

## 5.0 Appendix E – Risk and Vulnerability Assessment: Data and Results

## ***Crude Oil and Ethanol Transportation: Risk and Vulnerability Assessment Methodology***

This section presents a top-level summary of the risks and vulnerabilities associated with transporting crude oil and ethanol by rail through Iowa. The analysis considers crude oil transportation routes, recorded previous events, likelihood of future incidents, and potential impacts from those incidents to derive an aggregate value for risk. County-specific information may be available to those who are authorized to review it upon official request to Iowa DOT.

This risk assessment is a building block process using various factors, such as length of railroad track, volume of traffic on the rails, and populations, critical facilities, and environmentally important segments within an identified hazard area. The individual factors are analyzed to determine and overall risk for a given county. The data and information provided for this risk and vulnerability assessment are the best available data at the time of collection and should be regarded as a snapshot in time; data could change over time.

It is important to note that eight counties were excluded from the RVA results. This is because no unit-train quantities of bulk crude oil and ethanol are hauled through them [at the time of the Study], or there were no critical infrastructure, population, or environmental exposures located within the hazard buffer zone. Reference Figure 6 - Current Iowa Railroad Routes for Bulk Crude Oil and Ethanol Transportation when examining Tables E-9 thru E-12 and Tables E-15 thru E-16.

The results of the “Risk and Vulnerability Assessment” are provided in Table E-16 (and Figure E-1) and are intended for planning purposes only, including: to prioritize and develop prevention, protection, mitigation, response, and/or recovery strategies and resources. Sections 5.1 through 5.8 describe the terms used within the risk and vulnerability assessments, the associated methodologies, and the data collection references. Section 5.9 provides the results of the assessment.

**Note:** All risk assessment results are based on methodology designed specifically for the State of Iowa using Iowa-specific data, statistics, and conditions.

### **5.1 Hazard Area**

The “hazard area” is set at the geographic area within 0.5-miles of the centerline of the identified crude oil and ethanol rail transportation infrastructure.

This hazard area is expressed as a “buffer” (a constant offset from a non-point geographical feature). This buffer distance was selected because 0.5-miles corresponds to the USDOT Emergency Response Guidebook evacuation zone for a crude oil and ethanol rail transportation incident involving fire and explosion, which represents the worst-case scenario.

### **5.2 Exposure**

“Exposure” refers to the population, structures, and environment within the identified hazard area.

The following exposure categories were researched and analyzed:

- Population – The estimated number of people living within the buffer

- Housing – The estimated number of housing units within the buffer
- Critical Facilities – The estimated number of critical facility structures within the buffer zone. For the purposes of this report, this category includes public safety, fire, emergency medical (ambulance) facilities, jails, prisons, courthouses, K-12 schools, childcare centers, hospital facilities, nursing homes, town and city halls, and water intake facilities.
- Environmental – The estimated number of acres of environmentally sensitive lands. For the purposes of this report the environmental impact researched and studied includes the following:
  - Significant Public Lakes – Significant public lakes are managed by the Iowa Department of Natural Resources to be accessible and provide fishing opportunities for any angler.<sup>22</sup>
  - Federal Reservoirs – Large natural or artificial lakes used as a source of water supply. Federal reservoirs in Iowa include:
    - Saylorville
    - Red Rock
    - Rathbun
    - Coralville<sup>23</sup>
  - Protected Wetlands and Setbacks – Wetlands are transitional areas, sandwiched between permanently flooded environments and well-drained uplands. They include mangroves, marshes, swamps, forested wetlands, bogs, wet prairies, prairie potholes, and vernal pools.<sup>24</sup>
  - Outstanding Streams – a surface water that Iowa DNR has classified as an outstanding state resource water body in the water quality standards.<sup>25</sup>
  - Designated Streams – water bodies that maintain flow throughout the year, or contain sufficient pooled areas during intermittent flow periods, to maintain a viable aquatic community.<sup>26</sup>
  - Protected Streams – land areas adjacent to five designated scenic rivers in Iowa. These areas are legislatively authorized as having outstanding cultural and natural resource values in accordance with Iowa code. They are:
    - Wapsipinicon River (Sweets Marsh to Mississippi)
    - Middle Raccoon River (Panora to Redfield)

<sup>22</sup> Iowa Department of Natural Resources. Retrieved from <http://www.iowadnr.gov/Fishing/Where-to-Fish/Lakes-Ponds-Reservoirs>. December 7, 2015.

<sup>23</sup> The Handbook of Iowa Boating Laws and Responsibilities. Iowa Department of Natural Resources. 2014. Print.

<sup>24</sup> USGS National Wetlands Research Center. Retrieved from <http://www.nwrc.usgs.gov/wetlands.htm>. December 2, 2015.

<sup>25</sup> Iowa Antidegradation Implementation Procedure. Iowa Department of Natural Resources Water Resources Section. February 17, 2010. Print.

<sup>26</sup> Iowa Surface Water Classifications (567 IAC 61.3). 2010. Print.

- Upper Iowa River (Kendallville to Highway 76)
- Little Sioux River (Spencer to Linn Grove)
- Boone River ((Brewers Creek to Des Moines River)<sup>27</sup>

A “top ten list” of County Exposure Rankings is located in Appendix F, and County Profiles are listed in Appendix G.

### 5.3 Vulnerability

“Vulnerability” is defined as the population, facilities, and environment that are susceptible to impacts by the hazard. Vulnerability is a subset of exposure. As it relates to crude oil and ethanol by rail accidents, any particular incident is likely to affect only a small portion of the buffer. Therefore, an accepted planning assumption of 10 percent of the total exposure per linear rail mile within each county was determined to be vulnerable. The 10 percent value was derived from calculations of population distribution along the railroads coupled with the fact that freight trains are rarely more than one mile long meaning an area of impact would be no greater than one mile along any 10-mile stretch of railroad.

$$\text{Average Total Exposure Per Linear Mile} \times 10\% = \text{Vulnerability}$$

### 5.4 Impact

The “impact” is the potential effect an incident might have on populations, facilities, and the environment, including casualties, damage to buildings, and/or harm to the environment.

#### 5.4.1 Impact Level

In order to analyze impact, an Impact Rating Scale was developed. The Impact Rating Scale, shown in Table E-1, assigns a qualitative level (low, medium, or high) to the effects an incident would likely have on vulnerable assets – that is, 10 percent of an average population or number of critical facilities along one linear mile of track and within the buffer. Environmental impacts, having a fixed geographic location are factored at 10 percent impact of the total vulnerable area. This report assumes all exposed areas to have the potential to suffer at least a low impact level.

**Table E-1. Impact Rating Scale**

Impact Level	Potential Population Impact	Potential Critical Facilities Impact	Potential Environmental Impact
Low	No more than one injury or fatality	Less than 10% damage impact to critical facilities	0 acres or 0 linear miles environmentally sensitive land affected
Medium	More than one but fewer than 10 injuries and/or fatalities	At least 10% and less than 20% damage to critical facilities	.01 – 10 acres or .01 – 1 mile of environmentally sensitive land affected
High	10 or more injuries and/or	At least 20% damage to	>10 acres or >1 linear mile

<sup>27</sup> Iowa Department of Natural Resources. *Protected Waters*. <http://www.iowadnr.gov/Things-to-Do/Canoeing-Kayaking/Stream-Care/Protected-Water-Areas>.

Impact Level	Potential Population Impact	Potential Critical Facilities Impact	Potential Environmental Impact
	fatalities	critical facilities	of environmentally sensitive land affected

The impact levels were assigned as described below.

### 5.4.2 Population Impact Level

The Population Impact Level results are provided in Table E-9. They were assigned quantitatively, based on Table E-1 above where the population vulnerability was analyzed, by county, to be:

- zero (0) to one (1) injuries and/or fatalities, a low value was assigned;
- one (1) or more, but fewer than ten (10) injuries and/or fatalities, a medium value was assigned; or
- ten (10) or more or more injuries and/or fatalities, a high value was assigned.

### 5.4.3 Critical Facilities Impact Level

The Critical Facilities Impact Level results are provided in Table E-10. They were assigned quantitatively, based on Table E-1 above where the critical facilities vulnerability was analyzed, by county, to be:

- less than 10 percent damage to critical facilities, a low value was assigned;
- at least 10 percent but less than 20 percent damage to critical facilities, a medium value was assigned; or
- At least 20 percent damage to critical facilities, a high value was assigned.

### 5.4.4 Environmental Impact Level

The Environmental Impact Level results are provided in Tables E-11 and E-12. They were assigned quantitatively, based on Table E-1 above where the environmental vulnerability was analyzed, by county, to be:

- 0 acres or 0 linear miles, a low value was assigned;
- 0.01-10 acres or 0.01 to 1 linear miles, a medium value was assigned; or
- >10 acres or >1 linear mile, a high value was assigned.

### 5.4.5 Average Impact Value

An average impact value for each county was calculated by assigning a quantitative value to each impact level within each exposure category (population, critical facilities, and environmental impacts). The values were weighted and multiplied to produce a non-linear distribution of results, to better identify highly impacted outliers. (Refer to Table E-2).

**Table E-2. Impact Value**

Impact Level	Impact Value
Low	1
Medium	3
High	5

To calculate the Average Impact Value:

$$(\text{Population Impact Value} + \text{Critical Facility Impact Value} + \text{Environmental Impact Value}) \div 3 = \text{Average Impact Value}$$

## 5.5 Likelihood

Likelihood is an estimate of how often an incident might occur within the buffer. Incidents may occur within the buffer with or without impact. In this Study, likelihood is described by a Likelihood Rating Scale – an assessment of the chances that a hazard event might occur in the buffer zone during a 20-year timespan, based on a review of historic events and available data.

The railroad likelihood value was derived in a multi-step process. Each county’s total train miles was determined by multiplying the total linear mile of main track by the average number of trains per day that traverse the tracks. The average number of trains per day was calculated using the highest combined value of the ranges of both crude oil and ethanol trains, based on the most recent available data provided by the railroads. The highest values were used to develop a worst-case scenario for planning purposes. It is important to note that the actual number of trains per day can vary depending on crude oil and ethanol production and transportation routing. This assessment should be considered as a snapshot of a regularly changing and adjusting transportation industry.

$$(\text{Linear Mile of Main Track} \times \text{Average \# Trains}) = \text{Train Miles}$$

Each county’s train miles were evaluated to determine the percent of total main train miles within the state.

$$\text{County Train Miles} \div \text{State Train Miles} = \% \text{ Total Train Miles}$$

The county’s percent of the total train miles was then multiplied by the total number of incidents projected to occur in Iowa within a 20-year period. This resulted in the Railroad Likelihood Value. Historical incident values are provided in the Railroad Likelihood results, Section 3.9.4.

$$\% \text{ Total Train Miles} \times 20 = \text{Railroad Likelihood Value (20-year)}$$

The result is a projected number of incidents that could occur in any county over the next 20 years, from which probability is derived.

The 20-year probability was then annualized by dividing the railroad likelihood value by 20.

Railroad Likelihood Value ÷ 20 = Annual Probability

**Table E-3. Likelihood Rating Scale**

Likelihood Value	Likelihood Level	% Probability per 20 years
1	Negligible	<0.10%
2	Low	0.11% – 0.99%
3	Moderate	1.00% – 1.99%
4	High	2.00%-2.99%
5	Highest	>3.0%

## 5.6 Risk (Sensitivity)

“Risk” is a metric that aggregates all the analyses described above. It combines the potential impacts with the likelihood of occurrence. In this report, risk is expressed using three metrics: risk level (H, M, L); risk (sensitivity) value (an absolute numeric value).

### 5.6.1 Risk (Sensitivity) Value

A numeric value representing each county’s risk (sensitivity) was calculated by multiplying the Average Impact Value by the assigned Likelihood Value.

$$\text{Average Impact Value} \times \text{Likelihood Value} = \text{Risk (Sensitivity) Value}$$

### 5.6.2 Risk (Sensitivity) Level

Each county was assigned a risk level using the calculated Risk Value as shown in Table E-4.

**Table E-4. Assigning Risk (Sensitivity) Level**

Risk (Sensitivity) Value	Risk (Sensitivity) Level
0.00-4.99	Low
5.00-9.99	Medium
10.00+	High

## 5.7 Data Collection and Metadata

### 5.7.1 Transportation Network Datasets

The following datasets were used to derive the buffer zones based on known crude oil and ethanol transportation railroads:

**Table E-5. Transportation Network Datasets**

Data Name	Data Provided By	Data Description	Data Type
Railroad Mainline	Iowa DOT	Railroad Mainlines	Esri FGDB Feature Class Polyline File

### 5.7.2 Population Vulnerability

The following datasets were used to derive the vulnerable population based on geographic location (not demographic factors):

**Table E-6. Population Datasets**

Data Name	Data Provided By	Data Description	Data Type
Housing Units	Iowa DNR Natural Resources Geographic Information Systems Library	2010 Census Block Level Housing Units	Esri FGDB Feature Class Polygon File
Population	Iowa DNR Natural Resources Geographic Information Systems Library	2010 Census Block Level Population	Esri FGDB Feature Class Polygon File

Population estimates were interpolated from the proportional area of each block level group population within the 1-mile corridor for each county.

### 5.7.3 Critical Facilities Vulnerability

The following datasets were used to derive the vulnerable critical facilities:

**Table E-7. Critical Facilities Vulnerability**

Data Name	Data Provided By	Data Description	Data Type
Medical Ambulances, Fire Protection	Iowa DOT	Locations of Medical Ambulance and Fire Protection Services	Esri FGDB Feature Class Point File
Courthouses Prisons, Jails, Public Safety Providers	Iowa DOT (via Info Group)	Locations of Courthouses Prisons and Safety Providers(Police, Fire)	Esri FGDB Feature Class Point File
School K-12	Iowa DOT	Location of K-12 Schools	Esri FGDB Feature Class Point File
Childcare Centers	Iowa DOT (via Info Group)	Locations of Childcare Centers	Esri FGDB Feature Class Point File
Hospitals	Iowa DOT (via Info Group)	Locations of Hospitals / Health Providers	Esri FGDB Feature Class Point File
Nursing Homes	Iowa DOT (via Info Group)	Locations of Nursing Homes	Esri FGDB Feature Class Point File
Town and City Halls	Iowa DOT (via Info Group)	Locations of Town Halls, City Halls, Government facilities	Esri FGDB Feature Class Point File
Surface Water Public	Iowa DNR	Surface water intakes (and infiltration galleries) at	Esri FGDB

Data Name	Data Provided By	Data Description	Data Type
Intake	Natural Resources Geographic Information Systems Library	facilities with operating permits for Public Water Supplies (systems that serve 25 or more people) for drinking water. This data is from the Iowa DNR's Safe Drinking Water Information System (SDWIS).	Feature Class Point File

### 5.7.4 Environmental Vulnerability

The following datasets were used to derive the environmental vulnerability:

**Table E-8. Environmental Vulnerability**

Data Name	Data Provided By	Data Description	Data Type
Significant Public Lakes	Iowa DNR Natural Resources Geographic Information Systems Library	Public lakes are the recognized significant publicly-owned lakes by the Iowa Department of Natural Resources	Esri FGDB Feature Class Polygon File
Federal Reservoirs	Iowa DNR Natural Resources Geographic Information Systems Library	Federally Owned Reservoirs of Iowa	Esri FGDB Feature Class Polygon File
Designated Wetland Setbacks	Iowa DNR Natural Resources Geographic Information Systems Library	Wetlands Designated as Protected by the Iowa DNR	Esri FGDB Feature Class Polygon File
Outstanding Iowa Waters	Iowa DNR Natural Resources Geographic Information Systems Library	A surface water that Iowa DNR has classified as an outstanding state resource water in the water quality standards	Esri FGDB Feature Class Polyline File
Designated Rivers	Iowa DNR Natural Resources Geographic Information Systems Library	This coverage consists of designated stream segments in the state of Iowa. Classifications for designated streams are determined through a Use Assessment/Use Attainability Analysis. The coverage was developed using the National Hydrography Dataset (NHD) and Hydro Event Management (HEM) tools. Stream segments delineated from the NHD were related to the Surface Water Classification Document (SWC), which is the rule referenced document in Chapter 61.3(5)	Esri FGDB Feature Class Polyline File
Protected Water Areas	Iowa DNR Natural Resources Geographic	Protected water area means a water area permanently designated by the Natural Resource Commission for inclusion in the protected water area system	Esri FGDB Feature Class Polyline File

Data Name	Data Provided By	Data Description	Data Type
Conservation and Recreation Lands	Information Systems Library	Conservation and Recreational Lands with public access (Parks, WMA, DNR Lands)	Esri FGDB Feature Class Polygon File
	Iowa DNR Natural Resources Geographic Information Systems Library		

## 5.8 Metadata

Each exposure dataset was overlaid and “clipped” by the 0.5-mile buffer using geographic information systems (GIS) to produce four *exposure* datasets for each county:

- Population exposed to rail hazards
- Housing units exposed to rail hazards
- Critical infrastructure exposed to rail hazards
- Environmental areas exposed to rail hazards

A summary of county data can be found in Appendix B: County Profiles.

## 5.9 Crude Oil and Ethanol by Rail Transportation Risk and Vulnerability

### 5.9.1 Railroad Vulnerable Population Impact

While each county’s vulnerability accounts for the linear miles of railroad that transports either crude oil or ethanol, or both, the amount of railroad infrastructure in a county is not directly proportionate to the risk to population. For example, Harrison County contains the most linear miles of railroad main track (130.16 miles), with 6,706 people and 3,173 housing units within the 0.5-mile buffer zone. Linn County has the largest population (45,876) and number of housing units (20,325) within the 0.5-mile buffer zone, and contains 118.32 linear miles of main track, or 387.73 people per mile of railroad compared to 51.52 people per mile of railroad in Harrison County.

Table E-9 provides, by county, the length of railroad, estimated population, and housing units within the buffer, and the vulnerable population impact level. Methodology for Population Impact is provided in Section 5.4.2.

**Table E-9. Railroad Vulnerable Population Impact**

County	Estimated Linear Mile of Railroad	Estimated Population	Average Vulnerable Population per Linear Mile of Track	Impact to 10% of the Population per Linear Mile	Impact Level
Adair	7.75	1,409	182	18	High
Adams	34.88	1,499	14	1	Low

County	Estimated Linear Mile of Railroad	Estimated Population	Average Vulnerable Population per Linear Mile of Track	Impact to 10% of the Population per Linear Mile	Impact Level
Allamakee	40.14	3,954	14	1	Low
Appanoose	22.36	1,339	12	1	Low
Benton	74.55	10,724	24	2	Medium
Black Hawk	77.65	38,100	164	16	High
Boone	49.18	9,525	65	6	Medium
Bremer	23.65	5,994	253	25	High
Buchanan	27.45	6,881	84	8	Medium
Buena Vista	36.27	11,915	329	33	High
Butler	46.00	6,421	140	14	High
Calhoun	40.67	3,380	83	8	Medium
Carroll	74.65	7,530	25	3	Medium
Cass	25.82	3,723	144	14	High
Cedar	57.23	5,435	19	2	Medium
Cerro Gordo	77.70	25,388	54	5	Medium
Cherokee	29.80	5,656	190	19	High
Chickasaw	33.35	4,727	47	5	Medium
Clarke	51.92	4,580	29	3	Medium
Clay	24.39	7,245	297	30	High
Clayton	59.29	5,251	13	1	Low
Clinton	102.66	20,639	40	4	Medium
Crawford	109.52	8,483	19	2	Medium
Dallas	17.50	2,549	146	15	High
Delaware	38.68	4,668	121	12	High
Des Moines	44.70	14,700	110	11	High
Dickinson	2.18	143	65	7	Medium
Dubuque	62.16	26,166	60	6	Medium
Emmet	36.22	4,570	126	13	High
Fayette	0.50*	295	295	15	High
Floyd	64.52	8,133	42	4	Medium
Franklin	26.16	1,830	17	2	Medium
Fremont	26.93	381	14	1	Low
Greene	61.53	3,543	14	1	Low
Grundy	3.01*	10	3	1	Low
Guthrie	25.76	2,218	86	9	Medium
Hamilton	51.03	7,598	149	15	High
Hancock	24.30	3,508	144	14	High
Hardin	58.09	4,804	21	2	Medium
Harrison	130.16	6,706	9	1	Low
Henry	38.72	7,135	61	6	Medium
Humboldt	31.36	1,199	38	4	Medium
Ida	8.92	1,892	212	21	High
Iowa	34.03	4,017	39	4	Medium
Jackson	32.96	2,602	16	2	Medium
Jasper	38.22	8,870	232	23	High
Jefferson	53.19	5,212	12	1	Low
Johnson	27.20	32,980	606	61	High

County	Estimated Linear Mile of Railroad	Estimated Population	Average Vulnerable Population per Linear Mile of Track	Impact to 10% of the Population per Linear Mile	Impact Level
Keokuk	9.40	81	2	0	Low
Kossuth	54.51	5,093	93	9	Medium
Lee	79.03	14,750	62	6	Medium
Linn	118.32	45,876	65	6	Medium
Louisa	19.01	2,030	21	2	Medium
Lucas	73.65	5,327	12	1	Low
Lyon	18.49	1,092	15	1	Low
Madison	8.54	1,450	170	17	High
Mahaska	25.31	7,614	301	30	High
Marion	16.35	1,425	29	3	Medium
Marshall	67.55	10,076	37	4	Medium
Mills	66.50	4,063	15	2	Medium
Mitchell	30.45	4,121	135	14	High
Monona	25.71	3,648	71	7	Medium
Monroe	72.19	4,207	6	1	Low
Montgomery	46.89	4,724	25	3	Medium
Muscatine	50.35	16,641	83	8	Medium
O' Brien	12.75	3,673	96	10	High
Osceola	18.00	2,285	63	6	Medium
Page	11.83	3,263	276	28	High
Palo Alto	51.61	5,701	110	11	High
Plymouth	84.80	10,627	18	2	Medium
Pocahontas	36.87	2,882	78	8	Medium
Polk	56.62	41,180	182	18	High
Pottawattamie	126.60	29,784	59	6	Medium
Poweshiek	48.63	9,641	198	20	High
Sac	35.05	1,768	50	5	Medium
Scott	62.49	38,248	87	9	Medium
Shelby	24.16	1,304	54	5	Medium
Sioux	59.56	7,824	19	2	Medium
Story	90.94	34,614	95	10	High
Tama	50.75	2,678	18	2	Medium
Union	44.23	6,067	46	5	Medium
Wapello	84.24	10,088	15	1	Low
Warren	14.04	2,447	58	6	Medium
Washington	25.62	4,773	37	4	Medium
Wayne	43.00	2,591	12	1	Low
Webster	86.74	18,314	211	21	High
Winnebago	16.32	2,188	134	13	High
Winneshiek	29.71	2,708	46	5	Medium
Woodbury	41.16	31,035	108	11	High
Worth	45.33	4,022	89	9	Medium
Wright	21.63	3,843	44	4	Medium

*\* Fayette and Grundy counties do not have crude oil or ethanol rail transportation within their jurisdictional borders, but do have areas within the 0/5 mile buffer zones. The Estimated Linear Miles of Railroad for these counties refer to these buffer zones.*

## 5.9.2 Railroad Critical Facilities Impact

The potential impact of a railroad incident on critical facilities was estimated through an analysis of the number of critical facilities within the buffer (refer to Table E-10). Methodology for Critical Facilities Impact is provided in Section 5.4.3.

**Table E-10. Railroad Vulnerable Critical Facilities Impact**

County	Estimated Linear Mile of Railroad	EMS and Fire	Court-houses and Public Safety	K - 12 Schools	Childcare Centers	Hospital Facilities	Nursing Homes	Town and City Halls	Water Intake Facilities	Average # of Facilities per Train Mile of Track	10% Impact to Facilities per Mile of Track	Impact Level
Adair	7.75	2	3	0	0	1	1	3	0	1.29	12.91%	Medium
Adams	34.88	2	8	3	1	2	0	11	1	0.80	8.03%	Low
Allamakee	40.14	4	5	5	5	4	1	15	0	0.97	9.72%	Low
Appanoose	22.36	1	2	3	0	0	0	4	0	0.45	4.47%	Low
Benton	74.55	5	13	10	2	4	2	26	0	0.83	8.32%	Low
Black Hawk	77.65	4	20	20	11	11	7	31	0	1.34	13.39%	Medium
Boone	49.18	2	8	11	3	4	7	19	0	1.10	10.98%	Medium
Bremer	23.65	3	2	7	3	4	3	2	0	1.01	10.15%	Medium
Buchanan	27.45	3	3	12	4	4	3	5	0	1.24	12.39%	Medium
Buena Vista	36.27	3	7	13	4	4	4	24	0	1.63	16.27%	Medium
Butler	46.00	6	9	6	3	5	5	10	0	0.96	9.56%	Low
Calhoun	40.67	1	8	6	1	3	6	20	0	1.11	11.06%	Medium
Carroll	74.65	3	16	7	7	13	2	25	0	0.98	9.78%	Low
Cass	25.82	2	8	1	3	5	1	17	0	1.43	14.33%	Medium
Cedar	57.23	5	9	7	3	4	3	9	0	0.70	6.99%	Low
Cerro Gordo	77.70	3	7	18	15	25	8	12	0	1.13	11.33%	Medium
Cherokee	29.80	6	10	10	6	4	3	22	0	2.05	20.47%	High
Chickasaw	33.35	0	7	6	4	3	3	15	0	1.14	11.39%	Medium
Clarke	51.92	3	8	3	2	2	5	10	0	0.64	6.36%	Low
Clay	24.39	2	12	7	5	4	2	15	1	1.97	19.68%	Medium
Clayton	59.29	3	4	6	4	1	7	10	0	0.59	5.90%	Low
Clinton	102.66	6	14	16	6	7	4	16	1	0.68	6.82%	Low
Crawford	109.52	5	6	12	2	5	5	33	0	0.62	6.21%	Low
Dallas	17.50	2	2	3	2	0	0	3	0	0.69	6.86%	Low
Delaware	38.68	6	6	5	7	3	6	20	0	1.37	13.70%	Medium
Des Moines	44.70	4	12	13	6	9	3	23	0	1.57	15.66%	Medium
Dickinson	2.18	1	1	0	0	0	0	1	0	1.38	13.76%	Medium
Dubuque	62.16	4	16	19	12	12	9	32	0	1.67	16.73%	Medium
Emmet	36.22	1	8	4	2	4	2	13	0	0.94	9.39%	Low
Fayette	0.50*	0	0	0	0	0	0	0	0	0.00	0.00%	Low
Floyd	64.52	2	5	7	8	6	6	10	0	0.68	6.82%	Low
Franklin	26.16	0	3	1	0	0	0	5	0	0.34	3.44%	Low

County	Estimated Linear Mile of Railroad	EMS and Fire	Court-houses and Public Safety	K - 12 Schools	Childcare Centers	Hospital Facilities	Nursing Homes	Town and City Halls	Water Intake Facilities	Average # of Facilities per Mile of Track	10% Impact to Facilities per Mile of Track	Impact Level
Fremont	26.93	1	0	0	0	1	0	0	0	0.07	0.74%	Low
Greene	61.53	2	4	3	1	2	3	16	0	0.50	5.04%	Low
Grundy	3.01*	0	0	0	0	0	0	0	0	0.00	0.00%	Low
Guthrie	25.76	2	4	3	0	2	1	4	0	0.62	6.21%	Low
Hamilton	51.03	4	9	8	2	5	0	25	0	1.04	10.39%	Medium
Hancock	24.30	2	3	2	1	7	2	14	0	1.28	12.76%	Medium
Hardin	58.09	4	4	2	3	8	3	8	0	0.55	5.51%	Low
Harrison	130.16	4	13	13	4	9	3	23	0	0.53	5.30%	Low
Henry	38.72	1	9	7	5	6	8	18	0	1.39	13.95%	Medium
Humboldt	31.36	0	0	4	0	0	0	4	0	0.26	2.55%	Low
Ida	8.92	2	3	5	1	2	1	9	0	2.58	25.79%	High
Iowa	34.03	2	7	3	2	1	2	12	0	0.85	8.52%	Low
Jackson	32.96	2	3	3	0	1	1	7	0	0.52	5.16%	Low
Jasper	38.22	3	9	6	7	8	4	17	0	1.41	14.13%	Medium
Jefferson	53.19	2	9	8	0	7	4	19	1	0.94	9.40%	Low
Johnson	27.20	8	15	11	23	31	3	46	1	5.07	50.74%	High
Keokuk	9.40	0	0	0	0	0	0	0	0	0.00	0.00%	Low
Kossuth	54.51	4	8	8	1	2	1	18	0	0.77	7.70%	Low
Lee	79.03	4	14	8	6	1	7	19	2	0.77	7.72%	Low
Linn	118.32	15	33	16	26	29	12	58	1	1.61	16.06%	Medium
Louisa	19.01	0	2	2	2	1	0	2	0	0.47	4.73%	Low
Lucas	73.65	3	4	7	3	4	2	17	1	0.56	5.57%	Low
Lyon	18.49	2	1	2	0	0	0	6	0	0.59	5.95%	Low
Madison	8.54	1	0	3	1	1	0	3	0	1.05	10.54%	Medium
Mahaska	25.31	1	5	8	10	2	5	14	0	1.78	17.78%	Medium
Marion	16.35	1	1	3	0	1	0	3	0	0.55	5.50%	Low
Marshall	67.55	4	10	8	6	8	1	19	0	0.83	8.29%	Low
Mills	66.50	4	8	4	3	3	9	19	0	0.75	7.52%	Low
Mitchell	30.45	1	8	6	1	2	5	12	0	1.15	11.49%	Medium
Monona	25.71	1	6	4	1	0	3	13	0	1.09	10.89%	Medium
Monroe	72.19	2	4	5	3	5	8	8	0	0.48	4.85%	Low
Montgomery	46.89	2	7	5	2	2	4	18	0	0.85	8.53%	Low
Muscatine	50.35	5	13	6	5	3	1	19	0	1.03	10.33%	Medium

County	Estimated Linear Mile of Railroad	EMS and Fire	Court-houses and Public Safety	K - 12 Schools	Childcare Centers	Hospital Facilities	Nursing Homes	Town and City Halls	Water Intake Facilities	Average # of Facilities per Mile of Track	10% Impact to Facilities per Mile of Track	Impact Level
O' Brien	12.75	3	2	3	2	6	4	12	0	2.51	25.09%	High
Osceola	18.00	1	3	0	0	1	4	13	0	1.22	12.22%	Medium
Page	11.83	1	4	5	2	0	3	4	0	1.61	16.06%	Medium
Palo Alto	51.61	0	10	12	5	5	9	25	0	1.28	12.79%	Medium
Plymouth	84.80	4	13	15	5	8	8	26	0	0.93	9.32%	Low
Pocahontas	36.87	2	5	8	1	0	4	8	0	0.76	7.59%	Low
Polk	56.62	5	59	12	19	31	16	128	2	4.80	48.04%	High
Pottawattamie	126.60	5	20	17	17	16	10	31	0	0.92	9.16%	Low
Poweshiek	48.63	3	5	5	1	6	3	13	1	0.76	7.61%	Low
Sac	35.05	1	3	4	0	1	2	9	0	0.57	5.71%	Low
Scott	62.49	5	14	20	13	11	6	31	1	1.62	16.16%	Medium
Shelby	24.16	4	5	3	0	0	2	3	0	0.70	7.04%	Low
Sioux	59.56	4	3	8	2	10	5	11	0	0.72	7.22%	Low
Story	90.94	7	16	14	6	11	6	37	0	1.07	10.67%	Medium
Tama	50.75	2	4	5	0	0	0	7	0	0.35	3.55%	Low
Union	44.23	2	7	8	4	2	5	13	1	0.95	9.50%	Low
Wapello	84.24	4	10	8	2	9	3	22	5	0.75	7.48%	Low
Warren	14.04	2	2	3	2	0	0	1	0	0.71	7.12%	Low
Washington	25.62	1	7	4	2	2	2	13	0	1.21	12.10%	Medium
Wayne	43.00	3	7	7	1	6	2	9	1	0.84	8.37%	Low
Webster	86.74	7	22	15	9	15	9	49	0	1.45	14.53%	Medium
Winnebago	16.32	2	3	5	2	2	2	8	0	1.47	14.70%	Medium
Winneshiek	29.71	3	4	7	2	3	0	8	0	0.91	9.09%	Low
Woodbury	41.16	4	22	23	22	24	8	46	1	3.64	36.45%	High
Worth	45.33	6	12	6	3	2	4	14	0	1.04	10.37%	Medium
Wright	21.63	1	3	3	2	2	2	3	0	0.74	7.40%	Low

\* Fayette and Grundy counties do not have crude oil or ethanol rail transportation within their jurisdictional borders, but do have areas within the 0/5 mile buffer zones. The Estimated Linear Miles of Railroad for these counties refer to these buffer zones.

### 5.9.3 Railroad Vulnerable Environmental Impact

Tables E-11 and E-12 provide, by county, the total area, in acres or linear miles within the buffer, and the determined impact level. The entire area, each of these summed, is used to calculate the vulnerability for each county from which the impact level was assigned as described in Section 5.4.4 Environmental Impact Level.

**Table E-11. Railroad Vulnerable Environmental Impact in Acres – Lakes, Reservoirs, Wetlands, and Setbacks**

County	Public Lakes	Federal Reservoirs	Protected Wetlands and Setbacks	Vulnerable Acres	Impact Level
Adair	0.00	0.00	0.00	0.00	Low
Adams	0.00	0.00	0.00	0.00	Low
Allamakee	0.00	0.00	0.00	0.00	Low
Appanoose	0.00	75.49	0.00	7.55	Medium
Benton	0.00	0.00	528.15	52.81	High
Black Hawk	28.29	0.00	0.00	2.83	Medium
Boone	0.00	0.00	100.91	10.09	High
Bremer	0.00	0.00	0.00	0.00	Low
Buchanan	0.00	0.00	0.00	0.00	Low
Buena Vista	200.22	0.00	469.29	66.95	High
Butler	0.00	0.00	0.00	0.00	Low
Calhoun	0.00	0.00	0.00	0.00	Low
Carroll	0.00	0.00	0.00	0.00	Low
Cass	21.39	0.00	0.00	2.14	Medium
Cedar	0.00	0.00	0.00	0.00	Low
Cerro Gordo	732.72	0.00	1,181.27	191.40	High
Cherokee	0.00	0.00	0.00	0.00	Low
Chickasaw	0.00	0.00	0.00	0.00	Low
Clarke	20.37	0.00	0.00	2.04	Medium
Clay	0.00	0.00	1,999.60	199.96	High
Clayton	0.00	0.00	721.81	72.18	High
Clinton	0.00	0.00	0.00	0.00	Low
Crawford	6.62	0.00	0.00	0.66	Medium
Dallas	0.00	0.00	0.00	0.00	Low
Delaware	0.00	0.00	4.71	0.47	Medium
Des Moines	0.00	0.00	479.98	48.00	High
Dickinson	0.00	0.00	0.00	0.00	Low
Dubuque	0.00	0.00	0.00	0.00	Low
Emmet	0.00	0.00	467.04	46.70	High
Fayette	0.00	0.00	0.00	0.00	Low
Floyd	0.00	0.00	0.00	0.00	Low
Franklin	36.06	0.00	0.00	3.61	Medium
Fremont	0.00	0.00	0.00	0.00	Low
Greene	0.00	0.00	0.00	0.00	Low
Grundy	0.00	0.00	0.00	0.00	Low
Guthrie	0.00	0.00	0.00	0.00	Low
Hamilton	35.58	0.00	28.94	6.45	Medium
Hancock	26.02	0.00	972.66	99.87	High
Hardin	0.00	0.00	0.00	0.00	Low
Harrison	0.00	0.00	1,039.27	103.93	High
Henry	0.00	0.00	0.00	0.00	Low
Humboldt	0.00	0.00	0.00	0.00	Low
Ida	0.00	0.00	0.00	0.00	Low

County	Public Lakes	Federal Reservoirs	Protected Wetlands and Setbacks	Vulnerable Acres	Impact Level
Iowa	0.00	0.00	0.00	0.00	Low
Jackson	0.00	0.00	0.00	0.00	Low
Jasper	0.00	0.00	0.00	0.00	Low
Jefferson	0.00	0.00	0.00	0.00	Low
Johnson	11.89	0.00	0.00	1.19	Medium
Keokuk	0.00	0.00	0.00	0.00	Low
Kossuth	0.00	0.00	0.00	0.00	Low
Lee	0.00	0.00	0.00	0.00	Low
Linn	0.00	0.00	0.00	0.00	Low
Louisa	0.00	0.00	0.00	0.00	Low
Lucas	0.26	0.00	13.14	1.34	Medium
Lyon	0.00	0.00	0.00	0.00	Low
Madison	0.00	0.00	0.00	0.00	Low
Mahaska	0.00	0.00	0.00	0.00	Low
Marion	0.00	0.00	0.00	0.00	Low
Marshall	0.00	0.00	0.00	0.00	Low
Mills	0.00	0.00	0.00	0.00	Low
Mitchell	0.00	0.00	0.00	0.00	Low
Monona	0.00	0.00	0.00	0.00	Low
Monroe	0.00	0.00	0.00	0.00	Low
Montgomery	7.64	0.00	0.00	0.76	Medium
Muscatine	0.00	0.00	8.73	0.87	Medium
O' Brien	0.00	0.00	0.00	0.00	Low
Osceola	0.00	0.00	0.00	0.00	Low
Page	0.00	0.00	0.00	0.00	Low
Palo Alto	252.59	0.00	0.00	25.26	High
Plymouth	0.00	0.00	0.00	0.00	Low
Pocahontas	0.00	0.00	0.00	0.00	Low
Polk	67.56	0.00	180.35	24.79	High
Pottawattamie	0.00	0.00	0.00	0.00	Low
Poweshiek	6.44	0.00	0.00	0.64	Medium
Sac	0.00	0.00	1,094.30	109.43	High
Scott	0.00	0.00	0.00	0.00	Low
Shelby	0.00	0.00	0.00	0.00	Low
Sioux	0.00	0.00	0.00	0.00	Low
Story	0.00	0.00	0.00	0.00	Low
Tama	0.00	0.00	2,565.67	256.57	High
Union	12.41	0.00	0.00	1.24	Medium
Wapello	12.64	0.00	0.00	1.26	Medium
Warren	0.00	0.00	0.00	0.00	Low
Washington	0.00	0.00	0.00	0.00	Low
Wayne	0.00	0.00	0.00	0.00	Low
Webster	0.00	0.00	0.00	0.00	Low
Winnebago	0.00	0.00	867.51	86.75	High
Winneshiek	26.77	0.00	0.00	2.68	Medium
Woodbury	0.00	0.00	0.00	0.00	Low
Worth	0.00	0.00	0.00	0.00	Low
Wright	0.00	0.00	0.00	0.00	Low

**Table E-12. Railroad Vulnerable Environmental Impact in Linear Miles – Streams**

County	Outstanding Streams	Designated Streams	Protected Streams	Vulnerable Miles	Impact Level
Adair	0.00	1.65	0.00	0.16	Medium
Adams	0.00	14.91	0.00	1.49	High
Allamakee	1.34	5.06	0.00	0.64	Medium
Appanoose	0.00	4.74	0.00	0.47	Medium
Benton	0.00	30.89	0.00	3.09	High
Black Hawk	0.00	28.65	2.08	3.07	High
Boone	0.00	4.57	0.00	0.46	Medium
Bremer	0.00	11.13	0.00	1.11	High
Buchanan	0.00	5.79	6.71	1.25	High
Buena Vista	0.00	2.09	0.00	0.21	Medium
Butler	0.00	43.08	0.00	4.31	High
Calhoun	0.00	5.02	0.00	0.50	Medium
Carroll	0.00	20.16	0.00	2.02	High
Cass	0.00	11.91	0.00	1.19	High
Cedar	0.00	9.05	0.00	0.90	Medium
Cerro Gordo	0.00	32.12	0.00	3.21	High
Cherokee	0.00	9.15	0.00	0.91	Medium
Chickasaw	0.00	12.56	0.00	1.26	High
Clarke	0.00	0.00	0.00	0.00	Low
Clay	0.00	12.08	0.33	1.24	High
Clayton	8.72	18.99	0.00	2.77	High
Clinton	0.00	19.43	1.82	2.13	High
Crawford	0.00	56.13	0.00	5.61	High
Dallas	0.00	15.09	0.00	1.51	High
Delaware	0.00	8.77	0.00	0.88	Medium
Des Moines	0.00	7.74	0.00	0.77	Medium
Dickinson	0.00	0.00	0.00	0.00	Low
Dubuque	0.00	26.00	0.00	2.60	High
Emmet	0.00	13.48	0.00	1.35	Medium
Fayette	0.00	0.18	0.00	0.02	Medium
Floyd	0.00	21.44	0.00	2.14	High
Franklin	0.00	6.52	0.00	0.65	Medium
Fremont	0.00	0.00	0.00	0.00	Low
Greene	0.00	13.02	0.00	1.30	High
Grundy	0.00	0.00	0.00	0.00	Low
Guthrie	0.00	10.00	0.00	1.00	High
Hamilton	0.00	21.54	2.80	2.43	High
Hancock	0.00	1.01	0.00	0.10	Medium
Hardin	0.00	6.94	0.00	0.69	Medium
Harrison	0.00	41.53	0.00	4.15	High
Henry	0.00	3.94	0.00	0.39	Medium
Humboldt	0.00	9.31	0.00	0.93	Medium
Ida	0.00	11.96	0.00	1.20	High
Iowa	0.00	23.09	0.00	2.31	High
Jackson	0.00	4.16	0.00	0.42	Medium
Jasper	0.00	13.74	0.00	1.37	High
Jefferson	0.00	6.98	0.00	0.70	Medium
Johnson	0.00	22.97	0.00	2.30	High
Keokuk	0.00	3.11	0.00	0.31	Medium
Kossuth	0.00	7.51	0.00	0.75	Medium
Lee	0.00	11.34	0.00	1.13	High

County	Outstanding Streams	Designated Streams	Protected Streams	Vulnerable Miles	Impact Level
Linn	0.00	43.78	2.44	4.62	High
Louisa	0.00	1.04	0.00	0.10	Medium
Lucas	0.00	17.75	0.00	1.77	High
Lyon	0.00	2.73	0.00	0.27	Medium
Madison	0.00	0.00	0.00	0.00	Low
Mahaska	0.00	19.15	0.00	1.91	High
Marion	0.00	3.73	0.00	0.37	Medium
Marshall	0.00	19.39	0.00	1.94	High
Mills	0.00	9.00	0.00	0.90	Medium
Mitchell	0.00	2.60	0.00	0.26	Medium
Monona	0.00	11.07	0.00	1.11	High
Monroe	0.00	16.04	0.00	1.60	High
Montgomery	0.00	11.39	0.00	1.14	High
Muscatine	0.00	29.17	0.00	2.92	High
O' Brien	0.00	9.03	0.00	0.90	Medium
Osceola	0.00	7.60	0.00	0.76	Medium
Page	0.00	2.99	0.00	0.30	Medium
Palo Alto	0.00	2.66	0.00	0.27	Medium
Plymouth	0.00	72.42	0.00	7.24	High
Pocahontas	0.00	1.16	0.00	0.12	Medium
Polk	0.00	25.52	0.00	2.55	High
Pottawattamie	0.00	36.44	0.00	3.64	High
Poweshiek	0.00	26.75	0.00	2.68	High
Sac	0.00	20.46	0.00	2.05	High
Scott	0.00	16.15	1.55	1.77	High
Shelby	0.00	19.40	0.00	1.94	High
Sioux	0.00	58.41	0.00	5.84	High
Story	0.00	10.70	0.00	1.07	High
Tama	0.00	19.48	0.00	1.95	High
Union	0.00	10.05	0.00	1.01	High
Wapello	0.00	25.07	0.00	2.51	High
Warren	0.00	5.77	0.00	0.58	Medium
Washington	0.00	8.81	0.00	0.88	Medium
Wayne	0.00	1.48	0.00	0.15	Medium
Webster	0.00	17.23	0.00	1.72	High
Winnebago	0.00	3.77	0.00	0.38	Medium
Winneshiek	0.00	6.50	0.00	0.65	Medium
Woodbury	0.00	9.30	0.00	0.93	Medium
Worth	0.00	5.80	0.00	0.58	Medium
Wright	0.00	10.14	0.00	1.01	High

### 5.9.4 Railroad Likelihood

While future rail incidents cannot be predicted, a historical review can be used to conservatively estimate the chances of railroad accidents per year. Based on PHMSA data, Iowa experienced ten serious railroad incidents from 2004 through 2014.<sup>28</sup> PHMSA considers a railroad incident to be “serious” if it involves:

- A fatality or major injury caused by the release of a hazardous material.

<sup>28</sup> U.S. Department of Transportation, Pipeline Hazardous Materials Safety Administration, *Incident Reports Database Search*, <https://hazmatonline.phmsa.dot.gov/IncidentReportsSearch/> (accessed December 4, 2015).

- The evacuation of 25 or more employees or responders or any number of the general public as a result of release of a hazardous material or exposure to fire.
- A release or exposure to fire which results in the closure of a major transportation artery.
- The alteration of an aircraft flight plan or operation.
- The release of radioactive materials from Type B packaging.
- The suspected release of a “Risk Group 3” or “Risk Group 4” infectious substance.
- The release of over 11.9 gallons or 88.2 pounds of a severe marine pollutant.
- The release of a bulk quantity (over 119 gallons or 882 pounds) of a hazardous material.<sup>29</sup>

**Table E-13. Railroad 10 Year Incident**

2004–2014		
	<i>10 Year Average</i>	<i>10 Year Range</i>
Incident Count	1	0 - 10
# Evacuated	15.81	1581
Fatalities	0	0
Injuries	0.2	2
Property Damage	\$0	\$0 - \$0

Causative factors range from human error, to equipment malfunction, to infrastructure failure. Table E-15 is calculated by tank car, rather than per incident.

**Table E-14. Serious Railroad Incidents by Cause**

Failure Cause Description	% of All Accidents
Over-pressurized	20%
Loose Closure	30%
Liner	10%
Missing Component	10%
Misaligned Component	10%
Derailment	10%
Human Error	10%

Based on historical data presented in Table E-14, Iowa is estimated to experience an annualized one significant railroad incidents per year, or approximately ten incidents over the next ten years (based on annualized incidents). Of those ten incidents, based on statistical data, it is reasonable to assume that approximately one of those would be caused by derailment.

<sup>29</sup> U.S. Department of Transportation, Pipeline Hazardous Materials Safety Administration, *Serious Incident Definition*, <http://www.phmsa.dot.gov/portal/site/PHMSA/menuitem.6f23687cf7b00b0f22e4c6962d9c8789/?vgnextoid=706851d415b7c110VgnVCM1000009ed07898RCRD&vgnnextchannel=8010dd246007c110VgnVCM1000009ed07898RCRD> (accessed December 4, 2015).

## 5.9.5 Railroad Incident Likelihood

### ***Railroad: Likelihood Rating***

The likelihood rating was then assigned by examining the percent probability and assigning the appropriate value as outlined in Table E-15. Methodology for Likelihood Rating is provided in Section 5.5.

**Table E-15. Railroad Likelihood Rating**

County	Estimated Linear Miles of Rail	Number of Trains per day	Total Train Miles	% Total Train Miles (Statewide) per day	Likelihood Value	Annual Probability	Likelihood Level
Adair	7.75	1	7.75	0.05%	0.01	0.05%	Negligible
Adams	34.88	3	104.64	0.66%	0.13	0.66%	Low
Allamakee	40.14	7	281.01	1.78%	0.36	1.78%	Moderate
Appanoose	22.36	5	111.80	0.71%	0.14	0.71%	Low
Benton	74.55	6	447.30	2.84%	0.57	2.84%	High
Black Hawk	77.65	3	232.94	1.48%	0.30	1.48%	Moderate
Boone	49.18	3	147.55	0.94%	0.19	0.94%	Low
Bremer	23.65	1	23.65	0.15%	0.03	0.15%	Low
Buchanan	27.45	3	82.35	0.52%	0.10	0.52%	Low
Buena Vista	36.27	1	36.27	0.23%	0.05	0.23%	Low
Butler	46.00	1	46.00	0.29%	0.06	0.29%	Low
Calhoun	40.67	1	40.67	0.26%	0.05	0.26%	Low
Carroll	74.65	4	298.60	1.89%	0.38	1.89%	Moderate
Cass	25.82	1	25.82	0.16%	0.03	0.16%	Low
Cedar	57.23	5	286.13	1.82%	0.36	1.82%	Moderate
Cerro Gordo	77.70	6	466.17	2.96%	0.59	2.96%	High
Cherokee	29.80	1	29.80	0.19%	0.04	0.19%	Low
Chickasaw	33.35	3	100.05	0.63%	0.13	0.63%	Low
Clarke	51.92	3	155.76	0.99%	0.20	0.99%	Low
Clay	24.39	1	24.39	0.15%	0.03	0.15%	Low
Clayton	59.29	7	415.04	2.63%	0.53	2.63%	High
Clinton	102.66	5	513.30	3.26%	0.65	3.26%	Highest
Crawford	109.52	4	438.07	2.78%	0.56	2.78%	High
Dallas	17.50	1	17.50	0.11%	0.02	0.11%	Low
Delaware	38.68	1	38.68	0.25%	0.05	0.25%	Low
Des Moines	44.70	3	134.11	0.85%	0.17	0.85%	Low
Dickinson	2.18	1	2.18	0.01%	0.00	0.01%	Negligible
Dubuque	62.16	7	435.14	2.76%	0.55	2.76%	High
Emmet	36.22	1	36.22	0.23%	0.05	0.23%	Low
Fayette	0.50*	1	0.50	0.00%	0.00	0.00%	Negligible
Floyd	64.52	3	193.56	1.23%	0.25	1.23%	Moderate
Franklin	26.16	4	104.63	0.66%	0.13	0.66%	Low
Fremont	26.93	1	26.93	0.17%	0.03	0.17%	Low
Greene	61.53	4	246.12	1.56%	0.31	1.56%	Moderate
Grundy	3.01*	1	3.01	0.02%	0.00	0.02%	Negligible
Guthrie	25.76	1	25.76	0.16%	0.03	0.16%	Low
Hamilton	51.03	1	51.03	0.32%	0.06	0.32%	Low
Hancock	24.30	1	24.30	0.15%	0.03	0.15%	Low
Hardin	58.09	4	232.34	1.47%	0.29	1.47%	Moderate
Harrison	130.16	6	780.97	4.96%	0.99	4.96%	Highest
Henry	38.72	3	116.15	0.74%	0.15	0.74%	Low

County	Estimated Linear Miles of Rail	Number of Trains per day	Total Train Miles	% Total Train Miles (Statewide) per day	Likelihood Value	Annual Probability	Likelihood Level
Humboldt	31.36	1	31.36	0.20%	0.04	0.20%	Low
Ida	8.92	1	8.92	0.06%	0.01	0.06%	Negligible
Iowa	34.03	3	102.08	0.65%	0.13	0.65%	Low
Jackson	32.96	5	164.79	1.05%	0.21	1.05%	Moderate
Jasper	38.22	1	38.22	0.24%	0.05	0.24%	Low
Jefferson	53.19	8	425.55	2.70%	0.54	2.70%	High
Johnson	27.20	2	54.39	0.35%	0.07	0.35%	Low
Keokuk	9.40	5	46.99	0.30%	0.06	0.30%	Low
Kossuth	54.51	1	54.51	0.35%	0.07	0.35%	Low
Lee	79.03	3	237.08	1.50%	0.30	1.50%	Moderate
Linn	118.32	6	709.90	4.50%	0.90	4.50%	Highest
Louisa	19.01	5	95.04	0.60%	0.12	0.60%	Low
Lucas	73.65	6	441.88	2.80%	0.56	2.80%	High
Lyon	18.49	4	73.95	0.47%	0.09	0.47%	Low
Madison	8.54	1	8.54	0.05%	0.01	0.05%	Negligible
Mahaska	25.31	1	25.31	0.16%	0.03	0.16%	Low
Marion	16.35	3	49.05	0.31%	0.06	0.31%	Low
Marshall	67.55	4	270.21	1.71%	0.34	1.71%	Moderate
Mills	66.50	4	265.98	1.69%	0.34	1.69%	Moderate
Mitchell	30.45	1	30.45	0.19%	0.04	0.19%	Low
Monona	25.71	2	51.42	0.33%	0.07	0.33%	Low
Monroe	72.19	9	649.75	4.12%	0.82	4.12%	Highest
Montgomery	46.89	4	187.56	1.19%	0.24	1.19%	Moderate
Muscatine	50.35	4	201.41	1.28%	0.26	1.28%	Moderate
O' Brien	12.75	3	38.26	0.24%	0.05	0.24%	Low
Osceola	18.00	2	36.00	0.23%	0.05	0.23%	Low
Page	11.83	1	11.83	0.08%	0.02	0.08%	Negligible
Palo Alto	51.61	1	51.61	0.33%	0.07	0.33%	Low
Plymouth	84.80	7	593.62	3.77%	0.75	3.77%	Highest
Pocahontas	36.87	1	36.87	0.23%	0.05	0.23%	Low
Polk	56.62	4	226.50	1.44%	0.29	1.44%	Moderate
Pottawattamie	126.60	4	506.41	3.21%	0.64	3.21%	Highest
Poweshiek	48.63	1	48.63	0.31%	0.06	0.31%	Low
Sac	35.05	1	35.05	0.22%	0.04	0.22%	Low
Scott	62.49	7	437.40	2.78%	0.56	2.78%	High
Shelby	24.16	1	24.16	0.15%	0.03	0.15%	Low
Sioux	59.56	7	416.89	2.65%	0.53	2.65%	High
Story	90.94	4	363.76	2.31%	0.46	2.31%	High
Tama	50.75	3	152.26	0.97%	0.19	0.97%	Low
Union	44.23	3	132.69	0.84%	0.17	0.84%	Low
Wapello	84.24	8	673.90	4.28%	0.86	4.28%	Highest
Warren	14.04	3	42.13	0.27%	0.05	0.27%	Low
Washington	25.62	5	128.08	0.81%	0.16	0.81%	Low
Wayne	43.00	5	215.02	1.36%	0.27	1.36%	Moderate
Webster	86.74	1	86.74	0.55%	0.11	0.55%	Low
Winnebago	16.32	1	16.32	0.10%	0.02	0.10%	Low
Winneshek	29.71	2	59.43	0.38%	0.08	0.38%	Low
Woodbury	41.16	7	288.10	1.83%	0.37	1.83%	Moderate
Worth	45.33	1	45.33	0.29%	0.06	0.29%	Low
Wright	21.63	4	86.52	0.55%	0.11	0.55%	Low

\* Fayette and Grundy counties do not have crude oil or ethanol rail transportation within their jurisdictional borders, but do have areas within the 0.5-mile buffer zones. The Estimated Linear Miles of Railroad for these counties refer to these buffer zones.

### 5.9.6 Crude Oil and Ethanol Railroad Transportation Sensitivity

Table E-16 summarizes the likelihood, impact, and associated sensitivity (risk) in each county for railroad crude oil and ethanol rail transportation based on utilizing the methodology presented in Section 5.6: Risk. Figure 1 depicts the sensitivity levels for each county where crude oil and/or ethanol are transported by rail. All other maps supporting the RVA are located in Appendix I: Maps. Methodology for Railroad Risk (Sensitivity) is provided in Section 5.6.

**Table E-16. Sensitivity**

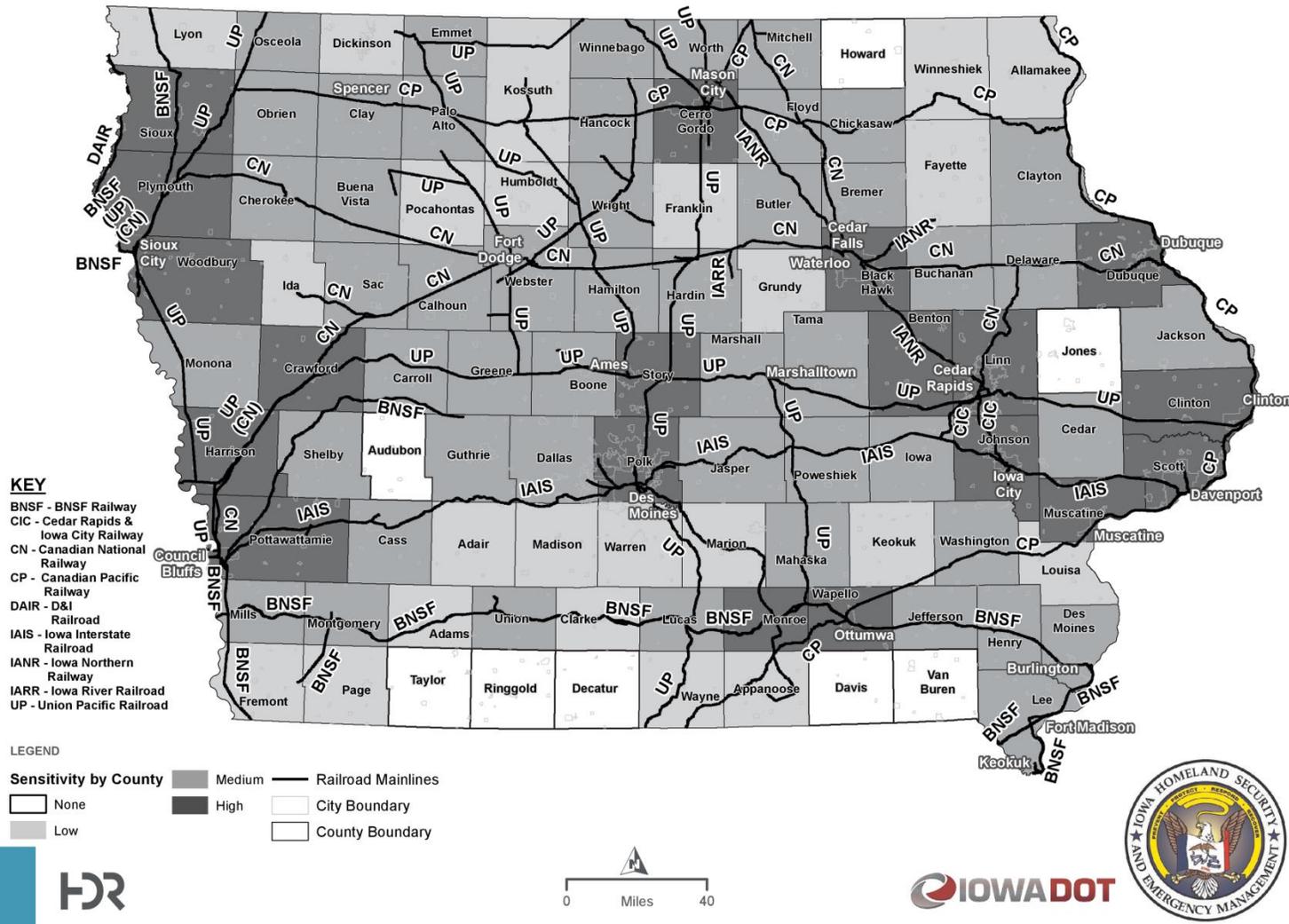
All Counties	Population Impact Level	Critical Facilities Impact Level	Environmental Impact Level	Average Impact Value	Likelihood Level	Likelihood Value	Sensitivity Value	Assigned Sensitivity Level
Adair	5	3	3	3.67	Negligible	1	3.67	Low
Adams	1	1	5	2.33	Low	2	4.67	Low
Allamakee	1	1	3	1.67	Moderate	3	5.00	Low
Appanoose	1	1	3	1.67	Low	2	3.33	Low
Benton	3	1	5	3.00	High	4	12.00	High
Black Hawk	5	3	5	4.33	Moderate	3	13.00	High
Boone	3	3	5	3.67	Low	2	7.33	Medium
Bremer	5	3	5	4.33	Low	2	8.67	Medium
Buchanan	3	3	5	3.67	Low	2	7.33	Medium
Buena Vista	5	3	5	4.33	Low	2	8.67	Medium
Butler	5	1	5	3.67	Low	2	7.33	Medium
Calhoun	3	3	3	3.00	Low	2	6.00	Medium
Carroll	3	1	5	3.00	Moderate	3	9.00	Medium
Cass	5	3	5	4.33	Low	2	8.67	Medium
Cedar	3	1	3	2.33	Moderate	3	7.00	Medium
Cerro Gordo	3	3	5	3.67	High	4	14.67	High
Cherokee	5	5	3	4.33	Low	2	8.67	Medium
Chickasaw	3	3	5	3.67	Low	2	7.33	Medium
Clarke	3	1	3	2.33	Low	2	4.67	Low
Clay	5	3	5	4.33	Low	2	8.67	Medium
Clayton	1	1	5	2.33	High	4	9.33	Medium
Clinton	3	1	5	3.00	Highest	5	15.00	High
Crawford	3	1	5	3.00	High	4	12.00	High
Dallas	5	1	5	3.67	Low	2	7.33	Medium
Delaware	5	3	3	3.67	Low	2	7.33	Medium
Des Moines	5	3	5	4.33	Low	2	8.67	Medium
Dickinson	3	3	1	2.33	Negligible	1	2.33	Low
Dubuque	3	3	5	3.67	High	4	14.67	High
Emmet	5	1	5	3.67	Low	2	7.33	Medium
Fayette	5	1	3	3.00	Negligible	1	3.00	Low
Floyd	3	1	5	3.00	Moderate	3	9.00	Medium
Franklin	3	1	3	2.33	Low	2	4.67	Low
Fremont	1	1	1	1.00	Low	2	2.00	Low
Greene	1	1	5	2.33	Moderate	3	7.00	Medium
Grundy	1	1	1	1.00	Negligible	1	1.00	Low
Guthrie	3	1	5	3.00	Low	2	6.00	Medium
Hamilton	5	3	5	4.33	Low	2	8.67	Medium

All Counties	Population Impact Level	Critical Facilities Impact Level	Environmental Impact Level	Average Impact Value	Likelihood Level	Likelihood Value	Sensitivity Value	Assigned Sensitivity Level
Hancock	5	3	5	4.33	Low	2	8.67	Medium
Hardin	3	1	3	2.33	Moderate	3	7.00	Medium
Harrison	1	1	5	2.33	Highest	5	11.67	High
Henry	3	3	3	3.00	Low	2	6.00	Medium
Humboldt	3	1	3	2.33	Low	2	4.67	Low
Ida	5	5	5	5.00	Negligible	1	5.00	Low
Iowa	3	1	5	3.00	Low	2	6.00	Medium
Jackson	3	1	3	2.33	Moderate	3	7.00	Medium
Jasper	5	3	5	4.33	Low	2	8.67	Medium
Jefferson	1	1	3	1.67	High	5	8.33	Medium
Johnson	5	5	5	5.00	Low	2	10.00	High
Keokuk	1	1	3	1.67	Low	2	3.33	Low
Kossuth	3	1	3	2.33	Low	2	4.67	Low
Lee	3	1	5	3.00	Moderate	3	9.00	Medium
Linn	3	3	5	3.67	Highest	5	18.33	High
Louisa	3	1	3	2.33	Low	2	4.67	Low
Lucas	1	1	5	2.33	High	4	9.33	Medium
Lyon	1	1	3	1.67	Low	2	3.33	Low
Madison	5	3	1	3.00	Negligible	1	3.00	Low
Mahaska	5	3	5	4.33	Low	2	8.67	Medium
Marion	3	1	3	2.33	Low	2	4.67	Low
Marshall	3	1	5	3.00	Moderate	3	9.00	Medium
Mills	3	1	3	2.33	Moderate	3	7.00	Medium
Mitchell	5	3	3	3.67	Low	2	7.33	Medium
Monona	3	3	5	3.67	Low	2	7.33	Medium
Monroe	1	1	5	2.33	Highest	5	11.67	High
Montgomery	3	1	5	3.00	Moderate	3	9.00	Medium
Muscatine	3	3	5	3.67	Moderate	3	11.00	High
O' Brien	5	5	3	4.33	Low	2	8.67	Medium
Osceola	3	3	3	3.00	Low	2	6.00	Medium
Page	5	3	3	3.67	Negligible	1	3.67	Low
Palo Alto	5	3	5	4.33	Low	2	8.67	Medium
Plymouth	3	1	5	3.00	Highest	5	15.00	High
Pocahontas	3	1	3	2.33	Low	2	4.67	Low
Polk	5	5	5	5.00	Moderate	3	15.00	High
Pottawattamie	3	1	5	3.00	Highest	5	15.00	High
Poweshiek	5	1	5	3.67	Low	2	7.33	Medium
Sac	3	1	5	3.00	Low	2	6.00	Medium
Scott	3	3	5	3.67	High	4	14.67	High
Shelby	3	1	5	3.00	Low	2	6.00	Medium
Sioux	3	1	5	3.00	High	4	12.00	High
Story	5	3	5	4.33	High	4	17.33	High
Tama	3	1	5	3.00	Low	2	6.00	Medium
Union	3	1	5	3.00	Low	2	6.00	Medium
Wapello	1	1	5	2.33	Highest	5	11.67	High
Warren	3	1	3	2.33	Low	2	4.67	Low
Washington	3	3	3	3.00	Low	2	6.00	Medium
Wayne	1	1	3	1.67	Moderate	3	5.00	Low
Webster	5	3	5	4.33	Low	2	8.67	Medium
Winnebago	5	3	5	4.33	Low	2	8.67	Medium
Winneshiek	3	1	3	2.33	Low	2	4.67	Low

All Counties	Population Impact Level	Critical Facilities Impact Level	Environmental Impact Level	Average Impact Value	Likelihood Level	Likelihood Value	Sensitivity Value	Assigned Sensitivity Level
Woodbury	5	5	3	4.33	Moderate	3	13.00	High
Worth	3	3	3	3.00	Low	2	6.00	Medium
Wright	3	1	5	3.00	Low	2	6.00	Medium

Figure E-1. Ranking of Crude Oil and Ethanol Railroad Transportation Sensitivity, by County (2015)

RANKING OF CRUDE OIL AND ETHANOL RAIL TRANSPORTATION SENSITIVITY, BY COUNTY (2015)



Source: HDR, as of 3/24/2016

### 5.9.7 Sensitivity Examples

The following examples of sensitivity calculations are provided to aid in understanding of how each county was assessed, and how the results of the assessment determined the county's sensitivity rating:

#### ***Marion County – Low Sensitivity Rating***

Marion County has an estimated population of 33,365 with 1,425 (4.27 percent) of that total population residing within ½ mile of the crude oil and ethanol transporting railroads. This results in an averaged 29 people per train mile of track. Using a 10 percent impact factor, the assessment assumes a potential population impact to be three people, resulting in a medium population impact rating (Value: 3).

There are a total of nine critical facilities within the identified hazard area of Marion County, which averages out to 0.55 facilities per mile of track. A 10 percent impact to critical facilities per mile of track equals 5.5 percent, which is less than 10 percent for overall loss to the facilities and results in a low critical facility impact rating (Value: 1).

Marion County has no exposed water bodies but it does have 3.73 miles of exposed stream length, creating a 10 percent vulnerability of 0.37 miles. This results in a low impact rating for water bodies and a medium impact rating for streams. Since the overall potential impact to the county is 0.37 miles, the overall impact rating is medium (Value: 3).

The population, critical facility, and environmental factors are calculated together to create an Average Impact Value of 2.33.

Marion County has 16.35 miles of active railroads that transport crude oil and ethanol. They average three crude oil/ethanol trains per day, which calculates out to be 49.05 total train miles, or 0.31 percent of the total train miles in Iowa. Given the historical accounts for significant rail incidents during transport in Iowa, the annual probability, or likelihood, of occurrence in Marion County is 0.31 percent, a low likelihood rating (Value: 2).

The Average Impact Value and Likelihood Value are multiplied together, resulting in the Low Sensitivity Level with a Sensitivity Rating of 4.67.

#### ***Wright County – Medium Sensitivity Rating***

Wright County has an estimated population of 12,480 with 3,843 (29.93 percent) of that total population residing within ½ mile of the crude oil and ethanol transporting railroads. This results in an averaged 44 people per train mile of track. Using a 10 percent impact factor, the assessment assumes a potential population impact to be four people, resulting in a medium population impact rating (Value: 3).

There are a total of 16 critical facilities within the identified hazard area of Wright County, which averages out to 0.74 facilities per mile of track. A 10 percent impact to critical facilities per mile of track equals 7.4 percent, which is less than 10 percent for overall loss to the facilities and results in a low critical facility impact rating (Value: 1).

Wright County has no exposed water bodies but it does have 10.14 miles of exposed stream length, creating a 10 percent vulnerability of 1.01 miles. This results in a low impact rating for

water bodies and a high impact rating for streams. Since the overall potential impact to the county is 1.01 miles, the overall impact rating is high (Value: 5).

The population, critical facility, and environmental factors are calculated together to create an Average Impact Value of 2.33.

Wright County has 21.63 miles of active railroads that transport crude oil and ethanol. They average four crude oil/ethanol trains per day, which calculates out to be 86.52 total train miles, or 0.55 percent of the total train miles in Iowa. Given the historical accounts for significant rail incidents during transport in Iowa, the annual probability, or likelihood, of occurrence in Wright County is 0.55 percent, a low likelihood rating (Value: 2).

The Average Impact Value and Likelihood Value are multiplied together, resulting in the Medium Sensitivity Level with a Sensitivity Rating of 6.00.

### ***Dubuque County – High Sensitivity Rating***

Dubuque County has an estimated population of 96,370 with 26,166 (27.15 percent) of that total population residing within ½ mile of the crude oil and ethanol transporting railroads. This results in an averaged 60 people per train mile of track. Using a 10 percent impact factor, the assessment assumes a potential population impact to be six people, resulting in a medium population impact rating (Value: 3).

There are a total of 104 critical facilities within the identified hazard area of Dubuque County, which averages out to 1.67 facilities per mile of track. A 10 percent impact to critical facilities per mile of track equals 16.73 percent, which is between 10 percent and 20 percent for overall loss to the facilities and results in a medium critical facility impact rating (Value: 3).

Dubuque County has no exposed water bodies but it does have 26.0 miles of exposed stream length, creating a 10 percent vulnerability of 2.60 miles. This results in a low impact rating for water bodies and a high impact rating for streams. Since the overall potential impact to the county is 2.60 miles, the overall impact rating is high (Value: 5).

The population, critical facility, and environmental factors are calculated together to create an Average Impact Value of 2.33.

Dubuque County has 62.16 miles of active railroads that transport crude oil and ethanol. They average seven crude oil/ethanol trains per day, which calculates out to be 435.14 total train miles, or 2.76 percent of the total train miles in Iowa. Given the historical accounts for significant rail incidents during transport in Iowa, the annual probability of occurrence in Dubuque County is 2.76 percent, a high likelihood rating (Value: 4).

The Average Impact Value and Likelihood Value are multiplied together, resulting in the High Sensitivity Level with a Sensitivity Rating of 14.69.