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HDI PNP 2022-032 10 CFR 50, Appendix E

September 7, 2022

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Subject: Palisades Nuclear Plant 2022 Evacuation Time Estimate Report

Palisades Nuclear Plant
Docket No. 50-255
Renewed Facility Operating License No. DPR-20

In accordance with Title 10 of the Code of Federal Regulations Part 50 (10 CFR 50), Appendix E, *Emergency Planning and Preparedness for Production and Utilization Facilities*, Section IV., *Content of Emergency Plans*, Paragraph 4., Holtec Decommissioning International, LLC, is submitting on behalf of Holtec Palisades, LLC, the 2022 Evacuation Time Estimate (ETE) Report for Palisades Nuclear Plant (PNP). The PNP 2022 ETE Report is provided in the Enclosure to this letter.

This letter contains no new commitments and no revised commitments.

Should you have any questions or require additional information, please contact Jim Miksa, Regulatory Assurance Engineer at (269) 764-2945.

Respectfully,

Jean A. Fleming Digitally signed by Jean A. Fleming
Date: 2022.09.07 11:26:48 -04'00'

Jean A. Fleming
Vice President of Licensing, Regulatory Affairs & PSA
Holtec International

Enclosure: Palisades Nuclear Plant 2022 Evacuation Time Estimate Report

cc: NRC Region III Regional Administrator
NRC Senior Resident Inspector – Palisades Nuclear Plant
NRC Project Manager – Palisades Nuclear Plant
State of Michigan Official

Enclosure to

HDI PNP 2022-032

Palisades Nuclear Plant

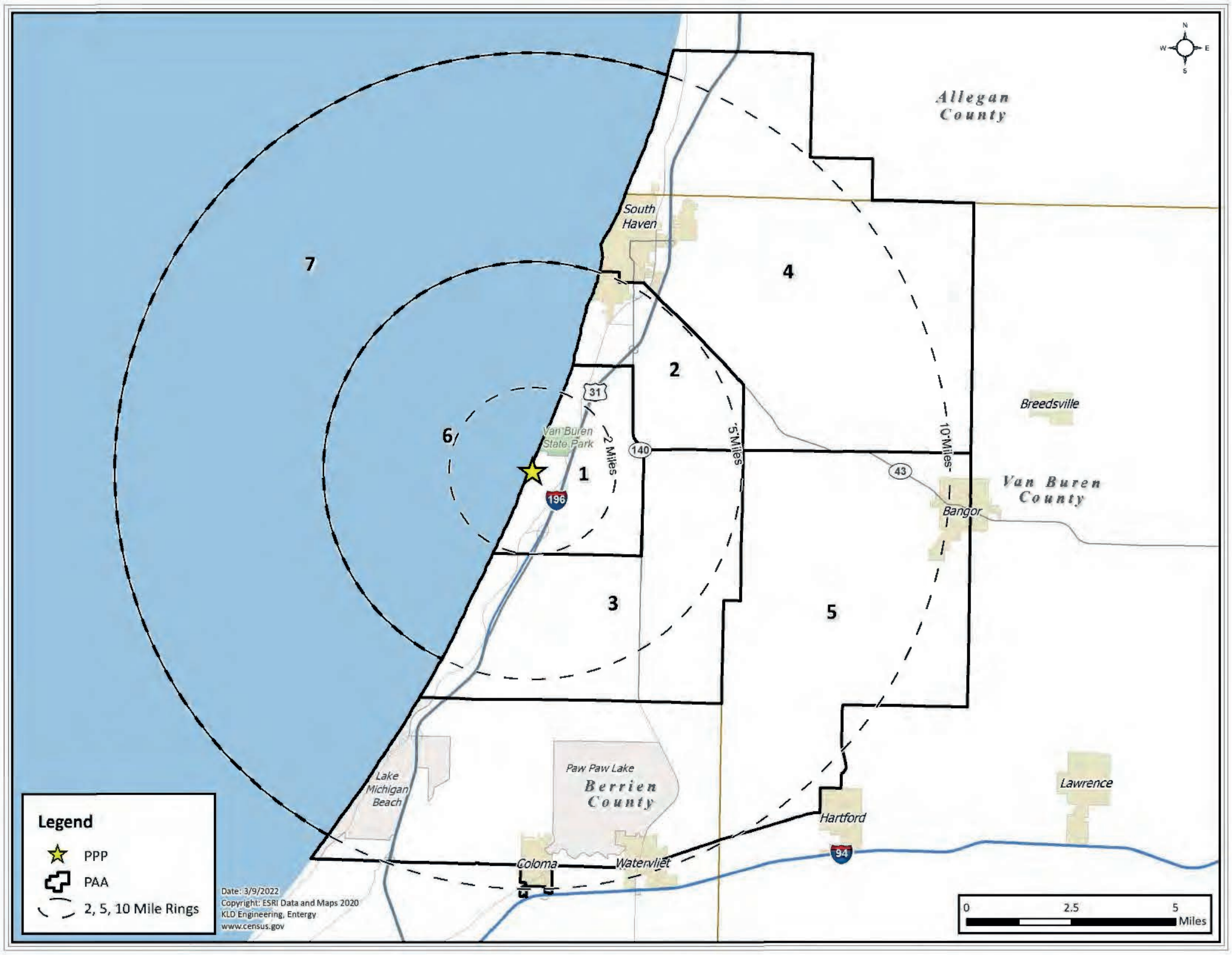
Palisades Nuclear Plant 2022 Evacuation Time Estimate Report

(366 Pages)

KLD ENGINEERING, P.C.

Palisades Power Plant

Development of Evacuation Time Estimates



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September 1, 2022 **Final Report, Rev. 0** **KLD TR – 1254**

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EXECUTIVE SUMMARY

This report describes the analyses undertaken and the results obtained by a study to develop Evacuation Time Estimates (ETE) for the Palisades Power Plant (PPP) located in Van Buren County, Michigan. ETE are part of the required planning basis and provide Entergy/Holtec and state and local governments with site-specific information needed for Protective Action decision-making.

In the performance of this effort, guidance is provided by documents published by Federal Governmental agencies. Most important of these are:

- Title 10, Code of Federal Regulations, Appendix E to Part 50 (10CFR50), Emergency Planning and Preparedness for Production and Utilization Facilities, NRC, 2011.
- Revision 1 of the Criteria for Development of Evacuation Time Estimate Studies, NUREG/CR-7002, February 2021.
- FEMA, "Radiological Emergency Preparedness Program Manual" (FEMA P-1028), December 2019.

<u>Project Activities</u>

This project began in February 2021 and extended over a period of about 17 months. The major activities performed are briefly described in chronological sequence:

- Attended "kick-off" meetings with Entergy/Holtec personnel and emergency management personnel representing state and county governments.
- Accessed the 2020 U.S. Census Bureau data files.
- Estimated the number of employees who reside outside the Emergency Planning Zone (EPZ) and commute to work within the EPZ based upon data provided by the counties. The plant employee data was provided by Entergy/Holtec.
- Studied Geographic Information Systems (GIS) maps of the area in the vicinity of the plant, then conducted a detailed field survey of the highway network to observe any roadway changes relative to the previous ETE study done in 2012.
- Updated the analysis network representing the highway system topology and capacities within the EPZ, plus a Shadow Region covering the region between the EPZ boundary and approximately 15 miles radially from the plant.
- Designed and conducted an online demographic survey of residents within the EPZ to gather focused data needed for this ETE study that were not contained within the census database. The survey instrument was reviewed and modified by the licensee and offsite response organization (ORO) personnel prior to the survey.
- A data needs matrix (requesting data) was provided to Entergy/Holtec and the OROs at the kickoff meeting. Available data was provided by Allegan, Berrien, and Van Buren County emergency management officials for transient attractions, schools, and special

facilities. Internet searches were also utilized where data was missing. If updated information was not provided or available, the data gathered for the 2012 ETE study was utilized (after being reviewed and confirmed as accurate by the OROs).

- The traffic demand and trip-generation rates of evacuating vehicles were estimated from the gathered data. The trip generation rates reflect the estimated mobilization time (i.e., the time required by evacuees to prepare for the evacuation trip) computed using the results of the demographic survey.
- Following federal guidelines, the EPZ is subdivided into 7 Protective Action Areas (PAA). These PAAs are then grouped within circular areas or "keyhole" configurations (circles plus radial sectors) that define a total of 13 Evacuation Regions.
- The time-varying external circumstances are represented as Evacuation Scenarios, each described in terms of the following factors: (1) Season (Summer, Winter); (2) Day of Week (Midweek, Weekend); (3) Time of Day (Midday, Evening); and (4) Weather (Good, Rain/Light Snow, Heavy Snow). One special event scenario, South Haven's Fourth of July Celebration, was considered. One roadway impact scenario was considered wherein a single lane was closed on Interstate 196 northbound for the duration of the evacuation.
- Staged evacuation was considered for those regions wherein the 2 mile radius and sectors downwind to 5 miles were evacuated.
- As per NUREG/CR-7002, Rev. 1, the Planning Basis for the calculation of ETE is:
  - A rapidly escalating accident at the PPP that quickly assumes the status of General Emergency such that the Advisory to Evacuate (ATE) is virtually coincident with the siren alert, and no early protective actions have been implemented.
  - While an unlikely accident scenario, this planning basis will yield ETE, measured as the elapsed time from the ATE until the stated percentage of the population exits the impacted Region, that represent "upper bound" estimates. This conservative Planning Basis is applicable for all initiating events.
- If the emergency occurs while schools are in session, the ETE study assumes that the children will be evacuated by bus directly to the temporary host facilities located outside the EPZ. Parents, relatives, and neighbors are advised to not pick up their children at school prior to the arrival of the buses dispatched for that purpose. The ETE for schoolchildren are calculated separately.
- Evacuees who do not have access to a private vehicle will either ride-share with relatives, friends or neighbors, or be evacuated by buses provided as specified in the county evacuation plans. Those in special facilities will likewise be evacuated with public transit, as needed: bus, wheelchair transport, or ambulance, as required. Separate ETE are calculated for the transit-dependent evacuees, for homebound population with access and/or functional needs, and for those evacuated from special facilities.

- A “final” meeting was held with Entergy/Holtec personnel and emergency management personnel representing the OROs to present final results from the study.

Computation of ETE

A total of 182 ETE were computed for the evacuation of the general public. Each ETE quantifies the aggregate evacuation time estimated for the population within one of the 13 Evacuation Regions to evacuate from that Region, under the circumstances defined for one of the 14 Evacuation Scenarios (13 x 14 = 182). Separate ETE are calculated for transit-dependent evacuees, including schoolchildren for applicable scenarios.

Except for Region R03, which is the evacuation of the entire EPZ, only a portion of the people within the EPZ would be advised to evacuate. That is, the ATE applies only to those people occupying the specified impacted region. It is assumed that 100% of the people within the impacted region will evacuate in response to this ATE. The people occupying the remainder of the EPZ outside the impacted region may be advised to take shelter.

The computation of ETE assumes that 20% of the population within the EPZ but outside the impacted region, will elect to “voluntarily” evacuate. In addition, 20% of the population in the Shadow Region will also elect to evacuate. These voluntary evacuees could impede those who are evacuating from within the impacted region. The impedance that could be caused by voluntary evacuees is considered in the computation of ETE for the impacted region.

Staged evacuation is considered wherein those people within the 2-mile region evacuate immediately, while those beyond 2 miles, but within the EPZ, shelter-in-place. Once 90% of the 2-mile region is evacuated, those people beyond 2 miles begin to evacuate. As per federal guidance, 20% of people beyond 2 miles will evacuate (non-compliance) even though they are advised to shelter-in-place.

The computational procedure is outlined as follows:

- A link-node representation of the highway network is coded. Each link represents a unidirectional length of highway; each node usually represents an intersection or merge point. The capacity of each link is estimated based on the field survey observations and on established traffic engineering procedures.
- The evacuation trips are generated at locations called “zonal centroids” located within the EPZ and Shadow Region. The trip generation rates vary over time reflecting the mobilization process, and from one location (centroid) to another depending on population density and on whether a centroid is within, or outside, the impacted area.
- The evacuation model computes the routing patterns for evacuating vehicles that are compliant with federal guidelines (outbound relative to the location of the plant), then simulate the traffic flow movements over space and time. This simulation process estimates the rate that traffic flow exits the impacted region.

The ETE statistics provide the elapsed times for 90% and 100%, respectively, of the population within the impacted region, to evacuate from within the impacted region. These statistics are presented in tabular and graphical formats. The 90th percentile ETE have been identified as the values that should be considered when making protective action decisions because the 100th

percentile ETE are prolonged by those relatively few people who take longer to mobilize. This is referred to as the "evacuation tail" in Section 4.0 of NUREG/CR-7002, Rev. 1.

Traffic Management

This study reviewed, modeled and analyzed the existing comprehensive Traffic Management Plans (TMP) provided by Allegan, Berrien, and Van Buren Counties. Due to the limited traffic congestion within the EPZ, no additional Traffic Control Points (TCPs) or Access Control Points (ACPs) have been identified as a result of this study. Refer to Section 9 and Appendix G for additional information.

Selected Results

A compilation of selected information is presented on the following pages in the form of figures and tables extracted from the body of the report; these are described below.

- Table 3-1 presents the estimates of permanent resident population in each PAA based on the 2020 Census data.
- Table 6-1 defines each of the 13 Evacuation Regions in terms of their respective groups of PAA.
- Table 6-2 lists the Evacuation Scenarios.
- Tables 7-1 and 7-2 are compilations of ETE. These data are the times needed to clear the indicated regions of 90% and 100% of the population occupying these regions, respectively. These computed ETE include consideration of mobilization time and of estimated voluntary evacuations from other regions within the EPZ and from the Shadow Region.
- Tables 7-3 and 7-4 presents ETE for the 2-mile region when evacuating additional PAAs downwind to 5 miles for un-staged and staged evacuations for the 90th and 100th percentiles, respectively.
- Table 8-2 presents ETE for the schoolchildren in good weather.
- Table 8-5 presents ETE for transit-dependent population in good weather.
- Table 8-8 presents ETE for the medical facilities in good weather.
- Figure 6-1 displays a map of the PPP EPZ showing the layout of the 7 PAAs that comprise, in aggregate, the EPZ.
- Figure H-5 presents an example of an Evacuation Region (Region R05) to be evacuated under the circumstances defined in Table 6-1. Maps of all regions are provided in Appendix H.

Conclusions

- General population ETE were computed for 182 unique cases – a combination of 13 unique Evacuation Regions and 14 unique Evacuation Scenarios. Table 7-1 and Table 7-2 document these ETE for the 90th and 100th percentiles. These ETE range from 2:05 (hr:min) to 3:30 at the 90th percentile and 4:45 to 6:10 at the 100th percentile.
- Inspection of Table 7-1 and Table 7-2 indicates that the ETE for the 100th percentile are significantly longer than those for the 90th percentile. This is the result of the relatively long mobilization time of a small proportion of the resident population and some isolated traffic congestion within the EPZ. When the system becomes congested, traffic exits the EPZ at rates somewhat below capacity until some evacuation routes have cleared. As more routes clear, the aggregate rate of egress slows since many vehicles have already left the EPZ. Towards the end of the process, relatively few evacuees (those with the longest mobilization times) travel freely out of the EPZ. See Figures 7-7 through 7-20. Federal guidance recommends using the 90th percentile ETE in formulating protective action decisions.
- Inspection of Table 7-3 and Table 7-4 indicates that a staged evacuation provides no benefits to evacuees from within the 2 mile region and adversely impacts evacuees located beyond 2 miles from the plant (compare Regions R02, R04 and R05 with Regions R11, R12 and R13, respectively, in Tables 7-1 and 7-2). See Section 7.6 for additional discussion.
- Comparison of Scenarios 5 (summer, weekend, evening, good weather) and 13 (summer, weekend, evening, 4th of July Celebration) in Table 7-1 indicates that the special event significantly impacts (increases of up to 1 hour and 10 minutes) the 90th percentile ETE for Evacuation Regions wherein PAA 4 evacuates, but does not affect the 100th percentile ETE (Table 7-2). See Section 7.5 for additional discussion.
- Comparison of Scenarios 1 and 14 in Table 7-1 indicates that the roadway closure – one lane northbound on I-196 from the interchange with County Road 378 (Exit 13) to the interchange with County Road 89 (Exit 32) – does not have a material impact on the ETE. See Section 7.5 for additional discussion.
- South Haven and Watervliet are the two most congested areas in the EPZ during an evacuation. Watervliet is the last location in the EPZ to be clear of traffic congestion. All congestion within the EPZ clears by 2 hours and 35 minutes after the ATE. See Section 7.3 and Figures 7-3 through 7-6.
- Separate ETE were computed for schools, medical facilities, transit-dependent persons and access and/or functional needs persons. The average single-wave ETE for schools and medical facilities are less than the general population ETE at the 90th percentile. The average single-wave ETE for transit-dependent persons and access and/or functional needs persons exceed the 90th percentile ET for the general population. See Section 8.
- Table 8-1 indicates that there are enough transportation resources to evacuate the schools, medical facilities, transit-dependent population, and access and/or functional needs population within the EPZ in a single wave. Nonetheless, second-wave ETE were

computed for these populations in the event there is a shortfall of transportation resources or drivers. See Section 8.

- The general population ETE at the 90th percentile is sensitive to reductions in the base trip generation time of 4 hours and 45 minutes. See Table M-1.
- The general population ETE is insensitive to the voluntary evacuation of vehicles in the Shadow Region. When the shadow percent is increased to 100%, the ETE only increases by 5 minutes. See Table M-2.
- An increase in permanent resident population (EPZ plus Shadow Region) of 107% or greater results in an increase in the longest 90th percentile ETE of 30 minutes, which meets the federal criterion for performing a fully updated ETE study between decennial censuses. See Section M.3.
- A decrease in the average household size from 2.77 people per household to 2.41 people per household results in approximately 15% more evacuating vehicles and increases the 90th percentile ETE by up to 25 minutes; 100th percentile ETE are not impacted. See Section M.4.

Table 3-1. EPZ Permanent Resident Population

PAA	2010 Population	2020 Population
1	1,548	1,463
2	2,205	2,019
3	2,221	1,841
4	10,356	10,040
5	14,675	14,231
6	0	0
7	0	0
EPZ TOTAL:	**31,005**	**29,594**
EPZ Population Growth (2010-2020):		**-4.55%**

Table 6-1. Description of Evacuation Regions

Radial Regions								
Region	**Description**	**PAA**						
		1	**2**	**3**	**4**	**5**	**6**	**7**
R01	2-Mile Region	X					X	
R02	5-Mile Region	X	X	X			X	
R03	Full EPZ	X	X	X	X	X	X	X
Evacuate 2-Mile Region and Downwind to 5-Miles								
Region	**Wind Direction From (Degrees)**	**PAA**						
		1	**2**	**3**	**4**	**5**	**6**	**7**
N/A	≥56 and <169	**Refer to R01**						
R04	≥169 and <236	X	X				X	
N/A	≥236 and <303	**Refer to R02**						
R05	≥303 and <56	X		X			X	
Evacuate 2-Mile Region and Downwind to the EPZ Boundary								
Region	**Wind Direction From (Degrees)**	**PAA**						
		1	**2**	**3**	**4**	**5**	**6**	**7**
R06	≥56 and <169	X					X	X
R07	≥169 and <236	X	X		X		X	X
R08	≥236 and <303	X	X	X	X	X	X	
R09	≥303 and <348	X		X		X	X	
R10	≥348 and <56	X		X		X	X	X
Staged Evacuation - 2-Mile Region Evacuates, then Evacuate Downwind to 5-Miles								
Region	**Wind Direction From (Degrees)**	**PAA**						
		1	**2**	**3**	**4**	**5**	**6**	**7**
R11	5-Mile Region	X	X	X			X	
N/A	≥56 and <169	**Refer to R01**						
R12	≥169 and <236	X	X				X	
N/A	≥236 and <303	**Refer to R11**						
R13	≥303 and <56	X		X			X	
PAA(s) Evacuate		PAA(s) Shelter-in-Place			PAA(s) Shelter-in-Place until 90% ETE for R01, then Evacuate			

Table 6-2. Evacuation Scenario Definitions

Scenario	Season[1]	Day of Week	Time of Day	Weather	Special
1	Summer	Midweek	Midday	Good	None
2	Summer	Midweek	Midday	Rain	None
3	Summer	Weekend	Midday	Good	None
4	Summer	Weekend	Midday	Rain	None
5	Summer	Midweek, Weekend	Evening	Good	None
6	Winter	Midweek	Midday	Good	None
7	Winter	Midweek	Midday	Light Rain/Snow	None
8	Winter	Midweek	Midday	Heavy Snow	None
9	Winter	Weekend	Midday	Good	None
10	Winter	Weekend	Midday	Light Rain/Snow	None
11	Winter	Weekend	Midday	Heavy Snow	None
12	Winter	Midweek, Weekend	Evening	Good	None
13	Summer	Weekend	Evening	Good	South Haven Fourth of July Celebration
14	Summer	Midweek	Midday	Good	Roadway Impact – Lane Closure on I-196 Northbound

[1] Winter means that school is in session at normal enrollment levels (also applies to spring and autumn). Summer means that school is in session at summer school enrollment levels (lower than normal enrollment).

Table 7-1. Time to Clear the Indicated Area of *90* Percent of the Affected Population

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Special Event	Roadway Impact
Radial Regions – 2-Mile, 5-Mile, Full EPZ														
R01	2:05	2:10	2:05	2:05	2:10	2:05	2:10	2:20	2:05	2:05	2:15	2:05	2:10	2:05
R02	2:20	2:20	2:10	2:15	2:15	2:20	2:20	3:05	2:10	2:15	2:50	2:15	2:15	2:20
R03	2:40	2:40	2:20	2:25	2:25	2:45	2:45	3:30	2:25	2:25	3:15	2:25	3:15	2:45
Evacuate 2-Mile Radius and Downwind to 5-Mile Radius														
R04	2:15	2:15	2:10	2:10	2:15	2:15	2:15	2:55	2:10	2:10	2:40	2:15	2:15	2:15
R05	2:15	2:15	2:10	2:10	2:15	2:15	2:15	2:45	2:10	2:10	2:30	2:10	2:15	2:15
Evacuate 2-Mile Radius and Downwind to the EPZ Boundary														
R06	2:05	2:10	2:05	2:05	2:10	2:05	2:10	2:20	2:05	2:05	2:15	2:05	2:10	2:05
R07	2:35	2:35	2:15	2:15	2:20	2:35	2:35	3:25	2:15	2:15	3:05	2:20	3:30	2:40
R08	2:40	2:40	2:20	2:25	2:25	2:45	2:45	3:30	2:25	2:25	3:15	2:25	3:15	2:45
R09	2:35	2:35	2:20	2:25	2:25	2:40	2:40	3:30	2:20	2:25	3:10	2:25	2:25	2:35
R10	2:35	2:35	2:20	2:25	2:25	2:40	2:40	3:30	2:20	2:25	3:10	2:25	2:25	2:35
Staged Evacuation - 2-Mile Radius Evacuates, then Evacuate Downwind to 5-Mile Radius														
R11	2:35	2:35	2:30	2:30	2:35	2:35	2:35	3:05	2:30	2:30	2:50	2:35	2:35	2:35
R12	2:30	2:30	2:30	2:30	2:35	2:30	2:30	2:55	2:30	2:30	2:40	2:35	2:35	2:30
R13	2:25	2:25	2:20	2:20	2:25	2:25	2:25	2:45	2:20	2:20	2:35	2:25	2:25	2:25

Table 7-2. Time to Clear the Indicated Area of _100_ Percent of the Affected Population

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Special Event	Roadway Impact
Radial Regions – 2-Mile, 5-Mile, Full EPZ														
R01	4:45	4:45	4:45	4:45	4:45	4:45	4:45	6:00	4:45	4:45	6:00	4:45	4:45	4:45
R02	4:50	4:50	4:50	4:50	4:50	4:50	4:50	6:05	4:50	4:50	6:05	4:50	4:50	4:50
R03	4:55	4:55	4:55	4:55	4:55	4:55	4:55	6:10	4:55	4:55	6:10	4:55	5:00	4:55
Evacuate 2-Mile Radius and Downwind to 5-Mile Radius														
R04	4:50	4:50	4:50	4:50	4:50	4:50	4:50	6:05	4:50	4:50	6:05	4:50	4:50	4:50
R05	4:50	4:50	4:50	4:50	4:50	4:50	4:50	6:05	4:50	4:50	6:05	4:50	4:50	4:50
Evacuate 2-Mile Radius and Downwind to the EPZ Boundary														
R06	4:45	4:45	4:45	4:45	4:45	4:45	4:45	6:10	4:45	4:45	6:10	4:45	4:45	4:45
R07	4:55	4:55	4:55	4:55	4:55	4:55	4:55	6:10	4:55	4:55	6:10	4:55	5:00	4:55
R08	4:55	4:55	4:55	4:55	4:55	4:55	4:55	6:10	4:55	4:55	6:10	4:55	5:00	4:55
R09	4:55	4:55	4:55	4:55	4:55	4:55	4:55	6:10	4:55	4:55	6:10	4:55	4:55	4:55
R10	4:55	4:55	4:55	4:55	4:55	4:55	4:55	6:10	4:55	4:55	6:10	4:55	4:55	4:55
Staged Evacuation - 2-Mile Radius Evacuates, then Evacuate Downwind to 5-Mile Radius														
R11	4:50	4:50	4:50	4:50	4:50	4:50	4:50	6:05	4:50	4:50	6:05	4:50	4:50	4:50
R12	4:50	4:50	4:50	4:50	4:50	4:50	4:50	6:05	4:50	4:50	6:05	4:50	4:50	4:50
R13	4:50	4:50	4:50	4:50	4:50	4:50	4:50	6:05	4:50	4:50	6:05	4:50	4:50	4:50

Table 7-3. Time to Clear ***90 Percent*** of the **2-Mile Region** within the Indicated Region

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Special Event	Roadway Impact
Unstaged Evacuation - 2-Mile Region and 5-Mile Region														
R01	2:05	2:10	2:05	2:05	2:10	2:05	2:10	2:20	2:05	2:05	2:15	2:05	2:10	2:05
R02	2:05	2:10	2:05	2:05	2:10	2:05	2:10	2:20	2:05	2:05	2:15	2:05	2:10	2:05
Unstaged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R04	2:05	2:10	2:05	2:05	2:10	2:05	2:10	2:20	2:05	2:05	2:15	2:05	2:10	2:05
R05	2:05	2:10	2:05	2:05	2:10	2:05	2:10	2:20	2:05	2:05	2:15	2:05	2:10	2:05
Staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R11	2:05	2:10	2:05	2:05	2:10	2:05	2:10	2:20	2:05	2:05	2:15	2:05	2:10	2:05
R12	2:05	2:10	2:05	2:05	2:10	2:05	2:10	2:20	2:05	2:05	2:15	2:05	2:10	2:05
R13	2:05	2:10	2:05	2:05	2:10	2:05	2:10	2:20	2:05	2:05	2:15	2:05	2:10	2:05

Table 7-4. Time to Clear *100 Percent* of the *2-Mile Region* within the Indicated Region

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Special Event	Roadway Impact
Unstaged Evacuation - 2-Mile Region and 5-Mile Region														
R01	4:45	4:45	4:45	4:45	4:45	4:45	4:45	6:00	4:45	4:45	6:00	4:45	4:45	4:45
R02	4:45	4:45	4:45	4:45	4:45	4:45	4:45	6:00	4:45	4:45	6:00	4:45	4:45	4:45
Unstaged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R04	4:45	4:45	4:45	4:45	4:45	4:45	4:45	6:00	4:45	4:45	6:00	4:45	4:45	4:45
R05	4:45	4:45	4:45	4:45	4:45	4:45	4:45	6:00	4:45	4:45	6:00	4:45	4:45	4:45
Staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R11	4:45	4:45	4:45	4:45	4:45	4:45	4:45	6:00	4:45	4:45	6:00	4:45	4:45	4:45
R12	4:45	4:45	4:45	4:45	4:45	4:45	4:45	6:00	4:45	4:45	6:00	4:45	4:45	4:45
R13	4:45	4:45	4:45	4:45	4:45	4:45	4:45	6:00	4:45	4:45	6:00	4:45	4:45	4:45

Table 8-2. School Evacuation Time Estimates – Good Weather

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to THF (mi.)	Travel Time from EPZ Bdry to THF (min)	ETA to THF (hr:min)
ALLEGAN COUNTY, MI									
Baseline Middle School	90	15	4.5	55.0	5	**1:50**	14.7	17	**2:10**
North Shore Elementary School	90	15	3.9	55.0	5	**1:50**	14.7	17	**2:10**
BERRIEN COUNTY, MI									
Salem Lutheran Preschool	90	15	1.4	21.9	4	**1:50**	15.1	17	**2:10**
Watervliet North Elementary School	90	15	1.0	9.3	7	**1:55**	0.4	1	**2:00**
Coloma Elementary School	90	15	0.9	25.3	3	**1:50**	15.1	17	**2:10**
Coloma Intermediate School	90	15	0.9	25.3	3	**1:50**	15.1	17	**2:10**
Coloma High School	90	15	0.9	25.3	3	**1:50**	15.1	17	**2:10**
Coloma Junior High School	90	15	0.9	25.3	3	**1:50**	15.1	17	**2:10**
VAN BUREN COUNTY, MI									
Maple Grove Elementary School	90	15	7.5	55.0	9	**1:55**	14.7	17	**2:15**
Head Start - South Haven	90	15	7.0	50.1	9	**1:55**	14.7	17	**2:15**
Covert Middle School	90	15	10.1	30.6	20	**2:05**	0.6	1	**2:10**
Covert High School	90	15	10.1	30.6	20	**2:05**	0.6	1	**2:10**
Covert Elementary School	90	15	10.1	30.6	20	**2:05**	0.6	1	**2:10**
Head Start - Migrant at Lincoln Elementary	90	15	7.0	44.8	10	**1:55**	14.7	17	**2:15**
Lincoln Elementary School	90	15	7.0	44.8	10	**1:55**	14.7	17	**2:15**
L.C. Mohr High School	90	15	7.0	44.8	10	**1:55**	14.7	17	**2:15**
St. Paul Lutheran School	90	15	6.9	52.9	8	**1:55**	14.7	17	**2:15**
St. Basil Catholic School	90	15	6.9	46.1	9	**1:55**	14.7	17	**2:15**
WAY- South Haven Schools (LMC Campus)	90	15	5.7	55.0	7	**1:55**	14.7	17	**2:15**
Lake Michigan College - South Haven Campus	90	15	5.7	55.0	7	**1:55**	14.7	17	**2:15**

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to THF (mi.)	Travel Time from EPZ Bdry to THF (min)	ETA to THF (hr:min)
Wood School	90	15	4.0	41.2	6	**1:55**	14.2	16	**2:15**
Bangor High School	90	15	0.4	19.5	2	**1:50**	14.2	16	**2:10**
Bangor Middle School	90	15	0.4	19.5	2	**1:50**	14.2	16	**2:10**
Head Start - Bangor	90	15	0.4	19.5	2	**1:50**	14.2	16	**2:10**
Bangor Alternative High School	90	15	0.4	19.5	2	**1:50**	14.2	16	**2:10**
South Walnut Elementary School	90	15	0.4	19.5	2	**1:50**	14.2	16	**2:10**
Maximum for EPZ:						**2:05**	**Maximum:**		**2:15**
Average for EPZ:						**1:55**	**Average:**		**2:15**

Table 8-5. Transit-Dependent Evacuation Time Estimates – Good Weather

Route Number	Number of Buses	One-Wave						Two-Wave						
		Mobilization (min)	Route Length (miles)	Route Speed (mph)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)	Distance to Rec. Ctr. (miles)	Travel Time to Rec. Ctr. (min)	Unload (min)	Driver Rest (min)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)
1	1	150	9.8	55.0	11	30	**3:15**	8.3	9	5	10	30	30	**4:40**
2	1	150	9.0	55.0	10	30	**3:10**	14.7	16	5	10	36	30	**4:50**
3	1	150	8.6	51.0	10	30	**3:15**	0.4	0	5	10	20	30	**4:20**
4	2	150	5.8	48.3	7	30	**3:10**	14.7	16	5	10	29	30	**4:40**
	2	170	5.8	48.5	7	30	**3:30**	14.7	16	5	10	29	30	**5:00**
5	2	150	6.2	46.8	8	30	**3:10**	14.2	15	5	10	30	30	**4:40**
	1	170	6.2	47.2	8	30	**3:30**	14.2	15	5	10	30	30	**5:00**
6	2	150	7.8	55.0	9	30	**3:10**	14.4	16	5	10	33	30	**4:45**
	1	170	7.8	55.0	9	30	**3:30**	14.4	16	5	10	33	30	**5:05**
						Maximum ETE:	**3:30**						**Maximum ETE:**	**5:05**
						Average ETE:	**3:20**						**Average ETE:**	**4:50**

Table 8-8. Medical Facility Evacuation Time Estimates – Good Weather

Medical Facility	Patient	Mobilization (min)	Loading Rate (min per person)	People	Total Loading Time (min)	Dist. To EPZ Bdry (mi)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
Country Side Nursing Home	Ambulatory	90	1	43	30	4.9	6	**2:10**
	Wheelchair bound	90	5	46	75	4.9	6	**2:55**
	Bedridden	90	15	4	30	4.9	6	**2:10**
Forest Beach AFC Home Inc	Ambulatory	90	1	16	16	1.4	10	**2:00**
Juniper Home	Ambulatory	90	1	2	2	1.3	8	**1:40**
	Wheelchair bound	90	5	4	20	1.3	8	**2:00**
Bronson South Haven Hospital	Ambulatory	90	1	3	3	6.8	7	**1:40**
	Wheelchair bound	90	5	2	10	6.8	7	**1:50**
	Bedridden	90	15	1	15	6.8	8	**1:55**
South Haven Nursing & Rehabilitation Community	Ambulatory	90	1	10	10	6.8	7	**1:50**
	Wheelchair bound	90	5	51	75	6.8	7	**2:55**
Turner Tender Care	Ambulatory	90	1	3	3	8.9	10	**1:45**
	Wheelchair bound	90	5	3	15	8.9	10	**1:55**
River Ridge Retirement Village	Ambulatory	90	1	26	26	4.8	5	**2:05**
	Wheelchair bound	90	5	13	65	4.8	5	**2:40**
	Bedridden	90	15	3	30	4.8	5	**2:05**
							Maximum ETE:	**2:55**
							Average ETE:	**2:05**

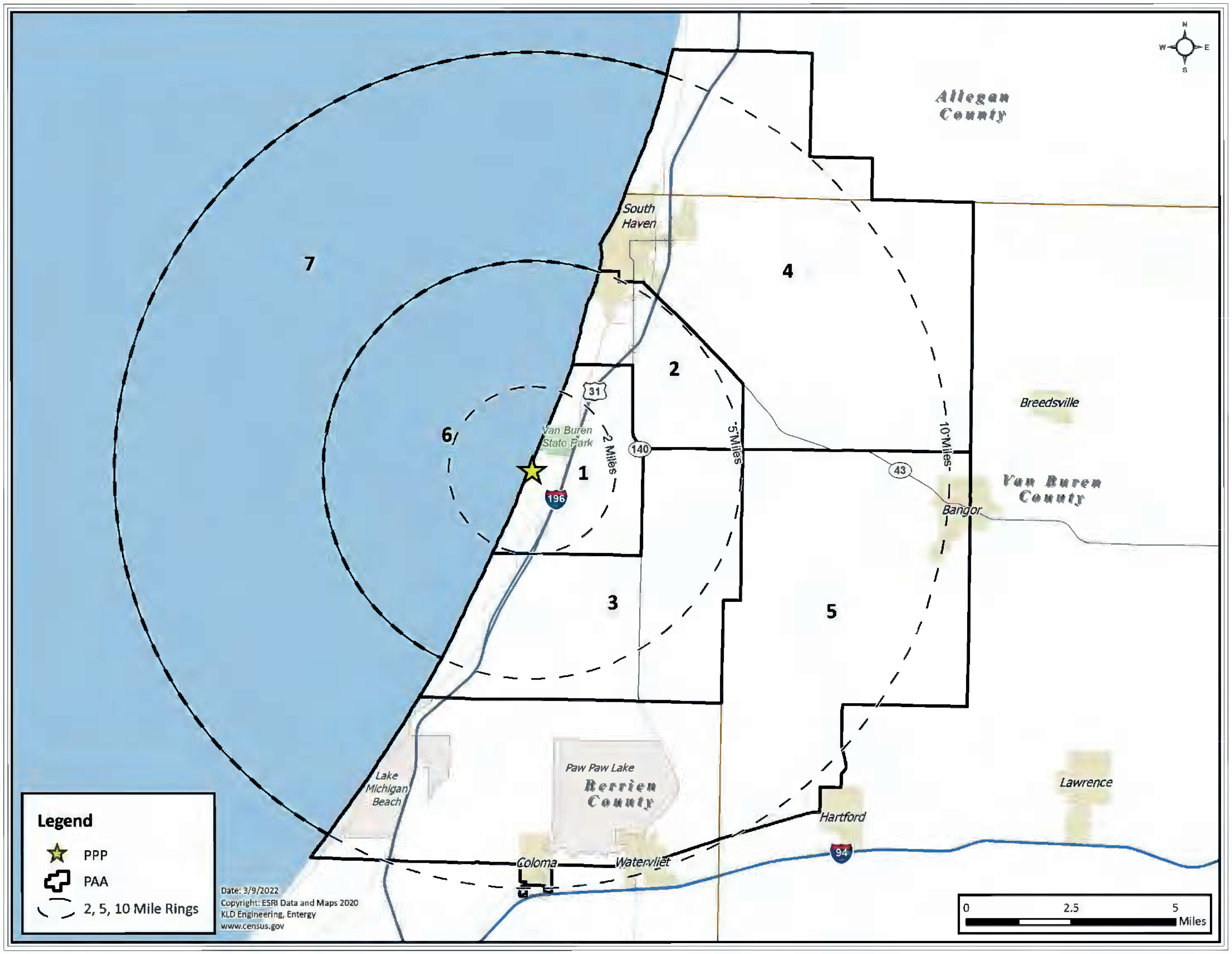


Figure 6-1. PAAs Comprising the PPP EPZ

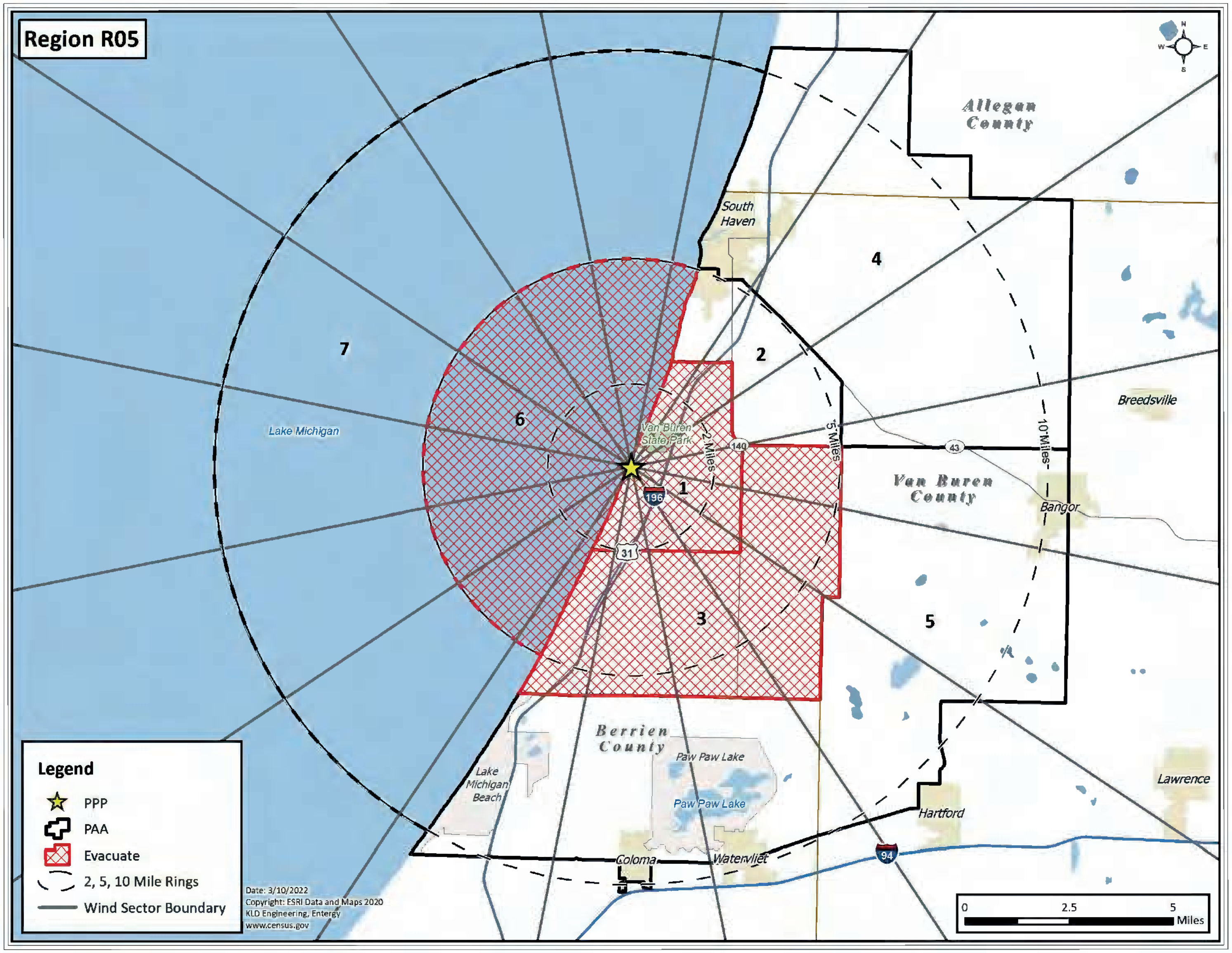


Figure H-5. Region R05

1 INTRODUCTION

This report describes the analyses undertaken and the results obtained by a study to develop Evacuation Time Estimates (ETE) for the Palisades Power Plant (PPP), located in Van Buren County, Michigan. ETE provide state and local governments with site-specific information needed for Protective Action decision-making.

In the performance of this effort, guidance is provided by documents published by Federal Government agencies. Most important of these are:

- Title 10, Code of Federal Regulations, Appendix E to Part 50 (10CFR50), Emergency Planning and Preparedness for Production and Utilization Facilities, NRC, 2011.
- Revision 1 of the Criteria for Development of Evacuation Time Estimate Studies, NUREG/CR-7002, February 2021.
- FEMA, "Radiological Emergency Preparedness Program Manual" (FEMA P-1028), December 2019.

The work effort reported herein was supported and guided by local stakeholders who contributed suggestions, critiques, and the local knowledge base required. Table 1-1 presents a summary of stakeholders and interactions.

1.1 Overview of the ETE Process

The following outline presents a brief description of the work effort in chronological sequence:

1. Information Gathering:
   a. Defined the scope of work in discussions with representatives from Entergy/Holtec.
   b. Attended meetings with emergency planners from the State of Michigan and Allegan, Berrien and Van Buren County Emergency Management Offices to identify issues to be addressed and resources available.
   c. Conducted a detailed field survey of the highway system and of area traffic conditions within the Emergency Planning Zone (EPZ) and Shadow Region.
   d. Obtained demographic data from the 2020 Census (See Section 3.1).
   e. Conducted an online demographic survey of EPZ residents.
   f. Conducted a data collection effort to identify and describe schools, special facilities, major employers, tourist attractions, transportation providers, and other important information.
2. Estimated distributions of Trip Generation times representing the time required by various population groups (permanent residents, employees, and transients) to prepare (mobilize) for the evacuation trip. These estimates are primarily based upon the online demographic survey.

3. Defined Evacuation Scenarios. These scenarios reflect the variation in demand, in trip generation distribution and in highway capacities, associated with different seasons, day of week, time of day and weather conditions.

4. Reviewed the existing Traffic Management Plan (TMP) to be implemented by local and state police in the event of an incident at the plant. Traffic and access control is applied at specified Traffic Control Points (TCP) and Access Control Points (ACP) located within the EPZ.

5. Used existing Protective Action Areas (PAA) to define Evacuation Regions. The EPZ is partitioned into 7 PAA along political and geographic boundaries. "Regions" are groups of contiguous PAA for which ETE are calculated. The configurations of these Regions reflect wind direction and the radial extent of the impacted area. Each Region, other than those that approximate circular areas, approximates a "key-hole section" within the EPZ as recommended by NUREG/CR-7002, Rev. 1.

6. Estimated demand for transit services for persons at "Special Facilities" (schools, medical facilities, etc.) and for transit-dependent persons at home.

7. Prepared the input streams for the DYNEV II system, which computes ETE (see Appendices B and C).
   a. Estimated the evacuation traffic demand, based on the available information derived from Census data, and from data provided by local and state agencies, Entergy/Holtec and from the demographic survey.
   b. Updated the link-node representation of the evacuation network, using observations from the field survey and aerial imagery, which is used as the basis for the computer analysis that calculates the ETE.
   c. Applied the procedures specified in the 2016 Highway Capacity Manual (HCM[1]) to the data acquired during the field survey, to estimate the capacity of all highway segments comprising the evacuation routes.
   d. Calculated the evacuating traffic demand for each Region and for each Scenario.
   e. Specified selected candidate destinations for each "origin" (location of each "source" where evacuation trips are generated over the mobilization time) to support evacuation travel consistent with outbound movement relative to the location of the plant.

8. Executed the DYNEV II models to provide the estimates of evacuation routing and ETE for all residents, transients and employees ("general population") with access to private vehicles. Generated a complete set of ETE for all specified Regions and Scenarios.

9. Documented ETE in formats in accordance with NUREG/CR-7002, Rev. 1.

10. Calculated the ETE for all transit activities including those for special facilities, for the transit-dependent population and for homebound population with access and/or functional needs.

[1] Highway Capacity Manual (HCM 2016), Transportation Research Board, National Research Council, 2016.

1.2 The Palisades Power Plant Location

The PPP is located on the shores of Lake Michigan in Van Buren County, Michigan. The site is approximately 55 miles southwest of Grand Rapids, Michigan and 75 miles northeast of Chicago, Illinois. The EPZ consists of parts of Allegan, Berrien and Van Buren Counties. Figure 1-1 displays the area surrounding the PPP, identifying the communities in the area and the major roads.

1.3 Preliminary Activities

These activities are described below.

Field Surveys of the Highway Network

In March 2021, KLD personnel drove the entire highway system within the EPZ and the Shadow Region which consists of the area between the EPZ boundary and approximately 15 miles radially from the plant. The characteristics of each section of highway were recorded. These characteristics are listed in Table 1-2.

Video and audio recording equipment were used to capture a permanent record of the highway infrastructure. No attempt was made to meticulously measure such attributes as lane width and shoulder width; estimates of these measures based on visual observation and recorded images were considered appropriate for the purpose of estimating the capacity of highway sections. For example, Exhibit 15-7 in the HCM 2016 indicates that a reduction in lane width from 12 feet (the "base" value) to 10 feet can reduce free flow speed (FFS) by 1.1 mph – not a material difference – for two-lane highways. Exhibit 15-46 in the HCM 2016 shows little sensitivity for the estimates of Service Volumes at Level of Service (LOS) E (near capacity), with respect to FFS, for two-lane highways.

The data from the audio and video recordings were used to create detailed Geographic Information Systems (GIS) shapefiles and databases of the roadway characteristics and of the traffic control devices observed during the road survey; this information was referenced while preparing the input stream for the DYNEV II System.

As documented on page 15-6 of the HCM 2016, the capacity of a two-lane highway is 1,700 passenger cars per hour in one direction. For freeway sections, a value of 2,250 vehicles per hour per lane is assigned, as per Exhibit 12-37 of the HCM 2016. The road survey has identified several segments which are characterized by adverse geometrics on two-lane highways which are reflected in reduced values for both capacity and speed. These estimates are consistent with the service volumes for LOS E presented in HCM Exhibit 15-46. Link capacity is an input to DYNEV II which computes the ETE. Further discussion of roadway capacity is provided in Section 4 of this report.

Traffic signals are either pre-timed (signal timings are fixed over time and do not change with the traffic volume on competing approaches) or are actuated (signal timings vary over time based on the changing traffic volumes on competing approaches). Actuated signals require detectors to provide the traffic data used by the signal controller to adjust the signal timings.

These detectors are typically magnetic loops in the roadway, or video cameras mounted on the signal masts and pointed toward the intersection approaches. If detectors were observed on the approaches to a signalized intersection during the road survey, detailed signal timings were not collected as the timings vary with traffic volume. TCPs at locations which have control devices are represented as actuated signals in the DYNEV II system.

If no detectors were observed, the signal control at the intersection was considered pre-timed, and detailed signal timings were gathered for several signal cycles. These signal timings were input to the DYNEV II system used to compute ETE, as per NUREG/CR-7002, Rev. 1 guidance.

Figure 1-2 presents the link-node analysis network that was constructed to model the evacuation roadway network in the EPZ and Shadow Region. The directional arrows on the links and the node numbers have been removed from Figure 1-2 to clarify the figure. The detailed figures provided in Appendix K depict the analysis network with directional arrows shown and node numbers provided. The observations made during the field survey were used to calibrate the analysis network.

Demographic Survey

A demographic survey was undertaken to gather information needed for the evacuation study. Appendix F presents the survey instrument, the procedures used, and tabulations of data compiled from the survey responses.

These data were utilized to develop estimates of vehicle occupancy to estimate the number of evacuating vehicles during an evacuation and to estimate elements of the mobilization process. This database was also referenced to estimate the number of transit-dependent residents.

Computing the Evacuation Time Estimates

The overall study procedure is outlined in Appendix D. Demographic data were obtained from several sources, as detailed later in this report. These data were analyzed and converted into vehicle demand data. The vehicle demand was loaded onto appropriate "source" links of the analysis network using GIS mapping software. The DYNEV II system was then used to compute ETE for all Regions and Scenarios.

Analytical Tools

The DYNEV II System that was employed for this study is comprised of several integrated computer models. One of these is the DYNEV (Dynamic Network Evacuation) macroscopic simulation model, a new version of the IDYNEV model that was developed by KLD under contract with the Federal Emergency Management Agency (FEMA).

DYNEV II consists of four sub-models:

- A macroscopic traffic simulation model (for details, see Appendix C).
- A Trip Distribution (TD), model that assigns a set of candidate destination (D) nodes for each "origin" (O) located within the analysis network, where evacuation trips are "generated" over time. This establishes a set of O-D tables.
- A Dynamic Traffic Assignment (DTA), model which assigns trips to paths of travel

(routes) which satisfy the O-D tables, over time. The TD and DTA models are integrated to form the DTRAD (Dynamic Traffic Assignment and Distribution) model, as described in Appendix B.

- A Myopic Traffic Diversion model which diverts traffic to avoid intense, local congestion, if possible.

Another software product developed by KLD, named UNITES (UNIfied Transportation Engineering System) was used to expedite data entry and to automate the production of output tables.

The dynamics of traffic flow over the network are graphically animated using the software product, EVAN (Evacuation Animator), developed by KLD. EVAN is GIS based, and displays statistics such as LOS, vehicles discharged, average speed, and percent of vehicles evacuated, output by the DYNEV II System. The use of a GIS framework enables the user to zoom in on areas of congestion and query road name, town name and other geographical information.

The procedure for applying the DYNEV II System within the framework of developing ETE is outlined in Appendix D. Appendix A is a glossary of terms.

For the reader interested in an evaluation of the original model, I-DYNEV, the following references are suggested:

- NUREG/CR-4873 – Benchmark Study of the I-DYNEV Evacuation Time Estimate Computer Code
- NUREG/CR-4874 – The Sensitivity of Evacuation Time Estimates to Changes in Input Parameters for the I-DYNEV Computer Code

The evacuation analysis procedures are based upon the need to:

- Route traffic along paths of travel that will expedite their travel from their respective points of origin to points outside the EPZ.
- Restrict movement toward the plant to the extent practicable and disperse traffic demand so as to avoid focusing demand on a limited number of highways.
- Move traffic in directions that are generally outbound, relative to the location of the plant.

DYNEV II provides a detailed description of traffic operations on the evacuation network. This description enables the analyst to identify bottlenecks and to develop countermeasures that are designed to represent the behavioral responses of evacuees. The effects of these countermeasures may then be tested with the model.

1.4 Comparison with Prior ETE Study

Table 1-3 presents a comparison of the present ETE study with the previous ETE study (KLD TR-500, dated August 2012). The 90th percentile ETE for the entire EPZ increased by 40 minutes for a winter midweek midday scenario and by 15 minutes for a summer weekend midday scenario when compared with the 2012 study. The 100th percentile ETE increased by 15 minutes for both a winter midweek midday scenario and for a summer weekend midday scenario. The major factors contributing to the differences between the ETE values obtained in this study and those of the previous study can be summarized as follows:

- Although the permanent resident population decreased by 4.55%, the number of evacuating vehicles (approximately 16,000 vehicles) for the permanent resident population is comparable with the 2012 study. Similarly, the number of evacuating vehicles from the Shadow Region from the 2012 and current studies are nearly the same. Thus, permanent resident population change should have minimal impact on ETE.
- The transient population and number of transient vehicles increased by 12.5% and 8.6%, respectively, mostly due to more seasonal population identified in this study. This could lead to longer ETE for weekend scenarios when transient population is at its peak.
- Trip generation and mobilization characteristics have changed. The time to mobilize 100% of residents with commuters and residents without commuters takes an additional 15 minutes in this study relative to the 2012 study. This directly explains the 15 minute increase in 100th percentile ETE given that traffic congestion clears well before mobilization time (see Section 7.3) and trip generation times dictate the ETE.
- The increases in 90th percentile ETE can also be explained by changes in mobilization time:
  - It took 150 minutes to mobilize about 90% of residents with commuters returning in the 2012 study versus 180 minutes in this study, a difference of 30 minutes.
  - It took 105 minutes to mobilize 90% of residents without commuters returning in the 2012 study versus 150 minutes in this study, a difference of 45 minutes.

Table 1-1. Stakeholder Interaction

Stakeholder	Nature of Stakeholder Interaction
Entergy/Holtec emergency planning personnel	Attended kickoff meeting to define project methodology and data requirements. Set up contacts with local government agencies. Provided recent plant employee data. Reviewed and approved all project assumptions. Engaged in the ETE development and was informed of the study results and coordinated with the OROs.
State of Michigan and Allegan, Berrien and Van Buren County Emergency Management Offices	Attended kickoff meeting to discuss the project methodology, key project assumptions and to define data needs. Provided state and county emergency plans, special facility data and existing traffic management plans. Reviewed and approved all project assumptions. Engaged in the ETE development and was informed of the study results.

Table 1-2. Highway Characteristics

- Number of lanes
- Lane width
- Shoulder type & width
- Interchange geometries
- Lane channelization & queuing capacity (including turn bays/lanes)
- Geometrics: curves, grades (>4%)
- Posted speed
- Actual free speed
- Abutting land use
- Control devices
- Intersection configuration (including roundabouts where applicable)
- Traffic signal type
- Unusual characteristics: Narrow bridges, sharp curves, poor pavement, flood warning signs, inadequate delineations, toll booths, etc.

Table 1-3. ETE Study Comparisons

Topic	Previous ETE Study	Current ETE Study
Resident Population Basis	ArcGIS Software using 2010 US Census blocks; area ratio method used.	ArcGIS Software using 2020 US Census blocks; area ratio method used.
	Population = 31,005	Population = 29,594
Resident Population Vehicle Occupancy	2.40 persons/household, 1.25 evacuating vehicles/household yielding: 1.92 persons/vehicle.	2.77 persons/household, 1.50 evacuating vehicles/household yielding: 1.85 persons/vehicle.
	Resident vehicles = 16,169	Resident vehicles = 15,898
Shadow Population	ArcGIS Software using 2010 US Census blocks; area ratio method used.	ArcGIS Software using 2020 US Census blocks; area ratio method used.
	Shadow Population = 24,296 Shadow vehicles = 12,698	Shadow Population = 23,192 Shadow vehicles = 12,446
Employee Population	Employee estimates based on information provided about major employers in EPZ by the employers themselves. 1.08 employees per vehicle based on the telephone survey results.	Employee estimates based on information provided about major employers in EPZ by the employers themselves. 1.10 employees per vehicle based on the demographic survey results.
	Employees = 797 Employee vehicles = 738	Employees = 753 Employee vehicles = 684
Transient Population	Transient estimates based upon information provided about transient attractions in EPZ, supplemented by observations of the facilities during the road survey and from aerial photography. Seasonal population estimated using vacant household data from the U.S. Census Bureau.	Transient estimates based upon information provided about transient attractions in EPZ, supplemented by observations of the facilities during the road survey and from aerial photography. Seasonal population estimated using vacant household data from the U.S. Census Bureau.
	Transients = 18,965 Transient vehicles = 8,837	Transients = 21,347 Transient vehicles = 9,596

Topic	Previous ETE Study	Current ETE Study
Medical Facilities	Special facility population based on information provided by each county within the EPZ. Current census = 224 Buses Required = 7 Wheelchair Buses Required = 10 Wheelchair Vans Required = 0 Ambulances Required = 6	Medical facility population based on information provided by each county within the EPZ. Current census = 230 Buses Required = 8 Wheelchair Buses Required = 9 Wheelchair Vans Required = 3 Ambulances Required = 5
School Population	School population based on information provided by each county within the EPZ. Current enrollment = 7,219 Buses required = 105	School population based on information provided by each county within the EPZ. Current enrollment = 5,740 Buses required = 107 (excluding 109 private vehicles for commuter students at Lake Michigan College)
Voluntary evacuation from within EPZ in areas outside region to be evacuated	20% of the population within the EPZ, but not within the Evacuation Region (see Figure 2-1)	20% of the population within the EPZ, but not within the Evacuation Region (see Figure 2-1)
Shadow Evacuation	20% of people outside of the EPZ within the Shadow Region (see Figure 7-2)	20% of people outside of the EPZ within the Shadow Region (see Figure 7-2)
Network Size	795 Links; 556 Nodes.	898 Links; 630 Nodes.
Roadway Geometric Data	Field surveys conducted in November of 2010. Major intersections were video archived. Road capacities based on 2010 HCM.	Field surveys conducted in March of 2021. Major intersections were video archived. Road capacities based on HCM 2016.
School Evacuation	Direct evacuation to designated Reception Center/ Temporary Host Facilities.	Direct evacuation to designated Reception Center/ Temporary Host Facilities.

Topic	Previous ETE Study	Current ETE Study
Transit- Dependent Population	Estimates based upon U.S. Census data and the results of the telephone survey. A total of 733 people who do not have access to a vehicle, requiring 50 buses to evacuate. An additional 21 homebound people with access and/or functional needs are reported within the three counties. Special transportation to evacuate: 1 ambulance, 1 wheelchair accessible van, and 3 regular buses.	Estimates based upon U.S. Census data and the results of the demographic survey. A total of 336 people who do not have access to a vehicle, requiring 13 buses to evacuate. An additional 55 homebound people with access and/or functional needs are reported within the three counties. Transportation needed to evacuate: 2 ambulances, 3 wheelchair accessible buses, and 3 regular buses.
Ridesharing	50% of transit-dependent persons will ride out with a neighbor or friend as per NUREG/CR-7002.	76% of transit-dependent persons will ride out with a neighbor or friend as per the demographic survey results.
Trip Generation for Evacuation	Based on residential telephone survey of specific pre-trip mobilization activities:	Based on the demographic survey of specific pre-trip mobilization activities:
	Residents with commuters returning leave between 30 and 270 minutes.	Residents with commuters returning leave between 30 and 285 minutes.
	Residents without commuters returning leave between 0 and 210 minutes.	Residents without commuters returning leave between 15 and 225 minutes.
	Employees and transients leave between 0 and 105 minutes.	Employees and transients leave between 0 and 105 minutes.
	All times measured from the Advisory to Evacuate.	All times measured from the Advisory to Evacuate.
Weather	Normal, Rain, or Snow. The capacity and free flow speed of all links in the network are reduced by 10% in the event of rain and 20% for snow.	Normal, Rain/Light Snow, or Heavy Snow. The capacity and free flow speed of all links in the network are reduced by 10% in the event of rain/light snow and 15% and 25% for heavy snow, respectively.
Modeling	DYNEV II System – Version 4.0.0.0	DYNEV II System – Version 4.0.20.0
Special Events	Fourth of July celebration at North and South Beach in South Haven, MI. Attracts approximately 15,000 people, 35% of which are considered transients.	Fourth of July celebration at North and South Beach in South Haven, MI. Attracts 33,899 transients.

Topic	Previous ETE Study	Current ETE Study
	Transients: 4,302 Vehicles: 1,434	Transients: 33,899 Vehicles: 9,908
Evacuation Cases	10 Regions (central sector wind direction and each adjacent sector technique used) and 14 Scenarios producing 140 unique cases.	13 Regions (central sector wind direction and each adjacent sector technique used) and 14 Scenarios producing 182 unique cases.
Evacuation Time Estimates Reporting	ETE reported for 90th and 100th percentiles. Results presented by Region and Scenario.	ETE reported for 90th and 100th percentiles. Results presented by Region and Scenario.
Evacuation Time Estimates for the entire EPZ, 90th percentile	Winter Weekday Midday, Good Weather (Scenario 6): 2:05	Winter Weekday Midday, Good Weather (Scenario 6): 2:45
	Summer Weekend, Midday, Good Weather (Scenario 3): 2:05	Summer Weekend, Midday, Good Weather (Scenario 3): 2:20
Evacuation Time Estimates for the entire EPZ, 100th percentile	Winter Weekday Midday, Good Weather (Scenario 6): 4:40	Winter Weekday Midday, Good Weather (Scenario 6): 4:55
	Summer Weekend, Midday, Good Weather (Scenario 3): 4:40	Summer Weekend, Midday, Good Weather (Scenario 3): 4:55

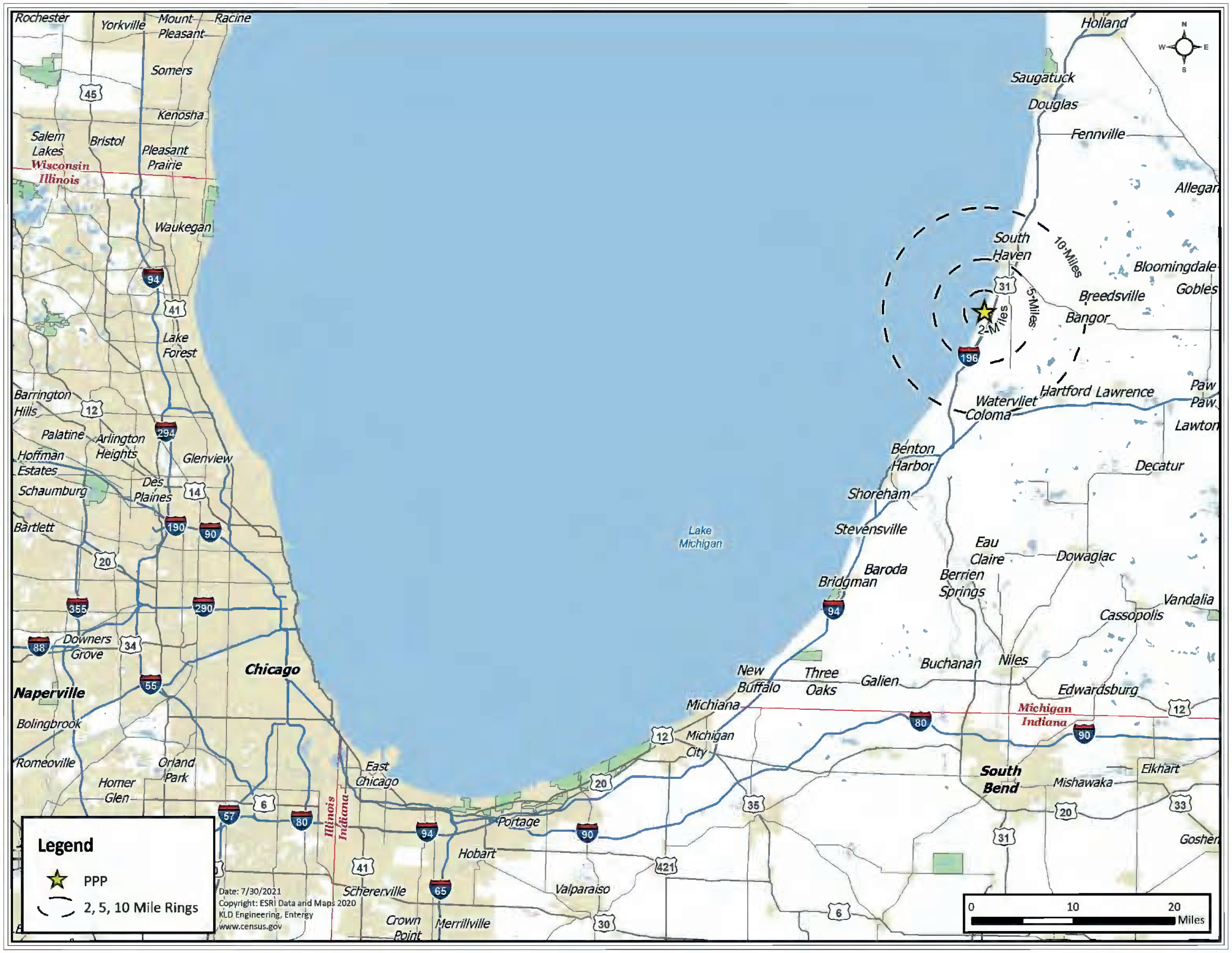


Figure 1-1. PPP Location

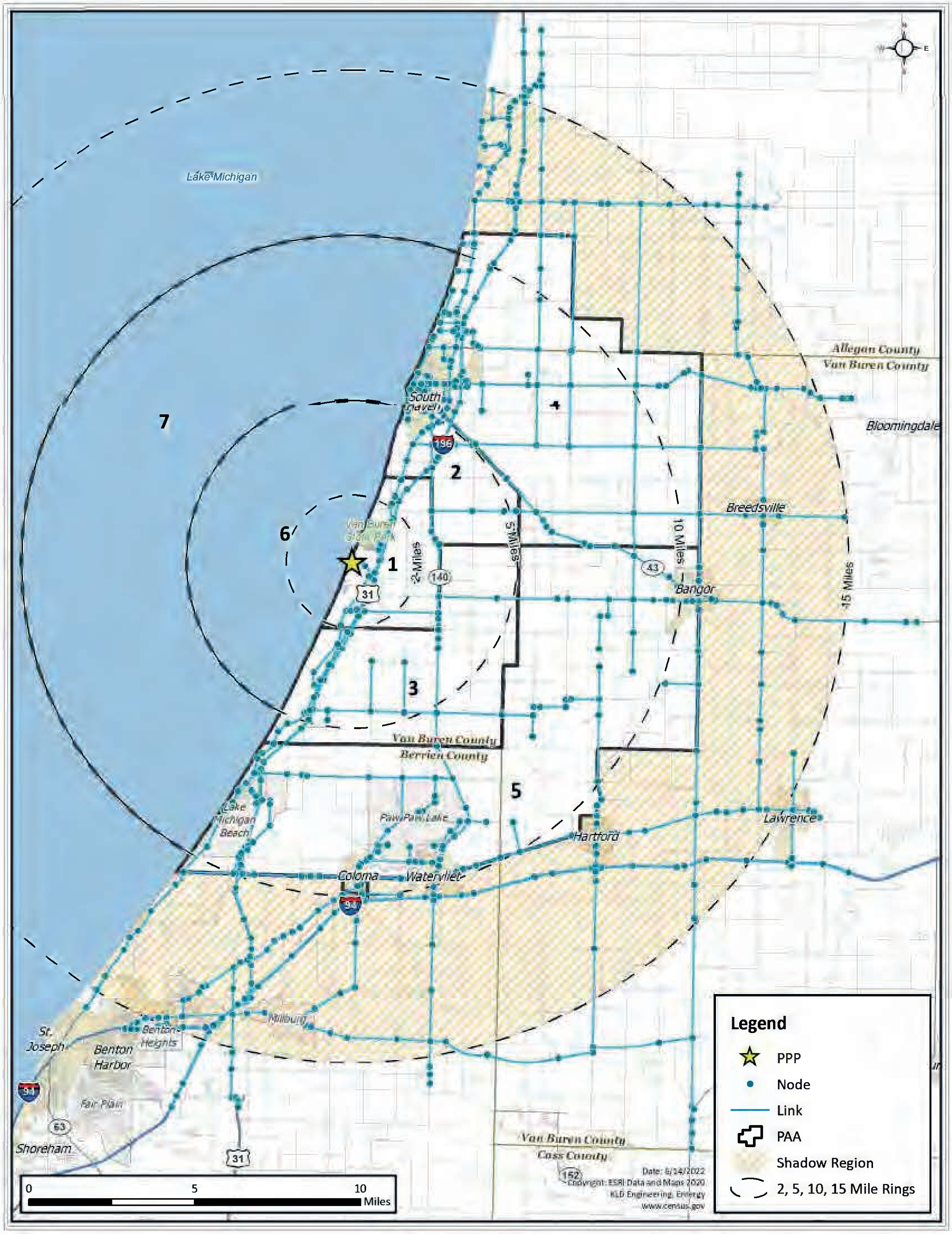


Figure 1-2. PPP Link-Node Analysis Network

2 STUDY ESTIMATES AND ASSUMPTIONS

This section presents the estimates and assumptions utilized in the development of the evacuation time estimates.

2.1 Data Estimates Assumptions

1. The permanent resident population is based on the 2020 U.S. Census population from the Census Bureau website[1]. A methodology, referred to as the "area ratio method", is employed to estimate the population within portions of census blocks that are divided by Protective Action Area (PAA) boundaries. It is assumed that the population is evenly distributed across a census block in order to employ the area ratio method. (See Section 3.1.)
2. Estimates of employees who reside outside the Emergency Planning Zone (EPZ) and commute to work within the EPZ are based upon data provided by each county and by Entergy/Holtec. (See Section 3.4.)
3. Population estimates at transient and special facilities are based on the data from the previous ETE study confirmed and updated by the EPZ county emergency management agencies.
4. The relationship between permanent resident population and evacuating vehicles is based on the results of the recent online demographic survey (see Appendix F). Values of 2.77 persons per household and 1.50 evacuating vehicles per household are used for the permanent resident population.
5. Where data is not provided, the average household size is assumed to be the vehicle occupancy rate for transient facilities.
6. Employee vehicle occupancies are based on the results of the demographic survey. 1.10 employees per vehicle are used in the study. In addition, it is assumed there are two people per carpool, on average. (See Appendix F, sub-section F.3.1 and Figure F-6.)
7. The maximum bus speed assumed within the EPZ is 55 mph based on state laws for buses and on average posted speed limits on major roadways within the EPZ.
8. Roadway capacity estimates are based on field surveys performed in 2021 (verified by aerial imagery), and the application of the Highway Capacity Manual 2016.
    a. In accordance with NUREG/CR-7002, Rev. 1, only those roadway construction projects that are completed prior to the finalization of this report are considered in an ETE study. As no roadway projects were identified by Entergy/Holtec or the OROs, no future roadway improvement projects (affecting roadway capacity estimates) are considered in this study.

[1] www.census.gov

2.2 Methodological Assumptions

1. The Planning Basis Assumption for the calculation of ETE is a rapidly escalating accident that requires evacuation, and includes the following[2] (as per NRC guidance):
    a. Advisory to Evacuate (ATE) is announced coincident with the siren notification.
    b. Mobilization of the general population will commence within 15 minutes after siren notification.
    c. ETE is measured relative to the ATE.
2. The center-point of the plant is located at the center of the containment building 42°19'22.1"N, 86°18'51.5"W.
3. The DYNEV II[3] system is used to compute ETE in this study.
4. Evacuees will drive safely, travel radially away from the plant to the extent practicable given the highway network and obey all traffic control devices and traffic guides. All major evacuation routes are used in the analysis.
5. The existing EPZ and PAA boundaries are used. See Figure 3-1.
6. The Shadow Region extends to 15 miles radially from the plant or approximately 5 miles radially from the EPZ boundary, as per NRC guidance. See Figure 7-2.
7. One hundred percent (100%) of the people within the impacted keyhole will evacuate. Twenty percent (20%) of the population within the Shadow Region and within PAAs of the EPZ not advised to evacuate will voluntarily evacuate, as shown in Figure 2-1, as per NRC guidance. Sensitivity studies explore the effect on ETE of increasing the percentage of voluntary evacuees in the Shadow Region (see Appendix M).
8. Shadow population characteristics (household size, evacuating vehicles per household, and mobilization time) are assumed to be the same as that of the permanent resident population within the EPZ.
9. The ETE is presented at the 90th and 100th percentiles in graphical and tabular format, as per NRC guidance. The percentile ETE is defined as the elapsed time from the ATE issued to a specific Region of the EPZ, to the time that Region is clear of the indicated percentile of evacuees.
10. This study does not assume that roadways are empty at the start of the evacuation. Rather, there is an initialization period (often referred to as "fill time" in traffic simulation) wherein the anticipated traffic volumes from the start of the evacuation are

[2] We emphasize that the adoption of this planning basis is not a representation that these events will occur within the indicated time frame. Rather, these assumptions are necessary in order to:
1. Establish a temporal framework for estimating the Trip Generation distribution in the format recommended in Section 2.13 of NUREG/CR-6863.
2. Identify temporal points of reference that uniquely define "Clear Time" and ETE.

It is likely that a longer time will elapse between the various stages of an emergency.

[3] The models of the I-DYNEV System were recognized as state of the art by the Atomic Safety & Licensing Board (ASLB) in past hearings. (Sources: Atomic Safety & Licensing Board Hearings on Seabrook and Shoreham; Urbanik). The models have continuously been refined and extended since those hearings and were independently validated by a consultant retained by the NRC. The DYNEV II model incorporates the latest technology in traffic simulation and in dynamic traffic assignment.

loaded onto roadways in the study area. The amount of initialization/fill traffic that is on the roadways in the study area at the start of the evacuation depends on the scenario and the region being evacuated. See Section 3.11.

11. To account for boundary conditions (roadway conditions outside the study area that are not specifically modeled due to the limited radius of the study area) beyond the study area, this study assumes a 25% reduction in capacity on two-lane roads and multi-lane highways for roadways that have traffic signals downstream. The 25% reduction in capacity is based on the prevalence of actuated traffic signals in the study area and the fact that the evacuating traffic ("main street") volume is more significant than the competing traffic ("side street") volume at any downstream signalized intersections, thereby warranting a more significant percentage (75% in this case) of the signal green time. There is no reduction in capacity for freeways due to boundary conditions.
12. The ETE also includes consideration of "through" (External-External, traffic that originates its trip outside of the study area and has its destination outside of the study area) trips during the time that such traffic is permitted to enter the evacuated Region. See Section 3.10.

2.3 Assumptions on Mobilization Times

1. Trip generation time (also known as mobilization time, or the time required by evacuees to prepare for the evacuation) are based upon the results of the recent online demographic survey (see Section 5 and Appendix F). It is assumed that stated events take place in sequence such that all preceding events must be completed before the current event can occur.
2. One hundred percent (100%) of the EPZ population can be notified within 45 minutes, in accordance with the 2019 Federal Emergency Management Agency (FEMA) Radiological Emergency Preparedness Program Manual.
3. Commuter percentages (and percentage of residents awaiting the return of a commuter) are based on the results of the demographic survey. According to the survey results, 86% of the households in the EPZ have at least 1 commuter; 58% of those households with commuters will await the return of a commuter before beginning their evacuation trip (see Appendix F, sub-sections F.3.1 and F.3.2). Therefore, 50% (86% x 58% = 50%) of EPZ households will await the return of a commuter, prior to beginning their evacuation trip.

2.4 Transit Dependent Assumptions

1. The percentage of transit-dependent people who will rideshare with a neighbor or friend is based on the results of the demographic survey. According to the survey results, 76% of the transit-dependent population will rideshare (see Appendix F, sub-section F.3.1).
2. Buses are used to transport those without access to private vehicles:
    a. Schools and preschools

i. If schools and preschools are in session, transport (buses) will evacuate students directly to the designated temporary host facilities.
ii. Buses will evacuate children at preschools within the EPZ, as needed.
iii. Children at day cares within the EPZ are picked up by parents and evacuated in private vehicles.
iv. For the schools/preschools that are evacuated via buses, it is assumed no school children are picked up by their parents prior to the arrival of the buses.
v. Schoolchildren, if school is in session, are given priority in assigning transit vehicles.

b. Medical Facilities
   i. Buses, vans, passenger cars, wheelchair buses, wheelchair vans and ambulances will evacuate patients at medical facilities and at any senior facilities within the EPZ, as needed.
   ii. The percent breakdown of ambulatory (46%), wheelchair bound (50%) and bedridden patients (4%) from the 2012 study are used to determine the number of ambulatory, wheelchair bound and bedridden patients at the medical facilities within the EPZ.
c. Transit-dependent permanent residents:
   i. Transit-dependent general population is evacuated to reception centers.
   ii. Access and/or functional needs population may require county assistance (ambulance, bus or wheelchair transport) to evacuate. This is considered separately from the general population ETE, as per NRC guidance.
   iii. Households with 3 or more vehicles were assumed to have no need for transit vehicles.
d. Analysis of the number of required round-trips ("waves") of evacuating transit vehicles are presented.
e. Transport of transit-dependent evacuees from reception centers to congregate care centers are not considered in this study.

3. Transit vehicle capacities:
   a. School buses = 70 students per bus for primary schools/preschools and 50 students per bus for middle/high schools
   b. Ambulatory transit-dependent persons and medical facility patients = 30 persons per bus
   c. Vans = 5 persons
   d. Ambulances = 2 bedridden persons (includes advanced and basic life support)
   e. Wheelchair vans = 4 wheelchair bound persons
   f. Wheelchair buses = 15 wheelchair bound persons

4. Transit vehicles mobilization times, which are considered in ETE calculations:
   a. School buses will arrive at schools and preschools to be evacuated within 90 minutes of the ATE.

b. Transit dependent buses are mobilized when approximately 90% of residents with no commuters have completed their mobilization. If necessary, multiple waves of buses are utilized to gather transit dependent people who mobilize more slowly.
c. Vehicles will arrive at hospitals, medical facilities, and senior living facilities to be evacuated within 90 minutes of the ATE.

5. Transit Vehicle loading times:
   a. Concurrent loading on multiple buses/transit vehicles is assumed.
   b. School buses are loaded in 15 minutes.
   c. Transit Dependent buses will require 1 minute of loading time per passenger.
   d. Buses for hospitals and medical facilities will require 1 minute of loading time per ambulatory passenger.
   e. Wheelchair transport vehicles will require 5 minutes of loading time per passenger.
   f. Ambulances are loaded in 15 minutes per bedridden passenger.

6. Drivers for all transit vehicles are available.

2.5 Traffic and Access Control Assumptions

1. Traffic Control Points (TCP) and Access Control Points (ACP) as defined in the approved county and state emergency plans are considered in the ETE analysis, as per NRC guidance. See Appendix G.

2. TCP and ACP are staffed approximately 120 minutes after the ATE, as per NRC guidance. It is assumed that no through traffic will enter the EPZ after this 120-minute time period.

3. All transit vehicles and other responders entering the EPZ to support the evacuation are unhindered by personnel manning TCPs and ACPs.

2.6 Scenarios and Regions

1. A total of 14 "Scenarios" representing different temporal variations (season, time of day, day of week) and weather conditions are considered. Scenarios to be considered are defined in Table 2-1:
   a. The Fourth of July Celebration in South Haven is considered as the special event (single or multi-day event that attracts a significant population into the EPZ; recommended by NRC guidance) for Scenario 13.
   b. As per NRC guidance, one segment of one of the highest volume roadways is out of service or one lane outbound on a freeway must be closed for a roadway impact scenario. This study will consider the closure of one lane on I-196 northbound from the interchange with County Road 378/32nd Ave (Exit 13) to the interchange with Blue Star Highway (Exit 30) for the roadway impact scenario – Scenario 14.

2. Two types of adverse weather scenarios are considered. Rain may occur for either winter or summer scenarios; snow occurs in winter scenarios only. It is assumed that the rain or snow begins at about the same time the evacuation advisory is issued. Thus, no weather-related reduction in the number of transients who may be present in the EPZ is assumed. It is further assumed that snow removal equipment is available, the appropriate agencies are clearing/treating the roads as they would normally during snow, and the roads are passable albeit at lower speeds and capacities.
3. Adverse weather affects roadway capacity and free flow speeds. Transportation research indicates capacity and speed reductions of about 10% for rain and a range of 10% to 25% for snow. In accordance with Table 3-1 of Revision 1 to NUREG/CR-7002, this study assumes a 10% reduction in speed and capacity for rain/light snow and a speed and capacity reduction of 15% and 25%, respectively, for heavy snow. These factors are shown in Table 2-2.
4. Some evacuees will need additional time to clear their driveways and access the public roadway system for heavy snow scenarios. The distribution of time for this activity was gathered through the demographic survey of the public and takes up to 180 minutes (see Appendix F, Figure F-15). It is assumed that the time needed by evacuees to remove snow from their driveways is sufficient time for snow removal crews to mobilize and clear/treat the public roadway system.
5. Employment is reduced slightly in the summer for vacations.
6. Mobilization and loading times for transit vehicles are slightly longer in adverse weather. Mobilization times are 10 minutes and 20 minutes longer in rain/light snow and heavy snow, respectively. Loading times for school buses are 5 minutes and 10 minutes longer in rain/light snow and heavy snow, respectively. Loading times for transit buses are 10 minutes and 20 minutes longer in rain/light snow and heavy snow, respectively. Refer to Table 2-2.
7. Regions are defined by the underlying “keyhole” or circular configurations as specified in Section 1.4 of NUREG/CR-7002, Rev. 1. These Regions, as defined, display irregular boundaries reflecting the geography of the PAAs included within these underlying configurations. All 16 cardinal and intercardinal wind direction keyhole configurations are considered. Regions to be considered are defined in Table 6-1. It is assumed that everyone within the group of PAAs forming a Region that is issued an ATE will, in fact, respond and evacuate in general accord with the planned routes.
8. Due to the irregular shapes of the PAAs, there are instances wherein a small portion of a PAA (a “sliver”) is within the keyhole and the population within that small portion is low (less than 500 people or 10% of the PAA population, whichever is less). Under those circumstances, the PAA would not be included in the Region so as to not evacuate large numbers of people outside of the keyhole for a small number of people that are actually in the keyhole, unless otherwise stated in the PAR document.

9. Staged evacuation is considered as defined in NUREG/CR-7002, Rev. 1 – those people between 2 miles and 5 miles will shelter-in-place until 90% of the 2-Mile Region has evacuated, then they will evacuate. See Regions R11 through R13 in Table 6-1.

Table 2-1. Evacuation Scenario Definitions

Scenario	Season[4]	Day of Week	Time of Day	Weather	Special
1	Summer	Midweek	Midday	Good	None
2	Summer	Midweek	Midday	Rain	None
3	Summer	Weekend	Midday	Good	None
4	Summer	Weekend	Midday	Rain	None
5	Summer	Midweek, Weekend	Evening	Good	None
6	Winter	Midweek	Midday	Good	None
7	Winter	Midweek	Midday	Light Rain/Snow	None
8	Winter	Midweek	Midday	Heavy Snow	None
9	Winter	Weekend	Midday	Good	None
10	Winter	Weekend	Midday	Light Rain/Snow	None
11	Winter	Weekend	Midday	Heavy Snow	None
12	Winter	Midweek, Weekend	Evening	Good	None
13	Summer	Weekend	Evening	Good	South Haven Fourth of July Celebration
14	Summer	Midweek	Midday	Good	Roadway Impact – Lane Closure on I-196 Northbound

[4] Winter means that school is in session at normal enrollment levels (also applies to spring and autumn). Summer means that school is in session at summer school enrollment levels (lower than normal enrollment).

Table 2-2. Model Adjustment for Adverse Weather

Scenario	Highway Capacity*	Free Flow Speed*	Mobilization Time for General Population	Mobilization Time	Loading Time for School Buses	Loading Time for Transit Buses[5]
Rain/Light Snow	90%	90%	No Effect	10-minute increase	5-minute increase	10-minute increase
Heavy Snow	75%	85%	Clear driveway before leaving home (See Figure F-15)	20-minute increase	10-minute increase	20-minute increase

*Adverse weather capacity and speed values are given as a percentage of good weather conditions. Roads are assumed to be passable.

[5] Does not apply to medical facilities and those with access and/or functional needs as loading times for these people are already conservative.

Figure 2-1. Voluntary Evacuation Methodology

3 DEMAND ESTIMATION

The estimates of demand, expressed in terms of people and vehicles, constitute a critical element in developing an evacuation plan. These estimates consist of three components:

1. An estimate of population within the EPZ, stratified into groups (resident, employee, transient).
2. An estimate, for each population group, of mean occupancy per evacuating vehicle. This estimate is used to determine the number of evacuating vehicles.
3. An estimate of potential double-counting of vehicles.

Appendix E presents much of the source material for the population estimates. Our primary source of population data, the 2020 Census, is not adequate for directly estimating some transient groups.

Throughout the year, vacationers and tourists enter the EPZ. These non-residents may dwell within the EPZ for a short period (e.g., a few days or one or two weeks), or may enter and leave within one day. Estimates of the size of these population components must be obtained, so that the associated number of evacuating vehicles can be ascertained.

The potential for double-counting people and vehicles must be addressed. For example:

- A resident who works and shops within the EPZ could be counted as a resident, again as an employee and once again as a shopper.
- A visitor who stays at a hotel and spends time at a park, then goes shopping could be counted three times.

Furthermore, the number of vehicles at a location depends on time of day. For example, motel parking lots may be full at dawn and empty at noon. Similarly, parking lots at area parks, which are full at noon, may be almost empty at dawn. Estimating counts of vehicles by simply adding up the capacities of different types of parking facilities will tend to overestimate the number of transients and can lead to ETE that are too conservative.

Analysis of the population characteristics of the PPP EPZ indicates the need to identify four distinct groups:

- Permanent residents - people who are year-round residents of the EPZ.
- Transients - people who reside outside of the EPZ who enter the area for a specific purpose (shopping, recreation) and then leave the area.
- Seasonal Transients - people who reside outside of the EPZ and enter the area and stay in accommodations other than hotels.
- Employees - people who reside outside of the EPZ and commute to work within the EPZ on a daily basis.

Estimates of the population and number of evacuating vehicles for each of the population groups are presented for each PAA and by polar coordinate representation (population rose). The PPP EPZ is subdivided into 7 PAAs. The PAAs comprising the EPZ are shown in Figure 3-1.

3.1 Permanent Residents

The primary source for estimating permanent population is the 2020 U.S. Census data with an availability date of September 16, 2021. The average household size (2.77 persons/household – See Appendix F, Sub-section F.3.1) and the number of evacuating vehicles per household (1.50 vehicles/household – See Appendix F, Sub-section F.3.2) were adapted from the demographic survey.

The permanent resident population is estimated by cutting the census block polygons by the PAA and EPZ boundaries using GIS software. A ratio of the original area of each census block and the updated area (after cutting) is multiplied by the total block population to estimate the population within the EPZ. This methodology (referred to as the "area ratio method") assumes that the population is evenly distributed across a census block. Table 3-1 provides permanent resident population within the EPZ, by PAA, for 2010 and for 2020 (based on the methodology above). As indicated, the permanent resident population within the EPZ has decreased by -4.55% since the 2010 Census.

To estimate the number of vehicles, the 2020 Census permanent resident population is divided by the average household size and multiplied by the average number of evacuating vehicles per household. Permanent resident population and vehicle estimates are presented in Table 3-2. Figure 3-2 and Figure 3-3 present the permanent resident population and permanent resident vehicle estimates by sector and distance from the PPP. This population "rose" was constructed using GIS software. Note, the 2020 Census includes residents living in group quarters, such as skilled nursing facilities, group homes, etc. These people are transit dependent (will not evacuate in personal vehicles) and are included in the special facility evacuation demand estimates. To avoid double counting vehicles, the vehicle estimates for these people have been removed. The resident vehicles in Table 3-2 and Figure 3-3 have been adjusted accordingly.

3.2 Shadow Population

A portion of the population living outside the evacuation area extending to 15 miles radially from the PPP may elect to evacuate without having been instructed to do so. This area is called the Shadow Region. Based upon NUREG/CR-7002, Rev. 1 guidance, it is assumed that 20 percent of the permanent resident population, based on U.S. Census Bureau data, in the Shadow Region will elect to evacuate.

Shadow population characteristics (household size, evacuation vehicles per household, mobilization time) are assumed to be the same as that for the EPZ permanent resident population. Table 3-3, Figure 3-4, and Figure 3-5 present estimates of the shadow population and vehicles, by sector. Similar to the EPZ resident vehicle estimates, resident vehicles at group quarters have been removed from the shadow population vehicle demand in Table 3-3 and Figure 3-5.

3.3 Transient Population

Transient population groups are defined as those people (who are not permanent residents, nor commuting employees or students) who enter the EPZ for a specific purpose (shopping, recreation). Transients may spend less than one day or stay overnight at camping facilities, hotels, and motels.

Data for transient facilities within the EPZ was provided by the counties within the EPZ. This data includes the number of transients and vehicles during the peak times. Where data was not provided, the maximum capacities of people or parking spaces were obtained by internet searches and aerial imagery. It is assumed that visitors travel to transient facilities as a family/household. As such, the average household size (2.77 persons/household – see Section 3.1) was used to estimate the number of transients and vehicles. The transient facilities within the PPP EPZ are summarized as follows:

- Beaches – 2,027 transients and 638 vehicles; an average of 3.18 transients per vehicle
- Campgrounds – 3,849 transients and 1,513 vehicles; an average of 2.54 transients per vehicle (Note, recreational vehicles (RVs) at campgrounds are treated as 2 vehicles due to their larger size and more sluggish operating characteristics)
- Golf Courses – 384 transients and 97 vehicles; an average of 3.96 transients per vehicle
- Marinas – 2,555 transients and 1,285 vehicles; an average of 1.99 transients per vehicle (Note, vehicles with boat trailers at marinas are treated as 1.5 vehicles)
- Parks – 1,370 transients and 615 vehicles; an average of 2.23 transients per vehicle
- Casino – 5,000 transients and 2,500 vehicles; an average of 2.00 transients per vehicle
- Lodging Facilities – 2,586 transients and 971 vehicles; an average of 2.66 transients per vehicle

Appendix E summarizes the transient data that was estimated for the EPZ. Tables E-4 and E-5 include the number of transients visiting recreational areas and marinas, while Table E-6 presents the number of transients at lodging facilities within the EPZ.

3.3.1 Seasonal Transient Population

The PPP EPZ has a second category of transient population which is seasonal residents. These people will enter the area during the summer months and may stay considerably longer (several weeks or the entire season) than the average transient using a hotel or motel. The seasonal population use other lodging facilities such as condominiums, beach houses and summer rentals that otherwise would not be captured in a typical lodging population.

2020 census block data was used to estimate the seasonal resident population. Each census block includes information regarding the number of vacant and occupied households. An average vacant household percentage was calculated for the entire PPP EPZ (29.7%) using this data.

It is assumed that seasonal residents will be renting homes near the Lake Michigan shoreline. Using only those census blocks that are within one mile of the shoreline, the number of seasonal homes was calculated. It is further assumed that 29.7% (EPZ average) of the vacant

homes within these census blocks are not rental homes and are in fact vacant homes. The remaining households were considered to be seasonal households. An average household size of 2.77 persons per household was used to determine the seasonal transient population, and 1.50 evacuating vehicles per seasonal household was used to determine the number of seasonal transient vehicles.

It is estimated that there is an additional seasonal population of 3,576 transients and 1,977 transient vehicles within the PPP EPZ.

In total, there are 21,347 transients in the EPZ at peak times, evacuating in 9,596 vehicles (an average vehicle occupancy of 2.22 transients per vehicle). Table 3-4 presents the transient population and vehicle estimates by PAA. Figure 3-6 and Figure 3-7 present these data by sector and distance from the plant.

3.4 Employees

Employees who work within the EPZ fall into three categories:

- Those who live and work in the EPZ
- Those who live outside of the EPZ and commute to jobs within the EPZ
- Those who are migratory workers who commute into the EPZ daily to do agricultural work

Those of the first category are already counted as part of the permanent resident population. To avoid double counting, we focus only on those employees commuting from outside the EPZ who will evacuate along with the permanent resident population.

Employment data was provided by Entergy/Holtec and by Van Buren County, including the maximum shift employment and percentage of employees commuting into the EPZ. As per NUREG/CR-7002, Rev. 1 guidance, employers with 200 or more employees working in a single shift are considered as major employers. As such, the employers not meeting this criterion are not considered in this study.

Those of the third category were not considered in this study. Allegan, Berrien and Van Buren Counties estimate that the migratory workforce would constitute approximately 5% of the EPZ population during peak times. However, data on where these individuals are working is difficult to obtain because it can change on a daily basis. A sensitivity study was performed to determine the impact on ETE of changes in resident population. Table M-3 in Appendix M documents the results of this study; as indicated a 108% change (more than twenty-one times the estimated migratory workforce) in population is needed to significantly impact on the ETE. Therefore, considering the migratory workforce in this study would not have a significant effect on ETE.

To estimate the evacuating employee vehicles, a vehicle occupancy rate of 1.10 employees per vehicle obtained from the demographic survey (see Appendix F, Sub-section F.3.1) was applied for all the major employers. Appendix E, Table E-3 includes the detailed information of each

major employer. Table 3-5 presents employee and vehicle estimates commuting into the EPZ by PAA. Figure 3-8 and Figure 3-9 present these data by sector.

3.5 Medical Facilities

Data for medical facilities identified within the EPZ were provided by the county emergency agencies, supplemented by internet searches where no data was provided. Table E-2 in Appendix E summarizes the data gathered for medical facilities. Table 3-6 presents the census of medical facilities in the EPZ. As shown in these tables, 230 people have been identified as living in, or being treated in, these facilities. This data includes the number of ambulatory, wheelchair-bound and bedridden patients at each facility. The average breakdown of ambulatory (46%), wheelchair bound (50%) and bedridden patients (4%) from the 2012 ETE study was used to determine the number of ambulatory, wheelchair bound, and bedridden patients at the medical facilities wherein updated data was not provided.

The transportation requirements for the special facility population are also presented in Table 3-6. The number of ambulance runs is determined by assuming that up to 2 patients can be accommodated per ambulance trip; the number of wheelchair bus runs assumes up to 15 wheelchairs per trip; the number of wheelchair van runs assumes up to 4 wheelchairs per trip, and the number of bus runs estimated assumes 30 ambulatory patients per trip.

3.6 School Population Demand

Table 3-7 presents the school population and transportation requirements for the direct evacuation of all schools within the EPZ for the 2020-2021 school year. This information was provided by the counties supplemented by internet searches where no data was provided. The column in Table 3-7 entitled "Buses Required" specifies the number of buses required for each school under the following set of assumptions and estimates:

- No students will be picked up by their parents prior to the arrival of the buses.
- While many high school students commute to school using private automobiles (as discussed in Section 2.4 of NUREG/CR-7002, Rev. 1), the estimate of buses required for school evacuation does not consider the use of these private vehicles, since the intent of schools is to evacuate all students by bus.
- Bus capacity, expressed in students per bus, is set to 70 for primary schools and 50 for middle and high schools.
- Those staff members who do not accompany the students will evacuate in their private vehicles.
- No allowance is made for student absenteeism, which is typically 3 percent daily.
- Commuter students at Lake Michigan College – South Haven Campus will use passenger vehicles. See Sub-Section 3.6.1 below for more details.

The counties in the EPZ could introduce procedures whereby the schools are contacted prior to the dispatch of buses from the depot, to ascertain the current estimate of students to be evacuated. In this way, the number of buses dispatched to the schools will reflect the actual

number needed. The need for buses would be reduced by any high school students who have evacuated using private automobiles (if permitted by school authorities). Those buses originally allocated to evacuate schoolchildren that are not needed due to children being picked up by their parents, can be gainfully assigned to service other facilities or those persons who do not have access to private vehicles or to ride-sharing.

Table 10-3 presents a list of the host schools for each school in the EPZ. Students will be transported to these host schools where they will be subsequently retrieved by their respective families or guardians.

3.6.1 Commuter College

There is one college campus within the EPZ: Lake Michigan College – South Haven Campus. It is located in PAA 4, 7.0 miles north-northeast of the plant. Data provided by Van Buren County indicates the college has an enrollment of 400 students at this campus. Since the campus does not provide student living accommodations, all students commute to school. According to the previous ETE study, approximately 30% of these students commute from outside of the EPZ. Thus, there are 120 (400 x 30%) commuting students. The remaining 280 (400 – 120) students who live within the EPZ are considered as permanent residents that have been included in Section 3.1. The vehicle occupancy rate for commuting students was obtained from the demographic survey (1.10 commuting students/vehicle obtained – See Appendix F, Sub-Section F.3.1). As such, a total of 120 students and 109 (120 ÷ 1.10) vehicles were assigned to this commuter college.

3.7 Special Event

A special event can attract large numbers of transients to the EPZ for short periods of time, creating a temporary surge in demand as per Section 2.5.1 of NUREG/CR-7002, Rev. 1. The county and state emergency management agencies were polled regarding potential special events in the EPZ. The only potential special event identified by the county and state agencies that attracts transients from outside the EPZ is the Fourth of July Celebration in South Haven.

Thus, the special event considered for this study is the annual Fourth of July Celebration held at both the North and South Beaches in South Haven. The data for this event was provided by the Executive Director of the South Haven/Van Buren County Convention and Visitors Bureau:

- All parking spaces in the City of South Haven, including along all side streets from Baseline Road to the intersection of Monroe Blvd and Blue Star Highway and at least as far east as Blue Star Hwy are filled. Aerial imagery was used to estimate 6,346 parking spaces. Thus, there are 6,346 transient vehicles. It is assumed that there are 4 transients per vehicle, for a total of 25,384 transients
- There are approximately 1,075 seasonal/long-term rental units that are members of the South Haven/Van Buren County Convention and Visitors Bureau. It is estimated that there are 2 vehicles and 4 people per rental unit for a total of 2,150 vehicles and 4,300 transients.
- There are approximately 1,200 short term (Airbnb, VRBO, etc.) rentals in South Haven. It

is estimated that there are 2 vehicles and 5 people per rental unit for a total of 2,400 vehicles and 6,000 transients.
- As discussed in Section 3.3.1, there are 3,576 seasonal residents and 1,977 seasonal resident vehicles already considered in the EPZ; of those, 1,785 seasonal residents and 988 seasonal resident vehicles are in South Haven. These people/vehicles are subtracted from the Special Event vehicles to avoid double counting.

A total of 33,899 transients (25,384 + 4,300 + 6,000 – 1,785) and 9,908 transient vehicles (6,346 + 2,150 + 2,400 - 988) are considered for this special event. The special event vehicle trips are generated utilizing the same mobilization distributions as transients. The special event vehicles are uniformly distributed amongst the roadways in South Haven.

3.8 Access and/or Functional Needs Population

The county emergency management agencies have an annual registration for homebound (non-institutionalized) people with access and/or functional needs. Based on data provided by Van Buren, Berrien, and Allegan Counties, there are an estimated 55 homebound people with access and/or functional needs who require transportation assistance to evacuate. Among them, 32, 19, and 4 people are within the Van Buren, Berrien, and Allegan County portions of the EPZ respectively. The percentage breakdown of bedridden (6%), wheelchair bound (38%), and ambulatory (56%) people was provided by Van Buren County and was applied to Allegan and Berrien Counties as well to estimate the functional needs of the total homebound population with access and/or functional needs. Thus, 31 of these residents require buses, 21 require wheelchair buses/vans and 3 people need ambulances to evacuate. See Table 3-8.

3.9 Transit Dependent Population

The demographic survey (see Appendix F) results were used to estimate the portion of the population requiring transit service, including:

- Those persons in households that do not have a vehicle available.
- Those persons in households that do have vehicle(s) that would not be available at the time the evacuation is advised.

In the latter group, the vehicle(s) may be used by a commuter(s) who does not return (or is not expected to return) home to evacuate the household. Table 3-9 presents estimates of transit-dependent people. Note:

- Estimates of persons requiring transit vehicles include schoolchildren. For those evacuation scenarios where children are at school when an evacuation is ordered, separate transportation is provided for the schoolchildren. The actual need for transit vehicles by residents is thereby less than the given estimates. However, estimates of transit vehicles are not reduced when schools are in session.
- It is reasonable and appropriate to consider that many transit-dependent persons will evacuate by ridesharing with neighbors, friends or family. For example, nearly 80% of

those who evacuated from Mississauga, Ontario[1] who did not use their own cars, shared a ride with neighbors or friends. Other documents report that approximately 70% of transit dependent persons were evacuated via ride sharing. **Based on the results of the demographic survey (see Appendix F, sub-section F.3.1), approximately 76% of the transit-dependent population will rideshare.**

The estimated number of bus trips needed to service transit-dependent persons is based on an estimated average bus occupancy of 30 persons at the conclusion of the bus run. Transit vehicle seating capacities typically equal or exceed 60 children on average (roughly equivalent to 40 adults). If transit vehicle evacuees are two thirds adults and one third children, then the number of "adult seats" taken by 30 persons is 20 + (2/3 x 10) = 27. On this basis, the average load factor anticipated is (27/40) x 100 = 68%. Thus, if the actual demand for service exceeds the estimates of Table 3-9 by 50%, the demand for service can still be accommodated by the available bus seating capacity.

$$\left[20 + \left(\frac{2}{3} \times 10\right)\right] \div 40 \times 1.5 = 1.00$$

Table 3-9 indicates that transportation must be provided for 336 people. Therefore, a total of twelve (12) bus run is required from a capacity standpoint. In order to service all of the transit dependent population and have at least one bus drive through each of the PAAs to pick up transit dependent people, **13 buses** are used in the ETE calculations. See Section 8.1 for further discussion. These buses are represented as two vehicles in the ETE simulations due to their larger size and more sluggish operating characteristics.

To illustrate this estimation procedure, we calculate the number of persons, P, requiring public transit or ride-share, and the number of buses, B, required for the PPP EPZ:

$$\boldsymbol{P = No.of\ HH\ \times \sum_{i=0}^{n} \{(\%\ HH\ with\ i\ vehicles) \times [(Average\ HH\ Size) - i]\} \times A^i C^i}$$

Where:

A = Percent of households with commuters

C = Percent of households who will not await the return of a commuter

$$\boldsymbol{P} = 10{,}684 \times [0.189 \times (2.04 - 1) \times 0.856 \times 0.417 + 0.492 \times (2.98 - 2) \times (0.856 \times 0.417)^2] = 1408$$

$$\boldsymbol{B} = [(1 - 0.762) \times \boldsymbol{P}] \div 30 = (0.238 \times 1{,}408) \div 30 = 12$$

These calculations, based on the demographic survey results, are explained as follows:

- The total number of persons requiring public transit is the sum of such people in HH

[1] Institute for Environmental Studies, University of Toronto, THE MISSISSAUGA EVACUATION FINAL REPORT, June 1981. The report indicates that 6,600 people of a transit-dependent population of 8,600 people shared rides with other residents; a ride share rate of 77% (Page 5-10).

with no vehicles, or with 1 or 2 vehicles that are away from home.

- The number of households (HH) is computed by dividing the EPZ population by the average household size (29,594 ÷ 2.77) and is 10,684.
- There are no households with zero vehicles available.
- The members of HH with 1 vehicle away (18.9%), who are at home, equal (2.04 - 1). The number of HH where the commuter will not return home is equal to (10,684 x 0.189 x 1.04 x 0.856 x 0.417), as 85.6% of EPZ households have a commuter, 41.7% of which would not return home in the event of an emergency. The number of persons who will evacuate by public transit or ride-share is equal to the product of these two terms.
- The members of HH with 2 vehicles that are away (49.2%), who are at home, equal (2.98 – 2). The number of HH where neither commuter will return home is equal to 10,684 x 0.492 x 0.98 x $(0.856 \times 0.417)^2$. The number of persons who will evacuate by public transit or ride-share is equal to the product of these two terms (the last term is squared to represent the probability that neither commuter will return).
- Households with 3 or more vehicles are assumed to have no need for transit vehicles.
- The number of buses is computed based on 76.2% of the transit-dependent population ridesharing with a neighbor or friend and a capacity of 30 people per bus.

The estimate of transit-dependent population in Table 3-9 exceeds the number of registered transit-dependent persons (access and/or functional needs population) in the EPZ (discussed in Section 3.8). This is consistent with the findings of NUREG/CR-6953, Volume 2, in that a large majority of the transit-dependent population within the EPZs of U.S. nuclear plants does not register with their local emergency response agency.

3.10 External Traffic

Vehicles will be traveling through the EPZ (external-external trips which have their origins and destinations outside of the EPZ) at the time of an accident. After the Advisory to Evacuate is announced, these through-travelers will also evacuate. These through vehicles are assumed to travel on the major routes traversing the EPZ – I-194 and I-94. It is assumed that this traffic will continue to enter the EPZ during the first 120 minutes following the Advisory to Evacuate.

Average Annual Daily Traffic (AADT) data was obtained from the Michigan Department of Transportation using their interactive online traffic volume map to estimate the number of vehicles per hour on the aforementioned routes. The AADT was multiplied by the K-Factor, which is the proportion of the AADT on a roadway segment or link during the design hour, resulting in the design hour volume (DHV). The design hour is usually the 30th highest hourly traffic volume of the year, measured in vehicles per hour (vph). The DHV is then multiplied by the D-Factor, which is the proportion of the DHV occurring in the peak direction of travel (also known as the directional split). The resulting values are the directional design hourly volumes (DDHV), and are presented in Table 3-10, for each of the routes considered. The DDHV is then multiplied by 2 hours (access control points – ACP – are assumed to be activated at 120 minutes

after the advisory to evacuate) to estimate the total number of external vehicles loaded on the analysis network. As indicated, there are 7,950 vehicles entering the EPZ as external-external trips prior to the activation of the ACP and the diversion of this traffic. This number is reduced by 60% for evening scenarios (Scenarios 5 and 12) as discussed in Section 6.

3.11 Background Traffic

Section 5 discusses the time needed for the people in the EPZ to mobilize and begin their evacuation trips. As shown in Table 5-9, there are 15 time periods during which traffic is loaded on to roadways in the study area to model the mobilization time of people in the EPZ. Note, there is no traffic generated during the 15th time period, as this time period is intended to allow traffic that has already begun evacuating to clear the study area boundaries.

This study does not assume that roadways are empty at the start of the evacuation (Time Period 1). Rather, there is an initialization period (often referred to as "fill time" in traffic simulation) wherein the anticipated traffic volumes from the start of the evacuation are loaded onto roadways in the study area. The amount of initialization/fill traffic that is on the roadways in the study area at the start of the evacuation depends on the scenario and the region being evacuated (see Section 6). There are 1,699 vehicles on the roadways in the study area at the end of fill time for an evacuation of the entire EPZ (Region R03) under Scenario 3 (summer, weekend, midday, good weather) conditions.

3.12 Summary of Demand

A summary of population and vehicle demand is summarized in Table 3-11 and Table 3-12, respectively. This summary includes all population groups described in this section. A total of 96,486 people and 46,896 vehicles are considered in this study.

Table 3-1. EPZ Permanent Resident Population

PAA	2010 Population	2020 Population
1	1,548	1,463
2	2,205	2,019
3	2,221	1,841
4	10,356	10,040
5	14,675	14,231
6	0	0
7	0	0
EPZ TOTAL:	31,005	29,594
EPZ Population Growth (2010-2020):		-4.55%

Table 3-2. Permanent Resident Population and Vehicles by PAA

PAA	2020 Population	Resident Vehicles
1	1,463	789
2	2,019	1,091
3	1,841	993
4	10,040	5,369
5	14,231	7,656
6	0	0
7	0	0
EPZ TOTAL:	29,594	15,898

Table 3-3. Shadow Population and Vehicles by Sector

Sector	Population	Evacuating Vehicles
N	0	0
NNE	1,038	561
NE	1,536	833
ENE	1,406	746
E	2,071	1,109
ESE	1,462	784
SE	4,677	2,513
SSE	2,102	1,134
S	3,406	1,797
SSW	5,494	2,969
SW	0	0
WSW	0	0
W	0	0
WNW	0	0
NW	0	0
NNW	0	0
TOTAL:	23,192	12,446

Table 3-4. Summary of Transients and Transient Vehicles

PAA	Transients	Transient Vehicles	Seasonal Residents	Seasonal Resident Vehicles	Total Transients	Total Transient Vehicles
1	792	230	591	322	1,383	552
2	314	107	118	68	432	175
3	1,052	526	113	62	1,165	588
4	9,151	3,781	2,207	1,223	11,358	5,004
5	6,462	2,975	547	302	7,009	3,277
6	0	0	0	0	0	0
7	0	0	0	0	0	0
EPZ TOTAL:	17,771	7,619	3,576	1,977	21,347	9,596

Table 3-5. Summary of Employees and Employee Vehicles Commuting into the EPZ

PAA	Employees	Employee Vehicles
1	403	366
2	0	0
3	0	0
4	140	127
5	210	191
6	0	0
7	0	0
EPZ TOTAL:	753	684

Table 3-6. Medical Facility Transit Demand

PAA	Facility Name	Municipality	Capacity	Current Census	Ambu-latory	Wheel-chair Bound	Bed-ridden	Bus Runs	Wheel-chair Bus Runs	Wheel-chair Van Runs	Ambulance Runs
ALLEGAN COUNTY, MI											
4	Country Side Nursing Home	South Haven	93	93	43	46	4	2	4	0	2
		Allegan County Subtotal:	*93*	*93*	*43*	*46*	*4*	*2*	*4*	*0*	*2*
BERRIEN COUNTY, MI											
5	Forest Beach AFC Home Inc	Watervliet	20	16	16	0	0	1	0	0	0
5	Juniper Home	Watervliet	6	6	2	4	0	1	0	1	0
		Berrien County Subtotal:	*26*	*22*	*18*	*4*	*0*	*2*	*0*	*1*	*0*
VAN BUREN COUNTY, MI											
4	Bronson South Haven Hospital	South Haven	8	6	3	2	1	1	0	1	1
4	South Haven Nursing & Rehabilitation Community	South Haven	88	61	10	51	0	1	4	0	0
4	Turner Tender Care	South Haven	6	6	3	3	0	1	0	1	0
4	River Ridge Retirement Village	South Haven	44	42	26	13	3	1	1	0	2
		Van Buren County Subtotal:	*146*	*115*	*42*	*69*	*4*	*4*	*5*	*2*	*3*
		TOTAL:	**265**	**230**	**103**	**119**	**8**	**8**	**9**	**3**	**5**

Table 3-7. School Population Demand Estimates

PAA	School Name	Enrollment	Buses Required
ALLEGAN COUNTY, MI			
4	Baseline Middle School	460	10
4	North Shore Elementary School	314	5
	Allegan County Subtotal:	*774*	*15*
BERRIEN COUNTY, MI			
5	Salem Lutheran Preschool	6	1
5	Watervliet North Elementary School	293	5
5	Coloma Elementary School	375	6
5	Coloma Intermediate School	375	8
5	Coloma High School	430	9
5	Coloma Junior High School	300	6
	Berrien County Subtotal:	*1,779*	*35*
VAN BUREN COUNTY, MI			
2	Maple Grove Elementary School	303	5
2	Head Start - South Haven	40	1
3	Covert Middle School	73	2
3	Covert High School	102	3
3	Covert Elementary School	100	2
4	Head Start - Migrant at Lincoln Elementary	15	1
4	Lincoln Elementary School	207	3
4	L.C. Mohr High School	522	11
4	St. Paul Lutheran School	73	2
4	St. Basil Catholic School	125	2
4	WAY- South Haven Schools (LMC Campus)	30	1
4	Lake Michigan College - South Haven Campus	400	109
5	Wood School	25	1
5	Bangor High School	360	8
5	Bangor Middle School	335	7
5	Head Start - Bangor	47	1
5	Bangor Alternative High School	100	2
5	South Walnut Elementary School	330	5
	Van Buren County Subtotal:	*3,187*	*166*
	TOTAL:	**5,740**	**216**

Note: Total Buses Required for Lake Michigan College - South Haven Campus is equal to the number of commuter student vehicles. See Section 3.6.1 for additional information.

Table 3-8. Demand Estimates for Homebound Population with Access and/or Functional Needs

Population Group	Transportation Needed	Population	Vehicles deployed
ALLEGAN COUNTY, MI			
Ambulatory	Bus	2	1
Wheelchair bound	Wheelchair Bus	2	1
Bedridden	Ambulance	0	0
	Allegan County Subtotal:	*4*	*2*
BERRIEN COUNTY, MI			
Ambulatory	Bus	11	1
Wheelchair bound	Wheelchair Bus	7	1
Bedridden	Ambulance	1	1
	Berrien County Subtotal:	*19*	*3*
VAN BUREN COUNTY, MI			
Ambulatory	Bus	18	1
Wheelchair bound	Wheelchair Bus	12	1
Bedridden	Ambulance	2	1
	Van Buren County Subtotal:	*32*	*3*
	TOTAL:	**55**	**8**

Table 3-9. Transit-Dependent Population Estimates

2020 EPZ Population	Survey Average HH Size with Indicated No. of Vehicles			Estimated No. of Households	Survey Percent HH with Indicated No. of Vehicles			Survey Percent HH with Commuters	Survey Percent HH with Non-Returning Commuters	Total People Requiring Transport	Estimated Ridesharing Percentage	People Requiring Public Transit	Percent Population Requiring Public Transit
	0	1	2		0	1	2						
29,594	0.00	2.04	2.98	10,684	0.00%	18.90%	49.20%	85.61%	41.73%	1,408	76.2%	336	1.1%

Table 3-10. Palisades EPZ External Traffic

Upstream Node	Downstream Node	Road Name	Direction	AADT[2]	K-Factor[3]	D-Factor[3]	Hourly Volume	External Traffic
8089	89	I-94	Eastbound	24,008	0.107	0.5	1,284	2,568
8060	60	I-196	Southbound	24,008	0.107	0.5	1,284	2,568
8082	81	I-94	Westbound	26,300	0.107	0.5	1,407	2,814
							TOTAL:	**7,950**

Table 3-11. Summary of Population Demand

PAA	Residents	Transit-Dependent	Transients[4]	Employees	Medical Facilities	Schools, Preschools, Colleges	Special Event	Shadow Population[5]	External Traffic	Total
1	1,463	17	1,383	403	0	0	0	0	0	3,266
2	2,019	23	432	0	0	343	0	0	0	2,817
3	1,841	21	1,165	0	0	275	0	0	0	3,302
4	10,040	114	11,358	140	208	2,146	33,899	0	0	57,905
5	14,231	161	7,009	210	22	2,976	0	0	0	24,609
6	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
Shadow Region	0	0	0	0	0	0	0	4,638	0	4,638
TOTAL:	**29,594**	**336**	**21,347**	**753**	**230**	**5,740**	**33,899**	**4,638**	**0**	**96,537**

[2] MDOT Traffic Volumes Map

[3] HCM 2016

[4] Transients include seasonal population

[5] Shadow Population has been reduced to 20%. Refer to Figure 2-1 for additional information.

Table 3-12. Summary of Vehicle Demand

PAA	Residents	Transit-Dependent	Transients	Employees	Medical Facilities	Schools, Preschools, Colleges	Special Event	Shadow Vehicles[6]	External Traffic	Total
1	789	2	552	366	0	0	0	0	0	1,709
2	1,091	2	175	0	0	12	0	0	0	1,280
3	993	2	588	0	0	14	0	0	0	1,597
4	5,369	8	5,004	127	37	179[7]	9,908	0	0	20,632
5	7,656	12	3,277	191	5	118	0	0	0	11,259
6	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0
Shadow Region	0	0	0	0	0	0	0	2,489	7,950	10,439
TOTAL:	**15,898**	**26**	**9,596**	**684**	**42**	**323**	**9,908**	**2,489**	**7,950**	**46,916**

NOTE: Buses represented as two passenger vehicles. Refer to Section 8 for additional information.

[6] Shadow vehicles have been reduced to 20%

[7] Includes 109 commuter vehicles for the students at Lake Michigan College - South Haven Campus

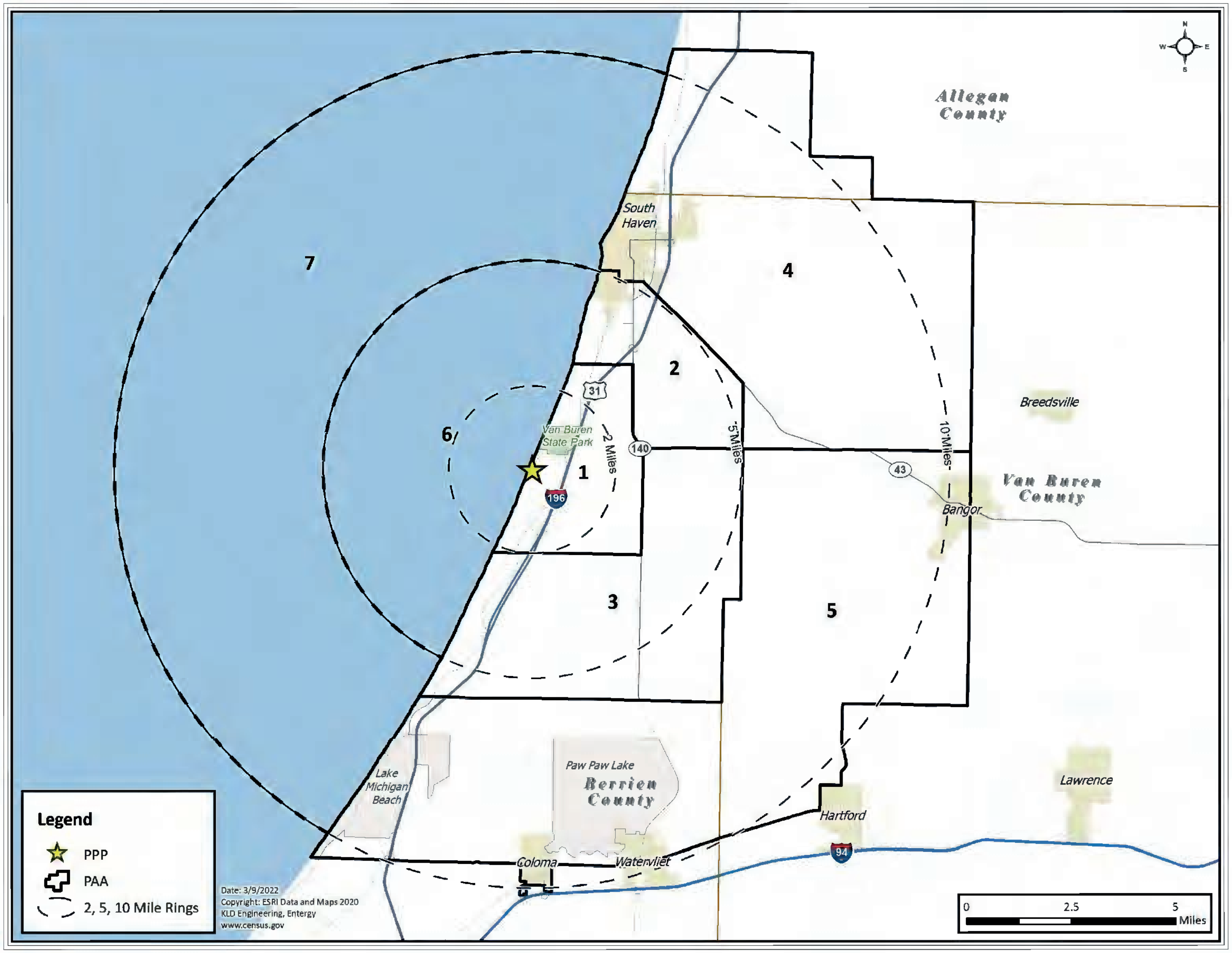
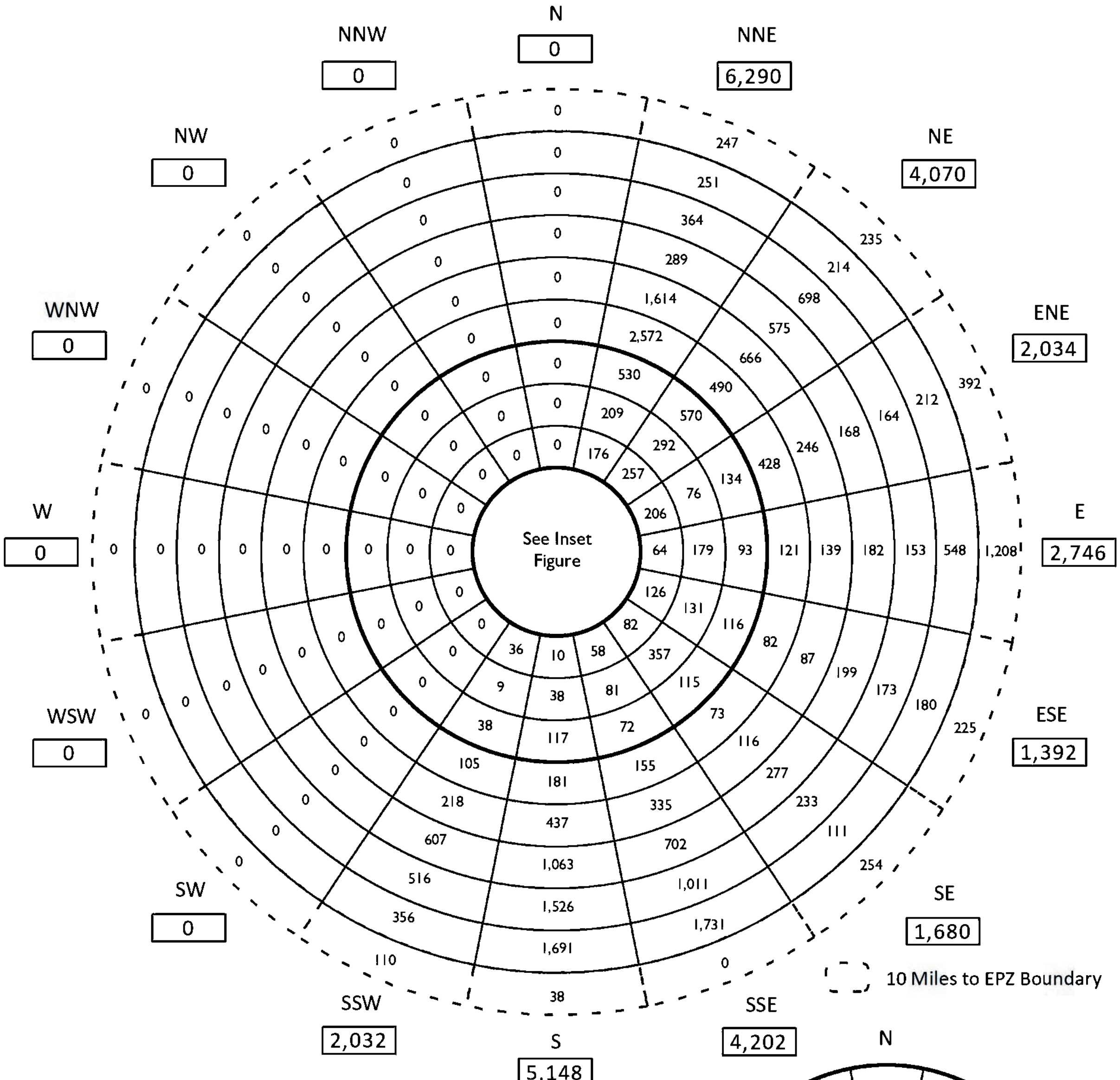


Figure 3-1. PAAs Comprising the PPP EPZ



2020 Permanent Resident Population

Miles	Subtotal by Ring	Cumulative Total
0 - 1	47	47
1 - 2	407	454
2 - 3	1,015	1,469
3 - 4	1,372	2,841
4 - 5	1,785	4,626
5 - 6	4,207	8,833
6 - 7	3,858	12,691
7 - 8	4,062	16,753
8 - 9	4,838	21,591
9 - 10	5,294	26,885
10 - EPZ	2,709	29,594
	Total:	29,594

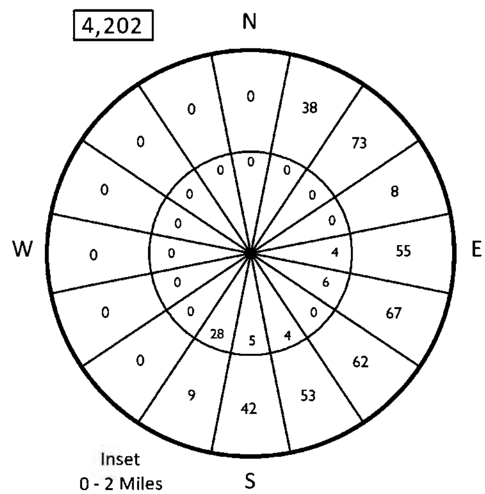
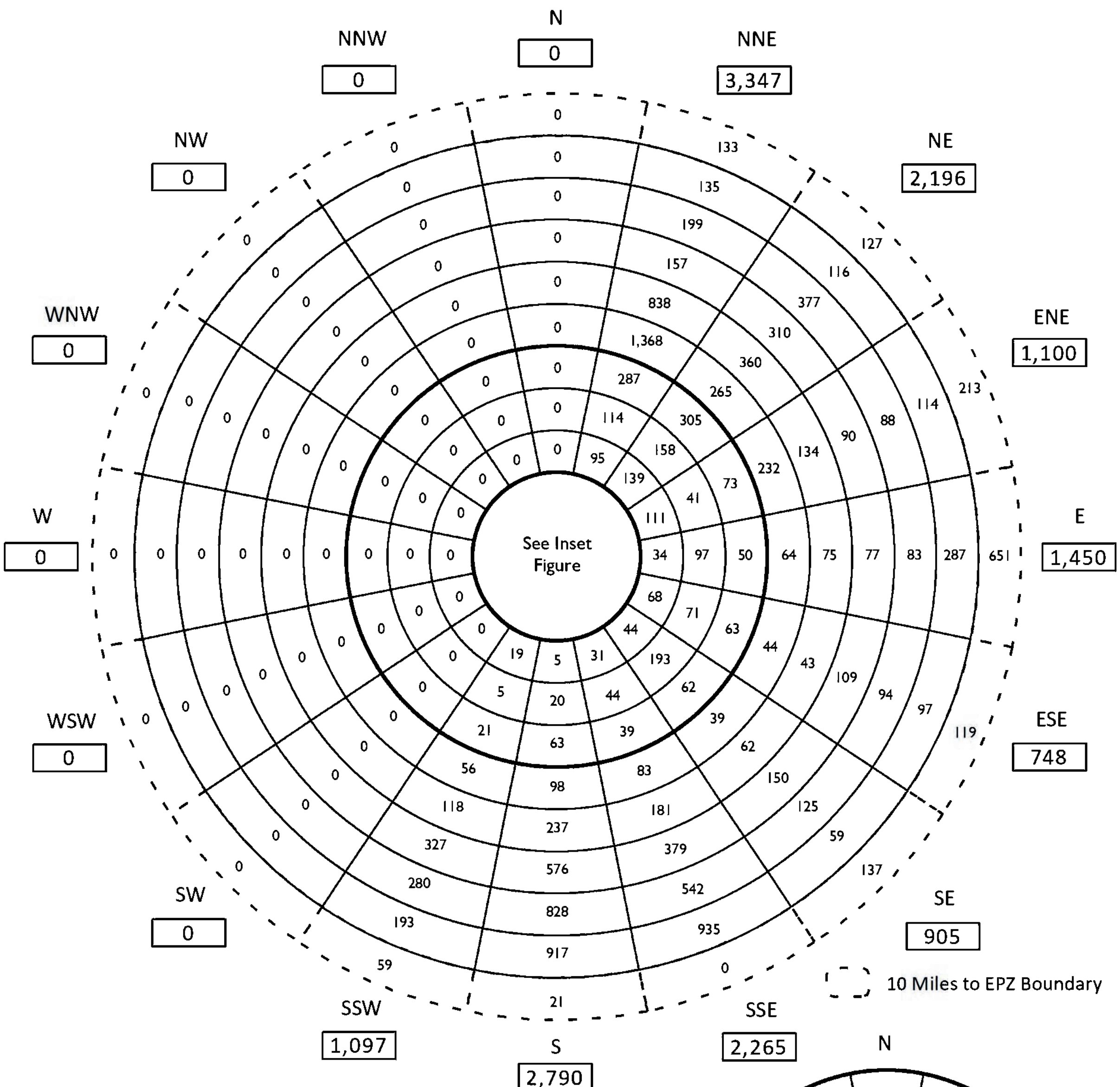


Figure 3-2. Permanent Resident Population by Sector



Resident Vehicles

Miles	Subtotal by Ring	Cumulative Total
0 - 1	24	24
1 - 2	221	245
2 - 3	546	791
3 - 4	743	1,534
4 - 5	963	2,497
5 - 6	2,249	4,746
6 - 7	2,048	6,794
7 - 8	2,175	8,969
8 - 9	2,616	11,585
9 - 10	2,853	14,438
10 - EPZ	1,460	15,898
	Total:	15,898

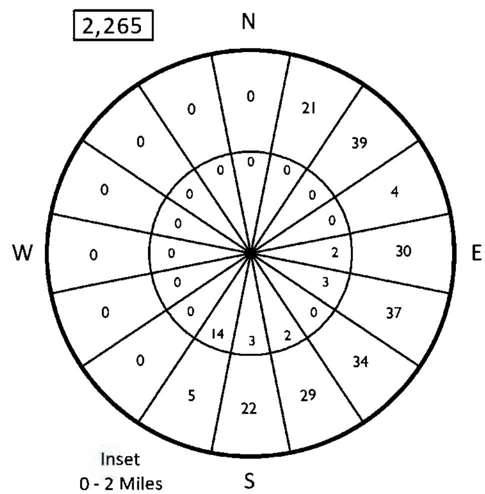
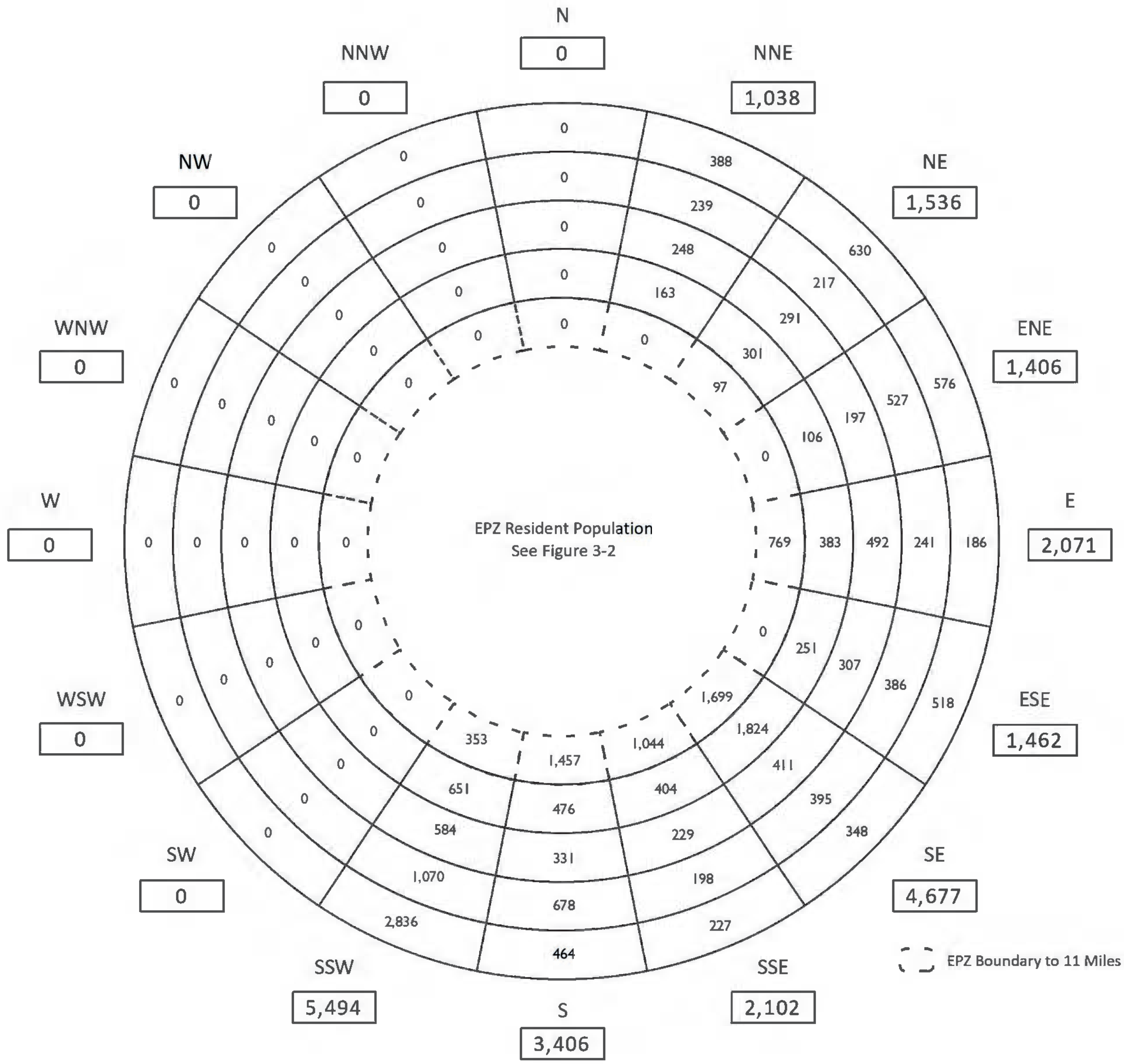


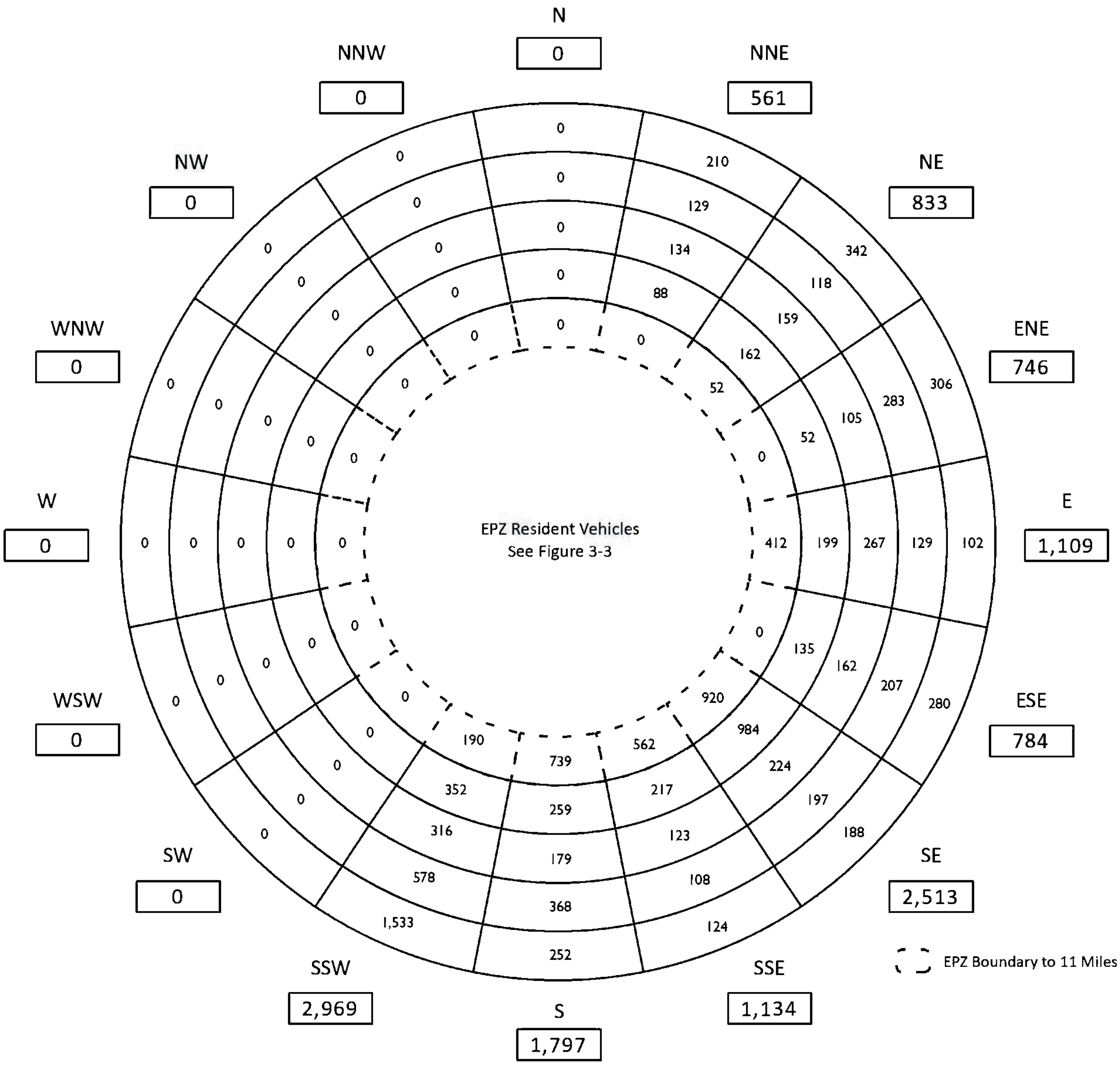
Figure 3-3. Permanent Resident Vehicles by Sector



2020 Shadow Population

Miles	Subtotal by Ring	Cumulative Total
EPZ - 11	5,419	5,419
11 - 12	4,559	9,978
12 - 13	3,090	13,068
13 - 14	3,951	17,019
14 - 15	6,173	23,192
	Total:	23,192

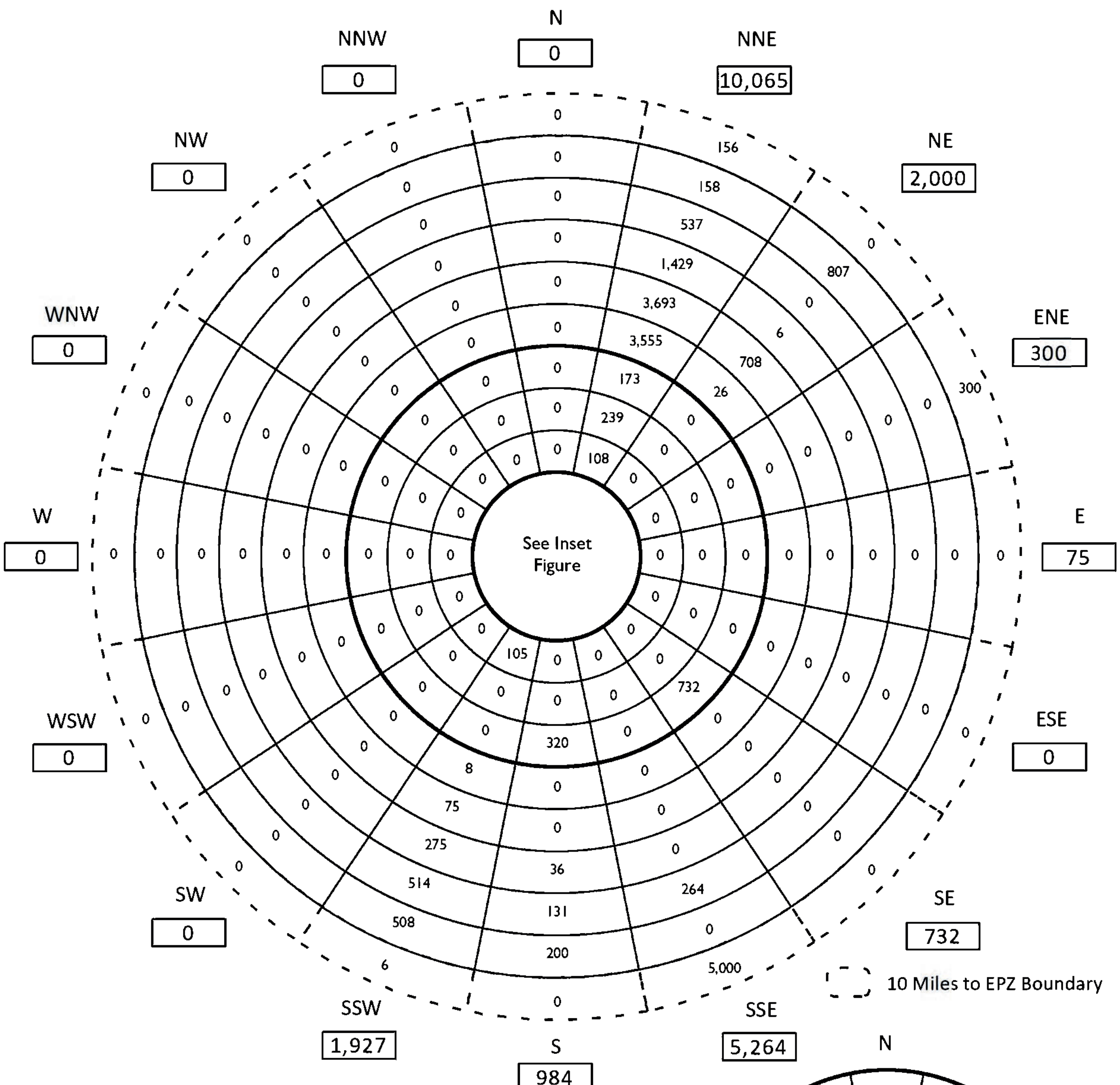
Figure 3-4. Shadow Population by Sector



Shadow Vehicles

Miles	Subtotal by Ring	Cumulative Total
EPZ - 11	2,875	2,875
11 - 12	2,448	5,323
12 - 13	1,669	6,992
13 - 14	2,117	9,109
14 - 15	3,337	12,446
	Total:	12,446

Figure 3-5. Shadow Vehicles by Sector



Transients

Miles	Subtotal by Ring	Cumulative Total
0 - 1	567	567
1 - 2	711	1,278
2 - 3	213	1,491
3 - 4	239	1,730
4 - 5	1,225	2,955
5 - 6	3,589	6,544
6 - 7	4,476	11,020
7 - 8	1,746	12,766
8 - 9	1,446	14,212
9 - 10	1,673	15,885
10 - EPZ	5,462	21,347
	Total:	21,347

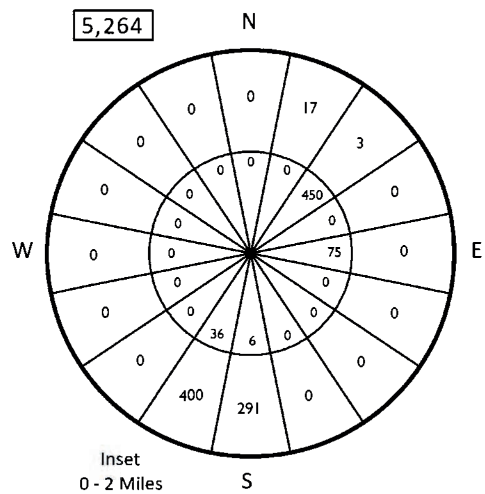
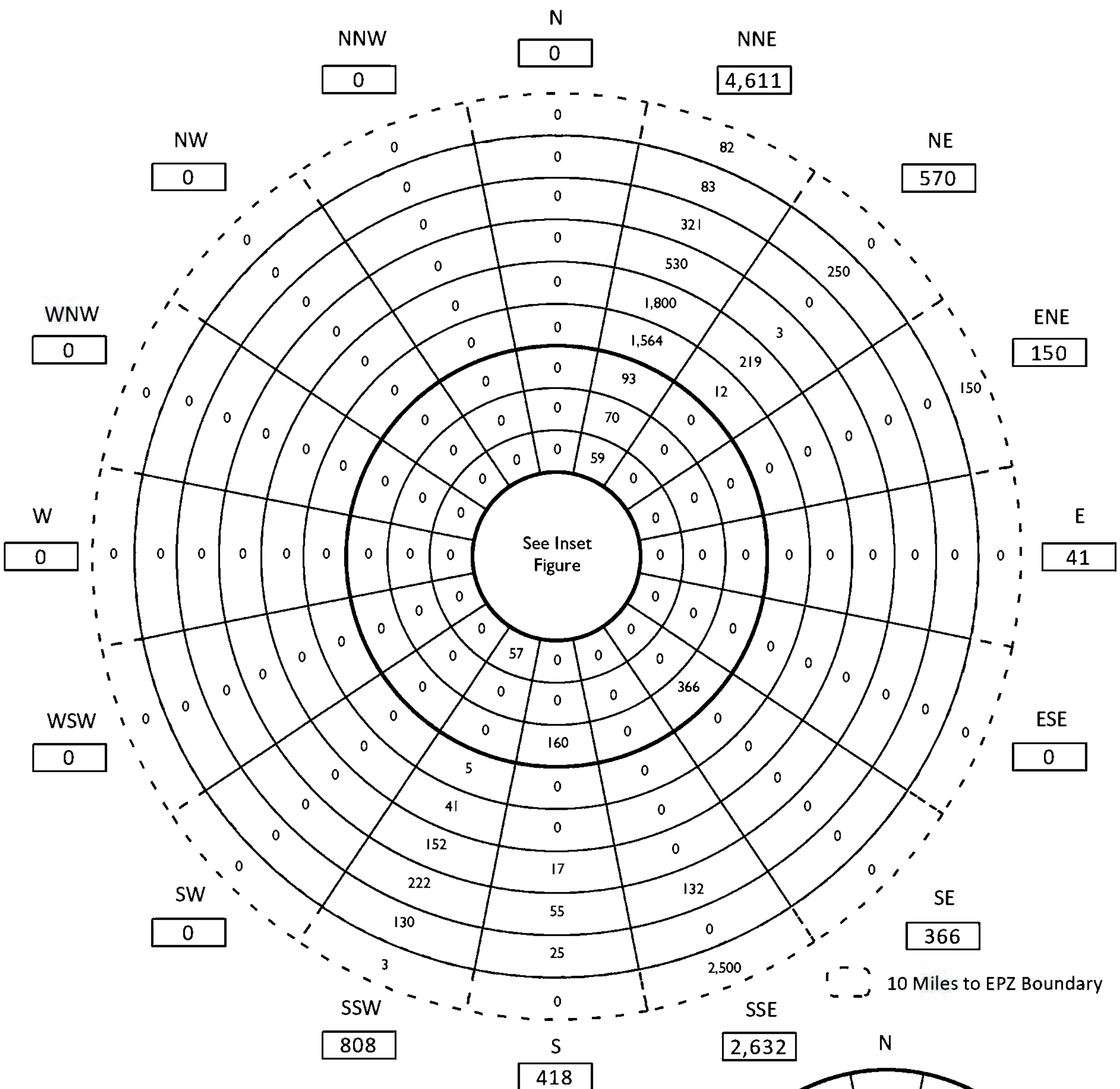


Figure 3-6. Transient Population by Sector



Transient Vehicles

Miles	Subtotal by Ring	Cumulative Total
0 - 1	148	148
1 - 2	347	495
2 - 3	116	611
3 - 4	70	681
4 - 5	619	1,300
5 - 6	1,581	2,881
6 - 7	2,060	4,941
7 - 8	702	5,643
8 - 9	730	6,373
9 - 10	488	6,861
10 - EPZ	2,735	9,596
	Total:	9,596

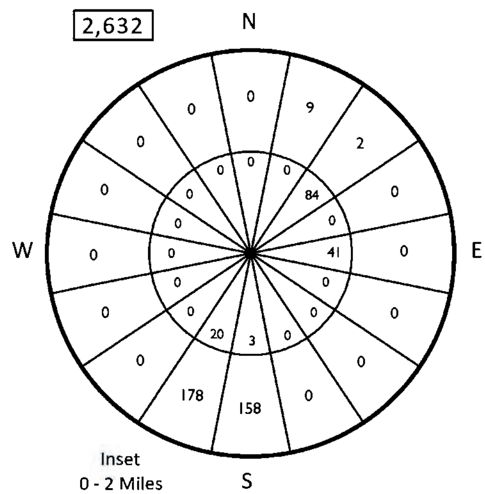
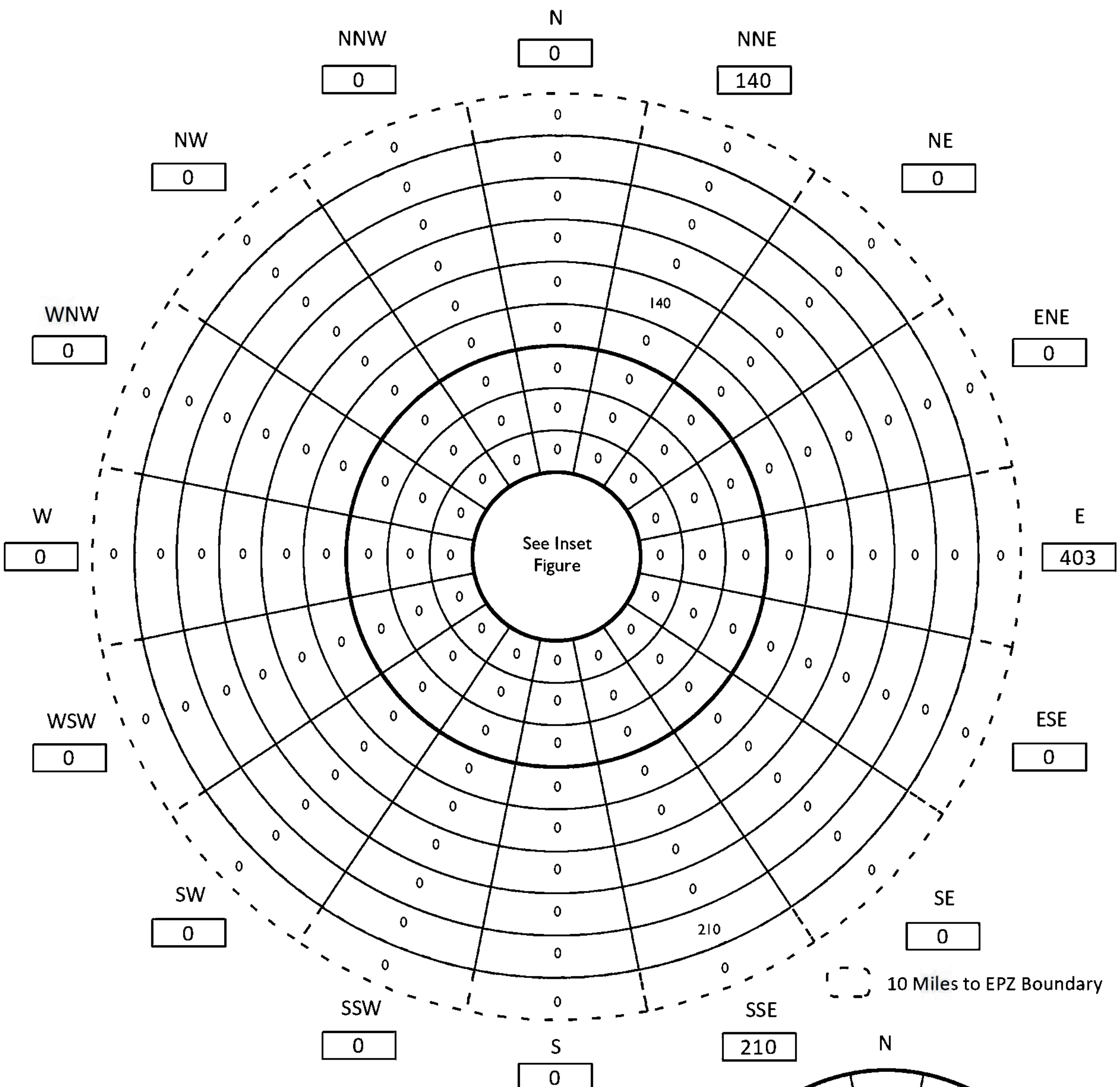


Figure 3-7. Transient Vehicles by Sector



Employees

Miles	Subtotal by Ring	Cumulative Total
0 - 1	403	403
1 - 2	0	403
2 - 3	0	403
3 - 4	0	403
4 - 5	0	403
5 - 6	0	403
6 - 7	140	543
7 - 8	0	543
8 - 9	0	543
9 - 10	210	753
10 - EPZ	0	753
	Total:	753

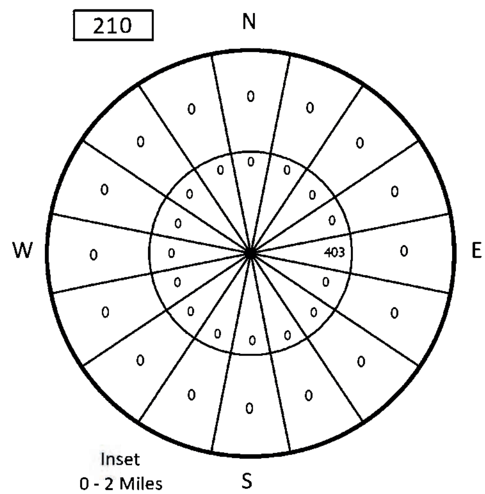
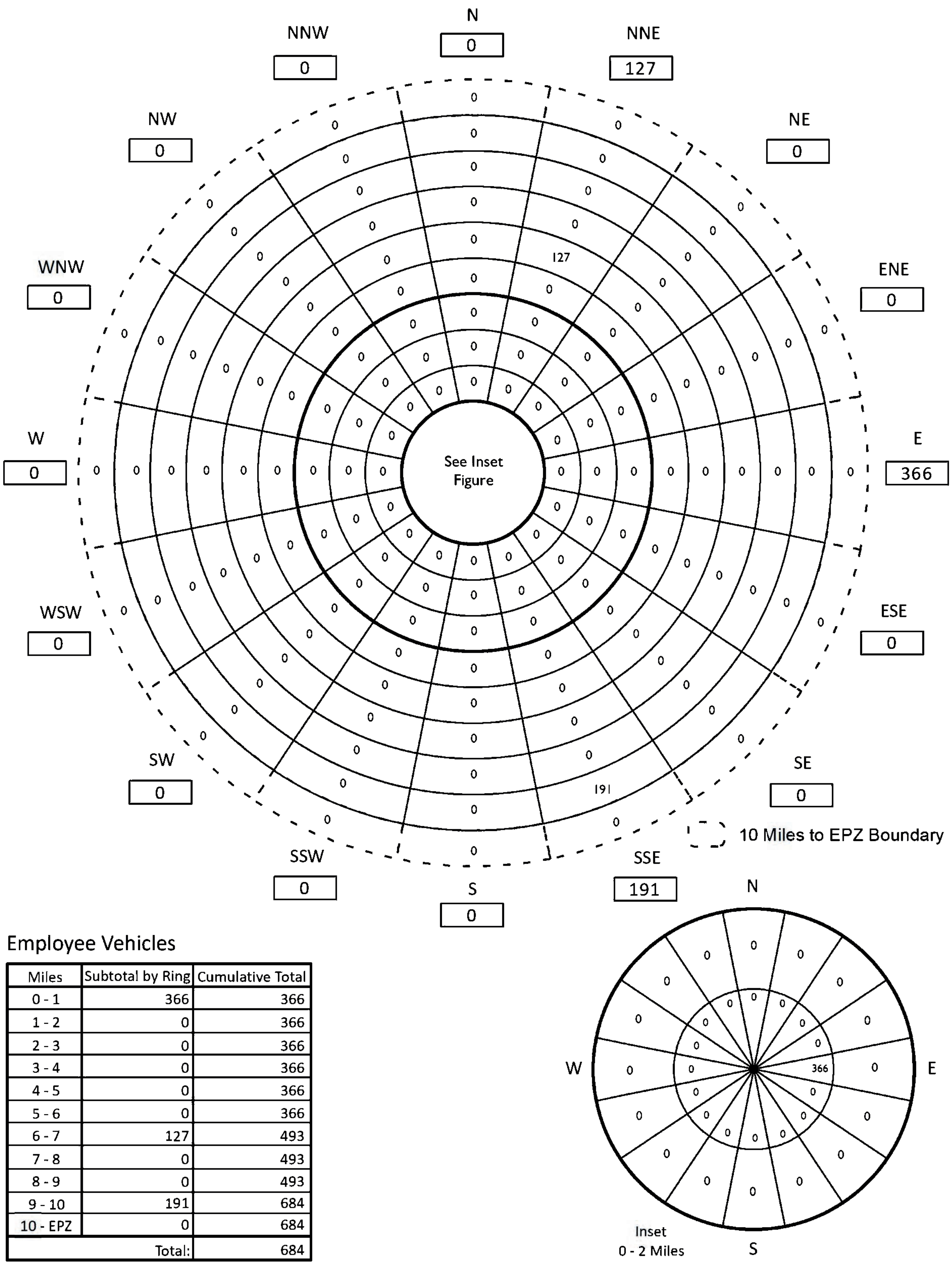


Figure 3-8. Employee Population by Sector



Employee Vehicles

Miles	Subtotal by Ring	Cumulative Total
0 - 1	366	366
1 - 2	0	366
2 - 3	0	366
3 - 4	0	366
4 - 5	0	366
5 - 6	0	366
6 - 7	127	493
7 - 8	0	493
8 - 9	0	493
9 - 10	191	684
10 - EPZ	0	684
	Total:	684

Figure 3-9. Employee Vehicles by Sector

4 ESTIMATION OF HIGHWAY CAPACITY

The ability of the road network to service vehicle demand is a major factor in determining how rapidly an evacuation can be completed. The capacity of a road is defined as the maximum hourly rate at which persons or vehicles can reasonably be expected to traverse a point or uniform section of a lane of roadway during a given time period under prevailing roadway, traffic and control conditions, as stated in the 2016 Highway Capacity Manual (HCM 2016). This section discusses how the capacity of the roadway network was estimated.

In discussing capacity, different operating conditions have been assigned alphabetical designations, A through F, to reflect the range of traffic operational characteristics. These designations have been termed "Levels of Service" (LOS). For example, LOS A connotes free-flow and high-speed operating conditions; LOS F represents a forced flow condition. LOS E describes traffic operating at or near capacity.

Another concept, closely associated with capacity, is "Service Volume". Service Volume (SV) is defined as "The maximum hourly rate at which vehicles, bicycles or persons reasonably can be expected to traverse a point or uniform section of a roadway during an hour under specific assumed conditions while maintaining a designated level of service." This definition is similar to that for capacity. The major distinction is that values of SV vary from one LOS to another, while capacity is the SV at the upper bound of LOS E, only.

Thus, in simple terms, the SV is the maximum traffic that can travel on a road and still maintain a certain perceived level of quality to a driver based on the A, B, C, rating system (LOS). Any additional vehicles above the SV would drop the rating to a lower letter grade.

This distinction is illustrated in Exhibit 12-37 of the HCM 2016. As indicated there, the SV varies with Free Flow Speed (FFS), and LOS. The SV is calculated by the DYNEV II simulation model, based on the specified link attributes, FFS, capacity, control device and traffic demand.

Other factors also influence capacity. These include, but are not limited to:

- Lane width
- Shoulder width
- Pavement condition
- Horizontal and vertical alignment (curvature and grade)
- Percent truck traffic
- Control device (and timing, if it is a signal)
- Weather conditions (rain, snow, fog, wind speed, ice)

These factors are considered during the road survey and in the capacity estimation process; some factors have greater influence on capacity than others. For example, lane and shoulder width have only a limited influence on Base Free Flow Speed (BFFS[1]) according to Exhibit 15-7 of the HCM. Consequently, lane and shoulder widths at the narrowest points were observed

[1] A very rough estimate of BFFS might be taken as the posted speed limit plus 10 mph (HCM 2016, Page 15-15)

during the road survey and these observations were recorded, but no detailed measurements of lane or shoulder width were taken. Horizontal and vertical alignment can influence both FFS and capacity. The estimated FFS were measured using the survey vehicle's speedometer and observing local traffic, under free flow conditions. Free flow speeds ranged from 25 to 75 mph. Capacity is estimated from the procedures of the HCM 2016. For example, HCM Exhibit 7-1(b) shows the sensitivity of SV at the upper bound of LOS D to grade (capacity is the SV at the upper bound of LOS E).

The amount of traffic that can flow on a roadway is effectively governed by vehicle speed and spacing. The faster that vehicle can travel when closely spaced, the higher the amount of flow. As discussed in Section 2.6, it is necessary to adjust capacity figures to represent the prevailing conditions. Adverse conditions like inclement weather, construction, and other incidents tend to slow traffic down and often, also increases vehicle-to-vehicle separation, thus decreasing the amount of traffic flow. Based on limited empirical data, weather conditions such as rain reduce the values of free-flow speed and of highway capacity by approximately 10 percent. Over the last decade new studies have been made on the effects of rain/light snow and heavy snow on traffic capacity. These studies indicate a range of effects between 5 and 25 percent depending on wind speed and precipitation rates. As indicated in Section 2.6, we employ a reduction in free speed and in highway capacity of 10% for rain/light snow and a reduction in free speed and in highway capacity of 15% and 25% for heavy snow, respectively.

Since congestion arising from evacuation may be significant, estimates of roadway capacity must be determined with great care. Because of its importance, a brief discussion of the major factors that influence highway capacity is presented in this section.

Rural highways generally consist of: (1) one or more uniform sections with limited access (driveways, parking areas) characterized by "uninterrupted" flow; and (2) approaches to at-grade intersections where flow can be "interrupted" by a control device or by turning or crossing traffic at the intersection. Due to these differences, separate estimates of capacity must be made for each section. Often, the approach to the intersection is widened by the addition of one or more lanes (turn pockets or turn bays), to compensate for the lower capacity of the approach due to the factors there that can interrupt the flow of traffic. These additional lanes are recorded during the field survey and later entered as input to the DYNEV II system.

4.1 Capacity Estimations on Approaches to Intersections

At-grade intersections are apt to become the first bottleneck locations under local heavy traffic volume conditions. This characteristic reflects the need to allocate access time to the respective competing traffic streams by exerting some form of control. During evacuation, control at critical intersections will often be provided by traffic control personnel assigned for that purpose, whose directions may supersede traffic control devices. The existing traffic management plans documented in county emergency plans are extensive and were adopted without change. See Appendix G for more information.

The per-lane capacity of an approach to a signalized intersection can be expressed (simplistically) in the following form:

$$Q_{cap,m} = \left(\frac{3600}{h_m}\right) \times \left(\frac{G-L}{C}\right)_m = \left(\frac{3600}{h_m}\right) \times P_m$$

where:

$Q_{cap,m}$	=	Capacity of a single lane of traffic on an approach, which executes movement, *m*, upon entering the intersection; vehicles per hour (vph)
h_m	=	Mean queue discharge headway of vehicles on this lane that are executing movement, *m*; seconds per vehicle
G	=	Mean duration of GREEN time servicing vehicles that are executing movement, *m*, for each signal cycle; seconds
L	=	Mean "lost time" for each signal phase servicing movement, *m*; seconds
C	=	Duration of each signal cycle; seconds
P_m	=	Proportion of GREEN time allocated for vehicles executing movement, *m*, from this lane. This value is specified as part of the control treatment.
m	=	The movement executed by vehicles after they enter the intersection: through, left-turn, right-turn, and diagonal.

The turn-movement-specific mean discharge headway h_m, depends in a complex way upon many factors: roadway geometrics, turn percentages, the extent of conflicting traffic streams, the control treatment, and others. A primary factor is the value of "saturation queue discharge headway", h_{sat}, which applies to through vehicles that are not impeded by other conflicting traffic streams. This value, itself, depends upon many factors including motorist behavior. Formally, we can write,

$$h_m = f_m(h_{sat}, F, F_2, \dots)$$

where:

h_{sat}	=	Saturation discharge headway for through vehicles; seconds per vehicle
F_1, F_2	=	The various known factors influencing h_m
$f_m(\ )$	=	Complex function relating h_m to the known (or estimated) values of h_{sat}, F_1, F_2, …

The estimation of h_m for specified values of h_{sat}, F_1, F_2, ... is undertaken within the DYNEV II simulation model by a mathematical model[2]. The resulting values for h_m always satisfy the condition:

$$h_m \geq h_{sat}$$

That is, the turn-movement-specific discharge headways are always greater than, or equal to the saturation discharge headway for through vehicles. These headways (or its inverse equivalent, "saturation flow rate"), may be determined by observation or using the procedures of the HCM 2016.

The above discussion is necessarily brief given the scope of this evacuation time estimate (ETE) report and the complexity of the subject of intersection capacity. In fact, Chapters 19, 20 and 21 in the HCM 2016 address this topic. The factors, F_1, F_2,…, influencing saturation flow rate are identified in equation (19-8) of the HCM 2016.

The traffic signals within the EPZ and Shadow Region are modeled using representative phasing plans and phase durations obtained as part of the field data collection. Traffic responsive signal installations allow the proportion of green time allocated (P_m) for each approach to each intersection to be determined by the expected traffic volumes on each approach during evacuation circumstances. The amount of green time (G) allocated is subject to maximum and minimum phase duration constraints; 2 seconds of yellow time are indicated for each signal phase and 1 second of all-red time is assigned between signal phases, typically. If a signal is pre-timed, the yellow and all-red times observed during the road survey are used. A lost time (L) of 2.0 seconds is used for each signal phase in the analysis.

4.2 Capacity Estimation along Sections of Highway

The capacity of highway sections -- as distinct from approaches to intersections -- is a function of roadway geometrics, traffic composition (e.g., percent heavy trucks and buses in the traffic stream) and, of course, motorist behavior. There is a fundamental relationship which relates SV (i.e., the number of vehicles serviced within a uniform highway section in a given time period) to traffic density. The top curve in Figure 4-1 illustrates this relationship.

As indicated, there are two flow regimes: (1) Free Flow (left side of curve); and (2) Forced Flow (right side). In the Free Flow regime, the traffic demand is fully serviced; the SV increases as demand volume and density increase, until the SV attains its maximum value, which is the capacity of the highway section. As traffic demand and the resulting highway density increase beyond this "critical" value, the rate at which traffic can be serviced (i.e., the SV) can actually decline below capacity ("capacity drop"). Therefore, in order to realistically represent traffic performance during congested conditions (i.e., when demand exceeds capacity), it is necessary to estimate the SV, V_F, under congested conditions.

[2]Lieberman, E., "Determining Lateral Deployment of Traffic on an Approach to an Intersection", McShane, W. & Lieberman, E., "Service Rates of Mixed Traffic on the far Left Lane of an Approach". Both papers appear in Transportation Research Record 772, 1980. Lieberman, E., Xin, W., "Macroscopic Traffic Modeling For Large-Scale Evacuation Planning", presented at the TRB 2012 Annual Meeting, January 22-26, 2012

The value of V_F can be expressed as:

$$V_F = R \times Capacity$$

where:

R = Reduction factor which is less than unity

We have employed a value of R=0.90. The advisability of such a capacity reduction factor is based upon empirical studies that identified a fall-off in the service flow rate when congestion occurs at "bottlenecks" or "choke points" on a freeway system. Zhang and Levinson[3] describe a research program that collected data from a computer-based surveillance system (loop detectors) installed on the Interstate Highway System, at 27 active bottlenecks in the twin cities metro area in Minnesota over a 7-week period. When flow breakdown occurs, queues are formed which discharge at lower flow rates than the maximum capacity prior to observed breakdown. These queue discharge flow (QDF) rates vary from one location to the next and vary by day of week and time of day based upon local circumstances. The cited reference presents a mean QDF of 2,016 passenger cars per hour per lane (pcphpl). This figure compares with the nominal capacity estimate of 2,250 pcphpl estimated for the ETE and indicated in Appendix K for freeway links. The ratio of these two numbers is 0.896 which translates into a capacity reduction factor of 0.90.

Since the principal objective of ETE analyses is to develop a "realistic" estimate of evacuation times, use of the representative value for this capacity reduction factor (R=0.90) is justified. This factor is applied only when flow breaks down, as determined by the simulation model.

Rural roads, like freeways, are classified as "uninterrupted flow" facilities. (This is in contrast with urban street systems which have closely spaced signalized intersections and are classified as "interrupted flow" facilities.) As such, traffic flow along rural roads is subject to the same effects as freeways in the event traffic demand exceeds the nominal capacity, resulting in queuing and lower QDF rates. As a practical matter, rural roads rarely break down at locations away from intersections. Any breakdowns on rural roads are generally experienced at intersections where other model logic applies, or at lane drops which reduce capacity there. Therefore, the application of a factor of 0.90 is appropriate on rural roads, but rarely, if ever, activated.

The estimated value of capacity is based primarily upon the type of facility and on roadway geometrics. Sections of roadway with adverse geometrics are characterized by lower free-flow speeds and lane capacity. Exhibit 15-46 in the HCM 2016 was referenced to estimate saturation flow rates. The impact of narrow lanes and shoulders on free-flow speed and on capacity is not material, particularly when flow is predominantly in one direction as is the case during an evacuation.

[3] Lei Zhang and David Levinson, "Some Properties of Flows at Freeway Bottlenecks," Transportation Research Record 1883, 2004.

The procedure used here was to estimate "section" capacity, V_E, based on observations made traveling over each section of the evacuation network, based on the posted speed limits and travel behavior of other motorists and by reference to the HCM 2016. The DYNEV II simulation model determines for each highway section, represented as a network link, whether its capacity would be limited by the "section-specific" service volume, V_E, or by the intersection-specific capacity. For each link, the model selects the lower value of capacity.

4.3 Application to the PPP Study Area

As part of the development of the link-node analysis network for the study area, an estimate of roadway capacity is required. The source material for the capacity estimates presented herein is contained in:

> 2016 Highway Capacity Manual (HCM 2016)
> Transportation Research Board
> National Research Council
> Washington, D.C.

The highway system in the study area consists primarily of three categories of roads and, of course, intersections:

- Two-Lane roads: Local, State
- Multilane Highways (at-grade)
- Freeways

Each of these classifications will be discussed.

4.3.1 Two-Lane Roads

Ref: HCM 2016 Chapter 15

Two lane roads comprise the majority of highways within the study area (EPZ and Shadow Region). The per-lane capacity of a two-lane highway is estimated at 1,700 passenger cars per hour (pc/h). This estimate is essentially independent of the directional distribution of traffic volume except that, for extended distances, the two-way capacity will not exceed 3,200 pc/h. The HCM 2016 procedures then estimate Level of Service (LOS) and Average Travel Speed. The DYNEV II simulation model accepts the specified value of capacity as input and computes average speed based on the time-varying demand: capacity relations.

Based on the field survey and on expected traffic operations associated with evacuation scenarios:

- Most sections of two-lane roads within the study area, are classified as “Class I”, with "level terrain"; some are “rolling terrain”.
- “Class II” highways are mostly those within urban and suburban centers.

4.3.2 Multilane Highway

Ref: HCM 2016 Chapter 14

Exhibit 12-8 of the HCM 2016 presents a set of curves that indicate a per-lane capacity ranging from approximately 1,900 to 2,200 pc/h, for free-speeds of 45 to 70 mph, respectively. Based on observation, the multilane highways outside of urban areas within the study area service traffic with free-speeds in this range. The actual time-varying speeds computed by the simulation model reflect the demand to capacity relationship and the impact of control at intersections. A conservative estimate of per-lane capacity of 1,900 pc/h is adopted for this study for multilane highways outside of urban areas, as shown in Appendix K.

4.3.3 Freeways

Ref: HCM 2016 Chapters 10, 12, 13, 14

Chapter 10 of the HCM 2016 describes a procedure for integrating the results obtained in Chapters 12, 13 and 14, which compute capacity and LOS for freeway components. Chapter 10 also presents a discussion of simulation models. The DYNEV II simulation model automatically performs this integration process.

Chapter 12 of the HCM 2016 presents procedures for estimating capacity and LOS for "Basic Freeway Segments". Exhibit 12-37 of the HCM 2016 presents capacity vs. free speed estimates, which are provided below.

Free Speed (mph):	55	60	65	70+
Per-Lane Capacity (pc/h):	2,250	2,300	2,350	2,400

The inputs to the simulation model are highway geometrics, free-speeds and capacity based on field observations. The simulation logic calculates actual time-varying speeds based on demand: capacity relationships. A conservative estimate of per-lane capacity of 2,250 pc/h is adopted for this study for freeways, as shown in Appendix K.

Chapter 13 of the HCM 2016 presents procedures for estimating capacity, speed, density and LOS for freeway weaving sections. The simulation model contains logic that relates speed to demand volume: capacity ratio. The value of capacity obtained from the computational procedures detailed in Chapter 13 depends on the "Type" and geometrics of the weaving segment and on the "Volume Ratio" (ratio of weaving volume to total volume).

Chapter 14 of the HCM 2016 presents procedures for estimating capacities of ramps and of "merge" areas. There are three significant factors to the determination of capacity of a ramp-freeway junction: The capacity of the freeway immediately downstream of an on-ramp or immediately upstream of an off-ramp; the capacity of the ramp roadway; and the maximum flow rate entering the ramp influence area. In most cases, the freeway capacity is the controlling factor. Values of this merge area capacity are presented in Exhibit 14-10 of the HCM

2016 and depend on the number of freeway lanes and on the freeway free speed. Ramp capacity is presented in Exhibit 14-12 and is a function of the ramp FFS. The DYNEV II simulation model logic simulates the merging operations of the ramp and freeway traffic in accord with the procedures in Chapter 14 of the HCM 2016. If congestion results from an excess of demand relative to capacity, then the model allocates service appropriately to the two entering traffic streams and produces LOS F conditions (The HCM 2016 does not address LOS F explicitly).

4.3.4 Intersections

Ref: HCM 2016 Chapters 19, 20, 21, 22

Procedures for estimating capacity and LOS for approaches to intersections are presented in Chapter 19 (signalized intersections), Chapters 20, 21 (un-signalized intersections) and Chapter 22 (roundabouts). The complexity of these computations is indicated by the aggregate length of these chapters. The DYNEV II simulation logic is likewise complex.

The simulation model explicitly models intersections: Stop/yield controlled intersections (both 2-way and all-way) and traffic signal controlled intersections. Where intersections are controlled by fixed time controllers, traffic signal timings are set to reflect average (non-evacuation) traffic conditions. Actuated traffic signal settings respond to the time-varying demands of evacuation traffic to adjust the relative capacities of the competing intersection approaches.

The model is also capable of modeling the presence of manned traffic control. At specific locations where it is advisable or where existing plans call for overriding existing traffic control to implement manned control, the model will use actuated signal timings that reflect the presence of traffic guides. At locations where a special traffic control strategy (continuous left-turns, contra-flow lanes) is used, the strategy is modeled explicitly. The type of traffic control for nodes in the evacuation network are noted in Appendix K..

4.4 Simulation and Capacity Estimation

Chapter 6 of the HCM 2016 is entitled, "HCM and Alternative Analysis Tools." The chapter discusses the use of alternative tools such as simulation modeling to evaluate the operational performance of highway networks. Among the reasons cited in Chapter 6 to consider using simulation as an alternative analysis tool is:

> *"The system under study involves a group of different facilities or travel modes with mutual interactions invoking several HCM chapters. Alternative tools are able to analyze these facilities as a single system."*

This statement succinctly describes the analyses required to determine traffic operations across an area encompassing an EPZ operating under evacuation conditions. The model utilized for this study, DYNEV II, is further described in Appendix C. It is essential to recognize that simulation models do not replicate the methodology and procedures of the HCM 2016 – they *replace* these procedures by describing the complex interactions of traffic flow and computing Measures of Effectiveness (MOE) detailing the operational performance of traffic over time and

by location. The DYNEV II simulation model includes some HCM 2016 procedures only for the purpose of estimating capacity.

All simulation models must be calibrated properly with field observations that quantify the performance parameters applicable to the analysis network. Two of the most important of these are: (1) FFS; and (2) saturation headway, h_{sat}. The first of these is estimated by direct observation during the road survey; the second is estimated using the concepts of the HCM 2016, as described earlier. These parameters are listed in Appendix K, for each network link.

It is important to note that simulation is a mathematical representation of an assumed set of conditions using the best available knowledge and understanding of traffic flow and available inputs. Simulation should not be assumed to be a prediction of what will happen under any event because a real evacuation can be impacted by an infinite number of things – many of which will differ from these test cases – and many others cannot be taken into account with the tools available.

4.5 Boundary Condition

As illustrated in Figure 1-2 and in Appendix K, the link-node analysis network used for this study is finite. The analysis network does extend well beyond the 15-mile radial study area in some locations in order to model intersections with other major evacuation routes beyond the study area. However, the network does have an end at the destination (exit) nodes as discussed in Appendix C. Beyond these destination nodes, there may be signalized intersections or merge points that impact the capacity of the evacuation routes leaving the study area. Rather than neglect these "boundary conditions," this study assumes a 25% reduction in capacity on two-lane roads (Section 4.3.1 above) and multilane highways (Section 4.3.2 above). There is no reduction in capacity for freeways due to boundary conditions. The 25% reduction in capacity is based on the prevalence of actuated traffic signals in the study area and the fact that the evacuating traffic volume will be more significant than the competing traffic volume at any downstream signalized intersections, thereby warranting a more significant percentage (75% in this case) of the signal green time.

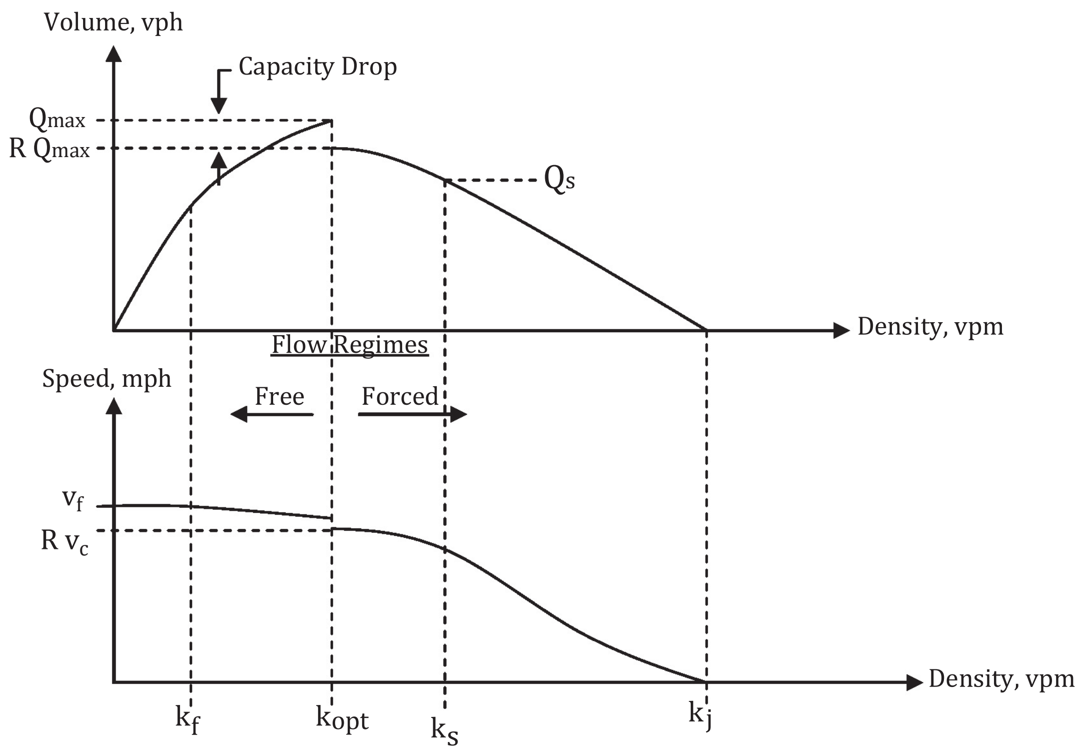


Figure 4-1. Fundamental Diagrams

5 ESTIMATION OF TRIP GENERATION TIME

Federal guidance (see NUREG/CR-7002, Rev. 1) specify that the Evacuation Time Estimate (ETE) study estimate the distributions of elapsed times associated with mobilization activities undertaken by the public to prepare for the evacuation trip. The elapsed time associated with each activity is represented as a statistical distribution reflecting differences between members of the public. The quantification of these activity-based distributions relies largely on the results of the demographic survey. We define the sum of these distributions of elapsed times as the Trip Generation Time Distribution.

5.1 Background

In general, an accident at a nuclear power plant is characterized by the following Emergency Action Levels (see Section C of Part IV of Appendix E of 10 CFR 50 for details):

1. Unusual Event
2. Alert
3. Site Area Emergency
4. General Emergency

At each level, the Federal guidelines specify a set of Actions to be undertaken by the Licensee, and by the state and local offsite agencies. As a Planning Basis, we will adopt a conservative posture, in accordance with Section 1.2 of NUREG/CR-7002, Rev. 1, that a rapidly escalating accident at the plant wherein evacuation is ordered promptly and no early protective actions have been implemented will be considered in calculating the Trip Generation time. We will assume:

1. The Advisory to Evacuate (ATE) will be announced coincident with the siren notification.
2. Mobilization of the general population will commence within 15 minutes after the siren notification.
3. The ETE are measured relative to the ATE.

We emphasize that the adoption of this planning basis is not a representation that these events will occur within the indicated time frame. Rather, these assumptions are necessary in order to:

1. Establish a temporal framework for estimating the Trip Generation distribution in the format recommended in Section 2.13 of NUREG/CR-6863.
2. Identify temporal points of reference that uniquely define "Clear Time" and ETE.

It is likely that a longer time will elapse between the various classes of an emergency. For example, suppose one-hour elapses from the siren alert to the ATE. In this case, it is reasonable to expect some degree of spontaneous evacuation by the public during this one-hour period. As a result, the population within the Emergency Planning Zone (EPZ) will be lower when the ATE is announced, than at the time of the siren alert. In addition, many will engage in preparation activities to evacuate, in anticipation that an Advisory will be broadcasted. Thus, the time needed to complete the mobilization activities and the number of people remaining to

evacuate the EPZ after the ATE, will both be somewhat less than the estimates presented in this report. Consequently, the ETE presented in this report are higher than the actual evacuation time, if this hypothetical situation were to take place.

The notification process consists of two events:

1. Transmitting information using the alert and notification systems (ANS) available within the EPZ (e.g., sirens, tone alerts, EAS broadcasts, loud speakers).
2. Receiving and correctly interpreting the information that is transmitted.

The population within the EPZ is dispersed over an area of approximately 183 square miles and is engaged in a wide variety of activities. It must be anticipated that some time will elapse between the transmission and receipt of the information advising the public of an accident.

The amount of elapsed time will vary from one individual to the next depending on where that person is, what that person is doing, and related factors. Furthermore, some persons who will be directly involved with the evacuation process may be outside the EPZ at the time the emergency is declared. These people may be commuters, shoppers and other travelers who reside within the EPZ and who will return to join the other household members upon receiving notification of an emergency.

As indicated in Section 2.13 of NUREG/CR-6863, the estimated elapsed times for the receipt of notification can be expressed as a distribution reflecting the different notification times for different people within, and outside, the EPZ. By using time distributions, it is also possible to distinguish between different population groups and different day-of-week and time-of-day scenarios, so that accurate ETE may be computed.

For example, people at home or at work within the EPZ will be notified by siren, and/or tone alert and/or radio (if available). Those well outside the EPZ will be notified by telephone, radio, TV and word-of-mouth, with potentially longer time lags. Furthermore, the spatial distribution of the EPZ population will differ with time of day - families will be united in the evenings, but dispersed during the day. In this respect, weekends will differ from weekdays.

As indicated in Section 4.1 of NUREG/CR-7002, Rev. 1 the information required to compute trip generation times is typically obtained from a demographic survey of EPZ residents. Such a survey was conducted in support of this ETE study for this site. Appendix F discusses the survey sampling plan, documents the survey instrument utilized, and provides the survey results. It is important to note that the shape and duration of the evacuation trip mobilization distribution is important at sites where traffic congestion is not expected to cause the ETE to extend in time well beyond the trip generation period. The remaining discussion will focus on the application of the trip generation data obtained from the demographic survey to the development of the ETE documented in this report.

5.2 Fundamental Considerations

The environment leading up to the time that people begin their evacuation trips consists of a sequence of events and activities. Each event (other than the first) occurs at an instant in time and is the outcome of an activity.

Activities are undertaken over a period of time. Activities may be in "series" (to undertake an activity implies the completion of all preceding events) or may be in parallel (two or more activities may take place over the same period of time). Activities conducted in series are functionally dependent on the completion of prior activities; activities conducted in parallel are functionally independent of one another. The relevant events associated with the public's preparation for evacuation are:

Event Number	Event Description
1	Notification
2	Awareness of Situation
3	Depart Work
4	Arrive Home
5	Depart on Evacuation Trip

Associated with each sequence of events are one or more activities, as outlined in Table 5-1:

These relationships are shown graphically in Figure 5-1.

- An Event is a 'state' that exists at a point in time (e.g., depart work, arrive home)
- An Activity is a 'process' that takes place over some elapsed time (e.g., prepare to leave work, travel home)

As such, a completed Activity changes the 'state' of an individual (e.g., the activity, 'travel home' changes the state from 'depart work' to 'arrive home'). Therefore, an Activity can be described as an 'Event Sequence'; the elapsed times to perform an event sequence vary from one person to the next and are described as statistical distributions on the following pages.

An employee who lives outside the EPZ will follow sequence (c) of Figure 5-1. A household within the EPZ that has one or more commuters at work and will await their return before beginning the evacuation trip will follow the first sequence of Figure 5-1(a). A household within the EPZ that has no commuters at work, or that will not await the return of any commuters, will follow the second sequence of Figure 5-1(a), regardless of day of week or time of day.

Households with no commuters on weekends or in the evening/night-time, will follow the applicable sequence in Figure 5-1(b). Transients will always follow one of the sequences of Figure 5-1(b). Some transients away from their residence could elect to evacuate immediately without returning to the residence, as indicated in the second sequence.

It is seen from Figure 5-1, that the Trip Generation time (i.e., the total elapsed time from Event 1 to Event 5) depends on the scenario and will vary from one household to the next. Furthermore, Event 5 depends, in a complicated way, on the time distributions of all activities preceding that event. That is, to estimate the time distribution of Event 5, we must obtain estimates of the time distributions of all preceding events. For this study, we adopt the conservative posture that all activities will occur in sequence.

In some cases, assuming certain events occur strictly sequential (for instance, commuter returning home before beginning preparation to leave, or removing snow only after the preparation to leave) can result in rather *conservative* (that is, longer) estimates of mobilization times. It is reasonable to expect that at least some parts of these events will overlap for many households, but that assumption is not made in this study.

5.3 Estimated Time Distributions of Activities Preceding Event 5

The time distribution of an event is obtained by "summing" the time distributions of all prior contributing activities. (This "summing" process is quite different than an algebraic sum since it is performed on distributions – not scalar numbers).

Time Distribution No. 1, Notification Process: Activity 1 → 2

Federal regulations (10CFR50 Appendix E, Item IV.D.3) stipulate, "[t]he design objective of the prompt public alert and notification system shall be to have the capability to essentially complete the initial alerting and initiate notification of the public within the plume exposure pathway EPZ within about 15 minutes". Furthermore, the 2019 Federal Emergency Management Agency (FEMA) Radiological Emergency Preparedness (REP) Program Manual Part V, Section B.1, bullet 3 states that arrangements will be made to assure 100% coverage within 45 minutes of the population who may not have received the initial notification within the entire plume exposure EPZ.

Given the federal regulations and guidance, and the presence of sirens within the EPZ, it is assumed that 100% of the population in the EPZ can be notified within 45 minutes. The assumed distribution for notifying the EPZ population is provided in Table 5-2. The distribution is plotted in Figure 5-2.

Distribution No. 2, Prepare to Leave Work: Activity 2 → 3

It is reasonable to expect that the vast majority of business enterprises within the EPZ will elect to shut down following notification and most employees would leave work quickly. Commuters, who work outside the EPZ could, in all probability, also leave quickly since facilities outside the EPZ would remain open and other personnel would remain. Personnel or farmers responsible for equipment/livestock would require additional time to secure their facility. The distribution of Activity 2 → 3 shown in Table 5-3 reflects data obtained by the demographic survey for employees working inside or outside of the EPZ who return home prior to evacuating and for commuting college students who return home prior to evacuating. This distribution is also applicable for residents to leave stores, restaurants, parks, and other locations within the EPZ. This distribution is plotted in Figure 5-2.

Distribution No. 3, Travel Home: Activity 3 → 4

These data are provided directly by those households which responded to the demographic survey. This distribution is plotted in Figure 5-2 and listed in Table 5-4.

Distribution No. 4, Prepare to Leave Home: Activity 2, 4 → 5

These data are provided directly by those households which responded to the demographic survey. This distribution is plotted in Figure 5-2 and listed in Table 5-5.

Distribution No. 5, Snow Clearance Time Distribution

Inclement weather scenarios involving snowfall must address the time lags associated with snow clearance. It is assumed that snow equipment is mobilized and deployed during the snowfall to maintain passable roads. The general consensus is that the snow-plowing efforts are successful for all but the most extreme blizzards when the rate of snow accumulation exceeds that of snow clearance over a period of many hours. Evacuation would not be prudent during an extreme blizzard.

Consequently, it is reasonable to assume that the highway system will remain passable – albeit at a lower capacity – under the vast majority of snow conditions. Nevertheless, for the vehicles to gain access to the highway system, it may be necessary for driveways and employee parking lots to be cleared to the extent needed to permit vehicles to gain access to the roadways. These clearance activities take time; this time must be incorporated into the trip generation time distributions. These data are provided by those households which responded to the demographic survey. This distribution is plotted in Figure 5-2 and listed in Table 5-6.

Note that those respondents (23% – see Appendix F, Figure F-15) who answered that they would not take time to clear their driveway were assumed to be ready immediately at the start of this activity. Essentially, they would drive through the snow on the driveway to access the roadway and begin their evacuation trip.

5.4 Calculation of Trip Generation Time Distribution

The time distributions for each of the mobilization activities presented herein must be combined to form the appropriate Trip Generation Distributions. As discussed above, this study assumes that the stated events take place in sequence such that all preceding events must be completed before the current event can occur. For example, if a household awaits the return of a commuter, the work-to-home trip (Activity 3 → 4) must precede Activity 4 → 5.

To calculate the time distribution of an event that is dependent on two sequential activities, it is necessary to “sum” the distributions associated with these prior activities. The distribution summing algorithm is applied repeatedly to form the required distribution. As an outcome of this procedure, new time distributions are formed; we assign “letter” designations to these intermediate distributions to describe the procedure. Table 5-7 presents the summing procedure to arrive at each designated distribution.

Table 5-8 presents a description of each of the final trip generation distributions achieved after the summing process is completed.

5.4.1 Statistical Outliers

As already mentioned, some portion of the survey respondents answer "decline to state" to some questions or choose to not respond to a question. The mobilization activity distributions are based upon actual responses. But, it is the nature of surveys that a few numeric responses are inconsistent with the overall pattern of results. An example would be a case in which for 600 responses, almost all of them estimate less than two hours for a given answer, but 3 say "four hours" and 4 say "six or more hours".

These "outliers" must be considered: are they valid responses, or so atypical that they should be dropped from the sample?

In assessing outliers, there are three alternates to consider:

1) Some responses with very long times may be valid, but reflect the reality that the respondent really needs to be classified in a different population subgroup, based upon access and/or functional needs;

2) Other responses may be unrealistic (6 hours to return home from commuting distance, or 2 days to prepare the home for departure);

3) Some high values are representative and plausible, and one must not cut them as part of the consideration of outliers.

The issue of course is how to make the decision that a given response or set of responses are to be considered "outliers" for the component mobilization activities, using a method that objectively quantifies the process.

There is considerable statistical literature on the identification and treatment of outliers singly or in groups, much of which assumes the data is normally distributed and some of which uses non-parametric methods to avoid that assumption. The literature cites that limited work has been done directly on outliers in sample survey responses.

In establishing the <u>overall</u> mobilization time/trip generation distributions, the following principles are used:

1) It is recognized that the overall trip generation distributions are <u>conservative</u> estimates, because they assume a household will do the mobilization activities sequentially, with no overlap of activities;
2) The individual mobilization <u>activities</u> (prepare to leave work, travel home, prepare home, clear snow) are reviewed for outliers, and <u>then</u> the overall trip generation distributions are created (see Figure 5-1, Table 5-7, Table 5-8);
3) Outliers can be eliminated either because the response reflects a special population (e.g., access and/or functional needs, transit dependent) <u>or</u> lack of realism, because the purpose is to estimate trip generation patterns for personal vehicles;

4) To eliminate outliers,

    a) the mean and standard deviation of the specific activity are estimated from the responses,

    b) the median of the same data is estimated, with its position relative to the mean noted,

    c) the histogram of the data is inspected, and

    d) all values greater than 3.5 standard deviations are flagged for attention, taking special note of whether there are gaps (categories with zero entries) in the histogram display.

   In general, only flagged values more than 4 standard deviations from the mean are allowed to be considered outliers, with gaps in the histogram expected. However, other flagged values between 3.5 and 4 standard deviations from the mean were also removed based on careful consideration.

   When flagged values are classified as outliers and dropped, steps "a" to "d" are repeated.

5) As a practical matter, even with outliers eliminated by the above, the resultant histogram, viewed as a cumulative distribution, is not a normal distribution. A typical situation that results is shown below in Figure 5-3.

6) In particular, the cumulative distribution differs from the normal distribution in two key aspects, both very important in loading a network to estimate evacuation times:
   - Most of the real data is to the left of the "normal" curve above, indicating that the network loads faster for the first 80-85% of the vehicles, potentially causing more (and earlier) congestion than otherwise modeled;
   - The last 10-15% of the real data "tails off" slower than the comparable "normal" curve, indicating that there is significant traffic still loading at later times.

   Because these two features are important to preserve, it is the histogram of the data that is used to describe the mobilization activities, <u>not</u> a "normal" curve fit to the data. One could consider other distributions, but using the shape of the *actual* data curve is unambiguous and preserves these important features;

7) With the mobilization activities each modeled according to Steps 1-6, including preserving the features cited in Step 6, the overall (or total) mobilization times are constructed.

This is done by using the data sets and distributions under different scenarios (e.g., commuter returning, no commuter returning, no snow or snow in each). In general, these are additive, using weighting based upon the probability distributions of each element; Figure 5-4 presents the combined trip generation distributions for each population group considered. These distributions are presented on the same time scale. (As discussed earlier, the use of strictly additive activities is a conservative approach, because it makes all activities <u>sequential</u> – travel home from work follows preparation to leave work; preparation for departure follows the return of the commuter; snow clearance follows the preparation for departure, and so forth. In practice, it is reasonable

that some of these activities are done in parallel, at least to some extent – for instance, preparation to depart begins by a household member at home while the commuter is still on the road.)

The mobilization distribution results are used in their tabular/graphical form as direct inputs to later computations that lead to the ETE.

The DYNEV II simulation model is designed to accept varying rates of vehicle trip generation for each origin centroid, expressed in the form of histograms. These histograms, which represent Distributions A, C, D, E and F, properly displaced with respect to one another, are tabulated in Table 5-9 (Distribution B, Arrive Home, omitted for clarity).

The final time period (15) is 600 minutes long. This time period is added to allow the analysis network to clear, in the event congestion persists beyond the trip generation period. Note that there are no trips generated during this final time period.

5.4.2 Staged Evacuation Trip Generation

As defined in NUREG/CR-7002, Rev. 1, staged evacuation consists of the following:

1. PAAs comprising the 2 mile region are advised to evacuate immediately.
2. PAAs comprising regions extending from 2 to 5 miles downwind are advised to shelter in-place while the 2 mile region is cleared.
3. As vehicles evacuate the 2 mile region, sheltered people from 2 to 5 miles downwind continue preparation for evacuation.
4. The population sheltering in the 2 to 5 mile region are advised to begin evacuating when approximately 90% of those originally within the 2 mile region evacuate across the 2 mile region boundary.
5. Non-compliance with the shelter recommendation is the same as the shadow evacuation percentage of 20%.

Assumptions

1. The EPZ population in PAAs beyond 5 miles will shelter-in-place. A non-compliance voluntary evacuation percentage of 20% is assumed for this population.
2. The population in the Shadow Region beyond the EPZ boundary, extending to approximately 15 miles radially from the plant, will react as they do for all non-staged evacuation scenarios. That is 20% of these households will elect to evacuate with no shelter delay.
3. The transient population will not be expected to stage their evacuation because of the limited sheltering options available to people who may be at parks, on a beach, or at other venues. Also, notifying the transient population of a staged evacuation would prove difficult.
4. Employees will also be assumed to evacuate without first sheltering.

Procedure

1. Trip generation for population groups in the 2 mile region will be as computed based upon the results of the demographic survey and analysis.
2. Trip generation for the population subject to staged evacuation will be formulated as follows:
   a. Identify the 90th percentile evacuation time for the PAAs comprising the two mile region. This value, T_{Scen}^* is obtained from simulation results. It will become the time at which the region being sheltered will be told to evacuate for each scenario.
   b. The resultant trip generation curves for staging are then formed as follows:
      i. The non-shelter trip generation curve is followed until a maximum of 20% of the total trips are generated (to account for shelter non-compliance).
      ii. No additional trips are generated until time T_{Scen}^*
      iii. Following time T_{Scen}^*, the balance of trips are generated:
         1. by stepping up and then following the non-shelter trip generation curve (if T_{Scen}^* is $\leq$ max trip generation time) or
         2. by stepping up to 100% (if T_{Scen}^* is > max trip generation time)
   c. Note: This procedure implies that there may be different staged trip generation distributions for different scenarios; however, that was not the case for this site. NUREG/CR-7002, Rev. 1, uses the statement "approximately 90th percentile" as the time to end staging and begin evacuating. The value of T_{Scen}^* is 2:00 for all scenarios (see Region R01 in Table 7-1; average ETE is 2:08).
3. Staged trip generation distributions are created for the following population groups:
   a. Residents with returning commuters
   b. Residents without returning commuters
   c. Residents with returning commuters and heavy snow conditions
   d. Residents without returning commuters and heavy snow conditions

Figure 5-5 presents the staged trip generation distributions for both residents with and without returning commuters and with and without heavy snow. The average 90th percentile two-mile evacuation time is 128 minutes. At T_{Scen}^*, 20% of the population (who normally would have completed their mobilization activities for an un-staged evacuation) advised to shelter has nevertheless departed the area. These people do not comply with the shelter advisory. Also included on the plot are the trip generation distributions for these groups as applied to the regions advised to evacuate immediately.

Since the 90th percentile evacuation time occurs before the end of the trip generation time, after the sheltered region is advised to evacuate, the shelter trip generation distribution rises to meet the balance of the non-staged trip generation distribution. Following time T_{Scen}^*, the balance of staged evacuation trips that are ready to depart are released within 15 minutes. After T_{Scen}^*+15, the remainder of evacuation trips are generated in accordance with the unstaged trip generation distribution.

Table 5-10 provides the trip generation histograms for staged evacuation.

5.4.3 Trip Generation for Waterways and Recreational Areas

The Allegan County Emergency Operations Plan (Emergency Services Function 2 – ESF2 – "Warning & Communication") specifies that warnings will be provided to the local area through means such as the National Oceanic and Atmospheric Administration (NOAA) broadcast, AM and FM commercial radio stations, television stations, the local Emergency Alert System, as well as siren warning systems.

Additional information provided by Allegan, Berrien, and Van Buren Counties specifies that boaters on Lake Michigan will be notified through marine radio as well as marine patrol boats. Recreational facilities will be notified through the facilities public address (PA) and warning systems. This information is also published in the Palisades Power Plant public information brochure.

As indicated in Table 5-2, this study assumes 100% notification in 45 minutes which is consistent with the 2019 FEMA REP Program Manual. Table 5-9 indicates that all transients will have mobilized within 1 hour and 45 minutes. It is assumed that this 1 hour and 45 minutes timeframe is sufficient time for boaters, campers and other transients to return to their vehicles and begin their evacuation trip.

Table 5-1. Event Sequence for Evacuation Activities

Event Sequence	Activity	Distribution
1 → 2	Receive Notification	1
2 → 3	Prepare to Leave Work	2
2,3 → 4	Travel Home	3
2,4 → 5	Prepare to Leave to Evacuate	4
N/A	Snow Clearance	5

Table 5-2. Time Distribution for Notifying the Public

Elapsed Time (Minutes)	Percent of Population Notified
0	0%
5	7%
10	13%
15	27%
20	47%
25	66%
30	87%
35	92%
40	97%
45	100%

Table 5-3. Time Distribution for Commuters to Prepare to Leave Work/College

Elapsed Time (Minutes)	Cumulative Percent Commuters Leaving Work/College	Elapsed Time (Minutes)	Cumulative Percent Commuters Leaving Work/College
0	0%	40	90%
5	28%	45	91%
10	54%	50	91%
15	71%	55	91%
20	80%	60	98%
25	81%	65	99%
30	85%	70	99%
35	86%	75	100%

NOTE: The survey data was normalized to distribute the "Decline to State" response. That is, the sample was reduced in size to include only those households who responded to this question. The underlying assumption is that the distribution of this activity for the "Decline to State" responders, if the event takes place, would be the same as those responders who provided estimates.

Table 5-4. Time Distribution for Commuters to Travel Home

Elapsed Time (Minutes)	Cumulative Percent Returning Home	Elapsed Time (Minutes)	Cumulative Percent Returning Home
0	0%	35	90%
5	15%	40	93%
10	42%	45	95%
15	59%	50	98%
20	73%	55	99%
25	78%	60	100%
30	86%		

NOTE: The survey data was normalized to distribute the "Decline to State" response

Table 5-5. Time Distribution for Population to Prepare Home to Evacuate

Elapsed Time (Minutes)	Cumulative Percent Ready to Evacuate
0	0%
15	6%
30	27%
45	45%
60	67%
75	79%
90	83%
105	84%
120	87%
135	94%
150	95%
165	96%
180	97%
195	100%

NOTE: The survey data was normalized to distribute the "Decline to State" response

Table 5-6. Time Distribution for Population to Clear 6"-8" of Snow

Elapsed Time (Minutes)	Cumulative Percent Ready to Evacuate
0	23%
15	43%
30	61%
45	73%
60	80%
75	86%
90	89%
105	92%
120	94%
135	98%
150	99%
165	99%
180	100%

NOTE: The survey data was normalized to distribute the "Decline to State" response

Table 5-7. Mapping Distributions to Events

Apply "Summing" Algorithm To:	Distribution Obtained	Event Defined
Distributions 1 and 2	Distribution A	Event 3
Distributions A and 3	Distribution B	Event 4
Distributions B and 4	Distribution C	Event 5
Distributions 1 and 4	Distribution D	Event 5
Distributions C and 5	Distribution E	Event 5
Distributions D and 5	Distribution F	Event 5

Table 5-8. Description of the Distributions

Distribution	Description
A	Time distribution of commuters departing place of work (Event 3). Also applies to employees who work within the EPZ who live outside, and to Transients within the EPZ.
B	Time distribution of commuters arriving home (Event 4).
C	Time distribution of residents with commuters who return home, leaving home to begin the evacuation trip (Event 5).
D	Time distribution of residents without commuters returning home, leaving home to begin the evacuation trip (Event 5).
E	Time distribution of residents with commuters who return home, leaving home to begin the evacuation trip, after snow clearance activities (Event 5).
F	Time distribution of residents with no commuters returning home, leaving to begin the evacuation trip, after snow clearance activities (Event 5).

Table 5-9. Trip Generation Histograms for the EPZ Population for Unstaged Evacuation

		Percent of Total Trips Generated Within Indicated Time Period					
Time Period	Duration (Min)	Employees (Distribution A)	Transients (Distribution A)	Residents with Commuters (Distribution C)	Residents Without Commuters (Distribution D)	Residents With Commuters Snow (Distribution E)	Residents Without Commuters Snow (Distribution F)
1	15	6%	6%	0%	0%	0%	0%
2	15	31%	31%	0%	4%	0%	1%
3	30	50%	50%	6%	31%	2%	13%
4	30	11%	11%	25%	36%	11%	25%
5	15	2%	2%	16%	9%	10%	12%
6	15	0%	0%	15%	3%	12%	10%
7	30	0%	0%	16%	7%	20%	13%
8	30	0%	0%	10%	6%	15%	11%
9	30	0%	0%	6%	2%	12%	7%
10	15	0%	0%	2%	2%	4%	2%
11	60	0%	0%	4%	0%	11%	5%
12	30	0%	0%	0%	0%	1%	1%
13	30	0%	0%	0%	0%	1%	0%
14	15	0%	0%	0%	0%	1%	0%
15	600	0%	0%	0%	0%	0%	0%

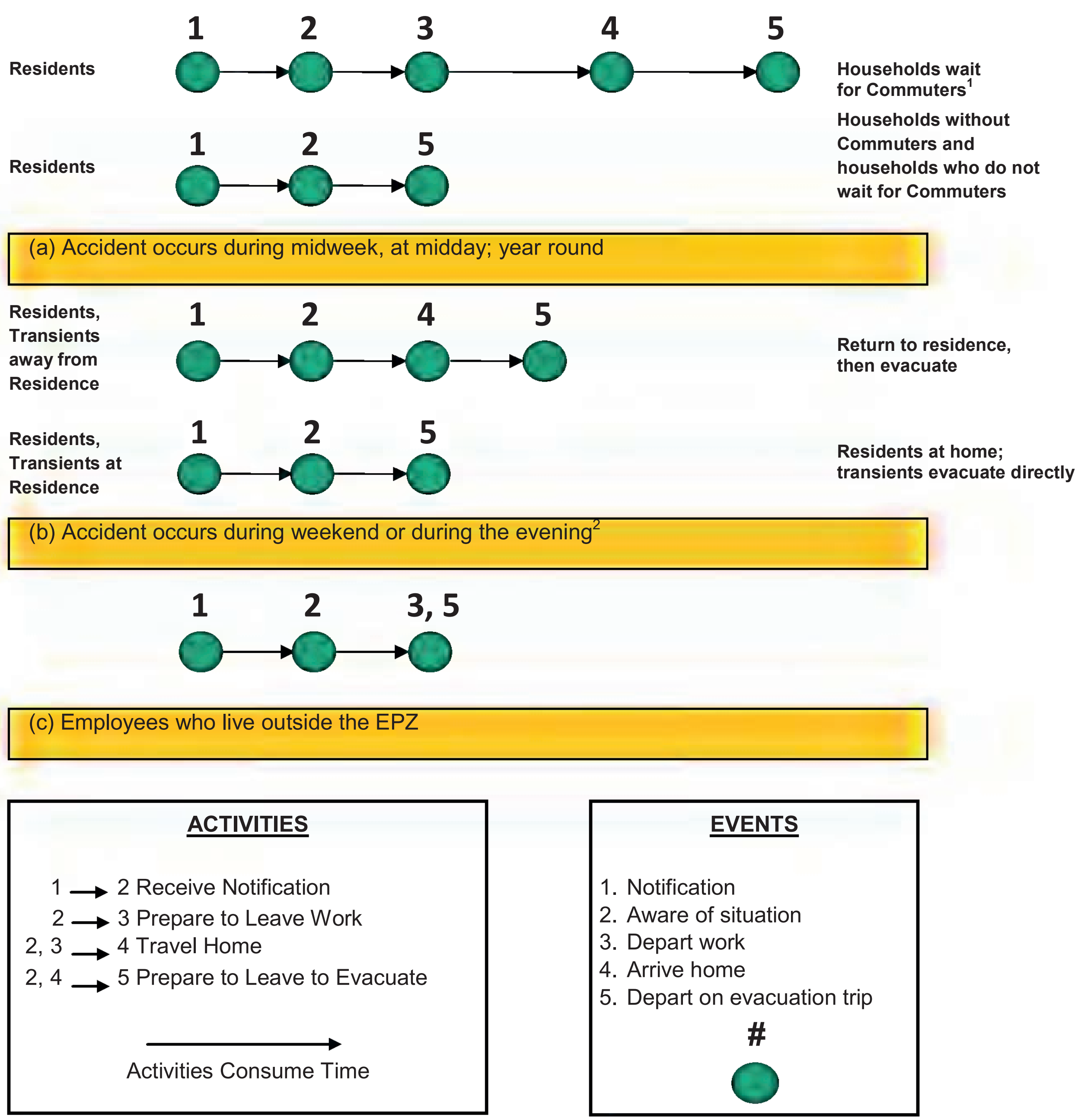
NOTE:

- Shadow vehicles are loaded onto the analysis network (Figure 1-2) using Distributions C and E for good weather and snow, respectively.
- Special event vehicles are loaded using Distribution A.

Table 5-10. Trip Generation Histograms for the EPZ Population for Staged Evacuation

Time Period	Duration (Min)	Percent of Total Trips Generated Within Indicated Time Period*			
		Residents with Commuters (Distribution C)	Residents Without Commuters (Distribution D)	Residents With Commuters Snow (Distribution E)	Residents Without Commuters Snow (Distribution F)
1	15	0%	0%	0%	0%
2	15	0%	1%	0%	0%
3	30	1%	6%	0%	3%
4	30	5%	7%	3%	5%
5	15	3%	2%	2%	2%
6	15	3%	1%	2%	2%
7	30	66%	73%	48%	62%
8	30	10%	6%	15%	11%
9	30	6%	2%	12%	7%
10	15	2%	2%	4%	2%
11	60	4%	0%	11%	5%
12	30	0%	0%	1%	1%
13	30	0%	0%	1%	0%
14	15	0%	0%	1%	0%
15	600	0%	0%	0%	0%

*Trip Generation for Employees and Transients (see Table 5-9) is the same for Unstaged and Staged Evacuation.



[1] Applies for evening and weekends also if commuters are at work.
[2] Applies throughout the year for transients.

Figure 5-1. Events and Activities Preceding the Evacuation Trip

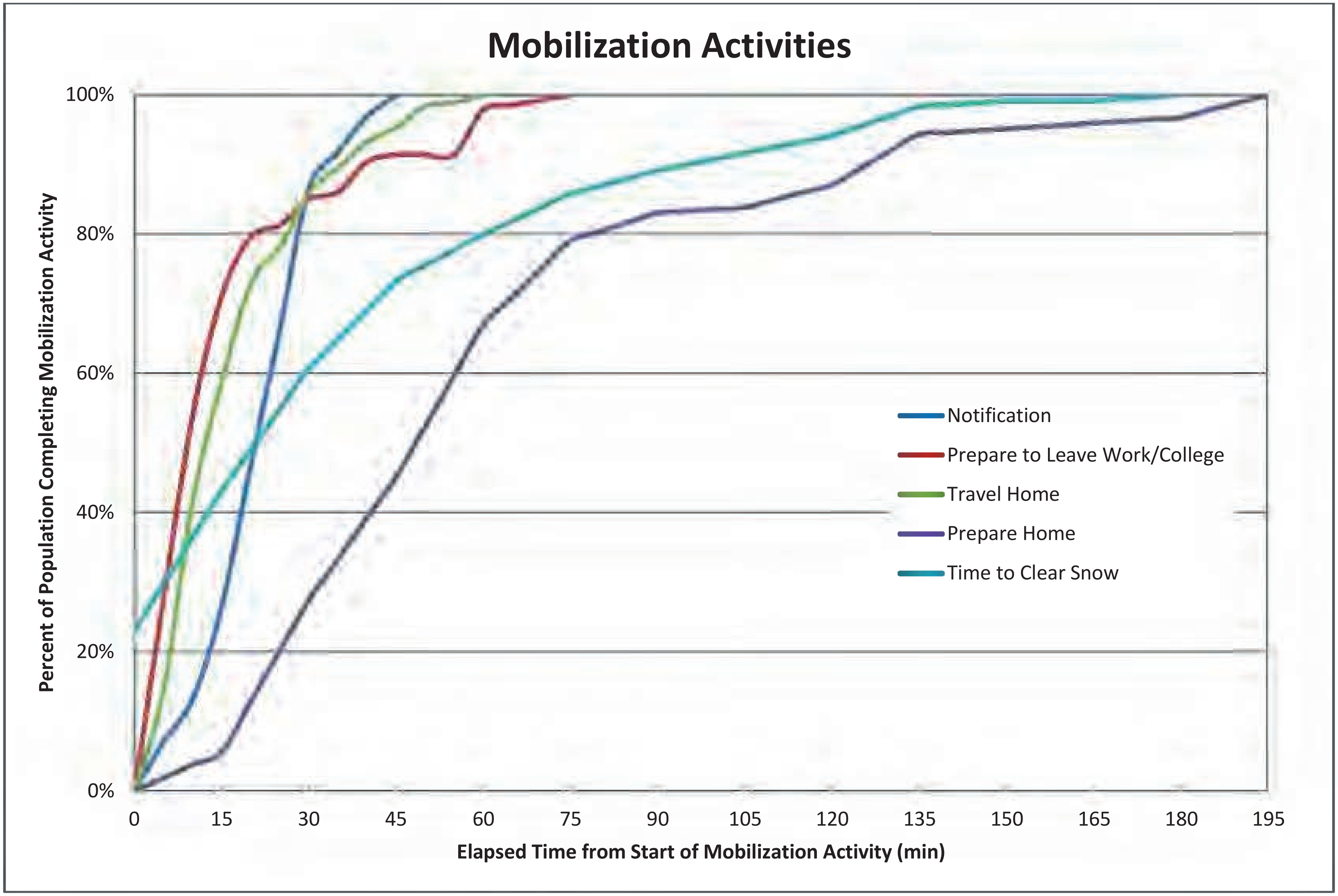


Figure 5-2. Evacuation Mobilization Activities

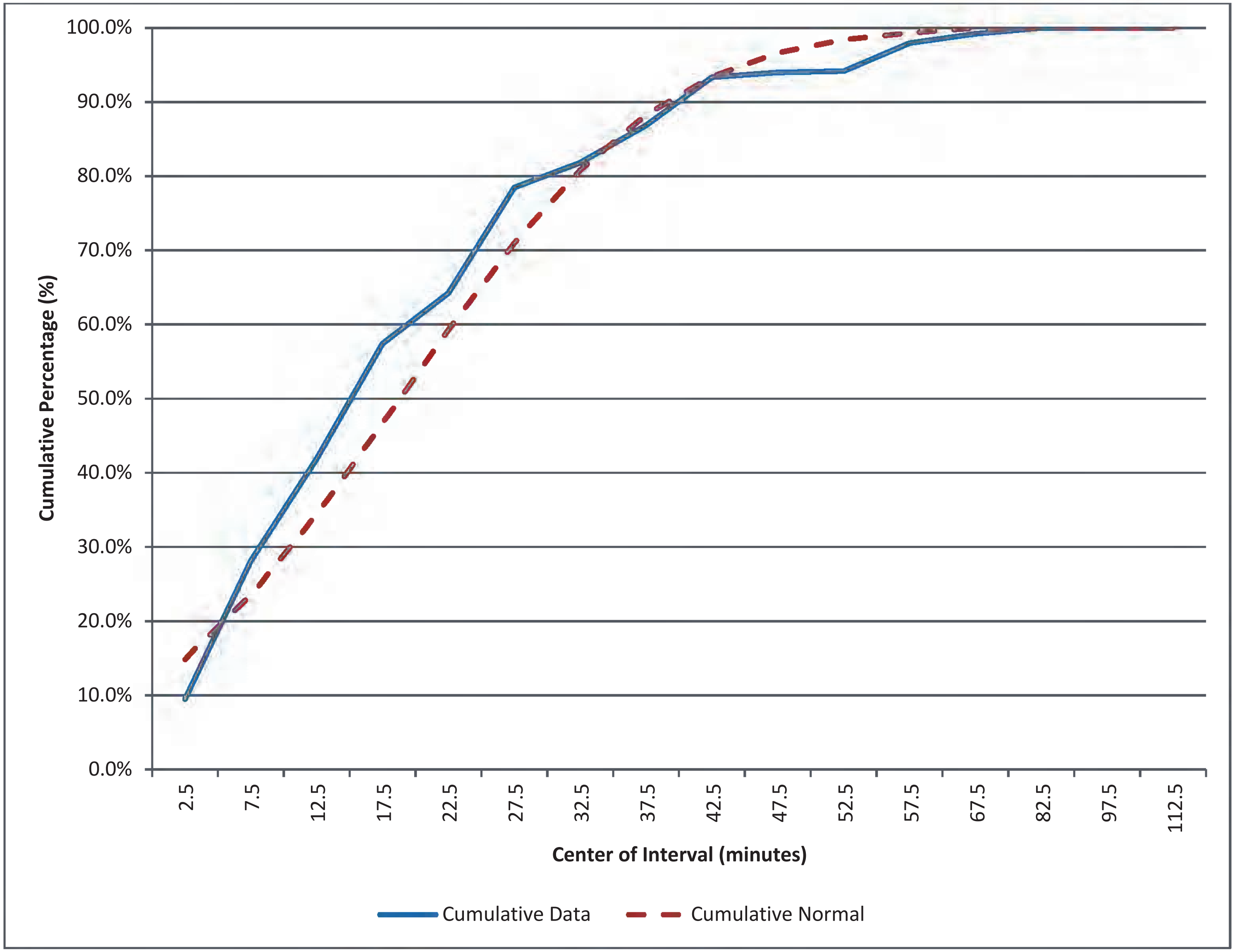


Figure 5-3. Comparison of Data Distribution and Normal Distribution

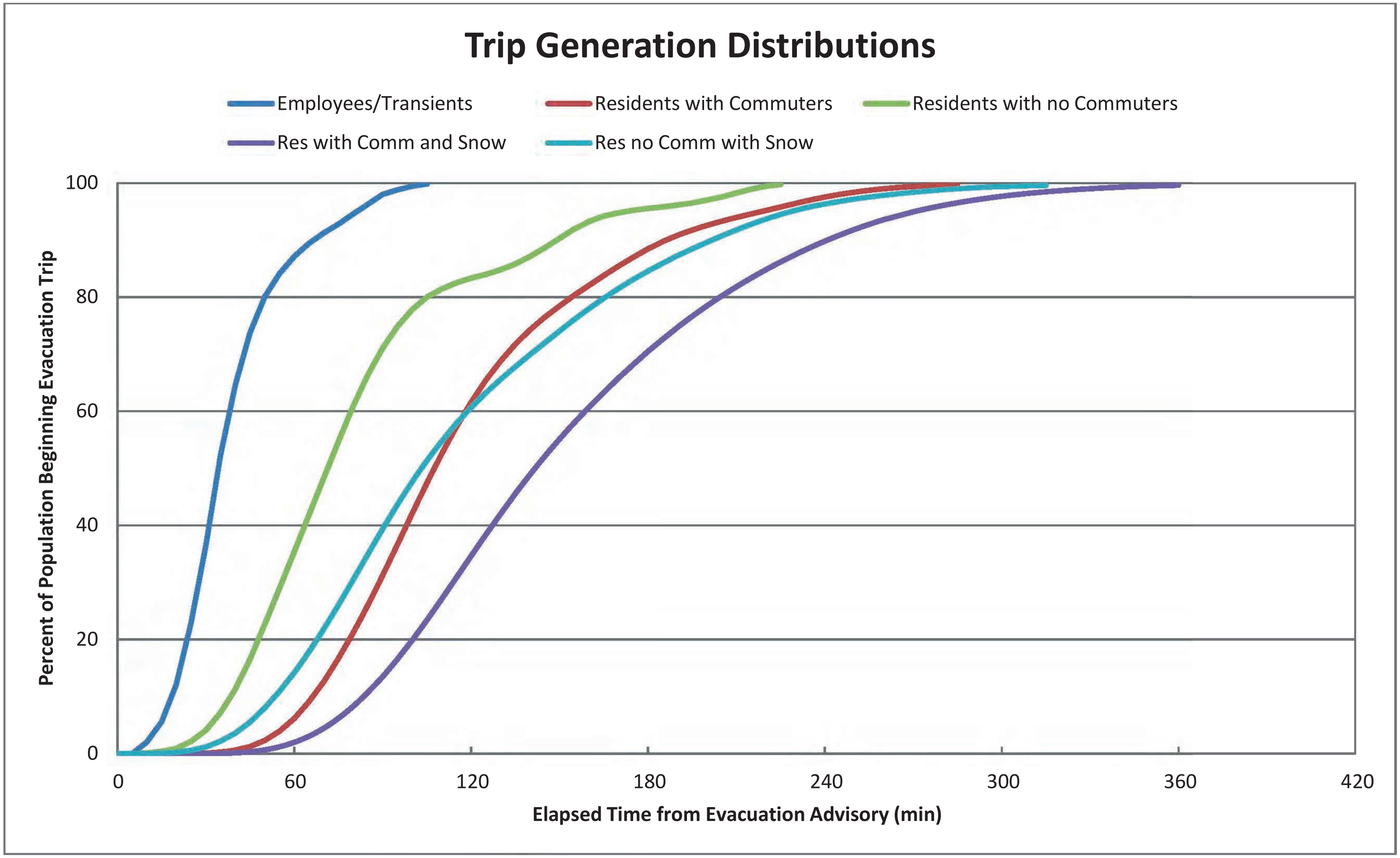


Figure 5-4. Comparison of Trip Generation Distributions

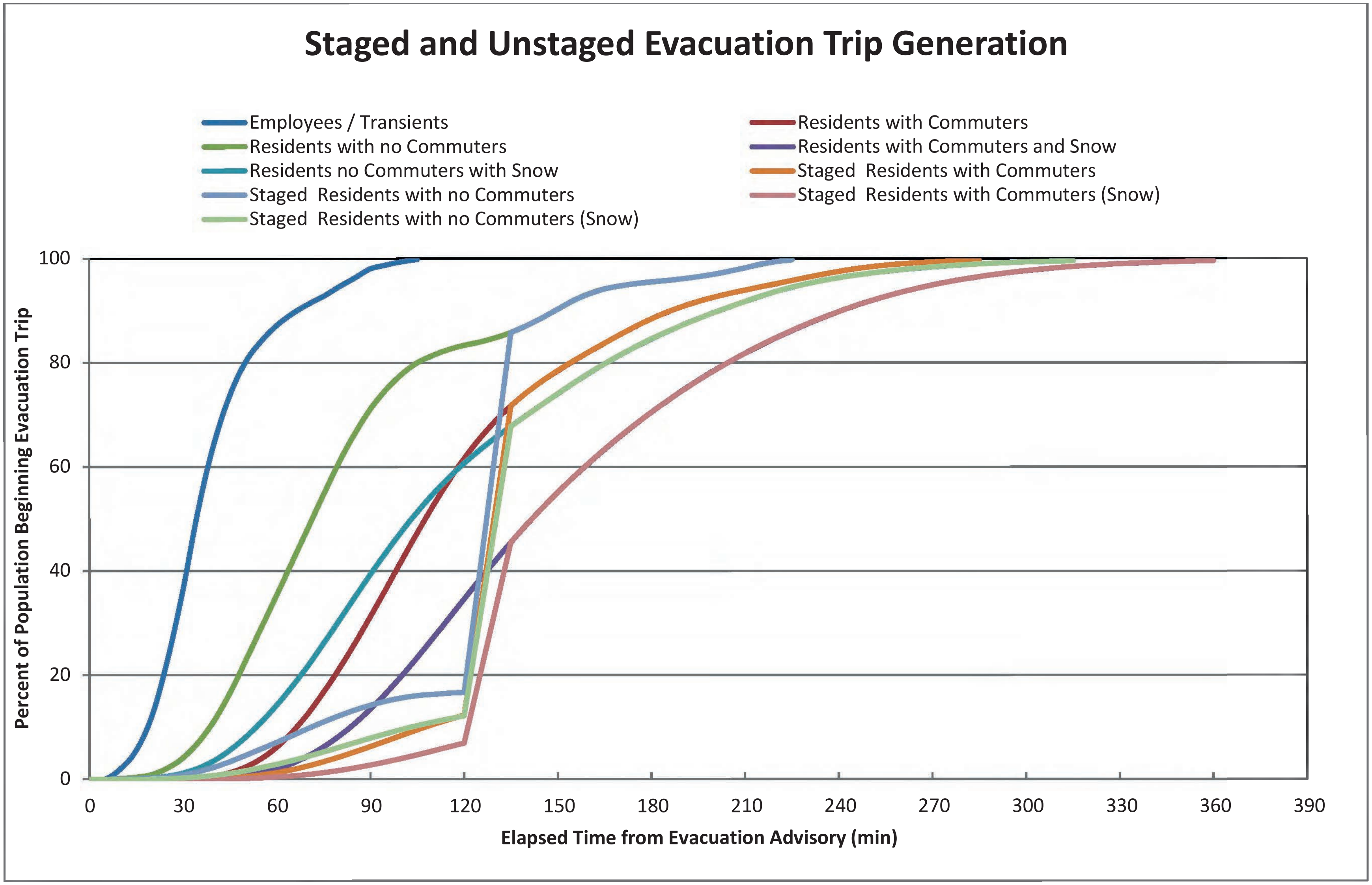


Figure 5-5. Comparison of Staged and Unstaged Trip Generation Distributions in the 2 to 5 Mile Region

6 DEMAND ESTIMATION FOR EVACUATION SCENARIOS

An evacuation "case" defines a combination of Evacuation Region and Evacuation Scenario. The definitions of "Region" and "Scenario" are as follows:

Region A grouping of contiguous evacuating PAA that forms either a "keyhole" sector-based area, or a circular area within the EPZ, that must be evacuated in response to a radiological emergency.

Scenario A combination of circumstances, including time of day, day of week, season, and weather conditions. Scenarios define the number of people in each of the affected population groups and their respective mobilization time distributions.

A total of 13 Regions were defined which encompass all the groupings of PAAs considered. These Regions are defined in Table 6-1. The PAA configurations are identified in Figure 6-1. Each keyhole sector-based area consists of a central circle centered at the power plant, and three adjoining sectors, each with a central angle of 22.5 degrees, as per NUREG/CR-7002 guidance. The central sector coincides with the wind direction. These sectors extend to 5 miles from the plant (Regions R04 and R05) or to the EPZ boundary (Regions R06 through R10).

Regions R01, R02 and R03 represent evacuations of circular areas with radii of 2, 5 and 10 miles, respectively. Regions R11 through R13 are identical to Regions R02, R04 and R05, respectively; however, those PAAs between 2 miles and 5 miles are staged until 90% of the 2-mile region (Region R01) has evacuated.

A total of 14 Scenarios were evaluated for all Regions. Thus, there are a total of 13 x 14 = 182 evacuation cases. Table 6-2 is a description of all Scenarios.

Each combination of region and scenario implies a specific population to be evacuated. Table 6-3 presents the percentage of each population group estimated to evacuate for each scenario. Table 6-4 presents the vehicle counts for each scenario for an evacuation of Region R03 – the entire EPZ. The vehicle estimates presented in Section 3 are peak values. These peak values are adjusted depending on the scenario and region being considered using scenario and region-specific percentages; the scenario percentages are presented in Table 6-3, while the regional percentages are provided in Table H-1. The percentages presented in Table 6-3 were determined as follows:

The number of residents with commuters during the week (when workforce is at its peak) is equal to the product of 86% (the number of households with at least one commuter) and 58% (the number of households with a commuter that would await the return of the commuter prior to evacuating). See assumption 3 in Section 2.3. It is estimated for weekend and evening scenarios that 10% of households with returning commuters will have a commuter at work during those times.

It can be argued that this estimate of permanent residents overstates, somewhat, the number of evacuating vehicles, especially during the summer. It is certainly reasonable to assert that

some portion of the population would be on vacation during the summer and would travel elsewhere. A rough estimate of this reduction can be obtained as follows:

- Assume 50% of all households vacation for a period over the summer.
- Assume these vacations, in aggregate, are uniformly dispersed over 10 weeks, i.e., 10% of the population is on vacation during each two-week interval.
- Assume half of these vacationers leave the area.

On this basis, the permanent resident population would be reduced by 5% in the summer and by a lesser amount in the off-season. Given the uncertainty in this estimate, we elected to apply no reductions in permanent resident population for the summer scenarios to account for residents who may be out of the area.

Employment is assumed to be at its peak (100%) during the winter, midweek, midday scenarios. Employment is reduced slightly (96%) for summer, midweek, midday scenarios. This is based on the estimation that 50% of the employees commuting into the EPZ will be on vacation for a week during the approximate 12 weeks of summer. It is further estimated that those taking vacation will be uniformly dispersed throughout the summer with approximately 4% of employees vacationing each week. It is further estimated that only 10% of the employees are working in the evenings and during the weekends.

Transient activity is estimated to be at its peak during summer weekends and less during the week. As shown in Appendix E, there is a large casino that attracts a significant transient population and a significant number of lodging facilities and campgrounds offering overnight accommodations in the EPZ; thus, transient activity is estimated to be high during evening hours – 75% for summer and 55% for winter. Transient activity is less in the winter – 30% during the week and 45% on weekends.

Seasonal population is estimated to be 100% during summer months, and 0% during all other times.

As noted in the shadow footnote to Table 6-3, the shadow percentages are computed using a base of 20% (see assumption 7 in Section 2.2); to include the employees within the shadow region who may choose to evacuate, the voluntary evacuation is multiplied by a scenario-specific proportion of employees to permanent residents in the shadow region. For example, using the values provided in Table 6-4 for Scenario 1, the shadow percentage is computed as follows:

$$20\% \times \left(1 + \frac{657}{7{,}894 + 8{,}004}\right) = 21\%$$

One special event – South Haven Fourth of July Celebration – was considered as Scenario 13. Thus, the special event traffic is 100% evacuated for Scenario 13, and 0% for all other scenarios.

Vehicles evacuation medical facilities include buses, wheelchair buses and ambulance as

discussed in Section 3.5. These vehicles are 100% evacuated for all scenarios as the medical facility population is present in the EPZ for all scenarios.

As discussed in the footnote to Table 2-1, schools are in session during the winter season, midweek, midday and 100% of buses will be needed under those circumstances. It is estimated that summer school enrollment is approximately 10% of enrollment during the regular school year for summer, midweek, midday scenarios. School is not in session during weekends and evenings, thus no buses for school children are needed under those circumstances.

Transit buses for the transit-dependent population are set to 100% for all scenarios as it is assumed that the transit-dependent population is present in the EPZ for all scenarios.

External traffic is estimated to be significantly less (40%) during evening scenarios and is 100% for all other scenarios.

Table 6-1. Description of Evacuation Regions

Radial Regions								
Region	Description	PAA						
		1	2	3	4	5	6	7
R01	2-Mile Region	X					X	
R02	5-Mile Region	X	X	X			X	
R03	Full EPZ	X	X	X	X	X	X	X
Evacuate 2-Mile Region and Downwind to 5-Miles								
Region	Wind Direction From (Degrees)	PAA						
		1	2	3	4	5	6	7
N/A	≥56 and <169	Refer to R01						
R04	≥169 and <236	X	X				X	
N/A	≥236 and <303	Refer to R02						
R05	≥303 and <56	X		X			X	
Evacuate 2-Mile Region and Downwind to the EPZ Boundary								
Region	Wind Direction From (Degrees)	PAA						
		1	2	3	4	5	6	7
R06	≥56 and <169	X					X	X
R07	≥169 and <236	X	X		X		X	X
R08	≥236 and <303	X	X	X	X	X	X	
R09	≥303 and <348	X		X		X	X	
R10	≥348 and <56	X		X		X	X	X
Staged Evacuation - 2-Mile Region Evacuates, then Evacuate Downwind to 5-Miles								
Region	Wind Direction From (Degrees)	PAA						
		1	2	3	4	5	6	7
R11	5-Mile Region	X	X	X			X	
N/A	≥56 and <169	Refer to R01						
R12	≥169 and <236	X	X				X	
N/A	≥236 and <303	Refer to R11						
R13	≥303 and <56	X		X			X	
PAA(s) Evacuate		PAA(s) Shelter-in-Place			PAA(s) Shelter-in-Place until 90% ETE for R01, then Evacuate			

Table 6-2. Evacuation Scenario Definitions

Scenario	Season[1]	Day of Week	Time of Day	Weather	Special
1	Summer	Midweek	Midday	Good	None
2	Summer	Midweek	Midday	Rain	None
3	Summer	Weekend	Midday	Good	None
4	Summer	Weekend	Midday	Rain	None
5	Summer	Midweek, Weekend	Evening	Good	None
6	Winter	Midweek	Midday	Good	None
7	Winter	Midweek	Midday	Light Rain/Snow	None
8	Winter	Midweek	Midday	Heavy Snow	None
9	Winter	Weekend	Midday	Good	None
10	Winter	Weekend	Midday	Light Rain/Snow	None
11	Winter	Weekend	Midday	Heavy Snow	None
12	Winter	Midweek, Weekend	Evening	Good	None
13	Summer	Weekend	Evening	Good	South Haven Fourth of July Celebration
14	Summer	Midweek	Midday	Good	Roadway Impact – Lane Closure on I-196 Northbound

[1] Winter means that school is in session at normal enrollment levels (also applies to spring and autumn). Summer means that school is in session at summer school enrollment levels (lower than normal enrollment).

Table 6-3. Percent of Population Groups Evacuating for Various Scenarios

Scenario	Households With Returning Commuters	Households Without Returning Commuters	Employees	Transients	Shadow	Special Event	Medical Facilities	Seasonal Population	School Buses	Transit Buses	External Through Traffic
1	50%	50%	96%	55%	21%	0%	100%	100%	10%	100%	100%
2	50%	50%	96%	55%	21%	0%	100%	100%	10%	100%	100%
3	5%	95%	10%	85%	20%	0%	100%	100%	0%	100%	100%
4	5%	95%	10%	85%	20%	0%	100%	100%	0%	100%	100%
5	5%	95%	10%	75%	20%	0%	100%	100%	0%	100%	40%
6	50%	50%	100%	30%	21%	0%	100%	0%	100%	100%	100%
7	50%	50%	100%	30%	21%	0%	100%	0%	100%	100%	100%
8	50%	50%	100%	30%	21%	0%	100%	0%	100%	100%	100%
9	5%	95%	10%	45%	20%	0%	100%	0%	0%	100%	100%
10	5%	95%	10%	45%	20%	0%	100%	0%	0%	100%	100%
11	5%	95%	10%	45%	20%	0%	100%	0%	0%	100%	100%
12	5%	95%	10%	55%	20%	0%	100%	0%	0%	100%	40%
13	5%	95%	10%	75%	20%	100%	100%	100%	0%	100%	40%
14	50%	50%	96%	55%	21%	0%	100%	100%	10%	100%	100%

Households with Returning Commuters..........Households of EPZ residents who await the return of commuters prior to beginning the evacuation trip.
Households without Returning Commuters ....Households of EPZ residents who do not have commuters or will not await the return of commuters prior to beginning the evacuation trip.
Employees..EPZ employees who live outside the EPZ
Transients ....People who are in the EPZ at the time of an accident for recreational or other (non-employment) purposes.
Shadow..Residents and employees in the shadow region (outside of the EPZ) who will spontaneously decide to relocate during the evacuation. The basis for the values shown is a 20% relocation of shadow residents along with a proportional percentage of shadow employees.
Special Event...Additional vehicles in the EPZ due to the identified special event.
Medical Facilities.......................................Vehicle-equivalents present on the road during evacuation servicing medical facility population (buses and wheelchair buses are equivalent to 2 passenger vehicles each, ambulances are 1 passenger vehicle).
Seasonal Population ....People who reside outside of the EPZ and enter the area to stay in accommodations other than hotels.
School and Transit Buses ....Vehicle-equivalents present on the road during evacuation servicing schools and transit-dependent people (1 bus is equivalent to 2 passenger vehicles).
External Through Traffic ....Traffic on interstates/freeways at the start of the evacuation. This traffic is stopped by access control approximately 2 hours after the evacuation begins.

Table 6-4. Vehicle Estimates by Scenario

Scenario	Households With Returning Commuters	Households Without Returning Commuters	Employees	Transients	Shadow	Special Event	Medical Facilities	Seasonal Population	School Buses	Transit Buses	External Through Traffic	Total Scenario Vehicles
1	7,894	8,004	657	4,190	2,592	-	42	1,977	32	26	7,950	33,364
2	7,894	8,004	657	4,190	2,592	-	42	1,977	32	26	7,950	33,364
3	789	15,109	68	6,476	2,500	-	42	1,977	-	26	7,950	34,937
4	789	15,109	68	6,476	2,500	-	42	1,977	-	26	7,950	34,937
5	789	15,109	68	5,714	2,500	-	42	1,977	-	26	3,180	29,405
6	7,894	8,004	684	2,286	2,596	-	42	-	323	26	7,950	29,805
7	7,894	8,004	684	2,286	2,596	-	42	-	323	26	7,950	29,805
8	7,894	8,004	684	2,286	2,596	-	42	-	323	26	7,950	29,805
9	789	15,109	68	3,429	2,500	-	42	-	-	26	7,950	29,913
10	789	15,109	68	3,429	2,500	-	42	-	-	26	7,950	29,913
11	789	15,109	68	3,429	2,500	-	42	-	-	26	7,950	29,913
12	789	15,109	68	4,190	2,500	-	42	-	-	26	3,180	25,904
13	789	15,109	68	5,714	2,500	9,908	42	1,977	-	26	3,180	39,313
14	7,894	8,004	657	4,190	2,592	-	42	1,977	32	26	7,950	33,364

Note: Vehicle estimates are for an evacuation of the entire EPZ (Region R03)

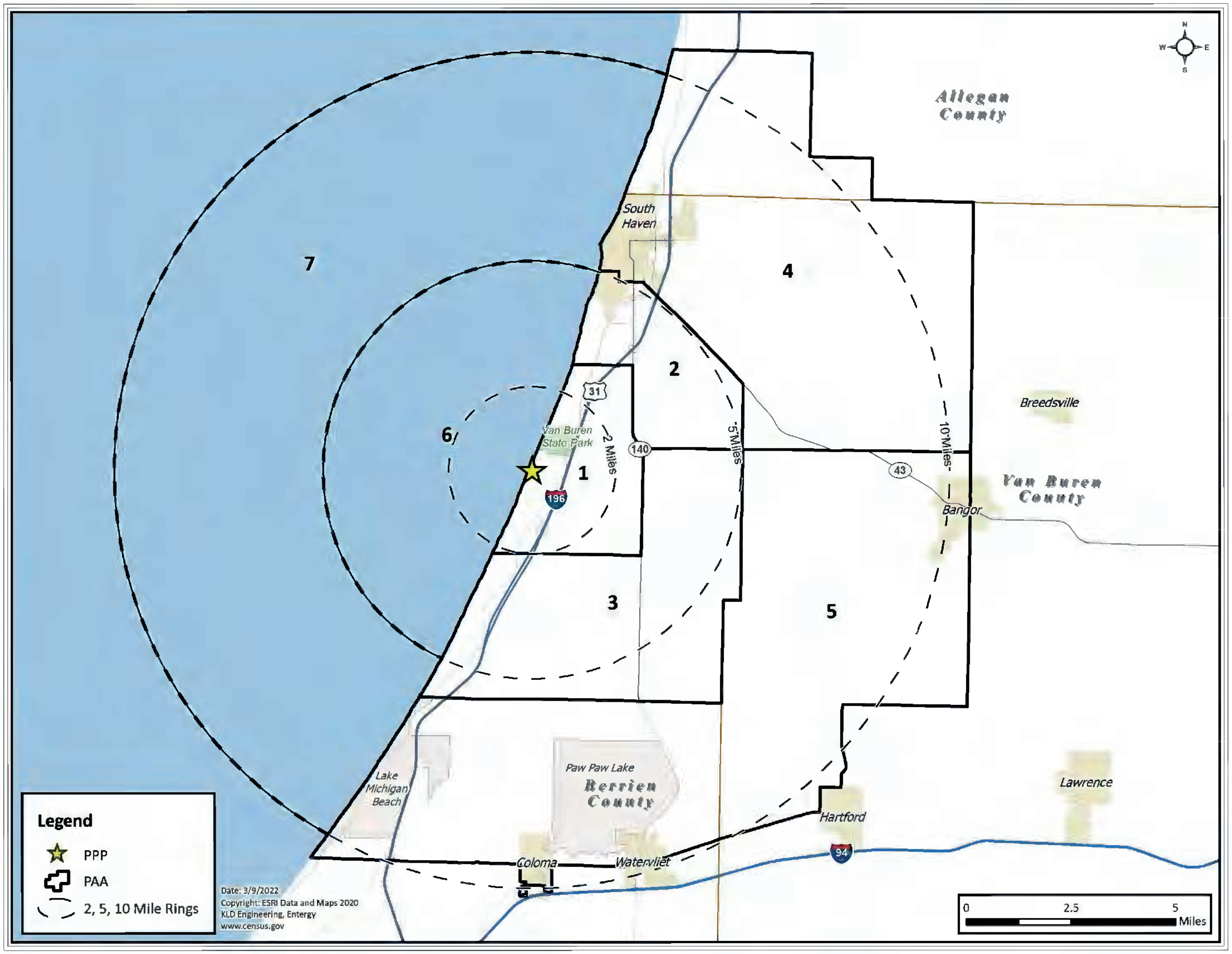


Figure 6-1. PAA Comprising the PPP EPZ

7 GENERAL POPULATION EVACUATION TIME ESTIMATES (ETE)

This section presents the ETE results of the computer analyses using the DYNEV II System described in Appendices B, C and D. These results cover 13 regions within the PPP EPZ and the 14 Evacuation Scenarios discussed in Section 6.

The ETE for all Evacuation Cases are presented in Table 7-1 and Table 7-2. These tables present the estimated times to clear the indicated population percentages from the Evacuation Regions for all Evacuation Scenarios. The ETE for the 2-mile region in both staged and un-staged regions are presented in Table 7-3 and Table 7-4. Table 7-5 defines the Evacuation Regions considered. The tabulated values of ETE are obtained from the DYNEV II System outputs which are generated at 5-minute intervals.

7.1 Voluntary Evacuation and Shadow Evacuation

"Voluntary evacuees" are people within the EPZ in PAAs for which an Advisory to Evacuate (ATE) has not been issued, yet who elect to evacuate. "Shadow evacuation" is the voluntary evacuation of some people from the Shadow Region (outside the EPZ) for whom no protective action recommendation has been issued. Both voluntary and shadow evacuations are assumed to take place over the same time frame as the evacuation from within the impacted Evacuation Region.

The ETE for the PPP EPZ addresses the issue of voluntary evacuees in the manner shown in Figure 7-1. Within the EPZ, 20% of permanent residents located in PAAs outside of the evacuation region who are not advised to evacuate, are assumed to elect to evacuate. Similarly, it is assumed that 20% of those permanent residents in the Shadow Region will choose to leave the area.

Figure 7-2 presents the area identified as the Shadow Region. This region extends radially from the plant to cover a region between the EPZ boundary and approximately 15 miles. The population and number of evacuating vehicles in the Shadow Region were estimated using the same methodology that was used for permanent residents within the EPZ (see Section 3.1). As discussed in Section 3.2, it is estimated that a total of 23,192 people reside in the Shadow Region; 20% of them would evacuate. See Table 6-4 for the number of evacuating vehicles from the Shadow Region.

Traffic generated within this Shadow Region, including external-external traffic, traveling away from the plant location, has the potential for impeding evacuating vehicles from within the Evacuation Region. All ETE calculations include this shadow traffic movement.

7.2 Staged Evacuation

As defined in NUREG/CR-7002, staged evacuation consists of the following:

1. PAAs comprising the 2-Mile region are advised to evacuate immediately.
2. PAAs comprising regions extending from 2 to 5 miles downwind are advised to shelter in-place while the 2-Mile region is cleared.
3. As vehicles evacuate the 2-Mile region, people from 2 to 5 miles downwind continue preparation for evacuation while they shelter.
4. The population sheltering in the 2 to 5-Mile region is advised to evacuate when approximately 90% of the 2 mile region evacuating traffic crosses the 2 mile region boundary.
5. Non-compliance with the shelter recommendation is the same as the shadow evacuation percentage of 20%.

See Section 5.4.2 for additional information on staged evacuation.

7.3 Patterns of Traffic Congestion during Evacuation

Figure 7-3 through Figure 7-6 illustrate the patterns of traffic congestion that arise for the case when the entire EPZ (Region R03) is advised to evacuate during the summer, weekend, midday period under good weather conditions (Scenario 3 – the non-special event scenario with the largest number of evacuating vehicles – see Table 6-4).

Traffic congestion, as the term is used here, is defined as Level of Service (LOS) F. LOS F is defined as follows (HCM 2016):

> The HCM uses LOS F to define operations that have either broken down (i.e., demand exceeds capacity) or have reached a point that most users would consider unsatisfactory, as described by a specified service measure value (or combination of service measure values). However, analysts may be interested in knowing just how bad the LOS F condition is, particularly for planning applications where different alternatives may be compared. Several measures are available to describe individually, or in combination, the severity of a LOS F condition:
>
> • *Demand-to-capacity ratios* describe the extent to which capacity is exceeded during the analysis period (e.g., by 1%, 15%).
>
> • *Duration of LOS F* describes how long the condition persists (e.g., 15 min, 1 h, 3 h).
>
> • *Spatial extent measures* describe the areas affected by LOS F conditions. These include measures such as the back of queue, and the identification of the specific intersection approaches or system elements experiencing LOS F conditions.

All highway "links" which experience LOS F are delineated in these figures by a thick red line; all others are lightly indicated. Congestion develops rapidly around concentrations of population

and traffic bottlenecks.

At 30 minutes after the Advisory to Evacuate (ATE), Figure 7-3 displays the developing traffic congestion in South Haven (the most densely populated area in the EPZ) at the I-196 on ramps from N Shore Dr and from County Road (CR)-388 (Phoenix Hwy) . Pronounced congestion can be seen at the driveway of Four Winds Casino to access Red Arrow Highway. Red Arrow Highway is also between Watervliet and Hartford as a result of the transients leaving the Four Winds Casino. Interstate-196 (I-196) and Interstate-94 (I-94), which are servicing the external-external trips and the entering evacuating trips, are displaying only moderate traffic demand (LOS B and C). Congestion is developing along CR-687 southbound leaving Hartford and along Michigan State Route 140 (MI-140) southbound leaving Watervliet.

At one hour after the ATE, Figure 7-4 displays pronounced traffic congestion within South Haven and areas to the north of South Haven as evacuees try to access the various ramps to I-196. CR-388 is particularly congested. Moderate traffic volume is observed along CR-388 eastbound leaving the EPZ and in the Shadow Region, along CR-380 eastbound towards Breedsville, and along CR-378 eastbound through Bangor. Congestion persists leaving the Four Winds Casino. Traffic congestion has intensified in Coloma, Watervliet, and Hartford, with MI-140 southbound leaving Watervliet operating at LOS F. Traffic is also operating at LOS F at the interchange of I-196 and I-94 in the Shadow Region as evacuating vehicles from I-196 southbound and I-94 southbound merge.

At 2 hours after the ATE, as shown in Figure 7-5, congestion in Bangor, Coloma and Hartford has subsided. The N Shore Dr on ramp to I-196 in the northern portion of South Haven is displaying moderate traffic congestion at this time; the remainder of South Haven is free flowing. Pronounced traffic congestion is seen northbound along 68th St leaving the EPZ due to the stop sign at 109th Ave. Evacuees from South Haven use 68th St northbound as an alternate route to bypass the congestion at the on ramps for I-196. The intersection of 56th St and 109th Ave is also operating at LOS F in the Shadow Region. This intersection is also stop controlled. MI-140 southbound through Watervliet is still operating at LOS F at this time due to the resident population in the area and transients visiting Paw Paw Lake. Congestion has dissipated at the interchange of I-196 and I-94.

Traffic congestion has cleared from the entire EPZ at two and half hours after the ATE as displayed in Figure 7-6. Moderate traffic volume (LOS B) is observed near the EPZ boundary on M-140 southbound through Watervliet, on I-94 in the Shadow Region between Hartford and Lawrence and on 109th Ave near the I-196 on-ramp in the Shadow Region. All roadways in the study area are operating at LOS A five minutes later.

7.4 Evacuation Rates

Evacuation is a continuous process, as implied by Figure 7-7 through Figure 7-20. These figures indicate the rate at which traffic flows out of the indicated areas for the case of an evacuation of the full EPZ (Region R03) under the indicated conditions. One figure is presented for each scenario considered.

As indicated in Figure 7-7, there is typically a long "tail" to these distributions. Vehicles begin to evacuate an area slowly at first, as people respond to the ATE at different rates. Then traffic demand builds rapidly (slopes of curves increase). When the system becomes congested, traffic exits the EPZ at rates somewhat below capacity until some evacuation routes have cleared. As more routes clear, the aggregate rate of egress slows since many vehicles have already left the EPZ. Towards the end of the process, relatively few evacuees (those with the longest mobilization times) travel freely out of the EPZ.

This decline in aggregate flow rate, towards the end of the process, is characterized by these curves flattening and gradually becoming horizontal. Ideally, it would be desirable to fully saturate all evacuation routes equally so that all will service traffic near capacity levels and all will clear at the same time. For this ideal situation, all curves would retain the same slope until the end – thus minimizing evacuation time. In reality, this ideal is generally unattainable reflecting the spatial variation in population density, mobilization rates and in highway capacity over the EPZ.

7.5 Evacuation Time Estimate (ETE) Results

Table 7-1 through Table 7-2 present the ETE values for all 13 Evacuation Regions and all 14 Evacuation Scenarios. Table 7-3 through Table 7-4 present the ETE values for the 2-Mile region for both staged and un-staged keyhole regions downwind to 5 miles. They are organized as follows:

Table	Contents
7-1	ETE represents the elapsed time required for 90% of the population within a Region, to evacuate from that Region. All Scenarios are considered, as well as Staged Evacuation scenarios.
7-2	ETE represents the elapsed time required for 100% of the population within a Region, to evacuate from that Region. All Scenarios are considered, as well as Staged Evacuation scenarios.
7-3	ETE represents the elapsed time required for 90% of the population within the 2-mile Region, to evacuate from that Region with both Concurrent and Staged Evacuations.
7-4	ETE represents the elapsed time required for 100% of the population within the 2-mile Region, to evacuate from that Region with both Concurrent and Staged Evacuations.

The animation snapshots described above reflect the ETE statistics for the concurrent (un-staged) evacuation scenarios and regions, which are displayed in Figure 7-3 through Figure 7-6. Most of the traffic congestion is located in PAAs 4 and 5 which are beyond the 5-mile region, thereby explaining why 90th percentile ETE are longer for Region R03 than for Region R02 ranging from 10 minutes to 1 hour. Also, the 90th percentile ETE for keyhole evacuations extending to 10 miles (Regions R07 through R10 – note R06 extends over Lake Michigan) are 20

minutes longer, on average, than ETE for keyhole evacuations extending to 5 miles (Regions R04 and R05).

The 100th percentile ETE for all Regions and for all Scenarios are equal to mobilization time plus a nominal travel time to the boundary of the region being evacuated. This fact implies that the congestion within the EPZ dissipates prior to the end of mobilization, as is displayed in Figure 7-6.

Comparison of Scenarios 5 and 13 in Table 7-1 indicates that the Special Event – the South Haven Fourth of July Celebration – increases the 90th percentile ETE by up to 1 hour and 10 minutes for those Regions wherein PAA 4 evacuates. The additional 9,908 vehicles present for the special event exacerbate congestion along CR-388 eastbound and on the on ramps to I-196, thereby prolonging ETE. While the additional vehicles present for the special event prolong traffic congestion in South Haven beyond 3 hours and 30 minutes from the ATE, congestion still clears prior to the end of mobilization time at 4 hours and 45 minutes. Thus, the 100th percentile ETE are not significantly impacted by the special event.

Comparison of Scenarios 1 and 14 in Table 7-1 indicates that the roadway closure – one lane northbound on I-196 from the interchange with CR-378 (Exit 13) to the interchange with CR-89 (Exit 32) – does not have a material impact (at most 5 minute increases) on the 90th percentile ETE or the 100th percentile ETE (no change). As discussed in Section 7.3, I-196 does not experience significant levels of congestion. Rather, the ramps to access I-196 are the bottlenecks. Thus, the reduced capacity on I-196 still provides adequate capacity to service the evacuation demand.

7.6 Staged Evacuation Results

Table 7-3 and Table 7-4 present a comparison of the ETE compiled for the concurrent (un-staged) and staged evacuation studies. Note that Regions R11 through R13 are the same geographic areas as Regions R02, R04, and R05, respectively.

To determine whether the staged evacuation strategy is worthy of consideration, one must show that the ETE for the 2 Mile region can be reduced without significantly affecting the region between 2 miles and 5 miles. In all cases, as shown in these tables, the 90th percentile and 100th percentile ETE for the 2 mile region are unchanged when a staged evacuation is implemented. The reason for this is that the congestion within the 5-mile region does not extend upstream to the extent that it penetrates to within 2 miles of the PPP. Consequently, the impedance, due to this congestion within the 5-mile area, to evacuees from within the 2-mile area is not sufficient to materially influence the 90th percentile ETE for the 2-mile area. Therefore, staging the evacuation to reduce congestion within the 5-mile area, provides no benefits to evacuees from within the 2 mile region.

While failing to provide benefit to evacuees from within 2 miles of the PPP, staging produces a negative impact on the ETE for those evacuating from within the 2 to 5-mile area. A comparison of ETE between Regions, R11 and R02; R12 and R04; and R13 and R05; reveals that staging retards the 90th percentile evacuation time for those in the 2 to 5-mile area by up to 20

minutes (see Table 7-1). This extending of ETE is due to the delay in beginning the evacuation trip, experienced by those who shelter, plus the effect of the trip-generation "spike" (significant volume of traffic beginning the evacuation trip at the same time – see Figure 5-5) that follows their eventual ATE, in creating congestion within the EPZ area beyond 2 miles. The 100th percentile ETE are not impacted.

In summary, the staged evacuation option provides no benefits to evacuees from the 2 mile region and adversely impacts many evacuees located beyond 2 miles from the PPP.

7.7 Guidance on Using ETE Tables

The user first determines the percentile of population for which the ETE is sought (NRC guidance calls for the 90th percentile). The applicable value of ETE within the chosen table may then be identified using the following procedure:

1. Identify the applicable **Scenario** (Step 1):
   - Season
     - Summer
     - Winter (also Autumn and Spring)
   - Day of Week
     - Midweek
     - Weekend
   - Time of Day
     - Midday
     - Evening
   - Weather Condition
     - Good Weather
     - Rain/Light Snow
     - Heavy Snow
   - Special Event
     - South Haven Fourth of July Celebration
   - Roadway Impact
     - Road Closure (a lane on I-196 northbound is closed)
   - Evacuation Staging
     - No, Staged Evacuation is not considered
     - Yes, Staged Evacuation is considered

While these Scenarios are designed, in aggregate, to represent conditions throughout the year, some further clarification is warranted:

- The conditions of a summer evening (either midweek or weekend) and rain are not explicitly identified in the Tables. For these conditions, Scenarios (2) and (4) apply.
- The conditions of a winter evening (either midweek or weekend) and rain/light snow are not explicitly identified in the Tables. For these conditions, Scenarios (7) and (10) for rain/light snow apply.
- The conditions of a winter evening (either midweek or weekend) and heavy snow

are not explicitly identified in the Tables. For these conditions, Scenarios (8) and (11) for heavy snow apply.

- The seasons are defined as follows:
  - Summer assumes public school is in session, at summer enrollment levels (lower than normal enrollment).
  - Winter (includes Spring and Autumn) considers that public schools are in session, at normal enrollment levels.
- Time of Day: Midday implies the time over which most commuters are at work or are travelling to/from work.

2. With the desired percentile ETE and Scenario identified, now identify the **Evacuation Region** (Step 2):
   - Determine the projected azimuth direction of the plume (coincident with the wind direction). This direction is expressed in terms of compass orientation: from N, NNE, NE, …
   - Determine the distance that the Evacuation Region will extend from the plant. The applicable distances and their associated candidate Regions are given below:
     - 2 Miles (Region R01)
     - To 5 Miles (Region R02, R04, R05, and staged regions R11 through R13)
     - To EPZ Boundary (Regions R03, R06 through R10)
   - Enter Table 7-5 and identify the applicable group of candidate Regions based on the distance that the selected Region extends from the plant. Select the Evacuation Region identifier in that row, based on the azimuth direction of the plume, from the first column of the Table.
3. Determine the **ETE Table based on the percentile selected.** Then, for the **Scenario** identified in Step 1 and the Evacuation **Region** identified in Step 2, proceed as follows:
   - The columns of Table 7-1 are labeled with the Scenario numbers. Identify the proper column in the selected Table using the Scenario number defined in Step 1.
   - Identify the row in this table that provides ETE values for the Region identified in Step 2.
   - The unique data cell defined by the column and row so determined contains the desired value of ETE expressed in Hours:Minutes.

Example

It is desired to identify the ETE for the following conditions:

- Sunday, August 10th at 4:00 AM.
- It is raining.
- Wind direction is from the southwest (SW) or from 225°.
- Wind speed is such that the distance to be evacuated is judged to be a 2-mile radius and downwind to 10 miles (to EPZ boundary).
- The desired ETE is that value needed to evacuate 90% of the population from within the impacted Region.
- A staged evacuation is not desired.

Table 7-1 is applicable because the 90th percentile ETE is desired. Proceed as follows:

1. Identify the Scenario as summer, weekend, evening and raining. Entering Table 7-1, it is seen that there is no match for these descriptors. However, the clarification given above assigns this combination of circumstances to Scenario 4.
2. Enter Table 7-5 and locate the Region described as "Evacuate 2-Mile Radius and Downwind to the EPZ Boundary" for wind direction from the SW or 225°) and read Region R07 in the first column for the row with Wind Direction From (Degrees) listed as ≥169 and <236.
3. Enter Table 7-1 to locate the data cell containing the value of ETE for Scenario 4 and Region R07. This data cell is in column (4) and in the row for Region R07; it contains the ETE value of 2:15.

Table 7-1. Time to Clear the Indicated Area of *90* Percent of the Affected Population

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Special Event	Roadway Impact
Radial Regions – 2-Mile, 5-Mile, Full EPZ														
R01	2:05	2:10	2:05	2:05	2:10	2:05	2:10	2:20	2:05	2:05	2:15	2:05	2:10	2:05
R02	2:20	2:20	2:10	2:15	2:15	2:20	2:20	3:05	2:10	2:15	2:50	2:15	2:15	2:20
R03	2:40	2:40	2:20	2:25	2:25	2:45	2:45	3:30	2:25	2:25	3:15	2:25	3:15	2:45
Evacuate 2-Mile Radius and Downwind to 5-Mile Radius														
R04	2:15	2:15	2:10	2:10	2:15	2:15	2:15	2:55	2:10	2:10	2:40	2:15	2:15	2:15
R05	2:15	2:15	2:10	2:10	2:15	2:15	2:15	2:45	2:10	2:10	2:30	2:10	2:15	2:15
Evacuate 2-Mile Radius and Downwind to the EPZ Boundary														
R06	2:05	2:10	2:05	2:05	2:10	2:05	2:10	2:20	2:05	2:05	2:15	2:05	2:10	2:05
R07	2:35	2:35	2:15	2:15	2:20	2:35	2:35	3:25	2:15	2:15	3:05	2:20	3:30	2:40
R08	2:40	2:40	2:20	2:25	2:25	2:45	2:45	3:30	2:25	2:25	3:15	2:25	3:15	2:45
R09	2:35	2:35	2:20	2:25	2:25	2:40	2:40	3:30	2:20	2:25	3:10	2:25	2:25	2:35
R10	2:35	2:35	2:20	2:25	2:25	2:40	2:40	3:30	2:20	2:25	3:10	2:25	2:25	2:35
Staged Evacuation - 2-Mile Radius Evacuates, then Evacuate Downwind to 5-Mile Radius														
R11	2:35	2:35	2:30	2:30	2:35	2:35	2:35	3:05	2:30	2:30	2:50	2:35	2:35	2:35
R12	2:30	2:30	2:30	2:30	2:35	2:30	2:30	2:55	2:30	2:30	2:40	2:35	2:35	2:30
R13	2:25	2:25	2:20	2:20	2:25	2:25	2:25	2:45	2:20	2:20	2:35	2:25	2:25	2:25

Table 7-2. Time to Clear the Indicated Area of *100* Percent of the Affected Population

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Special Event	Roadway Impact
Radial Regions – 2-Mile, 5-Mile, Full EPZ														
R01	4:45	4:45	4:45	4:45	4:45	4:45	4:45	6:00	4:45	4:45	6:00	4:45	4:45	4:45
R02	4:50	4:50	4:50	4:50	4:50	4:50	4:50	6:05	4:50	4:50	6:05	4:50	4:50	4:50
R03	4:55	4:55	4:55	4:55	4:55	4:55	4:55	6:10	4:55	4:55	6:10	4:55	5:00	4:55
Evacuate 2-Mile Radius and Downwind to 5-Mile Radius														
R04	4:50	4:50	4:50	4:50	4:50	4:50	4:50	6:05	4:50	4:50	6:05	4:50	4:50	4:50
R05	4:50	4:50	4:50	4:50	4:50	4:50	4:50	6:05	4:50	4:50	6:05	4:50	4:50	4:50
Evacuate 2-Mile Radius and Downwind to the EPZ Boundary														
R06	4:45	4:45	4:45	4:45	4:45	4:45	4:45	6:10	4:45	4:45	6:10	4:45	4:45	4:45
R07	4:55	4:55	4:55	4:55	4:55	4:55	4:55	6:10	4:55	4:55	6:10	4:55	5:00	4:55
R08	4:55	4:55	4:55	4:55	4:55	4:55	4:55	6:10	4:55	4:55	6:10	4:55	5:00	4:55
R09	4:55	4:55	4:55	4:55	4:55	4:55	4:55	6:10	4:55	4:55	6:10	4:55	4:55	4:55
R10	4:55	4:55	4:55	4:55	4:55	4:55	4:55	6:10	4:55	4:55	6:10	4:55	4:55	4:55
Staged Evacuation - 2-Mile Radius Evacuates, then Evacuate Downwind to 5-Mile Radius														
R11	4:50	4:50	4:50	4:50	4:50	4:50	4:50	6:05	4:50	4:50	6:05	4:50	4:50	4:50
R12	4:50	4:50	4:50	4:50	4:50	4:50	4:50	6:05	4:50	4:50	6:05	4:50	4:50	4:50
R13	4:50	4:50	4:50	4:50	4:50	4:50	4:50	6:05	4:50	4:50	6:05	4:50	4:50	4:50

Table 7-3. Time to Clear ***90 Percent*** of the ***2-Mile Region*** within the Indicated Region

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Special Event	Roadway Impact
Unstaged Evacuation - 2-Mile Region and 5-Mile Region														
R01	2:05	2:10	2:05	2:05	2:10	2:05	2:10	2:20	2:05	2:05	2:15	2:05	2:10	2:05
R02	2:05	2:10	2:05	2:05	2:10	2:05	2:10	2:20	2:05	2:05	2:15	2:05	2:10	2:05
Unstaged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R04	2:05	2:10	2:05	2:05	2:10	2:05	2:10	2:20	2:05	2:05	2:15	2:05	2:10	2:05
R05	2:05	2:10	2:05	2:05	2:10	2:05	2:10	2:20	2:05	2:05	2:15	2:05	2:10	2:05
Staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R11	2:05	2:10	2:05	2:05	2:10	2:05	2:10	2:20	2:05	2:05	2:15	2:05	2:10	2:05
R12	2:05	2:10	2:05	2:05	2:10	2:05	2:10	2:20	2:05	2:05	2:15	2:05	2:10	2:05
R13	2:05	2:10	2:05	2:05	2:10	2:05	2:10	2:20	2:05	2:05	2:15	2:05	2:10	2:05

Table 7-4. Time to Clear *100 Percent* of the *2-Mile Region* within the Indicated Region

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Special Event	Roadway Impact
Unstaged Evacuation - 2-Mile Region and 5-Mile Region														
R01	4:45	4:45	4:45	4:45	4:45	4:45	4:45	6:00	4:45	4:45	6:00	4:45	4:45	4:45
R02	4:45	4:45	4:45	4:45	4:45	4:45	4:45	6:00	4:45	4:45	6:00	4:45	4:45	4:45
Unstaged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R04	4:45	4:45	4:45	4:45	4:45	4:45	4:45	6:00	4:45	4:45	6:00	4:45	4:45	4:45
R05	4:45	4:45	4:45	4:45	4:45	4:45	4:45	6:00	4:45	4:45	6:00	4:45	4:45	4:45
Staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R11	4:45	4:45	4:45	4:45	4:45	4:45	4:45	6:00	4:45	4:45	6:00	4:45	4:45	4:45
R12	4:45	4:45	4:45	4:45	4:45	4:45	4:45	6:00	4:45	4:45	6:00	4:45	4:45	4:45
R13	4:45	4:45	4:45	4:45	4:45	4:45	4:45	6:00	4:45	4:45	6:00	4:45	4:45	4:45

Table 7-5. Description of Evacuation Regions

Region	Description	PAA 1	PAA 2	PAA 3	PAA 4	PAA 5	PAA 6	PAA 7
Radial Regions								
Region	**Description**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
R01	2-Mile Region	X					X	
R02	5-Mile Region	X	X	X			X	
R03	Full EPZ	X	X	X	X	X	X	X
Evacuate 2-Mile Region and Downwind to 5-Miles								
Region	**Wind Direction From (Degrees)**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
N/A	≥56 and <169	**Refer to R01**						
R04	≥169 and <236	X	X				X	
N/A	≥236 and <303	**Refer to R02**						
R05	≥303 and <56	X		X			X	
Evacuate 2-Mile Region and Downwind to the EPZ Boundary								
Region	**Wind Direction From (Degrees)**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
R06	≥56 and <169	X					X	X
R07	≥169 and <236	X	X		X		X	X
R08	≥236 and <303	X	X	X	X	X	X	
R09	≥303 and <348	X		X		X	X	
R10	≥348 and <56	X		X		X	X	X
Staged Evacuation - 2-Mile Region Evacuates, then Evacuate Downwind to 5-Miles								
Region	**Wind Direction From (Degrees)**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
R11	5-Mile Region	X	X	X			X	
N/A	≥56 and <169	**Refer to R01**						
R12	≥169 and <236	X	X				X	
N/A	≥236 and <303	**Refer to R11**						
R13	≥303 and <56	X		X			X	
PAA(s) Evacuate		PAA(s) Shelter-in-Place		PAA(s) Shelter-in-Place until 90% ETE for R01, then Evacuate				

Figure 7-1. Voluntary Evacuation Methodology

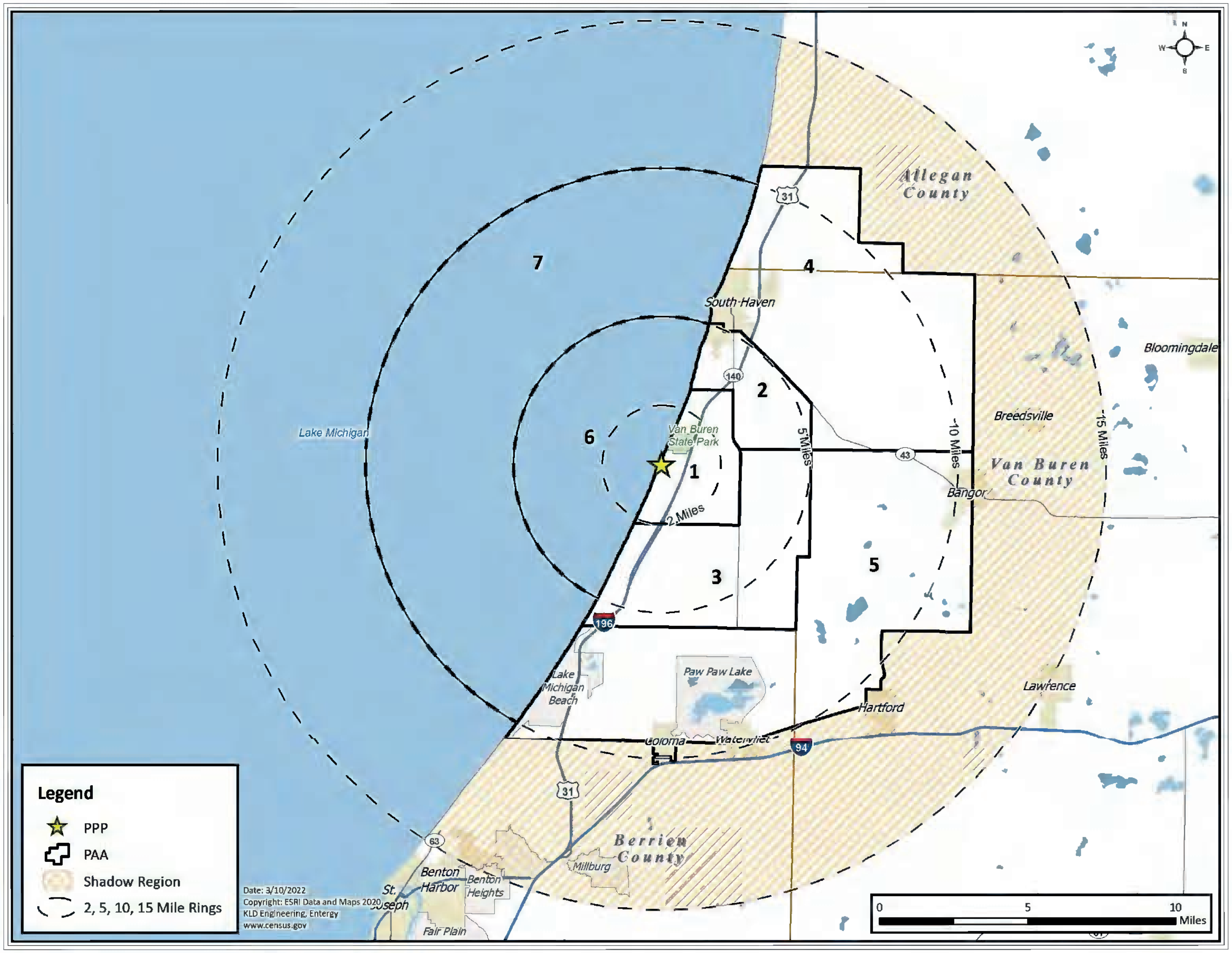


Figure 7-2. PPP Shadow Region

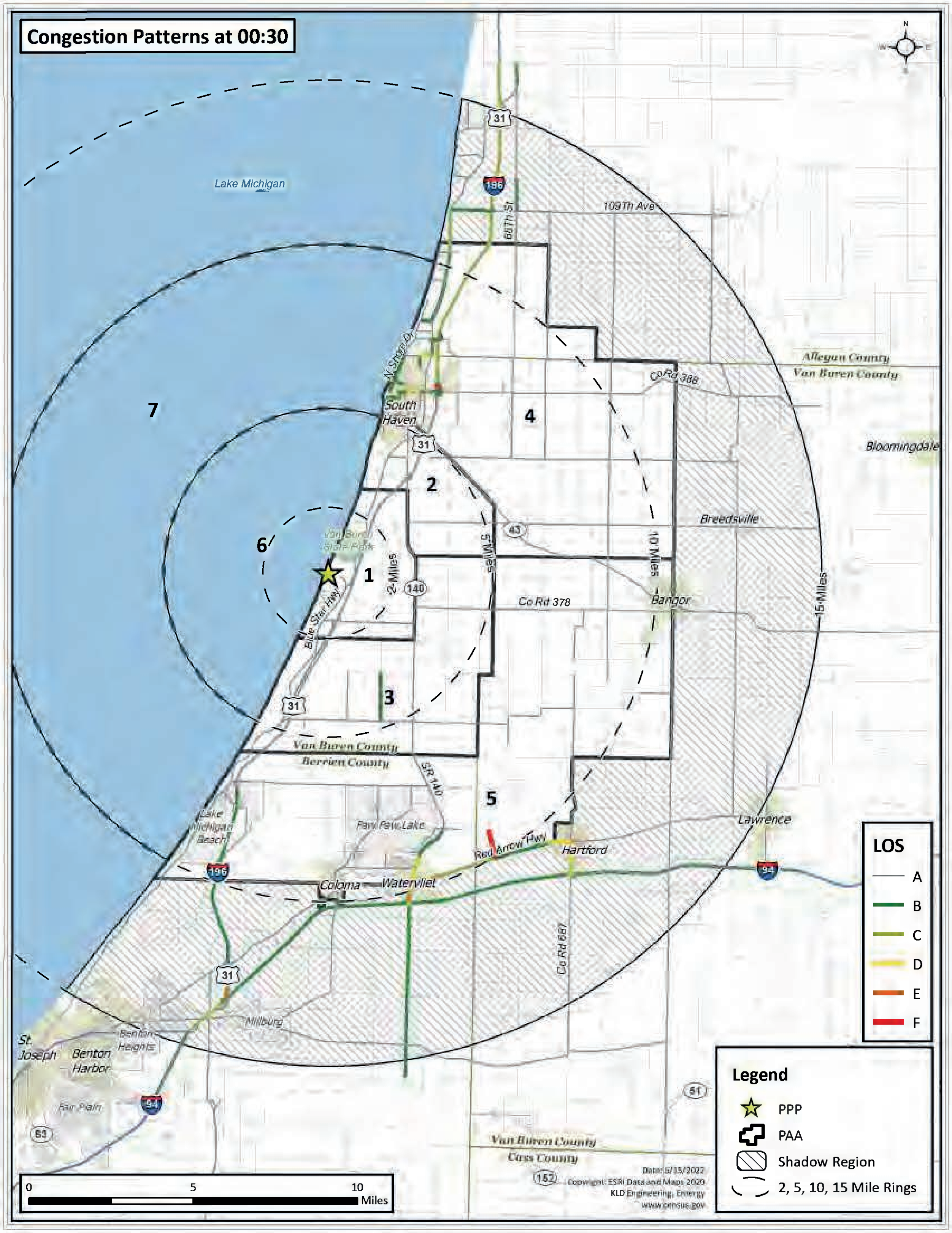


Figure 7-3. Congestion Patterns at 30 Minutes after the Advisory to Evacuate

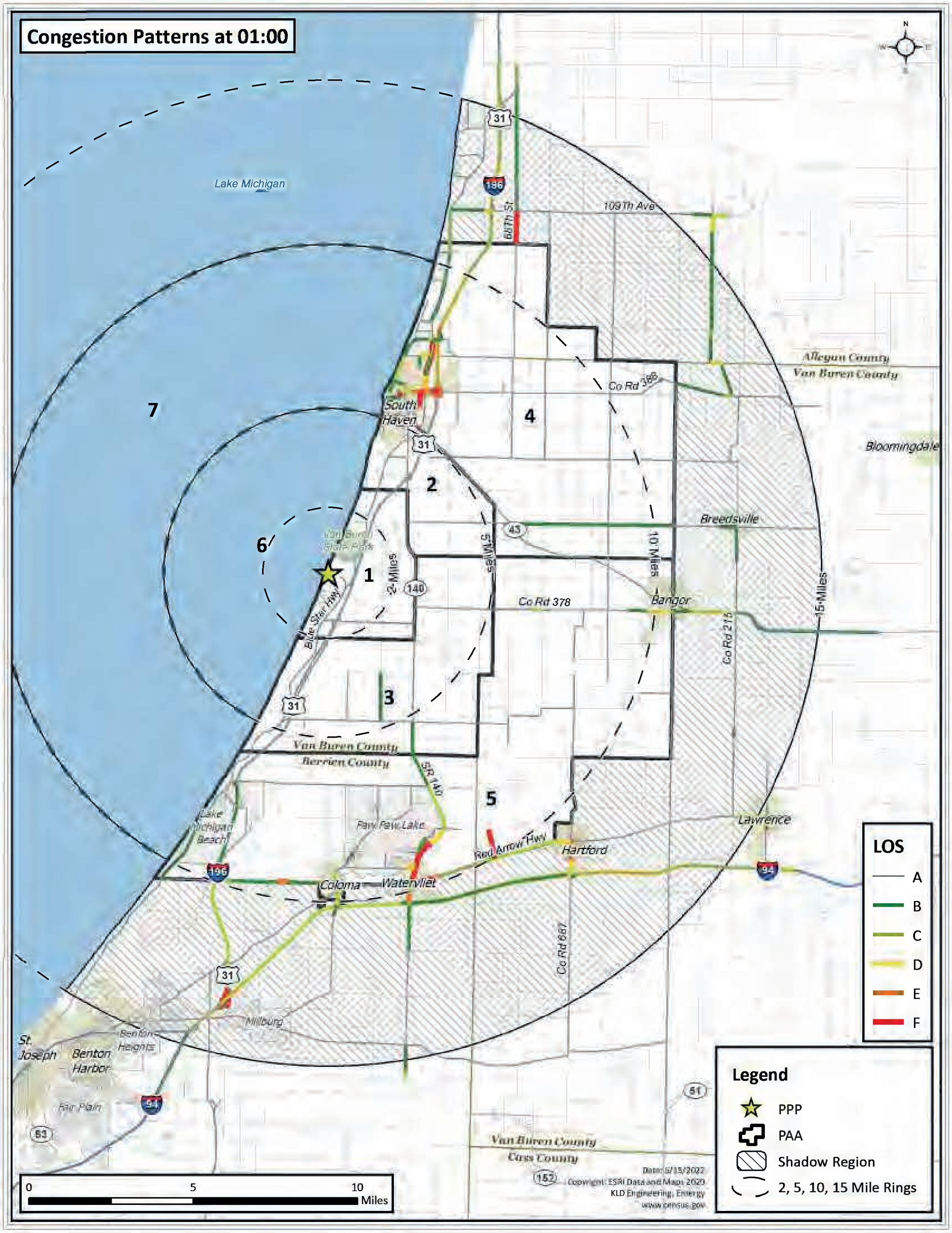


Figure 7.4. Congestion Patterns at 1 Hour after the Advisory to Evacuate

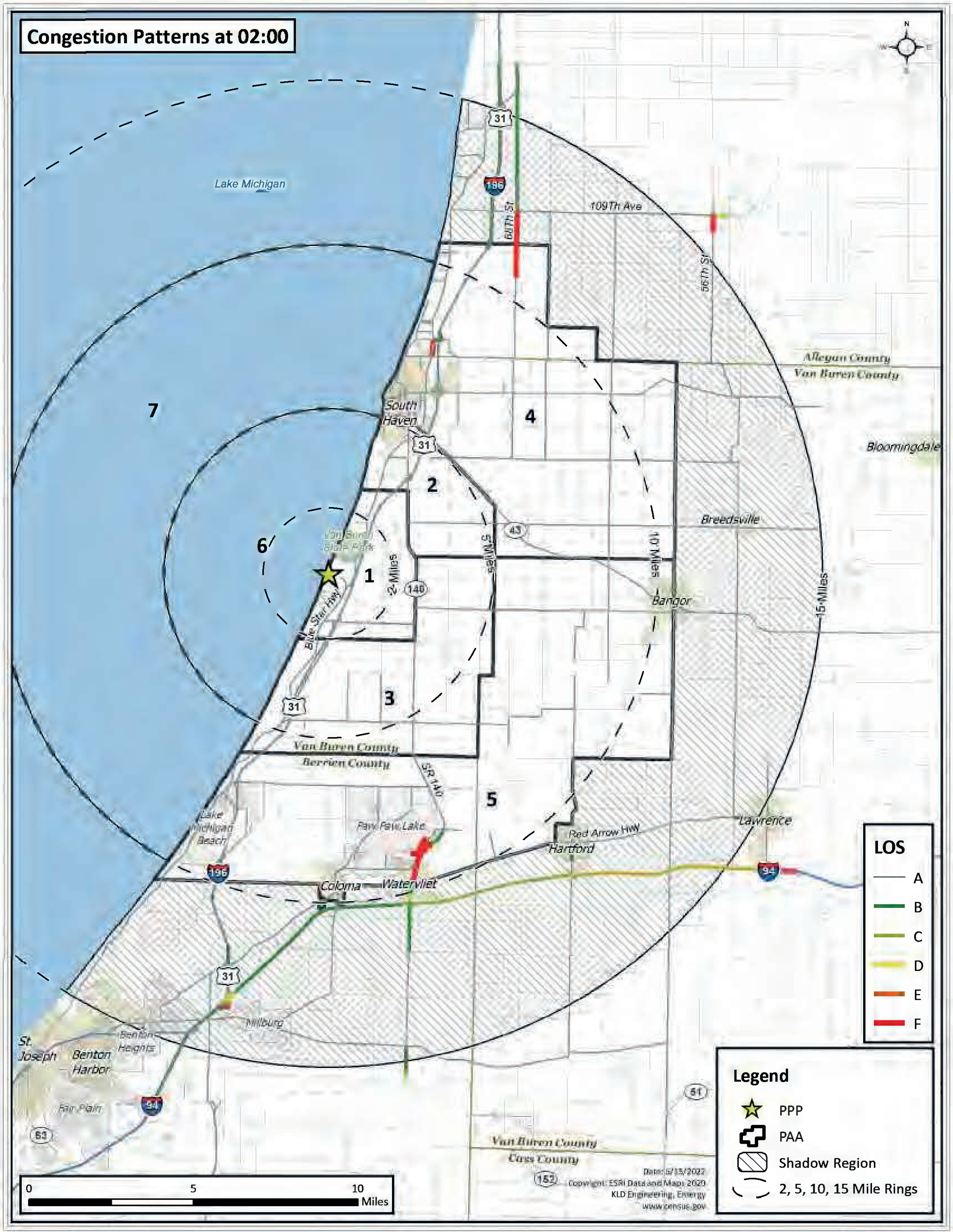


Figure 7.5. Congestion Patterns at 2 Hours after the Advisory to Evacuate

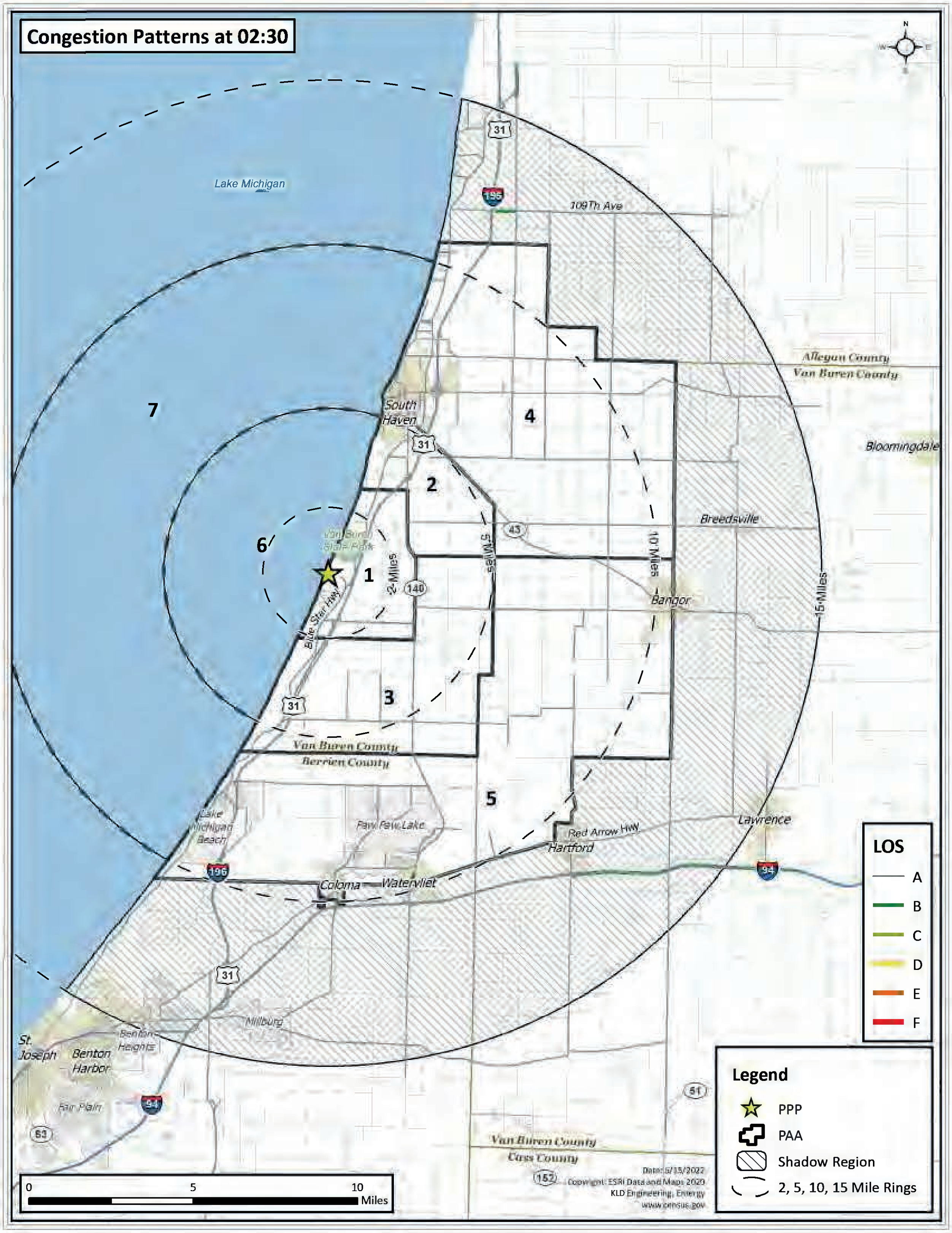


Figure 7.6. Congestion Patterns at 2 Hours and 30 Minutes after the Advisory to Evacuate

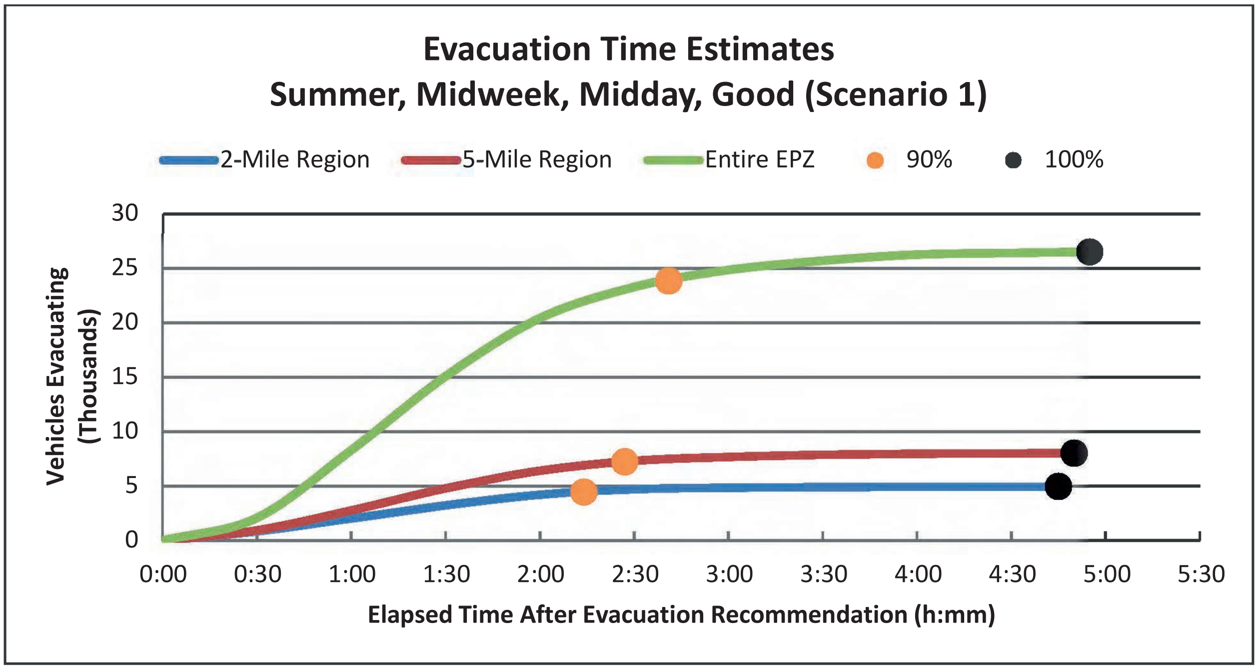


Figure 7-7. Evacuation Time Estimates - Scenario 1 for Region R03

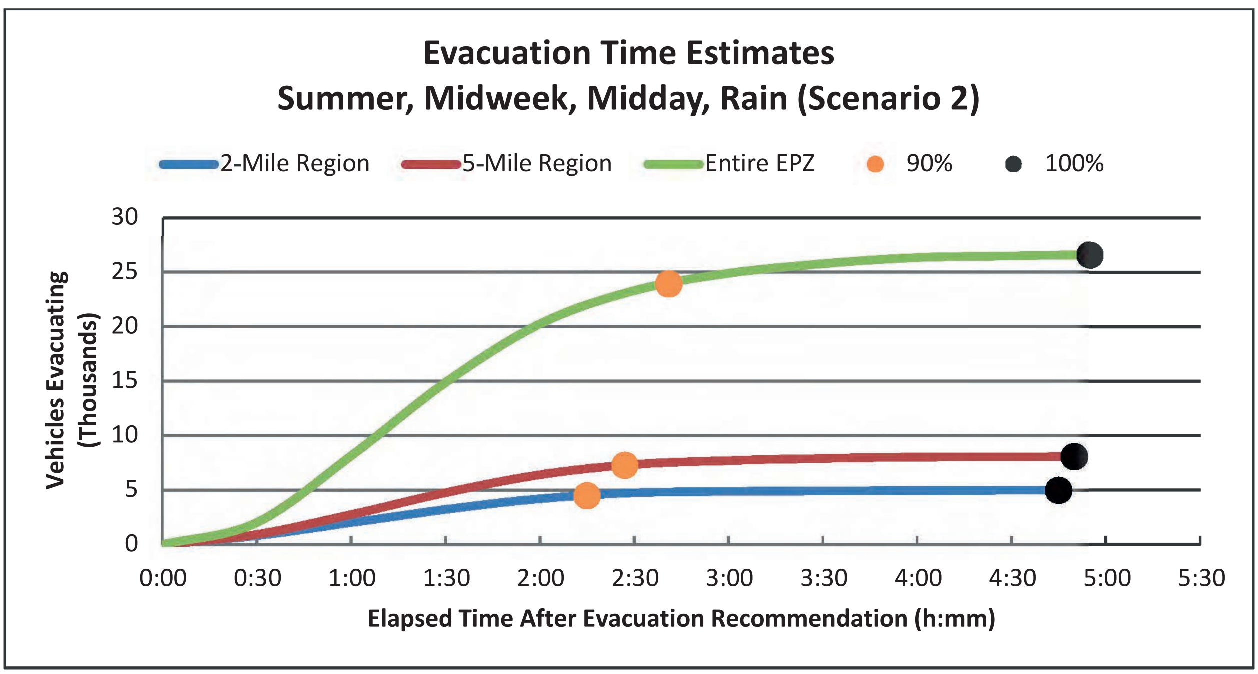


Figure 7-8. Evacuation Time Estimates - Scenario 2 for Region R03

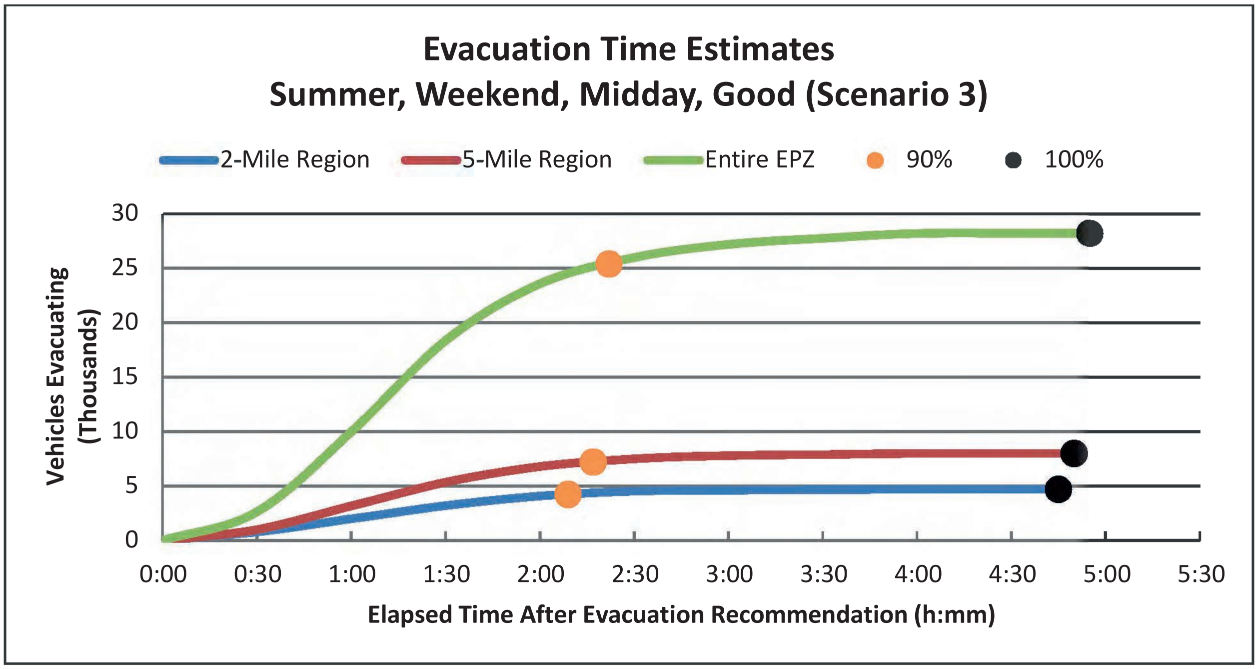


Figure 7-9. Evacuation Time Estimates - Scenario 3 for Region R03

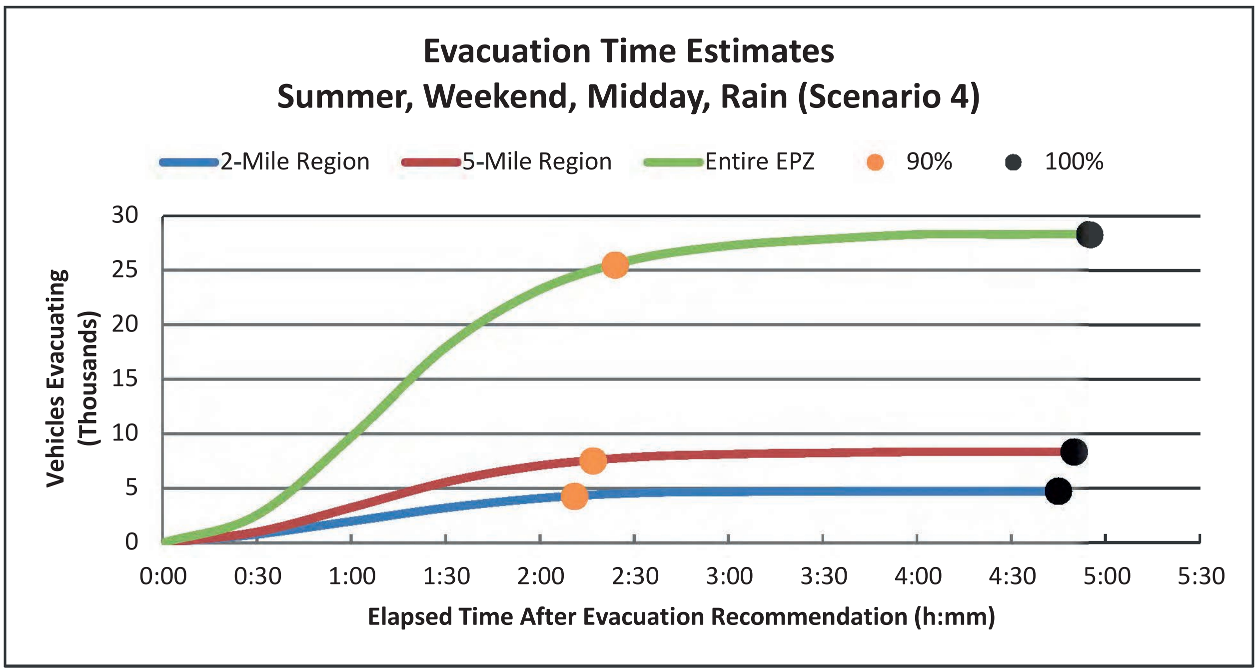


Figure 7-10. Evacuation Time Estimates - Scenario 4 for Region R03

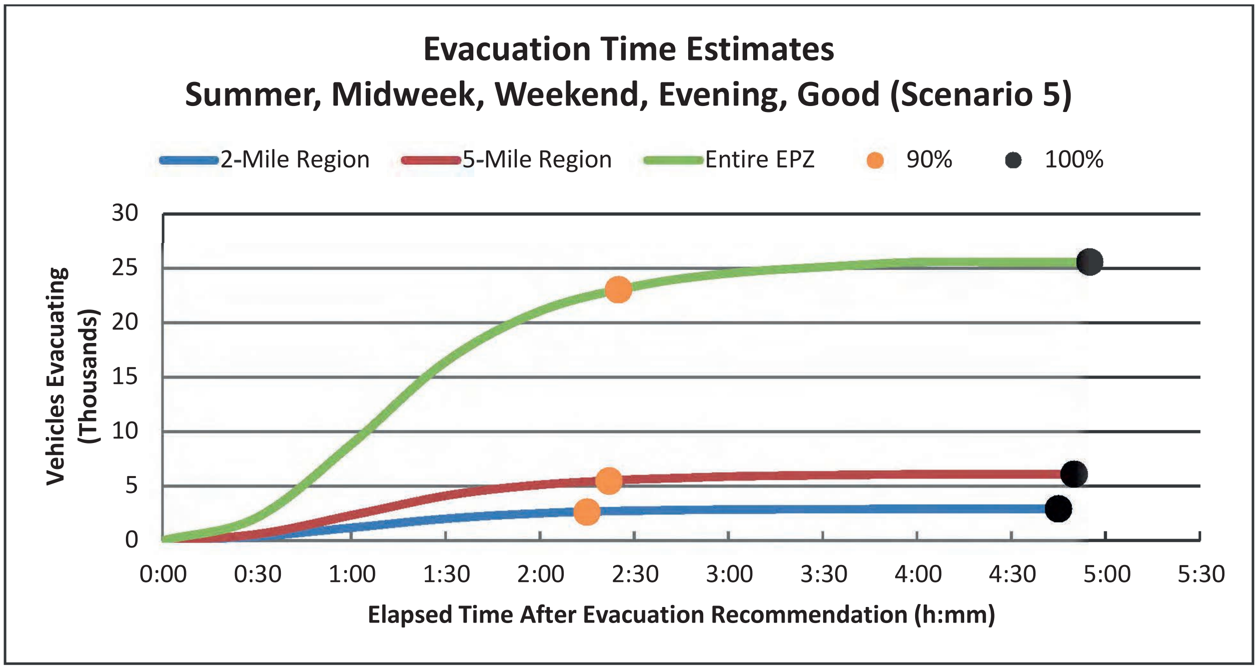


Figure 7-11. Evacuation Time Estimates - Scenario 5 for Region R03

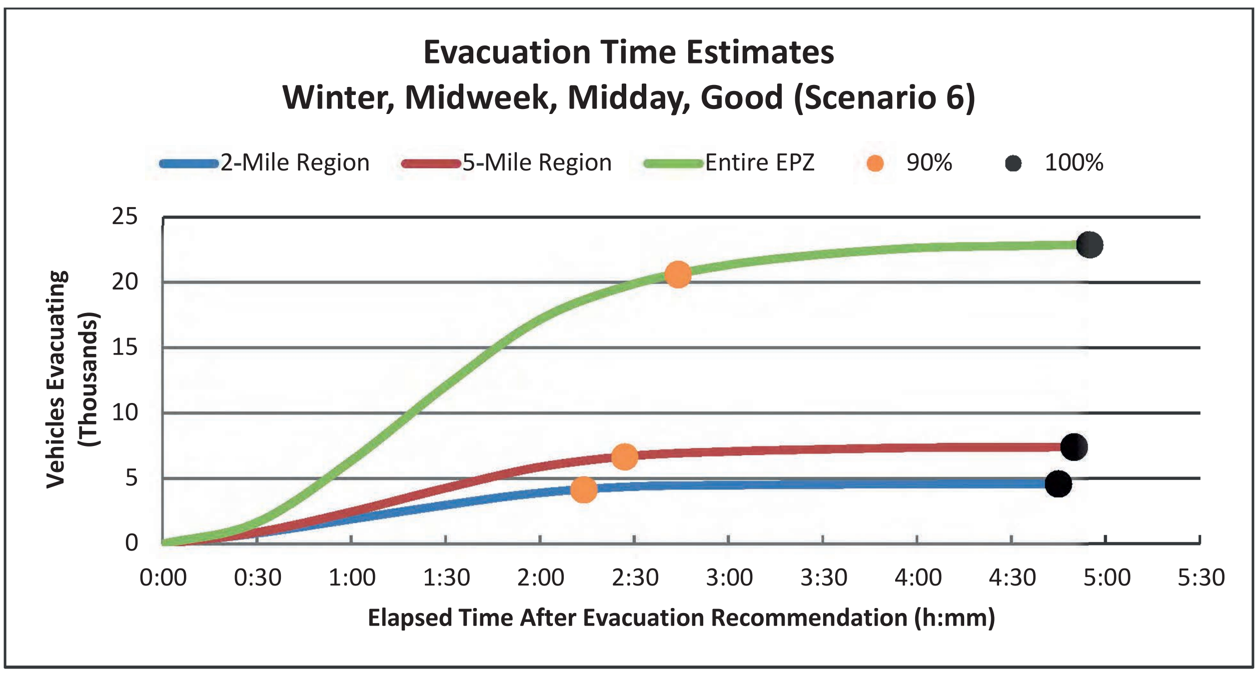


Figure 7-12. Evacuation Time Estimates - Scenario 6 for Region R03

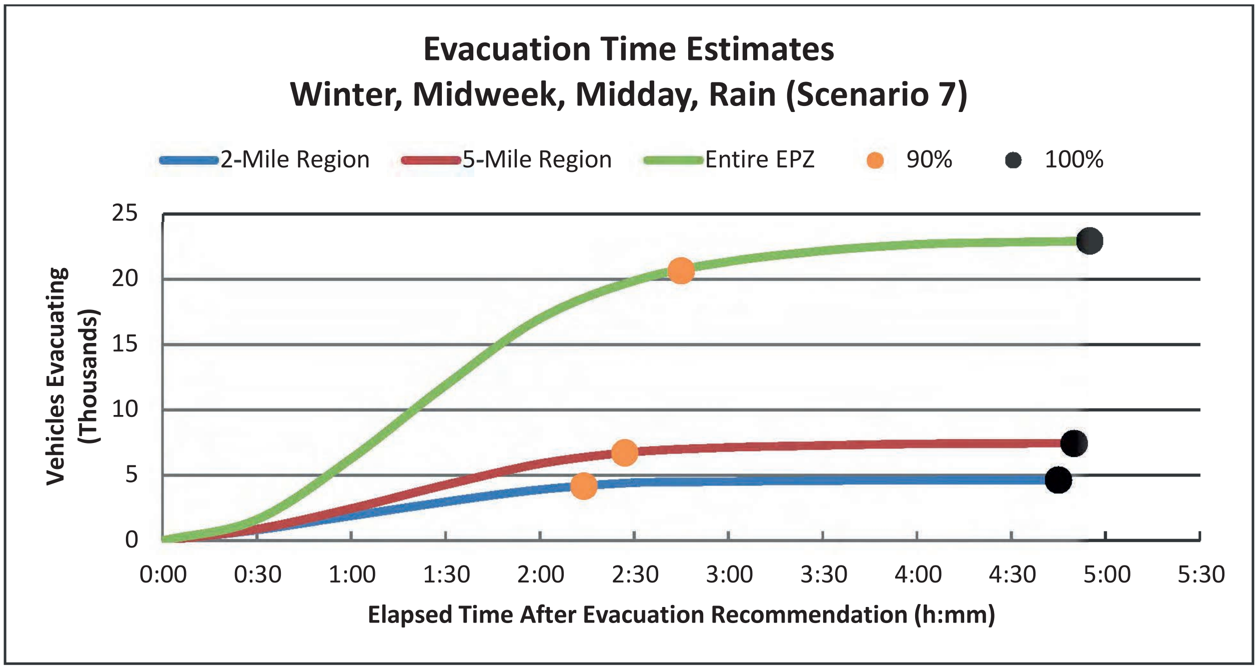


Figure 7-13. Evacuation Time Estimates - Scenario 7 for Region R03

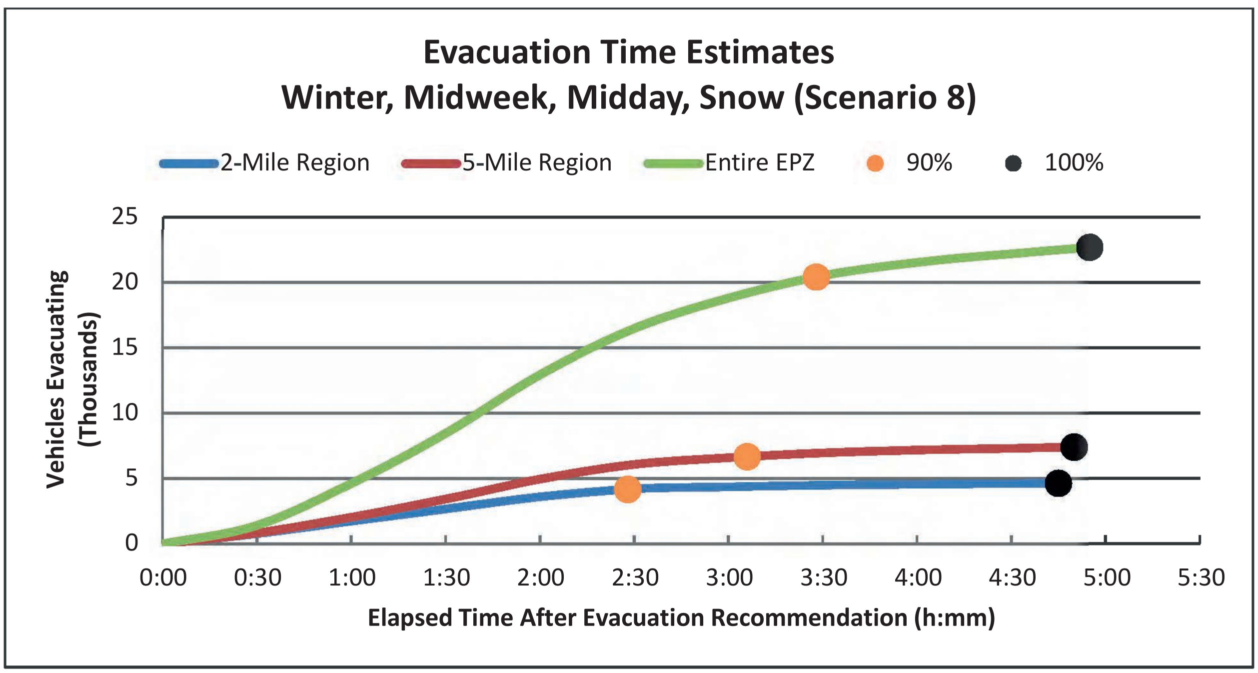


Figure 7-14. Evacuation Time Estimates - Scenario 8 for Region R03

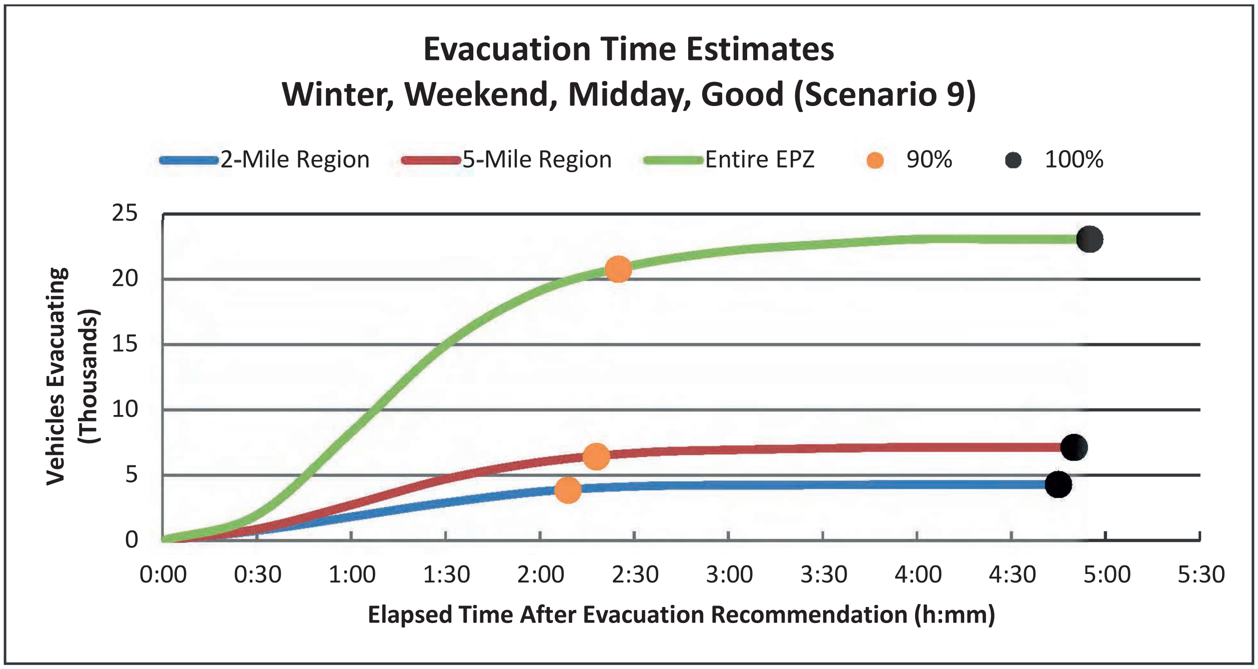


Figure 7-15. Evacuation Time Estimates - Scenario 9 for Region R03

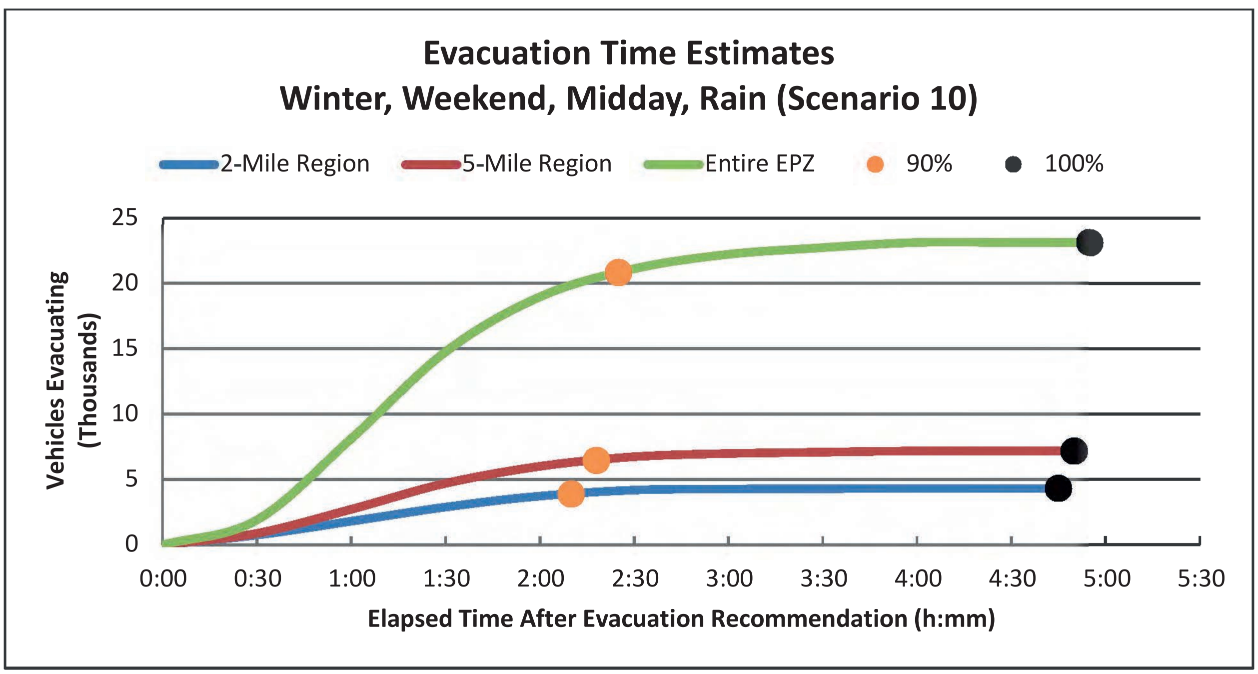


Figure 7-16. Evacuation Time Estimates - Scenario 10 for Region R03

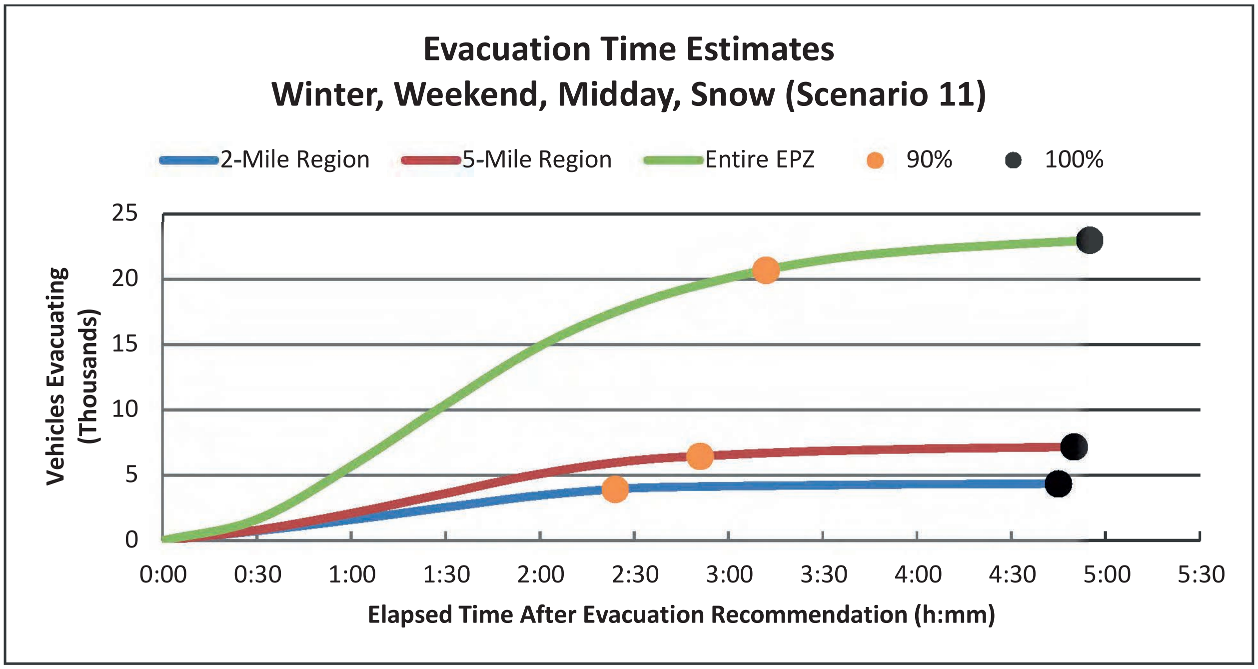


Figure 7-17. Evacuation Time Estimates - Scenario 11 for Region R03

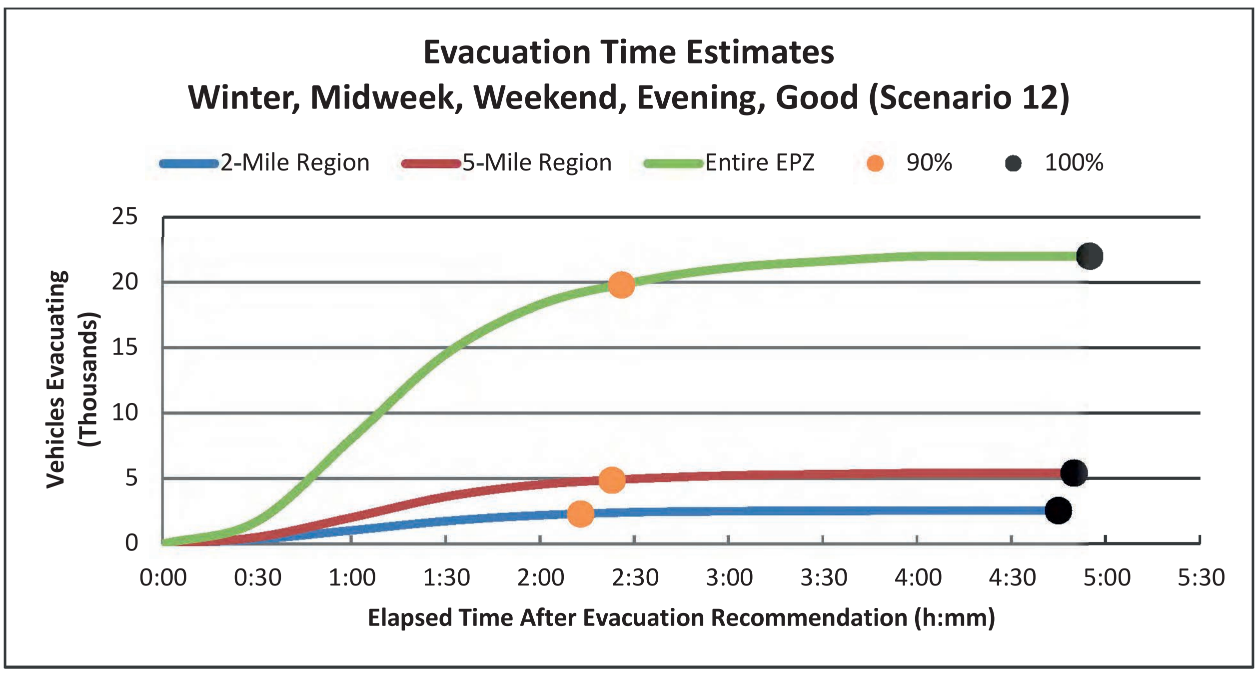


Figure 7-18. Evacuation Time Estimates - Scenario 12 for Region R03

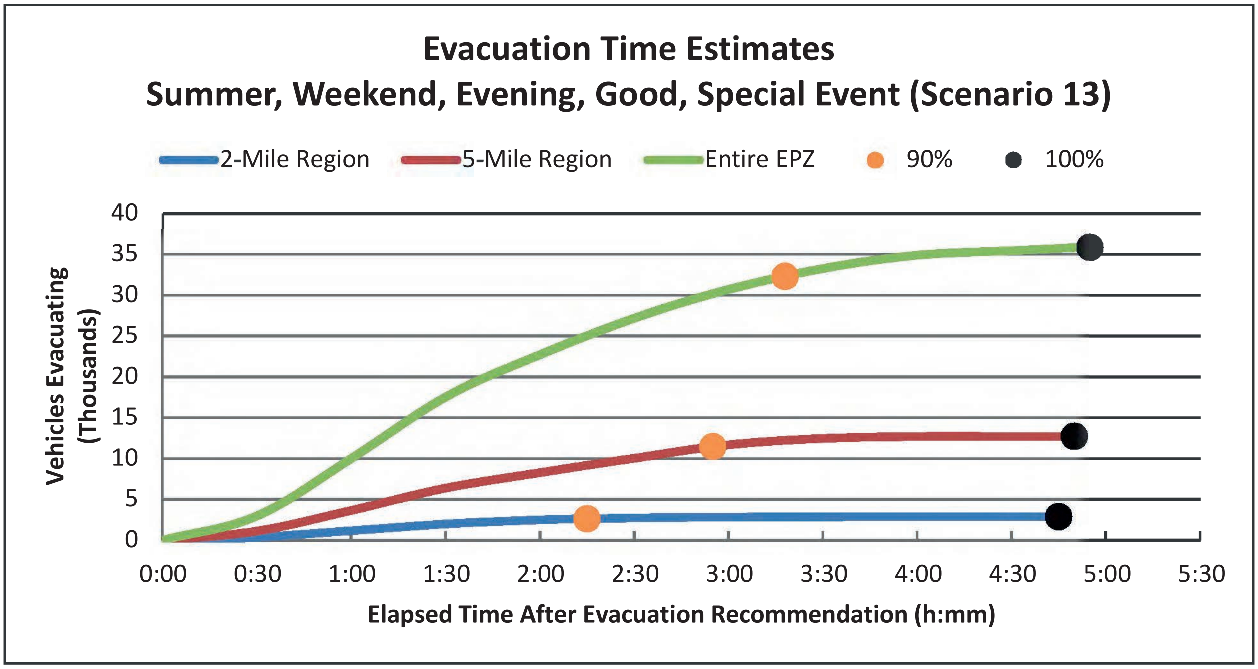


Figure 7-19. Evacuation Time Estimates - Scenario 13 for Region R03

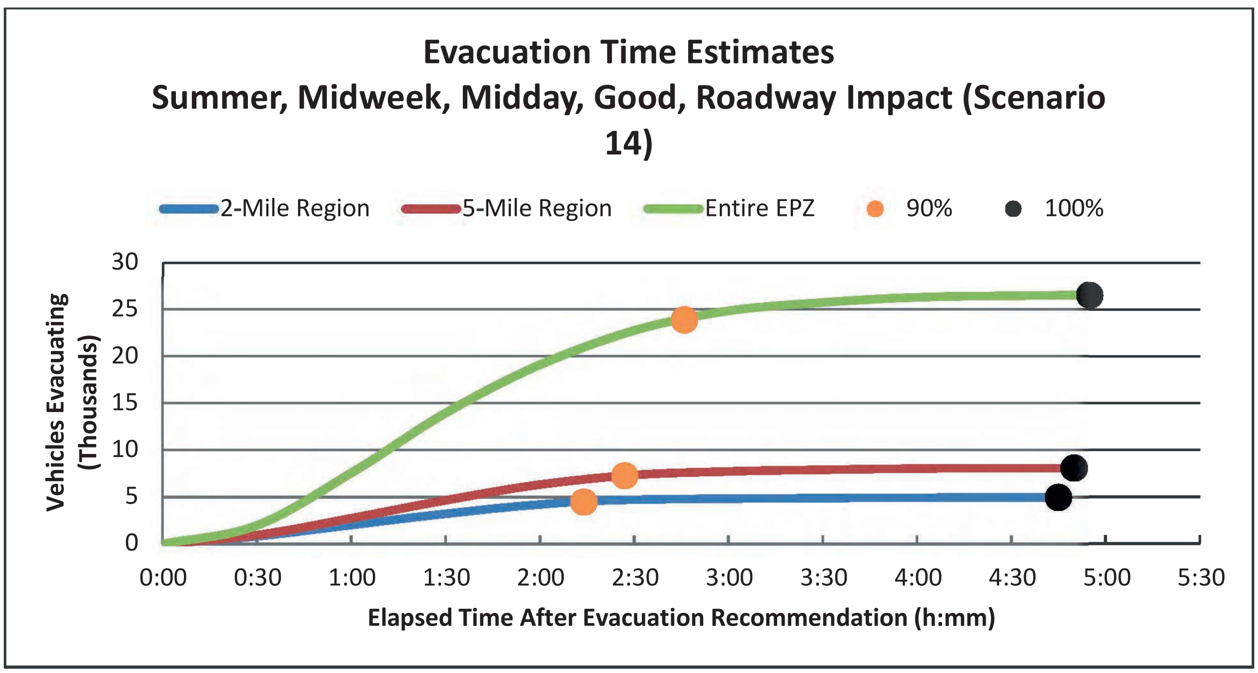


Figure 7-20. Evacuation Time Estimates - Scenario 14 for Region R03

8 TRANSIT-DEPENDENT AND SPECIAL FACILITY EVACUATION TIME ESTIMATES

This section details the analyses applied and the results obtained in the form of ETE for transit vehicles (e.g., buses, wheelchair transport, and ambulances). The demand for transit service reflects the needs of three population groups:

- residents with no vehicles available;
- residents of special facilities such as schools, medical facilities; and
- homebound population with access and/or functional needs.

These transit vehicles mix with the general evacuation traffic that is comprised mostly of "passenger cars" (pc's). The presence of each transit vehicle in the evacuating traffic stream is represented within the modeling paradigm described in Appendix D as equivalent to two pc's. This equivalence factor represents the longer size and more sluggish operating characteristics of a transit vehicle, relative to those of a pc.

Transit vehicles must be mobilized in preparation for their respective evacuation missions. Specifically:

- Bus drivers must be alerted
- They must travel to the bus depot
- They must be briefed there and assigned to a route or facility

These activities consume time. Based on discussion with the offsite agencies, it is estimated that bus mobilization time will average approximately 90 minutes for schools and medical facilities extending from the ATE, to the time when buses first arrive at the facility to be evacuated.

During this mobilization period, other mobilization activities are taking place. One of these is the action taken by parents, neighbors, relatives and friends to pick up children from school prior to the arrival of buses, so that they may join their families. Virtually all studies of evacuations have concluded that this "bonding" process of uniting families is universally prevalent during emergencies and should be anticipated in the planning process. The current public information disseminated to residents of the PPP EPZ indicates that schoolchildren will be evacuated to temporary host facilities (THF) at emergency action levels of Site Area Emergency or higher, and that parents should pick schoolchildren up at the appropriate THF. As discussed in Section 2, this study assumes a fast-breaking general emergency. Therefore, children are evacuated to the THF. Picking up children at school could add to traffic congestion at the schools, delaying the departure of the buses evacuating schoolchildren, which may have to return in a subsequent "wave" to the EPZ to evacuate the transit-dependent population. This report provides estimates of buses under the assumption that no children will be picked up by their parents (in accordance with NUREG/CR-7002, Rev. 1), to present an upper bound estimate of buses required. It is assumed that children at day-care centers are picked up by parents or guardians and that the time to perform this activity is included in the trip generation times discussed in Section 5.

The procedure for computing transit-dependent ETE is to:

- Estimate demand for transit service
- Estimate time to perform all transit functions
- Estimate route travel times to the EPZ boundary and to the THF/reception centers

ETE for transit trips were developed using both good weather and adverse weather conditions. Figure **8-1** presents the chronology of events relevant to transit operations. The elapsed time for each activity will now be discussed with reference to Figure **8-1**.

8.1 ETEs for Schools, Transit-Dependent People, and Special Facilities

Available transportation resources were provided by the Berrien and Van Buren County emergency management agencies. Allegan County does not provide transportation services in the EPZ. Table 8-1 lists the transportation resources by provider and the transportation needs to evacuate the transit dependent and special facility population in the EPZ. As shown in the table, there are sufficient bus resources to evacuate the entire school, transit dependent population and ambulatory population at medical facilities. EPZ bus resources are assigned to evacuating schoolchildren (if school is in session at the time of the ATE) as the first priority in the event of an emergency. In the event that the allocation of buses dispatched from the depots to the various facilities and to the bus routes is somewhat "inefficient", or if there is a shortfall of available drivers, then there may be a need for some buses to return to the EPZ from the reception center or THF after completing their first evacuation trip, to complete a "second wave" of providing transport service to evacuees. For this reason, the ETE for the transit-dependent population will be calculated for both a one wave transit evacuation and for two waves. Of course, if the impacted Evacuation Region is other than R03 (the entire EPZ), then there will likely be ample transit resources relative to demand in the impacted Region and this discussion of a second wave would likely not apply.

When school evacuation needs are satisfied, subsequent assignments of buses to service the transit-dependent population should be sensitive to their mobilization time. Clearly, the buses should be dispatched after people have completed their mobilization activities and are in a position to board the buses when they arrive at the pick-up points.

School Evacuation

Activity: Mobilize Drivers (A→B→C)

Mobilization is the elapsed time from the ATE until the time the buses arrive at the facility to be evacuated. It is assumed that for a rapidly escalating radiological emergency with no observable indication before the fact, drivers would likely require 90 minutes to be contacted, to travel to the depot, be briefed, and to travel to the transit-dependent facilities. Mobilization time is slightly longer in adverse weather – 100 minutes for rain/light snow, and 110 minutes for heavy snow.

Activity: Board Passengers (C→D)

Based on discussions with offsite agencies, a loading time of 15 minutes (20 minutes for rain/light snow and 25 minutes for heavy snow) for school buses is used. See Section 2.4, assumption 5 and Table 2-2.

Activity: Travel to EPZ Boundary (D→E)

The buses servicing the schools are ready to begin their evacuation trips at 105 minutes after the ATE – 90 minute mobilization time plus 15 minute loading time – in good weather. The UNITES software discussed in Section 1.3 was used to define bus routes along the most likely path from a school being evacuated to the EPZ boundary, traveling toward the appropriate THF. This is done in UNITES by interactively selecting the series of nodes from the school to the EPZ boundary. Each bus route is given an identification number and is written to the DYNEV II input stream. DYNEV computes the route length and outputs the average speed for each 5-minute interval, for each bus route. The specified bus routes are documented in in Section 10 in Table 10-2 (refer to the maps of the link-node analysis network in Appendix K for node locations). Data provided by DYNEV during the appropriate timeframe depending on the mobilization and loading times (i.e., 105 minutes after the ATE for good weather) were used to compute the average speed for each route, as follows:

$$Average\ Speed\ \left(\frac{mi.}{hr}\right) = \left[\frac{\sum_{i-1}^{n} length\ of\ link\ i\ (mi)}{\sum_{i-1}^{n} Delay\ on\ link\ i\ (min.) + \dfrac{length\ of\ link\ i\ (mi.)}{current\ speed\ on\ link\ i\ \left(\frac{mi.}{hr.}\right)} \times \dfrac{60\ min.}{1\ hr.}}\right] \times \frac{60\ min.}{1\ hr.}$$

The average speed computed (using this methodology) for the buses servicing each of the schools in the EPZ is shown in Table 8-2 through Table 8-4 for school evacuation, The travel time to the EPZ boundary was computed for each bus using the computed average speed and the distance to the EPZ boundary along the most likely route out of the EPZ. Speeds were reduced in Table 8-2 through Table 8-4 to 55 mph (50 mph for rain/light snow – a 10% decrease – and 47 mph for snow – a 15% decrease) for those calculated bus speeds which exceed 55 mph, as the school bus speed limit for state routes in Michigan is 55 mph (see assumption 7 in Section 2.1).

Table 8-2 (good weather), Table 8-3 (rain/light snow) and Table 8-4 (heavy snow) present the following ETE (rounded up to the nearest 5 minutes) for schools in the EPZ:

1. The elapsed time from the ATE until the bus exits the EPZ; and
2. The elapsed time until the bus reaches the THF.

The evacuation time out of the EPZ can be computed as the sum of times associated with Activities A→B→C, C→D, and D→E (For example: 90 min. + 15 + 2 = 107 minutes or 1:50, rounded up to the nearest 5 minutes, for Bangor High School, with good weather). The average single-wave ETE, for schools, is less than the 90th percentile ETE for evacuation of the general population in the entire EPZ (Region R03) under winter, midweek, midday, good weather (Scenario 6) conditions and will not impact protective action decision making.

The evacuation time to the THF is determined by adding the time associated with Activity E→F (discussed below), to this EPZ evacuation time.

<u>Activity: Travel to THF (E→F)</u>

The distances from the EPZ boundary to the THF are measured using GIS software along the most likely route from the EPZ exit point to the THF. The THF are mapped in Figure 10-3. For a one-wave evacuation, this travel time outside the EPZ does not contribute to the ETE. For a two-wave evacuation, the ETE for buses must be considered separately when making a protective action decision, since it could exceed the ETE for the general public. Assumed bus speeds of 55 mph, 50 mph (10% reduction), and 47 mph (15% reduction) for good weather, rain/light snow, and heavy snow, respectively, will be applied for this activity for buses servicing the school population.

<u>Activity: Passengers Leave Bus (F→G)</u>

A bus can empty within 5 minutes. The driver takes a 10-minute break.

<u>Activity: Bus Returns to Route for Second Wave Evacuation (G→C →D→E)</u>

As shown in Table 8-1, there are sufficient buses for evacuation of children in a single wave, if the entire EPZ is evacuated at once (a highly unlikely event). However, there might be a shortfall of drivers. As such, a two-wave evacuation may be needed for some schools. Due to the large number of schools in the EPZ, second wave ETE were not computed for each school. Rather, the following representative ETE is provided to estimate the additional time needed for a second wave evacuation of schools. The travel time from the THF back to the EPZ boundary and then back to the school was computed assuming an average speed of 55 mph (good weather), 50 mph (rain/light snow) and 47 mph (heavy snow) as buses will be traveling counter to the evacuation traffic. Time and distance are based on averages for all schools in the EPZ for good weather:

- School buses arrive at THF at 2:15.
- Bus discharges passengers (5 minutes) and driver takes a 10-minute rest: 15 minutes.
- Bus returns to EPZ and completes second route: 14 minutes to return to the EPZ (equal to average travel time to THF for good weather) + 5 minutes to return to the start of the route (4.3 miles, average distance to EPZ boundary from Table 8-2 @ 55 mph) + 5 minutes to perform a second wave of service on the route (4.3 miles, average distance to EPZ boundary from Table 8-2 @ 55 mph, average network speed at this time) = 24 minutes.
- Loading Time: 15 minutes.

- Bus exits EPZ at time 2:15 + 0:15 + 0:24 + 0:15 = 3:10 after the ATE, rounded to the nearest 5 minutes.

Given the average single wave ETE for schools is 1:55, a second wave evacuation would require an additional 1 hour and 15 minutes, on average for good weather.

Evacuation of Transit Dependent People (Residents without access to a vehicle)

As detailed in Section 3.9, transit dependent population estimates were calculated using the results of the demographic survey. KLD designed 6 bus routes to service the major evacuation routes and major population centers in the EPZ (see Section 10 for additional discussion). The routes are shown graphically in Figure 10-2 and described in Table 10-1.

Activity: Mobilize Drivers (A→B→C)

Mobilization time is the elapsed time from the ATE until the time the buses arrive at their designated route. The buses dispatched from the depots to service the transit-dependent evacuees will be scheduled so that they arrive at their respective routes after a majority of their passengers have completed their mobilization. As shown in Figure 5-4 (Residents with no Commuters), approximately 90% of the evacuees will have completed their mobilization when the buses will begin their routes, approximately 150 minutes after the ATE for good weather. Those routes with multiple buses have been designed such that buses are dispatched using 20-minute headways. The use of bus headways ensures that those people who take longer to mobilize will be picked up.

Activity: Board Passengers (C→D)

For multiple stops along a pick-up route (transit-dependent bus routes) estimation of travel time must allow for the delay associated with stopping and starting at each pick-up point. The time, t, required for a bus to decelerate at a rate, "a", expressed in ft/sec/sec, from a speed, "v", expressed in ft/sec, to a stop, is t = v/a. Assuming the same acceleration rate and final speed following the stop yields a total time, T, to service boarding passengers:

$$T = t + B + t = B + 2t = B + \frac{2v}{a},$$

Where B = Dwell time to service passengers. The total distance, "s" in feet, travelled during the deceleration and acceleration activities is: $s = v^2/a$. If the bus had not stopped to service passengers, but had continued to travel at speed, v, then its travel time over the distance, s, would be: s/v = v/a. Then the total delay (i.e., pickup time, P) to service passengers is:

$$P = T - \frac{v}{a} = B + \frac{v}{a}$$

Assigning reasonable estimates:

- B = 50 seconds: a generous value for a single passenger, carrying personal items, to board per stop
- v = 25 mph = 37 ft/sec
- a = 4 ft/sec/sec, a moderate average rate

Then, P ≈ 1 minute per stop. It is assumed that the bus has a capacity of 30 passenger per bus.

Thus, bus pick-up time is 30 minutes per bus, for good weather. It is assumed that bus acceleration and speed will be less in rain/light snow and heavy snow resulting in loading times that are 10 minutes and 20 minutes longer, respectively.

Activity: Travel to EPZ Boundary (D→E)

The travel distance along the respective pick-up routes within the EPZ is estimated using the UNITES software. Bus travel times within the EPZ are computed using average speeds computed by DYNEV, using the aforementioned methodology that was used for school evacuation.

Table 8-5 through Table 8-7 present the transit-dependent population evacuation time estimates for each bus route calculated using the above procedures for good weather, rain/light snow and heavy snow, respectively. Similar to schools, bus speeds are capped at 55mph for good weather, 50mph for rain/light snow, and 47mph for heavy snow.

For example, the ETE for the bus route servicing PAA 1 (Route 1) is computed as 150 + 11 + 30 = 3:15 for good weather (rounded up to nearest 5 minutes). Here, 11 minutes is the time to travel 9.8 miles at 55.0 mph, the average speed output by the model for this route starting at 150 minutes. As mentioned before, 30 minutes is the bus pickup time for good weather.

The ETE for a second wave (discussed below) is presented in the event there is a shortfall of available buses or bus drivers, as previously discussed.

The average ETE for a one-wave evacuation of transit-dependent people exceeds the ETE for the general population by 35 minutes at the 90th percentile for an evacuation of the entire EPZ (Region R03) under winter, midweek, midday, good weather (Scenario 6) and could impact protective action decision making.

Activity: Travel to Reception Centers (E→F)

The distances from the EPZ boundary to the reception centers are measured using GIS software along the most likely route from the EPZ exit point to the reception center. The general population reception centers are mapped in Figure 10-3. For a single-wave evacuation, this travel time outside the EPZ does not contribute to the ETE. Assumed bus speeds of 55 mph, 50 mph, and 47 mph for good weather, rain/light snow, and heavy snow, respectively, will be applied for this activity for buses servicing the transit-dependent population.

Activity: Passengers Leave Bus (F→G)

A bus can empty within 5 minutes. The driver takes a 10-minute break.

Activity: Bus Returns to Route for Second Wave Evacuation (G→C→D→E)

The buses assigned to return to the EPZ to perform a "second wave" evacuation of transit-dependent evacuees will be those that have already evacuated transit-dependent people who mobilized more quickly. The first wave of transit dependent people departs the bus, and the bus then returns to the EPZ, travels to its route and proceeds to pick up more transit-dependent evacuees along the route. The travel time back to the EPZ is equal to the travel time to the reception center.

The second-wave ETE for the bus route servicing PAA 1 (Route 1) is computed as follows for good weather:

- Bus arrives at reception center at 3:24 in good weather (3:15 to exit EPZ + 9-minute travel time to reception center).
- Bus discharges passengers (5 minutes) and driver takes a 10-minute rest: 15 minutes.
- Bus returns to EPZ and completes second route: 9 minutes (equal to travel time to reception center) + 11 minutes (9.8 miles @ 55 mph – assumed speed to start of route) + 11 minutes (9.8 miles @ 55.0 mph – network wide speed at the time the bus starts route for the second time) = 31 minutes.
- Bus completes pick-ups along route: 30 minutes.
- Bus exits EPZ at time 3:24 + 0:15 + 0:31 + 0:30 = 4:40 after the ATE.

The ETE for the completion of the second wave for all transit-dependent bus routes are provided in Table 8-5 through Table 8-7. The average ETE for a two-wave evacuation of transit-dependent people exceeds the ETE for the general population at the 90th percentile for an evacuation of the entire EPZ (Region R03) under winter, midweek, midday, good weather (Scenario 6) and could impact protective action decision making.

The relocation of transit-dependent evacuees from the reception centers to congregate care centers, if the counties decide to do so, is not considered in this study.

Evacuation of Medical Facilities

As discussed in Section 2.4, assumption 4c and in Table 2-2, it is assumed that the mobilization time for medical facilities average 90 minutes in good weather, 100 minutes in rain/light snow and 110 minutes for heavy snow. Specially trained medical support staff (working their regular shift) will be on site to assist in the evacuation of patients. Additional staff (if needed) could be mobilized over this same 90-minute timeframe.

Activity: Board Passengers (C→D)

Assumption 5 in Section 2.4 discusses transit vehicle loading times for medical facilities. Loading times are assumed to be 1 minute per ambulatory passenger, 5 minutes per wheelchair bound passenger, and 15 minutes per bedridden passenger for buses, wheelchair transport vehicles, and ambulances, respectively. Assumption 3 in Section 2.4 discusses transit vehicle capacities to cap loading times per vehicle type – 30 minutes per bus (30 passengers times 1 minute per passenger), 20 minutes per wheelchair van (4 passengers times 5 minutes per passenger), 75 minutes per wheelchair bus (15 passengers time 5 minutes per passenger) and 30 minutes per ambulance (2 passengers times 15 minutes per passenger). Concurrent loading on multiple buses, wheelchair vans, wheelchair buses, and ambulances at capacity is assumed such that the maximum loading times for buses, wheelchair vans, wheelchair buses and ambulances are 30, 20, 75, and 30 minutes, respectively.

Activity: Travel to EPZ Boundary (D→E)

The travel distance along the respective pick-up routes within the EPZ is estimated using the

UNITES software. Transit vehicle travel times within the EPZ are computed using average speeds computed by DYNEV, using the aforementioned methodology that was used for school and transit-dependent evacuation.

Table 8-8 through Table 8-10 summarize the ETE for medical facilities within the EPZ for good weather, rain/light snow, and heavy snow. Average speeds output by the model for Scenario 6 (Scenario 7 for rain/light snow and Scenario 8 for heavy snow) Region 3, capped at 55 mph (50 mph for rain/light snow and 47 mph for heavy snow), are used to compute travel time to the EPZ boundary. The travel time to the EPZ boundary is computed by dividing the distance to the EPZ boundary by the average travel speed. The ETE is the sum of the mobilization time, total passenger loading time, and travel time out of the EPZ boundary. All ETE are rounded up to the nearest 5 minutes.

For example, the calculation of ETE for the Country Side Nursing Home with 43 ambulatory residents during good weather is:

ETE: 90 + 30 x 1 + 6 = 126 min or 2:10 (rounded up to the nearest 5 minutes)

It is assumed that medical facility population is directly evacuated to appropriate host medical facilities outside of the EPZ. Relocation of this population to permanent facilities and/or passing through the reception center before arriving at the host facility are not considered in this analysis.

The average single wave ETE for medical facilities in the EPZ does not exceed the 90th percentile ETE for the general population for a winter, midweek, midday, good weather scenario and should not impact protect action decision making.

<u>Activity: Vehicles Travel to Host Facilities (E→F), Passengers Leave (F→G), Vehicle Returns to Route for Second Wave Evacuation (G→C→D→E)</u>

As shown in Table 8-1, there are sufficient wheelchair buses, wheelchair vans, and ambulances to evacuate the wheelchair bound and bedridden patients at the medical facilities in the EPZ. It is assumed that these medical facilities are evacuated to the Lakeland Medical Center in St. Joseph, Michigan, which is 11 miles from the EPZ boundary.

For simplicity, second wave ETE for these vehicle types were not computed for each medical facility. Rather, the following representative ETE is provided to estimate the additional time needed for a second wave evacuation for ambulances.

Times and distances are based on facility-wide averages:

- Bedridden patients:
  - Ambulances arrive at Host Hospitals at 2:15 (2:03 Average ETE for ambulances to exit the EPZ plus 12 minutes to travel 11 miles at 55 mph).
  - Ambulances discharges passengers (25 minutes – average loading time for ambulances from Table 8-8) and driver takes a 10-minute rest: 35 minutes.
  - Ambulances returns to facility: 12 minutes to travel back to the EPZ boundary (time needed to travel 11 miles back to the EPZ at 55 mph) + 6 minutes to travel back to the facility (average distance to EPZ = 5.5 miles for ambulances from

Table 8-8 @ 55 mph) = 18 minutes.
  - Remaining patients loaded on ambulance (average): 25 minutes.
  - Ambulance travels to EPZ boundary: 6 minutes (average distance from medical facilities to EPZ boundary (5.5 miles) at 55 mph (network wide average speed at 3:35).
  - Ambulances exits EPZ at time 2:15 + 0:35 + 0:18 + 0:25 + 0:06 = 3:40 (rounded up to nearest 5 minutes) after the ATE.

Thus, the second wave evacuation for ambulances requires about 1 hour and 40 minutes more than the first wave ETE. The average ETE for a two-wave evacuation of medical facilities exceeds the ETE for the general population at the 90th percentile for a winter, midweek, midday, good weather scenario (Scenario 6) conditions and could impact protective action decision making.

8.2 ETE for Access and/or Functional Needs Population

The access and/or functional needs population was provided by the offsite agencies and is further discussed in Section 3.8. Table 8-11 summarizes the ETE for access and/or functional needs population. The table is broken down by weather condition and by vehicle type. It is assumed that the special needs population will be picked up from their homes. Furthermore, it is conservatively assumed that bedridden households are spaced 3 miles apart. Bus, wheelchair bus, and ambulance speeds approximate 20 mph between households in good weather (10% slower in rain/light snow, 15% slower in heavy snow). Mobilization times of 90 minutes were used (100 minutes for rain/light snow, and 110 minutes for heavy snow). The last household is assumed to be 5 miles from the EPZ boundary, and the network-wide average speed, capped at 55 mph (50 mph for rain/light snow and 47 mph for heavy snow), after the last pickup is used to compute travel time.

ETE is computed by summing mobilization time, loading time at the first household, travel to the subsequent households, loading time at subsequent households, and travel time to the EPZ boundary. All ETE are rounded up to the nearest 5 minutes.

For example, assuming no more than one special needs person per household implies that 3 households need to be serviced for bedridden patients. Ambulances are assumed to have a capacity of two persons per ambulance resulting in a total of 2 ambulances needed to complete the evacuation in a single wave. The following outlines the ETE calculations:

1. Assume 2 ambulances are deployed, each with about 2 stops, to service a total of 3 HH.
2. The ETE is calculated as follows:
   a. Ambulances arrive at the first pickup location: 90 minutes
   b. Load passenger at first pickup: 15 minutes
   c. Travel to next pickup location: 9 minutes (assumed 3 miles @ 20 mph)
   d. Load passenger at subsequent pickup location: 15 minutes
   e. Travel to EPZ boundary: 5 minutes (5 miles @ 55 mph).

   ETE: 90 + 15 + 9 + 15 + 5 = 2:15 rounded up to the nearest 5 minutes

The ETE of a single wave evacuation of the access and/or functional needs population within the EPZ is 45 minutes greater than the 90th percentile ETE for evacuation of the general population in the Full EPZ (Region R03) under winter, midweek, midday, good weather (Scenario 6) conditions and could impact protective action decision making.

The following outlines the ETE calculations of a second wave using ambulances after the medical facilities have been evacuated assuming the host medical facilities are located 11 miles away from the EPZ boundary:

a. Ambulances arrive at host medical facilities: 2:15 (2:03 Average ETE for ambulances to exit the EPZ from Table 8-8 plus 12 minutes to travel 11-miles @ 55 mph) on average.
b. Unload patients at host medical facilities: 30 minutes.
c. Driver takes 10-minute rest: 10 minutes.
d. Travel time back to EPZ: 12 minutes (11-miles @ 55 mph).
e. Travel to first household: 15 minutes (5 miles @ 20 mph).
f. Loading time at first household: 15 minutes.
g. Travel to subsequent pickup location: 1 @ 9 minutes = 9 minutes
h. Loading time at subsequent household: 1 stop @ 15 minutes = 15 minutes
i. Travel time to EPZ boundary: 5 miles @55 mph (at 4:01) = 5 minutes

Bus exits EPZ at time: 2:15 + 30 + 10 + 12 + 15 + 15 + 9 + 15 + 5 = 4:10 after the ATE, rounded to the nearest 5-minutes.

The average ETE of a second-wave evacuation of the bedridden access and/or functional needs population within the EPZ is 1 hour and 25 minutes longer than the 90th percentile ETE for an evacuation of the general population in the Full EPZ (Region R03) under winter, midweek, midday, good weather (Scenario 6) conditions and could impact protective action decision making.

Table 8-1. Summary of Transportation Resources

Transportation Provider[1]	Cars	Buses	Vans	Wheelchair Buses	Wheelchair Vans	Ambulances
Resources Available						
BERRIEN COUNTY, MI						
Benton Harbor Schools (FST)	0	30	3	2	0	0
Berrien County Public Transportation	0	0	1	18	0	1
Berrien RESA (FST)	0	0	24	20	0	0
Berrien Springs Public Schools	0	20	8	0	0	0
Brandywine Community Schools	1	10	1	0	2	0
Bridgman Public Schools	0	8	4	1	0	0
Buchanan Community Schools	0	12	9	0	0	0
Coloma Community Schools	0	11	4	0	0	0
Eau Claire Public School	0	12	4	0	0	0
Medic 1	0	0	0	0	0	6
New Buffalo Schools	0	10	6	0	0	0
Niles Community Schools (FST)	0	35	3	3	2	0
Pine Ridge	1	0	1	0	0	0
Resource Transportation Group	25	0	25	10	0	0
SHAES	0	0	0	0	0	1
St Joseph Public Schools	0	14	7	0	0	0
Twin Cities Area Transportation Authority	2	0	2	0	2	2
Watervliet Public Schools	0	8	3	1	0	0
West Woods of Bridgman	0	0	0	1	0	0
Berrien County Subtotal:	*29*	*170*	*105*	*56*	*6*	*10*

[1] According to Allegan County Emergency Management, Allegan County does not provide transportation services inside the 10-mile EPZ.

Transportation Provider[1]	Cars	Buses	Vans	Wheelchair Buses	Wheelchair Vans	Ambulances
VAN BUREN COUNTY, MI						
Bangor School District	0	13	0	1	0	0
Bloomingdale School District	0	17	0	0	1	0
Covert School District	0	7	0	1	0	0
Decatur School District	0	9	0	1	0	0
Gobles School District	0	9	0	0	0	0
Hartford School District	0	12	0	0	0	0
Lawrence School District	0	8	0	0	0	0
Lawton School District	0	13	0	0	1	0
Mattawan School District	0	37	0	5	0	0
Paw Paw School District	0	19	0	1	0	0
South Haven School District	0	17	0	2	0	0
Van Buren ISD	0	9	0	25	0	0
Van Buren Transit	0	1	0	19	3	0
Van Buren County Subtotal:	*0*	*171*	*0*	*55*	*5*	*0*
EPZ TOTAL:	**29**	**341**	**105**	**111**	**11**	**10**
Resources Needed						
Schools (Table 3-7):	0	107[2]	0	0	0	0
Transit-Dependent Population (Table 3-9):	0	13	0	0	0	0
Medical Facilities (Table 3-12):	0	8	0	9	3	5
Homebound Population with Access and/or Functional Needs (Table 3-8):	0	3	0	3	0	2
TOTAL TRANSPORTATION NEEDS:	**0**	**131**	**0**	**12**	**3**	**7**

[2] Resources needed for schools exclude 109 private vehicles used by the commuter students at Lake Michigan College – South Haven Campus

Table 8-2. School Evacuation Time Estimates - Good Weather

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to THF (mi.)	Travel Time from EPZ Bdry to THF (min)	ETA to THF (hr:min)
ALLEGAN COUNTY, MI									
Baseline Middle School	90	15	4.5	55.0	5	**1:50**	14.7	17	**2:10**
North Shore Elementary School	90	15	3.9	55.0	5	**1:50**	14.7	17	**2:10**
BERRIEN COUNTY, MI									
Salem Lutheran Preschool	90	15	1.4	21.9	4	**1:50**	15.1	17	**2:10**
Watervliet North Elementary School	90	15	1.0	9.3	7	**1:55**	0.4	1	**2:00**
Coloma Elementary School	90	15	0.9	25.3	3	**1:50**	15.1	17	**2:10**
Coloma Intermediate School	90	15	0.9	25.3	3	**1:50**	15.1	17	**2:10**
Coloma High School	90	15	0.9	25.3	3	**1:50**	15.1	17	**2:10**
Coloma Junior High School	90	15	0.9	25.3	3	**1:50**	15.1	17	**2:10**
VAN BUREN COUNTY, MI									
Maple Grove Elementary School	90	15	7.5	55.0	9	**1:55**	14.7	17	**2:15**
Head Start - South Haven	90	15	7.0	50.1	9	**1:55**	14.7	17	**2:15**
Covert Middle School	90	15	10.1	30.6	20	**2:05**	0.6	1	**2:10**
Covert High School	90	15	10.1	30.6	20	**2:05**	0.6	1	**2:10**
Covert Elementary School	90	15	10.1	30.6	20	**2:05**	0.6	1	**2:10**
Head Start - Migrant at Lincoln Elementary	90	15	7.0	44.8	10	**1:55**	14.7	17	**2:15**
Lincoln Elementary School	90	15	7.0	44.8	10	**1:55**	14.7	17	**2:15**
L.C. Mohr High School	90	15	7.0	44.8	10	**1:55**	14.7	17	**2:15**
St. Paul Lutheran School	90	15	6.9	52.9	8	**1:55**	14.7	17	**2:15**
St. Basil Catholic School	90	15	6.9	46.1	9	**1:55**	14.7	17	**2:15**
WAY- South Haven Schools (LMC Campus)	90	15	5.7	55.0	7	**1:55**	14.7	17	**2:15**
Lake Michigan College - South Haven Campus	90	15	5.7	55.0	7	**1:55**	14.7	17	**2:15**

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to THF (mi.)	Travel Time from EPZ Bdry to THF (min)	ETA to THF (hr:min)
Wood School	90	15	4.0	41.2	6	**1:55**	14.2	16	**2:15**
Bangor High School	90	15	0.4	19.5	2	**1:50**	14.2	16	**2:10**
Bangor Middle School	90	15	0.4	19.5	2	**1:50**	14.2	16	**2:10**
Head Start - Bangor	90	15	0.4	19.5	2	**1:50**	14.2	16	**2:10**
Bangor Alternative High School	90	15	0.4	19.5	2	**1:50**	14.2	16	**2:10**
South Walnut Elementary School	90	15	0.4	19.5	2	**1:50**	14.2	16	**2:10**
					Maximum for EPZ:	**2:05**		**Maximum:**	**2:15**
					Average for EPZ:	**1:55**		**Average:**	**2:15**

Table 8-3. School Evacuation Time Estimates – Rain/Light Snow

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to THF (mi.)	Travel Time from EPZ Bdry to THF (min)	ETA to THF (hr:min)
ALLEGAN COUNTY, MI									
Baseline Middle School	100	20	4.5	50.0	6	**2:10**	14.7	18	**2:30**
North Shore Elementary School	100	20	3.9	50.0	5	**2:05**	14.7	18	**2:25**
BERRIEN COUNTY, MI									
Salem Lutheran Preschool	100	20	1.4	18.2	5	**2:05**	15.1	19	**2:25**
Watervliet North Elementary School	100	20	1.0	9.1	7	**2:10**	0.4	1	**2:15**
Coloma Elementary School	100	20	0.9	23.0	3	**2:05**	15.1	19	**2:25**
Coloma Intermediate School	100	20	0.9	23.0	3	**2:05**	15.1	19	**2:25**
Coloma High School	100	20	0.9	23.0	3	**2:05**	15.1	19	**2:25**
Coloma Junior High School	100	20	0.9	23.0	3	**2:05**	15.1	19	**2:25**
VAN BUREN COUNTY, MI									
Maple Grove Elementary School	100	20	7.5	50.0	9	**2:10**	14.7	18	**2:30**
Head Start - South Haven	100	20	7.0	46.5	10	**2:10**	14.7	18	**2:30**
Covert Middle School	100	20	10.1	26.1	24	**2:25**	0.6	1	**2:30**
Covert High School	100	20	10.1	26.1	24	**2:25**	0.6	1	**2:30**
Covert Elementary School	100	20	10.1	26.1	24	**2:25**	0.6	1	**2:30**
Head Start - Migrant at Lincoln Elementary	100	20	7.0	41.7	11	**2:15**	14.7	18	**2:35**
Lincoln Elementary School	100	20	7.0	41.7	11	**2:15**	14.7	18	**2:35**
L.C. Mohr High School	100	20	7.0	41.7	11	**2:15**	14.7	18	**2:35**
St. Paul Lutheran School	100	20	6.9	49.1	9	**2:10**	14.7	18	**2:30**
St. Basil Catholic School	100	20	6.9	43.0	10	**2:10**	14.7	18	**2:30**
WAY- South Haven Schools (LMC Campus)	100	20	5.7	50.0	7	**2:10**	14.7	18	**2:30**
Lake Michigan College - South Haven Campus	100	20	5.7	50.0	7	**2:10**	14.7	18	**2:30**

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to THF (mi.)	Travel Time from EPZ Bdry to THF (min)	ETA to THF (hr:min)
Wood School	100	20	4.0	37.8	7	**2:10**	14.2	18	**2:30**
Bangor High School	100	20	0.4	19.8	2	**2:05**	14.2	18	**2:25**
Bangor Middle School	100	20	0.4	19.8	2	**2:05**	14.2	18	**2:25**
Head Start - Bangor	100	20	0.4	19.8	2	**2:05**	14.2	18	**2:25**
Bangor Alternative High School	100	20	0.4	19.8	2	**2:05**	14.2	18	**2:25**
South Walnut Elementary School	100	20	0.4	19.8	2	**2:05**	14.2	18	**2:25**
					Maximum for EPZ:	**2:25**		**Maximum:**	**2:35**
					Average for EPZ:	**2:10**		**Average:**	**2:30**

Table 8-4. School Evacuation Time Estimates – Heavy Snow

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to THF (mi.)	Travel Time from EPZ Bdry to THF (min)	ETA to THF (hr:min)
ALLEGAN COUNTY, MI									
Baseline Middle School	110	25	4.5	47.0	6	**2:25**	14.7	19	**2:45**
North Shore Elementary School	110	25	3.9	47.0	5	**2:20**	14.7	19	**2:40**
BERRIEN COUNTY, MI									
Salem Lutheran Preschool	110	25	1.4	16.5	6	**2:25**	15.1	20	**2:45**
Watervliet North Elementary School	110	25	1.0	8.2	8	**2:25**	0.4	1	**2:30**
Coloma Elementary School	110	25	0.9	22.2	3	**2:20**	15.1	20	**2:40**
Coloma Intermediate School	110	25	0.9	22.2	3	**2:20**	15.1	20	**2:40**
Coloma High School	110	25	0.9	22.2	3	**2:20**	15.1	20	**2:40**
Coloma Junior High School	110	25	0.9	22.2	3	**2:20**	15.1	20	**2:40**
VAN BUREN COUNTY, MI									
Maple Grove Elementary School	110	25	7.5	47.0	10	**2:25**	14.7	19	**2:45**
Head Start - South Haven	110	25	7.0	42.7	10	**2:25**	14.7	19	**2:45**
Covert Middle School	110	25	10.1	32.6	19	**2:35**	0.6	1	**2:40**
Covert High School	110	25	10.1	32.6	19	**2:35**	0.6	1	**2:40**
Covert Elementary School	110	25	10.1	32.6	19	**2:35**	0.6	1	**2:40**
Head Start - Migrant at Lincoln Elementary	110	25	7.0	38.4	11	**2:30**	14.7	19	**2:50**
Lincoln Elementary School	110	25	7.0	38.4	11	**2:30**	14.7	19	**2:50**
L.C. Mohr High School	110	25	7.0	38.4	11	**2:30**	14.7	19	**2:50**
St. Paul Lutheran School	110	25	6.9	45.0	10	**2:25**	14.7	19	**2:45**
St. Basil Catholic School	110	25	6.9	39.4	11	**2:30**	14.7	19	**2:50**
WAY- South Haven Schools (LMC Campus)	110	25	5.7	47.0	8	**2:25**	14.7	19	**2:45**
Lake Michigan College - South Haven Campus	110	25	5.7	47.0	8	**2:25**	14.7	19	**2:45**
Wood School	110	25	4.0	35.3	7	**2:25**	14.2	19	**2:45**

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to THF (mi.)	Travel Time from EPZ Bdry to THF (min)	ETA to THF (hr:min)
Bangor Middle School	110	25	0.4	19.3	2	**2:20**	14.2	19	**2:40**
Head Start - Bangor	110	25	0.4	19.3	2	**2:20**	14.2	19	**2:40**
Bangor Alternative High School	110	25	0.4	19.3	2	**2:20**	14.2	19	**2:40**
South Walnut Elementary School	110	25	0.4	19.3	2	**2:20**	14.2	19	**2:40**
Bangor Middle School	110	25	0.4	19.3	2	**2:20**	14.2	19	**2:40**
					Maximum for EPZ:	**2:35**		**Maximum:**	**2:50**
					Average for EPZ:	**2:25**		**Average:**	**2:45**

Table 8-5. Transit-Dependent Evacuation Time Estimates - Good Weather

		One-Wave						Two-Wave						
Route Number	Number of Buses	Mobilization (min)	Route Length (miles)	Route Speed (mph)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)	Distance to Rec. Ctr. (miles)	Travel Time to Rec. Ctr. (min)	Unload (min)	Driver Rest (min)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)
1	1	150	9.8	55.0	11	30	**3:15**	8.3	9	5	10	30	30	**4:40**
2	1	150	9.0	55.0	10	30	**3:10**	14.7	16	5	10	36	30	**4:50**
3	1	150	8.6	51.0	10	30	**3:15**	0.4	0	5	10	20	30	**4:20**
4	2	150	5.8	48.3	7	30	**3:10**	14.7	16	5	10	29	30	**4:40**
	2	170	5.8	48.5	7	30	**3:30**	14.7	16	5	10	29	30	**5:00**
5	2	150	6.2	46.8	8	30	**3:10**	14.2	15	5	10	30	30	**4:40**
	1	170	6.2	47.2	8	30	**3:30**	14.2	15	5	10	30	30	**5:00**
6	2	150	7.8	55.0	9	30	**3:10**	14.4	16	5	10	33	30	**4:45**
	1	170	7.8	55.0	9	30	**3:30**	14.4	16	5	10	33	30	**5:05**
						Maximum ETE:	**3:30**						**Maximum ETE:**	**5:05**
						Average ETE:	**3:20**						**Average ETE:**	**4:50**

Table 8-6. Transit-Dependent Evacuation Time Estimates – Rain/Light Snow

Route Number	Number of Buses	One-Wave						Two-Wave						
		Mobilization (min)	Route Length (miles)	Route Speed (mph)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)	Distance to Rec. Ctr. (miles)	Travel Time to Rec. Ctr. (min)	Unload (min)	Driver Rest (min)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)
1	1	160	9.8	50.0	12	40	**3:35**	8.3	10	5	10	34	40	**5:15**
2	1	160	9.0	50.0	11	40	**3:35**	14.7	18	5	10	40	40	**5:30**
3	1	160	8.6	46.4	11	40	**3:35**	0.4	0	5	10	22	40	**4:55**
4	2	160	5.8	44.2	8	40	**3:30**	14.7	18	5	10	33	40	**5:20**
	2	180	5.8	43.6	8	40	**3:50**	14.7	18	5	10	33	40	**5:40**
5	2	160	6.2	42.4	9	40	**3:30**	14.2	17	5	10	33	40	**5:15**
	1	180	6.2	41.4	9	40	**3:50**	14.2	17	5	10	33	40	**5:35**
6	2	160	7.8	50.0	9	40	**3:30**	14.4	17	5	10	36	40	**5:20**
	1	180	7.8	49.9	9	40	**3:50**	14.4	17	5	10	36	40	**5:40**
						Maximum ETE:	**3:50**						**Maximum ETE:**	**5:40**
						Average ETE:	**3:40**						**Average ETE:**	**5:25**

Table 8-7. Transit Dependent Evacuation Time Estimates – Heavy Snow

Route Number	Number of Buses	One-Wave						Two-Wave						
		Mobilization (min)	Route Length (miles)	Route Speed (mph)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)	Distance to Rec. Ctr. (miles)	Travel Time to Rec. Ctr. (min)	Unload (min)	Driver Rest (min)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)
1	1	170	9.8	47.0	13	50	**3:55**	8.3	11	5	10	34	50	**5:45**
2	1	170	9.0	47.0	11	50	**3:55**	14.7	19	5	10	40	50	**6:00**
3	1	170	8.6	42.8	12	50	**3:55**	0.4	1	5	10	23	50	**5:25**
4	2	170	5.8	41.4	8	50	**3:50**	14.7	19	5	10	34	50	**5:50**
	2	190	5.8	41.7	8	50	**4:10**	14.7	19	5	10	33	50	**6:10**
5	2	170	6.2	39.3	9	50	**3:50**	14.2	18	5	10	35	50	**5:50**
	1	190	6.2	39.1	10	50	**4:10**	14.2	18	5	10	34	50	**6:10**
6	2	170	7.8	47.0	10	50	**3:50**	14.4	18	5	10	37	50	**5:50**
	1	190	7.8	47.0	10	50	**4:10**	14.4	18	5	10	36	50	**6:10**
						Maximum ETE:	**4:10**						**Maximum ETE:**	**6:10**
						Average ETE:	**4:00**						**Average ETE:**	**5:55**

Table 8-8. Medical Facility Evacuation Time Estimates – Good Weather

Medical Facility	Patient	Mobilization (min)	Loading Rate (min per person)	People	Total Loading Time (min)	Dist. To EPZ Bdry (mi)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
Country Side Nursing Home	Ambulatory	90	1	43	30	4.9	6	**2:10**
	Wheelchair bound	90	5	46	75	4.9	6	**2:55**
	Bedridden	90	15	4	30	4.9	6	**2:10**
Forest Beach AFC Home Inc	Ambulatory	90	1	16	16	1.4	10	**2:00**
Juniper Home	Ambulatory	90	1	2	2	1.3	8	**1:40**
	Wheelchair bound	90	5	4	20	1.3	8	**2:00**
Bronson South Haven Hospital	Ambulatory	90	1	3	3	6.8	7	**1:40**
	Wheelchair bound	90	5	2	10	6.8	7	**1:50**
	Bedridden	90	15	1	15	6.8	8	**1:55**
South Haven Nursing & Rehabilitation Community	Ambulatory	90	1	10	10	6.8	7	**1:50**
	Wheelchair bound	90	5	51	75	6.8	7	**2:55**
Turner Tender Care	Ambulatory	90	1	3	3	8.9	10	**1:45**
	Wheelchair bound	90	5	3	15	8.9	10	**1:55**
River Ridge Retirement Village	Ambulatory	90	1	26	26	4.8	5	**2:05**
	Wheelchair bound	90	5	13	65	4.8	5	**2:40**
	Bedridden	90	15	3	30	4.8	5	**2:05**
							Maximum ETE:	**2:55**
							Average ETE:	**2:05**

Table 8-9. Medical Facility Evacuation Time Estimates – Rain/Light Snow

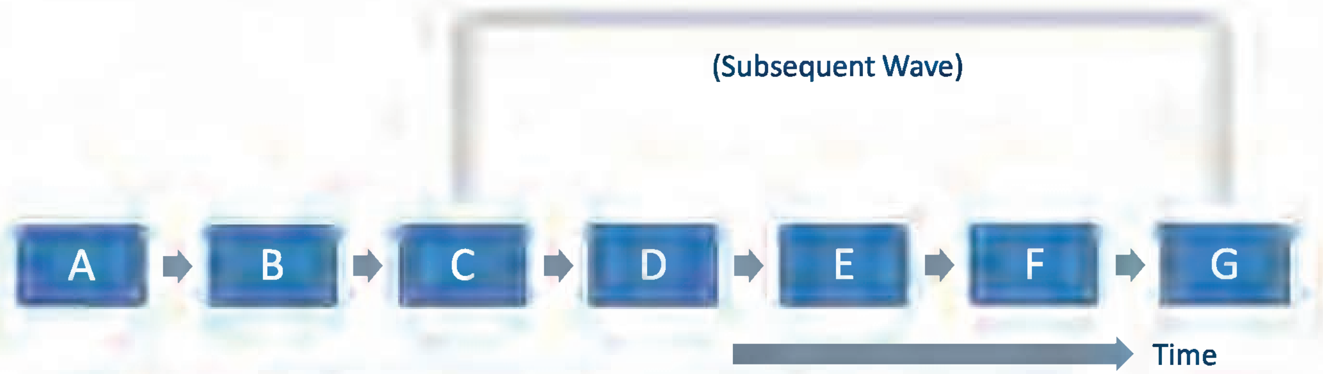
Medical Facility	Patient	Mobilization (min)	Loading Rate (min per person)	People	Total Loading Time (min)	Dist. To EPZ Bdry (mi)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
Country Side Nursing Home	Ambulatory	100	1	43	30	4.9	6	**2:20**
	Wheelchair bound	100	5	46	75	4.9	6	**3:05**
	Bedridden	100	15	4	30	4.9	6	**2:20**
Forest Beach AFC Home Inc	Ambulatory	100	1	16	16	1.4	14	**2:10**
Juniper Home	Ambulatory	100	1	2	2	1.3	9	**1:55**
	Wheelchair bound	100	5	4	20	1.3	8	**2:10**
Bronson South Haven Hospital	Ambulatory	100	1	3	3	6.8	8	**1:55**
	Wheelchair bound	100	5	2	10	6.8	8	**2:00**
	Bedridden	100	15	1	15	6.8	8	**2:05**
South Haven Nursing & Rehabilitation Community	Ambulatory	100	1	10	10	6.8	8	**2:00**
	Wheelchair bound	100	5	51	75	6.8	8	**3:05**
Turner Tender Care	Ambulatory	100	1	3	3	8.9	11	**1:55**
	Wheelchair bound	100	5	3	15	8.9	11	**2:10**
River Ridge Retirement Village	Ambulatory	100	1	26	26	4.8	6	**2:15**
	Wheelchair bound	100	5	13	65	4.8	6	**2:55**
	Bedridden	100	15	3	30	4.8	6	**2:20**
							Maximum ETE:	**3:05**
							Average ETE:	**2:20**

Table 8-10. Medical Facility Evacuation Time Estimates – Heavy Snow

Medical Facility	Patient	Mobilization (min)	Loading Rate (min per person)	People	Total Loading Time (min)	Dist. To EPZ Bdry (mi)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
Country Side Nursing Home	Ambulatory	110	1	43	30	4.9	7	**2:30**
	Wheelchair bound	110	5	46	75	4.9	7	**3:15**
	Bedridden	110	15	4	30	4.9	7	**2:30**
Forest Beach AFC Home Inc	Ambulatory	110	1	16	16	1.4	9	**2:15**
Juniper Home	Ambulatory	110	1	2	2	1.3	9	**2:05**
	Wheelchair bound	110	5	4	20	1.3	9	**2:20**
Bronson South Haven Hospital	Ambulatory	110	1	3	3	6.8	9	**2:05**
	Wheelchair bound	110	5	2	10	6.8	9	**2:10**
	Bedridden	110	15	1	15	6.8	9	**2:15**
South Haven Nursing & Rehabilitation Community	Ambulatory	110	1	10	10	6.8	9	**2:10**
	Wheelchair bound	110	5	51	75	6.8	9	**3:15**
Turner Tender Care	Ambulatory	110	1	3	3	8.9	11	**2:05**
	Wheelchair bound	110	5	3	15	8.9	11	**2:20**
River Ridge Retirement Village	Ambulatory	110	1	26	26	4.8	6	**2:25**
	Wheelchair bound	110	5	13	65	4.8	6	**3:05**
	Bedridden	110	15	3	30	4.8	6	**2:30**
							Maximum ETE:	**3:15**
							Average ETE:	**2:30**

Table 8-11. Homebound Population with Access and/or Functional needs Evacuation Time Estimates

Vehicle Type	People Requiring Vehicle	Vehicles deployed	Stops	Weather Conditions	Mobilization Time (min)	Loading Time at 1st Stop (min)	Travel to Subsequent Stops (min)	Total Loading Time at Subsequent Stops (min)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
Buses	31	3	11	Good	90	1	90	10	5	**3:20**
				Rain	100		100		6	**3:40**
				Snow	110		110		7	**4:00**
Wheelchair Buses	21	3	7	Good	90	5	54	30	5	**3:05**
				Rain	100		60		6	**3:25**
				Snow	110		66		7	**3:40**
Ambulances	3	2	2	Good	90	15	9	15	5	**2:15**
				Rain	100		10		6	**2:30**
				Snow	110		11		7	**2:40**
									Maximum ETE:	**4:00**
									Average ETE:	**3:30**



Event	
A	Advisory to Evacuate
B	Bus Dispatched from Depot
C	Bus Arrives at Facility/Pick-up Route
D	Bus Departs for Reception Center
E	Bus Exits Region
F	Bus Arrives at Reception Center/THF
G	Bus Available for “Second Wave” Evacuation Service

Activity	
A→B	Driver Mobilization
B→C	Travel to Facility or to Pick-up Route
C→D	Passengers Board the Bus
D→E	Bus Travels Towards Region Boundary
E→F	Bus Travels Towards Reception Center/THF Outside the EPZ
F→G	Passengers Leave Bus; Driver Takes a Break

Figure 8-1. Chronology of Transit Evacuation Operations

9 TRAFFIC MANAGEMENT STRATEGY

This section discusses the suggested Traffic Management Plan (TMP) that is designed to expedite the movement of evacuating traffic. The resources required to implement the TMP include:

- Personnel with the capabilities of performing the planned control functions of traffic guides (preferably, not necessarily, law enforcement officers).
- The Manual on Uniform Traffic Control Devices (MUTCD) published by the Federal Highway Administration (FHWA) of the U.S.D.O.T. provides guidance for Traffic Control Devices to assist these personnel in the performance of their tasks. All state and most county transportation agencies have access to the MUTCD, which is available online: http://mutcd.fhwa.dot.gov which provides access to the official PDF version.
- A written plan that defines all Traffic Control Point (TCP) and Access Control Point (ACP) locations, provides necessary details and is documented in a format that is readily understood by those assigned to perform traffic control.

The functions to be performed in the field are:

1. Facilitate evacuating traffic movements that safely expedite travel out of the EPZ.
2. Discourage traffic movements that move evacuating vehicles in a direction which takes them significantly closer to the power plant, or which interferes with the efficient flow of other evacuees.

We employ the terms "facilitate" and "discourage" rather than "enforce" and "prohibit" to indicate the need for flexibility in performing the traffic control function. There are always legitimate reasons for a driver to prefer a direction other than that indicated. For example:

- A driver may be traveling home from work or from another location, to join other family members prior to evacuating.
- An evacuating driver may be travelling to pick up a relative, or other evacuees.
- The driver may be an emergency worker en route to perform an important activity.

The implementation of a TMP must also be flexible enough for the application of sound judgment by the traffic guide.

The TMP is the outcome of the following process:

1. The existing TCPs and ACPs identified by the offsite agencies in their existing emergency plans serve as the basis of the TMP, as per NUREG/CR-7002, Rev. 1. The ETE analysis treated all controlled intersections that are existing TCP or ACP locations in the county plans as being controlled by actuated signals. Appendix K identifies the number of intersections that were modeled as TCPs.
2. Evacuation simulations were run using DYNEV II to predict traffic congestion during evacuation (see Section 7.3 and Figure 7-3 through Figure 7-6). These simulations help to identify the best routing and critical intersections that experience pronounced traffic congestion during an evacuation. Any critical intersections that would benefit from

traffic or access control which are not already identified in the existing offsite plans are examined. No additional TCPs or ACPs were identified as part of this study.

3. Prioritization of TCPs and ACPs. Application of traffic and access control at some TCPs and ACPs will have a more pronounced influence on expediting traffic movements than at other TCPs and ACPs. For example, TCPs controlling traffic originating from areas in close proximity to the power plant could have a more beneficial effect on minimizing potential exposure to radioactivity than those TCPs located far from the power plant. Key locations for Manual Traffic Control (MTC) were analyzed and their impact to ETE was quantified, as per NUREG/CR-7002, Rev. 1. See Appendix G for more detail.

Appendix G documents the existing TMP and a list of priority TCPs using the process enumerated above.

9.1 Assumptions

- The ETE calculations documented in Section 7 and 8 assume that the TMP is implemented during evacuation.
- The ETE calculations reflect the assumptions that all "external-external" trips are interdicted and diverted after 2 hours have elapsed from the ATE.
- All transit vehicles and other responders entering the EPZ to support the evacuation are assumed to be unhindered by personal manning TCPs and ACPs.
- Study assumptions 1 through 3 in Section 2.5 further discuss TCP and ACP operations.

9.2 Additional Considerations

The use of Intelligent Transportation Systems (ITS) technologies can reduce the manpower and equipment needs, while still facilitating the evacuation process. Dynamic Message Signs (DMS) can be placed within the EPZ to provide information to travelers regarding traffic conditions, route selection, and reception center information. DMS placed outside of the EPZ will warn motorists to avoid using routes that may conflict with the flow of evacuees away from the power plant. Highway Advisory Radio (HAR) can be used to broadcast information to evacuees during egress through their vehicle's stereo systems. Automated Travel Information Systems (ATIS) can also be used to provide evacuees with information. Internet websites can provide traffic and evacuation route information before the evacuee begins their trip, while the on-board navigation systems (GPS units) and smartphones can be used to provide information during the evacuation trip.

These are only some examples of how ITS technologies can benefit the evacuation process. Consideration should be given that ITS technologies be used to facilitate the evacuation process, and any additional signage placed should consider evacuation needs.

10 EVACUATION ROUTES AND RECEPTION CENTERS

10.1 Evacuation Routes

Evacuation routes are comprised of two distinct components:

- Routing from a PAA being evacuated to the boundary of the Evacuation Region and thence out of the EPZ.
- Routing of transit-dependent evacuees (schools, medical facilities and residents, employees or transients who do not own or have access to a private vehicle) from the EPZ boundary to THF/reception centers.

Evacuees will select routes within the EPZ in such a way as to minimize their exposure to risk. This expectation is met by the DYNEV II model routing traffic away from the location of the plant, to the extent practicable. The DTRAD model satisfies this behavior by routing traffic so as to balance traffic demand relative to the available highway capacity to the extent possible. See Appendices B through D for further discussion. The major evacuation routes for the EPZ are presented in Figure 10-1. These routes will be used by the general population evacuating in private vehicles, and by the transit-dependent population evacuating in buses. Transit-dependent evacuees will be routed to reception centers. General population may evacuate to either a reception center or some alternate destination (e.g., lodging facilities, relative's home, campgrounds) outside the EPZ.

The routing of transit-dependent evacuees from the EPZ boundary to reception centers is designed to minimize the amount of travel outside the EPZ, from the points where these routes cross the EPZ boundary. The six bus routes, shown graphically in Figure 10-2 and described in Table 10-1, were designed as part of this ETE study for the express purpose of computing ETE for the transit-dependent population. The routes were designed to traverse the major routes through the population centers in the EPZ. This does not imply that these exact routes would be used in an emergency. It is assumed that residents will walk to and congregate along the routes or walk along major evacuation routes to flag down a bus.

Schools and medical facilities were routed along the most likely path from the facility being evacuated to the EPZ boundary, traveling toward the appropriate THF or medical host facility.

The specified bus routes for all the transit-dependent population are documented in Table 10-2 (refer to the maps of the link-node analysis network in Appendix K for node locations). This study does not consider the transport of evacuees from reception centers to congregate care centers if the counties do make the decision to relocate evacuees.

10.2 Reception Centers

Figure 10-3 maps the primary reception centers and THF for evacuees. Table 10-3 identifies the THF for each of the schools in the EPZ. It is assumed that all school evacuees will be taken to the appropriate THF and subsequently picked up by parents or guardians. Transit-dependent evacuees are transported to the nearest reception center for each county.

Table 10-1. Summary of Transit-Dependent Bus Routes

Route	No. of Buses	Descriptions	Length (mi.)
1	1	Servicing communities in PAA 1	9.8
2	1	Servicing communities in PAA 2	9.0
3	1	Servicing communities in PAA 3	8.6
4	4	Servicing communities in PAA 4	5.8
5	3	Servicing communities in PAA 5	6.2
6	3	Servicing communities in PAA 5	7.8
Total:	**13**		

Table 10-2. Bus Route Descriptions

Bus Route Number	Description	Nodes Traversed from Route Start to EPZ Boundary
	Transit-Dependent Routes	
1	Transit Dependent Route for PAA 1	96, 322, 297, 298, 321, 299, 300, 301, 302, 303, 304, 305, 306, 307, 308, 309, 310, 311, 312, 313
2	Transit Dependent Route for PAA 2	109, 110, 111, 112, 368, 113, 114, 115, 116, 117, 118, 566, 161, 44, 45, 46, 47, 48, 49, 50, 51
3	Transit Dependent Route for PAA 3	211, 476, 212, 477, 478, 213, 214, 215, 216, 217, 514, 218, 219, 513, 512, 220
4	Transit Dependent Route for PAA 4	115, 116, 117, 118, 119, 120, 121, 435, 380, 381, 382, 436, 123, 603, 604, 124, 125, 126, 127, 128, 129
5	Transit Dependent Route for PAA 5 (1 of 2)	426, 427, 428, 402, 524, 403, 263, 386, 387, 388, 264
6	Transit Dependent Route for PAA 5 (2 of 2)	234, 233, 383, 232, 231, 230, 15, 14, 13, 12, 11, 10
	School Routes	
9	Salem Lutheran Preschool	537, 517, 247, 248, 249, 373, 250
10	Watervliet North Elementary School	219, 513, 512, 220, 511
11	Bangor High School, Bangor Middle School, Head Start - Bangor, Bangor Alternative High School, South Walnut Elementary School	387, 388, 264
12	Wood School	402, 524, 403, 263, 386, 387, 388, 264
14	Covert High School, Covert Middle School, Covert Elementary School	211, 476, 212, 477, 478, 213, 214, 215, 216, 217, 514, 218, 219, 513, 512, 220
15	North Shore Elementary School	469, 122, 380, 381, 163, 46, 47, 48, 49, 50, 51
16	Baseline Middle School	121, 435, 380, 381, 163, 46, 47, 48, 49, 50, 51, 52
29	L.C. Mohr High School, Lincoln Elementary School, Head Start - Migrant at Lincoln Elementary	473, 472, 471, 202, 470, 201, 150, 466, 467, 118, 566, 161, 44, 45, 46, 47, 48, 49, 50, 51
30	St. Paul Lutheran School	165, 154, 115, 116, 117, 118, 566, 161, 44, 45, 46, 47, 48, 49, 50, 51, 52
32	Head Start - South Haven	166, 165, 154, 115, 116, 117, 118, 566, 161, 44, 45, 46, 47, 48, 49, 50, 51

Bus Route Number	Description	Nodes Traversed from Route Start to EPZ Boundary
School Routes (Continued)		
33	St. Basil Catholic School	545, 474, 202, 470, 201, 150, 466, 467, 118, 566, 161, 44, 45, 46, 47, 48, 49, 50, 51
34	Coloma High School, Coloma Junior High School, Coloma Intermediate School, Coloma Elementary School	249, 373, 250
35	Maple Grove Elementary School	168, 115, 116, 117, 118, 566, 161, 44, 45, 46, 47, 48, 49, 50, 51, 52
36	Lake Michigan College - South Haven Campus, WAY- South Haven Schools (LMC Campus)	571, 565, 563, 161, 44, 45, 46, 47, 48, 49, 50, 51, 52
Medical Facility Routes		
24	Juniper Home	515, 243, 219, 513, 512, 220
25	Forest Beach AFC Home Inc	535, 619, 618, 218, 219, 513, 512, 220
26	Bronson South Haven Hospital, South Haven Nursing & Rehabilitation Community	153, 154, 115, 116, 117, 118, 566, 161, 44, 45, 46, 47, 48, 49, 50, 51, 52
27	Country Side Nursing Home	157, 601, 121, 435, 380, 381, 163, 46, 47, 48, 49, 50, 51, 52
28	River Ridge Retirement Village	121, 435, 380, 381, 163, 46, 47, 48, 49, 50, 51, 52
37	Turner Tender Care	440, 439, 160, 563, 161, 44, 45, 46, 47, 48, 49, 50

Table 10-3. Temporary Host Facilities

School	Temporary Host Facility
Baseline Middle School	Fennville Middle School
North Shore Elementary School	
Salem Lutheran Preschool	St. Joseph High School
Watervliet North Elementary School	Watervliet South Elementary
Coloma Elementary School	St. Joseph High School
Coloma Intermediate School	
Coloma High School	
Coloma Junior High School	
Maple Grove Elementary School	Fennville Middle School
Head Start – South Haven	
Covert Middle School	Hartford High School
Covert High School	
Covert Elementary School	
Head Start – Migrant at Lincoln Elementary	Fennville Middle School
Lincoln Elementary School	
L.C. Mohr High School	
St. Paul Lutheran School	
St. Basil Catholic School	
WAY- South Haven Schools (LMC Campus)	
Lake Michigan College – South Haven Campus	
Wood School	Bloomingdale High School
Bangor High School	
Bangor Middle School	
Head Start – Bangor	
Bangor Alternative High School	
South Walnut Elementary School	

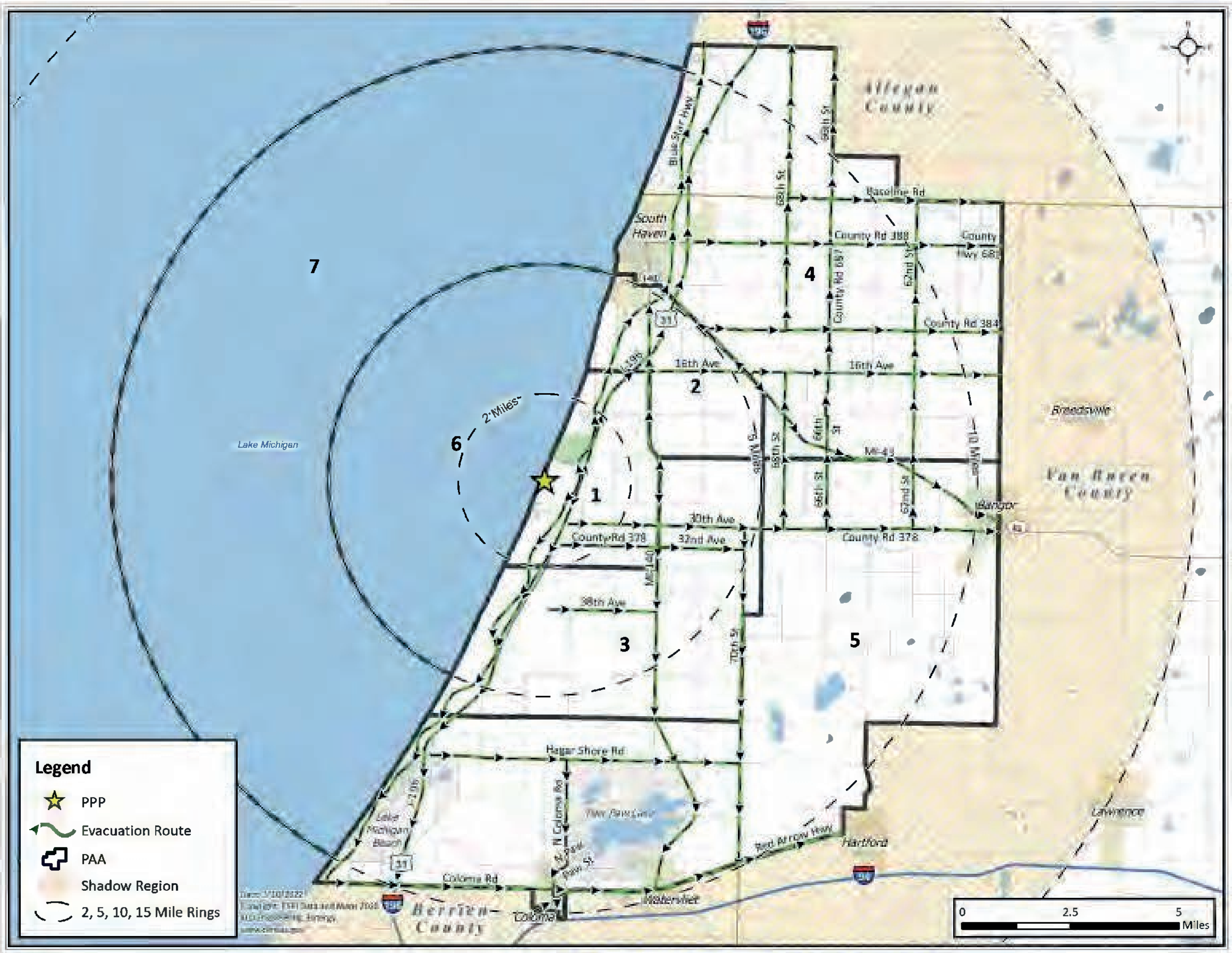


Figure 10-1. Evacuation Route Map

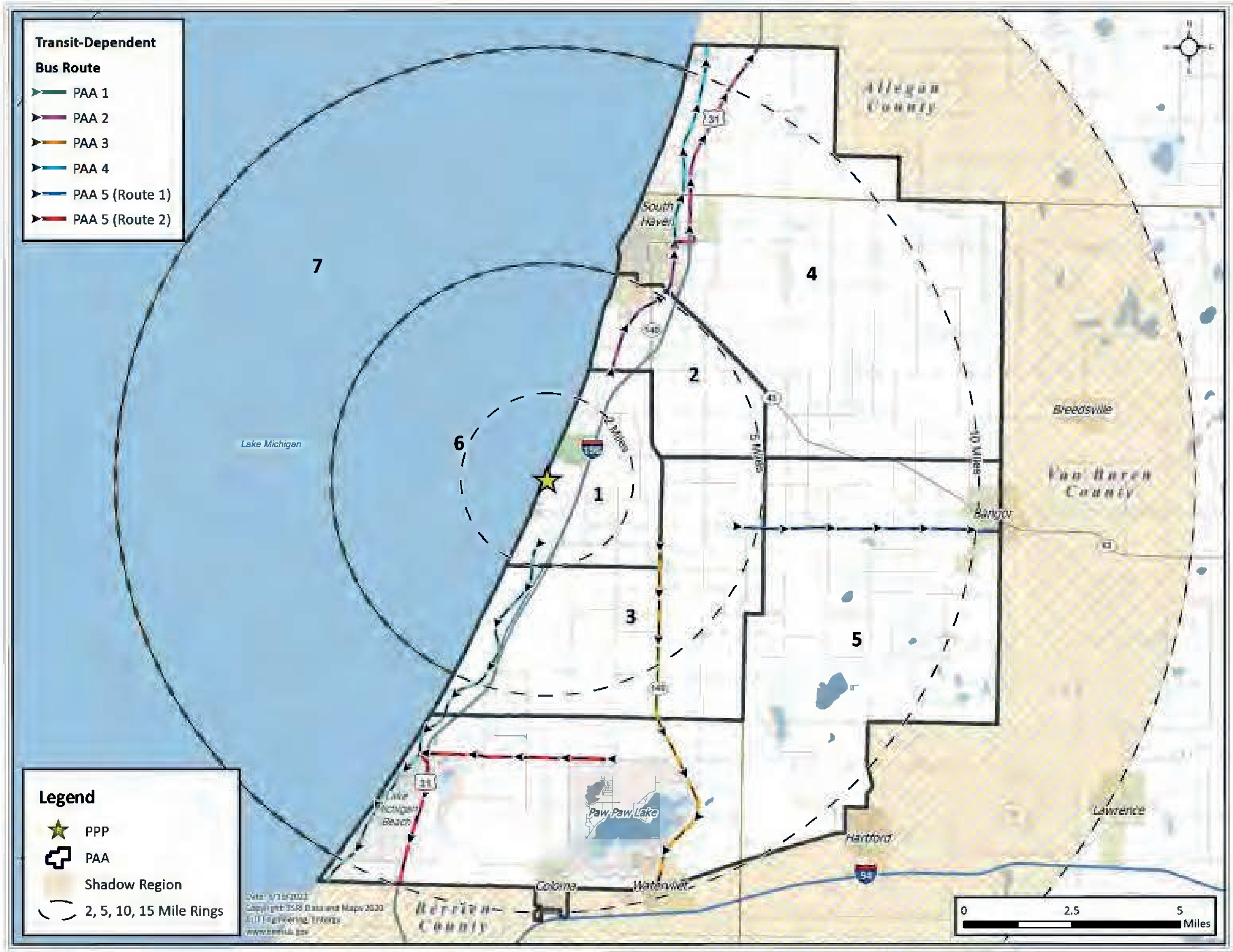


Figure 10-2. Transit-Dependent Bus Routes

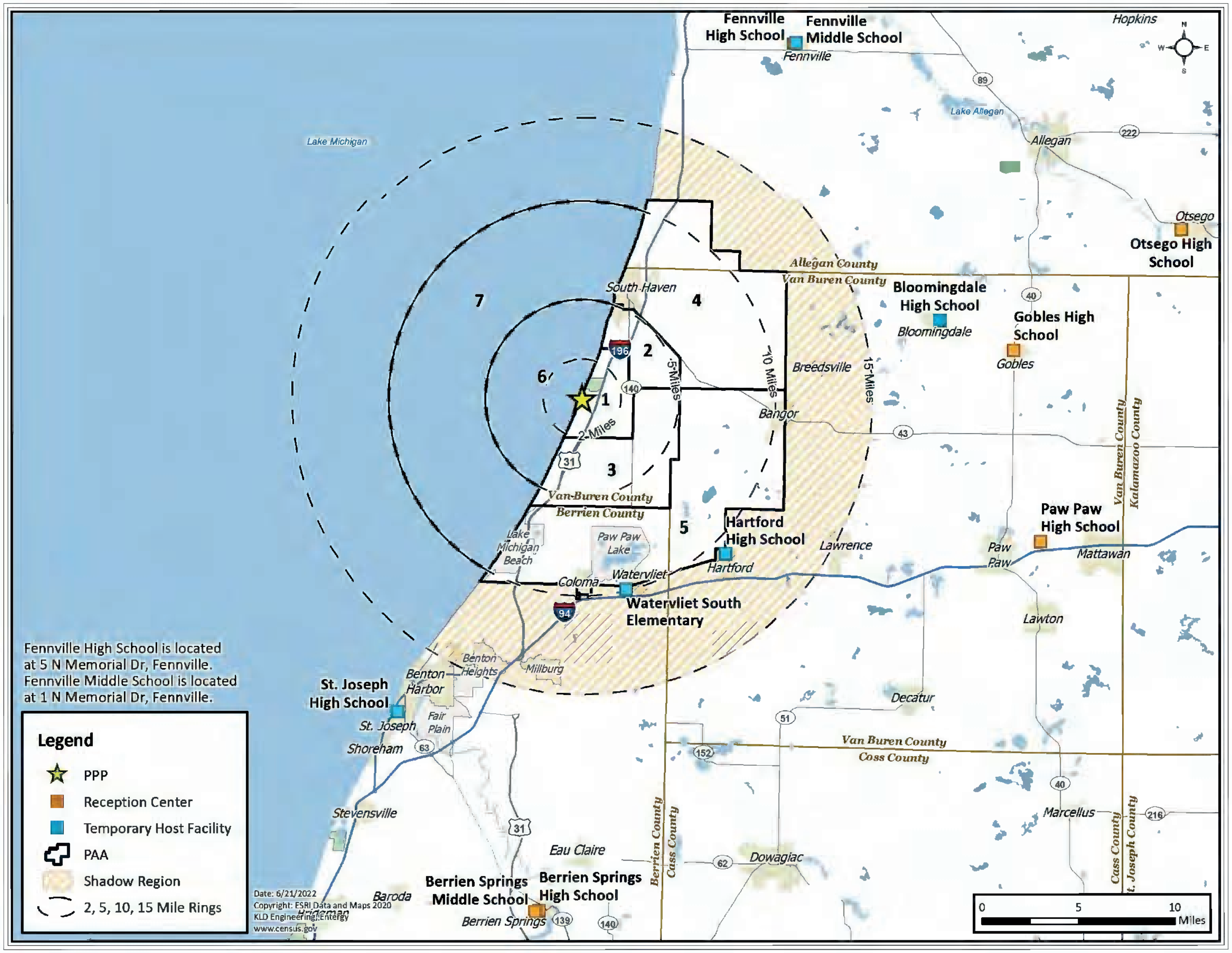


Figure 10-3. General Population Reception Centers and Temporary Host Facilities

APPENDIX A

Glossary of Traffic Engineering Terms

A. GLOSSARY OF TRAFFIC ENGINEERING TERMS

Table A-1. Glossary of Traffic Engineering Terms

Term	Definition
Analysis Network	A graphical representation of the geometric topology of a physical roadway system, which is comprised of directional links and nodes.
Link	A network link represents a specific, one-directional section of roadway. A link has both physical (length, number of lanes, topology, etc.) and operational (turn movement percentages, service rate, free-flow speed) characteristics.
Measures of Effectiveness	Statistics describing traffic operations on a roadway network.
Node	A network node generally represents an intersection of network links. A node has control characteristics, i.e., the allocation of service time to each approach link.
Origin	A location attached to a network link, within the EPZ or Shadow Region, where trips are generated at a specified rate in vehicles per hour (vph). These trips enter the roadway system to travel to their respective destinations.
Prevailing Roadway and Traffic Conditions	Relates to the physical features of the roadway, the nature (e.g., composition) of traffic on the roadway and the ambient conditions (weather, visibility, pavement conditions, etc.).
Service Rate	Maximum rate at which vehicles, executing a specific turn maneuver, can be discharged from a section of roadway at the prevailing conditions, expressed in vehicles per second (vps) or vehicles per hour (vph).
Service Volume	Maximum number of vehicles which can pass over a section of roadway in one direction during a specified time period with operating conditions at a specified Level of Service (The Service Volume at the upper bound of Level of Service, E, equals Capacity). Service Volume is usually expressed as vehicles per hour (vph).
Signal Cycle Length	The total elapsed time to display all signal indications, in sequence. The cycle length is expressed in seconds.
Signal Interval	A single combination of signal indications. The interval duration is expressed in seconds. A signal phase is comprised of a sequence of signal intervals, usually green, yellow, red.

Term	Definition
Signal Phase	A set of signal indications (and intervals) which services a particular combination of traffic movements on selected approaches to the intersection. The phase duration is expressed in seconds.
Traffic (Trip) Assignment	A process of assigning traffic to paths of travel in such a way as to satisfy all trip objectives (i.e., the desire of each vehicle to travel from a specified origin in the network to a specified destination) and to optimize some stated objective or combination of objectives. In general, the objective is stated in terms of minimizing a generalized "cost". For example, "cost" may be expressed in terms of travel time.
Traffic Density	The number of vehicles that occupy one lane of a roadway section of specified length at a point in time, expressed as vehicles per mile (vpm).
Traffic (Trip) Distribution	A process for determining the destinations of all traffic generated at the origins. The result often takes the form of a Trip Table, which is a matrix of origin-destination traffic volumes.
Traffic Simulation	A computer model designed to replicate the real-world operation of vehicles on a roadway network, so as to provide statistics describing traffic performance. These statistics are called Measures of Effectiveness.
Traffic Volume	The number of vehicles that pass over a section of roadway in one direction, expressed in vehicles per hour (vph). Where applicable, traffic volume may be stratified by turn movement.
Travel Mode	Distinguishes between private auto, bus, rail, pedestrian and air travel modes.
Trip Table or Origin-Destination Matrix	A rectangular matrix or table, whose entries contain the number of trips generated at each specified origin, during a specified time period, that are attracted to (and travel toward) each of its specified destinations. These values are expressed in vehicles per hour (vph) or in vehicles.
Turning Capacity	The capacity associated with that component of the traffic stream which executes a specified turn maneuver from an approach at an intersection.

APPENDIX B

DTRAD: Dynamic Traffic Assignment and Distribution Model

B. DYNAMIC TRAFFIC ASSIGNMENT AND DISTRIBUTION MODEL

This section describes the integrated dynamic trip assignment and distribution model named DTRAD (Dynamic Traffic Assignment and Distribution) that is expressly designed for use in analyzing evacuation scenarios. DTRAD employs logit-based path-choice principles and is one of the models of the DYNEVII System. The DTRAD module implements path-based *Dynamic Traffic Assignment* (DTA) so that time dependent Origin-Destination (OD) trips are "assigned" to routes over the network based on prevailing traffic conditions.

To apply the DYNEV II System, the analyst must specify the highway network, link capacity information, the time-varying volume of traffic generated at all origin centroids and, optionally, a set of accessible candidate destination nodes on the periphery of the EPZ for selected origins. DTRAD calculates the optimal dynamic trip distribution (i.e., trip destinations) and the optimal dynamic trip assignment (i.e., trip routing) of the traffic generated at each origin node traveling to its set of candidate destination nodes, so as to minimize evacuee travel "cost".

Overview of Integrated Distribution and Assignment Model

The underlying premise is that the selection of destinations and routes is intrinsically coupled in an evacuation scenario. That is, people in vehicles seek to travel out of an area of potential risk as rapidly as possible by selecting the "best" routes. The model is designed to identify these "best" routes in a manner that realistically distributes vehicles from origins to destinations and routes them over the highway network, in a consistent and optimal manner, reflecting evacuee behavior.

For each origin, a set of "candidate destination nodes" is selected by the software logic and by the analyst to reflect the desire by evacuees to travel away from the power plant and to access major highways. The specific destination nodeswithin this set that are selected by travelers and the selection of the connecting paths of travel, are both determined by DTRAD. This determination is made by a logit-based path choice model in DTRAD, so as to minimize the trip "cost", as discussed later.

The traffic loading on the network and the consequent operational traffic environment of the network (density, speed, throughput on each link) vary over time as the evacuation takes place. The DTRAD model, which is interfaced with the DYNEV simulation model, executes a succession of "sessions" wherein it computes the optimal routing and selection of destination nodes for the conditions that exist at that time.

Interfacing the DYNEV Simulation Model with DTRAD

The DYNEV II system reflects NRC guidance that evacuees will seek to travel in a general direction away from the location of the hazardous event. An algorithm was developed to support the DTRAD model in dynamically varying the Trip Table (O-D matrix) over time from one DTRAD session to the next. Another algorithm executes a "mapping" from the specified "geometric" network (link-node analysis network) that represents the physical highway system, to a "path" network that represents the vehicle [turn] movements. DTRAD computations are performed on the "path" network: DYNEV simulation model, on the "geometric" network.

DTRAD Description

DTRAD is the DTA module for the DYNEV II System.

When the road network under study is large, multiple routing options are usually available between trip origins and destinations. The problem of loading traffic demands and propagating them over the network links is called Network Loading and is addressed by DYNEVII using macroscopic traffic simulation modeling. Traffic assignment deals with computing the distribution of the traffic over the road network for given O-D demands and is a model of the route choice of the drivers. Travel demand changes significantly over time, and the road network may have time dependent characteristics, e.g., time-varying signal timing or reduced road capacity because of lane closure, or traffic congestion. To consider these time dependencies, DTA procedures are required.

The DTRAD DTA module represents the dynamic route choice behavior of drivers, using the specification of dynamic origin-destination matrices as flow input. Drivers choose their routes through the network based on the travel cost they experience (as determined by the simulation model). This allows traffic to be distributed over the network according to the time-dependent conditions. The modeling principles of D-TRAD include:

- It is assumed that drivers not only select the best route (i.e., lowest cost path) but some also select less attractive routes. The algorithm implemented by DTRAD archives several “efficient” routes for each O-D pair from which the drivers choose.
- The choice of one route out of a set of possible routes is an outcome of “discrete choice modeling”. Given a set of routes and their generalized costs, the percentages of drivers that choose each route is computed. The most prevalent model for discrete choice modeling is the logit model. DTRAD uses a variant of Path-Size-Logit model (PSL). PSL overcomes the drawback of the traditional multinomial logit model by incorporating an additional deterministic path size correction term to address path overlapping in the random utility expression.
- DTRAD executes the Traffic Assignment (TA) algorithm on an abstract network representation called "the path network" which is built from the actual physical link-node analysis network. This execution continues until a stable situation is reached: the volumes and travel times on the edges of the path network do not change significantly from one iteration to the next. The criteria for this convergence are defined by the user.
- Travel “cost” plays a crucial role in route choice. In DTRAD, path cost is a linear summation of the generalized cost of each link that comprises the path. The generalized cost for a link, a, is expressed as

  $$c_a = \alpha t_a + \beta l_a + \gamma s_a ,$$

  where c_a is the generalized cost for link a, and α, β, and γ are cost coefficients for link travel time, distance, and supplemental cost, respectively. Distance and supplemental costs are defined as invariant properties of the network model, while travel time is a dynamic property dictated by prevailing traffic conditions. The DYNEV simulation model

computes travel times on all edges in the network and DTRAD uses that information to constantly update the costs of paths. The route choice decision model in the next simulation iteration uses these updated values to adjust the route choice behavior. This way, traffic demands are dynamically re-assigned based on time dependent conditions. The interaction between the DTRAD traffic assignment and DYNEV II simulation models is depicted in Figure B-1. Each round of interaction is called a Traffic Assignment Session (TA session). A TA session is composed of multiple iterations, marked as loop B in the figure.

- The supplemental cost is based on the "survival distribution" (a variation of the exponential distribution).The Inverse Survival Function is a "cost" term in DTRAD to represent the potential risk of travel toward the plant:

  $s_a = -\beta \ln(p), 0 \leq p \leq l ; \beta > 0$

  $p = \frac{d_n}{d_0}$

  d_n = Distance of node, n, from the plant
  d_0 =Distance from the plant where there is zero risk
  β = Scaling factor

The value of d_o = 10 miles, the outer distance of the EPZ. Note that the supplemental cost, s_a, of link, a, is (high, low), if its downstream node, n, is (near, far from) the power plant.

Network Equilibrium

In 1952, John Wardrop wrote:

> *Under equilibrium conditions traffic arranges itself in congested networks in such a way that no individual trip-maker can reduce his path costs by switching routes.*

The above statement describes the “User Equilibrium” definition, also called the “Selfish Driver Equilibrium”. It is a hypothesis that represents a [hopeful] condition that evolves over time as drivers search out alternative routes to identify those routes that minimize their respective “costs”. It has been found that this “equilibrium” objective to minimize costs is largely realized by most drivers who routinely take the same trip over the same network at the same time (i.e., commuters). Effectively, such drivers “learn” which routes are best for them over time. Thus, the traffic environment “settles down” to a near-equilibrium state.

Clearly, since an emergency evacuation is a sudden, unique event, it does not constitute a long-term learning experience which can achieve an equilibrium state. Consequently, DTRAD was not designed as an equilibrium solution, but to represent drivers in a new and unfamiliar situation, who respond in a flexible manner to real-time information (either broadcast or observed) in such a way as to minimize their respective costs of travel.

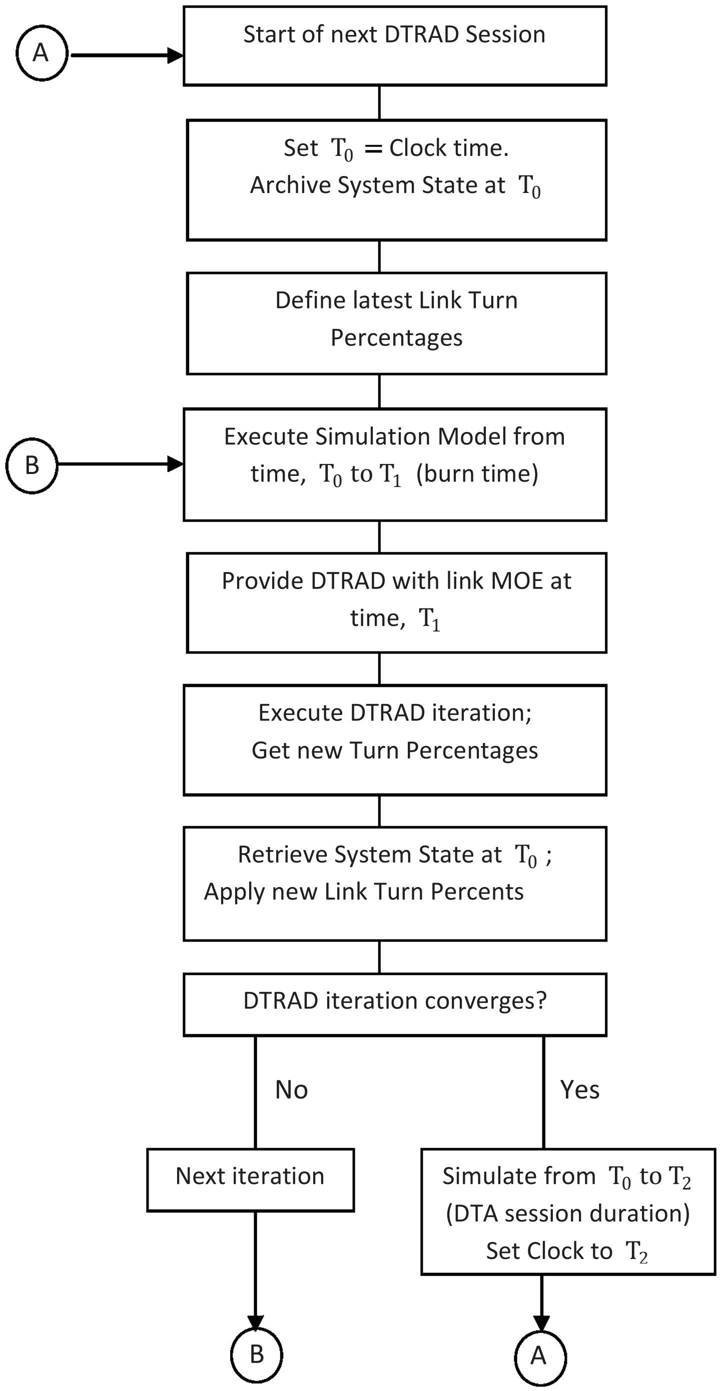


Figure B-1. Flow Diagram of Simulation-DTRAD Interface

APPENDIX C

DYNEV Traffic Simulation Model

C. DYNEV TRAFFIC SIMULATION MODEL

The DYNEV traffic simulation model is a *macroscopic* model that describes the operations of traffic flow in terms of aggregate variables: vehicles, flow rate, mean speed, volume, density, queue length, *on each link*, for each turn movement, during each Time Interval (simulation time step). The model generates trips from "sources" and from Entry Links and introduces them onto the analysis network at rates specified by the analyst based on the mobilization time distributions. The model simulates the movements of all vehicles on all network links over time until the network is empty. At intervals, the model outputs Measures of Effectiveness (MOE) such as those listed in Table C-1.

Model Features Include:

- Explicit consideration is taken of the variation in density over the time step; an iterative procedure is employed to calculate an average density over the simulation time step for the purpose of computing a mean speed for moving vehicles.
- Multiple turn movements can be serviced on one link; a separate algorithm is used to estimate the number of (fractional) lanes assigned to the vehicles performing each turn movement, based, in part, on the turn percentages provided by the DTRAD model.
- At any point in time, traffic flow on a link is subdivided into two classifications: queued and moving vehicles. The number of vehicles in each classification is computed. Vehicle spillback, stratified by turn movement for each network link, is explicitly considered and quantified. The propagation of stopping waves from link to link is computed within each time step of the simulation. There is no "vertical stacking" of queues on a link.
- Any link can accommodate "source flow" from zones via side streets and parking facilities that are not explicitly represented. This flow represents the evacuating trips that are generated at the source.
- The relation between the number of vehicles occupying the link and its storage capacity is monitored every time step for every link and for every turn movement. If the available storage capacity on a link is exceeded by the demand for service, then the simulator applies a "metering" rate to the entering traffic from both the upstream feeders and source node to ensure that the available storage capacity is not exceeded.
- A "path network" that represents the specified traffic movements from each network link is constructed by the model; this path network is utilized by the DTRAD model.
- A two-way interface with DTRAD: (1) provides link travel times; (2) receives data that translates into link turn percentages.
- Provides MOE to animation software, EVAN
- Calculates ETE statistics

All traffic simulation models are data-intensive. Table C-2 outlines the necessary input data elements.

To provide an efficient framework for defining these specifications, the physical highway environment is represented as a network. The unidirectional links of the network represent roadway sections: rural, multi-lane, urban streets or freeways. The nodes of the network generally represent intersections or points along a section where a geometric property changes (e.g. a lane drop, change in grade or free flow speed).

Figure C-1 is an example of a small network representation. The freeway is defined by the sequence of links, (20,21), (21,22), and (22,23). Links (8001, 19) and (3, 8011) are Entry and Exit links, respectively. An arterial extends from node 3 to node 19 and is partially subsumed within a grid network. Note that links (21,22) and (17,19) are grade-separated.

C.1 Methodology

C.1.1 The Fundamental Diagram

It is necessary to define the fundamental diagram describing flow-density and speed-density relationships. Rather than "settling for" a triangular representation, a more realistic representation that includes a "capacity drop", (I-R)Q_{max}, at the critical density when flow conditions enter the forced flow regime, is developed and calibrated for each link. This representation, shown in Figure C-2, asserts a constant free speed up to a density, k_f, and then a linear reduction in speed in the range, $k_f \leq k \leq k_c = 45$ vpm, the density at capacity. In the flow-density plane, a quadratic relationship is prescribed in the range, $k_c < k \leq k_s = 95$ vpm which roughly represents the "stop-and-go" condition of severe congestion. The value of flow rate, Q_s, corresponding to k_s, is approximated at $0.7\ RQ_{max}$. A linear relationship between k_s and k_j completes the diagram shown in Figure C-2. Table C-3 is a glossary of terms.

The fundamental diagram is applied to <u>moving</u> traffic on every link. The specified calibration values for each link are: (1) Free speed, v_f ; (2) Capacity, Q_{max} ; (3) Critical density, $k_c = 45$ vpm ; (4) Capacity Drop Factor, R = 0.9 ; (5) Jam density, k_j . Then, $v_c = \frac{Q_{max}}{k_c}$, $k_f = k_c - \frac{(V_f - V_c)\, k_c^2}{Q_{max}}$. Setting $\bar{k} = k - k_c$, then $Q = RQ_{max} - \frac{RQ_{max}}{8333}\bar{k}^2$ for $0 \leq \bar{k} \leq \bar{k}_s = 50$. It can be shown that $Q = \left(0.98 - 0.0056\ \bar{k}\right) RQ_{max}$ for $\bar{k}_s \leq \bar{k} \leq \bar{k}_j$, where $\bar{k}_s = 50$ and $\bar{k}_j = 175$.

C.1.2 The Simulation Model

The simulation model solves a sequence of "unit problems". Each unit problem computes the movement of traffic on a link, for each specified turn movement, over a specified time interval (TI) which serves as the simulation time step for all links. Figure C-3 is a representation of the unit problem in the time-distance plane. Table C-3 is a glossary of terms that are referenced in the following description of the unit problem procedure.

The formulation and the associated logic presented below are designed to solve the unit problem for each sweep over the network (discussed below), for each turn movement serviced

on each link that comprises the evacuation network, and for each TI over the duration of the evacuation.

Given $= Q_b, M_b, L, TI, E_0, LN, {}^G/_C, h, L_v, R_0, L_c, E, M$
Compute $= O, Q_e, M_e$
Define $O = O_Q + O_M + O_E$; $E = E_1 + E_2$

1. For the first sweep, s = 1, of this TI, get initial estimates of mean density, k_0, the R – factor, R_0 and entering traffic, E_0, using the values computed for the final sweep of the prior TI. For each subsequent sweep, $s > 1$, calculate $E = \sum_i P_i \; O_i + S$ where P_i, O_i are the relevant turn percentages from feeder link, i , and its total outflow (possibly metered) over this TI; S is the total source flow (possibly metered) during the current TI.
   Set iteration counter, n = 0, $k = k_0$, and $E = E_0$.

2. Calculate $v(k)$ such that $k \leq 130$ using the analytical representations of the fundamental diagram.
   Calculate $\text{Cap} = \frac{Q_{max}(TI)}{3600} \left({}^G/_C\right) LN$, in vehicles, this value may be reduced due to metering
   Set $R = 1.0$ if ${}^G/_C < 1$ or if $k \leq k_c$; Set $R = 0.9$ only if ${}^G/_C = 1$ and $k > k_c$
   Calculate queue length, $L_b = Q_b \frac{L_v}{LN}$

3. Calculate $t_1 = TI - \frac{L}{V}$. If $t_1 \prec 0$, set $t_1 = E_1 = O_E = 0$; Else, $E_1 = E \frac{t_1}{TI}$.

4. Then $E_2 = E - E_1$; $t_2 = TI - t_1$

5. If $Q_b \geq \text{Cap}$, then
   $O_Q = \text{Cap}, O_M = O_E = 0$
   If $t_1 > 0$, then
   $Q'_e = Q_b + M_b + E_1 - \text{Cap}$
   Else
   $Q'_e = Q_b - \text{Cap}$
   End if
   Calculate Q_e and M_e using Algorithm A (below)

6. Else $(Q_b \prec \text{Cap})$
   $O_Q = Q_b$, $\text{RCap} = \text{Cap} - O_Q$

7. If $M_b \leq \text{RCap}$, then

8. If $t_1 > 0$, $O_M = M_b$, $O_E = \min\left(RCap - M_b, \frac{t_1\,Cap}{TI}\right) \geq 0$

$Q'_e = E_1 - O_E$

If $Q'_e > 0$, then

Calculate Q_e, M_e with Algorithm A

Else

$Q_e = 0$, $M_e = E_2$

End if

Else $(t_1 = 0)$

$O_M = \left(\frac{v(TI) - L_b}{L - L_b}\right) M_b$ and $O_E = 0$

$M_e = M_b - O_M + E$; $Q_e = 0$

End if

9. Else $(M_b > RCap)$

$O_E = 0$

If $t_1 > 0$, then

$O_M = RCap$, $Q'_e = M_b - O_M + E_1$

Calculate Q_e and M_e using Algorithm A

10. Else $(t_1 = 0)$

$M_d = \left[\left(\frac{v(TI) - L_b}{L - L_b}\right) M_b\right]$

If $M_d > RCap$, *then*

$O_M = RCap$

$Q'_e = M_d - O_M$

Apply Algorithm A to calculate Q_e and M_e

Else

$O_M = M_d$

$M_e = M_b - O_M + E$ and $Q_e = 0$

End if

End if

End if

End if

11. Calculate a new estimate of average density, $\bar{k}_n = \frac{1}{4}[k_b + 2\,k_m + k_e]$,

where k_b = density at the beginning of the TI

k_e = density at the end of the TI

k_m = density at the mid-point of the TI

All values of density apply only to the <u>moving</u> vehicles.

If $|\bar{k}_n - \bar{k}_{n-1}| > \epsilon$ and $n < N$

where $N =$ max number of iterations, and ϵ is a convergence criterion, then

12. set $n = n + 1$, and return to step 2 to perform iteration, n, using $k = \bar{k}_n$.
End if

Computation of unit problem is now complete. Check for excessive inflow causing spillback.

13. If $Q_e + M_e > \frac{(L-W)\,LN}{L_v}$, then

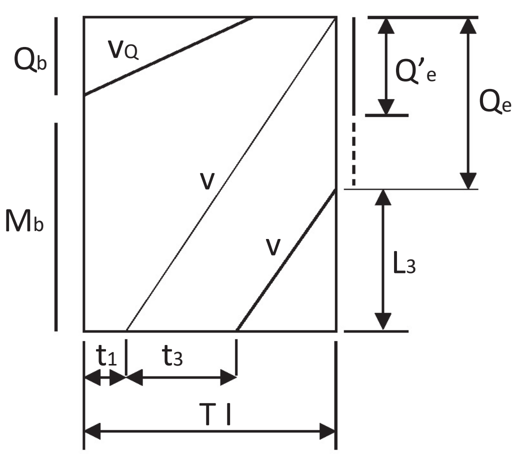
The number of excess vehicles that cause spillback is: $SB = Q_e + M_e - \frac{(L-W)\cdot LN}{L_v}$, where W is the width of the upstream intersection. To prevent spillback, meter the outflow from the feeder approaches and from the source flow, S, during this TI by the amount, SB. That is, set

$$M = 1 - \frac{SB}{(E+S)} \geq 0 \text{, where M is the metering factor (over all movements).}$$

This metering factor is assigned appropriately to all feeder links and to the source flow, to be applied during the next network sweep, discussed later.

Algorithm A

This analysis addresses the flow environment over a TI during which moving vehicles can join a standing or discharging queue. For the case shown, $Q_b \leq Cap$, with $t_1 > 0$ and a queue of length, Q'_e, formed by that portion of M_b and E that reaches the stop-bar within the TI, but could not discharge due to inadequate capacity. That is, $Q_b + M_b + E_1 > Cap$. This queue length, $Q'_e = Q_b + M_b + E_1 - Cap$ can be extended to Q_e by traffic entering the approach during the current TI, traveling at speed, v, and reaching the rear of the queue within the TI. A portion of the entering vehicles, $E_3 = E\,\frac{t_3}{TI}$, will likely join the queue. This analysis calculates t_3, Q_e and M_e for the input values of L, TI, v, E, t, L_v, LN, Q'_e .



When $t_1 > 0$ and $Q_b \leq Cap$:

Define: $L'_e = Q'_e\,\frac{L_v}{LN}$. From the sketch, $L_3 = v(TI - t_1 - t_3) = L - (Q'_e + E_3)\frac{L_v}{LN}$.

Substituting $E_3 = \frac{t_3}{TI}\,E$ yields: $-vt_3 + \frac{t_3}{TI}\,E\,\frac{L_v}{LN} = L - v(TI - t_1) - L'_e$. Recognizing that the first two terms on the right hand side cancel, solve for t_3 to obtain:

$$t_3 = \frac{L'_e}{\left[v - \frac{E}{TI}\frac{L_v}{LN}\right]} \qquad \text{such that} \quad 0 \leq t_3 \leq TI - t_1$$

If the denominator, $\left[v - \frac{E}{TI}\frac{L_v}{LN}\right] \leq 0$, set $t_3 = TI - t_1$.

$$\text{Then, } Q_e = Q'_e + E\,\frac{t_3}{TI} \quad , \qquad M_e = E\left(1 - \frac{t_1 + t_3}{TI}\right)$$

The complete Algorithm A considers all flow scenarios; space limitation precludes its inclusion, here.

C.1.3 Lane Assignment

The "unit problem" is solved for each turn movement on each link. Therefore it is necessary to calculate a value, LN_x , of allocated lanes for each movement, x. If in fact all lanes are specified by, say, arrows painted on the pavement, either as full lanes or as lanes within a turn bay, then the problem is fully defined. If however there remain un-channelized lanes on a link, then an analysis is undertaken to subdivide the number of these physical lanes into turn movement specific virtual lanes, LN_x.

C.2 Implementation

C.2.1 Computational Procedure

The computational procedure for this model is shown in the form of a flow diagram as Figure C-4. As discussed earlier, the simulation model processes traffic flow for each link independently over TI that the analyst specifies; it is usually 60 seconds or longer. The first step is to execute an algorithm to define the sequence in which the network links are processed so that as many links as possible are processed after their feeder links are processed, within the same network sweep. Since a general network will have many closed loops, it is not possible to guarantee that every link processed will have all of its feeder links processed earlier.

The processing then continues as a succession of time steps of duration, TI, until the simulation is completed. Within each time step, the processing performs a series of "sweeps" over all network links; this is necessary to ensure that the traffic flow is synchronous over the entire network. Specifically, the sweep ensures continuity of flow among all the network links; in the context of this model, this means that the values of E, M, and S are all defined for each link such that they represent the synchronous movement of traffic from each link to all of its outbound links. These sweeps also serve to compute the metering rates that control spillback.

Within each sweep, processing solves the "unit problem" for each turn movement on each link. With the turn movement percentages for each link provided by the DTRAD model, an algorithm allocates the number of lanes to each movement serviced on each link. The timing at a signal, if

any, applied at the downstream end of the link, is expressed as a G/C ratio, the signal timing needed to define this ratio is an input requirement for the model. The model also has the capability of representing, with macroscopic fidelity, the actions of actuated signals responding to the time-varying competing demands on the approaches to the intersection.

The solution of the unit problem yields the values of the number of vehicles, O, that discharge from the link over the time interval and the number of vehicles that remain on the link at the end of the time interval as stratified by queued and moving vehicles: $Q_e \text{ and } M_e$. The procedure considers each movement separately (multi-piping). After all network links are processed for a given network sweep, the updated consistent values of entering flows, E; metering rates, M; and source flows, S are defined so as to satisfy the “no spillback” condition. The procedure then performs the unit problem solutions for all network links during the following sweep.

Experience has shown that the system converges (i.e. the values of E, M and S “settle down” for all network links) in just two sweeps if the network is entirely under-saturated or in four sweeps in the presence of extensive congestion with link spillback. (The initial sweep over each link uses the final values of E and M, of the prior TI). At the completion of the final sweep for a TI, the procedure computes and stores all measures of effectiveness for each link and turn movement for output purposes. It then prepares for the following time interval by defining the values of $Q_b \text{ and } M_b$ for the start of the next TI as being those values of $Q_e \text{ and } M_e$ at the end of the prior TI. In this manner, the simulation model processes the traffic flow over time until the end of the run. Note that there is no space-discretization other than the specification of network links.

C.2.2 Interfacing with Dynamic Traffic Assignment (DTRAD)

The **DYNEV II** system reflects NRC guidance that evacuees will seek to travel in a general direction away from the location of the hazardous event. Thus, an algorithm was developed to identify an appropriate set of destination nodes for each origin based on its location and on the expected direction of travel. This algorithm also supports the DTRAD model in dynamically varying the Trip Table (O-D matrix) over time from one DTRAD session to the next.

Figure B-1 depicts the interaction of the simulation model with the DTRAD model in the **DYNEV II** system. As indicated, **DYNEV II** performs a succession of DTRAD "sessions"; each such session computes the turn link percentages for each link that remain constant for the session duration, $[T_0, T_2]$, specified by the analyst. The end product is the assignment of traffic volumes from each origin to paths connecting it with its destinations in such a way as to minimize the network-wide cost function. The output of the DTRAD model is a set of updated link turn percentages which represent this assignment of traffic.

As indicated in Figure B-1, the simulation model supports the DTRAD session by providing it with operational link MOE that are needed by the path choice model and included in the DTRAD cost function. These MOE represent the operational state of the network at a time, $T_1 \leq T_2$, which lies within the session duration, $[T_0, T_2]$. This "burn time", $T_1 - T_0$, is selected by the analyst. For each DTRAD iteration, the simulation model computes the change in network operations over this burn time using the latest set of link turn percentages computed by the DTRAD model. Upon convergence of the DTRAD iterative procedure, the simulation model accepts the latest turn percentages provided by the Dynamic Traffic Assignment (DTA) model, returns to the origin time, T_0, and executes until it arrives at the end of the DTRAD session duration at time, T_2. At this time the next DTA session is launched and the whole process repeats until the end of the **DYNEV II** run.

Additional details are presented in Appendix B.

Table C-1. Selected Measures of Effectiveness Output by DYNEV II

Measure	Units	Applies To
Vehicles Discharged	Vehicles	Link, Network, Exit Link
Speed	Miles/Hours (mph)	Link, Network
Density	Vehicles/Mile/Lane	Link
Level of Service	LOS	Link
Content	Vehicles	Network
Travel Time	Vehicle-hours	Network
Evacuated Vehicles	Vehicles	Network, Exit Link
Trip Travel Time	Vehicle-minutes/trip	Network
Capacity Utilization	Percent	Exit Link
Attraction	Percent of total evacuating vehicles	Exit Link
Max Queue	Vehicles	Node, Approach
Time of Max Queue	Hours:minutes	Node, Approach
Route Statistics	Length (mi); Mean Speed (mph); Travel Time (min)	Route
Mean Travel Time	Minutes	Evacuation Trips; Network

Table C-2. Input Requirements for the DYNEV II Model

HIGHWAY NETWORK

- Links defined by upstream and downstream node numbers
- Link lengths
- Number of lanes (up to 6) and channelization
- Turn bays (1 to 3 lanes)
- Destination (exit) nodes
- Network topology defined in terms of downstream nodes for each receiving link
- Node Coordinates (X,Y)
- Nuclear Power Plant Coordinates (X,Y)

GENERATED TRAFFIC VOLUMES

- On all entry links and source nodes (origins), by Time Period

TRAFFIC CONTROL SPECIFICATIONS

- Traffic signals: link-specific, turn movement specific
- Signal control treated as fixed time or actuated
- Location of traffic control points (these are represented as actuated signals)
- Stop and Yield signs
- Right-turn-on-red (RTOR)
- Route diversion specifications
- Turn restrictions
- Lane control (e.g., lane closure, movement-specific)

DRIVER'S AND OPERATIONAL CHARACTERISTICS

- Driver's (vehicle-specific) response mechanisms: free-flow speed, discharge headway
- Bus route designation.

DYNAMIC TRAFFIC ASSIGNMENT

- Candidate destination nodes for each origin (optional)
- Duration of DTA sessions
- Duration of simulation "burn time"
- Desired number of destination nodes per origin

INCIDENTS

- Identify and Schedule of closed lanes
- Identify and Schedule of closed links

Table C-3. Glossary

Cap	The maximum number of vehicles, of a particular movement, that can discharge from a link within a time interval.
E	The number of vehicles, of a particular movement, that enter the link over the time interval. The portion, E_{TI}, can reach the stop-bar within the TI.
G/C	The green time: cycle time ratio that services the vehicles of a particular turn movement on a link.
h	The mean queue discharge headway, seconds.
k	Density in vehicles per lane per mile.
$\bar{k}$	The average density of <u>moving</u> vehicles of a particular movement over a TI, on a link.
L	The length of the link in feet.
L_b , L_e	The queue length in feet of a particular movement, at the [beginning, end] of a time interval.
LN	The number of lanes, expressed as a floating point number, allocated to service a particular movement on a link.
L_v	The mean effective length of a queued vehicle including the vehicle spacing, feet.
M	Metering factor (Multiplier): 1.
M_b , M_e	The number of moving vehicles on the link, of a particular movement, that are moving at the [beginning, end] of the time interval. These vehicles are assumed to be of equal spacing, over the length of link upstream of the queue.
O	The total number of vehicles of a particular movement that are discharged from a link over a time interval.
O_Q , O_M , O_E	The components of the vehicles of a particular movement that are discharged from a link within a time interval: vehicles that were Queued at the beginning of the TI; vehicles that were Moving within the link at the beginning of the TI; vehicles that Entered the link during the TI.
P_x	The percentage, expressed as a fraction, of the total flow on the link that executes a particular turn movement, x.

Q_b , Q_e	The number of queued vehicles on the link, of a particular turn movement, at the [beginning, end] of the time interval.
Q_{max}	The maximum flow rate that can be serviced by a link for a particular movement in the absence of a control device. It is specified by the analyst as an estimate of link capacity, based upon a field survey, with reference to the HCM 2016.
R	The factor that is applied to the capacity of a link to represent the "capacity drop" when the flow condition moves into the forced flow regime. The lower capacity at that point is equal to RQ_{max} .
RCap	The remaining capacity available to service vehicles of a particular movement after that queue has been completely serviced, within a time interval, expressed as vehicles.
S_x	Service rate for movement x, vehicles per hour (vph).
t_1	Vehicles of a particular turn movement that enter a link over the first t_1 seconds of a time interval, can reach the stop-bar (in the absence of a queue down-stream) within the same time interval.
TI	The time interval, in seconds, which is used as the simulation time step.
v	The mean speed of travel, in feet per second (fps) or miles per hour (mph), of moving vehicles on the link.
v_Q	The mean speed of the last vehicle in a queue that discharges from the link within the TI. This speed differs from the mean speed of moving vehicles, v.
W	The width of the intersection in feet. This is the difference between the link length which extends from stop-bar to stop-bar and the block length.

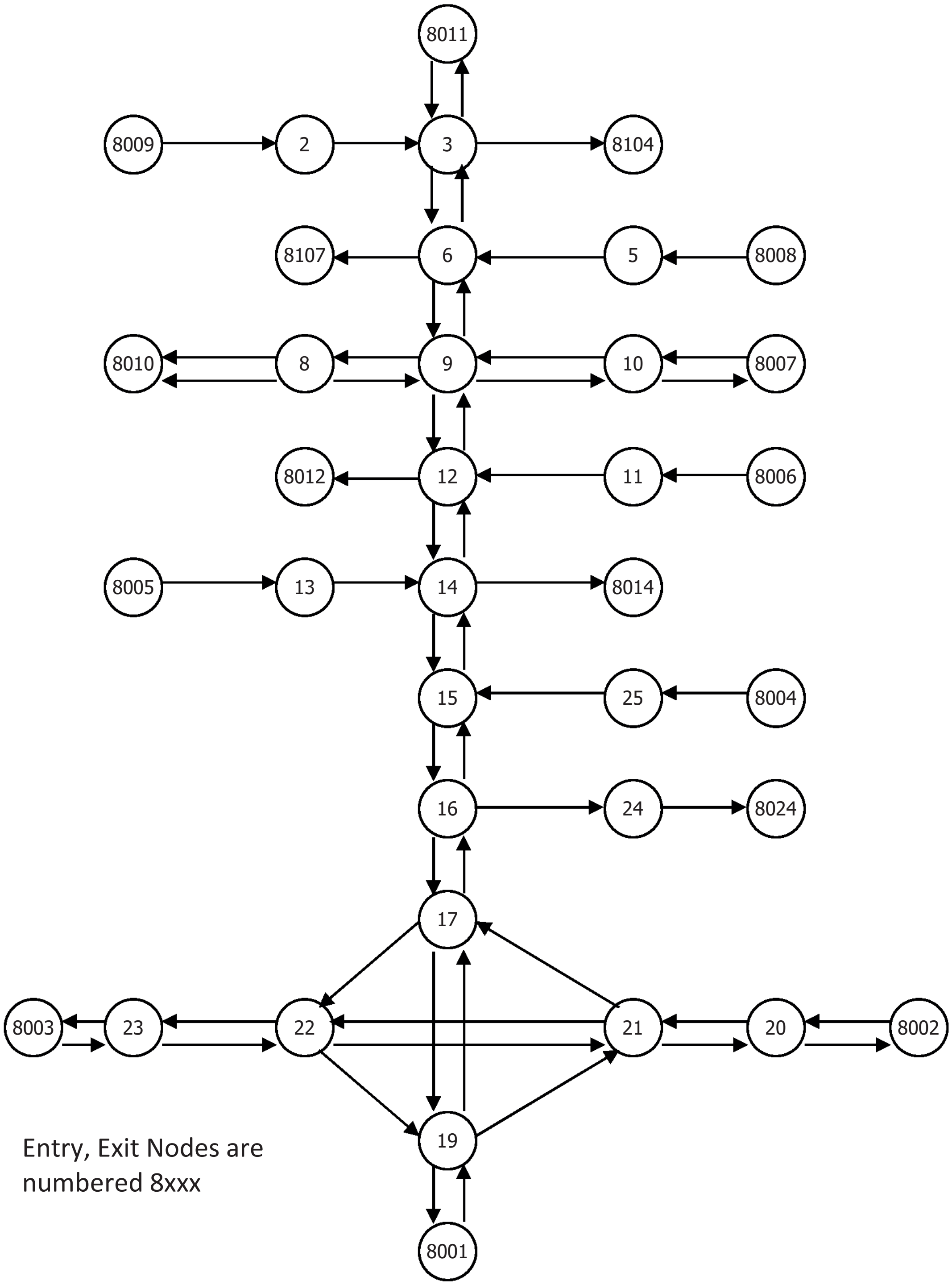


Figure C-1. Representative Analysis Network

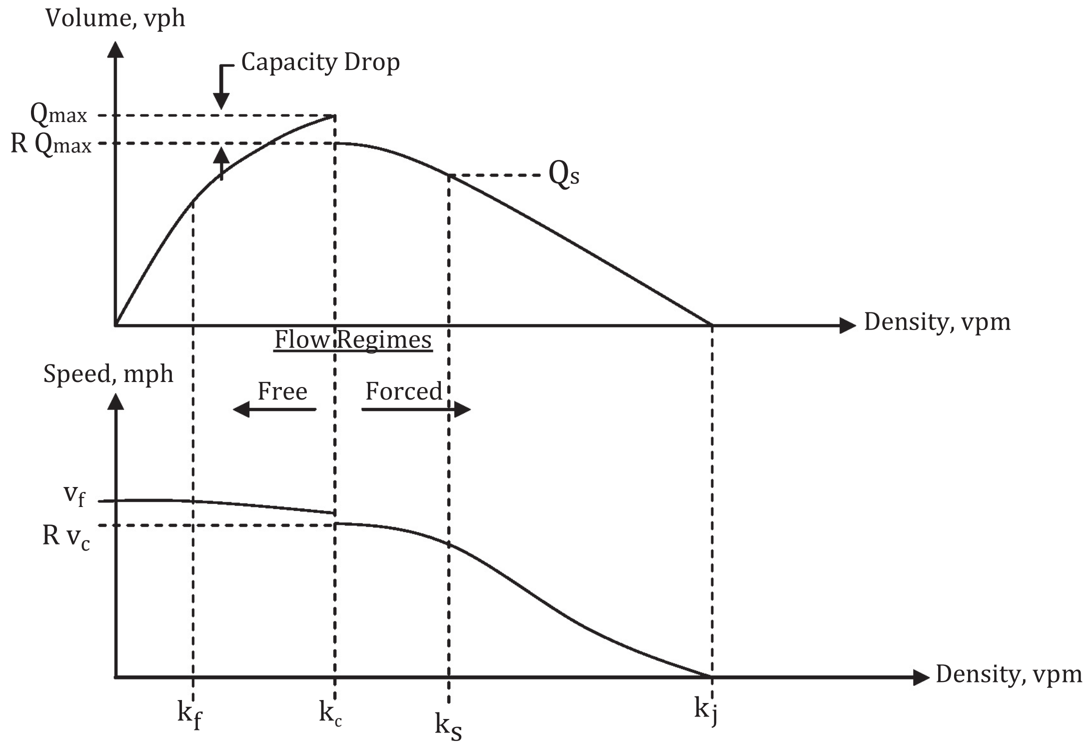


Figure C-2. Fundamental Diagrams

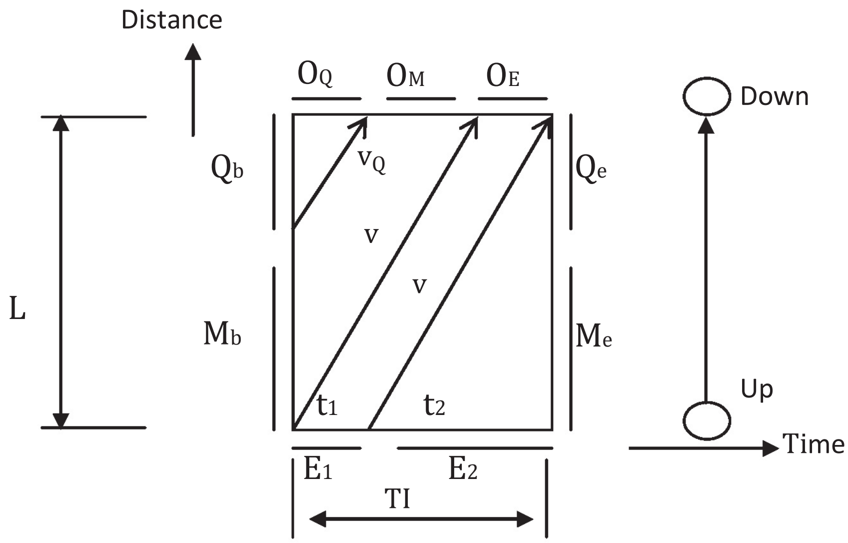


Figure C-3. A UNIT Problem Configuration with $t_1 > 0$

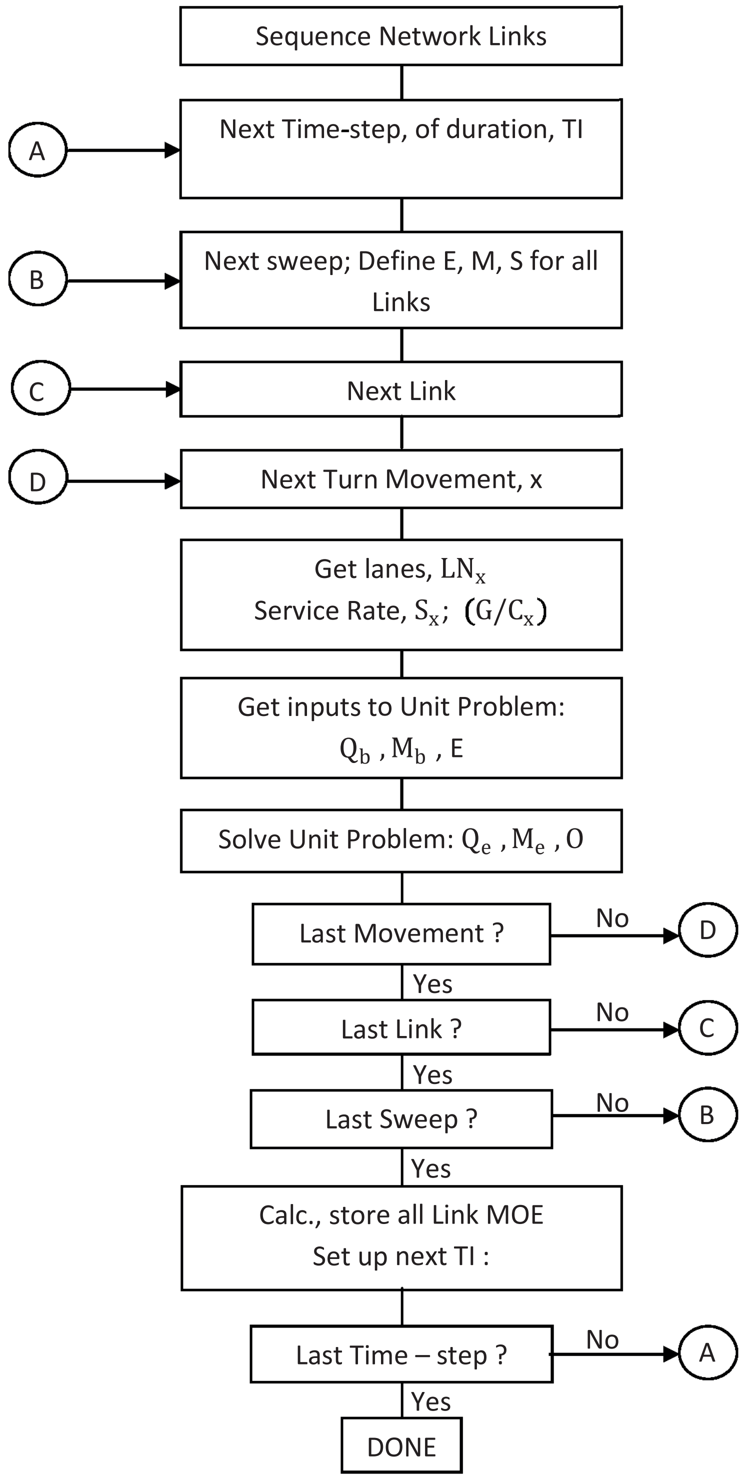


Figure C-4. Flow of Simulation Processing (See Glossary: Table C-3)

APPENDIX D

DETAILED DESCRIPTION OF STUDY PROCEDURE

D. DETAILED DESCRIPTION OF STUDY PROCEDURE

This appendix describes the activities that were performed to compute Evacuation Time Estimates. The individual steps of this effort are represented as a flow diagram in Figure D-1. Each numbered step in the description that follows corresponds to the numbered element in the flow diagram.

Step 1

The first activity was to obtain EPZ boundary information and create a GIS base map. The base map extends beyond the Shadow Region which extends approximately 15 miles (radially) from the power plant location. The base map incorporates the local roadway topology, a suitable topographic background and the EPZ and PAA boundaries.

Step 2

2020 Census block information was obtained in GIS format. This information was used to estimate the permanent resident population within the EPZ and Shadow Region and to define the spatial distribution and demographic characteristics of the population within the study area. The employee, transient, school and other special facility data used in the 2012 ETE study was updated by the county emergency management agencies and by Entergy/Holtec.

Step 3

A kickoff meeting was conducted with major stakeholders (state and county emergency planning personnel, on-site and off-site utility emergency planning personnel, local and state law enforcement agencies). The purpose of the kickoff meeting was to present an overview of the work effort, identify key agency personnel, and indicate the data requirements for the study. Specific requests for information were presented to county emergency planning personnel. Unique features of the study area were discussed to identify the local concerns that should be addressed by the ETE study.

Step 4

Next, a physical survey of the roadway system in the study area was conducted to determine the geometric properties of the highway sections, the channelization of lanes on each section of roadway, whether there are any turn restrictions or special treatment of traffic at intersections, the type and functioning of traffic control devices, gathering signal timings for pre-timed traffic signals (if any exist within the study area), and to make the necessary observations needed to estimate realistic values of roadway capacity. Roadway characteristics were also verified using aerial imagery.

Step 5

An online demographic survey of households within the EPZ was conducted to identify household dynamics, trip generation characteristics, and evacuation-related demographic information of the EPZ population. This information was used to determine important study factors including the average number of evacuating vehicles used by each household, and the time required to perform pre-evacuation mobilization activities.

Step 6

A computerized representation of the physical roadway system, called a link-node analysis network, was developed using the most recent UNITES software (see Section 1.3) developed by KLD. Once the geometry of the network was completed, the network was calibrated using the information gathered during the road survey (Step 4) and information obtained from aerial imagery. Estimates of highway capacity for each link and other link-specific characteristics were introduced to the network description. Traffic signal timings were input accordingly. The link-node analysis network was imported into a GIS map. The 2020 permanent resident population estimates (Step 2) were overlaid in the map, and origin centroids where trips would be generated during the evacuation process were assigned to appropriate links.

Step 7

The EPZ is subdivided into 7 PAAs. Based on wind direction and speed, Regions (groupings of PAAs) that may be advised to evacuate, were developed.

The need for evacuation can occur over a range of time-of-day, day-of-week, seasonal and weather-related conditions. Scenarios were developed to capture the variation in evacuation demand, highway capacity and mobilization time, for different time of day, day of the week, time of year, and weather conditions.

Step 8

The input stream for the DYNEV II model, which integrates the dynamic traffic assignment and distribution model, DTRAD, with the evacuation simulation model, was created for a prototype evacuation case – the evacuation of the entire EPZ for a representative scenario.

Step 9

After creating this input stream, the DYNEV II System was executed on the prototype evacuation case to compute evacuating traffic routing patterns consistent with the appropriate NRC guidelines. DYNEV II contains an extensive suite of data diagnostics which check the completeness and consistency of the input data specified. The analyst reviews all warning and error messages produced by the model and then corrects the database to create an input stream that properly executes to completion.

The model assigns destinations to all origin centroids consistent with a (general) radial evacuation of the EPZ and Shadow Region. The analyst may optionally supplement and/or replace these model-assigned destinations, based on professional judgment, after studying the topology of the analysis highway network. The model produces link and network-wide measures of effectiveness as well as estimates of evacuation time.

Step 10

The results generated by the prototype evacuation case are critically examined. The examination includes observing the animated graphics (using the EVAN software – see Section 1.3) and reviewing the statistics output by the model. This is a labor-intensive activity, requiring the direct participation of skilled engineers who possess the necessary practical experience to interpret the results and to determine the causes of any problems reflected in

the results.

Essentially, the approach is to identify those bottlenecks in the network that represent locations where congested conditions are pronounced and to identify the cause of this congestion. This cause can take many forms, either as excess demand due to high rates of trip generation, improper routing, a shortfall of capacity, or as a quantitative flaw in the way the physical system was represented in the input stream. This examination leads to one of two conclusions:

- The results are satisfactory; or
- The input stream must be modified accordingly.

This decision requires, of course, the application of the user's judgment and experience based upon the results obtained in previous applications of the model and a comparison of the results of the latest prototype evacuation case iteration with the previous ones. If the results are satisfactory in the opinion of the user, then the process continues with Step 13. Otherwise, proceed to Step 11.

Step 11

There are many "treatments" available to the user in resolving apparent problems. These treatments range from decisions to reroute the traffic by assigning additional evacuation destinations for one or more sources, imposing turn restrictions where they can produce significant improvements in capacity, changing the control treatment at critical intersections so as to provide improved service for one or more movements, adding routes or in prescribing specific treatments for channelizing the flow so as to expedite the movement of traffic along major roadway systems. Such "treatments" take the form of modifications to the original prototype evacuation case input stream. All treatments are designed to improve the representation of evacuation behavior.

Step 12

As noted above, the changes to the input stream must be implemented to reflect the modifications undertaken in Step 11. At the completion of this activity, the process returns to Step 9 where the DYNEV II System is again executed.

Step 13

Evacuation of transit-dependent evacuees and special facilities are included in the evacuation analysis. Fixed routing for transit buses and for school buses, ambulances, and other transit vehicles are introduced into the final prototype evacuation case data set. DYNEV II generates route-specific speeds over time for use in the estimation of evacuation times for the transit dependent and special facility population groups.

Step 14

The prototype evacuation case was used as the basis for generating all region and scenario-specific evacuation cases to be simulated. This process was automated through the UNITES user interface. For each specific case, the population to be evacuated, the trip generation

distributions, the highway capacity and speeds, and other factors are adjusted to produce a customized case-specific data set.

Step 15

All evacuation cases are executed using the DYNEV II System to compute ETE. Once results were available, quality control procedures were used to assure the results were consistent, dynamic routing was reasonable, and traffic congestion/bottlenecks were addressed properly. Traffic management plans are analyzed, and traffic control points are prioritized, if applicable. Additional analysis is conducted to identify the sensitivity of the ETE to changes in some base evacuation conditions and model assumptions.

Step 16

Once vehicular evacuation results are accepted, average travel speeds for transit and special facility routes were used to compute ETE for transit-dependent permanent residents, schools, medical facilities, and homebound population with access and/or functional needs .

Step 17

The simulation results are analyzed, tabulated and graphed. The results were then documented, as required by NUREG/CR-7002, Rev. 1.

Step 18

Following the completion of documentation activities, the ETE criteria checklist (see Appendix N) was completed. An appropriate report reference is provided for each criterion provided in the checklist.

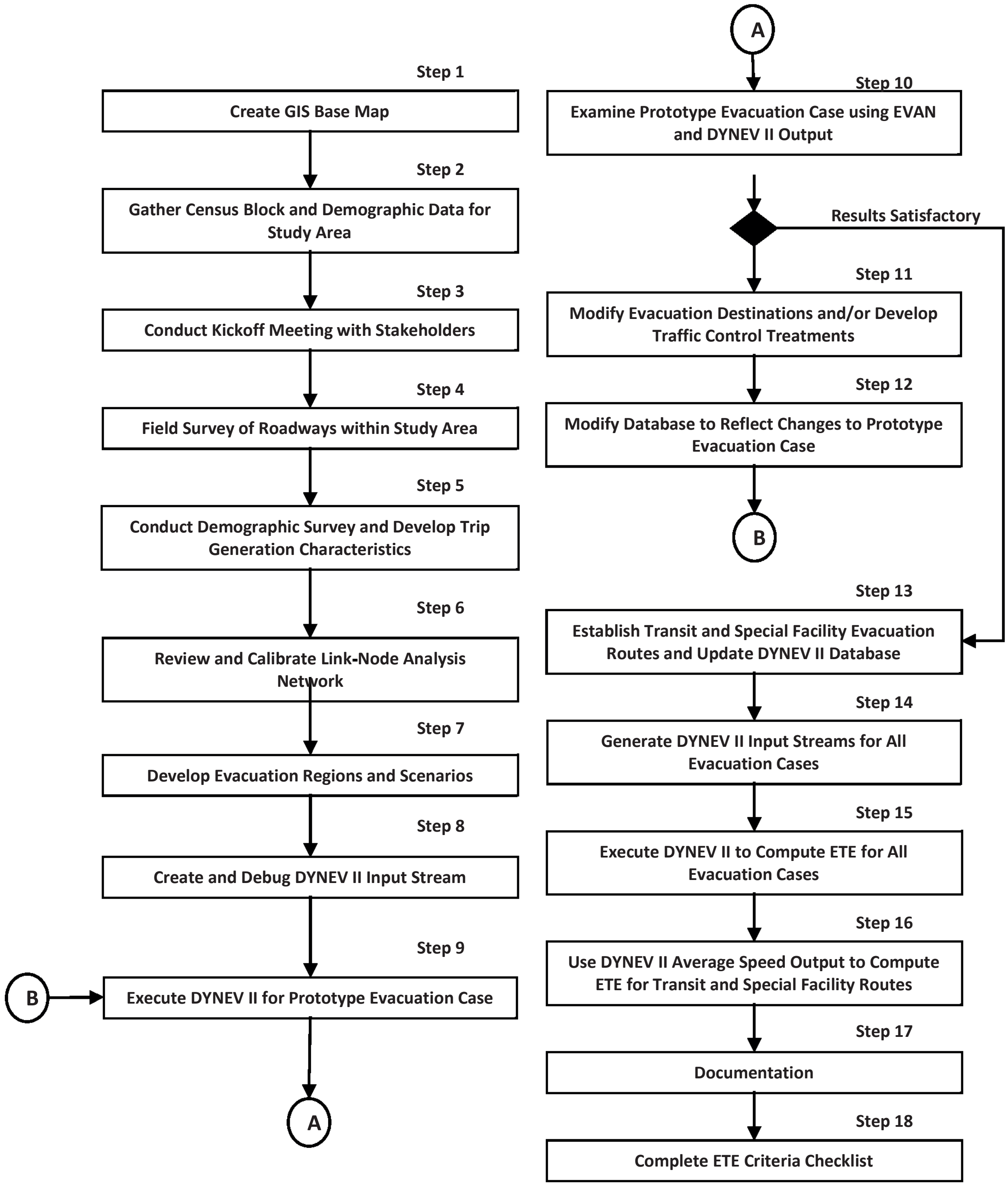


Figure D-1. Flow Diagram of Activities

APPENDIX E

Special Facility Data

E. SPECIAL FACILITY DATA

The following tables list population information, as of May 2022, for special facilities that are located within the PPP EPZ. Special facilities are defined as schools, preschools, and medical facilities. Transient population data is included in the tables for recreational areas (beaches, campgrounds, golf courses, marinas, parks, other recreational areas) and lodging facilities. Employment data is included in the table for major employers. Each table is grouped by county. The location of the facility is defined by its straight-line distance (miles) and direction (magnetic bearing) from the center point of the plant. Maps of each school, preschool, medical facility, major employer, recreational area (beach, campground, golf course, marina, park, casino), and lodging facility are also provided.

Table E-1. Schools and Preschools within the EPZ

PAA	Distance (miles)	Dire-ction	School Name	Street Address	Municipality	Enroll-ment
ALLEGAN COUNTY,MI						
4	7.4	NNE	Baseline Middle School	7357 Baseline Rd	South Haven	460
4	7.6	NNE	North Shore Elementary School	7320 N Shore Dr	South Haven	314
					Allegan County Subtotal:	*774*
BERRIEN COUNTY,MI						
5	9.1	S	Salem Lutheran Preschool	275 Marvin St	Coloma	6
5	9.1	SSE	Watervliet North Elementary School	287 Baldwin Ave	Watervliet	293
5	9.7	S	Coloma Elementary School	262 S W St	Coloma	375
5	9.7	S	Coloma Intermediate School	274 S W St	Coloma	375
5	10.0	S	Coloma High School	300 W St Joseph St	Coloma	430
5	10.1	S	Coloma Junior High School	300 W St Joseph St	Coloma	300
					Berrien County Subtotal:	*1,779*
VAN BUREN COUNTY,MI						
2	5.0	NE	Maple Grove Elementary School	72399 12th Ave	South Haven	303
2	5.0	NNE	Head Start - South Haven	540 Aylworth Ave	South Haven	40
3	3.6	SE	Covert Middle School	35323 M 140 Hwy	Covert	73
3	3.6	SE	Covert High School	35323 M 140 Hwy	Covert	102
3	3.6	SE	Covert Elementary School	35323 M 140 Hwy	Covert	100
4	5.2	NNE	Head Start - Migrant at Lincoln Elementary	500 Elkenburg St	South Haven	15
4	5.2	NNE	Lincoln Elementary School	500 Elkenburg St	South Haven	207
4	5.3	NNE	L.C. Mohr High School	600 Elkenburg St	South Haven	522
4	5.3	NNE	St. Paul Lutheran School	718 Arbor Ct	South Haven	73
4	5.6	NNE	St. Basil Catholic School	94 Superior St	South Haven	125
4	7.0	NNE	WAY- South Haven Schools (LMC Campus)	125 Veterans Blvd	South Haven	30
4	7.0	NNE	Lake Michigan College - South Haven Campus	125 Veterans Blvd	South Haven	400
5	6.6	E	Wood School	29842 66th St	Bangor	25
5	9.9	E	Bangor High School	801 W Arlington St	Bangor	360
5	9.9	E	Bangor Middle School	803 W Arlington St	Bangor	335
5	10.4	E	Head Start - Bangor	305 W Douglas St	Bangor	47
5	10.4	E	Bangor Alternative High School	12 N Walnut St	Bangor	100
5	10.5	E	South Walnut Elementary School	309 S Walnut St	Bangor	330
					Van Buren County Subtotal:	*3,187*
					EPZ TOTAL:	***5,740***

Table E-2. Medical Facilities within the EPZ

PAA	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Cap-acity	Current Census	Ambul-atory Patients	Wheel-chair Patients	Bed-ridden Patients
ALLEGAN COUNTY,MI										
4	7.0	NNE	Country Side Nursing Home	120 Baseline Rd	South Haven	93	93	43	46	4
					Allegan County Subtotal:	*93*	*93*	*43*	*46*	*4*
BERRIEN COUNTY,MI										
5	8.7	SSE	Forest Beach AFC Home Inc	8021 Forest Beach Rd	Watervliet	20	16	16	0	0
5	9.1	SSE	Juniper Home	612 Van Atter Ct	Watervliet	6	6	2	4	0
					Berrien County Subtotal:	*26*	*22*	*18*	*4*	*0*
VAN BUREN COUNTY,MI										
4	5.4	NNE	Bronson South Haven Hospital	955 S Bailey Ave	South Haven	8	6	3	2	1
4	5.5	NNE	South Haven Nursing & Rehabilitation Community	850 Phillips St	South Haven	88	61	10	51	0
4	6.8	NE	Turner Tender Care	10871 68th St	South Haven	6	6	3	3	0
4	7.1	NNE	River Ridge Retirement Village	706 Kentucky Ave	South Haven	44	42	26	13	3
					Van Buren County Subtotal:	*146*	*115*	*42*	*69*	*4*
					EPZ TOTAL:	**265**	**230**	**103**	**119**	**8**

Table E-3. Major Employers within the EPZ

PAA	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Employees (Max Shift)	% Employees Commuting into the EPZ	Employees Commuting into the EPZ	Employee Vehicles Commuting into the EPZ
VAN BUREN COUNTY,MI									
1	-	-	Palisades Nuclear Generating Station	27780 Blue Star Memorial Hwy	Covert	568	71.0%	403	366
4	6.4	NNE	Meijer	1223 Phoenix St	South Haven	234	60.0%	140	127
5	9.8	SSE	Four Winds Casino Hartford	68600 Red Arrow Hwy	Hartford	300	70.0%	210	191
					Van Buren County Subtotal:	*1,102*	*-*	*753*	*684*
					EPZ TOTAL:	**1,102**	**-**	**753**	**684**

Table E-4. Recreational Areas within the EPZ

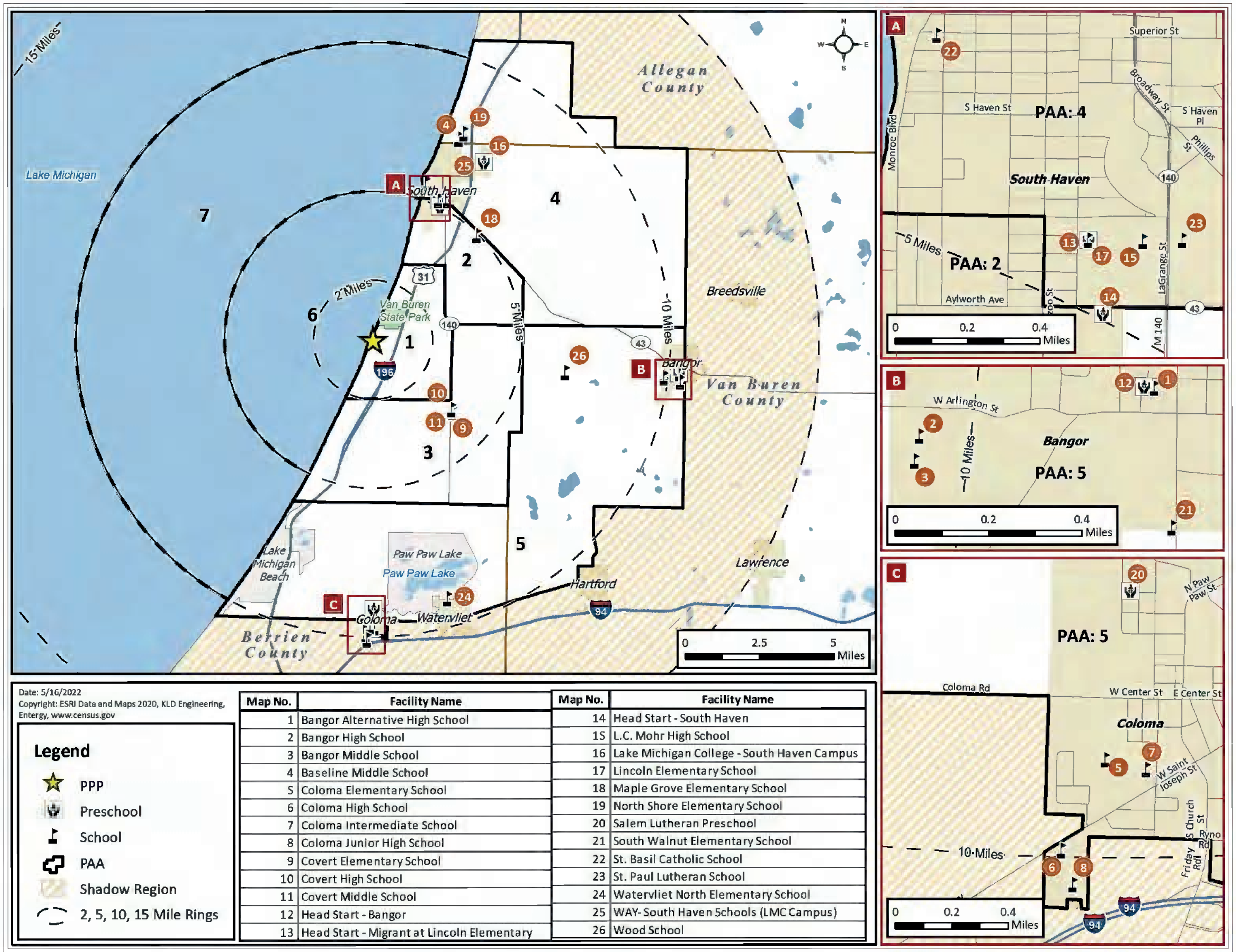
PAA	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Facility Type	Transients	Vehicles
ALLEGAN COUNTY,MI								
4	7.6	NNE	Jensen's RV Park & Motel	7366 N Shore Dr	South Haven	Campground	80	30
4	7.8	NNE	Cousins' R/V park	105 Blue Star Hwy-N. Shore Dr	South Haven	Campground	600	140
4	8.2	NNE	Singing Sands RV Park	262 74th St	South Haven	Campground	360	240
4	10.3	NNE	Hawkshead Links	523 Hawks Nest Dr	South Haven	Golf Course	100	50
						Seasonal Population:	*503*	*281*
						Allegan County Subtotal:	*1,643*	*741*
BERRIEN COUNTY,MI								
5	8.6	SSW	Hagar Park/Beach	5408 M-63	Coloma	Beach	277	100
5	8.7	SSE	Paw Paw River Campgrounds	5355 M-140	Watervliet	Campground	264	132
5	9.1	S	Paw Paw Lake Golf Club	4548 Forest Beach Rd	Watervliet	Golf Course	200	25
5	9.7	SSW	Coloma-St. Joseph KOA	3527 Coloma Rd	Riverside	Campground	500	125
						Seasonal Population:	*547*	*302*
						Berrien County Subtotal:	*1,788*	*684*
VAN BUREN COUNTY,MI								
1	0.7	NE	Van Buren State Park	23960 Ruggles Rd	South Haven	Park	450	84
1	1.6	SSW	Covert Township Park	80559 32nd Ave	Covert	Park	342	146
3	4.3	SE	Covert / South Haven KOA Holiday	39397 Michigan 140	Covert	Campground	732	366
3	4.5	S	Dune Lake Campground	80739 County Rd 376	Coloma	Campground	320	160
4	5.6	NNE	South Beach	Water St	South Haven	Beach	875	269
4	6.0	NNE	North Beach	Lakeshore Dr	South Haven	Beach	875	269
4	6.7	NNE	Kal-Haven Trail	North Bailey Ave	South Haven	Park	38	13
4	6.8	NE	Black River Trails Campground	68840 8th Ave	South Haven	Campground	194	74
4	6.9	NNE	Lake Michigan College	125 Veterans Blvd	South Haven	Park	240	222
4	7.0	NE	Beeches Golf Club	09601 68th St	South Haven	Golf Course	84	22
4	9.2	NE	Kal-Haven Outpost	00500 Co Rd 687	South Haven	Campground	231	104
4	9.5	NE	Yogi Bear's Jellystone Park Camp-Resort	03403 64th St	South Haven	Campground	568	142
4	10.5	ENE	GingerMan Raceway	61414 Phoenix Rd	South Haven	Park	300	150
5	10.1	SSE	Four Winds Casino	68600 Red Arrow Hwy	Hartford	Casino	5,000	2,500
						Seasonal Population:	*2,526*	*1,394*
						Van Buren County Subtotal:	*12,775*	*5,915*
						EPZ TOTAL:	**16,206**	**7,340**

Table E-5. Marinas within the EPZ

PAA	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Transients	Vehicles
BERRIEN COUNTY,MI							
5	8.3	S	Paw Paw Lake Yacht Club	5097 Shoreview Dr	Coloma	27	7
					Berrien County Subtotal:	*27*	*7*
VAN BUREN COUNTY,MI							
4	5.8	NNE	South Haven Municipal Marina South	345 Water St	South Haven	733	458
4	5.9	NNE	South Haven Municipal Marina North	148 Black River St	South Haven	350	174
4	6.0	NNE	South Haven Yacht Club	401 Williams St	South Haven	28	7
4	6.0	NNE	All Seasons Marine Inc	234 Black River St	South Haven	200	50
4	6.1	NNE	Maritime Docks	268 Black River St	South Haven	112	56
4	6.3	NNE	Slip Away Cove Marina and Residences	132 Dunkley Ave	South Haven	50	27
4	6.4	NNE	1st Choice Marine Inc.	626 Dunkley Ave	South Haven	8	4
4	6.4	NNE	Black River Park Marina and Boat Launch	E Wells St	South Haven	240	120
4	6.6	NNE	Black River Yacht Club	Oak St	South Haven	275	138
4	6.6	NNE	River Noire Yacht Club	Oak St	South Haven	90	23
4	6.7	NNE	Jones River Services	12 N Bailey Ave	South Haven	90	45
4	6.8	NNE	Woodland Harbor Marina	525 Kentucky Ave	South Haven	352	176
					Van Buren County Subtotal:	*2,528*	*1,278*
					EPZ TOTAL:	**2,555**	**1,285**

Table E-6. Lodging Facilities within the EPZ

PAA	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Transients	Vehicles
ALLEGAN COUNTY,MI							
4	7.4	NNE	A Country Place Bed & Breakfast	79 N Shore Dr	South Haven	55	25
4	7.6	NNE	Sleepy Hollow Resort	7400 N Shore Dr	South Haven	120	40
4	7.6	NNE	Jensen's RV Park & Motel	7366 N Shore Dr	South Haven	24	14
4	8.1	NNE	Sun N Sand Resort	176 N Blue Star Hwy	South Haven	91	33
4	9.6	NNE	Martha's Vineyard	473 Blue Star Hwy	South Haven	57	26
					Allegan County Subtotal:	*347*	*138*
BERRIEN COUNTY,MI							
5	7.6	S	Duffield's Cottages	7039 Little Paw Paw Lake Rd	Coloma	36	17
5	7.6	SSW	Sand Castles of Lake Michigan	6125 Ontario St	Coloma	18	9
5	8.2	SSW	Sweet Cherry Resort	3312 Chestnut Ave	Coloma	36	12
5	8.5	S	Paw Paw Lake Motel	4881 Wil-O-Paw Dr	Coloma	104	48
					Berrien County Subtotal:	*194*	*86*
VAN BUREN COUNTY,MI							
2	3.9	NNE	Lake Bluff Inn & Suites	76648 11th Ave	South Haven	208	52
2	4.7	NNE	Great Lakes Inn Suites	9814 Michigan 140	South Haven	106	55
4	5.6	NE	Monroe Manor Inn Bed & Breakfast	72861 8th Ave	South Haven	26	12
4	6.0	NNE	Sunset Inn Bed & Breakfast	72 N. Shore Dr	South Haven	22	11
4	6.0	NNE	Carriage House at the Harbor	118 Woodman St	South Haven	23	12
4	6.0	NNE	Historic Hotel Nichols	201 Center St	South Haven	34	17
4	6.0	NNE	Last Resort Bed & Breakfast	86 N Shore Dr	South Haven	21	14
4	6.1	NNE	Old Harbor Inn	515 Williams St	South Haven	180	45
4	6.2	NNE	Yelton Manor Boutique Hotel B&B	140 N Shore Dr	South Haven	17	17
4	6.2	NNE	Inn at the Park Bed & Breakfast	233 Dyckman Ave	South Haven	20	10
4	6.4	NNE	A&R's North Beach Cottages	282 N Shore Dr	South Haven	40	14
4	6.4	NNE	MichiMonaMac Lakeshore Cottage	337 N Shore Dr	South Haven	30	7
4	6.5	NNE	Hampton Inn	4299 Cecilia Dr	South Haven	180	120
4	6.6	NNE	Victoria Resort Bed & Breakfast	241 Oak St	South Haven	64	16
4	6.6	NNE	Baymont Inn & Suites	1555 Phoenix St	South Haven	360	90
4	6.7	NE	Holiday Inn Express Hotel & Suites South Haven	1741 Phoenix St	South Haven	186	62
4	6.7	NE	Comfort Suites	1755 Phoenix St	South Haven	244	61
4	7.2	NNE	Great Lakes Inn & Suites	186 Blue Star Hwy	South Haven	270	125
4	7.9	NE	Black River Inn Bed and Breakfast	704 70th St	South Haven	6	3
4	9.8	NE	Elmhurst Farm Inn	634 64th St	South Haven	8	4
					Van Buren County Subtotal:	*2,045*	*747*
					EPZ TOTAL:	**2,586**	**971**



Map No.	Facility Name	Map No.	Facility Name
1	Bangor Alternative High School	14	Head Start - South Haven
2	Bangor High School	15	L.C. Mohr High School
3	Bangor Middle School	16	Lake Michigan College - South Haven Campus
4	Baseline Middle School	17	Lincoln Elementary School
5	Coloma Elementary School	18	Maple Grove Elementary School
6	Coloma High School	19	North Shore Elementary School
7	Coloma Intermediate School	20	Salem Lutheran Preschool
8	Coloma Junior High School	21	South Walnut Elementary School
9	Covert Elementary School	22	St. Basil Catholic School
10	Covert High School	23	St. Paul Lutheran School
11	Covert Middle School	24	Watervliet North Elementary School
12	Head Start - Bangor	25	WAY- South Haven Schools (LMC Campus)
13	Head Start - Migrant at Lincoln Elementary	26	Wood School

Figure E-1. Schools and Preschools within the EPZ

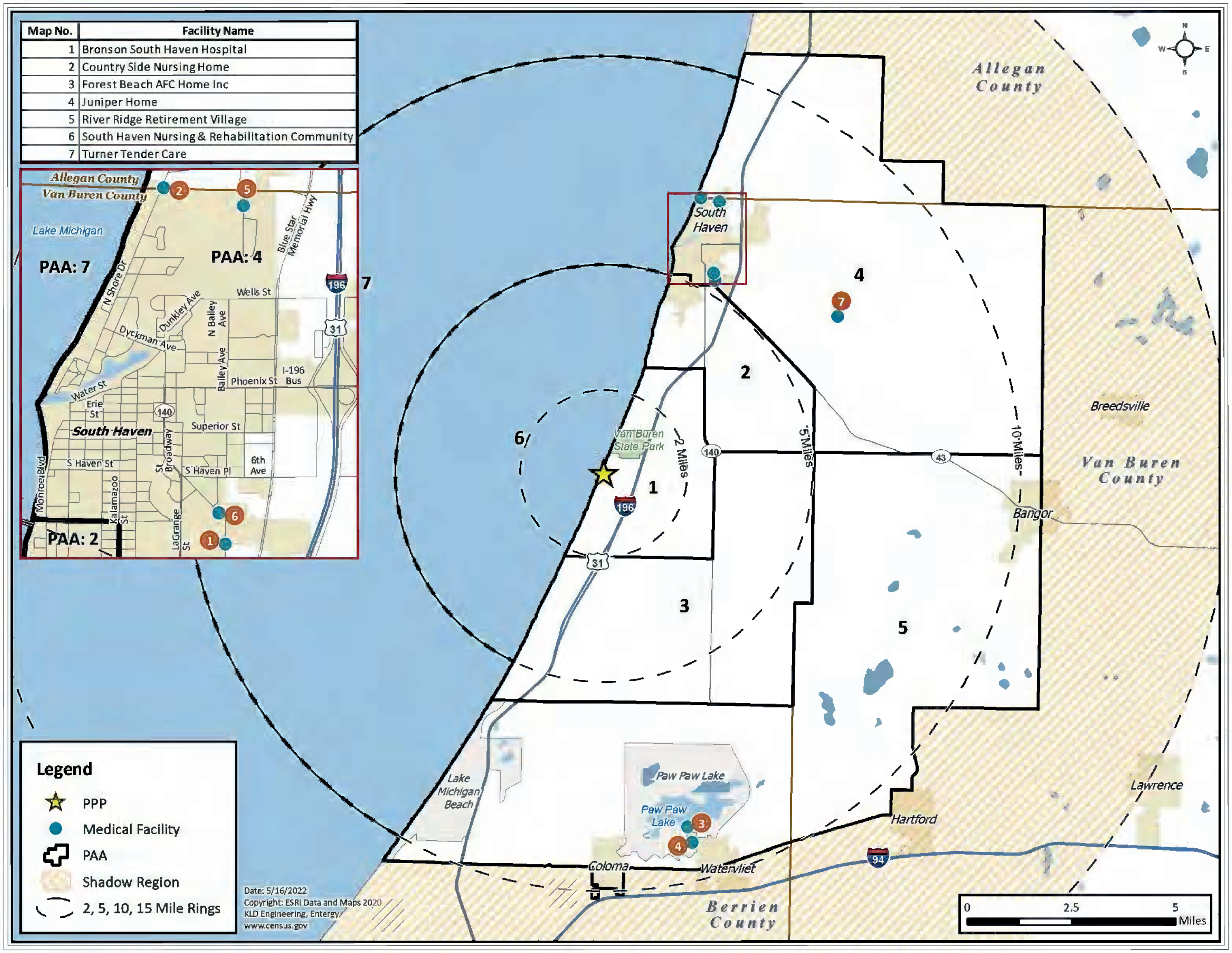


Figure E-2. Medical Facilities within the EPZ

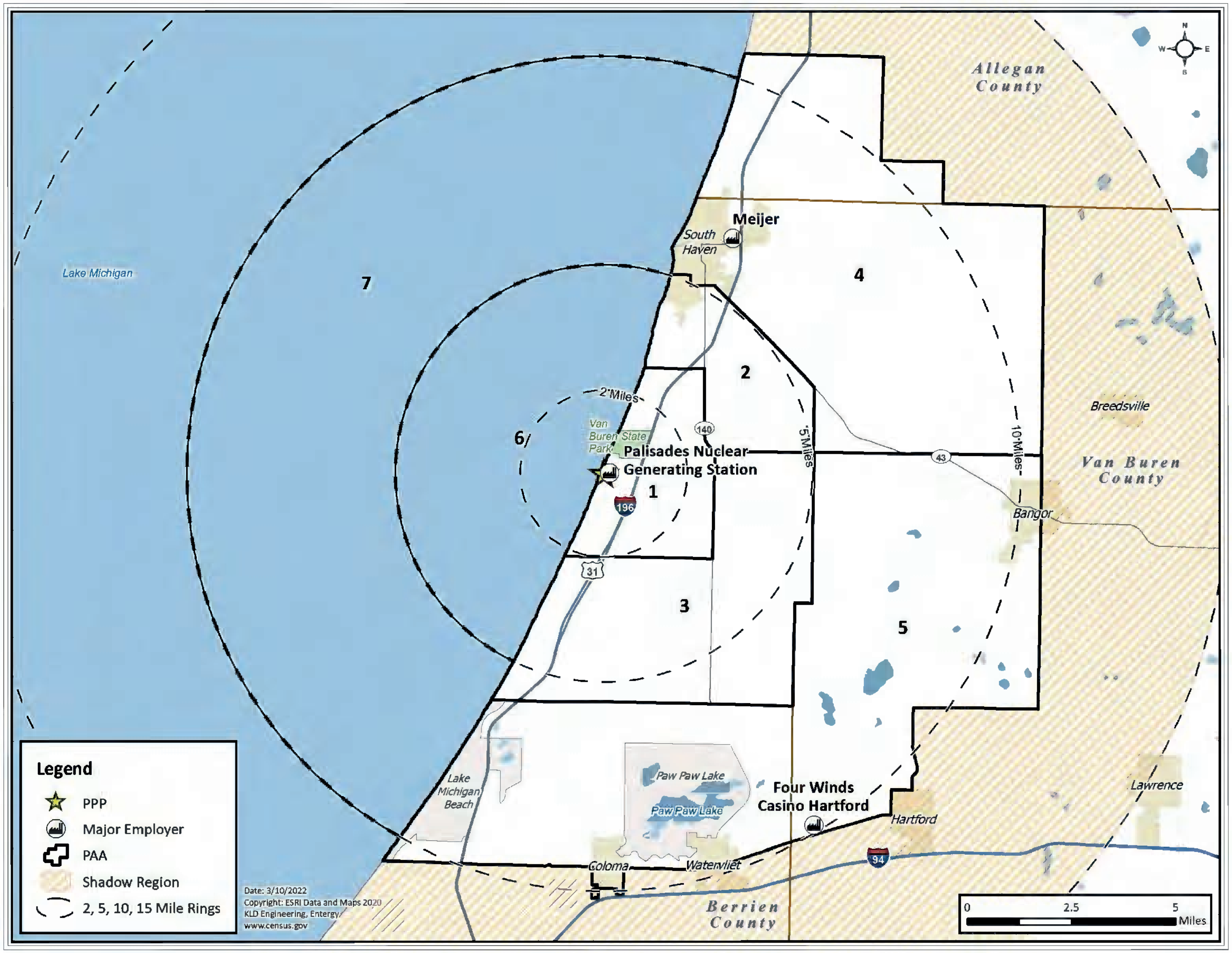


Figure E-3. Major Employers within the EPZ

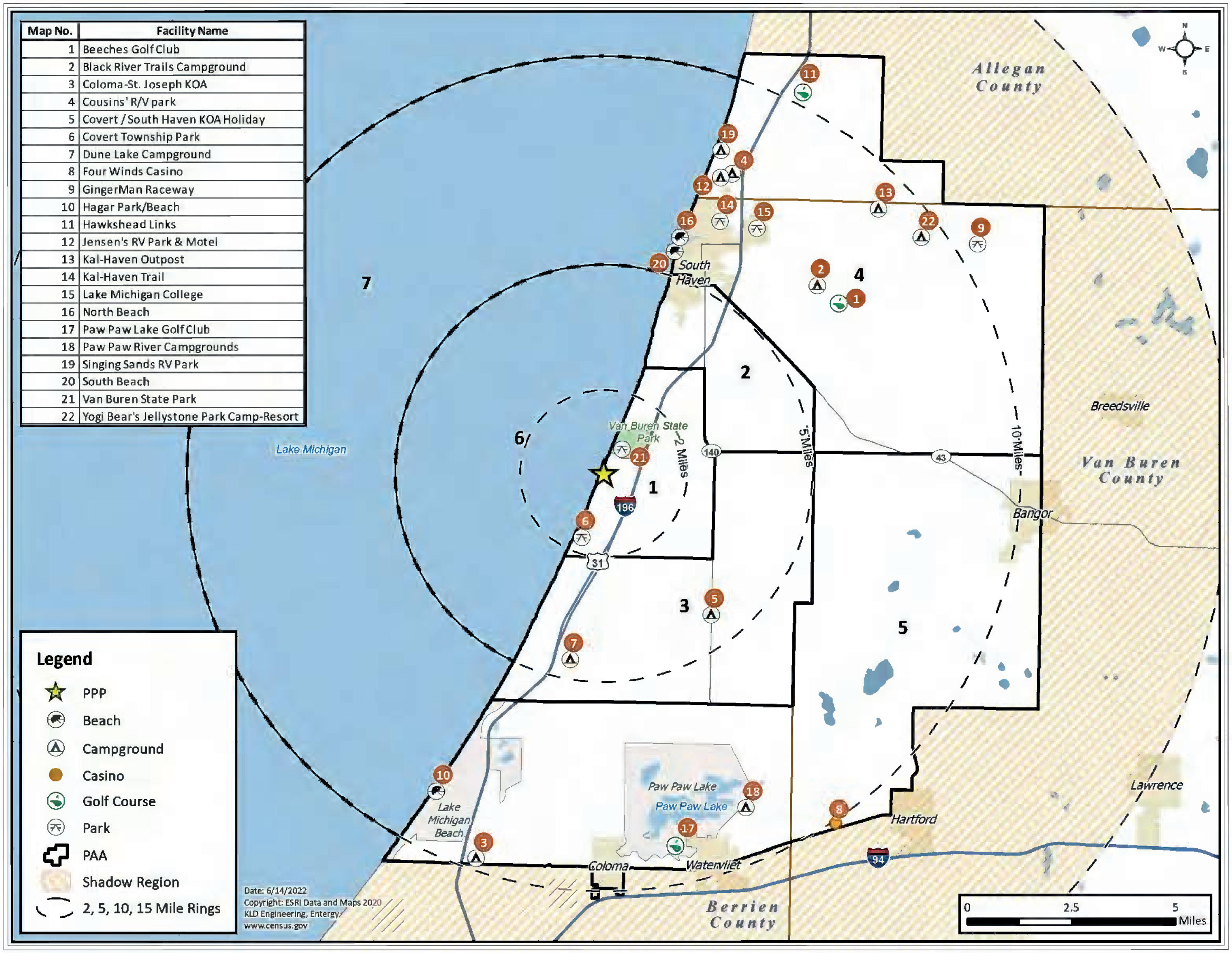


Figure E-4. Recreational Areas within the EPZ

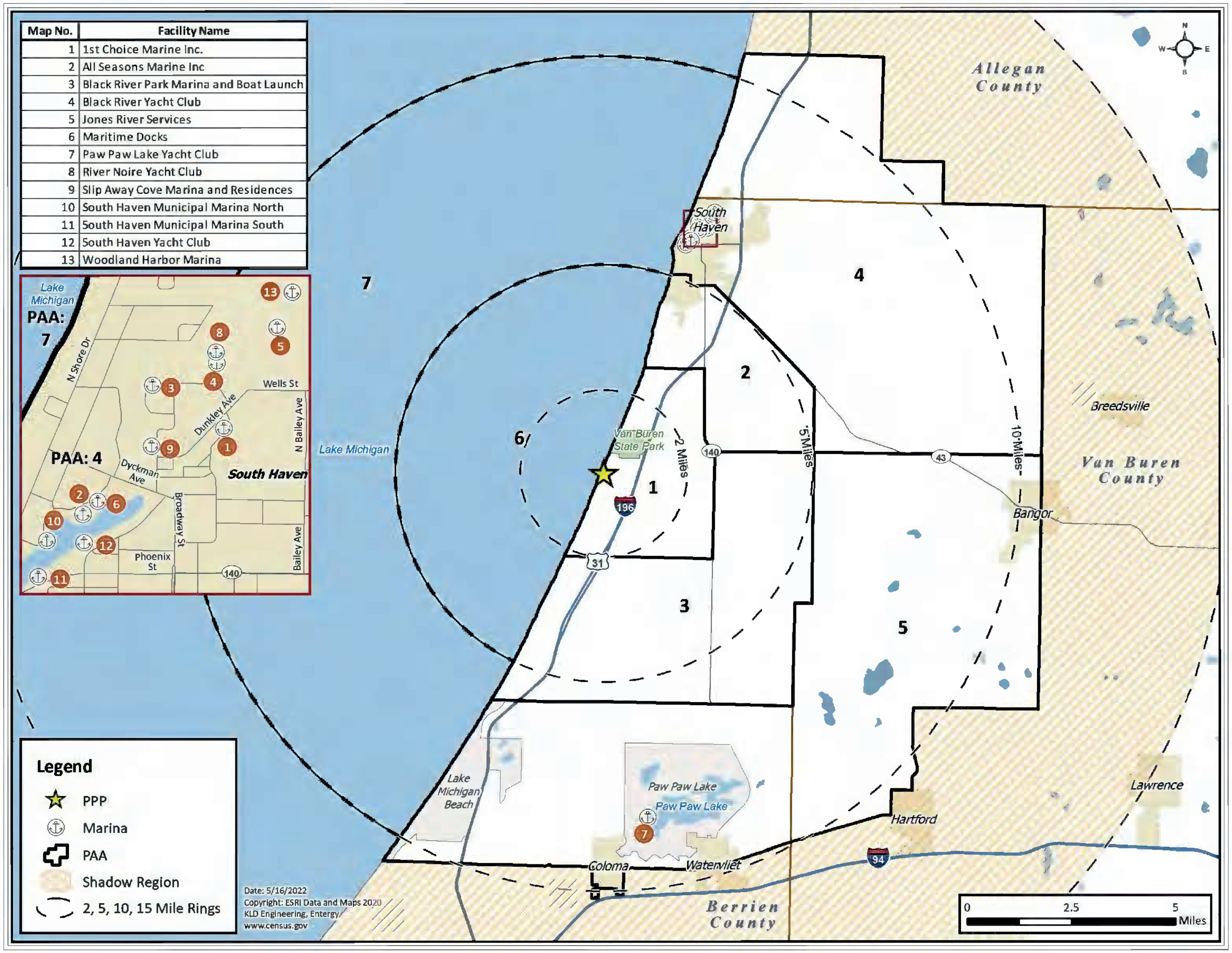


Figure E-5. Marinas within the EPZ

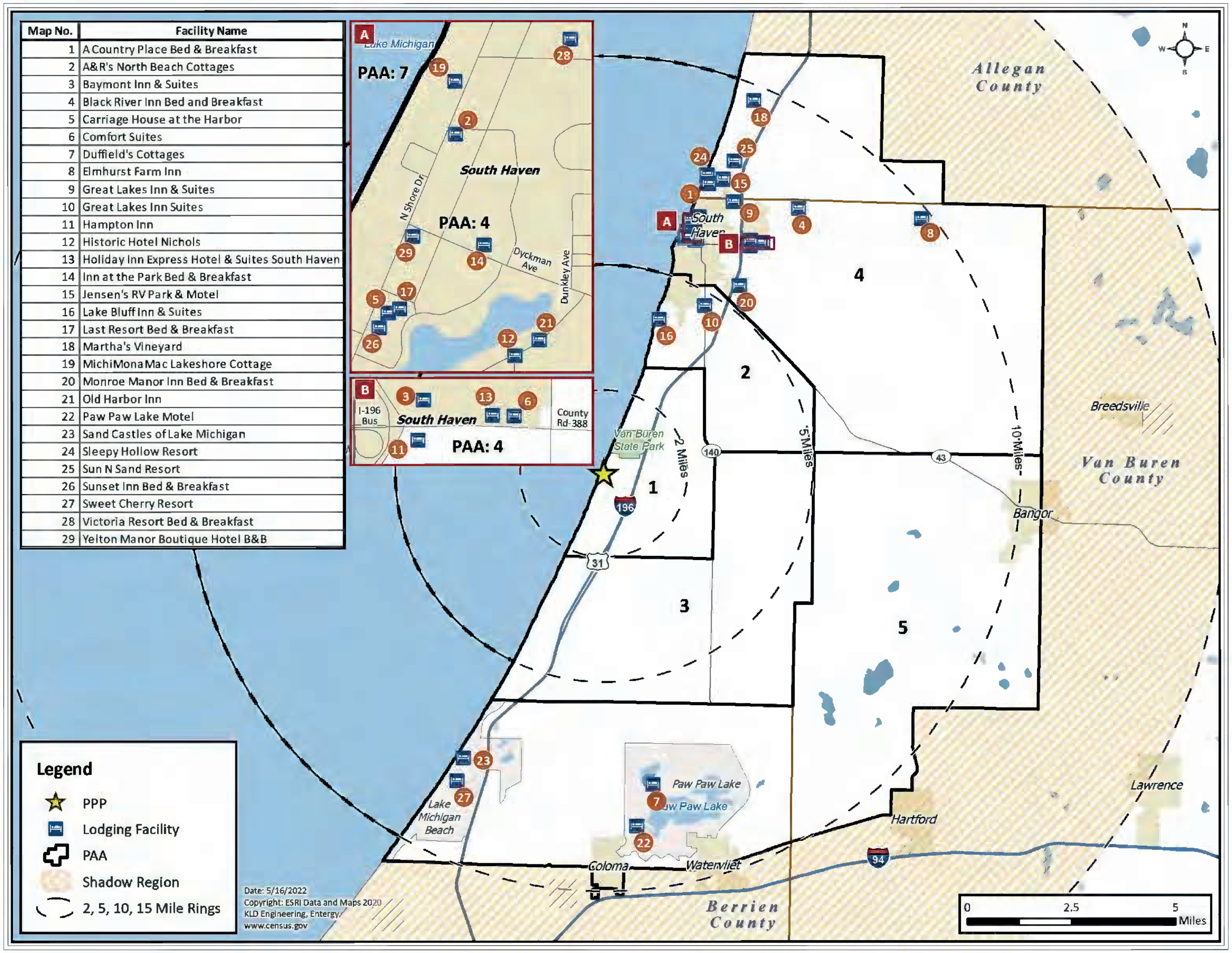


Figure E-6. Lodging Facilities within the EPZ

APPENDIX F

Demographic Survey

F. DEMOGRAPHIC SURVEY

F.1 Introduction

The development of ETE for the PPP EPZ requires the identification of travel patterns, car ownership and household size of the population within the EPZ. Demographic information can be obtained from Census data. The use of this data has several limitations when applied to emergency planning. First, the Census data do not encompass the range of information needed to identify the time required for preliminary activities (mobilization) that must be undertaken prior to evacuating the area. Secondly, Census data do not contain attitudinal responses needed from the population of the EPZ and consequently may not accurately represent the anticipated behavioral characteristics of the evacuating populace.

These concerns are addressed by conducting a demographic survey of a representative sample of the EPZ population. The survey is designed to elicit information from the public concerning family demographics and estimates of response times to well defined events. The design of the survey includes a limited number of questions of the form "What would you do if …?" and other questions regarding activities with which the respondent is familiar ("How long does it take you to …?")

F.2 Survey Instrument and Sampling Plan

Attachment A presents the final survey instrument used for the demographic survey in this study. A draft of the instrument was submitted to stakeholders for comment. Comments were received and the survey instrument was modified accordingly, prior to conducting the survey.

Following the completion of the instrument, a sampling plan was developed. Since the demographic survey discussed herein began in July 2021 before the release of the 2020 Census data in September 2021, 2010 Census data was used to develop the sampling plan. A sample size of approximately 379 **completed** survey forms yields results with a sampling error of ±5% at the 95% confidence level. The desired sample was to be obtained from the EPZ population. Consequently, a list of zip codes in the EPZ was developed using geographic information system (GIS) software. This list is shown in Table F-1. Along with each zip code, an estimate of the population and number of households in each area was determined by overlaying 2010 Census data and the EPZ boundary, again using GIS software. The proportional number of desired completed survey interviews for each area was identified, as shown in Table F-1. Note that the average household size computed in Table F-1 was an estimate for sampling purposes and was not used in the ETE study.

A total of 133 completed surveys were obtained in the survey, corresponding to a sampling error of ±8.5% at the 95% confidence level based on the 2010 Census data. Although the number of completed surveys provided in Table F-1 was less than the desired number of surveys, the analysis results are somewhat in-line with the 2010 telephone survey used in the previous (2012) ETE study

F.3 Survey Results

The results of the survey fall into two categories. First, the household demographics of the area can be identified. Demographic information includes such factors as household size, automobile ownership, and automobile availability. The distributions of the time to perform certain pre-evacuation activities are the second category of survey results. These data are processed to develop the trip generation distributions used in the evacuation modeling effort, as discussed in Section 5.

A review of the survey instrument reveals that several questions have a “decline to state” entry for a response. It is accepted practice in conducting surveys of this type to accept the answers of a respondent who offers a ”decline to state” response for a few questions or who refuses to answer a few questions. To address the issue of occasional “decline to state” responses from a large sample, the practice is to assume that the distribution of these responses is the same as the underlying distribution of the positive responses. In effect, the “decline to state” responses are ignored, and the distributions are based upon the positive data that is acquired.

F.3.1 Household Demographic Results

Household Size

Figure F-1 presents the distribution of household size within the EPZ based on the responses to the demographic survey. According to the responses, the average household contains 2.77 people. The estimated average household size from the 2010 Census data is 2.51 people and from the 2020 Census data is 2.41 people. A sensitivity study was conducted to estimate the impact of using the 2020 Census data household size on ETE – see Appendix M.

Automobile Ownership

The average number of automobiles available per household in the EPZ is 2.26. It should be noted that all households within the EPZ have access to an automobile according to the demographic survey. The distribution of automobile ownership is presented in Figure F-2. Figure F-3 presents the automobile availability by household size.

Ridesharing

The overwhelming proportion (76%) of the households surveyed responded that they would share a ride with a neighbor, relative, or friend if a car was not available to them when advised to evacuate in the event of an emergency, as shown in Figure F-4.

Commuters

Figure F-5 presents the distribution of the number of commuters in each household. Commuters are defined as household members who travel to work or college on a daily basis. The data shows an average of 1.53 commuters per household in the EPZ, and 86% of households have at least one commuter.

Commuter Travel Modes

Figure F-6 presents the mode of travel that commuters use on a daily basis. The vast majority (89%) of commuters use their private automobiles to travel to work or college. The data shows an average of 1.10 employees per vehicle, assuming 2 people per vehicle – on average – for carpools.

Impact of COVID-19 on Commuters

Figure F-7 presents the distribution of the number of commuters in each household that were temporarily impacted by the COVID-19 pandemic. Forty-two percent (42.4%) of households indicated someone in their household had a work and/or school commute that was temporarily impacted by the COVID-19 pandemic. The commuter patterns were compared to the telephone survey conducted for the previous ETE study (2012). The commuter travel patterns are very similar between the telephone survey and the demographic survey, despite the significant number of households impacted by the COVID-19 pandemic.

Functional or Transportation Needs

Figure F-8 presents the distribution of the number of individuals with functional or transportation need. The survey results show that 11 households (3.4% of the total surveyed) have functional or transportation needs. Of those with functional or transportation needs, 6 homes (55%) require a bus, and 5 homes (45%) require some other transportation mode. As discussed in Section 3.8, there are 55 people registered with the EPZ counties as having access and/or functional needs, which is only 0.2% of the EPZ population.

F.3.2 Evacuation Response

Several questions were asked to gauge the population's response to an emergency. These are now discussed:

"How many of the vehicles would your household use during an evacuation?" The response is shown in Figure F-9. On average, evacuating households would use 1.50 vehicles.

"Would your family await the return of other family members prior to evacuating the area?" Of the survey participants who responded, 58% said they would await the return of other family members before evacuating and 42% indicated that they would not await the return of other family members.

"Emergency officials advise you to take shelter-in-place in an emergency. Would you?" This question is designed to elicit information regarding compliance with instructions to shelter-in-place. The results indicate that 72% of households who are advised to shelter in place would do so; the remaining 28% would choose to evacuate the area. Note the baseline ETE study assumes 20% of households will not comply with the shelter advisory, as per Section 2.5.2 of NUREG/CR-7002, Rev. 1. Thus, the compliance rate obtained through the survey is higher (8% more) than the federal guidance recommendation. A sensitivity study was conducted to estimate the impact of shadow evacuation (non-compliance to a shelter advisory) on ETE – see Appendix M.

"Emergency officials advise you to take shelter-in-place now in an emergency and possibly evacuate later while people in other areas are advised to evacuate now. Would you?" This question is designed to elicit information specifically related to the possibility of a staged evacuation. That is, asking a population to shelter in place now and then to evacuate after a specified period of time. Results indicate that 51% of households would follow instructions and delay the start of evacuation until so advised, while the balance of 49% would choose to begin evacuating immediately.

"Emergency officials advise you to evacuate due to an emergency. Where would you evacuate to?" This question is designed to elicit information regarding the destination of evacuees in case of an evacuation. Approximately 56% of households indicated that they would evacuate to a friend or relatives' home, 3% to a reception center, 15% to a hotel, motel or campground, 5% to a second or seasonal home, and the remaining 21% answered other/decline to state to this question, as shown in Figure F-10. It should be noted that none of the households surveyed indicated they would not evacuate.

"If you had a household pet, would you take your pet with you if you were asked to evacuate the area?" Based on the responses to the survey, 66% of households have a family pet, service animal, and or animal/livestock. Of the households with pets, 97% percent of them indicated that they would take their pets with them; approximately 34% of households would take their pets to a shelter with them, 63% would take their pets with them somewhere else, and 3% would leave their pet at home, as shown in Figure F-11.

"What type of pet(s) and/or animal(s) do you have?" Based on the responses to the survey, 87% of households have a household pet (dog, cat, bird, reptile, or fish), 9% of households have farm animals (horse, chicken, goat, pig, etc.), and 4% have other small pets/animals.

F.3.3 Time Distribution Results

The survey asked several questions about the amount of time it takes to perform certain pre-evacuation activities. These activities involve actions taken by residents during the course of their day-to-day lives. Thus, the answers fall within the realm of the responder's experience.

As discussed in Section F.3.1 and shown in Figure F-7, the majority (57.6%) of respondents indicated no commuters were impacted by the COVID-19 pandemic; therefore the results for the time distribution of commuters (time to prepare to leave work/college and time to travel home from work/college) were used, as is, in this study.

The mobilization distributions provided below are the result of having applied the analysis described in Section 5.4.1 on the component activities of the mobilization.

"How long does it take the commuter to complete preparation for leaving work/college?" Figure F-12 presents the cumulative distribution; in all cases, the activity is completed within 75 minutes. Eighty-five percent (85%) can leave within 30 minutes.

"How long would it take the commuter to travel home?" Figure F-13 presents the work/college to home travel time for the EPZ. About 86 percent of commuters can arrive home

within 30 minutes of leaving work/college; all within 60 minutes.

"How long would it take the family to pack clothing, secure the house, and load the car?" Figure F-14 presents the time required to prepare for leaving on an evacuation trip. In many ways this activity mimics a family's preparation for a short holiday or weekend away from home. Hence, the responses represent the experience of the responder in performing similar activities.

The distribution shown in Figure F-14 has a long "tail." About 83% of households can be ready to leave home within 90 minutes; the remaining households require up to an additional one hour and 45 minutes.

"How long would it take you to clear 6 to 8 inches of snow from your driveway?" During adverse, snowy weather conditions, an additional activity may be performed before residents can depart on the evacuation trip. Although snow scenarios assume that the roads and highways have been plowed and are passable (albeit at lower speeds and capacities), it may be necessary to clear a private driveway prior to leaving the home so that the vehicle can access the street.

Figure F-15 presents the time distribution for removing 6 to 8 inches of snow from a driveway. Approximately 80% of driveways are passable within 60 minutes; the remaining households would require up to an additional two hours to begin their evacuation trip. Note that those respondents (approximately 23%) who answered that they would not take time to clear their driveway were assumed to be ready immediately at the start of this activity. Essentially, they would drive through the snow on the driveway to access the roadway and begin their evacuation trip.

Table F-1. Palisades Demographic Survey Sampling Plan

Zip Code	Population within EPZ (2010)	Households within EPZ (2010)	Desired Number of Samples	Obtained Samples
49013	3,352	1,205	37	10
49022	181	70	2	2
49038	7,935	3,239	99	8
49043	2,462	854	26	10
49056	306	106	3	2
49057	977	377	12	5
49064	40	18	1	2
49090	12,760	5,265	161	90
49098	2,992	1,235	38	4
Total EPZ	**31,005**	**12,369**	**379**	**133**
Average HH Size[1]:			**2.51**	

[1] It is an estimate for sampling purposes and was not used in the ETE study

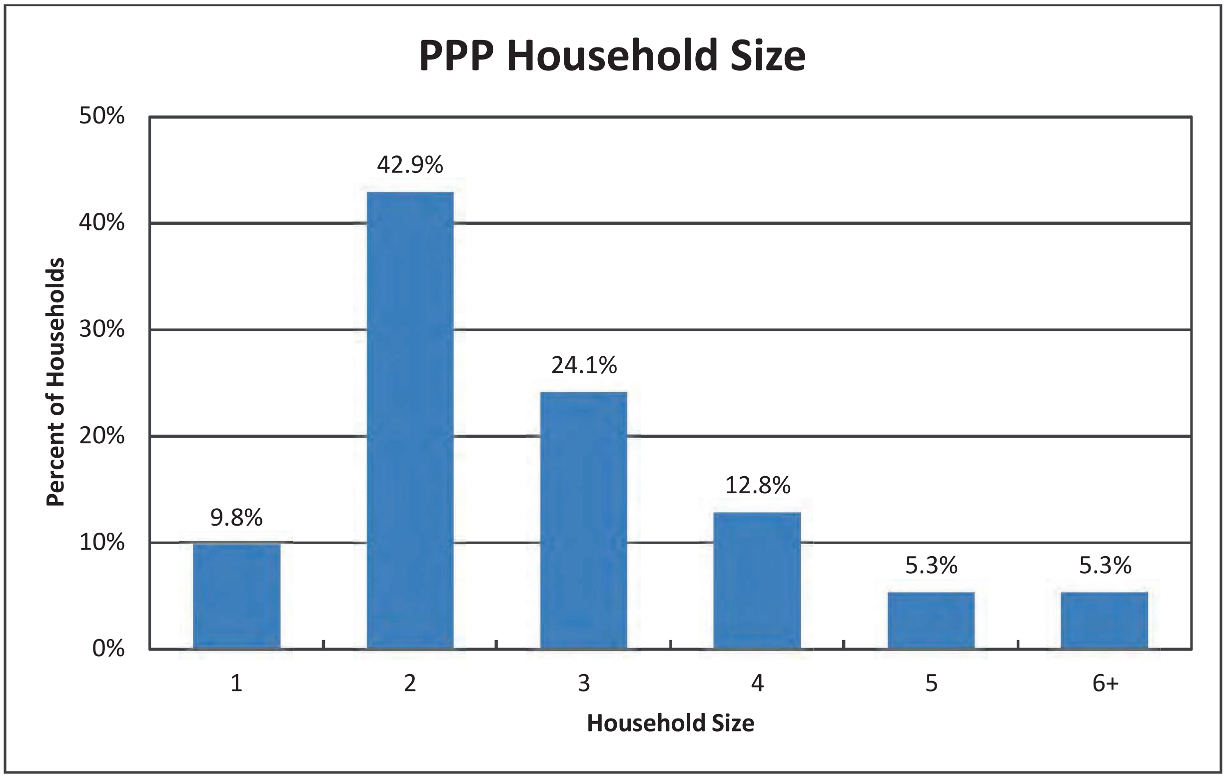


Figure F-1. Household Size in the EPZ

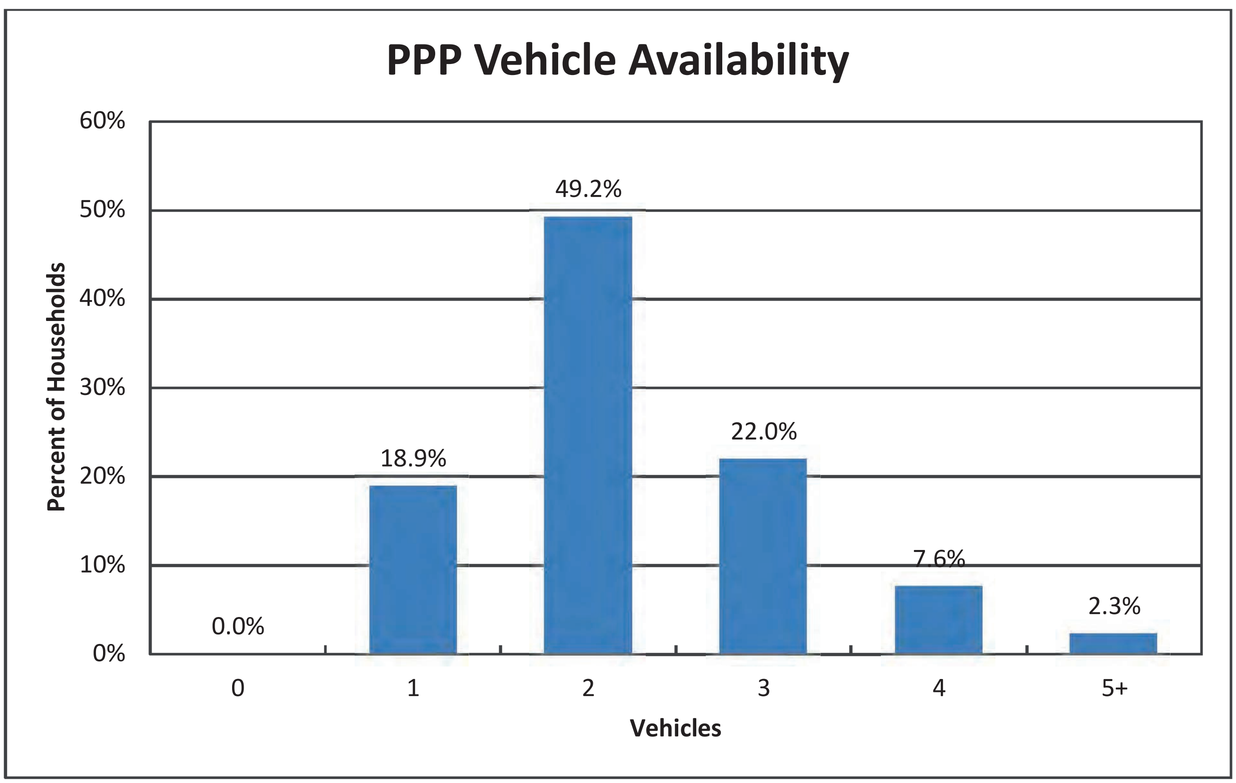


Figure F-2. Household Vehicle Availability

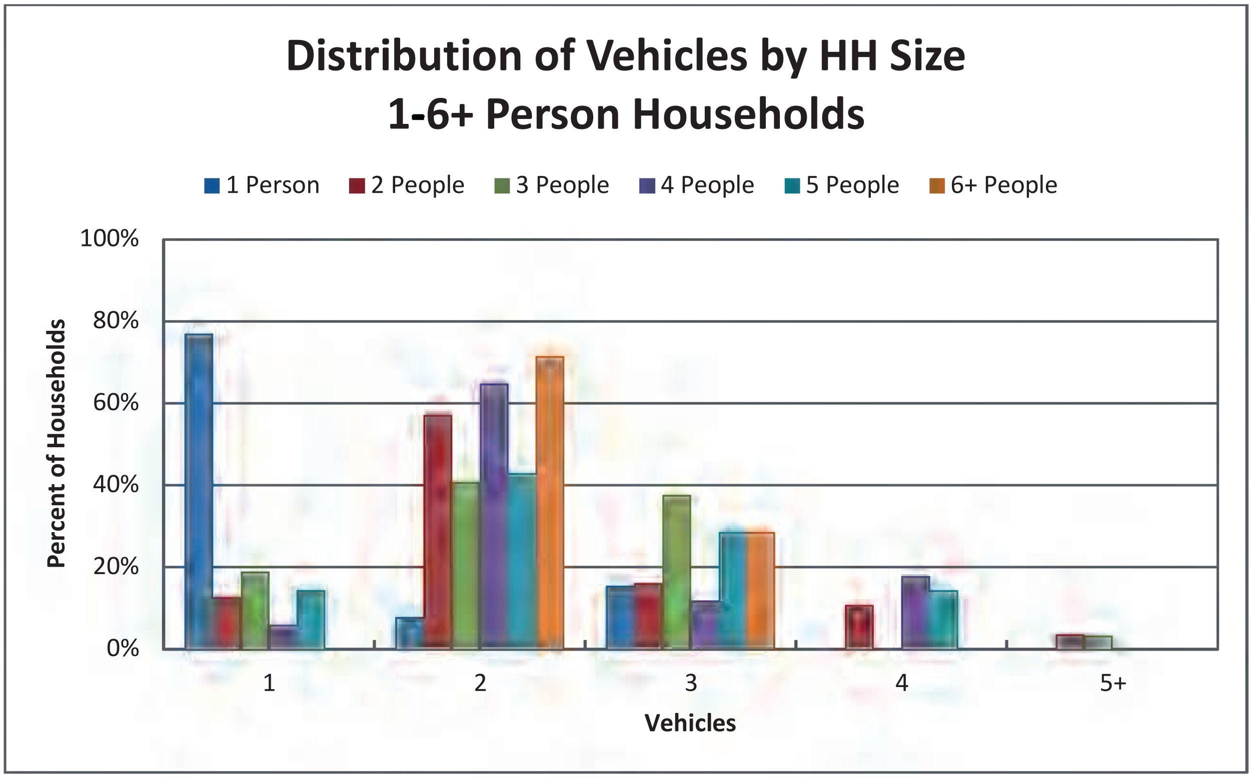


Figure F-3. Vehicle Availability - 1 to 6+ Person Households

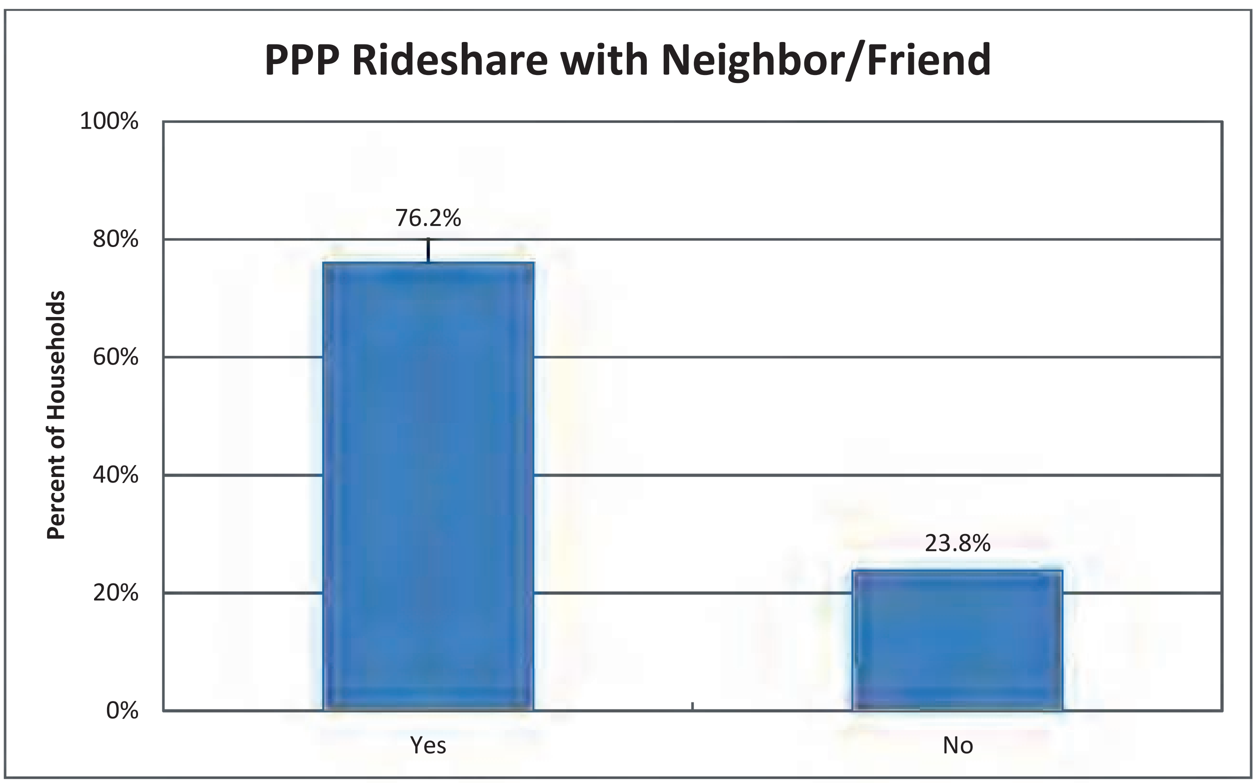


Figure F-4. Household Ridesharing Preference

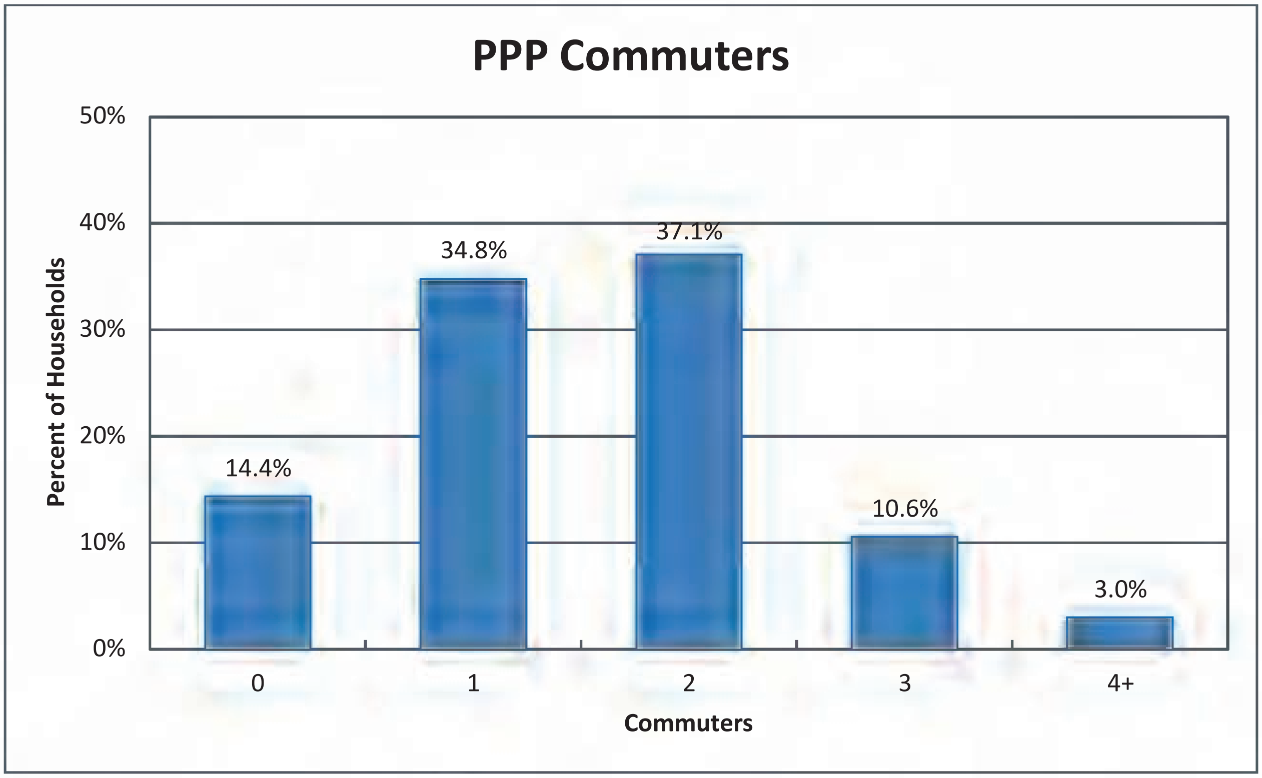


Figure F-5. Commuters in Households in the EPZ

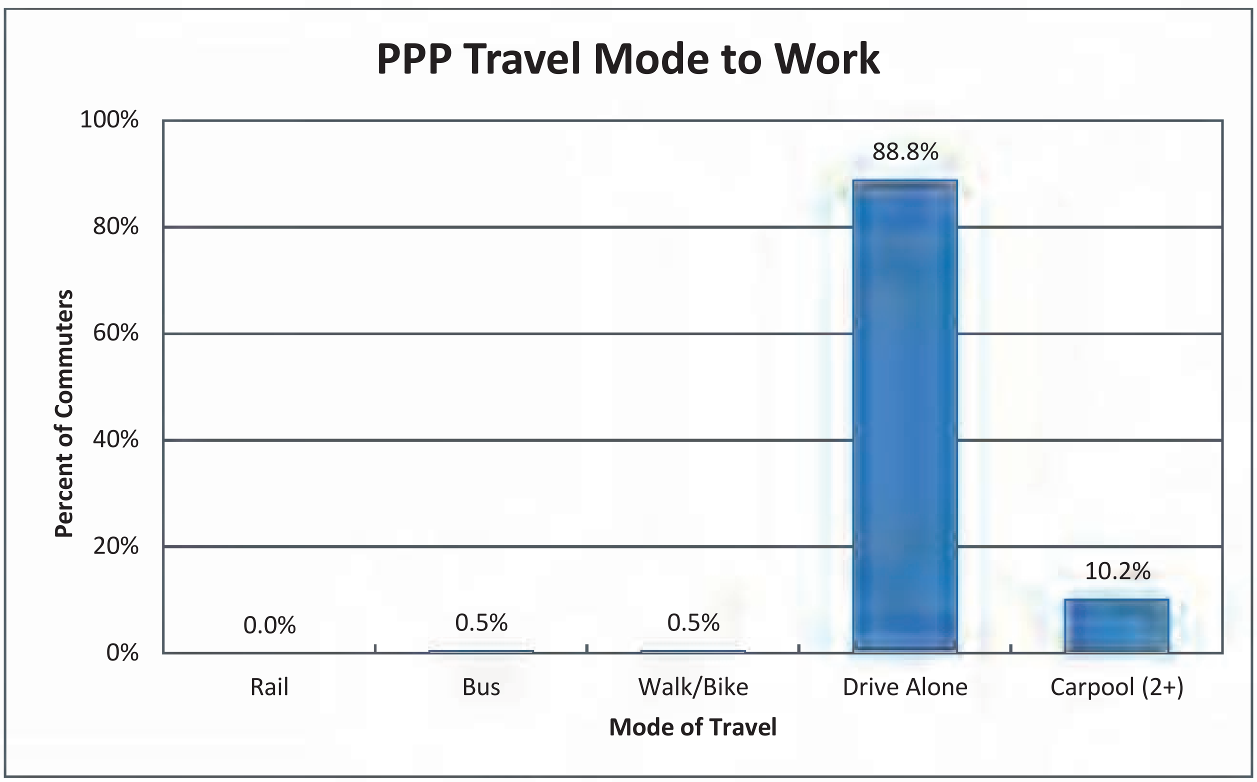


Figure F-6. Modes of Travel in the EPZ

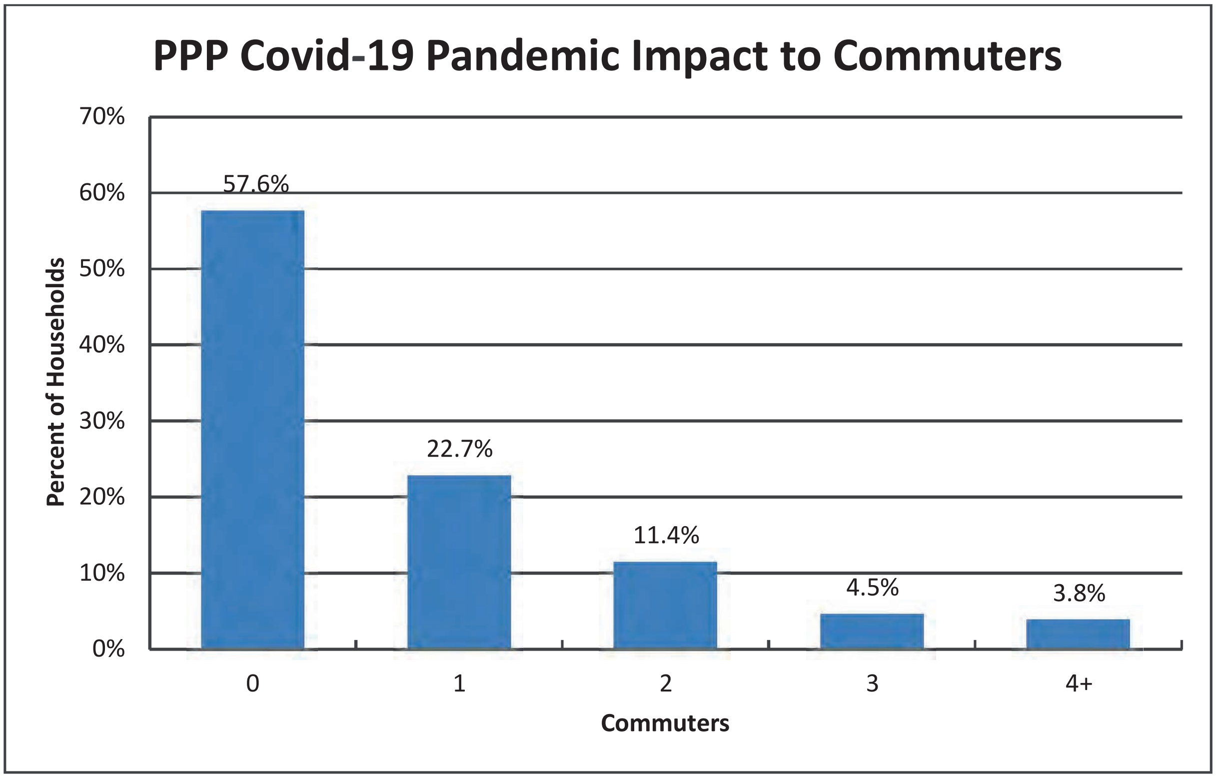


Figure F-7. Commuters Impacted by COVID-19

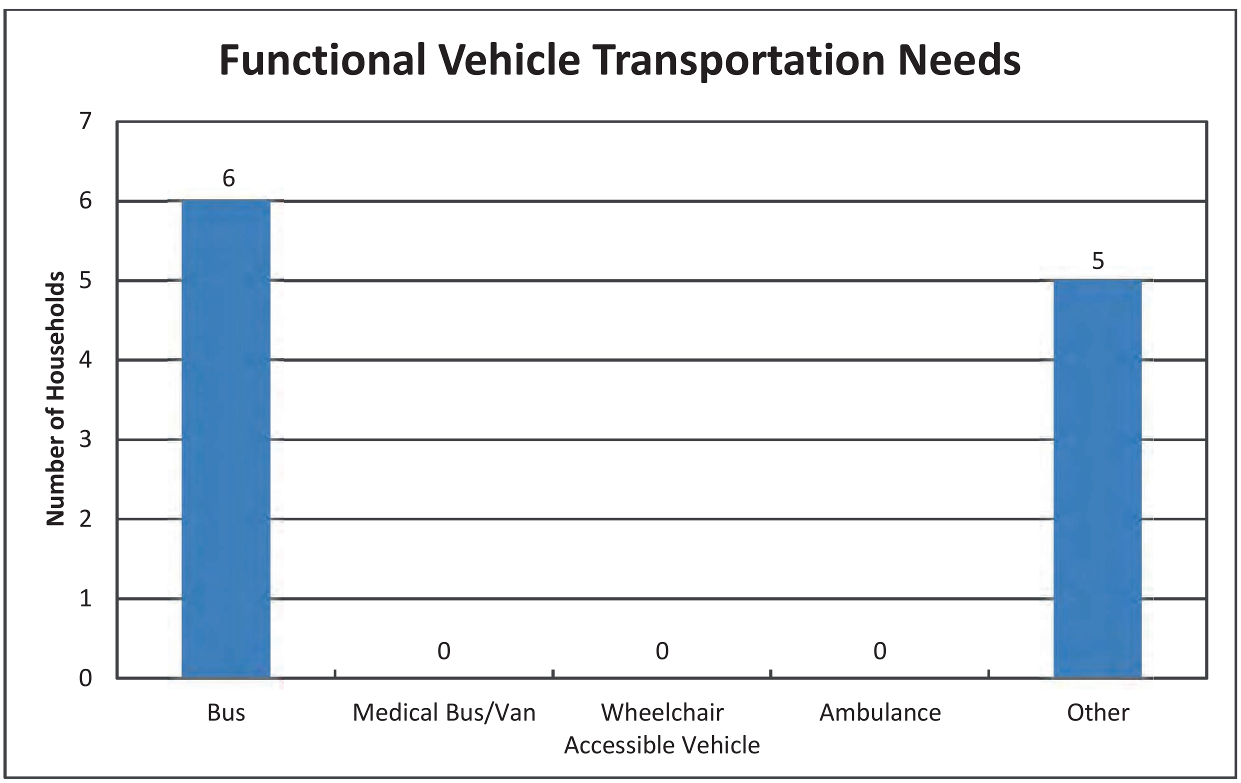


Figure F-8. Households with Functional or Transportation Needs

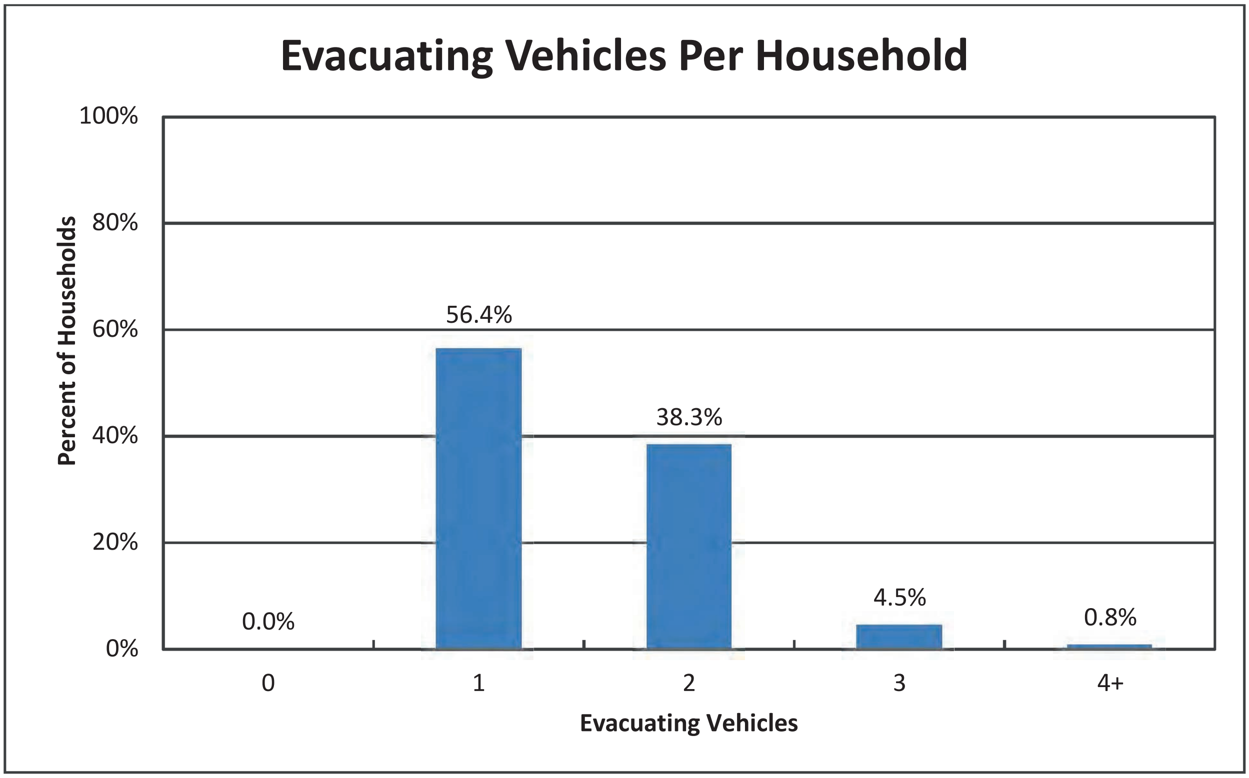


Figure F-9. Number of Vehicles Used for Evacuation

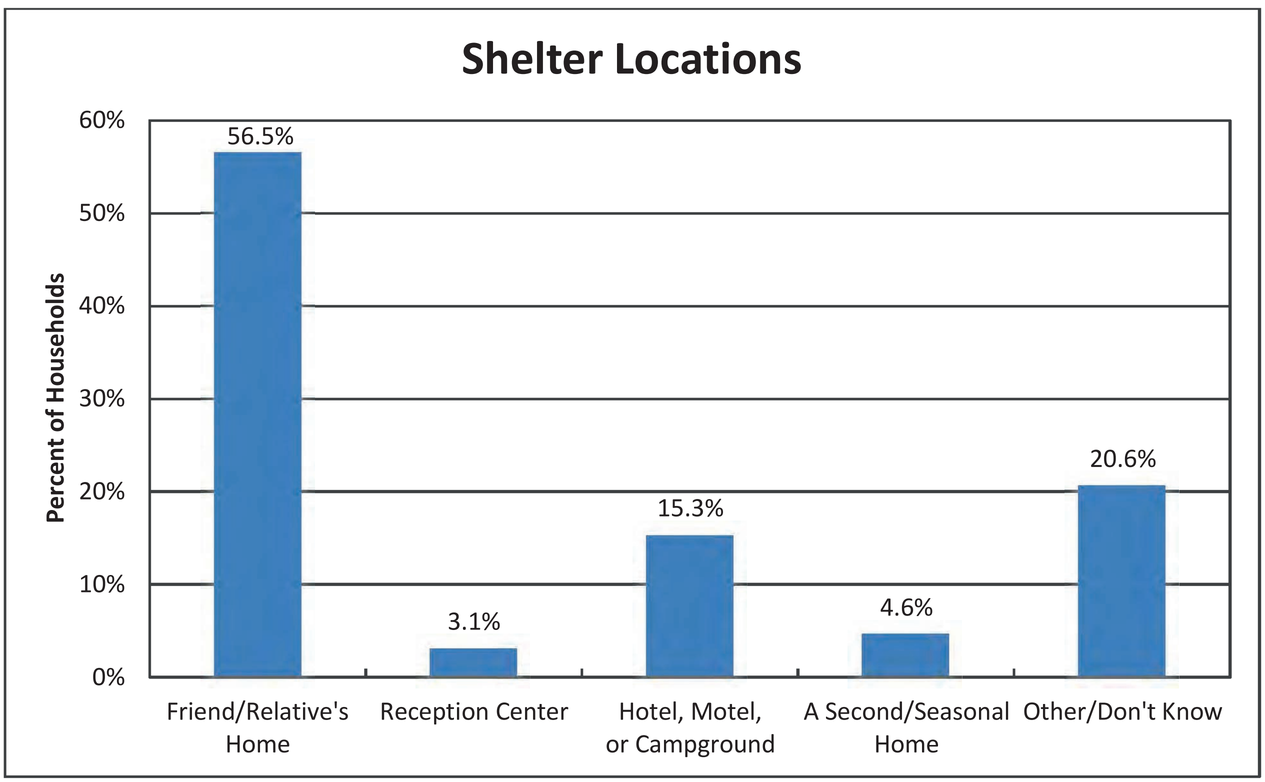


Figure F-10. Preferred Shelter Locations

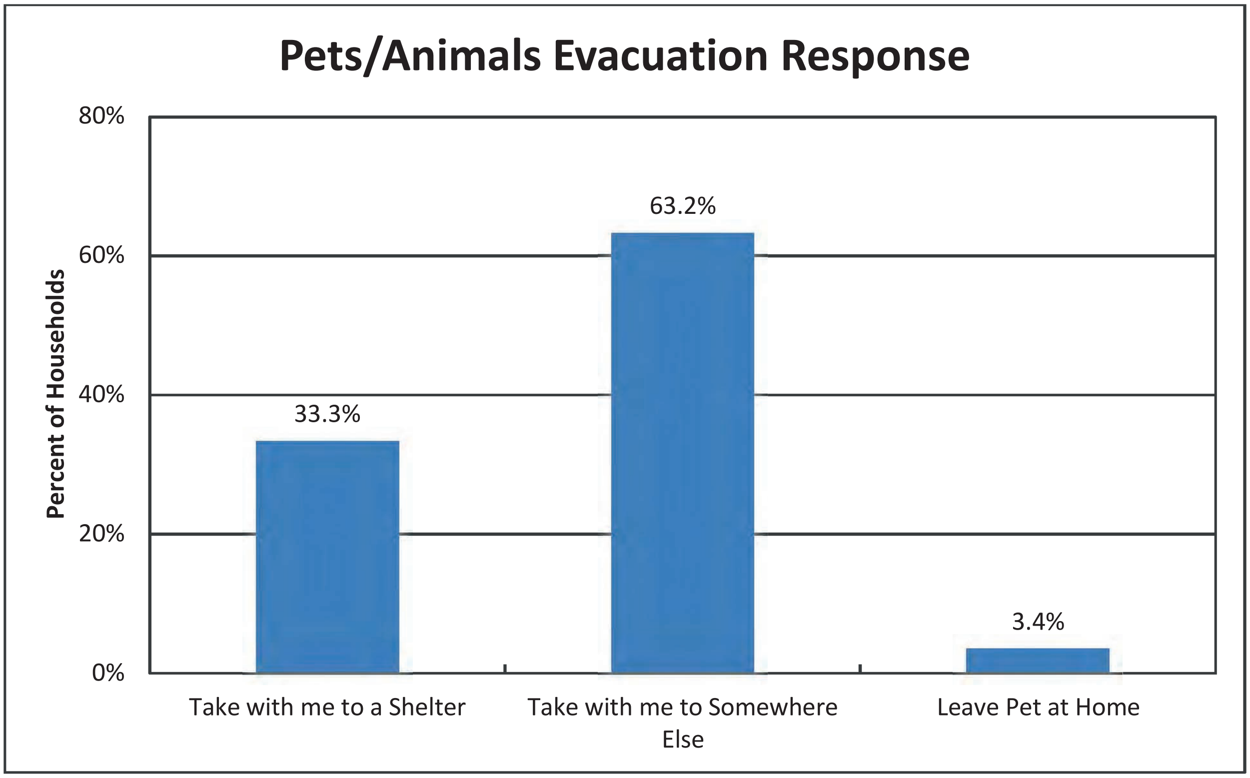


Figure F-11. Households Evacuating with Pets

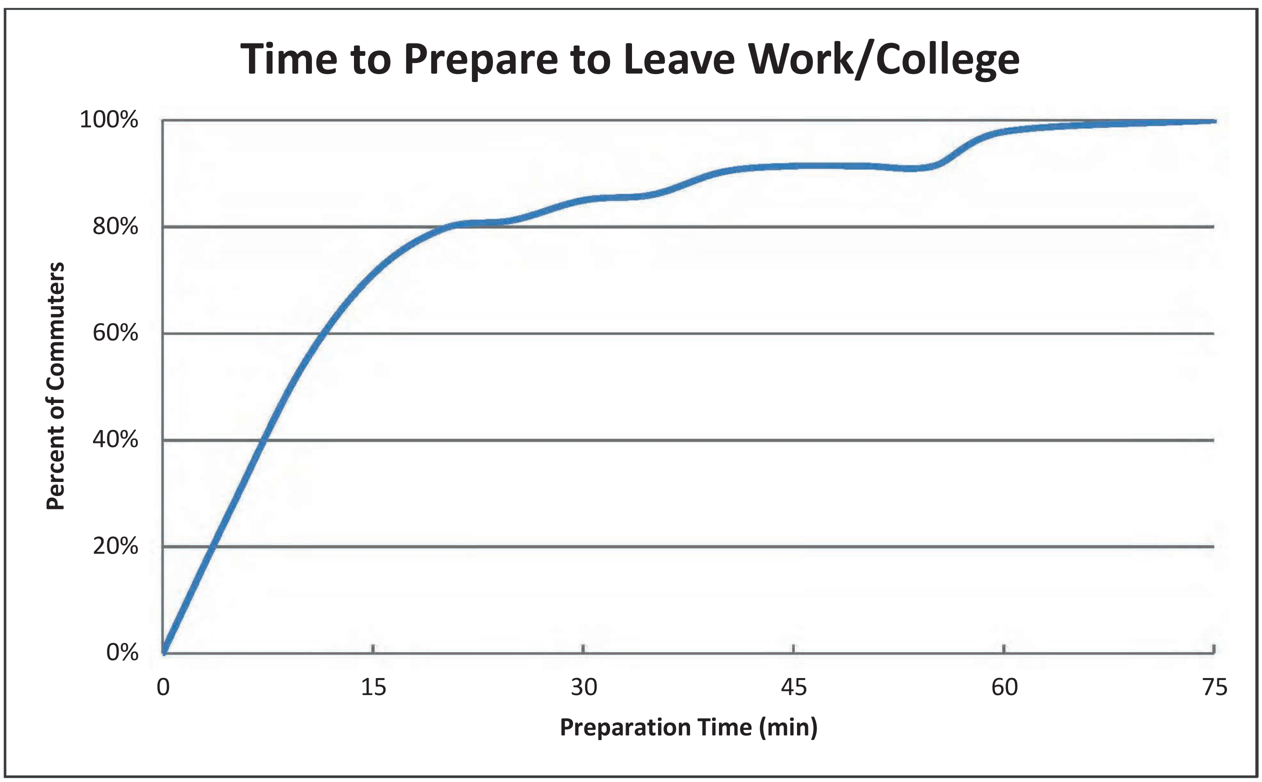


Figure F-12. Time Required to Prepare to Leave Work/College

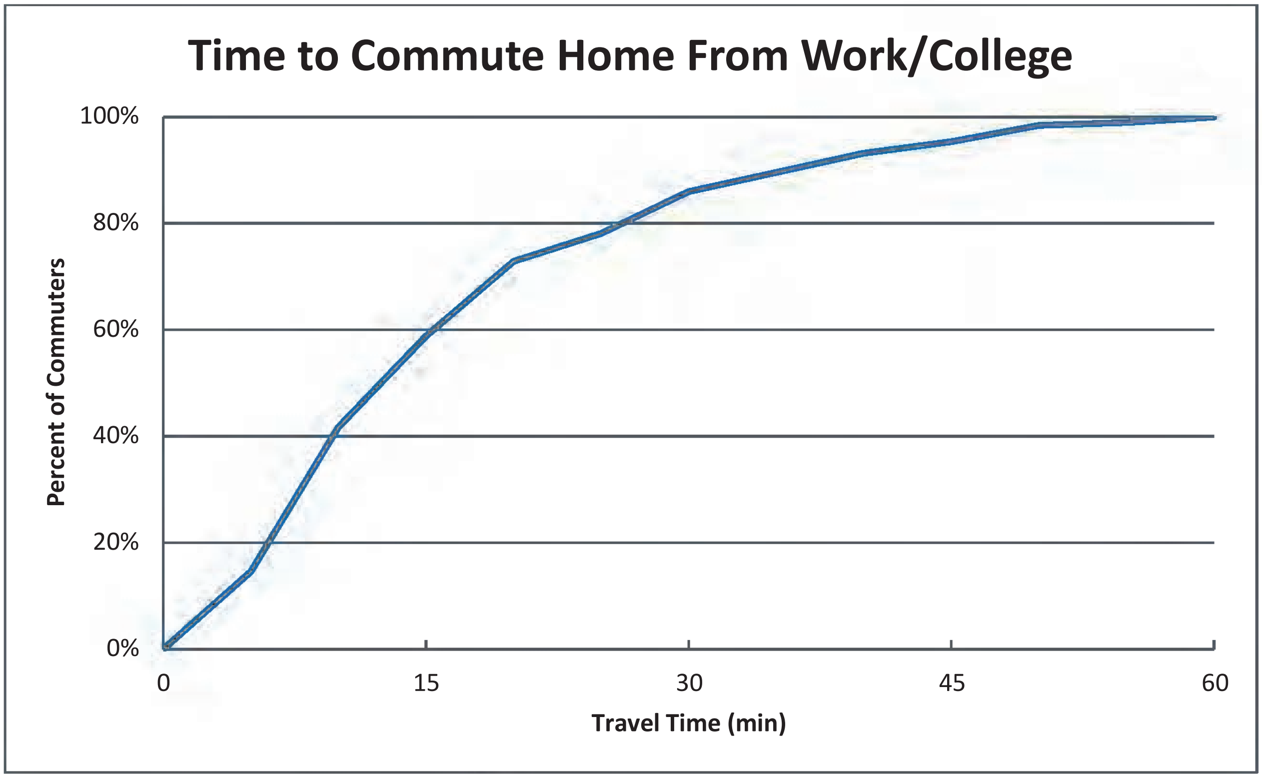


Figure F-13. Work to Home Travel Time

Figure F-14. Time to Prepare Home for Evacuation

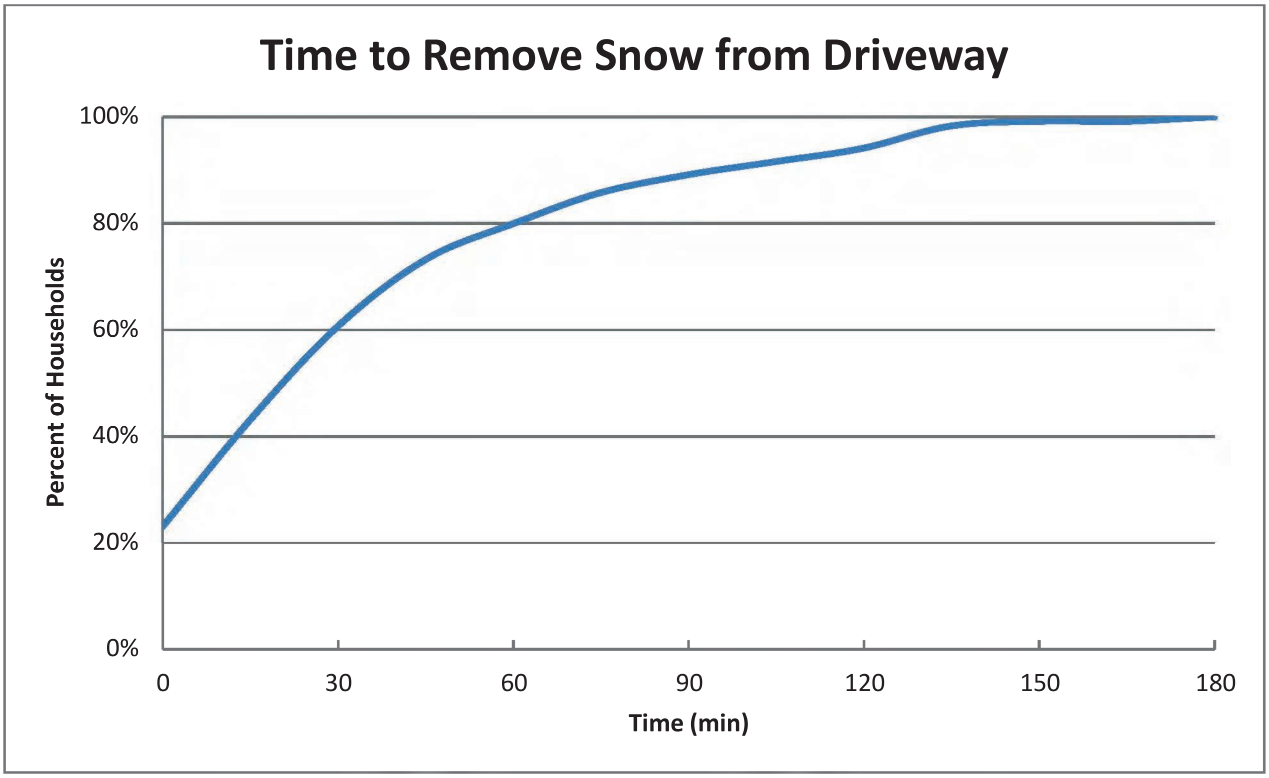


Figure F-15. Time to Clear Driveway of 6"-8" of Snow

ATTACHMENT A

Demographic Survey Instrument

Palisades Power Plant Demographic Survey

* Required

Purpose
The purpose of this survey is to identify local behavior during emergency situations. The information gathered in this survey will be shared with local emergency planning personnel to enhance emergency response plans in your area. Your responses will greatly contribute to local emergency preparedness. **Please only complete one survey per household. Please have the head of the household (18 years or older) complete the survey.** Do not provide your name or any personal information, and the survey will take less than 5 minutes to complete.

1. 1. What is your gender?

   Mark only one oval.

   - ◯ Male
   - ◯ Female
   - ◯ Decline to State
   - ◯ Other: ______________________

2. 2. What is your home zip code? *

   ____

3. 3A. In total, how many running cars, or other vehicles are usually available to the household?

Mark only one oval.

- ONE
- TWO
- THREE
- FOUR
- FIVE
- SIX
- SEVEN
- EIGHT
- NINE OR MORE
- ZERO (NONE)
- DECLINE TO STATE

4. 3B. In an emergency, could you get a ride out of the area with a neighbor or friend?

Mark only one oval.

- YES
- NO
- DECLINE TO STATE

5. 4. How many vehicles would your household use during an evacuation?

Mark only one oval.

- ONE
- TWO
- THREE
- FOUR
- FIVE
- SIX
- SEVEN
- EIGHT
- NINE OR MORE
- ZERO (NONE)
- I WOULD EVACUATE BY BICYCLE
- I WOULD EVACUATE BY BUS
- DECLINE TO STATE

6. 5A. How many people usually live in this household?

Mark only one oval.

- ONE
- TWO
- THREE
- FOUR
- FIVE
- SIX
- SEVEN
- EIGHT
- NINE
- TEN
- ELEVEN
- TWELVE
- THIRTEEN
- FOURTEEN
- FIFTEEN
- SIXTEEN
- SEVENTEEN
- EIGHTEEN
- NINETEEN OR MORE
- DECLINE TO STATE

7. 5B. Of these people that live in this household, are any of them seasonal residents?

seasonal residents refers to the residents who do not reside in the household the majority of the year.

Mark only one oval.

- Yes
- No *Skip to question 10*
- Decline to State *Skip to question 10*

Skip to question 10

Seasonal Population

8. 5C. How many of the household residents are seasonal?

Mark only one oval.

- ONE
- TWO
- THREE
- FOUR
- FIVE
- SIX
- SEVEN
- EIGHT
- NINE
- TEN
- ELEVEN
- TWELVE
- THIRTEEN
- FOURTEEN
- FIFTEEN
- SIXTEEN
- SEVENTEEN
- EIGHTEEN
- NINETEEN OR MORE
- DECLINE TO STATE

9. 5D. What season do the seasonal residents live in this home?

Mark only one oval.

- Summer
- Fall
- Winter
- Spring
- Decline to State

COVID-19

10. 6. How many people in your household have a work and/or school commute that has been temporarily impacted due to the COVID-19 pandemic?

Mark only one oval.

- ZERO
- ONE
- TWO
- THREE
- FOUR OR MORE
- DECLINE TO STATE

Skip to question 11

Commuters

11. 7. How many people in the household normally (during non-COVID conditions) commute to a job, or to college on a daily basis? *

Mark only one oval.

- ZERO *Skip to question 56*
- ONE *Skip to question 12*
- TWO *Skip to question 13*
- THREE *Skip to question 14*
- FOUR OR MORE *Skip to question 15*
- DECLINE TO STATE *Skip to question 56*

Mode of Travel

12. 8. Thinking about each commuter, how does each person usually travel to work or college?

Mark only one oval per row.

	Rail	Bus	Walk/Bicycle	Drive Alone	Carpool-2 or more people	Don't know
Commuter 1						

Skip to question 16

Mode of Travel

13. 8. Thinking about each commuter, how does each person usually travel to work or college?

Mark only one oval per row.

	Rail	Bus	Walk/Bicycle	Drive Alone	Carpool-2 or more people	Don't know
Commuter 1	○	○	○	○	○	○
Commuter 2	○	○	○	○	○	○

Skip to question 18

Mode of Travel

14. 8. Thinking about each commuter, how does each person usually travel to work or college?

Mark only one oval per row.

	Rail	Bus	Walk/Bicycle	Drive Alone	Carpool-2 or more people	Don't know
Commuter 1	○	○	○	○	○	○
Commuter 2	○	○	○	○	○	○
Commuter 3	○	○	○	○	○	○

Skip to question 22

Mode of Travel

15. 8. Thinking about each commuter, how does each person usually travel to work or college?

Mark only one oval per row.

	Rail	Bus	Walk/Bicycle	Drive Alone	Carpool-2 or more people	Don't know
Commuter 1	⬭	⬭	⬭	⬭	⬭	⬭
Commuter 2	⬭	⬭	⬭	⬭	⬭	⬭
Commuter 3	⬭	⬭	⬭	⬭	⬭	⬭
Commuter 4	⬭	⬭	⬭	⬭	⬭	⬭

Skip to question 28

Travel Home From Work/College

16. 9-1. How much time on average, would it take Commuter #1 to travel home from work or college?

Mark only one oval.

- 5 MINUTES OR LESS
- 6-10 MINUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 - 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

17. If Over 2 Hours for Question 9-1, Specify Here

leave blank if your answer for Question 9-1, is under 2 hours.

____

Skip to question 36

Travel Home From Work/College

18. 9-1. How much time on average, would it take Commuter #1 to travel home from work or college?

Mark only one oval.

- 5 MINUTES OR LESS
- 6-10 MINUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 - 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

19. If Over 2 Hours for Question 9-1, Specify Here

leave blank if your answer for Question 9-1, is under 2 hours.

____

20. 9-2. How much time on average, would it take Commuter #2 to travel home from work or college?

Mark only one oval.

- 5 MINUTES OR LESS
- 6-10 MINUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 - 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

21. If Over 2 Hours for Question 9-2, Specify Here

leave blank if your answer for Question 9-2, is under 2 hours.

____

Skip to question 38

Travel Home From Work/College

22. 9-1. How much time on average, would it take Commuter #1 to travel home from work or college?

Mark only one oval.

- 5 MINUTES OR LESS
- 6-10 MINUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 - 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

23. If Over 2 Hours for Question 9-1, Specify Here

leave blank if your answer for Question 9-1, is under 2 hours.

____

24. 9-2. How much time on average, would it take Commuter #2 to travel home from work or college?

Mark only one oval.

- 5 MINUTES OR LESS
- 6-10 MINUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 - 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

25. If Over 2 Hours for Question 9-2, Specify Here

leave blank if your answer for Question 9-2, is under 2 hours.

____

26. 9-3. How much time on average, would it take Commuter #3 to travel home from work or college?

Mark only one oval.

- 5 MINUTES OR LESS
- 6-10 MINUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 - 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

27. If Over 2 Hours for Question 9-3, Specify Here

leave blank if your answer for Question 9-3, is under 2 hours.

____

Skip to question 42

Travel Home From Work/College

28. 9-1. How much time on average, would it take Commuter #1 to travel home from work or college?

Mark only one oval.

- 5 MINUTES OR LESS
- 6-10 MINUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 - 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

29. If Over 2 Hours for Question 9-1, Specify Here

leave blank if your answer for Question 9-1, is under 2 hours.

____

30. 9-2. How much time on average, would it take Commuter #2 to travel home from work or college?

Mark only one oval.

- ( ) 5 MINUTES OR LESS
- ( ) 6-10 MINUTES
- ( ) 11-15 MINUTES
- ( ) 16-20 MINUTES
- ( ) 21-25 MINUTES
- ( ) 26-30 MINUTES
- ( ) 31-35 MINUTES
- ( ) 36-40 MINUTES
- ( ) 41-45 MINUTES
- ( ) 46-50 MINUTES
- ( ) 51-55 MINUTES
- ( ) 56 - 1 HOUR
- ( ) OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- ( ) BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- ( ) BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- ( ) BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- ( ) OVER 2 HOURS
- ( ) DECLINE TO STATE

31. If Over 2 Hours for Question 9-2, Specify Here

leave blank if your answer for Question 9-2, is under 2 hours.

____

32. 9-3. How much time on average, would it take Commuter #3 to travel home from work or college?

Mark only one oval.

- ◯ 5 MINUTES OR LESS
- ◯ 6-10 MINUTES
- ◯ 11-15 MINUTES
- ◯ 16-20 MINUTES
- ◯ 21-25 MINUTES
- ◯ 26-30 MINUTES
- ◯ 31-35 MINUTES
- ◯ 36-40 MINUTES
- ◯ 41-45 MINUTES
- ◯ 46-50 MINUTES
- ◯ 51-55 MINUTES
- ◯ 56 - 1 HOUR
- ◯ OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- ◯ BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- ◯ BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- ◯ BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- ◯ OVER 2 HOURS
- ◯ DECLINE TO STATE

33. If Over 2 Hours for Question 9-3, Specify Here

leave blank if your answer for Question 9-3, is under 2 hours.

____

34. 9-4. How much time on average, would it take Commuter #4 to travel home from work or college?

Mark only one oval.

- 5 MINUTES OR LESS
- 6-10 MINUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 - 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

35. If Over 2 Hours for Question 9-4, Specify Here

leave blank if your answer for Question 9-4, is under 2 hours.

____

Skip to question 48

Preparation to leave Work/College

36. 10-1. Approximately how much time would it take Commuter #1 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

- ◯ 5 MINUTES OR LESS
- ◯ 6-10 MINUTES
- ◯ 11-15 MINUTES
- ◯ 16-20 MINUTES
- ◯ 21-25 MINUTES
- ◯ 26-30 MINUTES
- ◯ 31-35 MINUTES
- ◯ 36-40 MINUTES
- ◯ 41-45 MINUTES
- ◯ 46-50 MINUTES
- ◯ 51-55 MINUTES
- ◯ 56 - 1 HOUR
- ◯ OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- ◯ BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- ◯ BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- ◯ BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- ◯ OVER 2 HOURS
- ◯ DECLINE TO STATE

37. If Over 2 Hours for Question 10-1, Specify Here

leave blank if your answer for Question 10-1, is under 2 hours.

____

Skip to question 56

Preparation to leave Work/College

38. 10-1. Approximately how much time would it take Commuter #1 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

- 5 MINUTES OR LESS
- 6-10 MINUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 - 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

39. If Over 2 Hours for Question 10-1, Specify Here

leave blank if your answer for Question 10-1, is under 2 hours.

____

40. 10-2. Approximately how much time would it take Commuter #2 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

- ( ) 5 MINUTES OR LESS
- ( ) 6-10 MINUTES
- ( ) 11-15 MINUTES
- ( ) 16-20 MINUTES
- ( ) 21-25 MINUTES
- ( ) 26-30 MINUTES
- ( ) 31-35 MINUTES
- ( ) 36-40 MINUTES
- ( ) 41-45 MINUTES
- ( ) 46-50 MINUTES
- ( ) 51-55 MINUTES
- ( ) 56 - 1 HOUR
- ( ) OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- ( ) BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- ( ) BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- ( ) BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- ( ) OVER 2 HOURS
- ( ) DECLINE TO STATE

41. If Over 2 Hours for Question 10-2, Specify Here

leave blank if your answer for Question 10-2, is under 2 hours.

____

Skip to question 56

Preparation to leave Work/College

42. 10-1. Approximately how much time would it take Commuter #1 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

- 5 MINUTES OR LESS
- 6-10 MINUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 - 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

43. If Over 2 Hours for Question 10-1, Specify Here

leave blank if your answer for Question 10-1, is under 2 hours.

____

44. 10-2. Approximately how much time would it take Commuter #2 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

- 5 MINUTES OR LESS
- 6-10 MINUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 - 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

45. If Over 2 Hours for Question 10-2, Specify Here

leave blank if your answer for Question 10-2, is under 2 hours.

____

46. 10-3. Approximately how much time would it take Commuter #3 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

- 5 MINUTES OR LESS
- 6-10 MINUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 - 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

47. If Over 2 Hours for Question 10-3, Specify Here

leave blank if your answer for Question 10-3, is under 2 hours.

____

Skip to question 56

Preparation to leave Work/College

48. 10-1. Approximately how much time would it take Commuter #1 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

- 5 MINUTES OR LESS
- 6-10 MINUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 - 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

49. If Over 2 Hours for Question 10-1, Specify Here

leave blank if your answer for Question 10-1, is under 2 hours.

____

50. 10-2. Approximately how much time would it take Commuter #2 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

- 5 MINUTES OR LESS
- 6-10 MINUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 - 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

51. If Over 2 Hours for Question 10-2, Specify Here

leave blank if your answer for Question 10-2, is under 2 hours.

____

52. 10-3. Approximately how much time would it take Commuter #3 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

- 5 MINUTES OR LESS
- 6-10 MINUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 - 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

53. If Over 2 Hours for Question 10-3, Specify Here

leave blank if your answer for Question 10-3, is under 2 hours.

____

54. 10-4. Approximately how much time would it take Commuter #4 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

- 5 MINUTES OR LESS
- 6-10 MINUTES
- 11-15 MINUTES
- 16-20 MINUTES
- 21-25 MINUTES
- 26-30 MINUTES
- 31-35 MINUTES
- 36-40 MINUTES
- 41-45 MINUTES
- 46-50 MINUTES
- 51-55 MINUTES
- 56 - 1 HOUR
- OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
- BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
- BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
- BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
- OVER 2 HOURS
- DECLINE TO STATE

55. If Over 2 Hours for Question 10-4, Specify Here

leave blank if your answer for Question 10-4, is under 2 hours.

____

Skip to question 56

Additional Questions

56. 11. If you were advised by local authorities to evacuate, how much time would it take the household to pack clothing, medications, secure the house, load the car, and complete preparations prior to evacuating the area?

Mark only one oval.

- LESS THAN 15 MINUTES
- 15-30 MINUTES
- 31-45 MINUTES
- 46 MINUTES - 1 HOUR
- 1 HOUR TO 1 HOUR 15 MINUTES
- 1 HOUR 16 MINUTES TO 1 HOUR 30 MINUTES
- 1 HOUR 31 MINUTES TO 1 HOUR 45 MINUTES
- 1 HOUR 46 MINUTES TO 2 HOURS
- 2 HOURS TO 2 HOURS 15 MINUTES
- 2 HOURS 16 MINUTES TO 2 HOURS 30 MINUTES
- 2 HOURS 31 MINUTES TO 2 HOURS 45 MINUTES
- 2 HOURS 46 MINUTES TO 3 HOURS
- 3 HOURS TO 3 HOURS 15 MINUTES
- 3 HOURS 16 MINUTES TO 3 HOURS 30 MINUTES
- 3 HOURS 31 MINUTES TO 3 HOURS 45 MINUTES
- 3 HOURS 46 MINUTES TO 4 HOURS
- 4 HOURS TO 4 HOURS 15 MINUTES
- 4 HOURS 16 MINUTES TO 4 HOURS 30 MINUTES
- 4 HOURS 31 MINUTES TO 4 HOURS 45 MINUTES
- 4 HOURS 46 MINUTES TO 5 HOURS
- 5 HOURS TO 5 HOURS 30 MINUTES
- 5 HOURS 31 MINUTES TO 6 HOURS
- OVER 6 HOURS
- WILL NOT EVACUATE
- DECLINE TO STATE

57. If Over 6 Hours for Question 11, Specify Here

leave blank if your answer for Question 11, is under 6 hours.

____

58. 12. If there are 6-8 inches of snow on your driveway or curb, would you need to shovel out to evacuate? If yes, how much time, on average, would it take you to clear the 6-8 inches of snow to move the car from the driveway or curb to begin the evacuation trip? Assume the roads are passable.

Mark only one oval.

- LESS THAN 15 MINUTES
- 15-30 MINUTES
- 31-45 MINUTES
- 46 MINUTES – 1 HOUR
- 1 HOUR TO 1 HOUR 15 MINUTES
- 1 HOUR 16 MINUTES TO 1 HOUR 30 MINUTES
- 1 HOUR 31 MINUTES TO 1 HOUR 45 MINUTES
- 1 HOUR 46 MINUTES TO 2 HOURS
- 2 HOURS TO 2 HOURS 15 MINUTES
- 2 HOURS 16 MINUTES TO 2 HOURS 30 MINUTES
- 2 HOURS 31 MINUTES TO 2 HOURS 45 MINUTES
- 2 HOURS 46 MINUTES TO 3 HOURS
- NO, WILL NOT SHOVEL OUT
- OVER 3 HOURS
- DECLINE TO STATE

59. If Over 3 Hours for Question 12, Specify Here

leave blank if your answer for Question 12, is under 3 hours.

____

60. 13. Please specify the number of people in your household who require Functional or Transportation needs in an evacuation:

Mark only one oval per row.

	0	1	2	3	4	More than 4
Bus	◯	◯	◯	◯	◯	◯
Medical Bus/Van	◯	◯	◯	◯	◯	◯
Wheelchair Accessible Vehicle	◯	◯	◯	◯	◯	◯
Ambulance	◯	◯	◯	◯	◯	◯
Other	◯	◯	◯	◯	◯	◯

61. Specify "Other" Transportation Need Below

____

62. 14. Please choose one of the following:

Mark only one oval.

◯ I would await the return of household members to evacuate together.

◯ I would evacuate independently and meet other household members later.

◯ Decline to State

63. 15A. Emergency officials advise you to shelter-in-place in an emergency because you are not in the area of risk. Would you:

Mark only one oval.

- SHELTER-IN-PLACE
- EVACUATE
- DECLINE TO STATE

64. 15B. Emergency officials advise you to shelter-in-place now in an emergency and possibly evacuate later while people in other areas are advised to evacuate now. Would you:

Mark only one oval.

- SHELTER-IN-PLACE
- EVACUATE
- DECLINE TO STATE

65. 15C. Emergency officials advise you to evacuate due to an emergency. Where would you evacuate to?

Mark only one oval.

- A RELATIVE'S OR FRIEND'S HOME
- A RECEPTION CENTER
- A HOTEL, MOTEL OR CAMPGROUND
- A SECOND/SEASONAL HOME
- WOULD NOT EVACUATE
- DON'T KNOW
- OTHER (Specify Below)
- DECLINE TO STATE

66. Fill in OTHER answers for question 15C

____

Pet Questions

67. 16A. Do you have any pet(s) and/or animal(s)?

Mark only one oval.

- ◯ YES
- ◯ NO
- ◯ DECLINE TO STATE

Pet Questions

68. 16B. What type of pet(s) and/or animal(s) do you have?

Check all that apply.

- ☐ DOG
- ☐ CAT
- ☐ BIRD
- ☐ REPTILE
- ☐ HORSE
- ☐ FISH
- ☐ CHICKEN
- ☐ GOAT
- ☐ PIG
- ☐ OTHER SMALL PETS/ANIMALS (Specify Below)
- ☐ OTHER LARGE PETS/ANIMALS (Specify Below)
- ☐ Other: _______________________________

69. *Mark only one oval.*

- ⬭ DECLINE TO STATE

Pet Questions

70. 16C. What would you do with your pet(s) and/or animal(s) if you had to evacuate?

Mark only one oval.

- ⬭ TAKE PET WITH ME TO A SHELTER
- ⬭ TAKE PET WITH ME SOMEWHERE ELSE
- ⬭ LEAVE PET AT HOME
- ⬭ DECLINE TO STATE

Pet Questions

71. 16D. Do you have sufficient room in your vehicle(s) to evacuate with your pet(s) and/or animal(s)?

Mark only one oval.

- ⬭ YES
- ⬭ NO
- ⬭ DECLINE TO STATE
- ⬭ Other: ______________________________

APPENDIX G

Traffic Management Plan

G. TRAFFIC MANAGEMENT PLAN

NUREG/CR-7002, Rev. 1 indicates that the existing Traffic Management Plans (TMP) consisting of Traffic Control Points (TCPs) and Access Control Points (ACPs) identified by the offsite agencies should be used in the evacuation simulation modeling. The TMP for the EPZ were provided in the emergency plans from each of the counties within the EPZ.

These plans were reviewed and only ACPs were identified. These ACPs were modeled accordingly. An analysis of the ACP locations was performed, and it was determined to model the ETE simulations with the existing ACPs that were provided in the approved county emergency plans, with no additional ACPs recommended.

G.1 Manual Traffic Control

The ACPs are forms of Manual Traffic Control (MTC). As discussed in Section 9, MTC at intersections (which are controlled) are modeled as actuated signals. If an intersection has a pre-timed signal, stop, or yield control, and the intersection is identified as an ACP, the control type was changed to an actuated signal in the DYNEV II system, in accordance with Section 3.3 of NUREG/CR-7002, Rev. 1. MTCs at existing actuated traffic signalized intersections were essentially left alone.

Table K-1 provides the number of nodes with each control type. If the existing control was changed due to the point being an ACP, the control type is indicated as "ACP" in Table K-1. The ACPs within the emergency plans are mapped as in Figure G-1. These ACPs are concentrated on roadways giving access to the EPZ and to individual PAAs within the EPZ. These ACPs would be manned during evacuation by traffic guides who would direct evacuees in the proper direction away from the PPP and facilitate the flow of traffic through the intersections. No additional locations for MTC are suggested in this study.

It is assumed that the ACPs will be established within 120 minutes of the ATE to discourage through travelers from using major through routes which traverse the study area. As discussed in Section 3.10, external traffic was considered on Interstate (I)-194 and I-94 in this analysis.

G.2 Analysis of Key ACP Locations

As discussed in Section 5.2 of NUREG/CR-7002, Rev. 1, MTC at intersections could benefit from the ETE analysis. The MTC locations identified in the TMPs were analyzed to determine key locations where MTC would be most useful and could be readily implemented. As previously mentioned, signalized intersections that were actuated based on field data collection were essentially left as actuated traffic signals in the model, with modifications to green time allocation as needed. Other controlled intersections (pre-timed signals, stop signs and yield signs) were changed to actuated traffic signals to represent the MTC that would be implemented according to the TMPs.

The majority of the ACPs identified in the TMPs were located at intersections with stop control. Table G-1 shows a list of the controlled intersections that were identified as MTC points in the

TMPs that were not previously actuated signals, including the type of control that currently exists at each location. To determine the impact of MTC at these locations, a summer, weekend, midday, with good weather scenario (Scenario 3) evacuation of the 2-Mile Region, 5-Mile Region, and the Entire EPZ (Region R01, R02, and R03) were simulated wherein these intersections were left as is (without MTC). The results were compared to the results presented in Section 7 for Scenario 3 and Regions R01, R02, and R03. The ETE were not impacted when compared to the cases wherein these controlled intersections were modeled as actuated signals (with MTC) as presented in Table G-2. Although localized congestion may worsen, there is no impact to the 90th and 100th percentile ETE when MTC was not present at these intersections. The remaining ACPs at controlled intersections were left as actuated signals in the model and, therefore, had no impact to ETE.

As shown in Figure 7-3 through Figure 7-6, several population centers in the study area experience moderate to heavy traffic congestion. The congestion in the EPZ lasted for nearly two and half hours after the ATE. During this time, the major bottlenecks including the ramps to I-196 near South Haven and MI-140 southbound at the intersection with Red Arrow Hwy exhibit persistent congestion. These bottlenecks which are causing delays and prolonging ETE are at intersections with actuated traffic signals or at ramps to freeways wherein MTC will have no impact. As a result, the ACPs within the EPZ do not impact the 90th percentile ETE. In addition, congestion within the EPZ clears prior to the completion of mobilization time, indicating that 100th percentile ETE is dictated by mobilization time. Thus, MTC has no impact on the 100th percentile ETE.

Although there is no reduction in ETE when MTC is implemented, traffic and access control can be beneficial in the reduction of localized congestion and driver confusion and can be extremely helpful for fixed point surveillance and the prevention of vehicles from entering various PAAs (as a majority of the ACPs are located at the PAA boundaries), amongst other things. Should there be a shortfall of personnel to staff the ACPs, the list of locations provided in Table G-1 could be considered as priority locations when implementing the TMP.

Table G-1. List of Key Manual Traffic Control Locations

ACP Number	Node Number (See Appendix K)	Type of Control (Prior to being an ACP)
V-10	211	Stop Control
V-15h	166	Stop Control
V-17	168	Yield Control/Traffic Circle
V-48	484	Stop Control
V-60g	183	Stop Control
V-60k	264	Stop Control
V-63	390	Stop Control
A-38	462	Stop Control

Table G-2. ETE with No MTC

Region	Scenario 3					
	90th Percentile ETE			100th Percentile ETE		
	Base	No MTC	Difference	Base	No MTC	Difference
R01 (2-Mile Region)	2:05	2:05	0:00	4:50	4:50	0:00
R02 (5-Mile Region)	2:10	2:10	0:00	4:55	4:55	0:00
R03 (Full EPZ)	2:20	2:20	0:00	5:00	5:00	0:00

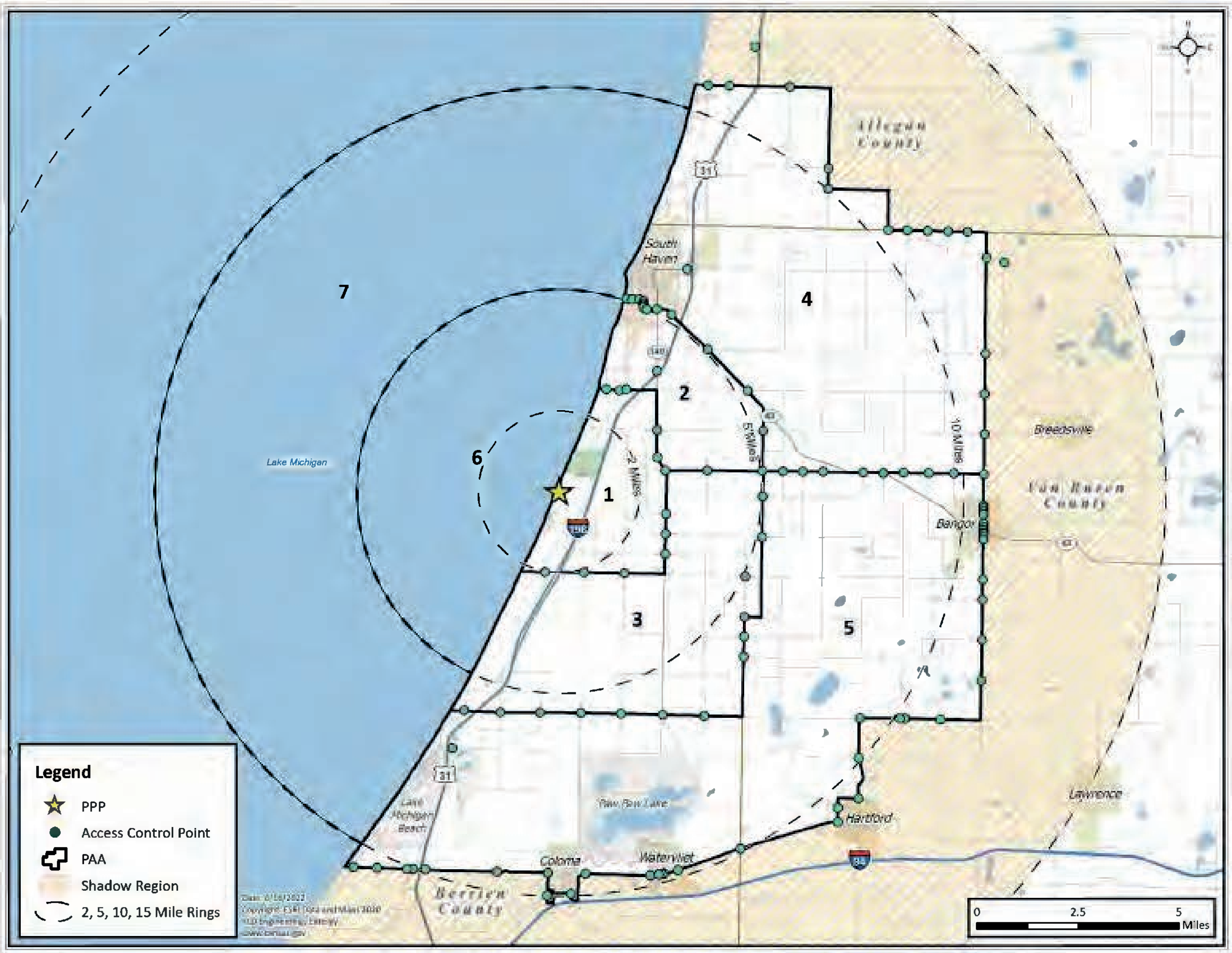


Figure G-1. **Access Control Points for PPP**

APPENDIX H

Evacuation Regions

H EVACUATION REGIONS

This appendix presents the evacuation percentages for each Evacuation Region (Table H-1) and maps of all Evacuation Regions (Figure H-1 through Figure H-13). The percentages presented in Table H-1 are based on the methodology discussed in assumption 7 of Section 2.2 and shown in Figure 2-1.

Note the baseline ETE study assumes 20 percent of households will not comply with the shelter advisory, as per Section 2.5.2 of NUREG/CR-7002, Rev. 1.

Table H-1. Percent of PAA Population Evacuating for Each Region

Radial Regions								
Region	Description	PAA						
		1	2	3	4	5	6	7
R01	2-Mile Region	100%	20%	20%	20%	20%	100%	20%
R02	5-Mile Region	100%	100%	100%	20%	20%	100%	20%
R03	Full EPZ	100%	100%	100%	100%	100%	100%	100%
Evacuate 2-Mile Region and Downwind to 5-Miles								
Region	Wind Direction From (Degrees)	PAA						
		1	2	3	4	5	6	7
N/A	≥56 and <169	Refer to R01						
R04	≥169 and <236	100%	100%	20%	20%	20%	100%	20%
N/A	≥236 and <303	Refer to R02						
R05	≥303 and <56	100%	20%	100%	20%	20%	100%	20%
Evacuate 2-Mile Region and Downwind to the EPZ Boundary								
Region	Wind Direction From (Degrees)	PAA						
		1	2	3	4	5	6	7
R06	≥56 and <169	100%	20%	20%	20%	20%	100%	100%
R07	≥169 and <236	100%	100%	20%	100%	20%	100%	100%
R08	≥236 and <303	100%	100%	100%	100%	100%	100%	20%
R09	≥303 and <348	100%	20%	100%	20%	100%	100%	20%
R10	≥348 and <56	100%	20%	100%	20%	100%	100%	100%
Staged Evacuation - 2-Mile Region Evacuates, then Evacuate Downwind to 5-Miles								
Region	Wind Direction From (Degrees)	PAA						
		1	2	3	4	5	6	7
R11	5-Mile Region	100%	100%	100%	20%	20%	100%	20%
N/A	≥56 and <169	Refer to R01						
R12	≥169 and <236	100%	100%	20%	20%	20%	100%	20%
N/A	≥236 and <303	Refer to R11						
R13	≥303 and <56	100%	20%	100%	20%	20%	100%	20%
PAA(s) Evacuate		PAA(s) Shelter-in-Place			PAA(s) Shelter-in-Place until 90% ETE for R01, then Evacuate			

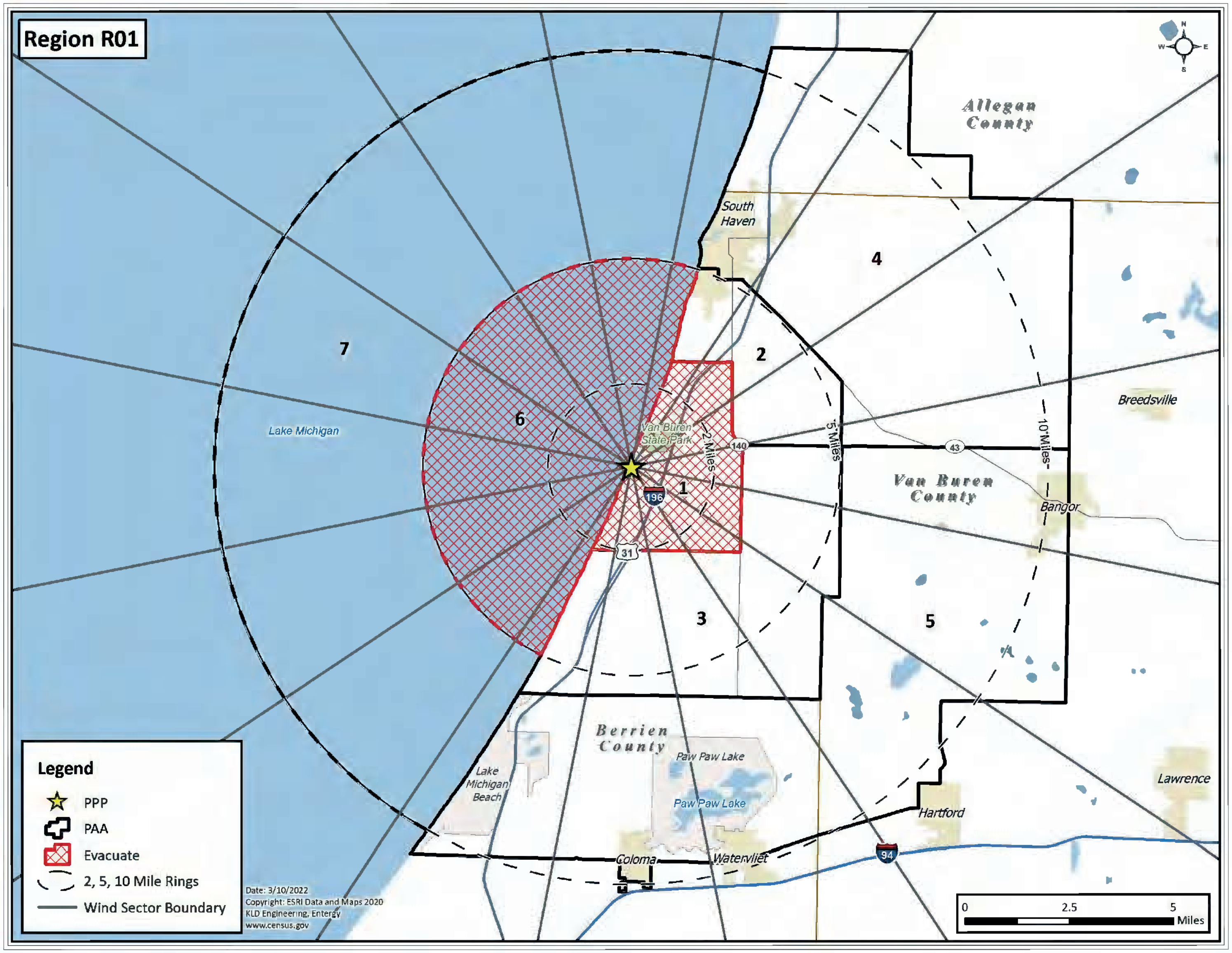


Figure H-1. Region R01

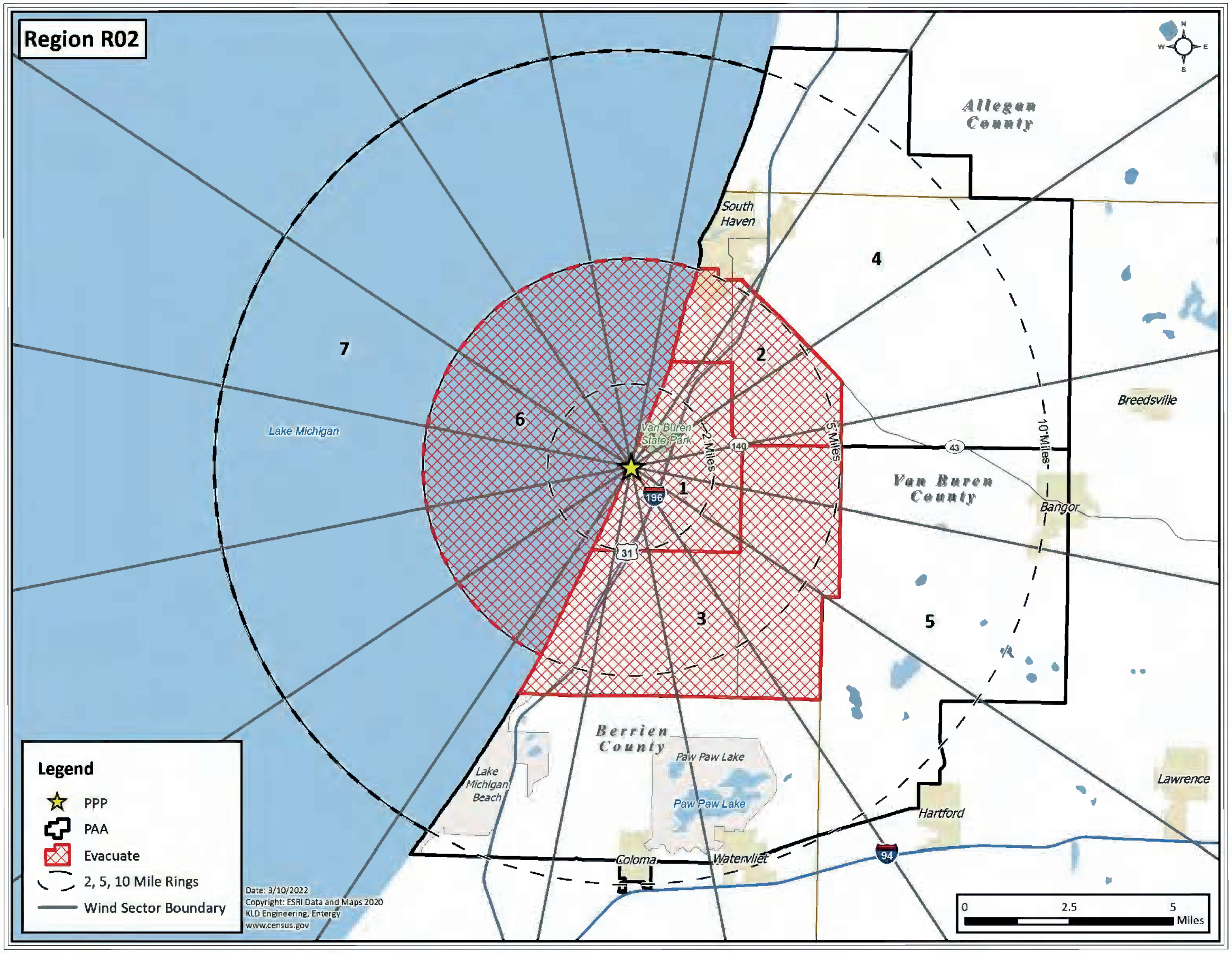


Figure H-2. Region R02

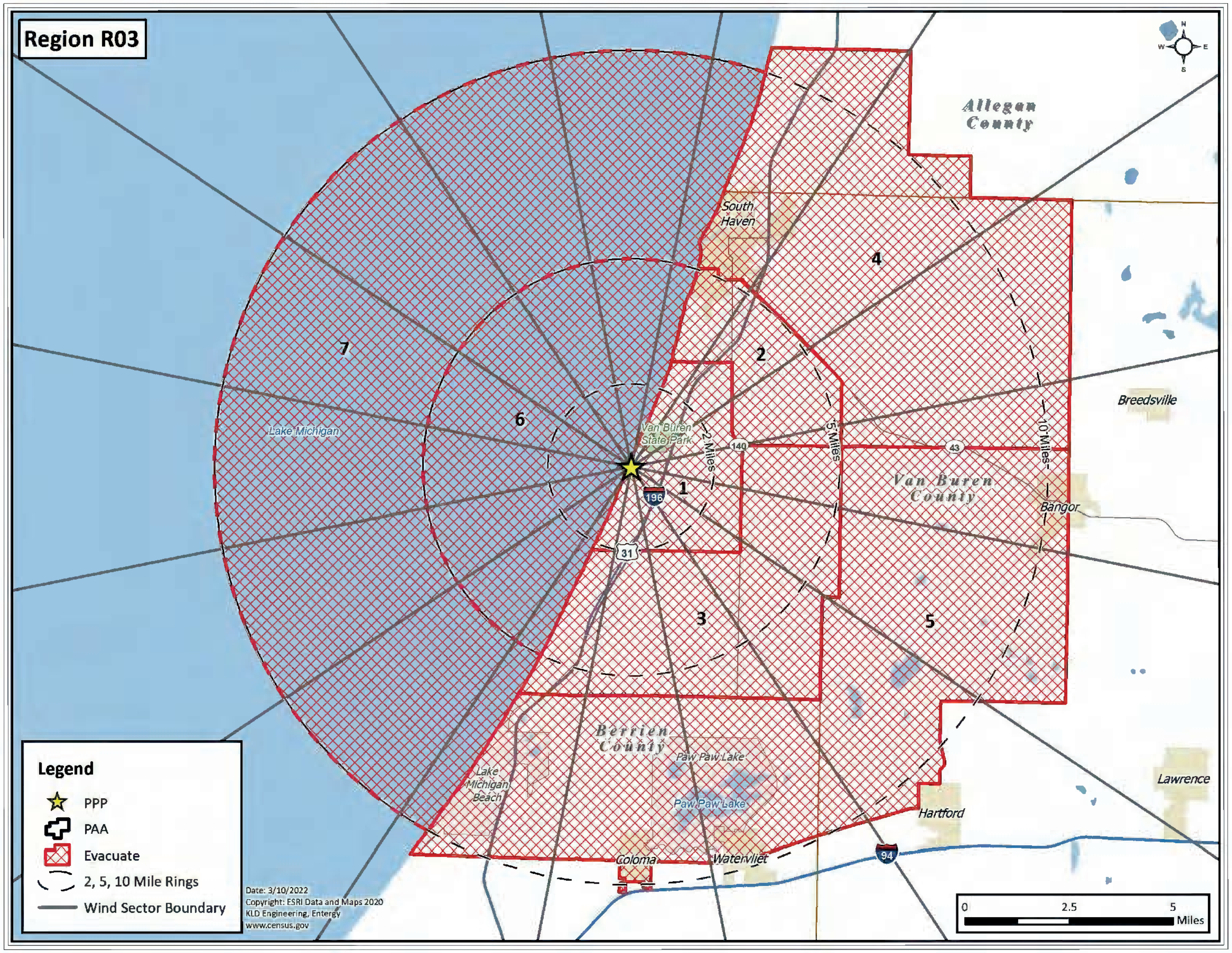


Figure H-3. Region R03

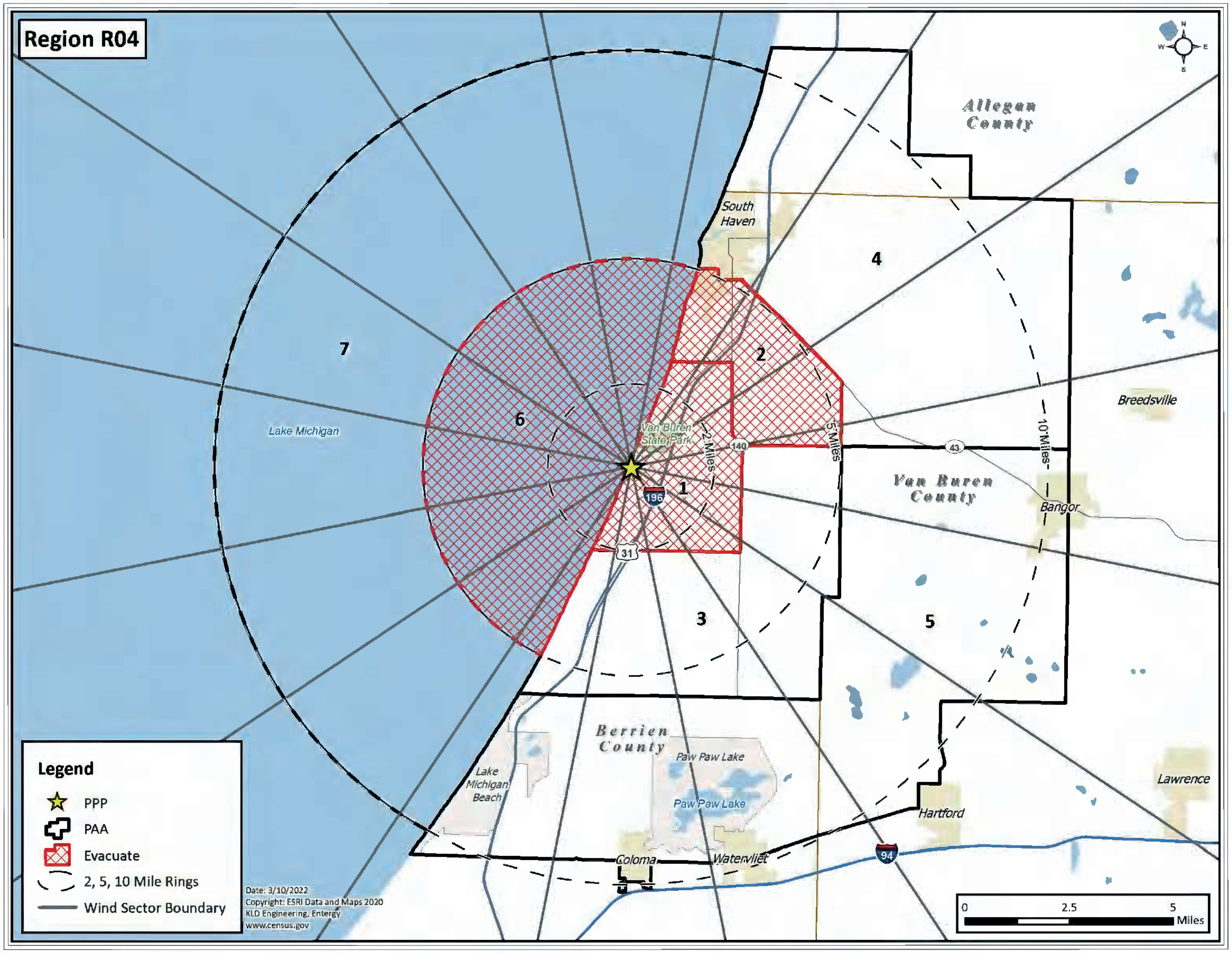


Figure H-4. Region R04

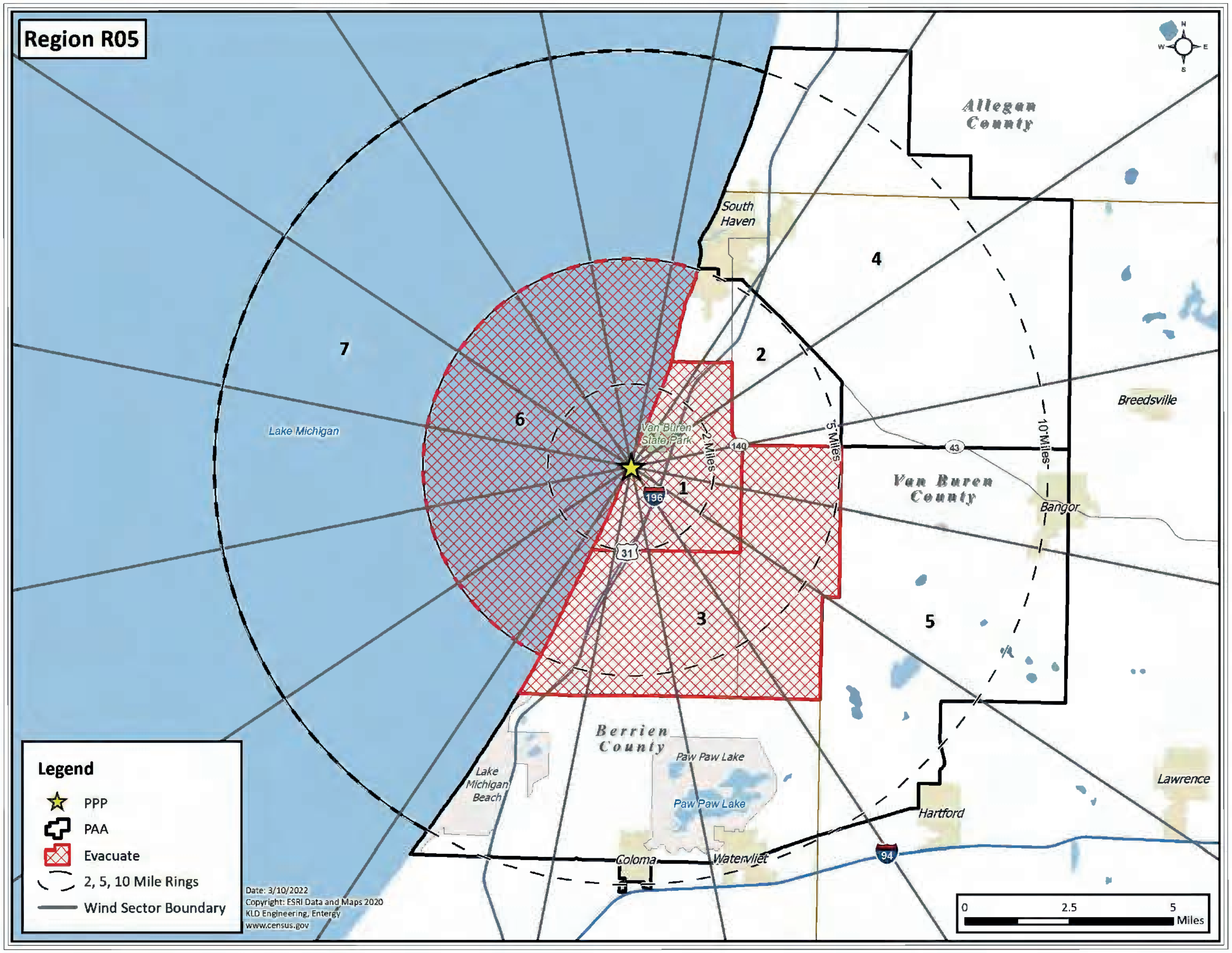


Figure H-5. Region R05

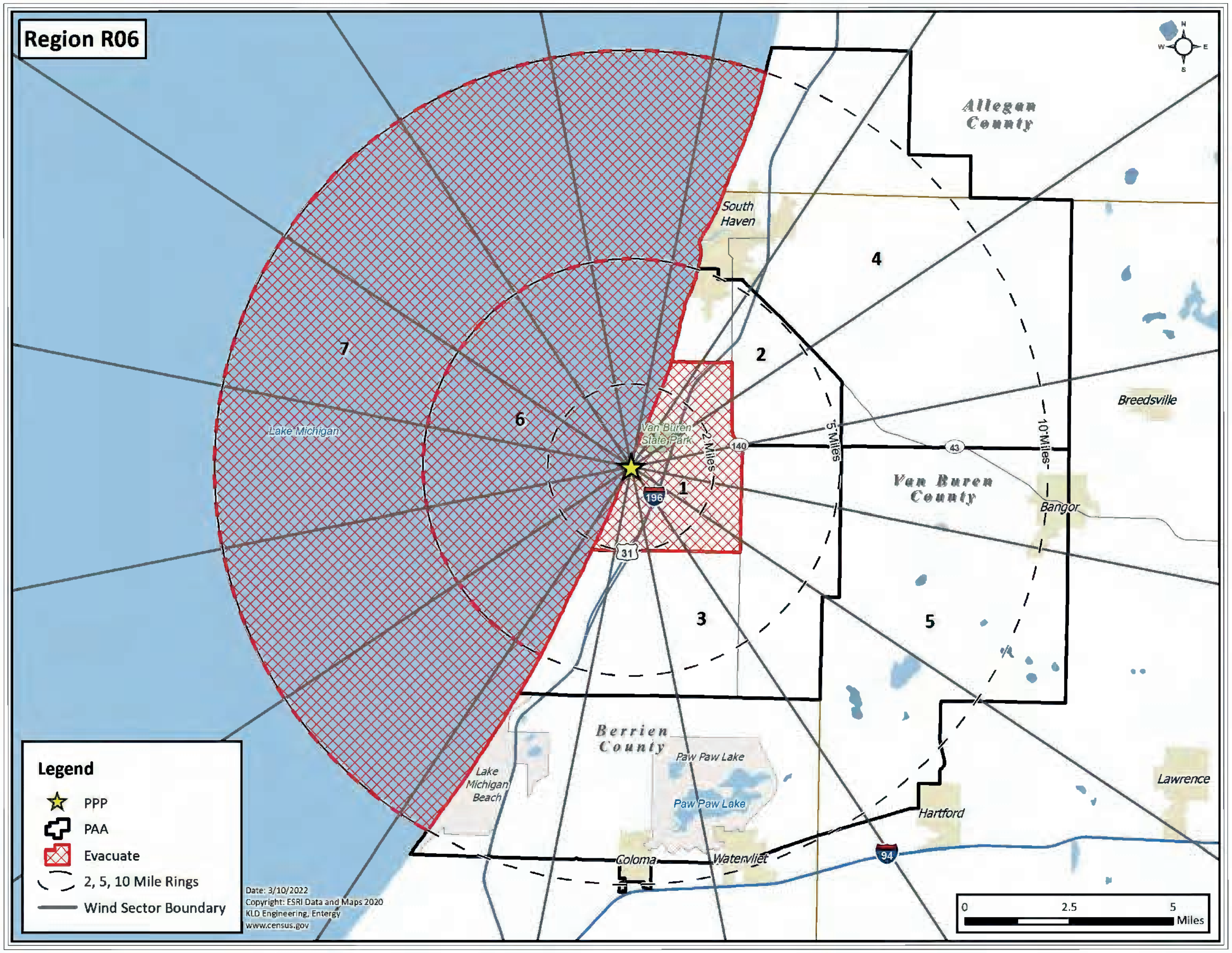


Figure H-6. Region R06

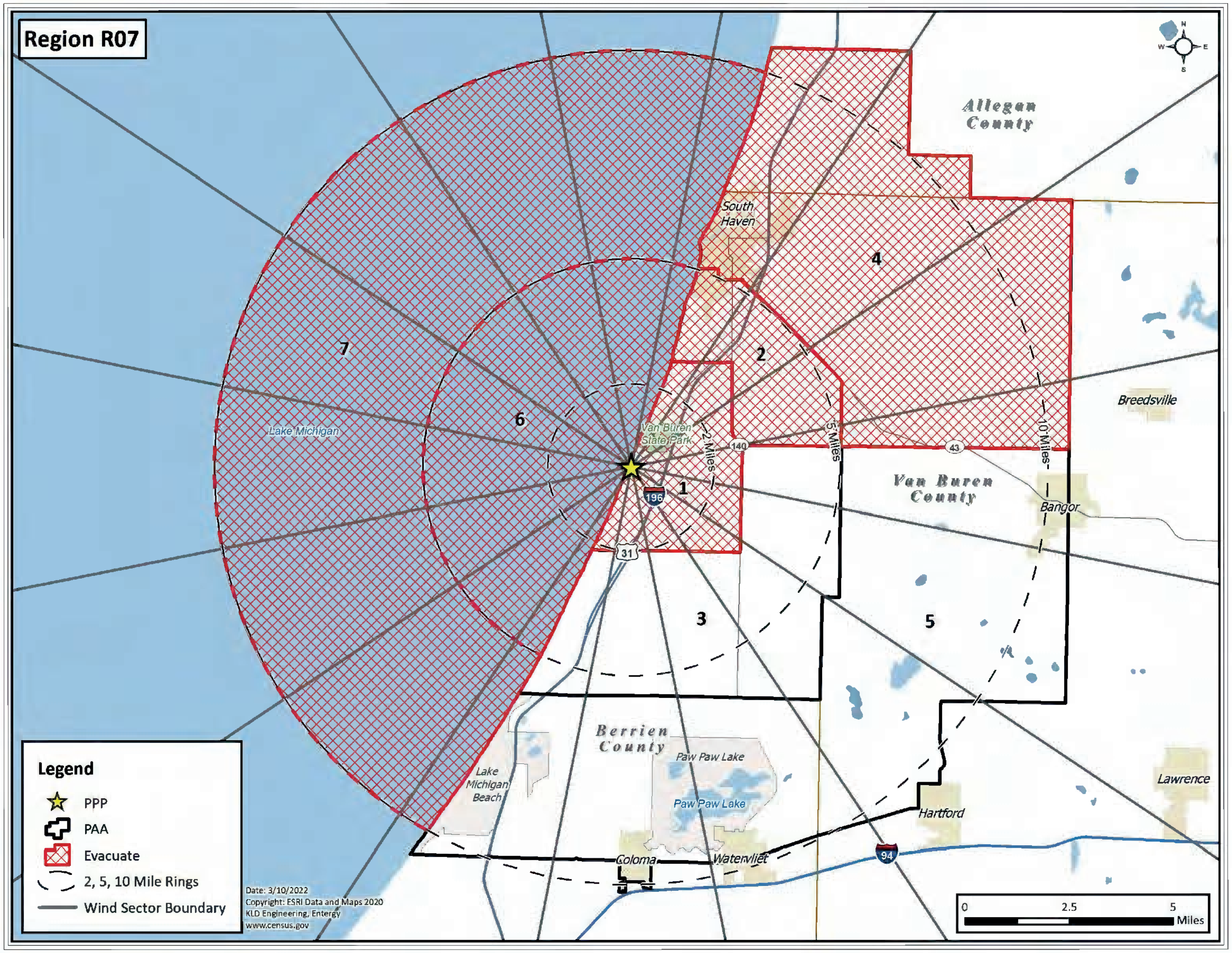


Figure H-7. Region R07

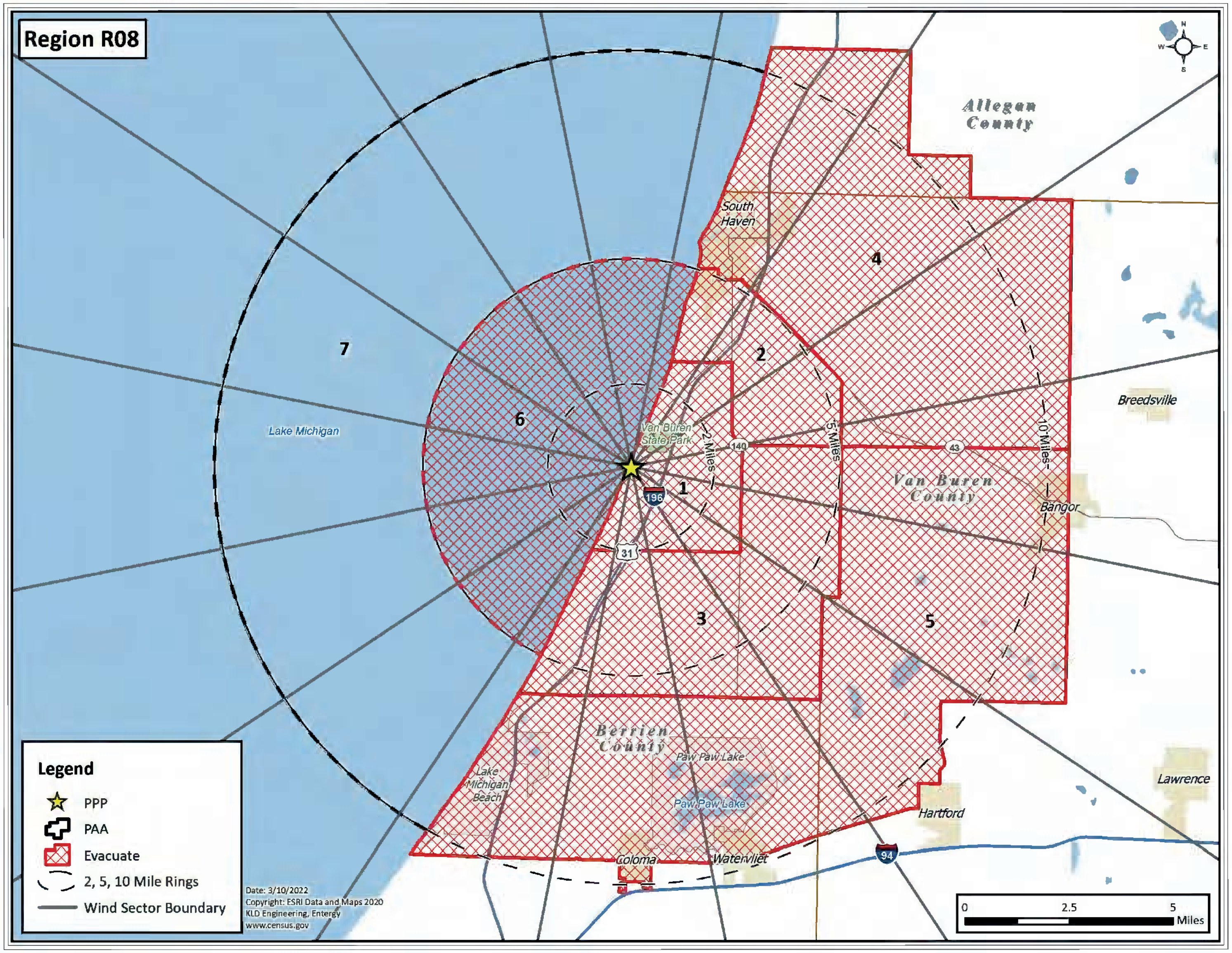


Figure H-8. Region R08

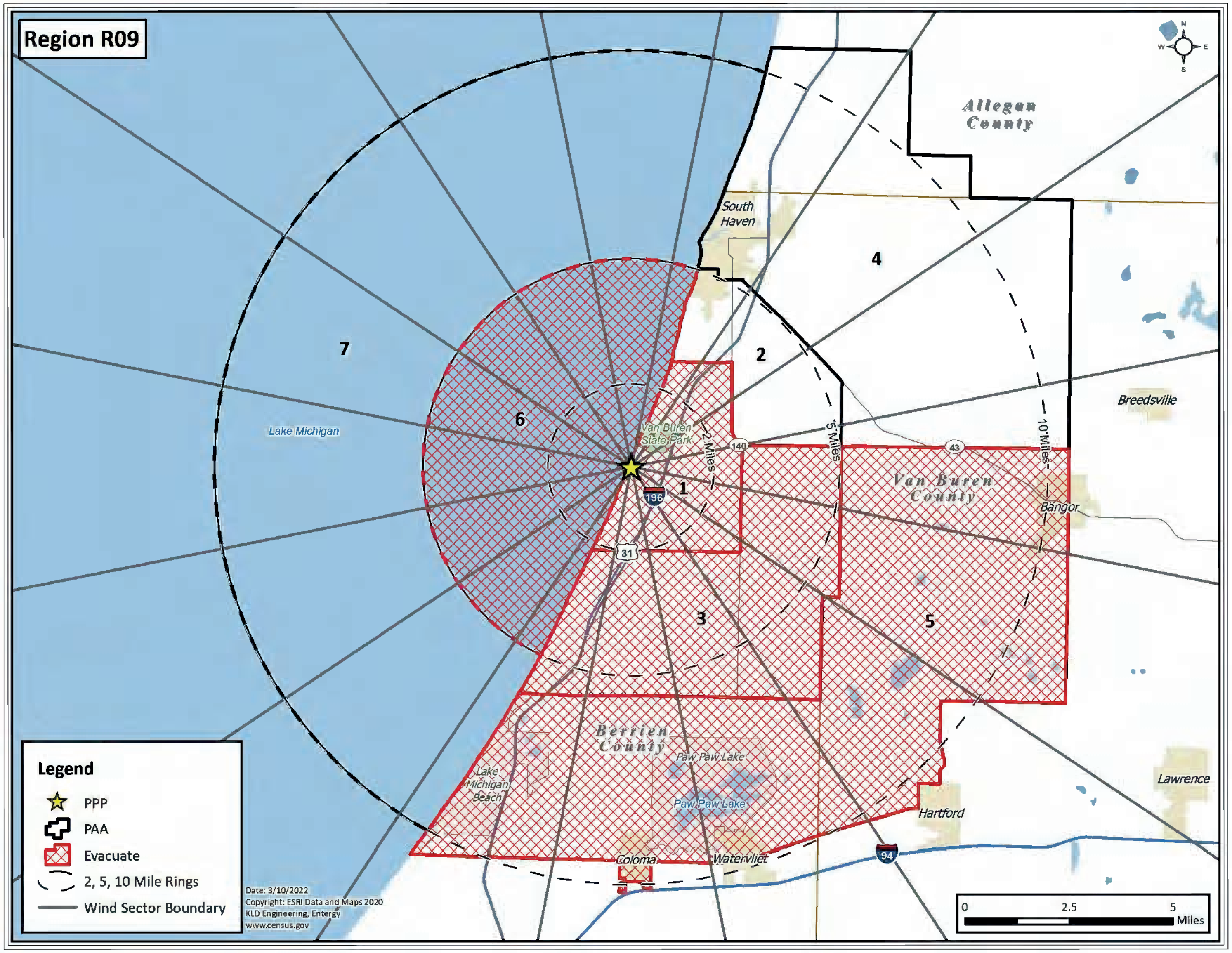


Figure H-9. Region R09

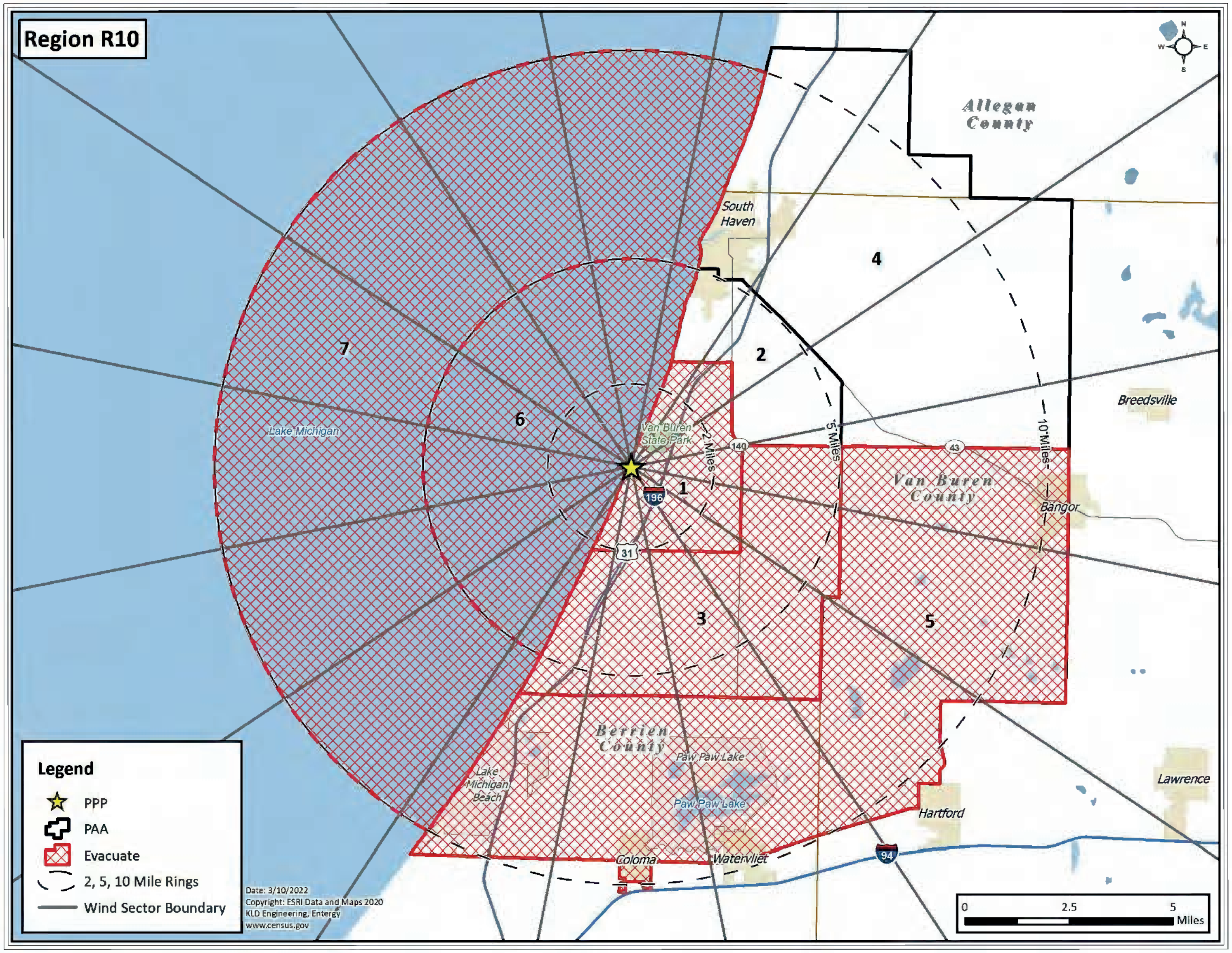


Figure H-10. Region R10

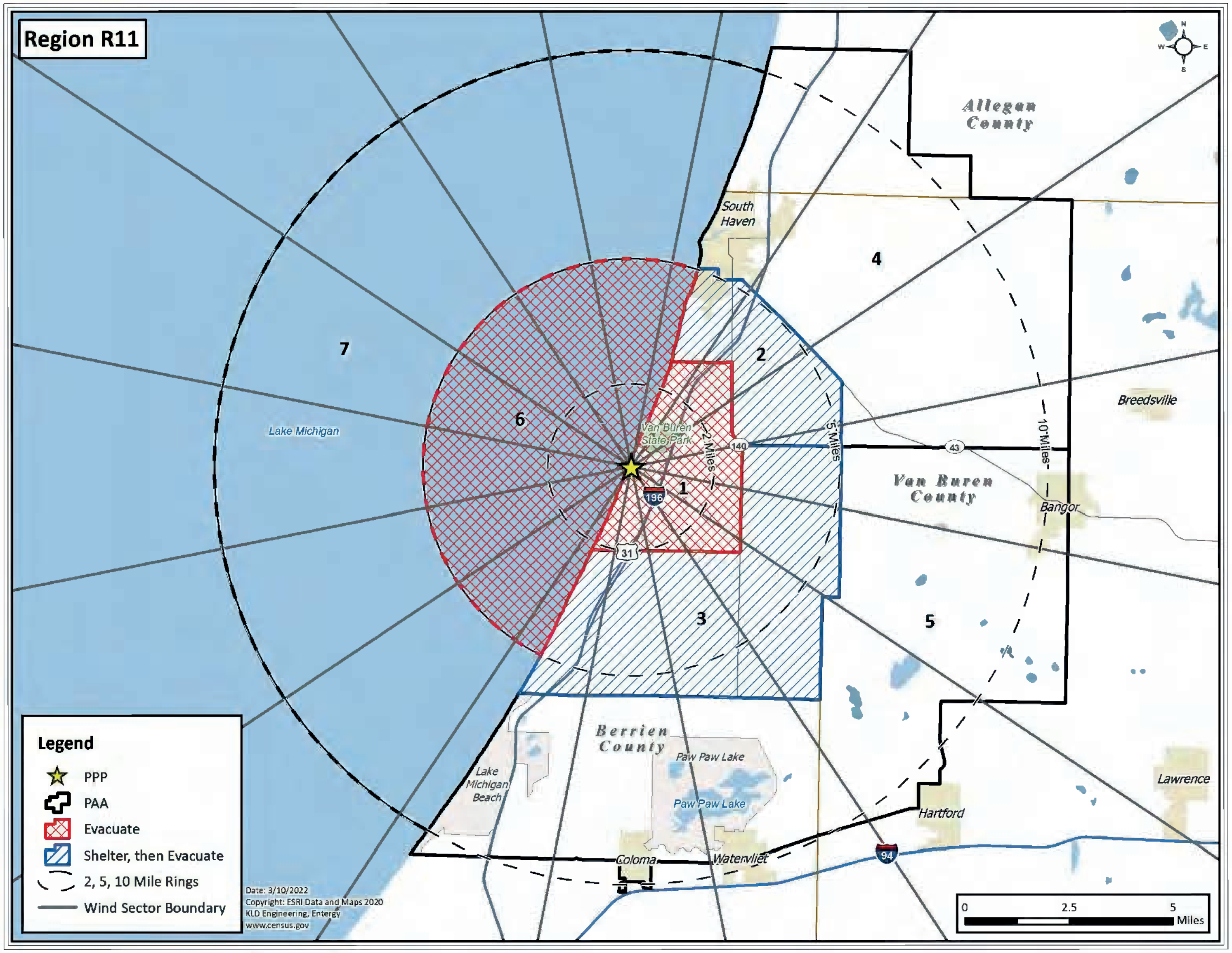


Figure H-11. Region R11

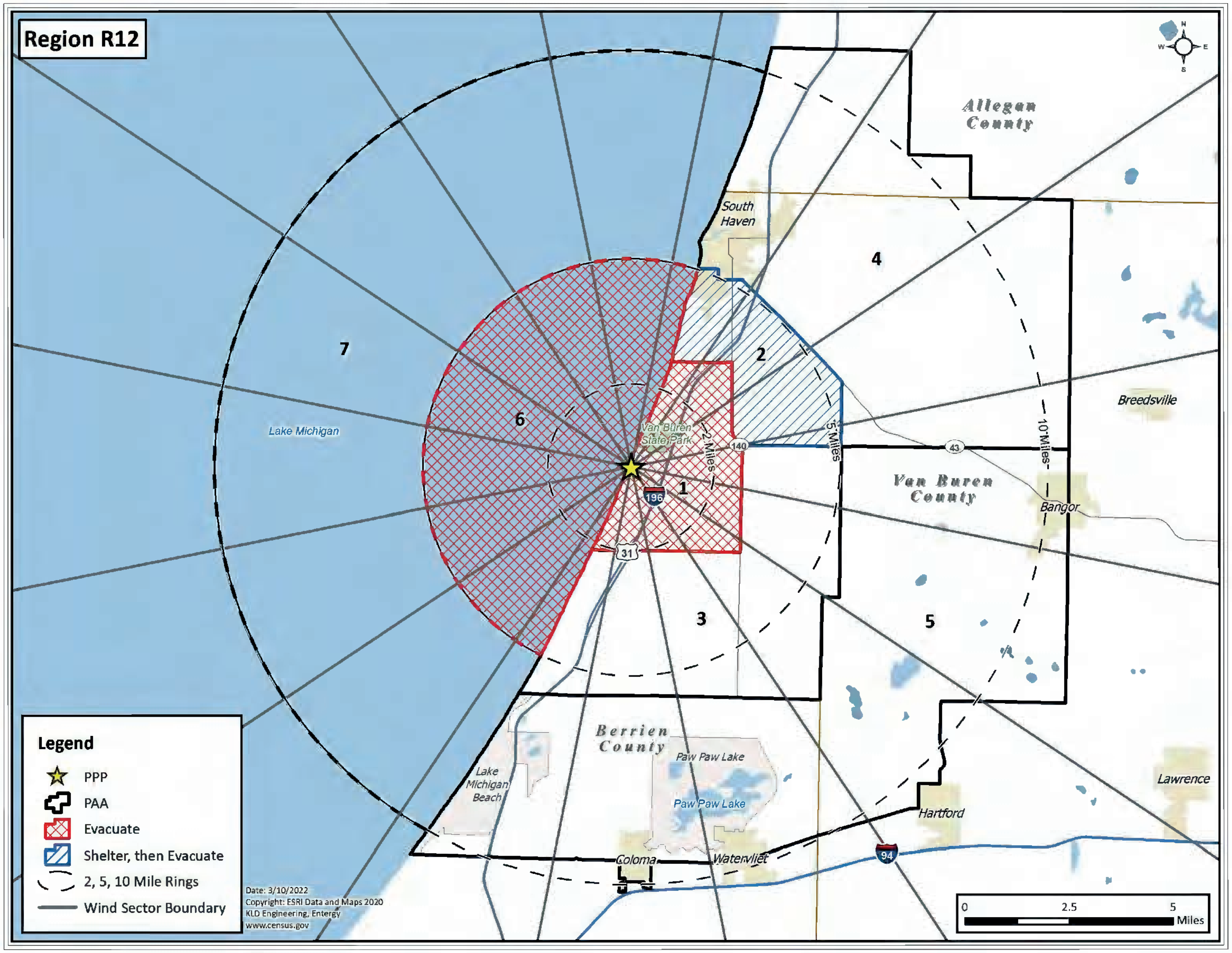


Figure H-12. Region R12

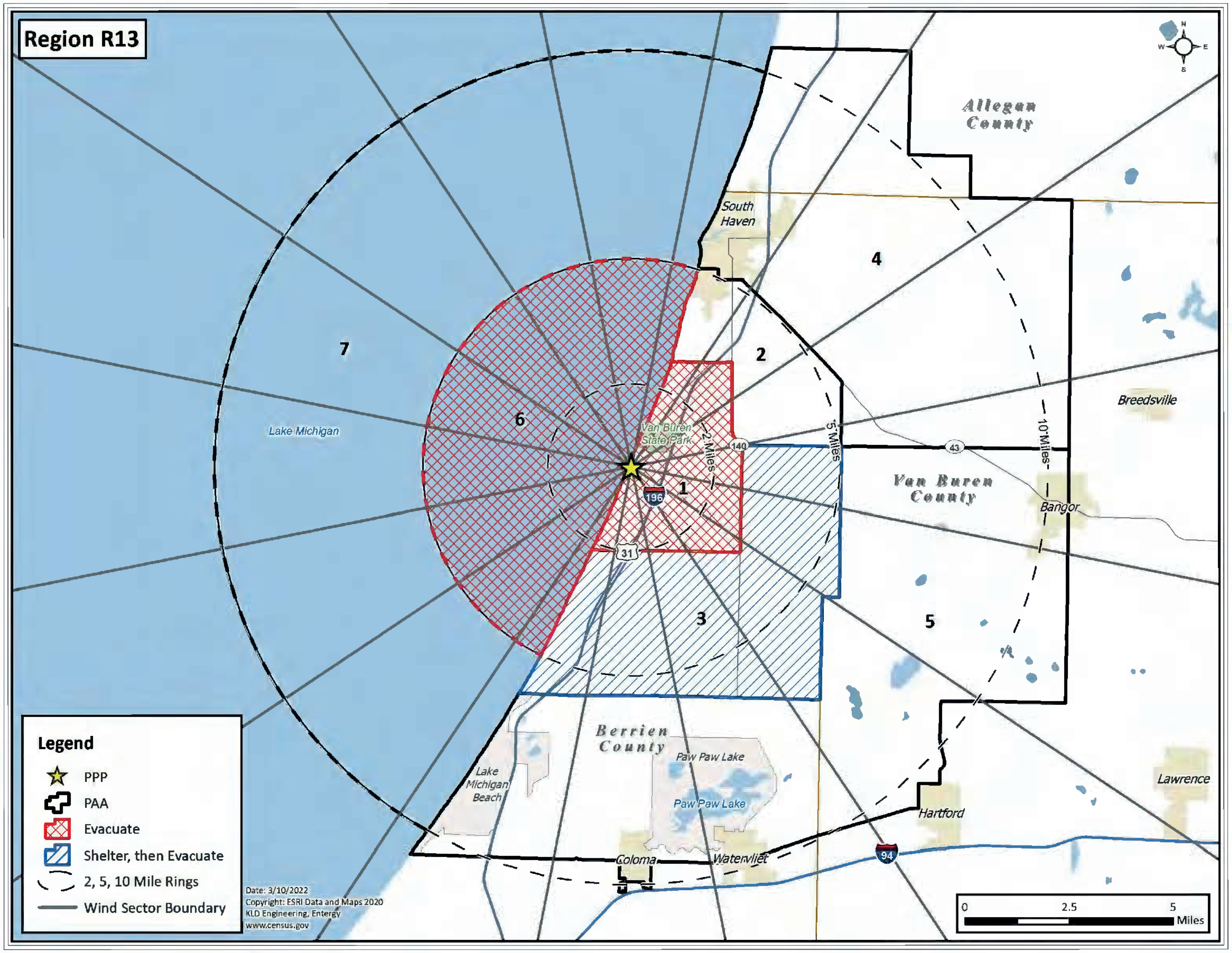


Figure H-13. Region R13

APPENDIX J

Representative Inputs to and Outputs from the DYNEV II System

J. REPRESENTATIVE INPUTS TO AND OUTPUTS FROM THE DYNEV II SYSTEM

This appendix presents data input to and output from the DYNEV II System.

Table J-1 provides source (vehicle loading) and destination information for several roadway segments (links) in the analysis network. In total, there are a total of 342 source links (origins) in the model. The source links are shown as centroid points in Figure J-1. On average, evacuees travel a straight-line distance of 6.72 miles to exit the study area.

Table J-2 provides network–wide statistics (average travel time, average delay, average speed and number of vehicles) for an evacuation of the entire EPZ (Region R03) for each scenario. As expected, rain and snow scenarios (Scenarios 2, 4, 7, 8, 10 and 11) exhibit slower average speeds, higher delays and longer average travel times than the corresponding good weather scenarios. When comparing scenario 13 (special event) and scenario 5, evacuees during the special event experience slower average speeds, longer delays and increased travel times as a result of the approximately the 10,000 additional evacuating vehicles attending the special event in South Haven. When comparing scenario 14 (roadway closure) and scenario 1, the lane closure on I-196 northbound reduces the average speed, causes longer delays and increases travel time.

Table J-3 provides statistics (average speed and travel time) for the major evacuation routes – Interstate 94, Blue Star Hwy, MI-43 Eastbound, and Interstate 196 – for an evacuation of the entire EPZ (Region R03) under Scenario 1 (summer, midweek, midday with good weather) conditions. These major evacuation routes do not experience significant traffic congestion except on their access ramps and in the small sections of roadway in population centers. There is evidence of some of this localized congestion in the speed and travel time trends along MI-43 Eastbound and Blue Star Hwy Northbound, while the remaining routes do not experience localized congestion and maintain relatively constant speeds throughout the evacuation.

Table J-4 provides the number of vehicles discharged and the cumulative percent of total vehicles discharged for each link exiting the analysis network, for an evacuation of the entire EPZ (Region R03) under Scenario 1 conditions.

Figure J-2 through Figure J-15 plot the trip generation time versus the ETE for each of the 14 Scenarios considered. The distance between the trip generation and ETE curves is the travel time. Plots of trip generation versus ETE are indicative of the level of traffic congestion during evacuation. For low population density sites, the curves are close together, indicating short travel times and minimal traffic congestion. For higher population density sites, the curves are farther apart indicating longer travel times and the presence of traffic congestion. As seen in Figure J-2 through Figure J-15, the curves are spatially separated as a result of the traffic congestion in the EPZ, which was discussed in detail in Section 7.3. As expected, the special event (Scenario 13) experiences the longest travel times (up to 1 hour and 30 minutes) due to the delays caused by the additional 10,000 vehicles evacuating from South Haven.

Table J-1. Sample Simulation Model Input

Route Name	Upstream Node	Downstream Node	Vehicles Entering Network on this Link	Directional Preference	Destination Nodes	Destination Capacity
Blue Star Hwy	96	322	2	S	8320	2,850
					8540	1,275
					8089	6,750
Blue Star Hwy	298	321	81	S	8320	2,850
					8540	1,275
					8089	6,750
Co Rd 388	192	193	97	NE	8200	1,275
					8554	1,275
					8635	1,275
Meijer Dr	567	566	239	NE	8060	4,500
					8554	1,275
					8635	1,275
Co Rd 372	233	383	463	S	8320	2,850
					8540	1,275
					8089	6,750
Coloma Rd	375	376	81	S	8540	1,275
					8089	6,750
62nd St	523	524	47	E	8634	1,275
					8082	4,500
					8557	1,275
109th Ave	228	461	14	NE	8554	1,275
					8635	1,275
SR 63	316	317	49	SW	8320	2,850
Co Rd 215	446	455	0	NE	8554	1,275
					8635	1,275

Table J-2. Selected Model Outputs for the Evacuation of the Entire EPZ (Region R03)

Scenario	1	2	3	4	5	6	7
Network-Wide Average Travel Time (Min/Veh-Mi)	1.1	1.2	1.2	1.5	1.4	1.0	1.2
Network-Wide Average Delay Time (Min/Veh-Mi)	0.0	0.0	0.0	0.3	0.2	0.0	0.0
Network-Wide Average Speed (mph)	57.1	50.3	48.3	41.4	44.3	58.7	52.1
Total Vehicles Exiting Network	35,116	35,240	36,818	36,948	30,346	31,485	31,590
Scenario	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Network-Wide Average Travel Time (Min/Veh-Mi)	1.3	1.1	1.2	1.3	1.2	2.2	1.4
Network-Wide Average Delay Time (Min/Veh-Mi)	0.1	0.0	0.0	0.1	0.0	1.0	0.2
Network-Wide Average Speed (mph)	46.5	55.9	49.3	45.6	51.8	27.0	44.1
Total Vehicles Exiting Network	31,600	31,594	31,731	31,743	26,757	40,788	35,120

Table J-3. Average Speed (mph) and Travel Time (min) for Major Evacuation Routes (Region R03, Scenario 1)

		Elapsed Time (hours)									
		1:00		2:00		3:00		4:00		4:55	
Route Name	Length (miles)	Speed (mph)	Travel Time (min)	Speed	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed	Travel Time
I-94 Eastbound	22.4	69.8	19.2	66.2	20.3	73.7	18.2	71.3	18.8	73.7	18.2
I-94 Westbound	22.4	72.7	18.5	72.8	18.4	73.6	18.2	72.6	18.5	73.7	18.2
Blue Star Hwy Southbound	15.4	57.1	16.2	57.4	16.1	57.6	16.0	57.3	16.1	57.6	16.0
Blue Star Hwy Northbound	17.7	50.1	21.1	51.1	20.7	51.4	20.6	52.2	20.3	53.1	20.0
MI-43 Eastbound	17.6	47.6	22.2	47.2	22.3	47.9	22.0	46.9	22.5	49.0	21.5
I-196 Northbound	34.8	71.0	29.4	72.6	28.8	72.7	28.7	72.1	29.0	68.9	30.3
I-196 Southbound	34.7	71.9	28.9	71.9	29.0	72.5	28.7	72.0	28.9	72.5	28.7

Table J-4. Simulation Model Outputs at Network Exit Links for Region R03, Scenario 1

Route Name	Upstream Node	Downstream Node	Elapsed Time (hours)				
			1	2	3	4	5
			Cumulative Vehicles Discharged by the Indicated Time				
			Cumulative Percent of Vehicles Discharged by the Indicated Time Interval				
I-196 NB	59	60	1,977	5,356	6,424	6,856	6,918
			21.7%	21.0%	19.6%	19.7%	19.7%
I-94 EB	80	81	1,997	6,314	8,067	8,229	8,270
			22.0%	24.7%	24.6%	23.7%	23.6%
I-94 WB	88	89	2,987	6,153	7,937	8,318	8,387
			32.8%	24.1%	24.2%	23.9%	23.9%
MI-43 EB	190	191	217	1,008	1,372	1,494	1,522
			2.4%	3.9%	4.2%	4.3%	4.3%
109th Ave EB	229	554	183	735	991	1,083	1,099
			2.0%	2.9%	3.0%	3.1%	3.1%
56th St NB	229	635	110	475	645	708	718
			1.2%	1.9%	2.0%	2.0%	2.0%
MI-63 SB	319	320	163	631	830	909	926
			1.8%	2.5%	2.5%	2.6%	2.6%
W Main St WB	540	558	242	859	1,132	1,216	1,236
			2.7%	3.4%	3.5%	3.5%	3.5%
Blue Star Hwy NB	552	553	405	1,067	1,308	1,408	1,425
			4.5%	4.2%	4.0%	4.1%	4.1%
Red Arrow Hwy EB	556	557	81	578	808	874	884
			0.9%	2.3%	2.5%	2.5%	2.5%
MI-140 SB	624	226	523	1,222	1,699	1,901	1,952
			5.7%	4.8%	5.2%	5.5%	5.6%
Co Rd 388 EB	625	200	81	363	503	558	570
			0.9%	1.4%	1.5%	1.6%	1.6%
US 31 SB	628	629	93	400	562	622	634
			1.0%	1.6%	1.7%	1.8%	1.8%
MI-51 SB	633	634	43	394	527	569	576
			0.5%	1.5%	1.6%	1.6%	1.6%

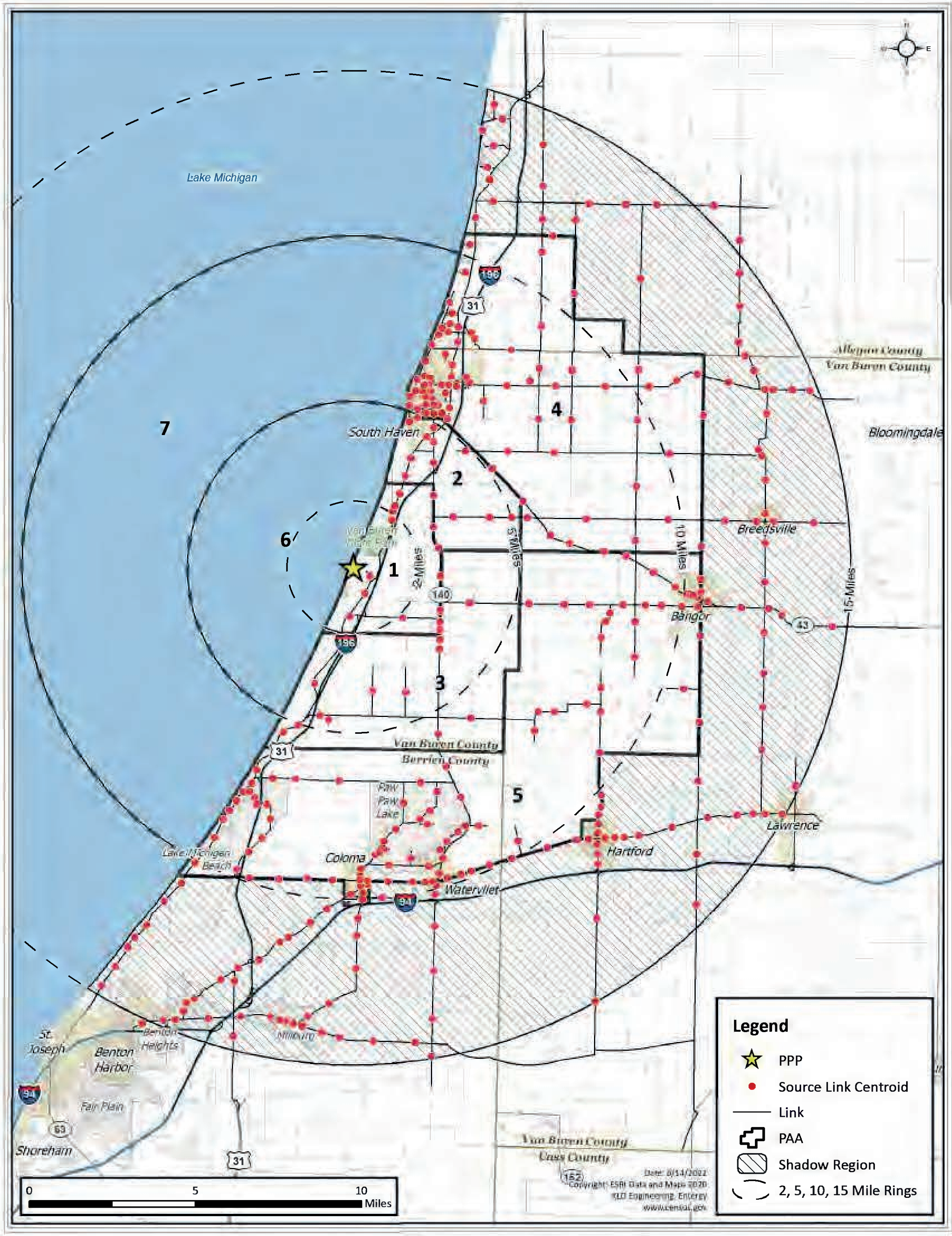


Figure J-1. Network Sources/Origins

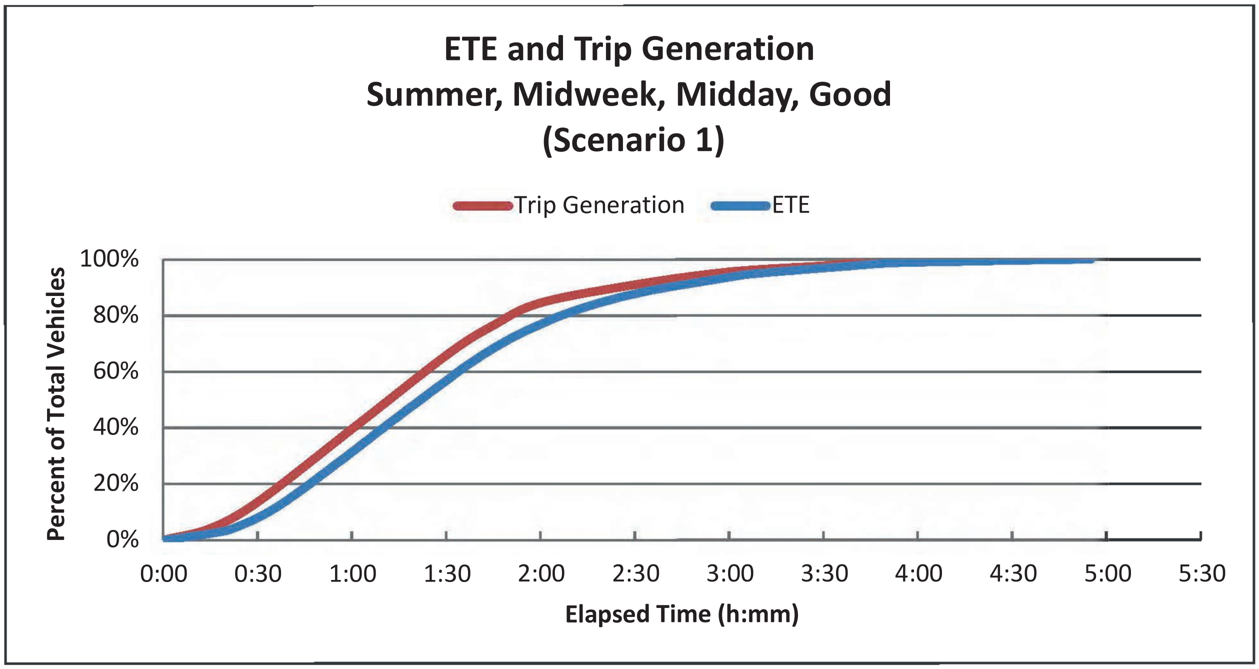


Figure J-2. ETE and Trip Generation: Summer, Midweek, Midday, Good Weather (Scenario 1)

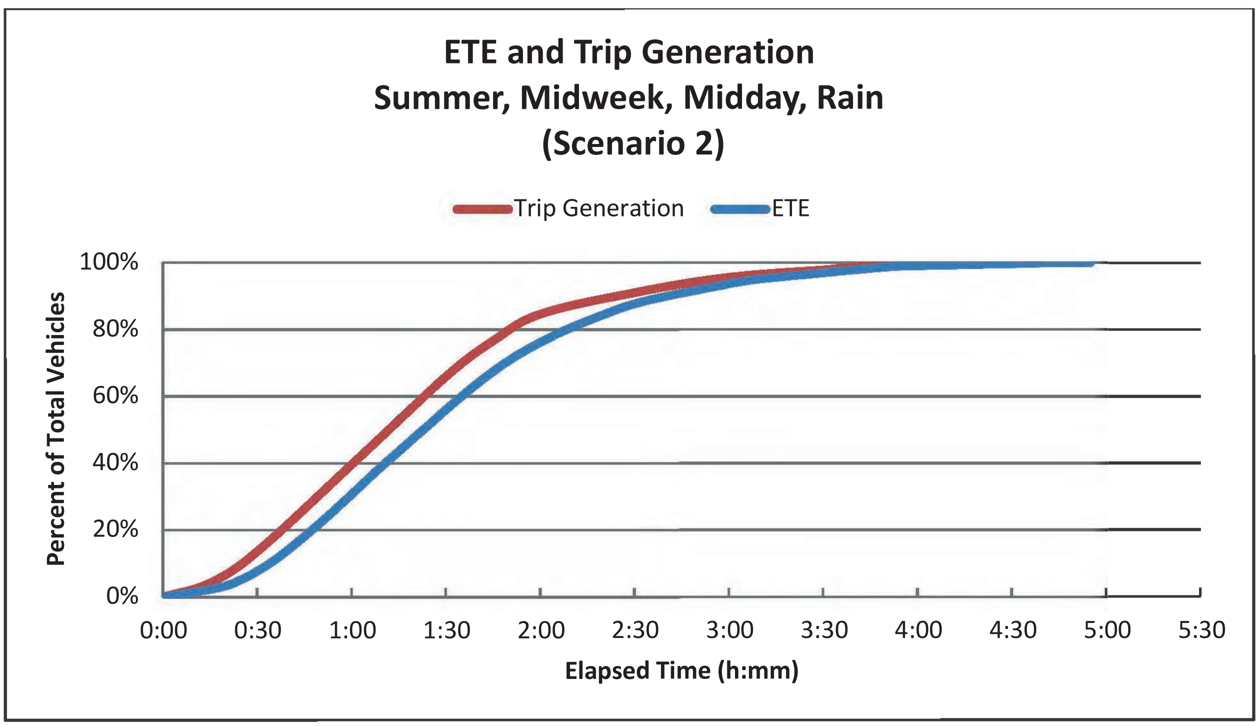


Figure J-3. ETE and Trip Generation: Summer, Midweek, Midday, Rain (Scenario 2)

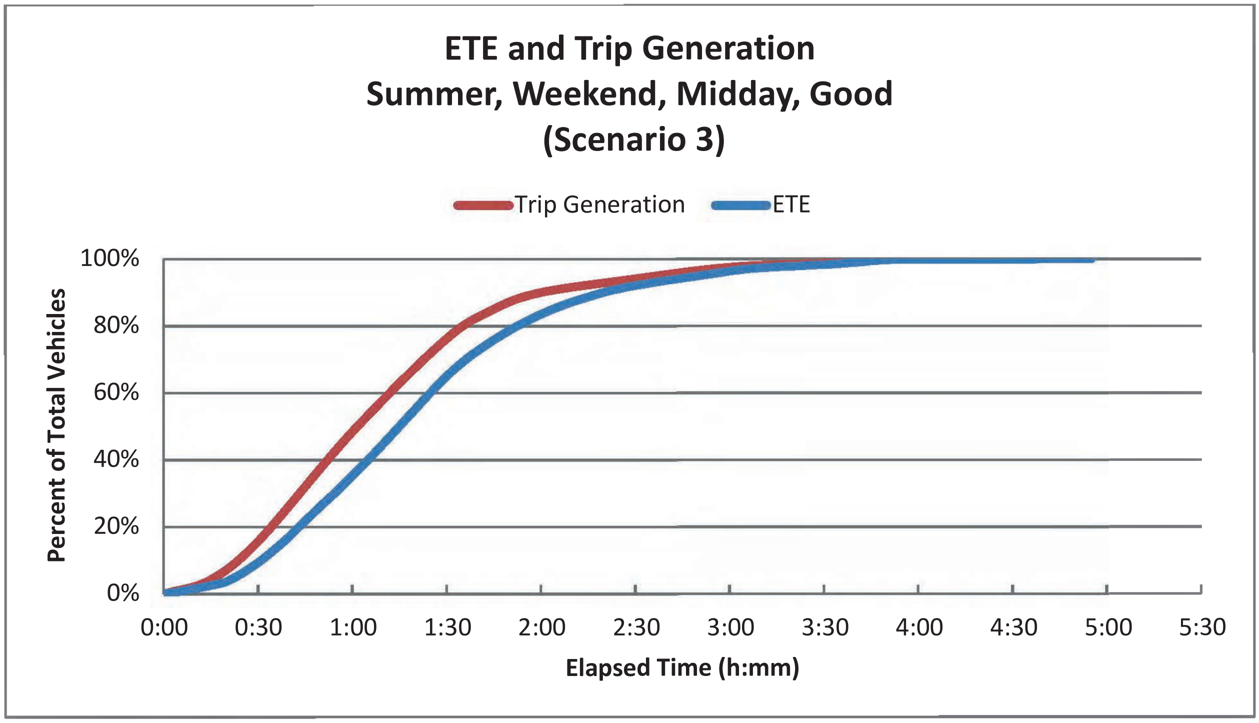


Figure J-4. ETE and Trip Generation: Summer, Weekend, Midday, Good Weather (Scenario 3)

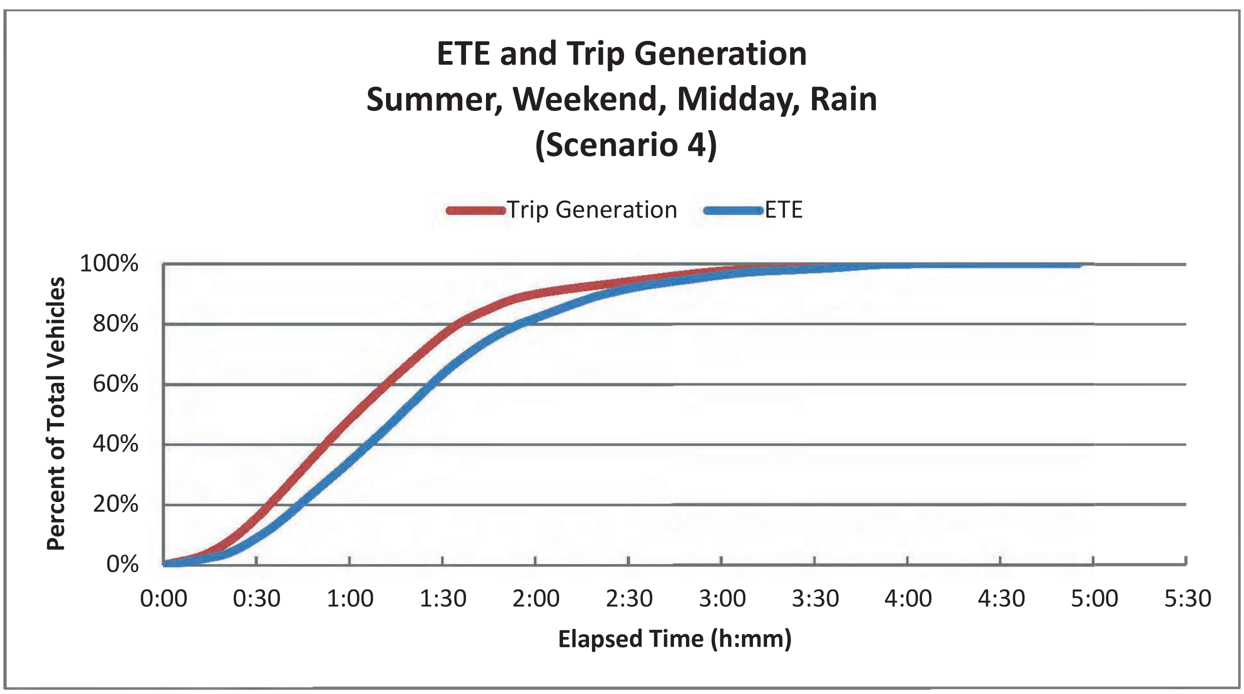


Figure J-5. ETE and Trip Generation: Summer, Weekend, Midday, Rain (Scenario 4)

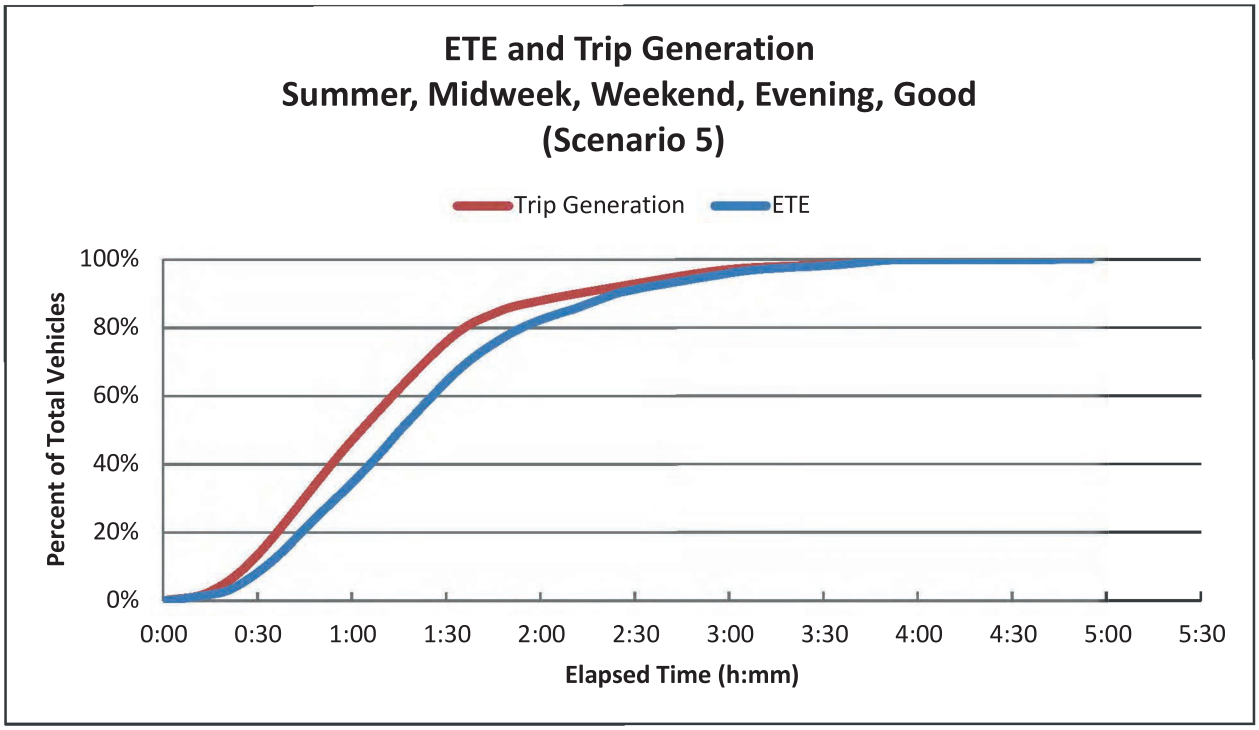


Figure J-6. ETE and Trip Generation: Summer, Midweek, Weekend, Evening, Good Weather (Scenario 5)

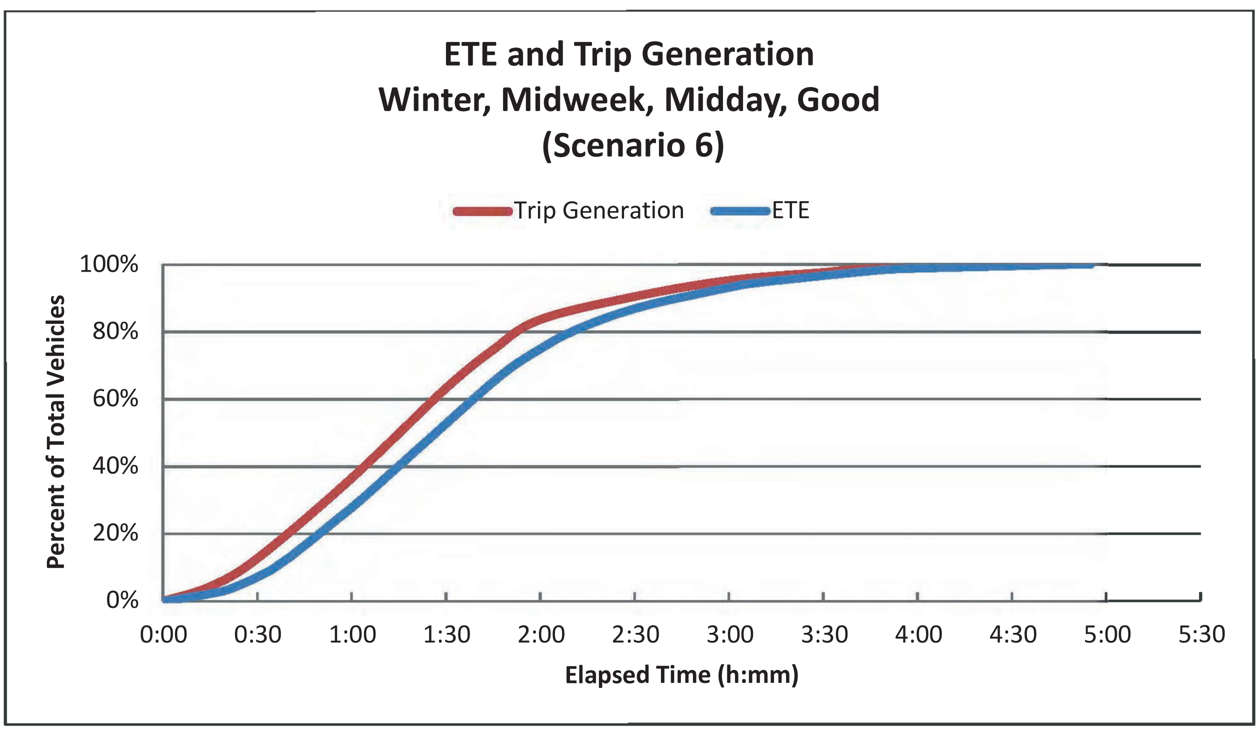


Figure J-7. ETE and Trip Generation: Winter, Midweek, Midday, Good Weather (Scenario 6)

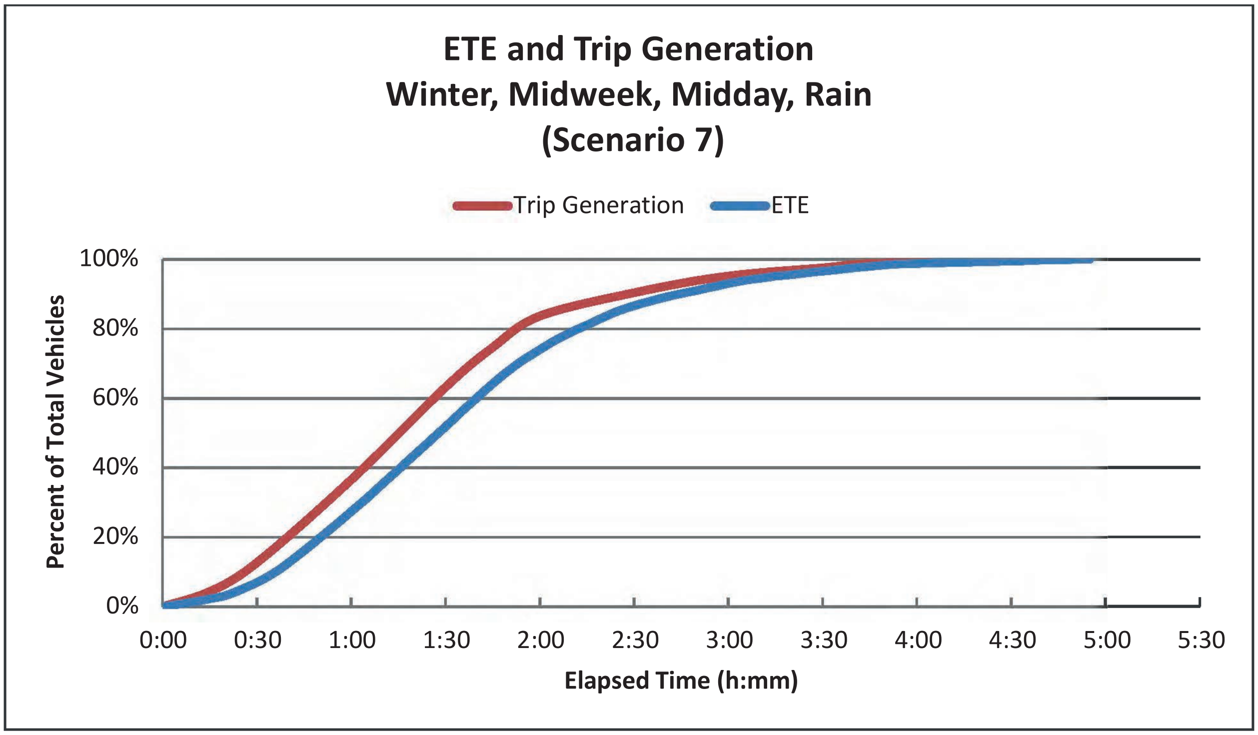


Figure J-8. ETE and Trip Generation: Winter, Midweek, Midday, Rain (Scenario 7)

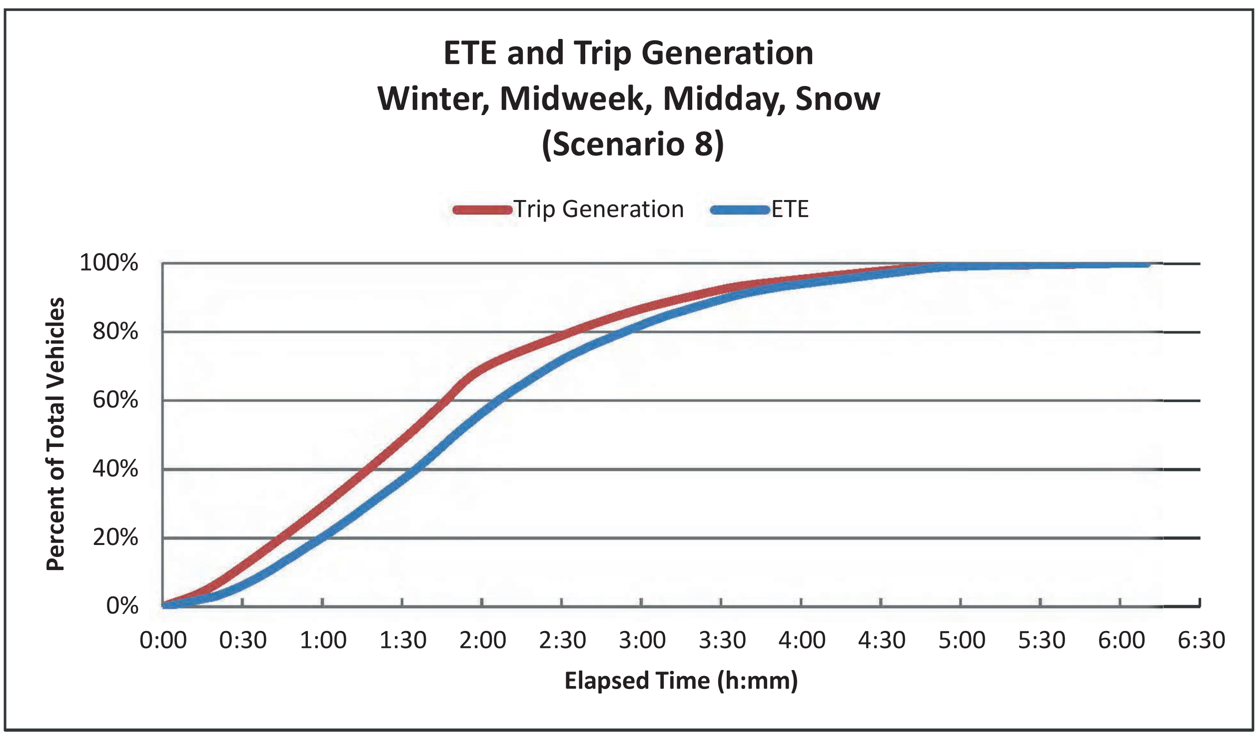


Figure J-9. ETE and Trip Generation: Winter, Midweek, Midday, Snow (Scenario 8)

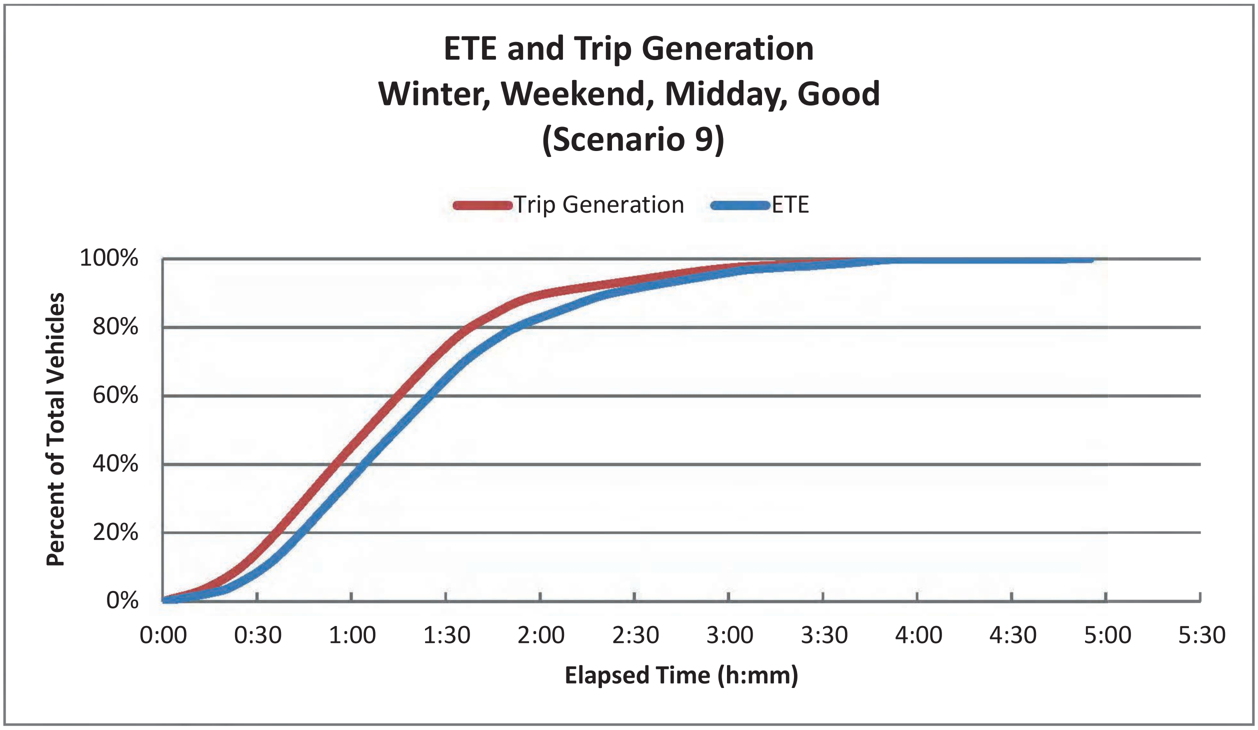


Figure J-10. ETE and Trip Generation: Winter, Weekend, Midday, Good Weather (Scenario 9)

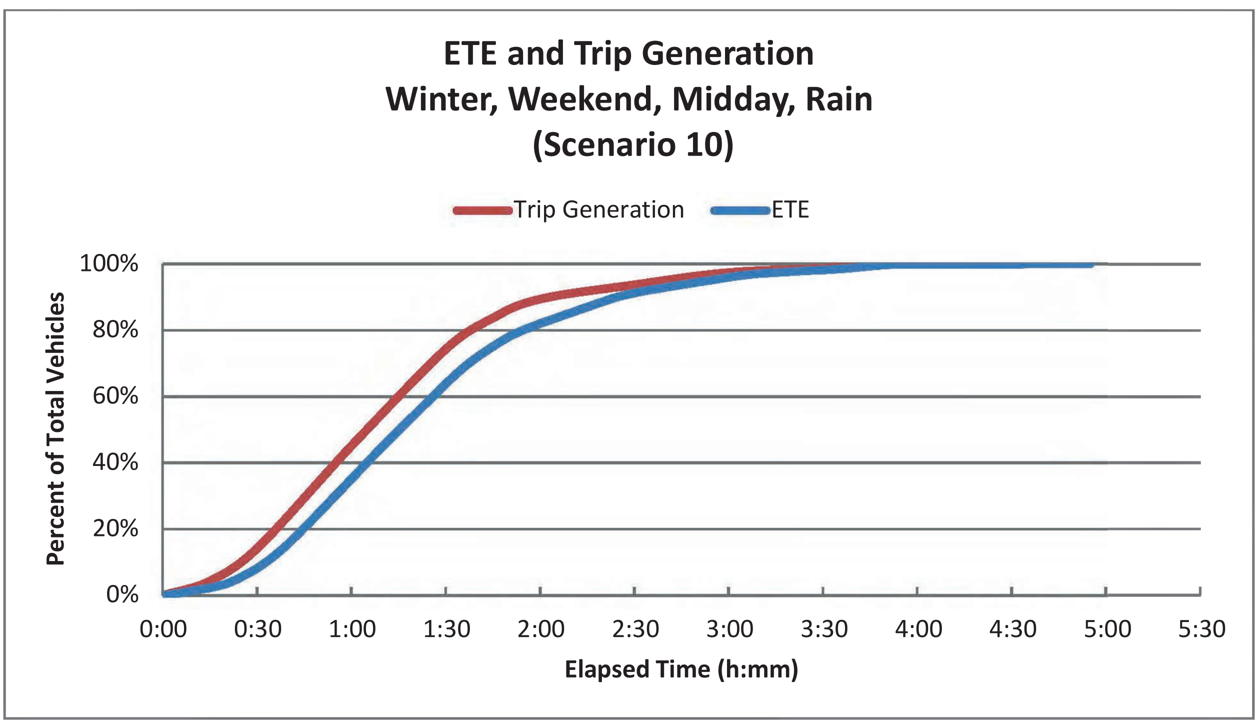


Figure J-11. ETE and Trip Generation: Winter, Weekend, Midday, Rain (Scenario 10)

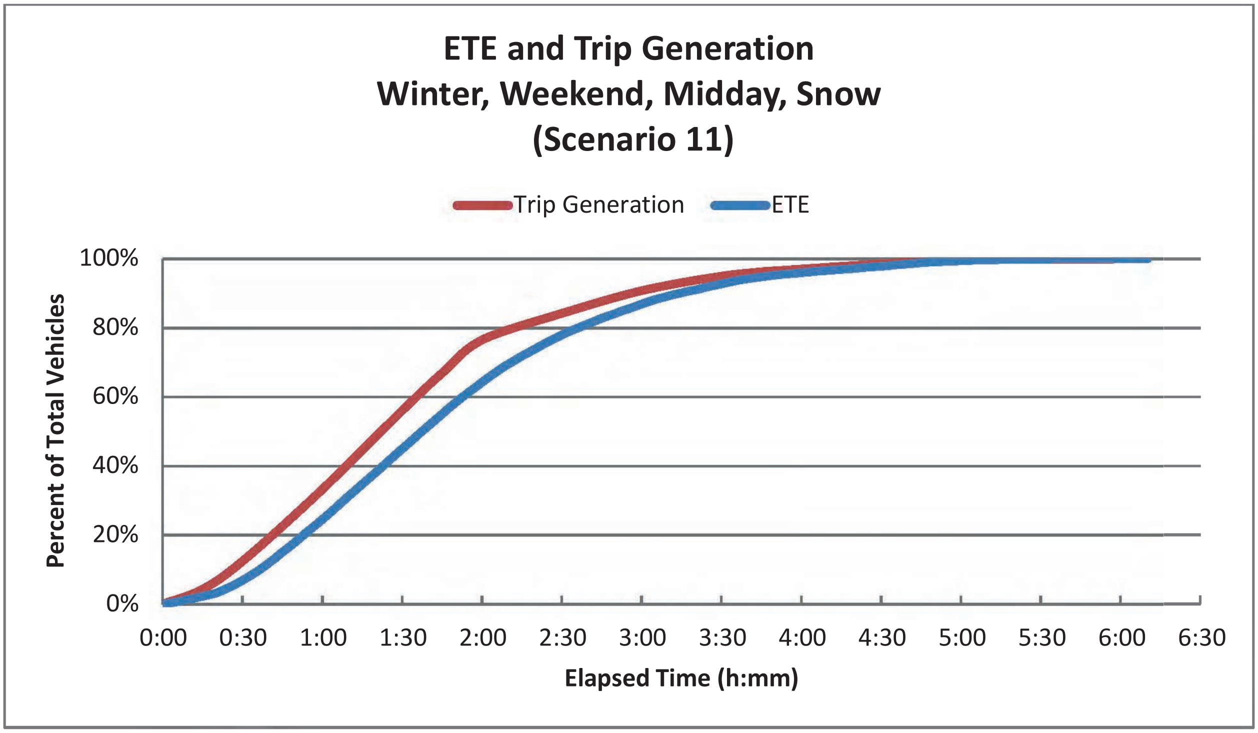


Figure J-12. ETE and Trip Generation: Winter, Weekend, Midday, Snow (Scenario 11)

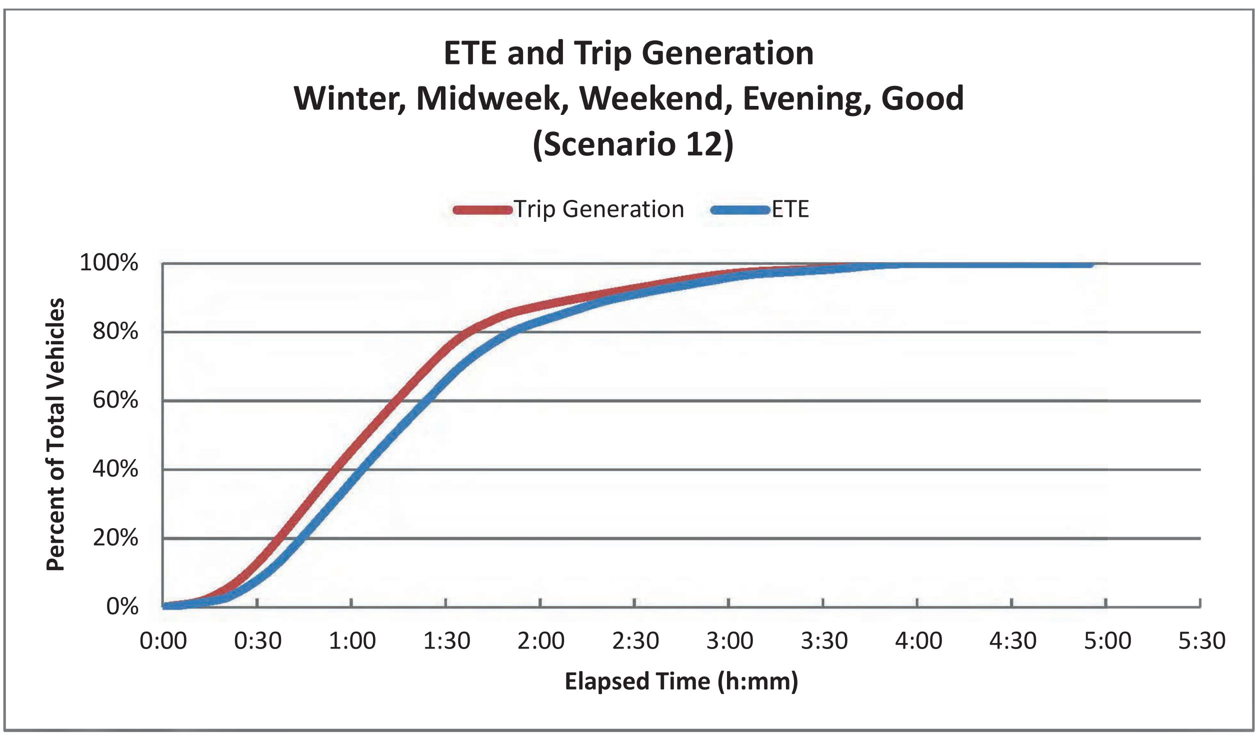


Figure J-13. ETE and Trip Generation: Winter, Midweek, Weekend, Evening, Good Weather (Scenario 12)

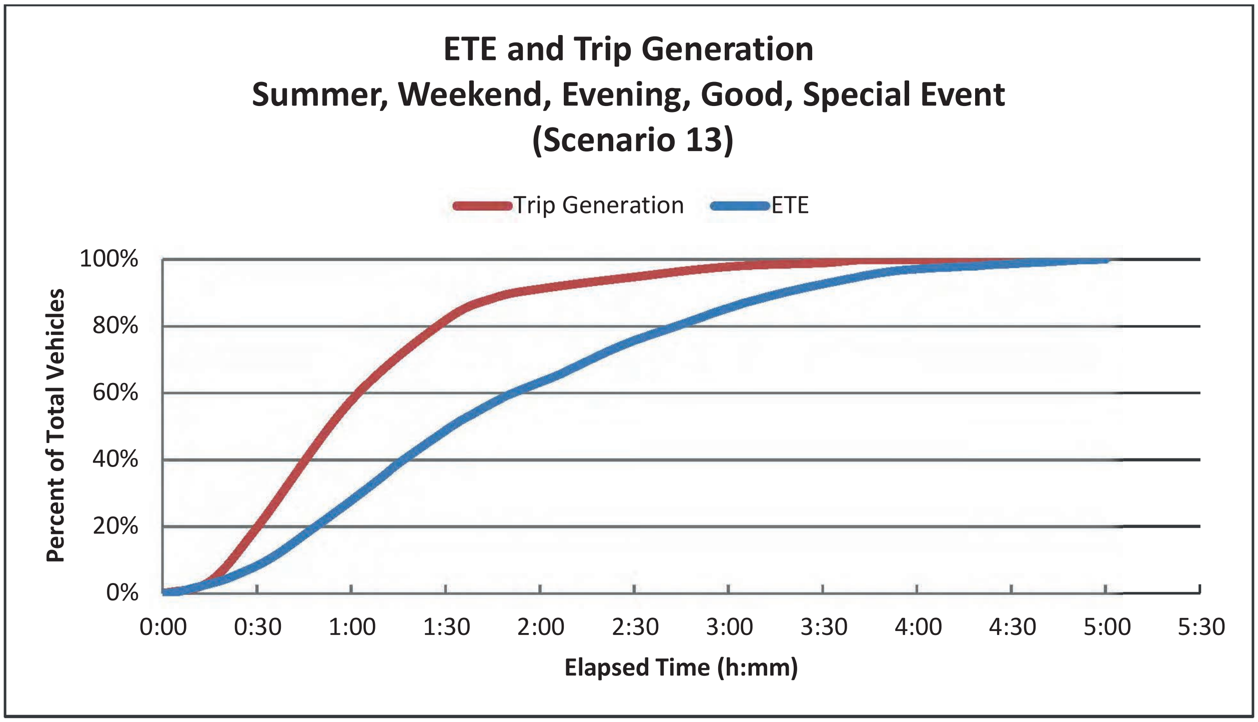


Figure J-14. ETE and Trip Generation: Summer, Weekend, Evening, Good Weather, Special Event (Scenario 13)

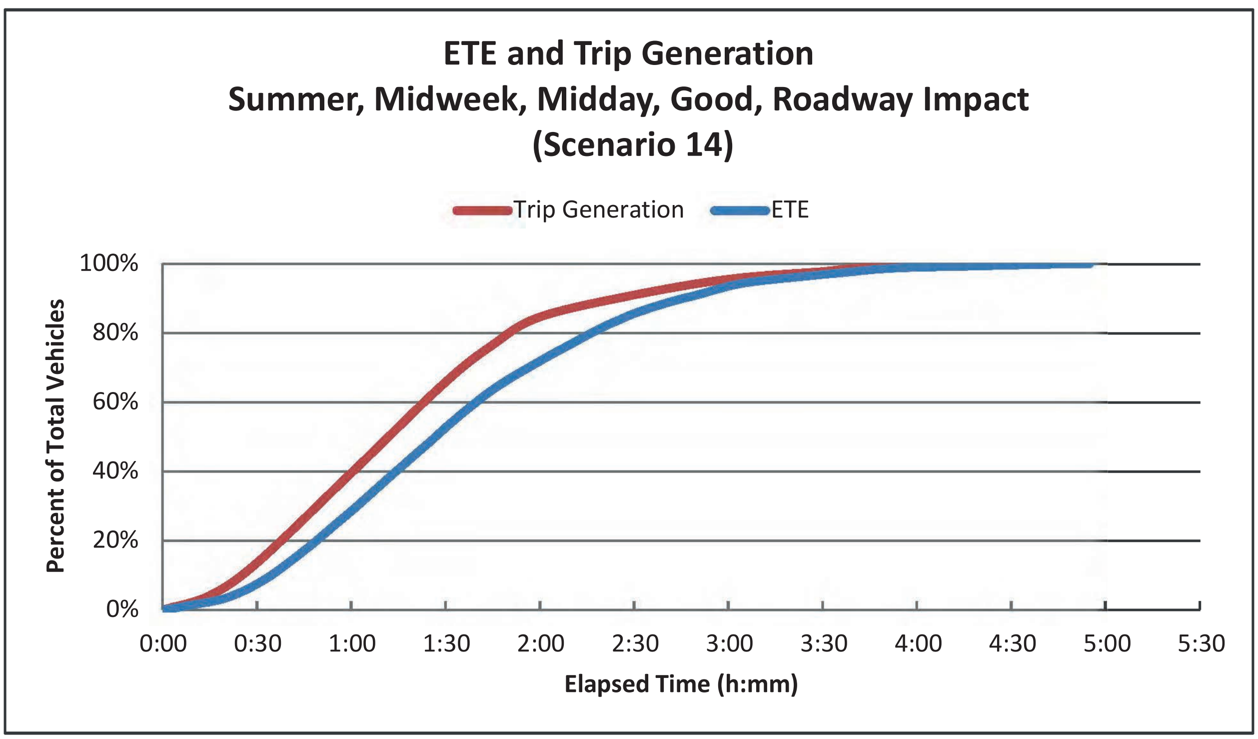


Figure J-15. ETE and Trip Generation: Summer, Midweek, Midday, Good Weather, Roadway Impact (Scenario 14)

APPENDIX K

Evacuation Roadway Network

K. EVACUATION ROADWAY NETWORK

As discussed in Section 1.3, a link-node analysis network was constructed to model the roadway network within the study area. Figure K-1 provides an overview of the link-node analysis network. The figure has been divided up into 30 more detailed figures (Figure K-2 through Figure K-31) which show each of the links and nodes in the network.

The analysis network was calibrated using observations made during the field survey conducted in March 2021.

Table K-1 summarizes the number of nodes by the type of control (stop sign, yield sign, pre-timed signal, actuated signal, access control point [ACP], uncontrolled).

Table K-1. Summary of Nodes by the Type of Control

Control Type	Number of Nodes
Uncontrolled	476
Pretimed	4
Actuated	8
Stop	96
ACP	40
Yield	6
Total:	**630**

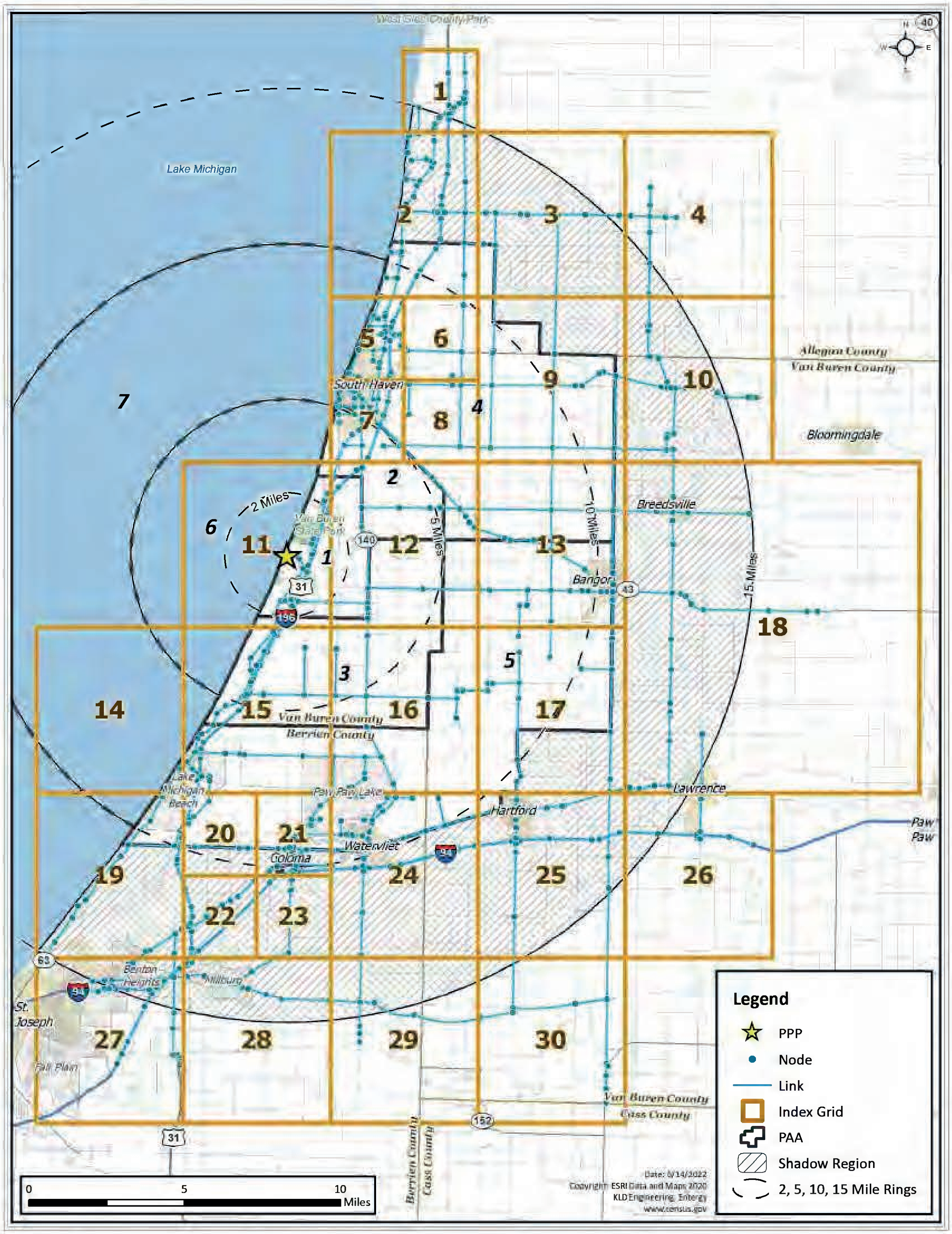


Figure K-1. PPP Link-Node Analysis Network

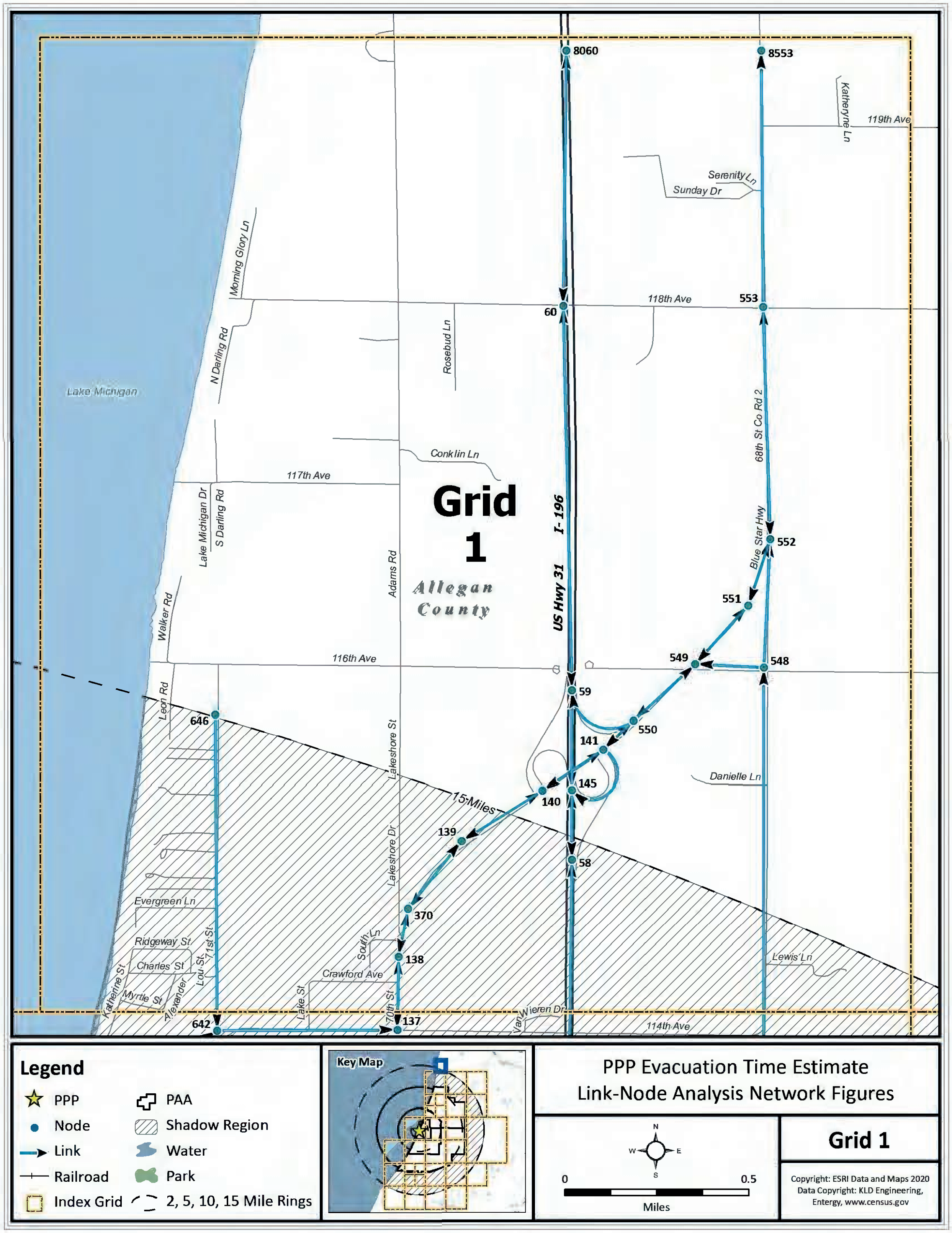


Figure K-2. Link-Node Analysis Network – Grid 1

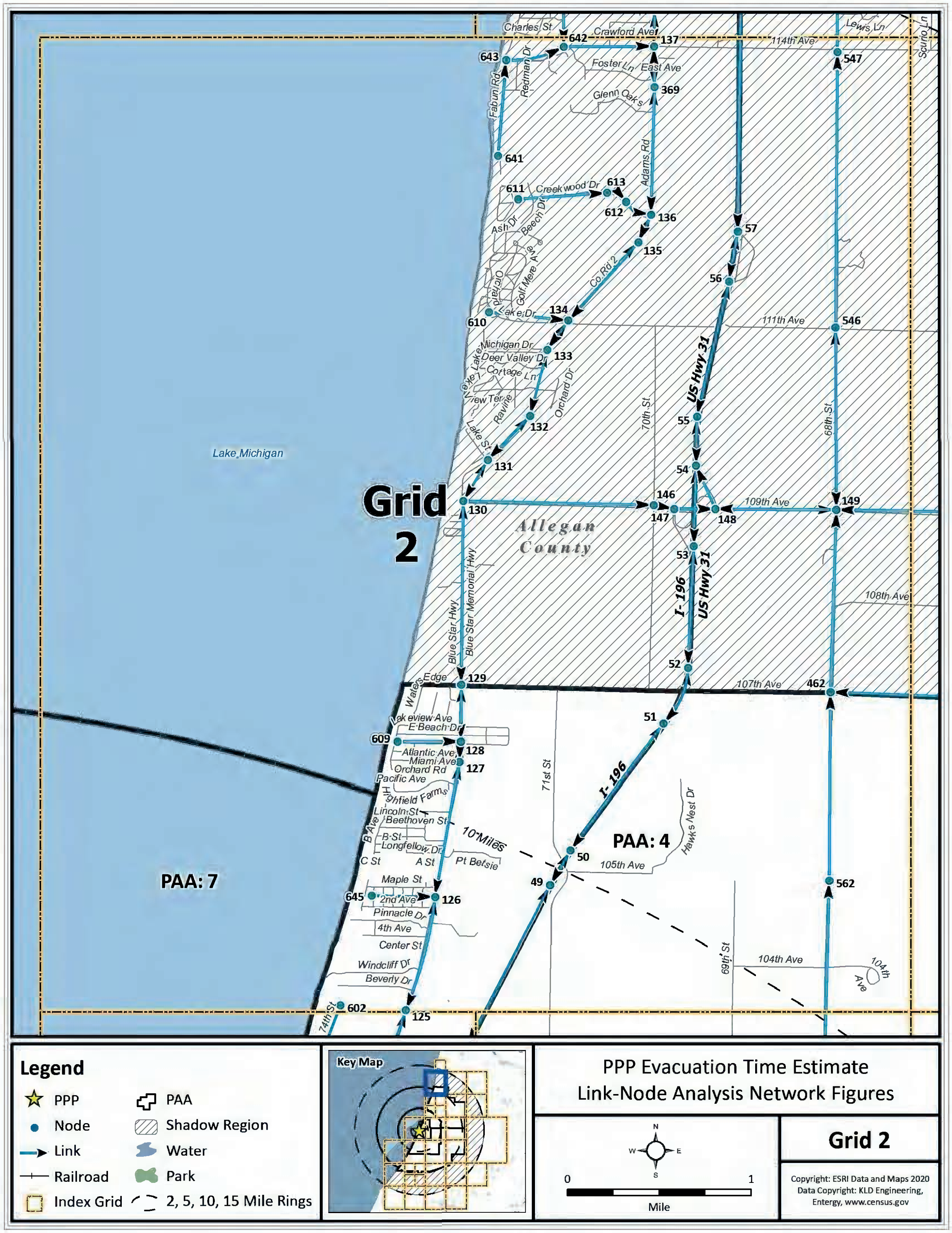


Figure K-3. Link-Node Analysis Network – Grid 2

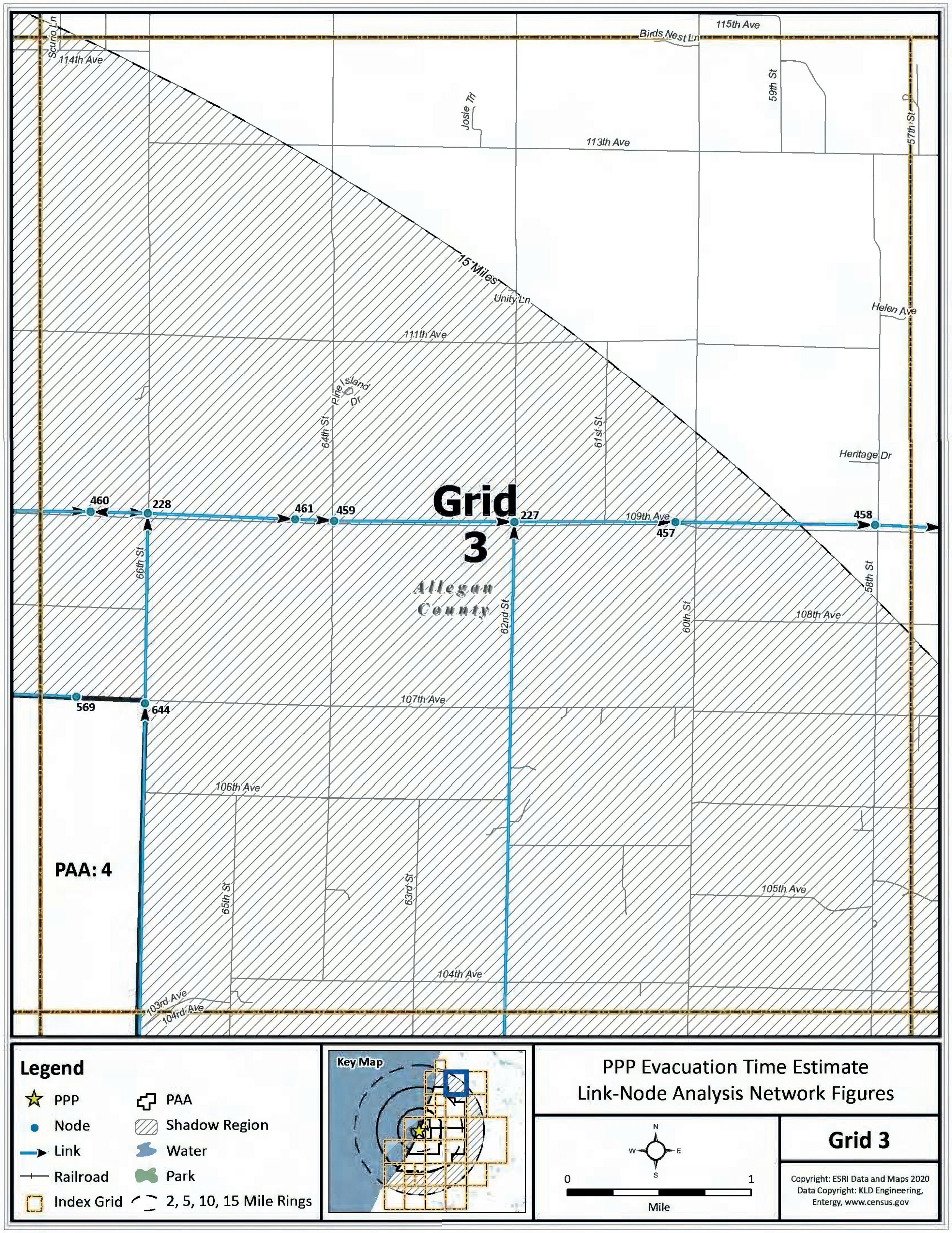


Figure K-4. Link-Node Analysis Network – Grid 3

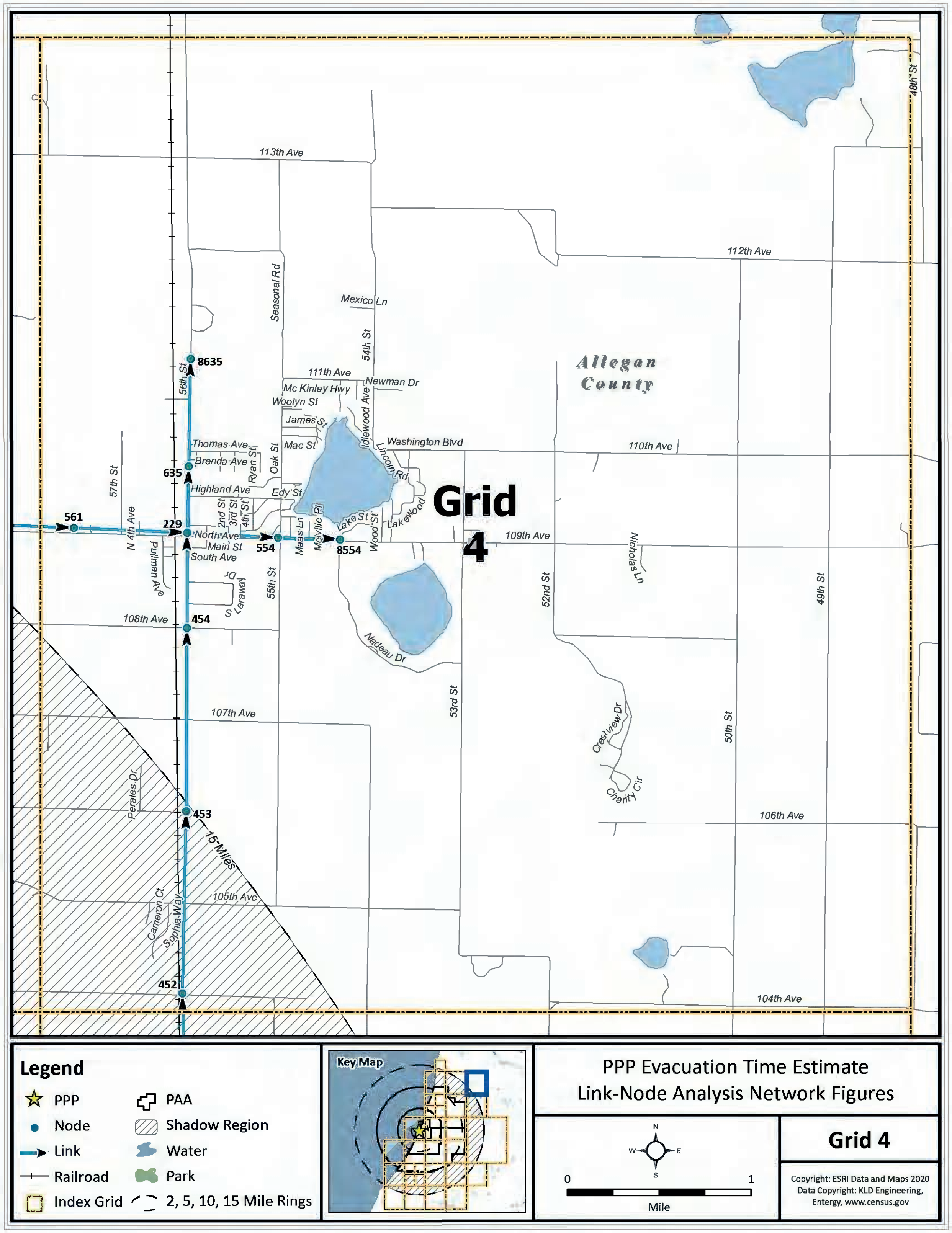


Figure K-5. Link-Node Analysis Network – Grid 4

Figure K-6. Link-Node Analysis Network – Grid 5

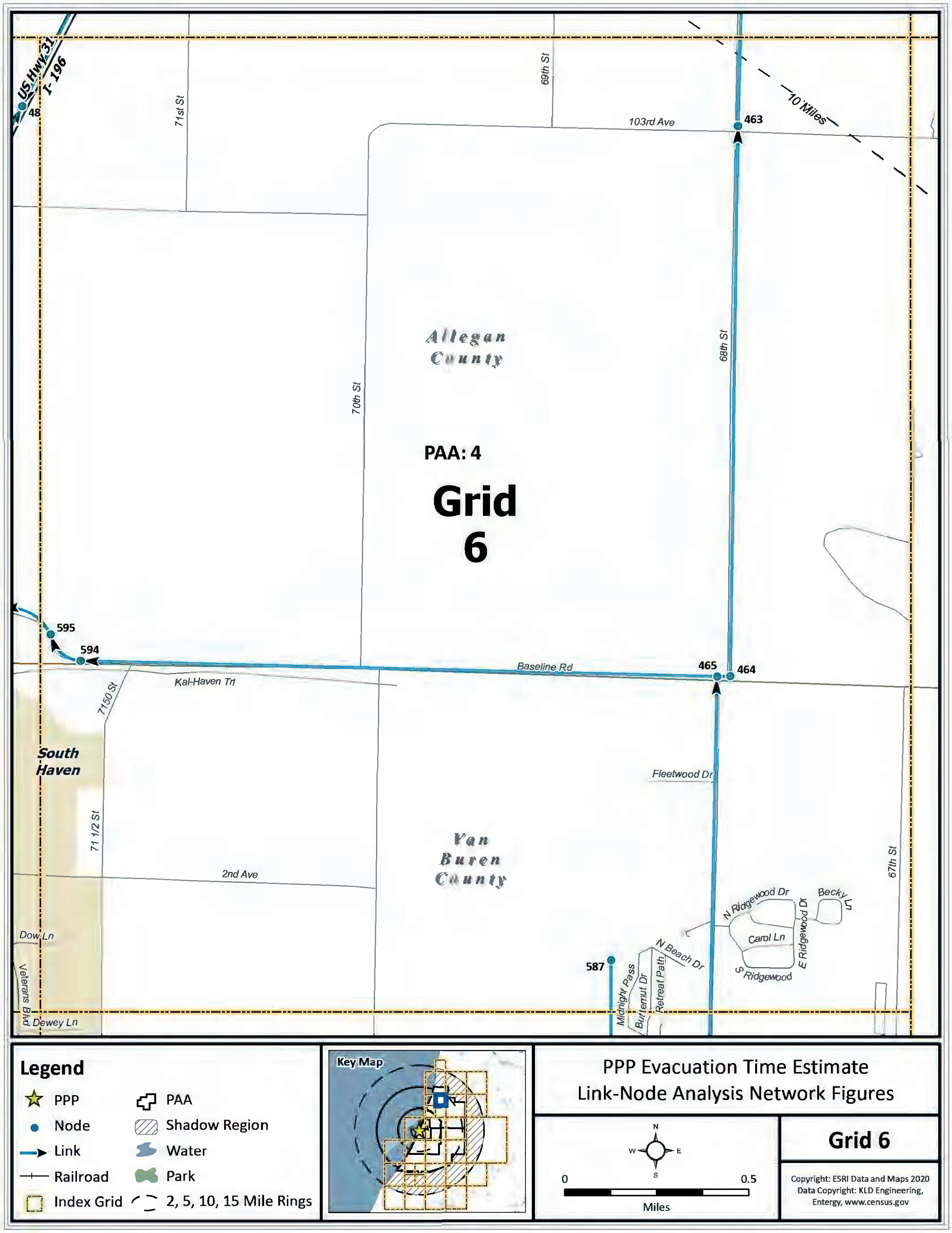


Figure K-7. Link-Node Analysis Network – Grid 6

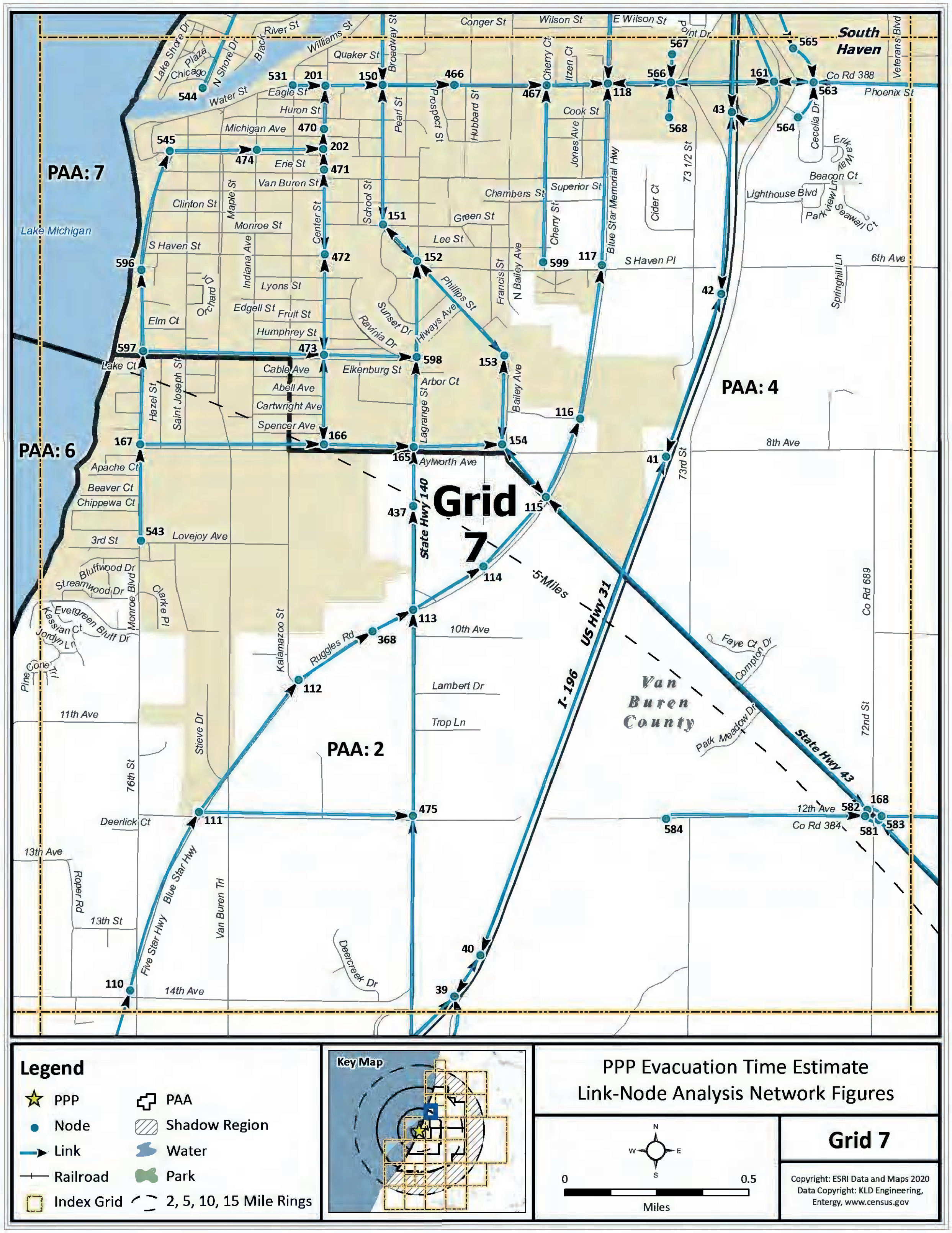


Figure K-8. Link-Node Analysis Network – Grid 7

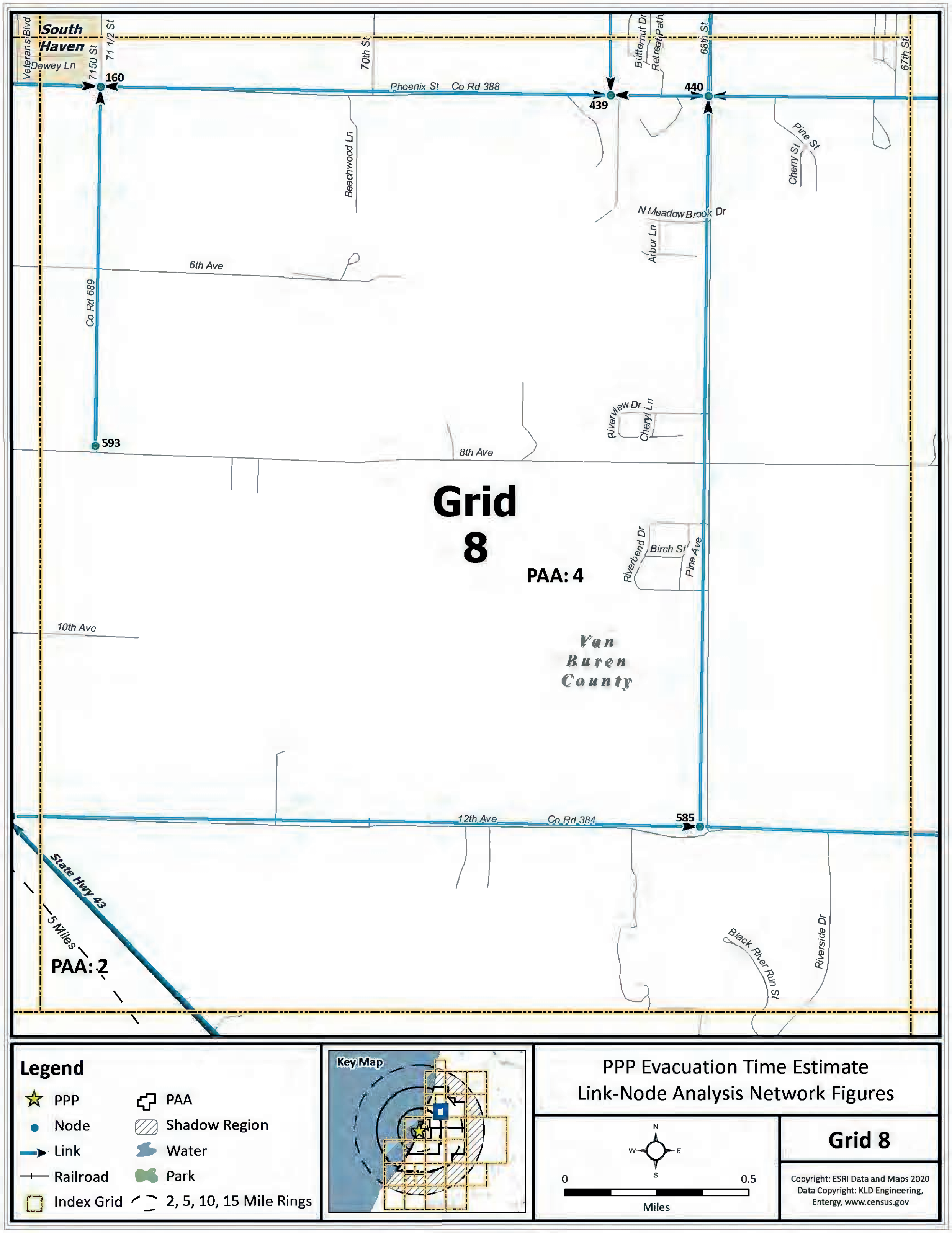


Figure K-9. Link-Node Analysis Network – Grid 8

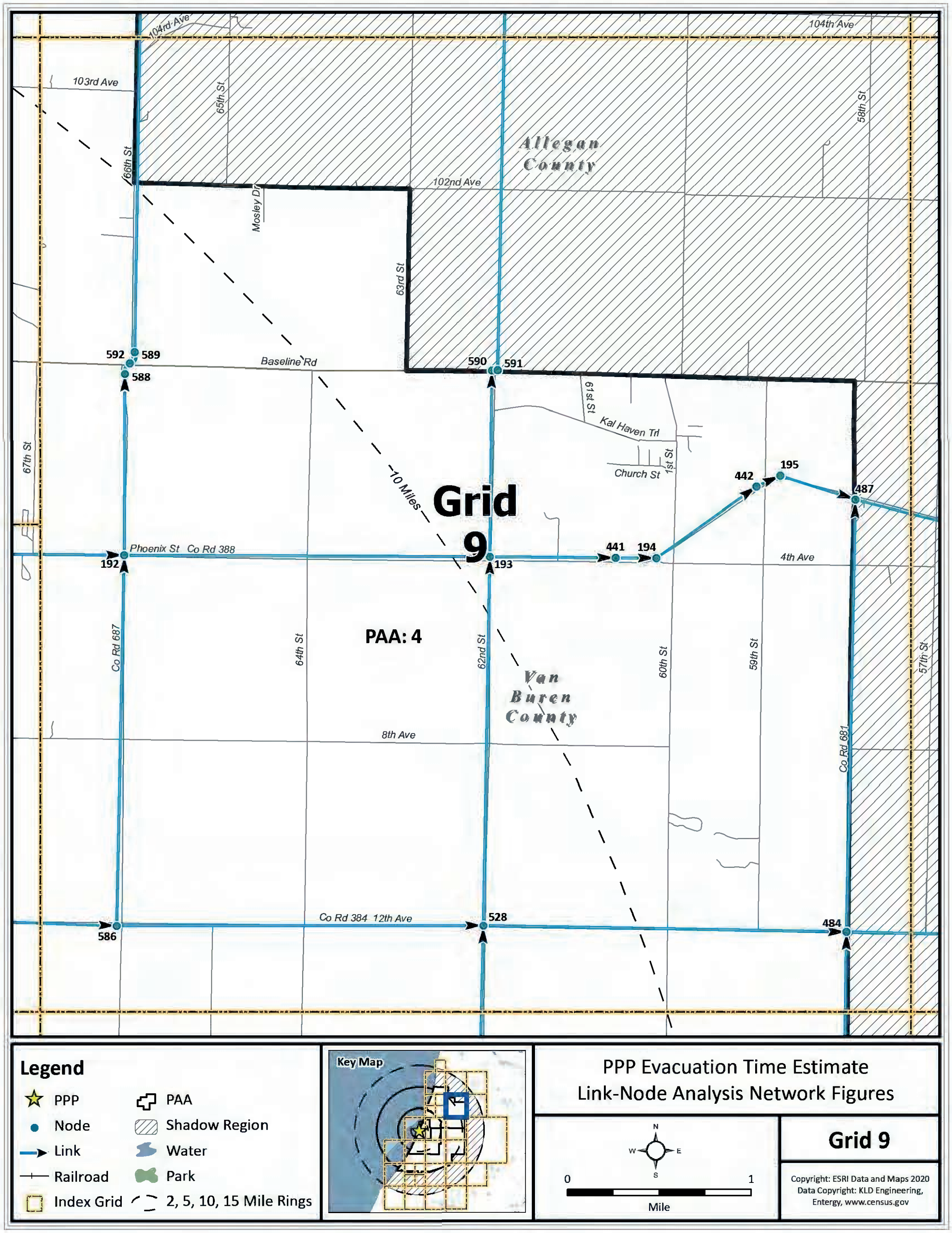


Figure K-10. Link-Node Analysis Network – Grid 9

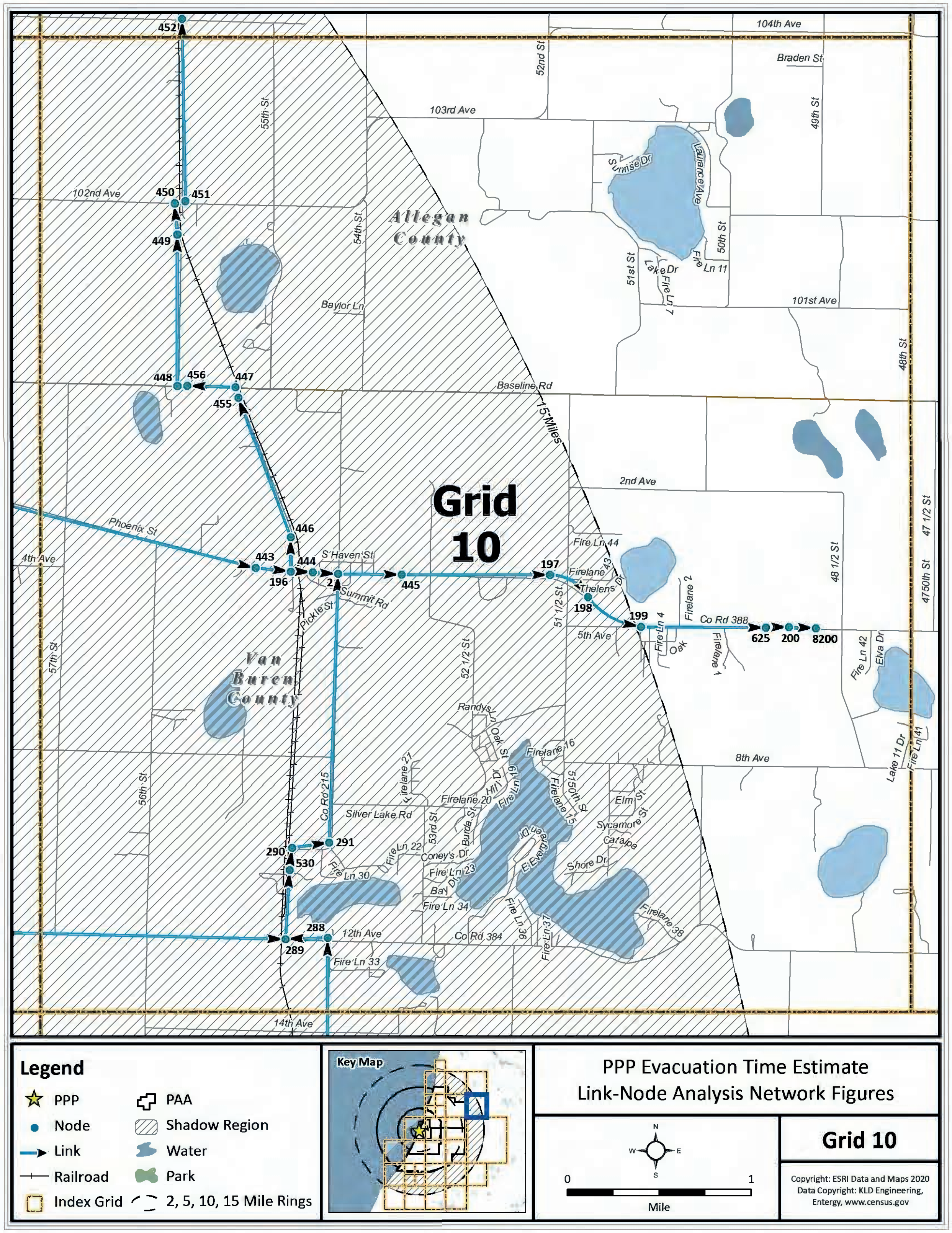


Figure K-11. Link-Node Analysis Network – Grid 10

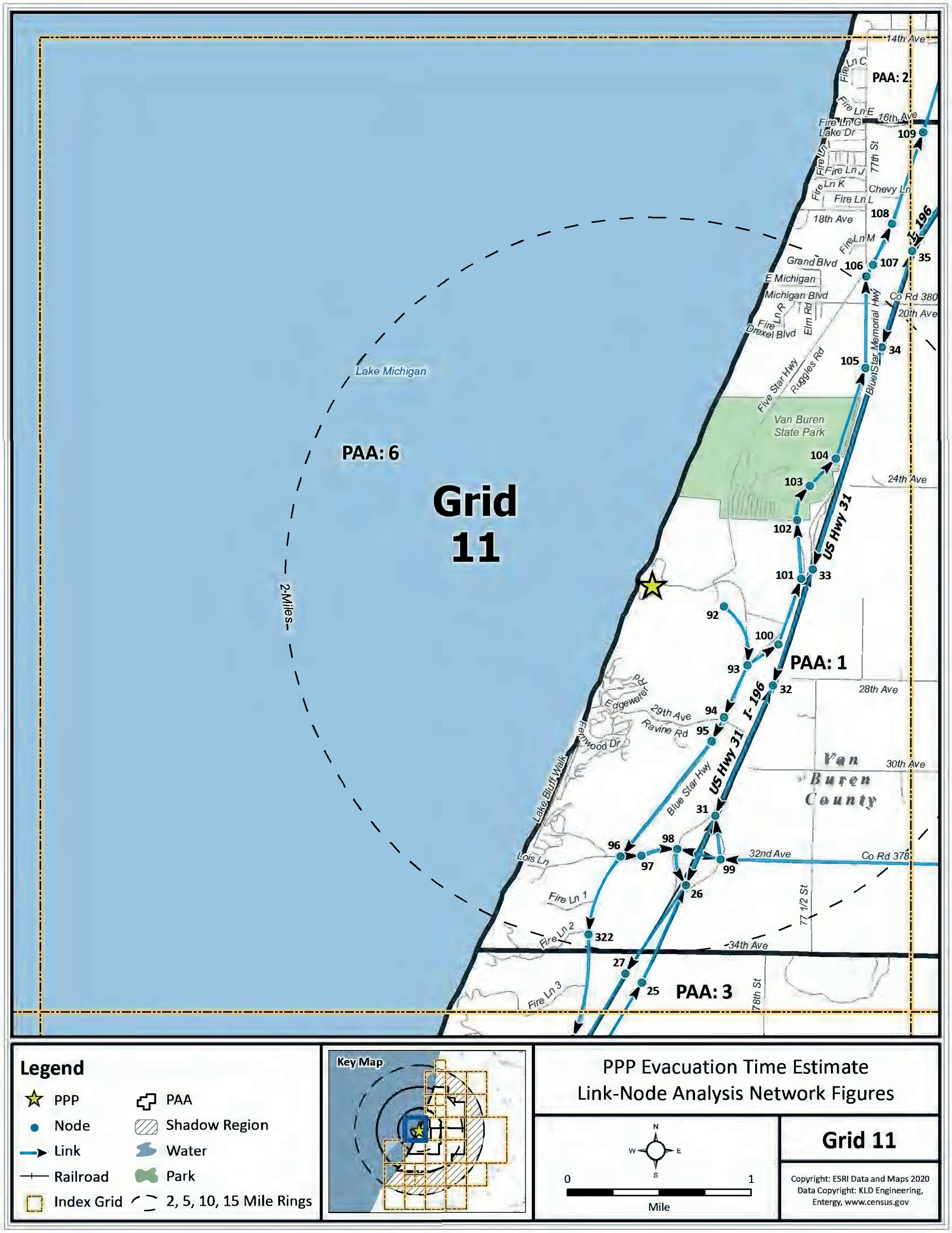


Figure K-12. Link-Node Analysis Network – Grid 11

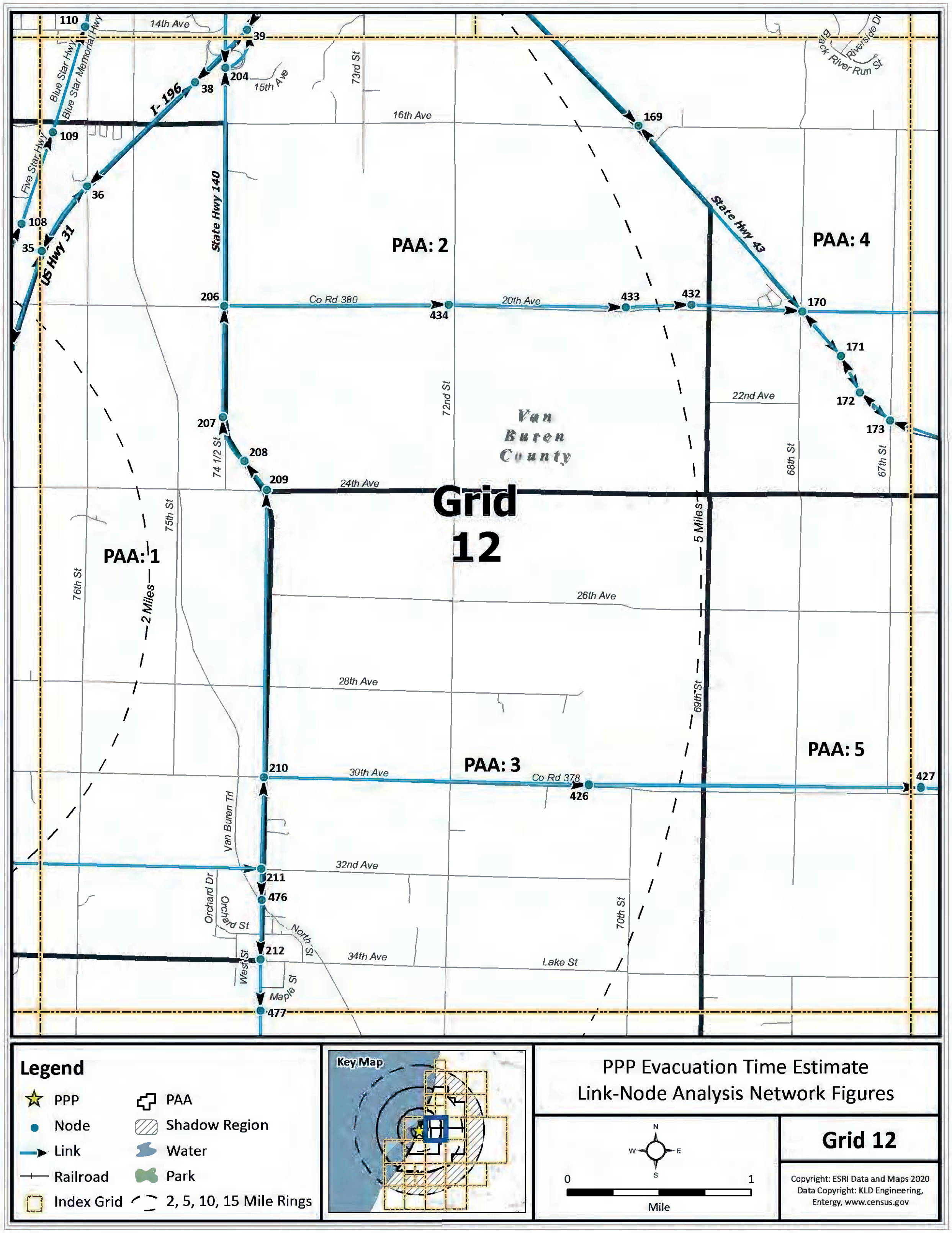


Figure K-13. Link-Node Analysis Network – Grid 12

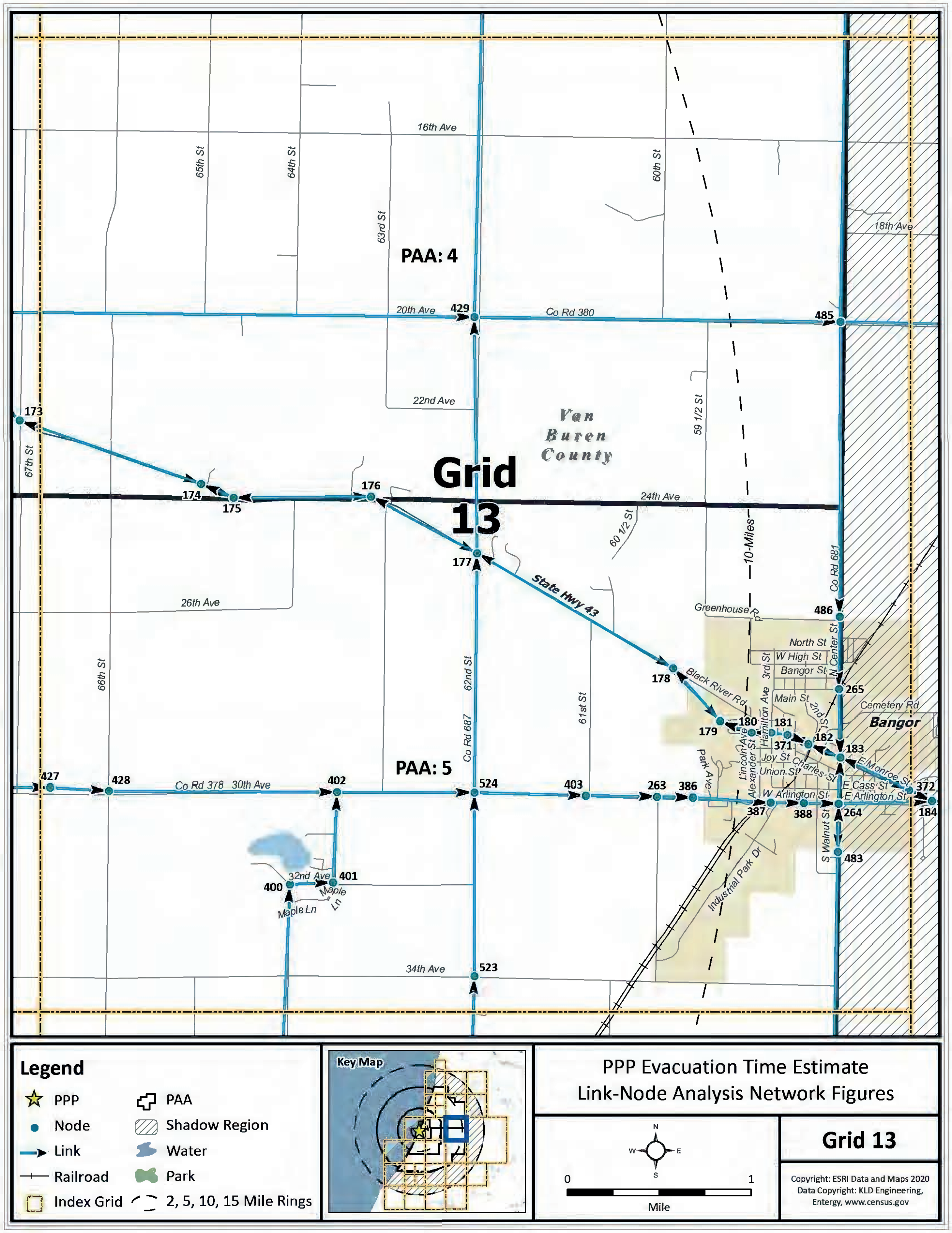


Figure K-14. Link-Node Analysis Network – Grid 13

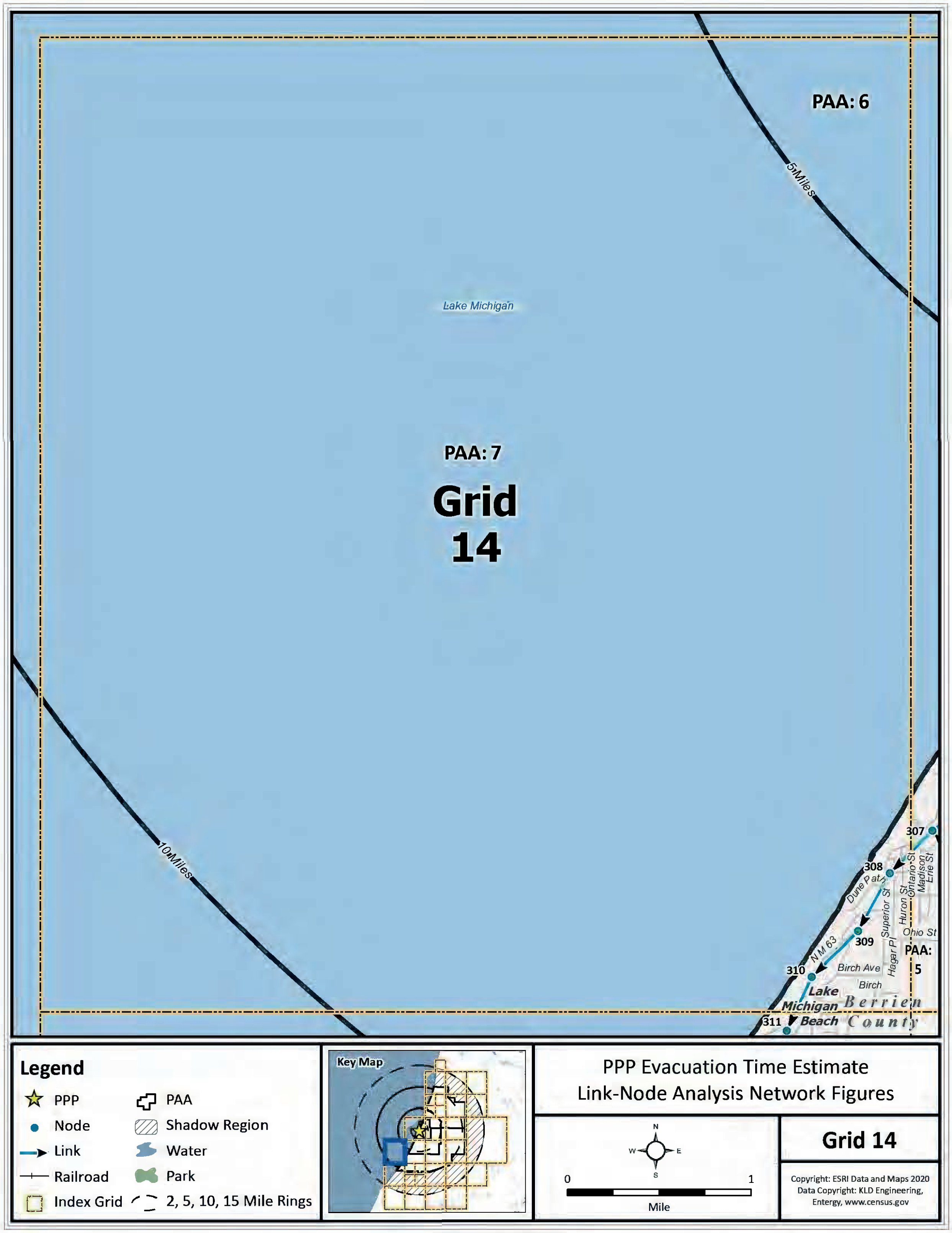


Figure K-15. Link-Node Analysis Network – Grid 14

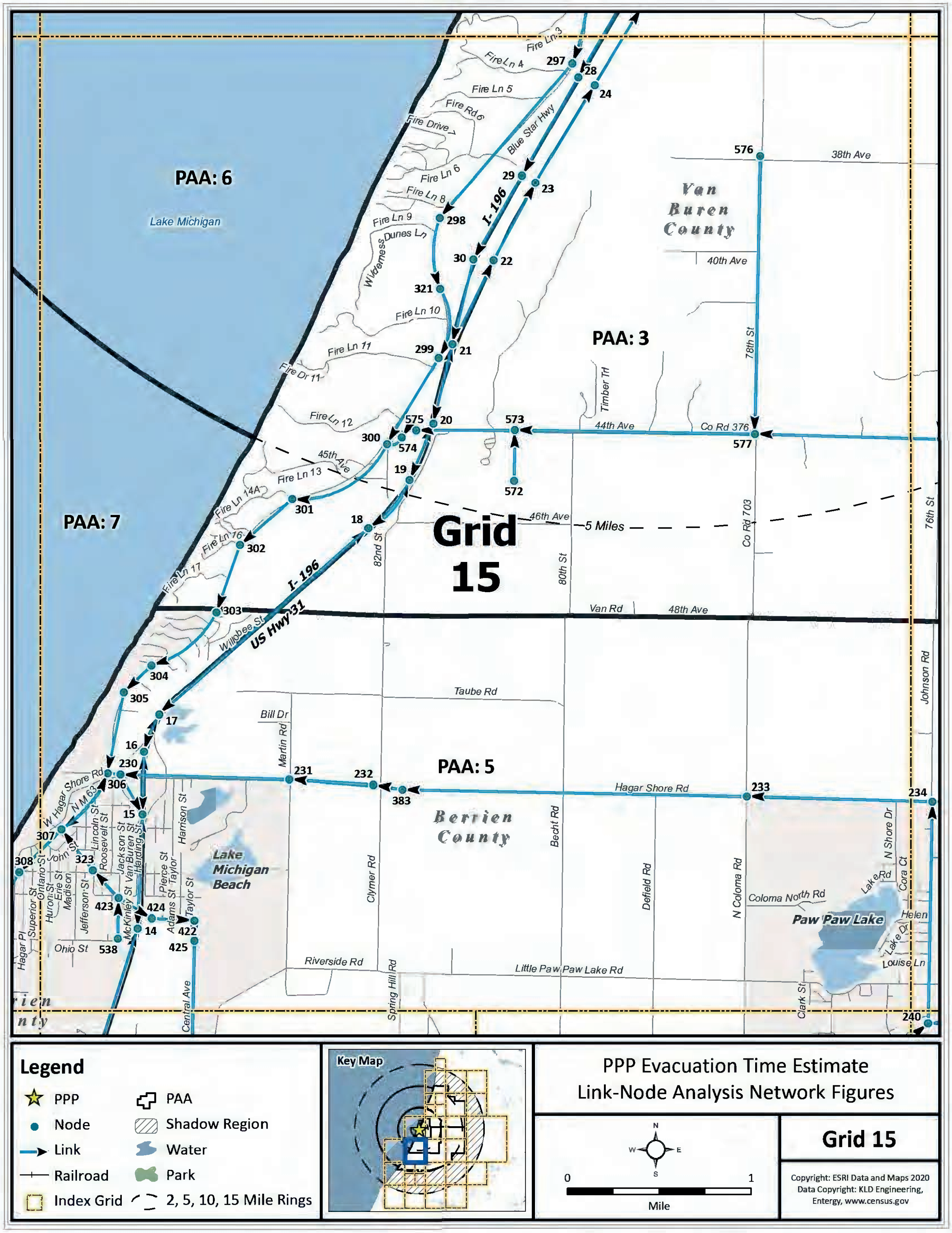


Figure K-16. Link-Node Analysis Network – Grid 15

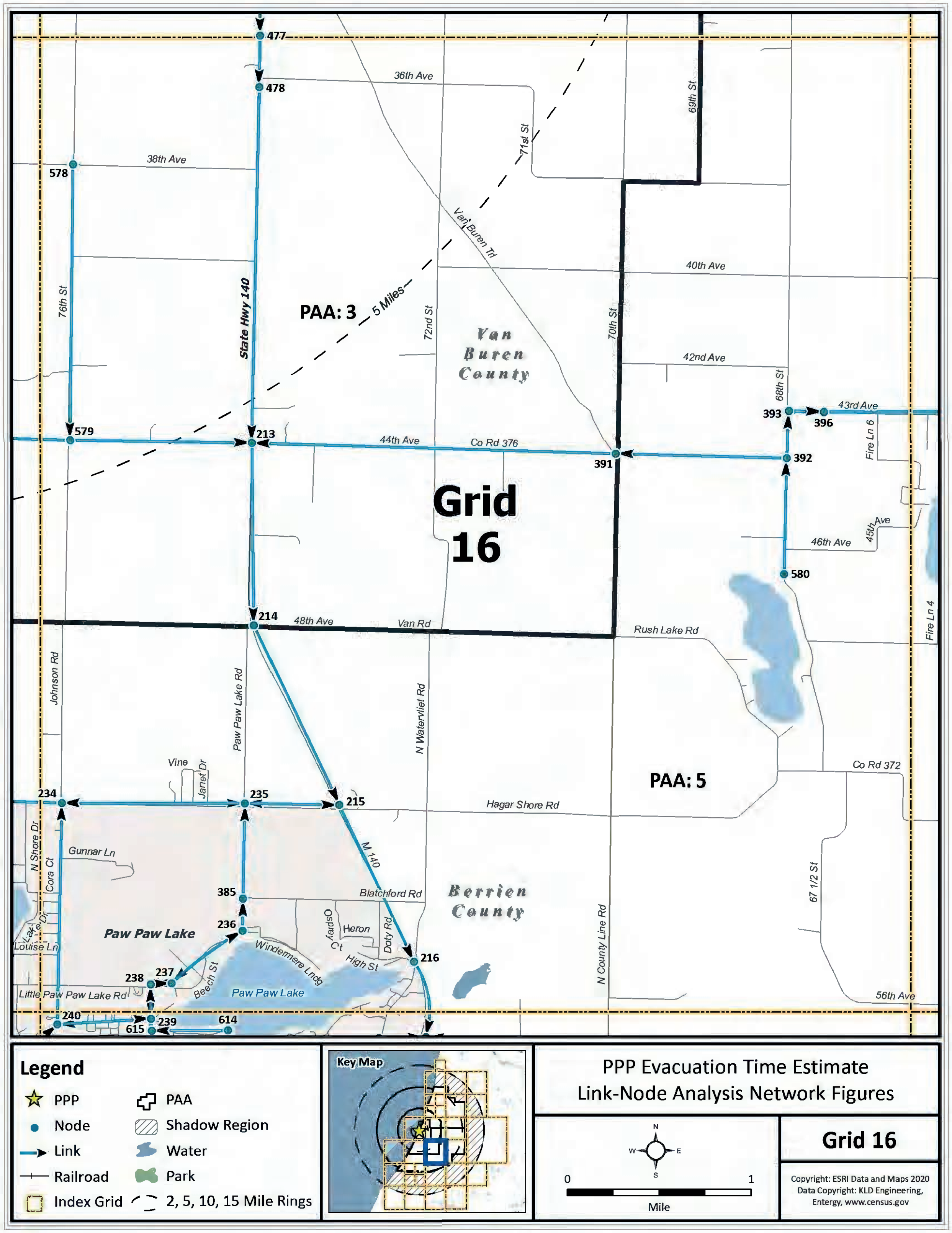


Figure K-17. Link-Node Analysis Network – Grid 16

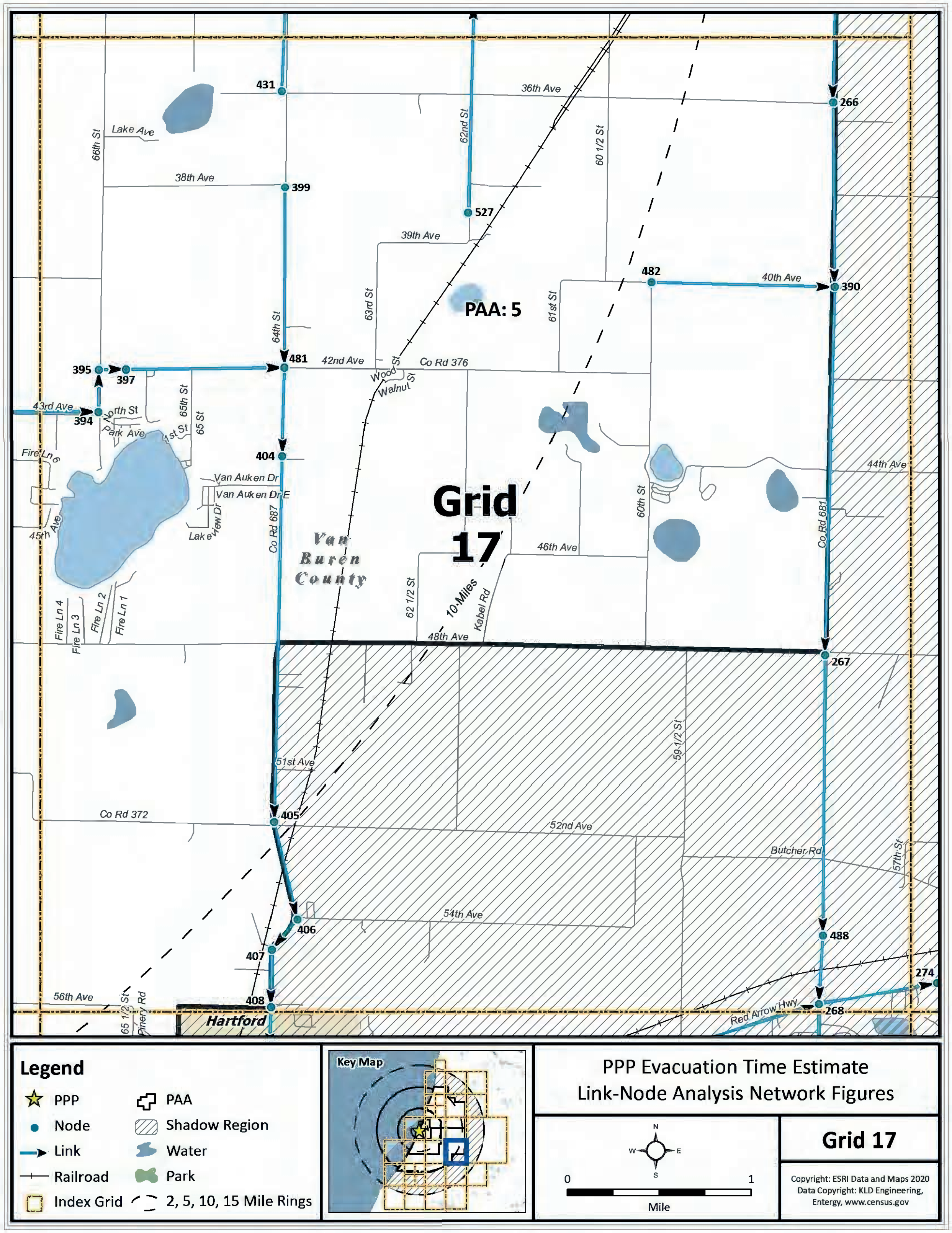


Figure K-18. Link-Node Analysis Network – Grid 17

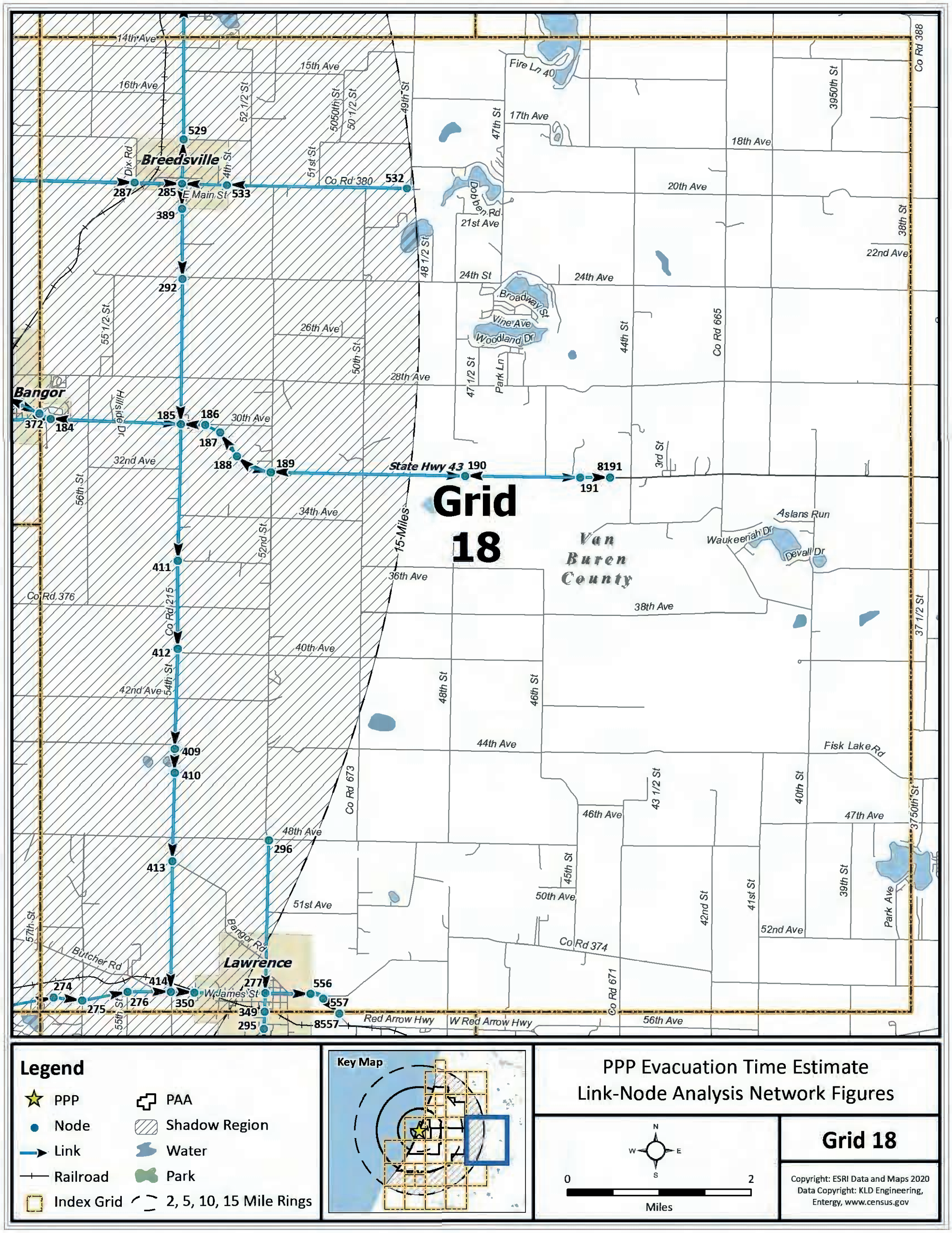


Figure K-19. Link-Node Analysis Network – Grid 18

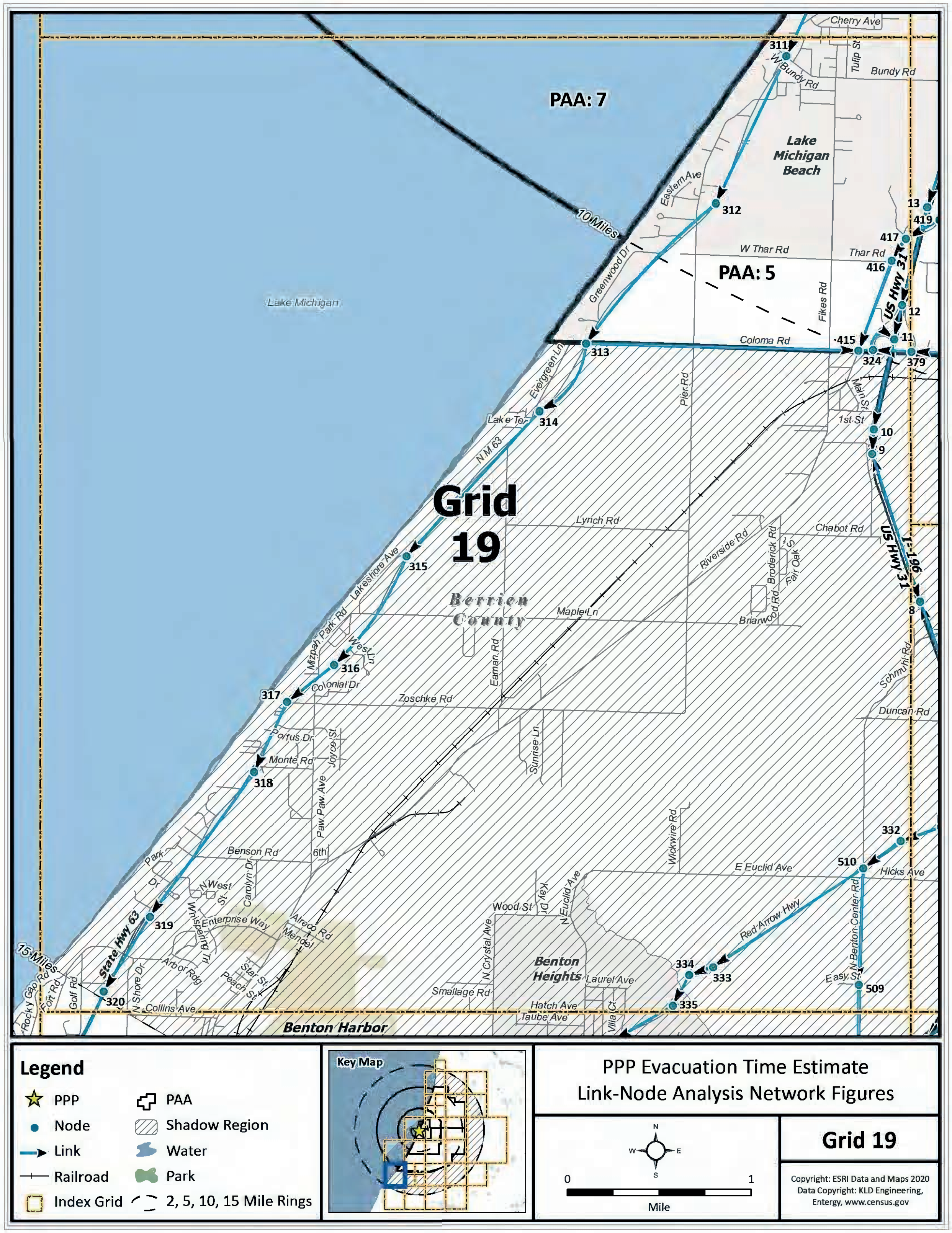


Figure K-20. Link-Node Analysis Network – Grid 19

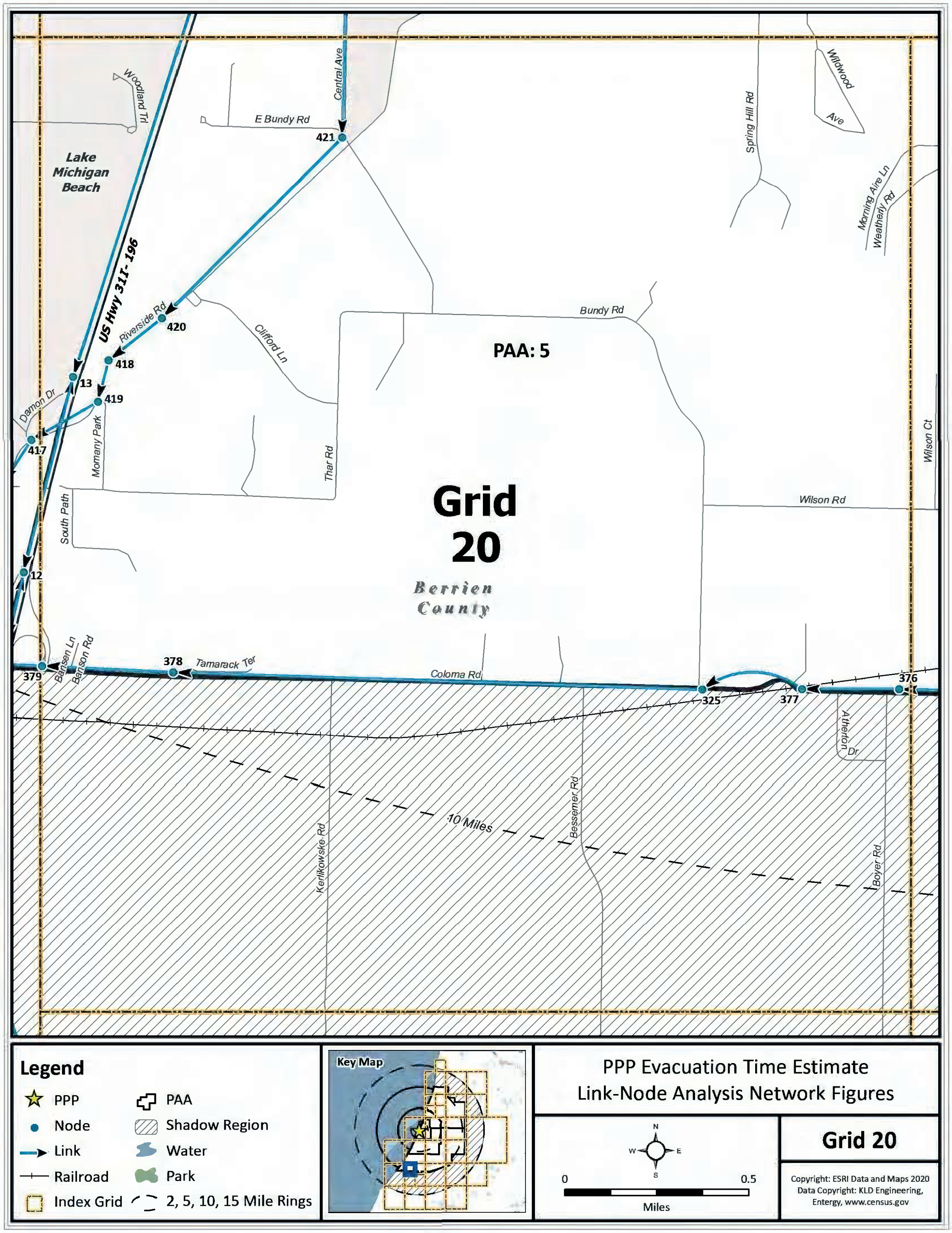


Figure K-21. Link-Node Analysis Network – Grid 20

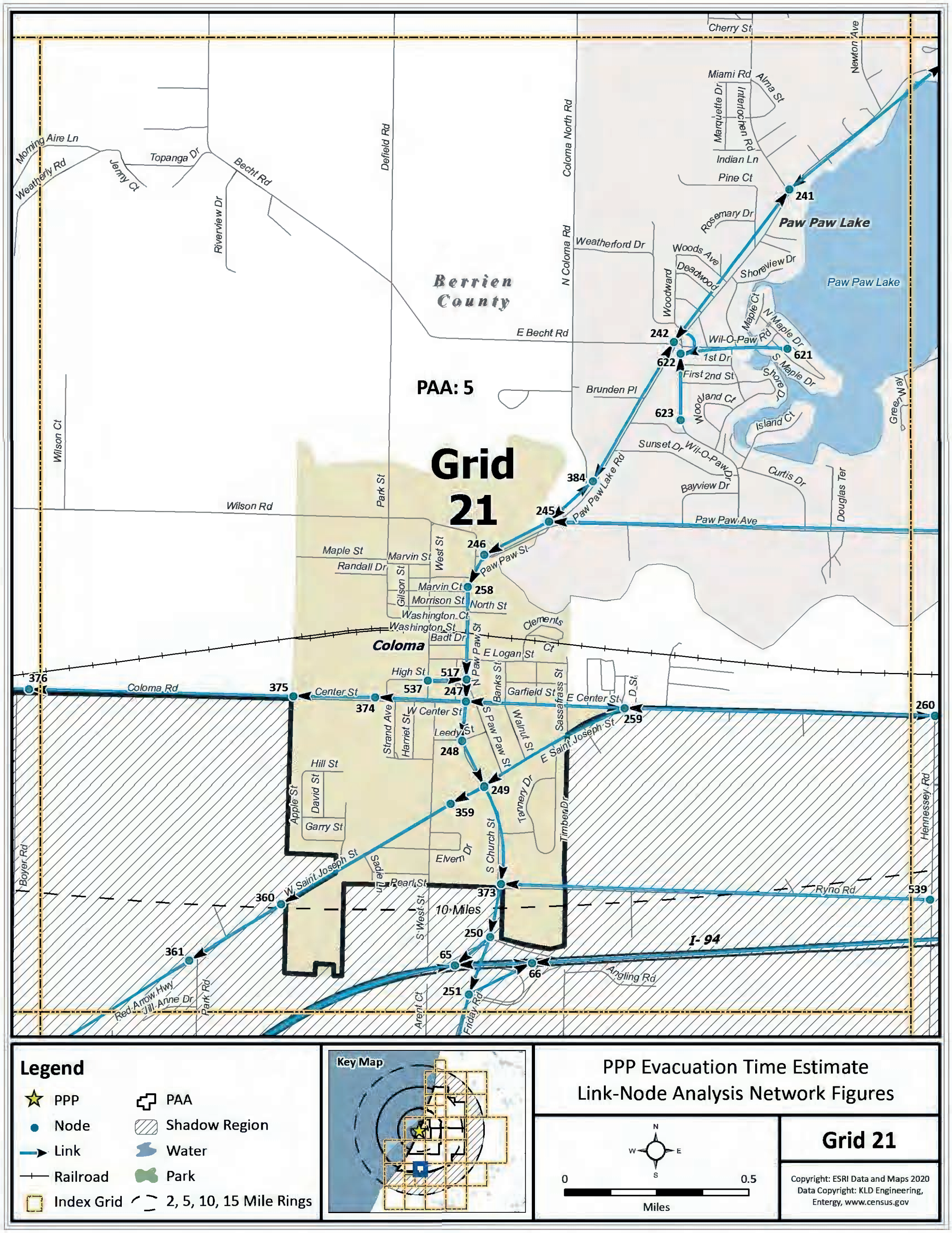


Figure K-22. Link-Node Analysis Network – Grid 21

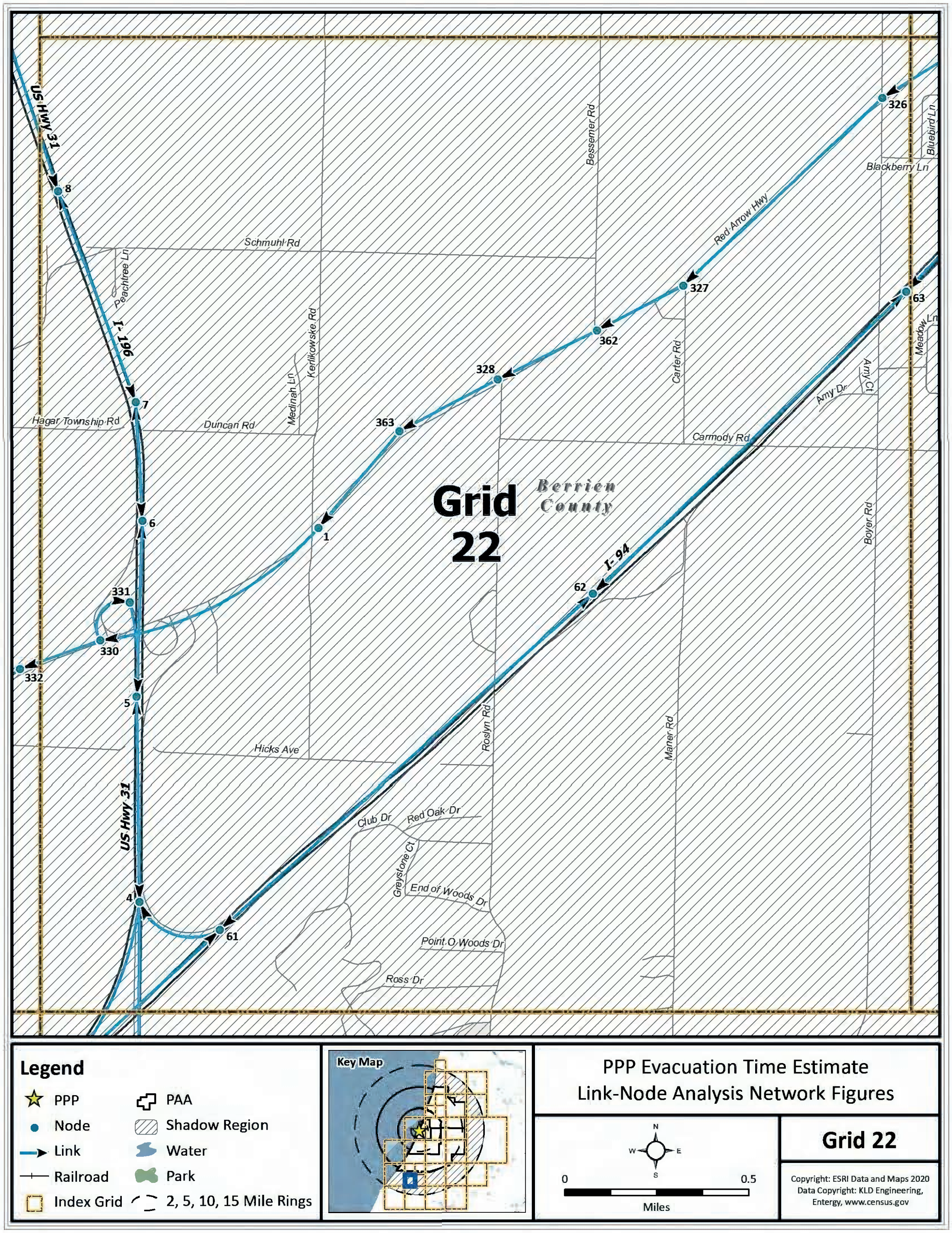


Figure K-23. Link-Node Analysis Network – Grid 22

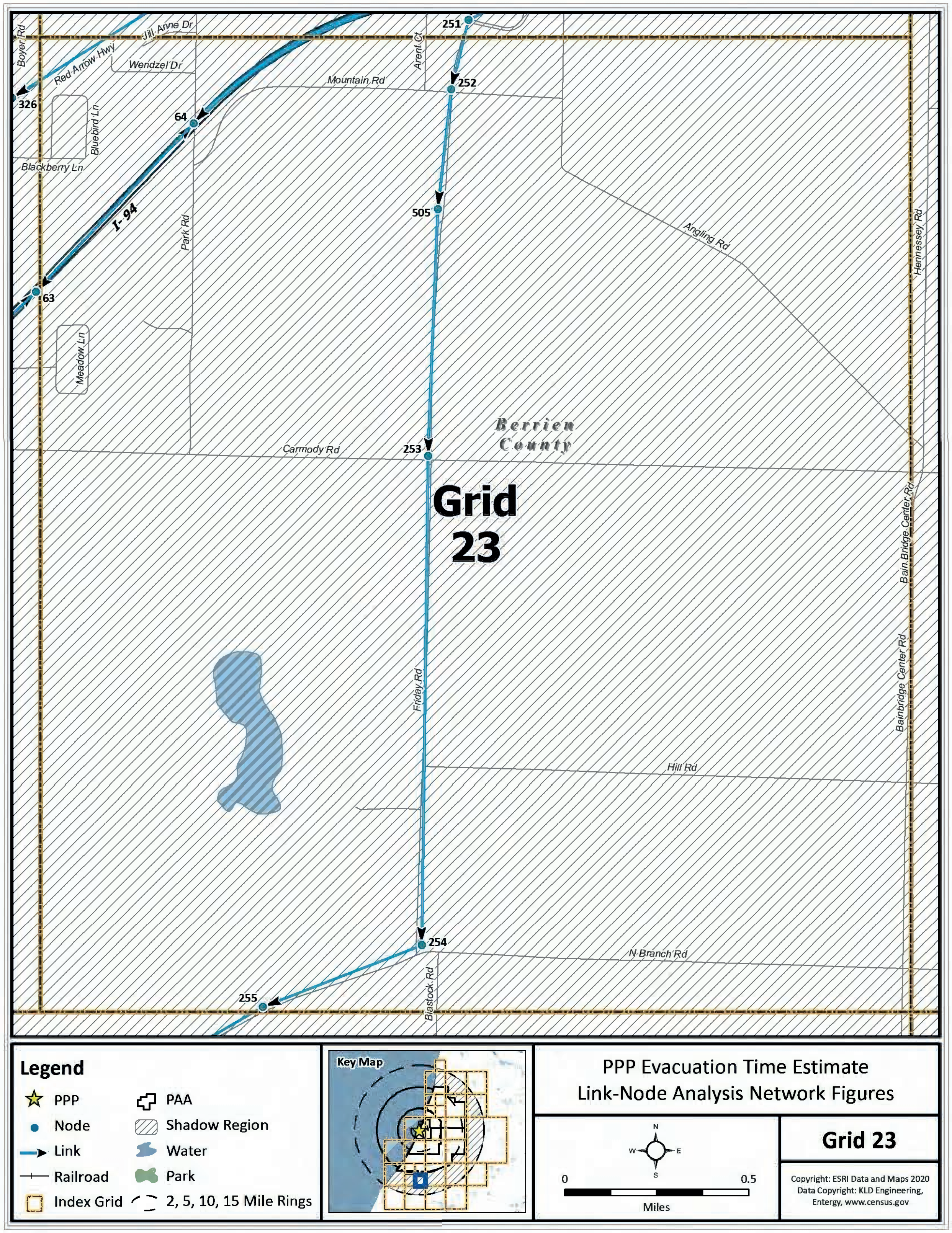


Figure K-24. Link-Node Analysis Network – Grid 23

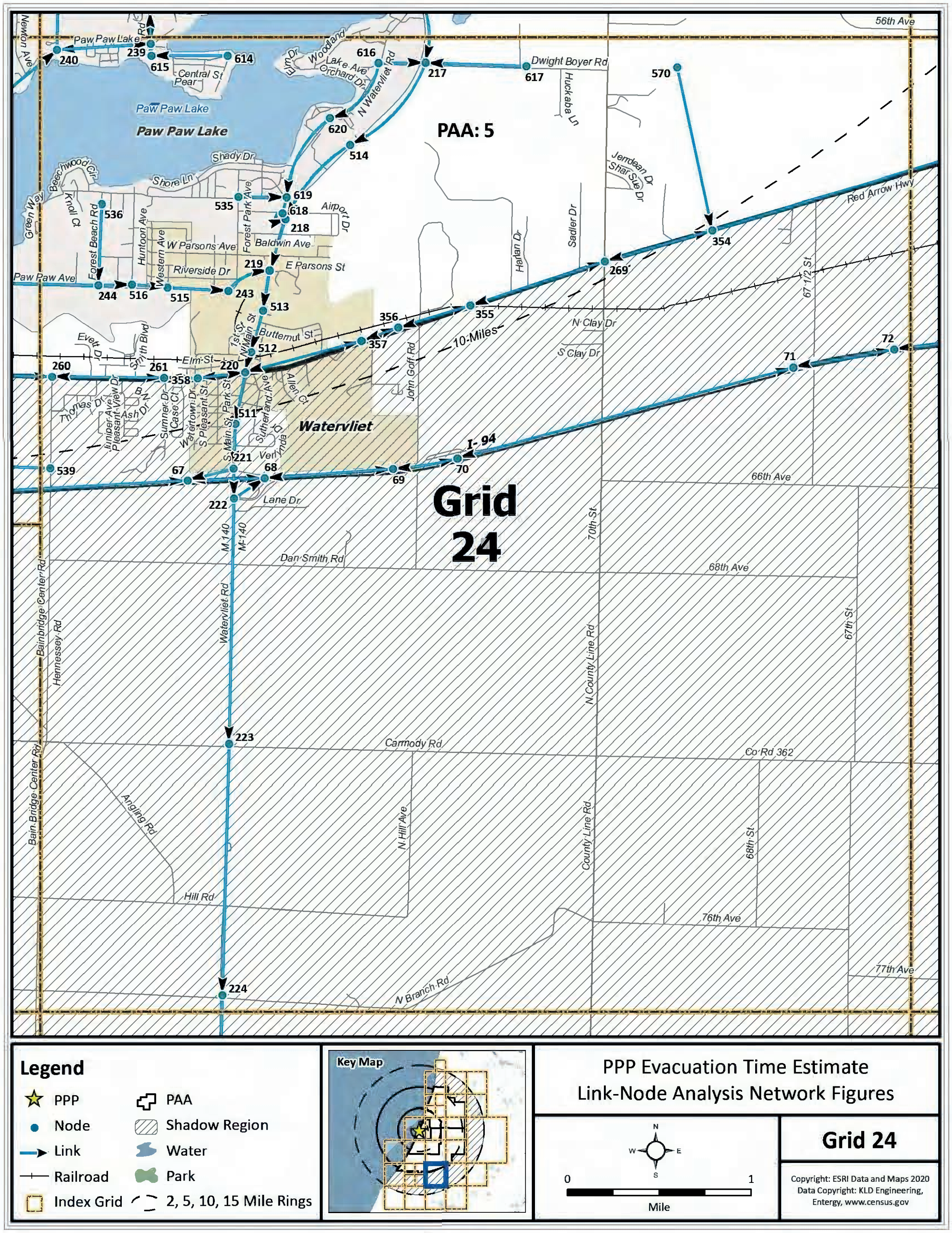


Figure K-25. Link-Node Analysis Network – Grid 24

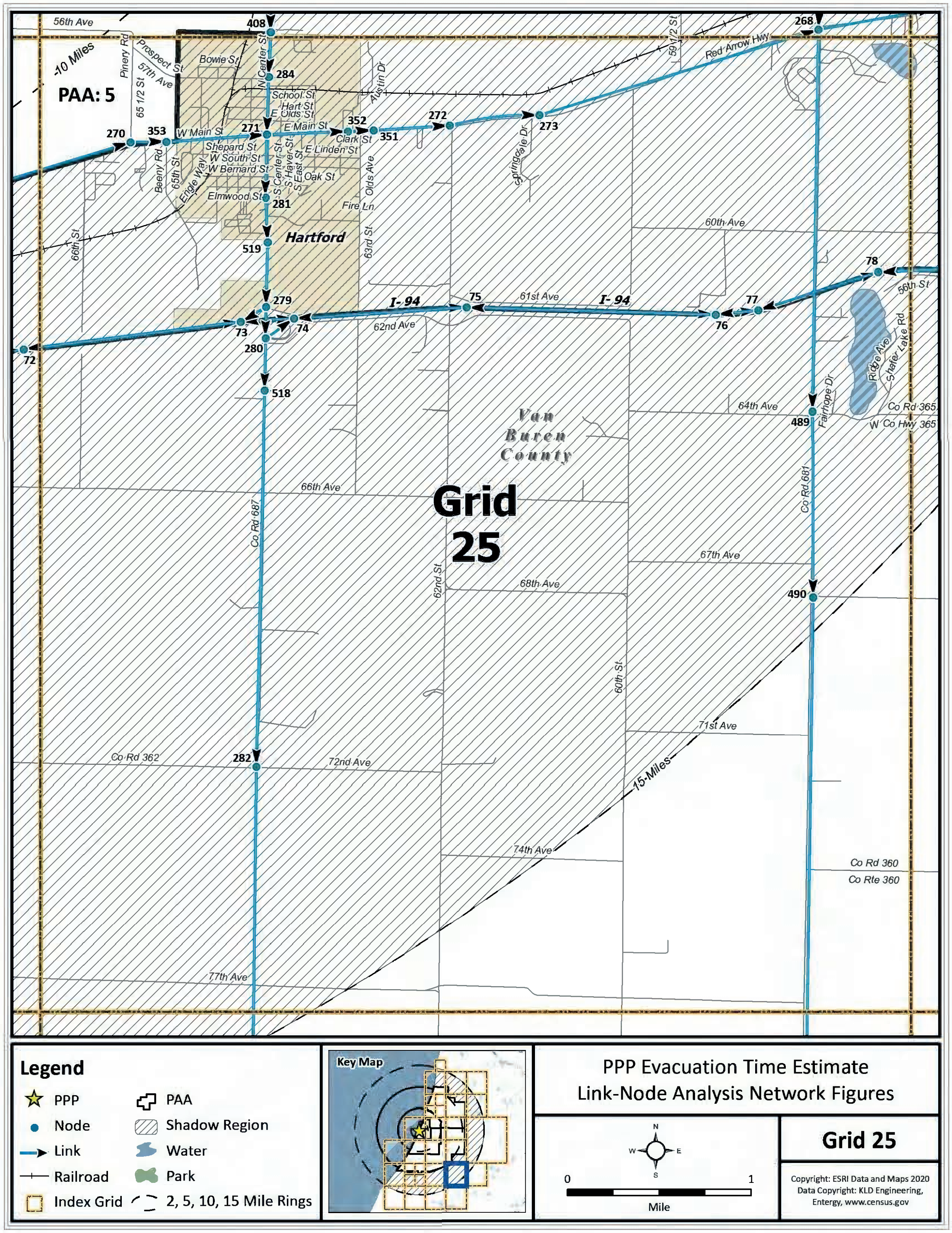


Figure K-26. Link-Node Analysis Network – Grid 25

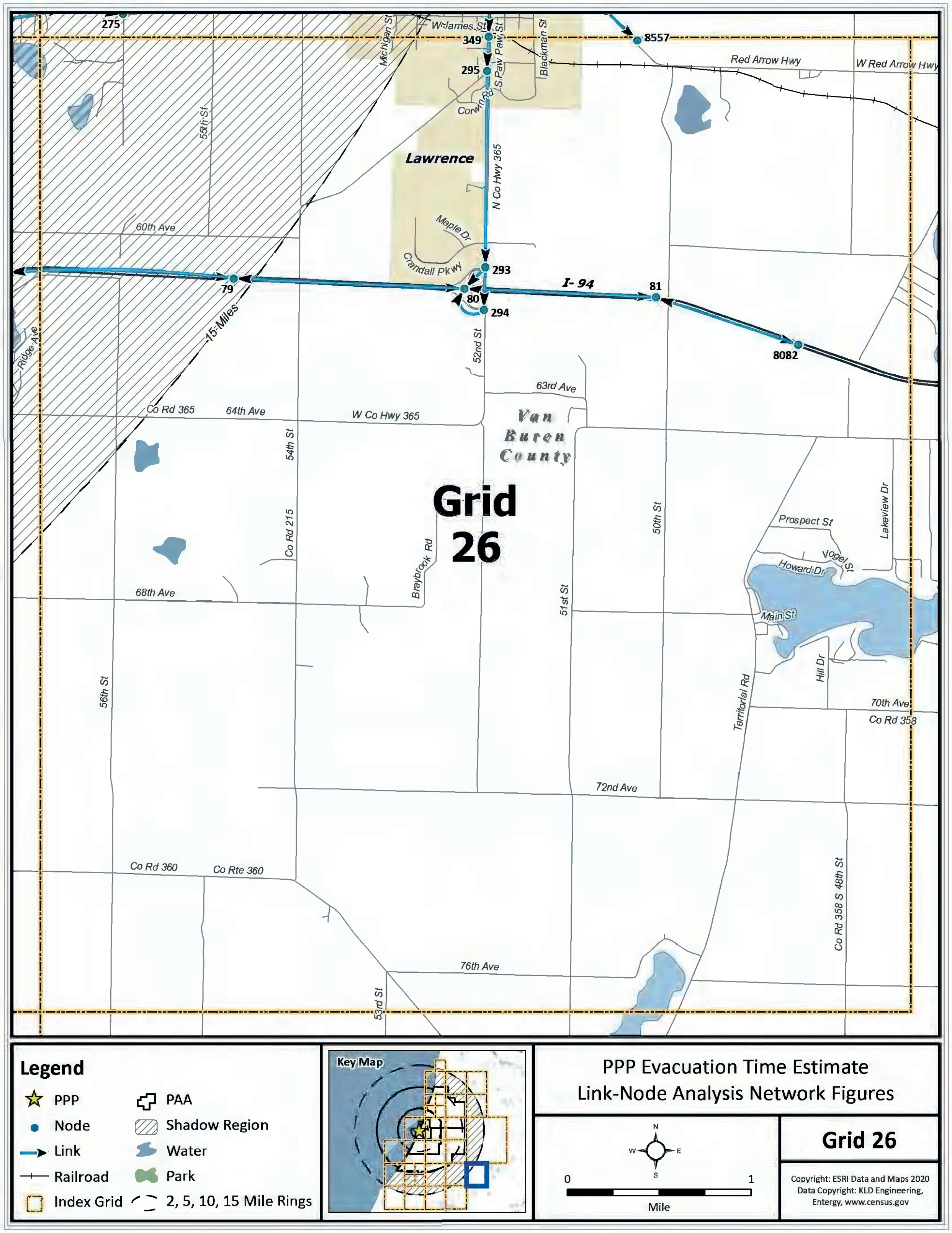


Figure K-27. Link-Node Analysis Network – Grid 26

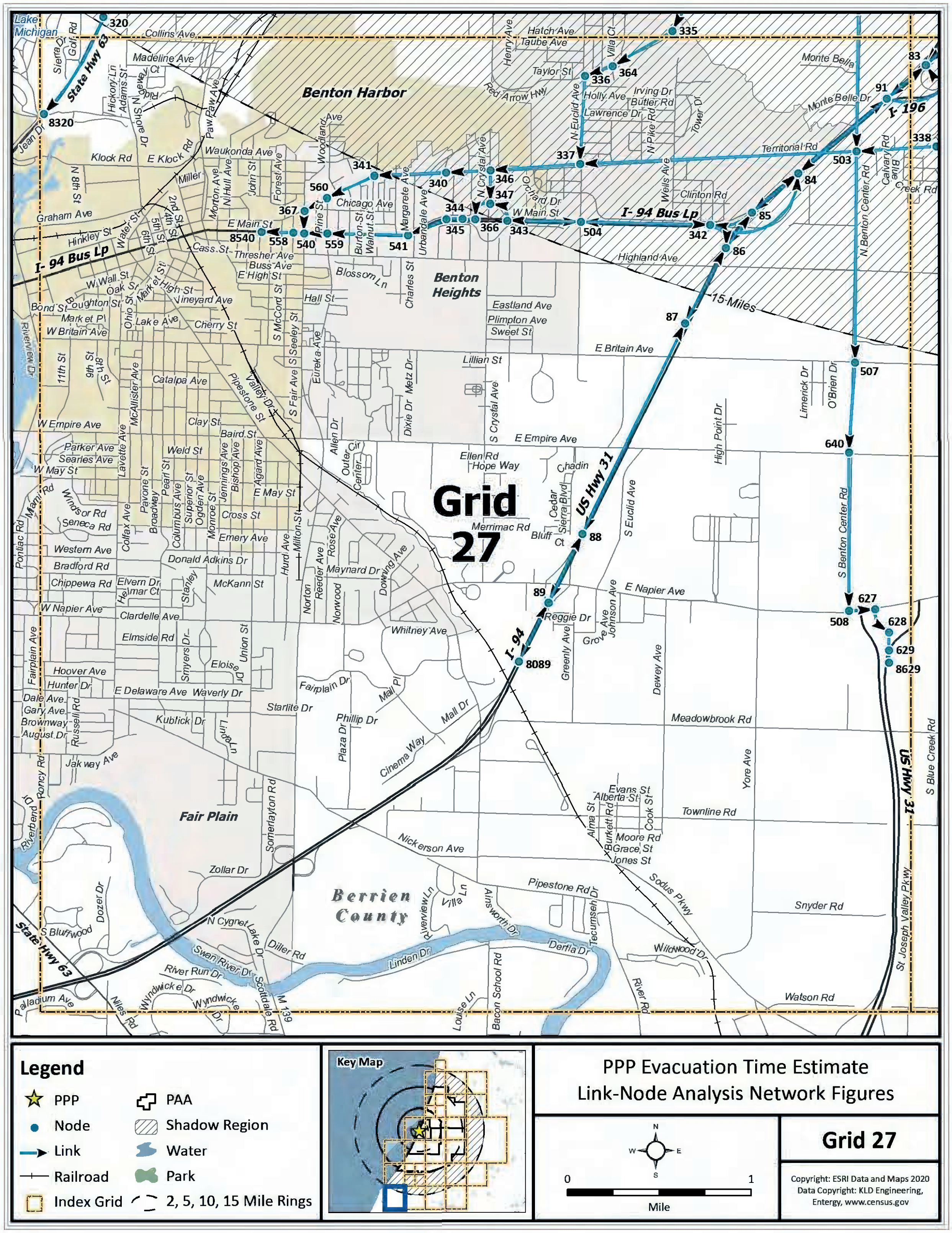


Figure K-28. Link-Node Analysis Network – Grid 27

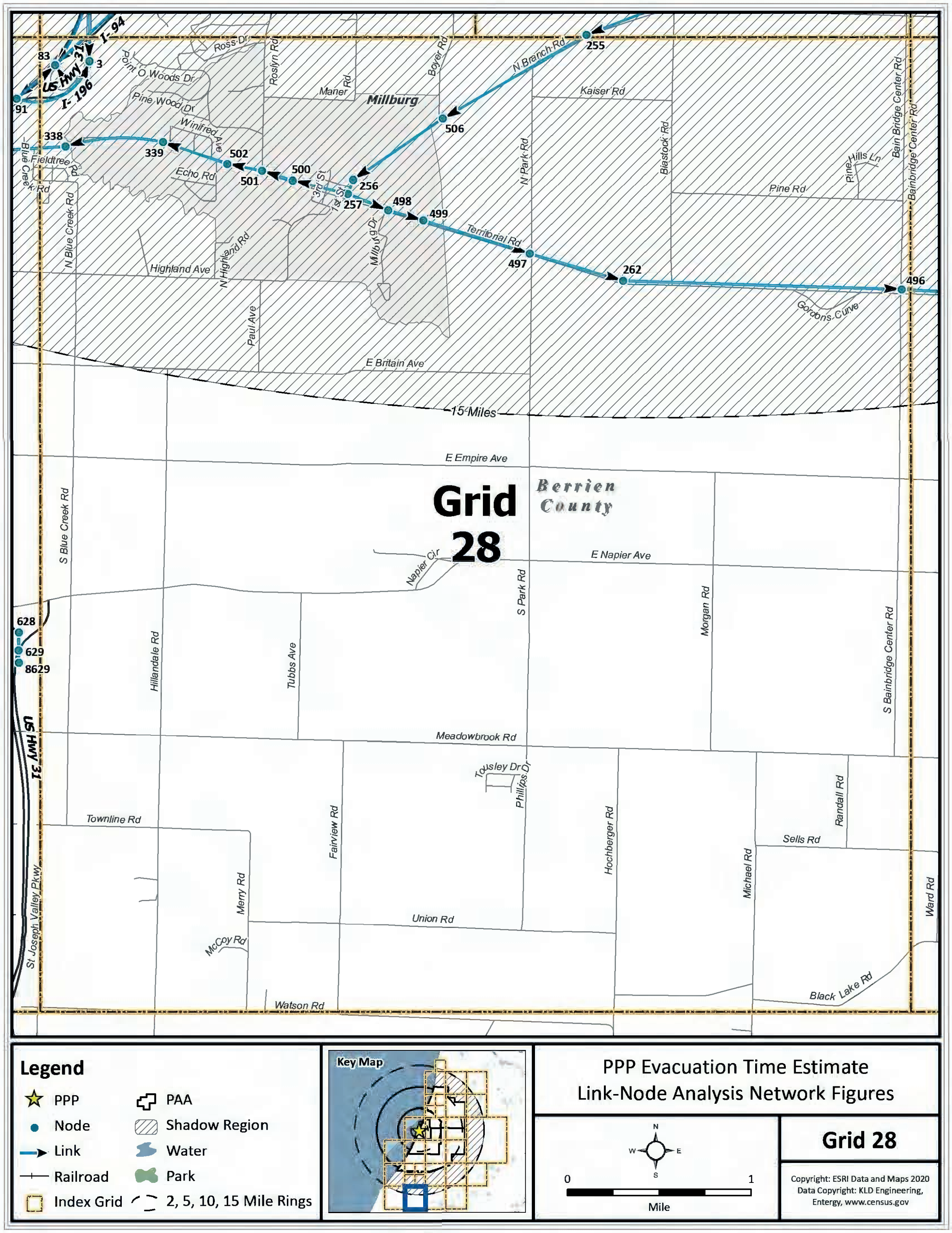


Figure K-29. Link-Node Analysis Network – Grid 28

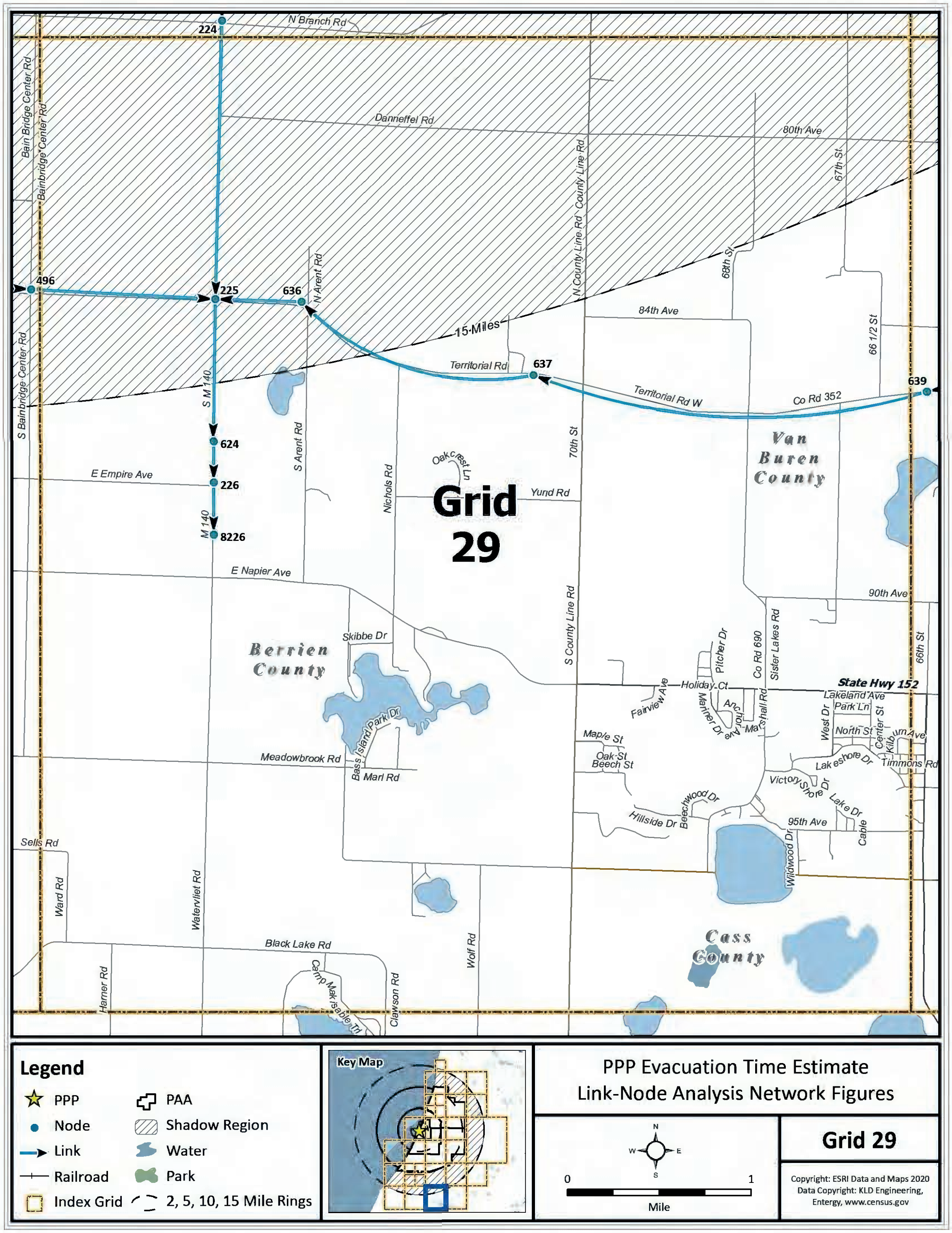


Figure K-30. Link-Node Analysis Network – Grid 29

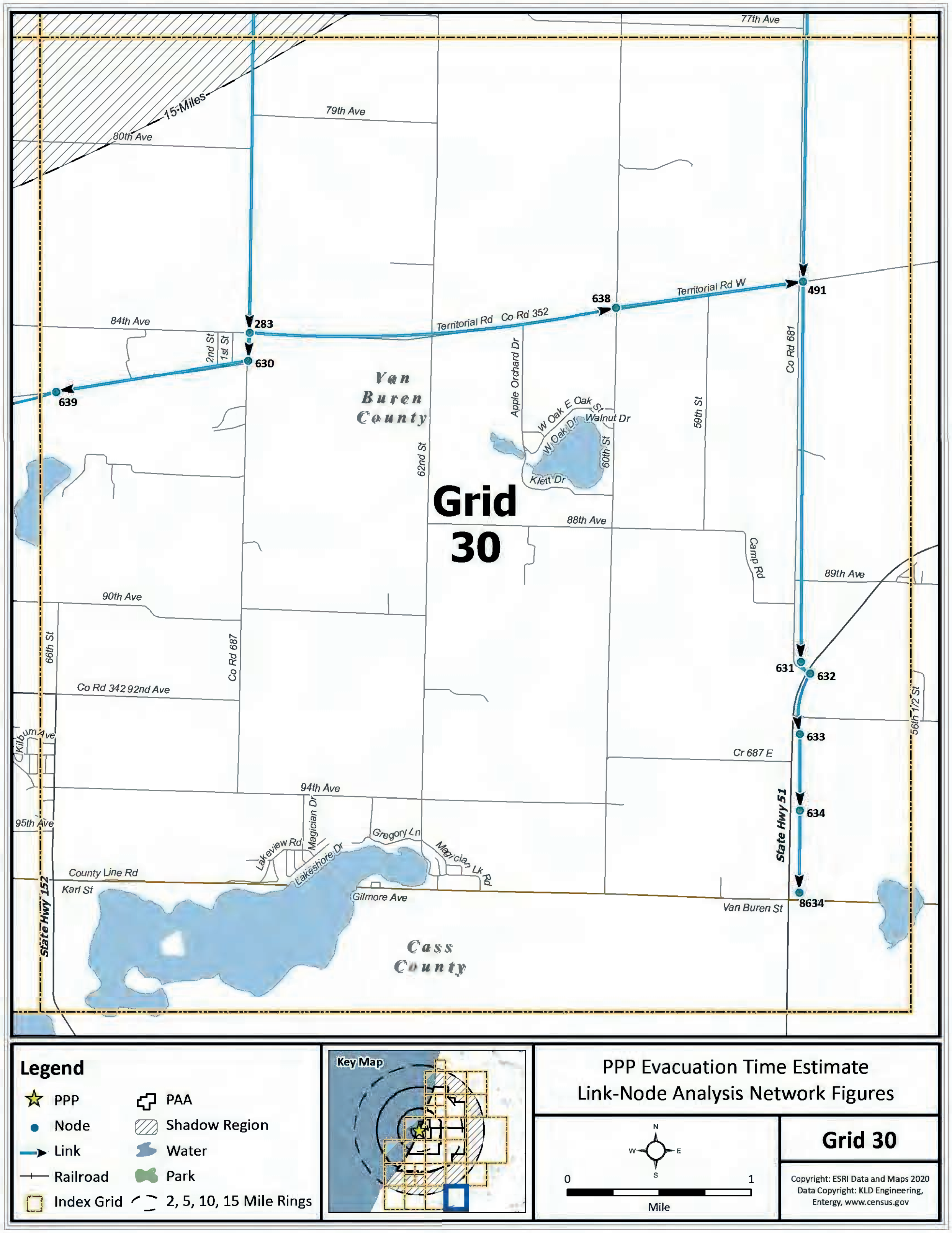


Figure K-31. Link-Node Analysis Network – Grid 30

APPENDIX L

PAA Boundaries

L. PAA BOUNDARIES

PAA 1 — County: Van Buren

Defined as the area within the following boundary: Includes Van Buren state park and western parts of Covert bounded by M-140 to the east; 16th Ave to the north; Lake Michigan to the west; and 34th Ave to the south.

PAA 2 — County: Van Buren

Defined as the area within the following boundary: South Haven Township bounded by Elkenburg St., Kalamazoo St. and Aylworth Ave to the north; 69th St. and SR-43 to the east; 16th Ave, M-140 and 24th Ave to the south; and Lake Michigan to the west.

PAA 3 — County: Van Buren

Defined as the area within the following boundary: Eastern Covert bounded by Lake Michigan, M-140 and 34th Ave to the west, 24th Ave to the north, 69th St and 70th St the east, and the Berrien / Van Buren County line to the south.

PAA 4 — County: Allegan and Van Buren

Defined as the area within the following boundary: The City of South Haven bounded by Elkenburg St., Kalamazoo St., Aylworth Ave, SR-43, 69th St. and Lake Michigan to the west; 24th Ave to the south; CR-681, the Van Buren / Allegan County line, 63rd St., 102nd Ave and 66th St. to the east; and 107th Ave to the north. Includes all of South Haven and West Bangor.

PAA 5 — County: Berrien and Van Buren

Defined as the area within the following boundary: Parts of Coloma, Watervliet and Bangor bounded by the Berrien / Van Buren County Line, M-140 and 24th Ave to the north; CR-681, 48th Ave and CR-687 to the east; Red Arrow Hwy / Coloma Rd to the south; and Lake Michigan to the west. Excludes Hartford.

PAA6 — Lake Area 6

Area 6 is the portion of Lake Michigan within a 5-mile radius of the PPP.

PAA7 — Lake Area 7

Area 7 is the portion of Lake Michigan between 5 and 10 miles from the PPP.

APPENDIX M

Evacuation Sensitivity Studies

M. EVACUATION SENSITIVITY STUDIES

This appendix presents the results of a series of sensitivity analyses. These analyses are designed to identify the sensitivity of the ETE to changes in some base evacuation conditions.

M.1 Effect of Changes in Trip Generation Times

A sensitivity study was performed to determine whether changes in the estimated trip generation time have an effect on the ETE for the entire EPZ. Specifically, if the tail of the mobilization distribution were truncated (i.e., if those who responded most slowly to the ATE could be persuaded to respond much more rapidly) or if the tail were elongated (i.e., spreading out the departure of evacuees to limit the demand during peak times), how would the ETE be affected? The case considered was Scenario 3, Region 3; a summer, weekend, midday, with good weather evacuation of the entire EPZ. Table M-1 presents the results of this study.

If evacuees mobilize one hour quicker, the 90th percentile ETE is reduced by 15 minutes and the 100th percentile ETE is reduced by 1 hour (a significant change), respectively. If evacuees mobilize one hour slower, the 90th percentile and 100th percentile ETE are increased by 40 minutes and 1 hour, respectively – both significant changes.

As discussed in Section 7.3, traffic congestion persists within the EPZ for about 2 hours and 30 minutes after the ATE, well before the completion of trip generation time at 4 hours and 45 minutes. As such, the 100th percentile ETE directly parallel mobilization time. The 90th percentile are impacted by traffic congestion as evidenced by the ETE only dropping by 15 minutes when evacuees mobilize 1 hour faster. See Table M-1.

M.2 Effect of Changes in the Number of People in the Shadow Region Who Relocate

A sensitivity study was conducted to determine the effect on ETE of changes in the percentage of people who decide to relocate from the Shadow Region. The case considered was Scenario 3, Region 3; a summer, weekend, midday, with good weather evacuation of the entire EPZ. The movement of people in the Shadow Region has the potential to impede vehicles evacuating from an Evacuation Region within the EPZ. Refer to Section 3.2 and Section 7.1 for additional information on population within the Shadow Region.

Table M-2 presents the ETE for each of the cases considered. The results show that eliminating (0%), doubling (40%), tripling (60%), and quadrupling (80%) the shadow evacuation has no effect on the 90th and 100th percentile ETE. A full shadow evacuation (100%) increases the 90th percentile ETE by 5 minutes and has no effect on the 100th percentile ETE.

Note the demographic survey results presented in Appendix F indicate that 28% of households would elect to evacuate if advised to shelter, which is significantly higher than the base assumption of 20% non-compliance suggested in the NUREG/CR-7002, Rev. 1. A sensitivity study was run using 28% shadow evacuation and the 90th and 100th percentile ETE were not impacted.

The Shadow Region for PPP is sparsely populated except for two population centers - Hartford and Watervliet (half of which is in the EPZ). These towns are too small to cause a significant disruption to the evacuation of the EPZ. As shown in Figure 7-3 through Figure 7-6, the congestion within Hartford does not propagate into the EPZ such that EPZ evacuees would be delayed. Congestion near Watervliet does propagate into the EPZ for about two hours; however, most of this congestion is caused by Paw Paw Lake and the northern half of Watervliet – both of which are in the EPZ.

M.3 Effect of Changes in the Permanent Resident Population

A sensitivity study was conducted to determine the effect on ETE of changes in the permanent resident population within the study area (EPZ plus Shadow Region). As population in the study area changes over time, the time required to evacuate the public may increase, decrease, or remain the same. Since the ETE is related to the demand to capacity ratio present within the study area, changes in population will cause the demand side of the equation to change and could impact ETE if there is not a corresponding increase in capacity (i.e., roadway improvements).

As per the NRC's response to the Emergency Planning Frequently Asked Question (EPFAQ) 2013-001, the ETE population sensitivity study must be conducted to determine what percentage increase in permanent resident population causes an increase in the 90th percentile ETE of 25% or 30 minutes, whichever is less. The sensitivity study must use the scenario with the <u>longest 90th percentile ETE</u> (excluding the roadway impact scenario and the special event scenario if it is a one day per year special event).

Thus, the sensitivity study was conducted using the following planning assumptions:

1. The percent change in population within the study area was increased by up to 107%. Changes in population were applied to permanent residents only (as per federal guidance), in both the EPZ and the Shadow Region.
2. The transportation infrastructure (as presented in Appendix K) remained fixed; the presence of future proposed roadway changes and/or highway capacity improvements were not considered.
3. The study was performed for the 2-Mile Region (R01), 5-Mile Region (R02) and the Entire EPZ (R03).
4. The scenario (excluding roadway impact and special event) which yielded the <u>longest 90th percentile ETE</u> values was selected as the case to be considered in this sensitivity study (Scenario 8 – Winter, Midweek, Midday with Heavy Snow).

Table M-3 presents the results of the sensitivity study. Section IV of Appendix E to 10 CFR Part 50, and NUREG/CR-7002, Rev. 1, Section 5.4, require licensees to provide an updated ETE analysis to the NRC when a population increase within the EPZ causes the longest 90th percentile ETE values (for the 2-Mile -Region, 5-Mile Region, or entire EPZ) to increase by 25% or 30 minutes, whichever is less. The base ETE values for the 2-Mile Region (R02), 5-Mile Region (R02) and for the Entire EPZ (R03) are greater than 2 hours; 25% of these base ETE is always greater than 30 minutes. Thus, the criterion for updating is 30 minutes.

The percent population change which results in the longest 90th percentile ETE change greater than or equal to 30 minutes is highlighted in red in Table M-3 – a 107% or greater increase in the 2-Mile Region permanent resident population. Entergy/Holtec will have to estimate the EPZ population on an annual basis. If the 2-Mile Region population increases by 107% or more, an updated ETE analysis will be needed.

M.4 Effect of Changes in Average Household Size

As discussed in Appendix F, the average household size obtained from the results of the demographic survey is 2.77 persons per household. The 2020 Census indicates an average household size of 2.41 persons per household. The difference between the Census data and survey data is 14.9%, which exceeds the survey sampling error of 8.5%. Upon discussions with Entergy/Holtec, it was decided that the estimated household size (2.77 persons per household) from the demographic survey results would be used in the ETE study. A sensitivity study was performed to determine how sensitive the ETE is to changes in the average household size. It should be noted that only resident and shadow vehicles were changed for this sensitivity study. The case considered was Scenario 3 - a summer, weekend, midday, with good weather evacuation of the 2-Mile Region (R01), 5-Mile Region (R02), and the Entire EPZ (R03). Table M-4 presents the results of this study.

As discussed in Sections 3.1 and 3.2, the permanent resident evacuating vehicles in the EPZ and in the Shadow Region are determined by dividing the 2020 Census population by the average household size, then multiplying by the average evacuating vehicles per household obtained from the demographic survey. Give that household size is in the denominator of the equation used to compute evacuating vehicles, decreasing the average household size by 14.9% increases the total number of permanent resident evacuating vehicles in the EPZ and in the Shadow Region by 14.9%.

The change in average household size increases the 90th percentile ETE by 15 minutes and 25 minutes for the 5-Mile Region (R02) and Entire EPZ (R03), respectively. These changes are not significant, which is defined in the federal regulations as 25% or 30 minutes, whichever is less. The change in average household size does not impact ETE at the 100th percentile as the traffic congestion in the major population centers within the EPZ clears within about 2 hours and 30 minutes and trip generation time dictates the ETE. The ETE for the 2-Mile Region (R01) is not impacted by the change in average household size.

M.5 Enhancements in Evacuation Time

This appendix documents sensitivity studies on critical variables that could potentially impact ETE. Possible improvements to ETE are further discussed below:

- Reducing trip generation time by an hour reduces the 90th percentile ETE by 15 minutes, and the 100th percentile ETE by 1 hour (Section M.1). Public outreach encouraging evacuees to mobilize more quickly or in a timely manner can decrease ETE.
- Increasing the shadow evacuation percentage has minimal impact on ETE (Section M.2). Nonetheless, public outreach could be considered to inform those people within the EPZ (and potentially beyond the EPZ) that if they are not advised to evacuate, they should not.
- Population growth results in more evacuating vehicles, which could significantly increase ETE (Section M.3). Decreasing the average household size (increasing the total number of evacuating vehicles) increases the 90th percentile ETE by up to 25 minutes (Section M.4). Public outreach to encourage EPZ residents to carpool and evacuate as a family in a single vehicle could reduce the number of evacuating vehicles and could reduce ETE or offset the impact of population growth.

Table M-1. Evacuation Time Estimates for Trip Generation Sensitivity Study

Trip Generation Period	Evacuation Time Estimate for Entire EPZ	
	90th Percentile	100th Percentile
3 Hours and 45 Minutes	2:05	3:55
4 Hours and 45 Minutes (Base)	2:20	4:55
5 Hours and 45 Minutes	3:00	5:55

Table M-2. Evacuation Time Estimates for Shadow Sensitivity Study

Percent Shadow Evacuation	Evacuating Shadow Vehicles[1]	Evacuation Time Estimate for Entire EPZ	
		90th Percentile	100th Percentile
0	0	2:20	4:55
20 (Base)	2,500	2:20	4:55
28 (Survey)	3,500	2:20	4:55
40	5,000	2:20	4:55
60	7,500	2:20	4:55
80	10,000	2:20	4:55
100	12,500	2:25	4:55

[1] The Evacuating Shadow Vehicles in Table M-2 represent the residents and employees who will spontaneously decide to relocate during the evacuation. The basis for the values shown is a 20% relocation of shadow residents along with a proportional percentage of shadow employees. See Section 6 for further discussion.

Table M-3. Evacuation Time Estimates for Variation with Population Change

EPZ and 20% Shadow Permanent Resident Population	Base	105%	106%	107%
	34,232	70,176	70,518	70,860
ETE (hrs:mins) for the 90th Percentile				
Region	Base	Population Change		
		105%	106%	107%
2-Mile Region (R01)	2:20	2:45	2:45	2:50
5-Mile Region (R02)	3:05	3:25	3:25	3:25
Entire EPZ (R03)	3:30	3:50	3:50	3:50
ETE (hrs:mins) for the 100th Percentile				
Region	Base	Population Change		
		105%	106%	107%
2-Mile Region (R01)	6:00	6:05	6:05	6:05
5-Mile Region (R02)	6:05	6:05	6:05	6:05
Entire EPZ (R03)	6:10	6:15	6:15	6:15

Table M-4. Evacuation Time Estimates for Change in Average Household Size

EPZ and Shadow Evacuating Vehicles	Base Case Average Household Size (2.77 people per household)	Sensitivity Case Average Household Size (2.41 people per household)
	18,398 vehicles	21,146 vehicles
ETE (hrs:mins) for the 90th Percentile		
2-Mile Region (R01)	2:05	2:05
5-Mile Region (R02)	2:10	2:25
Entire EPZ (R03)	2:20	2:45
ETE (hrs:mins) for the 100th Percentile		
2-Mile Region (R01)	4:45	4:45
5-Mile Region (R02)	4:50	4:50
Entire EPZ (R03)	4:55	4:55

APPENDIX N

ETE Criteria Checklist

N. ETE CRITERIA CHECKLIST

Table N-1. ETE Review Criteria Checklist

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
1.0 Introduction		
a. The emergency planning zone (EPZ) and surrounding area is described.	Yes	Section 1
b. A map is included that identifies primary features of the site including major roadways, significant topographical features, boundaries of counties, and population centers within the EPZ.	Yes	Figures 1-1, 3-1, 6-1
c. A comparison of the current and previous ETE is provided including information similar to that identified in Table 1-1, "ETE Comparison."	Yes	Table 1-3
1.1 Approach		
a. The general approach is described in the report as outlined in Section 1.1, "Approach."	Yes	Section 1.1, Section 1.3, Appendix D, Table 1-1,
1.2 Assumptions		
a. Assumptions consistent with Table 1-2, "General Assumptions," of NUREG/CR-7002 are provided and include the basis to support use.	Yes	Section 2
1.3 Scenario Development		
a. The scenarios in Table 1-3, "Evacuation Scenarios," are developed for the ETE analysis. A reason is provided for use of other scenarios or for not evaluating specific scenarios.	Yes	Section 6, Table 6-2

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
1.4 Evacuation Planning Areas		
a. A map of the EPZ with emergency response planning areas (ERPAs) is included.	Yes	Figure 3-1, Figure 6-1
1.4.1 Keyhole Evacuation		
a. A table similar to Table 1-4 "Evacuation Areas for a Keyhole Evacuation", is provided identifying the ERPAs considered for each ETE calculation by downwind direction.	Yes	Table 6-1, Table 7-5, Table H-1
1.4.2 Staged Evacuation		
a. The approach used in development of a staged evacuation is discussed.	Yes	Section 7.2
b. A table similar to Table 1-5, "Evacuation Areas for a Staged Evacuation," is provided for staged evacuations identifying the ERPAs considered for each ETE calculation by downwind direction.	Yes	Table 6-1, Table 7-5, Table H-1
2.0 Demand Estimation		
a. Demand estimation is developed for the four population groups (permanent residents of the EPZ, transients, special facilities, and schools).	Yes	Section 3
2.1 Permanent Residents and Transient Population		
a. The U.S. Census is the source of the population values, or another credible source is provided.	Yes	Section 3.1
b. The availability date of the census data is provided.	Yes	Section 3.1
c. Population values are adjusted as necessary for growth to reflect population estimates to the year of the ETE.	Yes	N/A - 2020 used as the base year of the analysis

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
d. A sector diagram, similar to Figure 2-1, "Population by Sector," is included showing the population distribution for permanent residents.	Yes	Figure 3-2
2.1.1 Permanent Residents with Vehicles		
a. The persons per vehicle value is between 1 and 3 or justification is provided for other values.	Yes	Section 3.1
2.1.2 Transient Population		
a. A list of facilities that attract transient populations is included, and peak and average attendance for these facilities is listed. The source of information used to develop attendance values is provided.	Yes	Section 3.3, Table E-4, Table E-5 and Table E-6
b. Major employers are listed.	Yes	Section 3.4, Table E-3
c. The average population during the season is used, itemized and totaled for each scenario.	Yes	Table 3-4, Table 3-5 and Appendix E itemize the peak transient population and employee estimates. These estimates are multiplied by the scenario specific percentages provided in Table 6-3 to estimate average transient population by scenario – see Table 6-4.
d. The percentage of permanent residents assumed to be at facilities is estimated.	Yes	Section 3.3 and Section 3.4
e. The number of people per vehicle is provided. Numbers may vary by scenario, and if so, reasons for the variation are discussed.	Yes	Section 3.3 and Section 3.4

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
f. A sector diagram is included, similar to Figure 2-1, "Population by Sector", is included showing the population distribution for the transient population.	Yes	Figure 3-6 (transients) and Figure 3-8 (employees)
2.2 Transit Dependent Permanent Residents		
a. The methodology (e.g., surveys, registration programs) used to determine the number of transit dependent residents is discussed.	Yes	Section 3.9
b. The State and local evacuation plans for transit dependent residents are used in the analysis.	Yes	Section 8.1
c. The methodology used to determine the number of people with disabilities and those with access and functional needs who may need assistance and do not reside in special facilities is provided. Data from local/county registration programs are used in the estimate.	Yes	Section 3.8
d. Capacities are provided for all types of transportation resources. Bus seating capacity of 50 percent is used or justification is provided for higher values.	Yes	Item 3 of Section 2.4
e. An estimate of the transit dependent population is provided.	Yes	Section 3.9, Table 3-9, Table 3-11
f. A summary table showing the total number of buses, ambulances, or other transport assumed available to support evacuation is provided. The quantification of resources is detailed enough to ensure that double counting has not occurred.	Yes	Table 3-12, Table 8-1

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
2.3 Special Facility Residents		
a. Special facilities, including the type of facility, location, and average population, are listed. Special facility staff is included in the total special facility population.	Yes	Table E-2 lists all medical facilities by facility name, location, and average population.
b. The method of obtaining special facility data is discussed.	Yes	Section 3.5
c. An estimate of the number and capacity of vehicles assumed available to support the evacuation of the facility is provided.	Yes	Table 3-6
d. The logistics for mobilizing specially trained staff (e.g., medical support or security support for prisons, jails, and other correctional facilities) are discussed when appropriate.	Yes	Section 8.1 – under Evacuation of Medical Facilities There are no Correctional Facilities within the EPZ
2.4 Schools		
a. A list of schools including name, location, student population, and transportation resources required to support the evacuation, is provided. The source of this information should be identified.	Yes	Table 3-7, Table E-1, Section 3.6
b. Transportation resources for elementary and middle schools are based on 100 percent of the school capacity.	Yes	Section 3.6
c. The estimate of high school students who will use personal vehicle to evacuate is provided and a basis for the values used is given.	Yes	Section 3.6
d. The need for return trips is identified.	Yes	Section 8.1

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
2.5 Other Demand Estimate Considerations		
2.5.1 Special Events		
a. A complete list of special events is provided including information on the population, estimated duration, and season of the event.	Yes	Section 3.7
b. The special event that encompasses the peak transient population is analyzed in the ETE.	Yes	Section 3.7
c. The percentage of permanent residents attending the event is estimated.	Yes	Section 3.7
2.5.2 Shadow Evacuation		
a. A shadow evacuation of 20 percent is included consistent with the approach outlined in Section 2.5.2, "Shadow Evacuation".	Yes	Item 7 of Section 2.2, Figure 2-1 and Figure 7-1, Section 3.2
b. Population estimates for the shadow evacuation in the shadow region beyond the EPZ are provided by sector.	Yes	Section 3.2, Table 3-3, Figure 3-4
c. The loading of the shadow evacuation onto the roadway network is consistent with the trip generation time generated for the permanent resident population.	Yes	Section 5 – Table 5-9 (footnote)
2.5.3 Background and Pass Through Traffic		
a. The volume of background traffic and pass-through traffic is based on the average daytime traffic. Values may be reduced for nighttime scenarios.	Yes	Section 3.10 and Section 3.11

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
b. The method of reducing background and pass-through traffic is described.	Yes	Section 2.2 – Assumptions 10 and 11 Section 2.5 Section 3.10 and Section 3.11 Table 6-3 – External Through Traffic footnote
c. Pass-through traffic is assumed to have stopped entering the EPZ about two (2) hours after the initial notification.	Yes	Section 2.5
2.6 Summary of Demand Estimation		
a. A summary table is provided that identifies the total populations and total vehicles used in the analysis for permanent residents, transients, transit dependent residents, special facilities, schools, shadow population, and pass-through demand in each scenario.	Yes	Table 3-11, Table 3-12, and Table 6-4
3.0 Roadway Capacity		
a. The method(s) used to assess roadway capacity is discussed.	Yes	Section 4
3.1 Roadway Characteristics		
a. The process for gathering roadway characteristic data is described including the types of information gathered and how it is used in the analysis.	Yes	Section 1.3, Appendix D
b. Legible maps are provided that identify nodes and links of the modeled roadway network similar to Figure A-1, "Roadway Network Identifying Nodes and Links," and Figure A-2, "Grid Map Showing Detailed Nodes and Links."	Yes	Appendix K

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
3.2 Model Approach		
a. The approach used to calculate the roadway capacity for the transportation network is described in detail, and the description identifies factors that are expressly used in the modeling.	Yes	Section 4
b. Route assignment follows expected evacuation routes and traffic volumes.	Yes	Appendix B and Appendix C
c. A basis is provided for static route choices if used to assign evacuation routes.	N/A	Static route choices are not used to assign evacuation routes. Dynamic traffic assignment is used.
d. Dynamic traffic assignment models are described including calibration of the route assignment.	Yes	Appendix B and Appendix C
3.3 Intersection Control		
a. A list that includes the total numbers of intersections modeled that are unsignalized, signalized, or manned by response personnel is provided.	Yes	Table K-1
b. The use of signal cycle timing, including adjustments for manned traffic control, is discussed.	Yes	Section 4, Appendix G
3.4 Adverse Weather		
a. The adverse weather conditions are identified.	Yes	Assumption 2, 3, 4 and 6 of Section 2.6
b. The speed and capacity reduction factors identified in Table 3-1, "Weather Capacity Factors," are used or a basis is provided for other values, as applicable to the model.	Yes	Table 2-2
c. The calibration and adjustment of driver behavior models for adverse weather conditions are described, if applicable.	N/A	Driver behavior is not adjusted for adverse weather conditions.

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
d. The effect of adverse weather on mobilization is considered and assumptions for snow removal on streets and driveways are identified, when applicable.	Yes	Table 2-2
4.0 Development of Evacuation Times		
4.1 Traffic Simulation Models		
a. General information about the traffic simulation model used in the analysis is provided.	Yes	Section 1.3, Table 1-3, Appendix B, Appendix C
b. If a traffic simulation model is not used to perform the ETE calculation, sufficient detail is provided to validate the analytical approach used.	N/A	Not applicable since a traffic simulation model was used.
4.2 Traffic Simulation Model Input		
a. Traffic simulation model assumptions and a representative set of model inputs are provided.	Yes	Section 2, Appendix J
b. The number of origin nodes and method for distributing vehicles among the origin nodes are described.	Yes	Appendix J, Appendix C
c. A glossary of terms is provided for the key performance measures and parameters used in the analysis.	Yes	Appendix A
4.3 Trip Generation Time		
a. The process used to develop trip generation times is identified.	Yes	Section 5
b. When surveys are used, the scope of the survey, area of the survey, number of participants, and statistical relevance are provided.	Yes	Appendix F
c. Data used to develop trip generation times are summarized.	Yes	Appendix F, Section 5

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
d. The trip generation time for each population group is developed from site-specific information.	Yes	Section 5
e. The methods used to reduce uncertainty when developing trip generation times are discussed, if applicable.	Yes	Appendix F
4.3.1 Permanent Residents and Transient Population		
a. Permanent residents are assumed to evacuate from their homes but are not assumed to be at home at all times. Trip generation time includes the assumption that a percentage of residents will need to return home before evacuating.	Yes	Section 5 discusses trip generation for households with and without returning commuters. Table 6-3 presents the percentage of households with returning commuters and the percentage of households either without returning commuters or with no commuters. Appendix F presents the percent households who will await the return of commuters. Section 2.3, Assumption 3
b. The trip generation time accounts for the time and method to notify transients at various locations.	Yes	Section 5
c. The trip generation time accounts for transients potentially returning to hotels before evacuating.	Yes	Section 5, Figure 5-1
d. The effect of public transportation resources used during special events where a large number of transients are expected is considered.	Yes	Section 3.7 Public Transportation is not provided for the special event and was therefore not considered.

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
4.3.2 Transit Dependent Permanent Residents		
a. If available, existing and approved plans and bus routes are used in the ETE analysis.	N/A	Established bus routes do not exist. Section 8.1 under Evacuation of Transit-Dependent People
b. The means of evacuating ambulatory and non-ambulatory residents are discussed.	Yes	Section 8.1 under Evacuation of Transit-Dependent People, Section 8.2
c. Logistical details, such as the time to obtain buses, brief drivers and initiate the bus route are used in the analysis.	Yes	Section 8.1, Figure 8-1
d. The estimated time for transit dependent residents to prepare and then travel to a bus pickup point, including the expected means of travel to the pickup point, is described.	Yes	Section 8.1 under Evacuation of Transit-Dependent People
e. The number of bus stops and time needed to load passengers are discussed.	Yes	Section 8.1, Table 8-5 though Table 8-7
f. A map of bus routes is included.	Yes	Figure 10-2
g. The trip generation time for non-ambulatory persons including the time to mobilize ambulances or special vehicles, time to drive to the home of residents, time to load, and time to drive out of the EPZ, is provided.	Yes	Section 8.2
h. Information is provided to support analysis of return trips, if necessary.	Yes	Section 8.1 and 8.2
4.3.3 Special Facilities		
a. Information on evacuation logistics and mobilization times is provided.	Yes	Section 2.4, Section 8.1, Table 8-8 through Table 8-10

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
b. The logistics of evacuating wheelchair and bed bound residents are discussed.	Yes	Section 8.1, Table 8-8 through Table 8-10
c. Time for loading of residents is provided.	Yes	Section 2.4, Section 8.1, Table 8-8 through Table 8-10
d. Information is provided that indicates whether the evacuation can be completed in a single trip or if additional trips are needed.	Yes	Section 8.1
e. Discussion is provided on whether special facility residents are expected to pass through the reception center before being evacuated to their final destination.	Yes	Section 8.1
f. Supporting information is provided to quantify the time elements for each trip, including destinations if return trips are needed.	Yes	Section 8.1
4.3.4 Schools		
a. Information on evacuation logistics and mobilization times is provided.	Yes	Section 2.4, Section 8.1, Table 8-2 through Table 8-4
b. Time for loading of students is provided.	Yes	Section 2.4, Section 8.1, Table 8-2 through Table 8-4
c. Information is provided that indicates whether the evacuation can be completed in a single trip or if additional trips are needed.	Yes	Section 8.1
d. If used, reception centers should be identified. A discussion is provided on whether students are expected to pass through the reception center before being evacuated to their final destination.	Yes	Section 8.1, Table 10-3

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
e. Supporting information is provided to quantify the time elements for each trip, including destinations if return trips are needed.	Yes	Section 8.1, Table 8-2 through Table 8-4
4.4 Stochastic Model Runns		
a. The number of simulation runs needed to produce average results is discussed.	N/A	DYNEV does not rely on simulation averages or random seeds for statistical confidence. For DYNEV/DTRAD, it is a meso-scopic simulation and uses dynamic traffic assignment model to obtain the "average" (stable) network work flow distribution. This is different from microscopic simulation, which is monte-carlo random sampling by nature relying on different seeds to establish statistical confidence. Refer to Appendix B for more details
b. If one run of a single random seed is used to produce each ETE result, the report includes a sensitivity study on the 90 percent and 100 percent ETE using 10 different random seeds for evacuation of the full EPZ under Summer, Midweek, Daytime, Normal Weather conditions.	N/A	
4.5 Model Boundaries		
a. The method used to establish the simulation model boundaries is discussed.	Yes	Section 4.5
b. Significant capacity reductions or population centers that may influence the ETE and that are located beyond the evacuation area or shadow region are identified and included in the model, if needed.	Yes	Section 4.5

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
4.6 Traffic Simulation Model Output		
a. A discussion of whether the traffic simulation model used must be in equilibration prior to calculating the ETE is provided.	Yes	Appendix B
b. The minimum following model outputs for evacuation of the entire EPZ are provided to support review: 1. Evacuee average travel distance and time. 2. Evacuee average delay time. 3. Number of vehicles arriving at each destination node. 4. Total number and percentage of evacuee vehicles not exiting the EPZ. 5. A plot that provides both the mobilization curve and evacuation curve identifying the cumulative percentage of evacuees who have mobilized and exited the EPZ. 6. Average speed for each major evacuation route that exits the EPZ.	Yes	1. Appendix J, Table J-2 2. Table J-2 3. Table J-4 4. None and 0%. 100 percent ETE is based on the time the last vehicle exits the evacuation zone 5. Figures J-2 through J-15 (one plot for each scenario considered) 6. Table J-3
c. Color coded roadway maps are provided for various times (e.g., at 2, 4, 6 hrs.) during a full EPZ evacuation scenario, identifying areas where congestion exists.	Yes	Figure 7-3 through Figure 7-6
4.7 Evacuation Time Estimates for the General Public		
a. The ETE includes the time to evacuate 90 percent and 100 percent of the total permanent resident and transient population.	Yes	Table 7-1 and Table 7-2
b. Termination criteria for the 100 percent ETE are discussed, if not based on the time the last vehicle exits the evacuation zone.	N/A	100 percent ETE is based on the time the last vehicle exits the evacuation zone.

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
c. The ETE for 100 percent of the general public includes all members of the general public. Any reductions or truncated data is explained.	Yes	Section 5.4.1 – truncating survey data to eliminate statistical outliers Table 7-2 – 100th percentile ETE for general population
d. Tables are provided for the 90 and 100 percent ETEs similar to Table 4-3, "ETEs for a Staged Evacuation," and Table 4-4, "ETEs for a Keyhole Evacuation."	Yes	Table 7-3 and Table 7-4
e. ETEs are provided for the 100 percent evacuation of special facilities, transit dependent, and school populations.	Yes	Section 8
5.0 Other Considerations		
5.1 Development of Traffic Control Plans		
a. Information that responsible authorities have approved the traffic control plan used in the analysis are discussed.	Yes	Section 9, Appendix G
b. Adjustments or additions to the traffic control plan that affect the ETE is provided.	Yes	Section 9, Appendix G
5.2 Enhancements in Evacuation Time		
a. The results of assessments for enhancing evacuations are provided.	Yes	Appendix M
5.3 State and Local Review		
a. A list of agencies contacted is provided and the extent of interaction with these agencies is discussed.	Yes	Table 1-1

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
b. Information is provided on any unresolved issues that may affect the ETE.	Yes	Results of the ETE study were formally presented to state and local agencies at the final project meeting. There are no unresolved issues.
5.4 Reviews and Updates		
a. The criteria for when an updated ETE analysis is required to be performed and submitted to the NRC is discussed.	Yes	Appendix M, Section M.3
5.4.1 Extreme Conditions		
a. The updated ETE analysis reflects the impact of EPZ conditions not adequately reflected in the scenario variations.	N/A	This ETE is being updated as a result of the availability of US Census Bureau decennial census data.
5.5 Reception Centers and Congregate Care Center		
a. A map of congregate care centers and reception centers is provided.	Yes	Figure 10-3