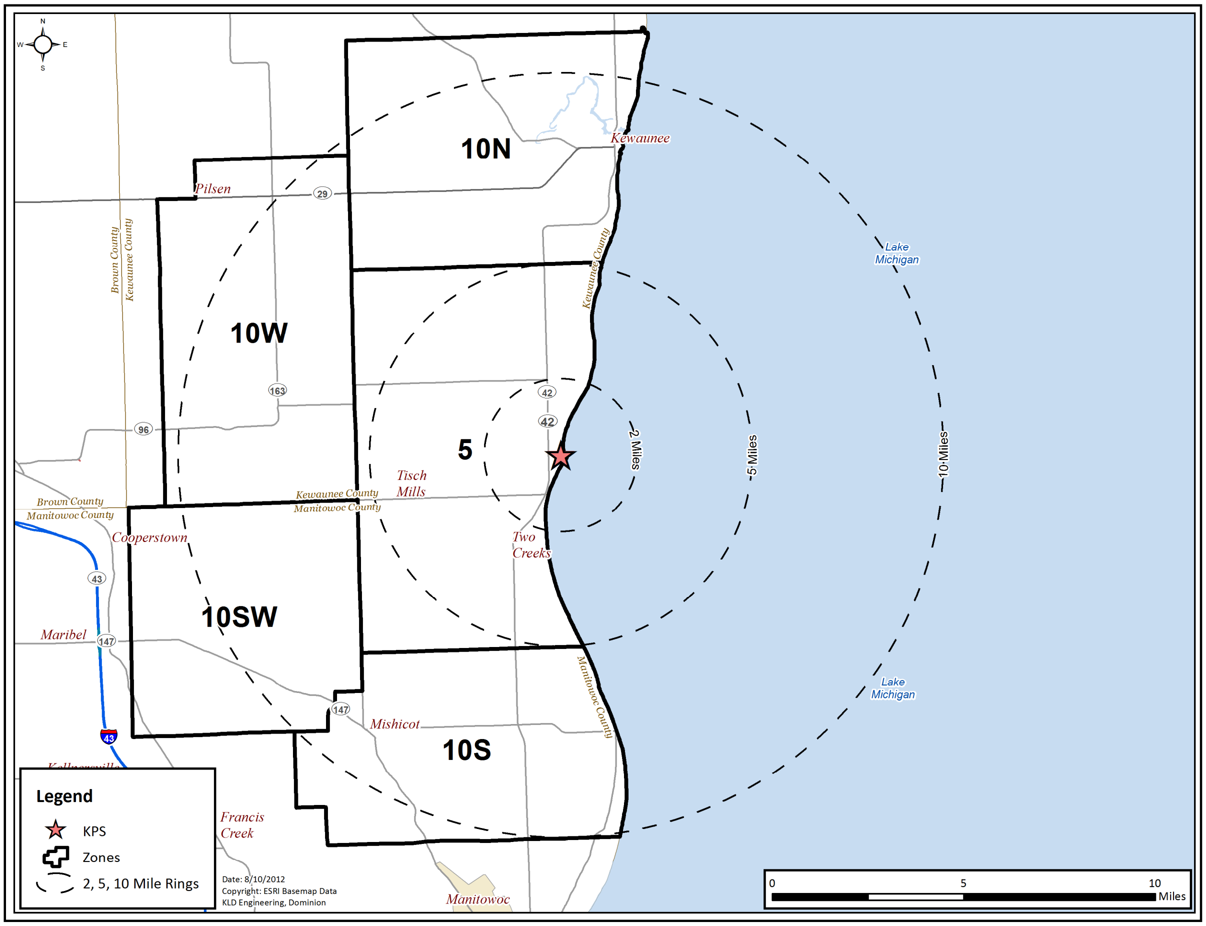
KLD ENGINEERING, P.C.

Kewaunee Power Station

Development of Evacuation Time Estimates



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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 Kewaunee Power Station (KPS) located in Kewaunee County, Wisconsin. ETE are part of the required planning basis and provide Dominion 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:

- Criteria for Development of Evacuation Time Estimate Studies, NUREG/CR-7002, November 2011.
- Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants, NUREG-0654/FEMA-REP-1, Rev. 1, November 1980.
- Development of Evacuation Time Estimates for Nuclear Power Plants, NUREG/CR-6863, January 2005.
- 10CFR50, Appendix E – "Emergency Planning and Preparedness for Production and Utilization Facilities"

Overview of Project Activities

This project began in November, 2011 and extended over a period of 12 months. The major activities performed are briefly described in chronological sequence:

- Attended "kick-off" meetings with Dominion personnel and emergency management personnel representing state and county governments.
- Accessed U.S. Census Bureau data files for the year 2010. Studied Geographical Information Systems (GIS) maps of the area in the vicinity of the Kewaunee Power Station, then conducted a detailed field survey of the highway network.
- Synthesized this information to create an analysis network representing the highway system topology and capacities within the Emergency Planning Zone (EPZ), plus a Shadow Region covering the region between the EPZ boundary and approximately 15 miles radially from the plant.
- Designed and sponsored a telephone 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.
- Data collection forms (provided to the OROs at the kickoff meeting) were returned with data pertaining to employment, transients, and special facilities in each county.

Telephone calls to specific facilities supplemented the data provided.

- The traffic demand and trip-generation rates of evacuating vehicles were estimated from the gathered data. The trip generation rates reflected the estimated mobilization time (i.e., the time required by evacuees to prepare for the evacuation trip) computed using the results of the telephone survey of EPZ residents.
- Following federal guidelines, the EPZ is subdivided into 5 zones. These zones are then grouped within circular areas or "keyhole" configurations (circles plus radial sectors) that define a total of 17 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, Snow) as shown in Table 6-2. One special event scenario involving an outage and KPS was considered. One roadway impact scenario was considered wherein a section of SR 42 was closed between Miller St and Peterson St.
- 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, the Planning Basis for the calculation of ETE is:
  - A rapidly escalating accident at the KPS that quickly assumes the status of General Emergency such that the Advisory to Evacuate 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 Advisory to Evacuate 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 reception centers or host schools 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, van, or ambulance, as required. Separate ETE are calculated for the transit-dependent evacuees, for homebound special needs population, and for those evacuated from special facilities.

<u>Computation of ETE</u>

A total of 238 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 17 Evacuation

Regions to evacuate from that Region, under the circumstances defined for one of the 14 Evacuation Scenarios (17 x 14 = 238). Separate ETE are calculated for transit-dependent evacuees, including schoolchildren for applicable scenarios.

Except for Region R02, 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 Advisory to Evacuate applies only to those people occupying the specified impacted region. It is assumed that 100 percent of the people within the impacted region will evacuate in response to this Advisory. 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 percent and 100 percent, 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.

The use of a public outreach (information) program to emphasize the need for evacuees to

minimize the time needed to prepare to evacuate (secure the home, assemble needed clothes, medicines, etc.) should also be considered.

Traffic Management

This study references the comprehensive traffic management plan provided by Kewaunee and Manitowoc Counties. Due to the limited traffic congestion within the EPZ, no additional traffic or access control measures have been identified as a result of this study.

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.

- Figure 6-1 displays a map of the KPS EPZ showing the layout of the 5 zones that comprise, in aggregate, the EPZ.
- Table 3-1 presents the estimates of permanent resident population in each zone based on the 2010 Census data.
- Table 6-1 defines each of the 17 Evacuation Regions in terms of their respective groups of zones.
- Table 6-2 lists the Evacuation Scenarios.
- Table 7-1 and Table 7-2 are compilations of ETE. These data are the times needed to clear the indicated regions of 90 and 100 percent 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.
- Table 7-3 and Table 7-4 present ETE for the 5-mile region for un-staged and staged evacuations for the 90^{th} and 100^{th} percentiles, respectively.
- Table 8-7 presents ETE for the schoolchildren in good weather.
- Table 8-11 presents ETE for the transit-dependent population in good weather.
- Figure H-8 presents an example of an Evacuation Region (Region R08) 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 238 unique cases – a combination of 17 unique Evacuation Regions and 14 unique Evacuation Scenarios. Table 7-1 and Table 7-2 document these ETE for the 90^{th} and 100^{th} percentiles. These ETE range from 1:35 (hr:min) to 2:10 (slightly higher for snow) at the 90^{th} percentile.
- Inspection of Table 7-1 and Table 7-2 indicates that the ETE for the 100^{th} percentile are significantly longer than those for the 90^{th} percentile. This is the result of the long trip generation "tail". As these stragglers mobilize, the aggregate rate of egress slows since many vehicles have already left the EPZ. Towards the end of the process, relatively few evacuation routes service the remaining demand. See Figures 7-7 through 7-20.
- Inspection of Table 7-3 and Table 7-4 indicates that a staged evacuation provides no

benefits to evacuees from within the 5 mile region (compare Regions R02 through R09 with Regions R17 and R10 through R16, respectively, in Tables 7-1 and 7-2). See Section 7.6 for additional discussion.

- Comparison of Scenarios 6 (winter, midweek, midday) and 13 (winter, midweek, midday, special event) in Table 7-2 indicates that the special event does not materially affect the ETE. See Section 7.5 for additional discussion.
- Comparison of Scenarios 1 and 14 in Table 7-1 indicates that the roadway closure – a section of SR 42 was closed between Miller St and Peterson St- has no impact on the 90^{th} or 100^{th} percentile ETE. Sufficient reserve highway capacity mitigates the impacts of the capacity reduction considered.
- There is minimal traffic congestion within the EPZ. All congestion within the EPZ clears by 1 hour and 15 minutes after the Advisory to Evacuate. See Section 7.3 and Figures 7-3 through 7-6.
- Separate ETE were computed for schools, medical facilities, transit-dependent persons and homebound special needs persons. The average single-wave ETE for schools and medical facilities are within a similar range as the general population ETE at the 90^{th} percentile. The average single-wave ETE for transit dependent persons and homebound special needs persons are approximately 30 minutes longer than the 90^{th} percentile ETE for the general population. See Section 8.
- Table 8-5 indicates that there are enough buses and wheelchair accessible vans and ambulances available to evacuate the transit-dependent population within the EPZ in a single wave.
- The general population ETE at the 90^{th} percentile is insensitive to reductions in the base trip generation time of 3 hours, 30 minutes. The general population ETE at the 100^{th} percentile, however, closely mirrors trip generation time. See Table M-1.
- The general population ETE is insensitive to the voluntary evacuation of vehicles in the Shadow Region (tripling the shadow evacuation percentage results in no change in the 90^{th} percentile ETE). See Table M-2.
- An increase in permanent resident population of 350% or more, or a decrease in population of 90% or more results in ETE changes which meet the NRC criteria for updating ETE between decennial Censuses. See Section M.3.

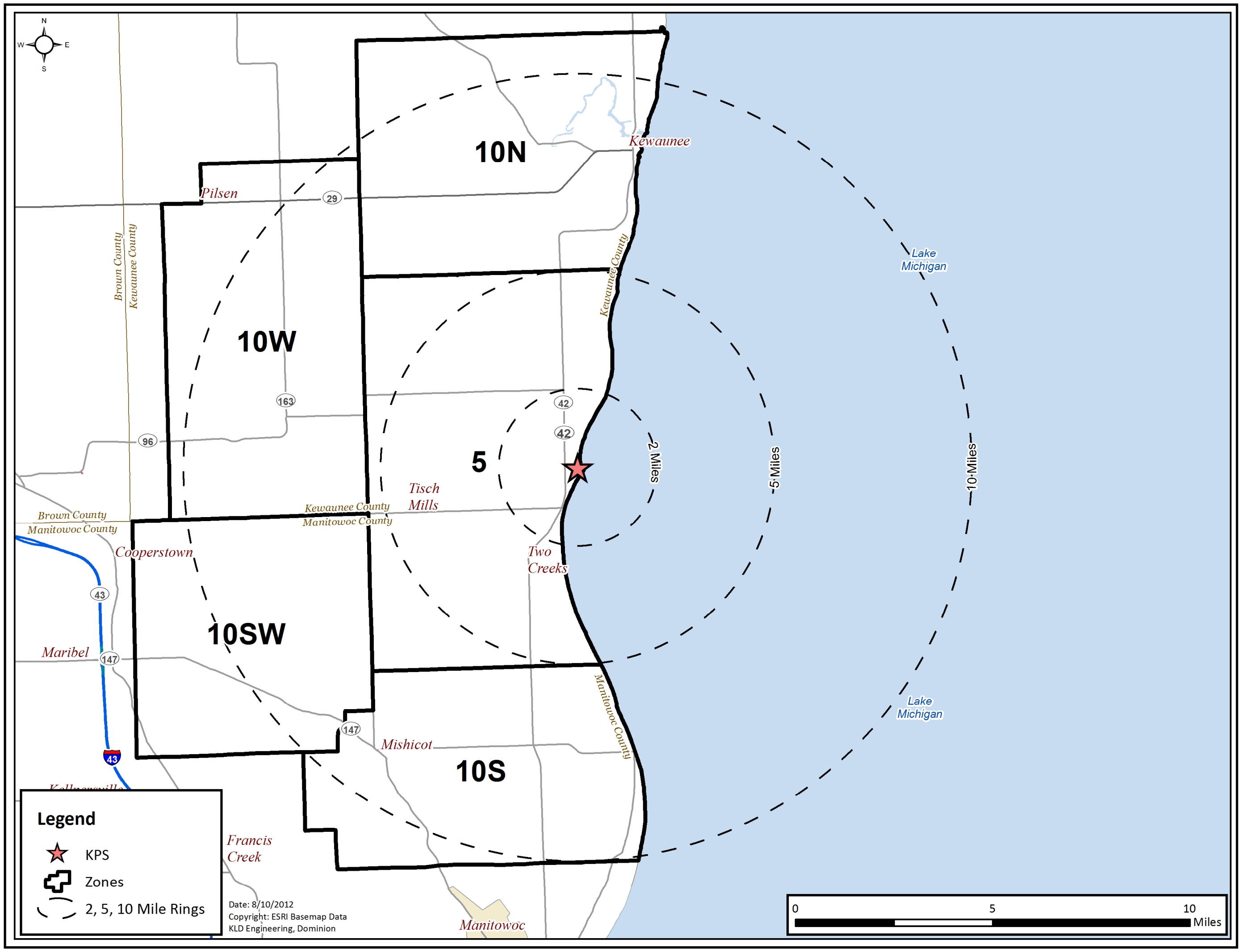


Figure 6-1. KPS EPZ Zones

Table 3-1. EPZ Permanent Resident Population

Zone	2000 Population	2010 Population
5	1,841	1,728
10N	4,207	4,367
10S	2,507	2,748
10SW	1,785	1,349
10W	1,385	1,404
TOTAL	**11,725**	**11,596**
EPZ Population Growth:		**-1.10%**

Table 6-1. Description of Evacuation Regions

Region	Description	Zone				
		5	10N	10W	10SW	10S
R01	2-Mile Radius	X				
N/A	5-Mile Radius	**Refer to R01**				
R02	Full EPZ	X	X	X	X	X
Evacuate 2-Mile Radius and Downwind to 5 Miles						
Region	**Wind From °**	**Zone**				
		5	**10N**	**10W**	**10SW**	**10S**
N/A	Full 360	**Refer to R01**				
Evacuate 5-Mile Radius and Downwind to 10 Miles						
Region	**Wind From °**	**Zone**				
		5	**10N**	**10W**	**10SW**	**10S**
R03	324 - 9	X				X
R04	9 – 54	X			X	X
R05	54 – 80.5	X		X	X	X
R06	80.5 – 99	X		X	X	
R07	99 – 103	X	X	X	X	
R08	103 – 170.5	X	X	X		
R09	170.5 – 215.5	X	X			
N/A	215.5 – 324	**Refer to R01**				
Staged Evacuation - 5-Mile Radius Evacuates, then Evacuate Downwind to 10 Miles						
Region	**Wind From °**	**Zone**				
		5	**10N**	**10W**	**10SW**	**10S**
R10	324 - 9	X				X
R11	9 – 54	X			X	X
R12	54 – 80.5	X		X	X	X
R13	80.5 – 99	X		X	X	
R14	99 – 103	X	X	X	X	
R15	103 – 170.5	X	X	X		
R16	170.5 – 215.5	X	X			
N/A	215.5 – 324	**Refer to R01**				
R17	Full EPZ	X	X	X	X	X
Zone(s) Shelter-in-Place until 90% ETE for R01, then Evacuate		Zone(s) Shelter-in-Place			Zone(s) 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	Rain	None
8	Winter	Midweek	Midday	Snow	None
9	Winter	Weekend	Midday	Good	None
10	Winter	Weekend	Midday	Rain	None
11	Winter	Weekend	Midday	Snow	None
12	Winter	Midweek, Weekend	Evening	Good	None
13	Winter	Midweek	Midday	Good	Plant outage at Kewaunee Power Station
14	Summer	Midweek	Midday	Good	Roadway Impact – Close NB lane on SR 42

[1] Winter means that school is in session (also applies to spring and autumn). Summer means that school is not in session.

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

	Summer		Summer		Summer	Winter			Winter			Winter	Winter	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Region	Midday		Midday		Evening	Midday			Midday			Evening	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather	Special Event	Roadway Impact
Entire 5-Mile Region and EPZ														
R01	1:35	1:35	1:40	1:40	1:40	1:35	1:35	2:05	1:40	1:40	2:15	1:40	1:30	1:35
R02	1:50	1:50	1:40	1:40	1:40	1:55	1:55	2:25	1:40	1:40	2:15	1:45	1:50	1:50
5-Mile Region and Keyhole to EPZ Boundary														
R03	1:40	1:45	1:35	1:35	1:35	1:45	1:50	2:15	1:35	1:40	2:10	1:40	1:40	1:40
R04	1:45	1:45	1:35	1:35	1:40	1:50	1:50	2:20	1:40	1:40	2:15	1:40	1:45	1:45
R05	1:50	1:50	1:40	1:40	1:40	1:50	1:55	2:20	1:40	1:40	2:15	1:40	1:50	1:50
R06	1:50	1:50	1:45	1:45	1:45	1:50	1:50	2:20	1:45	1:45	2:20	1:45	1:45	1:50
R07	1:50	1:50	1:40	1:40	1:40	1:55	1:55	2:25	1:45	1:45	2:20	1:45	1:50	1:50
R08	1:50	1:50	1:40	1:40	1:40	1:55	1:55	2:25	1:45	1:45	2:20	1:45	1:50	1:50
R09	1:50	1:50	1:40	1:40	1:40	1:50	1:50	2:20	1:40	1:40	2:15	1:40	1:45	1:50
Staged Evacuation - 5-Mile Region and Keyhole to EPZ Boundary														
R10	2:00	2:00	2:00	2:00	2:00	2:00	2:00	2:30	2:00	2:00	2:30	2:00	2:00	2:00
R11	2:00	2:00	2:00	2:00	2:00	2:00	2:00	2:35	2:00	2:00	2:35	2:00	2:00	2:00
R12	2:00	2:05	2:00	2:00	2:00	2:05	2:05	2:35	2:05	2:05	2:35	2:05	2:00	2:00
R13	2:00	2:05	2:00	2:05	2:05	2:00	2:05	2:35	2:05	2:05	2:35	2:05	2:00	2:00
R14	2:05	2:05	2:05	2:05	2:05	2:05	2:05	2:40	2:05	2:05	2:40	2:05	2:05	2:05
R15	2:05	2:05	2:05	2:05	2:05	2:05	2:10	2:40	2:05	2:05	2:40	2:05	2:05	2:05
R16	2:05	2:05	2:05	2:05	2:05	2:05	2:05	2:40	2:05	2:05	2:40	2:05	2:05	2:05
R17	2:05	2:05	2:05	2:05	2:05	2:05	2:05	2:40	2:05	2:05	2:40	2:05	2:05	2:05

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

	Summer		Summer		Summer	Winter			Winter			Winter	Winter	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek	Midweek
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
Region	Midday		Midday		Evening	Midday			Midday			Evening	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather	Special Event	Roadway Impact
Entire 5-Mile Region, and EPZ														
R01	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R02	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
5-Mile Region and Keyhole to EPZ Boundary														
R03	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R04	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R05	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R06	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R07	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R08	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R09	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
Staged Evacuation - 5-Mile Region and Keyhole to EPZ Boundary														
R10	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R11	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R12	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R13	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R14	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R15	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R16	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R17	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40

Table 7-3. Time to Clear *90* Percent of the 5-Mile Area within the Indicated Region

	Summer		Summer		Summer	Winter			Winter			Winter	Winter	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek	Midweek
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
Region	Midday		Midday		Evening	Midday			Midday			Evening	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather	Special Event	Roadway Impact
Entire 5-Mile Region, and EPZ														
R01	1:35	1:35	1:40	1:40	1:40	1:35	1:35	2:05	1:40	1:40	2:15	1:40	1:30	1:35
R02	1:40	1:40	1:40	1:40	1:40	1:40	1:40	2:05	1:40	1:40	2:15	1:40	1:30	1:40
Unstaged Evacuation - 5-Mile Region and Keyhole to EPZ Boundary														
R03	1:35	1:40	1:40	1:40	1:40	1:35	1:35	2:05	1:40	1:40	2:15	1:40	1:30	1:35
R04	1:40	1:40	1:40	1:40	1:40	1:40	1:40	2:05	1:40	1:40	2:15	1:40	1:30	1:40
R05	1:40	1:40	1:40	1:40	1:40	1:40	1:40	2:05	1:40	1:40	2:15	1:40	1:30	1:40
R06	1:40	1:40	1:40	1:40	1:40	1:40	1:40	2:05	1:40	1:40	2:15	1:40	1:30	1:40
R07	1:40	1:40	1:40	1:40	1:40	1:40	1:40	2:05	1:40	1:40	2:15	1:40	1:30	1:40
R08	1:40	1:40	1:40	1:40	1:40	1:35	1:40	2:05	1:40	1:40	2:15	1:40	1:30	1:40
R09	1:35	1:35	1:40	1:40	1:40	1:35	1:35	2:05	1:40	1:40	2:15	1:40	1:30	1:35
Staged Evacuation - 5-Mile Region and Keyhole to EPZ Boundary														
R10	1:45	1:45	1:50	1:50	1:50	1:45	1:45	2:15	1:50	1:50	2:25	1:50	1:35	1:45
R11	1:50	1:50	1:55	1:55	1:55	1:50	1:50	2:20	1:55	1:55	2:25	1:55	1:40	1:50
R12	1:50	1:50	1:55	1:55	1:55	1:50	1:50	2:20	1:55	1:55	2:30	1:55	1:45	1:50
R13	1:50	1:50	1:55	1:55	1:55	1:50	1:50	2:20	1:55	1:55	2:25	1:55	1:40	1:50
R14	1:50	1:50	1:55	1:55	1:55	1:50	1:50	2:20	1:55	1:55	2:25	1:55	1:40	1:50
R15	1:45	1:45	1:50	1:50	1:50	1:45	1:45	2:15	1:50	1:50	2:25	1:50	1:35	1:45
R16	1:40	1:40	1:50	1:50	1:50	1:40	1:40	2:10	1:50	1:50	2:20	1:50	1:30	1:40
R17	1:50	1:50	1:55	1:55	1:55	1:50	1:50	2:20	1:55	1:55	2:30	1:55	1:45	1:50

Table 7-4. Time to Clear *100* Percent of the 5-Mile Area within the Indicated Region

	Summer		Summer		Summer	Winter			Winter			Winter	Winter	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Region	Midday		Midday		Evening	Midday			Midday			Evening	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather	Special Event	Roadway Impact
Entire 5-Mile Region, and EPZ														
R01	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R02	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
5-Mile Region and Keyhole to EPZ Boundary														
R03	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R04	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R05	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R06	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R07	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R08	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R09	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
Staged Evacuation - 5-Mile Region and Keyhole to EPZ Boundary														
R10	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R11	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R12	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R13	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R14	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R15	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R16	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R17	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35

Table 8-7. 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 H.S. (mi.)	Travel Time from EPZ Bdry to H.S. (min)	ETE to H.S. (hr:min)
KEWAUNEE COUNTY SCHOOLS									
Holy Rosary Catholic School	90	15	6.2	52.5	8	**1:55**	8.8	12	**2:05**
Kewaunee Grade School	90	15	5.6	52.0	7	**1:55**	8.8	12	**2:05**
Kewaunee High School	90	15	5.6	52.0	7	**1:55**	8.8	12	**2:05**
Kewaunee Intermediate School	90	15	5.6	52.0	7	**1:55**	8.8	12	**2:05**
Lakeshore Alternative School	90	15	6.0	49.4	8	**1:55**	8.8	12	**2:05**
MANITOWOC COUNTY SCHOOLS									
East Twin Lutheran School	90	15	3.3	50.2	4	**1:50**	14.7	20	**2:10**
Mishicot High School	90	15	4.8	49.1	6	**1:55**	18.9	26	**2:20**
Mishicot Middle School	90	15	4.8	49.1	6	**1:55**	18.9	26	**2:20**
Schultz Elementary School	90	15	5.0	47.0	7	**1:55**	18.9	26	**2:20**
					Maximum for EPZ:	**1:55**		**Maximum:**	**2:20**
					Average for EPZ:	**1:55**		**Average:**	**2:10**

Table 8-11. Transit-Dependent Evacuation Time Estimates - Good Weather

Route Number	Bus Number	One-Wave							Two-Wave					
		Mobilization (min)	Route Length (miles)	Speed (mph)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)	Distance to R. C. (miles)	Travel Time to R. C. (min)	Unload (min)	Driver Rest (min)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)
13	1	90	7.5	54.6	8	30	**2:10**	8.0	11	5	10	29	30	**3:35**
	2	110	7.5	55.0	8	30	**2:30**	8.0	11	5	10	29	30	**3:55**
14	1	90	14.9	55.0	16	30	**2:20**	23.8	32	5	10	68	30	**4:45**
15	1	90	12.5	55.0	14	30	**2:15**	8.0	11	5	10	42	30	**3:55**
16	1	90	6.1	54.0	7	30	**2:10**	7.2	10	5	10	24	30	**3:30**
17	1	90	4.3	52.0	5	30	**2:05**	5.2	7	5	10	18	30	**3:15**
	2	110	4.3	52.7	5	30	**2:25**	5.2	7	5	10	17	30	**3:35**
						Maximum ETE:	**2:30**						**Maximum ETE:**	**4:45**
						Average ETE:	**2:20**						**Average ETE:**	**3:50**

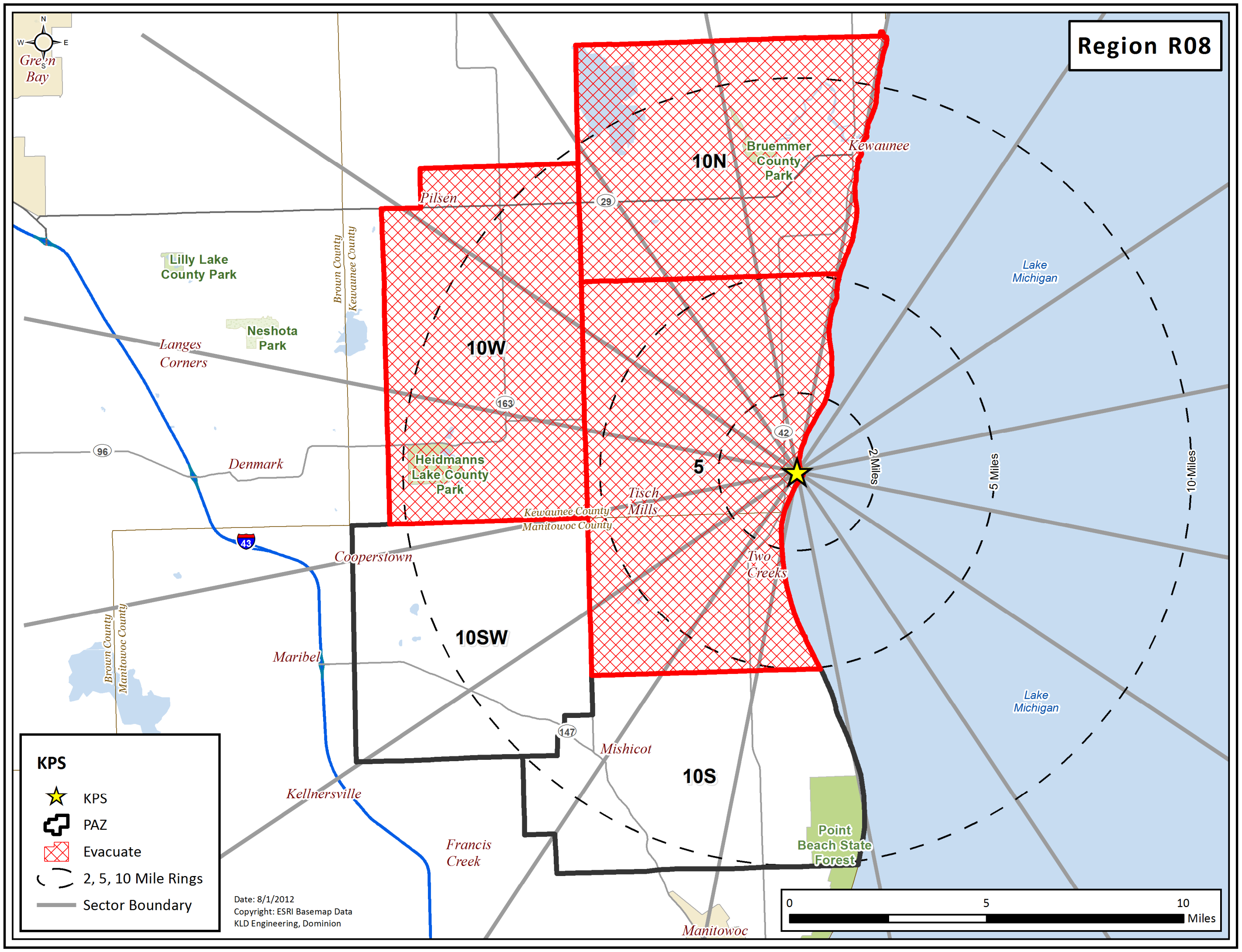


Figure H-8. Region R08

1 INTRODUCTION

This report describes the analyses undertaken and the results obtained by a study to develop Evacuation Time Estimates (ETE) for the Kewaunee Power Station (KPS), located in Kewaunee County, Wisconsin. 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 Governmental agencies. Most important of these are:

- Criteria for Development of Evacuation Time Estimate Studies, NUREG/CR-7002, November 2011.
- Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants, NUREG 0654/FEMA REP 1, Rev. 1, November 1980.
- Analysis of Techniques for Estimating Evacuation Times for Emergency Planning Zones, NUREG/CR 1745, November 1980.
- Development of Evacuation Time Estimates for Nuclear Power Plants, NUREG/CR-6863, January 2005.

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.

Table 1-1. Stakeholder Interaction

Stakeholder	Nature of Stakeholder Interaction
Dominion emergency planning personnel	Meetings to define data requirements and set up contacts with local government agencies
Kewaunee County Department of Emergency Management	Meetings to define data requirements and set up contacts with local government agencies. Obtain local emergency plans, special facility data, major employment data
Manitowoc County Division of Emergency Services	
Wisconsin Department of Military Affairs Division of Emergency Management	Obtain state emergency plan
Local and State Police Agencies	Obtain existing traffic management plans

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 Dominion.

b. Attended meetings with emergency planners from the Wisconsin Department of Military Affairs Division of Emergency Management, Kewaunee County Department of Emergency Management, and Manitowoc County Division of Emergency Services 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 2010 census, and local agencies.

e. Conducted a random sample telephone survey of EPZ residents.

f. Conducted a data collection effort to identify and describe schools, special facilities, major employers, 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 random sample telephone 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 to be implemented by local and state police in the event of an incident at the plant. Traffic control is applied at specified Traffic Control Points (TCP) located within the EPZ.

5. Used existing zones to define Evacuation Regions. The EPZ is partitioned into 5 zones along jurisdictional and geographic boundaries. "Regions" are groups of contiguous zones 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.

6. Estimated demand for transit services for persons at "Special Facilities" and for transit-dependent persons at home.

7. Prepared the input streams for the DYNEV II system.

    a. Estimated the evacuation traffic demand, based on the available information derived from Census data, and from data provided by local and state agencies, Dominion and from the telephone survey.

    b. Applied the procedures specified in the 2010 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.

[1] Highway Capacity Manual (HCM 2010), Transportation Research Board, National Research Council, 2010.

c. Developed the link-node representation of the evacuation network, which is used as the basis for the computer analysis that calculates the ETE.

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 Kewaunee Power Station.

8. Executed the DYNEV II model to determine optimal evacuation routing and compute 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.

10. Calculated the ETE for all transit activities including those for special facilities (schools, medical facilities, etc.), for the transit-dependent population and for homebound special needs population.

1.2 The Kewaunee Power Plant Location

The KPS is located along the shores of Lake Michigan in Carlton, Kewaunee County, Wisconsin. The site is approximately 30 miles southeast of Green Bay, WI. The Emergency Planning Zone (EPZ) consists of parts of Kewaunee, and Manitowoc Counties in Wisconsin. Figure 1-1 displays the area surrounding the KPS. This map identifies the communities in the area and the major roads.

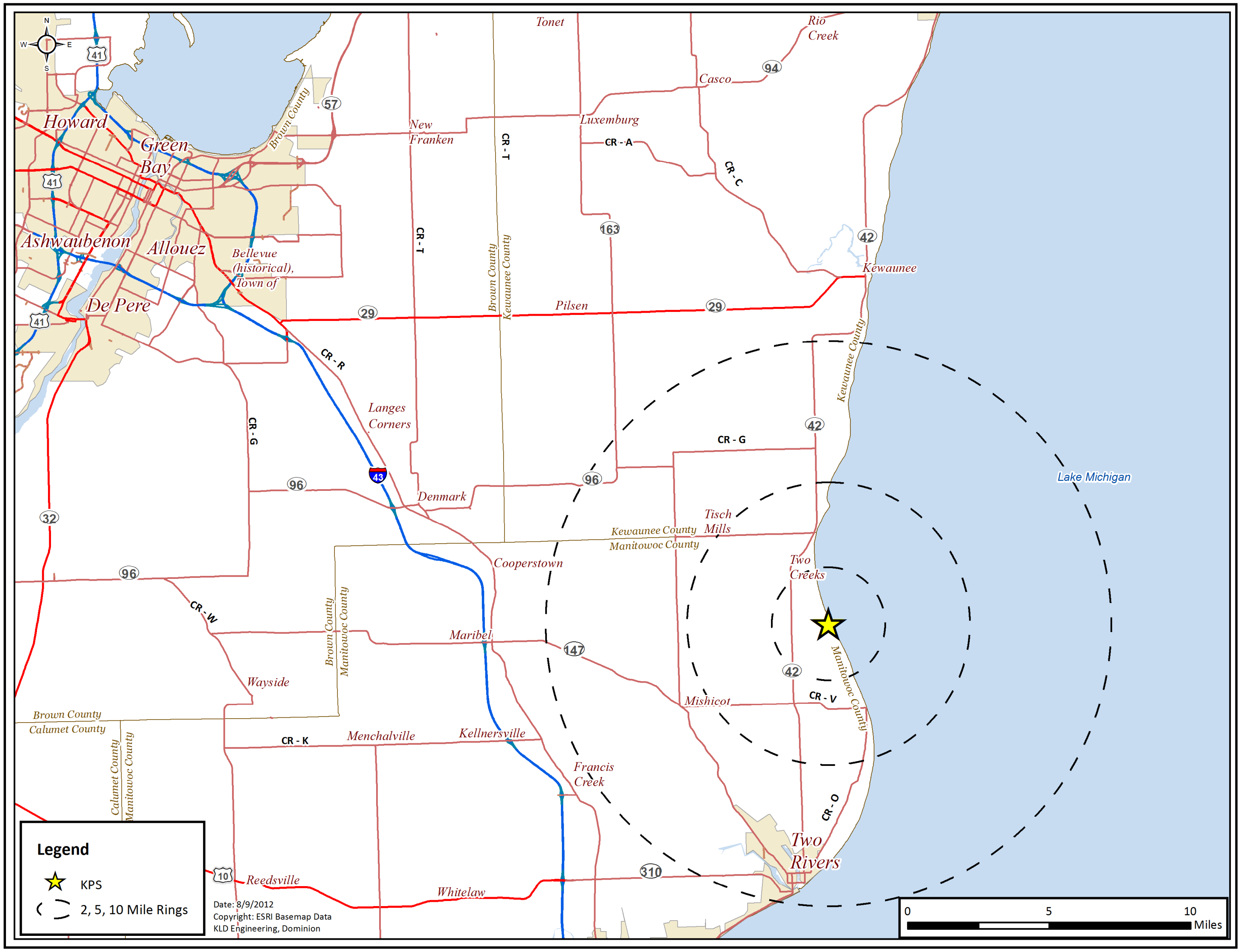


Figure 1-1. Kewaunee Power Station Location

1.3 Preliminary Activities

These activities are described below.

<u>Field Surveys of the Highway Network</u>

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 shown in Table 1-2:

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.

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 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 15-30 in the HCM 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 geographical 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 15-5 of the HCM 2010, the capacity of a two-lane highway is 1700 passenger cars per hour in one direction. For freeway sections, a value of 2250 vehicles per hour per lane is assigned, as per Exhibit 11-17 of the HCM 2010. 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 15-30. These links may be

identified by reviewing Appendix K. 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 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.

Telephone Survey

A telephone 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 returns.

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).

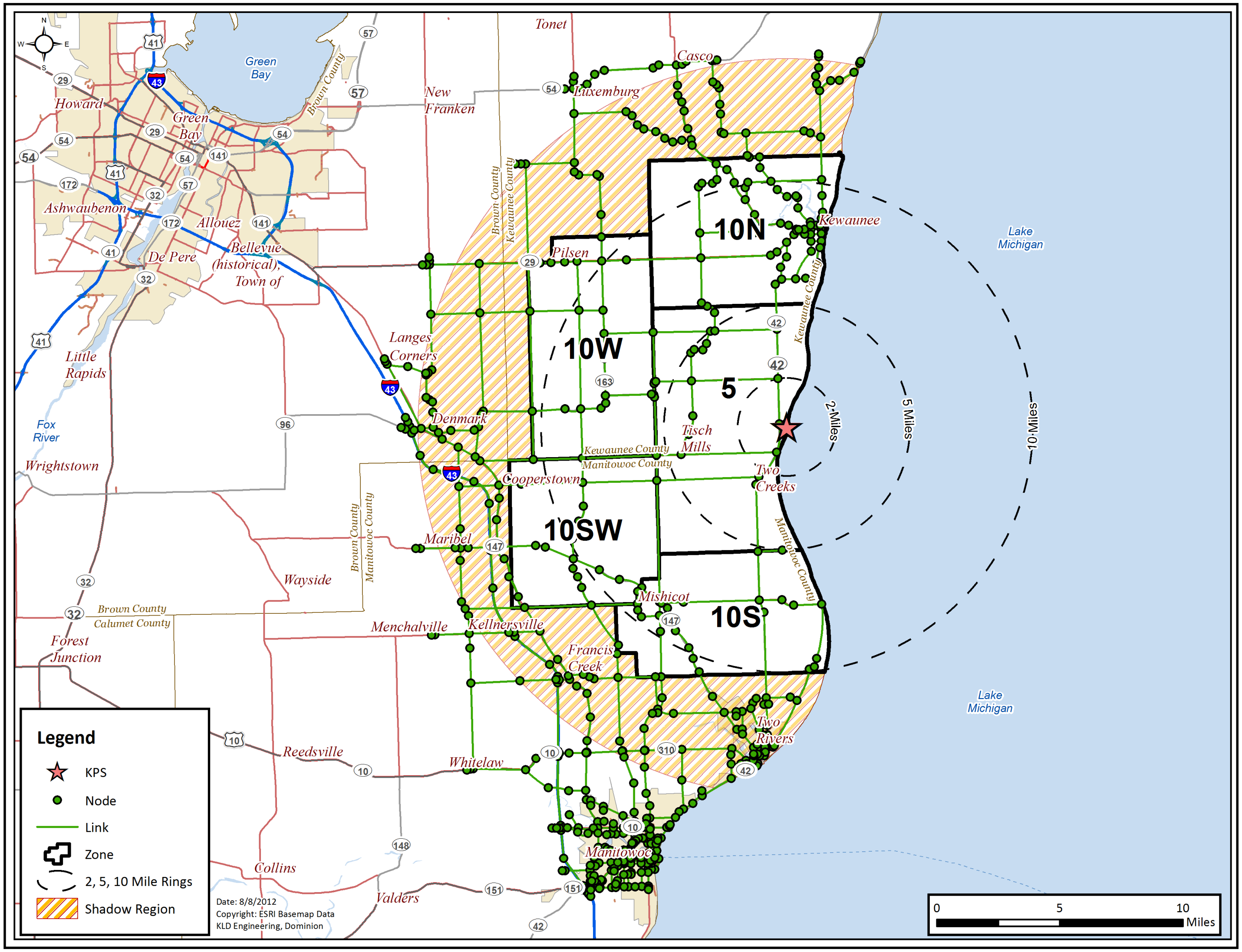


Figure 1-2. KPS Link-Node Analysis Network

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 Kewaunee Power Station.

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 2005 study. 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:

- A slight decrease in permanent resident population.
- Vehicle occupancy and Trip-generation rates are based on the results of a telephone survey of EPZ residents.
- Voluntary and shadow evacuations are considered.
- The highway representation is far more detailed.
- Dynamic evacuation modeling.

Table 1-3. ETE Study Comparisons

Topic	Previous ETE Study	Current ETE Study
Resident Population Basis	2000 US Census Data; Population = 11,775	ArcGIS Software using 2010 US Census blocks; area ratio method used. Population = 11,596
Resident Population Vehicle Occupancy	Vehicle occupancy based upon the average number of registered vehicles per household and average household size for each county. It was assumed all vehicles registered to a household would be used during the evacuation. Kewaunee County: 2.05 persons/vehicle Manitowoc County: 1.99 persons/vehicle	2.30 persons/household, 1.22 evacuating vehicles/household yielding: 1.89 persons/vehicle.
Employee Population	Employee estimates based on information provided about major employers in EPZ. 1.0 employees/vehicle was used for all major employers. Employees = 1,288	Employee estimates based on information provided about major employers in EPZ. 1.04 employees per vehicle based on telephone survey results. Employees = 1,071

Topic	Previous ETE Study	Current ETE Study
Transit-Dependent Population	N/A	Estimates based upon U.S. Census data and the results of the telephone survey. A total of 207 people who do not have access to a vehicle, requiring 7 buses to evacuate. An additional 7 homebound special needs persons needed special transportation to evacuate (7 required a bus, none required a wheelchair-accessible vehicle, or an ambulance).
Transient Population	Populations and vehicle estimates for parks and recreational facilities based on telephone conversations, Internet searches and available parking spaces along with the assumption of 4 persons/parking space. Populations and vehicle estimates for motels and hotels were based on the following assumptions: 2 persons/room 1 vehicle/room Transients = 1,339	Transient estimates based upon information provided about transient attractions in EPZ as well as telephone calls to facilities, supplemented by observations during the road survey and from aerial photography. Transients = 3,119
Special Facilities Population	Special facility population based on information provided by each facility within the EPZ as well as from each county. Special Facility Population = 110 Vehicles originating at special facilities = 25 ambulances	Special facility population based on information provided by each county within the EPZ. Current census = 90 Buses Required = 4 Wheelchair Vans Required = 5 Ambulances Required = 13
School Population	School population based on information provided by each county within the EPZ. Included in Special Facilities Population. School enrollment = 2,420 Bus capacity of 72 students/bus.	School population based on information provided by each county within the EPZ. School enrollment = 1,984 Buses required = 36
Voluntary evacuation from within EPZ in areas outside region to be evacuated	Not considered	20 percent of the population within the EPZ, but not within the Evacuation Region (see Figure 2-1)

Topic	Previous ETE Study	Current ETE Study
Shadow Evacuation	Not considered	20% of people outside of the EPZ within the Shadow Region (see Figure 7-2)
Network Size	Not provided	870 links; 584 nodes
Roadway Geometric Data	Used data from the prior ETE study. Road capacities based on 2000 HCM.	Field surveys conducted in November 2011. Roads and intersections were video archived. Road capacities based on 2010 HCM.
School Evacuation	Direct evacuation to designated Reception Center/Host School.	Direct evacuation to designated Reception Center/Host School.
Ridesharing	Not considered	50 percent of transit-dependent persons will evacuate with a neighbor or friend.
Trip Generation for Evacuation	Trip Generation curves based on a series of assumptions. Permanent residents evacuate between 30 and 150 minutes after the advisory to evacuate. Employees and transients leave between 30 and 60 minutes.	Based on residential telephone survey of specific pre-trip mobilization activities: Residents with commuters returning leave between 15 and 210 minutes. Residents without commuters returning leave between 0 and 180 minutes. Employees and transients leave between 15 and 120 minutes. 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 20% in the event of rain and 25% for snow.	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.
Modeling	Traffic Software Integrated System (TSIS)	DYNEV II System – Version 4.0.8.0
Special Events	Kewaunee Trout Festival 10,400 persons 3 persons/vehicle 3,467 vehicles	Plant outage at Kewaunee Power Station Special Event Population = 800 additional employees

Topic	Previous ETE Study	Current ETE Study
EPZ Definition	Considered a 7 zone EPZ with the 5 mile region broken into three separate Zones: 2, 5N and 5S.	Considered only the updated 5 zone EPZ with the 5 mile region consolidated into a single zone (Zone 5).
Evacuation Cases	22 Regions and 17 Scenarios (16 Scenarios with results reported) producing 352 unique cases.	17 Regions (central sector wind direction and each adjacent sector technique used) and 14 Scenarios producing 238 unique cases.
Evacuation Time Estimates Reporting	ETE reported for the 100th percentile population for all regions. Results presented by Region and Scenario.	ETE reported for 90th and 100th percentile population. Results presented by Region and Scenario.
Evacuation Time Estimates for the entire EPZ, 100th percentile	Winter Weekday Midday, Good Weather: 3:40 Summer Weekend, Midday, Good Weather: 2:40	Winter Weekday Midday, Good Weather: 3:40 Summer Weekend, Midday, Good Weather: 3:40

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

1. Population estimates are based upon Census 2010 data.
2. Estimates of employees who reside outside the EPZ and commute to work within the EPZ are based upon surveys of major employers in the EPZ.
3. Population estimates at special facilities are based on available data from county emergency management departments and from phone calls to specific facilities.
4. Roadway capacity estimates are based on field surveys and the application of the Highway Capacity Manual 2010.
5. Population mobilization times are based on a statistical analysis of data acquired from a random sample telephone survey of EPZ residents (see Section 5 and Appendix F).
6. The relationship between resident population and evacuating vehicles is developed from the telephone survey. Average values of 2.30 persons per household and 1.22 evacuating vehicles per household are used. The relationship between persons and vehicles for transients and employees is as follows:
    a. Employees: 1.04 employees per vehicle (telephone survey results) for all major employers.
    b. Parks: Vehicle occupancy varies based upon data gathered from local transient facilities.
    c. Special Event: Additional outage staff at Kewaunee Power Station will use the average employee vehicle occupancy of 1.04 persons per vehicle, taken from the telephone survey results.

2.2 Study Methodological Assumptions

1. ETE are presented for the evacuation of the 90th and 100th percentiles of population for each Region and for each Scenario. The percentile ETE is defined as the elapsed time from the Advisory to Evacuate issued to a specific Region of the EPZ, to the time that Region is clear of the indicated percentile of evacuees. A Region is defined as a group of zones that is issued an Advisory to Evacuate. A scenario is a combination of circumstances, including time of day, day of week, season, and weather conditions.
2. The ETE are computed and presented in tabular format and graphically, in a format compliant with NUREG/CR-7002.
3. Evacuation movements (paths of travel) are generally outbound relative to the plant to the extent permitted by the highway network. All major evacuation routes are used in the analysis.
4. Regions are defined by the underlying "keyhole" or circular configurations as specified in Section 1.4 of NUREG/CR-7002. These Regions, as defined, display irregular boundaries reflecting the geography of the zones included within these underlying configurations. Due to the geographic boundaries of the EPZ, there is no 2-mile region downwind to 10 miles; instead there is a 5-mile region downwind to the EPZ boundary.
5. As indicated in Figure 2-2 of NUREG/CR-7002, 100% of people within the impacted "keyhole" evacuate. 20% of those people within the EPZ, not within the impacted keyhole, will voluntarily evacuate. 20% of those people within the Shadow Region will voluntarily evacuate. See Figure 2-1 for a graphical representation of these evacuation percentages. Sensitivity studies explore the effect on ETE of increasing the percentage of voluntary evacuees in the Shadow Region (see Appendix M).
6. A total of 14 "Scenarios" representing different temporal variations (season, time of day, day of week) and weather conditions are considered. These Scenarios are outlined in Table 2-1.
7. Scenario 14 considers the closure of a northbound segment of SR 42 north of the intersection with Miller St in the town of Kewaunee.
8. 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[1]). The models have continuously been refined and extended since those hearings and were independently validated by a consultant retained by the NRC. The new DYNEV II model incorporates the latest technology in traffic simulation and in dynamic traffic assignment.

[1] Urbanik, T., et. al. Benchmark Study of the I-DYNEV Evacuation Time Estimate Computer Code, NUREG/CR-4873, Nuclear Regulatory Commission, June, 1988.

Table 2-1. Evacuation Scenario Definitions

Scenario	Season[2]	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	Rain	None
8	Winter	Midweek	Midday	Snow	None
9	Winter	Weekend	Midday	Good	None
10	Winter	Weekend	Midday	Rain	None
11	Winter	Weekend	Midday	Snow	None
12	Winter	Midweek, Weekend	Evening	Good	None
13	Winter	Midweek	Midday	Good	Plant outage at Kewaunee Power Station
14	Summer	Midweek	Midday	Good	Roadway Impact – Closure on SR 42 NB

[2] Winter assumes that school is in session (also applies to spring and autumn). Summer assumes that school is not in session.

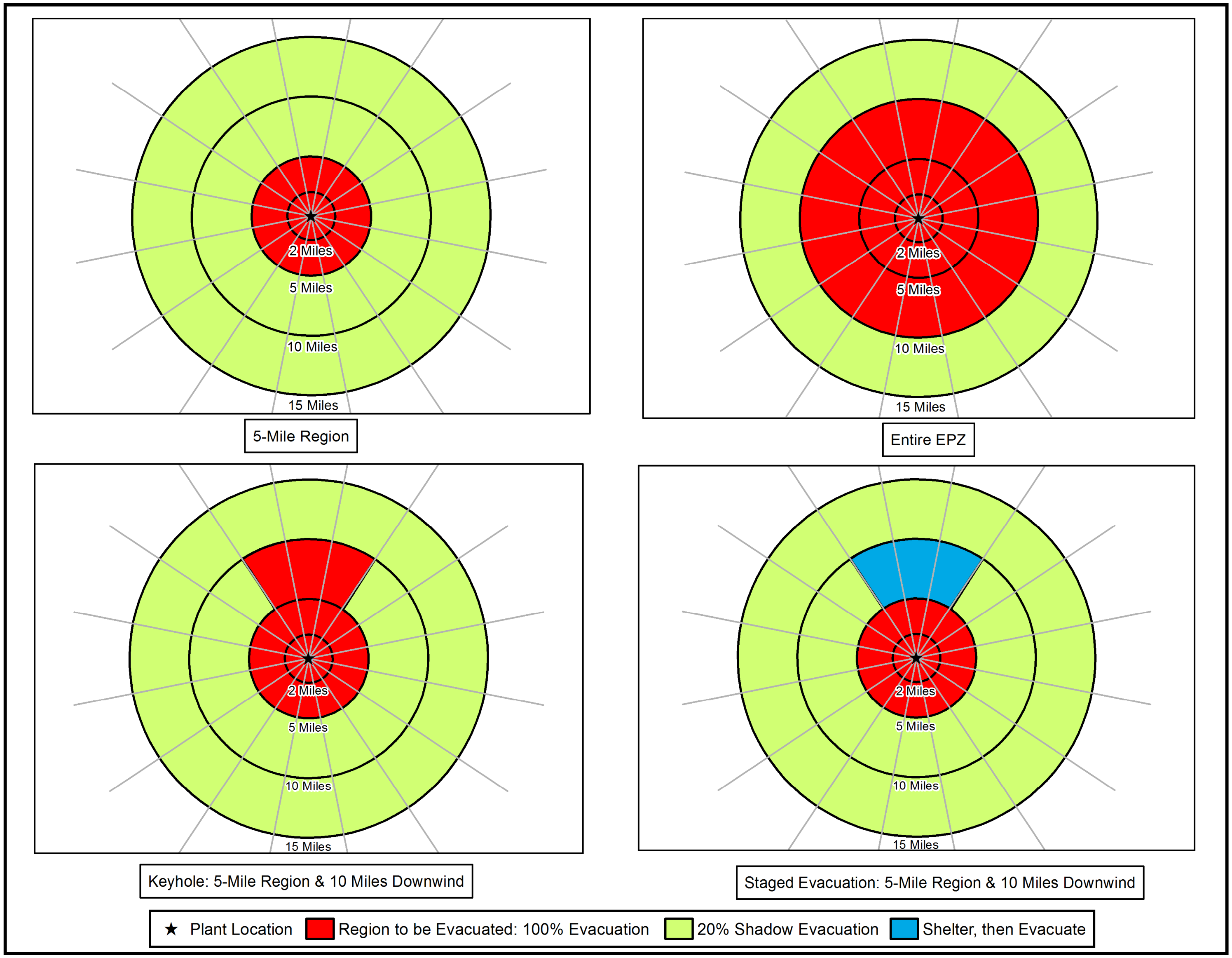


Figure 2-1. Voluntary Evacuation Methodology

2.3 Study Assumptions

1. The Planning Basis Assumption for the calculation of ETE is a rapidly escalating accident that requires evacuation, and includes the following:
    a. Advisory to Evacuate is announced coincident with the siren notification.
    b. Mobilization of the general population will commence within 15 minutes after siren notification.
    c. ETE are measured relative to the Advisory to Evacuate.
2. It is assumed that everyone within the group of zones forming a Region that is issued an Advisory to Evacuate will, in fact, respond and evacuate in general accord with the planned routes.
3. 56 percent of the households in the EPZ have at least 1 commuter; 46 percent of those households with commuters will await the return of a commuter before beginning their evacuation trip, based on the telephone survey results. Therefore 26 percent (56% x 46% = 26%) of EPZ households will await the return of a commuter, prior to beginning their evacuation trip.
4. The ETE will also include consideration of "through" (External-External) trips during the time that such traffic is permitted to enter the evacuated Region. "Normal" traffic flow is assumed to be present within the EPZ at the start of the emergency.
5. Traffic Control Points (TCP) will be staffed within approximately 120 minutes following the siren notifications, to divert traffic attempting to enter the EPZ. Earlier activation of TCP locations could delay returning commuters. It is assumed that no through traffic will enter the EPZ after this 120 minute time period.
6. Traffic Control Points (TCP) within the EPZ will be staffed over time, beginning at the Advisory to Evacuate. Their number and location will depend on the Region to be evacuated and resources available. The objectives of these TCP are:
    a. Facilitate the movements of all (mostly evacuating) vehicles at the location.
    b. Discourage inadvertent vehicle movements towards the plant.
    c. Provide assurance and guidance to any traveler who is unsure of the appropriate actions or routing.
    d. Act as local surveillance and communications center.
    e. Provide information to the emergency operations center (EOC) as needed, based on direct observation or on information provided by travelers.

    In calculating ETE, it is assumed that evacuees will drive safely, travel in directions identified in the plan, and obey all control devices and traffic guides.

7. Buses will be used to transport those without access to private vehicles:
    a. If schools are in session, transport (buses) will evacuate students directly to the designated host facilities.
    b. Transport (buses) will evacuate children at day care centers directly to the designated host facility.
    c. Buses, wheelchair vans and ambulances will evacuate patients at medical facilities and at any senior facilities within the EPZ, as needed.
    d. Transit-dependent general population will be evacuated to Reception Centers.
    e. Schoolchildren, if school is in session, are given priority in assigning transit vehicles.
    f. Bus mobilization time is considered in ETE calculations.
    g. Analysis of the number of required round-trips ("waves") of evacuating transit vehicles is presented.
    h. Transport of transit-dependent evacuees from reception centers to congregate care centers is not considered in this study.
8. Provisions are made for evacuating the transit-dependent portion of the general population to reception centers by bus, based on the assumption that some of these people will ride-share with family, neighbors, and friends, thus reducing the demand for buses. We assume that the percentage of people who rideshare is 50 percent. This assumption is based upon reported experience for other emergencies[3], and on guidance in Section 2.2 of NUREG/CR-7002.
9. 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 earlier or at about the same time the evacuation advisory is issued. No weather-related reduction in the number of transients who may be present in the EPZ is assumed. It is assumed that roads are passable and that the appropriate agencies are plowing the roads as they would normally when snowing.

   Adverse weather scenarios affect roadway capacity and the free flow highway speeds. The factors applied for the ETE study are based on recent research on the effects of weather on roadway operations[4]; the factors are shown in Table 2-2.

[3] 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 76% (Page 5-10).

[4] Agarwal, M. et. Al. Impacts of Weather on Urban Freeway Traffic Flow Characteristics and Facility Capacity, Proceedings of the 2005 Mid-Continent Transportation Research Symposium, August, 2005. The results of this paper are included as Exhibit 10-15 in the HCM 2010.

10. School buses used to transport students are assumed to transport 70 students per bus for elementary schools and 50 students per bus for middle and high schools, based on discussions with county offices of emergency management. Transit buses used to transport the transit-dependent general population are assumed to transport 30 people per bus.

Table 2-2. Model Adjustment for Adverse Weather

Scenario	Highway Capacity*	Free Flow Speed*	Mobilization Time for General Population
Rain	90%	90%	No Effect
Snow	80%	80%	Clear driveway before leaving home (See Figure F-13)
*Adverse weather capacity and speed values are given as a percentage of good weather conditions. Roads are assumed to be passable.			

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 2010 Census, however, 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 Kewaunee Power Station EPZ indicates the need to identify three 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.
- Employees - people who reside outside of the EPZ and commute to businesses 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 zone and by polar coordinate representation (population rose). The Kewaunee Power Station EPZ is subdivided into 5 zones. The EPZ is shown in Figure 3-1.

3.1 Permanent Residents

The primary source for estimating permanent population is the latest U.S. Census data. The average household size (2.30 persons/household – See Figure F-1) and the number of evacuating vehicles per household (1.22 vehicles/household – See Figure F-8) were adapted from the telephone survey results.

Population estimates are based upon Census 2010 data. The estimates are created by cutting the census block polygons by the zone and EPZ boundaries. 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 what the population is within the EPZ. This methodology assumes that the population is evenly distributed across a census block. Table 3-1 provides the permanent resident population within the EPZ, by zone based on this methodology.

The year 2010 permanent resident population is divided by the average household size and then multiplied by the average number of evacuating vehicles per household in order to estimate number of vehicles. Permanent resident population and vehicle estimates are presented in Figure 3-2 and Figure 3-3 present the permanent resident population and permanent resident vehicle estimates by sector and distance from Kewaunee Power Station. This "rose" was constructed using GIS software.

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 percent of all households vacation for a two-week period over the summer.
- Assume these vacations, in aggregate, are uniformly dispersed over 10 weeks, i.e. 10 percent 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 percent 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.

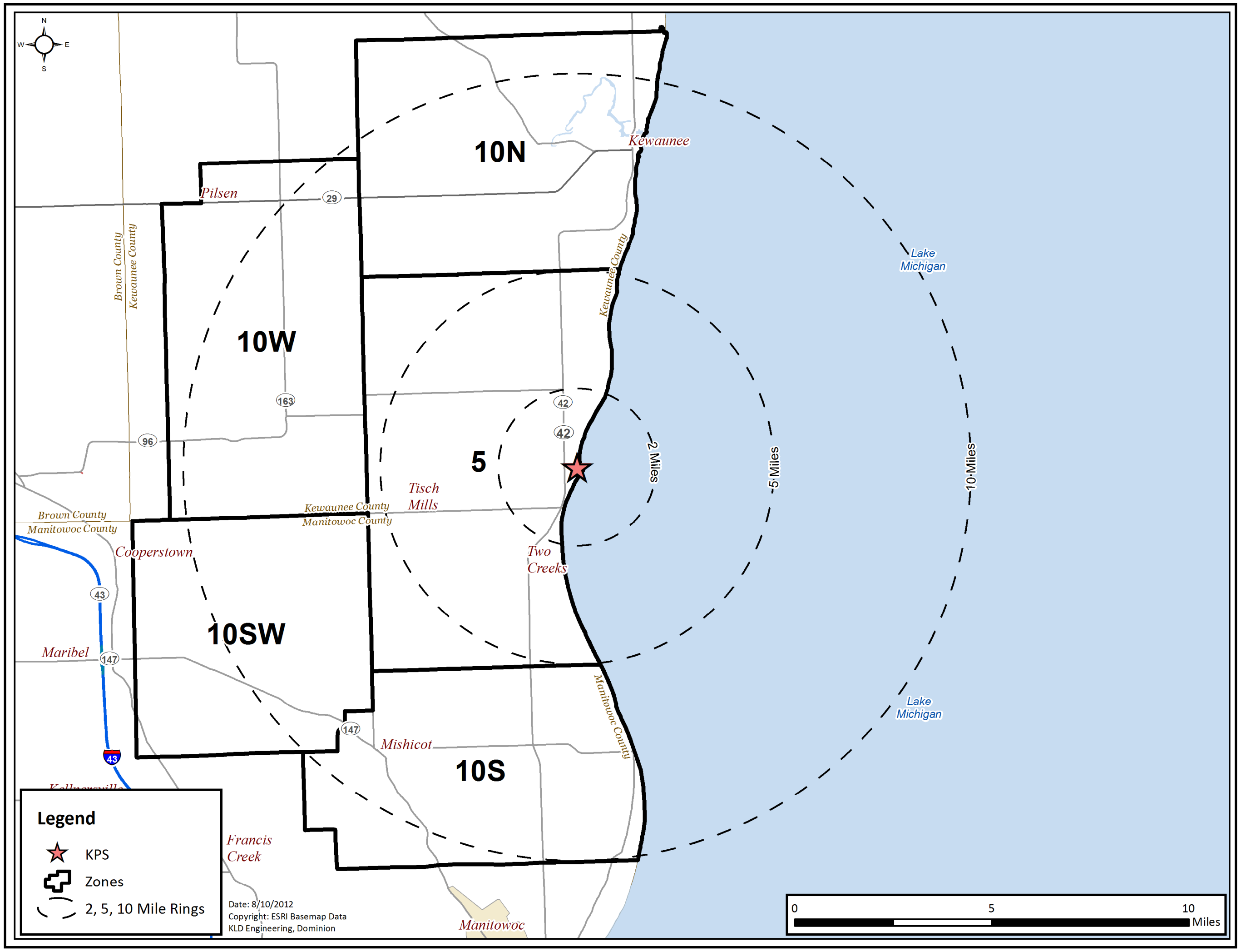


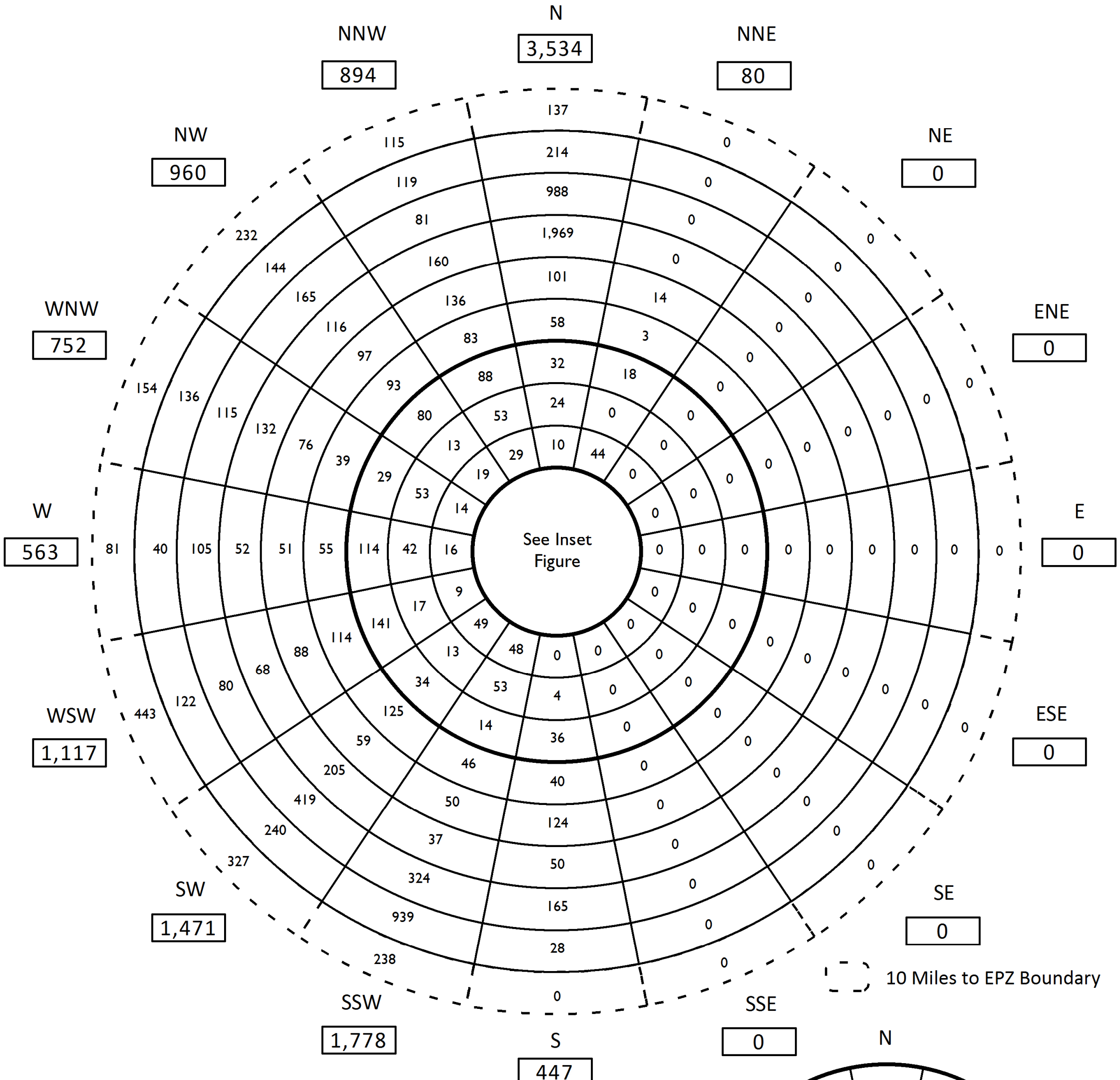
Figure 3-1. Kewaunee Power Station EPZ

Table 3-1. EPZ Permanent Resident Population

Zone	2000 Population	2010 Population
5	1,841	1,728
10N	4,207	4,367
10S	2,507	2,748
10SW	1,785	1,349
10W	1,385	1,404
TOTAL	**11,725**	**11,596**
EPZ Population Growth:		**-1.10%**

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

Zone	2010 Population	2010 Resident Vehicles
5	1,728	922
10N	4,367	2,322
10S	2,748	1,459
10SW	1,349	719
10W	1,404	745
TOTAL	**11,596**	**6,167**



Resident Population

Miles	Subtotal by Ring	Cumulative Total
0 - 1	30	30
1 - 2	78	108
2 - 3	238	346
3 - 4	272	618
4 - 5	586	1,204
5 - 6	656	1,860
6 - 7	796	2,656
7 - 8	2,789	5,445
8 - 9	2,442	7,887
9 - 10	1,982	9,869
10 - EPZ	1,727	11,596
	Total:	11,596

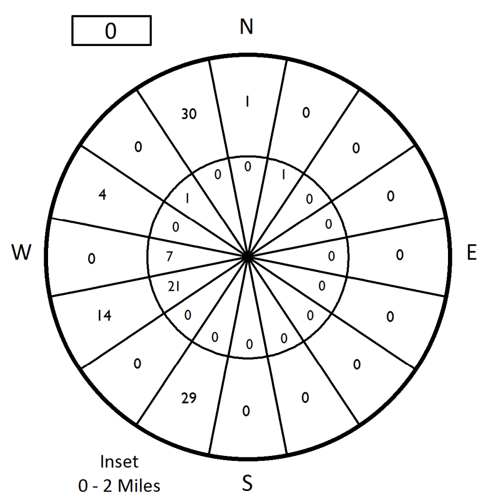
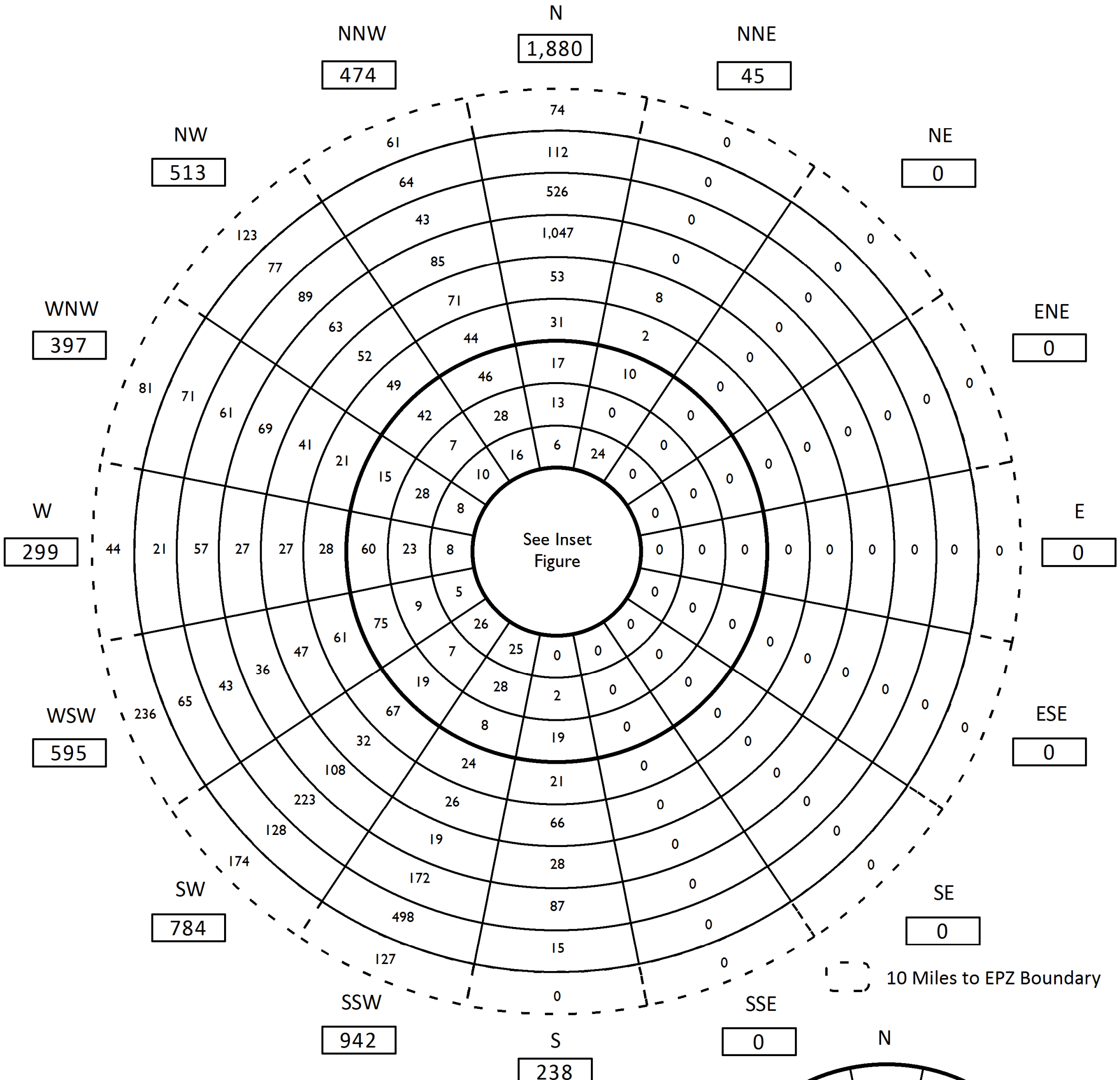
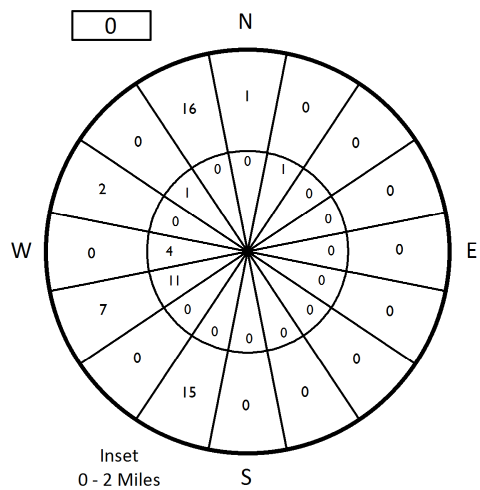


Figure 3-2. Permanent Resident Population by Sector





Resident Vehicles

Miles	Subtotal by Ring	Cumulative Total
0 - 1	17	17
1 - 2	41	58
2 - 3	128	186
3 - 4	145	331
4 - 5	311	642
5 - 6	348	990
6 - 7	423	1,413
7 - 8	1,482	2,895
8 - 9	1,301	4,196
9 - 10	1,051	5,247
10 - EPZ	920	6,167
	Total:	6,167

Figure 3-3. Permanent Resident Vehicles by Sector

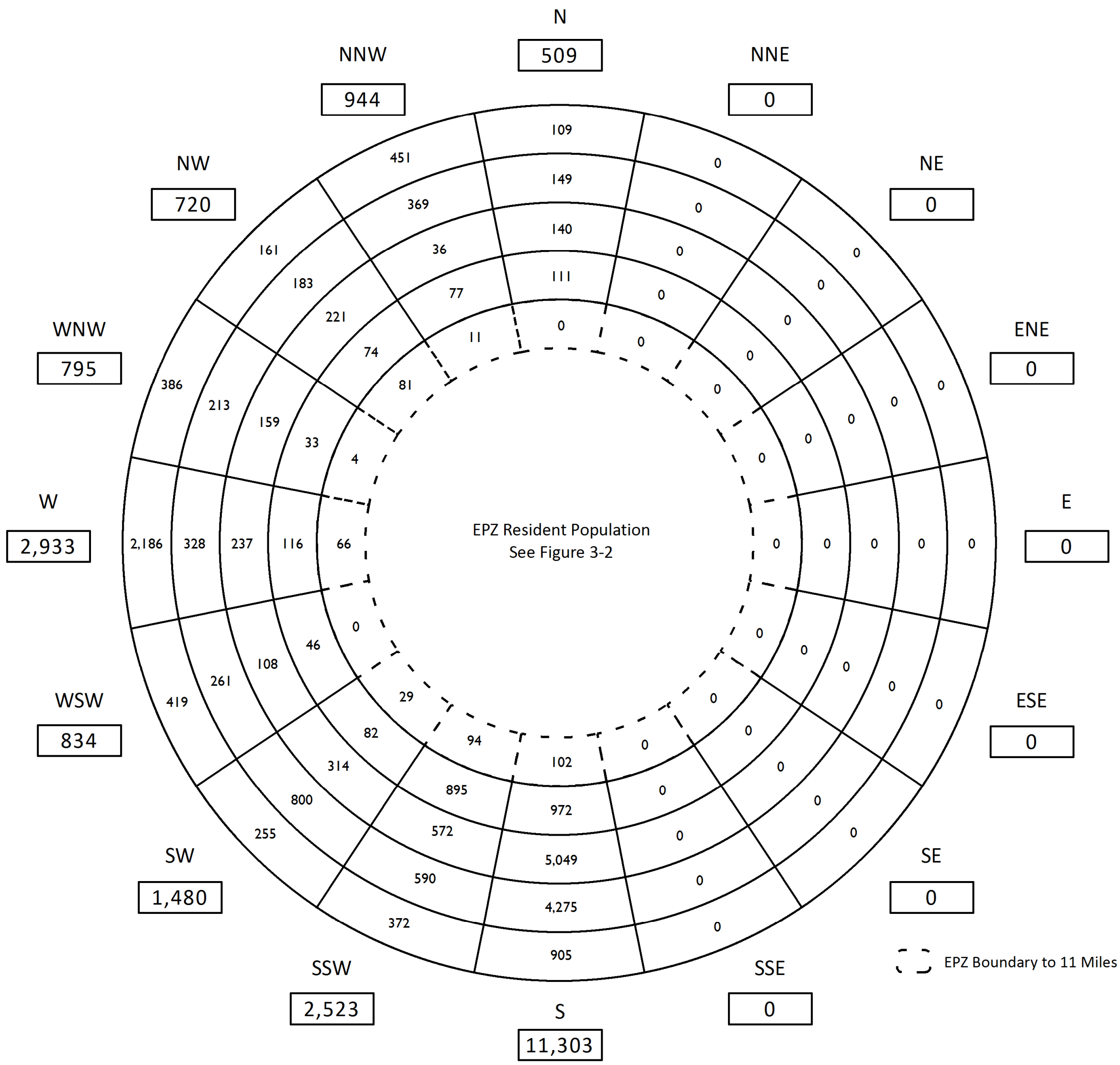
3.2 Shadow Population

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

Shadow population characteristics (household size, evacuating 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.

Table 3-3. Shadow Population and Vehicles by Sector

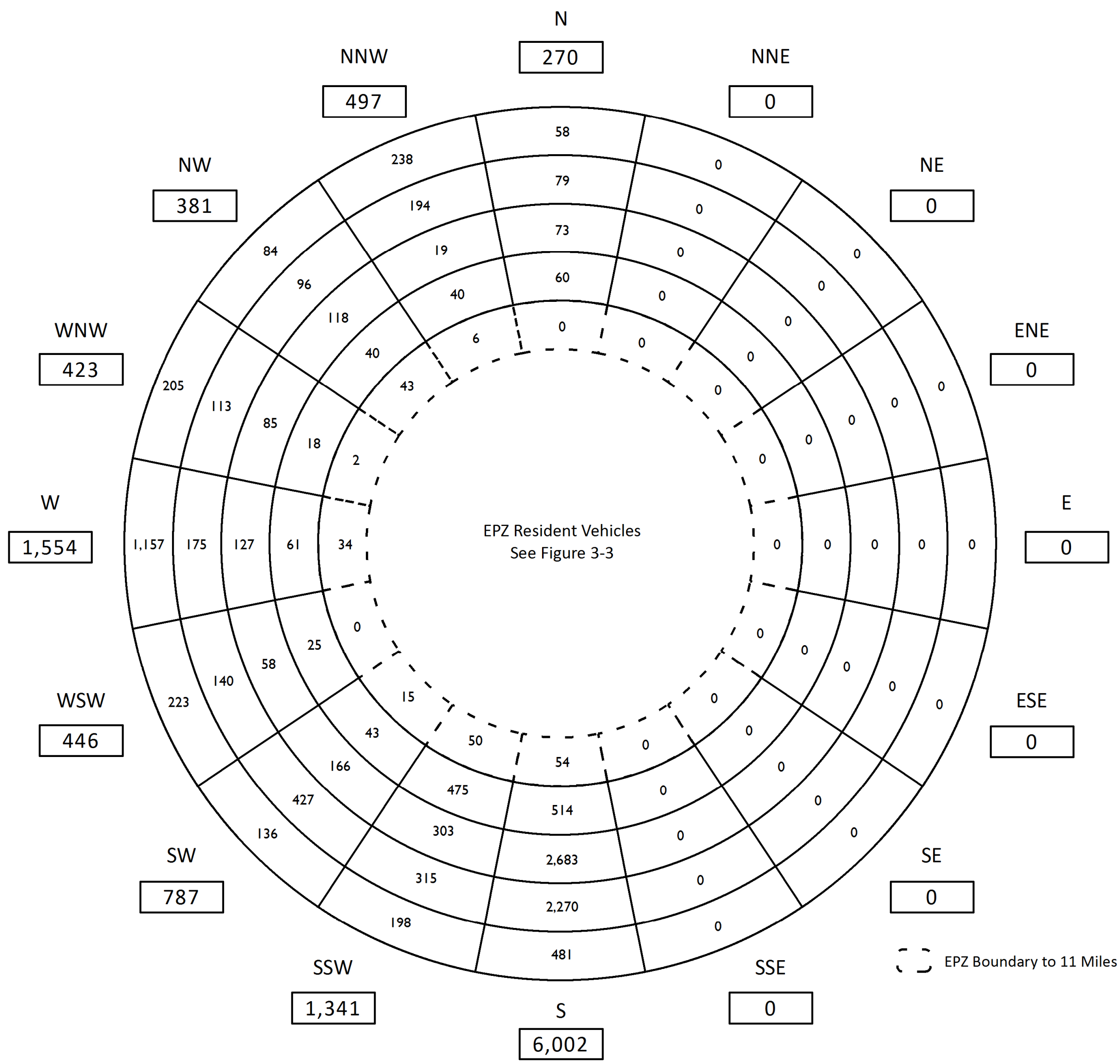
Sector	Population	Evacuating Vehicles
N	509	270
NNE	0	0
NE	0	0
ENE	0	0
E	0	0
ESE	0	0
SE	0	0
SSE	0	0
S	11,303	6,002
SSW	2,523	1,341
SW	1,480	787
WSW	834	446
W	2,933	1,554
WNW	795	423
NW	720	381
NNW	944	497
TOTAL	**22,041**	**11,701**



Shadow Population

Miles	Subtotal by Ring	Cumulative Total
EPZ - 11	387	387
11 - 12	2,406	2,793
12 - 13	6,836	9,629
13 - 14	7,168	16,797
14 - 15	5,244	22,041
	Total:	22,041

Figure 3-4. Shadow Population by Sector



Shadow Vehicles

Miles	Subtotal by Ring	Cumulative Total
EPZ - 11	204	204
11 - 12	1,276	1,480
12 - 13	3,632	5,112
13 - 14	3,809	8,921
14 - 15	2,780	11,701
	Total:	11,701

Figure 3-5. Shadow Vehicles by Sector

3.3 Transient Population

Transient population groups are defined as those people (who are not permanent residents, nor commuting employees) 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. The Kewaunee Power Station EPZ has a number of areas and facilities that attract transients, including:

- Lodging Facilities
- Marinas
- Campgrounds
- Golf Courses

Surveys of lodging facilities within the EPZ were conducted to determine the number of rooms, percentage of occupied rooms at peak times, and the number of people and vehicles per room for each facility. These data were used to estimate the number of transients and evacuating vehicles at each of these facilities. A total of 1,329 transients in 741 vehicles are assigned to lodging facilities in the EPZ.

Surveys of marinas within the EPZ were conducted to determine average daily attendance, and peak season. These data were used to estimate the number of transients and evacuating vehicles at each of these facilities. A total of 414 transients and 273 vehicles are assigned to marinas in the EPZ.

A survey of the Kewaunee Village RV Park was conducted to determine the number of campsites, peak occupancy, and the number of vehicles and people per campsite for this facility. This data was used to estimate the number of evacuating vehicles for transients at this facility. A total of 170 transients and 74 vehicles are assigned to this campground.

A survey of Point Beach State Forrest was conducted to determine the peak number of vehicles and people that visit for this facility. This data was used to estimate the number of evacuating vehicles for transients at this facility. A total of 1,000 transients and 250 vehicles are assigned to this park.

There is one golf course within the EPZ, Fox Hills Resort & Country Club. A survey was conducted to determine the number of golfers and vehicles at this facility on a typical peak day, and the number of golfers that travels from outside the area. A total of 120 transients and 50 vehicles are assigned to this golf course.

Supplemented by data provided by Kewaunee County, surveys of the hunting grounds and public fishing areas were conducted to determine the peak season, the number of vehicles and people these facilities attract. A total of 86 transients and 36 vehicles are assigned to these natural areas.

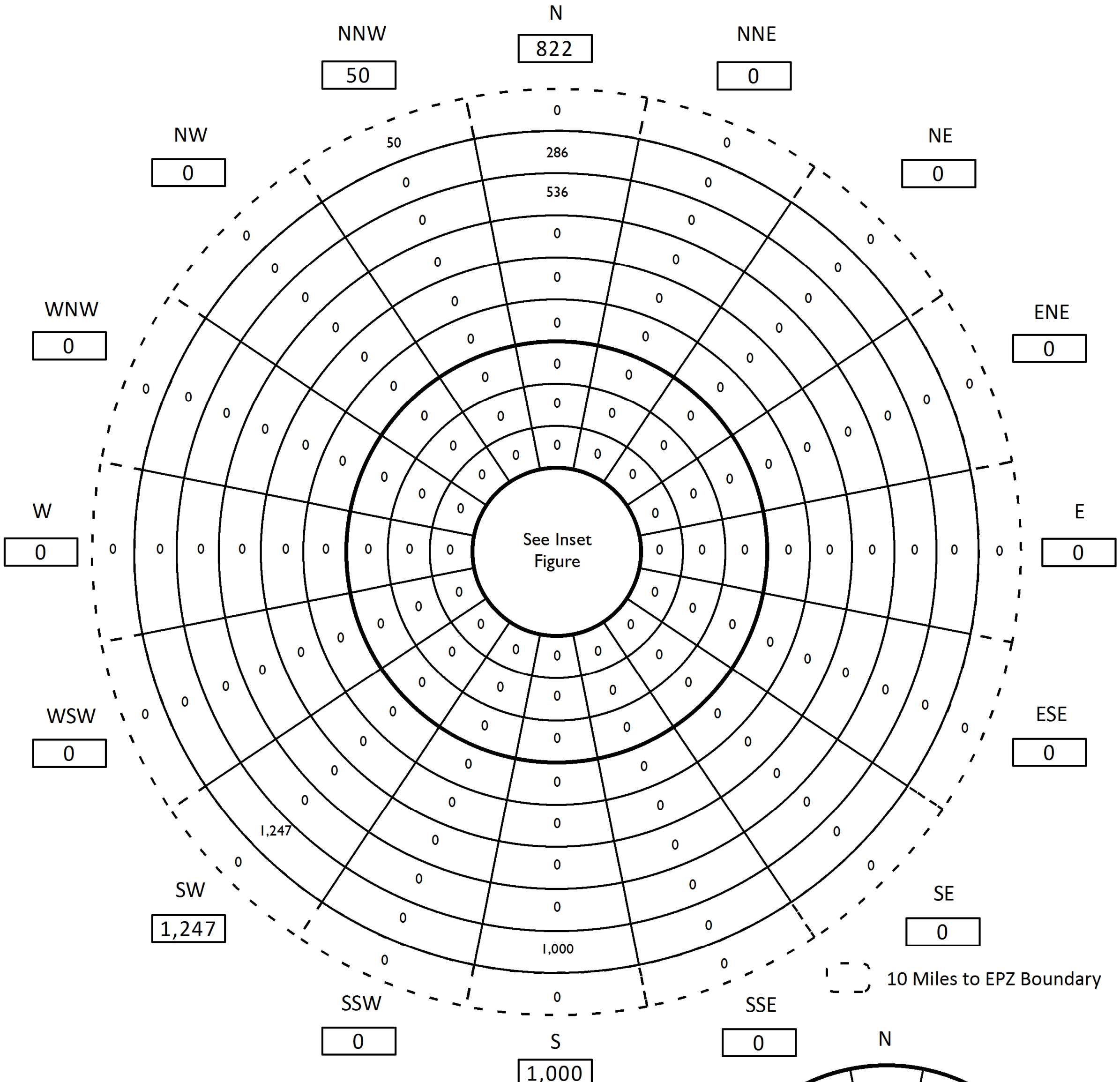
Appendix E summarizes the transient data that was estimated for the EPZ. Table E-4 presents the number of transients visiting recreational areas, while Table E-5 presents the number of

transients at lodging facilities within the EPZ.

Table 3-4 presents transient population and transient vehicle estimates by zone. Figure 3-6 and Figure 3-7 present these data by sector and distance from the plant.

Table 3-4. Summary of Transients and Transient Vehicles

Zone	Transients	Transient Vehicles
5	0	0
10N	872	480
10S	2,247	944
10SW	0	0
10W	0	0
TOTAL	**3,119**	**1,424**



Transients

Miles	Subtotal by Ring	Cumulative Total
0 - 1	0	0
1 - 2	0	0
2 - 3	0	0
3 - 4	0	0
4 - 5	0	0
5 - 6	0	0
6 - 7	0	0
7 - 8	0	0
8 - 9	536	536
9 - 10	2,533	3,069
10 - EPZ	50	3,119
	Total:	3,119

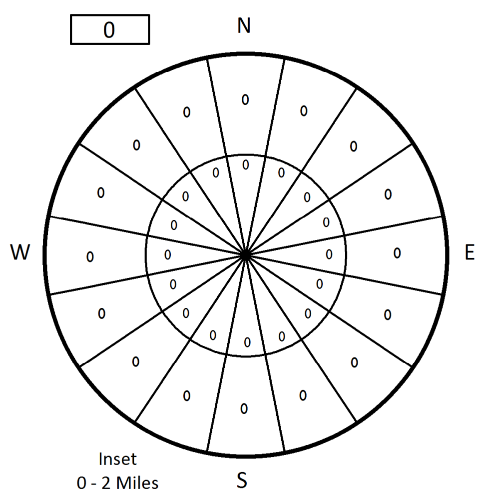
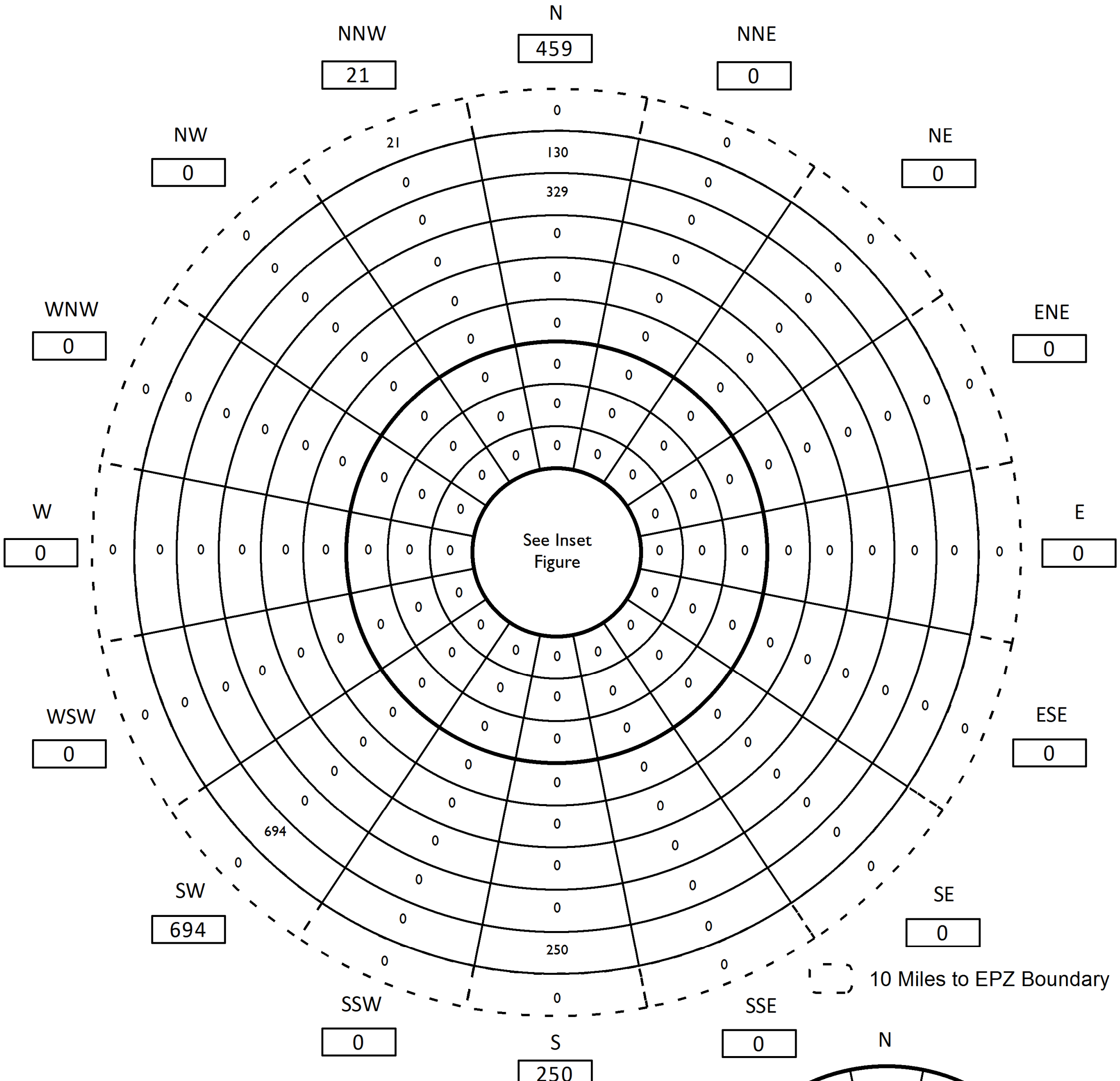


Figure 3-6. Transient Population by Sector



Transient Vehicles

Miles	Subtotal by Ring	Cumulative Total
0 - 1	0	0
1 - 2	0	0
2 - 3	0	0
3 - 4	0	0
4 - 5	0	0
5 - 6	0	0
6 - 7	0	0
7 - 8	0	0
8 - 9	329	329
9 - 10	1,074	1,403
10 - EPZ	21	1,424
	Total:	1,424

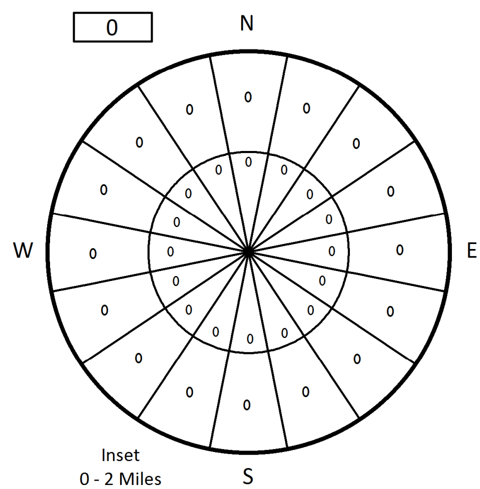


Figure 3-7. Transient Vehicles by Sector

3.4 Employees

Employees who work within the EPZ fall into two categories:

- Those who live and work in the EPZ
- Those who live outside of the EPZ and commute to jobs within the EPZ.

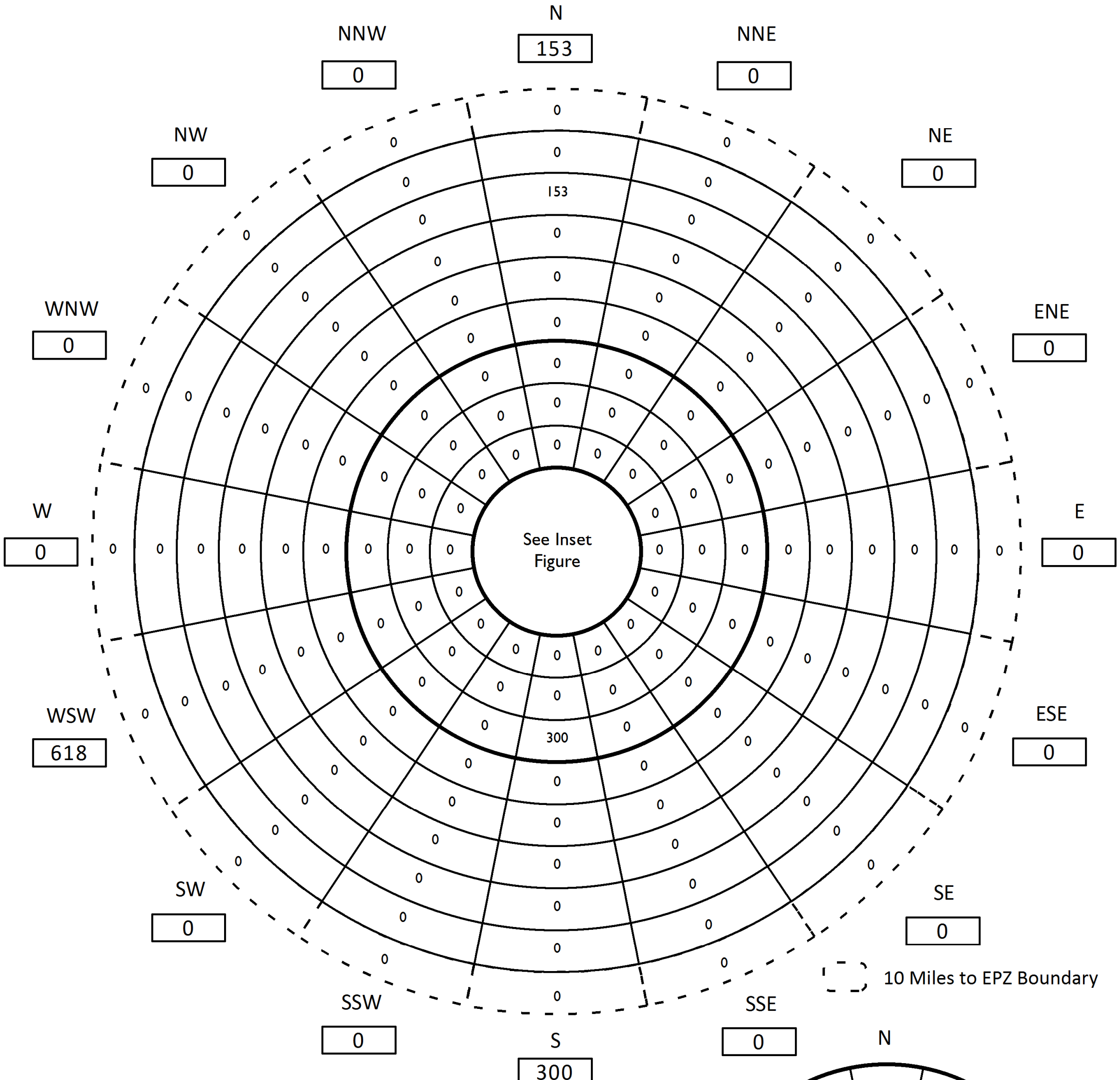
Those of the first category are already counted as part of the permanent resident population. To avoid double counting, we focus only on those employees commuting from outside the EPZ who will evacuate along with the permanent resident population.

In Table E-3, the Employees (Max Shift) is multiplied by the percent Non-EPZ factor to determine the number of employees who are not residents of the EPZ. A vehicle occupancy of 1.04 employees per vehicle obtained from the telephone survey (See Figure F-7) was used to determine the number of evacuating employee vehicles for all major employers.

Table 3-5 presents non-EPZ Resident employee and vehicle estimates by zone. Figure 3-8 and Figure 3-9 present these data by sector.

Table 3-5. Summary of Non-EPZ Resident Employees and Employee Vehicles

Zone	Employees	Employee Vehicles
5	918	882
10N	153	147
10S	0	0
10SW	0	0
10W	0	0
TOTAL	**1,071**	**1,029**



Employees

Miles	Subtotal by Ring	Cumulative Total
0 - 1	618	618
1 - 2	0	618
2 - 3	0	618
3 - 4	0	618
4 - 5	300	918
5 - 6	0	918
6 - 7	0	918
7 - 8	0	918
8 - 9	153	1,071
9 - 10	0	1,071
10 - EPZ	0	1,071
Total:		1,071

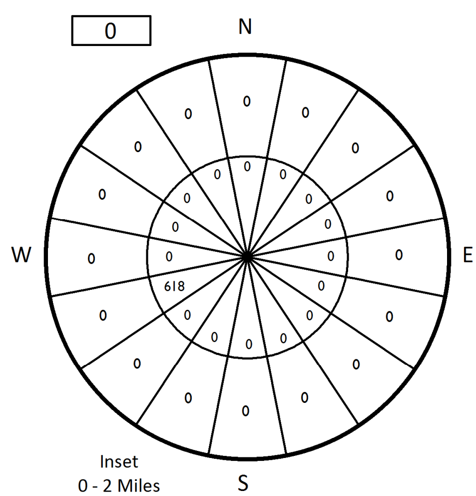
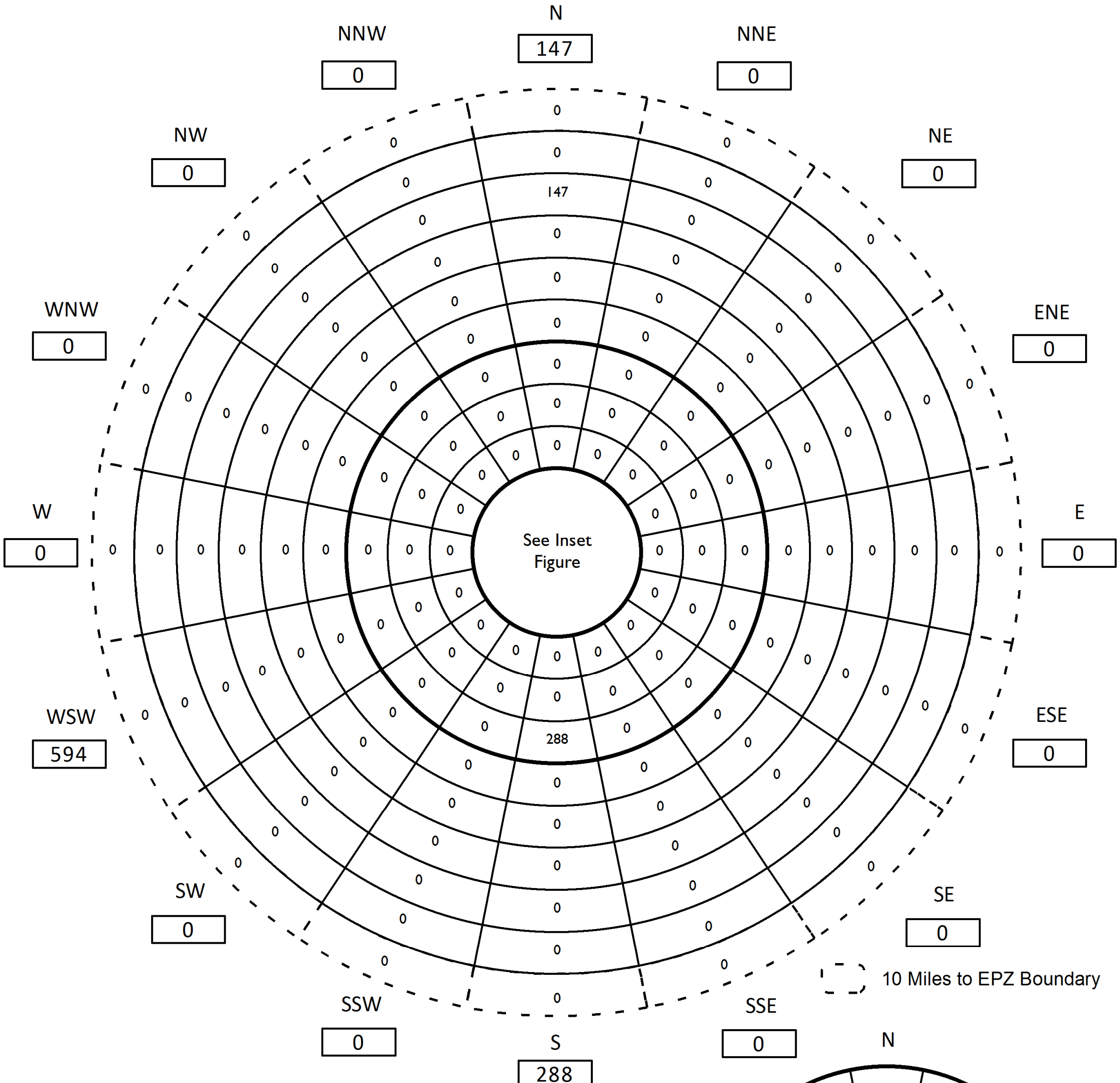


Figure 3-8. Employee Population by Sector



Employee Vehicles

Miles	Subtotal by Ring	Cumulative Total
0 - 1	594	594
1 - 2	0	594
2 - 3	0	594
3 - 4	0	594
4 - 5	288	882
5 - 6	0	882
6 - 7	0	882
7 - 8	0	882
8 - 9	147	1,029
9 - 10	0	1,029
10 - EPZ	0	1,029
	Total:	1,029

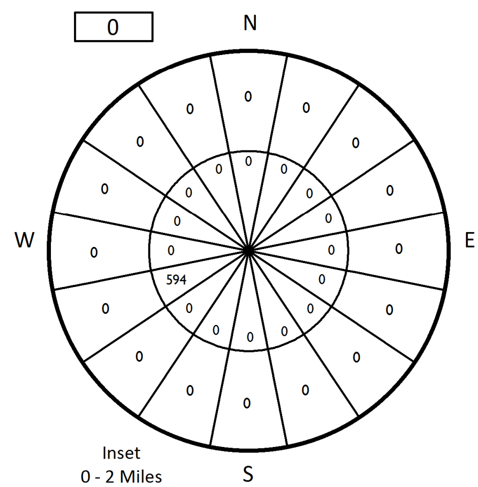


Figure 3-9. Employee Vehicles by Sector

3.5 Medical Facilities

Data were provided by the counties for each of the medical facilities within the EPZ. Table E-2 in Appendix E summarizes the data gathered. Section 8 details the evacuation of medical facilities and their patients. The number and type of evacuating vehicles that need to be provided depend on the patients' state of health. It is estimated that buses can transport up to 30 people; wheelchair accessible vans, up to 2 people; and ambulances, up to 2 people.

3.6 Total Demand in Addition to Permanent Population

Vehicles will be traveling through the EPZ (external-external trips) 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 route traversing the study area – I 43. It is assumed that this traffic will continue to enter the study area during the first 120 minutes following the Advisory to Evacuate.

Average Annual Daily Traffic (AADT) data was obtained from Federal Highway Administration 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 30^{th} 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 3-6, for each of the routes considered. The DDHV is then multiplied by 2 hours (traffic control points – TCP – 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 4,384 vehicles entering the study area as external-external trips prior to the activation of the TCP and the diversion of this traffic. This number is reduced by 60% for evening scenarios (Scenarios 5 and 12) as discussed in Section 6.

3.7 Special Event

One special event (Scenario 13) is considered for the ETE study – a plant outage at Kewaunee Power Station. Outages may occur in spring (March/April) or fall (September/October) and typically last a month. Data obtained from emergency management personnel at Kewaunee Power Station indicate there are 800 additional employees onsite during an outage, of which nearly all commute from outside the EPZ. Using a vehicle occupancy factor of 1.04 obtained from the telephone survey, there are a total of 769 additional vehicles at the plant during an outage. The special event vehicle trips were generated utilizing the same mobilization distributions as employees.

Table 3-6. Kewaunee Power Station EPZ External Traffic

Up Node	Dn Node	Road Name	Direction	HPMS[1] AADT	K-Factor[2]	D-Factor[2]	Hourly Volume	External Traffic
8022	22	I 43	South	18,901	0.116	0.5	1,096	2,192
8311	311	I 43	North	18,901	0.116	0.5	1,096	2,192
							TOTAL:	**4,384**

[1]Highway Performance Monitoring System (HPMS), Federal Highway Administration (FHWA), Washington, D.C., 2011
[2]HCM 2010

3.8 Summary of Demand

A summary of population and vehicle demand is summarized in Table 3-7 and Table 3-8, respectively. This summary includes all population groups described in this section. Additional population groups – transit-dependent, special facility and school population – are described in greater detail in Section 8. A total of 22,475 people and 15,456 vehicles are considered in this study.

Table 3-7. Summary of Population Demand

Zone	Residents	Transit-Dependent	Transients	Employees	Special Facilities	Schools	Shadow Population	External Traffic	Total
5	1,728	31	0	918	0	0	0	0	2,677
10N	4,367	77	872	153	90	1,099	0	0	6,658
10S	2,748	50	2,247	0	0	885	0	0	5,930
10SW	1,349	24	0	0	0	0	0	0	1,373
10W	1,404	25	0	0	0	0	0	0	1,429
Shadow	0	0	0	0	0	0	4,408	0	4,408
Total	**11,596**	**207**	**3,119**	**1,071**	**90**	**1,984**	**4,408**	**0**	**22,475**

NOTE: Shadow Population has been reduced to 20%. Refer to Figure 2-1 for additional information.

NOTE: Special Facilities include both medical facilities and correctional facilities.

Table 3-8. Summary of Vehicle Demand

Zone	Residents	Transit-Dependent	Transients	Employees	Special Facilities	Schools	Shadow Vehicles	External Traffic	Total
5	922	2	0	882	0	0	0	0	1,806
10N	2,322	4	480	147	26	40	0	0	3,019
10S	1,459	4	944	0	0	32	0	0	2,439
10SW	719	2	0	0	0	0	0	0	721
10W	745	2	0	0	0	0	0	0	747
Shadow	0	0	0	0	0	0	2,340	4,384	6,724
Total	**6,167**	**14**	**1,424**	**1,029**	**26**	**72**	**2,340**	**4,384**	15,456

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

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 2010 Highway Capacity Manual (HCM 2010).

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" (SV). Service volume 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 service volume at the upper bound of LOS E, only.

This distinction is illustrated in Exhibit 11-17 of the HCM 2010. 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 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. Capacity is estimated from the procedures of

[1] A very rough estimate of BFFS might be taken as the posted speed limit plus 10 mph (HCM 2010 Page 15-15)

the 2010 HCM. For example, HCM Exhibit 7-1(b) shows the sensitivity of Service Volume at the upper bound of LOS D to grade (capacity is the Service Volume at the upper bound of LOS E).

As discussed in Section 2.3, it is necessary to adjust capacity figures to represent the prevailing conditions during inclement weather. Based on limited empirical data, weather conditions such as rain reduce the values of free speed and of highway capacity by approximately 10 percent. Over the last decade new studies have been made on the effects of rain on traffic capacity. These studies indicate a range of effects between 5 and 20 percent depending on wind speed and precipitation rates. As indicated in Section 2.3, we employ a reduction in free speed and in highway capacity of 10 percent and 20 percent for rain and 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 traffic control points 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 the county emergency plans are extensive and were adopted without change.

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,

$$h_m = f_m(h_{sat}, F_1, F_2, \dots)$$

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:

$$h_m \geq h_{sat}$$

[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

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 2010.

The above discussion is necessarily brief given the scope of this ETE report and the complexity of the subject of intersection capacity. In fact, Chapters 18, 19 and 20 in the HCM 2010 address this topic. The factors, F_1, F_2,..., influencing saturation flow rate are identified in equation (18-5) of the HCM 2010.

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 service volume (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 service volume increases as demand volume and density increase, until the service volume 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 service volume) 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 service volume, V_F, under congested conditions.

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 also 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 evacuation time estimate 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 15-30 in the Highway Capacity Manual 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.

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 2010 HCM. 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.

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

4.3 Application to the Kewaunee Power Station 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:

2010 Highway Capacity Manual (HCM)
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
- Multi-Lane Highways (at-grade)
- Freeways

Each of these classifications will be discussed.

4.3.1 Two-Lane Roads

Ref: HCM Chapter 15

Two lane roads comprise the majority of highways within the EPZ. The per-lane capacity of a two-lane highway is estimated at 1700 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 3200 pc/h. The HCM 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 EPZ 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 Multi-Lane Highway

Ref: HCM Chapter 14

Exhibit 14-2 of the HCM 2010 presents a set of curves that indicate a per-lane capacity ranging from approximately 1900 to 2200 pc/h, for free-speeds of 45 to 60 mph, respectively. Based on observation, the multi-lane highways outside of urban areas within the EPZ service traffic with free-speeds in this range. The actual time-varying speeds computed by the simulation model reflect the demand: capacity relationship and the impact of control at intersections. A

conservative estimate of per-lane capacity of 1900 pc/h is adopted for this study for multi-lane highways outside of urban areas, as shown in Appendix K.

4.3.3 Freeways

Ref: HCM Chapters 10, 11, 12, 13

Chapter 10 of the HCM 2010 describes a procedure for integrating the results obtained in Chapters 11, 12 and 13, 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 11 of the HCM 2010 presents procedures for estimating capacity and LOS for "Basic Freeway Segments". Exhibit 11-17 of the HCM 2010 presents capacity vs. free speed estimates, which are provided below.

Free Speed (mph):	55	60	65	70+
Per-Lane Capacity (pc/h):	2250	2300	2350	2400

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 2250 pc/h is adopted for this study for freeways, as shown in Appendix K.

Chapter 12 of the HCM 2010 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 12 depends on the "Type" and geometrics of the weaving segment and on the "Volume Ratio" (ratio of weaving volume to total volume).

Chapter 13 of the HCM 2010 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 13-8 of the HCM 2010, and depend on the number of freeway lanes and on the freeway free speed. Ramp capacity is presented in Exhibit 13-10 and is a function of the ramp free flow speed. The DYNEV II simulation model logic simulates the merging operations of the ramp and freeway traffic in accord with the procedures in Chapter 13 of the HCM 2010. 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 does not address LOS F explicitly).

4.3.4 Intersections

Ref: HCM Chapters 18, 19, 20, 21

Procedures for estimating capacity and LOS for approaches to intersections are presented in Chapter 18 (signalized intersections), Chapters 19, 20 (un-signalized intersections) and Chapter 21 (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. Where applicable, the location and type of traffic control for nodes in the evacuation network are noted in Appendix K. The characteristics of the ten highest volume signalized intersections are detailed in Appendix J.

4.4 Simulation and Capacity Estimation

Chapter 6 of the HCM 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 procedural chapters of the HCM. 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 – 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 2010 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) Free flow speed (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 2010, as described earlier. These parameters are listed in Appendix K, for each network link.

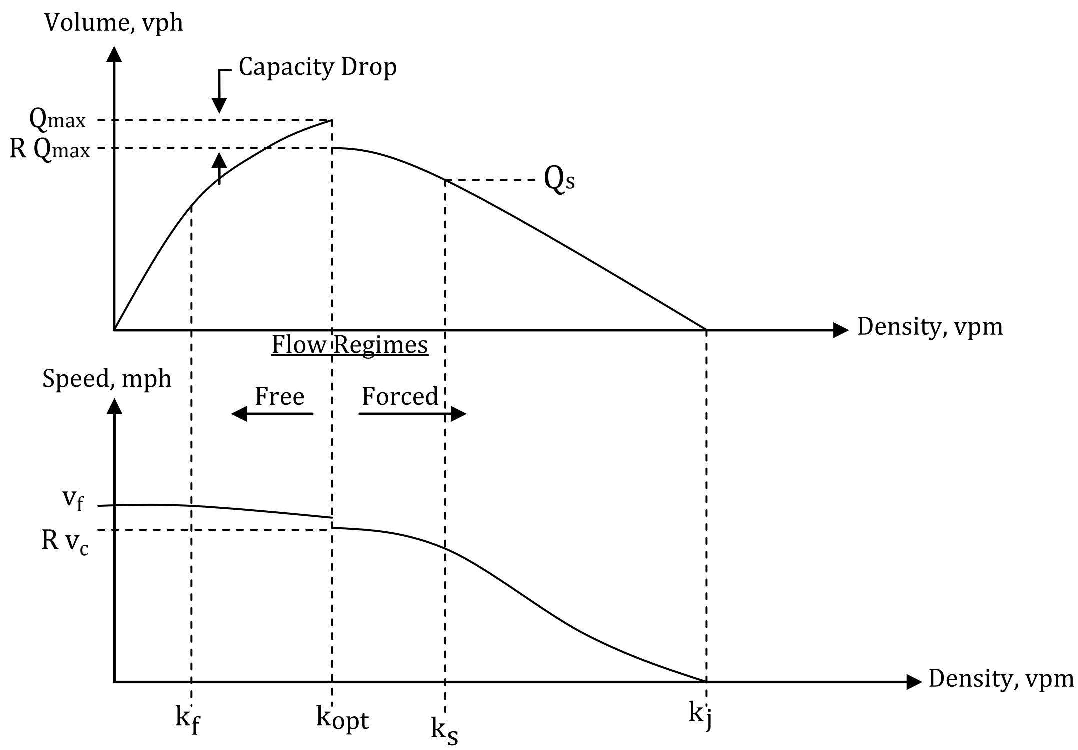


Figure 4-1. Fundamental Diagrams

5 ESTIMATION OF TRIP GENERATION TIME

Federal Government guidelines (see NUREG CR-7002) specify that the planner 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 telephone 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 Classification Levels (see Appendix 1 of NUREG 0654 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 State and Local offsite authorities. As a Planning Basis, we will adopt a conservative posture, in accordance with Section 1.2 of NUREG/CR-7002, that a rapidly escalating accident will be considered in calculating the Trip Generation Time. We will assume:

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

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 Advisory to Evacuate. 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 EPZ will be lower when the Advisory to Evacuate 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 broadcast. Thus, the time needed to complete the mobilization activities and the number of people

remaining to evacuate the EPZ after the Advisory to Evacuate, 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 notification systems 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 160 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, the information required to compute trip generation times is typically obtained from a telephone survey of EPZ residents. Such a survey was conducted in support of this ETE study. Appendix F presents the survey sampling plan, survey instrument, and raw 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 evacuation time estimate 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 telephone 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" (i.e. 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 below:

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

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)

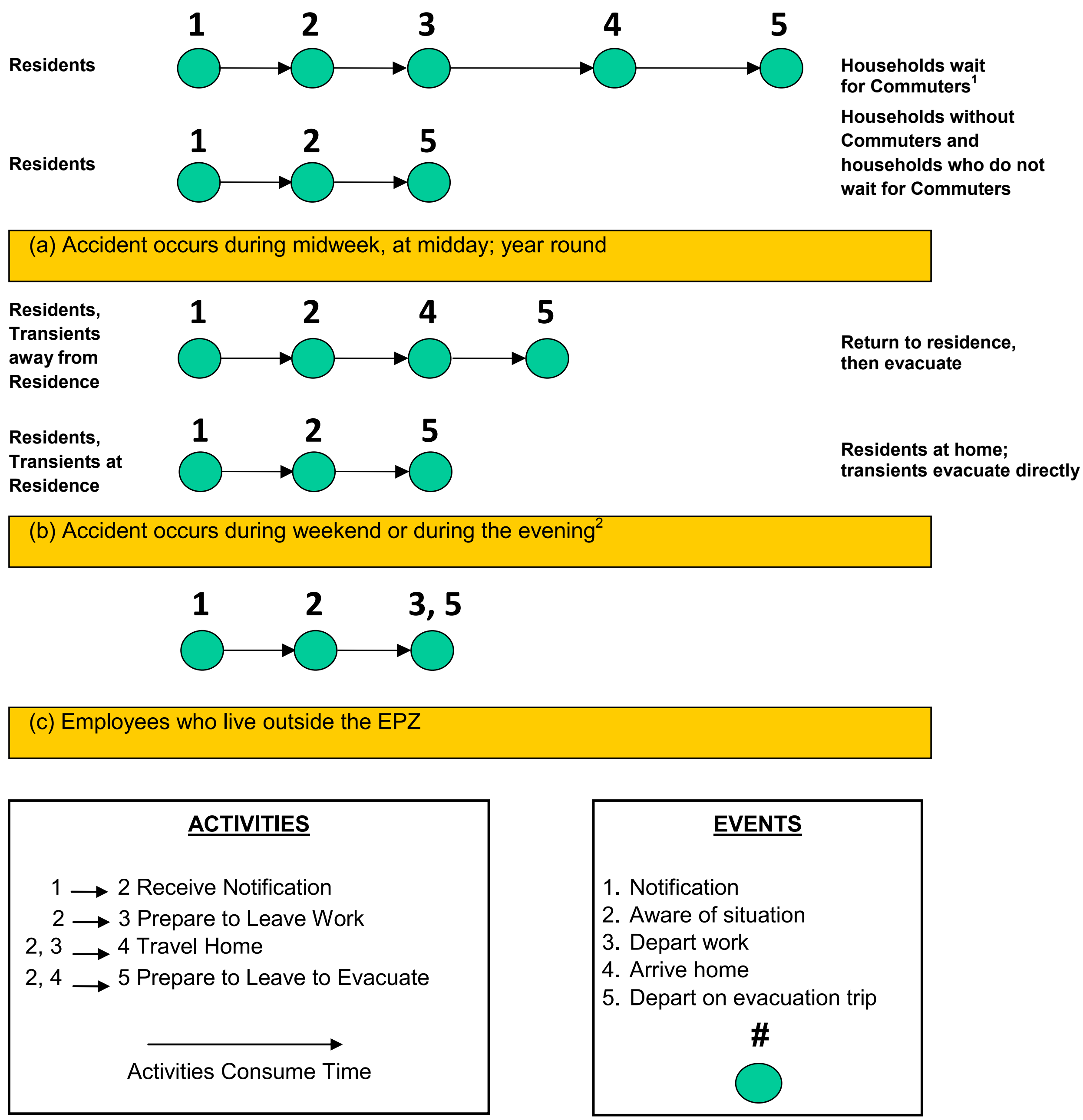
As such, a completed Activity changes the ‘state’ of an individual (e.g. the activity, ‘travel home’ changes the state from ‘depart work’ to ‘arrive home’). Therefore, an Activity can be described as an ‘Event Sequence’; the elapsed times to perform an event sequence vary from one person to the next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



[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

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

It is assumed (based on the presence of sirens within the EPZ) that 87 percent of those within the EPZ will be aware of the accident within 30 minutes with the remainder notified within the following 15 minutes. The notification distribution is given below:

Table 5-2. Time Distribution for Notifying the Public

Elapsed Time (Minutes)	Percent of Population Notified
0	0.0%
5	7.1%
10	13.3%
15	26.5%
20	46.9%
25	66.3%
30	86.7%
35	91.8%
40	96.9%
45	100.0%

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 telephone survey. This distribution is plotted in Figure 5-2.

Table 5-3. Time Distribution for Employees to Prepare to Leave Work

Elapsed Time (Minutes)	Cumulative Percent Employees Leaving Work	Elapsed Time (Minutes)	Cumulative Percent Employees Leaving Work
0	0.0%	45	96.0%
5	49.6%	50	96.3%
10	66.0%	55	96.3%
15	76.7%	60	99.0%
20	80.6%	75	100.0%
25	82.1%		
30	93.1%		
35	93.5%		
40	94.5%		

NOTE: The survey data was normalized to distribute the "Don't know" 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 “Don’t know” responders, if the event takes place, would be the same as those responders who provided estimates.

Distribution No. 3, Travel Home: Activity 3 $\rightarrow$ 4

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

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	0.0%	40	94.0%
5	20.4%	45	99.1%
10	39.0%	50	99.3%
15	55.9%	55	99.5%
20	73.1%	60	100.0%
25	77.7%		
30	88.9%		
35	90.7%		

NOTE: The survey data was normalized to distribute the "Don't know" response

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

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

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

Elapsed Time (Minutes)	Cumulative Percent Ready to Evacuate
0	0.0%
15	20.0%
30	62.4%
45	72.3%
60	88.0%
75	93.4%
90	94.6%
105	95.1%
120	97.9%
135	100.0%

NOTE: The survey data was normalized to distribute the "Don't know" response

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 generally 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.

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 telephone survey. This distribution is plotted in Figure 5-2 and listed in Table 5-6.

Note that those respondents (34.9%) 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 5-6. Time Distribution for Population to Clear 6"-8" of Snow

Elapsed Time (Minutes)	Completing Snow Removal
0	34.9%
15	49.2%
30	81.2%
45	86.6%
60	94.0%
75	96.6%
90	97.5%
105	98.0%
120	100.0%

NOTE: The survey data was normalized to distribute the "Don't know" response

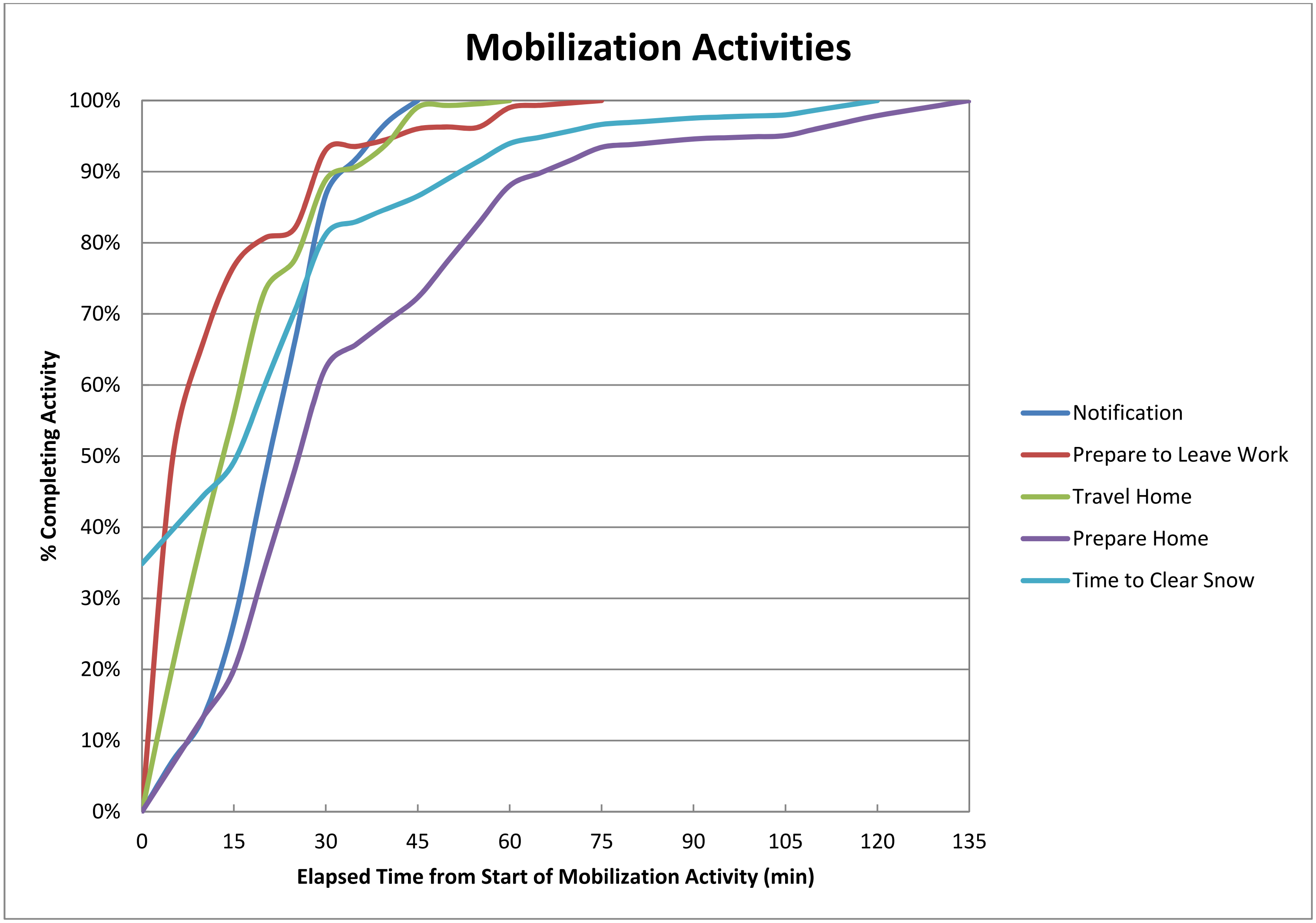


Figure 5-2. Evacuation Mobilization Activities

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 $\rightarrow$ 4) must precede Activity 4 $\rightarrow$ 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 as shown 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 5-7. 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 presents a description of each of the final trip generation distributions achieved after the summing process is completed.

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).

5.4.1 Statistical Outliers

As already mentioned, some portion of the survey respondents answer "don't know" 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 500 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 special 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 overall mobilization time/trip generation distributions, the following principles are used:

1) It is recognized that the overall trip generation distributions are conservative estimates, because they assume a household will do the mobilization activities sequentially, with no overlap of activities;

2) The individual mobilization activities (prepare to leave work, travel home, prepare home, clear snow) are reviewed for outliers, and then 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. special needs, transit dependent) or 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.

   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.

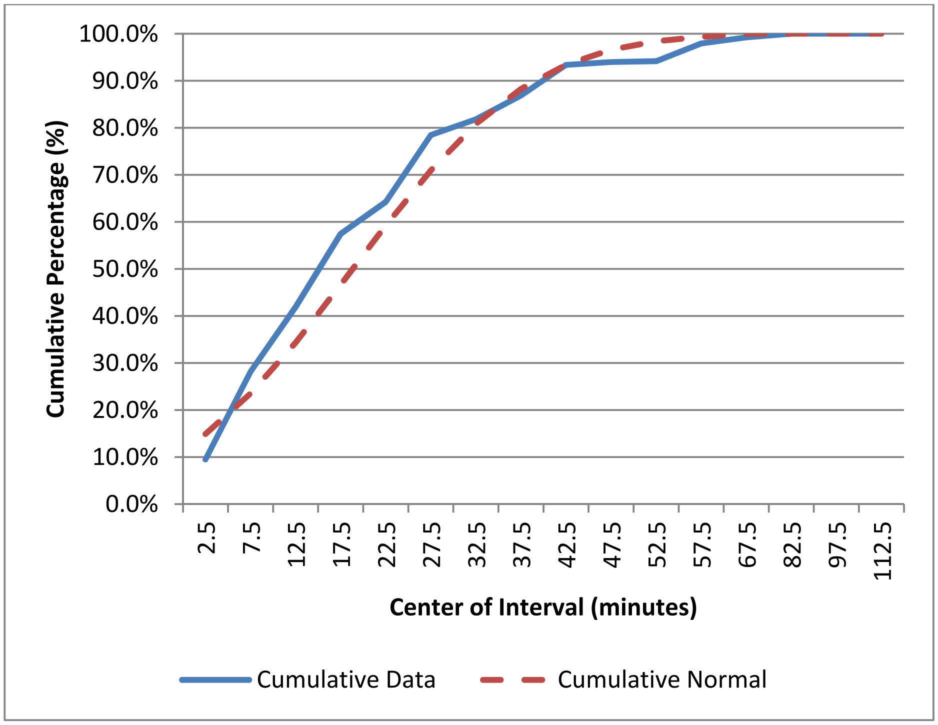


Figure 5-3. Comparison of Data Distribution and Normal Distribution

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 designated A, C, D, E and F. 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 sequential – 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 distributions that result 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, staged evacuation consists of the prompt evacuation of the 2 mile region, while those beyond 2 miles shelter-in-place. As discussed in Section 6, the KPS always evacuates at least the 5 mile radius. Thus, this study considers staged evacuation based on a 5 mile prompt evacuation as discussed below:

1. Zones comprising the 5 mile region are advised to evacuate immediately
2. Zones comprising regions extending from 5 to 10 miles downwind are advised to shelter in-place while the two mile region is cleared
3. As vehicles evacuate the 5 mile region, sheltered people from 5 to 10 miles downwind continue preparation for evacuation
4. The population sheltering in the 5 to 10 mile region are advised to begin evacuating when approximately 90% of those originally within the 5 mile region evacuate across the 5 mile region boundary
5. Non-compliance with the shelter recommendation is the same as the shadow evacuation percentage of 20%

<u>Assumptions</u>

1. 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.
2. 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.
3. Employees will also be assumed to evacuate without first sheltering.

<u>Procedure</u>

1. Trip generation for population groups in the 5 mile region will be as computed based upon the results of the telephone 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 Zone 5 which comprises the 5 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. NUREG/CR-7002 uses the statement "approximately 90th percentile" as the time to end staging and begin evacuating. The value of T_{Scen}^* is 1:35 for non-snow scenarios and 2:05 for snow scenarios.

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 snow conditions
   d. Residents without returning commuters and snow conditions

Figure 5-5 presents the staged trip generation distributions for both residents with and without returning commuters; the 90th percentile 5 mile region evacuation time is 95 minutes for good weather and 125 minutes for snow scenarios. At the 90th percentile evacuation time, 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 30 minutes. After T_{Scen}^*+30, 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

<u>Annex 1, Section 4 of the Manitowoc County</u>
Emergency Operations Plan states that warning will be accomplished by outdoor warning sirens, radio pagers, public broadcasting media (i.e., Emergency Alert System-EAS and cable TV systems serving the 10-mile EPZs and mobile public address equipment.) People fishing on Lake Michigan will be warned by the U.S. Coast Guard and if weather is favorable, by aircraft/public address system fly-over. The aircraft will also notify Kewaunee County population along Lake Michigan shoreline, or as siren system back-up, upon request of Kewaunee County Sheriff or designee.

As indicated in Table 5-2, this study assumes 100% notification in 45 minutes, consistent with the FEMA REP Program Manual. Table 5-9 indicates that all transients will have mobilized

within 75 minutes. It is assumed that this timeframe is sufficient time for boaters, campers and other transients to return to their vehicles and begin their evacuation trip.

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

Time Period	Duration (Min)	Percent of Total Trips Generated Within Indicated Time Period					
		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	8%	8%	0%	1%	0%	0%
2	15	36%	36%	1%	11%	0%	5%
3	15	35%	35%	4%	27%	2%	13%
4	15	14%	14%	14%	26%	6%	18%
5	15	4%	4%	20%	14%	12%	18%
6	15	2%	2%	19%	10%	15%	16%
7	30	1%	1%	26%	6%	30%	17%
8	30	0%	0%	10%	4%	19%	7%
9	30	0%	0%	4%	1%	9%	4%
10	15	0%	0%	1%	0%	3%	1%
11	15	0%	0%	1%	0%	2%	1%
12	15	0%	0%	0%	0%	1%	0%
13	15	0%	0%	0%	0%	0%	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.

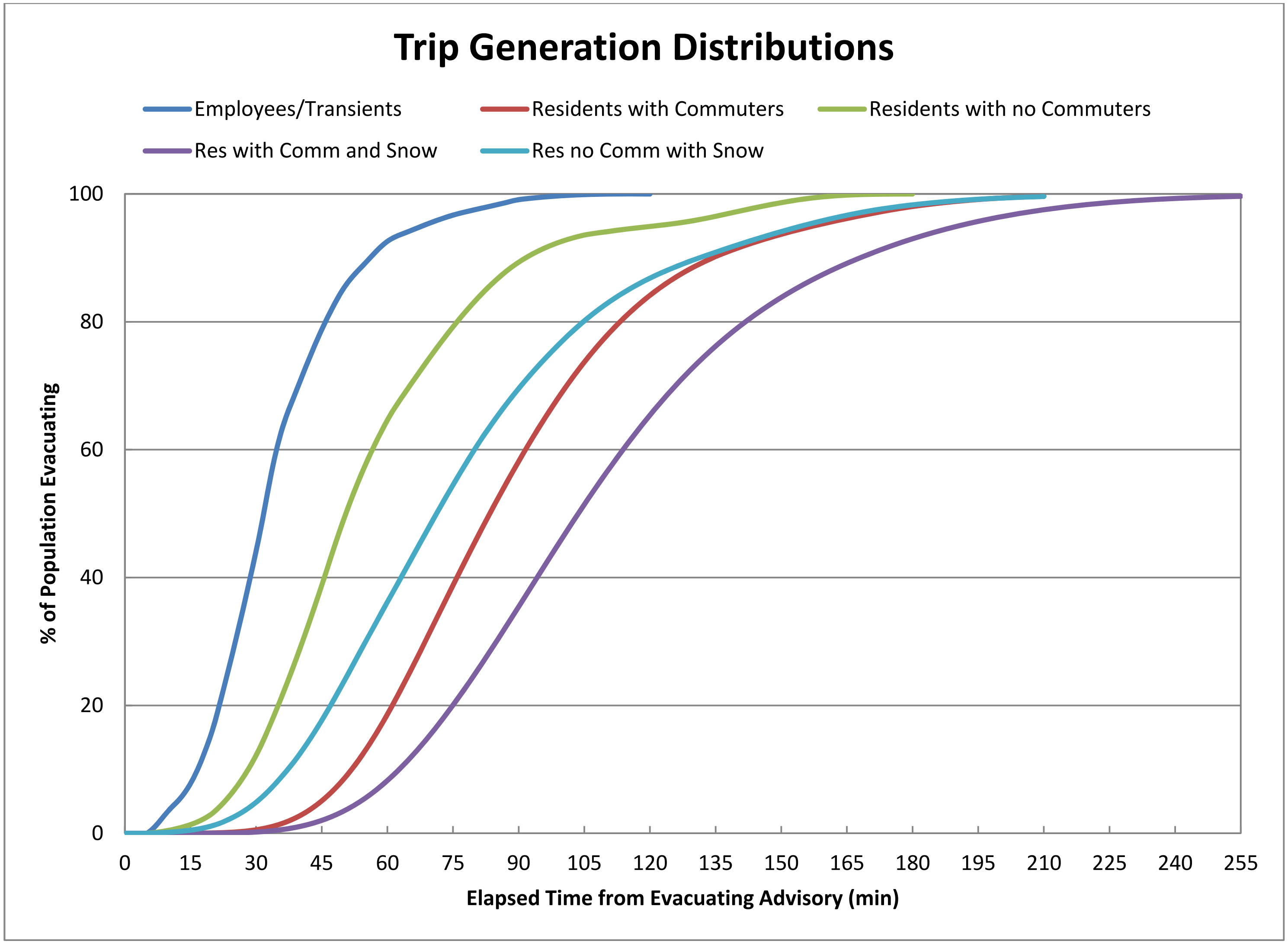


Figure 5-4. Comparison of Trip Generation Distributions

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%	2%	0%	1%
3	15	1%	6%	0%	3%
4	15	3%	5%	2%	3%
5	15	4%	3%	2%	4%
6	15	4%	2%	3%	3%
7	30	72%	77%	6%	3%
8	30	10%	4%	71%	77%
9	30	4%	1%	9%	4%
10	15	1%	0%	3%	1%
11	15	1%	0%	2%	1%
12	15	0%	0%	1%	0%
13	15	0%	0%	0%	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.

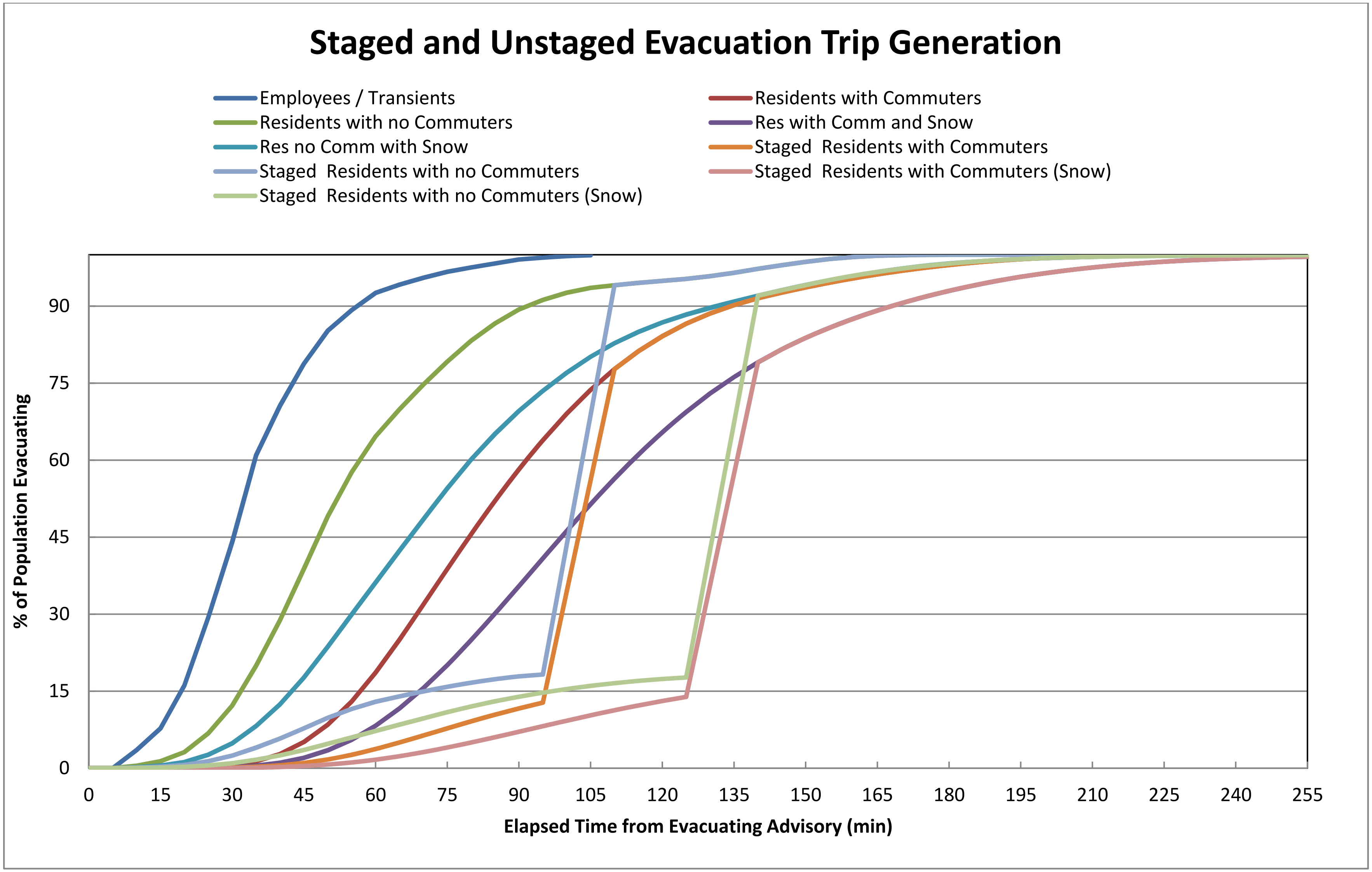


Figure 5-5. Comparison of Staged and Unstaged Trip Generation Distributions in the 5 to 10 Mile Region

6 DEMAND ESTIMATION FOR EVACUATION SCENARIOS

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

Region A grouping of contiguous evacuating zones 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 17 Regions were defined which encompass all the groupings of zones considered. These Regions are defined in Table 6-1. The zone 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. In addition to the 3 sector keyhole, Kewaunee Power Station can make site specific Protective Action Recommendations (PAR) that entail evacuating 4 sectors if the wind direction is within 2° of a sector boundary.

These sectors extend to 5 miles from the plant (Region R01) or to the EPZ boundary (Regions R02 through R17). Regions R01 and R02 represent evacuations of circular areas with radii 5 and 10 miles, respectively. Regions R10 through R16 are identical to Regions R03 through R09 respectively and R02 is identical to R17. However, in R10 through R17, those zones between 5 miles and 10 miles are staged until 90% of the 5-mile region (Region R01) has evacuated.

A total of 14 Scenarios were evaluated for all Regions. Thus, there are a total of 17x14=238 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 R02 – 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, such that the average population is considered for each evacuation case. 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 56% (the number of households with at least one commuter) and 46% (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.

Employment is assumed to be at its peak 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 (75%) during the week. As shown in Appendix E, there is a significant amount of lodging and campgrounds offering overnight accommodations in the EPZ; thus, transient activity is estimated to be high during evening hours – 72% for summer and 33% for winter. Transient activity on winter weekends is estimated to be 45%.

As noted in the shadow footnote to Table 6-3, the shadow percentages are computed using a base of 20% (see assumption 5 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:

$$20\% \times \left(1 + \frac{988}{4{,}589 + 1{,}578}\right) = 23\%$$

One special event – Outage at Kewaunee Power Station – was considered as Scenario 13. Thus, the special event traffic is 100% evacuated for Scenario 13, and 0% for all other scenarios.

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. As discussed in Section 7, schools are in session during the winter season, midweek, midday and 100% of buses will be 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 reduced by 60% during evening scenarios and is 100% for all other scenarios.

Table 6-1. Description of Evacuation Regions

Region	Description	Zone				
		5	10N	10W	10SW	10S
R01	2-Mile Radius	**X**				
N/A	5-Mile Radius	**Refer to R01**				
R02	Full EPZ	**X**	**X**	**X**	**X**	**X**
Evacuate 2-Mile Radius and Downwind to 5 Miles						
Region	**Wind From °**	**Zone**				
		5	**10N**	**10W**	**10SW**	**10S**
N/A	Full 360	**Refer to R01**				
Evacuate 5-Mile Radius and Downwind to 10 Miles						
Region	**Wind From °**	**Zone**				
		5	**10N**	**10W**	**10SW**	**10S**
R03	324 - 9	**X**				**X**
R04	9 – 54	**X**			**X**	**X**
R05	54 – 80.5	**X**		**X**	**X**	**X**
R06	80.5 – 99	**X**		**X**	**X**	
R07	99 – 103	**X**	**X**	**X**	**X**	
R08	103 – 170.5	**X**	**X**	**X**		
R09	170.5 – 215.5	**X**	**X**			
N/A	215.5 – 324	**Refer to R01**				
Staged Evacuation - 5-Mile Radius Evacuates, then Evacuate Downwind to 10 Miles						
Region	**Wind From °**	**Zone**				
		5	**10N**	**10W**	**10SW**	**10S**
R10	324 - 9	**X**				**X**
R11	9 – 54	**X**			**X**	**X**
R12	54 – 80.5	**X**		**X**	**X**	**X**
R13	80.5 – 99	**X**		**X**	**X**	
R14	99 – 103	**X**	**X**	**X**	**X**	
R15	103 – 170.5	**X**	**X**	**X**		
R16	170.5 – 215.5	**X**	**X**			
N/A	215.5 – 324	**Refer to R01**				
R17	Full EPZ	**X**	**X**	**X**	**X**	**X**
Zone(s) Shelter-in-Place until 90% ETE for R01, then Evacuate		Zone(s) Shelter-in-Place			Zone(s) Evacuate	

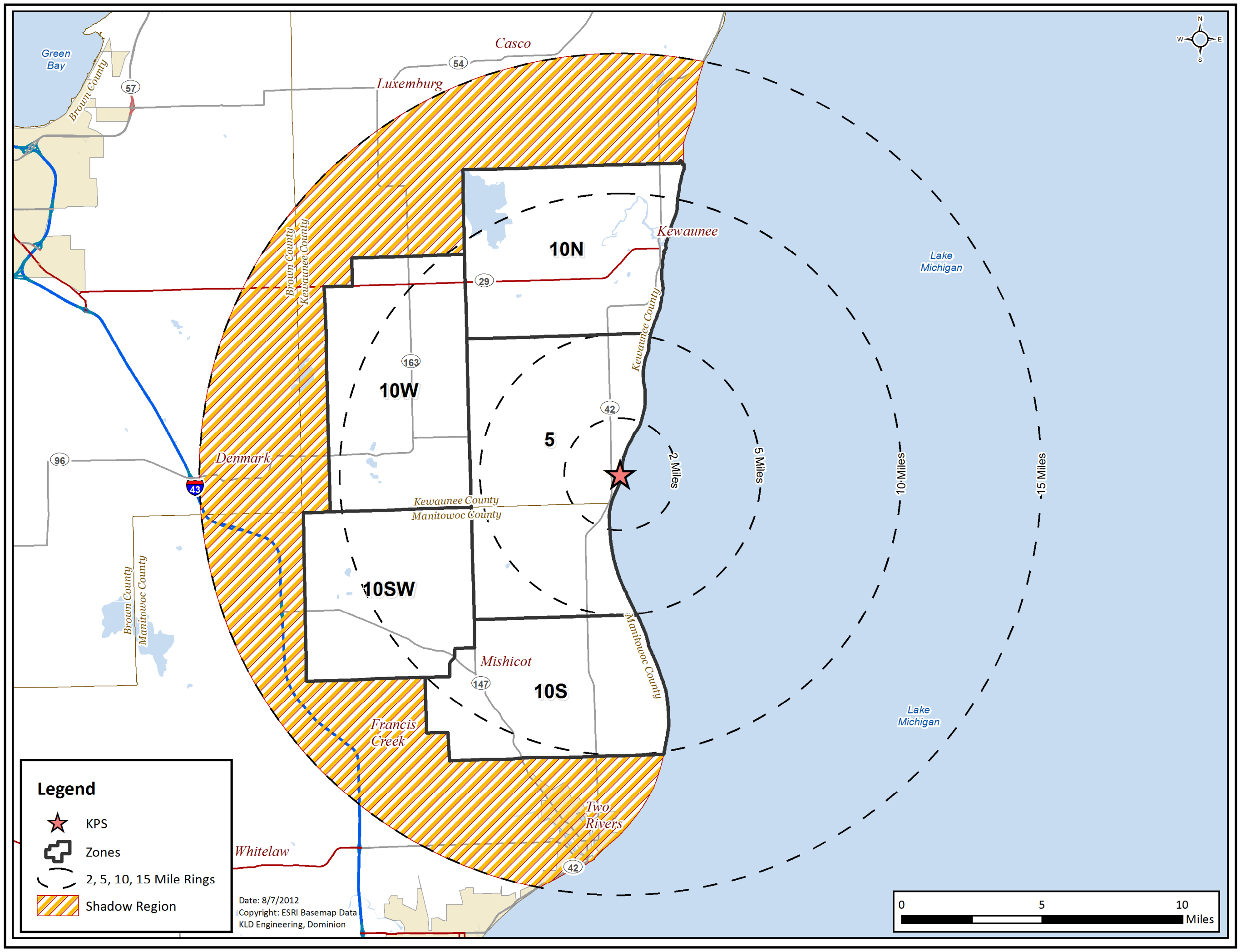


Figure 6-1. KPS EPZ Zones

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	Rain	None
8	Winter	Midweek	Midday	Snow	None
9	Winter	Weekend	Midday	Good	None
10	Winter	Weekend	Midday	Rain	None
11	Winter	Weekend	Midday	Snow	None
12	Winter	Midweek, Weekend	Evening	Good	None
13	Winter	Midweek	Midday	Good	Plant outage at Kewaunee Power Station
14	Summer	Midweek	Midday	Good	Roadway Impact – Close NB lane on SR 42

[1] Winter means that school is in session (also applies to spring and autumn). Summer means that school is not in session.

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

Scenario	Households With Returning Commuters	Households Without Returning Commuters	Employees	Transients	Shadow	Special Events	School Buses	Transit Buses	External Through Traffic
1	26%	74%	96%	75%	23%	0%	10%	100%	100%
2	26%	74%	96%	75%	23%	0%	10%	100%	100%
3	3%	97%	10%	100%	20%	0%	0%	100%	100%
4	3%	97%	10%	100%	20%	0%	0%	100%	100%
5	3%	97%	10%	72%	20%	0%	0%	100%	40%
6	26%	74%	100%	34%	23%	0%	100%	100%	100%
7	26%	74%	100%	34%	23%	0%	100%	100%	100%
8	26%	74%	100%	34%	23%	0%	100%	100%	100%
9	3%	97%	10%	45%	20%	0%	0%	100%	100%
10	3%	97%	10%	45%	20%	0%	0%	100%	100%
11	3%	97%	10%	45%	20%	0%	0%	100%	100%
12	3%	97%	10%	33%	20%	0%	0%	100%	40%
13	26%	74%	100%	34%	23%	100%	100%	100%	100%
14	26%	74%	96%	75%	23%	0%	10%	100%	100%

Resident Households with Commuters ....Households of EPZ residents who await the return of commuters prior to beginning the evacuation trip.
Resident Households with No 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 Events ....Additional vehicles in the EPZ due to the identified special event.
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 and major arterial roads 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 Events	School Buses	Transit Buses	External Through Traffic	Total Scenario Vehicles
1	1,578	4,589	988	1,068	2,715	-	7	14	4,384	15,343
2	1,578	4,589	988	1,068	2,715	-	7	14	4,384	15,343
3	158	6,009	103	1,424	2,379	-	-	14	4,384	14,471
4	158	6,009	103	1,424	2,379	-	-	14	4,384	14,471
5	158	6,009	103	1,025	2,379	-	-	14	1,754	11,442
6	1,578	4,589	1,029	484	2,731	-	72	14	4,384	14,881
7	1,578	4,589	1,029	484	2,731	-	72	14	4,384	14,881
8	1,578	4,589	1,029	484	2,731	-	72	14	4,384	14,881
9	158	6,009	103	641	2,379	-	-	14	4,384	13,688
10	158	6,009	103	641	2,379	-	-	14	4,384	13,688
11	158	6,009	103	641	2,379	-	-	14	4,384	13,688
12	158	6,009	103	470	2,379	-	-	14	1,754	10,887
13	1,578	4,589	1,029	484	2,731	769	72	14	4,384	15,650
14	1,578	4,589	988	1,068	2,715	-	7	14	4,384	15,343

Note: Vehicle estimates are for an evacuation of the entire EPZ (Region R02)

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 17 regions within the KPS 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 of the 5-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 zones for which an Advisory to Evacuate has not been issued, yet who elect to evacuate. "Shadow evacuation" is the voluntary outward movement 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 KPS EPZ addresses the issue of voluntary evacuees in the manner shown in Figure 7-1. Within the EPZ, 20 percent of people located in zones outside of the evacuation region who are not advised to evacuate, are assumed to elect to evacuate. Similarly, it is assumed that 20 percent of those people 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 22,041 people reside in the Shadow Region; 20 percent of them would evacuate. See Table 6-4 for the number of evacuating vehicles from the Shadow Region.

Traffic generated within this Shadow Region, traveling away from the KPS 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

For this study, staged evacuation consists of the following:

1. Zones comprising the 5 mile region are advised to evacuate immediately.
2. Zones comprising regions extending from 5 to 10 miles downwind are advised to shelter in-place while the two mile region is cleared.

3. As vehicles evacuate the 5 mile region, people from 5 to 10 miles downwind continue preparation for evacuation while they shelter.
4. The population sheltering in the 5 to 10 mile region is advised to evacuate when approximately 90% of the 5 mile region evacuating traffic crosses the 5 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 R02) is advised to evacuate during the summer, midweek, midday period under good weather conditions (Scenario 1).

Traffic congestion, as the term is used here, is defined as Level of Service (LOS) F. LOS F is defined as follows (HCM 2010, page 5-5):

> The HCM uses LOS F to define operations that have either broken down (i.e., demand exceeds capacity) or have exceeded a specified service measure value, or combination of service measure values, that most users would consider unsatisfactory. However, particularly for planning applications where different alternatives may be compared, analysts may be interested in knowing just how bad the LOS F condition is. 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%, etc.);
>
> • *Duration of LOS F* describes how long the condition persists (e.g., 15 min, 1 h, 3 h); and
>
> • *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. At 45 minutes after the ATE, Figure 7-3 displays light traffic caused by employee vehicles evacuating from the plant. Moderate traffic (LOS C) exists on SR 42 northbound in the City of Kewaunee. The 5 mile region is essentially clear of congestion. Congestion begins to develop in the City of Two Rivers which lies in the southern portion of the shadow region.

At 1 hour, 15 minutes after the ATE, Figure 7-4 shows that the EPZ is essentially clear of congestion, well before the completion of trip generation (mobilization) time. LOS F is exhibited

at the stop sign on the CR O approach to SR 42 in the northern portion of the Shadow Region. Congestion persists in the City of Two Rivers in the southern portion of the Shadow Region.

At 1 hour and 30 minutes after the ATE, Figure 7-5 shows that congestion at the intersection of CR O and SR 42 has cleared and the congestion in Two Rivers begins to dissipate.

Figure 7-6 shows Two Rivers is completely clear of congestion at 1 hour and 55 minutes after the ATE.

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 R02) 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 evacuation routes service the remaining demand.

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 and Table 7-2 present the ETE values for all 17 Evacuation Regions and all 14 Evacuation Scenarios. Table 7-3 and Table 7-4 present the ETE values for the 5-Mile region for both staged and un-staged keyhole regions downwind to 10 miles. The tables are organized as follows:

Table	Contents
7-1	ETE represents the elapsed time required for 90 percent 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 percent 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 percent of the population within the 5-mile Region, to evacuate from that Region with both Concurrent and Staged Evacuations.
7-4	ETE represents the elapsed time required for 100 percent of the population within the 5-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. There is minimal traffic congestion within the EPZ, which results in ETE values which parallel mobilization time; this is reflected in the ETE statistics:

- The 90th percentile ETE for Region R01 (5-mile area) is approximately 1 hour and 40 minutes (higher during snow scenarios). As shown in Figure 5-4, 90 percent of residents without commuters mobilize in about 1 hour and 45 minutes and 90 percent of residents with commuters mobilize in about 2 hours and 10 minutes. The 90th percentile ETE is slightly less than the mobilization time for Region R01, primarily because almost half of the evacuees from Region R01 are employees at KPS, who mobilize quickly. Figure 5-4 indicates that 90 percent of employees mobilize in about 55 minutes.
- The 90th percentile ETE for regions which extend to the EPZ boundary are approximately 10 minutes longer, on average and range from 1:35 to 1:55 (slightly higher during snow scenarios).

The 100th percentile ETE for all regions and for all scenarios parallel mobilization time, as well. 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 6 and 13 in Table 7-1 indicates that the Special Event – an outage at the plant – does not have a significant impact on the ETE for the 90th percentile. There is

sufficient capacity to accommodate the additional 769 employee vehicles at the KPS. For some regions, the resulting ETE is slightly (5 minutes) less during an outage because the additional workers mobilize at the same rate as employees (see Table 5-9).

Comparison of Scenarios 1 and 14 in Table 7-1 indicates that the roadway closure – the northbound segment of the SR 42 between Miller St. and Peterson St. – has no impact on 90th or 100th percentile ETE because there exists sufficient reserve capacity on other routes exiting the City of Kewaunee.

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 R10 through R17 are the same geographic areas as Regions R03 through R09 and R02, respectively.

To determine whether the staged evacuation strategy is worthy of consideration, one must show that the ETE for the 5 Mile region can be reduced without significantly affecting the region between 5 miles and 10 miles. As shown in Figure 7-3, traffic in the 5-mile region never accumulates to a point where it would become an impedance to those evacuees from within the 5-mile region. In all cases, as shown in these tables, the ETE for the 5 mile region is unchanged when a staged evacuation is implemented.

While failing to provide assistance to evacuees from within 5 miles of the KPS, staging produces a negative impact on the ETE for those evacuating from within the 10-mile region. A comparison of ETE between Regions R10 through R17 and R03 through R09 and R02; reveals that staging retards the 90th percentile evacuation time for those in the 5 to 10-mile area by up to 25 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) that follows the eventual ATE, in creating congestion within the EPZ beyond 2 miles.

In summary, the staged evacuation protective action strategy provides no benefits to evacuees from within 5 miles and adversely impacts many evacuees located beyond 5 miles from the KPS.

7.7 Guidance on Using ETE Tables

The user first determines the percentile of population for which the ETE is sought (The 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**:
    - Season
        - Summer
        - Winter (also Autumn and Spring)
    - Day of Week
        - Midweek
        - Weekend

- Time of Day
  - Midday
  - Evening
- Weather Condition
  - Good Weather
  - Rain
  - Snow
- Special Event
  - Outage at Kewaunee Power Station
  - Road Closure (a section of SR 42 NB is closed between Miller St. and Peterson St.)
- 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 are not explicitly identified in the Tables. For these conditions, Scenarios (7) and (10) for rain apply.
- The conditions of a winter evening (either midweek or weekend) and snow are not explicitly identified in the Tables. For these conditions, Scenarios (8) and (11) for snow apply.
- The seasons are defined as follows:
  - Summer assumes that public schools are not in session.
  - Winter (includes Spring and Autumn) considers that public schools are in session.
- 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**:
   - Determine the projected azimuth direction of the plume (coincident with the wind direction). This direction is expressed in terms of compass orientation in degrees (0° is North).
   - Determine the distance that the Evacuation Region will extend from the nuclear power plant. The applicable distances and their associated candidate Regions are given below:
     - 5 Miles (Region R01)
     - To EPZ Boundary (Regions R02 through R17)
   - Enter Table 7-5 and identify the applicable group of candidate Regions based on the distance that the selected Region extends from the KPS. 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 **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.

<u>Example</u>

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 50°.
- Wind speed is such that the distance to be evacuated is judged to be a 5-mile radius and downwind to 10 miles (to EPZ boundary).
- The desired ETE is that value needed to evacuate 90 percent 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 5-Mile Radius and Downwind to the EPZ Boundary” for wind direction from 50° and read Region R04 in the first column of that row.
3. Enter Table 7-1 to locate the data cell containing the value of ETE for Scenario 4 and Region R04. This data cell is in column (4) and in the row for Region R04; it contains the ETE value of **1:35**.

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

	Summer		Summer		Summer	Winter			Winter			Winter	Winter	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Midday		Midday		Evening	Midday			Midday			Evening	Midday	Midday
Region	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather	Special Event	Roadway Impact
Entire 5-Mile Region and EPZ														
R01	1:35	1:35	1:40	1:40	1:40	1:35	1:35	2:05	1:40	1:40	2:15	1:40	1:30	1:35
R02	1:50	1:50	1:40	1:40	1:40	1:55	1:55	2:25	1:40	1:40	2:15	1:45	1:50	1:50
5-Mile Region and Keyhole to EPZ Boundary														
R03	1:40	1:45	1:35	1:35	1:35	1:45	1:50	2:15	1:35	1:40	2:10	1:40	1:40	1:40
R04	1:45	1:45	1:35	1:35	1:40	1:50	1:50	2:20	1:40	1:40	2:15	1:40	1:45	1:45
R05	1:50	1:50	1:40	1:40	1:40	1:50	1:55	2:20	1:40	1:40	2:15	1:40	1:50	1:50
R06	1:50	1:50	1:45	1:45	1:45	1:50	1:50	2:20	1:45	1:45	2:20	1:45	1:45	1:50
R07	1:50	1:50	1:40	1:40	1:40	1:55	1:55	2:25	1:45	1:45	2:20	1:45	1:50	1:50
R08	1:50	1:50	1:40	1:40	1:40	1:55	1:55	2:25	1:45	1:45	2:20	1:45	1:50	1:50
R09	1:50	1:50	1:40	1:40	1:40	1:50	1:50	2:20	1:40	1:40	2:15	1:40	1:45	1:50
Staged Evacuation - 5-Mile Region and Keyhole to EPZ Boundary														
R10	2:00	2:00	2:00	2:00	2:00	2:00	2:00	2:30	2:00	2:00	2:30	2:00	2:00	2:00
R11	2:00	2:00	2:00	2:00	2:00	2:00	2:00	2:35	2:00	2:00	2:35	2:00	2:00	2:00
R12	2:00	2:05	2:00	2:00	2:00	2:05	2:05	2:35	2:05	2:05	2:35	2:05	2:00	2:00
R13	2:00	2:05	2:00	2:05	2:05	2:00	2:05	2:35	2:05	2:05	2:35	2:05	2:00	2:00
R14	2:05	2:05	2:05	2:05	2:05	2:05	2:05	2:40	2:05	2:05	2:40	2:05	2:05	2:05
R15	2:05	2:05	2:05	2:05	2:05	2:05	2:10	2:40	2:05	2:05	2:40	2:05	2:05	2:05
R16	2:05	2:05	2:05	2:05	2:05	2:05	2:05	2:40	2:05	2:05	2:40	2:05	2:05	2:05
R17	2:05	2:05	2:05	2:05	2:05	2:05	2:05	2:40	2:05	2:05	2:40	2:05	2:05	2:05

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

	Summer		Summer		Summer	Winter			Winter			Winter	Winter	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Midday		Midday		Evening	Midday			Midday			Evening	Midday	Midday
Region	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather	Special Event	Roadway Impact
Entire 5-Mile Region, and EPZ														
R01	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R02	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
5-Mile Region and Keyhole to EPZ Boundary														
R03	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R04	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R05	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R06	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R07	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R08	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R09	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
Staged Evacuation - 5-Mile Region and Keyhole to EPZ Boundary														
R10	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R11	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R12	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R13	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R14	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R15	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R16	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40
R17	3:40	3:40	3:40	3:40	3:40	3:40	3:40	4:25	3:40	3:40	4:25	3:40	3:40	3:40

Table 7-3. Time to Clear *90* Percent of the 5-Mile Area within the Indicated Region

	Summer		Summer		Summer	Winter			Winter			Winter	Winter	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
	Midday		Midday		Evening	Midday			Midday			Evening	Midday	Midday
Region	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather	Special Event	Roadway Impact
Entire 5-Mile Region, and EPZ														
R01	1:35	1:35	1:40	1:40	1:40	1:35	1:35	2:05	1:40	1:40	2:15	1:40	1:30	1:35
R02	1:40	1:40	1:40	1:40	1:40	1:40	1:40	2:05	1:40	1:40	2:15	1:40	1:30	1:40
Unstaged Evacuation - 5-Mile Region and Keyhole to EPZ Boundary														
R03	1:35	1:40	1:40	1:40	1:40	1:35	1:35	2:05	1:40	1:40	2:15	1:40	1:30	1:35
R04	1:40	1:40	1:40	1:40	1:40	1:40	1:40	2:05	1:40	1:40	2:15	1:40	1:30	1:40
R05	1:40	1:40	1:40	1:40	1:40	1:40	1:40	2:05	1:40	1:40	2:15	1:40	1:30	1:40
R06	1:40	1:40	1:40	1:40	1:40	1:40	1:40	2:05	1:40	1:40	2:15	1:40	1:30	1:40
R07	1:40	1:40	1:40	1:40	1:40	1:40	1:40	2:05	1:40	1:40	2:15	1:40	1:30	1:40
R08	1:40	1:40	1:40	1:40	1:40	1:35	1:40	2:05	1:40	1:40	2:15	1:40	1:30	1:40
R09	1:35	1:35	1:40	1:40	1:40	1:35	1:35	2:05	1:40	1:40	2:15	1:40	1:30	1:35
Staged Evacuation - 5-Mile Region and Keyhole to EPZ Boundary														
R10	1:45	1:45	1:50	1:50	1:50	1:45	1:45	2:15	1:50	1:50	2:25	1:50	1:35	1:45
R11	1:50	1:50	1:55	1:55	1:55	1:50	1:50	2:20	1:55	1:55	2:25	1:55	1:40	1:50
R12	1:50	1:50	1:55	1:55	1:55	1:50	1:50	2:20	1:55	1:55	2:30	1:55	1:45	1:50
R13	1:50	1:50	1:55	1:55	1:55	1:50	1:50	2:20	1:55	1:55	2:25	1:55	1:40	1:50
R14	1:50	1:50	1:55	1:55	1:55	1:50	1:50	2:20	1:55	1:55	2:25	1:55	1:40	1:50
R15	1:45	1:45	1:50	1:50	1:50	1:45	1:45	2:15	1:50	1:50	2:25	1:50	1:35	1:45
R16	1:40	1:40	1:50	1:50	1:50	1:40	1:40	2:10	1:50	1:50	2:20	1:50	1:30	1:40
R17	1:50	1:50	1:55	1:55	1:55	1:50	1:50	2:20	1:55	1:55	2:30	1:55	1:45	1:50

Table 7-4. Time to Clear *__100__* Percent of the 5-Mile Area within the Indicated Region

	Summer		Summer		Summer	Winter			Winter			Winter	Winter	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Region	Midday		Midday		Evening	Midday			Midday			Evening	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather	Special Event	Roadway Impact
Entire 5-Mile Region, and EPZ														
R01	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R02	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
5-Mile Region and Keyhole to EPZ Boundary														
R03	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R04	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R05	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R06	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R07	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R08	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R09	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
Staged Evacuation - 5-Mile Region and Keyhole to EPZ Boundary														
R10	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R11	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R12	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R13	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R14	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R15	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R16	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35
R17	3:35	3:35	3:35	3:35	3:35	3:35	3:35	4:20	3:35	3:35	4:20	3:35	3:35	3:35

Table 7-5. Description of Evacuation Regions

Region	Description	Zone				
		5	10N	10W	10SW	10S
R01	2-Mile Radius	X				
N/A	5-Mile Radius	Refer to R01				
R02	Full EPZ	X	X	X	X	X
Evacuate 2-Mile Radius and Downwind to 5 Miles						
Region	**Wind From °**	**Zone**				
		5	**10N**	**10W**	**10SW**	**10S**
N/A	Full 360	Refer to R01				
Evacuate 5-Mile Radius and Downwind to EPZ Boundary						
Region	**Wind From °**	**Zone**				
		5	**10N**	**10W**	**10SW**	**10S**
R03	324 - 9	X				X
R04	9 – 54	X			X	X
R05	54 – 80.5	X		X	X	X
R06	80.5 – 99	X		X	X	
R07	99 – 103	X	X	X	X	
R08	103 – 170.5	X	X	X		
R09	170.5 – 215.5	X	X			
N/A	215.5 – 324	Refer to R01				
Staged Evacuation - 5-Mile Radius Evacuates, then Evacuate Downwind to EPZ Boundary						
Region	**Wind From °**	**Zone**				
		5	**10N**	**10W**	**10SW**	**10S**
R10	324 - 9	X				X
R11	9 – 54	X			X	X
R12	54 – 80.5	X		X	X	X
R13	80.5 – 99	X		X	X	
R14	99 – 103	X	X	X	X	
R15	103 – 170.5	X	X	X		
R16	170.5 – 215.5	X	X			
N/A	215.5 – 324	Refer to R01				
R17	Full EPZ	X	X	X	X	X

Zone(s) Shelter-in-Place until 90% ETE for R01, then Evacuate	Zone(s) Shelter-in-Place	Zone(s) Evacuate

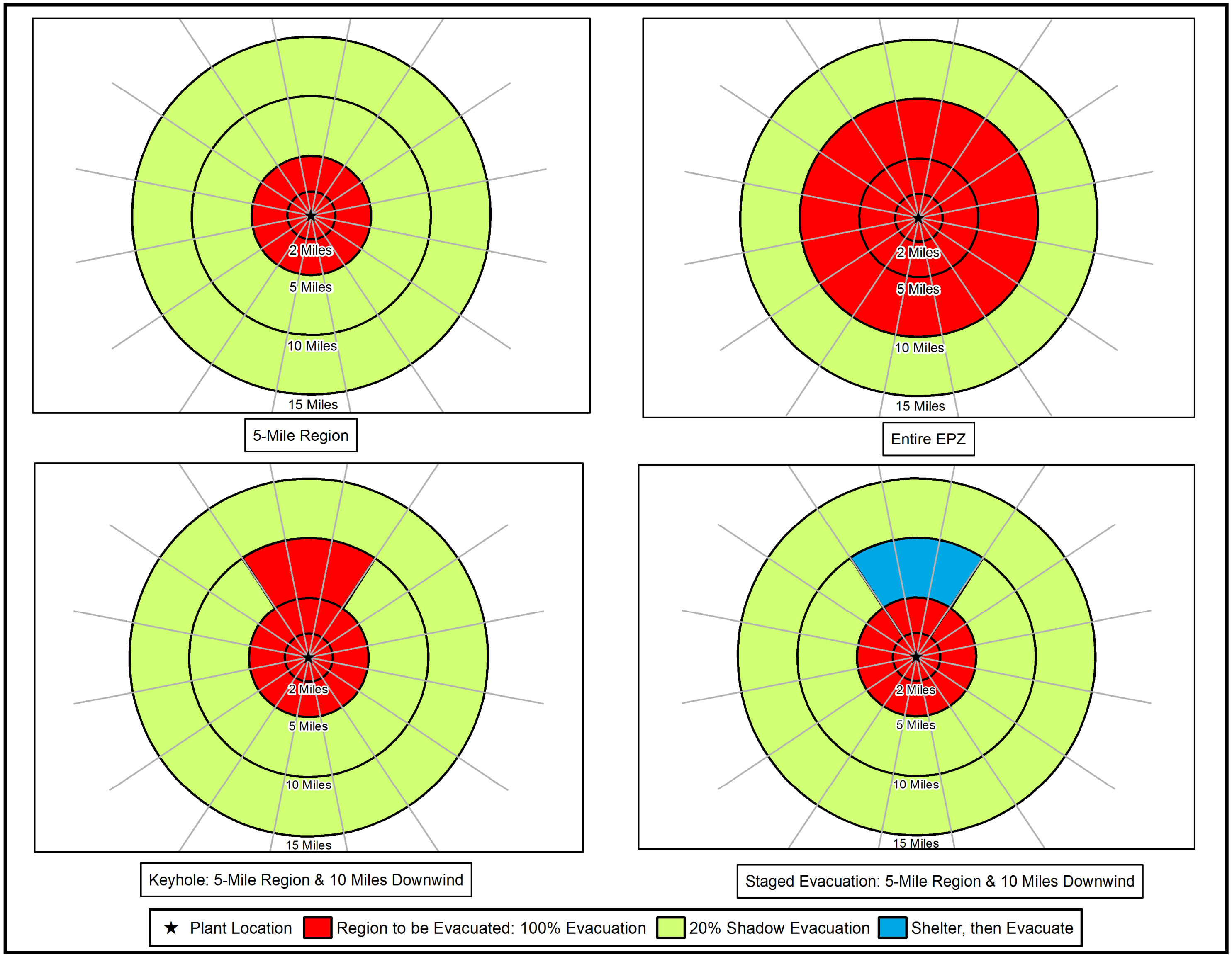


Figure 7-1. Voluntary Evacuation Methodology

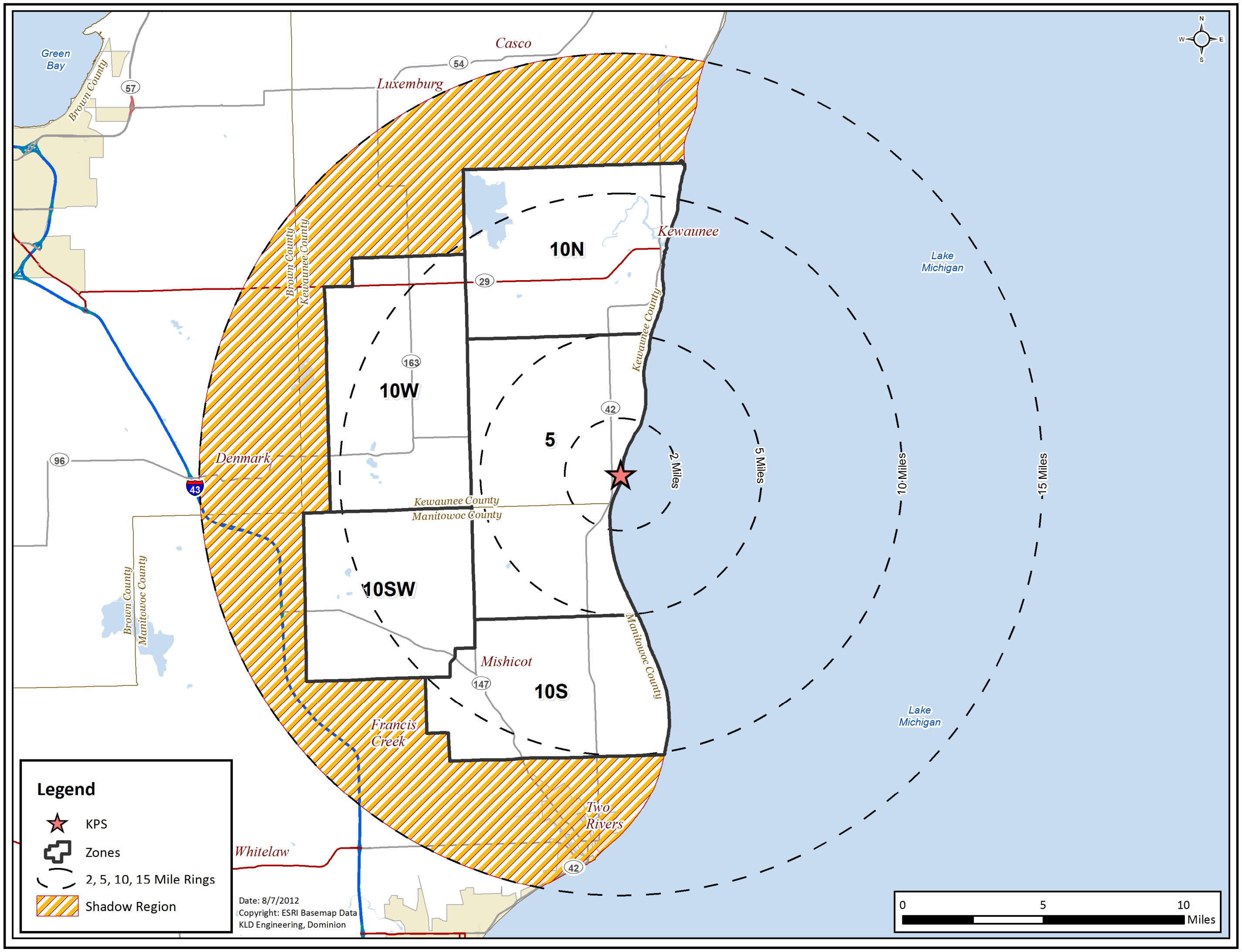


Figure 7-2. Kewaunee Power Station Shadow Region

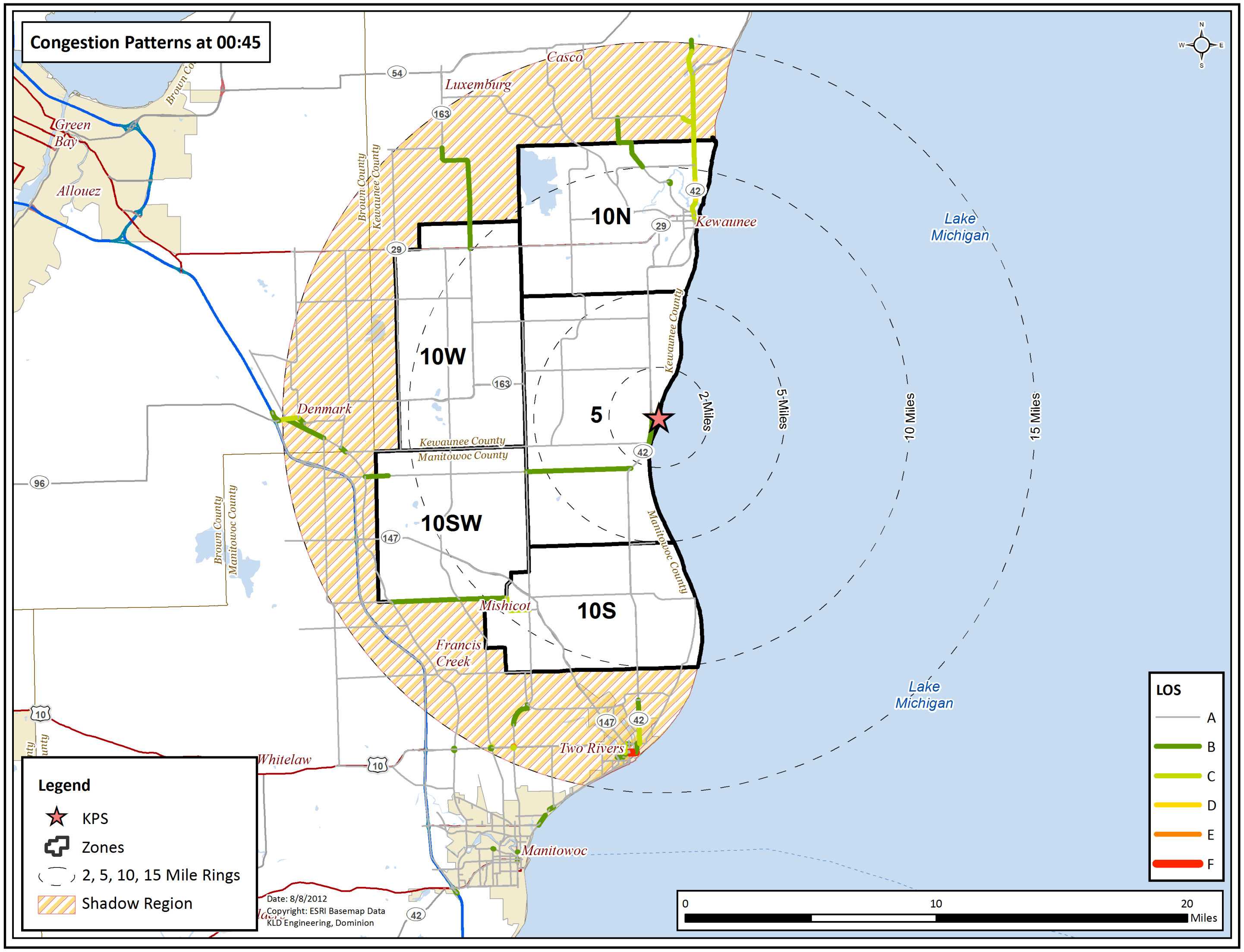


Figure 7-3. Congestion Patterns at 45 Minutes after the Advisory to Evacuate

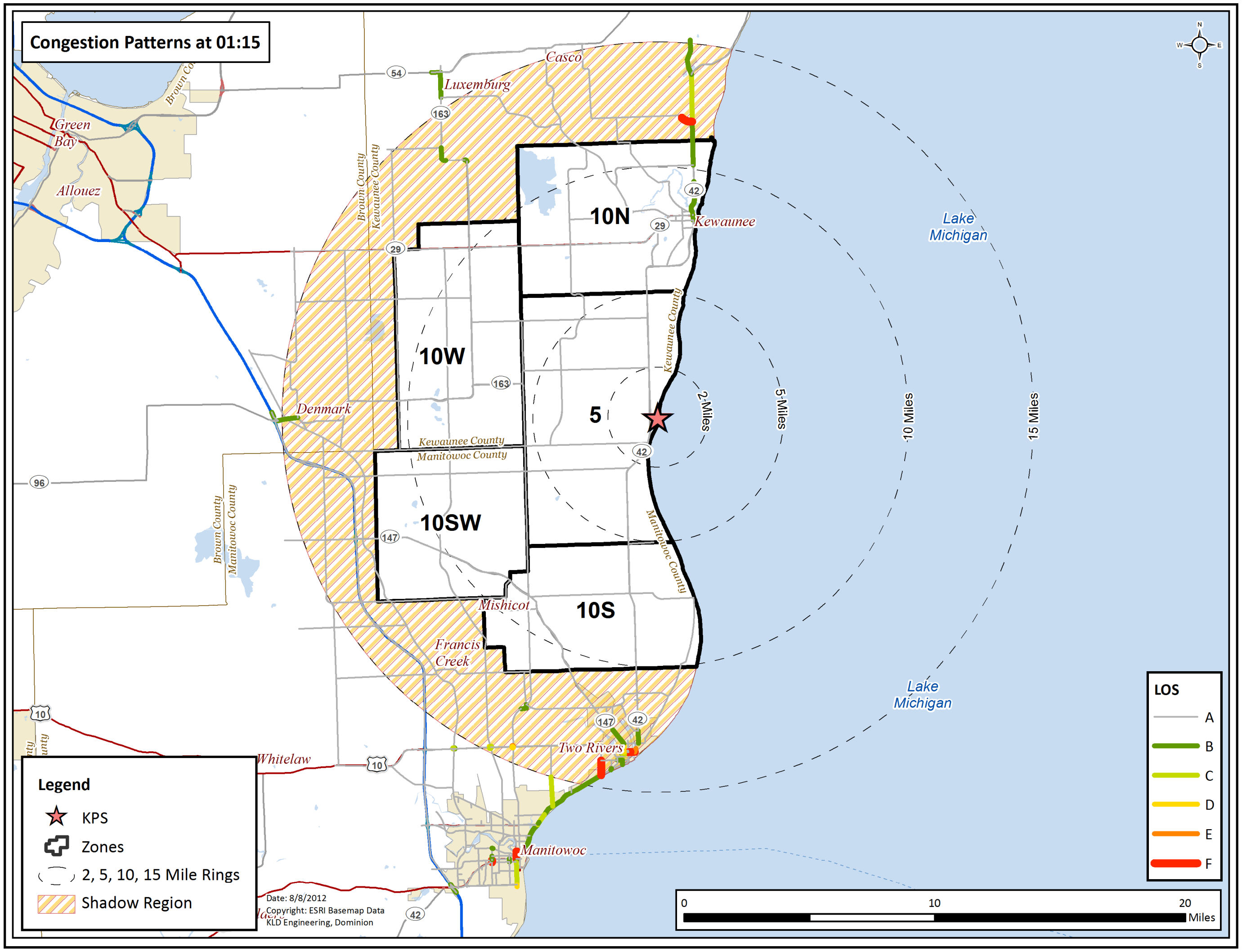


Figure 7-4. Congestion Patterns at 1 Hour, 15 Minutes after the Advisory to Evacuate

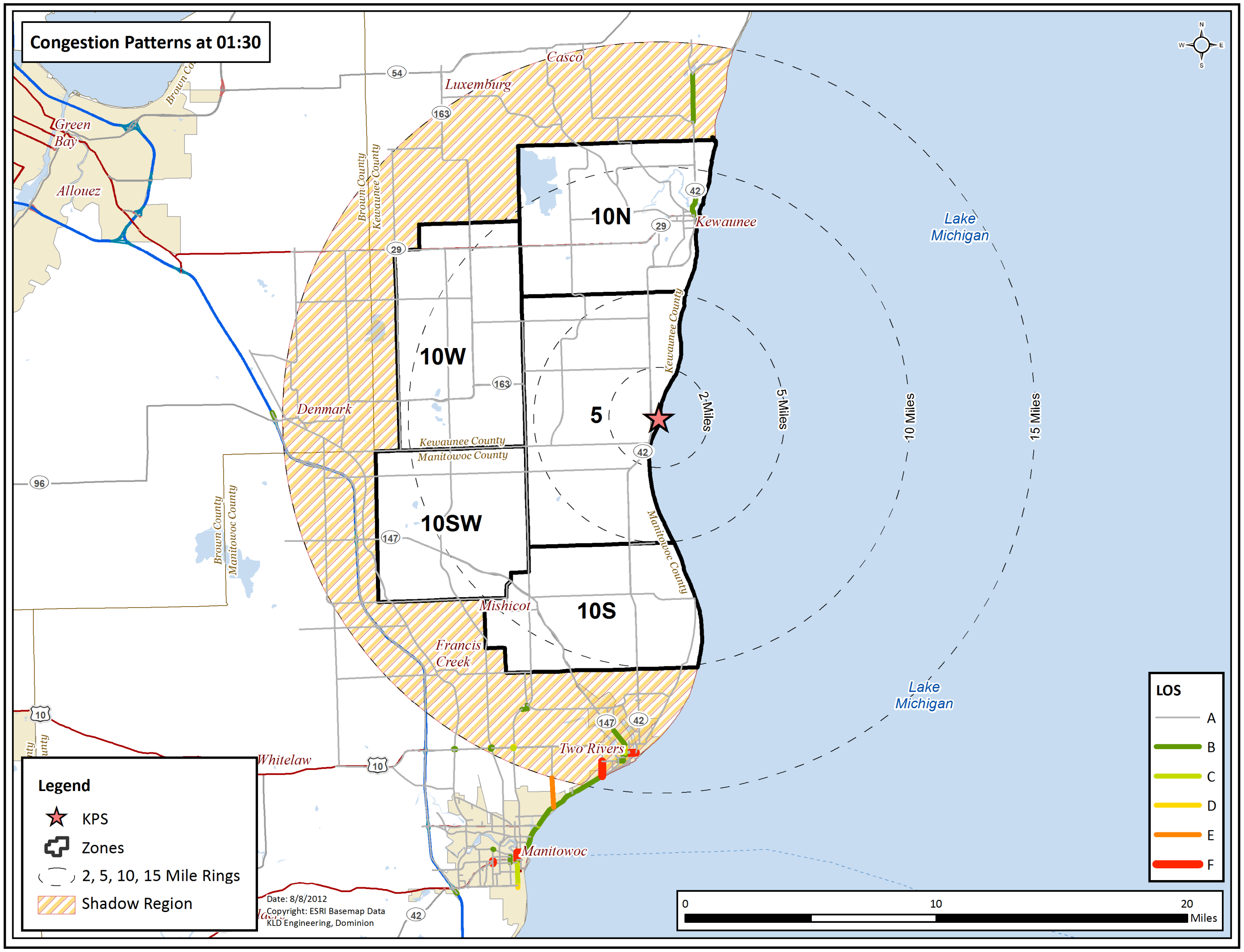


Figure 7-5. Congestion Patterns at 1 Hour, 30 Minutes after the Advisory to Evacuate

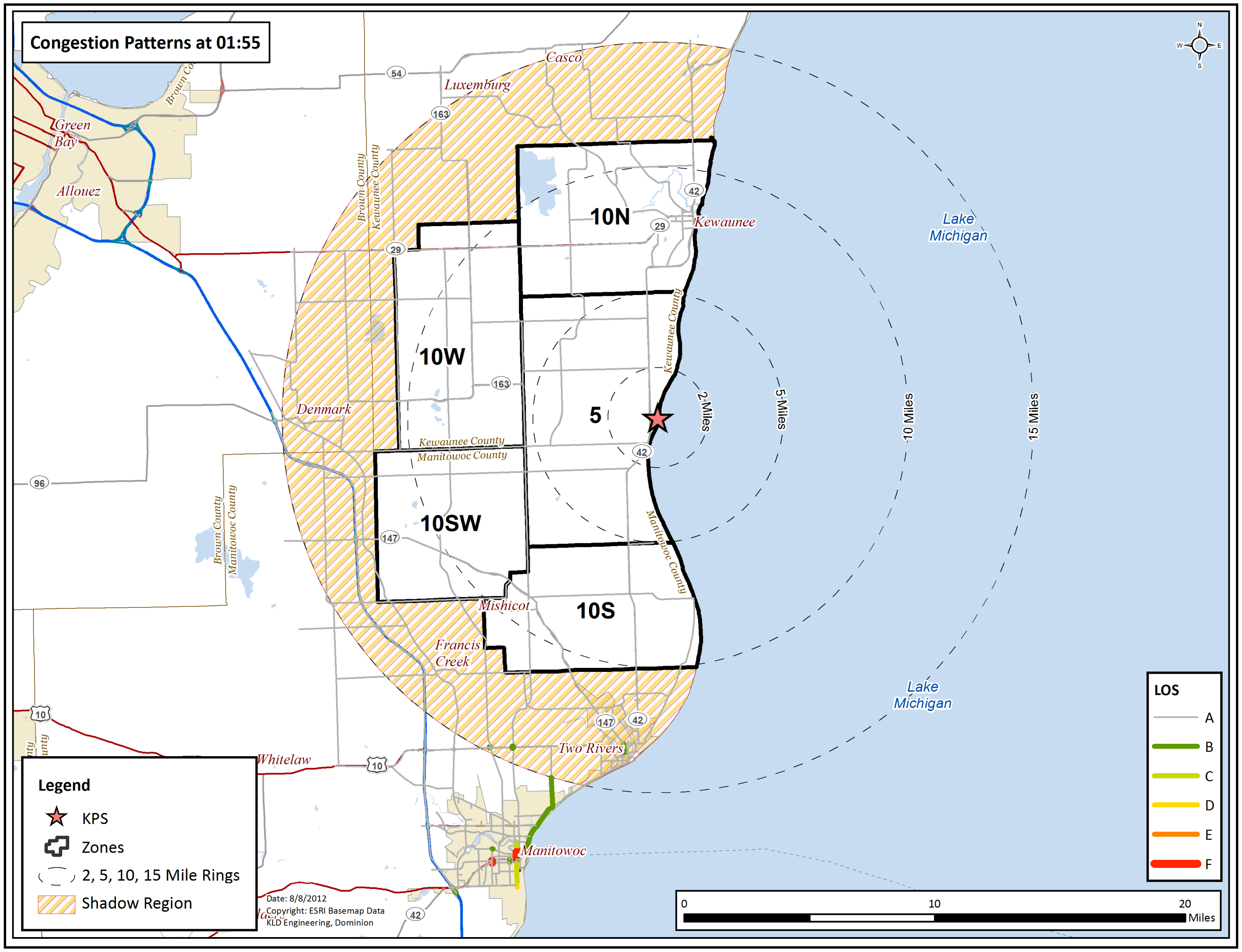


Figure 7-6. Congestion Patterns at 1 Hour, 55 Minutes after the Advisory to Evacuate

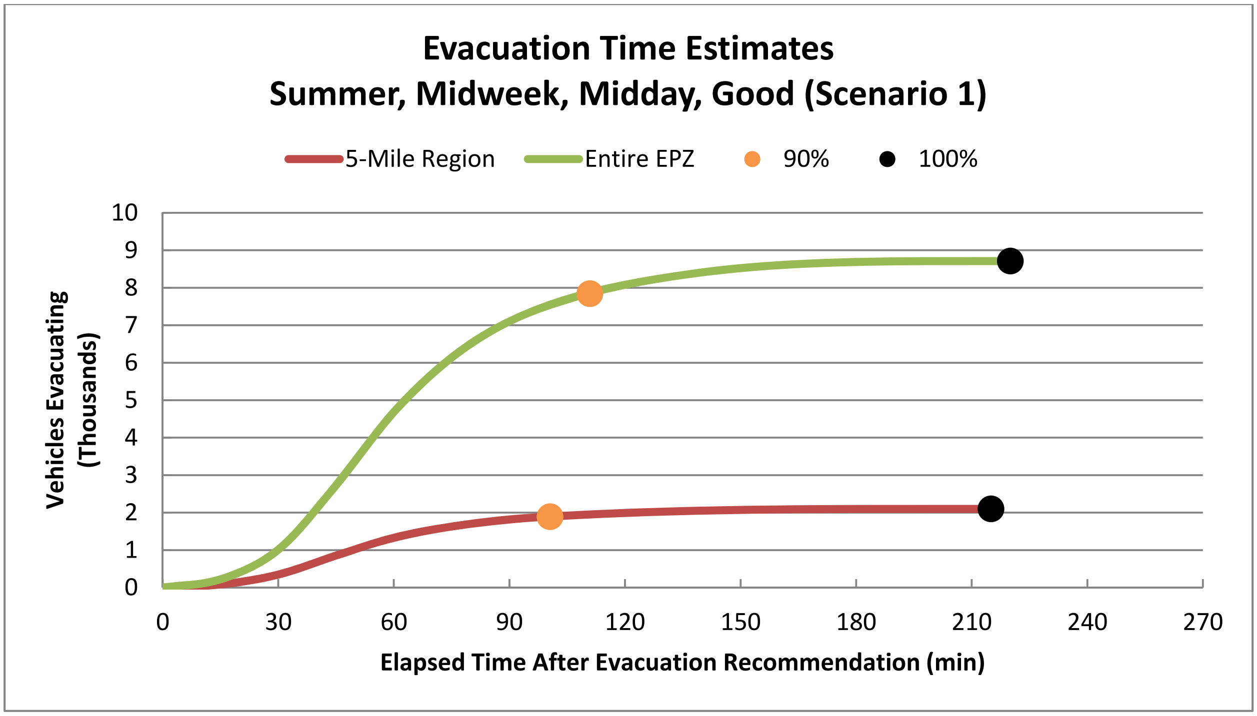


Figure 7-7. Evacuation Time Estimates - Scenario 1 for Region R02

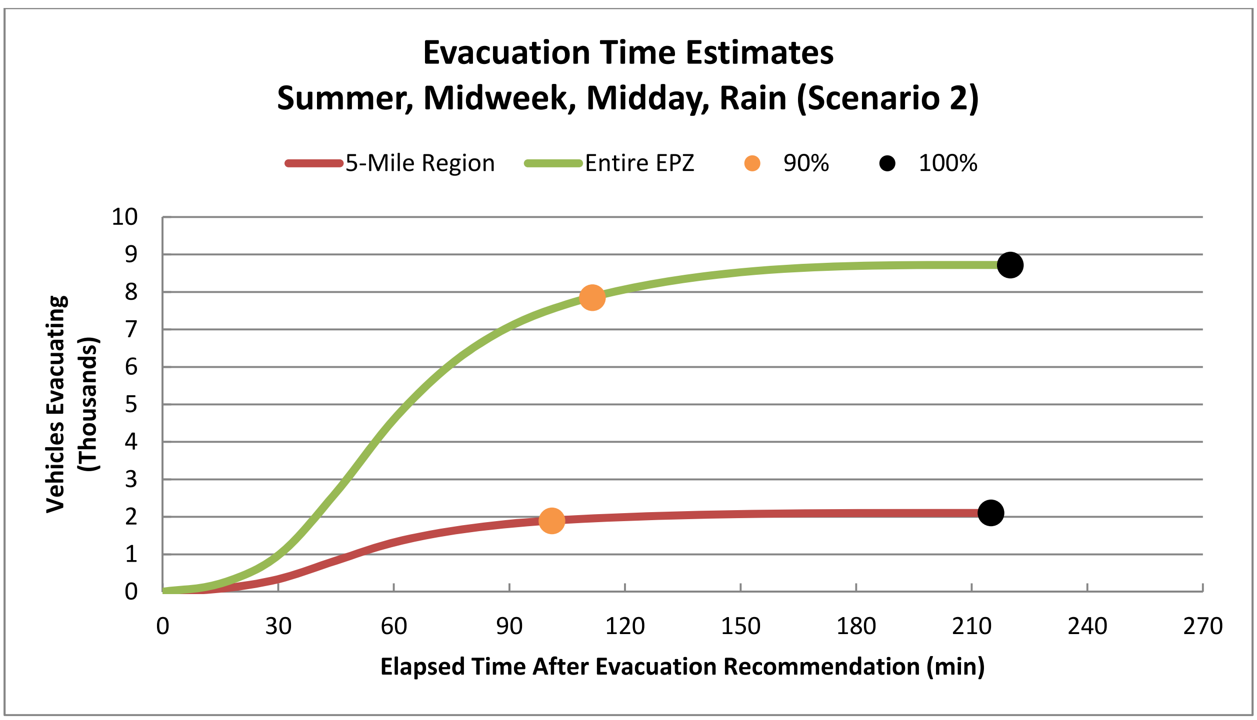


Figure 7-8. Evacuation Time Estimates - Scenario 2 for Region R02

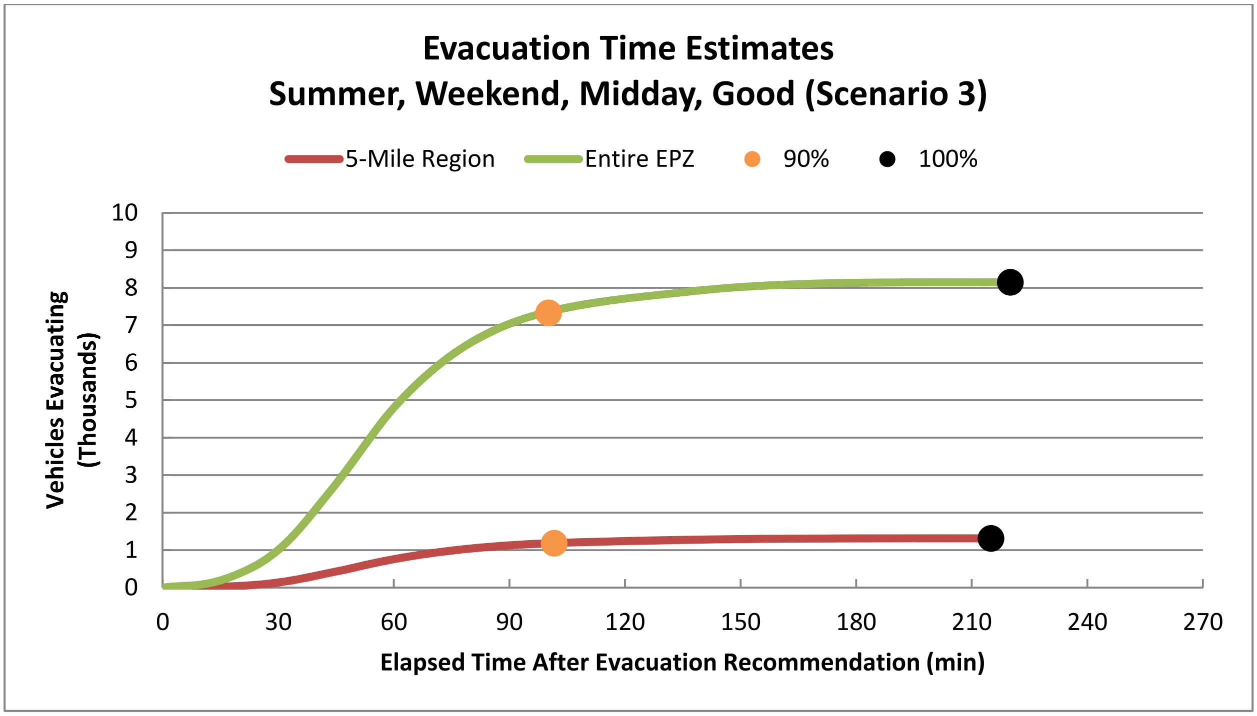


Figure 7-9. Evacuation Time Estimates - Scenario 3 for Region R02

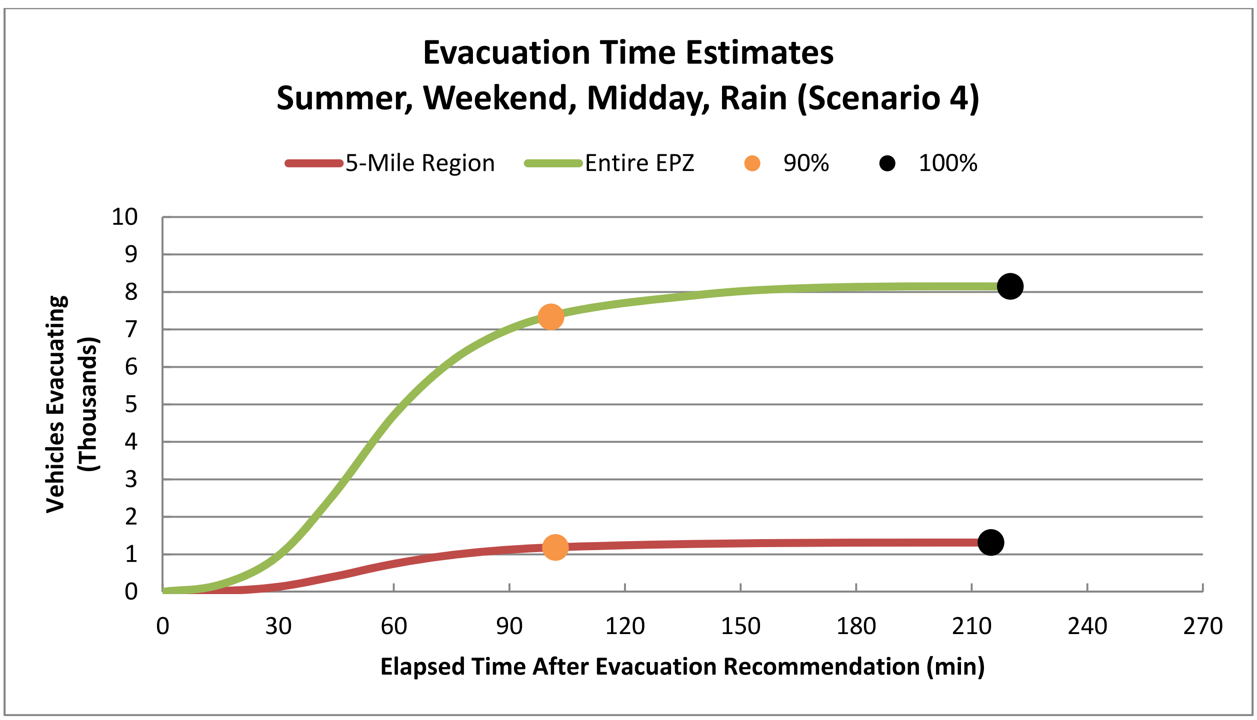


Figure 7-10. Evacuation Time Estimates - Scenario 4 for Region R02

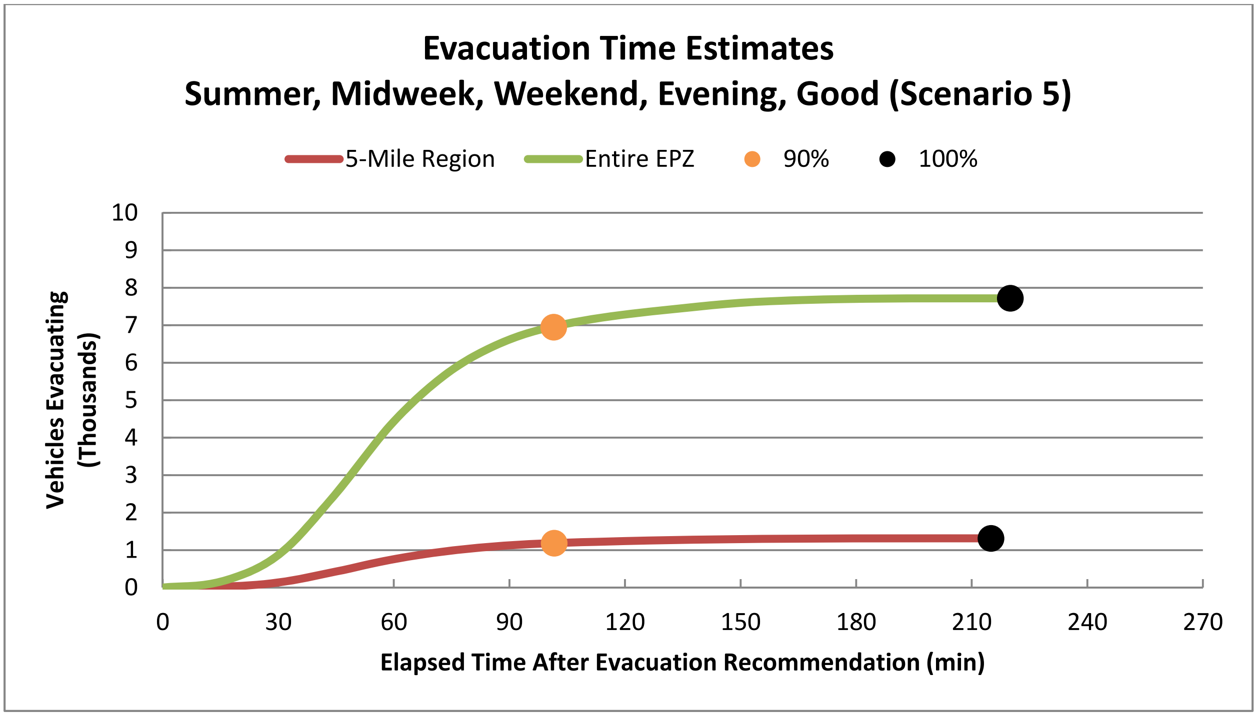


Figure 7-11. Evacuation Time Estimates - Scenario 5 for Region R02

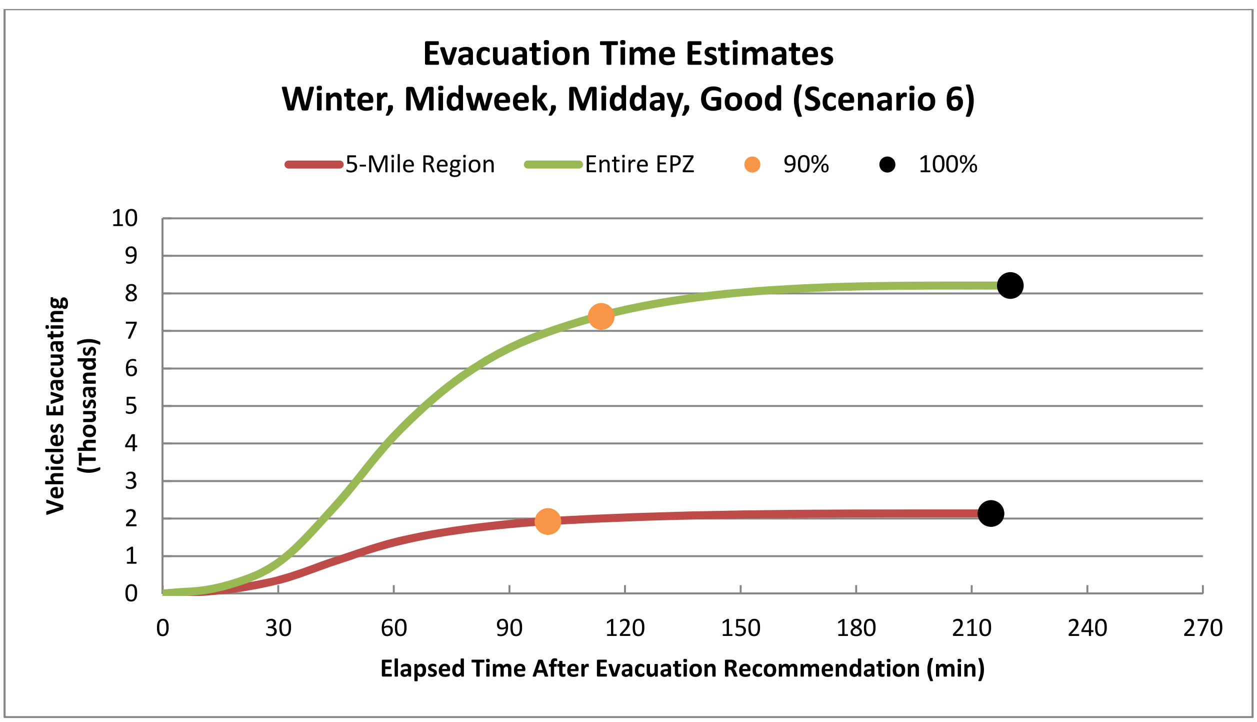


Figure 7-12. Evacuation Time Estimates - Scenario 6 for Region R02

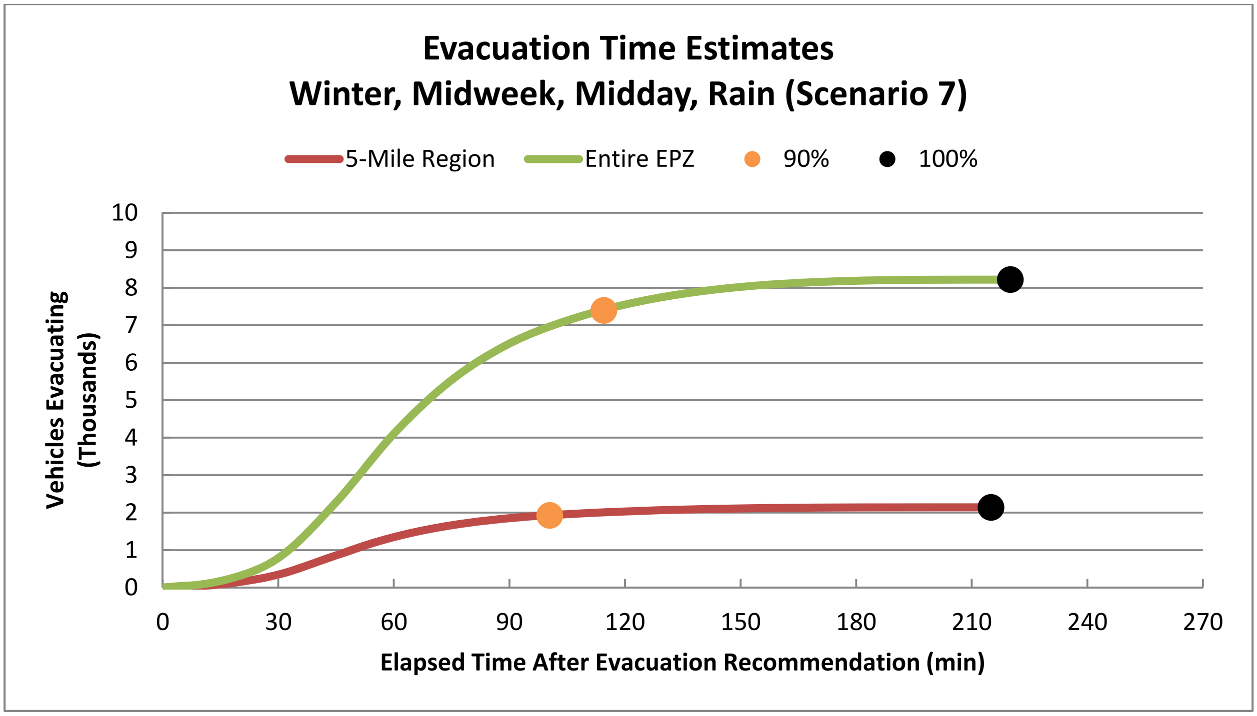


Figure 7-13. Evacuation Time Estimates - Scenario 7 for Region R02

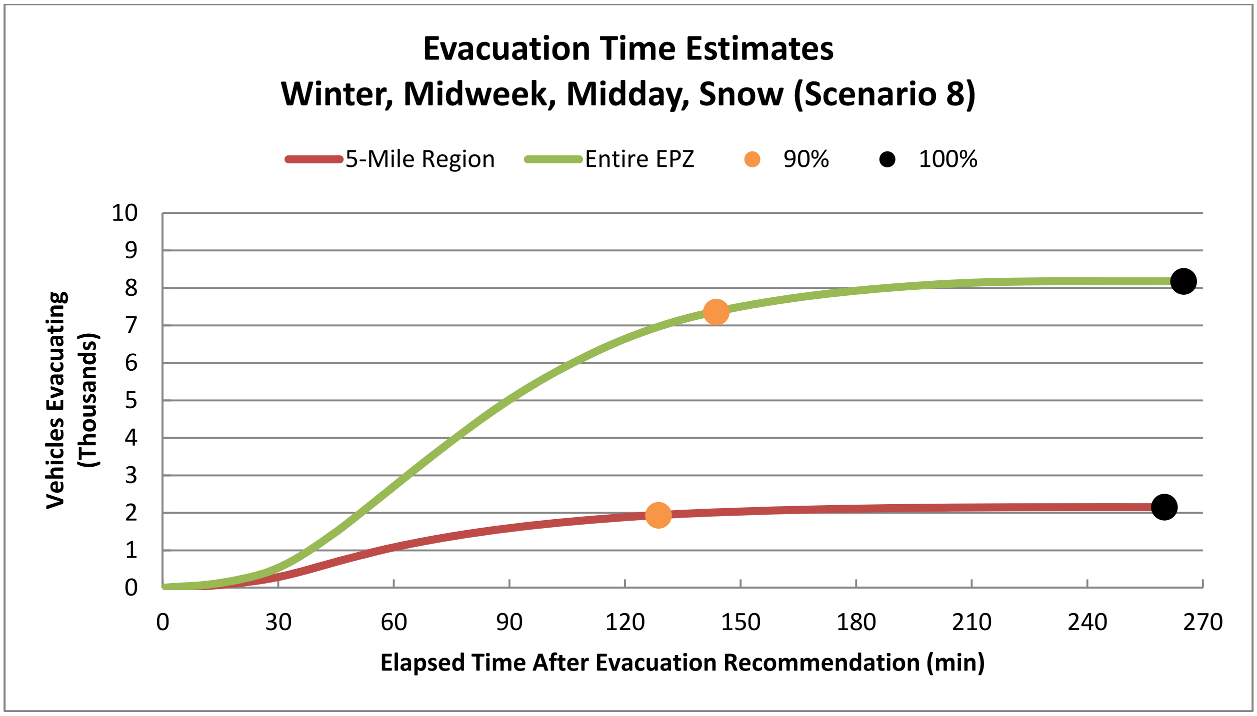


Figure 7-14. Evacuation Time Estimates - Scenario 8 for Region R02

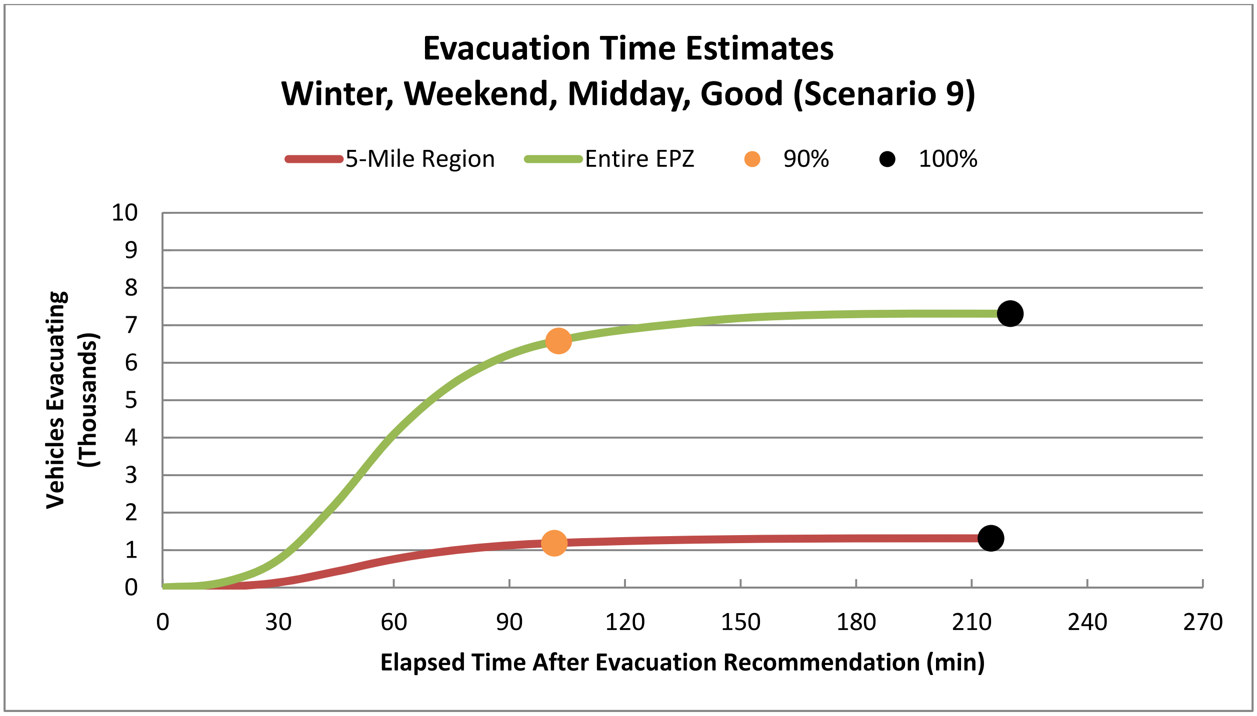


Figure 7-15. Evacuation Time Estimates - Scenario 9 for Region R02

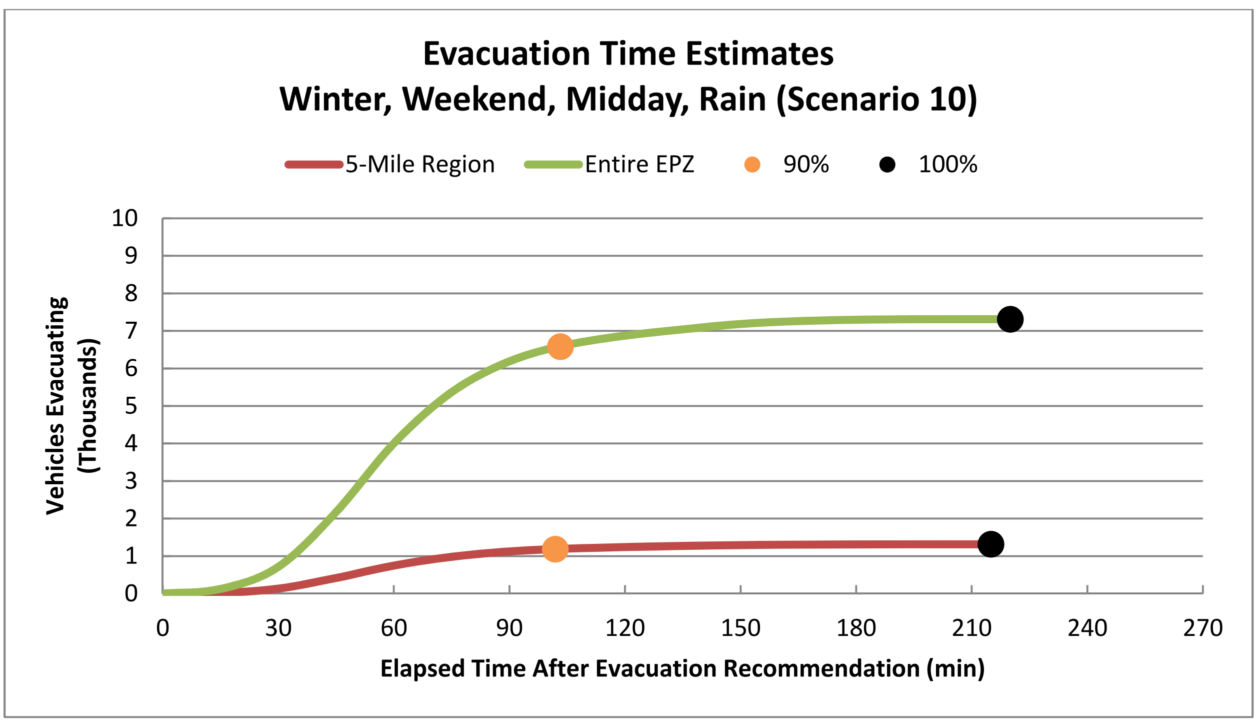


Figure 7-16. Evacuation Time Estimates - Scenario 10 for Region R02

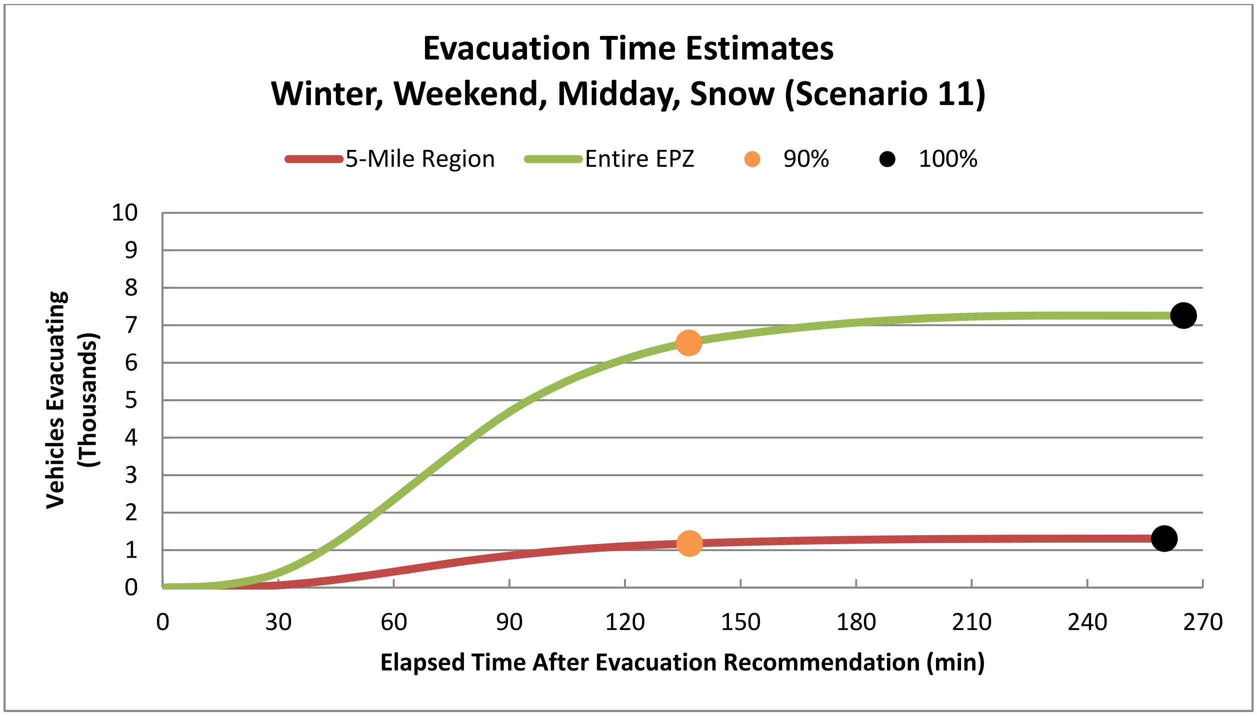


Figure 7-17. Evacuation Time Estimates - Scenario 11 for Region R02

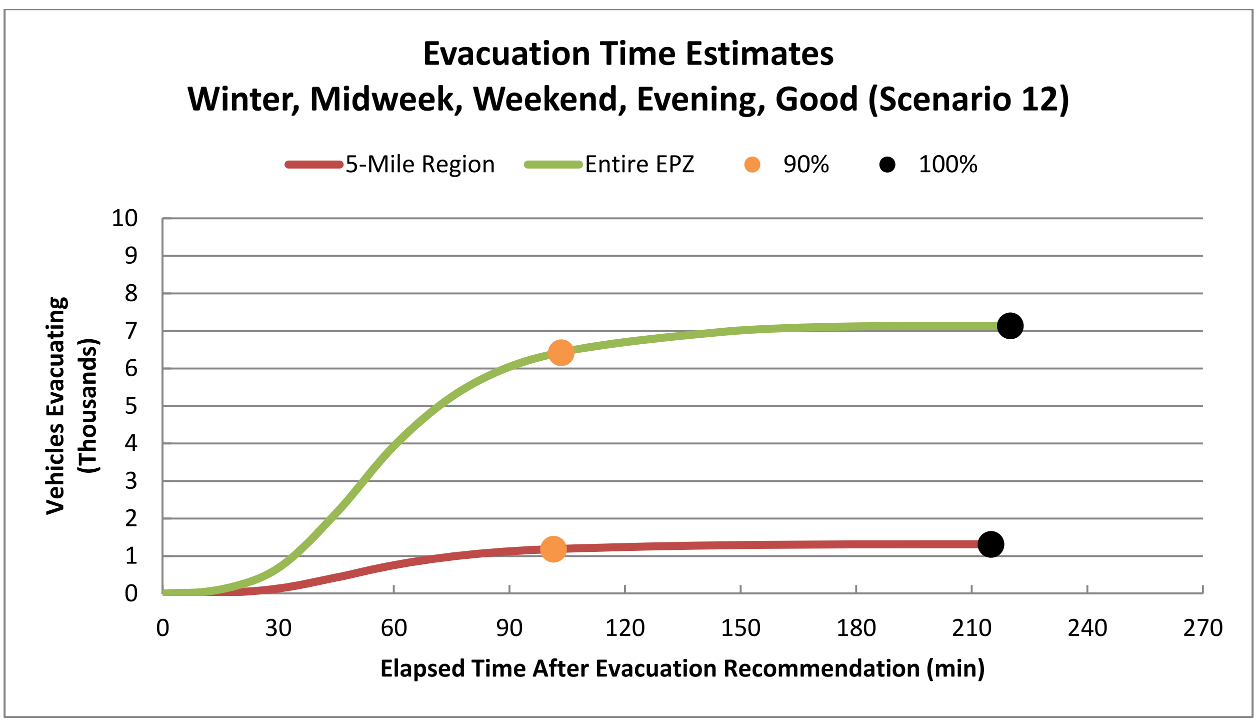


Figure 7-18. Evacuation Time Estimates - Scenario 12 for Region R02

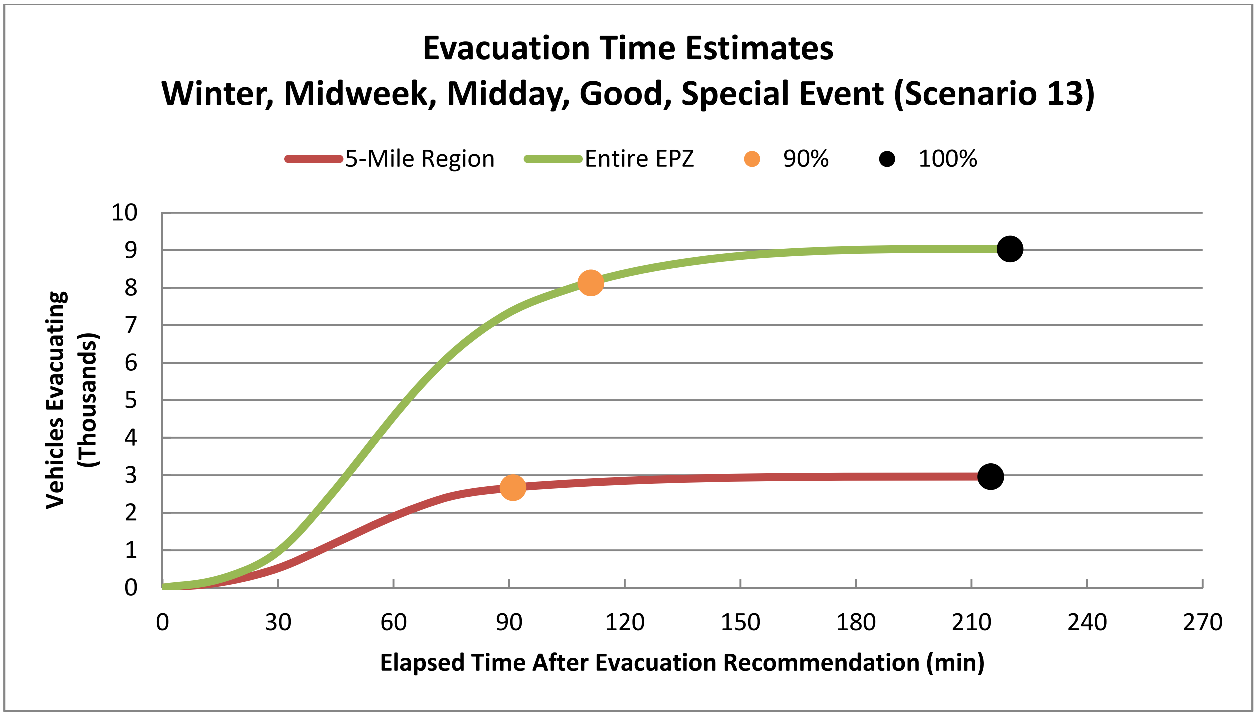


Figure 7-19. Evacuation Time Estimates - Scenario 13 for Region R02

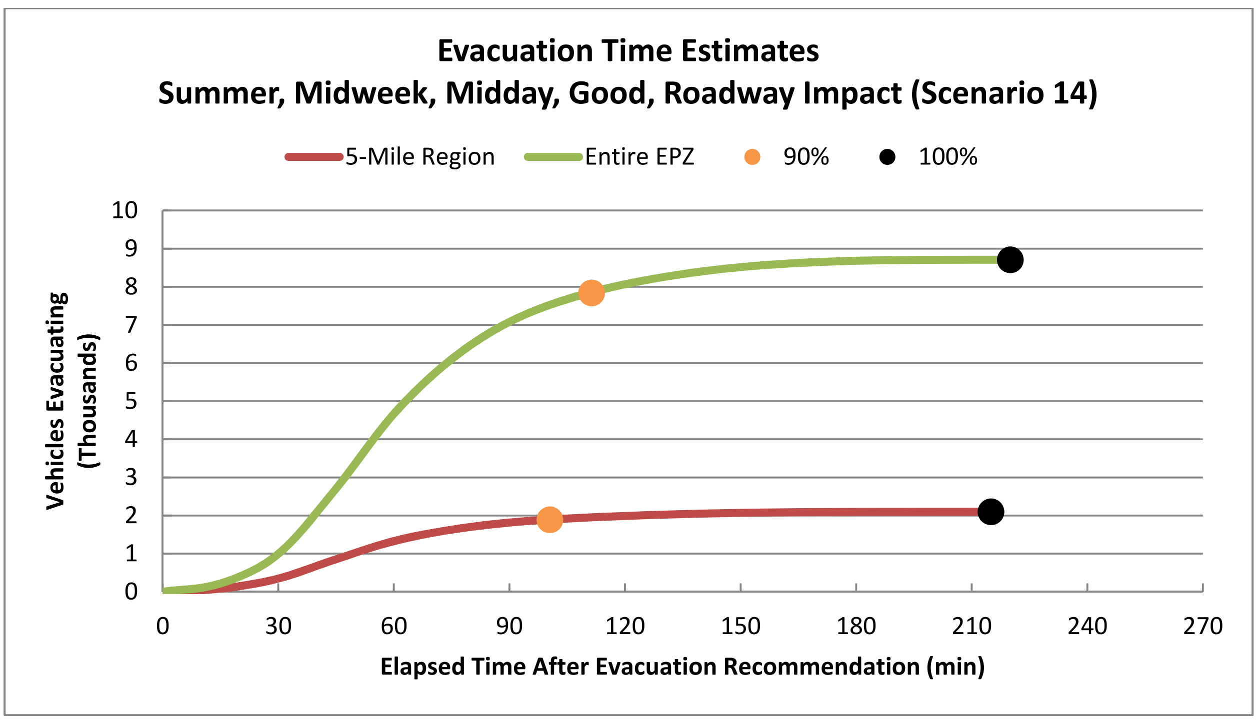


Figure 7-20. Evacuation Time Estimates - Scenario 14 for Region R02

8 TRANSIT-DEPENDENT AND SPECIAL FACILITY EVACUATION TIME ESTIMATES

This section details the analyses applied and the results obtained in the form of evacuation time estimates for transit vehicles. The demand for transit service reflects the needs of three population groups: (1) residents with no vehicles available; (2) residents of special facilities such as schools and medical facilities; and (3) homebound special needs population.

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 extending from the Advisory to Evacuate, 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 KPS EPZ indicates that schoolchildren will be evacuated to host schools. As discussed in Section 2, this study assumes a fast breaking general emergency. Therefore, children are evacuated to these host schools. 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), to present an upper bound estimate of buses required. It is assumed that children at day-care centers will also be transported to host facilities in accordance with the county emergency plans.

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 reception centers

8.1 Transit Dependent People Demand Estimate

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

- 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 8-1 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 ride-sharing with neighbors, friends or family. For example, nearly 80 percent of those who evacuated from Mississauga, Ontario who did not use their own cars, shared a ride with neighbors or friends. Other documents report that approximately 70 percent of transit dependent persons were evacuated via ride sharing. **We will adopt a conservative estimate that 50 percent of transit dependent persons will ride share, in accordance with NUREG/CR-7002.**

The estimated number of bus trips needed to service transit-dependent persons is based on an estimate of 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 x10) = 27. On this basis, the average load factor anticipated is (27/40) x 100 = 68 percent. Thus, if the actual demand for service exceeds the estimates of Table 8-1 by 50 percent, 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 8-1 indicates that transportation must be provided for 207 people. Therefore, a total of **7 bus runs** are required to transport this population to reception centers.

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 KPS EPZ:

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

Where,

A = Percent of households with commuters

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

$$P = 5{,}042 \times [0.0161 \times 1.13 + 0.2791 \times (1.58 - 1) \times 0.56 \times 0.54 + 0.4719 \times (2.34 - 2) \times (0.56 \times 0.54)^2] = 5{,}042 \times 0.0818 = 413$$

$$B = (0.5 \times P) \div 30 = 7$$

These calculations are explained as follows:

- All members (1.13 avg.) of households (HH) with no vehicles (1.61%) will evacuate by public transit or ride-share. The term 5,042 (number of households) x 0.0161 x 1.13, accounts for these people.
- The members of HH with 1 vehicle away (27.91%), who are at home, equal (1.58-1). The number of HH where the commuter will not return home is equal to (5,042 x 0.2791 x 0.56 x 0.54), as 56% of EPZ households have a commuter, 54% 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 (47.19%), who are at home, equal (2.34 – 2). The number of HH where neither commuter will return home is equal to 5,042 x 0.4719 x $(0.56 \times 0.54)^2$. 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 total number of persons requiring public transit is the sum of such people in HH with no vehicles, or with 1 or 2 vehicles that are away from home.

The estimate of transit-dependent population in Table 8-1 far exceeds the number of registered transit-dependent persons in the EPZ as provided by the counties (discussed below in Section 0). 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.

8.2 School Population – Transit Demand

Table 8-2 presents the school population and transportation requirements for the direct evacuation of all schools within the EPZ for the 2011-2012 school year. This information was provided by the local county emergency management agencies. The column in Table 8-2 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), the estimate of buses required for school evacuation do not consider the use of these private vehicles.
- 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, typically 3 percent daily.

It is recommended that the counties in the EPZ 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 8-3 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.

8.3 Medical Facility Demand

Table 8-4 presents the census of medical facilities in the EPZ. 90 people have been identified as living in, or being treated in, these facilities. The current census for each facility were provided by the county emergency management agencies. This data includes the number of ambulatory, wheelchair-bound and bedridden patients at each facility.

The transportation requirements for the medical facility population are also presented in Table 8-4. The number of ambulance runs is determined by assuming that 2 patients can be accommodated per ambulance trip; the number of bus runs estimated assumes 30 ambulatory patients per trip. Each wheelchair equipped vehicle can accommodate 2 wheelchair bound people on average.

8.4 Evacuation Time Estimates for Transit Dependent People

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 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 R02 (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 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.

Evacuation Time Estimates 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.

Activity: Mobilize Drivers (A→B→C)

Mobilization is the elapsed time from the Advisory to Evacuate 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, school bus 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 when raining, 110 minutes when snowing.

Activity: Board Passengers (C→D)

Based on discussions with offsite agencies, a loading time of 15 minutes (20 minutes for rain and 25 minutes for snow) for school buses is used.

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. Allowing 30 minutes pick-up time per bus run implies 30 stops per run, for good weather. It is assumed that bus acceleration and speed will be less in rain; total loading time is 40 minutes per bus in rain, 50 minutes in snow.

<u>Activity: Travel to EPZ Boundary (D→E)</u>

<u>School Evacuation</u>

Transportation resources available were provided by the EPZ county emergency management agencies and are summarized in Table 8-5. Also included in the table are the total vehicle capacities needed to evacuate schools, medical facilities, transit-dependent population, and homebound special needs (discussed below in Section 0). These numbers indicate there are sufficient resources available to evacuate everyone in a single wave.

The buses servicing the schools are ready to begin their evacuation trips at 105 minutes after the advisory to evacuate – 90 minutes mobilization time plus 15 minutes 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 school reception center. 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 Table 8-6 (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., 100 to 105 minutes after the advisory to evacuate 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 8-7 through Table 8-9 for school evacuation, and in Table 8-11 through Table 8-13 for the transit vehicles evacuating transit-dependent persons, which are discussed later. 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. The travel time from the EPZ boundary to the Reception Center was computed assuming an average speed of 45 mph, 40 mph, and 35 mph for good weather, rain and snow, respectively. Wisconsin state law prohibits school buses from operating above the posted speed limit, which is, at most, 55 mph within the study area. Therefore, all speeds in Table 8-7 through Table 8-9 were reduced to 55 mph (50 mph for rain – 10% decrease – and 45 mph for snow – 20% decrease) for those calculated bus speeds which exceed 55 mph.

Table 8-7 (good weather), Table 8-8 (rain) and Table 8-9 (snow) present the following evacuation time estimates (rounded up to the nearest 5 minutes) for schools in the EPZ: (1) The elapsed time from the Advisory to Evacuate until the bus exits the EPZ; and (2) The elapsed time until the bus reaches the host school. 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 + 7 = 1:55 (roundup up to the nearest 5 minutes) for Kewaunee High School, with good weather). The evacuation time to the host school is determined by adding the time associated with Activity E→F (discussed below), to this EPZ evacuation time.

Evacuation of Transit-Dependent Population

The buses dispatched from the depots to service the transit-dependent evacuees will be scheduled so that they arrive at their respective routes after their passengers have completed their mobilization. As shown in Figure 5-4 (Residents with no Commuters), approximately 90 percent of the evacuees will complete their mobilization when the buses will begin their routes, approximately 90 minutes after the Advisory to Evacuate. Zones 10N and 10S have higher transit-dependent populations and require more buses than the other Zones (Table 8-10). As such, two buses have been assigned to each of these Zones. The start of service on these routes is separated by 20 minute headways, as shown in Table 8-11 through Table 8-13. The use of bus headways ensures that those people who take longer to mobilize will be picked up. Mobilization time is 10 and 20 minutes longer in rain and snow, respectively, to account for slower travel speeds and reduced roadway capacity.

Those buses servicing the transit-dependent evacuees will first travel along their pick-up routes, then proceed out of the EPZ. The public information and emergency plans do not identify pick-up locations for persons without access to a personal vehicle. The 5 bus routes (number 13 through 17) shown graphically in Figure 8-2 and described in Table 8-10 were designed as part of this study to service the major routes through each zone and to service population along major routes in each Zone. It is assumed that residents will walk to and flag buses along these routes, and that they can arrive at the stops within the 90 minute bus mobilization time (good weather).

As previously discussed, a pickup time of 30 minutes (good weather) is estimated for 30 individual stops to pick up passengers, with an average of one minute of delay associated with each stop. A longer pickup time of 40 minutes and 50 minutes are used for rain and snow, respectively.

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 8-11 through Table 8-13 present the transit-dependent population evacuation time estimates for each bus route calculated using the above procedures for good weather, rain and snow, respectively.

For example, the ETE for Route 13 is computed as 90 + 10 + 30 = 2:10 for good weather. Here, 10 minutes is the time to travel 7.5 miles at 47.0 mph, the average speed output by the model for this route starting at 90 minutes. 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.

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 reception centers are mapped in Figure 10-1. 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, since it could exceed the ETE for the general population. Assumed bus speeds of 45 mph, 40 mph, and 35 mph for good weather, rain, and 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)

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 depart 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 Route 13 is computed as follows for good weather:

- Bus arrives at reception center at 2:21 in good weather (2:10 to exit EPZ + 11 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: 11 minutes (equal to travel time to reception center) + 9 minutes (8.0 miles @ 54.6 mph) + 9 minutes(8.0 miles @ 55 mph= 29 minutes
- Bus completes pick-ups along route: 30 minutes.
- Bus exits EPZ at time 2:21 + 0:15 + 0:29 + 0:30 = 3:35 after the ATE.

The ETE for the completion of the second wave for all transit-dependent bus routes are provided in Table 8-11 through Table 8-13. The average ETE for a two-wave evacuation of transit-dependent people exceeds the ETE for the general population at the 90th percentile.

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

The transit operations for these facilities are similar to those for school evacuation except:

- Buses are assigned on the basis of 30 patients to allow for staff to accompany the patients.
- The passenger loading time will be longer at approximately one minute per patient to account for the time to move patients from inside the facility to the vehicles.

Table 8-4 indicates that 4 bus runs, 1 wheelchair bus run and 13 ambulance runs are needed to service all of the medical facilities in the EPZ. According to Table 8-5, the counties can collectively provide 144 buses, 29 vans and 30 ambulances. The vehicles available by the various transportation providers are equipped to carry both ambulatory and wheelchair-bound persons. The exact capacities for each type of vehicle varied across the different fleets. Therefore, the total available capacity for each mobility class is also provided in Table 8-5. There exists a sufficient amount of transportation resources, from a capacity standpoint, to evacuate the ambulatory, wheelchair-bound and bedridden persons from within the EPZ in a single wave.

As is done for the schools, it is estimated that mobilization time averages 90 minutes during good weather (100 and 110 minutes for rain and snow, respectively). 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.

Table 8-14 through Table 8-16 summarize the ETE for medical facilities within the EPZ for good weather, rain, and snow. Loading times of 1 minute, 5 minutes, and 15 minutes are assumed for ambulatory patients, wheelchair bound patients, and bedridden patients, respectively. Average speeds output by the model for Scenario 6 (Scenario 7 for rain and Scenario 8 for

snow) Region 2, capped at 55 mph (50 mph for rain and 45 mph for snow), are used to compute travel time to 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. Concurrent loading on multiple buses, wheelchair buses/vans, and ambulances at capacity is assumed such that the maximum loading times for buses, wheelchair equipped vehicles and ambulances are 30, 10 and 30 minutes, respectively. All ETE are rounded to the nearest 5 minutes. For example, the calculation of ETE for the Kewaunee Health Care Center with 31 ambulatory residents during good weather is:

ETE: 90 + 30 (assumed concurrent loading on multiple buses for the 31 patients) + 5 = 125 min. or 2:05

It is assumed that medical facility population is directly evacuated to appropriate host medical facilities. 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.

8.5 Special Needs Population

The county emergency management agencies have a combined registration for transit-dependent and homebound special needs persons. Based on data provided by the counties, there are an estimated 4 homebound special needs people within the Kewaunee County portion of the EPZ, and 3 people within the Manitowoc County portion of the EPZ who require transportation assistance to evacuate. There are 7 ambulatory and no wheelchair bound or bedridden persons in the entire EPZ.

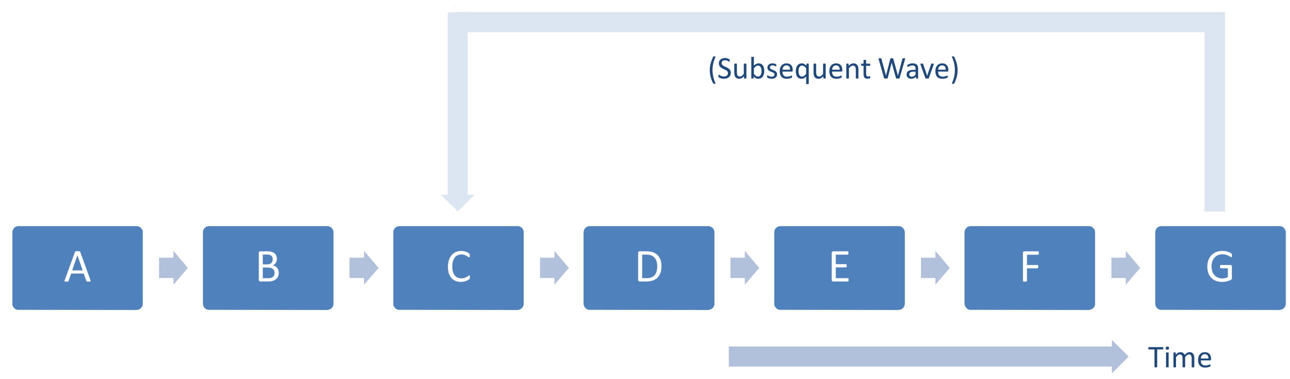
ETE for Homebound Special Needs Persons

Table 8-17 summarizes the ETE for homebound special needs people. The table is categorized by weather condition. The table takes into consideration the deployment of multiple vehicles to reduce the number of stops per vehicle. It is conservatively assumed that special needs households are spaced 3 miles apart. Bus speeds approximate 20 mph between households (10% slower in rain, 20% slower in snow). Mobilization times of 90 minutes were used (100 minutes for rain, and 110 minutes for snow). The last HH is assumed to be 5 miles from the EPZ boundary, and the network-wide average speed, capped at 55 mph (50 mph for rain and 45 mph for snow), after the last pickup is used to compute travel time. ETE is computed by summing mobilization time, loading time at first household, travel to subsequent households, loading time at subsequent households, and travel time to EPZ boundary. All ETE are rounded to the nearest 5 minutes.

For example, assuming no more than one special needs person per HH implies that 7 ambulatory households need to be serviced. While only 1 bus is needed from a capacity perspective, if 2 buses are deployed to service these special needs HH, then each would require, at most, only 4 stops. The following outlines the ETE calculations:

1. Assume 2 buses are deployed, with at most 4 stops, to service a total of 4 HH.
2. The ETE is calculated as follows:
    a. Buses arrive at the first pickup location: 90 minutes
    b. Load HH members at first pickup: 5 minutes
    c. Travel to subsequent pickup locations: 3 @ 9 minutes = 27 minutes
    d. Load HH members at subsequent pickup locations: 3 @ 5 minutes = 15 minutes
    e. Travel to EPZ boundary: 6 minutes (5 miles @ 51.9 mph).

ETE: 90 + 5 + 27 + 15 + 6 = 2:25 (rounded up to nearest 5 minutes) after the ATE.



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/Host Facility
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 Outside the EPZ
F→G	Passengers Leave Bus; Driver Takes a Break

Figure 8-1. Chronology of Transit Evacuation Operations

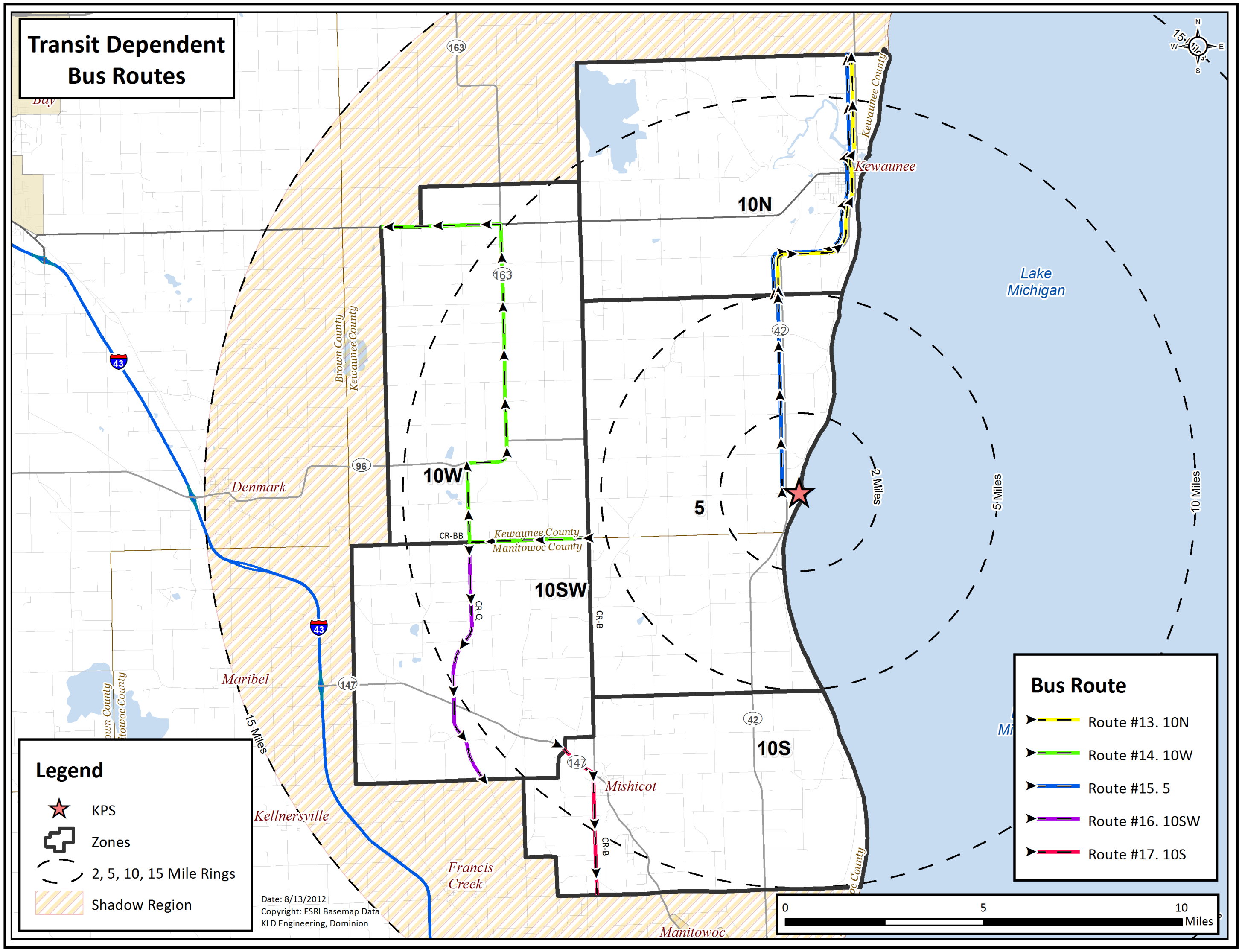


Figure 8-2. Transit-Dependent Bus Routes

Table 8-1. Transit-Dependent Population Estimates

2010 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						
11,596	1.13	1.58	2.34	5,042	1.61%	27.91%	47.19%	56%	54%	413	50%	207	1.8%

Table 8-2. School Population Demand Estimates

Zone	School Name	Enrollment	Buses Required
10N	Holy Rosary Catholic School	96	2
10N	Kewaunee Grade School	662	10
10N	Kewaunee High School[1]	321	7
10N	Kewaunee Intermediate School[1]		
10N	Lakeshore Alternative School	20	1
10S	East Twin Lutheran School	4	1
10S	Mishicot High School[1]	881	15
10S	Mishicot Middle School[1]		
10S	Schultz Elementary School[1]		
	Total:	**1,984**	**36**

[1] Facility is part of an educational complex on a single site where data was reported in aggregate.

Table 8-3. School Reception Centers

School	Host School
Holy Rosary Catholic School	Luxemburg-Casco High School
Kewaunee Grade School	
Kewaunee High School	
Kewaunee Intermediate School	
Lakeshore Alternative School	
East Twin Lutheran School	Valders High School
Mishicot High School	
Mishicot Middle School	
Schultz Elementary School	

Table 8-4. Medical Facility Transit Demand

Zone	Facility Name	Municipality	Current Census	Ambu-latory	Wheel-chair Bound	Bed-ridden	Bus Runs	Van Runs[1]	Ambulance
10N	Kewaunee Health Care Center	Kewaunee	66	31	10	25	2	5	13
10N	Linden Manor	Kewaunee	16	16	0	0	1	0	0
10N	Silver Leaf Manor	Kewaunee	8	8	0	0	1	0	0
		TOTAL:	**90**	**55**	**10**	**25**	**4**	**5**	**13**

[1]Vans are mixed use but each could accommodate 2 wheelchair-bound persons on average.

Table 8-5. Summary of Transportation Resources

Transportation Resource	Buses	Vans	Ambulances	Total Ambulatory Capacity	Total Wheelchair Capacity	Total Bedridden Capacity
Resources Available						
Brandt Buses	40	0	0	1,620	15	0
Assist-To-Transport	7	4	0	112	29	0
Mishicot School District	13	5	0	936	20	0
Maritime Buses	9	0	0	304	36	0
Two Rivers Buses	23	0	0	1,260	30	0
Manitowoc Fire	0	0	11	0	0	22
Two Rivers Fire	0	0	3	0	0	6
Mishicot Ambulance	0	0	2	0	0	4
Valders Ambulance	0	0	2	0	0	4
Kiel Ambulance	0	0	2	0	0	4
Viking Ambulance	0	0	2	0	0	4
Luxemburg-Casco School District	32	0	0	2,304	0	0
Dvorak Bus Service	20	0	0	1,340	6	0
Red Cross	0	14	0	0	42	0
East Shore Industry	0	6	0	0	11	0
Kewaunee Rescue	0	0	3	0	0	6
Luxemburg Rescue	0	0	3	0	0	6
Algoma Rescue	0	0	2	0	0	4
TOTAL:	**144**	**29**	**30**	**7,876**	**189**	**60**
Resources Needed						
Population Group/Mobility Level				**Ambulatory**	**Wheelchair Bound**	**Bedridden**
Schools (Table 8-2):				1,982	2	0
Medical Facilities (Table 8-4):				55	10	25
Transit-Dependent Population (Table 8-10):				207	0	0
Homebound Special Needs (Section 8.5):				7	0	0
TOTAL TRANSPORTATION NEEDS:				**2,251**	**12**	**25**

Table 8-6. Bus Route Descriptions

Bus Route Number	Description	Nodes Traversed from Route Start to EPZ Boundary
1	East Twin Lutheran School	110, 109, 121, 540, 108, 139, 118
2	Holy Rosary Catholic School	338, 396, 442, 362, 363, 364, 365, 394, 381, 384, 385, 372, 387
3	Kewaunee Grade School	395, 396, 442, 362, 363, 364, 365, 394, 381, 384, 385, 372, 387
4	Kewaunee High School	395, 396, 442, 362, 363, 364, 365, 394, 381, 384, 385, 372, 387
5	Kewaunee Intermediate School	395, 396, 442, 362, 363, 364, 365, 394, 381, 384, 385, 372, 387
6	Lakeshore Alternative School	335, 342, 338, 396, 442, 362, 363, 364, 365, 394, 381, 384, 385, 372, 387
7	Mishicot High School	128, 110, 109, 121, 540, 108, 139, 118
8	Mishicot Middle School	128, 110, 109, 121, 540, 108, 139, 118
9	Schultz Elementary School	539, 110, 109, 121, 540, 108, 139, 118
10	Kewaunee Health Care Center	335, 342, 338, 337, 400, 401, 402, 443, 404, 403
11	Linden Manor	335, 342, 338, 337, 400, 401, 402, 443, 404, 403
12	Silver Leaf Manor	335, 342, 338, 444, 399, 400, 401, 402, 443, 404, 403
13	Transit Dependents, Zone 10N	326, 327, 328, 361, 348, 347, 346, 345, 341, 337, 400, 401, 402, 443, 404, 403
14	Transit Dependents, Zone 10W	27, 35, 62, 68, 549, 548, 547, 69
15	Transit Dependents, Zone 5	135, 29, 326, 327, 328, 361, 348, 347, 346, 345, 341, 337, 400, 401, 402, 443, 404, 403
16	Transit Dependents, Zone 10SW	80, 117, 116, 115, 89, 131, 132, 133, 126, 120, 119, 118
17	Transit Dependents, Zone 10S	109, 121, 540, 108

Table 8-7. 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 H.S. (mi.)	Travel Time from EPZ Bdry to H.S. (min)	ETE to H.S. (hr:min)
KEWAUNEE COUNTY SCHOOLS									
Holy Rosary Catholic School	90	15	6.2	52.5	8	**1:55**	8.8	12	**2:05**
Kewaunee Grade School	90	15	5.6	52.0	7	**1:55**	8.8	12	**2:05**
Kewaunee High School	90	15	5.6	52.0	7	**1:55**	8.8	12	**2:05**
Kewaunee Intermediate School	90	15	5.6	52.0	7	**1:55**	8.8	12	**2:05**
Lakeshore Alternative School	90	15	6.0	49.4	8	**1:55**	8.8	12	**2:05**
MANITOWOC COUNTY SCHOOLS									
East Twin Lutheran School	90	15	3.3	50.2	4	**1:50**	14.7	20	**2:10**
Mishicot High School	90	15	4.8	49.1	6	**1:55**	18.9	26	**2:20**
Mishicot Middle School	90	15	4.8	49.1	6	**1:55**	18.9	26	**2:20**
Schultz Elementary School	90	15	5.0	47.0	7	**1:55**	18.9	26	**2:20**
					Maximum for EPZ:	**1:55**		**Maximum:**	**2:20**
					Average for EPZ:	**1:55**		**Average:**	**2:10**

Table 8-8. School Evacuation Time Estimates – Rain

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 H.S. (mi.)	Travel Time from EPZ Bdry to H.S. (min)	ETE to H.S. (hr:min)
KEWAUNEE COUNTY SCHOOLS									
Holy Rosary Catholic School	100	20	6.2	46.7	8	**2:10**	8.8	14	**2:25**
Kewaunee Grade School	100	20	5.6	46.2	8	**2:10**	8.8	14	**2:25**
Kewaunee High School	100	20	5.6	46.2	8	**2:10**	8.8	14	**2:25**
Kewaunee Intermediate School	100	20	5.6	46.2	8	**2:10**	8.8	14	**2:25**
Lakeshore Alternative School	100	20	6.0	44.7	9	**2:10**	8.8	14	**2:25**
MANITOWOC COUNTY SCHOOLS									
East Twin Lutheran School	100	20	3.3	45.5	5	**2:05**	14.7	23	**2:30**
Mishicot High School	100	20	4.8	42.3	7	**2:10**	18.9	29	**2:40**
Mishicot Middle School	100	20	4.8	42.3	7	**2:10**	18.9	29	**2:40**
Schultz Elementary School	100	20	5.0	40.3	8	**2:10**	18.9	29	**2:40**
					Maximum for EPZ:	**2:10**		**Maximum:**	**2:40**
					Average for EPZ:	**2:10**		**Average:**	**2:30**

Table 8-9. School Evacuation Time Estimates – 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 H.S. (mi.)	Travel Time from EPZ Bdry to H.S. (min)	ETE to H.S. (hr:min)
A COUNTY SCHOOLS									
Holy Rosary Catholic School	110	25	6.2	42.1	9	**2:25**	8.8	16	**2:40**
Kewaunee Grade School	110	25	5.6	41.7	9	**2:25**	8.8	16	**2:40**
Kewaunee High School	110	25	5.6	41.7	9	**2:25**	8.8	16	**2:40**
Kewaunee Intermediate School	110	25	5.6	41.7	9	**2:25**	8.8	16	**2:40**
Lakeshore Alternative School	110	25	6.0	39.9	10	**2:25**	8.8	16	**2:45**
B COUNTY SCHOOLS									
East Twin Lutheran School	110	25	3.3	39.7	5	**2:20**	14.7	26	**2:50**
Mishicot High School	110	25	4.8	39.3	8	**2:25**	18.9	33	**3:00**
Mishicot Middle School	110	25	4.8	39.3	8	**2:25**	18.9	33	**3:00**
Schultz Elementary School	110	25	5.0	37.5	8	**2:25**	18.9	33	**3:00**
					Maximum for EPZ:	**2:25**		**Maximum:**	**3:00**
					Average for EPZ:	**2:25**		**Average:**	**2:50**

Table 8-10. Summary of Transit-Dependent Bus Routes

Route	No. of Buses	Route Name	Route Description	Length (mi.)
13	2	Zone 10N	Travel along SR 42 N	7.5
14	1	Zone 10W	Travel CR Q N then on CR KB N and then SR 29 W	14.9
15	1	Zone 5	Travel along SR 42 N	12.5
16	1	Zone 10SW	Travel on CR Q S	6.1
17	2	Zone 10S	Travel along SR 147 S into Mishicot and then onto CR B S	4.3
Total:	**7**			

Table 8-11. Transit-Dependent Evacuation Time Estimates - Good Weather

		One-Wave							Two-Wave					
Route Number	Bus Number	Mobilization (min)	Route Length (miles)	Speed (mph)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)	Distance to R. C. (miles)	Travel Time to R. C. (min)	Unload (min)	Driver Rest (min)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)
13	1	90	7.5	54.6	8	30	**2:10**	8.0	11	5	10	29	30	**3:35**
	2	110	7.5	55.0	8	30	**2:30**	8.0	11	5	10	29	30	**3:55**
14	1	90	14.9	55.0	16	30	**2:20**	23.8	32	5	10	68	30	**4:45**
15	1	90	12.5	55.0	14	30	**2:15**	8.0	11	5	10	42	30	**3:55**
16	1	90	6.1	54.0	7	30	**2:10**	7.2	10	5	10	24	30	**3:30**
17	1	90	4.3	52.0	5	30	**2:05**	5.2	7	5	10	18	30	**3:15**
	2	110	4.3	52.7	5	30	**2:25**	5.2	7	5	10	17	30	**3:35**
						Maximum ETE:	**2:30**						**Maximum ETE:**	**4:45**
						Average ETE:	**2:20**						**Average ETE:**	**3:50**

Table 8-12. Transit-Dependent Evacuation Time Estimates – Rain

		One-Wave							Two-Wave					
Route Number	Bus Number	Mobilization (min)	Route Length (miles)	Speed (mph)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)	Distance to R. C. (miles)	Travel Time to R. C. (min)	Unload (min)	Driver Rest (min)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)
13	1	100	7.5	50.0	9	40	**2:30**	8.0	12	5	10	31	40	**4:10**
	2	120	7.5	49.0	9	40	**2:50**	8.0	12	5	10	31	40	**4:30**
14	1	100	14.9	50.0	18	40	**2:40**	23.8	36	5	10	73	40	**5:25**
15	1	100	12.5	50.0	15	40	**2:35**	8.0	12	5	10	44	40	**4:30**
16	1	100	6.1	49.8	7	40	**2:30**	7.2	11	5	10	27	40	**4:05**
17	1	100	4.3	47.0	5	40	**2:30**	5.2	8	5	10	19	40	**3:50**
	2	120	4.3	45.3	6	40	**2:50**	5.2	8	5	10	19	40	**4:10**
						Maximum ETE:	**2:50**						**Maximum ETE:**	**5:25**
						Average ETE:	**2:40**						**Average ETE:**	**4:25**

Table 8-13. Transit Dependent Evacuation Time Estimates - Snow

Route Number	Bus Number	One-Wave							Two-Wave					
		Mobilization (min)	Route Length (miles)	Speed (mph)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)	Distance to R. C. (miles)	Travel Time to R. C. (min)	Unload (min)	Driver Rest (min)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)
13	1	110	7.5	45.0	10	50	**2:50**	8.0	14	5	10	34	50	**4:45**
	2	130	7.5	44.5	10	50	**3:15**	8.0	14	5	10	34	50	**5:05**
14	1	110	14.9	41.9	21	50	**3:05**	23.8	41	5	10	81	50	**6:10**
15	1	110	12.5	43.5	17	50	**3:00**	8.0	14	5	10	47	50	**5:05**
16	1	110	6.1	45.0	8	50	**2:50**	7.2	12	5	10	29	50	**4:35**
17	1	110	4.3	41.3	6	50	**2:50**	5.2	9	5	10	21	50	**4:25**
	2	130	4.3	41.1	6	50	**3:10**	5.2	9	5	10	21	50	**4:45**
						Maximum ETE:	**3:15**						**Maximum ETE:**	**6:10**
						Average ETE:	**3:00**						**Average ETE:**	**5:00**

Table 8-14. 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)
Kewaunee Health Care Center	Ambulatory	90	1	31	30	4.2	5	**2:05**
	Wheelchair bound	90	5	10	10	4.2	5	**1:45**
	Bedridden	90	15	25	30	4.2	5	**2:05**
Linden Manor	Ambulatory	90	1	16	16	4.4	6	**1:55**
Silver Leaf Manor	Ambulatory	90	1	8	8	4.3	6	**1:45**
							Maximum ETE:	**2:05**
							Average ETE:	**1:55**

Table 8-15. Medical Facility Evacuation Time Estimates - Rain

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)
Kewaunee Health Care Center	Ambulatory	100	1	31	30	4.2	6	**2:20**
	Wheelchair bound	100	5	10	10	4.2	6	**2:00**
	Bedridden	100	15	25	30	4.2	6	**2:20**
Linden Manor	Ambulatory	100	1	16	16	4.4	6	**2:05**
Silver Leaf Manor	Ambulatory	100	1	8	8	4.3	6	**1:55**
							Maximum ETE:	**2:20**
							Average ETE:	**2:10**

Table 8-16. Medical Facility Evacuation Time Estimates - 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)
Kewaunee Health Care Center	Ambulatory	110	1	31	30	4.2	7	**2:30**
	Wheelchair bound	110	5	10	50	4.2	6	**2:50**
	Bedridden	110	15	25	30	4.2	7	**2:30**
Linden Manor	Ambulatory	110	1	16	16	4.4	7	**2:15**
Silver Leaf Manor	Ambulatory	110	1	8	8	4.3	7	**2:05**
							Maximum ETE:	**2:50**
							Average ETE:	**2:15**

Table 8-17. Homebound Special Needs Population 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	7	2	4	Normal	90	5	27	15	6	**2:25**
				Rain	100		30		6	**2:40**
				Snow	110		33		7	**2:50**
									Maximum ETE:	**2:50**
									Average ETE:	**2:40**

9 TRAFFIC MANAGEMENT STRATEGY

This section discusses the suggested traffic control and management strategy that is designed to expedite the movement of evacuating traffic. The resources required to implement this strategy include:

- Personnel with the capabilities of performing the planned control functions of traffic guides (preferably, not necessarily, law enforcement officers).
- Traffic Control Devices to assist these personnel in the performance of their tasks. These devices should comply with the guidance of the Manual of Uniform Traffic Control Devices (MUTCD) published by the Federal Highway Administration (FHWA) of the U.S.D.O.T. All state and most county transportation agencies have access to the MUTCD, which is available on-line: http://mutcd.fhwa.dot.gov which provides access to the official PDF version.
- A plan that defines all 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.

The terms "facilitate" and "discourage" are employed 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 plan must also be flexible enough for the application of sound judgment by the traffic guide.

The traffic management plan is the outcome of the following process:

1. The existing TCPs identified by the offsite agencies in their existing emergency plans serve as the basis of the traffic management plan, as per NUREG/CR-7002.
2. The existing TCPs and how they were applied in this study are discussed in Appendix G.
3. Computer analysis of the evacuation traffic flow environment (see Figures 7-3 through 7-6). As discussed in Section 7.3, congestion within the EPZ is clear by 1 hour and 55 minutes after the ATE. Based on the limited traffic congestion within the EPZ, no additional TCPs are identified as a result of this study. The existing traffic management plans are adequate.

The use of Intelligent Transportation Systems (ITS) technologies (if available) can reduce

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 can also be placed outside of the EPZ to 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 en route through their vehicle stereo systems. Automated Traveler 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 on board navigation systems (GPS units), cell phones, and pagers can be used to provide information en route. These are only several 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.

The ETE analysis treated all controlled intersections that are existing TCP locations in the offsite agency plans as being controlled by actuated signals.

Chapters 2N and 5G, and Part 6 of the 2009 MUTCD are particularly relevant and should be reviewed during emergency response training.

The ETE calculations reflect the assumption 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 personnel manning TCPs.

Study Assumptions 5 and 6 in Section 2.3 discuss TCP staffing schedules and operations.

10 EVACUATION ROUTES

Evacuation routes are comprised of two distinct components:

- Routing from a zone being evacuated to the boundary of the Evacuation Region and thence out of the EPZ.
- Routing of transit-dependent evacuees from the EPZ boundary to 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 routing of transit-dependent evacuees from the EPZ boundary to reception centers or host facilities is designed to minimize the amount of travel outside the EPZ, from the points where these routes cross the EPZ boundary.

Figure 10-1 presents the general population reception centers and school host facilities for evacuees. The major evacuation routes for the EPZ are presented in Figure 10-2.

It is assumed that all school evacuees will be taken to the appropriate school reception center and subsequently picked up by parents or guardians. Transit-dependent evacuees are transported to the nearest primary care center for each county. 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.

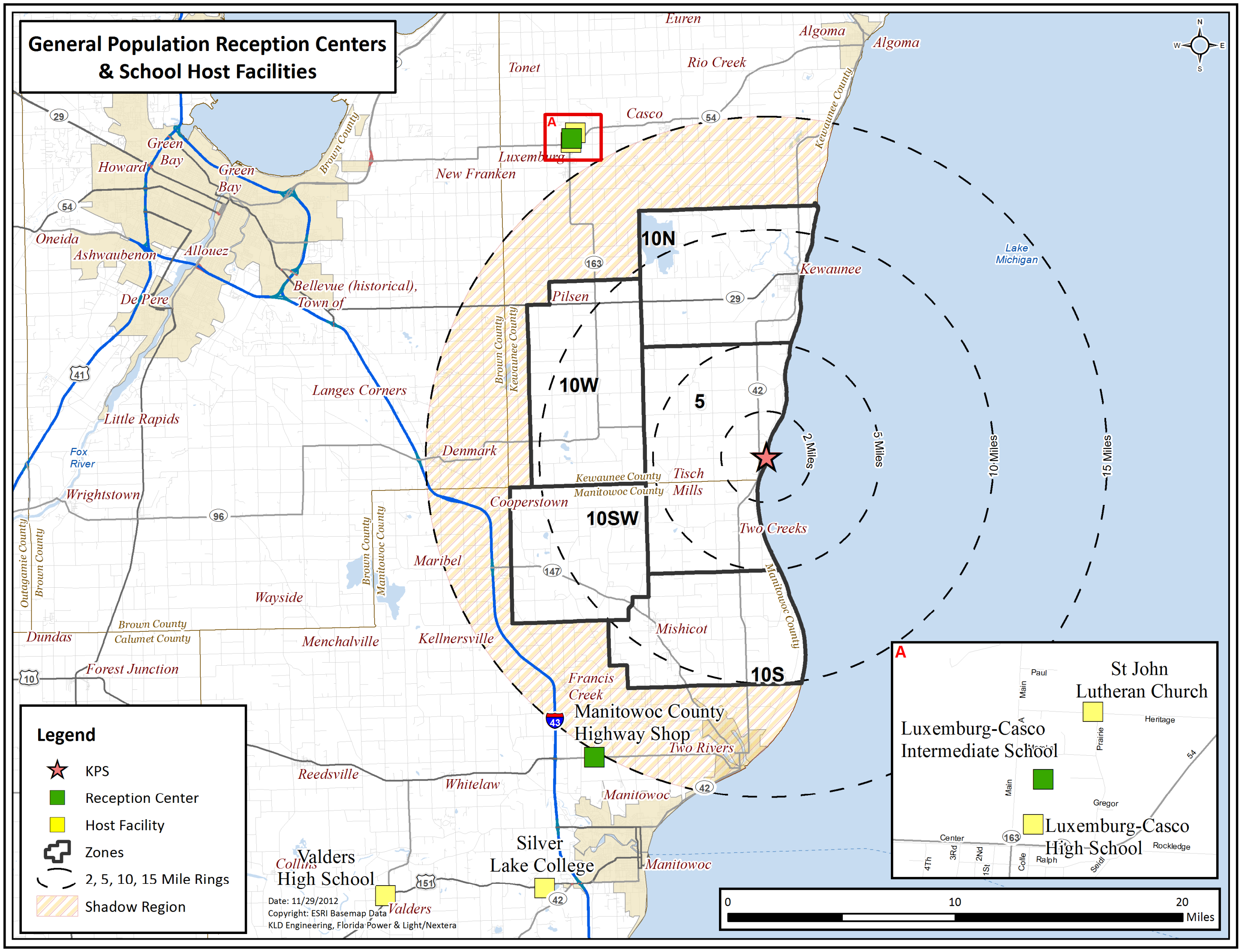


Figure 10-1. General Population Reception Centers and School Host Facilities

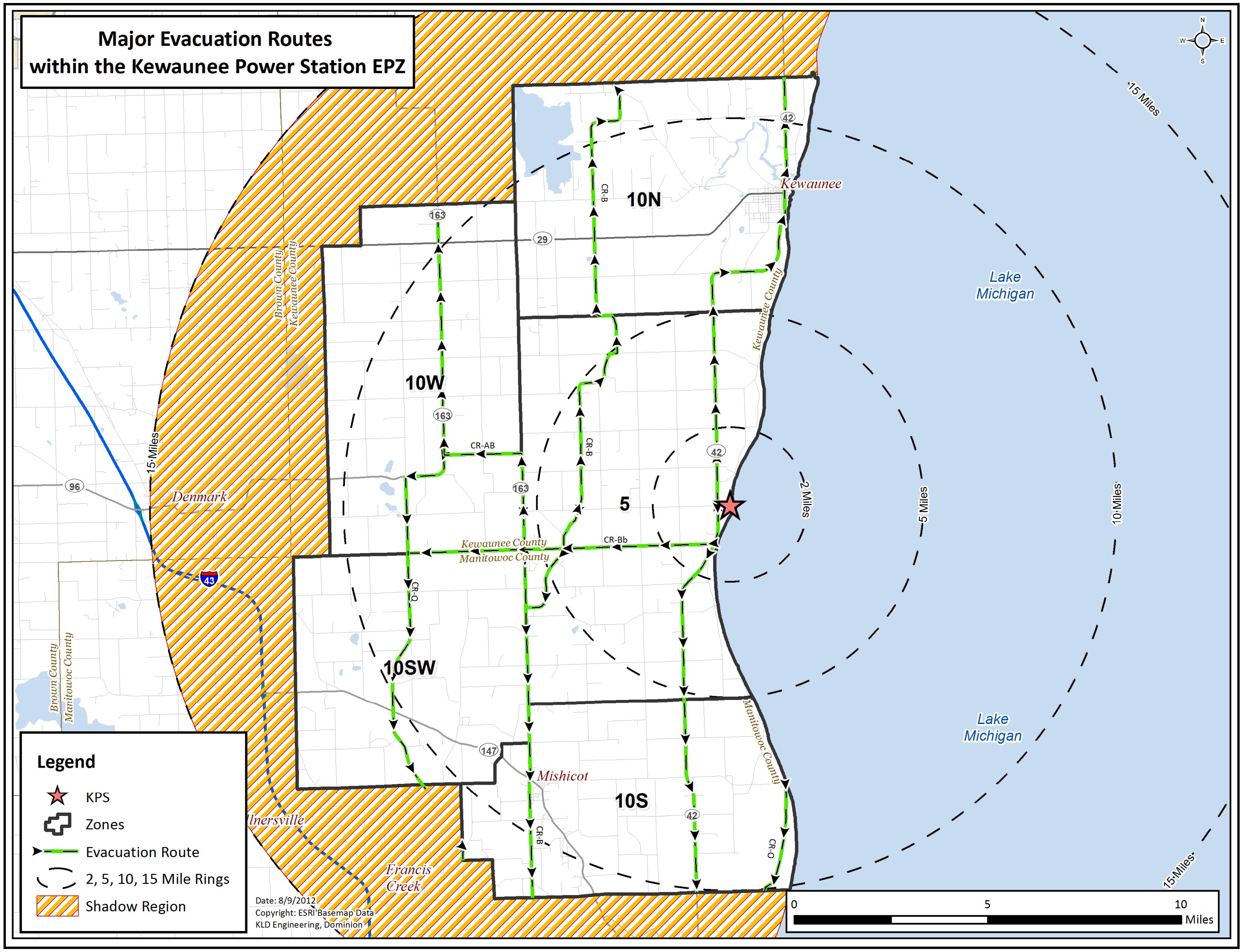


Figure 10-2. Evacuation Route Map

11 SURVEILLANCE OF EVACUATION OPERATIONS

There is a need for surveillance of traffic operations during the evacuation. There is also a need to clear any blockage of roadways arising from accidents or vehicle disablement. Surveillance can take several forms.

1. Traffic control personnel, located at Traffic Control and Access Control points, provide fixed-point surveillance.
2. Ground patrols may be undertaken along well-defined paths to ensure coverage of those highways that serve as major evacuation routes.
3. Aerial surveillance of evacuation operations may also be conducted using helicopter or fixed-wing aircraft, if available.
4. Cellular phone calls (if cellular coverage exists) from motorists may also provide direct field reports of road blockages.

These concurrent surveillance procedures are designed to provide coverage of the entire EPZ as well as the area around its periphery. It is the responsibility of the Counties to support an emergency response system that can receive messages from the field and be in a position to respond to any reported problems in a timely manner. This coverage should quickly identify, and expedite the response to any blockage caused by a disabled vehicle.

<u>Tow Vehicles</u>

In a low-speed traffic environment, any vehicle disablement is likely to arise due to a low-speed collision, mechanical failure or the exhaustion of its fuel supply. In any case, the disabled vehicle can be pushed onto the shoulder, thereby restoring traffic flow. Past experience in other emergencies indicates that evacuees who are leaving an area often perform activities such as pushing a disabled vehicle to the side of the road without prompting.

While the need for tow vehicles is expected to be low under the circumstances described above, it is still prudent to be prepared for such a need. Consideration should be given that tow trucks with a supply of gasoline be deployed at strategic locations within, or just outside, the EPZ. These locations should be selected so that:

- They permit access to key, heavily loaded, evacuation routes.
- Responding tow trucks would most likely travel counter-flow relative to evacuating traffic.

Consideration should also be given that the state and local emergency management agencies encourage gas stations to remain open during the evacuation.

12 CONFIRMATION TIME

It is necessary to confirm that the evacuation process is effective in the sense that the public is complying with the Advisory to Evacuate. The EPZ county radiological emergency plans do not discuss a procedure for confirming evacuation. Should procedures not already exist, the following alternative or complementary approach is suggested.

The suggested procedure employs a stratified random sample and a telephone survey. The size of the sample is dependent on the expected number of households that do not comply with the Advisory to Evacuate. It is reasonable to assume, for the purpose of estimating sample size that at least 80 percent of the population within the EPZ will comply with the Advisory to Evacuate. On this basis, an analysis could be undertaken (see Table 12-1) to yield an estimated sample size of approximately 300.

The confirmation process should start at about 2 hours after the Advisory to Evacuate, which is when approximately 90 percent of evacuees have completed their mobilization activities (see Table 5-9). At this time, virtually all evacuees will have departed on their respective trips and the local telephone system will be largely free of traffic.

As indicated in Table 12-1, approximately 7½ person hours are needed to complete the telephone survey. If six people are assigned to this task, each dialing a different set of telephone exchanges (e.g., each person can be assigned a different set of zones), then the confirmation process will extend over a timeframe of about 75 minutes. Thus, the confirmation should be completed before the evacuated area is cleared. Of course, fewer people would be needed for this survey if the Evacuation Region were only a portion of the EPZ. Use of modern automated computer controlled dialing equipment or other technologies (e.g., reverse 911 or equivalent, if available) can significantly reduce the manpower requirements and the time required to undertake this type of confirmation survey.

If this method is indeed used by the offsite agencies, consideration should be given to maintain a list of telephone numbers within the EPZ in the Emergency Operations Center (EOC) at all times. Such a list could be purchased from vendors and could be periodically updated. As indicated above, the confirmation process should not begin until 2 hours after the Advisory to Evacuate, to ensure that households have had enough time to mobilize. This 2-hour timeframe will enable telephone operators to arrive at their workplace, obtain a call list and prepare to make the necessary phone calls.

Should the number of telephone responses (i.e., people still at home) exceed 20 percent, then the telephone survey should be repeated after an hour's interval until the confirmation process is completed.

Other techniques could also be considered. After traffic volumes decline, the personnel manning TCPs can be redeployed to travel through residential areas to observe and to confirm evacuation activities.

Table 12-1. Estimated Number of Telephone Calls Required for Confirmation of Evacuation

Problem Definition

Estimate number of phone calls, n, needed to ascertain the proportion, F of households that have not evacuated.

Reference: Burstein, H., Attribute Sampling, McGraw Hill, 1971

Given:

- No. of households plus other facilities, N, within the EPZ (est.) = 5,100
- Est. proportion, F, of households that will not evacuate = 0.20
- Allowable error margin, e: 0.05
- Confidence level, α: 0.95 (implies A = 1.96)

Applying Table 10 of cited reference,

$$p = F + e = 0.25; \;\; q = 1 - p = 0.75$$

$$n = \frac{A^2 pq + e}{e^2} = 308$$

Finite population correction:

$$n_F = \frac{nN}{n + N - 1} = 291$$

Thus, some 300 telephone calls will confirm that approximately 20 percent of the population has not evacuated. If only 10 percent of the population does not comply with the Advisory to Evacuate, then the required sample size, n_F = 215.

Est. Person Hours to complete 300 telephone calls

Assume:

- Time to dial using touch tone (random selection of listed numbers): 30 seconds
- Time for 6 rings (no answer): 36 seconds
- Time for 4 rings plus short conversation: 60 sec.
- Interval between calls: 20 sec.

Person Hours:

$$\frac{300[30 + 0.8(36) + 0.2(60) + 20]}{3600} = 7.6$$

13 RECOMMENDATIONS

The following recommendations are offered:

1. Examination of the general population ETE in Section 7 shows that the ETE for 100 percent of the population is generally 1 hour and 30 minutes to 2 hours longer than for 90 percent of the population. Specifically, the additional time needed for the last 10 percent of the population to evacuate can be as much as double the time needed to evacuate 90 percent of the population. This non-linearity reflects the fact that these relatively few stragglers require significantly more time to mobilize (i.e. prepare for the evacuation trip) than their neighbors. This leads to two recommendations:
    a. The public outreach (information) program should emphasize the need for evacuees to minimize the time needed to prepare to evacuate (secure the home, assemble needed clothes, medicines, etc.).
    b. The decision makers should reference Table 7-1 which list the time needed to evacuate 90 percent of the population, when preparing recommended protective actions, as per NUREG/CR-7002 guidance.
2. Staged evacuation is not beneficial due to the low population within the 5 and 10-mile regions of the plant and the limited traffic congestion within these regions.
3. A road closure on S.R. 42 northbound lane between Miller St. and Peterson St. has no impact on the 90^{th} or 100^{th} percentile ETE. Sufficient reserve highway capacity mitigates the impacts of the capacity reduction considered.
4. Counties should implement procedures whereby schools are contacted prior to dispatch of buses from the depots to get an accurate count of students needing transportation and the number of buses required (See Section 8).
5. Intelligent Transportation Systems (ITS) such as Dynamic Message Signs (DMS), Highway Advisory Radio (HAR), Automated Traveler Information Systems (ATIS), etc. should be used to facilitate the evacuation process (See Section 9). The placement of additional signage should consider evacuation needs.
6. Counties/State should establish strategic locations to position tow trucks provided with gasoline containers in the event of a disabled vehicle during the evacuation process (see Section 11) and should encourage gas stations to remain open during the evacuation.
7. Counties/states should establish a system/procedure to confirm that the Advisory to Evacuate is being adhered to (see the approach suggested by KLD in Section 12). Should the approach recommended by KLD in Section 12 be used, consideration should be given to keep a list of telephone numbers within the EPZ in the Emergency Operations Center (EOC) at all times.

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.
Free Speed	The average speed that a motorist would travel if there were no congestion or other adverse conditions (such as bad weather).
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 nodes within 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 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:

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

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

  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 = 15 miles, the outer distance of the shadow region. 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.

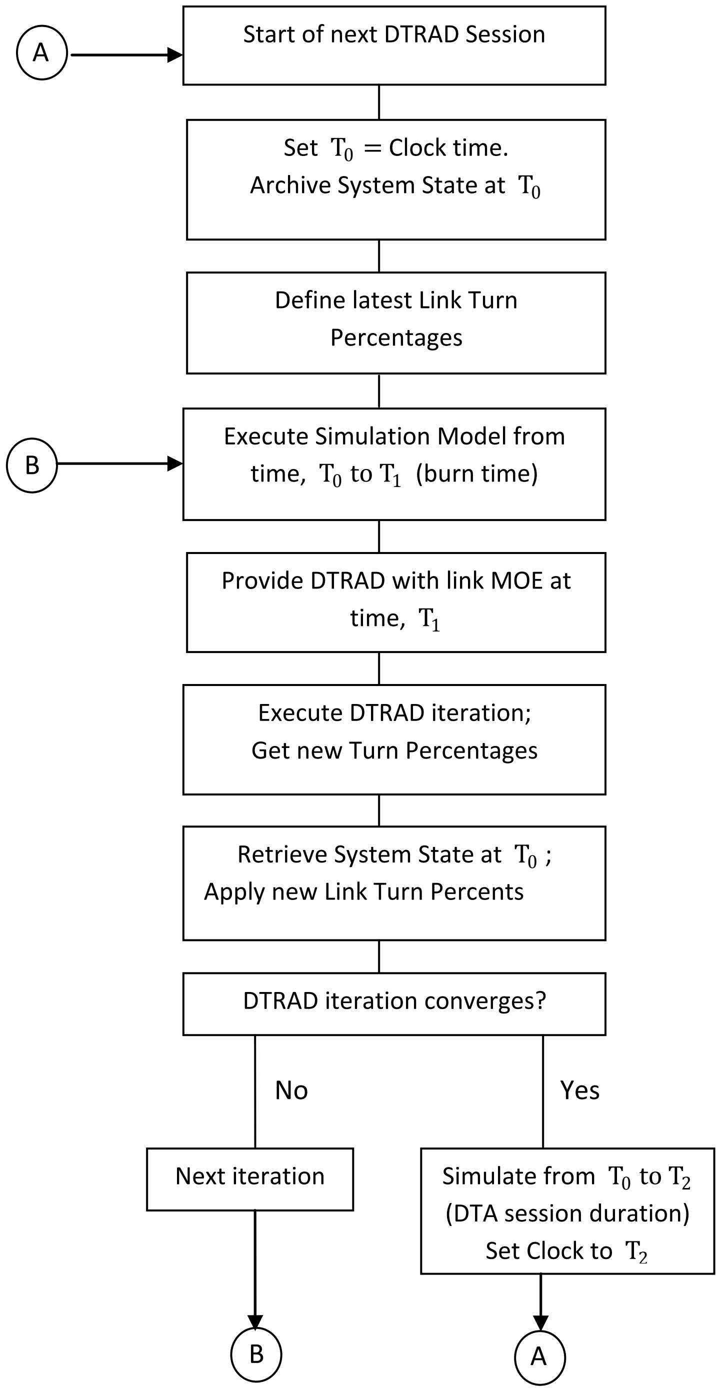


Figure B-1. Flow Diagram of Simulation-DTRAD Interface

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.

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 9) 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

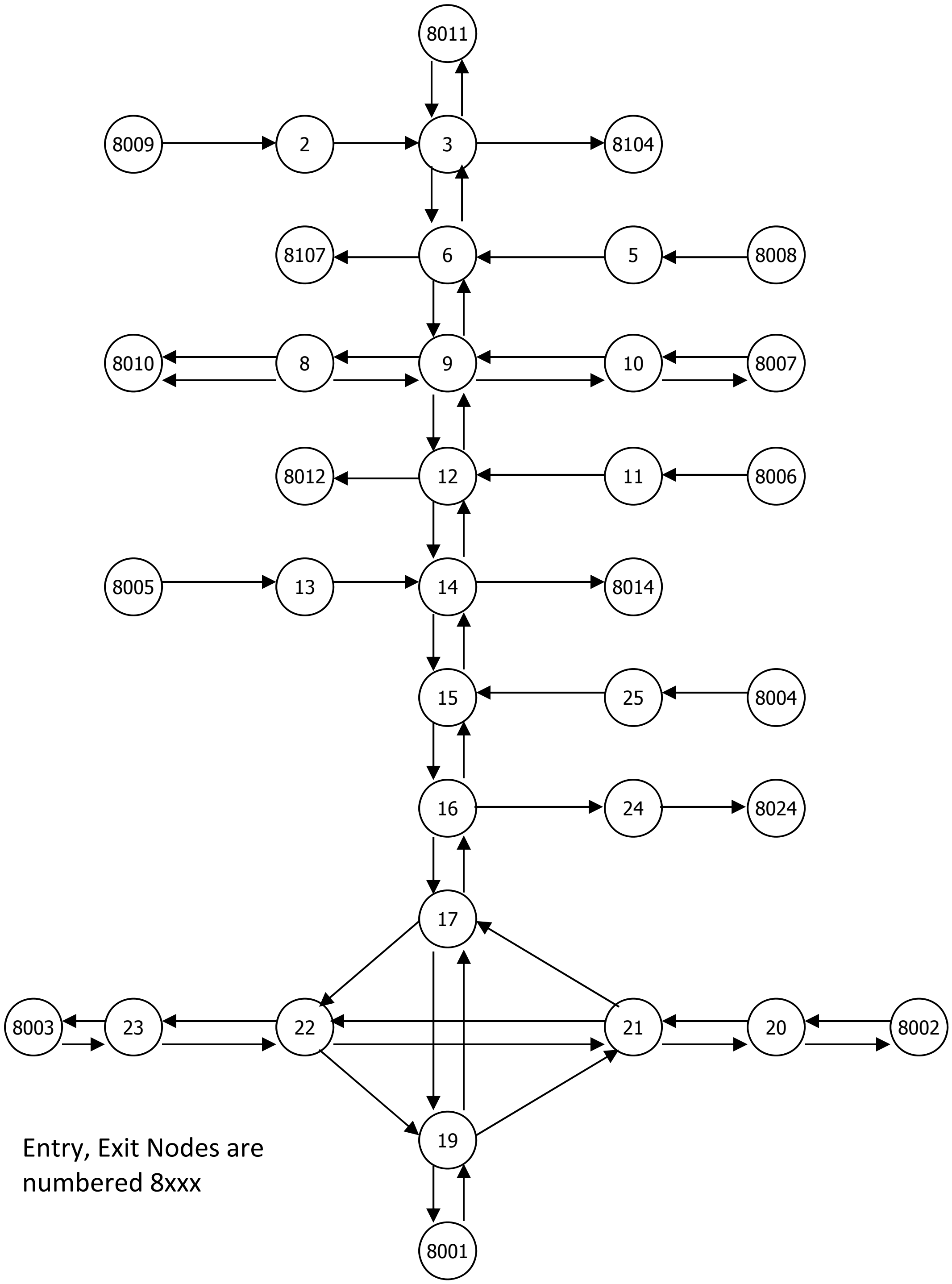


Figure C-1. Representative Analysis Network

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.

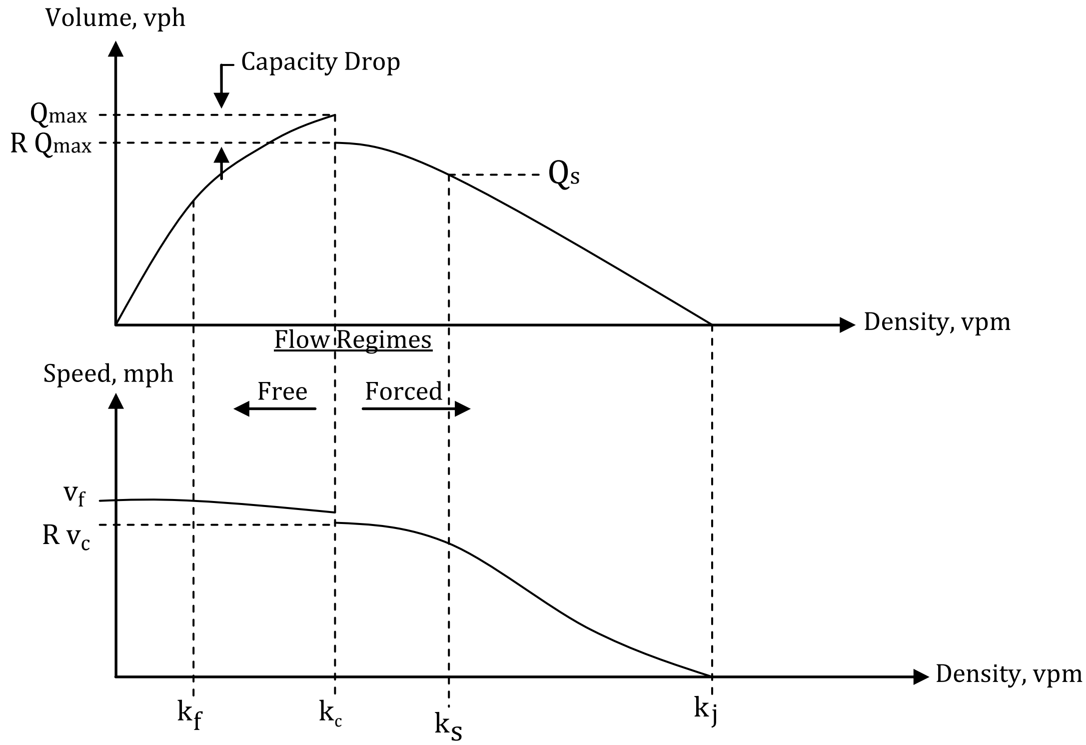


Figure C-2. Fundamental Diagrams

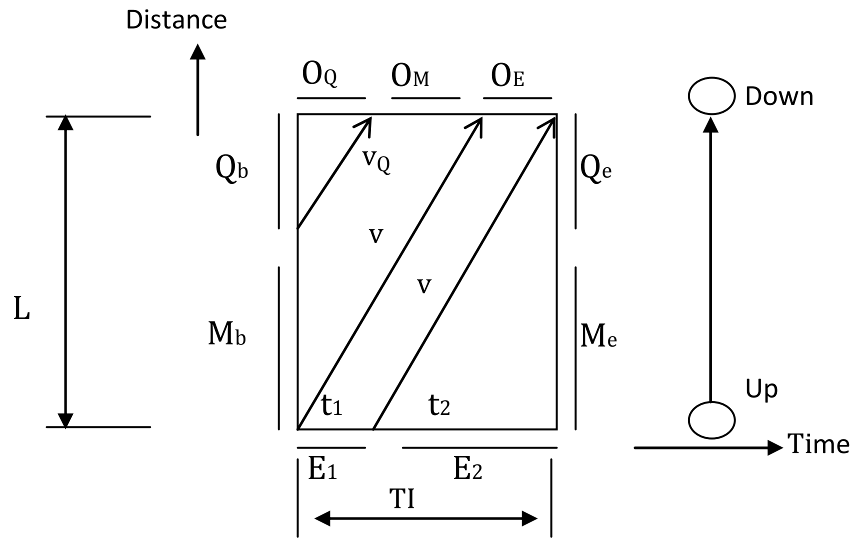


Figure C-3. A UNIT Problem Configuration with $t_1 > 0$

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.
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.

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 $|\bar{k}_n - \bar{k}_{n-1}| > \in$ 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

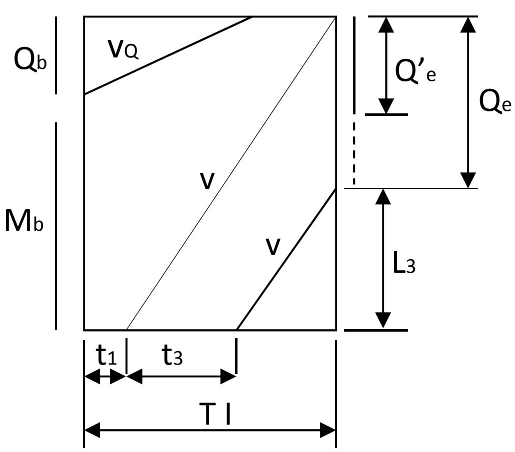
The number of excess vehicles that cause spillback is: $SB = Q_e + M_e - \frac{(L-W) \cdot LN}{L_v}$, where W is the width of the upstream intersection. To prevent spillback, meter the outflow from the feeder approaches and from the source flow, S, during this TI by the amount, SB. That is, set

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

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:

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

If the denominator, $\left[v - \frac{E}{TI}\frac{L_v}{LN}\right] \le 0$, 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 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 and M_b for the start of the next TI as being those values of Q_e 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.

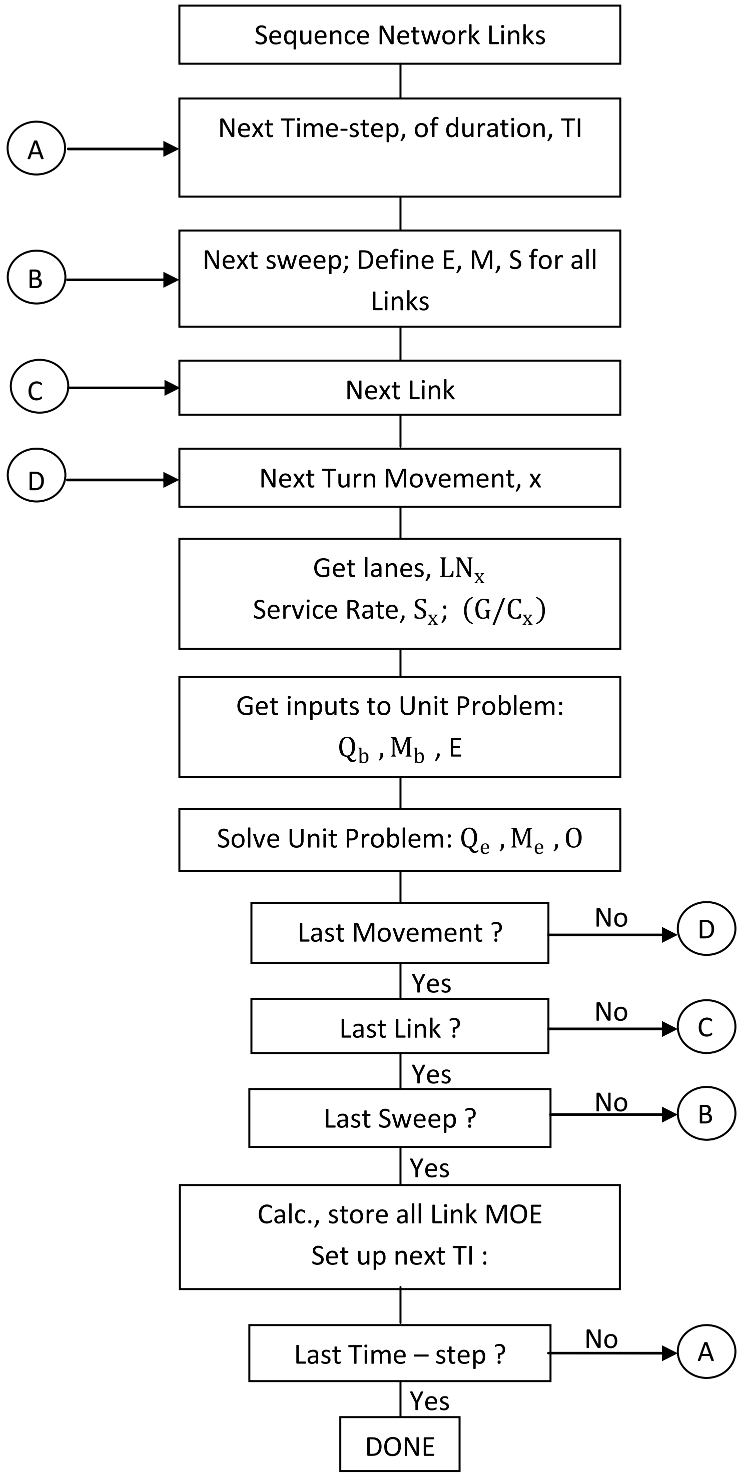


Figure C-4. Flow of Simulation Processing (See Glossary: Table C-3)

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 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.

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 boundary.

Step 2

2010 Census block information was obtained in GIS format. This information was used to estimate the resident population within the EPZ and Shadow Region and to define the spatial distribution and demographic characteristics of the population within the study area. Employee data was obtained from local emergency management officials and from phone calls to major employers. Transient data were obtained from local emergency management agencies and from phone calls to transient attractions. Information concerning schools, medical and other types of special facilities within the EPZ was obtained from county and municipal sources.

Step 3

A kickoff meeting was conducted with major stakeholders (state and local emergency managers, on-site and off-site utility emergency managers). 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 local emergency managers. 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, and to make the necessary observations needed to estimate realistic values of roadway capacity.

Step 5

A telephone 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 UNITES software 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). 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. 2010 Census data 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 5 zones. Based on wind direction and speed, Regions (groupings of zones) 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 which operates on data produced by DYNEV II) 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, 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.

Step 16

Once vehicular evacuation results are accepted, average travel speeds for transit and special facility routes were used to compute evacuation time estimates for transit-dependent permanent residents, schools, hospitals, and other special facilities.

Step 17

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

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.

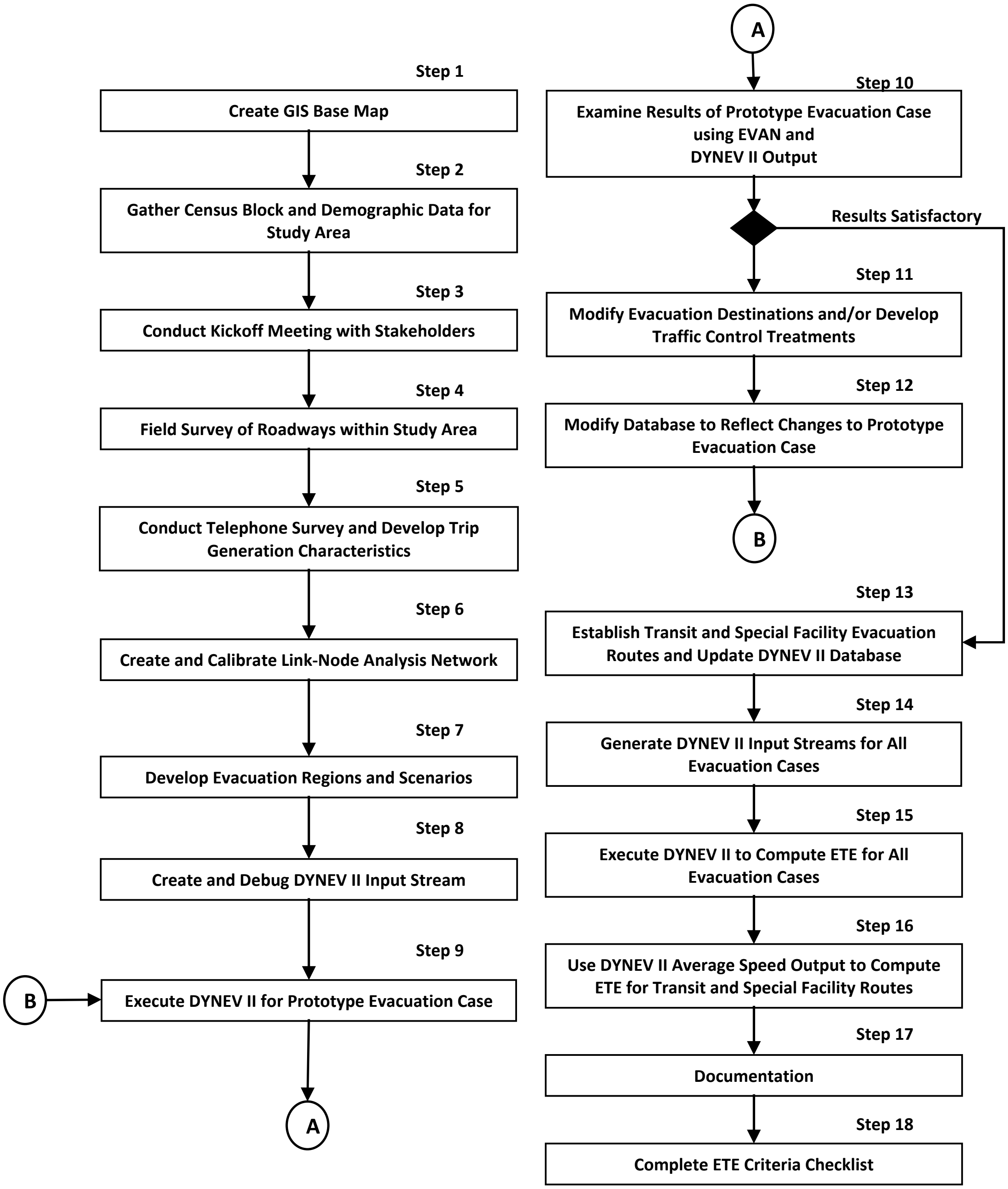


Figure D-1. Flow Diagram of Activities

APPENDIX E

Special Facility Data

E. SPECIAL FACILITY DATA

The following tables list population information, as of January 2012, for special facilities, transient attractions and major employers that are located within the KPS EPZ. Special facilities are defined as schools, day care centers, hospitals and other medical care facilities. Transient population data is included in the tables for recreational areas and lodging facilities. Employment data is included in the tables 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, day care center, recreational area, lodging facility, and major employer are also provided.

Table E-1. Schools within the EPZ

Zone	Distance (miles)	Dire-ction	School Name	Street Address	Municipality	Phone	Enroll-ment	Staff
Kewaunee County								
10N	8.2	N	Holy Rosary Catholic School	519 Kilbourn Street	Kewaunee	(920) 388-2431	96	15
10N	7.9	N	Kewaunee Grade School[1]	921 3rd Street	Kewaunee	(920) 388-2458	662	75
10N	7.9	N	Kewaunee Intermediate School[1]	921 3rd Street	Kewaunee	(920) 388-3458		
10N	8.0	N	Kewaunee High School	911 3rd Street	Kewaunee	(920) 388-2951	321	40
10N	7.9	N	Lakeshore Alternative School	915 2nd Street	Kewaunee	(920) 388-3230	20	2
						Kewaunee County Subtotals:	*1,099*	*132*
Manitowoc County								
10S	8.4	SW	East Twin Lutheran School	325 Randolph Street	Mishicot	(920) 755-3857	4	2
10S	8.4	SSW	Mishicot High School[1]	660 Washington Street	Mishicot	(920) 755-2311	881	88
10S	8.4	SSW	Mishicot Middle School[1]	660 Washington Street	Mishicot	(920) 755-2808		
10S	8.3	SSW	Schultz Elementary School[1]	510 Woodlawn Drive	Mishicot	(920) 755-2391		
						Manitowoc County Subtotals:	*885*	*90*
						TOTAL:	**1,984**	**222**

[1] Facility is part of an educational complex on a site where data was reported in aggregate.

Table E-2. Medical Facilities within the EPZ

Zone	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Phone	Current Census	Ambul-atory Patients	Wheel-chair Patients	Bed-ridden Patients
Kewaunee County										
10N	7.6	N	Kewaunee Health Care Center	1308 Lincoln Street	Kewaunee	(920) 388-4111	66	31	0	25
10N	7.6	N	Linden Manor	1204 4th Street	Kewaunee	(920) 388-0110	16	16	0	0
10N	7.6	N	Silver Leaf Manor	1310 Lincoln Street	Kewaunee	(920) 388-2204	8	8	0	0
						TOTAL:	**90**	**55**	**0**	**25**

Table E-3. Major Employers within the EPZ

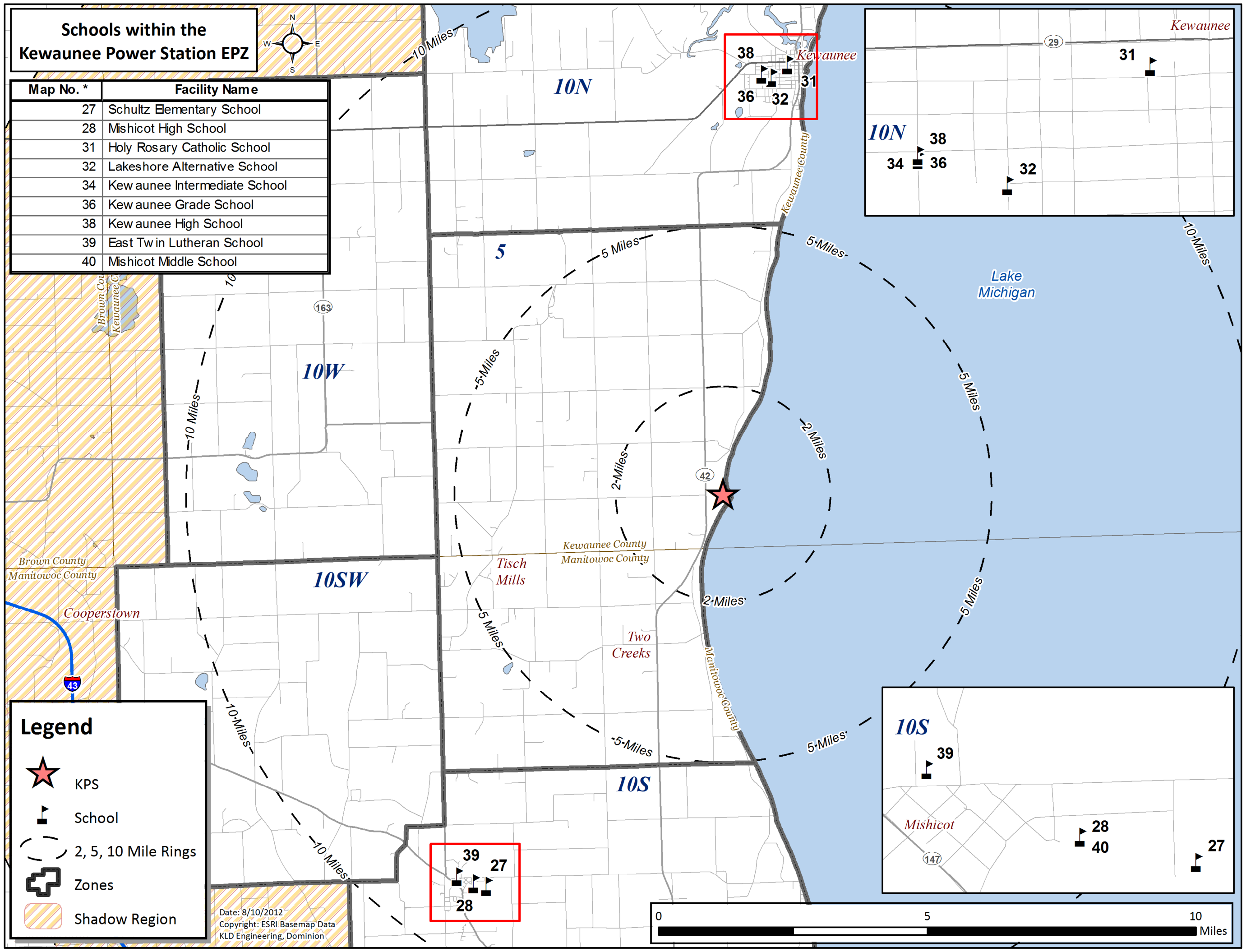
Zone	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Phone	Employees (max shift)	% Non-EPZ	Employees (Non EPZ)
Kewaunee County									
5	0.0	N/A	Kewaunee Power Station	N490 State Highway 42	Kewaunee	(920) 388-2560	650	95%	618
10N	8.8	N	Kewaunee Fabrications LLC	520 North Main Street	Kewaunee	(920) 388-2000	245	55%	135
10N	8.3	N	Vollrath Co	23 Kilbourn Street	Kewaunee	(920) 388-3113	35	50%	18
						Kewaunee County Subtotals:	*930*	*-*	*771*
Manitowoc County									
5	4.2	S	FPL Energy Point Beach LLC	6610 Nuclear Road	Two Rivers	(920) 755-6557	600	50%	300
						Manitowoc County Subtotals:	*600*	*-*	*300*
TOTAL:						**TOTAL:**	**1,530**	**-**	**1,071**

Table E-4. Parks/Recreational Attractions within the EPZ

Zone	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Phone	Transients	Vehicles
Kewaunee County								
10N	8.7	N	Kewaunee Marina	123 North Main Street	Kewaunee	(920) 388-3300	184	112
10N	9.1	N	Kewaunee River State Public Fishery Area	N/A	West Kewaunee	N/A	36	15
10N	10.5	NNW	Kewaunee State Public Hunting Grounds	N/A	West Kewaunee	N/A	50	21
10N	9.5	N	Kewaunee Village RV Park	333 Terraqua Drive	Kewaunee	(920) 388-4851	170	74
10N	8.9	N	Salmon Harbor Marina LLC	312 North Main Street	Kewaunee	(920) 388-2120	230	161
						Kewaunee County Subtotals:	*670*	*383*
Manitowoc County								
10S	9.2	SW	Fox Hills Resort & Country Club	300 Church Street	Mishicot	(920) 755-2365	120	50
10S	9.1	S	Point Beach State Forest	9400 County Road O	Two Rivers	(920) 794-7480	1,000	250
						Manitowoc County Subtotals:	*1,120*	*300*
						TOTAL:	**1,790**	**683**

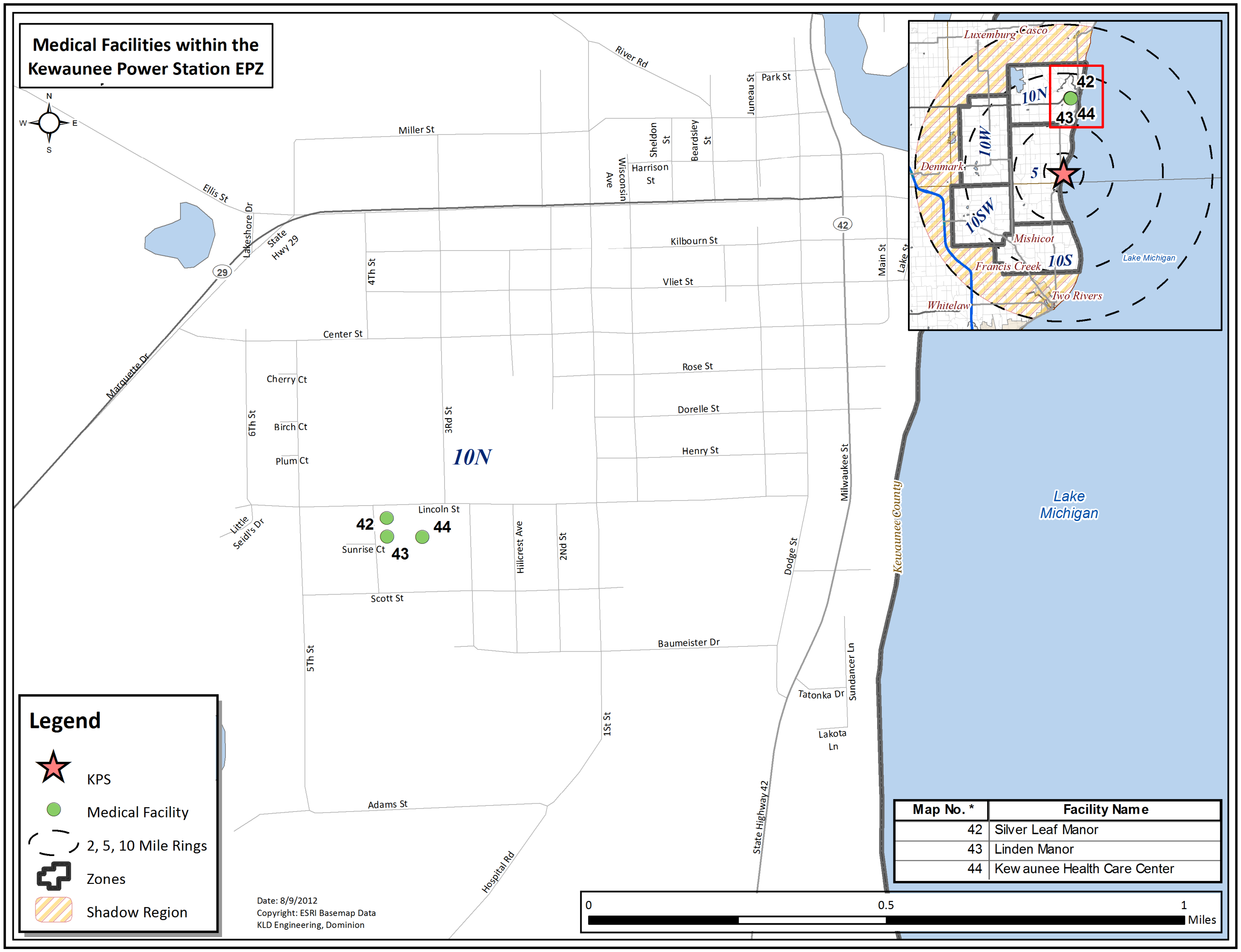
Table E-5. Lodging Facilities within the EPZ

Zone	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Phone	Transients	Vehicles
Kewaunee County								
10N	9.3	N	Coho Motel	705 North Main Street	Kewaunee	(920) 388-3565	74	37
10N	8.5	N	Harbor Lights Lodge Kewaunee	211 Milwaukee	Kewaunee	(920) 388-3700	76	33
10N	9.1	N	Norman General Store Bed & Breakfast	E3296 County Road G	Kewaunee	(920) 388-4580	6	4
10N	8.3	N	The Kewaunee Inn	122 Ellis Street	Kewaunee	(920) 388-0800	46	23
						Kewaunee County Subtotals:	*202*	*97*
Manitowoc County								
10S	9.2	SW	Fox Hills Resort	250 W Church St	Mishicot	(920) 755-2376	1,127	644
						Manitowoc County Subtotals:	*1,127*	*644*
						TOTAL:	**1,329**	**741**



Map No. *	Facility Name
27	Schultz Elementary School
28	Mishicot High School
31	Holy Rosary Catholic School
32	Lakeshore Alternative School
34	Kewaunee Intermediate School
36	Kewaunee Grade School
38	Kewaunee High School
39	East Twin Lutheran School
40	Mishicot Middle School

Figure E-1. Schools within the EPZ



Map No. *	Facility Name
42	Silver Leaf Manor
43	Linden Manor
44	Kewaunee Health Care Center

Figure E-2. Medical Facilities within the EPZ

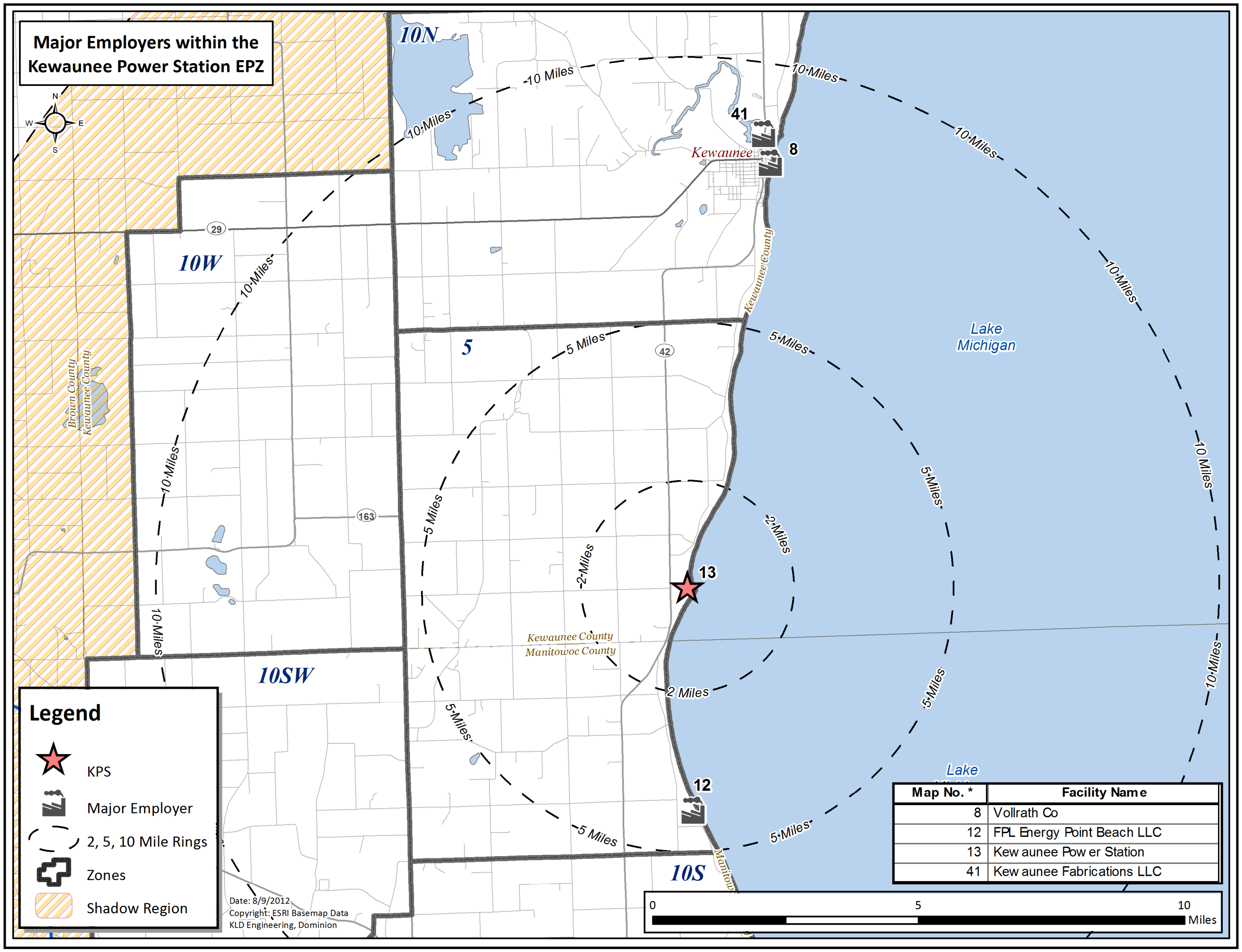
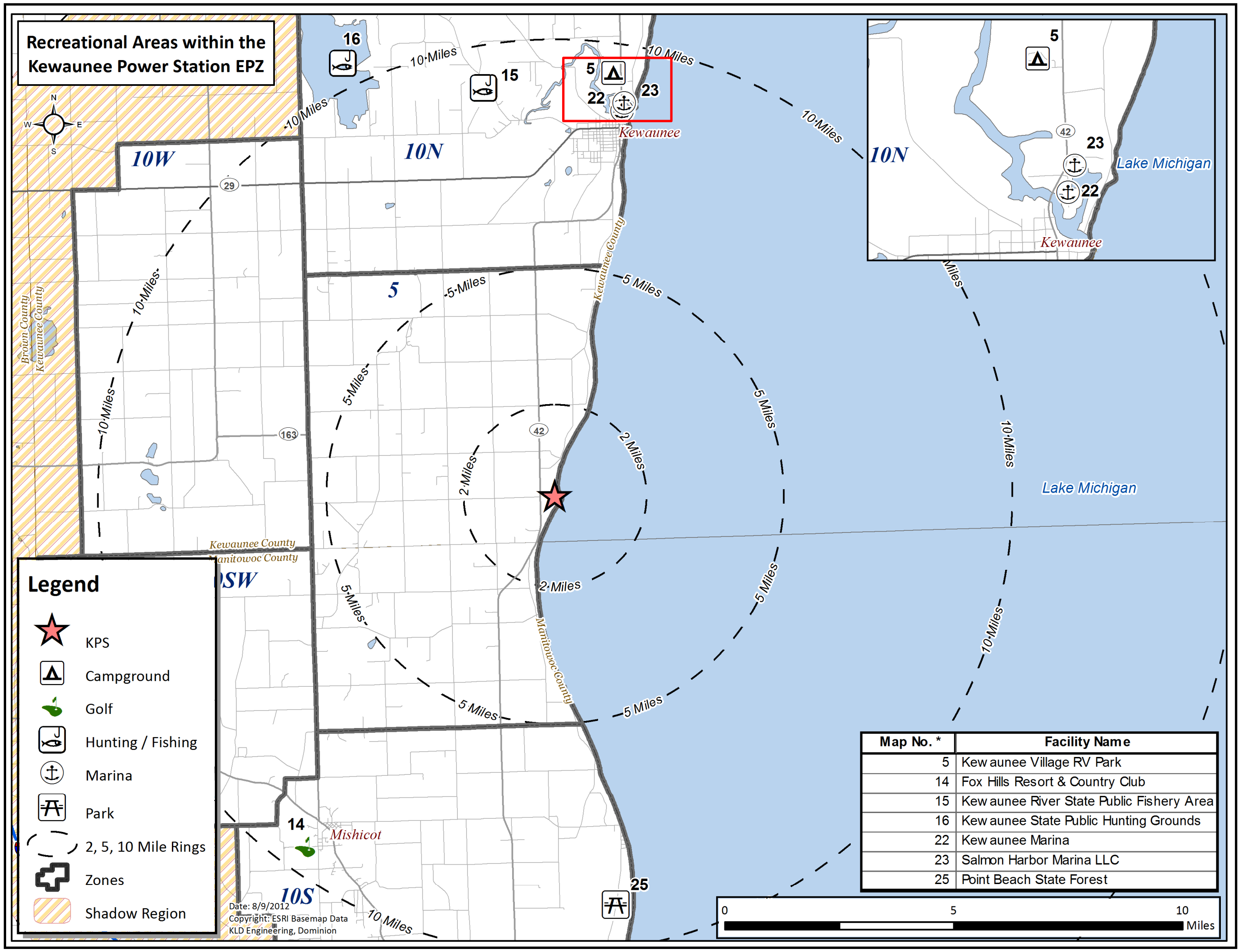


Figure E-3. Major Employers within the EPZ



Map No. *	Facility Name
5	Kewaunee Village RV Park
14	Fox Hills Resort & Country Club
15	Kewaunee River State Public Fishery Area
16	Kewaunee State Public Hunting Grounds
22	Kewaunee Marina
23	Salmon Harbor Marina LLC
25	Point Beach State Forest

Figure E-4. Recreational Areas within the EPZ

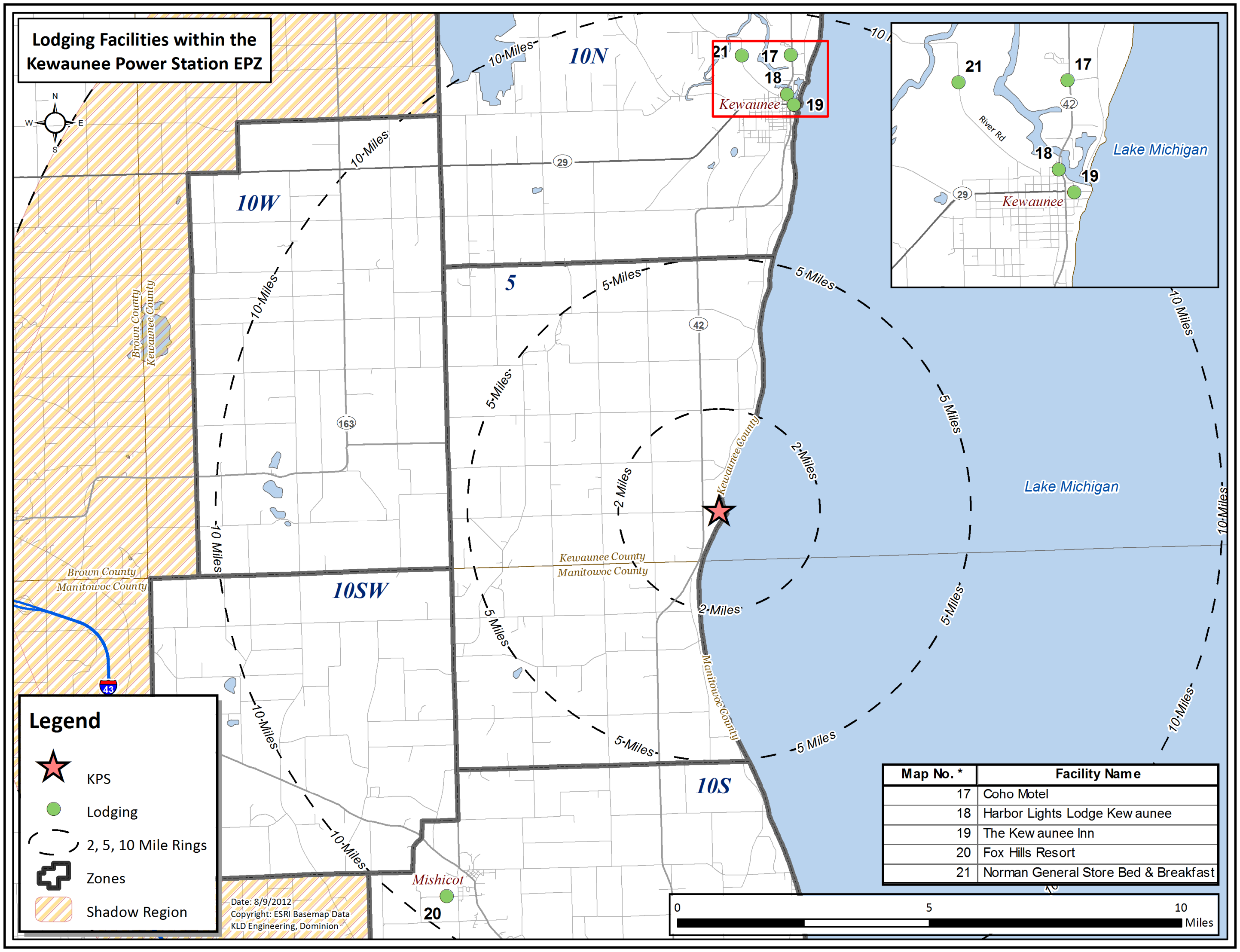


Figure E-5. Lodging within the EPZ

APPENDIX F

Telephone Survey

F. TELEPHONE SURVEY

F.1 Introduction

The development of evacuation time estimates for the Emergency Planning Zone (EPZ) of the Kewaunee Power Station 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 telephone 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 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. A sample size of approximately 500 **completed** survey forms yields results with a sampling error of ±4.5% at the 95% confidence level. The sample must be drawn from the EPZ population. Consequently, a list of zip codes in the EPZ was developed using 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 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. The survey was conducted in English, Spanish and Hmong account for the significant Spanish and Hmong speaking population within the EPZ.

The completed survey adhered to the sampling plan.

Table F-1. Kewaunee Telephone Survey Sampling Plan

Zip Code	Population within EPZ (2010)	Households	Required Sample
54208	944	371	17
54216	5805	2375	109
54217	322	110	5
54220	723	301	14
54227	321	128	6
54228	2669	1105	51
54241	14840	6381	294
54247	220	79	4
Total	25844	10850	500
Average Household Size:			2.38
Total Sample Required:			500

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 "don't know" (DK) or "refused" entry for a response. It is accepted practice in conducting surveys of this type to accept the answers of a respondent who offers a DK response for a few questions or who refuses to answer a few questions. To address the issue of occasional DK/refused 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 DK/refused 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. The average household contains 2.30 people. The estimated household size (2.38 persons) used to determine the survey sample (Table F-1) was drawn from Census data. The close agreement between the average household size obtained from the survey and from the Census is an indication of the reliability of the survey.

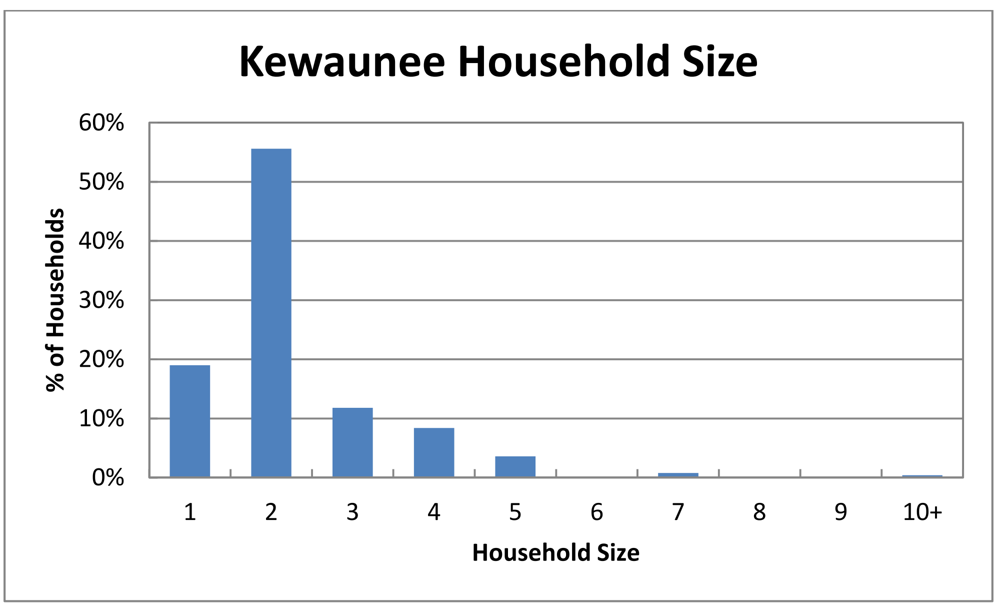


Figure F-1. Household Size in the EPZ

Automobile Ownership

The average number of automobiles available per household in the EPZ is 2.01. It should be noted that approximately 1.6 percent of households do not have access to an automobile. The distribution of automobile ownership is presented in Figure F-2. Figure F-3 and Figure F-4 present the automobile availability by household size. Note that the majority of households without access to a car are single person households. As expected, nearly all households of 2 or more people have access to at least one vehicle.

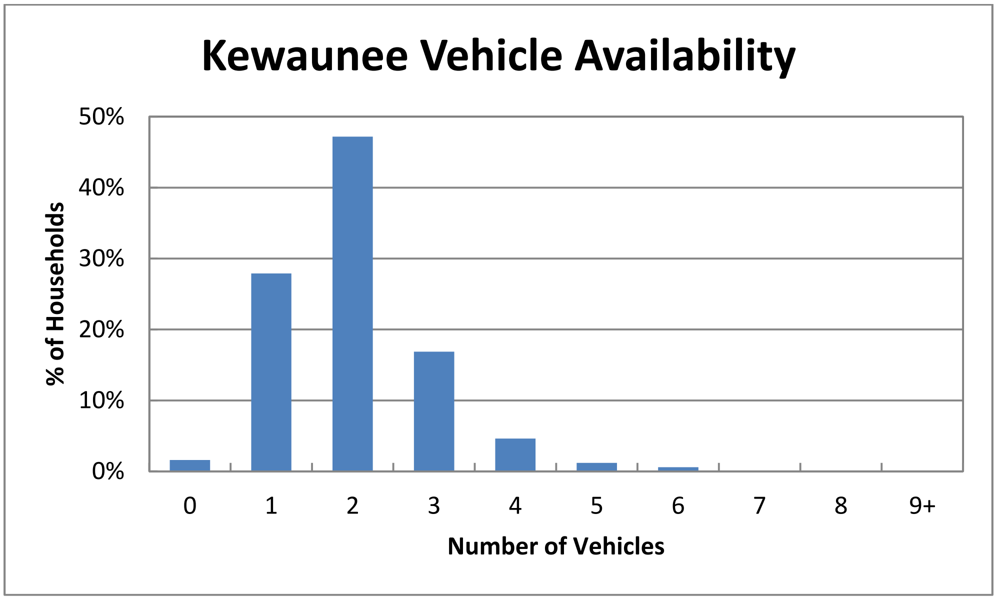


Figure F-2. Household Vehicle Availability

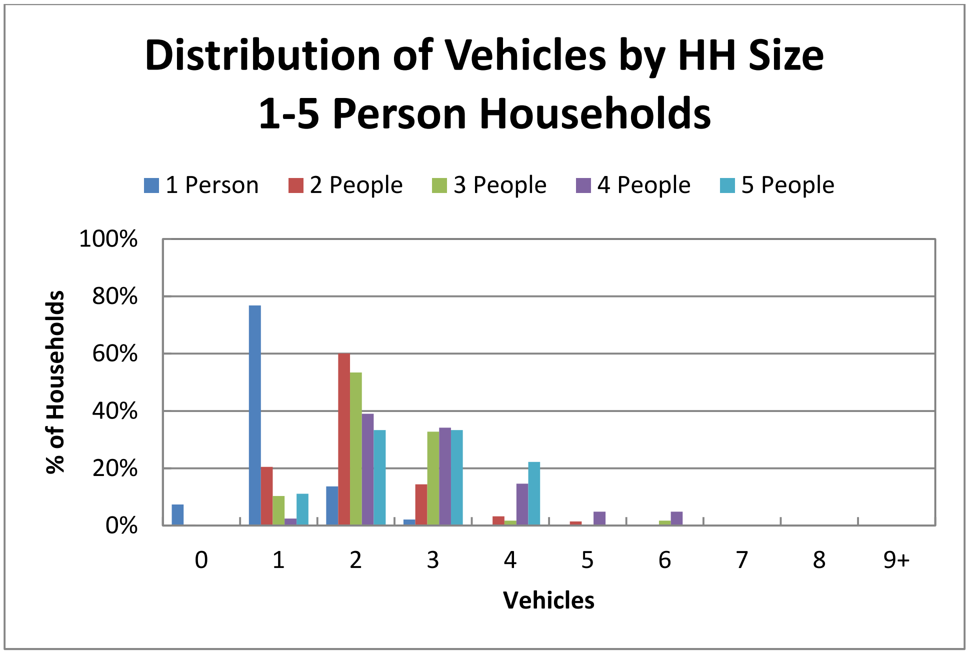


Figure F-3. Vehicle Availability - 1 to 5 Person Households

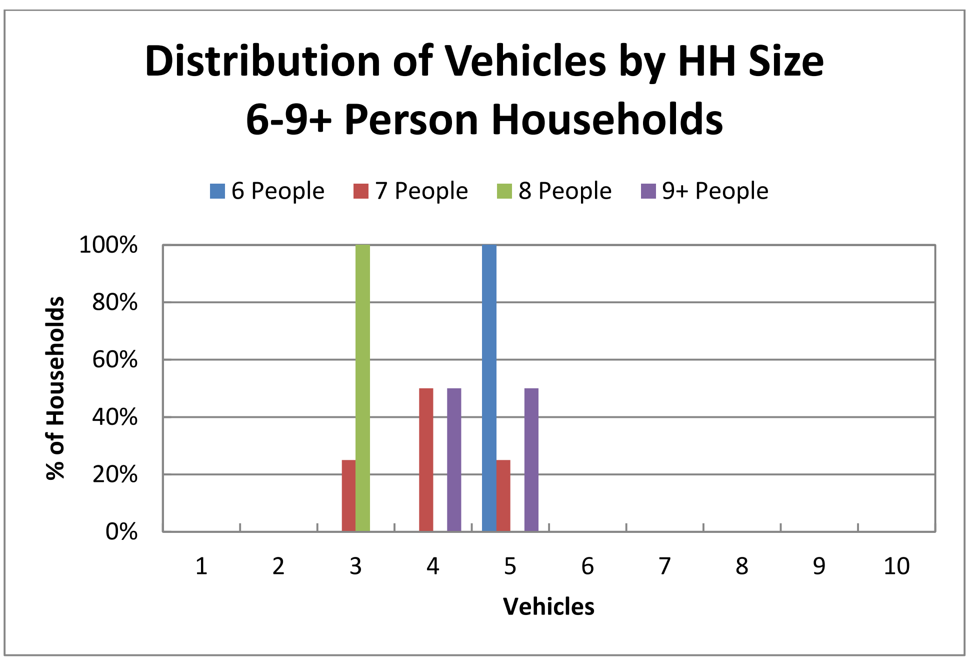


Figure F-4. Vehicle Availability - 6 to 9+ Person Households

Ridesharing

89% of the households surveyed (who do not own a vehicle) responded that they would share a ride with a neighbor, relative, or friend if a car was not available to them when asked to evacuate in the event of an emergency. . Note, however, that only those households with no access to a vehicle – 10 total out of the sample size of 500 – answered this question. Thus, the results are not statistically significant. As such, the NRC recommendation of 50% ridesharing is used throughout this study. Figure F-5 presents this response.

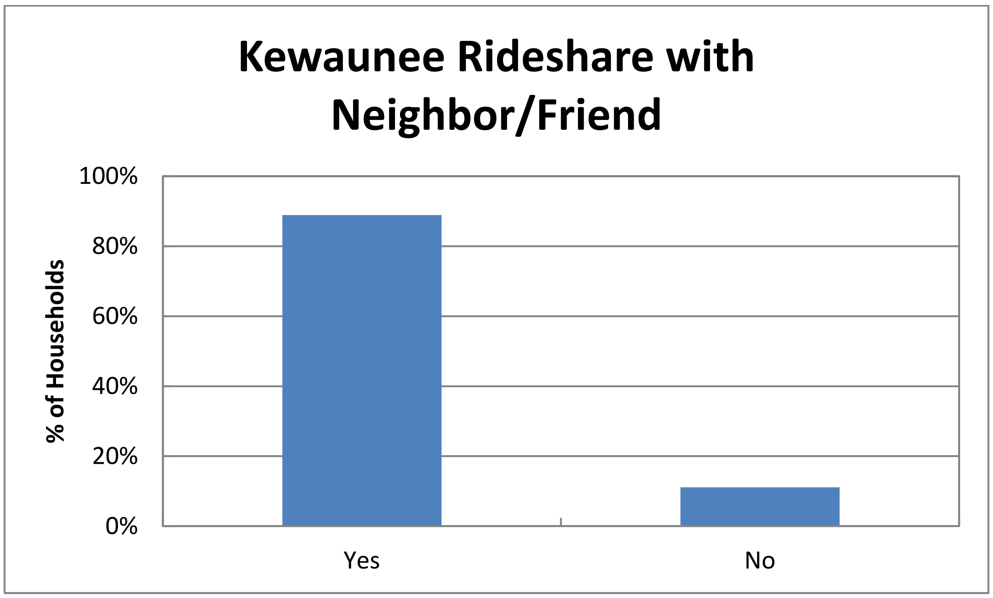


Figure F-5. Household Ridesharing Preference

<u>Commuters</u>

Figure F-6 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 0.92 commuters in each household in the EPZ, and 56% of households have at least one commuter.

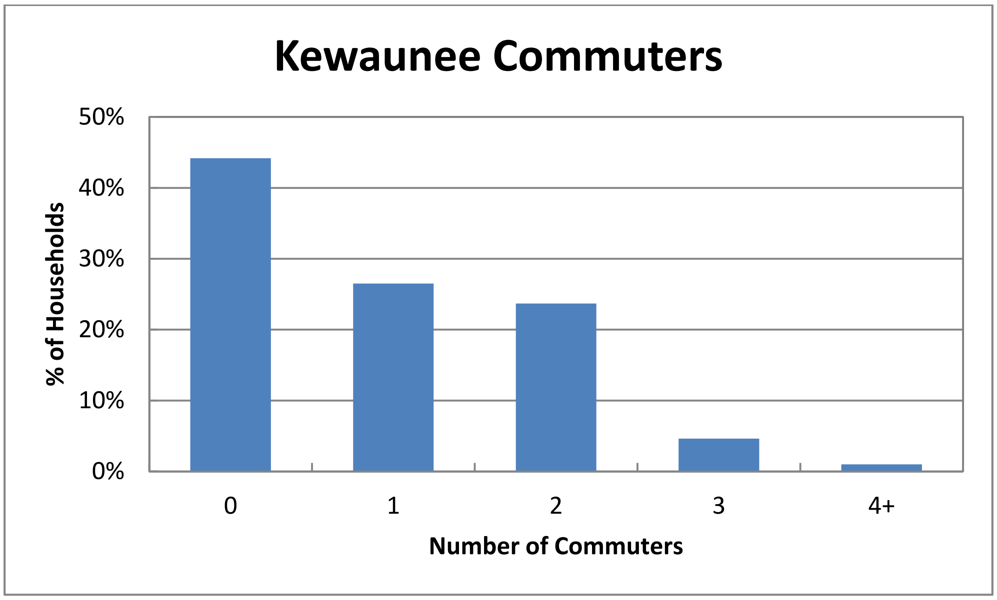


Figure F-6. Commuters in Households in the EPZ

Commuter Travel Modes

Figure F-7 presents the mode of travel that commuters use on a daily basis. The vast majority of commuters use their private automobiles to travel to work. The data shows an average of 1.04 employees per vehicle, assuming 2 people per vehicle – on average – for carpools.

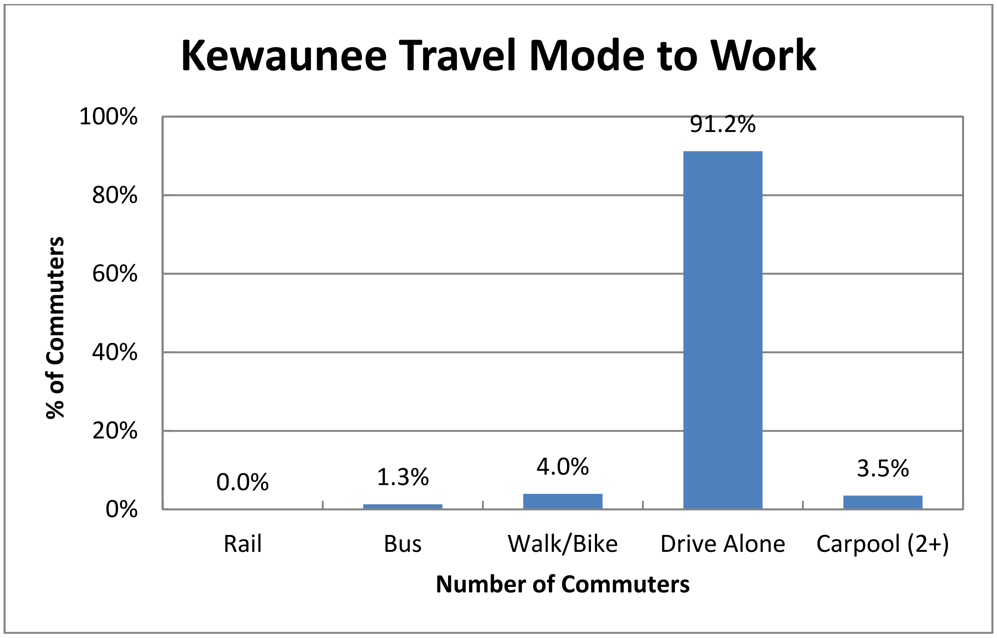


Figure F-7. Modes of Travel in the EPZ

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-8. On average, evacuating households would use 1.22 vehicles.

"Would your family await the return of other family members prior to evacuating the area?" Of the survey participants who responded, 46 percent said they would await the return of other family members before evacuating and 54 percent indicated that they would not await the return of other family members.

"If you had a household pet, would you take your pet with you if you were asked to evacuate the area?" As shown in Figure F-9, 50 percent of households do not have a family pet. Of the households with pets, 91 percent of them indicated that they would take their pets.

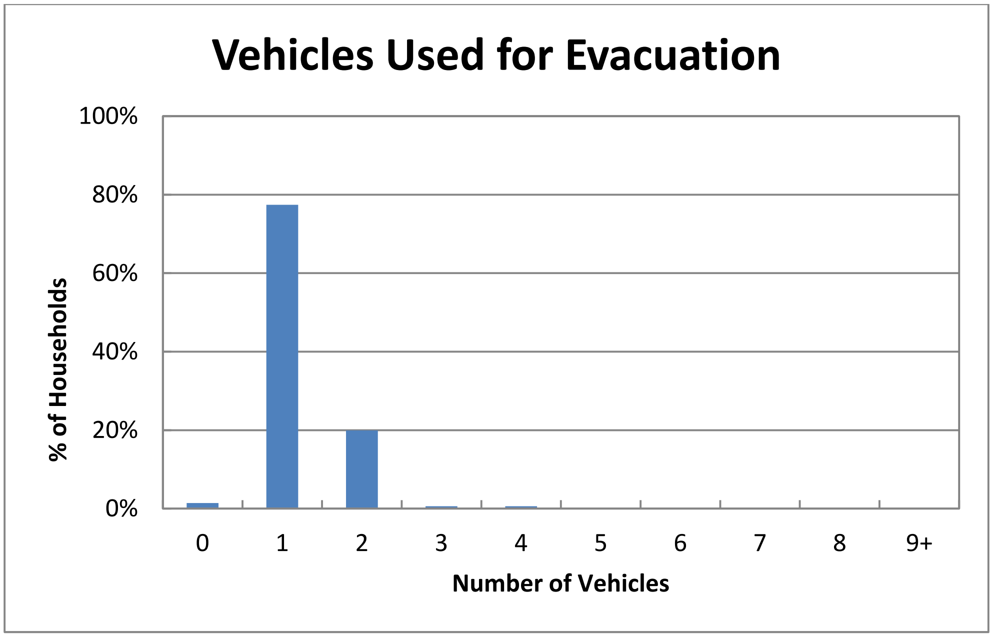


Figure F-8. Number of Vehicles Used for Evacuation

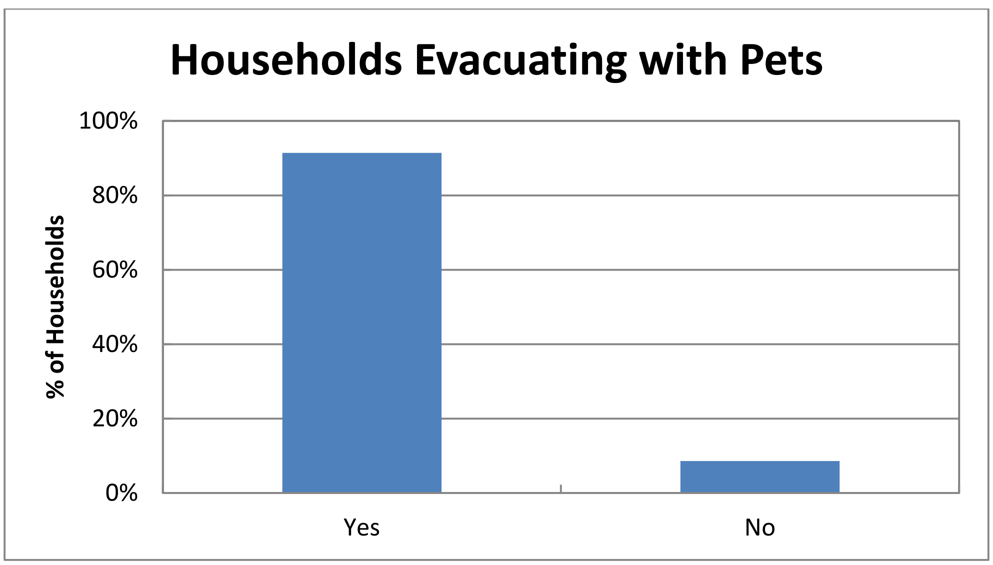


Figure F-9. Households Evacuating with Pets

"Emergency officials advise you to take shelter at home in an emergency. Would you?" This question is designed to elicit information regarding compliance with instructions to shelter in place. The results indicate that 80 percent of households who are advised to shelter in place would do so; the remaining 20 percent would choose to evacuate the area. 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. Thus, the data obtained above is in good agreement with the federal guidance.

"Emergency officials advise you to take shelter at home 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 70 percent of households would follow instructions and delay the start of evacuation until so advised, while the balance of 30 percent would choose to begin evacuating immediately.

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.

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?" Figure F-10 presents the cumulative distribution; in all cases, the activity is completed by about 75 minutes. Eighty percent can leave within 20 minutes.

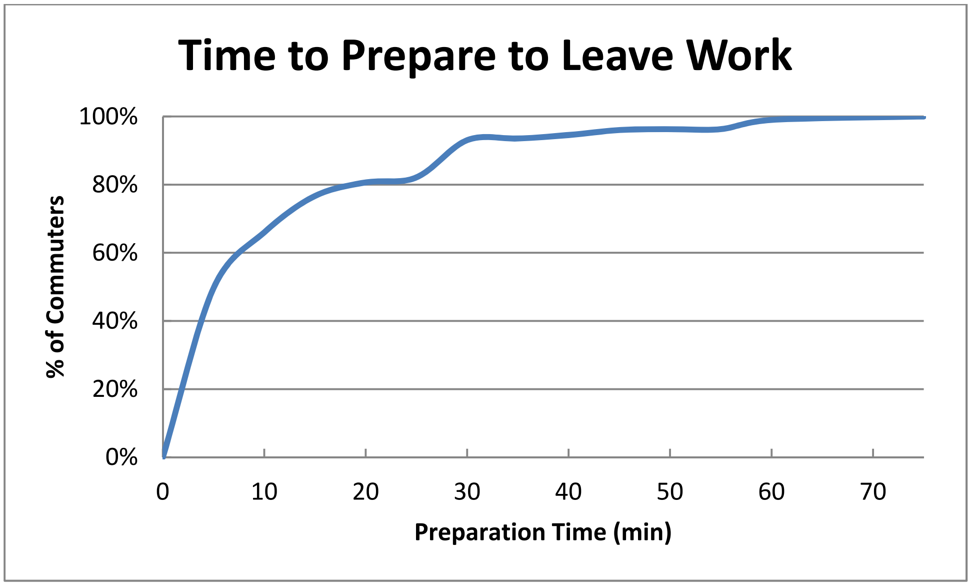


Figure F-10. Time Required to Prepare to Leave Work/School

"How long would it take the commuter to travel home?" Figure F-11 presents the work to home travel time for the EPZ. About 90 percent of commuters can arrive home within about 35 minutes of leaving work; all within 60 minutes.

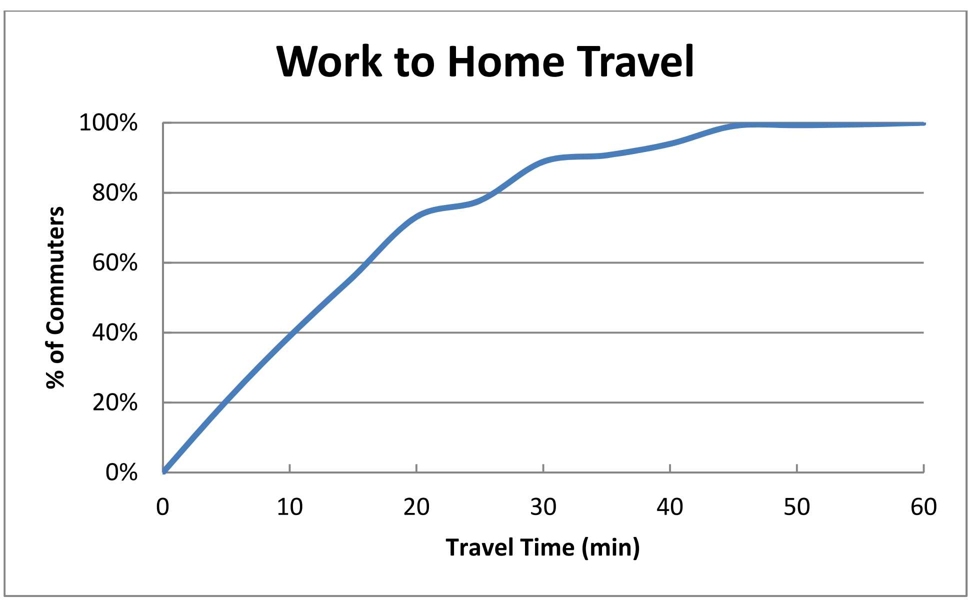


Figure F-11. Work to Home Travel Time

"How long would it take the family to pack clothing, secure the house, and load the car?" Figure F-12 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-12 has a long "tail." About 88 percent of households can be ready to leave home within 60 minutes; the remaining households require up to an additional 75 minutes.

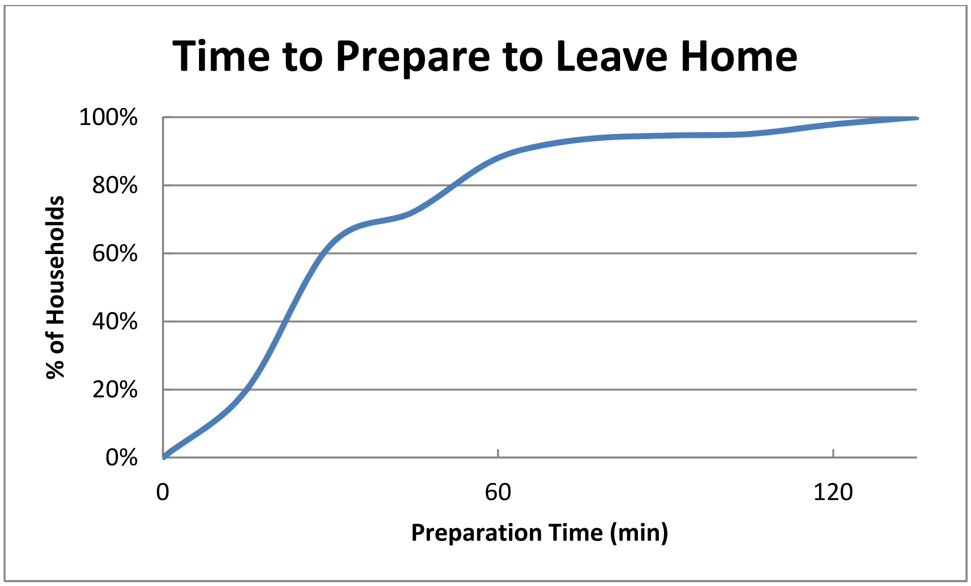


Figure F-12. Time to Prepare Home for Evacuation

"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 must 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-13 presents the time distribution for removing 6 to 8 inches of snow from a driveway. The time distribution for clearing the driveway has a long tail; about 81 percent of driveways are passable within 30 minutes. The last driveway is cleared two hours after the start of this activity. Note that those respondents (35%) 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.

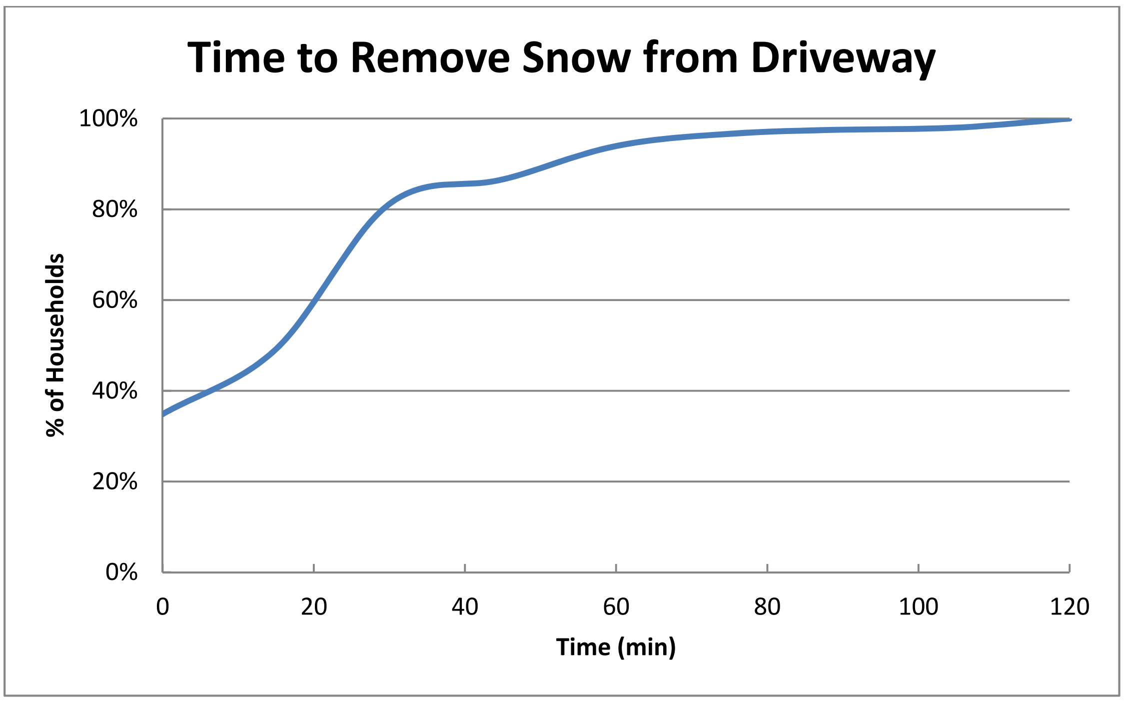


Figure F-13. Time to Clear Driveway of 6"-8" of Snow

F.4 Conclusions

The telephone survey provides valuable, relevant data associated with the EPZ population, which have been used to quantify demographics specific to the EPZ, and "mobilization time" which can influence evacuation time estimates.

ATTACHMENT A

Telephone Survey Instrument

Telephone Survey Instrument

Hello, my name is _______and I am working with Manitowoc and Kewaunee County Emergency Management on a survey to identify local behavior during emergency situations. This information will be used for emergency planning and will be shared with local officials to enhance emergency response plans in your area for all hazards; emergency planning for some hazards may require evacuation. Your responses will greatly contribute to Manitowoc and Kewaunee Counties emergency preparedness. I will not ask for your name and the survey shall take no more than 10 minutes to complete.

COL. 1	Unused
COL. 2	Unused
COL. 3	Unused
COL. 4	Unused
COL. 5	Unused
Sex	COL. 8
	1 Male
	2 Female

INTERVIEWER: ASK TO SPEAK TO THE HEAD OF HOUSEHOLD OR THE SPOUSE OF THE HEAD OF HOUSEHOLD. (Terminate call if not a residence.)

DO NOT ASK:

1A.	Record area code. To Be Determined	COL. 9-11	
1B.	Record exchange number. To Be Determined	COL. 12-14	
2.	What is your home zip code?	COL. 15-19	
3A.	In total, how many running cars, or other running vehicles are usually available to the household? (DO NOT READ ANSWERS)	COL. 20	SKIP TO
		1 ONE	Q. 4
		2 TWO	Q. 4
		3 THREE	Q. 4
		4 FOUR	Q. 4
		5 FIVE	Q. 4
		6 SIX	Q. 4
		7 SEVEN	Q. 4
		8 EIGHT	Q. 4
		9 NINE OR MORE	Q. 4
		0 ZERO (NONE)	Q. 3B
		X DON'T KNOW/REFUSED	Q. 3B
3B.	In an emergency, could you get a ride out of the area with a neighbor or friend?	COL. 21	
		1 YES	
		2 NO	
		X DON'T KNOW/REFUSED	

4.	How many people usually live in this household? (DO NOT READ ANSWERS)	COL. 22 1 ONE 2 TWO 3 THREE 4 FOUR 5 FIVE 6 SIX 7 SEVEN 8 EIGHT 9 NINE	COL. 23 0 TEN 1 ELEVEN 2 TWELVE 3 THIRTEEN 4 FOURTEEN 5 FIFTEEN 6 SIXTEEN 7 SEVENTEEN 8 EIGHTEEN 9 NINETEEN OR MORE X DON'T KNOW/REFUSED

		COL. 24		SKIP TO
5.	How many adults in the household commute to a job, or to college on a daily basis?	0	ZERO	Q. 9
		1	ONE	Q. 6
		2	TWO	Q. 6
		3	THREE	Q. 6
		4	FOUR OR MORE	Q. 6
		5	DON'T KNOW/REFUSED	Q. 9

INTERVIEWER: For each person identified in Question 5, ask Questions 6, 7, and 8.

6. Thinking about commuter #1, how does that person usually travel to work or college? (REPEAT QUESTION FOR EACH COMMUTER)

	Commuter #1 COL. 25	Commuter #2 COL. 26	Commuter #3 COL. 27	Commuter #4 COL. 28
Rail	1	1	1	1
Bus	2	2	2	2
Walk/Bicycle	3	3	3	3
Drive Alone	4	4	4	4
Carpool-2 or more people	5	5	5	5
Don't know/Refused	6	6	6	6

7. How much time on average, would it take Commuter #1 to travel home from work or college? (REPEAT QUESTION FOR EACH COMMUTER) (DO NOT READ ANSWERS)

COMMUTER #1				COMMUTER #2			
COL. 29		COL. 30		COL. 31		COL. 32	
1	5 MINUTES OR LESS	1	46-50 MINUTES	1	5 MINUTES OR LESS	1	46-50 MINUTES
2	6-10 MINUTES	2	51-55 MINUTES	2	6-10 MINUTES	2	51-55 MINUTES
3	11-15 MINUTES	3	56 – 1 HOUR	3	11-15 MINUTES	3	56 – 1 HOUR
4	16-20 MINUTES	4	OVER 1 HOUR, BUT LESS THAN 1 HOUR 15	4	16-20 MINUTES	4	OVER 1 HOUR, BUT LESS THAN 1 HOUR

			MINUTES				15 MINUTES
5	21-25 MINUTES	5	BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES	5	21-25 MINUTES	5	BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
6	26-30 MINUTES	6	BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES	6	26-30 MINUTES	6	BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
7	31-35 MINUTES	7	BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS	7	31-35 MINUTES	7	BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
8	36-40 MINUTES	8	OVER 2 HOURS (SPECIFY ______)	8	36-40 MINUTES	8	OVER 2 HOURS (SPECIFY ______)
9	41-45 MINUTES	9		9	41-45 MINUTES	9	
		0				0	
		X	DON'T KNOW /REFUSED			X	DON'T KNOW /REFUSED

COMMUTER #3				COMMUTER #4			
COL. 33		COL. 34		COL. 35		COL. 36	
1	5 MINUTES OR LESS	1	46-50 MINUTES	1	5 MINUTES OR LESS	1	46-50 MINUTES
2	6-10 MINUTES	2	51-55 MINUTES	2	6-10 MINUTES	2	51-55 MINUTES
3	11-15 MINUTES	3	56 – 1 HOUR	3	11-15 MINUTES	3	56 – 1 HOUR
4	16-20 MINUTES	4	OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES	4	16-20 MINUTES	4	OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
5	21-25 MINUTES	5	BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES	5	21-25 MINUTES	5	BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
6	26-30 MINUTES	6	BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES	6	26-30 MINUTES	6	BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
7	31-35 MINUTES	7	BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS	7	31-35 MINUTES	7	BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
8	36-40 MINUTES	8	OVER 2 HOURS (SPECIFY ______)	8	36-40 MINUTES	8	OVER 2 HOURS (SPECIFY ______)
9	41-45 MINUTES	9		9	41-45 MINUTES	9	
		0				0	
		X	DON'T KNOW /REFUSED			X	DON'T KNOW /REFUSED

8. Approximately how much time does it take Commuter #1 to complete preparation for leaving work or college prior to starting the trip home? (REPEAT QUESTION FOR EACH COMMUTER) (DO NOT READ ANSWERS)

COMMUTER #1				COMMUTER #2			
COL. 37		COL. 38		COL. 39		COL. 40	
1	5 MINUTES OR LESS	1	46-50 MINUTES	1	5 MINUTES OR LESS	1	46-50 MINUTES
2	6-10 MINUTES	2	51-55 MINUTES	2	6-10 MINUTES	2	51-55 MINUTES
3	11-15 MINUTES	3	56 – 1 HOUR	3	11-15 MINUTES	3	56 – 1 HOUR
4	16-20 MINUTES	4	OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES	4	16-20 MINUTES	4	OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
5	21-25 MINUTES	5	BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES	5	21-25 MINUTES	5	BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
6	26-30 MINUTES	6	BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES	6	26-30 MINUTES	6	BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
7	31-35 MINUTES	7	BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS	7	31-35 MINUTES	7	BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
8	36-40 MINUTES	8	OVER 2 HOURS (SPECIFY ______)	8	36-40 MINUTES	8	OVER 2 HOURS (SPECIFY ______)
9	41-45 MINUTES	9		9	41-45 MINUTES	9	
		0				0	
		X	DON'T KNOW /REFUSED			X	DON'T KNOW /REFUSED

COMMUTER #3				COMMUTER #4			
COL. 41		COL. 42		COL. 43		COL. 44	
1	5 MINUTES OR LESS	1	46-50 MINUTES	1	5 MINUTES OR LESS	1	46-50 MINUTES
2	6-10 MINUTES	2	51-55 MINUTES	2	6-10 MINUTES	2	51-55 MINUTES
3	11-15 MINUTES	3	56 – 1 HOUR	3	11-15 MINUTES	3	56 – 1 HOUR
4	16-20 MINUTES	4	OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES	4	16-20 MINUTES	4	OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
5	21-25 MINUTES	5	BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES	5	21-25 MINUTES	5	BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
6	26-30 MINUTES	6	BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES	6	26-30 MINUTES	6	BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
7	31-35 MINUTES	7	BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS	7	31-35 MINUTES	7	BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
8	36-40 MINUTES	8	OVER 2 HOURS (SPECIFY ______)	8	36-40 MINUTES	8	OVER 2 HOURS (SPECIFY ______)
9	41-45 MINUTES	9		9	41-45 MINUTES	9	
		0				0	
		X	DON'T KNOW /REFUSED			X	DON'T KNOW /REFUSED

9. 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? (DO NOT READ ANSWERS)

COL. 45

1 LESS THAN 15 MINUTES
2 15-30 MINUTES
3 31-45 MINUTES
4 46 MINUTES – 1 HOUR
5 1 HOUR TO 1 HOUR 15 MINUTES
6 1 HOUR 16 MINUTES TO 1 HOUR 30 MINUTES
7 1 HOUR 31 MINUTES TO 1 HOUR 45 MINUTES
8 1 HOUR 46 MINUTES TO 2 HOURS
9 2 HOURS TO 2 HOURS 15 MINUTES
0 2 HOURS 16 MINUTES TO 2 HOURS 30 MINUTES
X 2 HOURS 31 MINUTES TO 2 HOURS 45 MINUTES
Y 2 HOURS 46 MINUTES TO 3 HOURS

COL. 46

1 3 HOURS TO 3 HOURS 15 MINUTES
2 3 HOURS 16 MINUTES TO 3 HOURS 30 MINUTES
3 3 HOURS 31 MINUTES TO 3 HOURS 45 MINUTES
4 3 HOURS 46 MINUTES TO 4 HOURS
5 4 HOURS TO 4 HOURS 15 MINUTES
6 4 HOURS 16 MINUTES TO 4 HOURS 30 MINUTES
7 4 HOURS 31 MINUTES TO 4 HOURS 45 MINUTES
8 4 HOURS 46 MINUTES TO 5 HOURS
9 5 HOURS TO 5 HOURS 30 MINUTES
0 5 HOURS 31 MINUTES TO 6 HOURS
X OVER 6 HOURS (SPECIFY _______)

COL. 47

1 DON'T KNOW/REFUSED

10. If there is 6-8” 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” of snow to move the car from the driveway or curb to begin the evacuation trip? Assume the roads are passable. (DO NOT READ RESPONSES)

COL. 48

1 LESS THAN 15 MINUTES
2 15-30 MINUTES
3 31-45 MINUTES
4 46 MINUTES – 1 HOUR
5 1 HOUR TO 1 HOUR 15 MINUTES
6 1 HOUR 16 MINUTES TO 1 HOUR 30 MINUTES
7 1 HOUR 31 MINUTES TO 1 HOUR 45 MINUTES
8 1 HOUR 46 MINUTES TO 2 HOURS
9 2 HOURS TO 2 HOURS 15 MINUTES
0 2 HOURS 16 MINUTES TO 2 HOURS 30 MINUTES
X 2 HOURS 31 MINUTES TO 2 HOURS 45 MINUTES
Y 2 HOURS 46 MINUTES TO 3 HOURS
Z NO, WILL NOT SHOVEL OUT

COL. 49

1 OVER 3 HOURS (SPECIFY _______)
2 DON’T KNOW/REFUSED

11. Please choose one of the following (READ ANSWERS):

If you were at home and were asked to evacuate,

A. I would await the return of household commuters to evacuate together.

B. I would evacuate independently and meet other household members later.

COL. 50

1 A
2 B
X DON’T KNOW/REFUSED

12. How many vehicles would your household use during an evacuation? (DO NOT READ ANSWERS)

COL. 51

1 ONE
2 TWO
3 THREE
4 FOUR
5 FIVE
6 SIX
7 SEVEN
8 EIGHT
9 NINE OR MORE
0 ZERO (NONE)
X DON’T KNOW/REFUSED

13A.	Emergency officials advise you to take shelter at home in an emergency. Would you: (READ ANSWERS) A. SHELTER; or B. EVACUATE	<u>COL. 52</u> 1 A 2 B X DON'T KNOW/REFUSED
13B.	Emergency officials advise you to take shelter at home now in an emergency and possibly evacuate later while people in other areas are advised to evacuate now. Would you: (READ ANSWERS) A. SHELTER; or B. EVACUATE	<u>COL. 53</u> 1 A 2 B X DON'T KNOW/REFUSED

14. If you have a household pet, how many of them would you take with you if you were asked to evacuate the area? (READ ANSWERS)

<u>COL. 54</u>

0 WOULD NOT TAKE PET
1 WOULD TAKE ONE PET
2 WOULD TAKE TWO PETS
3 WOULD TAKE MORE THAN 2 PETS
X DO NOT HAVE A PET
Y DON'T KNOW/REFUSED

Thank you very much. ________________________________

(TELEPHONE NUMBER CALLED)

<u>IF REQUESTED:</u>

For additional information, contact your County Emergency Management Agency during normal business hours.

County	EMA Phone
Kewaunee	(920) 487-2940
Manitowoc	(920) 683-4207

APPENDIX G

Traffic Management Plan

G. TRAFFIC MANAGEMENT PLAN

NUREG/CR-7002 indicates that the existing TCPs identified by the offsite agencies should be used in the evacuation simulation modeling. The traffic and access control plans for the EPZ were provided by each county.

These plans were reviewed and the TCPs were modeled accordingly.

G.1 Traffic Control Points

As discussed in Section 9, traffic control points 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 a traffic control point, the control type was changed to an actuated signal in the DYNEV II system. Table K-2 provides the control type and node number for those nodes which are controlled. If the existing control was changed due to the point being a TCP, the control type is indicated as "Traffic Control Point" in Table K-2.

It is assumed that TCPs will be established within 2 hours of the advisory to evacuate to discourage through travelers from using major through routes which traverse the EPZ. As discussed in Section 3.7, external traffic was considered on one route which traverses the study area – I 43 – in this analysis. The generation of the external trips on I 43 are also assumed to cease at 2 hours after the advisory to evacuate in the simulation.

Figure G-1 maps the TCPs identified in the county emergency plans. These TCPs are concentrated on roadways giving access to the EPZ and would be manned during evacuation by traffic guides who would direct evacuees in the proper direction away from KPS and facilitate the flow of traffic through the intersections.

This study did not identify any additional intersections that should be identified as TCPs.

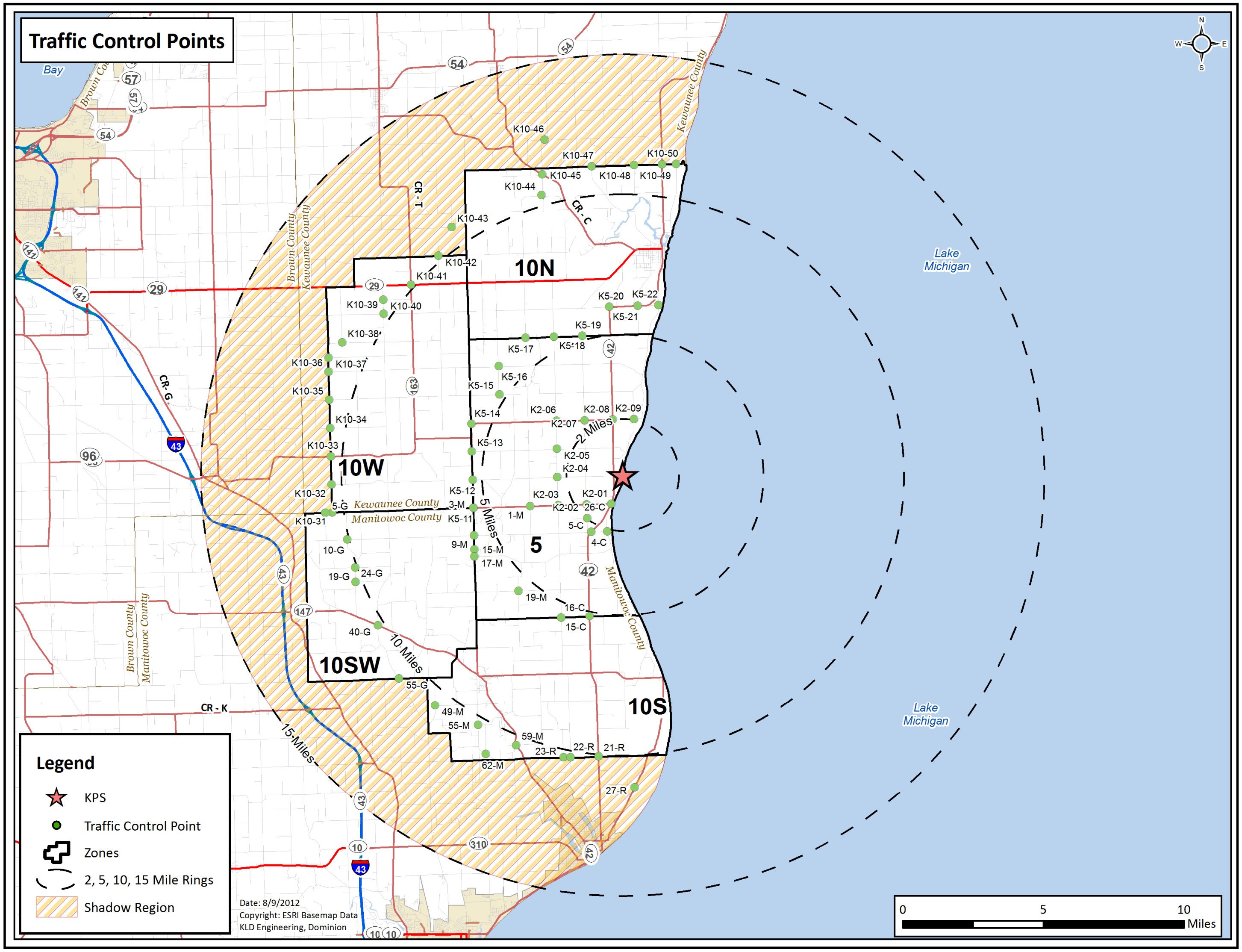


Figure G-1. Traffic Control Points for the Kewaunee Power Station

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. The percentages presented in Table H-1 are based on the methodology discussed in assumption 5 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.

Table H-1. Percent of Zone Population Evacuating for Each Region

Region	Description	Zone 5	Zone 10N	Zone 10W	Zone 10SW	Zone 10S
R01	2-Mile Radius	100%	20%	20%	20%	20%
N/A	5-Mile Radius	Refer to R01				
R02	Full EPZ	100%	100%	100%	100%	100%
Evacuate 2-Mile Radius and Downwind to 5 Miles						
Region	**Wind From °**	**5**	**10N**	**10W**	**10SW**	**10S**
N/A	Full 360	Refer to R01				
Evacuate 5-Mile Radius and Downwind to 10 Miles						
Region	**Wind From °**	**5**	**10N**	**10W**	**10SW**	**10S**
R03	324 - 9	100%	20%	20%	20%	100%
R04	9 – 54	100%	20%	20%	100%	100%
R05	54 – 80.5	100%	20%	100%	100%	100%
R06	80.5 – 99	100%	20%	100%	100%	20%
R07	99 – 103	100%	100%	100%	100%	20%
R08	103 – 170.5	100%	100%	100%	20%	20%
R09	170.5 – 215.5	100%	100%	20%	20%	20%
N/A	215.5 – 324	Refer to R01				
Staged Evacuation - 5-Mile Radius Evacuates, then Evacuate Downwind to 10 Miles						
Region	**Wind From °**	**5**	**10N**	**10W**	**10SW**	**10S**
R10	324 - 9	100%	20%	20%	20%	100%
R11	9 – 54	100%	20%	20%	100%	100%
R12	54 – 80.5	100%	20%	100%	100%	100%
R13	80.5 – 99	100%	20%	100%	100%	20%
R14	99 – 103	100%	100%	100%	100%	20%
R15	103 – 170.5	100%	100%	100%	20%	20%
R16	170.5 – 215.5	100%	100%	20%	20%	20%
N/A	215.5 – 324	Refer to R01				
R17	Full EPZ	100%	100%	100%	100%	100%

Legend: Zone(s) Shelter-in-Place until 90% ETE for R01, then Evacuate[1] (blue) | Zone(s) Shelter-in-Place (white) | Zone(s) Evacuate (red)

[1] 20% of population in these subareas will not comply with the shelter advisory, as per Section 2.5.2 of NUREG/CR-7002. Once 90% of the 2-mile Region has evacuated, the remaining population in these subareas will evacuate.

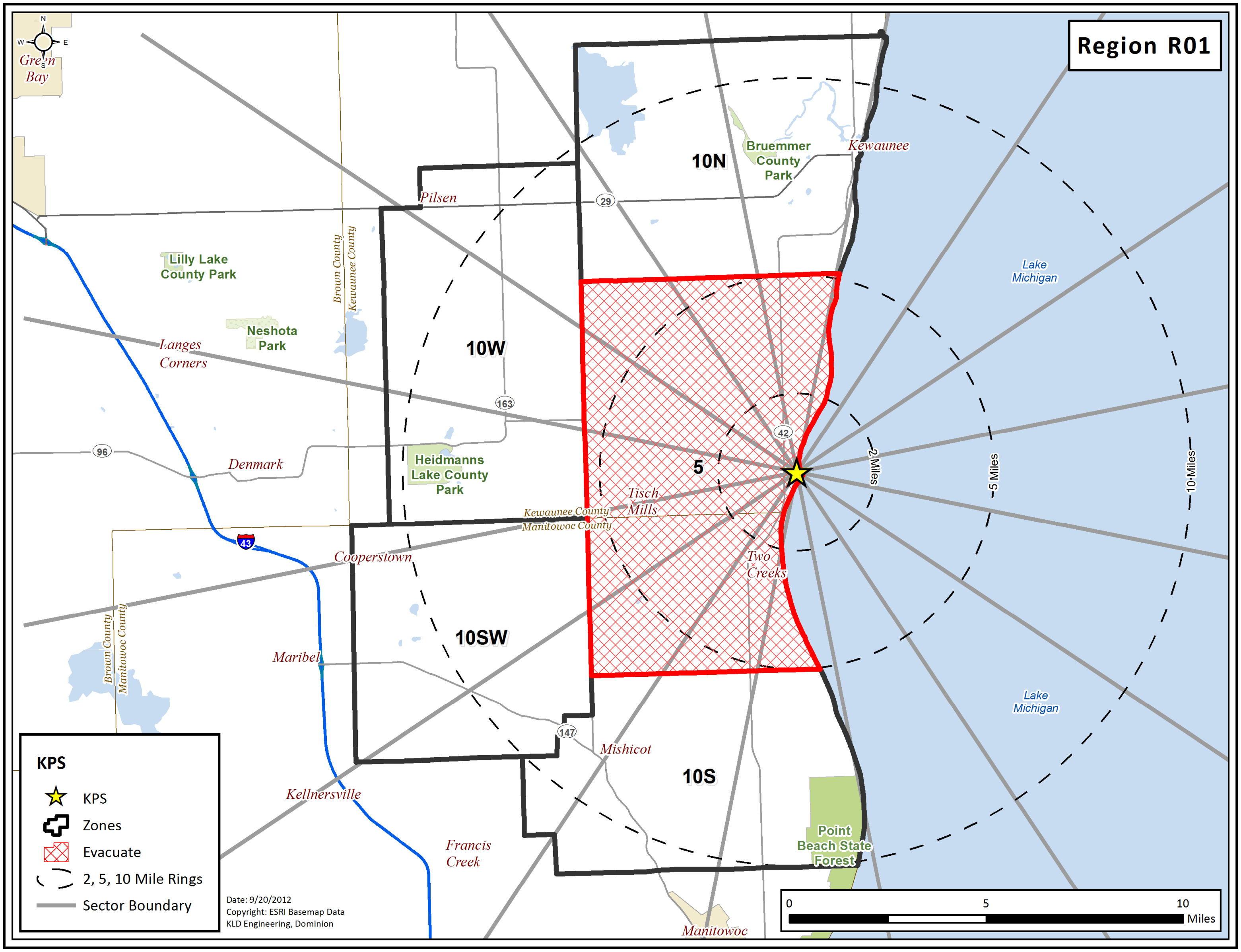


Figure H-1. Region R01

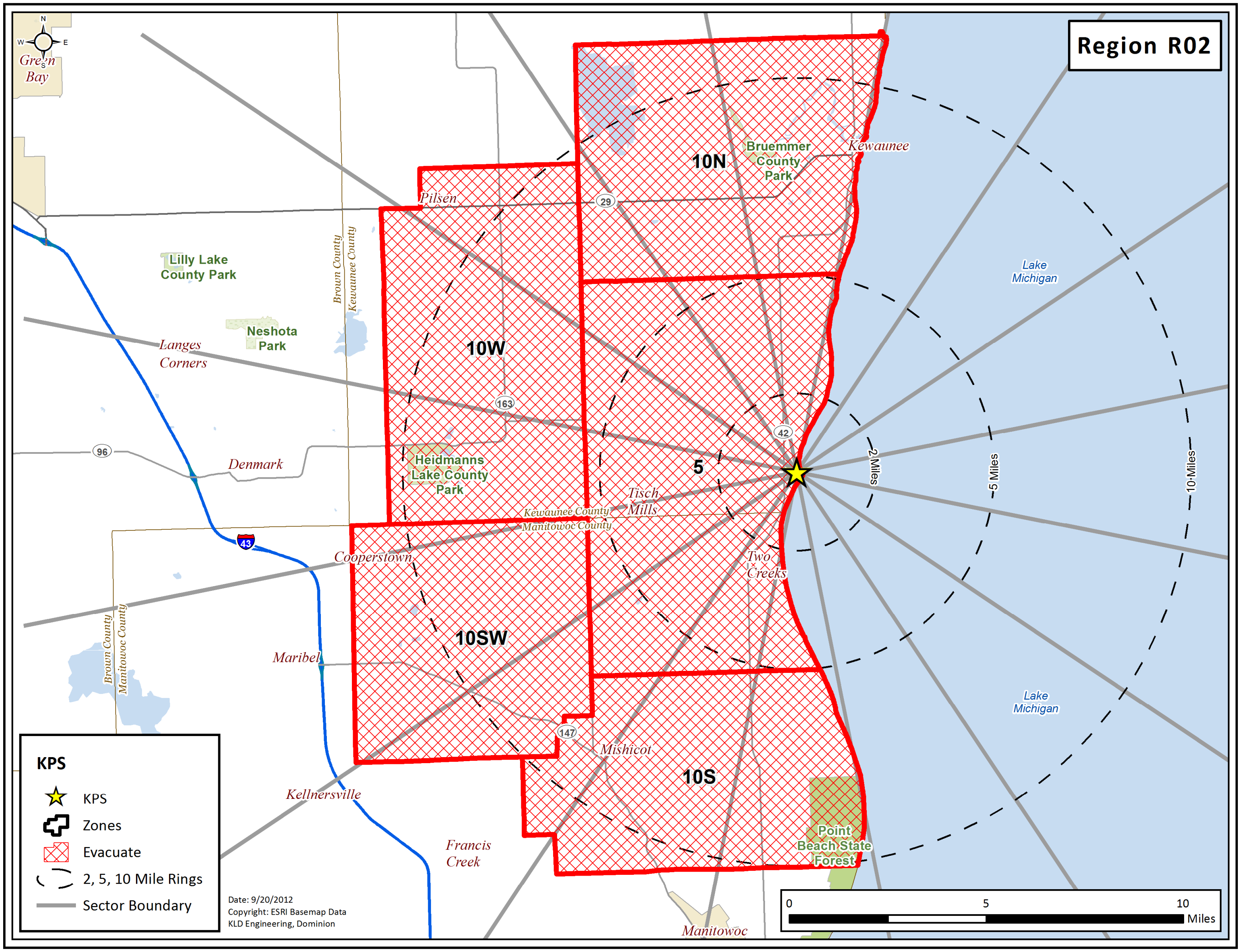


Figure H-2. Region R02

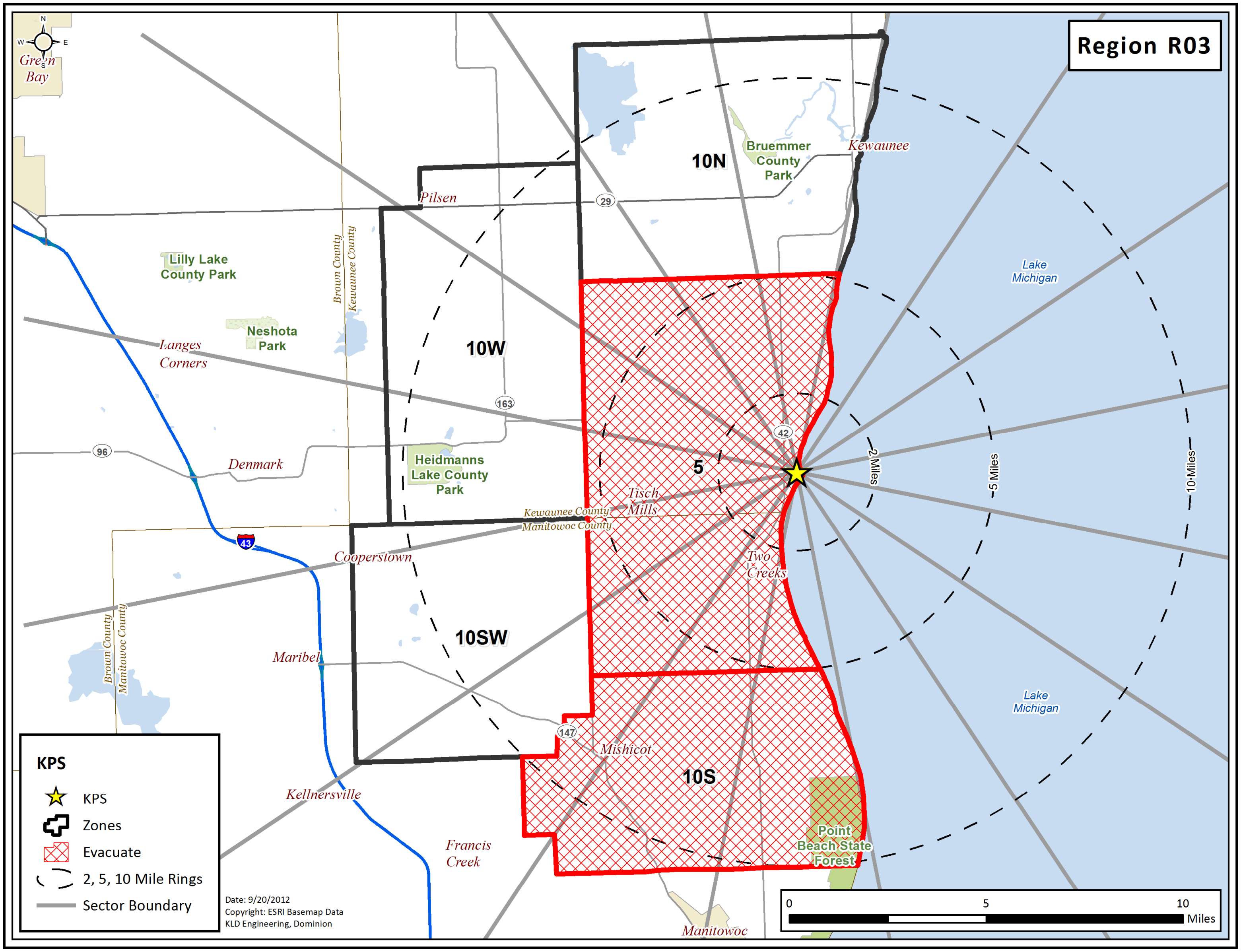


Figure H-3. Region R03

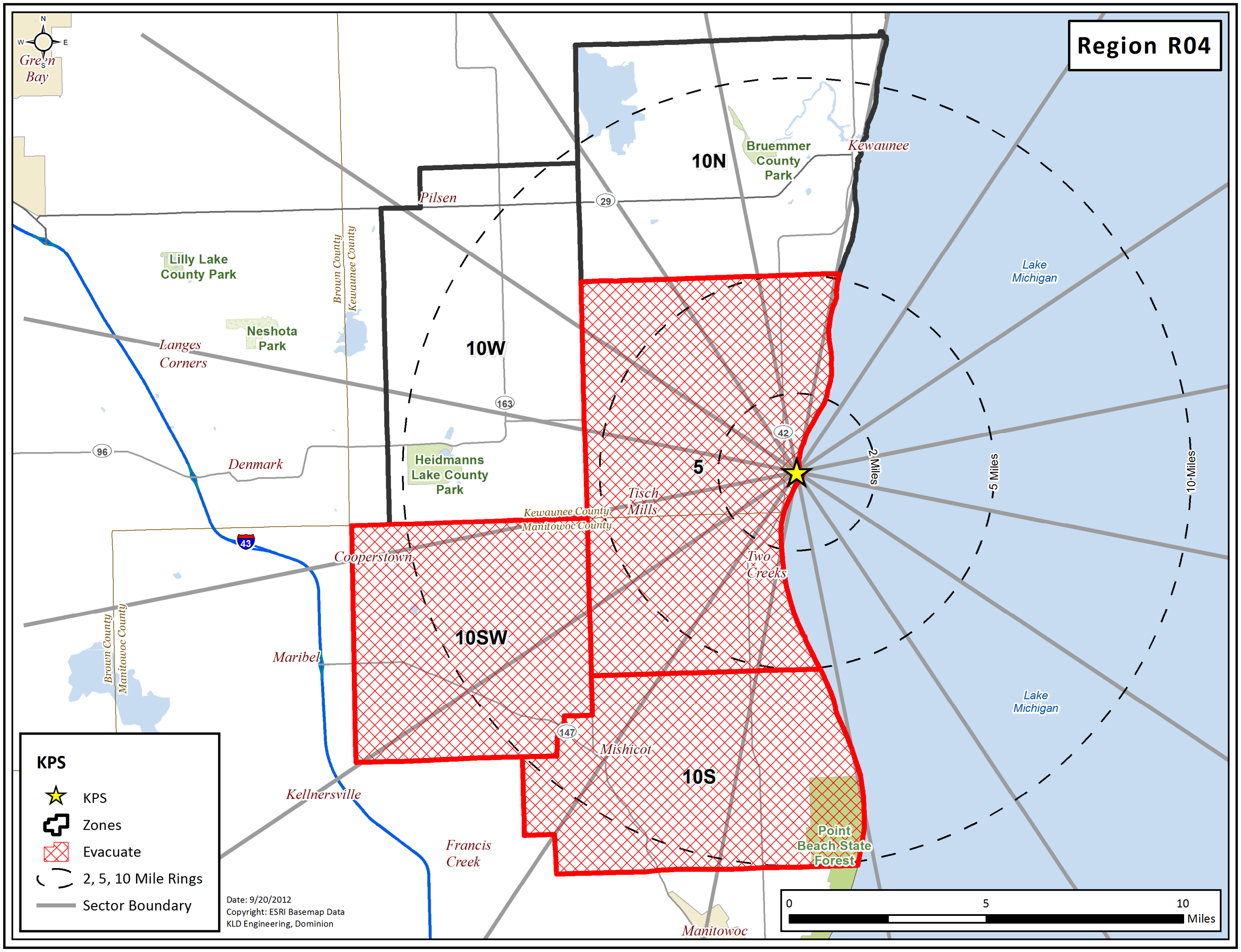


Figure H-4. Region R04

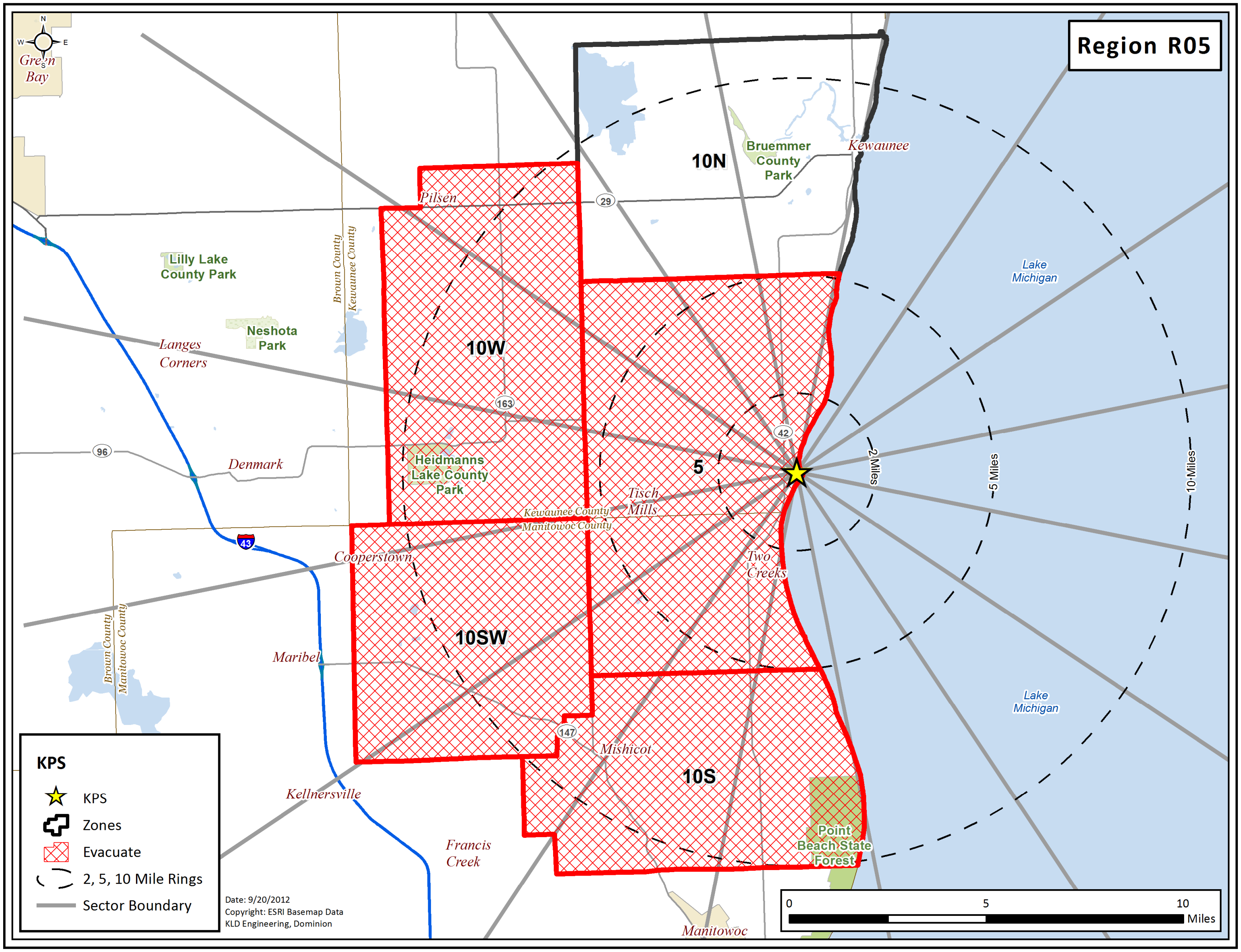


Figure H-5. Region R05

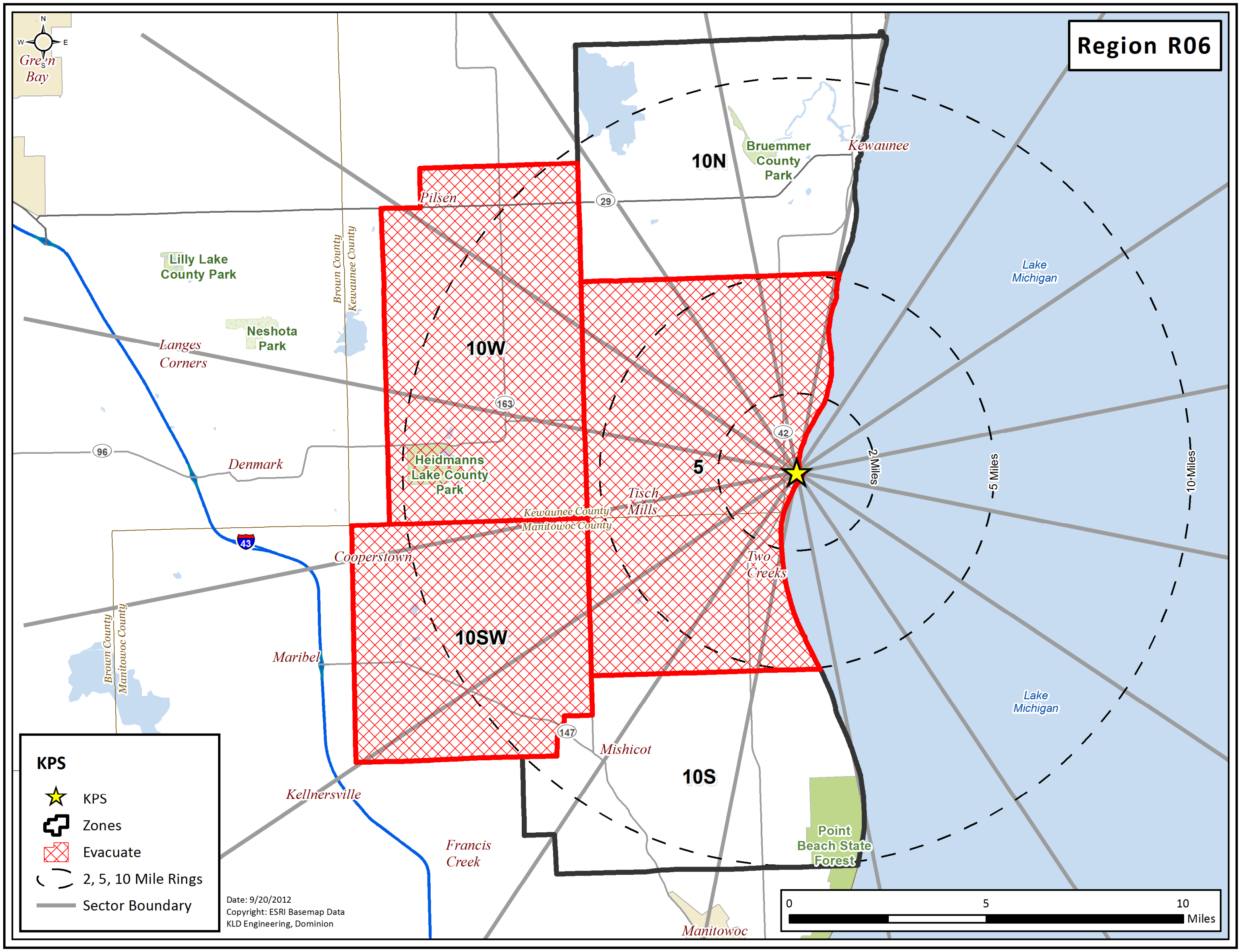


Figure H-6. Region R06

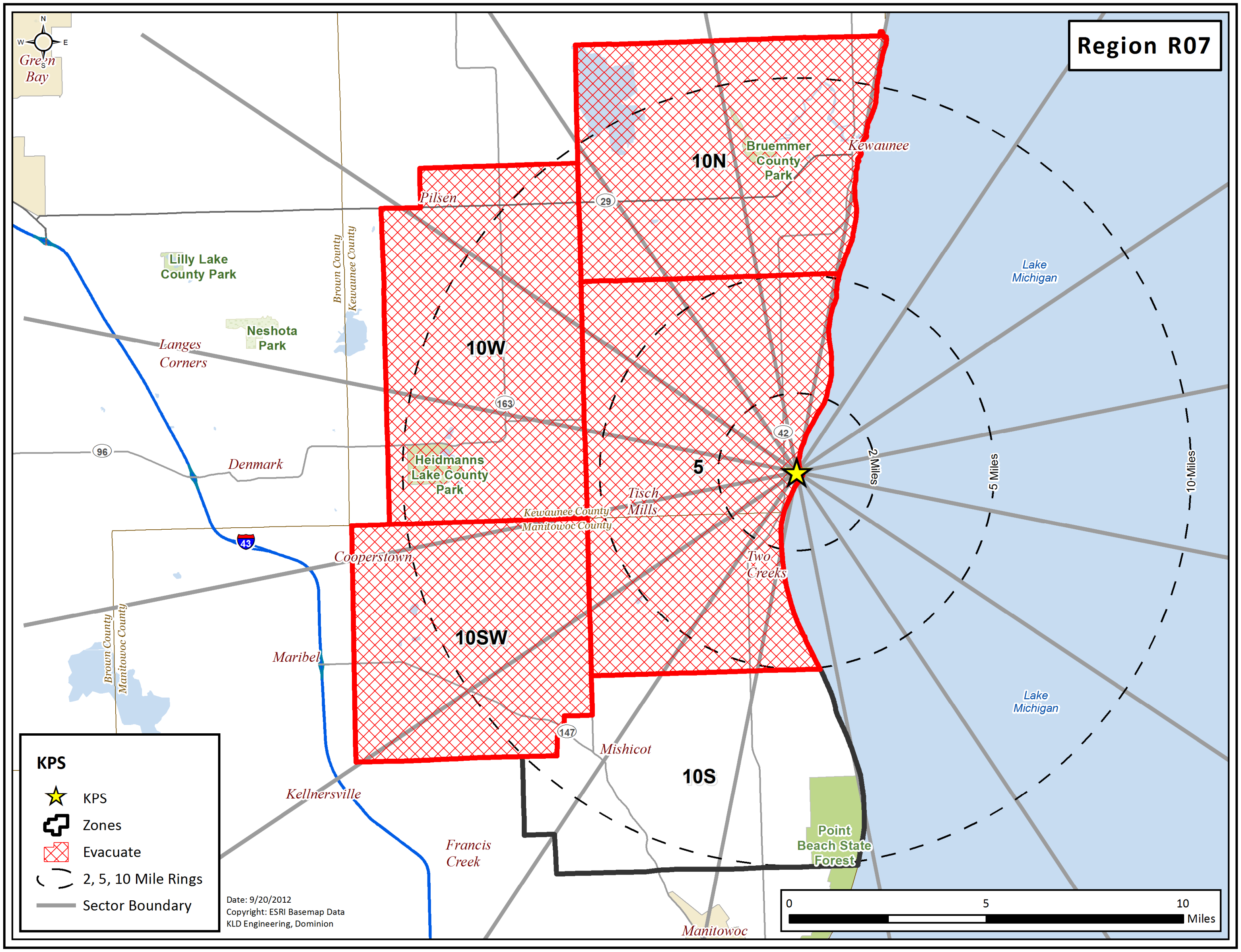


Figure H-7. Region R07

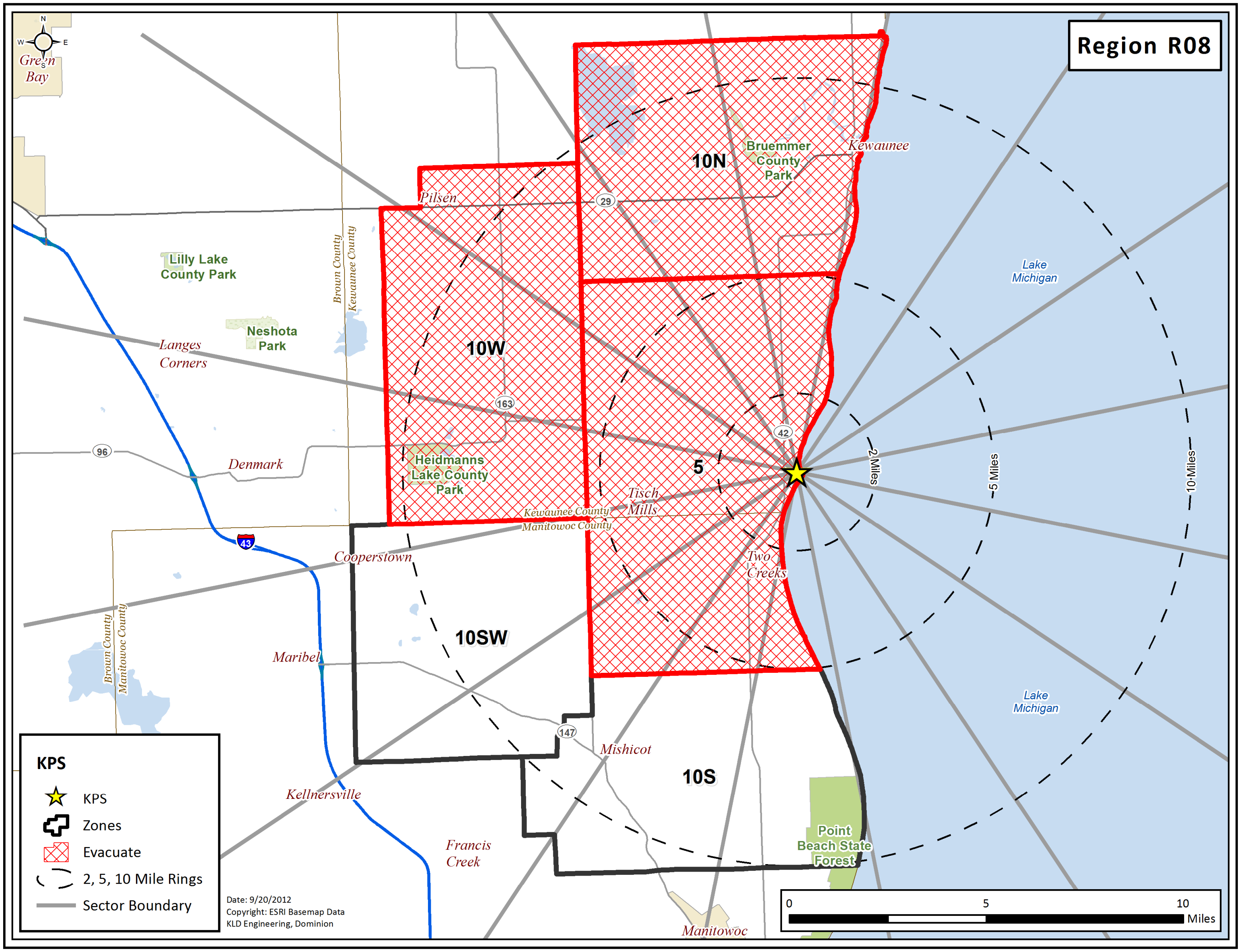


Figure H-8. Region R08

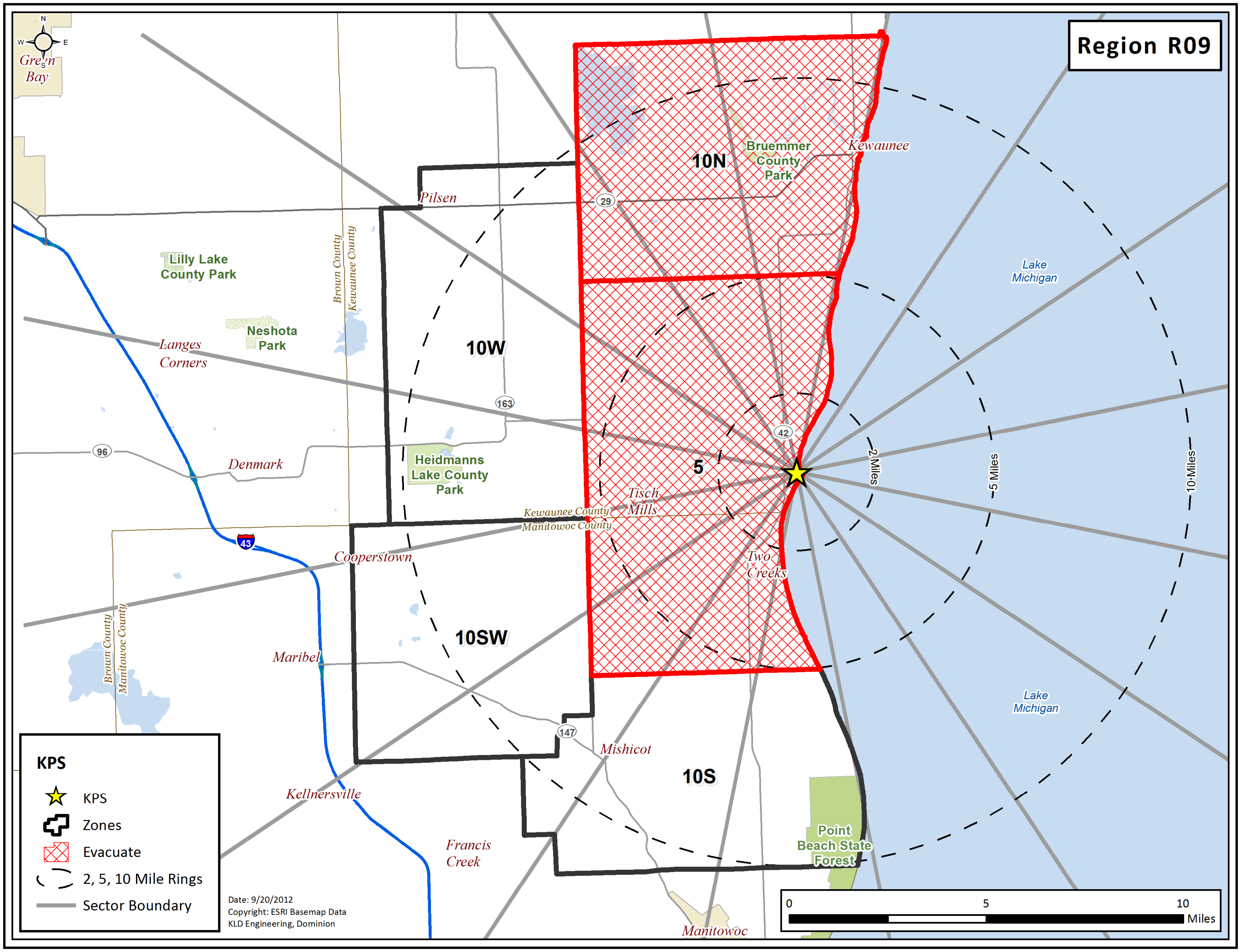


Figure H-9. Region R09

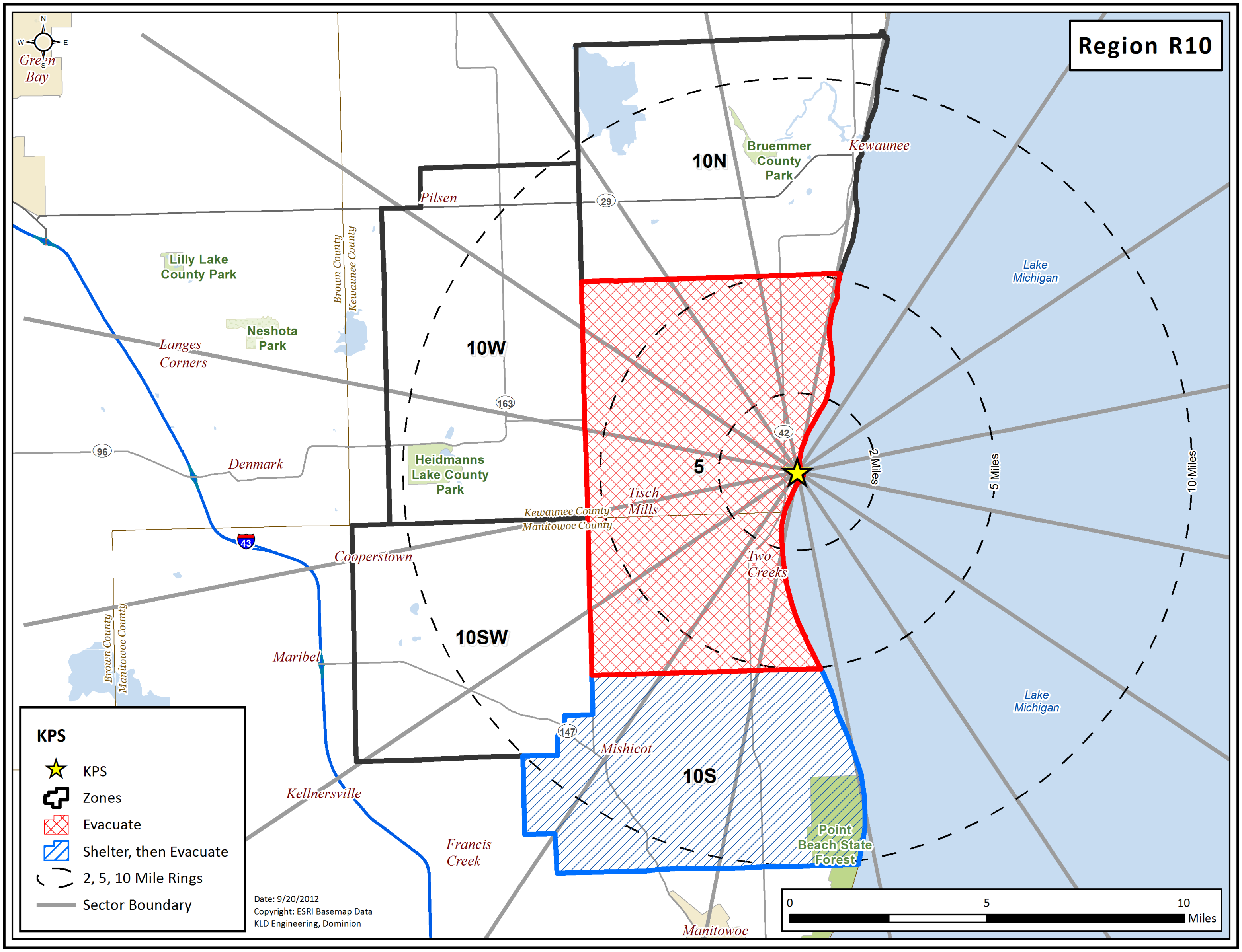


Figure H-10. Region R10

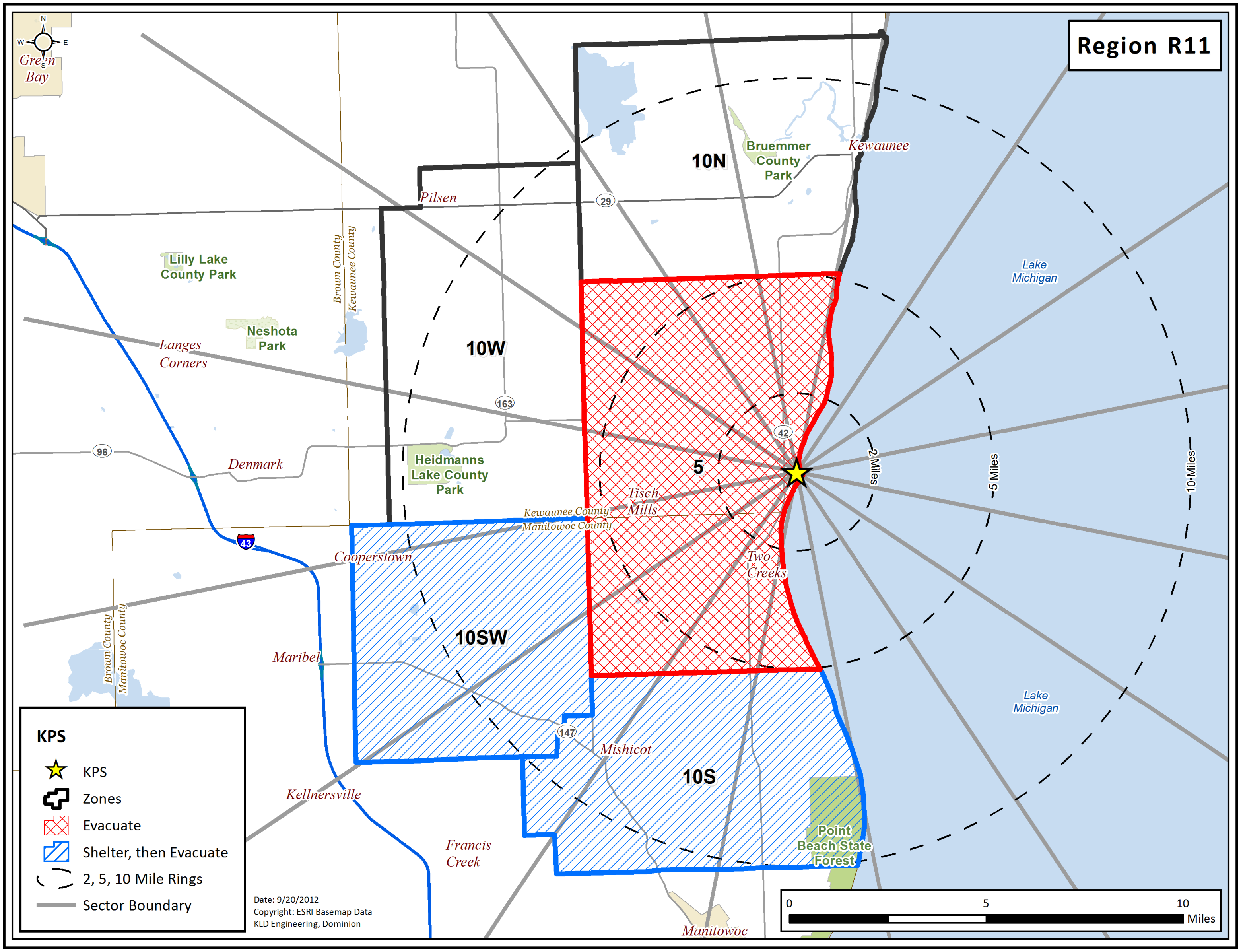


Figure H-11. Region R11

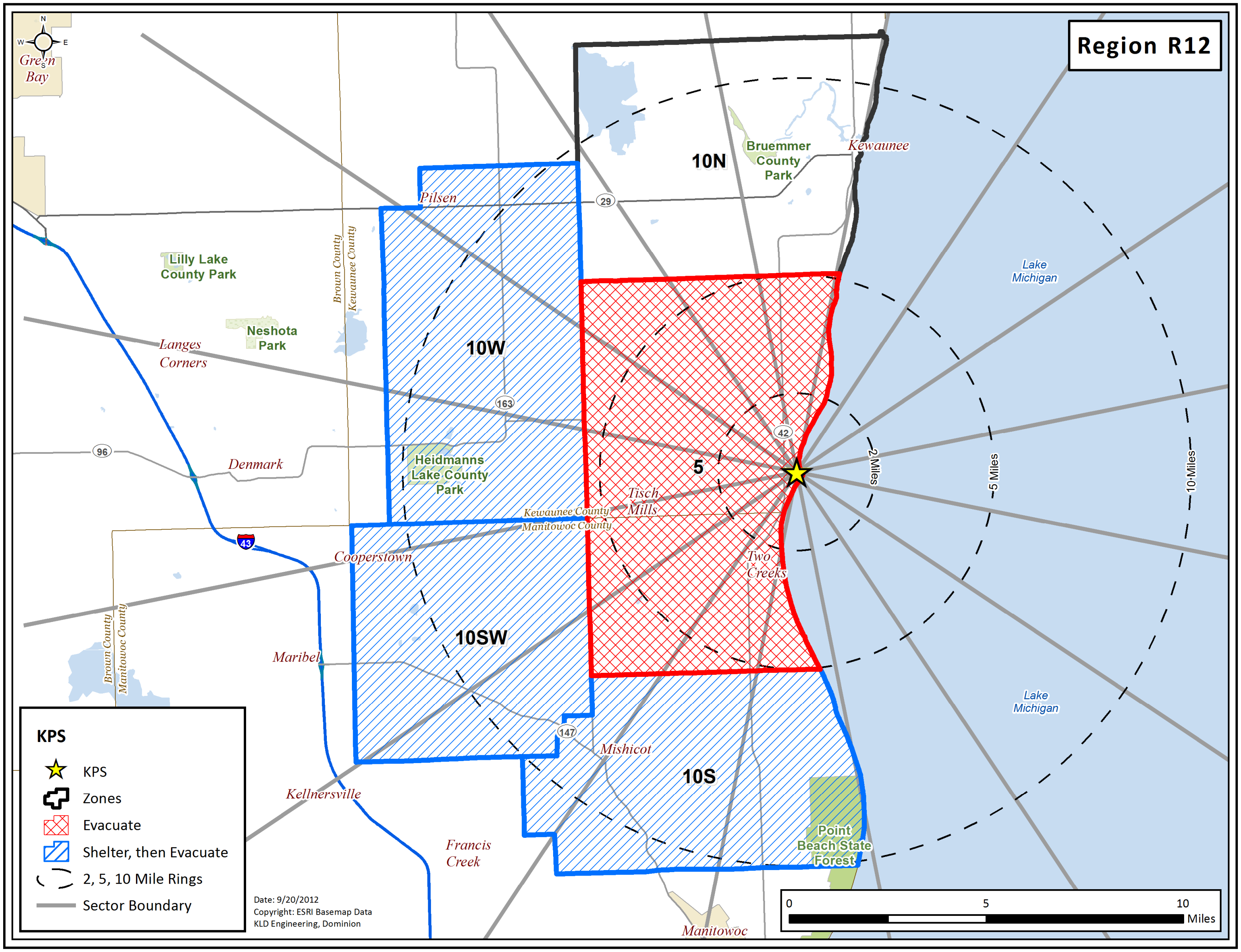


Figure H-12. Region R12

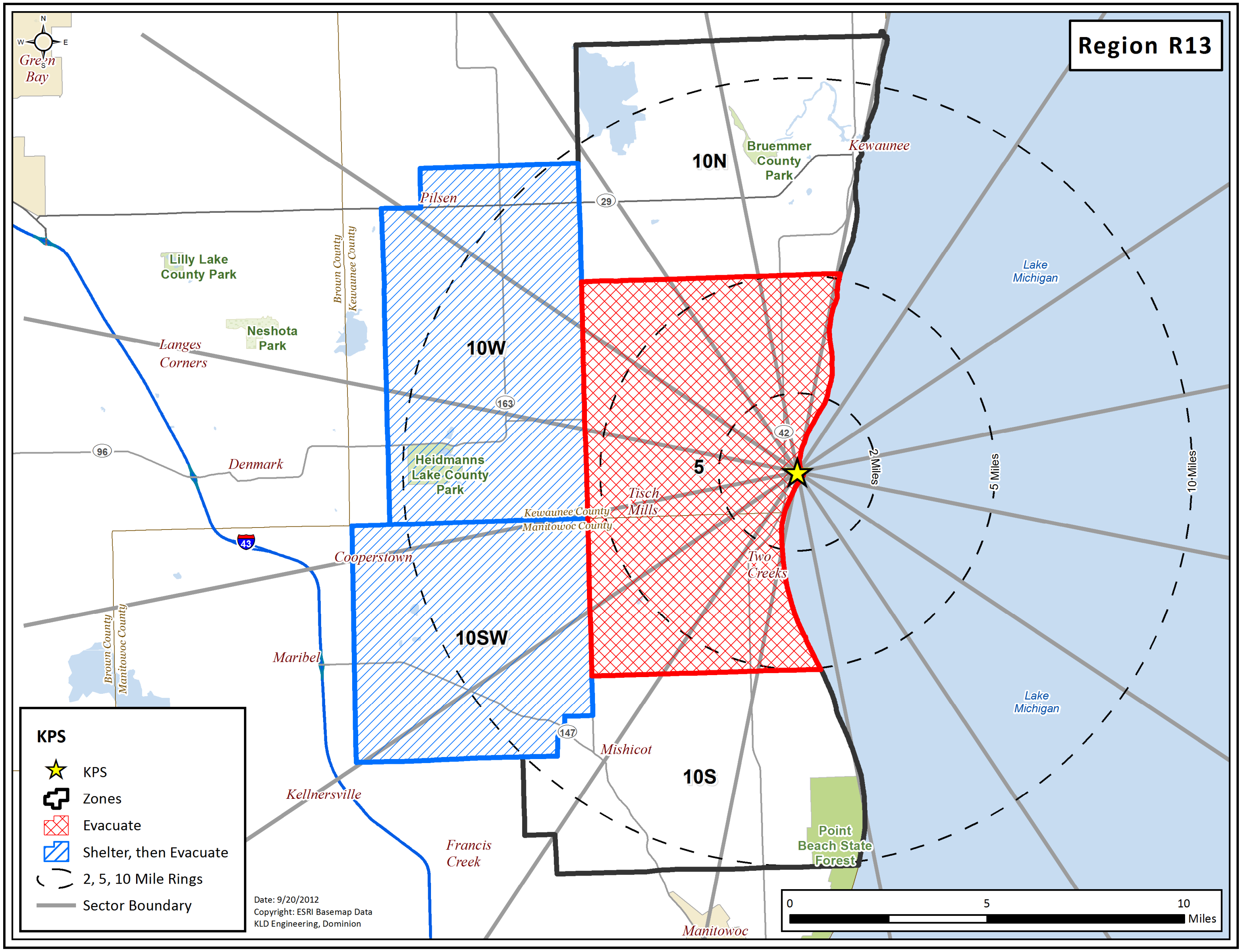


Figure H-13. Region R13

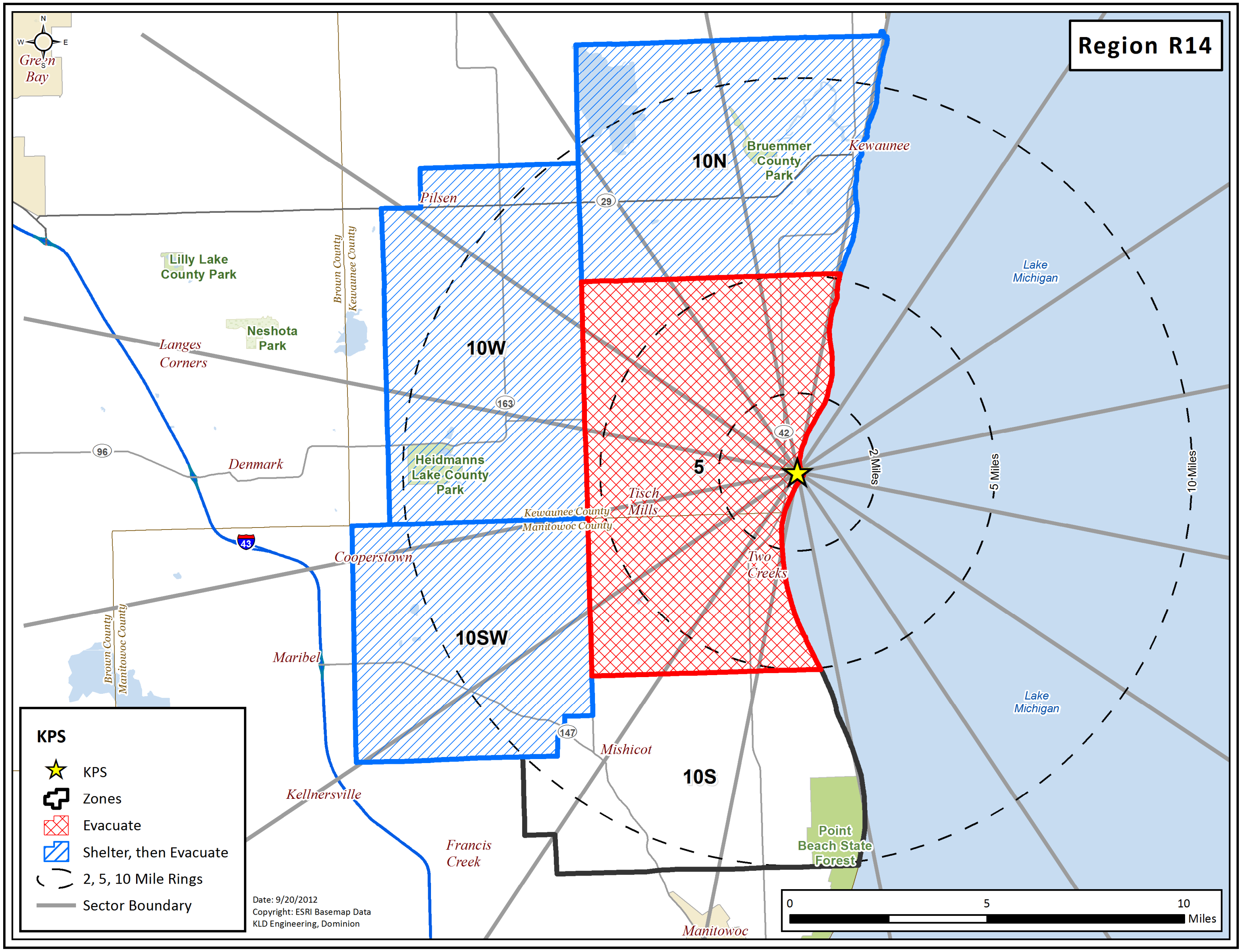


Figure H-14. Region R14

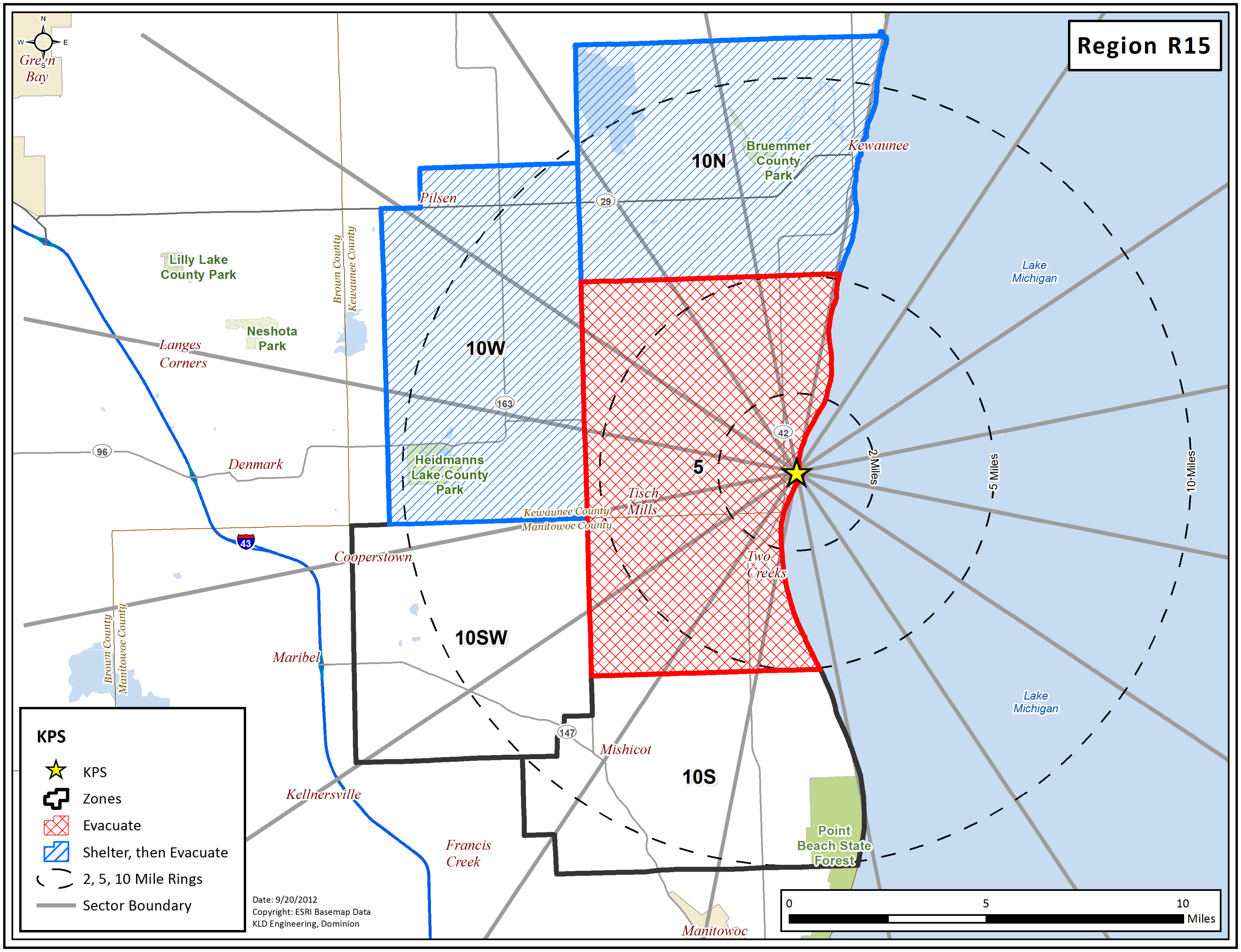


Figure H-15. Region R15

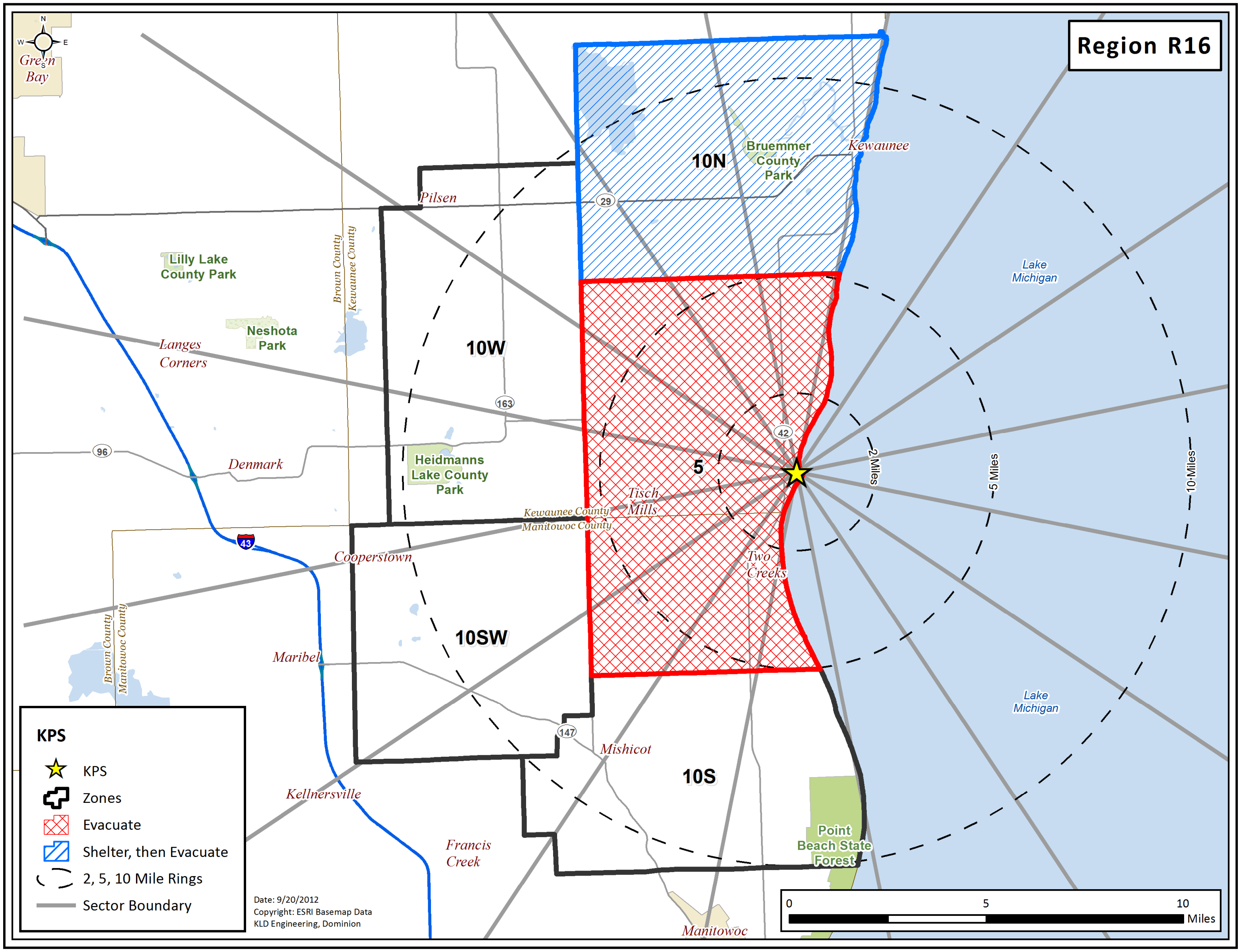


Figure H-16. Region R16

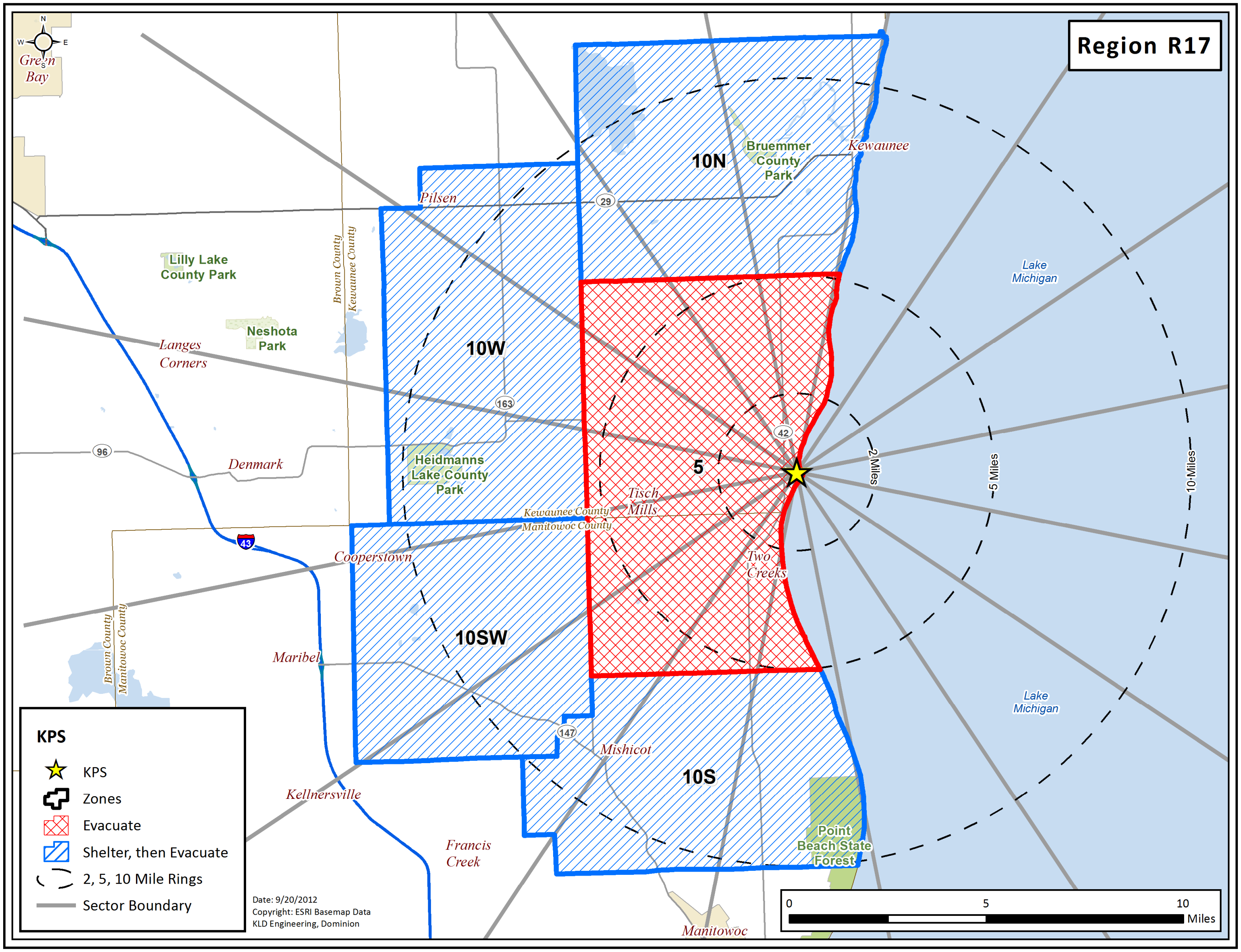


Figure H-17. Region R17

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 the volume and maximum residual queues for the ten highest volume signalized intersections in the study area. A residual queue exists at the start of the RED signal indication, indicating that the demand could not be entirely served by the GREEN phase. A zero residual queue indicates that the traffic movement is under-saturated (i.e., not congested) throughout the duration of evacuation. Refer to Table K-2 and the figures in Appendix K for a map showing the geographic location of each intersection.

Table J-2 provides source (vehicle loading) and destination information for several roadway segments (links) in the analysis network. Refer to Table K-1 and the figures in Appendix K for a map showing the geographic location of each link.

Table J-3 provides network–wide statistics (average travel time, average speed and number of vehicles) for an evacuation of the entire EPZ (Region R02) for each scenario. As expected, Scenarios 8 and 11, which are snow scenarios, exhibit the slowest average speed and longest average travel times.

Table J-4 provides statistics (average speed and travel time) for the major evacuation routes – SR 42 and SR 29 – for an evacuation of the entire EPZ (Region R02) under Scenario 1 conditions. As discussed in Section 7.3 and shown in Figures 7-3 through 7-6, there is very little congestion in the EPZ throughout the duration of the evacuation. As such, the average speeds on the main evacuation routes are relatively unaffected.

Table J-5 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 R02) under Scenario 1 conditions. Refer to Table K-1 and the figures in Appendix K for a map showing the geographic location of each link.

Figure J-1 through Figure J-14 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-1 through Figure J-14, the curves are close together as a result of the minimal traffic congestion in the EPZ, which was discussed in detail in Section 7.3.

Table J-1. Characteristics of the Ten Highest Volume Signalized Intersections

Node	Location	Intersection Control	Approach (Up Node)	Total Volume (Veh)	Max. Turn Queue (Veh)
270	Memorial Dr & E. Reed Ave	Actuated	218	2,547	0
			269	312	0
			TOTAL	2,859	-
197	Memorial Dr & Taylor St	Actuated	188	2,182	0
			518	0	0
			TOTAL	2,182	-
230	Franklin St & S 10th St	Pretimed	476	2,079	134
			475	0	0
			TOTAL	2,079	-
222	Maritime Dr & S 8th St	Actuated	219	1,864	41
			231	0	0
			TOTAL	1,864	-
172	SR 310 & Monroe St	Actuated	542	1,354	0
			178	201	0
			TOTAL	1,555	-
229	Washington St & S 10th St	Pretimed	478	0	0
			230	1,410	30
			TOTAL	1,410	-
239	Marshall St and S 10th St	Pretimed	472	1,406	0
			471	0	0
			TOTAL	1,406	-
179	SR 310 & Madison St	Actuated	172	1,403	0
			522	0	0
			TOTAL	1,403	-
214	SR 42 & CR B	Pretimed	269	550	0
			516	348	0
			530	377	3
			TOTAL	1,275	-
226	SR 42 & N 11th St	Actuated	214	1,275	0
			272	0	0
			TOTAL	1,275	-

Table J-2. Sample Simulation Model Input

Link Number	Vehicles Entering Network on this Link	Directional Preference	Destination Nodes	Destination Capacity
181	16	SW	8316	1,698
			8311	4,500
229	168	S	8097	1,698
			8316	1,698
			8311	4,500
284	108	S	8316	1,698
			8311	4,500
			8280	1,698
317	6	S	8316	1,698
			8311	4,500
			8280	1,698
59	14	NW	8359	1,698
			8075	1,698
			8076	1,698
551	72	N	8430	1,698
			8002	1,698
			8433	1,698
603	15	N	8433	1,698
			8561	1,572
			8560	1,572
657	9	N	8002	1,698
702	26	W	8114	1,698
			8097	1,698
			8316	1,698
807	3	NW	8359	1,698
			8075	1,698
			8076	1,698

Table J-3. Selected Model Outputs for the Evacuation of the Entire EPZ (Region R02)

Scenario	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Network-Wide Average Travel Time (Min/Veh-Mi)	1.2	1.3	1.2	1.2	1.2	1.2	1.2	1.4	1.1	1.2	1.4	1.2	1.2	1.2
Network-Wide Average Speed (mph)	50.9	47.8	52.3	48.9	49.3	51.8	48.6	43.1	53.4	49.9	44.4	49.4	49.9	50.2
Total Vehicles Exiting Network	16,857	16,761	15,914	15,858	12,279	16,324	16,239	16,419	15,042	14,963	15,072	11,682	17,223	16,907

Table J-4. Average Speed (mph) and Travel Time (min) for Major Evacuation Routes (Region R02, Scenario 1)

Elapsed Time (hours)							
		1		2		3	
Route Name	Length (miles)	Speed (mph)	Travel Time (min)	Speed	Travel Time	Speed	Travel Time
SR 42 Northbound	13.1	57.0	13.8	58.4	13.5	59.0	13.4
SR 42 Southbound	11.5	59.6	11.6	62.4	11.0	65.0	10.6
SR 29 Westbound	7.2	59.2	7.3	60.8	7.1	61.2	7.0

Table J-5. Simulation Model Outputs at Network Exit Links for Region R02, Scenario 1

EPZ Exit Link	Elapsed Time (hours)		
	1	2	3
	Cumulative Vehicles Discharged by Indicated Time		
	Cumulative Percent of Vehicles Discharged by the Indicated Time		
0	0	0	0
	0	0	0
1	216	602	684
	4	4	4
39	1,486	2,992	3,446
	25	21	21
94	224	440	483
	4	3	3
104	66	241	270
	1	2	2
127	87	249	288
	1	2	2
128	112	305	346
	2	2	2
156	320	624	676
	5	4	4
478	86	180	246
	1	1	1
493	1,353	3,008	3,568
	23	21	21
503	48	318	444
	1	2	3
565	174	485	556
	3	3	3
654	239	508	557
	4	4	3
658	503	1,017	1,115
	8	7	7
662	321	663	726
	5	5	4
784	164	464	582
	3	3	3

EPZ Exit Link	Elapsed Time (hours)		
	1	2	3
	Cumulative Vehicles Discharged by Indicated Time		
	Cumulative Percent of Vehicles Discharged by the Indicated Time		
787	80	207	231
	1	1	1
812	162	499	570
	3	4	3
813	73	242	281
	1	2	2
833	243	1,175	1,671
	4	8	10

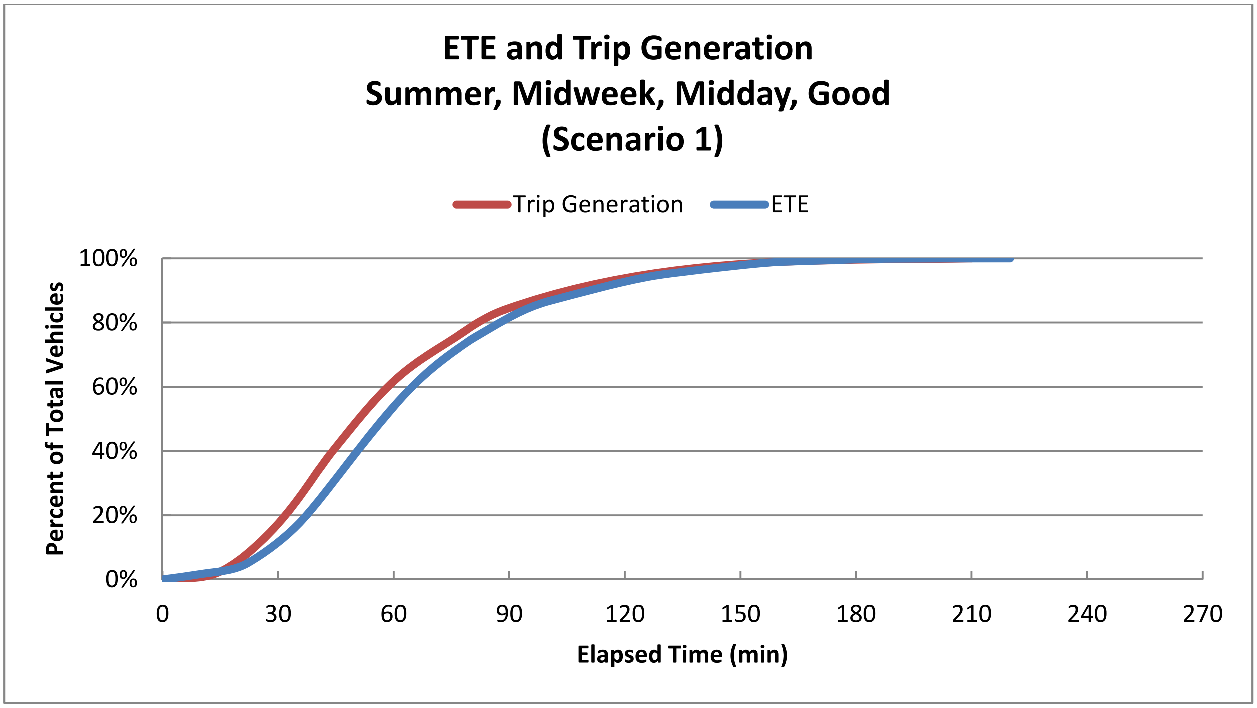


Figure J-1. ETE and Trip Generation: Summer, Midweek, Midday, Good Weather (Scenario 1)

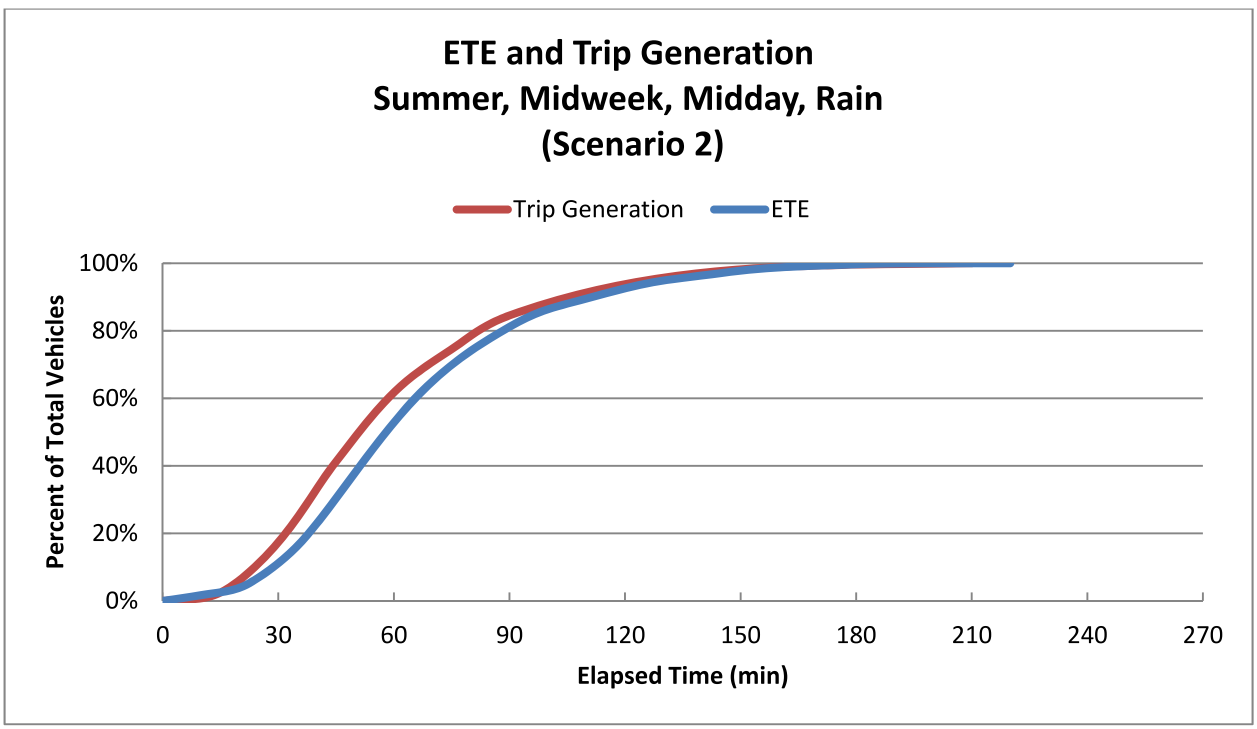


Figure J-2. ETE and Trip Generation: Summer, Midweek, Midday, Rain (Scenario 2)

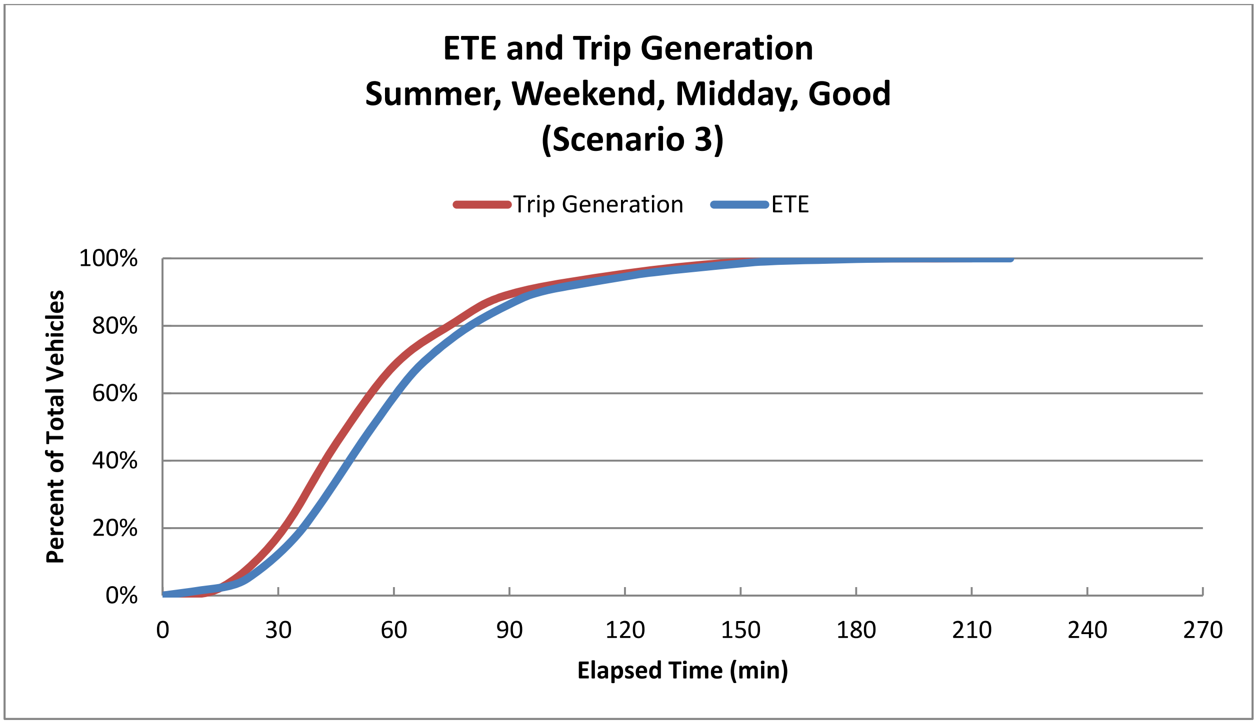


Figure J-3. ETE and Trip Generation: Summer, Weekend, Midday, Good Weather (Scenario 3)

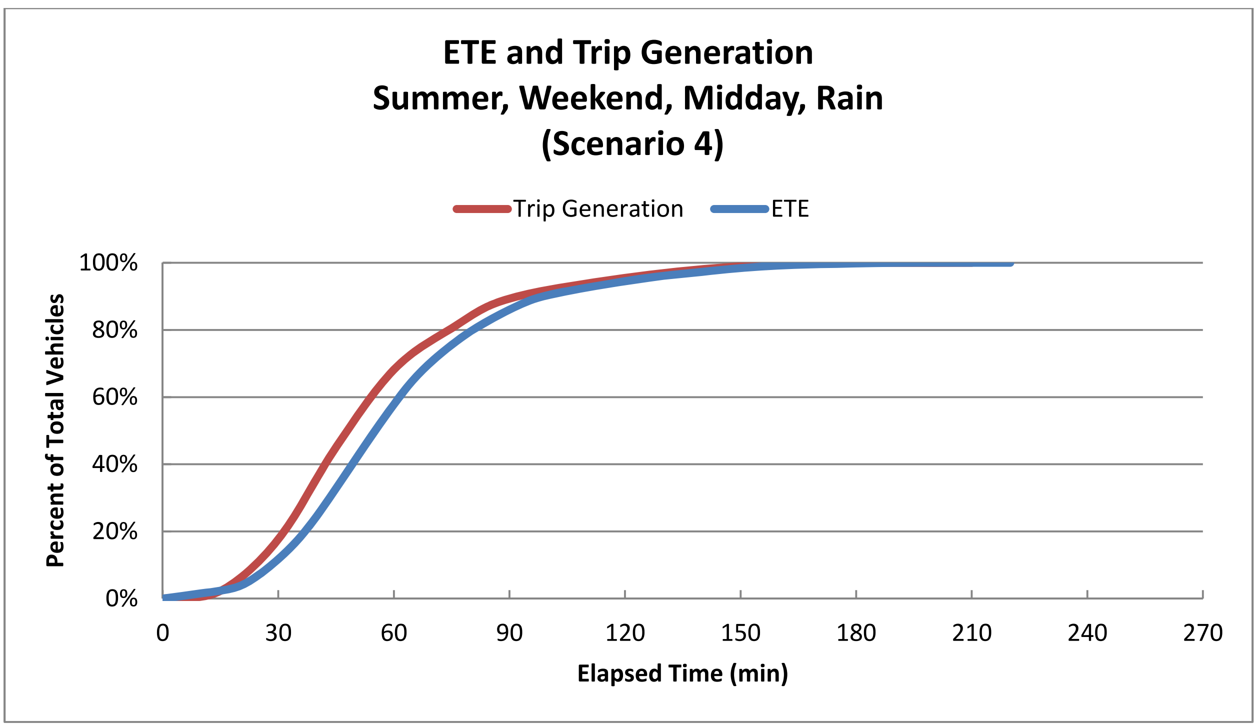


Figure J-4. ETE and Trip Generation: Summer, Weekend, Midday, Rain (Scenario 4)

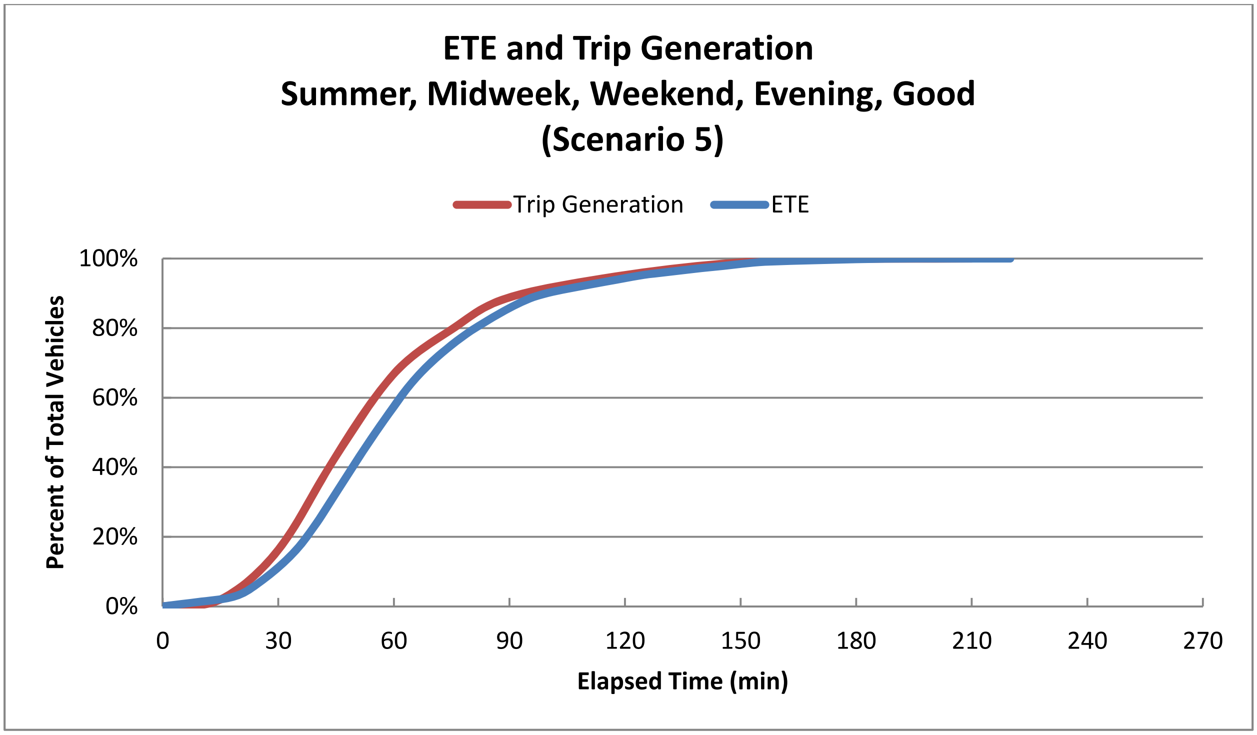


Figure J-5. ETE and Trip Generation: Summer, Midweek, Weekend, Evening, Good Weather (Scenario 5)

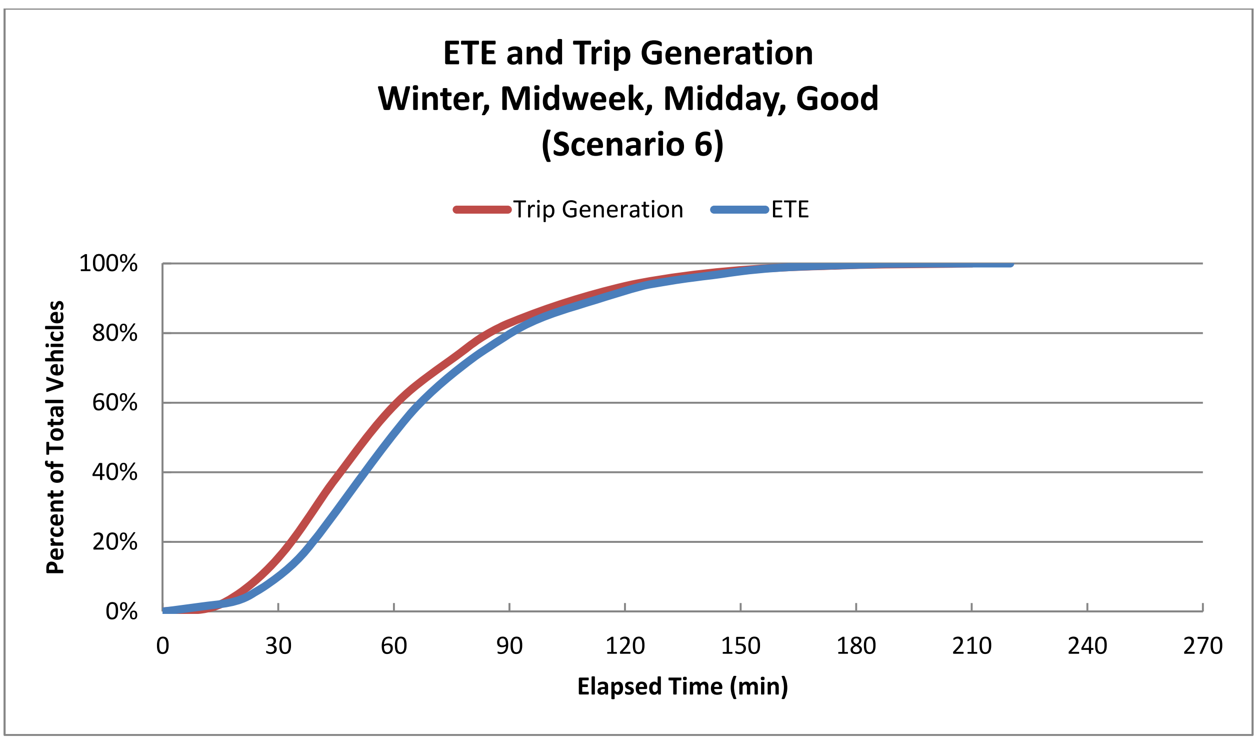


Figure J-6. ETE and Trip Generation: Winter, Midweek, Midday, Good Weather (Scenario 6)

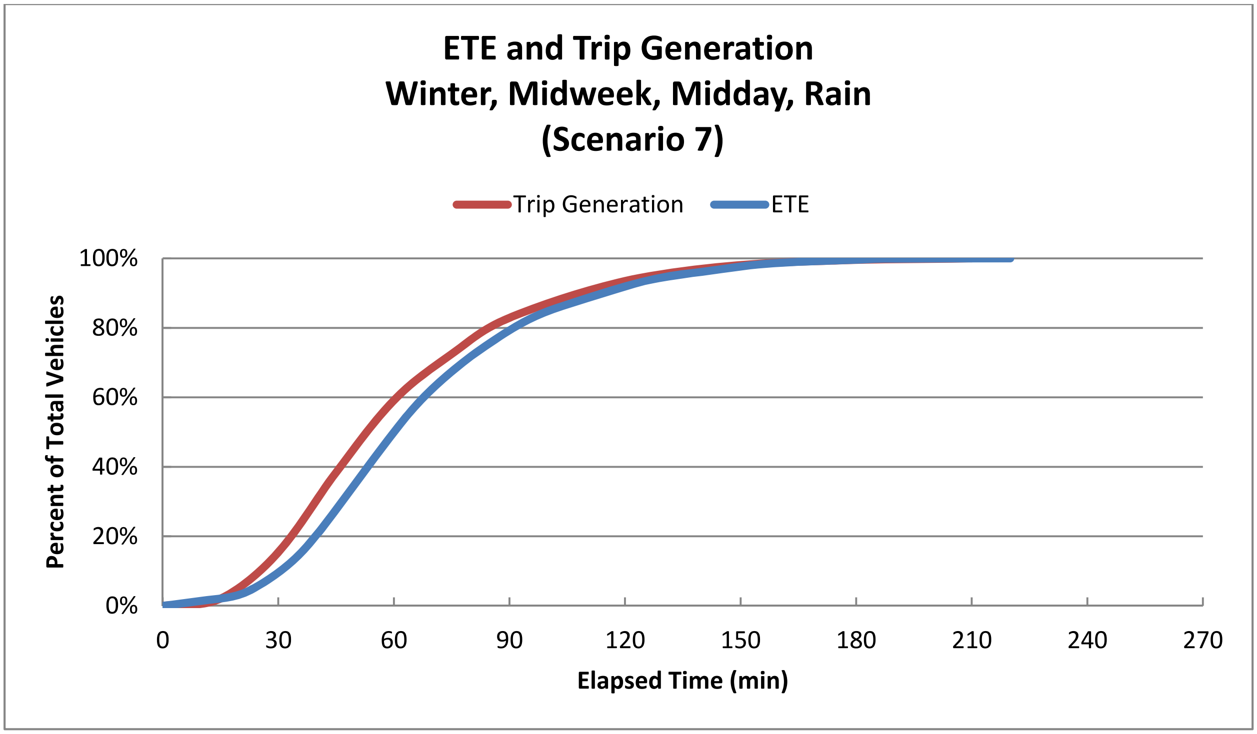


Figure J-7. ETE and Trip Generation: Winter, Midweek, Midday, Rain (Scenario 7)

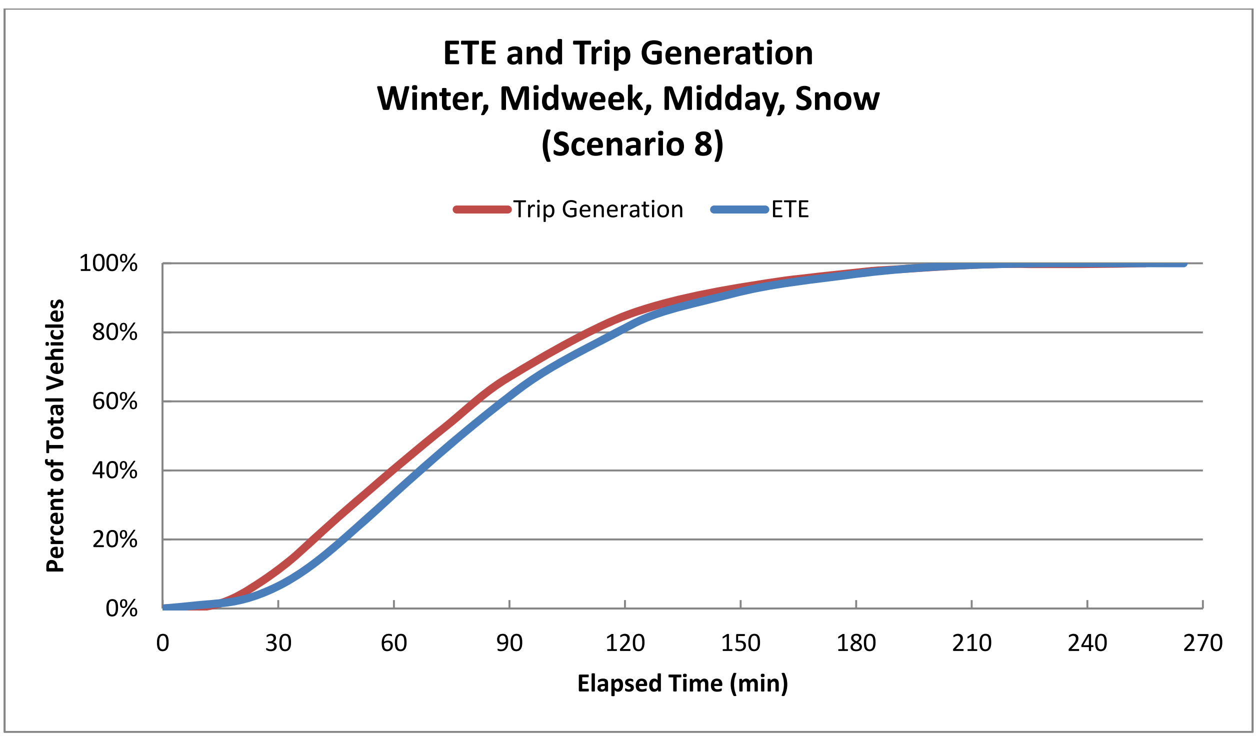


Figure J-8. ETE and Trip Generation: Winter, Midweek, Midday, Snow (Scenario 8)

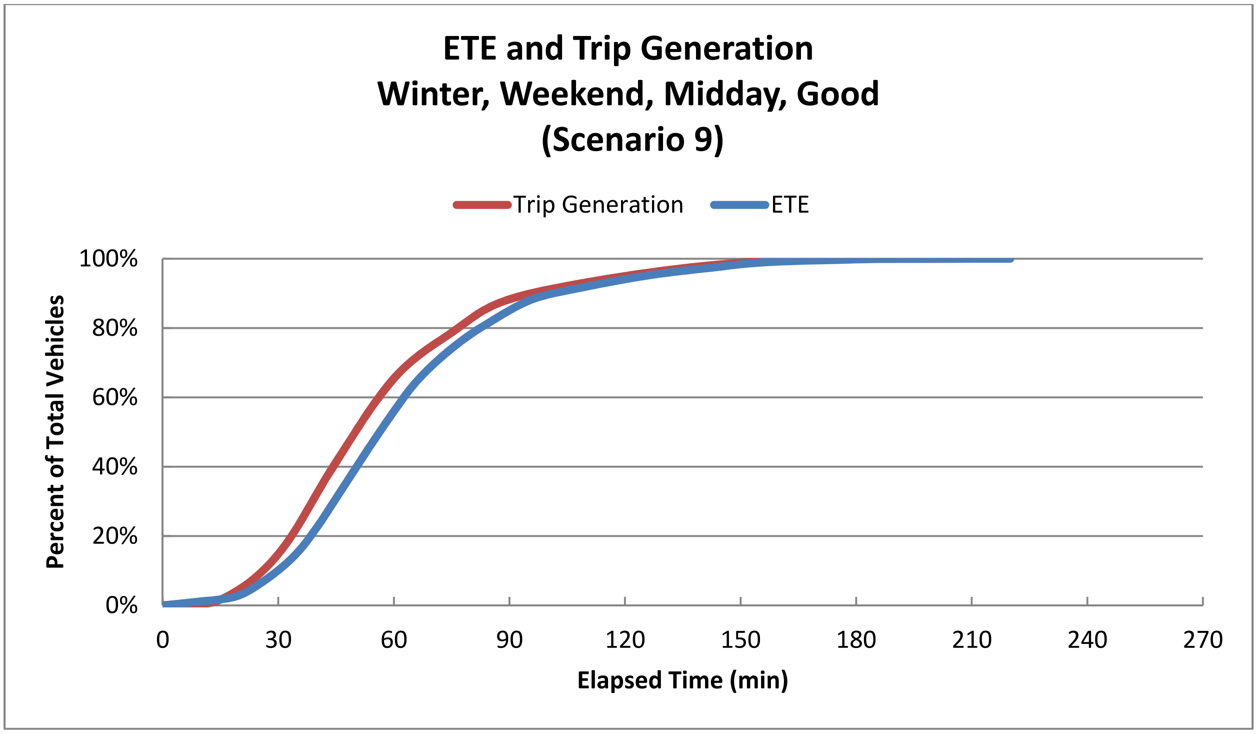


Figure J-9. ETE and Trip Generation: Winter, Weekend, Midday, Good Weather (Scenario 9)

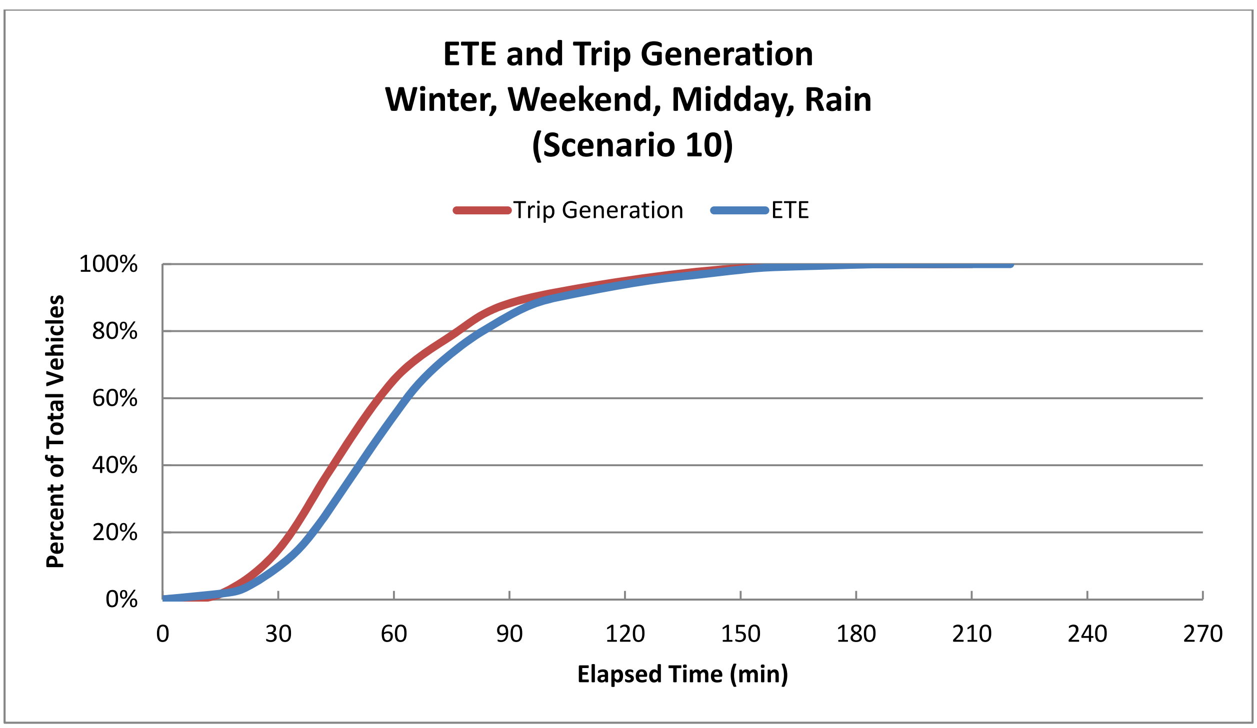


Figure J-10. ETE and Trip Generation: Winter, Weekend, Midday, Rain (Scenario 10)

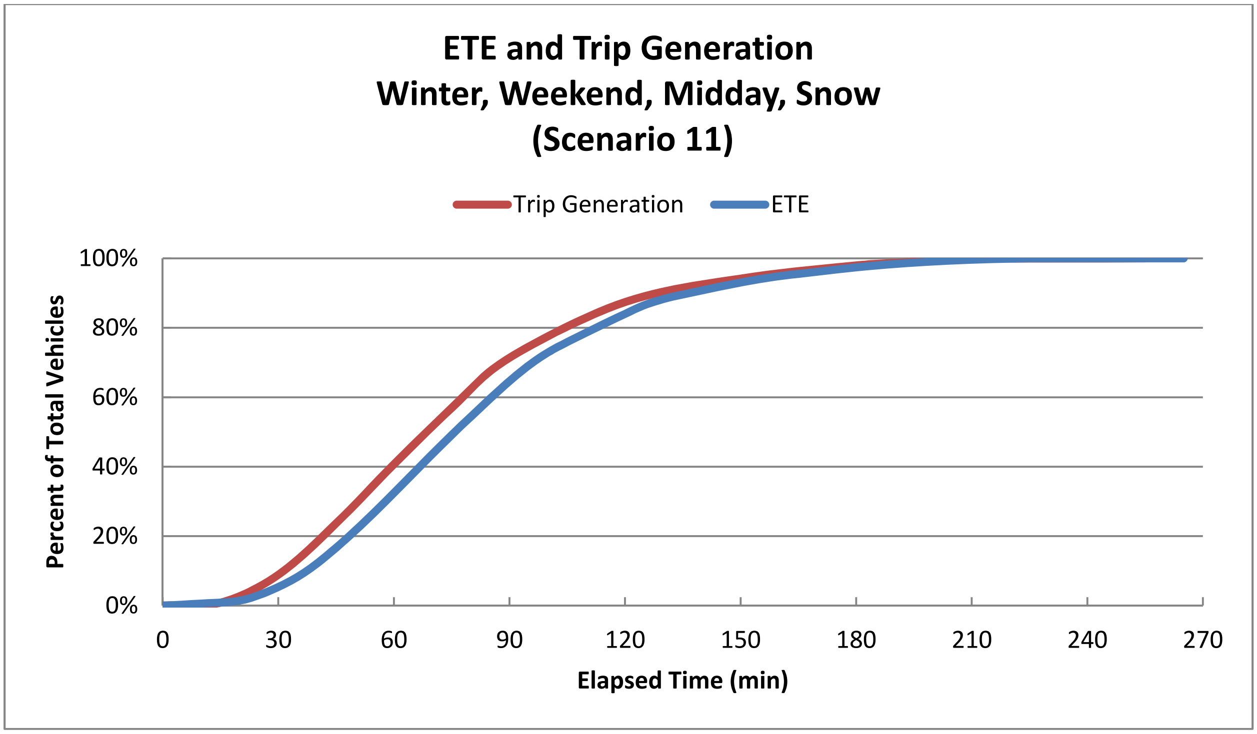


Figure J-11. ETE and Trip Generation: Winter, Weekend, Midday, Snow (Scenario 11)

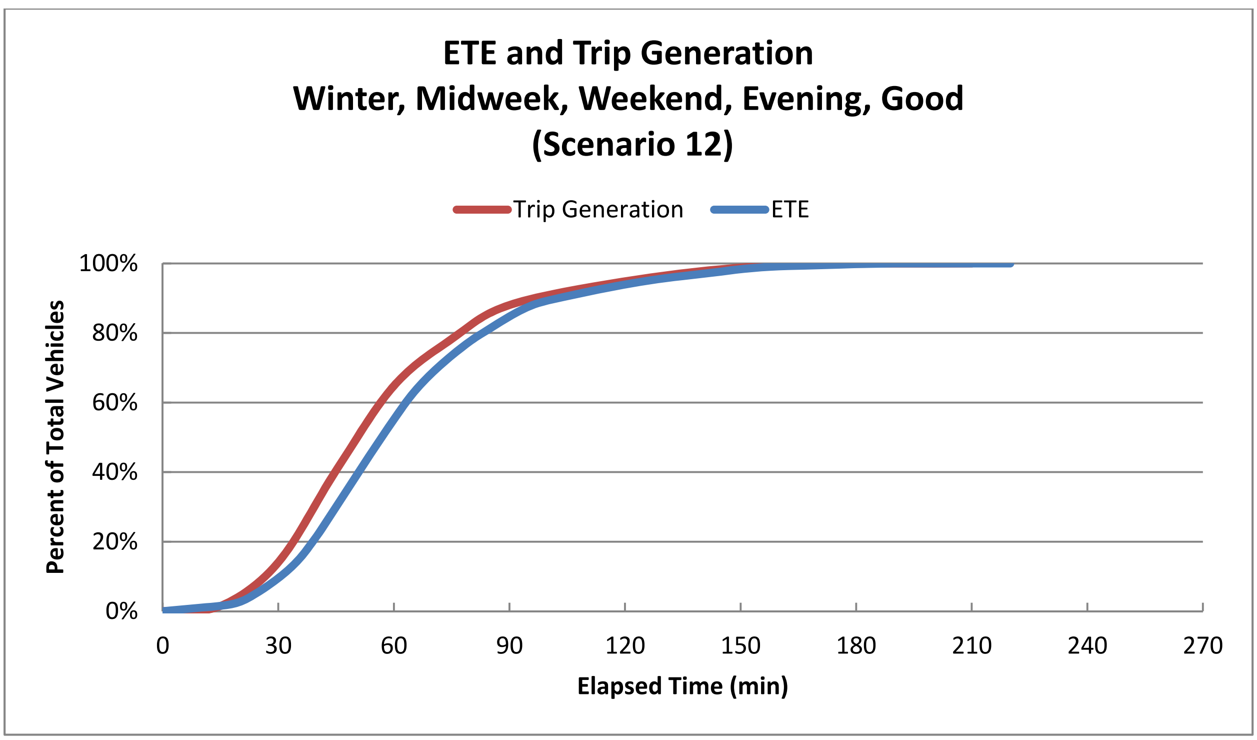


Figure J-12. ETE and Trip Generation: Winter, Midweek, Weekend, Evening, Good Weather (Scenario 12)

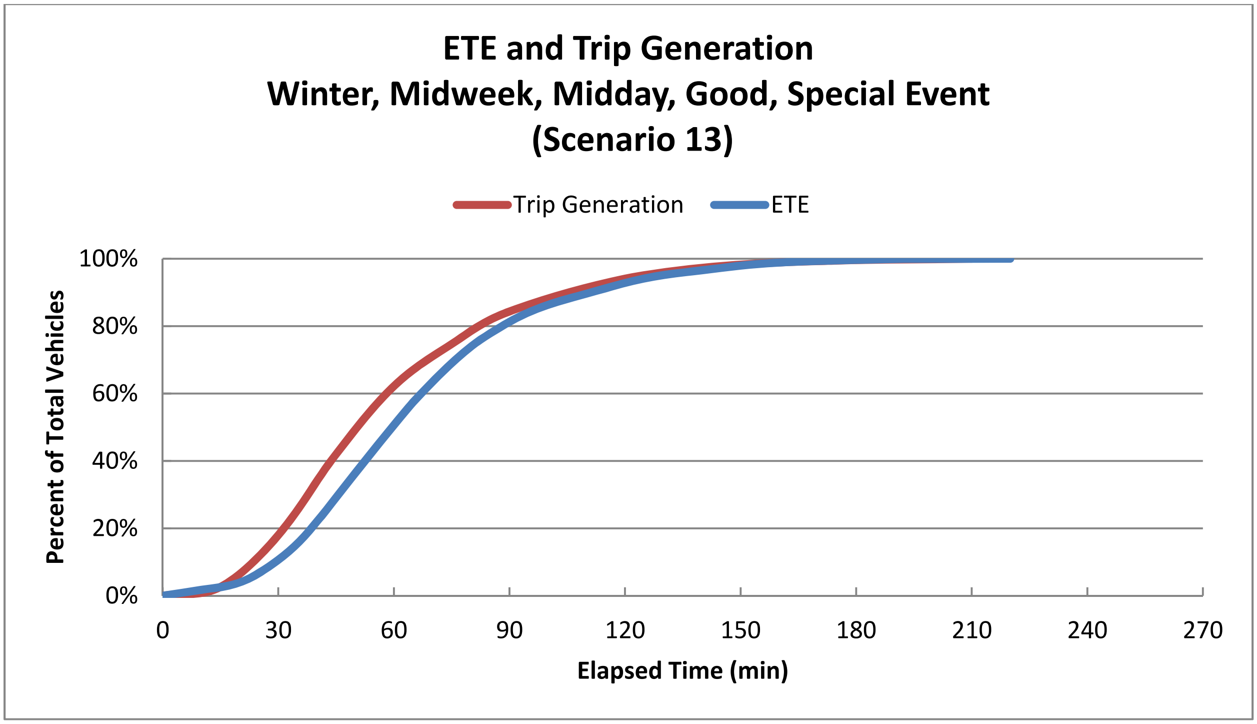


Figure J-13. ETE and Trip Generation: Summer, Weekend, Evening, Good Weather, Special Event (Scenario 13)

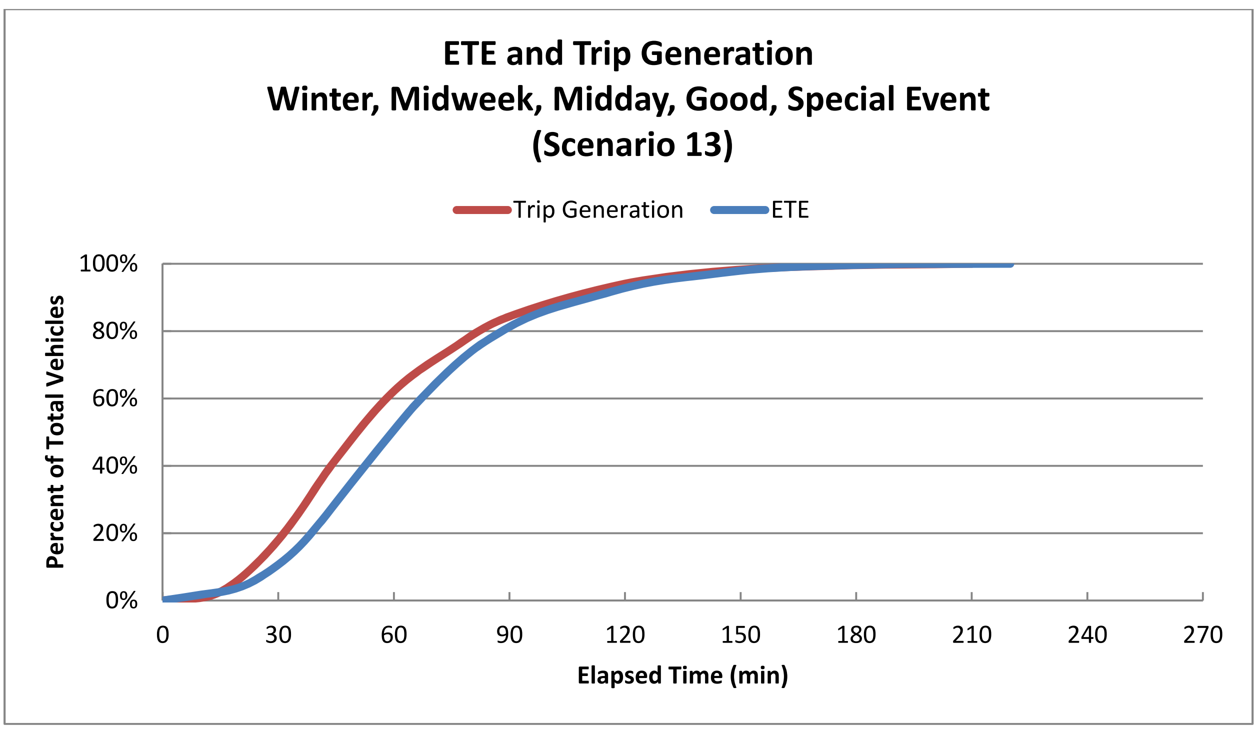


Figure J-14. ETE and Trip Generation: Summer, Midweek, Midday, Good Weather, Roadway Impact (Scenario 14)

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 34 more detailed figures (Figure K-2 through Figure K-35) which show each of the links and nodes in the network.

The analysis network was calibrated using the observations made during the field survey conducted in November 2011. Table K-1 lists the characteristics of each roadway section modeled in the ETE analysis. Each link is identified by its road name and the upstream and downstream node numbers. The geographic location of each link can be observed by referencing the grid map number provided in Table K-1. The roadway type identified in Table K-1 is generally based on the following criteria:

- Freeway: limited access highway, 2 or more lanes in each direction, high free flow speeds
- Freeway ramp: ramp on to or off of a limited access highway
- Major arterial: 3 or more lanes in each direction
- Minor arterial: 2 or more lanes in each direction
- Collector: single lane in each direction
- Local roadways: single lane in each direction, local roads with low free flow speeds

The term, "No. of Lanes" in Table K-1 identifies the number of lanes that extend throughout the length of the link. Many links have additional lanes on the immediate approach to an intersection (turn pockets); these have been recorded and entered into the input stream for the DYNEV II System.

As discussed in Section 1.3, lane width and shoulder width were not physically measured during the road survey. Rather, estimates of these measures were based on visual observations and recorded images.

Table K-2 identifies each node in the network that is controlled and the type of control (stop sign, yield sign, pre-timed signal, actuated signal, traffic control point) at that node. Uncontrolled nodes are not included in Table K-2. The location of each node can be observed by referencing the grid map number provided.

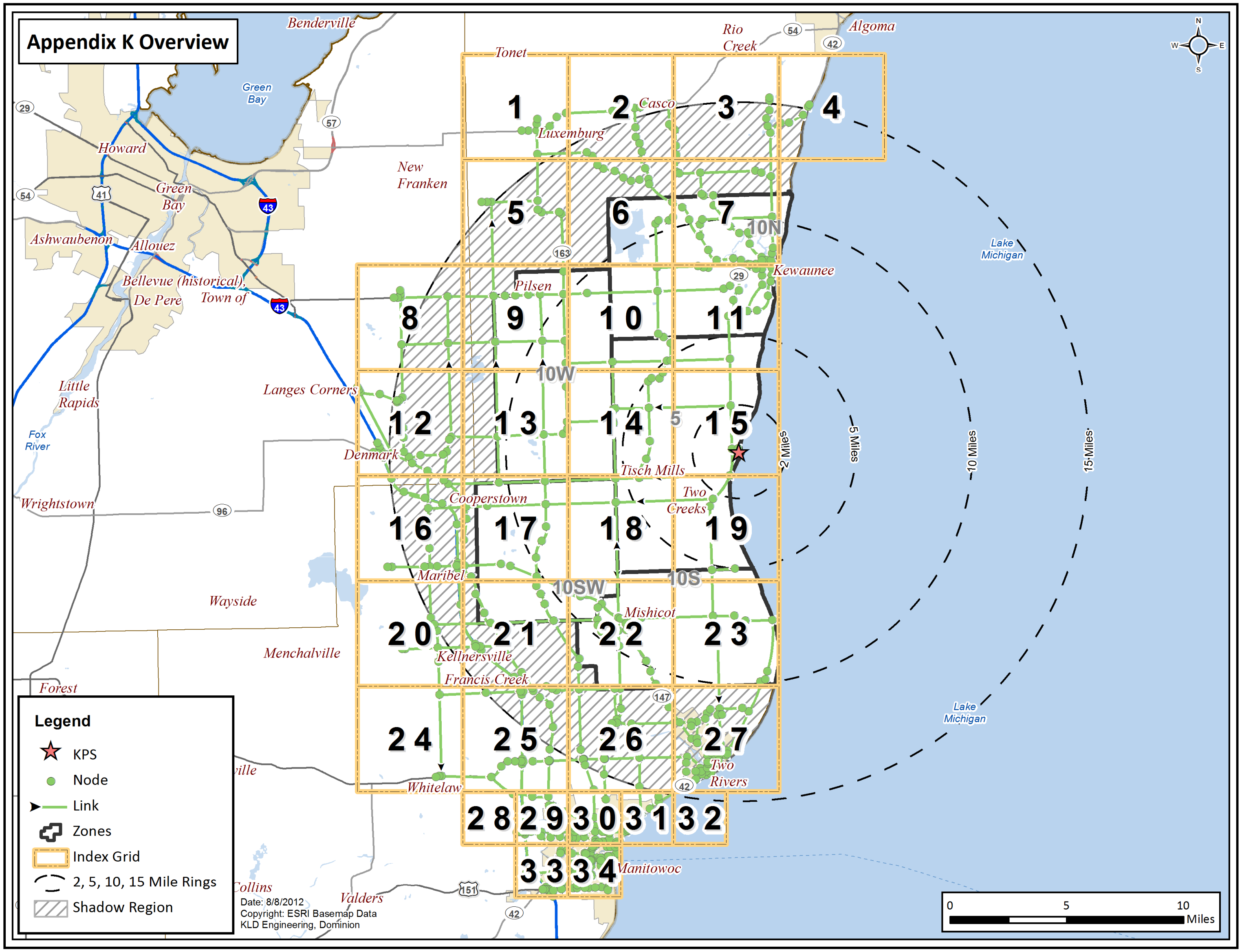


Figure K-1. Kewaunee Link-Node Analysis Network

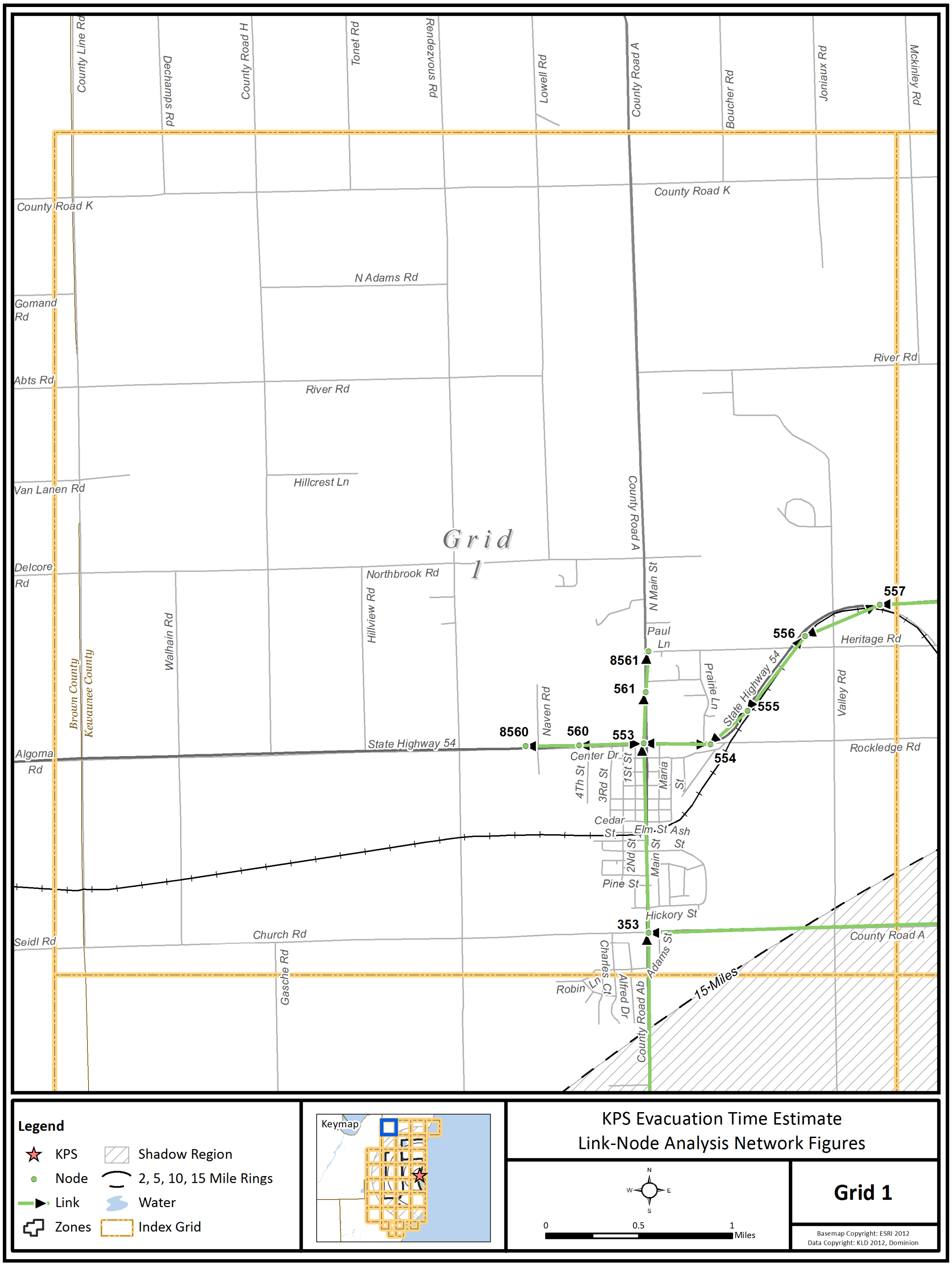


Figure K-2. Link-Node Analysis Network – Grid 1

Figure K-3. Link-Node Analysis Network – Grid 2

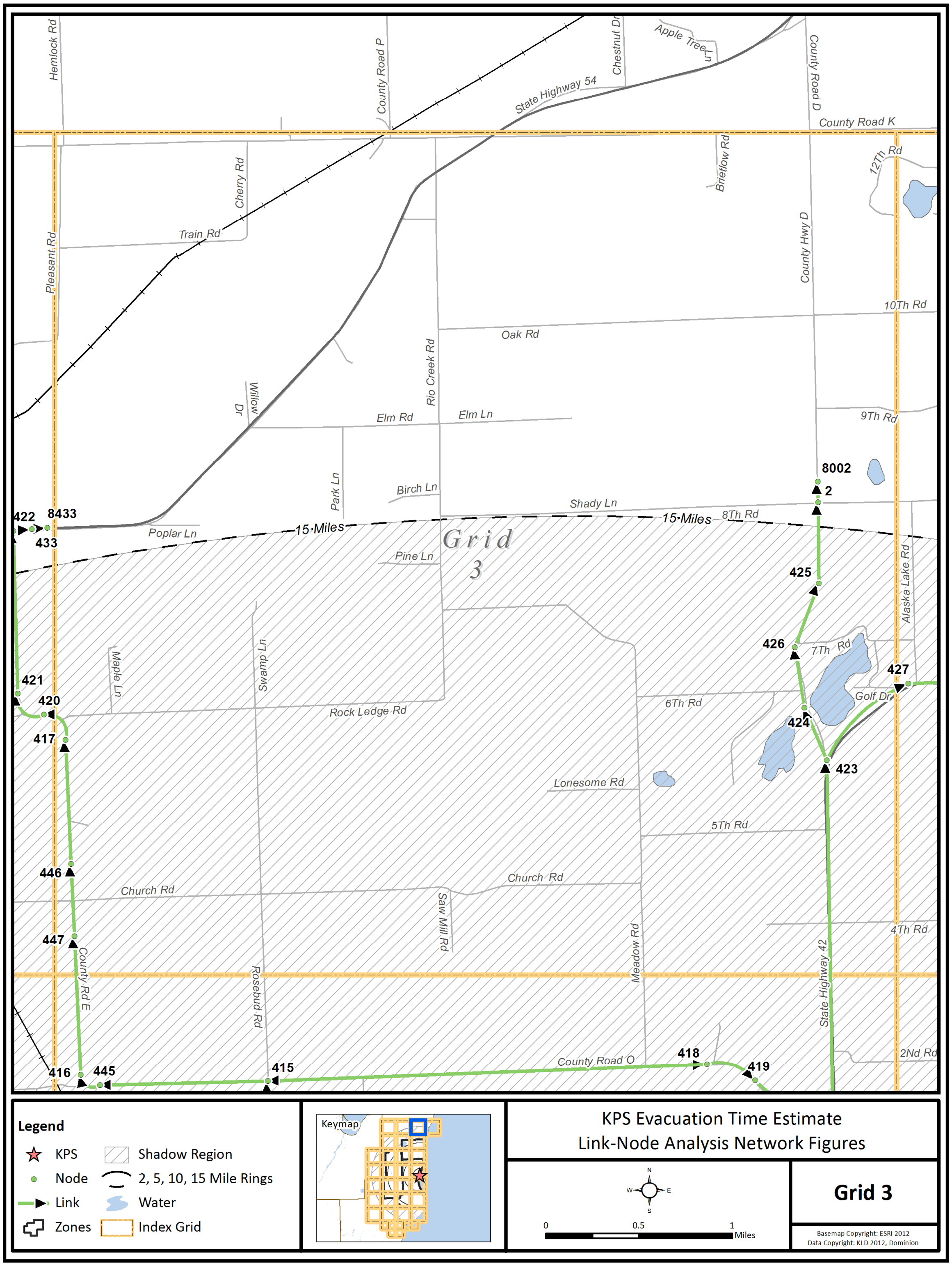


Figure K-4. Link-Node Analysis Network – Grid 3

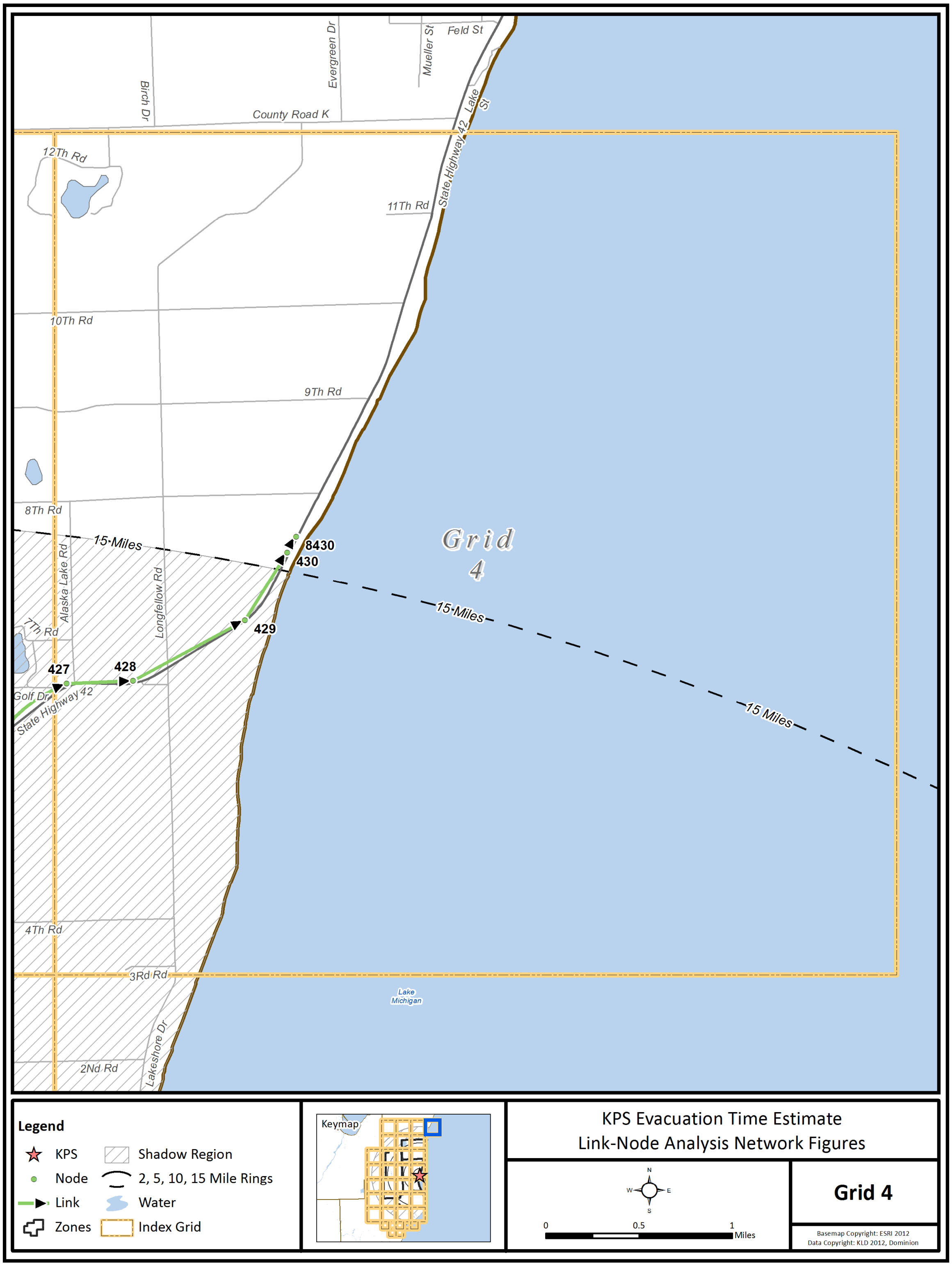


Figure K-5. Link-Node Analysis Network – Grid 4

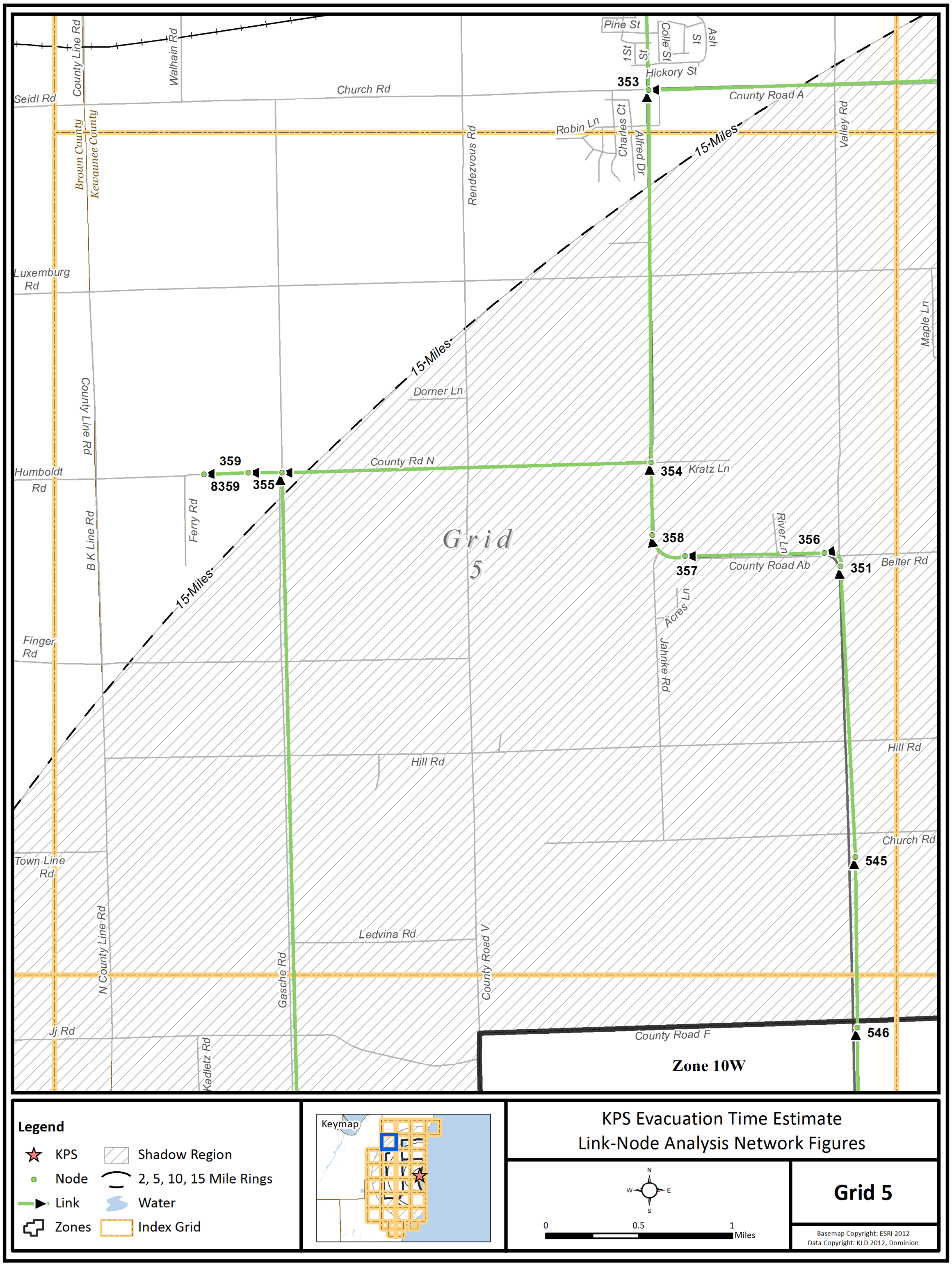


Figure K-6. Link-Node Analysis Network – Grid 5

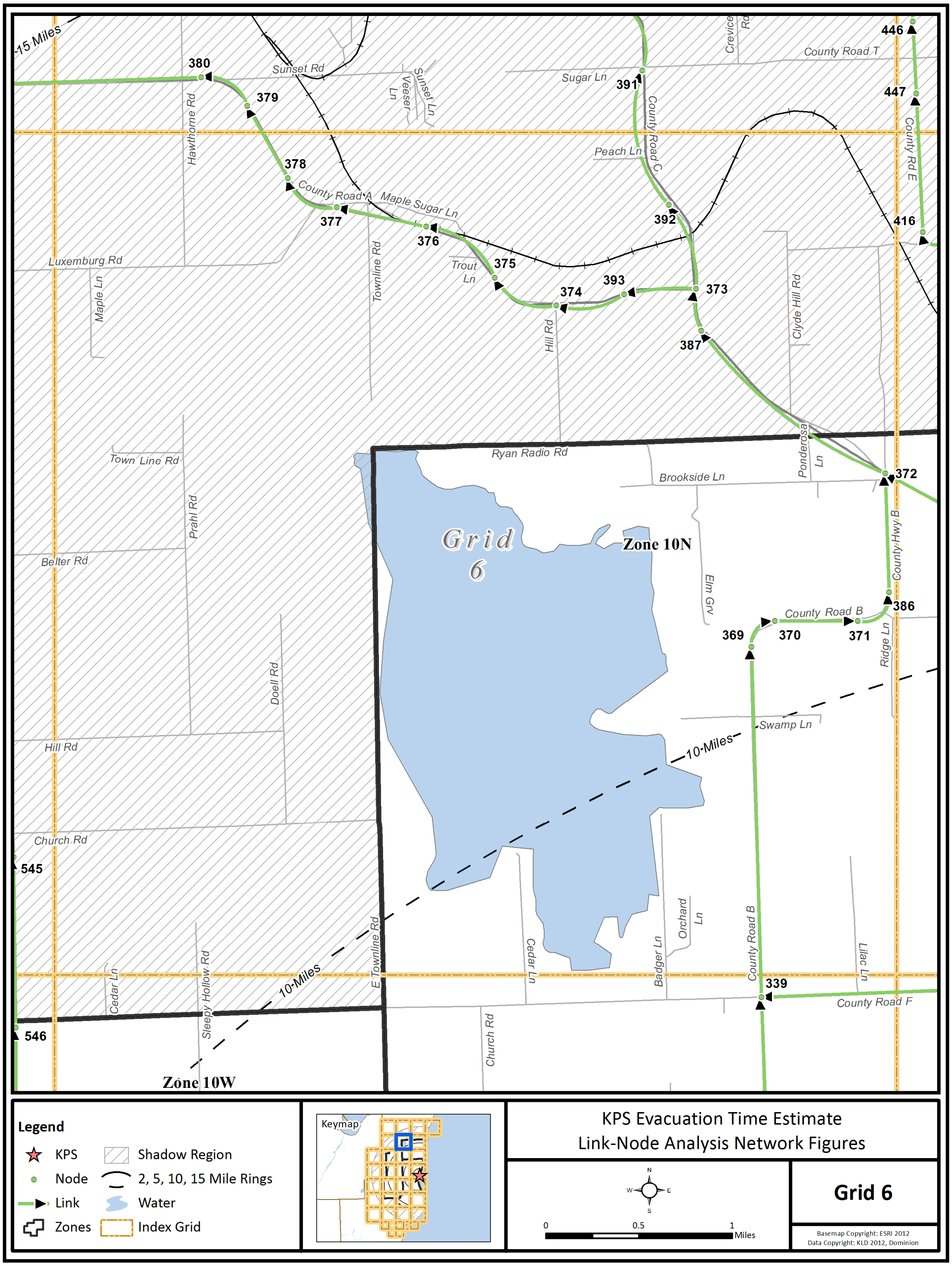


Figure K-7. Link-Node Analysis Network – Grid 6

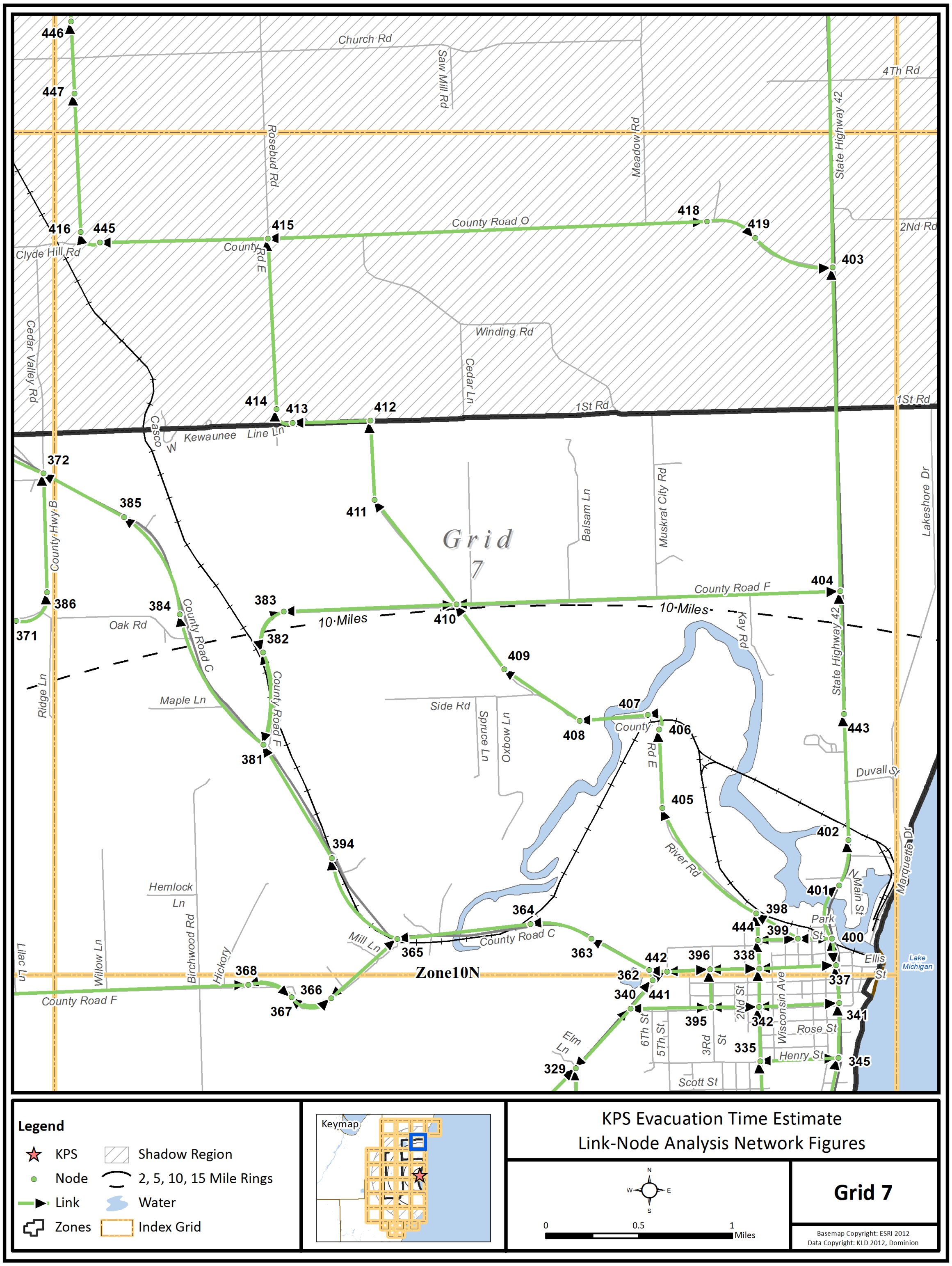


Figure K-8. Link-Node Analysis Network – Grid 7

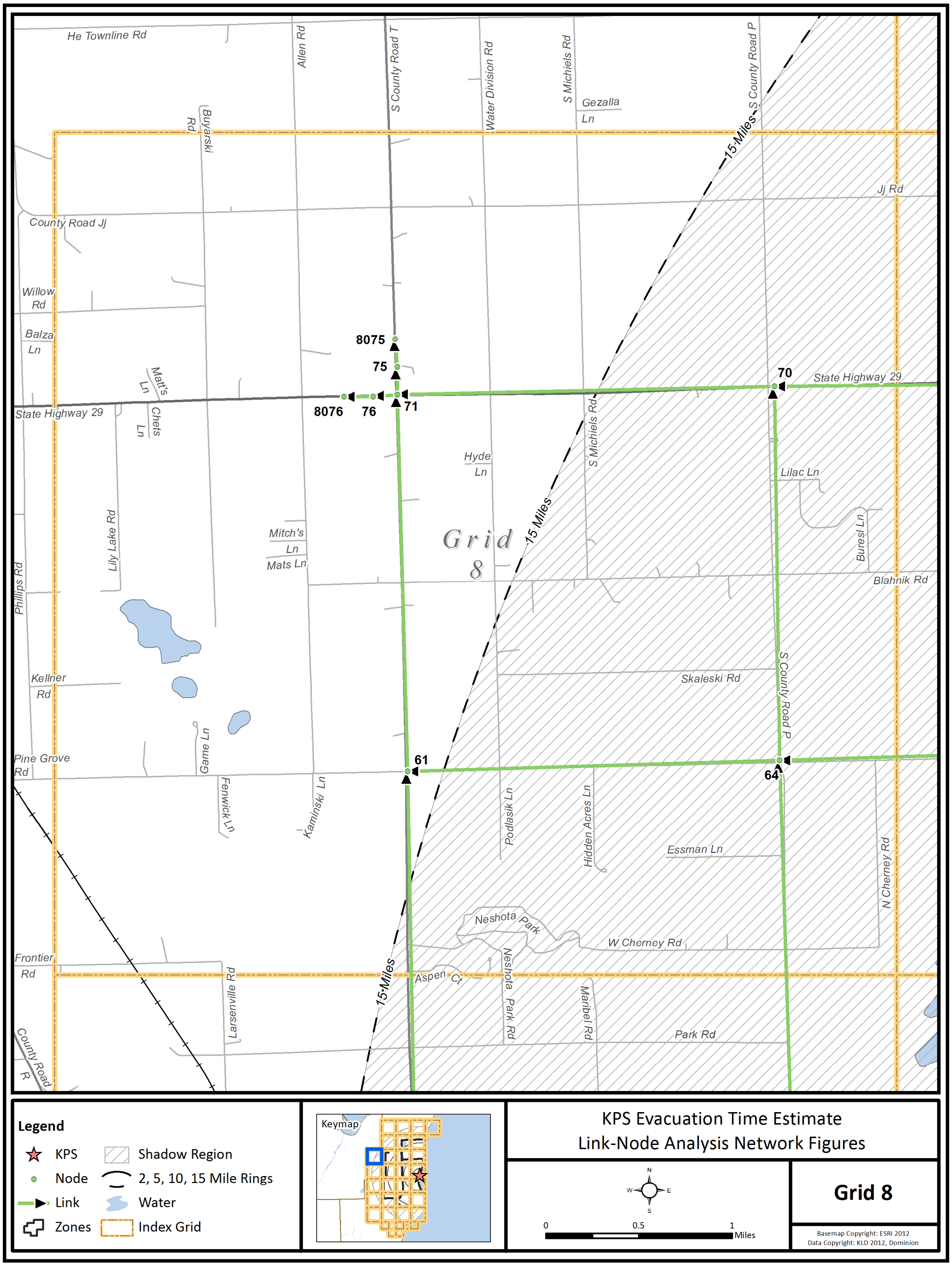


Figure K-9. Link-Node Analysis Network – Grid 8

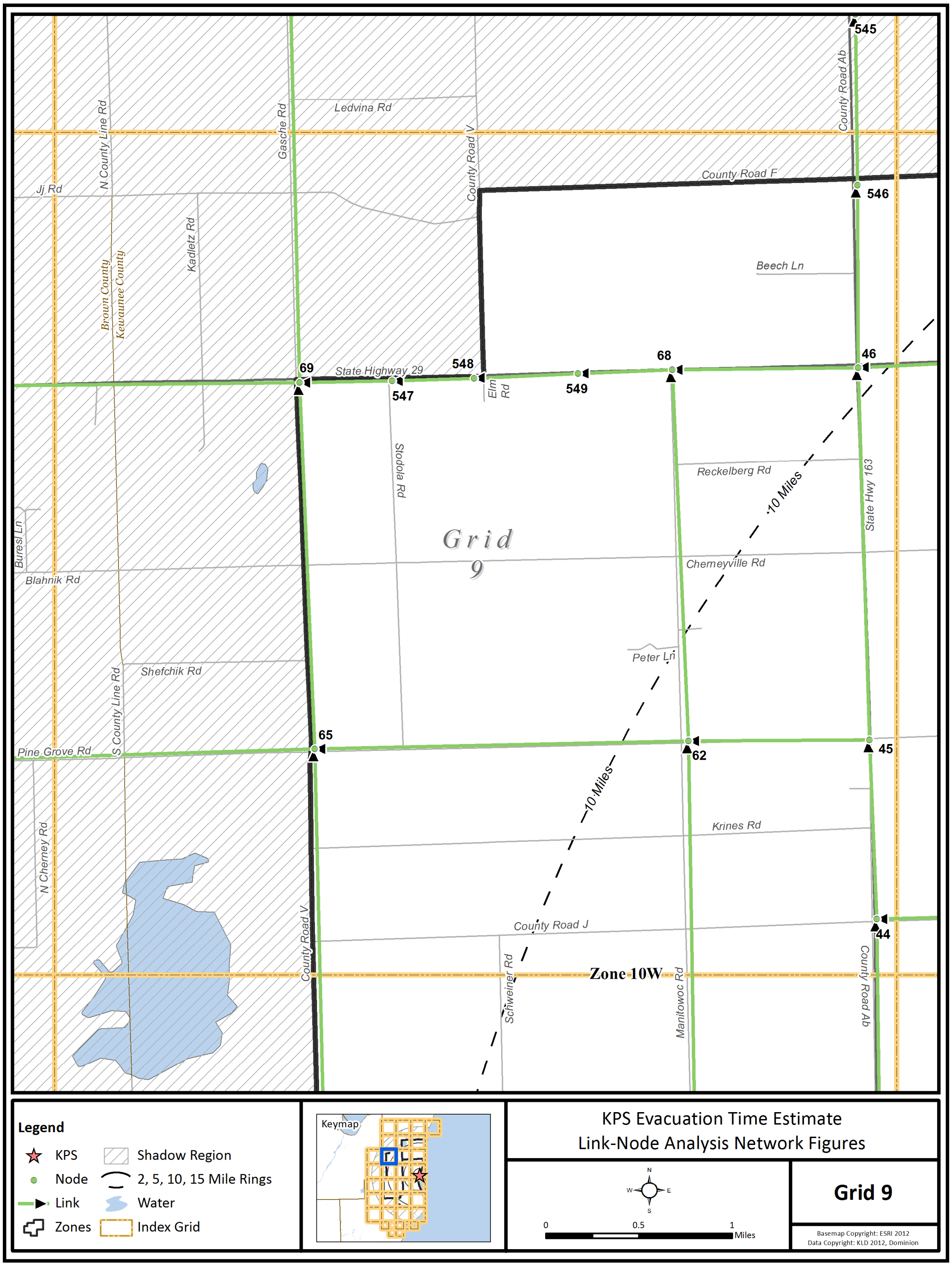


Figure K-10. Link-Node Analysis Network – Grid 9

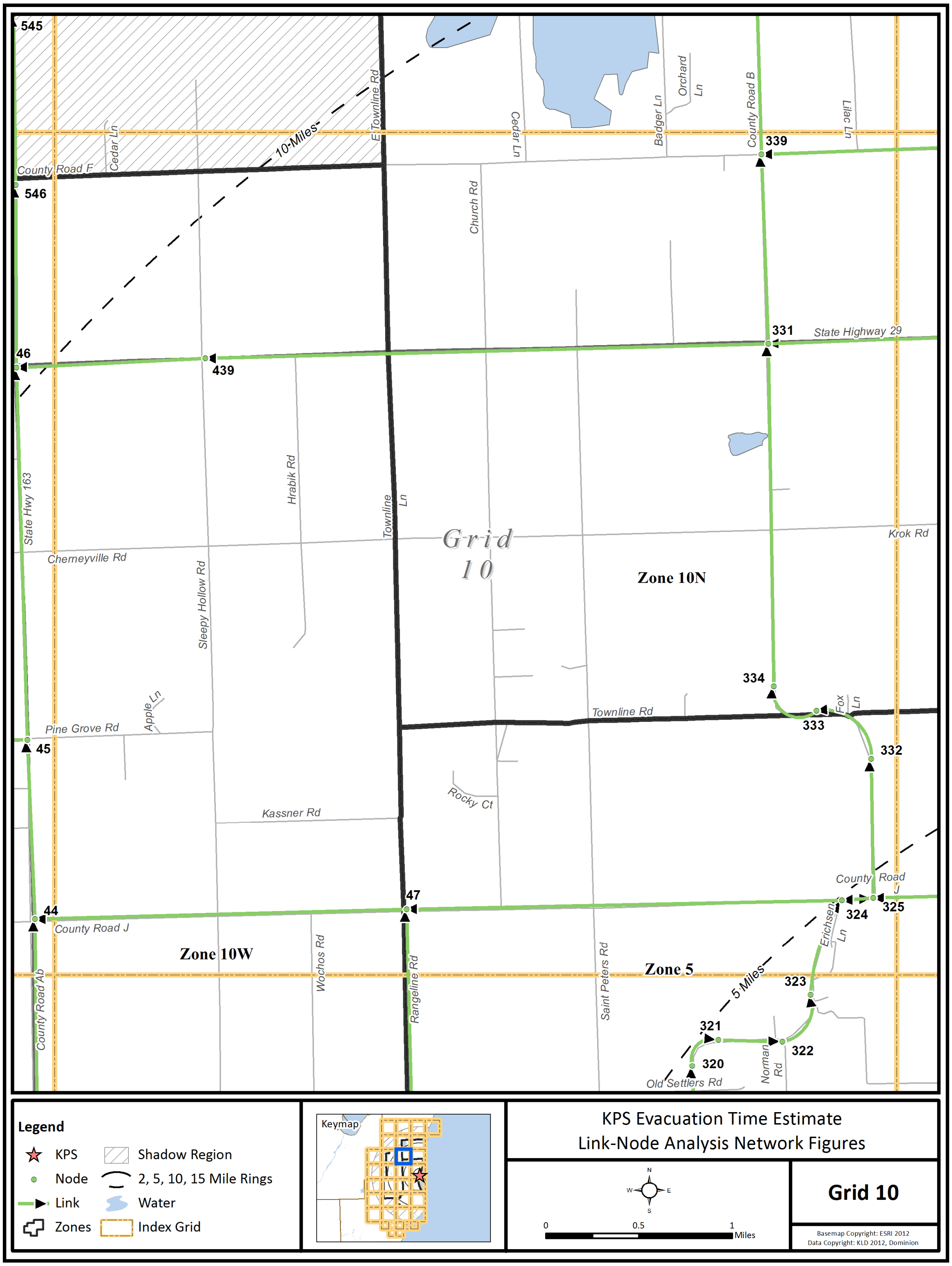


Figure K-11. Link-Node Analysis Network – Grid 10

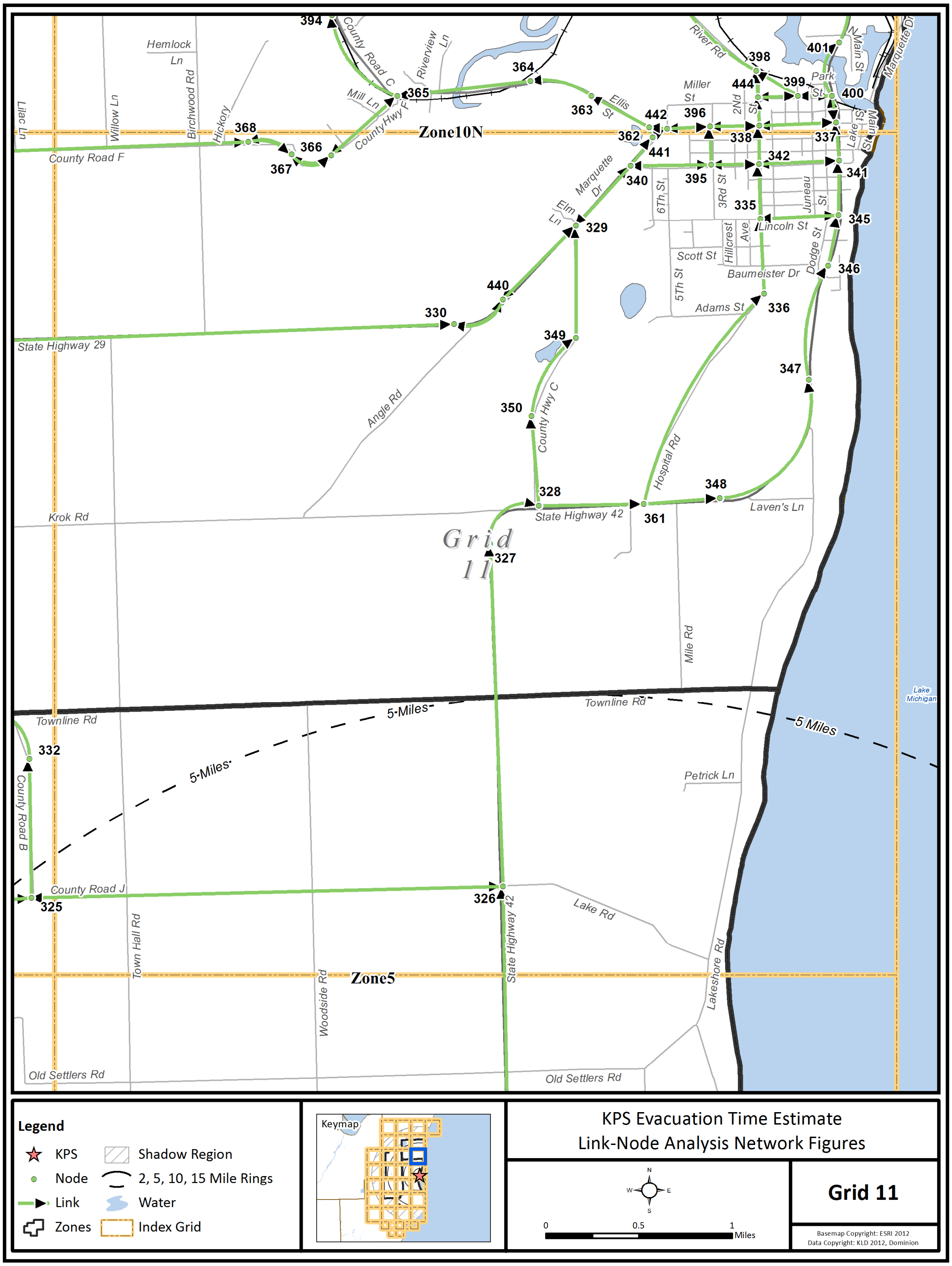


Figure K-12. Link-Node Analysis Network – Grid 11

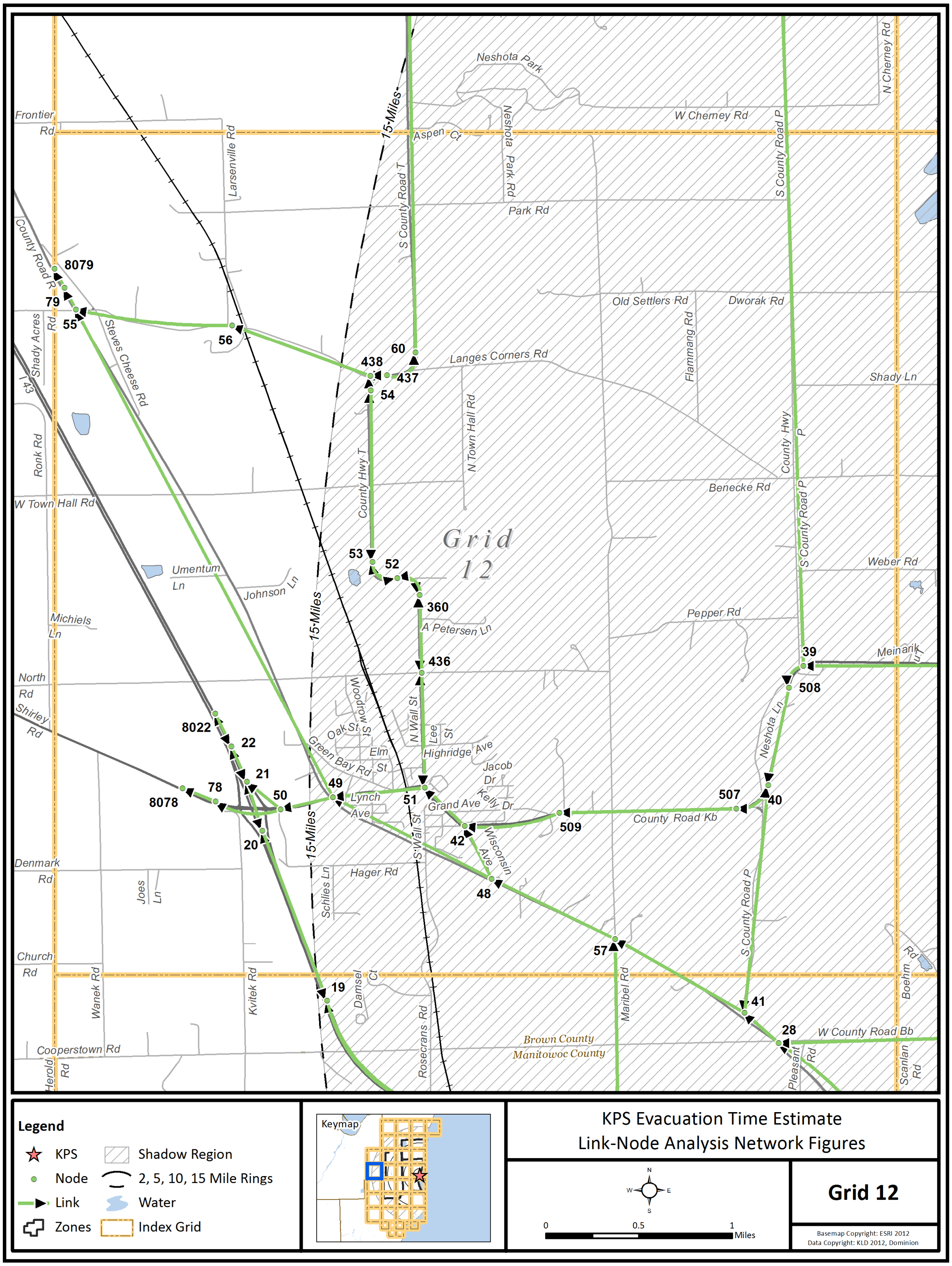


Figure K-13. Link-Node Analysis Network – Grid 12

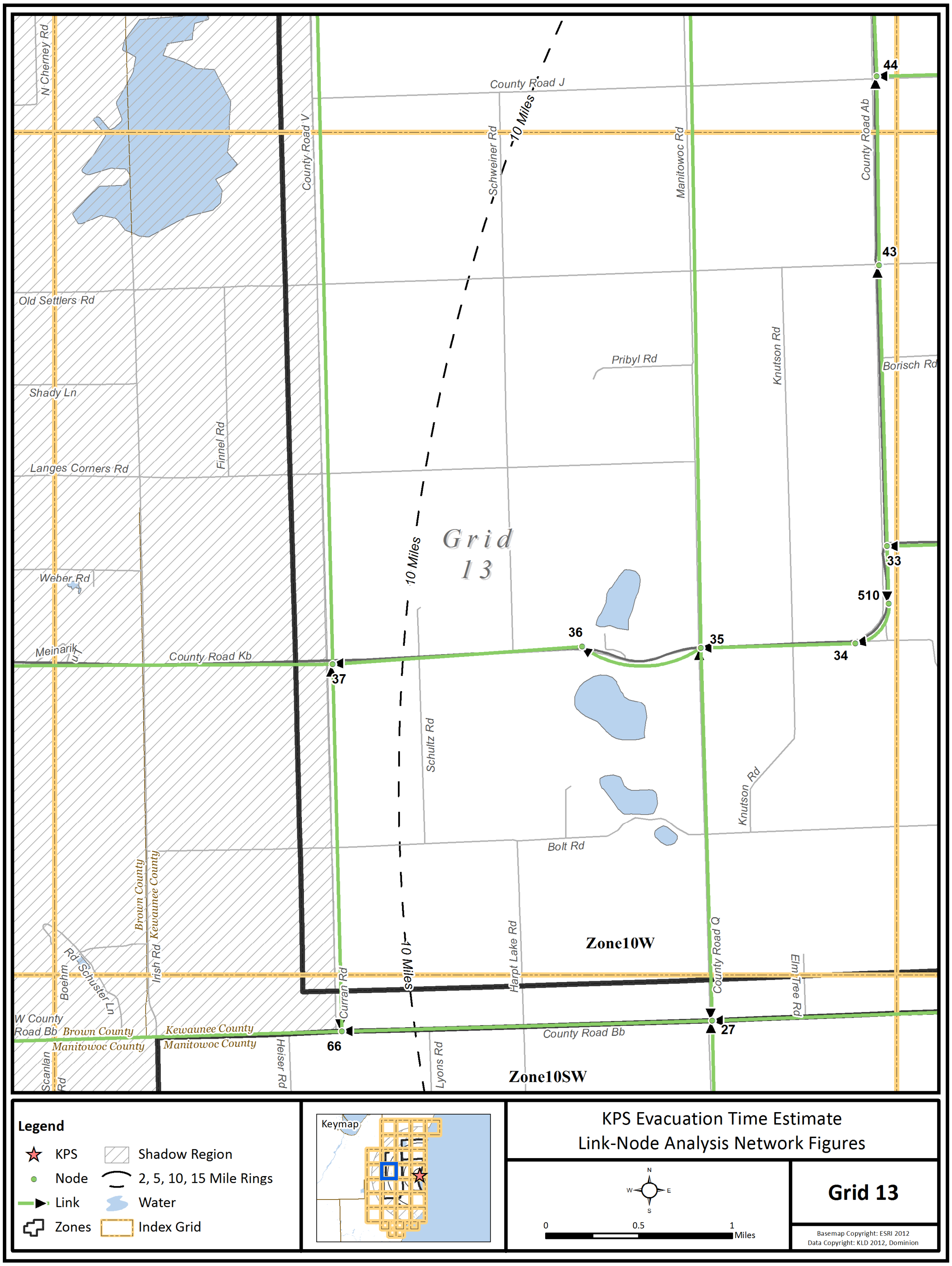


Figure K-14. Link-Node Analysis Network – Grid 13

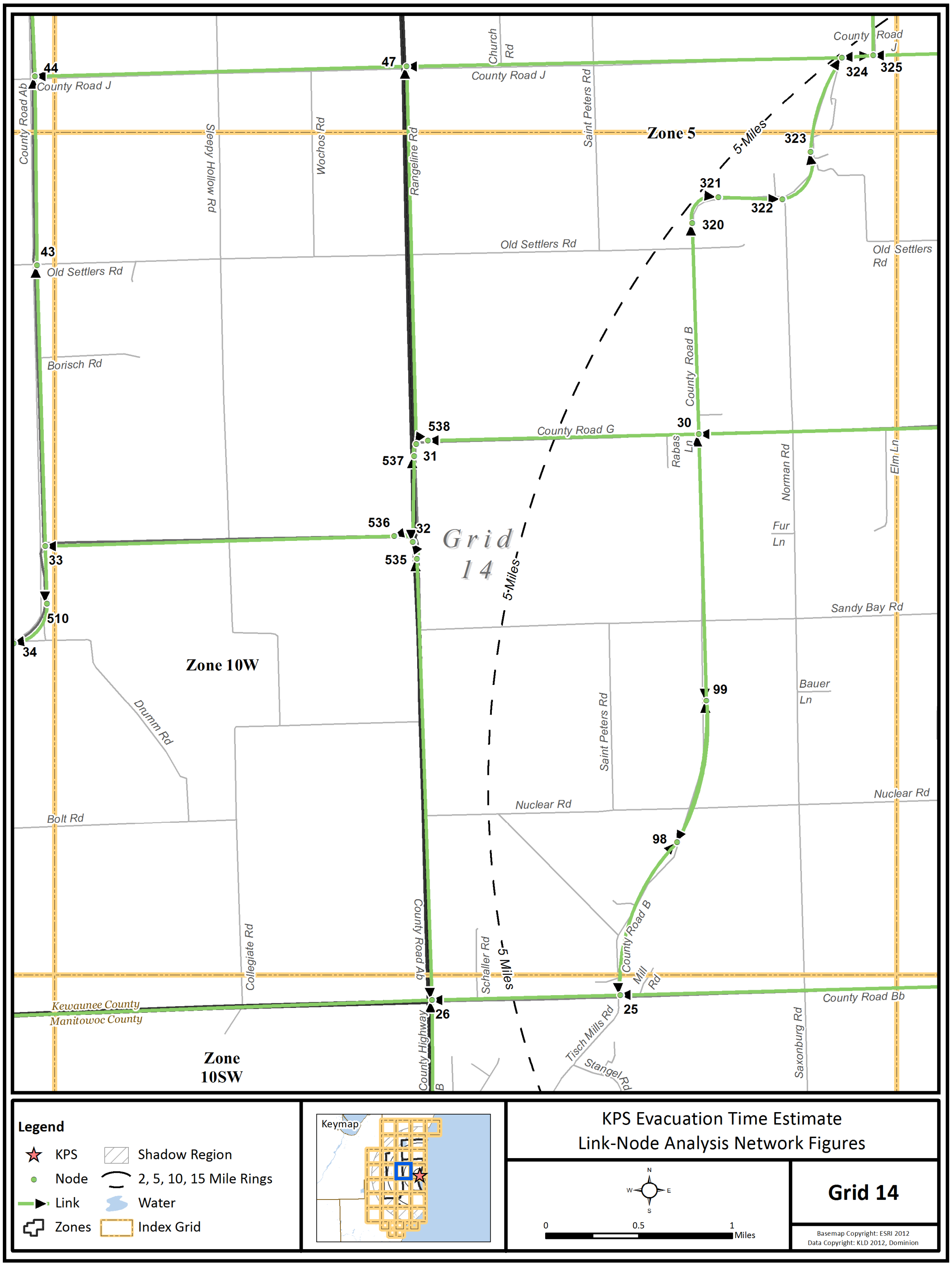


Figure K-15. Link-Node Analysis Network – Grid 14

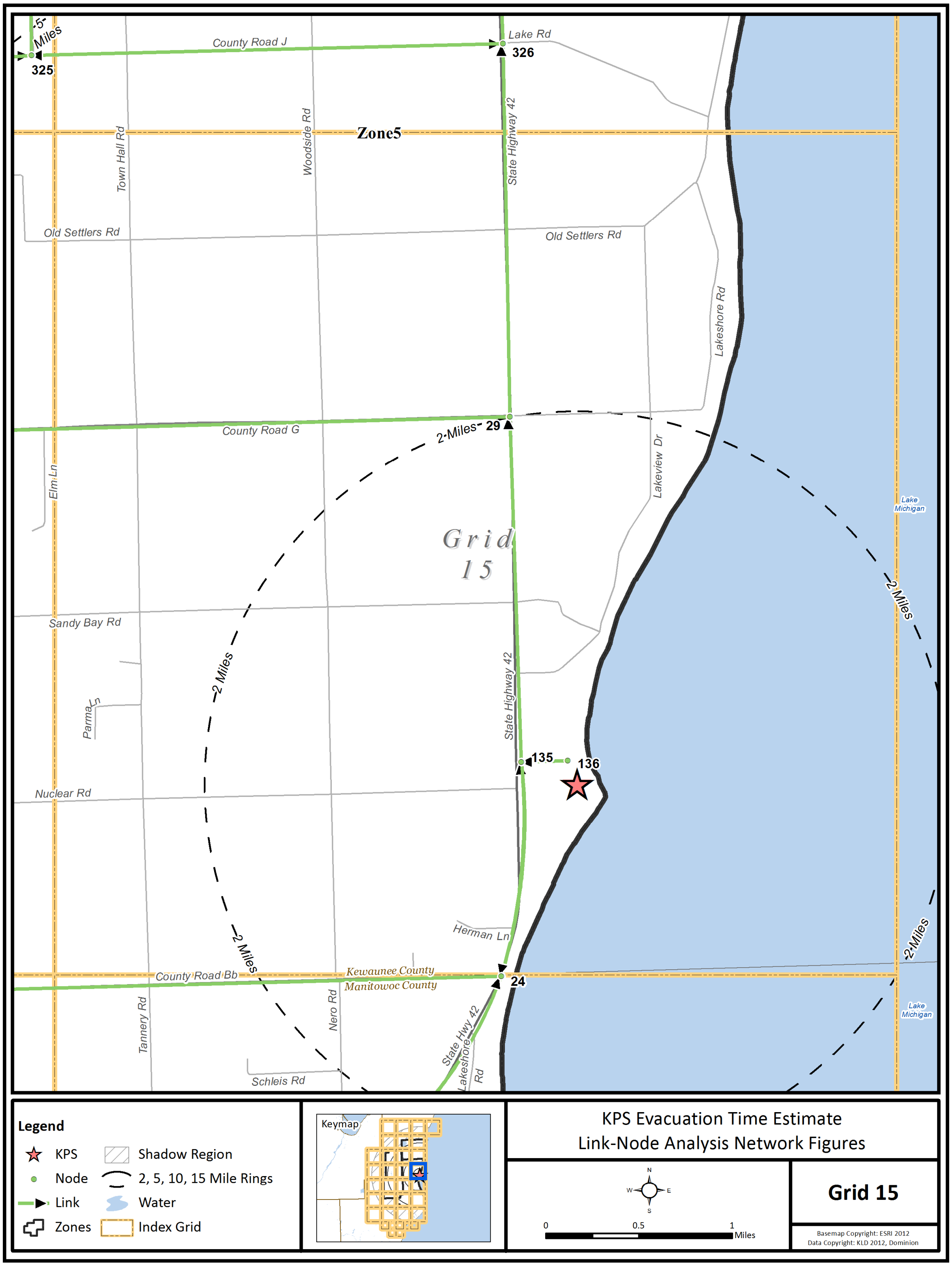


Figure K-16. Link-Node Analysis Network – Grid 15

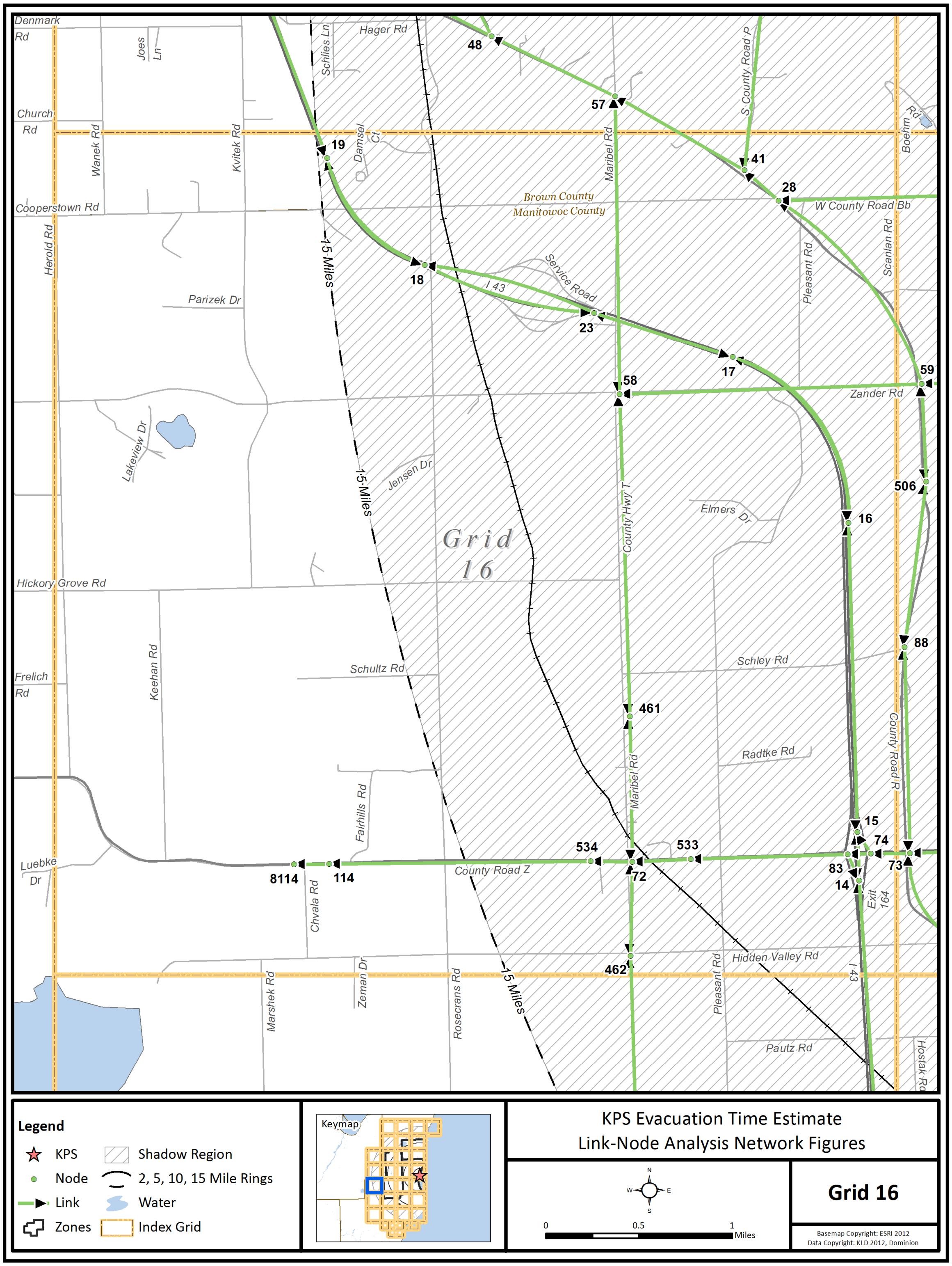


Figure K-17. Link-Node Analysis Network – Grid 16

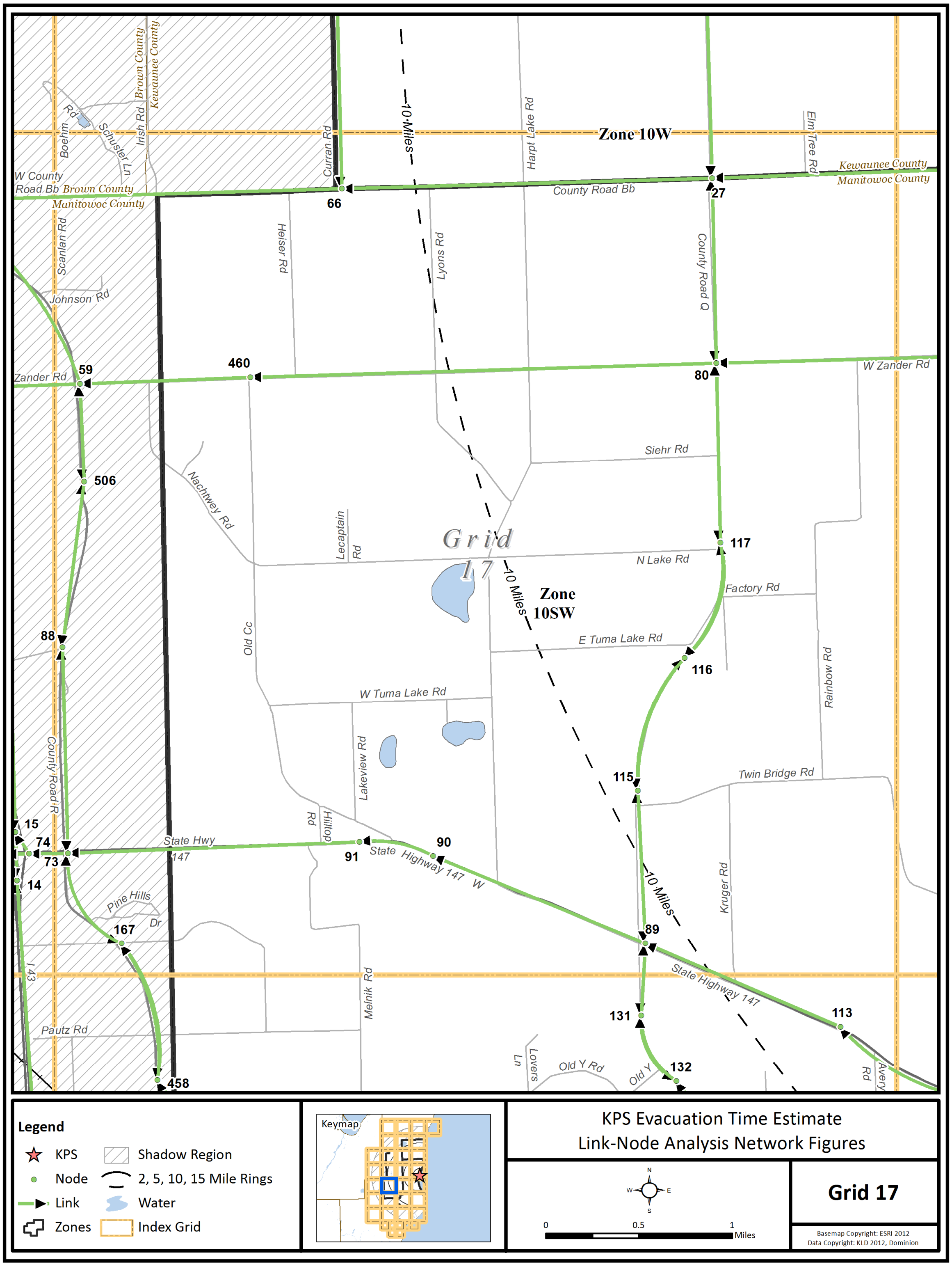


Figure K-18. Link-Node Analysis Network – Grid 17

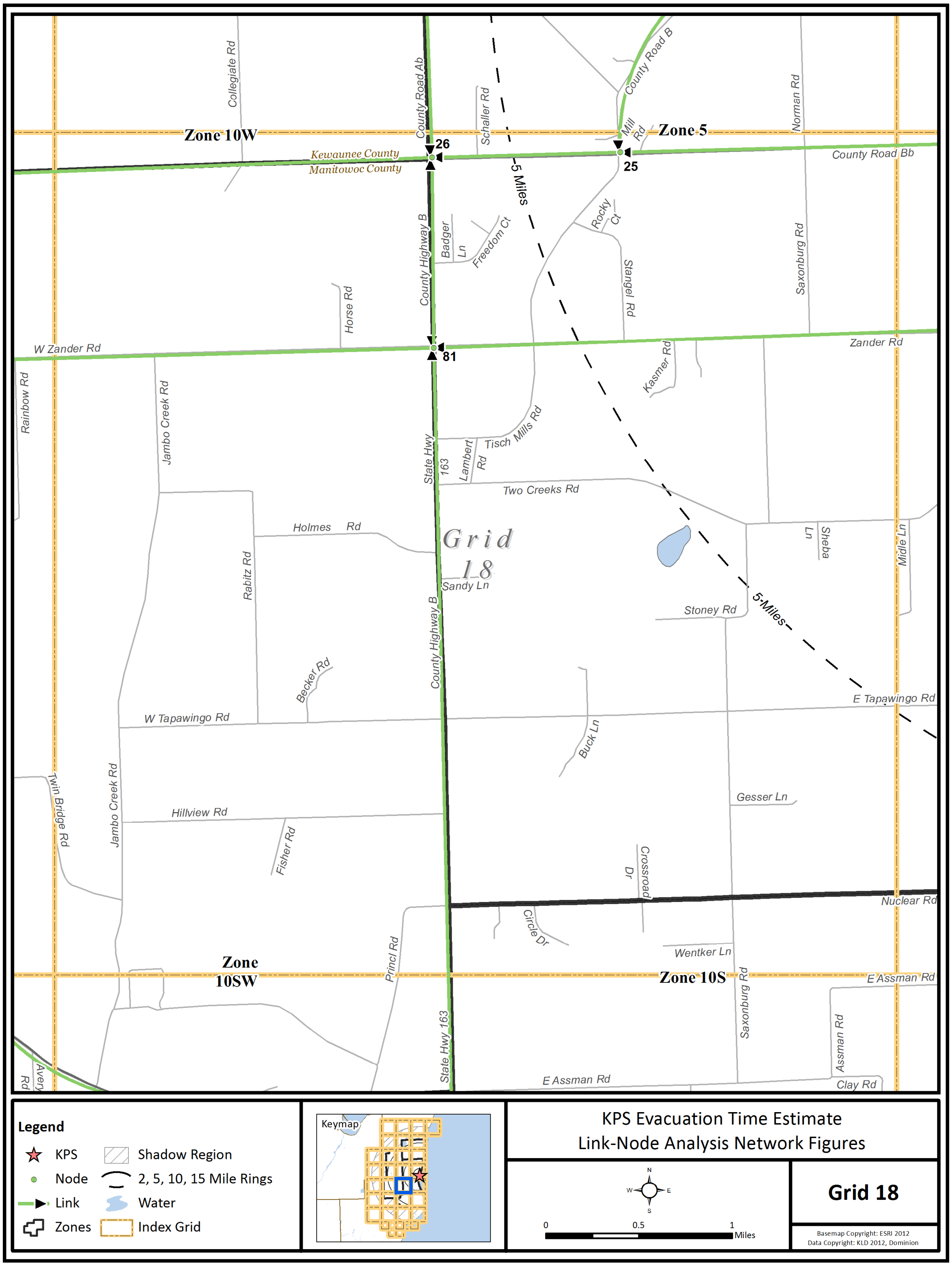


Figure K-19. Link-Node Analysis Network – Grid 18

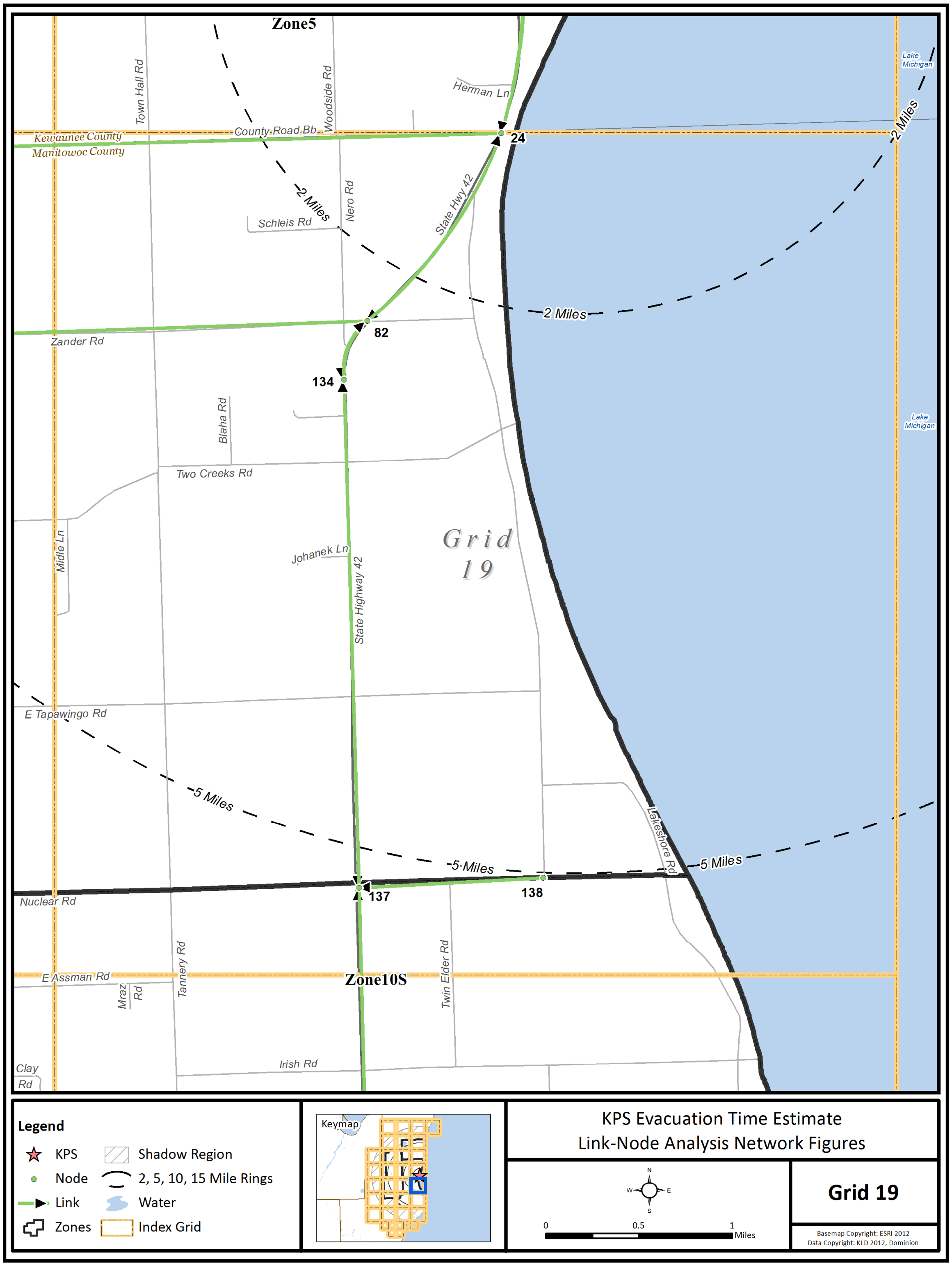


Figure K-20. Link-Node Analysis Network – Grid 19

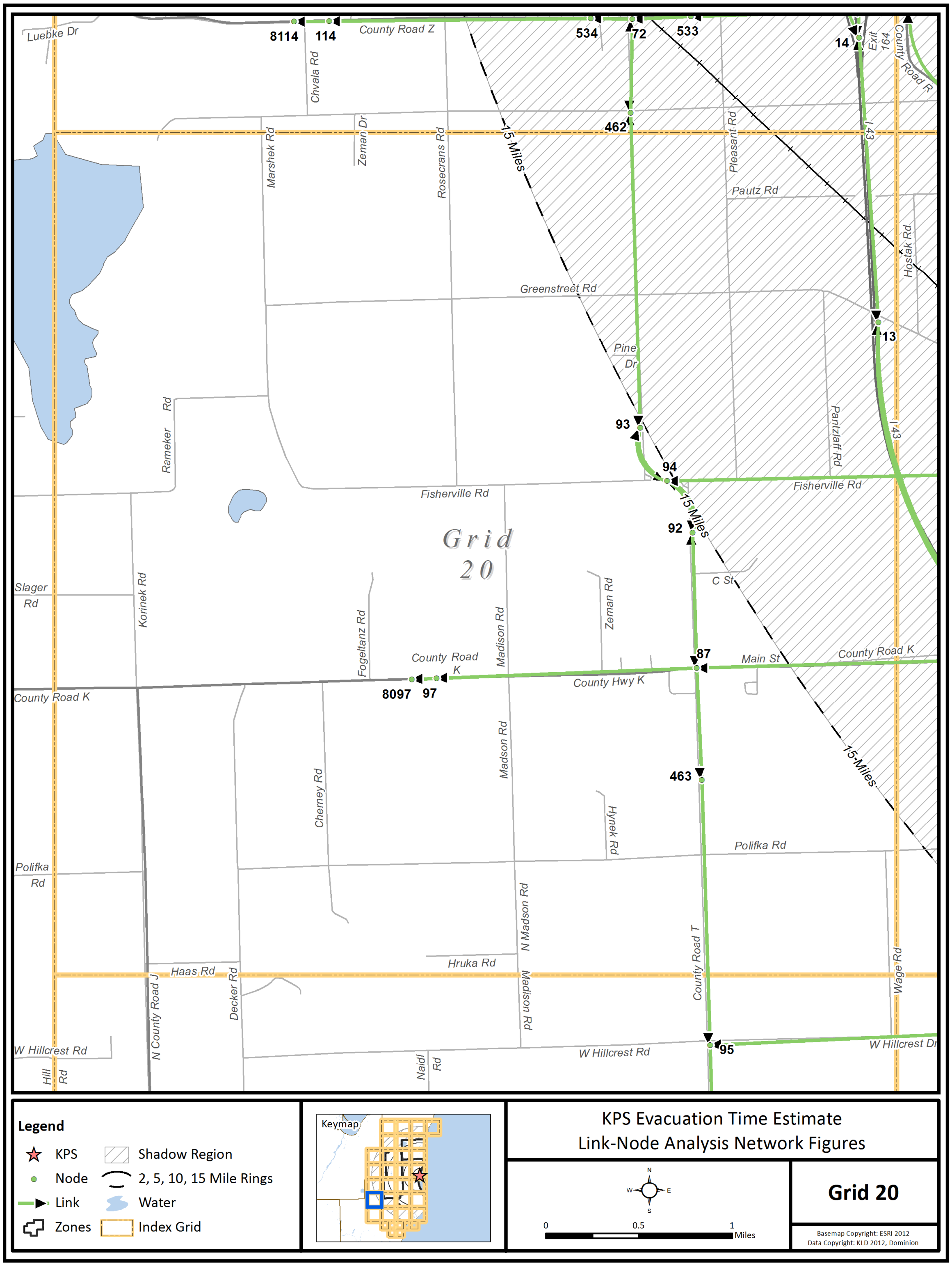


Figure K-21. Link-Node Analysis Network – Grid 20

Figure K-22. Link-Node Analysis Network – Grid 21

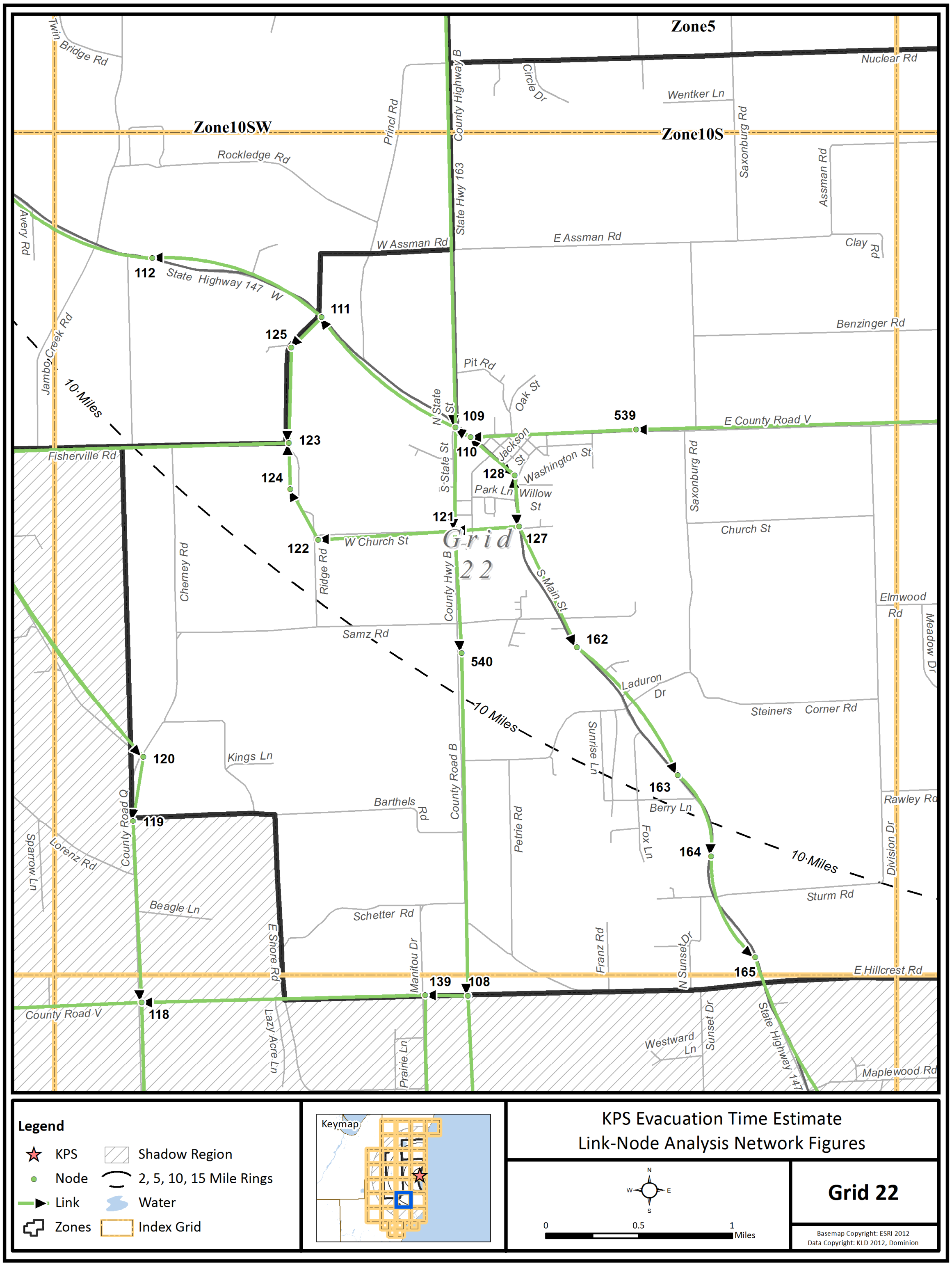


Figure K-23. Link-Node Analysis Network – Grid 22

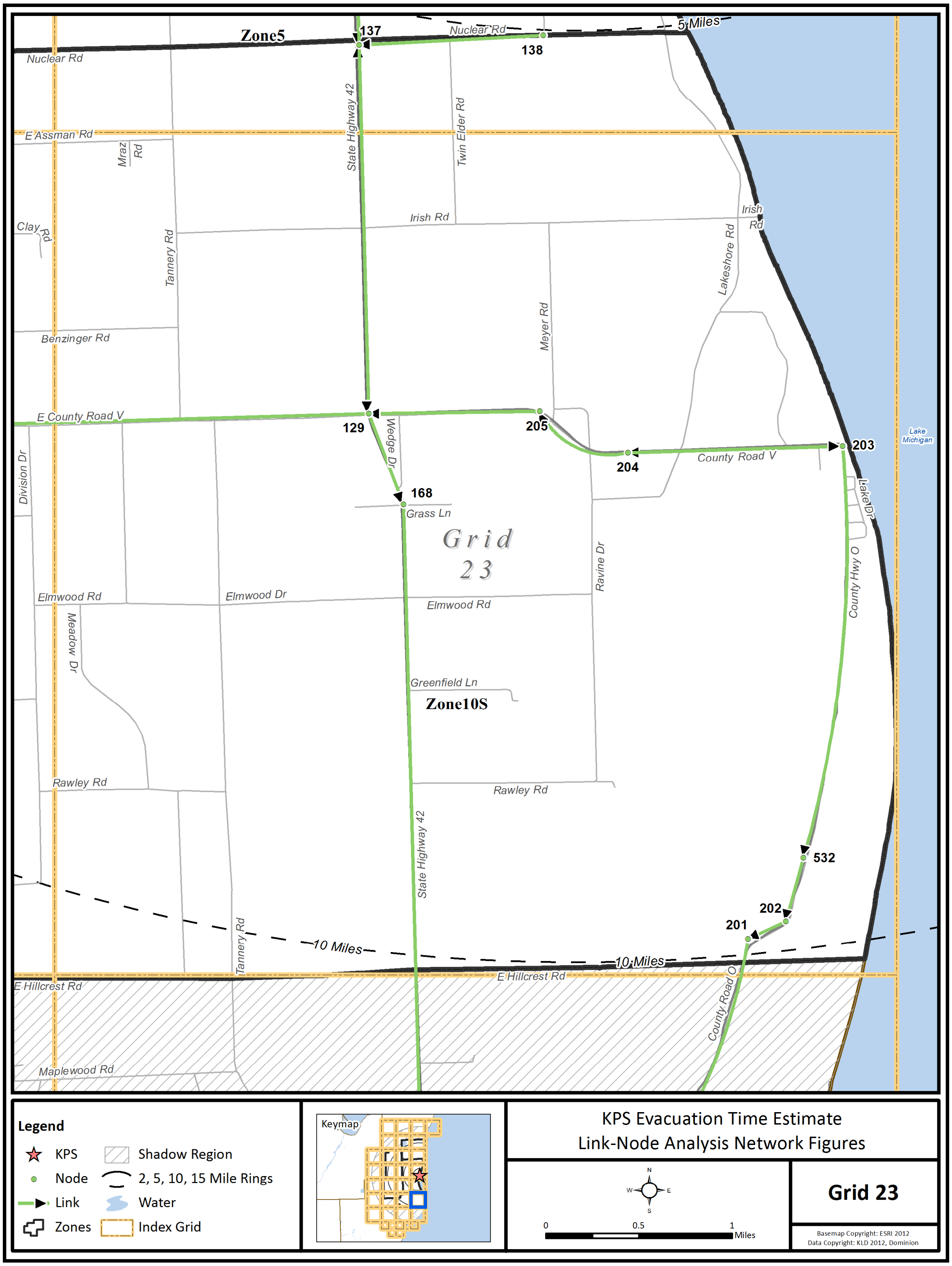


Figure K-24. Link-Node Analysis Network – Grid 23

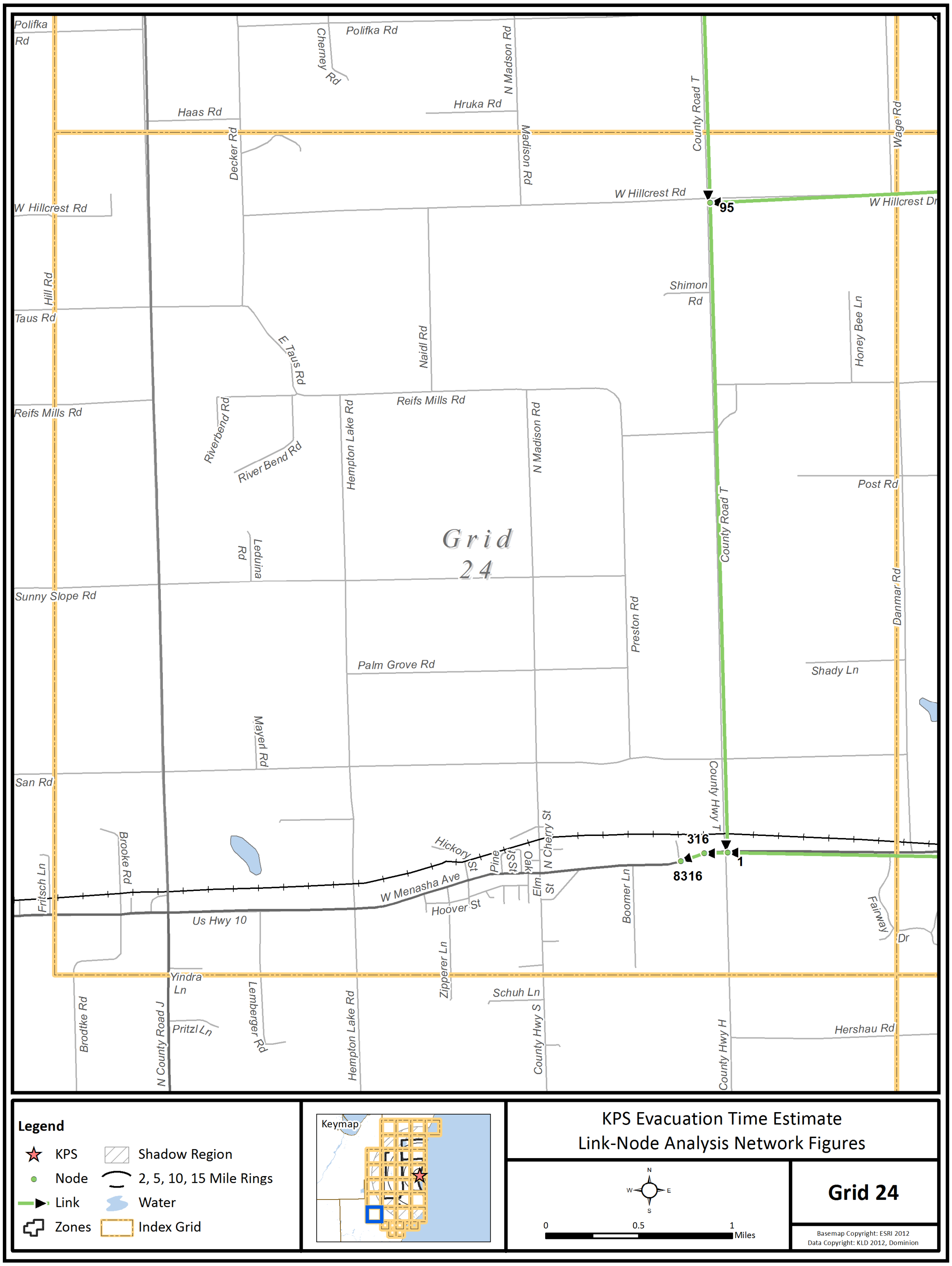


Figure K-25. Link-Node Analysis Network – Grid 24

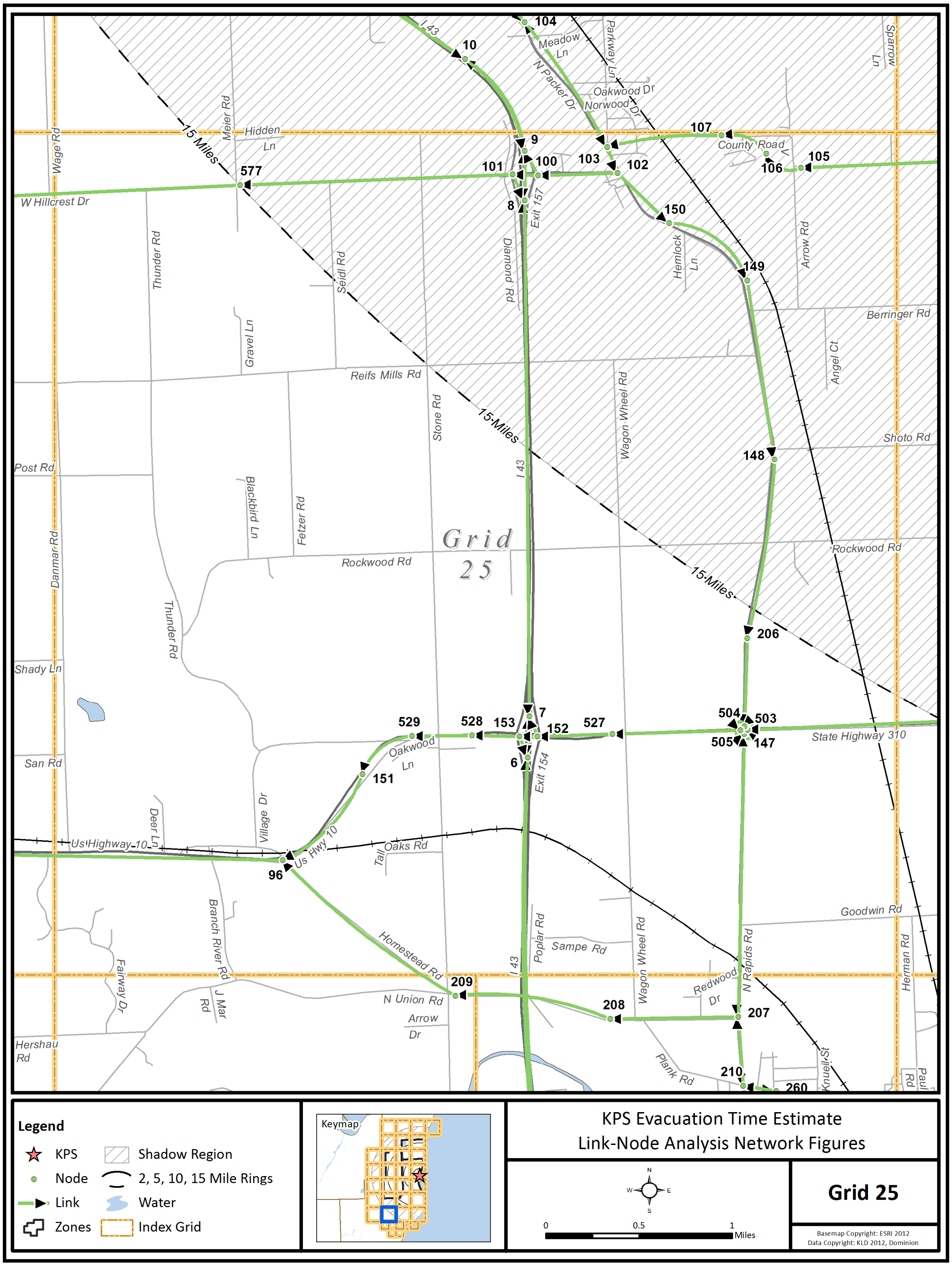


Figure K-26. Link-Node Analysis Network – Grid 25

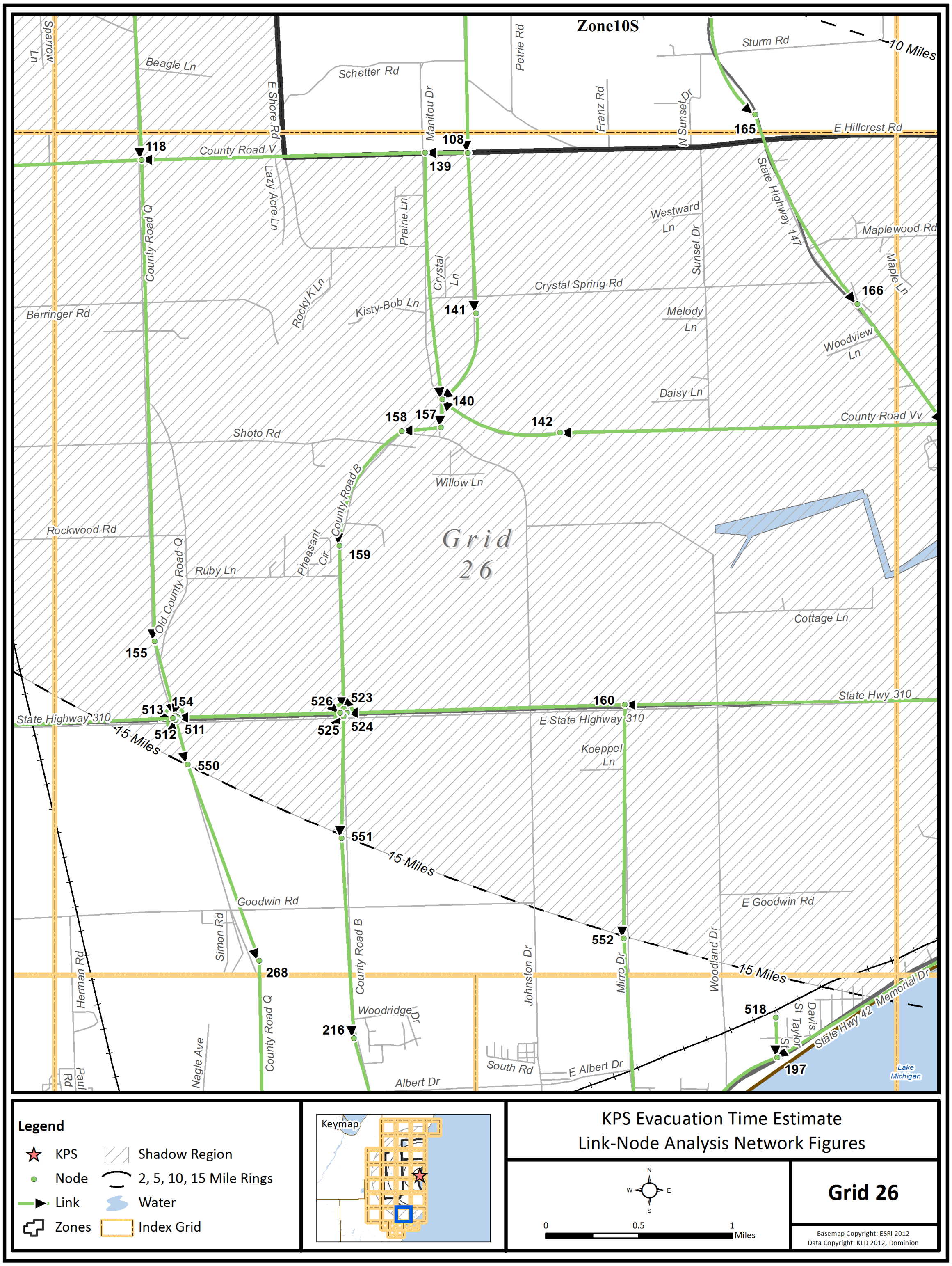


Figure K-27. Link-Node Analysis Network – Grid 26

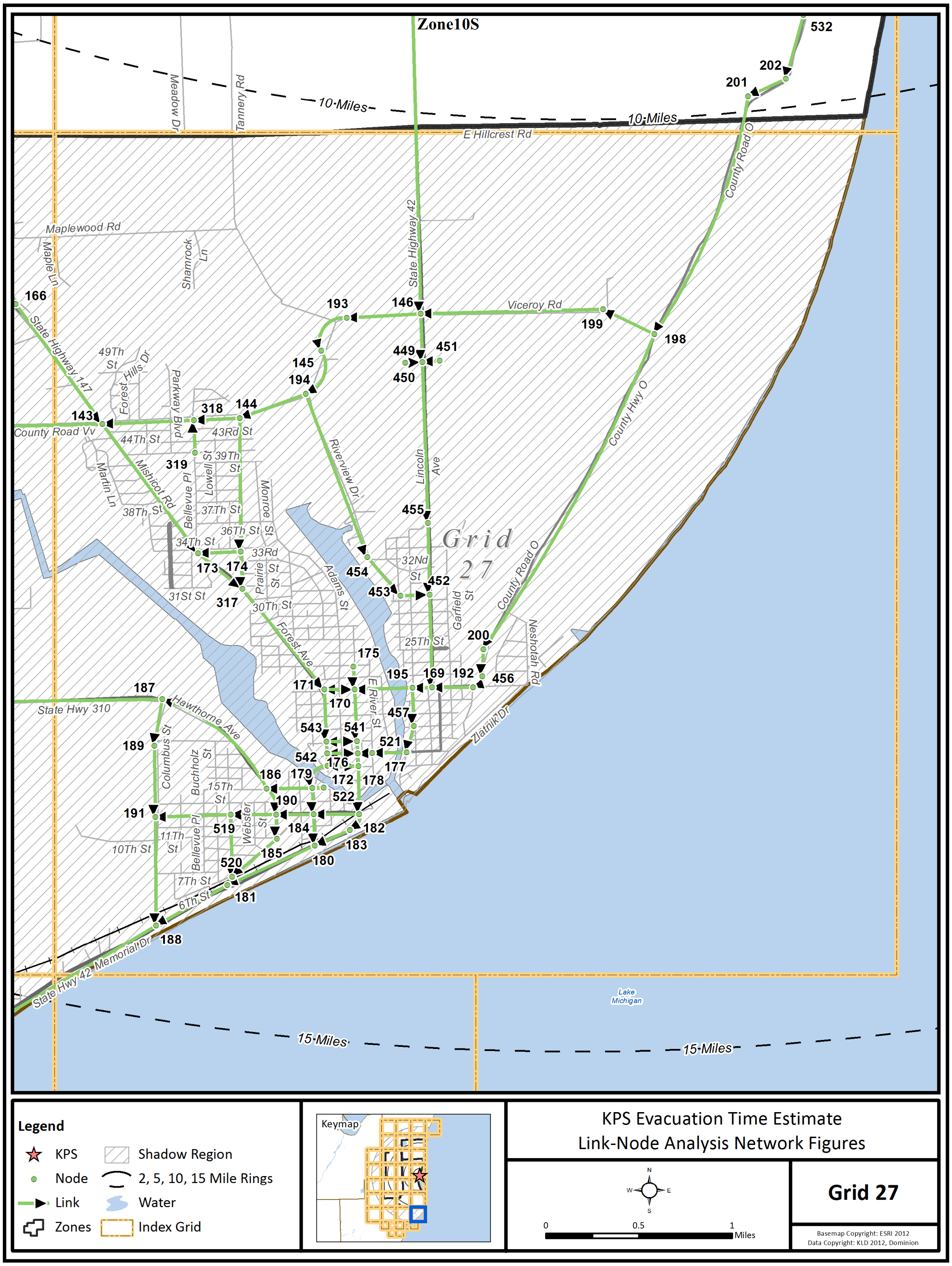


Figure K-28. Link-Node Analysis Network – Grid 27

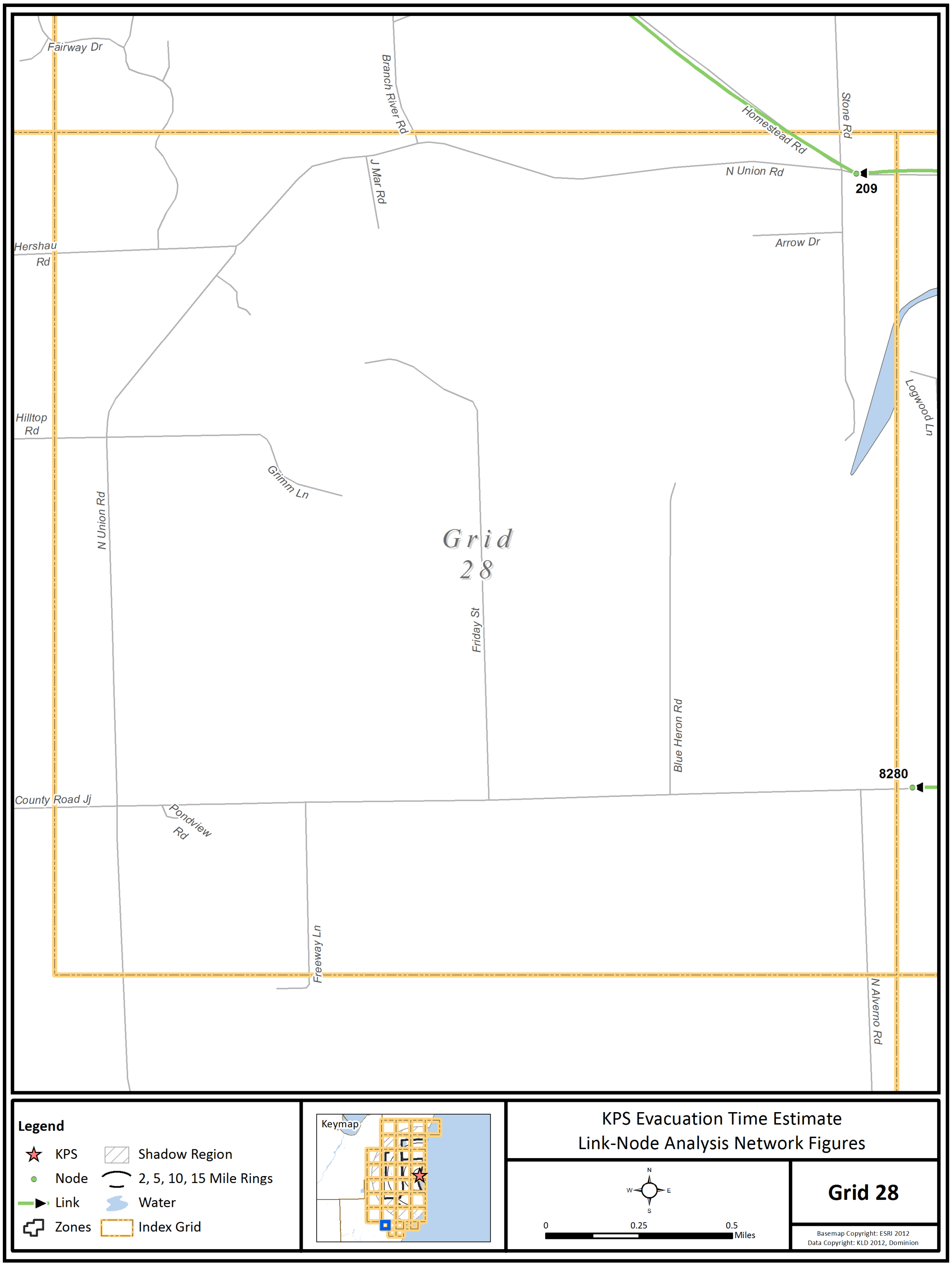


Figure K-29. Link-Node Analysis Network – Grid 28

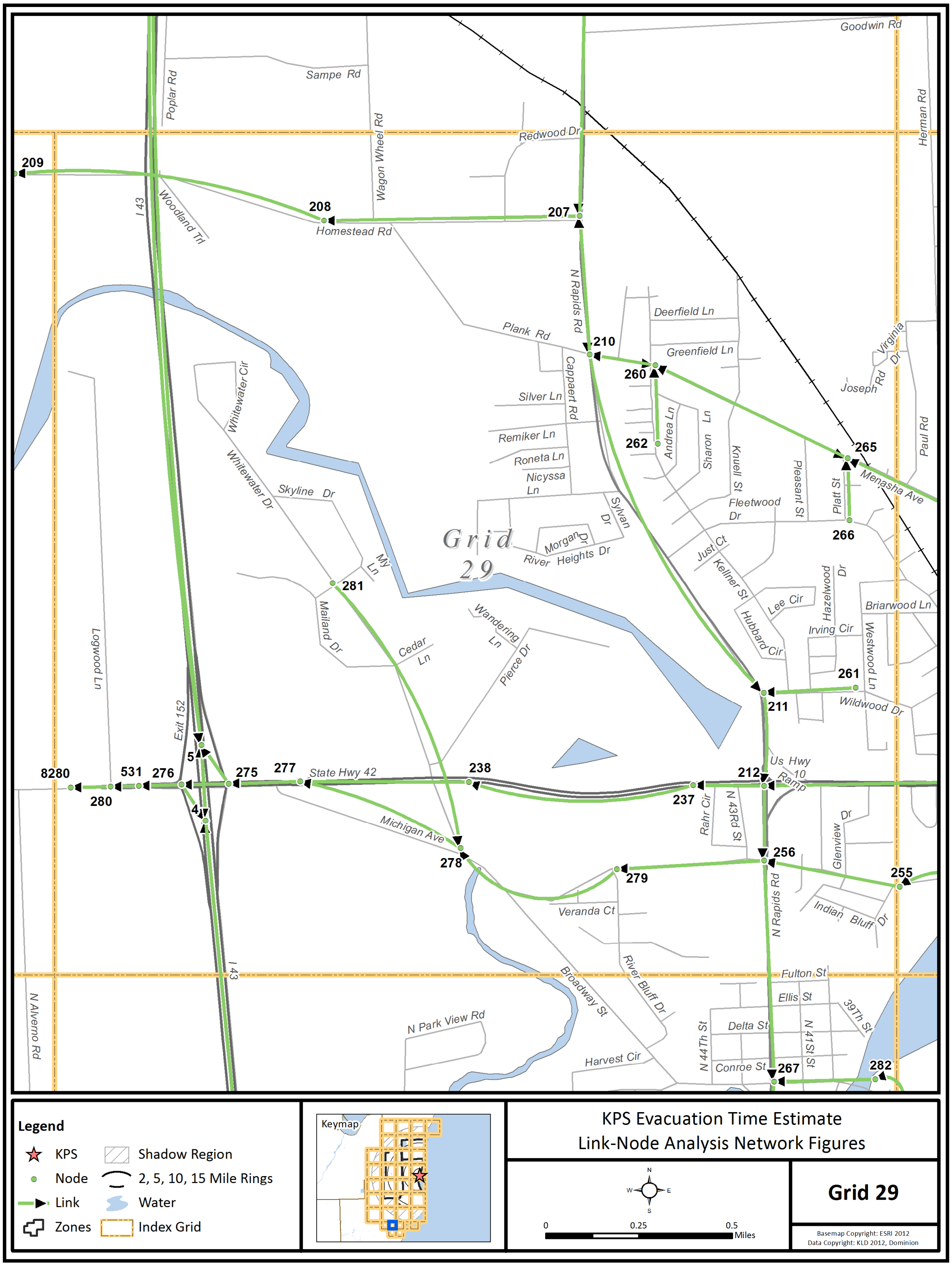


Figure K-30. Link-Node Analysis Network – Grid 29

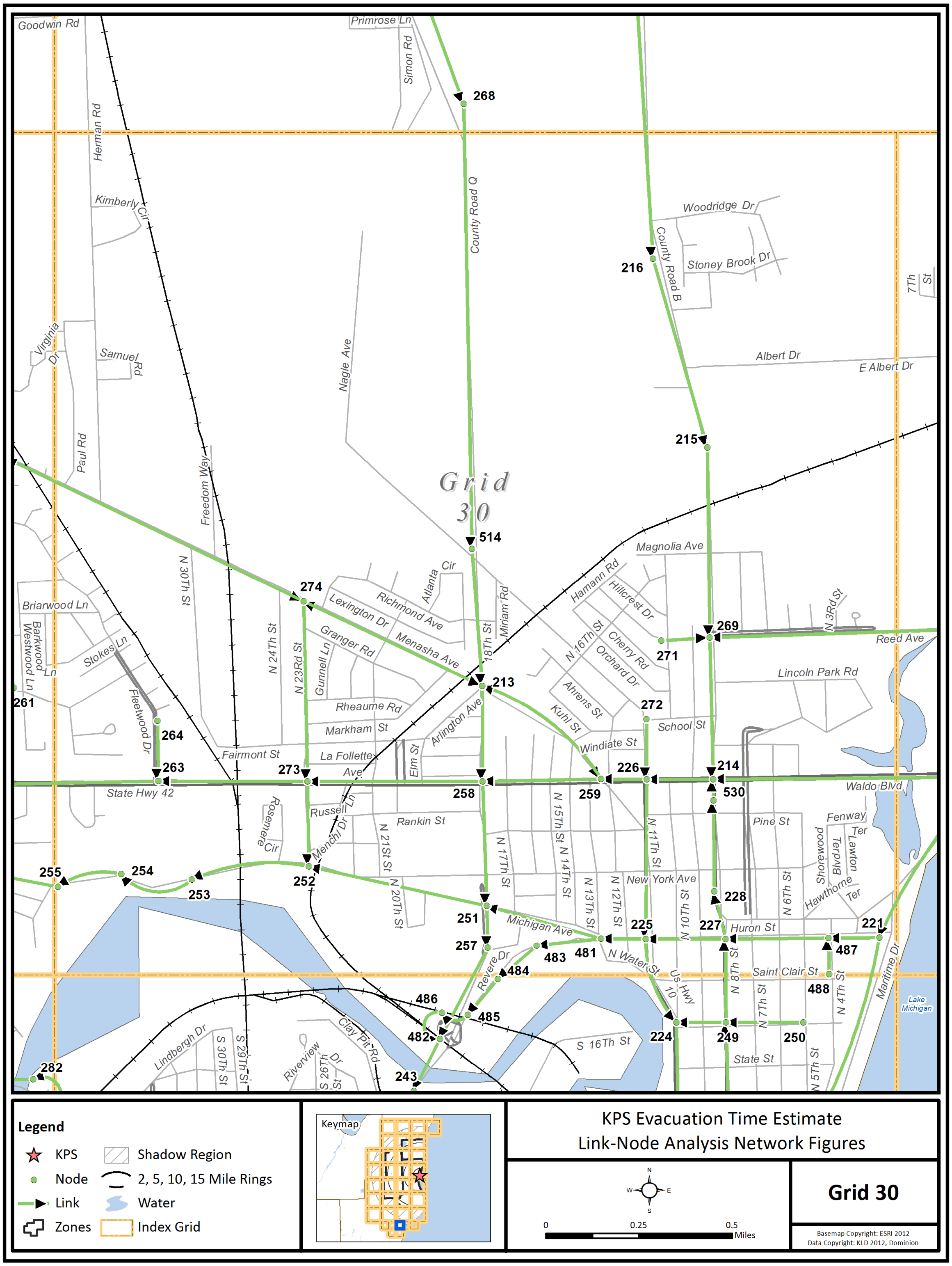


Figure K-31. Link-Node Analysis Network – Grid 30

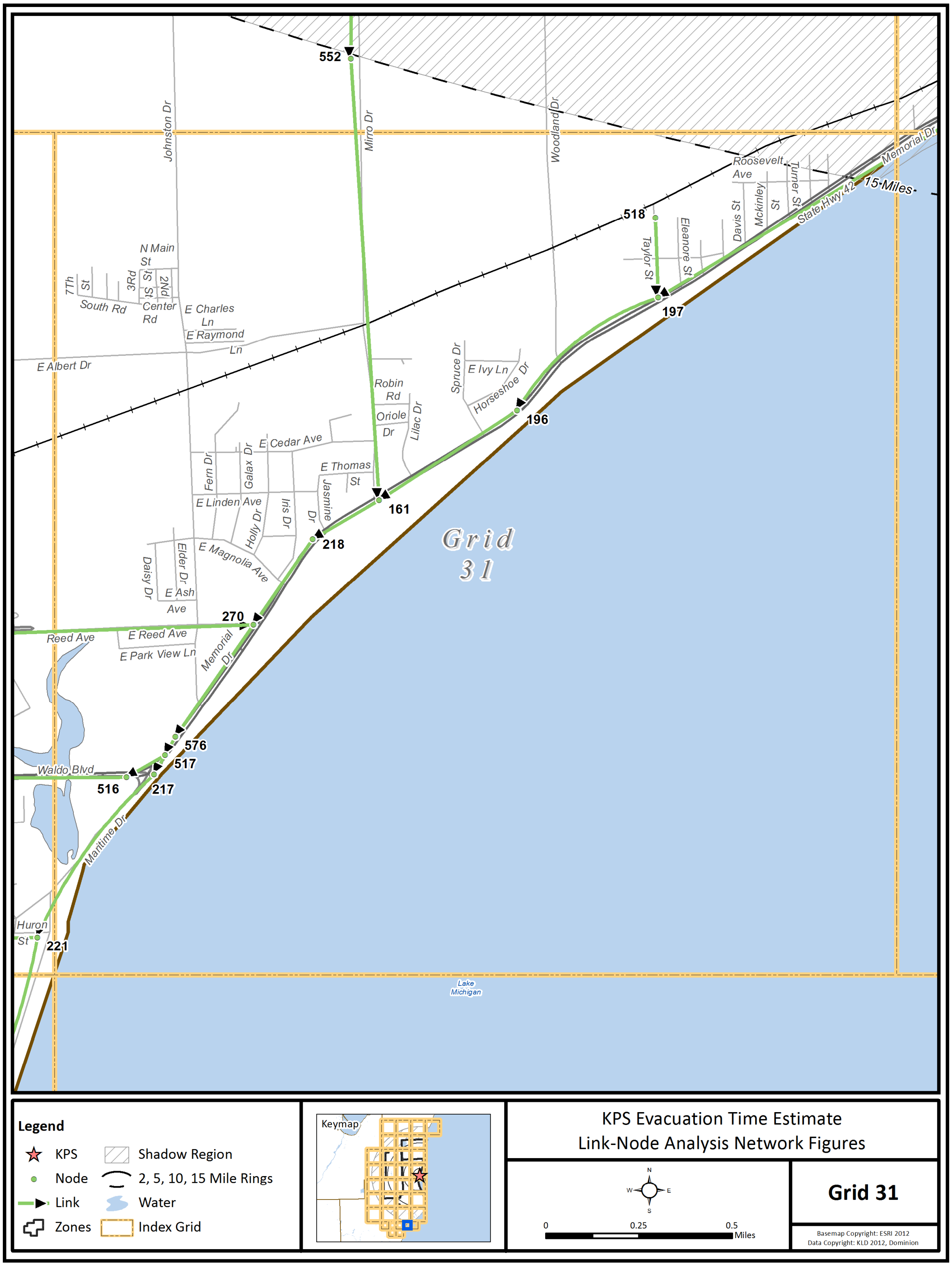


Figure K-32. Link-Node Analysis Network – Grid 31

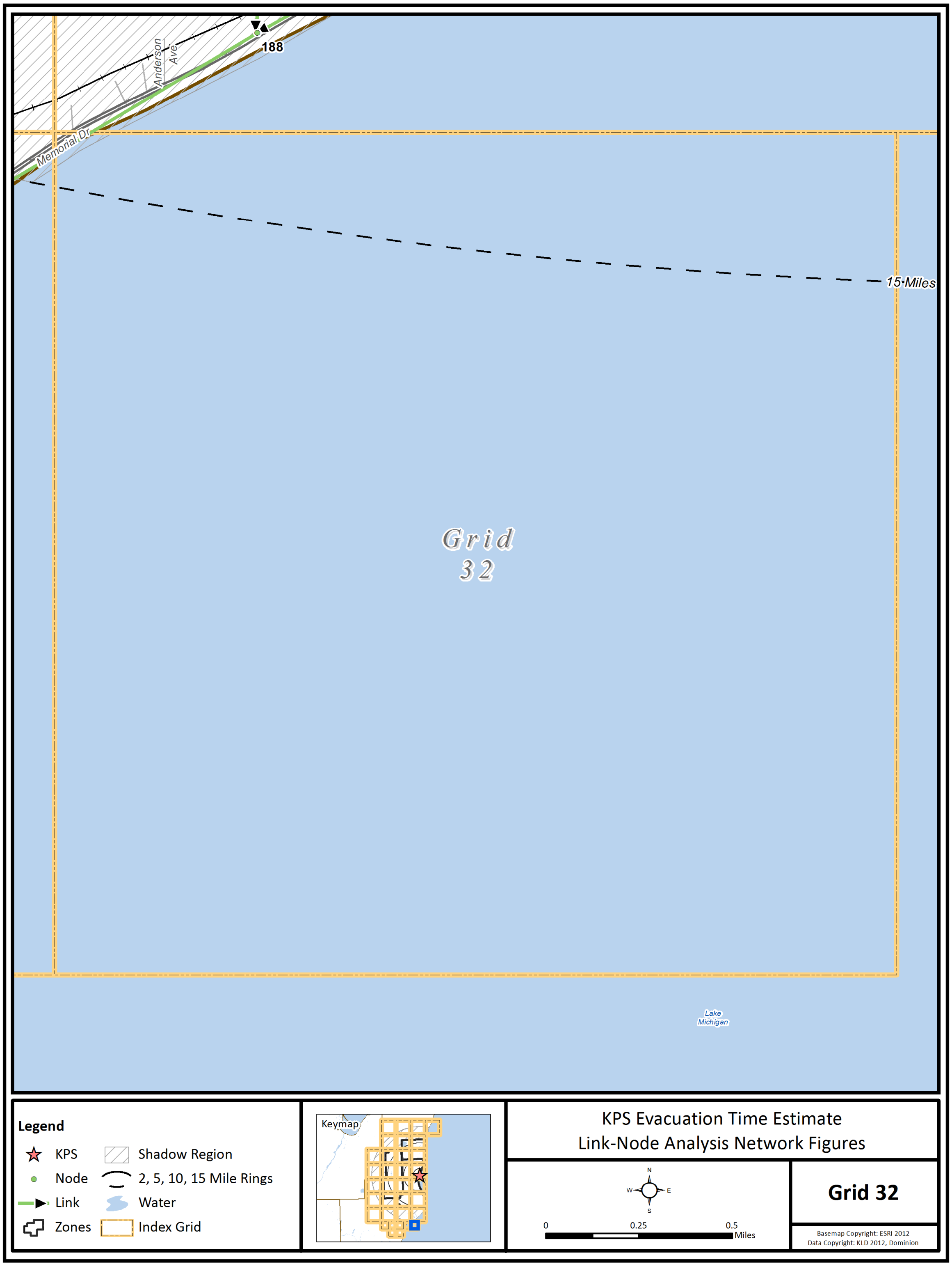


Figure K-33. Link-Node Analysis Network – Grid 32

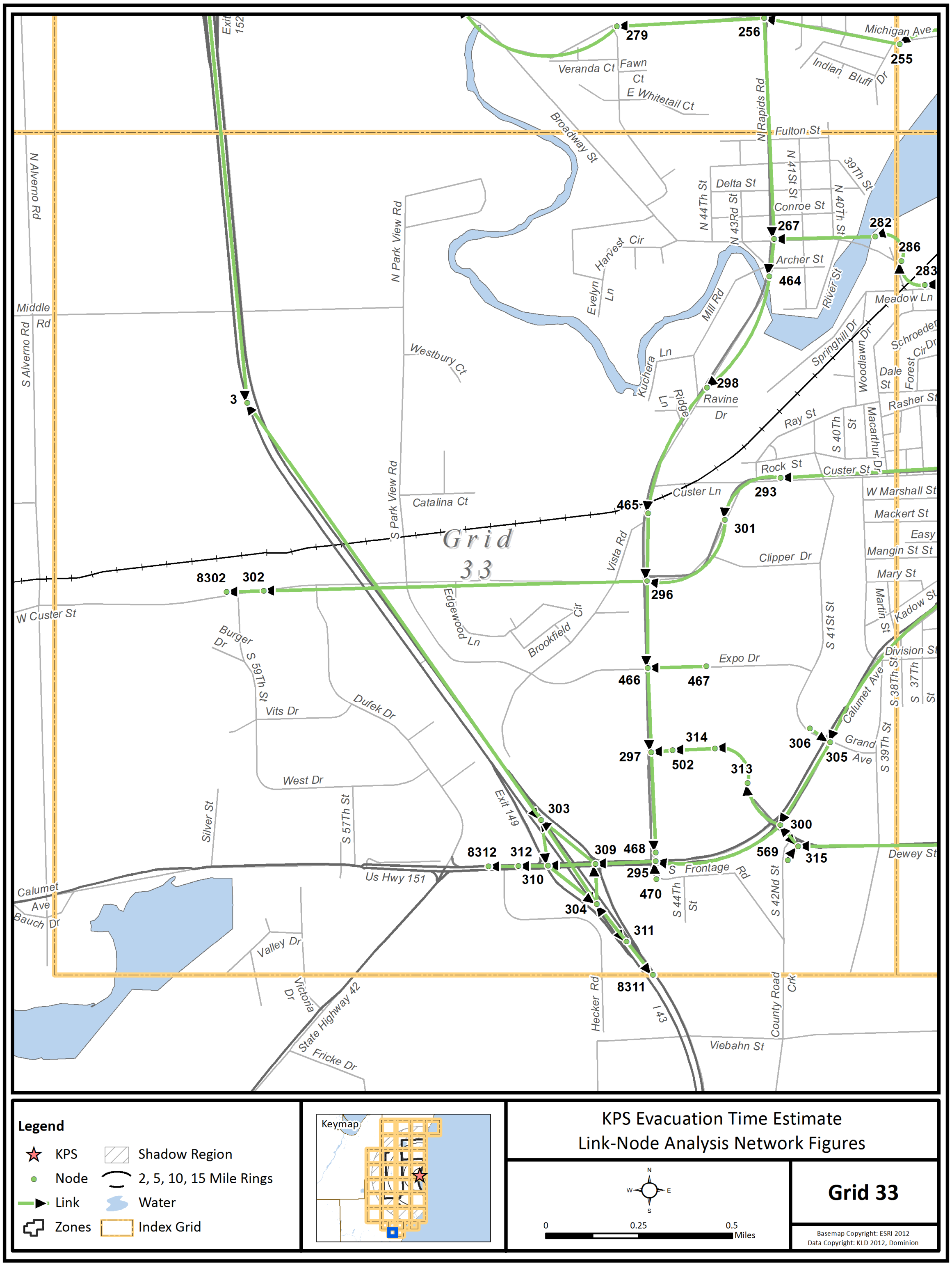


Figure K-34. Link-Node Analysis Network – Grid 33

Figure K-35. Link-Node Analysis Network – Grid 34

Table K-1. Evacuation Roadway Network Characteristics

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
1	1	316	US 10	MINOR ARTERIAL	660	1	12	8	1700	65	24
2	3	4	I-43	FREEWAY	6045	2	12	8	2250	70	33
3	3	303	I-43	FREEWAY	7230	2	12	8	2250	70	33
4	4	3	I-43	FREEWAY	6045	2	12	8	2250	70	33
5	4	5	I-43	FREEWAY	1070	2	12	8	2250	70	29
6	5	4	I-43	FREEWAY	1070	2	12	8	2250	70	29
7	5	6	I-43	FREEWAY	14871	2	12	8	2250	70	29
8	6	5	I-43	FREEWAY	14878	2	12	8	2250	70	29
9	6	7	I-43	FREEWAY	1156	2	12	8	2250	70	25
10	7	6	I-43	FREEWAY	1156	2	12	8	2250	70	25
11	7	8	I-43	FREEWAY	14627	2	12	8	2250	70	25
12	8	7	I-43	FREEWAY	14627	2	12	8	2250	70	25
13	8	9	I-43	FREEWAY	1400	2	12	8	2250	70	25
14	9	8	I-43	FREEWAY	1400	2	12	8	2250	70	25
15	9	10	I-43	FREEWAY	3184	2	12	8	2250	70	21
16	10	9	I-43	FREEWAY	3168	2	12	8	2250	70	21
17	10	11	I-43	FREEWAY	9609	2	12	8	2250	70	21
18	11	10	I-43	FREEWAY	9604	2	12	8	2250	70	21
19	11	12	I-43	FREEWAY	1990	2	12	8	2250	70	21
20	12	11	I-43	FREEWAY	1990	2	12	8	2250	70	21
21	12	13	I-43	FREEWAY	9749	2	12	8	2250	70	21
22	13	12	I-43	FREEWAY	9785	2	12	8	2250	70	21
23	13	14	I-43	FREEWAY	8078	2	12	8	2250	70	20

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
24	14	13	I-43	FREEWAY	8078	2	12	8	2250	70	20
25	14	15	I-43	FREEWAY	1367	2	12	8	2250	70	16
26	15	14	I-43	FREEWAY	1367	2	12	8	2250	70	16
27	15	16	I-43	FREEWAY	8760	2	12	8	2250	70	16
28	16	15	I-43	FREEWAY	8760	2	12	8	2250	70	16
29	16	17	I-43	FREEWAY	6105	2	12	8	2250	70	16
30	17	16	I-43	FREEWAY	6089	2	12	8	2250	70	16
31	17	23	I-43	FREEWAY	4121	2	12	8	2250	70	16
32	18	19	I-43	FREEWAY	4247	2	12	8	2250	70	16
33	18	23	I-43	FREEWAY	5024	2	12	8	2250	70	16
34	19	18	I-43	FREEWAY	4260	2	12	8	2250	70	16
35	19	20	I-43	FREEWAY	5148	2	12	8	2250	70	12
36	20	19	I-43	FREEWAY	5148	2	12	8	2250	70	12
37	20	21	I-43	FREEWAY	1464	2	12	8	2250	70	12
38	21	20	I-43	FREEWAY	1464	2	12	8	2250	70	12
39	21	22	I-43	FREEWAY	1085	2	12	8	2250	70	12
40	22	21	I-43	FREEWAY	1085	2	12	8	2250	70	12
41	23	17	I-43	FREEWAY	4121	2	12	8	2250	70	16
42	23	18	I-43	FREEWAY	5012	2	12	8	2250	70	16
43	24	25	CR BB	COLLECTOR	20507	1	12	0	1700	65	19
44	24	82	SR 42	MINOR ARTERIAL	6587	1	12	8	1750	65	19
45	24	135	SR 42	MINOR ARTERIAL	6127	1	12	8	1700	65	15
46	25	26	CR BB	COLLECTOR	5339	1	12	0	1750	55	18

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
47	25	98	CR B	COLLECTOR	4738	1	12	0	1700	60	14
48	26	27	CR BB	COLLECTOR	15932	1	12	0	1700	65	18
49	26	81	CR B	COLLECTOR	5393	1	12	0	1750	65	18
50	26	535	CR AB	COLLECTOR	12507	1	12	0	1700	60	14
51	27	35	CR Q	COLLECTOR	10570	1	12	4	1700	60	13
52	27	66	CR BB	COLLECTOR	10504	1	12	0	1750	65	17
53	27	80	CR Q	COLLECTOR	5242	1	12	4	1700	60	17
54	28	41	CR R	COLLECTOR	1296	1	12	6	1700	55	16
55	29	30	CR G	COLLECTOR	18521	1	12	0	1700	60	15
56	29	326	SR 42	MINOR ARTERIAL	10564	1	12	8	1700	65	15
57	30	99	CR B	COLLECTOR	7560	1	12	0	1700	65	14
58	30	320	CR B	COLLECTOR	5966	1	12	0	1700	65	14
59	30	538	CR G	COLLECTOR	7677	1	12	0	1700	60	14
60	31	47	RANGELINE RD	COLLECTOR	10696	1	12	0	1700	60	14
61	31	537	CR G	COLLECTOR	347	1	12	0	1700	50	14
62	32	535	CR AB	COLLECTOR	512	1	12	0	1700	50	14
63	32	536	CR AB	COLLECTOR	582	1	12	0	1700	50	14
64	32	537	CR G	COLLECTOR	2444	1	12	0	1700	60	14
65	33	43	CR AB	COLLECTOR	7963	1	12	4	1700	60	13
66	33	510	CR KB	COLLECTOR	1637	1	12	0	1700	60	13
67	34	35	CR KB	COLLECTOR	4386	1	12	4	1700	60	13
68	35	27	CR Q	COLLECTOR	10570	1	12	4	1700	60	13
69	35	36	CR KB	COLLECTOR	3553	1	12	0	1700	55	13
70	35	62	MANITOWOC RD	COLLECTOR	21231	1	12	0	1700	60	13

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
71	36	37	CR KB	COLLECTOR	7088	1	12	0	1750	60	13
72	37	39	CR KB	COLLECTOR	10527	1	12	0	1700	65	13
73	37	65	CR V	COLLECTOR	21475	1	12	0	1700	60	13
74	37	66	CURRAN RD	COLLECTOR	10405	1	12	0	1750	50	13
75	39	64	CR P	COLLECTOR	21210	1	12	0	1700	60	12
76	39	508	CR P	COLLECTOR	770	1	12	4	1700	45	12
77	40	41	CR P	COLLECTOR	6481	1	11	0	1700	50	12
78	40	507	CR KB	COLLECTOR	1196	1	12	4	1700	45	12
79	41	40	CR P	COLLECTOR	6481	1	11	0	1700	50	12
80	41	57	CR R	COLLECTOR	4223	1	12	6	1700	55	16
81	42	51	CR KB	COLLECTOR	1573	1	12	4	1575	35	12
82	43	44	CR AB	COLLECTOR	5358	1	12	4	1700	45	13
83	44	45	CR AB	COLLECTOR	5066	1	12	4	1700	45	9
84	45	46	CR AB	COLLECTOR	10558	1	12	4	1750	65	9
85	45	62	PINE GROVE RD	COLLECTOR	5128	1	12	0	1700	55	9
86	46	68	SR 29	MINOR ARTERIAL	5279	1	12	6	1700	50	9
87	46	546	CR AB	COLLECTOR	5171	1	12	4	1700	60	9
88	47	44	CR J	COLLECTOR	10539	1	12	0	1700	65	10
89	48	42	CR T	COLLECTOR	1678	1	12	4	1700	45	12
90	48	49	CR R	COLLECTOR	5066	1	12	4	1700	40	12
91	49	50	CR KB	COLLECTOR	1524	1	12	0	1700	40	12
92	49	55	CR R	COLLECTOR	15614	1	12	4	1700	60	12
93	50	21	I-43 RAMP	FREEWAY RAMP	1233	1	12	8	1700	45	12

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
94	50	78	CR KB	COLLECTOR	1911	1	12	4	1700	45	12
95	51	49	CR KB	COLLECTOR	2620	1	12	4	1575	35	12
96	51	436	CR T	COLLECTOR	3254	1	12	4	1575	35	12
97	52	53	CR T	COLLECTOR	957	1	12	0	1575	35	12
98	52	360	CR T	COLLECTOR	901	1	12	0	1575	35	12
99	53	52	CR T	COLLECTOR	935	1	12	0	1575	35	12
100	53	54	CR T	COLLECTOR	4860	1	12	4	1700	60	12
101	54	53	CR T	COLLECTOR	4860	1	12	4	1700	60	12
102	54	437	CR T	COLLECTOR	724	1	12	4	1700	40	12
103	54	438	LANGES CORNER RD	LOCAL ROADWAY	408	1	12	0	1700	40	12
104	55	79		COLLECTOR	696	1	12	4	1700	60	12
105	56	55	LANGES CORNER RD	COLLECTOR	4465	1	12	4	1700	60	12
106	57	48	CR R	COLLECTOR	3885	1	12	4	1700	60	12
107	57	58	CR T	COLLECTOR	8436	1	12	0	1700	65	16
108	58	57	CR T	MINOR ARTERIAL	8436	1	12	0	1700	65	16
109	58	461	CR T	COLLECTOR	9145	1	12	0	1700	65	16
110	59	28	CR R	COLLECTOR	6700	1	12	6	1700	55	16
111	59	58	ZANDER ST	COLLECTOR	8576	1	12	0	1700	55	16
112	59	506	CR R	COLLECTOR	2777	1	12	4	1700	60	17
113	60	61	CR T	COLLECTOR	12009	1	12	0	1700	60	12
114	61	71	CR T	COLLECTOR	10682	1	12	0	1700	60	8
115	62	65	PINE GROVE RD	COLLECTOR	10600	1	12	0	1700	55	9
116	62	68	MANITOWOC RD	COLLECTOR	10528	1	12	0	1700	60	9

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
117	64	61	PINE GROVE RD	COLLECTOR	10548	1	12	0	1700	55	8
118	64	70	CR P	COLLECTOR	10600	1	12	0	1700	65	8
119	65	64	PINE GROVE RD	COLLECTOR	10698	1	12	0	1700	55	9
120	65	69	CR V	COLLECTOR	10388	1	12	0	1700	60	9
121	66	28	CR BB	COLLECTOR	11498	1	12	0	1700	65	17
122	66	37	CURRAN RD	COLLECTOR	10405	1	12	0	1750	50	13
123	68	549	SR 29	MINOR ARTERIAL	2672	1	12	4	1700	65	9
124	69	70	SR 29	MINOR ARTERIAL	10410	1	12	6	1700	65	9
125	69	355	GASCHE RD	COLLECTOR	21321	1	12	0	1700	60	5
126	70	71	SR 29	MINOR ARTERIAL	10692	1	12	6	1700	60	8
127	71	75	CR T	COLLECTOR	776	1	12	0	1700	60	8
128	71	76	SR 29	MINOR ARTERIAL	687	1	12	6	1700	60	8
129	72	461	CR T	COLLECTOR	4112	1	12	0	1700	40	16
130	72	462	CR T	COLLECTOR	2663	1	12	0	1700	40	16
131	72	534	CR Z	COLLECTOR	1176	1	12	3	1700	40	16
132	73	74	SR 147	MAJOR ARTERIAL	1113	1	12	4	1700	60	16
133	73	88	CR R	COLLECTOR	5831	1	12	4	1700	65	17
134	73	167	CR R	COLLECTOR	3125	1	12	4	1700	50	17
135	74	15	I-43 RAMP	FREEWAY RAMP	719	1	12	8	1700	45	16
136	74	83	CR Z	COLLECTOR	658	1	12	3	1700	60	16

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
137	80	27	CR Q	COLLECTOR	5242	1	12	4	1700	60	17
138	80	117	CR Q	COLLECTOR	5083	1	12	4	1700	60	17
139	80	460	ZANDER ST	COLLECTOR	13213	1	12	0	1700	55	17
140	81	26	CR B	COLLECTOR	5393	1	12	0	1750	65	18
141	81	80	ZANDER ST	COLLECTOR	15863	1	12	0	1700	55	18
142	81	109	CR B	COLLECTOR	26128	1	12	0	1700	65	18
143	82	24	SR 42	MINOR ARTERIAL	6589	1	12	8	1750	65	19
144	82	81	ZANDER ST	COLLECTOR	22002	1	12	0	1750	55	18
145	82	134	SR 42	MINOR ARTERIAL	1859	1	12	8	1700	65	19
146	83	14	I-43 RAMP	FREEWAY RAMP	810	1	12	8	1700	45	16
147	83	533	CR Z	COLLECTOR	4451	1	12	3	1700	60	16
148	84	12	I-43 RAMP	FREEWAY RAMP	1271	1	12	8	1700	45	21
149	84	85	CR K	COLLECTOR	1031	1	12	4	1700	60	21
150	85	11	I-43 RAMP	FREEWAY RAMP	1504	1	12	8	1700	45	21
151	85	87	CR K	COLLECTOR	8593	1	12	4	1700	65	20
152	86	84	CR K	COLLECTOR	5619	1	12	4	1700	65	21
153	86	104	CR R	COLLECTOR	7180	1	12	4	1700	65	21
154	86	130	CR R	COLLECTOR	6061	1	12	4	1700	60	21
155	87	92	CR T	COLLECTOR	3842	1	12	0	1700	45	20
156	87	97	CR K	COLLECTOR	7379	1	12	4	1700	65	20
157	87	463	CR T	COLLECTOR	3171	1	12	0	1700	50	20

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
158	88	73	CR R	COLLECTOR	5831	1	12	4	1700	65	17
159	88	506	CR R	COLLECTOR	4737	1	12	4	1700	60	17
160	89	90	SR 147	MAJOR ARTERIAL	6505	1	12	4	1700	60	17
161	89	115	CR Q	COLLECTOR	4334	1	12	4	1700	60	17
162	89	131	CR Q	COLLECTOR	2052	1	12	4	1700	60	21
163	90	91	SR 147	MAJOR ARTERIAL	2155	1	12	4	1700	60	17
164	91	73	SR 147	MAJOR ARTERIAL	8264	1	12	4	1700	60	17
165	92	87	CR T	COLLECTOR	3842	1	12	0	1700	45	20
166	92	94	CR T	COLLECTOR	1750	1	12	0	1700	65	20
167	93	94	CR T	COLLECTOR	1804	1	12	0	1700	50	20
168	93	462	CR T	COLLECTOR	8910	1	12	0	1700	65	20
169	94	92	CR T	COLLECTOR	1709	1	12	0	1700	65	20
170	94	93	CR T	COLLECTOR	1898	1	12	0	1700	65	20
171	95	1	CR T	COLLECTOR	18423	1	12	0	1700	65	24
172	96	1	US 10	MINOR ARTERIAL	11260	1	12	8	1700	65	25
173	98	25	CR B	COLLECTOR	4731	1	12	0	1700	60	14
174	98	99	CR B	COLLECTOR	4136	1	12	0	1700	60	14
175	99	30	CR B	COLLECTOR	7560	1	12	0	1700	65	14
176	99	98	CR B	COLLECTOR	4151	1	12	0	1700	60	14
177	100	9	I-43 RAMP	FREEWAY RAMP	789	1	12	8	1700	45	25
178	100	101	CR V	COLLECTOR	718	1	12	4	1700	60	25

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
179	101	8	I-43 RAMP	FREEWAY RAMP	805	1	12	8	1700	45	25
180	101	577	CR V	COLLECTOR	7733	1	12	0	1700	60	25
181	102	100	CR V	COLLECTOR	2254	1	12	4	1700	60	25
182	102	150	CR R	COLLECTOR	2046	1	12	4	1700	50	25
183	103	102	CR R	COLLECTOR	793	1	12	4	1700	40	25
184	103	104	CR R	COLLECTOR	4245	1	12	6	1700	50	21
185	104	86	CR R	COLLECTOR	7171	1	12	4	1700	65	21
186	104	103	CR R	COLLECTOR	4246	1	12	6	1700	50	21
187	105	106	CR V	COLLECTOR	1173	1	12	0	1700	50	25
188	106	107	CR V	COLLECTOR	1421	1	12	0	1700	50	25
189	107	103	CR V	COLLECTOR	3269	1	12	0	1575	35	25
190	108	139	CR V	COLLECTOR	1208	1	12	0	1700	60	26
191	108	141	CR B	COLLECTOR	4541	1	12	0	1700	60	26
192	109	81	CR B	COLLECTOR	26128	1	12	0	1750	65	18
193	109	110	SR 147	MINOR ARTERIAL	511	1	12	0	1575	35	22
194	109	111	SR 147	MINOR ARTERIAL	4967	1	12	0	1700	40	22
195	109	121	CR B	COLLECTOR	2934	1	12	0	1700	40	22
196	110	109	SR 147	MINOR ARTERIAL	511	1	12	0	1575	35	22
197	110	128	SR 147	MINOR ARTERIAL	1656	1	12	0	1575	35	22
198	111	112	CR 147	MAJOR ARTERIAL	5192	1	12	0	1700	55	22

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
199	111	125	RIDGE RD	COLLECTOR	1223	1	12	4	1700	45	22
200	112	113	CR 147	MAJOR ARTERIAL	4937	1	12	0	1700	55	22
201	113	89	CR 147	MAJOR ARTERIAL	6019	1	12	0	1750	55	21
202	115	89	CR Q	COLLECTOR	4334	1	12	4	1750	60	17
203	115	116	CR Q	COLLECTOR	4066	1	12	4	1700	55	17
204	116	115	CR Q	COLLECTOR	4075	1	12	4	1700	55	17
205	116	117	CR Q	COLLECTOR	3561	1	12	4	1700	55	17
206	117	80	CR Q	COLLECTOR	5083	1	12	4	1700	60	17
207	117	116	CR Q	COLLECTOR	3542	1	12	4	1700	55	17
208	118	105	CR V	COLLECTOR	5181	1	12	0	1700	55	25
209	118	155	CR Q	COLLECTOR	13648	1	12	4	1700	60	26
210	119	118	CR Q	COLLECTOR	5145	1	12	4	1700	60	22
211	120	119	CR Q	COLLECTOR	1843	1	12	4	1700	60	22
212	120	126	CR Q	COLLECTOR	10412	1	12	4	1750	60	21
213	121	122	CHRUCH ST	LOCAL ROADWAY	3874	1	12	0	1700	45	22
214	121	540	CR B	COLLECTOR	3476	1	12	0	1700	45	22
215	122	124	RIDGE RD	COLLECTOR	1634	1	12	4	1700	45	22
216	123	126	CR Y	COLLECTOR	9929	1	12	0	1750	60	22
217	124	123	RIDGE RD	COLLECTOR	1324	1	12	4	1700	45	22
218	125	123	RIDGE RD	COLLECTOR	2688	1	12	4	1700	45	22
219	126	120	CR Q	COLLECTOR	10408	1	12	4	1700	60	21
220	126	130	CR Y	COLLECTOR	14330	1	12	0	1700	65	21
221	126	133	CR Q	COLLECTOR	4379	1	12	4	1700	60	21

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
222	127	121	CHRUCH ST	LOCAL ROADWAY	1829	1	12	0	1575	35	22
223	127	128	SR 147	MINOR ARTERIAL	1456	1	12	0	1575	35	22
224	127	162	SR 147	MINOR ARTERIAL	3798	1	12	4	1700	40	22
225	128	110	SR 147	MINOR ARTERIAL	1656	1	12	0	1575	35	22
226	128	127	SR 147	MINOR ARTERIAL	1456	1	12	0	1575	35	22
227	129	137	SR 42	MINOR ARTERIAL	10444	1	12	8	1750	65	23
228	129	168	SR 42	MINOR ARTERIAL	2754	1	12	8	1700	65	23
229	129	539	CR V	COLLECTOR	16291	1	12	0	1700	60	23
230	130	86	CR R	COLLECTOR	6061	1	12	4	1700	60	21
231	130	94	FISHERVILLE RD	COLLECTOR	12779	1	12	0	1700	55	20
232	130	459	CR R	COLLECTOR	2898	1	12	4	1700	55	21
233	131	89	CR Q	COLLECTOR	2052	1	12	4	1750	60	21
234	131	132	CR Q	COLLECTOR	2196	1	12	4	1700	60	21
235	132	131	CR Q	COLLECTOR	2181	1	12	4	1700	60	21
236	132	133	CR Q	COLLECTOR	2472	1	12	4	1700	60	21
237	133	126	CR Q	COLLECTOR	4385	1	12	4	1750	60	21
238	133	132	CR Q	COLLECTOR	2474	1	12	4	1700	60	21
239	134	82	SR 42	MINOR ARTERIAL	1853	1	12	8	1750	65	19

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
240	134	137	SR 42	MINOR ARTERIAL	14394	1	12	8	1750	65	19
241	135	24	SR 42	MINOR ARTERIAL	6122	1	12	8	1750	65	15
242	135	29	SR 42	MINOR ARTERIAL	9783	1	12	8	1700	65	15
243	136	135	KEWAUNEE DRIVEWAY	LOCAL ROADWAY	1315	1	12	4	1350	30	15
244	137	129	SR 42	MINOR ARTERIAL	10443	1	12	8	1700	65	23
245	137	134	SR 42	MINOR ARTERIAL	14394	1	12	8	1700	65	19
246	138	137	NUCLEAR ROAD	COLLECTOR	5229	1	12	4	1750	55	19
247	139	118	CR V	COLLECTOR	8048	1	12	0	1700	60	26
248	139	140	MANITOU DR	COLLECTOR	7015	1	12	4	1700	50	26
249	140	157	CR B	COLLECTOR	794	1	12	0	1575	35	26
250	141	140	CR B	COLLECTOR	2742	1	12	0	1700	60	26
251	142	140	CR VV	COLLECTOR	3578	1	12	4	1700	55	26
252	143	142	CR VV	COLLECTOR	10895	1	12	4	1700	60	26
253	143	173	SR 147	MINOR ARTERIAL	4564	1	16	0	1700	40	27
254	144	174	TANNEY RD	COLLECTOR	3788	1	12	0	1575	35	27
255	144	318	CR VV	COLLECTOR	1300	1	12	4	1700	45	27
256	145	194	CR VV	COLLECTOR	1444	1	12	4	1700	45	27
257	146	193	CR VV	COLLECTOR	2105	1	12	4	1700	55	27
258	146	449	SR 42	MINOR ARTERIAL	1377	1	12	8	1700	65	27

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
259	147	207	CR R	COLLECTOR	8007	1	12	4	1700	45	25
260	147	503	SR 310/CR R ROUNDABOUT	MINOR ARTERIAL	159	1	12	0	900	20	25
261	148	206	CR R	COLLECTOR	5146	1	12	4	1700	65	25
262	149	148	CR R	COLLECTOR	5122	1	12	4	1700	65	25
263	150	149	CR R	COLLECTOR	2887	1	12	4	1700	60	25
264	151	96	SR 310	MINOR ARTERIAL	3394	1	12	4	1700	65	25
265	152	7	I-43 RAMP	FREEWAY RAMP	609	1	12	8	1700	45	25
266	152	153	SR 310	MINOR ARTERIAL	505	2	12	4	1900	60	25
267	153	6	I-43 RAMP	FREEWAY RAMP	640	1	12	8	1700	45	25
268	153	528	SR 310	MINOR ARTERIAL	1344	2	12	4	1900	60	25
269	154	513	SR 310/CR Q ROUNDABOUT	MINOR ARTERIAL	99	1	12	0	900	20	26
270	155	154	CR Q	COLLECTOR	2185	1	12	4	1700	60	26
271	157	158	CR B	COLLECTOR	1117	1	12	0	1700	40	26
272	158	159	CR B	COLLECTOR	3816	1	12	0	1700	50	26
273	159	523	CR B	COLLECTOR	4631	1	12	0	1700	60	26
274	160	524	SR 310	MINOR ARTERIAL	7873	1	12	4	1700	60	26
275	160	552	CR DD	COLLECTOR	6607	1	12	4	1700	60	26
276	161	218	MEMORIAL DR	MAJOR ARTERIAL	1092	2	12	6	1900	50	31

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
277	162	163	SR 147	MINOR ARTERIAL	4655	1	12	4	1700	60	22
278	163	164	SR 147	MINOR ARTERIAL	2570	1	12	4	1700	60	22
279	164	165	SR 147	MINOR ARTERIAL	3206	1	12	4	1700	60	22
280	165	166	SR 147	MINOR ARTERIAL	6121	1	12	4	1700	60	26
281	166	143	SR 147	MINOR ARTERIAL	4195	1	12	4	1700	60	27
282	167	73	CR R	COLLECTOR	3138	1	12	4	1700	50	17
283	167	458	CR R	COLLECTOR	4111	1	12	4	1700	50	21
284	168	146	SR 42	MINOR ARTERIAL	18476	1	12	8	1700	65	23
285	169	195	SR 42	MINOR ARTERIAL	553	2	12	0	1900	35	27
286	170	171	SR 147	MINOR ARTERIAL	859	1	12	0	1575	35	27
287	170	541	WASHINGTON ST	MAJOR ARTERIAL	1478	2	12	0	1750	35	27
288	171	170	SR 147	MINOR ARTERIAL	859	1	12	0	1750	35	27
289	171	543	MONROE ST	LOCAL ROADWAY	1481	1	12	0	1575	35	27
290	172	178	SR 310	COLLECTOR	870	1	12	0	1750	35	27
291	172	179	SR 310	COLLECTOR	836	1	12	0	1750	35	27
292	173	317	SR 147	MINOR ARTERIAL	1613	1	16	0	1700	40	27

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
293	174	173	42ND ST	LOCAL ROADWAY	1210	1	12	0	1575	35	27
294	174	317	TANNEY RD	COLLECTOR	1061	1	12	0	1575	35	27
295	175	170	WASHINGTON ST	COLLECTOR	646	2	12	0	1750	35	27
296	176	178	WASHINGTON ST	MAJOR ARTERIAL	359	2	12	0	1750	35	27
297	176	542	17TH ST	LOCAL ROADWAY	865	1	12	0	1350	30	27
298	177	521	17TH ST	LOCAL ROADWAY	973	1	12	0	1350	30	27
299	178	172	SR 310	COLLECTOR	870	1	12	0	1750	35	27
300	178	182	WASHINGTON ST	MAJOR ARTERIAL	1355	2	12	0	1900	45	27
301	179	184	MADISON ST	COLLECTOR	741	1	12	0	1750	35	27
302	179	186	SR 310	COLLECTOR	1300	1	12	0	1575	35	27
303	180	181	MEMORIAL DR	MAJOR ARTERIAL	2721	2	12	6	1900	50	27
304	181	188	MEMORIAL DR	MAJOR ARTERIAL	2322	2	12	6	1900	55	27
305	182	183	MEMORIAL DR	MAJOR ARTERIAL	565	2	12	0	1900	35	27
306	182	184	12TH ST	LOCAL ROADWAY	1289	1	12	0	1750	30	27
307	183	180	MEMORIAL DR	MAJOR ARTERIAL	1080	2	12	6	1900	55	27
308	184	180	MADISON ST	COLLECTOR	899	1	12	0	1575	35	27
309	184	190	12TH ST	LOCAL ROADWAY	1062	1	12	0	1350	30	27

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
310	185	520	ROOSEVELT AVE	LOCAL ROADWAY	1658	1	12	0	1350	30	27
311	186	187	SR 310	COLLECTOR	3982	1	12	0	1700	45	27
312	186	190	HAWTHORNE AVE	LOCAL ROADWAY	800	1	12	0	1350	30	27
313	187	160	SR 310	MINOR ARTERIAL	10761	1	12	4	1700	60	26
314	187	189	COLUMBUS ST	COLLECTOR	1347	1	12	0	1575	35	27
315	188	197	MEMORIAL DR	MAJOR ARTERIAL	7291	2	12	6	1750	55	31
316	189	191	COLUMBUS ST	COLLECTOR	2017	1	12	0	1575	35	27
317	190	185	HAWTHORNE AVE	LOCAL ROADWAY	692	1	12	0	1350	30	27
318	190	519	12TH ST	LOCAL ROADWAY	1284	1	12	0	1350	30	27
319	191	188	COLUMBUS ST	COLLECTOR	3071	1	12	0	1575	35	27
320	192	169	CR O	COLLECTOR	1169	1	12	0	1575	35	27
321	193	145	CR VV	COLLECTOR	1340	1	12	4	1700	45	27
322	194	144	CR VV	COLLECTOR	1992	1	12	4	1700	45	27
323	194	454	RIVERVIEW DR	COLLECTOR	4949	1	12	0	1700	40	27
324	195	170	SR 42	COLLECTOR	1636	2	12	0	1750	35	27
325	195	457	JACKSON ST	LOCAL ROADWAY	1090	1	12	0	1350	30	27
326	196	161	MEMORIAL DR	MAJOR ARTERIAL	2333	2	12	6	1900	50	31
327	197	196	MEMORIAL DR	MAJOR ARTERIAL	2603	2	12	6	1900	50	31

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
328	198	199	CR VV	COLLECTOR	1609	1	12	4	1700	50	27
329	198	200	CR O	COLLECTOR	10186	1	12	0	1700	50	27
330	199	146	CR VV	COLLECTOR	5176	1	12	0	1700	50	27
331	200	456	CR O	COLLECTOR	760	1	12	0	1700	45	27
332	201	198	CR O	COLLECTOR	7293	1	12	0	1700	50	27
333	202	201	CR O	COLLECTOR	1176	1	12	0	1575	35	23
334	203	204	CR V	COLLECTOR	6087	1	12	0	1700	50	23
335	203	532	CR O	COLLECTOR	11776	1	12	0	1700	45	23
336	204	203	CR V	COLLECTOR	6087	1	12	0	1700	50	23
337	204	205	CR V	COLLECTOR	2945	1	12	0	1700	50	23
338	205	129	CR V	COLLECTOR	4857	1	12	0	1700	55	23
339	206	504	CR R	COLLECTOR	2493	1	12	4	1700	65	25
340	207	147	CR R	COLLECTOR	8008	1	12	4	1700	45	25
341	207	208	CR P	COLLECTOR	3627	1	12	4	1700	50	29
342	207	210	CR R	COLLECTOR	1970	1	12	4	1750	45	29
343	208	209	CR P	COLLECTOR	4474	1	12	4	1700	50	29
344	209	96	CR P	COLLECTOR	6240	1	12	4	1700	45	25
345	210	207	CR R	COLLECTOR	1971	1	12	4	1700	45	29
346	210	211	CR R	COLLECTOR	5457	1	12	6	1700	45	29
347	210	260	MENASHA AVE	COLLECTOR	945	1	12	0	1700	40	29
348	211	212	CR R	MAJOR ARTERIAL	1321	2	12	4	1750	45	29
349	212	237	SR 42	MAJOR ARTERIAL	1004	2	12	0	1900	45	29
350	212	256	CR R	MAJOR ARTERIAL	1060	2	12	0	1750	40	29

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
351	213	258	CR Q	COLLECTOR	1350	1	12	9	1750	35	30
352	213	259	MENASHA AVE	COLLECTOR	2170	1	12	0	1700	40	30
353	213	274	MENASHA AVE	COLLECTOR	2799	1	12	0	1700	40	30
354	214	226	SR 42	MAJOR ARTERIAL	943	2	12	0	1750	45	30
355	215	269	CR B	COLLECTOR	2695	1	12	0	1750	40	30
356	216	215	CR B	COLLECTOR	2778	1	12	0	1700	50	30
357	217	221	MARITIME DR	MAJOR ARTERIAL	2855	2	12	0	1900	40	31
358	218	270	MEMORIAL DR	MAJOR ARTERIAL	1477	2	12	6	1750	50	31
359	219	222	MARITIME DR	MAJOR ARTERIAL	755	2	12	0	1750	35	34
360	220	219	MARITIME DR	MAJOR ARTERIAL	814	2	12	0	1900	35	34
361	221	220	MARITIME DR	MAJOR ARTERIAL	2889	2	12	0	1900	40	34
362	221	487	HURON ST	LOCAL ROADWAY	719	1	13	0	1575	35	30
363	222	249	N 8TH ST	MINOR ARTERIAL	2133	2	12	0	1900	35	34
364	222	480	MARITIME DRIVE	MINOR ARTERIAL	553	2	12	0	1900	30	34
365	223	476	S 10TH ST	MINOR ARTERIAL	750	4	12	0	1900	35	34
366	224	223	N 10TH ST	MAJOR ARTERIAL	2136	2	12	0	1900	35	34

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
367	225	224	N 11TH ST	MINOR ARTERIAL	1278	2	12	0	1900	35	34
368	225	481	HURON ST	LOCAL ROADWAY	634	1	13	0	1575	35	30
369	226	225	N 11TH ST	MINOR ARTERIAL	2258	2	12	0	1900	35	30
370	226	259	SR 42	MAJOR ARTERIAL	646	2	12	0	1900	45	30
371	227	225	HURON ST	LOCAL ROADWAY	1134	1	13	0	1575	35	30
372	227	228	N 8TH ST	MINOR ARTERIAL	690	2	12	0	1900	30	30
373	228	530	N 8TH ST	MINOR ARTERIAL	1287	2	12	0	1900	35	30
374	229	472	S 10TH ST	MINOR ARTERIAL	438	1	12	0	1350	30	34
375	229	489	US 151	MAJOR ARTERIAL	1468	2	12	0	1750	35	34
376	230	229	S 10TH ST	MINOR ARTERIAL	604	2	12	0	1900	30	34
377	230	289	FRANKLIN ST	COLLECTOR	450	2	12	0	1900	30	34
378	231	222	S 8TH ST	MINOR ARTERIAL	907	2	12	0	1750	35	34
379	231	475	FRANKLIN ST	COLLECTOR	520	1	12	0	1350	30	34
380	232	231	S 8TH ST	MINOR ARTERIAL	601	2	12	0	1750	30	34
381	232	240	S 8TH ST	MINOR ARTERIAL	627	1	12	0	1350	30	34

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
382	232	478	WASHINGTON ST	MAJOR ARTERIAL	189	1	12	0	1350	30	34
383	233	248	S 10TH ST	MINOR ARTERIAL	642	1	12	0	1575	35	34
384	234	236	US 10	COLLECTOR	693	1	12	0	1575	35	34
385	235	234	US 10	COLLECTOR	2447	1	12	4	1700	45	34
386	236	233	US 10	COLLECTOR	738	1	12	0	1575	35	34
387	237	238	SR 42	MAJOR ARTERIAL	3222	2	12	0	1900	45	29
388	238	277	SR 42	MAJOR ARTERIAL	2392	2	12	0	1900	45	29
389	239	473	S 10TH ST	MINOR ARTERIAL	174	2	12	0	1900	35	34
390	239	474	MARSHALL ST	COLLECTOR	151	2	12	0	1900	35	34
391	240	232	S 8TH ST	MINOR ARTERIAL	627	1	12	0	1750	30	34
392	240	236	S 8TH ST	MINOR ARTERIAL	1259	1	12	0	1575	35	34
393	240	471	MARSHALL ST	COLLECTOR	564	1	12	0	1350	30	34
394	241	244	US 151	MAJOR ARTERIAL	1137	2	12	0	1900	35	34
395	241	245	S 21 ST	COLLECTOR	636	1	12	4	1575	35	34
396	242	562	S 21ST ST	COLLECTOR	430	1	12	0	1575	35	34
397	243	285	S 21ST ST	MINOR ARTERIAL	986	2	12	0	1750	35	34
398	244	246	US 151	MAJOR ARTERIAL	436	2	12	0	1750	35	34

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
399	245	242	S 21ST ST	COLLECTOR	1858	1	12	0	1575	35	34
400	245	290	MARSHALL ST	COLLECTOR	1490	1	12	0	1750	35	34
401	246	290	S 26TH ST	LOCAL ROADWAY	410	1	12	0	1750	35	34
402	246	291	US 151	MAJOR ARTERIAL	333	2	12	0	1750	35	34
403	246	292	CUSTER ST	COLLECTOR	383	1	12	0	1575	35	34
404	247	497	S 21ST ST	MINOR ARTERIAL	141	2	12	0	1900	35	34
405	247	498	FRANKLIN ST	COLLECTOR	184	2	12	0	1900	35	34
406	248	493	COLUMBUS ST	LOCAL ROADWAY	1442	1	12	0	1575	35	34
407	248	565	S 10TH ST	MINOR ARTERIAL	2990	1	12	0	1575	35	34
408	249	224	PARK ST	LOCAL ROADWAY	703	1	12	0	1350	30	34
409	249	227	N 8TH ST	MINOR ARTERIAL	1189	2	12	0	1900	35	34
410	250	249	PARK ST	LOCAL ROADWAY	1094	1	12	0	1350	30	34
411	251	252	MICHIGAN AVE	COLLECTOR	2580	1	12	0	1575	35	30
412	251	257	N 18TH ST	MINOR ARTERIAL	597	2	12	0	1900	35	30
413	252	253	MICHIGAN AVE	COLLECTOR	1687	1	12	0	1700	40	30
414	253	254	MICHIGAN AVE	COLLECTOR	1090	1	12	0	1700	40	30
415	254	255	MICHIGAN AVE	COLLECTOR	931	1	12	0	1700	40	30
416	255	256	MICHIGAN AVE	COLLECTOR	1959	1	12	0	1750	40	29

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
417	256	267	CR R	MAJOR ARTERIAL	3139	2	12	0	1750	40	29
418	256	279	MICHIGAN AVE	COLLECTOR	2091	1	12	0	1700	50	29
419	257	482	REVERE DR	MINOR ARTERIAL	1461	2	12	0	1900	35	34
420	258	251	N 18TH ST	MINOR ARTERIAL	1765	2	12	0	1750	35	30
421	258	273	SR 42	MAJOR ARTERIAL	2482	2	12	0	1900	45	30
422	259	213	MENASHA AVE	COLLECTOR	2167	1	12	0	1700	40	30
423	259	258	SR 42	MAJOR ARTERIAL	1679	2	12	0	1750	35	30
424	260	210	MENASHA AVE	COLLECTOR	945	1	12	0	1750	40	29
425	260	265	MENASHA AVE	COLLECTOR	3026	1	12	0	1700	40	29
426	261	211	WILDWOOD DR	LOCAL ROADWAY	1305	1	12	0	1575	35	29
427	262	260	KELLNER ST	LOCAL ROADWAY	1106	1	12	0	1575	35	29
428	263	212	SR 42	MAJOR ARTERIAL	3346	2	12	0	1750	45	29
429	264	263	FLEETWOOD DR	LOCAL ROADWAY	850	1	12	0	1575	35	30
430	265	260	MENASHA AVE	COLLECTOR	3026	1	12	0	1700	40	29
431	265	274	MENASHA AVE	COLLECTOR	4688	1	12	0	1700	40	30
432	266	265	PLATT ST	LOCAL ROADWAY	880	1	12	0	1350	30	29
433	267	464	CR R	MAJOR ARTERIAL	530	2	12	0	1900	40	33

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
434	268	514	CR Q	COLLECTOR	6297	1	12	4	1700	60	30
435	269	214	CR B	COLLECTOR	2005	1	12	0	1750	40	30
436	269	270	E REED AVE	COLLECTOR	5470	1	12	0	1750	35	31
437	270	269	E REED AVE	COLLECTOR	5469	1	12	0	1750	35	31
438	270	576	MEMORIAL DR	MAJOR ARTERIAL	1934	2	12	6	1900	45	31
439	271	269	REED AVE	LOCAL ROADWAY	688	1	12	0	1750	35	30
440	272	226	N 11TH ST	COLLECTOR	852	1	12	0	1750	35	30
441	273	252	N 23RD ST	LOCAL ROADWAY	1203	1	12	0	1350	30	30
442	273	263	SR 42	MAJOR ARTERIAL	2114	2	12	0	1900	45	30
443	274	213	MENASHA AVE	COLLECTOR	2799	1	12	0	1700	40	30
444	274	265	MENASHA AVE	COLLECTOR	4688	1	12	0	1700	40	30
445	274	273	N 23RD ST	LOCAL ROADWAY	2546	1	12	0	1350	30	30
446	275	5	I-43 RAMP	FREEWAY RAMP	669	1	12	8	1700	45	29
447	275	276	SR 42	MAJOR ARTERIAL	674	2	12	0	1900	45	29
448	276	4	I-43 RAMP	FREEWAY RAMP	619	1	12	8	1700	45	29
449	276	531	SR 42	MAJOR ARTERIAL	603	2	12	0	1900	45	29
450	277	275	SR 42	MAJOR ARTERIAL	1012	2	12	0	1900	45	29

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
451	278	277	MICHIGAN AVE	COLLECTOR	2474	1	12	0	1700	50	29
452	279	278	MICHIGAN AVE	COLLECTOR	2540	1	12	0	1700	50	29
453	281	278	WHITEWATER DR	LOCAL ROADWAY	4227	1	12	4	1575	35	29
454	282	267	BROADWAY ST	COLLECTOR	1434	1	12	0	1750	40	33
455	283	286	BROADWAY ST	COLLECTOR	540	1	12	0	1575	35	34
456	284	285	WESTERN AVE	COLLECTOR	1543	1	12	0	1750	35	34
457	284	308	MEADOW LANE	COLLECTOR	2841	1	12	0	1575	35	34
458	284	435	S 26TH ST	LOCAL ROADWAY	1680	1	12	0	1575	35	34
459	285	287	WESTERN AVE	COLLECTOR	1378	1	12	0	1575	35	34
460	285	496	S 21ST ST	MINOR ARTERIAL	940	2	12	0	1900	35	34
461	285	515	WESTERN AVE	COLLECTOR	1277	2	12	0	1900	35	34
462	286	282	BROADWAY ST	COLLECTOR	563	1	12	0	1575	35	34
463	287	285	WESTERN AVE	COLLECTOR	1378	1	12	0	1750	35	34
464	287	491	CLARK ST	COLLECTOR	970	1	12	4	1575	35	34
465	288	289	S WATER ST	COLLECTOR	944	1	12	0	1575	35	34
466	288	491	CLARK ST	COLLECTOR	281	1	12	4	1575	35	34
467	289	288	S WATER ST	COLLECTOR	944	1	12	0	1575	35	34
468	289	492	FRANKLIN ST	COLLECTOR	1009	1	12	4	1700	40	34
469	290	291	MARSHALL ST	COLLECTOR	206	3	12	0	1750	35	34
470	290	570	S 26TH ST	LOCAL ROADWAY	2337	1	12	0	1700	40	34
471	291	292	CUSTER ST	COLLECTOR	358	1	12	0	1575	35	34

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
472	291	294	US 151	MAJOR ARTERIAL	1314	2	12	0	1750	45	34
473	292	574	CUSTER ST	COLLECTOR	941	1	12	0	1575	35	34
474	293	301	CUSTER ST	COLLECTOR	1063	1	12	0	1575	35	33
475	294	499	S 30TH ST	COLLECTOR	3146	1	12	0	1700	40	34
476	294	500	US 151	MAJOR ARTERIAL	983	2	12	0	1750	45	34
477	295	309	US 151	MAJOR ARTERIAL	858	2	12	6	1750	50	33
478	296	302	CUSTER ST	COLLECTOR	5440	1	12	4	1700	50	33
479	296	466	CR R	MAJOR ARTERIAL	1230	2	12	0	1750	45	33
480	297	468	CR R	MAJOR ARTERIAL	1422	2	12	0	1900	45	33
481	298	465	CR R	MAJOR ARTERIAL	1993	1	12	4	1700	50	33
482	299	305	US 151	MAJOR ARTERIAL	2972	2	12	0	1750	45	33
483	299	566	S 35TH ST	LOCAL ROADWAY	3646	1	12	0	1700	40	34
484	300	295	US 151	MAJOR ARTERIAL	1892	2	12	0	1750	45	33
485	300	313	DEWEY ST	COLLECTOR	785	2	12	0	1900	35	33
486	300	315	DEWEY ST	MINOR ARTERIAL	392	2	12	0	1750	45	33
487	301	296	CUSTER ST	COLLECTOR	1576	1	12	0	1750	35	33
488	303	3	I-43	FREEWAY	7230	2	12	8	2250	70	33

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
489	303	304	I-43	FREEWAY	1431	2	12	8	2250	70	33
490	303	310	I-43 RAMP	FREEWAY RAMP	654	1	12	4	1750	45	33
491	304	303	I-43	FREEWAY	1431	2	12	8	2250	70	33
492	304	309	I-43 RAMP	FREEWAY RAMP	567	1	12	4	1750	45	33
493	304	311	I-43	FREEWAY	678	2	12	8	2250	70	33
494	305	300	US 151	MAJOR ARTERIAL	1369	2	12	0	1750	45	33
495	306	305	S 41ST ST	COLLECTOR	347	1	12	0	1750	35	33
496	307	293	CUSTER ST	COLLECTOR	2583	1	12	0	1575	35	33
497	307	299	S 35TH ST	LOCAL ROADWAY	1706	1	12	0	1750	35	34
498	308	283	MEADOW LANE	COLLECTOR	462	1	12	0	1575	35	34
499	308	307	S 35TH ST	LOCAL ROADWAY	2614	1	12	0	1575	35	34
500	309	303	I-43 RAMP	FREEWAY RAMP	992	1	12	8	1700	45	33
501	309	310	US 151	MAJOR ARTERIAL	673	2	12	6	1750	50	33
502	310	304	I-43 RAMP	FREEWAY RAMP	882	1	12	8	1700	45	33
503	310	312	US 151	MAJOR ARTERIAL	419	2	12	6	1900	50	33
504	311	304	I-43	FREEWAY	678	2	12	8	2250	70	33
505	313	314	DEWEY ST	COLLECTOR	728	2	12	0	1900	35	33
506	314	502	DEWEY ST	COLLECTOR	600	2	12	0	1900	35	33

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
507	315	300	DEWEY ST	MINOR ARTERIAL	392	2	12	0	1750	45	33
508	315	566	DEWEY ST	MINOR ARTERIAL	2479	2	12	0	1900	45	33
509	317	171	SR 147	MINOR ARTERIAL	3675	1	16	0	1700	40	27
510	318	143	CR VV	COLLECTOR	2603	1	12	4	1700	40	27
511	319	318	BELLVUE PL	LOCAL ROADWAY	925	1	12	0	1575	35	27
512	320	321	CR B	COLLECTOR	1275	1	12	0	1700	50	14
513	321	322	CR B	COLLECTOR	1814	1	12	0	1700	60	14
514	322	323	CR B	COLLECTOR	1685	1	12	0	1700	45	14
515	323	324	CR B	COLLECTOR	2854	1	12	0	1700	55	10
516	324	47	CR J	COLLECTOR	12354	1	12	0	1700	65	10
517	324	325	CR J	COLLECTOR	887	1	12	4	1700	60	10
518	325	324	CR J	COLLECTOR	887	1	12	0	1700	65	10
519	325	326	CR J	COLLECTOR	13377	1	12	0	1700	60	11
520	325	332	CR B	COLLECTOR	3941	1	12	0	1700	60	10
521	326	325	CR J	COLLECTOR	13377	1	12	0	1700	60	11
522	326	327	SR 42	MINOR ARTERIAL	9705	1	12	8	1700	65	11
523	327	328	SR 42	MINOR ARTERIAL	2074	1	12	8	1700	50	11
524	328	350	CR C	COLLECTOR	2557	1	12	4	1700	55	11
525	328	361	SR 42	MINOR ARTERIAL	2976	1	12	8	1700	65	11

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
526	329	340	SR 29	MINOR ARTERIAL	2299	1	12	4	1700	45	11
527	329	440	SR 29	MINOR ARTERIAL	2940	1	12	6	1700	60	11
528	330	331	SR 29	MINOR ARTERIAL	14977	1	12	6	1700	65	11
529	330	440	SR 29	MINOR ARTERIAL	1658	1	12	6	1700	40	11
530	331	330	SR 29	MINOR ARTERIAL	14977	1	12	6	1700	65	11
531	331	339	CR B	COLLECTOR	5365	1	12	0	1700	65	10
532	331	439	SR 29	MINOR ARTERIAL	15962	1	12	6	1700	65	10
533	332	333	CR B	COLLECTOR	2279	1	12	0	1700	50	10
534	333	334	CR B	COLLECTOR	1830	1	12	0	1700	50	10
535	334	331	CR B	COLLECTOR	9700	1	12	0	1700	65	10
536	335	342	1ST ST	LOCAL ROADWAY	1545	1	12	0	1575	35	11
537	335	345	LINCOLN ST	COLLECTOR	2223	1	12	0	1575	35	11
538	336	335	1ST ST	LOCAL ROADWAY	2123	1	12	0	1575	35	11
539	337	338	SR 29	MINOR ARTERIAL	2180	1	12	4	1700	40	7
540	337	400	SR 42	MINOR ARTERIAL	768	1	12	4	1350	30	7
541	338	337	SR 29	MINOR ARTERIAL	2180	1	12	4	1700	40	7

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
542	338	396	SR 29	MINOR ARTERIAL	1393	1	12	4	1700	40	7
543	338	444	1ST ST	LOCAL ROADWAY	815	1	10	0	1125	25	7
544	339	368	CR F	COLLECTOR	9323	1	12	0	1700	60	11
545	339	369	CR B	COLLECTOR	9928	1	12	0	1700	65	6
546	340	329	SR 29	MINOR ARTERIAL	2299	1	12	4	1700	45	11
547	340	395	CENTER ST	LOCAL ROADWAY	2286	1	12	0	1575	35	11
548	340	441	SR 29	MINOR ARTERIAL	1014	1	12	4	1700	45	11
549	341	337	SR 42	MINOR ARTERIAL	1080	1	12	0	1700	40	11
550	341	342	CENTER ST	LOCAL ROADWAY	2283	1	12	0	1575	35	11
551	342	338	1ST ST	LOCAL ROADWAY	1083	1	12	0	1575	35	11
552	342	341	CENTER ST	LOCAL ROADWAY	2283	1	12	0	1575	35	11
553	342	395	CENTER ST	LOCAL ROADWAY	1351	1	12	0	1575	35	11
554	345	335	LINCOLN ST	COLLECTOR	2223	1	12	0	1575	35	11
555	345	341	SR 42	MINOR ARTERIAL	1545	1	12	0	1700	40	11
556	346	345	SR 42	MINOR ARTERIAL	1461	1	12	0	1700	40	11

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
557	347	346	SR 42	MINOR ARTERIAL	3350	1	12	8	1700	60	11
558	348	347	SR 42	MINOR ARTERIAL	4656	1	12	8	1700	60	11
559	349	329	CR C	COLLECTOR	3167	1	12	4	1700	55	11
560	350	349	CR C	COLLECTOR	2608	1	12	4	1700	55	11
561	351	356	CR AB	COLLECTOR	665	1	12	4	1700	55	5
562	353	553	CR AB	COLLECTOR	5360	1	12	4	1750	35	1
563	354	353	CR AB	COLLECTOR	10552	1	12	4	1700	55	5
564	354	355	CR N	COLLECTOR	10480	1	12	0	1700	65	5
565	355	359	CR N	COLLECTOR	951	1	12	0	1700	65	5
566	356	357	CR AB	COLLECTOR	3946	1	12	4	1700	60	5
567	357	358	CR AB	COLLECTOR	1262	1	12	4	1700	55	5
568	358	354	CR AB	COLLECTOR	2053	1	12	4	1700	60	5
569	360	52	CR T	COLLECTOR	881	1	12	0	1575	35	12
570	360	436	CR T	COLLECTOR	2197	1	12	0	1700	55	12
571	361	336	HOSPITAL RD	LOCAL ROADWAY	6948	1	12	0	1700	50	11
572	361	348	SR 42	MINOR ARTERIAL	2154	1	12	8	1700	65	11
573	362	363	CR C	COLLECTOR	1869	1	12	0	1700	50	7
574	363	364	CR C	COLLECTOR	1806	1	12	0	1700	55	7
575	364	365	CR C	COLLECTOR	3796	1	12	0	1700	55	7
576	365	366	CR F	COLLECTOR	2524	1	12	0	1700	50	7
577	365	394	CR C	COLLECTOR	3082	1	12	0	1700	60	7
578	366	365	CR F	COLLECTOR	2524	1	12	0	1700	50	7

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
579	366	367	CR F	COLLECTOR	1226	1	12	0	1700	50	11
580	367	366	CR F	COLLECTOR	1241	1	12	0	1700	50	11
581	367	368	CR F	COLLECTOR	1336	1	12	0	1700	50	11
582	368	339	CR F	COLLECTOR	9323	1	12	0	1700	60	11
583	368	367	CR F	COLLECTOR	1326	1	12	0	1700	50	11
584	369	370	CR B	COLLECTOR	1100	1	12	0	1700	55	6
585	370	371	CR B	COLLECTOR	2350	1	12	0	1700	60	6
586	371	386	CR B	COLLECTOR	1338	1	12	0	1700	55	6
587	372	387	CR C	COLLECTOR	6677	1	12	4	1700	65	6
588	373	392	CR C	COLLECTOR	2549	1	12	3	1700	55	6
589	373	393	CR A	COLLECTOR	2050	1	12	4	1700	55	6
590	374	375	CR A	COLLECTOR	2020	1	12	4	1700	55	6
591	375	376	CR A	COLLECTOR	2519	1	12	4	1700	55	6
592	376	377	CR A	COLLECTOR	2595	1	12	4	1700	55	6
593	377	378	CR A	COLLECTOR	1748	1	12	4	1700	55	6
594	378	379	CR A	COLLECTOR	2345	1	12	4	1700	55	6
595	379	380	CR A	COLLECTOR	1636	1	12	4	1700	55	2
596	380	353	CR A	COLLECTOR	11196	1	12	4	1700	55	1
597	381	382	CR F	COLLECTOR	2645	1	12	0	1700	55	7
598	381	384	CR C	COLLECTOR	4468	1	12	4	1700	50	7
599	382	381	CR F	COLLECTOR	2669	1	12	0	1700	55	7
600	382	383	CR F	COLLECTOR	1445	1	12	0	1700	50	7
601	383	382	CR F	COLLECTOR	1388	1	12	0	1700	50	7
602	383	410	CR F	COLLECTOR	4897	1	12	0	1700	55	7
603	384	385	CR C	COLLECTOR	3272	1	12	4	1700	50	7

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
604	385	372	CR C	COLLECTOR	2597	1	12	4	1750	60	7
605	386	372	CR B	COLLECTOR	3372	1	12	0	1750	60	6
606	387	373	CR C	COLLECTOR	1209	1	12	4	1700	50	6
607	388	431	SR 54	MINOR ARTERIAL	1231	1	12	0	1700	40	2
608	388	559	SR 54	MINOR ARTERIAL	3844	1	12	4	1700	60	2
609	389	448	CR C	COLLECTOR	2136	1	12	0	1700	50	2
610	390	389	CR C	COLLECTOR	1919	1	12	0	1700	40	2
611	391	390	CR C	COLLECTOR	2066	1	12	0	1700	40	2
612	392	391	CR C	COLLECTOR	4036	1	12	0	1700	55	6
613	393	374	CR A	COLLECTOR	2010	1	12	4	1700	55	6
614	394	381	CR C	COLLECTOR	3752	1	12	0	1700	55	7
615	395	340	CENTER ST	LOCAL ROADWAY	2286	1	12	0	1575	35	11
616	395	342	CENTER ST	LOCAL ROADWAY	1351	1	12	0	1575	35	11
617	395	396	3RD ST	LOCAL ROADWAY	1078	1	12	0	1350	30	11
618	396	338	SR 29	MINOR ARTERIAL	1393	1	12	4	1700	40	7
619	396	442	SR 29	MINOR ARTERIAL	1221	1	12	4	1700	40	7
620	398	405	CR E	COLLECTOR	4070	1	11	0	1700	40	7
621	399	398	CR E	COLLECTOR	1384	1	11	0	1700	40	7
622	399	400	MILLER ST	LOCAL ROADWAY	966	1	12	4	1350	30	7

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
623	399	444	MILLER ST	LOCAL ROADWAY	1133	1	12	4	1350	30	7
624	400	337	SR 42	MINOR ARTERIAL	768	1	12	4	1350	30	7
625	400	399	MILLER ST	LOCAL ROADWAY	966	1	12	4	1350	30	7
626	400	401	SR 42	MINOR ARTERIAL	1667	1	12	4	1700	40	7
627	401	402	SR 42	MINOR ARTERIAL	1316	1	12	4	1700	45	7
628	402	443	SR 42	MINOR ARTERIAL	3567	1	12	4	1700	55	7
629	403	423	SR 42	MINOR ARTERIAL	9916	1	12	4	1700	65	3
630	404	403	SR 42	MINOR ARTERIAL	9186	1	12	4	1700	65	7
631	404	410	CR F	COLLECTOR	10895	1	12	0	1700	60	7
632	405	406	CR E	COLLECTOR	2214	1	11	0	1700	45	7
633	406	407	CR E	COLLECTOR	611	1	11	0	1125	25	7
634	407	408	CR E	COLLECTOR	1942	1	11	0	1700	55	7
635	408	409	CR E	COLLECTOR	2588	1	12	4	1700	55	7
636	409	410	CR E	COLLECTOR	2281	1	12	4	1700	60	7
637	410	383	CR F	COLLECTOR	4897	1	12	0	1700	55	7
638	410	404	CR F	COLLECTOR	10895	1	12	0	1700	60	7
639	410	411	CR E	COLLECTOR	3762	1	12	3	1700	55	7
640	411	412	CR E	COLLECTOR	2257	1	12	3	1700	55	7
641	412	413	CR E	COLLECTOR	2208	1	12	3	1700	55	7

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
642	413	414	CR E	COLLECTOR	750	1	12	4	1700	40	7
643	414	415	CR E	COLLECTOR	4834	1	12	3	1700	60	7
644	415	418	CR O	COLLECTOR	12455	1	12	0	1700	55	7
645	415	445	CR E	COLLECTOR	4768	1	14	0	1700	60	7
646	416	447	CR E	COLLECTOR	3939	1	14	0	1700	65	7
647	417	420	CR E	COLLECTOR	1047	1	12	3	1700	45	3
648	418	415	CR O	COLLECTOR	12455	1	12	0	1700	55	7
649	418	419	CR O	COLLECTOR	1508	1	12	0	1700	55	7
650	419	403	CR O	COLLECTOR	2416	1	12	0	1700	55	7
651	420	421	CR E	COLLECTOR	1200	1	12	3	1700	40	2
652	421	422	CR E	COLLECTOR	4611	1	12	3	1700	65	2
653	422	432	SR 54	MINOR ARTERIAL	5586	1	12	4	1700	65	2
654	422	433	SR 54	MINOR ARTERIAL	529	1	12	4	1700	65	2
655	423	424	CR D	COLLECTOR	1605	1	12	4	1700	50	3
656	423	427	SR 42	MINOR ARTERIAL	3237	1	12	4	1700	55	3
657	424	426	CR D	COLLECTOR	1746	1	12	4	1700	50	3
658	425	2	CR D	COLLECTOR	2306	1	12	4	1700	60	3
659	426	425	CR D	COLLECTOR	1929	1	12	4	1700	50	3
660	427	428	SR 42	MINOR ARTERIAL	1884	1	12	4	1700	55	4
661	428	429	SR 42	MINOR ARTERIAL	3604	1	12	4	1700	55	4

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
662	429	430	SR 42	MINOR ARTERIAL	2260	1	12	4	1700	55	4
663	431	388	SR 54	MINOR ARTERIAL	1231	1	12	0	1700	40	2
664	431	432	SR 54	MINOR ARTERIAL	1067	1	12	4	1700	55	2
665	432	422	SR 54	MINOR ARTERIAL	5586	1	12	4	1700	65	2
666	432	431	SR 54	MINOR ARTERIAL	1067	1	12	4	1700	55	2
667	435	544	S 26TH ST	LOCAL ROADWAY	722	1	12	0	1575	35	34
668	436	51	CR T	COLLECTOR	3254	1	12	4	1575	35	12
669	436	360	CR T	COLLECTOR	2197	1	12	0	1700	55	12
670	437	60	CR T	COLLECTOR	1164	1	12	4	1700	40	12
671	437	438	LANGES CORNER RD	LOCAL ROADWAY	476	1	12	0	1700	40	12
672	438	56	LANGES CORNER RD	COLLECTOR	4171	1	12	4	1700	60	12
673	439	46	SR 29	MINOR ARTERIAL	5366	1	12	6	1750	50	10
674	440	329	SR 29	MINOR ARTERIAL	2940	1	12	6	1700	60	11
675	440	330	SR 29	MINOR ARTERIAL	1666	1	12	6	1700	40	11
676	441	362	FRANKLIN RD	LOCAL ROADWAY	304	1	12	4	1350	30	11
677	441	442	SR 29	MINOR ARTERIAL	482	1	12	4	1700	40	11

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
678	442	362	CR C	LOCAL ROADWAY	511	1	12	0	1350	30	7
679	442	396	SR 29	MINOR ARTERIAL	1221	1	12	4	1700	40	7
680	443	404	SR 42	MINOR ARTERIAL	3473	1	12	4	1700	65	7
681	444	398	1ST ST	LOCAL ROADWAY	754	1	10	0	1125	25	7
682	444	399	MILLER ST	LOCAL ROADWAY	1133	1	12	4	1350	30	7
683	445	416	CR E	COLLECTOR	756	1	14	0	1700	40	7
684	446	417	CR E	COLLECTOR	3522	1	14	0	1700	65	3
685	447	446	CR E	COLLECTOR	2044	1	14	0	1700	50	3
686	448	388	CR C	COLLECTOR	4430	1	12	0	1700	40	2
687	449	455	SR 42	MINOR ARTERIAL	4559	1	12	4	1700	55	27
688	450	449	EGGERS DR	LOCAL ROADWAY	489	1	12	0	1350	30	27
689	451	449	TWO RIVERS HIGH SCHOOL DRIVEWAY	LOCAL ROADWAY	496	1	12	0	1350	30	27
690	452	169	SR 42	MINOR ARTERIAL	2617	1	12	0	1575	35	27
691	453	452	30TH ST	COLLECTOR	830	1	12	0	1575	35	27
692	454	453	RIVERVIEW DR	COLLECTOR	1447	1	12	0	1700	40	27
693	455	452	SR 42	MINOR ARTERIAL	2045	1	12	0	1575	35	27
694	456	192	CR O	COLLECTOR	457	1	12	0	1350	30	27

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
695	457	177	EAST ST	LOCAL ROADWAY	777	1	12	0	1350	30	27
696	458	167	CR R	COLLECTOR	4086	1	12	4	1700	50	21
697	458	459	CR R	COLLECTOR	4752	1	12	4	1700	60	21
698	459	130	CR R	COLLECTOR	2890	1	12	4	1700	55	21
699	459	458	CR R	COLLECTOR	4739	1	12	4	1700	60	21
700	460	59	ZANDER ST	COLLECTOR	4838	1	12	0	1700	45	17
701	461	58	CR T	COLLECTOR	9144	1	12	0	1700	65	16
702	461	72	CR T	COLLECTOR	4112	1	12	0	1700	40	16
703	462	72	CR T	COLLECTOR	2661	1	12	0	1700	40	16
704	462	93	CR T	COLLECTOR	8908	1	12	0	1700	65	20
705	463	95	CR T	COLLECTOR	7520	1	12	0	1700	65	20
706	464	298	CR R	MAJOR ARTERIAL	1839	1	12	4	1700	50	33
707	465	296	CR R	MAJOR ARTERIAL	960	2	12	0	1750	45	33
708	466	297	CR R	MAJOR ARTERIAL	1198	2	12	0	1750	45	33
709	467	466	EXPO DR	COLLECTOR	830	1	12	4	1750	35	33
710	468	295	CR R	MINOR ARTERIAL	120	1	12	0	1750	45	33
711	470	295	FRONTAGE ROAD	COLLECTOR	253	1	12	4	1750	35	33
712	471	239	MARSHALL ST	COLLECTOR	164	2	12	0	1750	30	34
713	472	239	S 10TH ST	MINOR ARTERIAL	185	2	12	0	1750	30	34
714	473	233	S 10TH ST	MINOR ARTERIAL	1096	1	12	0	1575	35	34

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
715	474	490	MARSHALL ST	COLLECTOR	1329	1	12	0	1575	35	34
716	475	230	FRANKLIN ST	COLLECTOR	200	2	12	0	1750	30	34
717	476	230	S 10TH ST	MINOR ARTERIAL	153	3	12	0	1750	40	34
718	477	232	WASHINGTON ST	LOCAL ROADWAY	325	2	12	0	1750	30	34
719	478	229	WASHINGTON ST	MAJOR ARTERIAL	538	2	12	0	1750	30	34
720	479	231	FRANKLIN ST	LOCAL ROADWAY	751	1	12	0	1750	30	34
721	480	223	MARITIME DRIVE	MINOR ARTERIAL	158	1	12	0	1350	30	34
722	481	251	MICHIGAN AVE	COLLECTOR	1686	1	12	0	1750	35	30
723	481	483	SPRING ST	COLLECTOR	915	1	12	0	1700	40	30
724	482	243	S 21ST ST	MINOR ARTERIAL	830	2	12	0	1900	35	34
725	483	484	SPRING ST	COLLECTOR	731	1	12	0	1700	40	30
726	484	485	SPRING ST	COLLECTOR	657	1	12	0	1700	40	34
727	485	486	SPRING ST	COLLECTOR	408	1	12	0	1350	30	34
728	486	482	SPRING ST	COLLECTOR	527	1	12	0	1125	25	34
729	487	227	HURON ST	LOCAL ROADWAY	1458	1	13	0	1575	35	30
730	488	487	N 4TH ST	LOCAL ROADWAY	514	1	12	0	1350	30	30
731	489	241	US 151	MAJOR ARTERIAL	2191	2	12	0	1750	35	34

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
732	489	490	S 14TH ST	LOCAL ROADWAY	607	1	12	0	1350	30	34
733	490	245	MARSHALL ST	COLLECTOR	2187	1	12	0	1575	35	34
734	490	493	S 14TH ST	LOCAL ROADWAY	1924	1	12	0	1350	30	34
735	491	287	CLARK ST	COLLECTOR	971	1	12	4	1575	35	34
736	491	288	CLARK ST	COLLECTOR	281	1	12	4	1575	35	34
737	491	492	S 14TH ST	LOCAL ROADWAY	583	1	12	0	1350	30	34
738	492	489	S 14TH ST	LOCAL ROADWAY	638	1	12	0	1750	30	34
739	492	495	FRANKLIN ST	COLLECTOR	1979	1	12	0	1575	35	34
740	493	242	COLUMBUS ST	LOCAL ROADWAY	2247	1	12	0	1575	35	34
741	493	567	S 14TH ST	LOCAL ROADWAY	2994	1	12	0	1575	35	34
742	495	247	FRANKLIN ST	COLLECTOR	220	2	12	0	1750	35	34
743	496	247	S 21ST ST	MINOR ARTERIAL	143	3	12	0	1750	35	34
744	497	241	S 21ST ST	MINOR ARTERIAL	520	1	12	0	1750	35	34
745	498	435	FRANKLIN ST	COLLECTOR	1314	1	12	0	1575	35	34
746	499	573	S 30TH ST	COLLECTOR	778	1	12	0	1700	40	34
747	500	299	US 151	MAJOR ARTERIAL	711	2	12	0	1750	45	34
748	501	500	PLAZA DRIVEWAY	LOCAL ROADWAY	539	1	12	0	1750	30	34

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
749	502	297	DEWEY ST	COLLECTOR	305	1	12	0	1750	35	33
750	503	504	SR 310/CR R ROUNDABOUT	MINOR ARTERIAL	157	1	12	0	900	20	25
751	504	505	SR 310/CR R ROUNDABOUT	MINOR ARTERIAL	165	1	12	0	900	20	25
752	505	147	SR 310/CR R ROUNDABOUT	MINOR ARTERIAL	167	1	12	0	900	20	25
753	505	527	SR 310	MINOR ARTERIAL	3631	1	12	4	1700	60	25
754	506	59	CR R	COLLECTOR	2777	1	12	4	1700	60	17
755	506	88	CR R	COLLECTOR	4737	1	12	4	1700	60	17
756	507	509	CR KB	COLLECTOR	5020	1	12	4	1700	55	12
757	508	40	CR P	COLLECTOR	2833	1	12	4	1700	65	12
758	509	42	CR KB	COLLECTOR	2740	1	12	4	1700	45	12
759	510	34	CR KB	COLLECTOR	1588	1	12	0	1700	50	13
760	511	154	SR 310/CR Q ROUNDABOUT	MINOR ARTERIAL	103	1	12	0	900	20	26
761	512	550	CR Q	COLLECTOR	1296	1	12	4	1700	65	26
762	513	503	SR 310	MINOR ARTERIAL	7577	1	12	4	1700	60	25
763	513	512	SR 310/CR Q ROUNDABOUT	MINOR ARTERIAL	106	1	12	0	900	20	26
764	514	213	CR Q	COLLECTOR	1945	1	12	4	1700	45	30
765	515	284	WESTERN AVE	COLLECTOR	266	1	12	0	1575	35	34
766	516	214	SR 42	MAJOR ARTERIAL	3618	2	12	0	1750	45	30

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
767	517	217	MEMORIAL DR	MAJOR ARTERIAL	313	2	12	0	1900	35	31
768	517	516	MEMORIAL DR	MAJOR ARTERIAL	628	2	12	0	1900	45	31
769	518	197	TAYLOR ST	LOCAL ROADWAY	1129	1	12	0	1750	35	31
770	519	191	12TH ST	LOCAL ROADWAY	2146	1	12	0	1350	30	27
771	519	520	LOWELL ST	LOCAL ROADWAY	1768	1	12	0	1350	30	27
772	520	181	ROOSEVELT AVE	LOCAL ROADWAY	275	1	12	0	1350	30	27
773	521	176	17TH ST	LOCAL ROADWAY	410	1	12	0	1750	30	27
774	522	179	14TH ST	LOCAL ROADWAY	316	1	12	0	1750	30	27
775	523	526	SR 310/CR B ROUNDABOUT	MINOR ARTERIAL	162	1	12	0	900	20	26
776	524	523	SR 310/CR B ROUNDABOUT	MINOR ARTERIAL	161	1	12	0	900	20	26
777	525	551	CR B	COLLECTOR	3453	1	12	0	1700	60	26
778	526	511	SR 310	MINOR ARTERIAL	4611	1	12	4	1700	60	26
779	526	525	SR 310/CR B ROUNDABOUT	MINOR ARTERIAL	147	1	12	0	900	20	26
780	527	152	SR 310	MINOR ARTERIAL	2132	2	12	4	1900	60	25

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
781	528	529	SR 310	MINOR ARTERIAL	1704	1	12	4	1700	60	25
782	529	151	SR 310	MINOR ARTERIAL	1846	1	12	4	1700	55	25
783	530	214	N 8TH ST	MINOR ARTERIAL	302	1	12	0	1750	35	30
784	531	280	SR 42	MAJOR ARTERIAL	399	1	12	0	1700	45	29
785	532	202	CR O	COLLECTOR	1944	1	12	0	1700	40	23
786	533	72	CR Z	COLLECTOR	1660	1	12	3	1700	40	16
787	534	114	CR Z	COLLECTOR	7414	1	12	3	1700	65	16
788	535	26	CR AB	COLLECTOR	12508	1	12	0	1750	60	14
789	535	32	CR AB	COLLECTOR	500	1	12	0	1700	50	14
790	536	33	CR AB	COLLECTOR	9892	1	12	0	1700	60	14
791	537	31	CR G	COLLECTOR	348	1	12	0	1750	50	14
792	537	32	CR G	COLLECTOR	2444	1	12	0	1700	60	14
793	538	31	CR G	COLLECTOR	367	1	12	0	1750	50	14
794	539	110	CR V	COLLECTOR	4701	1	12	0	1700	40	22
795	540	108	CR B	COLLECTOR	9704	1	12	0	1700	65	22
796	541	176	WASHINGTON ST	MAJOR ARTERIAL	340	2	12	0	1750	35	27
797	541	543	18TH ST	LOCAL ROADWAY	866	1	12	0	1350	30	27
798	542	172	MONROE ST	LOCAL ROADWAY	346	1	12	0	1750	35	27
799	542	176	17TH ST	LOCAL ROADWAY	865	1	12	0	1750	30	27

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
800	543	541	18TH ST	LOCAL ROADWAY	866	1	12	0	1750	30	27
801	543	542	MONROE ST	LOCAL ROADWAY	336	1	12	0	1575	35	27
802	544	246	S 26TH ST	LOCAL ROADWAY	111	2	12	0	1750	35	34
803	545	351	CR AB	COLLECTOR	8235	1	12	4	1700	60	5
804	546	545	CR AB	COLLECTOR	4838	1	12	4	1700	60	5
805	547	69	SR 29	MINOR ARTERIAL	2622	1	12	4	1700	65	9
806	548	547	SR 29	MINOR ARTERIAL	2329	1	12	4	1700	65	9
807	549	548	SR 29	MINOR ARTERIAL	2946	1	12	4	1700	65	9
808	550	268	CR Q	COLLECTOR	5924	1	12	4	1700	65	26
809	551	216	CR B	COLLECTOR	5666	1	12	0	1700	60	26
810	552	161	CR DD	COLLECTOR	6259	1	12	4	1700	45	31
811	553	554	SR 54	MINOR ARTERIAL	1891	1	12	4	1575	35	1
812	553	560	SR 54	MINOR ARTERIAL	1834	1	12	4	1575	35	1
813	553	561	CR AB	COLLECTOR	1461	1	12	4	1575	35	1
814	554	553	SR 54	MINOR ARTERIAL	1891	1	12	4	1750	35	1
815	554	555	SR 54	MINOR ARTERIAL	1419	1	12	4	1575	35	1
816	555	554	SR 54	MINOR ARTERIAL	1419	1	12	4	1575	35	1

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
817	555	556	SR 54	MINOR ARTERIAL	2674	1	12	4	1700	60	1
818	556	555	SR 54	MINOR ARTERIAL	2674	1	12	4	1700	60	1
819	556	557	SR 54	MINOR ARTERIAL	2297	1	12	4	1700	60	1
820	557	556	SR 54	MINOR ARTERIAL	2297	1	12	4	1700	60	1
821	557	558	SR 54	MINOR ARTERIAL	10465	1	12	4	1700	60	2
822	558	557	SR 54	MINOR ARTERIAL	10465	1	12	4	1700	60	2
823	558	559	SR 54	MINOR ARTERIAL	1344	1	12	4	1700	60	2
824	559	388	SR 54	MINOR ARTERIAL	3844	1	12	4	1700	60	2
825	559	558	SR 54	MINOR ARTERIAL	1344	1	12	4	1700	60	2
826	560	553	SR 54	MINOR ARTERIAL	1834	1	12	4	1750	35	1
827	562	563	DIVISION ST	COLLECTOR	690	1	12	0	1575	35	34
828	563	564	S 23RD ST	LOCAL ROADWAY	2667	1	12	0	1700	40	34
829	563	570	DIVISION ST	COLLECTOR	865	1	12	0	1575	35	34
830	564	571	DEWEY ST	MINOR ARTERIAL	896	2	12	0	1900	45	34
831	564	575	DEWEY ST	MINOR ARTERIAL	1448	2	12	0	1900	45	34

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
832	565	567	DEWEY ST	MINOR ARTERIAL	1440	1	12	0	1700	45	34
833	565	568	S 10TH ST	MINOR ARTERIAL	384	1	12	0	1575	35	34
834	566	315	DEWEY ST	MINOR ARTERIAL	2479	2	12	0	1750	45	33
835	566	572	DEWEY ST	MINOR ARTERIAL	890	2	12	0	1750	45	34
836	567	565	DEWEY ST	MINOR ARTERIAL	1440	1	12	0	1700	45	34
837	567	575	DEWEY ST	MINOR ARTERIAL	1429	1	12	0	1700	45	34
838	569	315	S 42 ST	COLLECTOR	247	2	12	4	1750	45	33
839	570	571	S 26TH ST	LOCAL ROADWAY	2625	1	12	0	1700	40	34
840	571	564	DEWEY ST	MINOR ARTERIAL	896	2	12	0	1900	45	34
841	571	572	DEWEY ST	MINOR ARTERIAL	1788	2	12	0	1750	45	34
842	572	566	DEWEY ST	MINOR ARTERIAL	890	2	12	0	1900	45	34
843	572	571	DEWEY ST	MINOR ARTERIAL	1788	2	12	0	1900	45	34
844	573	572	S 30TH ST	COLLECTOR	702	1	12	0	1750	40	34
845	574	294	S 30TH ST	COLLECTOR	823	1	12	0	1750	40	34
846	574	307	CUSTER ST	COLLECTOR	1443	1	12	0	1575	35	34
847	575	564	DEWEY ST	MINOR ARTERIAL	1448	2	12	0	1900	45	34

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
848	575	567	DEWEY ST	MINOR ARTERIAL	1429	1	12	0	1700	45	34
849	576	517	MEMORIAL DR	MAJOR ARTERIAL	296	3	12	6	1900	45	31
850	577	95	CR V	COLLECTOR	10558	1	12	0	1700	60	24
851	8022	22	I-43	FREEWAY	1043	2	12	8	2250	70	12
Exit Link	302	8302	CUSTER	COLLECTOR	527	1	12	4	1700	55	33
Exit Link	311	8311	I-43	FREEWAY	606	2	12	8	2250	70	33
Exit Link	312	8312	US 151	MAJOR ARTERIAL	421	2	12	6	1900	50	33
Exit Link	316	8316	US 10	MINOR ARTERIAL	706	1	12	8	1700	65	24
Exit Link	2	8002	CR D	COLLECTOR	578	1	12	4	1700	60	3
Exit Link	22	8022	I-43	FREEWAY	1043	2	12	8	2250	70	12
Exit Link	75	8075	CR T	COLLECTOR	801	1	12	4	1700	60	8
Exit Link	76	8076	SR 29	MINOR ARTERIAL	833	1	12	6	1700	60	8
Exit Link	78	8078	CR KB	COLLECTOR	1003	1	12	4	1700	45	12
Exit Link	79	8079	CR R	COLLECTOR	606	1	12	4	1700	60	12
Exit Link	97	8097	CR K	COLLECTOR	705	1	12	4	1700	60	20

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
Exit Link	114	8114	CR Z	COLLECTOR	995	1	12	3	1700	65	16
Exit Link	280	8280	SR 42	MAJOR ARTERIAL	569	1	12	0	1700	45	29
Exit Link	359	8359	CR N	COLLECTOR	1260	1	12	0	1700	65	5
Exit Link	430	8430	SR 42	MINOR ARTERIAL	523	1	12	4	1700	55	4
Exit Link	433	8433	SR 54	MINOR ARTERIAL	445	1	12	4	1700	65	2
Exit Link	560	8560	SR 54	MINOR ARTERIAL	1516	1	12	4	1575	35	1
Exit Link	561	8561	CR AB	COLLECTOR	1151	1	12	4	1575	35	1
Exit Link	568	8568	S 10TH ST	MINOR ARTERIAL	338	1	12	0	1575	35	34

Table K-2. Nodes in the Link-Node Analysis Network which are Controlled

Node	X Coordinate (ft)	Y Coordinate (ft)	Control Type	Grid Map Number
1	2545606	121708	Stop	24
24	2610799	189820	TCP-Actuated	19
25	2590299	189283	Stop	18
26	2584962	189143	TCP-Actuated	18
27	2569040	188558	Stop	17
28	2547048	187922	Stop	16
29	2611040	205676	TCP-Uncontrolled	15
30	2592526	205184	Stop	14
31	2584517	204904	TCP-Actuated	14
32	2584421	202122	Stop	14
33	2573999	202002	Stop	13
35	2568713	199123	Stop	13
37	2558275	198661	TCP-Actuated	13
40	2546752	195230	Stop	12
41	2546080	188784	Stop	16
42	2538148	194072	Stop	12
44	2573705	215319	Stop	9
46	2573179	230934	TCP-Actuated	9
47	2584240	215596	Stop	10
49	2534411	194897	Stop	12
51	2537017	195164	Stop	12
55	2527125	208707	Stop	12
57	2542413	190878	Stop	12
58	2542542	182442	Stop	16
59	2551113	182733	Stop	17
61	2536532	219494	Stop	8
62	2568367	220351	Stop	9
64	2547076	219806	Stop	8
65	2557769	220130	Stop	9
66	2558540	188259	TCP-Actuated	17
68	2567901	230869	Stop	9
69	2557339	230509	Stop	9
70	2546930	230405	Stop	8
71	2536241	230172	Stop	8
72	2542899	169190	Stop	16
73	2550776	169433	Stop	17
80	2569154	183317	Stop	17

Node	X Coordinate (ft)	Y Coordinate (ft)	Control Type	Grid Map Number
81	2585011	183750	TCP-Actuated	18
82	2606999	184520	TCP-Actuated	19
87	2544727	150808	Stop	20
89	2567143	166882	TCP-Actuated	17
94	2543886	156104	Stop	20
95	2545108	140124	Stop	24
96	2556864	121491	Stop	25
103	2566059	141695	Stop	25
109	2585629	157629	Stop	22
110	2586058	157352	Stop	22
118	2576728	141334	Stop	26
120	2576775	148294	Stop	22
121	2585606	154696	Stop	22
126	2570982	156908	TCP-Actuated	21
129	2607039	158017	Stop	23
130	2556662	156381	Stop	21
135	2611369	195885	Stop	15
137	2606771	168457	TCP-Actuated	19
140	2585258	134547	Stop	26
143	2599487	133855	Stop	27
146	2608515	136979	Stop	27
147	2569947	125064	Yield	25
154	2577677	125585	Yield	26
157	2585220	133754	Stop	26
161	2590802	113029	Stop	31
169	2608834	126387	Stop	27
170	2606646	126332	Actuated	27
171	2605787	126332	Stop	27
172	2605875	124171	Actuated	27
173	2602203	130188	Stop	27
176	2606730	124516	Pre-Timed	27
177	2608113	124550	Stop	27
178	2606745	124157	Pre-Timed	27
179	2605446	123541	Actuated	27
180	2605515	121903	Stop	27
181	2603033	120790	Yield	27
184	2605479	122801	Actuated	27
185	2604435	122102	Stop	27

Node	X Coordinate (ft)	Y Coordinate (ft)	Control Type	Grid Map Number
186	2604146	123519	Stop	27
187	2601191	126064	Yield	27
188	2601010	119649	Stop	27
190	2604417	122794	Stop	27
191	2600988	122720	Stop	27
197	2594756	115902	Actuated	31
198	2615139	136403	TCP-Uncontrolled	27
210	2569914	115092	Actuated	29
211	2572384	110305	Stop	29
212	2572386	108986	Actuated	29
213	2580330	110401	Stop	30
214	2583601	109080	Pre-Timed	30
217	2587611	109145	Stop	31
222	2583834	103501	Actuated	34
224	2583081	105636	Stop	34
225	2582644	106818	Stop	30
226	2582658	109076	Actuated	30
227	2583779	106821	Stop	30
229	2583129	101993	Pre-Timed	34
230	2583121	102598	Pre-Timed	34
231	2583841	102594	Actuated	34
232	2583856	101993	Actuated	34
233	2583155	100100	Stop	34
236	2583893	100107	Stop	34
239	2583137	101370	Pre-Timed	34
241	2579471	101929	Pre-Timed	34
242	2579491	99435	Stop	34
245	2579471	101293	Stop	34
246	2577959	101712	Pre-Timed	34
247	2579463	102590	Pre-Timed	34
249	2583784	105633	Stop	34
251	2580389	107287	Actuated	30
252	2577870	107846	Stop	30
256	2572389	107926	Actuated	29
258	2580332	109051	Actuated	30
259	2582012	109083	Stop	30
260	2570848	114943	Stop	29
263	2575736	109052	Stop	30

Node	X Coordinate (ft)	Y Coordinate (ft)	Control Type	Grid Map Number
265	2573573	113628	Stop	29
267	2572528	104790	Actuated	33
269	2583552	111084	Actuated	30
270	2589019	111264	Actuated	31
273	2577849	109049	Stop	30
277	2565811	109050	Stop	29
278	2568083	108100	Stop	29
284	2577968	104225	Stop	34
285	2579408	103671	Pre-Timed	34
289	2582671	102592	Stop	34
290	2577981	101303	Pre-Timed	34
291	2577820	101409	Pre-Timed	34
292	2577584	101648	Yield	34
294	2576682	100781	Actuated	34
295	2570853	95981	Actuated	33
296	2570730	99949	Actuated	33
297	2570787	97522	Actuated	33
299	2575263	99859	Actuated	34
300	2572618	96492	Actuated	33
305	2573326	97663	Actuated	33
307	2575202	101565	Stop	34
309	2569995	95942	Actuated	33
310	2569322	95920	Actuated	33
315	2572872	96193	Actuated	33
317	2603459	129175	Stop	27
318	2602088	133966	Stop	27
324	2596592	215845	Stop	10
326	2610849	216239	Stop	11
329	2612914	234951	Stop	11
331	2594496	231608	Stop	10
335	2618143	235150	Stop	11
337	2620293	237874	Stop	7
338	2618115	237778	Stop	7
339	2594308	236969	Stop	10
341	2620384	236798	Stop	11
342	2618103	236695	Stop	11
345	2620363	235253	Stop	11
353	2567232	262669	Stop	1

Node	X Coordinate (ft)	Y Coordinate (ft)	Control Type	Grid Map Number
355	2556836	251824	Stop	5
362	2614994	237737	Stop	7
365	2607857	238630	Stop	7
372	2597817	251807	TCP-Actuated	6
381	2604059	244122	Stop	7
388	2589292	273128	Stop	2
395	2616752	236681	Stop	11
396	2616722	237758	Stop	7
398	2618026	239344	Stop	7
403	2620199	257640	Stop	7
404	2620415	248457	Stop	7
410	2609526	248089	Stop	7
412	2607090	253310	TCP-Uncontrolled	7
415	2604185	258457	Stop	7
422	2596960	274051	Stop	2
435	2577965	102545	Stop	34
436	2536929	198417	Stop	12
438	2535474	206825	Stop	12
444	2618082	238592	Yield	7
449	2608561	135603	Stop	27
452	2608772	129002	Stop	27
466	2570739	98719	Actuated	33
482	2579726	105398	Stop	34
487	2585237	106833	Stop	30
489	2581662	101969	Actuated	34
490	2581656	101362	Stop	34
492	2581662	102606	Stop	34
493	2581738	99440	Stop	34
500	2575841	100272	Actuated	34
503	2570046	125179	Yield	25
504	2569950	125283	Yield	25
511	2577752	125529	Yield	26
519	2603133	122794	Stop	27
520	2603173	121026	Stop	27
521	2607140	124530	Stop	27
523	2582461	125773	Yield	26
524	2582561	125664	Yield	26
541	2606709	124856	Pre-Timed	27

Node	X Coordinate (ft)	Y Coordinate (ft)	Control Type	Grid Map Number
542	2605865	124517	Stop	27
543	2605843	124852	Stop	27
553	2567094	268028	Actuated	1
562	2579509	99005	Stop	34
564	2578921	96334	Stop	34
565	2583236	96469	Stop	34
566	2575351	96214	Stop	34
567	2581796	96447	Stop	34
570	2577954	98966	Stop	34
571	2578025	96342	Stop	34
572	2576240	96245	Actuated	34

[1]Coordinates are in the North American Datum of 1983 Wisconsin Central State Plane Zone

APPENDIX L

Zone Boundaries

L. ZONE BOUNDARIES

Zone 5 — County: Kewaunee/Manitowoc

Defined as the area within the following boundary: Bounded on the north by Townline Road, on the east by Lake Michigan, on the south by Nuclear Road, and on the west by County Road AB and Rangeline Road. Includes the Town of Two Creeks and Tisch Mills.

Zone 10N — County: Kewaunee

Defined as the area within the following boundary: Bounded on the north by Ryan Radio Road, Casco W Kewaunee Line Road and 1st Road, on the east by Lake Michigan, on the south by Townline Rd, and on the west by Rangeline Road and E Townline Road. Includes the City of Kewaunee.

Zone 10S — County: Manitowoc

Defined as the area within the following boundary: Bounded on the north by Nuclear Road, on the east by Lake Michigan, on the south by E Hillcrest Road and County Road V, on the southwest by E Shore Road and Barthels Road extended, on the west by County Road Q extended, and on the northwest by Fisherville Road, Ridge Road, Assman Road extended and Highway B County Trunk. Includes Mishicot Village.

Zone 10SW — County: Manitowoc

Defined as the area within the following boundary: Bounded on the north by West County Road BB, on the east by Highway B County Truck, on the southeast by Assman Road extended and Ridge Road, on the south by Fisherville Road and on the west by Irish Road Extended. Includes the town of Cooperstown.

Zone 10W — County: Kewaunee

Defined as the area within the following boundary: Bounded on the north by County Road F, on the east by Townline Road and County Road AB, on the south by West County Road BB, on the west by Curran Road and County Road V, and on the northwest by Wisconsin Route 29 and County Road V. Includes the town of Pilsen.

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 Advisory to Evacuate, could be persuaded to respond much more rapidly), how would the ETE be affected? The case considered was Scenario 6, Region 2; a winter, midweek, midday, good weather evacuation of the entire EPZ. Table M-1 presents the results of this study.

Table M-1. Evacuation Time Estimates for Trip Generation Sensitivity Study

Trip Generation Period	Evacuation Time Estimate for Entire EPZ	
	90th Percentile	100th Percentile
2 Hours 30 Minutes	1:45	2:40
3 Hours	1:55	3:10
3 Hours 30 Minutes(Base)	1:55	3:40

The results confirm the importance of accurately estimating the trip generation (mobilization) times. The ETE for the 100th percentile closely mirror the values for the time the last evacuation trip is generated. In contrast, the 90th percentile ETE is less sensitive to truncating the tail of the mobilization time distribution. As indicated in Section 7.3, traffic congestion within the EPZ clears at about 1:30 after the ATE, well before the completion of trip generation time. The results indicate that programs to educate the public and encourage them toward faster responses for a radiological emergency, translates into shorter ETE at the 100th percentile. The results also justify the guidance to employ the [stable] 90th percentile ETE for protective action decision making.

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 6, Region 2; a winter, midweek, midday, good weather evacuation for 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 Sections 3.2 and 7.1 for additional information on population within the shadow region.

Table M-2 presents the evacuation time estimates for each of the cases considered. The results show that the ETE is not impacted by shadow evacuation from 0% to 20%. Tripling the shadow percentage has no effect on ETE. Note, the telephone survey results presented in Appendix F indicate that 20% of households would elect to evacuate if advised to shelter. Thus, the base assumption of 20% non-compliance suggested in NUREG/CR-7002 is valid.

Table M-2. Evacuation Time Estimates for Shadow Sensitivity Study

Percent Shadow Evacuation	Evacuating Shadow Vehicles	Evacuation Time Estimate for Entire EPZ	
		90th Percentile	100th Percentile
0	0	1:55	3:40
15	1,755	1:55	3:40
20 (Base)	2,340	1:55	3:40
60	7,021	1:55	3:40

M.3 Effect of Changes in EPZ Resident Population

A sensitivity study was conducted to determine the effect on ETE of changes in the 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. The sensitivity study was conducted using the following planning assumptions:

1. The percent change in population within the study area was varied between +350% and -90%. Changes in population were applied to permanent residents only (as per federal guidance), in both the EPZ area and in the Shadow Region.
2. The transportation infrastructure remained fixed; the presence of new roads or highway capacity improvements were not considered.
3. The study was performed for the 5-Mile Region (R01) and the entire EPZ (R02).
4. The good weather scenario which yielded the highest ETE values was selected as the case to be considered in this sensitivity study (Scenario 6).

Table M-3 presents the results of the sensitivity study. Section IV of Appendix E to 10 CFR Part 50, and NUREG/CR-7002, Section 5.4, require licensees to provide an updated ETE analysis to the NRC when a population increase within the EPZ causes ETE values (for the 5-Mile Region or entire EPZ) to increase by 25 percent or 30 minutes, whichever is less. Note that the base ETE values for the 100th percentile are greater than 2 hours; therefore, 30 minutes is the lesser and is the criterion for updating at the 100th percentile. Twenty five percent of the 90th percentile ETE for the 5-Mile region (1:35) is 23 minutes, and for the full EPZ (1:55) is 29 minutes; both less than 30 minutes.

Those percent population changes which result in ETE changes greater than 30 minutes or 23 minutes for the 5-mile region at the 90th percentile or 29 minutes for the full EPZ at the 100th percentile, are highlighted in red below – a 350% increase or 90% decrease in the EPZ population. Dominion will have to estimate the EPZ population on an annual basis. If the EPZ population increases by 350% or more, or decreases by 90% or more, an updated ETE analysis will be needed.

Table M-3. ETE Variation with Population Change

Resident Population		Population Change							Population Change		
	11,596	23,192	28,990	34,788	40,586	46,384	52,182	11,596	3,479	2,319	1,160
ETE for 90th Percentile											
Region	**Base**	**Population Change**						**Base**	**Population Change**		
		100%	**150%**	**200%**	**250%**	**300%**	**350%**		**-70%**	**-80%**	**-90%**
5-MILE	1:35	1:45	1:50	1:50	1:50	1:55	1:55	1:35	1:20	1:15	**1:10**
FULL EPZ	1:55	1:55	2:00	2:00	2:05	2:15	**2:25**	1:55	1:45	1:40	1:30
ETE for 100th Percentile											
Region	**Base**	**Population Change**						**Base**	**Population Change**		
		100%	**150%**	**200%**	**250%**	**300%**	**350%**		**-70%**	**-80%**	**-90%**
5-MILE	3:35	3:35	3:35	3:35	3:35	3:35	3:35	3:35	3:35	3:35	3:35
FULL EPZ	3:40	3:40	3:40	3:40	3:40	3:50	**4:20**	3:40	3:40	3:40	3:40

APPENDIX N

ETE Criteria Checklist

N. ETE CRITERIA CHECKLIST

Table N-1. ETE Review Criteria Checklist

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
1.0 Introduction		
a. The emergency planning zone (EPZ) and surrounding area should be described.	Yes	Section 1
b. A map should be included that identifies primary features of the site, including major roadways, significant topographical features, boundaries of counties, and population centers within the EPZ.	Yes	Figure 1-1
c. A comparison of the current and previous ETE should be provided and includes similar information as identified in Table 1-1, "ETE Comparison," of NUREG/CR-7002.	Yes	Table 1-3
1.1 Approach		
a. A discussion of the approach and level of detail obtained during the field survey of the roadway network should be provided.	Yes	Section 1.3
b. Sources of demographic data for schools, special facilities, large employers, and special events should be identified.	Yes	Section 2.1 Section 3
c. Discussion should be presented on use of traffic control plans in the analysis.	Yes	Section 1.3, Section 2.3, Section 9, Appendix G
d. Traffic simulation models used for the analyses should be identified by name and version.	Yes	Section 1.3, Table 1-3, Appendix B, Appendix C

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
e. Methods used to address data uncertainties should be described.	Yes	Section 3 – avoid double counting Section 5, Appendix F – 4.5% sampling error at 95% confidence interval for telephone survey Appendix M
1.2 Assumptions		
a. The planning basis for the ETE includes the assumption that the evacuation should be ordered promptly and no early protective actions have been implemented.	Yes	Section 2.3 – Assumption 1 Section 5.1
b. Assumptions consistent with Table 1-2, "General Assumptions," of NUREG/CR-7002 should be provided and include the basis to support their use.	Yes	Sections 2.2, 2.3
1.3 Scenario Development		
a. The ten scenarios in Table 1-3, Evacuation Scenarios, should be developed for the ETE analysis, or a reason should be provided for use of other scenarios.	Yes	Tables 2-1, 6-2
1.3.1 Staged Evacuation		
a. A discussion should be provided on the approach used in development of a staged evacuation.	Yes	Sections 5.4.2, 7.2
1.4 Evacuation Planning Areas		
a. A map of EPZ with emergency response planning areas (ERPAs) should be included.	Yes	Figure 6-1
b. A table should be provided identifying the ERPAs considered for each ETE calculation by downwind direction in each sector.	Yes	Table 6-1

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
c. A table similar to Table 1-4, "Evacuation Areas for a Staged Evacuation Keyhole," of NUREG/CR-7002 should be provided and includes the complete evacuation of the 2, 5, and 10 mile areas and for the 2 mile area/5 mile keyhole evacuations.	Yes	Table 7-5
2.0 Demand Estimation		
a. Demand estimation should be developed for the four population groups, including permanent residents of the EPZ, transients, special facilities, and schools.	Yes	Permanent residents, employees, transients – Section 3, Appendix E Special facilities, schools – Section 8, Appendix E
2.1 Permanent Residents and Transient Population		
a. The US Census should be the source of the population values, or another credible source should be provided.	Yes	Section 3.1
b. Population values should be adjusted as necessary for growth to reflect population estimates to the year of the ETE.	Yes	2010 used as the base year for analysis. No growth of population necessary.
c. A sector diagram should be included, similar to Figure 2-1, "Population by Sector," of NUREG/CR-7002, showing the population distribution for permanent residents.	Yes	Figure 3-2
2.1.1 Permanent Residents with Vehicles		
a. The persons per vehicle value should be between 1 and 2 or justification should be provided for other values.	Yes	1.89 persons per vehicle – Table 1-3
b. Major employers should be listed.	Yes	Appendix E – Table E-3
2.1.2 Transient Population		

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
a. A list of facilities which attract transient populations should be included, and peak and average attendance for these facilities should be listed. The source of information used to develop attendance values should be provided.	Yes	Sections 3.3, 3.4, Appendix E
b. The average population during the season should be used, itemized and totaled for each scenario.	Yes	Tables 3-4, 3-5 and Appendix E itemize the transient population and employee estimates. These estimates are multiplied by the scenario specific percentages provided in Table 6-3 to estimate transient population by scenario.
c. The percent of permanent residents assumed to be at facilities should be estimated.	Yes	Sections 3.3, 3.4
d. The number of people per vehicle should be provided. Numbers may vary by scenario, and if so, discussion on why values vary should be provided.	Yes	Sections 3.3, 3.4
e. A sector diagram should be included, similar to Figure 2-1 of NUREG/CR-7002, showing the population distribution for the transient population.	Yes	Figure 3-6 – transients Figure 3-8 – employees
2.2 Transit Dependent Permanent Residents		
a. The methodology used to determine the number of transit dependent residents should be discussed.	Yes	Section 8.1, Table 8-1
b. Transportation resources needed to evacuate this group should be quantified.	Yes	Section 8.1, Tables 8-5, 8-10
c. The county/local evacuation plans for transit dependent residents should be used in the analysis.	Yes	Sections 8.1, 8.4

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
d. 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 should be provided. Data from local/county registration programs should be used in the estimate, but should not be the only set of data.	Yes	Section 8.5
e. Capacities should be provided for all types of transportation resources. Bus seating capacity of 50% should be used or justification should be provided for higher values.	Yes	Section 2.3 – Assumption 10 Sections 3.5, 8.1, 8.2, 8.3
f. An estimate of this population should be provided and information should be provided that the existing registration programs were used in developing the estimate.	Yes	Table 8-1 – transit dependents Section 8.5 – special needs
g. A summary table of the total number of buses, ambulances, or other transport needed to support evacuation should be provided and the quantification of resources should be detailed enough to assure double counting has not occurred.	Yes	Section 8.4 – page 8-6 Table 8-5, Section 8-3
2.3 Special Facility Residents		
a. A list of special facilities, including the type of facility, location, and average population should be provided. Special facility staff should be included in the total special facility population.	Yes	Table E-2 list facilities, location, and population
b. A discussion should be provided on how special facility data was obtained.	Yes	Sections 8.2, 8.3

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
c. The number of wheelchair and bed-bound individuals should be provided.	Yes	Section 3.5
d. An estimate of the number and capacity of vehicles needed to support the evacuation of the facility should be provided.	Yes	Section 8.3 Tables 8-4, 8-5
e. The logistics for mobilizing specially trained staff (e.g., medical support or security support for prisons, jails, and other correctional facilities) should be discussed when appropriate.	Yes	Section 3.5 - No correctional facilities exist within the EPZ.
2.4 Schools		
a. A list of schools including name, location, student population, and transportation resources required to support the evacuation, should be provided. The source of this information should be provided.	Yes	Table 8-2 Section 8.2
b. Transportation resources for elementary and middle schools should be based on 100% of the school capacity.	Yes	Table 8-2
c. The estimate of high school students who will use their personal vehicle to evacuate should be provided and a basis for the values used should be discussed.	Yes	Section 8.2
d. The need for return trips should be identified if necessary.	Yes	There are sufficient resources to evacuate schools in a single wave. However, Section 8.4 and Figure 8-1 discuss the potential for a multiple wave evacuation

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
2.5.1 Special Events		
a. A complete list of special events should be provided and includes 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 should be analyzed in the ETE.	Yes	Section 3.7
c. The percent of permanent residents attending the event should be estimated.	Yes	Section 3.7
2.5.2 Shadow Evacuation		
a. A shadow evacuation of 20 percent should be included for areas outside the evacuation area extending to 15 miles from the NPP.	Yes	Section 2.2 – Assumption 5 Figure 2-1 Section 3.2
b. Population estimates for the shadow evacuation in the 10 to 15 mile area beyond the EPZ are provided by sector.	Yes	Section 3.2 Figure 3-4 Table 3-3
c. The loading of the shadow evacuation onto the roadway network should be consistent with the trip generation time generated for the permanent resident population.	Yes	Section 5 – Table 5-9
2.5.3 Background and Pass Through Traffic		

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
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 3.6 Table 3-6 Section 6 Table 6-3
b. Pass through traffic is assumed to have stopped entering the EPZ about two hours after the initial notification.	Yes	Section 2.3 – Assumption 5 Section 3.6
2.6 Summary of Demand Estimation		
a. A summary table should be provided that identifies the total populations and total vehicles used in analysis for permanent residents, transients, transit dependent residents, special facilities, schools, shadow population, and pass-through demand used in each scenario.	Yes	Tables 3-7, 3-8
3.0 Roadway Capacity		
a. The method(s) used to assess roadway capacity should be discussed.	Yes	Section 4
3.1 Roadway Characteristics		
a. A field survey of key routes within the EPZ has been conducted.	Yes	Section 1.3
b. Information should be provided describing the extent of the survey, and types of information gathered and used in the analysis.	Yes	Section 1.3
c. A table similar to that in Appendix A, “Roadway Characteristics,” of NUREG/CR-7002 should be provided.	Yes	Appendix K, Table K-1

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
d. Calculations for a representative roadway segment should be provided.	Yes	Section 4
e. A legible map of the roadway system that identifies node numbers and segments used to develop the ETE should be provided and should be similar to Figure 3-1, "Roadway Network Identifying Nodes and Segments," of NUREG/CR-7002.	Yes	Appendix K, Figures K-1 through K-35 present the entire link-node analysis network at a scale suitable to identify all links and nodes
3.2 Capacity Analysis		
a. The approach used to calculate the roadway capacity for the transportation network should be described in detail and identifies factors that should be expressly used in the modeling.	Yes	Section 4
b. The capacity analysis identifies where field information should be used in the ETE calculation.	Yes	Section 1.3, Section 4
3.3 Intersection Control		
a. A list of intersections should be provided that includes the total number of intersections modeled that are unsignalized, signalized, or manned by response personnel.	Yes	Appendix K, Table K-2
b. Characteristics for the 10 highest volume intersections within the EPZ are provided including the location, signal cycle length, and turn lane queue capacity.	Yes	Table J-1
c. Discussion should be provided on how signal cycle time is used in the calculations.	Yes	Section 4.1, Appendix C.
3.4 Adverse Weather		

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
a. The adverse weather condition should be identified and the effects of adverse weather on mobilization time should be considered.	Yes	Table 2-1, Section 2.3 – Assumption 9 Mobilization time – Table 2-2, Section 5.3 (page 5-10)
b. The speed and capacity reduction factors identified in Table 3-1, "Weather Capacity Factors," of NUREG/CR-7002 should be used or a basis should be provided for other values.	Yes	Table 2-2 – based on HCM 2010. The factors provided in Table 3-1 of NUREG/CR-7002 are from HCM 2000.
c. The study identifies assumptions for snow removal on streets and driveways, when applicable.	Yes	Section 5.3 – page 5-10 Appendix F – Section F.3.3
4.0 Development of Evacuation Times		
4.1 Trip Generation Time		
a. The process used to develop trip generation times should be identified.	Yes	Section 5
b. When telephone surveys are used, the scope of the survey, area of survey, number of participants, and statistical relevance should be provided.	Yes	Appendix F
c. Data obtained from telephone surveys should be summarized.	Yes	Appendix F
d. The trip generation time for each population group should be developed from site specific information.	Yes	Section 5, Appendix F
4.1.1 Permanent Residents and Transient Population		

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
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 prior to 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.
b. Discussion should be provided on the time and method used to notify transients. The trip generation time discusses any difficulties notifying persons in hard to reach areas such as on lakes or in campgrounds.	Yes	Section 5.4.3
c. The trip generation time accounts for transients potentially returning to hotels prior to evacuating.	Yes	Section 5, Figure 5-1
d. Effect of public transportation resources used during special events where a large number of transients should be expected should be considered.	Yes	Section 3.7
e. The trip generation time for the transient population should be integrated and loaded onto the transportation network with the general public.	Yes	Section 5, Table 5-9
4.1.2 Transit Dependent Residents		

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
a. If available, existing plans and bus routes should be used in the ETE analysis. If new plans should be developed with the ETE, they have been agreed upon by the responsible authorities.	Yes	Section 8.4 – page 8-8. Pre-established bus routes do not exist. Basic bus routes were developed for the ETE analysis – see Figure 8-2, Table 8-10.
b. Discussion should be included on the means of evacuating ambulatory and non-ambulatory residents.	Yes	Section 8.4
c. The number, location, and availability of buses, and other resources needed to support the demand estimation should be provided.	Yes	Section 8.4 Table 8-5
d. Logistical details, such as the time to obtain buses, brief drivers, and initiate the bus route should be provided.	Yes	Section 8.4, Figure 8-1
e. Discussion should identify the time estimated for transit dependent residents to prepare and travel to a bus pickup point, and describes the expected means of travel to the pickup point.	Yes	Section 8.4
f. The number of bus stops and time needed to load passengers should be discussed.	Yes	Section 8.4
g. A map of bus routes should be included.	Yes	Figure 8-2
h. The trip generation time for non-ambulatory persons includes the time to mobilize ambulances or special vehicles, time to drive to the home of residents, loading time, and time to drive out of the EPZ should be provided.	Yes	Section 8.4
i. Information should be provided to supports analysis of return trips, if necessary.	Yes	Section 8.4 Figure 8-1 Tables 8-11 through 8-13

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
4.1.3 Special Facilities		
a. Information on evacuation logistics and mobilization times should be provided.	Yes	Section 8-4, 8-14 through 8-16
b. Discussion should be provided on the inbound and outbound speeds.	Yes	Sections 8.4.
c. The number of wheelchair and bed-bound individuals should be provided, and the logistics of evacuating these residents should be discussed.	Yes	Section 8.4 Tables 8-4, 8-14 through 8-16
d. Time for loading of residents should be provided	Yes	Section 8.4
e. Information should be provided that indicates whether the evacuation can be completed in a single trip or if additional trips should be needed.	Yes	Section 8.4, Table 8-4, Table 8-5
f. If return trips should be needed, the destination of vehicles should be provided.	Yes	Return trips are not needed.
g. Discussion should be provided on whether special facility residents are expected to pass through the reception center prior to being evacuated to their final destination.	Yes	Section 8.4
h. Supporting information should be provided to quantify the time elements for the return trips.	Yes	Return trips are not needed.
4.1.4 Schools		
a. Information on evacuation logistics and mobilization time should be provided.	Yes	Section 8.4

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
b. Discussion should be provided on the inbound and outbound speeds.	Yes	School bus routes are presented in Table 8-6. School bus speeds are presented in Tables 8-7 through 8-9. Outbound speeds are defined as the minimum of the evacuation route speed and the State school bus speed limit. Inbound speeds are limited to the State school bus speed limit.
c. Time for loading of students should be provided.	Yes	Tables 8-7 through 8-9, Discussion in Section 8.4
d. Information should be provided that indicates whether the evacuation can be completed in a single trip or if additional trips are needed.	Yes	Section 8.4 – page 8-6
e. If return trips are needed, the destination of school buses should be provided.	Yes	Return trips are not needed.
f. If used, reception centers should be identified. Discussion should be provided on whether students are expected to pass through the reception center prior to being evacuated to their final destination.	Yes	Table 8-3. Students are evacuated to host schools where they will be picked up by parents or guardians.
g. Supporting information should be provided to quantify the time elements for the return trips.	Yes	Return trips are not needed. Tables 8-7 and 8-9 provide time needed to arrive at host school, which could be used to compute a second wave evacuation if necessary

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
4.2 ETE Modeling		
a. General information about the model should be provided and demonstrates its use in ETE studies.	Yes	DYNEV II (Ver. 4.0.8.0). Section 1.3, Table 1-3, Appendix B, Appendix C.
b. If a traffic simulation model is not used to conduct the ETE calculation, sufficient detail should be provided to validate the analytical approach used. All criteria elements should have been met, as appropriate.	No	Not applicable as a traffic simulation model was used.
4.2.1 Traffic Simulation Model Input		
a. Traffic simulation model assumptions and a representative set of model inputs should be provided.	Yes	Appendices B and C describe the simulation model assumptions and algorithms Table J-2
b. A glossary of terms should be provided for the key performance measures and parameters used in the analysis.	Yes	Appendix A Tables C-1, C-2
4.2.2 Traffic Simulation Model Output		
a. A discussion regarding whether the traffic simulation model used must be in equilibration prior to calculating the ETE should be provided.	Yes	Appendix B

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
b. The minimum following model outputs should be provided to support review: 1. Total volume and percent by hour at each EPZ exit node. 2. Network wide average travel time. 3. Longest queue length for the 10 intersections with the highest traffic volume. 4. Total vehicles exiting the network. 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. Table J-5. 2. Table J-3. 3. Table J-1. 4. Table J-3. 5. Figures J-1 through J-14 (one plot for each scenario considered). 6. Table J-4. Network wide average speed also provided in Table J-3.
c. Color coded roadway maps should be provided for various times (i.e., at 2, 4, 6 hrs., etc.) during a full EPZ evacuation scenario, identifying areas where long queues exist including level of service (LOS) “E” and LOS “F” conditions, if they occur.	Yes	Figures 7-3 through 7-6
4.3 Evacuation Time Estimates for the General Public		
a. The ETE should include the time to evacuate 90% and 100% of the total permanent resident and transient population	Yes	Tables 7-1, 7-2

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
b. The ETE for 100% of the general public should include all members of the general public. Any reductions or truncated data should be explained.	Yes	Section 5.4 – truncating survey data to eliminate statistical outliers Table 7-2 – 100th percentile ETE for general public
c. Tables should be provided for the 90 and 100 percent ETEs similar to Table 4-3, "ETEs for Staged Evacuation Keyhole," of NUREG/CR-7002.	Yes	Tables 7-3, 7-4
d. ETEs should be provided for the 100 percent evacuation of special facilities, transit dependent, and school populations.	Yes	Section 8.4 School: Tables 8-7 through 8-9 Transit Dependent: Tables 8-11 through 8-13 Special Facilities: Tables 8-14 through 8-16
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 should be provided.	Yes	Section 9, Appendix G
b. A discussion of adjustments or additions to the traffic control plan that affect the ETE should be provided.	Yes	Appendix G
5.2 Enhancements in Evacuation Time		
a. The results of assessments for improvement of evacuation time should be provided.	Yes	Section 13, Appendix M

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
b. A statement or discussion regarding presentation of enhancements to local authorities should be provided.	Yes	Results of the ETE study will be formally presented to local authorities at the final project meeting. Recommended enhancements will be discussed.
5.3 State and Local Review		
a. A list of agencies contacted and the extent of interaction with these agencies should be discussed.	Yes	Table 1-1
b. Information should be provided on any unresolved issues that may affect the ETE.	Yes	There are no outstanding issues. All issues were discussed at the project kickoff and final meetings.
5.4 Reviews and Updates		
a. A discussion of when an updated ETE analysis is required to be performed and submitted to the NRC.	Yes	Appendix M, Section M.3
5.5 Reception Centers and Congregate Care Center		
a. A map of congregate care centers and reception centers should be provided.	Yes	Figure 10-1
b. If return trips are required, assumptions used to estimate return times for buses should be provided.	Yes	Section 8.3 discusses a multi-wave evacuation procedure. Figure 8-1
c. It should be clearly stated if it is assumed that passengers are left at the reception center and are taken by separate buses to the congregate care center.	Yes	Section 2.3 – Assumption 7h Section 10

Technical Reviewer ________________________________ Date __________________________

Supervisory Review ________________________________ Date __________________________