Vinton Solar Energy LLC
Case No. 17-774-EL-BGN

Application Part 3 of 5

Part 3 includes:

- **Exhibit A Solar Modules - CONFIDENTIAL (filed under seal)**
- **Exhibit B Solar Inverters - CONFIDENTIAL (filed under seal)**
- **Exhibit C Road Survey Report May**
- **Exhibit D TRC Site Characterization Report June 2017**
- **Exhibit E TRC Vinton Raptor Nest Survey June 2017**

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Attorneys for Vinton Solar Energy LLC

Date Filed: July 5, 2017

Vinton Solar Energy LLC
Case No. 17-774-EL-BGN

Exhibit A
Solar Modules

CONFIDENTIAL
FILED UNDER SEAL

Vinton Solar Energy LLC has requested confidential treatment of these documents in accordance with OAC Rule 4906-2-21.

These documents contain critical infrastructure information, confidential research and development information, commercial information, trade secrets, and/or proprietary information and, as such, are entitled to confidential treatment under state and/or federal statutes and regulations.

An unredacted version of the following documents have been submitted to the Docketing Division of the OPSB in accordance with OAC Rule 4906-2-21(D)(2):

1) Jinko Solar Multi Module
2) Jinko Solar Mono Module
3) Hanwha Q Cell Multi Module
4) Hanwha Q Cell Mono Module
5) Trina Solar Multi Module
6) Trina Solar Mono Module
7) JA Solar Multi Module
8) JA Solar Mono Module
9) First Solar Series 4 PV Module
10) Canadian Solar Multi Module
11) Canadian Solar Mono Module

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Exhibit B

Solar Inverters

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These documents contain critical infrastructure information, confidential research and development information, commercial information, trade secrets, and/or proprietary information and, as such, are entitled to confidential treatment under state and/or federal statutes and regulations.

An unredacted version of the following documents have been submitted to the Docketing Division of the OPSB in accordance with OAC Rule 4906-2-21(D)(2):

1) SMA SC2500 Inverter
2) ABB PVS980 Inverter
3) Power Electronic Inverter
4) Ingecon SUN Inverter
5) GE 4MVA UL Inverter

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Vinton Solar Energy LLC
Case No. 17-774-EL-BGN

Exhibit C

Road Survey Report
May 2017

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Exhibit C

Vinton Solar

Road Survey Report

Prepared for
Invenergy, LLC

May, 2017

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Minneapolis, MN 55435
952.832.2600
www.barr.com

Road Survey Report

May, 2017

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Certifications

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly licensed Professional Engineer under the laws of the State of Ohio.

______________________________	5/03/17
Matthew B. Johnson	Date
E-74181	

1.0 Executive Summary

A road survey consisting of a video survey, a pavement visual assessment, and identification of areas of concern from visual inspection was performed for Vinton Solar, a proposed solar power development located in Vinton County, Ohio.

Vinton Solar road was divided into four sections. Two sections of approximately 2000 feet each near Highway 23, one section of 800 feet near Highway 677, and one section for the remainder of the road. Sections 1 and 2 were observed in failed conditions; section 4 in very poor conditions; section 3 is aggregate and not subject to pavement condition indexing.

1.1 Recommendations

Infirmary Rd is in extremely poor conditions and would require reconstruction of paved sections. The gravel sections are in adequate condition and only require some maintenance to fill in washed out areas and to smooth out the surface. Since it appears that maintenance for the paved areas consists of adding gravel instead of bituminous patching, it is recommended to mill the entire road, leave millings in-place, mix with aggregate and compact. This will create a more uniform section throughout.

Access to the site for most construction traffic will have to be from Highway 93 since the bridge near Highway 677 has a weigh restriction of 23 tons.

Another option is to access the project site from Highway 677 at the existing trail across from the powder plant entrance. This trail accesses the project area on the east end of Vinton Solar 1 and can be upgraded to a grave road to better suit construction traffic. This requires constructing roughly 2,900 feet of road in lieu of upgrading 4,400 of asphalt road (Infirmary Rd).

2.0 Introduction

Invenergy, LLC (Invenergy) is planning to construct Vinton Solar, a proposed solar power development located in Vinton County, Ohio.

Invenergy requested a road survey to identify possible impacts and mitigation measures which will allow them to permit the site with Ohio Power Siting Board. The road survey consists of a video survey, a pavement visual assessment, and identification of areas of concern from visual inspection. Road surveys are limited to township and local roads. State Highways are not evaluated under this report.

This report describes the findings from the road survey.

3.0 Project information

The project site is located near the town of McArthur, OH in Vinton County. The project site can be accessed from State Highway 93 or State Highway 677.

One road was surveyed as part of the Vinton Solar project:

- Infirmary Road from Hwy 93 to Hwy 677.

See Appendix A – Figure 1 for site layout.

4.0 Road Study

4.1 General

The conditions of existing pavement were assessed visually and rated using American Society for Testing and Materials (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 3-1.

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, they can be used to confirm these observations of 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. 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 throughout each section.

4.2 Results

Vinton Solar road was divided into four sections. Two sections of approximately 2000 feet each near Highway 23, one section of 800 feet near Highway 677, and one section for the remainder of the road.

Section 1 from Highway 23 to 19+00 (Morgan Rd) was observed in failed condition. The pavement presents several bumps and dips, alligator cracking, rutting, potholes and extreme asphalt weathering throughout. The ride quality for this section is very poor with the need for reduced speed due to bumps and dips.

Three sample units were selected within the section.

Table 4-2 Infirmary Rd Section 1 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	2	FAILED
2	4	FAILED
3	0	FAILED

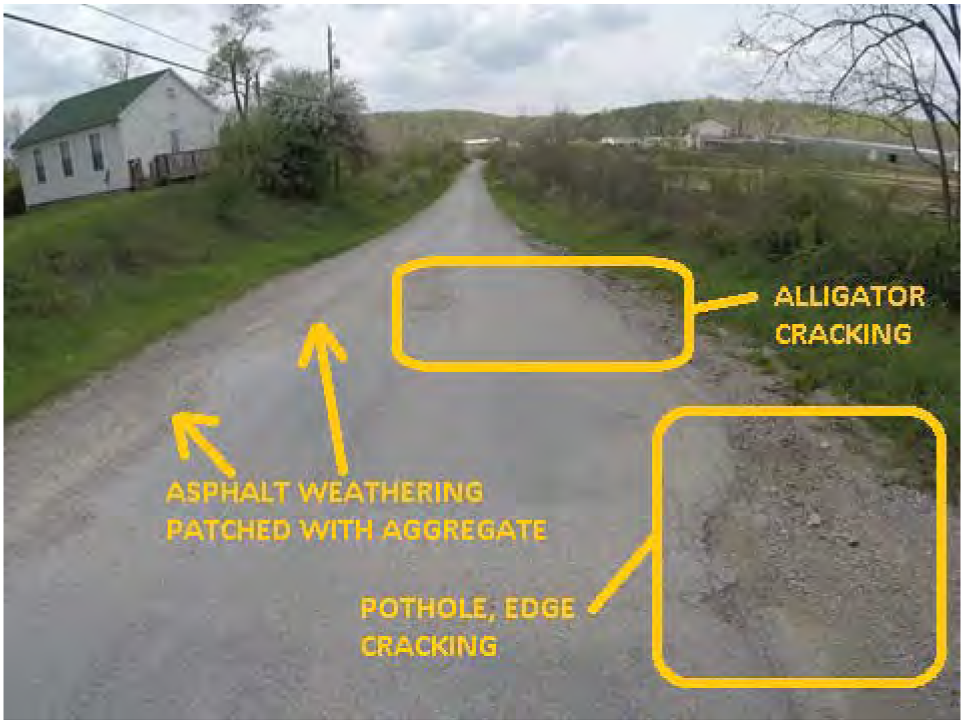


Figure 4-1 Infirmary Rd at STA 18+00 (west)

Section 2 from 19+00 to 44+00 was observed in failed condition. The pavement presents several bumps and dips, alligator cracking, rutting, bleeding, potholes and extreme asphalt weathering throughout. Similar to Section 1, the ride quality for this section is very poor.

Four sample units were selected within the section.

Table 4-3 Infirmary Rd Section 2 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	7	FAILED
2	16	SERIOUS
3	8	FAILED
4	0	FAILED

Figure 4-2 Infirmary Rd at STA 39+00 (west)

Section 3 from 44+00 to 153+00 has no asphalt. Gravel roads are not subject to pavement assessment. Gravel section seems in good shape with some washout areas and rutting along the edges. Ride is constant without any mayor bumps. There is a weight limit of 23 Tons for a bridge located east of the project site.

Figure 4-3 Infirmary Rd at STA 73+00 (west)

Figure 4-4 Infirmary Rd at STA 146+50 (west)

Section 4 from 153+00 to 161+00 was observed generally very poor condition. The pavement has several patches, bumps and sags, alligator cracking and rutting. The ride quality for this section is poor. Driving at posted speeds presents vehicle vibration and some areas that require slight reduction in speed due to bumps and dips.

Two sample units were selected within the section.

Table 4-4 Infirmary Rd Section 4 – PCI Summary

SAMPLE UNIT	PCI	RATING
1	27	VERY POOR
2	32	VERY POOR

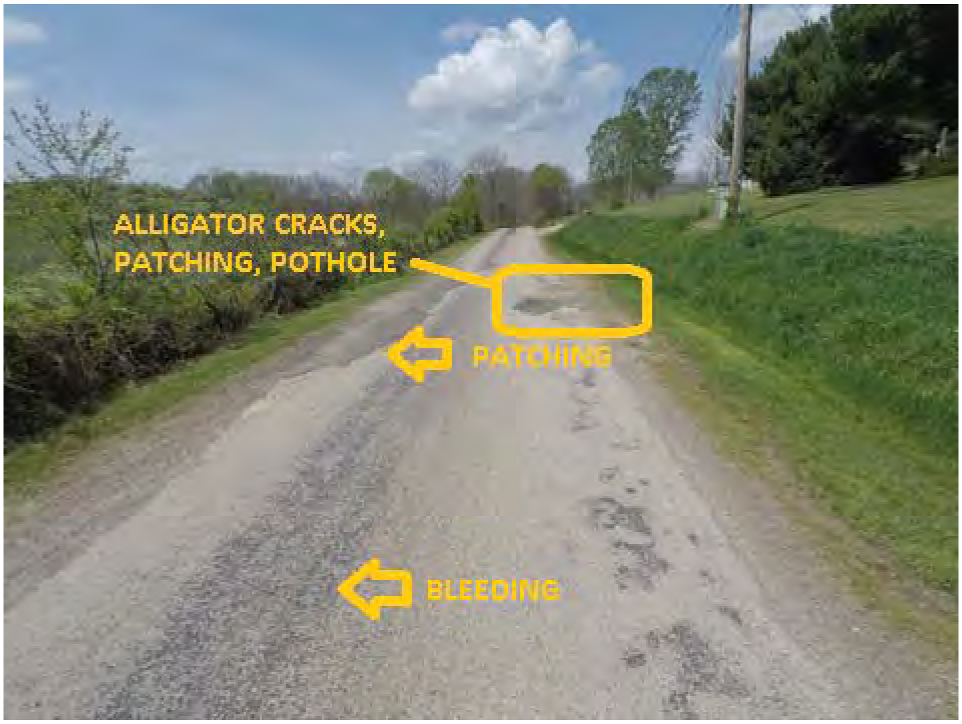
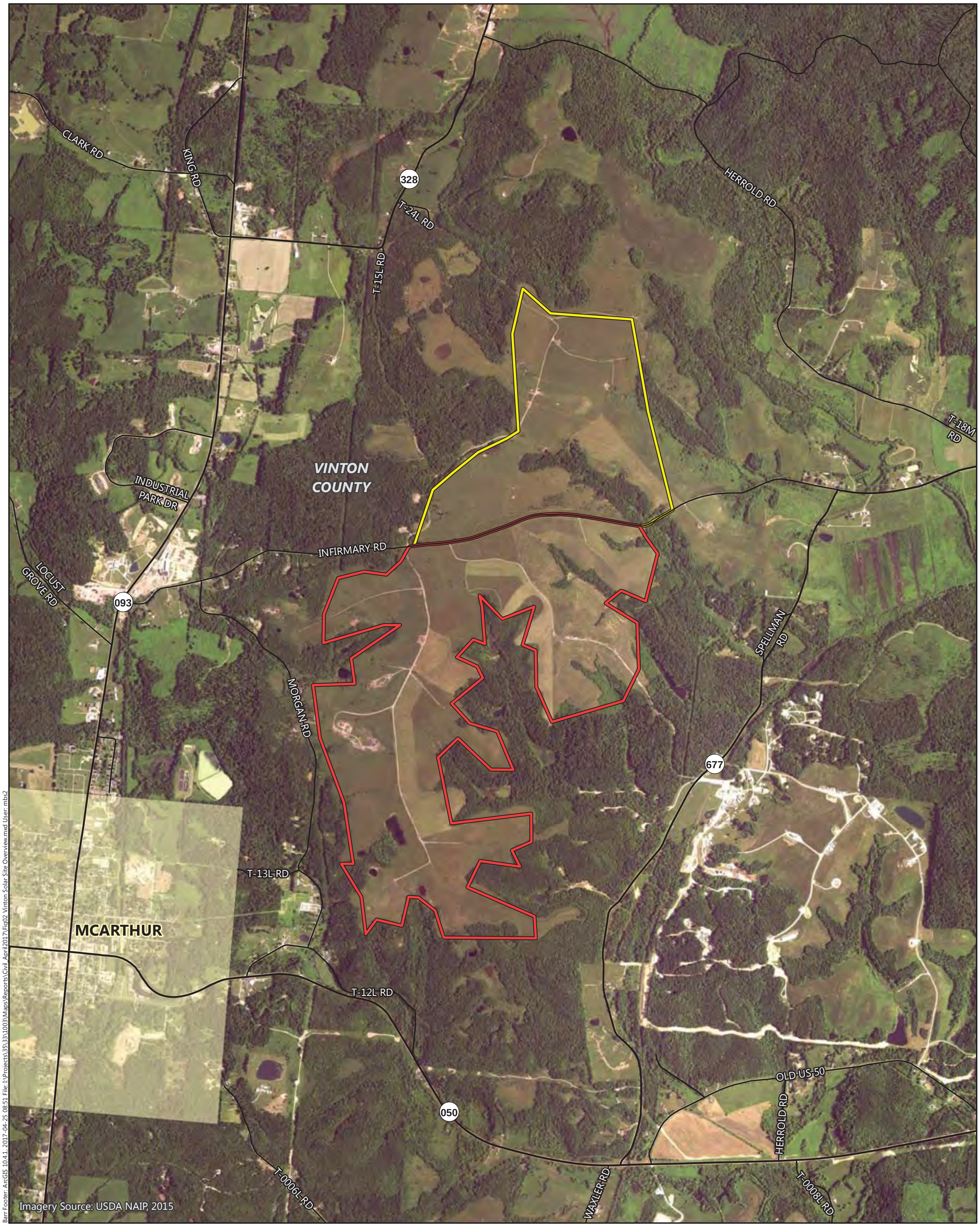


Figure 4-5 Infirmary Rd at STA 157+00 (west)

Appendix A

Figures



Project Boundary

Vinton County Solar

Vinton County Solar 2

Feet

2,000 0 2,000

Meters

600 0 600

Figure 1

VINTON SOLAR PROJECT
SITE OVERVIEW
Invenergy LLC
Vinton 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, $\pm$ 1000 ft^2 (225 $\pm$ 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.

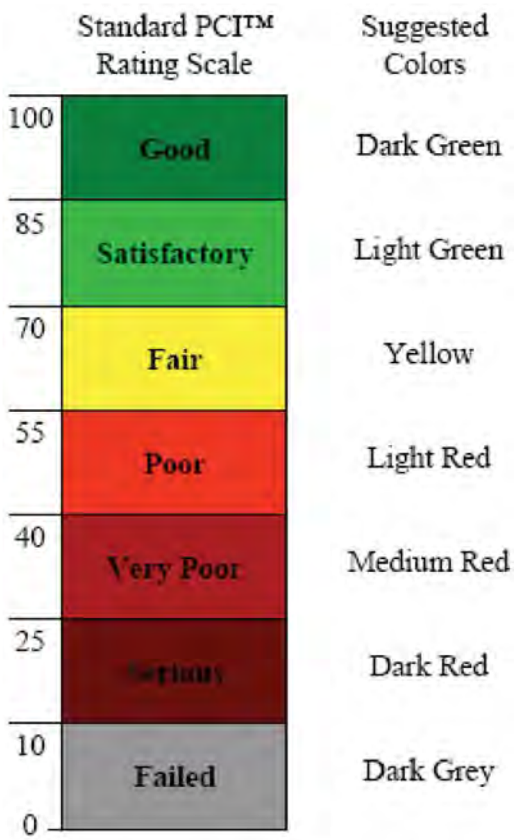


FIG. 1 Pavement Condition Index (PCI), Rating Scale, and Suggested Colors

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
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

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

DIST TYPE	SEV	NO. SLABS	DENSITY %	DEDUCT VALUE

SKETCH:

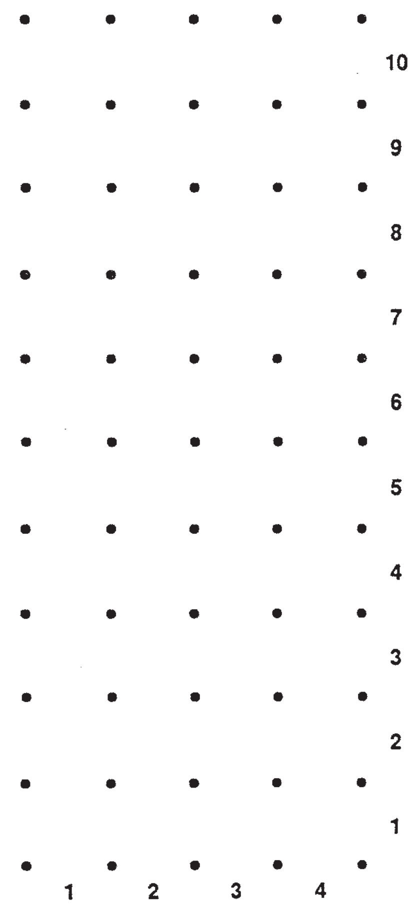


FIG. 3 Joint Rigid Pavement Condition Survey Data Sheet for Sample Unit

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

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

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):

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

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.

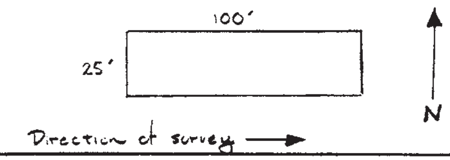
9.5.2 List the individual deduct values in descending order. For example, in Fig. 4 this will be 25.1, 23.4, 17.9, 11.2, 7.9, 7.5, 6.9, and 5.3.

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

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

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

SKETCH:



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

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

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

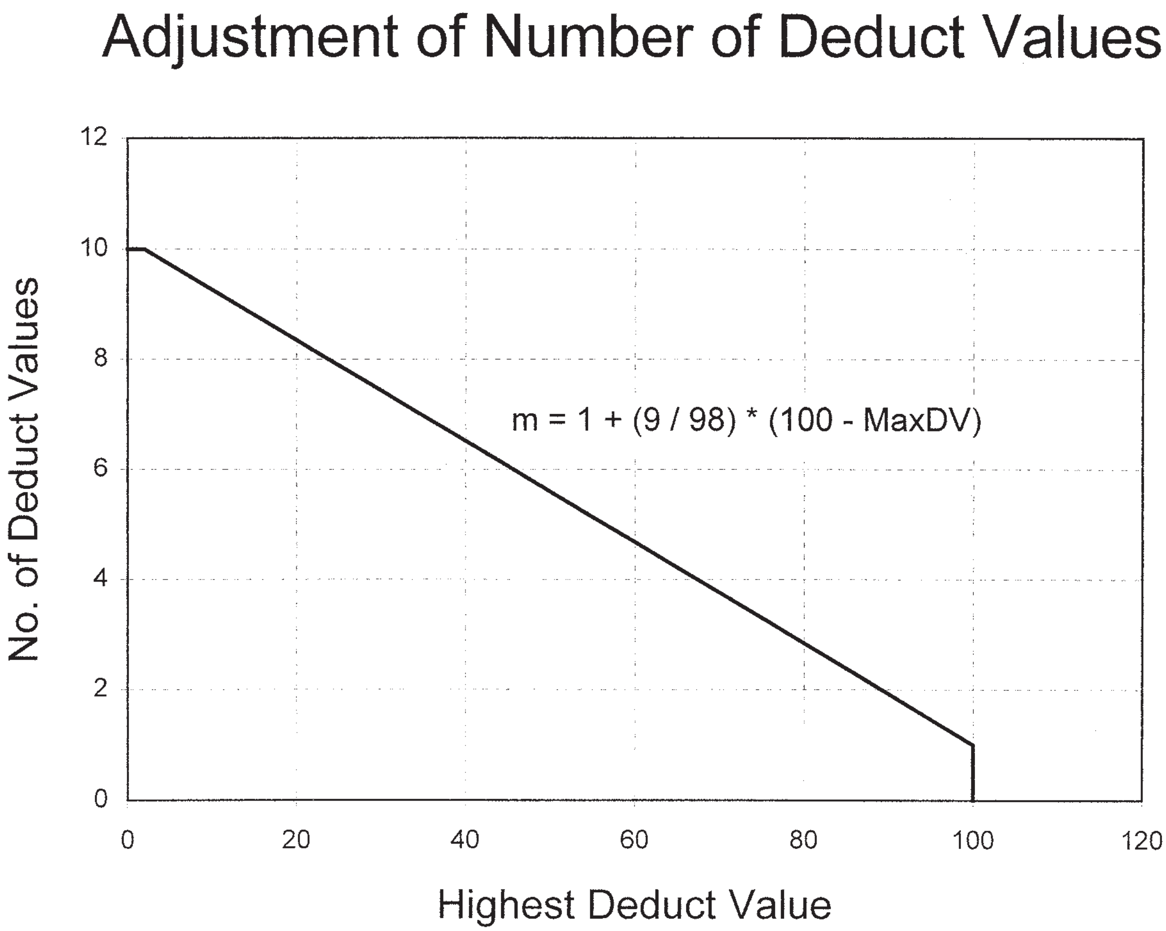


FIG. 5 Adjustment of Number of Deduct Values

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:

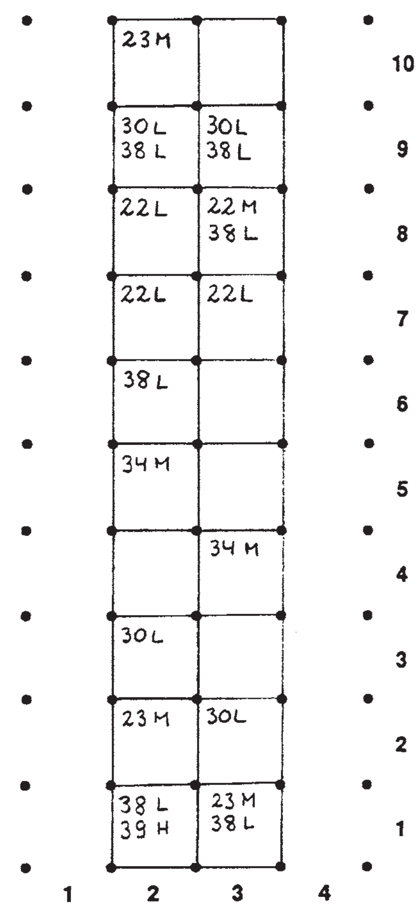


FIG. 7 Example of a Jointed Rigid Pavement Condition Survey Data Sheet

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.

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

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

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

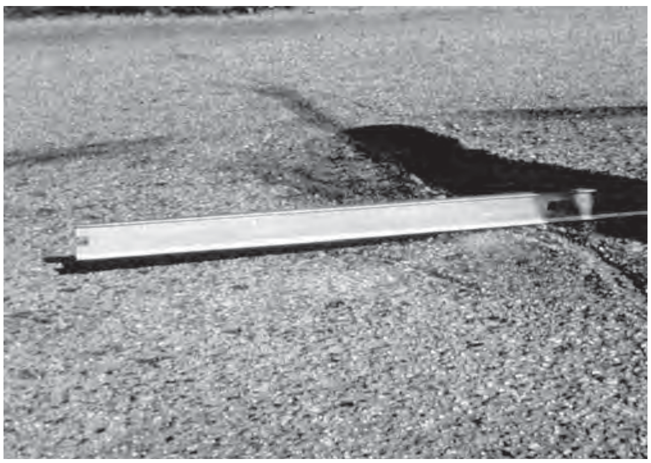


FIG. X1.10 Low-Severity Bumps and Sags

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

FIG. X1.12 High-Severity Bumps and Sags

the traffic direction. This type of distress usually is caused by traffic action combined with an unstable pavement surface or base.

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

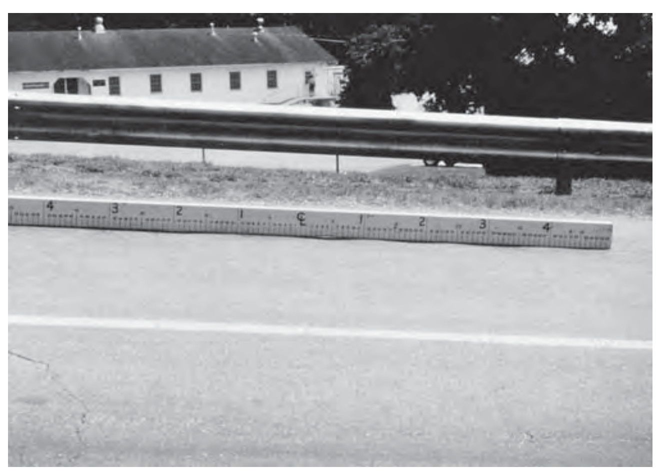


FIG. X1.13 Low-Severity Corrugation

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

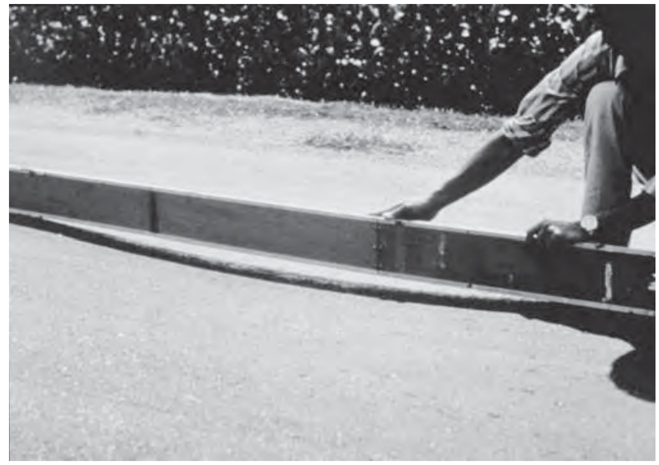


FIG. X1.17 Medium-Severity Depression

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 (3⁄8 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 (3⁄8 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

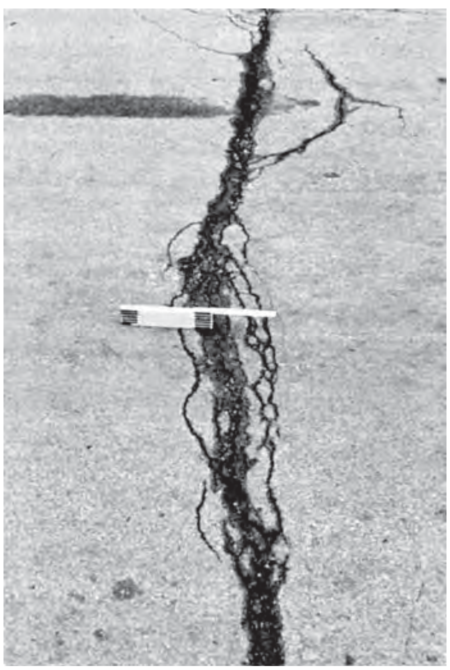


FIG. X1.24 High-Severity Joint Reflection Cracking

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

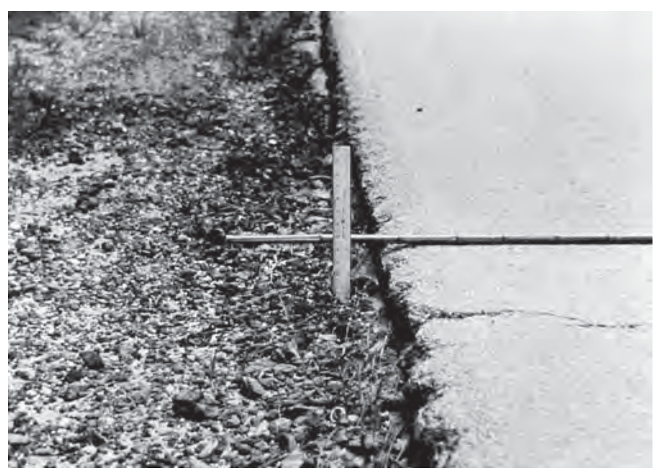


FIG. X1.27 High-Severity Lane/Shoulder Drop-Off

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 (3⁄8 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 (3⁄8 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

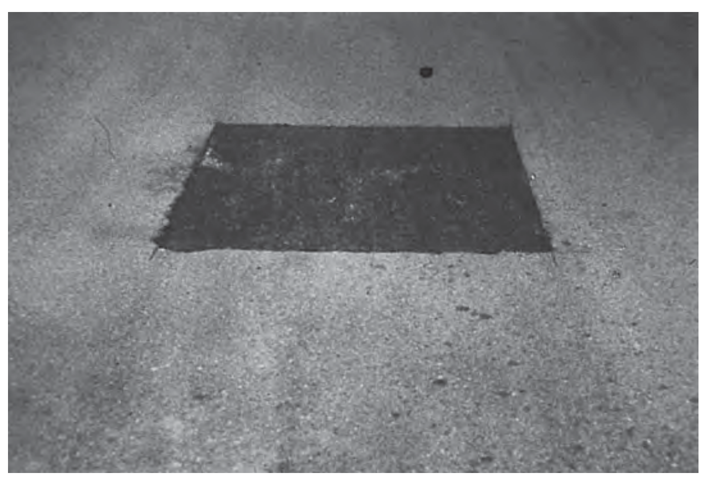


FIG. X1.31 Low-Severity Patching and Utility Cut Patching

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

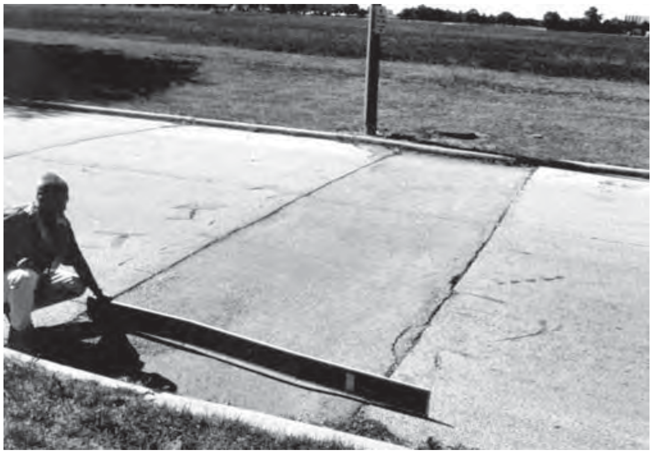


FIG. X1.32 Medium-Severity Patching and Utility Cut Patching

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*:

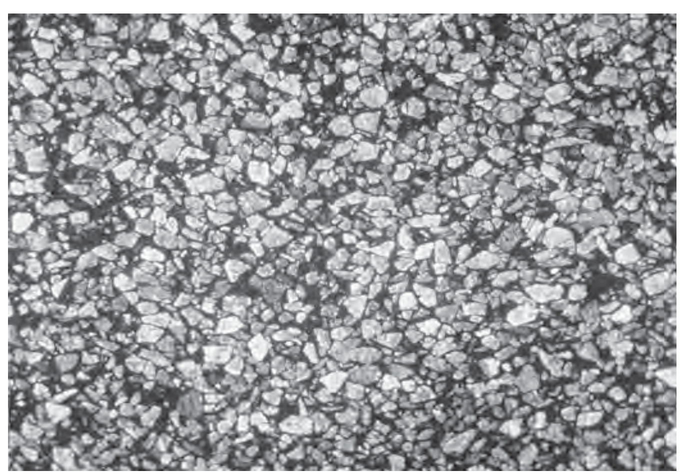


FIG. X1.34 Polished Aggregate

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

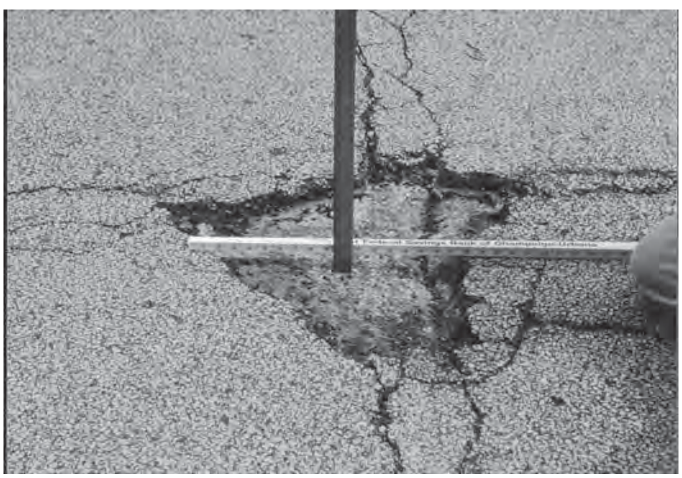


FIG. X1.36 Medium-Severity Pothole

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.

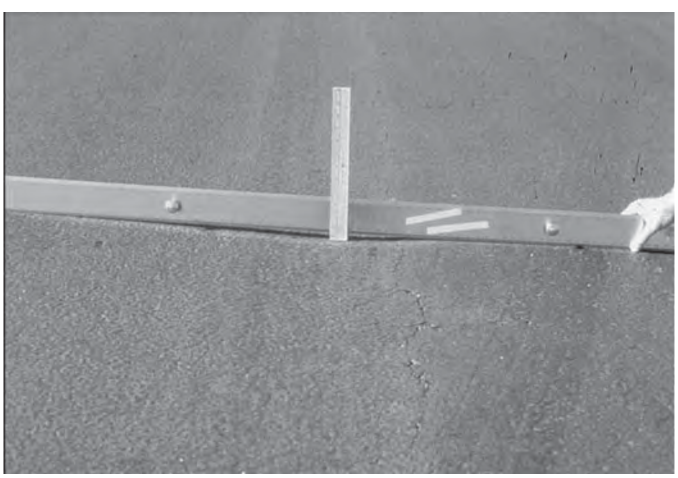


FIG. X1.41 Low-Severity Rutting

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.

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

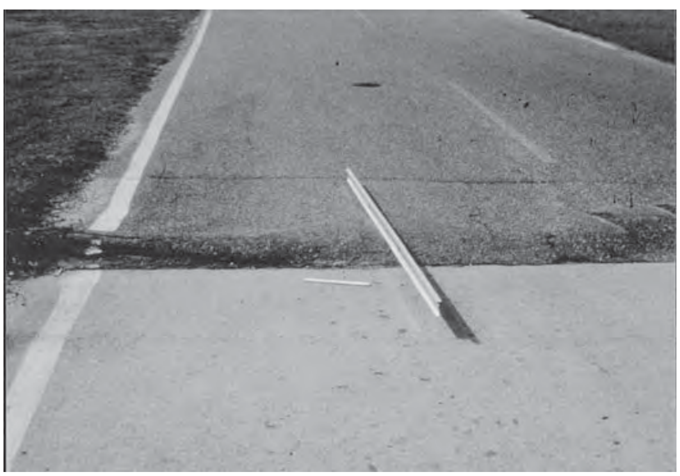


FIG. X1.46 High-Severity Shoving

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.

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. X1.47 Low-Severity Slippage Cracking

FIG. X1.48 Medium-Severity Slippage Cracking

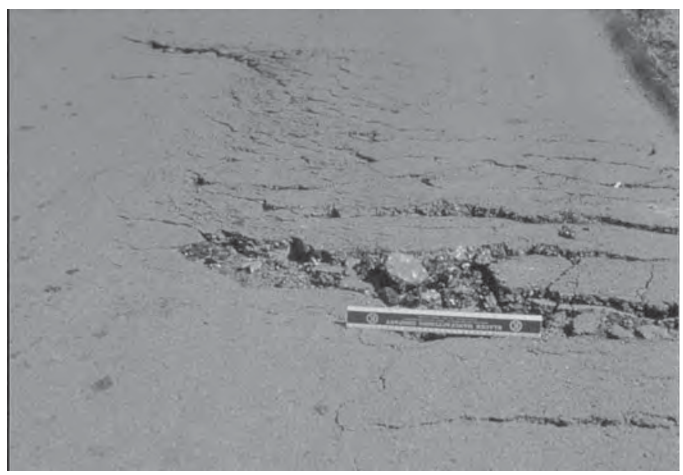


FIG. X1.49 High-Severity Slippage Cracking

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.

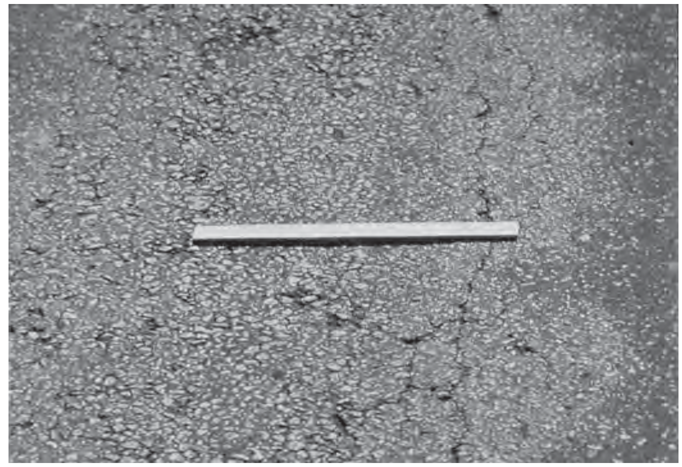


FIG. X1.51 Low-Severity Weathering and Raveling

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

FIG. X2.4 Low-Severity Corner Break

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. X2.5 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

FIG. X2.7 Low-Severity Divided Slab

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 (>1⁄8 and <3⁄8 in.)
M	>10 and <20 mm (>3⁄8 and <3⁄4 in.)
H	>20 mm (>3⁄4 in.)

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.

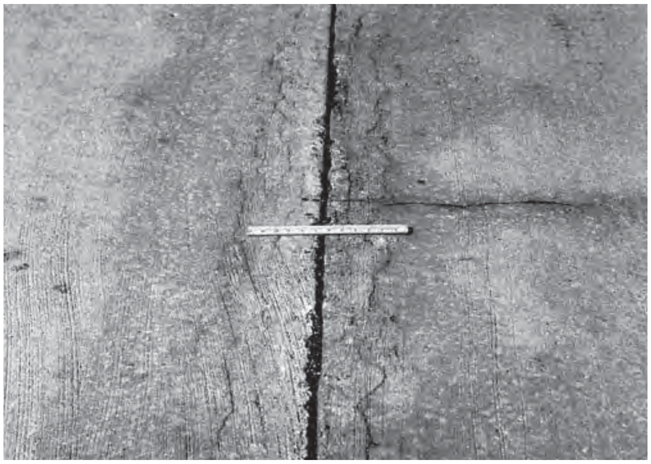


FIG. X2.10 Low-Severity Durability Cracking

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

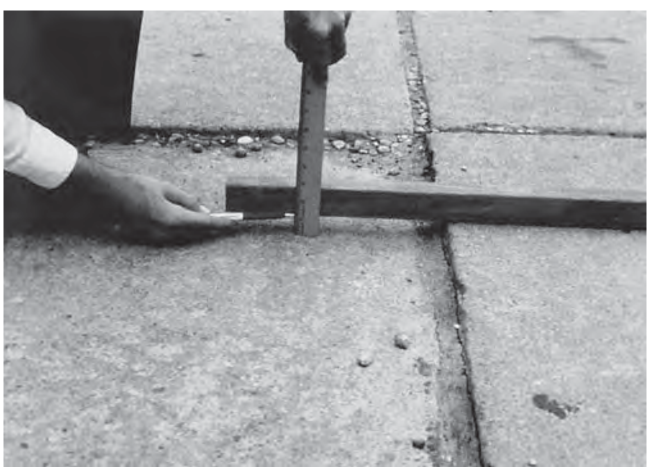


FIG. X2.15 High-Severity Faulting

FIG. X2.16 Low-Severity Joint Seal Damage

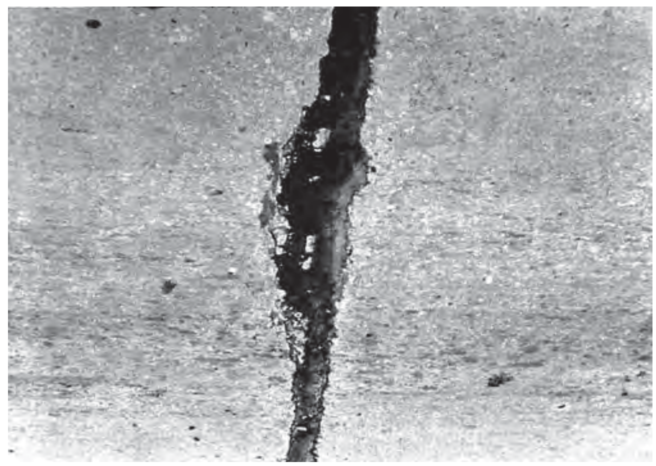


FIG. X2.17 Medium-Severity Joint Seal Damage

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 (1⁄8 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).

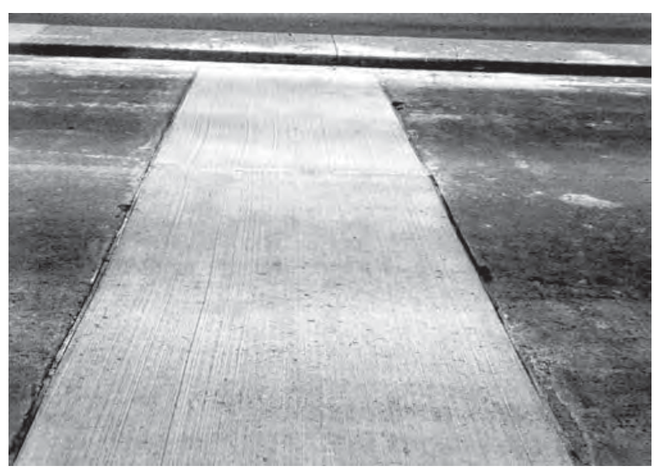


FIG. X2.25 Low-Severity Patching, Large and Utility Cuts

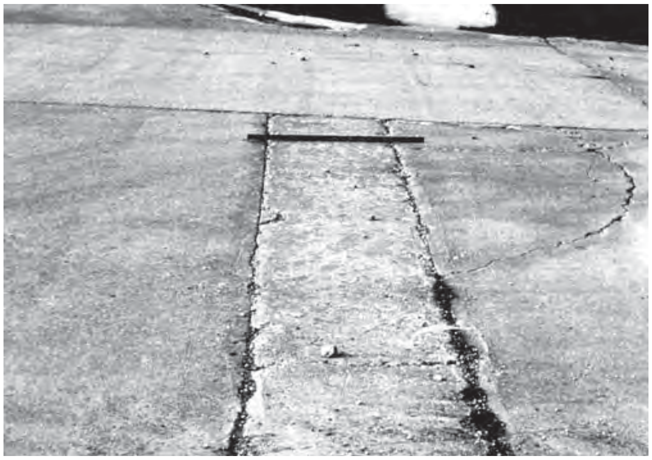


FIG. X2.26 Medium-Severity Patching, Large and Utility Cuts

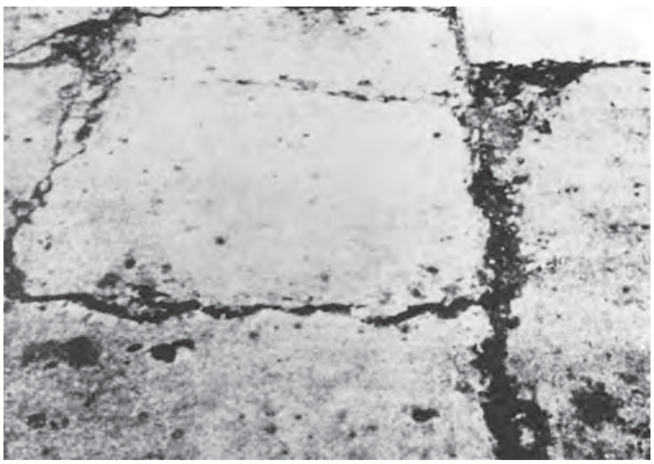


FIG. X2.27 High-Severity Patching, Large and Utility Cuts

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

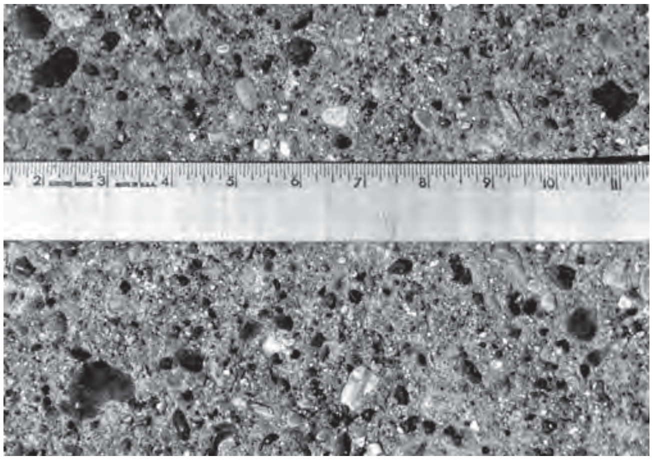


FIG. X2.31 Polished Aggregate

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.

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

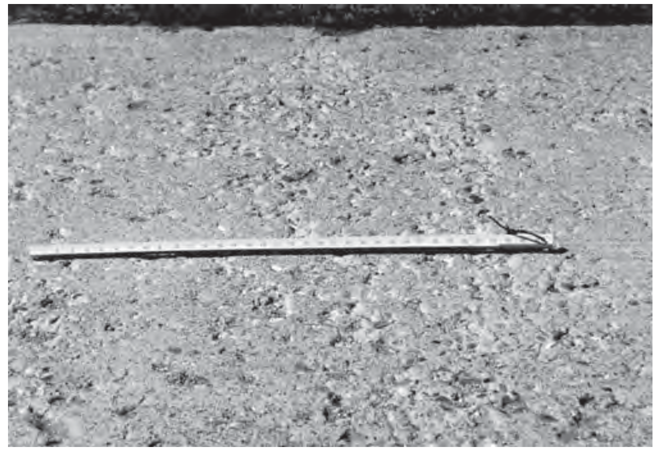


FIG. X2.42 Medium-Severity Scaling, Map Cracking, and Crazing

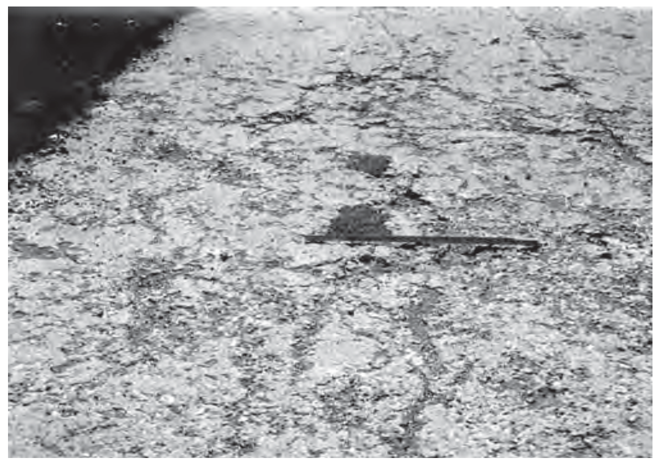


FIG. X2.43 High-Severity Scaling, Map Cracking, and Crazing

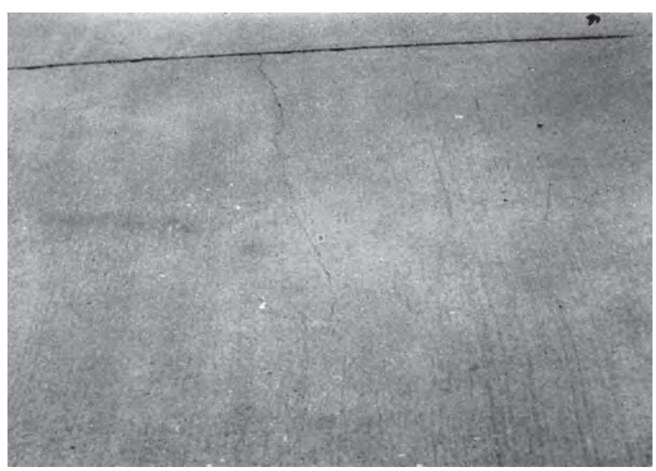


FIG. X2.44 Shrinkage Cracks

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

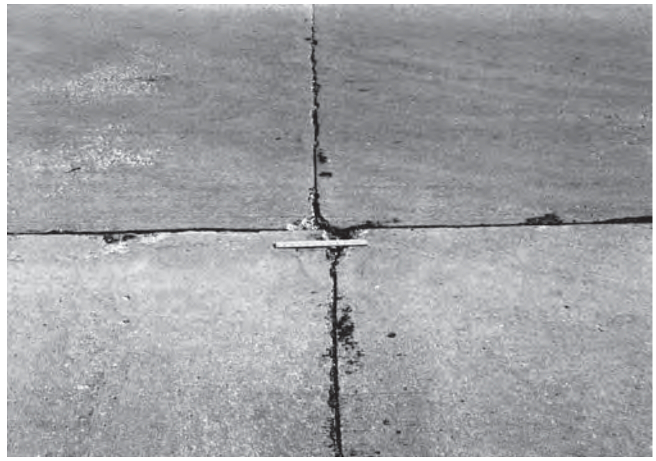


FIG. X2.45 Low-Severity Spalling, Corner

FIG. X2.46 Medium-Severity Spalling, Corner

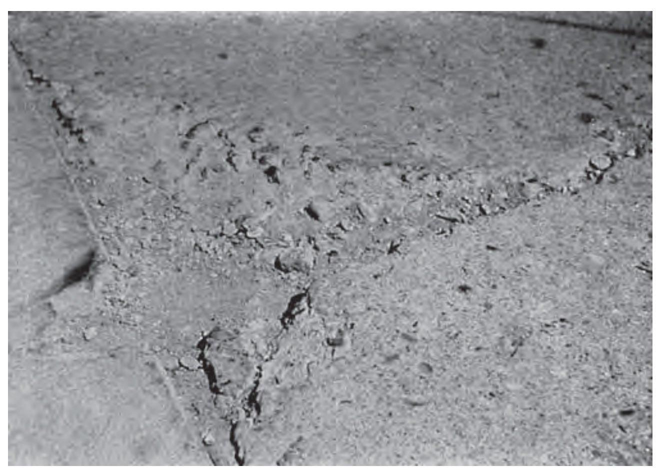


FIG. X2.47 High-Severity Spalling, Corner

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**

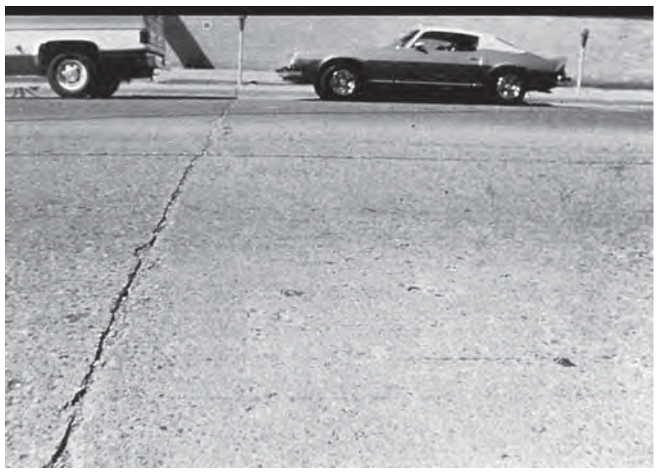


FIG. X2.48 Low-Severity Spalling, Joint

FIG. X2.49 Medium-Severity Spalling, Joint

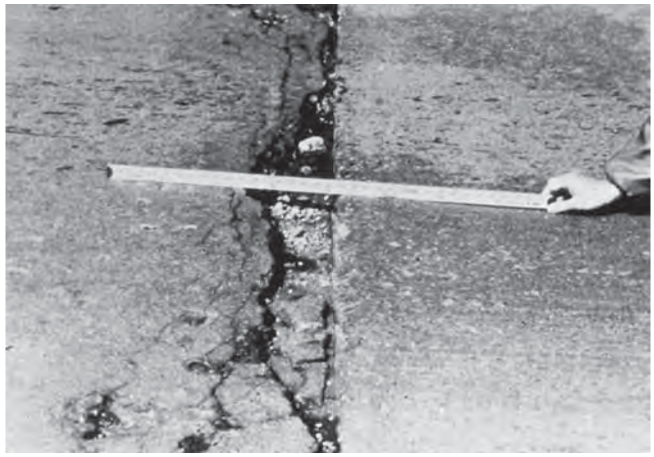


FIG. X2.50 High-Severity Spalling, Joint

X3. DEDUCT VALUE CURVES FOR ASPHALT

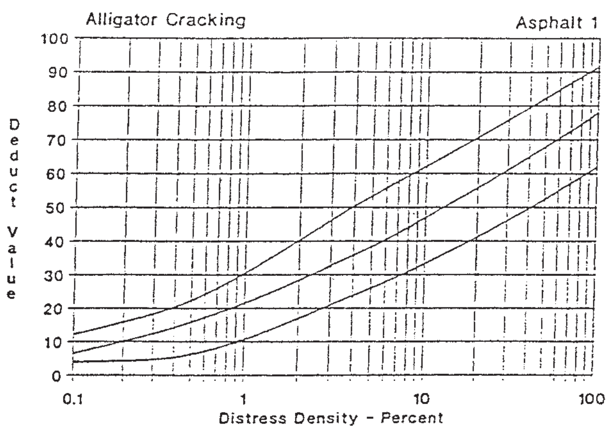


FIG. X3.1 Alligator Cracking

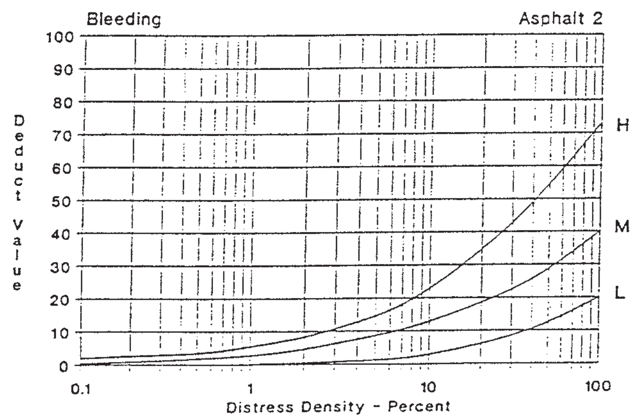


FIG. X3.2 Bleeding

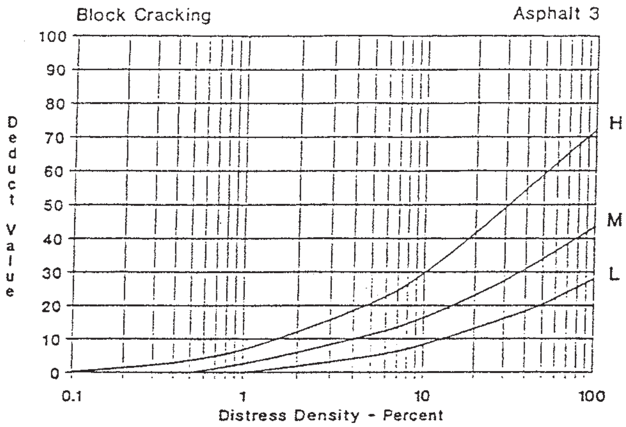


FIG. X3.3 Block Cracking

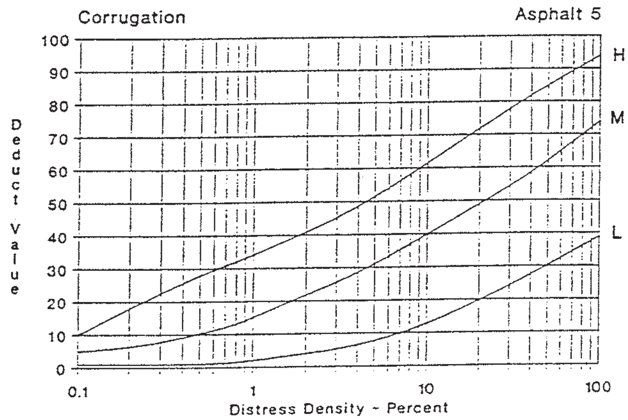


FIG. X3.6 Corrugation

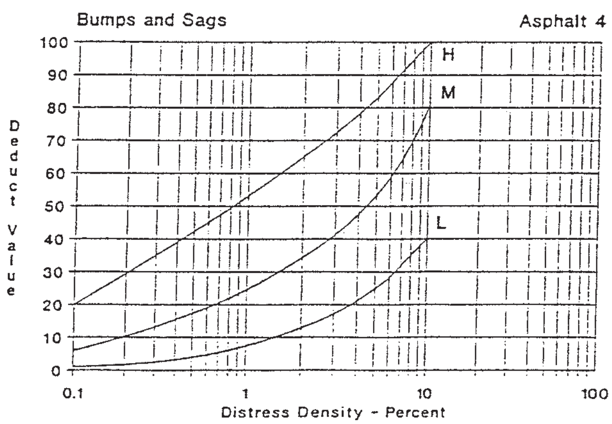


FIG. X3.4 Bumps and Sags

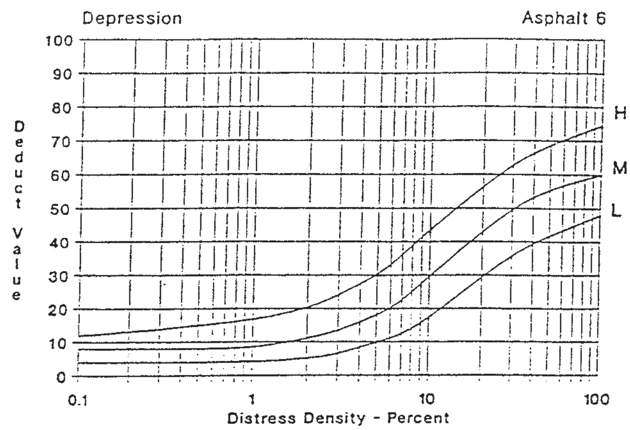


FIG. X3.7 Depression

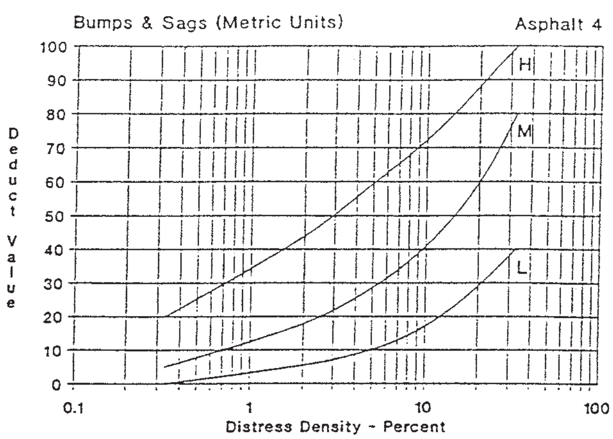


FIG. X3.5 Bumps and Sags (Metric units)

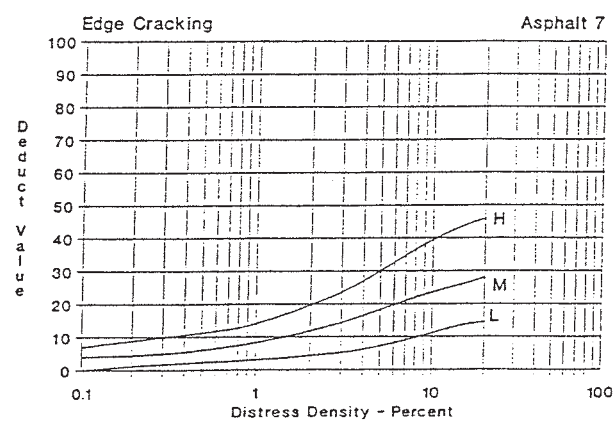


FIG. X3.8 Edge Cracking

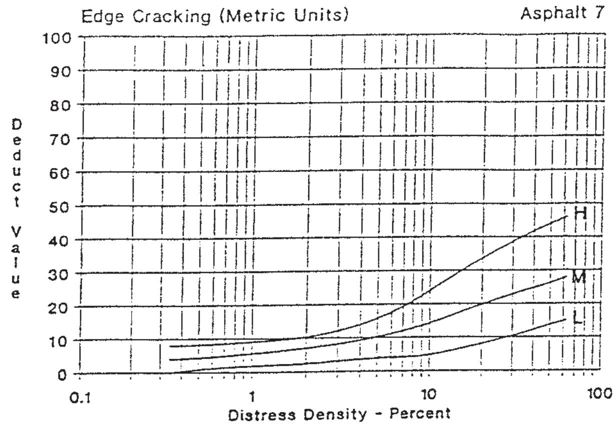


FIG. X3.9 Edge Cracking (metric units)

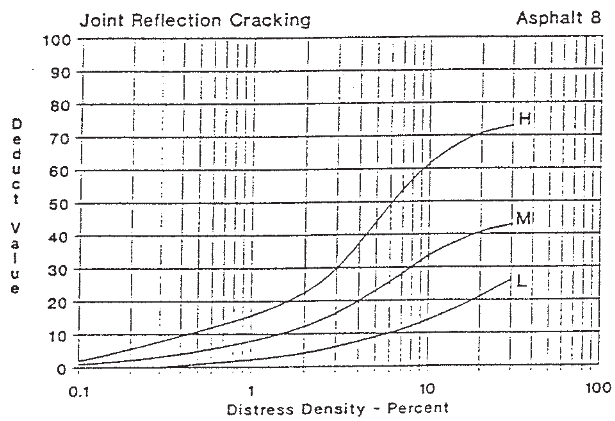


FIG. X3.10 Joint Reflection Cracking

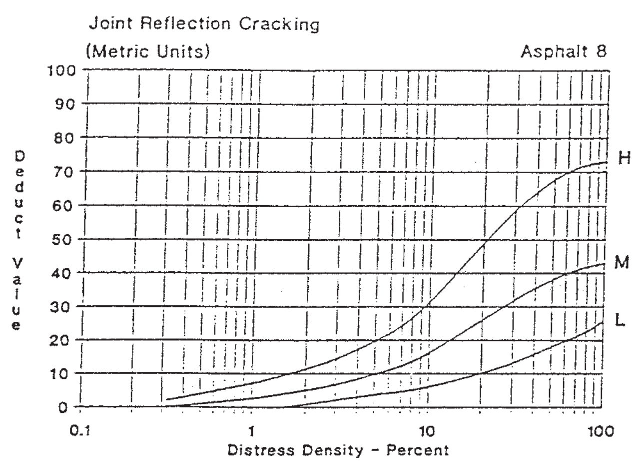


FIG. X3.11 Joint Reflection Cracking (metric units)

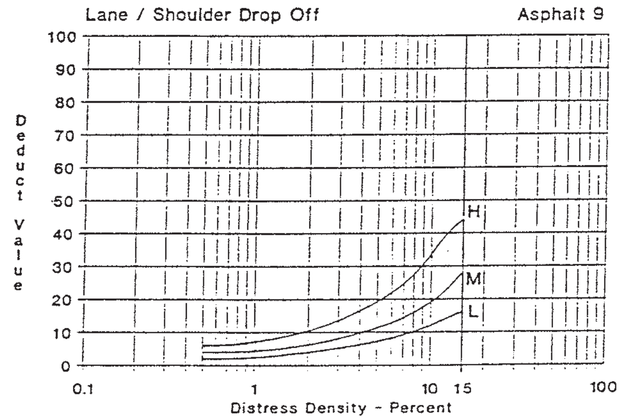


FIG. X3.12 Lane/Shoulder Drop-Off

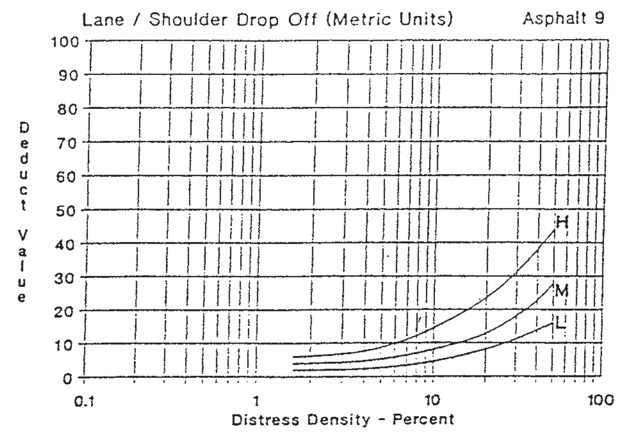


FIG. X3.13 Lane/Shoulder Drop-Off (metric units)

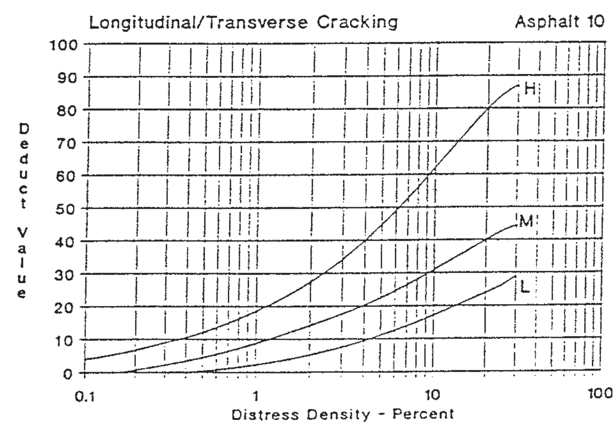


FIG. X3.14 Longitudinal/Transverse Cracking

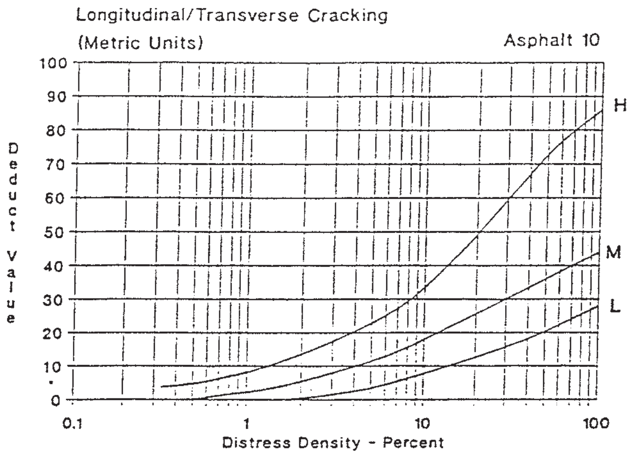


FIG. X3.15 Longitudinal/Transverse Cracking (metric units)

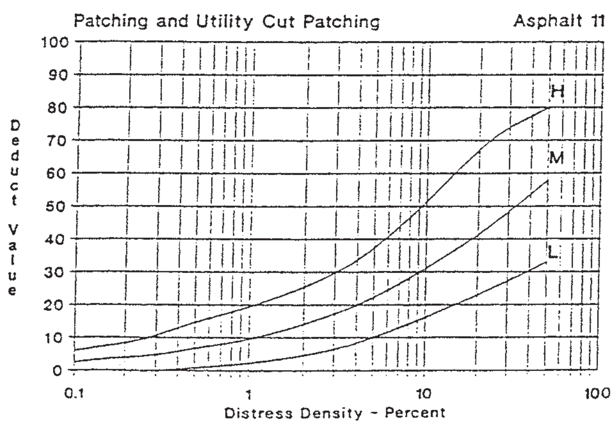


FIG. X3.16 Patching and Utility Cut Patching

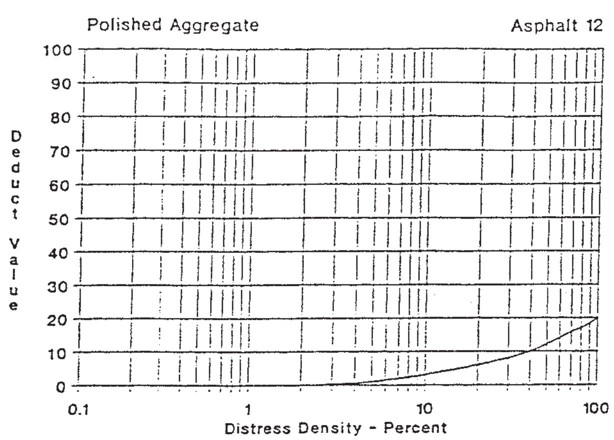


FIG. X3.17 Polished Aggregate

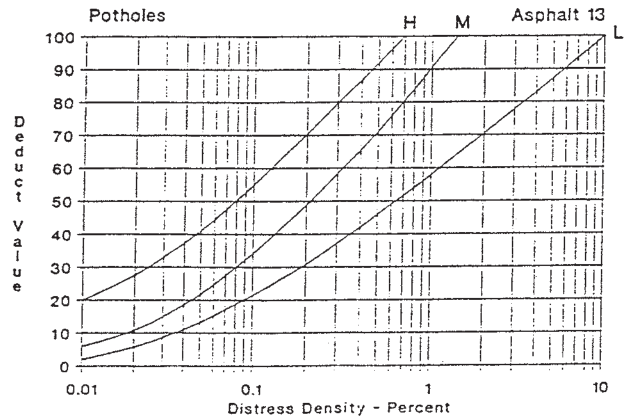


FIG. X3.18 Potholes

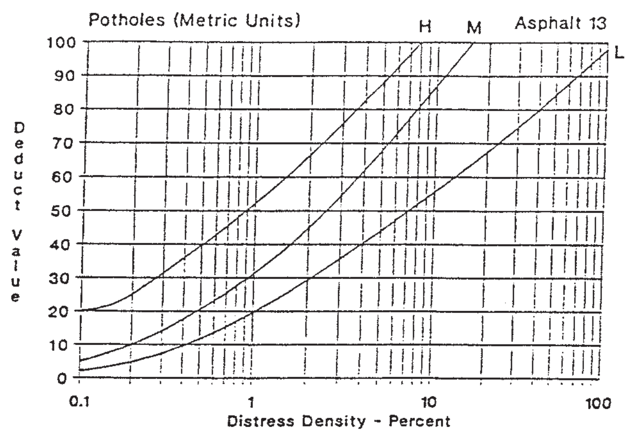


FIG. X3.19 Potholes (metric units)

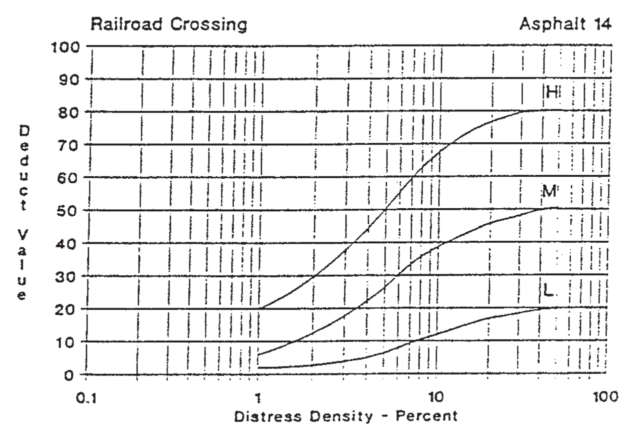


FIG. X3.20 Railroad Crossing

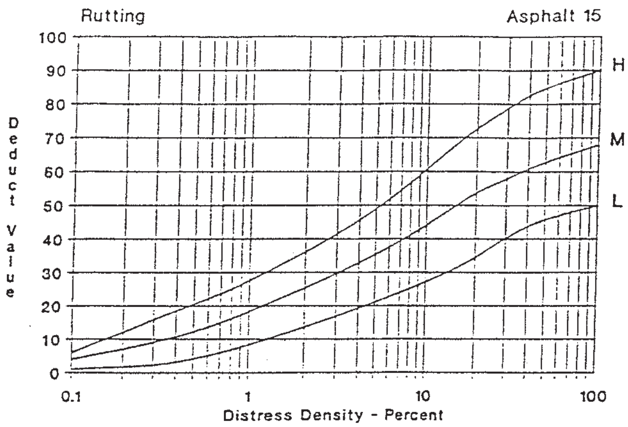


FIG. X3.21 Rutting

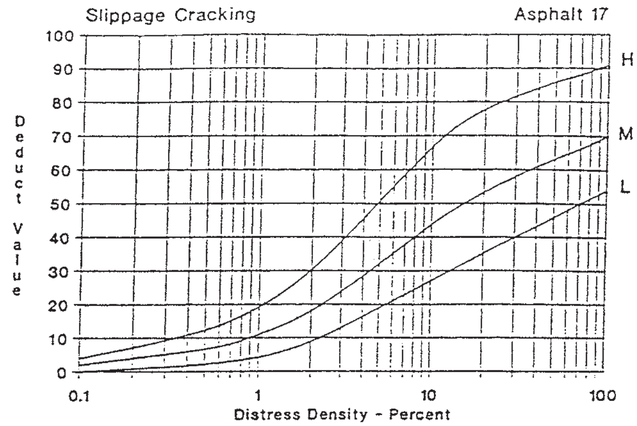


FIG. X3.23 Slippage Cracking

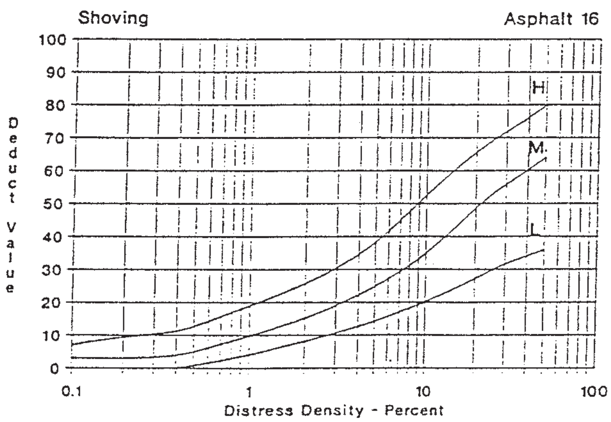


FIG. X3.22 Shoving

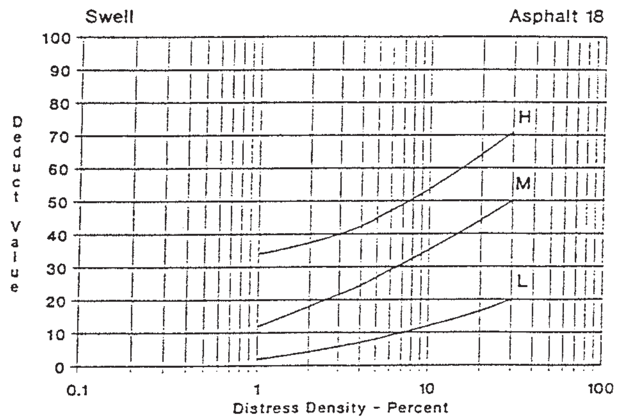


FIG. X3.24 Swell

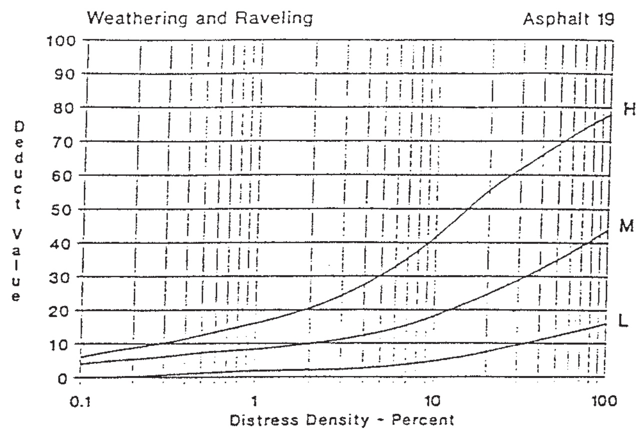


FIG. X3.25 Weathering and Raveling

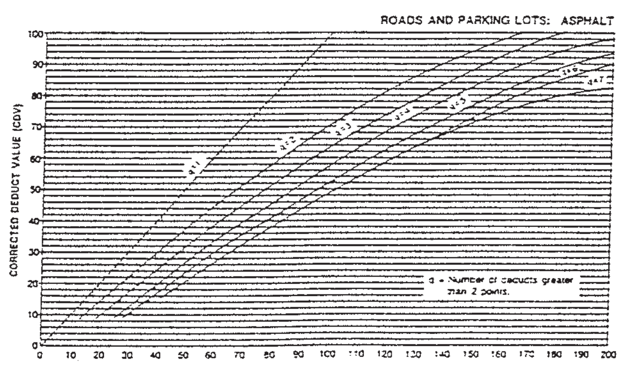


FIG. X3.26 Total Deduct Value

X4. DEDUCT VALUE CURVES FOR CONCRETE

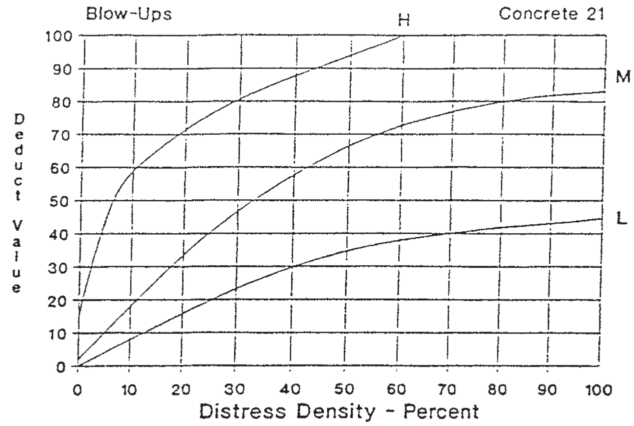


FIG. X4.1 Blowups

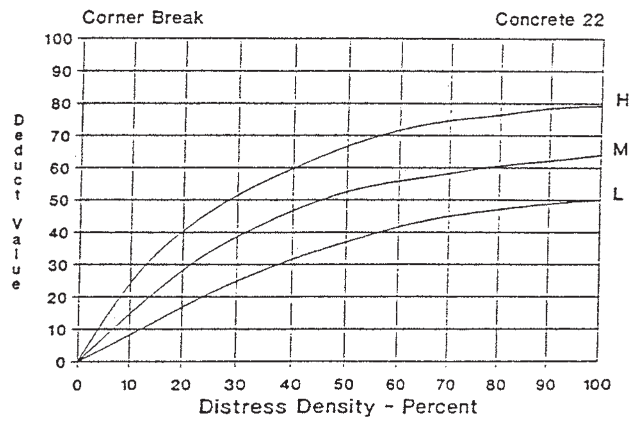


FIG. X4.2 Corner Break

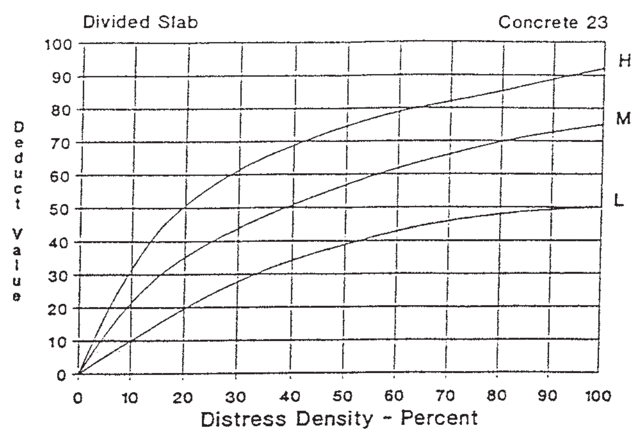


FIG. X4.3 Divided Slab

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.

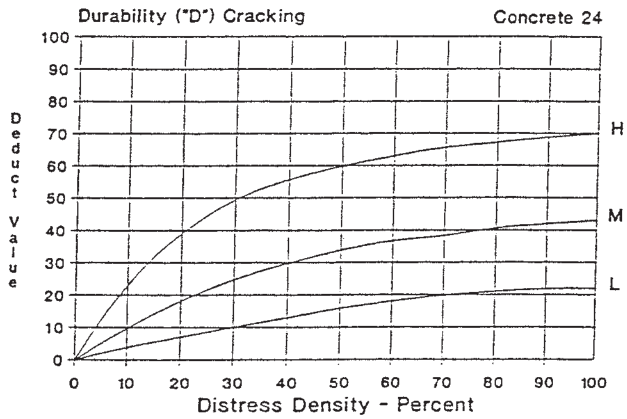


FIG. X4.4 Durability ("D") Cracking

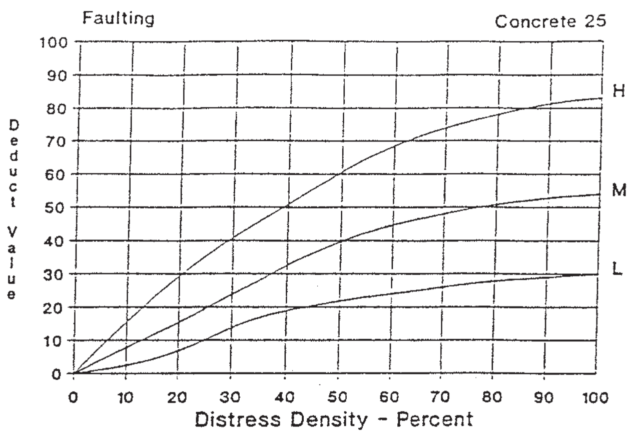


FIG. X4.5 Faulting

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

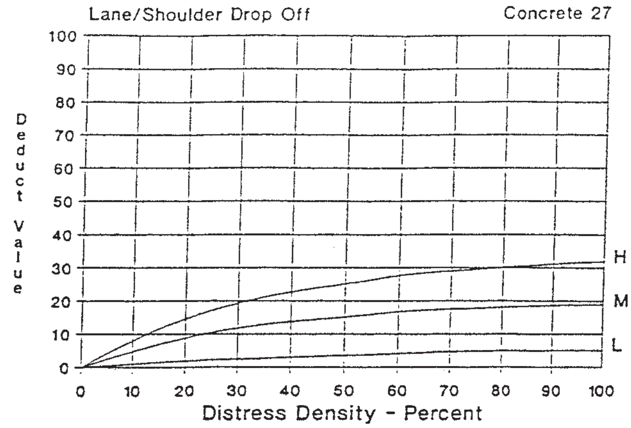


FIG. X4.7 Lane/Shoulder Drop-Off

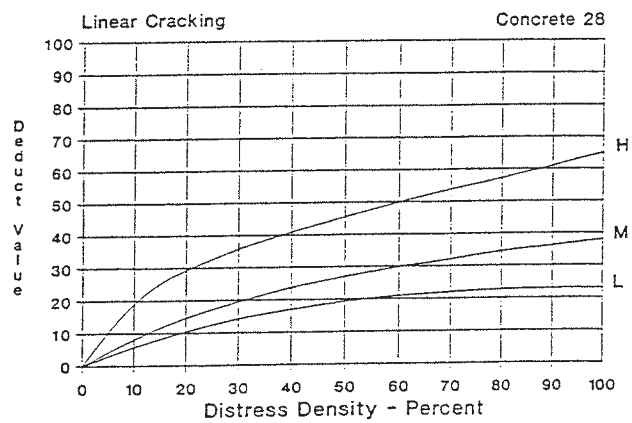


FIG. X4.8 Linear Cracking

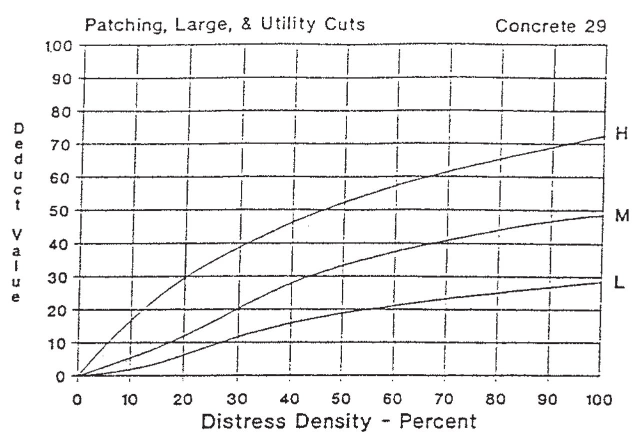


FIG. X4.9 Patching, Large, and Utility Cuts

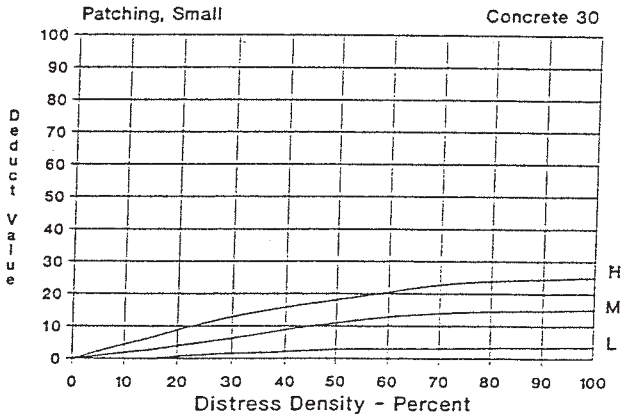


FIG. X4.10 Patching, Small

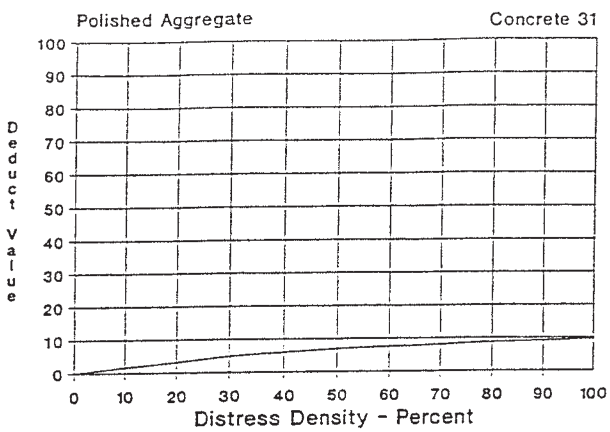


FIG. X4.11 Polished Aggregate

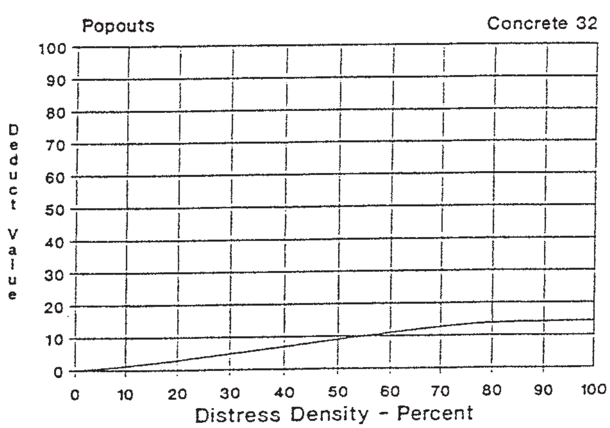


FIG. X4.12 Popouts

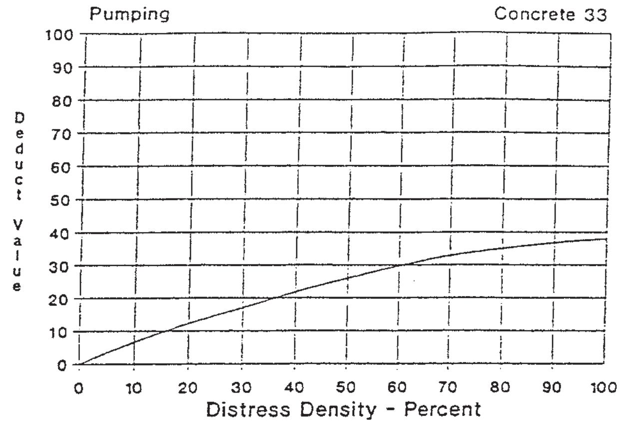


FIG. X4.13 Pumping

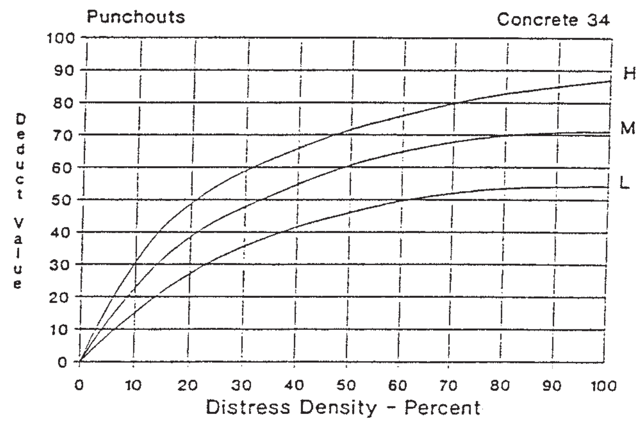


FIG. X4.14 Punchouts

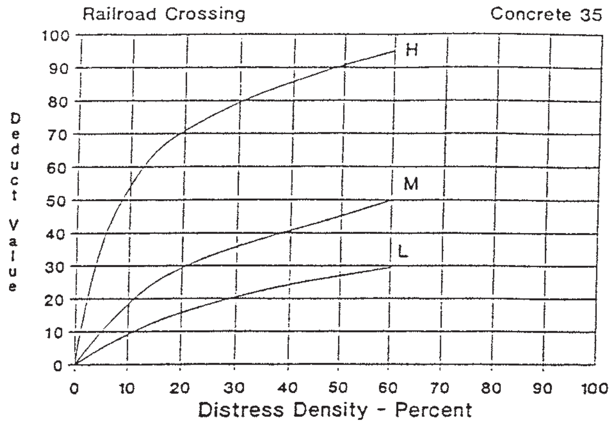


FIG. X4.15 Railroad Crossing

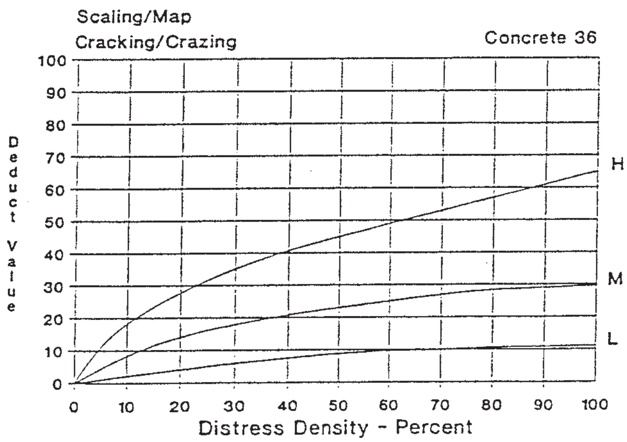


FIG. X4.16 Scaling/Map Cracking/Crazing

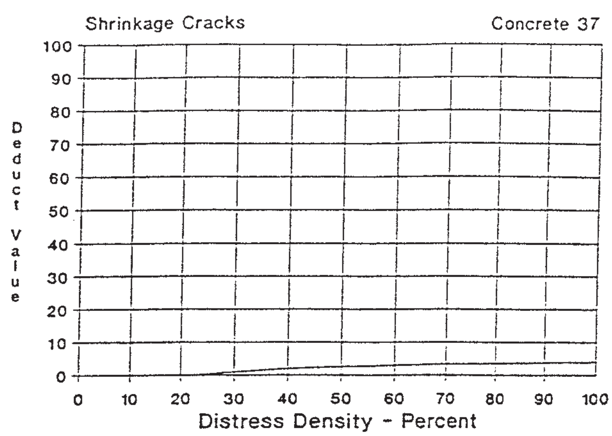


FIG. X4.17 Shrinkage Cracks

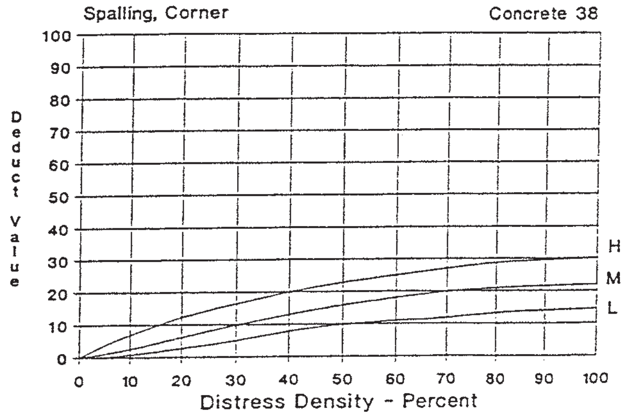


FIG. X4.18 Spalling, Corner

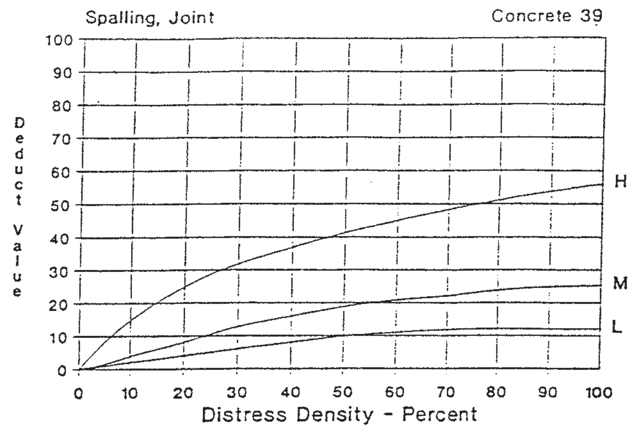
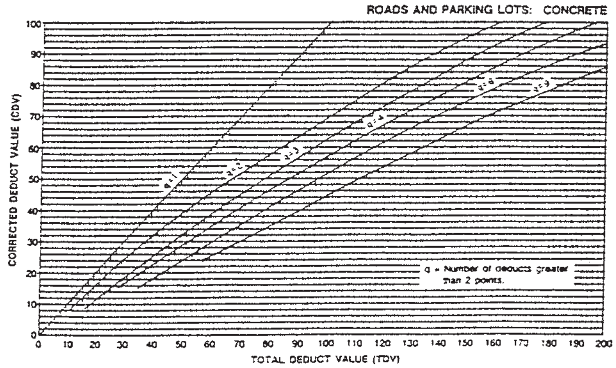


FIG. X4.19 Spalling, Joint



Corrected deduct values for jointed concrete pavement.

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

Vinton Solar Energy LLC
Case No. 17-774-EL-BGN

Exhibit D

TRC Site Characterization Report
June 2017

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Attorneys for Vinton Solar Energy LLC

Exhibit D

SITE CHARACTERIZATION STUDY REPORT

Vinton Solar Energy Center

Vinton County, Ohio

June 2017

TRC Project No. 274099.0000.0004

Prepared For:

Vinton Solar Energy, LLC
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Prepared By:

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Mike Sponsler
Senior Project Manager

Justin Pitts
Ecological Project Manager

TRC
Results you can rely on

CONFIDENTIAL BUSINESS INFORMATION

Table of Contents

List of Tables

List of Figures

Acronyms

DOW	ODNR Division of Wildlife
GIS	Geographic Information System
GPS	Global Positioning System
IPaC	USFWS Information for Planning and Conservation
MW	Megawatt
NLCD	National Land Cover Database
NRCS	Natural Resources Conservation Service
NWI	National Wetland Inventory
OAC	Ohio Administration Code
ODNR	Ohio Department of Natural Resources
OPSB	Ohio Power Siting Board
TRC	TRC Environmental Corporation
USACE	United States Army Corps of Engineers
USDA-NRCS	United States Department of Agriculture – Natural Resources Conservation Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VSE	Vinton Solar Energy, LLC

1.0 Introduction

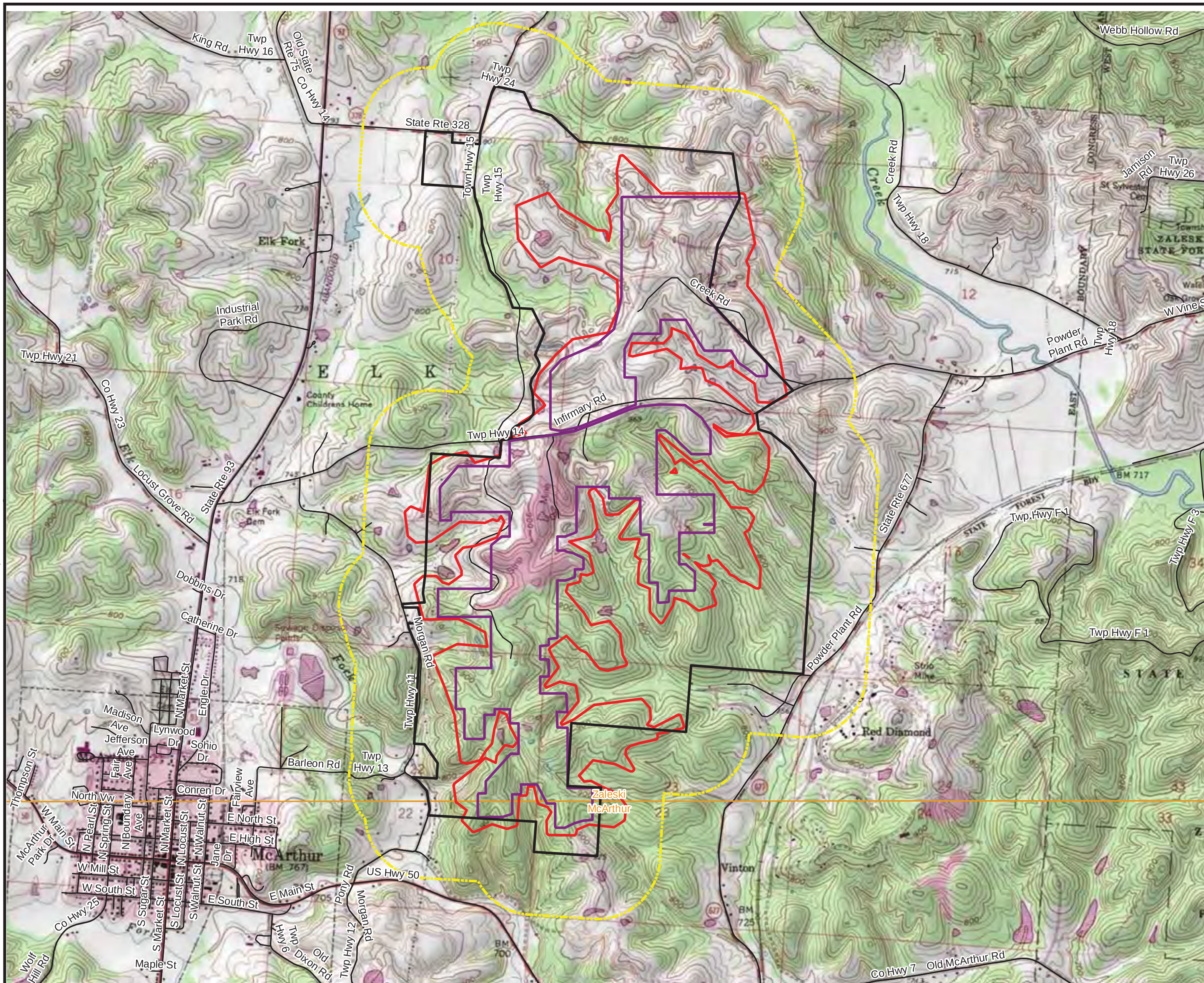
On behalf of Vinton Solar Energy, LLC (VSE), TRC Environmental Corporation (TRC) has prepared this Site Characterization Report as part of the environmental studies conducted for the Vinton Solar Energy Center Project (Project). The proposed solar facility will generate up to 125 megawatts (MW) of power.

For the purposes of this report, the Project Area is the area which VSE will propose to include within their Ohio Power Siting Board (OPSB) application for a certificate of environmental compatibility and public need, issued by the OPSB. The land is privately owned and is located approximately 1.0 miles (1.6 kilometers) northeast of the Village of McArthur in Vinton County, Ohio (Figure 1.1).

The Study Area as used in this report consists of the area where potential construction disturbance will occur (Impact Area) and an additional approximately 100-foot (30-meter) buffer in accordance with the Ohio Administration Code (OAC) 4906-4-08(B)(1)(b). This Study Area is approximately 1,250 acres (506 hectares) of primarily hay/pasture lands. Except for small thin wooded unmined fringes of land and roads, the Study Area was entirely surface-mined for coal and reclaimed to modern standards (i.e. grading to approximate original contour, replacement of topsoil and revegetation with a stable ground cover).

The study objectives were to provide information needed to address questions posed under the Tier 1 Preliminary Site Evaluation and Tier 2 Site Characterization Study tiers of the U.S. Fish and Wildlife Service's (USFWS) Land-Based Wind Energy Guidelines (WEG; USFWS, 2012), and to provide data to comply with the Ohio Power Siting Board (OPSB) requirements at OAC 4906-4-08(B)(1). The wind guidelines were used because the USFWS has not developed a similar tiered approach for solar development.

The Project lies within the Unglaciated Plateau section of the Allegheny Plateau physiographic province of Ohio. The Unglaciated Plateau covers southeastern Ohio and contains deep valleys, high hills, and winding streams (Wilkin, E, F J Nava, and G Griffith. 2011). Sandstone is common in the region and the region supports a variety of cliffs, gorges, natural bridges and waterfalls. A long belt of high hills from Monroe to Columbiana Counties divides streams that flow to the east and west. (Wilkin, E, F J Nava, and G Griffith. 2011). Topography in the region consists of steep slopes and high ridges, with elevations ranging from approximately 781 feet (238 meters) to approximately 961 feet (293 meters) above mean sea level along the ridgetops. The soils consist mostly of Bethesda Silty Clay Loam and Wharton-Latham Silt Loams (NRCS 2017), which are reclaimed mined land soil types.



LEGEND

Project Area

Study Area

Impact Area

Quarter Mile Buffer - Per OAC 4906-4-08

Roads

U.S. Geological Survey 24k Quad

0 1,000 2,000 Feet

1 " = 2,000 '

1:24,000

PROJECT:

VINTON SOLAR ENERGY, LLC
VINTON SOLAR ENERGY CENTER PROJECT
CONFIDENTIAL BUSINESS INFORMATION

TITLE:

USGS TOPOGRAPHIC FIGURE

DRAWN BY:	N.RENAUDIN	PROJ NO.:	274099.0000.0000
CHECKED BY:	J.PITTS		1.1
APPROVED BY:	M.SPONSLER		
DATE:	JUNE 2017		

TRC

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FILE NO.: Figure 1.1 Updated Vinton.mxd

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TRC - GIS

2.0 Methods

The preliminary site assessment and site characterization were completed using a combination of a) existing information obtained from available public sources including reports, published literature, on-line databases, and geographic information system (GIS) data, b) field reconnaissance, and c) agency consultation.

2.1 Existing Information from Available Public Sources

The following publicly available data sources were used to complete a literature review required by OAC 4906-4-08(B)(1)(c), which specifies including review of a 0.25-mile (0.40-kilometer) buffer beyond the Project Area boundary – (Figure 1.1 - Quarter Mile Buffer). The following data sources were used to complete this review:

- Google Earth ("Google Earth – Google Earth." Google Earth. Google, no date (n.d.) Web. 10 Apr. 2017. *https://earth.google.com/*).
- National Audubon's Important Bird Areas ("Important Bird Areas." Audubon. No publisher (N.p.), (n.d.) Web. 10 Apr. 2017. *http://www.audubon.org/important-bird-areas*).
- National Audubon's Christmas Bird Count ("Christmas Bird Count." Audubon. N.p., n.d. Web. 10 Apr. 2017. *http://www.audubon.org/conservation/science/christmas-bird-count*).
- United States Geological Survey (USGS) National Land Cover Database (NLCD) (Survey, U.S. Geological. "National Land Cover Database (NLCD)." LCS Program: NLCD. N.p., n.d. Web. 10 Apr. 2017. *https://www2.usgs.gov/climate_landuse/lcs/projects/nlcd.asp*).
- Ohio Department of Natural Resources (ODNR) National Heritage Database (Wildlife, Ohio DNR Division of. "Ohio.gov / search." Ohio DNR Division of Wildlife. N.p., n.d. Web. 10 Apr. 2017. *http://wildlife.ohiodnr.gov/species-and-habitats/ohio-natural-heritage-database*).
- U.S. Department of Agriculture (USDA), National Resource Conservation Service (NRCS), Web-Soil Survey (Web Soil Survey. N.p., n.d. Web. 10 Apr. 2017. *https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx*).
- USFWS Information for Planning and Conservation (IPaC) IPaC: Home. N.p., n.d. Web. 10 Apr. 2017. *https://ecos.fws.gov/ipac/*).
- USFWS National Wetlands Inventory (NWI) (U.S. Fish and Wildlife Service; National Wetlands Inventory; National Standards and Support Team. "Wetlands Mapper." Official Web page of the

U S Fish and Wildlife Service. N.p., n.d. Web. 10 Apr. 2017. *https://www.fws.gov/wetlands/data/Mapper.html*).

From these sources, TRC created a land cover map, a National Wetlands Inventory (NWI) wetlands map, and a list of species of concern possibly occurring in the Study Area and their typical habitat requirements.

2.2 Field Reconnaissance

A field reconnaissance of the Study Area was conducted April 4 through April 7, 2017, to complete the following:

- Ground-truth NLCD land cover types and locations;
- Document where land cover types provide habitat for species of concern;
- Ground-truth NWI mapped potential wetland locations;
- Document readily observable features that may serve to attract wildlife, if any; and
- Record incidental wildlife observations.

Vegetation and surface waters were surveyed in the Study Area. Based on field observations, the NLCD classification map units were either confirmed or reclassified. Readily identifiable land cover changes (i.e., areas that had been converted to mined and reclaimed to pasture were recorded and mapped. These were mapped based on vegetative structure and dominant species composition. The boundaries were mapped in the field using a global positioning system (GPS) (where accessible) and completed using current Google Earth™ imagery.

Data developed from existing information were utilized during the field reconnaissance to document areas where land cover types may provide suitable habitat for species of concern. Land cover types were field-verified, and locations were documented if they provided potentially suitable habitat for species of concern. For species with specific or narrowly-defined habitat requirements, potentially suitable habitats were viewed (where accessible), and the presence or absence of the specific habitat requirements were recorded.

NWI mapped wetland locations were assessed to ascertain the presence or absence of wetland vegetation and wetland hydrology (noting the predominant vegetative strata, dominant plant species, and type, i.e., stream, pond, lake, etc.).

Readily observable features that could serve as suitable habitat for wildlife, if any, were mapped and briefly described. Incidental wildlife observations were recorded.

3.0 Results

3.1 Land Cover

Cover types in the Study Area, prior to mining activity, were comprised of a mixture of cultivated crops, barren land and hay/pasture, as mapped by the NLCD (USGS 2017a) (Figure 3.1.1). However, post-mining activity land cover types within the Study Area, consist primarily of hay/pasture, as mapped by the NLCD (USGS 2017a) (Figure 3.1.2). Land cover types were field-verified to confirm post-mining cover types. As shown in Table 3.1 (below), NLCD data indicate that approximately 89 percent of the Study Area is comprised of hay/pasture.

Table 3.1. Field-Verified National Land Cover Database Land Cover Types within the Vinton Solar Energy Center Study Area, Vinton County, Ohio, 2017.

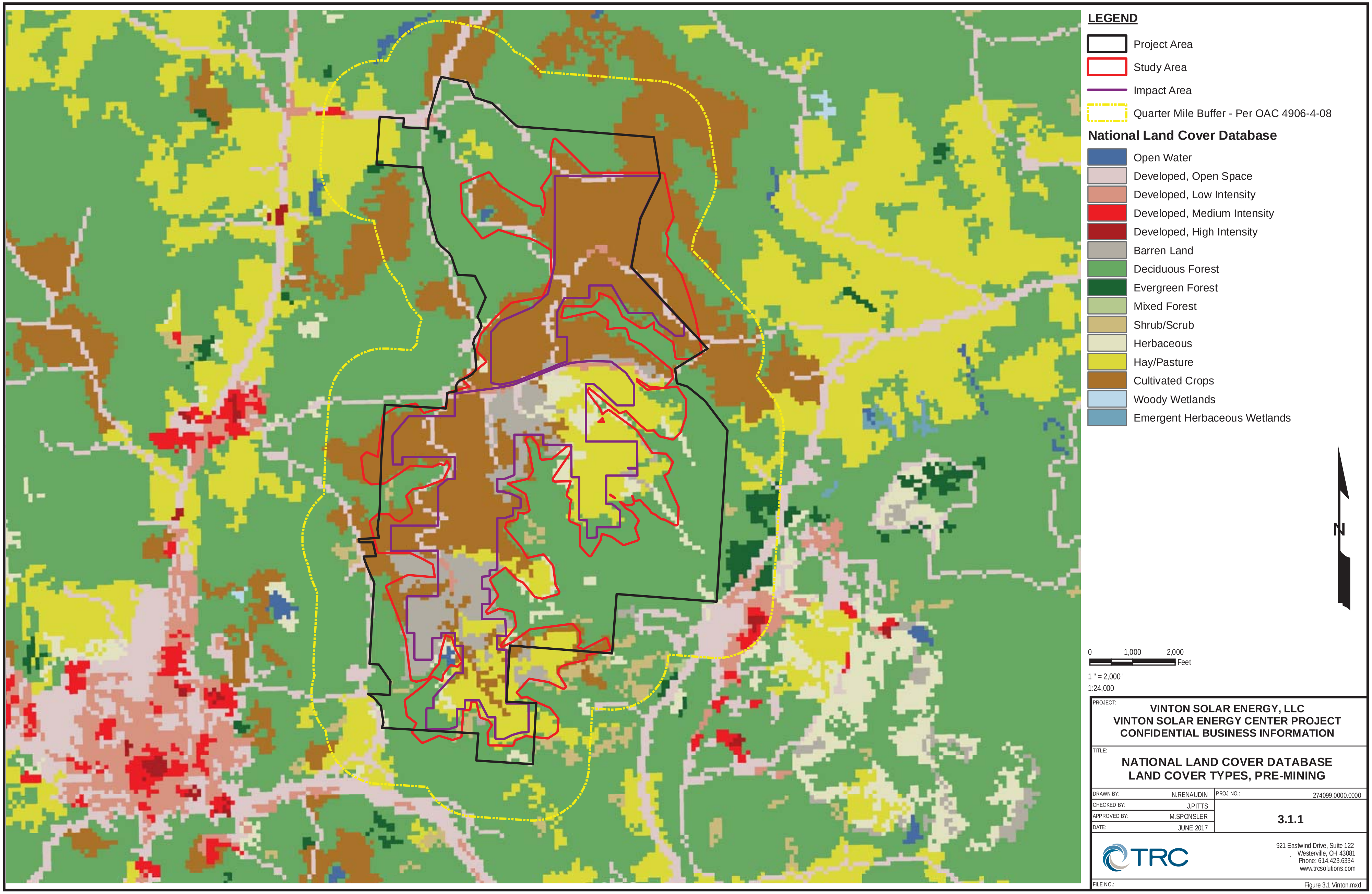
Cover Type	Acres	Hectares	Percent (%)
Hay/Pasture	1,109	449	89
Deciduous Forest	102	41	8
Barren Land	22	9	1
Emergent Herbaceous Wetlands	14	5	1
Open Water	2	<1	<1
Shrub/Scrub	1	<1	<1
Total	**1,250**	**506**	**100.00**

3.2 NWI Wetlands

Prior to conducting the field reconnaissance, in accordance with Ohio Administrative Code (OAC) 4906-4-08(B)(1)(c), a literature review of NWI maps (USFWS NWI 2017) identified two freshwater emergent wetlands, one freshwater forested/scrub-shrub wetland and 17 freshwater ponds within the 0.25-mile (0.40-kilometer) buffer around the Project Area boundary (Figure 3.2).

In the field, TRC identified and documented the boundaries of 17 freshwater wetlands, 17 freshwater ponds and 17 watercourses within the Study Area. The freshwater emergent and forested/scrub-shrub wetlands and freshwater ponds documented during field reconnaissance were depicted on the NWI maps.

Based on the review of NWI maps, less than 0.30 percent of the Study Area is comprised of wetlands, excluding other waters of the U.S., (ephemeral, intermittent and perennial streams). The predominant wetland type is freshwater palustrine emergent wetland (0.24 percent), followed by freshwater palustrine scrub-shrub (0.04 percent) (Table 3.2). However, additional mapped NWI wetland areas are located adjacent to the Study Area within the 0.25-mile (0.40-kilometer) buffer around the Project Area boundary (Figure 3.2).



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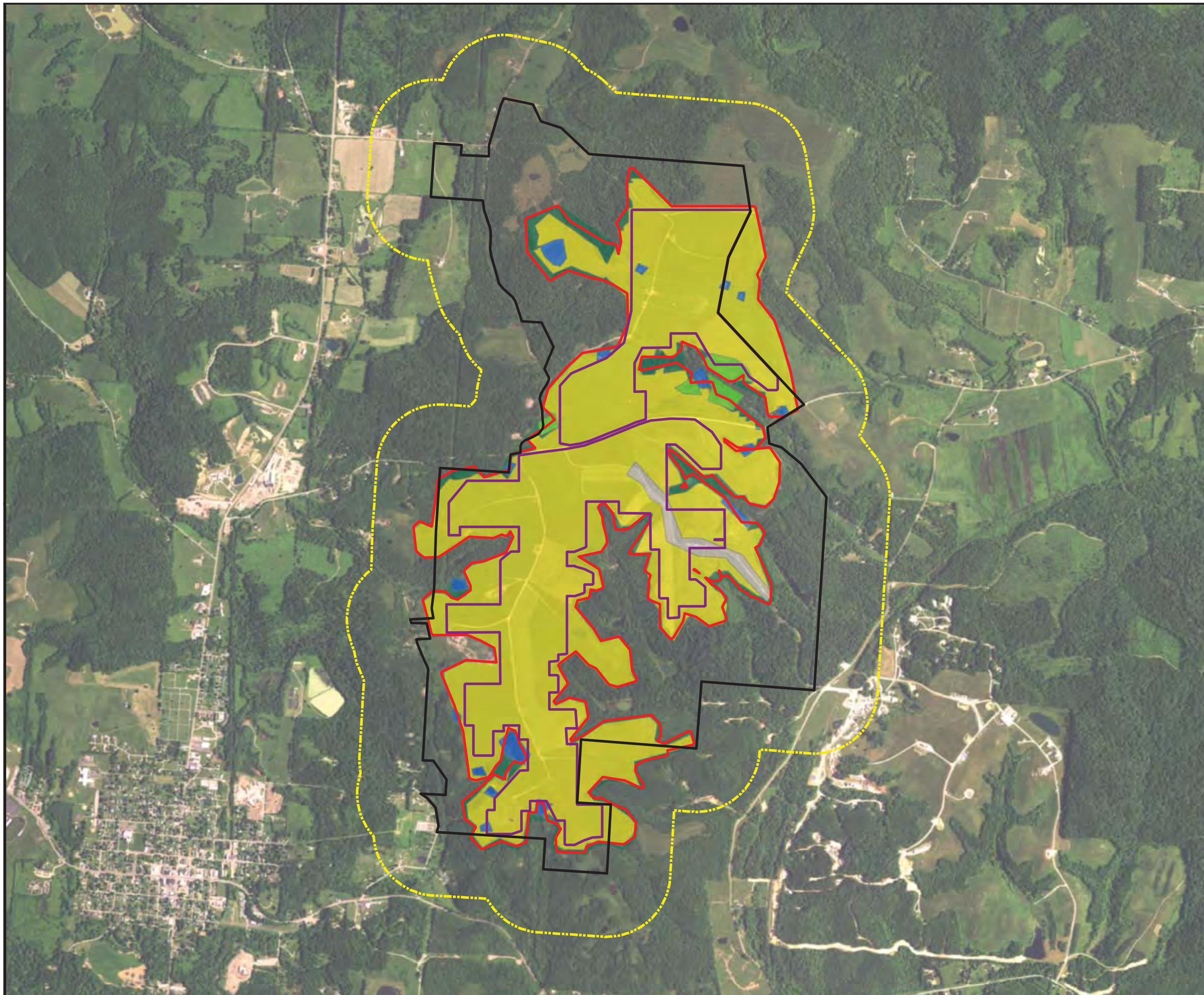
TRC - GIS



LEGEND

- Project Area
- Study Area
- Impact Area
- Quarter Mile Buffer - Per OAC 4906-4-08

Ground Truthed Land Use

- BARREN LAND
- ERMERGENT HERBACEUOUS WETLAND
- OPEN WATER
- DECIDUOUS FOREST
- HAY/PASUTRE

0 1,000 2,000 Feet

1 " = 2,000 '
1:24,000

PROJECT:	VINTON SOLAR ENERGY, LLC VINTON SOLAR ENERGY CENTER PROJECT CONFIDENTIAL BUSINESS INFORMATION
TITLE:	NATIONAL LAND COVER DATABASE GROUND TRUTHED LAND USE

DRAWN BY:	N.RENAUDIN	PROJ NO.:	274099.0000.0000
CHECKED BY:	J.PITTS		3.1.2
APPROVED BY:	M.SPONSLER		
DATE:	JUNE 2017		

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TRC - GIS

Table 3.2. National Wetland Inventory Wetland Types within the Vinton Solar Energy Center Study Area, Vinton County, Ohio, 2017.

Wetland Type	Acres	Hectares	Percent (%)
Palustrine emergent	1.70	0.69	0.24
Palustrine shrub/scrub	0.28	0.11	0.04
Total	**1.98**	**0.80**	**0.28**

3.3 Habitat Description

The Study Area is primarily reclaimed surface-mined pasture land that is actively grazed by cattle. Continuous disturbance by grazing has resulted in a vegetative cover of short grass that provides limited habitat diversity. Grasses recorded are smooth bromegrass (*Bromus inermis*) and orchardgrass (*Dactylis glomerata*) dominating the ground cover. Red clover (*Trifolium pretense*), white clover (*Trifolium repens*), and Kentucky bluegrass (*Poa pratensis*) were also common. Invasive species present in grazed pasture are common, such as dandelion (*Taraxacum officinale*) and broomsedge bluestem (*Andropogon virginicus*).

Freshwater ponds and wetlands occur intermittently throughout the Study Area (Figure 3.2). Most of the water features are remnants of the mining activity, such as former sediment control ponds and patches with differential soil settlement of the reclaimed land. Water features are located along woodland edges, outside the construction Impact Area (Figure 3.2). Wetlands mapped within the construction Impact Area were found to be small and low quality (Category 1). These wetlands are characterized by grasses and legumes planted during land reclamation as described above and wetland species, such as common rush (*Juncus effusus*), narrowleaf cattail (*Typha augustifolia*), broadleaf cattail (*Typha latifolia*), and fox sedge (*Carex vulpinoidea*). These species are opportunistic and colonize areas with soil settlement and wet conditions.

Correspondence received from the USFWS (2017b) in a Technical Assistance Letter dated April 12, 2017, indicated that no federal wilderness areas, wildlife refuges or designated critical habitat were identified on or within a 1.0-mile (1.6-kilometer) radius of the Study Area. Correspondence dated April 13, 2017, from the ODNR Natural Heritage Database (2017a), indicates that the ODNR Division of Wildlife (DOW) is unaware of any unique ecological sites, geologic features, animal assemblages, scenic rivers, state wildlife areas, nature preserves, parks or forests, national wildlife refuges, or other protected natural areas on or within a 1.0-mile (1.6-kilometer) radius of the Study Area. ODNR reported records of unique plant communities within 0.5 miles of the 0.25-mile (0.40-kilometer) Project Area buffer.

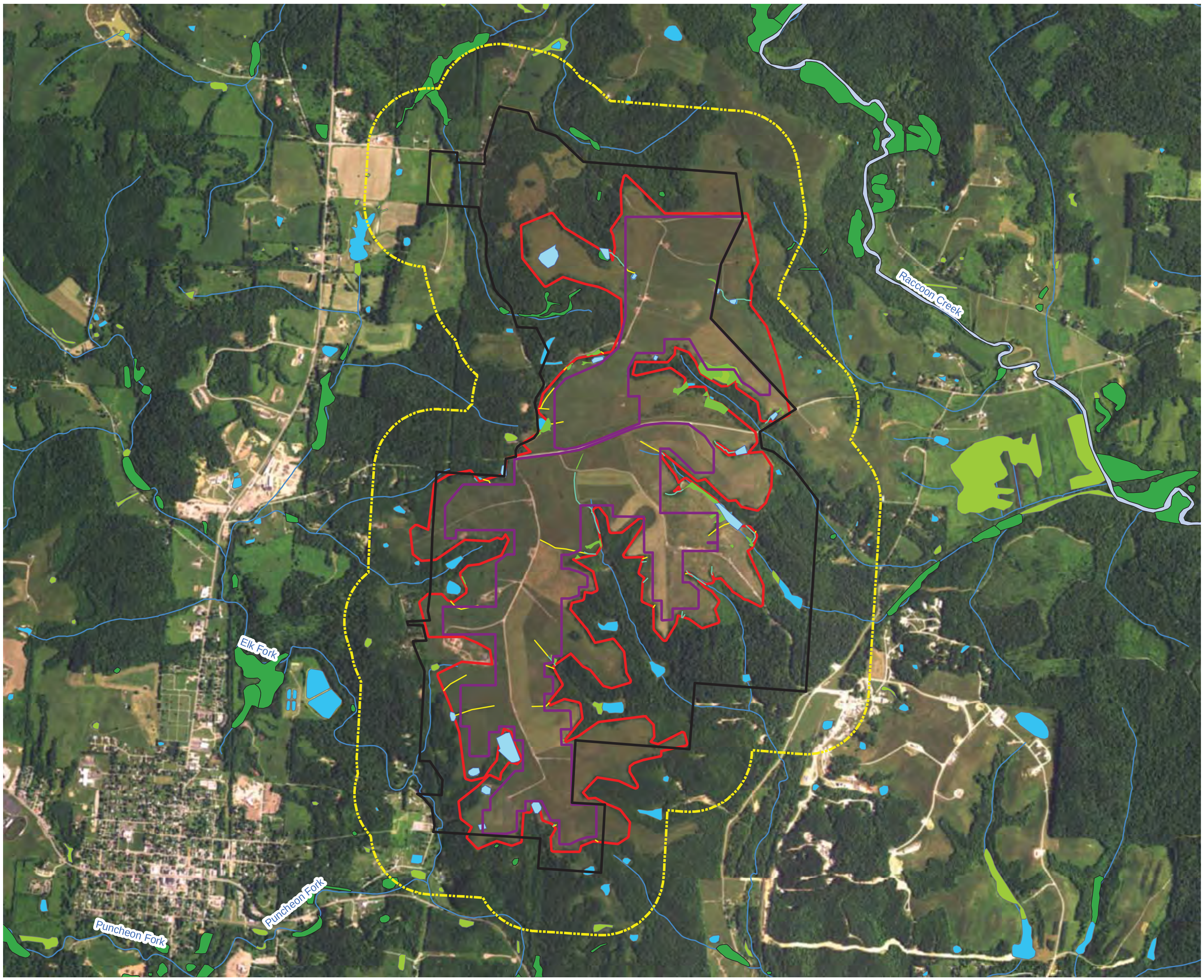
Field surveys completed within the Study Area confirmed ODNR results that no unique, sensitive or critical habitats were present. The land was restored to pasture after surface coal mining reclamation operations and is actively managed for grazing of beef cattle. Continuous disturbance by grazing has resulted in a vegetative cover of short grass that provides limited habitat diversity. Field reconnaissance was consistent with the land use data, indicating that little habitat diversity exists within the Study Area. The vegetation within the Study Area provides limited habitat that may be attractive to species of concern, and contains no high quality habitat (i.e., no large undisturbed grasslands and no woodlands) at risk of fragmentation. The topography within the Study Area is hilly but without prominent ridgelines that may attract raptors. Manmade structures (i.e., buildings) that may have the potential to attract bat species are absent.

3.4 Wildlife Species

According to ODNR (2017a) and USFWS (2017b), there are no records of species of concern within the Study Area. The USFWS IPaC resource (USFWS 2017c) identified one plant, one insect, 21 migratory birds of conservation concern and two bat species as having ranges that overlap the Study Area. No significant suitable habitat for these species was observed in the Study Area. Nesting or roosting habitat is present along the edges of the Study Area, but these habitats are not planned for disturbance. Foraging is available over the pastures and ponds for some of the species. Refer to Section 3.4.1 and Table 3.3 for further detail on threatened and endangered species.

3.4.1 Federally Listed Species

The USFWS (2017b) identified the federally endangered species running buffalo clover (*Trifolium stoloniferum*), federally endangered American burying beetle (*Nicrophorus americanus*), federally endangered Indiana bat (*Myotis sodalis*), and federally threatened northern long-eared bat (*Myotis septentrionalis*) as having the potential to occur within Vinton County. None of the aforementioned species were identified by the USFWS as having recorded occurrences within the Study Area (USFWS 2017b, c) (Table 3.3).



LEGEND

- Project Area
- Study Area
- Impact Area
- Quarter Mile Buffer - Per OAC 4906-4-08
- Delineated Wetland
- Delineated Stream Centerline
- Delineated Non-Jurisdictional Drainage
- Delineated Pond
- National Hydrography Dataset (NHD) Streams

National Wetlands Inventory (NWI) Wetlands

- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Riverine

0 1,000 2,000 Feet

1 " = 2,000 '

1:24,000

PROJECT:

VINTON SOLAR ENERGY, LLC
VINTON SOLAR ENERGY CENTER PROJECT
CONFIDENTIAL BUSINESS INFORMATION

TITLE:

NATIONAL WETLAND INVENTORY AND DELINEATED FEATURES

DRAWN BY:	N.RENAUDIN	PROJ NO.:	274099.0000.0000
CHECKED BY:	J.PITTS		3.2
APPROVED BY:	M.SPONSLER		
DATE:	JUNE 2017		

TRC

921 Eastwind Drive, Suite 122
Westerville, OH 43081
Phone: 614.423.6334
www.trcsolutions.com

FILE NO.: Figure 3.2 Vinton.mxd

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Path: C:\Users\nrenaudin.EMPLOYEES\Desktop\Vinton County Project\Habitat Asses\Figure 3.2 Vinton.mxd

Coordinate System: NAD 1983 CORS96 StatePlane Ohio South FIPS 3402 Ft US (Foot US)

Map Rotation: 0

TRC - GIS

Table 3.3. Wildlife Species Of Concern, Status, Preferred Habitat, And Potential Seasons Of Occurrence For Species That Are Known Or Likely To Occur In The Vinton Solar Energy Center Study Area.

Wildlife Type/ Common Name	Scientific Name	Status[1]	Habitat by Season	Seasons of Potential Occurrence and Likelihood of Occurrence in the Study Area[2]			
				Spring	**Summer**	**Fall**	**Winter**
BIRDS							
Raptors							
Bald eagle	*Haliaeetus leucocephalus*	SC	Nests near mature trees and snags winter through spring; forages in various habitats	L	L	L	L
Short-eared owl	*Asio flammeus*	SC	Ground nester in grasslands; needs grasslands for hunting in all seasons	L	N	L	L
Peregrine Falcon	*Falco peregrinus*	SC	Nests on ledges or man-made structures, e.g. tall buildings; more populace in western states and Alaska; may winter anywhere in North American range; migration widespread with coastal concentrations	L	N	L	N
Non-raptors							
Black-billed cuckoo	*Coccyzus erythropthalmus*	SC	Nests in deciduous woodlands and thickets and uses the same for migration; winters in South America	L	L	L	N
Blue-winged Warbler	*Vermivora pinus*	SC	Nests in mid-successional habitats and forest clearings on or near ground; winters in Central America	L	N	L	N
Canada Warbler	*Wilsonia canadensis*	SC	Nests in riparian thickets, brushy ravines, forest bogs, etc. at a wide range of elevations and across a variety of forest types; winters in South America	L	L	L	N

Table 3.3. Wildlife Species Of Concern, Status, Preferred Habitat, And Potential Seasons Of Occurrence For Species That Are Known Or Likely To Occur In The Vinton Solar Energy Center Study Area.

Wildlife Type/ Common Name	Scientific Name	Status[1]	Habitat by Season	Seasons of Potential Occurrence and Likelihood of Occurrence in the Study Area[2]			
				Spring	**Summer**	**Fall**	**Winter**
Cerulean Warbler	*Dendroica cerulea*	SC	Breeds in large deciduous forests; winters in South America	L	N	L	N
Dickcissel	*Spiza americana*	SC	Nests and forages in grassy habitats in all seasons; winters in Central and South America	L	L	L	N
Fox Sparrow	*Passerella iliaca*	SC	Nests in scrubby, brushy woods and forest edges (containing spruce, balsam fir, tamarack, aspen, birch, willow, and alder) from Alaska to Newfoundland; winters in Midwest, central, and southern U.S.	L	L	L	L
Henslow's sparrow	*Ammodramus henslowii*	SC	Uses large grasslands in all seasons; winters in the southern U.S.	L	L	L	N
Kentucky warbler	*Oporonis formosus*	SC	Ground nester in moist deciduous forest; uses woodlands during migration and winters in Central and South America	L	L	L	N
Least Bittern	*Ixobrychus exilis*	SC	Nests in tall emergent vegetation in marshes; winters in Mexico Central and South America.	L	N	L	N
Loggerhead shrike	*Lanius ludovicianus*	SC	Nests in thorny vegetation in open country habitat with well-spaced shrubs and low trees; winters in southern U.S. and Mexico	L	L	L	L

Table 3.3. Wildlife Species Of Concern, Status, Preferred Habitat, And Potential Seasons Of Occurrence For Species That Are Known Or Likely To Occur In The Vinton Solar Energy Center Study Area.

Wildlife Type/ Common Name	Scientific Name	Status[1]	Habitat by Season	Seasons of Potential Occurrence and Likelihood of Occurrence in the Study Area[2]			
				Spring	Summer	Fall	Winter
Louisiana Waterthrush	*Parkesia motacilla*	SC	Nests along open-banked, fast- or slow-moving streams with steep to moderate gradients, forested watersheds or swampy areas with standing water; winters in central and South America	L	L	L	N
Pied-billed Grebe	*Podilymbus podiceps*	SC	Floating nest on water or on platform near water/wetlands throughout Ohio; winters in southern states	L	N	L	N
Prairie Warbler	*Dendroica discolor*	SC	Found in scrubby fields and forests throughout the eastern and south-central United States; winters in the Caribbean	L	L	L	N
Prothonotary Warbler	*Protonotaria citrea*	SC	Cavity nester in large flooded forests; winters in Mexico, Central and South America	L	N	L	N
Red-headed woodpecker	*Melanerpes erythrocephalus*	SC	A year round resident of Ohio; a cavity nester in deciduous woodlands with oak or beech, groves of dead or dying trees year around	L	L	L	L
Willow flycatcher	*Empidonax traillii*	SC	Nests in moist, shrubby areas, often with standing or running water; winters in shrubby clearings in Central and South America	L	L	L	N

Table 3.3. Wildlife Species Of Concern, Status, Preferred Habitat, And Potential Seasons Of Occurrence For Species That Are Known Or Likely To Occur In The Vinton Solar Energy Center Study Area.

Wildlife Type/ Common Name	Scientific Name	Status[1]	Habitat by Season	Seasons of Potential Occurrence and Likelihood of Occurrence in the Study Area[2]			
				Spring	**Summer**	**Fall**	**Winter**
Wood thrush	*Hylocichla mustelina*	SC	Nest in deciduous woodland and mixed forests throughout eastern U.S.in small trees or saplings; a ground forager in woodlands throughout the year; it winters in Central America	L	L	L	N
Worm-eating Warbler	*Helmitheros vermivorum*	SC	Found on steep slopes with dense understory in the eastern deciduous forests; winters in Central America and the Caribbean	N	N	N	N
INSECTS							
American burying beetle	*Nicrophorus americanus*	FE	Lives in many types of habitat, with a slight preference for grasslands and open understory hickory forests	L	L	L	L
MAMMALS							
Indiana bat	*Myotis sodalis*	FE	Summer roosting in trees with loose bark over 9.0 inches (22.9 centimeters) in diameter; winters in caves	L	L	L	N
Northern long-eared bat	*Myotis septentrionalis*	FT	Summer roosting in trees with loose bark over 3.0 inches (7.6 centimeters) in diameter; winters in caves	L	L	L	N
PLANTS							

Table 3.3. Wildlife Species Of Concern, Status, Preferred Habitat, And Potential Seasons Of Occurrence For Species That Are Known Or Likely To Occur In The Vinton Solar Energy Center Study Area.

Wildlife Type/ Common Name	Scientific Name	Status[1]	Habitat by Season	Seasons of Potential Occurrence and Likelihood of Occurrence in the Study Area[2]			
				Spring	Summer	Fall	Winter
Running buffalo clover	*Trifolium stoloniferum*	FE	Occurs in mesic habitats of partial to filtered sunlight where there is a pattern of moderate disturbance (mowing, grazing, etc.); most found in regions underlain with limestone or calcareous bedrock; majority of populations occur within the Appalachian and Bluegrass regions	L	L	L	L

Sources:

Cornell Lab of Ornithology, Birds of North America https://birdsna.org/Species-Account/bna/species accessed May 9, 2017

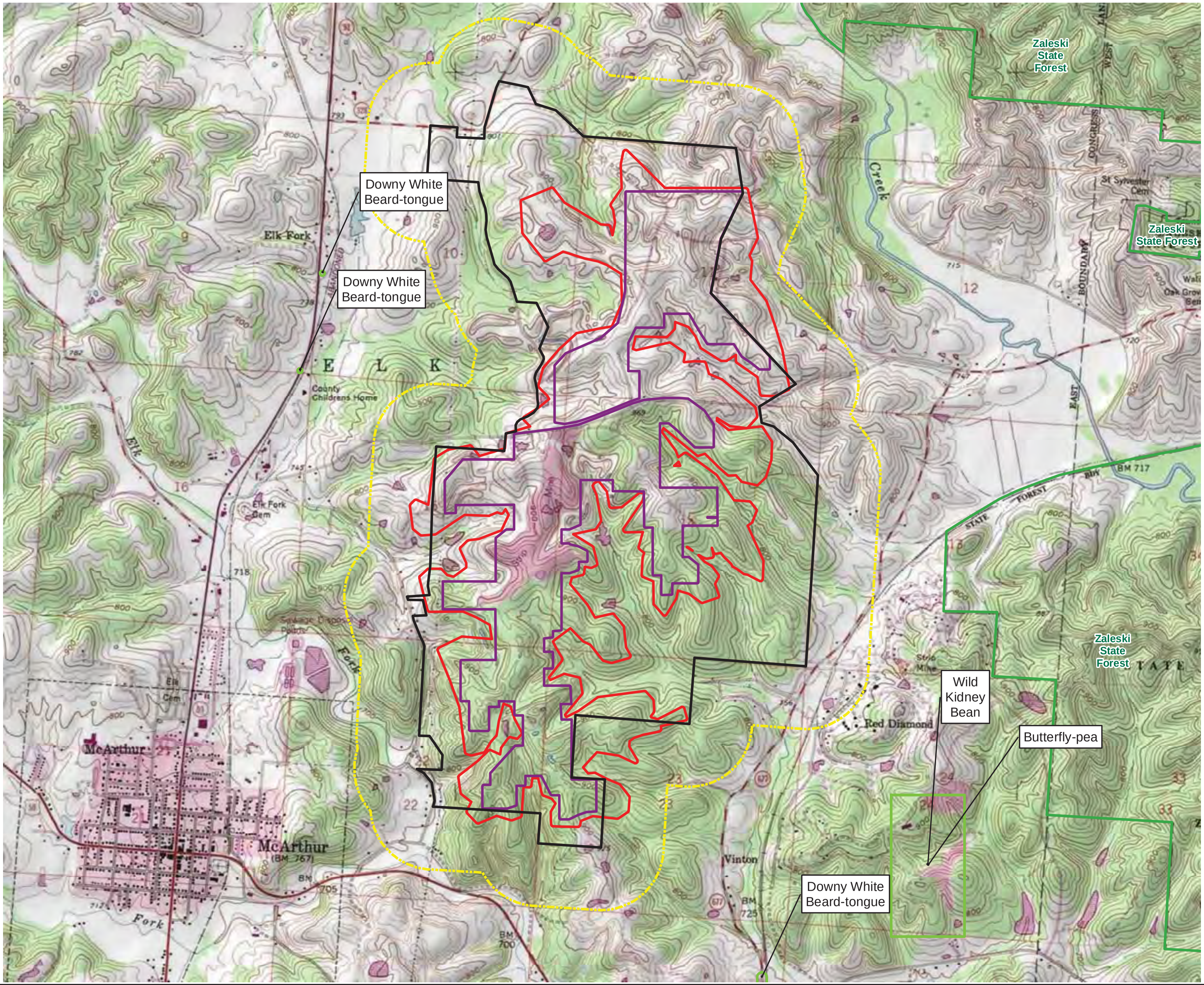
McCormac, Jim, and Gregory Kennedy. Birds of Ohio. Edmonton: Lone Pine Pub., 2004. Print.

ODNR website http://wildlife.ohiodnr.gov/species-and-habitats/state-listed-species accessed May 9, 2017

USFWS website https://www.fws.gov/midwest/endangered/index.html accessed May 9, 2017.

[1] FE = Federal-endangered, FT = Federal-threatened, SC = Species of Concern

[2] Likelihood of occurrence Key: H = High potential; M = Moderate potential; L = Low potential and N = No potential; C = Confirmed sighting



LEGEND

- Project Area
- Study Area
- Impact Area
- Quarter Mile Buffer - Per OAC 4906-4-08
- Plant Communities Of Concern
- Federal, State, Local Owned or Managed Lands

PROJECT:	VINTON SOLAR ENERGY, LLC VINTON SOLAR ENERGY CENTER PROJECT CONFIDENTIAL BUSINESS INFORMATION
TITLE:	PLANT COMMUNITIES OF CONCERN AND FEDERAL/STATE/LOCAL OWNED OR MANAGED LANDS
DRAWN BY: N.RENAUDIN	PROJ NO.: 274099.0000.0000
CHECKED BY: J.PITTS	3.3
APPROVED BY: M.SPONSLER	
DATE: JUNE 2017	
TRC	921 Eastwind Drive, Suite 122 Westerville, OH 43081 Phone: 614.423.6334 www.trcsolutions.com
FILE NO.:	Figure 3.3 Vinton.mxd

Coordinate System: NAD 1983 CORS96 StatePlane Ohio South FIPS 3402 Ft US (Foot US)
Map Rotation: 0

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Federally Threatened and Endangered Species

Running Buffalo Clover (*Trifolium stolonifera*)

The federally endangered running buffalo clover requires periodic disturbance and a somewhat open habitat to successfully flourish, but it cannot tolerate full-sun, full-shade, or severe disturbance. Historically, running buffalo clover was found in rich soils in the ecotone between open forest and prairie. Those areas were probably maintained by the disturbance caused by American bison (*Bison bison*). Today, the species is found in partially shaded woodlots, mowed areas (lawns, parks, cemeteries), and along streams and trails (USFWS 2015).

The literature review, agency consultation and field reconnaissance survey found no potential habitat in the construction Impact Area, because it is heavily grazed pasture in full sun. Potential habitat occurs in the Study Area, but outside of the construction Impact Area; the species was not detected during the field reconnaissance.

American Burying Beetle (*Nicrophorus americanus*)

Historical records offer little insight into what type of habitat is preferred by the federally endangered American burying beetle. Current information suggests that this species is a habitat generalist, capable of living in many types of habitat. It has a slight preference for grasslands and open understory oak hickory forests. However, the beetles are carrion specialists in that they need carrion the size of a dove or a chipmunk in order to reproduce. Carrion availability may be the greatest factor determining where the species can survive (USFWS 2017).

The literature review and field reconnaissance survey found low potential habitat in the construction Impact Area, because it is heavily grazed pasture without open forest understory that would not typically have carrion the size of doves or chipmunks. Potential habitat occurs in areas outside of the construction Impact Area, but none were detected during the field reconnaissance.

Indiana bat (*Myotis sodalis*)

The federally endangered, Indiana bat occurs over a range that extends from the east coast to Midwestern United States, including Ohio (USFWS 2017d). Indiana bats hibernate during winter in caves and mines, subsequently migrating to their summer habitat in wooded areas where they usually roost under loose tree bark on dead or dying trees. Indiana bats utilize a variety habitats to forage on flying insects found along rivers, lakes, open fields and uplands (USFWS 2017d).

Although Indiana bats have the potential to inhabit all counties in Ohio, correspondence with the ODNR (2017a) Natural Heritage database, dated April 13, 2017, indicates no Indiana bat capture locations within a 5.0-mile (8.0-kilometer) radius, or hibernacula within a 10-mile (16-kilometer) radius of the Study Area.

Based on data reviewed, the likelihood of occurrence of the Indiana bat within the Study Area is low during spring, summer and fall (Table 3.3).

Northern long-eared bat (*Myotis septentrionalis*)

The federally threatened northern long-eared bat range extends throughout most of southern Canada and the eastern and Midwestern United States (excluding parts of the southeast United States) and is primarily associated with North American forests (USFWS 2017d). Historically, the northern long-eared bat is found statewide in Ohio (USFWS 2017b). Currently, ODNR (2017a) data related to the northern long-eared bat species remains incomplete.

The northern long-eared bat forages over open fields near caves and forests (USFWS 2017d). The northern long-eared bat is similar to the Indiana bat in its use of caves and mines for hibernation. The northern long-eared bat requires very high humidity associated with selected hibernacula. After hibernation, the bats are found in wooded or semi-wooded habitats for the duration of the summer months. The northern long-eared bat utilizes crevices and loose bark on trees (> 3.0 inches [7.6 centimeters] in diameter at breast height) for roosting, although it is considered to be opportunistic and less selective than the Indiana bat (USFWS 2017d).

Literature review, agency consultation and field reconnaissance survey identified woodlands that are potential summer roosting and foraging habitat in the woodland edge of the Study Area that will not be disturbed. Based on data reviewed and field reconnaissance, the likelihood of occurrence of the northern long-eared bat within the Study Area is low during spring, summer and fall (Table 3.3).

Bald and Golden Eagle Protection Act

Bald eagle (*Haliaeetus leucocephalus*) habitat includes estuaries, large lakes, reservoirs, rivers and some seacoasts and marshes where they forage for fish. Bald eagles will also feed on waterfowl, turtles, rabbits, snakes, other small animals and carrion (USFWS 2017c). Bald eagles require a combination of readily available prey, perching areas, and nesting sites. In winter, bald eagles congregate near open water in tall trees for spotting prey and night roosts for shelter (USFWS 2017c).

According to USFWS (2017b) and ODNR (2017a), no record of bald eagles are known to occur within the Study Area. Habitat such as open water and tall trees is limited in the Study Area. Based on this information bald eagles have a low potential of occurrence in the Study Area.

Golden eagles (*Aquila chrysaetos*) are rare in Ohio and are not expected in the Study Area.

3.4.2 State-listed Species

The ODNR identified the three state-listed species as being present within 1.0 mile (1.6 kilometers) of the Study Area, including the state threatened downy white beard-tongue (*Penstemon brevisepalus*), the state potentially threatened butterfly-pea (*Clitoria mariana*), and the state potentially threatened wild kidney bean (*Phaseolus polystachios*). These species however were not present within the Project Impact Area or within a 0.25-mile (0.40-kilometer) buffer around the Project Area boundary required by OPSB (Figure 3.3).

Downy White Beard-Tongue (*Penstemon brevisepalus*)

The downy white beard-tongue is an herbaceous rhizomatous perennial that is typically flowering in May and June, and fruiting in June and July. Post-1980 records indicate it is found in Vinton County, Ohio within fields and open woods, and along roadsides (ODNR 2017a).

Presence of this species in the Project Impact Area is not expected due to the predominance of reclaimed surface-mined pastures and extensive grazing by the American bison.

Butterfly-Pea (*Clitoria mariana*)

The butterfly-pea is a low, ascending or twining perennial herb that is typically flowering from June to August and fruiting from August to September. Post-1980 records indicate it is found in Vinton County, Ohio in open to semi-open situations in dry to moist soils: upland woods, borders or prairie opening, and barrens (ODNR 2017a).

Presence of this species in the Project Impact Area is not expected due to the predominance of reclaimed surface-mined pastures.

Wild Kidney Bean *(Phaseolus polystachios)*

The wild kidney bean is a perennial herb with twining stems up to 13 feet (4 meters) in length. The herb is typically flowering from July to September and fruiting from August to October. Post-1980 records indicate it is found in Vinton County, Ohio within dry to moist open woods and thickets, and roadside banks (ODNR 2017a).

Presence of this species in the Project Impact Area is not expected due to the predominance of reclaimed surface-mined pastures.

Other State-Listed Species

Although summer roosting occurrences for the state-listed Indiana bat and northern long-eared bat have been recorded in Vinton County, ODNR (2017a) data indicate that no occurrences for capture locations have been recorded within a 5.0-mile (8.0-kilometer) radius, or hibernacula within a 10-mile (16-kilometer) radius of the Study Area.

No state-listed bird species were recorded during incidental observations in the Study Area (Table 3.4).

Table 3.4. Incidental Bird Species Observations at the Vinton Solar Energy Center, Vinton County, Ohio, 2017.

Common Name	Scientific Name	Listed Status
Killdeer	*Charadrius vociferus*	None
American Robin	*Turdus migratorius*	None
European Starling	*Sturnus vulgaris*	None
Brown-headed Cowbird	*Molothrus ater*	None
Turkey Vulture	*Cathartes aura*	None
Red-winged Blackbird	*Agelaius phoeniceus*	None
Horned Lark	*Eremophila alpestris*	None
American Kestrel	*Falco sparverius*	None
American Crow	*Corvus brachyrhynchos*	None
Canada Goose	*Branta canadensis*	None
Mallard	*Anas platyrhynchos*	None
Purple Martin	*Prongne subis*	None
Eastern Meadowlark	*Sturnella magna*	None
Eastern Towhee	*Pipilo erythrophthalmus*	None
Northern Cardinal	*Cardinalis Cardinalis*	None
White-breasted Nuthatch	*Sitta carolinensis*	None
Field Sparrow	*Spizella pusilla*	None
Red-bellied Woodpecker	*Melanerpes carolinus*	None
Red-tailed Hawk	*Buteo jamaicensis*	None
Northern Flicker	*Colaptes auratus*	None
Northern Mockingbird	*Mimus polyglottos*	None
Wild Turkey	*Meleagris gallopavo*	None
Broad-winged Hawk	*Buteo platypterus*	None

3.4.3 Federal and State Species of Concern[1]

The Study Area is previously surface-mined and actively grazed pastureland with limited habitat diversity. The ODNR (2017a) did not identify species of concern. The USFWS (2017b) identified only Migratory Birds of Conservation Concern (Section 3.4.4. below). No other wildlife species were identified as species of concern.

[1] Species of Concern is an informal term. It is not defined in the federal Endangered Species Act. The term commonly refers to species that are declining or appear to be in need of conservation, which avoids formal listing.

3.4.4 Birds of Conservation Concern

TRC reviewed the USFWS IPaC Resources Report (USFWS 2017c) for Migratory Birds of Conservation Concern that could potentially occur in the Study Area, which included a list of 21 species that are listed above in Table 3.3. Grazed pastures are abundant within the Study Area and provide limited diversity for migratory bird species. Ponds formed by the surface coal mining reclamation offer some habitat for migrating waterfowl that could include some species listed as Birds of Conservation Concern, however Project plans do not include disturbance of any waters of the U.S. within the Study Area.

3.4.5 Breeding Bird Survey Routes

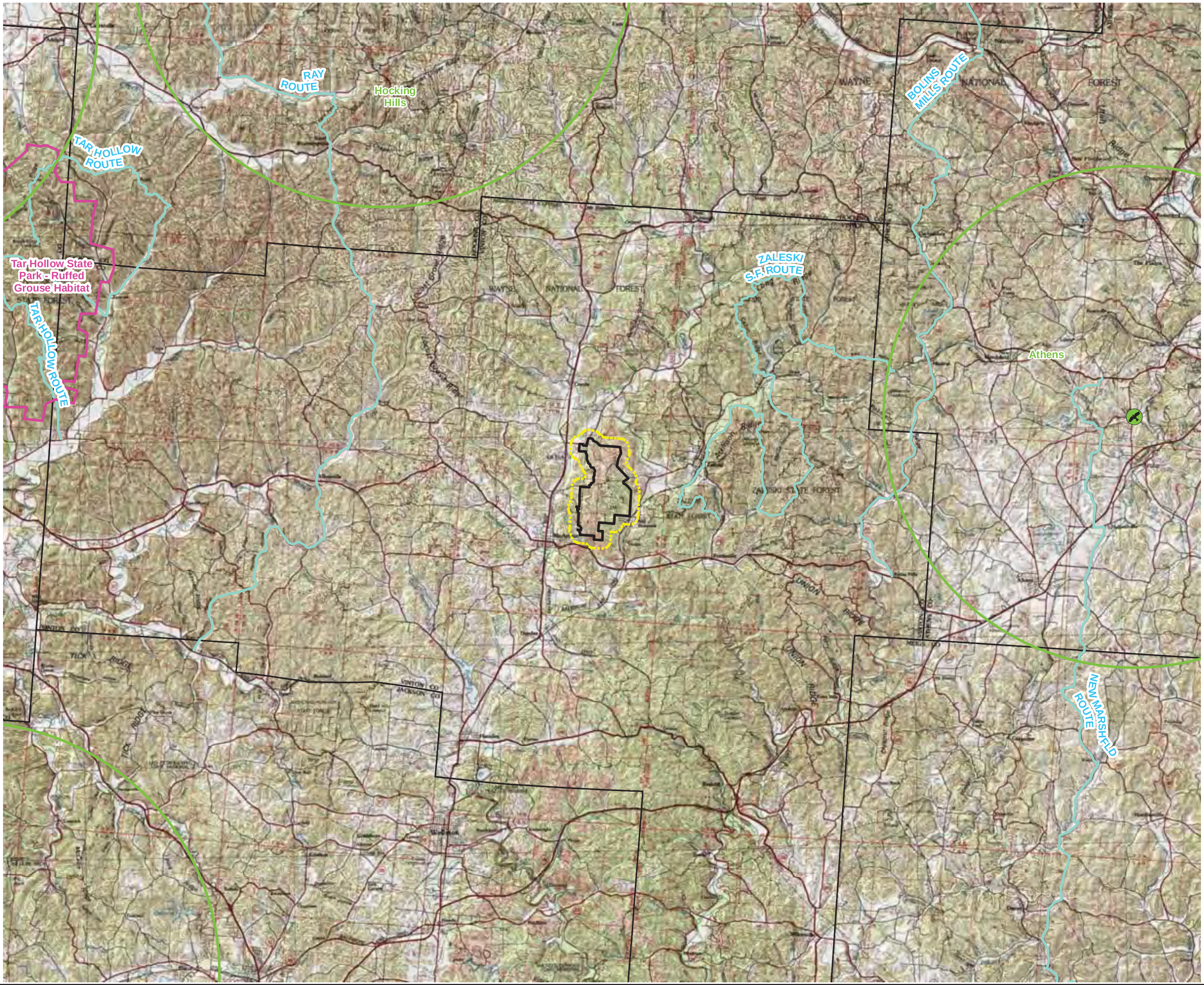
The nearest Breeding Bird Survey Route (USGS 2017b) is located approximately 2.0 miles (3.2 kilometers) east of the Study Area, known as the Zaleski State Forest Route (Figure 3.4). The ten most common birds recorded on this Breeding Bird Survey Route are listed in Table 3.5. In general these species are characteristic of woodland habitats, with the exception of the American robin (*Turdus migratorius)* and American crow (*Corvus brachyrhynchos)* which are more habitat generalists. None of the species listed are Birds of Conservation Concern (Figure 3.4).

Table 3.5. Ten Most common Species Observed on the Zaleski State Forest Route, Vinton County, Ohio, 2017.

Common Name	Scientific Name
Wood Thrush	*Hylocichla mustelina*
Red-eyed Vireo	*Vireo olivaceus*
Ovenbird	*Seiurus aurocapilla*
Eastern Towhee	*Pipilo erythrophthalmus*
American Crow	*Corvus brachyrhynchos*
Scarlet Tanager	*Piranga olivacea*
American Robin	*Turdus migratorius*
Tufted Titmouse	*Baeolophus bicolor*
Hooded Warbler	*Wilsonia citrina*
Eastern Wood-Pewee	*Contopus sordidulus*

3.4.6 Christmas Bird Counts

The nearest Christmas Bird Count Circle is located in Athens, Ohio, located approximately 8.0 miles (12.8 kilometers) east of the Study Area (Figure 3.4). The ten most common species observed are birds that primarily utilize open spaces and open water resources. None of these species are Birds of Conservation Concern.



LEGEND

- Project Area
- Quarter Mile Buffer - Per OAC 4906-4-08
- Important Bird Areas
- Breeding Bird Survey Route Locations
- Christmas Bird Count Circles
- Christmas Bird Count Circles 15 Mile Buffer

PROJECT:
VINTON SOLAR ENERGY, LLC
VINTON SOLAR ENERGY CENTER PROJECT
CONFIDENTIAL BUSINESS INFORMATION

TITLE:
BREEDING BIRD ROUTES, CHRISTMAS BIRD COUNT CIRCLES AND IMPORTANT BIRD AREAS

DRAWN BY:	N.RENAUDIN	PROJ NO.:	274099.0000.0000
CHECKED BY:	J.PITTS		3.4
APPROVED BY:	M.SPONSLER		
DATE:	JUNE 2017		

TRC

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FILE NO.: Figure 3.4 Vinton.mxd

Coordinate System: NAD 1983 CORS96 StatePlane Ohio South FIPS 3402 Ft US (Foot US)
Map Rotation: 0

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Table 3.6. Bird Species Commonly Observed on National Audubon Society's Athens Christmas Bird Counts.

Common Name	Scientific Name
European starling	*Sturnus vulgaris*
Canada goose	*Branta canadensis*
American Robin	*Turdus migratorius*
Turkey Vulture	*Cathartes aura*
American Crow	*Corvus brachyrhynchos*
Northern Cardinal	*Cardinalis cardinalis*
Carolina Chickadee	*Poecile carolinensis*
Mourning dove	*Zenaida macroura*
Mallard	*Anas platyrhynchos*
American Goldfinch	*Spinus tristis*

3.4.7 Important Bird Areas

The nearest designated National Audubon Society Important Bird Area in the vicinity of the Project is Tar Hollow State Park - Ruffed Grouse Management Area, located approximately 15.0 miles (24.1 kilometers) from the Study Area (Figure 3.4). Approximately 1,700 acres (688 hectares) have been set aside to improve grouse habitat.

Important breeding species known to occur at the Tar Hollow State Park include the cerulean warbler (*Setophaga cerulea*), Kentucky warbler (*Geothlypis formosa*), hooded warbler (*Wilsonia citrina*), black and white warbler (*Mniotilta varia*), worm eating warbler (*Helmitheros vermivorum*), northern parula (*Setophaga americana*), yellow-throated warblers (*Setophaga dominica*), Louisiana waterthrush (*Parkesia motacilla*) and pine warblers (*Setophaga pinus*) (National Audubon Society 2017).

The habitats that occur at Tar Hollow State Park are dissimilar to those available within the Study Area, which is reclaimed surface-mined land, maintained as pastureland.

3.4.8 Species of Habitat Fragmentation Concern

The Study Area has no habitats of fragmentation concern as it is comprised of reclaimed surface-mined land, maintained as pastureland. The surrounding areas contain trees that will not be removed.

4.0 Special Status Lands

Agency correspondence and queries were based on the Study Area as well as the 1.0-mile (1.6-kilometer) radius of the surrounding area.

4.1 Conservation Lands

The USFWS (2017b) Technical Assistance Letter reported “no federal wilderness areas, wildlife refuges or designated critical habitat is present within the vicinity" of the Study area. Correspondence from ODNR dated April 13, 2017, reported that the agency is unaware of any unique ecological sites, geologic features, animal assemblages, scenic rivers, state wildlife areas, nature preserves, parks or forests, national wildlife refuges, or other protected natural areas within a 1.0-mile (1.6-kilometer) radius of the Study Area.

Publicly available databases showed one public land, the Zaleski State Forest, is located within 10 miles (16 kilometers) of the Study Area. The State Forest is located within 2.0 miles (3.2 kilometers) of the Study Area (Figure 3.3). Zaleski State Forest is the second largest forest in Ohio’s system of state forests. The park provides backpacking opportunities as well as some educational outreach about the historic aspects of the forest. Within the Zaleski State Forest is a 1,100-acre (445-hectare) Grouse Management Area as well as approximately, 4,000 acres (1,618 hectares) of forest designated as a Turkey Management Area. These areas are managed under cooperative agreements between the Division of Forestry, the Division of Wildlife and the Ruffed Grouse Society.

4.2 Habitats of Biodiversity Significance

Ohio does not inventory and classify sites of biodiversity significance. Ohio has a Natural Areas and Preserves program which designates areas as a State Nature Preserve based on its unique features such as remnants of Ohio’s pre-settlement past, rare and endangered species, and geologic formations (ODNR 2017b). As indicated in Section 4.1 above, no unique properties or critical habitat are within the vicinity of the Study Area.

5.0 Plant Communities of Concern

No plant communities of concern were identified through agency queries (USFWS 2017b, ODNR 2017a) or data base reviews within the Study Area or the surrounding 1.0-mile (1.6-kilometer) radius.

6.0 Literature Cited

National Audubon Society. (2017). Important Bird Areas. Retrieved from Audubon: http://www.audubon.org/important-bird-areas.

Google Earth. (2017). Google Earth – Google Earth. Retrieved from Google Earth: https://earth.google.com/

McCormac, Jim, and Gregory Kennedy. Birds of Ohio. Edmonton: Lone Pine Pub., 2004. Print.

National Audubon Society. (2017). Christmas Bird Count. Retrieved from Audubon: *http://www.audubon.org/conservation/science/christmas-bird-count).*

NRCS (2017). Web Soil Survey 3.0. Retrieved from U.S. Department of Agriculture, Natural Resources Conservation Service: http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx

ODNR and USFW (2016) Ohio Mussel Survey Protocol. https://wildlife.ohiodnr.gov/portals/wildlife/pdfs/licenses%20&%20permits/OH%20Mussel%20Survey%20Protocol.pdf. Accessed May 5, 2017.

ODNR (2017a). Natural Heritage Database review response from Debbie Woischke dated April 13, 2017. Ohio Department of Natural Resources (ODNR) National Heritage Database (Wildlife, Ohio DNR Division of. "Ohio.gov / search." Ohio DNR Division of Wildlife. N.p., n.d. Web. 10 Apr. 2017. http://wildlife.ohiodnr.gov/species-and-habitats/ohio-natural-heritage-database).

ODNR (2017b). Natural Areas and Preserves website review. May 21, 2017. http://naturepreserves.ohiodnr.gov/

The Cornell Lab of Ornithology. 2016. Birds of North America https://birdsna.org/Species-Account/bna/species accessed May 8, 2017.

USACE. 2012. *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region (Version 2.0).* U.S. Army Corps of Engineers, Vicksburg: U.S. Army Engineer Research and Development Center Environmental Laboratory, 176.

USFWS (2012). Land-Based Wind Energy Guidelines. https://www.fws.gov/ecological-services/es-library/pdfs/WEG_final.pdf. Accessed May 1, 2017.

USFWS 2016. *National Wetlands Invnetory Online Mapper v 2.0.* http://www.fws.gov/wetlands/Data/Mapper.html.

USFWS (2017a) National Wetlands Inventory (NWI) (U.S. Fish and Wildlife Service; National Wetlands Inventory; National Standards and Support Team. "Wetlands Mapper." Official Web page of the

U S Fish and Wildlife Service. N.p., n.d. Web. 10 Apr. 2017. https://www.fws.gov/wetlands/data/Mapper.html).

USFWS (2017b). Technical Assistance Letter from Susan Zimmerman dated April 12, 2017. TAILS: 03E15000-2017-TA-1090.

USFWS (2017c). Information for Planning and Conservation (IPaC). Retrieved from USFWS: https://ecos.fws.gov/ipac/).

USFWS (2017d). Endangered, Threatened, Proposed, and Candidates in the Upper Midwest. Available online: https://www.fws.gov/midwest/endangered/mammals.

USGS (2017a). National Land Cover Database (NLCD). Retrieved from: LCS Program: https://www2.usgs.gov/climate_landuse/lcs/projects/nlcd.asp).

USGS (2017b) Patuxent Wildlife Research Center, North American Breeding Bird Survey. https://www.pwrc.usgs.gov/bbs/index.cfm

USGS (1994). Topographical Quadrangle Maps (7.5-minute series). U.S. Geological Survey.

Wilkin, E, F J Nava, and G Griffith. 2011. North American Terrestrial Ecoregions Level III. Commission for Environmental Cooperation, Canada. http://www.cec.org/Atlas/Files/Terrestrial_Ecoregions_L1/TerrestrialEcoregions_L1_GeoPDF.zip

Vinton Solar Energy LLC
Case No. 17-774-EL-BGN

Exhibit E

TRC Vinton Raptor Nest Survey
June 2017

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Attorneys for Vinton Solar Energy LLC

Exhibit E

RAPTOR NEST SURVEY REPORT

Vinton Solar Energy Center Project

Vinton County, Ohio

June 2017

TRC PROJECT NO. 274099.0000.0005

Prepared For:

Invenergy, LLC

One South Wacker Drive, Suite 1800

Chicago, IL 60606

312.224.1400

Prepared By:

TRC Environmental Corporation

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Mike Sponsler
Senior Project Manager

Justin Pitts
Ecological Project Manager

Results you can rely on

CONFIDENTIAL BUSINESS INFORMATION

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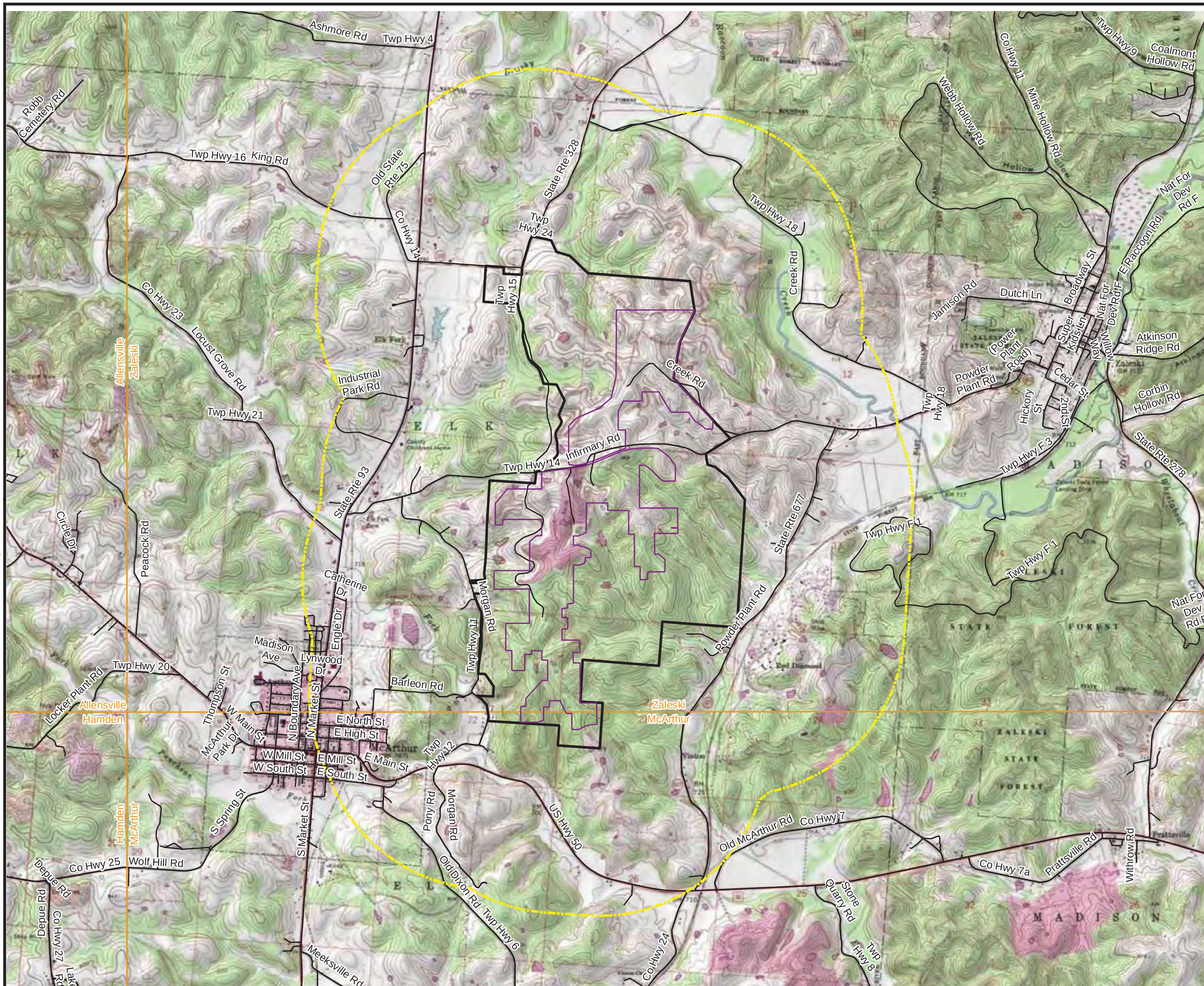
Acronyms

GPS	Global Positioning System
IPaC	USFWS Information for Planning and Conservation
MW	Megawatt
NLCD	National Land Cover Database
ODNR	Ohio Department of Natural Resources
TRC	TRC Environmental Corporation
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VSE	Vinton Solar Energy, LLC

1.0 Introduction

On behalf of Vinton Solar Energy, LLC (VSE), TRC Environmental Corporation (TRC) has prepared this Raptor Nest Survey as part of environmental studies conducted for the Vinton Solar Energy Center Project located in Vinton County, Ohio. The proposed solar facility will generate up to 125 megawatts (MW) of power. The Project Area is privately owned and located approximately 1.0 mile (1.6 kilometers) northeast of the Village of McArthur, Vinton County, Ohio (Figure 1.1). The Project Area is located within Elk Township in Vinton County, Ohio.

The objective of the survey described herein was to identify and map raptor nests within the Project Area and additional surrounding buffer of 1.0 mile (1.6 kilometers) (Study Area), representing an area of 8,905 acres (3,602 hectares).



LEGEND

- Project Area
- Impact Area
- Study Area
- Roads
- U.S. Geological Survey 24k Quad

0 1,250 2,500 Feet

1 " = 3,000 '
1:36,000

PROJECT:
VINTON SOLAR ENERGY, LLC
VINTON SOLAR ENERGY CENTER PROJECT
CONFIDENTIAL BUSINESS INFORMATION

TITLE:
USGS TOPOGRAPHIC MAP

DRAWN BY:	N.RENAUDIN	PROJ NO.:	274099.0000.0000
CHECKED BY:	J.PITTS		Figure 1.1
APPROVED BY:	M.SPONSLER		
DATE:	JUNE 2017		

TRC

921 Eastwind Drive, Suite 122
Westerville, OH 43081
Phone: 614.423.6334
www.trcsolutions.com

FILE NO.: Figure 1.1 Vinton.mxd

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Coordinate System: NAD 1983 CORS96 StatePlane Ohio South FIPS 3402 Ft US (Foot US)
Map Rotation: 0

TRC - GIS

2.0 Methods

TRC conducted a ground-based survey for raptor nests within the Study Area on April 4, 2017. The Study Area for the Vinton Solar Energy Center Raptor Nest Survey is defined as the Project Area and an additional surrounding buffer of 1.0 mile (1.6 kilometers), representing a total area of 8,905 acres (3,602 hectares). Within the Project Area, the land anticipated to be disturbed for construction of the Vinton Solar Energy Center is defined as the Impact Area (Figure 1.1).

Prior to conducting the ground-based survey for raptor nests, TRC conducted agency consultation to identify existing records of nests in the Study Area (ODNR 2017, USFWS 2017a). TRC also visually inspected aerial photographs of the Study Area for potential raptor nesting habitat(s).

TRC biologists conducted the ground-based Raptor Nest Survey, via vehicle. One TRC biologist drove the vehicle, while the other biologists searched for nests using 10x magnification Nikon binoculars. At points during the study where sight lines were good, both biologists searched outside the vehicle. Both public and private roads within the Study Area were driven during the nest search. Woodlots with potential raptor nest trees in the Study Area were investigated from public locations. Incidental raptor observations were also recorded during the field survey.

Documentation protocols for each nest, if found, included location, nest status (active or inactive), the number of adults and young present, and species occupying the nest site. Location(s) of identified nest sites were photographed (Appendix A), recorded using global positioning system (GPS) coordinates and were identified on a United States Geological Survey (USGS) 1:24,000 topographic quadrangles map, as recommended by the Ohio Department of Natural Resources (ODNR) On-Shore Bird and Bat Pre- and Post-Construction Monitoring Protocol for Commercial Wind Energy Facilities in Ohio Protocol (ODNR 2009).

3.0 Results

3.1 Study Area

Within the Study Area, elevations range from approximately 700 feet (213 meters) to 961 feet (293 meters) above mean sea level. Field observations, aerial photography and National Land Cover Database (NLCD 2017) maps indicate this landscape is predominately covered by deciduous forest (50 percent), hay/pasture (16 percent) and cultivated crops (16 percent) (Table 3.1). The remaining area is comprised of a combination of open space, herbaceous ground cover, some development, barren land and scrub/shrub (17 percent). Small amounts of each of the following cover types; wetlands, forest and/or open water, collectively comprise approximately one percent of the land within the Study Area. During the study, trees suitable for raptor stick nest building were targeted within the deciduous forested areas. These deciduous forest areas were located within the Study Area buffer, but outside of the Impact Area (Figure 1.1).

Table 3.1 National Land Cover Database Land Cover Types within the Vinton Solar Energy Center Raptor Nest Study Area, Vinton County, Ohio, 2017

Cover Type	Acres	Hectares	Percent (%)
Deciduous Forest	4416	1787	50
Hay/Pasture	1452	588	16
Cultivated Crops	1397	565	16
Developed, Open Space	721	292	8
Herbaceous	236	95	3
Developed, Low Intensity	201	81	2
Barren Land	175	71	2
Scrub/Shrub	93	37	1
Developed, Medium Intensity	92	37	1
Evergreen Forest	62	25	< 1
Open Water	27	11	< 1
Developed, High Intensity	18	7	< 1
Emergent Herbaceous Wetlands	8	3	< 1
Woody Wetlands	6	2	< 1
Mixed Forest	1	< 1	< 1
Total	**8,905**	**3,601**	

3.2 Agency Consultation Data

Combined information and correspondence from the ODNR (ODNR 2017) dated April 13, 2017 (ODNR 2017), Natural Heritage Database results, and the United States Fish and Wildlife (USFWS) (USFWS 2017a) Technical Assistance Letter dated April 12, 2017, did not identify raptor nests within the Study

Area. The USFWS Information for Planning and Conservation (IPaC) tool was accessed on April 10, 2017, and did not identify records of raptor nests (USFWS 2017b) in the Study Area. Although the IPaC report identified the Study Area to be within the known range of the bald eagle (*Haliaeetus leucocephalus*), no specific records were identified. In a telephone conversation with TRC on April 3, 2017, Keith Lott, USFWS biologist, stated the nearest bald eagle nest record is associated with Lake Rupert, 2.6 miles (4.2 kilometers) to the southwest of the Study Area (USFWS 2017c).

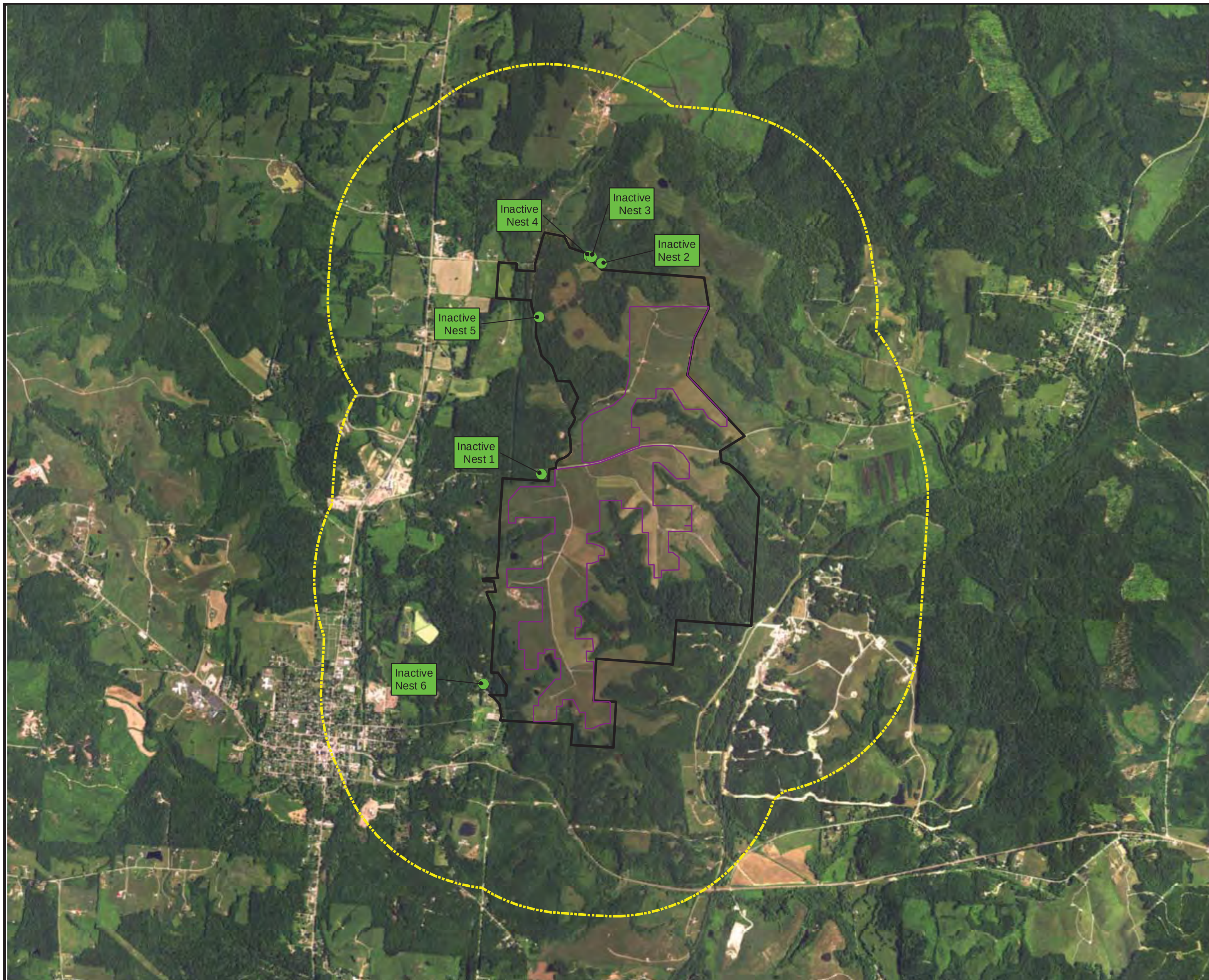
3.3 Raptor Nest Survey

No active nests were observed at the time of the Raptor Nest Survey. A total of six inactive raptor nests were identified within the Study Area (Table 3.2.). No raptors were observed on or near the nests. None of the nests showed signs of recent nest use (e.g. white washing beneath the nests, new stick placement, etc.). Due to the disrepair of the nests and lack of observed bird use, the species using the nests could not be determined. As shown on Figure 3.2, four of the inactive nests were recorded within the Project Area, two within the one mile buffer and none within the Impact Area.

Table 3.2. Raptor Nests Observed in Study Area of the Proposed Vinton Solar Energy Center, April 4, 2017

Nest Number	Status	Species	Location	Distance from Impact Area, feet (ft), meters (m)
1	Inactive	Undetermined	Project Area	273 ft (83 m)
2	Inactive	Undetermined	Project Area	969 ft (295 m)
3	Inactive	Undetermined	Buffer	1,367 ft (417 m)
4	Inactive	Undetermined	Project Area	1,530 ft (466 m)
5	Inactive	Undetermined	Buffer	6,572 ft (200 m)
6	Inactive	Undetermined	Buffer	1,208 ft (368 m)

Incidental observations of raptors identified in the Study Area were the American kestrel *(Falco sparverius)*, broad-winged hawk *(Buteo platypterus*), red-tailed hawk (*Buteo jamaicensis*), and turkey vulture (*Cathartes aura*). None of these raptors are listed as species of concern.



LEGEND

- Project Area
- Impact Area
- Study Area
- Nest Locations

N

0 1,500 3,000 Feet
1 " = 3,000 '
1:36,000

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TITLE:	RAPTOR SURVEY MAP
DRAWN BY: N.RENAUDIN	PROJ NO.: 274099.0000.0000
CHECKED BY: J.PITTS	Figure 3.2
APPROVED BY: M.SPONSLER	
DATE: JUNE 2017	
TRC	921 Eastwind Drive, Suite 122 Westerville, OH 43081 Phone: 614.423.6334 www.trcsolutions.com
FILE NO.:	Figure 1 Vinton.mxd

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Map Rotation: 0

TRC - GIS

4.0 Literature Cited

NLCD (2017). National Land Cover Database (NLCD). Retrieved from: LCS Program: https://www2.usgs.gov/climate_landuse/lcs/projects/nlcd.asp).

ODNR (2009). Ohio Department of Natural Resources On-Shore Bird and Bat Pre- and Post-Construction Monitoring Protocol for Commercial Wind Energy Facilities in Ohio (ODNR 2009) Protocol. An Addendum to the Ohio Department of Natural Resource's Voluntary Cooperative Agreement. "Ohio DNR Division of Wildlife. N.p., n.d. Web. 10 Apr. 2017. http://wildlife.ohiodnr.gov/portals/wildlife/pdfs/species%20and%20habitats/windwildlifemonitoringprotocol.pdf

ODNR (2017). Natural Heritage Database review response from Debbie Woischke dated April 13, 2017. Ohio Department of Natural Resources (ODNR) National Heritage Database (Wildlife, Ohio DNR Division of. "Ohio.gov / search." Ohio DNR Division of Wildlife. N.p., n.d. Web. 10 Apr. 2017. http://wildlife.ohiodnr.gov/species-and-habitats/ohio-natural-heritage-database).

USFWS (2017a). Technical Assistance Letter from Susan Zimmerman dated April 12, 2017. TAILS: 03E15000-2017-TA-1090.

USFWS (2017b). Information for Planning and Conservation (IPaC). Retrieved from USFWS: https://ecos.fws.gov/ipac/).

USFWS (2017c). Personal Communication with Keith Lott, USFWS biologist in discussion with TRC personnel Mike Sponsler on April 3, 2017.

Appendix A: Representative Photographs of Raptor Nests

Date: 04-04-2017 **Feature:** Raptor Nest 1 **Comments:** Representative photograph of Inactive Nest 1. The nest is located along a Township Road, adjacent to the Study Area.	
Date: 04-04-2017 **Feature:** Raptor Nest 1 **Comments:** Representative photograph of Inactive Nest 1 located in close proximity to a pond.	

<table>
<tr><td colspan="2">Invenergy LLC</td><td>State: Ohio</td><td>County: Vinton</td></tr>
<tr><td colspan="4">Project Name: Vinton Solar Energy Center Project</td></tr>
<tr><td>Date: 04-04-2017

Feature: Raptor Nest 4

Comments:
Representative photograph of a raptor nest, Inactive Nest 4, located within the forested area at the northern edge of the Project Area.</td><td colspan="3"></td></tr>
<tr><td>Date: 04-04-2017

Feature: Raptor Nest 4

Comments:
Representative photograph of a raptor nest, Inactive Nest 4. The nest is located adjacent to additional raptor nests, Inactive Nest 2 and 3.</td><td colspan="3"></td></tr>
</table>

Date: 04-04-2017 **Feature:** Raptor Nest 6 **Comments:** Representative photograph of Inactive Nest 6 located outside the Project Area.	
Date: 04-04-2017 **Feature:** Raptor Nest 6 **Comments:** Representative photograph of Inactive Nest 6. The nest is located adjacent to residential housing and in close proximity to a stream.