetration Phase			
Surcharge (psf)	50	50	
Corrected CBR Values			
at 0.1 inch (%)	**5.7%**	**2.2%**	
at 0.2 inch (%)	5.7%	2.0%	
Moisture Content After Penetration			
Top 1" of Specimen:			
Average of specimen:	#DIV/0!	#DIV/0!	

Stress vs. Penetration Graph



9530 James Ave South

SOIL ENGINEERING TESTING, INC.

Bloomington, MN 55431

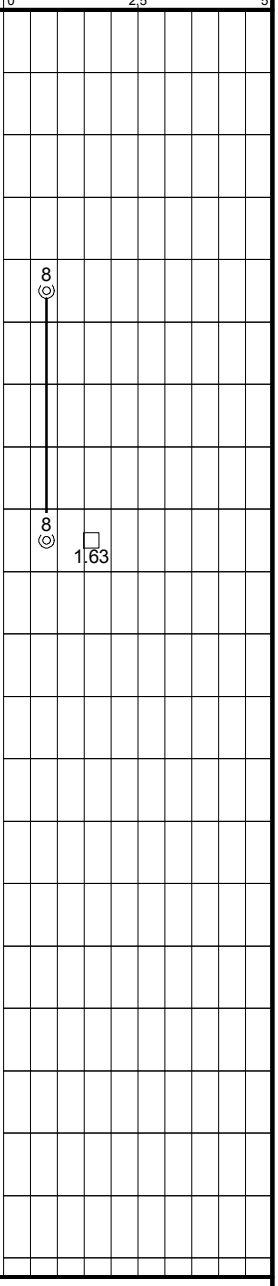
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-47

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	Auger/Hammer
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:268403.4319m, E:4506799.966m	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.:						
	0.5	ASPHALT: black and gray; 10" asphalt thickness.						
	1.0	SILTY SAND [FILL] (SM): fine to coarse grained; dark brown; moist; some silt; few fine grained gravel.	0.8ft					
	1.5	LEAN CLAY WITH GRAVEL (CL): dark brown; moist; little fine to coarse grained gravel.	1.3ft					
	2.0					47A	79	8
	2.5	LEAN TO FAT CLAY (CL/CH): dark gray to grayish brown; moist; high plasticity.	2.3ft					
	3.0							
	3.5							
	4.0					47B	63	8
	4.5							
	5.0							
		Bottom of Boring at 5.0 feet	5.3ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5



Date Boring Started:	11/17/16	Water Levels (ft)	Remarks:
Date Boring Completed:	11/17/16	▼ At Time of Drilling: Dry	
Logged By:	RQM	▽ After Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather:

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-48

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	Auger/Hammer
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:268318.5228m, E:4506543.933m	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40); REC%; RQD % ◆ (20 40 60 80); SHEAR STRENGTH, tsf; □ Qp/2 (0 2,5 5)
	0.0	Surface Elev.:						
	0.5	ASPHALT: black and gray; 8" asphalt thickness.						
	1.0	SILTY SAND [FILL] (SM): fine to coarse grained; dark brown to brown; moist; little fine to coarse grained gravel. 0.7ft						
	1.5	LEAN TO FAT CLAY (CL/CH): gray and grayish brown; moist; high plasticity. 1.3ft						
	2.0				48A	15	6	6 ◎
	2.5							
	3.0							
	3.5							
	4.0				48B	44	12	12 ◎ 1.13
	4.5							
	5.0	Bottom of Boring at 5.0 feet 5.3ft						

Date Boring Started:	11/17/16	Water Levels (ft)	Remarks:
Date Boring Completed:	11/17/16	▼ At Time of Drilling — Dry	
Logged By:	RQM	▽ After Drilling — Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather:

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LOG OF BORING RD-49

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	Auger/Hammer
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:268339.59m, E:4506270.925m	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.:						
	0.5	ASPHALT: black and gray; 10" asphalt thickness.						
	1.0	SILTY SAND [FILL] (SM): fine to coarse grained; dark brown; moist; trace fine grained gravel; some silt.	0.8ft					
	1.5	SILTY SAND (SM): fine to medium grained; light brown; moist; trace coarse grained particles; some silt.	1.3ft					
	2.0	FAT CLAY (CH): grayish brown and gray; moist; trace sand and gravel; high plasticity.	2.2ft			49A	9	6
	2.5							
	3.0							
	3.5							
	4.0					49B	65	8
	4.5							
	5.0							
		Bottom of Boring at 5.0 feet	5.3ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2,5 5

Date Boring Started:	11/17/16	Water Levels (ft)	Remarks:
Date Boring Completed:	11/17/16	At Time of Drilling: Dry	
Logged By:	RQM	After Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather:

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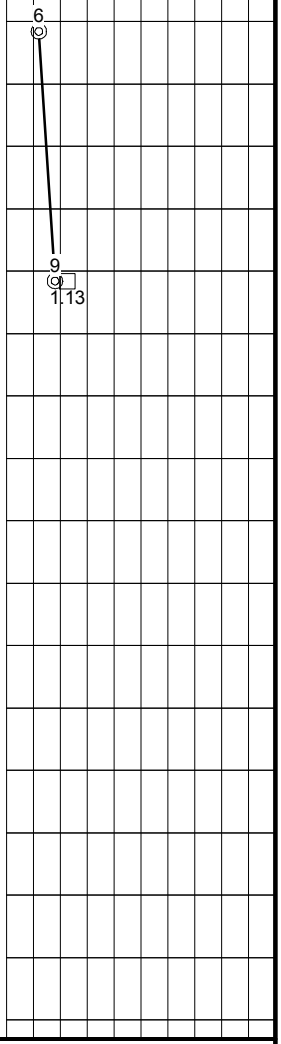
LOG OF BORING RD-50

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	Auger/Hammer
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:268410.4847m, E:4506195.139m	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.:						
	0.0	ASPHALT: black and gray; 8" asphalt thickness.						
	0.5	SILTY SAND [FILL] (SM): coarse grained; dark brown; moist.	0.7ft					
	1.0							
	1.5	LEAN TO FAT CLAY (CL/CH): gray and reddish brown; moist; trace sand and gravel; high plasticity.	1.4ft					
	2.0					50A	33	6
	2.5							
	3.0							
	3.5							
	4.0					50B	50	9
	4.5							
	5.0	Bottom of Boring at 5.0 feet	5.1ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5



Date Boring Started:	11/17/16	Water Levels (ft)	Remarks:
Date Boring Completed:	11/17/16	▼ At Time of Drilling: Dry	
Logged By:	RQM	▽ After Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather:

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LOG OF BORING RD-51

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	Auger/Hammer
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:268751.9301m, E:4506181.553m	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf □ Qp/2 (0 2.5 5)
	Surface Elev.:								
	0.0	ASPHALT: black and gray; 7" asphalt thickness.							
	0.5	SILTY GRAVEL WITH SAND [FILL] (GM): fine to coarse grained; dark brown; moist; some coarse grained sand.	0.6ft						
	1.0	LEAN TO FAT CLAY (CL/CH): gray and brownish gray; moist.	1.0ft			51A	100	6	6
	1.5								
	2.0								
	2.5								
	3.0								
	3.5								
	4.0					51B	100	17	17 (1.75)
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	11/17/16	Water Levels (ft)	Remarks:
Date Boring Completed:	11/17/16	▼ At Time of Drilling — Dry	
Logged By:	RQM	▽ After Drilling — Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather:

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LOG OF BORING RD-52

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	Auger/Hammer
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:269153.8898m, E:4506157.843m	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.:						
	0.0	ASPHALT: black and gray; 7" asphalt thickness.						
	0.5	SILTY GRAVEL WITH SAND [FILL] (GM): fine to coarse grained; dark brown; moist; some coarse grained sand.	0.6ft					
	1.0	LEAN TO FAT CLAY (CL/CH): gray; moist.	1.0ft					
	1.5							
	2.0					52A	15	7
	2.5							
	3.0							
	3.5							
	4.0					52B	59	8
	4.5							
	5.0	Bottom of Boring at 5.0 feet	5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5

7
8
□ 1.38

Date Boring Started:		Water Levels (ft)	Remarks:
Date Boring Completed:		At Time of Drilling: Dry	
Logged By:	RQM	After Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather:

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LOG OF BORING RD-53

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	Auger/Hammer
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:269281.1811m, E:4506462.284m	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf (0 2,5 5)
		Surface Elev.:						
	0.0	ASPHALT: black and gray; 7.5" asphalt thickness.						
	0.5	SILTY GRAVEL WITH SAND [FILL] (GM): fine to coarse grained; dark brown; moist; some coarse grained sand. 0.6ft						
	1.0	LEAN TO FAT CLAY (CL/CH): gray to grayish brown; moist; trace sand and gravel. 1.0ft			53A	54	7	7
	1.5							
	2.0							
	2.5							
	3.0							
	3.5							
	4.0				53B	63	15	15
	4.5							
	5.0	Bottom of Boring at 5.0 feet 5.0ft						

Date Boring Started:		Water Levels (ft)	Remarks:
Date Boring Completed:		▼ At Time of Drilling Dry	
Logged By:	RQM	▽ After Drilling Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather:

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LOG OF BORING RD-54

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	Auger/Hammer
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:268927.5277m, E:4506639.041m	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.:					
	0.0	ASPHALT: black and gray; 8" asphalt thickness.					
	0.5						
	0.7	SILTY SAND (SM): fine to coarse grained; dark brown; moist; with gravel.					
	1.0	LEAN TO FAT CLAY (CL/CH): gray to gray with reddish brown mottling; moist.					
	1.5						
	2.0				54A	63	7
	2.5						
	3.0						
	3.5						
	4.0				54B	52	14
	4.5						
	5.0						
	5.0	Bottom of Boring at 5.0 feet					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5

7
14
2.25

		Water Levels (ft)	
Date Boring Started:		At Time of Drilling	Remarks:
Date Boring Completed:		Dry	
Logged By:	RQM	After Drilling	
Drilling Contractor:	TTL	Dry	
Drill Rig:	CME 45		Weather:

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LOG OF BORING RD-55

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	Auger/Hammer
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:268563.3968m, E:4506798.961m	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40); REC%; RQD % ◆ (20 40 60 80); SHEAR STRENGTH, tsf; □ Qp/2 (0 2,5 5)
	Surface Elev.:							
	0.0	ASPHALT: black and gray; 8" asphalt thickness.						
	0.5							
		SILTY GRAVEL WITH SAND [FILL] (GM): fine to coarse grained; dark brown; moist; some coarse grained sand. 0.7ft						
	1.0	LEAN TO FAT CLAY (CL/CH): gray to grayish brown; moist; trace sand and gravel. 1.0ft						
	1.5							
	2.0				55A	69	9	9 ◎
	2.5							
	3.0							
	3.5							
	4.0				55B	59	13	13 ◎; □ 0.625
	4.5							
	5.0	Bottom of Boring at 5.0 feet 5.0ft						

Date Boring Started:		Water Levels (ft)	Remarks:
Date Boring Completed:		▼ At Time of Drilling Dry	
Logged By:	RQM	▽ After Drilling Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather:

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LOG OF BORING RD-56

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	Auger/Hammer
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:269322.4737m, E:4509083.902m	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40); REC%; RQD % ◆ (20 40 60 80); SHEAR STRENGTH, tsf; □ Qp/2 (0 2,5 5)
	Surface Elev.:							
	0.0	ASPHALT: black and gray; 6.5" asphalt thickness.						
	0.5	SILTY GRAVEL WITH SAND [FILL] (GM): fine to coarse grained; dark brown; moist; some coarse grained sand. 0.5ft						
	1.0	LEAN TO FAT CLAY (CL/CH): brown; moist. 1.1ft						
	1.5							
	2.0				56A	71	8	8 ◎
	2.5							
	3.0							
	3.5							
	4.0				56B	75	14	14 ◎ 1.5
	4.5							
	5.0	Bottom of Boring at 5.0 feet 5.1ft						

Date Boring Started:		Water Levels (ft)	Remarks:
Date Boring Completed:		▼ At Time of Drilling Dry	
Logged By:	RQM	▽ After Drilling Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather:

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LOG OF BORING RD-57

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	Auger/Hammer
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:269300.3226m, E:4508694.78m	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.:						
	0.0	ASPHALT: black and gray; 6.75" asphalt thickness.						
	0.5	SILTY SAND (SM): fine to coarse grained; dark brown; moist; with gravel.	0.6ft					
	1.0	LEAN TO FAT CLAY (CL/CH): gray; moist.	1.0ft					
	1.5							
	2.0					57A	63	11
	2.5							
	3.0							
	3.5							
	4.0					57A	54	12
	4.5							
	5.0	Bottom of Boring at 5.0 feet	5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5

Date Boring Started:		Water Levels (ft)	Remarks:
Date Boring Completed:		At Time of Drilling: Dry	
Logged By:	RQM	After Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather:

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LOG OF BORING RD-58

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:269294.6341m, E:4508326.876m	Completion Depth:	5.1 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.:					
	0.0	ASPHALT: black and gray; 8" asphalt thickness.					
	0.5						
	0.7	SILTY SAND (SM): fine to coarse grained; dark brown; moist; with gravel.					
	1.0	LEAN TO FAT CLAY (CL/CH): gray; moist.					
	1.1						
	1.5						
	2.0				58A	59	9
	2.5						
	3.0						
	3.5						
	4.0				58B	59	13
	4.5						
	5.0						
	5.1	Bottom of Boring at 5.1 feet					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5

9 ◎
13 ◎
□ 0.875

Date Boring Started:	11/17/16 10:00 am	Water Levels (ft)	Remarks:
Date Boring Completed:	11/17/16 10:15 am	▼ At Time of Drilling Dry	
Logged By:	RQM	▽ After Drilling Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather:

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LOG OF BORING RD-59

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:269269.9484m, E:4507932.329m	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.:					
	0.0	ASPHALT: black and gray; 8" asphalt thickness.					
	0.5	SILTY SAND (SM): fine to coarse grained; dark brown; moist; with gravel. 0.7ft					
	1.0	LEAN TO FAT CLAY (CL/CH): brown; moist; trace sand and gravel. 1.0ft					
	1.5	LEAN TO FAT CLAY (CL/CH): brown to gray; moist; slightly blocky. 1.6ft			59A	79	8
	2.0						
	2.5						
	3.0						
	3.5				59B	67	12
	4.0						
	4.5						
	5.0	Bottom of Boring at 5.0 feet 5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5

8
12
1.88

Date Boring Started:	11/17/16 10:15 am	Water Levels (ft)	Remarks:
Date Boring Completed:	11/17/16 10:30 am	At Time of Drilling Dry	
Logged By:	RQM	After Drilling Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather: Sunny, 55 F

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LOG OF BORING RD-60

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:269261.1113m, E:4507564.293m	Completion Depth:	5.2 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.:					
	0.5	ASPHALT: black and gray; 8" asphalt thickness.					
	1.0	SILTY SAND (SM): fine to coarse grained; dark brown; moist; with gravel. 0.7ft					
	1.5	LEAN TO FAT CLAY (CL/CH): gray and reddish brown; moist; slightly blocky; trace sand. 1.2ft					
	2.0				60A	0	8
	2.5						
	3.0						
	3.5						
	4.0				60B	52	10
	4.5						
	5.0	Bottom of Boring at 5.2 feet 5.2ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5

8 ◎
10 □ ◎
0.875

Date Boring Started:	11/17/16 10:45 am	Water Levels (ft)	Remarks:
Date Boring Completed:	11/17/16 11:00 am	▼ At Time of Drilling: Dry	
Logged By:	RQM	▽ After Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather: Sunny, 55 F

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LOG OF BORING RD-61

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:269266.694m, E:4507201.019m	Completion Depth:	5.1 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.:					
	0.0	ASPHALT: black and gray; 8" asphalt thickness.					
	0.5						
	0.7	SILTY SAND (SM): fine to coarse grained; dark brown; moist; with gravel.					
	1.0						
	1.1	LEAN TO FAT CLAY (CL/CH): gray to grayish brown; moist; trace sand.					
	1.5						
	2.0				61A	52	9
	2.5						
	3.0						
	3.5						
	4.0				61B	71	15
	4.5						
	5.0						
	5.1	Bottom of Boring at 5.1 feet					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5

9
15
□ 1.88

		Water Levels (ft)	Remarks:
Date Boring Started:	11/17/16 11:05 am	▼ At Time of Drilling Dry	
Date Boring Completed:	11/17/16 11:15 am	▽ After Drilling Dry	
Logged By:	RQM		
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather: Sunny, 55 F

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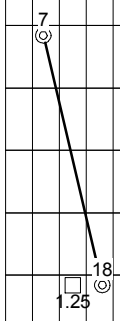
LOG OF BORING RD-62

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:269311.6733m, E:4506833.856m	Completion Depth:	5.1 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.:					
	0.0	ASPHALT: black and gray; 8" asphalt thickness.					
	0.5						
	0.7	SILTY SAND WITH GRAVEL (SM): fine to coarse grained; dark brown; moist.					
	1.0						
	1.1	LEAN TO FAT CLAY (CL/CH): gray to reddish brown; moist; trace sand.					
	1.5						
	2.0				62A	54	7
	2.5						
	3.0						
	3.5						
	4.0				62B	71	18
	4.5						
	5.0						
	5.1	Bottom of Boring at 5.1 feet					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC% ▬▬▬
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5



Date Boring Started:	11/17/16 11:20 am	Water Levels (ft)	Remarks:
Date Boring Completed:	11/17/16 11:45 am	▼ At Time of Drilling: Dry	
Logged By:	RQM	▽ After Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather: Sunny, 55 F

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LOG OF BORING RD-63

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:269340.7533m, E:4506439.089m	Completion Depth:	5.2 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / REC% / RQD % ◆ / SHEAR STRENGTH, tsf □ Qp/2
		Surface Elev.:							
	0.0	ASPHALT: black and gray; 3" asphalt thickness.							
	0.5	SILTY GRAVEL WITH SAND [FILL] (GM): fine to coarse grained; dark brown; moist; some coarse grained sand.	0.3ft						
	1.0	SILTY SAND WITH GRAVEL (SM): fine to coarse grained; dark brown; moist.	0.8ft						
	1.5	LEAN TO FAT CLAY WITH GRAVEL (CL/CH): brown to dark brown; moist; with sand.	1.2ft						
	2.0	LEAN TO FAT CLAY (CL/CH): gray to brown; moist; trace sand.	2.0ft			63A	17	7	7 ◎
	2.5								
	3.0								
	3.5								
	4.0					63B	29	10	10 ◎
	4.5								
	5.0								
		Bottom of Boring at 5.2 feet	5.2ft						

Date Boring Started:	11/17/16 11:50 am	Water Levels (ft)	Remarks:
Date Boring Completed:	11/17/16 12:05 pm	▼ At Time of Drilling: Dry	
Logged By:	RQM	▽ After Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather: Sunny, 60 F

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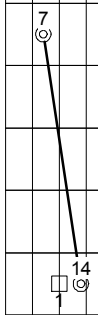
LOG OF BORING RD-64

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:269334.6309m, E:4509469.051m	Completion Depth:	4.8 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.:					
		ASPHALT: black and gray; 6" asphalt thickness.					
	0.5	SILTY GRAVEL WITH SAND [FILL] (GM): fine to coarse grained; dark brown; moist; some coarse grained sand. 0.5ft					
	0.8	LEAN TO FAT CLAY (CL/CH): gray; moist; trace sand and gravel. 0.8ft					
	1.0						
	1.5				64A	69	7
	2.0						
	2.5						
	3.0						
	3.5				64B	67	14
	4.0						
	4.5						
		Bottom of Boring at 4.8 feet 4.8ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5



Date Boring Started:	11/17/16 9:05 am	Water Levels (ft)	Remarks:
Date Boring Completed:	11/17/16 9:20 am	At Time of Drilling Dry	
Logged By:	RQM	After Drilling Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather: Sunny, 45 F

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LOG OF BORING RD-65

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:269791.6973m, E:4509461.444m	Completion Depth:	4.9 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.:					
		ASPHALT: black and gray; 6" asphalt thickness.					
	0.5	SILTY GRAVEL WITH SAND [FILL] (GM): fine to coarse grained; dark brown; moist; some coarse grained sand. 0.5ft					
	1.0	LEAN TO FAT CLAY (CL/CH): gray; moist; trace sand and gravel; trace organics. 0.9ft			65A	67	8
	1.5						
	2.0						
	2.5						
	3.0						
	3.5				65B	88	14
	4.0						
	4.5	Bottom of Boring at 4.9 feet 4.9ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5

8
14

Date Boring Started:	11/17/16
Date Boring Completed:	11/17/16
Logged By:	RQM
Drilling Contractor:	TTL
Drill Rig:	CME 45

Water Levels (ft)
▼ At Time of Drilling
Dry
▽ After Drilling
Dry

Remarks:

Weather: Sunny, 45 F

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LOG OF BORING RD-66

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:270234.9414m, E:4509425.395m	Completion Depth:	4.8 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf □ Qp/2 (0 2.5 5)
		Surface Elev.:						
	0.0	ASPHALT: black and gray; 6" asphalt thickness.						
	0.5	SILTY GRAVEL WITH SAND [FILL] (GM): fine to coarse grained; dark brown; moist; some coarse grained sand. 0.5ft						
	1.0	LEAN TO FAT CLAY (CL/CH): gray to dark gray; moist; trace sand and gravel. 0.8ft			66A	71	7	7 ◎
	1.5							
	2.0							
	2.5							
	3.0							
	3.5				66B	69	15	15 ◎
	4.0							□ 0.875
	4.5	Bottom of Boring at 4.8 feet 4.8ft						

Date Boring Started:	11/17/16 8:10 am	Water Levels (ft)	Remarks:
Date Boring Completed:	11/17/16 8:30 am	▼ At Time of Drilling: Dry	
Logged By:	RQM	▽ After Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather: Sunny, 40 F

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LOG OF BORING RD-67

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:270664.9564m, E:4509415.804m	Completion Depth:	4.7 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.:					
		ASPHALT: black and gray; 6" asphalt thickness.					
	0.5	SILTY GRAVEL WITH SAND [FILL] (GM): fine to coarse grained; dark brown; moist; some coarse grained sand. 0.5ft / 0.7ft					
	1.0	LEAN TO FAT CLAY (CL/CH): gray to dark gray; moist; trace sand and gravel.			67A	85	6
	1.5						
	2.0						
	2.5						
	3.0						
	3.5				67B	50	11
	4.0						
	4.5	Bottom of Boring at 4.7 feet 4.7ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5

6
11
0.875

Date Boring Started:	11/17/16 7:45 am	Water Levels (ft)	Remarks:
Date Boring Completed:	11/17/16 8:00 am	At Time of Drilling: Dry	
Logged By:	RQM	After Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather: Sunny, 40 F

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LOG OF BORING RD-68

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:271068.6849m, E:4509391.316m	Completion Depth:	4.7 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.:					
	0.0	ASPHALT: black and gray; 7.5" asphalt thickness.					
	0.5	LEAN TO FAT CLAY (CL/CH): gray; moist; trace sand and gravel. 0.6ft			68A	59	7
	1.0						
	1.5						
	2.0						
	2.5						
	3.0				68B	59	19
	3.5						
	4.0						
	4.5	Bottom of Boring at 4.7 feet 4.8ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5

7
19
2.25

Date Boring Started:	11/16/16 12:30 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	11/16/16 12:45 pm	▼ At Time of Drilling: Dry	
Logged By:	RQM	▽ After Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather: Foggy, 60 F

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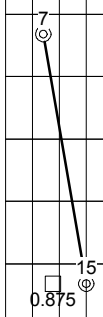
LOG OF BORING RD-69

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:271464.8463m, E:4509380.124m	Completion Depth:	4.7 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.:					
	0.0	ASPHALT: black and gray; 8" asphalt thickness.					
	0.5	LEAN TO FAT CLAY (CL/CH): brown and gray; moist; trace sand and gravel. 0.7ft			69A	71	7
	1.0						
	1.5						
	2.0						
	2.5						
	3.0				69B	59	15
	3.5						
	4.0						
	4.5	Bottom of Boring at 4.7 feet 4.7ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5



Date Boring Started:	11/16/16 12:55 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	11/16/16 1:10 pm	▼ At Time of Drilling Dry	
Logged By:	RQM	▽ After Drilling Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather: Foggy, 60 F

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LOG OF BORING RD-70

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:271869.739m, E:4509355.505m	Completion Depth:	5.5 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎
	0.0	Surface Elev.:						
		ASPHALT: black and gray; 6.5" asphalt thickness.						
	0.5	LEAN TO FAT CLAY (CL/CH): brown and gray; moist; trace sand and gravel. 0.5ft			70A	67	8	8
	1.0							
	1.5							
	2.0							
	2.5							
	3.0							
	3.5				70B	69	24	24
	4.0							
	4.5	4.5ft						
	5.0							
	5.5	Bottom of Boring at 5.5 feet						

REC%
RQD % ◆
SHEAR STRENGTH, tsf
□ Qp/2
2.25

Date Boring Started:	11/16/16 1:15 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	11/16/16 1:35 pm	▼ At Time of Drilling: Dry	
Logged By:	RQM	▽ After Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather: Foggy, 60 F

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LOG OF BORING RD-71

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:272266.4163m, E:4509344.829m	Completion Depth:	4.8 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf □ Qp/2 (0 2.5 5)
	Surface Elev.:							
	0.0	ASPHALT: black and gray; 6.5" asphalt thickness.						
	0.5	LEAN TO FAT CLAY (CL/CH): brown and gray; moist; trace sand and gravel. 0.6ft						
	1.0							
	1.5				71A	42	7	7 ◎
	2.0							
	2.5							
	3.0							
	3.5				71B	100	16	16 ◎
	4.0							□ 0.875
	4.5							
		Bottom of Boring at 4.8 feet 4.8ft						

Date Boring Started:	11/16/16 1:40 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	11/16/16 1:55 pm	▼ At Time of Drilling: Dry	
Logged By:	RQM	▽ After Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather: Foggy, 60 F

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LOG OF BORING RD-72

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:272565.7149m, E:4509169.435m	Completion Depth:	4.8 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.:					
	0.0	ASPHALT: black and gray; 6" asphalt thickness.					
	0.5	POORLY GRADED GRAVEL WITH SILT AND SAND [FILL] (GP-GM): fine to coarse grained; dark brown; moist; some coarse grained sand. 0.5ft					
	1.0	LEAN TO FAT CLAY (CL/CH): gray; moist; trace sand and gravel. 1.0ft			72A	63	6
	1.5						
	2.0						
	2.5						
	3.0						
	3.5				72B	42	9
	4.0						
	4.5	Bottom of Boring at 4.8 feet 5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5

Date Boring Started:	11/16/16 2:00 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	11/16/16 2:10 pm	▽ At Time of Drilling Dry	
Logged By:	RQM	▽ After Drilling Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather: Foggy, 60 F

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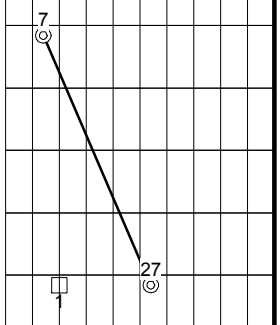
LOG OF BORING RD-73

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:272549.3636m, E:4508767.479m	Completion Depth:	5.1 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.:					
	0.0	ASPHALT: black and gray; 6" asphalt thickness.					
	0.5	POORLY GRADED GRAVEL WITH SILT AND SAND [FILL] (GP-GM): fine to coarse grained; dark brown; moist; some coarse grained sand. 0.5ft					
	1.0	LEAN TO FAT CLAY (CL/CH): brown; moist; trace sand and gravel. 1.1ft			73A	54	7
	1.5						
	2.0						
	2.5						
	3.0						
	3.5						
	4.0				73B	75	27
	4.5						
	5.0	Bottom of Boring at 5.1 feet 5.1ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5



Date Boring Started:	11/16/16 2:15 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	11/16/16 2:30 pm	▼ At Time of Drilling Dry	
Logged By:	RQM	▽ After Drilling Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather: Sunny, 60 F

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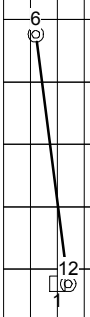
LOG OF BORING RD-74

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:272526.6623m, E:4508365.682m	Completion Depth:	5.1 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.:					
	0.0	ASPHALT: black and gray; 6" asphalt thickness.					
	0.5	POORLY GRADED GRAVEL WITH SILT AND SAND [FILL] (GP-GM): fine to coarse grained; dark brown; moist; some coarse grained sand. 0.5ft					
	1.0	LEAN TO FAT CLAY (CL/CH): brown; moist; trace sand and gravel. 1.1ft			74A	65	6
	1.5						
	2.0						
	2.5						
	3.0						
	3.5						
	4.0				75A	42	12
	4.5						
	5.0	Bottom of Boring at 5.1 feet 5.1ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5



Date Boring Started:	11/16/16 2:35 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	11/16/16 2:55 pm	▽ At Time of Drilling Dry	
Logged By:	RQM	▽ After Drilling Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather: Sunny, 60 F

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LOG OF BORING RD-75

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:272511.2635m, E:4507963.409m	Completion Depth:	5.1 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf □ Qp/2 (0 2.5 5)
	Surface Elev.:							
	0.0	ASPHALT: black and gray; 6" asphalt thickness.						
	0.5	POORLY GRADED GRAVEL WITH SILT AND SAND [FILL] (GP-GM): fine to coarse grained; dark brown; moist; some coarse grained sand. 0.5ft						
	1.0	LEAN TO FAT CLAY (CL/CH): gray and brown; moist; trace sand and gravel. 1.1ft						
	1.5							
	2.0				75A	54	4	4
	2.5							
	3.0							
	3.5							
	4.0				75B	79	13	13
	4.5							1.13
	5.0							
		Bottom of Boring at 5.1 feet 5.1ft						

Date Boring Started:	11/16/16 3:00 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	11/16/16 3:15 pm	▼ At Time of Drilling: Dry	
Logged By:	RQM	▽ After Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather: Sunny, 60 F

M:\GINT\PROJECTS\35331001 HARDIN COUNTY WIND_2016.GPJ BARRLIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-76

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:271032.3109m, E:4510803.748m	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.:					
	0.0	ASPHALT: black and gray; 6" asphalt thickness.					
	0.5	POORLY GRADED GRAVEL WITH SILT AND SAND [FILL] (GP-GM): fine to coarse grained; dark brown; moist; some coarse grained sand. 0.5ft					
	1.0	LEAN TO FAT CLAY (CL/CH): gray and brown; moist; trace sand and gravel. 1.0ft			76A	79	4
	1.5						
	2.0						
	2.5						
	3.0						
	3.5				76B	63	10
	4.0						
	4.5						
		Bottom of Boring at 5.0 feet 5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5

4 (◎)
10 (◎) 1.13

Date Boring Started:	11/16/16 3:15 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	11/16/16 3:30 pm	At Time of Drilling: Dry	
Logged By:	RQM	After Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather: Sunny, 60 F

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Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-78

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:271002.8381m, E:4510403.224m	Completion Depth:	4.8 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf □ Qp/2 (0 2,5 5)
		Surface Elev.:						
	0.0	ASPHALT: black and gray; 6" asphalt thickness.						
	0.5	POORLY GRADED GRAVEL WITH SILT AND SAND [FILL] (GP-GM): fine to coarse grained; dark brown; moist; some coarse grained sand. 0.5ft						
	1.0	LEAN TO FAT CLAY (CL/CH): gray and brown; moist; trace sand and gravel. 0.8ft			78A	79	8	8 ◎
	1.5							
	2.0							
	2.5							
	3.0							
	3.5				78B	79	12	12 ◎ □ 1.75
	4.0							
	4.5	Bottom of Boring at 4.8 feet 4.8ft						

Date Boring Started:	11/16/16 4:35 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	11/16/16 4:55 pm	▽ At Time of Drilling Dry	
Logged By:	RQM	▽ After Drilling Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather: Sunny, 60 F

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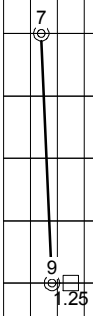
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-79

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:270989.1459m, E:4510003.371m	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.:					
	0.0	ASPHALT: black and gray; 5.75" asphalt thickness.					
	0.5	POORLY GRADED GRAVEL WITH SILT AND SAND [FILL] (GP-GM): fine to coarse grained; dark brown; moist; some coarse grained sand. 0.5ft					
	1.0	LEAN TO FAT CLAY (CL/CH): gray and brown; moist; trace sand and gravel. 1.0ft			79A	88	7
	1.5						
	2.0						
	2.5						
	3.0						
	3.5						
	4.0				79B	73	9
	4.5						
	5.0	Bottom of Boring at 5.0 feet 5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5



Date Boring Started:	11/16/16 4:15 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	11/16/16 4:30 pm	▼ At Time of Drilling Dry	
Logged By:	RQM	▽ After Drilling Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather: Sunny, 50 F

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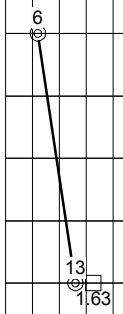
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-80

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:270961.6995m, E:4509595.419m	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.:					
	0.0	ASPHALT: black and gray; 6.5" asphalt thickness.					
	0.5	POORLY GRADED GRAVEL WITH SILT AND SAND [FILL] (GP-GM): fine to coarse grained; dark brown; moist; some coarse grained sand. 0.6ft					
	1.0	LEAN TO FAT CLAY (CL/CH): brown with occasional gray; moist; trace sand and gravel. 1.0ft			80A	63	6
	1.5						
	2.0						
	2.5						
	3.0						
	3.5				80B	63	13
	4.0						
	4.5						
	5.0	Bottom of Boring at 5.0 feet 5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5



Date Boring Started:	11/16/16 4:00 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	11/16/16 4:10 pm	▼ At Time of Drilling Dry	
Logged By:	RQM	▽ After Drilling Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather: Sunny, 50 F

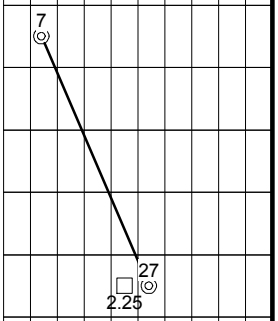
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-81

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:270950.1372m, E:4509205.74m	Completion Depth:	4.8 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.:						
		ASPHALT: black and gray; 6" asphalt thickness.						
	0.5	POORLY GRADED GRAVEL WITH SILT AND SAND [FILL] (GP-GM): fine to coarse grained; dark brown; moist; some coarse grained sand.	0.5ft					
	1.0	LEAN TO FAT CLAY (CL/CH): brown with occasional gray; moist to wet; trace sand and gravel; occasional laminations of sand.	0.8ft			81A	67	7
	1.5							
	2.0							
	2.5							
	3.0							
	3.5					81B	100	27
	4.0							
	4.5							
		Bottom of Boring at 4.8 feet	4.8ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5



Date Boring Started:	11/16/16 3:40 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	11/16/16 3:55 pm	▼ At Time of Drilling: Dry	
Logged By:	RQM	▽ After Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather: Sunny, 50 F

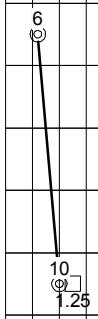
Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD-82

Project:	Hardin County Wind Project	Surface Elevation:	
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split Spoon
Coordinates:	UTM 17 N:270925.6019m, E:4508798.742m	Completion Depth:	4.8 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.:						
		ASPHALT: black and gray; 6" asphalt thickness.						
	0.5	POORLY GRADED GRAVEL WITH SILT AND SAND [FILL] (GP-GM): fine to coarse grained; dark brown; moist; some coarse grained sand.	0.5ft					
	1.0	LEAN TO FAT CLAY (CL/CH): gray and brown; moist to wet; trace sand and gravel; occasional laminations of sand.	0.8ft			81A	67	6
	1.5							
	2.0							
	2.5							
	3.0							
	3.5					81B	67	10
	4.0							
	4.5	Bottom of Boring at 4.8 feet	4.8ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5



Date Boring Started:	11/16/16 3:25 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	11/16/16 3:35 pm	▼ At Time of Drilling: Dry	
Logged By:	RQM	▽ After Drilling: Dry	
Drilling Contractor:	TTL		
Drill Rig:	CME 45		Weather: Sunny, 50 F

Geotechnical Investigation – Remainder of Hardin roads

1.1 Geotechnical Investigation

Barr Engineering Co. (Barr), under authorization and contract with Invenergy, LLC (Invenergy), has completed a geotechnical investigation of roads around the Hardin Wind Project in Hardin County, Ohio. As part of this geotechnical investigation, Barr completed 62 geotechnical borings along road alignments adjacent to proposed turbine locations in the project area.

This letter report and its attachments provide geotechnical findings from the investigation. Barr previously completed 51 road borings with California bearing ratio (CBR) testing along other travel alignments adjacent to proposed wind turbine locations. Barr previously completed a geotechnical investigation of the overall project area and prepared a comprehensive geotechnical report with recommendations for foundation design of turbines, original substation location, O&M building, overhead collector, and met towers.

1.1.1 Field Work

Under subcontract to Barr, TTL Associates, INC of Toledo, Ohio, completed 62 shallow borings along existing county road alignments using a truck mounted drill rig to depths of approximately five feet in one mobilization on December 6, 2017. Standard penetration tests were performed and split-spoon samples were collected at approximately 2.5- foot intervals to a depth of approximately 5 ft. Drilling was advanced using solid-stem augers (SSA). Completed borings were backfilled with cuttings and topped with cold-patch asphalt.

The coordinates of the borings are included in the Table 1 and shown on Figure 1 attached.

Table 1 Testing Conditions and Coordinates

Geotechnical Boring ID	Latitude [deg.]	Longitude [deg.]	Boring	CBR
RD99	40.65983	-83.83762	X	
RD100	40.65987	-83.83287	X	
RD101	40.65991	-83.82811	X	
RD102	40.66342	-83.82312	X	
RD103	40.66761	-83.82306	X	
RD104	40.68935	-83.72577	X	
RD105	40.68931	-83.72101	X	
RD106	40.68927	-83.71625	X	
RD107	40.71004	-83.74908	X	
RD108	40.70649	-83.74939	X	X
RD109	40.70398	-83.74796	X	
RD110	40.70392	-83.74233	X	
RD111	40.70402	-83.75185	X	
RD112	40.61594	-83.84203	X	
RD113	40.61594	-83.83727	X	
RD114	40.61593	-83.83252	X	
RD115	40.61593	-83.82777	X	X

RD116	40.61592	-83.82301	X	
RD117	40.61592	-83.81826	X	
RD118	40.61591	-83.81520	X	
RD119	40.63763	-83.84292	X	
RD120	40.63763	-83.83817	X	
RD121	40.63763	-83.83341	X	
RD122	40.63763	-83.82866	X	
RD123	40.63763	-83.82390	X	
RD124	40.63763	-83.81915	X	X
RD125	40.63763	-83.81440	X	
RD126	40.63763	-83.80964	X	X
RD127	40.63764	-83.80489	X	
RD128	40.63764	-83.80013	X	
RD129	40.63817	-83.79549	X	
RD130	40.63907	-83.79089	X	
RD131	40.64033	-83.78539	X	
RD132	40.64534	-83.78446	X	
RD133	40.64510	-83.78683	X	
RD134	40.64863	-83.78789	X	
RD135	40.65244	-83.78905	X	
RD136	40.66003	-83.79787	X	
RD137	40.66003	-83.80263	X	
RD138	40.66003	-83.80739	X	
RD139	40.66002	-83.81214	X	
RD140	40.66002	-83.81690	X	X
RD141	40.66002	-83.82309	X	
RD142	40.70398	-83.81874	X	
RD143	40.70353	-83.81349	X	
RD144	40.67466	-83.80907	X	
RD145	40.67466	-83.80431	X	
RD146	40.67465	-83.79956	X	
RD147	40.67464	-83.79480	X	
RD148	40.67463	-83.79004	X	X
RD149	40.67420	-83.74556	X	
RD150	40.67425	-83.75031	X	
RD151	40.67430	-83.75507	X	
RD152	40.67435	-83.75983	X	
RD153	40.67440	-83.76458	X	
RD154	40.67445	-83.76934	X	
RD155	40.67451	-83.77410	X	
RD156	40.67458	-83.77885	X	
RD157	40.67465	-83.78361	X	
RD158	40.67538	-83.72550	X	
RD159	40.62935	-83.78847	X	

RD160	40.63686	-83.78014	X	

1.1.2 Bulk Soil Sampling

Bulk samples of representative material from the site were collected for the purpose of laboratory testing. A total of six bulk soil samples (5-gallon buckets) were collected across the project site in support of California Bearing Ratio (CBR) testing. Sampling locations were selected to provide a representative sampling of soils present across the project area.

1.2 Subsurface Conditions

The results of the geotechnical borings and laboratory tests were compiled to obtain an understanding of the lithology of the study areas.

The typical stratigraphy, as determined from the field data collected at the road boring locations, consists of a surficial layer of asphalt underlain a base course of either poorly graded gravel with sand and silt or poorly graded sand with silt underlain by native lean to fat clay. Organic clay to organic silt was encountered in 17 of the road borings. Two road locations, RD-102 and RD-103 were completed in a dirt field access road with no asphalt or gravel surficial cover. Native silty to clayey sand was encountered in five boring locations at RD-118, RD-128, RD-133, RD-134, and RD-153.

1.2.1 Asphalt

Asphalt was encountered in 60 of the 62 road boring locations. Asphalt thicknesses at boring locations where asphalt was present ranged from 1 to 12 inches. The average asphalt thickness was approximately 7 inches.

1.2.2 Base Course

Crushed stone gravel with various amounts of silt and sand was encountered in 60 of the 62 road boring locations below the asphalt. Two borings (RD-102 and RD-103) were completed on an undeveloped dirt access road. It was primarily classified as a poorly graded gravel with silt and sand. The thickness of the base course where present ranged from 4 to 33 inches with an average of approximately 9 inches.

1.2.3 Lean Clay to Fat Clay

Lean to fat clay was encountered in 61 of the 62 road boring locations in thicknesses ranging from approximately 1 feet to 4.1 feet. N-values from Standard Penetration Testing (SPT) conducted in the clays ranged from 1 to 58 blows per foot (bpf) with an average of 10 bpf. These results indicate that the clays typically have consistencies ranging from very soft to hard.

1.2.4 Organic Clay

Organic clay was encountered in 17 of the road boring locations in thicknesses ranging from approximately 0.5 feet to 4.7 feet. N-values from Standard Penetration Testing (SPT) conducted in the organic clays ranged from 1 to 12 blows per foot (bpf) with an average of approximately 6 bpf. These results indicate that the clays typically have consistencies ranging from very soft to stiff.

1.3 Groundwater Conditions

No evidence of groundwater was observed during the course of the geotechnical field investigation, however the road borings did not extend greater than five feet below existing grade. As a result, groundwater is not anticipated to be a significant factor in the current road construction.

1.4 Laboratory Testing

Laboratory testing was performed on selected samples as described below.

1.4.1 Moisture Content

A total of five moisture content tests were performed on soils at the project site. The moisture content for clayey soils ranged from 15 to 72 percent, with an average of 22 percent, indicating that soils were generally in a moist condition. The results of the moisture content testing can be found in Table 2 below and attached.

1.4.2 Atterberg Limits

A total of five Atterberg Limits tests were performed on cohesive soils at the project site. Four test were performed on lean to fat clay. Atterberg Limits testing of these samples indicated a Liquid Limit ranging from 34 to 62 percent, a Plastic Limit ranging from 17 to 21, and Plasticity Indices ranging from 17 to 43 percent. According to the USCS plasticity chart, these are classified as lean clay (CL) and fat clay (CH). One sample of organic clay was tested for Atterberg Limits and this sample indicated a Liquid Limit of 113 percent, a Plastic Limit of 80, and Plasticity Index of 33 percent. The results of the Atterberg Limits testing can be found in Table 2 below and attached.

1.4.3 Organic Content

A test of organic content tests was performed on one sample from the project site. The organic content was found to be 31.5 percent. The results of the organic content testing can be found in Table 2 below.

Table 2 Moisture Content and Atterberg Limits Testing Results

Geotechnical Boring ID	USCS	Depth [ft]	Moisture Content [%]	Organic Content [%]	Atterberg Limits		
					Liquid Limit [%]	Plastic Limit [%]	Plasticity Index
RD-109	CH	3.5-5.0	28.3	--	62	19	43
RD-127	CL	5-6.5	31.9	--	43	20	23
RD-134	OH	1.5-3.0	72.1	31.5	113	80	33
RD-151	CH	3.5-5.0	27.7	--	57	21	36
RD-156	CL	1.5-3	14.8	--	34	17	17

1.4.4 California Bearing Ratio Testing

Design for roads and general working areas is based in part on the strength of the subgrade that can be reasonably achieved. California Bearing Ratio (CBR) tests were completed on soil samples collected from the selected locations across the site to determine the field strength of the subgrade.

A total of six samples of the shallow subgrade soils were collected either adjacent to the road borings in the shoulders or directly beneath the gravel base in the road borings (Figure 1). The bulk samples were collected from soil immediately below topsoil or fill materials, which typically corresponded to a depth of approximately 3 to 15 inches below the surface, though one sample was composited from material collected Add comment from 2 to 6 feet. The soil samples were prepared to approximate 95, 98 and 100 percent of the standard Proctor maximum dry density at the optimum moisture content. The results of the CBR testing at 95% compaction are presented in Table 3 as well as being attached to this letter report.

In general, the CBR samples were classified as lean clay with various amount of sand and gravel though one sample of organic clay was obtained and tested. Results from the testing conducted on the subgrade samples indicate that CBR values at 0.1 inch of deflection under a surcharge of 50 psf range from 2.5 -4.7 percent, when compacted to 95 percent of the standard Proctor density at optimum moisture and. 2.9-6.2 percent, when compacted to 98 percent of the standard Proctor density at optimum moisture. There was little to no apparent gain when looking at the results of samples compacted to 100 percent of the standard Proctor density at optimum moisture. This is likely due to the effects of the soil actually breaking down or being overworked in the process of applying the comp active effort required to allow the sample to reach 100 percent. The results indicate that the soils at the site are fairly consistent in their ability to support roads.

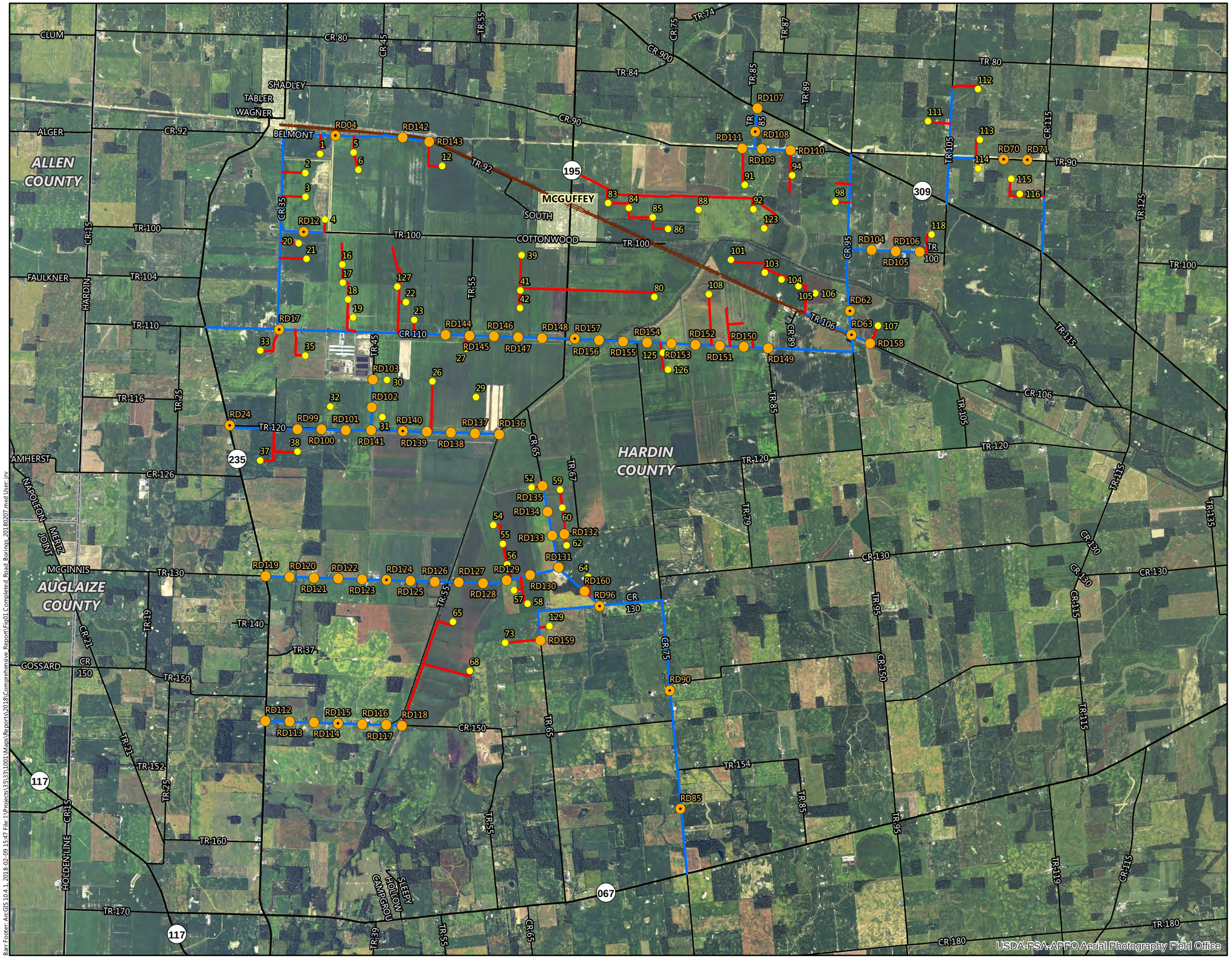
Table 3 CBR Testing Results

Geotechnical Boring ID	USCS	California Bearing Ratio Value (Optimum Moisture Content)*		
		95% Compaction	98% Compaction	100% Compaction
RD-108	CH	2.8	3.6	3.6
RD-115	CL	4.7	5.9	5.9
RD-124	CL/OL	3.4	4.6	4.9
RD-126	OH	2.5	2.9	2.6
RD-140	OL	4.4	6.2	5.9
RD-148	CL	4.1	5	4.9

Attachments:

Boring Logs

Laboratory Test Results



Turbine Location (11/17/2017)

Access Road (11/17/2017)

Transportation Route (11/17/2017)

Completed Road Boring

Completed Road Boring and CBR Location

City Boundary

County Boundary

Feet

5,000 0 5,000

Meters

1,600 0 1,600

Figure 1

COMPLETED ROAD BORINGS LOCATIONS - 2/9/2018

Hardin Wind Project
Invenergy LLC
Hardin County, Ohio

California Bearing Ratio ASTM:D1883

Project:	Hardin Wind	Job:	**11211-A**
Client:	Barr Engineering Company	Date:	12/27/17

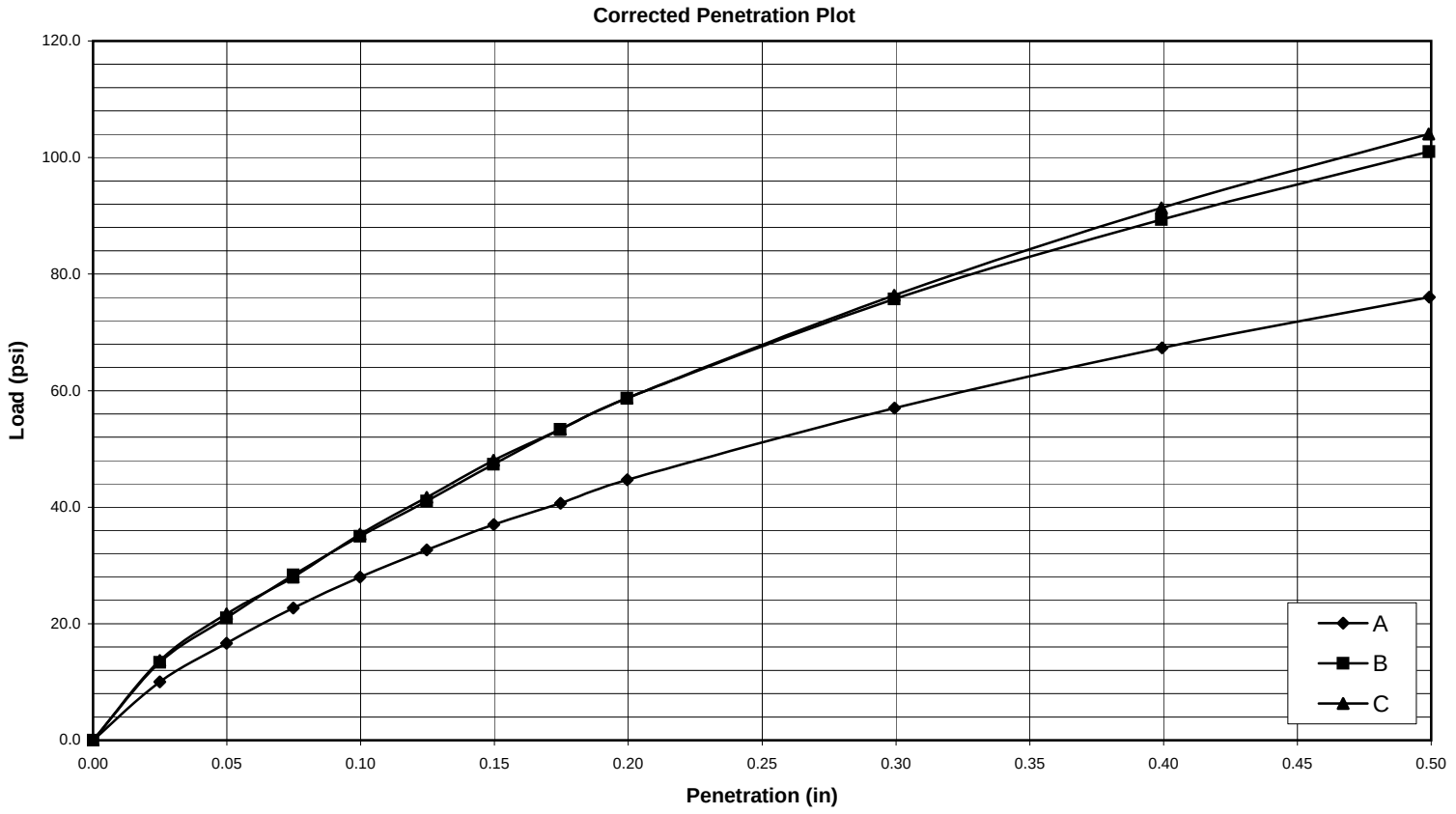
Boring #: RD-108	Procedural Method:
Sample:	Specimens compacted to approximately 95%, 98% and 100% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): 7"-18" Type: Bulk	
Location:	
Classification: Fat Clay w/a trace of gravel (CH)	

Laboratory Moisture-Density Values		Index Properties	
Method:	ASTM:D698 Method B	LL:	Gs:
Maximum Dry Density (PCF):	95.6	PL:	Organic Content:
Optimum Water Content:	24.6%	PI:	pH:

Initial Molding Conditions

Specimen	A	B	C
Compaction Hammer:	5 lb	5 lb	5 lb
Number of Layers:	3	3	3
Blows per Layer:	NA	NA	NA
Initial Moisture Content:	24.6%	24.6%	24.6%
Initial Dry Density (PCF)	90.9	93.8	95.5
Relative Compaction	95.0%	98.1%	99.9%
Soaking Phase			
Days Soaked	4	4	4
Surcharge (psf)	50	50	50
Total Swell (%)	1.4%	1.3%	1.3%
Penetration Phase			
Surcharge (psf)	50	50	50
Corrected CBR Values			
at 0.1 inch (%)	**2.8%**	**3.6%**	**3.6%**
at 0.2 inch (%)	3.0%	3.9%	3.9%
Moisture Content After Penetration			
Top 1" of Specimen:	28.4%	25.9%	27.5%
Average of specimen:	27.7%	25.7%	25.6%

Stress vs. Penetration Graph



9530 James Ave South

SOIL ENGINEERING TESTING, INC.

Bloomington, MN 55431

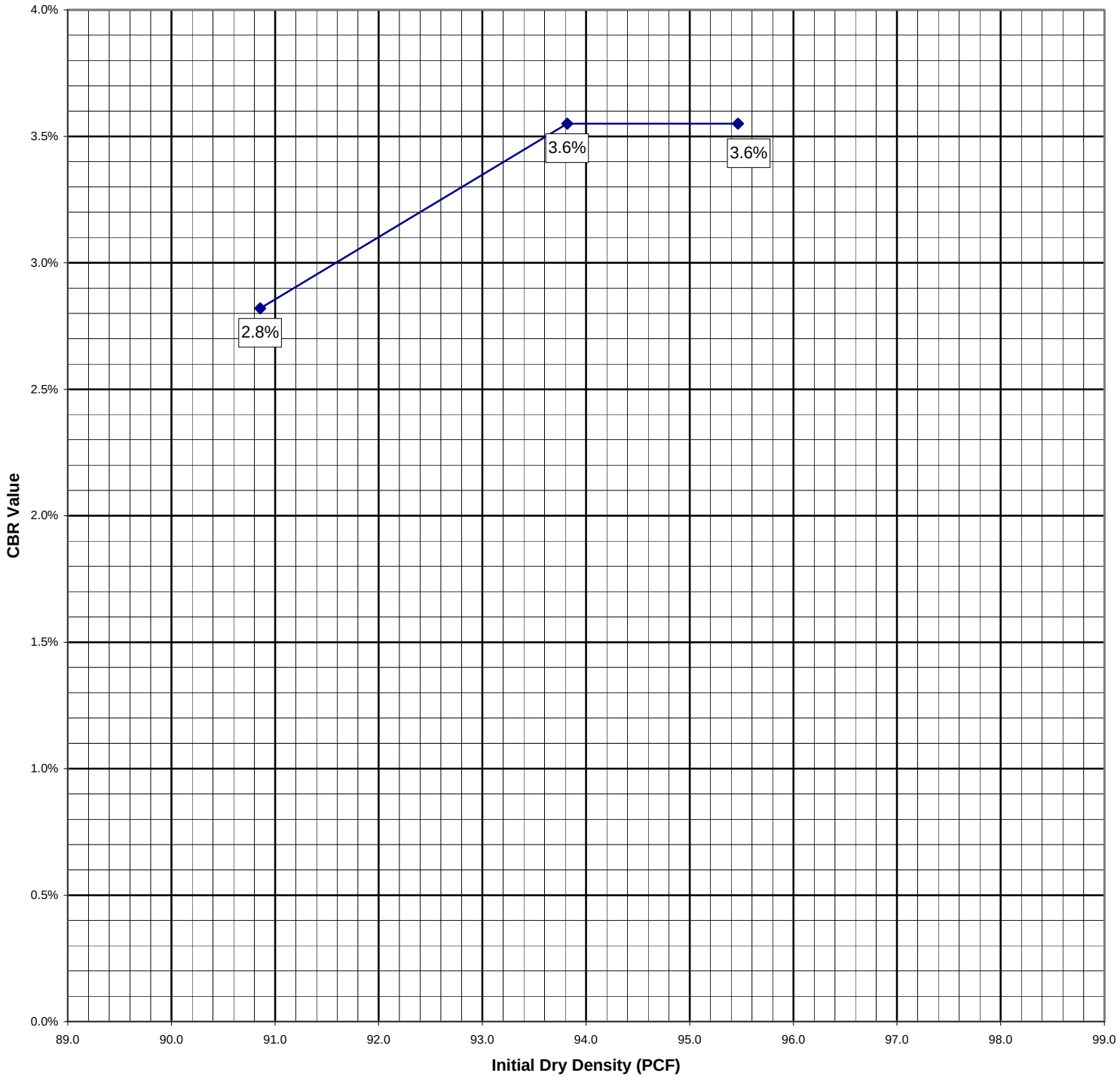
California Bearing Ratio ASTM:D1883

Project:	Hardin Wind	Job:	11211-A
Client:	Barr Engineering Company	Date:	12/27/17

Boring #: RD-108	Procedural Method:
Sample:	Specimens compacted to approximately 95%, 98% and 100% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): 7"-18" Type: Bulk	
Location:	
Classification: Fat Clay w/a trace of gravel (CH)	

Test Plot

Dry Density vs CBR



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SOIL ENGINEERING TESTING, INC.

Bloomington, MN 55431

California Bearing Ratio ASTM:D1883

Project:	Hardin Wind	Job:	**11211-A**
Client:	Barr Engineering Company	Date:	12/27/17

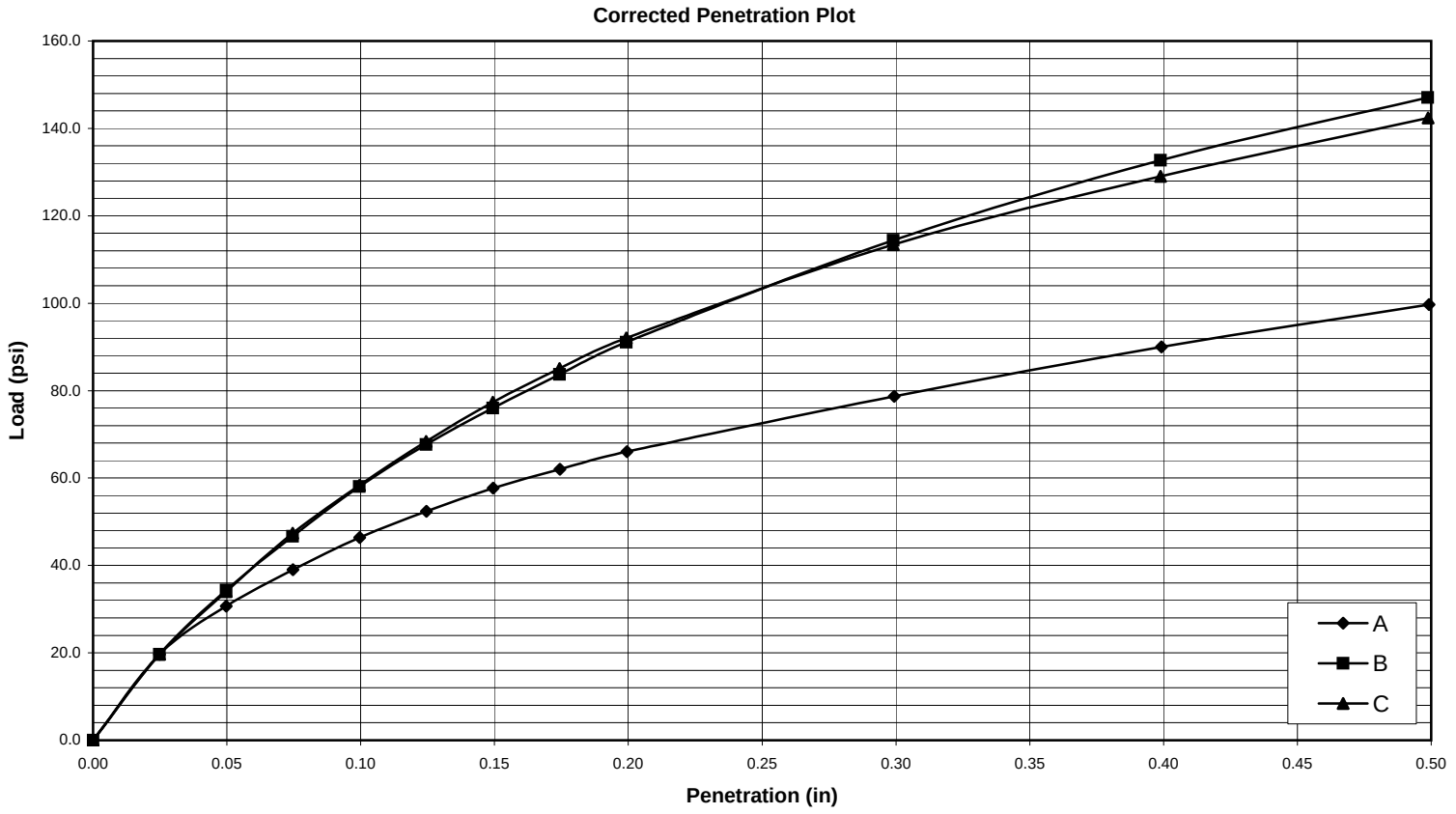
Boring #: RD-115	Procedural Method:
Sample:	Specimens compacted to approximately 95%, 98% and 100% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): 3"-15" Type: Bulk	
Location:	
Classification: Lean Clay with sand and a little gravel (CL)	

Laboratory Moisture-Density Values		Index Properties	
Method:	ASTM:D698 Method B	LL:	Gs:
Maximum Dry Density (PCF):	113.3	PL:	Organic Content:
Optimum Water Content:	14.7%	PI:	pH:

Initial Molding Conditions

Specimen	A	B	C
Compaction Hammer:	5 lb	5 lb	5 lb
Number of Layers:	3	3	3
Blows per Layer:	NA	NA	NA
Initial Moisture Content:	14.7%	14.7%	14.7%
Initial Dry Density (PCF)	107.8	111.1	113.3
Relative Compaction	95.2%	98.1%	100.0%
Soaking Phase			
Days Soaked	4	4	4
Surcharge (psf)	50	50	50
Total Swell (%)	0.8%	0.7%	0.8%
Penetration Phase			
Surcharge (psf)	50	50	50
Corrected CBR Values			
at 0.1 inch (%)	**4.7%**	**5.9%**	**5.9%**
at 0.2 inch (%)	4.4%	6.1%	6.2%
Moisture Content After Penetration			
Top 1" of Specimen:	18.3%	17.8%	19.8%
Average of specimen:	17.5%	17.5%	19.0%

Stress vs. Penetration Graph



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SOIL ENGINEERING TESTING, INC.

Bloomington, MN 55431

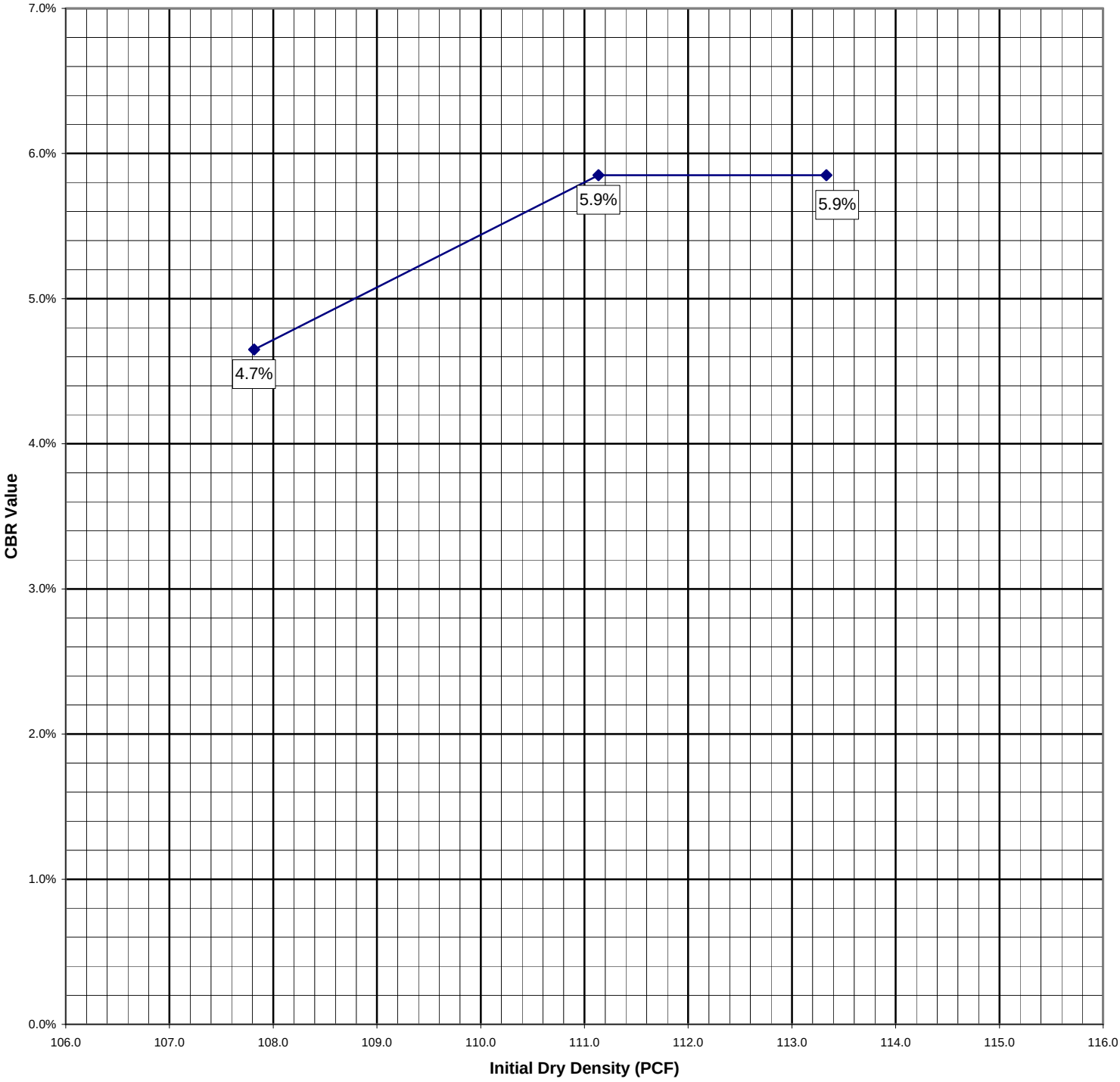
California Bearing Ratio ASTM:D1883

Project:	Hardin Wind	Job:	11211-A
Client:	Barr Engineering Company	Date:	12/27/17

Boring #: RD-115	Procedural Method:
Sample:	Specimens compacted to approximately 95%, 98% and 100% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): 3"-15" Type: Bulk	
Location:	
Classification: Lean Clay with sand and a little gravel (CL)	

Test Plot

Dry Density vs CBR



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SOIL ENGINEERING TESTING, INC.

Bloomington, MN 55431

California Bearing Ratio ASTM:D1883

Project:	Hardin Wind	Job:	**11211-A**
Client:	Barr Engineering Company	Date:	12/27/17

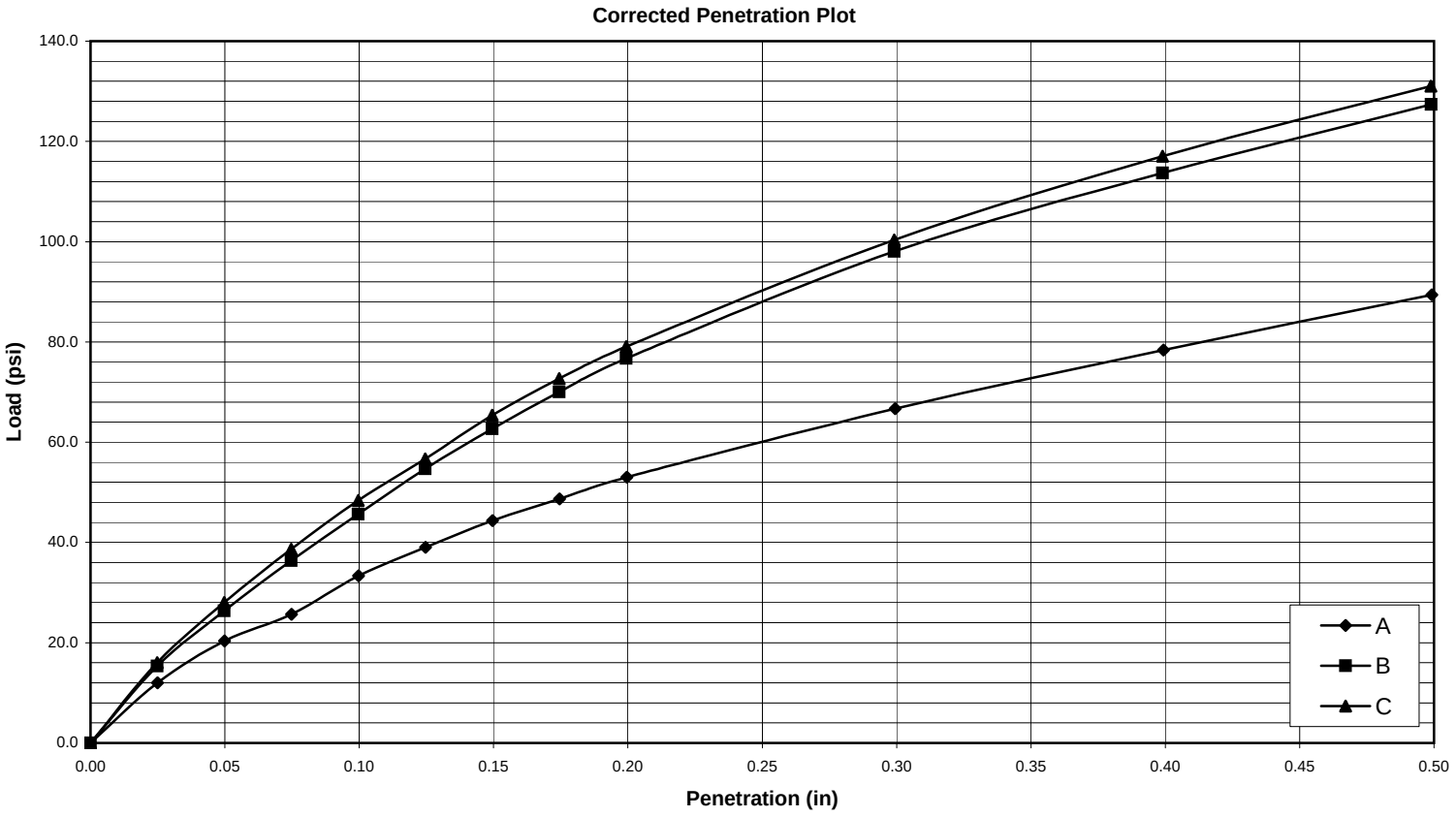
Boring #: RD-124	Procedural Method:
Sample:	Specimens compacted to approximately 95%, 98% and 100% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): 5"-17" Type: Bulk	
Location:	
Classification: Lean Clay with organic fines (CL/OL)	

Laboratory Moisture-Density Values		Index Properties	
Method:	ASTM:D698 Method B	LL:	Gs:
Maximum Dry Density (PCF):	98.0	PL:	Organic Content:
Optimum Water Content:	22.8%	PI:	pH:

Initial Molding Conditions

Specimen	A	B	C
Compaction Hammer:	5 lb	5 lb	5 lb
Number of Layers:	3	3	3
Blows per Layer:	NA	NA	NA
Initial Moisture Content:	22.8%	22.8%	22.8%
Initial Dry Density (PCF)	93.2	96.1	97.9
Relative Compaction	95.1%	98.0%	99.9%
Soaking Phase			
Days Soaked	4	4	4
Surcharge (psf)	50	50	50
Total Swell (%)	0.8%	0.7%	0.7%
Penetration Phase			
Surcharge (psf)	50	50	50
Corrected CBR Values			
at 0.1 inch (%)	**3.4%**	**4.6%**	**4.9%**
at 0.2 inch (%)	3.6%	5.1%	5.3%
Moisture Content After Penetration			
Top 1" of Specimen:	28.1%	23.6%	24.6%
Average of specimen:	27.0%	23.0%	23.7%

Stress vs. Penetration Graph



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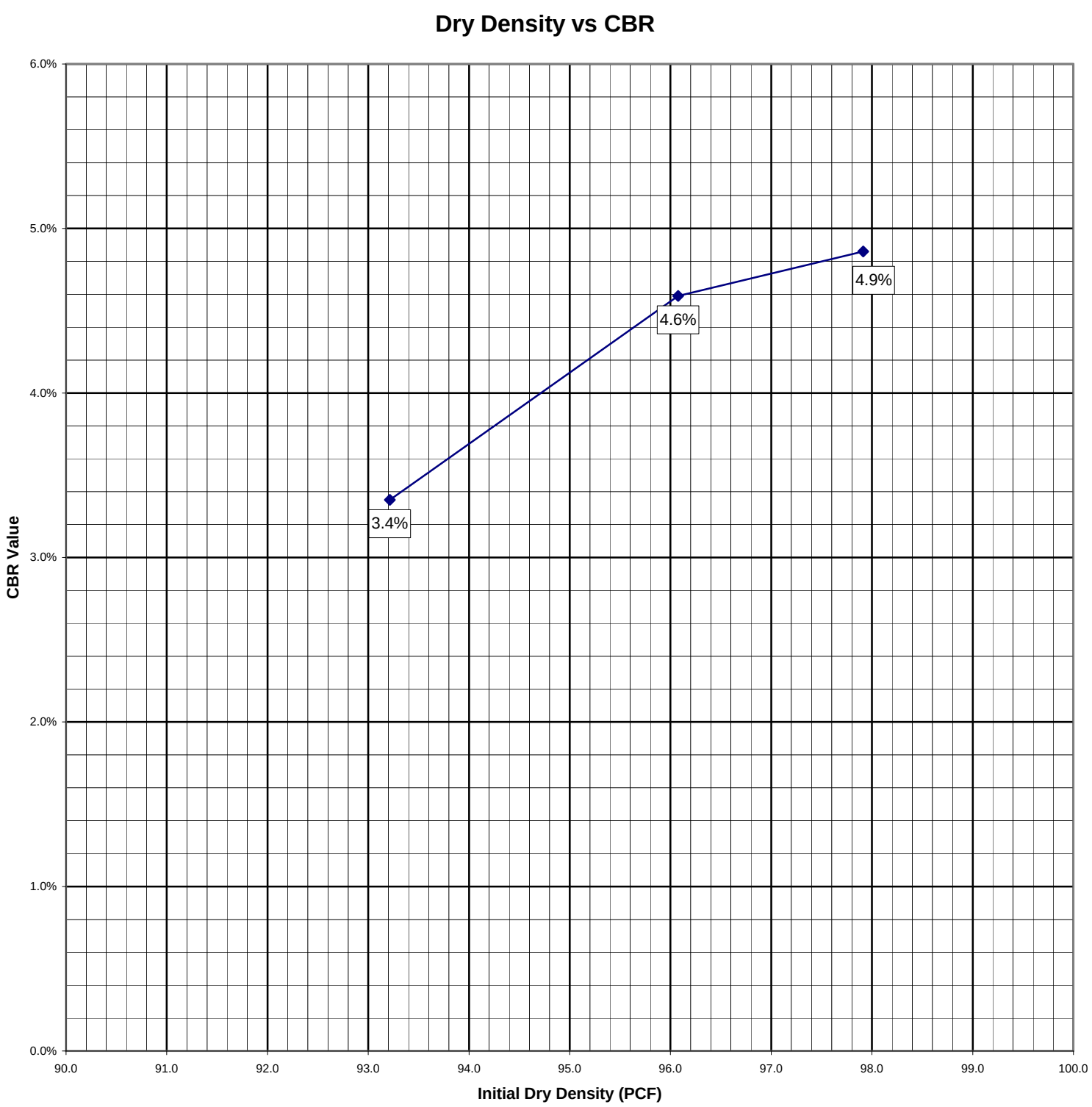
California Bearing Ratio ASTM:D1883

Project:	Hardin Wind	Job:	11211-A
Client:	Barr Engineering Company	Date:	12/27/17

Boring #: RD-124		Procedural Method:
Sample:		Specimens compacted to approximately 95%, 98% and 100% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): 5"-17"	Type: Bulk	
Location:		

Classification: Lean Clay with organic fines (CL/OL)

Test Plot



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Bloomington, MN 55431

California Bearing Ratio ASTM:D1883

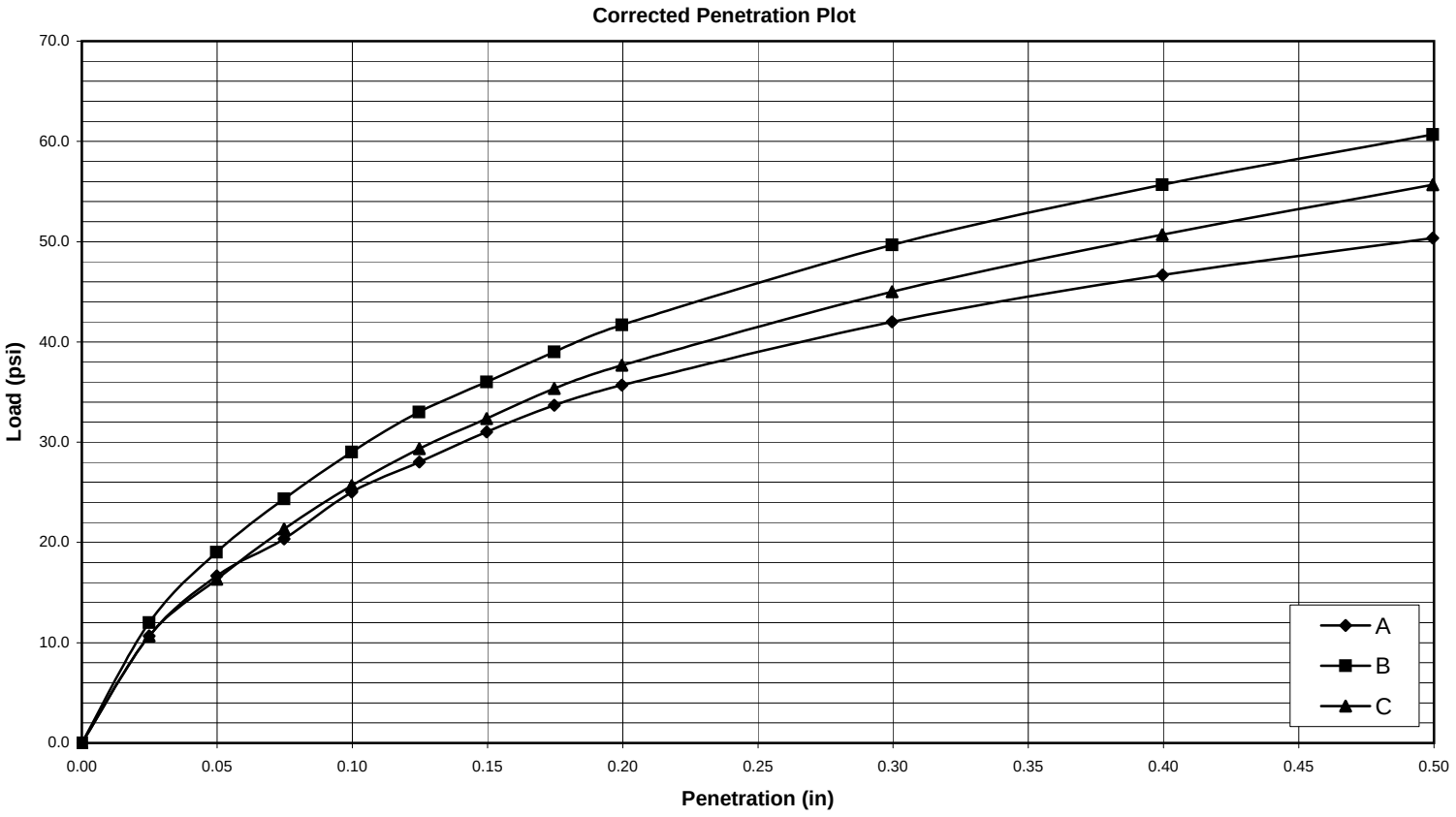
Project:	Hardin Wind	Job:	**11211-A**
Client:	Barr Engineering Company	Date:	12/27/17

Boring #: RD-126	Procedural Method:
Sample:	Specimens compacted to approximately 95%, 98% and 100% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): 2-6 Type: Bulk	
Location:	
Classification: Organic Clay (OH)	

Laboratory Moisture-Density Values		Index Properties	
Method:	ASTM:D698 Method B	LL:	Gs:
Maximum Dry Density (PCF):	42.0	PL:	Organic Content:
Optimum Water Content:	90.0%	PI:	pH:

Initial Molding Conditions			
Specimen	A	B	C
Compaction Hammer:	5 lb	5 lb	5 lb
Number of Layers:	3	3	3
Blows per Layer:	NA	NA	NA
Initial Moisture Content:	90.0%	90.0%	90.0%
Initial Dry Density (PCF)	40.2	41.2	42.0
Relative Compaction	95.7%	98.1%	100.1%
Soaking Phase			
Days Soaked	4	4	4
Surcharge (psf)	50	50	50
Total Swell (%)	1.6%	1.6%	1.7%
Penetration Phase			
Surcharge (psf)	50	50	50
Corrected CBR Values			
at 0.1 inch (%)	**2.5%**	**2.9%**	**2.6%**
at 0.2 inch (%)	2.4%	2.8%	2.5%
Moisture Content After Penetration			
Top 1" of Specimen:	95.7%	95.3%	94.6%
Average of specimen:	100.7%	96.8%	93.1%

Stress vs. Penetration Graph



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Bloomington, MN 55431

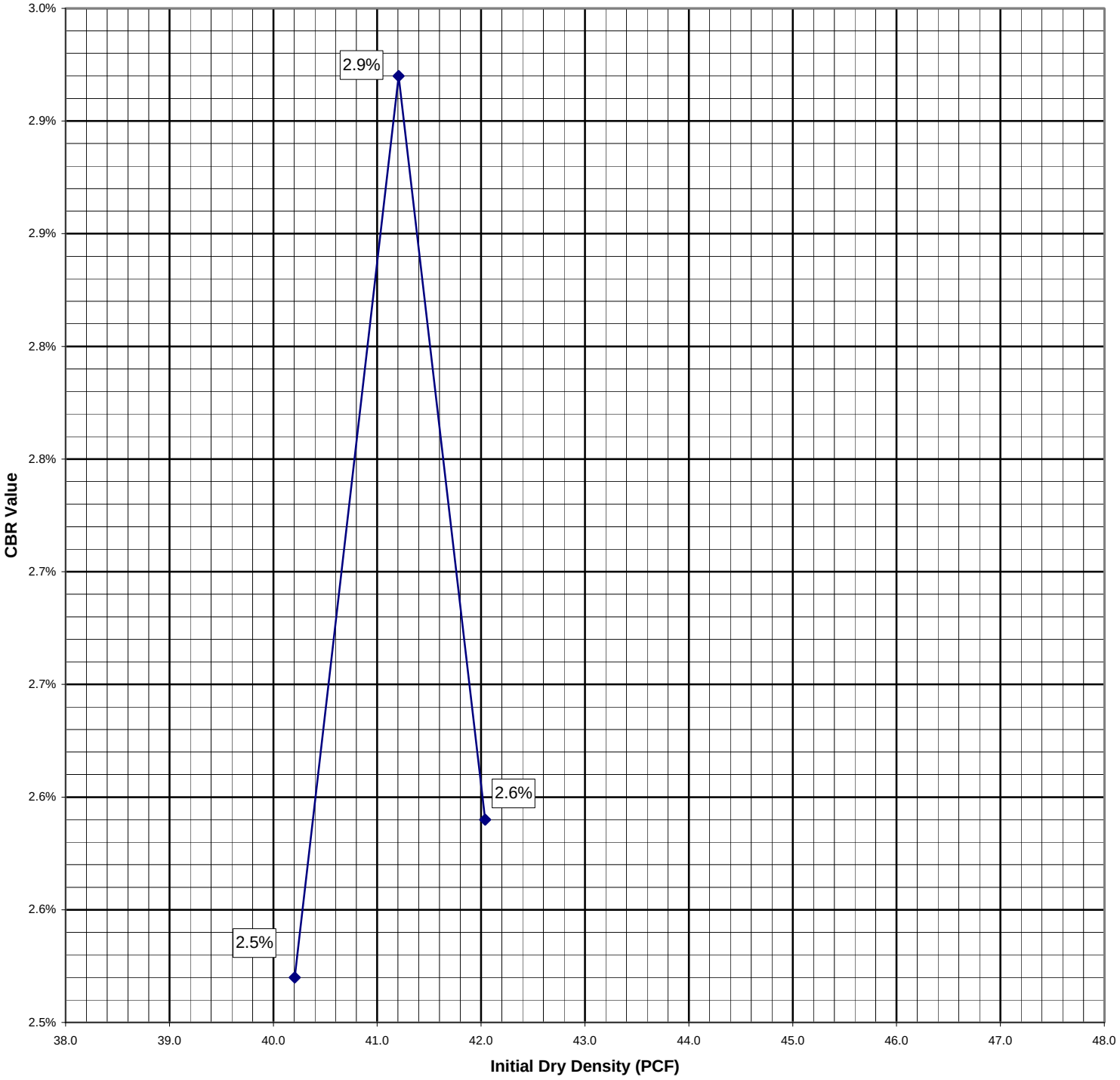
California Bearing Ratio ASTM:D1883

Project:	Hardin Wind	Job:	11211-A
Client:	Barr Engineering Company	Date:	12/27/17

Boring #: RD-126	Procedural Method:
Sample:	Specimens compacted to approximately 95%, 98% and 100% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): 2-6 Type: Bulk	
Location:	
Classification: Organic Clay (OH)	

Test Plot

Dry Density vs CBR



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Bloomington, MN 55431

California Bearing Ratio ASTM:D1883

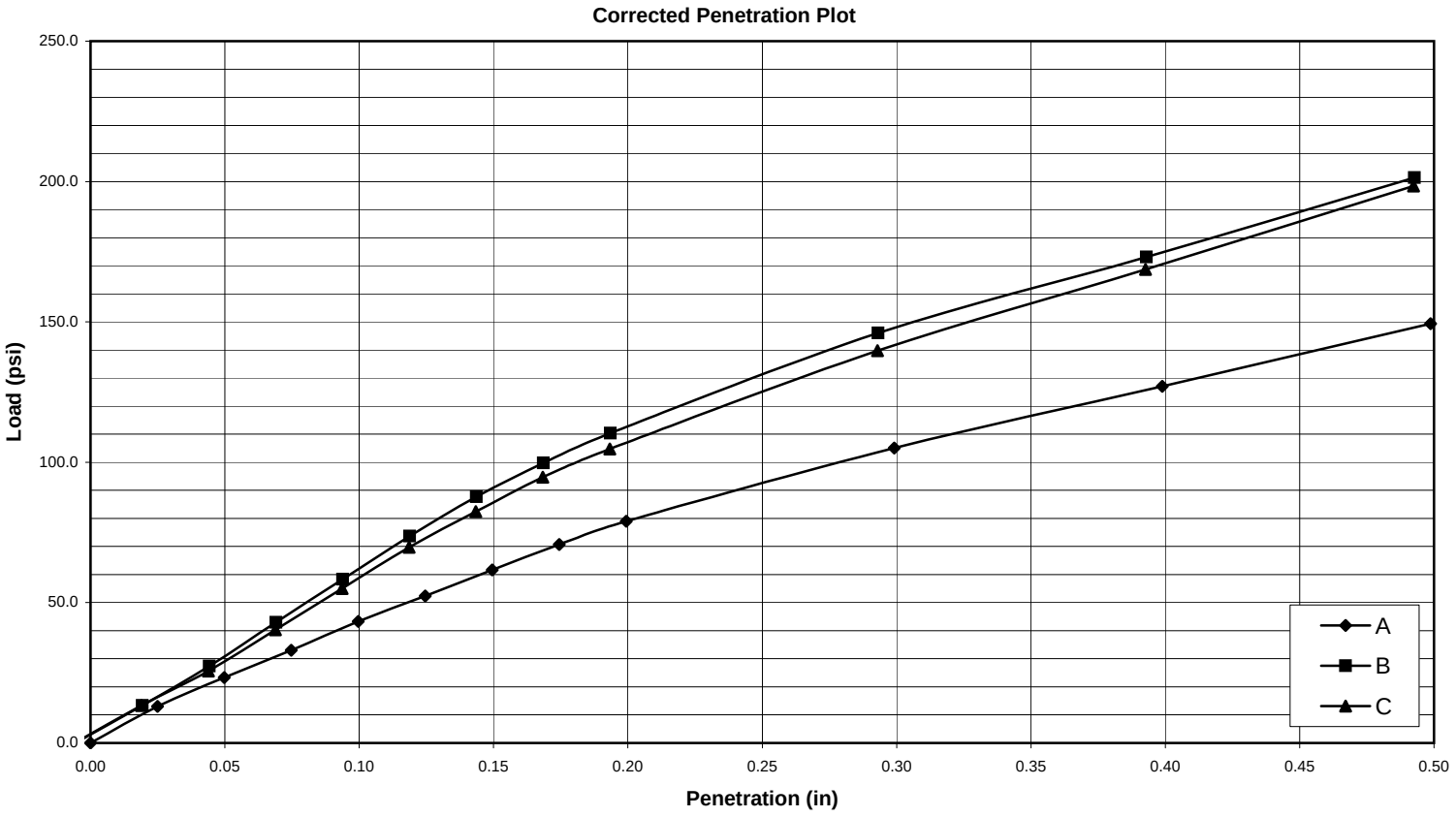
Project:	Hardin Wind	Job:	**11211-A**
Client:	Barr Engineering Company	Date:	12/27/17

Boring #: RD-140	Procedural Method:
Sample:	Specimens compacted to approximately 95%, 98% and 100% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): 7"-20" Type: Bulk	
Location:	
Classification: Organic Clay w/gravel (OL)	

Laboratory Moisture-Density Values		Index Properties	
Method:	ASTM:D698 Method B	LL:	Gs:
Maximum Dry Density (PCF):	100.7	PL:	Organic Content:
Optimum Water Content:	19.8%	PI:	pH:

Initial Molding Conditions			
Specimen	A	B	C
Compaction Hammer:	5 lb	5 lb	5 lb
Number of Layers:	3	3	3
Blows per Layer:	NA	NA	NA
Initial Moisture Content:	19.8%	19.8%	19.8%
Initial Dry Density (PCF)	95.7	98.8	100.9
Relative Compaction	95.1%	98.1%	100.2%
Soaking Phase			
Days Soaked	4	4	4
Surcharge (psf)	50	50	50
Total Swell (%)	1.0%	1.0%	1.0%
Penetration Phase			
Surcharge (psf)	50	50	50
Corrected CBR Values			
at 0.1 inch (%)	**4.4%**	**6.2%**	**5.9%**
at 0.2 inch (%)	5.3%	7.6%	7.1%
Moisture Content After Penetration			
Top 1" of Specimen:	25.5%	22.8%	22.4%
Average of specimen:	25.0%	22.9%	21.4%

Stress vs. Penetration Graph



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Bloomington, MN 55431

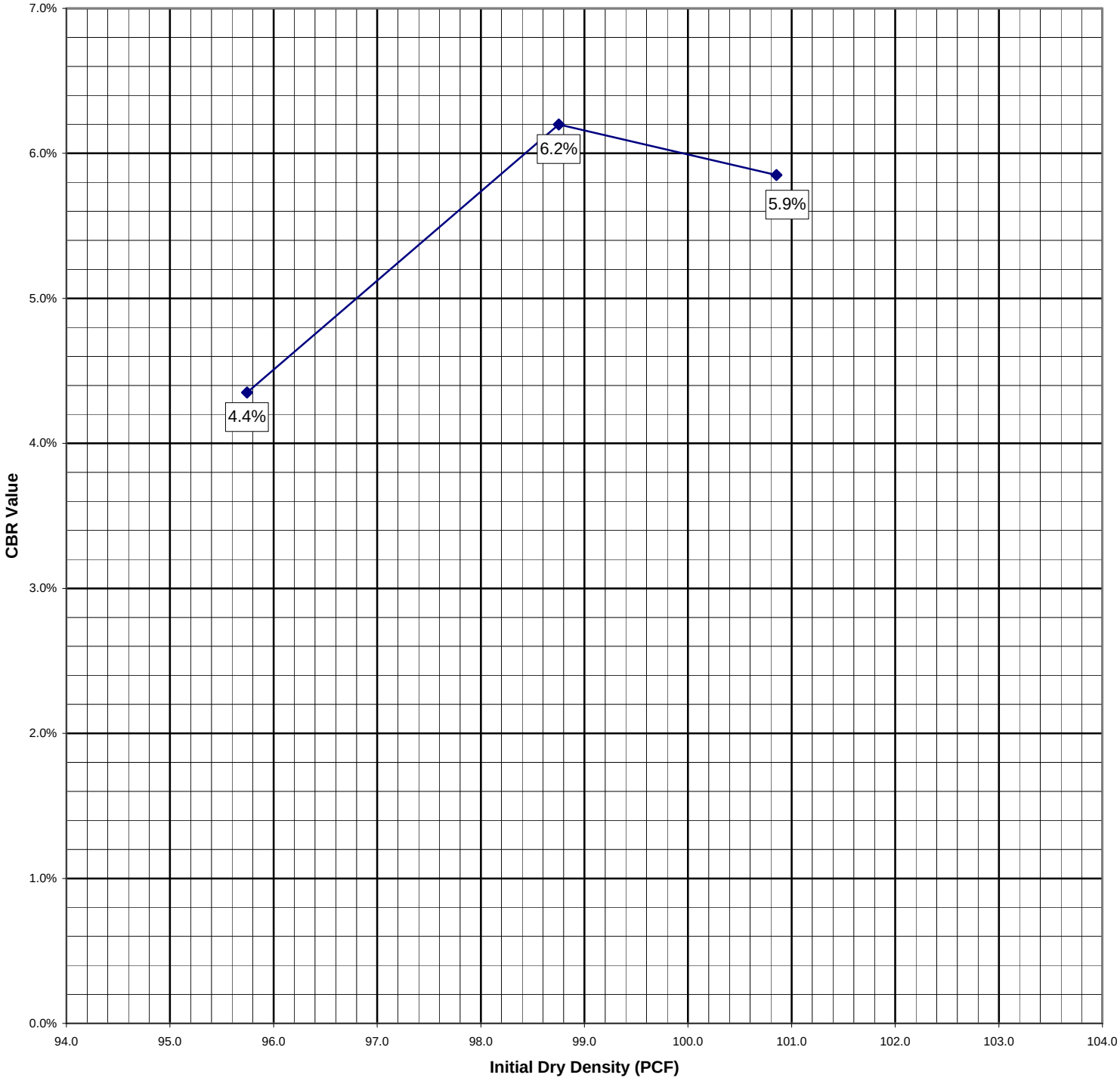
California Bearing Ratio ASTM:D1883

Project:	Hardin Wind	Job:	11211-A
Client:	Barr Engineering Company	Date:	12/27/17

Boring #: RD-140	Procedural Method:
Sample:	Specimens compacted to approximately 95%, 98% and 100% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): 7"-20" Type: Bulk	
Location:	
Classification: Organic Clay w/gravel (OL)	

Test Plot

Dry Density vs CBR



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SOIL ENGINEERING TESTING, INC.

Bloomington, MN 55431

California Bearing Ratio ASTM:D1883

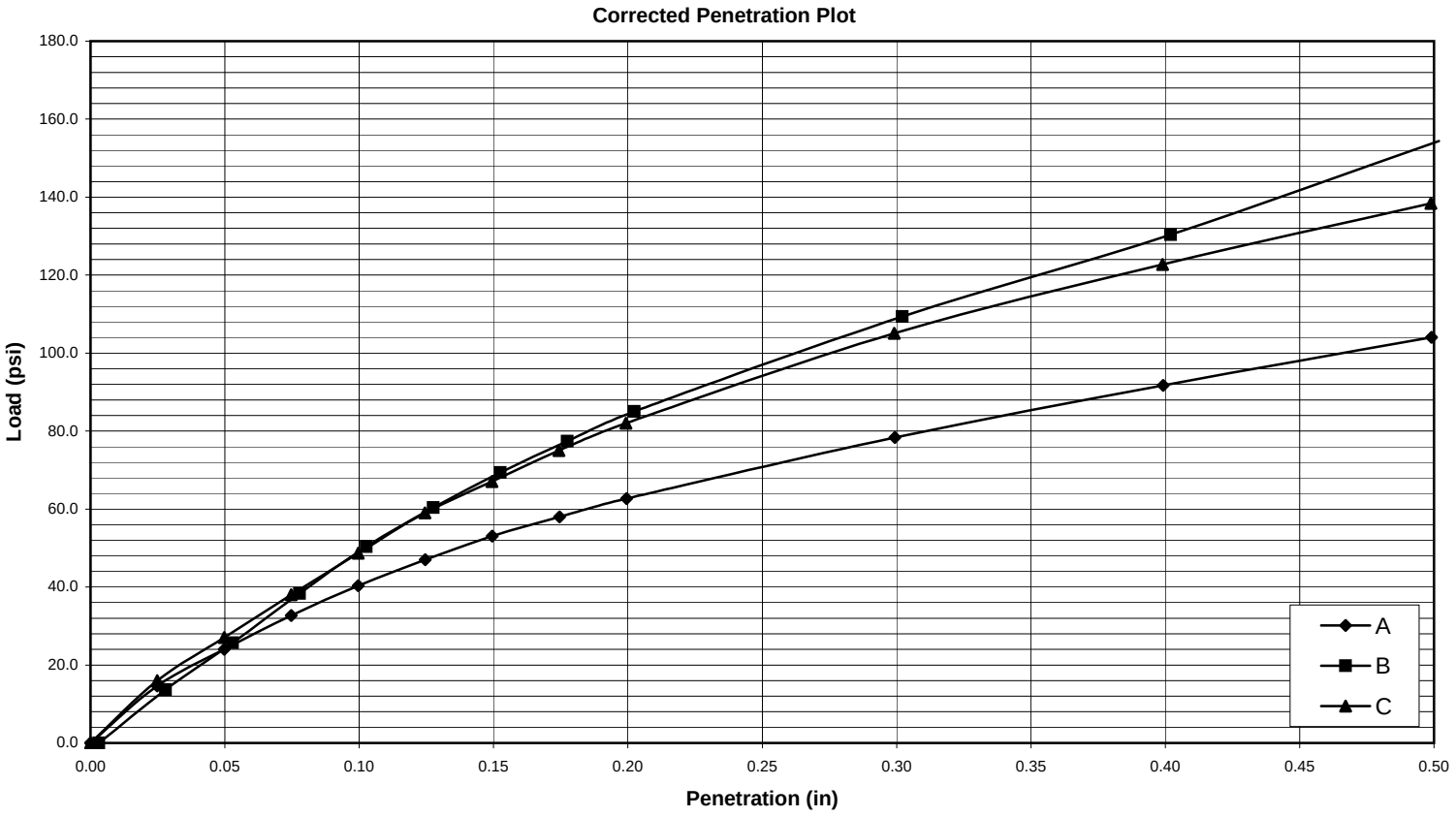
Project:	Hardin Wind	Job:	**11211-A**
Client:	Barr Engineering Company	Date:	12/27/17

Boring #: RD-148	Procedural Method:
Sample:	Specimens compacted to approximately 95%, 98% and 100% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): 2"-14" Type: Bulk	
Location:	
Classification: Lean Clay with gravel and organic fines (CL)	

Laboratory Moisture-Density Values		Index Properties	
Method:	ASTM:D698 Method B	LL:	Gs:
Maximum Dry Density (PCF):	105.0	PL:	Organic Content:
Optimum Water Content:	18.2%	PI:	pH:

Initial Molding Conditions			
Specimen	A	B	C
Compaction Hammer:	5 lb	5 lb	5 lb
Number of Layers:	3	3	3
Blows per Layer:	NA	NA	NA
Initial Moisture Content:	18.2%	18.2%	18.2%
Initial Dry Density (PCF)	100.0	103.2	105.3
Relative Compaction	95.3%	98.2%	100.3%
Soaking Phase			
Days Soaked	4	4	4
Surcharge (psf)	50	50	50
Total Swell (%)	1.1%	1.0%	1.2%
Penetration Phase			
Surcharge (psf)	50	50	50
Corrected CBR Values			
at 0.1 inch (%)	**4.1%**	**5.0%**	**4.9%**
at 0.2 inch (%)	4.2%	5.6%	5.5%
Moisture Content After Penetration			
Top 1" of Specimen:	22.1%	20.4%	21.6%
Average of specimen:	21.7%	21.5%	20.4%

Stress vs. Penetration Graph



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Bloomington, MN 55431

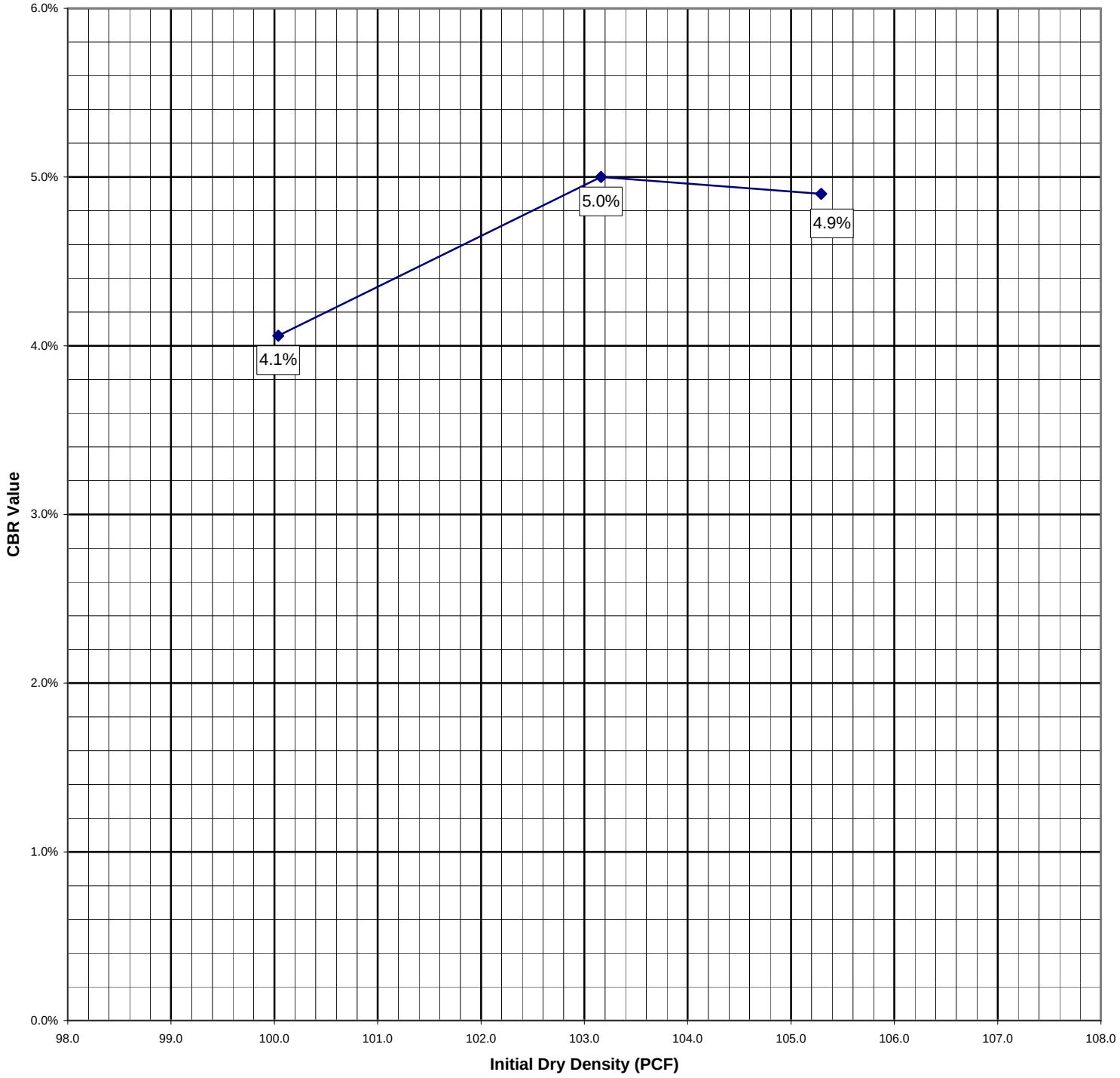
California Bearing Ratio ASTM:D1883

Project:	Hardin Wind	Job:	11211-A
Client:	Barr Engineering Company	Date:	12/27/17

Boring #: RD-148		Procedural Method:
Sample:		Specimens compacted to approximately 95%, 98% and 100% of maximum standard proctor density at optimum moisture content. Specimens soaked for a period of 4 days before CBR test was performed.
Depth (ft): 2"-14"	Type: Bulk	
Location:		
Classification: Lean Clay with gravel and organic fines (CL)		

Test Plot

Dry Density vs CBR



9530 James Ave South

SOIL ENGINEERING TESTING, INC.

Bloomington, MN 55431

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD083

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.59752° Long: -83.75876°	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf (0 2.5 5)	NATURAL DRY DENSITY (pcf) ☆ (80 100 120) WATER CONTENT (%) × PL LL (20 40 60)
	0.0	Surface Elev.: Unknown								
	0.0	ASPHALT: black.								
	0.8	CRUSHED STONE: [fill].	0.8ft							
	1.2	LEAN CLAY (CL): brown; moist; stiff; with gray and red mottling; trace gravel; trace fine sand.	1.2ft			1	78	11	11 ◎	
	3.0	SANDY LEAN CLAY (CL): grayish brown; moist; stiff; trace fine sand; trace gravel.	3.0ft			2	89	12	12 ◎	14.8 ×
	5.0	Bottom of Boring at 5.0 feet	5.0ft							

Date Boring Started:	7/5/17 4:40 pm	Water Levels (ft)	Remarks: Located ~3.5' E of shoulder
Date Boring Completed:	7/5/17 4:55 pm	▼ At Time of Drilling	
Logged By:	AMS3	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

M:\GINT\PROJECTS\HARDIN ROAD DECEMBER 2017_35331001_CJS.GPJ BARRLIBRARY.GLB BOREHOLE LOG REPORT BARR TEMPLATE.GDT

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD084

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.60115° Long: -83.75936°	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.: Unknown					
	0.0	ASPHALT: black.					
	0.5	CRUSHED STONE: [fill]. 0.5ft					
	1.0	LEAN CLAY (CL): grayish brown; moist; medium stiff; with orange mottling; trace to with sand. 1.0ft			1	78	7
	3.0	LEAN TO FAT CLAY (CL/CH): dark brown; moist; medium stiff; trace sand. 3.0ft			2	67	6
	5.0	Bottom of Boring at 5.0 feet 5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40)
REC%
RQD % ◆ (20, 40, 60, 80)
SHEAR STRENGTH, tsf (0, 2.5, 5)
7 ◎
6 ◎

NATURAL DRY DENSITY (pcf) ☆ (80, 100, 120)
WATER CONTENT (%) × (20, 40, 60)
PL 18
LL 44
22.4

Date Boring Started:	7/5/17 4:20 pm	Water Levels (ft)	Remarks: Located ~4' E of shoulder
Date Boring Completed:	7/5/17 4:40 pm	▽ At Time of Drilling	
Logged By:	AMS3	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD085

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.60465° Long: -83.75989°	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf (0 2,5 5)
	0.0	Surface Elev.: Unknown							
	0.5	ASPHALT: black.							
		CRUSHED STONE: [fill].	0.8ft						
	1.0	POORLY GRADED SAND (SP): fine grained; brown; moist; loose; with gravel; trace silt.	1.0ft						
	1.5	SANDY LEAN CLAY (CL): brown; moist; medium stiff; trace black and gray mottling.	1.3ft			1	67	6	6 ◎
	2.0								
	2.5	FAT CLAY (CH): brown; moist; trace black and orangish gray mottling; trace sand.	2.5ft						
	3.0								
	3.5								
	4.0					2	78	7	7 ◎
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	7/5/17 4:05 pm	Water Levels (ft)	Remarks: Located ~3' E of shoulder
Date Boring Completed:	7/5/17 4:15 pm	▼ At Time of Drilling	
Logged By:	AMS3	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD086

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.60833° Long: -83.76056°	Completion Depth:	5.5 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.: Unknown						
	0.0	ASPHALT: black.						
	1.0	CRUSHED STONE: [fill].	0.9ft					
	1.7	LEAN TO FAT CLAY (CL/CH): dark brown; moist; stiff; trace sand; trace gravel.	1.7ft			1	67	9
	3.0	FAT CLAY (CH): grayish brown; moist; medium stiff.	3.0ft			2	6	6
	5.0					3	100	6
	5.5	Bottom of Boring at 5.5 feet	5.5ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
0 2.5 5

9 ◎
6 ◎
6 ◎

Date Boring Started:	7/5/17 3:40 pm	Water Levels (ft)	Remarks: Located ~3' E of shoulder
Date Boring Completed:	7/5/17 3:55 pm	▽ At Time of Drilling	
Logged By:	AMS3	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

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Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD087

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.61165° Long: -83.76108°	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.: Unknown						
	0.0	ASPHALT: black.						
	0.5	CRUSHED STONE: [fill].	0.5ft					
	1.0							
	1.5	FAT CLAY (CH): dark brown; moist; medium stiff; trave red mottling; trace sand.	1.4ft			1	100	6
	2.0							
	2.5	FAT CLAY (CH): brown; moist; medium stiff; with gray and red mottling; trace to with sand.	2.5ft					
	3.0							
	3.5							
	4.0					2	67	8
	4.5							
	5.0	Bottom of Boring at 5.0 feet	5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
0 2.5 5

NATURAL DRY DENSITY (pcf) ☆
80 100 120
WATER CONTENT (%) ×
PL LL
20 40 60

6 ◎
8 ◎
19 × 55
26.5

Date Boring Started:	7/5/17 3:20 pm	Water Levels (ft)	Remarks: Located ~3.5' E of shoulder
Date Boring Completed:	7/5/17 3:35 pm	▽ At Time of Drilling	
Logged By:	AMS3	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

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Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD088

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.61522° Long: -83.76163°	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.: Unknown						
	0.0	ASPHALT: black.						
	0.5	CRUSHED STONE: [fill].	0.5ft					
	1.0	FAT CLAY (CH): dark brown; moist; stiff; trace red mottling; trace sand.	1.2ft			1	67	9
	3.0	FAT CLAY (CH): brown; moist; medium stiff to stiff; with gray and red mottling; trace sand.	3.0ft			2	100	7
	5.0	Bottom of Boring at 5.0 feet	5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
0 2.5 5

Date Boring Started:	7/5/17 3:00 pm	Water Levels (ft)	Remarks: Located ~4' E of shoulder
Date Boring Completed:	7/5/17 3:15 pm	▽ At Time of Drilling	
Logged By:	AMS3	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

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LOG OF BORING RD089

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.61877° Long: -83.76226°	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf (0 2,5 5)
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5								
		CRUSHED STONE: [fill].	0.7ft						
	1.0								
	1.5	LEAN CLAY (CL): brown; moist; medium stiff; with gray and red mottling; with sand; trace gravel.	1.4ft			1	78	7	7 ◎
	2.0								
	2.5								
	3.0	SANDY LEAN CLAY (CL): brown; moist; medium stiff to very stiff; trace gravel.	3.0ft						
	3.5								
	4.0	FAT CLAY (CH): brown; moist; very stiff; with gray mottling; trace gravel.	4.0ft			2	100	19	19 ◎
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	7/5/17 2:40 pm	Water Levels (ft)	Remarks: Located ~4' E of shoulder
Date Boring Completed:	7/5/17 2:50 pm	▽ At Time of Drilling	
Logged By:	AMS3	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

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LOG OF BORING RD090

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.62237° Long: -83.76282°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Depth, feet	MATERIAL DESCRIPTION	Sample No.	% Recovery	SPT, N value or RQD %
0.0	ASPHALT: black.			
0.7	CRUSHED STONE: [fill].			
1.4	FAT CLAY (CH): dark brown; moist; medium stiff; trace reddish mottling; trace sand. 1.4'-3': trace organics.	1	67	7
		2	56	6
5.0	Bottom of Boring at 5.0 feet			

STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10, 20, 30, 40)
REC%
RQD % ◆ (20, 40, 60, 80)
SHEAR STRENGTH, tsf (0, 2.5, 5)

NATURAL DRY DENSITY (pcf) ☆ (80, 100, 120)
WATER CONTENT (%) × (PL, LL; 20, 40, 60)
26.7

Date Boring Started:	7/5/17 2:20 pm	Water Levels (ft)	Remarks: Located ~4' E of shoulder
Date Boring Completed:	7/5/17 2:35 pm	▽ At Time of Drilling	
Logged By:	AMS3	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

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LOG OF BORING RD091

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.62601° Long: -83.76336°	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf (0 2,5 5)
	0.0	Surface Elev.: Unknown							
	0.5	ASPHALT: black.							
	1.0	CRUSHED STONE: [fill].	0.7ft						
	1.5	LEAN TO FAT CLAY (CL/CH): brown; moist; medium stiff; trace gray and red mottling; trace sand; trace gravel.	1.4ft			1	72	8	8 ◎
	2.0								
	2.5								
	3.0								
	3.5	FAT CLAY (CH): brown; moist; medium stiff; with dark brown and gray mottling; trace gravel; trace sand.	3.5ft						
	4.0					2	78	8	8 ◎
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	7/5/17 2:05 pm	Water Levels (ft)	Remarks: Located ~3.5' E of shoulder. Drilled ~1.5' and hit cobbles. Moved ~1' S and drillied this hole.
Date Boring Completed:	7/5/17 2:20 pm	▽ At Time of Drilling Dry	
Logged By:	AMS3		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

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LOG OF BORING RD092

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.62966° Long: -83.76398°	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf (0 2,5 5)
	0.0	Surface Elev.: Unknown							
	0.5	ASPHALT: black.							
	1.0	CRUSHED STONE: [fill].	0.8ft						
	1.5	LEAN TO FAT CLAY (CL/CH): brown; moist; medium stiff; with gray and red mottling; trace fine sand; trace gravel.	1.2ft			1	78	7	7 ◎
	2.0								
	2.5								
	3.0								
	3.5	FAT CLAY (CH): brown; moist; medium stiff; with fine to medium sand.	3.5ft						
	4.0	POORLY GRADED CLAYEY SAND (SP-SC): fine to medium grained; brown; moist; loose; trace silt.	4.0ft			2	100	5	5 ◎
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	7/5/17 1:40 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	7/5/17 1:55 pm	▼ At Time of Drilling	
Logged By:	AMS3	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

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LOG OF BORING RD093

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.63312° Long: -83.76453°	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.: Unknown						
	0.0	ASPHALT: black.						
	0.5	CRUSHED STONE: [fill].	0.6ft					
	1.0							
	1.5	POORLY GRADED SAND (SP): fine grained; brown; moist; loose; trace clay; trace crushed gravel.	1.6ft			1	44	5
	2.0	LEAN TO FAT CLAY (CL/CH): dark brown; moist; medium stiff; trace fine sand.	2.0ft					
	2.5							
	3.0							
	3.5	FAT CLAY (CH): brown; moist; medium stiff; trace gray and red mottling; trace gravel; trace sand.	3.5ft					
	4.0					2	22	6
	4.5							
	5.0	Bottom of Boring at 5.0 feet	5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
0 2.5 5

Date Boring Started:	7/5/17 1:05 pm	Water Levels (ft)	Remarks:
Date Boring Completed:	7/5/17 1:25 pm	▼ At Time of Drilling	
Logged By:	AMS3	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

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LOG OF BORING RD094

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.63570° Long: -83.76746°	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.: Unknown					
	0.0	ASPHALT: black.					
	0.5	CRUSHED STONE: [fill]. 0.4ft					
	1.0	FAT CLAY (CH): drak brownish gray to brown; moist; medium stiff; with gray mottling at 1.5'; trace gravel; trace fine sand. 1.0ft			1	78	7
	3.0	LEAN TO FAT CLAY (CL/CH): brown; moist; stiff; with gray mottling; trace gravel; trace fine sand. 3.0ft			2	67	9
	5.0	Bottom of Boring at 5.0 feet 5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
0 2.5 5
7
9

NATURAL DRY DENSITY (pcf) ☆
80 100 120
WATER CONTENT (%) ×
PL LL
20 40 60
19 60
28.1

Date Boring Started:	7/5/17 12:45 pm	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	7/5/17 1:00 pm	▽ At Time of Drilling	
Logged By:	AMS3	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

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LOG OF BORING RD095

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.63524° Long: -83.77223°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Depth, feet	MATERIAL DESCRIPTION		Sample No.	% Recovery	SPT, N value or RQD %
0.0	ASPHALT: black.				
0.5	CRUSHED STONE: [fill].	0.4ft			
1.0	FAT CLAY (CH): dark brownish black; moist; medium stiff; trace reddish brown mottling; trace organics; trace sand.	1.1ft	1	67	7
2.0	FAT CLAY (CH): grayish brown; moist; stiff; with reddish brown mottling; trace gravel; trace to with sand.	2.0ft			
3.0			2	78	15
4.0					
5.0	Bottom of Boring at 5.0 feet	5.0ft			

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
0 2.5 5
7 ◎
15 ◎

NATURAL DRY DENSITY (pcf) ☆
80 100 120
WATER CONTENT (%) ×
PL LL
20 40 60
18.5 ×

Date Boring Started:	7/5/17 12:25 pm	Water Levels (ft)	Remarks: Located ~3' N of shoulder
Date Boring Completed:	7/5/17 12:40 pm	▽ At Time of Drilling	
Logged By:	AMS3	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 85 F

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LOG OF BORING RD096

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.63479° Long: -83.77712°	Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf (0 2,5 5)
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5								
		CRUSHED STONE: [fill].	0.7ft						
	1.0								
	1.5	FAT CLAY (CH): dark brownish black; moist; medium stiff; trace reddish brown mottling; trace fine sand.	1.5ft			1	56	7	7 ◎
	2.0								
	2.5								
	3.0								
		FAT CLAY (CH): grayish brown; moist; medium stiff; trace reddish brown mottling; with gravel; trace sand.	3.3ft						
	3.5								
	4.0					2	78	6	6 ◎
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	7/5/17 12:05 pm	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	7/5/17 12:20 pm	▽ At Time of Drilling	
Logged By:	AMS3	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 80 F

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LOG OF BORING RD097

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.63437° Long: -83.78170°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.						
	0.5	CRUSHED STONE: [fill].	0.5ft					
	1.0	SANDY LEAN CLAY (CL): grayish brown; moist; stiff; trace gray mottling; trace sand; few gravel.	0.9ft			1	67	10
	1.5							
	2.0							
	2.5							
	3.0	LEAN CLAY (CL): brown; moist; stiff; trace black and red mottling.	3.0ft			2	67	9
	3.5							
	4.0							
	4.5							
	5.0	Bottom of Boring at 5.0 feet	5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
0 2.5 5

NATURAL DRY DENSITY (pcf) ☆
80 100 120
WATER CONTENT (%) ×
PL LL
20 40 60

10 ◎
9 ◎
16 33
× 12.8

Date Boring Started:	7/5/17 11:40 am	Water Levels (ft)	Remarks: Located 2.5' N of shoulder
Date Boring Completed:	7/5/17 11:55 am	▽ At Time of Drilling	
Logged By:	AMS3	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 80 F

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LOG OF BORING RD098

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:	Lat: 40.63384° Long: -83.78651°	Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	ASPHALT: black.						
	0.5	CRUSHED STONE: [fill].	0.5ft					
	1.0	FAT CLAY (CH): dark brown to dark grayish brown; moist; medium stiff; trace organics; trace brown mottling.	1.0ft			1	11	6
	3.0	FAT CLAY (CH): grayish brown; moist; medium stiff; trace red mottling; trace gravel; trace sand at 5'.	3.0ft			2	33	5
	5.0	Bottom of Boring at 5.0 feet	5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
0 2.5 5

NATURAL DRY DENSITY (pcf) ☆
80 100 120
WATER CONTENT (%) ×
PL LL
20 40 60

6 ◎
5 ◎
22.8 ×

Date Boring Started:	7/5/17 11:20 am	Water Levels (ft)	Remarks: Located 2.5' N of shoulder
Date Boring Completed:	7/5/17 11:40 am	▽ At Time of Drilling	
Logged By:	AMS3	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 80 F

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LOG OF BORING RD099

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf □ Qp/2 (0 2,5 5)
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill].	0.5ft						
	1.0								
	1.5	LEAN TO FAT CLAY (CL-CH): dark gray to brown; moist; medium stiff to stiff; trace organics; trace sand and gravel.	1.7ft						
	2.0					1	44	11	11 ◎ 1.25
	2.5								
	3.0								
	3.5								
	4.0					2	64	8	8 ◎
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/8/17 10:00 am	Water Levels (ft)	Remarks: Located 2.5' N of shoulder
Date Boring Completed:	12/8/17 10:20 am	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 20 F

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LOG OF BORING RD100

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf □ Qp/2 (0 2,5 5)
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill].	0.5ft						
	1.0								
	1.5	LEAN TO FAT CLAY (CL-CH): dark gray to brown; moist; medium stiff to stiff; trace organics; trace sand and gravel; trace orange mottling.	1.7ft						
	2.0					1	39	10	◎ 10, □ 1.25
	2.5								
	3.0								
	3.5								
	4.0					2	61	7	◎ 7, □ 1.13
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/8/17 9:40 am	Water Levels (ft)	Remarks: Located 2' N of shoulder
Date Boring Completed:	12/8/17 9:55 am	▼ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 18 F

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LOG OF BORING RD101

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ 10 20 30 40 REC% RQD % ◆ 20 40 60 80 SHEAR STRENGTH, tsf □ Qp/2 0 2.5 5
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill].	0.5ft						
	1.0								
	1.5	LEAN TO FAT CLAY (CL-CH): dark gray to brown; moist; medium stiff to stiff; trace organics; trace sand and gravel; trace orange mottling.	1.7ft						
	2.0					1	28	9	9 ◎
	2.5								
	3.0								
	3.5								
	4.0					2	67	7	7 ◎ 0.875
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/8/17 9:25 am	Water Levels (ft)	Remarks: Located 3.5' N of shoulder
Date Boring Completed:	12/8/17 9:35 am	▼ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 18 F

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LOG OF BORING RD102

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40; REC%; RQD % ◆ 20 40 60 80; SHEAR STRENGTH, tsf; □ Qp/2; 0 2.5 5)
	0.0	Surface Elev.: Unknown						
	0.5	TOPSOIL: dark brown to black; moist.						
	1.0							
	1.5	LEAN TO FAT CLAY (CL-CH): dark gray to brown; moist; medium stiff to stiff; trace organics; trace sand and gravel. 1.5ft			1	56	7	7 ◎ 0.75
	2.0							
	2.5							
	3.0							
	3.5							
	4.0				2	78	10	10 ◎ 1.13
	4.5							
	5.0	Bottom of Boring at 5.0 feet 5.0ft						

Date Boring Started:	12/8/17 10:30 am	Water Levels (ft)	Remarks: Located 5' W of tilled field on field access road
Date Boring Completed:	12/8/17 10:50 am	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 20 F

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LOG OF BORING RD103

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf □ Qp/2 (0 2,5 5)
		Surface Elev.: Unknown							
	0.0	TOPSOIL: dark brown to black; moist.							
	0.5								
	1.0								
	1.5								
	2.0	LEAN TO FAT CLAY (CL-CH): dark gray to brown; moist; medium stiff to stiff; trace organics; trace sand and gravel.	2.0ft			1	47	11	11 ◎ 1.13
	2.5								
	3.0								
	3.5								
	4.0					2	78	9	9 ◎
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/8/17 11:00 am	Water Levels (ft)	Remarks: Located 6' W of tilled field on field access road
Date Boring Completed:	12/8/17 11:20 am	▽ At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 20 F

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LOG OF BORING RD104

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ 10 20 30 40 REC% RQD % ◆ 20 40 60 80 SHEAR STRENGTH, tsf □ Qp/2 0 2.5 5
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill].	0.5ft						
	1.0	LEAN TO FAT CLAY (CL-CH): dark gray to brown; moist; stiff; trace organics; trace sand and gravel; trace orange mottling.	1.0ft			1	50	14	14 ◎ □ 1.63
	2.0								
	2.5								
	3.0								
	3.5								
	4.0					2	67	10	10 ◎ □ 1.38
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/6/17	Water Levels (ft)	Remarks: Located 2.5' N of shoulder
Date Boring Completed:	12/6/17	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

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LOG OF BORING RD105

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40); REC%; RQD % ◆ (20 40 60 80); SHEAR STRENGTH, tsf; □ Qp/2 (0 2,5 5)
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill].	0.5ft						
	1.0	LEAN TO FAT CLAY (CL-CH): dark gray to brown; moist; stiff; trace organics; trace sand and gravel; trace orange mottling.	1.1ft						
	1.5								
	2.0					1	50	11	11 ◎ 1.13
	2.5								
	3.0								
	3.5								
	4.0					2	78	12	12 ◎ 1.38
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/6/17	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	12/6/17	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

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LOG OF BORING RD106

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / SHEAR STRENGTH, tsf □ Qp/2
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill].	0.7ft						
	1.0	LEAN TO FAT CLAY (CL-CH): dark gray to brown; moist; medium stiff; trace organics; trace sand and gravel; trace orange mottling.	1.1ft			1	25	8	8 ◎ □ 1.25
	2.0								
	2.5								
	3.0								
	3.5								
	4.0					2	92	7	7 ◎ □ 0.875
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

STANDARD PENETRATION TEST DATA N in blows/ft ◎: 10 20 30 40
REC% ▬
RQD % ◆: 20 40 60 80
SHEAR STRENGTH, tsf □ Qp/2: 0 2,5 5

Date Boring Started:	12/6/17	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	12/6/17	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

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LOG OF BORING RD107

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40); REC%; RQD % ◆ (20 40 60 80); SHEAR STRENGTH, tsf; □ Qp/2 (0 2,5 5)
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5								
		CRUSHED STONE: very loose; [fill].	0.7ft						
	1.0								
	1.5								
		LEAN TO FAT CLAY (CL-CH): brown; moist; stiff; trace organics; trace sand and gravel; trace orange mottling.	1.8ft			1	44	9	◎ 9; □ 2.25
	2.0								
	2.5								
	3.0								
	3.5								
	4.0					2	67	18	◎ 18; □ 1.75
	4.5								
	5.0								
		Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/6/17	Water Levels (ft)	Remarks: Located 3.5' NE of shoulder
Date Boring Completed:	12/6/17	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

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LOG OF BORING RD108

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf □ Qp/2 (0 2,5 5)
	0.0	Surface Elev.: Unknown							
	0.5	ASPHALT: black.							
		CRUSHED STONE: [fill].	0.5ft						
	1.0	LEAN TO FAT CLAY (CL-CH): brown; moist to wet; stiff; trace organics; trace sand and gravel; trace orange mottling.	0.9ft						
	1.5								
	2.0					1	61	8	8 ◎ 0.625
	2.5								
	3.0								
	3.5								
	4.0					2	61	7	7 ◎
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/6/17	Water Levels (ft)	Remarks: Located 2' E of shoulder
Date Boring Completed:	12/6/17	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

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LOG OF BORING RD109

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.: Unknown						
	0.0	ASPHALT: black.						
	1.0	CRUSHED STONE: [fill].	1.0ft					
	1.8	LEAN TO FAT CLAY (CL-CH): brown; moist; stiff; trace organics; trace sand and gravel; trace orange mottling.	1.8ft			1	44	11
	2					2	50	9
	5.0	Bottom of Boring at 5.0 feet	5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5

11
1.5
9
0.625

Date Boring Started:	12/6/17	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	12/6/17	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

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LOG OF BORING RD110

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ 10 20 30 40 REC% RQD % ◆ 20 40 60 80 SHEAR STRENGTH, tsf □ Qp/2 0 2,5 5
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill].	0.5ft						
	1.0	POORLY GRADED SAND WITH SILT (SP-SM): fine to coarse grained; brown; moist; [fill]; with gravel.	1.0ft						
	1.5	LEAN TO FAT CLAY (CL-CH): brown; moist; stiff; trace organics; trace sand and gravel; trace orange mottling.	1.8ft			1	28	6	6 □ 0.375
	2.0								
	2.5								
	3.0								
	3.5								
	4.0					2	83	8	8 □ 0.625
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/6/17	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	12/6/17	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

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LOG OF BORING RD111

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf □ Qp/2 (0 2,5 5)
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill].	0.5ft						
	1.0	LEAN TO FAT CLAY (CL-CH): dark gray to brown; moist; stiff to very stiff; trace organics; trace sand and gravel; trace orange mottling.	1.0ft			1	50	9	9 ◎ □ 1.13
	2.0								
	2.5								
	3.0								
	3.5								
	4.0					2	83	19	19 ◎ □ 2.25
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/6/17	Water Levels (ft)	Remarks: Located 3' S of shoulder
Date Boring Completed:	12/6/17	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

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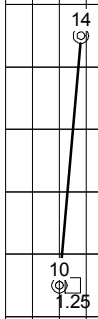
LOG OF BORING RD112

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.: Unknown						
	0.0	ASPHALT: black.						
	0.5	CRUSHED STONE: [fill].	0.7ft					
	1.0	POORLY GRADED SAND WITH SILT (SP-SM): fine to coarse grained; brown; moist; [fill]; with gravel.	1.3ft					
	1.5	LEAN TO FAT CLAY (CL-CH): brown; moist; stiff; trace organics; trace sand and gravel; trace orange mottling.	1.7ft			1	56	14
	2.0							
	2.5							
	3.0							
	3.5							
	4.0					2	61	10
	4.5							
	5.0	Bottom of Boring at 5.0 feet	5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5



Date Boring Started:	12/7/17 12:50 pm	Water Levels (ft)	Remarks: Located 4' N of shoulder
Date Boring Completed:	12/7/17 1:05 pm	At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		Weather: Sunny, 25 F
Drill Rig:			

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LOG OF BORING RD113

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf □ Qp/2 (0 2,5 5)
	0.0	Surface Elev.: Unknown							
	0.5	ASPHALT: black.							
	1.0	CRUSHED STONE: [fill].	0.7ft						
	1.5	LEAN TO FAT CLAY (CL-CH): brown; moist; stiff to very stiff; trace organics; trace to with sand; trace gravel; trace orange mottling.	1.4ft						
	2.0					1	67	11	11 ◎ □ 1.75
	2.5								
	3.0								
	3.5								
	4.0					2	83	21	21 ◎ □ 2.25
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/7/17 1:15 pm	Water Levels (ft)	Remarks: Located 3.5' N of shoulder
Date Boring Completed:	12/7/17 1:30 pm	▼ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 20 F

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LOG OF BORING RD114

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / REC% / RQD % ◆ / SHEAR STRENGTH, tsf □ Qp/2
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5								
		CRUSHED STONE: [fill].	0.7ft						
	1.0								
	1.5	LEAN TO FAT CLAY (CL-CH): brown; moist; medium stiff to stiff; trace organics; trace to with sand; trace gravel; trace orange mottling.	1.4ft			1	61	15	15 ◎ □ 1.88
	2.0								
	2.5								
	3.0								
	3.5								
	4.0					2	44	7	7 ◎ □ 1.13
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/7/17 1:30 pm	Water Levels (ft)	Remarks: Located 4' N of shoulder
Date Boring Completed:	12/7/17 1:45 pm	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 20 F

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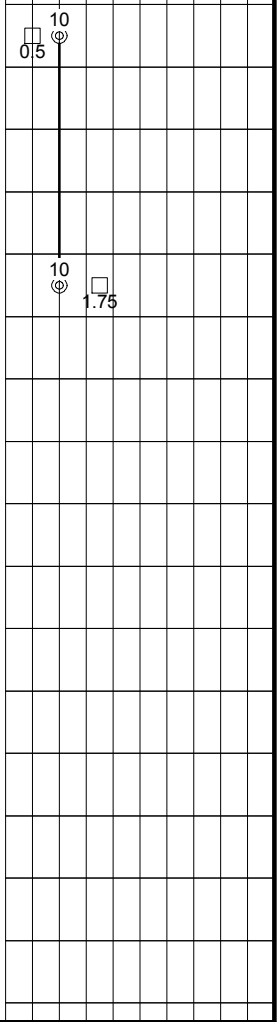
LOG OF BORING RD115

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.: Unknown						
	0.0	ASPHALT: black.						
	0.5							
	0.8	CRUSHED STONE: [fill].	0.8ft					
	1.0							
	1.4	LEAN TO FAT CLAY (CL-CH): brown; moist; medium stiff to stiff; trace organics; trace to with sand; trace gravel; trace orange mottling.	1.4ft					
	2.0					1	28	10
	2.5							
	3.0							
	3.5							
	4.0					2	67	10
	4.5							
	5.0	Bottom of Boring at 5.0 feet	5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5



Date Boring Started:	12/7/17 1:50 pm	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	12/7/17 2:15 pm	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 20 F

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LOG OF BORING RD116

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40); REC%; RQD % ◆ (20 40 60 80); SHEAR STRENGTH, tsf; □ Qp/2 (0 2,5 5)
	0.0	Surface Elev.: Unknown							
	0.5	ASPHALT: black.							
	1.0	CRUSHED STONE: [fill].	0.8ft						
	1.5	LEAN TO FAT CLAY (CL-CH): brown; moist; stiff; trace organics; trace to with sand; trace gravel; trace orange mottling.	1.5ft			1	56	10	10 ◎
	2.0								
	2.5								
	3.0								
	3.5								
	4.0					2	78	10	10 ◎
	4.5								□ 0.375
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/7/17 2:20 pm	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	12/7/17 2:35 pm	▽ At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Overcast, 20 F

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LOG OF BORING RD117

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf □ Qp/2 (0 2,5 5)
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5								
		CRUSHED STONE: [fill].	0.7ft						
	1.0								
	1.5	LEAN TO FAT CLAY (CL-CH): brown; moist; very stiff; trace organics; trace to with sand; trace gravel; trace orange mottling.	1.4ft						
	2.0					1	72	17	17 ◎ □ 2.25
	2.5								
	3.0								
	3.5								
	4.0					2	89	22	22 ◎ 2.25
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/7/17 2:45 pm	Water Levels (ft)	Remarks: Located 4' N of shoulder
Date Boring Completed:	12/7/17 3:00 pm	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Overcast, 20 F

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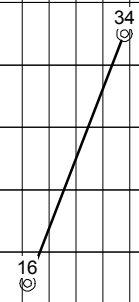
LOG OF BORING RD118

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
		Surface Elev.: Unknown						
	0.0	ASPHALT: black.						
	0.5							
	1.0	CRUSHED STONE: brown and black; moist; dense; [fill]; mix of natural stone and recycled asphalt.	0.8ft					
	1.5							
	2.0					1	72	34
	2.5							
	3.0							
	3.5	SILTY SAND (SM): brown; moist; medium dense; with gravel.	3.5ft					
	4.0					2	56	16
	4.5							
	5.0	Bottom of Boring at 5.0 feet	5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
0 2.5 5



Date Boring Started:	12/7/17 3:05 pm	Water Levels (ft)	Remarks: Located 5' N of shoulder
Date Boring Completed:	12/7/17 3:20 pm	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Overcast, 20 F

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LOG OF BORING RD119

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ 10 20 30 40 REC% RQD % ◆ 20 40 60 80 SHEAR STRENGTH, tsf □ Qp/2 0 2,5 5
	0.0	Surface Elev.: Unknown							
	0.5	ASPHALT: black.							
	1.0	CRUSHED STONE: [fill].	0.6ft						
	1.5	LEAN TO FAT CLAY (CL-CH): brown; moist; stiff; trace organics; trace to with sand; trace gravel; trace orange mottling.	1.3ft			1	33	11	11 ◎
	2.0								
	2.5								
	3.0								
	3.5								
	4.0					2	67	9	9 ◎ □
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Located 3' E of shoulder
Date Boring Completed:	12/5/17	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

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LOG OF BORING RD120

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / REC% / RQD % ◆ / SHEAR STRENGTH, tsf □ Qp/2
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill].	0.6ft						
	1.0								
	1.5								
	2.0	LEAN TO FAT CLAY (CL-CH): gray to brown to bluish gray; moist; medium stiff; trace organics; trace to with sand; trace gravel; trace orange mottling.	2.0ft			1	67	8	◎ 8; □ 1.63
	2.5								
	3.0								
	3.5								
	4.0					2	39	6	◎ 6; □ 0.25
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	12/5/17	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

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LOG OF BORING RD121

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf (0 2,5 5)
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill].	0.6ft						
	1.0								
	1.5	POORLY GRADED SAND WITH SILT (SP-SM): fine grained; brown; moist; with gravel.	1.5ft						
	2.0	LEAN TO FAT CLAY (CL-CH): gray to brown to bluish gray; moist; medium stiff to very stiff; trace to with sand; trace gravel; trace orange mottling.	2.0ft			1	56	8	8 ◎
	2.5								
	3.0								
	3.5								
	4.0					2	94	28	28 ◎
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	12/5/17	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

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LOG OF BORING RD122

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40); REC%; RQD % ◆ (20 40 60 80); SHEAR STRENGTH, tsf; □ Qp/2 (0 2,5 5)
	0.0	Surface Elev.: Unknown							
	0.5	ASPHALT: black.							
	1.0	CRUSHED STONE: [fill].	0.7ft						
	1.5	LEAN TO FAT CLAY (CL-CH): gray to brown; moist; stiff to very stiff; trace organics; trace to with sand; trace gravel; trace orange mottling.	1.2ft						
	2.0					1	72	12	◎ 12, □ 1.38
	2.5								
	3.0								
	3.5								
	4.0					2	83	17	◎ 17, □ 1.13
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	12/5/17	▼ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

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LOG OF BORING RD123

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Surface Elev.: Unknown

Depth, feet	MATERIAL DESCRIPTION	Sample No.	% Recovery	SPT, N value or RQD %
0.0	ASPHALT: black. 0.1ft			
0.5	CRUSHED STONE: [fill].			
1.0				
1.2ft	LEAN TO FAT CLAY (CL-CH): gray to brown; moist; stiff; trace organics; trace to with sand; trace gravel; trace orange mottling.			
1.5				
2.0		1	50	9
2.5				
3.0				
3.5				
4.0		2	83	11
4.5				
5.0	Bottom of Boring at 5.0 feet 5.0ft			

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5

9 ◎ □ 1.38
11 ◎ □ 2.25

Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Located 2.5' N of shoulder
Date Boring Completed:	12/5/17	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

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LOG OF BORING RD124

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40); REC%; RQD % ◆ (20 40 60 80); SHEAR STRENGTH, tsf; □ Qp/2 (0 2.5 5)
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5								
	1.0	CRUSHED STONE: [fill].	0.8ft						
	1.5	LEAN TO FAT CLAY (CL-CH): gray to brown; moist; medium stiff; trace organics; trace to with sand; trace gravel; trace orange mottling.	1.4ft						
	2.0					1	28	8	8, 1.13
	2.5								
	3.0	ORGANIC CLAY (OH): black to dark gray; moist; loose; trace gravel.	2.7ft						
	3.5		3.5ft						
	4.0					2	22	1	1
	4.5								
	5.0	Bottom of Boring at 5.0 feet				3	28	4	4

Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Located 3.5' N of shoulder
Date Boring Completed:	12/5/17	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

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LOG OF BORING RD125

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40); REC%; RQD % ◆ (20 40 60 80); SHEAR STRENGTH, tsf (0 2,5 5)
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill].	0.4ft						
	1.0	LEAN TO FAT CLAY (CL-CH): gray to brown; moist; medium stiff; trace organics; trace to with sand; trace gravel; trace orange mottling.	1.0ft			1	28	9	9 ◎
	2.5	ORGANIC CLAY (OH): black to dark gray; moist; loose; trace gravel.	2.6ft						
	3.5		3.5ft			2	22	3	3 ◎
	5.0	Bottom of Boring at 5.0 feet							

Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Located 3.5' N of shoulder
Date Boring Completed:	12/5/17	▽ At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		Weather: Partly Cloudy, 35 F
Drill Rig:			

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LOG OF BORING RD126

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	7.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf (0 2,5 5)
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill].	0.6ft						
	1.0								
	1.5	ORGANIC CLAY (OH): black to dark gray; moist; very loose to loose; trace gravel.	1.3ft			1	17	5	5 ◎
	2.0								
	2.5								
	3.0								
	3.5								
	4.0					2	11	3	3 ◎
	4.5								
	5.0								
	5.5								
	6.0	LEAN TO FAT CLAY (CL-CH): gray to brown; moist; trace to with sand; trace gravel; trace orange mottling.	6.0ft						
	6.5								
	7.0	Bottom of Boring at 7.0 feet	7.0ft						

Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Located 4' N of shoulder
Date Boring Completed:	12/5/17	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

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LOG OF BORING RD127

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	6.5 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.: Unknown						
	0.0	ASPHALT: black.						
	1.0	CRUSHED STONE: [fill].	1.0ft					
	1.5	LEAN TO FAT CLAY (CL-CH): blueish gray; moist; medium stiff; trace sand; trace gravel.	1.5ft			1	22	7
	3.5	ORGANIC CLAY (OH): black to dark gray; moist; trace gravel and sand.	3.5ft					
	4.0	LEAN TO FAT CLAY (CL-CH): blueish gray; moist; very soft to soft; trace sand; trace gravel.	4.0ft			2, 3	50	1
	5.5					4	100	4
	6.5	Bottom of Boring at 6.5 feet	6.5ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5

7 ◎ □ 1.38
1 ◎ □ 0
4 ◎ □ 0.25

Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Located 3.5' N of shoulder
Date Boring Completed:	12/5/17	▼ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

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LOG OF BORING RD128

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	6.5 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf (0 2,5 5)
	0.0	Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill]; with sand.	0.4ft						
	2.0	CLAYEY SAND (SC): medium to coarse grained; brown; moist; very loose to loose; trace gravel.	2.0ft			1	28	8	8 ◎
	4.0					2	8	1	1 ◎
	5.0	LEAN TO FAT CLAY (CL-CH): blueish gray; moist; very loose; trace sand; trace gravel.	5.0ft			3	67	4	4 ◎
	6.5	Bottom of Boring at 6.5 feet	6.5ft						

Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	12/5/17	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

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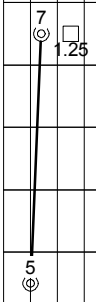
LOG OF BORING RD129

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.: Unknown						
	0.0	ASPHALT: black.						
	0.5	CRUSHED STONE: [fill].	0.3ft					
	1.0	POORLY GRADED SAND (SP-SM): medium to coarse grained; [fill]; with gravel.	1.0ft					
	1.5	LEAN TO FAT CLAY (CL-CH): light brown to greenish gray; moist; medium stiff; trace gravel.	1.5ft					
	2.0	ORGANIC CLAY (OH): black; moist.	2.3ft			1	22	7
	2.5							
	3.0							
	3.5	SANDY LEAN CLAY (CL): greenish gray; moist; medium stiff; trace organics; trace gravel.	3.5ft					
	4.0					2	22	5
	4.5							
	5.0	Bottom of Boring at 5.0 feet	5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5



Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Located 4' N of shoulder
Date Boring Completed:	12/5/17	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

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LOG OF BORING RD130

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf (0 2,5 5)
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill]; with sand.	0.4ft						
	1.0	OGANIC SILT (OH): very dark brown; moist; very loose to medium dense; trace sand and gravel.	1.1ft			1	44	7	7 ◎
	2.0								
	2.5								
	3.0								
	3.5								
	4.0					2	11	2	2 ◎
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Located 3.5' N of shoulder
Date Boring Completed:	12/5/17	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

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LOG OF BORING RD131

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf (0 2,5 5)
	0.0	Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill]; with sand.	0.6ft						
	1.0								
	1.5	ORGANIC CLAY (OH): very dark brown; moist; very loose to medium dense; trace sand.	1.3ft			1	50	11	11 ◎
	2.0								
	2.5								
	3.0								
	3.5								
	4.0					2	0	3	3 ◎
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Boring in intersection approximately 12 ft E and 12 ft W of each shoulder
Date Boring Completed:	12/5/17	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		Weather: Partly Cloudy, 35 F
Drill Rig:			

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LOG OF BORING RD132

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf (0 2,5 5)
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill]; with sand.	0.3ft						
		ORGANIC CLAY (OH): very dark brown; moist; loose.	0.6ft						
	1.0								
	1.5								
	2.0					1	17	5	5 ◎
	2.5								
	3.0								
	3.5	LEAN TO FAT CLAY (CL-CH): blueish gray; moist; medium stiff; trace sand; trace gravel.	3.5ft						
	4.0					2	50	7	7 ◎
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/7/17	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	12/7/17	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

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LOG OF BORING RD133

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf (0 2,5 5)
	0.0	Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill]; with sand.	0.7ft						
	1.0	CLAYEY SAND (SC): fine to medium grained; brown; moist; medium dense; with gravel.	1.3ft			1	56	11	11 ◎
	2.0								
	2.5								
	3.0	ORGANIC CLAY (OH): very dark brown; moist; soft; trace sand.	2.8ft						
	3.5								
	4.0					2	44	4	4 ◎
	4.5	LEAN TO FAT CLAY (CL-CH): gray; moist; trace sand; trace gravel.	4.5ft						
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/7/17 4:25 pm	Water Levels (ft)	Remarks: Located 4' N of shoulder
Date Boring Completed:	12/7/17 4:40 pm	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Overcast, 25 F

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LOG OF BORING RD134

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf (0 2,5 5)
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5								
	1.0	CRUSHED STONE: [fill]; with sand.	0.8ft						
	1.5	CLAYEY SAND (SC): fine to medium grained; brown; moist; with gravel.	1.4ft						
		ORGANIC CLAY (OH): very dark brown; moist; medium stiff; trace sand.	1.7ft						
	2.0					1	22	8	8 ◎
	2.5								
	3.0								
	3.5								
		LEAN TO FAT CLAY (CL-CH): gray; moist; soft; trace sand; trace gravel.	3.7ft						
	4.0					2	58	4	4 ◎
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/7/17 4:45 pm	Water Levels (ft)	Remarks: Located 4' N of shoulder
Date Boring Completed:	12/7/17 4:55 pm	▽ At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Overcast, 25 F

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LOG OF BORING RD135

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf (0 2,5 5)
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5								
	0.8	CRUSHED STONE: [fill]; with sand.	0.8ft						
	1.0								
	1.5	LEAN TO FAT CLAY (CL-CH): brown; moist; medium stiff; trace sand; trace gravel.	1.5ft						
	2.0								6 ◎
	2.2	ORGANIC CLAY (OH): very dark brown; moist; soft; trace sand.	2.2ft			1	11	6	
	2.5								
	3.0								
	3.5								
	4.0	LEAN TO FAT CLAY (CL-CH): gray to brown; moist; trace sand; trace gravel.	4.0ft			2	56	4	4 ◎
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/7/17 5:00 pm	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	12/7/17 5:15 pm	▽ At Time of Drilling Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Overcast, 25 F

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LOG OF BORING RD136

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40); REC%; RQD % ◆ (20 40 60 80); SHEAR STRENGTH, tsf; □ Qp/2 (0 2,5 5)
	0.0	Surface Elev.: Unknown							
	0.5	ASPHALT: black.							
		CRUSHED STONE: [fill]; with sand.	0.4ft						
	1.0	LEAN TO FAT CLAY (CL-CH): brown; moist; very stiff; trace sand; trace gravel.	1.0ft			1	67	17	17 ◎ at 1.63
	1.5								
	2.0								
	2.5	ORGANIC CLAY (OH): very dark brown; moist; trace sand.	2.5ft						
	3.0								
	3.5	LEAN TO FAT CLAY (CL-CH): gray to brown; moist; stiff; trace sand; trace gravel.	3.5ft						
	4.0					2	50	12	12 ◎ at 1.88 □
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/7/17 10:20 am	Water Levels (ft)	Remarks: Located 3.5' N of shoulder
Date Boring Completed:	12/7/17 10:40 am	▽ At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Overcast, 25 F

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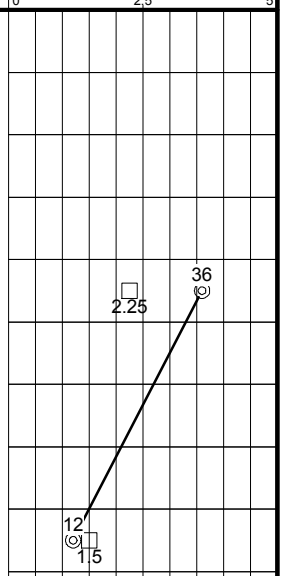
LOG OF BORING RD137

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.: Unknown						
	0.0	ASPHALT: black.						
	0.5	CRUSHED STONE: [fill]; with sand.	0.4ft					
	1.0							
	1.5	LEAN TO FAT CLAY (CL-CH): brown to gray; moist; stiff to hard; trace sand; trace gravel.	1.3ft			1	72	36
	2.0							
	2.5							
	3.0							
	3.5							
	4.0					2	83	12
	4.5							
	5.0	Bottom of Boring at 5.0 feet	5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC% ▬▬▬
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5



Date Boring Started:	12/7/17 10:45 am	Water Levels (ft)	Remarks: Located 4' S of shoulder
Date Boring Completed:	12/7/17 11:05 am	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Overcast, 25 F

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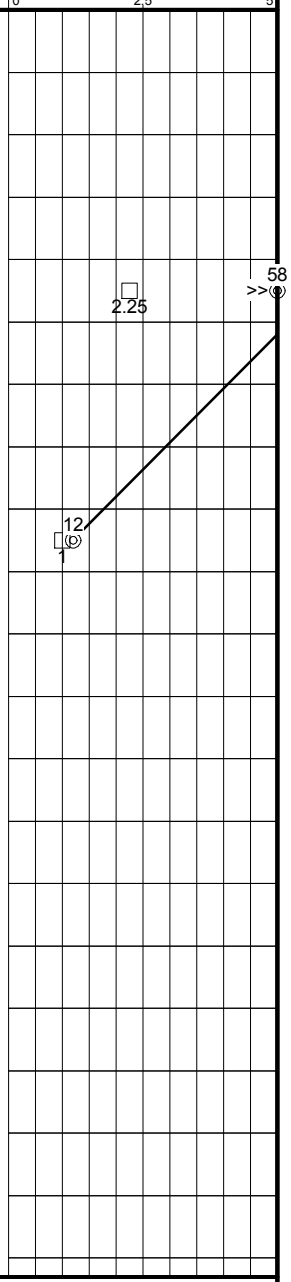
LOG OF BORING RD138

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.: Unknown					
	0.0	ASPHALT: black.					
	0.5	CRUSHED STONE: [fill]; with sand. 0.5ft					
	1.0						
	1.3	LEAN TO FAT CLAY (CL-CH): brown to gray; moist; stiff to hard; trace sand; trace gravel.			1	61	58
	2.0						
	2.5						
	3.0						
	3.5						
	4.0				2	86	12
	4.5						
	5.0	Bottom of Boring at 5.0 feet 5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5



Date Boring Started:	12/7/17 11:45 am	Water Levels (ft)	Remarks: Located 4' S of shoulder
Date Boring Completed:	12/5/17	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Overcast, 25 F

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LOG OF BORING RD139

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf (0 2,5 5)
	0.0	Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill]; with sand.	0.5ft						
	1.0								
	1.5	ORGANIC CLAY (OH): very dark brown; moist; loose; trace sand; trace gravel.	1.3ft			1	28	6	6 ◎
	2.0								
	2.5								
	3.0								
	3.5								
	4.0	LEAN TO FAT CLAY (CL-CH): gray to brown; moist; medium stiff; trace sand; trace gravel.	4.0ft			2	28	5	5 ◎
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/8/17 8:00 am	Water Levels (ft)	Remarks: Located 2.5' N of shoulder
Date Boring Completed:	12/8/17 8:15 am	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 16 F

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LOG OF BORING RD140

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf □ Qp/2 (0 2.5 5)
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill]; with sand.	0.5ft						
	1.0	LEAN TO FAT CLAY (CL-CH): brown to gray; moist; trace sand; trace gravel.	1.3ft						
	1.5	ORGANIC CLAY (OH): very dark brown; moist; loose; trace sand; trace gravel.	1.8ft			1	33	9	◎ 9, □ 1.5
	2.0								
	2.5								
	3.0								
	3.5	LEAN TO FAT CLAY (CL-CH): gray; moist; medium stiff; trace sand; trace gravel.	3.7ft			2	72	5	◎ 5, □ 0.875
	4.0								
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/8/17 8:30 am	Water Levels (ft)	Remarks: Located 3' N of shoulder
Date Boring Completed:	12/8/17 8:45 am	▽ At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 16 F

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LOG OF BORING RD141

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill]; with sand.	0.5ft						
	1.0	ORGANIC CLAY (OH): very dark brown; moist; stiff; trace sand; trace gravel.	1.2ft			1	17	12	12 (◎)
	3.5	LEAN TO FAT CLAY (CL-CH): gray to brown; moist; stiff; trace sand; trace gravel.	3.5ft			2	75	12	12 (◎) 1.25
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

REC%
RQD % ◆
SHEAR STRENGTH, tsf
□ Qp/2

Date Boring Started:	12/8/17 8:55 am	Water Levels (ft)	Remarks: Located 2' N of shoulder
Date Boring Completed:	12/8/17 9:15 am	▼ At Time of Drilling	
Logged By:	MAN2	⏚ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 16 F

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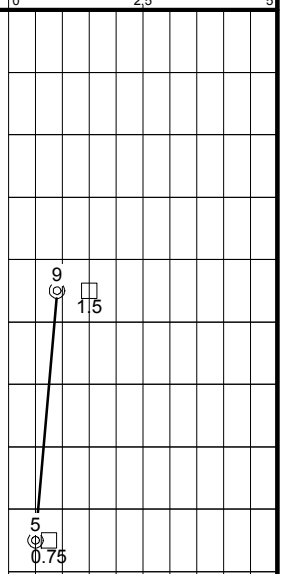
LOG OF BORING RD142

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.: Unknown						
	0.0	ASPHALT: black.						
	0.5							
	0.7	CRUSHED STONE: [fill]; with sand.	0.7ft					
	1.0							
	1.4	LEAN TO FAT CLAY (CL-CH): gray to brown; moist; medium stiff to stiff; trace sand; trace gravel.	1.4ft					
	1.5					1	44	9
	2.0							
	2.5							
	3.0							
	3.5							
	4.0					2	44	5
	4.5							
	5.0	Bottom of Boring at 5.0 feet	5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5



Date Boring Started:	12/6/17	Water Levels (ft)	Remarks: Located 3.5' N of shoulder
Date Boring Completed:	12/6/17	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

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LOG OF BORING RD143

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf □ Qp/2 (0 2.5 5)
	0.0	Surface Elev.: Unknown							
	0.5	ASPHALT: black.							
		CRUSHED STONE: [fill]; with sand.	0.6ft						
	1.0	LEAN TO FAT CLAY (CL-CH): gray to brown; moist; stiff; trace sand; trace gravel.	1.0ft			1	50	11	◎ 11, □ 1.63
	1.5								
	2.0								
	2.5								
	3.0								
	3.5								
	4.0					2	72	9	◎ 9, □ 1.88
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/6/17	Water Levels (ft)	Remarks: Located 2' N of shoulder
Date Boring Completed:	12/6/17	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

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LOG OF BORING RD144

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.: Unknown						
	0.0	ASPHALT: black.						
	0.5	CRUSHED STONE: [fill]; with sand.	0.7ft					
	1.0	LEAN TO FAT CLAY (CL-CH): brown to dark brown; moist; medium stiff to very stiff; trace to with sand; trace gravel; trace orange mottling.	1.3ft			1	28	5
	2.0							
	2.5							
	3.0							
	3.5							
	4.0					2	72	17
	4.5							
	5.0	Bottom of Boring at 5.0 feet	5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5

5 ◎ □ 0.75
17 ◎ □ 2.25

Date Boring Started:	12/7/17 9:30 am	Water Levels (ft)	Remarks: Located 4' S of shoulder
Date Boring Completed:	12/7/17 9:45 am	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Overcast, 25 F

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Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD145

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / REC% / RQD % ◆ / SHEAR STRENGTH, tsf □ Qp/2
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill]; with sand.	0.6ft						
	1.0								
	1.5	LEAN TO FAT CLAY (CL-CH): brown to dark brown; moist; medium stiff to stiff; trace to with sand; trace gravel; trace orange mottling.	1.3ft			1	50	11	◎ 11, □ 1.75
	2.0								
	2.5								
	3.0								
	3.5								
	4.0					2	44	7	◎ 7, □ 1.25
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/7/17 9:10 am	Water Levels (ft)	Remarks: Located 2.5' N of shoulder
Date Boring Completed:	12/7/17 9:25 am	▽ At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 25 F

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Telephone: 952-832-2600

LOG OF BORING RD146

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf □ Qp/2 (0 2.5 5)
	0.0	Surface Elev.: Unknown							
	0.5	ASPHALT: black.							
	1.0	CRUSHED STONE: [fill]; with sand.	0.6ft						
	1.5	LEAN TO FAT CLAY (CL-CH): brown to gray; moist; stiff to very stiff; trace to with sand; trace gravel.	1.3ft			1	72	16	16 ◎ □ 2.25
	2.0								
	2.5								
	3.0								
	3.5								
	4.0					2	50	15	15 ◎ □ 2.25
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/7/17 8:50 am	Water Levels (ft)	Remarks: Located 2.5' N of shoulder
Date Boring Completed:	12/7/17 9:05 am	▼ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 25 F

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LOG OF BORING RD147

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / REC% / RQD % ◆ / SHEAR STRENGTH, tsf □ Qp/2
		Surface Elev.: Unknown							10 20 30 40 / 20 40 60 80 / 0 2.5 5
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill]; with sand.	0.6ft						
	1.0	LEAN TO FAT CLAY (CL-CH): brown; moist; medium stiff to very stiff; trace to with sand; trace gravel.	1.3ft						
	1.5								
	2.0					1	56	16	16 ◎ □ 2.25
	2.5								
	3.0								
	3.5								
	4.0					2	83	8	8 ◎ □ 1.75
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/7/17 8:30 am	Water Levels (ft)	Remarks: Located 3' S of shoulder
Date Boring Completed:	12/7/17 8:45 am	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 25 F

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Telephone: 952-832-2600

LOG OF BORING RD148

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / SHEAR STRENGTH, tsf □ Qp/2
	0.0	Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill]; with sand.	0.6ft						
	1.0								
	1.5	LEAN TO FAT CLAY (CL-CH): brown to dark brown; moist; medium stiff to very stiff; trace to with sand; trace gravel.	1.3ft			1	64	17	◎ 17, □ 1.88
	2.0								
	2.5								
	3.0								
	3.5								
	4.0					2	61	8	◎ 8, □ 1.75
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/7/17 7:50 am	Water Levels (ft)	Remarks: Located 1.5' S of shoulder
Date Boring Completed:	12/7/17 8:10 am	▽ At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 25 F

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LOG OF BORING RD149

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ 10 20 30 40 REC% RQD % ◆ 20 40 60 80 SHEAR STRENGTH, tsf □ Qp/2 0 2.5 5
	0.0	Surface Elev.: Unknown							
	0.5	ASPHALT: black.							
		CRUSHED STONE: [fill]; with sand.	0.8ft						
	1.0								
	1.5	LEAN TO FAT CLAY (CL-CH): brown to dark brown with gray; moist; medium stiff to stiff; trace to with sand; trace gravel; trace orange mottling.	1.7ft			1	22	11	11 ◎ 1.25
	2.0								
	2.5								
	3.0								
	3.5								
	4.0					2	47	7	7 ◎ 0.75
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/6/17 2:00 pm	Water Levels (ft)	Remarks: Located 3' S of shoulder
Date Boring Completed:	12/6/17 2:15 pm	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

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LOG OF BORING RD150

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf □ Qp/2 (0 2,5 5)
	0.0	Surface Elev.: Unknown							
	0.5	ASPHALT: black.							
	1.0	CRUSHED STONE: [fill]; with sand.	0.8ft						
	1.5	LEAN TO FAT CLAY (CL-CH): brown to dark brown with gray; moist; medium stiff to stiff; trace to with sand; trace gravel; trace orange mottling.	1.2ft			1	14	9	9 ◎
	2.0								
	2.5								
	3.0								
	3.5								
	4.0					2	83	9	9 ◎ □
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/6/17 2:15 pm	Water Levels (ft)	Remarks: Located 2' S of shoulder
Date Boring Completed:	12/6/17 2:30 pm	▼ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

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LOG OF BORING RD151

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION	Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf □ Qp/2 (0 2,5 5)
	0.0	Surface Elev.: Unknown						
	0.5	ASPHALT: black.						
	1.0	CRUSHED STONE: [fill]; with sand. 0.8ft						
	1.5	LEAN TO FAT CLAY (CL-CH): brown to dark brown with gray; moist; stiff; trace to with sand; trace gravel; trace orange mottling; trace organics. 1.2ft			1	14	9	9 ◎ 0.5
	2.0							
	2.5							
	3.0							
	3.5							
	4.0				2	83	9	9 ◎ 0.875
	4.5							
	5.0	Bottom of Boring at 5.0 feet 5.0ft						

Date Boring Started:	12/6/17 2:35 pm	Water Levels (ft)	Remarks: Located 2' S of shoulder
Date Boring Completed:	12/6/17 2:50 pm	▽ At Time of Drilling: Dry	
Logged By:	MAN2		
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

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LOG OF BORING RD152

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf (0 2,5 5)
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5								
		CRUSHED STONE: [fill]; with sand.	0.7ft						
	1.0								
	1.5	LEAN TO FAT CLAY (CL-CH): brown to gray; moist; medium stiff; trace sand.	1.4ft						
	2.0								
		ORGANIC CLAY (OH): very dark brown; moist; trace sand; trace gravel.	2.3ft			1	22	7	7 ◎
	2.5								
	3.0								
	3.5	LEAN TO FAT CLAY (CL-CH): brown to gray; moist; stiff; trace sand; trace gravel.	3.5ft						
	4.0					2	100	9	9 ◎
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/6/17 3:00 pm	Water Levels (ft)	Remarks: Located 2' S of shoulder
Date Boring Completed:	12/6/17 3:15 pm	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

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LOG OF BORING RD153

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf (0 2,5 5)
	0.0	Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill]; with sand.	0.5ft						
	1.0								
	1.5	ORGANIC CLAY (OH): very dark brown; moist; medium dense; trace sand; trace gravel.	1.5ft			1	22	7	7 ◎
	2.0								
	2.5								
	3.0	CLAYEY SAND (SC): fine to coarse grained; brown; moist; loose; trace gravel; orange mottling.	3.0ft						
	3.5								
	4.0					2	67	7	7 ◎
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/6/17 3:25 pm	Water Levels (ft)	Remarks: Located 5' S of shoulder
Date Boring Completed:	12/6/17 3:45 pm	▼ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

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LOG OF BORING RD154

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf □ Qp/2 (0 2.5 5)
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill]; with sand.	0.6ft						
	1.0	ORGANIC CLAY (OH): very dark brown; moist; loose; trace sand; trace gravel.	1.3ft			1	11	7	7 ◎
	1.5								
	2.0								
	2.5								
	3.0								
	3.5								
	4.0	LEAN TO FAT CLAY (CL-CH): brown to gray; moist; medium stiff; trace sand; trace gravel.	4.0ft			2	36	7	7 ◎ □ 0.5
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/6/17 3:50 pm	Water Levels (ft)	Remarks: Located 4' S of shoulder
Date Boring Completed:	12/6/17 4:05 pm	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

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LOG OF BORING RD155

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf (0 2,5 5)
	0.0	Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill]; with sand.	0.6ft						
	1.0	ORGANIC CLAY (OH): very dark brown; moist; loose; trace sand; trace gravel.	1.3ft			1	11	7	7 ◎
	1.5								
	2.0								
	2.5								
	3.0								
	3.5	LEAN TO FAT CLAY (CL-CH): brown to gray; moist; stiff; trace sand; trace gravel.	3.5ft			2	94	11	11 ◎
	4.0								
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/6/17 4:10 pm	Water Levels (ft)	Remarks: Located 3' S of shoulder
Date Boring Completed:	12/6/17 4:25 pm	▼ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

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LOG OF BORING RD156

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ / REC% / RQD % ◆ / SHEAR STRENGTH, tsf □ Qp/2
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill]; with sand.	0.6ft						
	1.0	SANDY LEAN CLAY (CL): brown to dark brown; moist; stiff; trace sand; trace gravel.	1.3ft			1	83	15	◎ 15, □ 2.25
	2.0								
	2.5								
	3.0								
	3.5								
	4.0	ORGANIC CLAY (OH): very dark brown; moist; loose; trace sand; trace gravel.	4.2ft			2	56	8	◎ 8, □ 0.625
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/6/17 4:30 pm	Water Levels (ft)	Remarks: Located 3' S of shoulder
Date Boring Completed:	12/6/17 4:45 pm	▼ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

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LOG OF BORING RD157

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ (10 20 30 40) REC% RQD % ◆ (20 40 60 80) SHEAR STRENGTH, tsf □ Qp/2 (0 2.5 5)
		Surface Elev.: Unknown							
	0.0	ASPHALT: black.							
	0.5	CRUSHED STONE: [fill]; with sand.	0.6ft						
	1.0								
	1.5	SANDY LEAN CLAY (CL): brown to dark brown; moist; stiff; trace sand; trace gravel.	1.3ft						
	2.0	LEAN TO FAT CLAY (CL-CH): brown to gray; moist; trace sand; trace gravel.	2.0ft			1	56	11	◎11 □2
	2.5								
	3.0								
	3.5	ORGANIC CLAY (OH): very dark brown; moist; loose; trace sand; trace gravel.	3.5ft						
	4.0					2	56	7	◎7 □0.25
	4.5	LEAN TO FAT CLAY (CL-CH): brown to gray; moist; trace sand; trace gravel.	4.5ft						
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/6/17 4:50 pm	Water Levels (ft)	Remarks: Located 3' S of shoulder
Date Boring Completed:	12/6/17 5:10 pm	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

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LOG OF BORING RD158

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ 10 20 30 40 REC% RQD % ◆ 20 40 60 80 SHEAR STRENGTH, tsf □ Qp/2 0 2.5 5
	0.0	Surface Elev.: Unknown							
	0.5	ASPHALT: black.							
	1.0	CRUSHED STONE: [fill]; with sand.	0.8ft						
	1.5	LEAN TO FAT CLAY (CL-CH): brown to dark brown with gray; moist; medium stiff; trace to with sand; trace gravel; trace orange mottling.	1.5ft			1	22	8	8 ◎ 0.75
	2.0								
	2.5								
	3.0								
	3.5								
	4.0					2	50	7	7 ◎
	4.5								
	5.0	Bottom of Boring at 5.0 feet	5.0ft						

Date Boring Started:	12/6/17	Water Levels (ft)	Remarks: Located 1.5' NE of shoulder
Date Boring Completed:	12/6/17	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Sunny, 35 F

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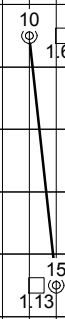
LOG OF BORING RD159

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %
	0.0	Surface Elev.: Unknown						
	0.0	ASPHALT: black.						
	0.5	CRUSHED STONE: [fill]; with sand.	0.5ft					
	1.0	POORLY GRADED SAND WITH SILT AND GRAVEL: [fill]; with sand.	1.0ft					
	1.5	LEAN TO FAT CLAY (CL-CH): brown; moist; trace to with sand; trace gravel.	1.5ft			1	50	10
	2.0							
	2.5							
	3.0							
	3.5							
	4.0					2	78	15
	4.5							
	5.0	Bottom of Boring at 5.0 feet	5.0ft					

STANDARD PENETRATION TEST DATA N in blows/ft ◎
10 20 30 40
REC%
RQD % ◆
20 40 60 80
SHEAR STRENGTH, tsf
□ Qp/2
0 2.5 5



Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Located 3' E of shoulder
Date Boring Completed:	12/5/17	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING RD160

Project:	Hardin Wind Project	Surface Elevation:	Unknown
Job No.:	35331001	Drilling Method:	SSA
Location:	Hardin County, Ohio	Sampling Method:	Split spoon
Coordinates:		Completion Depth:	5.0 ft
Datum:	NAD83		

Elevation, feet	Depth, feet	MATERIAL DESCRIPTION		Graphic Log	Samples	Sample No.	% Recovery	SPT, N value or RQD %	STANDARD PENETRATION TEST DATA N in blows/ft ◎ 10 20 30 40 REC% RQD % ◆ 20 40 60 80 SHEAR STRENGTH, tsf □ Qp/2 0 2.5 5
	0.0	Surface Elev.: Unknown							
	0.5	ASPHALT: black.							
		CRUSHED STONE: [fill]; with sand.	0.5ft						
	1.5	LEAN TO FAT CLAY (CL-CH): brown; moist; medium stiff to stiff; trace to with sand; trace gravel.	1.5ft			1	50	9	9 ◎ □ 0.5
	5.0	Bottom of Boring at 5.0 feet	5.0ft			2	58	8	8 ◎ 0.625

Date Boring Started:	12/5/17	Water Levels (ft)	Remarks: Located 4' NE of shoulder
Date Boring Completed:	12/5/17	▽ At Time of Drilling	
Logged By:	MAN2	▽ Dry	
Drilling Contractor:	TTL Associates		
Drill Rig:			Weather: Partly Cloudy, 35 F

Attachment B

Hardin County Wind Farm

Transportation Route Review

Prepared for
Invenergy, LLC

June 2019

4300 MarketPointe Drive, Suite 200
Minneapolis, MN 55435
952.832.2600
www.barr.com

Transportation Route Review

June 2019

Contents

List of Figures

List of Appendices

1.0 Introduction

Invenergy, LLC (Invenergy) is planning to construct the Hardin County Wind Project, a proposed wind power development located in Hardin County, Ohio. Invenergy has requested a study to determine possible constraints along the delivery routes for the project.

This document describes the methods for determining possible existing road profile constraints, results of field review, locations of overhead obstructions, and bridge evaluation along the tentative delivery routes for turbine components. This study is limited to areas immediately adjacent to the project. Final route selection and constraint verification shall be performed by the transportation company selected for delivery.

2.0 Desktop review

The initial part of the study consisted of a desktop review of the roads along the delivery routes for the project.

2.1 Road profiles

As part of the initial route review, Barr downloaded existing LiDAR from State of Ohio Office of Information Technology, Ohio Geographically Referenced Information program, 2006. This data was used to create a surface along the delivery route roads.

Barr created alignments and existing ground profiles for all roads associated to the delivery route within the project area identified. Additionally, turbine manufacturer restrictions for vertical curves were used to create approximate profiles for the roads.

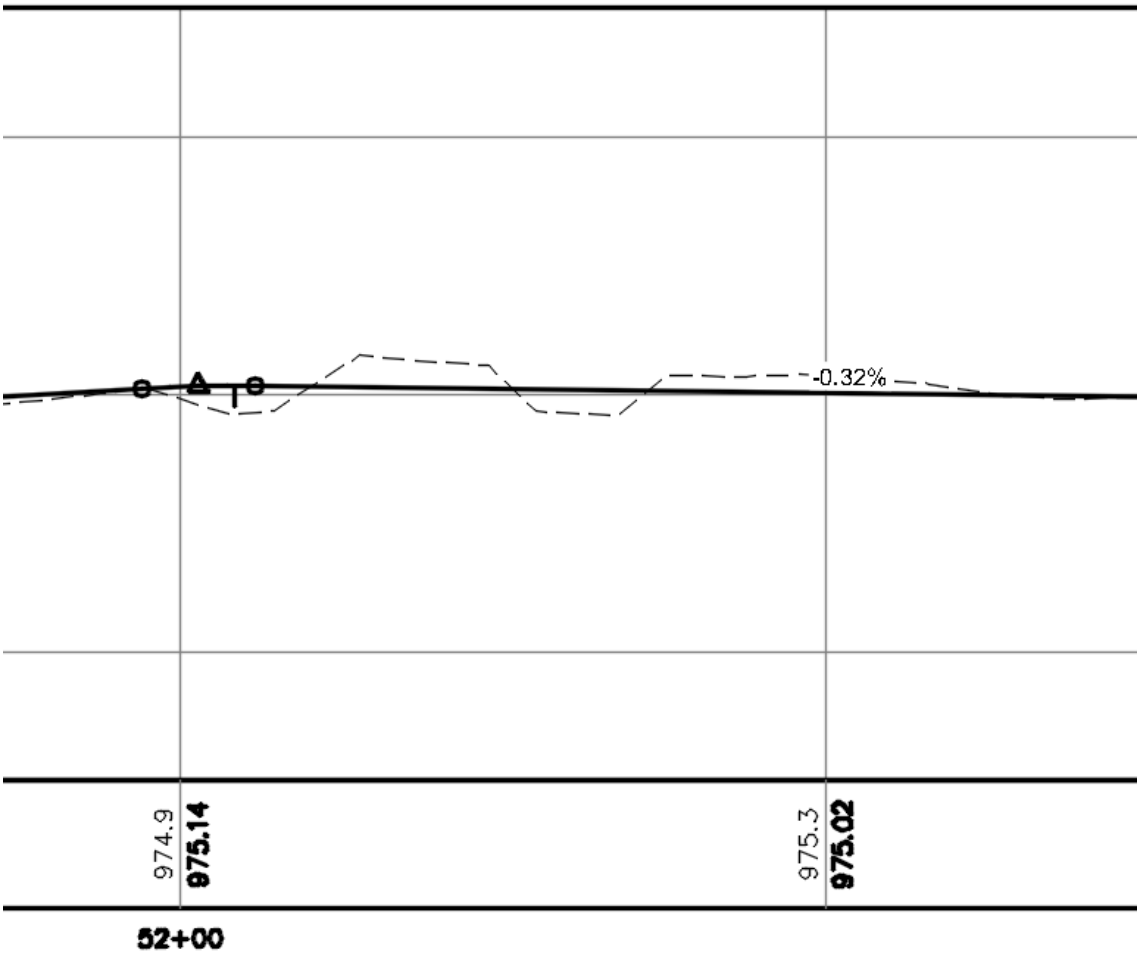


Figure 2-1 CR-35 Profile

Barr reviewed all profiles to identify possible dips and bumps along with areas that may need to be modified to comply with turbine manufacturer requirements. The areas showing possible issues were identified and tagged for field review. **Error! Reference source not found.** shows an example of areas identified.

2.2 Desktop findings

A total of 35 different locations were identified as potential dips and bumps that would require further investigation in the field, as shown in Figure 1 (See Appendix A).

3.0 Site Verification

On May 29-30, 2019, Barr Engineering Co. (Barr) mobilized to the project location in order to investigate the existence bumps and dips in the roads that will be used to deliver materials to the wind turbine locations.

While investigating the potential dip and bump locations in the field, they were determined to be inconsequential. The majority of the potential dips and bumps were found to be either nonexistent or locations where the road was flat but passed over ditches, streams, or rivers. Figure 3-1 shows the locations identified in the profile from Figure 2-2.

Figure 3-1 CR-35 STA 52+00

3.1 Follow-up review

One of the dips and bumps identified prior to the field investigation was determined to require further investigation by the Invenergy transportation coordinator. This location was along County Road 130, just east of the intersection with Township Highway 195. At this location, there is an approximately 90-foot long bridge, with a 20 foot ramp on either end, each with an estimated 6-12 inch increase in elevation. Figures 3-2 and 3-3 show the bridge approaches.

Figure 3-2 CR-130 Bridge from west

Figure 3-3 CR-130 Bridge from east

4.0 Overhead constraints

During the field investigation, Barr identified all locations along the delivery route within the project area where overhead utility lines may not be high enough for over-height permit loads in order to coordinate with the appropriate utility company if lines must be temporarily relocated. A total of 56 low-hanging utility crossings above potential access routes were identified.

4.1 Follow-up review

The majority of these have an estimated minimum height of 20 feet or more above the road, but 14 will require further investigation by the Invenergy transportation coordinator. Figure 2 shows all the crossing and identifies those requiring further investigation as "Low Crossing Location" (See Appendix A). An example of low utility crossing is shown in Figure 4-1.

Figure 4-1 Low utility crossing

These locations shown as low crossing are as follows:

- Along Township Road 92, approximately 0.4 mile east of the intersection with County Road 35: two residential electric or telephone service lines approximately 18 feet above the road.

- Along County Road 35, approximately 0.13 mile south of the intersection with Township Road 92: a residential electric or telephone service line and low-hanging branches approximately 18 feet above the road.

- Along Ohio State Road 235, approximately 0.5 mile north of the intersection with Ohio State Road 67: a residential electric or telephone service line approximately 18 feet above the road.

- Along County Road 130, approximately 150 feet west of the intersection with County Road 75: a residential electric or telephone service line approximately 18 feet above the road.

- Along Township Road 120, approximately 0.5 mile west of the intersection with Ohio State Road 195: a residential electric or telephone service line approximately 18 feet above the road.

- Along Township Road 120, approximately 0.25 mile east of the intersection with Township Road 45: a residential electric or telephone service line approximately 18 feet above the road.

- Along Ohio State Road 195, approximately 400 feet south of the intersection with Cottonwood Road: a residential electric or telephone service line approximately 15 feet above the road.

- Along Ohio State Road 195, approximately 150 feet south of the intersection with Pamelia Street: a commercial electric or telephone service line approximately 18 feet above the road.

- Along Ohio State Road 195, just south of the intersection with Main Street: a commercial electric or telephone service line approximately 18 feet above the road.

- Along Ohio State Road 195, just south of the intersection with Columbus Street: multiple residential electric or telephone service lines approximately 18 feet above the road.

- Along Ohio State Road 195, approximately 0.2 mile north of the intersection with County Road 80: multiple residential electric or telephone service lines approximately 18 feet above the road.

- Along Township Road 105, approximately 0.1 mile north of the intersection with County Road 90: low hanging branches approximately 15 feet above the road.

- Along County Road 95, approximately 0.1 mile north of the intersection with Township Road 100: a residential electric or telephone service line approximately 15 feet above the road.

- Along County Road 110, just east of the intersection with County Road 89: residential electric or telephone service lines approximately 15 feet above the road.

5.0 Bridge evaluation

Additional to identifying possible vertical constraints along the delivery route. Bridges were evaluated and will be rated for construction traffic and turbine delivery vehicles.

Barr is using WHKS as sub-consultant to review the bridge condition and rating. Initial evaluation of identified bridges along delivery route were performed on May 28-29.

5.1 Preliminary Bridge Condition

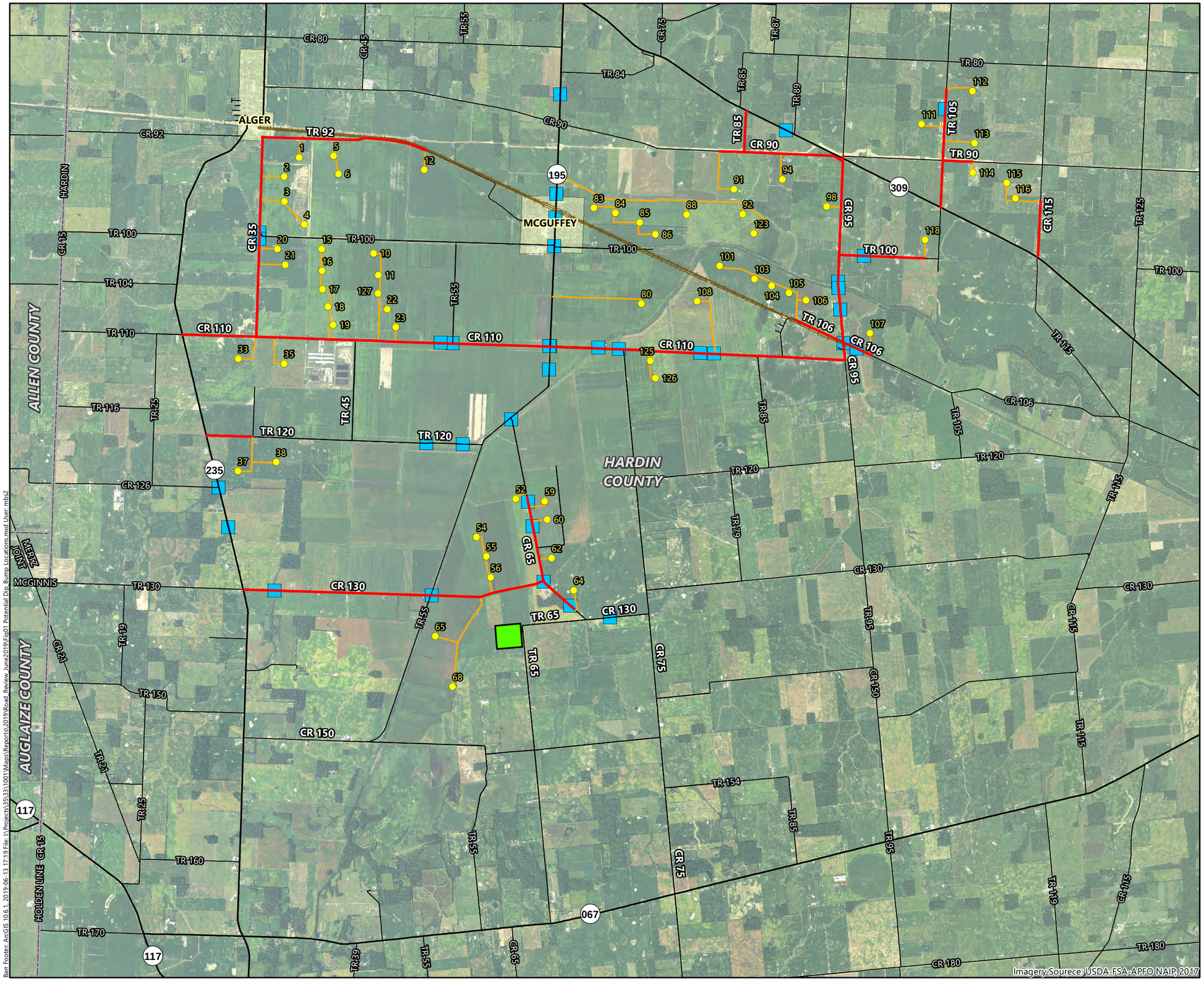
WHKS performed a preliminary bridge condition assessment prior to bridge rating (See Appendix B). Initial assessment show all bridges to be satisfactory. The bridges can be used by construction vehicles adhering to Ohio legal loads with the exception of bridge 3334406 (CR-95 over Scioto River) and bridge 3346935 (CR-130 over Scioto River) which are posted. Posted limits must be followed for these locations. Figures 5-1 and 5-2 show the postings.

Figure 5-1 CR-95 bridge posting

Figure 5-2 CR-130 bridge posting

Appendix A

Figures



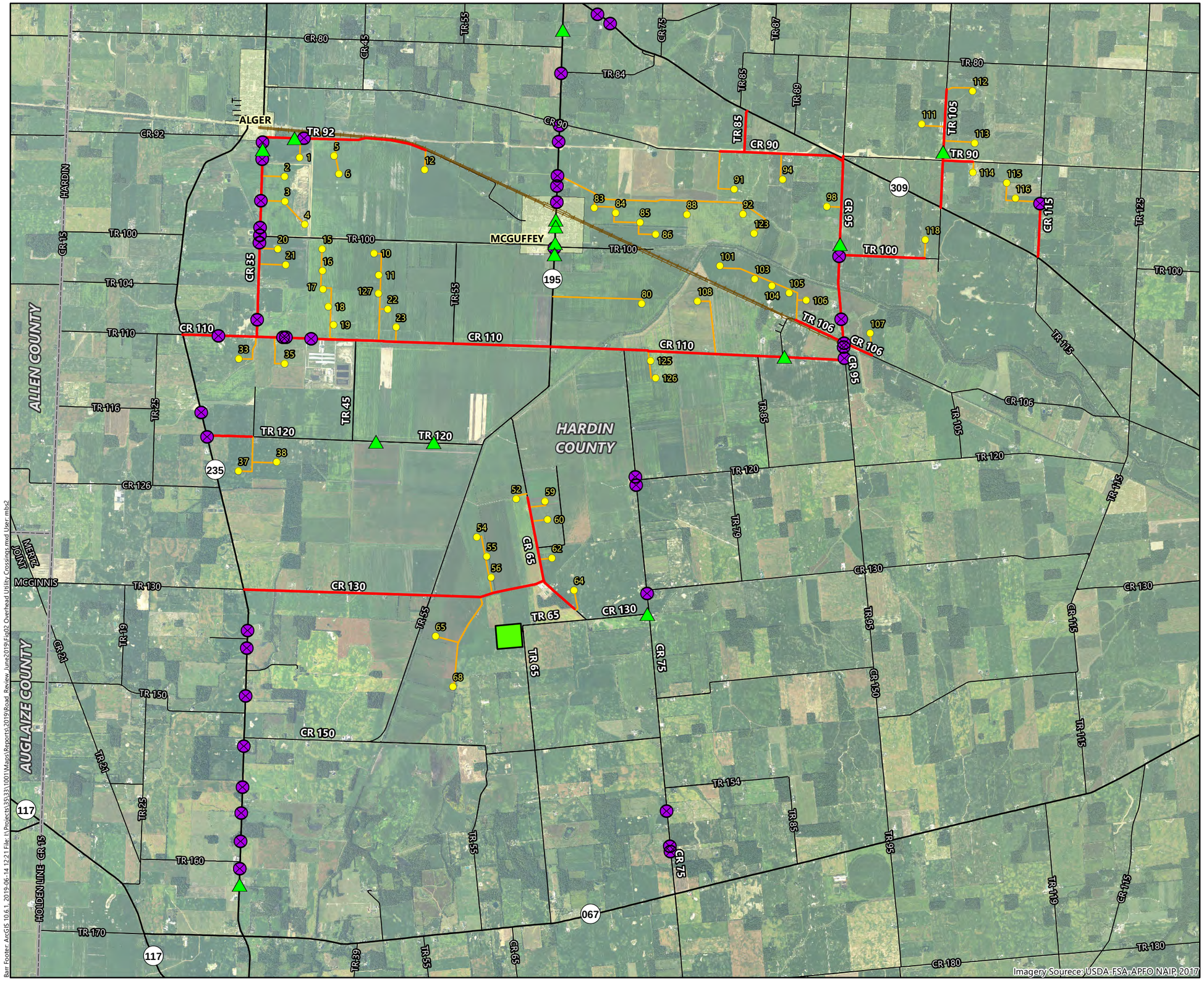
Turbine Location
Potential Dip/Bump Location
Access Road
Transportation Route
Substion, POI, and O&M Building Area
City Boundary
County Boundary

Feet
5,000 0 5,000

Meters
1,600 0 1,600

Figure 1

POTENTIAL DIP/BUMP LOCATION
Hardin Wind Project
Invenergy LLC
Hardin County, Ohio



- Turbine Location
- Low Crossing Location
- Utility Crossing Location
- Access Road
- Transportation Route
- Substion, POI, and O&M Building Area
- City Boundary
- County Boundary

Feet
5,000 0 5,000

Meters
1,600 0 1,600

Figure 2

OVERHEAD UTILITY CROSSINGS
Hardin Wind Project
Invenergy LLC
Hardin County, Ohio

Appendix B

Bridge Evaluation

1412 6th Street SW
P.O. Box 1467
Mason City, IA 50402
Phone: 641.423.8271
Fax: 641.423.8450
Email: masoncity@whks.com
Website: www.whks.com

whks
engineers + planners + land surveyors

May 31, 2019

Mr. Cristian Diaz, P.E.
Senior Civil Engineer
Barr Engineering Co.
4300 MarketPointe Drive, Suite 200
Minneapolis, MN 55435

RE: Hardin Wind Project
Hardin County, Ohio
Preliminary Bridge Condition Report

Dear Mr. Diaz:

WHKS has completed preliminary evaluation of the county bridges on haul routes for wind farm construction planned for summer 2019. The 14 bridges originally identified per our agreement (8 NBI bridges, 6 culverts or short span slab bridges) are included in the report below. NBI bridges are those structures exceeding 20 ft. length which are on the National Bridge Inventory and are regularly inspected by the County. The culverts or short span slab bridges less than 20 ft. length are non-NBI structures and do not generally have inspection records or ratings on file.

Field assessment was a visual, cursory inspection to confirm the current bridge inspection records provided by the owner sufficiently depict deficiencies which may impact the ratings. The records have been used to provide the summary below that includes the following for NBI bridges: bridge description, span length, width, traffic, sufficiency rating, general observation of condition, deficiencies, and rating information. The summary for non-NBI or short bridges includes a description, general observation of condition, deficiencies, and measurements that were taken for rating purposes.

NBI Bridges

Bridge 3330002: County Road 75 over Sponsler Ditch

This is a 29’ long x 27’ wide single span concrete tee beam bridge built in 2014. The ADT is 484 vehicles per day (VPD) in 2015. The bridge sufficiency rating is 92.9. The bridge is in overall good condition and no new deficiencies were noted.

The bridge inspection report states hairline flexural cracks in the bottom edges of beams 6 and 9 and joints between beams are leaking. There are full height vertical cracks in south abutment near beams 1, 5 and 7. No efflorescence, no offset in wall, sounds solid.

The bridge rates satisfactorily for HL-93 load at inventory and operating levels and is not posted for Ohio legal loads.

Bridge 3330028: County Road 110 over Sheldon Ditch

This is a 32' long x 27' wide single span concrete tee beam bridge built in 2010. The ADT is 350 vehicles per day (VPD) in 2015. The bridge sufficiency rating is 92.9. The bridge is in overall good condition and no new deficiencies were noted.

The bridge inspection report states most of the beams have hairline transverse flexural cracks in the middle third of the span. Efflorescence has developed in numerous cracks. Numerous joints between beams are leaking. Spalling concrete at top exposed edge of north fascia beam along most of the length.

The bridge rates satisfactorily for HS-20 load at inventory and operating levels and is not posted for Ohio legal loads.

Bridge 3333086: County Road 106 over McCoy Run

This is a 32' long x 22' wide single span steel beam bridge built in 1953. The ADT is 291 vehicles per day (VPD) in 2015. The bridge sufficiency rating is 70.5. Beams 1, 2, & 10 have heavy rust and the rest of the beams are rusting as well. There were no new deficiencies noted and the bridge overall is in satisfactory condition.

The bridge inspection report states most beam ends have heavy rust and section loss but repairs have been made. Beams 1, 2 & 10 have heavy rust along the top and bottom flanges. Fascia beams have heavy rust around guardrail arm welds to webs. Some chloride and rust bleeding through deck seams at welds, with minimal section loss. Both abutments have several small full-height cracks, map cracking with efflorescence near tops, and three voids at bottom of west wall.

The bridge rates satisfactorily for HS-20 load at inventory and operating levels and is not posted for Ohio legal loads.

Bridge 3334406: County Road 95 over Scioto River

This is a 132' long x 24' wide steel thru-truss bridge built in 1922 and rehabilitated with new deck and galvanized floor beams and stringers in 2004. The ADT is 190 vehicles per day (VPD) in 2015. The bridge sufficiency rating is 76.1. There were no new deficiencies noted and the bridge overall looked to be in satisfactory condition.

The bridge inspection report states the left diagonal truss post has been hit and inboard flange bent approximately ½" x 1' just below the guardrail. The truss gusset plates have light to moderate pitting along the inside face at bottom chord; no bending noted. Some efflorescence and chloride coating noted at stringers and floor beams. North abutment wall has full height vertical cracks at 1/3 points, but no differential movement. Random map cracks at stringer seats and top of abutment.

The bridge rates satisfactorily for HS-20 load at operating level and rating factor = 0.69 at inventory level. The bridge rates satisfactorily for Ohio legal loads; however, the bridge is posted 29 T for EV2 and 41 T for EV3 trucks.

Bridge 3336107: County Road 110 over Newland Ditch

This is a 31' long x 32' wide single span steel beam bridge built in 2005. The ADT is 744 vehicles per day (VPD) in 2015. The bridge sufficiency rating is 96.8. There were no new deficiencies noted and the bridge overall is in good condition.

The bridge inspection report states top east half of concrete deck along south edge is cracked, saturated, heaving, and has several small concrete spalls. There is some pitting on steel beams, some rust, and moderate to heavy white/chloride coating below deck joints and at beam ends.

The bridge rates satisfactorily for HS-20 load at inventory and operating levels and is not posted for Ohio legal loads.

Bridge 3336336: County Road 35 over Cottonwood Ditch

This is a 83' long x 24' wide 2-span steel beam bridge built in 1933 and rehabilitated in 2004 with new piers and new galvanized W21x68 stringers. The ADT is 916 vehicles per day (VPD) in 2015. The bridge sufficiency rating is 80.0. There were no new deficiencies noted and the bridge overall is in good condition.

The bridge inspection report states there is slight deflection of the outer two beams on each side of deck (suspected to be built that way). Live load response is excellent. Numerous chip marks in galvanizing at edge and end of beams over pier. Rust spots on pier cap/piles and white/chloride coating noted at backwalls and top flange of floor beams. Rear abutment seat has light map cracks with efflorescence and Beams 2 and 3. North abutment has an open vertical crack (3/4" wide) with no offset in left half of wall. CMPs used for pier pile protection are rusted along bottom 1/3 of height.

The bridge rates satisfactorily for HS-20 load at inventory and operating levels and is not posted for Ohio legal loads.

Bridge 3346277: County Road 130 over Elder Creek

This is a 32' long x 24' wide single span concrete tee beam bridge built in 2006. The ADT is 204 vehicles per day (VPD) in 2015. The bridge sufficiency rating is 85.3. The bridge is in overall good condition and no new deficiencies were noted.

The bridge inspection report states deck is leaking through joints with moderate efflorescence. Light spalling along top of outside beam edges. There are light full height vertical cracks with efflorescence beneath beams 2, 4, 6, and 8 in west abutment wall and beams 2, 4 and 7 in east abutment wall. Top of abutment footing at NE corner is exposed from scour but appears stable at this time.

The bridge rates satisfactorily for HS-20 load at operating level and has a rating factor = 0.78 at inventory level. The bridge is not posted for Ohio legal loads.

Bridge 3346935: County Road 130 over Scioto River

This is a 84' long x 26' wide steel thru-truss bridge built in 1979 and reconstructed in 2000. The ADT is 204 vehicles per day (VPD) in 2015. The bridge sufficiency rating is 66.4. There were no new deficiencies noted and the bridge overall looked to be in satisfactory condition.

The bridge inspection report states the concrete wearing surface has failed and leaks considerably. There is cracking and efflorescence along the edges of deck. Stone has built up on the bottom chord of the truss. The gusset plates are in good condition with no bending noted, but with light rust on the inboard gusset connection to floor beam #4 at south end. Numerous spots on the top flanges of stringers and floor beams are heavily rusted. White coating of efflorescence/chlorides on ends of floor beams, below deck joints, and around field welds. Slope protection is in need of repair.

The bridge has an HS-20 rating factor = 0.96 at operating level and rating factor = 0.62 at inventory level. The bridge is posted for SHV vehicles and EV vehicles.

Short Bridges (Non-NBI)

#1 County Road 75 over Flat Branch/Sponsler Ditch

8'x5.5' arch reinforced concrete pipe (RCP), 8" thick, and 2.5' fill. Rebar is exposed at both ends near the waterline. There were no other deficiencies noted and the structure overall looked to be in satisfactory condition.

#2 County Road 130 over Drainage Ditch

6' dia. corrugated metal pipe (CMP), 1/8" thick, 2 2/3 x 2/3 corrugations, and 5'-2" fill. There were no deficiencies noted and the structure overall looked to be in satisfactory condition.

#7 County Road 110 over Drainage Ditch

7' dia. CMP, 1/8" thick, 6x2 corrugations, and 4' fill. There were no deficiencies noted and the structure overall looked to be in satisfactory condition.

#8 County Road 110 over Drainage Ditch

Possible CMP, could not inspect or measure due to depth of water. This culvert should be avoided because it cannot be rated.

#13 Township Road 100 over McCoy Run

This is a simple span cast-in-place concrete tee beam bridge with a span of 19' face-to-face of abutments. Beams are 3' wide x 14" deep and have a 6" HMA wearing surface. Beam dimensions are similar to bridge #3330028. There were no deficiencies noted and the structure overall looked to be in satisfactory condition. Plans are needed for rating.

#22 Township Road 92 over Drainage Ditch

This is a simple span cast-in-place concrete slab bridge with a span of 18' CL-CL abutments. Slab thickness equals 16" with 10" fill and 10" curbs. There were no deficiencies noted and the structure overall looked to be in satisfactory condition. Plans are needed for rating.

The next steps will include rating the above bridges for wind turbine tractor-trailer loads and contractor equipment loading, as desired. The deliverable will include an "allowed-not allowed" matrix for all bridges and equipment.

There were 16 additional structures discovered (6 NBI bridges and 10 culverts with shallow fill) on possible haul routes. Since the routes are not yet confirmed, WHKS will wait to provide a condition report or perform ratings until the contractor decides on the final routes that will be used.

WHKS appreciates the opportunity to be of service. Please call if you have any questions or need additional information.

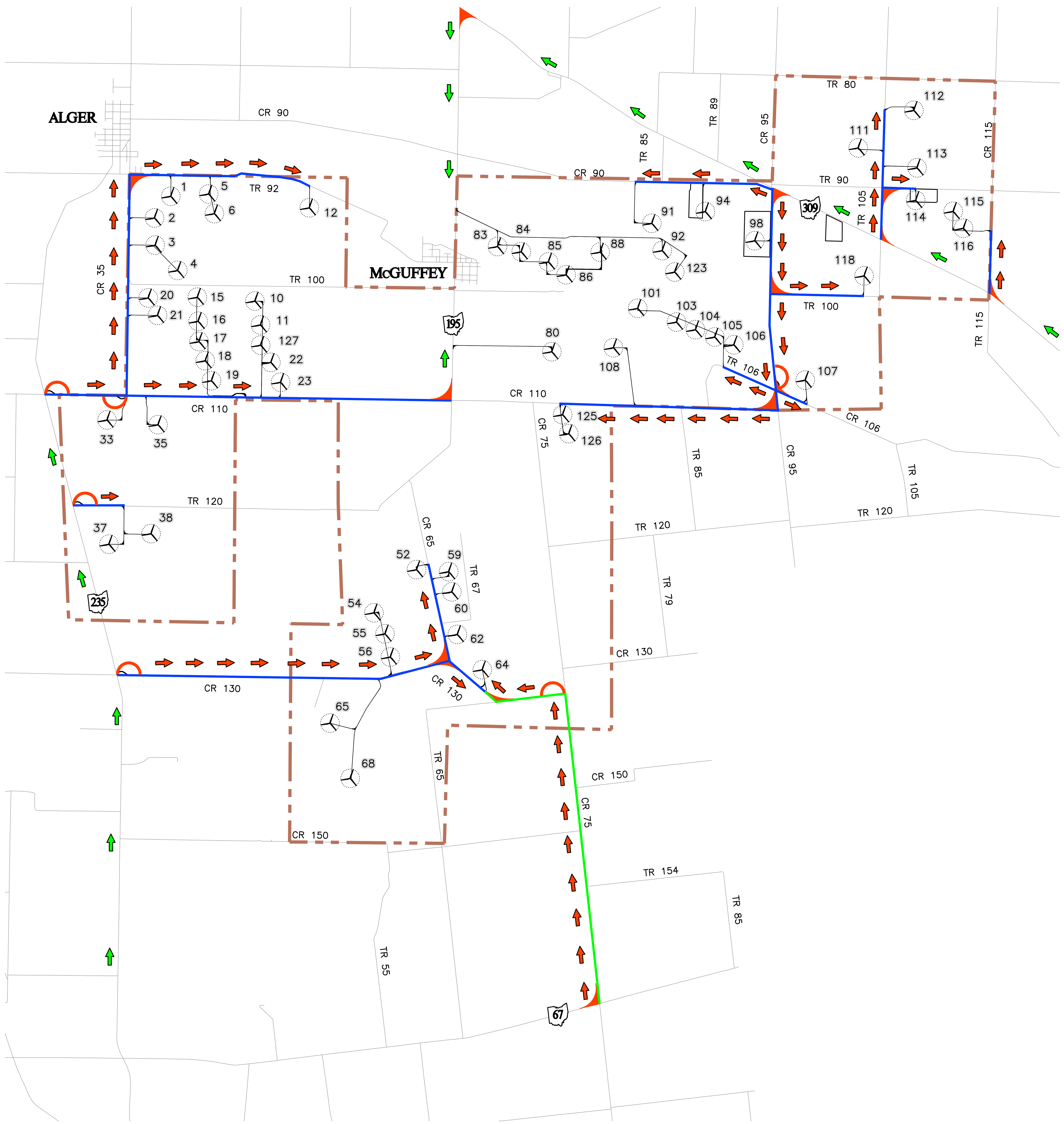
Sincerely,

***WHKS** & CO.*

Joshua J. Opheim, P.E. (IA)
Project Manager

Chad Hodel, P.E. (IL, OH)
Senior Associate, Structural Engineer

CEH/JJO:jjo
8868.00
Attachment (Map with Bridges)



LEGEND

- DELIVERY ROUTE
- ALTERNATE DELIVERY ROUTE
- DELIVERY ROUTE DIRECTION
- HIGHWAY DELIVERY DIRECTION
- INTERSECTION IMPROVEMENT
- PROPOSED TURBINE ACCESS ROAD
- EXISTING ROAD
- PROPOSED TURBINE NUMBER AND LOCATION (XX)
- PROJECT BOUNDARY
- POSSIBLE LAYDOWN YARD LOCATIONS

1 / – PLAN: TURBINE DELIVERY PLAN

0 3000 6000
SCALE IN FEET

N

90% ISSUED FOR REVIEW

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NO.	BY	CHK.	APP.	DATE	REVISION DESCRIPTION

RELEASED TO/FOR	A	B	C	D	0	1	2
CLIENT	05/18/19	05/31/19	06/14/19	—	—	—	—
BID	—	—	—	—	—	—	—
CONSTRUCTION	—	—	—	—	—	—	—
	DATE RELEASED						

BARR
Corporate Headquarters: Minneapolis, Minnesota Ph: 1-800-632-2277

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Scale	AS SHOWN
Date	05/13/19
Drawn	NJB2
Checked	MBJ
Designed	CAD
Approved	MBJ

Invenergy

HARDIN WIND PROJECT
HARDIN COUNTY, OHIO

TURBINE DELIVERY PLAN

BARR PROJECT No. 35/33-1001
CLIENT PROJECT No. –
DWG. No. C-03
REV. No. C

Case No(s). 09-0479-EL-BGN, 11-3446-EL-BGA, 16-0469-EL-BGA, 16-2404-EL-BGA

Summary: Notification of Phase 3 – Compliance with Condition 24,
Delivery Route Plan electronically filed by Christine M.T. Pirik on behalf of Hardin Wind Energy LLC