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September 7, 2022

L-XE-22-008
10 CFR 50 Appendix E

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

Prairie Island Nuclear Generating Plant,
Units 1 and 2
Dockets 50-282 and 50-306
Renewed Facility Operating License Nos.
DPR-42 and DPR-60

Monticello Nuclear Generating Plant
Docket 50-263
Renewed Facility Operating License
No. DPR-22

10 CFR 50 Appendix E Evacuation Time Estimate Analysis for the Monticello and Prairie Island Nuclear Generating Plants

Pursuant to 10 CFR 50, Appendix E, Section IV, Northern States Power Company, a Minnesota corporation (NSPM), d/b/a Xcel Energy, hereby submits the evacuation time estimate analysis (ETE) for the Monticello Nuclear Generating Plant (MNGP), and the Prairie Island Nuclear Generating Plant (PINGP).

The regulation requires the licensee to submit an updated analysis within 365 days of the availability of the most recent decennial census data. Updated decennial census data became available September 16, 2021.

The MNGP and PINGP ETEs were developed in accordance with the federal guidance in NUREG/CR-7002, Revision 1, "Criteria for Development of Evacuation Time Estimate Studies".

Enclosure 1 contains a copy of the MNGP ETE analysis. Enclosure 2 contains a copy of the PINGP ETE analysis.

The enclosed ETE analyses provide the methods used to derive the time for public evacuation for planning purposes.

Summary of Commitments

This letter makes no new commitments and no revisions to existing commitments.



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Northern States Power Company – Minnesota

Enclosures: (2)

cc: Administrator, Region III, USNRC
Project Manager, Monticello and Prairie Island, USNRC
Resident Inspector, Monticello, USNRC
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Enclosure 1

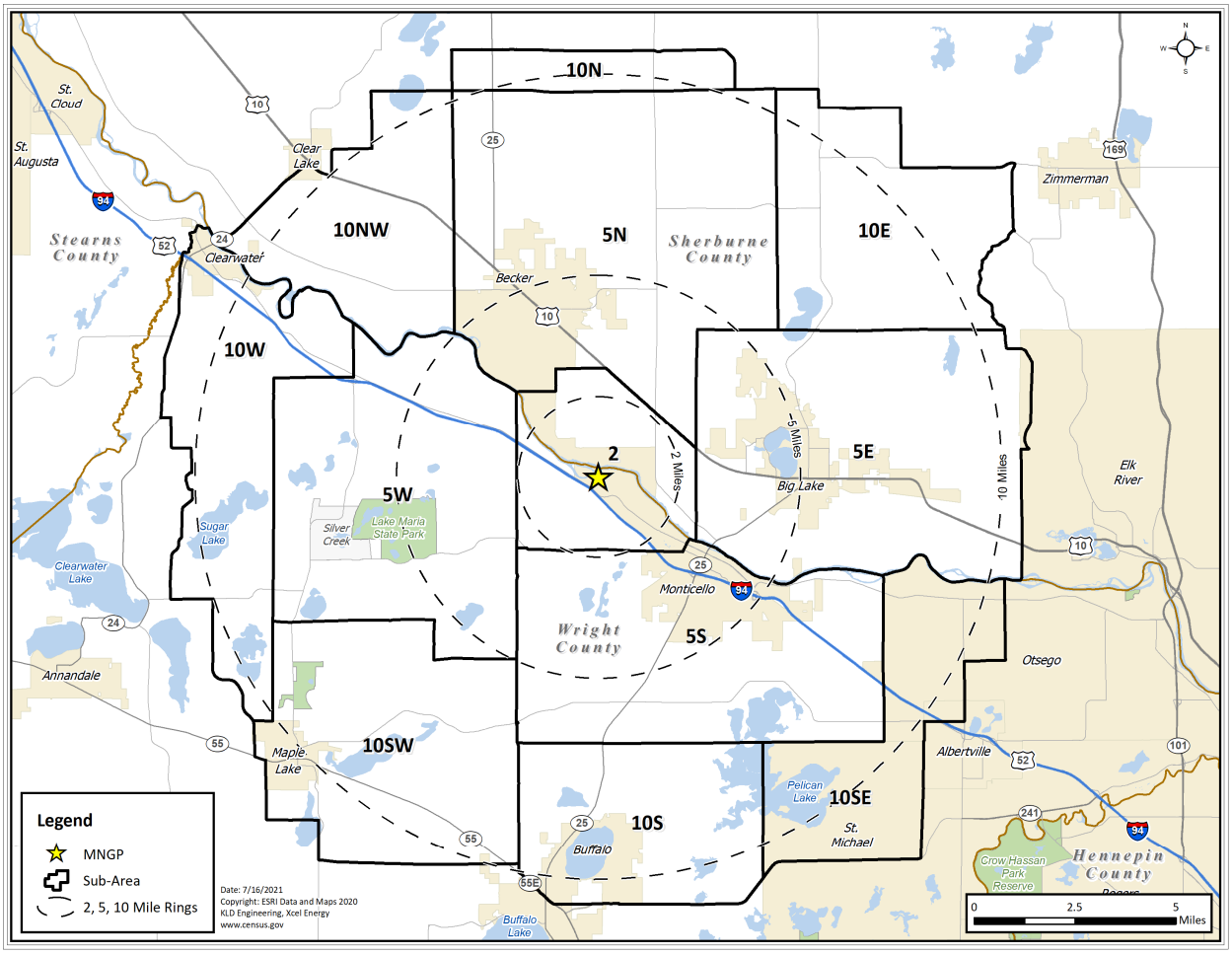
2022 Monticello Nuclear Generating Plant Emergency Planning Zone Evacuation Time Estimate Analysis

(403 pages to follow)

KLD ENGINEERING, P.C.

Monticello Nuclear Generating Plant

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 Monticello Nuclear Generating Plant (MNGP) located in Wright County, Minnesota. ETE are part of the required planning basis and provide Xcel Energy as well as state and local governments with site-specific information needed for Protective Action decision-making.

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

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

Project Activities

This project began in January 2021 and extended over a period of about 18 months. The major activities performed are briefly described in chronological sequence:

- Conducted a virtual "kick-off" meeting with Xcel Energy personnel and emergency management personnel representing state and county governments.
- Estimated the number of employees who reside outside the Emergency Planning Zone (EPZ) and commute to work within the EPZ based upon data from the US Census Longitudinal Employer-Household Dynamics from the OnTheMap Census analysis tool[1].
- Studied Geographic Information Systems (GIS) maps of the area in the vicinity of the MNGP, then conducted a detailed field survey of the highway network to observe any roadway changes relative to the previous ETE study done in 2012.
- Updated the analysis network representing the highway system topology and capacities within the EPZ, plus a Shadow Region covering the region between the EPZ boundary and approximately 15 miles radially from the plant.
- Used the existing Sub-Areas to identify Evacuation Regions.
- Conducted an online random-sample demographic survey of residents within the EPZ, to gather focused data needed for this ETE study that were not contained within the census database.
- A data matrix was provided to Xcel Energy and the OROs at the kickoff meeting to solicit data needed for the ETE study. Available data was provided by Wright County and

[1] http://onthemap.ces.census.gov/

Sherburne County emergency management officials for transient attractions and special facilities (schools, medical facilities, etc.). Internet searches were also utilized. If updated information was not provided or available, the data gathered for the 2012 ETE study was utilized after being confirmed by the counties.

- The traffic demand and trip-generation rates of evacuating vehicles were estimated from the gathered data. The trip generation rates reflect the estimated mobilization time (i.e., the time required by evacuees to prepare for the evacuation trip) computed using the results of the demographic survey of EPZ residents.
- Following federal guidelines, the existing 12 Sub-Areas within the EPZ were grouped within circular areas or "keyhole" configurations (circles plus radial sectors) that define a total of 34 Evacuation Regions.
- The time-varying external circumstances are represented as Evacuation Scenarios, each described in terms of the following factors: (1) Season (Summer, Winter); (2) Day of Week (Midweek, Weekend); (3) Time of Day (Midday, Evening); and (4) Weather (Good, Rain/Light Snow, Heavy Snow). One special event scenario for the summer services at Laestadian Lutheran Church was considered. One roadway impact scenario was considered wherein a single lane was closed on Interstate (I)-94 eastbound from a location by MNGP (between exits 183 and 193) to the end of the analysis-network at the interchange with SR-101 (exit 207), for the duration of the evacuation.
- Staged evacuation was considered for those regions wherein the 2-mile radius and sectors downwind to 5 miles are evacuated.
- As per NUREG/CR-7002, Rev. 1, the planning basis for the calculation of ETE is:
    - A rapidly escalating accident at the MNGP that quickly assumes the status of a general emergency wherein evacuation is ordered promptly and no early protective actions have been implemented such that the Advisory to Evacuate (ATE) is virtually coincident with the siren notification.
    - While an unlikely accident scenario, this planning basis will yield ETE, measured as the elapsed time from the ATE until the stated percentage of the population exits the impacted Region that represent "upper bound" estimates. This conservative planning basis is applicable for all initiating events.
- If the emergency occurs while schools are in session, the ETE study assumes that the children will be evacuated by bus directly to the reception center 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. Those in special facilities will likewise be evacuated with public transit, as needed: full-size bus, mid-size bus, passenger car, van, wheelchair transport or ambulance, as required. Separate ETE are calculated for the

transit-dependent evacuees, for the access and/or functional needs population, and for those evacuated from special facilities.

- Attended a "final" meeting with Xcel Energy personnel and emergency management personnel representing state and county governments to present results from the study.

Computation of ETE

A total of 476 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 34 Evacuation Regions to evacuate from that Region, under the circumstances defined for one of the 14 Evacuation Scenarios (34 x 14 = 476). Separate ETE are calculated for transit-dependent evacuees, including schoolchildren for applicable scenarios.

Except for Region R03, which is the evacuation of the entire EPZ, only a portion of the people within the EPZ would be advised to evacuate. That is, the ATE applies only to those people occupying the specified impacted region. It is assumed that 100% of the people within the impacted region will evacuate in response to this 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 MNGP) and then simulates the traffic flow movements over space and time. This simulation process estimates the rate that traffic flow exits the impacted region.

The ETE statistics provide the elapsed times for 90% and 100%, respectively, of the population within the impacted region to evacuate from within the impacted region. These statistics are presented in tabular and graphical formats. The 90th percentile ETE have been identified as the values that should be considered when making protective action decisions because the 100th percentile ETE are prolonged by those relatively few people who take longer to mobilize. This is referred to as the "evacuation tail" in Section 4.0 of NUREG/CR-7002, Rev. 1.

Traffic Management

This study applied the existing comprehensive Traffic Management Plan (TMP) provided by Xcel Energy. As discussed in Section 9 and Appendix G, no additional Traffic and Access Control Points (TACP) are recommended 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.

- Table 3-1 presents the estimates of permanent resident population in each Sub-Area based on the 2020 Census data.
- Table 6-1 defines each of the 34 Evacuation Regions in terms of their respective groups of Sub-Areas.
- Table 6-2 defines the 14 Evacuation Scenarios.
- Tables 7-1 and 7-2 are compilations of ETE. These data are the times needed to clear the indicated regions of 90% and 100% of the population occupying these regions, respectively. These computed ETE include consideration of mobilization time and of estimated voluntary evacuations from other regions within the EPZ and from the Shadow Region.
- Tables 7-3 and 7-4 present ETE for the 2-mile region for un-staged and staged evacuations for the 90th and 100th percentiles, respectively.
- Table 8-2 presents ETE for the schools in good weather.
- Table 8-5 presents ETE for the transit-dependent population in good weather.
- Table 8-8 presents ETE for the medical facility population in good weather.
- Table M-3 shows the results of the sensitivity study conducted to determine the effect on ETE due to changes in the permanent resident population within the study area (EPZ plus Shadow Region).
- Figure 6-1 displays a map of the MNGP EPZ showing the layout of the 12 Sub-Areas that comprise, in aggregate, the EPZ.
- 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 476 unique cases. Table 7-1 and Table 7-2 document the ETE for the 90th and 100th percentiles. The 90th percentile ETE range from

2:05 (hr:min) to 3:50 for unstaged cases. The 100th percentile ETE range from 4:30 to 5:40 for unstaged cases.

- Inspection of Table 7-1 and Table 7-2 indicates that the ETE for the 100th percentile are significantly longer than those for the 90th percentile. 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. As a result, those vehicles who take longest to mobilize dictate the 100th percentile ETE. See Sections 7.3 through 7.5, and Figures 7-10 through 7-23.
- Inspection of Table 7-3 and Table 7-4 indicates that a staged evacuation provides no benefits to evacuees from within the 2-mile region (compare Region R01 with Regions R26 through R34, in Table 7-3 and Table 7-4) and adversely impacts some evacuees beyond the 2-mile region (compare Regions R02 and R04 through R11 with Regions R26 through R34, respectively, in Table 7-1). See Section 7.6 for additional discussion.
- Comparison of Scenarios 3 (summer, weekend, midday) and 13 (summer, weekend, midday) in Table 7-1 and Table 7-2 indicates that the special event, summer services at Laestadian Lutheran Church, has minimal impact on both the 90th percentile ETE (increases 10 minutes at most) and has no impact on the 100th percentile ETE. See Section 7.5 for additional discussion.
- Comparison of Scenarios 1 and 14 in Table 7-1 and Table 7-2 indicates that the roadway closure – one lane on I-94 eastbound – a significant impact on the 90th percentile ETE with increases of up to 55 minutes. The roadway closure has no impact on the 100th percentile ETE. See Section 7.5 for additional discussion.
- The towns of Big Lake and Buffalo, as well as I-94 eastbound near Albertville and US-10 near Elk River are the most congested areas throughout the evacuation. Both I-94 eastbound and US-10 eastbound experience significant congestion throughout the evacuation period. All congestion within the EPZ clears by 3 hours and 45 minutes after the Advisory to Evacuate. See Section 7.3 and Figures 7-3 through 7-9.
- Separate ETE were computed for schools, medical facilities, transit-dependent persons and access and/or functional needs persons. The average single-wave ETE for schools, medical facilities, and transit dependent individuals is equal to or less than the general population ETE at the 90th percentile. The average single-wave ETE for access and/or functional needs persons is 15 minutes longer than the general population ETE at the 90th percentile. See Section 8.
- Table 8-1 indicates that there are not sufficient full size buses or ambulances available to evacuate the transit-dependent population in a single wave. See Section 8.
- A reduction in the base trip generation time by 1 hour reduces the general population ETE at the 90th percentile by 10 minutes. An increase in mobilization time by 1 hour increases the 90th percentile ETE by 40 minutes. See Table M-1.
- An increase in voluntary evacuation of vehicles in the Shadow Region has a significant impact (at most a 1 hour and 50 minute increase) on the general population ETE. See Table M-2.

- An increase in permanent resident population (EPZ plus Shadow Region) of 24% or greater results in an increase in the longest 90th percentile ETE of 30 minutes, which meets the federal criterion for performing a fully updated ETE study between decennial Censuses. See Section M.3.
- An increase in the average household size from 2.82 people per household to 3.23 people per household will result in 10% less evacuating vehicles and minimally impacts ETE with a reduction of 10 minutes in a full EPZ evacuation (Region R03) at the 90th percentile. See Section M.4.

Table 3-1. EPZ Permanent Resident Population

Sub-Area	2010 Population	2020 Population
2	3,158	3,141
5N	8,634	9,657
5E	17,571	19,760
5S	13,527	15,339
5W	2,557	2,777
10N	708	699
10E	2,920	2,979
10SE	3,044	3,978
10S	8,176	8,109
10SW	3,812	3,955
10W	3,449	3,789
10NW	1,079	1,196
EPZ TOTAL:	**68,635**	**75,379**
EPZ Population Growth (2010-2020):		**9.83%**

Table 6-1. Description of Evacuation Regions

Radial Regions													
Region	**Description**	**Wind From (in Degrees)**	**Sub-Area**										
			2	**5N**	**5E**	**5S**	**5W**	**10N**	**10E**	**10SE**	**10S**	**10SW**	**10W**	**10NW**
R01	2-Mile Region	N/A	X											
R02	5-Mile Region	N/A	X	X	X	X	X							
R03	Full EPZ	N/A	X	X	X	X	X	X	X	X	X	X	X	X
Evacuate 2-Mile Region and Downwind to 5 Miles														
Region	**Wind Direction From**	**Wind From (in Degrees)**	**Sub-Area**											
			2	**5N**	**5E**	**5S**	**5W**	**10N**	**10E**	**10SE**	**10S**	**10SW**	**10W**	**10NW**
R04	N, NNE, NE, ENE	349-78	X			X	X							
R05	E	79-101	X				X							
R06	ESE, SE, SSE	102-169	X	X			X							
R07	S	170-191	X	X										
R08	SSW, SW, WSW	192-258	X	X	X									
R09	W	259-281	X	X	X	X								
R10	WNW, NW	282-326	X		X	X								
R11	NNW	327-348	X			X								
Evacuate 2-Mile Region and Downwind to the EPZ Boundary														
Region	**Wind Direction From**	**Wind From (in Degrees)**	**Sub-Area**											
			2	**5N**	**5E**	**5S**	**5W**	**10N**	**10E**	**10SE**	**10S**	**10SW**	**10W**	**10NW**
R12	N	349-11	X			X	X			X	X	X		
R13	NNE, NE	12-56	X			X	X				X	X	X	
R14	ENE	57-78	X			X	X					X	X	
R15	E	79-101	X				X					X	X	X
R16	ESE	102-124	X	X			X						X	X
R17	SE	125-146	X	X			X	X					X	X
R18	SSE	147-169	X	X			X	X						X
R19	S	170-191	X	X				X	X					X
R20	SSW, SW	192-236	X	X	X			X	X					
R21	WSW	237-258	X	X	X				X					
R22	W	259-281	X	X	X	X			X	X				
R23	WNW	282-303	X		X	X				X				
R24	NW	304-326	X		X	X				X	X			
R25	NNW	327-348	X			X				X	X			

Staged Evacuation - 2-Mile Region Evacuates, then Evacuate Downwind to 5 Miles														
Region	**Wind Direction From**	**Wind From (in Degrees)**	**Sub-Area**											
			2	**5N**	**5E**	**5S**	**5W**	**10N**	**10E**	**10SE**	**10S**	**10SW**	**10W**	**10NW**
R26	N/A	5-Mile Region	X	X	X	X	X							
R27	N, NNE, NE, ENE	349-78	X			X	X							
R28	E	79-101	X				X							
R29	ESE, SE, SSE	102-169	X	X			X							
R30	S	170-191	X	X										
R31	SSW, SW, WSW	192-258	X	X	X									
R32	W	259-281	X	X	X	X								
R33	WNW, NW	282-326	X		X	X								
R34	NNW	327-348	X			X								
Sub-Area(s) Evacuate			Sub-Area(s) Shelter-in-Place						Sub-Area(s) Shelter-in-Place until 90% ETE for R01, then Evacuate					

Table 6-2. 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/Light Snow	None
8	Winter	Midweek	Midday	Heavy Snow	None
9	Winter	Weekend	Midday	Good	None
10	Winter	Weekend	Midday	Rain/Light Snow	None
11	Winter	Weekend	Midday	Heavy Snow	None
12	Winter	Midweek, Weekend	Evening	Good	None
13	Summer	Weekend	Midday	Good	Summer Services at Laestadian Lutheran Church
14	Summer	Midweek	Midday	Good	Roadway Impact - Lane Closures on I-94 EB

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

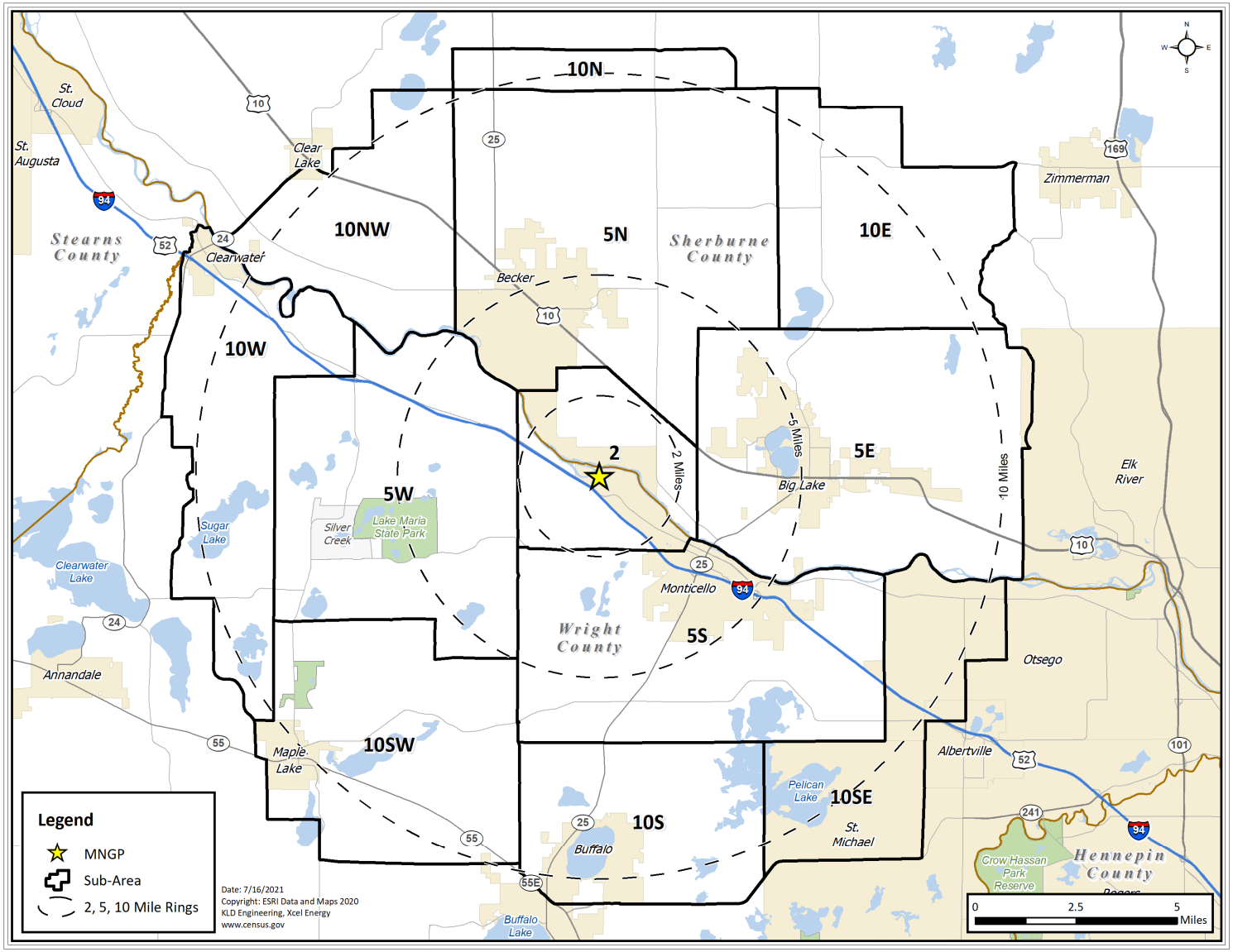


Figure 6-1. Sub-Areas Comprising the MNGP EPZ

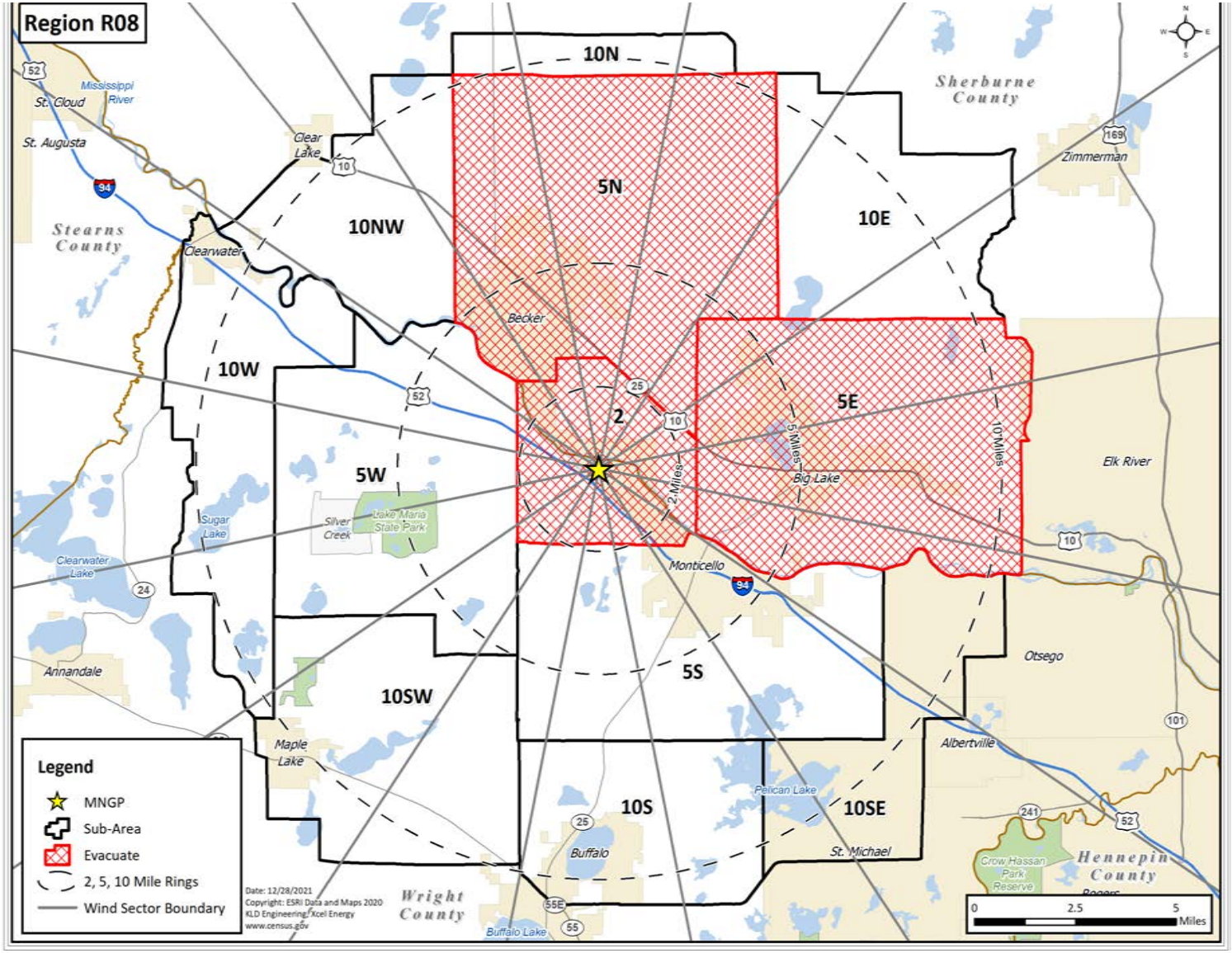


Figure H-8. Region R08

1 INTRODUCTION

This report describes the analyses undertaken and the results obtained by a study to develop Evacuation Time Estimates (ETE) for the Monticello Nuclear Generating Plant (MNGP), located in Wright County, Minnesota. This ETE study provides Xcel Energy and state and local governments with site-specific information needed for Protective Action decision-making.

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

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

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

1.1 Overview of the ETE Process

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

1. Information Gathering:
    a. Defined the scope of work in discussions with representatives from Xcel Energy.
    b. Attended meetings with emergency planners from Wright County Emergency Management, Sherburne County Emergency Management and Minnesota Emergency Management to discuss methodology and project assumptions.
    c. Conducted a detailed field survey of the highway system and of area traffic conditions within the Emergency Planning Zone (EPZ) and Shadow Region (area between the EPZ boundary and 15 miles radially from the plant).
    d. Obtained demographic data from the 2020 census (see Section 3.1).
    e. Conducted an online demographic survey of EPZ residents.
    f. Conducted a data collection effort to identify and describe schools, special facilities, major employers, 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 responses to the online demographic survey.

3. Defined Evacuation Scenarios which reflect the variation in demand, in trip generation distribution and in highway capacities, associated with different seasons, day of week, time of day and weather conditions.
4. Reviewed the existing Traffic Management Plan (TMP) to be implemented by local and state police in the event of an incident at the plant. Traffic control is applied at specified Traffic and Access Control Points (TACPs) located within the study area.
5. Used existing Sub-Areas to define Evacuation Regions. The EPZ is partitioned into 12 Sub-Areas along jurisdictional and geographic boundaries. "Regions" are groups of contiguous Sub-Areas for which ETE are calculated. The configurations of these Regions reflect wind direction and the radial extent of the impacted area. Each Region, other than those that approximate circular areas, approximates a "key-hole section" within the EPZ as recommended by NUREG/CR-7002, Rev. 1.
6. Estimated demand for transit services for persons at special facilities (schools, daycares, preschools, medical facilities, and correctional facilities), for transit-dependent persons at home, and for people with access and/or functional needs 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, Xcel Energy and from the demographic survey.
    b. Applied the procedures specified in the 2016 Highway Capacity Manual (HCM[1]) to the data acquired during the field survey, to estimate the capacity of all highway segments comprising the evacuation routes.
    c. Updated 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 plant.
8. Executed the DYNEV II system 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, Rev 1.

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

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

1.2 The Monticello Nuclear Generating Plant Location

MNGP is located along the south bank of the Mississippi River in the town of Monticello in Wright County, Minnesota. The site is approximately 35 miles northwest of Minneapolis, MN and 20 miles southeast of St. Cloud, MN. The Emergency Planning Zone (EPZ) consists of parts of Sherburne and Wright Counties in Minnesota. Figure 1-1 displays the area surrounding MNGP. This map identifies the communities in the area and the major roads.

1.3 Preliminary Activities

These activities are described below.

Field Surveys of the Highway Network

In January 2021, KLD personnel drove the entire highway system within the EPZ and the Shadow Region. The characteristics of each section of highway were recorded. These characteristics are listed in Table 1-2.

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

The data from the audio and video recordings were used to create detailed geographic information systems (GIS) shapefiles and databases of the roadway characteristics and of the traffic control devices observed during the road survey; this information was referenced while preparing the input stream for the DYNEV II System. Roadway types were assigned 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 roadway: single lane in each direction, local road with low free flow speeds

As documented on page 15-6 of the HCM 2016, the capacity of a two-lane highway is 1,700 passenger cars per hour in one direction. For freeway sections, a value of 2,250 vehicles per

hour per lane is assigned, as per Exhibit 12-37 of the HCM 2016. The road survey has identified several segments which are characterized by adverse geometrics on two-lane highways which are reflected in reduced values for both capacity and speed. These estimates are consistent with the service volumes for LOS E presented in HCM Exhibit 15-46. Link capacity is an input to DYNEV II which computes the ETE. Further discussion of roadway capacity is provided in Section 4 of this report.

Traffic signals are either pre-timed (signal timings are fixed over time and do not change with the traffic volume on competing approaches) or are actuated (signal timings vary over time based on the changing traffic volumes on competing approaches). Actuated signals require detectors to provide the traffic data used by the signal controller to adjust the signal timings. These detectors are typically magnetic loops in the roadway, or video cameras mounted on the signal masts and pointed toward the intersection approaches. If detectors were observed on the approaches to a signalized intersection during the road survey, detailed signal timings were not collected as the timings vary with traffic volume. TCPs and ACPs at locations which have control devices are represented as actuated signals in the DYNEV II system.

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

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

Demographic Survey

An online demographic survey was performed to gather information needed for the ETE study. Appendix F presents the survey instrument, the procedures used, and tabulations of data compiled from the survey returns along with discussion validating the use of the survey results in this study.

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

Computing the Evacuation Time Estimates

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

Analytical Tools

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

DYNEV II consists of four sub-models:

- A macroscopic traffic simulation model (for details, see Appendix C).
- A Trip Distribution (TD), model that assigns a set of candidate destination (D) nodes for each "origin" (O) located within the analysis network, where evacuation trips are "generated" over time. This establishes a set of O-D tables.
- A Dynamic Traffic Assignment (DTA), model which assigns trips to paths of travel (routes) which satisfy the O-D tables, over time. The TD and DTA models are integrated to form the DTRAD (Dynamic Traffic Assignment and Distribution) model, as described in Appendix B.
- A Myopic Traffic Diversion model which diverts traffic to avoid intense, local congestion, if possible.

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

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

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

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

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

The evacuation analysis procedures are based upon the need to:

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

- Move traffic in directions that are generally outbound, relative to the location of the plant.

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

1.4 Comparison with Prior ETE Study

Table 1-3 presents a comparison of the present ETE study with the previous ETE study (KLD TR-505, dated November 2012). The 90th percentile ETE for the full EPZ increased by 40 minutes for a winter, midweek, midday, good weather scenario and by 30 minutes for a summer, weekend, midday, good weather scenario when compared with the 2012 study. The 100th percentile ETE increased by 30 minutes for the same scenarios. The major factors contributing to the increases in ETE are:

- The permanent resident population increased by about 10% and the number of evacuating vehicles for the permanent resident population increased by 29%. More vehicles with about the same roadway capacity will result in higher ETE.
- Mobilization (trip generation times) increased by 30 minutes for residents with returning commuters and by 75 minutes for residents without returning commuters based on responses to the demographic survey. This increase in mobilization time directly explains increase in the 100th percentile ETE since all congestion clears prior to the end of mobilization time (see Section 7.3) and mobilization time dictates the 100th percentile ETE.
- The number of employees and employee vehicles commuting into the EPZ decreased by about 50%. This decrease in quickly mobilizing employees can increase the 90th percentile ETE as it will take longer to reach an evacuation of 90% of the population. This is due to the NRC's change in criteria for major employers (from 50+ employees to 200+ employees) and has the biggest impact on midweek, midday scenarios. Since employees are present at lower rates on weekends and evenings, this has less of an impact on those scenarios.
- Capacity and speed reductions for heavy snow have increased. Higher capacity reductions result in lower capacity to process vehicles which can drive up ETE for heavy snow scenarios.

Table 1-1. Stakeholder Interaction

Stakeholder	Nature of Stakeholder Interaction
Xcel Energy emergency planning personnel	Meetings to define data requirements and set up contacts with local and state agencies. Reviewed and approved all project assumptions. Attended final meeting where the ETE study results were presented.
Wright County Emergency Management & Sherburne County Emergency Management	Met to discuss project methodology, key project assumptions and to define data needs. Provided county emergency plans, special facility data and existing traffic management plans. Reviewed and approved all project assumptions. Attended final meeting where the ETE study results were presented.
Minnesota Department of Public Safety Division of Homeland Security and Emergency Management	Met to discuss project methodology, key project assumptions and to define data needs. Provided state emergency plans, special facility data and existing traffic management plans. Reviewed and approved all project assumptions. Attended final meeting where the ETE study results were presented.

Table 1-2. Highway Characteristics

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

Table 1-3. ETE Study Comparisons

Topic	Previous ETE Study	Current ETE Study
Resident Population Basis	ArcGIS Software using 2010 US Census blocks; area ratio method used. Population = 68,635 Vehicles = 34,833	ArcGIS Software using 2020 US Census blocks; area ratio method used. Population = 75,379 Vehicles = 44,892
Resident Population Vehicle Occupancy	2.74 persons/household, 1.39 evacuating vehicles/household yielding: 1.97 persons/vehicle.	2.81 persons/household, 1.68 evacuating vehicles/household yielding: 1.67 persons/vehicle.
Shadow Population	ArcGIS Software using 2010 US Census blocks; area ratio method used. Population = 82,505 Vehicles = 41,970	ArcGIS software using 2020 US Census blocks; area ratio method used. Population = 93,892 Vehicles = 55,222
Employee Population	Employee estimates based on information provided and phone calls to major employers in the EPZ. 1.03 employees per vehicle based on telephone survey results. Employees = 1,128 Vehicles = 1,096	Employee estimates based on information provided about major employers in EPZ. 1.06 employees per vehicle based on demographic survey results. Employees = 562 Vehicles = 529
Transient Population	Transient estimates based upon information provided and phone calls to transient attractions in the EPZ. Significant decrease in transient population is attributed to double counting individuals as transients and EPZ residents in the previous ETE study. Transients = 2,060 Vehicles = 957	Transient estimates based upon information provided by the counties within the EPZ, by contacting each transient facility, internet searches, and satellite imagery, supplemented by data from the previous ETE study. Transients = 2,430 Vehicles = 1,147
Transit- Dependent Population	Estimates based upon U.S. Census data and the results of the telephone survey. Population = 1,488 Buses = 50	Estimates based upon U.S. Census data and the results of the 2020 demographic survey. Population = 815 Buses = 34
Population with Access and/or Functional Needs	Information provided by the counties within the EPZ. Population = 110 Buses = 9 Wheelchair buses = 0 Ambulances = 7	Information provided by the counties within the EPZ. Population = 14 Buses = 3 Wheelchair buses = 2 Ambulances = 0

Topic	Previous ETE Study	Current ETE Study
Special Facility Population	Special facility population based on information provided by each county within the EPZ. Medical Facility: Current census = 290 Buses Required = 28 Ambulances Required = 18 Correctional facility = 110 inmates (shelter-in-place)	Special facility population based on information provided by internet searches and supplemented by data from the previous ETE study (confirmed by the counties). Medical Facility: Current census = 304 Buses Required = 9 Wheelchair Vehicles Required = 26 Ambulances Required = 19 Correctional facility = 155 inmates (shelter-in-place)
School, Daycare, and Preschool Population	School population based on information provided by each county within the EPZ (Daycares are included in these estimates.) School enrollment = 20,446 Buses required = 423	School population based on information obtained from internet searches. (Daycares are included in these population estimates but require no buses since parents will pick up children.) School enrollment = 21,099 Buses required = 388
Voluntary evacuation from within EPZ in areas outside region to be evacuated	20% of the population within the EPZ, but not within the Evacuation Region	20% of the population within the EPZ, but not within the Evacuation Region
Shadow Evacuation	20% of people outside of the EPZ within the Shadow Region	20% of people outside of the EPZ within the Shadow Region
Network Size	1,517 links; 1,162 nodes	1,808 Links; 1,358 Nodes
Roadway Geometric Data	Field surveys conducted in February 2012. Roads and intersections were video archived. Road capacities based on 2010 HCM.	Field surveys conducted in January 2021. Roads and intersections were video archived. Road capacities based on 2016 HCM.
School Evacuation	Direct evacuation to designated Sister School.	Direct evacuation to designated Sister School.
Ridesharing	50% of transit-dependent persons will evacuate with a neighbor or friend as per federal guidance.	73% of transit-dependent persons will evacuate with a neighbor or friend as per the demographic survey results.

Topic	Previous ETE Study	Current ETE Study
Trip Generation for Evacuation	Based on residential telephone survey of specific pre-trip mobilization activities: Residents with commuters returning leave between 15 and 240 minutes. Residents without commuters returning leave between 0 and 165 minutes. Employees and transients leave between 0 and 90 minutes. All times measured from the Advisory to Evacuate.	Based on residential online demographic survey of specific pre-trip mobilization activities: Residents with commuters returning leave between 30 and 270 minutes. Residents without commuters returning leave between 15 and 240 minutes. Employees and transients leave between 0 and 75 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 10% in the event of rain and 20% for snow.	Normal, Rain/Light Snow, or Heavy Snow. The capacity of all links in the network is reduced by 10% in the event of rain and 25% for snow. The free flow speed of all links in the network is reduced by 10% in the event of rain and 15% for snow.
Modeling	DYNEV II System – Version 4.0.11.0	DYNEV II System – Version 4.0.21.0
Special Events	Riverfest Special Event Population = 990 additional transients Vehicles = 361	Summer Services at Laestadian Lutheran Church Special Event Population = 6,000 additional transients Vehicles = 2,000
Evacuation Cases	34 Regions (central sector wind direction and each adjacent sector technique used) and 14 Scenarios producing 476 unique cases.	34 Regions (central sector wind direction and each adjacent sector technique used) and 14 Scenarios producing 476 unique cases.
Evacuation Time Estimates Reporting	ETE reported for 90th and 100th percentiles. Results presented by Region and Scenario.	ETE reported for 90th and 100th percentiles. Results presented by Region and Scenario.
Evacuation Time Estimates for the entire EPZ, 90th percentile	Winter Weekday Midday, Good Weather (Scenario 6): 2:25 Summer Weekend, Midday, Good Weather (Scenario 3): 2:20	Winter Weekday Midday, Good Weather (Scenario 6): 3:05 Summer Weekend, Midday, Good Weather (Scenario 3): 2:50
Evacuation Time Estimates for the entire EPZ, 100th percentile	Winter Weekday Midday, Good Weather (Scenario 6): 4:10 Summer Weekend, Midday, Good Weather (Scenario 3): 4:10	Winter Weekday Midday, Good Weather (Scenario 6): 4:40 Summer Weekend, Midday, Good Weather (Scenario 3): 4:40

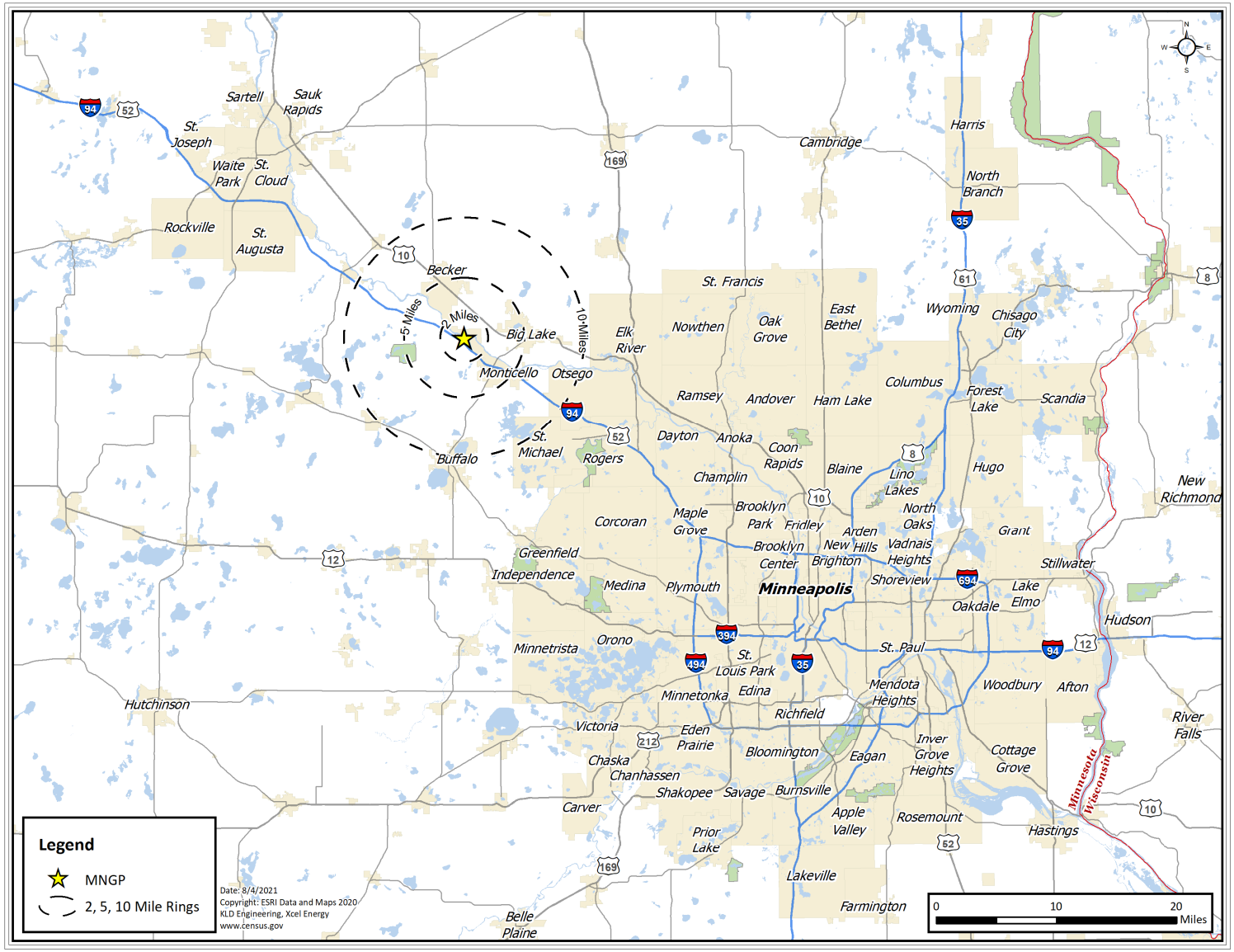


Figure 1-1. MNGP Location

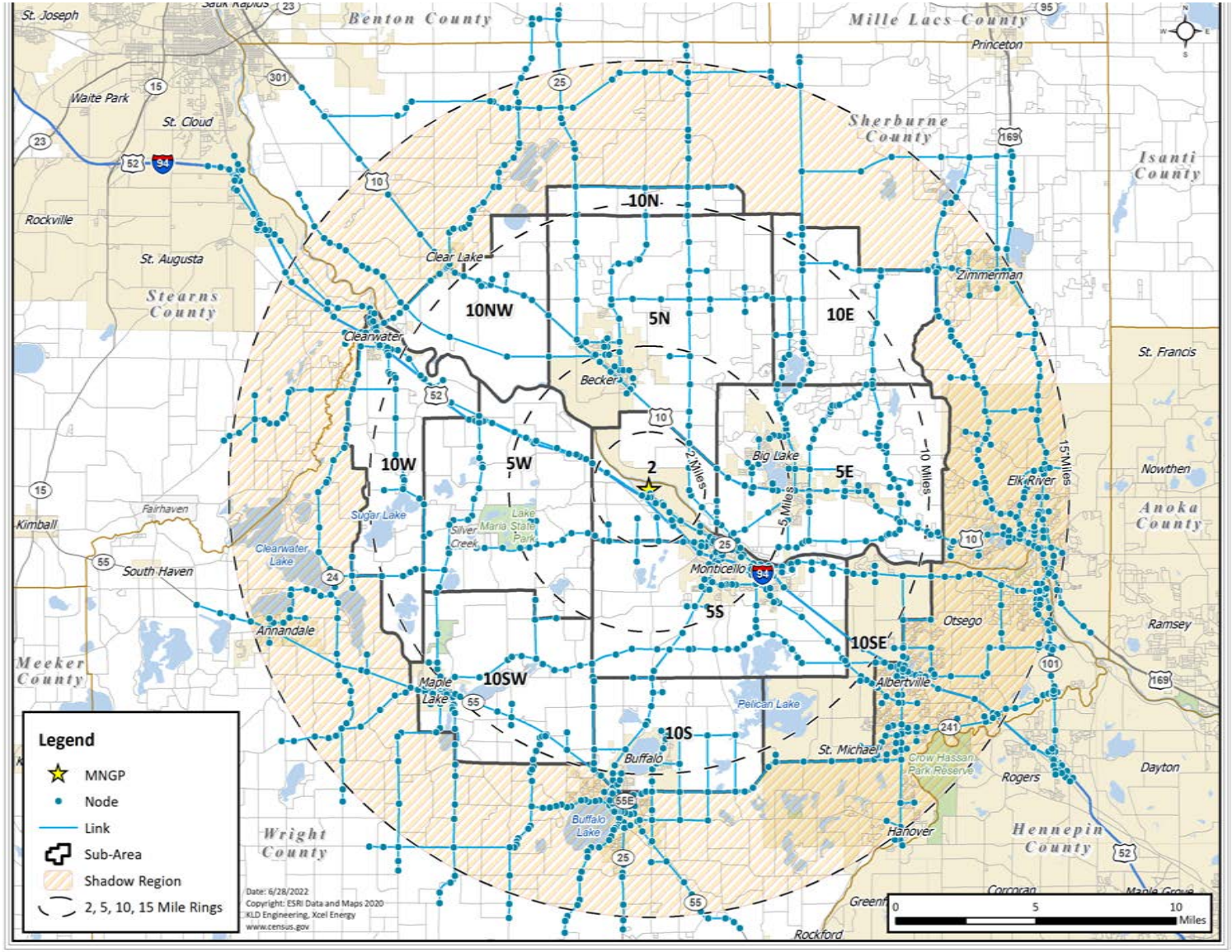


Figure 1-2. MNGP Link-Node Analysis Network

2 STUDY ESTIMATES AND ASSUMPTIONS

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

2.1 Data Estimates

1. The permanent resident population are based on the 2020 U.S. Census population from the Census Bureau website[1]. (See Section 3.1.)
2. Estimates of employees who reside outside the Emergency Planning Zone (EPZ) and commute to work within the EPZ are based upon data provided by each county as well as from the US Census Longitudinal Employer-Household Dynamics from the OnTheMap Census analysis tool[2]. (See Section 3.4.)
3. Population estimates at transient and special facilities are based on the data received from the counties within the EPZ, the National Center for Education Statistics website[3], the Minnesota Department of Human Services[4], phone calls/emails to the facilities, satellite imagery of the facilities, and the previous ETE study, supplemented by internet searches where data was missing.
4. The relationship between permanent resident population and evacuating vehicles is based on Census data and the results of the demographic survey (see Appendix F). Values of 2,82 persons per household and 1.68 evacuating vehicles per household are used for the permanent resident population.
5. Employee vehicle occupancies are based on the results of the demographic survey; 1.06 employees per vehicle is used in the study. (See Figure F-7.)
6. The maximum bus speed assumed within the EPZ is 55 mph for buses and average posted speed limits on roadways within the EPZ.
7. Roadway capacity estimates are based on field surveys performed in 2020 (verified by aerial imagery), roadway construction (provided by the County and public records), and the application of the Highway Capacity Manual 2016.

2.2 Methodological Assumptions

1. The Planning Basis Assumption for the calculation of ETE is a rapidly escalating accident that requires evacuation, and includes the following[5] (as per NRC guidance):

[1] www.census.gov
[2] http://onthemap.ces.census.gov/
[3] https://nces.ed.gov/ccd/schoolsearch/index.asp
[4] https://mn.gov/dhs/

[5] 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.

a. Advisory to Evacuate (ATE) is announced coincident with the siren notification.
b. Mobilization of the general population will commence within 15 minutes after siren notification.
c. ETE are measured relative to the ATE.

2. The center-point of the plant is located at the center of the containment building 45.334°N, 93.849° W.
3. The DYNEV II[6] system is used to compute ETE in this study.
4. Evacuees will drive safely, travel radially away from the plant to the extent practicable given the highway network, and obey all control devices and traffic guides. All major evacuation routes are used in the analysis.
5. The existing EPZ and Sub-Area boundaries are used. See Figure 3-1.
6. The Shadow Region extends to 15 miles radially from the plant or approximately 5 miles radially from the EPZ boundary, as per NRC guidance. See Figure 7-2.
7. Shadow population characteristics (household size, evacuating vehicles per household, and mobilization time) was assumed to be the same as that of the permanent resident population within the EPZ.
8. ETE are presented at the 90th and 100th percentiles, as well as in graphical and tabular format, as per NRC guidance. 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.
9. One hundred percent (100%) of the people within the impacted keyhole will evacuate. Twenty percent (20%) of the population within the Shadow Region and within Sub-Areas of the EPZ not advised to evacuate will voluntarily evacuate, as shown in Figure 2-1, as per NRC guidance. Sensitivity studies explore the effect on ETE of increasing the percentage of voluntary evacuees in the Shadow Region (see Appendix M).
10. This study does not assume that roadways are empty at the start of the first time period. Rather, there is an initialization period (often referred to as "fill time in traffic simulation) wherein the traffic volumes from the first time period are loaded onto roadways in the study area. The amount of initialization/fill traffic that is on the roadways in the study area at the start of the first time period depends on the scenario and the region being evacuated. See Section 3.12.
11. To account for boundary conditions beyond the study area, this study assumes a 25% reduction in capacity on two-lane roads and multi-lane highways for roadways that have traffic signals downstream. The 25% reduction in capacity is based on the prevalence of

It is likely that a longer time will elapse between the various stages of an emergency. See Section 5.1 for more detail.

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

actuated traffic signals in the study area and the fact that the evacuating traffic volume will be more significant than the competing traffic volume at any downstream signalized intersections, thereby warranting a more significant percentage (75% in this case) of the signal green time. There is no reduction in capacity for freeways due to boundary conditions.

12. The ETE also includes 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. See Section 3.11.

2.3 Assumptions on Mobilization Times

1. Trip generation time (also known as mobilization time, or the time required by evacuees to prepare for the evacuation) are based upon the results of the demographic survey.
2. One hundred percent (100%) of the EPZ population can be notified within 45 minutes, in accordance with the 2019 Federal Emergency Management Agency (FEMA) Radiological Emergency Preparedness Program Manual.
3. Commuter percentages (and percentage of residents awaiting the return of a commuter) are based on the results of the demographic survey. According to the survey results, 90% of the households in the EPZ have at least 1 commuter (see Section F.3.1.); 53.5% of those households with commuters will await the return of a commuter before beginning their evacuation trip (see Section F.3.2.). Therefore, 48 percent (90% x 53.5% = 48%) of EPZ households will await the return of a commuter, prior to beginning their evacuation trip.

2.4 Transit Dependent Assumptions

1. The percentage of transit-dependent people who will rideshare with a neighbor or friend are based on the results of the demographic survey. According to the survey results, 73% of the transit-dependent population will rideshare.
2. Transit vehicles are used to transport those without access to private vehicles:
    a. Schools and daycare centers
        i. If schools are in session, buses will evacuate students directly to the designated sister school.
        ii. It is assumed that parents will pick up children at small daycare centers prior to evacuation.
        iii. For the schools that are evacuated via buses, it is assumed no school children are picked up by their parents prior to the arrival of the buses.
        iv. Schoolchildren, if school is in session, are given priority in assigning transit vehicles.
    b. Medical Facilities
        i. Buses, wheelchair buses, and ambulances will evacuate patients at

medical facilities and at any senior facilities within the EPZ, as needed.

ii. The percent breakdown of ambulatory, wheelchair bound and bedridden patients from the previous study is used to determine the number of ambulatory, wheelchair bound and bedridden patients at the medical facilities wherein data was not provided.

c. Correctional Facilities

i. Wright County Jail will shelter in place in the event of an emergency.

d. Transit-dependent permanent residents:

i. Transit-dependent general population are evacuated to reception centers.

ii. Access and/or functional needs population may require county assistance (ambulance, bus or wheelchair transport) to evacuate. This is considered separately from the general population ETE, as per NRC guidance.

iii. Households with 3 or more vehicles were assumed to have no need for transit vehicles.

e. Analysis of the number of required round-trips ("waves") of evacuating transit vehicles is presented.

f. Transport of transit-dependent evacuees from reception centers to congregate care centers is not considered in this study.

3. Transit vehicle capacities:
   a. School buses = 70 students per bus for elementary schools/childcare centers and 50 students per bus for middle/high schools
   b. Ambulatory transit-dependent persons and medical facility patients = 30 ambulatory persons per bus
   c. Midsize buses = 14 passengers per bus
   d. Vans = 6 passengers per van
   e. Wheelchair bound medical facility patients = 4 wheelchair-bound persons per bus (same buses as ambulatory patients)
   f. Ambulances = 2 bedridden persons (includes advanced and basic life support)
   g. Wheelchair vans = 4 wheelchair-bound persons
   h. Passenger cars = 4 passengers per vehicle

4. Transit vehicles mobilization times:

   a. School buses will arrive at schools and facilities to be evacuated within 90 minutes of the ATE.
   b. Transit dependent buses are mobilized when approximately 90% of residents with no commuters have completed their mobilization at 135 minutes after the advisory to evacuate. If necessary, multiple waves of buses will be utilized to gather transit dependent people who mobilize more slowly.
   c. Vehicles will arrive at hospitals, medical facilities, and senior living facilities to be evacuated within 90 minutes of the ATE.

5. Transit Vehicle loading times:
    a. School buses are loaded in 15 minutes.
    b. Transit Dependent buses will require 1 minute of loading time per passenger.
    c. Buses for hospitals and medical facilities will require 1 minute of loading time per ambulatory passenger.
    d. Wheelchair transport vehicles will require 5 minutes of loading time per passenger.
    e. Ambulances are loaded in 15 minutes per bedridden passenger.
6. It is assumed that drivers for all transit vehicles are available.

2.5 Traffic and Access Control Assumptions

1. Traffic and Access Control Points (TACP) as defined in the approved county and state emergency plans are considered in the ETE analysis, as per NRC guidance. See Appendix G.
2. TACPs are assumed to be staffed approximately 120 minutes after the ATE, as per NRC guidance. It is assumed that no through traffic will enter the EPZ after this 120-minute time period.
3. All transit vehicles and other responders entering the EPZ to support the evacuation are unhindered by personnel manning TACPs.

2.6 Scenarios and Regions

1. A total of 14 "Scenarios" representing different temporal variations (season, time of day, day of week) and weather conditions are considered. Scenarios to be considered are defined in Table 2-1:
    a. Summer Services at Laestadian Lutheran Church, located in Sub-Area 2, is considered as the special event (single or multi-day event that attracts a significant population into the EPZ; recommended by NRC guidance) for Scenario 13. According to county emergency management officials, this event occurs every 3-5 years. It will be conservatively assumed that all event attendees are not local residents.
    b. As per NRC guidance, one segment of one of the highest volume roadways will be out of service or one lane outbound on a freeway must be closed for a roadway impact scenario. This study considers the closure of one lane on I-94 eastbound (EB) from a location by the plant (between exits 183 and 193) to the end of the analysis-network at the interchange with SR-101 (exit 207) or the roadway impact scenario – Scenario 14.
2. Two types of adverse weather scenarios are considered. Rain may occur for either winter or summer scenarios; snow occurs in winter scenarios only. It is assumed that the rain or snow begins 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 further assumed that snow removal equipment is available, the appropriate agencies are clearing/treating the roads as they would normally during snow, and the roads are passable albeit at lower speeds and capacities.

3. Adverse weather affects roadway capacity and free flow speeds. Transportation research indicates capacity and speed reductions of about 10% for rain and a range of 10% to 25% for snow. In accordance with Table 3-1 of Revision 1 to NUREG/CR-7002, this study assumes a 10% reduction in speed and capacity for rain and light snow and a speed and capacity reduction of 15% and 25%, respectively, for heavy snow. The factors are shown in Table 2-2.
4. Some evacuees will need additional time to clear their driveways and access the public roadway system. The distribution of time for this activity was gathered through a demographic survey of the public and takes up to 135 minutes. It is assumed that the time needed by evacuees to remove snow from their driveways is sufficient time for snow removal crews to mobilize and clear/treat the public roadway system.
5. Employment is reduced slightly in the summer for vacations.
6. The mobilization and loading times for transit vehicles are slightly longer in adverse weather. It is assumed that mobilization times are 10 minutes and 20 minutes longer in rain/light snow and heavy snow, respectively. It is assumed that loading times for school buses are 5 minutes and 10 minutes longer in rain/light snow and heavy snow, respectively. It is assumed that loading times for transit buses are 10 minutes and 20 minutes longer in rain/light snow and heavy snow, respectively. Refer to Table 2-2.
7. Regions are defined by the underlying “keyhole” or circular configurations as specified in Section 1.4 of NUREG/CR-7002, Rev. 1. These Regions, as defined, display irregular boundaries reflecting the geography of the Sub-Areas included within these underlying configurations. All 16 cardinal and intercardinal wind direction keyhole configurations are considered. Regions to be considered are defined in Table 6-1. It is assumed that everyone within the group of Sub-Areas forming a Region that is issued an ATE will, in fact, respond and evacuate in general accord with the planned routes.
8. Staged evacuation is considered as defined in NUREG/CR-7002, Rev. 1 – those people between 2 and 5 miles will shelter-in-place until 90% of the 2-mile region has evacuated, then they will evacuate. See Regions R26 through R34 in Table 6-1.

Table 2-1. Evacuation Scenario Definitions

Scenario	Season[7]	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/Light Snow	None
8	Winter	Midweek	Midday	Heavy Snow	None
9	Winter	Weekend	Midday	Good	None
10	Winter	Weekend	Midday	Rain/Light Snow	None
11	Winter	Weekend	Midday	Heavy Snow	None
12	Winter	Midweek, Weekend	Evening	Good	None
13	Summer	Weekend	Midday	Good	Summer Services at Laestadian Lutheran Church
14	Summer	Midweek	Midday	Good	Roadway Impact - Lane Closures on I-94 EB

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

Table 2-2. Model Adjustment for Adverse Weather

Scenario	Highway Capacity*	Free Flow Speed*	Mobilization Time for General Population	Mobilization Time for Transit Vehicles	Loading Time for School Buses	Loading Time for Transit Buses[8]
Rain/Light Snow	90%	90%	No Effect	10-minute increase	5-minute increase	10-minute increase
Heavy Snow	75%	85%	See Section 5	20-minute increase	10-minute increase	20-minute increase
*Adverse weather capacity and speed values are given as a percentage of good weather conditions. Roads are assumed to be passable.						

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

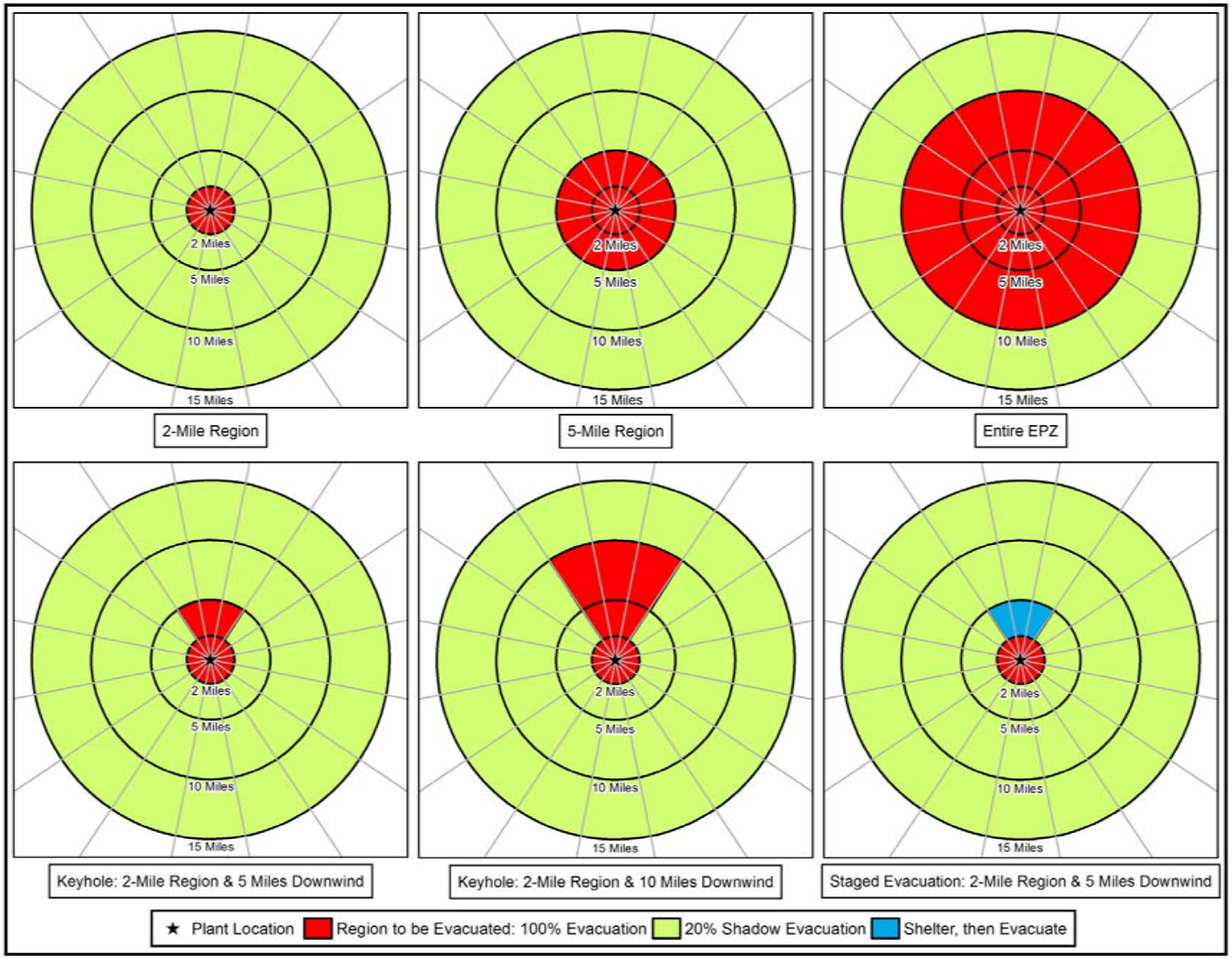


Figure 2-1. Voluntary Evacuation Methodology

3 DEMAND ESTIMATION

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

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

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

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

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

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

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

Analysis of the population characteristics of the MNGP 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 work within the EPZ on a daily basis.

Estimates of the population and number of evacuating vehicles for each of the population groups are presented for each Sub-Area and by polar coordinate representation (population rose). The MNGP EPZ is subdivided into 12 Sub-Areas. The Sub-Areas comprising the EPZ are shown in Figure 3-1.

3.1 Permanent Residents

The primary source for estimating permanent population is the latest U.S. Census data with an availability date of September 16, 2021. The average household size (2.81 persons/household – See Section 2.1) was estimated using the U.S. Census data (See Appendix F, Sub-section F.3.1). The number of evacuating vehicles per household (1.68 vehicles/household – See Appendix F, Sub-section F.3.2) was adapted from the demographic survey.

The permanent resident population is estimated by cutting the census block polygons by the Sub-Area and EPZ boundaries using GIS software. A ratio of the original area of each census block and the updated area (after cutting) is multiplied by the total block population to estimate the population within the EPZ. This methodology (referred to as the "area ratio method") assumes that the population is evenly distributed across a census block. Table 3-1 provides permanent resident population within the EPZ, by Sub-Area, for 2010 and for 2020 (based on the methodology above). As indicated, the permanent resident population within the EPZ has increased by 9.83% since the 2010 Census.

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

3.2 Shadow Population

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

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

3.3 Transient Population

Transient population groups are defined as those people (who are not permanent residents, nor commuting employees) who enter the EPZ for a specific purpose (shopping, recreation). Transients may spend less than one day or stay overnight at camping facilities, hotels and motels. Data for these facilities were provided by the counties within the EPZ. Where data was not provided, the number of transient vehicles was estimated based on the parking lot capacity or accommodation capacity obtained from aerial imagery and facility websites. It is assumed that transients would travel as a family/household. As such, the average household size of 2.81 persons per household (see Section 3.1) was used for those facilities. The transient attractions within the MNGP EPZ are summarized as follows:

- Campgrounds – 468 transients and 238 vehicles; an average of 1.97 transients per vehicle (NOTE: Recreational Vehicles (RVs) are treated as 2 vehicles due to their larger size and more sluggish operating characteristics.)
- Golf Courses – 770 transients and 496 vehicles; an average of 1.55 transients per vehicle
- Parks – 447 transients and 84 vehicles; an average of 5.32 transients per vehicle
- Lodging Facilities – 745 transients and 329 vehicles; an average of 2.26 transients per vehicle

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

In total, there are 2,430 transients evacuating in 1,147 vehicles (an average of 2.12 transients per vehicle) in the EPZ. Table 3-4 presents transient population and transient vehicle estimates by Sub-Area. Figure 3-6 and Figure 3-7 present these data by sector and distance from the plant.

3.4 Employees

Employees who work within the EPZ fall into 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.

As per the NUREG/CR-7002, Rev. 1 guidance, employers with 200 or more employees working in a single shift are considered as major employers. There are three major employers that meet this criteria in the EPZ. Employment data for the plant was provided by Xcel Energy, including the number of employees who work at MNGP but live outside of the EPZ. Data for the remaining two employers were provided by the counties in the EPZ in support of the previous study. Sherburne County confirmed the data for the Sherco Plant is still accurate. The maximum shift employment, as well as the percentage of employees who commute into the EPZ, was estimated by extrapolating the data used for the previous study for Cargill Kitchen Solutions, Inc. to 2020

using the short-term employment projections provided by Minnesota Department of Employment and Economic Development website[1] and the 2018 LEHD (Longitudinal Employer-Household Dynamics) Origin-Destination Employment Statistics (LODES) data[2] from U.S. Census's OnTheMap analysis tool[3] website.

To estimate the evacuating employee vehicles, a vehicle occupancy of 1.06 employees per vehicle obtained from the demographic survey (see Appendix F, Sub-section F.3.1) was used for all major employers. Appendix E, Table E-3 includes the detailed information of each major employer. Table 3-5 presents the estimates of employees and vehicles commuting into the EPZ by Sub-Area. Figure 3-8 and Figure 3-9 present these data by sector.

3.5 Medical Facilities

Data for the medical facilities in the Wright County portion of the EPZ were obtained from the 2012 ETE study as it was confirmed to be still valid by Wright County emergency management personnel. A new medical facility has been identified in Sherburne County. The current census data for this facility was obtained from the 2020 Census data. The percent breakdown of ambulatory (56.6%), wheelchair bound (31.4%), and bedridden patients (12.1%) from the previous study was used to estimate the number of ambulatory, wheelchair bound and bedridden patients at the new medical facility. Table 3-6 presents the census of medical facilities in the EPZ. A total of 304 persons have been identified as living in, or being treated in, these facilities.

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

3.6 Transit Dependent Population

The 2020 demographic 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.

[1] https://apps.deed.state.mn.us/lmi/projections/Results.aspx?dataset=6&geog=2701000000&code=

[2] The LODES data is part of the LEHD data products from the U.S. Census Bureau. This dataset provides detailed spatial distributions of workers' employment and residential locations and the relation between the two at the census block level. For detailed information, please refer to this site: https://lehd.ces.census.gov/data/

[3] http://onthemap.ces.census.gov/ OnTheMap is an interactive map displaying workplace and residential distributions by user-defined geographies at census block level detail. It also reports the work characteristics detail on age, and earnings industry groups.

Table 3-7 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[4] 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. **Based on the results of the demographic survey, approximately 73% of the transit-dependent population will rideshare.**

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 3-7 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 3-7 indicates that transportation must be provided for 815 people. Therefore, a total of 28 bus runs are required from a capacity standpoint. In order to service all of the transit dependent population and have at least one bus drive through each of the Sub-Areas to pick up transit dependent people, **34 bus runs** are used in the ETE calculations, see Section 8.1 for further discussion.

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 MNGP 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

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

$$P = 26{,}825 \times [0.00 + 0.079 \times (1.45 - 1) \times 0.90 \times 0.465 + 0.521 \times (3.07 - 2) \times (0.90 \times 0.465)^2] = 3{,}018$$

$B = [(1 - 0.73) \times P] \div 30 = (0.27 \times 3{,}018) \div 30 = 28$ (rounded up to the nearest bus)

These calculations, based on the 2020 demographic survey results, are explained as follows:

- There are about 26,825 households (75,379 people ÷ 2.81 people per household) in the EPZ.
- There were no households with no vehicles, so the term 0.00 represents those who do not have access to a vehicle.
- The members of HH with 1 vehicle away (7.9%), who are at home, equal (1.45-1). The number of HH where the commuter will not return home is equal to (26,825 x 0.079 x 0.45 x 0.90 x 0.465), as 90% of EPZ households have a commuter, 46.5% 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 (52.1%), who are at home, equal (3.07 – 2). The number of HH where neither commuter will return home is equal to 26,825 x 0.521 x 1.07 x $(0.90 \times 0.465)^2$. 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 3-7 far exceeds the number of registered transit-dependent persons in the EPZ as provided by the counties (discussed below in Section 3.9). This is consistent with the findings of NUREG/CR-6953, Volume 2, in that a large majority of the transit-dependent population within the EPZs of U.S. nuclear plants does not register with their local emergency response agency.

3.7 School Population Demand

Table 3-8 presents the school, day care, and preschool population and transportation requirements for the direct evacuation of all schools within the EPZ for the 2020 to 2021 school year. The column in Table 3-8 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.
- Parents will pick up their children at day cares and preschools. Therefore, no buses are required for these facilities.
- While many high school students commute to school using private automobiles (as discussed in Section 2.4 of NUREG/CR-7002, Rev.1), the estimate of buses required for school evacuation does not consider the use of these private vehicles.
- Bus capacity, expressed in students per bus, is set to 70 for elementary 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.

Implementation of a process to confirm individual school transportation needs prior to bus dispatch may improve bus utilization. In this way, the number of buses dispatched to the schools will reflect the actual number needed. The need for buses would be reduced by any high school students who have evacuated using private automobiles (if permitted by school authorities). Those buses originally allocated to evacuate schoolchildren that are not needed due to children being picked up by their parents, can be gainfully assigned to service other facilities or those persons who do not have access to private vehicles or to ride-sharing.

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

3.8 Special Event

A special event can attract large numbers of transients to the EPZ for short periods of time, creating a temporary surge in demand as per Section 2.5.1 of NUREG/CR-7002, Rev. 1. The emergency management agencies for each county in the EPZ were polled regarding potential special events in the EPZ; there were two potential special events identified:

- Summer services at Laestadian Lutheran Church, a multi-day which attracts approximately 6,000 transients (6,000 attendees where nobody resides within the EPZ).
- Riverfest which attracts approximately 1,750 transients (5,000 attendees where 65% reside within the EPZ).

Since the summer services at Laestadian Lutheran Church attract significantly more transients, this was the only special event (Scenario 13) considered for this study. This multi-day event occurs during the summer every 3 to 5 years on the grounds of Laestadian Lutheran Church which is located in Sub-Area 2. This event draws 6,000 transients from outside of the EPZ. Based on the data provided by Wright County Emergency Management, the vehicle occupancy of this event is 3 people per vehicle. A total of 2,000 vehicles (6,000 ÷ 3) were incorporated for this special event. The special event vehicle trips were generated utilizing the same mobilization distributions as transients. Public transportation is not provided for the attendees of this event.

3.9 Access and/or Functional Needs Population

The county emergency management agencies have a registration for access and/or functional needs persons. The current number of access and/or functional needs people was provided by the counties. There are an estimated 10 access and/or functional needs people (6 ambulatory and 4 wheelchair-bound) within the Wright County portion of the EPZ and 4 access and/or functional needs people (3 ambulatory and 1 wheelchair-bound) within the Sherburne County portion of the EPZ. This results in 9 ambulatory persons and 5 wheelchair-bound persons a total

access and/or functional needs population of 14 people. Table 3-9 summarizes the total number of people registered for access and/or functional needs by type of vehicle needed assuming 4 wheelchair-bound persons per wheelchair bus and 30 ambulatory people per bus (additional buses are assumed to be dispatched to gather these people in a shorter period of time – see Section 8.2).

3.10 Correctional Facilities

As shown in Table E-7 there is one correctional facility within the EPZ – Wright County Jail. According to Wright County emergency plans, this facility will shelter-in-place in the event of an emergency. As shown in this table, there are as many as 155 inmates at this facility.

3.11 External Traffic

Vehicles will be traveling through the EPZ (external-external trips) at the time of an emergency event. After the Advisory to Evacuate is announced, these through-travelers will also evacuate. These through vehicles are assumed to travel on the major routes traversing the study area – I-94 and US-10. Emergency management agencies indicated that this traffic will continue to enter the study during the first 120 minutes following the Advisory to Evacuate.

Average Annual Daily Traffic (AADT) data was obtained from the Minnesota Department of Transportation (MnDOT) to estimate the number of vehicles per hour on the aforementioned routes. The AADT was multiplied by the K-Factor, which is the proportion of the AADT on a roadway segment or link during the design hour, resulting in the design hour volume (DHV). The design hour is usually the 30th highest hourly traffic volume of the year, measured in vehicles per hour (vph). The DHV is then multiplied by the D-Factor, which is the proportion of the DHV occurring in the peak direction of travel (also known as the directional split). The resulting values are the directional design hourly volumes (DDHV) and are presented in Table 3-10, for each of the routes considered. The DDHV is then multiplied by 2 hours (Traffic and Access Control Points – TACP – are assumed to be activated at 120 minutes after the advisory to evacuate based upon information provided by emergency management agencies) to estimate the total number of external vehicles loaded on the analysis network. As indicated, there are 12,608 vehicles entering the study area as external-external trips prior to the activation of the TACP and the diversion of this traffic. This number is reduced by 60% for evening scenarios (Scenarios 5 and 12) as discussed in Section 6.

3.12 Background Traffic

Section 5 discusses the time needed for the people in the EPZ to mobilize and begin their evacuation trips. As shown in Table 5-9 there are 14 time periods during which traffic is loaded on to roadways in the study area to model the mobilization time of people in the EPZ. Note, there is no traffic generated during the 15th time period, as this time period is intended to allow traffic that has already begun evacuating to clear the study area boundaries.

This study does not assume that roadways are empty at the start of Time Period 1. Rather, there is an initialization time period (often referred to as "fill time" in traffic simulation) wherein the traffic volumes from Time Period 1 are loaded onto roadways in the study area. The amount of initialization/fill traffic that is on the roadways in the study area at the start of Time Period 1 depends on the scenario and the region being evacuated (see Section 6). There are 3,101 vehicles on the roadways in the study area at the end of fill time for an evacuation of the entire EPZ (Region R03) under Scenario 6 (winter, midweek, midday, good weather) conditions.

3.13 Summary of Demand

A summary of population and vehicle demand is provided in Table 3-11 and Table 3-12, respectively. This summary includes all population groups described in this section, except access and/or functional needs since the exact location of these people is unknown. A total of 125,374 people and 73,153 vehicles are considered in this study.

Table 3-1. EPZ Permanent Resident Population

Sub-Area	2010 Population	2020 Population
2	3,158	3,141
5N	8,634	9,657
5E	17,571	19,760
5S	13,527	15,339
5W	2,557	2,777
10N	708	699
10E	2,920	2,979
10SE	3,044	3,978
10S	8,176	8,109
10SW	3,812	3,955
10W	3,449	3,789
10NW	1,079	1,196
EPZ TOTAL:	**68,635**	**75,379**
EPZ Population Growth (2010-2020):		**9.83%**

Table 3-2. Permanent Resident Population and Vehicles by Sub-Area

Sub-Area	2020 Population	2020 Resident Vehicles
2	3,141	1,860
5N	9,657	5,771
5E	19,760	11,795
5S	15,339	9,108
5W	2,777	1,660
10N	699	417
10E	2,979	1,785
10SE	3,978	2,375
10S	8,109	4,779
10SW	3,955	2,359
10W	3,789	2,269
10NW	1,196	714
EPZ TOTAL:	**75,379**	**44,892**

Table 3-3. Shadow Population and Vehicles by Sector

Sector	2020 Population	Evacuating Vehicles
N	1,314	771
NNE	108	64
NE	3,457	2,057
ENE	6,482	3,876
E	17,560	9,882
ESE	17,790	10,624
SE	22,416	13,390
SSE	1,900	1,118
S	8,629	4,978
SSW	3,379	2,014
SW	855	501
WSW	4,116	2,427
W	1,167	696
WNW	1,427	854
NW	1,467	877
NNW	1,825	1,093
TOTAL:	**93,892**	**55,222**

Table 3-4. Summary of Transients and Transient Vehicles

Sub-Area	Transients	Transient Vehicles
2	100	100
5N	480	233
5E	34	26
5S	430	186
5W	711	250
10N	0	0
10E	204	72
10SE	155	77
10S	0	0
10SW	0	0
10W	138	87
10NW	178	116
EPZ TOTAL:	**2,430**	**1,147**

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

Sub-Area	Employees	Employee Vehicles
2	186	175
5N	186	175
5E	0	0
5S	190	179
5W	0	0
10N	0	0
10E	0	0
10SE	0	0
10S	0	0
10SW	0	0
10W	0	0
10NW	0	0
EPZ TOTAL:	**562**	**529**

Table 3-6. Medical Facility Transit Demand

Sub-Area	Facility Name	Municipality	Capacity	Current Census	Ambu-latory	Wheel-chair Bound	Bed-ridden	Bus Runs	Wheel-chair Bus Runs	Ambulance Runs
Sherburne County										
5E	Cherrywood Advanced Living	Big Lake	14	14	8	4	2	1	1	1
		Sherburne County Subtotal:	14	14	8	4	2	1	1	1
Wright County										
5S	New River Medical Center	Monticello	31	25	9	5	11	1	2	6
5S	CentraCare - Monticello Care Center	Monticello	89	84	3	71	10	1	18	5
5S	St. Benedict's Senior Community	Monticello	150	146	139	5	2	5	2	1
10S	Buffalo Hospital	Buffalo	65	35	13	10	12	1	3	6
		Wright County Subtotal:	335	290	164	91	35	8	25	18
		EPZ TOTAL:	**349**	**304**	**172**	**95**	**37**	**9**	**26**	**19**

Table 3-7. Transit-Dependent Population Estimates

2020 EPZ Population	Survey Average HH Size with Indicated No. of Vehicles			Estimated No. of Households	Survey Percent HH with Indicated No. of Vehicles			Survey Percent HH with Commuters	Survey Percent HH with Non-Returning Commuters	Total People Requiring Transport	Estimated Ridesharing Percentage	People Requiring Public Transit	Percent Population Requiring Public Transit
	0	1	2		0	1	2						
75,379	0.00	1.45	3.07	26,825	0.0%	7.9%	52.1%	90.0%	46.5%	3,021	73%	815	1.1%

Table 3-8. School Population Demand Estimates

Sub-Area	School Name	Enrollment	Buses Required
5N	Becker Intermediate School	662	14
5N	Becker Primary School	656	10
5N	Becker High School	915	19
5N	Becker Middle School	709	15
5E	Big Lake High School	889	18
5E	Big Lake Middle School	750	15
5E	Independence Elementary School	699	10
5E	Liberty Elementary School	718	11
10N	Jubilee Christian Center	34	1
2	Prairie House Recovery Center	7	1
2	Pinewood Elementary School	899	13
5S	Swan River Montessori School	158	3
5S	Turning Point Alternative Learning Program	24	1
5S	Monticello Middle School	1,046	21
5S	Holy Spirit Academy	35	1
5S	Little Mountain Elementary School	639	10
5S	Monticello High School	1,215	25
5S	Eastview Education Center	420	9
10SE	Kaleidoscope Charter School	572	12
10SE	St. Michael-Albertville High School	2,085	42
10SE	Fieldstone Elementary School	625	9
10S	St Francis Xavier School	231	4
10S	Cornerstone High School	18	1
10S	Eastern Wright Program	7	1
10S	Wright Technical Center High School	350	7
10S	Buffalo Community Middle School	1,380	28
10S	Buffalo High School	1,858	38
10S	Tatanka Elementary School	516	8
10SW	Maple Lake Elementary School	409	6
10SW	Maple Lake High School	441	9
10SW	St. Timothy's Catholic School	120	3
10SW	Westside Alternative School	9	1
S.R.	Northwinds Elementary School	519	8
S.R.	Phoenix Learning Center	37	1
S.R.	Parkside Elementary School	367	6
S.R.	Discovery Elementary School	125	2
S.R.	Discovery Elementary School	247	4
S.R.	PRIDE Transitions	13	1
	School Subtotal:	*20,404*	*388*

Sub-Area	Day Care/Preschool Name	Enrollment	Buses Required[5]
5N	Red Balloon Child Care Center	150	0
5N	Becker Primary School Early Childhood	183	0
5E	Heritage Montessori School	20	0
5E	New Creations Child Care & Learning Center	120	0
5S	Playhouse Child Care Center	97	0
5S	Pumpkin Patch Pre-School	30	0
5S	Love Your Child Daycare	10	0
10S	St. Francis Xavier Child Development Preschool	40	0
10SW	Maple Lake Preschool	25	0
10W	Clearwater Headstart	20	0
	Day Care/Preschool Subtotal:	*695*	*0*
	TOTAL:	**21,099**	**388**

Table 3-9. Access and/or Functional Needs Demand Summary

Population Group	Transportation Needed	Population	Vehicles needed/deployed
Ambulatory	Bus	9	3
Wheelchair bound	Wheelchair Bus	5	2
	Total:	**14**	**5**

[5] It is assumed parents will pick up children at day cares. Therefore, no buses are required for day cares and preschools. Refer to Section 2.4.

Table 3-10. MNGP EPZ External Traffic

Upstream Node	Downstream Node	Road Name	Direction	AADT[6]	K-Factor[7]	D-Factor[9]	Hourly Volume	External Traffic
8003	3	I-94	Eastbound	44,500	0.107	0.5	2,381	4,762
8045	45	I-94	Westbound	44,500	0.107	0.5	2,381	4,762
8658	658	US-10	Eastbound	13,300	0.116	0.5	771	1,542
8230	230	US-10	Westbound	13,300	0.116	0.5	771	1,542
							TOTAL	**12,608**

[6] MnDOT Traffic Forecasting & Analysis Traffic Mapping Application
[7] HCM 2016

Table 3-11. Summary of Population Demand[8]

Sub-Area	Residents	Transit-Dependent	Transients	Employees	Medical Facilities	Schools	Special Event	Shadow Population[9]	External Traffic	Total
2	3,141	34	100	186	0	906	6,000	0	0	10,367
5N	9,657	105	480	186	0	3,275	0	0	0	13,703
5E	19,760	216	34	0	14	3,196	0	0	0	23,220
5S	15,339	167	430	190	255	3,674	0	0	0	20,055
5W	2,777	30	711	0	0	0	0	0	0	3,518
10N	699	8	0	0	0	34	0	0	0	741
10E	2,979	33	204	0	0	0	0	0	0	3,216
10SE	3,978	43	155	0	0	3,282	0	0	0	7,458
10S	8,109	89	0	0	35	4,400	0	0	0	12,633
10SW	3,955	43	0	0	0	1,004	0	0	0	5,002
10W	3,789	41	138	0	0	20	0	0	0	3,988
10NW	1,196	13	178	0	0	0	0	0	0	1,387
Shadow Region	0	0	0	0	0	1,308	0	18,778	0	20,086
TOTAL:	**75,379**	**822**	**2,430**	**562**	**304**	**21,099**	**6,000**	**18,778**	**0**	**125,374**

[8] Since the spatial distribution of the access and/or functional needs population is unknown, they are not included in this table.
[9] Shadow Population has been reduced to 20%. Refer to Figure 2-1 for additional information.

Table 3-12. Summary of Vehicle Demand

Sub-Area	Residents	Transit-Dependent[10]	Transients	Employees	Medical Facilities[11]	Schools	Special Event	Shadow Population	External Traffic	Total
2	1,860	4	100	175	0	28	2,000	0	0	4,167
5N	5,771	8	233	175	0	116	0	0	0	6,303
5E	11,795	16	26	0	5	108	0	0	0	11,950
5S	9,108	12	186	179	70	140	0	0	0	9,695
5W	1,660	6	250	0	0	0	0	0	0	1,916
10N	417	0	0	0	0	2	0	0	0	419
10E	1,785	4	72	0	0	0	0	0	0	1,861
10SE	2,375	4	77	0	0	126	0	0	0	2,582
10S	4,779	6	0	0	14	174	0	0	0	4,973
10SW	2,359	0	0	0	0	38	0	0	0	2,397
10W	2,269	4	87	0	0	0	0	0	0	2,360
10NW	714	4	116	0	0	0	0	0	0	834
Shadow Region	0	0	0	0	0	44	0	11,044	12,608	23,696
TOTAL:	**44,892**	**68**	**1,147**	**529**	**89**	**776**	**2,000**	**11,044**	**12,608**	**73,153**

[10] Buses (including wheelchair buses) represented as two passenger vehicles. Refer to Section 8 for additional information.

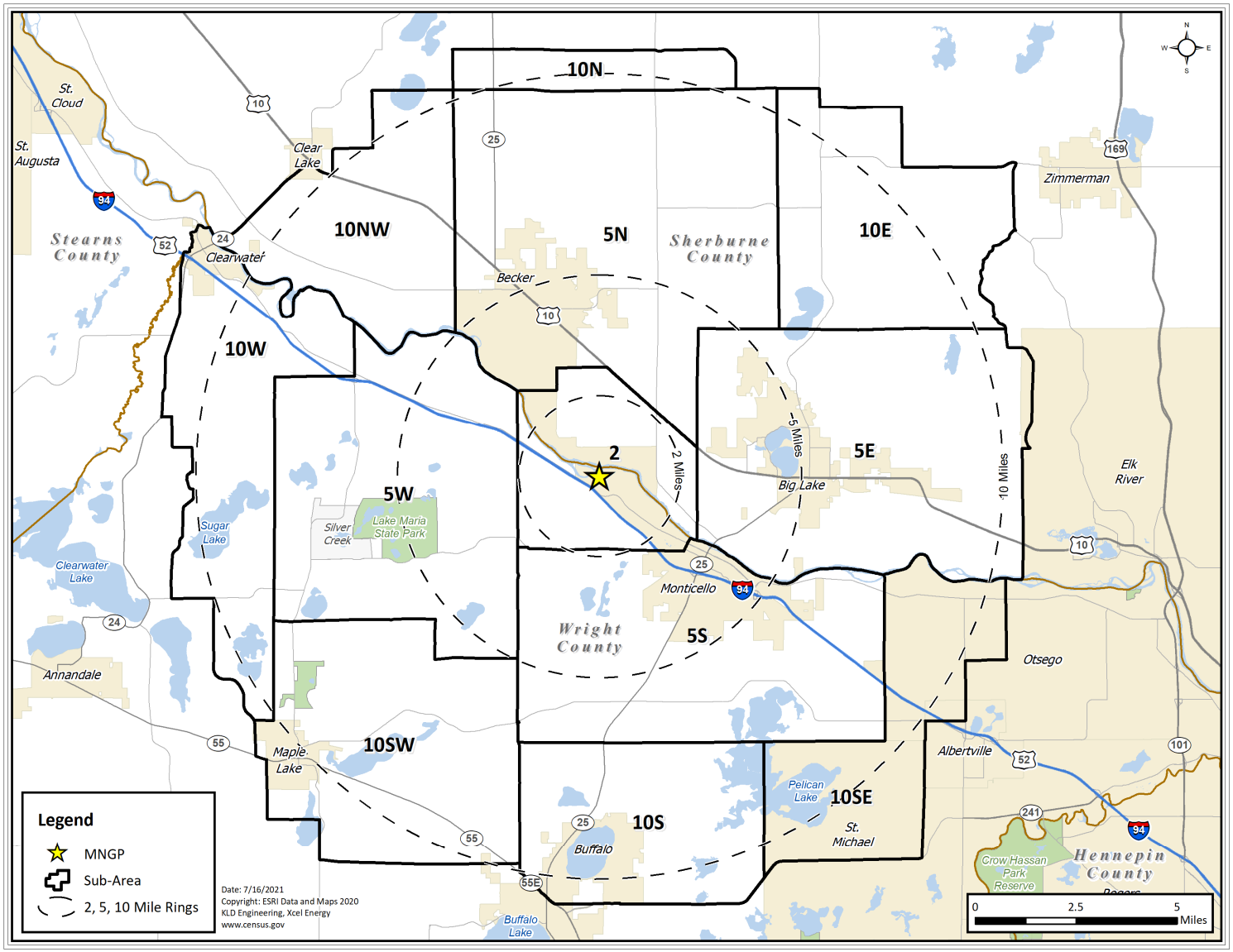
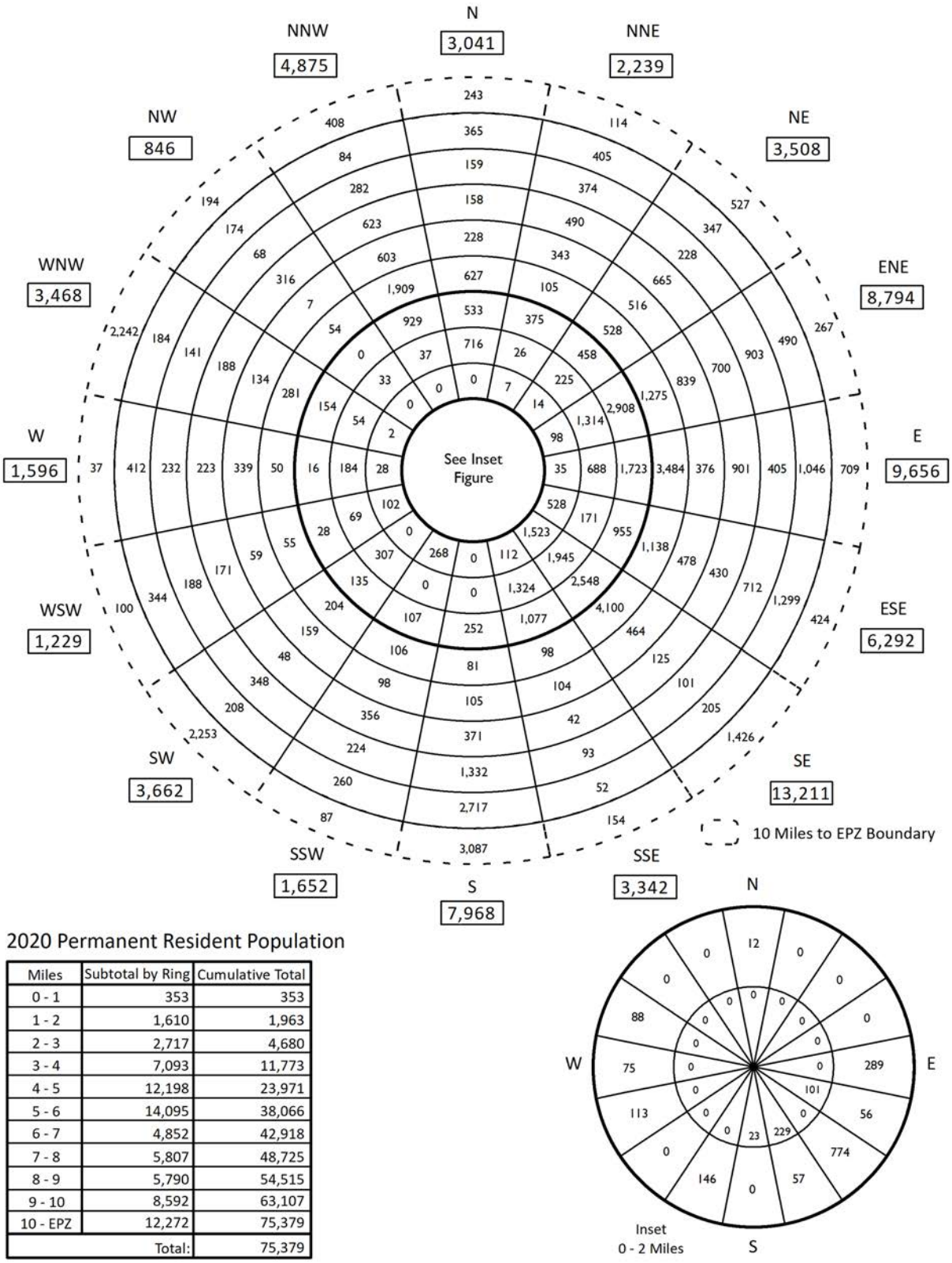


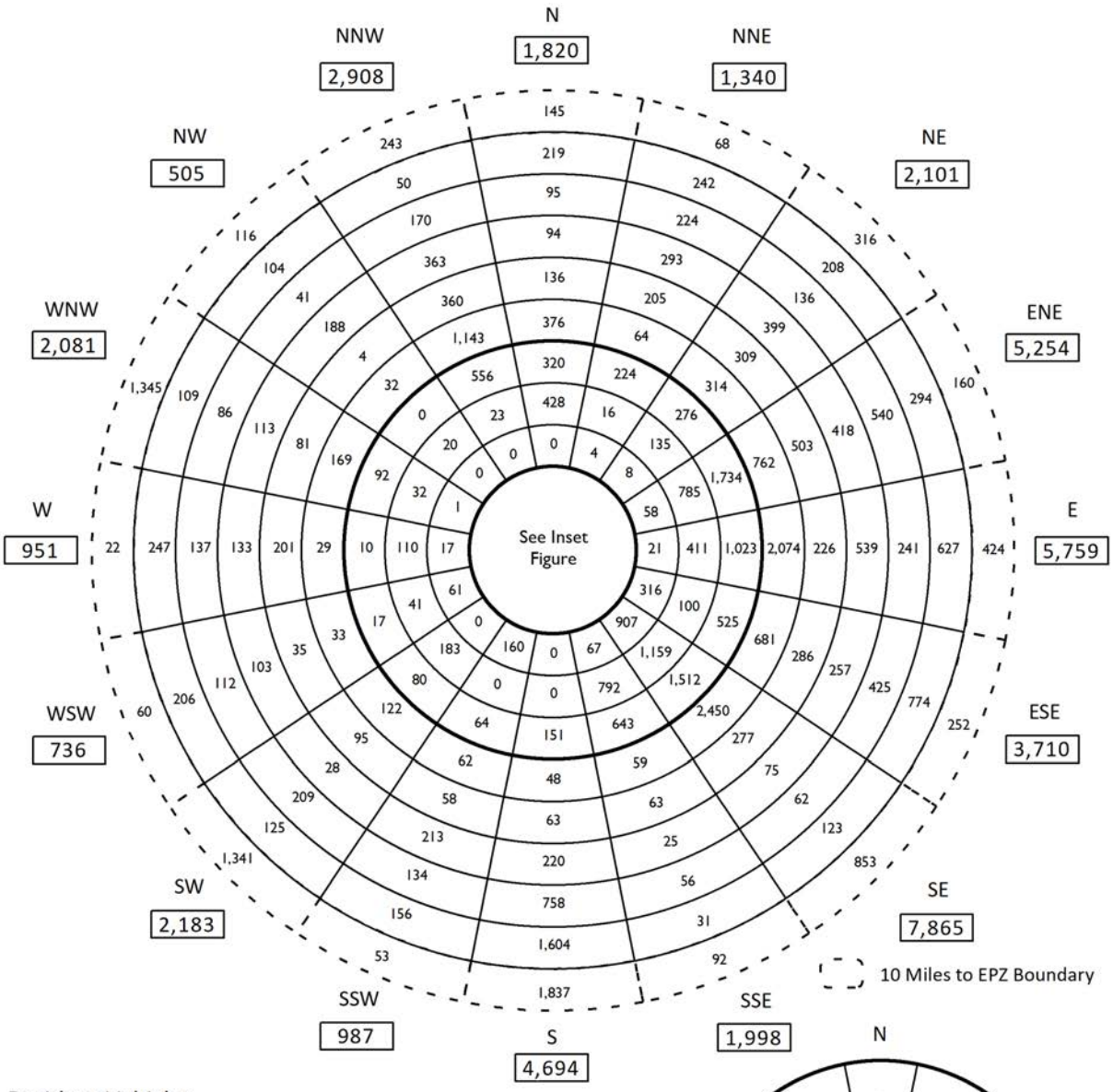
Figure 3-1. Sub-Areas Comprising the MNGP EPZ



2020 Permanent Resident Population

Miles	Subtotal by Ring	Cumulative Total
0 - 1	353	353
1 - 2	1,610	1,963
2 - 3	2,717	4,680
3 - 4	7,093	11,773
4 - 5	12,198	23,971
5 - 6	14,095	38,066
6 - 7	4,852	42,918
7 - 8	5,807	48,725
8 - 9	5,790	54,515
9 - 10	8,592	63,107
10 - EPZ	12,272	75,379
	Total:	75,379

Figure 3-2. Permanent Resident Population by Sector



Resident Vehicles

Miles	Subtotal by Ring	Cumulative Total
0 - 1	209	209
1 - 2	948	1,157
2 - 3	1,620	2,777
3 - 4	4,235	7,012
4 - 5	7,227	14,239
5 - 6	8,418	22,657
6 - 7	2,902	25,559
7 - 8	3,461	29,020
8 - 9	3,426	32,446
9 - 10	5,119	37,565
10 - EPZ	7,327	44,892
	Total:	44,892

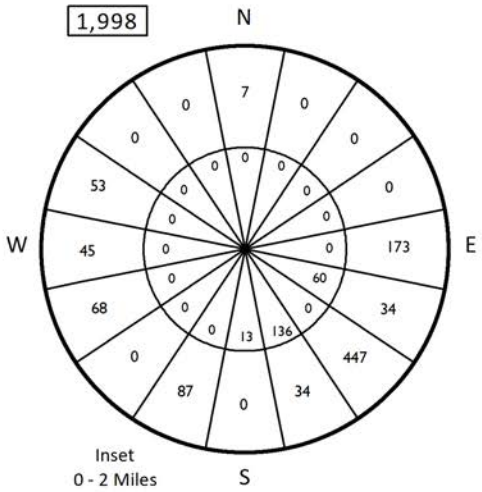
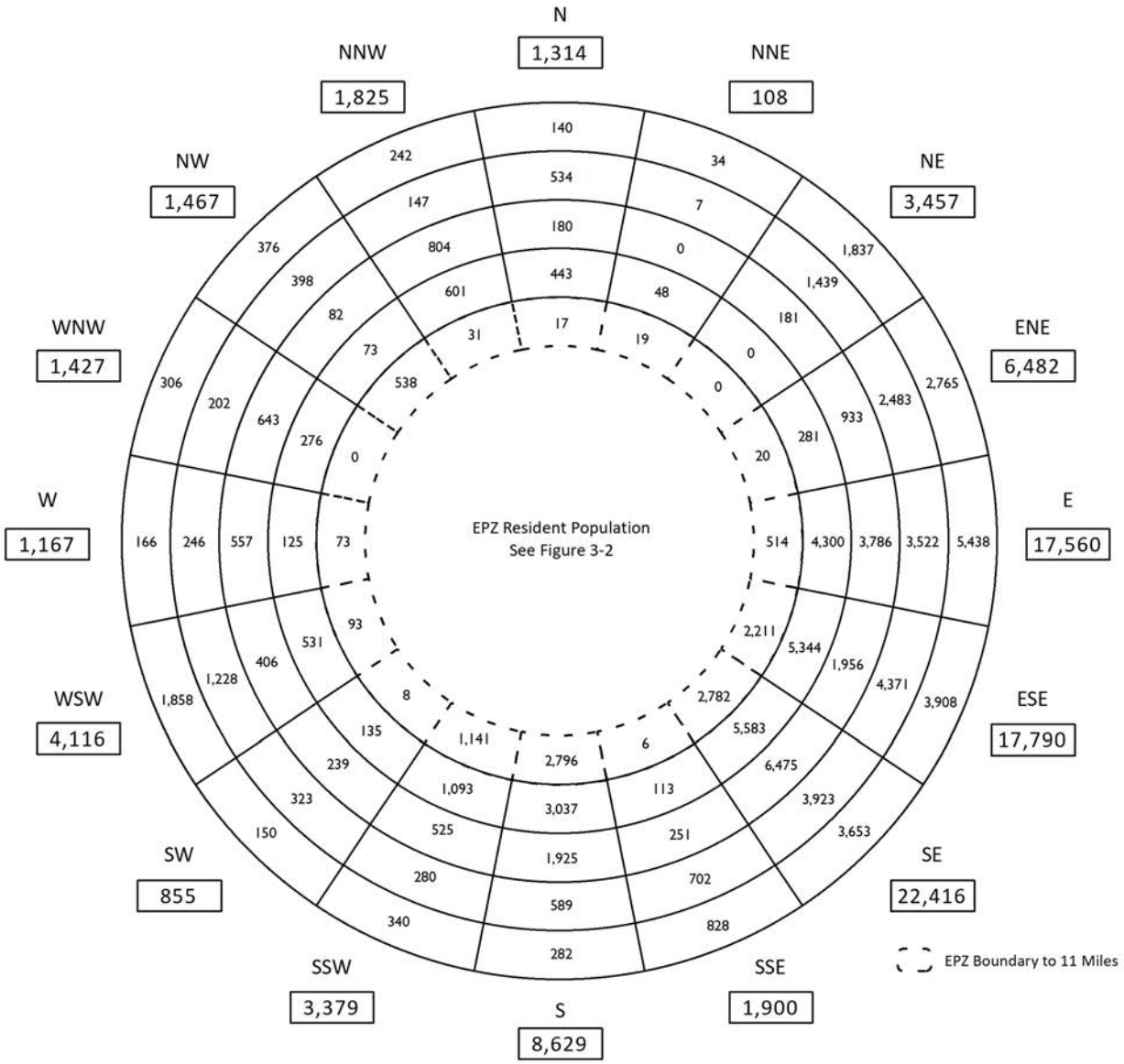


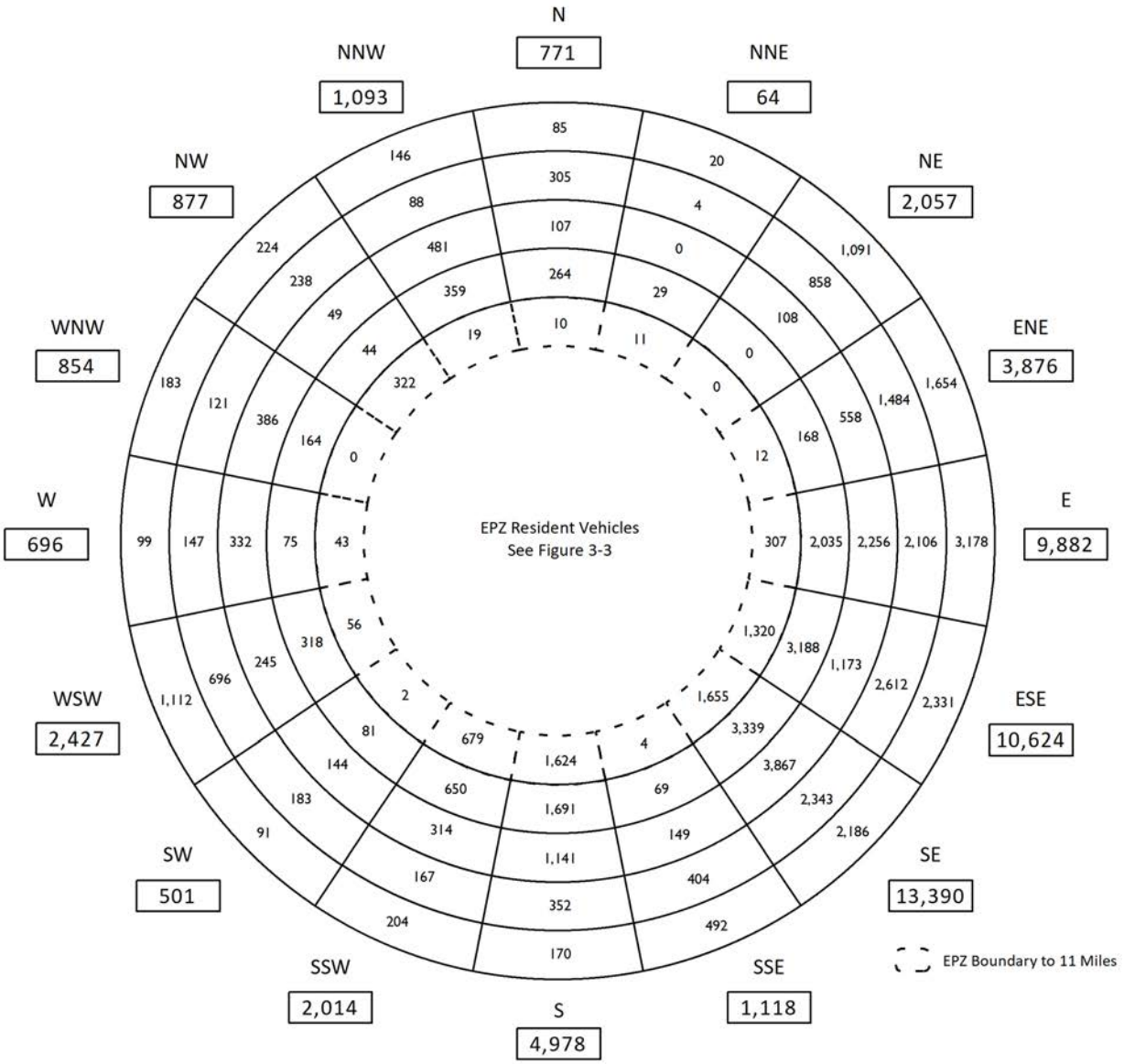
Figure 3-3. Permanent Resident Vehicles by Sector



2020 Shadow Population

Miles	Subtotal by Ring	Cumulative Total
EPZ - 11	10,249	10,249
11 - 12	21,983	32,232
12 - 13	18,943	51,175
13 - 14	20,394	71,569
14 - 15	22,323	93,892
	Total:	93,892

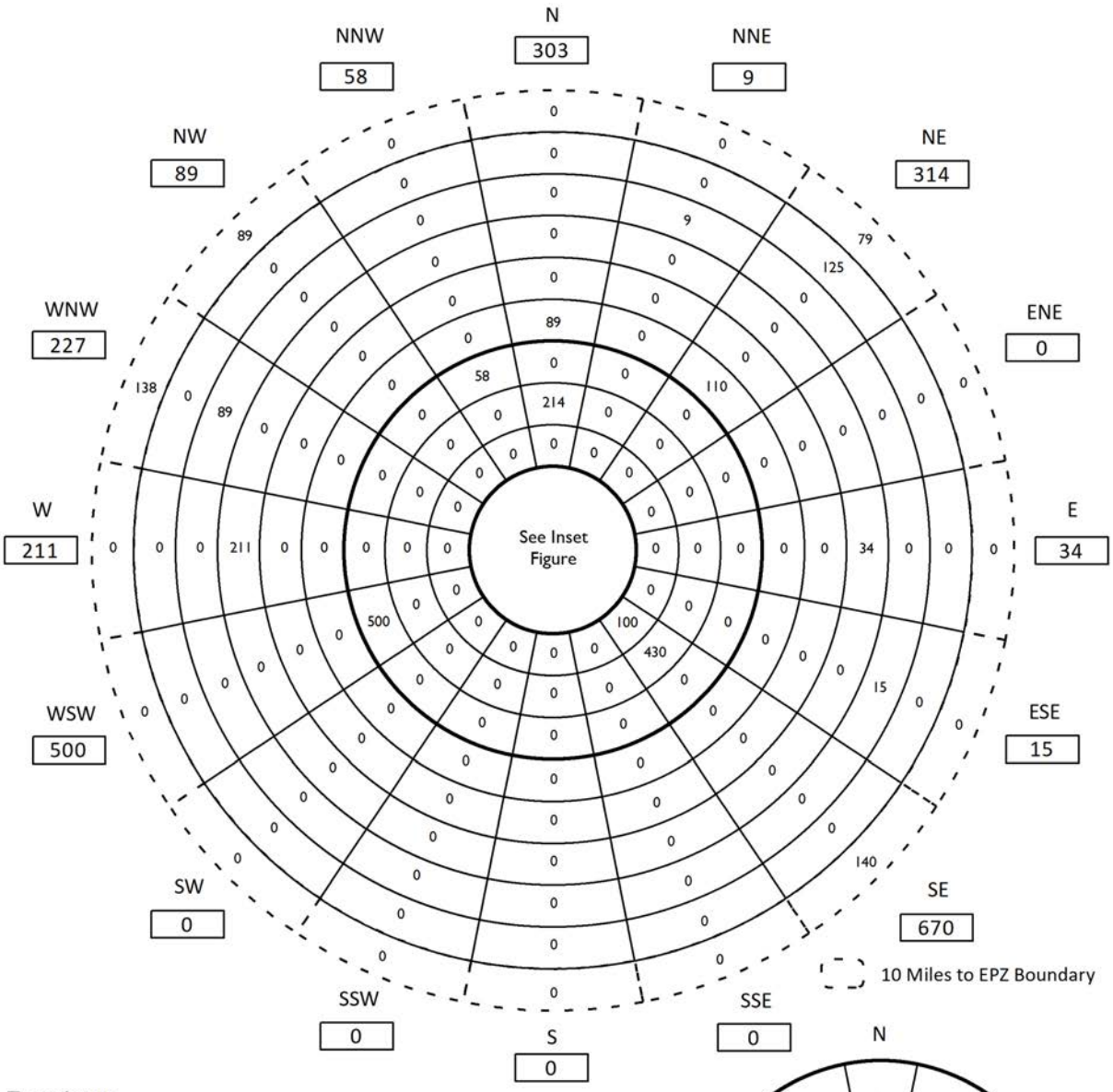
Figure 3-4. Shadow Population by Sector



Shadow Vehicles

Miles	Subtotal by Ring	Cumulative Total
EPZ - 11	6,064	6,064
11 - 12	12,474	18,538
12 - 13	11,310	29,848
13 - 14	12,108	41,956
14 - 15	13,266	55,222
	Total:	55,222

Figure 3-5. Shadow Vehicles by Sector



Transients

Miles	Subtotal by Ring	Cumulative Total
0 - 1	0	0
1 - 2	0	0
2 - 3	100	100
3 - 4	644	744
4 - 5	558	1,302
5 - 6	199	1,501
6 - 7	0	1,501
7 - 8	245	1,746
8 - 9	113	1,859
9 - 10	125	1,984
10 - EPZ	446	2,430
	Total:	2,430

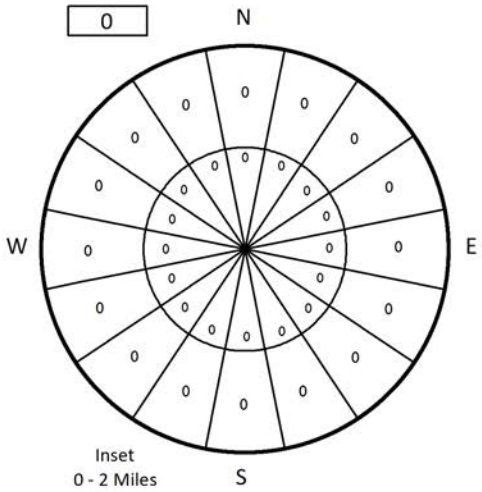
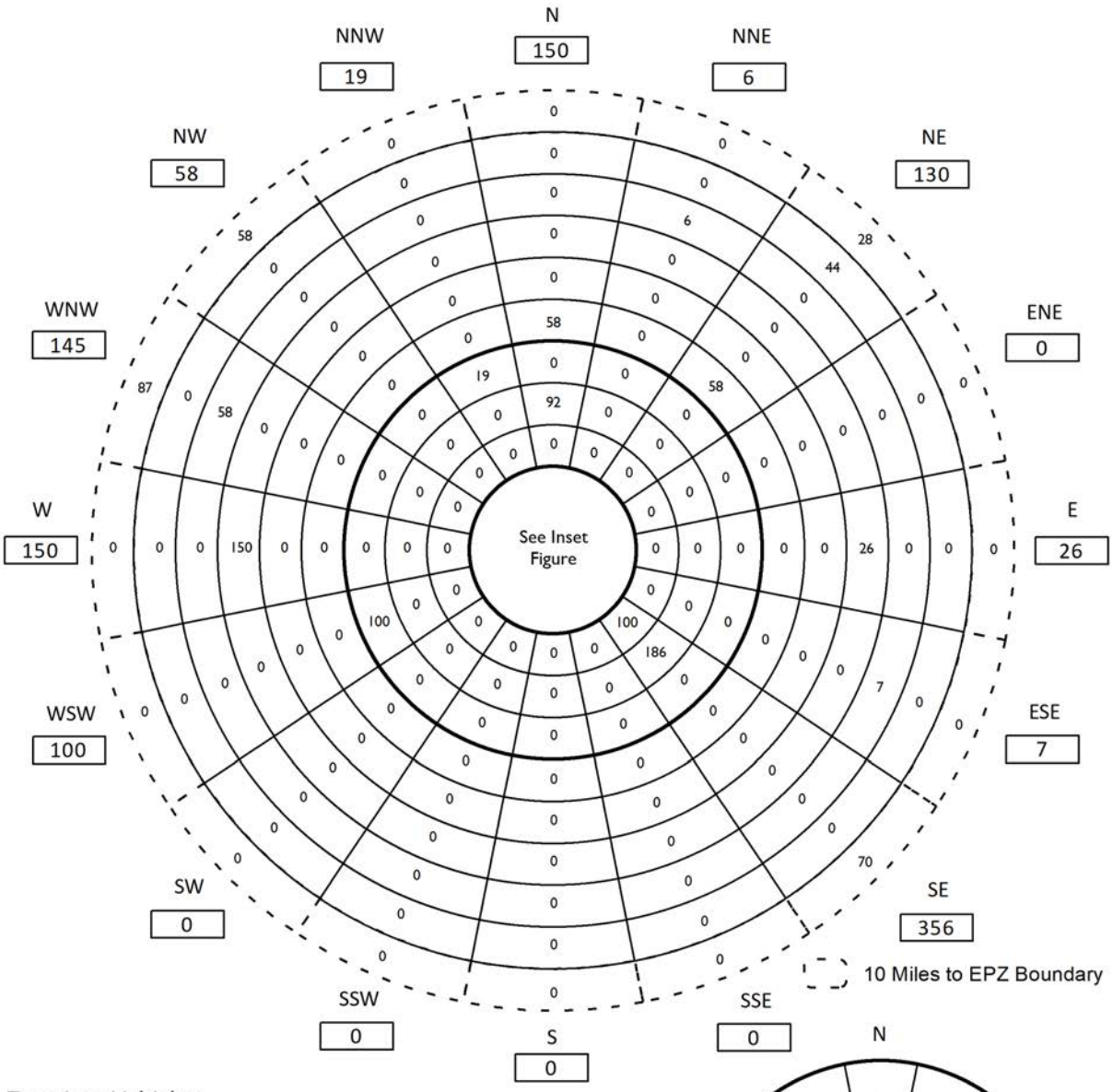


Figure 3-6. Transient Population by Sector



Transient Vehicles

Miles	Subtotal by Ring	Cumulative Total
0 - 1	0	0
1 - 2	0	0
2 - 3	100	100
3 - 4	278	378
4 - 5	119	497
5 - 6	116	613
6 - 7	0	613
7 - 8	176	789
8 - 9	71	860
9 - 10	44	904
10 - EPZ	243	1,147
	Total:	1,147

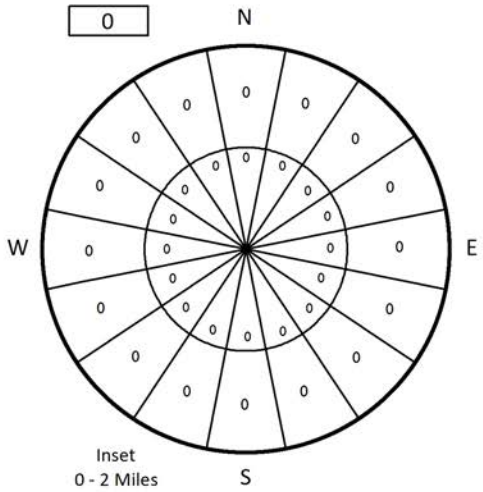
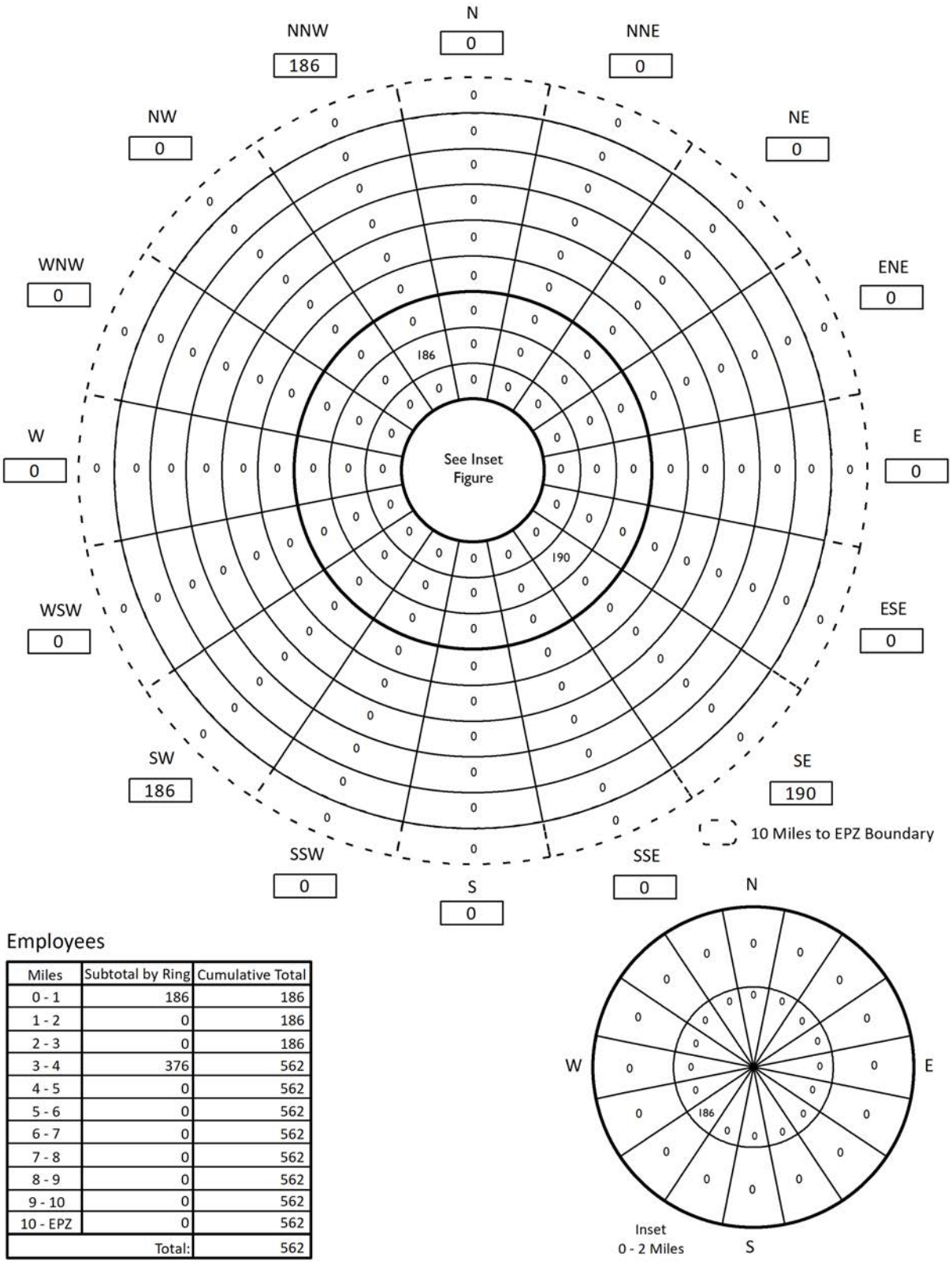


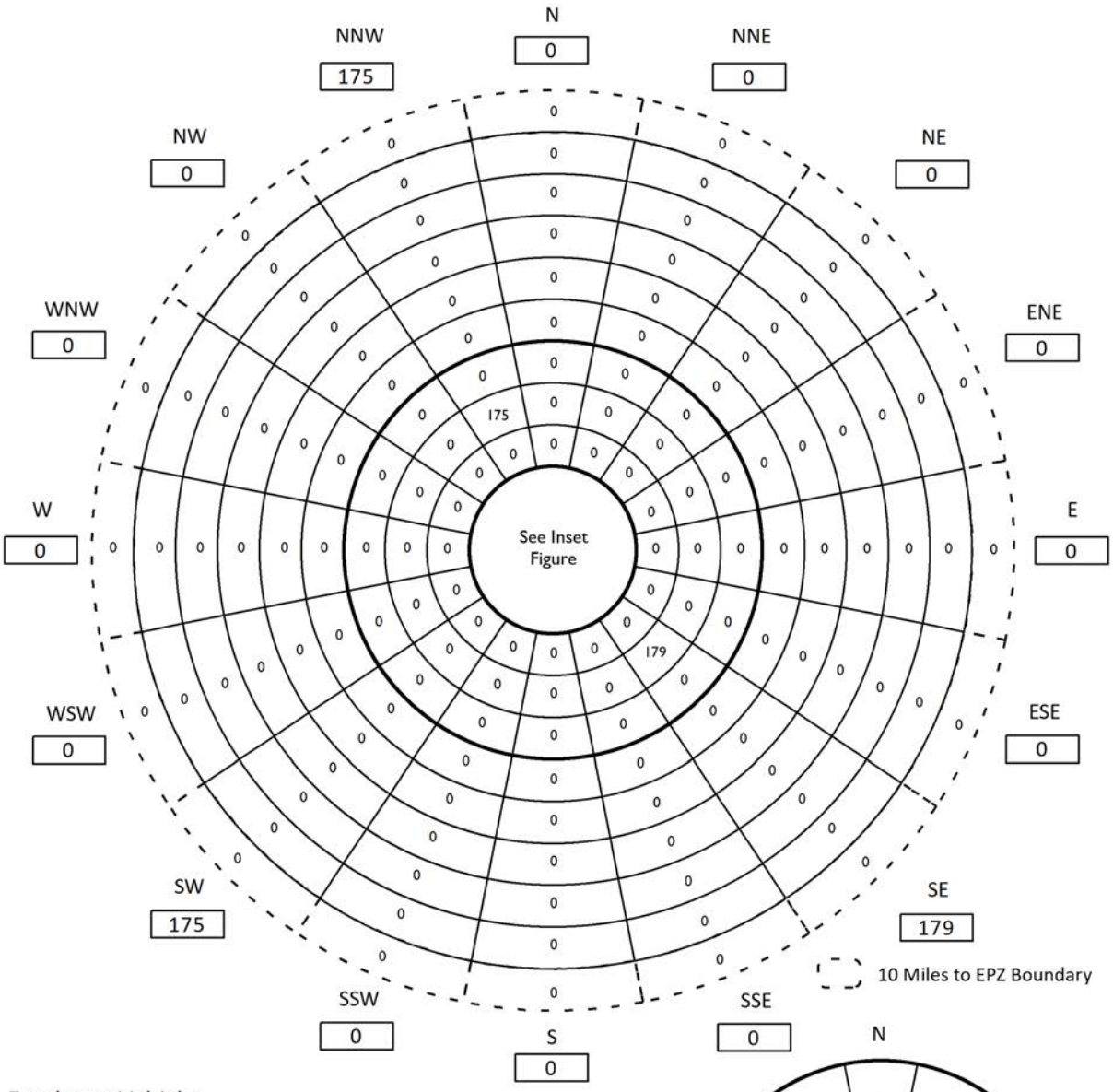
Figure 3-7. Transient Vehicles by Sector



Employees

Miles	Subtotal by Ring	Cumulative Total
0 - 1	186	186
1 - 2	0	186
2 - 3	0	186
3 - 4	376	562
4 - 5	0	562
5 - 6	0	562
6 - 7	0	562
7 - 8	0	562
8 - 9	0	562
9 - 10	0	562
10 - EPZ	0	562
	Total:	562

Figure 3-8. Employee Population by Sector



Employee Vehicles

Miles	Subtotal by Ring	Cumulative Total
0 - 1	175	175
1 - 2	0	175
2 - 3	0	175
3 - 4	354	529
4 - 5	0	529
5 - 6	0	529
6 - 7	0	529
7 - 8	0	529
8 - 9	0	529
9 - 10	0	529
10 - EPZ	0	529
	Total:	529

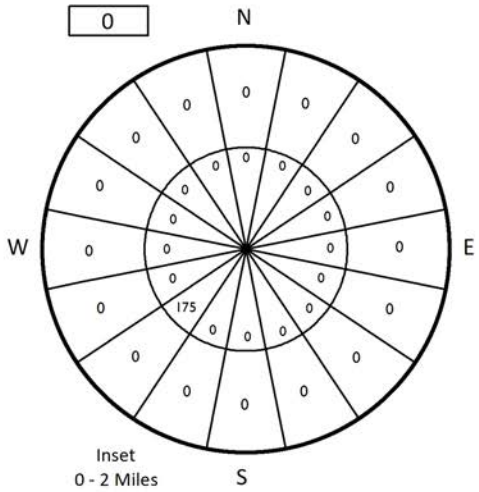


Figure 3-9. Employee Vehicles by Sector

4 ESTIMATION OF HIGHWAY CAPACITY

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

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

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

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

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

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

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

These factors are considered during the road survey and in the capacity estimation process; some factors have greater influence on capacity than others. For example, lane and shoulder width have only a limited influence on Base Free Flow Speed (BFFS[1]) according to Exhibit 15-7 of the HCM. Consequently, lane and shoulder widths at the narrowest points were observed during the road survey and these observations were recorded, but no detailed measurements of lane or

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

shoulder width were taken. Horizontal and vertical alignment can influence both FFS and capacity. The estimated FFS were measured using the survey vehicle's speedometer and observing local traffic, under free flow conditions. Free flow speeds ranged from 15 to 75 mph in the study area. Capacity is estimated from the procedures of the 2016 HCM. For example, HCM Exhibit 7-1(b) shows the sensitivity of SV at the upper bound of LOS D to grade (capacity is the SV at the upper bound of LOS E).

As discussed in Section 2.6, 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-flow speed and of highway capacity by approximately 10%. Over the last decade new studies have been made on the effects of rain and snow on traffic capacity. These studies indicate a range of effects between 10% and 25% depending on wind speed and precipitation rates. As indicated in Section 2.6, we employ a reduction in free speed and in highway capacity of 10% for rain/light snow and a 15% reduction in free speed and 25% reduction in highway capacity for heavy snow.

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

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

4.1 Capacity Estimations on Approaches to Intersections

At-grade intersections are apt to become the first bottleneck locations under local heavy traffic volume conditions. This characteristic reflects the need to allocate access time to the respective competing traffic streams by exerting some form of control. During evacuation, control at critical intersections will often be provided by traffic control personnel assigned for that purpose, whose directions may supersede traffic control devices. See Appendix G for more information.

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

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

where:

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

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

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

where:

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

The estimation of h_m for specified values of h_{sat}, F_1, F_2, ... is undertaken within the DYNEV II

simulation model by a mathematical model[2]. The resulting values for h_m always satisfy the condition:

$$h_m \geq h_{sat}$$

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

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

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

4.2 Capacity Estimation along Sections of Highway

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

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

The value of V_F can be expressed as:

[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.

$$V_F = R \times Capacity$$

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 for freeway links. The ratio of these two numbers is 0.896 which translates into a capacity reduction factor of 0.90.

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

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

The estimated value of capacity is based primarily upon the type of facility and on roadway geometrics. Sections of roadway with adverse geometrics are characterized by lower free-flow speeds and lane capacity. Exhibit 15-46 in the 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 2016 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 MNGP Study Area

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

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

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

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

Each of these classifications will be discussed.

4.3.1 Two-Lane Roads

Ref: HCM Chapter 15

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

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

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

4.3.2 Multilane Highway

Ref: HCM Chapter 12

Exhibit 12-8 of the HCM 2016 presents a set of curves that indicate a per-lane capacity ranging from approximately 1,900 to 2,300 pc/h, for free-speeds of 45 to 60 mph, respectively. Based on observation, the multilane highways outside of urban areas within the study area, service traffic with free-speeds in this range. The actual time-varying speeds computed by the simulation model reflect the demand and capacity relationship and the impact of control at intersections. A

conservative estimate of per-lane capacity of 1,900 pc/h is adopted for this study for multilane highways outside of urban areas.

4.3.3 Freeways

Ref: HCM Chapters 10, 12, 13, 14

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

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

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

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

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

Chapter 14 of the HCM 2016 presents procedures for estimating capacities of ramps and of "merge" areas. There are three significant factors to the determination of capacity of a ramp-freeway junction: The capacity of the freeway immediately downstream of an on-ramp or immediately upstream of an off-ramp; the capacity of the ramp roadway; and the maximum flow rate entering the ramp influence area. In most cases, the freeway capacity is the controlling factor. Values of this merge area capacity are presented in Exhibit 14-10 of the HCM 2016 and depend on the number of freeway lanes and on the freeway free speed. Ramp capacity is presented in Exhibit 14-12 and is a function of the ramp FFS. The DYNEV II simulation model logic simulates the merging operations of the ramp and freeway traffic in accord with the procedures in Chapter 14 of the HCM 2016. If congestion results from an excess of demand relative to capacity, then the model allocates service appropriately to the two entering traffic streams and produces LOS F conditions (The HCM does not address LOS F explicitly).

4.3.4 Intersections

Ref: HCM Chapters 19, 20, 21, 22

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

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

The model is also capable of modeling the presence of manned traffic control. At specific locations where it is advisable or where existing plans call for overriding existing traffic control to implement manned control, the model will use actuated signal timings that reflect the presence of traffic guides. At locations where a special traffic control strategy (continuous left-turns, contra-flow lanes) is used, the strategy is modeled explicitly. A list that includes the total number of intersections modeled that are unsignalized, signalized, or manned by response personnel is noted in Appendix K.

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 involving several HCM chapters. Alternative tools are able to analyze these facilities as a single system."*

This statement succinctly describes the analyses required to determine traffic operations across an area encompassing a study area 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 2016 procedures only for the purpose of estimating capacity.

All simulation models must be calibrated properly with field observations that quantify the performance parameters applicable to the analysis network. Two of the most important of these are: (1) FFS; and (2) saturation headway, h_{sat}. The first of these is estimated by direct observation

during the road survey; the second is estimated using the concepts of the HCM, as described earlier.

4.5 Boundary Conditions

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

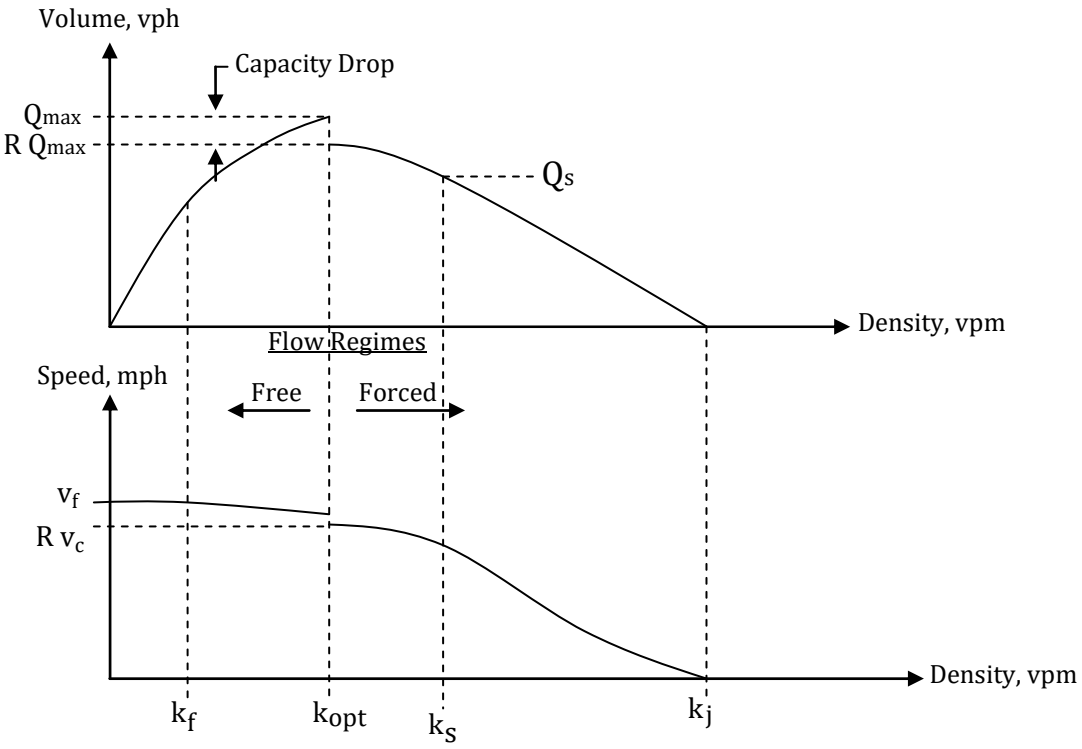


Figure 4-1. Fundamental Diagrams

5 ESTIMATION OF TRIP GENERATION TIME

Federal guidance (see NUREG CR/7002, Rev. 1) specify that the 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 demographic survey. We define the sum of these distributions of elapsed times as the Trip Generation Time Distribution.

5.1 Background

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

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

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

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

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

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

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

For example, suppose one-hour elapses from the siren alert to the ATE. In this case, it is reasonable to expect some degree of spontaneous evacuation by the public during this one-hour period. As a result, the population within the EPZ will be lower when the ATE is announced, than at the time of the siren alert. In addition, many will engage in preparation activities to evacuate, in anticipation that an Advisory will be broadcast. Thus, the time needed to complete the mobilization activities and the number of people remaining to evacuate the EPZ after the ATE, will both be somewhat less than the estimates presented in this report.

Consequently, the ETE presented in this report are likely to be higher than the actual evacuation time, if this hypothetical situation were to take place.

The notification process consists of two events:

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

The population within the EPZ is dispersed over an area of approximately 370 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 event.

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 4.3 of NUREG/CR-7002, Rev. 1, the information required to compute trip generation times is typically obtained from a demographic survey of EPZ residents. Such a survey was conducted in support of this ETE study. Appendix F presents the survey sampling plan, survey instrument, and survey results. The remaining discussion will focus on the application of the trip generation data obtained from the demographic survey to the development of the ETE documented in this report.

5.2 Fundamental Considerations

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

Activities are undertaken over a period of time. Activities may be in "series" (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 in Table 5-1.

These relationships are shown graphically in Figure 5-1.

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

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

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

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

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

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

5.3 Estimated Time Distributions of Activities Preceding Event 5

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

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

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

Given the federal regulations and guidance it is assumed that 100 percent of those within the EPZ will be aware of the accident within 45 minutes. The assumed distribution for notifying the EPZ population is provided in Table 5-2.

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

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

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

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

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

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

Distribution No. 5, Snow Clearance Time Distribution

Inclement weather scenarios involving snowfall must address the time lags associated with snow clearance. It is assumed that snow equipment is mobilized and deployed during the snowfall to maintain passable roads. The general consensus is that the snow-plowing efforts are 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 (Note – evacuation may not be a prudent protective action under such blizzard conditions).

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

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

5.4.1 Statistical Outliers

As already mentioned, some portion of the survey respondents answer "Decline to State" to some questions or choose to not respond to a question. The mobilization activity distributions are based upon actual responses. But, it is the nature of surveys that a few numeric responses are inconsistent with the overall pattern of results. An example would be a case in which for 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 access and/or functional needs;

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

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

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

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

In establishing the 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.
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, not 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 for each population group considered. These distributions are presented on the same time scale. (As discussed earlier, the use of strictly additive activities is a conservative approach, because it makes all activities 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. Rev. 1, staged evacuation consists of the following:

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

Assumptions

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

Procedure

1. Trip generation for population groups in the 2-mile region will be as computed based upon the results of the demographic survey and analysis.
2. Trip generation for the population subject to staged evacuation will be formulated as follows:
    a. Identify the 90th percentile evacuation time for the Sub-Area comprising the 2-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, Rev. 1 uses the statement "approximately 90th percentile" as the time to end staging and begin evacuating. The value of T_{Scen}^{*} is 2:05 in good weather/rain/light snow and 2:15 in heavy snow.
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 while snowing
    d. Residents without returning commuters while snowing

Figure 5-5 and Table 5-10 presents the staged trip generation distributions for both residents with and without returning commuters and employees. At T_{Scen}^{*}, 20 percent of the permanent resident population (who normally would have completed their mobilization activities for an un-staged evacuation) advised to shelter has nevertheless departed the area. These people do not comply with the shelter advisory. Also included on the plot are the trip generation distributions for these groups as applied to the regions advised to evacuate immediately.

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

5.4.3 Trip Generation for Waterways

The Wright County Emergency Response Plan, dated October 2019, indicates that both the Wright County Sheriff's Water Patrol and Sherburne County Sheriff's Water Patrol, in conjunction with the Minnesota Department of Natural Resources will be responsible for controlling watercraft traffic on the Mississippi River.

As indicated in Table 5-2, this study assumes 100% notification in 45 minutes. Table 5-9 indicates that all transients will have mobilized within 1 hour and 15 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 5-1. Event Sequence for Evacuation Activities

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

Table 5-2. Time Distribution for Notifying the Public

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

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

Elapsed Time (Minutes)	Cumulative Percent Employees Leaving Work
0	0.0%
5	37.6%
10	61.7%
15	79.4%
20	87.8%
25	90.6%
30	97.7%
35	98.6%
40	99.3%
45	100.0%

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

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

Elapsed Time (Minutes)	Cumulative Percent Returning Home
0	0.0%
5	8.5%
10	17.8%
15	31.1%
20	43.5%
25	55.4%
30	68.7%
35	74.0%
40	78.3%
45	85.2%
50	89.9%
55	92.3%
60	96.3%
65	97.3%
70	98.2%
75	99.2%
80	99.5%
85	99.7%
90	100.0%

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

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

Elapsed Time (Minutes)	Cumulative Percent Ready to Evacuate
0	0.0%
15	4.8%
30	25.5%
45	42.6%
60	63.7%
75	75.1%
90	80.8%
105	83.5%
120	89.5%
135	97.0%
150	97.9%
165	97.9%
180	98.5%
195	100.0%

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

Table 5-6. Time Distribution for Population to clear 6” - 8” of Snow

Elapsed Time (Minutes)	Cumulative Percent Ready to Evacuate
0	18.4%
15	40.7%
30	67.2%
45	79.4%
60	90.2%
75	94.4%
90	95.1%
105	96.4%
120	97.4%
135	100.0%

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

Table 5-7. Mapping Distributions to Events

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

Table 5-8. Description of the Distributions

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

Table 5-9. Trip Generation Histograms for the EPZ Population for Un-staged 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	7%	7%	0%	0%	0%	0%
2	15	35%	35%	0%	4%	0%	1%
3	15	41%	41%	1%	11%	0%	4%
4	30	17%	17%	11%	37%	4%	20%
5	15	0%	0%	12%	16%	6%	14%
6	15	0%	0%	16%	9%	9%	14%
7	15	0%	0%	15%	5%	11%	11%
8	15	0%	0%	12%	5%	13%	8%
9	15	0%	0%	9%	6%	12%	7%
10	60	0%	0%	20%	6%	31%	17%
11	30	0%	0%	2%	1%	7%	2%
12	30	0%	0%	2%	0%	4%	1%
13	30	0%	0%	0%	0%	2%	1%
14	30	0%	0%	0%	0%	1%	0%
15	600	0%	0%	0%	0%	0%	0%

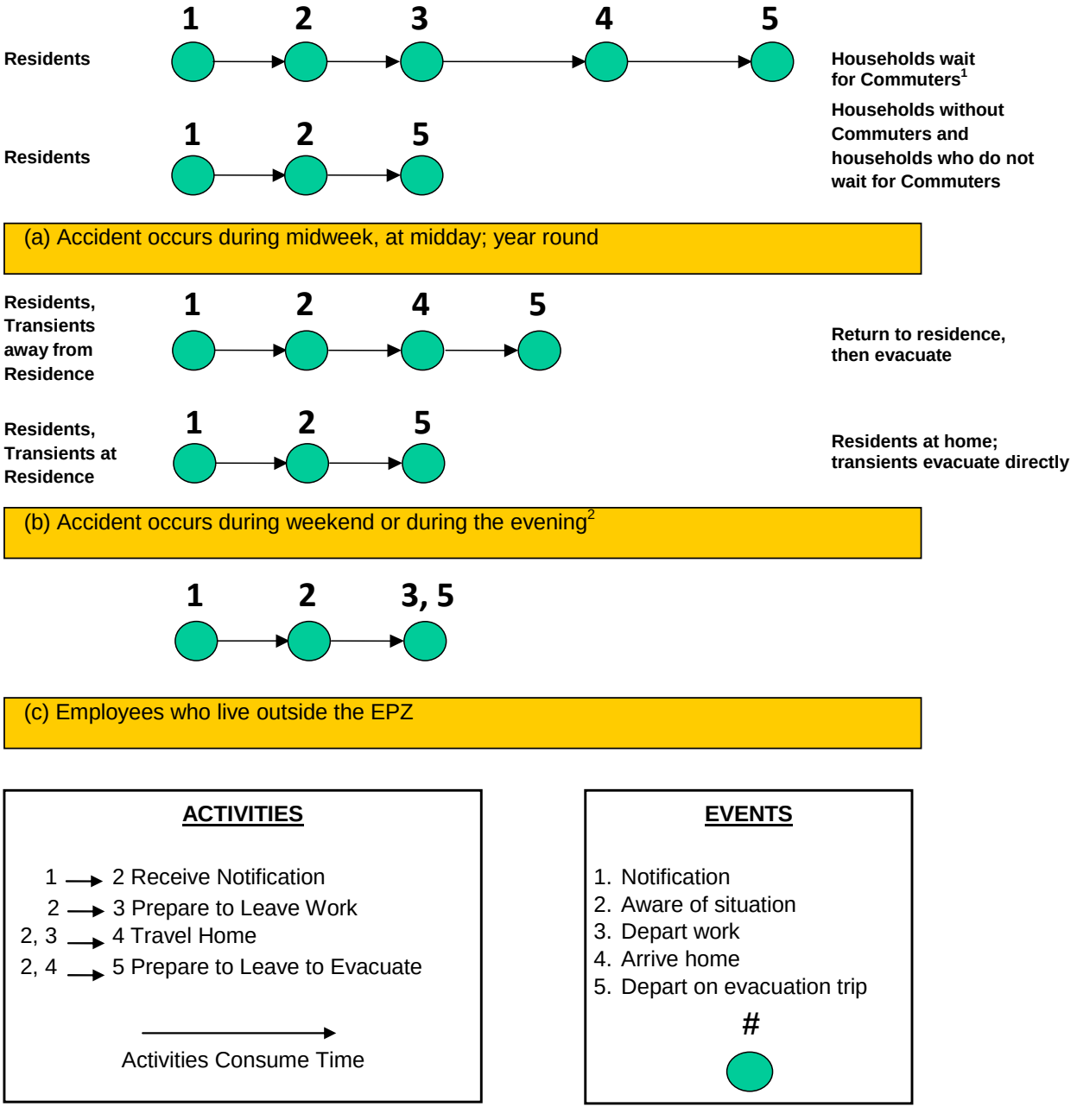
NOTE:

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

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

Time Period	Duration (Min)	Percent of Total Trips Generated Within Indicated Time Period*			
		Residents with Commuters (Distribution C)	Residents Without Commuters (Distribution D)	Residents with Commuters Snow (Distribution E)	Residents without Commuters Snow (Distribution F)
1	15	0%	0%	0%	0%
2	15	0%	1%	0%	0%
3	15	0%	2%	0%	1%
4	30	2%	7%	1%	4%
5	15	3%	4%	1%	3%
6	15	3%	1%	2%	3%
7	15	3%	1%	2%	2%
8	15	56%	71%	3%	1%
9	15	9%	6%	46%	65%
10	60	20%	6%	31%	17%
11	30	2%	1%	7%	2%
12	30	2%	0%	4%	1%
13	30	0%	0%	2%	1%
14	30	0%	0%	1%	0%
15	600	0%	0%	0%	0%

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



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

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

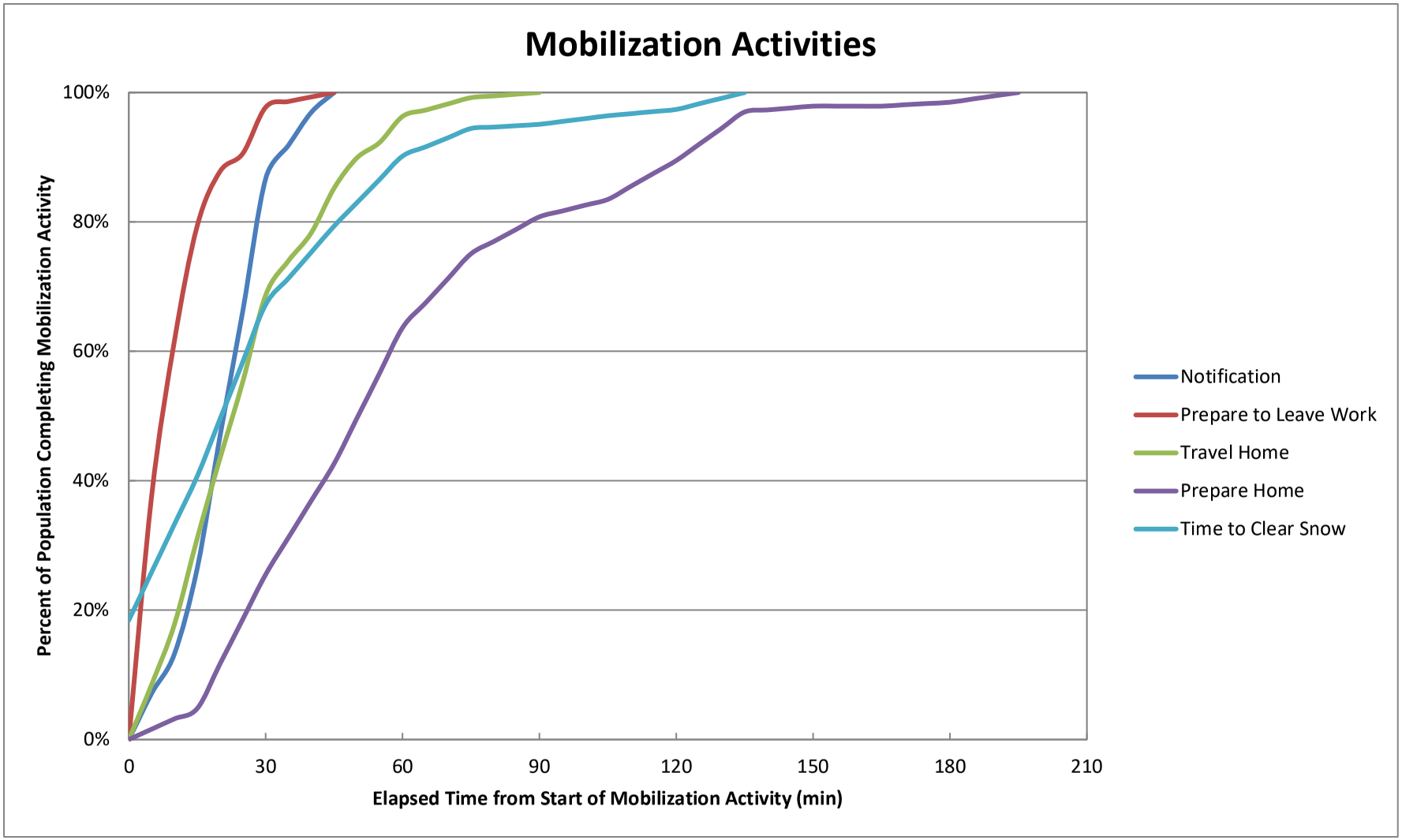


Figure 5-2. Time Distributions for Evacuation Mobilization Activities

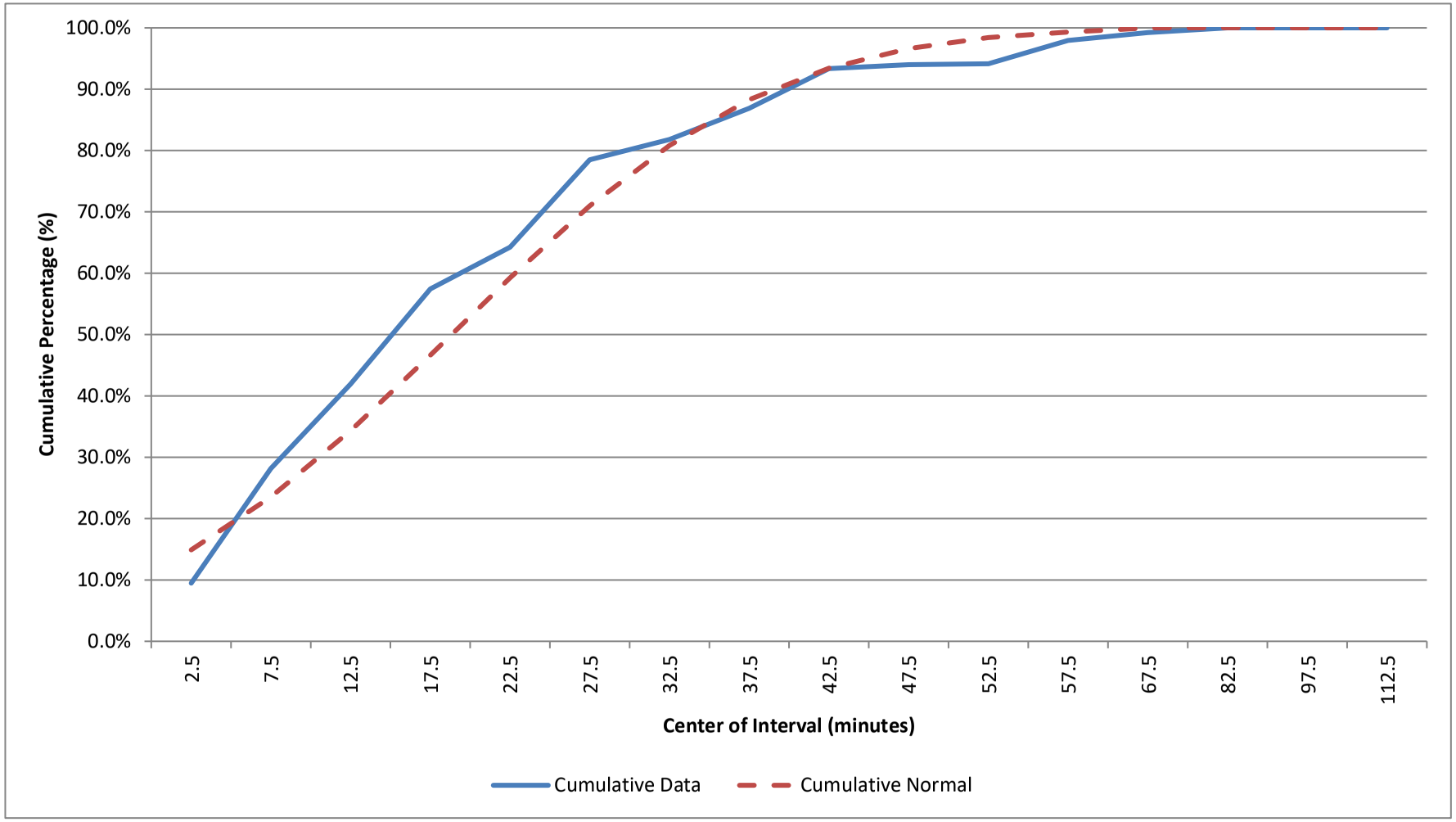


Figure 5-3. Comparison of Data Distribution and Normal Distribution

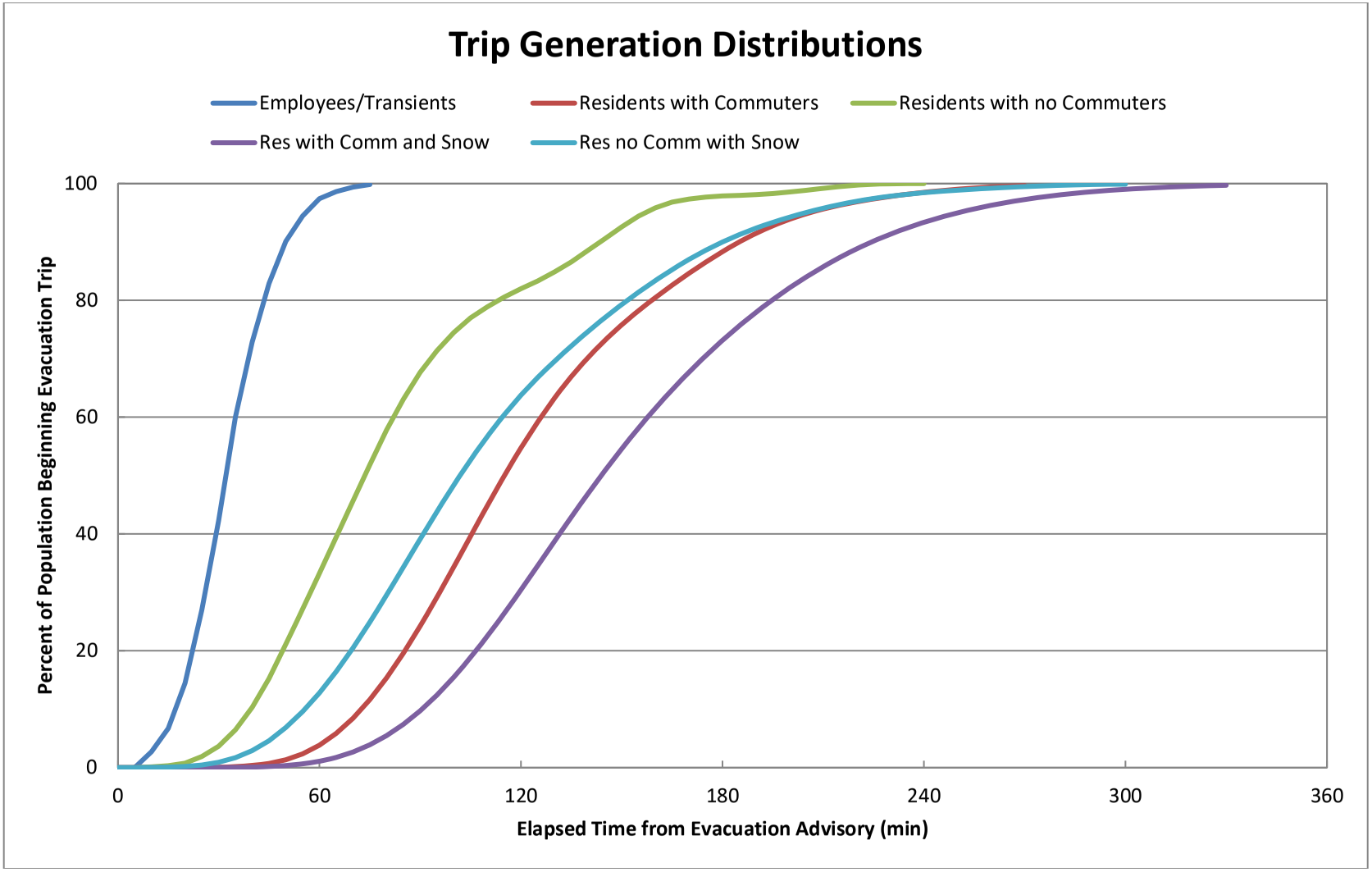


Figure 5-4. Comparison of Trip Generation Distributions

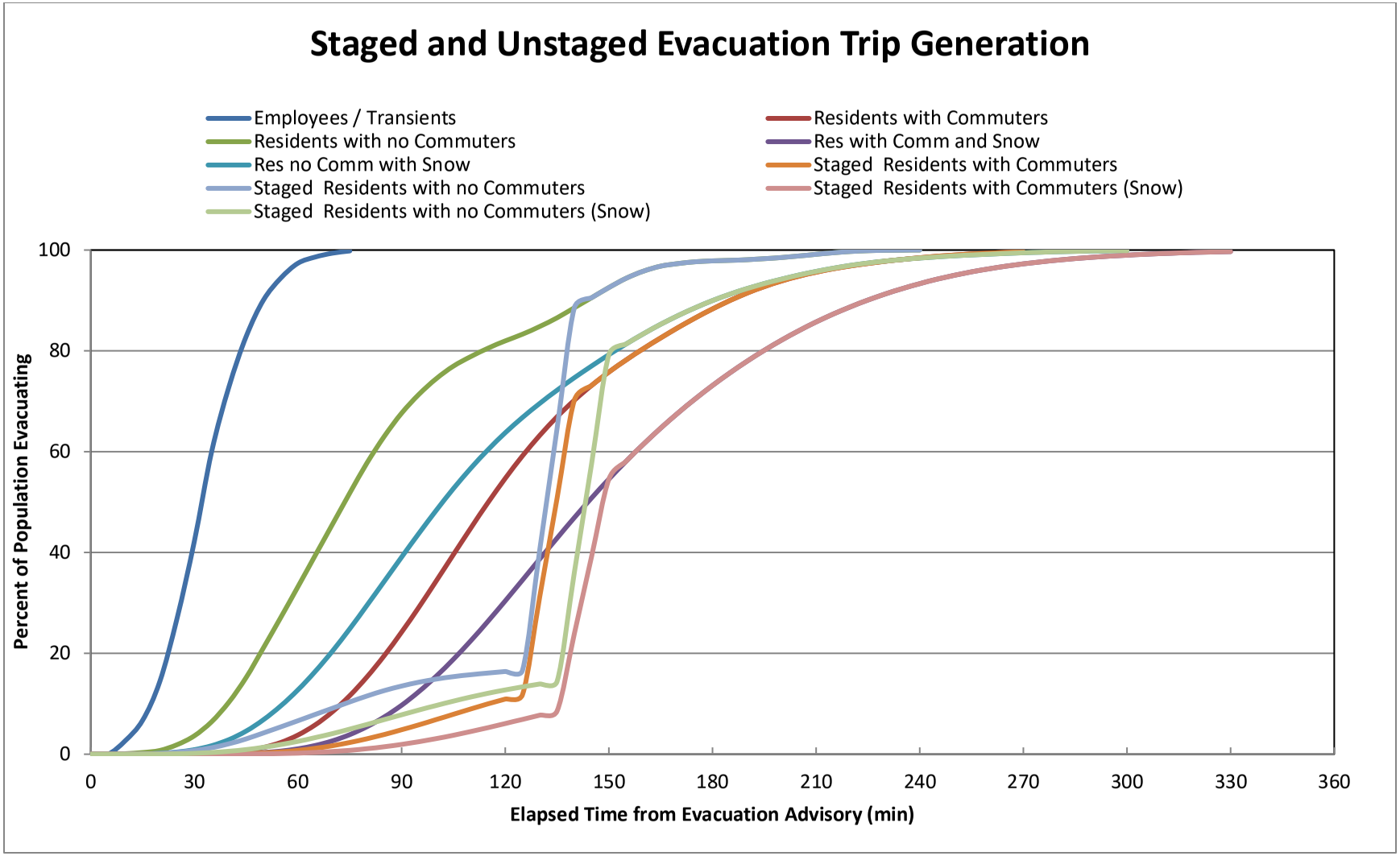


Figure 5-5. Comparison of Staged and Un-staged Trip Generation Distributions in the 2 to 5 Mile Region

6 EVACUATION CASES

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

Region A grouping of contiguous evacuating Sub-Areas 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 34 Regions were defined which encompass all the groupings of Sub-Areas considered. These Regions are defined in Table 6-1. The Sub-Area 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, Rev. 1 guidance. The central sector coincides with the wind direction. These sectors extend to 5 miles from the plant (Regions R04 through R11) or to the EPZ boundary (Regions R12 through R25).

Regions R01, R02 and R03 represent evacuations of circular areas with radii of 2, 5 and 10 miles, respectively. Regions R26 through R34 are identical to Regions R02, and R04 through R11, respectively; however, those Sub-Areas between 2 miles and 5 miles are staged until 90% of the 2-mile region (Region R01) has evacuated.

A total of 14 Scenarios were evaluated for all Regions. Thus, there are a total of 34 x 14 = 476 evacuation cases. Table 6-2 is a description of all Scenarios.

Each combination of region and scenario implies a specific population to be evacuated. The population and vehicle estimates presented in Section 3 and in Appendix E 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 48%, which is the product of 90% (the number of households with at least one commuter) and 53.5% (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 those households with returning commuters will have a commuter at work during those times.

It can be argued that the 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 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.

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

Transient activity is estimated to be at its peak (80%) during summer weekends and less (65%) during the week due to the large number of parks, golf courses, and campgrounds that are at reduced occupancy during the week. Transient activity on winter weekends is assumed to be 25% and less (20%) during the week because some facilities are closed in the winter. Transient activity is 55% in the evening during the summer and less (35%) during winter evenings as campgrounds and lodging facilities make up about half of the transient vehicle demand and these facilities peak during evening hours. Similar to other transient facilities, winter sees less activity than summer which is why winter evenings have a lower percentage that summer evenings.

As noted in the shadow footnote to Table 6-3, the shadow percentages are computed using a base of 20% (see assumption 9 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:

$$20\% \times \left(1 + \frac{508}{21{,}617 + 23{,}275}\right) = 20.2\%$$

One special event – Summer Services at Laestadian Lutheran Church – 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 and medical facilities 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 40% during evening scenarios and is 100% for all other scenarios.

Table 6-1. Description of Evacuation Regions

Radial Regions													
Region	Description	Wind From (in Degrees)	Sub-Area											
			2	5N	5E	5S	5W	10N	10E	10SE	10S	10SW	10W	10NW
R01	2-Mile Region	N/A	X											
R02	5-Mile Region	N/A	X	X	X	X	X							
R03	Full EPZ	N/A	X	X	X	X	X	X	X	X	X	X	X	X
Evacuate 2-Mile Region and Downwind to 5 Miles														
Region	Wind Direction From	Wind From (in Degrees)	Sub-Area											
			2	5N	5E	5S	5W	10N	10E	10SE	10S	10SW	10W	10NW
R04	N, NNE, NE, ENE	349-78	X			X	X							
R05	E	79-101	X				X							
R06	ESE, SE, SSE	102-169	X	X			X							
R07	S	170-191	X	X										
R08	SSW, SW, WSW	192-258	X	X	X									
R09	W	259-281	X	X	X	X								
R10	WNW, NW	282-326	X		X	X								
R11	NNW	327-348	X			X								

Evacuate 2-Mile Region and Downwind to the EPZ Boundary													
Region	Wind Direction From	Wind From (in Degrees)	Sub-Area										
			2	5N	5E	5S	5W	10N	10E	10SE	10S	10SW	10W	10NW
R12	N	349-11	X			X	X			X	X	X		
R13	NNE, NE	12-56	X			X	X				X	X	X	
R14	ENE	57-78	X			X	X					X	X	
R15	E	79-101	X				X					X	X	X
R16	ESE	102-124	X	X			X						X	X
R17	SE	125-146	X	X			X	X					X	X
R18	SSE	147-169	X	X			X	X						X
R19	S	170-191	X	X				X	X					X
R20	SSW, SW	192-236	X	X	X			X	X					
R21	WSW	237-258	X	X	X				X					
R22	W	259-281	X	X	X	X			X	X				
R23	WNW	282-303	X		X	X				X				
R24	NW	304-326	X		X	X				X	X			
R25	NNW	327-348	X			X				X	X			

Staged Evacuation - 2-Mile Region Evacuates, then Evacuate Downwind to 5 Miles													
Region	Wind Direction From	Wind From (in Degrees)	Sub-Area										
			2	5N	5E	5S	5W	10N	10E	10SE	10S	10SW	10W	10NW
R26	N/A	5-Mile Region	X	X	X	X	X							
R27	N, NNE, NE, ENE	349-78	X			X	X							
R28	E	79-101	X				X							
R29	ESE, SE, SSE	102-169	X	X			X							
R30	S	170-191	X	X										
R31	SSW, SW, WSW	192-258	X	X	X									
R32	W	259-281	X	X	X	X								
R33	WNW, NW	282-326	X		X	X								
R34	NNW	327-348	X			X								

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

Table 6-2. Evacuation Scenario Definitions

Scenario	Season[1]	Day of Week	Time of Day	Weather	Special
1	Summer	Midweek	Midday	Good	None
2	Summer	Midweek	Midday	Rain	None
3	Summer	Weekend	Midday	Good	None
4	Summer	Weekend	Midday	Rain	None
5	Summer	Midweek, Weekend	Evening	Good	None
6	Winter	Midweek	Midday	Good	None
7	Winter	Midweek	Midday	Rain/Light Snow	None
8	Winter	Midweek	Midday	Heavy Snow	None
9	Winter	Weekend	Midday	Good	None
10	Winter	Weekend	Midday	Rain/Light Snow	None
11	Winter	Weekend	Midday	Heavy Snow	None
12	Winter	Midweek, Weekend	Evening	Good	None
13	Summer	Weekend	Midday	Good	Summer Services at Laestadian Lutheran Church
14	Summer	Midweek	Midday	Good	Roadway Impact - Lane Closures on I-94 EB

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

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

Scenario	Households With Returning Commuters	Households Without Returning Commuters	Employees	Transients	Shadow	Special Events	Medical Vehicles	School Buses	Transit Buses	External Through Traffic
1	48%	52%	96%	65%	20%	0%	100%	10%	100%	100%
2	48%	52%	96%	65%	20%	0%	100%	10%	100%	100%
3	5%	95%	10%	80%	20%	0%	100%	0%	100%	100%
4	5%	95%	10%	80%	20%	0%	100%	0%	100%	100%
5	5%	95%	10%	55%	20%	0%	100%	0%	100%	40%
6	48%	52%	100%	20%	20%	0%	100%	100%	100%	100%
7	48%	52%	100%	20%	20%	0%	100%	100%	100%	100%
8	48%	52%	100%	20%	20%	0%	100%	100%	100%	100%
9	5%	95%	10%	25%	20%	0%	100%	0%	100%	100%
10	5%	95%	10%	25%	20%	0%	100%	0%	100%	100%
11	5%	95%	10%	25%	20%	0%	100%	0%	100%	100%
12	5%	95%	10%	35%	20%	0%	100%	0%	100%	40%
13	5%	95%	10%	80%	20%	100%	100%	0%	100%	100%
14	48%	52%	96%	65%	20%	0%	100%	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.
Medical Vehicles, 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 TACPs 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	Medical Vehicles	School Buses	Transit Buses	External Through Traffic	Total Scenario Vehicles[2]
1	21,617	23,275	508	746	11,169	0	89	78	68	12,608	70,158
2	21,617	23,275	508	746	11,169	0	89	78	68	12,608	70,158
3	2,162	42,730	53	918	11,057	0	89	0	68	12,608	69,685
4	2,162	42,730	53	918	11,057	0	89	0	68	12,608	69,685
5	2,162	42,730	53	631	11,057	0	89	0	68	5,043	61,833
6	21,617	23,275	529	229	11,175	0	89	776	68	12,608	70,366
7	21,617	23,275	529	229	11,175	0	89	776	68	12,608	70,366
8	21,617	23,275	529	229	11,175	0	89	776	68	12,608	70,366
9	2,162	42,730	53	287	11,057	0	89	0	68	12,608	69,054
10	2,162	42,730	53	287	11,057	0	89	0	68	12,608	69,054
11	2,162	42,730	53	287	11,057	0	89	0	68	12,608	69,054
12	2,162	42,730	53	401	11,057	0	89	0	68	5,043	61,603
13	2,162	42,730	53	918	11,057	2,000	89	0	68	12,608	71,685
14	21,617	23,275	508	746	11,169	0	89	78	68	12,608	70,158

[2] Vehicle estimates are for an evacuation of the entire EPZ (Region R03)

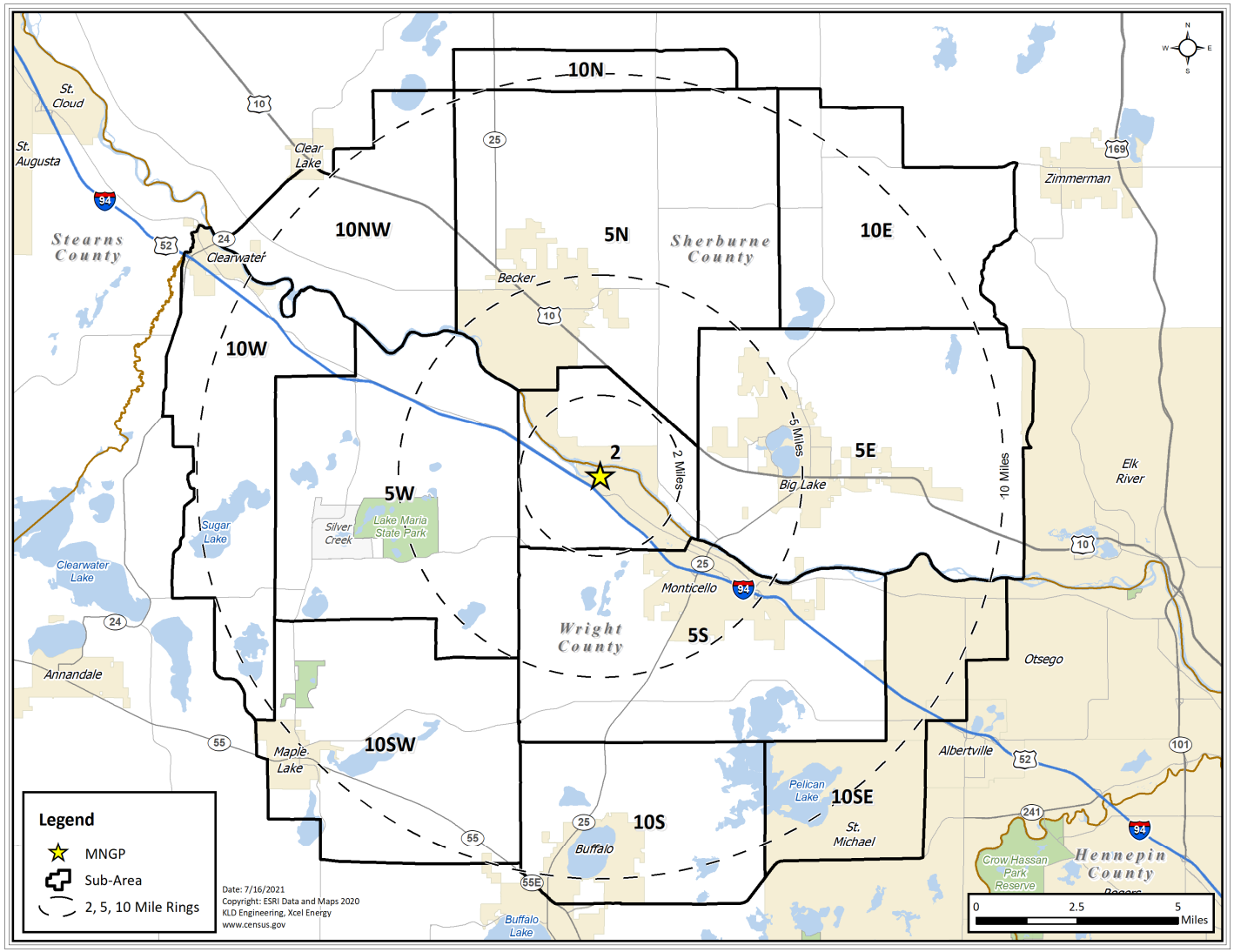


Figure 6-1. Sub-Areas Comprising the MNGP EPZ

7 GENERAL POPULATION EVACUATION TIME ESTIMATES (ETE)

This section presents the ETE results of the computer analyses using the DYNEV II System described in Appendices B, C and D. These results cover 34 regions within the MNGP 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 2-mile region in both staged and un-staged regions are presented in Table 7-3 and Table 7-4. Table 7-5 defines the Evacuation Regions considered. The tabulated values of ETE are obtained from the DYNEV II System outputs which are generated at 5-minute intervals.

7.1 Voluntary Evacuation and Shadow Evacuation

"Voluntary evacuees" are permanent residents within the EPZ in Sub-Areas for which an Advisory to Evacuate (ATE) has not been issued, yet who elect to evacuate. "Shadow evacuation" is the voluntary outward movement of some permanent residents 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 MNGP EPZ addresses the issue of voluntary evacuees in the manner shown in Figure 7-1. Within the EPZ, 20% of permanent residents located in Sub-Areas outside of the evacuation region who are not advised to evacuate, are assumed to elect to evacuate. Similarly, it is assumed that 20% of those permanent residents in the Shadow Region will choose to leave the area.

Figure 7-2 presents the area identified as the Shadow Region. This region extends radially from the plant to cover a region between the EPZ boundary and 15 miles radially from MNGP. 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 (and shown in Table 3-3), it is estimated that a total of 93,892 people reside in the Shadow Region; 20% of them would evacuate. See Table 6-4 for the number of evacuating vehicles from the Shadow Region.

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

7.2 Staged Evacuation

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

1. Sub-Areas comprising the 2-mile region are advised to evacuate immediately.

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

See Section 5.4.2 for additional information on staged evacuation.

7.3 Patterns of Traffic Congestion during Evacuation

Figure 7-3 through Figure 7-9 illustrate the patterns of traffic congestion that arise for the case when the entire EPZ (Region R03) is advised to evacuate during the winter, midweek, midday period under good weather conditions (Scenario 6).

Traffic congestion, as the term is used here, is defined as Level of Service (LOS) F. LOS F is defined as follows (HCM 2016, page 5-5):

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

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

Figure 7-3 displays congestion patterns within the study area at 45 minutes after the ATE. Congestion is developing on US-10 eastbound from Big Lake to the intersection with US-169, where LOS C and D conditions are observed. Congestion is also building in the population centers of Monticello, Big Lake, and Buffalo. LOS C conditions are observed on both I-94 eastbound in the

EPZ and shadow region towards Rogers and westbound in the EPZ and shadow region towards St. Cloud. At this time, about 15% of vehicles have mobilized and 12% of vehicles have evacuated the EPZ.

At 1 hour and 15 minutes after the ATE, traffic congestion within the study area has intensified, as shown in Figure 7-4. LOS F conditions can be observed in Big Lake, Monticello, and Buffalo within the EPZ, as well as along CR-39, US-10, and CR-4. In the shadow region, I-94 exhibits LOS F conditions in Albertville and Rogers. CR 5, CR-15, CR-11 and SR-25 northbound are all heavily utilized with Sections of roadway exhibiting LOS D or better. At this time, about 39% of vehicles have mobilized and 31% of vehicles have successfully evacuated the EPZ. The 2-mile region (Sub-Area 2) is nearly clear of congestion with the exception of a small piece of W Broadway St southbound.

Figure 7-5 displays the congestion patterns within the EPZ at 1 hour and 45 minutes after the ATE. The major evacuation routes for Buffalo (SR-55 and CR-12) and Big Lake (US-10 and CR-4 by way of 190th St northbound) experience up to LOS F conditions. Most of the congestion on I-94 eastbound is observed in the shadow region in Albertville and Rogers. Congestion on CR-39 has worsened as more residents of Monticello are using this route to evacuate. Congestion remains on SR-55 south of Buffalo in the shadow region as well. Vehicles evacuating along CR-9 and CR-45 to the north towards Princeton are also caught in LOS F conditions. At this time, about 66% of vehicles have mobilized and 53% of vehicles have successfully evacuated the EPZ.

Figure 7-6 displays the congestion patterns at 2 hours and 10 minutes after the ATE. Since TACPs were established at 2 hours, all of the capacity I-94 and US-10 is now fully available to evacuees and is no longer being shared with traffic entering the EPZ. The roads in Big Lake are still exhibiting LOS F conditions. Big Lake is the last area within 5 miles of MNGP to clear of congestion. The evacuation routes north of Big Lake are also experiencing LOS F conditions along 190th St and CR-5 in the EPZ and along CR-45 and CR-9 in the shadow region. The congestion on CR-39 has worsened. Both I-94 exhibits LOS D conditions within the EPZ but exhibits LOS F conditions in the shadow region in Albertville and Rogers. CR-37 exhibits LOS F leaving the EPZ. At the edge of the study area there is heavy congestion on SR-241 as vehicles attempt to access the already very congested I-94. At this time, about 80% of vehicles have mobilized and 69% of vehicles have successfully evacuated the EPZ.

Figure 7-7 displays the patterns of congestion at 3 hours and 5 minutes after the ATE. Congestion in Big Lake has lessened and congestion in Buffalo has nearly cleared. The congestion on SR-39 is still experiencing LOS F conditions in Sub-Area 10SE but has improved. Heavy congestion still exists on I-94, SR-241, and SR-101 in Albertville and Rogers outside of the EPZ. LOS D through F conditions are still observed near along US-10 in the shadow region. At this time, about 93% of vehicles have mobilized and 90% of vehicles have successfully evacuated the EPZ.

Figure 7-8 displays the conditions 3 hours and 45 minutes after the ATE at which time congestion is clear within the EPZ. The only visible congestion in the study area is on SR-241 (LOS F) on the approaching I-94, CR-45 northbound and CR-9 eastbound are also congested but outside of the study area. At this time, about 99% of vehicles have mobilized and 98% of vehicles have successfully evacuated the EPZ.

At 4 hours and 30 minutes after the ATE, the study area (EPZ plus shadow region) is completely clear of congestion, as shown in Figure 7-9. At this time all vehicles have mobilized, and all vehicles clear the EPZ 10 minutes later at 4 hours and 40 minutes after the ATE.

7.4 Evacuation Rates

Evacuation is a continuous process, as implied by Figure 7-10 through Figure 7-23. These figures display the rate at which traffic flows out of the indicated areas for the case of an evacuation of the full EPZ (Region R03) under the indicated conditions. One figure is presented for each scenario considered.

As indicated in Figure 7-10, 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 of mobilization time – thus minimizing evacuation time. In reality, this ideal is generally unattainable reflecting the spatial variation in population density, mobilization rates and in highway capacity over the EPZ.

7.5 Evacuation Time Estimate (ETE) Results

Table 7-1 through Table 7-2 present the ETE values for all 34 Evacuation Regions and all 14 Evacuation Scenarios. Table 7-3 through Table 7-4 present the ETE values for the 2-mile region for both staged and un-staged keyhole regions downwind to 5 miles. They are organized as follows:

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

7-4	ETE represents the elapsed time required for 100% of the population within the 2-mile Region, to evacuate from the 2-mile Region with both Concurrent and Staged Evacuations of additional Sub-Areas downwind in the keyhole Region.

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 7-9. Most of the traffic congestion is located beyond the 2-mile radius; this is reflected in the ETE statistics:

- There is no congestion within the 2-Mile Region (R01) when it evacuates alone which means that ETE is dictated by the time it takes to establish TACPs along I-94 and US-10. TACPs are established at 2 hours after the ATE, it then takes about 15 minutes, or less, for the last bit of external traffic to flow through the 2-mile region. As such, the 90th percentile ETE for this region ranges from 2:05 (hr:min) to 2:15 for all non-special scenarios.
- The 5-Mile Region (R02) experiences heavy congestion, specifically in the area of Big Lake. As a result, the 90th percentile ETE for Region R02 and Regions R08 through R10 range between 2:35 and 3:15 for non-snow scenarios (up to 3:40 for snow scenarios).
- The 90th percentile ETE for Region R03 (full EPZ) are at most 15 minutes longer than the ETE for Region R02 all scenarios, due to the congestion beyond the 5-mile radius. The 90th percentile ETE for all scenarios extending to the EPZ boundary range between 2:15 and 3:50. Those regions that contain Big Lake (Sub-Area 5E – Regions R03, and R20 through R24) are generally longer than those that do not.
- The 100th percentile ETE for the non-staged regions (Regions R01 through R25) for all scenarios is equal to the mobilization time plus a 5 to 15 minute travel time to the region boundary.

Comparison of Scenarios 3 and 13 in Table 7-1 and Table 7-2 indicates that the Special Event – summer services at Laestadian Lutheran Church – has minimal impact on the 90th percentile ETE (10 minutes at most) and has no impact on the 100th percentile ETE. During the special event, an additional 6,000 transients in 2,000 vehicles are parked on the grounds of the Laestadian Lutheran Church. There is sufficient roadway capacity to accommodate these additional vehicles.

Comparison of Scenarios 1 and 14 in Table 7-1 and Table 7-2 indicates that the roadway closure – eastbound on I-94 from a location by MNGP (between exits 183 and 193) to the end of the analysis-network at the interchange with SR-101 (exit 207) – has a significant impact on the 90th percentile ETE with increases of up to 55 minutes. The roadway closure has no impact on the 100th percentile ETE. Regions that include Sub-Areas 5S and 10SE are the most effected by the lane closure, as the evacuees from these Sub-Areas rely heavily on I-94 eastbound. With a lane closed on I-94 eastbound, the capacity of I-94 is reduced, increasing congestion and prolonging ETE. The lane closure does not impact the 100th percentile ETE because congestion clears within the EPZ at 3 hours and 45 minutes after the ATE, as discussed in Section 7.3, which is before the mobilization time which dictates the 100th percentile ETE.

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 R26 through R34 are the same geographic areas as Regions R02 and R04 through R11, respectively. The times shown in Table 7-3 and Table 7-4 are when the 2-mile region is 90% clear and 100% clear, respectively.

The objective of a staged evacuation strategy is to ensure the ETE for the 2-mile region is not significantly increased (30 minutes or 25%, whichever is less) when evacuating areas beyond 2 miles. Additionally, staged evacuation should not significantly increase the ETE for people evacuating beyond 2 miles. In all cases, as shown in these tables, the ETE for the 2-mile region is unchanged at the 90th and 100th percentiles when a staged evacuation is implemented for scenarios.

As discussed in Section 7.3, there is minimal congestion within the 2-mile region and heavy congestion in the 5-mile region. However, the congestion beyond 5 miles does not extend upstream to the extent that it penetrates within 2 miles of MNGP, so evacuees from within the 2-mile region are not impeded. Therefore, staging the evacuation provides no benefits to evacuees from within the 2-mile region.

To determine the effect of staged evacuation on residents beyond the 2-mile region, the ETE for Regions R02 and R04 through R11 are compared to Regions R26 through R34, respectively, in Table 7-1 and Table 7-2. A comparison of ETE between these similar regions reveals that staging increases the 90th percentile ETE for those in the 2 to 5-mile area by at most 50 minutes (see Table 7-1) and at most 35 minutes for the 100th percentile ETE.

The increase in the ETE is due to evacuating vehicles, beyond the 2-mile region, sheltering and delaying the start of their evacuation. As shown in Figure 5-5, staging the evacuation causes a significant “spike” (sharp increase) in mobilization (trip-generation rate) of evacuating vehicles.

In summary, the staged evacuation option provides no benefits to evacuees from within the 2-mile region, and adversely impacts some evacuees located beyond 2 miles from the plant.

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/Light Snow
    - Heavy Snow
- Special Event
    - Summer Services at Laestadian Lutheran Church
- Roadway Impact
    - Lane Closure on I-94 eastbound
- Evacuation Staging
    - No, Staged Evacuation is not considered
    - Yes, Staged Evacuation is considered

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

- The conditions of a summer evening (either midweek or weekend) and rain are not explicitly identified in the tables. For these conditions, Scenarios (2) and (4) apply.
- The conditions of a winter evening (either midweek or weekend) and rain/light snow are not explicitly identified in the tables. For these conditions, Scenarios (7) and (10) for rain/light snow apply.
- The conditions of a winter evening (either midweek or weekend) and heavy snow are not explicitly identified in the tables. For these conditions, Scenarios (8) and (11) for heavy snow apply.
- The seasons are defined as follows:
    - Summer assumes school is in session at summer school enrollment levels (lower than normal enrollment).
    - Winter (includes Spring and Autumn) considers that public schools are in session at normal enrollment levels.
- Time of Day: Midday implies the time over which most commuters are at work or are travelling to/from work.

2. With the desired percentile ETE and Scenario identified, now identify **the Evacuation Region:**
    - Determine the projected azimuth direction of the plume (coincident with the wind direction). This direction is expressed in terms of compass orientation – from N, NNE, NE – or in degrees.
    - 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:
        - 2 Miles (Region R01)
        - To 5 Miles (Region R02, R04 through R11)
        - To EPZ Boundary (Regions R03, R12 through R25)
    - Enter Table 7-5 and identify the applicable group of candidate Regions based on the distance that the selected Region extends from MNGP. 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 through Table 7-4 are labeled with the Scenario numbers. Identify the proper column in the selected Table using the Scenario number defined in Step 1.
   - Identify the row in this table that provides ETE values for the Region identified in Step 2.
   - The unique data cell defined by the column and row so determined contains the desired value of ETE expressed in Hours:Minutes.

Example

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

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

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

1. Identify the Scenario as summer, weekend, evening and raining. Entering Table 7-1, it is seen that there is no match for these descriptors. However, the clarification given above assigns this combination of circumstances to **Scenario 4**.
2. Enter Table 7-5 and locate the Region described as "Evacuate 2-Mile Region and Downwind to the EPZ Boundary" for wind direction from NE and read **Region R13** 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 R13. This data cell is in column (4) and in the row for Region R13; it contains the ETE value of **2:30**.

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

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Region	Midday		Midday		Evening	Midday			Midday			Evening	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region, 5-Mile Region, and EPZ														
R01	2:05	2:10	2:05	2:05	2:05	2:05	2:10	2:15	2:05	2:05	2:10	2:05	2:05	2:35
R02	2:50	3:00	2:35	2:45	2:35	2:55	3:00	3:35	2:35	2:45	3:25	2:35	2:45	3:15
R03	3:05	3:10	2:50	3:00	2:45	3:05	3:10	3:45	2:50	3:00	3:35	2:45	2:55	3:25
2-Mile Region and Keyhole to 5 Miles														
R04	2:25	2:25	2:15	2:20	2:20	2:25	2:25	3:00	2:15	2:20	2:45	2:20	2:20	3:10
R05	2:10	2:10	2:10	2:10	2:10	2:10	2:10	2:20	2:10	2:10	2:15	2:10	2:15	2:35
R06	2:20	2:20	2:10	2:15	2:15	2:20	2:20	2:50	2:10	2:15	2:30	2:15	2:20	2:40
R07	2:15	2:15	2:10	2:10	2:15	2:15	2:15	2:40	2:10	2:10	2:25	2:15	2:10	2:40
R08	2:50	3:00	2:40	2:50	2:40	2:55	3:00	3:35	2:40	2:50	3:25	2:40	2:40	3:00
R09	2:50	3:00	2:35	2:45	2:35	2:55	3:00	3:35	2:35	2:45	3:25	2:35	2:35	3:15
R10	2:50	3:00	2:40	2:50	2:40	2:55	3:00	3:40	2:40	2:50	3:25	2:40	2:40	3:20
R11	2:20	2:25	2:15	2:20	2:20	2:20	2:25	3:00	2:15	2:20	2:45	2:20	2:15	3:15
2-Mile Region and Keyhole to EPZ Boundary														
R12	2:45	2:55	2:30	2:40	2:35	2:50	2:55	3:30	2:30	2:40	3:20	2:35	2:40	3:25
R13	2:40	2:40	2:25	2:30	2:30	2:40	2:40	3:25	2:25	2:30	3:05	2:30	2:35	3:15
R14	2:30	2:30	2:20	2:25	2:25	2:30	2:30	3:10	2:20	2:25	2:50	2:25	2:25	3:10
R15	2:20	2:20	2:15	2:15	2:20	2:20	2:20	2:50	2:15	2:15	2:30	2:20	2:20	2:35
R16	2:25	2:25	2:15	2:15	2:20	2:25	2:25	3:00	2:15	2:15	2:40	2:20	2:25	2:40
R17	2:25	2:25	2:15	2:15	2:20	2:25	2:25	3:05	2:15	2:20	2:40	2:20	2:25	2:45
R18	2:20	2:20	2:15	2:15	2:20	2:20	2:20	2:55	2:15	2:15	2:35	2:20	2:20	2:40
R19	2:30	2:30	2:15	2:20	2:25	2:30	2:30	3:10	2:15	2:20	2:50	2:25	2:15	2:30
R20	3:10	3:10	2:55	3:00	2:50	3:15	3:15	3:50	2:55	3:05	3:40	2:50	2:55	3:10
R21	3:10	3:10	2:55	3:00	2:50	3:15	3:15	3:50	2:55	3:00	3:45	2:50	2:55	3:10
R22	3:05	3:10	2:50	3:00	2:40	3:05	3:10	3:45	2:50	3:00	3:35	2:40	2:50	3:25
R23	2:55	3:05	2:45	3:00	2:40	2:55	3:10	3:45	2:45	3:00	3:30	2:40	2:45	3:25
R24	3:00	3:10	2:50	3:00	2:45	3:00	3:15	3:50	2:50	3:00	3:35	2:45	2:50	3:25
R25	2:45	2:55	2:30	2:40	2:35	2:45	3:00	3:30	2:30	2:40	3:20	2:35	2:30	3:30

Staged Evacuation - 2-Mile Region and Keyhole to 5 Miles														
R26	3:20	3:25	3:15	3:25	3:20	3:25	3:30	4:00	3:15	3:20	3:55	3:20	3:15	3:35
R27	2:55	3:00	2:50	2:50	2:55	2:55	3:00	3:20	2:50	2:55	3:15	2:55	3:00	3:25
R28	2:15	2:20	2:15	2:15	2:20	2:15	2:20	2:35	2:15	2:15	2:30	2:20	2:15	2:35
R29	2:40	2:40	2:35	2:35	2:45	2:40	2:40	3:10	2:35	2:35	3:00	2:45	2:40	2:50
R30	2:35	2:40	2:30	2:35	2:45	2:35	2:40	3:05	2:30	2:35	3:00	2:45	2:30	2:50
R31	3:25	3:35	3:20	3:30	3:30	3:25	3:35	4:10	3:20	3:30	4:05	3:30	3:20	3:25
R32	3:25	3:30	3:15	3:25	3:20	3:25	3:30	4:00	3:15	3:25	3:55	3:20	3:15	3:40
R33	3:25	3:30	3:20	3:25	3:25	3:25	3:35	4:05	3:20	3:25	4:00	3:25	3:20	3:45
R34	2:55	2:55	2:50	2:50	2:55	2:55	2:55	3:20	2:50	2:50	3:15	2:55	2:50	3:25

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

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Region	Midday		Midday		Evening	Midday			Midday			Evening	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region, 5-Mile Region, and EPZ														
R01	4:35	4:35	4:30	4:30	4:30	4:35	4:35	5:30	4:30	4:30	5:30	4:30	4:30	4:35
R02	4:40	4:40	4:35	4:35	4:35	4:40	4:40	5:35	4:35	4:35	5:35	4:35	4:35	4:40
R03	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	4:40	4:40
2-Mile Region and Keyhole to 5 Miles														
R04	4:40	4:40	4:35	4:35	4:35	4:40	4:40	5:35	4:35	4:35	5:35	4:35	4:35	4:40
R05	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	4:35	4:35
R06	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	4:35	4:35
R07	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	4:35	4:35
R08	4:40	4:40	4:35	4:35	4:35	4:40	4:40	5:35	4:35	4:35	5:35	4:35	4:35	4:40
R09	4:40	4:40	4:35	4:35	4:35	4:40	4:40	5:35	4:35	4:35	5:35	4:35	4:35	4:40
R10	4:40	4:40	4:35	4:35	4:35	4:40	4:40	5:35	4:35	4:35	5:35	4:35	4:35	4:40
R11	4:40	4:40	4:35	4:35	4:35	4:40	4:40	5:35	4:35	4:35	5:35	4:35	4:35	4:40
2-Mile Region and Keyhole to EPZ Boundary														
R12	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	4:40	4:40
R13	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	4:40	4:40
R14	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	4:40	4:40
R15	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	4:40	4:40
R16	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	4:40	4:40
R17	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	4:40	4:40
R18	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	4:40	4:40
R19	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	4:40	4:40
R20	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	4:40	4:40
R21	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	4:40	4:40
R22	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	4:40	4:40
R23	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	4:40	4:40
R24	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	4:40	4:40
R25	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	4:40	4:40

Staged Evacuation - 2-Mile Region and Keyhole to 5 Miles														
R26	5:00	5:10	5:00	5:10	4:55	5:05	5:10	5:45	5:00	5:05	5:45	4:55	5:00	5:00
R27	4:40	4:40	4:35	4:35	4:35	4:40	4:40	5:35	4:35	4:35	5:35	4:35	4:35	4:40
R28	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	4:35	4:35
R29	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	4:35	4:35
R30	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	4:35	4:35
R31	5:00	5:10	5:00	5:05	4:55	5:05	5:10	5:55	5:00	5:05	5:40	4:55	5:00	5:00
R32	5:00	5:10	5:00	5:05	4:55	5:05	5:15	5:55	5:00	5:05	5:45	4:55	5:00	5:00
R33	5:00	5:10	5:00	5:05	4:55	5:05	5:15	5:45	5:00	5:05	5:45	4:55	5:00	5:00
R34	4:40	4:40	4:35	4:35	4:35	4:40	4:40	5:35	4:35	4:35	5:35	4:35	4:35	4:40

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

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region and 5-Mile Region														
R01	2:05	2:10	2:05	2:05	2:05	2:05	2:10	2:15	2:05	2:05	2:10	2:05	2:05	2:35
R02	2:05	2:10	2:05	2:05	2:05	2:05	2:10	2:15	2:05	2:05	2:10	2:05	2:05	3:00
Unstaged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R04	2:05	2:10	2:05	2:05	2:05	2:05	2:10	2:15	2:05	2:05	2:10	2:05	2:05	2:55
R05	2:05	2:10	2:05	2:05	2:05	2:05	2:10	2:15	2:05	2:05	2:10	2:05	2:05	2:35
R06	2:05	2:10	2:05	2:05	2:05	2:05	2:10	2:15	2:05	2:05	2:10	2:05	2:05	2:35
R07	2:05	2:10	2:05	2:05	2:05	2:05	2:10	2:15	2:05	2:05	2:10	2:05	2:05	2:35
R08	2:05	2:10	2:05	2:05	2:05	2:05	2:10	2:15	2:05	2:05	2:10	2:05	2:05	2:35
R09	2:05	2:10	2:05	2:05	2:05	2:05	2:10	2:15	2:05	2:05	2:10	2:05	2:05	3:00
R10	2:05	2:10	2:05	2:05	2:05	2:05	2:10	2:15	2:05	2:05	2:10	2:05	2:05	2:55
R11	2:05	2:10	2:05	2:05	2:05	2:05	2:10	2:15	2:05	2:05	2:10	2:05	2:05	3:00
Staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R26	2:05	2:10	2:05	2:05	2:05	2:05	2:10	2:15	2:05	2:05	2:10	2:05	2:05	2:35
R27	2:05	2:10	2:05	2:05	2:05	2:05	2:10	2:15	2:05	2:05	2:10	2:05	2:05	2:35
R28	2:05	2:10	2:05	2:05	2:05	2:05	2:10	2:15	2:05	2:05	2:10	2:05	2:05	2:35
R29	2:05	2:10	2:05	2:05	2:05	2:05	2:10	2:15	2:05	2:05	2:10	2:05	2:05	2:35
R30	2:05	2:10	2:05	2:05	2:05	2:05	2:10	2:15	2:05	2:05	2:10	2:05	2:05	2:35
R31	2:05	2:10	2:05	2:05	2:05	2:05	2:10	2:15	2:05	2:05	2:10	2:05	2:05	2:35
R32	2:05	2:10	2:05	2:05	2:05	2:05	2:10	2:15	2:05	2:05	2:10	2:05	2:05	2:35
R33	2:05	2:10	2:05	2:05	2:05	2:05	2:10	2:15	2:05	2:05	2:10	2:05	2:05	2:35
R34	2:05	2:10	2:05	2:05	2:05	2:05	2:10	2:15	2:05	2:05	2:10	2:05	2:05	2:35

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

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region and 5-Mile Region														
R01	4:35	4:35	4:30	4:30	4:30	4:35	4:35	5:30	4:30	4:30	5:30	4:30	4:30	4:35
R02	4:35	4:35	4:30	4:30	4:30	4:35	4:35	5:30	4:30	4:30	5:30	4:30	4:30	4:35
Unstaged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R04	4:35	4:35	4:30	4:30	4:30	4:35	4:35	5:30	4:30	4:30	5:30	4:30	4:30	4:35
R05	4:35	4:35	4:30	4:30	4:30	4:35	4:35	5:30	4:30	4:30	5:30	4:30	4:30	4:35
R06	4:35	4:35	4:30	4:30	4:30	4:35	4:35	5:30	4:30	4:30	5:30	4:30	4:30	4:35
R07	4:35	4:35	4:30	4:30	4:30	4:35	4:35	5:30	4:30	4:30	5:30	4:30	4:30	4:35
R08	4:35	4:35	4:30	4:30	4:30	4:35	4:35	5:30	4:30	4:30	5:30	4:30	4:30	4:35
R09	4:35	4:35	4:30	4:30	4:30	4:35	4:35	5:30	4:30	4:30	5:30	4:30	4:30	4:35
R10	4:35	4:35	4:30	4:30	4:30	4:35	4:35	5:30	4:30	4:30	5:30	4:30	4:30	4:35
R11	4:35	4:35	4:30	4:30	4:30	4:35	4:35	5:30	4:30	4:30	5:30	4:30	4:30	4:35
Staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R26	4:35	4:35	4:30	4:30	4:30	4:35	4:35	5:30	4:30	4:30	5:30	4:30	4:30	4:35
R27	4:35	4:35	4:30	4:30	4:30	4:35	4:35	5:30	4:30	4:30	5:30	4:30	4:30	4:35
R28	4:35	4:35	4:30	4:30	4:30	4:35	4:35	5:30	4:30	4:30	5:30	4:30	4:30	4:35
R29	4:35	4:35	4:30	4:30	4:30	4:35	4:35	5:30	4:30	4:30	5:30	4:30	4:30	4:35
R30	4:35	4:35	4:30	4:30	4:30	4:35	4:35	5:30	4:30	4:30	5:30	4:30	4:30	4:35
R31	4:35	4:35	4:30	4:30	4:30	4:35	4:35	5:30	4:30	4:30	5:30	4:30	4:30	4:35
R32	4:35	4:35	4:30	4:30	4:30	4:35	4:35	5:35	4:30	4:30	5:30	4:30	4:30	4:35
R33	4:35	4:35	4:30	4:30	4:30	4:35	4:35	5:35	4:30	4:30	5:30	4:30	4:30	4:35
R34	4:35	4:35	4:30	4:30	4:30	4:35	4:35	5:35	4:30	4:30	5:30	4:30	4:30	4:35

Table 7-5. Description of Evacuation Regions

Radial Regions													
Region	**Description**	**Wind From (in Degrees)**	**Sub-Area**										
			2	**5N**	**5E**	**5S**	**5W**	**10N**	**10E**	**10SE**	**10S**	**10SW**	**10W**	**10NW**
R01	2-Mile Region	N/A	X											
R02	5-Mile Region	N/A	X	X	X	X	X							
R03	Full EPZ	N/A	X	X	X	X	X	X	X	X	X	X	X	X
Evacuate 2-Mile Region and Downwind to 5 Miles														
Region	**Wind Direction From**	**Wind From (in Degrees)**	**Sub-Area**											
			2	**5N**	**5E**	**5S**	**5W**	**10N**	**10E**	**10SE**	**10S**	**10SW**	**10W**	**10NW**
R04	N, NNE, NE, ENE	349-78	X			X	X							
R05	E	79-101	X				X							
R06	ESE, SE, SSE	102-169	X	X			X							
R07	S	170-191	X	X										
R08	SSW, SW, WSW	192-258	X	X	X									
R09	W	259-281	X	X	X	X								
R10	WNW, NW	282-326	X		X	X								
R11	NNW	327-348	X			X								

Evacuate 2-Mile Region and Downwind to the EPZ Boundary													
Region	**Wind Direction From**	**Wind From (in Degrees)**	**Sub-Area**										
			2	**5N**	**5E**	**5S**	**5W**	**10N**	**10E**	**10SE**	**10S**	**10SW**	**10W**	**10NW**
R12	N	349-11	X			X	X			X	X	X		
R13	NNE, NE	12-56	X			X	X				X	X	X	
R14	ENE	57-78	X			X	X					X	X	
R15	E	79-101	X				X					X	X	X
R16	ESE	102-124	X	X			X						X	X
R17	SE	125-146	X	X			X	X					X	X
R18	SSE	147-169	X	X			X	X						X
R19	S	170-191	X	X				X	X					X
R20	SSW, SW	192-236	X	X	X			X	X					
R21	WSW	237-258	X	X	X				X					
R22	W	259-281	X	X	X	X			X	X				
R23	WNW	282-303	X		X	X				X				
R24	NW	304-326	X		X	X				X	X			
R25	NNW	327-348	X			X				X	X			
Staged Evacuation - 2-Mile Region Evacuates, then Evacuate Downwind to 5 Miles													
Region	**Wind Direction From**	**Wind From (in Degrees)**	**Sub-Area**										
			2	**5N**	**5E**	**5S**	**5W**	**10N**	**10E**	**10SE**	**10S**	**10SW**	**10W**	**10NW**
R26	N/A	5-Mile Region	X	X	X	X	X							
R27	N, NNE, NE, ENE	349-78	X			X	X							
R28	E	79-101	X				X							
R29	ESE, SE, SSE	102-169	X	X			X							
R30	S	170-191	X	X										
R31	SSW, SW, WSW	192-258	X	X	X									
R32	W	259-281	X	X	X	X								
R33	WNW, NW	282-326	X		X	X								
R34	NNW	327-348	X			X								

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



Figure 7-1. Voluntary Evacuation Methodology

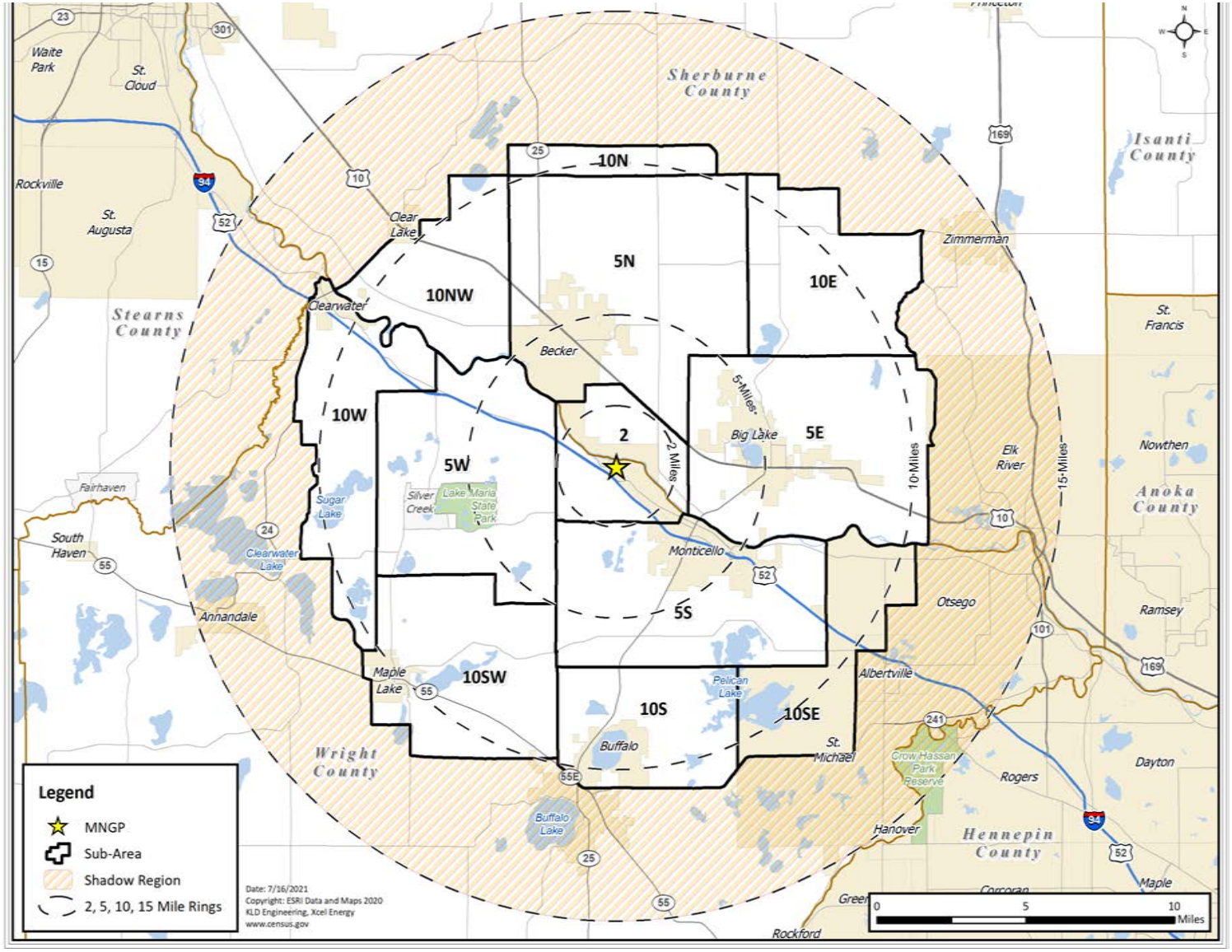


Figure 7-2. MNGP Shadow Region

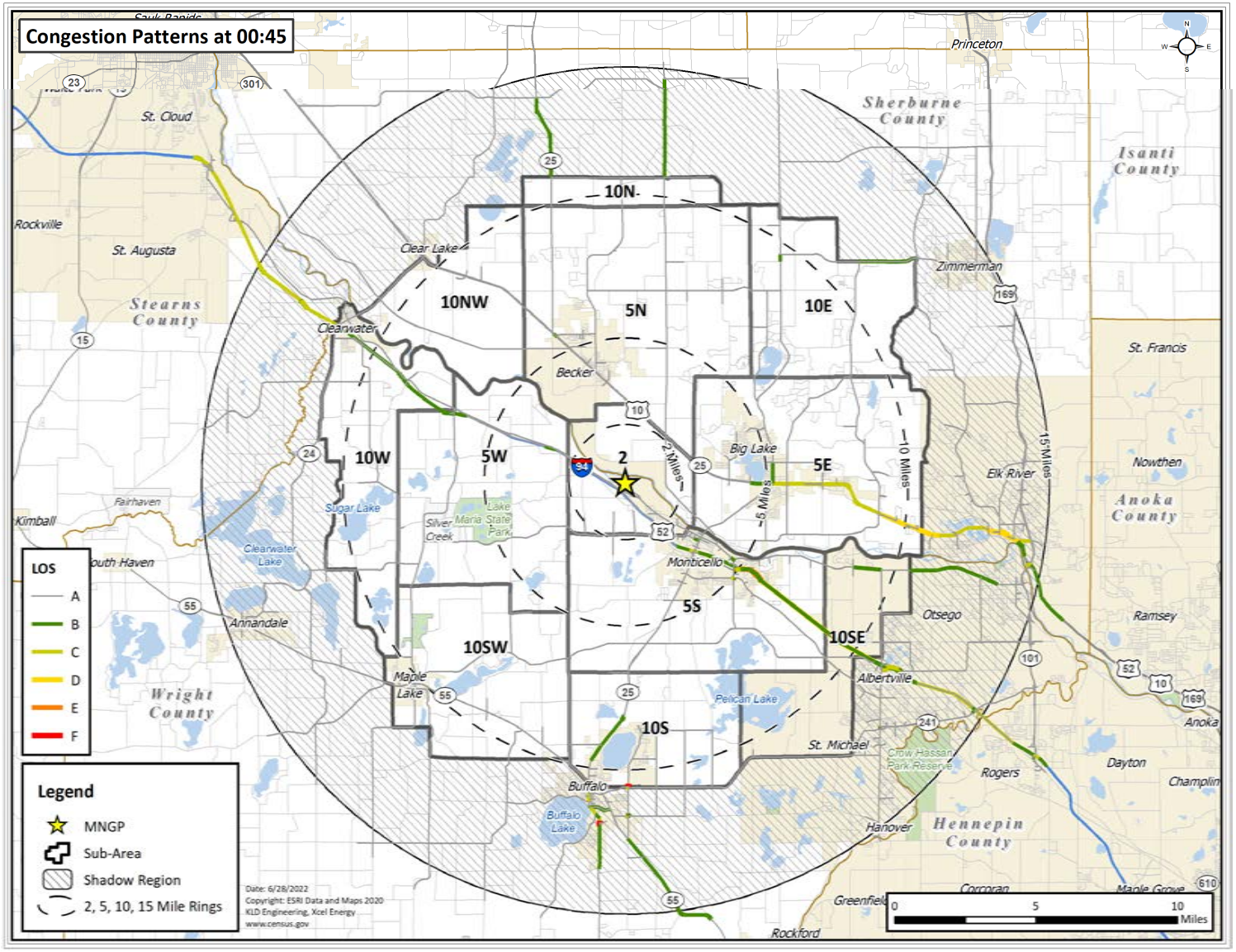


Figure 7-3. Congestion Patterns at 45 Minutes after the Advisory to Evacuate

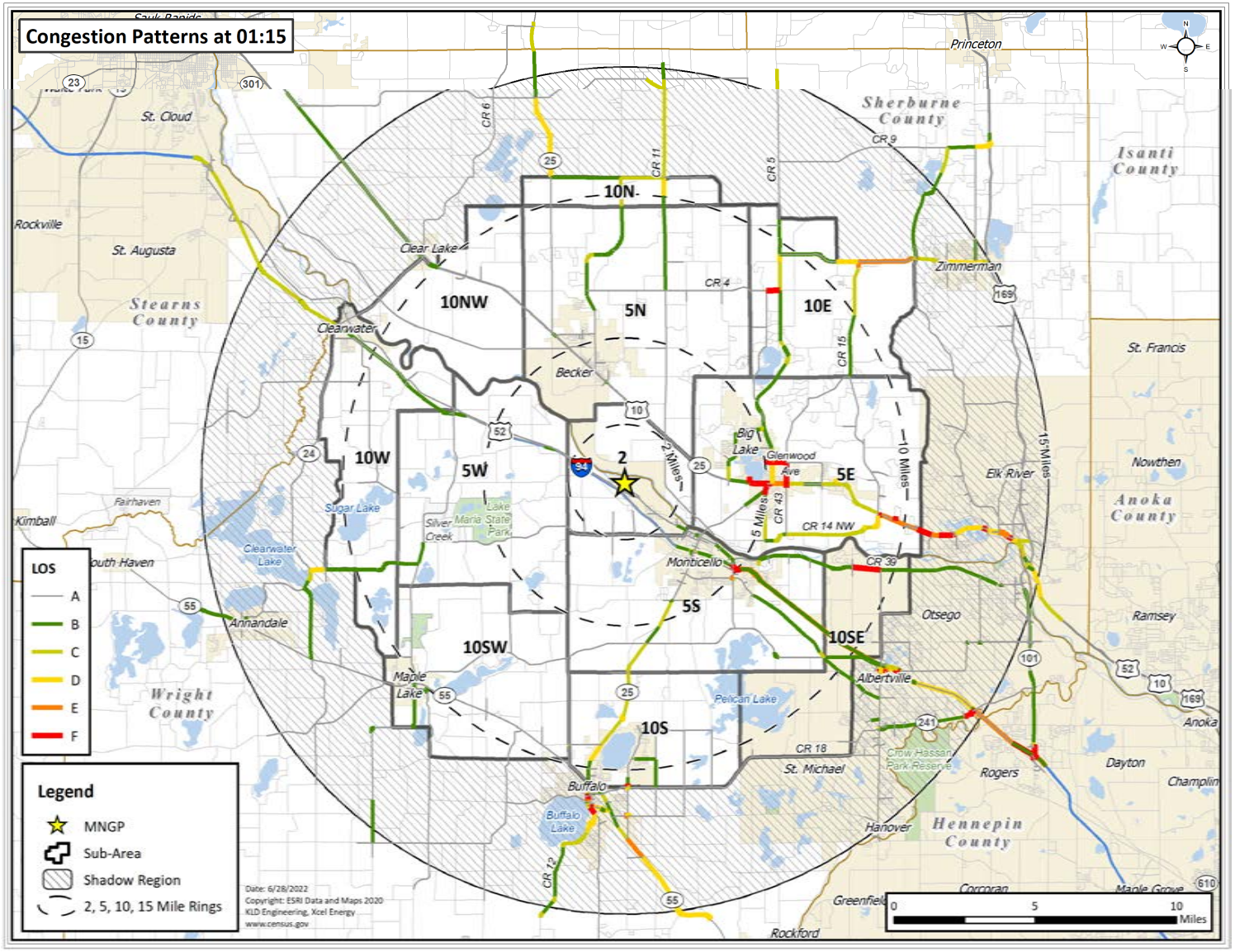


Figure 7-4. Congestion Patterns at 1 Hour and 15 minutes after the Advisory to Evacuate

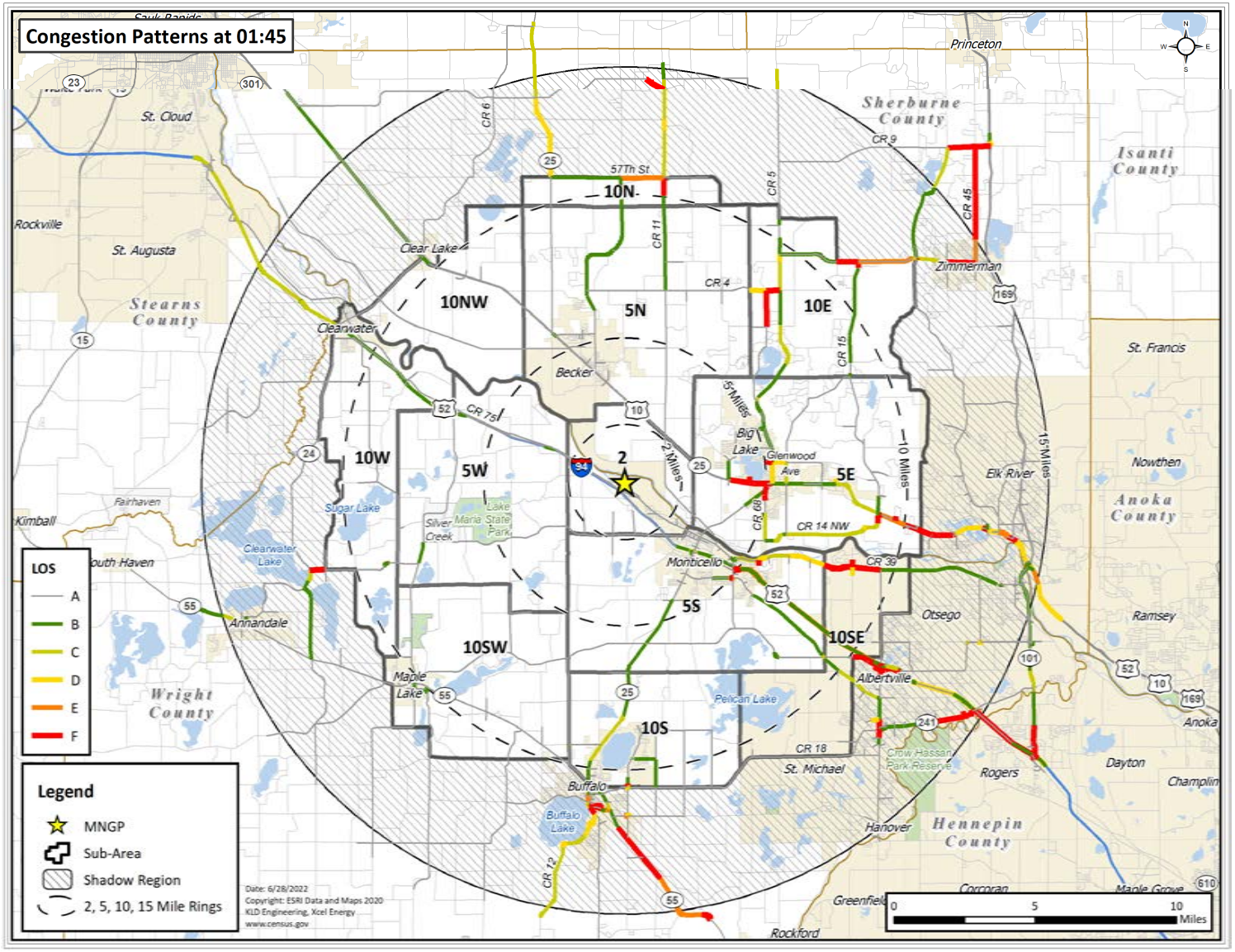


Figure 7-5. Congestion Patterns at 1 Hour and 45 Minutes after the Advisory to Evacuate

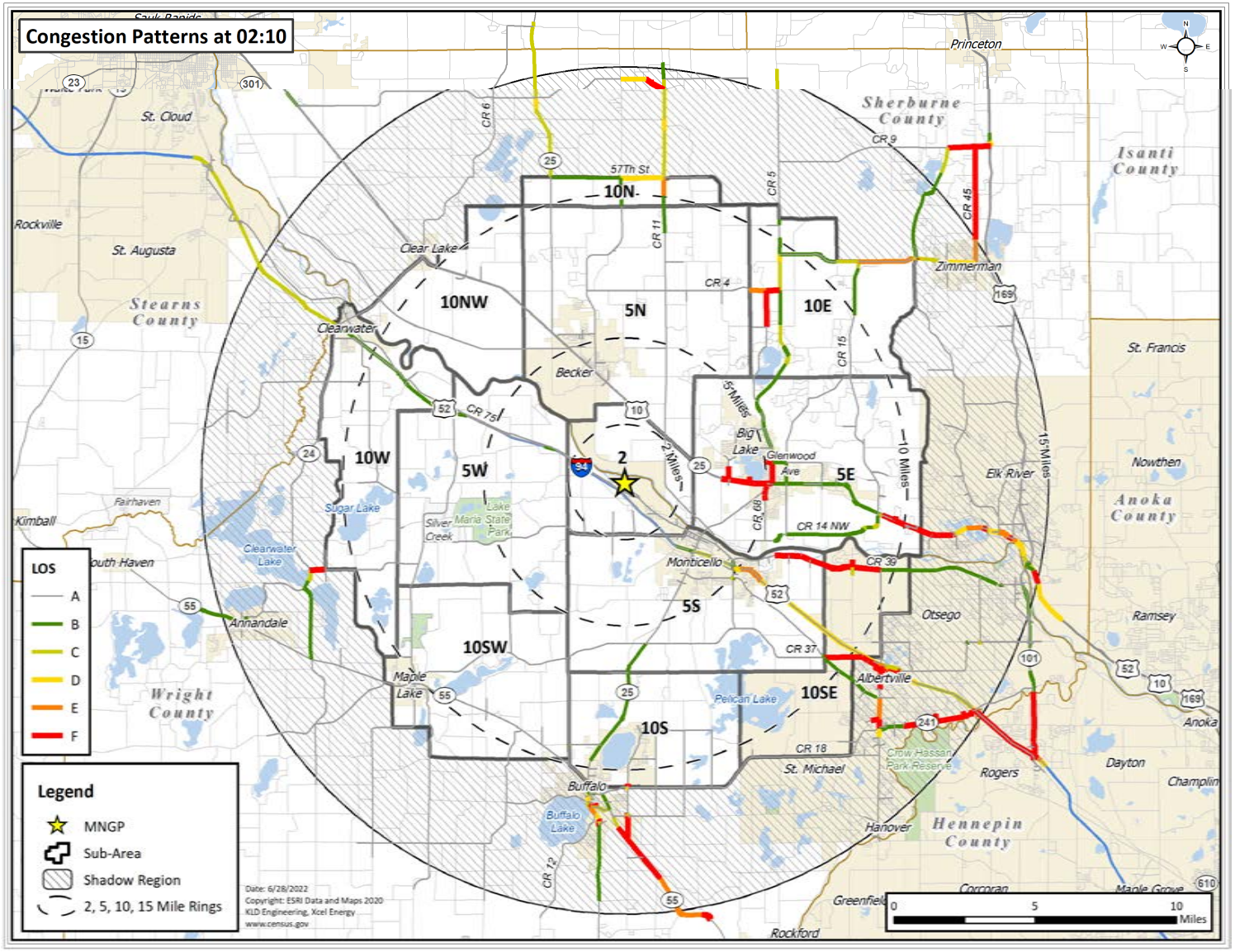


Figure 7-6. Congestion Patterns at 2 Hours and 10 minutes after the Advisory to Evacuate

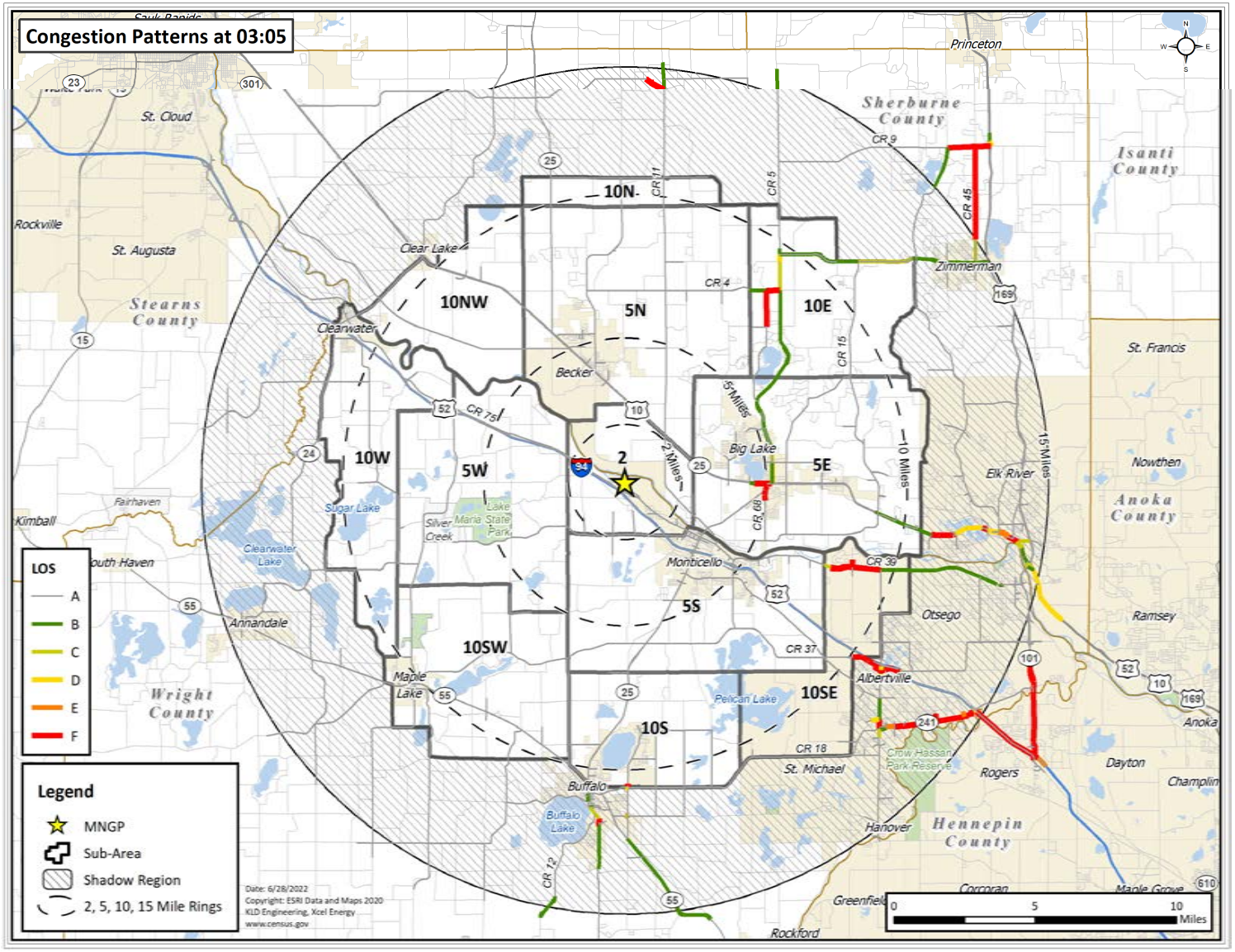


Figure 7-7. Congestion Patterns at 3 Hours and 5 Minutes after the Advisory to Evacuate

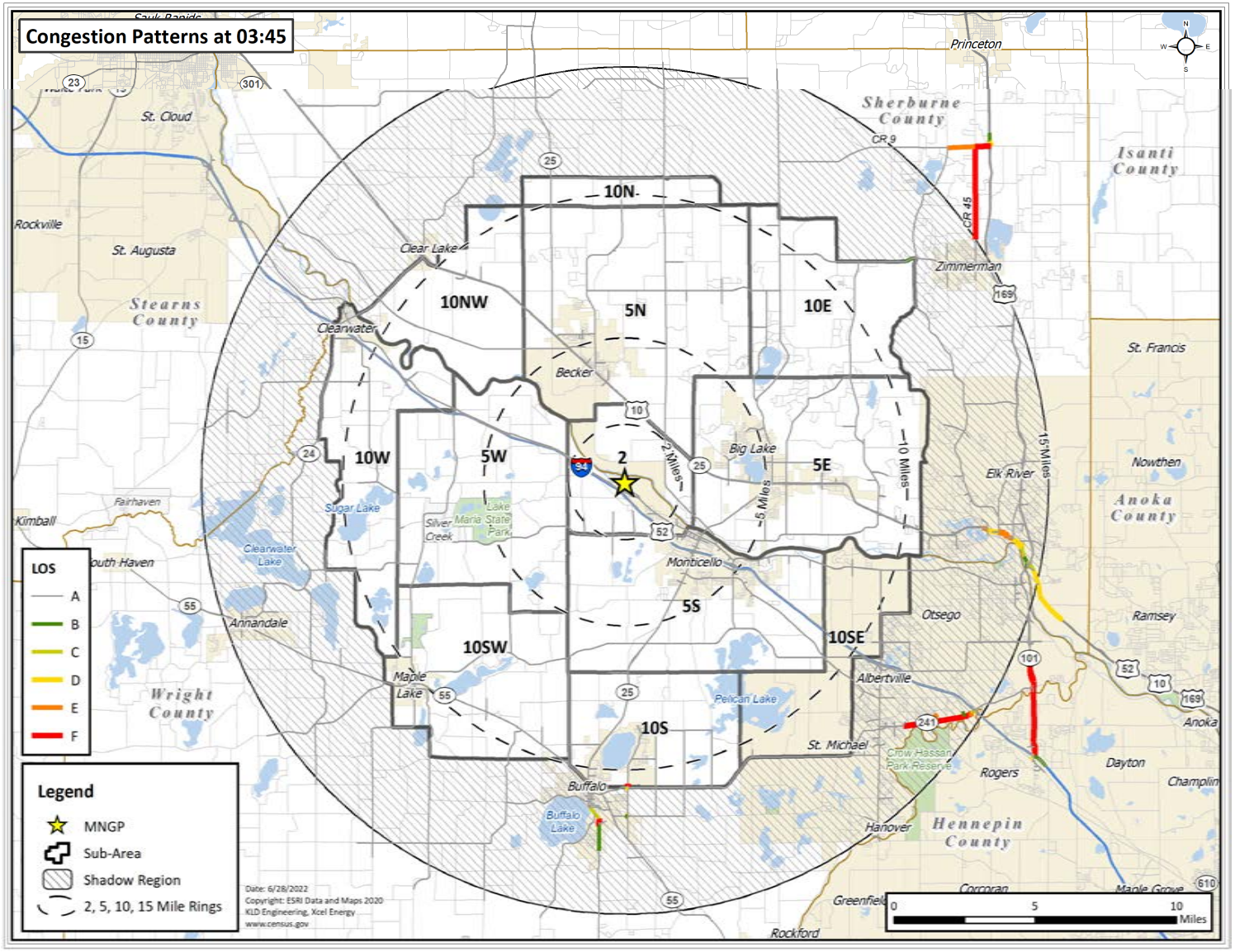


Figure 7-8. Congestion Patterns at 3 Hours 45 Minutes after the Advisory to Evacuate

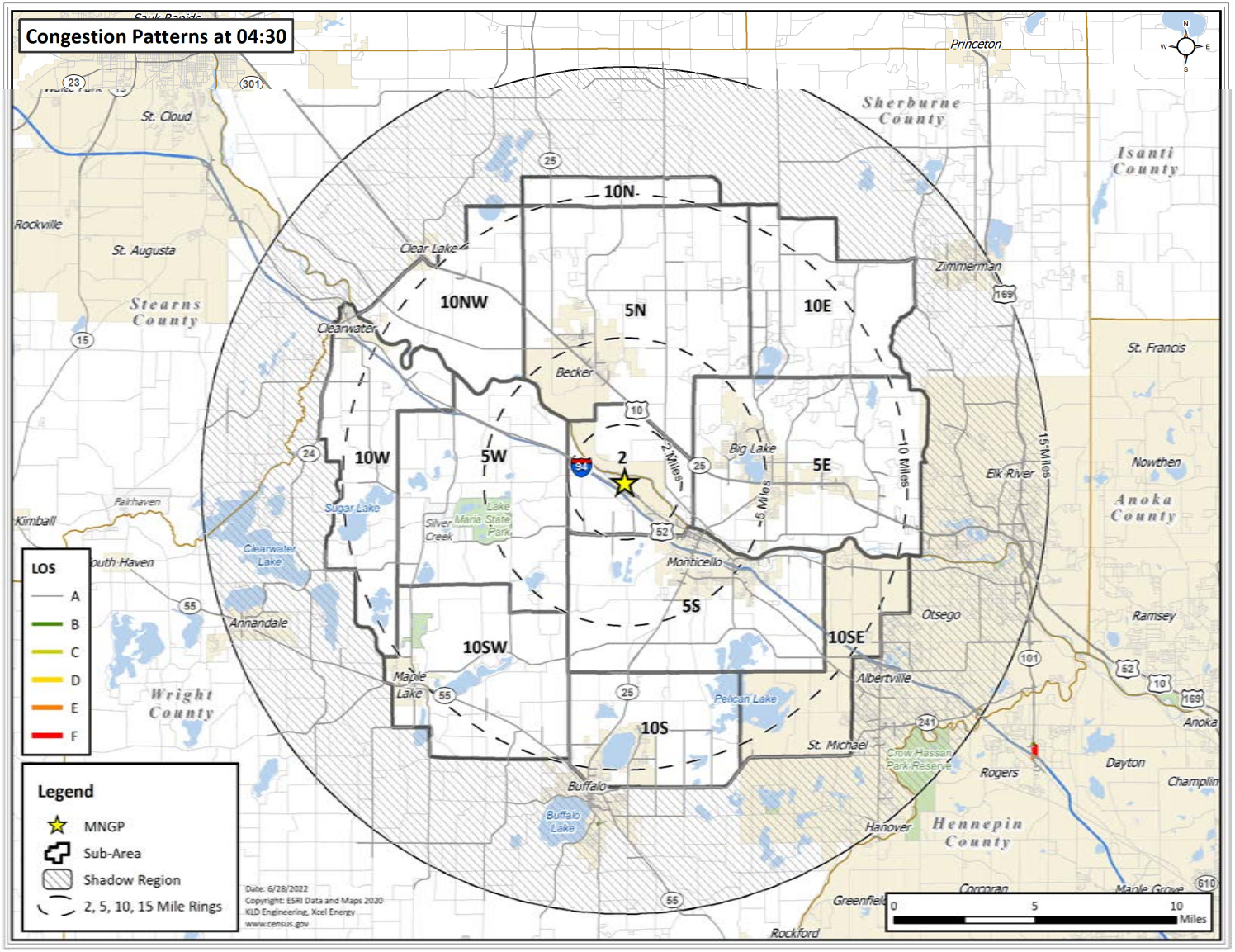


Figure 7-9. Congestion Patterns at 4 Hours 30 Minutes after the Advisory to Evacuate

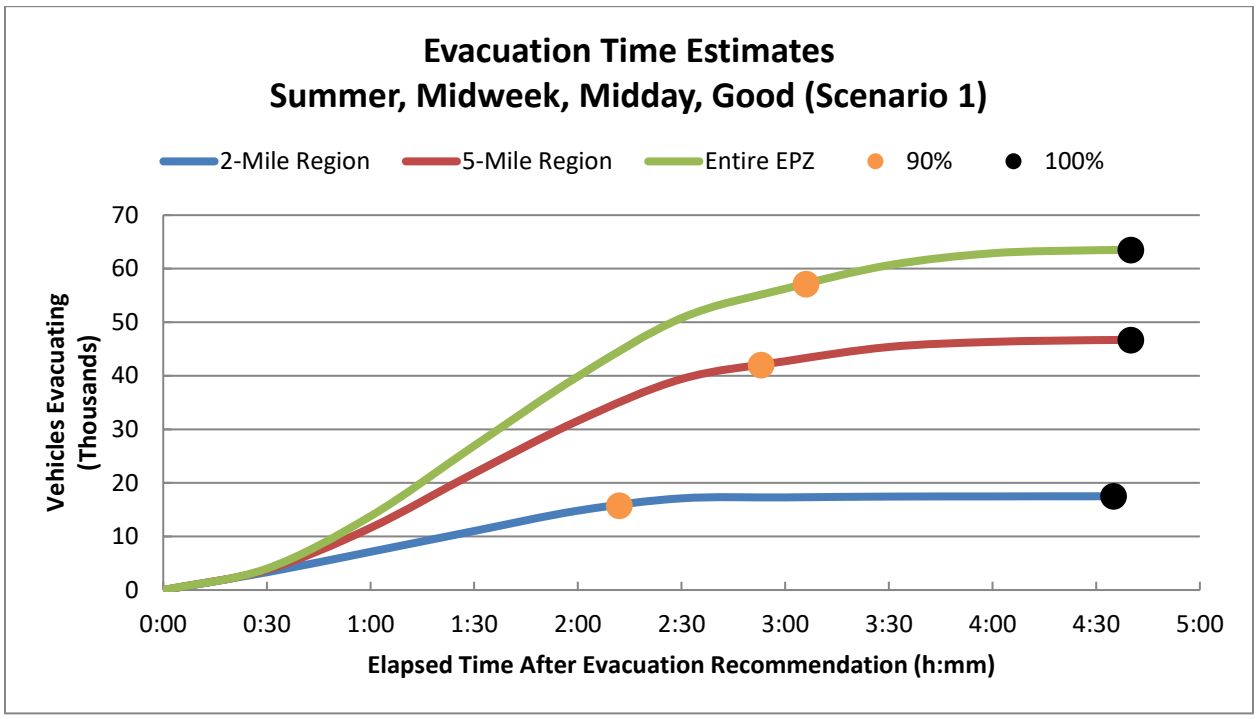


Figure 7-10. Evacuation Time Estimates - Scenario 1 for Region R03

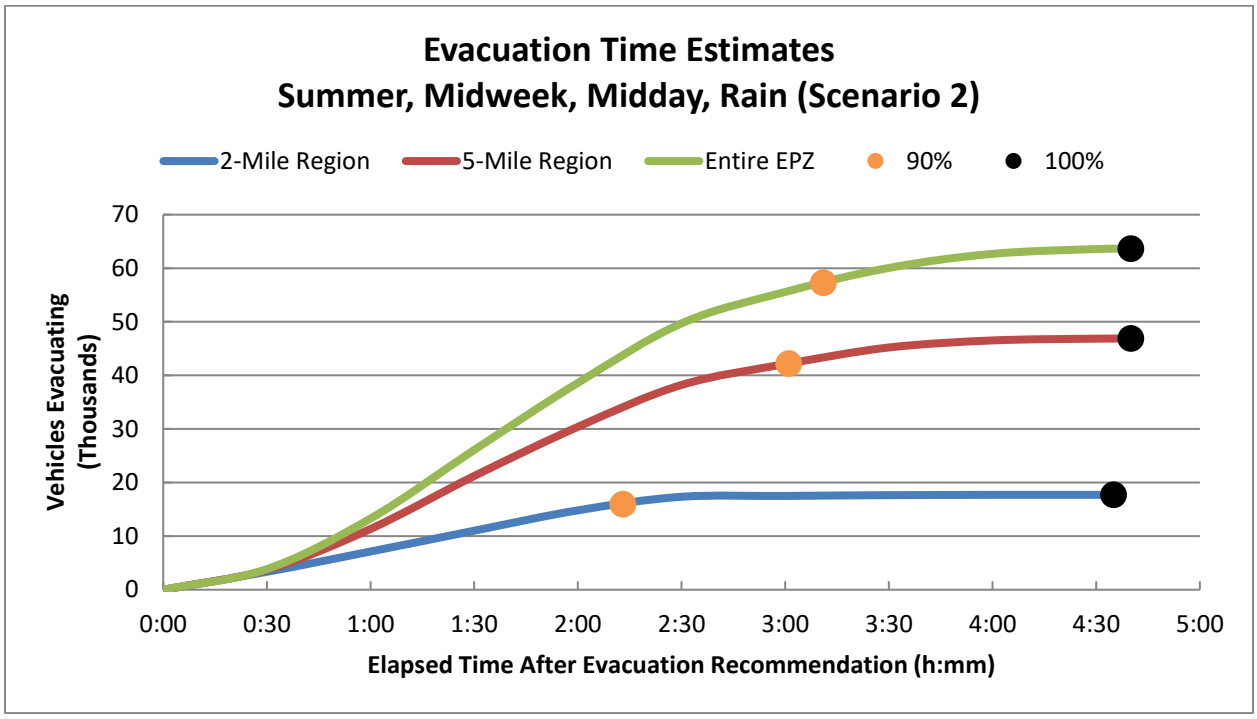


Figure 7-11. Evacuation Time Estimates - Scenario 2 for Region R03

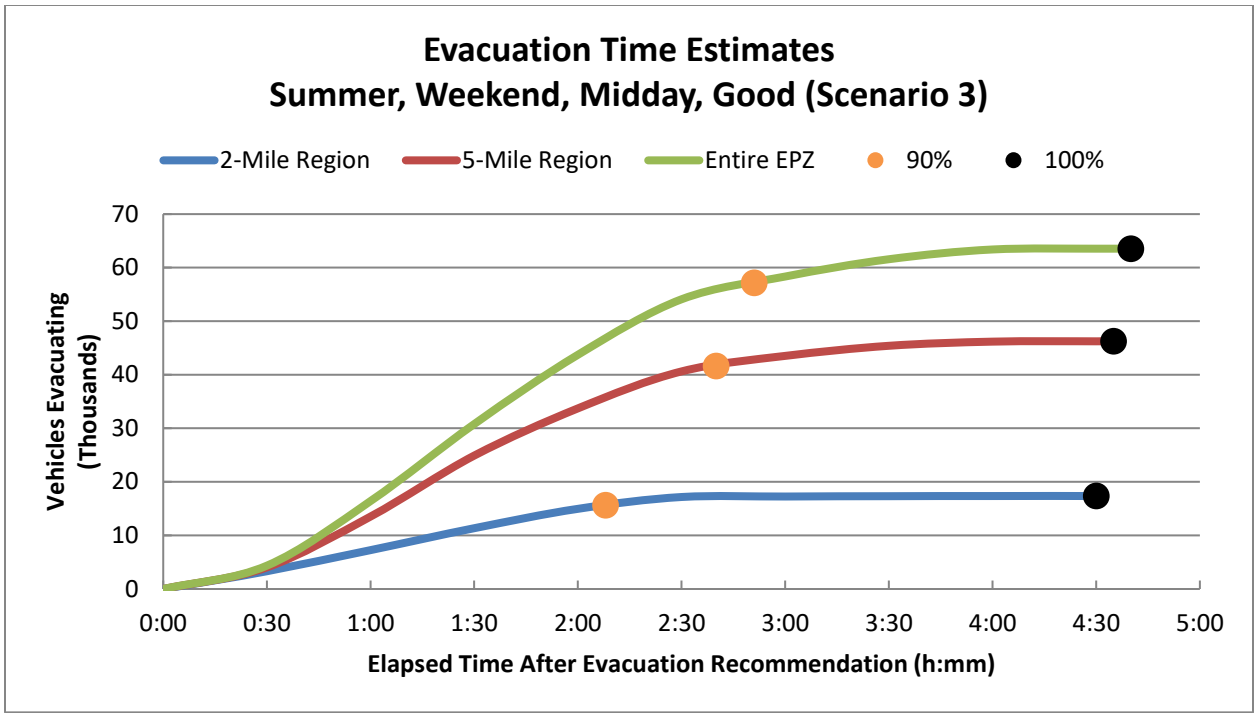


Figure 7-12. Evacuation Time Estimates - Scenario 3 for Region R03

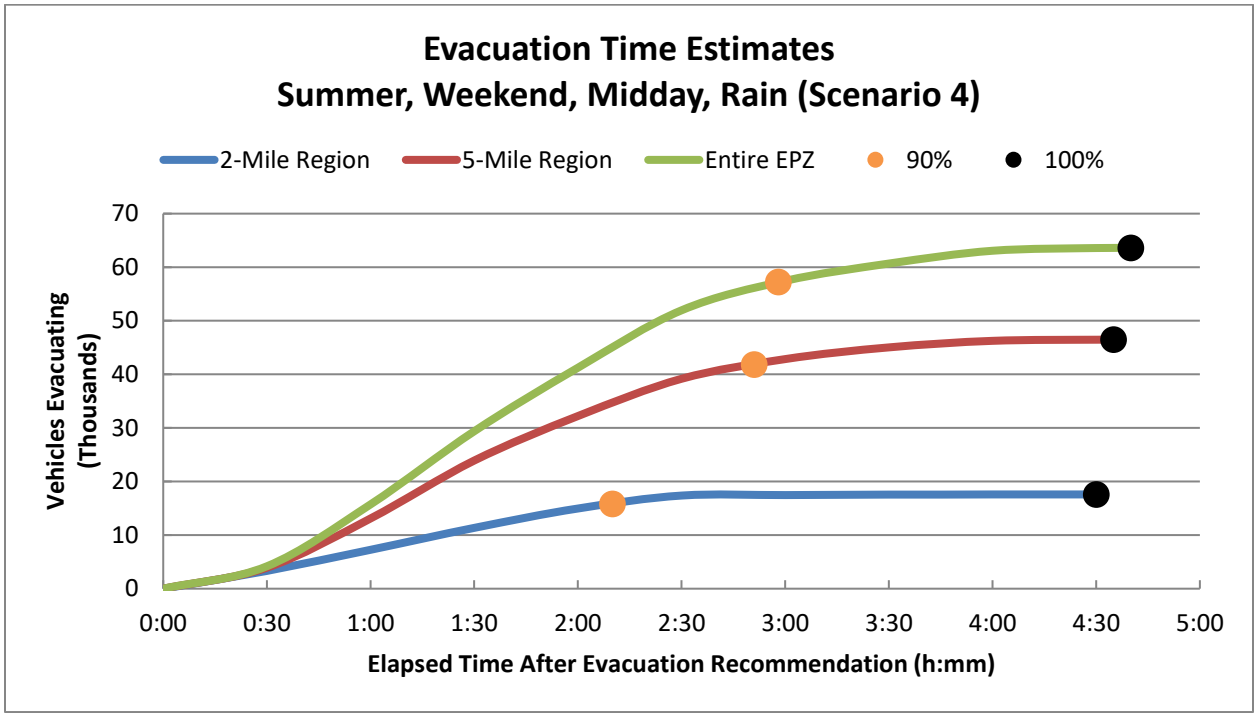


Figure 7-13. Evacuation Time Estimates - Scenario 4 for Region R03

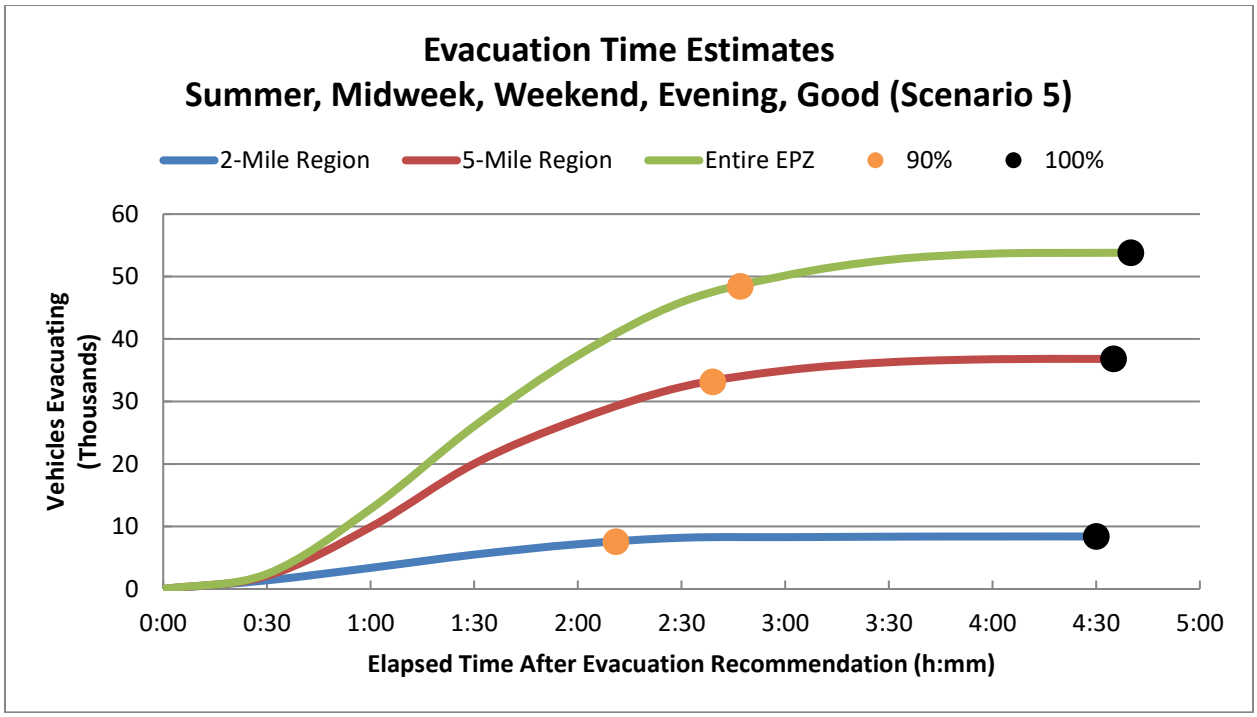


Figure 7-14. Evacuation Time Estimates - Scenario 5 for Region R03

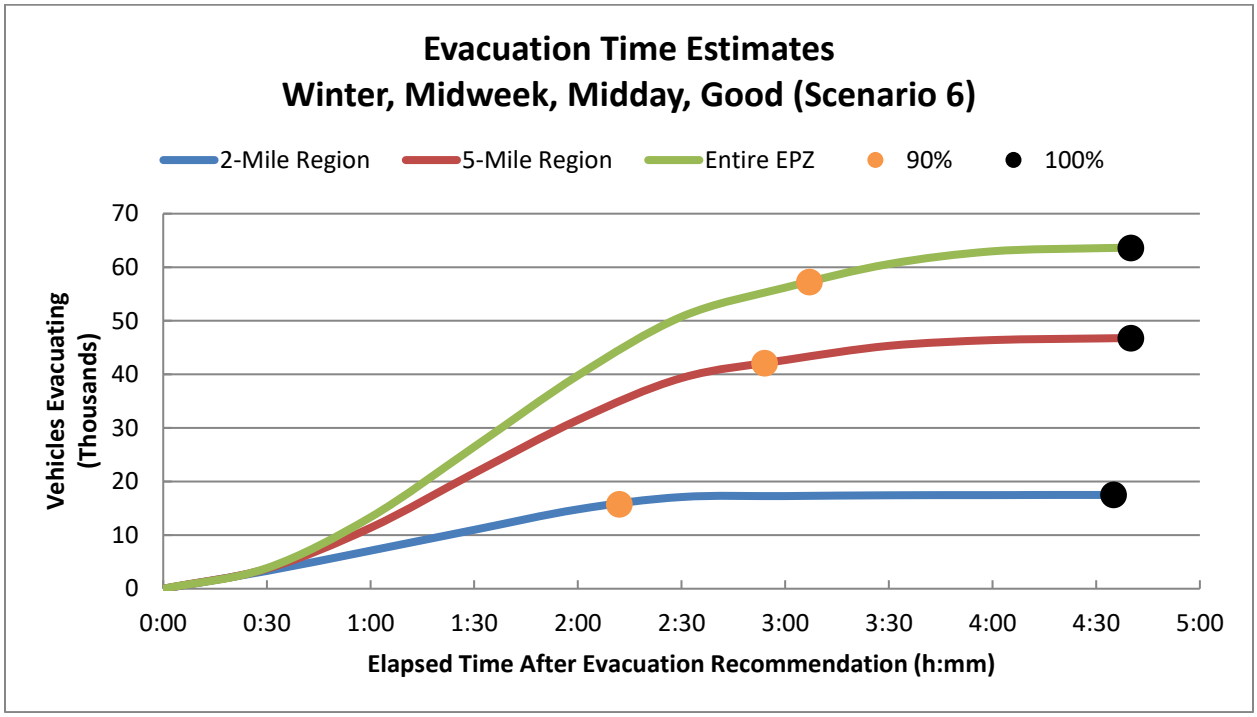


Figure 7-15. Evacuation Time Estimates - Scenario 6 for Region R03

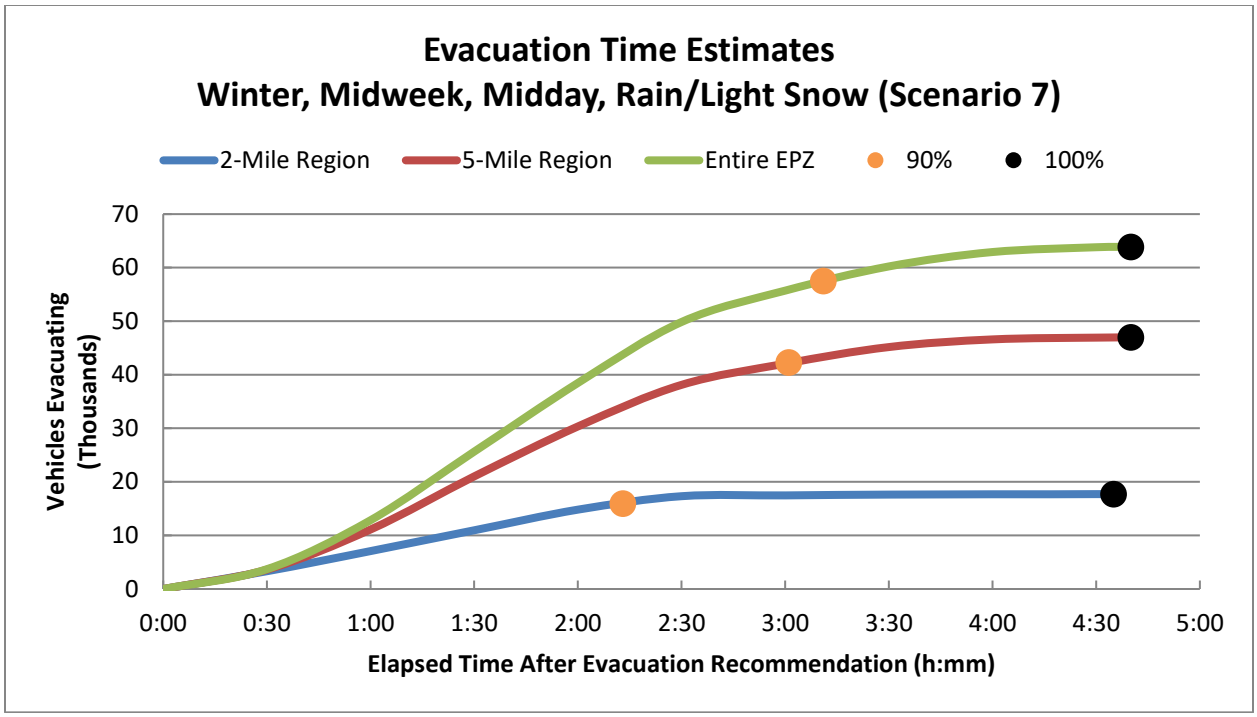


Figure 7-16. Evacuation Time Estimates - Scenario 7 for Region R03

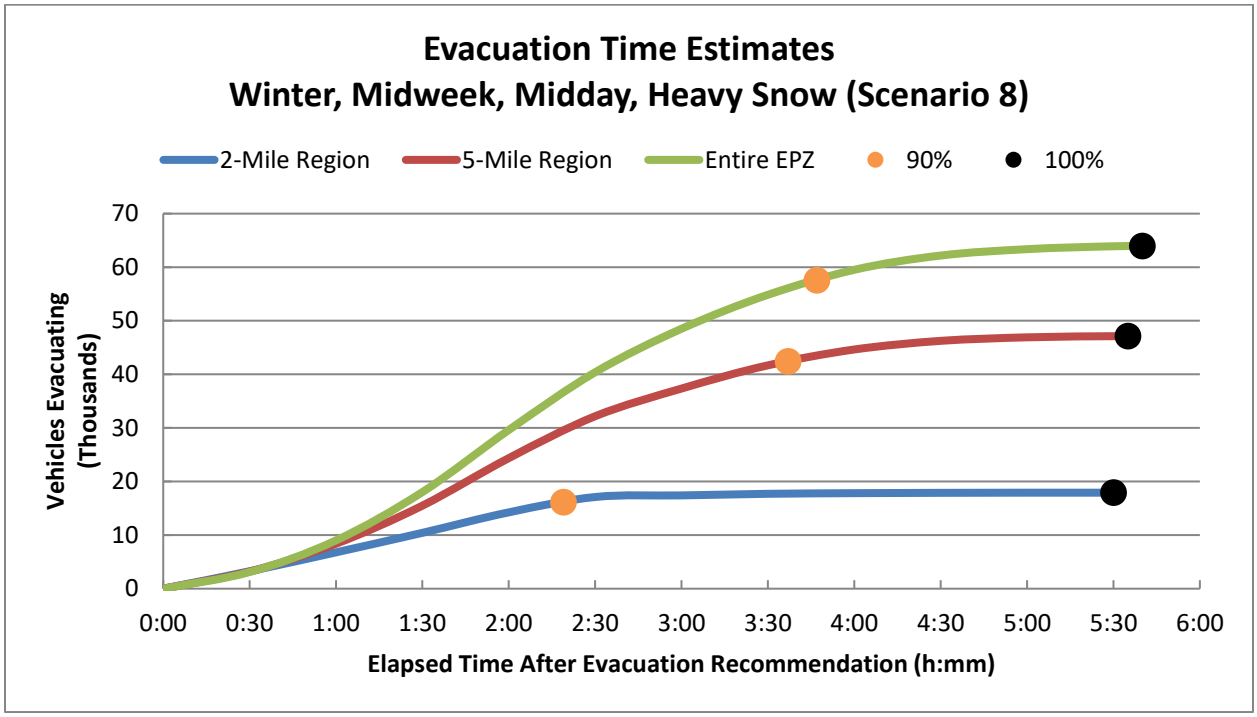


Figure 7-17. Evacuation Time Estimates - Scenario 8 for Region R03

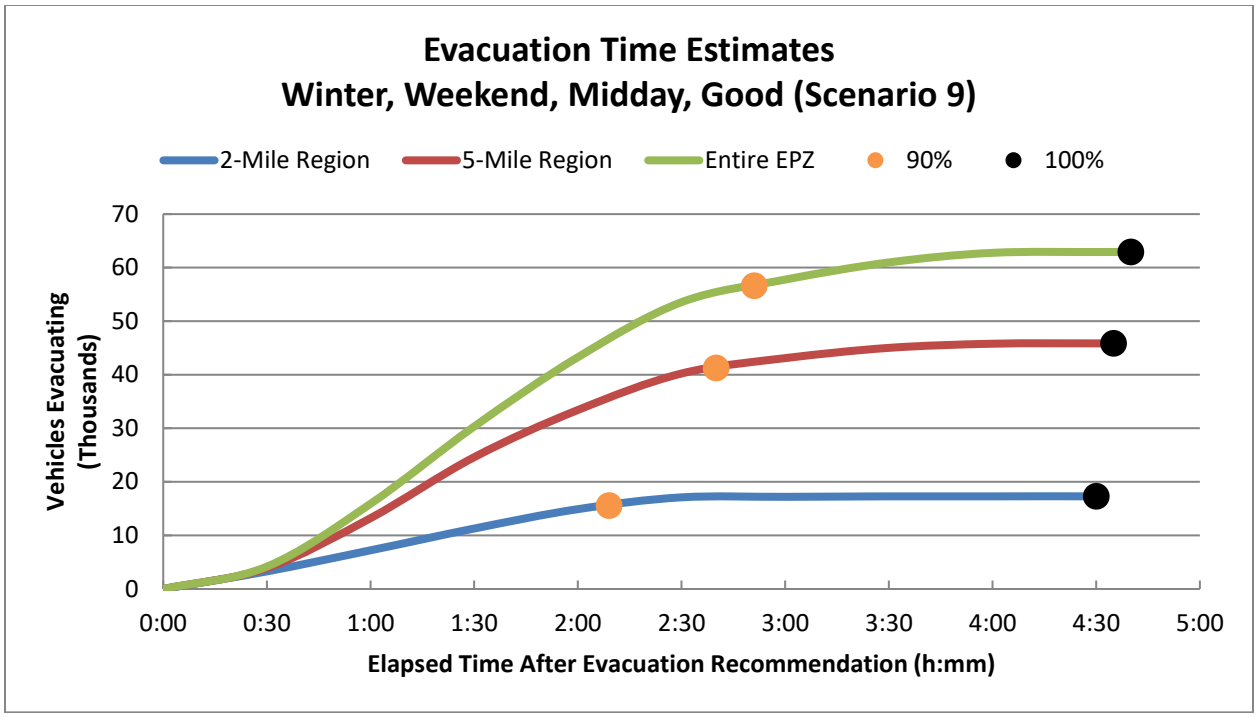


Figure 7-18. Evacuation Time Estimates - Scenario 9 for Region R03

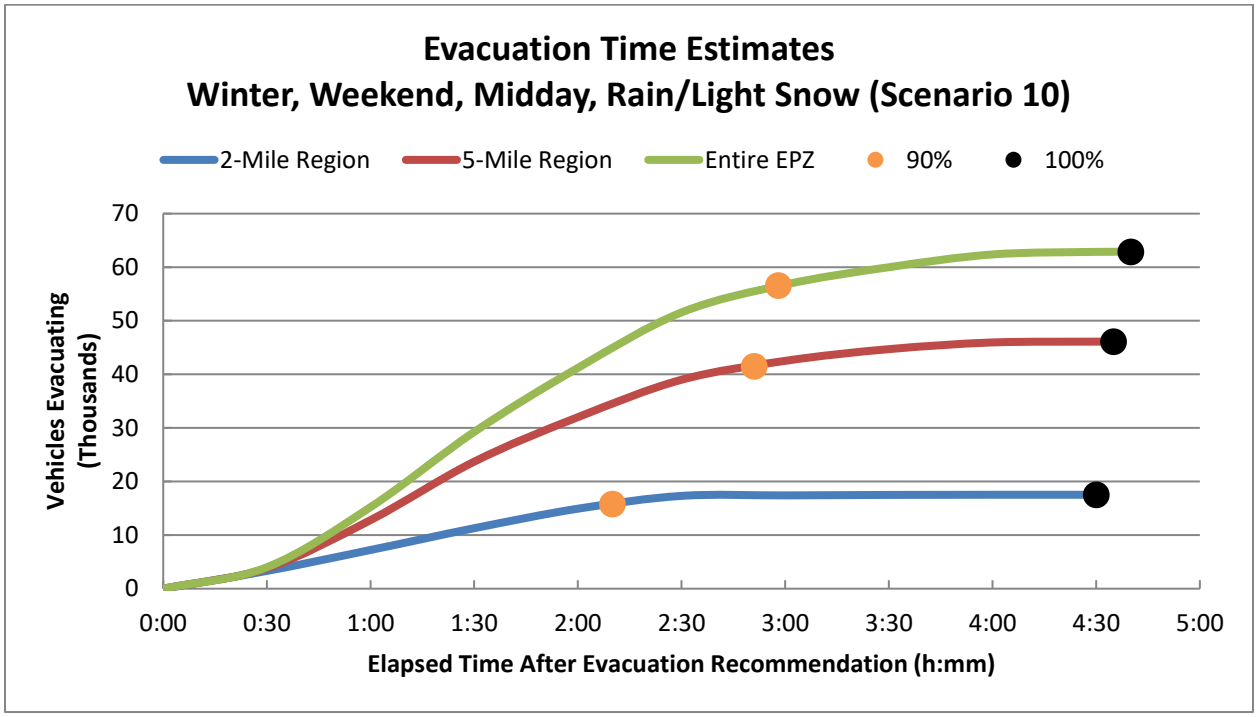


Figure 7-19. Evacuation Time Estimates - Scenario 10 for Region R03

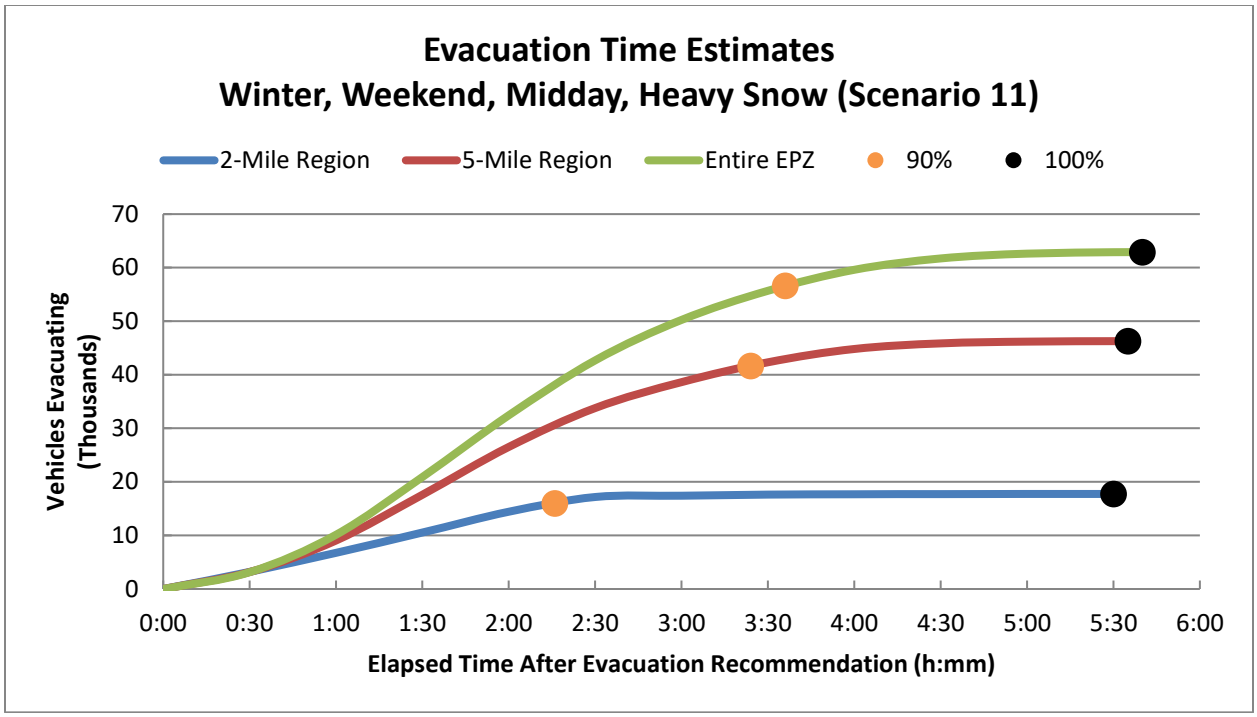


Figure 7-20. Evacuation Time Estimates - Scenario 11 for Region R03

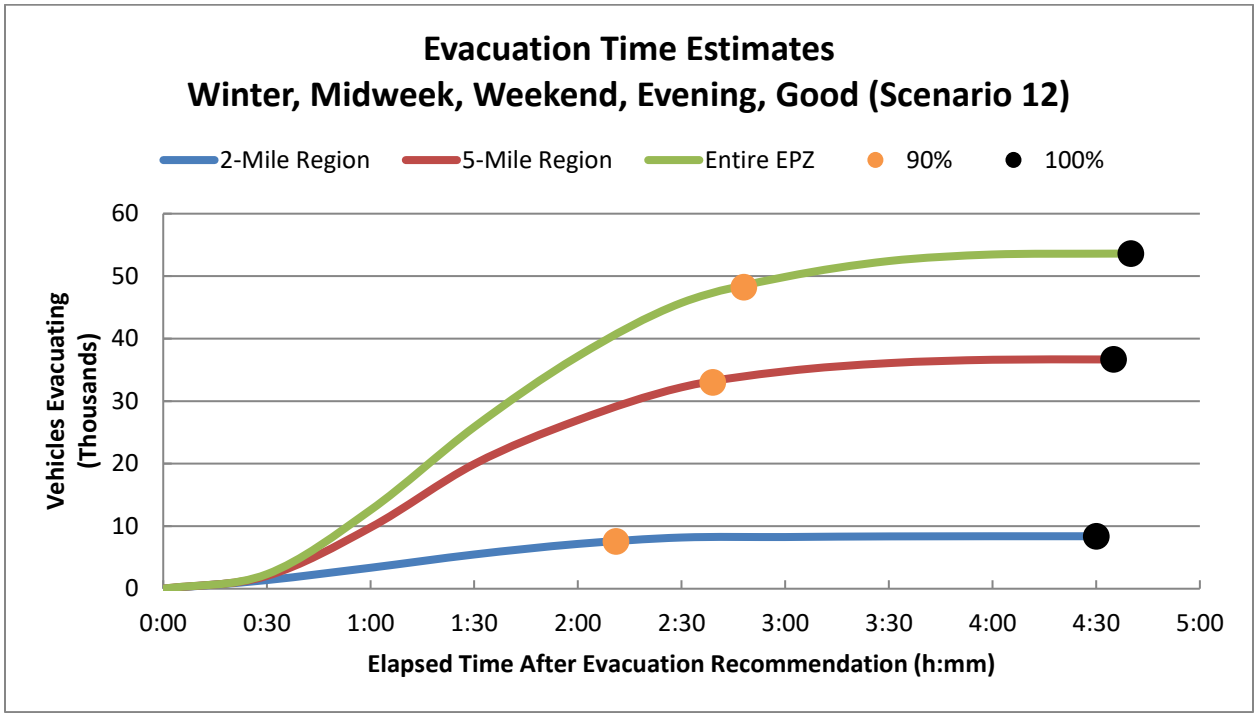


Figure 7-21. Evacuation Time Estimates - Scenario 12 for Region R03

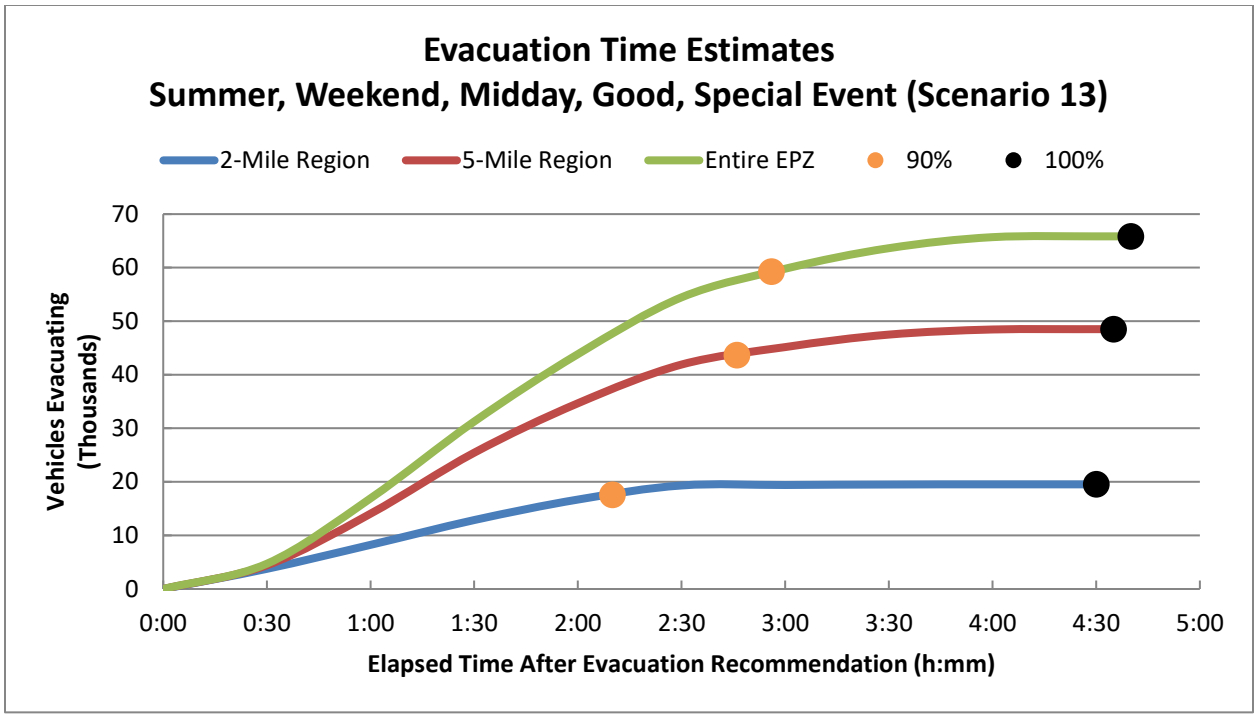


Figure 7-22. Evacuation Time Estimates - Scenario 13 for Region R03

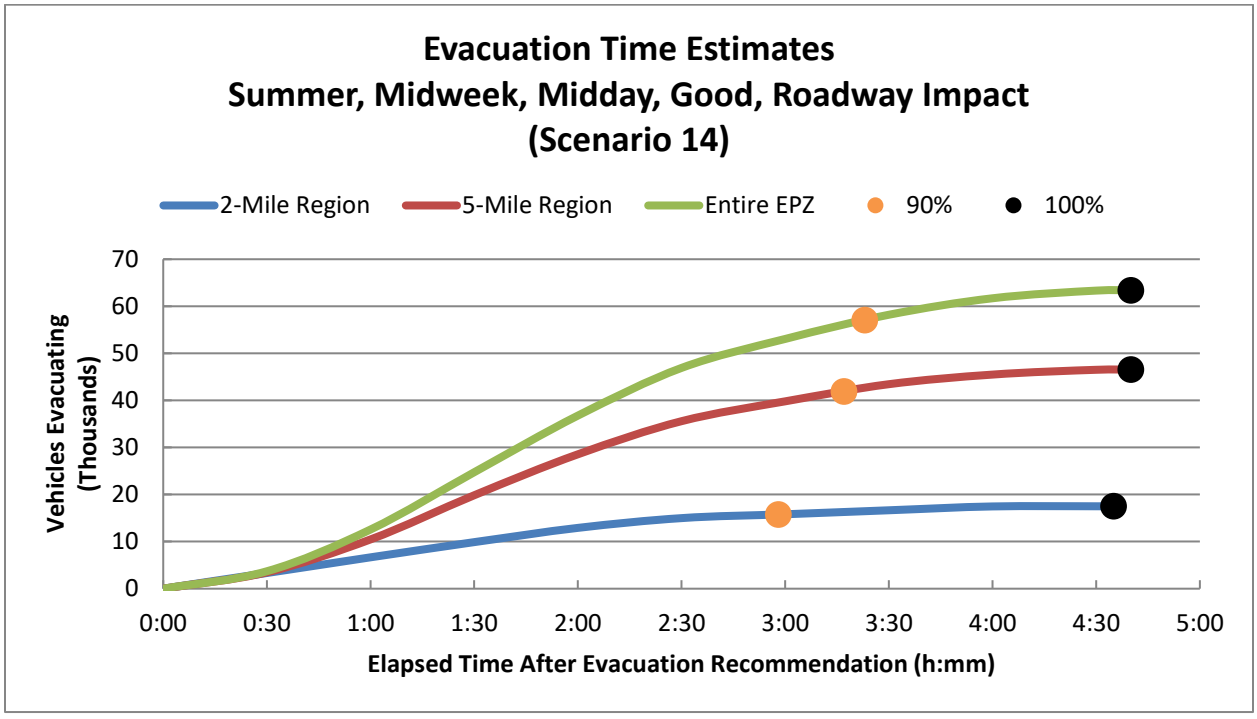


Figure 7-23. Evacuation Time Estimates - Scenario 14 for Region R03

8 TRANSIT-DEPENDENT AND SPECIAL FACILITY EVACUATION TIME ESTIMATES

This section details the analyses applied and the results obtained in the form of evacuation time estimates for transit vehicles (buses, ambulances, and wheelchair transport 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, day cares, preschools, and medical facilities; and (3) access and/or functional 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. The location of bus depots impacts the time to travel from the bus depots to the facilities being evacuated. Locations of bus depots were not identified in this study. Rather, the offsite agencies were asked to factor the location of the depots and the distance to the EPZ into the estimate of mobilization time.

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 or childcare 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 MNGP EPZ indicates that school children will be evacuated to sister schools where they can be picked up by their parents. As such, it is assumed no school children will be picked up by their parents prior to the arrival of the buses. It is assumed that children at small day care centers and preschools will be picked up by their parents and the time needed to do so is included in the time for residents to mobilize.

As discussed in Section 2, this study assumes a rapidly escalating event at the plant wherein evacuation is ordered promptly and no early protective actions have been implemented. Therefore, children are evacuated to sister 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 students will be picked up by their parents (in accordance with NUREG/CR-7002, Rev. 1), to present an upper bound estimate of buses required.

The procedure for computing transit-dependent ETE is to:

- Estimate demand for transit service (discussed in Section 3)
- Estimate time to perform all transit functions
- Estimate route travel times to the EPZ boundary and to the reception centers/sister schools

8.1 ETEs for Schools, Transit Dependent People, and Medical Facilities

EPZ bus resources are assigned to evacuating schoolchildren (if school is in session at the time of the ATE) as the first priority in the event of an emergency. In the event that the allocation of buses dispatched from the depots to the various facilities and to the bus routes is somewhat inefficient, or if there is a shortfall of available drivers, then there may be a need for some buses to return to the EPZ from the reception center or sister school after completing their first evacuation trip, to complete a "second wave" of providing transport service to evacuees. For this reason, the ETE for the transit-dependent population will be calculated for both a one wave transit evacuation and for two waves. Of course, if the impacted Evacuation Region is other than R03 (the entire EPZ), then there will likely be ample transit resources relative to demand in the impacted Region and this discussion of a second wave would likely not apply. A list of available transportation resources was provided by the counties within the EPZ and is shown in Table 8-1. Also included in the table are the number of buses needed to evacuate schools, special facilities, transit-dependent population and access and/or functional needs persons (discussed below in Section 0). These numbers indicate there are insufficient resources of full size buses and ambulances to evacuate everyone in a single wave. As discussed in Section 2, it is assumed that there are enough drivers available to staff all resources listed in Table 8-1.

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 various routes described in Table 10-1.

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

Evacuation of Schools

Activity: Mobilize Drivers (A→B→C)

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

Activity: Board Passengers (C→D)

As discussed in Section 2.4 and shown in Table 2-2, a loading time of 15 minutes (20 minutes for rain/light snow and 25 minutes for heavy snow) for school buses is assumed.

Activity: Travel to EPZ Boundary (D→E)

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 sister school. 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 10-2 (refer to the maps of the link-node analysis network in Appendix K for node locations). Data provided by DYNEV during the appropriate timeframe depending on the mobilization and loading times (i.e., 100 to 105 minutes after the advisory to evacuate for good weather) were used to compute the average speed for each route, as follows:

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

The average speed computed (using this methodology) for the buses servicing each of the schools in the EPZ is shown in Table 8-2 through Table 8-4 for good weather, rain/light snow and heavy snow, respectively. 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 sister schools were computed assuming an average speed of 55 mph, 50 mph, and 47 mph for good weather, rain and snow, respectively. Speeds were reduced in Table 8-2 through Table 8-4 to 55 mph (50 mph for rain – 10% decrease, rounded – and 47 mph for snow – 15% decrease, rounded) for those calculated bus speeds which exceed 55 mph.

Table 8-2 (good weather), Table 8-3 (rain/light snow) and Table 8-4 (heavy 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 ATE until the bus exits the EPZ; and (2) The elapsed time until the bus reaches the sister 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 + 15 + 64 = 2:50 for Becker Intermediate School in good weather). The average single wave ETE for schools is 1 hour and 5 minutes less than the 90th percentile ETE for Region R03 for the general population during Scenario 6 conditions (3:05 – 2:00 = 1:05). All school ETE are rounded up to the nearest 5 minutes.

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

Activity: Travel to Sister Schools (E→F)

The distances from the EPZ boundary to the sister schools are measured using GIS software along the most likely route from the EPZ exit point to the facility. The sister schools are mapped in Figure 10-3. For a one-wave evacuation, this travel time outside the EPZ does not contribute to the ETE. Assumed bus speeds of 55 mph, 50 mph, and 47 mph for good weather, rain/light snow, and heavy snow, respectively, will be applied for this activity for buses servicing the schools in the EPZ. Table 8-2 (good weather),Table 8-3 (rain/light snow) and Table 8-4 (heavy snow) present the elapsed time until the bus reaches the sister school.

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)

As shown in Table 8-1, there is a shortfall of full-size buses for evacuation of children in a single wave if the entire EPZ is evacuated at once (a highly unlikely event). As such, a two-wave evacuation may be needed for some schools. A second wave ETE was not computed for each school. Rather, the following representative ETE is provided to estimate the additional time needed for a second wave evacuation of schools. The travel time from the sister school back to the EPZ boundary and then back to the school was computed assuming an average speed of 55 mph (good weather), 50 mph (rain – 10% reduction) and 47 mph (snow – 15% reduction) as buses will be traveling counter to evacuating traffic. Times and distances are based on averages for all schools in the EPZ for good weather:

- Buses arrive at the sister school at 2:15 (see average value in Table 8-2)
- Bus discharges passengers (5 minutes) and driver takes a 10-minute rest: 15 minutes
- Bus returns to facility: 18 minutes (average distance to sister school (11.7 miles) + average distance to EPZ boundary (5.1 miles) at 55 mph)
- Loading Time: 15 minutes
- Bus completes second wave of service along route: 24 minutes (average distance to EPZ boundary (5.1 miles) at network wide average speed at 3:05 (13 mph))
- Bus exits EPZ at time 2:15 + 0:15 + 0:18 + 0:15 + 0:24 = 3:30 (rounded up to nearest 5 minutes) after the ATE.

Given the average single-wave ETE for schools is 2:00 (see Table 8-2); a second wave evacuation would require an additional 1 hour and 30 minutes on average. The average two-wave ETE of

schools is 25 minutes longer than the 90th percentile ETE (3:05) of the full EPZ during a winter, midweek, midday scenario (Scenario 6).

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

A detailed computation of transit-dependent population was done and is discussed in Section 3.6. The total number of transit dependent people per Sub-Area was determined using a weighted distribution based on population. See Table 3-11 for the distribution used. The number of buses required to evacuate this population was determined by the capacity of 30 people per bus. KLD designed 10 bus routes to service the major evacuation routes in each Sub-Area, for the purposes of this study to compute the ETE for the transit-dependent population. The pre-defined bus routes (as discussed in Section 10) are shown graphically in Figure 10-2 and described in Table 10-1. Those buses servicing the transit-dependent evacuees will first travel along these routes, then proceed out of the EPZ.

Activity: Mobilize Drivers (A→B→C)

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% of the evacuees will complete their mobilization at approximately 135 minutes after the ATE. As such, mobilization time for the first buses to arrive at each route will be 135 minutes during good weather, 145 minutes in rain/light snow and 155 minutes in heavy snow, to account for slower travel speeds and reduced roadway capacity in adverse weather.

Activity: Board Passengers (C→D)

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

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

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

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

Assigning reasonable estimates:

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

Then, P ≈ 1 minute per stop. 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 and snow; total loading time is 40 minutes per bus in rain, 50 minutes in snow.

Activity: Travel to EPZ Boundary (D→E)

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

Table 8-5 through Table 8-7 present the transit-dependent population evacuation time estimates for each bus route calculated using the above procedures for good weather, rain/light snow and heavy snow, respectively.

For example, the ETE for the bus servicing Sub-Area 2 (Route 1) is computed as 135 + 15 + 30 = 3:00 for good weather (rounded up to nearest 5 minutes). Here, 15 minutes is the time to travel 13.1 miles at 51.9 mph, the average speed output by the model for this route starting at 135 minutes.

The average single wave ETE for the transit dependent population is equal to (3:05) the 90th percentile ETE for the general population for a winter, midweek, midday, good weather scenario (Scenario 6).

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

Activity: Travel to Reception Centers (E→F)

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

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.

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. Similar to schools, assumed speeds of 55 mph, 50 mph and 47 mph

are used to estimate the travel time back to the EPZ in good weather, rain/light snow, and heavy snow, respectively, as buses are traveling counter to evacuating traffic.

The second-wave ETE for the bus route servicing Sub-Area 2 (Route 1) is computed as follows for good weather:

- Bus arrives at reception center at 3:09 in good weather (3:00 to exit EPZ + 9 minute travel time to reception center).
- Bus discharges passengers (5 minutes) and driver takes a 10-minute rest: 15 minutes.
- Bus returns to EPZ, drives to the start of the route and completes second route: 9 minutes (8.6 miles back to the EPZ @ 55 mph) + 14 minutes (equal to travel time to start of route, i.e., 13.1 miles @ 55 mph) + 15 minutes (equal to travel time for second route, i.e., 13.1 miles @ 53.1 mph – route specific speed at the time the bus begins the second route) = 38 minutes
- Bus completes pick-ups along route: 30 minutes.
- Bus exits EPZ at time 3:00 + 0:09 + 0:15 + 0:38 + 0:30 = 4:35 (rounded to nearest 5 minutes) after the ATE.

The ETE for the completion of the second wave for all transit-dependent bus routes are provided in Table 8-5 through Table 8-7.

The average ETE for a two-wave evacuation of transit-dependent people exceeds the ETE for the general population at the 90th percentile (3:05) by 1 hour and 45 minutes and could impact protective action decision making.

Evacuation of Medical Facilities

Activity: Mobilize Drivers (A→B→C)

As is done for the schools, it is estimated that mobilization time averages 90 minutes in good weather (100 minutes in rain/light snow, 110 in heavy snow). Specially trained medical support staff (working their regular shift) will be on site to assist in the evacuation of patients. Additional staff (if needed) could be mobilized over this same 90-minute timeframe.

Activity: Board Passengers (C→D)

Item 5 of Section 2.4 discusses transit vehicle loading times for medical facilities. Loading times are assumed to be 1 minute per ambulatory passenger, 5 minutes per wheelchair bound passenger, and 15 minutes per bedridden passenger for buses, wheelchair buses/vans, and ambulances, respectively. No reduction was made to loading times for adverse weather as these loading times are already conservative. Item 3 of Section 2.4 discusses transit vehicle capacities to cap loading times per vehicle type.

As shown in Table **8**-**1**, there is a shortfall of buses and ambulances in the EPZ. Two waves will be needed to evacuate the ambulatory population at medical facilities within the EPZ in the event of a full EPZ evacuation.

Activity: Travel to EPZ Boundary (D→E)

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

Table 8-8 through Table 8-10 summarize the ETE for medical facilities within the EPZ for good weather, rain/light snow, and heavy snow, respectively. The distances from the medical facilities to the EPZ boundary were estimated using GIS software. Average speeds output by the model for Scenario 6 (Scenario 7 for rain and Scenario 8 for snow) Region 3, capped at 55 mph (50 mph for rain and 47 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, and ambulances at capacity is assumed such that the maximum loading times for buses (maximum capacity of 30 times 1 minute per passenger), wheelchair buses (4 passengers on average times 5 minutes per passenger), and ambulances (2 passenger times 15 minutes per passenger) are 30, 20, and 30 minutes, respectively. All ETE are rounded to the nearest 5 minutes.

For example, the calculation of ETE for St. Benedict's Senior Community with 139 ambulatory residents during good weather is:

ETE: 90 + 30 (max capacity per bus with concurrent loading on multiple buses) x 1 + 9 = 129 minutes or 2:10 (rounded up to the nearest 5 minutes.)

It is assumed that the medical facility population is directly evacuated to reception centers or appropriate host medical facilities that are at approximately the same distances to the EPZ boundary as the reception centers.

Average single wave ETE for medical facilities are 1 hour less than the 90th percentile ETE (3:05) for the evacuation of the general population from Region R03 during Scenario 6 conditions and should not impact protective action decision making.

Activity: Travel to Reception Center (E→F), Passengers Leave Bus (F→G), Bus Returns to Route for Second Wave Evacuation (G→C)

A second wave ETE was not computed for each medical facility. Rather, the following representative ETE is provided to estimate the additional time needed for a second wave evacuation using school buses after the schools have been evacuated. Times and distances are based on facility-wide averages:

- Ambulatory patients (buses) assuming host medical facilities are as far as the closest hospital to the EPZ boundary (Maple Grove Hospital):
  - Buses leave EPZ at 1:56 on average (average ambulatory ETE from Table 8-8)
  - Ambulance travels to host medical facility: 15 minutes (14 miles at 55 mph).
  - Bus discharges passengers (13 minutes – average bus loading time from Table 8-8) and driver takes a 10-minute rest: 23 minutes.

- Bus returns to EPZ and completes second route: 15 minutes to travel back to the EPZ boundary (14 miles at 55 mph) + 7 minutes to travel back to the facility (average Dist. to EPZ Boundary in Table 8-8 – 6.6 miles @ 55 mph) = 22 minutes
- Loading Time: 13 minutes (average from Table 8-8)
- Bus travels back to the EPZ boundary (6.6 miles @ 16 mph) = 25 minutes. The average distance to EPZ boundary is approximately 6.6 miles in Table 8-8, and 14 mph is the network wide average speed at 3:10 for Scenario 6.
- Bus exits EPZ at time 1:56 + 0:15 + 0:23 + 0:22 + 0:13 + 0:25 = 3:35 (rounded to nearest 5 minutes) after the ATE.

- Bedridden patients (ambulances) assuming host medical facilities are as far as the closest hospital to the EPZ boundary (Maple Grove Hospital):
  - Ambulances leave EPZ at 2:11 on average (average bedridden ETE from Table 8-8)
  - Ambulance travels to host medical facility: 15 minutes (14 miles at 55 mph).
  - Bus discharges passengers (30 minutes – average ambulance loading time from Table 8-8) and driver takes a 10-minute rest: 40 minutes.
  - Bus returns to medical facility: 15 minutes to travel back to the EPZ boundary (14 miles at 55 mph) + 7 minutes to travel back to the facility (average Dist. to EPZ Boundary in Table 8-8 – 6.6 miles @ 55 mph) = 22 minutes.
  - Remaining bedridden patients loaded on bus (maximum): 30 minutes (average from Table 8-8 capped at 2 passengers per ambulance).
  - Bus travels to EPZ boundary: 23 minutes (average distance from medical facilities to EPZ boundary (6.6 miles) at 17 mph (network wide average speed at 4:00).
  - Bus exits EPZ at time 2:11 + 0:15 + 0:40 + 0:22 + 0:30 + 0:23 = 4:25 (rounded up to nearest 5 minutes) after the ATE.

Thus, the second wave evacuation for ambulatory patients and bedridden patients requires an additional 1 hours and 35 minutes (rounded up to the nearest 5 minutes) and an additional 2 hours and 15 minutes (rounded up to the nearest 5 minutes), respectively. The average ETE for a two-wave evacuation of medical facilities exceeds the ETE for the general population at the 90th percentile (3:05) and could impact protective action decision making.

Correctional Facilities

As discussed in Section 3.10, the Wright County Jail shelters in place during an emergency at MNGP. As such, ETE were not computed for this facility.

8.2 ETE for Access and/or Functional Needs Population

Table **8-11** summarizes the ETE for access and/or functional needs population. The table is categorized by type of vehicle required and then broken down by weather condition. The table takes into consideration the deployment of multiple vehicles (not filled to capacity) to reduce the number of stops per vehicle. Due to the potential mobility limitations for access and/or functional needs persons, it assumed they will be picked up from their homes. Furthermore, it is conservatively assumed that access and/or functional needs households are spaced 3 miles apart. Bus speeds approximate 20 mph between households in good weather (10% slower in rain/light

snow, 20% slower in heavy snow). Mobilization times of 135 minutes were used (145 minutes for rain, and 155 minutes for snow), similar to the transit- dependent population. Loading times of 1 minute per person are assumed for ambulatory people and 5 minutes for wheelchair bound people. The last household is assumed to be 5 miles from the EPZ boundary, and the network-wide average speed, capped at 55 mph (50 mph for rain/light snow and 47 mph for heavy snow), after the last pickup is used to compute travel time. ETE is computed by summing mobilization time, loading time at first household, travel to subsequent households, loading time at subsequent households, and travel time to EPZ boundary. According to the data received by the counties, there are no residents registered as bedridden within the ETE. All ETE are rounded to the nearest 5 minutes.

For example, assuming no more than one access and/or functional needs person per household implies that 9 ambulatory households need to be serviced. While only 1 midsize bus is needed from a capacity perspective, if 3 midsize buses are deployed to service these household, then each bus would require at most 3 stops. The following outlines the ETE calculations:

1. Assume 3 midsize buses are deployed, each with at most 3 stops, to service a total of 9 households.
2. The ETE is calculated as follows for midsize buses in good weather:
    a. Midsize buses arrive at the first pickup location: 135 minutes
    b. Load household members at first pickup: 1 minute
    c. Travel to subsequent pickup locations: 2 @ 9 minutes (3 miles @ 20 mph) = 18 minutes
    d. Load household members at subsequent pickup locations: 2 @ 1 minute = 2 minutes
    e. Travel to EPZ boundary: 22 minutes (5 miles @ 13.7 mph – network wide average speed at this time).

    ETE: 135 + 1 + 18 + 2 + 22 = 3:00 rounded up to the nearest 5 minutes.

The average ETE for a single wave evacuation of the access and/or functional needs population is 15 minutes longer than the general population ETE at the 90th percentile (3:05) for an evacuation of the entire EPZ (Region R03), during Scenario 6 conditions. Therefore, the evacuation of access and/or functional needs population could impact protective action decision making.

The following outlines the ETE calculations if a second wave is needed using school buses after the schools have been evacuated (see Table 8-2):

a. School buses arrive at sister schools: 2:15 on average
b. Unload students at sister school: 5 minutes.
c. Driver takes 10-minute rest: 10 minutes.
d. Travel time back to EPZ: 13 minutes (equal to average distance to sister school in Table 8-2 – 11.7 miles @ 55 mph)
e. Travel to first household: 9 minutes (3 miles @ 20 mph)
f. Loading time at first household: 1 minute

g. Travel to subsequent pickup locations: 2 @ 9 minutes = 18 minutes
h. Loading time at subsequent households: 2 stops @ 1 minutes = 2 minutes
i. Travel time to EPZ boundary at 5 miles @ 17 mph (network wide average speed at 3:15) = 18 minutes

Good Weather ETE: 2:15 + 5 + 10 + 13 + 9 + 1 + 18 + 2 + 18 = 3:35 rounded up to the nearest 5 minutes.

Rain/Light Snow ETE: 2:35 + 5 + 10 + 14 + 10 + 1 + 20 + 2 + 21 = 4:00 rounded up to the nearest 5 minutes.

Heavy Snow ETE: 2:50 + 5 + 10 + 15 + 11 + 1 + 22 + 2 + 24 = 4:25 rounded up to the nearest 5 minutes.

Table 8-1. Summary of Transportation Resources

Transportation Resource	Full Size Buses	Midsize Buses	Passenger Cars	Vans	Wheelchair Buses	Wheelchair Vans	Ambulances
Resources Available							
Sherburne County							
Vision Transportation - Elk River	90	0	0	0	15	0	0
Vision Transportation - Big Lake	35	15	0	0	0	0	0
Becker Schools	27	0	5	6	0	0	0
St. Benedict's Senior Community	0	1	0	0	0	0	0
New River Medical Center	1	0	0	0	0	0	4
Allina Medical Transit	0	0	0	0	0	0	4
Elk River Ambulance	0	0	0	0	0	0	2
New River Ambulance	0	0	0	0	0	0	2
North Memorial Ambulance - Milaca	0	0	0	0	0	0	1
Wright County							
American Transportation	53	16	0	0	3	2	0
M&M Bus Service	50	0	0	0	1	4	0
River Rider	7	7	0	0	0	0	0
Vision Transportation - Rogers	12	0	0	25	0	0	0
Hoglund	68	0	0	0	10	10	0
Don's Bus Service	34	0	0	8	2	0	0
TOTAL:	**377**	**39**	**5**	**39**	**31**	**16**	**13**
Resources Needed							
Medical Facilities (Table 3-6):	9	0	0	0	26	0	19
Transit-Dependent Population (Section 3.6):	34	0	0	0	0	0	0
Schools (Table 3-8):	388	0	0	0	0	0	0
Access and/or Functional Needs Population (Table 3-9):	0	3	0	0	2	0	0
TOTAL TRANSPORTATION NEEDS:	**431**	**3**	**0**	**0**	**28**	**0**	**19**

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

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to S.S. (mi.)	Travel Time from EPZ Bdry to S.S. (min)	ETA to S.S. (hr:min)
Sherburne County Schools									
Becker Intermediate School	90	15	15.3	14.3	64	**2:50**	2.6	3	**2:55**
Becker Primary School	90	15	15.3	14.3	64	**2:50**	2.6	3	**2:55**
Becker High School	90	15	15.3	14.3	64	**2:50**	2.6	3	**2:55**
Becker Middle School	90	15	15.3	14.3	64	**2:50**	2.6	3	**2:55**
Big Lake High School	90	15	11.1	34.4	19	**2:05**	14.1	15	**2:20**
Big Lake Middle School	90	15	11.1	34.4	19	**2:05**	14.1	15	**2:20**
Independence Elementary School	90	15	11.1	34.4	19	**2:05**	14.1	15	**2:20**
Liberty Elementary School	90	15	10.9	32.7	20	**2:05**	14.1	15	**2:20**
Jubilee Christian Center	90	15	1.2	21.2	3	**1:50**	18.5	20	**2:10**
Wright County Schools									
Prairie House Recovery Center	90	15	10.1	52.5	12	**2:00**	14.4	16	**2:20**
Pinewood Elementary School	90	15	9.1	52.3	10	**1:55**	14.4	16	**2:15**
Swan River Montessori School	90	15	8.1	50.0	10	**1:55**	14.4	16	**2:15**
Turning Point Alternative Learning Program	90	15	8.1	54.5	9	**1:55**	14.4	16	**2:15**
Monticello Middle School	90	15	7.2	30.0	14	**2:00**	14.4	16	**2:20**
Holy Spirit Academy	90	15	6.7	28.9	14	**2:00**	14.4	16	**2:20**
Little Mountain Elementary School	90	15	7.0	37.5	11	**2:00**	14.4	16	**2:20**
Monticello High School	90	15	6.3	37.5	10	**1:55**	14.4	16	**2:15**
Eastview Education Center	90	15	5.9	36.2	10	**1:55**	14.4	16	**2:15**
Kaleidoscope Charter School	90	15	1.4	22.6	4	**1:50**	2.7	3	**1:55**
St. Michael-Albertville High School	90	15	0.9	54.1	1	**1:50**	1.4	2	**1:55**
Fieldstone Elementary School	90	15	0.4	54.1	0	**1:45**	3.4	4	**1:50**
St Francis Xavier School	90	15	2.7	36.6	4	**1:50**	10.7	12	**2:05**

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 S.S. (mi.)	Travel Time from EPZ Bdry to S.S. (min)	ETA to S.S. (hr:min)
Cornerstone High School	90	15	1.1	36.9	2	**1:50**	10.8	12	**2:05**
Eastern Wright Program	90	15	1.1	36.9	2	**1:50**	10.8	12	**2:05**
Wright Technical Center High School	90	15	1.1	36.9	2	**1:50**	10.8	12	**2:05**
Buffalo Community Middle School	90	15	1.1	36.9	2	**1:50**	10.8	12	**2:05**
Buffalo High School	90	15	0.3	29.4	1	**1:50**	10.9	12	**2:05**
Tatanka Elementary School	90	15	0.2	16.6	1	**1:50**	10.7	12	**2:05**
Maple Lake Elementary School	90	15	1.3	44.3	2	**1:50**	20.2	22	**2:15**
Maple Lake High School	90	15	1.3	44.3	2	**1:50**	20.2	22	**2:15**
St. Timothy's Catholic School	90	15	1.3	55.0	1	**1:50**	20.2	22	**2:15**
Westside Alternative School	90	15	1.1	55.0	1	**1:50**	20.2	22	**2:15**
Northwinds Elementary School	90	15	1.7	37.9	3	**1:50**	10.7	12	**2:05**
Phoenix Learning Center	90	15	0.5	46.6	1	**1:50**	11.3	12	**2:05**
Parkside Elementary School	90	15	0.1	13.9	0	**1:45**	10.7	12	**2:00**
Discovery Elementary School	90	15	0.1	13.9	0	**1:45**	10.7	12	**2:00**
Discovery Elementary School	90	15	0.1	13.9	0	**1:45**	10.7	12	**2:00**
PRIDE Transitions	90	15	0.1	13.9	0	**1:45**	10.7	12	**2:00**
					Maximum for EPZ:	**2:50**		**Maximum:**	**2:55**
					Average for EPZ:	**2:00**		**Average:**	**2:15**

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

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to S.S. (mi.)	Travel Time from EPZ Bdry to S.S. (min)	ETA to S.S. (hr:min)
Sherburne County Schools									
Becker Intermediate School	100	20	15.3	16.1	57	**3:00**	2.6	3	**3:05**
Becker Primary School	100	20	15.3	16.1	57	**3:00**	2.6	3	**3:05**
Becker High School	100	20	15.3	16.1	57	**3:00**	2.6	3	**3:05**
Becker Middle School	100	20	15.3	16.1	57	**3:00**	2.6	3	**3:05**
Big Lake High School	100	20	11.1	32.2	21	**2:25**	14.1	17	**2:45**
Big Lake Middle School	100	20	11.1	32.2	21	**2:25**	14.1	17	**2:45**
Independence Elementary School	100	20	11.1	32.2	21	**2:25**	14.1	17	**2:45**
Liberty Elementary School	100	20	10.9	30.7	21	**2:25**	14.1	17	**2:45**
Jubilee Christian Center	100	20	1.2	14.7	5	**2:05**	18.5	22	**2:30**
Wright County Schools									
Prairie House Recovery Center	100	20	10.1	46.8	13	**2:15**	14.4	17	**2:35**
Pinewood Elementary School	100	20	9.1	46.6	12	**2:15**	14.4	17	**2:35**
Swan River Montessori School	100	20	8.1	45.1	11	**2:15**	14.4	17	**2:35**
Turning Point Alternative Learning Program	100	20	8.1	48.1	10	**2:10**	14.4	17	**2:30**
Monticello Middle School	100	20	7.2	18.3	24	**2:25**	14.4	17	**2:45**
Holy Spirit Academy	100	20	6.7	18.0	22	**2:25**	14.4	17	**2:45**
Little Mountain Elementary School	100	20	7.0	28.8	15	**2:15**	14.4	17	**2:35**
Monticello High School	100	20	6.3	28.8	13	**2:15**	14.4	17	**2:35**
Eastview Education Center	100	20	5.9	28.5	12	**2:15**	14.4	17	**2:35**
Kaleidoscope Charter School	100	20	1.4	21.9	4	**2:05**	2.7	3	**2:10**
St. Michael-Albertville High School	100	20	0.9	41.7	1	**2:05**	1.4	2	**2:10**
Fieldstone Elementary School	100	20	0.4	41.7	1	**2:05**	3.4	4	**2:10**
St Francis Xavier School	100	20	2.7	24.3	7	**2:10**	10.7	13	**2:25**
Cornerstone High School	100	20	1.1	13.0	5	**2:05**	10.8	13	**2:20**

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 S.S. (mi.)	Travel Time from EPZ Bdry to S.S. (min)	ETA to S.S. (hr:min)
Eastern Wright Program	100	20	1.1	13.0	5	**2:05**	10.8	13	**2:20**
Wright Technical Center High School	100	20	1.1	13.0	5	**2:05**	10.8	13	**2:20**
Buffalo Community Middle School	100	20	1.1	13.0	5	**2:05**	10.8	13	**2:20**
Buffalo High School	100	20	0.3	27.7	1	**2:05**	10.9	13	**2:20**
Tatanka Elementary School	100	20	0.2	36.0	0	**2:00**	10.7	13	**2:15**
Maple Lake Elementary School	100	20	1.3	42.0	2	**2:05**	20.2	24	**2:30**
Maple Lake High School	100	20	1.3	42.0	2	**2:05**	20.2	24	**2:30**
St. Timothy's Catholic School	100	20	1.3	50.0	2	**2:05**	20.2	24	**2:30**
Westside Alternative School	100	20	1.1	50.0	1	**2:05**	20.2	24	**2:30**
Northwinds Elementary School	100	20	1.7	36.6	3	**2:05**	10.7	13	**2:20**
Phoenix Learning Center	100	20	0.5	33.0	1	**2:05**	11.3	14	**2:20**
Parkside Elementary School	100	20	0.1	21.2	0	**2:00**	10.7	13	**2:15**
Discovery Elementary School	100	20	0.1	21.2	0	**2:00**	10.7	13	**2:15**
Discovery Elementary School	100	20	0.1	21.2	0	**2:00**	10.7	13	**2:15**
PRIDE Transitions	100	20	0.1	21.2	0	**2:00**	10.7	13	**2:15**
					Maximum for EPZ:	**3:00**		**Maximum:**	**3:05**
					Average for EPZ:	**2:15**		**Average:**	**2:35**

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

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to S.S. (mi.)	Travel Time from EPZ Bdry to S.S. (min)	ETA to S.S. (hr:min)
Sherburne County Schools									
Becker Intermediate School	110	25	15.3	19.7	47	**3:05**	2.6	3	**3:10**
Becker Primary School	110	25	15.3	19.7	47	**3:05**	2.6	3	**3:10**
Becker High School	110	25	15.3	19.7	47	**3:05**	2.6	3	**3:10**
Becker Middle School	110	25	15.3	19.7	47	**3:05**	2.6	3	**3:10**
Big Lake High School	110	25	11.1	21.6	31	**2:50**	14.1	18	**3:10**
Big Lake Middle School	110	25	11.1	21.6	31	**2:50**	14.1	18	**3:10**
Independence Elementary School	110	25	11.1	21.6	31	**2:50**	14.1	18	**3:10**
Liberty Elementary School	110	25	10.9	20.6	32	**2:50**	14.1	18	**3:10**
Jubilee Christian Center	110	25	1.2	15.0	5	**2:20**	18.5	24	**2:45**
Wright County Schools									
Prairie House Recovery Center	110	25	10.1	23.3	26	**2:45**	14.4	18	**3:05**
Pinewood Elementary School	110	25	9.1	22.3	24	**2:40**	14.4	18	**3:00**
Swan River Montessori School	110	25	8.1	19.4	25	**2:40**	14.4	18	**3:00**
Turning Point Alternative Learning Program	110	25	8.1	19.9	24	**2:40**	14.4	18	**3:00**
Monticello Middle School	110	25	7.2	16.0	27	**2:45**	14.4	18	**3:05**
Holy Spirit Academy	110	25	6.7	15.4	26	**2:45**	14.4	18	**3:05**
Little Mountain Elementary School	110	25	7.0	22.5	19	**2:35**	14.4	18	**2:55**
Monticello High School	110	25	6.3	22.5	17	**2:35**	14.4	18	**2:55**
Eastview Education Center	110	25	5.9	22.3	16	**2:35**	14.4	18	**2:55**
Kaleidoscope Charter School	110	25	1.4	20.7	4	**2:20**	2.7	3	**2:25**
St. Michael-Albertville High School	110	25	0.9	40.9	1	**2:20**	1.4	2	**2:25**
Fieldstone Elementary School	110	25	0.4	40.9	1	**2:20**	3.4	4	**2:25**
St Francis Xavier School	110	25	2.7	37.1	4	**2:20**	10.7	14	**2:35**
Cornerstone High School	110	25	1.1	32.6	2	**2:20**	10.8	14	**2:35**
Eastern Wright Program	110	25	1.1	32.6	2	**2:20**	10.8	14	**2:35**

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 S.S. (mi.)	Travel Time from EPZ Bdry to S.S. (min)	ETA to S.S. (hr:min)
Wright Technical Center High School	110	25	1.1	32.6	2	**2:20**	10.8	14	**2:35**
Buffalo Community Middle School	110	25	1.1	32.6	2	**2:20**	10.8	14	**2:35**
Buffalo High School	110	25	0.3	25.2	1	**2:20**	10.9	14	**2:35**
Tatanka Elementary School	110	25	0.2	14.7	1	**2:20**	10.7	14	**2:35**
Maple Lake Elementary School	110	25	1.3	38.0	2	**2:20**	20.2	26	**2:50**
Maple Lake High School	110	25	1.3	38.0	2	**2:20**	20.2	26	**2:50**
St. Timothy's Catholic School	110	25	1.3	45.3	2	**2:20**	20.2	26	**2:50**
Westside Alternative School	110	25	1.1	44.5	1	**2:20**	20.2	26	**2:50**
Northwinds Elementary School	110	25	1.7	33.2	3	**2:20**	10.7	14	**2:35**
Phoenix Learning Center	110	25	0.5	39.7	1	**2:20**	11.3	14	**2:35**
Parkside Elementary School	110	25	0.1	9.9	1	**2:20**	10.7	14	**2:35**
Discovery Elementary School	110	25	0.1	9.9	1	**2:20**	10.7	14	**2:35**
Discovery Elementary School	110	25	0.1	9.9	1	**2:20**	10.7	14	**2:35**
PRIDE Transitions	110	25	0.1	9.9	1	**2:20**	10.7	14	**2:35**
					Maximum for EPZ:	**3:05**		**Maximum:**	**3:10**
					Average for EPZ:	**2:35**		**Average:**	**2:50**

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

Route Number	UNITES Route #	Sub-Area(s) Serviced	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)
1	**50**	2	135	13.1	51.9	15	30	**3:00**	8.6	9	5	10	38	30	**4:35**
2	**51**	5N	135	13.7	53.8	15	30	**3:00**	19.8	22	5	10	52	30	**5:00**
3	**52**	5E	135	15.2	45.4	20	30	**3:05**	10.9	12	5	10	45	30	**4:50**
4	**53**	5S	135	9.3	43.6	13	30	**3:00**	8.8	10	5	10	33	30	**4:30**
5	**54**	5W & 10SW	135	26.8	54.8	29	30	**3:15**	8.8	10	5	10	69	30	**5:20**
6	**55**	10N & 10NW	135	14.2	51.0	17	30	**3:05**	19.8	22	5	10	53	30	**5:05**
7	**56**	10E	135	6.1	36.7	10	30	**2:55**	10.9	12	5	10	25	30	**4:20**
8	**57**	10SE	135	11.7	20.3	35	30	**3:20**	8.2	9	5	10	44	30	**5:00**
9	**58**	10S	135	13.2	38.8	20	30	**3:05**	8.1	9	5	10	44	30	**4:45**
10	**59**	10W	135	8.8	51.4	10	30	**2:55**	17.1	19	5	10	38	30	**4:40**
Maximum ETE:								**3:20**	**Maximum ETE:**						**5:20**
Average ETE:								**3:05**	**Average ETE:**						**4:50**

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

Route Number	UNITES Route #	Sub-Area(s) Serviced	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)
1	**50**	2	145	13.1	46.1	17	40	**3:25**	8.6	10	5	10	40	40	**5:10**
2	**51**	5N	145	13.7	48.2	17	40	**3:25**	19.8	24	5	10	55	40	**5:40**
3	**52**	5E	145	15.2	48.5	19	40	**3:25**	10.9	13	5	10	48	40	**5:25**
4	**53**	5S	145	9.3	38.3	15	40	**3:20**	8.8	11	5	10	35	40	**5:05**
5	**54**	5W & 10SW	145	26.8	50.0	32	40	**3:40**	8.8	11	5	10	72	40	**6:00**
6	**55**	10N & 10NW	145	14.2	45.1	19	40	**3:25**	19.8	24	5	10	56	40	**5:40**
7	**56**	10E	145	6.1	48.2	8	40	**3:15**	10.9	13	5	10	27	40	**4:50**
8	**57**	10SE	145	11.7	28.4	25	40	**3:30**	8.2	10	5	10	47	40	**5:25**
9	**58**	10S	145	13.2	34.6	23	40	**3:30**	8.1	10	5	10	47	40	**5:25**
10	**59**	10W	145	8.8	46.6	11	40	**3:20**	17.1	21	5	10	41	40	**5:20**
							Maximum ETE:	**3:40**						**Maximum ETE:**	**6:00**
							Average ETE:	**3:25**						**Average ETE:**	**5:25**

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

Route Number	UNITES Route #	Sub-Area(s) Serviced	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)
1	**50**	2	155	13.1	34.0	23	50	**3:50**	8.6	11	5	10	42	50	**5:50**
2	**51**	5N	155	13.7	37.9	22	50	**3:50**	19.8	25	5	10	58	50	**6:20**
3	**52**	5E	155	15.2	23.1	40	50	**4:05**	10.9	14	5	10	50	50	**6:15**
4	**53**	5S	155	9.3	35.0	16	50	**3:45**	8.8	11	5	10	36	50	**5:40**
5	**54**	5W & 10SW	155	26.8	45.9	35	50	**4:00**	8.8	11	5	10	75	50	**6:35**
6	**55**	10N & 10NW	155	14.2	33.2	26	50	**3:55**	19.8	25	5	10	59	50	**6:25**
7	**56**	10E	155	6.1	14.8	25	50	**3:50**	10.9	14	5	10	28	50	**5:40**
8	**57**	10SE	155	11.7	12.9	55	50	**4:20**	8.2	10	5	10	48	50	**6:25**
9	**58**	10S	155	13.2	31.7	25	50	**3:50**	8.1	10	5	10	48	50	**5:55**
10	**59**	10W	155	8.8	43.1	12	50	**3:40**	17.1	22	5	10	43	50	**5:50**
							Maximum ETE:	**4:20**						**Maximum ETE:**	**6:35**
							Average ETE:	**3:55**						**Average ETE:**	**6:05**

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

Medical Facility	Patient	Mobilization (min)	Loading Rate (min per person)	People	Total Loading Time (min)	Dist. To EPZ Bdry (mi)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
Cherrywood Advanced Living	Ambulatory	90	1	8	8	11.9	22	**2:00**
	Wheelchair bound	90	5	4	20	11.9	21	**2:15**
	Bedridden	90	15	2	30	11.9	20	**2:20**
New River Medical Center	Ambulatory	90	1	9	9	6.8	15	**1:55**
	Wheelchair bound	90	5	5	20	6.8	12	**2:05**
	Bedridden	90	15	11	30	6.8	10	**2:10**
CentraCare - Monticello Care Center	Ambulatory	90	1	3	3	6.8	17	**1:50**
	Wheelchair bound	90	5	71	20	6.8	12	**2:05**
	Bedridden	90	15	10	30	6.8	10	**2:10**
St. Benedict's Senior Community	Ambulatory	90	1	139	30	6.4	9	**2:10**
	Wheelchair bound	90	5	5	20	6.4	11	**2:05**
	Bedridden	90	15	2	30	6.4	9	**2:10**
Buffalo Hospital	Ambulatory	90	1	13	13	1.3	2	**1:45**
	Wheelchair bound	90	5	10	20	1.3	2	**1:55**
	Bedridden	90	15	12	30	1.3	2	**2:05**
							Maximum ETE:	**2:20**
							Average ETE:	**2:05**

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

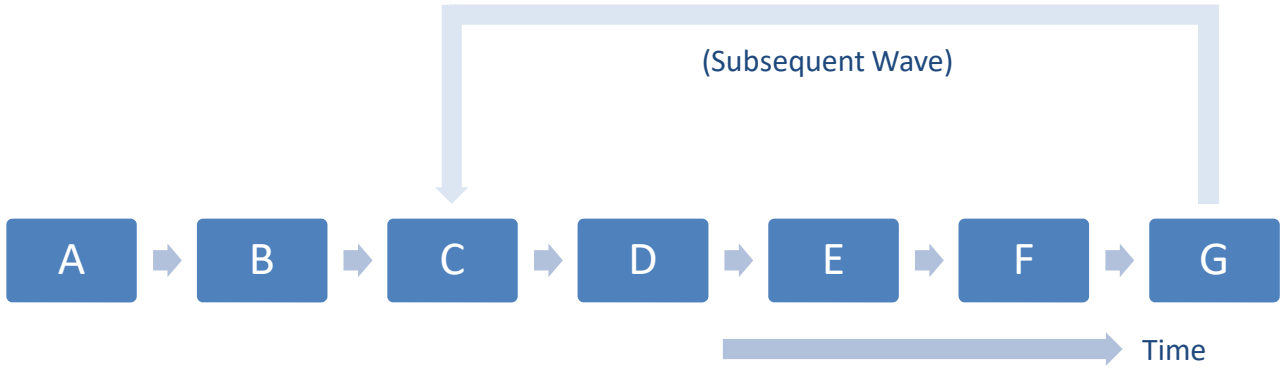
Medical Facility	Patient	Mobilization (min)	Loading Rate (min per person)	People	Total Loading Time (min)	Dist. To EPZ Bdry (mi)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
Cherrywood Advanced Living	Ambulatory	100	1	8	8	11.9	25	**2:15**
	Wheelchair bound	100	5	4	20	11.9	23	**2:25**
	Bedridden	100	15	2	30	11.9	21	**2:35**
New River Medical Center	Ambulatory	100	1	9	9	6.8	27	**2:20**
	Wheelchair bound	100	5	5	20	6.8	25	**2:25**
	Bedridden	100	15	11	30	6.8	17	**2:30**
CentraCare - Monticello Care Center	Ambulatory	100	1	3	3	6.8	28	**2:15**
	Wheelchair bound	100	5	71	20	6.8	25	**2:25**
	Bedridden	100	15	10	30	6.8	17	**2:30**
St. Benedict's Senior Community	Ambulatory	100	1	139	30	6.4	19	**2:30**
	Wheelchair bound	100	5	5	20	6.4	25	**2:25**
	Bedridden	100	15	2	30	6.4	19	**2:30**
Buffalo Hospital	Ambulatory	100	1	13	13	1.3	10	**2:05**
	Wheelchair bound	100	5	10	20	1.3	4	**2:05**
	Bedridden	100	15	12	30	1.3	2	**2:15**
							Maximum ETE:	**2:35**
							Average ETE:	**2:25**

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

Medical Facility	Patient	Mobilization (min)	Loading Rate (min per person)	People	Total Loading Time (min)	Dist. To EPZ Bdry (mi)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
Cherrywood Advanced Living	Ambulatory	110	1	8	8	11.9	29	**2:30**
	Wheelchair bound	110	5	4	20	11.9	34	**2:45**
	Bedridden	110	15	2	30	11.9	35	**2:55**
New River Medical Center	Ambulatory	110	1	9	9	6.8	24	**2:25**
	Wheelchair bound	110	5	5	20	6.8	26	**2:40**
	Bedridden	110	15	11	30	6.8	25	**2:45**
CentraCare - Monticello Care Center	Ambulatory	110	1	3	3	6.8	25	**2:20**
	Wheelchair bound	110	5	71	20	6.8	26	**2:40**
	Bedridden	110	15	10	30	6.8	25	**2:45**
St. Benedict's Senior Community	Ambulatory	110	1	139	30	6.4	25	**2:45**
	Wheelchair bound	110	5	5	20	6.4	26	**2:40**
	Bedridden	110	15	2	30	6.4	25	**2:45**
Buffalo Hospital	Ambulatory	110	1	13	13	1.3	2	**2:05**
	Wheelchair bound	110	5	10	20	1.3	2	**2:15**
	Bedridden	110	15	12	30	1.3	2	**2:25**
							Maximum ETE:	**2:55**
							Average ETE:	**2:35**

Table 8-11. Evacuation Time Estimates for Access and/or Functional Needs Population

Vehicle Type	People Requiring Vehicle	Vehicles deployed	Stops	Weather Conditions	Mobiliza-tion 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)
Midsize Buses	9	3	3	Good	135	1	18	2	22	**3:00**
				Rain	145		20		25	**3:15**
				Snow	155		22		22	**3:25**
Wheelchair Buses	5	2	3	Good	135	5	18	10	21	**3:10**
				Rain	145		20		24	**3:25**
				Snow	155		22		22	**3:35**
									Maximum ETE:	**3:35**
									Average ETE:	**3:20**



Event	
A	Advisory to Evacuate
B	Bus Dispatched from Depot
C	Bus Arrives at Facility/Pick-up Route
D	Bus Departs for Reception Center/Sister School
E	Bus Exits Region
F	Bus Arrives at Reception Center/Sister School
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/Sister School Outside the EPZ
F→G	Passengers Leave Bus; Driver Takes a Break

Figure 8-1. Chronology of Transit Evacuation Operations

9 TRAFFIC MANAGEMENT STRATEGY

This section discusses the suggested traffic management 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).
- The Manual on Uniform Traffic Control Devices (MUTCD) published by the Federal Highway Administration (FHWA) of the U.S.D.O.T. provides guidance for Traffic Control Devices to assist these personnel in the performance of their tasks. All state and most county transportation agencies have access to the MUTCD, which is available on-line: http://mutcd.fhwa.dot.gov which provides access to the official PDF version.
- A written plan that defines all Traffic and Access Control Point (TACP) 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 TACPs identified by the offsite agencies in their existing emergency plans serve as the basis of the traffic management plan, as per NUREG/CR-7002, Rev. 1. Appendix K identifies the number of intersections that were modeled as TACPs.
2. Evacuation simulations were run using DYNEV II to predict traffic congestion during an evacuation (see Section 7.3 and Figures 7-3 through 7-9). These simulations help to identify the best routing and critical intersections that experience pronounced congestion during evacuation. Any critical intersections that would benefit from traffic or access control which are not already identified in the existing offsite plans are examined. No additional TACPs were identified as part of this study.

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

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

9.1 Assumptions

The ETE calculations documented in Sections 7 and 8 assume that the traffic management plan is implemented during evacuation.

The ETE calculations reflect the assumption that all "external-external" trips are interdicted and diverted after 2 hours have elapsed from the Advisory to Evacuate (ATE).

All transit vehicles and other responders entering the EPZ to support the evacuation are assumed to be unhindered by personnel manning TACPs.

Section 2.5 discusses TACP operations.

9.2 Additional Considerations

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

These are only 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.

10 EVACUATION ROUTES AND RECEPTION CENTERS

10.1 Evacuation Routes

Evacuation routes are comprised of two distinct components:

- Routing from a Sub-Area 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 sister schools/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 to balance traffic demand relative to the available highway capacity to the extent possible. See Appendices B through D for further discussion.

The major evacuation routes for the EPZ are presented in Figure 10-1. These routes will be used by the general population evacuating in private vehicles, and by the transit-dependent population evacuating in buses. Transit-dependent evacuees will be routed to reception centers or sister schools. General population may evacuate to a reception center or some alternate destination (i.e., lodging facilities, relative's home, campgrounds) outside the EPZ.

The routing of transit-dependent evacuees from the EPZ boundary to reception centers/sister schools is designed to minimize the amount of travel outside the EPZ, from the points where these routes cross the EPZ boundary. The 10 bus routes shown graphically in Figure 10-2 and described in Table 10-1 were designed by KLD, as no pre-established transit-dependent bus routes exist within the EPZ or identified within the county emergency plans, in order to compute ETE. The routes were designed to service the major routes through a single or group of Sub-Area and then proceed to the reception centers assigned in the most recent public information. This does not imply that these exact routes would be used in an emergency. It is assumed that residents will walk to the nearest major roadway and flag down a passing bus, and that they can arrive at the roadway within the 135-minute bus mobilization time (good weather). In addition, representative routes were developed for all schools to a sister school.

The specified bus routes for all the transit-dependent population are documented in Table 10-2 (refer to maps of the link-node analysis network in Appendix K for node locations). Representative routes were developed for all schools and medical facilities within each Sub-Area. This study does not consider the transport of evacuees from the reception center to congregate care centers if the counties make the decision to relocate evacuees.

10.2 Reception Centers/Sister Schools

According to the current public information for EPZ residents, evacuees will be directed to reception centers. Figure 10-3 maps the general population reception centers for evacuees and sister schools for school evacuation. Table 10-3 presents a list of the sister school for each evacuating school in the EPZ. Children will be transported to these sister schools where they will be subsequently retrieved by their respective families.

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

Route	UNITES Route #	No. of Buses	Route Description	Sub-Area(s) Serviced	Length (mi.)
1	50	2	Sub-Area 2 - CR-75 eastbound into Monticello then to reception center	2	13.1
2	51	4	Sub-Area 5N - US 10 westbound into Becker then 140th Ave SE to CR 4 to CR 11 north then to reception center	5N	13.7
3	52	8	Sub-Area 5E - CR 73 southbound to Hiawatha Ave W around Lake Mitchell then southbound on CR 5 to CR 43 then to reception center	5E	15.2
4	53	6	Sub-Area 5S - County Hwy 75 in downtown Monticello to SR-25 southbound to School Blvd then to reception center	5S	9.3
5	54	3	Sub-Areas 5W, 10SW - southbound on CR 8 NW into Maple Lake then eastbound on CR 37 NW to I-94 eastbound in Albertville then to reception center	5W & 10SW	26.8
6	55	2	Sub-Areas 10N, 10NW - northbound on CR 58 into Clear Lake then eastbound on US 10 to CR 54 to CR 53 to 57th St SE then to reception center	10N & 10NW	14.2
7	56	2	Sub-Area 10E - northbound on CR 15 to CR 4 then to reception center	10E	6.1
8	57	2	Sub-Area 10SE - southbound on CR 19 through Albertville to CR 18 to 60th St NE to Iffert Ave NE to CR 35 then to reception center	10SE	11.7
9	58	3	Sub-Area 10S - southbound on SR 25 into Buffalo then eastbound on CR 35 to reception center	10S	13.2
10	59	2	Sub-Area 10W - northbound on CR 7 to SR 24 northbound then on I-94 westbound to reception center	10W	8.8
	Total:	34			

Table 10-2. Bus Route Descriptions

UNITES Bus Route #	Description	Nodes Traversed from Route Start to EPZ Boundary
Transit Dependent Routes		
56	TD_Sub-Area 10E	982, 719, 720, 721, 722, 723, 724, 725, 729, 730, 782
57	TD_Sub-Area 10SE	610, 1236, 1023, 1333, 1234, 609, 1331, 1233, 1027, 1232, 1030, 594
50	TD_Sub-Area 2	577, 562, 563, 564, 556, 879, 880, 881, 169, 889, 882, 1163, 1018, 168, 167, 166, 28, 29, 30, 31, 32, 33, 34
51	TD_Sub-Area 5N	929, 214, 215, 216, 217, 218, 219, 220, 221, 222
52	TD_Sub-Area 5E	1075, 1074, 280, 279, 1002, 1123, 1124, 1125, 1303, 1126, 1127, 1128, 1129, 1130, 1131, 1132, 1133, 1134, 982, 719, 720, 721, 722, 723, 724, 725, 729, 730, 782
53	TD_Sub-Area 5S	556, 879, 880, 881, 169, 889, 882, 1163, 1018, 168, 167, 197, 391, 174, 868, 387, 386, 385, 384, 383, 1293, 1292, 1291, 1108, 1109, 1110, 1111, 1147, 1112, 1113, 1114, 1115, 1116, 1117, 382
54	TD_Sub-Areas 5W, 10SW	113, 110, 111, 112, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 923, 126, 392, 393, 917, 394, 419, 919, 440, 519
55	TD_Sub-Areas 10N, 10NW	305, 979, 306, 588, 222, 223
59	TD_Sub-Area 10W	161, 160, 159, 158, 157, 156, 155, 154, 153, 152, 151, 150, 149, 148, 147, 146, 145, 144, 63, 57, 1371, 58, 59, 13
58	TD_Sub-Areas 10S	181, 182, 183, 184, 185, 1205, 186, 187, 906, 1194, 1195, 1196, 699, 901, 698, 697, 696, 430
School Routes		
27	Tatanka Elementary School	908, 429, 430
32	Kaleidoscope Charter School	1023, 1333, 1234, 609, 1331, 1233, 1027
34	Becker High School/Intermediate/Middle School/Primary School	934, 579, 580, 581, 582, 936, 937, 216, 938, 939, 940, 941, 942, 1072, 293, 294, 295, 726, 727, 728
4	Maple Lake High School/Elementary School	420, 394, 419, 919, 440, 519
2	Liberty Elementary School	1002, 1123, 1124, 1125, 1303, 1126, 1127, 1128, 1129, 1130, 1131, 1132, 1133, 1134, 982, 719, 720, 721, 722, 723, 724, 725, 729, 730, 782
7	Jubilee Christian Center	588, 222, 223
8	Pinewood Elementary School	564, 556, 879, 880, 881, 169, 889, 882, 1163, 1018, 168, 167, 166, 28, 29, 30, 31, 32, 33, 34
14	Swan River Montessori School	874, 876, 875, 882, 1163, 1018, 168, 167, 166, 28, 29, 30, 31, 32, 33
9	Turning Point ALP	1020, 1018, 168, 167, 166, 28, 29, 30, 31, 32, 33, 34

UNITES Bus Route #	Description	Nodes Traversed from Route Start to EPZ Boundary
11	Monticello Middle School	557, 1014, 1016, 388, 348, 349, 1211, 30, 31, 32, 33, 34
10	Holy Spirit Academy	1276, 348, 349, 1211, 30, 31, 32, 33, 34
13	Prairie House Recovery Center	563, 564, 556, 879, 880, 881, 169, 889, 882, 1163, 1018, 168, 167, 166, 28, 29, 30, 31, 32, 33, 34
12	Monticello High School/Little Mountain Elementary School	590, 349, 1211, 30, 31, 32, 33, 34
15	Eastview Education Center	352, 351, 350, 349, 1211, 30, 31, 32, 33, 34
33	St. Michael-Albertville High School	1044, 1043, 1042, 1041, 1040
3	Fieldstone Elementary School	1042, 1041, 1040
16	St Francis Xavier School	1217, 184, 185, 1205, 186, 187, 908, 429
28	Buffalo Middle School/Cornerstone High School/Eastern Wright Program/Wright Technical center High School	186, 187, 908, 429
17	Buffalo High School	623, 1198, 1197, 1199, 1140, 1141
5	St. Timothy's Catholic School	394, 419, 919, 440, 519
6	Westside Alternative School	919, 440, 519
18	Northwinds Elementary School	427, 428, 187, 908, 429
19	Phoenix Learning Center	622, 621, 620, 430
20	Parkside Elementary School/Discovery Elementary School/PRIDE Transitions	697, 696, 430, 1192
Medical Facility Routes		
21	Cherrywood Advanced Living	1002, 1123, 1124, 1125, 1303, 1126, 1127, 1128, 1129, 1130, 1131, 1132, 1133, 1134, 982, 719, 720, 721, 722, 723, 724, 725, 729, 730, 782
40	New River Medical Center/CentraCare	557, 1014, 1016, 388, 348, 349, 1211, 30, 31, 32, 33, 34
1	Big Lake High School/Middle School/Independence Elementary School	279, 1002, 1123, 1124, 1125, 1303, 1126, 1127, 1128, 1129, 1130, 1131, 1132, 1133, 1134, 982, 719, 720, 721, 722, 723, 724, 725, 729, 730, 782
22	St. Benedict's Senior Community	1276, 348, 349, 1211, 30, 31, 32, 33, 34
41	Buffalo Hospital	185, 1205, 186, 187, 908, 429

Table 10-3. Sister Schools for School Evacuation

School	Sister School
Becker Intermediate School	Zimmerman Middle and High School
Becker Primary School	
Becker High School	
Becker Middle School	
Big Lake High School	Princeton North Elementary School
Big Lake Middle School	Princeton Middle School
Independence Elementary School	
Liberty Elementary School	
Jubilee Christian Center	
Prairie House Recovery Center	Maple Grove High School
Pinewood Elementary School	
Swan River Montessori School	
Turning Point Alternative Learning Program	
Monticello Middle School	
Holy Spirit Academy	
Little Mountain Elementary School	
Monticello High School	
Eastview Education Center	
Kaleidoscope Charter School	St. Michael Elementary School
St. Michael-Albertville High School	St. Michael-Albertville Middle School
Fieldstone Elementary School	Big Woods Elementary School
Cornerstone High School	Rockford High School
Eastern Wright Program	
Wright Technical Center High School	
Buffalo Community Middle School	
Buffalo High School	Rockford Community Center (RES)
Phoenix Learning Center	

School	Sister School
Maple Lake Elementary School	Dassel-Cokato Middle & High School
Maple Lake High School	
St. Timothy's Catholic School	
Westside Alternative School	
Northwinds Elementary School	Rockford Elementary School
Parkside Elementary School	
Discovery Elementary School	
Discovery Elementary School	
PRIDE Transitions	
Tatanka Elementary School	
St Francis Xavier School	

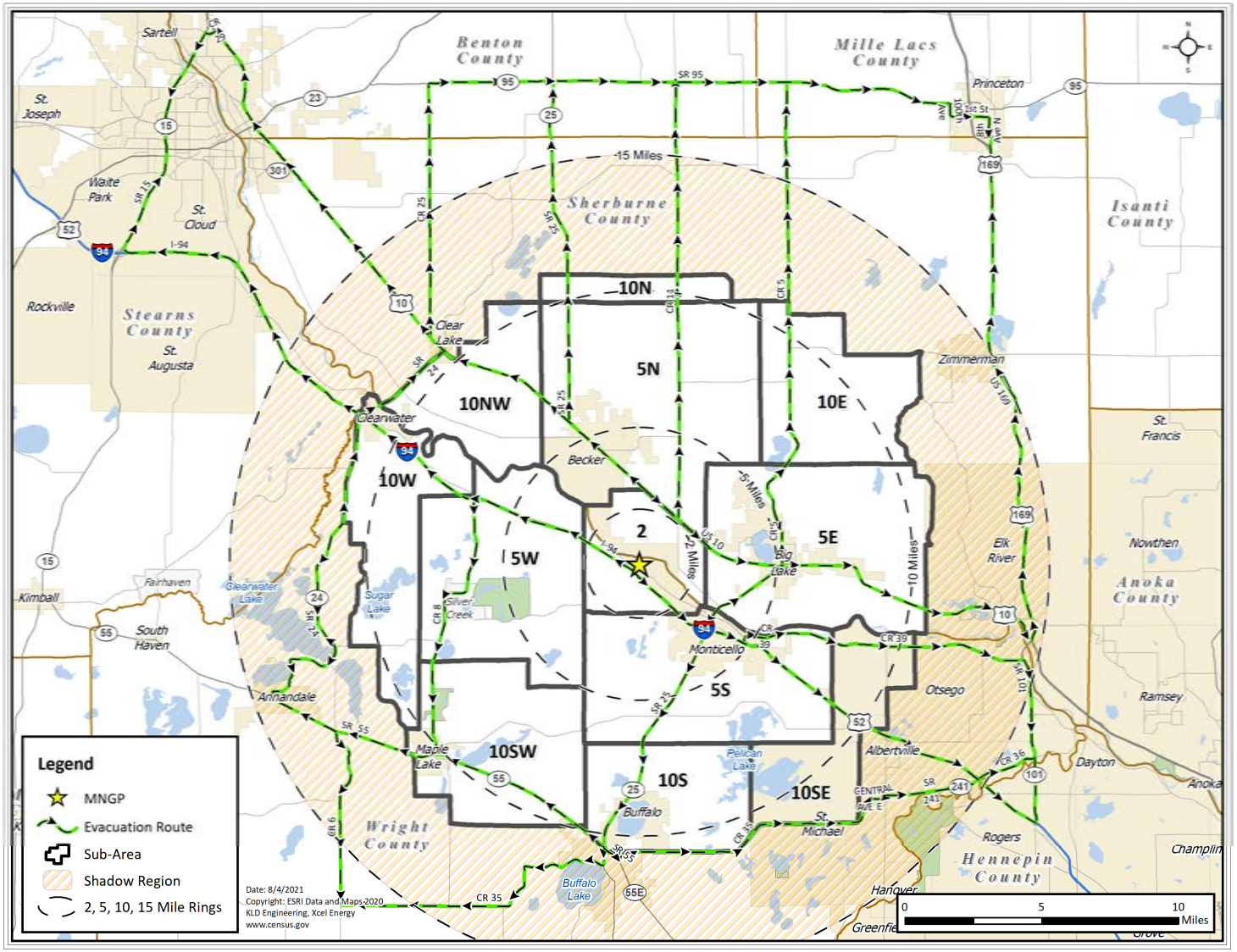


Figure 10-1. Evacuation Routes

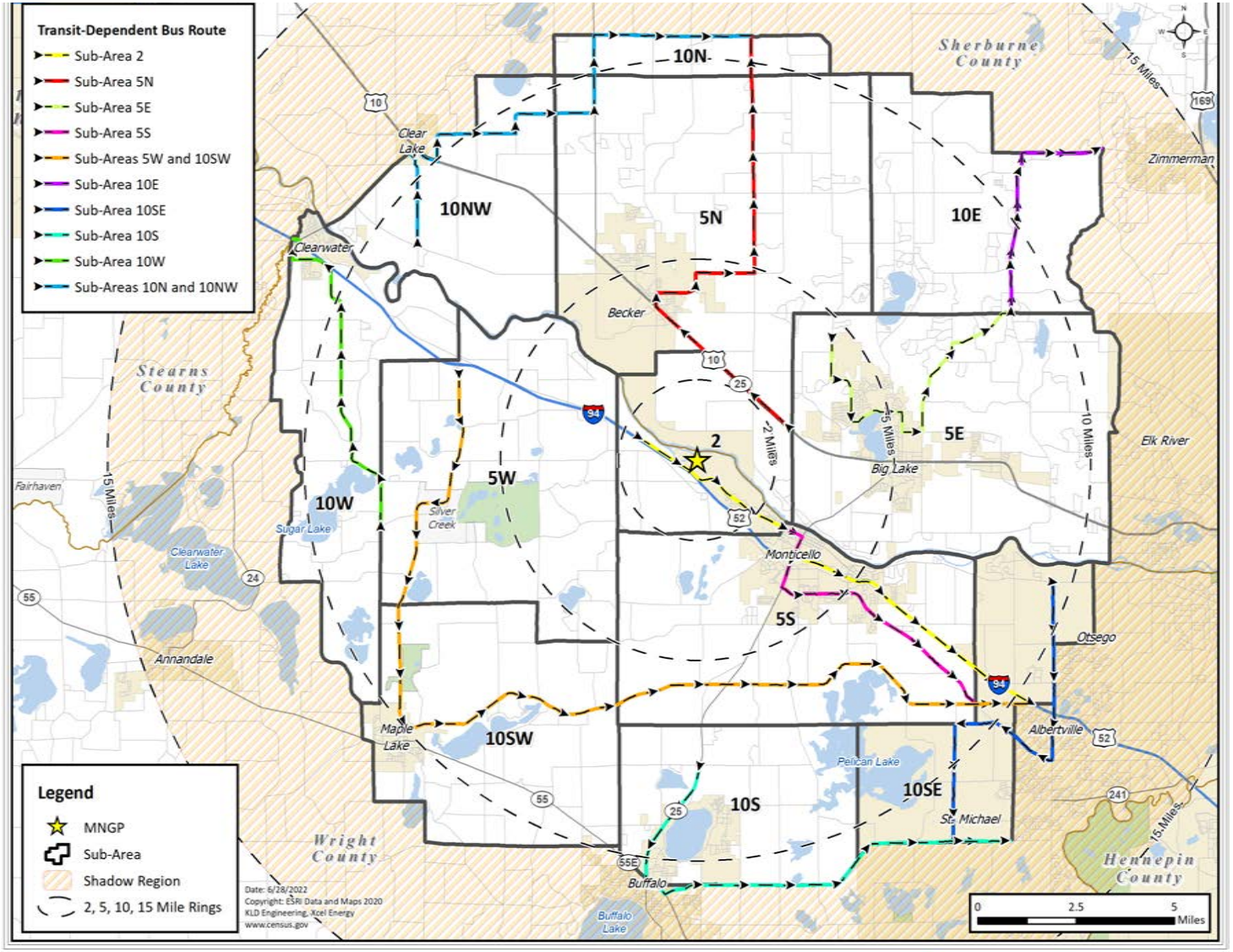


Figure 10-2. Transit-Dependent Bus Routes

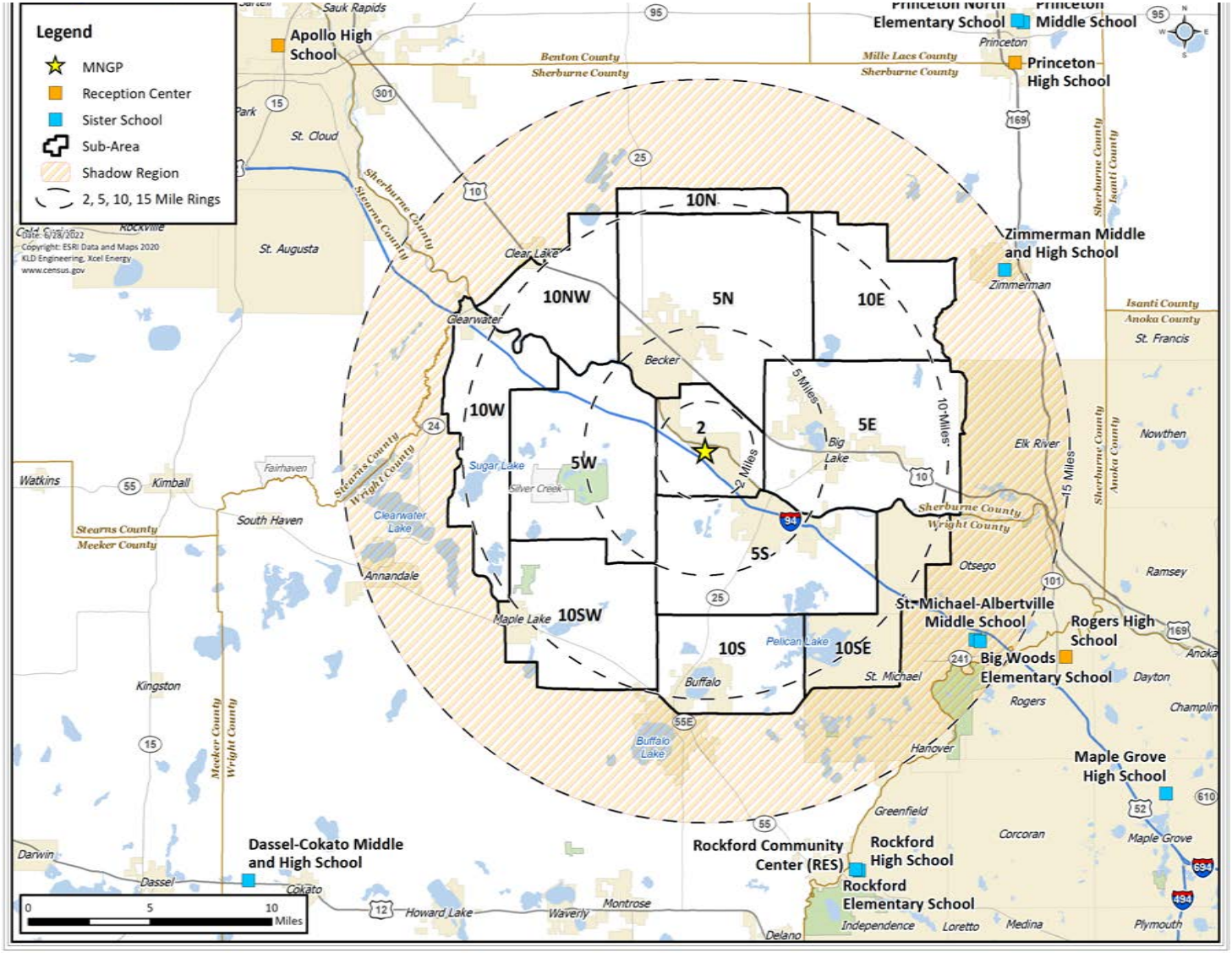


Figure 10-3. Reception Centers and Sister Schools

APPENDIX A

Glossary of Traffic Engineering Terms

A. GLOSSARY OF TRAFFIC ENGINEERING TERMS

Table A-1. Glossary of Traffic Engineering Terms

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

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

APPENDIX B

DTRAD: Dynamic Traffic Assignment and Distribution Model

B. DYNAMIC TRAFFIC ASSIGNMENT AND DISTRIBUTION MODEL

This section describes the integrated dynamic trip assignment and distribution model named DTRAD (Dynamic Traffic Assignment and Distribution) that is expressly designed for use in analyzing evacuation scenarios. DTRAD employs logit-based path-choice principles and is one of the models of the DYNEV II 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 DYNEV II 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 DTRAD include:

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

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

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

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

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

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

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

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

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

Network Equilibrium

In 1952, John Wardrop wrote:

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

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

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

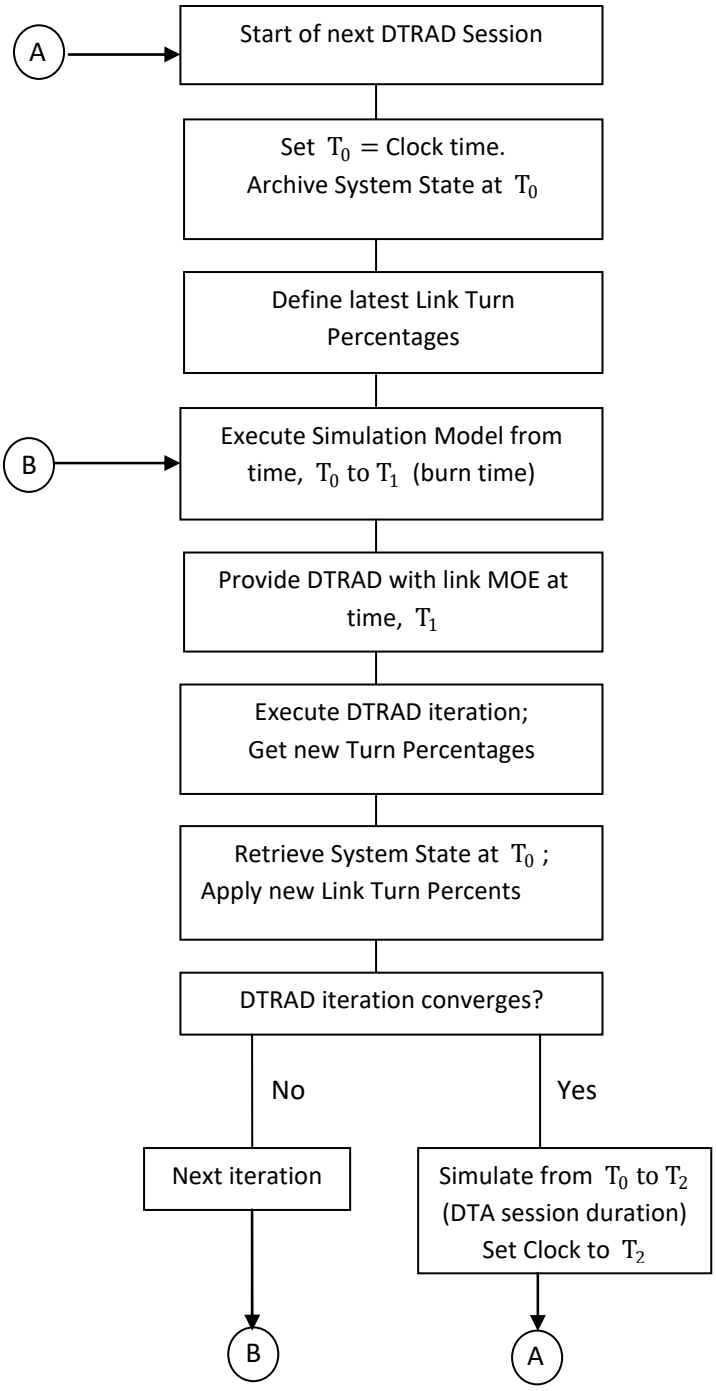


Figure B-1. Flow Diagram of Simulation-DTRAD Interface

APPENDIX C

DYNEV Traffic Simulation Model

C. DYNEV TRAFFIC SIMULATION MODEL

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

Model Features Include:

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

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

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

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

C.1 Methodology

C.1.1 The Fundamental Diagram

It is necessary to define the fundamental diagram describing flow-density and speed-density relationships. Rather than "settling for" a triangular representation, a more realistic representation that includes a "capacity drop", (I-R)$Q_{max,}$ at the critical density when flow conditions enter the forced flow regime, is developed and calibrated for each link. This representation, shown in Figure C-2, asserts a constant free speed up to a density, k_f, and then a linear reduction in speed in the range, $k_f \le k \le k_c = 45$ vpm, the density at capacity. In the flow-density plane, a quadratic relationship is prescribed in the range, $k_c < k \le k_s = 95$ 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 moving 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 $0 \le \bar{k} \le \bar{k}_s = 50$. It can be shown that $Q = \left(0.98 - 0.0056\,\bar{k}\right) RQ_{max}$ for $\bar{k}_s \le \bar{k} \le \bar{k}_j$, where $\bar{k}_s = 50$ and $\bar{k}_j = 175$.

C.1.2 The Simulation Model

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

The formulation and the associated logic presented below are designed to solve the unit problem for each sweep over the network (discussed below), for each turn movement serviced on each link that comprises the evacuation network, and for each TI over the duration of the evacuation.

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

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

2. Calculate $v(k)$ such that $k \leq 130$ using the analytical representations of the fundamental diagram.
   Calculate $Cap = \frac{Q_{max}(TI)}{3600} \left(G/C\right) LN$, 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 $t_1 < 0$, 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 $Q_b \geq Cap$, then
   $O_Q = Cap$, $O_M = O_E = 0$
   If $t_1 > 0$, then
   $Q'_e = Q_b + M_b + E_1 - Cap$
   Else
   $Q'_e = Q_b - Cap$
   End if
   Calculate Q_e and M_e using Algorithm A (below)

6. Else $(Q_b < Cap)$
   $O_Q = Q_b$, $RCap = Cap - O_Q$

7. If $M_b \leq RCap$, 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 moving vehicles.

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

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

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

End if

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

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

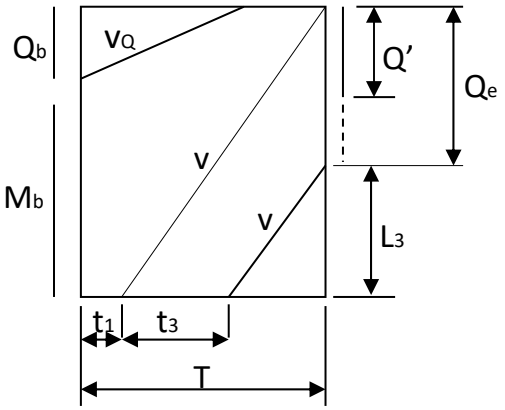
The number of excess vehicles that cause spillback is: $SB = Q_e + M_e - \frac{(L-W)\cdot LN}{L_v}$, where W is the width of the upstream intersection. To prevent spillback, meter the outflow from the feeder approaches and from the source flow, S, during this TI by the amount, SB. That is, set

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

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

Algorithm A

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



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

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

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

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

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

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

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.

C.2.2 Interfacing with Dynamic Traffic Assignment (DTRAD)

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

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

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

Additional details are presented in Appendix B.

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

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

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

HIGHWAY NETWORK

- Links defined by upstream and downstream node numbers
- Link lengths
- Number of lanes (up to 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

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 moving vehicles of a particular movement over a TI, on a link.
L	The length of the link in feet.
L_b , L_e	The queue length in feet of a particular movement, at the [beginning, end] of a time interval.
LN	The number of lanes, expressed as a floating point number, allocated to service a particular movement on a link.
L_v	The mean effective length of a queued vehicle including the vehicle spacing, feet.
M	Metering factor (Multiplier): 1.
M_b , M_e	The number of moving vehicles on the link, of a particular movement, that are moving at the [beginning, end] of the time interval. These vehicles are assumed to be of equal spacing, over the length of link upstream of the queue.
O	The total number of vehicles of a particular movement that are discharged from a link over a time interval.
O_Q , O_M , O_E	The components of the vehicles of a particular movement that are discharged from a link within a time interval: vehicles that were Queued at the beginning of the TI; vehicles that were Moving within the link at the beginning of the TI; vehicles that Entered the link during the TI.
P_x	The percentage, expressed as a fraction, of the total flow on the link that executes a particular turn movement, x.

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

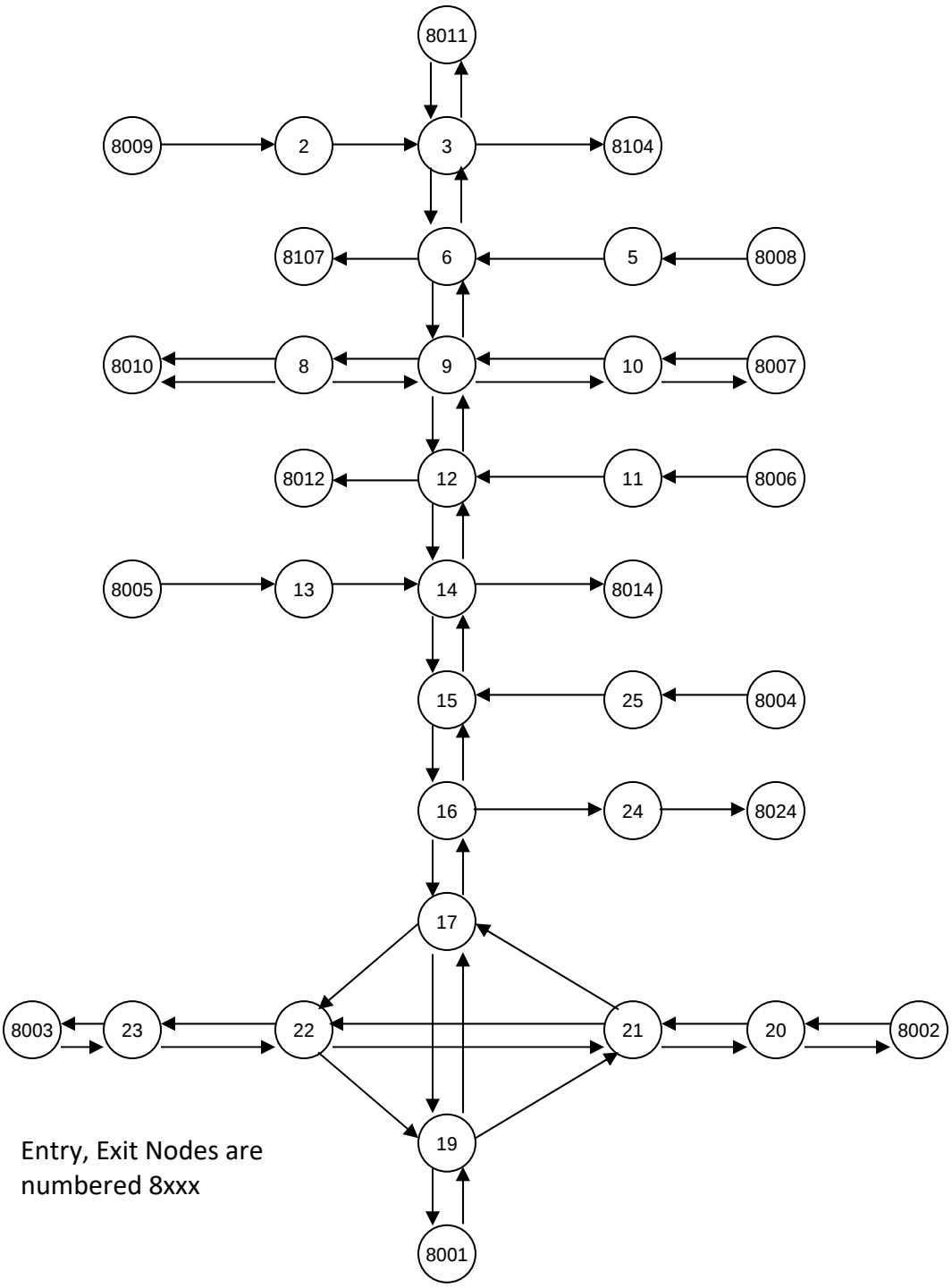


Figure C-1. Representative Analysis Network

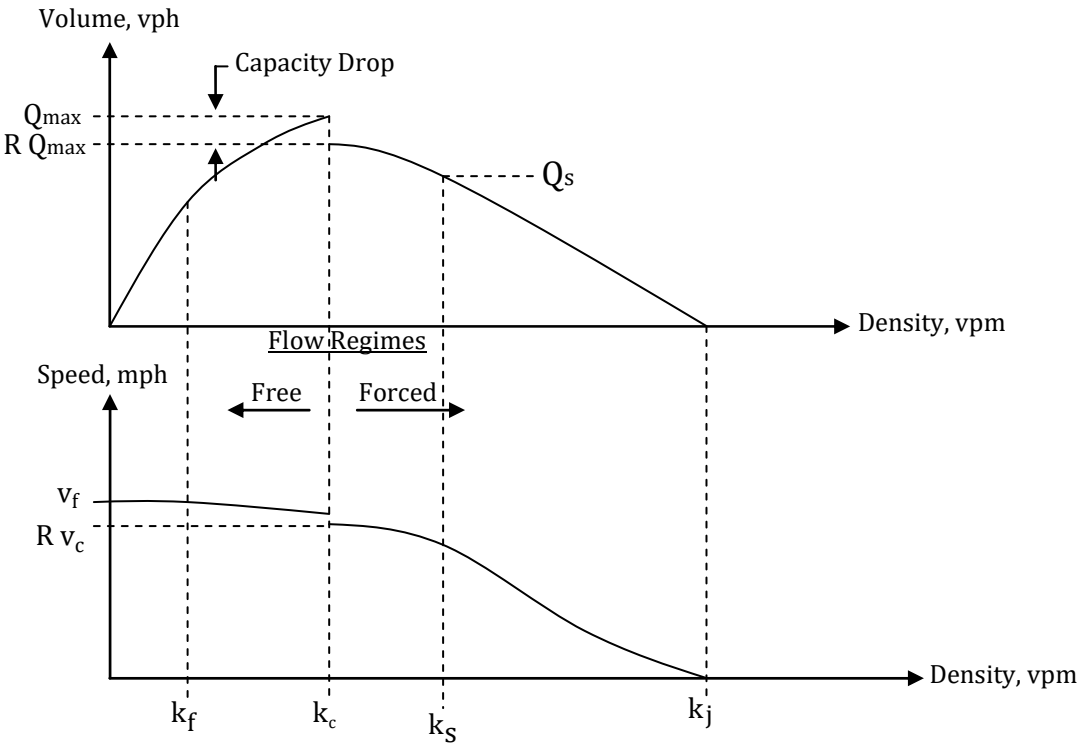


Figure C-2. Fundamental Diagrams

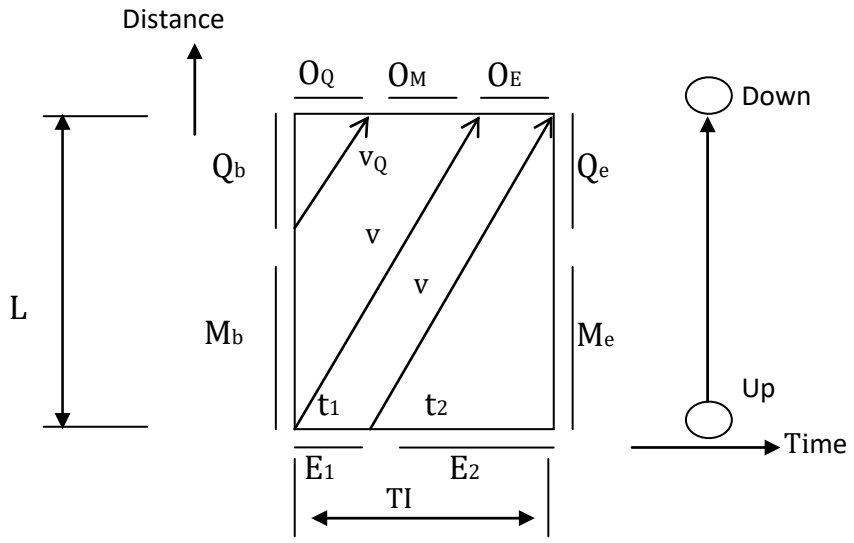


Figure C-3. A UNIT Problem Configuration with $t_1 > 0$

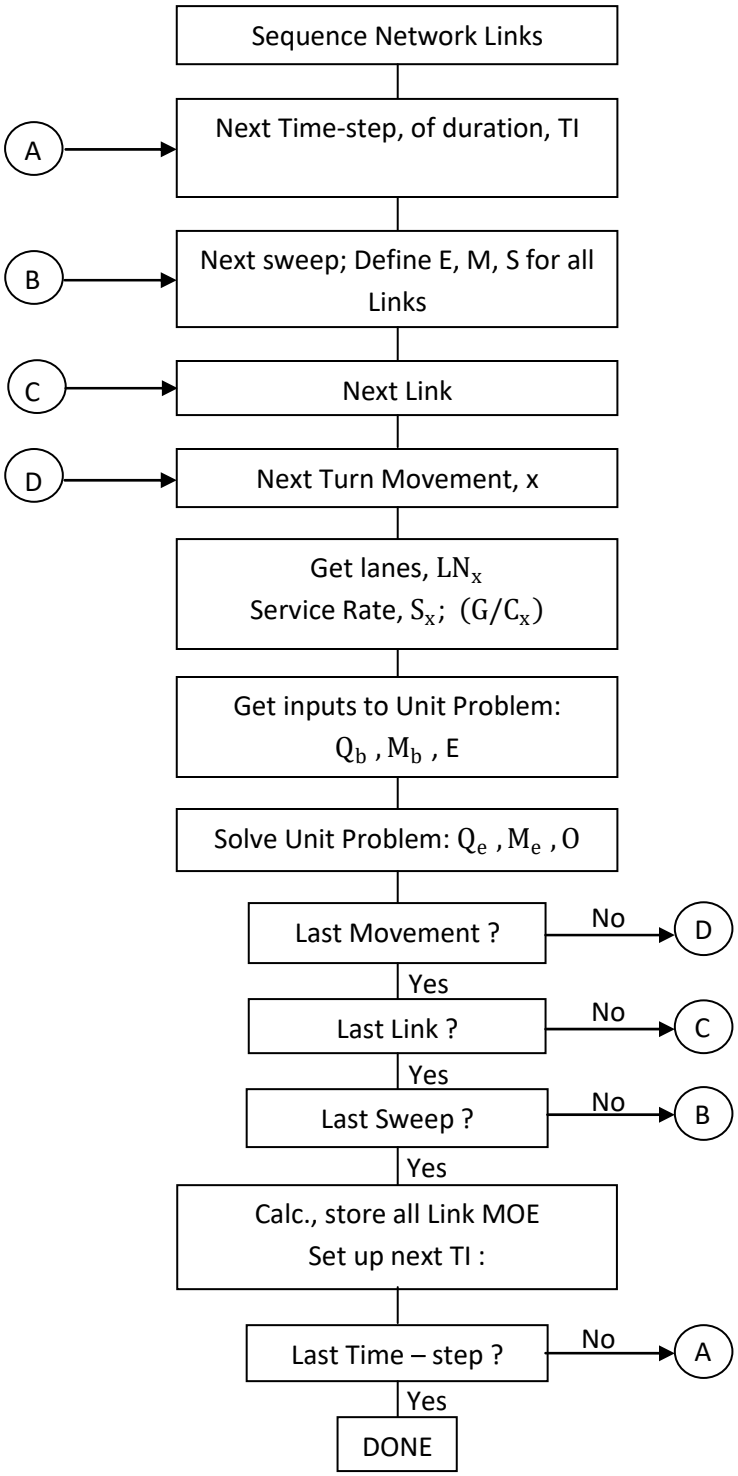


Figure C-4. Flow of Simulation Processing (See Glossary: Table C-3)

APPENDIX D

Detailed Description of Study Procedure

D. DETAILED DESCRIPTION OF STUDY PROCEDURE

This appendix describes the activities that were performed to compute Evacuation Time Estimates (ETE). 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 Emergency Planning Zone (EPZ) boundary information and create a Geographic Information System (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

2020 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 based on data provided by the counties as well as using the US Census Longitudinal Employer-Household Dynamics from the OnTheMap Census analysis tool[1]. Data for transients, schools, and other facilities were obtained from the counties within the EPZ, the National Center for Education Statistics website[2], the Minnesota Department of Human Services[3], phone calls/emails to the facilities, satellite imagery of the facilities, and the previous ETE study, supplemented by internet searches where data was missing.

Step 3

A kickoff meeting was conducted with major stakeholders (state and local emergency managers, and 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 the state and county 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 any changes to the roadway network since the previous study. This survey included consideration of 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

[1] https://onthemap.ces.census.gov/
[2] https://nces.ed.gov/ccd/schoolsearch/index.asp
[3] https://mn.gov/dhs/

timings for pre-timed traffic signals, and to make the necessary observations needed to estimate realistic values of roadway capacity. Roadway characteristics were also verified using aerial imagery.

Step 5

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

Step 6

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

Step 7

The EPZ is subdivided into 12 Sub-Areas. Based on wind direction and speed, Regions (groupings of Sub-Areas) 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 model was executed on the prototype evacuation case to compute evacuating traffic routing patterns consistent with the appropriate NRC guidelines. DYNEV II contains an extensive suite of data diagnostics which check the completeness and consistency of the input data specified. The analyst reviews all warning and error messages produced by the model and then corrects the database to create an input stream that properly executes to completion.

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

Step 10

The results generated by the prototype evacuation case are critically examined. The examination includes observing the animated graphics (using the EVAN software – see Section 1.3) 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, adding routes (which are paved and traversable) that were not previously modelled but may assist in an evacuation and increase the available roadway network capacity, 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 model is again executed.

Step 13

Evacuation of transit-dependent evacuees and special facilities are included in the evacuation analysis. Fixed routing for transit buses, 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 were executed using the DYNEV II model to compute ETE. Once results were available, quality control procedures were used to assure the results were consistent, dynamic routing was reasonable, and traffic congestion/bottlenecks were addressed properly. Traffic management plans are analyzed, and traffic control points are prioritized, if applicable. Additional analysis is conducted to identify the sensitivity of the ETE to changes in some base evacuation conditions and model assumptions.

Step 16

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

Step 17

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

Step 18

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

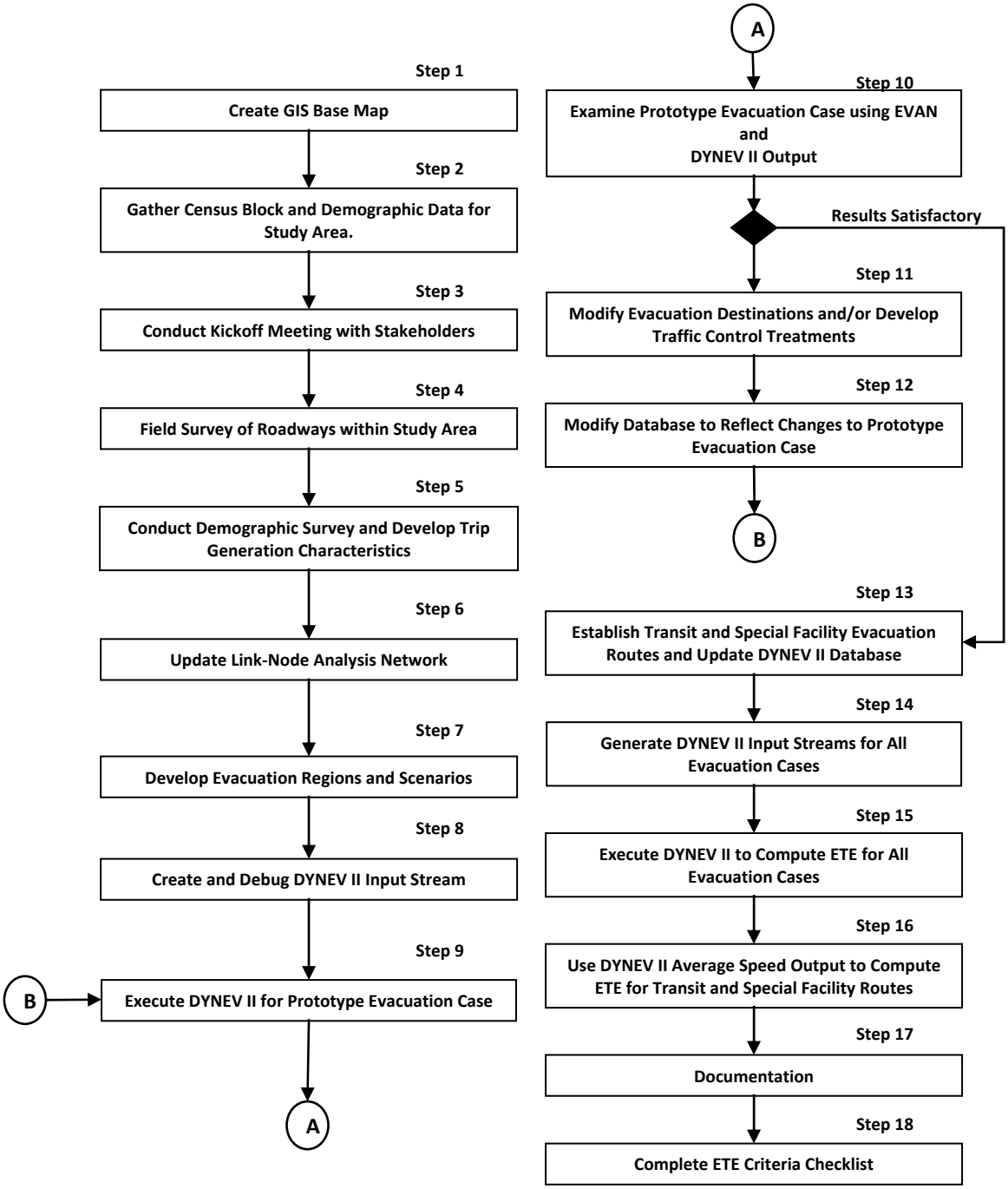


Figure D-1. Flow Diagram of Activities

APPENDIX E

Special Facility Data

E. SPECIAL FACILITY DATA

The following tables list population information, as of December 2021, for special facilities, transient attractions and major employers that are located within the MNGP EPZ. Special facilities are defined as schools, day cares/preschools, medical facilities, and correctional facilities. Transient population data is included in the tables for recreational areas (campgrounds, golf courses, parks) and lodging facilities. Employment data is included in the table for major employers. Each table is grouped by county. The location of the facility is defined by its straight-line distance (miles) and direction (magnetic bearing) from the center point of the plant. Maps of each school, day care/preschool, medical facility, campground, golf course, park, lodging facility, major employer, and correctional facility are also provided.

Table E-1. Schools within the Study Area

Sub-Area	Distance (miles)	Direction	School Name	Street Address	Municipality	Enrollment
SHERBURNE COUNTY						
5N	4.5	NNW	Becker Intermediate School	12000 Hancock St	Becker	662
5N	4.6	NNW	Becker Primary School	12050 2nd St SE	Becker	656
5N	4.7	NNW	Becker High School	12000 Hancock St	Becker	915
5N	4.8	NNW	Becker Middle School	12000 2nd St SE	Becker	709
5E	5.4	E	Big Lake High School	501 Minnesota Ave	Big Lake	889
5E	5.4	E	Big Lake Middle School	601 Minnesota Ave	Big Lake	750
5E	5.7	E	Independence Elementary School	701 Minnesota Ave	Big Lake	699
5E	6.1	E	Liberty Elementary School	17901 205th Ave NW	Big Lake	718
10N	10.4	N	Jubilee Christian Center	15455 59th St SE	Becker	34
					Sherburne County Subtotal:	*6,032*
WRIGHT COUNTY						
2	1.4	SE	Prairie House Recovery Center	305 Prairie Rd	Monticello	7
2	2.6	SE	Pinewood Elementary School	1010 W Broadway St	Monticello	899
5S	3.1	SE	Swan River Montessori School	500 Maple St	Monticello	158
5S	3.6	SE	Turning Point Alternative Learning Program	406 E 7th St #200	Monticello	24
5S	4.0	SE	Monticello Middle School	800 E Broadway St	Monticello	1,046
5S	4.2	SE	Holy Spirit Academy	1001 7th St E Suite 1	Monticello	35
5S	4.5	SE	Little Mountain Elementary School	9350 Fallon Ave NE	Monticello	639
5S	4.7	SE	Monticello High School	5225 School Blvd	Monticello	1,215
5S	4.9	SE	Eastview Education Center	9375 Fenning Ave NE	Monticello	420
10SE	10.1	ESE	Kaleidoscope Charter School	7525 Kalland Ave NE	Otsego	572
10SE	10.2	SE	St. Michael-Albertville High School	5800 Jamison Ave	Albertville	2,085
10SE	10.6	SE	Fieldstone Elementary School	5255 Jansen Ave NE	St. Michael	625
10S	9.1	S	St Francis Xavier School	219 19th St	Buffalo	231
10S	9.8	S	Cornerstone High School	1405 3rd Ave NE	Buffalo	18
10S	9.8	S	Eastern Wright Program	1405 3rd Ave NE	Buffalo	7
10S	9.9	S	Wright Technical Center High School	1405 3rd Ave NE	Buffalo	350
10S	10.0	S	Buffalo Community Middle School	1300 Hwy 25 N	Buffalo	1,380
10S	10.5	S	Buffalo High School	877 Bison Blvd	Buffalo	1,858
10S	10.6	S	Tatanka Elementary School	703 8th St. NE	Buffalo	516
10SW	10.1	SW	Maple Lake Elementary School	200 State Highway 55 E	Maple Lake	409

Sub-Area	Distance (miles)	Dire-ction	School Name	Street Address	Municipality	Enroll-ment
10SW	10.1	SW	Maple Lake High School	200 State Highway 55 E	Maple Lake	441
10SW	10.3	SW	St. Timothy's Catholic School	241 Start E St	Maple Lake	120
10SW	10.4	SW	Westside Alternative School	33 Birch S Ave	Maple Lake	9
S.R.	10.5	SSW	Northwinds Elementary School[1]	1111 7th Ave NW	Buffalo	519
S.R.	10.6	S	Phoenix Learning Center[1]	800 8th St NE	Buffalo	37
S.R.	10.9	S	Parkside Elementary School[1]	207 3rd St. NE	Buffalo	367
S.R.	11.0	S	Discovery Elementary School[1]	214 1st Ave NE	Buffalo	125
S.R.	11.0	S	Discovery Elementary School[1]	301 2nd Ave NE	Buffalo	247
S.R.	11.3	S	PRIDE Transitions[1]	15 1st Ave S	Buffalo	13
					Wright County Subtotal:	*14,372*
					STUDY AREA TOTAL:	**20,404**

Table E-2. Day Cares and Preschools within the EPZ

Sub-Area	Distance (miles)	Dire-ction	School Name	Street Address	Municipality	Enroll-ment
SHERBURNE COUNTY						
5N	3.9	NNW	Red Balloon Child Care Center	12601 Birch Ave	Becker	150
5N	4.4	NNW	Becker Primary School Early Childhood	12050 Hancock St	Becker	183
5E	4.9	E	Heritage Montessori School	310 Lake St S	Big Lake	20
5E	7.8	E	New Creations Child Care & Learning Center	16547 Marketplace Dr	Big Lake	120
					Sherburne County Subtotal:	*473*
WRIGHT COUNTY						
5S	3.3	SE	Playhouse Child Care Center	109 Sandberg Rd	Monticello	97
5S	5.4	SE	Pumpkin Patch Pre-School	9225 Jason Ave NE	Monticello	30
5S	5.7	SE	Love Your Child Daycare	8548 Troy Marquette Dr	Monticello	10
10S	9.1	S	St. Francis Xavier Child Development Preschool	233 19th St NW	Buffalo	40
10SW	10.1	SW	Maple Lake Preschool	200 State Highway 55 E	Maple Lake	25
10W	11.0	WNW	Clearwater Headstart	1155 County Rd 75	Clearwater	20
					Wright County Subtotal:	*222*
					EPZ TOTAL:	**695**

[1] According to Xcel Energy Nuclear Safety and Emergency Preparedness, these schools will evacuate in the event of an emergency at MNGP even though they are located in the Shadow Region (S.R.).

Table E-3. Medical Facilities within the EPZ

Sub-Area	Distance (miles)	Direction	Facility Name	Street Address	Municipality	Capacity	Current Census	Ambulatory Patients	Wheelchair Patients	Bedridden Patients
SHERBURNE COUNTY										
5E	5.5	E	Cherrywood Advanced Living	177 Henry Rd	Big Lake	14	14	8	4	2
Sherburne County Subtotal:						*14*	*14*	*8*	*4*	*2*
WRIGHT COUNTY										
5S	4.0	SE	New River Medical Center	1013 Hart Blvd	Monticello	31	25	9	5	11
5S	4.0	ESE	CentraCare - Monticello Care Center	1104 E River St	Monticello	89	84	3	71	10
5S	4.4	SE	St. Benedict's Senior Community	1301 E 7th St	Monticello	150	146	139	5	2
10S	9.6	S	Buffalo Hospital	303 Catlin St	Buffalo	65	35	13	10	12
Wright County Subtotal:						*335*	*290*	*164*	*91*	*35*
EPZ TOTAL:						**349**	**304**	**172**	**95**	**37**

Table E-4. Major Employers within the EPZ

Sub-Area	Distance (miles)	Direction	Facility Name	Street Address	Municipality	Employees (Max Shift)	% Employees Commuting into the EPZ	Employees Commuting into the EPZ	Employee Vehicles Commuting into the EPZ
SHERBURNE COUNTY									
5N	3.8	NNW	Sherco Plant	13999 Industrial Blvd	Becker	350	53%	186	175
Sherburne County Subtotal:						*350*	-	*186*	*175*
WRIGHT COUNTY									
2	-	-	Monticello Nuclear Generating Plant	2807 W CR 75	Monticello	300	62%	186	175
5S	3.2	SE	Cargill Kitchen Solutions, Inc.	206 West 4th St	Monticello	306	62%	190	179
Wright County Subtotal:						*606*	-	*376*	*354*
EPZ TOTAL:						**956**	**-**	**562**	**529**

Table E-5. Recreational Areas within the EPZ

Sub-Area	Distance (miles)	Direction	Facility Name	Street Address	Municipality	Facility Type	Transients	Vehicles
SHERBURNE COUNTY								
5N	5.2	N	Pebble Creek Country Club	14000 Club House Ln	Becker	Golf Course	89	58
5N	5.5	NE	Carefree Country Club	12311 185th Ave SE	Big Lake	Golf Course	110	58
5E	8.9	ESE	Dimmick Island Watercraft Campsite	9968 Kahler Ave NE	Otsego	Campground	Local Residents Only[2]	
10E	9.8	NE	Ann Lake Campground	Prairie's Edge Wildlife Dr	Big Lake	Campground	125	44
10E	10.0	NE	Sand Dunes State Forest	Day Use Rd	Big Lake	Park	79	28
10NW	8.9	WNW	Travelers Country Club on the Mississippi	11290 80th Ave SE	Clear Lake	Golf Course	89	58
10NW	10.2	NW	Travelers Country Club-Clear	8520 85th Ave	Clear Lake	Golf Course	89	58
						Sherburne County Subtotal:	*581*	*304*
WRIGHT COUNTY								
2	2.2	SE	Monticello Country Club	1209 Golf Course Rd	Monticello	Golf Course	100	100
5W	4.2	WSW	Lake Maria State Park	11411 Clementa Ave NW	Monticello	Park	368	56
5W	4.2	WSW	Lake Maria State Park	11411 Clementa Ave NW	Monticello	Campground	132	44
5W	7.6	W	Olson's Campground	5669 123rd St NW	Maple Lake	Campground	211	150
10SE	8.8	ESE	Riverwood National Golf Course	10247 95th St NE	Monticello	Golf Course	15	7
10SE	10.4	SE	Cedar Creek Golf Course	5700 Jason Avenue NE	Albertville	Golf Course	140	70
10W	10.2	WNW	Airborn Disc Golf Preserve	Eagle Dr	Clearwater	Golf Course	84	42
10W	10.8	WNW	Driftwood Golf and Fitness Center	1100 Main St	Clearwater	Golf Course	54	45
						Wright County Subtotal:	*1,104*	*514*
						EPZ TOTAL:	**1,685**	**818**

[2] Dimmick Island Watercraft Campsite is located on a small island that cannot be accessed by vehicles. The vast majority of the visitors to this facility are likely local residents. Therefore, no vehicles were assigned to this facility.

Table E-6. Lodging Facilities within the EPZ

Sub-Area	Distance (miles)	Direction	Facility Name	Street Address	Municipality	Transients	Vehicles
SHERBURNE COUNTY							
5N	3.6	N	GrandStay Hotel & Suites	14435 Bank St	Becker	214	92
5N	4.2	NNW	Becker Inn & Suites	13804 1st St	Becker	58	19
5N	8.4	NNE	Cameorose Country Retreat	11250 123rd St SE	Becker	9	6
5E	7.7	E	Americas Best Value Inn Big Lake	16776 198th Ave NW	Big Lake	34	26
					Sherburne County Subtotal:	*315*	*143*
WRIGHT COUNTY							
5S	3.5	SE	AmericInn Motel Monticello	118 E 7th St	Monticello	67	24
5S	3.6	SE	Super 8 Monticello	1114 Cedar St	Monticello	203	81
5S	3.7	SE	Days Inn Monticello	200 Oakwood Drive E	Monticello	87	42
5S	3.8	SE	Best Western Chelsea Inn & Suites	89 Chelsea Rd	Monticello	62	35
5S	3.9	SE	Historic Rand House	506 Old Territorial Rd	Monticello	11	4
					Wright County Subtotal:	*430*	*186*
					EPZ TOTAL:	**745**	**329**

Table E-7. Correctional Facilities within the EPZ

Sub-Area	Distance (miles)	Direction	Facility Name	Street Address	Municipality	Capacity	Current Census
WRIGHT COUNTY							
10S	8.7	S	Wright County Jail	3800 Braddock Ave NE	Buffalo	288	155
					Wright County Subtotal:	*288*	*155*
					EPZ TOTAL:	**288**	**155**

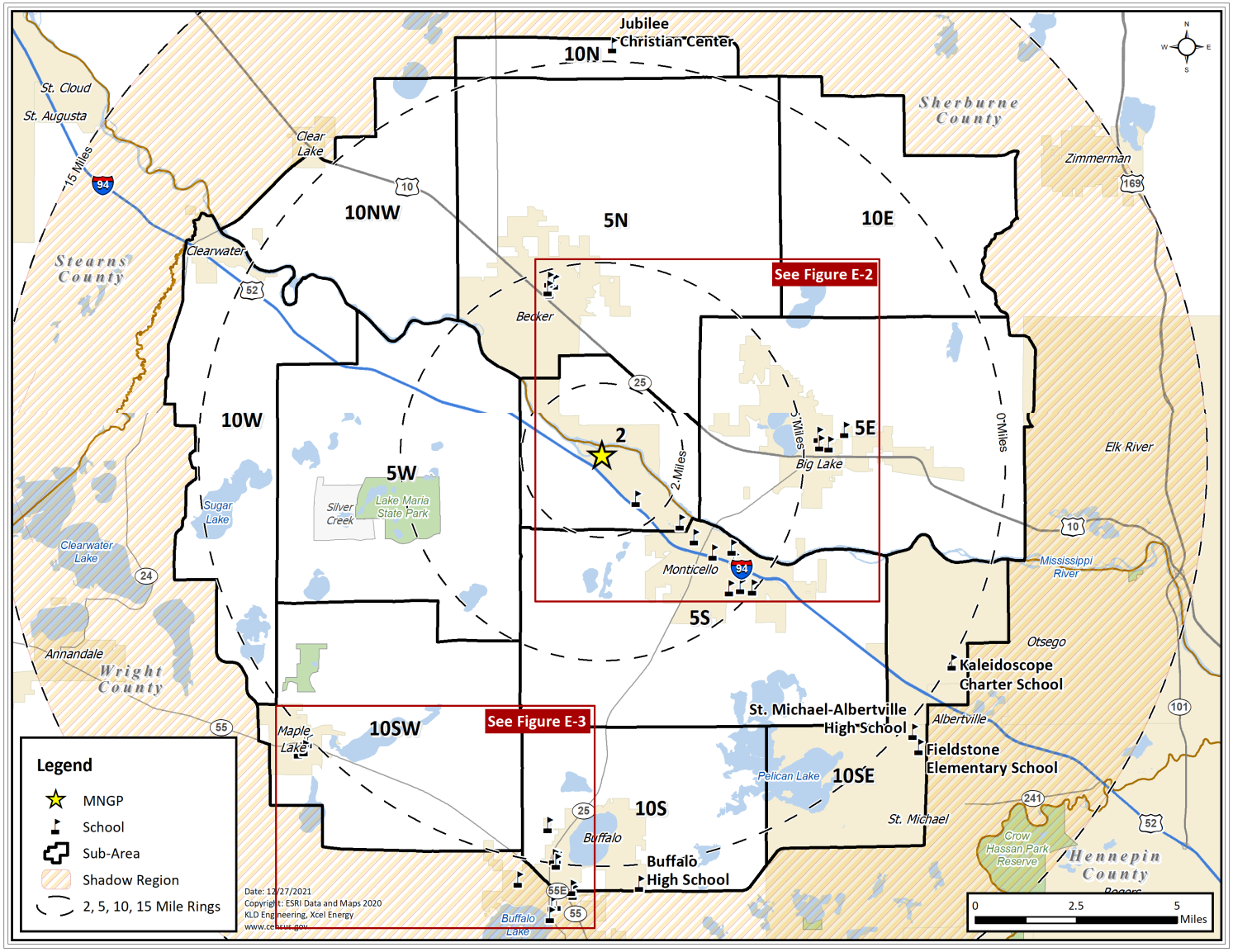


Figure E-1. Overview of Schools within the Study Area

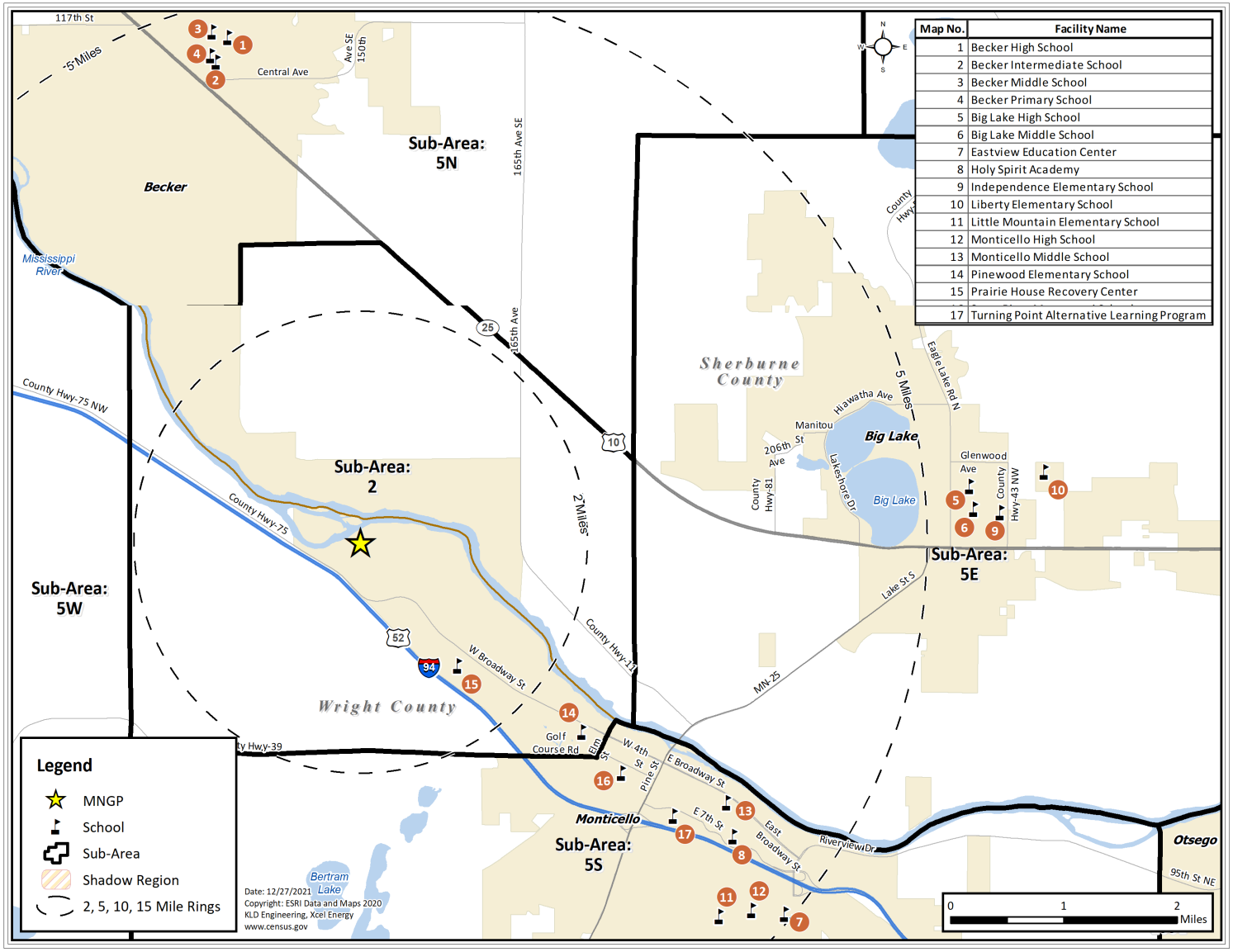


Figure E-2. Schools within Sub-Areas 2, 5E, 5N and 5S

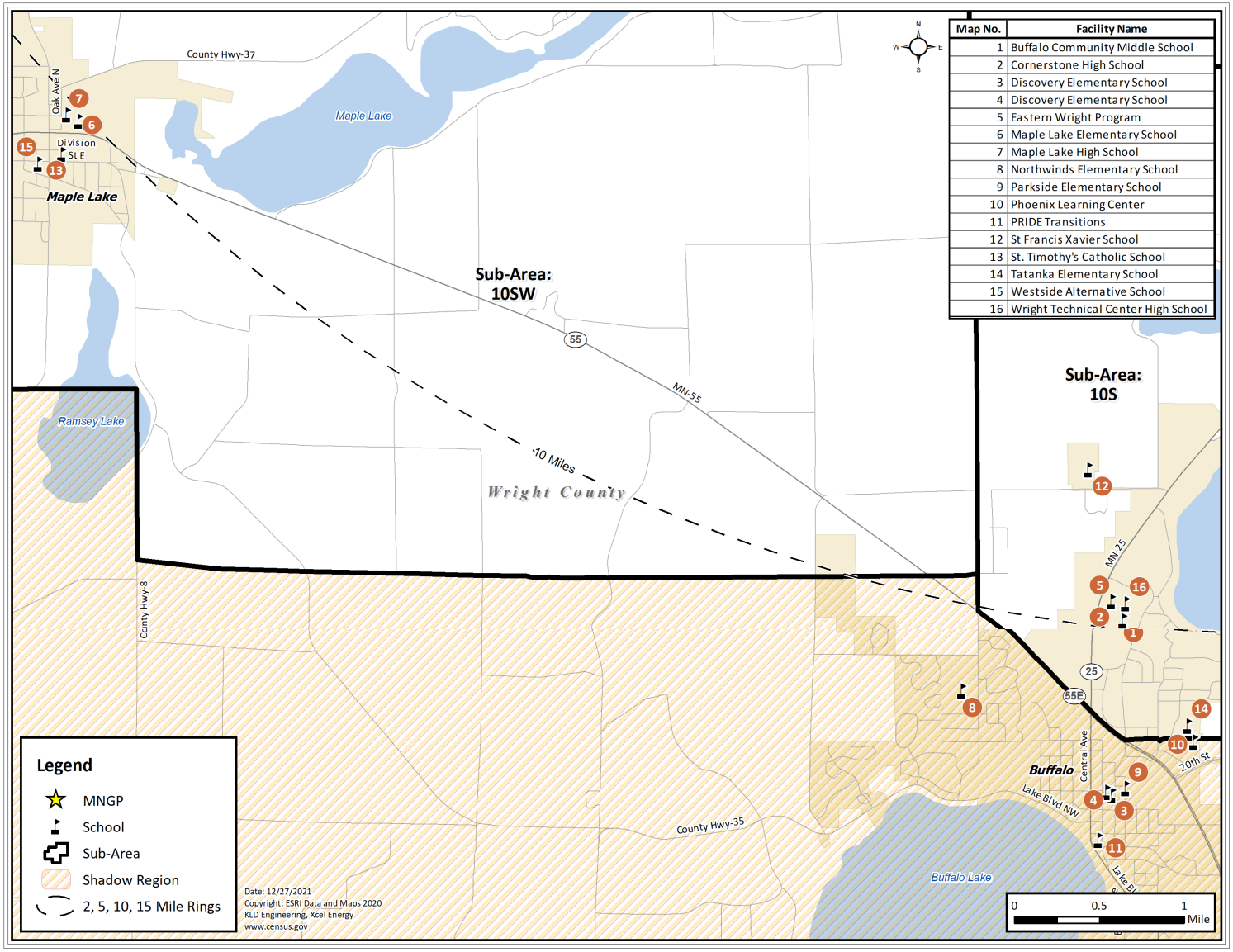


Figure E-3. Schools within Sub-Areas 10S, 10SW and Shadow Region

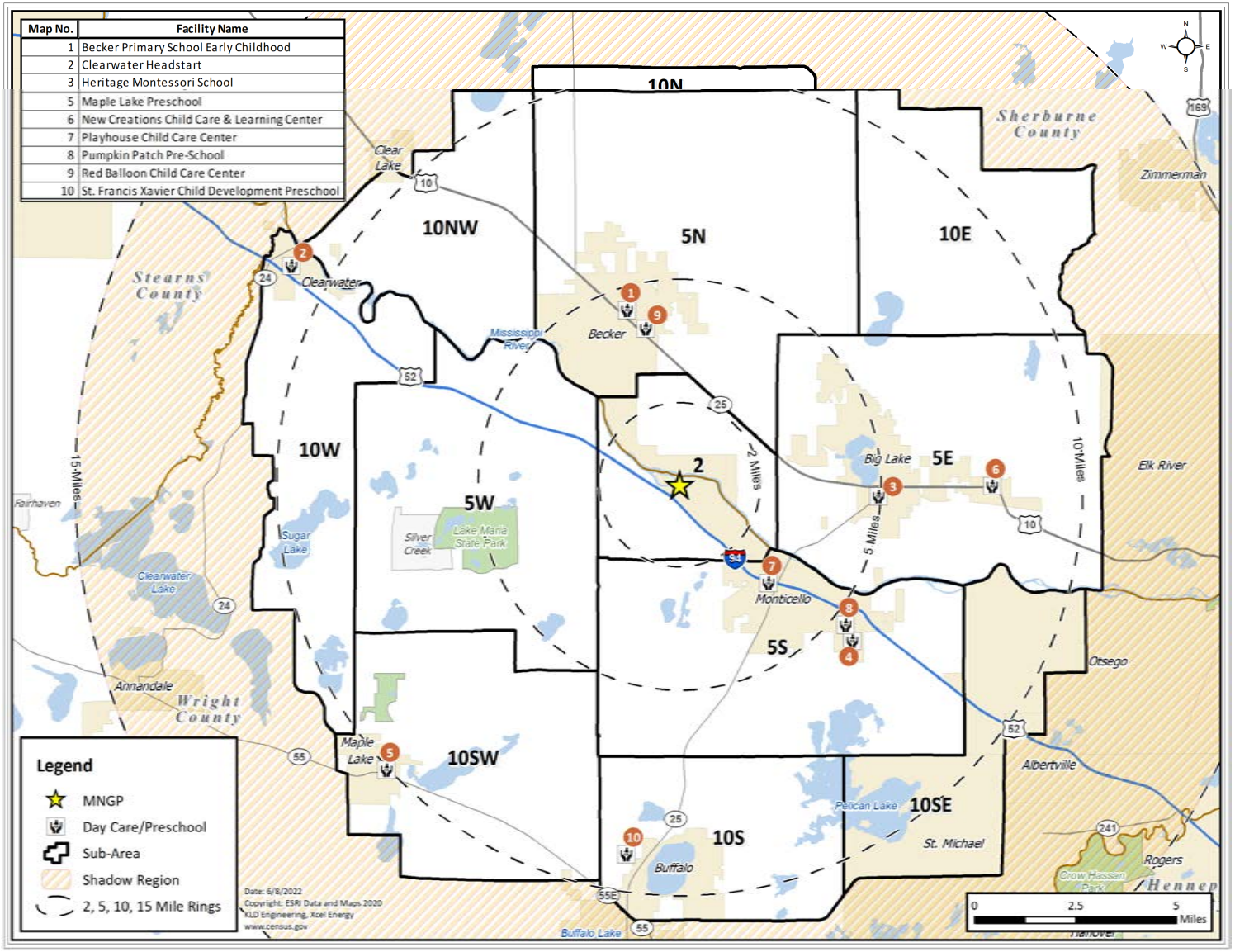


Figure E-4. Day Cares/Preschools within the EPZ

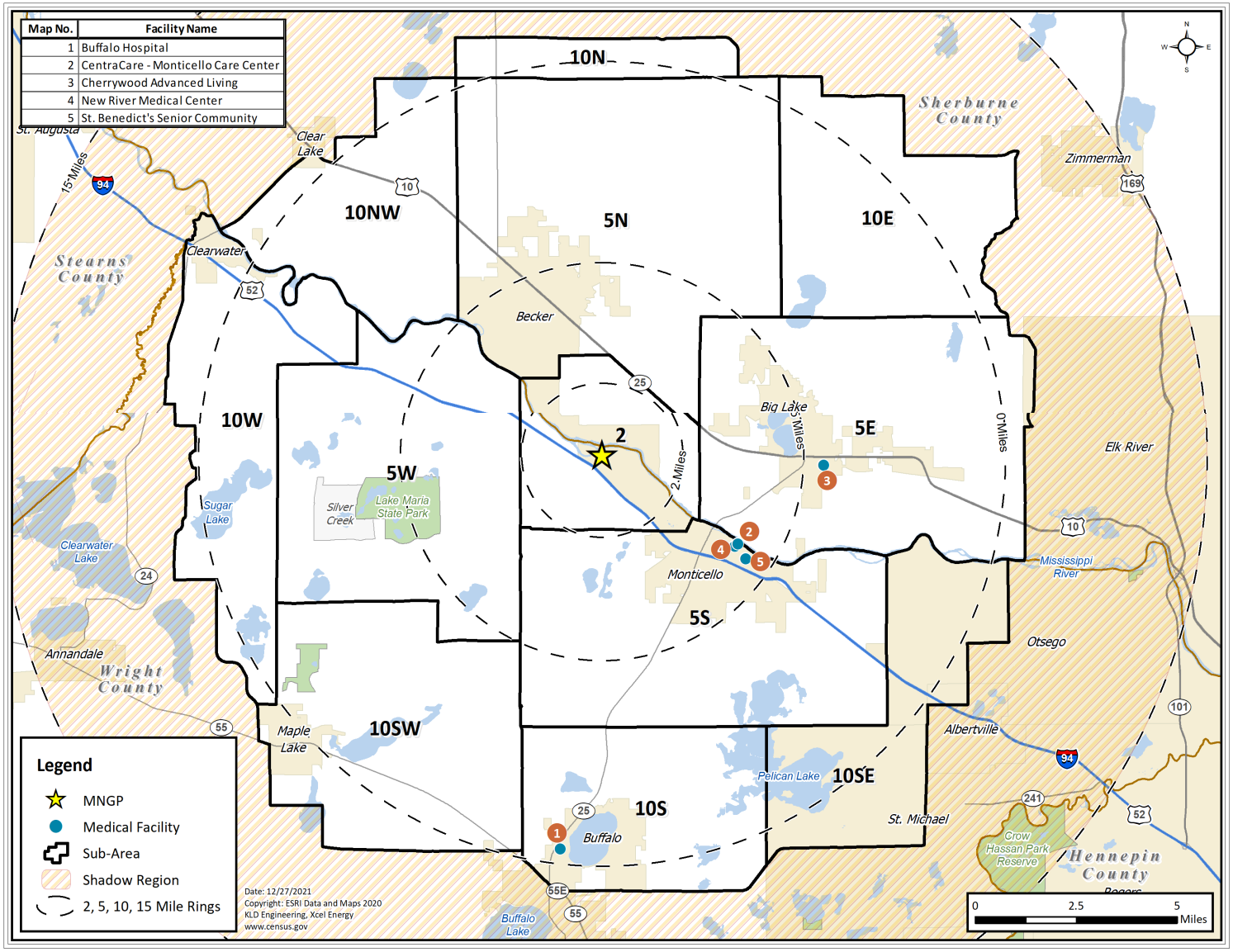


Figure E-5. Medical Facilities within the EPZ

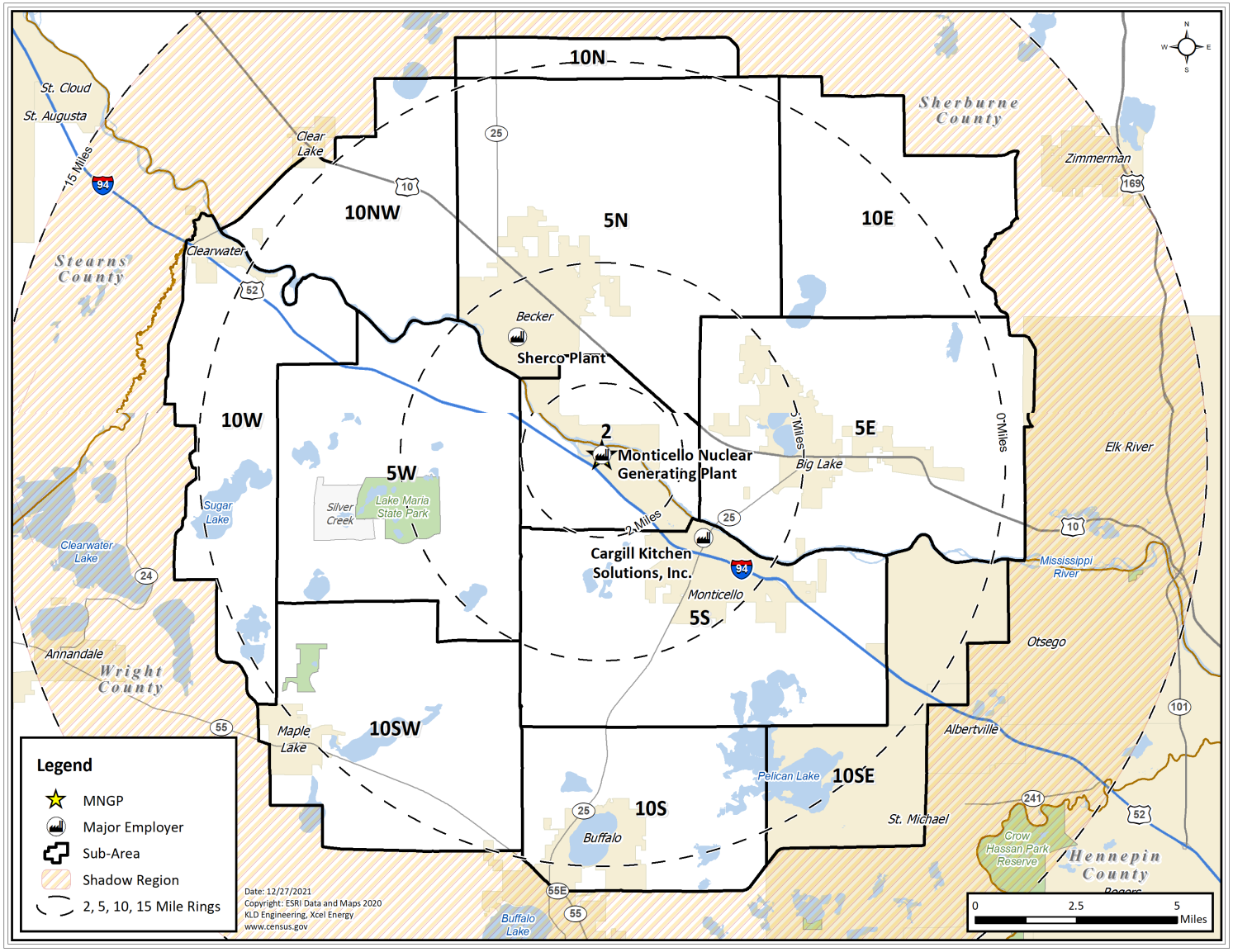


Figure E-6. Major Employers within the EPZ

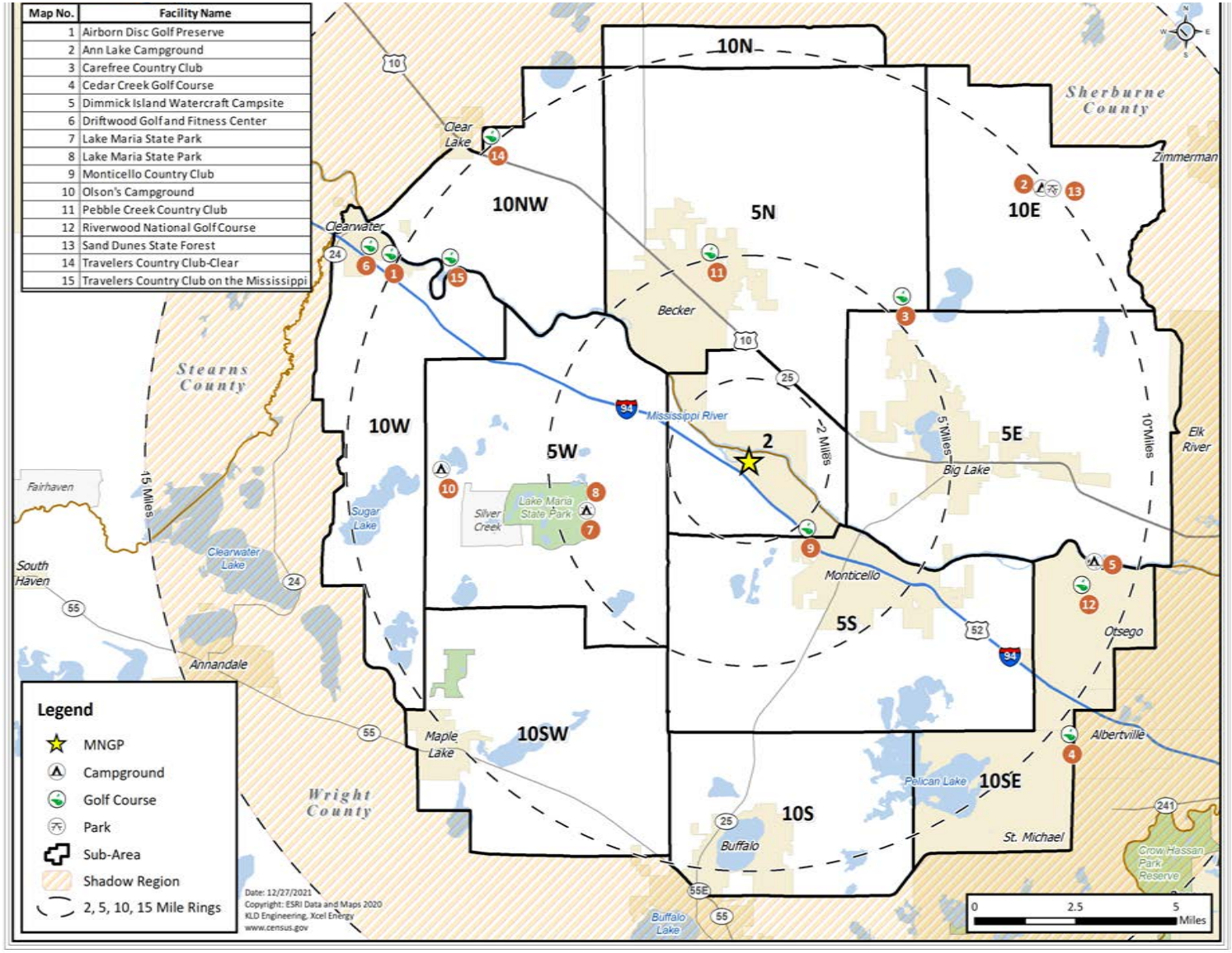


Figure E-7. Recreational Areas within the EPZ

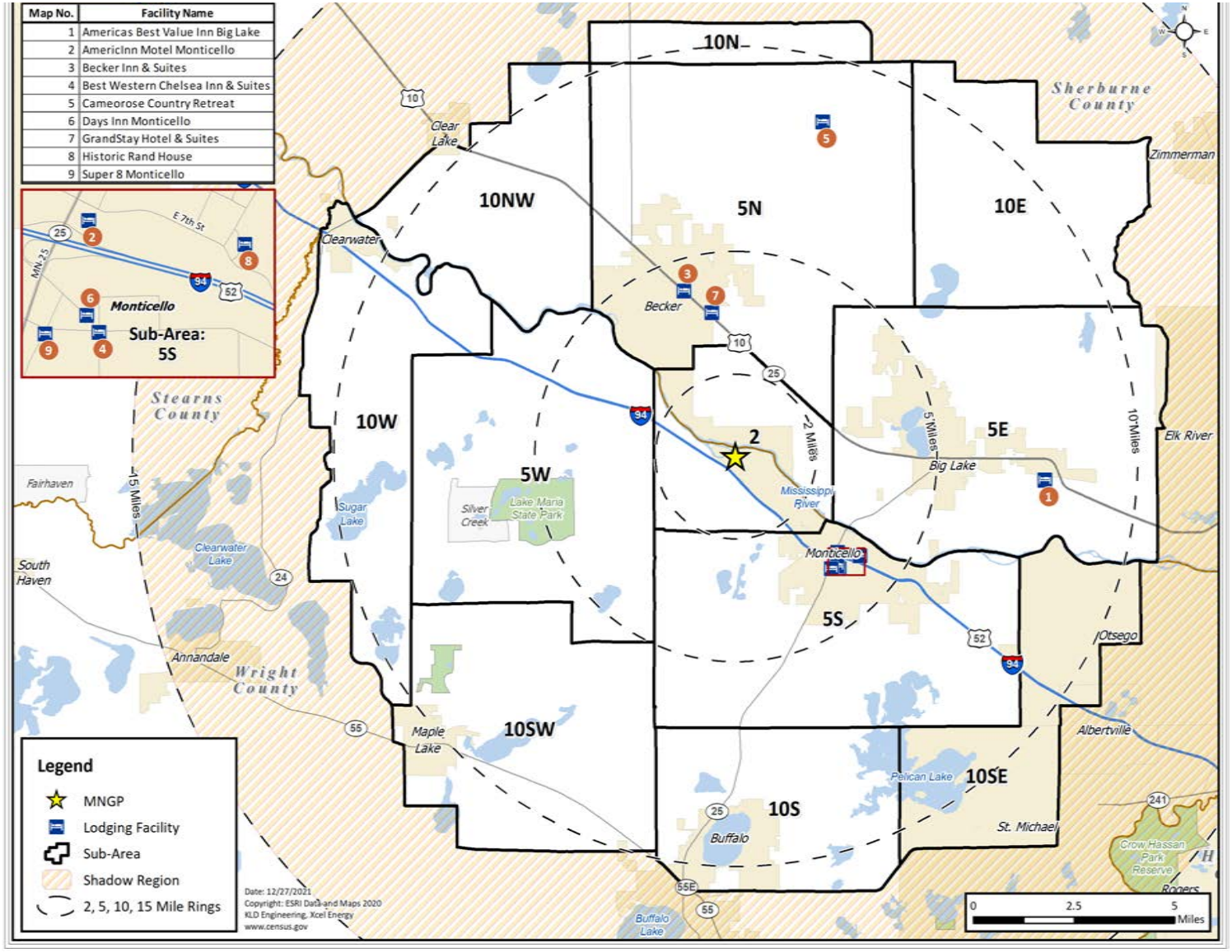


Figure E-8. Lodging Facilities within the EPZ

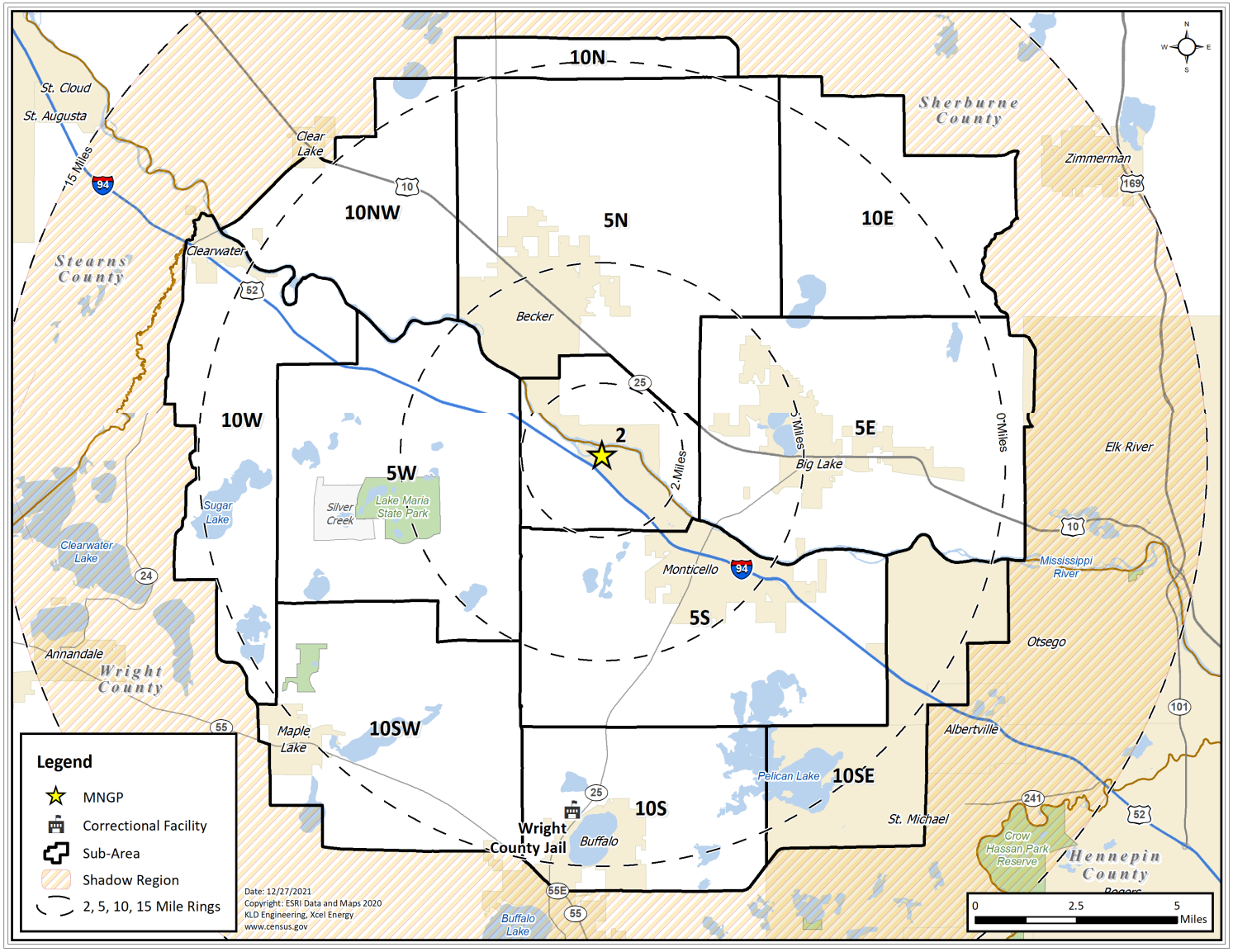


Figure E-9. Correctional Facilities within the EPZ

APPENDIX F

Demographic Survey

F. DEMOGRAPHIC SURVEY

F.1 Introduction

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

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

F.2 Survey Instrument and Sampling Plan

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

Following the completion of the instrument, a sampling plan was developed. Since the demographic survey discussed herein was performed in 2020 prior to the release of the 2020 Census, 2010 Census data was used to develop the sampling plan.

A sample size of approximately 379 **completed** survey forms yields results with a sampling error of ±5.0% 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. Note that the average household size computed in Table F-1 was an estimate for sampling purposes and was not used in the ETE study.

The results of the slightly exceeded the sampling plan. A total of 390 completed samples were obtained corresponding to a sampling error of ±4.93% at the 95% confidence level based on 2020 Census data. Table F-1 also shows the number of samples obtained within each zip code.

F.3 Survey Results

The results of the survey fall into two categories. First, the household demographics of the area can be identified. Demographic information includes such factors as household size, automobile ownership, and automobile availability. The distributions of the time to perform certain pre-

evacuation activities are the second category of survey results. These data are processed to develop the trip generation distributions used in the evacuation modeling effort, as discussed in Section 5.

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

F.3.1 Household Demographic Results

Household Size

Figure F-1 presents the distribution of household size within the EPZ based on the responses to the demographic survey. The average household contains 3.23 people. The estimated household size from the 2020 Census data is 2.82 people. The difference between the Census data and survey data is 14.5%, which exceeds the sampling error of 4.93%. This discrepancy was discussed with Xcel Energy, and it was decided that the U.S. Census estimate of 2.82 people per household should be used for this study. This results in a more conservative estimate when determining the number of households and evacuating vehicles. A sensitivity study was included in Appendix M wherein the impact of a larger household size on ETE is quantified.

Automobile Ownership

The average number of automobiles available per household in the EPZ is 2.46. It should be noted that all households in the EPZ have access to an automobile according to the demographic survey. The distribution of automobile ownership is presented in Figure F-2. Figure F-3 and Figure F-4 present the automobile availability by household size.

Ridesharing

About 73% of the households surveyed responded that they would share a ride with a neighbor, relative, or friend if a car was not available to them when advised to evacuate in the event of an emergency. Figure F-5 presents this response.

Commuters

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 1.71 commuters in each household in the EPZ, and 90% of households have at least one commuter.

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 1.06 commuters per vehicle, assuming 2 people per vehicle – on average – for carpools.

Impact of COVID-19 on Commuters

Figure F-8 presents the distribution of the number of commuters in each household that were temporarily impacted by the COVID-19 pandemic. Approximately 59% of households indicated someone in their household had a work and/or school commute that was temporarily impacted by the COVID-19 pandemic.

Functional or Transportation Needs

The data shows that approximately 2% of households have functional or transportation needs. Of those with functional or transportation needs, 93% require a bus and 7% require a wheelchair accessible vehicle.

F.3.2 Evacuation Response

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

"How many of the vehicles would your household use during an evacuation?" The response is shown in Figure F-9. On average, evacuating households would use 1.68 vehicles.

"Would your family await the return of other family members prior to evacuating the area?" Of the survey participants who responded, 53.5% said they would await the return of other family members before evacuating and 46.5% 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?" Based on responses from the survey, 74% of households have a family pet. Of the households with pets, 32% indicated that they would take their pets with them to a shelter, 63% indicated that they would take their pets somewhere else and 5% would leave their pet at home, as shown in Figure F-10. Of the households that would evacuate with their pets, 95% indicated that they have sufficient room in their vehicle to evacuate with their pet(s)/animal(s), including those who would use a trailer.

"What type of pet(s) and/or animal(s) do you have?" Based on responses from the survey, 89% of households have a household pet (dog, cat, bird, reptile, or fish), 9% of households have farm animals (horse, chicken, goat, pig, etc.), and 2% have other small pets/animals.

"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. As shown in Figure F-11 the results indicate that 81% of households who are advised to shelter in place would do so; the remaining 19% 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, Rev. 1. Thus, the data obtained above is in good agreement with the NRC's recommendation.

"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. As shown in Figure F-12, the results indicate that 63% of households would follow instructions and delay the start of evacuation until so advised, while the other 37% would choose to begin evacuating immediately.

"Emergency officials advise you to evacuate due to an emergency. Where would you evacuate to?" This question is designed to elicit information regarding the destination of evacuees in case of an evacuation. Approximately 60% of households indicated that they would evacuate to a friend or relatives' home, 1% to a reception center, 9% to a hotel, motel or campground, 9% to a second or seasonal home, and the remaining 21% answered "Other/Decline to state" to this question, as shown in Figure F-13.

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.

As discussed in Section F.3.1 and shown in Figure F-8, the COVID-19 pandemic had a significant impact on the commuting patterns of those who live in the MNGP EPZ. To minimize uncertainty in the trip generation time, data from the 2012 telephone survey for commuting patterns was compared with the results from the 2020 online demographic survey. For this reason, both the results of this survey, and the results of the 2012 survey for these questions (time to prepare to leave work/college and time to commute home from work/college) are discussed herein.

"How long does it take the commuter to complete preparation for leaving work/college?" Figure F-14 presents the cumulative distribution for the 2020 and 2012 survey responses. For both surveys, 75% of commuters can complete this activity in 15 minutes. The activity is complete in 45 minutes and 60 minutes based on the results of the 2020 survey and 2012 survey, respectively. As shown in Figure F-14, the patterns of the curves are similar between the two surveys, despite the previous survey being shifted to the right. Since the patterns were similar and the sample size was statistically significant with a low margin of error, the results of the 2020 survey were assumed to be valid. As a result, the 2020 survey results for this question were utilized in this study.

"How long would it take the commuter to travel home?" Figure F-15 presents the work to home travel time for the EPZ for the 2020 and 2012 survey responses. Approximately 70% of commuters can arrive home within 30 minutes of leaving work for both surveys. The activity is completed in 90 minutes and 120 minutes for the 2020 and 2012 survey, respectively. As shown in Figure F-15, the patterns of the curves are very similar between the two surveys, despite the previous survey having a longer 'tail' and ending 30 minutes later. Since the patterns were similar and the sample size was statistically significant with a low margin of error, the results of the 2020 survey were assumed to be valid. As a result, the 2020 survey results for this question were utilized in this study.

"How long would it take the family to pack clothing, secure the house, and load the car?" Figure F-16 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. In total, 97% of households can be ready to leave home withing 2 hours and 15 minutes; the remaining households require up to an additional one hour.

"How much time, on average, would it take you to clear 6-8 inches of snow to move the car from the driveway or curb to begin the evacuation trip assuming the roads are passable?" Figure F-17 presents the time required to clear 6-8 inches of snow and begin the evacuation trip. Approximately 90% of households can have their car cleared and the driveway passable within one hour; the remaining households would require up to an additional 1 hour and 15 minutes to begin their evacuation trip. It should be noted that 18% of households will not shovel out and would simply drive over the snow to evacuate.

F.3.4 Emergency Communications

"At your place of residence, how reliable is your cell phone signal?" This question is designed to elicit information regarding the ability to be notified in case of an evacuation. Approximately 90% of households indicated that they have very reliable signal to receive texts and phone calls, 4% indicated that their signal is reliable for text messages only, 5% indicated that they do not always receive cell communications at their residence, and about 1% indicated that they do not have cell service at their residence, as shown in Figure F-18.

"Emergency management officials in your state may send text messages, similar to AMBER Alerts, with emergency directions for the public during a radiological emergency at the Monticello Nuclear Generating Plant. How likely would you be to take action on these directions, if you received the message?" This question is designed to elicit information regarding the likelihood of an individual to take action based on emergency management officials' guidelines. 69% of households indicated that they are highly likely to take action on these directions, about 24% indicated likely, 4% indicated neither likely nor unlikely, 2% indicated unlikely, and 1% indicated they are highly unlikely to take action on emergency management officials' directions. This data is shown in Figure F-19.

"Which of the following emergency communication methods do you think is most likely to alert you at your residence?" This question is designed to elicit information regarding the most efficient way to alert residents within the EPZ. Approximately 80% of households indicated that a text message from emergency officials would be most likely to alert them at their residence, 15% indicated that a siren sounding near their home would be the most likely method, 2% indicated an alert broadcast on the TV. An alert broadcast on radio, a phone call/text message from a family member, friend or neighbor, and information on Twitter or Facebook were each selected by approximately 1% of those who responded as the most likely to alert type (for a total of about 3%). This data is shown in Figure F-20.

"Have you opted into your local Emergency Alert and Warning System?" Figure F-21 shows that approximately 52% of households opted-in to local emergency alert notifications with their

cellular phone. In addition, 18% of households opted-in through text messaging, 5% with email, 2% with their residential phone/land-line, and 23% of households did not opt in.

Table F-1. MNGP Demographic Survey Sampling Plan

Zip Code	2010 EPZ Population in Zip Code	2010 EPZ Households in Zip Code	2020 EPZ Population in Zip Code	2020 EPZ Households in Zip Code	Desired Samples	Samples Obtained
55301	482	173	803	279	3	18
55302	405	162	435	180	3	3
55308	8,774	2,846	9,669	3,254	45	88
55309	18,206	5,998	20,342	6,942	96	58
55313	9,501	3,290	9,528	3,416	52	23
55319	1,463	523	1,668	587	8	20
55320	2,865	1,088	3,160	1,246	17	9
55330	3,220	1,141	3,361	1,206	18	22
55358	4,167	1,591	4,380	1,668	25	11
55362	18,089	6,540	20,384	7,504	104	117
55376	1,417	419	1,616	468	7	17
55398	46	16	33	12	1	4
Total EPZ	**68,635**	**23,787**	**75,379**	**26,762**	**379**	**390**
Average HH Size:	**2.89**		**2.82**			

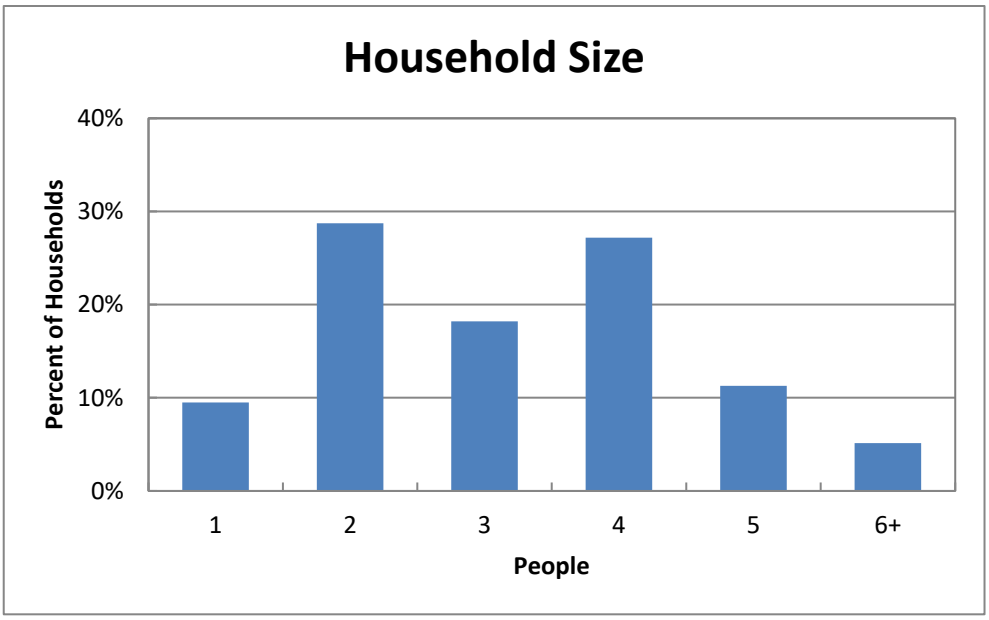


Figure F-1. Household Size in the EPZ

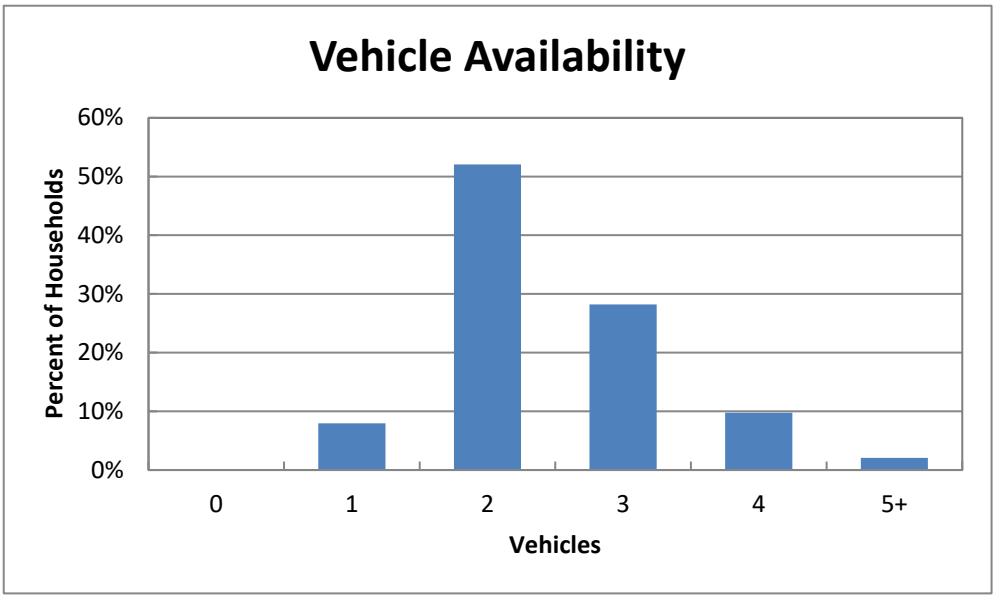


Figure F-2. Household Vehicle Availability

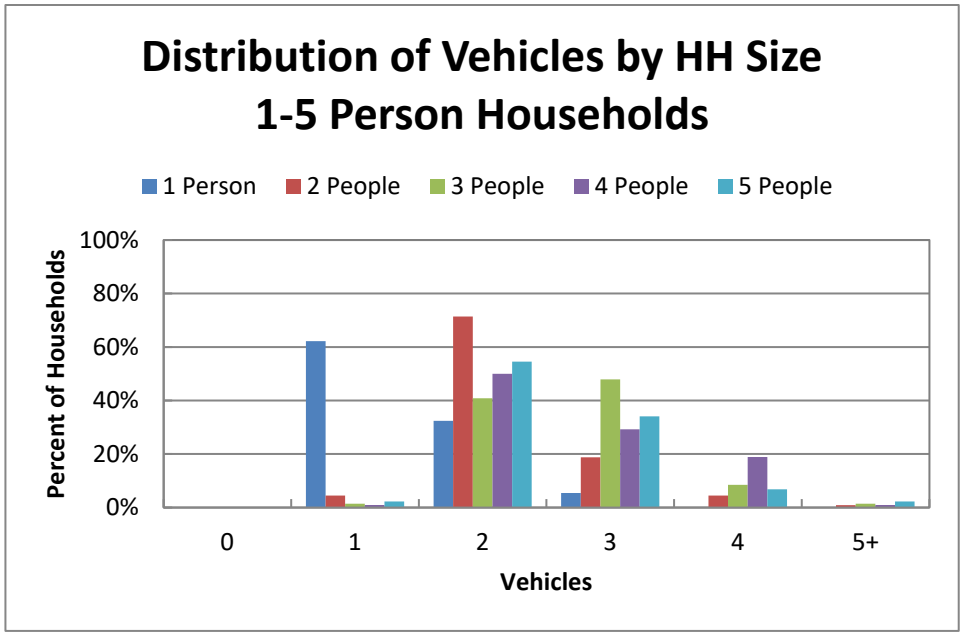


Figure F-3. Vehicle Availability - 1 to 5 Person Households

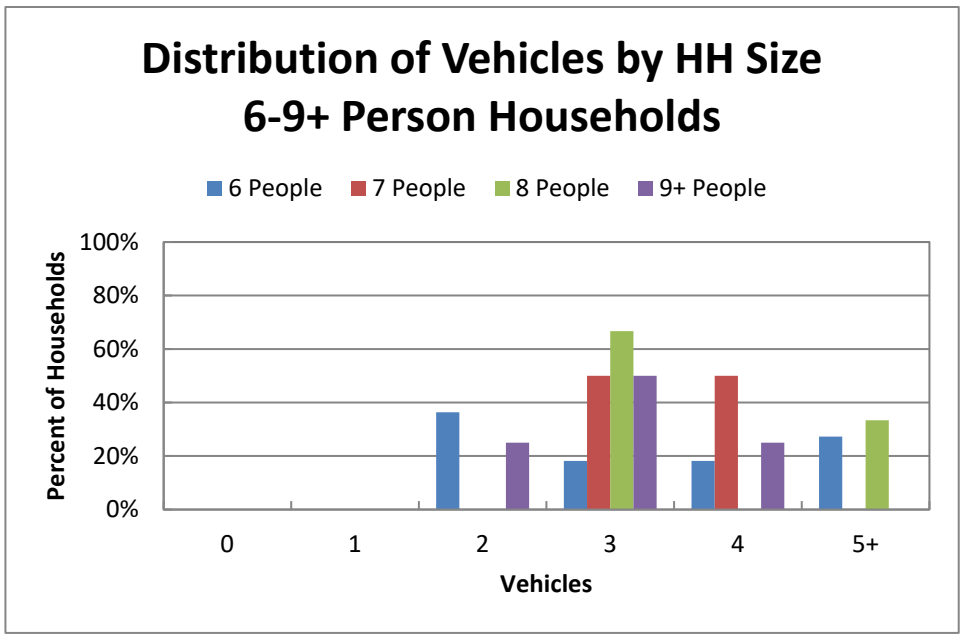


Figure F-4. Vehicle Availability - 6 to 9+ Person Households

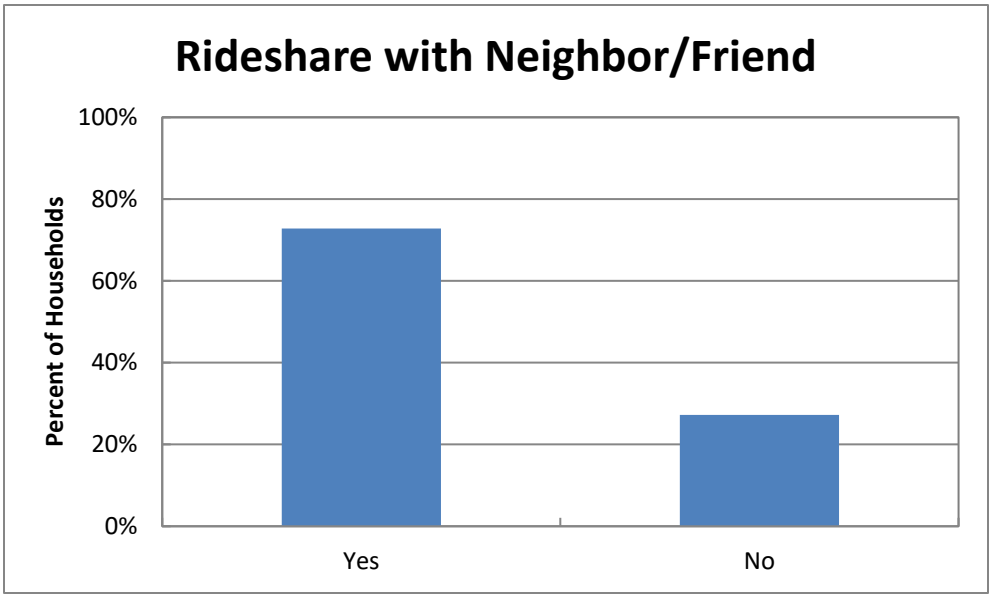


Figure F-5. Household Ridesharing Preference

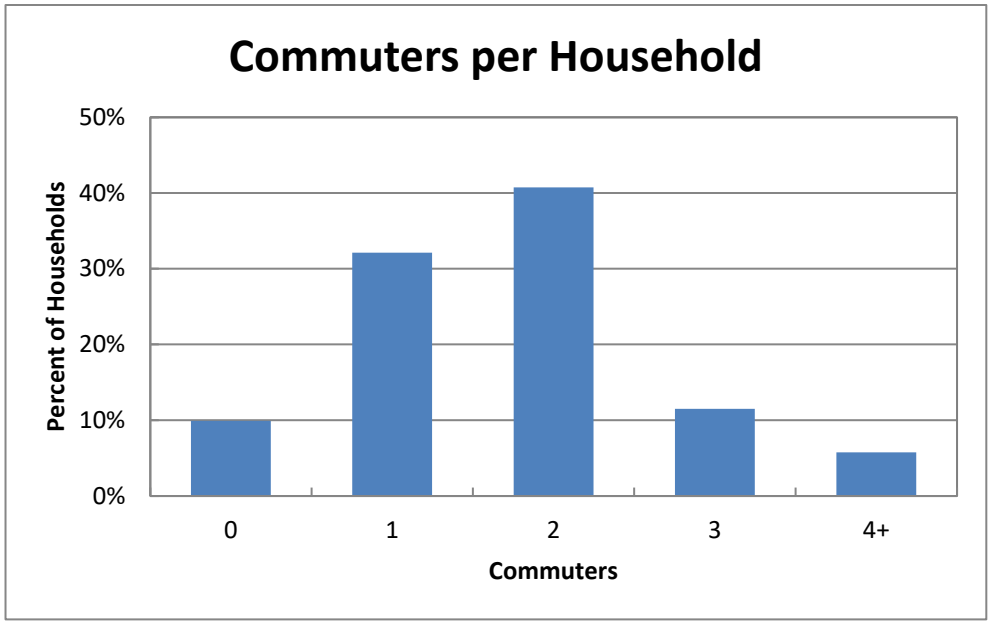


Figure F-6. Commuters per Households within the EPZ

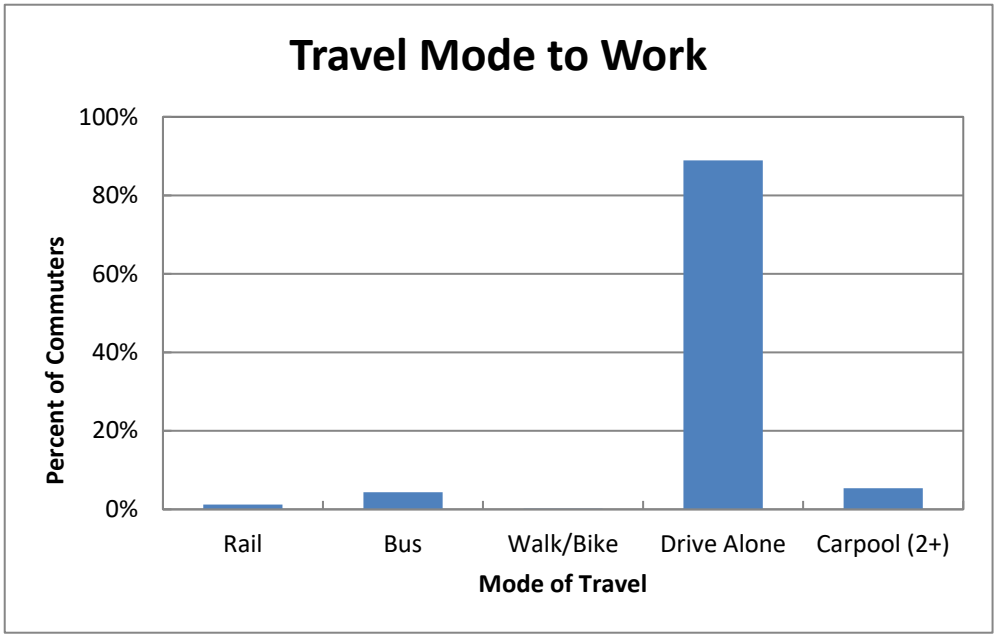


Figure F-7. Modes of Travel in the EPZ

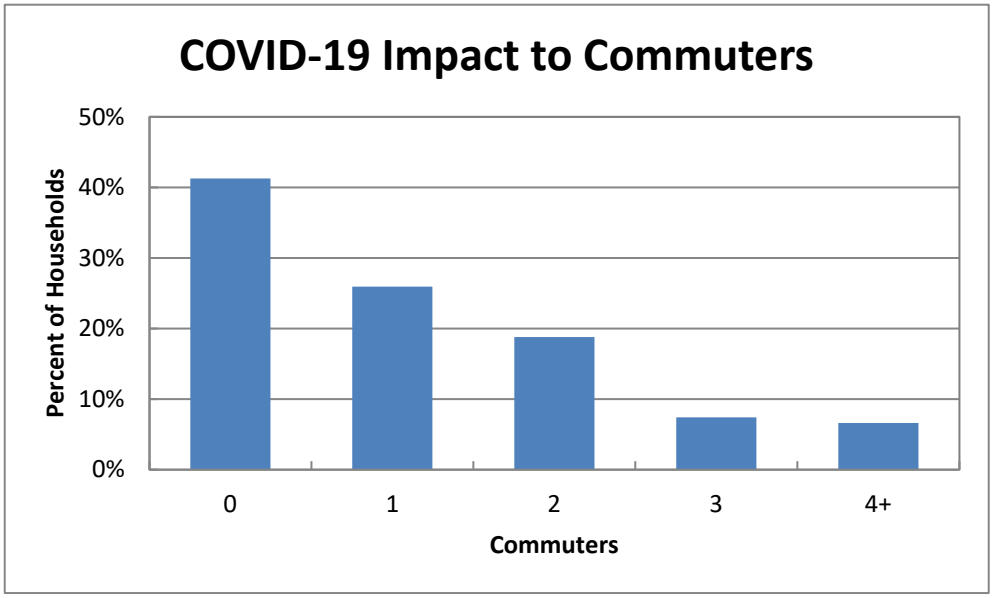


Figure F-8. Impact to Commuters due to the COVID-19 Pandemic

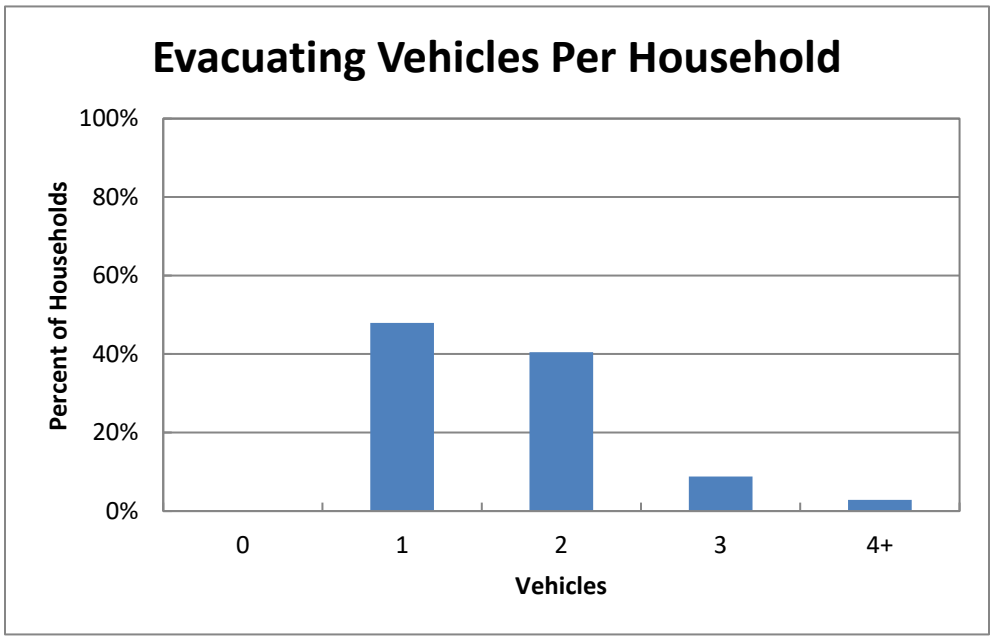


Figure F-9. Number of Vehicles Used for Evacuation

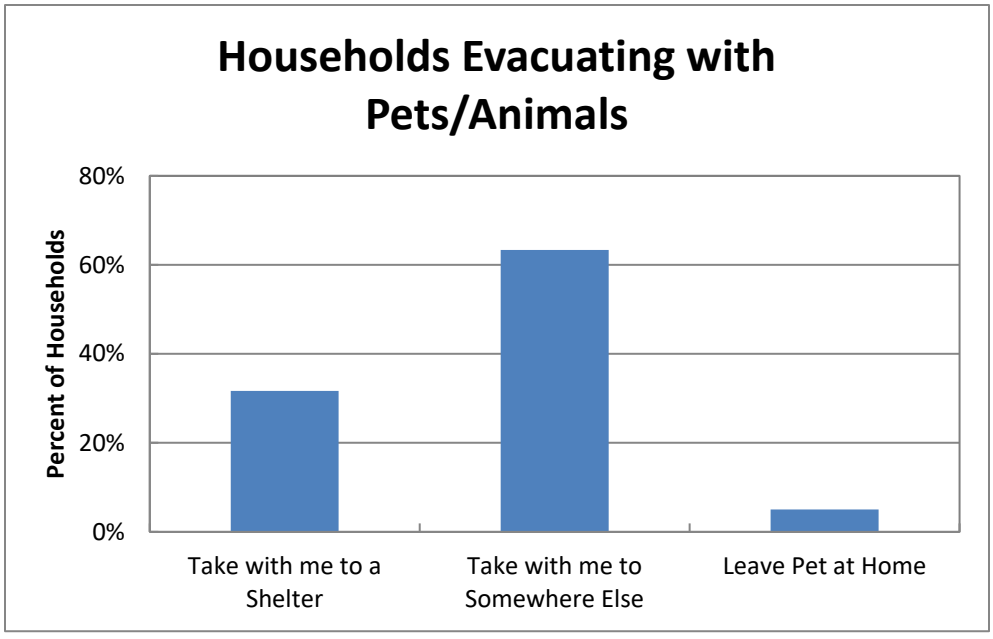


Figure F-10. Households Evacuating with Pets/Animals

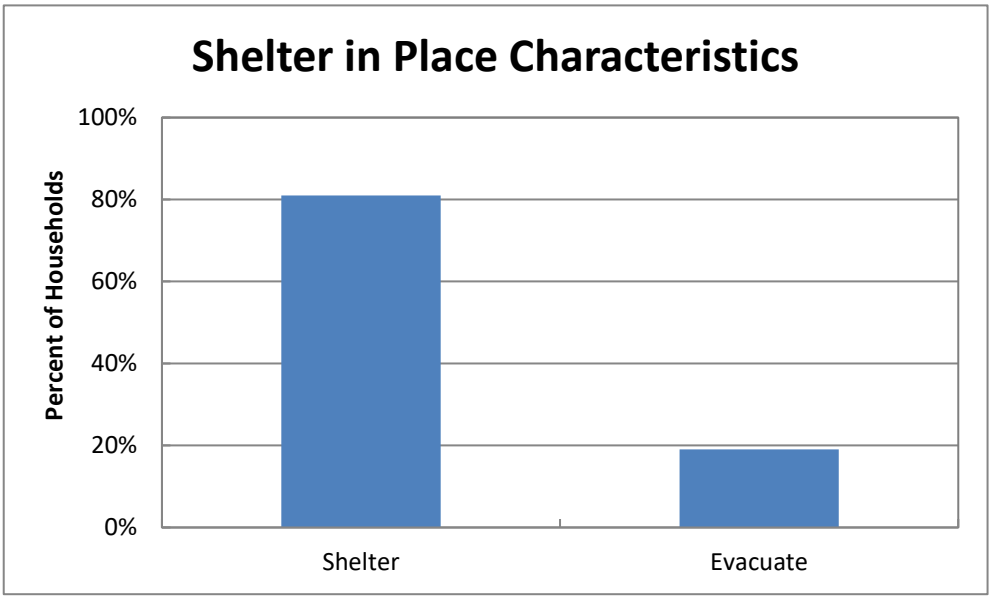


Figure F-11. Shelter in Place Characteristics

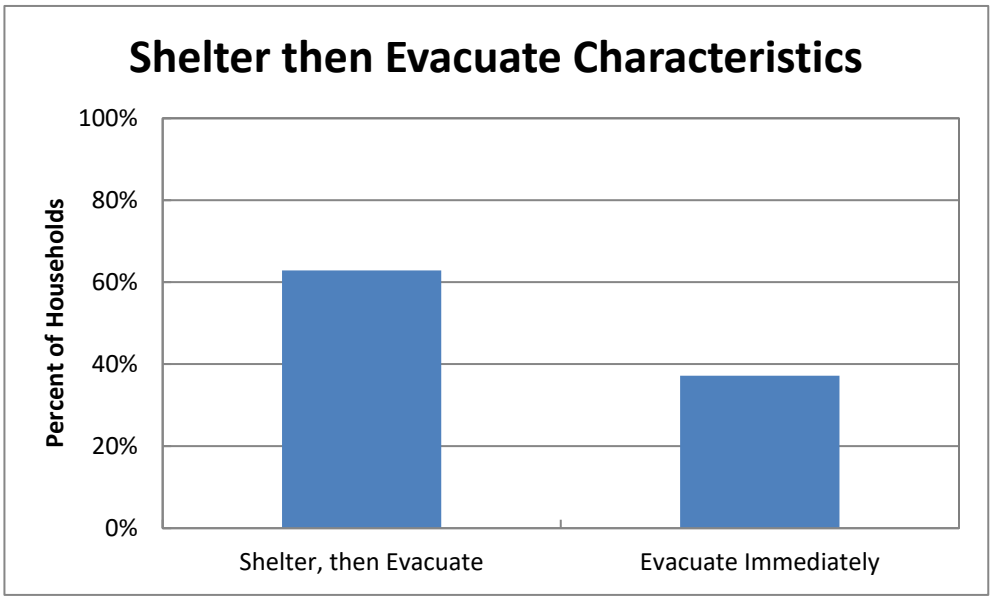


Figure F-12. Shelter Then Evacuate Characteristics

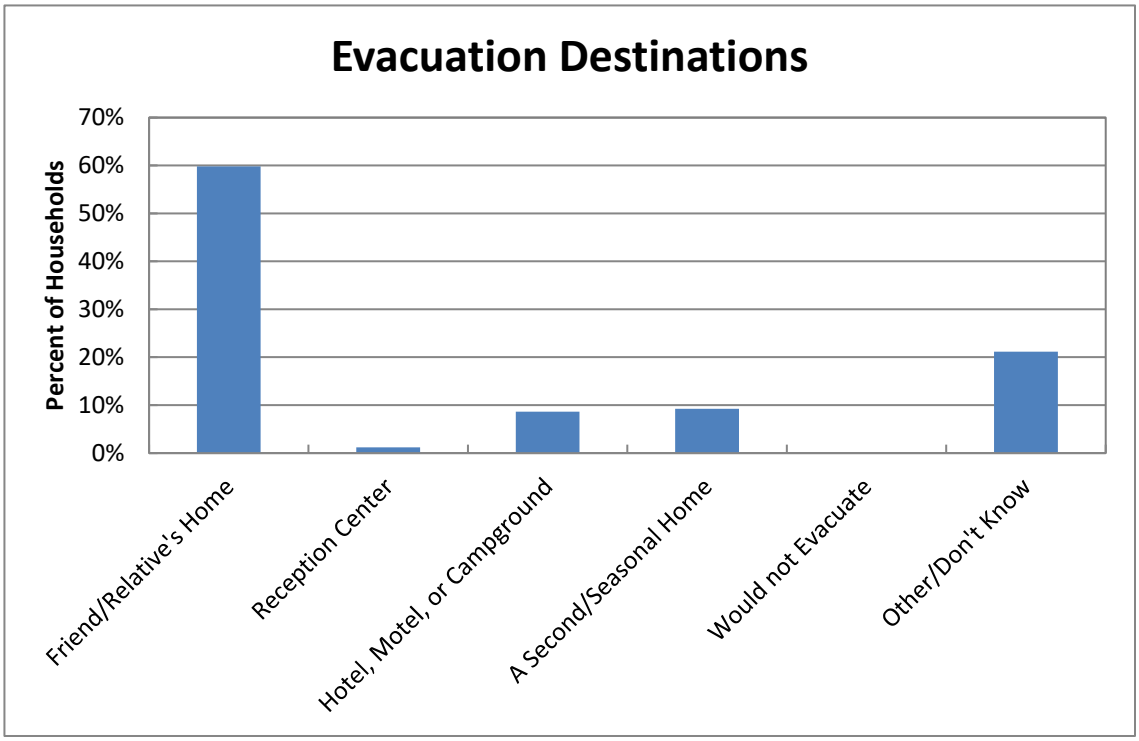


Figure F-13. Study Area Evacuation Destinations

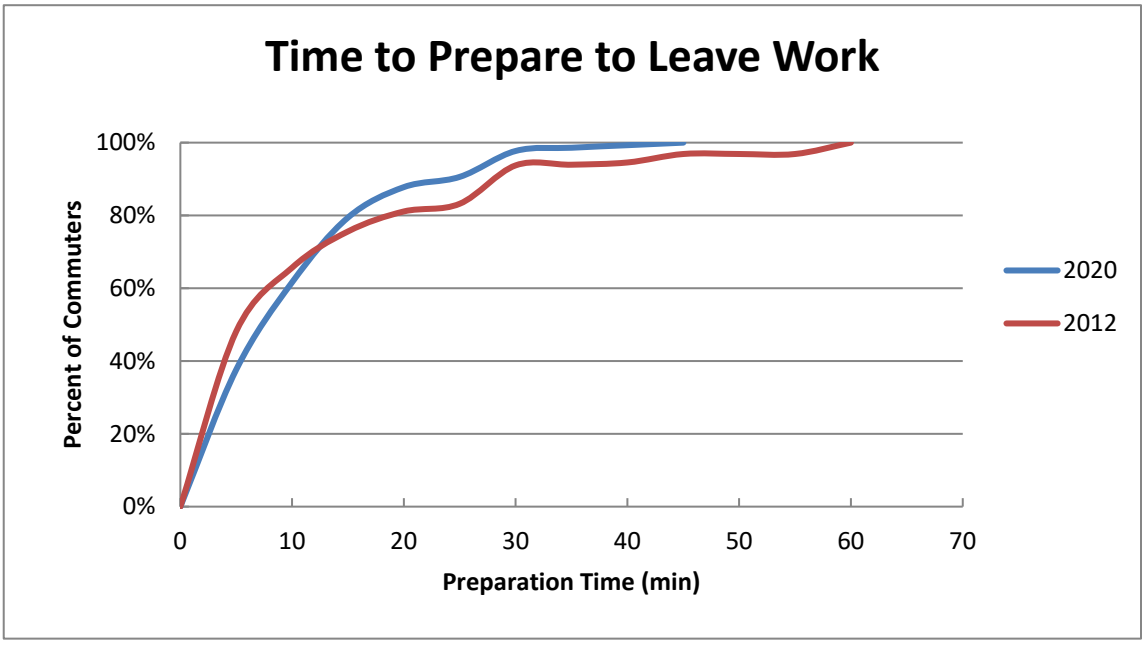


Figure F-14. Time Required to Prepare to Leave Work/College

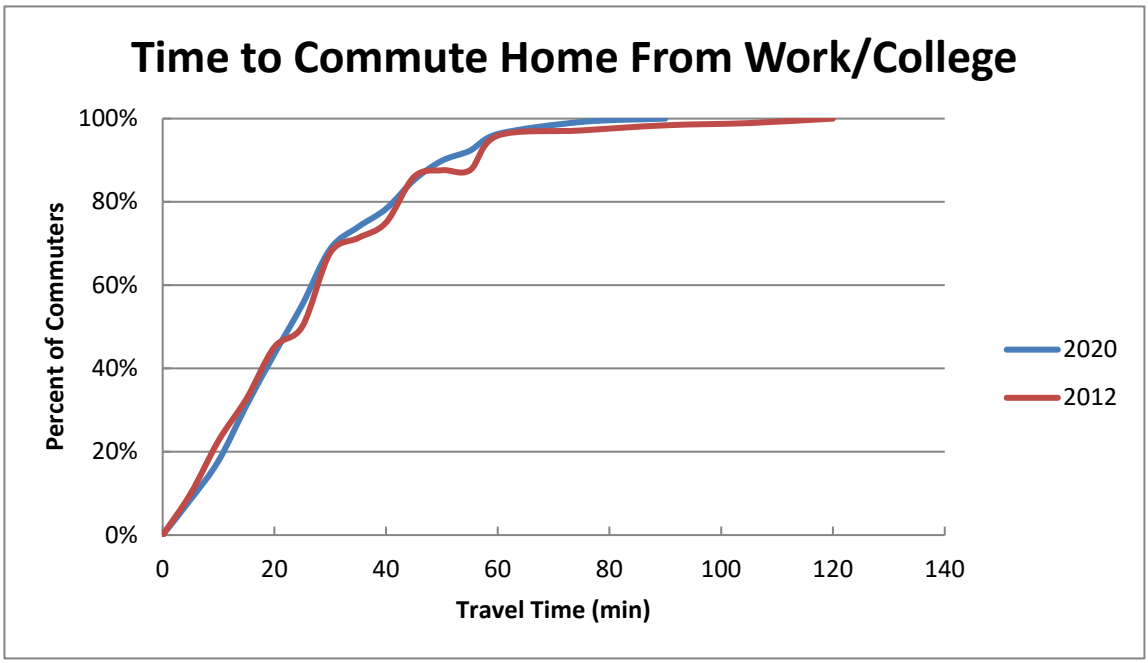


Figure F-15. Time to Commute Home from Work/College

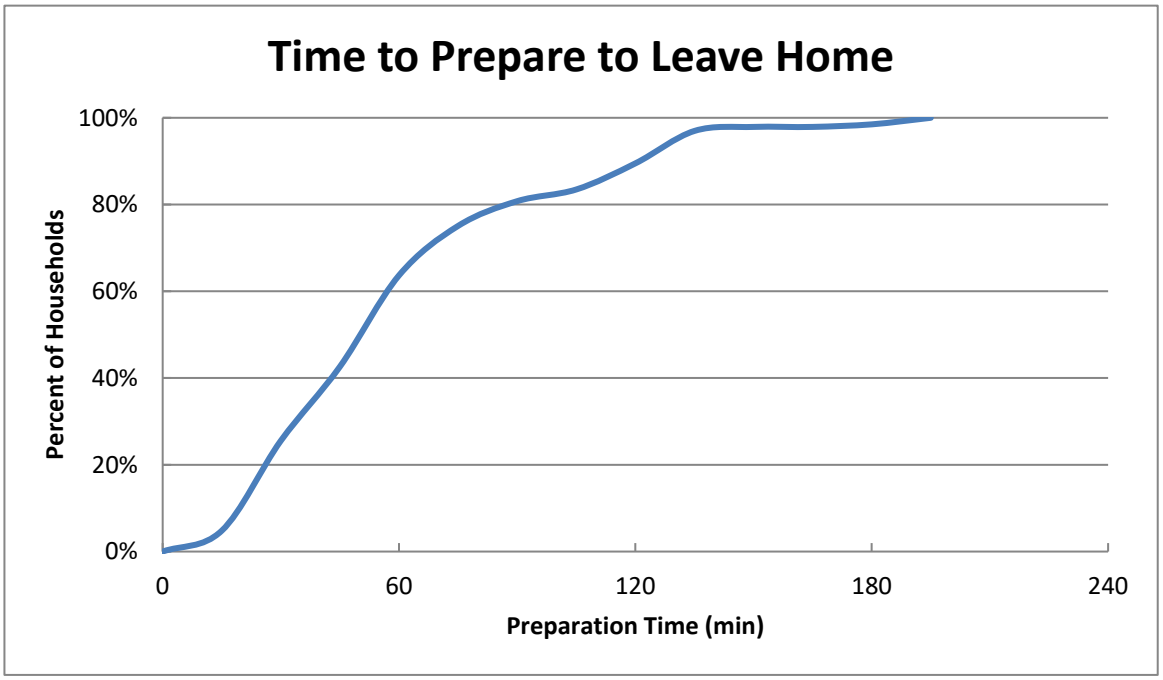


Figure F-16. Time to Prepare Home for Evacuation

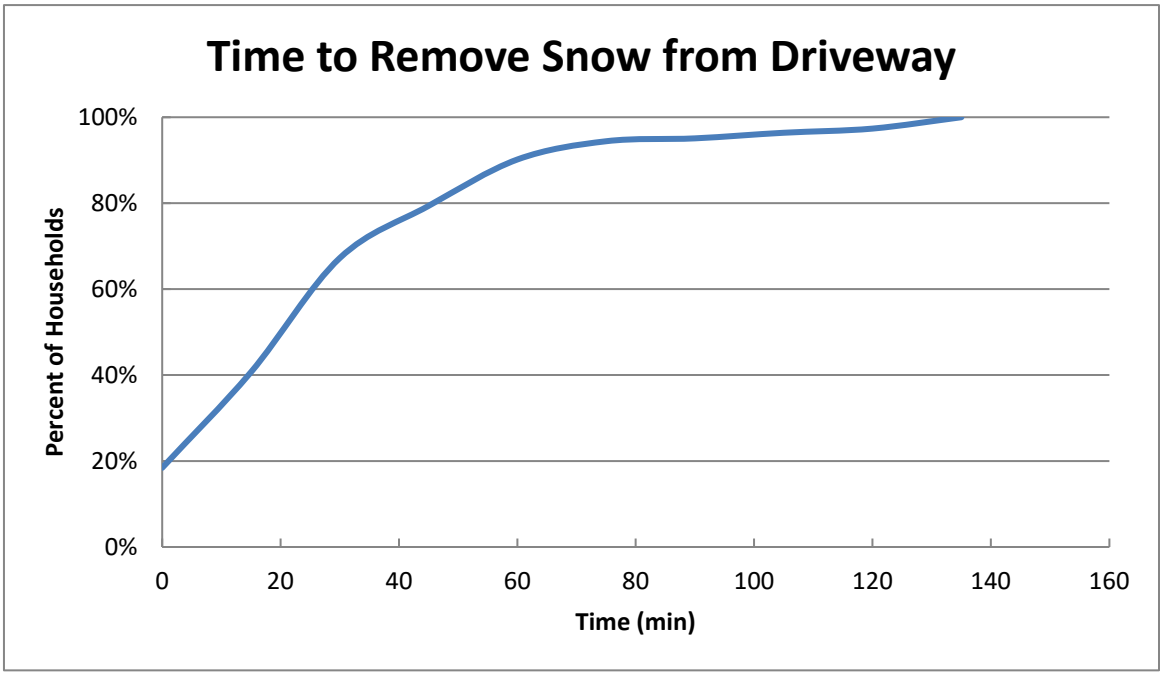


Figure F-17. Time to Remove Snow from Driveway

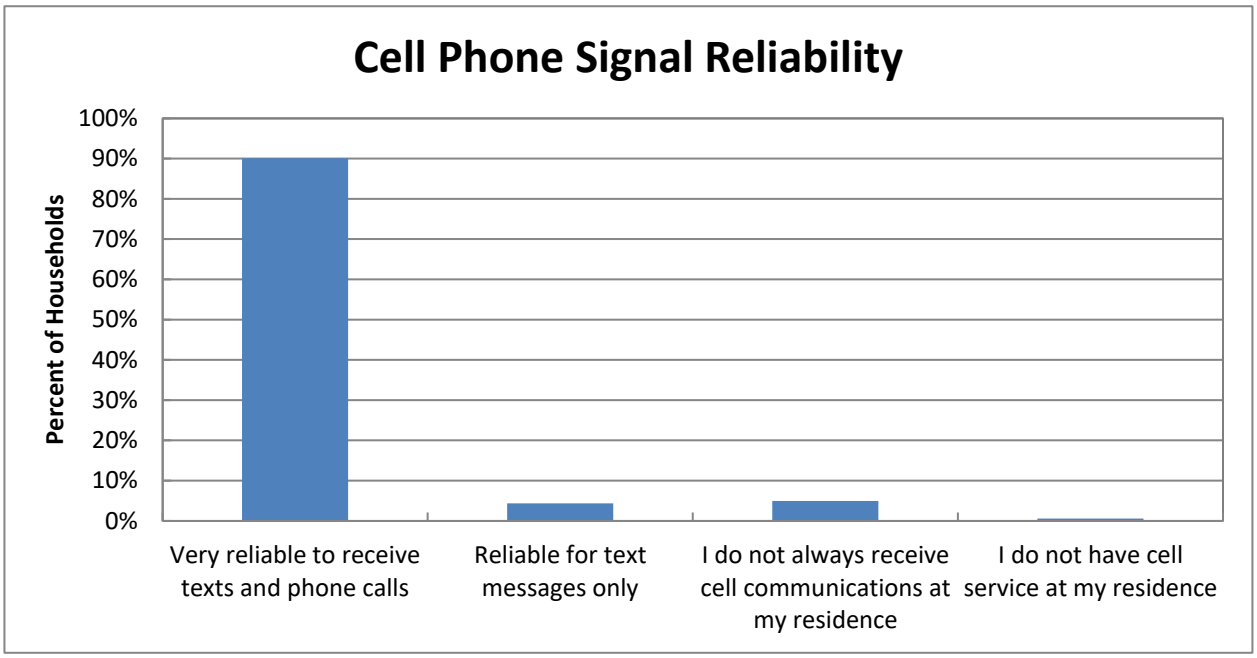


Figure F-18. Cell Phone Signal Reliability

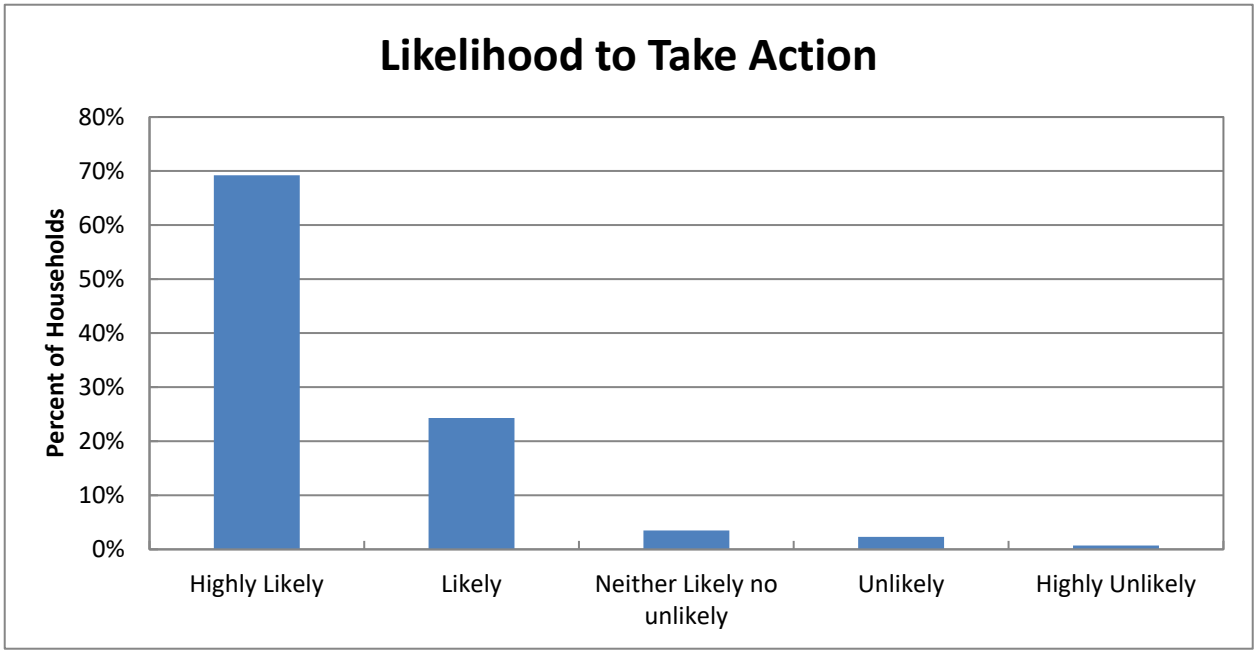


Figure F-19. Likelihood to Take Action Based off Emergency Management Officials Guidelines

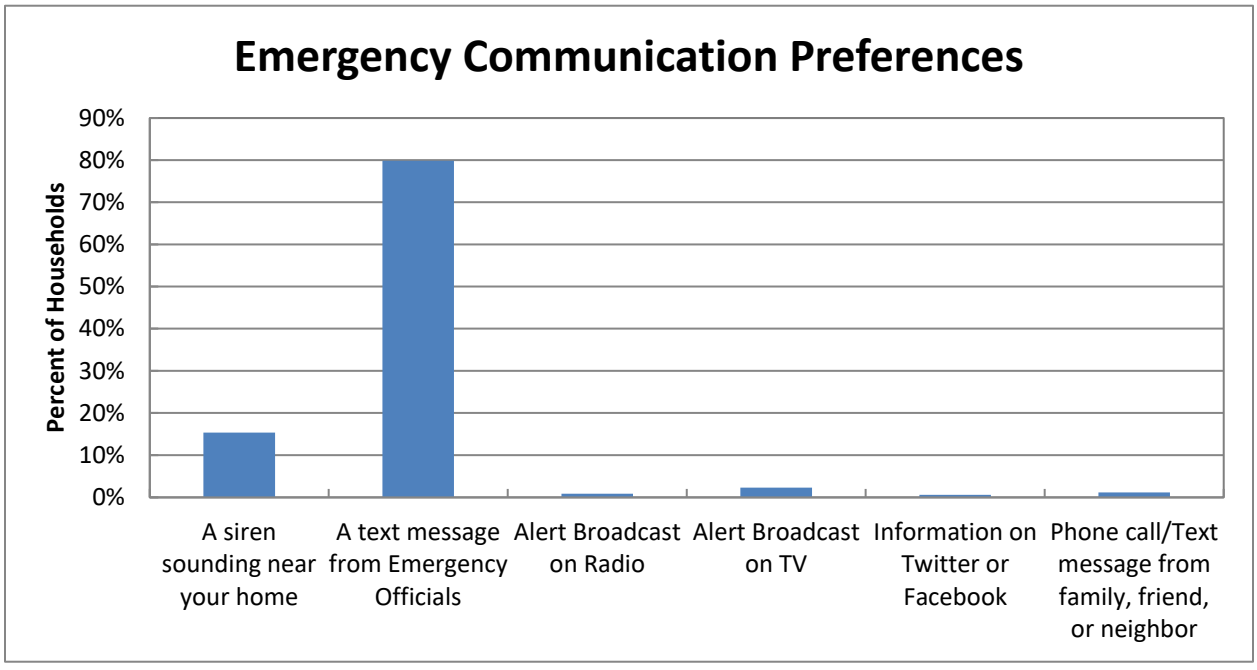


Figure F-20. Emergency Communication Alert

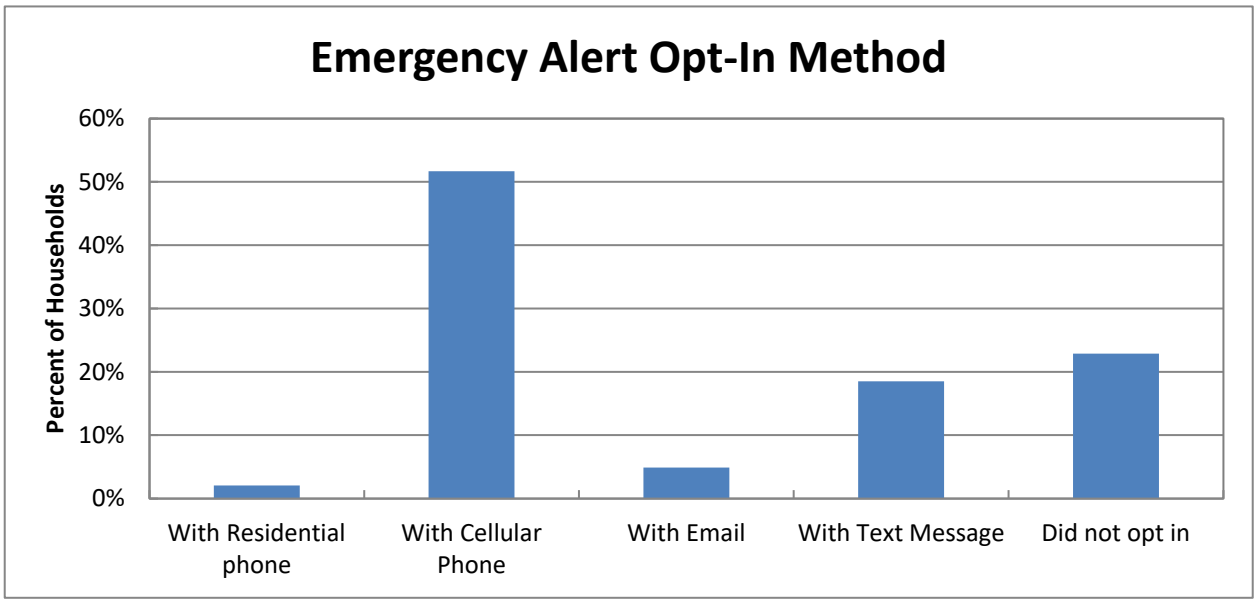


Figure F-21. Opt-In Method for Emergency Alert Notifications

ATTACHMENT A

Demographic Survey Instrument

Purpose

The purpose of this survey is to identify local behavior during emergency situations. The information gathered in this survey will be shared with Xcel Energy to enhance emergency response plans in your area. Your responses will greatly contribute to local emergency preparedness. Please only complete one survey per household. Please have the head of the household (18 years or older) complete the survey. Do not provide your name or any personal information, and the survey will take less than 10 minutes to complete.

1. What is your gender?

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

* 2. What is your home zip code

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

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

- ◯ Yes
- ◯ No
- ◯ Decline to State

5. How many vehicles would your household use during an evaculation

6. How many people usually live in this household?

COVID-19

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

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

Mode of Travel

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

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

Travel Home from Work/College

Skip ahead to the next page once you are through your household commuters.

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

11. If over 2 hours for commuter #1, specify here. Leave blank if answer is under 2 hours.

12. How much time on average, would it take Commuter #2 to travel home from work or college

13. If over 2 hours for commuter #2, specify here. Leave blank if answer is under 2 hours.

14. How much time on average, would it take Commuter #3 to travel home from work or college

15. If over 2 hours for commuter #3, specify here. Leave blank if answer is under 2 hours.

16. How much time on average, would it take Commuter #4 to travel home from work or college

17. If over 2 hours for commuter #4, specify here. Leave blank if answer is under 2 hours.

Preparation to leave Work/College

Skip ahead to the next page once you are through your household commuters.

18. Approximately how much time would it take Commuter #1 to complete preparation for leaving work or college prior to starting the trip home?

19. If over 2 hours for commuter #1, specify here. Leave blank if answer is under 2 hours.

20. Approximately how much time would it take Commuter #2 to complete preparation for leaving work or college prior to starting the trip home?

21. If over 2 hours for commuter #2, specify here. Leave blank if answer is under 2 hours.

22. Approximately how much time would it take Commuter #3 to complete preparation for leaving work or college prior to starting the trip home?

23. If over 2 hours for commuter #3, specify here. Leave blank if answer is under 2 hours.

24. Approximately how much time would it take Commuter #4 to complete preparation for leaving work or college prior to starting the trip home?

25. If over 2 hours for commuter #4, specify here. Leave blank if answer is under 2 hours.

Additional Questions

26. 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?

27. If Over 6 Hours, specify here

28. If there are 6-8 inches of snow on your driveway or curb, would you need to shovel out to evacuate? If yes, how much time, on average, would you take to clear the 6-8 inches of snow to move the car from the driveway or curb to begin the evacuation trip? Assume the roads are passable

29. Please specify the number of people in your household who require Functional or Transportation needs in an evacuation

	0	1	2	3	4	More than 4
Bus						
Medical Bus/Van						
Wheelchair Accessible Vehicle						
Ambulance						
Other						

Other (please specify)

30. Please choose one of the following:

- I would await the return of household members to evacuate together.
- I would evacuate independently and meet other household members later
- Decline to state

31. Emergency officials advise you to shelter-in-place in an emergency because you are not in the area of risk. Would you:

- Shelter-in-place
- Evacuate
- Decline to state

32. Emergency officials advise you to shelter-in-place now in an emergency and possibly evacuate later while people in other areas are advised to evacuate now. Would you:

- Shelter-in-place
- Evacuate
- Decline to state

33. Emergency officials advise you to evacuate due to an emergency. Where would you evacuate to?

Emergency Communication

34. At your place of residence, how reliable is your cell phone signal?

- Very reliable to receive texts and phone calls
- Reliable for text messages only
- I do not always receive cell communications at my residence
- I do not have cell service at my residence

35. Emergency management officials in your state may send texts messages, similar to AMBER alerts, with emergency directions for the public during a radiological emergency at Monticello Nuclear Generating Plant. How likely would you be to take action on these directions, if you received the message?

- Highly likely
- Likely
- Neither Likely no unlikely
- Unlikely
- High Unlikely

36. Which of the following emergency communication methods do you think is most likely to alert you at your residence?

- A siren sounding near your home
- A text message from emergency officials
- Alert broadcast on radio
- Alert broadcast on TV
- Information on Twitter or Facebook
- Phone call/Text message from family, friend or neighbor
- Other (please specify)

37. Have you opted into your local Emergency Alert and Warning Systems?

- [ ] With Residential phone
- [ ] With Cellular phone
- [ ] With email
- [ ] With text message
- [ ] Did not opt in
- [ ] Decline to state

38. Do you have any pet(s) and/or animal(s)?

- ◯ Yes
- ◯ No
- ◯ Decline to state

39. What type of pet(s) and/or animal(s) do you have?

- ☐ Dog
- ☐ Cat
- ☐ Bird
- ☐ Reptile
- ☐ Horse
- ☐ Fish
- ☐ Chicken
- ☐ Goat
- ☐ Pig
- ☐ Other Small Pets/Animals (Specify Below)
- ☐ Other Large Pets/Animals (Specify Below)
- ☐ Decline to State
- ☐ Other (please specify)

40. What would you do with your pet(s) and/or animal(s) if you had to evacuate?

- ◯ Take pet with me to a shelter
- ◯ Take pet with me somewhere else
- ◯ Leave pet at home
- ◯ Decline to state

41. Do you have sufficient room in your vehicle(s) to evacuate your pet(s) and/or animal(s)?

- ◡ Yes
- ◡ No
- ◡ Will use a trailer
- ◡ Decline to state
- ◡ Other (please specify)

APPENDIX G

Traffic Management Plan

G. TRAFFIC MANAGEMENT PLAN

NUREG/CR-7002, Rev. 1 indicates that the existing Traffic and Access Control Points (TACPs) identified by the offsite agencies should be used in the evacuation simulation modeling. The combined Traffic Management Plan (TMP) for the EPZ was provided by Xcel Energy.

This plan was reviewed and the TACPs were modeled accordingly. An analysis of the TACP locations was performed, and it was determined to model the ETE simulations with existing TACPs that were provided in the approved TMP, with no additional TACPs recommended.

G.1 Manual Traffic Control

The TACPs are forms of Manual Traffic Control (MTC). As discussed in Section 9, MTC at intersections (which are controlled) are modeled as actuated signals. If an intersection has a pre-timed signal, stop, or yield control, and the intersection is identified as a TACP, the control type was changed to an actuated signal in the DYNEV II system, in accordance with Section 3.3 of NUREG/CR-7002, Rev. 1. MTCs at existing actuated traffic signalized intersections were essentially left alone.

Table K-1 provides the number of nodes with each control type. If the existing control was changed due to the point being a TACP, the control type is indicated as "TACP" in Table K-1. The TACPs within the TMP are mapped as light blue dots in Figure G-1. The four critical TACPs, as discussed below, are represented by the light blude dots with red boxes in Figure G-1. The TACPs are concentrated along major evacuation routes and would be staffed during evacuation by traffic guides who would direct evacuees in the proper direction away from MNGP and facilitate the flow of traffic through the intersections, as well as along roadways giving access to the EPZ to stop the flow of traffic into the EPZ. No additional locations for MTC are suggested in this study as a result of the ETE simulations.

It is assumed that the TACPs will be established within 120 minutes of the ATE to discourage through travelers from using major through routes which traverse the study area. As discussed in Section 3.10, external traffic was considered on I-94 and US-10 in this analysis.

G.2 Analysis of Key TACP Locations

As discussed in Section 5.2 of NUREG/CR-7002, Rev. 1, MTC at intersections could benefit from the ETE analysis. The MTC locations contained within the TMP were analyzed to determine key locations where MTC would be most useful and could be readily implemented. As previously mentioned, signalized intersections that were actuated based on field data collection were essentially left as actuated traffic signals in the model with modifications to green time allocation as needed. Other controlled intersections (pre-timed signals, stop signs and yield signs) were changed to actuated traffic signals to represent the MTC that would be implemented according to the TMPs.

Table G-1 shows a list of the controlled intersections that were identified as MTC points in the Traffic Management Plans (TMPs) that were not previously actuated signals, including the type

of control that currently exists at each location. To determine the impact of MTC at these locations, a winter, weekday, midday, good weather scenario (Scenario 6) evacuation of the entire EPZ (R03) were simulated wherein these intersections were left as is (without MTC/no MTC). The results are shown in Table G-2. The ETE increased – 10 minutes at the 90th percentile and 15 minutes at the 100th percentile – when compared to the base case wherein these controlled intersections were modeled as actuated signals (with MTC).

The evacuation animations were compared in the two cases to determine the critical intersections causing the significant change in ETE. Four of the 20 intersections listed in Table G-1 appeared to be more critical than the rest since the congestion surrounding these intersections was significantly worse in the non-MTC animation. These intersections are listed as Priority 1 in Table G-1. These four intersections were reverted to MTC locations and a winter, weekday, midday, good weather evacuation of the entire EPZ (Region R03) was simulated again.

Table G-2 displays the results of this case as well labeled as "Priority 1 MTC Locations Only". When comparing the ETE to the base case with MTC, both the 90th percentile ETE and 100th percentile ETE remained the same. As a result, these intersections were determined to be the most critical (first priority) with the remainder of the intersections listed in Table G-1 as Priority 2 locations for MTC.

Table G-2 shows the congestion patterns of the case wherein all TACPs (MTC) is implemented (1), wherein no MTC is implemented (2), and when MTC is implemented at the four priority 1 intersections only (3) at 3 hours and 5 minutes after the ATE. The patterns of congestion are similar between the All MTC (1) case and the Priority 1 MTC Only (3) case and both of these cases are show less congestion than the No MTC (2) case.

The 4 critical (Priority 1) intersections are focused along 57th St on the EPZ boundary to the north of MNGP and on CR-15 as vehicles try to turn on CR-4. MTC allows more vehicles to be processed in the same amount of time than a stop sign – essentially increasing the capacity of these intersections. As shown in Figure 7-3 through Figure 7-9, many vehicles from the towns of Becker and Big Lake use CR-11, CR-23 and CR-15 northbound to evacuate. These routes lead to the four Priority 1 intersections. The increased capacity provided by the MTC allows vehicles to evacuate more quickly. When these intersections are left as stop signs, less vehicles can be processed, and congestion worsens - prolonging ETE.

The rest of the TACPs are in either less congested locations or in location with heavy competing movements. When heavy traffic persists in competing directions, MTC provides little to no benefit since both approaches need equal amounts of 'green time'. Although there is no reduction in ETE when the remaining TACPs are implemented, TACPs can be beneficial in the reduction of localized congestion and driver confusion and can be extremely helpful for fixed point surveillance, amongst other things. Should there be a shortfall of personnel to staff the TACPs, the list of locations provided in Table G-1 could be considered as key locations when implementing the TMP in the priority order shown.

Table G-1. List of Key Manual Traffic Control Locations

TACP Number	Intersection	Node Number (See Appendix K)	Type of Control (Prior to being a TACP)	Priority
1	SR-25 & 57th St	306	Stop	1
3	CR-11 & 57th St	222	Stop	1
4	CR-23 & 57th St	588	Stop	1
12	CR-4 & CR-15	725	Stop	1
16	SR-24 & CR-7	63	Stop	2
31	CR-7 & 112th St	161	Stop	2
34	CR-39 & Aetna Ave	885	Stop	2
35	CR-39 & Cameron Ave	553	Stop	2
45	CR-19 & 70th St	1023	Traffic circle	2
		1333		
		1235		
47	CR-37 & CR-18	382	Stop	2
58	CR-18 & Garrison Rd	628	Stop	2
61	CR-18 & Calder Ave	1197	Traffic circle	2
		1198		
63	CR-18 & Eaken Ave	624	Stop	2
76	CR-39 & Elm St	554	Stop	2
112	CR-39 & CR-7	162	Stop	2
143, 200	CR-43 & CR-15	982	Stop	2
210, 211	CR-19 & 80th St	610	Stop	2
212	CR-19 & W Laketowne Dr	609	Traffic circle	2
		1261		
240, 241	CR-12 & CR-138	468	Traffic circle	2
290	SR-24 & CR-104	61	Stop	2

Table G-2. ETE with No MTC and Priority MTC – Scenario 6 Region R03

	Base Case (with All MTC)	No MTC	Priority 1 MTC Locations Only
90th Percentile ETE	3:05	3:15	3:05
100th Percentile ETE	4:40	4:55	4:40

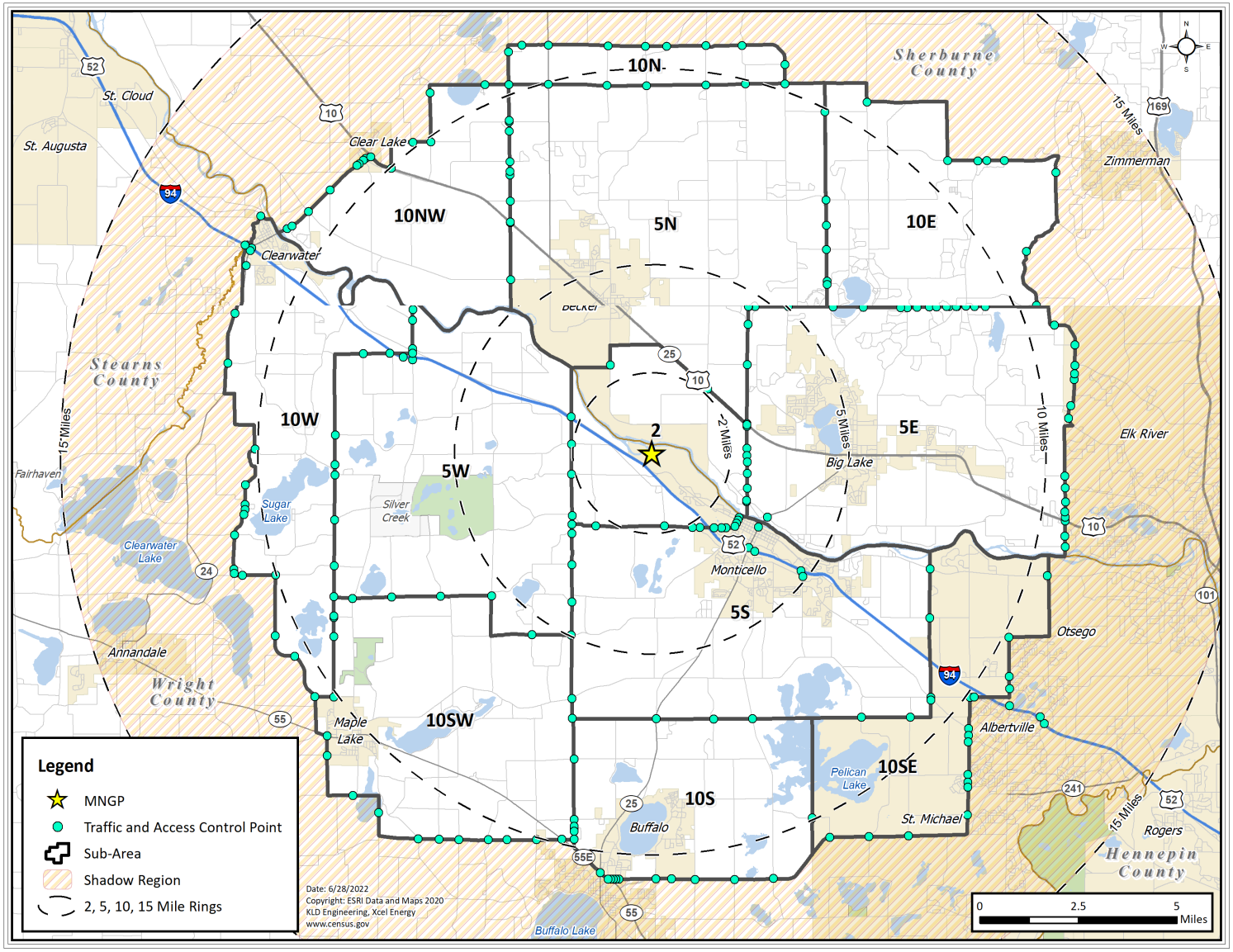


Figure G-1. Traffic and Access Control Points for MNGP

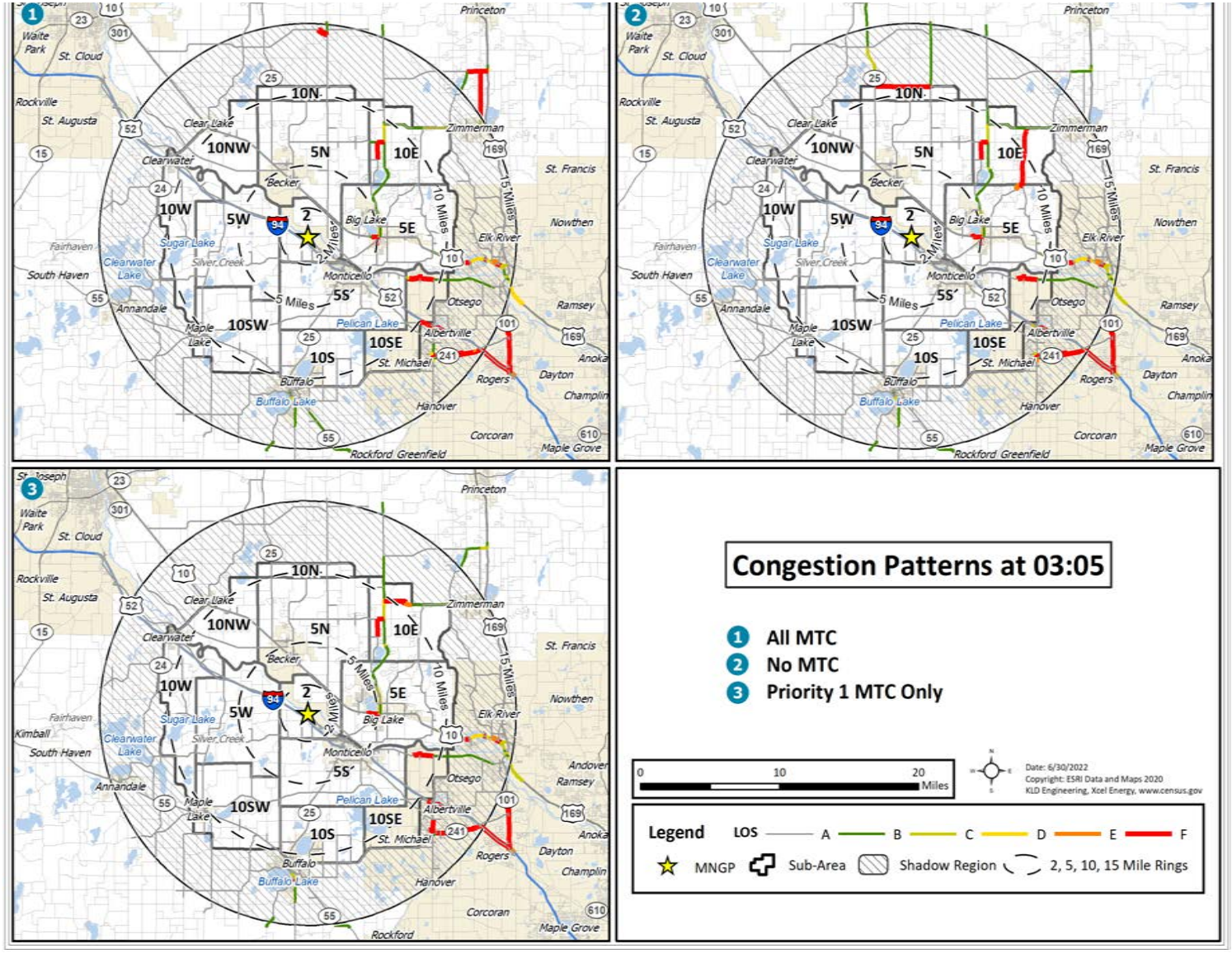


Figure G-2. Congestion Patterns at 3 hours and 5 minutes after the Advisory to Evacuate

APPENDIX H

Evacuation Regions

H. EVACUATION REGIONS

This appendix presents the evacuation percentages for each Evacuation Region (Table H-1) and maps of all Evacuation Regions (Figure H-1 through Figure H-34). The percentages presented in Table H-1 are based on the methodology discussed in assumption 9 of Section 2.2 and shown in Figure 2-1.

Note the baseline ETE study assumes 20 percent of households will not comply with the shelter advisory, as per Section 2.5.2 of NUREG/CR-7002, Rev. 1.

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

Radial Regions													
Region	Description	Wind From (in Degrees)	Sub-Area											
			2	5N	5E	5S	5W	10N	10E	10SE	10S	10SW	10W	10NW
R01	2-Mile Region	N/A	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R02	5-Mile Region	N/A	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%
R03	Full EPZ	N/A	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Evacuate 2-Mile Region and Downwind to 5 Miles														
Region	Wind Direction From	Wind From (in Degrees)	Sub-Area											
			2	5N	5E	5S	5W	10N	10E	10SE	10S	10SW	10W	10NW
R04	N, NNE, NE, ENE	349-78	100%	20%	20%	100%	100%	20%	20%	20%	20%	20%	20%	20%
R05	E	79-101	100%	20%	20%	20%	100%	20%	20%	20%	20%	20%	20%	20%
R06	ESE, SE, SSE	102-169	100%	100%	20%	20%	100%	20%	20%	20%	20%	20%	20%	20%
R07	S	170-191	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R08	SSW, SW, WSW	192-258	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R09	W	259-281	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%
R10	WNW, NW	282-326	100%	20%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%
R11	NNW	327-348	100%	20%	20%	100%	20%	20%	20%	20%	20%	20%	20%	20%
Evacuate 2-Mile Region and Downwind to the EPZ Boundary														
Region	Wind Direction From	Wind From (in Degrees)	Sub-Area											
			2	5N	5E	5S	5W	10N	10E	10SE	10S	10SW	10W	10NW
R12	N	349-11	100%	20%	20%	100%	100%	20%	20%	100%	100%	100%	20%	20%
R13	NNE, NE	12-56	100%	20%	20%	100%	100%	20%	20%	20%	100%	100%	100%	20%
R14	ENE	57-78	100%	20%	20%	100%	100%	20%	20%	20%	20%	100%	100%	20%
R15	E	79-101	100%	20%	20%	20%	100%	20%	20%	20%	20%	100%	100%	100%
R16	ESE	102-124	100%	100%	20%	20%	100%	20%	20%	20%	20%	20%	100%	100%
R17	SE	125-146	100%	100%	20%	20%	100%	100%	20%	20%	20%	20%	100%	100%
R18	SSE	147-169	100%	100%	20%	20%	100%	100%	20%	20%	20%	20%	20%	100%
R19	S	170-191	100%	100%	20%	20%	20%	100%	100%	20%	20%	20%	20%	100%
R20	SSW, SW	192-236	100%	100%	100%	20%	20%	100%	100%	20%	20%	20%	20%	20%
R21	WSW	237-258	100%	100%	100%	20%	20%	20%	100%	20%	20%	20%	20%	20%
R22	W	259-281	100%	100%	100%	100%	20%	20%	100%	100%	20%	20%	20%	20%

Region	Wind Direction From	Wind From (in Degrees)	Sub-Area											
			2	5N	5E	5S	5W	10N	10E	10SE	10S	10SW	10W	10NW
R23	WNW	282-303	**100%**	**20%**	**100%**	**100%**	**20%**	**20%**	**20%**	**100%**	**20%**	**20%**	**20%**	**20%**
R24	NW	304-326	**100%**	**20%**	**100%**	**100%**	**20%**	**20%**	**20%**	**100%**	**100%**	**20%**	**20%**	**20%**
R25	NNW	327-348	**100%**	**20%**	**20%**	**100%**	**20%**	**20%**	**20%**	**100%**	**100%**	**20%**	**20%**	**20%**
Staged Evacuation - 2-Mile Region Evacuates, then Evacuate Downwind to 5 Miles														
Region	**Wind Direction From**	**Wind From (in Degrees)**	**Sub-Area**											
			2	**5N**	**5E**	**5S**	**5W**	**10N**	**10E**	**10SE**	**10S**	**10SW**	**10W**	**10NW**
R26	N/A	5-Mile Region	**100%**	**100%**	**100%**	**100%**	**100%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**
R27	N, NNE, NE, ENE	349-78	**100%**	**20%**	**20%**	**100%**	**100%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**
R28	E	79-101	**100%**	**20%**	**20%**	**20%**	**100%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**
R29	ESE, SE, SSE	102-169	**100%**	**100%**	**20%**	**20%**	**100%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**
R30	S	170-191	**100%**	**100%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**
R31	SSW, SW, WSW	192-258	**100%**	**100%**	**100%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**
R32	W	259-281	**100%**	**100%**	**100%**	**100%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**
R33	WNW, NW	282-326	**100%**	**20%**	**100%**	**100%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**
R34	NNW	327-348	**100%**	**20%**	**20%**	**100%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**	**20%**
Sub-Area(s) Evacuate			Sub-Area(s) Shelter-in-Place			Sub-Area(s) Shelter-in-Place until 90% ETE for R01, then Evacuate								

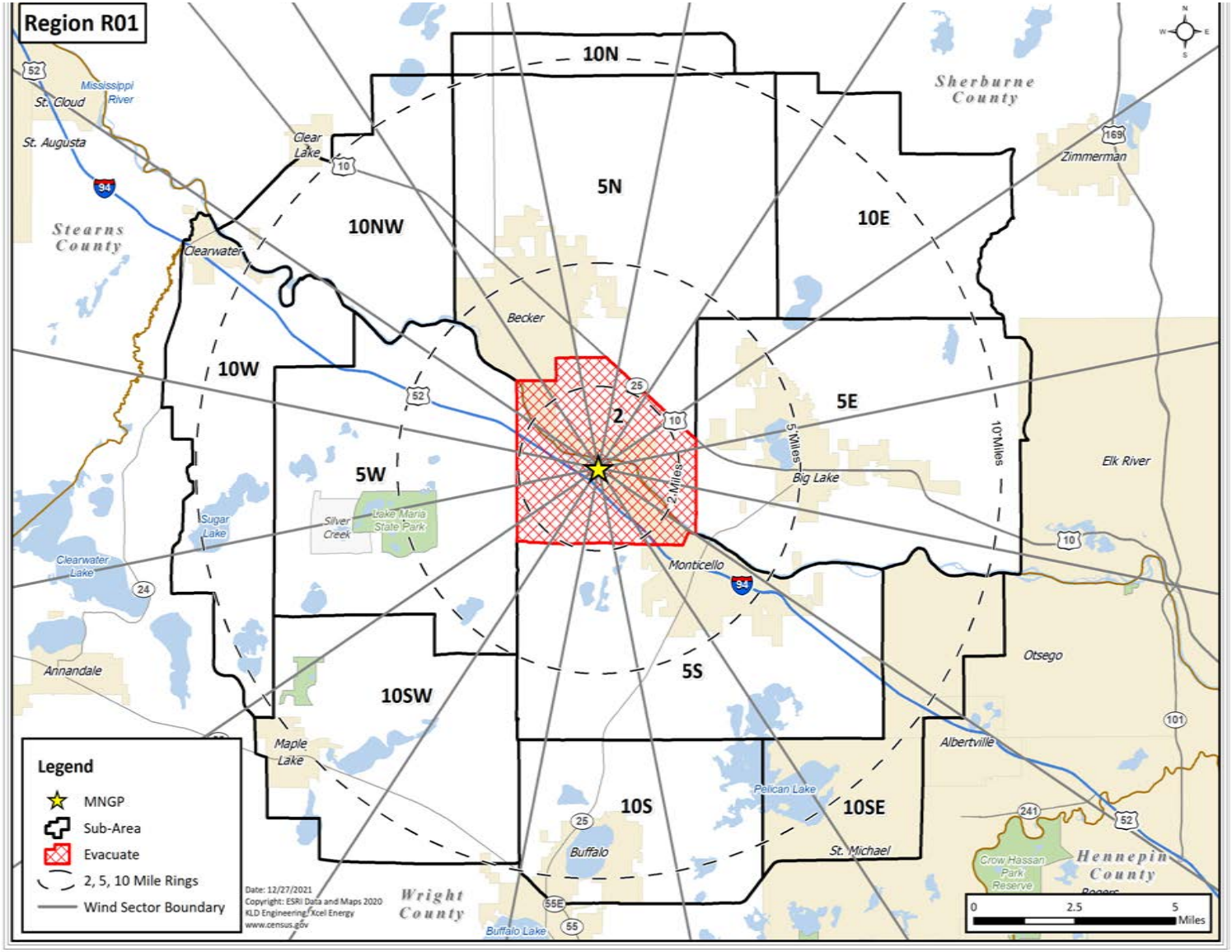


Figure H-1. Region R01

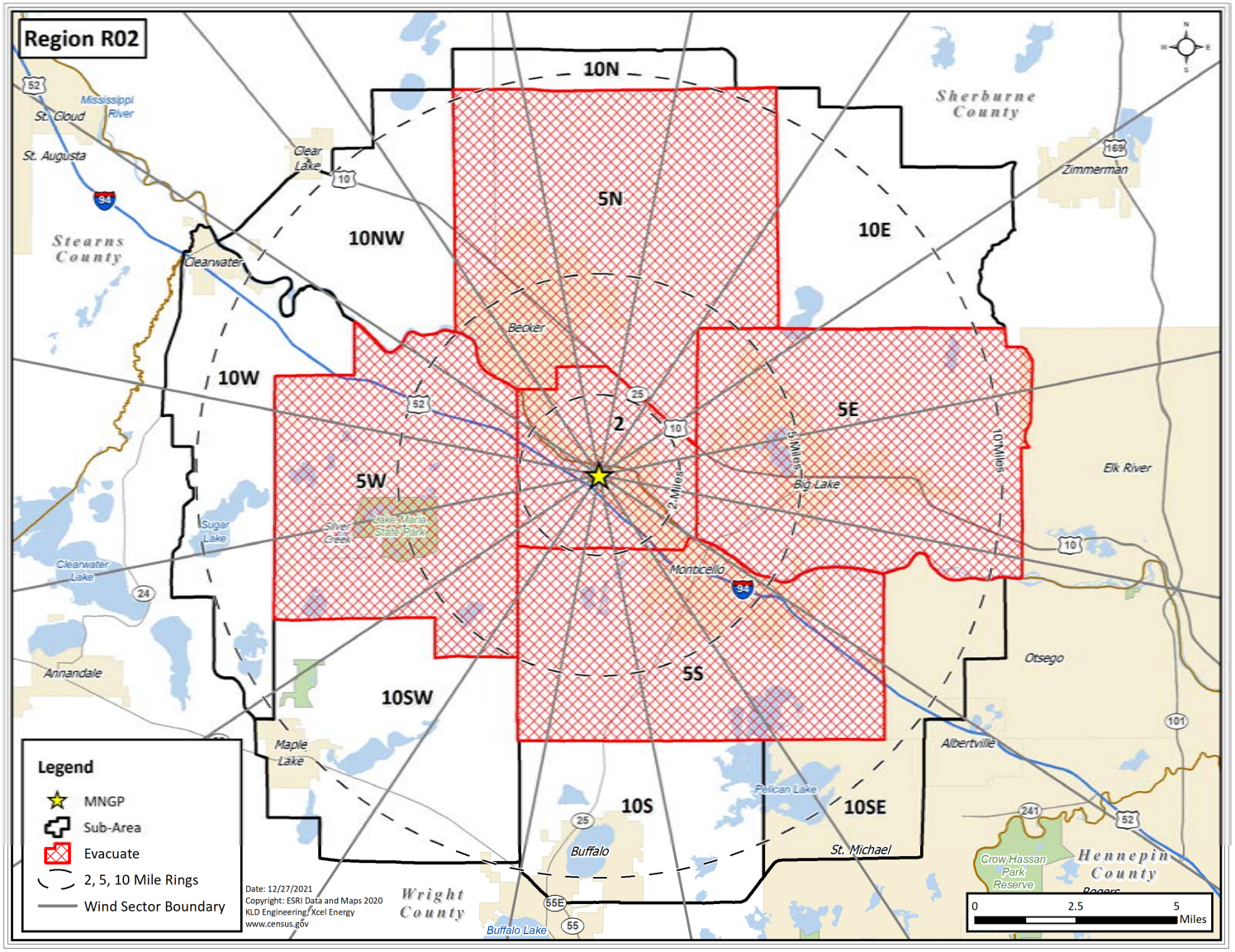


Figure H-2. Region R02

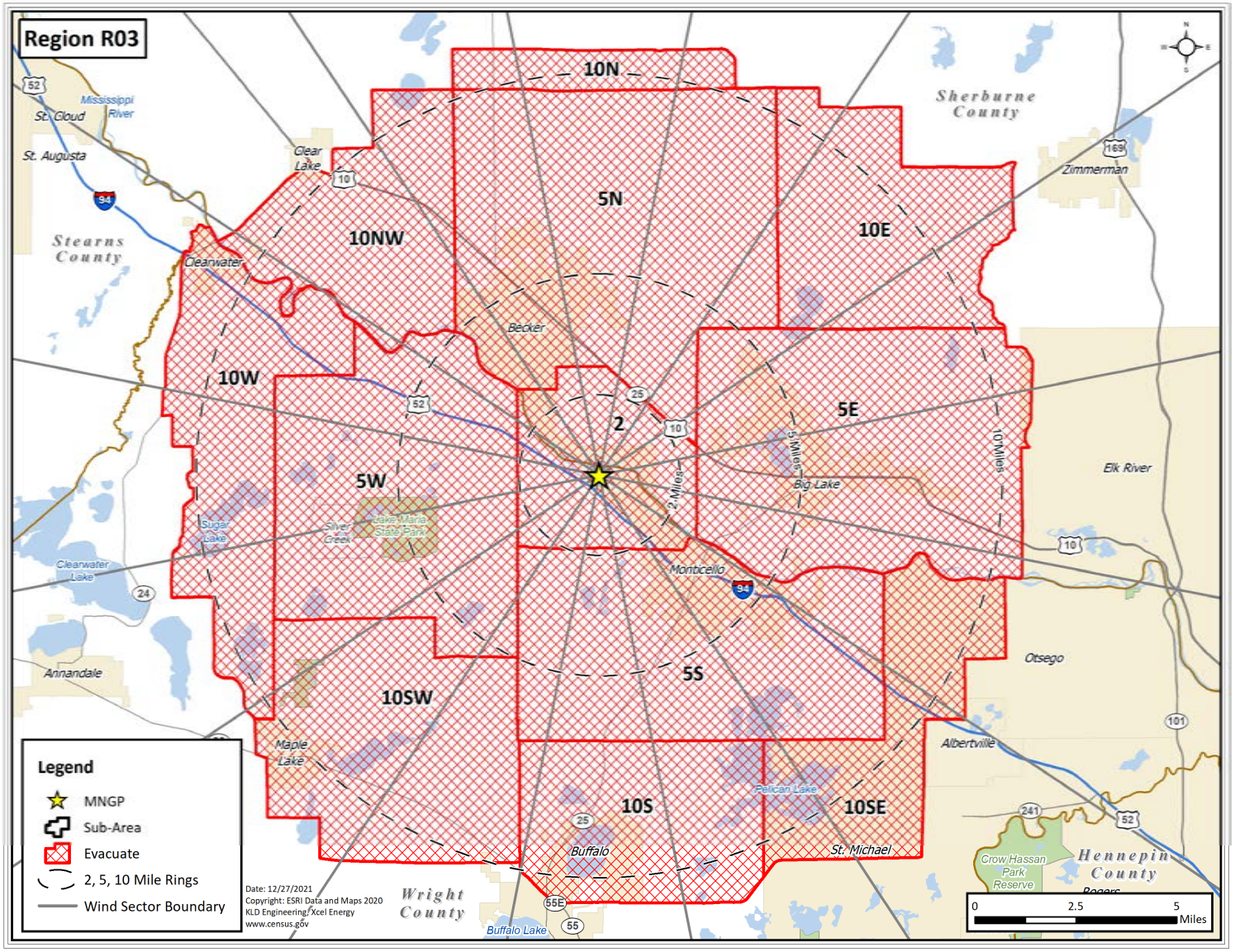


Figure H-3. Region R03

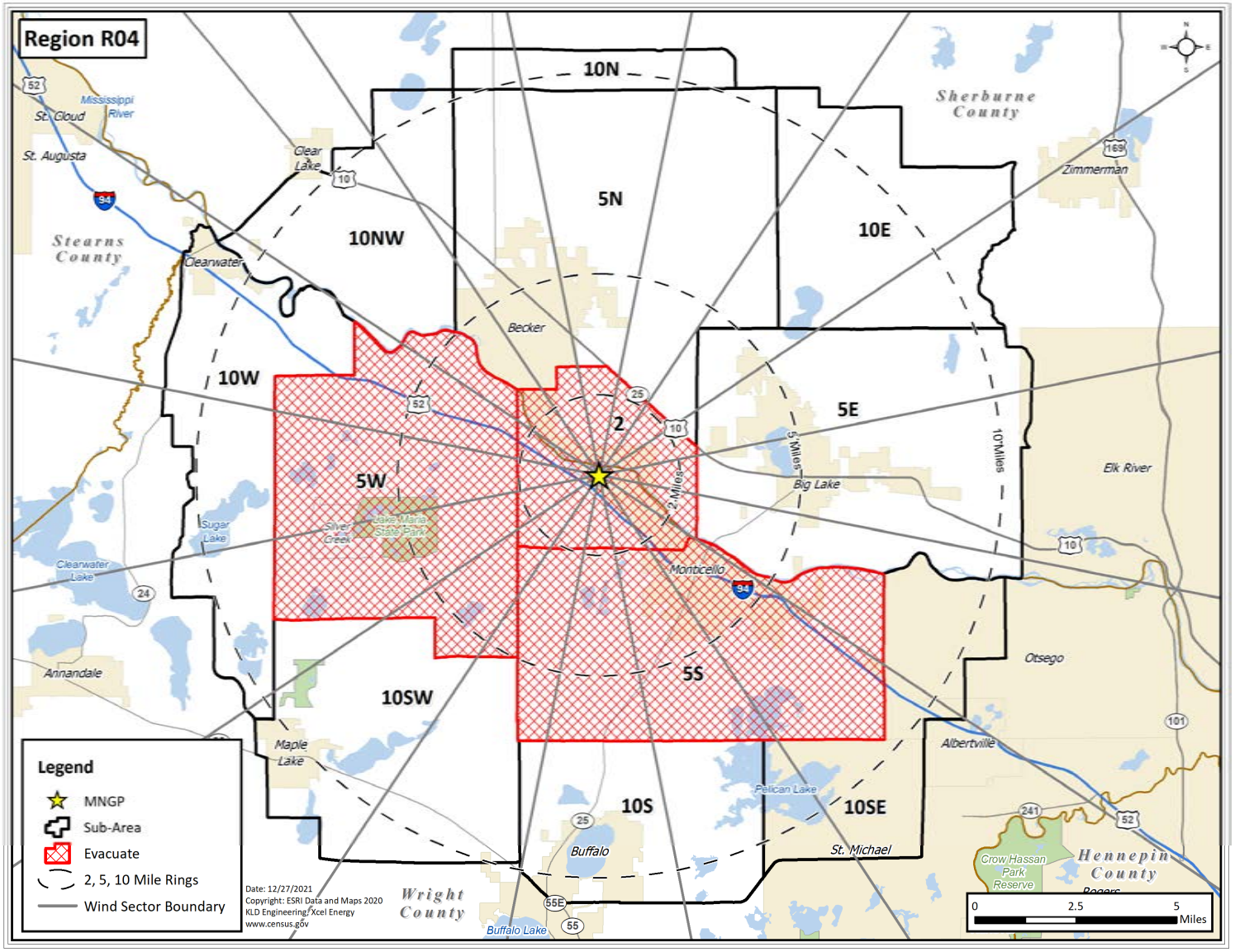


Figure H-4. Region R04

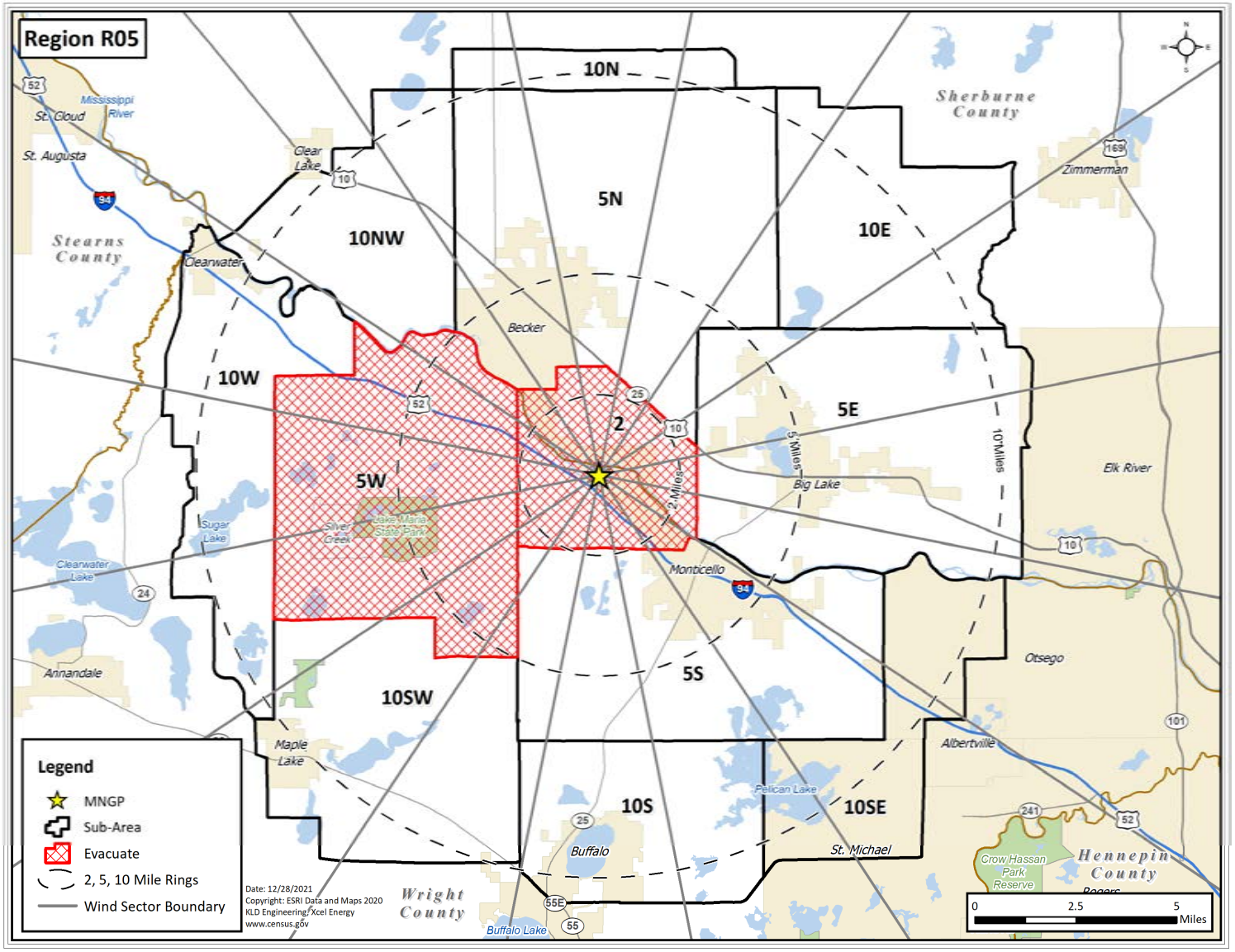


Figure H-5. Region R05

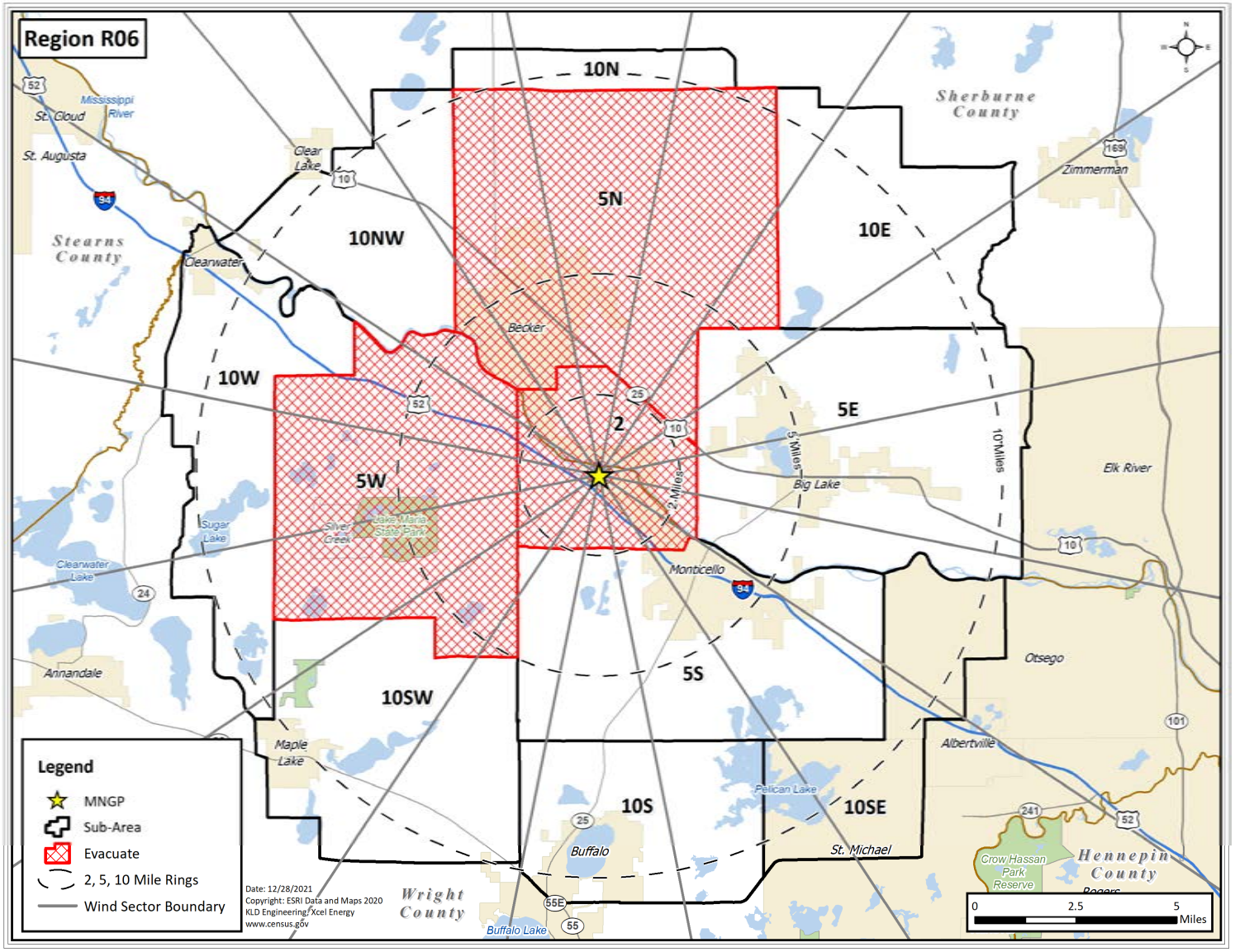


Figure H-6. Region R06

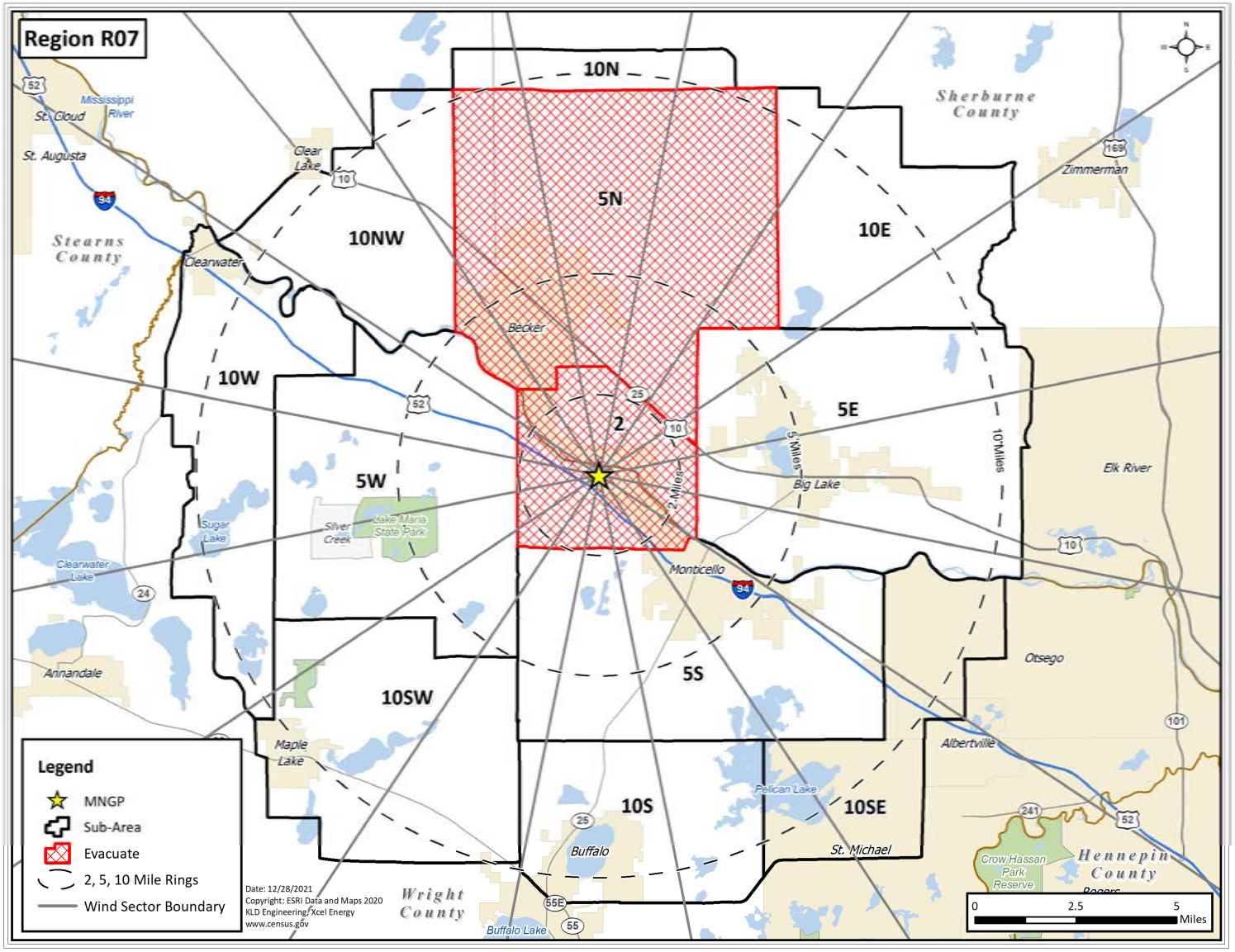


Figure H-7. Region R07

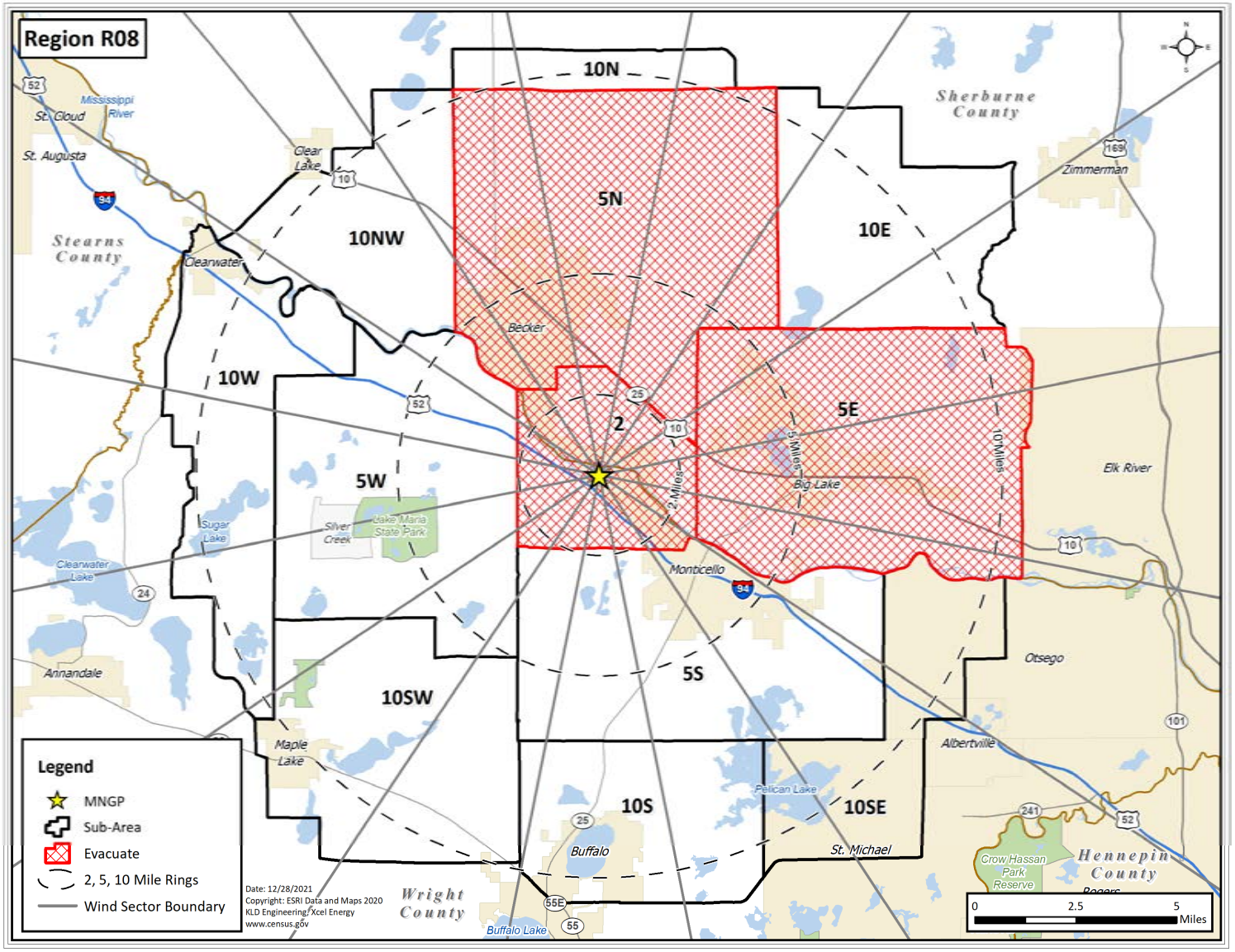


Figure H-8. Region R08

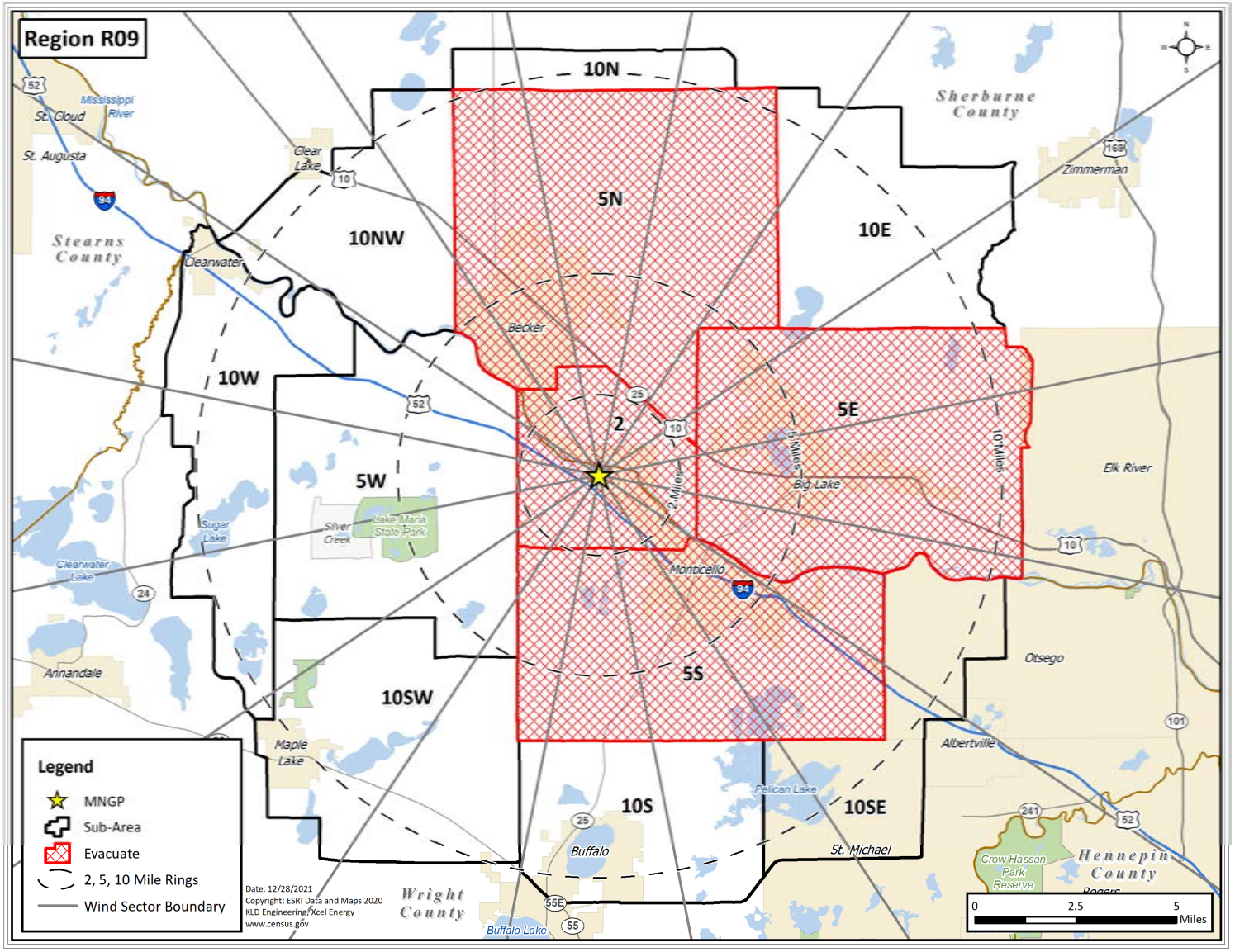


Figure H-9. Region R09

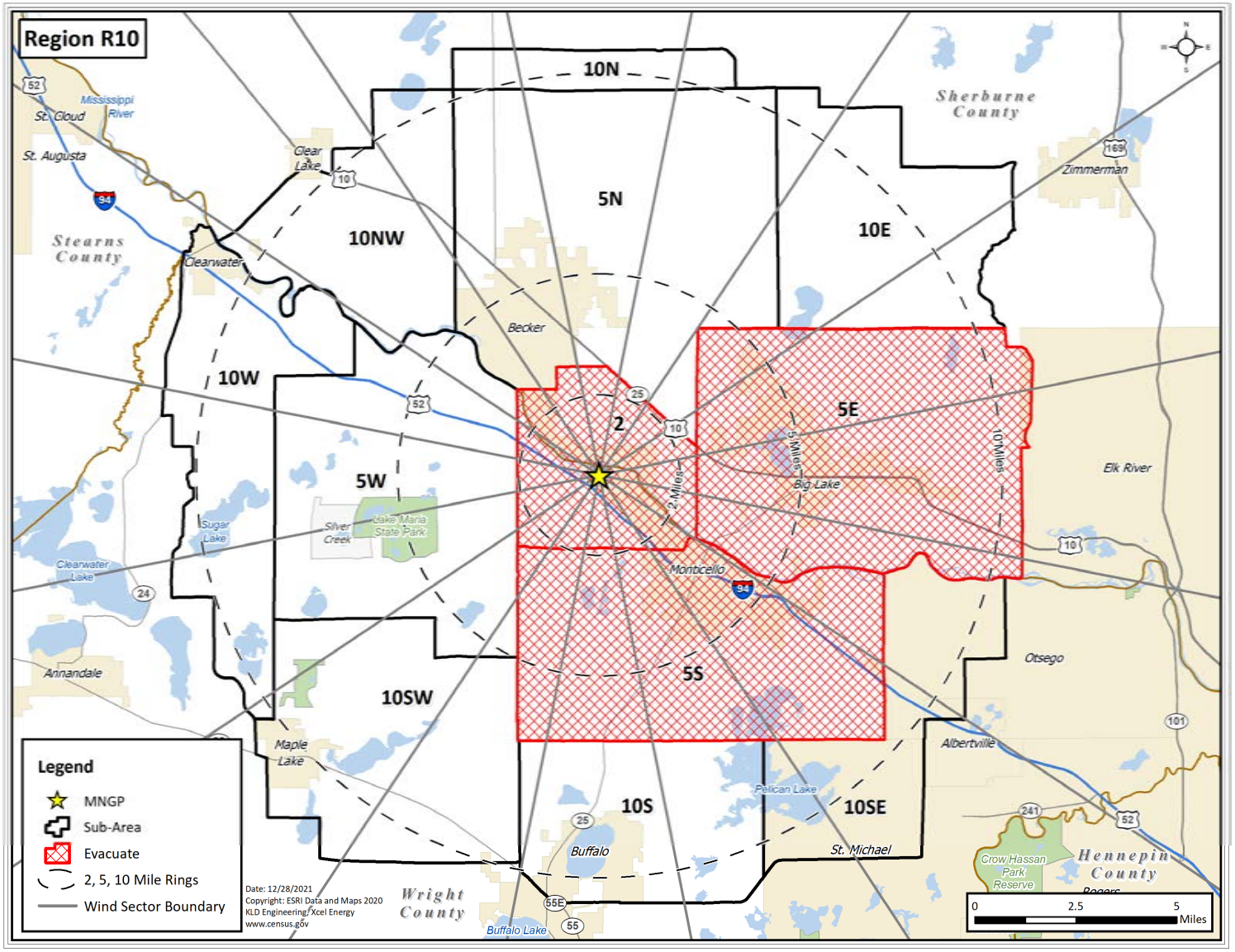


Figure H-10. Region R10

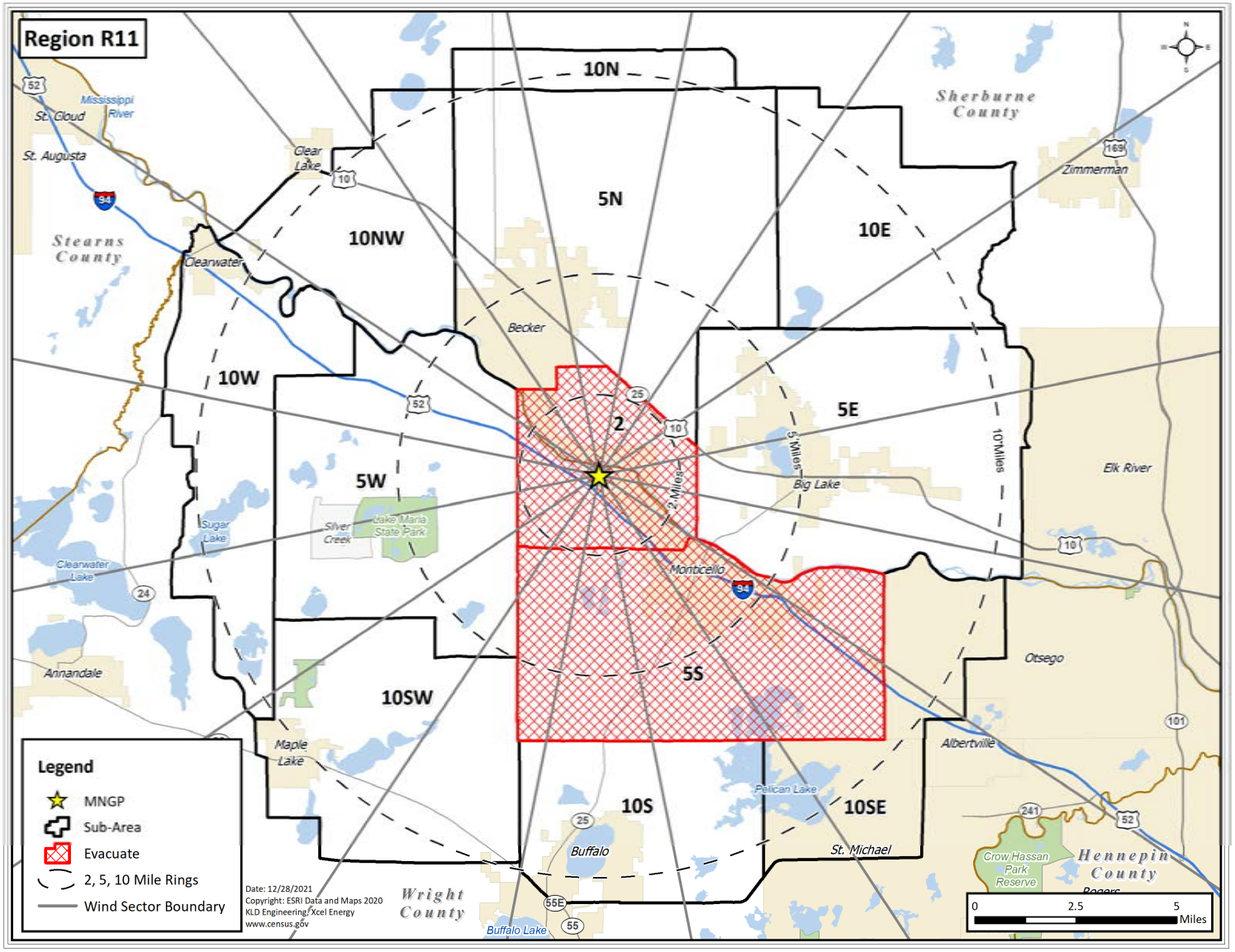


Figure H-11. Region R11

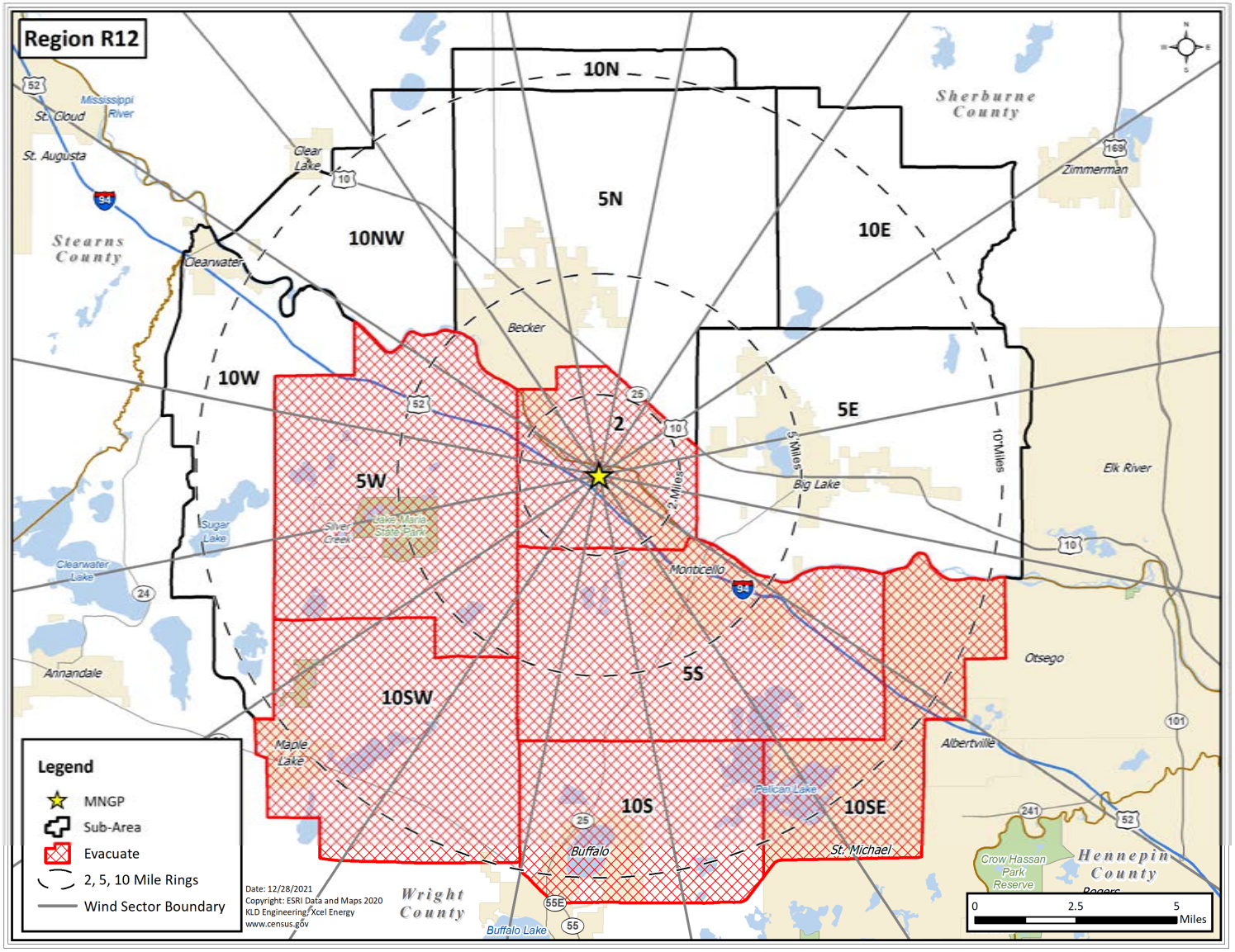


Figure H-12. Region R12

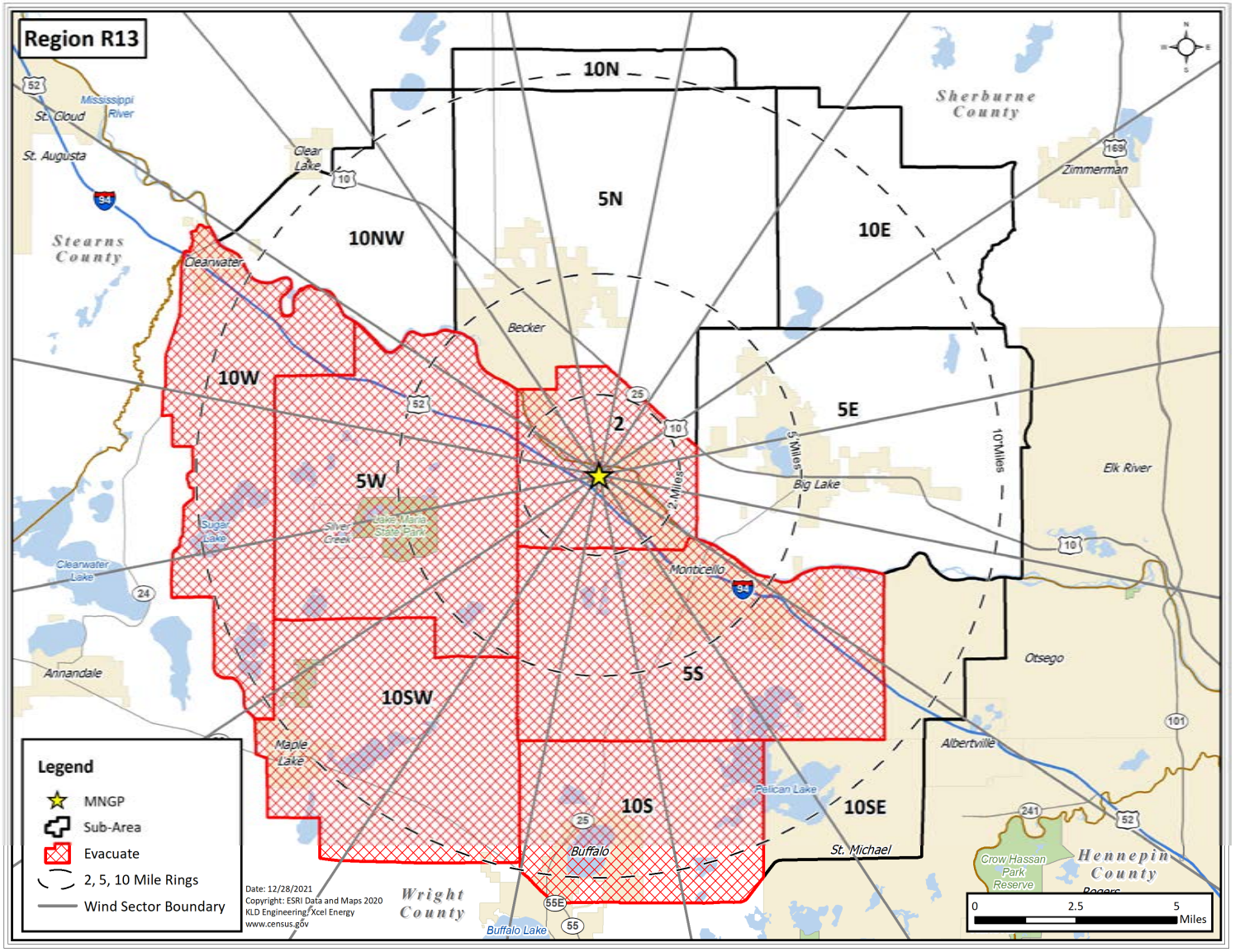


Figure H-13. Region R13

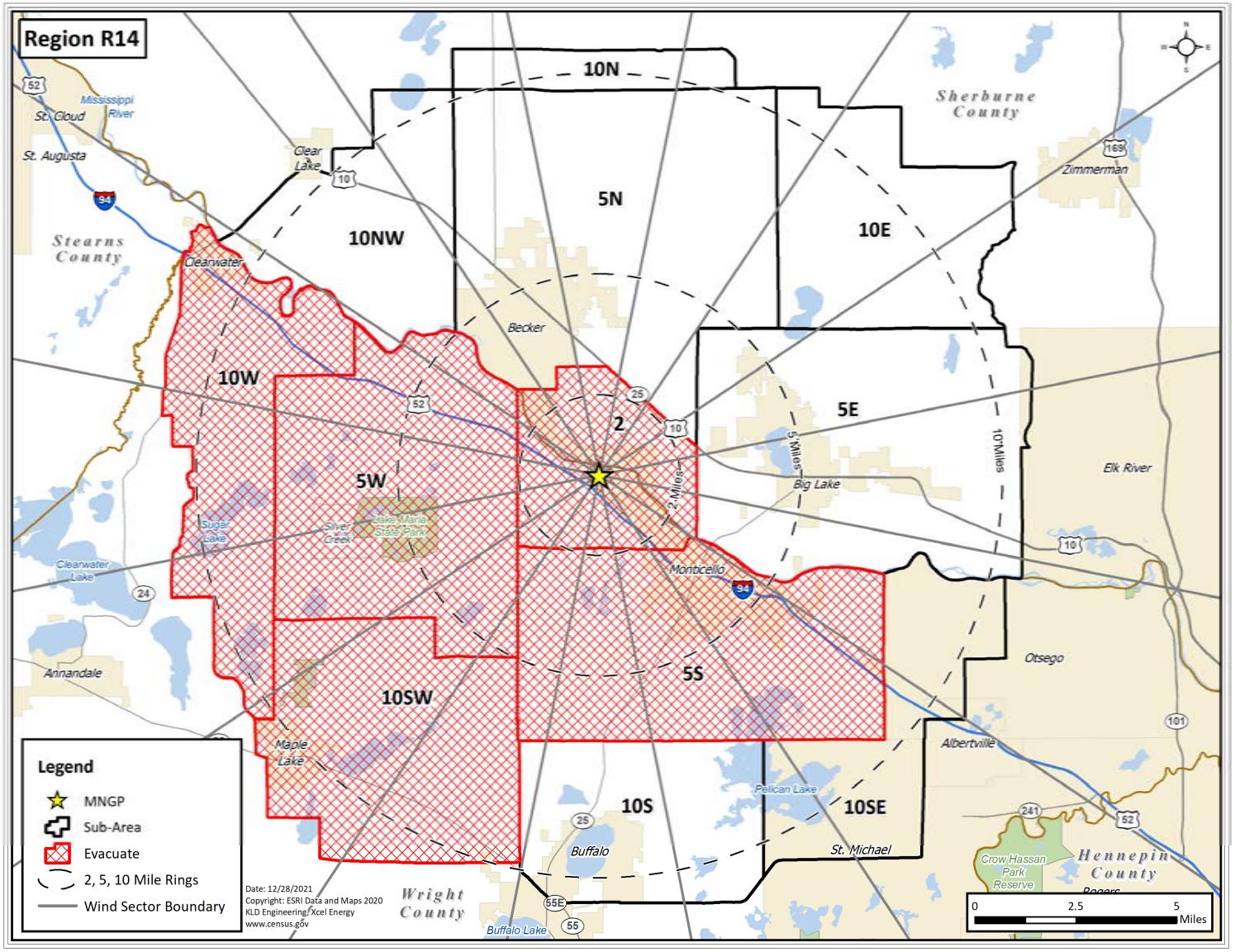


Figure H-14. Region R14

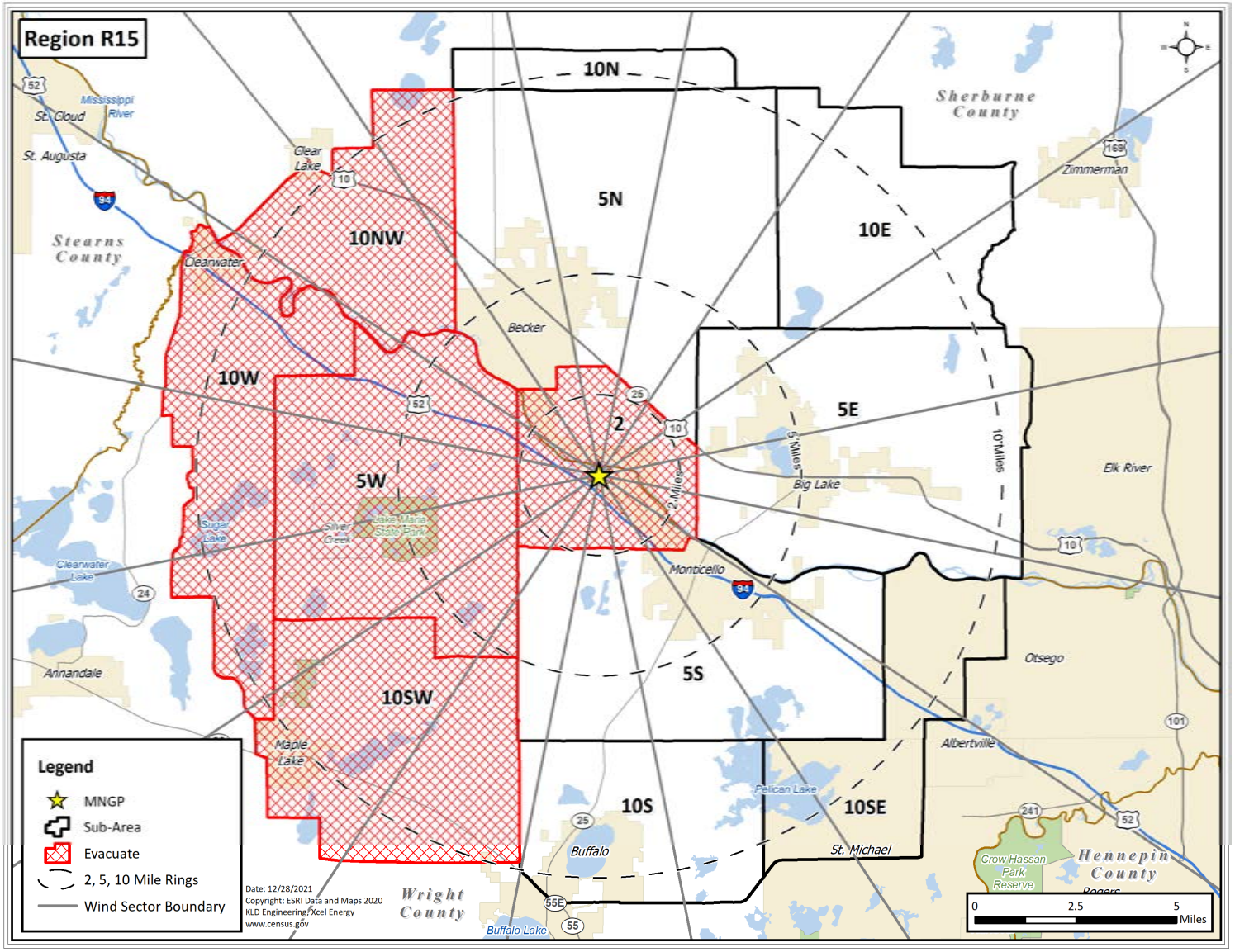


Figure H-15. Region R15

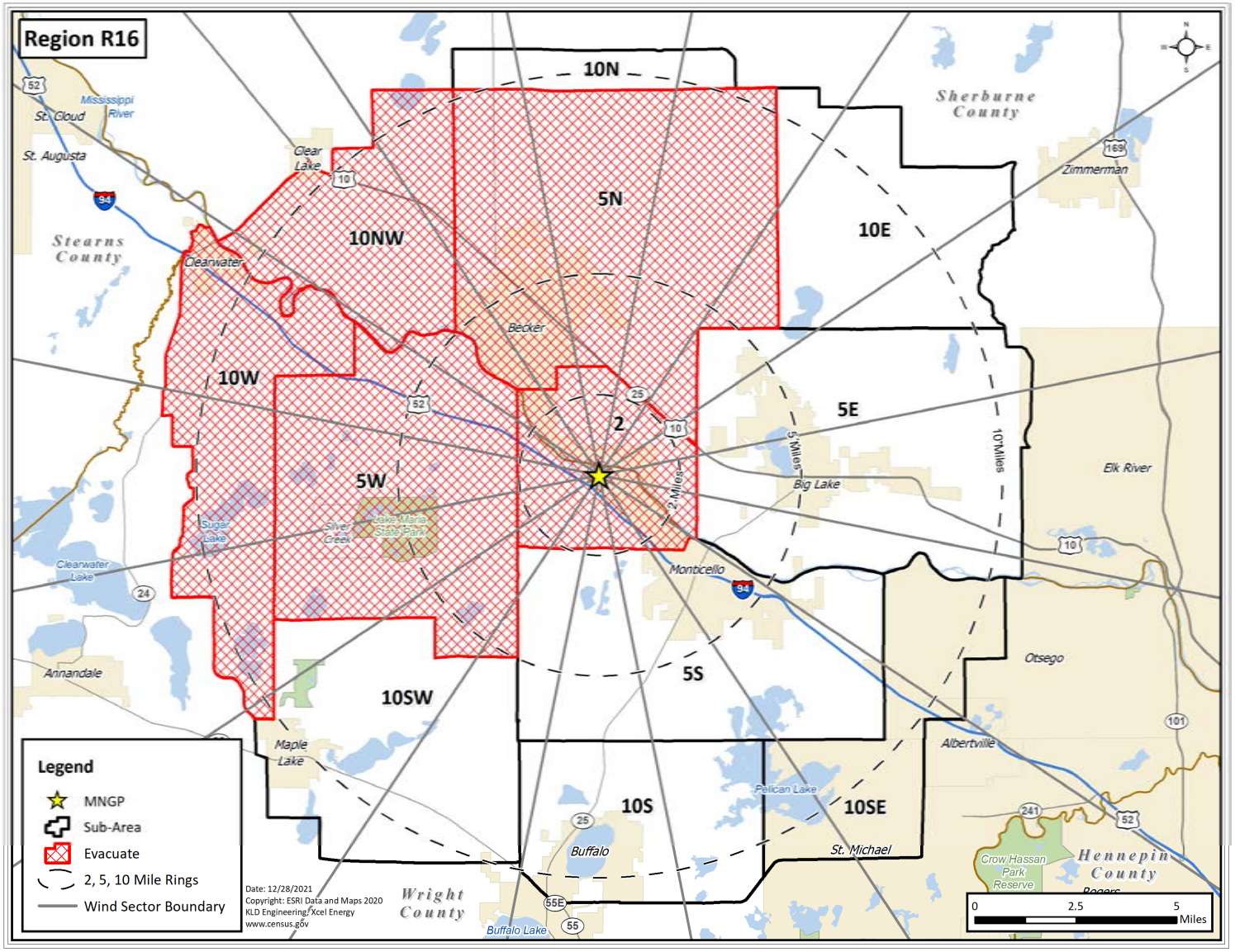


Figure H-16. Region R16

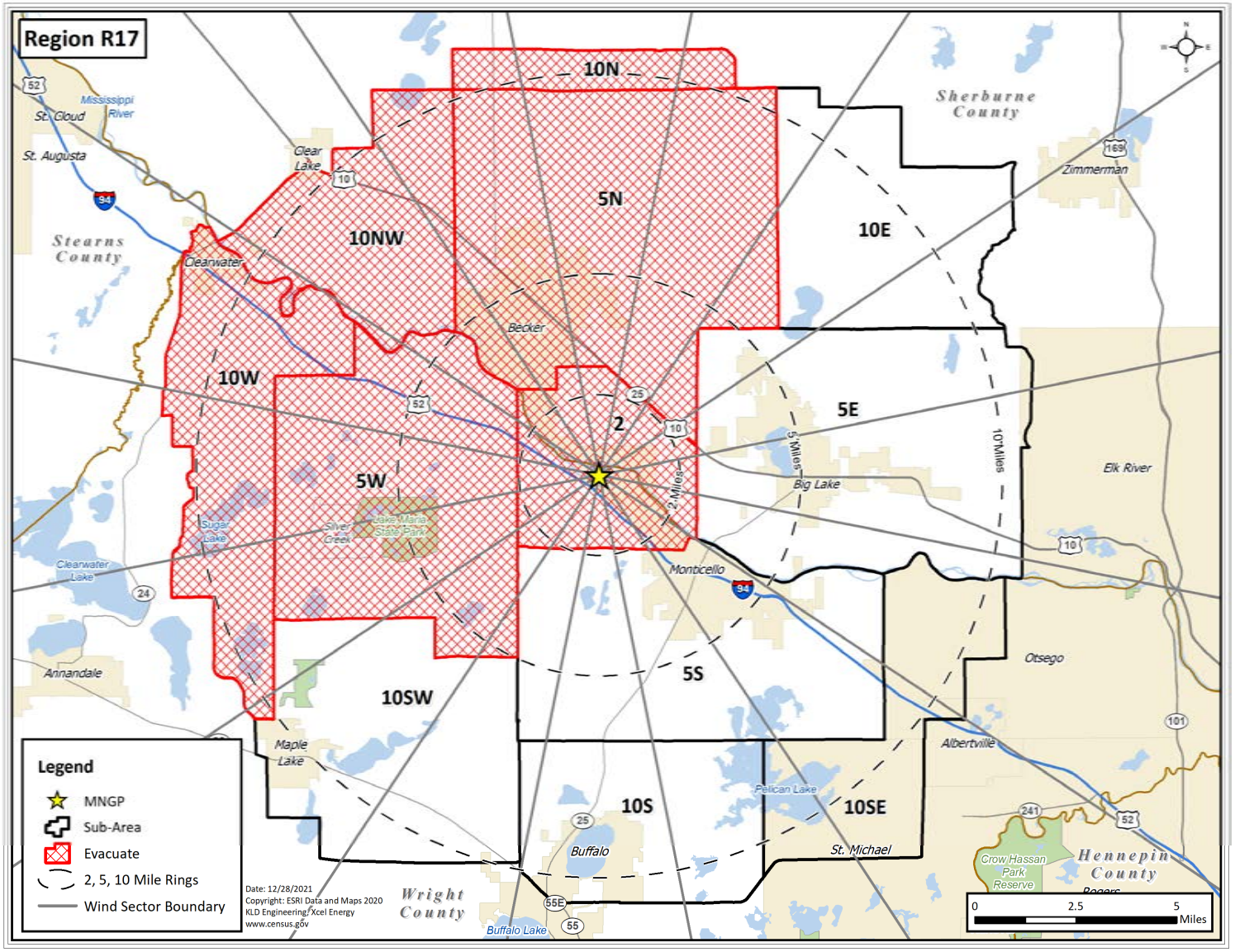


Figure H-17. Region R17

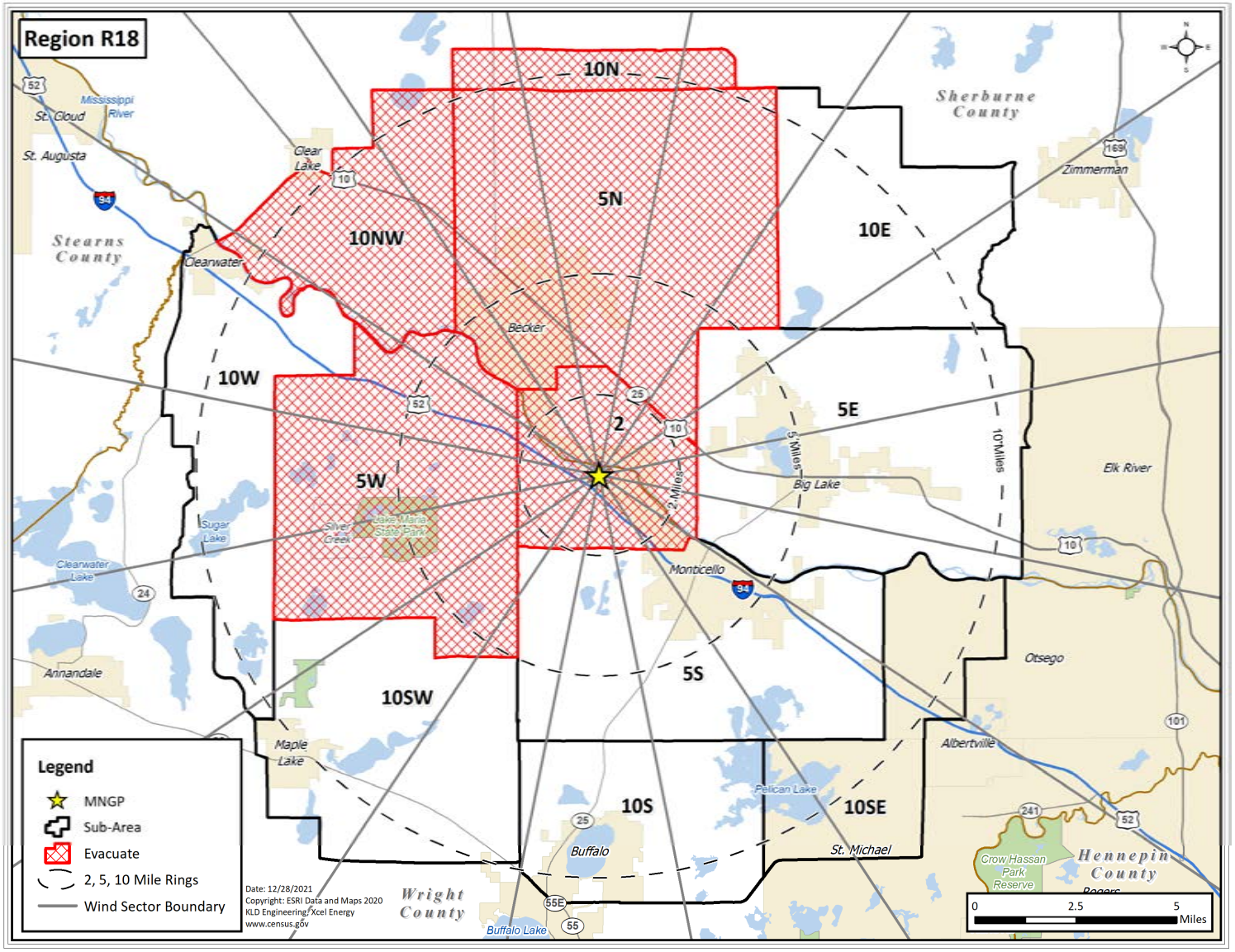


Figure H-18. Region R18

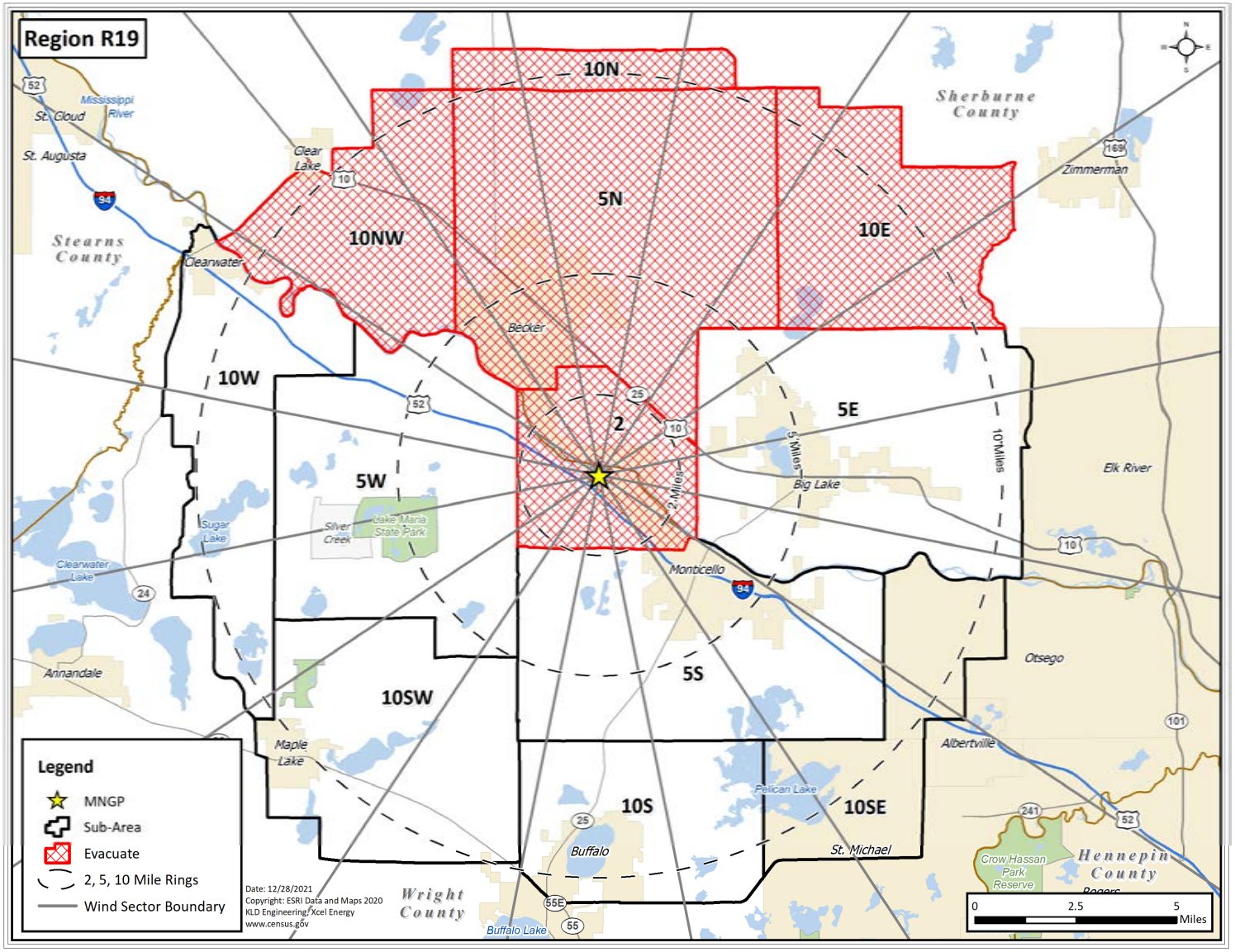


Figure H-19. Region R19

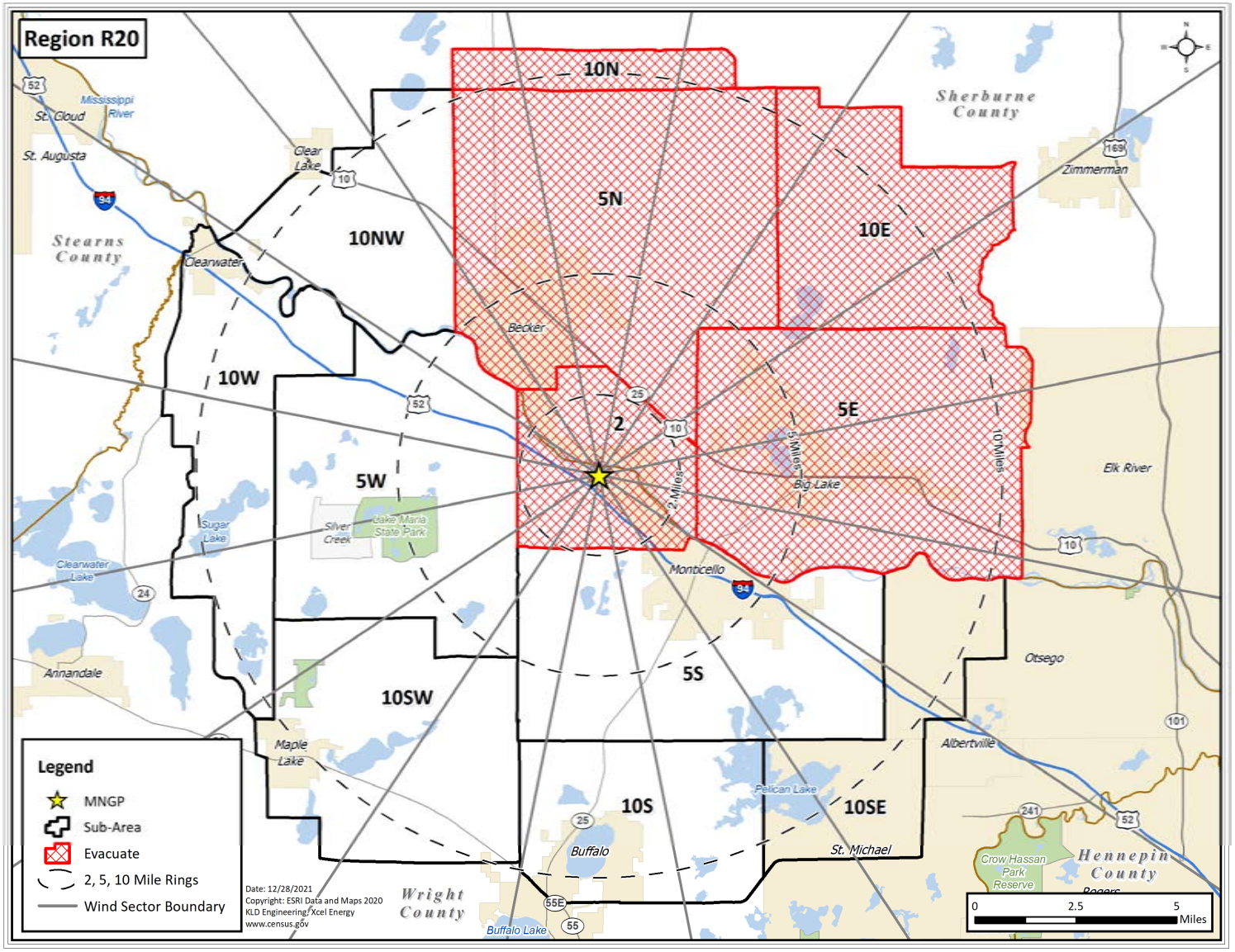


Figure H-20. Region R20

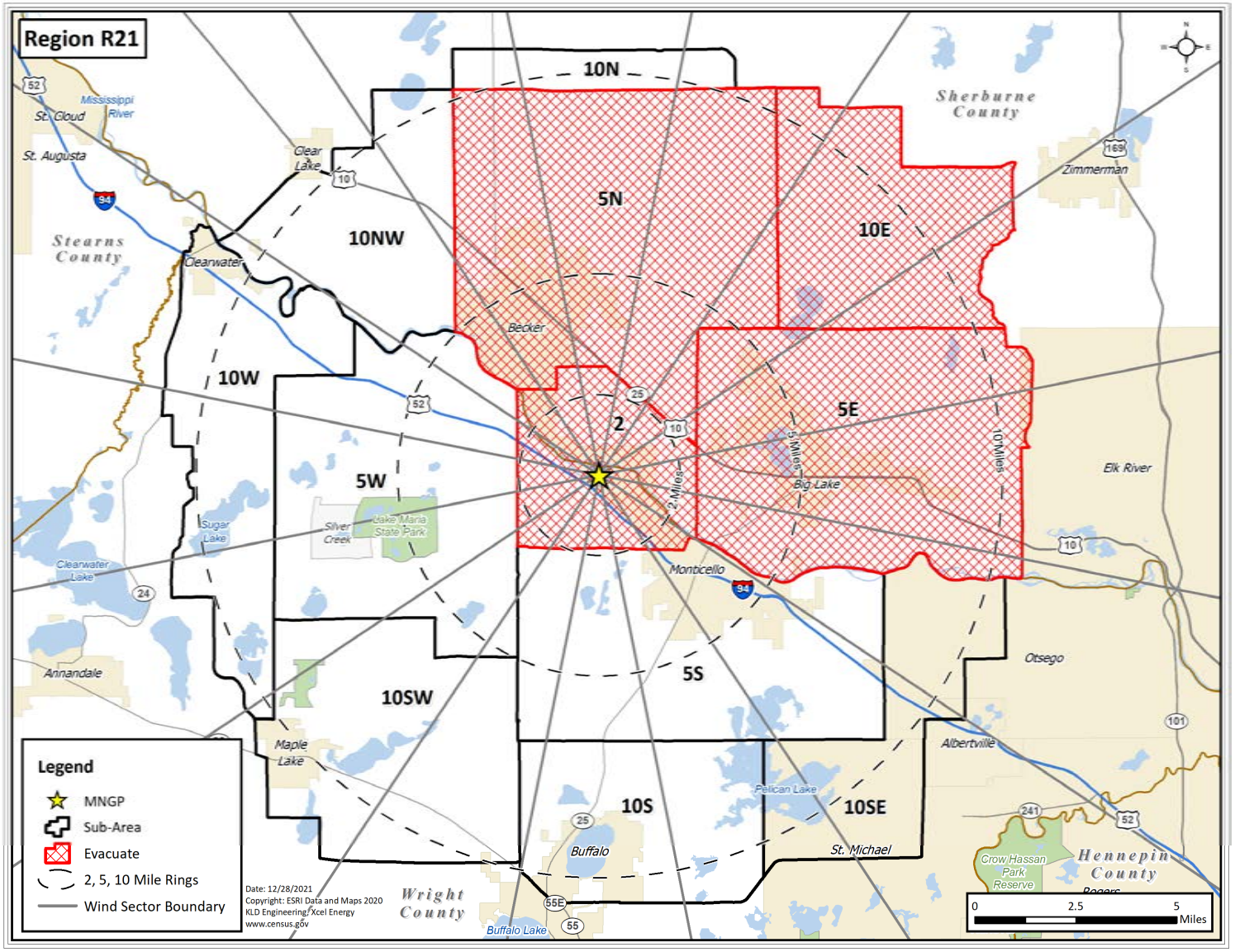


Figure H-21. Region R21

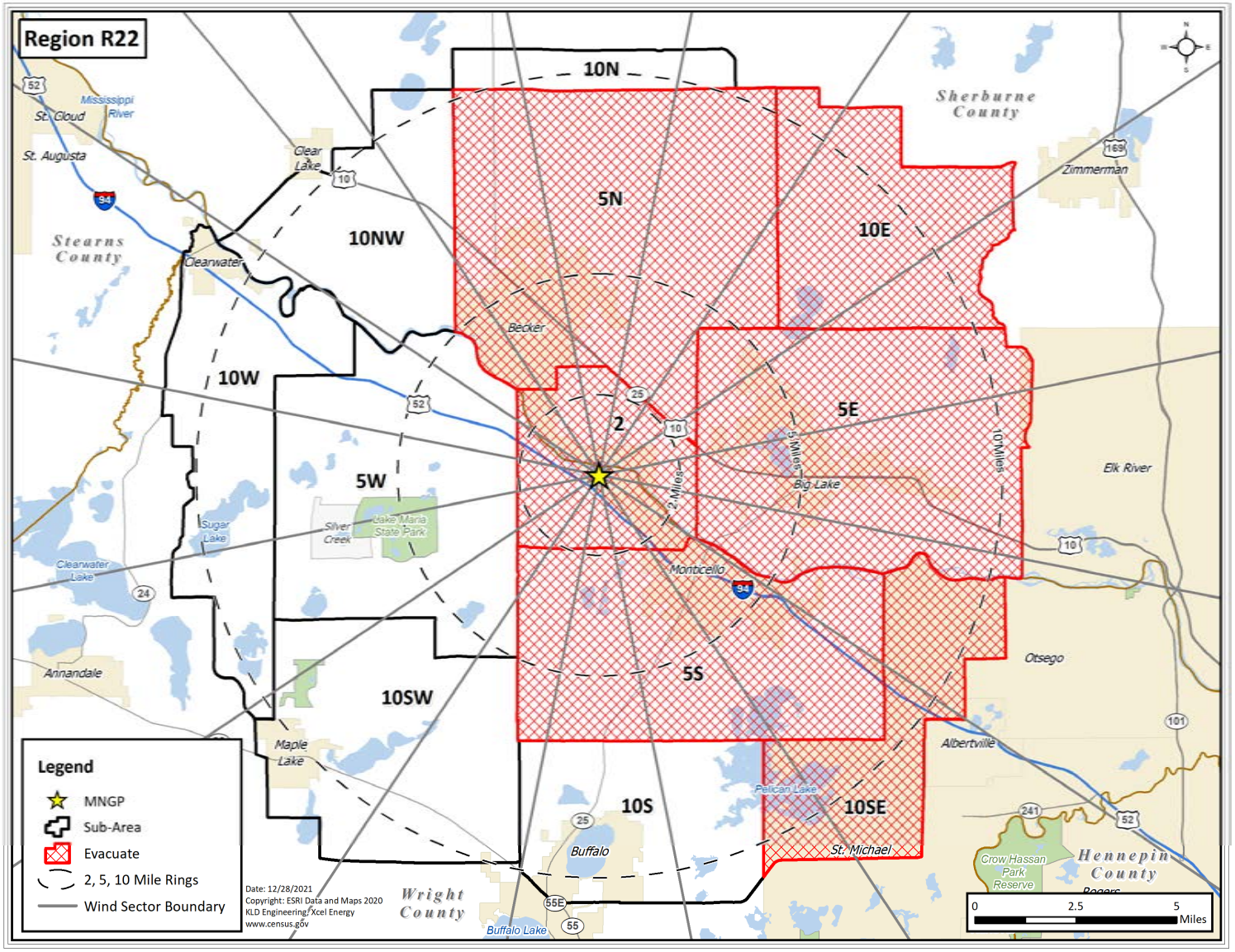


Figure H-22. Region R22

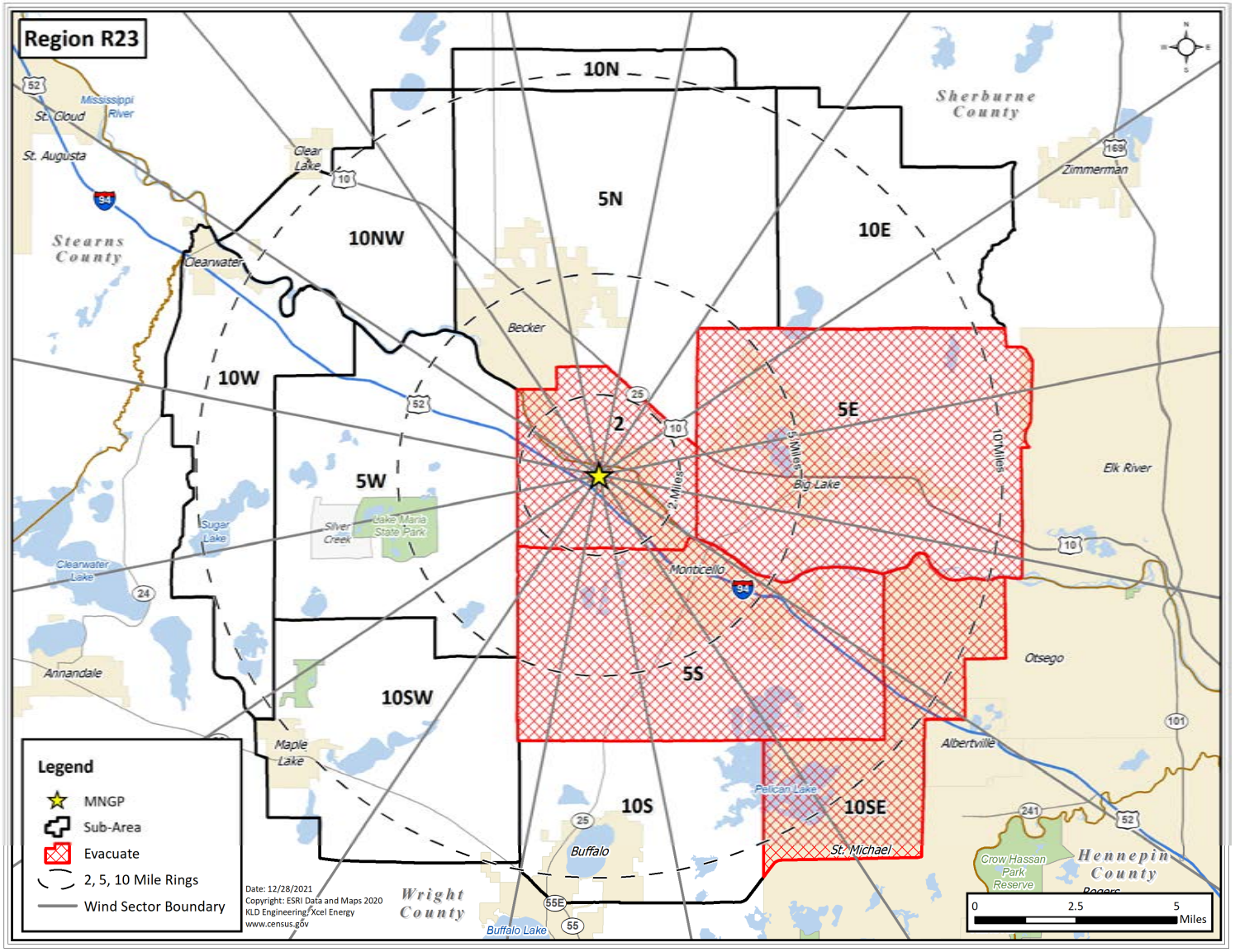


Figure H-23. Region R23

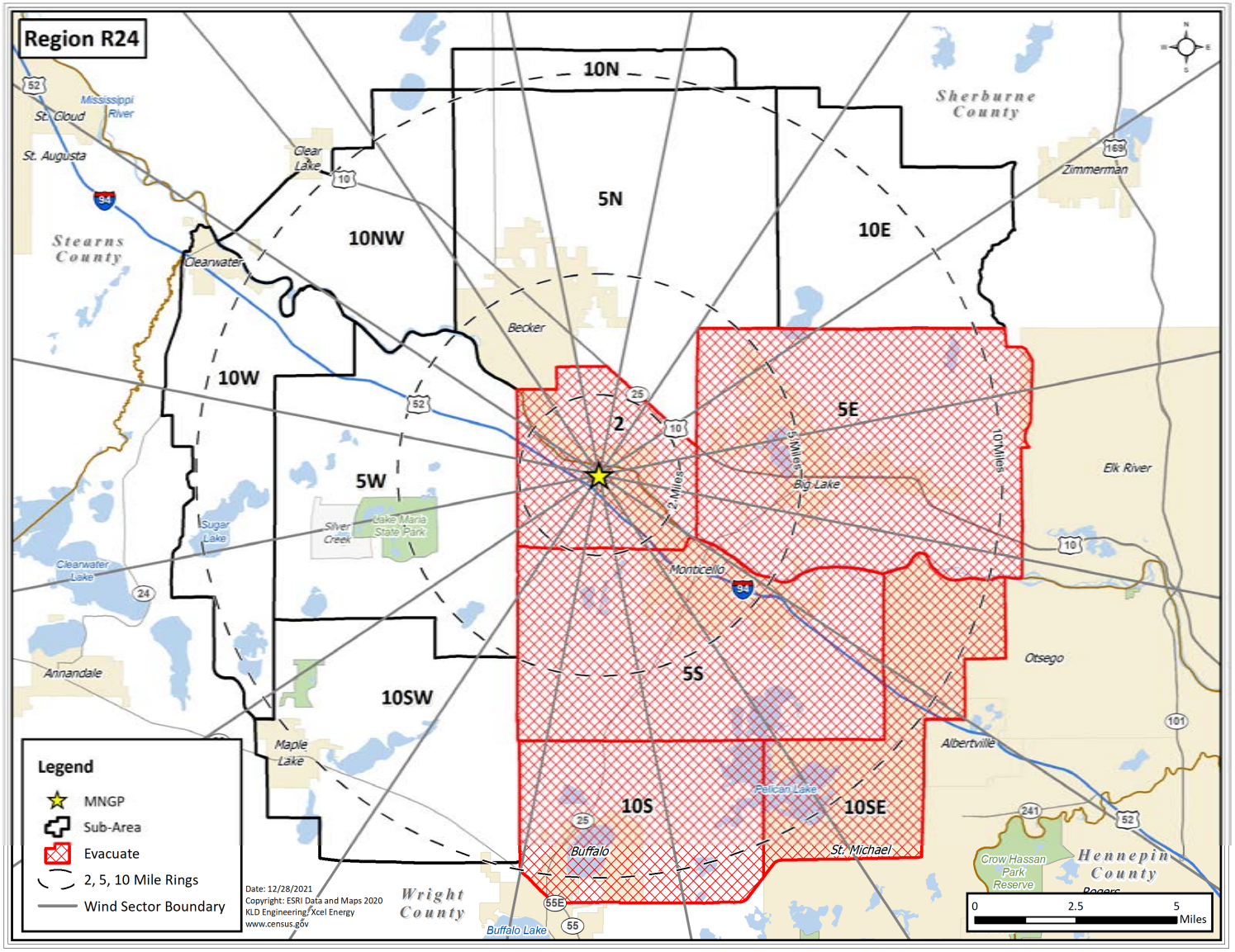


Figure H-24. Region R24

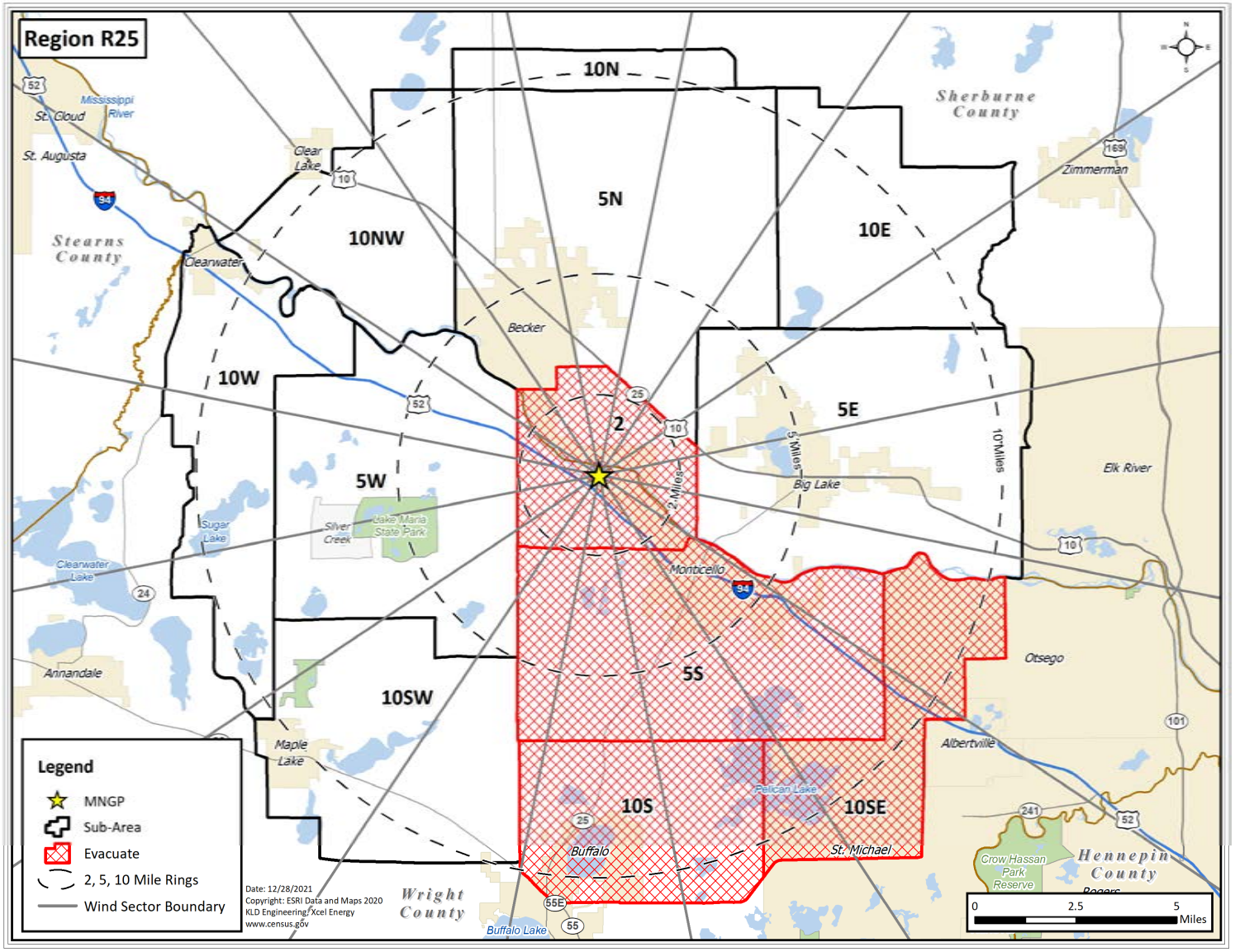


Figure H-25. Region R25

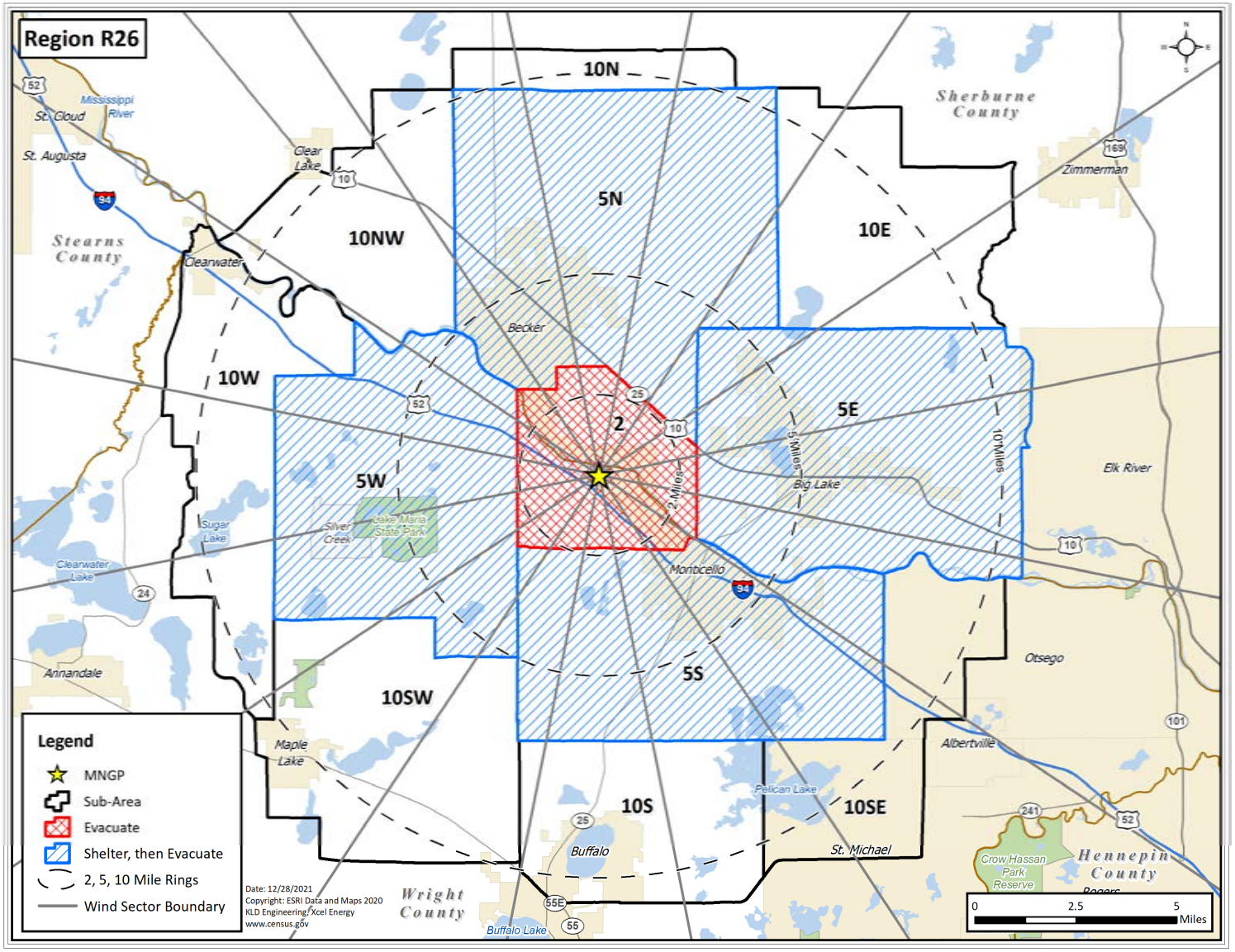


Figure H-26. Region R26

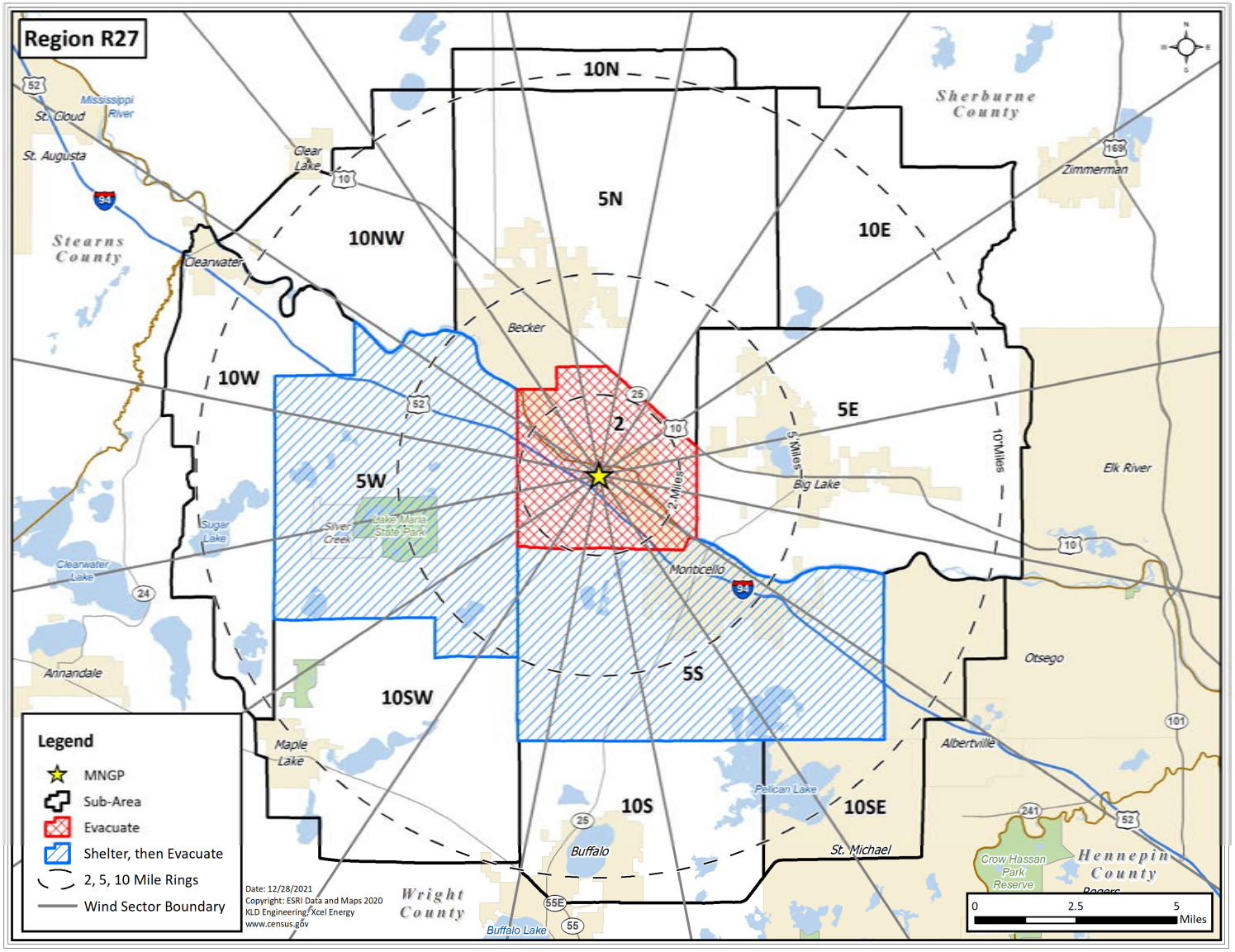


Figure H-27. Region R27

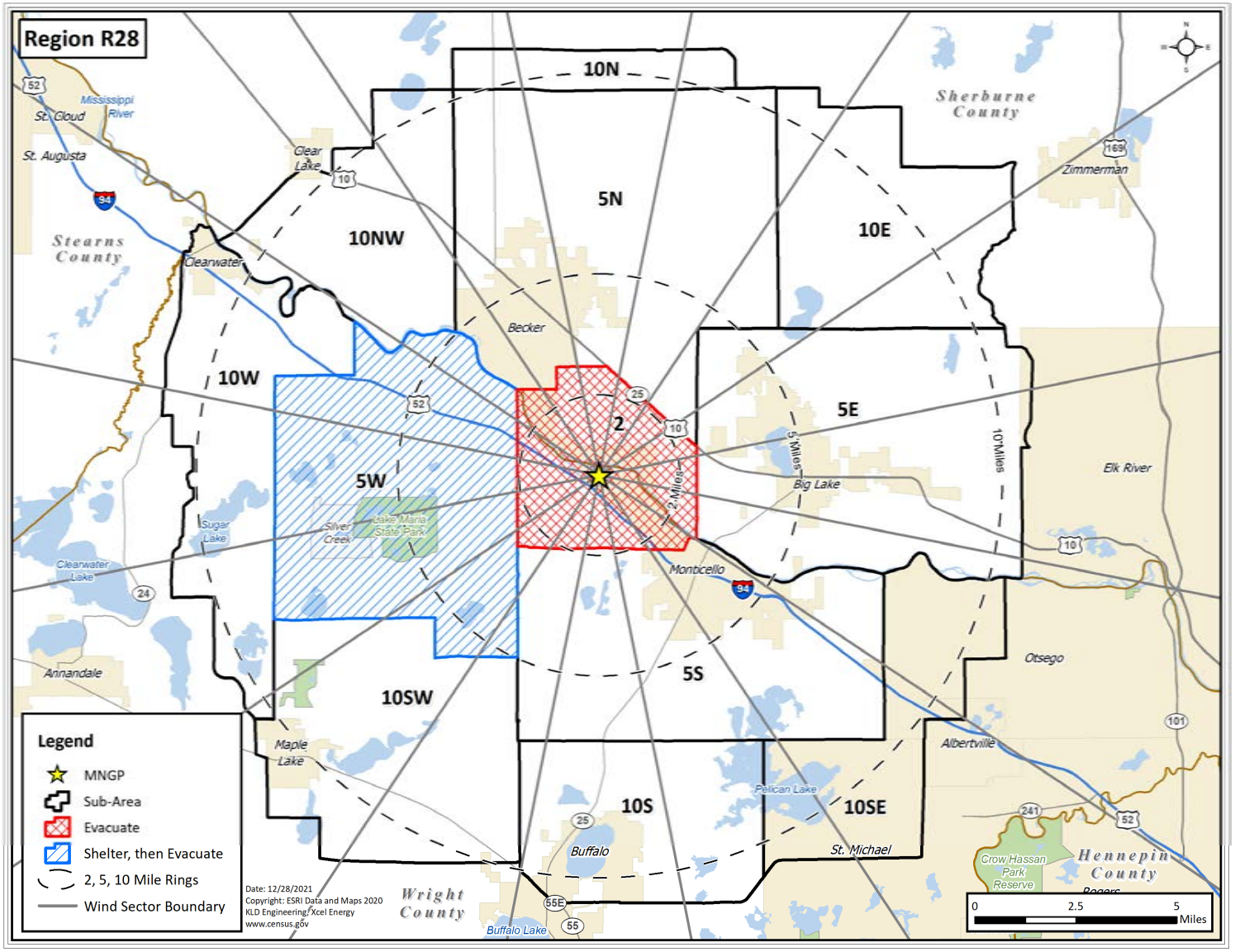


Figure H-28. Region R28

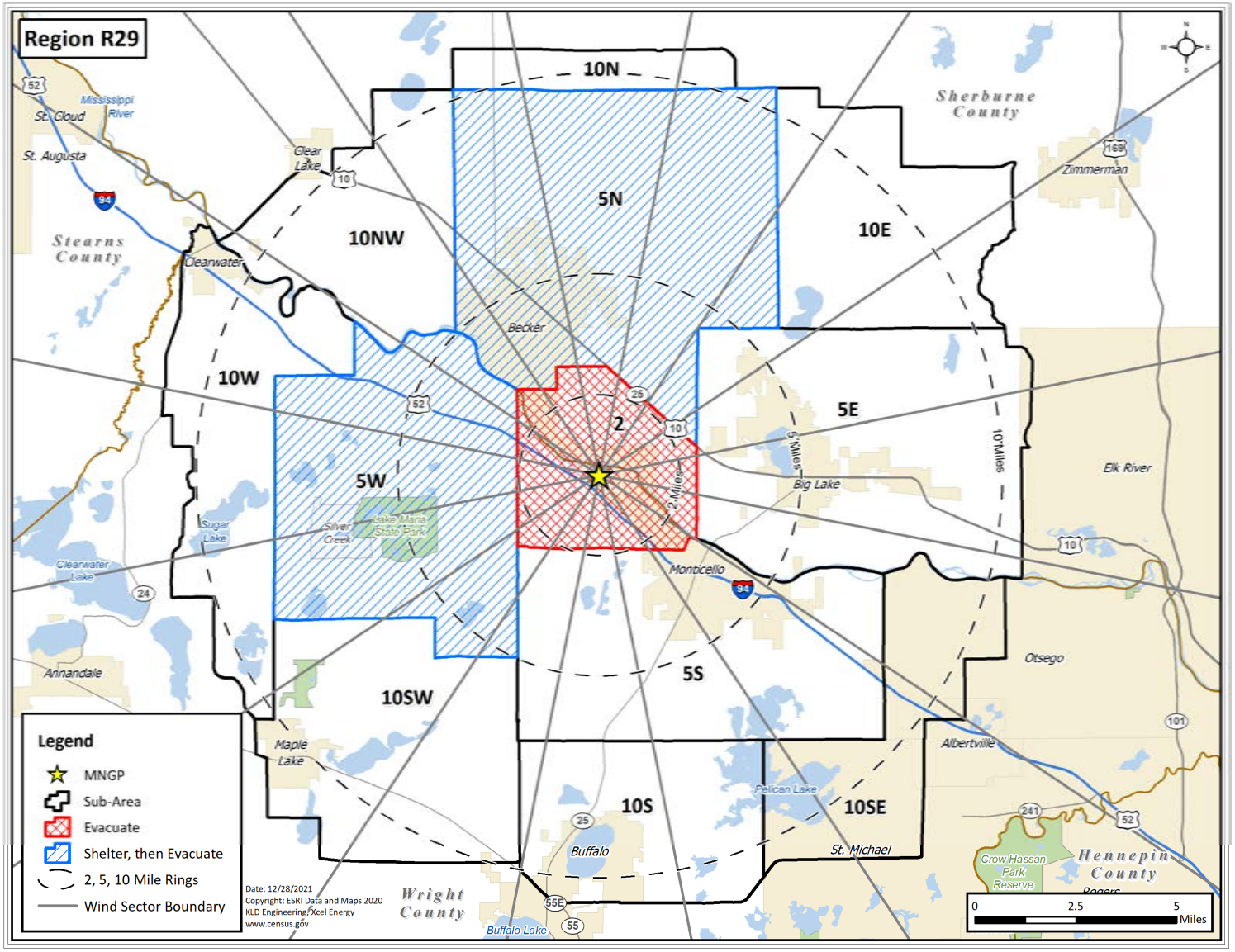


Figure H-29. Region R29

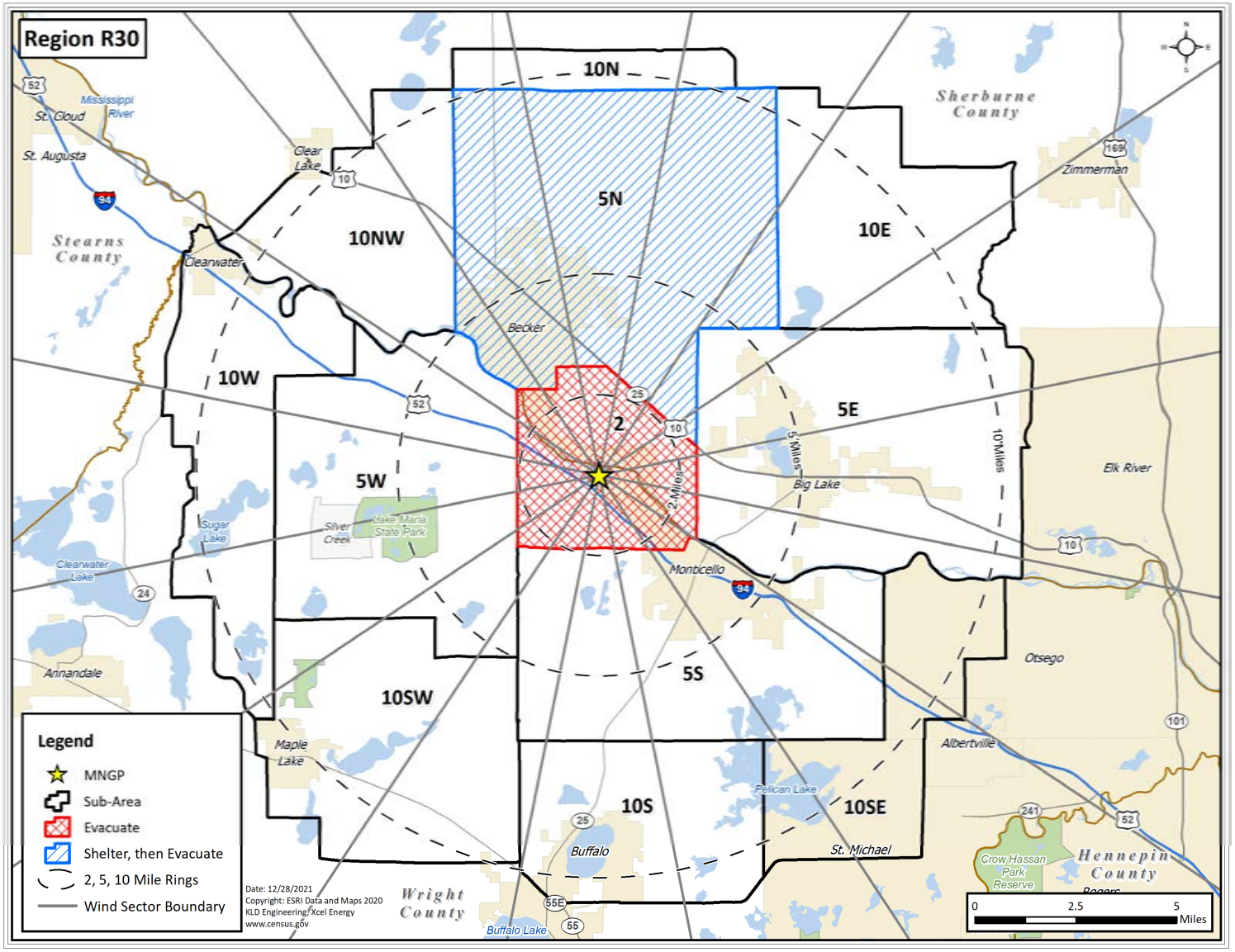


Figure H-30. Region R30

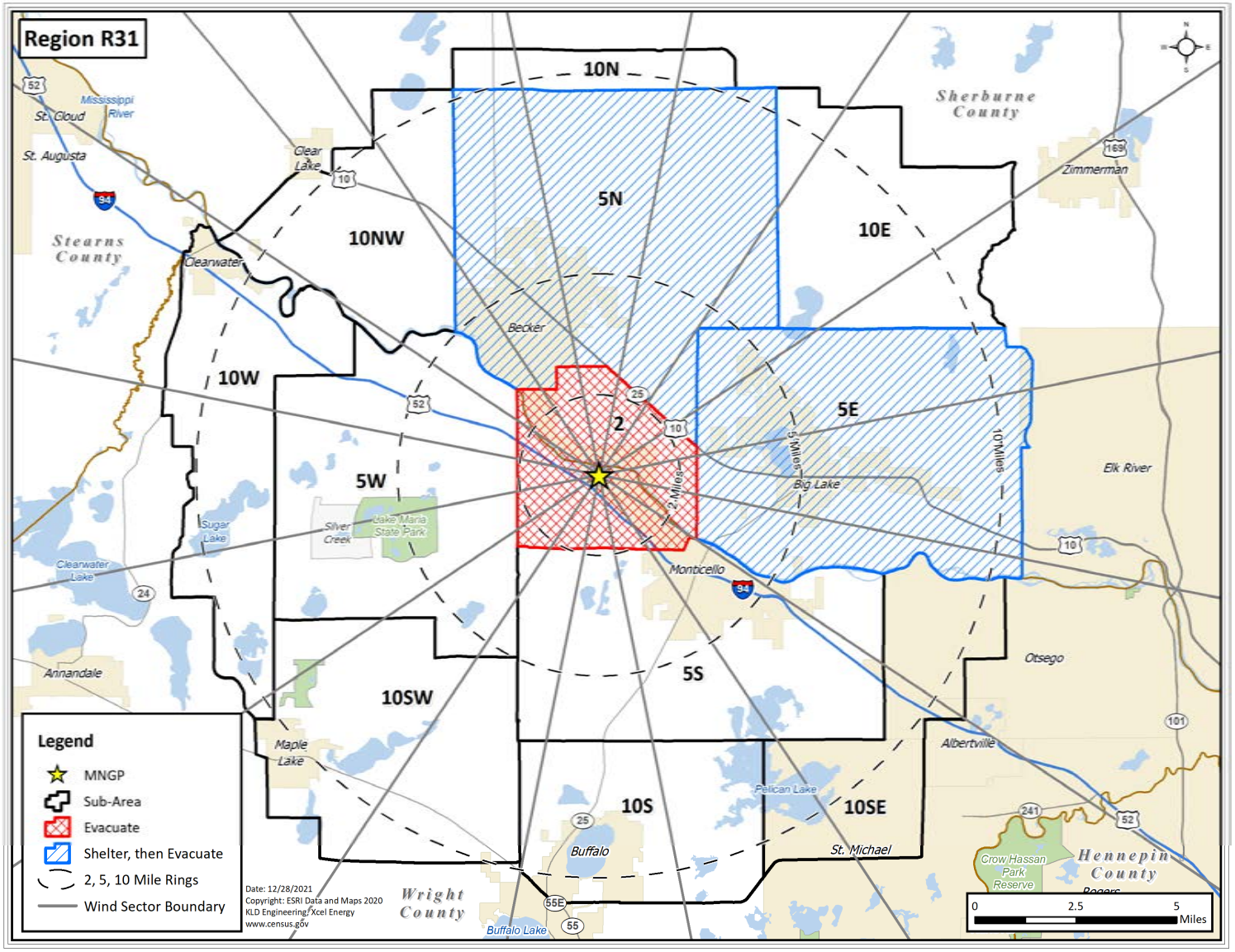


Figure H-31. Region R31

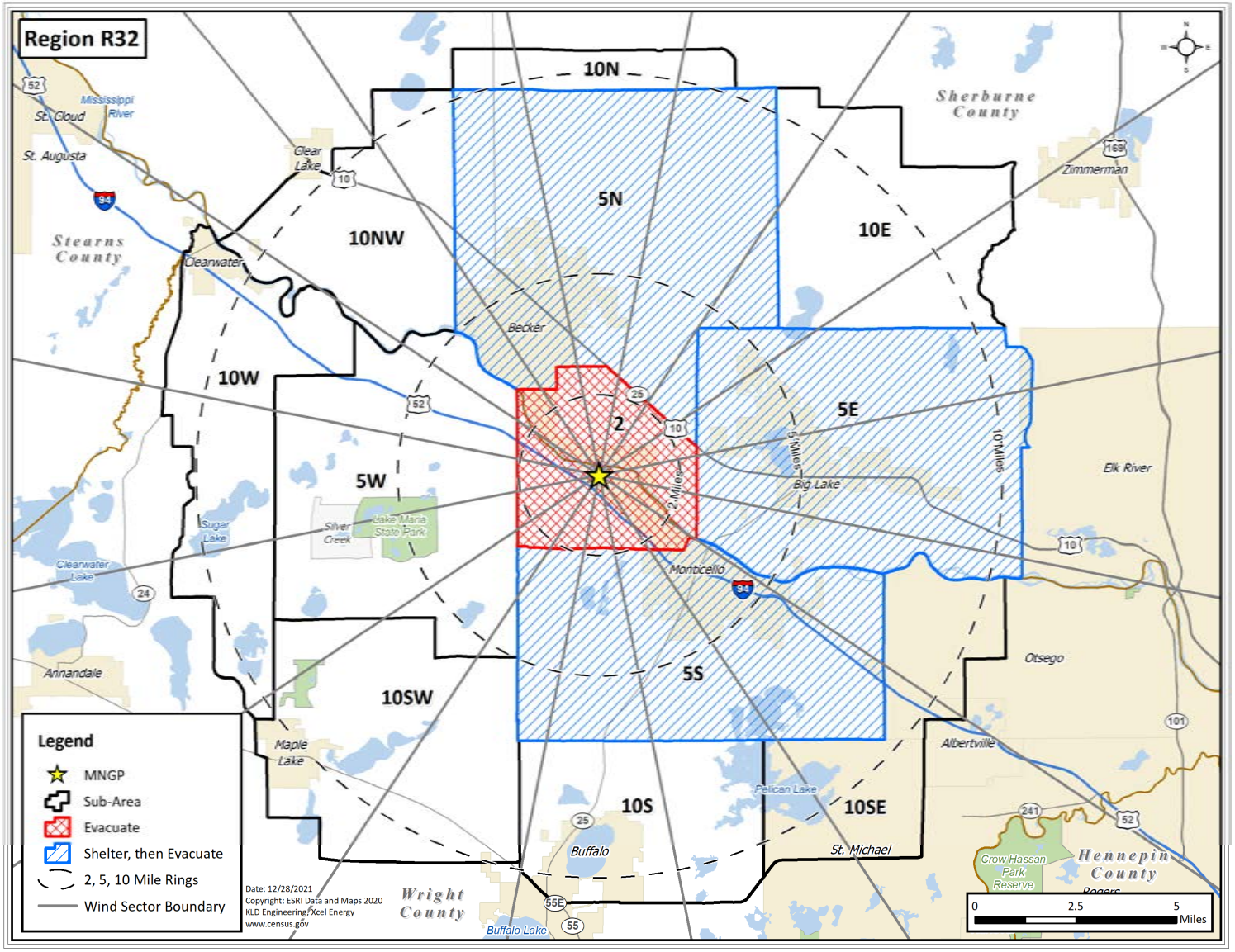


Figure H-32. Region R32

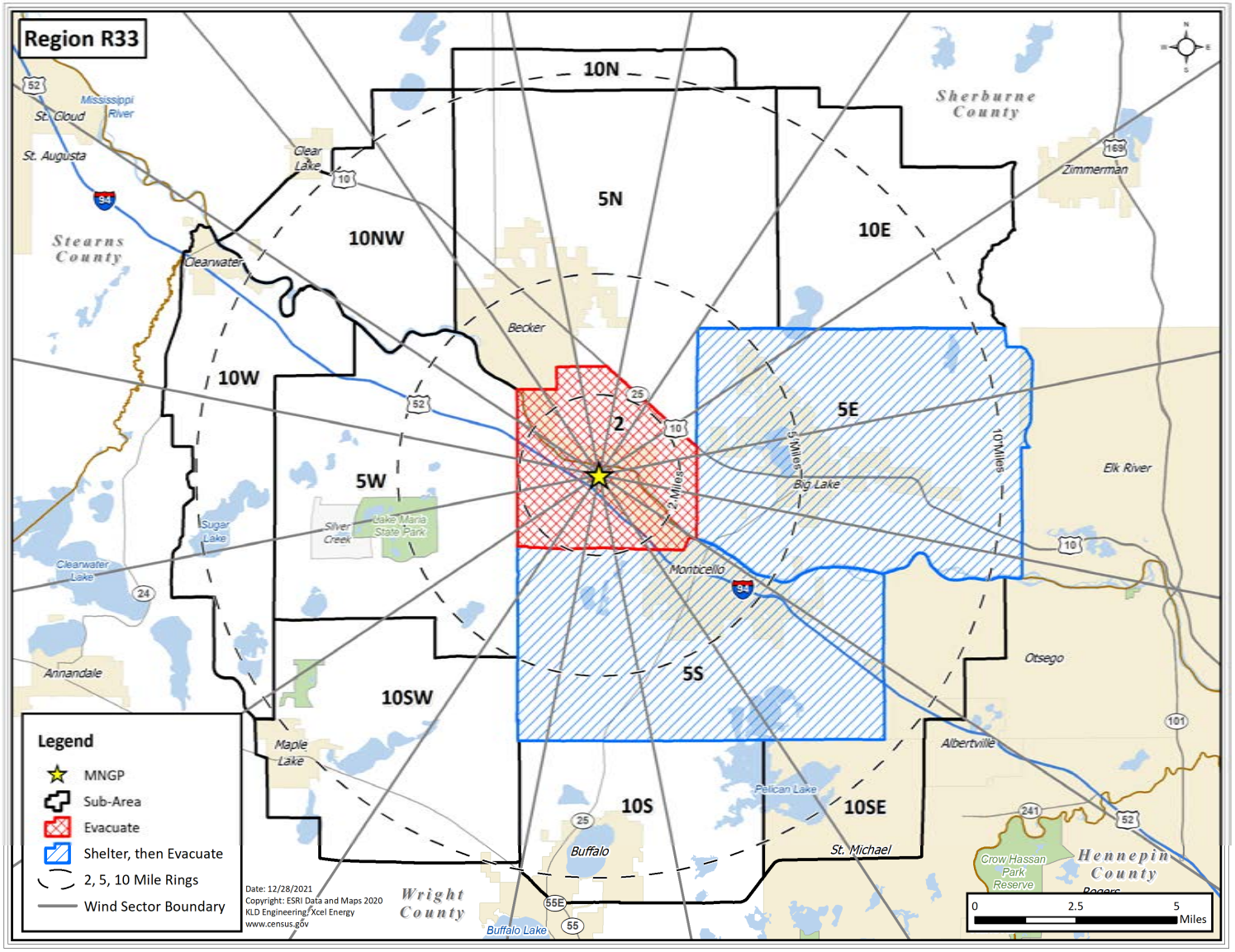


Figure H-33. Region R33

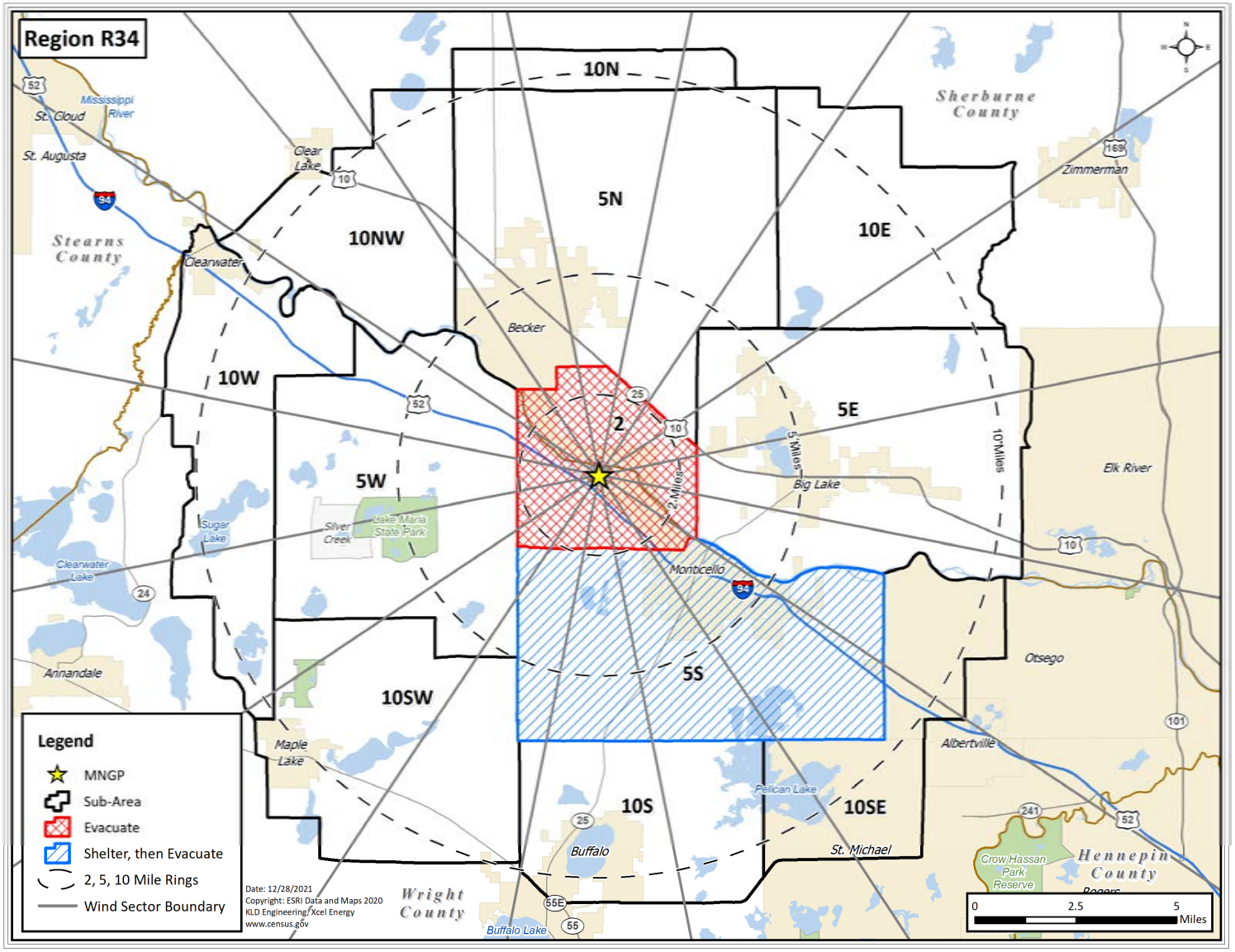


Figure H-34. Region R34

APPENDIX J

Representative Inputs to and Outputs from the DYNEV II System

J. REPRESENTATIVE INPUTS TO AND OUTPUTS FROM THE DYNEV II SYSTEM

This appendix presents data input to and output from the DYNEV II System.

Table J-1 provides source (vehicle loading) and destination information for several roadway segments (links) in the analysis network. In total, there are a total of 400 source links (origins) in the model. The source links are shown as centroid points in Figure J-1. On average, evacuees travel a straight-line distance of 5.1 miles to exit the network.

Table J-2 provides network–wide statistics (average travel time, average delay time[1], average speed and number of vehicles) for an evacuation of the entire EPZ (Region R03) for each scenario. Adverse weather scenarios (Scenarios 2, 4, 7, 8, 10, and 11) exhibit slower average speeds, higher delays, and longer average travel times than comparable good weather scenarios. When comparing Scenario 13 (special event) and Scenario 3, the additional vehicles from the special event lower the average speeds, cause longer delays and increase the travel time. When comparing Scenario 14 (roadway closure) and Scenario 1, the lane closure on I-94 eastbound lowers the average speeds, causes higher delays and increases the travel time.

Table J-3 provided statistics (average speed and travel time) for the major evacuation routes – US-10, I-94, SR-24, SR-55, SR-25, US-169, SR-101, CR-5, and CR-11 – for an evacuation of the entire EPZ (Region R03) under Scenario 1 conditions. As discussed in Section 7.3 and shown in Figures 7-3 through 7-9, US-10 eastbound, I-94 eastbound, and SR-101 southbound experience significant congestion for the majority of the evacuation. As such, the average speeds are comparably slower (and travel times longer) on these roads traveling in these directions than other major evacuation routes.

Table J-4 provides the number of vehicles discharged and the cumulative percent of total vehicles discharged for each link exiting the analysis network for an evacuation of the entire EPZ (Region R03) under Scenario 1 conditions. Refer to the figures in Appendix K for maps showing the geographic location of each link.

Figure J-2 through Figure J-15 plot the trip generation time versus the ETE for each of the 14 Scenarios considered. The distance between the trip generation and ETE curves is the travel time. Plots of trip generation versus ETE are indicative of the level of traffic congestion during evacuation. For low population density sites, the curves are close together, indicating short travel times and minimal traffic congestion. For higher population density sites, the curves are farther apart indicating longer travel times and the presence of traffic congestion. As seen in Figure J-2 through Figure J-15, the curves are spatially separated as a result of the traffic congestion in the EPZ, specifically near the town of Big Lake and on I-94 and US-10, which was discussed in detail in Section 7.3.

[1] Computed as the difference of the average travel time and the average ideal travel time under free flow conditions.

Table J-1. Sample Simulation Model Input

Link Number	Upstream Node	Downstream Node	Vehicles Entering Network on this Link	Directional Preference	Destination Nodes	Destination Capacity
316	198	199	103	E	8045	6,750
					8166	3,800
					8230	3,800
576	370	382	41	SE	8045	6,750
788	538	539	86	W	8412	1,700
1051	758	751	24	E	8230	3,800
					8045	6,750
					8166	3,800
1256	931	930	91	N	8302	1,700
					8873	1,700
					8312	1,700
1343	1006	753	217	E	8045	6,750
					8166	3,800
					8230	3,800
1465	1129	1130	70	NE	8739	3,800
					8302	1,700
1638	1276	348	179	SE	8045	6,750
1697	1328	1071	301	NE	8739	3,800
					8302	1,700

Table J-2. Selected Model Outputs for the Evacuation of the Entire EPZ (Region R03)

Scenario	1	2	3	4	5	6	7
Network-Wide Average Travel Time (Min/Veh-Mi)	2.0	2.3	2.3	2.6	2.3	2.0	2.4
Network-Wide Delay Time (Min/Veh-Mi)	0.9	1.3	1.2	1.5	1.2	1.0	1.3
Network-Wide Average Speed (mph)	30.6	26.2	26.7	23.5	26.4	30.0	25.5
Total Vehicles Exiting Network	75,240	75,213	74,861	74,918	64,918	75,417	75,388
Scenario	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Network-Wide Average Travel Time (Min/Veh-Mi)	2.5	2.2	2.5	2.6	2.3	2.3	2.5
Network-Wide Delay Time (Min/Veh-Mi)	1.4	1.2	1.5	1.6	1.3	1.3	1.5
Network-Wide Average Speed (mph)	24.4	27.1	23.8	22.7	26.2	25.7	23.8
Total Vehicles Exiting Network	75,367	74,185	74,158	74,135	64,623	77,288	75,158

Table J-3. Average Speed (mph) and Travel Time (min) for Major Evacuation Routes (Region R03, Scenario 1)

Route Name	Length (miles)	Elapsed Time (hours)									
		1:00		2:00		3:00		4:00		4:40	
		Speed (mph)	Travel Time (min)	Speed	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed	Travel Time
US-10 Eastbound	13.5	29.2	27.7	11.3	72.1	23.6	34.3	59.3	13.7	64.5	12.6
US-10 Westbound	12.4	64.0	11.6	64.4	11.6	68.7	10.8	68.7	10.8	69.7	10.7
I-94 Eastbound	16.8	63.6	15.9	38.5	26.2	54.6	18.5	75.0	13.5	64.5	15.6
I-94 Westbound	16.7	73.5	13.6	73.4	13.7	75.0	13.4	75.0	13.4	75.0	13.4
SR-24 Southbound	12.4	56.1	13.2	56.5	13.1	57.9	12.8	58.0	12.8	59.3	12.5
SR-55 Eastbound	6.9	54.9	7.6	55.2	7.5	56.4	7.4	56.4	7.4	58.4	7.1
SR-25 Southbound	8.6	50.8	10.1	50.8	10.1	50.3	10.2	51.2	10.0	56.1	9.1
SR-25 Northbound	6.9	56.5	7.3	55.6	7.5	62.1	6.7	63.3	6.6	64.8	6.4
US-169 Northbound	8.8	66.7	7.9	65.7	8.0	67.1	7.9	67.5	7.8	70.0	7.5
US-169 Southbound	3.4	47.3	4.3	47.4	4.3	47.3	4.3	53.0	3.8	66.1	3.1
SR-101 Southbound	6.6	67.2	5.9	11.4	34.8	7.0	56.1	10.4	38.0	68.3	5.8
CR-5 Northbound	7.4	58.2	7.6	54.9	8.1	55.7	8.0	57.7	7.7	58.7	7.6
CR-11 Northbound	9.5	57.2	10.0	47.4	12.0	58.5	9.8	58.3	9.8	60.0	9.5

Table J-4. Simulation Model Outputs at Network Exit Links for Region R03, Scenario 1

Network Exit Link	Upstream Node	Downstream Node	Elapsed Time (hours)				
			1:00	2:00	3:00	4:00	4:45
			Cumulative Vehicles Discharged by the Indicated Time				
			Cumulative Percent of Vehicles Discharged by the Indicated Time Interval				
US-10 Westbound	1	658	963	2,498	3,398	3,597	3,625
			8%	7%	6%	5%	5%
I-94 Westbound	4	3	2,517	5,533	7,131	7,246	7,261
			22%	15%	12%	10%	10%
I-94 Eastbound	44	45	3,797	9,784	15,982	20,484	21,989
			33%	26%	27%	28%	29%
CR-7 Northbound	49	1174	26	95	134	149	151
			0%	0%	0%	0%	0%
CR-45 Westbound	86	87	137	573	844	941	957
			1%	2%	1%	1%	1%
SR-25 Southbound	195	196	268	791	1,218	1,776	2,066
			2%	2%	2%	2%	3%
CR-11 Northbound	229	873	252	1,193	1,956	2,169	2,195
			2%	3%	3%	3%	3%
US-10 Eastbound	231	230	1,183	4,183	7,375	9,904	10,098
			10%	11%	12%	14%	13%
CR-5 Northbound	302	1005	260	1,398	2,472	3,208	3,317
			2%	4%	4%	4%	4%
CR-8 Southbound	410	411	55	328	488	555	565
			0%	1%	1%	1%	1%
SR-55 Westbound	413	412	177	1,006	1,585	1,784	1,810
			2%	3%	3%	2%	2%
SR-55 Eastbound	438	439	343	1,892	3,120	3,701	3,796
			3%	5%	5%	5%	5%
CR-35 Westbound	464	518	62	346	506	568	577
			1%	1%	1%	1%	1%
CR-7 Southbound	464	1034	102	555	810	906	921
			1%	1%	1%	1%	1%
CR-12 Southbound	484	485	78	781	1,509	1,963	2,272
			1%	2%	3%	3%	3%
Dempsey Ave Southbound	506	507	58	359	556	644	656
			1%	1%	1%	1%	1%
CR-37 Westbound	527	528	64	355	543	605	611
			1%	1%	1%	1%	1%

Network Exit Link	Upstream Node	Downstream Node	Elapsed Time (hours)				
			1:00	2:00	3:00	4:00	4:45
			Cumulative Vehicles Discharged by the Indicated Time				
			Cumulative Percent of Vehicles Discharged by the Indicated Time Interval				
CR-6 Southbound	656	657	125	632	940	1,051	1,068
			1%	2%	2%	1%	1%
CR-8 Northbound	693	694	46	172	243	268	272
			0%	0%	0%	0%	0%
SR-101 Southbound	1186	1166	116	778	1,449	2,079	2,317
			1%	2%	2%	3%	3%
SR-25 Northbound	1264	1267	325	1,454	2,142	2,358	2,392
			3%	4%	4%	3%	3%
US-169 Northbound	1362	739	434	2,599	4,666	6,072	6,242
			4%	7%	8%	8%	8%

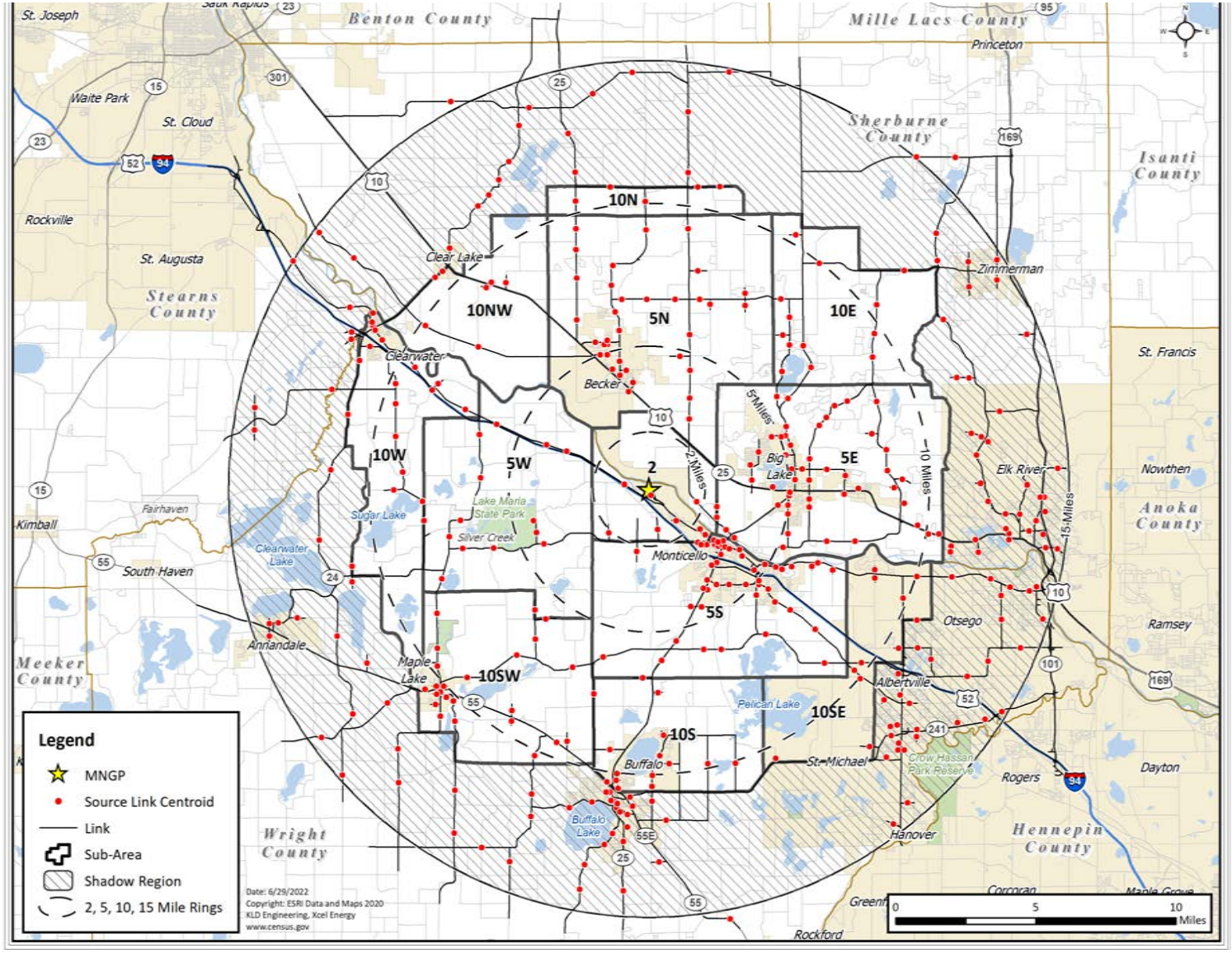


Figure J-1. Network Sources/Origins

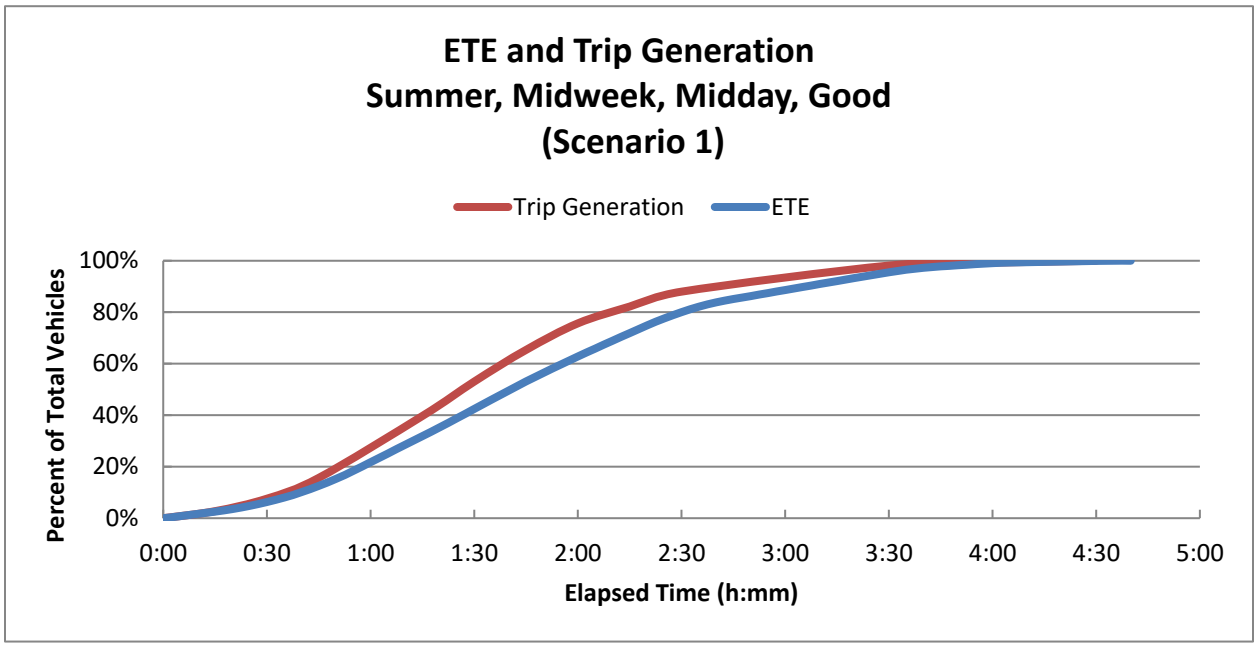


Figure J-2. ETE and Trip Generation: Summer, Midweek, Midday, Good Weather (Scenario 1)

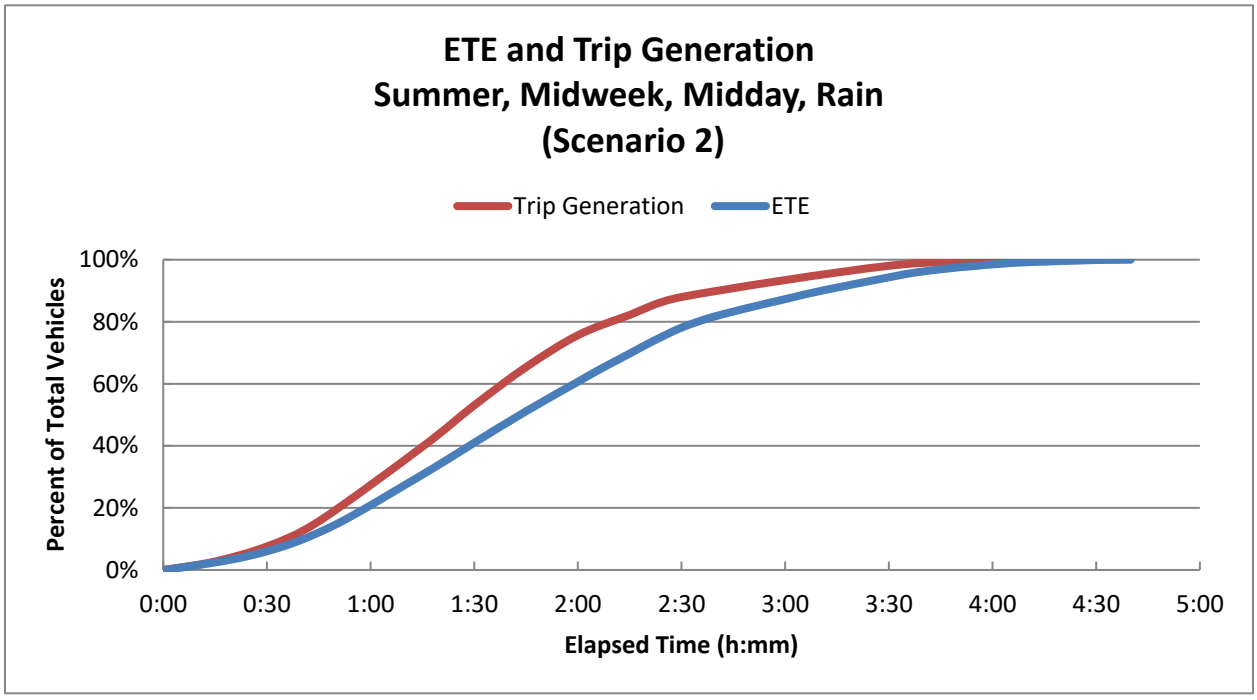


Figure J-3. ETE and Trip Generation: Summer, Midweek, Midday, Rain (Scenario 2)

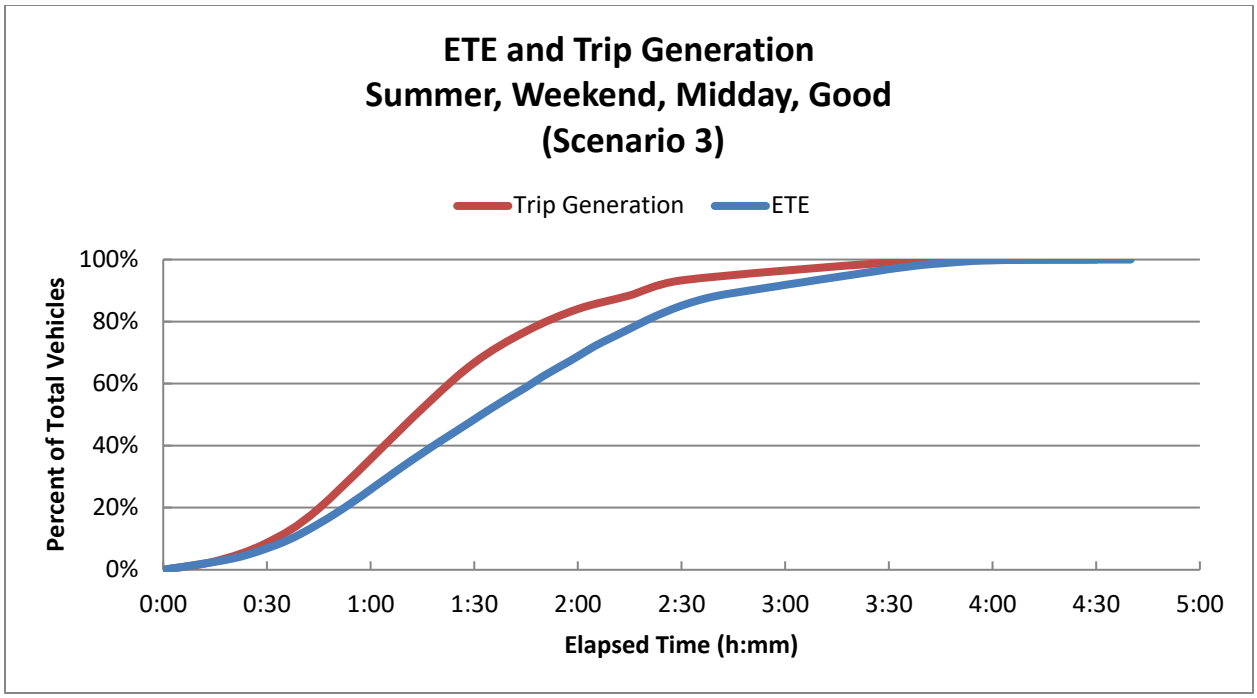


Figure J-4. ETE and Trip Generation: Summer, Weekend, Midday, Good Weather (Scenario 3)

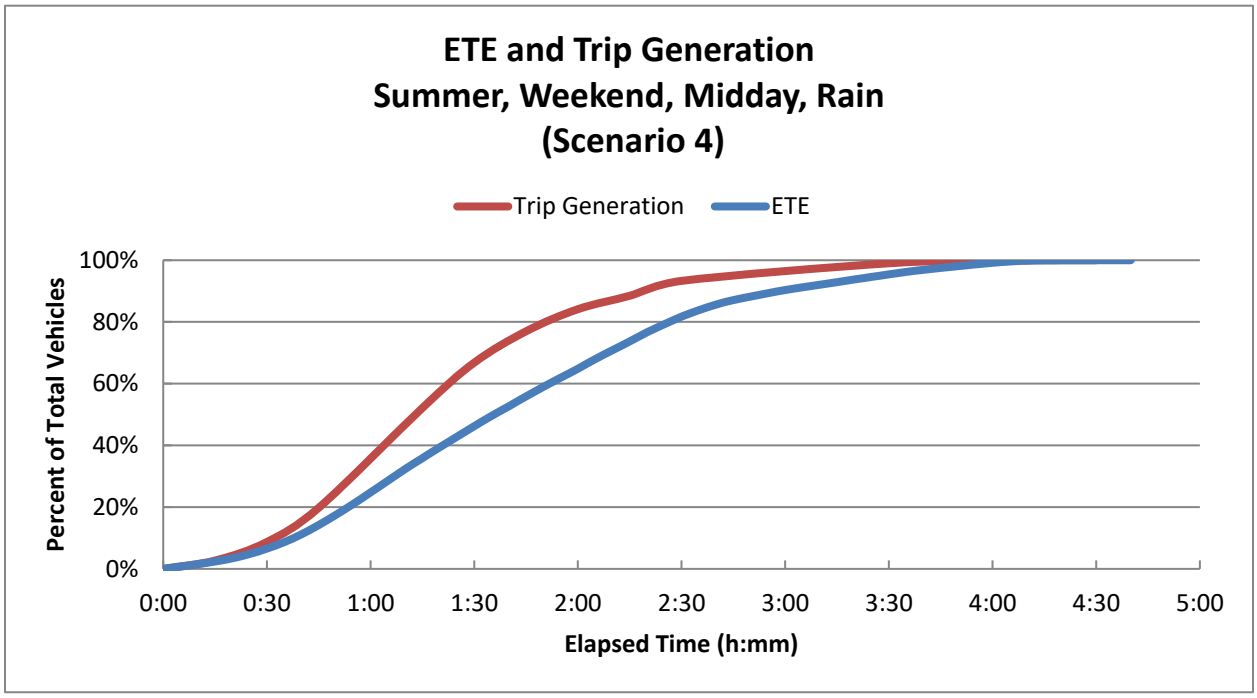


Figure J-5. ETE and Trip Generation: Summer, Weekend, Midday, Rain (Scenario 4)

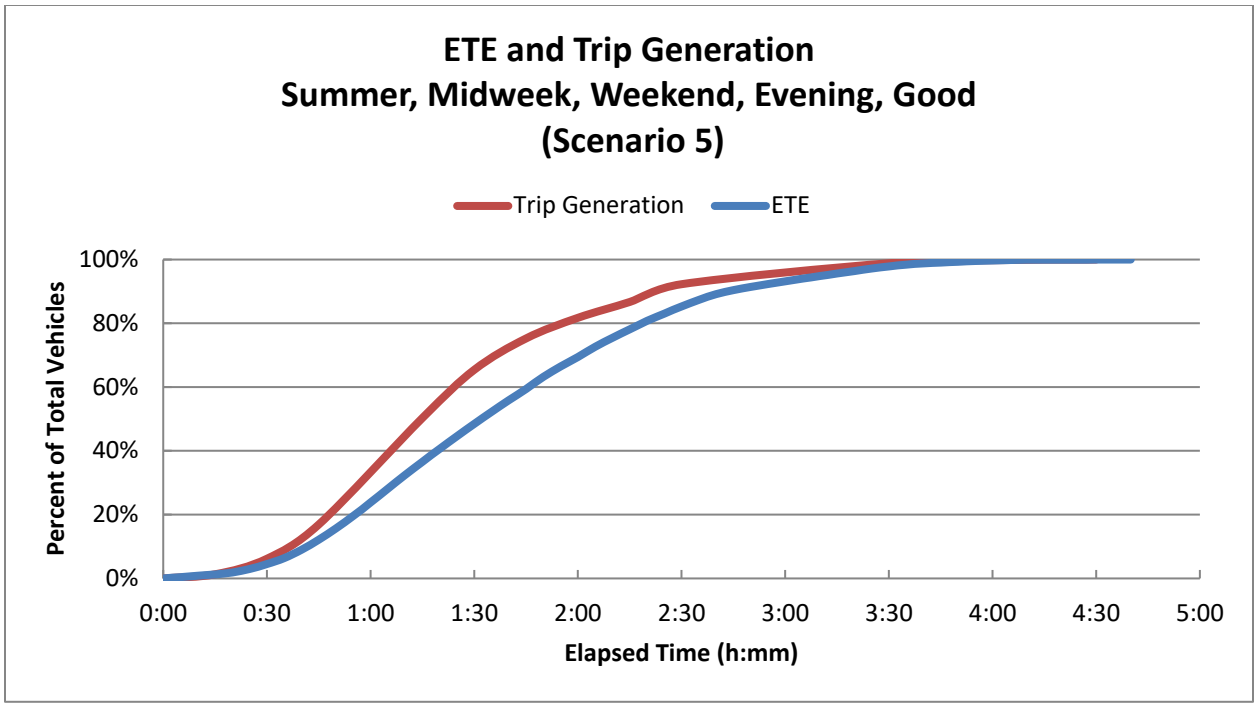


Figure J-6. ETE and Trip Generation: Summer, Midweek, Weekend, Evening, Good Weather (Scenario 5)

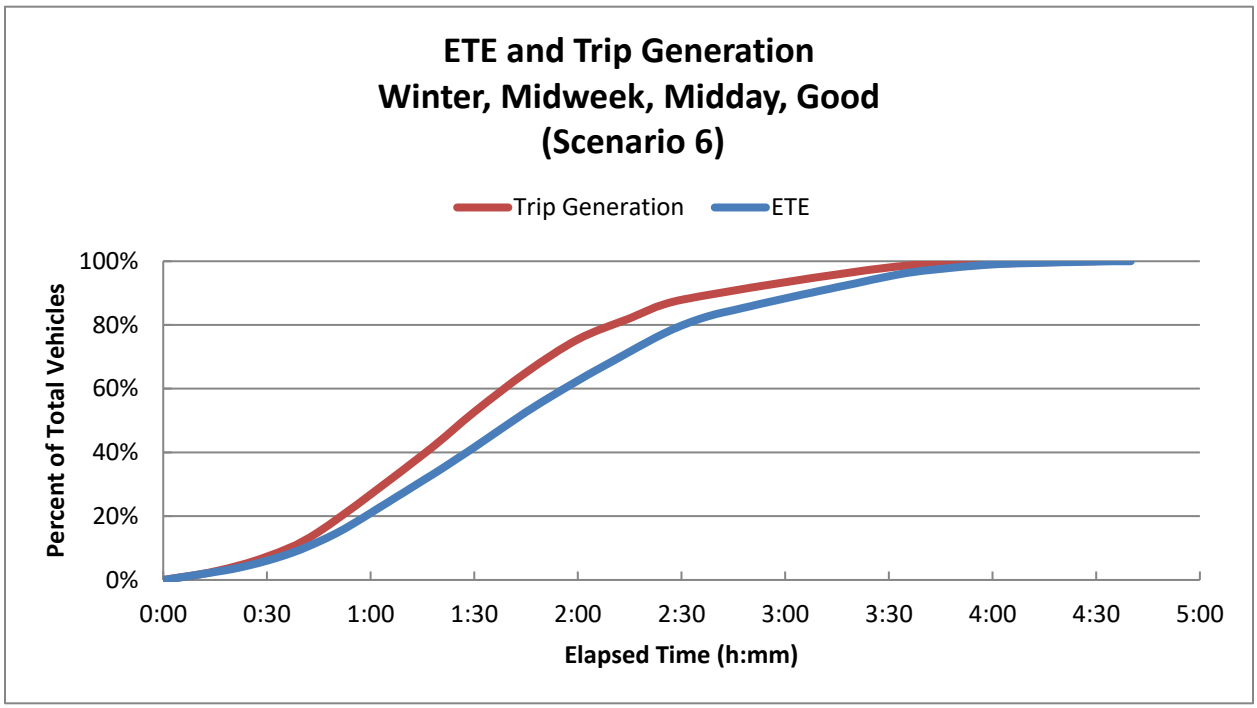


Figure J-7. ETE and Trip Generation: Winter, Midweek, Midday, Good Weather (Scenario 6)

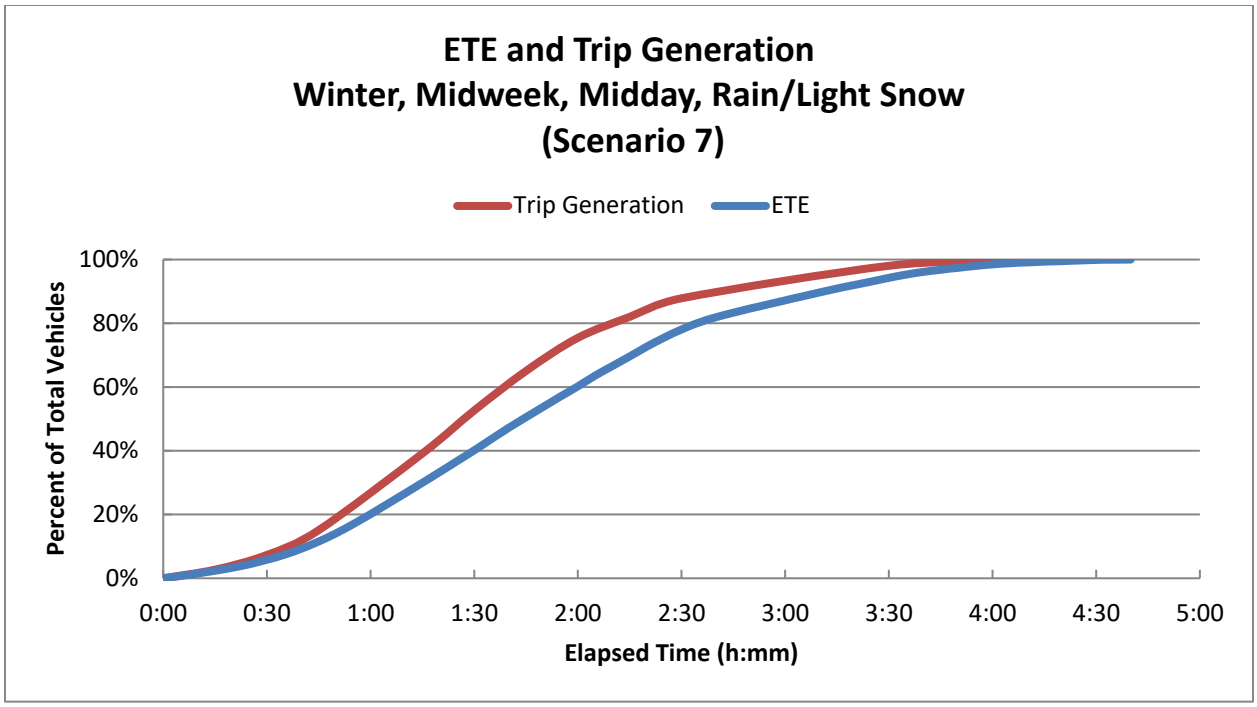


Figure J-8. ETE and Trip Generation: Winter, Midweek, Midday, Rain/Light Snow (Scenario 7)

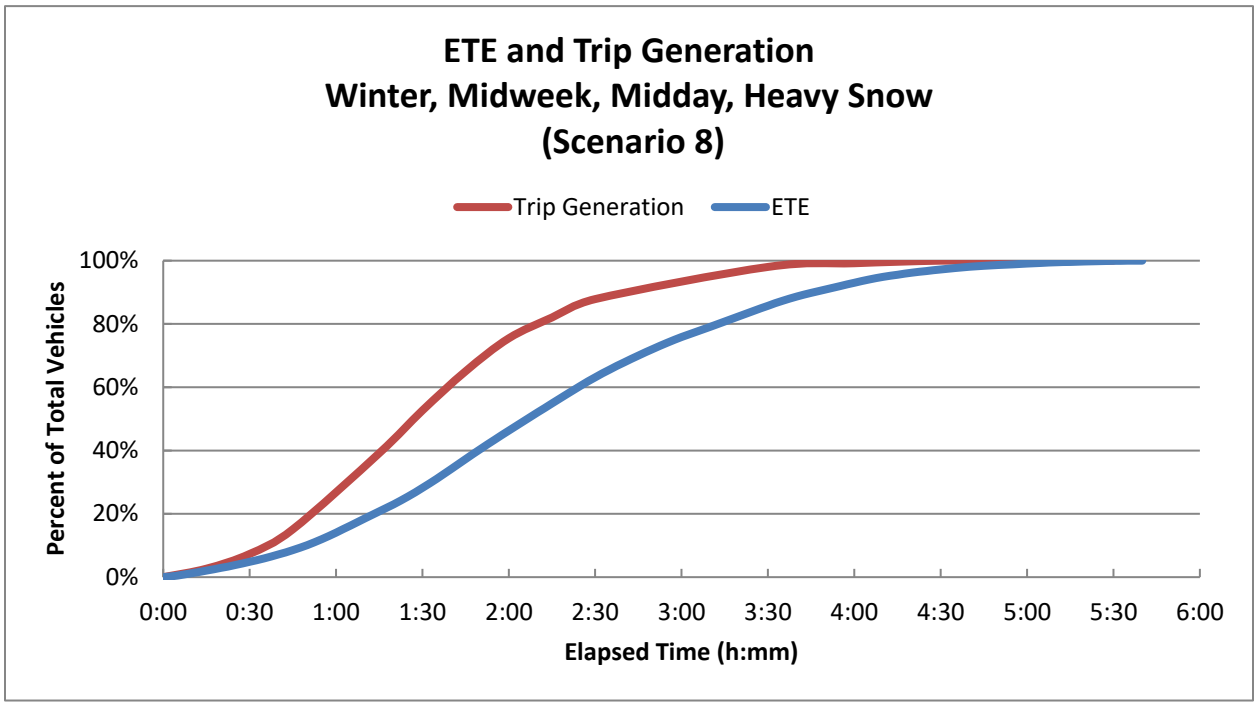


Figure J-9. ETE and Trip Generation: Winter, Midweek, Midday, Heavy Snow (Scenario 8)

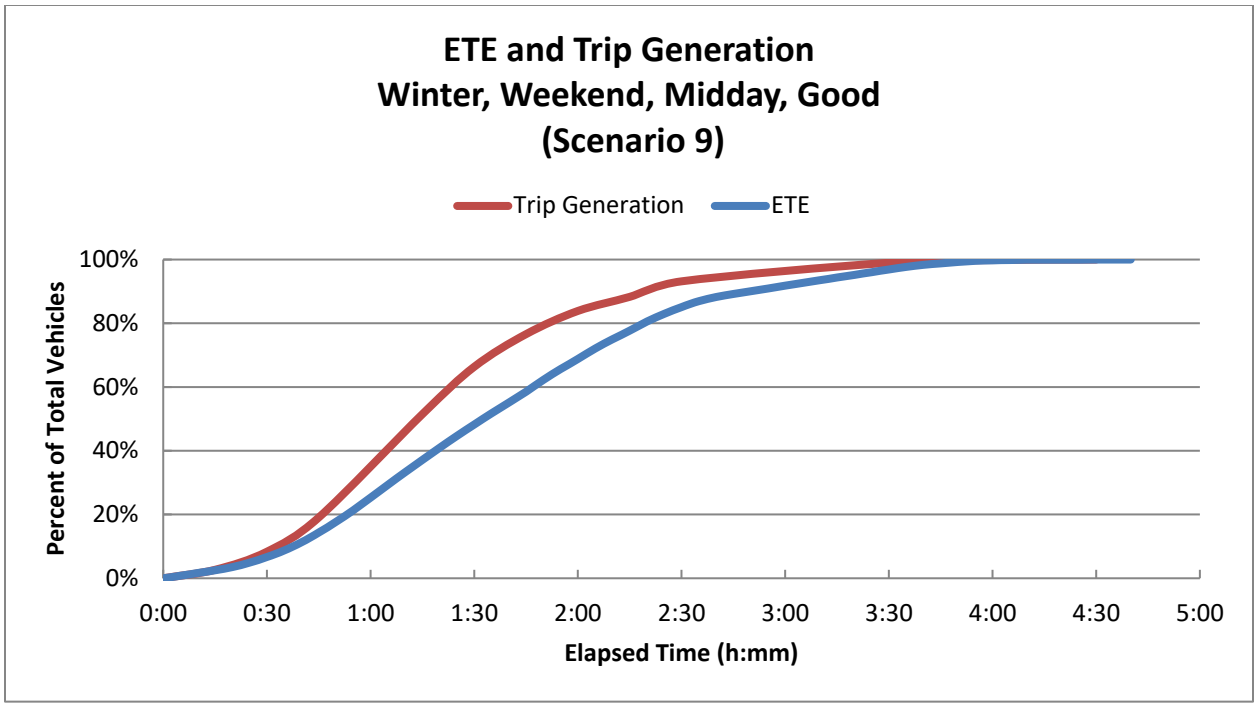


Figure J-10. ETE and Trip Generation: Winter, Weekend, Midday, Good Weather (Scenario 9)

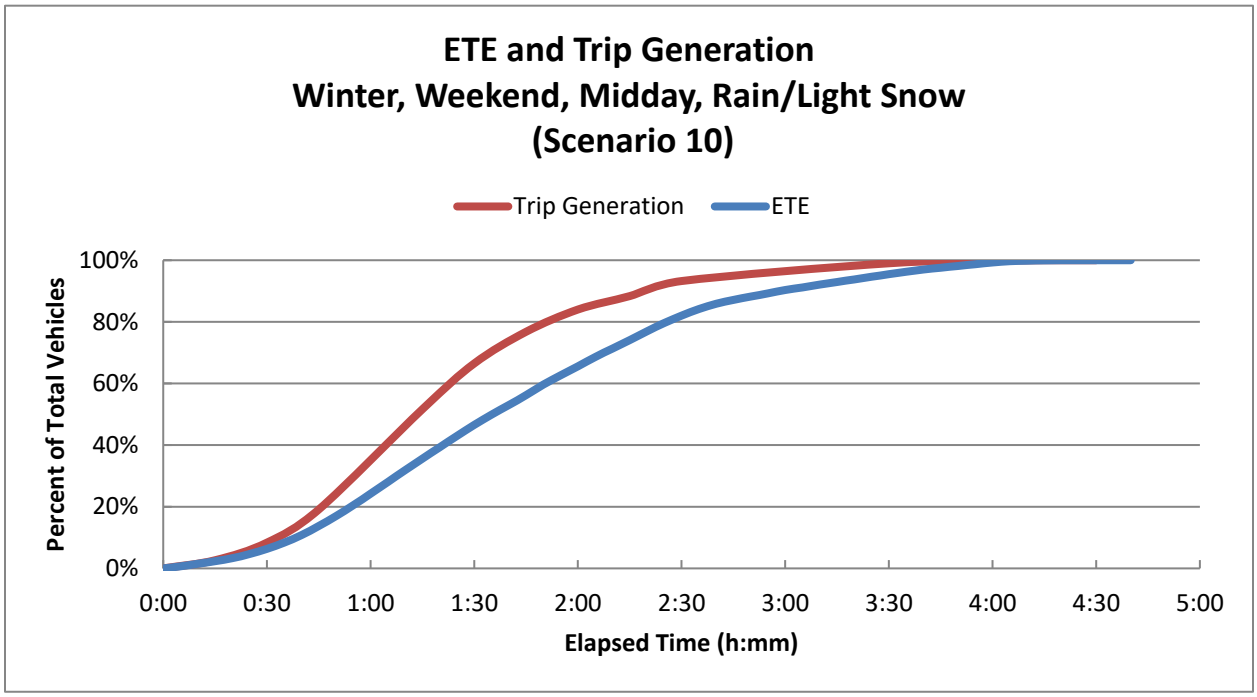


Figure J-11. ETE and Trip Generation: Winter, Weekend, Midday, Rain/Light Snow (Scenario 10)

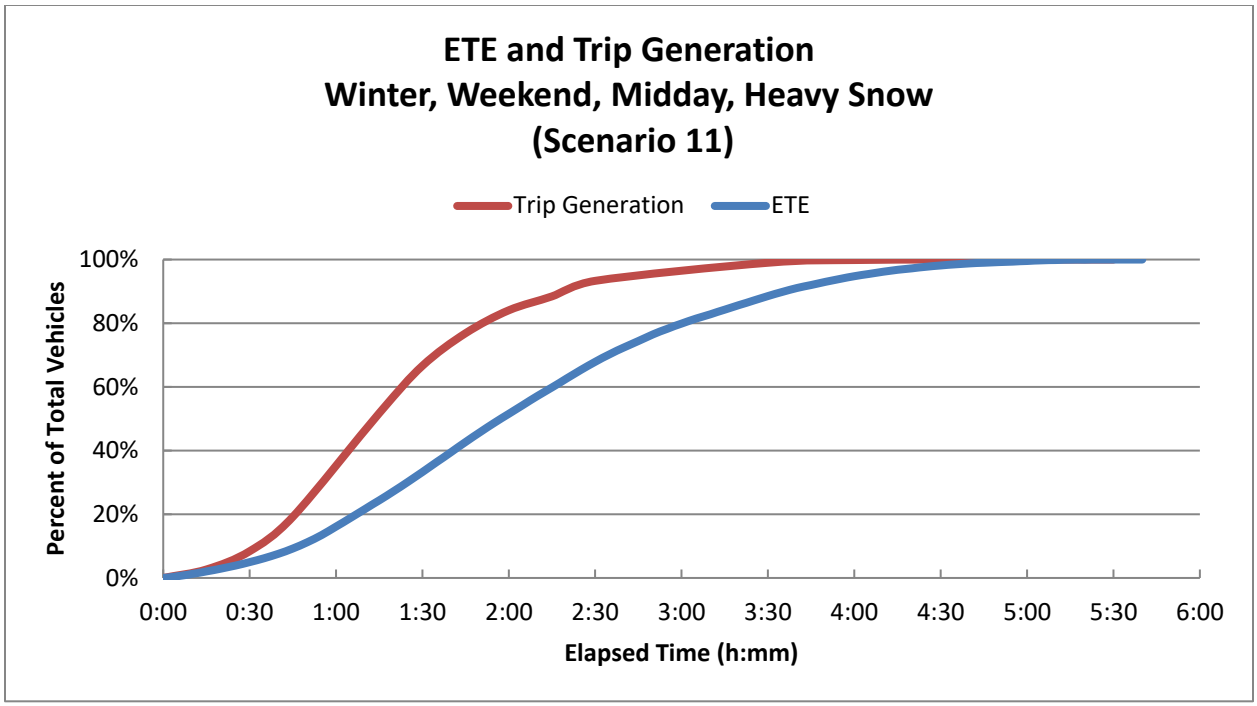


Figure J-12. ETE and Trip Generation: Winter, Weekend, Midday, Heavy Snow (Scenario 11)

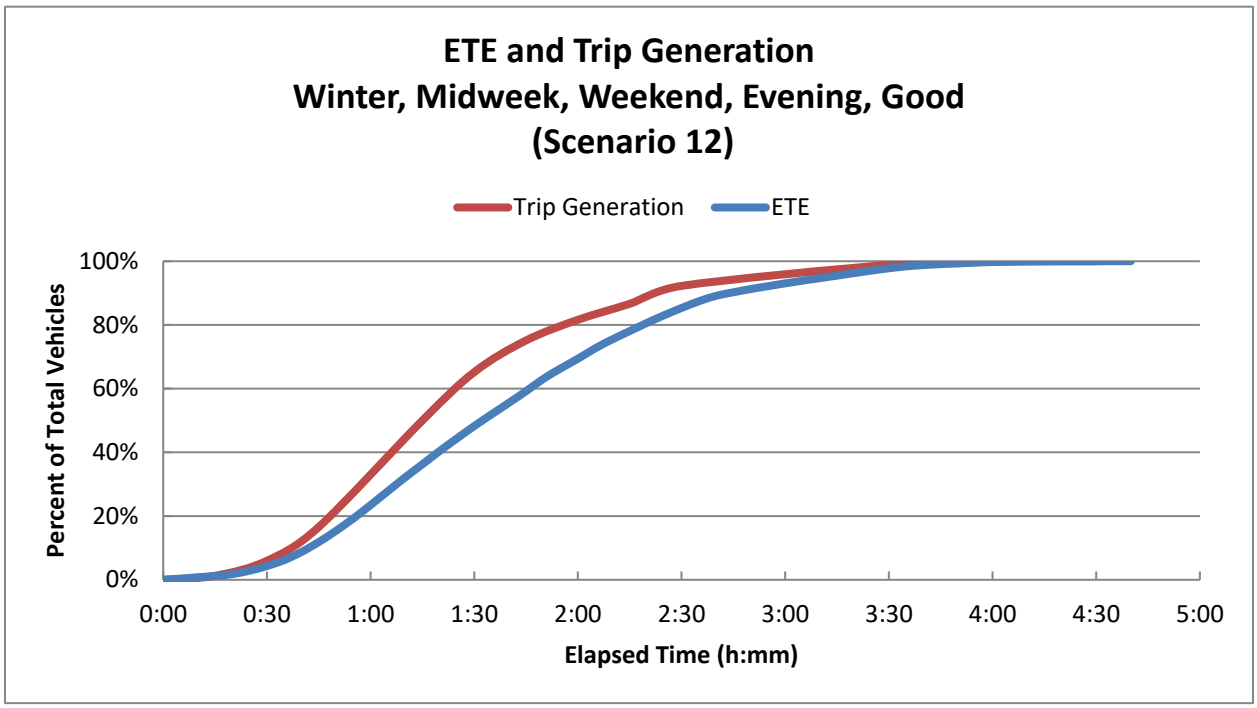


Figure J-13. ETE and Trip Generation: Winter, Midweek, Weekend, Evening, Good Weather (Scenario 12)

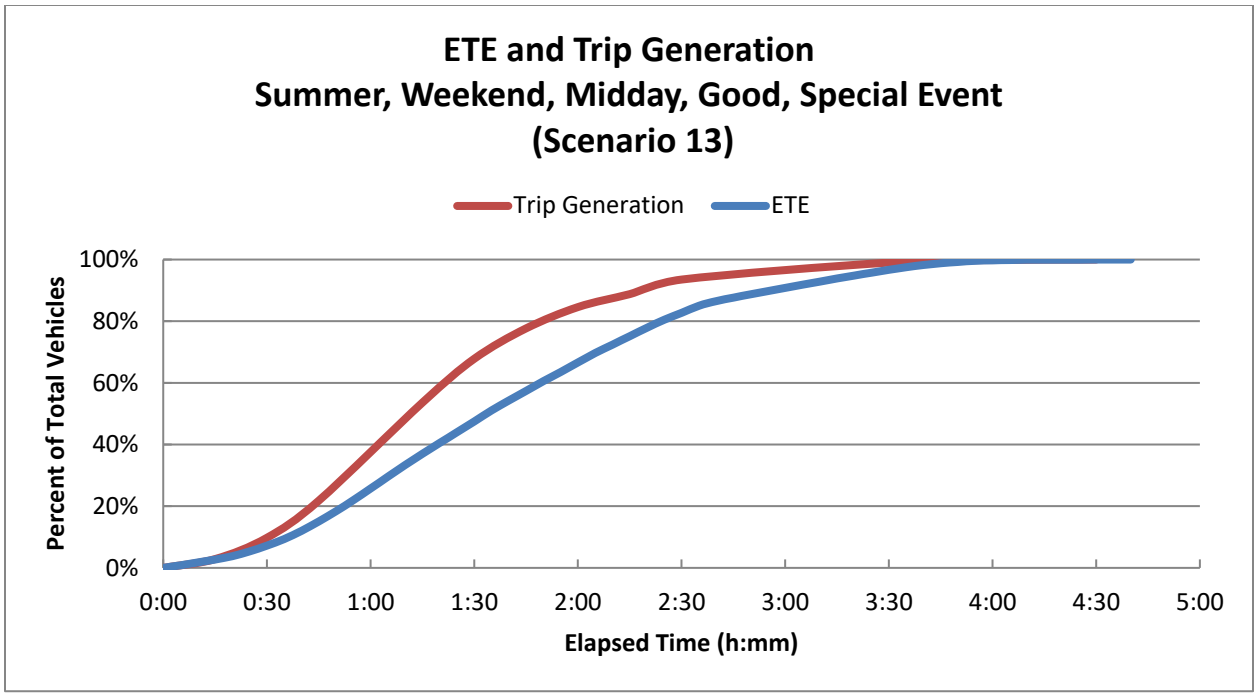


Figure J-14. ETE and Trip Generation: Summer, Weekend, Midday, Good Weather, Special Event (Scenario 13)

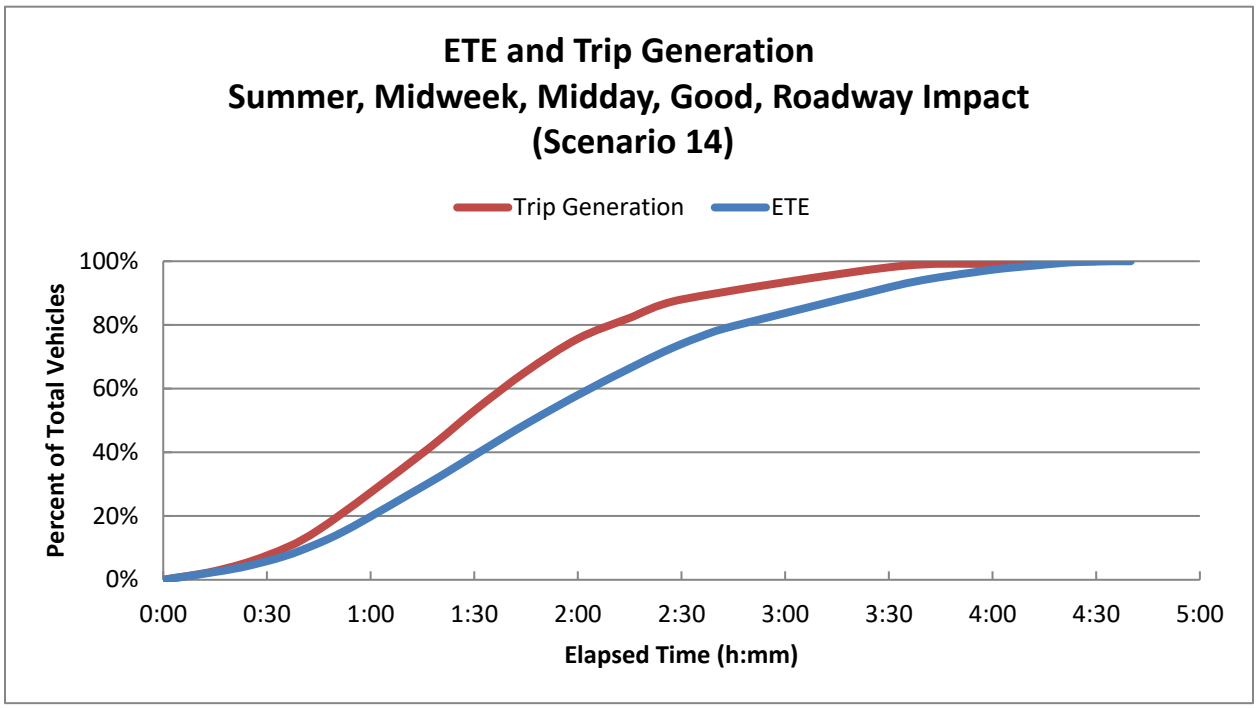


Figure J-15. ETE and Trip Generation: Summer, Midweek, Midday, Good Weather, Roadway Impact (Scenario 14)

APPENDIX K

Evacuation Roadway Network

K. EVACUATION ROADWAY NETWORK

As discussed in Section 1.3, a link-node analysis network was constructed to model the roadway network within the study area. Figure K-1 provides an overview of the link-node analysis network. The figure has been divided up into 50 more detailed figures (Figure K-2 through Figure K-51) which show each of the links and nodes in the network.

The analysis network was calibrated using the observations made during the field surveys conducted in January 2021.

Table K-1 summarizes the number of nodes by the type of control (stop sign, yield sign, pre-timed signal, actuated signal, traffic and access control point [TACP], uncontrolled).

Table K-1. Summary of Nodes by the Type of Control

Control Type	Number of Nodes
Uncontrolled	979
Pretimed	0
Actuated	85
Stop	166
TACP	92
Yield	36
Total:	**1,358**

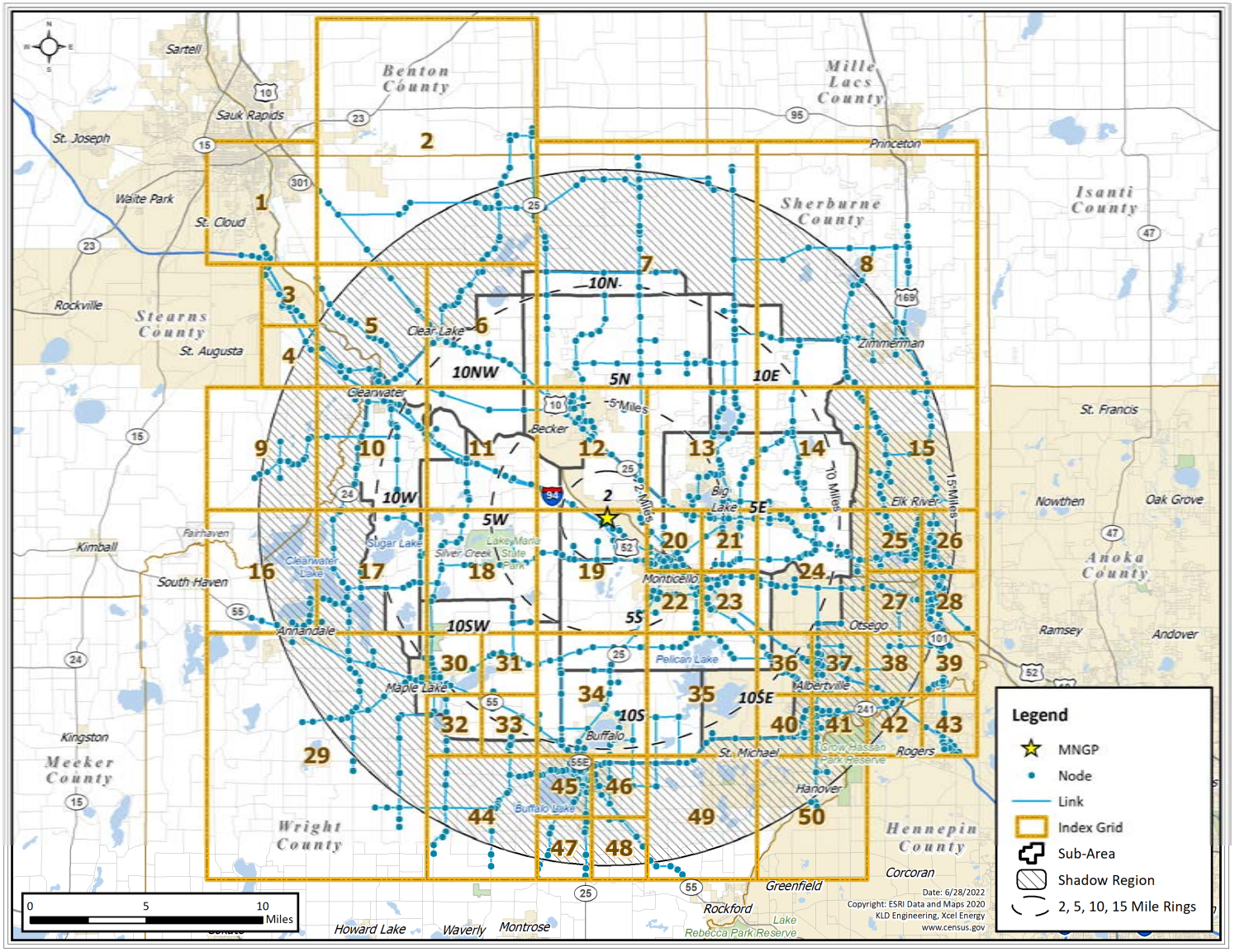


Figure K-1. MNGP Link-Node Analysis Network

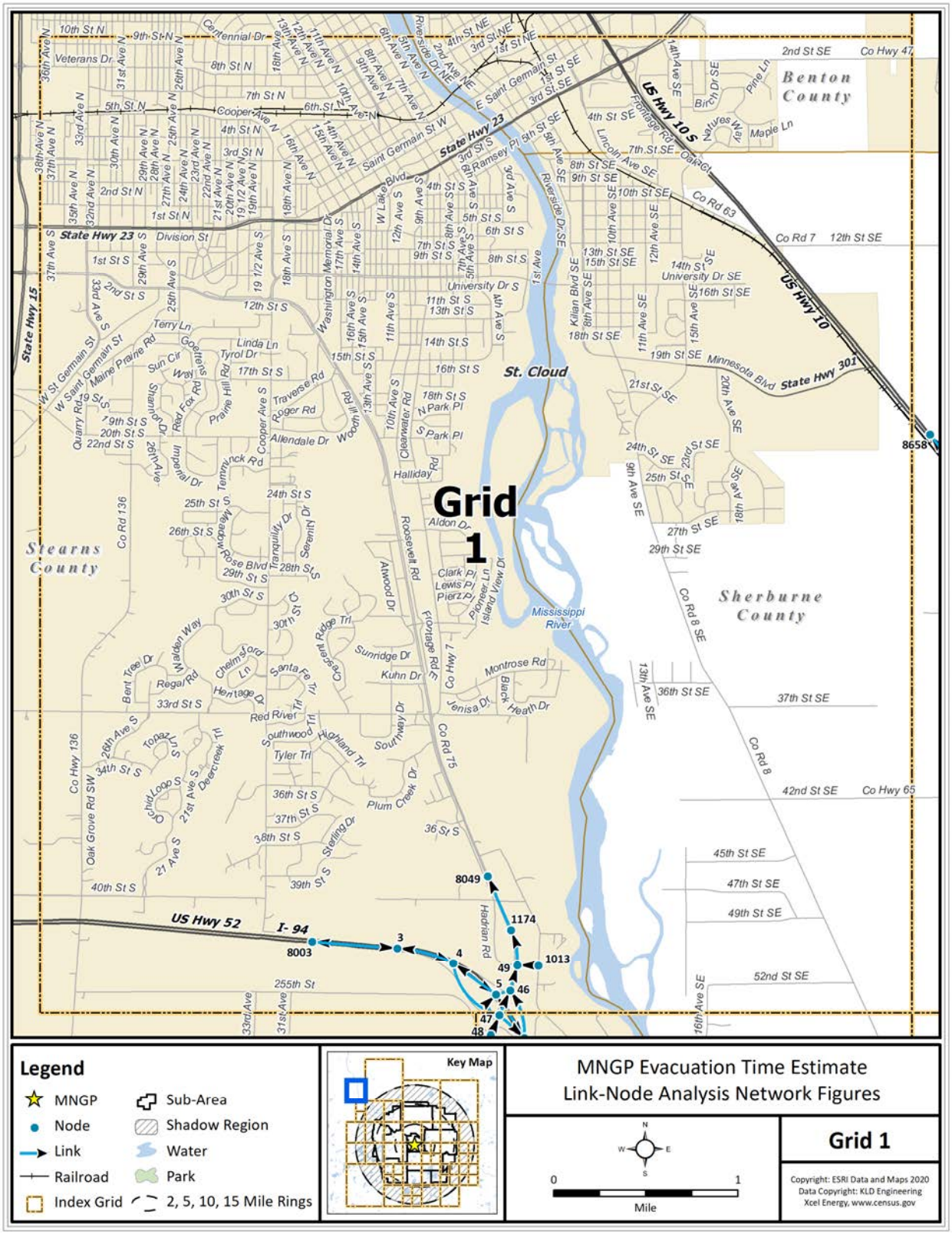


Figure K-2. Link-Node Analysis Network – Grid 1

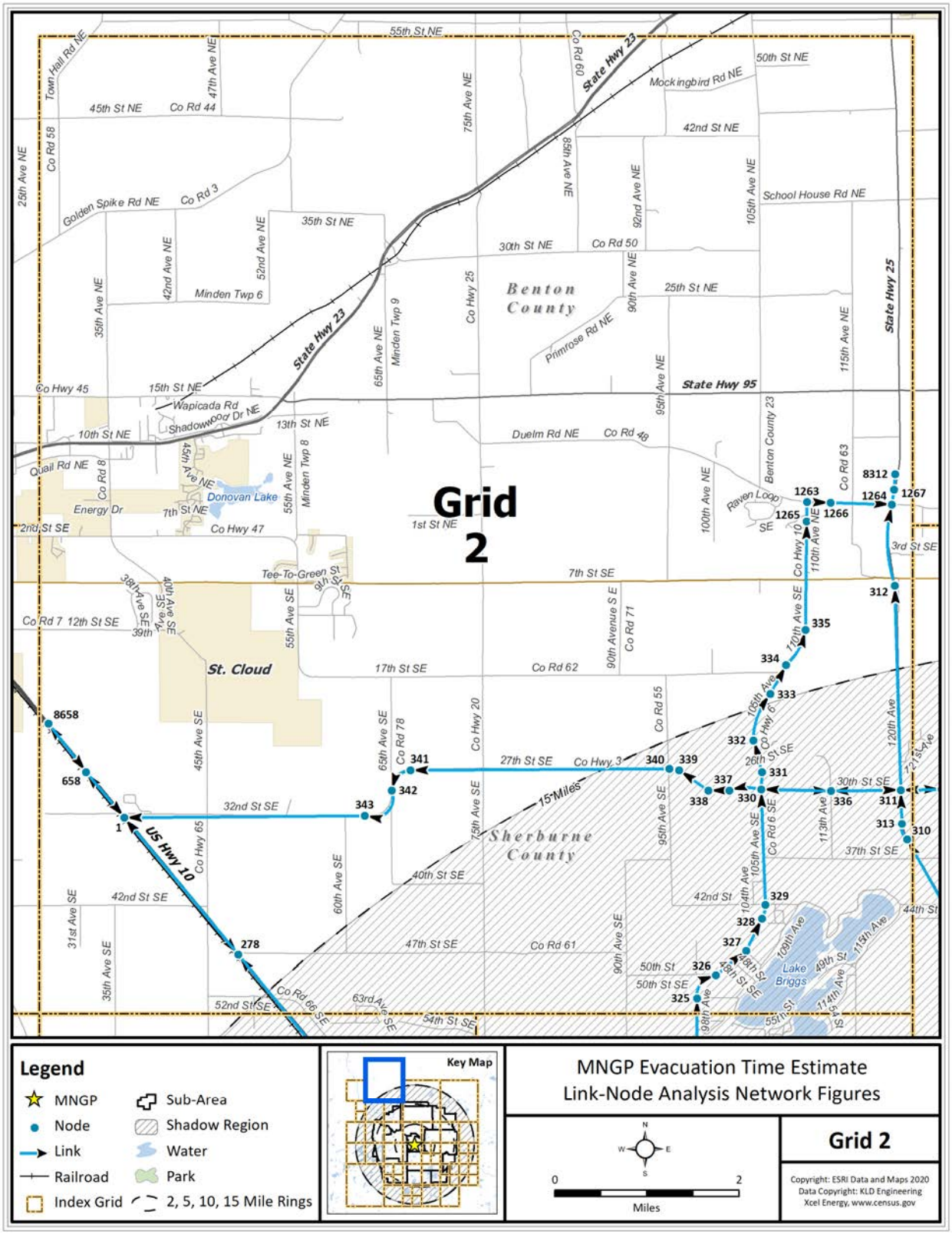


Figure K-3. Link-Node Analysis Network – Grid 2

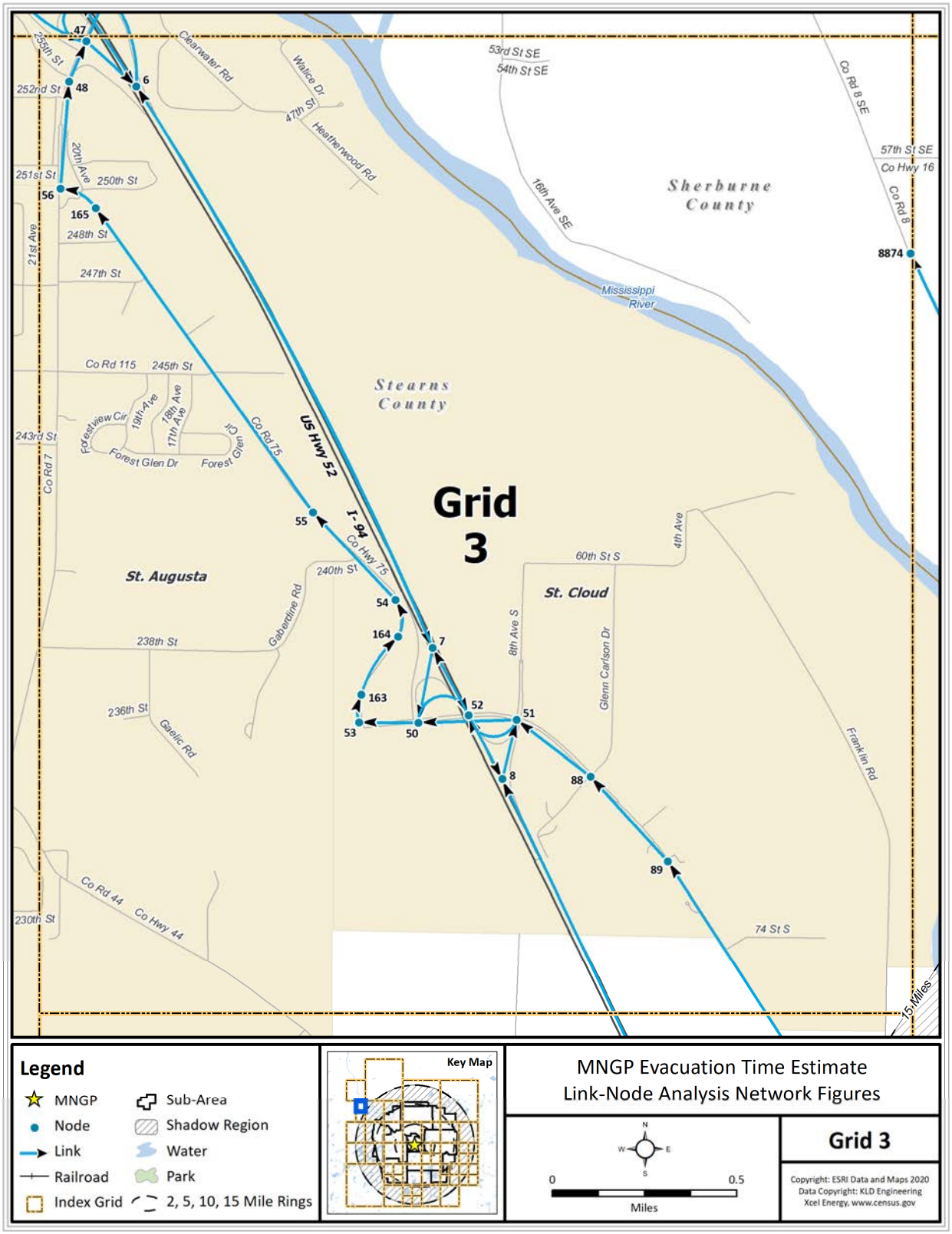


Figure K-4. Link-Node Analysis Network – Grid 3

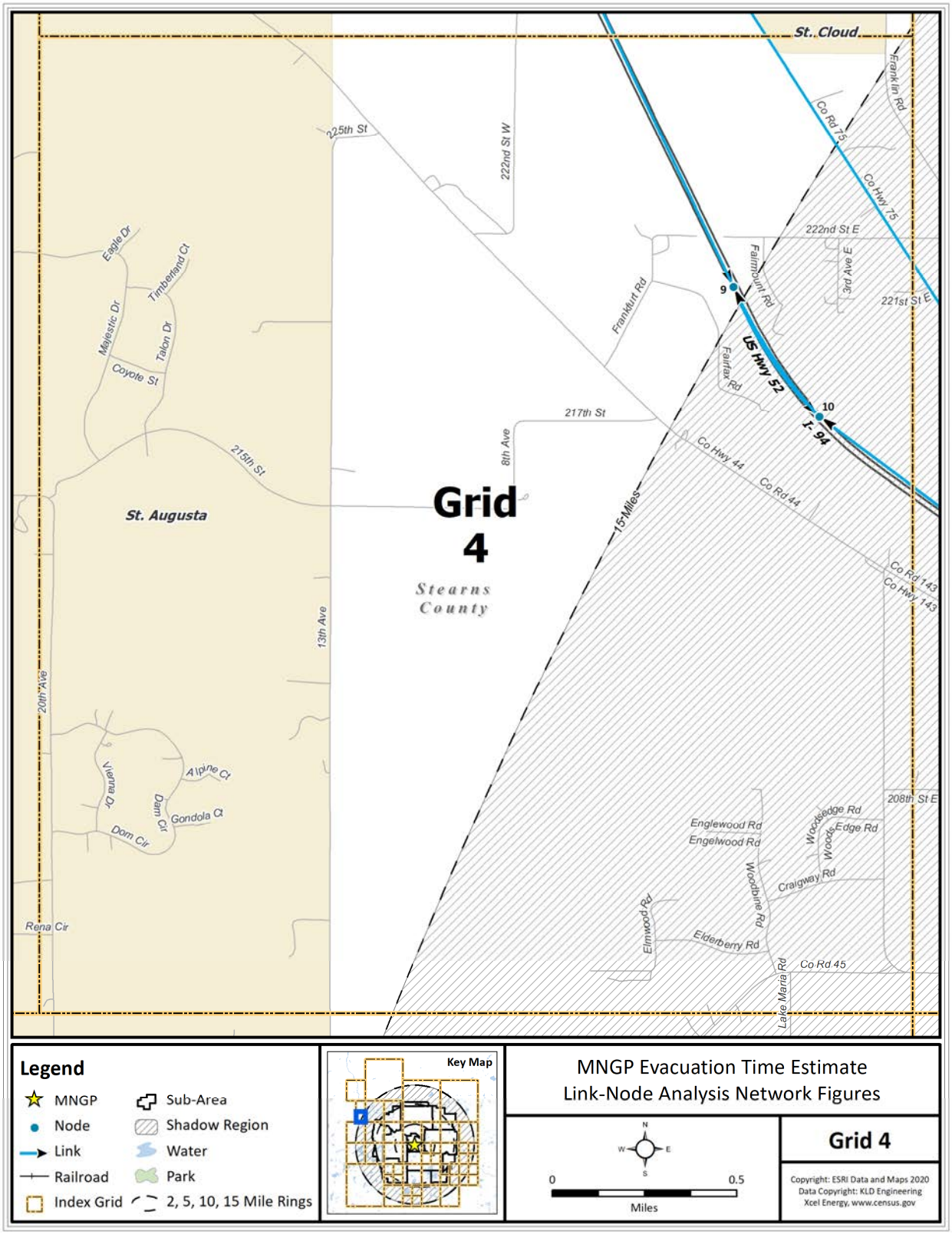


Figure K-5. Link-Node Analysis Network – Grid 4

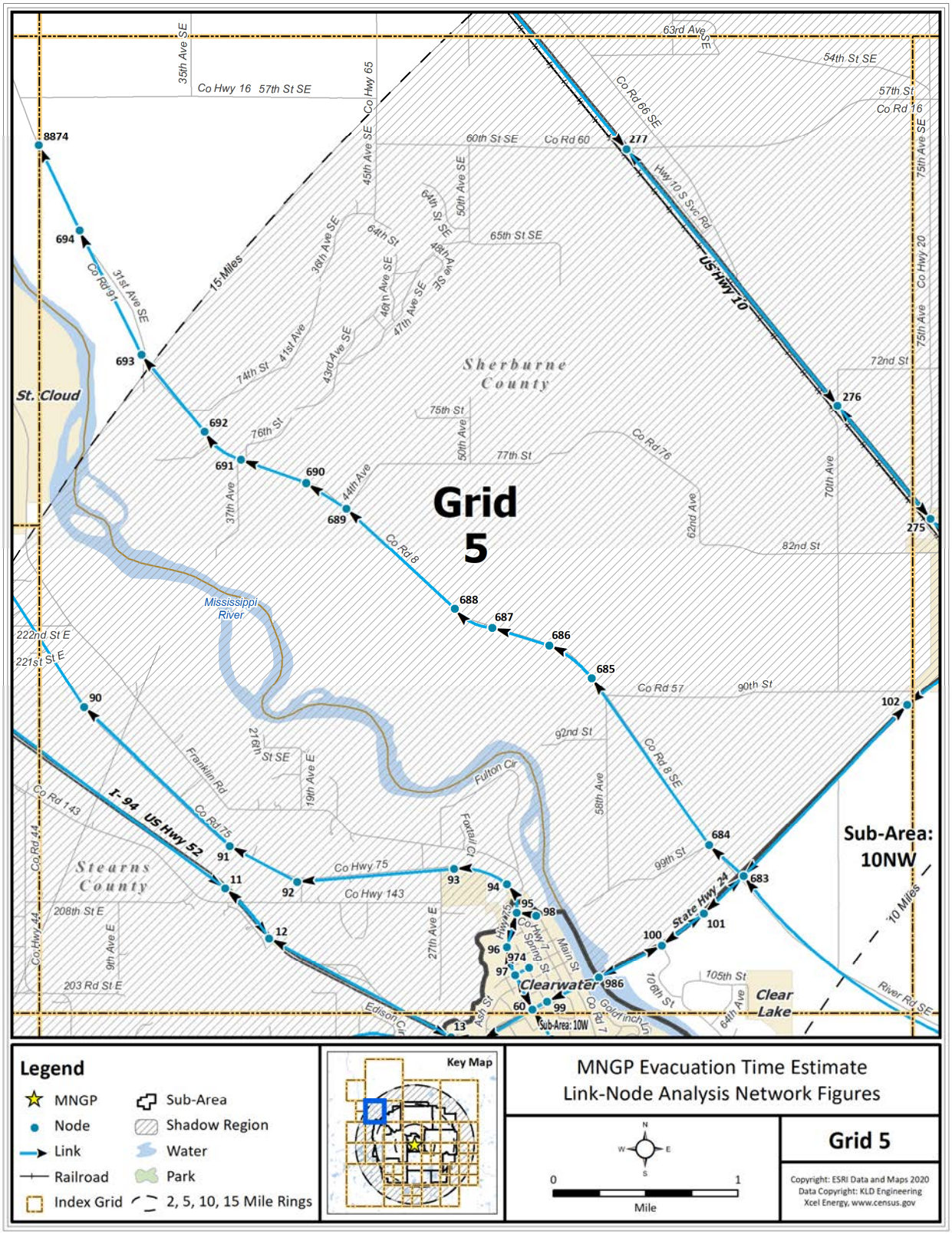


Figure K-6. Link-Node Analysis Network – Grid 5

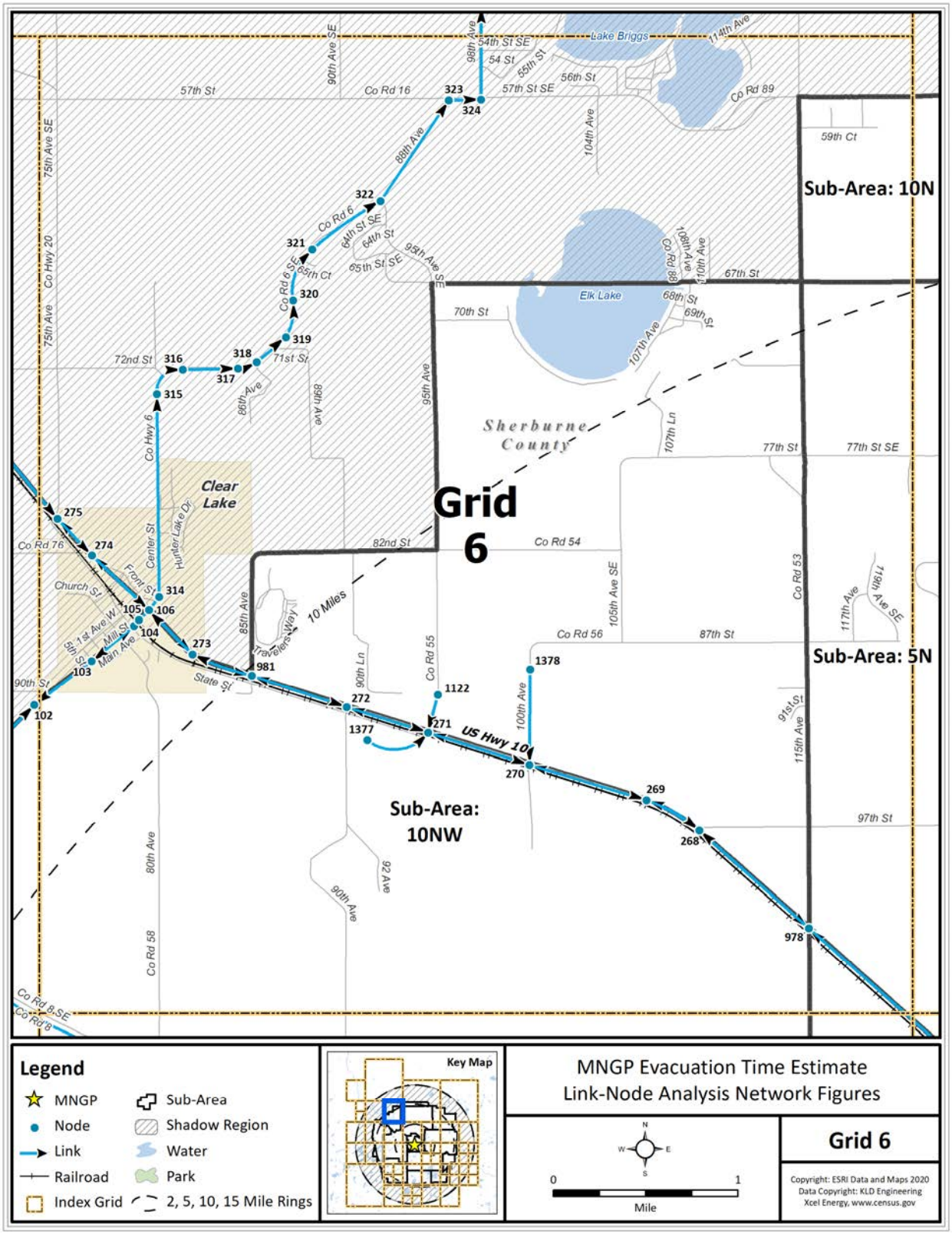


Figure K-7. Link-Node Analysis Network – Grid 6

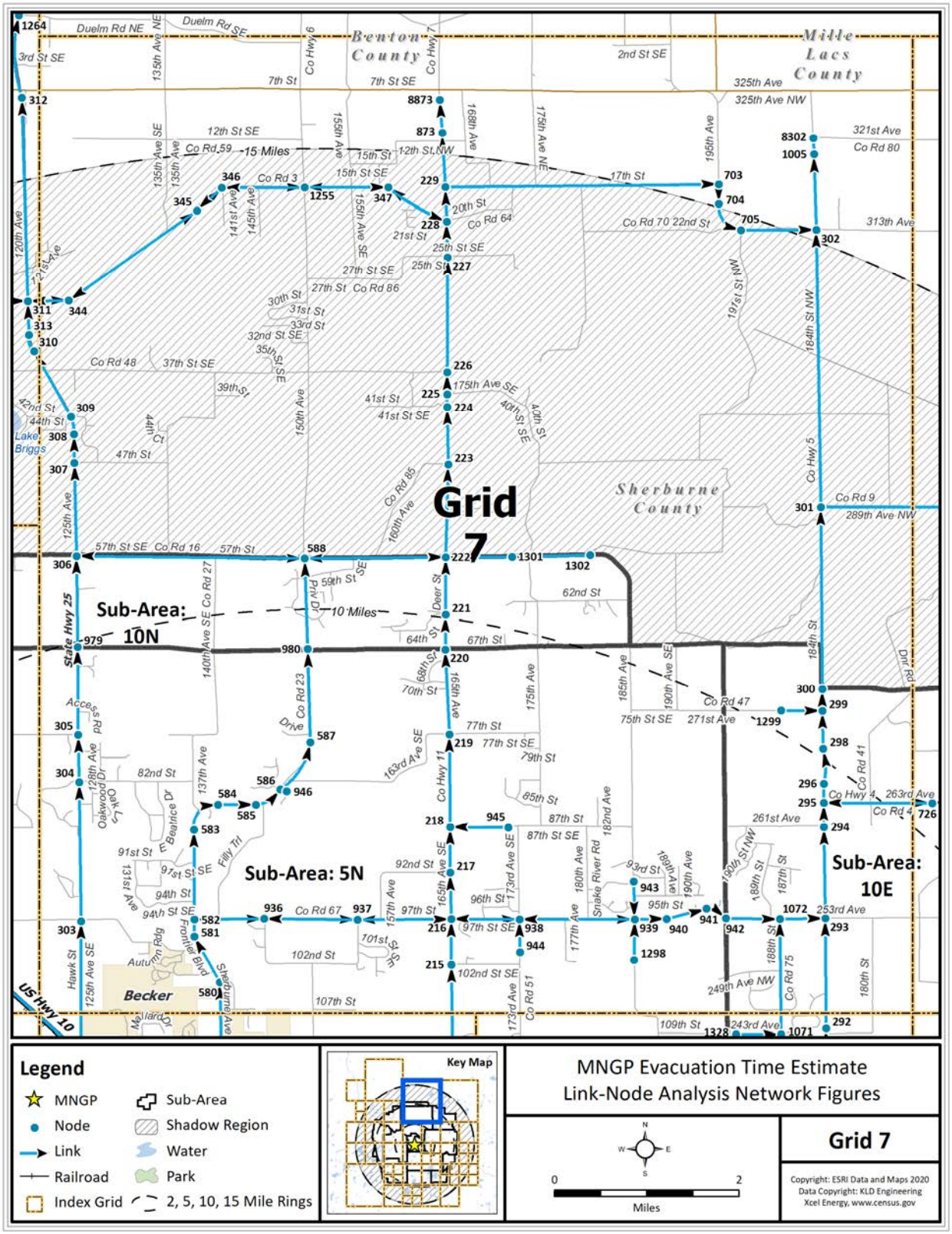


Figure K-8. Link-Node Analysis Network – Grid 7

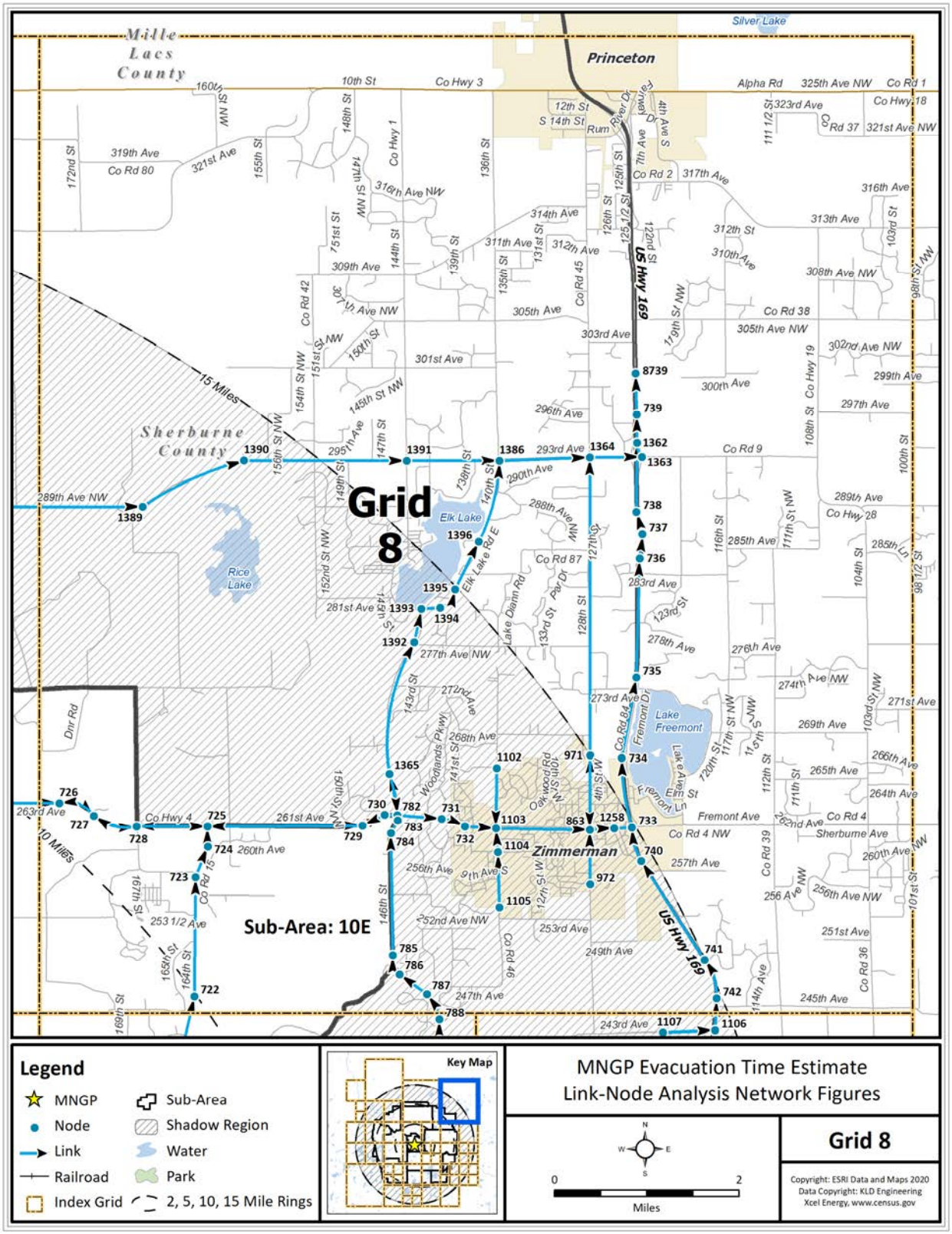


Figure K-9. Link-Node Analysis Network – Grid 8

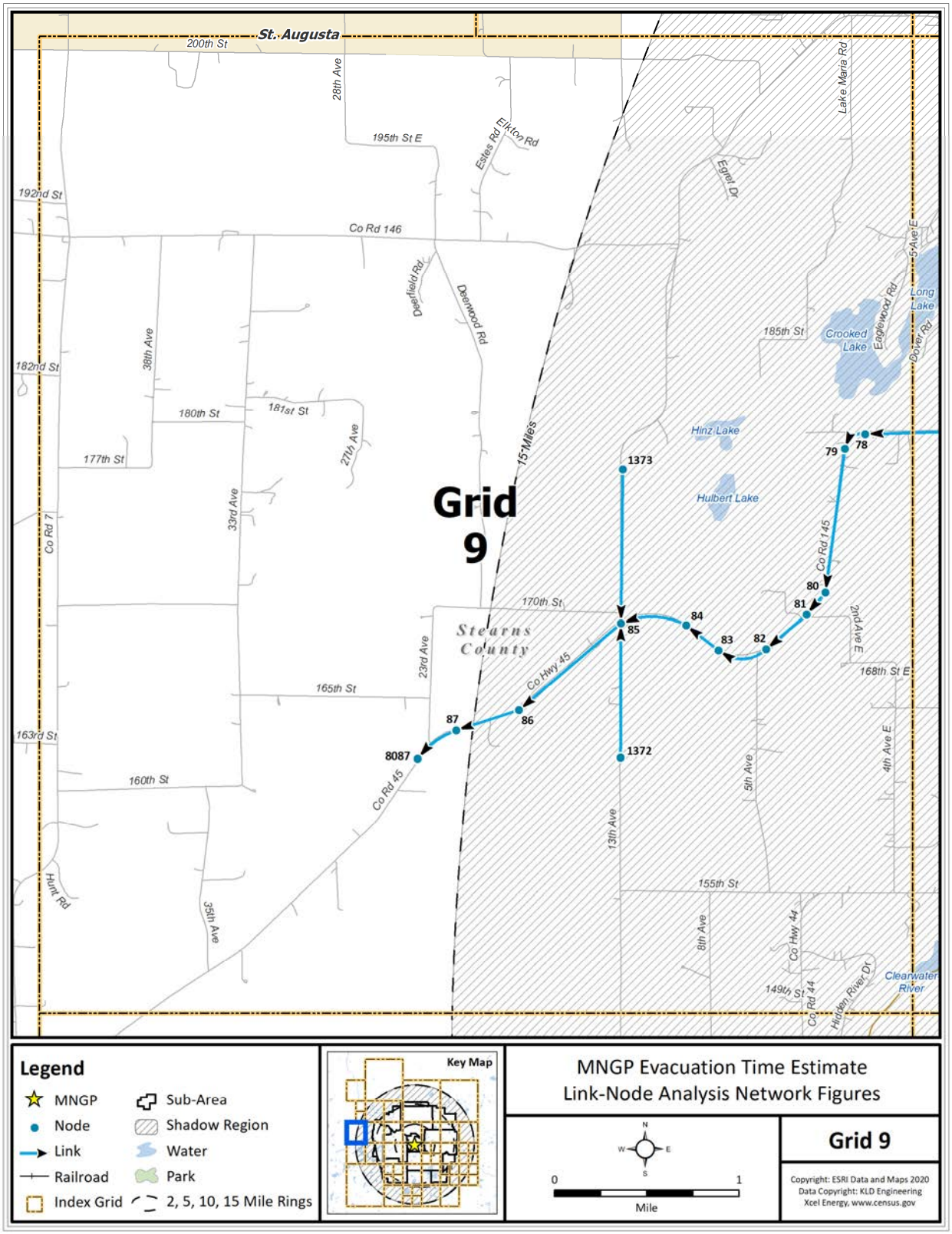


Figure K-10. Link-Node Analysis Network – Grid 9

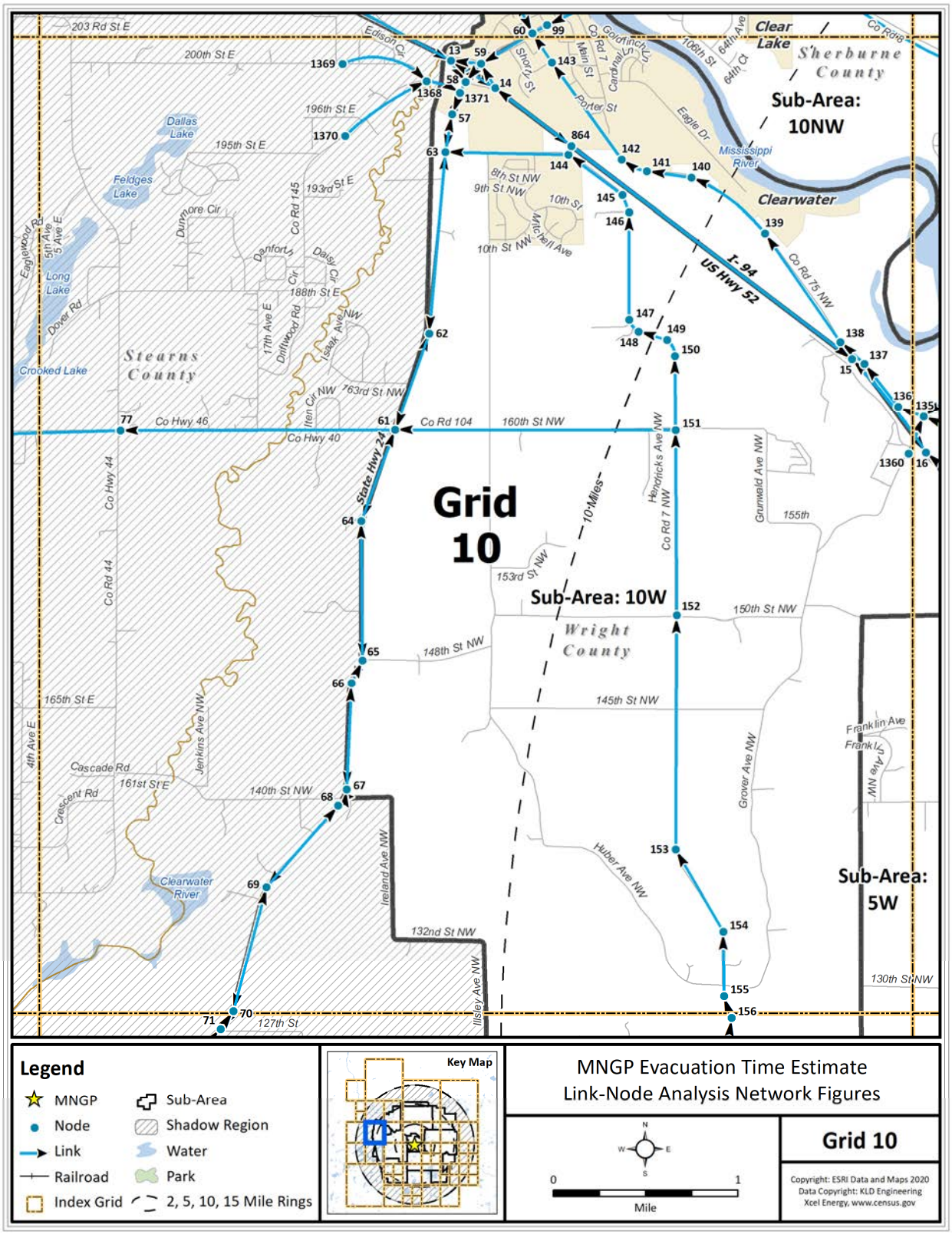


Figure K-11. Link-Node Analysis Network – Grid 10

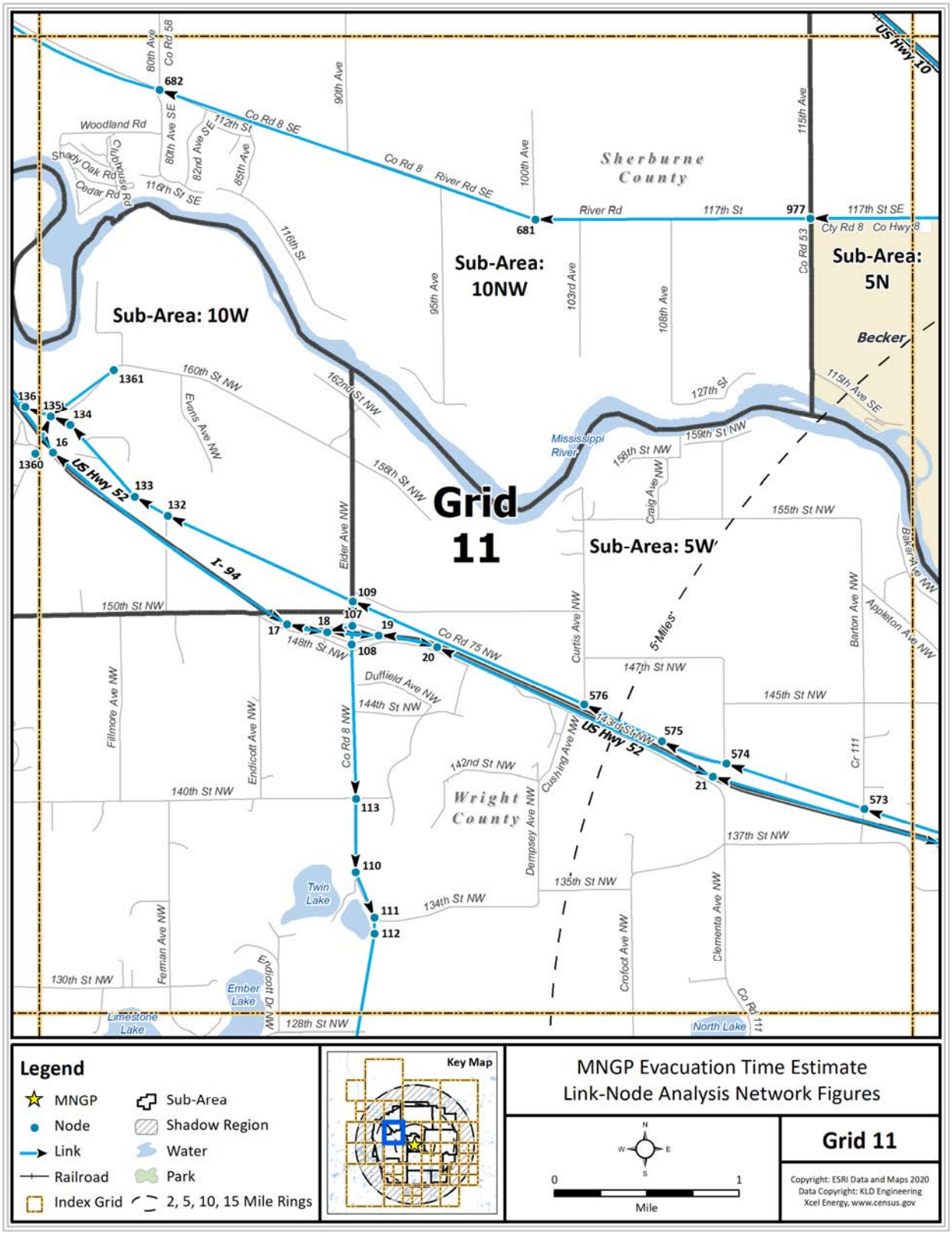


Figure K-12. Link-Node Analysis Network – Grid 11

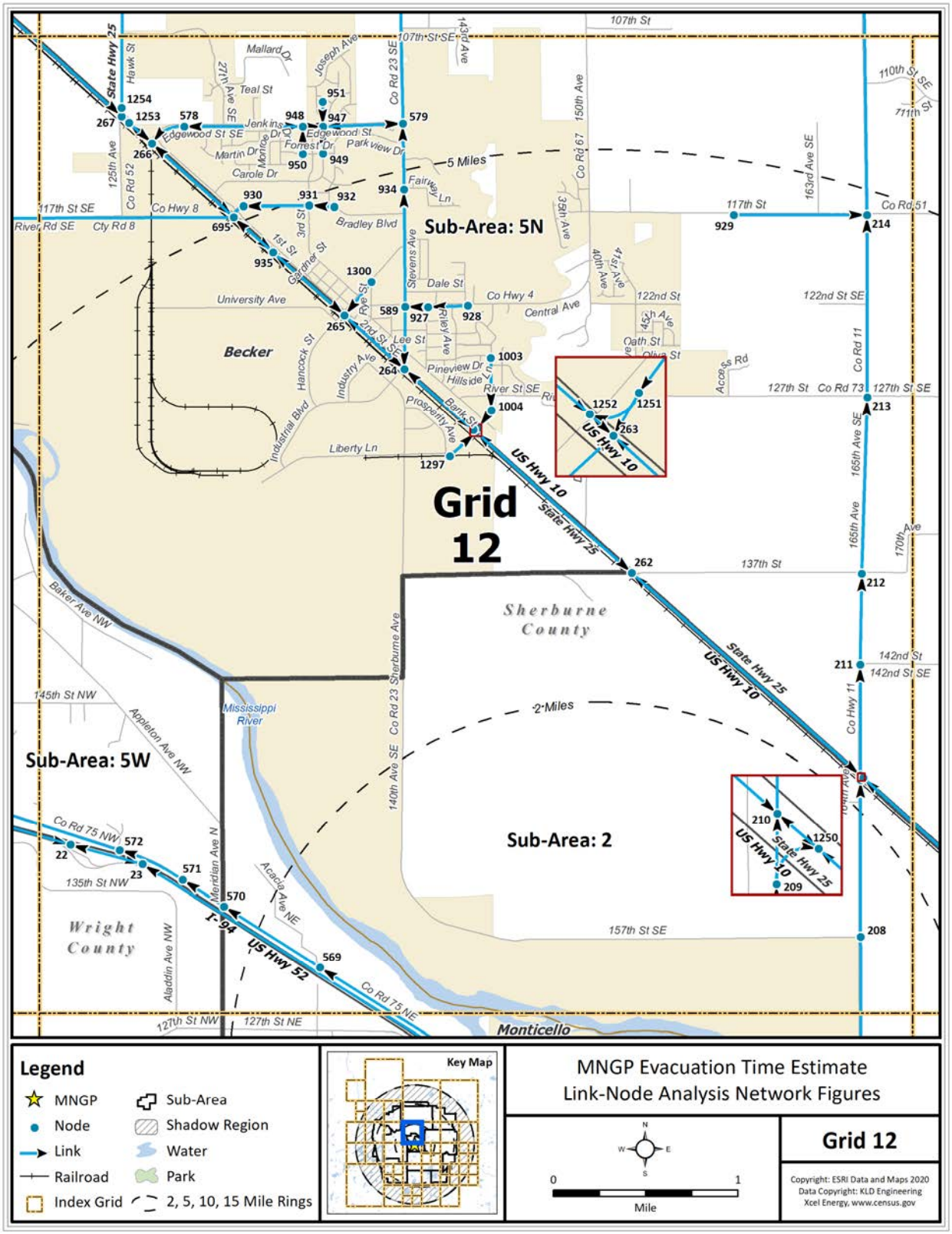


Figure K-13. Link-Node Analysis Network – Grid 12

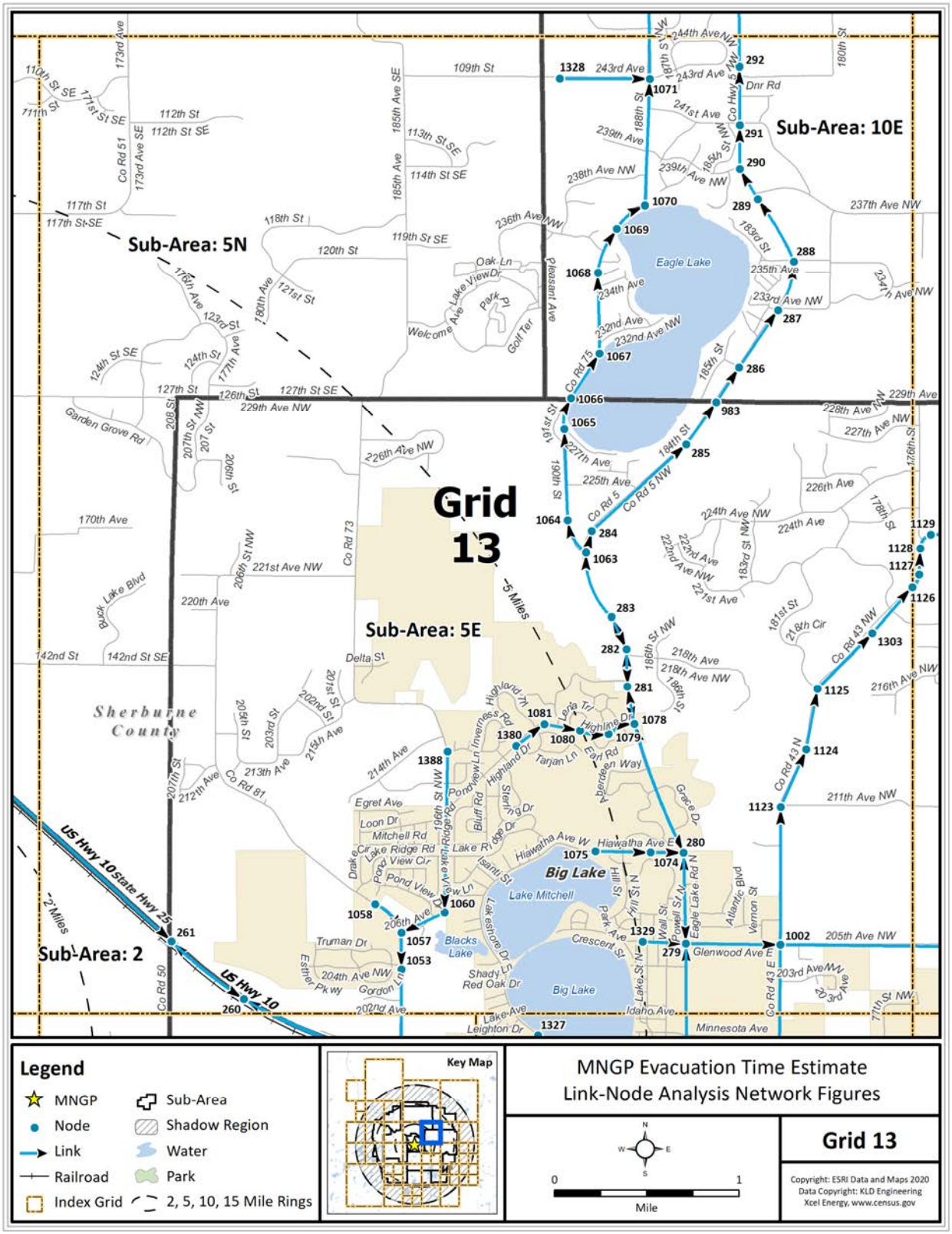


Figure K-14. Link-Node Analysis Network – Grid 13

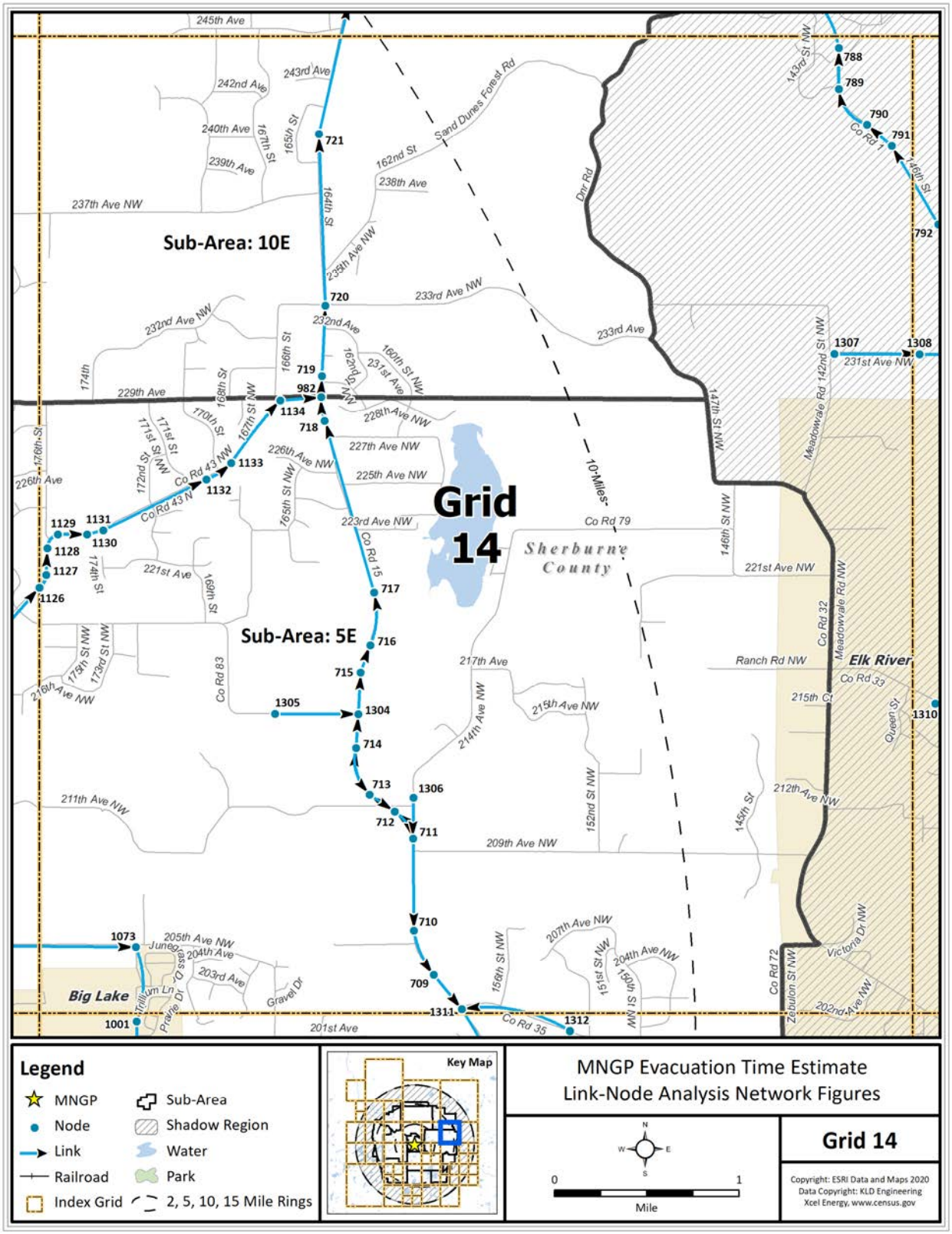


Figure K-15. Link-Node Analysis Network – Grid 14

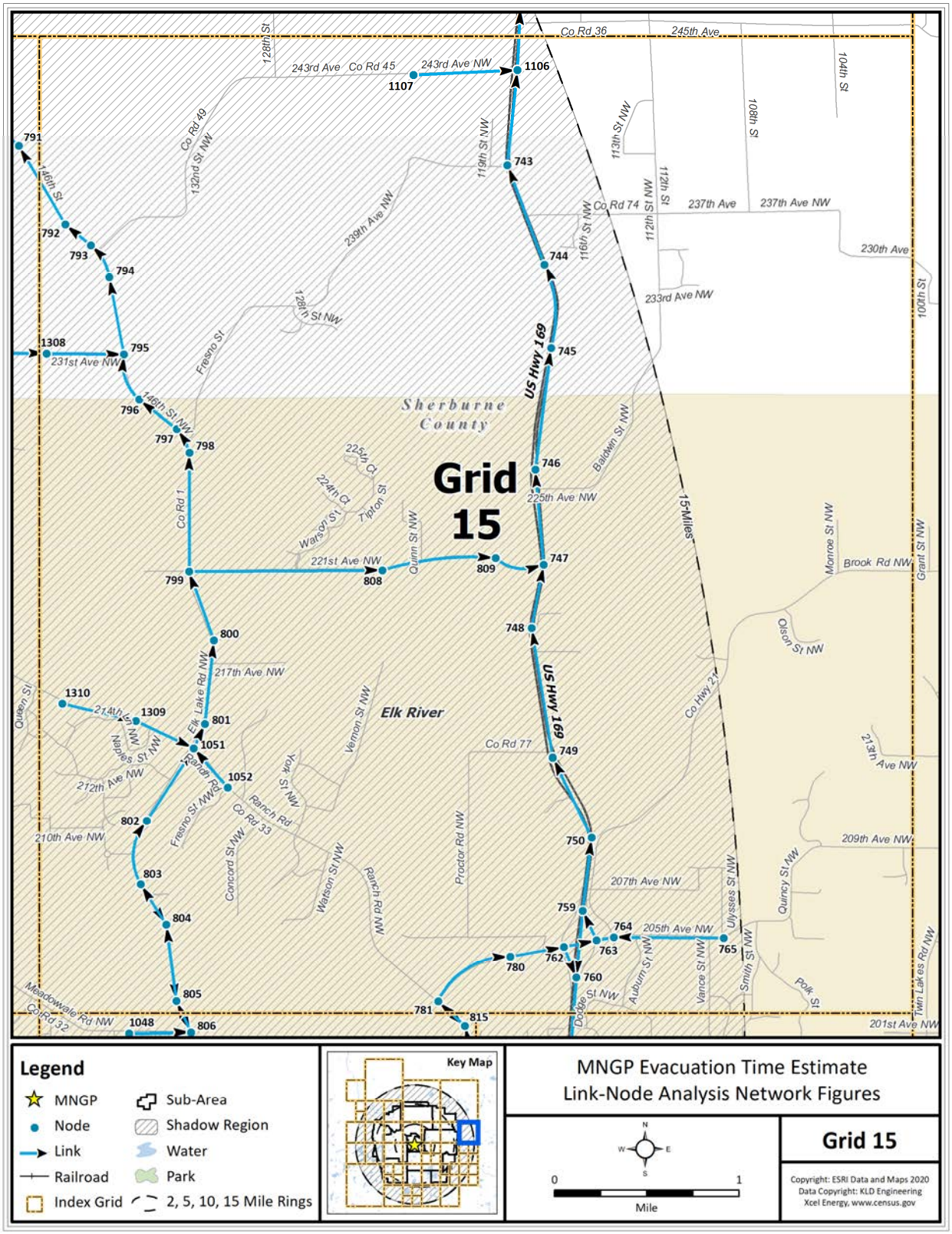


Figure K-16. Link-Node Analysis Network – Grid 15

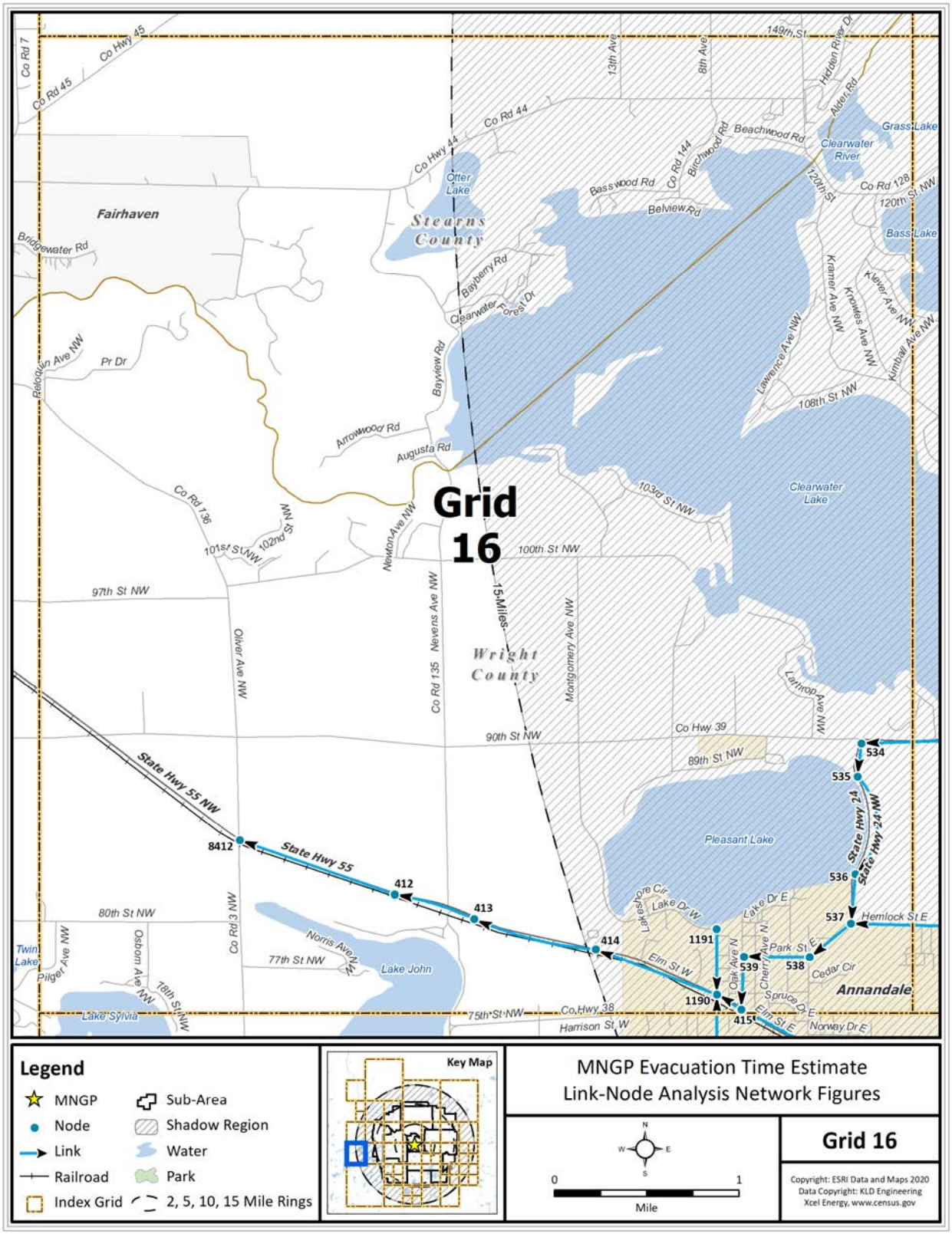


Figure K-17. Link-Node Analysis Network – Grid 16

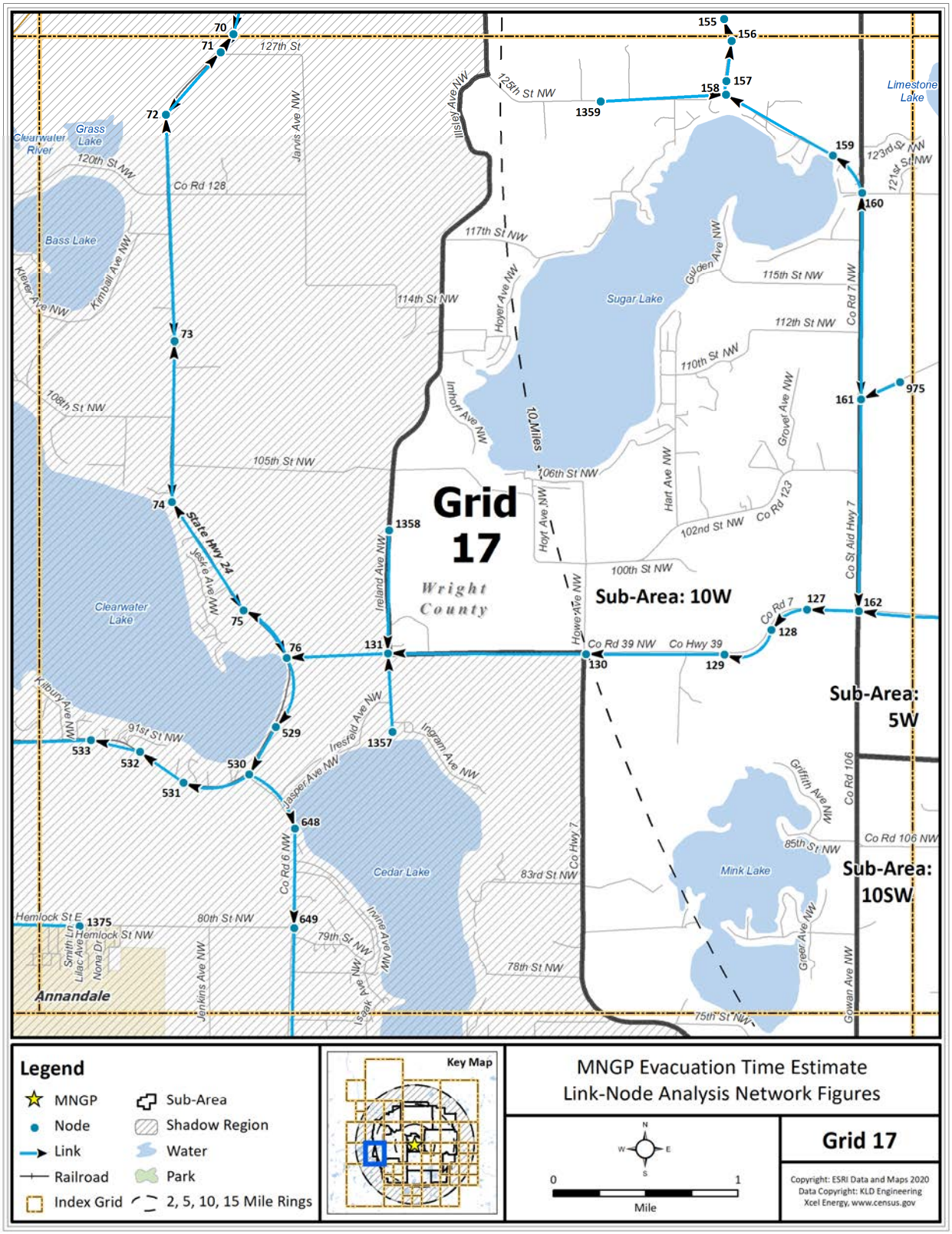


Figure K-18. Link-Node Analysis Network – Grid 17

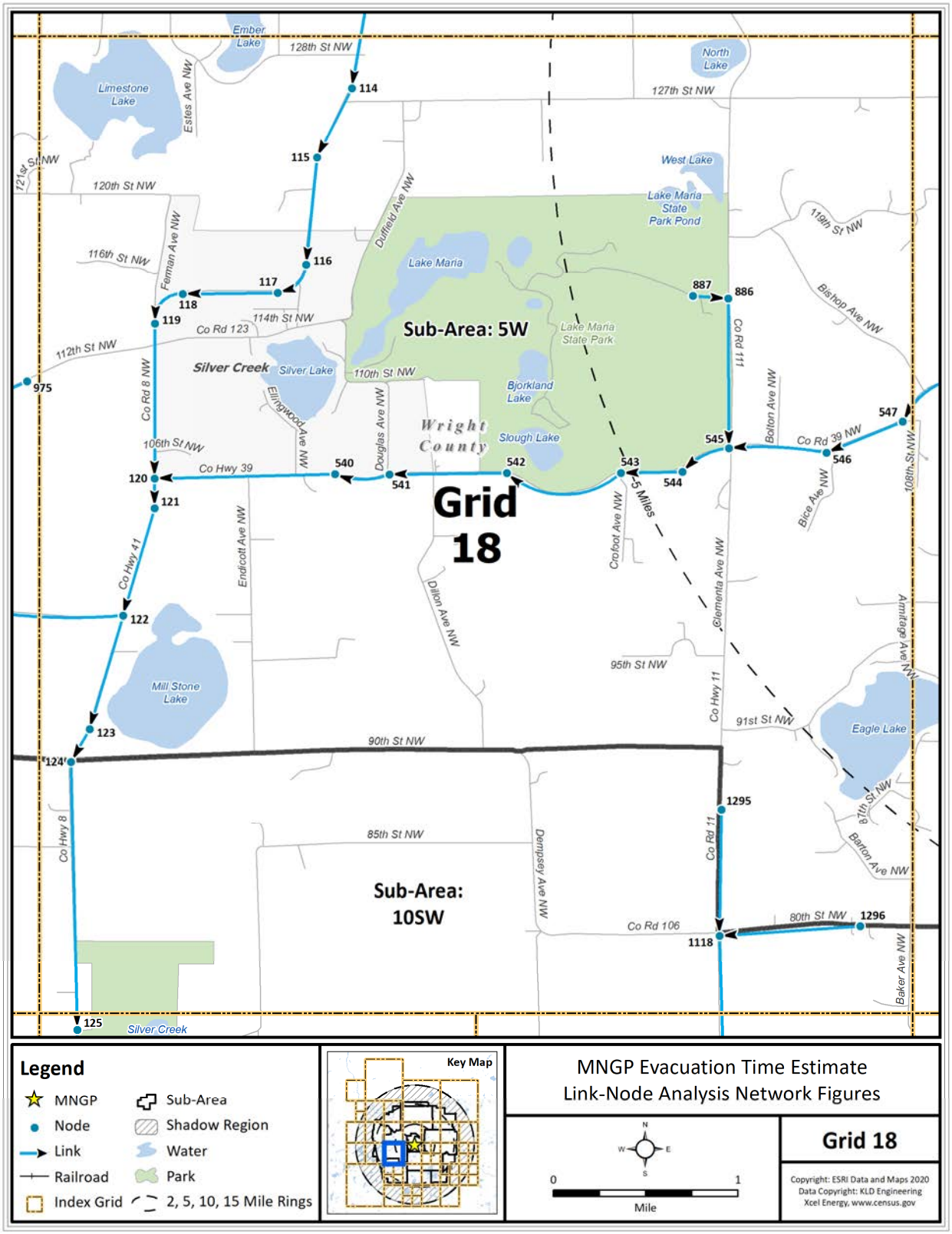


Figure K-19. Link-Node Analysis Network – Grid 18

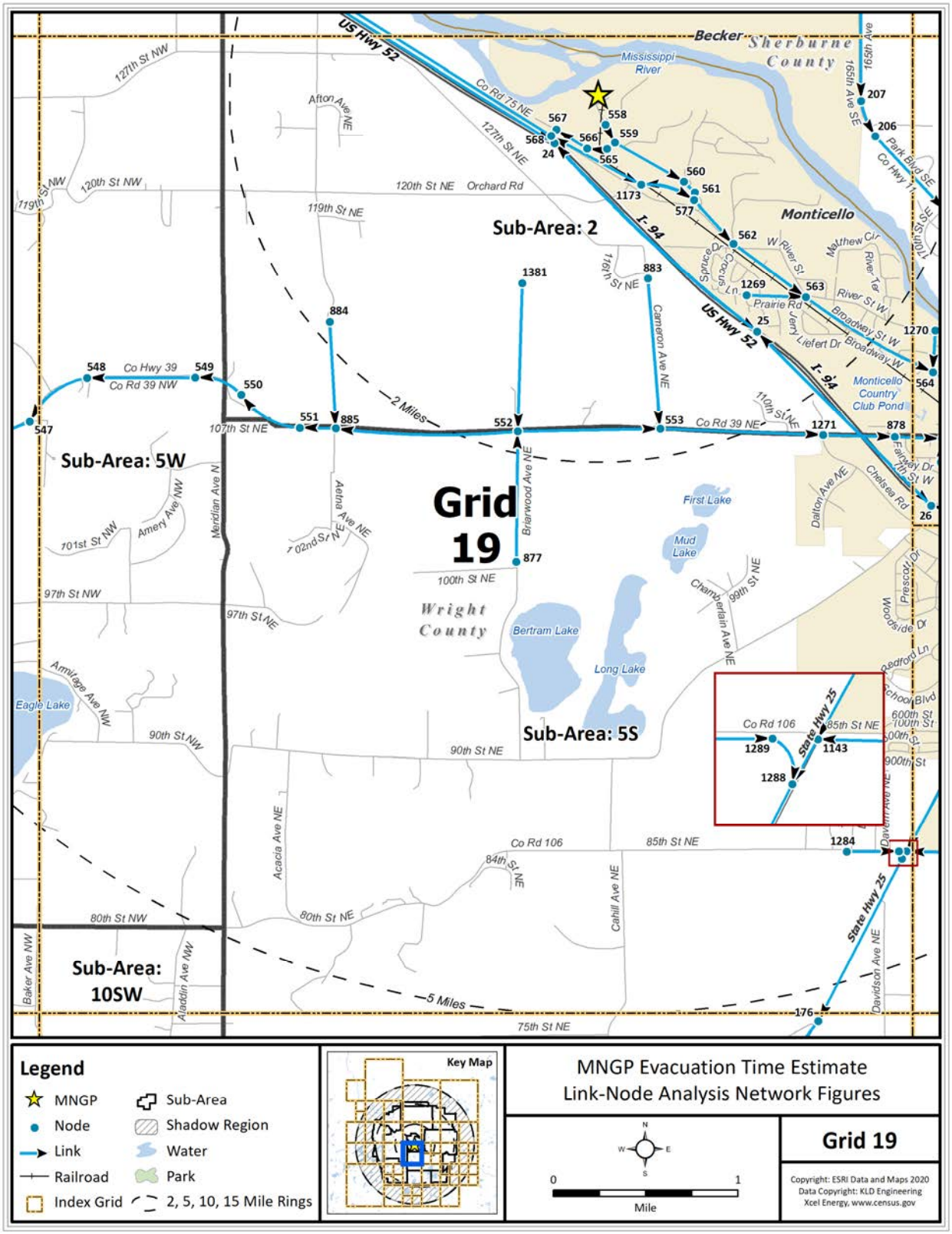


Figure K-20. Link-Node Analysis Network – Grid 19

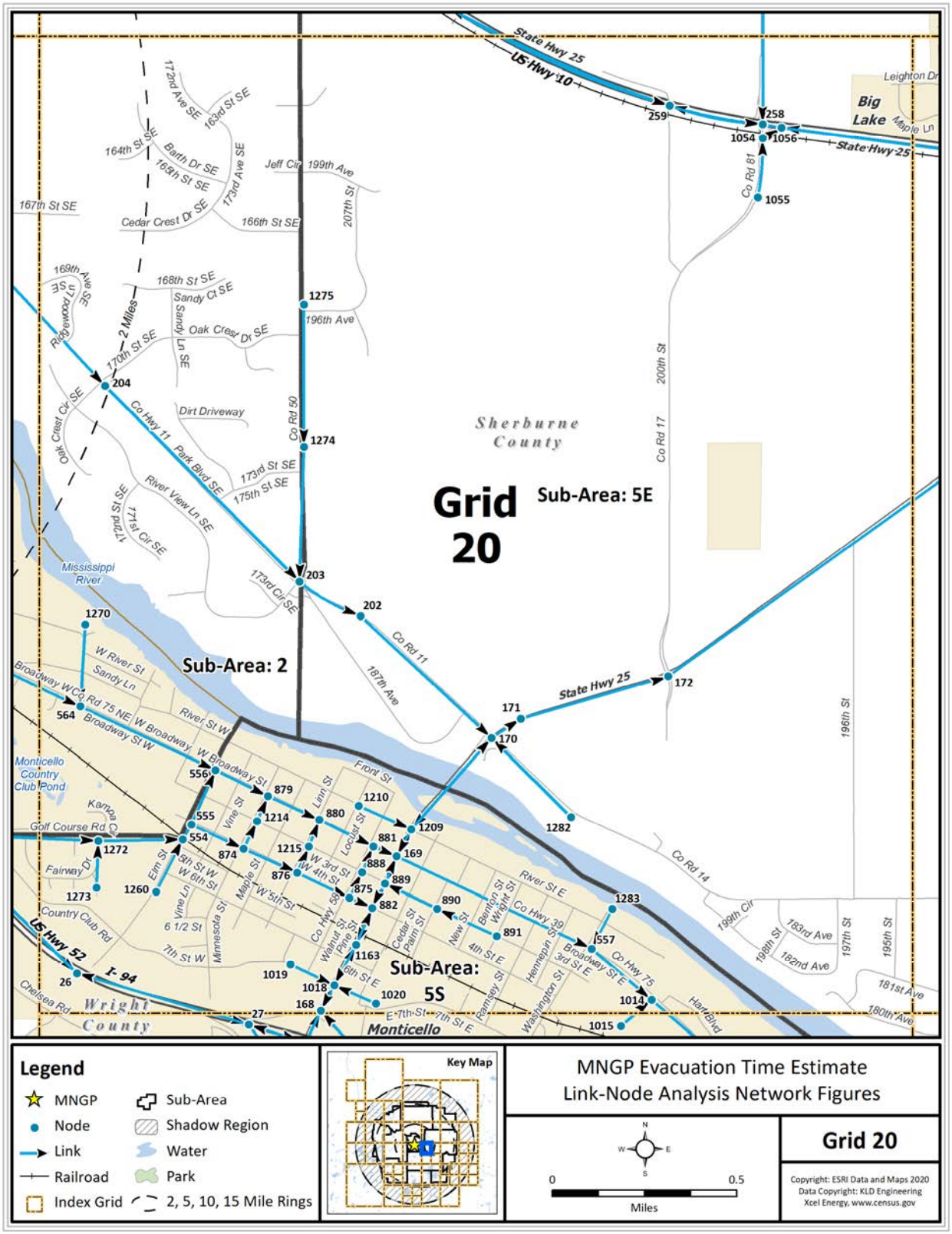


Figure K-21. Link-Node Analysis Network – Grid 20

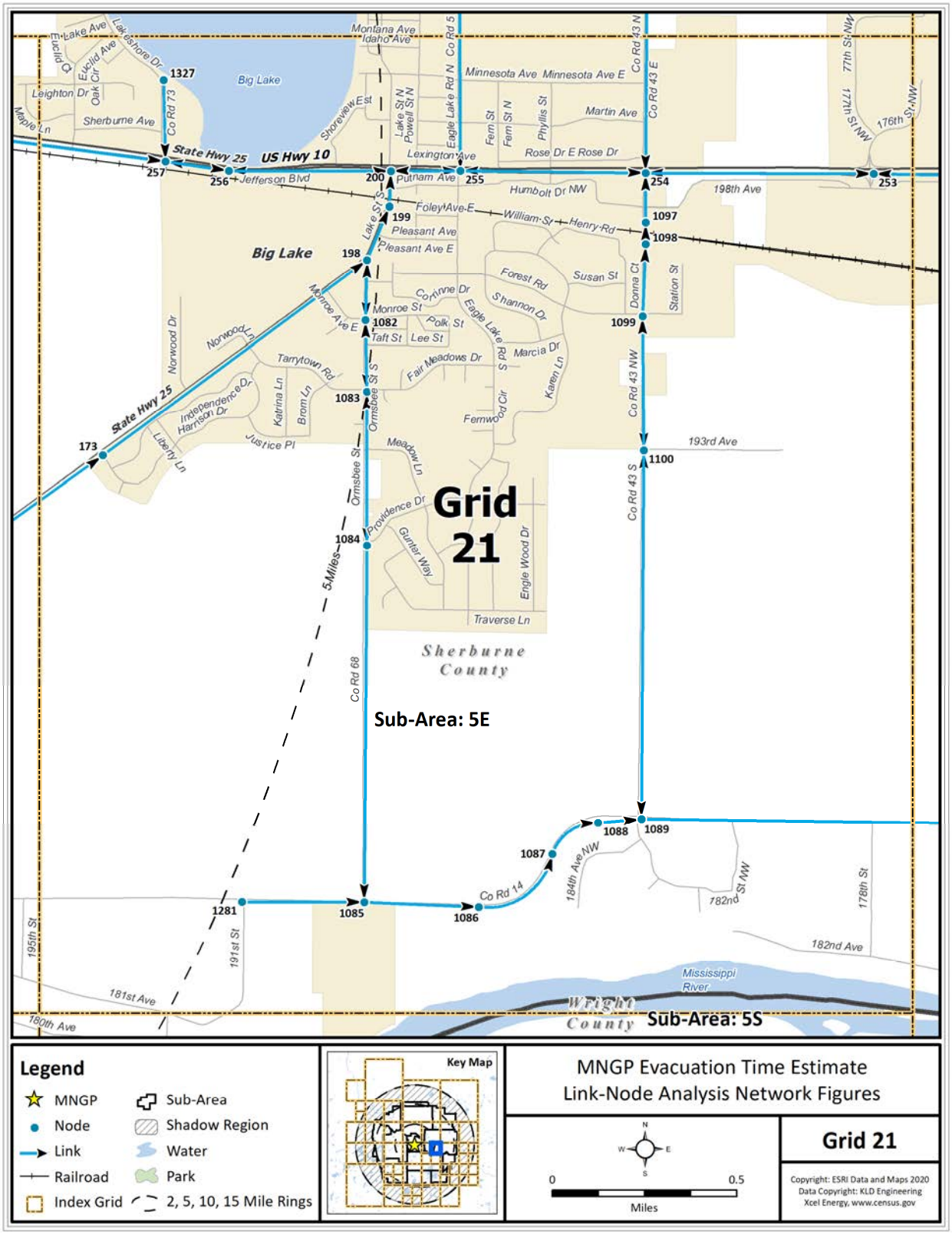


Figure K-22. Link-Node Analysis Network – Grid 21

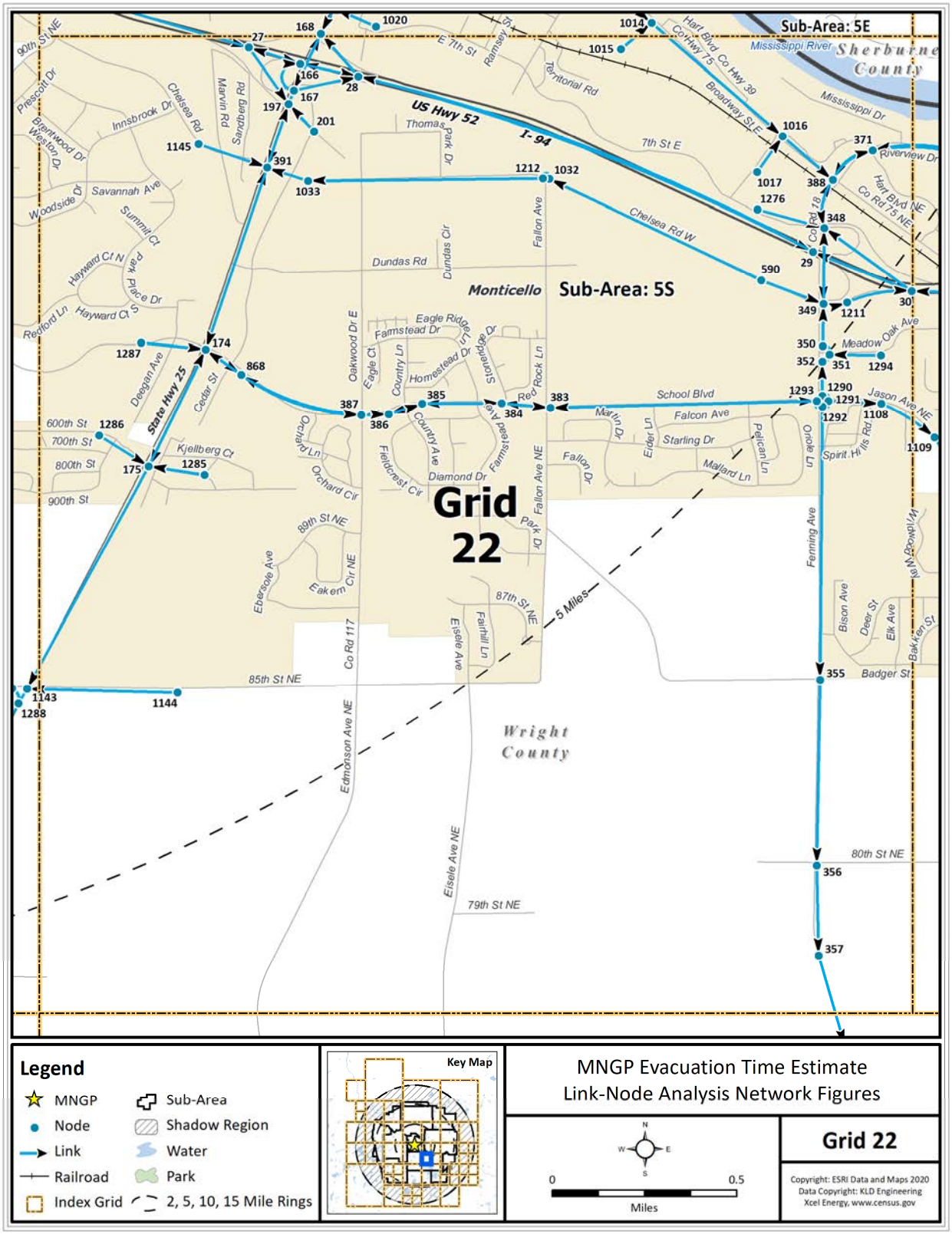


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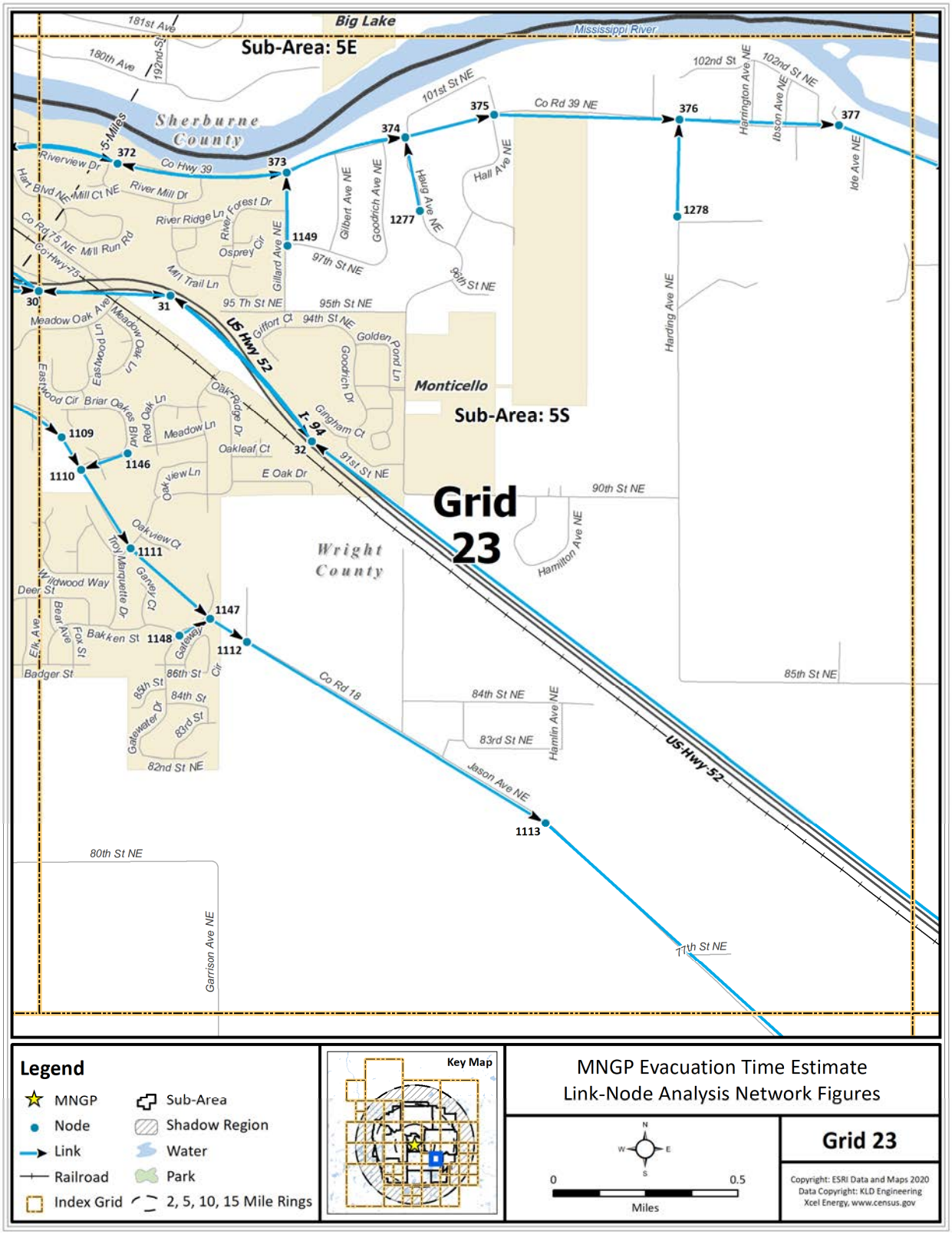


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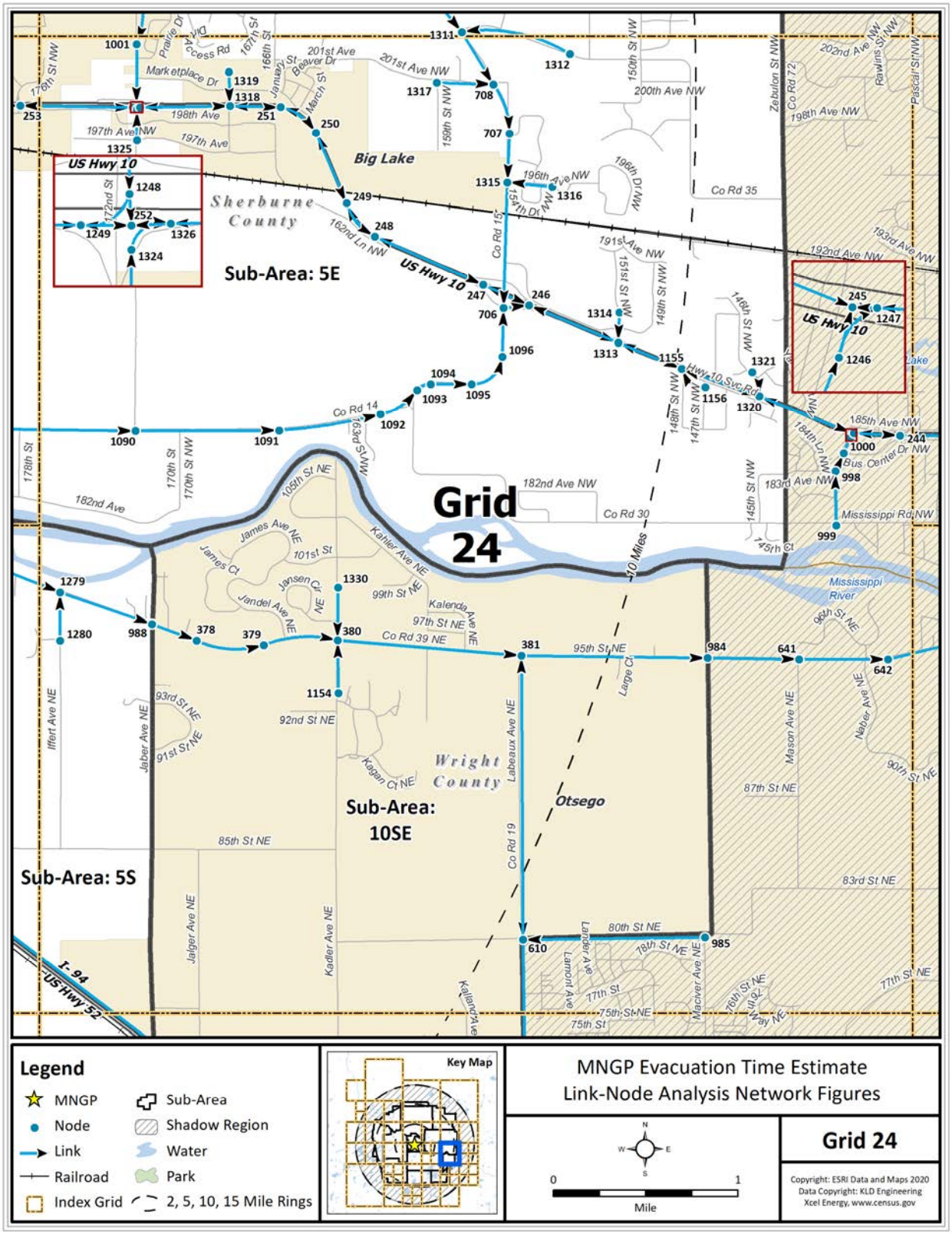


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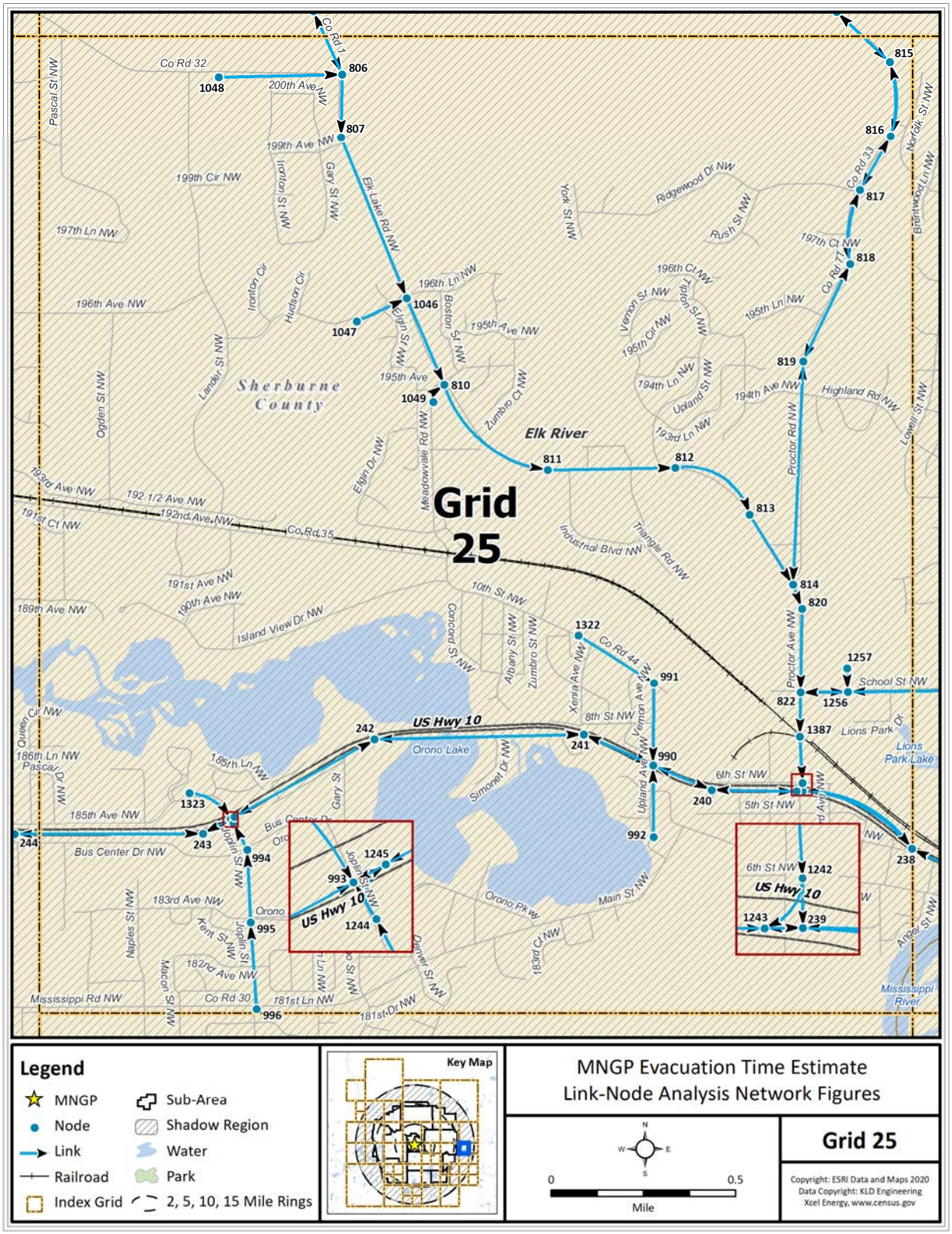


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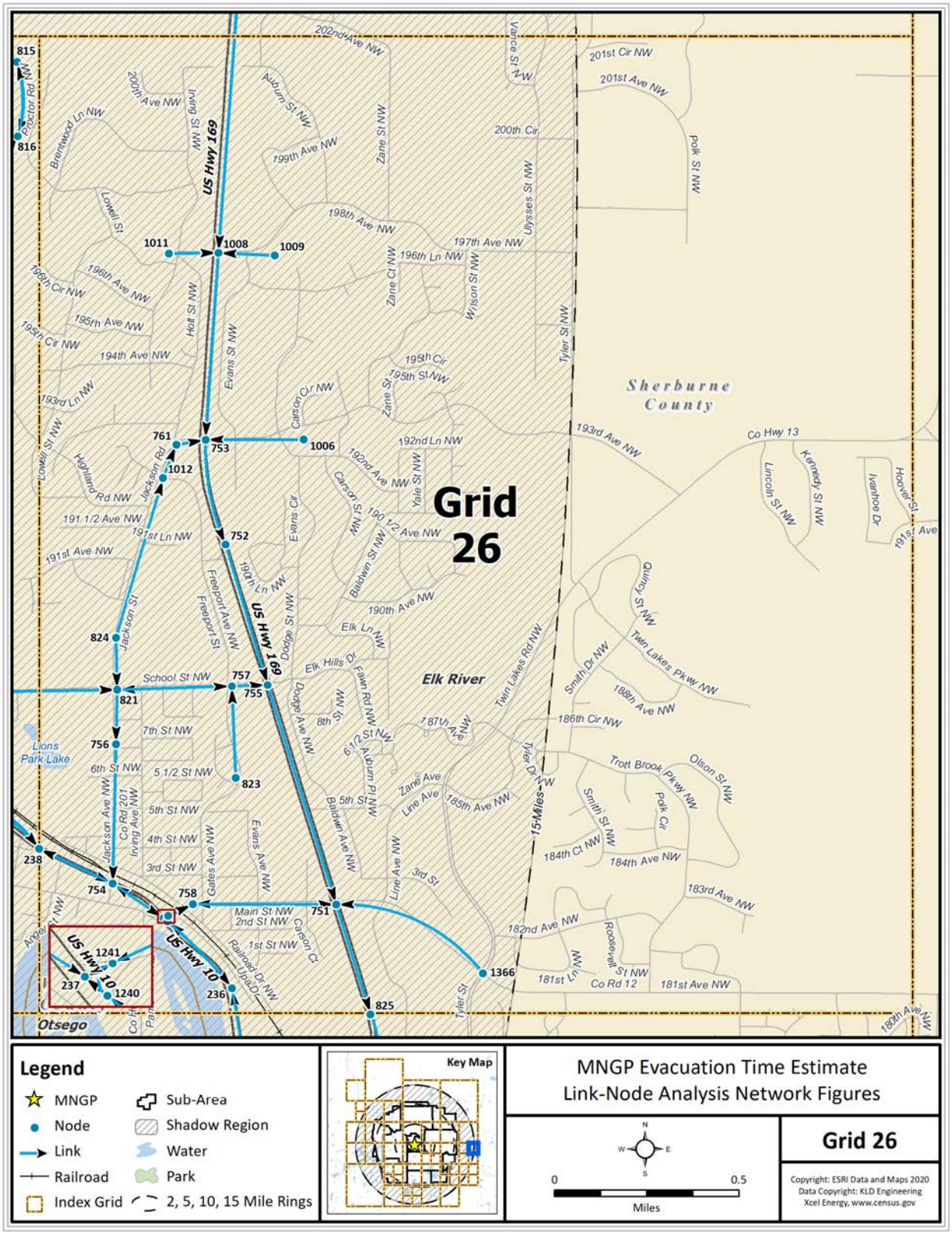


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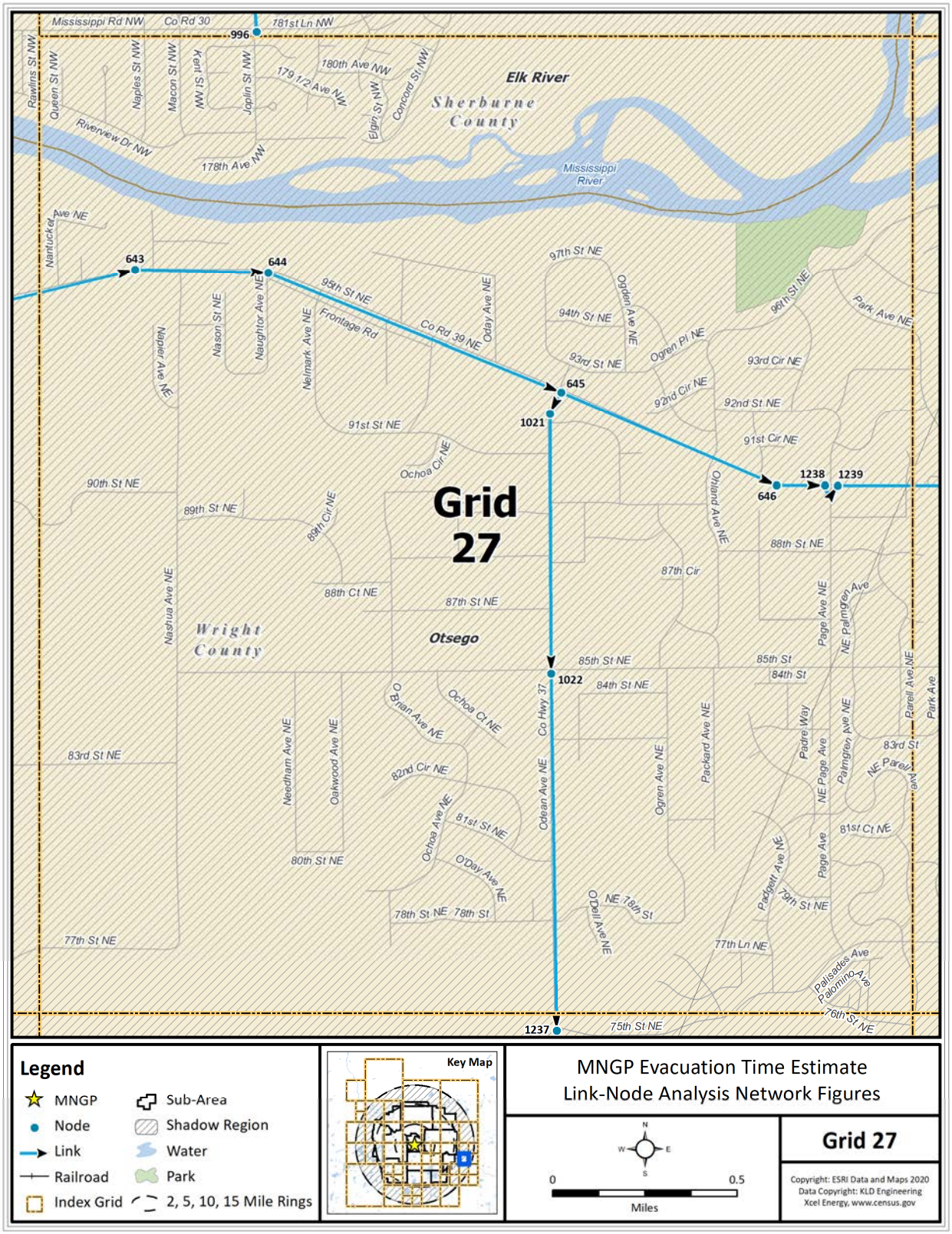


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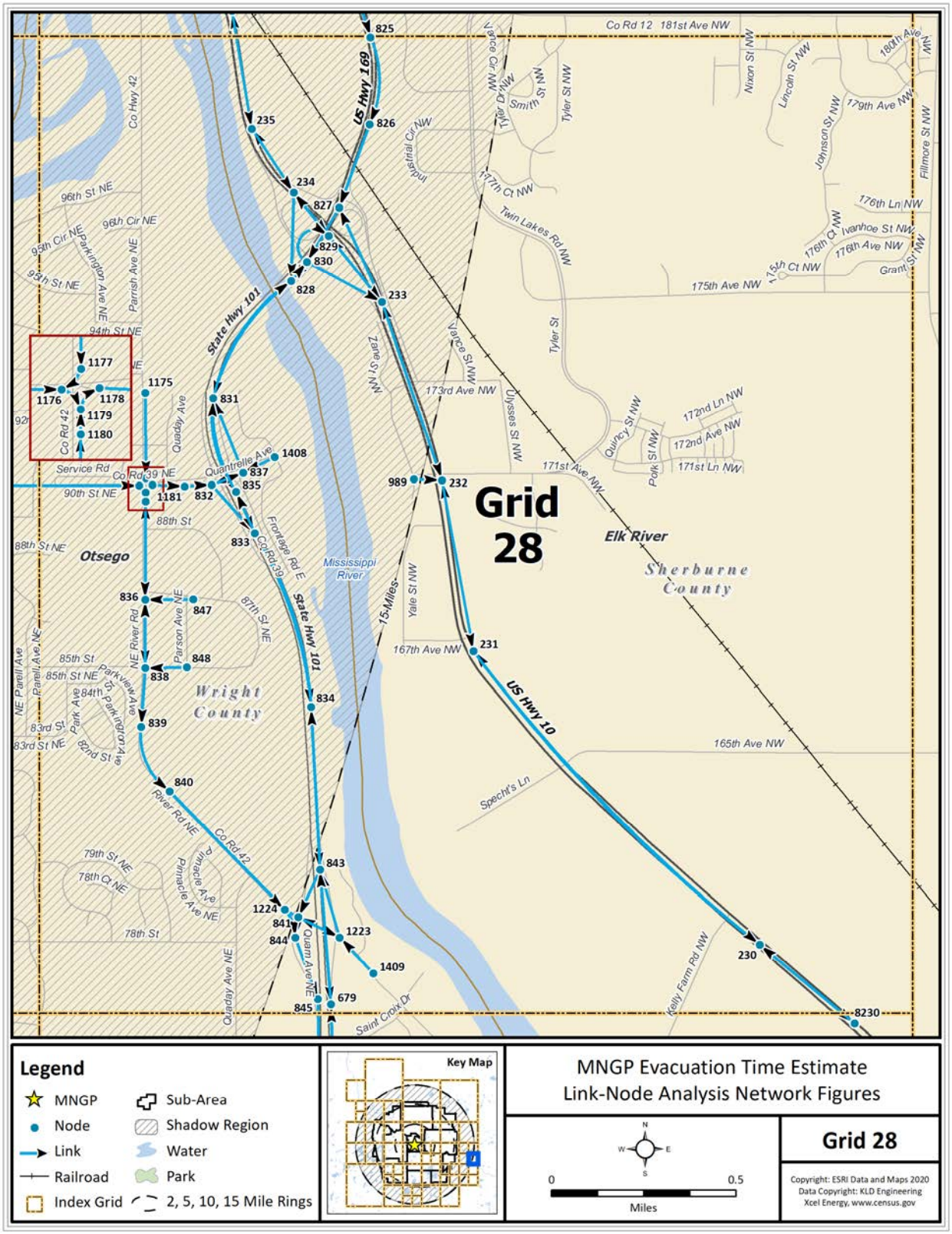


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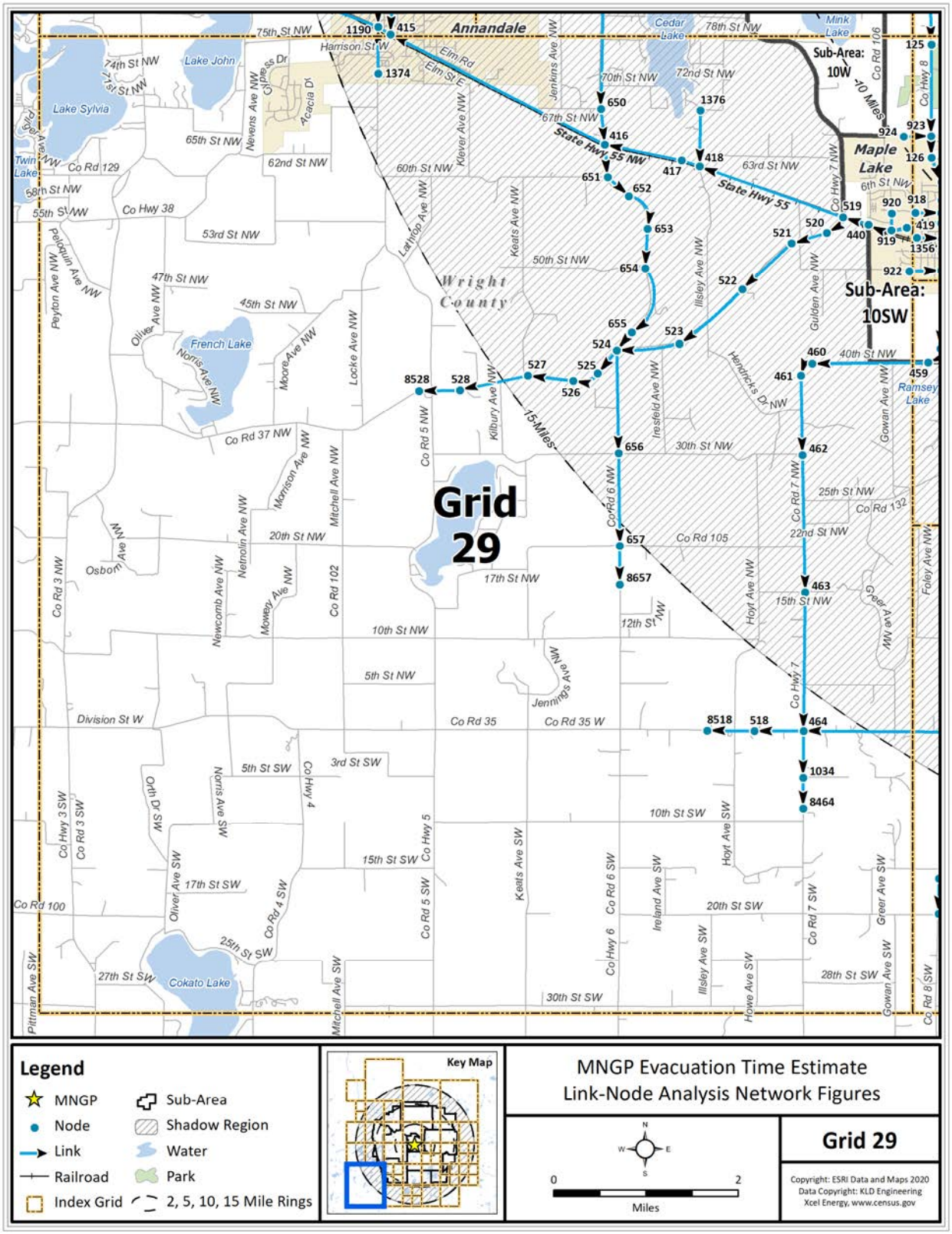


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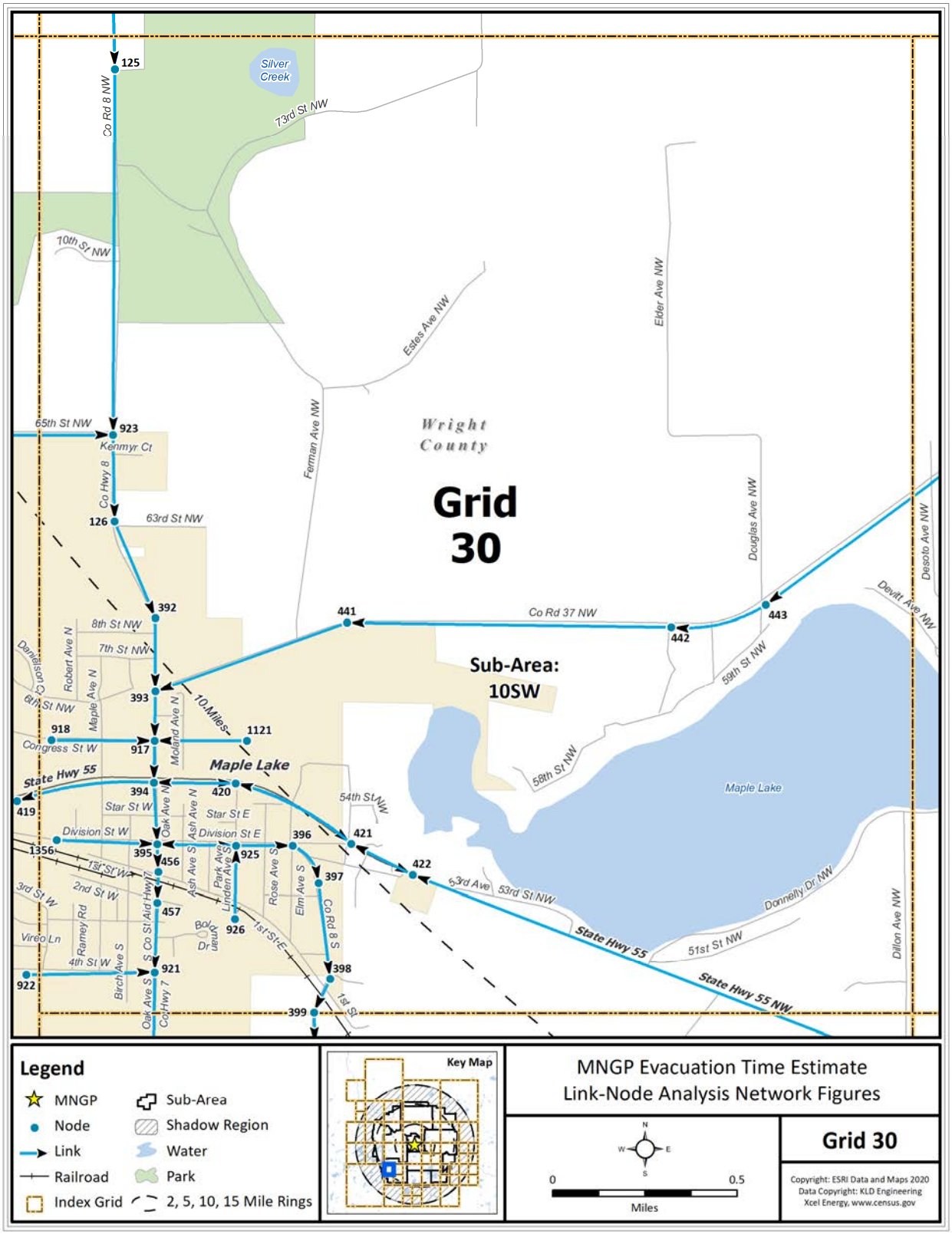


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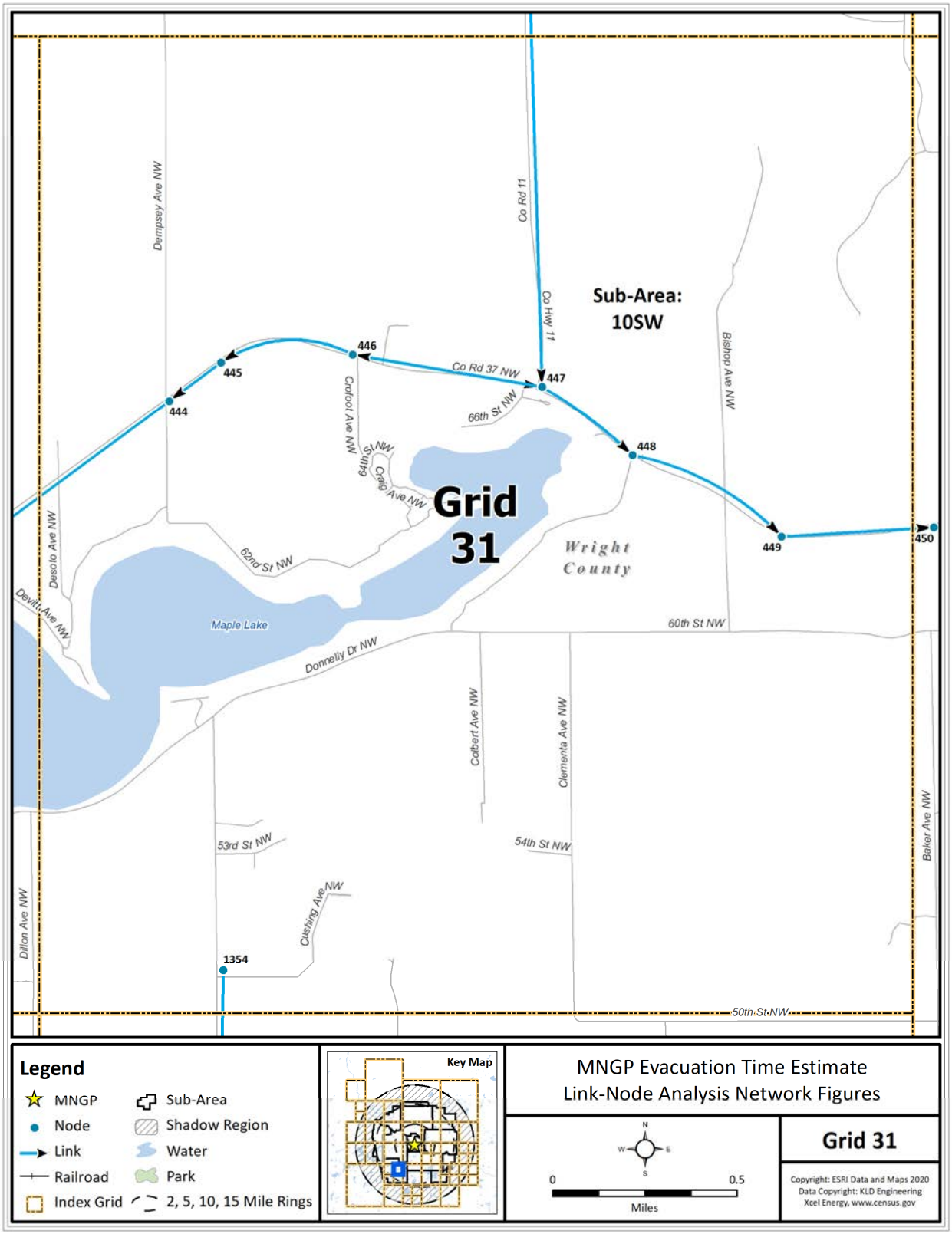


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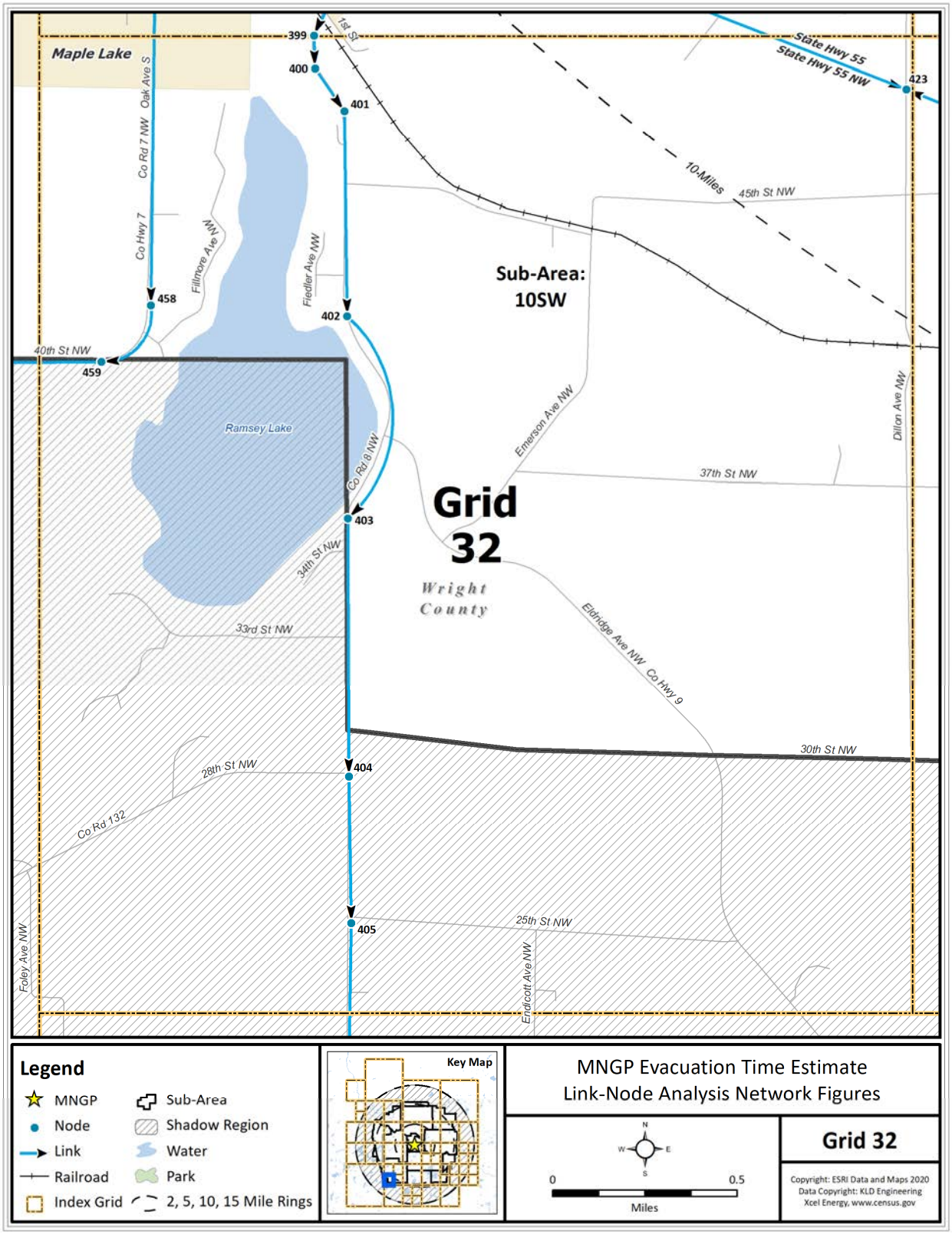


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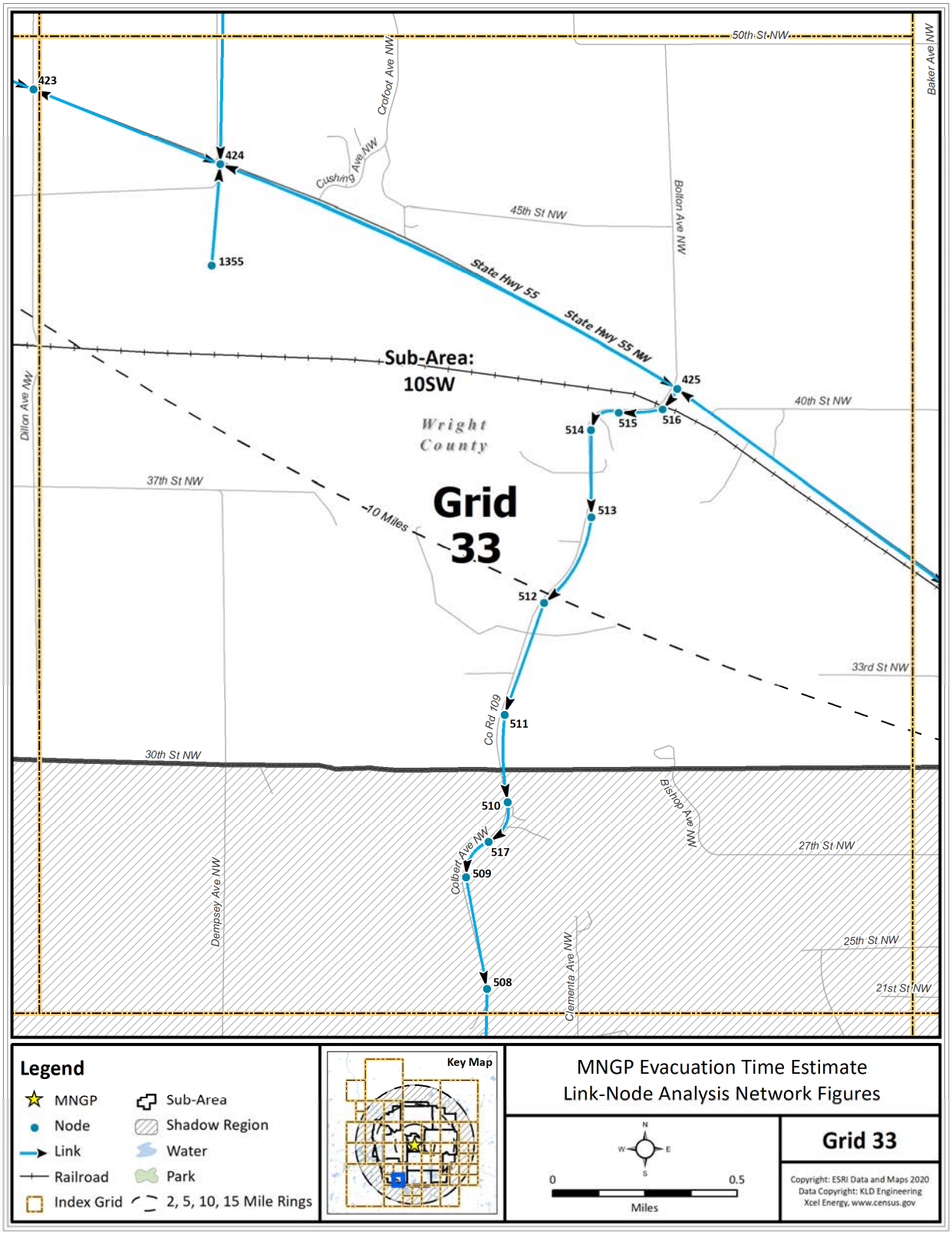


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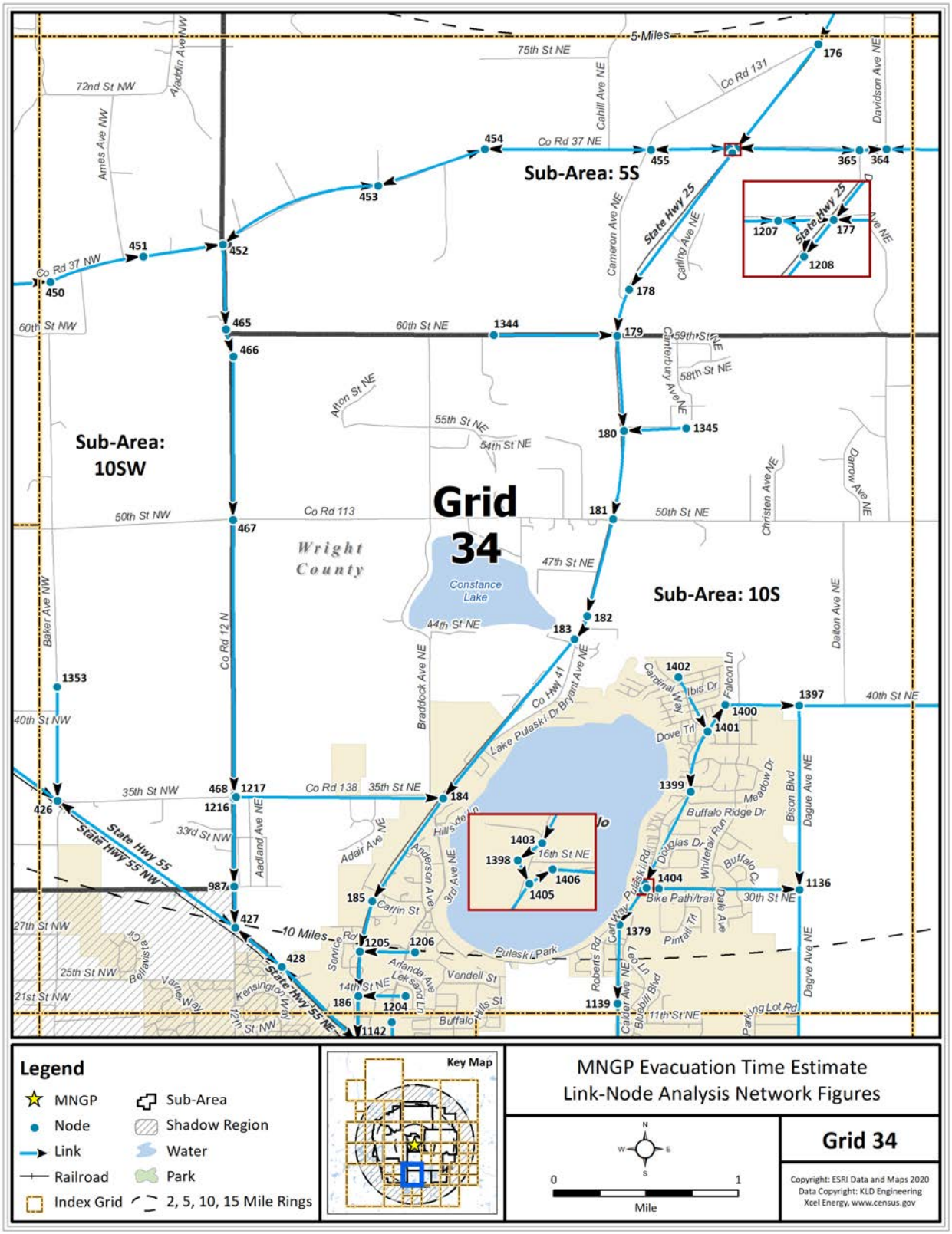


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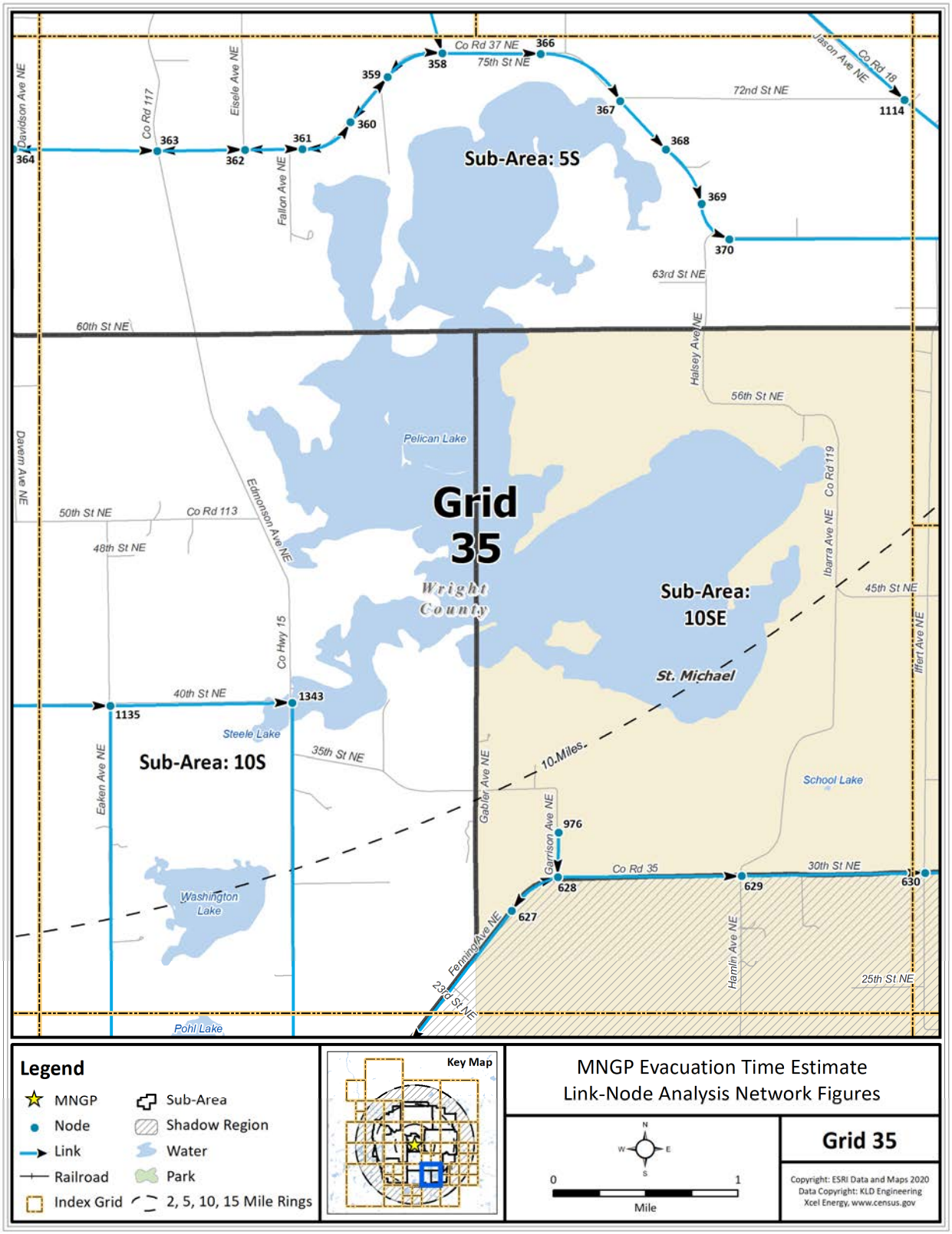


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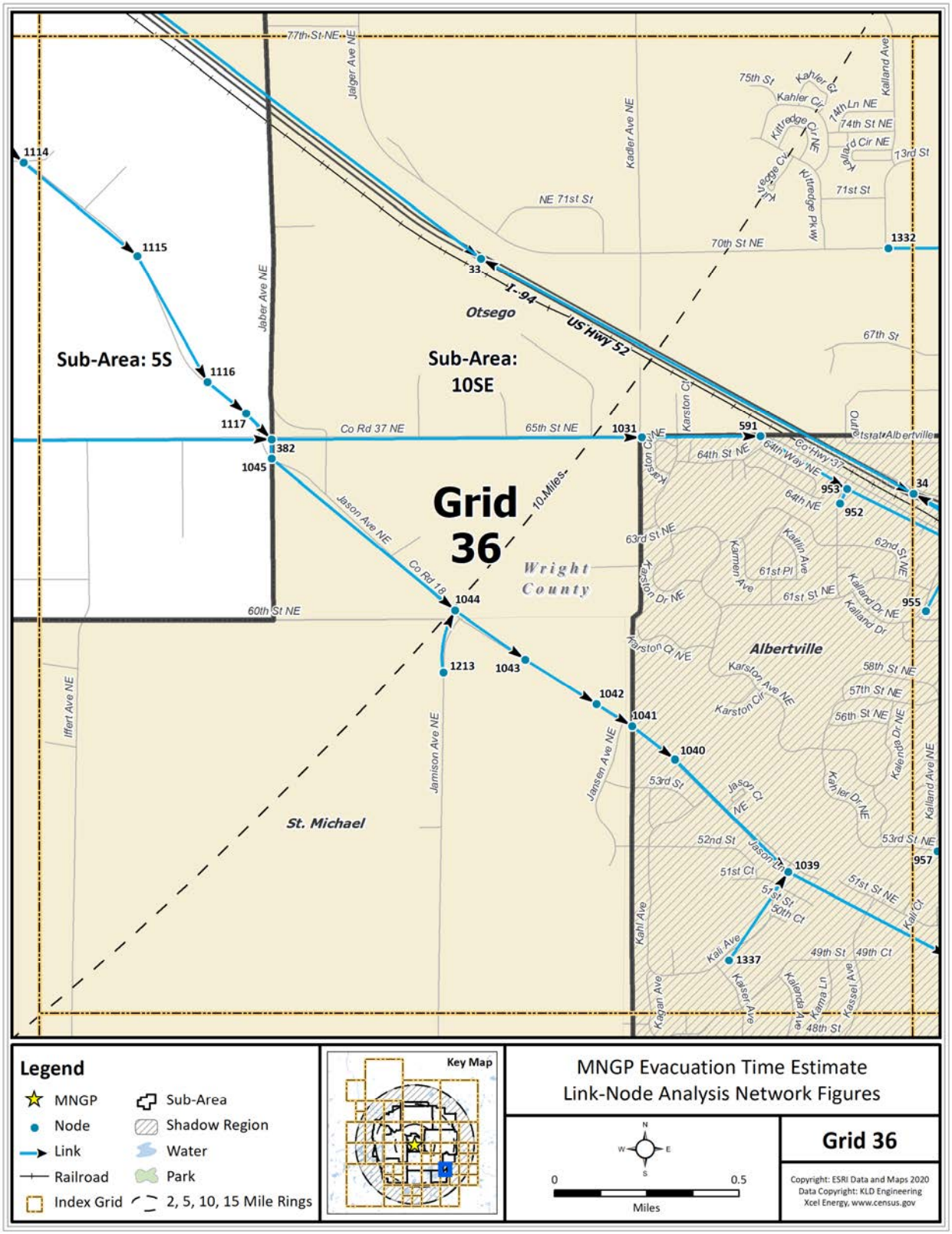


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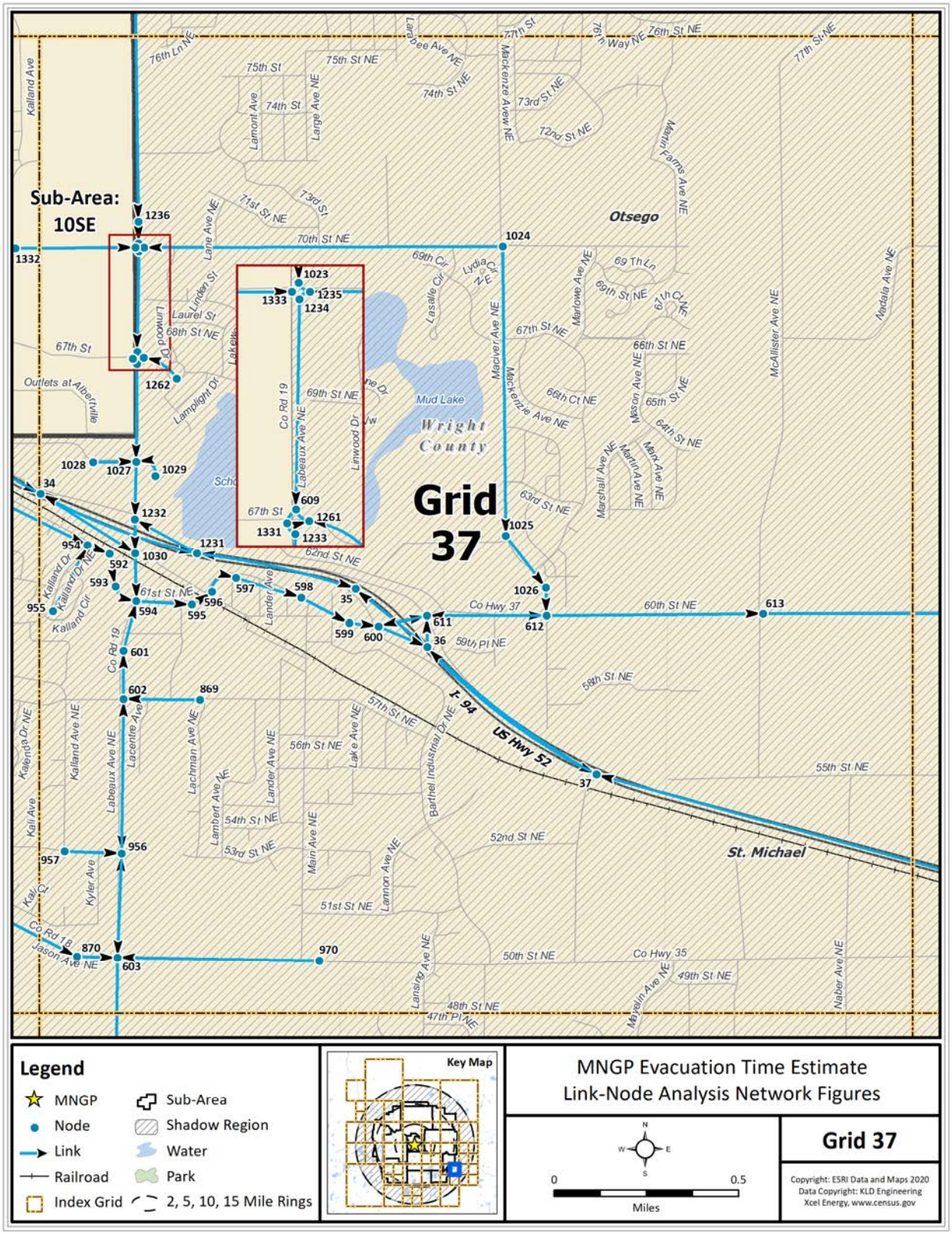


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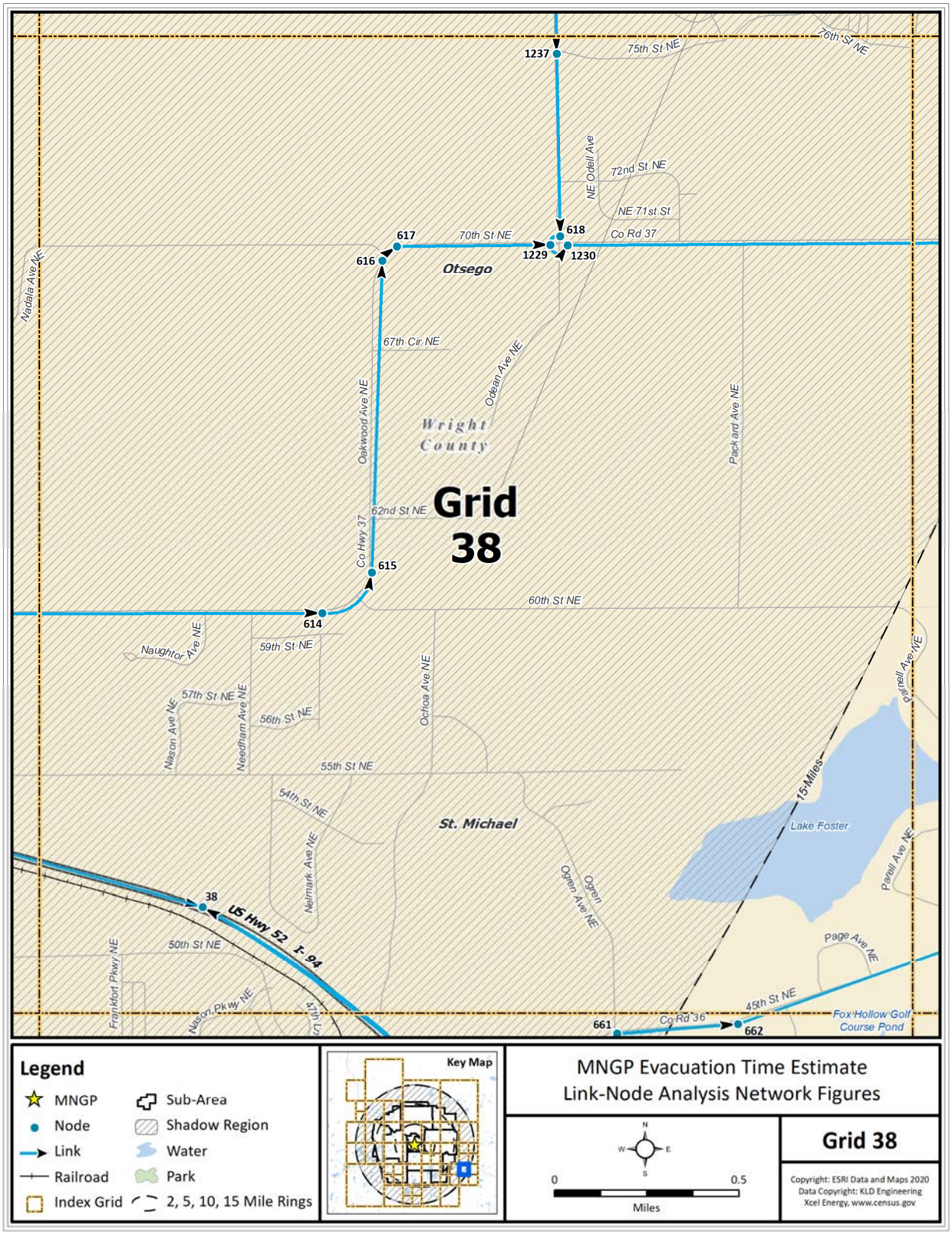


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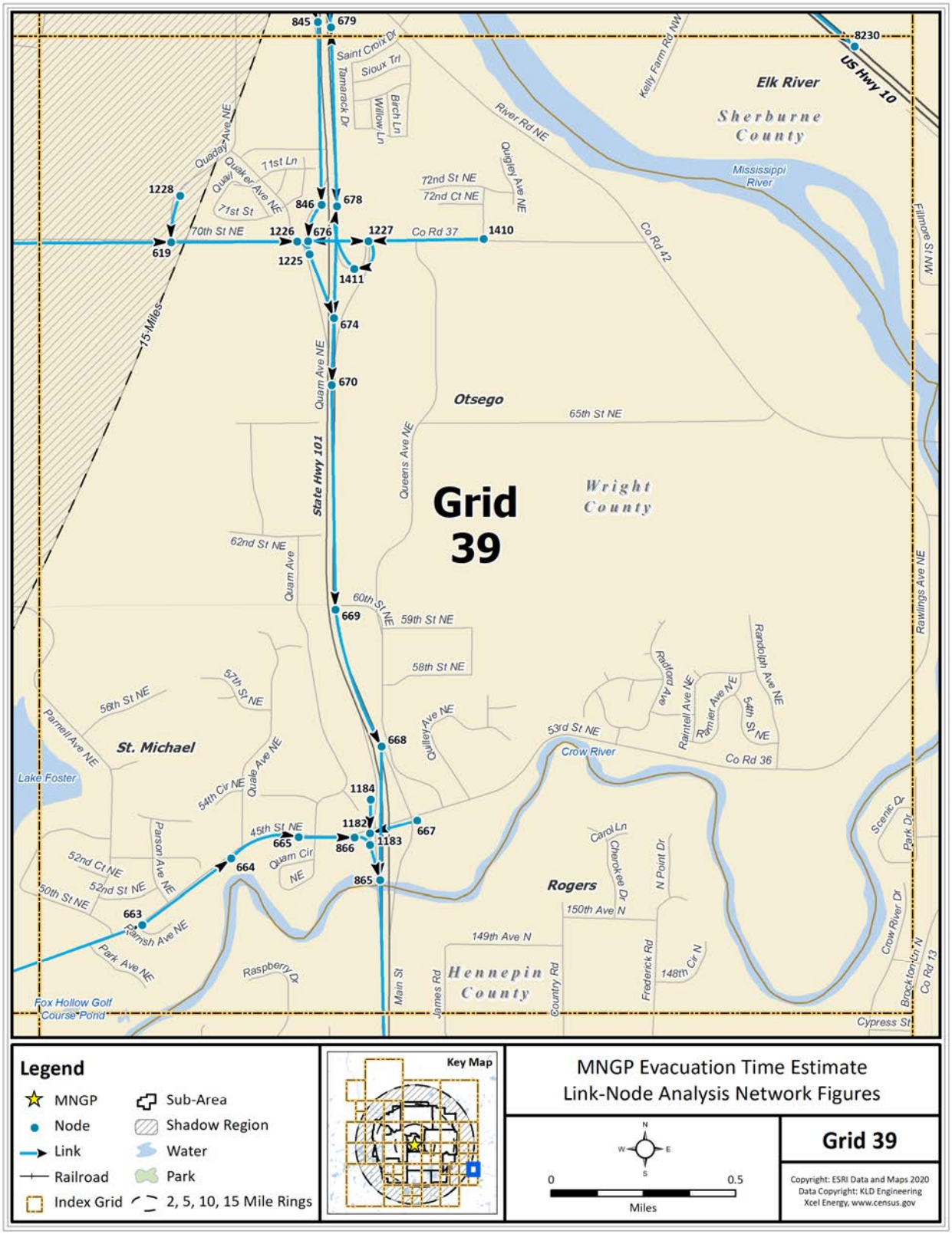


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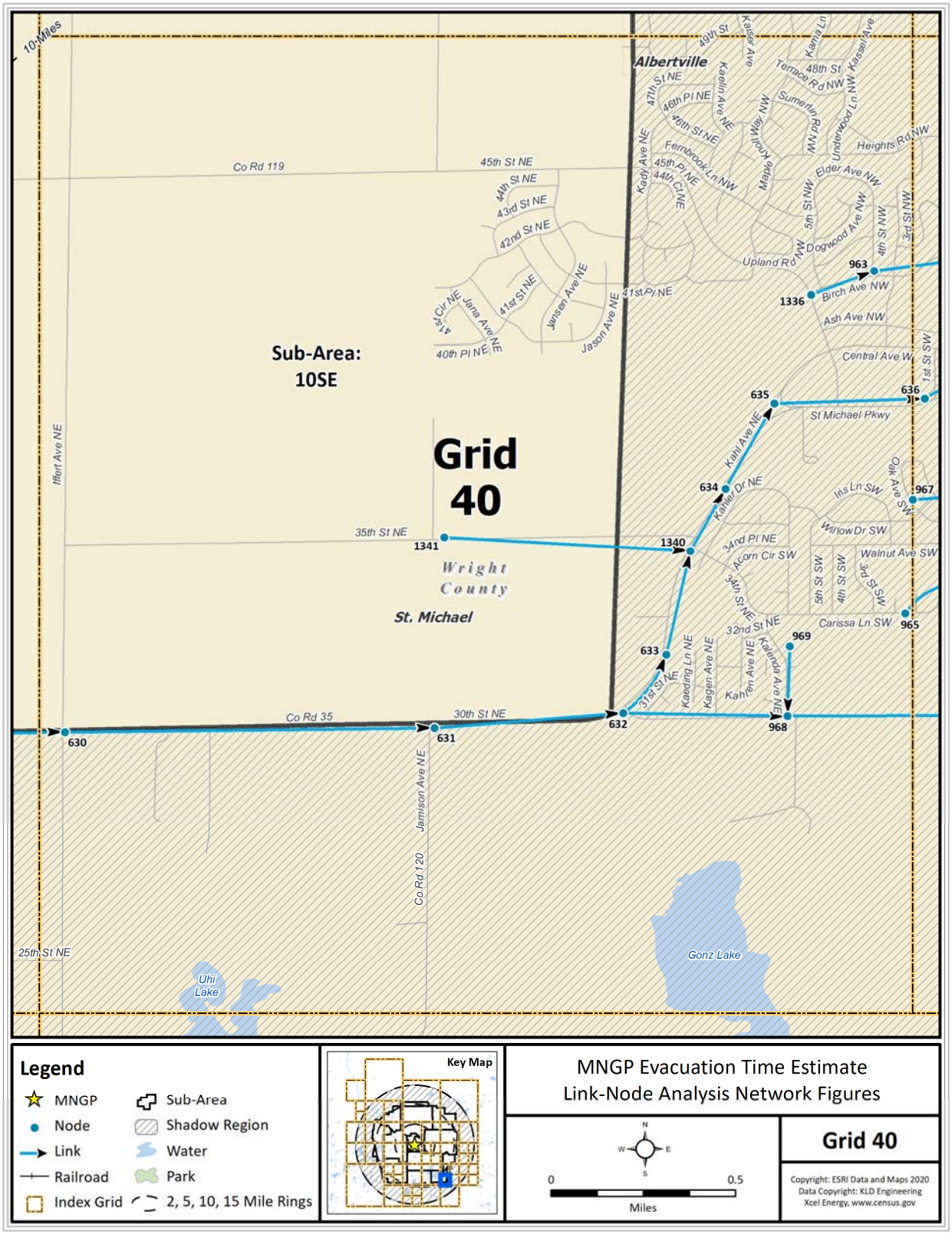


Figure K-41. Link-Node Analysis Network – Grid 40

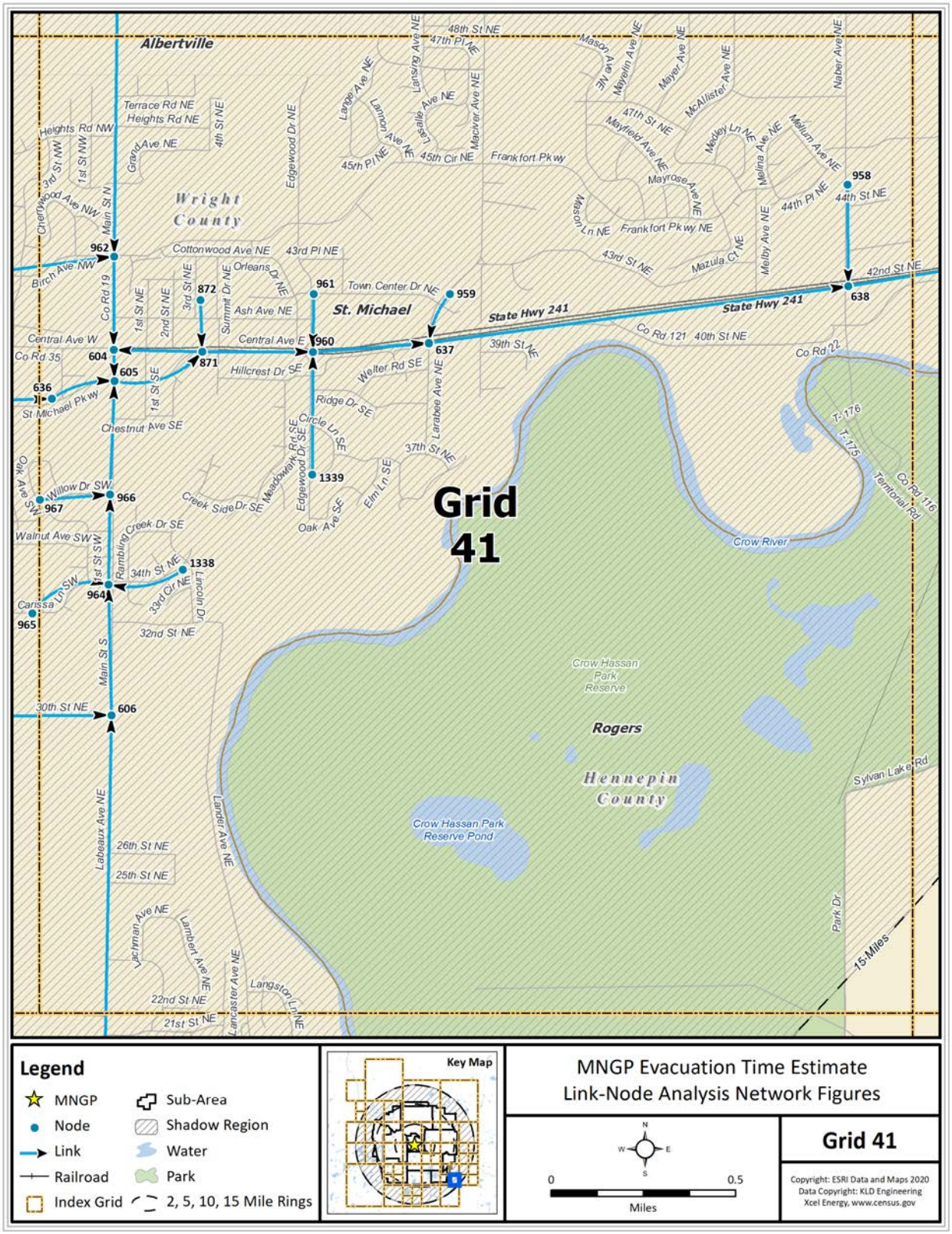


Figure K-42. Link-Node Analysis Network – Grid 41

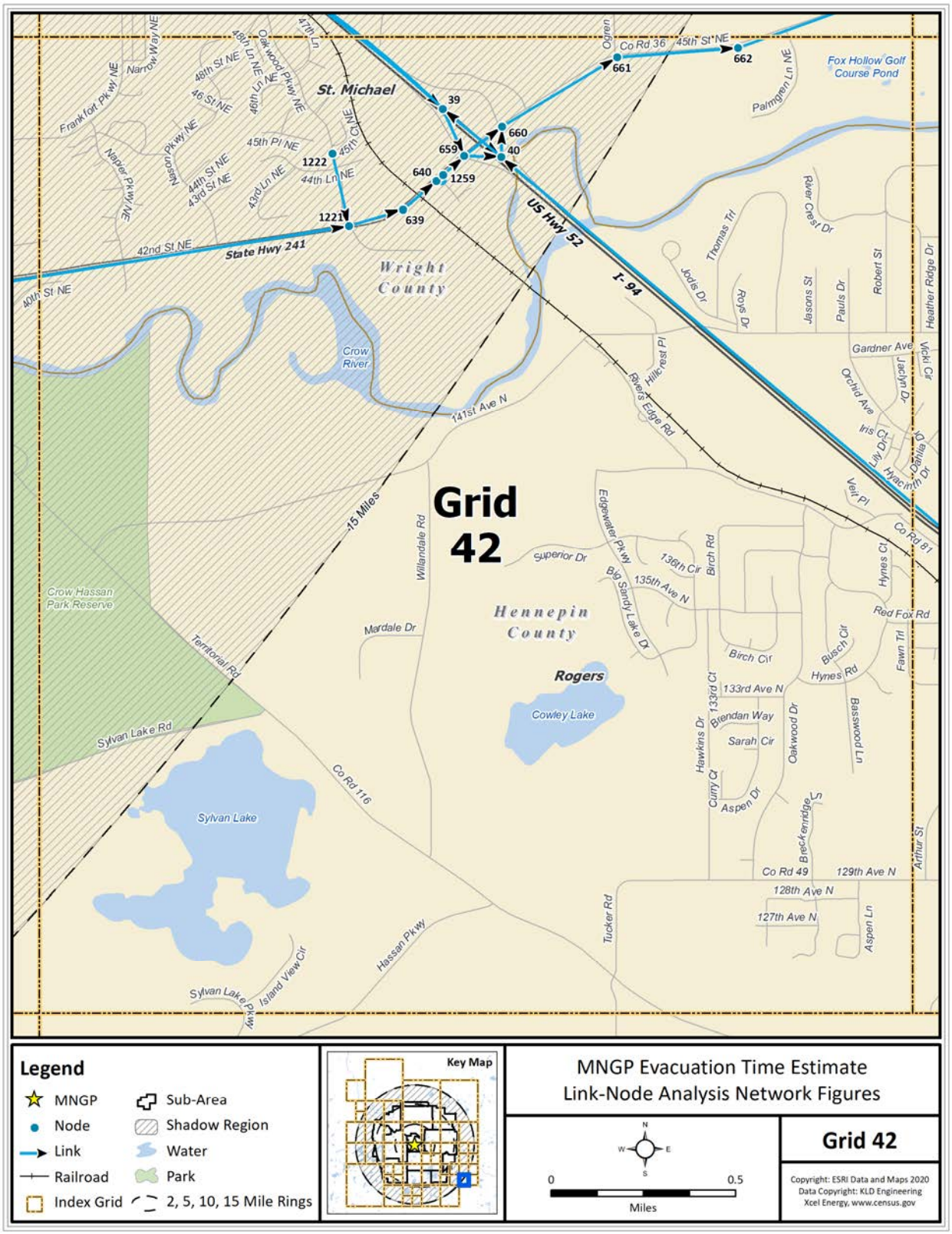


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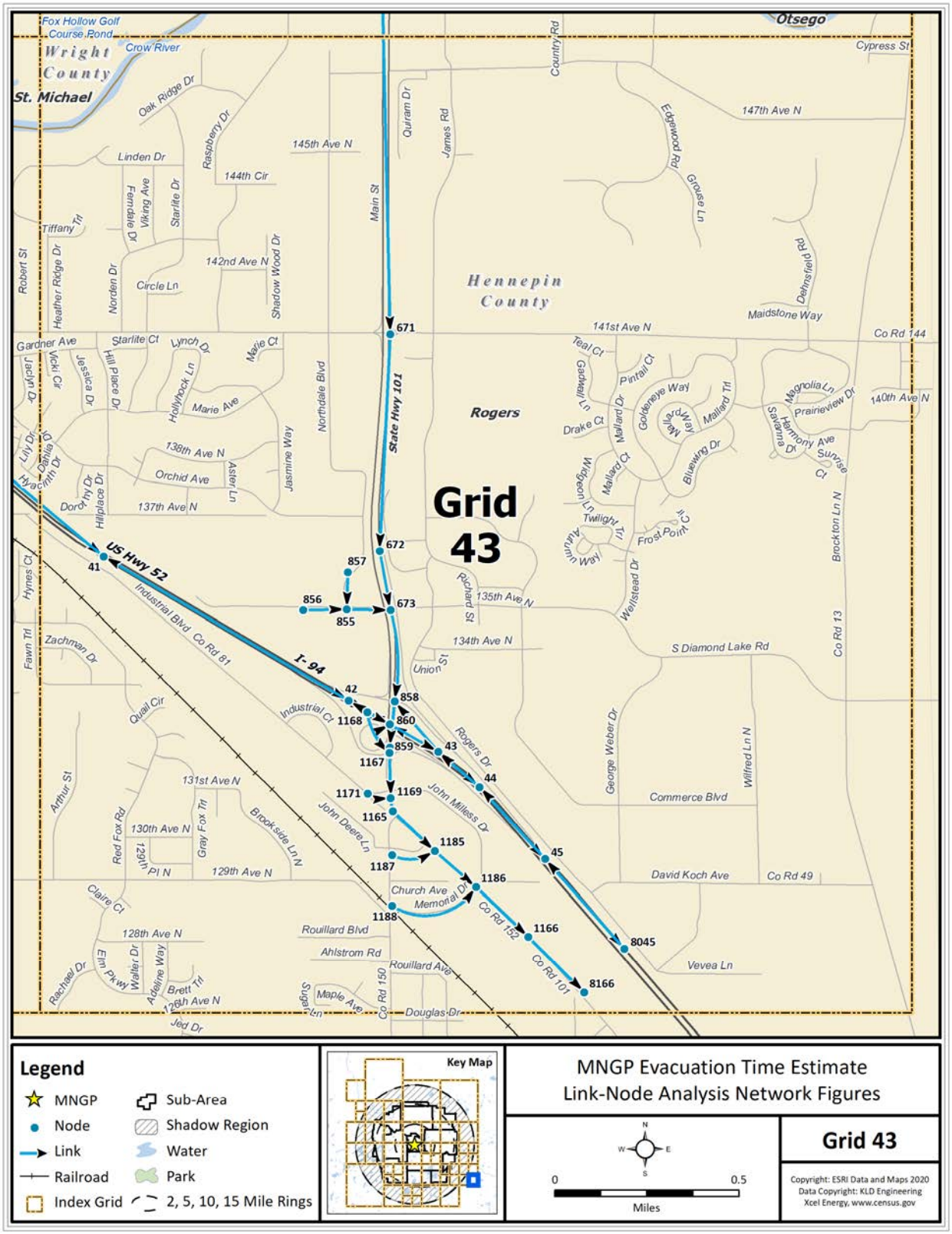


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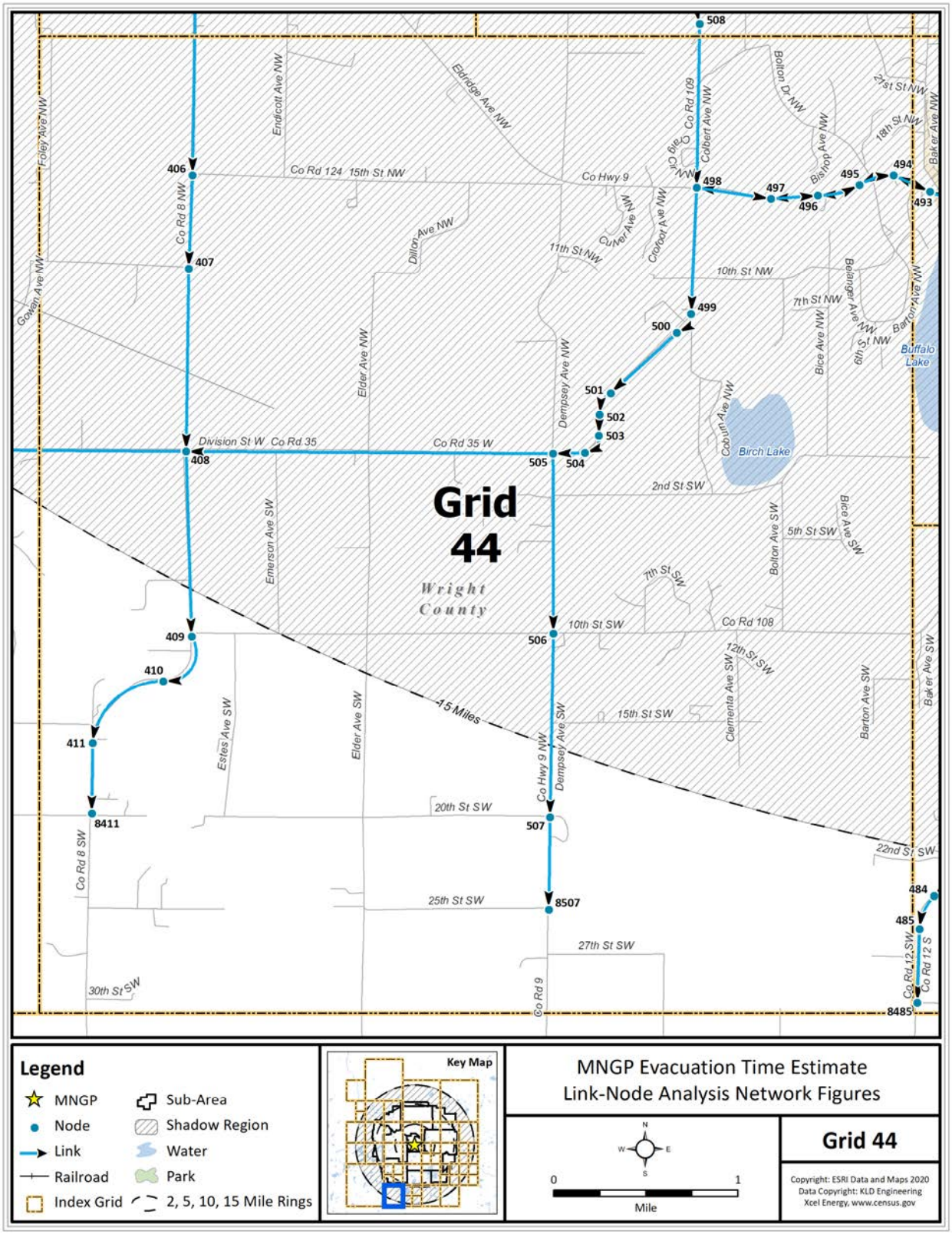


Figure K-45. Link-Node Analysis Network – Grid 44

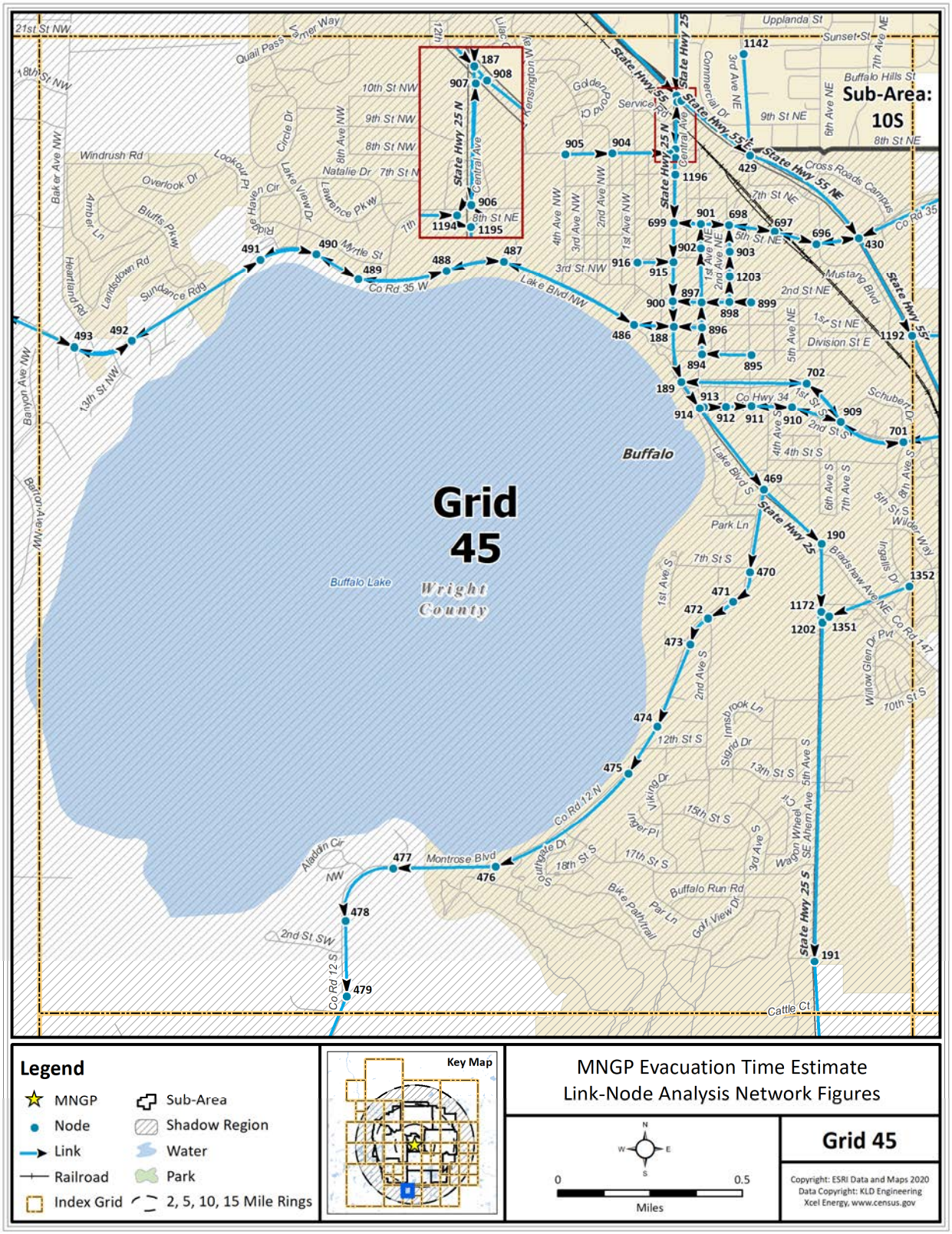


Figure K-46. Link-Node Analysis Network – Grid 45

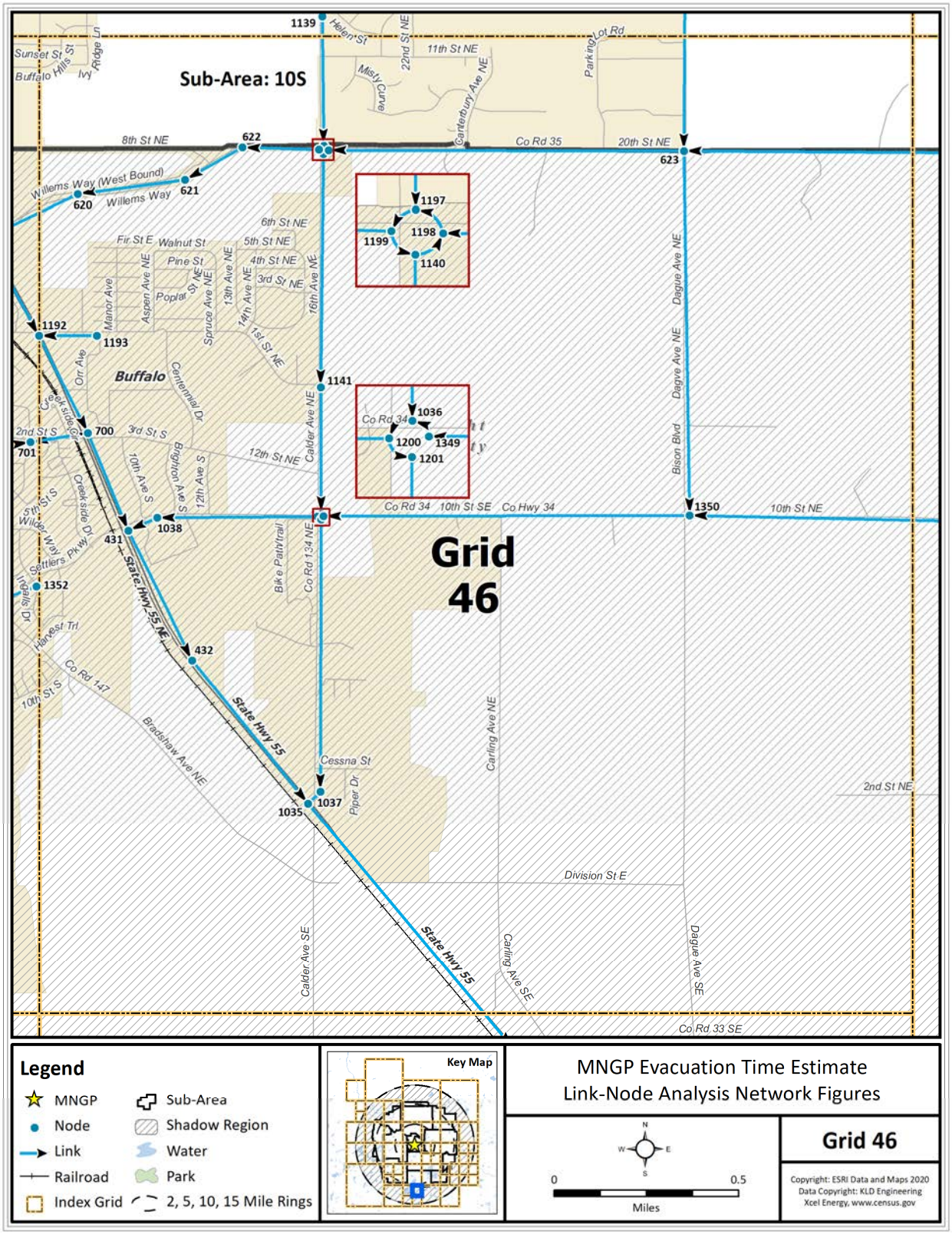


Figure K-47. Link-Node Analysis Network – Grid 46

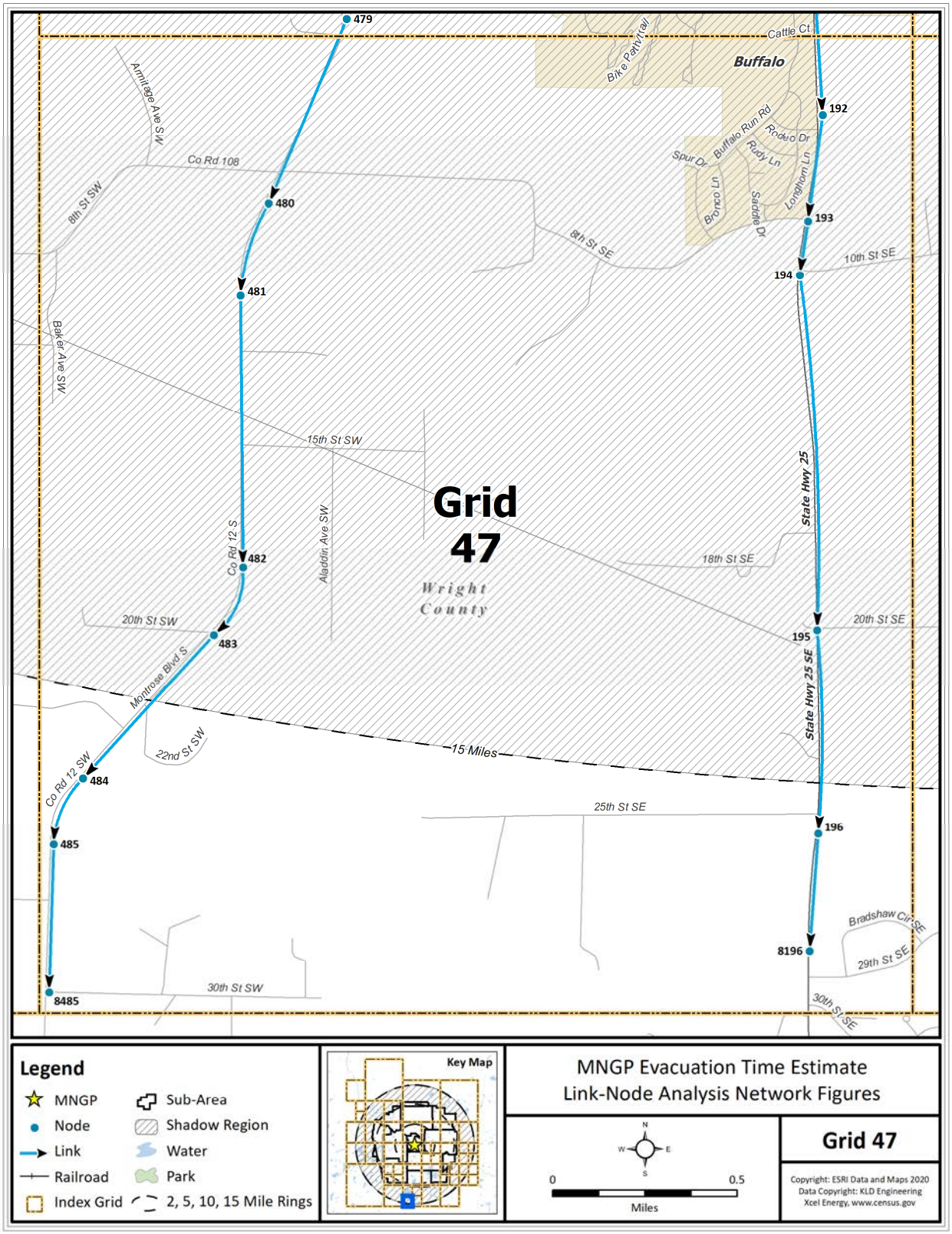


Figure K-48. Link-Node Analysis Network – Grid 47

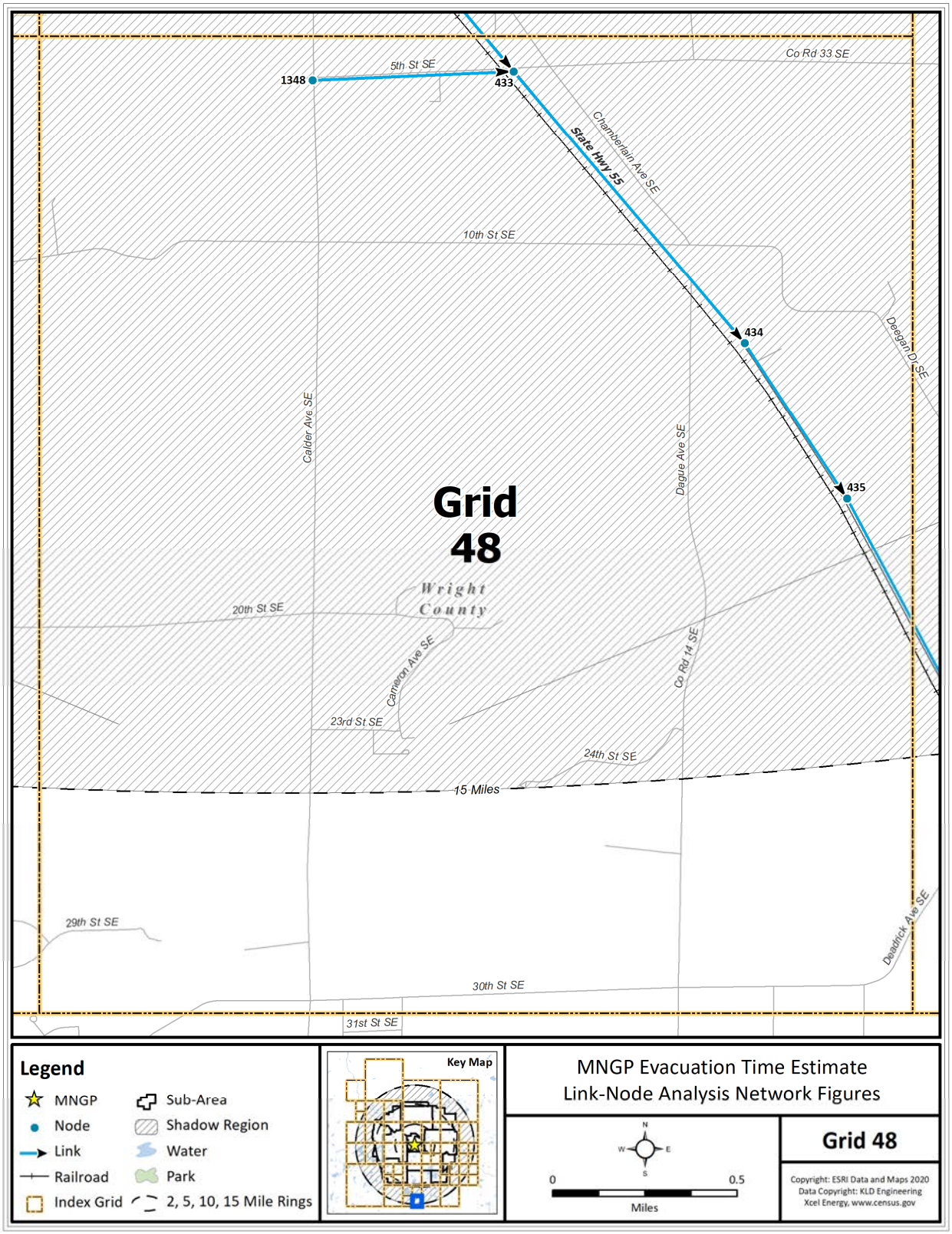


Figure K-49. Link-Node Analysis Network – Grid 48

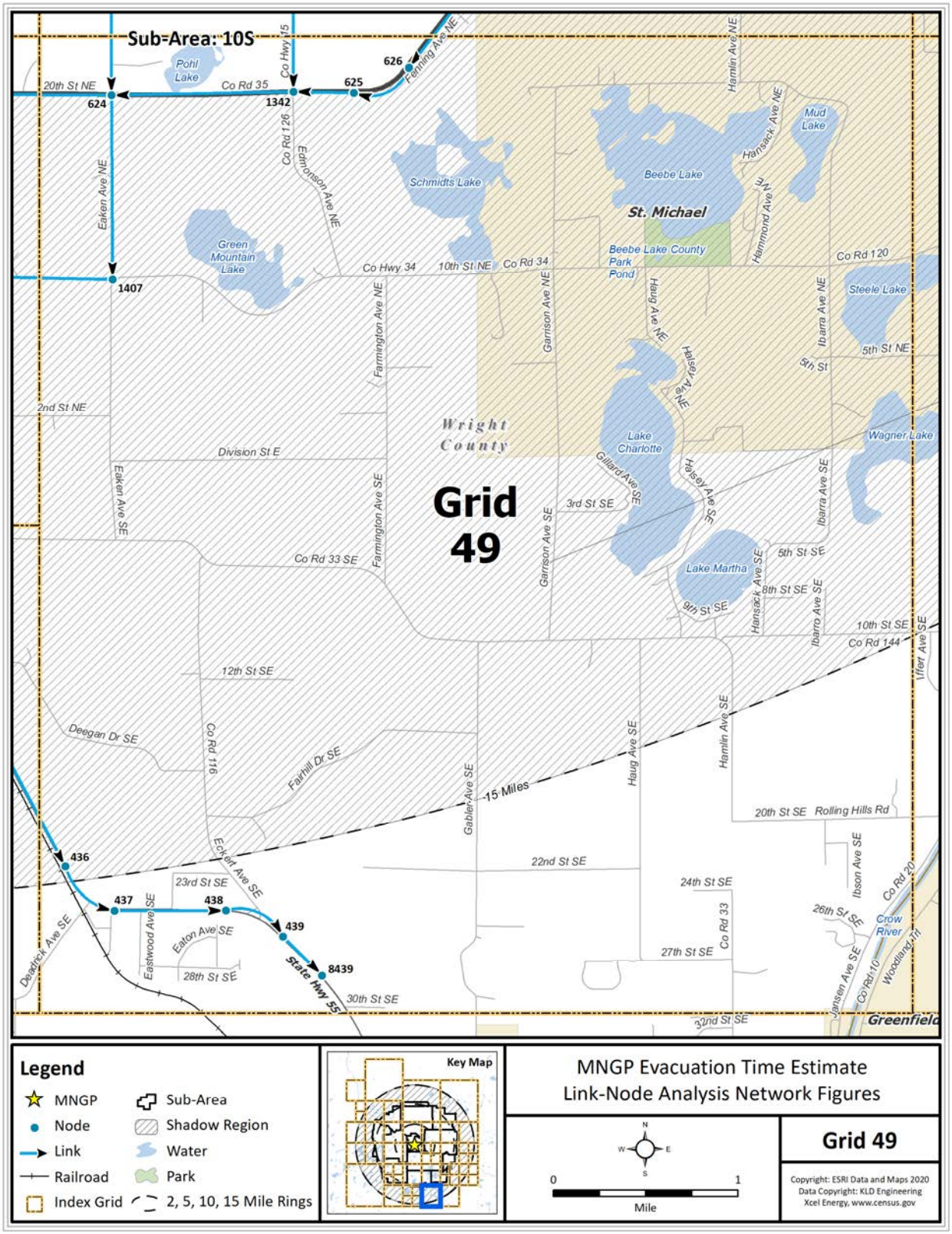


Figure K-50. Link-Node Analysis Network – Grid 49

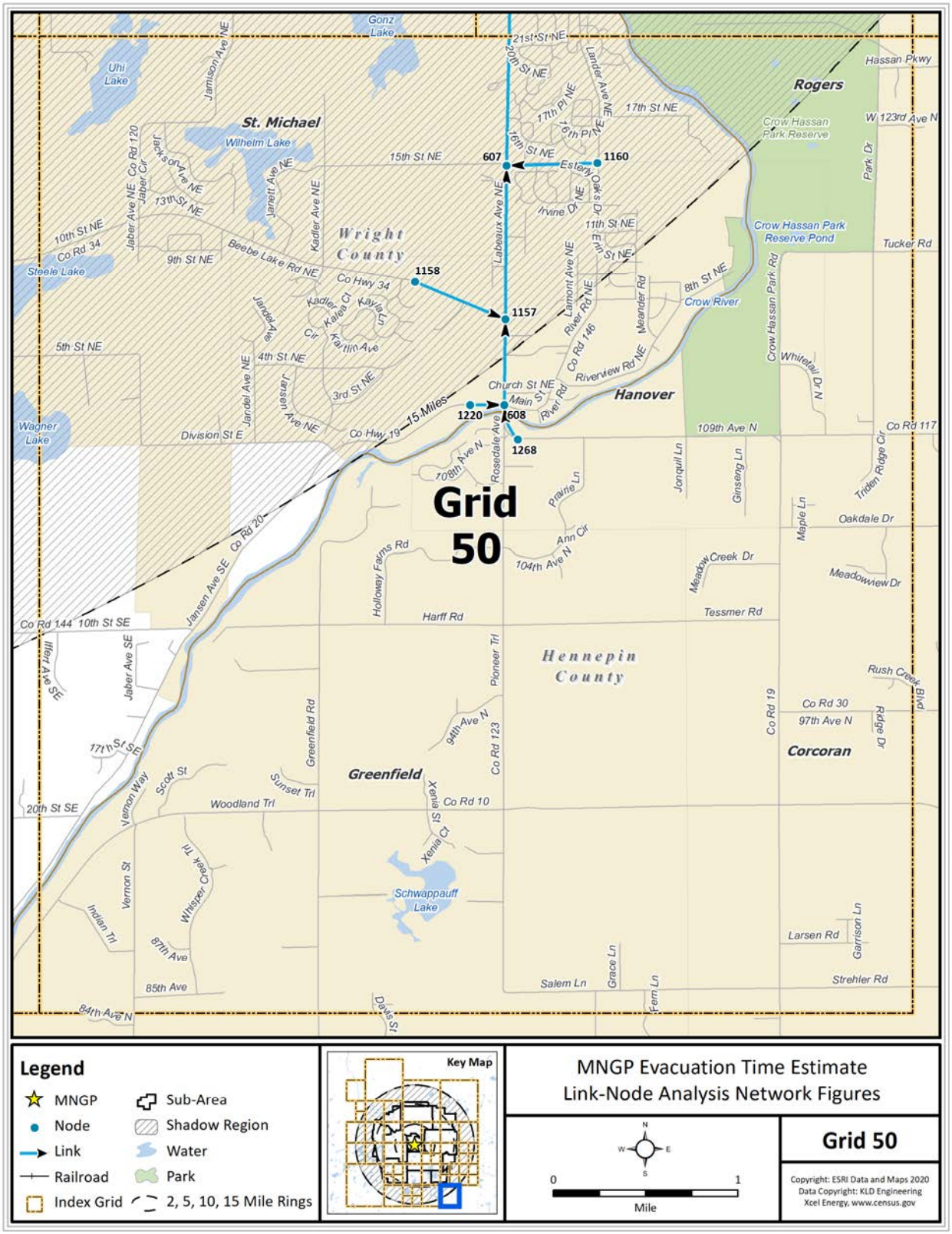


Figure K-51. Link-Node Analysis Network – Grid 50

APPENDIX L

Sub-Area Boundaries

L. SUB-AREA BOUNDARIES

Sub-Area 2

Counties: Sherburne and Wright

Defined as the area within the following boundary: North of County Road 39 (Golf Course Road) and west of Elm Street in Monticello and Monticello Township in Wright County.

West of County Road 50 and south of US Highway 10, 137th Street Southeast and 140th Avenue (Sherburne Avenue) in the southern portion of Becker and Becker Township in Sherburne County.

Sub-Area 5N

County: Sherburne

Defined as the area within the following boundary: Becker and Becker Township in Sherburne County.

Sub-Area 5E

County: Sherburne

Defined as the area within the following boundary: Big Lake and Big Lake Township in Sherburne County.

Sub-Area 5S

County: Wright

Defined as the area within the following boundary: North of County Road 106 (80th & 90th Streets) in the entire city of Monticello and all of Monticello Township in Wright County.

Sub-Area 5W

County: Wright

Defined as the area within the following boundary: Silver Creek Township and the northeast corner of Maple Lake Township in Wright County. This does include Lake Maria State Park.

Sub-Area 10N

County: Sherburne

Defined as the area within the following boundary: South of County Road 16 (57th Street Southeast) and west of Hwy 48 in Santiago Township in Sherburne County.

East of County Road 53 and south of County Road 16 (57th Street Southeast) in Palmer Township in Sherburne County.

Sub-Area 10E County: Sherburne

Defined as the area within the following boundary: The city of Orrock in Sherburne County. This area includes the Sand Dunes Game Refuge.

Sub-Area 10SE County: Wright

Defined as the area within the following boundary: West of County Road 19 in Otsego and Otsego Township in Wright County.

West of County Road 19 and north of County Road 35 in St. Michael Township. This does not include downtown St. Michael or downtown Albertville.

Sub-Area 10S County:

Defined as the area within the following boundary: North of Hwy 55, north of County Road 35, and west of Pelican Lake in the city of Buffalo and Buffalo Township, in Wright County.

Sub-Area 10SW County:

Defined as the area within the following boundary: Maple Lake Township and the city of Maple Lake in Wright County.

Sub-Area 10W County:

Defined as the area within the following boundary: South of the Mississippi River, west of Elder Road, west of Gowan Ave NW, and east of Hwy 24, Ireland road and Illsley Road in Clearwater Township and the city of Clearwater in Wright County.

East of Ireland Road and 91st street, east of Hwy 7 (south of County 39) and west of Gowan Ave NW in Corrina Township in Wright County.

Sub-Area 10NW County:

Defined as the area within the following boundary: South and east of State Highway 24 and the Clear Lake city limits in Clear Lake Township in Sherburne County. This area does not include the city of Clear Lake.

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 EPZ. Specifically, if the tail of the mobilization distribution were truncated (i.e., if those who responded most slowly to the Advisory to Evacuate (ATE), could be persuaded to respond much more rapidly) or if the tail were elongated (i.e., spreading out the departure of evacuees to limit the demand during peak times), how would the ETE be affected? The case considered was Scenario 6, Region 3; a winter, midweek, midday, with good weather evacuation of the entire EPZ. Table M-1 presents the results of this study.

If evacuees mobilize one hour quicker, the 90th percentile ETE is reduced by 10 minutes (a slight change) and the 100th percentile ETE is reduced by 30 minutes (a significant change), respectively. If evacuees mobilize one hour slower, the 90th and 100th percentile ETE are increased by 40 minutes and 1 hour, respectively – a significant change.

As discussed in Section 7.3, traffic congestion persists within the EPZ for about 3 hours and 45 minutes after the ATE. As such, the ETE at the 100th percentile are impacted by increases in trip generation times since the base trip generation time dictates the 100th percentile ETE beyond 3 hours and 45 minutes. Reductions in the trip generation time, however, that result in mobilization times less than 3 hours and 45 minutes can impact 100th percentile ETE. In this case, the compression of trip generation time to 3 hours and 30 minutes reduces the 100th percentile ETE until the time that congestion clears. When trip generation is compressed, more vehicles get on the road more quickly and this can overwhelm the roadway system, creating more congestion. As a result, not only is the 100th percentile ETE dictated by congestion, it actually takes longer to clear that congestion further elongating the 100th percentile ETE. The 90th percentile ETE, however, are relatively insensitive to truncating the tail of the mobilization time distribution.

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 3; a winter, midweek, midday, with 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 Section 3.2 and Section 7.1 for additional information on population within the Shadow Region.

Table M-2 presents the ETE for each of the cases considered. The results show that eliminating (0%), the shadow evacuation has no effect on the 90th and 100th percentile ETE. Doubling (40%) the shadow evacuation increases the 90th percentile ETE by 5 minutes and has no impact on the 100th percentile ETE. Tripling (60%) the shadow evacuation increases the 90th percentile ETE and 100th

percentile ETE by 10 minutes and 35 minutes, respectively. Increasing the shadow evacuation to 80% increases the 90th percentile ETE and 100th percentile ETE by 15 minutes and 1 hour, respectively. A full shadow evacuation (100%) increases the 90th percentile ETE by 20 minutes and increases the 100th percentile ETE by 1 hour and 50 minutes.

Note the demographic survey results presented in Appendix F indicate that 19% of households would elect to evacuate if advised to shelter, which is comparable to the base assumption of 20% non-compliance suggested in the NUREG/CR-7002, Rev. 1.

Reducing the shadow evacuation has little impact on ETE because the traffic congestion in the major population centers within the EPZ is significant and trip generation dictates the ETE. Increasing the shadow evacuation, however, does have a significant impact on ETE because the additional vehicles (specifically in Rogers, Elk River, and Buffalo) using roadways outside the EPZ reduces the available roadway capacity for EPZ evacuees thereby exacerbating the traffic congestion in the major population centers within the EPZ.

M.3 Effect of Changes in the Permanent Resident Population

A sensitivity study was conducted to determine the effect on ETE due to changes in the permanent resident population within the study area (EPZ plus Shadow Region). As population in the study area changes over time, the time required to evacuate the public may increase, decrease, or remain the same. Since the ETE is related to the demand to capacity ratio present within the study area, changes in population will cause the demand side of the equation to change and could impact ETE.

As per the NRC's response to the Emergency Planning Frequently Asked Question (EPFAQ) 2013-001, the ETE population sensitivity study must be conducted to determine what percentage increase in permanent resident population causes an increase in the 90th percentile ETE of 25% or 30 minutes, whichever is less. The sensitivity study must use the scenario with the longest 90th percentile ETE (excluding the roadway impact scenario and the special event scenario if it is a one day per year special event).

Thus, the sensitivity study was conducted using the following planning assumptions:

1. The percent change in population within the study area was increased by up to 24%. Changes in population were applied to permanent residents only (as per federal guidance), in both the EPZ and the Shadow Region.
2. The transportation infrastructure (as presented in Appendix K) remained fixed; the presence of future proposed roadway changes and/or highway capacity improvements were not considered.
3. The study was performed for the 2-Mile Region (R01), 5-Mile Region (R02) and the Entire EPZ (R03).

The scenario (excluding roadway impact and special event) which yielded the longest 90th percentile ETE values was selected as the case to be considered in this sensitivity study (Scenario 8 – Winter, Midweek, Midday with Heavy Snow). Table M-3 results of the sensitivity study. Section IV of Appendix E to 10 CFR Part 50, and NUREG/CR-7002, Rev. 1, Section 5.4, require

licensees to provide an updated ETE analysis to the NRC when a population increase within the EPZ causes the longest 90th percentile ETE values (for the 2-Mile, 5-Mile Region or entire EPZ) to increase by 25% or 30 minutes, whichever is less. The base ETE for the 2-Mile Region (R01), 5-Mile Region (R02) and for the Entire EPZ (R03) are greater than 2 hours; thus, 25% of these base ETE is always greater than 30 minutes. Therefore, the R01, R02, and R03 criterion for updating is 30 minutes.

Those percent population changes which result in changes to the longest 90th percentile ETE greater than or equal to 30 minutes are highlighted in red in Table M-3 – a 24% or greater increase in the Entire EPZ permanent resident population (includes 20% of the Shadow Region permanent resident population). Xcel Energy will have to estimate the full EPZ population on an annual basis. If the entire EPZ population increases by 24% or more, an updated ETE analysis will be needed.

M.4 Effect of Changes in Average Household Size

As discussed in Appendix F, the average household size obtained from the results of the demographic survey is 3.23 people per household. The 2020 census indicates an average household size of 2.82 people per household. The difference between the Census data and survey data is 14.5%, which exceeds the sampling error of 4.93%. Upon discussions with Xcel Energy, it was decided that the 2020 Census estimate of 2.82 people per household would be used in the study. A sensitivity study was performed to determine how sensitive the ETE is to changes in the average household size. It should be noted that only resident and shadow vehicles were changed for this sensitivity study. The case considered was Scenario 6, Region 3; a winter, midweek, midday, with good weather evacuation of the 2-mile region, 5-mile region, and entire EPZ. Table M-4 presents the results of this study.

Increasing the average household size (decreasing the total number evacuating vehicles) to 3.23 people per household decreases in the 90th percentile ETE by 10 minutes at most and has no impact on the 100th percentile ETE. The difference in vehicles is about 10% of the total evacuating traffic (7,100 vehicles of 70,340 vehicles for this scenario – see Table 6-4). This 10% reduction in evacuating vehicles decreases congestion, and therefore ETE, but not substantially.

As previously mentioned, the ETE is dictated by trip mobilization time at the 100th percentile. As a result, regardless of the reduction in vehicles, the 100th percentile ETE will remain the same.

M.5 Enhancements in Evacuation Time

This appendix documents sensitivity studies on critical variables that could potentially impact ETE. Possible improvements to ETE are further discussed below:

- Prolonging the trip generation time by an hour significantly impacts the 90th and 100th percentile ETE since the trip generation time dictates ETE (Section M.1). Public outreach encouraging evacuees to mobilize more quickly or in a timely manner could decrease ETE.
- Increasing the shadow evacuation percent has a significant impact on ETE (Section M.2). Public outreach could be considered to inform those people within the EPZ (and potentially beyond the EPZ) that if they are not advised to evacuate, they should not.

- Population growth results in more evacuating vehicles, which could significantly increase ETE (Section M.3). Public outreach to inform people within the EPZ to evacuate as a family in a single vehicle would reduce the number of evacuating vehicles and could reduce ETE or offset the impact of population growth.
- Increasing the average household size (decreasing the total number of evacuating vehicles) has minimal impact on the 90th or 100th percentile ETEs, as the trip generation dictates the ETE after 4 hours and 30 minutes. (Section M.4). Thus, public outreach to inform people within the EPZ to evacuate as a family in a single vehicle would reduce the number of evacuating vehicles and could reduce the 90th percentile ETE.

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

Trip Generation Period	Evacuation Time Estimate for Entire EPZ	
	90th Percentile	100th Percentile
3 Hours and 30 Minutes	2:55	4:10
4 Hours and 30 Minutes (Base)	3:05	4:40
5 Hours and 30 Minutes	3:45	5:40

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

Percent Shadow Evacuation	Evacuating Shadow Vehicles[1]	Evacuation Time Estimate for Entire EPZ	
		90th Percentile	100th Percentile
0	0	3:05	4:40
20 (Base)	11,175	3:05	4:40
40	22,350	3:10	4:40
60	33,525	3:15	5:15
80	44,700	3:20	5:40
100	55,875	3:25	6:30

[1] The Evacuating Shadow Vehicles in Table M-2 represent the residents and employees who will spontaneously decide to relocate from the Shadow Region during the evacuation. The basis for the values shown is a 20% relocation of shadow residents along with a proportional percentage of shadow employees. See Section 6 for further discussion.

Table M-3. Evacuation Time Estimates for Variation with Population Change

EPZ and 20% Shadow Permanent Resident Population	Base	Population Change		
		22%	23%	24%
	94,157	114,872	115,814	116,755
ETE (hrs:mins) for the 90th Percentile				
Region	**Base**	**Population Change**		
		22%	**23%**	**24%**
2-Mile Region (R01)	2:15	2:15	2:15	2:15
5-Mile Region (R02)	3:35	3:55	3:55	3:55
Entire EPZ (R03)	3:45	4:05	4:10	**4:15**
ETE (hrs:mins) for the 100th Percentile				
Region	**Base**	**Population Change**		
		22%	**23%**	**24%**
2-Mile Region (R01)	5:30	5:30	5:30	5:30
5-Mile Region (R02)	5:35	5:50	5:55	5:55
Entire EPZ (R03)	5:40	6:15	6:15	6:20

Table M-4. ETE Results for Change in Average Household Size

EPZ and 20% Shadow Resident Vehicles	Base (Average HH Size of 2.82 people per household)	Average HH Size of 3.23 people per household
	55,936	48,836
ETE for 90th Percentile		
2-MILE	2:05	2:05
5-MILE	2:55	2:45
FULL EPZ	3:05	2:55
ETE for 100th Percentile		
2-MILE	4:35	4:35
5-MILE	4:40	4:40
FULL EPZ	4:40	4:40

APPENDIX N

ETE Criteria Checklist

N. ETE CRITERIA CHECKLIST

Table N-1. ETE Review Criteria Checklist

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
1.0 Introduction		
a. The emergency planning zone (EPZ) and surrounding area is described.	Yes	Section 1
b. A map is included that identifies primary features of the site including major roadways, significant topographical features, boundaries of counties, and population centers within the EPZ.	Yes	Figures 1-1, 3-1, 6-1
c. A comparison of the current and previous ETE is provided including information similar to that identified in Table 1-1, "ETE Comparison."	Yes	Table 1-3
1.1 Approach		
a. The general approach is described in the report as outlined in Section 1.1, "Approach."	Yes	Section 1.1, Section 1.3, Appendix D, Table 1-1,
1.2 Assumptions		
a. Assumptions consistent with Table 1-2, "General Assumptions," of NUREG/CR-7002 are provided and include the basis to support use.	Yes	Section 2
1.3 Scenario Development		
a. The scenarios in Table 1-3, "Evacuation Scenarios," are developed for the ETE analysis. A reason is provided for use of other scenarios or for not evaluating specific scenarios.	Yes	Section 6, Table 6-2

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
1.4 Evacuation Planning Areas		
a. A map of the EPZ with emergency response planning areas (ERPAs) is included.	Yes	Figure 3-1, Figure 6-1
1.4.1 Keyhole Evacuation		
a. A table similar to Table 1-4 "Evacuation Areas for a Keyhole Evacuation", is provided identifying the ERPAs considered for each ETE calculation by downwind direction.	Yes	Table 6-1, Table 7-5, Table H-1
1.4.2 Staged Evacuation		
a. The approach used in development of a staged evacuation is discussed.	Yes	Section 7.2
b. A table similar to Table 1-5, "Evacuation Areas for a Staged Evacuation," is provided for staged evacuations identifying the ERPAs considered for each ETE calculation by downwind direction.	Yes	Table 7-3, Table 7-4
2.0 Demand Estimation		
a. Demand estimation is developed for the four population groups (permanent residents of the EPZ, transients, special facilities, and schools).	Yes	Section 3
2.1 Permanent Residents and Transient Population		
a. The U.S. Census is the source of the population values, or another credible source is provided.	Yes	Section 3.1
b. The availability date of the census data is provided.	Yes	Section 3.1
c. Population values are adjusted as necessary for growth to reflect population estimates to the year of the ETE.	Yes	N/A - 2020 used as the base year of the analysis

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
d. A sector diagram, similar to Figure 2-1, "Population by Sector," is included showing the population distribution for permanent residents.	Yes	Figure 3-2
2.1.1 Permanent Residents with Vehicles		
a. The persons per vehicle value is between 1 and 3 or justification is provided for other values.	Yes	Section 3.1
2.1.2 Transient Population		
a. A list of facilities that attract transient populations is included, and peak and average attendance for these facilities is listed. The source of information used to develop attendance values is provided.	Yes	Section 3.3, Table E-5 through Table E-6
b. Major employers are listed.	Yes	Section 3.4, Table E-4
c. The average population during the season is used, itemized and totaled for each scenario.	Yes	Table 3-4, Table 3-5 and Appendix E itemize the peak transient population and employee estimates. These estimates are multiplied by the scenario specific percentages provided in Table 6-3 to estimate average transient population by scenario – see Table 6-4.
d. The percentage of permanent residents assumed to be at facilities is estimated.	Yes	Section 3.3 and Section 3.4
e. The number of people per vehicle is provided. Numbers may vary by scenario, and if so, reasons for the variation are discussed.	Yes	Section 3.3 and Section 3.4

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
f. A sector diagram is included, similar to Figure 2-1, "Population by Sector", is included showing the population distribution for the transient population.	Yes	Figure 3-6 (transients) and Figure 3-8 (employees)
2.2 Transit Dependent Permanent Residents		
a. The methodology (e.g., surveys, registration programs) used to determine the number of transit dependent residents is discussed.	Yes	Section 3.6
b. The State and local evacuation plans for transit dependent residents are used in the analysis.	Yes	Section 8.1
c. The methodology used to determine the number of people with disabilities and those with access and functional needs who may need assistance and do not reside in special facilities is provided. Data from local/county registration programs are used in the estimate.	Yes	Section 3.9
d. Capacities are provided for all types of transportation resources. Bus seating capacity of 50 percent is used or justification is provided for higher values.	Yes	Item 3 of Section 2.4
e. An estimate of the transit dependent population is provided.	Yes	Section 3.6, Table 3-7, Table 3-9
f. A summary table showing the total number of buses, ambulances, or other transport assumed available to support evacuation is provided. The quantification of resources is detailed enough to ensure that double counting has not occurred.	Yes	Table 3-9, Table 8-1

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
2.3 Special Facility Residents		
a. Special facilities, including the type of facility, location, and average population, are listed. Special facility staff is included in the total special facility population.	Yes	Table E-3 lists all medical facilities by facility name, location, and average population. Staff estimates were not provided. Table E-7 lists all correctional facilities
b. The method of obtaining special facility data is discussed.	Yes	Section 3.5, Section 3.10
c. An estimate of the number and capacity of vehicles assumed available to support the evacuation of the facility is provided.	Yes	Table 3-6, Section 3.10
d. The logistics for mobilizing specially trained staff (e.g., medical support or security support for prisons, jails, and other correctional facilities) are discussed when appropriate.	Yes	Section 8.1 – under *Evacuation of Medical Facilities* and under *Correctional Facilities*
2.4 Schools		
a. A list of schools including name, location, student population, and transportation resources required to support the evacuation, is provided. The source of this information should be identified.	Yes	Table 3-8, Table E-1, Section 3.7
b. Transportation resources for elementary and middle schools are based on 100 percent of the school capacity.	Yes	Section 3.7
c. The estimate of high school students who will use personal vehicle to evacuate is provided and a basis for the values used is given.	Yes	Section 3.7
d. The need for return trips is identified.	Yes	Section 8.1

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
2.5 Other Demand Estimate Considerations		
2.5.1 Special Events		
a. A complete list of special events is provided including information on the population, estimated duration, and season of the event.	Yes	Section 3.8
b. The special event that encompasses the peak transient population is analyzed in the ETE.	Yes	Section 3.8
c. The percentage of permanent residents attending the event is estimated.	Yes	Section 3.8
2.5.2 Shadow Evacuation		
a. A shadow evacuation of 20 percent is included consistent with the approach outlined in Section 2.5.2, "Shadow Evacuation".	Yes	Item 9 of Section 2.2, Figure 2-1 and Figure 7-1, Section 3.2
b. Population estimates for the shadow evacuation in the shadow region beyond the EPZ are provided by sector.	Yes	Section 3.2, Table 3-3, Figure 3-4
c. The loading of the shadow evacuation onto the roadway network is consistent with the trip generation time generated for the permanent resident population.	Yes	Section 5 – Table 5-9 (footnote)
2.5.3 Background and Pass Through Traffic		
a. The volume of background traffic and pass-through traffic is based on the average daytime traffic. Values may be reduced for nighttime scenarios.	Yes	Section 3.11 and Section 3.12

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
b. The method of reducing background and pass-through traffic is described.	Yes	Section 2.2 – Assumptions 10 and 12 Section 2.5 Section 3.11 and Section 3.12 Table 6-3 – External Through Traffic footnote
c. Pass-through traffic is assumed to have stopped entering the EPZ about two (2) hours after the initial notification.	Yes	Section 2.5
2.6 Summary of Demand Estimation		
a. A summary table is provided that identifies the total populations and total vehicles used in the analysis for permanent residents, transients, transit dependent residents, special facilities, schools, shadow population, and pass-through demand in each scenario.	Yes	Table 3-11, Table 3-12, and Table 6-4
3.0 Roadway Capacity		
a. The method(s) used to assess roadway capacity is discussed.	Yes	Section 4
3.1 Roadway Characteristics		
a. The process for gathering roadway characteristic data is described including the types of information gathered and how it is used in the analysis.	Yes	Section 1.3, Appendix D
b. Legible maps are provided that identify nodes and links of the modeled roadway network similar to Figure A-1, "Roadway Network Identifying Nodes and Links," and Figure A-2, "Grid Map Showing Detailed Nodes and Links."	Yes	Appendix K

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
3.2 Model Approach		
a. The approach used to calculate the roadway capacity for the transportation network is described in detail, and the description identifies factors that are expressly used in the modeling.	Yes	Section 4
b. Route assignment follows expected evacuation routes and traffic volumes.	Yes	Appendix B and Appendix C
c. A basis is provided for static route choices if used to assign evacuation routes.	N/A	Static route choices are not used to assign evacuation routes. Dynamic traffic assignment is used.
d. Dynamic traffic assignment models are described including calibration of the route assignment.	Yes	Appendix B and Appendix C
3.3 Intersection Control		
a. A list that includes the total numbers of intersections modeled that are unsignalized, signalized, or manned by response personnel is provided.	Yes	Table K-1
b. The use of signal cycle timing, including adjustments for manned traffic control, is discussed.	Yes	Section 4, Appendix G
3.4 Adverse Weather		
a. The adverse weather conditions are identified.	Yes	Assumption 2 and 3 of Section 2.6
b. The speed and capacity reduction factors identified in Table 3-1, "Weather Capacity Factors," are used or a basis is provided for other values, as applicable to the model.	Yes	Table 2-2
c. The calibration and adjustment of driver behavior models for adverse weather conditions are described, if applicable.	N/A	Driver behavior is not adjusted for adverse weather conditions.

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
d. The effect of adverse weather on mobilization is considered and assumptions for snow removal on streets and driveways are identified, when applicable.	Yes	Table 2-2
4.0 Development of Evacuation Times		
4.1 Traffic Simulation Models		
a. General information about the traffic simulation model used in the analysis is provided.	Yes	Section 1.3, Table 1-3, Appendix B, Appendix C
b. If a traffic simulation model is not used to perform the ETE calculation, sufficient detail is provided to validate the analytical approach used.	N/A	Not applicable since a traffic simulation model was used.
4.2 Traffic Simulation Model Input		
a. Traffic simulation model assumptions and a representative set of model inputs are provided.	Yes	Section 2, Appendix J
b. The number of origin nodes and method for distributing vehicles among the origin nodes are described.	Yes	Appendix J, Appendix C
c. A glossary of terms is provided for the key performance measures and parameters used in the analysis.	Yes	Appendix A
4.3 Trip Generation Time		
a. The process used to develop trip generation times is identified.	Yes	Section 5
b. When surveys are used, the scope of the survey, area of the survey, number of participants, and statistical relevance are provided.	Yes	Appendix F
c. Data used to develop trip generation times are summarized.	Yes	Appendix F, Section 5

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
d. The trip generation time for each population group is developed from site-specific information.	Yes	Section 5
e. The methods used to reduce uncertainty when developing trip generation times are discussed, if applicable.	Yes	Appendix F
4.3.1 Permanent Residents and Transient Population		
a. Permanent residents are assumed to evacuate from their homes but are not assumed to be at home at all times. Trip generation time includes the assumption that a percentage of residents will need to return home before evacuating.	Yes	Section 5 discusses trip generation for households with and without returning commuters. Table 6-3 presents the percentage of households with returning commuters and the percentage of households either without returning commuters or with no commuters. Appendix F presents the percent households who will await the return of commuters. Section 2.3, Assumption 3
b. The trip generation time accounts for the time and method to notify transients at various locations.	Yes	Section 5
c. The trip generation time accounts for transients potentially returning to hotels before evacuating.	Yes	Section 5, Figure 5-1
d. The effect of public transportation resources used during special events where a large number of transients are expected is considered.	Yes	Section 3.8

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
4.3.2 Transit Dependent Permanent Residents		
a. If available, existing and approved plans and bus routes are used in the ETE analysis.	N/A	Section 8.1 under Evacuation of Transit-Dependent Population
b. The means of evacuating ambulatory and non-ambulatory residents are discussed.	Yes	Section 8.1 under Evacuation of Transit-Dependent Population, Section 8.2
c. Logistical details, such as the time to obtain buses, brief drivers and initiate the bus route are used in the analysis.	Yes	Section 8.1, Figure 8-1
d. The estimated time for transit dependent residents to prepare and then travel to a bus pickup point, including the expected means of travel to the pickup point, is described.	Yes	Section 8.1 under Evacuation of Transit-Dependent Population
e. The number of bus stops and time needed to load passengers are discussed.	Yes	Section 8.1, Table 8-5 though Table 8-7
f. A map of bus routes is included.	Yes	Figure 10-2
g. The trip generation time for non-ambulatory persons including the time to mobilize ambulances or special vehicles, time to drive to the home of residents, time to load, and time to drive out of the EPZ, is provided.	Yes	Section 8.2
h. Information is provided to support analysis of return trips, if necessary.	Yes	Section 8.1 and 8.2
4.3.3 Special Facilities		
a. Information on evacuation logistics and mobilization times is provided.	Yes	Section 2.4, Section 8.1, Table 8-8 through Table 8-10
b. The logistics of evacuating wheelchair and bed bound residents are discussed.	Yes	Section 8.1, Table 8-8 through Table 8-10

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
c. Time for loading of residents is provided.	Yes	Section 2.4, Section 8.1, Table 8-8 through Table 8-10
d. Information is provided that indicates whether the evacuation can be completed in a single trip or if additional trips are needed.	Yes	Section 8.1
e. Discussion is provided on whether special facility residents are expected to pass through the reception center before being evacuated to their final destination.	Yes	Section 8.1
f. Supporting information is provided to quantify the time elements for each trip, including destinations if return trips are needed.	Yes	Section 8.1
4.3.4 Schools		
a. Information on evacuation logistics and mobilization times is provided.	Yes	Section 2.4, Section 8.1, Table 8-2 through Table 8-4
b. Time for loading of students is provided.	Yes	Section 2.4, Section 8.1, Table 8-2 through Table 8-4
c. Information is provided that indicates whether the evacuation can be completed in a single trip or if additional trips are needed.	Yes	Section 8.1
d. If used, reception centers should be identified. A discussion is provided on whether students are expected to pass through the reception center before being evacuated to their final destination.	Yes	Section 8.1, Table 10-3

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
e. Supporting information is provided to quantify the time elements for each trip, including destinations if return trips are needed.	Yes	Section 8.1, Table 8-2 through Table 8-4
4.4 Stochastic Model Runs		
a. The number of simulation runs needed to produce average results is discussed.	N/A	DYNEV does not rely on simulation averages or random seeds for statistical confidence. For DYNEV/DTRAD, it is a meso-scopic simulation and uses dynamic traffic assignment model to obtain the "average" (stable) network work flow distribution. This is different from microscopic simulation, which is monte-carlo random sampling by nature relying on different seeds to establish statistical confidence. Refer to Appendix B for more details.
b. If one run of a single random seed is used to produce each ETE result, the report includes a sensitivity study on the 90 percent and 100 percent ETE using 10 different random seeds for evacuation of the full EPZ under Summer, Midweek, Daytime, Normal Weather conditions.	N/A	
4.5 Model Boundaries		
a. The method used to establish the simulation model boundaries is discussed.	Yes	Section 4.5
b. Significant capacity reductions or population centers that may influence the ETE and that are located beyond the evacuation area or shadow region are identified and included in the model, if needed.	Yes	Section 4.5

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
4.6 Traffic Simulation Model Output		
a. A discussion of whether the traffic simulation model used must be in equilibration prior to calculating the ETE is provided.	Yes	Appendix B
b. The minimum following model outputs for evacuation of the entire EPZ are provided to support review: 1. Evacuee average travel distance and time. 2. Evacuee average delay time. 3. Number of vehicles arriving at each destination node. 4. Total number and percentage of evacuee vehicles not exiting the EPZ. 5. A plot that provides both the mobilization curve and evacuation curve identifying the cumulative percentage of evacuees who have mobilized and exited the EPZ. 6. Average speed for each major evacuation route that exits the EPZ.	Yes	1. Appendix J, Table J-2 2. Table J-2 3. Table J-4 4. None and 0%. 100 percent ETE is based on the time the last vehicle exits the evacuation zone 5. Figures J-2 through J-15 (one plot for each scenario considered) 6. Table J-3
c. Color coded roadway maps are provided for various times (e.g., at 2, 4, 6 hrs.) during a full EPZ evacuation scenario, identifying areas where congestion exists.	Yes	Figure 7-3 through Figure 7-9
4.7 Evacuation Time Estimates for the General Public		
a. The ETE includes the time to evacuate 90 percent and 100 percent of the total permanent resident and transient population.	Yes	Table 7-1 and Table 7-2
b. Termination criteria for the 100 percent ETE are discussed, if not based on the time the last vehicle exits the evacuation zone.	N/A	100 percent ETE is based on the time the last vehicle exits the evacuation zone.

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
c. The ETE for 100 percent of the general public includes all members of the general public. Any reductions or truncated data is explained.	Yes	Section 5.4.1 – truncating survey data to eliminate statistical outliers Table 7-2 – 100th percentile ETE for general population
d. Tables are provided for the 90 and 100 percent ETEs similar to Table 4-3, "ETEs for a Staged Evacuation," and Table 4-4, "ETEs for a Keyhole Evacuation."	Yes	Table 7-3 and Table 7-4
e. ETEs are provided for the 100 percent evacuation of special facilities, transit dependent, and school populations.	Yes	Section 8
5.0 Other Considerations		
5.1 Development of Traffic Control Plans		
a. Information that responsible authorities have approved the traffic control plan used in the analysis are discussed.	Yes	Section 9, Appendix G
b. Adjustments or additions to the traffic control plan that affect the ETE is provided.	Yes	Section 9, Appendix G
5.2 Enhancements in Evacuation Time		
a. The results of assessments for enhancing evacuations are provided.	Yes	Appendix M
5.3 State and Local Review		
a. A list of agencies contacted is provided and the extent of interaction with these agencies is discussed.	Yes	Table 1-1

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
b. Information is provided on any unresolved issues that may affect the ETE.	Yes	Results of the ETE study were formally presented to state and local agencies at the final project meeting. Comments on the draft report were provided and were addressed in the final report. There are no unresolved issues.
5.4 Reviews and Updates		
a. The criteria for when an updated ETE analysis is required to be performed and submitted to the NRC is discussed.	Yes	Appendix M, Section M.3
5.4.1 Extreme Conditions		
a. The updated ETE analysis reflects the impact of EPZ conditions not adequately reflected in the scenario variations.	N/A	This ETE is being updated as a result of the availability of US Census Bureau decennial census data.
5.5 Reception Centers and Congregate Care Center		
a. A map of congregate care centers and reception centers is provided.	Yes	Figure 10-3

Enclosure 2

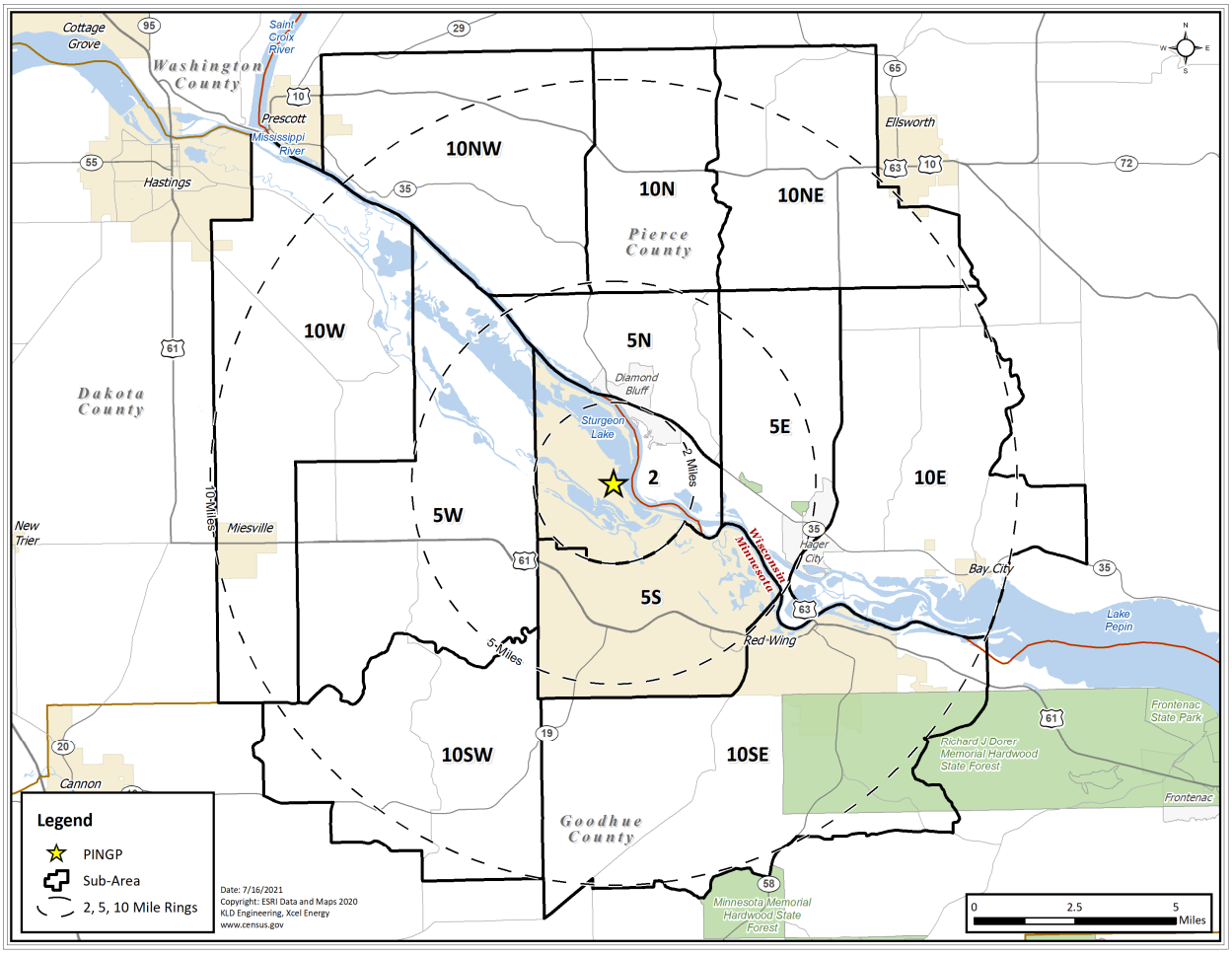
2022 Prairie Island Nuclear Generating Plant Emergency Planning Zone Evacuation Time Estimate Analysis

(410 pages to follow)

KLD ENGINEERING, P.C.

Prairie Island Nuclear Generating Plant

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 Prairie Island Nuclear Generating Plant (PINGP) located in Goodhue County, Minnesota. ETE are part of the required planning basis and provide Xcel Energy and States and local governments (offsite response organizations [OROs]) with site-specific information needed for protective action decision-making.

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

- Title 10, Code of Federal Regulations, Appendix E to Part 50 (10CFR50), Emergency Planning and Preparedness for Production and Utilization Facilities, NRC, 2011.
- Criteria for Development of Evacuation Time Estimate Studies, NUREG/CR-7002, Rev. 1, February 2021
- Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants, NUREG 0654/ Radiological Emergency Preparedness Program Manual, FEMA P-1028, December 2019.

Overview of Project Activities

This project began the end of January 2021 and extended over a period of 18 months. The major activities performed are briefly described in chronological sequence:

- Attended "kick-off" meetings with Xcel Energy personnel and the state and county emergency management agencies.
- Accessed the U.S. Census Bureau data files for the year 2020.
- Obtained the estimates of employees who reside outside the Emergency Planning Zone (EPZ[1]) and commute to work within the EPZ from Xcel Energy and the counties within the EPZ.
- Studied Geographic Information Systems (GIS) maps of the area in the vicinity of the PINGP, then conducted a detailed field survey of the highway network to observe any roadway changes relative to the previous ETE study done in 2012.
- Updated the analysis network representing the highway system topology and capacities within the EPZ, plus a Shadow Region covering the region between the EPZ boundary and approximately 15 miles radially from the plant.
- Designed and conducted an online demographic survey of residents within the study area (EPZ and Shadow Region), 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 ORO personnel prior to conducting the survey.

[1] All references to EPZ refer to the plume exposure pathway EPZ.

- 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, supplemented by internet searches to individual facilities where data was missing. If updated information was not provided and could not be obtained from online sources to the facilities, the data gathered in the 2012 ETE study (reviewed and confirmed still accurate by the OROs) was used for this study.
- 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 demographic survey of EPZ residents.
- Following federal guidelines, the EPZ is subdivided into 12 Sub-Areas. These Sub-Areas are then grouped within circular areas or "keyhole" configurations (circles plus radial sectors) that define a total of 28 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, Rain/Light Snow, Heavy Snow). One special event scenario - Treasure Island Casino Concert - was considered. One roadway impact scenario was considered wherein a segment of US-61 eastbound was closed from US-63 to County 292 Blvd.
- Staged evacuation was considered for those regions wherein the 2-Mile Region and sectors downwind to 5 miles were evacuated.
- As per NUREG/CR-7002, Rev. 1, the Planning Basis for the calculation of ETE is:
    - A rapidly escalating accident at the PINGP that quickly assumes the status of a general emergency wherein evacuation is ordered promptly, and no early protective actions have been implemented such that the Advisory to Evacuate (ATE) is virtually coincident with the siren notification.
    - While an unlikely accident scenario, this planning basis will yield ETE, measured as the elapsed time from the ATE until the stated percentage of the population exits the impacted Region, that represent "upper bound" estimates. This conservative Planning Basis is applicable for all initiating events.
- If the emergency occurs while schools are in session, the ETE study assumes that the children will be evacuated by bus directly to sister schools (reception centers for daycares) 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 medical facilities will likewise be evacuated with public transit, as needed: by bus, wheelchair bus, or ambulance, as required. Separate

ETE are calculated for the transit-dependent evacuees, for access and/or functional needs population, and for those evacuated from medical and correctional facilities.

- Attended a meeting with Xcel Energy personnel and the OROs to present results from the study.

Computation of ETE

A total of 392 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 28 Evacuation Regions to evacuate from that Region, under the circumstances defined for one of the 14 Evacuation Scenarios (28 x 14 = 392). Separate ETE are calculated for transit-dependent evacuees, including schoolchildren for applicable scenarios.

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

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

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

The computational procedure is outlined as follows:

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

The ETE statistics provide the elapsed times for 90% and 100%, respectively, of the population within the impacted region, to evacuate from within the impacted region. These statistics are presented in tabular and graphical formats. The 90th percentile ETE have been identified as the values that should be considered when making protective action decisions because the 100th percentile ETE are prolonged by those relatively few people who take longer to mobilize. This is referred to as the "evacuation tail" in Section 4.0 of NUREG/CR-7002, Rev. 1.

Traffic Management

This study reviewed, modeled and analyzed the existing comprehensive traffic management plans provided by Minnesota Department of Public Safety and Division of Homeland Security and Emergency Management, Goodhue, and Pierce Counties, and identifies critical intersections. The existing traffic management plans are adequate and no additional TACPs are 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.

- Table 3-1 presents the estimates of permanent resident population in each Sub-Area based on the 2020 Census data.
- Table 6-1 defines each of the 28 Evacuation Regions in terms of their respective groups of Sub-Area.
- Table 6-2 defines the 14 Evacuation Scenarios.
- Table 7-1 and Table 7-2 are compilations of ETE for the general population. These data are the times needed to clear the indicated regions of 90% and 100% of the population occupying these regions, respectively. These computed ETE include consideration of mobilization time and of estimated voluntary evacuations from other regions within the EPZ and from the Shadow Region. These tables also include ETE results for staged evacuation on residents beyond the 2-Mile Region.
- Table 7-3 and Table 7-4 present ETE for the 2-Mile Region for un-staged and staged evacuations for the 90th and 100th percentile ETE, respectively.
- Table 8-2 presents ETE for the schoolchildren in good weather.
- Table 8-5 presents ETE for the transit-dependent population in good weather.
- Table 8-8 presents ETE for the medical facility population in good weather.
- Table M-3 compares the results of the sensitivity study conducted to determine the effect on ETE due to changes in the permanent resident population within the study area (EPZ plus Shadow Region).
- Figure 6-1 displays a map of the PINGP EPZ showing the layout of the 12 Sub-Areas that comprise, in aggregate, the EPZ.
- 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 392 unique cases – a combination of 28 unique Evacuation Regions and 14 unique Evacuation Scenarios. Table 7-1 and Table 7-2 document these ETE for the 90th and 100th percentiles. The 90th percentile ETE range from 1:25 (hr:min) to 4:35. The 100th percentile ETE range from 4:30 to 5:55 and are dictated by the tip mobilization of residents (i.e., the time it takes to prepare to evacuate plus the time to travel to the EPZ boundary), except the ETE for Special Event scenario (Scenario 13).
- The comparison of Table 7-1 and Table 7-2 indicates that the 100th percentile ETE are significantly longer than those for the 90th percentile ETE. This is the result of the long trip generation "tail" of the evacuation curve caused by those evacuees who take longer to mobilize and not congestion within the EPZ. See Figures 7-8 through 7-21.
- Inspection of Table 7-3 and Table 7-4 indicates that a staged evacuation provides no benefits to evacuees from within the 2-Mile Region and unnecessarily delays the evacuation of those beyond the 2-Mile Region. See Section 7.6 for additional discussion.
- Comparison of Scenarios 5 (summer, midweek/weekend, evening with good weather) and 13 (summer, midweek/weekend, evening, special event) in Table 7-1 indicates that the special event has a significant impact on the 90th percentile ETE with increases of up to 3 hours and 5 minutes. See Section 7.5 for additional discussion.
- Comparison of Scenarios 1 and 14 in Table 7-1 indicates that the roadway closure – Closure US-61 EB between US-63 and County 292 Blvd – has no impact on the 90th or 100th percentile ETE. See Section 7.5 for additional discussion.
- Red Wing is the most congested area during an evacuation. The last location in the EPZ to exhibit traffic congestion is along SR-58 and US-61 out of Red Wing due to a lane drop in Hay Creek and a lane drop right before the intersection with County 292 Blvd. All congestion within the EPZ clears by 3 hours and 45 minutes after the Advisory to Evacuate. See Section 7.3 and Figures 7-3 through 7-7.
- Separate ETE were computed for schools, medical facilities, transit-dependent persons, the access and/or functional needs persons and correctional facilities. The average single-wave ETE for the transit dependent population is the same as or shorter than the general population ETE at the 90th percentile for a winter, midweek, midday, good weather scenario (Scenario 6). See Section 8.
- Table 8-1 indicates that there are sufficient buses, wheelchair vans, mini vans, and ambulances available to evacuate the transit-dependent population within the EPZ in a single wave.
- A reduction in the base trip generation time by 1 hour reduces the general population ETE at the 90th percentile and 100th percentile ETE by 5 minutes and 1 hour, respectively. An increase in mobilization by one hour increase the general population 90th and 100th percentile ETEs by 45 minutes and 1 hour, respectively. See Table M-1.
- The general population ETE is relatively insensitive to the voluntary evacuation of vehicles in the Shadow Region (Doubling, tripling, quadrupling, and full shadow evacuation only increases 90th percentile ETE by 5 minutes - not a significant change). The

100th percentile ETE does not get impacted by any changes in the shadow evacuation percentages since it is dictated by the trip generation time. See Table M-2.

- A population increase of 33% or greater result in the longest 90th percentile ETE to increase by 30 minutes for the full EPZ (Region R03), which meets the federal criteria for performing a fully updated ETE study between decennial Censuses. See Appendix M.3 and Table M-3.
- Table M-4 shows that increasing the Average Household Size to 2.61 (from demographic survey) instead of 2.45 (from Census data) have no impact to the 90th percentile ETE and 100th percentile ETE. See Appendix M.4 for additional information.

Table 3-1. EPZ Permanent Resident Population

Sub-Area	2010 Population	2020 Population
2 (Goodhue)	257	233
2 (Pierce)	158	146
5N	311	332
5E	971	1,034
5S	3,602	3,748
5W	754	855
10N	616	653
10NE	1,760	1,714
10E	2,063	1,995
10SE	13,870	13,854
10SW	729	671
10W	3,456	3,442
10NW	1,928	2,255
EPZ TOTAL	**30,475**	**30,932**
EPZ Population Growth (2010-2020):		**1.50%**

Table 6-1. Description of Evacuation Regions

Radial Regions													
Region	**Description**	**Degrees in PAR**	**Sub-Area**										
			2	**5N**	**5E**	**5S**	**5W**	**10N**	**10NE**	**10E**	**10SE**	**10SW**	**10W**	**10NW**
R01	2-Mile Radius	0°-359°	x											
R02	5-Mile Radius	0°-359°	x	x	x	x	x							
R03	Full EPZ	0°-359°	x	x	x	x	x	x	x	x	x	x	x	x
Evacuate 2-Mile Radius and Downwind to 5 Miles														
Region	**Wind Direction From:**	**Degrees in PAR**	**Sub-Area**											
			2	**5N**	**5E**	**5S**	**5W**	**10N**	**10NE**	**10E**	**10SE**	**10SW**	**10W**	**10NW**
R04	NNW, N	326.25°-11.25°	x		x	x	x							
R05	NNE, NE, ENE, E	11.25°-101.25°	x			x	x							
R06	ESE, SE	101.25°-146.25°	x	x			x							
R07	SSE, S, SSW	146.25°-213.75°	x	x	x		x							
R08	SW	213.75°-236.25°	x	x	x									
R09	WSW, W, WNW	236.25°-303.75°	x	x	x	x								
R10	NW	303.75°-326.25°	x		x	x								
Evacuate 5-Mile Radius and Downwind to the EPZ Boundary														
Region	**Wind Direction From:**	**Degrees in PAR**	**Sub-Area**											
			2	**5N**	**5E**	**5S**	**5W**	**10N**	**10NE**	**10E**	**10SE**	**10SW**	**10W**	**10NW**
R11	N, NNE, NE, ENE	348.75°-78.75°	x	x	x	x	x				x	x	x	
R12	E	78.75°-101.25°	x	x	x	x	x					x	x	x
R13	ESE	101.25°-123.75°	x	x	x	x	x						x	x
R14	SE	123.75°-146.25°	x	x	x	x	x	x					x	x
R15	SSE	146.25°-168.75°	x	x	x	x	x	x	x				x	x
R16	S	168.75°-191.25°	x	x	x	x	x	x	x	x			x	x
R17	SSW, SW	191.25°-236.25°	x	x	x	x	x	x	x	x				x
R18	WSW	236.25°-258.75°	x	x	x	x	x	x	x	x	x			
R19	W, WNW	258.75°-303.75°	x	x	x	x	x		x	x	x			
R20	NW, NNW	303.75°-348.75°	x	x	x	x	x			x	x	x		
Staged Evacuation - 2-Mile Radius Evacuates, then Evacuate Downwind to 5 Miles														
Region	**Wind Direction From:**	**Degrees in PAR**	**Sub-Area**											
			2	**5N**	**5E**	**5S**	**5W**	**10N**	**10NE**	**10E**	**10SE**	**10SW**	**10W**	**10NW**
R21	5-Mile Radius	0°-359°	x	x	x	x	x							
R22	NNW, N	326.25°-11.25°	x		x	x	x							
R23	NNE, NE, ENE, E	11.25°-101.25°	x			x	x							
R24	ESE, SE	101.25°-146.25°	x	x			x							
R25	SSE, S, SSW	146.25°-213.75°	x	x	x		x							
R26	SW	213.75°-236.25°	x	x	x									
R27	WSW, W, WNW	236.25°-303.75°	x	x	x	x								
R28	NW	303.75°-326.25°	x		x	x								

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

Table 6-2. 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/Light Snow	None
8	Winter	Midweek	Midday	Heavy Snow	None
9	Winter	Weekend	Midday	Good	None
10	Winter	Weekend	Midday	Rain/Light Snow	None
11	Winter	Weekend	Midday	Heavy Snow	None
12	Winter	Midweek, Weekend	Evening	Good	None
13	Summer	Midweek, Weekend	Evening	Good	Treasure Island Casino Concert
14	Summer	Midweek	Midday	Good	Closure US-61 EB between US-63 and County 292 Blvd

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

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

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek Weekend	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/Light Snow	Heavy Snow	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region, 5-Mile Region, and EPZ														
R01	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:40	1:55
R02	2:15	2:30	2:15	2:20	2:10	2:20	2:20	2:45	2:10	2:15	2:35	2:10	4:10	2:15
R03	2:55	3:10	2:50	3:00	2:40	2:55	3:05	3:45	2:50	2:55	3:35	2:40	3:45	2:55
Evacuate 2-Mile Region and Downwind to 5 Miles														
R04	2:15	2:30	2:15	2:20	2:10	2:20	2:20	2:40	2:10	2:15	2:30	2:10	4:10	2:15
R05	2:15	2:25	2:15	2:20	2:10	2:20	2:20	2:40	2:10	2:15	2:30	2:10	4:15	2:15
R06	2:10	2:25	2:15	2:20	2:00	2:10	2:10	2:20	2:05	2:10	2:20	2:00	4:25	2:10
R07	2:10	2:25	2:15	2:20	2:00	2:10	2:15	2:25	2:05	2:10	2:20	2:05	4:25	2:10
R08	2:00	2:25	2:05	2:15	1:40	1:55	1:55	2:30	1:40	1:50	2:15	1:35	4:35	2:00
R09	2:15	2:25	2:10	2:20	2:05	2:15	2:15	2:40	2:10	2:10	2:30	2:10	4:20	2:15
R10	2:15	2:25	2:10	2:20	2:05	2:15	2:15	2:40	2:10	2:10	2:30	2:10	4:20	2:15
Evacuate 5-Mile Region and Downwind to the EPZ Boundary														
R11	3:00	3:15	2:55	3:05	2:45	3:00	3:10	3:45	2:50	3:00	3:35	2:40	3:50	3:00
R12	2:30	2:45	2:25	2:35	2:25	2:30	2:35	3:05	2:25	2:25	2:50	2:25	4:10	2:30
R13	2:30	2:45	2:25	2:35	2:25	2:30	2:35	3:05	2:25	2:25	2:50	2:25	4:10	2:30
R14	2:35	2:45	2:30	2:35	2:25	2:30	2:35	3:05	2:25	2:25	2:50	2:25	4:10	2:35
R15	2:35	2:45	2:30	2:35	2:25	2:35	2:35	3:05	2:25	2:25	2:55	2:25	4:05	2:35
R16	2:35	2:45	2:30	2:35	2:25	2:35	2:35	3:05	2:25	2:25	2:55	2:25	4:05	2:35
R17	2:25	2:30	2:20	2:25	2:15	2:25	2:30	3:00	2:15	2:20	2:45	2:20	4:00	2:25
R18	3:00	3:10	2:50	3:00	2:40	3:00	3:05	3:50	2:50	3:00	3:35	2:40	3:40	3:00
R19	3:00	3:10	2:50	3:00	2:40	3:00	3:05	3:50	2:50	3:00	3:35	2:40	3:45	3:00
R20	3:00	3:10	2:50	3:00	2:40	3:05	3:05	3:50	2:50	3:00	3:35	2:40	3:45	3:00

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek Weekend	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/Light Snow	Heavy Snow	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Special Event	Roadway Impact
Staged Evacuation - 2-Mile Region Evacuates, then Evacuate Downwind to 5 Miles														
R21	2:30	2:30	2:30	2:30	2:30	2:30	2:30	2:45	2:30	2:30	2:40	2:30	4:10	2:30
R22	2:30	2:30	2:30	2:30	2:30	2:30	2:30	2:45	2:30	2:30	2:40	2:30	4:15	2:30
R23	2:30	2:30	2:25	2:30	2:30	2:30	2:30	2:40	2:30	2:30	2:35	2:30	4:15	2:30
R24	2:15	2:25	2:20	2:25	2:20	2:15	2:20	2:25	2:15	2:20	2:25	2:20	4:25	2:15
R25	2:20	2:25	2:20	2:25	2:25	2:20	2:25	2:30	2:20	2:25	2:25	2:25	4:25	2:20
R26	2:20	2:25	2:20	2:25	2:20	2:25	2:25	2:35	2:20	2:20	2:30	2:25	4:35	2:20
R27	2:30	2:30	2:25	2:30	2:30	2:30	2:30	2:40	2:30	2:30	2:35	2:30	4:20	2:30
R28	2:30	2:30	2:25	2:30	2:30	2:30	2:30	2:40	2:30	2:30	2:35	2:30	4:20	2:30

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

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek Weekend	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/Light Snow	Heavy Snow	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region, 5-Mile Region, and EPZ														
R01	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R02	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:25	4:35
R03	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	5:55	4:40
Evacuate 2-Mile Region and Downwind to 5 Miles														
R04	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:15	4:35
R05	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:15	4:35
R06	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:20	4:35
R07	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:25	4:35
R08	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:25	4:35
R09	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:25	4:35
R10	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:25	4:35
Evacuate 5-Mile Region and Downwind to the EPZ Boundary														
R11	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	5:45	4:40
R12	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	5:50	4:40
R13	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	5:45	4:40
R14	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	5:45	4:40
R15	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	5:45	4:40
R16	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	5:45	4:40
R17	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	5:15	4:40
R18	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	5:15	4:40
R19	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	5:15	4:40
R20	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	5:20	4:40

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek Weekend	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/Light Snow	Heavy Snow	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Special Event	Roadway Impact
Staged Evacuation - 2-Mile Region Evacuates, then Evacuate Downwind to 5 Miles														
R21	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:25	4:35
R22	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:15	4:35
R23	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:15	4:35
R24	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:20	4:35
R25	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:25	4:35
R26	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:25	4:35
R27	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:25	4:35
R28	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:25	4:35

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

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek Weekend	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region and 5-Mile Region														
R01	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:40	1:55
R02	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:25	1:55
Un-staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R04	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:25	1:55
R05	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:25	1:55
R06	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:40	1:55
R07	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:40	1:55
R08	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:40	1:55
R09	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:40	1:55
R10	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:40	1:55
Staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R21	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:25	1:55
R22	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:25	1:55
R23	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:25	1:55
R24	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:40	1:55
R25	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:40	1:55
R26	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:40	1:55
R27	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:25	1:55
R28	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:25	1:55

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

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek Weekend	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region and 5-Mile Region														
R01	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R02	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
Un-staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R04	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R05	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R06	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R07	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R08	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R09	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R10	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
Staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R21	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R22	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R23	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R24	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R25	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R26	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R27	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R28	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30

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

Facility Name	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 S.S. (mi.)	Travel Time from EPZ Bdry to S.S. (min)	ETA to S.S. (hr:min)
SCHOOLS									
GOODHUE COUNTY, MN									
Tower View Alternative High School	90	15	15.3	55.0	17	**2:05**	7.9	9	**2:15**
Burnside Elementary School	90	15	16.7	19.9	50	**2:35**	3.1	3	**2:40**
Jefferson Elementary School	90	15	22.7	23.6	58	**2:45**	3.1	3	**2:50**
St. John's Lutheran School	90	15	21.7	23.7	55	**2:40**	3.1	3	**2:45**
Colvill Family Center	90	15	21.7	23.7	55	**2:40**	3.1	3	**2:45**
Sunnyside Elementary School	90	15	22.7	23.6	58	**2:45**	3.1	3	**2:50**
Twin Bluff Middle School	90	15	24.6	25.0	59	**2:45**	5.0	5	**2:50**
Red Wing High School	90	15	24.6	25.0	59	**2:45**	5.0	5	**2:50**
					Maximum for EPZ:	**2:45**		**Maximum:**	**2:50**
					Average for EPZ:	**2:40**		**Average:**	**2:45**

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

Bus Route Servicing	Number of Buses	Single-Wave							Second-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)
Sub-Area 10SE	4	120	4.8	8.3	35	30	**3:05**	28.0	31	5	10	42	30	**5:05**
Sub-Areas 5S, 10SW	2	120	11.7	55.0	13	30	**2:45**	48.5	53	5	10	79	30	**5:45**
Sub-Areas 2, 5W, 10W	2	120	11.1	15.4	43	30	**3:15**	13.0	14	5	10	38	30	**4:55**
Sub-Areas 5N, 5E, 10E	1	120	14.1	55.0	15	30	**2:45**	19.6	21	5	10	52	30	**4:45**
Sub-Areas 10NW, 10N, 10NE	2	120	5.7	55.0	6	30	**2:40**	20.4	22	5	10	34	30	**4:25**
						Maximum ETE:	**3:15**						**Maximum ETE:**	**5:45**
						Average ETE:	**2:55**						**Average ETE:**	**5:00**

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

Medical Facility	Patient	Mobilization (min)	Loading Rate (min per person)	People	Total Loading Time (min)	Dist. To EPZ Bdry (mi)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
Deer Crest	Ambulatory	90	1	77	30	8.1	9	**2:10**
	Wheelchair bound	90	5	4	20	8.1	9	**2:00**
Mayo Clinic Health System-Red Wing	Ambulatory	90	1	7	7	8.1	9	**1:50**
	Wheelchair bound	90	5	4	20	8.1	9	**2:00**
	Bedridden	90	15	7	30	8.1	9	**2:10**
Bay View Nursing & Rehabilitation Center	Ambulatory	90	1	50	30	8.5	20	**2:20**
	Wheelchair bound	90	5	26	60	8.5	11	**2:45**
	Bedridden	90	15	2	30	8.5	20	**2:20**
Loving Residence	Ambulatory	90	1	5	5	6.8	20	**1:55**
	Wheelchair bound	90	5	2	10	6.8	19	**2:00**
Potter Ridge Assisted Living	Ambulatory	90	1	43	30	6.8	16	**2:20**
	Wheelchair bound	90	5	2	10	6.8	19	**2:00**
	Bedridden	90	15	3	30	6.8	16	**2:20**
The Downtown Plaza	Ambulatory	90	1	76	30	7.6	16	**2:20**
	Wheelchair bound	90	5	2	10	7.6	15	**1:55**
Jordan Towers I & II	Ambulatory	90	1	159	30	7.6	16	**2:20**

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)
St. Crispin Living Community	Ambulatory	90	1	16	16	4.7	10	**2:00**
	Wheelchair bound	90	5	45	60	4.7	10	**2:40**
Valentines Assisted Living	Ambulatory	90	1	12	12	4.8	8	**1:50**
	Wheelchair bound	90	5	1	5	4.8	7	**1:45**
							Maximum ETE:	**2:45**
							Average ETE:	**2:10**

Table M-3. ETE Variation with Population Change

EPZ and 20% Shadow Permanent Resident Population	Base	Population Change		
		31%	32%	33%
	38,716	50,718	51,105	51,492
ETE (hrs:mins) for the 90th Percentile				
Region	**Base**	**Population Change**		
		31%	**32%**	**33%**
2-MILE	2:05	2:10	2:10	2:10
5-MILE	2:45	2:50	2:50	2:50
FULL EPZ	3:45	4:10	4:10	**4:15**
ETE for the 100th Percentile				
Region	**Base**	**Population Change**		
		31%	**32%**	**33%**
2-MILE	5:30	5:30	5:30	5:30
5-MILE	5:35	5:35	5:35	5:35
FULL EPZ	5:40	5:40	5:40	5:40

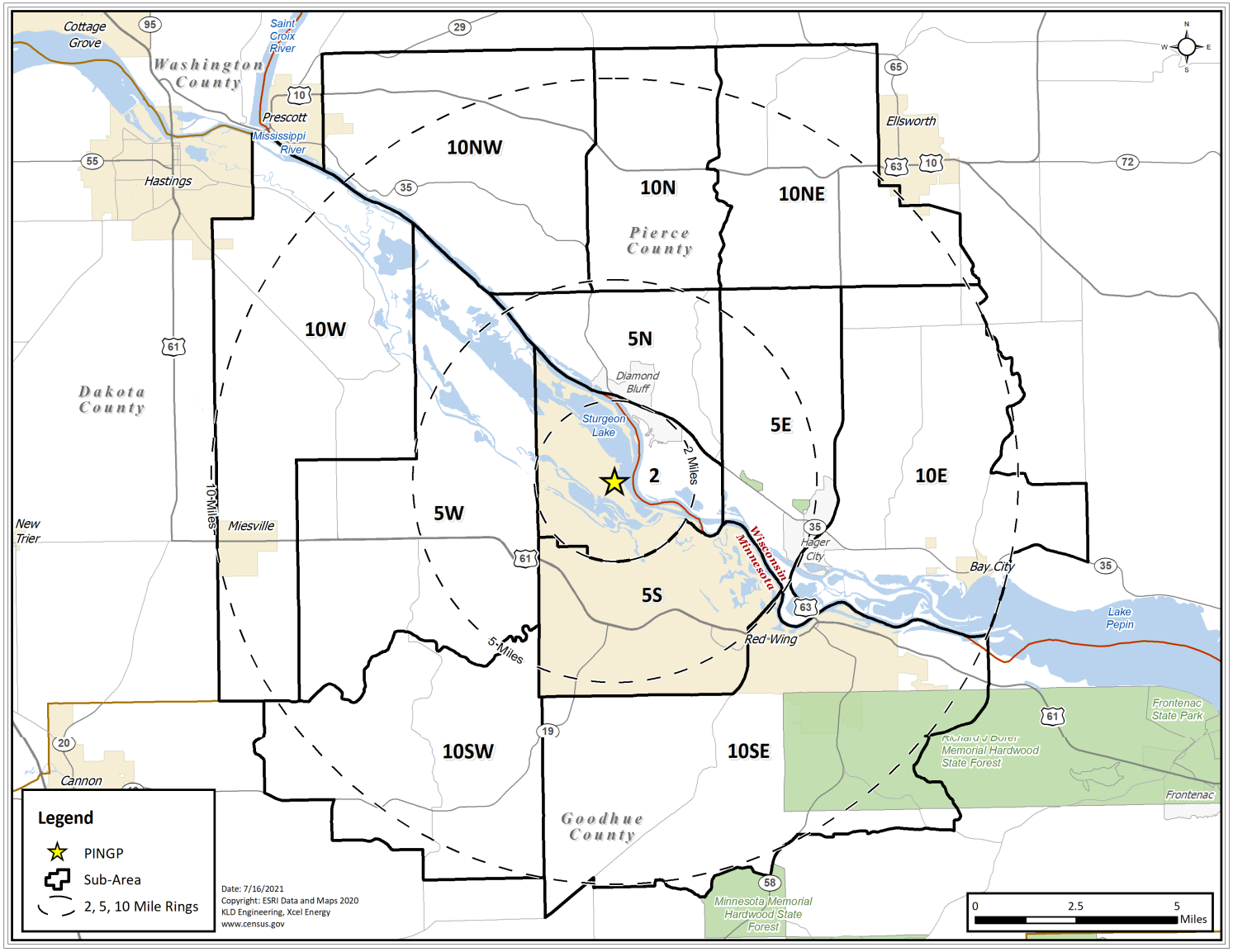


Figure 6-1. PINGP EPZ Sub-Areas

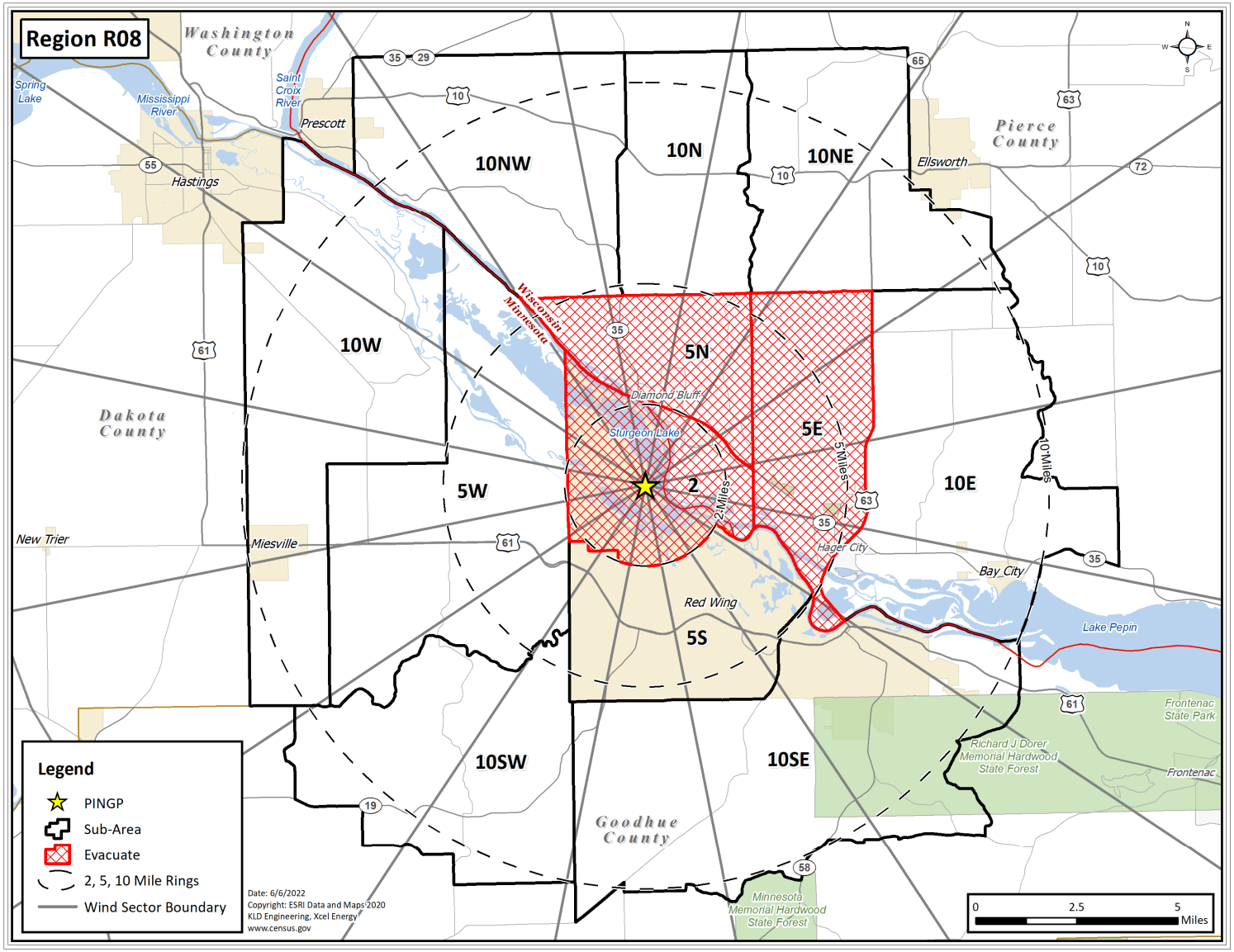


Figure H-8. Region R08

1 INTRODUCTION

This report describes the analyses undertaken and the results obtained by a study to develop Evacuation Time Estimates (ETE) for the Prairie Island Nuclear Generating Plant (PINGP), located in Goodhue County, Minnesota, Illinois. This ETE study provides Xcel Energy, state and local governments with site-specific information needed for Protective Action decision-making.

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

- Title 10, Code of Federal Regulations, Appendix E to Part 50 (10CFR50), Emergency Planning and Preparedness for Production and Utilization Facilities, NRC, 2011.
- Criteria for Development of Evacuation Time Estimate Studies, NUREG/CR-7002, Rev. 1, February 2021
- Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants, NUREG 0654/ Radiological Emergency Preparedness Program Manual, FEMA P-1028, December 2019.

The work effort reported herein was supported and guided by Xcel Energy and local stakeholders who contributed suggestions, critiques, and the local knowledge base required.

Table 1-1 presents a summary of stakeholders and interactions.

1.1 Overview of the ETE Process

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

1. Information Gathering:
    a. Defined the scope of work in discussions with representatives from Xcel Energy.
    b. Attended a project kickoff meeting with personnel from Xcel Energy, the emergency planners of the Goodhue County, Dakota County, Pierce County, Minnesota Department of Public Safety (DPS), Prairie Island Indian Community, Wisconsin Department of Military Affairs (DMA), and Red Wing Police Department to discuss methodology, project assumptions and to identify issues to be addressed and resources available.
    c. Conducted a detailed field survey of the highway system and of the area traffic conditions within the Emergency Planning Zone (EPZ[1]) and Shadow Region.
    d. Reviewed existing county and state Emergency Operations Plans.
    e. Conducted an online demographic survey of study area permanent residents (See Appendix F).
    f. Obtained demographic data from the 2020 Census (see Section 3.1).

[1] All references to EPZ refer to the plume exposure pathway EPZ.

g. Obtained data (to the extent available) to update the database of special facilities (i.e., schools, colleges, medical facilities and correctional facilities), major employers, transient attractions, access and/or functional needs population, transportation resources available, the special event, and other important information.

2. Estimated distributions of trip generation times representing the time required by various population groups (permanent residents, employees, and transients) to prepare (mobilize) for the evacuation trip. These estimates are primarily based upon the online demographic survey.
3. Defined Evacuation Scenarios (See Section 6). 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 and access control are applied at specified Traffic and Access Control Points (TACP) located within the study area. See Section 9 and Appendix G.
5. Used the 12 existing Sub-Areas which generally follow township boundaries and major roadways or rivers to define Evacuation Regions. "Regions" are groups of contiguous Sub-Areas 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 "keyhole section" within the EPZ as recommended by NUREG/CR-7002, Rev. 1.
6. Estimated demand for transit services for persons at schools[2], medical and correctional facilities, and for transit-dependent people at home, and those with access and/or functional needs.
7. Prepared the input streams for DYNEV II which computes ETE (see Appendices B and C).
    a. Estimated the evacuation traffic demand, based on the available information derived from Census data, and from data provided by county and state agencies, online sources, Xcel Energy and from the demographic survey.
    b. Updated the link-node representation of the evacuation network using the field survey and aerial imagery, which is used as the basis for the computer analysis that calculates the ETE.
    c. Applied the procedures specified in the 2016 Highway Capacity Manual (HCM 2016[3]) to the data acquired during the field survey, to estimate the capacity of all highway segments comprising the evacuation routes.
    d. Calculated the evacuating traffic demand for each Region and for each Scenario.

[2] Schools also include the commuter colleges/universities within the EPZ.
[3] Highway Capacity Manual (HCM 2016), Transportation Research Board, National Research Council, 2016.

e. Specified selected candidate destinations for each "origin" (location of each "source" where evacuation trips are generated over the mobilization time) to support evacuation travel consistent with outbound movement relative to the location of the plant.

8. Executed the DYNEV II system 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, Rev. 1.
10. Calculated the ETE for all transit activities including those for special facilities (schools, and medical facilities), for the transit-dependent population and for the access and/or functional needs population.

1.2 The Prairie Island Nuclear Generating Plant Location

The PINGP is located along the shores of the Mississippi River in Goodhue County, Minnesota. The site is approximately 40 miles southeast of Minneapolis-St. Paul, MN and approximately 55 miles west-southwest of Eau Claire, WI. The Emergency Planning Zone (EPZ) consists of parts of Dakota and Goodhue Counties in Minnesota and Pierce County in Wisconsin. Figure 1-1 displays the area surrounding the PINGP. This map identifies the communities in the area and the major roads.

1.3 Preliminary Activities

These activities are described below.

Field Surveys of the Highway Network

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

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

The data from the audio and video recordings were used to create detailed geographic information systems (GIS) shapefiles and databases of the roadway characteristics and of the traffic control devices observed during the road survey; this information was referenced while preparing the input stream for the DYNEV II model. Roadway types were assigned 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 lanes in each direction
- Collector: single lane in each direction
- Local Roadway: single lane in each direction, local road with low free flow speeds.

As documented on page 15-6 of the HCM 2016, the capacity of a two-lane highway is 1,700 passenger cars per hour in one direction. For freeway sections, a value of 2,250 vehicles per hour per lane is assigned, as per Exhibit 12-37 of the HCM 2016. The road survey has identified several segments which are characterized by adverse geometrics on two-lane highways which are reflected in reduced values for both capacity and speed. These estimates are consistent with the service volumes for LOS E presented in HCM 2016 Exhibit 15-46. . Link capacity is an input to DYNEV II. 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. TACPs at locations which have control devices are represented as actuated signals in the DYNEV II model.

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 model used to compute ETE, as per NUREG/CR-7002, Rev. 1 guidance.

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

Demographic Survey

An online demographic survey was performed to gather information needed for the ETE 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 model was then used to compute ETE for all Regions and Scenarios.

Analytical Tools

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

- A macroscopic traffic simulation model (for details, see Appendix C).
- A Trip Distribution (TD), model that assigns a set of candidate destination (D) nodes for each "origin" (O) located within the analysis network, where evacuation trips are "generated" over time. This establishes a set of O-D tables.
- A Dynamic Traffic Assignment (DTA), model which assigns trips to paths of travel (routes) which satisfy the O-D tables, over time. The TD and DTA models are integrated to form the DTRAD (Dynamic Traffic Assignment and Distribution) model, as described in Appendix B.
- A Myopic Traffic Diversion model which diverts traffic to avoid intense, local congestion, if possible.

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

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

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

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

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

The evacuation analysis procedures are based upon the need to:

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

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

1.4 Comparison with Prior ETE Study

The 90th percentile ETE for the full EPZ increased by at most 20 minutes for non-heavy snow scenarios and at most 25 minutes for heavy snow scenarios when compared with the previous ETE study. The 100th percentile ETE (dictated by the trip generation time plus 10-minute travel time to EPZ boundary) for the full EPZ increases by 30 minutes for all scenarios.

Table 1-3 presents a comparison of the present ETE study with the previous ETE study (KLD TR-504, dated November, 2012). The major factors contributing to the increases in the ETE values obtained in this study when compared those of the previous study can be summarized as follows:

- Trip mobilization (also known as trip generation), based on the data collected from the demographic survey, for the following population groups have changed:
  - The permanent residents with commuters increased by 30 minutes.
  - The permanent residents without commuters increased by 45 minutes.

  As the mobilization time dictates the 100th percentile ETE, as discussed in Section 7.3, these increases in mobilization are directly correlated with the increases in the 100th percentile ETE (and the 90th percentile ETE for some cases).
- The permanent resident population increased by 1.5%, which could result in more evacuating vehicles, but the permanent resident occupancy per vehicle decreased by approximately 11%, which results in an overall increase of 13.6% in the number of permanent resident vehicles, which can increase ETE.

- The permanent resident population in the Shadow Region has increased by 2.3%, and the number of Shadow Region permanent resident vehicles has increased by 14.1%, which results in more evacutaing vehicles the Shadow Region and reduces the available roadway capacity for EPZ evacuees, which can increase ETE.
- The number of employees commuting into the EPZ decreased significantly by 46.7%, due to the updated NRC's criteria for major employers from 50 or more employees per shift to 200 or more employees per shift. A decrease in this quickly mobilizing population group can cause the 90th percentile ETE to increase as it will take longer to reach an evacuation of 90% of all vehicles.

Table 1-1. Stakeholder Interaction

Stakeholder	Nature of Stakeholder Interaction
Xcel Energy	Attended kickoff meeting to define project methodology and data requirements. Set up contacts with local government agencies. Provided recent PINGP employee data. Reviewed and approved all project assumptions and draft report. Engaged in the ETE development and was informed of the study results and coordinated with OROs. Attended final meeting where the ETE study results were presented.
Dakota County Emergency Management	Attended kickoff meeting to discuss the project methodology, key project assumptions and to define data needs. Provided emergency plans, traffic management plans and other information critical to the ETE study. Reviewed, confirmed and provided special facility data and transient data. Reviewed and approved all study assumptions. Engaged in the ETE development and was informed of the study results. Attended final meeting where the ETE study results were presented.
Goodhue County Emergency Management	
Pierce County Emergency Management	
Minnesota Department of Public Safety (DPS)	
Prairie Island Indian Community	
Red Wing Police Department	
Wisconsin Department of Military Affairs (DMA)	

Table 1-2. Highway Characteristics

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

Table 1-3. ETE Study Comparisons

Topic	Previous (2012) ETE Study	Current ETE Study
Resident Population Basis	ArcGIS Software using 2010 US Census blocks; area ratio method used. Population = 30,475 Vehicles = 15,700	ArcGIS software using 2020 US Census blocks; area ratio method used. Population = 30,932 Vehicles = 17,841
Resident Population Vehicle Occupancy	2.47 persons/household, 1.27 evacuating vehicles/household yielding: 1.94 persons/vehicle.	2.45 persons/household, 1.43 evacuating vehicles/household yielding: 1.71 persons/vehicle
Employee Population	Employee estimates based on information provided and phone calls to major employers in the EPZ. 1.03 employees per vehicle based on telephone survey results. Employees = 1,273 Vehicles = 1,235	Employee estimates based on information provided by Xcel Energy and by the counties within the EPZ. The values of 1.01 employees per vehicle based on demographic survey results. Employees = 679 Vehicles = 673
Shadow Population	ArcGIS software using 2010 US Census blocks; area ratio method used. 20% Population = 7,607 20% Vehicles = 3,920	ArcGIS software using 2020 US Census blocks; area ratio method used. 20% Population = 7,784 20% Vehicles = 4,473

Topic	Previous (2012) ETE Study	Current ETE Study
Transit-Dependent Population	Estimates based upon U.S. Census data and the results of the telephone survey. A total of 715 people who do not have access to a vehicle, requiring 24 buses to evacuate. An additional 21 homebound special needs persons need special transportation to evacuate (16 require a bus and 5 require a wheelchair-accessible vehicle).	Estimates based upon U.S. Census data and the results of the demographic survey. A total of 252 people who do not have access to a vehicle, requiring 11 buses to evacuate. An additional 21 access and/or functional needs persons (based on the previous study) require special transportation to evacuate (5 buses, 1 wheelchair bus and 1 ambulance).
Transient Population	Transient estimates based upon information provided and phone calls to transient attractions in the EPZ, supplemented by observations of the facilities from aerial photography. Transients = 9,131 Transient Vehicles = 4,683	Transient estimates based upon information provided by the counties within the EPZ, obtained from aerial imagery and facility websites. Transients = 10,723 Transient Vehicles = 5,396
Special Facilities Population	Special facility population based on information provided by each county within the EPZ. Current census = 818 Buses Required = 26 Wheelchair Bus (15 passenger) Required = 11 Wheelchair Bus (6 passenger) Required = 13 Ambulances Required = 10	Special facility population based on information extracted from last study, reviewed and confirmed by Xcel Energy, and the counties within the EPZ, supplemented by internet searches Current Census = 543 Buses Required = 20 Wheelchair Buses = 13 Ambulances = 7
School Population	School population based on information provided by each county within the EPZ (Daycares are included in these estimates). School and daycare enrollment = 3,637 Buses required = 60	School population based on information obtained from internet searches, and Goodhue County. School enrollment = 3,012 in 41 buses College = 40 in 40 personal passenger vehicles
External Traffic	7,032 vehicles considered along US-52 and US-61 for first 2 hours of evacuation.	7,732 vehicles considered along US-52 and US-61 for first 2 hours of evacuation.
Voluntary evacuation from within EPZ in areas outside region to be evacuated	20% of the population within the EPZ, but not within the Evacuation Region (see Figure 2-1).	20% of the population within the EPZ, but not within the Evacuation Region (see Figure 2-1)

Topic	Previous (2012) ETE Study	Current ETE Study
Shadow Evacuation	20% of people outside of the EPZ within the Shadow Region. (see Figure 7-2)	20% of people outside of the EPZ within the Shadow Region (see Figure 7-2)
Network Size	1,173 links; 898 nodes	1,364 links; 1,013 nodes
Roadway Geometric Data	Field surveys conducted in March 2012. Roads and intersections were video archived. Road capacities based on 2010 HCM.	Field surveys conducted in January 2021. Roads and intersections were video archived. Road capacities based on HCM 2016.
School Evacuation	Direct evacuation to designated Sister School/Reception Center.	Direct evacuation to designated Relocation Center.
Ridesharing	50% of transit-dependent persons will evacuate with a neighbor or friend.	76.6% of transit-dependent persons will evacuate with a neighbor or friend based on results of the demographic survey.
Trip Generation for Evacuation	Based on residential telephone survey of specific pre-trip mobilization activities: Residents with commuters returning leave between 15 and 240 minutes (300 minutes with heavy snow). Residents without commuters returning leave between 15 and 195 minutes (255 minutes with heavy snow). Employees and transients leave between 15 and 120 minutes. All times measured from the Advisory to Evacuate.	Based on residential demographic survey of specific pre-trip mobilization activities: Residents with commuters returning leave between 30 and 270 minutes (330 minutes with heavy snow). Residents without commuters returning leave between 15 and 240 minutes (300 minutes with heavy snow). Employees and transients leave between 5 and 75 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 10% in the event of rain and 20% for snow.	Normal, Rain/Light Snow, or Heavy Snow. The capacity and free flow speed of all links in the network are reduced by 10% in the event of rain, 15% in rain/light snow and 25% for heavy snow.
Modeling	DYNEV II System – Version 4.0.10.0	DYNEV II System – Version 4.0.21.0
Special Events	Combined Treasure Island Resort & Casino and Pow Wow Weekend Special Event Population = 5,754 additional transients	Treasure Island Casino Concert Special Event Population = 19,800 additional transients Special Event Vehicles = 8,082
Evacuation Cases	29 Regions (central sector wind direction and each adjacent sector technique used) and 14 Scenarios producing 406 unique cases.	28 Regions (central sector wind direction and 5 sector approach) and 14 Scenarios producing 392 unique cases.
Evacuation Time Estimates Reporting	ETE reported for 90th and 100th percentile population. Results presented by Region and Scenario.	ETE reported for 90th and 100th percentile population. Results presented by Region and Scenario.

Topic	Previous (2012) ETE Study	Current ETE Study
Evacuation Time Estimates for the entire EPZ, 90th percentile	Winter, Midweek, Midday, Good Weather: 2:45 Rain: 2:50 Snow: 3:20 Summer, Weekend, Midday, Good Weather: 2:40 Rain: 2:50	Winter, Midweek, Midday, Good Weather: 2:55 Rain/Light Snow: 3:05 Heavy Snow: 3:45 Summer, Weekend, Midday, Good Weather: 2:50 Rain: 3:00
Evacuation Time Estimates for the entire EPZ, 100th percentile	Winter Midweek Midday, Good Weather: 4:10 Rain: 4:10 Snow: 5:10 Summer Weekend, Midday, Good Weather: 4:10 Rain: 4:10	Winter Midweek Midday, Good Weather: 4:40 Rain/Light Snow: 4:40 Heavy Snow: 5:40 Summer Weekend, Midday, Good Weather: 4:40 Rain: 4:40

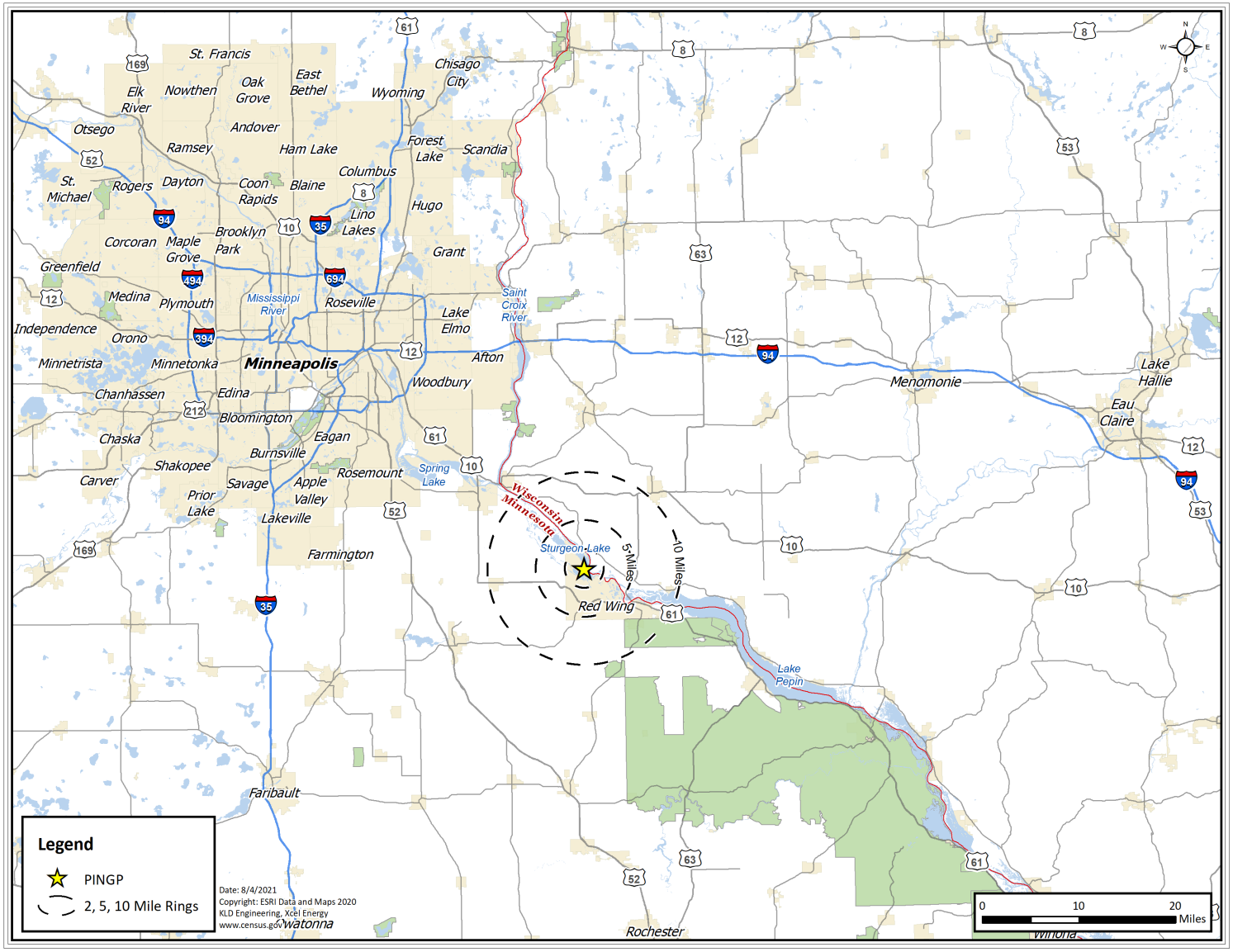


Figure 1-1. PINGP Site Location

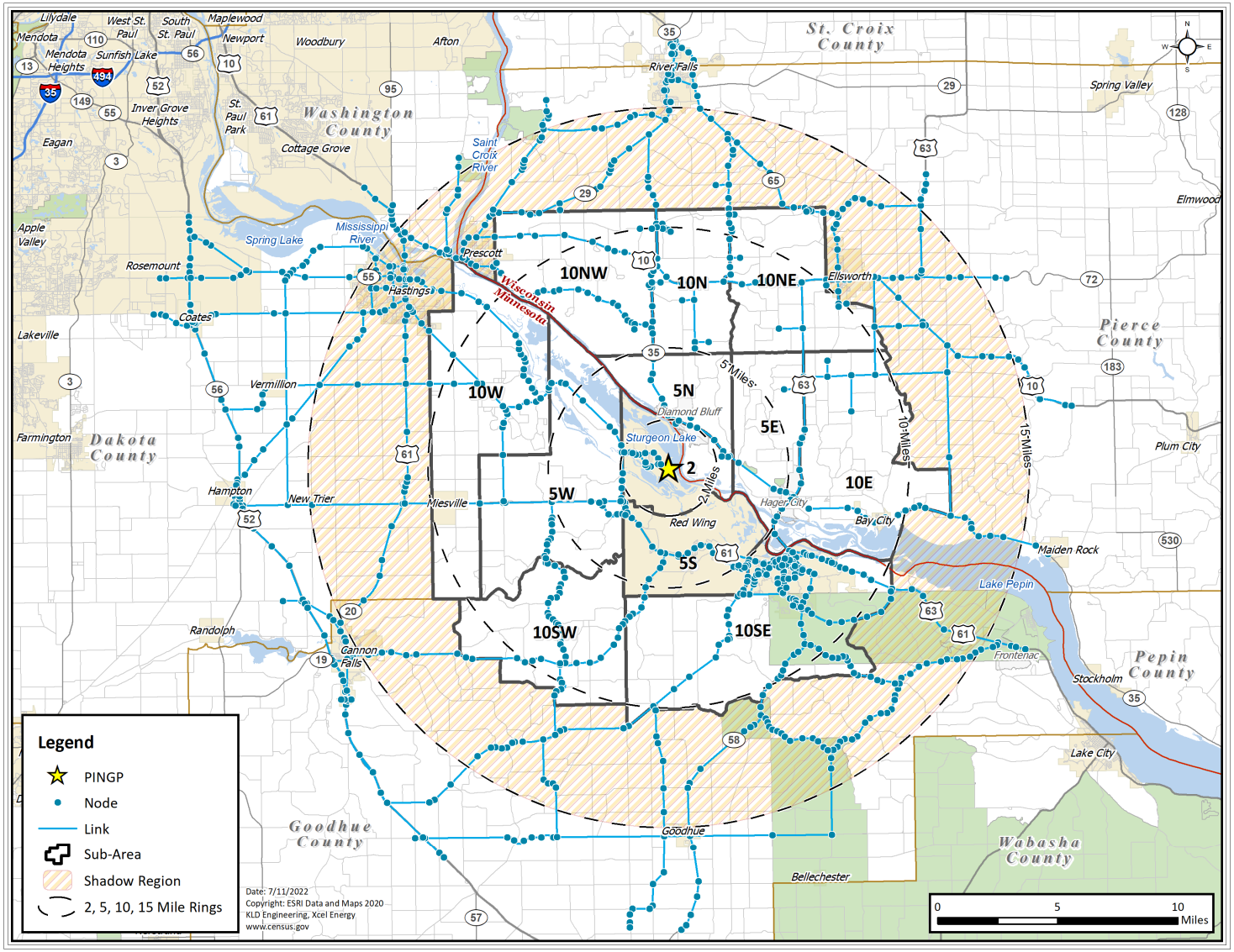


Figure 1-2. PINGP Link-Node Analysis Network

2 STUDY ESTIMATES AND ASSUMPTIONS

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

2.1 Data Estimates

1. The permanent resident population estimates are based on the 2020 U.S. Census population from the Census Bureau website[1]. A methodology, referred to as the "area ratio method", is employed to estimate the population within portions of census blocks that are divided by Sub-Area boundaries. It is assumed that the population is evenly distributed across a census block in order to employ the area ratio method (see Section 3.1.).
2. Estimates of employees who reside outside the EPZ and commute to work within the EPZ are based upon data provided by Xcel Energy and the data from the previous study that was confirmed to be still accurate by Goodhue County (see Section 3.4).
3. Population estimates at special and transient facilities are based on the data received from the counties within the EPZ, the National Center for Education Statistics website[2], Minnesota (MN) Department of Human Services[3], MN Dept of Corrections[4], and the previous ETE study, supplemented by internet searches, phone calls, and aerial imagery for parking spaces where data was missing.
4. The relationship between the permanent resident population and evacuating vehicles was based on the 2020 Census and the results of the demographic survey (see Appendix F). Average values of 2.45 persons per household (Section F.3.1) and 1.43 evacuating vehicles per household (Section F.3.2) are used.
5. On average, the relationship between persons and vehicles for transients (See Section 3.3) and the special event (see Section 3.10) are as follows:
    a. Campgrounds: 1.63 people per vehicle (NOTE: Vehicles with boat trailers are treated as 2 vehicles.)
    b. Golf Courses: 2.00 people per vehicle
    c. Marinas: 2.07 people per vehicle (NOTE: Vehicles with boat trailers are treated as 2 vehicles.)
    d. Lodging: 2.69 people per vehicle
    e. Retail: 2 people per vehicle
    f. Other Transient facilities: 1.94 people per vehicle

1 www.census.gov
2 https://nces.ed.gov/ccd/schoolsearch/index.asp
3 https://licensinglookup.dhs.state.mn.us/
4 https://mn.gov/doc/data-publications/statistics/

g. Special Event (Treasure Island Casino Concert): Transients attending the event travel as families (households) in a single vehicle. As such, the average household size of 2.45 transient per vehicle was used.
h. Where data was not provided, the average household size was assumed to be the vehicle occupancy rate for transient facilities.

6. Employee vehicle occupancies are based on the results of the demographic survey. 1.01 employees per vehicle is used in the study. In addition, it is assumed there are two people per carpool, on average.
7. The maximum bus speed assumed within the EPZ is 55 mph based on Minnesota state laws for buses and average posted speed limits on roadways within the EPZ.
8. Roadway capacity estimates are based on field surveys performed in January 2021 (verified by aerial imagery), and the application of the Highway Capacity Manual 2016.
    a. Revision 1 of NUREG/CR-7002 indicates that the impact of planned activities is assessed as part of the roadway impact scenario and are expected to have compensatory measures in place such that the activities do not significantly affect the ETE. No roadway projects were identified by Xcel Energy or the OROs. As such, no future roadway improvement projects (affecting roadway capacity estimates) were considered in this study.

2.2 Methodological Assumptions

1. The Planning Basis Assumption for the calculation of ETE is a rapidly escalating accident that requires evacuation, and includes the following[5] (as per NRC guidance):
    a. Advisory to Evacuate (ATE) is announced coincident with the siren notification.
    b. Mobilization of the general population will commence within 15 minutes after siren notification.
    c. The ETE are measured relative to the Advisory to Evacuate.
2. The center-point of the plant is located at 44°37'13.2"N, 92°37'57.7"W.
3. The DYNEV II[6] system is used to compute ETE in this study.
4. Evacuees will drive safely, travel radially away from the plant to the extent practicable given the highway network and obey all control devices and traffic guides. All major evacuation routes are used in the analysis.

[5] It is emphasized 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.

See Section 5.1 for more detail.

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

5. The existing EPZ and Sub-Area boundaries are used. (See Figure 3-1.)
6. The Shadow Region extends to 15 miles radially from the plant or approximately 5 miles radially from the EPZ boundary, as per NRC guidance. (See Figure 7-2.)
7. One hundred percent (100%) of the people within the impacted "keyhole" will evacuate. Twenty percent (20%) of the population within the Shadow Region and within Sub-Areas of the EPZ not advised to evacuate will voluntarily evacuate, as shown in Figure 2-1, as per NRC guidance. Sensitivity studies explore the effect on ETE of increasing the percentage of voluntary evacuees in the Shadow Region (see Appendix M).
8. Shadow population characteristics (household size, evacuating vehicles per household, and mobilization time) is assumed to be the same as that of the permanent resident population within the EPZ.
9. The ETE are presented for the evacuation of the 90th and 100th percentiles of population for each Region and for each Scenario, as well as in graphical and tabular format, as per NRC guidance. The percentile ETE is defined as the elapsed time from the ATE issued to a specific Region of the EPZ, to the time that Region is clear of the indicated percentile of evacuees.
10. The ETE also includes consideration of "through" (External-External traffic that originates its trip outside of the study area and has its destination outside of the study area) trips during the time that such traffic is permitted to enter the evacuated Region (see Section 3.11).
11. This study does not assume that roadways are empty at the start of the first time period. Rather, there is an initialization period (often referred to as "fill time" in traffic simulation) wherein the anticipated traffic volumes from the start of the evacuation are loaded onto roadways in the study area. The amount of initialization/fill traffic that is on the roadways in the study area at the start of the evacuation depends on the scenario and the region being evacuated. (See Section 3.12).
12. To account for boundary conditions (roadway conditions outside the study area that are not specifically modeled due to the limited radius of the study area) beyond the study area, this study assumed a 25% reduction in capacity on two-lane roads and multilane highways for roadways that have traffic signals downstream. The 25% reduction in capacity is based on the prevalence of actuated traffic signals in the study area and the fact that the evacuating traffic volume ("main street") is more significant than the competing ("side street") traffic volume at any downstream signalized intersections, thereby warranting a more significant percentage (75% in this case) of the signal green time. There is no reduction in capacity for freeways due to boundary conditions.

2.3 Assumptions on Mobilization Times

1. Trip generation time (also known as mobilization time, or the time required by evacuees to prepare for the evacuation) are based upon the results of the online demographic

survey (see Section 5 and Appendix F). It is assumed that stated events take place in sequence such that all preceding events must be completed before the current event can occur.

2. One hundred percent (100%) of the EPZ population can be notified within 45 minutes, in accordance with the 2019 Federal Emergency Management Agency (FEMA) Radiological Emergency Preparedness Program Manual.

3. Commuter percentages (and the percentage of residents awaiting the return of a commuter) are based on the results of the demographic survey. According to the survey results, 73.7% of the households in the EPZ have at least 1 commuter; 55.1% of those households with commuters will await the return of a commuter before beginning their evacuation trip. Therefore, 40.6% (73.7% x 55.1% = 40.6%) of EPZ households will await the return of a commuter, prior to beginning their evacuation trip.

2.4 Transit Dependent Assumptions

1. The percentage of transit-dependent people who rideshare with a neighbor or friend are based on the results of the demographic survey. According to the survey results, 76.6% of the transit-dependent population rideshare.

2. Transit Vehicles are used to transport those without access to private vehicles:

    a. Schools and day care centers
        i. If schools are in session, transport (buses) will evacuate students directly to the sister schools.
        ii. It is assumed that parents will pick up children at small day care facilities prior to evacuation.
        iii. For the schools that are evacuated via buses, it is assumed no school children will be picked up by their parents prior to the arrival of the buses.
        iv. Schoolchildren, if school is in session, are given priority in assigning transit vehicles.
    b. Medical Facilities
        i. Buses, wheelchair vans, mini vans and ambulances evacuate patients at medical facilities and at any medical facilities within the EPZ, as needed.
        ii. The percent breakdown of ambulatory, wheelchair bound and bedridden patients from the previous study was used to determine the number of ambulatory, wheelchair bound and bedridden patients at the medical facilities wherein new data was not provided.
    c. Correctional Facility – Minnesota Correctional Facility - Red Wing
        i. Buses evacuate inmates at Minnesota Correctional Facility at Red Wing to a local facility or other state correctional facility.
    d. Transit-dependent permanent residents
        i. Transit-dependent permanent resident population are evacuated to reception centers.

ii. Access and/or functional needs population may require county assistance (ambulance, bus or wheelchair transport) to evacuate. The type of assistance breakdown was not provided, so percent breakdown of ambulatory, wheelchair bound, and bedridden patients of the medical facilities was utilized. This is considered separately from the general population ETE, as per NRC guidance (see Section 8).
iii. Households with 3 or more vehicles were assumed to have no need for transit vehicles.

e. Analysis of the number of required round-trips ("waves") of evacuating transit vehicles are presented.
f. Transport of transit-dependent evacuees from reception centers to congregate care centers is not considered in this study.

3. Transit vehicle capacities:

   a. School buses = 77 students per bus.
   b. Buses used for transit dependent population, access and/or functional needs population, correctional facility, and medical facility patients = 30 persons per bus
   c. Mini Van = 2 wheelchair bound persons
   d. Ambulances = 2 bedridden persons (includes advanced and basic life support)
   e. Wheelchair buses = 6 wheelchair bound persons (Dakota County); up to 5 wheelchair bound persons (Pierce County); up to 12 wheelchair bound persons (Goodhue County)

4. Transit vehicles mobilization times, which will be considered in ETE calculations:

   a. School buses arrive at these facilities to be evacuated within 90 minutes of the ATE.
   b. Transit dependent buses are mobilized when 85% of the residents with no commuters have completed their mobilization at 120 minutes after the ATE.
   c. Vehicles arrive at hospitals, medical facilities, senior living facilities, and for access and/or functional needs population to be evacuated within 90 minutes of the ATE.
   d. Buses will arrive at Minnesota Correctional Facility - Red Wing within 90 minutes of the ATE.
   e. If necessary, multiple waves of buses will be utilized to gather transit dependent people who mobilize more slowly.

5. Transit Vehicle loading times:

   a. Concurrent loading on multiple buses/transit vehicles is assumed.
   b. School buses are loaded in 15 minutes.
   c. Transit Dependent buses require 1 minute of loading time per passenger.

d. Buses for medical facilities, correctional facilities, and senior living and the access and/or functional needs population require 1 minute of loading time per ambulatory passenger.
e. Wheelchair transport vehicles require 5 minutes of loading time per passenger.
f. Ambulances are loaded in 15 minutes per bedridden passenger.

6. Drivers for all transit vehicles, identified in Table 8-1, are available.

2.5 Traffic and Access Control Assumptions

1. Traffic and Access Control Points (TACP) as defined in the approved county and state emergency plans are considered in the ETE analysis, as per NRC guidance. See Table G-1 and in Appendix G.
2. The TACPs are assumed to be staffed approximately 120 minutes after the ATE, as per NRC guidance. It is assumed that no through traffic will enter the EPZ after this 120-minute time period.
3. It is assumed that all transit vehicles and other responders entering the EPZ to support the evacuation are unhindered by personnel manning TACPs.

2.6 Scenarios and Regions

1. A total of 14 "Scenarios" representing different temporal variations (season, time of day, day of week) and weather conditions are considered. Scenarios to be considered are defined in Table 2-1:
    a. Treasure Island Casino Concert, located in Sub-Area 2, is considered as the special event (single or multi-day event that attracts a significant population into the EPZ; recommended by NRC guidance) for Scenario 13.
    b. As per NRC guidance, one segment of one of the highest volume roadways must be closed or one lane outbound on a freeway must be closed for a roadway impact scenario. Since there are no freeways in the study area, this study considers the closure of a segment of US-61 eastbound from US-63 to County 292 Blvd – Scenario 14.
2. Two types of adverse weather scenarios are considered. Rain may occur for either winter or summer scenarios; snow occurs in winter scenarios only. It is assumed that the rain or snow begins earlier or at about the same time the evacuation advisory is issued. Thus, no weather-related reduction in the number of transients who may be present in the EPZ is assumed. It is assumed that snow removal equipment is available, the appropriate agencies are clearing/treating the roads as they would normally during with snow, and the roads are passable albeit at lower speeds and capacities.
3. Adverse weather affects roadway capacity and the free flow roadway speeds. Transportation research indicates capacity and speed reductions of about 10% for rain/light snow and a range of 10% to 25% for heavy snow. In accordance with Table 3-1 of NUREG/CR-7002, Rev. 1, this study assumes a 10% reduction in speed and capacity

for rain/light snow and a speed and capacity reduction of 15% and 25%, respectively, for heavy snow. The factors are shown in Table 2-2.

4. Some evacuees will need additional time for heavy snow scenarios to clear their driveways and access the public roadway system. The distribution of time for this activity was gathered through a demographic survey of the public and takes up to 150 minutes for permanent residents. It is assumed that the time needed by evacuees to remove snow from their driveways is sufficient time for snow removal crews to mobilize and clear/treat the public roadway system.
5. Employment is reduced slightly (4% reduction) in the summer for vacations.
6. Mobilization and loading times for transit vehicles are slightly longer in adverse weather. It is assumed that mobilization times are 10 minutes and 20 minutes longer in rain/light snow and heavy snow, respectively. It is assumed that loading times for school buses are 5 minutes (10 minutes for transit-dependent population) and 10 minutes longer (20 minutes longer for transit-dependent population) in rain/light snow and heavy snow, respectively. Refer to Table 2-2.
7. Regions are defined by the underlying "keyhole" or circular configurations as specified in Section 1.4 of NUREG/CR-7002, Rev. 1 using a 5-sector approach based on conversations with Xcel Energy. These Regions, as defined, display irregular boundaries reflecting the geography of the Sub-Areas included within these underlying configurations. All 16 cardinal and intercardinal wind direction keyhole configurations are considered. Regions to be considered are defined in Table 6-1. It is assumed that everyone within the group of Sub-Areas forming a Region that is issued an ATE will, in fact, respond and evacuate in general accord with the planned routes.
8. Staged evacuation will be considered as defined in NUREG/CR-7002, Rev. 1 – those people between 2 and 5 miles will shelter-in-place until 90% of the 2-Mile Region has evacuated, then they will evacuate. See Regions R21 through R28 in Table 6-1.

Table 2-1. Evacuation Scenario Definitions

Scenario	Season[7]	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/Light Snow	None
8	Winter	Midweek	Midday	Heavy Snow	None
9	Winter	Weekend	Midday	Good	None
10	Winter	Weekend	Midday	Rain/Light Snow	None
11	Winter	Weekend	Midday	Heavy Snow	None
12	Winter	Midweek, Weekend	Evening	Good	None
13	Summer	Midweek, Weekend	Evening	Good	Treasure Island Casino Concert
14	Summer	Midweek	Midday	Good	Closure US-61 EB between US-63 and County 292 Blvd

Table 2-2. Model Adjustment for Adverse Weather

Scenario	Highway Capacity*	Free Flow Speed*	Mobilization Time for General Population	Mobilization Time for Special Facility/Transit Vehicles	Loading Time for School Buses	Loading Time for Transit Buses[8]
Rain/Light Snow	90%	90%	No Effect	10-minute increase	5-minute increase	10-minute increase
Heavy Snow	75%	85%	Clear driveway before leaving home (See Figure F-19)	20-minute increase	10-minute increase	20-minute increase

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

[7] Winter means that school is in session at normal enrollment levels (also applies to spring and autumn). Summer means that school is in session at summer school enrollment levels (lower than normal enrollment).
[8] Does not apply to medical facilities and those with access and/or functional needs as loading times for these people are already conservative.

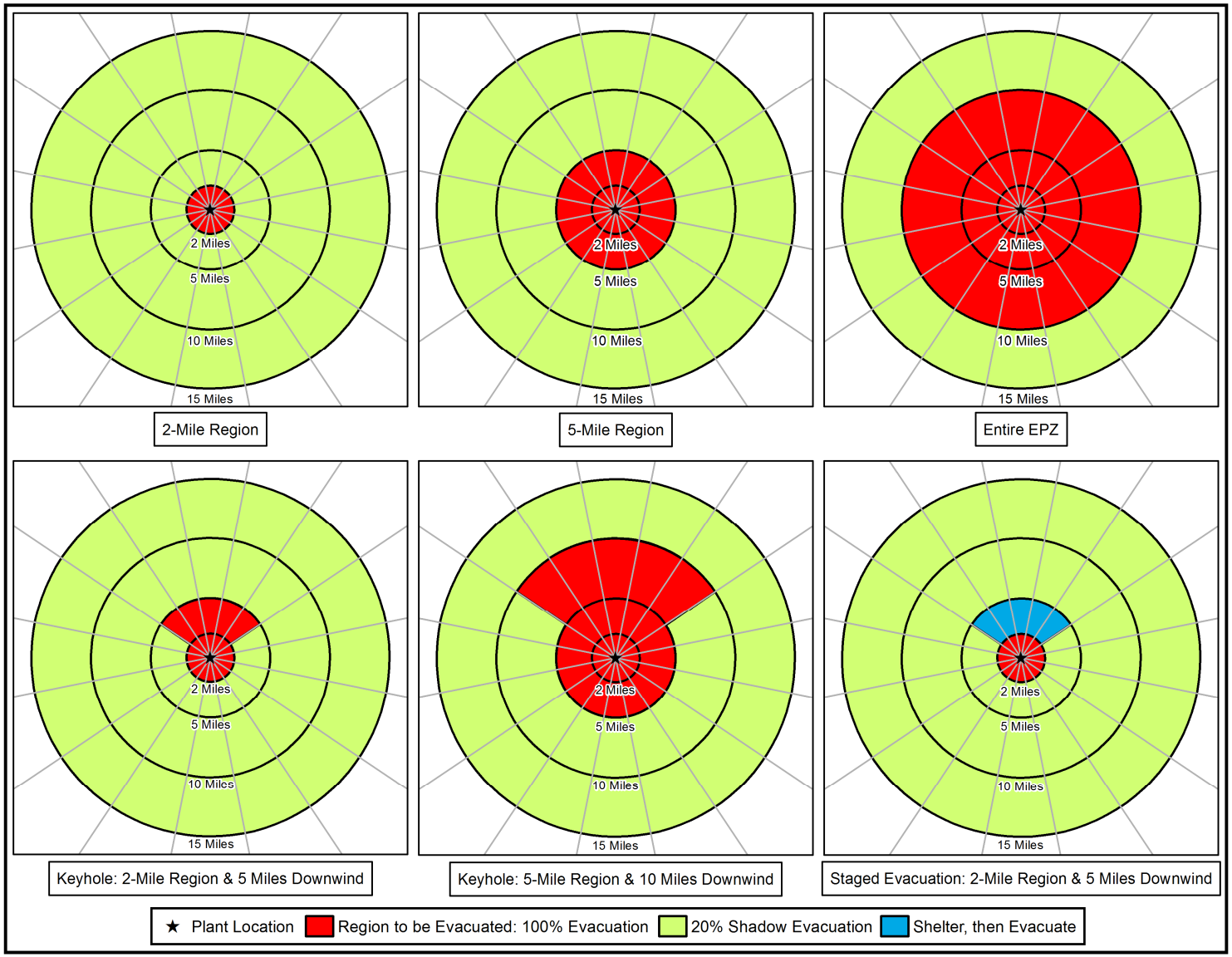


Figure 2-1. Voluntary Evacuation Methodology

3 DEMAND ESTIMATION

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

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

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

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

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

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

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

Analysis of the population characteristics of the PINGP 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 work within the EPZ on a daily basis.

Estimates of the population and number of evacuating vehicles for each of the population groups are presented for each Sub-Area and by polar coordinate representation (population rose). The PINGP EPZ is subdivided into 12 Sub-Areas. The Sub-Areas comprising the EPZ are shown in Figure 3-1.

3.1 Permanent Residents

The primary source for estimating permanent population is the latest U.S. Census data with an availability date of September 16, 2021. The average household size (2.45 persons/household – See Section 2.1) was estimated using the U.S. Census data (See Appendix F, Sub-section F.3.1). The number of evacuating vehicles per household (1.43 vehicles/household – See Appendix F, sub-section F.3.2) was adapted from the demographic survey.

The permanent resident population is estimated by cutting the census block polygons by Sub-Area and EPZ boundaries using GIS software. A ratio of the original area of each census block and the updated area (after cutting) is multiplied by the total block population to estimate the population within the EPZ. The methodology (referred to as the "area ratio method") assumes that the population is evenly distributed across a census block. Table 3-1 provides the permanent resident population within the EPZ, by Sub-Area, for 2010 and 2020 (based on the methodology above). As indicated, the permanent resident population within the EPZ has increased by 1.50% since the 2010 Census.

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

3.2 Shadow Population

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

Shadow population characteristics (household size, 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. Similar to the EPZ resident vehicle estimates, resident vehicles at group quarters have been removed from the shadow population vehicle demand in Table 3-3 and Figure 3-5.

3.3 Transient Population

Transient population groups are defined as those people (who are not permanent residents, nor commuting employees) who enter the EPZ for a specific purpose (shopping, recreation). Transients may spend less than one day or stay overnight at camping facilities, hotels and motels. Data for these facilities were provided by the counties within the EPZ. When data was not provided, the number of transient vehicles was estimated based on the parking lot capacity or accommodation capacity obtained from aerial imagery and facility websites. It is assumed that transients would travel as a family/household (2.45 persons per vehicle – See Section 3.1) to recreational areas, except for golf courses wherein 2 people per vehicle was assumed. These assumptions were used to estimate the transient population. The transient attractions within the PINGP EPZ are summarized as follows:

- Campgrounds – 1,108 transients and 678 vehicles; 1.63 transients per vehicle (NOTE: Recreational Vehicles (RVs) are treated as 2 vehicles due to their larger size and more sluggish operating characteristics.)
- Golf Courses – 328 transients and 164 vehicles; 2.00 transients per vehicle
- Marinas – 1,917 transients and 924 vehicles; 2.07 transients per vehicle (NOTE: Vehicles with boat trailers are treated as 2 vehicles.)
- Other Transient Attractions – 5,925 transients and 3,055 vehicles; 1.94 transients per vehicle
- Red Wing Mall – 300 transients and 150 vehicles; 2.00 transients per vehicle
- Lodging Facilities – 1,145 transients and 425 vehicles; 2.69 transients per vehicle

Appendix E summarizes the transient data that was estimated for the EPZ. Table E-4 through Table E-7 present the number of transients visiting recreational areas, while Table E-8 presents the number of transients at lodging facilities within the EPZ.

In total, there are 10,723 transients in the EPZ at peak times, evacuating in 5,396 vehicles (an average vehicle occupancy of 1.99 transients per vehicle). Table 3-4 presents transient population and transient vehicle estimates by Sub-Area. Figure 3-6 and Figure 3-7 present these data by sector and distance from the plant.

3.4 Employees

Employees who work within the EPZ fall into 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.

Employment data was provided by Xcel Energy and by the counties within the EPZ, including the maximum shift employment and percentage of employees commuting into the EPZ. As per NUREG/CR-7002, Rev. 1 guidance, employers with 200 or more employees working in a single

shift are considered as major employers. As such, the employers not meeting this criterion are not considered in this study. In the PINGP EPZ, four employers are identified as major employers in the Goodhue County portion of the EPZ, as shown in Appendix E, Table E-3.

To estimate the evacuating employee vehicles, a vehicle occupancy rate of 1.01 employees per vehicle obtained from the demographic survey (see Appendix F, Sub-section F.3.1) was used for all the major employers. Table 3-5 presents the estimates of employees and vehicles commuting into the EPZ by Sub-Area. Figure 3-8 and Figure 3-9 present these data by sector.

3.5 Medical Facility

Data was reviewed and confirmed by Xcel Energy and Goodhue County for each of the medical facilities within the EPZ. All medical facilities are located within Goodhue County. In addition to the preexisting medical facilities included in the previous study, there is a new facility – Loving Residence (located in Red Wing) - where the breakdown of patients was not available. The average percent breakdown of patient type at the medical facilities from previous study was used to estimate the number of ambulatory, wheelchair bound and bedridden patients at this facility. Table E-2 in Appendix E summarizes the data gathered. Table 3-6 presents the current population at medical facilities within the EPZ. A total of 543 people (445 ambulatory, 86 wheelchair-bound and 12 bedridden) have been identified as living in, or being treated in, these facilities. The number and type of evacuating vehicles that need to be provided depend on the patients' state of health.

The transportation requirements for the medical facility population are also presented in Table 3-6. The number of ambulance runs is determined by assuming that 2 patients can be accommodated per ambulance trip; the number of wheelchair bus runs assumes 12 wheelchairs per trip and the number of bus runs estimated assumes 30 ambulatory patients per trip. As such, a total of 40 vehicles (20 buses, 13 wheelchair buses, and 7 ambulances) are required. Buses are represented as two vehicles in the ETE simulations due to their larger size and more sluggish operating characteristics. As such 73 passenger car equivalents (pce's) are assigned to the medical facilities in the EPZ.

3.6 Correctional Facility

As detailed in Table E-9, there is one correctional facility within the EPZ – the Minnesota Correctional Facility - Red Wing. The total inmate population at this facility is 200 inmates, which was obtained from the Minnesota Department of Corrections website. The number of bus runs estimated assumes 30 inmates per trip. As such, a total of 7 buses (14 pce's) are needed for the evacuation of Minnesota Correctional Facility at Red Wing.

3.7 School Population Demand

3.7.1 Schools

Table 3-7 presents the school population and transportation requirements for the direct evacuation of all facilities obtained from the National Center for Education Statistics website[1], Minnesota (MN) Department of Human Services[2], and Goodhue County. The column in Table 3-7 entitled "Buses Required" specifies the number of buses required for each school under the following set of assumptions and estimates:

- No children at schools will be picked up by their parents prior to the arrival of the buses.
- It is assumed that parents will pick up children at day care facilities prior to evacuation and these facilities are, therefore, not included in Table 3-7.
- While many high school students commute to school using private automobiles (as discussed in Section 2.4 of NUREG/CR-7002, Rev. 1), the estimate of buses required for school evacuation do not consider the use of these private vehicles.
- Bus capacity, expressed in students per bus, is set to 77 for all 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.

The counties in the EPZ could introduce procedures whereby the schools are contacted prior to the dispatch of buses from the depot, to ascertain the current estimate of students to be evacuated, which may improve bus utilization. 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 (although they are not advised to do so), can be gainfully assigned to service other facilities or those persons who do not have access to private vehicles or to ride-sharing.

Buses for schools are represented as two vehicles in the ETE simulation due to their larger size and more sluggish operating characteristics.

3.7.2 Commuter College

There is one community college, Southeast Minnesota Technical College in Red Wing, located in Sub-Area 10SE, 10.0 miles southeast of PINGP. Since this college does not have campus housing, all students commute to school. The student population, having similar travel patterns to those as employees, was assumed to share the same vehicle occupancy rates as employees (1.01 commuting students/vehicle – See Appendix F, Sub-Section F.3.1). A total of 40 commuting students and 40 vehicles were assigned to the college campus.

[1] https://nces.ed.gov/ccd/schoolsearch/index.asp
[2] https://licensinglookup.dhs.state.mn.us/

3.8 Transit Dependent Population

The demographic 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 3-8 presents estimates of transit-dependent people. Note:

- Estimates of persons requiring transit vehicles include schoolchildren. For those evacuation scenarios where children are at school when an evacuation is ordered, separate transportation is provided for the schoolchildren. The actual need for transit vehicles by residents is thereby less than the given estimates. However, estimates of transit vehicles are not reduced when schools are in session.
- It is reasonable and appropriate to consider that many transit-dependent persons will evacuate by ridesharing with neighbors, friends or family. For example, nearly 80 percent of those who evacuated from Mississauga, Ontario[3] 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. **Based on the results of the demographic survey, 76.6% of the transit-dependent population will rideshare.**

The estimated number of bus trips needed to service transit-dependent persons is based on an estimated average bus occupancy of 30 persons at the conclusion of the bus run. Transit vehicle seating capacities typically equal or exceed 60 children on average (roughly equivalent to 40 adults). If transit vehicle evacuees are two thirds adults and one third children, then the number of "adult seats" taken by 30 persons is 20 + (2/3 x 10) = 27. On this basis, the average load factor anticipated is (27/40) x 100 = 68 percent. Thus, if the actual demand for service exceeds the estimates of Table 3-8 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 3-8 indicates that transportation must be provided for 252 people. Therefore, a total of 9 bus runs are required from a capacity standpoint. In order to service all of the transit dependent population and have a least one bus drive through each of the designated assembly points, as per IPRA emergency plan, to pick up transit dependent people, 11 bus runs are used in the ETE calculations. These buses are represented as two vehicles in the ETE simulations due

[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 77% (Page 5-10).

to their larger size and more sluggish operating characteristics.

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

$$P = 12{,}625 \times [0.0119 \times 1.4 + 0.1758 \times (1.54 - 1) \times 0.737 \times 0.449 + 0.4489 \times (2.76 - 2) \times (0.737 \times 0.449)^2] = 1{,}079$$

$$B = ((1 - 0.766) \times P) \div 30 = (0.234\ \times 1{,}079) \div 30 = 9\ (rounded\ up)$$

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

- The total number of persons requiring public transit is the sum of such people in households (HH) with no vehicles, or with 1 or 2 vehicles that are away from home.
- The HH is computed by dividing the EPZ population by the average household size (30,932 ÷ 2.45) and is 12,625.
- All of the members of HH (1.4) with no vehicles (1.19%) are assumed to need public transit or will ride-share.
- The members of HH with 1 vehicle away (17.58%), who are at home, equal (1.54-1). The number of HH where the commuter will not return home is equal to (12,625 x 0.1758 x 0.54 x 0.737 x 0.449), as 73.7% of EPZ households have a commuter, 44.9% 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 (44.89%), who are at home, equal (2.76 – 2). The number of HH where neither commuter will return home is equal to 12,625 x 0.4489 x 0.76 x $(0.737 \times 0.449)^2$. 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.

3.9 Access and/or Functional Needs Population

The 2012 access and/or functional needs population registered within the EPZ was confirmed for use in this study by Xcel Energy and off-site response organizations (OROs). Based on the data provided from the previous study, there are a total of 21 access and/or functional needs people within the EPZ (6 from Goodhue County, 0 from Dakota County, and 15 from Pierce County from state of Wisconsin). Details on the number of ambulatory, wheelchair bound and

bedridden people was not available, so the percentage breakdown of the medical facilities was used to estimate the breakdown of transportation need for these people. As such, 64.1% was considered ambulatory, 33.5% wheelchair-bound and 2.4% bedridden. Thus, the 21 access and/or functional needs people are comprised of 13 ambulatory persons, 7 wheelchair-bound persons and 1 bedridden person (see Table 3-9).

3.10 Special Event

A special event can attract large number of transits to the EPZ for short periods of time, creating a temporary surge in demand as per Section 2.5.1 of NUREG/CR-7002, Rev. 1. The counties and state emergency management agencies were polled regarding potential special events in the EPZ. The potential special event (Scenario 13) identified by the county and state agencies (that attracts the largest number of transients from outside the EPZ) is the Treasure Island Casino Concert, which occurs in Welch, Minnesota (Sub-Area 2 in Goodhue County).

Based on the data provided, the peak attendance during the event is approximately 25,000 people. It was assumed 90% of those people travel from outside the EPZ, and some attendees are likely to stay at hotels in the Red Wing area. These assumptions yield an additional 19,800 transients traveling in 8,082 vehicles (using the average household size of 2.45 people per household) at the Indian Reservation for the Treasure Island Casino Concert. It is conservatively assumed that these visitors are in addition to the daily visitors shown in Table E-7.

The special event vehicle trips were generated utilizing the same mobilization distributions for transients. Vehicles were loaded in parking lots at the casino for this scenario. Public transportation to transport attendees to parking lots are not considered as part of this study.

3.11 External Traffic

Vehicles will be traveling through the EPZ (external-external trips which have their origins and destinations outside of the EPZ) at the time of an accident. After the Advisory to Evacuate (ATE) is announced, these through-travelers will also evacuate. These through vehicles are assumed to travel on the major routes traversing the EPZ – US-52 and US-61. It is assumed that this traffic will continue to enter the EPZ during the first 120 minutes following the ATE.

Average Annual Daily Traffic (AADT) data was obtained from the Minnesota Department of Transportation Traffic Mapping website[4] to estimate the number of vehicles per hour on the aforementioned routes. The AADT was multiplied by the K-Factor, which is the proportion of the AADT on a roadway segment or link during the design hour, resulting in the design hour volume (DHV). The design hour is usually the 30th highest hourly traffic volume of the year, measured in vph. The DHV is then multiplied by the D-Factor, which is the proportion of the DHV occurring in the peak direction of travel (also known as the directional split). The resulting values are the directional design hourly volumes (DDHV) and are presented in Table 3-10, for each of the routes considered. The DDHV is then multiplied by 2 hours since traffic and access control posts (TACPs) are assumed to be activated at 120 minutes after the ATE to estimate the

[4] https://www.dot.state.mn.us/traffic/data/tma.html

total number of external vehicles loaded on the analysis network. As indicated, there are 7,732 vehicles entering the study area as external-external trips prior to the activation of the TACP and the diversion of this traffic. This number is reduced by 60% for evening scenarios (Scenarios 5, 12 and 13) as discussed in Section 6.

3.12 Background Traffic

Section 5 discusses the time needed for the people in the EPZ to mobilize and begin their evacuation trips. As shown in Table 5-9, there are 14 time periods during which traffic is loaded on to roadways in the study area to model the mobilization time of people in the EPZ. Note, there is no traffic generated during the 15th time period, as this time period is intended to allow traffic that has already begun evacuating to clear the study area boundaries.

This study does not assume that roadways are empty at the start of the evacuation (Time Period 1). Rather, there is an initialization time period (often referred to as "fill time" in traffic simulation) wherein the traffic volumes from Time Period 1 are loaded onto roadways in the study area. The amount of initialization/fill traffic that is on the roadways in the study area at the start of Time Period 1 depends on the scenario and the region being evacuated (see Section 6). There are 2,274 vehicles on the roadways in the study area at the end of fill time for an evacuation of the entire EPZ (Region R03) under Scenario 3 (summer, weekend, midday, with good weather) conditions

3.13 Summary of Demand

A summary of population and vehicle demand is provided in Table 3-11 and Table 3-12, respectively. This summary includes all population groups described in this section. A total of 73,925 people and 44,428 vehicles are considered in this study.

Table 3-1. EPZ Permanent Resident Population

Sub-Area	2010 Population	2020 Population
2 (Goodhue)	257	233
2 (Pierce)	158	146
5N	311	332
5E	971	1,034
5S	3,602	3,748
5W	754	855
10N	616	653
10NE	1,760	1,714
10E	2,063	1,995
10SE	13,870	13,854
10SW	729	671
10W	3,456	3,442
10NW	1,928	2,255
EPZ TOTAL	**30,475**	**30,932**
EPZ Population Growth (2010-2020):		**1.50%**

Table 3-2. Permanent Resident Population and Vehicles by Sub-Area

Sub-Area	2020 Population	2020 Resident Vehicles
2 (Goodhue)	233	137
2 (Pierce)	146	85
5N	332	196
5E	1,034	605
5S	3,748	2,175
5W	855	502
10N	653	383
10NE	1,714	998
10E	1,995	1,166
10SE	13,854	7,871
10SW	671	393
10W	3,442	2,011
10NW	2,255	1,319
EPZ TOTAL	**30,932**	**17,841**

Table 3-3. Shadow Population and Vehicles by Sector

Sector	2020 Population	Evacuating Vehicles
N	1,739	958
NNE	501	294
NE	3,825	2,156
ENE	541	318
E	413	245
ESE	325	191
SE	405	240
SSE	469	276
S	610	355
SSW	358	208
SW	568	333
WSW	1,507	865
W	828	483
WNW	14,184	8,197
NW	11,671	6,679
NNW	974	569
TOTAL	**38,918**	**22,367**

Table 3-4. Summary of Transients and Transient Vehicles

Sub-Area	Transients	Transient Vehicles
2 (Goodhue)	5,850	3,112
2 (Pierce)	0	0
5N	0	0
5E	364	182
5S	570	231
5W	0	0
10N	0	0
10NE	0	0
10E	244	159
10SE	2,936	1,295
10SW	525	213
10W	234	204
10NW	0	0
EPZ TOTAL	**10,723**	**5,396**

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

Sub-Area	Employees	Employee Vehicles
2 (Goodhue)	390	386
2 (Pierce)	0	0
5N	0	0
5E	0	0
5S	138	137
5W	0	0
10N	0	0
10NE	0	0
10E	0	0
10SE	151	150
10SW	0	0
10W	0	0
10NW	0	0
EPZ TOTAL	**679**	**673**

Table 3-6. Medical Facility Transit Demand

Sub-Area	Facility Name	Municipality	Current Census	Ambu-latory	Wheel-chair Bound	Bed-ridden	Bus Runs	Wheel-chair Bus Runs	Ambulance Runs
Goodhue County									
5S	Deer Crest	Red Wing	81	77	4	0	3	1	0
5S	Mayo Clinic Health System-Red Wing	Red Wing	18	7	4	7	1	1	4
10SE	Bay View Nursing & Rehabilitation Center	Red Wing	78	50	26	2	2	3	1
10SE	Loving Residence	Red Wing	7	5	2	0	1	1	0
10SE	Potter Ridge Assisted Living	Red Wing	48	43	2	3	2	1	2
10SE	The Downtown Plaza	Red Wing	78	76	2	0	3	1	0
10SE	Jordan Towers I & II	Red Wing	159	159	0	0	6	0	0
10SE	St. Crispin Living Community	Red Wing	61	16	45	0	1	4	0
10SE	Valentines Assisted Living	Red Wing	13	12	1	0	1	1	0
		TOTAL:	**543**	**445**	**86**	**12**	**20**	**13**	**7**

Table 3-7. School and College Population Demand Estimates

Sub-Area	School Name	Enrollment	Buses Required
5S	Tower View Alternative High School	68	1
5S	Burnside Elementary School	528	7
10SE	Jefferson Elementary School	185	3
10SE	St. John's Lutheran School	52	1
10SE	Colvill Family Center	76	1
10SE	Sunnyside Elementary School	450	6
10SE	Twin Bluff Middle School	644	9
10SE	Southeast Minnesota Technical College - Red Wing[5]	40	0
10SE	Red Wing High School	969	13
	TOTAL:	**3,012**	**41**

Table 3-8. Transit-Dependent Population Estimates

2020 EPZ Population	Survey Average HH Size with Indicated No. of Vehicles			Estimated No. of Households	Survey Percent HH with Indicated No. of Vehicles			Survey Percent HH with Commuters	Survey Percent HH with Non-Returning Commuters	Total People Requiring Transport	Estimated Ridesharing Percentage	People Requiring Public Transit	Percent Population Requiring Public Transit
	0	1	2		0	1	2						
30,932	1.40	1.54	2.76	12,625	1.19%	17.58%	44.89%	73.7%	44.9%	1,079	76.6%	252	0.8%

[5] All students commute to this school. As such, the students that attend this school will evacuate in personal vehicles and no buses were assigned to this facility.

Table 3-9. Access and/or Functional Needs Demand Summary

Population Group	Vehicle Type	Population	Vehicles deployed
Ambulatory	Buses	13	5
Wheelchair bound	Wheelchair Van	7	0
	Wheelchair Bus		1
Bedridden	Ambulances	1	1
	Total:	**21**	**3**

Table 3-10. External Traffic in the PINGP Study Area

Upstream Node	Downstream Node	Road Name	Direction	MNDOT[6] AADT	K-Factor[7]	D-Factor[2]	Hourly Volume	External Traffic
8341	341	US-52	NB	23,348	0.107	0.5	1,249	2,498
8360	896	US-52	SB	23,348	0.107	0.5	1,249	2,498
8048	48	US-61	NB	11,800	0.116	0.5	684	1,368
8403	403	US-61	SB	11,800	0.116	0.5	684	1,368
							TOTAL:	**7,732**

[6] MNDOT Traffic Mapping Application; https://www.dot.state.mn.us/traffic/data/tma.html
[7] HCM 2016

Table 3-11. Summary of Population Demand[8]

Sub-Area	Residents	Transit-Dependent	Transients	Employees	Special Facilities[9]	Colleges	Schools	Special Event	Shadow Population[10]	External Traffic	Total
2 (Goodhue)	233	2	5,850	390	0	0	0	19,800	0	0	26,275
2 (Pierce)	146	1	0	0	0	0	0	0	0	0	147
5N	332	3	0	0	0	0	0	0	0	0	335
5E	1,034	8	364	0	0	0	0	0	0	0	1,406
5S	3,748	31	570	138	99	0	596	0	0	0	5,182
5W	855	7	0	0	0	0	0	0	0	0	862
10N	653	5	0	0	0	0	0	0	0	0	658
10NE	1,714	14	0	0	0	0	0	0	0	0	1,728
10E	1,995	16	244	0	0	0	0	0	0	0	2,255
10SE	13,854	114	2,936	151	644	40	2,376	0	0	0	20,115
10SW	671	5	525	0	0	0	0	0	0	0	1,201
10W	3,442	28	234	0	0	0	0	0	0	0	3,704
10NW	2,255	18	0	0	0	0	0	0	0	0	2,273
Shadow Region	0	0	0	0	0	0	0	0	7,784	0	7,784
Total	**30,932**	**252**	**10,723**	**679**	**743**	**40**	**2,972**	**19,800**	**7,784**	**0**	**73,925**

[8] Since the spatial distribution of the access and/or functional needs population is unknown, vehicles needed to evacuate access and/or functional needs population are not included in this table
[9] Special Facilities include medical facilities and the Minnesota Correctional Facility - Red Wing
[10] Shadow Population has been reduced to 20%. Refer to Figure 2-1 for additional information

Table 3-12. Summary of Vehicle Demand

Sub-Area	Residents	Transit-Dependent[11]	Transients	Employees	Special Facilities[12]	Colleges	Schools[13]	Special Event	Shadow Population[14]	External Traffic	Total
2 (Goodhue)	137	4	3,112	386	0	0	0	8,082	0	0	11,721
2 (Pierce)	85	0	0	0	0	0	0	0	0	0	85
5N	196	2	0	0	0	0	0	0	0	0	198
5E	605	0	182	0	0	0	0	0	0	0	787
5S	2,175	4	231	137	16	0	16	0	0	0	2,579
5W	502	0	0	0	0	0	0	0	0	0	502
10N	383	4	0	0	0	0	0	0	0	0	387
10NE	998	0	0	0	0	0	0	0	0	0	998
10E	1,166	0	159	0	0	0	0	0	0	0	1,325
10SE	7,871	8	1,295	150	71	40	66	0	0	0	9,501
10SW	393	0	213	0	0	0	0	0	0	0	606
10W	2,011	0	204	0	0	0	0	0	0	0	2,215
10NW	1,319	0	0	0	0	0	0	0	0	0	1,319
Shadow Region	0	0	0	0	0	0	0	0	4,473	7,732	12,205
Total	**17,841**	**22**	**5,396**	**673**	**87**	**40**	**82**	**8,082**	**4,473**	**7,732**	**44,428**

[11] Sub-Areas 2 (Pierce), 5W, 10W buses are considered with Sub-Area 2 (Goodhue). Sub-Areas 5E and 10E buses are considered with Sub-Area 5N. Sub-Area 10SW buses are considered with Sub-Area 5S. Sub-Areas 10NE and 10NW buses are considered with Sub-Area 10N. See Section 10. Buses for the transit-depended population are represented as two passenger vehicles. Refer to Section 3.7 for additional information.
[12] Vehicles for special facilities include wheelchair vans, ambulances and buses. Buses are considered for the Minnesota Correctional Facility.
[13] Buses evacuating children from schools are represented as two passenger vehicles. Refer to Section 3.6 for additional information.
[14] Vehicles for shadow population have been reduced to 20%. Refer to Figure 2-1 for additional information.

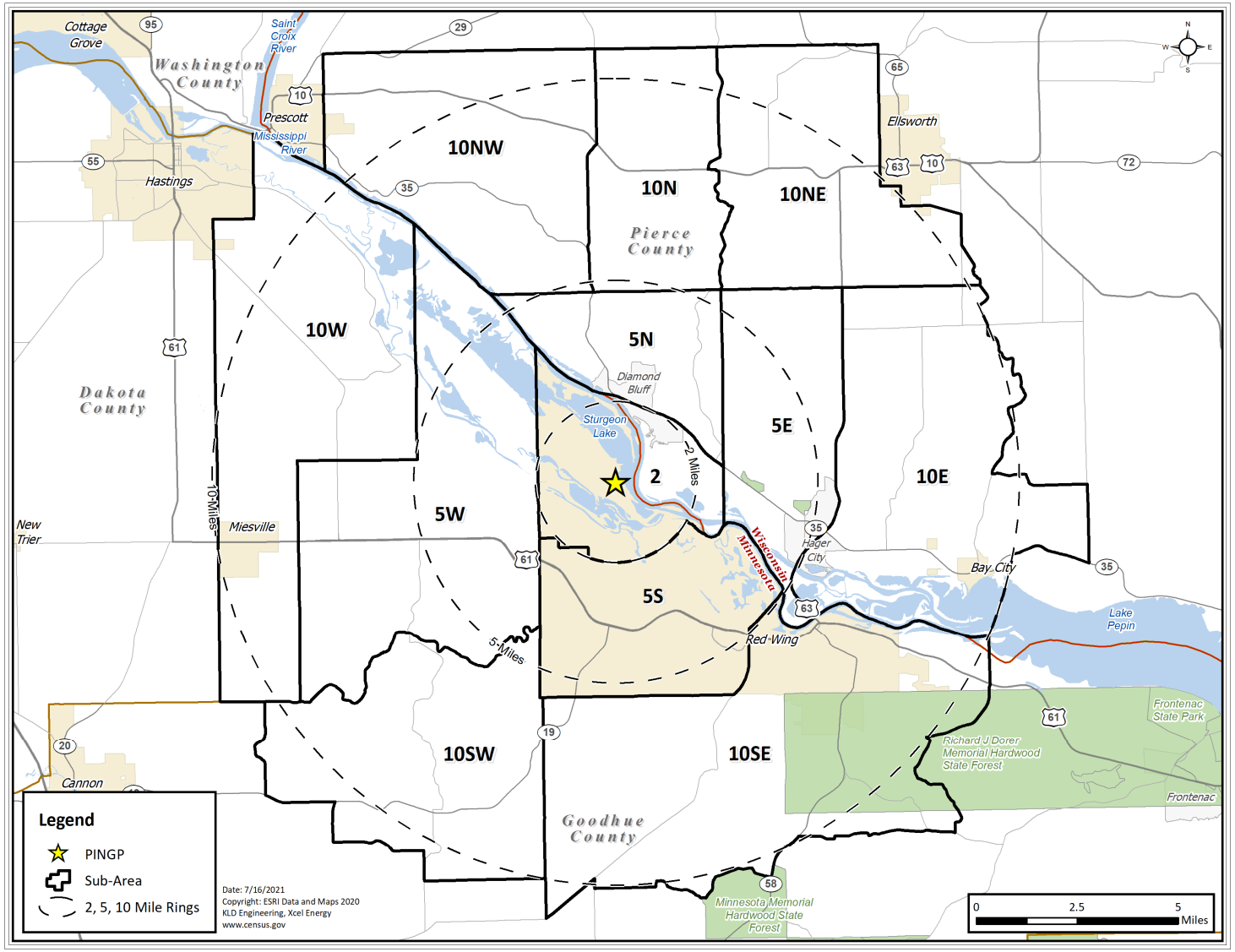
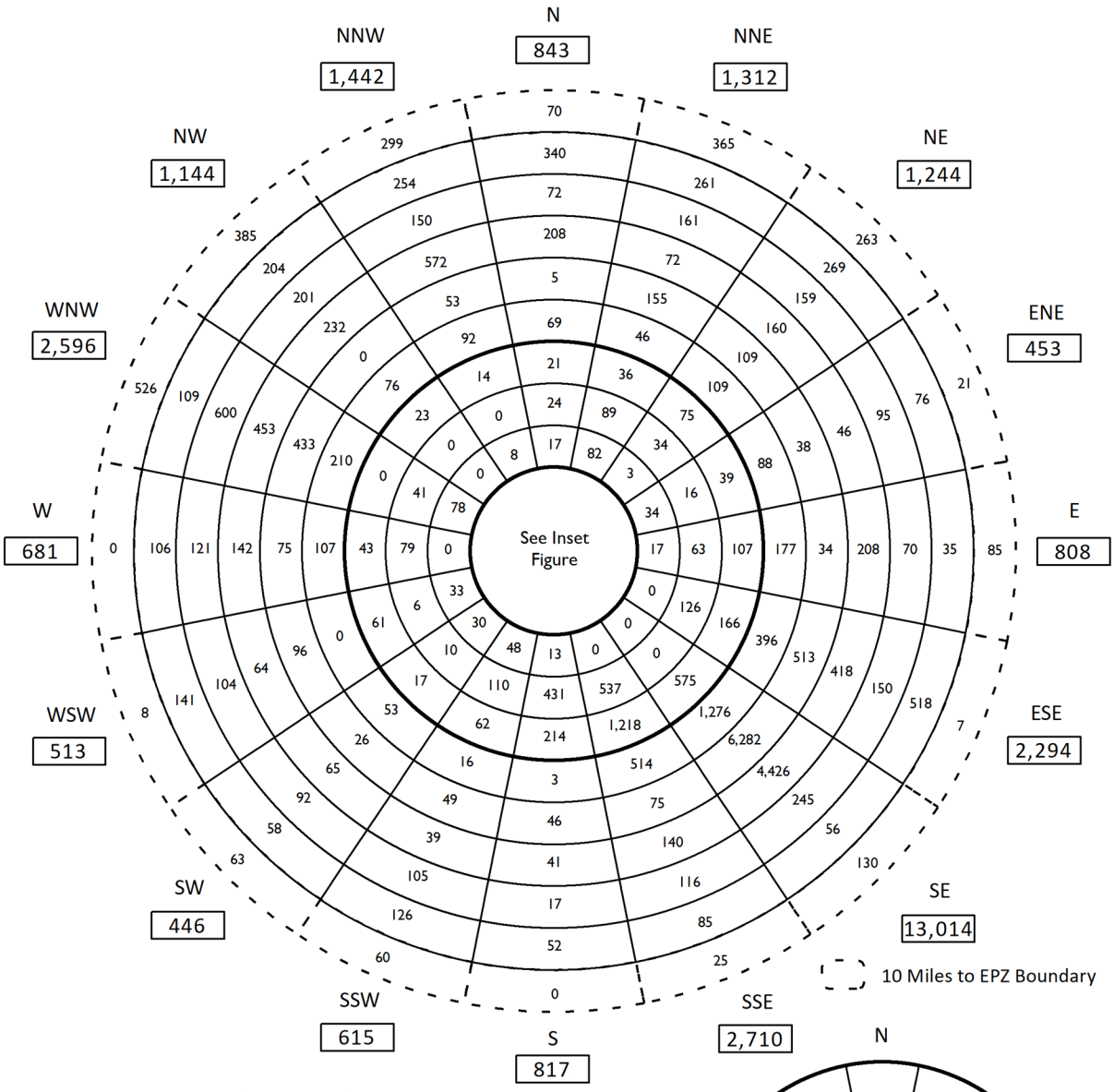


Figure 3-1. Sub-Areas Comprising the PINGP EPZ



2020 Permanent Resident Population

Miles	Subtotal by Ring	Cumulative Total
0 - 1	164	164
1 - 2	206	370
2 - 3	363	733
3 - 4	1,566	2,299
4 - 5	2,671	4,970
5 - 6	3,232	8,202
6 - 7	7,989	16,191
7 - 8	7,286	23,477
8 - 9	2,458	25,935
9 - 10	2,690	28,625
10 - EPZ	2,307	30,932
	Total:	30,932

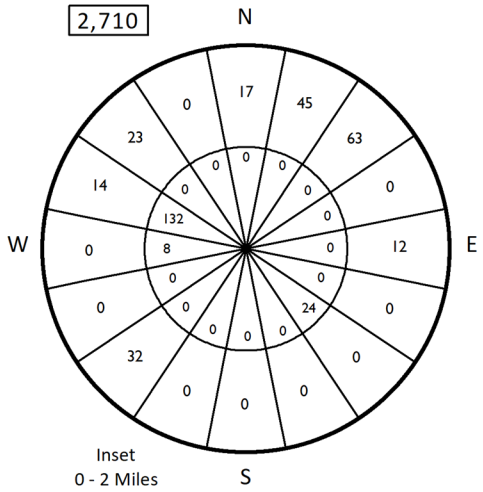
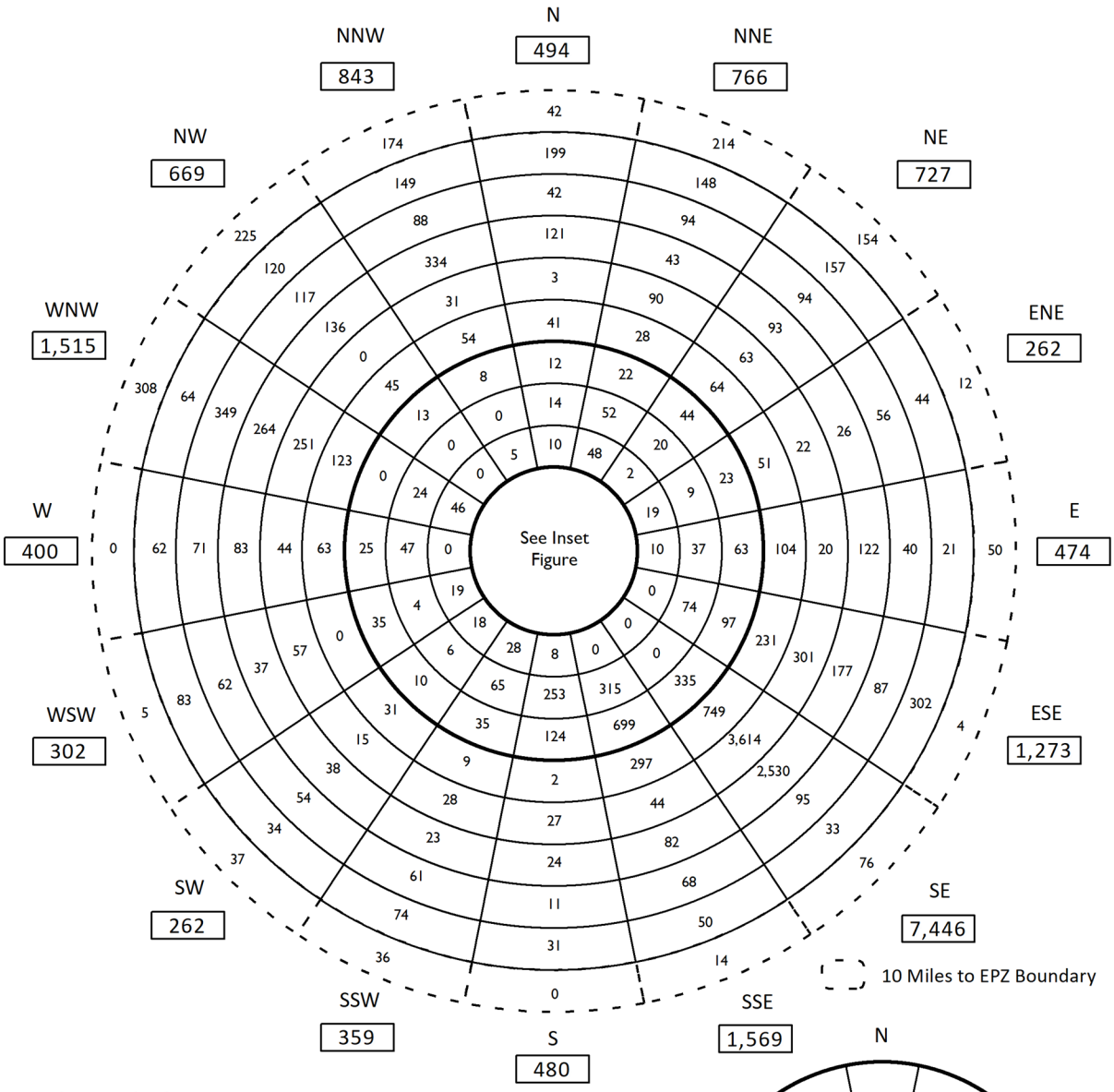


Figure 3-2. Permanent Resident Population by Sector



Resident Vehicles

Miles	Subtotal by Ring	Cumulative Total
0 - 1	96	96
1 - 2	121	217
2 - 3	213	430
3 - 4	920	1,350
4 - 5	1,545	2,895
5 - 6	1,892	4,787
6 - 7	4,610	9,397
7 - 8	4,133	13,530
8 - 9	1,389	14,919
9 - 10	1,571	16,490
10 - EPZ	1,351	17,841
	Total:	17,841

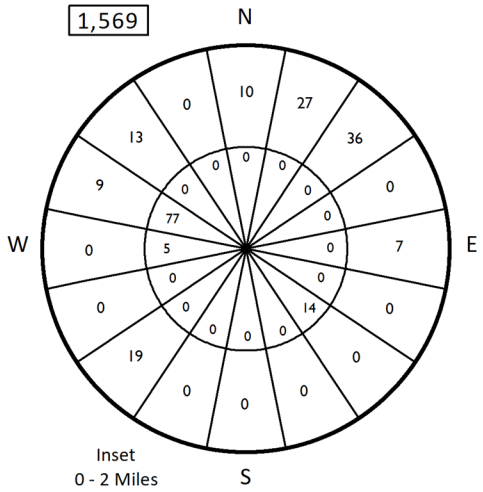
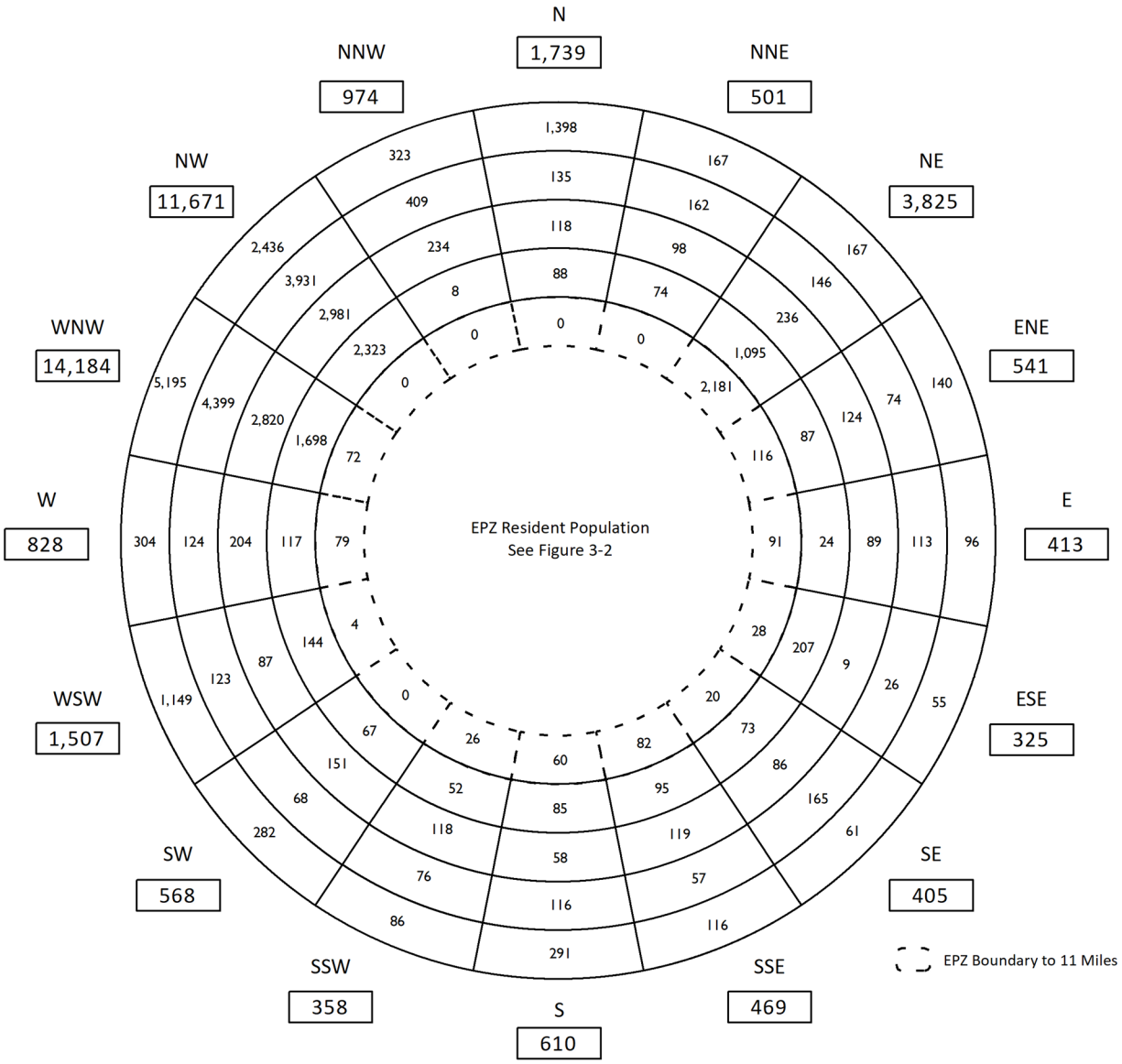


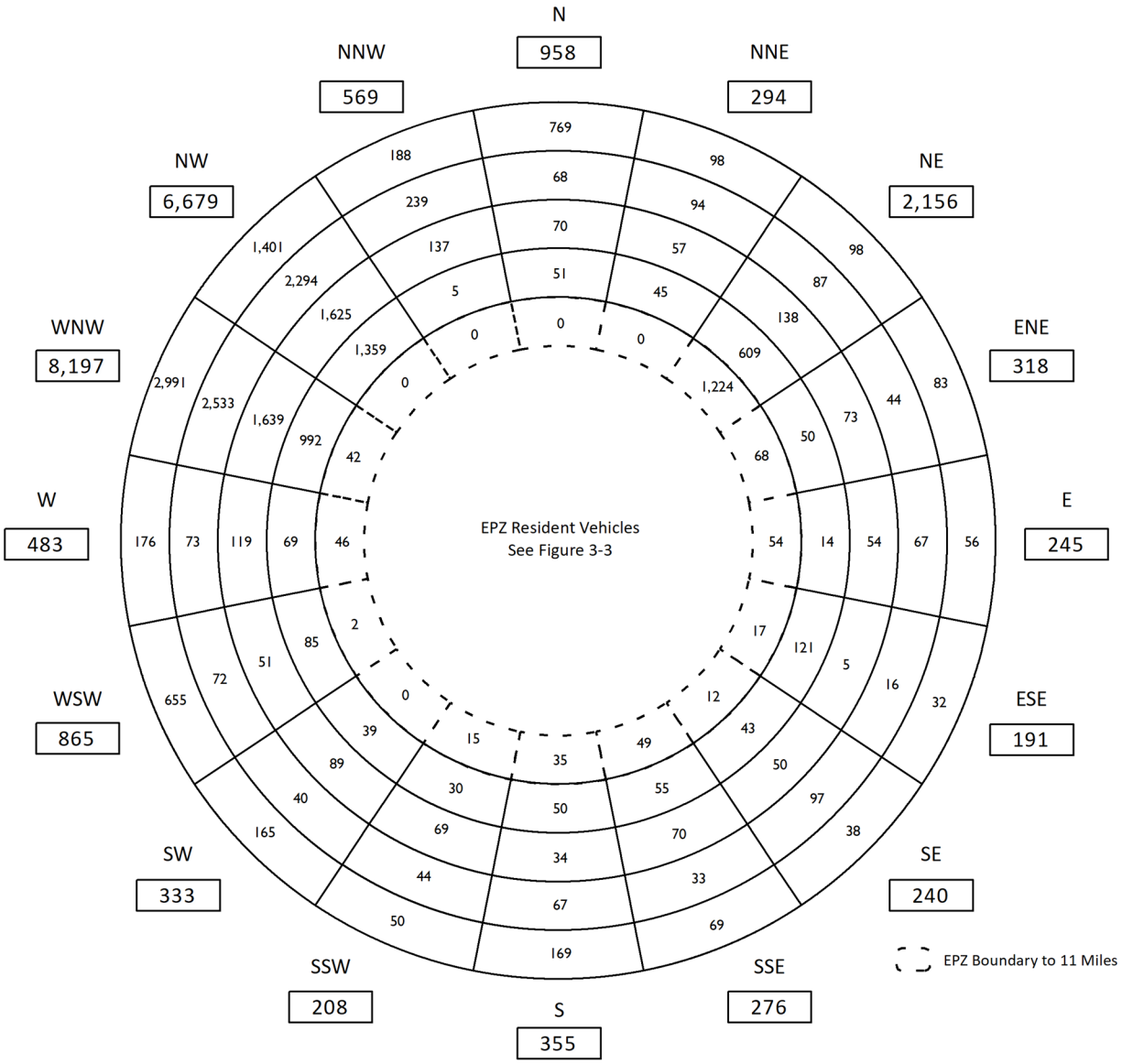
Figure 3-3. Permanent Resident Vehicles by Sector



2020 Shadow Population

Miles	Subtotal by Ring	Cumulative Total
EPZ - 11	2,759	2,759
11 - 12	6,237	8,996
12 - 13	7,532	16,528
13 - 14	10,124	26,652
14 - 15	12,266	38,918
	Total:	38,918

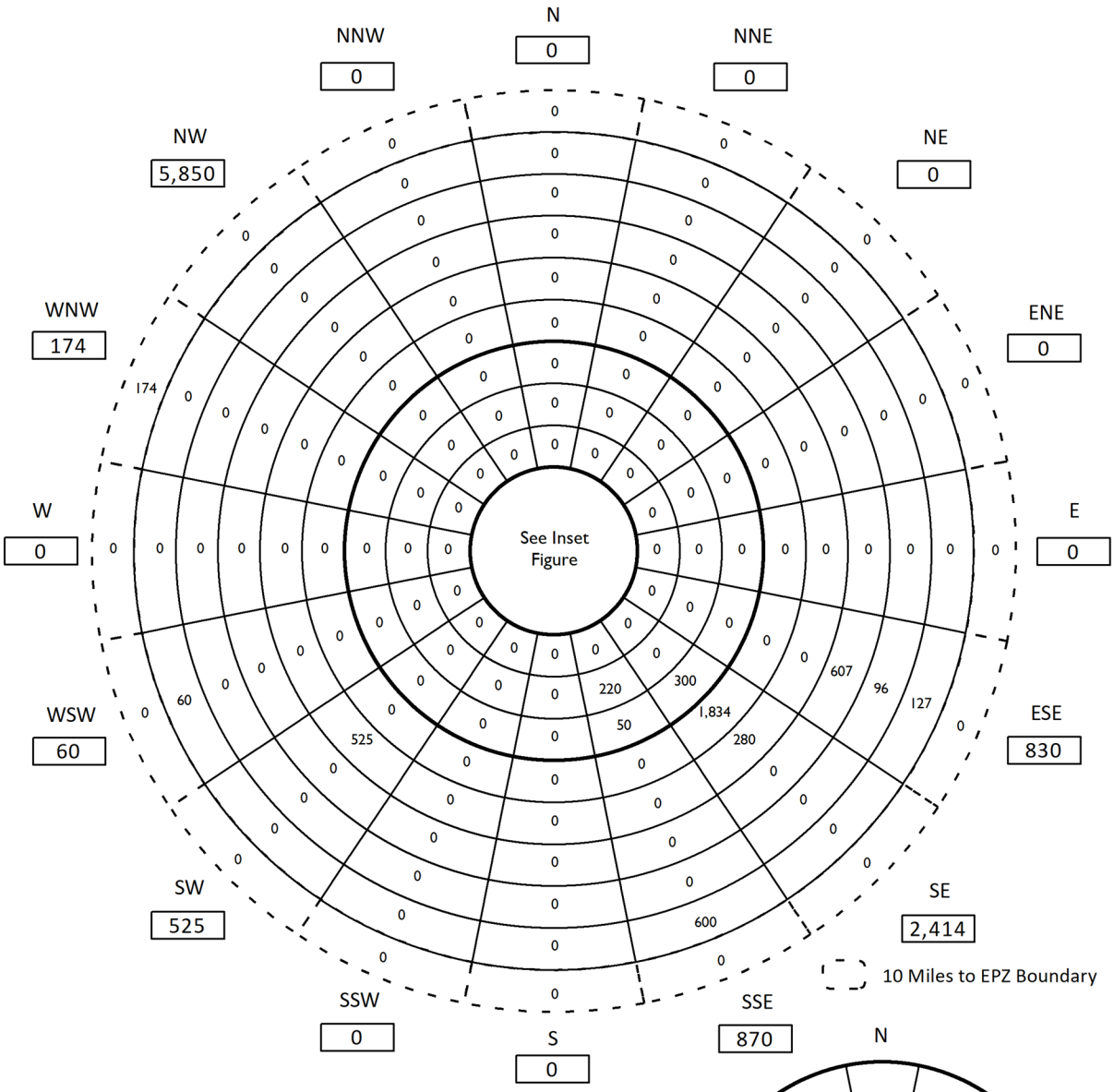
Figure 3-4. Shadow Population by Sector



Shadow Vehicles

Miles	Subtotal by Ring	Cumulative Total
EPZ - 11	1,564	1,564
11 - 12	3,617	5,181
12 - 13	4,280	9,461
13 - 14	5,868	15,329
14 - 15	7,038	22,367
	Total:	22,367

Figure 3-5. Shadow Vehicles by Sector



Transients

Miles	Subtotal by Ring	Cumulative Total
0 - 1	0	0
1 - 2	5,850	5,850
2 - 3	0	5,850
3 - 4	220	6,070
4 - 5	350	6,420
5 - 6	1,834	8,254
6 - 7	805	9,059
7 - 8	607	9,666
8 - 9	96	9,762
9 - 10	787	10,549
10 - EPZ	174	10,723
	Total:	10,723

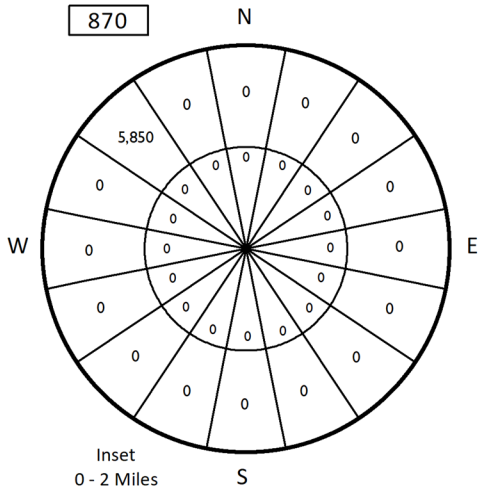
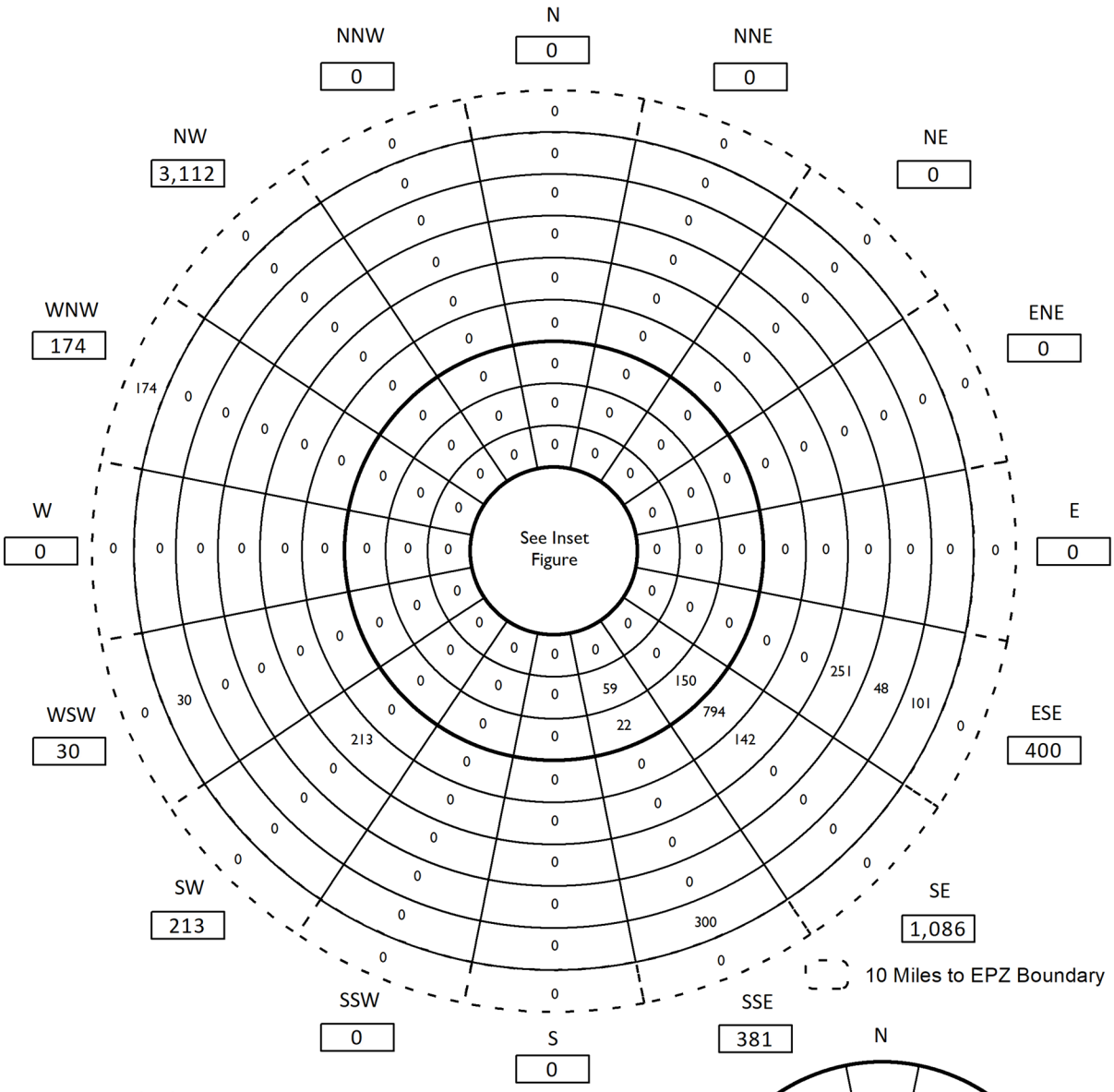


Figure 3-6. Transient Population by Sector



Transient Vehicles

Miles	Subtotal by Ring	Cumulative Total
0 - 1	0	0
1 - 2	3,112	3,112
2 - 3	0	3,112
3 - 4	59	3,171
4 - 5	172	3,343
5 - 6	794	4,137
6 - 7	355	4,492
7 - 8	251	4,743
8 - 9	48	4,791
9 - 10	431	5,222
10 - EPZ	174	5,396
	Total:	5,396

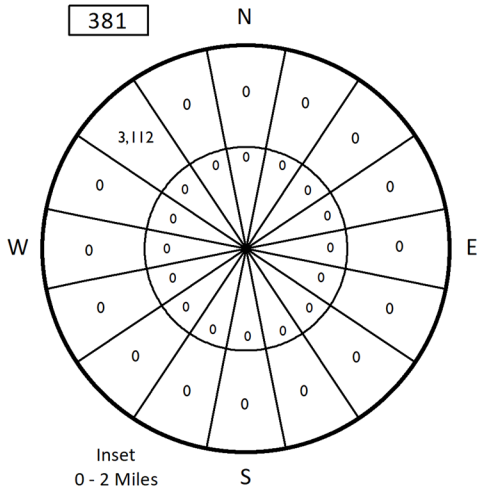
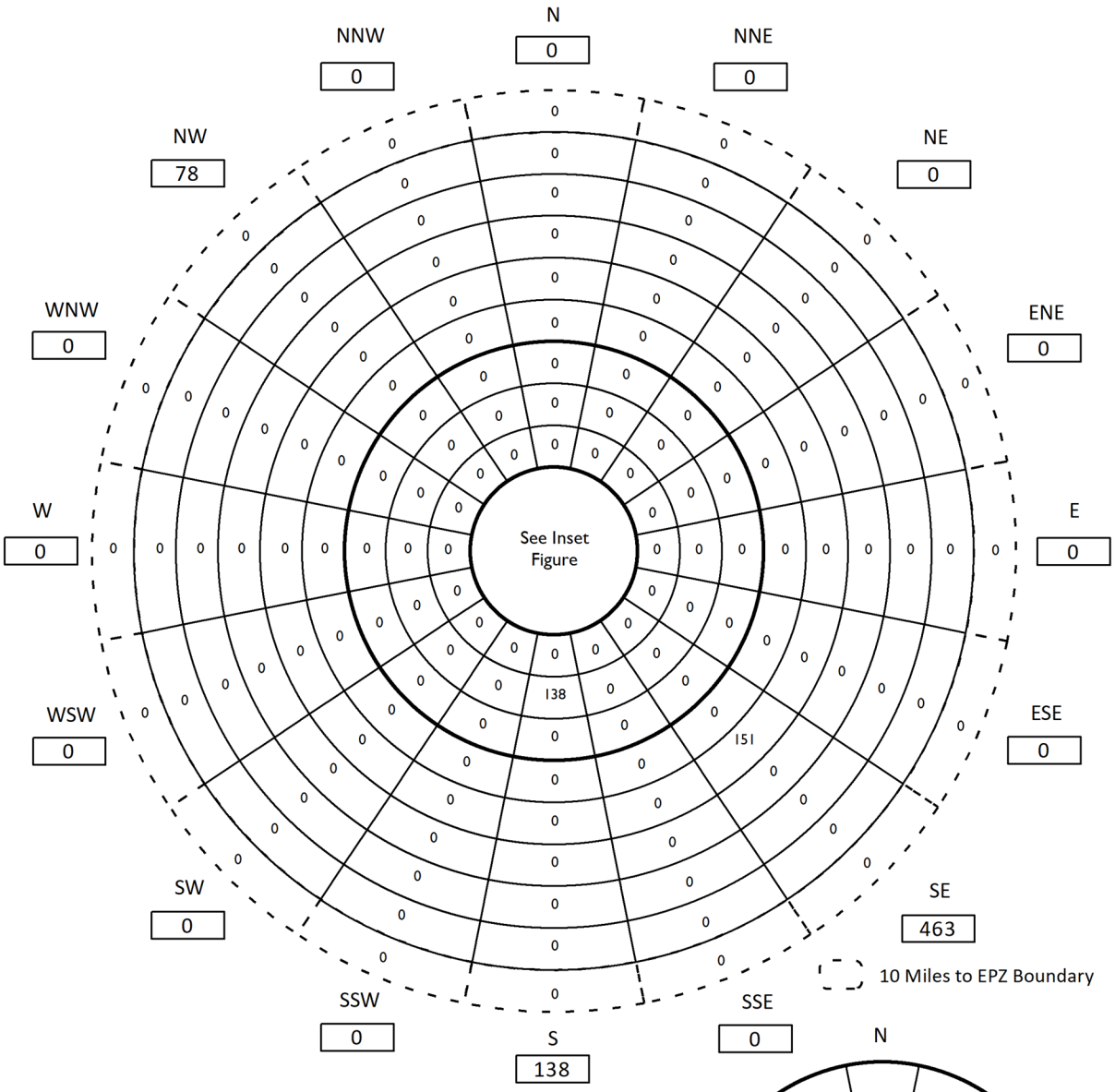


Figure 3-7. Transient Vehicles by Sector



Employees

Miles	Subtotal by Ring	Cumulative Total
0 - 1	312	312
1 - 2	78	390
2 - 3	0	390
3 - 4	138	528
4 - 5	0	528
5 - 6	0	528
6 - 7	151	679
7 - 8	0	679
8 - 9	0	679
9 - 10	0	679
10 - EPZ	0	679
	Total:	679

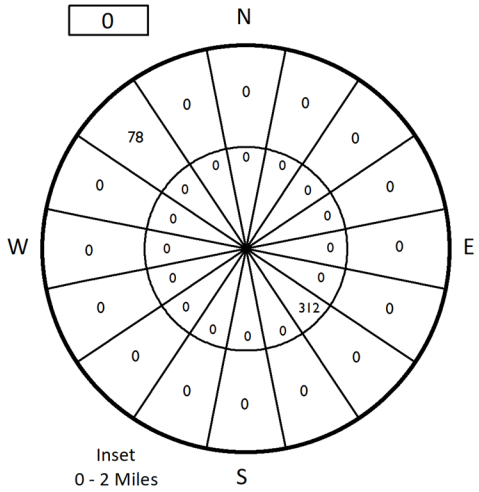
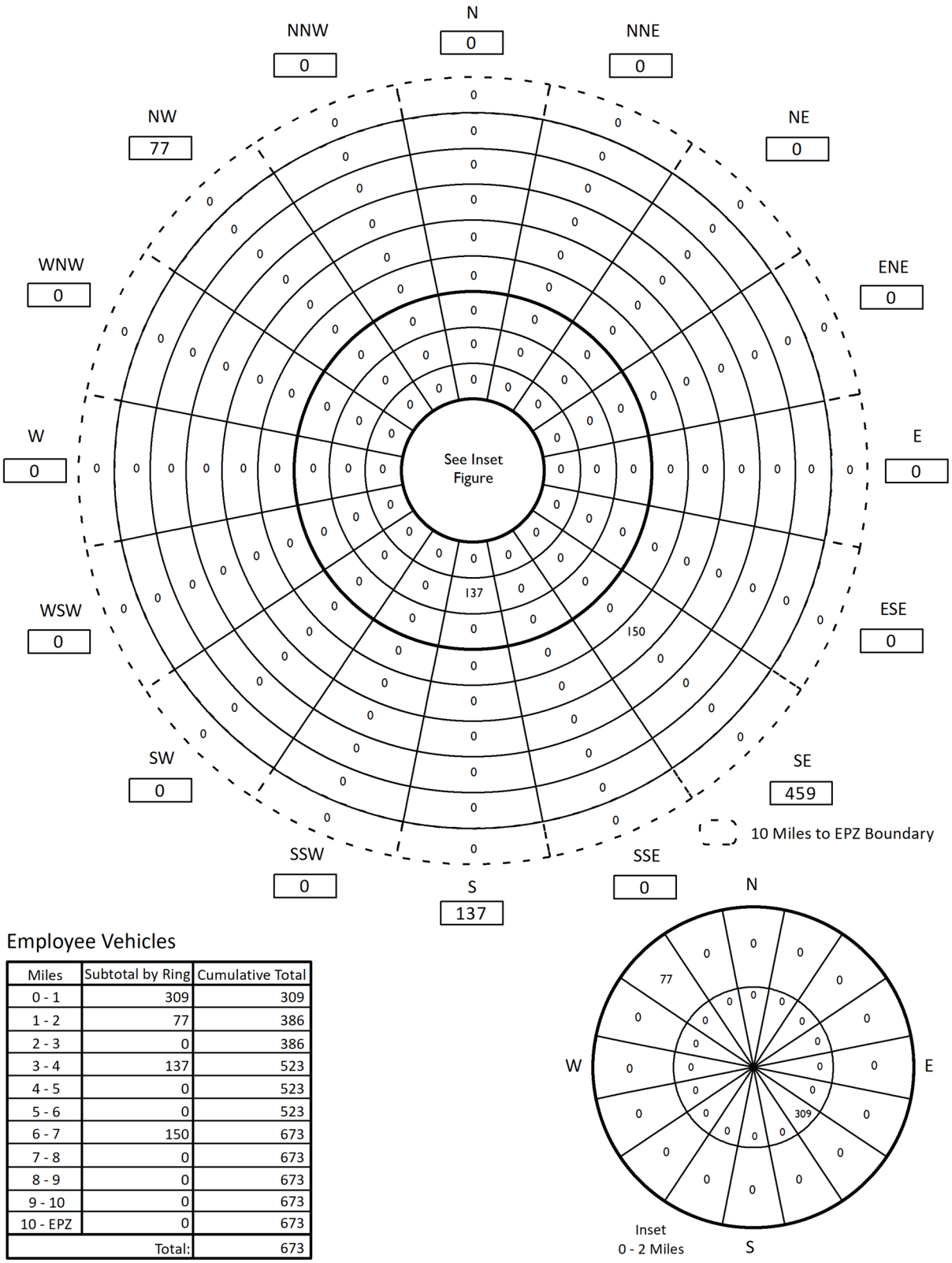


Figure 3-8. Employee Population by Sector



Employee Vehicles

Miles	Subtotal by Ring	Cumulative Total
0 - 1	309	309
1 - 2	77	386
2 - 3	0	386
3 - 4	137	523
4 - 5	0	523
5 - 6	0	523
6 - 7	150	673
7 - 8	0	673
8 - 9	0	673
9 - 10	0	673
10 - EPZ	0	673
	Total:	673

Figure 3-9. Employee Vehicles by Sector

4 ESTIMATION OF HIGHWAY CAPACITY

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

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

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

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

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

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

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

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

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

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 the HCM 2016. For example, HCM Exhibit 7-1(b) shows the sensitivity of SV at the upper bound of LOS D to grade (capacity is the SV at the upper bound of LOS E).

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

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

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

4.1 Capacity Estimations on Approaches to Intersections

At-grade intersections are apt to become the first bottleneck locations under local heavy traffic volume conditions. This characteristic reflects the need to allocate access time to the respective competing traffic streams by exerting some form of control. During evacuation, control at critical intersections will often be provided by traffic control personnel assigned for that purpose, whose directions may supersede traffic control devices. See Appendix G for more information.

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

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

where:

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

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

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

where:

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

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

$$h_m \geq h_{sat}$$

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

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

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

4.2 Capacity Estimation along Sections of Highway

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

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

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

The value of V_F can be expressed as:

$$V_F = R \times Capacity$$

where:

R = Reduction factor which is less than unity

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

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

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

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

The procedure used here was to estimate "section" capacity, V_E, based on observations made

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

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

4.3 Application to the PINGP Study Area

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

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

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

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

Each of these classifications will be discussed.

4.3.1 Two-Lane Roads

Ref: HCM 2016 Chapter 15

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

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

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

4.3.2 Multilane Highway

Ref: HCM 2016 Chapter 12

Exhibit 12-8 of the HCM 2016 presents a set of curves that indicate a per-lane capacity ranging from approximately 1,900 to 2,300 pc/h, for free-speeds of 45 to 70 mph, respectively. Based on observation, the multilane highways outside of urban areas within the study area, service traffic with free-speeds in this range. The actual time-varying speeds computed by the simulation model reflect the demand and capacity relationship and the impact of control at intersections. A conservative estimate of per-lane capacity of 1,900 pc/h is adopted for this study for multilane highways outside of urban areas.

4.3.3 Freeways

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

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

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

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

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

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

Chapter 14 of the HCM 2016 presents procedures for estimating capacities of ramps and of "merge" areas. There are three significant factors to the determination of capacity of a ramp-freeway junction: The capacity of the freeway immediately downstream of an on-ramp or immediately upstream of an off-ramp; the capacity of the ramp roadway; and the maximum flow rate entering the ramp influence area. In most cases, the freeway capacity is the controlling factor. Values of this merge area capacity are presented in Exhibit 14-10 of the HCM 2016 and depend on the number of freeway lanes and on the freeway free speed. Ramp capacity is presented in Exhibit 14-12 and is a function of the ramp FFS. The DYNEV II simulation model logic simulates the merging operations of the ramp and freeway traffic in accord with

the procedures in Chapter 14 of the HCM 2016. If congestion results from an excess of demand relative to capacity, then the model allocates service appropriately to the two entering traffic streams and produces LOS F conditions (The HCM 2016 does not address LOS F explicitly).

4.3.4 Intersections

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

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

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

The model is also capable of modeling the presence of manned traffic control. At specific locations where it is advisable or where existing plans call for overriding existing traffic control to implement manned control, the model will use actuated signal timings that reflect the presence of traffic guides. At locations where a special traffic control strategy (continuous left-turns, contra-flow lanes) is used, the strategy is modeled explicitly. A list that includes the total number of intersections modeled that are unsignalized, signalized, or manned by response personnel is noted in Appendix K.

4.4 Simulation and Capacity Estimation

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

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

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

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

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

4.5 Boundary Conditions

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

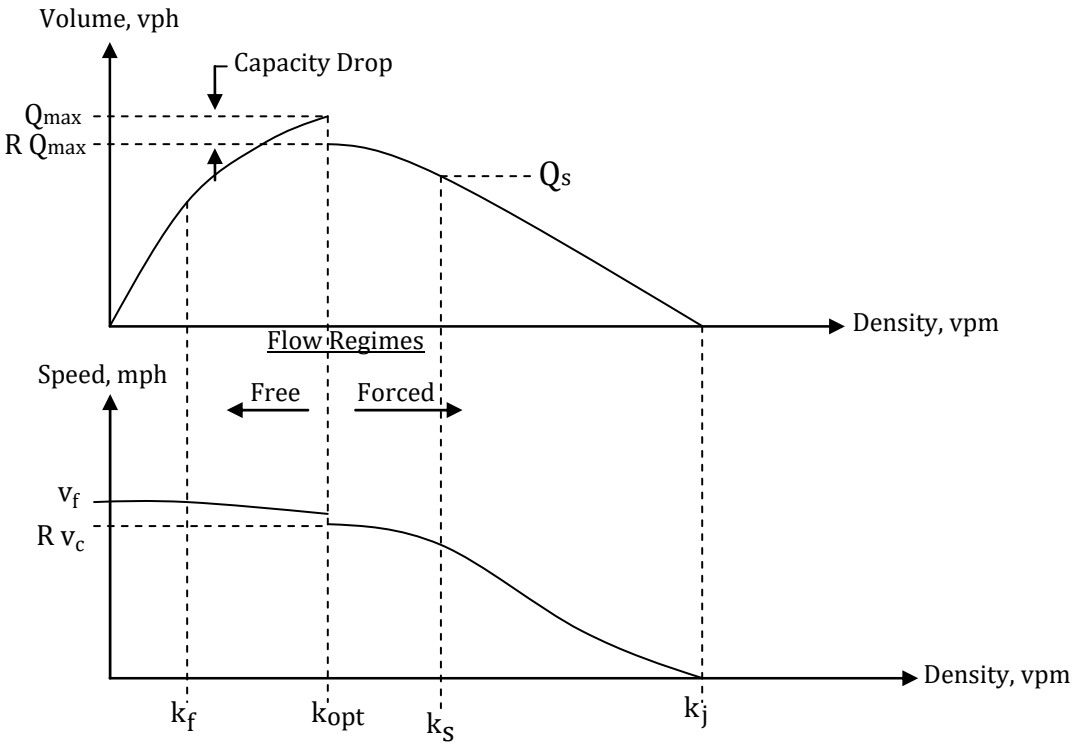


Figure 4-1. Fundamental Diagrams

5 ESTIMATION OF TRIP GENERATION TIME

Federal guidelines (see NUREG CR-7002, Rev. 1) 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 demographic survey. We define the sum of these distributions of elapsed times as the Trip Generation Time Distribution.

5.1 Background

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

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

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

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

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

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

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

For example, suppose one hour elapses from the siren alert to the ATE. In this case, it is reasonable to expect some degree of spontaneous evacuation by the public during this one-hour period. As a result, the population within the Emergency Planning Zone (EPZ) will be lower when the ATE is announced, than at the time of the siren alert. In addition, many will engage in preparation activities to evacuate, in anticipation that an Advisory will be

broadcasted. Thus, the time needed to complete the mobilization activities and the number of people remaining to evacuate the EPZ after the ATE, will both be somewhat less than the estimates presented in this report. Consequently, the ETE presented in this report are higher than the actual evacuation time, if this hypothetical situation were to take place.

The notification process consists of two events:

1. Transmitting information using the alert and notification systems available within the EPZ (e.g. sirens, tone alerts, Emergency Alert System (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 363 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 demographic survey of EPZ residents. Such a survey was conducted in support of this ETE study. Appendix F discusses the survey sampling plan, records the number of responses obtained, documents the survey instrument utilized and provides the survey results. It is important to note that the shape and duration of the evacuation trip mobilization distribution is important at sites where traffic congestion is not expected to cause the 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 demographic survey to the development of the ETE documented in this report.

5.2 Fundamental Considerations

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

Activities are undertaken over a period of time. Activities may be in "series" (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 Table 5-1.

These relationships are shown graphically in Figure 5-1.

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

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

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

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

It is seen from Figure 5-1, that the Trip Generation time (i.e. the total elapsed time from Event 1 to Event 5) depends on the scenario and will vary from one household to the next.

Furthermore, Event 5 depends, in a complicated way, on the time distributions of all activities preceding that event. That is, to estimate the time distribution of Event 5, we must obtain estimates of the time distributions of all preceding events. For this study, we adopt the conservative posture that all activities will occur in sequence.

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

5.3 Estimated Time Distributions of Activities Preceding Event 5

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

Time Distribution No. 1, Notification Process: Activity 1 $\rightarrow$ 2

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

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

Distribution No. 2, Prepare to Leave Work: Activity 2 $\rightarrow$ 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 $\rightarrow$ 3 shown in Table 5-3 reflects data obtained by the demographic survey. This distribution is plotted in Figure 5-2.

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

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

Distribution No. 4, Prepare to Leave Home: Activity 2, 4 $\rightarrow$ 5

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

Distribution No. 5, Snow Clearance Time Distribution

Inclement weather scenarios involving snowfall must address the time lags associated with snow clearance. It is assumed that snow equipment is mobilized and deployed during the snowfall to maintain passable roads. The general consensus is that the snow-plowing efforts are 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 demographic survey. This distribution is plotted in Figure 5-2 and listed in Table 5-6.

Note that those respondents (20.9%) 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.

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 to form the required distribution. As an outcome of this procedure, new time distributions are formed; we assign "letter" designations to these intermediate distributions to describe the procedure. Table 5-7 presents the summing procedure to arrive at each designated distribution.

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

5.4.1 Statistical Outliers

As already mentioned, some portion of the survey respondents answer "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 alternatives 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.
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:
   a) 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;
   b) 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, not 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 for each population group considered. These distributions are presented on the same time scale. (As discussed earlier, the use of strictly additive activities is a conservative approach, because it makes all activities 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 distribution results are used in their tabular/graphical form as direct inputs to later computations that lead to the ETE.

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

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

5.4.2 Staged Evacuation Trip Generation

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

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

Assumptions

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

Procedure

1. Trip generation for population groups in the 2-Mile Region will be as computed based upon the results of the demographic survey and analysis.
2. Trip generation for the population subject to staged evacuation will be formulated as follows:
    a. Identify the 90th percentile evacuation time for the Sub-Areas comprising the 2-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, Rev. 1 uses the statement "approximately 90th percentile" as the time to end staging and begin evacuating. The value of T_{Scen}^* is 2:00 for all scenarios.

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 and Table 5-10 presents the staged trip generation distributions for both residents with and without returning commuters, employees and transients. At T_{Scen}^*, 20% of the permanent resident 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 un-staged trip generation distribution.

5.4.3 Trip Generation for Waterways and Recreational Areas

Annex I of Pierce County EOP (October 2019) indicates that people on the Mississippi River will be warned by the Pierce County Water Patrol and/or National Guard helicopters. As indicated in Table 5-2, this study assumes 100% notification in 45 minutes. Table 5-9 indicates that all transients will have mobilized within 1 hour and 15 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 5-1. Event Sequence for Evacuation Activities

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

Table 5-2. Time Distribution for Notifying the Public

Elapsed Time (Minutes)	Percent of Population Notified
0	0.0%
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%

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%	30	95.6%
5	34.7%	35	97.9%
10	60.5%	40	98.7%
15	76.4%	45	99.4%
20	83.5%	50	100%
25	87.3%		

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.

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	86.8%
5	6.8%	45	91.7%
10	21.5%	50	94.8%
15	33.9%	55	96.3%
20	47.7%	60	97.1%
25	60.5%	75	98.6%
30	72.3%	90	100.0%
35	82.0%		

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

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

Elapsed Time (Minutes)	Cumulative Percent Ready to Evacuate	Elapsed Time (Minutes)	Cumulative Percent Ready to Evacuate
0	0.0%	105	85.1%
15	3.4%	120	88.3%
30	27.7%	135	96.6%
45	45.7%	150	96.9%
60	68.7%	165	97.1%
75	79.1%	180	97.9%
90	83.3%	195	100%

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

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

Elapsed Time (Minutes)	Cumulative Percent Completing Snow Removal
0	20.9%
15	41.3%
30	64.6%
45	76.7%
60	89.2%
75	94.0%
90	94.9%
105	96.0%
120	98.0%
135	99.7%
150	100.0%

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

Table 5-7. Mapping Distributions to Events

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

Table 5-8. Description of the Distributions

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

Table 5-9. Trip Generation Histograms for the EPZ Population for Un-staged 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	6%	6%	0%	0%	0%	0%
2	15	35%	35%	0%	3%	0%	1%
3	15	39%	39%	1%	13%	0%	4%
4	15	16%	16%	3%	20%	1%	9%
5	15	4%	4%	9%	20%	3%	12%
6	15	0%	0%	14%	16%	7%	15%
7	30	0%	0%	33%	12%	22%	25%
8	30	0%	0%	19%	8%	25%	14%
9	30	0%	0%	10%	5%	17%	10%
10	30	0%	0%	6%	2%	11%	5%
11	30	0%	0%	3%	1%	7%	3%
12	30	0%	0%	2%	0%	4%	1%
13	30	0%	0%	0%	0%	2%	1%
14	30	0%	0%	0%	0%	1%	0%
15	600	0%	0%	0%	0%	0%	0%

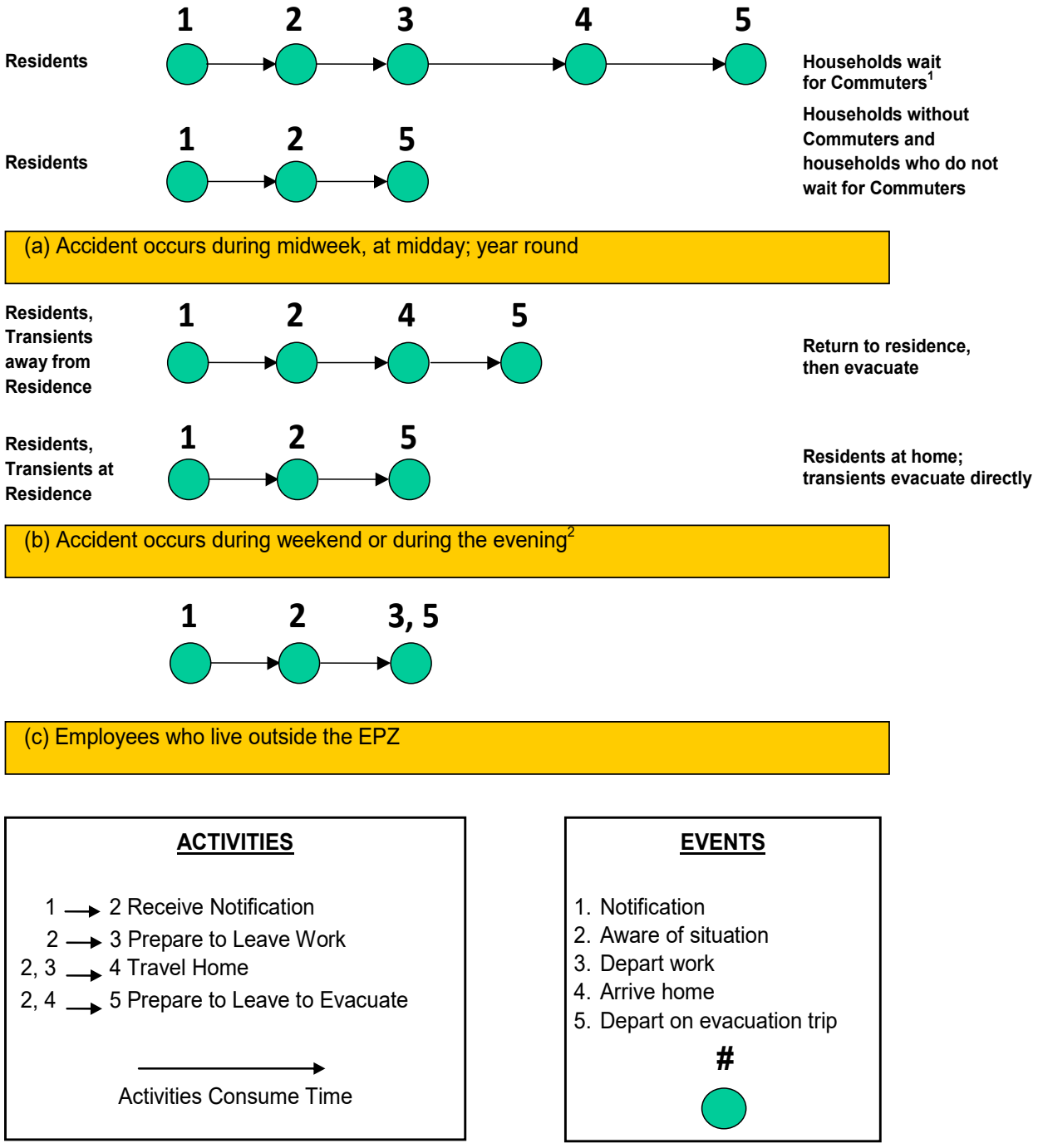
NOTE:

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

Table 5-10. Trip Generation Histograms for the EPZ Population for Staged Evacuation[1]

Time Period	Duration (Min)	Percent of Total Trips Generated Within Indicated Time Period*			
		Residents with Commuters (Distribution C)	Residents Without Commuters (Distribution D)	Residents With Commuters Snow (Distribution E)	Residents Without Commuters Snow (Distribution F)
1	15	0%	0%	0%	0%
2	15	0%	1%	0%	0%
3	15	0%	2%	0%	1%
4	15	1%	4%	0%	2%
5	15	2%	4%	1%	2%
6	15	2%	3%	1%	3%
7	30	7%	3%	5%	5%
8	30	67%	75%	51%	67%
9	30	10%	5%	17%	10%
10	30	6%	2%	11%	5%
11	30	3%	1%	7%	3%
12	30	2%	0%	4%	1%
13	30	0%	0%	2%	1%
14	30	0%	0%	1%	0%
15	600	0%	0%	0%	0%

[1] Trip Generation for Employees and Transients (see Table 5 9) is the same for Un-staged and Staged Evacuation



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

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

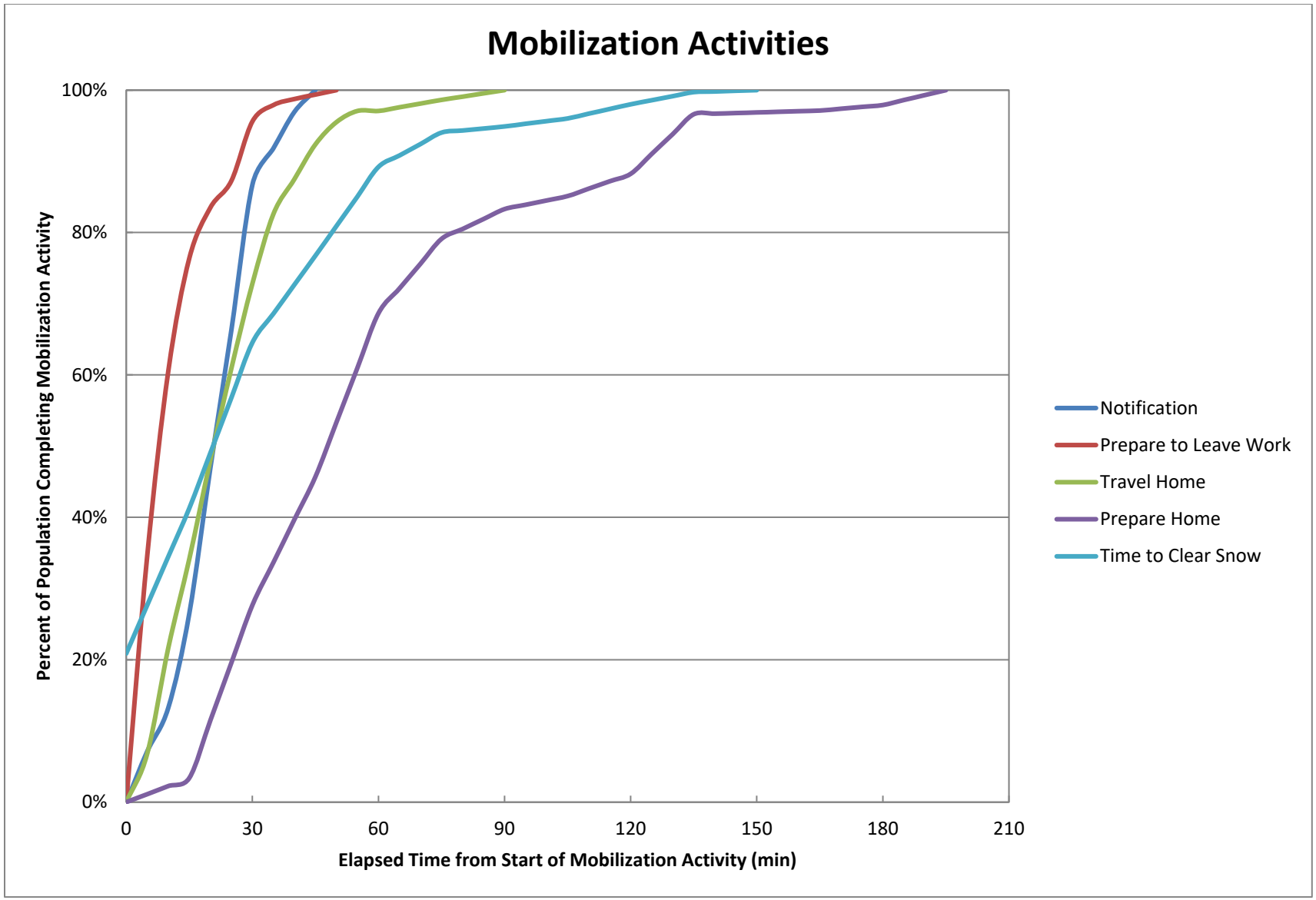


Figure 5-2. Time Distributions for Evacuation Mobilization Activities

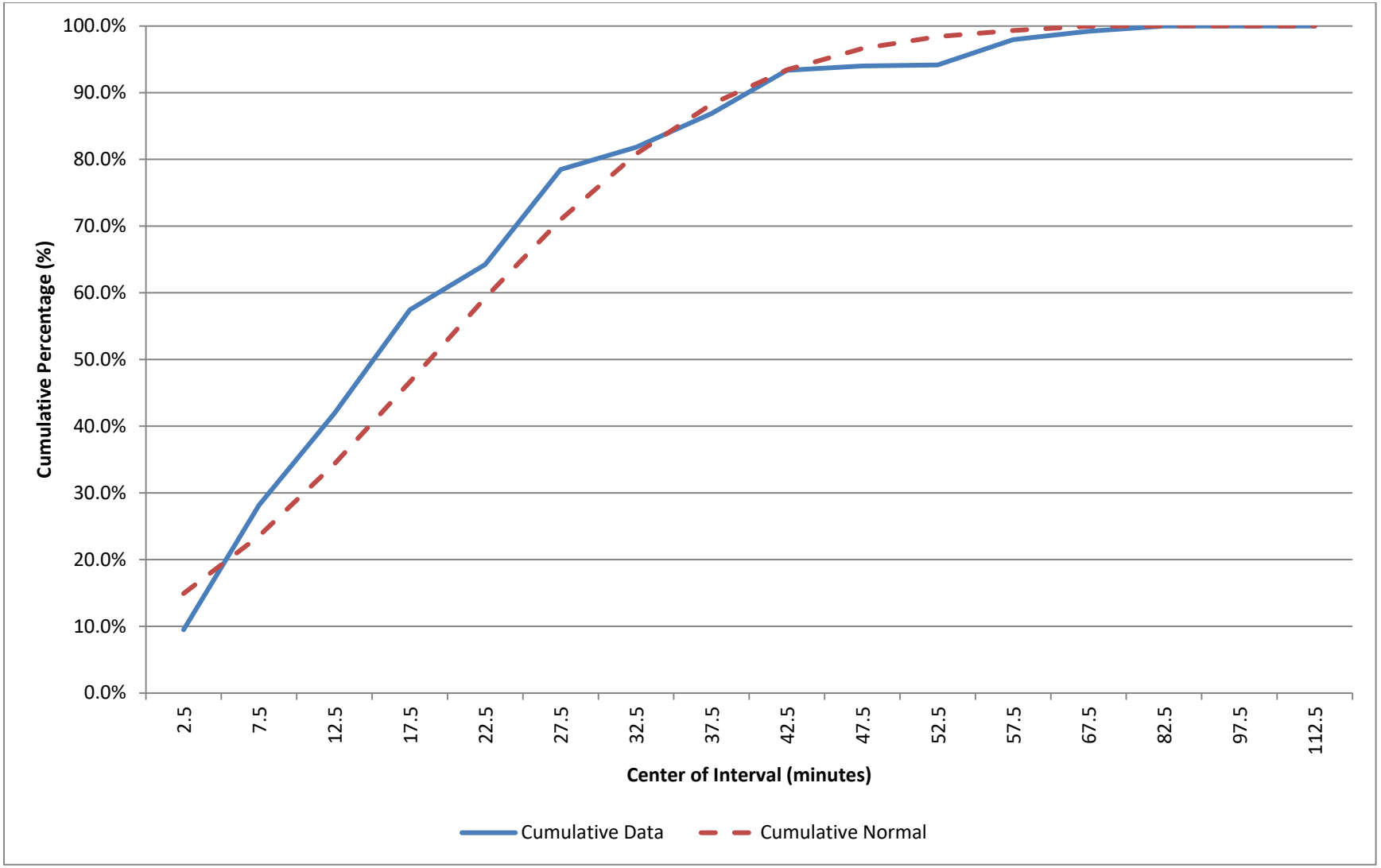


Figure 5-3. Comparison of Data Distribution and Normal Distribution

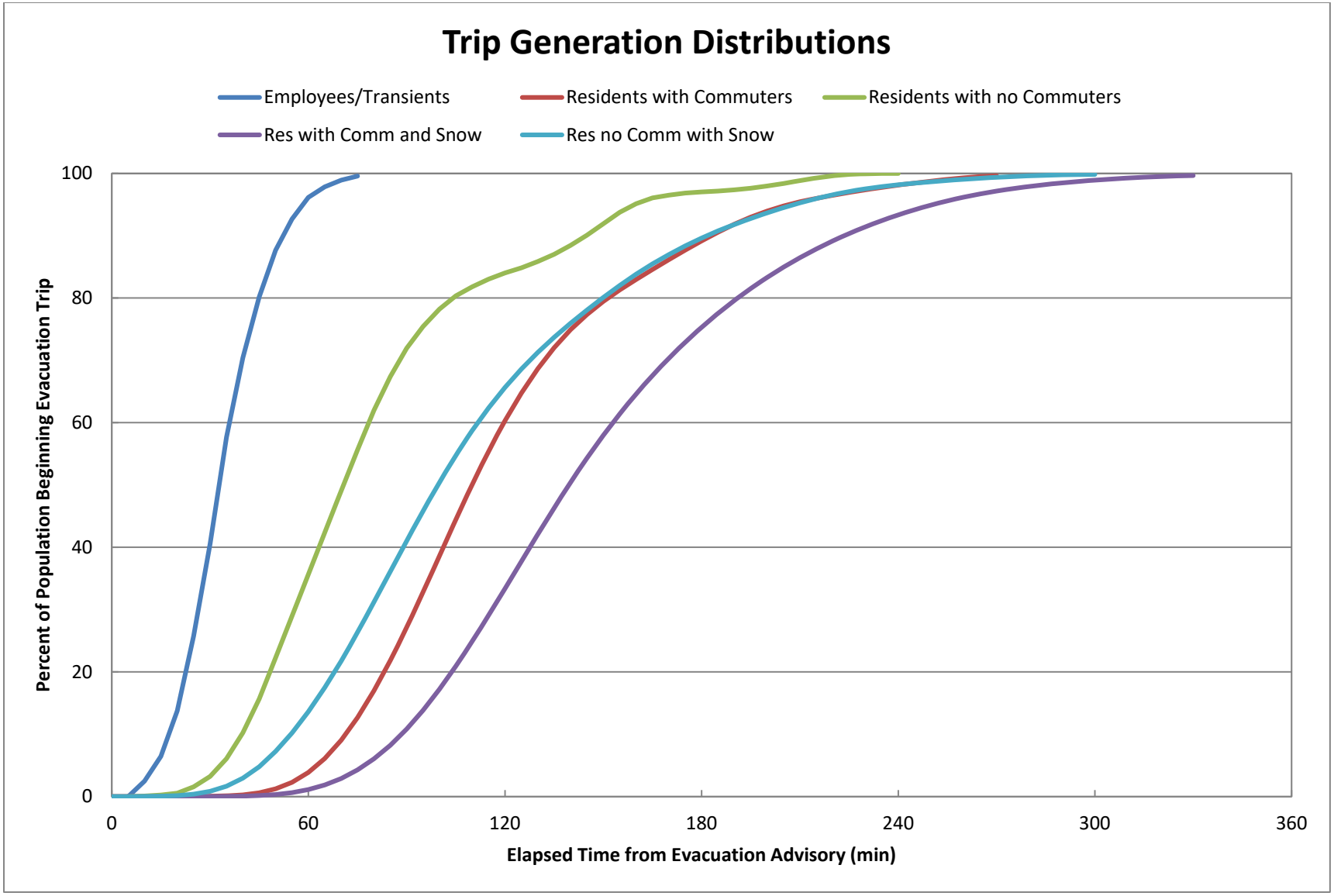


Figure 5-4. Comparison of Trip Generation Distributions

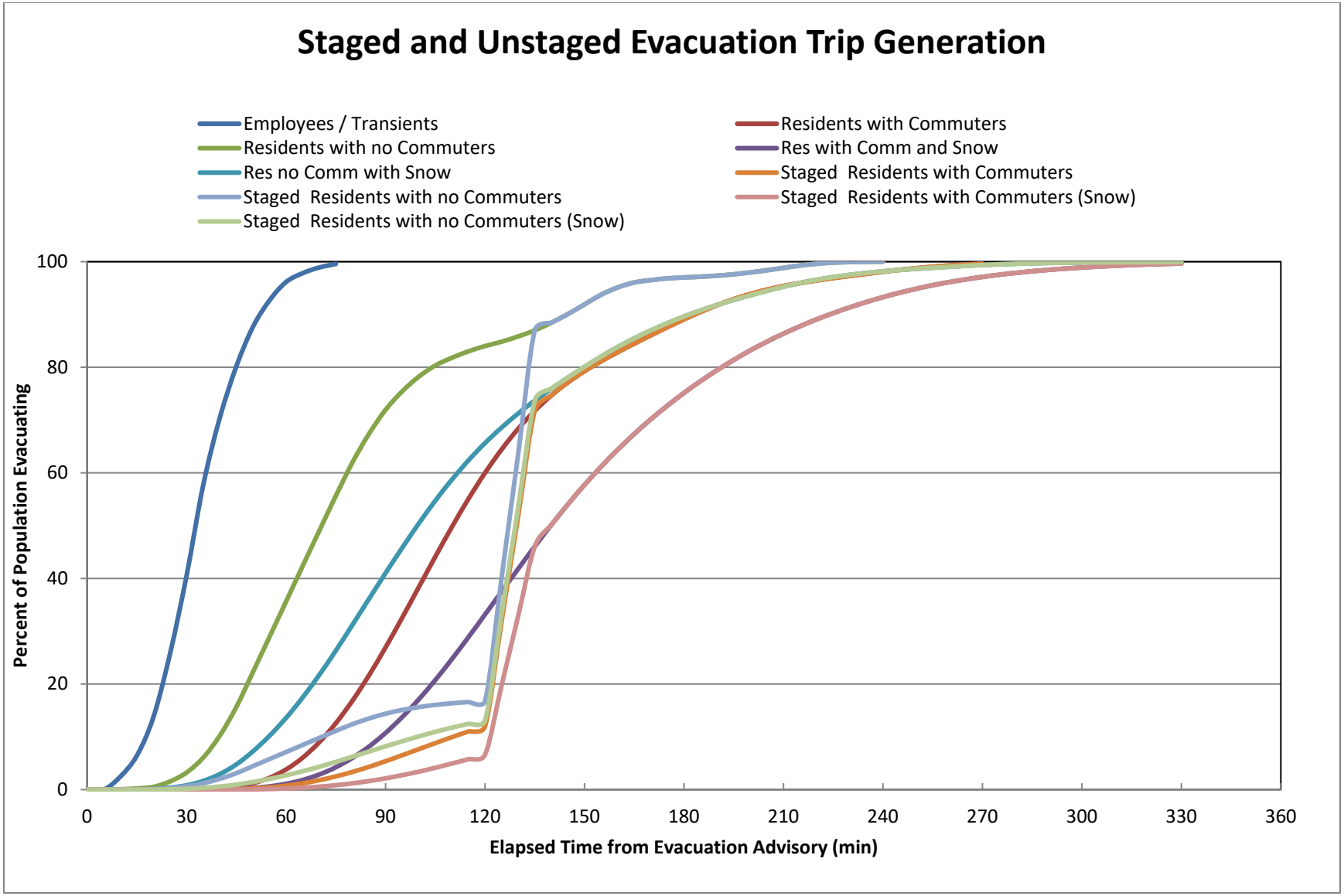


Figure 5-5. Comparison of Staged and Un-staged Trip Generation Distributions in the 2 to 5 Mile Region

6 EVACUATION CASES

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

Region A grouping of contiguous evacuating Sub-Areas 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 28 Regions were defined which encompass all the groupings of Sub-Areas considered. These Regions are defined in Table 6-1. The Sub-Area configurations are identified in Figure 6-1. Each keyhole sector-based area consists of a central circle centered at the power plant, and five adjoining sectors, each with a central angle of 22.5 degrees, as per NUREG/CR-7002, Rev. 1 guidance, the General Emergency Protective Action Recommendations (PAR) determination flowchart on page 26 of the Prairie Island Nuclear Generating Plant (PINGP) Emergency Plan Implementing Procedure, and the discussions with Xcel Energy. The central sector coincides with the wind direction. These sectors extend to 5 miles from the plant (Regions R04 through R10) or to the EPZ boundary (Regions R11 through R20). Each Sub-Area that intersects the keyhole is included in the Region, unless specified otherwise in the PAR determination flowchart.

Regions R01, R02 and R03 represent evacuations of circular areas with radii of 2, 5 and 10 miles, respectively. Regions R21, and R22 through R28 are geographically identical to Regions R02, and R04 through R10, respectively; however, those Sub-Areas between 2 miles and 5 miles are staged until 90% of the 2-Mile Region (Region R01) has evacuated.

A total of 14 Scenarios were evaluated for all Regions. Thus, there are a total of 28 x 14 = 392 evacuation cases. Table 6-2 provides a description of all Scenarios.

Each combination of Region and Scenario implies a specific population to be evacuated. The population and vehicle estimates presented in Section 3 and in Appendix E 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 population is considered for each evacuation case. The Scenario percentages are presented in Table 6-3, while the Region percentages are provided in Table H-1.

Table 6-4 presents the vehicle counts for each Scenario for an evacuation of Region R03 – the entire EPZ, based on the scenario percentages in Table 6-3. 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 40.6%, which is the product of 73.7% (the number of households with at least one commuter – see Figure F-6) and 55.1% (the number of households with a commuter that would

await the return of the commuter prior to evacuating – see Figure F-11). See assumption 3 in Section 2.3. It is estimated for weekend and evening scenarios that 10% of those households with returning commuters (40.6%) will have a commuter at work during those times, or approximately 4% (10% x 40.6% = 4%) of households overall.

It can be argued that the 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 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.

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

Transient activity is estimated to be at its peak (100%) during summer weekends and is less (80%) during the week as many people work during the week and not on weekends. Transient activity is estimated to be slightly less during winter weekends and weekdays, 70% and 60%, respectively, due to the presence of golf courses, parks, and marinas within the EPZ that are closed during winter months. Due to the casino and the large number of lodging facilities and campgrounds offering overnight accommodations, transient activity during the evening is estimated to be 70% in the summer and 60% in the winter.

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

$$20\% \times \left(1 + \frac{646}{7{,}238 + 10{,}603}\right) = 21\%$$

One special event – the Treasure Island Casino Concert – was considered as Scenario 13 (during the summer, midweek/weekend, evening with good weather). Thus, the special event traffic is 100% evacuated for Scenario 13, and 0% for all other scenarios.

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. It is estimated that summer school enrollment is approximately 10% of enrollment during the regular school year for summer, midweek, midday scenarios. Schools are not in session during weekends and evenings, thus no buses for schoolchildren are needed under those circumstances. The commuter colleges – Southeast Minnesota Technical College - Red Wing – are assumed to have the same scenario percentages as schools within the EPZ.

Transit vehicles for the transit-dependent population, patients at medical facilities, and inmates at the correctional facility are set to 100% for all scenarios as it is assumed that the transit-dependent population, medical patients, and inmates at the correctional facility are present in the EPZ at all times.

External traffic is estimated to be 100% for all midday scenarios, while it is significantly less (40%) during the evening scenarios 5 and 12.

Table 6-1. Description of Evacuation Regions

Radial Regions													
Region	**Description**	**Degrees in PAR**	**Sub-Area**										
			2	**5N**	**5E**	**5S**	**5W**	**10N**	**10NE**	**10E**	**10SE**	**10SW**	**10W**	**10NW**
R01	2-Mile Radius	0°-359°	x											
R02	5-Mile Radius	0°-359°	x	x	x	x	x							
R03	Full EPZ	0°-359°	x	x	x	x	x	x	x	x	x	x	x	x
Evacuate 2-Mile Radius and Downwind to 5 Miles														
Region	**Wind Direction From:**	**Degrees in PAR**	**Sub-Area**											
			2	**5N**	**5E**	**5S**	**5W**	**10N**	**10NE**	**10E**	**10SE**	**10SW**	**10W**	**10NW**
R04	NNW, N	326.25°-11.25°	x		x	x	x							
R05	NNE, NE, ENE, E	11.25°-101.25°	x			x	x							
R06	ESE, SE	101.25°-146.25°	x	x			x							
R07	SSE, S, SSW	146.25°-213.75°	x	x	x		x							
R08	SW	213.75°-236.25°	x	x	x									
R09	WSW, W, WNW	236.25°-303.75°	x	x	x	x								
R10	NW	303.75°-326.25°	x		x	x								
Evacuate 5-Mile Radius and Downwind to the EPZ Boundary														
Region	**Wind Direction From:**	**Degrees in PAR**	**Sub-Area**											
			2	**5N**	**5E**	**5S**	**5W**	**10N**	**10NE**	**10E**	**10SE**	**10SW**	**10W**	**10NW**
R11	N, NNE, NE, ENE	348.75°-78.75°	x	x	x	x	x				x	x	x	
R12	E	78.75°-101.25°	x	x	x	x	x					x	x	x
R13	ESE	101.25°-123.75°	x	x	x	x	x						x	x
R14	SE	123.75°-146.25°	x	x	x	x	x	x					x	x
R15	SSE	146.25°-168.75°	x	x	x	x	x	x	x				x	x
R16	S	168.75°-191.25°	x	x	x	x	x	x	x	x			x	x
R17	SSW, SW	191.25°-236.25°	x	x	x	x	x	x	x	x				x
R18	WSW	236.25°-258.75°	x	x	x	x	x	x	x	x	x			
R19	W, WNW	258.75°-303.75°	x	x	x	x	x		x	x	x			
R20	NW, NNW	303.75°-348.75°	x	x	x	x	x			x	x	x		
Staged Evacuation - 2-Mile Radius Evacuates, then Evacuate Downwind to 5 Miles														
Region	**Wind Direction From:**	**Degrees in PAR**	**Sub-Area**											
			2	**5N**	**5E**	**5S**	**5W**	**10N**	**10NE**	**10E**	**10SE**	**10SW**	**10W**	**10NW**
R21	5-Mile Radius	0°-359°	x	x	x	x	x							
R22	NNW, N	326.25°-11.25°	x		x	x	x							
R23	NNE, NE, ENE, E	11.25°-101.25°	x			x	x							
R24	ESE, SE	101.25°-146.25°	x	x			x							
R25	SSE, S, SSW	146.25°-213.75°	x	x	x		x							
R26	SW	213.75°-236.25°	x	x	x									
R27	WSW, W, WNW	236.25°-303.75°	x	x	x	x								
R28	NW	303.75°-326.25°	x		x	x								

Shelter-in-Place until 90% ETE for R01, then Evacuate	Sub-Area(s) Shelter-in-Place	Sub-Area(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/Light Snow	None
8	Winter	Midweek	Midday	Heavy Snow	None
9	Winter	Weekend	Midday	Good	None
10	Winter	Weekend	Midday	Rain/Light Snow	None
11	Winter	Weekend	Midday	Heavy Snow	None
12	Winter	Midweek, Weekend	Evening	Good	None
13	Summer	Midweek, Weekend	Evening	Good	Treasure Island Casino Concert
14	Summer	Midweek	Midday	Good	Closure US-61 EB between US-63 and County 292 Blvd

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

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

Scenario	Households With Returning Commuters	Households Without Returning Commuters	Employees	Transients	Shadow	Special Event	Special Facilities	Commuter Colleges	School Buses	Transit Buses	External Through Traffic
1	40.6%	59.4%	96%	80%	21%	0%	100%	10%	10%	100%	100%
2	40.6%	59.4%	96%	80%	21%	0%	100%	10%	10%	100%	100%
3	4%	96%	10%	100%	20%	0%	100%	0%	0%	100%	100%
4	4%	96%	10%	100%	20%	0%	100%	0%	0%	100%	100%
5	4%	96%	10%	70%	20%	0%	100%	0%	0%	100%	40%
6	40.6%	59.4%	100%	60%	21%	0%	100%	100%	100%	100%	100%
7	40.6%	59.4%	100%	60%	21%	0%	100%	100%	100%	100%	100%
8	40.6%	59.4%	100%	60%	21%	0%	100%	100%	100%	100%	100%
9	4%	96%	10%	70%	20%	0%	100%	0%	0%	100%	100%
10	4%	96%	10%	70%	20%	0%	100%	0%	0%	100%	100%
11	4%	96%	10%	70%	20%	0%	100%	0%	0%	100%	100%
12	4%	96%	10%	60%	20%	0%	100%	0%	0%	100%	40%
13	4%	96%	10%	70%	20%	100%	100%	0%	0%	100%	40%
14	40.6%	59.4%	96%	80%	21%	0%	100%	10%	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 Event ..... **Additional vehicles in the EPZ due to the identified special event.**
Commuter Colleges ..... **Colleges wherein all students drive themselves and would evacuate using their personal vehicles.**
School, Special Facilities &Transit Buses ..... **Vehicle-equivalents present on the road during evacuation servicing schools, medical facilities, correctional facility, and the transit-dependent people (1 bus is equivalent to 2 passenger vehicles).**
External Through Traffic ..... **Traffic on interstates/freeways and major arterial roads passing through the EPZ/study area at the start of the evacuation. This traffic is stopped by access control approximately two (2) hours after the evacuation begins.**

Table 6-4. Vehicle Estimates by Scenario[2]

Scenario	Households With Returning Commuters	Households Without Returning Commuters	Employees	Transients	Shadow	Special Event	Special Facilities[3]	Commuter Colleges	School Buses[4]	Transit Buses	External Through Traffic	Total Scenario Vehicles
1	7,238	10,603	646	4,317	4,635	0	87	4	8	22	7,732	35,292
2	7,238	10,603	646	4,317	4,635	0	87	4	8	22	7,732	35,292
3	724	17,117	67	5,396	4,490	0	87	0	0	22	7,732	35,635
4	724	17,117	67	5,396	4,490	0	87	0	0	22	7,732	35,635
5	724	17,117	67	3,777	4,490	0	87	0	0	22	3,093	29,377
6	7,238	10,603	673	3,238	4,642	0	87	40	82	22	7,732	34,357
7	7,238	10,603	673	3,238	4,642	0	87	40	82	22	7,732	34,357
8	7,238	10,603	673	3,238	4,642	0	87	40	82	22	7,732	34,357
9	724	17,117	67	3,777	4,490	0	87	0	0	22	7,732	34,016
10	724	17,117	67	3,777	4,490	0	87	0	0	22	7,732	34,016
11	724	17,117	67	3,777	4,490	0	87	0	0	22	7,732	34,016
12	724	17,117	67	3,238	4,490	0	87	0	0	22	3,093	28,838
13	724	17,117	67	3,777	4,490	8,082	87	0	0	22	3,093	37,459
14	7,238	10,603	646	4,317	4,635	0	87	4	8	22	7,732	35,292

[2] Vehicle estimates are for an evacuation of the entire EPZ (Region R03).
[3] Special facilities represent vehicles used for medical facilities and the correctional facility.
[4] Vehicles estimates include buses for schools only.

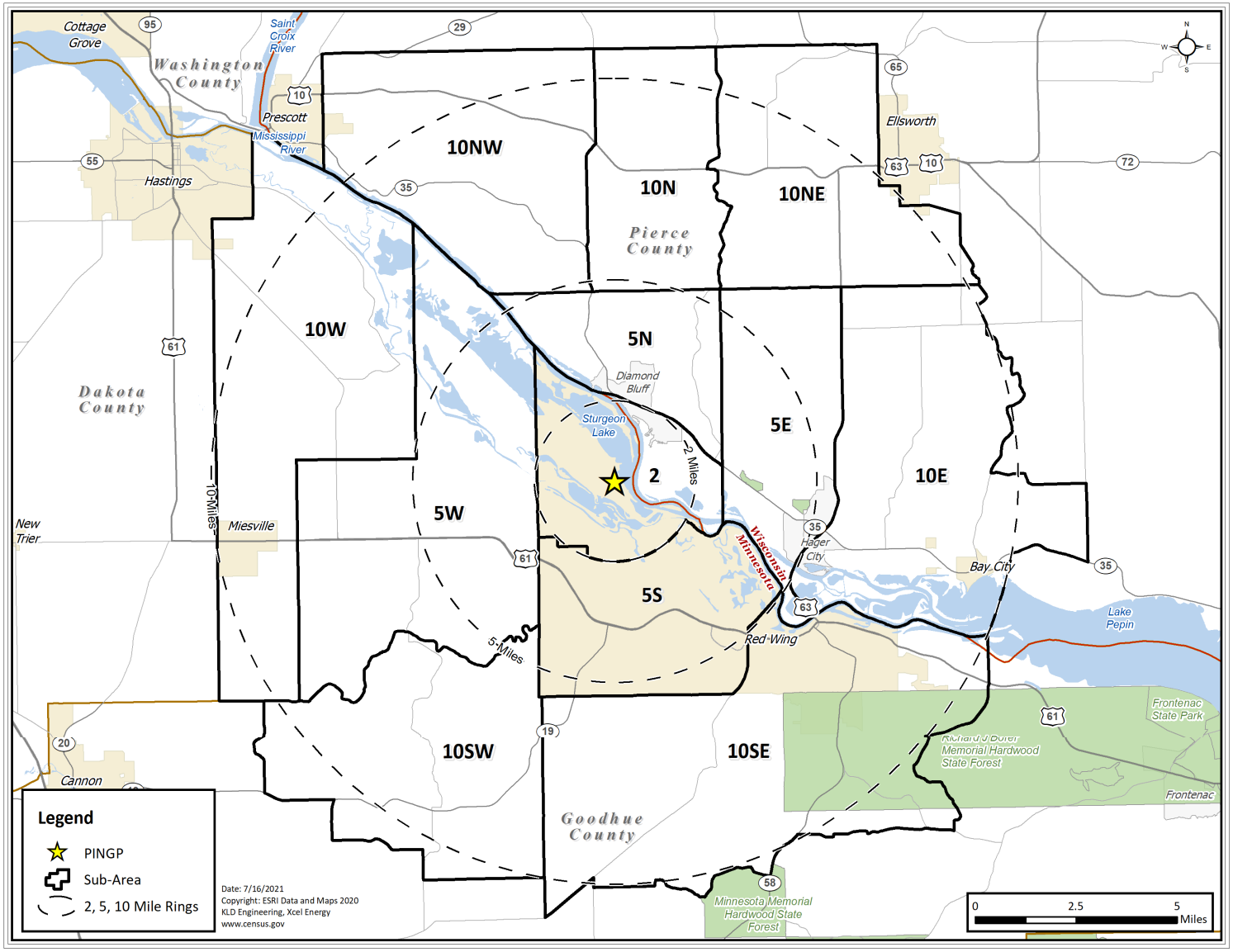


Figure 6-1. PINGP EPZ Sub-Areas

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 28 regions within the PINGP 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 2-Mile Region in both staged and un-staged regions are presented in Table 7-3 and Table 7-4. Table 7-5 defines the Evacuation Regions considered. The tabulated values of ETE are obtained from the DYNEV II model outputs which are generated at 5-minute intervals.

7.1 Voluntary Evacuation and Shadow Evacuation

"Voluntary evacuees" are permanent residents within the EPZ in Sub-Areas for which an Advisory to Evacuate (ATE) has not been issued, yet who elect to evacuate. "Shadow evacuation" is the voluntary outward movement of some permanent residents 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 PINGP EPZ addresses the issue of voluntary evacuees in the manner shown in Figure 7-1. Within the EPZ, 20 percent of people located in Sub-Areas 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 permanent residents in the Shadow Region will also 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 the permanent residents within the EPZ (see Section 3.1). As discussed in Section 3.2, it is estimated that a total of 38,918 permanent residents 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 (including external-external traffic), traveling away from the PINGP location, has the potential for impeding evacuating vehicles from within the Evacuation Region. All ETE calculations include this shadow traffic movement.

7.2 Staged Evacuation

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

1. Sub-Areas comprising the 2-Mile Region are advised to evacuate immediately.

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

See Section 5.4.2 for additional information on staged evacuation.

7.3 Patterns of Traffic Congestion during Evacuation

Figure 7-3 through Figure 7-7 illustrate the patterns of traffic congestion that arise for the case when the entire EPZ (Region R03) is advised to evacuate during the summer, weekend, midday period under good weather conditions (Scenario 3).

Traffic congestion, as the term is used here, is defined as Level of Service (LOS) F. LOS F is defined as follows (HCM 2016, 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. Congestion develops rapidly around concentrations of population and traffic bottlenecks.

Figure 7-3 displays the developing congestion within Red Wing to the east of PINGP and Hastings to the northwest of PINGP at just 30 minutes after the Advisory to Evacuate (ATE). The major evacuation route out of Red Wing - US-61 – experiences LOS F at the intersection with SR-58 and County 292 Blvd. Congestion develops on Sturgeon Lake Rd and CR-18 from employees leaving PINGP and transients leaving the Treasure Island Casino & Resort. Congestion also extends to SR-316 in the Shadow Region as traffic spills back from the

intersection with US-61. At this time, approximately 12% of the evacuees have begun their evacuation trip and about 7% of evacuees have successfully evacuated the EPZ.

At one hour and 30 minutes after the ATE, Figure 7-4 displays fully-developed congestion within the EPZ. In Red Wing, US-61, SR-58, and Pioneer Rd/Flower Valley Rd (as well as CR-1 leaving Red Wing) are all exhibiting LOS F conditions. SR-58 southbound exhibits heavy congestion near the EPZ boundary due to the loss of a lane in Hay Creek. The loss of a lane creates a bottleneck queuing vehicles for several miles. Similarly, US-61 eastbound exhibits heavy congestion due to a lane drop right before the intersection with County 292 Blvd. Sturgeon Lake Rd within the 2-Mile Region is still experiencing congestion as the employees and transients in Sub-Area 2 have completed their mobilization and have begun their evacuation trip. Roadways leaving the EPZ toward Hastings (SR-316, CR-54, and US-61) are experiencing congestion due to the confluence of shadow evacuees and those evacuees along these roadways. The stop sign at the intersection of SR-316 and US-61 impedes traffic on SR-316 from accessing US-61 and creates a queue on SR-316. US-52 outside of the Shadow Region is operating at LOS B (slightly below free flow conditions) at this time. CR-1 is congested at the intersection with US-52 due to the stop control for CR-1 at this intersection. The Wisconsin portion of the EPZ experiences slight congestion (LOS C or better) along SR-35, but this clears 10 minutes later at 1 hour and 40 minutes after the ATE. At this time, approximately 77% of the evacuees have begun their evacuation trip and about 50% of evacuees have successfully evacuated the EPZ.

At 2 hours and 15 minutes after the ATE, as shown in Figure 7-5, congestion has subsided within the heart of Red Wing, but still exists along US-61 southbound due the lane drop and capacity reduction thereafter. CR-21/Flower Valley Rd also experiences heavy congestion (LOS F) spilling back from the intersection with US-61. CR-1 is clear of congestion within the EPZ at this time, but SR-58 and CR-6 southbound still experience significant congestion (LOS D or worse). Sturgeon Lake Rd and CR-18 also still experience congestion although at lesser levels (LOS E or better). The 2-Mile Region clears of congestion 5 minutes later at 2 hours and 20 minutes after the ATE; the 5-Mile Region clears of congestion 10 minutes later at 2 hours and 25 minutes after the ATE. Hastings is at its peak congestion at this time as evacuees from the EPZ that have cleared the EPZ boundary are now mixing with the shadow vehicles in this city. At this time, approximately 87% evacuees have begun their evacuation trips, and 68% evacuees have successfully evacuated the EPZ.

Figure 7-6 shows the last remnants of congestion within the EPZ along SR-58 and US-61 southbound, CR-21/Flower Valley Rd, and SR-316 northbound at 3 hours after the ATE. Additional congestion in the Shadow Region exits along CR-6 and in the heart of Hastings. At this time, approximately 98% evacuees have begun their evacuation trips, and 92% evacuees have successfully evacuated the EPZ.

At 3 hours and 45 minutes after the ATE, as shown in Figure 7-7, all roads within the EPZ are operating at LOS A. At this time, approximately 99% evacuees have begun their evacuation trips, and 99% evacuees have successfully evacuated the EPZ. This indicates that the trip generation time plus the time to travel to the EPZ boundary (4 hours and 40 minutes) is

dictating the 100th percentile ETE as evacuees who depart at this time are encountering no traffic congestion or delays within the EPZ. In the Shadow Region, a segment of CR-6 is still operating at a LOS F due to the stop sign at the intersection with 380th St. A section of US-61 within Shadow Region is also congested as evacuees continue to clear the area. All congestion within the Shadow Region clears 20 minutes later at 4 hours and 5 minutes after the ATE.

7.4 Evacuation Rates

Evacuation is a continuous process, as implied by Figure 7-8 through Figure 7-21. These figures display the rate at which traffic flows out of the indicated areas for the case of an evacuation of the full EPZ (Region R03) under the indicated conditions. One figure is presented for each scenario considered.

As indicated in Figure 7-8 through Figure 7-21, there is typically a long "tail" to these distributions due to the mobilization and not congestion. 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, there are a few evacuation routes servicing 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 of the mobilization time – 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 28 Evacuation Regions and all 14 Evacuation Scenarios. Table 7-3 and Table 7-4 present the ETE values for the 2-Mile region for both staged and un-staged keyhole regions downwind to 5 miles. The tables are organized as follows:

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

The animation snapshots described in Section 7.3 reflect the ETE statistics for the concurrent (un-staged) evacuation scenarios and regions, which are displayed in Figure 7-3 through Figure 7-7. Most of the congestion is located in Red Wing, within the 2-mile region, and roadways leading toward Hastings; this is reflected in the ETE statistics:

- The 90th percentile ETE for Region R01 (2-Mile Region) is range from 1:25 (hr:min) to 2:20 for all scenarios except for the special event scenario. Region R01 contains a large number of transients and employees from the casino and the plant. These evacuees have a limited number of evacuation routes out of the area (essentially only Sturgeon Lake Rd to Prairie Island Blvd. As a result, significant congestion exists within the 2-mile region. As shown in Figure 7-5 and discussed above, it can take over 2 hours for this congestion to clear during peak times at the casino. As a result, the 90th percentile ETE for Region R01 is dictated by the congestion within the 2-Mile Region.
- The 90th percentile ETE for Region R02 (5-Mile Region) range between 2:10 (hr:min) to 2:45 for all scenarios except the special event. The increase in ETE for this region in comparison to the 2-mile region is due to the longer distance to travel to the 5-Mile Region boundary in some cases, and because of the congestion on CR-18 in other cases.
- The 90th percentile ETE for Region R03 (full EPZ) range from 2:40 (hr:min) to 3:45 for all scenarios. The increase in ETE for this region in comparison to the 5-mile region is due to the congestion in Red Wing, which is beyond 5 miles from PINGP as shown in the congestion diagrams discussed in Section 7.3.
- The 100th percentile ETE for all Regions and for almost all Scenarios are the same values as the mobilization times (plus a 5- or 10-minute travel time), with the exception of the special event. This fact implies that the congestion within the EPZ dissipates prior to the end of mobilization, as is displayed in Figure 7-7.

Comparison of Scenarios 5 and 13 in Table 7-1 indicates that the Special Event – Treasure Island Casino Concert – has a significant impact on the 90th percentile ETE with increases of up to 3 hours and 5 minutes. The 90th percentile ETE for the special event is the longest for Region R01 since the additional 8,082 special event vehicles have the largest impact on the smallest area being evacuated. Specifically, the congestion caused by the mixing of these evacuees and plant employees, as well as other transients at the casino, and limited capacity of Sturgeon Lake Rd prolong the 90th percentile ETE. The more vehicles that evacuate (and the more congestion that exists elsewhere) the less of an impact the additional transient vehicles have on the 90th percentile ETE. As such, the 90th percentile ETE decreases for the 5-mile region and full EPZ. The special event also has a material impact on the 100th percentile ETE with increases of up to 1 hour and 15 minutes, as shown in Table 7-2. The aforementioned anomaly, however, does not exist at the 100th percentile.

Comparison of Scenarios 1 and 14 in Table 7-1 and Table 7-2 indicate that the roadway closure – Closure US-61 EB between US-63 and County 292 Blvd – has no impact on the 90th percentile ETE and on the 100th percentile ETE.

7.6 Staged Evacuation Results

Table 7-3 and Table 7-4 present a comparison of the of the ETE compiled for the concurrent (un-staged) and staged evacuation results. Note that R21, R22 through R28 are the same geographically identical to Regions R02 and R04 through R10, respectively. The times shown in Table 7-3 and Table 7-4 are when the 2-Mile Region is 90% clear and 100% clear, respectively.

The objective of a staged evacuation is to ensure the ETE for the 2-Mile Region is **not significantly increased** (30 minutes or 25%, whichever is less) when evacuating areas beyond 2-Miles. Additionally, staged evacuation should not significantly increase the ETE for people evacuating beyond 2-Miles. As shown in Table 7-3, the 90th percentile ETE for the 2-Mile Region is not impacted when a staged evacuation is implemented for all scenarios, except Special Event Scenario (Scenario 13) where in the ETE for the 2-mile region actually decreases. This anomaly is a result of vehicles within 2 miles of the plant rerouting to the north when there is congestion to the south in the 2- to 5-mile region (when Sub-Areas 5S and 5W evacuates). When vehicles reroute to the north, they evacuate the 2-mile region more quickly. When there is no congestion beyond 2 miles (when the 2-mile region evacuates alone or the wind is blowing away from Red Wing), evacuees from within 2 miles prefer to evacuate southbound toward US-61, which is a longer path out of the area and results in a longer 90th percentile ETE. The decrease in ETE at the 90th percentile for the special event is not indicative of a benefit to staged evacuation since the ETE for the 2-mile region was not **increased** by an evacuation of those beyond 2 miles for this scenario which is the goal of a staged evacuation.

The 100th percentile ETE for the 2-Mile Region is unchanged when a staged evacuation is implemented for all scenarios, as the trip mobilization (plus the travel time to EPZ boundary) dictates the ETE as shown in Table 7-4.

To determine the effect of staged evacuation on the residents beyond the 2-Mile Region, Regions R02 and R04 through R10 are compared to Regions R21, R22 through R28, respectively, in Table 7-1 and Table 7-2. A comparison of ETE between these similar regions reveals that staging increases the ETE for those in the 2 to 5-Mile Region by at most 50 minutes for the 90th percentile ETE – a significant impact and has no impact on the 100th percentile ETE. This increase in the 90th percentile ETE is due to the large number of evacuating vehicles, beyond the 2-Mile Region, sheltering and delaying the start of their evacuation trip, beyond the 2-Mile Region. As shown in Figure 5-5, staging the evacuation causes a significant "spike" (sharp increase) in mobilization (trip generation rate) of evacuating vehicles. This spike oversaturates evacuation routes which increases traffic congestion and prolongs ETE. Therefore, the staged evacuation provides no benefits and adversely impacts many evacuees located beyond 2 miles from the PINGP.

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 (Step 1)**:
   - Season
     - Summer
     - Winter (also Autumn and Spring)
   - Day of Week
     - Midweek
     - Weekend
   - Time of Day
     - Midday
     - Evening
   - Weather Condition
     - Good Weather
     - Rain/Light Snow
     - Heavy Snow
   - Special Event
     - Treasure Island Casino Concert
     - Road Closure (Closure US-61 EB between US-63 and County 292 Blvd)
   - Evacuation Staging
     - No, Staged Evacuation is not considered
     - Yes, Staged Evacuation is considered

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

- The conditions of a summer evening (either midweek or weekend) and rain are not explicitly identified in the Tables. For these conditions, Scenarios (2) and (4) apply.
- The conditions of a winter evening (either midweek or weekend) and rain/light snow are not explicitly identified in the Tables. For these conditions, Scenarios (7) and (10) for rain and rain/light snow apply, respectively.
- The conditions of a winter evening (either midweek or weekend) and heavy snow are not explicitly identified in the Tables. For these conditions, Scenarios (8) and (11) for heavy snow apply.
- The seasons are defined as follows:
  - Summer assumes that public schools are in session at summer school enrollment levels (lower than normal enrollment).
  - Winter (includes Spring and Autumn) considers that public schools are in session at normal enrollment levels.
- Time of Day: Midday implies the time over which most commuters are at work or are travelling to/from work.

2. With the desired percentile ETE and Scenario identified, now identify the **Evacuation Region (Step 2)**:
   - Determine the projected azimuth direction of the plume (coincident with the wind direction). This direction is expressed in terms of compass orientation: from N, NNE, NE, … etc.

- 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:
  - 2 Miles (Region R01)
  - To 5 Miles (Region R02, R04 through R10)
  - To EPZ Boundary (Regions R03, R11 through R20)
- Enter Table 7-5 and identify the applicable group of candidate Regions based on the distance that the selected Region extends from the PINGP. Select the Evacuation Region identifier in that row, based on the azimuth direction of the plume, from the first column of the Table.

3. Determine the **ETE Table** based on the **percentile** selected. Then, for the **Scenario** identified in Step 1 and the **Evacuation Region** identified in Step 2, proceed as follows:
   - The columns of Table 7-1 through Table 7-4 are labeled with the Scenario numbers. Identify the proper column in the selected Table using the Scenario number determined in Step 1.
   - Identify the row in this table that provides ETE values for the Region identified in Step 2.
   - The unique data cell defined by the column and row so determined contains the desired value of ETE expressed in Hours:Minutes.

Example

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

- Sunday, August 10th at 4:00 AM (summer, weekend, evening).
- It is raining.
- Wind direction is from the northeast (NE).
- Wind speed is such that the distance to be evacuated is judged to be a 2-Mile Region and downwind to 5 miles.
- The desired ETE is that value needed to evacuate 90th 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 2-Mile Region and Downwind to the 5 Miles” for wind direction from the NE and read Region R05 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 R05. This data cell is in column (4) and in the row for Region R05; it contains the ETE value of 2:20.

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

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek Weekend	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/Light Snow	Heavy Snow	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region, 5-Mile Region, and EPZ														
R01	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:40	1:55
R02	2:15	2:30	2:15	2:20	2:10	2:20	2:20	2:45	2:10	2:15	2:35	2:10	4:10	2:15
R03	2:55	3:10	2:50	3:00	2:40	2:55	3:05	3:45	2:50	2:55	3:35	2:40	3:45	2:55
Evacuate 2-Mile Region and Downwind to 5 Miles														
R04	2:15	2:30	2:15	2:20	2:10	2:20	2:20	2:40	2:10	2:15	2:30	2:10	4:10	2:15
R05	2:15	2:25	2:15	2:20	2:10	2:20	2:20	2:40	2:10	2:15	2:30	2:10	4:15	2:15
R06	2:10	2:25	2:15	2:20	2:00	2:10	2:10	2:20	2:05	2:10	2:20	2:00	4:25	2:10
R07	2:10	2:25	2:15	2:20	2:00	2:10	2:15	2:25	2:05	2:10	2:20	2:05	4:25	2:10
R08	2:00	2:25	2:05	2:15	1:40	1:55	1:55	2:30	1:40	1:50	2:15	1:35	4:35	2:00
R09	2:15	2:25	2:10	2:20	2:05	2:15	2:15	2:40	2:10	2:10	2:30	2:10	4:20	2:15
R10	2:15	2:25	2:10	2:20	2:05	2:15	2:15	2:40	2:10	2:10	2:30	2:10	4:20	2:15
Evacuate 5-Mile Region and Downwind to the EPZ Boundary														
R11	3:00	3:15	2:55	3:05	2:45	3:00	3:10	3:45	2:50	3:00	3:35	2:40	3:50	3:00
R12	2:30	2:45	2:25	2:35	2:25	2:30	2:35	3:05	2:25	2:25	2:50	2:25	4:10	2:30
R13	2:30	2:45	2:25	2:35	2:25	2:30	2:35	3:05	2:25	2:25	2:50	2:25	4:10	2:30
R14	2:35	2:45	2:30	2:35	2:25	2:30	2:35	3:05	2:25	2:25	2:50	2:25	4:10	2:35
R15	2:35	2:45	2:30	2:35	2:25	2:35	2:35	3:05	2:25	2:25	2:55	2:25	4:05	2:35
R16	2:35	2:45	2:30	2:35	2:25	2:35	2:35	3:05	2:25	2:25	2:55	2:25	4:05	2:35
R17	2:25	2:30	2:20	2:25	2:15	2:25	2:30	3:00	2:15	2:20	2:45	2:20	4:00	2:25
R18	3:00	3:10	2:50	3:00	2:40	3:00	3:05	3:50	2:50	3:00	3:35	2:40	3:40	3:00
R19	3:00	3:10	2:50	3:00	2:40	3:00	3:05	3:50	2:50	3:00	3:35	2:40	3:45	3:00
R20	3:00	3:10	2:50	3:00	2:40	3:05	3:05	3:50	2:50	3:00	3:35	2:40	3:45	3:00

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek Weekend	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/Light Snow	Heavy Snow	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Special Event	Roadway Impact
Staged Evacuation - 2-Mile Region Evacuates, then Evacuate Downwind to 5 Miles														
R21	2:30	2:30	2:30	2:30	2:30	2:30	2:30	2:45	2:30	2:30	2:40	2:30	4:10	2:30
R22	2:30	2:30	2:30	2:30	2:30	2:30	2:30	2:45	2:30	2:30	2:40	2:30	4:15	2:30
R23	2:30	2:30	2:25	2:30	2:30	2:30	2:30	2:40	2:30	2:30	2:35	2:30	4:15	2:30
R24	2:15	2:25	2:20	2:25	2:20	2:15	2:20	2:25	2:15	2:20	2:25	2:20	4:25	2:15
R25	2:20	2:25	2:20	2:25	2:25	2:20	2:25	2:30	2:20	2:25	2:25	2:25	4:25	2:20
R26	2:20	2:25	2:20	2:25	2:20	2:25	2:25	2:35	2:20	2:20	2:30	2:25	4:35	2:20
R27	2:30	2:30	2:25	2:30	2:30	2:30	2:30	2:40	2:30	2:30	2:35	2:30	4:20	2:30
R28	2:30	2:30	2:25	2:30	2:30	2:30	2:30	2:40	2:30	2:30	2:35	2:30	4:20	2:30

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

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek Weekend	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/Light Snow	Heavy Snow	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region, 5-Mile Region, and EPZ														
R01	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R02	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:25	4:35
R03	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	5:55	4:40
Evacuate 2-Mile Region and Downwind to 5 Miles														
R04	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:15	4:35
R05	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:15	4:35
R06	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:20	4:35
R07	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:25	4:35
R08	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:25	4:35
R09	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:25	4:35
R10	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:25	4:35
Evacuate 5-Mile Region and Downwind to the EPZ Boundary														
R11	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	5:45	4:40
R12	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	5:50	4:40
R13	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	5:45	4:40
R14	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	5:45	4:40
R15	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	5:45	4:40
R16	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	5:45	4:40
R17	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	5:15	4:40
R18	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	5:15	4:40
R19	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	5:15	4:40
R20	4:40	4:40	4:40	4:40	4:40	4:40	4:40	5:40	4:40	4:40	5:40	4:40	5:20	4:40

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek Weekend	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/Light Snow	Heavy Snow	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Special Event	Roadway Impact
Staged Evacuation - 2-Mile Region Evacuates, then Evacuate Downwind to 5 Miles														
R21	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:25	4:35
R22	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:15	4:35
R23	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:15	4:35
R24	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:20	4:35
R25	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:25	4:35
R26	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:25	4:35
R27	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:25	4:35
R28	4:35	4:35	4:35	4:35	4:35	4:35	4:35	5:35	4:35	4:35	5:35	4:35	5:25	4:35

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

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek Weekend	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region and 5-Mile Region														
R01	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:40	1:55
R02	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:25	1:55
Un-staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R04	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:25	1:55
R05	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:25	1:55
R06	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:40	1:55
R07	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:40	1:55
R08	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:40	1:55
R09	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:40	1:55
R10	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:40	1:55
Staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R21	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:25	1:55
R22	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:25	1:55
R23	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:25	1:55
R24	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:40	1:55
R25	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:40	1:55
R26	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:40	1:55
R27	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:25	1:55
R28	1:55	2:20	2:05	2:15	1:35	1:35	1:45	2:05	1:35	1:45	2:05	1:25	4:25	1:55

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

	Summer		Summer		Summer	Winter			Winter			Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Midweek Weekend	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Rain/Light Snow	Heavy Snow	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region and 5-Mile Region														
R01	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R02	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
Un-staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R04	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R05	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R06	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R07	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R08	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R09	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R10	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
Staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R21	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R22	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R23	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R24	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R25	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R26	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R27	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30
R28	4:30	4:30	4:30	4:30	4:30	4:30	4:30	5:30	4:30	4:30	5:30	4:30	5:15	4:30

Table 7-5. Description of Evacuation Regions

Radial Regions													
Region	**Description**	**Degrees in PAR**	**Sub-Area**										
			2	**5N**	**5E**	**5S**	**5W**	**10N**	**10NE**	**10E**	**10SE**	**10SW**	**10W**	**10NW**
R01	2-Mile Radius	0°-359°	x											
R02	5-Mile Radius	0°-359°	x	x	x	x	x							
R03	Full EPZ	0°-359°	x	x	x	x	x	x	x	x	x	x	x	x
Evacuate 2-Mile Radius and Downwind to 5 Miles														
Region	**Wind Direction From:**	**Degrees in PAR**	**Sub-Area**											
			2	**5N**	**5E**	**5S**	**5W**	**10N**	**10NE**	**10E**	**10SE**	**10SW**	**10W**	**10NW**
R04	NNW, N	326.25°-11.25°	x		x	x	x							
R05	NNE, NE, ENE, E	11.25°-101.25°	x			x	x							
R06	ESE, SE	101.25°-146.25°	x	x			x							
R07	SSE, S, SSW	146.25°-213.75°	x	x	x		x							
R08	SW	213.75°-236.25°	x	x	x									
R09	WSW, W, WNW	236.25°-303.75°	x	x	x	x								
R10	NW	303.75°-326.25°	x		x	x								
Evacuate 5-Mile Radius and Downwind to the EPZ Boundary														
Region	**Wind Direction From:**	**Degrees in PAR**	**Sub-Area**											
			2	**5N**	**5E**	**5S**	**5W**	**10N**	**10NE**	**10E**	**10SE**	**10SW**	**10W**	**10NW**
R11	N, NNE, NE, ENE	348.75°-78.75°	x	x	x	x	x				x	x	x	
R12	E	78.75°-101.25°	x	x	x	x	x					x	x	x
R13	ESE	101.25°-123.75°	x	x	x	x	x						x	x
R14	SE	123.75°-146.25°	x	x	x	x	x	x					x	x
R15	SSE	146.25°-168.75°	x	x	x	x	x	x	x				x	x
R16	S	168.75°-191.25°	x	x	x	x	x	x	x	x			x	x
R17	SSW, SW	191.25°-236.25°	x	x	x	x	x	x	x	x				x
R18	WSW	236.25°-258.75°	x	x	x	x	x	x	x	x	x			
R19	W, WNW	258.75°-303.75°	x	x	x	x	x		x	x	x			
R20	NW, NNW	303.75°-348.75°	x	x	x	x	x			x	x	x		
Staged Evacuation - 2-Mile Radius Evacuates, then Evacuate Downwind to 5 Miles														
Region	**Wind Direction From:**	**Degrees in PAR**	**Sub-Area**											
			2	**5N**	**5E**	**5S**	**5W**	**10N**	**10NE**	**10E**	**10SE**	**10SW**	**10W**	**10NW**
R21	5-Mile Radius	0°-359°	x	x	x	x	x							
R22	NNW, N	326.25°-11.25°	x		x	x	x							
R23	NNE, NE, ENE, E	11.25°-101.25°	x			x	x							
R24	ESE, SE	101.25°-146.25°	x	x			x							
R25	SSE, S, SSW	146.25°-213.75°	x	x	x		x							
R26	SW	213.75°-236.25°	x	x	x									
R27	WSW, W, WNW	236.25°-303.75°	x	x	x	x								
R28	NW	303.75°-326.25°	x		x	x								

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

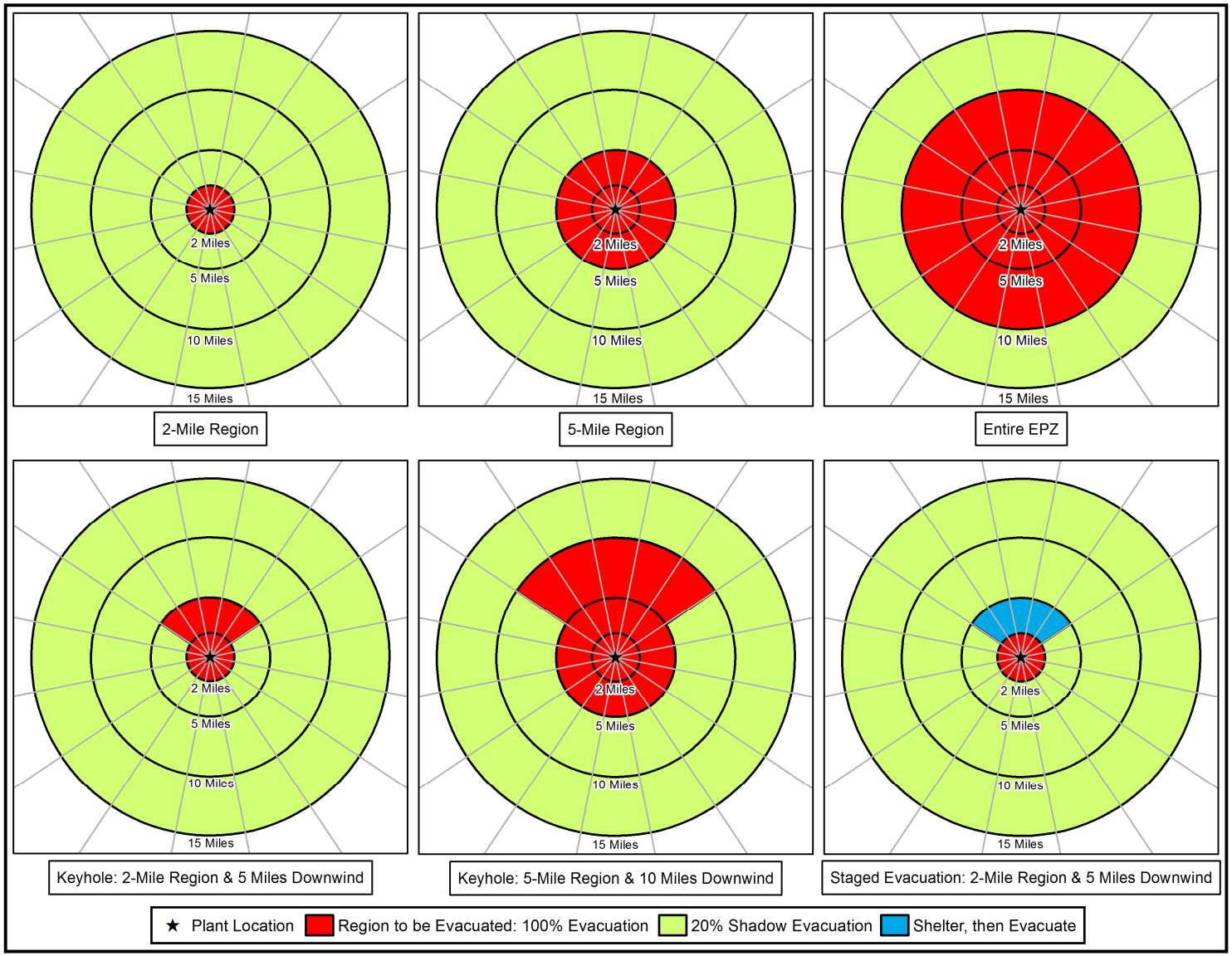


Figure 7-1. Voluntary Evacuation Methodology

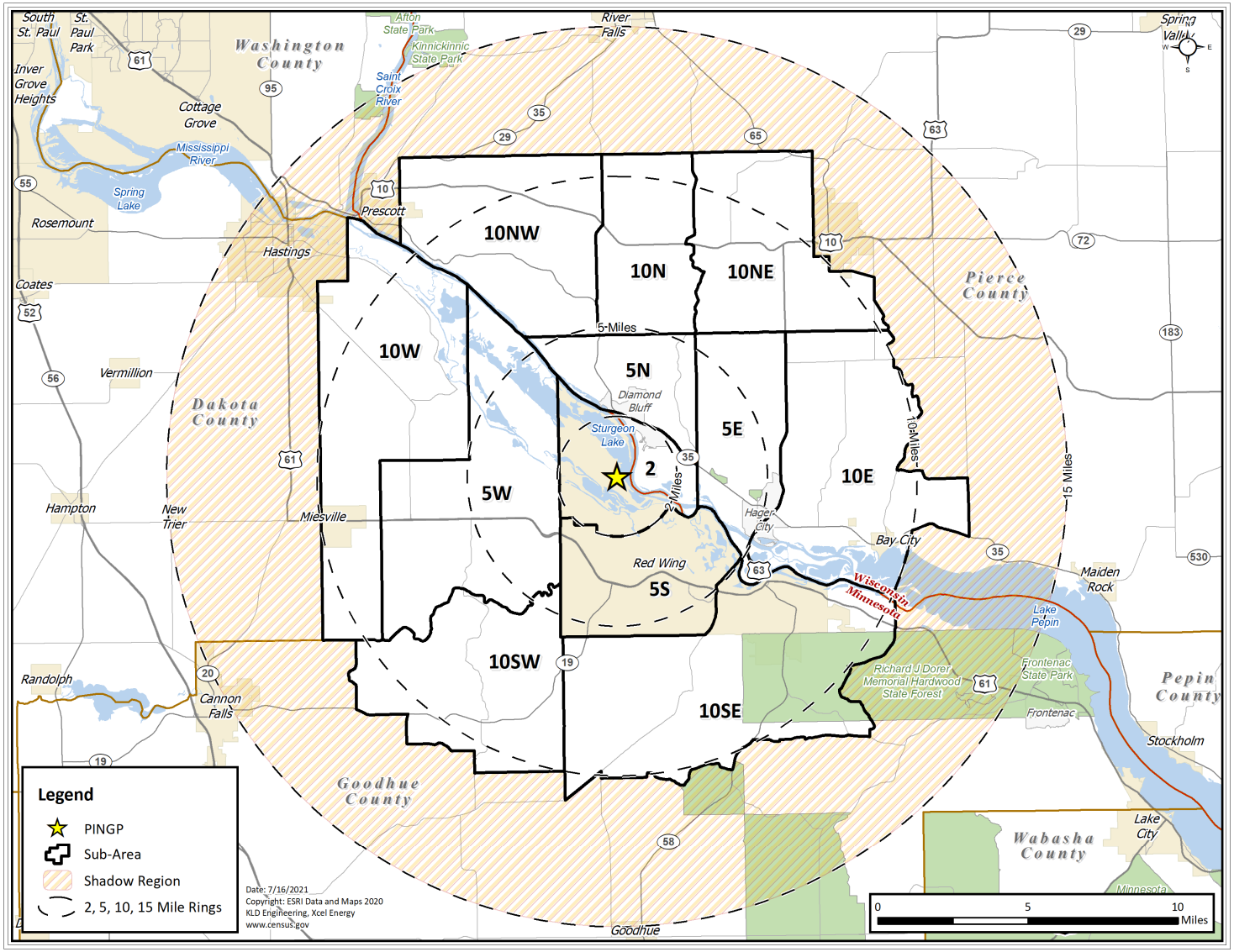


Figure 7-2. PINGP Shadow Region

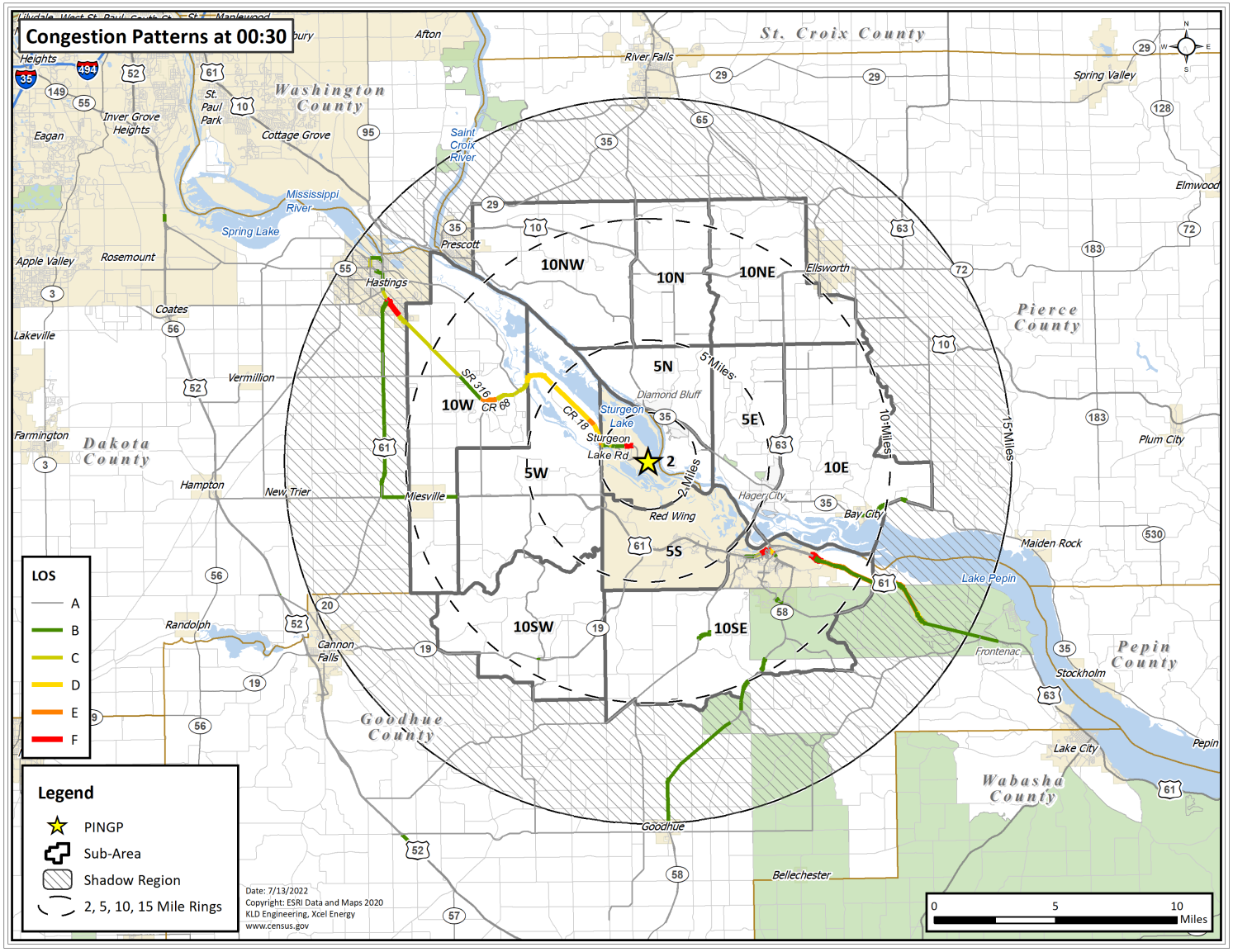


Figure 7-3. Congestion Patterns at 30 Minutes after the Advisory to Evacuate

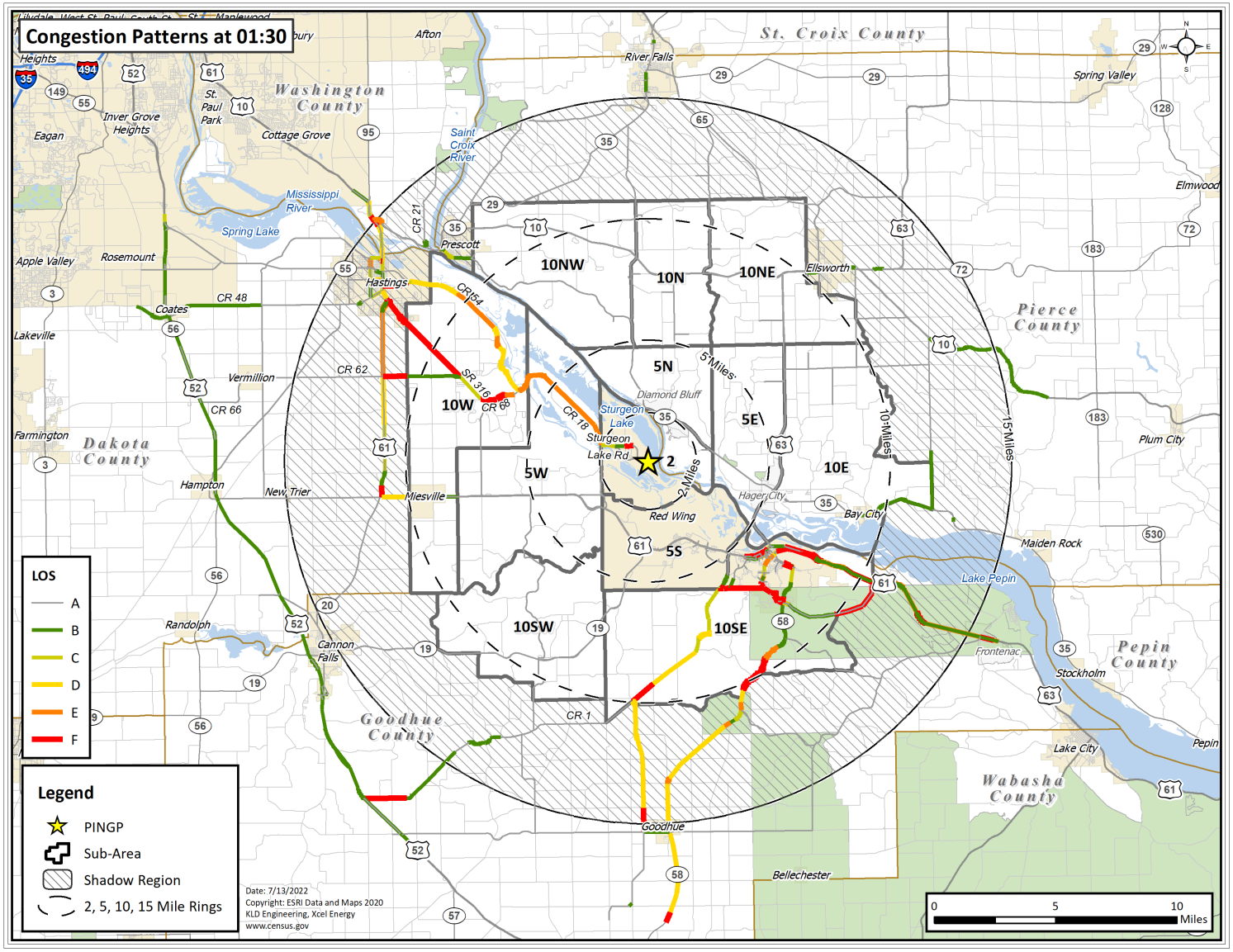


Figure 7-4. Congestion Patterns at 1 Hour and 30 Minutes after the Advisory to Evacuate

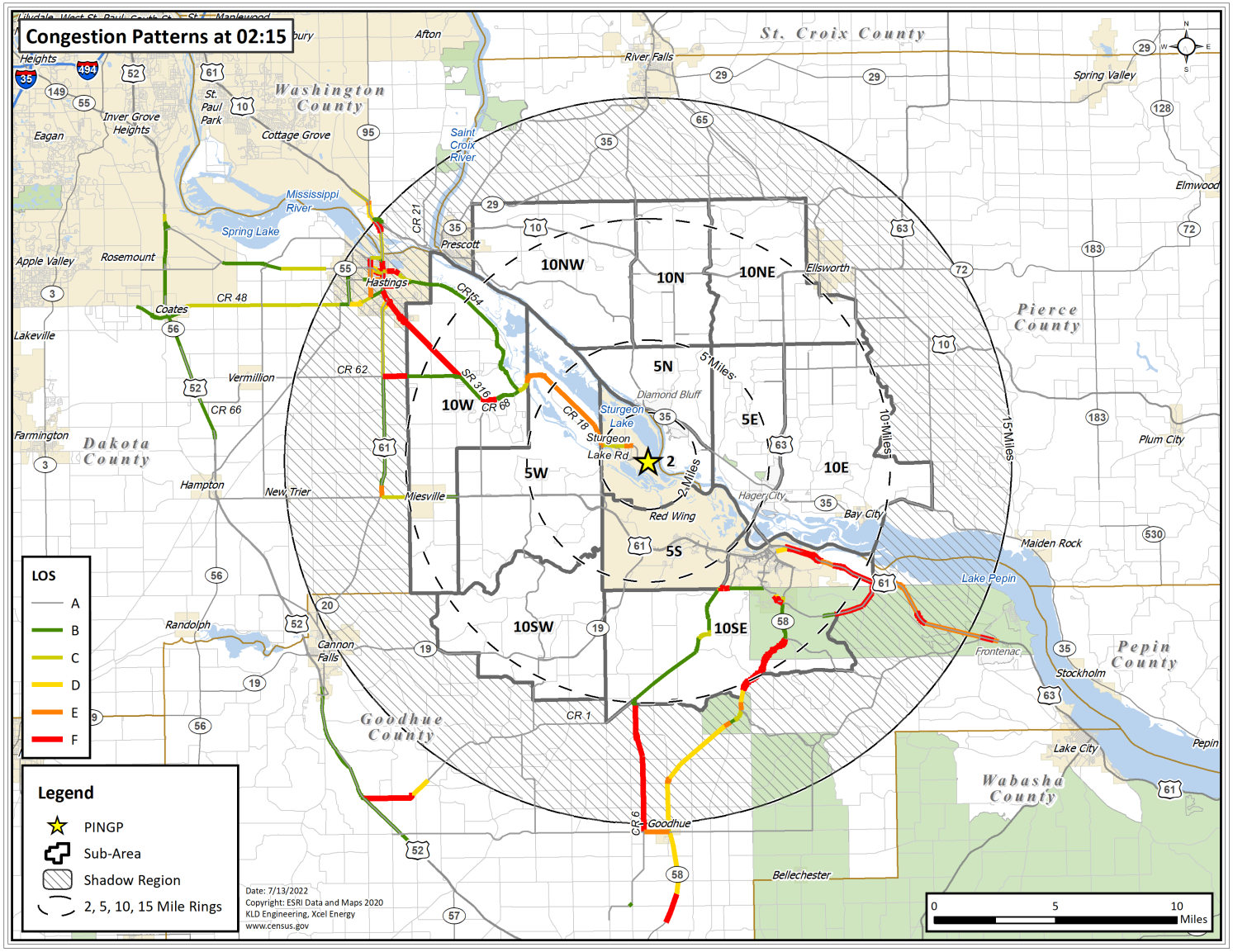


Figure 7-5. Congestion Patterns at 2 Hours and 15 Minutes after the Advisory to Evacuate

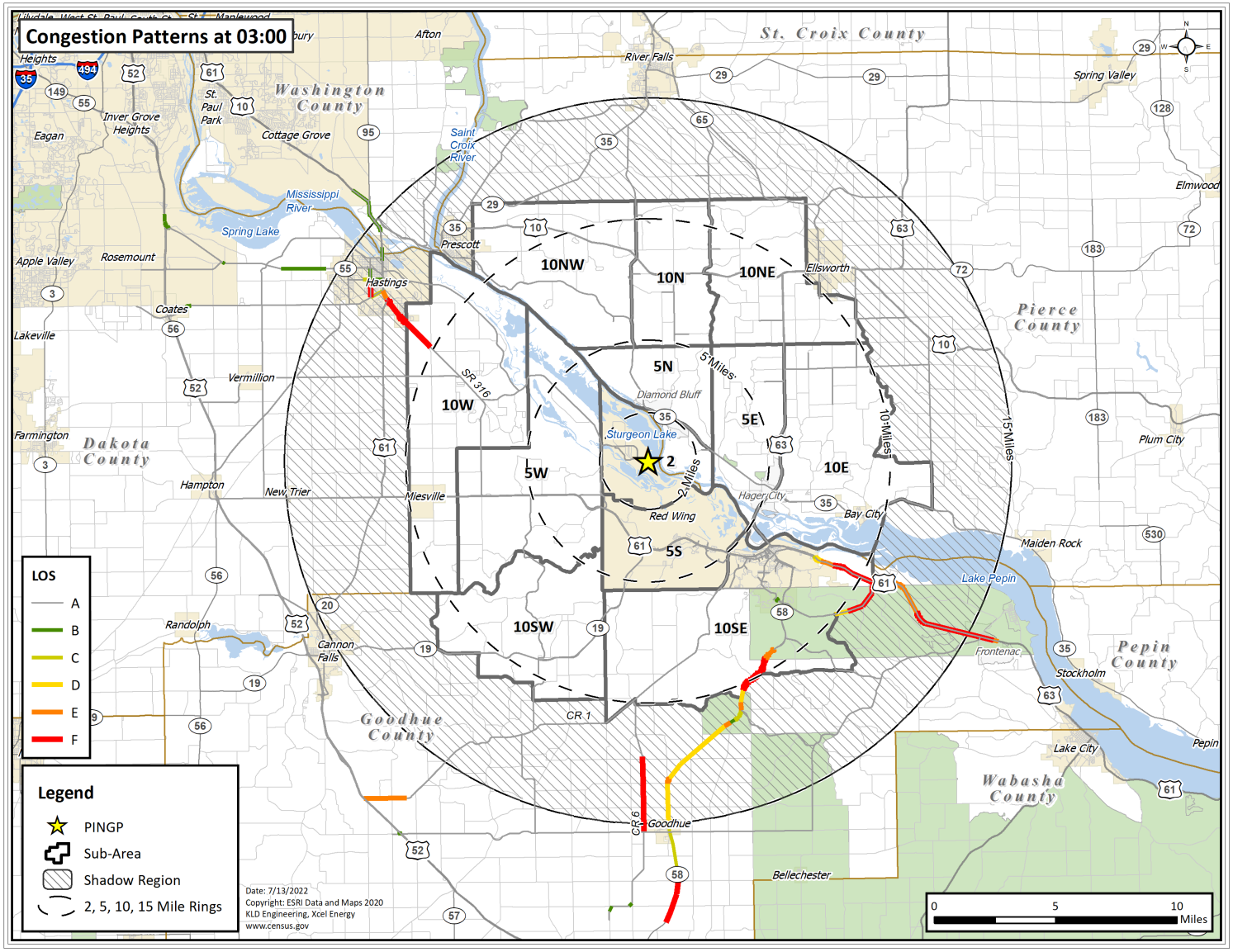


Figure 7-6. Congestion Patterns at 3 Hours after the Advisory to Evacuate

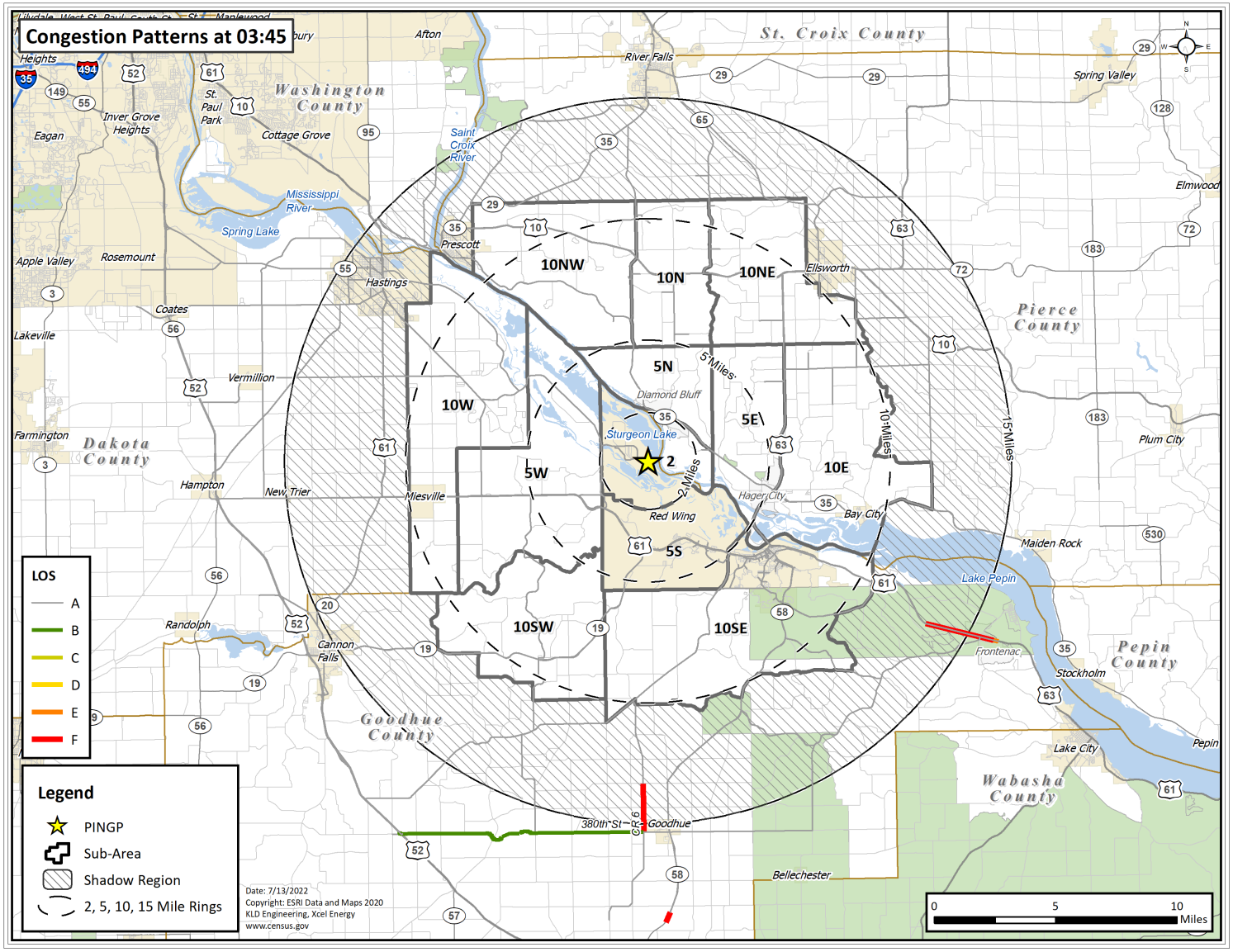


Figure 7-7. Congestion Patterns at 3 Hours and 45 Minutes after the Advisory to Evacuate

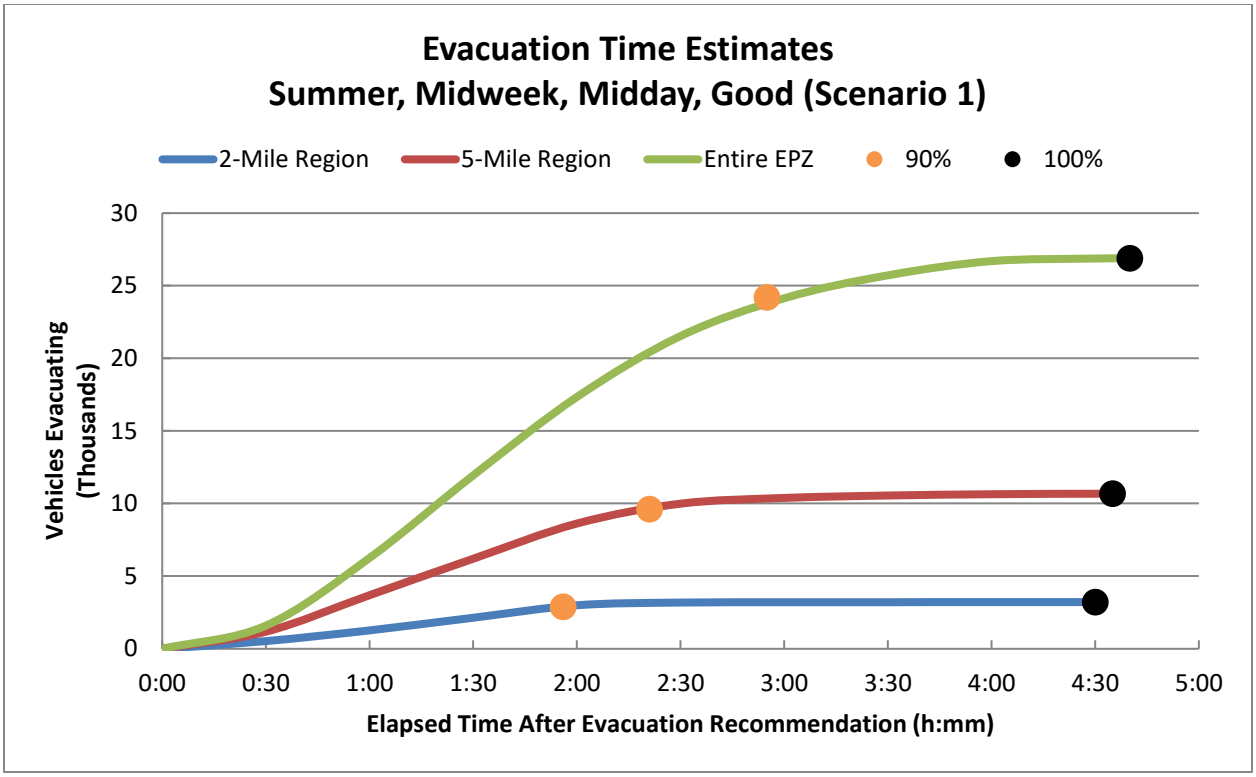


Figure 7-8. Evacuation Time Estimates - Scenario 1 for Region R03

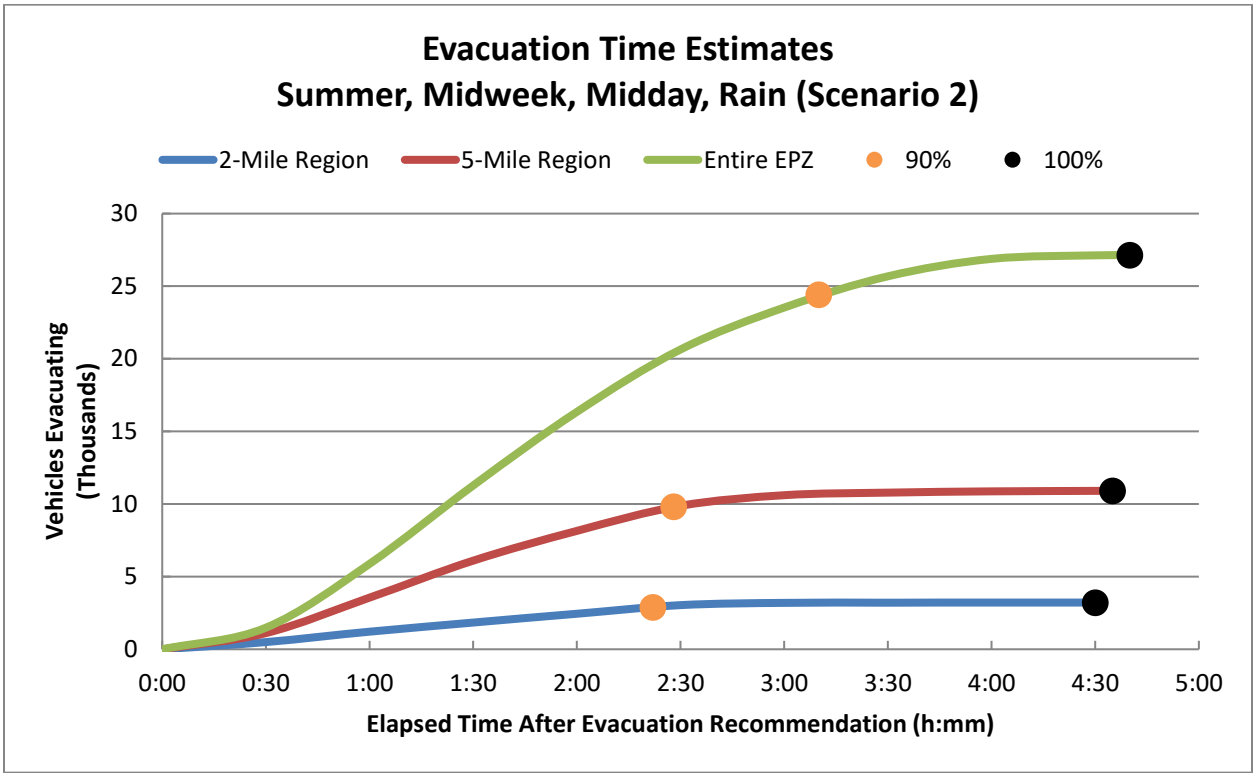


Figure 7-9. Evacuation Time Estimates - Scenario 2 for Region R03

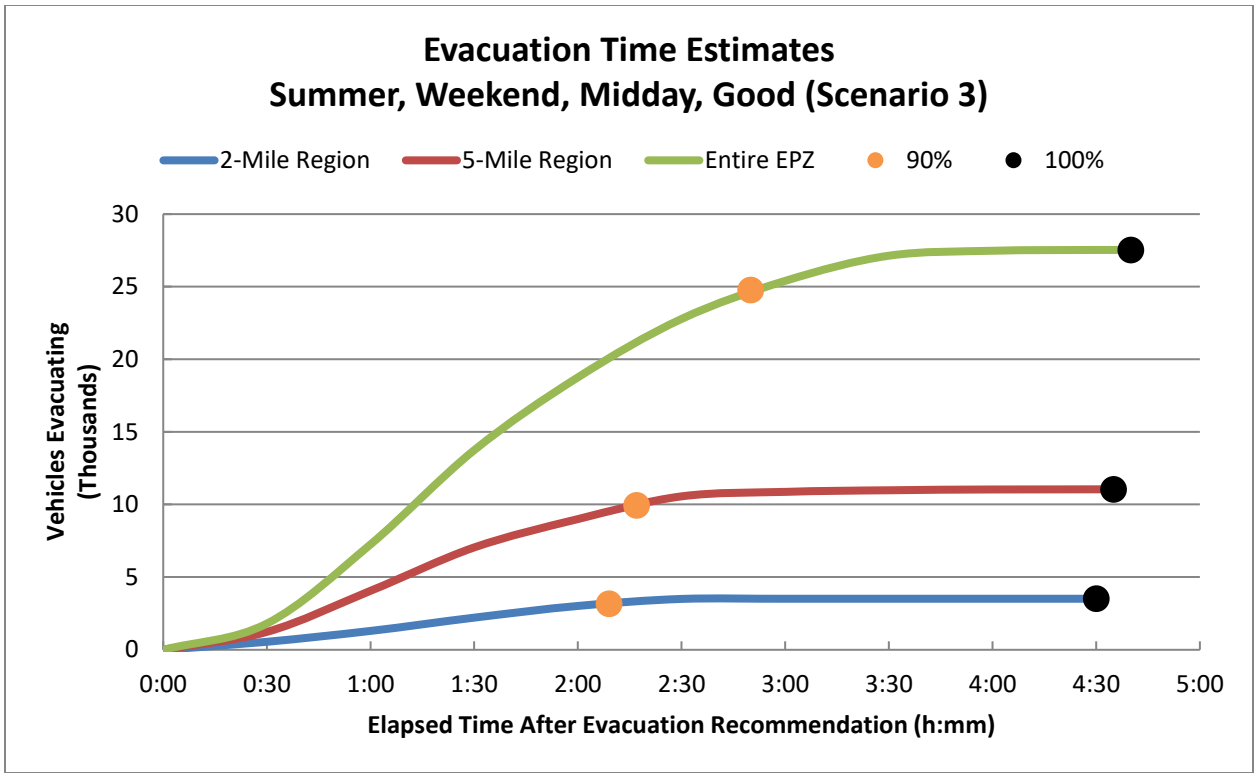


Figure 7-10. Evacuation Time Estimates - Scenario 3 for Region R03

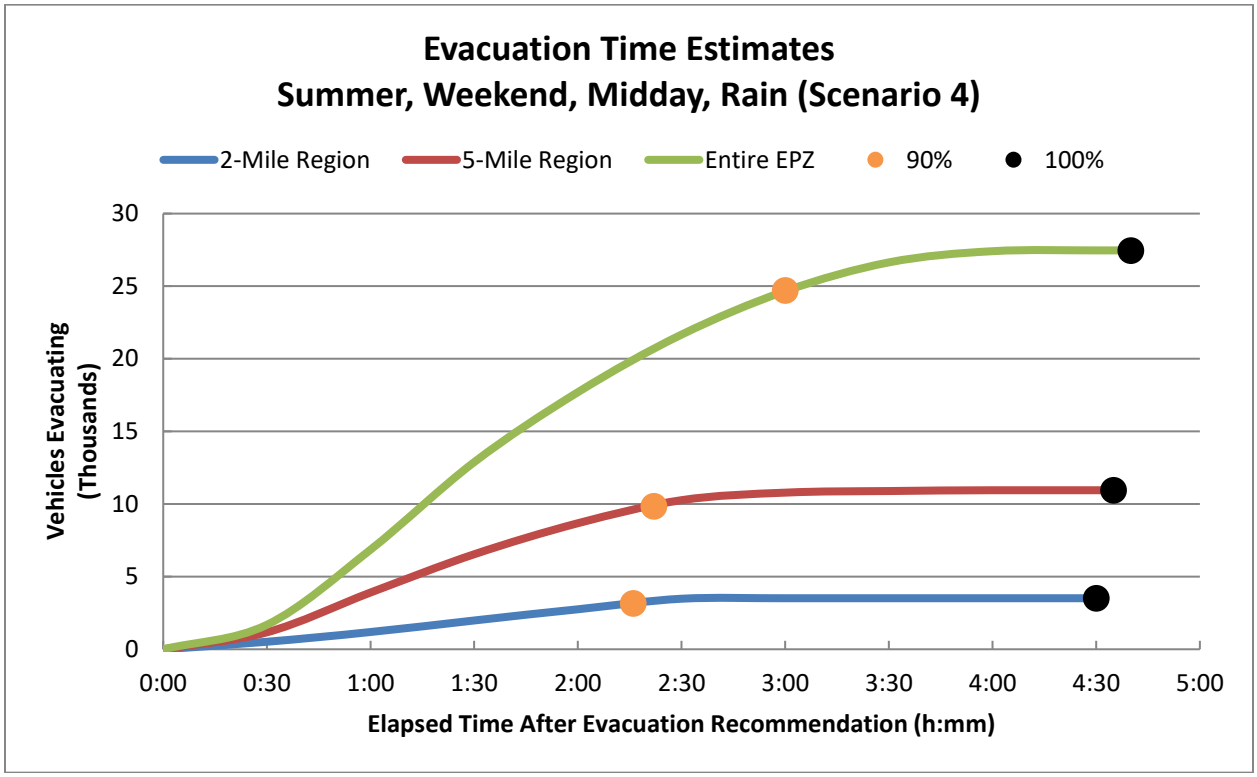


Figure 7-11. Evacuation Time Estimates - Scenario 4 for Region R03

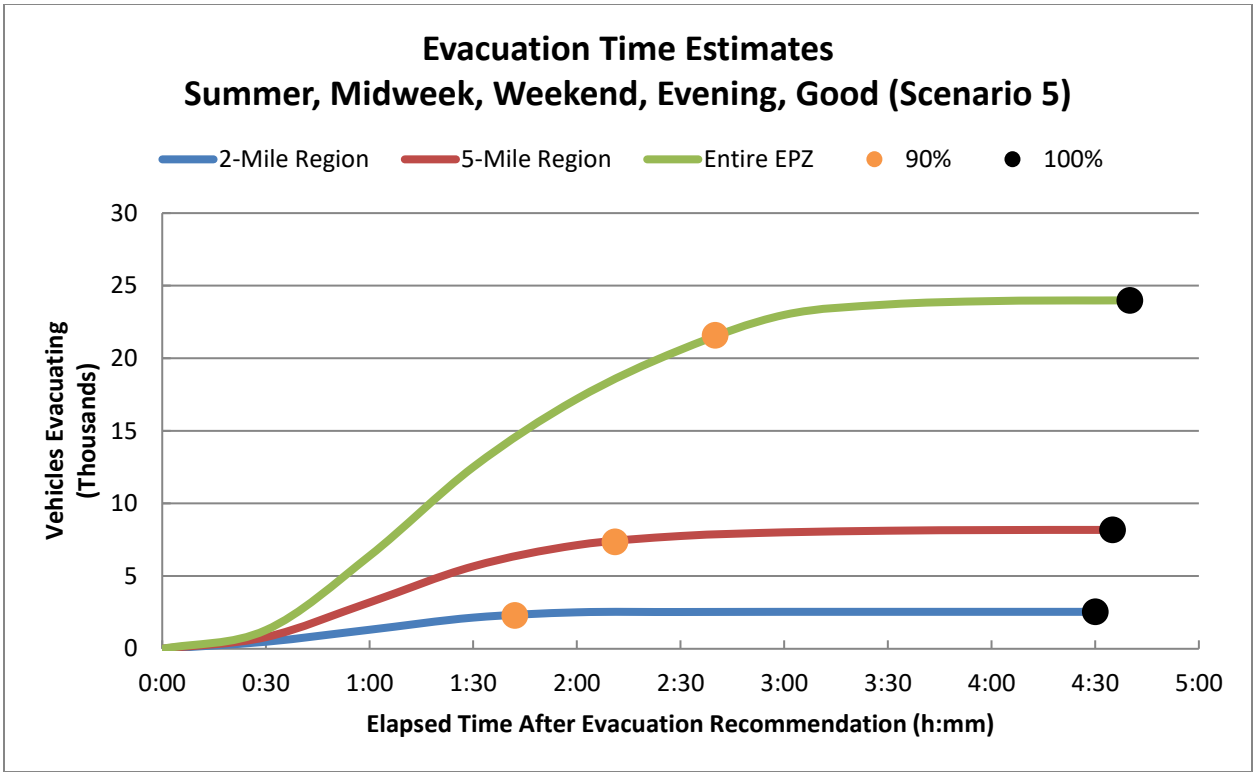


Figure 7-12. Evacuation Time Estimates - Scenario 5 for Region R03

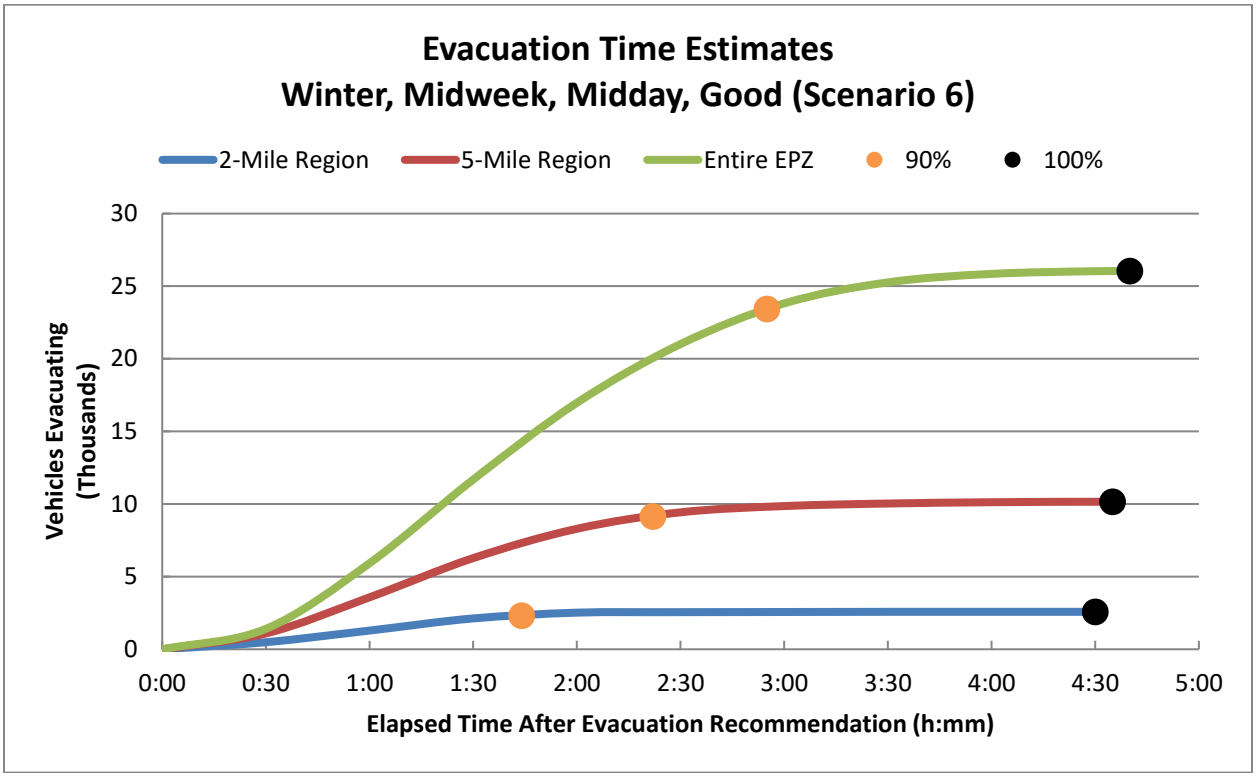


Figure 7-13. Evacuation Time Estimates - Scenario 6 for Region R03

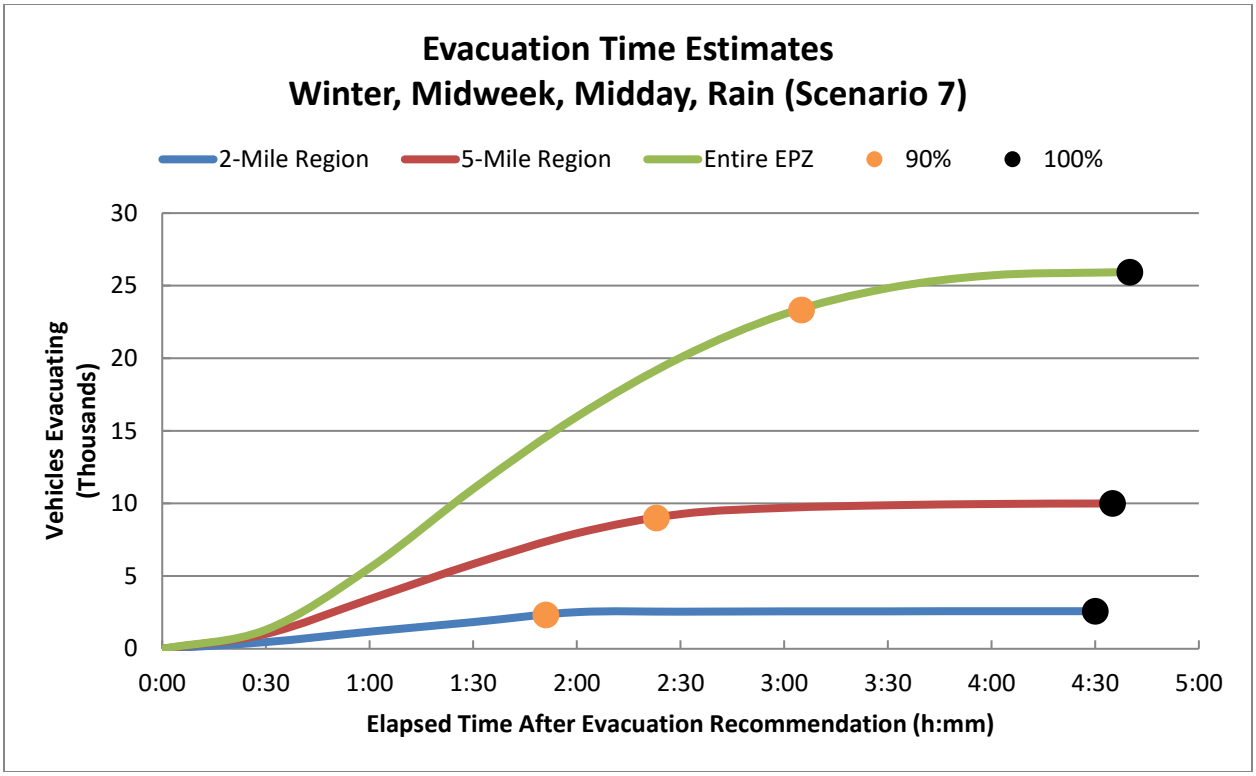


Figure 7-14. Evacuation Time Estimates - Scenario 7 for Region R03

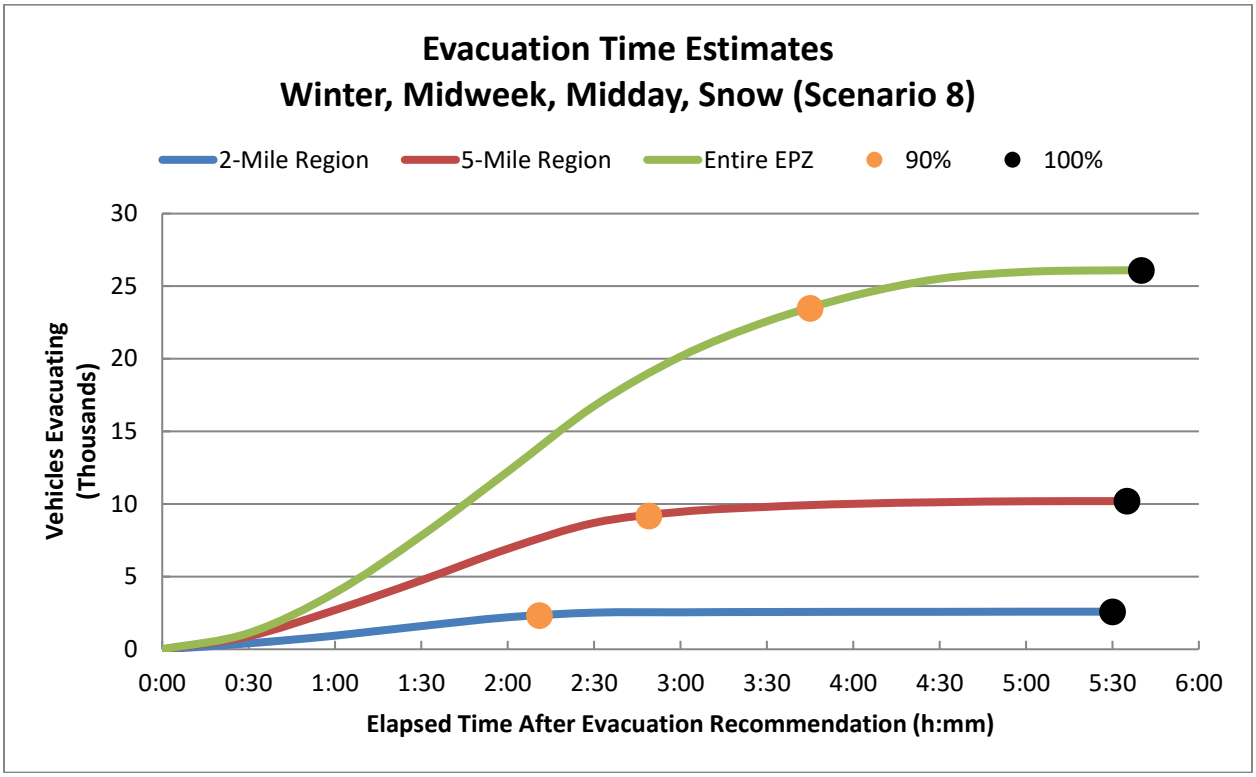


Figure 7-15. Evacuation Time Estimates - Scenario 8 for Region R03

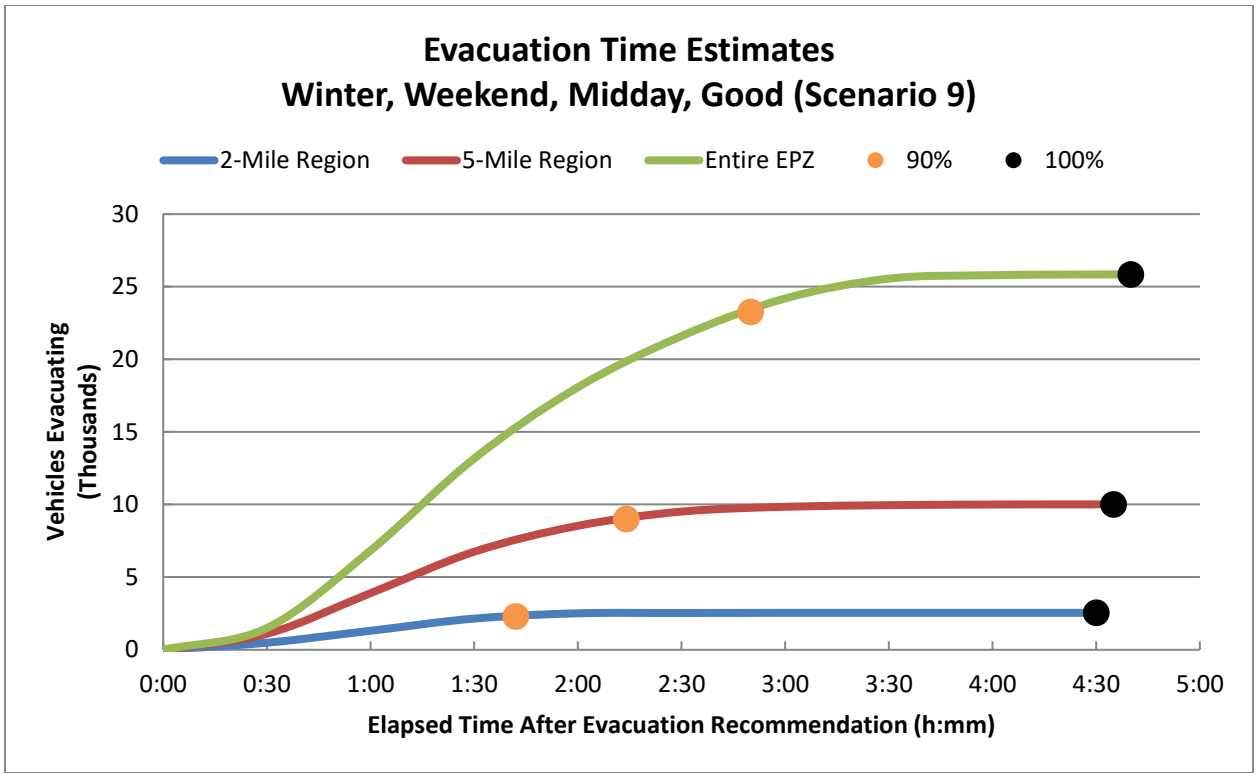


Figure 7-16. Evacuation Time Estimates - Scenario 9 for Region R03

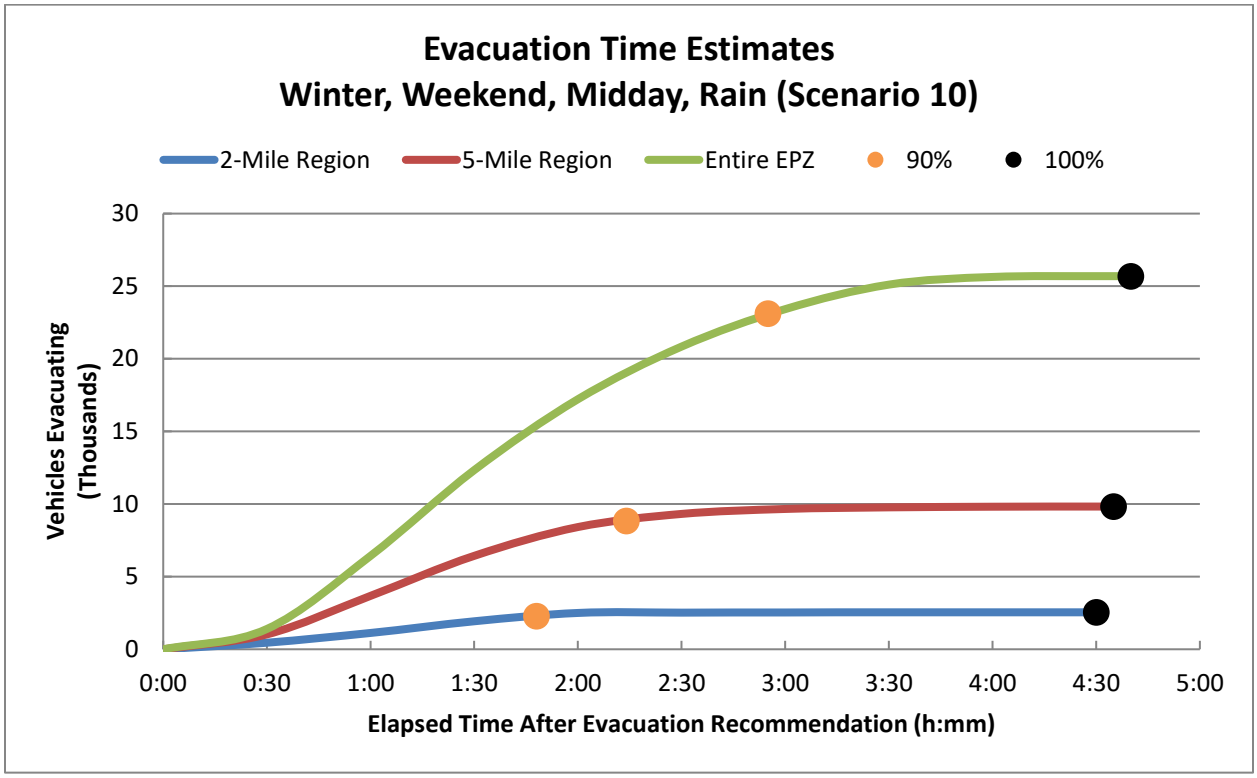


Figure 7-17. Evacuation Time Estimates - Scenario 10 for Region R03

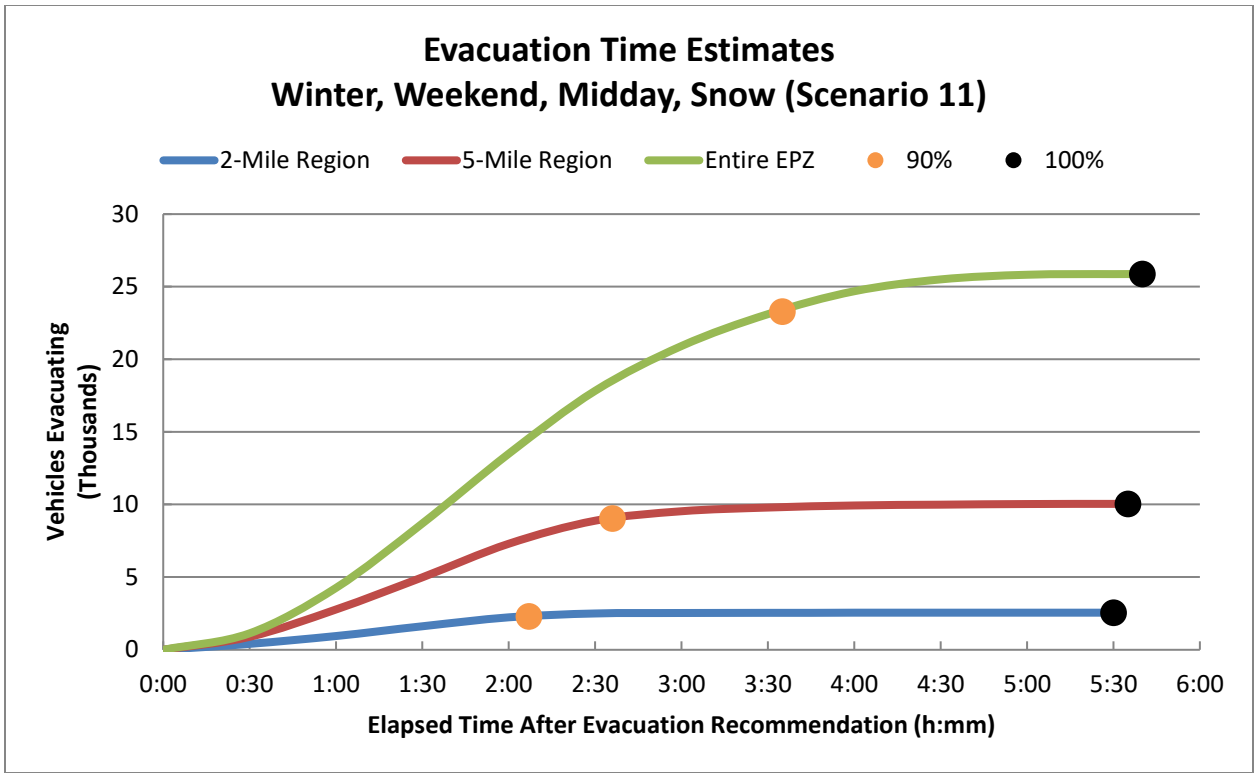


Figure 7-18. Evacuation Time Estimates - Scenario 11 for Region R03

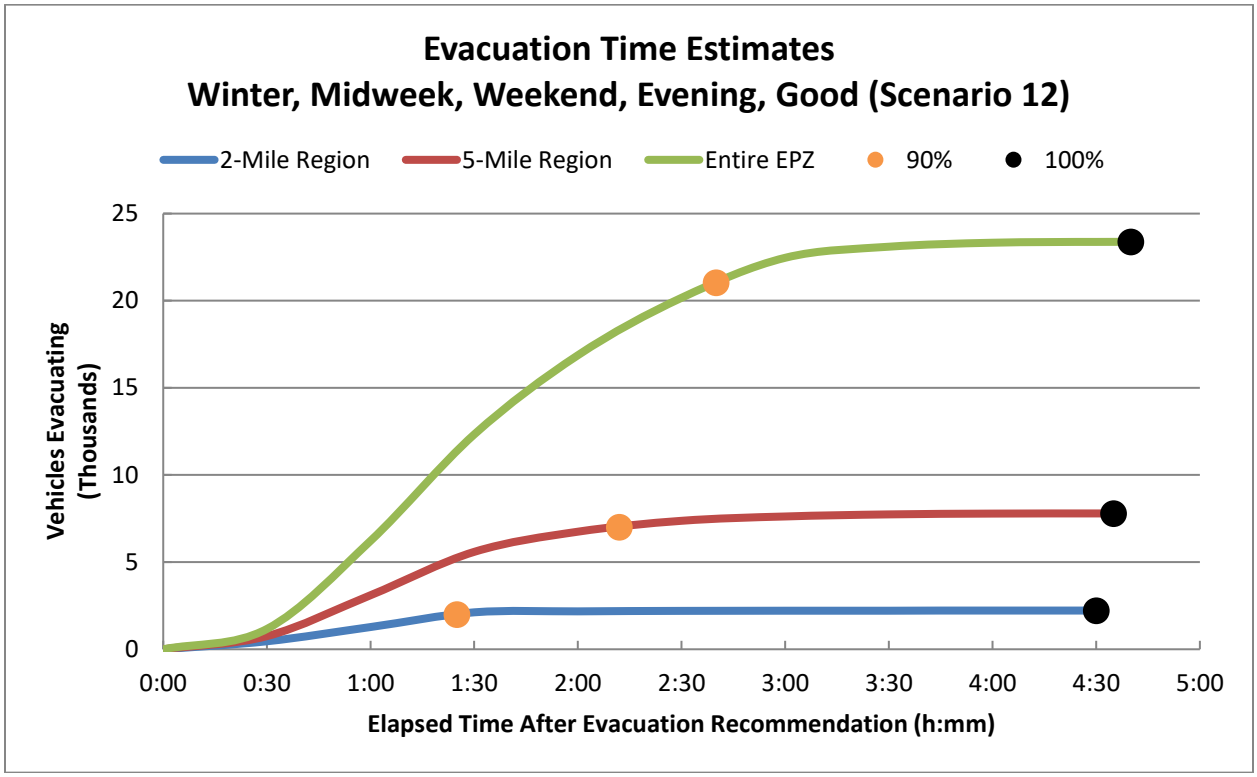


Figure 7-19. Evacuation Time Estimates - Scenario 12 for Region R03

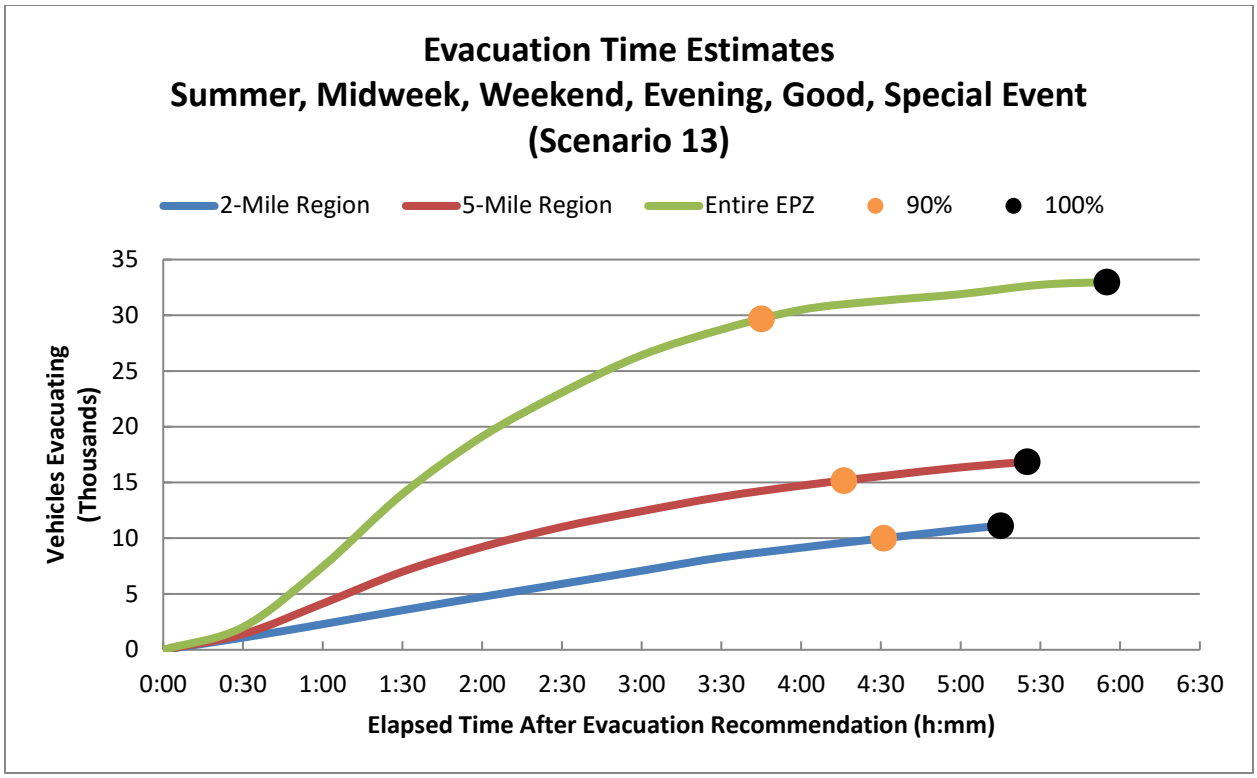


Figure 7-20. Evacuation Time Estimates - Scenario 13 for Region R03

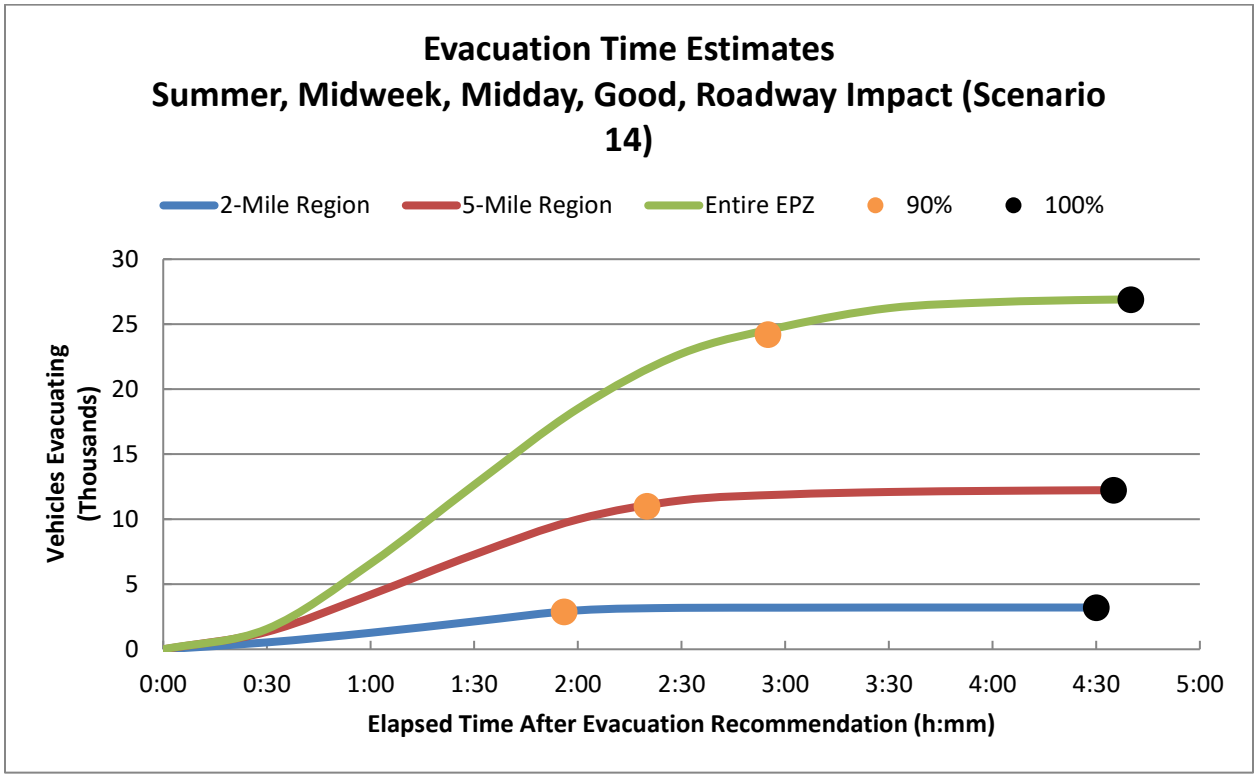


Figure 7-21. Evacuation Time Estimates - Scenario 14 for Region R03

8 TRANSIT-DEPENDENT AND SPECIAL FACILITY EVACUATION TIME ESTIMATES

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

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

These transit vehicles mix with the general evacuation traffic that is comprised mostly of "passenger cars" (pc's). The presence of buses 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. Mini vans and ambulances are treated as one 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. It is estimated that bus mobilization time will average approximately 90 minutes for school buses, medical facility transport vehicles, and buses for the Minnesota Correctional Facility at Red Wing extending from the Advisory to Evacuate (ATE), to the time when buses first arrive at the facility to be evacuated. Bus depots were not identified in this study. Rather, it assumed that the location of the depots and the distances to the EPZ is factored into the mobilization time. It is assumed transit dependent buses and access and/or functional needs transport vehicles are mobilized when about 85% of the residents with no commuters have completed their mobilization activities at 120 minutes after the ATE, as discussed in Section 2.

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 brochure accessible to residents of the PINGP EPZ indicates that schoolchildren will be evacuated to sister schools[1] if an evacuation were ordered, and that parents should pick up schoolchildren at the sister schools. This is not assumed for those

[1] In the most recent Nuclear Safety and Emergency Preparedness, reception centers/relocation centers for schools are called sister schools. Any reference to sister schools, will refer to the facilities used for receiving evacuees from schools.

children attending pre-schools and small day cares. Parents will pick up children at small day care facilities prior to evacuation.

As discussed in Section 2, this study assumes a rapidly escalating accident, wherein evacuation is ordered promptly, and no early protective actions have been implemented. This report provides estimates of buses under the assumption that no children will be picked up by their parents (in accordance with NUREG/CR-7002, Rev. 1) to present an upper bound estimate of buses required. Picking up children at school could add to traffic congestion at the schools, delaying the departure of the buses evacuating the children at these facilities, which may have to return in a subsequent "wave" to the EPZ to evacuate the transit-dependent population.

The procedure for computing transit-dependent ETE is to:

- Estimate demand for transit service (discussed in Section 3)
- Estimate time to perform all transit functions
- Estimate route travel times to the EPZ boundary and to the sister schools for schools, and reception centers for the medical facilities and general population

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

8.1 ETEs for Schools, Transit Dependent People, and Medical Facilities

The EPZ bus resources are assigned to evacuating schoolchildren (if schools are 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 or relocation center after completing their first evacuation trip, to complete a "second wave" of providing transportation service to evacuees. For this reason, the ETE for the transit-dependent population will be calculated for both a single wave transit evacuation and for a second wave. Of course, if the impacted Evacuation Region is other than R03 (the entire EPZ), then there will likely be ample transit resources relative to demand in the impacted Region and this discussion of a second wave would likely not apply.

The number of available transportation resources was provided by the offsite agencies. Table 8-1 summarizes the capacity of transportation resources. Also included in the table is the number of buses needed (transportation resources) to evacuate schools, medical facilities, transit-dependent population, the Minnesota Correctional Facility at Red Wing, and the access and/or functional needs population (discussed below in Section 8-3). These numbers indicate there are sufficient resources available to evacuate everyone in a single wave for schools, transit-dependent population, medical facilities, correctional facility, and access and/or functional needs population. It is assumed that there are enough drivers available to man all resources listed in Table 8-1.

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 of Schools

Activity: Mobilize Drivers (A→B→C)

The mobilization time is the elapsed time from the ATE until the time the buses arrive at the school to be evacuated. As discussed in item 4 of Section 2.4, it is assumed that for a rapidly escalating accident with no observable indication before the fact, bus drivers would require 90 minutes to be contacted, to travel to the depot, be briefed, and to travel to the schools that will be evacuated. Mobilization time is slightly longer in adverse weather – 100 minutes in rain/light snow, 110 minutes in heavy snow conditions.

Activity: Board Passengers (C→D)

A loading time of 15 minutes for good weather (20 minutes for rain/light snow and 25 minutes for heavy snow) for school buses is used.

Activity: Travel to EPZ Boundary (D→E)

The buses servicing the schools are ready to begin their evacuation trips at 105 minutes after the ATE – 90 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 sister school. This is done in UNITES by interactively selecting the series of nodes from the school/pre-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 10-2 (refer to the maps of the link-node analysis network in Appendix K for node locations). Data provided by DYNEV during the appropriate timeframe depending on the mobilization and loading times (i.e., 100 to 105 minutes after the ATE for good weather) were used to compute the average speed for each route, as follows:

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

The average speed computed (using this methodology) for the buses servicing each of the schools in the EPZ is shown in Table 8-2 through Table 8-4 for school evacuation. The travel time to the EPZ boundary was computed for each bus using the computed average speed and

the distance to the EPZ boundary along the most likely route out of the EPZ. The travel time from the EPZ boundary to the Sister School was computed assuming an average speed of 55 mph, 50 mph, and 47 mph for good weather, rain/light snow and heavy snow, respectively. Speeds were reduced in Table 8-2 through Table 8-4 for those calculated bus speeds which exceed 55 mph, as the school bus speed limit for state routes in Minnesota and Wisconsin is 55 mph.

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

(1) The elapsed time from the ATE until the bus exits the EPZ; and
(2) The elapsed time until the bus reaches the Relocation Center (R.C.).

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 minutes + 15 + 50 = 2:35 for Burnside Elementary School, in good weather, rounded up to the nearest 5 minutes).

The average ETE (2 hours and 40 minutes) for a single-wave evacuation of schools is 15 minutes less than the 90th percentile ETE (2 hours and 55 minutes) for evacuation of the general population for an evacuation of the entire EPZ (Region R03) under winter, midweek, midday, good weather (Scenario 6) conditions and will not impact protective action decision making.

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

Activity: Travel to Reception Centers (E→F)

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

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

A detailed computation of the transit dependent population was done and is discussed in Section 3.8. The total number of transit dependent people per Sub-Area was determined using a weighted distribution based on population (see Table 3-11). The number of buses required to evacuate this population was determined by the capacity of 30 people per bus and assuming at least one route per Sub-Area. KLD designed 5 bus routes to service the major evacuation routes in each Sub-Area, for the purposes of this study. The bus routes (as discussed in Section 10) are shown graphically in Figure 10-2 and described in Table 10-1. Those buses servicing the transit-dependent evacuees will first travel along these routes, then proceed out of the EPZ. It is assumed that residents will walk to and congregate along the nearest major evacuation route to flag down a passing bus and that they can arrive at the roadway within the 120-minute bus mobilization time (good weather).

The ETEs for the transit trips were developed using both good weather and adverse weather conditions. Table 8-5 (good weather), Table 8-6 (rain/light snow) and Table 8-7 (heavy snow) show the ETE breakdown for each step (discussed below) in the transit-dependent evacuation process.

Activity: Mobilize Drivers (A→B→C)

The mobilization time is the elapsed time from the ATE until the time the buses arrive at their designated route. The buses dispatched from the depots to service the transit-dependent evacuees will be scheduled so that they arrive at their respective routes after their passengers have completed their mobilization. As shown in Figure 5-4 (Residents with no Commuters), approximately 85% of the evacuees will complete their mobilization when the buses begin their routes, at approximately 120 minutes after the ATE for good weather. Mobilization time is slightly longer in adverse weather – 130 minutes in rain/light snow and 140 in heavy snow conditions.

Activity: Board Passengers (C→D)

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

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

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

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

Assigning reasonable estimates:

- B = 50 seconds: a generous value for a single passenger, carrying personal items, to board per stop
- v = 25 miles per hour (mph) = 37 feet/second (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/light snow or heavy snow resulting in a total loading time of 40 minutes per bus in rain/light snow and 50 minutes in heavy snow.

Activity: Travel to EPZ Boundary (D→E)

The travel distance along the respective pick-up routes within the EPZ is estimated using the UNITES software. Bus travel times within the EPZ are computed using average speeds

computed by DYNEV, using the aforementioned methodology that was used for school evacuation.

Table 8-5 through Table 8-7 present the transit-dependent population ETEs for each bus route calculated using the above procedures for good weather, rain/light snow and heavy snow, respectively.

For example, the ETE for bus route "Sub-Area 5N, 5E, 10E" servicing Sub-Area 5N, Sub-Area 5E, and Sub-Area 10E is computed as 120 + 15 + 30 = 2:45 for good weather. Here, 15 minutes is the time to travel 14.1 miles at 55.0 mph, the average speed output by the model for this route starting at 120 minutes.

The average single-wave ETE (2 hours and 55 minutes) for the transit dependent population is the same as the 90th percentile ETE for the general population (2 hours and 55 minutes) for a winter, midweek, midday, with good weather scenario (Scenario 6). Therefore, this will not impact protective action decision making.

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 10-3. For a single-wave evacuation, this travel time outside the EPZ does not contribute to the ETE. For a second-wave evacuation, the ETE for buses must be considered separately, since it could exceed the ETE for the general population. Assumed bus speeds of 55 mph, 50 mph, and 47 mph for good weather, rain/light snow, and heavy snow, respectively, will be applied for this activity for buses servicing the transit-dependent population.

Activity: Passengers Leave Bus (F→G)

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

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

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. Bus travel times within the EPZ are computed using average speeds computed by DYNEV, using the aforementioned methodology that was used for school evacuation.

The second wave ETE for bus route "Sub-Area 5N, 5E, 10E" is computed as follows for good weather:

- Bus arrives at reception center at 3:06 in good weather (2:45 to exit EPZ + 21-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-wave service along the route: 21 minutes (equal to travel time to reception center) + 15.4 minutes (14.1 miles @ 55 mph [assumed speed since bus is traveling against traffic] to return to the start of the route) + 15.4 minutes (14.1 miles @ 55 mph [route specific speed output from the model at this time]) = 52 minutes
- Bus completes pick-ups along route: 30 minutes.
- Bus exits EPZ at time 2:45 + 0:21 + 0:15 + 0:52 + 0:30 = 4:45 (rounded up to nearest 5 minutes) after the ATE.

The ETE for the completion of the second wave for all transit-dependent bus routes are provided in Table 8-5 through Table 8-7. The average ETE (5 hours) for a second-wave evacuation of transit-dependent population is 2 hours and 5 minutes longer on average than the ETE for the general population at the 90th percentile for an evacuation of the entire EPZ (Region R03) under winter, midweek, midday, with good weather conditions (Scenario 6) conditions and could impact protective action decision making.

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

Evacuation of Medical Facilities

The evacuation of medical facilities is similar to those for school evacuation except:

- Buses are assigned on the basis of 30 patients to allow for staff to accompany the patients.
- Wheelchair buses can accommodate 12 patients.
- Ambulances can accommodate 2 patients.

Table 3-6 indicates that 20 bus runs, 13 wheelchair bus runs, and 7 ambulance runs are needed to service all of the medical facilities in the EPZ. According to Table 8-1, the counties can collectively provide 131 buses, 21 wheelchair buses, and 20 ambulances. Thus, there are ample resources to evacuate the ambulatory, wheelchair-bound and bedridden patients from the medical facilities in a single wave.

Activity: Mobilize Drivers (A→B→C)

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

Activity: Board Passengers (C→D)

Item 5 of Section 2.4 discusses transit vehicle loading times for medical facilities. Loading times are assumed to be 1 minute per ambulatory passenger, 5 minutes per wheelchair bound passenger, and 15 minutes per bedridden passenger for buses, wheelchair accessible vans, and ambulances, respectively. Item 3 of Section 2.4 discusses transit vehicle capacities to cap loading times per vehicle type. Loading times were not adjusted for rain/light snow and heavy snow weather for medical facilities.

Activity: Travel to EPZ Boundary (D→E)

The travel distance along the respective evacuation 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 8-8 through Table 8-10 summarize the ETE for medical facilities within the EPZ for good weather, rain/light snow, and heavy snow. The distances shown were estimated using GIS software. Average speeds output by the model for Scenario 6 (Scenario 7 for rain/light snow and Scenario 8 for heavy snow) Region 3, capped at 55 mph (50 mph for rain/light snow and 47 mph for heavy snow), are used to compute travel time to 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 vans, and ambulances at capacity is assumed. All ETE are rounded up to the nearest 5 minutes.

For example, the calculation of ETE for Bay View Nursing & Rehabilitation Center with 50 ambulatory residents during good weather conditions is:

ETE: 90 + (30 x 1) + 20 = 140 minutes or 2:20 (rounded up to the nearest 5 minutes)It is assumed that the medical facility population is directly evacuated to health/medical facilities in Rochester, MN[2] outside of the EPZ. Relocation of this population to permanent facilities and/or passing through the reception center before arriving at the relocation center are not considered in this analysis.

The average single-wave ETE (2 hours and 10 minutes) for medical facilities in the EPZ does not exceed the 90th percentile ETE (2 hours and 55 minutes) for the general population for a winter, midweek, midday, with good weather scenario (Scenario 6). Therefore, ETE is not likely to impact protective action decision making.

8.2 ETEs for the Correctional Facilities

As detailed in Table E-9 and discussed in Section 3.6, there is one correctional facility within the EPZ – the Minnesota Correctional Facility - Red Wing. The total inmate population at this facility is 200 persons, which was obtained from the Minnesota Department of Corrections website. A

[2] The Goodhue County Radiological Emergency Response Plan states that the Rochester health/medical facilities have agreed to receive and care for the patients located in the Red Wing health/medical facilities should it become necessary to evacuate Red Wing.

total of 7 buses are needed to evacuate this facility, based on a capacity of 30 inmates per bus. According to the Goodhue County Radiological Emergency Response Plan, the Minnesota Correctional Facility in Red Wing will be evacuated to a local facility or another state correctional facility. It is assumed that inmates from Minnesota Correctional Facility will be evacuated to Dakota County Jail for purposes of computing ETE.

Mobilization time is assumed to be 90 minutes (100 minutes in rain/light snow and 110 minutes in heavy snow). It is estimated that it takes 1 minute to load each inmate onto a bus, and that 7 buses can be loaded in parallel. Thus, the total loading time is estimated at approximately 30 minutes. Using GIS software, the shortest route from the facility to the EPZ boundary, traveling away from the plant, is 23.5 miles. The travel time to traverse 23.5 miles is 49 minutes (average speed is 28.9 mph at 120 minutes (90 minutes mobilization time + 30 minutes loading time) after the advisory to evacuate) in good weather. All ETE are rounded up to the nearest 5 minutes. Table 8-11 summarizes the ETE for the Minnesota Correctional Facility - Red Wing.

Good weather ETE: 1:30 + 0:30 + 0:49 = 2:50

Rain/Light Snow ETE: 1:40 + 0:30 + 0:47 = 3:00

Heavy Snow ETE: 1:50 + 0:30 + 0:56 = 3:20

The average single wave ETE (2 hours and 50 minutes in good weather) for the Minnesota Correctional Facility at Red Wing is slightly shorter than the ETE for the generation population for Scenario 6 condition for an evacuation of the entire EPZ (Region R03) at the 90th percentile ETE (2 hours and 55 minutes), shown in Table 7-1. Thus, the time to evacuation the Minnesota Correctional Facility – Red Wing should not impact the protective action decision making.

8.3 ETEs for the Access and/or Functional Needs Population

The access and/or functional needs population registered within the EPZ was obtained from previous study and discussed in Section 3.9. Table 8-12 summarizes the ETE for access and/or functional needs people who would need transportation assistance in the event of an emergency. The table is categorized by type of vehicle required and then broken down by weather condition. The table takes into consideration the deployment of multiple vehicles (not filled to capacity) to reduce the number of stops per vehicle.

Due to the limitations on driving for access and/or functional needs persons, it assumed they will be picked up from their homes. Furthermore, it is conservatively assumed that ambulatory and wheelchair bound access and/or functional needs households are spaced 3 miles apart and bedridden households are spaced 5 miles apart. Mini van and bus speeds approximate 20 mph between households and ambulance speeds approximate 30 mph in good weather (10% slower in rain/light snow, 20% slower in heavy snow). Loading times of 1 minute per person are assumed for ambulatory people, 5 minutes per person for wheelchair bound people and 15 minutes per person are assumed for bedridden people. The mobilization time of 120 minutes was used (130 minutes and 140 minutes for rain/light snow and heavy snow, respectively) as that is when 75% of residents (with and without commuters) have mobilized. The last household (HH) is assumed to be 5 miles from the EPZ boundary, and the network-wide

average speed, capped at 55 mph (50 mph and 47 mph for rain and snow, respectively), is used to compute travel time after the last pick up.

The 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 access and/or functional needs person per HH implies that 13 ambulatory households need to be serviced. While only 1 bus are needed from a capacity perspective, if 5 buses are deployed to service these HH, then each would require at most 3 stops.

For example, the ETE for access and/or functional needs ambulatory people in good weather is computed as follows (similar calculations are performed for the wheelchair bound population:

1. Assume 5 buses are deployed, each with about 3 stops, to service a total of 13 HH.
2. ETE is equal to the total time to complete the following activities:
    a. Buses arrive at the first pickup location: 90 minutes
    b. Load HH members at first pickup: 1 minute
    c. Travel to subsequent pickup locations: 2 @ 9 minutes = 18 minutes
    d. Load HH members at subsequent pickup locations: 2 @ 1 minute = 2 minutes
    e. Travel to EPZ boundary: 18 minutes (5 miles @ 16.3mph).

    ETE: 120 + 1 + 18 + 2 + 18 = 2:40 rounded up to the nearest 5 minutes

Table 8-1 indicates that there are sufficient transportation resources available in the EPZ to evacuate the medical facilities and the access and/or functional needs population simultaneously.

The average ETE (3 hours) for a single wave evacuation of the access and/or functional needs population in good weather is approximately 5 minutes longer than the general population ETE (2 hours and 55 minutes) at the 90th percentile for an evacuation of the entire EPZ (Region R03) under winter, midweek, midday, good weather (Scenario 6) conditions and could (but not likely) impact protective action decision-making.

Table 8-1. Summary of Transportation Resources

Transportation Resource	Buses	Wheelchair Buses	Mini Vans	Ambulances
Resources Available				
Dakota County, MN	30	10	0	12
Goodhue County, MN	39	10	2	4
Pierce County, WI	62	1	8	4
TOTAL:	**131**	**21**	**10**	**20**
Resources Needed				
Medical Facilities (Table 3-6):	20	13	0	7
Schools (Table 3-7):	41	0	0	0
Access and/or Functional Needs (Table 3-9):	5	1	0	1
Transit-Dependent Population (Section 3.8):	11	0	0	0
Correctional Facility (Section 3.6):	7	0	0	0
TOTAL TRANSPORTATION NEEDS:	**84**	**14**	**0**	**8**

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

Facility Name	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 S.S. (mi.)	Travel Time from EPZ Bdry to S.S. (min)	ETA to S.S. (hr:min)
SCHOOLS									
GOODHUE COUNTY, MN									
Tower View Alternative High School	90	15	15.3	55.0	17	**2:05**	7.9	9	**2:15**
Burnside Elementary School	90	15	16.7	19.9	50	**2:35**	3.1	3	**2:40**
Jefferson Elementary School	90	15	22.7	23.6	58	**2:45**	3.1	3	**2:50**
St. John's Lutheran School	90	15	21.7	23.7	55	**2:40**	3.1	3	**2:45**
Colvill Family Center	90	15	21.7	23.7	55	**2:40**	3.1	3	**2:45**
Sunnyside Elementary School	90	15	22.7	23.6	58	**2:45**	3.1	3	**2:50**
Twin Bluff Middle School	90	15	24.6	25.0	59	**2:45**	5.0	5	**2:50**
Red Wing High School	90	15	24.6	25.0	59	**2:45**	5.0	5	**2:50**
					Maximum for EPZ:	**2:45**		**Maximum:**	**2:50**
					Average for EPZ:	**2:40**		**Average:**	**2:45**

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

Facility Name	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 S.S. (mi.)	Travel Time from EPZ Bdry to S.S. (min)	ETA to S.S. (hr:min)
SCHOOLS									
GOODHUE COUNTY, MN									
Tower View Alternative High School	100	20	15.3	50.0	18	**2:20**	7.9	9	**2:30**
Burnside Elementary School	100	20	16.7	22.3	45	**2:45**	3.1	4	**2:50**
Jefferson Elementary School	100	20	22.7	26.7	51	**2:55**	3.1	4	**3:00**
St. John's Lutheran School	100	20	21.7	26.7	49	**2:50**	3.1	4	**2:55**
Colvill Family Center	100	20	21.7	26.7	49	**2:50**	3.1	4	**2:55**
Sunnyside Elementary School	100	20	22.7	26.7	51	**2:55**	3.1	4	**3:00**
Twin Bluff Middle School	100	20	24.6	28.3	52	**2:55**	5.0	6	**3:05**
Red Wing High School	100	20	24.6	28.3	52	**2:55**	5.0	6	**3:05**
					Maximum for EPZ:	**2:55**		**Maximum:**	**3:05**
					Average for EPZ:	**2:50**		**Average:**	**2:55**

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

Facility Name	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 S.S. (mi.)	Travel Time from EPZ Bdry to S.S. (min)	ETA to S.S. (hr:min)
SCHOOLS									
GOODHUE COUNTY, MN									
Tower View Alternative High School	110	25	15.3	46.8	20	**2:35**	7.9	10	**2:45**
Burnside Elementary School	110	25	16.7	19.2	52	**3:10**	3.1	4	**3:15**
Jefferson Elementary School	110	25	22.7	23.9	57	**3:15**	3.1	4	**3:20**
St. John's Lutheran School	110	25	21.7	22.7	57	**3:15**	3.1	4	**3:20**
Colvill Family Center	110	25	21.7	22.7	57	**3:15**	3.1	4	**3:20**
Sunnyside Elementary School	110	25	22.7	23.9	57	**3:15**	3.1	4	**3:20**
Twin Bluff Middle School	110	25	24.6	24.0	61	**3:20**	5.0	6	**3:30**
Red Wing High School	110	25	24.6	24.0	61	**3:20**	5.0	6	**3:30**
					Maximum for EPZ:	**3:20**		**Maximum:**	**3:30**
					Average for EPZ:	**3:10**		**Average:**	**3:20**

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

Bus Route Servicing	Number of Buses	Single-Wave							Second-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)
Sub-Area 10SE	4	120	4.8	8.3	35	30	**3:05**	28.0	31	5	10	42	30	**5:05**
Sub-Areas 5S, 10SW	2	120	11.7	55.0	13	30	**2:45**	48.5	53	5	10	79	30	**5:45**
Sub-Areas 2, 5W, 10W	2	120	11.1	15.4	43	30	**3:15**	13.0	14	5	10	38	30	**4:55**
Sub-Areas 5N, 5E, 10E	1	120	14.1	55.0	15	30	**2:45**	19.6	21	5	10	52	30	**4:45**
Sub-Areas 10NW, 10N, 10NE	2	120	5.7	55.0	6	30	**2:40**	20.4	22	5	10	34	30	**4:25**
						Maximum ETE:	**3:15**						**Maximum ETE:**	**5:45**
						Average ETE:	**2:55**						**Average ETE:**	**5:00**

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

Bus Route Servicing	Number of Buses	Single-Wave							Second-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)
Sub-Area 10SE	4	130	4.8	14.0	21	40	**3:15**	28.0	34	5	10	46	40	**5:30**
Sub-Areas 5S, 10SW	2	130	11.7	49.8	14	40	**3:05**	48.5	58	5	10	86	40	**6:25**
Sub-Areas 2, 5W, 10W	2	130	11.1	18.2	37	40	**3:30**	13.0	16	5	10	43	40	**5:25**
Sub-Areas 5N, 5E, 10E	1	130	14.1	50.0	17	40	**3:10**	19.6	24	5	10	58	40	**5:30**
Sub-Areas 10NW, 10N, 10NE	2	130	5.7	50.0	7	40	**3:00**	20.4	24	5	10	38	40	**5:00**
						Maximum ETE:	**3:30**						**Maximum ETE:**	**6:25**
						Average ETE:	**3:15**						**Average ETE:**	**5:35**

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

Bus Route Servicing	Number of Buses	Single-Wave							Second-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)
Sub-Area 10SE	4	140	4.8	10.8	27	50	**3:40**	28.0	36	5	10	49	50	**6:10**
Sub-Areas 5S, 10SW	2	140	11.7	46.2	15	50	**3:25**	48.5	62	5	10	93	50	**7:05**
Sub-Areas 2, 5W, 10W	2	140	11.1	13.8	48	50	**4:00**	13.0	17	5	10	45	50	**6:10**
Sub-Areas 5N, 5E, 10E	1	140	14.1	46.6	18	50	**3:30**	19.6	25	5	10	61	50	**6:05**
Sub-Areas 10NW, 10N, 10NE	2	140	5.7	46.8	7	50	**3:20**	20.4	26	5	10	41	50	**5:35**
						Maximum ETE:	**4:00**						**Maximum ETE:**	**7:05**
						Average ETE:	**3:35**						**Average ETE:**	**6:15**

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

Medical Facility	Patient	Mobilization (min)	Loading Rate (min per person)	People	Total Loading Time (min)	Dist. To EPZ Bdry (mi)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
Deer Crest	Ambulatory	90	1	77	30	8.1	9	**2:10**
	Wheelchair bound	90	5	4	20	8.1	9	**2:00**
Mayo Clinic Health System-Red Wing	Ambulatory	90	1	7	7	8.1	9	**1:50**
	Wheelchair bound	90	5	4	20	8.1	9	**2:00**
	Bedridden	90	15	7	30	8.1	9	**2:10**
Bay View Nursing & Rehabilitation Center	Ambulatory	90	1	50	30	8.5	20	**2:20**
	Wheelchair bound	90	5	26	60	8.5	11	**2:45**
	Bedridden	90	15	2	30	8.5	20	**2:20**
Loving Residence	Ambulatory	90	1	5	5	6.8	20	**1:55**
	Wheelchair bound	90	5	2	10	6.8	19	**2:00**
Potter Ridge Assisted Living	Ambulatory	90	1	43	30	6.8	16	**2:20**
	Wheelchair bound	90	5	2	10	6.8	19	**2:00**
	Bedridden	90	15	3	30	6.8	16	**2:20**
The Downtown Plaza	Ambulatory	90	1	76	30	7.6	16	**2:20**
	Wheelchair bound	90	5	2	10	7.6	15	**1:55**
Jordan Towers I & II	Ambulatory	90	1	159	30	7.6	16	**2:20**
St. Crispin Living Community	Ambulatory	90	1	16	16	4.7	10	**2:00**
	Wheelchair bound	90	5	45	60	4.7	10	**2:40**
Valentines Assisted Living	Ambulatory	90	1	12	12	4.8	8	**1:50**
	Wheelchair bound	90	5	1	5	4.8	7	**1:45**
							Maximum ETE:	**2:45**
							Average ETE:	**2:10**

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

Medical Facility	Patient	Mobilization (min)	Loading Rate (min per person)	People	Total Loading Time (min)	Dist. To EPZ Bdry (mi)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
Deer Crest	Ambulatory	100	1	77	30	8.1	10	**2:20**
	Wheelchair bound	100	5	4	20	8.1	11	**2:15**
Mayo Clinic Health System-Red Wing	Ambulatory	100	1	7	7	8.1	11	**2:00**
	Wheelchair bound	100	5	4	20	8.1	11	**2:15**
	Bedridden	100	15	7	30	8.1	10	**2:20**
Bay View Nursing & Rehabilitation Center	Ambulatory	100	1	50	30	8.5	19	**2:30**
	Wheelchair bound	100	5	26	60	8.5	14	**2:55**
	Bedridden	100	15	2	30	8.5	19	**2:30**
Loving Residence	Ambulatory	100	1	5	5	6.8	22	**2:10**
	Wheelchair bound	100	5	2	10	6.8	20	**2:10**
Potter Ridge Assisted Living	Ambulatory	100	1	43	30	6.8	15	**2:25**
	Wheelchair bound	100	5	2	10	6.8	20	**2:10**
	Bedridden	100	15	3	30	6.8	15	**2:25**
The Downtown Plaza	Ambulatory	100	1	76	30	7.6	15	**2:25**
	Wheelchair bound	100	5	2	10	7.6	20	**2:10**
Jordan Towers I & II	Ambulatory	100	1	159	30	7.6	15	**2:25**
St. Crispin Living Community	Ambulatory	100	1	16	16	4.7	9	**2:05**
	Wheelchair bound	100	5	45	60	4.7	8	**2:50**
Valentines Assisted Living	Ambulatory	100	1	12	12	4.8	7	**2:00**
	Wheelchair bound	100	5	1	5	4.8	7	**1:55**
							Maximum ETE:	**2:55**
							Average ETE:	**2:20**

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

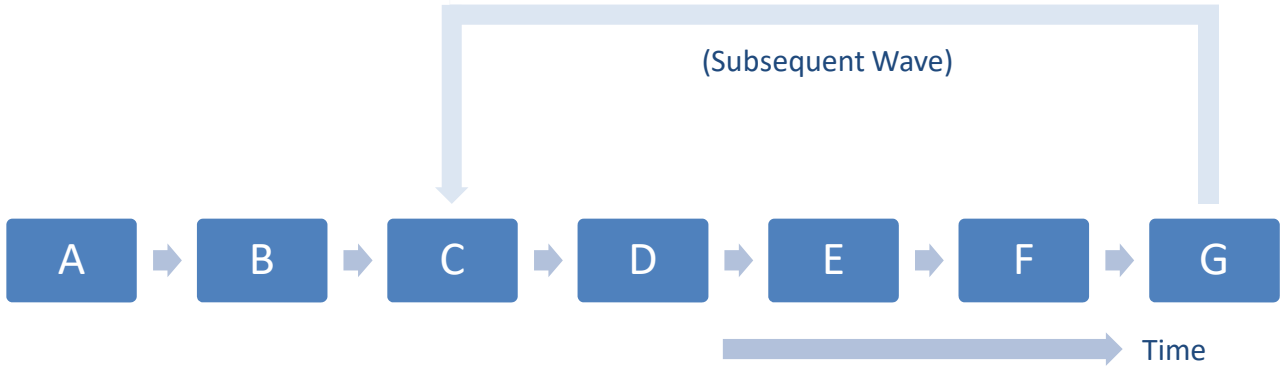
Medical Facility	Patient	Mobilization (min)	Loading Rate (min per person)	People	Total Loading Time (min)	Dist. To EPZ Bdry (mi)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
Deer Crest	Ambulatory	110	1	77	30	8.1	13	**2:35**
	Wheelchair bound	110	5	4	20	8.1	13	**2:25**
Mayo Clinic Health System-Red Wing	Ambulatory	110	1	7	7	8.1	14	**2:15**
	Wheelchair bound	110	5	4	20	8.1	13	**2:25**
	Bedridden	110	15	7	30	8.1	13	**2:35**
Bay View Nursing & Rehabilitation Center	Ambulatory	110	1	50	30	8.5	24	**2:45**
	Wheelchair bound	110	5	26	60	8.5	15	**3:05**
	Bedridden	110	15	2	30	8.5	24	**2:45**
Loving Residence	Ambulatory	110	1	5	5	6.8	22	**2:20**
	Wheelchair bound	110	5	2	10	6.8	21	**2:25**
Potter Ridge Assisted Living	Ambulatory	110	1	43	30	6.8	20	**2:40**
	Wheelchair bound	110	5	2	10	6.8	21	**2:25**
	Bedridden	110	15	3	30	6.8	20	**2:40**
The Downtown Plaza	Ambulatory	110	1	76	30	7.6	18	**2:40**
	Wheelchair bound	110	5	2	10	7.6	20	**2:20**
Jordan Towers I & II	Ambulatory	110	1	159	30	7.6	18	**2:40**
St. Crispin Living Community	Ambulatory	110	1	16	16	4.7	11	**2:20**
	Wheelchair bound	110	5	45	60	4.7	11	**3:05**
Valentines Assisted Living	Ambulatory	110	1	12	12	4.8	8	**2:10**
	Wheelchair bound	110	5	1	5	4.8	8	**2:05**
							Maximum ETE:	**3:05**
							Average ETE:	**2:35**

Table 8-11. Minnesota Correctional Facility - Red Wing Evacuation Time Estimate

Correctional Facility	Weather Conditions	Mobilization (min)	Number of Buses	Loading Rate (min per person)	Number of Inmates	Total Loading Time (min)	Dist. To EPZ Bdry (mi)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
Minnesota Correctional Facility - Red Wing	Good	90	7	1	200	30	23.5	49	**2:50**
	Rain/Light Snow	100						47	**3:00**
	Heavy Snow	110						56	**3:20**
								Maximum ETE:	**3:20**
								Average ETE:	**3:05**

Table 8-12. Access and/or Functional Needs Population Evacuation Time Estimates

Vehicle Type	People Requiring Vehicle	Vehicles deployed	Stops	Weather Conditions	Mobiliza-tion 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	13	5	3	Good	120	1	18	2	18	**2:40**
				Rain	130		20		23	**3:00**
				Snow	140		22		18	**3:05**
Wheelchair bound	7	1	7	Good	120	5	54	30	13	**3:45**
				Rain	130		60		20	**4:05**
				Snow	140		66		21	**4:25**
Ambulances	1	1	1	Good	120	15	0	0	17	**2:35**
				Rain	130		0		21	**2:50**
				Snow	140		0		17	**2:55**
									Maximum ETE:	**4:25**
									Average ETE:	**3:20**



Event	
A	Advisory to Evacuate
B	Bus Dispatched from Depot
C	Bus Arrives at Facility/Pick-up Route
D	Bus Departs for Reception Center/Sister School
E	Bus Exits Area Being Evacuated
F	Bus Arrives at Reception Center/Sister School
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/Sister School Outside the EPZ
F→G	Passengers Leave Bus; Driver Takes a Break

Figure 8-1. Chronology of Transit Evacuation Operations

9 TRAFFIC MANAGEMENT STRATEGY

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

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

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

The TMP is the outcome of the following process:

1. The detailed traffic and access control tactics discussed in the PINGP TACP map from Minnesota Department of Public Safety and Division of Homeland Security and Emergency Management, Goodhue County Emergency Response Plan for PINGP, and Pierce County Annex I serve as the basis of the traffic management plan, as per NUREG/CR-7002, Rev.1.

2. The ETE analysis treated all controlled intersections that are existing TACP locations in the PINGP TACP map and the Goodhue County and Pierce Emergency Response Plan as being controlled by actuated signals. In Appendix K, Table K-1 identifies the number of intersections that were modeled as TACPs. Appendix G shows a map of all existing TACP locations.
3. Evacuation simulations were run using DYNEV II to predict traffic congestion during evacuation (see Section 7.3 and Figures 7-3 through 7-7). These simulations help to identify the best routing and critical intersections that experience pronounced congestion during evacuation. Any critical intersections that would benefit from traffic or access control which are not already identified in the existing offsite agency plans are examined. No additional TACPs were identified which would benefit the Evacuation Time Estimate (ETE), as part of this study.
4. Prioritization of TACPs
    a. Application of traffic and access control at some TACPs will have a more pronounced influence on expediting traffic movements than at other TACPs. For example, TACPs controlling traffic originating from areas in close proximity to the power plant could have a more beneficial effect on minimizing potential exposure to radioactivity than those TACPs located farther from the power plant. Key locations for manual traffic control (MTC) were analyzed and their impact to ETE was quantified, as per NUREG/CR-7002, Rev. 1. See Appendix G for more detail.

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

9.1 Assumptions

The following are TMP assumptions made for this study:

- The ETE calculations documented in Sections 7 and 8 assume that the TMP is implemented during evacuation.
- The ETE calculations reflect the assumptions that all “external-external” trips are interdicted and diverted after 120 minutes have elapsed from the Advisory to Evacuate (ATE), by TACPs along the major highways traversing the EPZ.
- All transit vehicles and other responders entering the EPZ to support the evacuation are assumed to be unhindered by personnel manning TACPs.
- Study assumptions 1 through 3 in Section 2.5 discuss TACPs operations.

9.2 Additional Considerations

The use of Intelligent Transportation Systems (ITS) technologies can reduce the manpower and equipment needs, while still facilitating the evacuation process. Dynamic Message Signs (DMS) can also be placed within the EPZ to provide information to travelers regarding traffic conditions, route selection, and reception center information. DMS placed outside of the EPZ

will warn motorists to avoid using routes that may conflict with the flow of evacuees away from the power plant. Highway Advisory Radio (HAR) can be used to broadcast information to evacuees during egress through their vehicle's stereo systems. Automated 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 the on-board navigation systems (GPS units) and smartphones can be used to provide information during the evacuation trip.

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

10 EVACUATION ROUTES AND RECEPTION CENTER

Evacuation routes are comprised of two distinct components:

- Routing from a Sub-Area being evacuated to the boundary of the Evacuation Region and thence out of the EPZ.
- Routing of transit-dependent evacuees (schools, medical facilities, correctional facilities, or permanent residents who do no own or have access to private vehicles) from the EPZ boundary to reception centers located within reception communities.

Evacuees will select routes within the EPZ in such a way as to minimize their exposure to risk. This expectation is met by the DYNEV II model routing traffic away from the location of the plant, to the extent practicable. The DTRAD model satisfies this behavior by routing traffic so as to balance traffic demand relative to the available highway capacity to the extent possible. See Appendices B through D for further discussion.

The major evacuation routes for the EPZ are presented in Figure 10-1. These routes will be used by the general population evacuating in private vehicles, and by the transit-dependent population evacuating in buses. Transit-dependent evacuees will be routed towards a reception center. General population may evacuate to either a reception center or some alternate destination (i.e., lodging facilities, relative's home, campgrounds) outside the EPZ.

The routing of transit-dependent evacuees from the EPZ boundary to reception centers is designed to minimize the amount of travel outside the EPZ, from the points where these routes cross the EPZ boundary. The five (5) bus routes shown graphically in Figure 10-2 and described in Table 10-1, were designed by KLD to service major routes through each Sub-Area. It is assumed that residents will walk to and congregate along these routes to flag down a passing bus, and that they can arrive at the route within the 120-minute bus mobilization time (good weather).

Schools were routed along the most likely path from the facility to the EPZ boundary, traveling toward the designated sister schools. Medical facilities and correctional facility were routed along the most likely path from the facility being evacuated to the EPZ boundary, traveling toward the nearest health/medical service facility in Rochester and a local correctional facility, respectively, for ETE computations. The PINGP Nuclear Safety and Emergency Preparedness and the Goodhue County Radiological Emergency Response Plan list all the schools with their designated sister schools, and receiving health/medical service facility in Rochester and a local correctional facility.

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

10.1 Reception Centers and Sister Schools

According to the current public information for EPZ residents, evacuees will be directed to reception centers based on the Sub-Area being evacuated. Figure 10-3 displays the location of the reception centers. Transit-dependent evacuees and medical facility patients are transported to the nearest reception center for each Sub-Area for ETE computations.

Table 10-3 presents a list of the sister school for each school in the EPZ. Schoolchildren will be transported to these sister schools where they will be subsequently retrieved by parents or guardians.

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

Route	No. of Buses	Route Description	Length (mi.)
13	4	Services Sub-Area 10SE	4.8
14	2	Services Sub-Area 5S, 10SW	11.7
15	2	Services Sub-Area 2, 5W, 10W	11.1
16	1	Services Sub-Area 5N, 5E, 10E	14.1
17	2	Services Sub-Area 10NW, 10N, 10NE	5.7
Total:	**11**		

Table 10-2. Bus Route Descriptions

Bus Route Number	Description	Nodes Traversed from Route Start to EPZ Boundary
1	Burnside Elementary School	20, 19, 52, 18, 17, 16, 701, 51, 15, 14, 13, 819, 12, 11, 10, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293
2	Colvill Family Center St. John's Lutheran School	31, 736, 53, 852, 850, 30, 29, 28, 27, 26, 747, 25, 24, 23, 22, 21, 20, 19, 52, 18, 17, 16, 701, 51, 15, 14, 13, 819, 12, 11, 10, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293
3	Sunnyside Elementary School Jefferson Elementary School	850, 30, 29, 28, 27, 26, 747, 25, 24, 23, 22, 21, 20, 19, 52, 18, 17, 16, 701, 51, 15, 14, 13, 819, 12, 11, 10, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293
4	The Downtown Plaza Jordan Towers I & II	855, 859, 746, 244, 745, 243, 863, 242, 866, 241, 240, 239, 238, 237, 236, 235, 234, 233, 232, 231, 230, 229, 228, 227, 226, 225, 224
5	Red Wing High School Twin Bluff Middle School	736, 53, 852, 850, 30, 29, 28, 27, 26, 747, 25, 24, 23, 22, 21, 20, 19, 52, 18, 17, 16, 701, 51, 15, 14, 13, 819, 12, 11, 10, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293
6	Tower View Alternative High School	19, 52, 18, 17, 16, 701, 51, 15, 14, 13, 819, 12, 11, 10, 284, 285, 286, 287, 288, 289, 290, 291, 350, 754, 351
7	Deer Crest	823, 824, 825, 744, 743, 104, 826, 105, 845, 106, 107, 108, 109, 110, 111, 112, 114, 115, 116, 117, 118, 343
8	Mayo Clinic Health System-Red Wing Potter Ridge Assisted Living	834, 846, 845, 106, 107, 108, 109, 110, 111, 112, 114, 115, 116, 117, 118, 343
9	Loving Residence Valentines Assisted Living	246, 236, 235, 234, 233, 232, 231, 230, 229, 228, 227, 226, 225, 224
10	Bay View Nursing & Rehabilitation Center	844, 838, 837, 836, 835, 834, 846, 845, 106, 107, 108, 109, 110, 111, 112, 114, 115, 116, 117, 118, 343
11	St. Crispin Living Community	877, 236, 235, 234, 233, 232, 231, 230, 229, 228, 227, 226, 225, 224
12	Minnesota Correctional Facility - Red Wing	34, 33, 948, 32, 31, 736, 53, 852, 850, 30, 29, 28, 27, 26, 747, 25, 24, 23, 22, 21, 20, 19, 52, 18, 17, 16, 701, 51, 15, 14, 13, 819, 12, 11, 10, 284, 285, 286, 287, 288, 289, 290, 291, 292, 293
13	Transit Dependent - Sub-Area 10SE	245, 31, 32, 948, 33, 34, 35, 36, 37, 38, 39, 40, 41
14	Transit Dependent - Sub-Area 5S, 10SW	26, 747, 25, 24, 23, 22, 21, 20, 19, 142, 143, 144, 145, 146, 147, 149, 150, 151, 152, 153, 154, 155, 156, 157, 158, 159, 213, 214, 216, 217, 218, 123
15	Transit Dependent -Sub-Areas 2, 5W, 10W	683, 682, 681, 680, 679, 678, 677, 676, 675, 300, 299, 298, 297, 290, 291, 292, 293
16	Transit Dependent - Sub-Areas 5N,5E,10E	790, 451, 452, 453, 454, 455, 478, 479, 480, 484, 481, 771, 482, 796, 710, 614, 618
17	Transit Dependent - Sub-Areas 10NW10N10NE	609, 508, 507, 506, 505, 504, 503, 483, 502

Table 10-3. Sister Schools

School	Sister School
Burnside Elementary School	Hastings Middle School
Jefferson Elementary School	
St. John's Lutheran School	
Colvill Family Center	
Sunnyside Elementary School	
Twin Bluff Middle School	Hastings Senior High School
Red Wing High School	
Tower View Alternative High School	

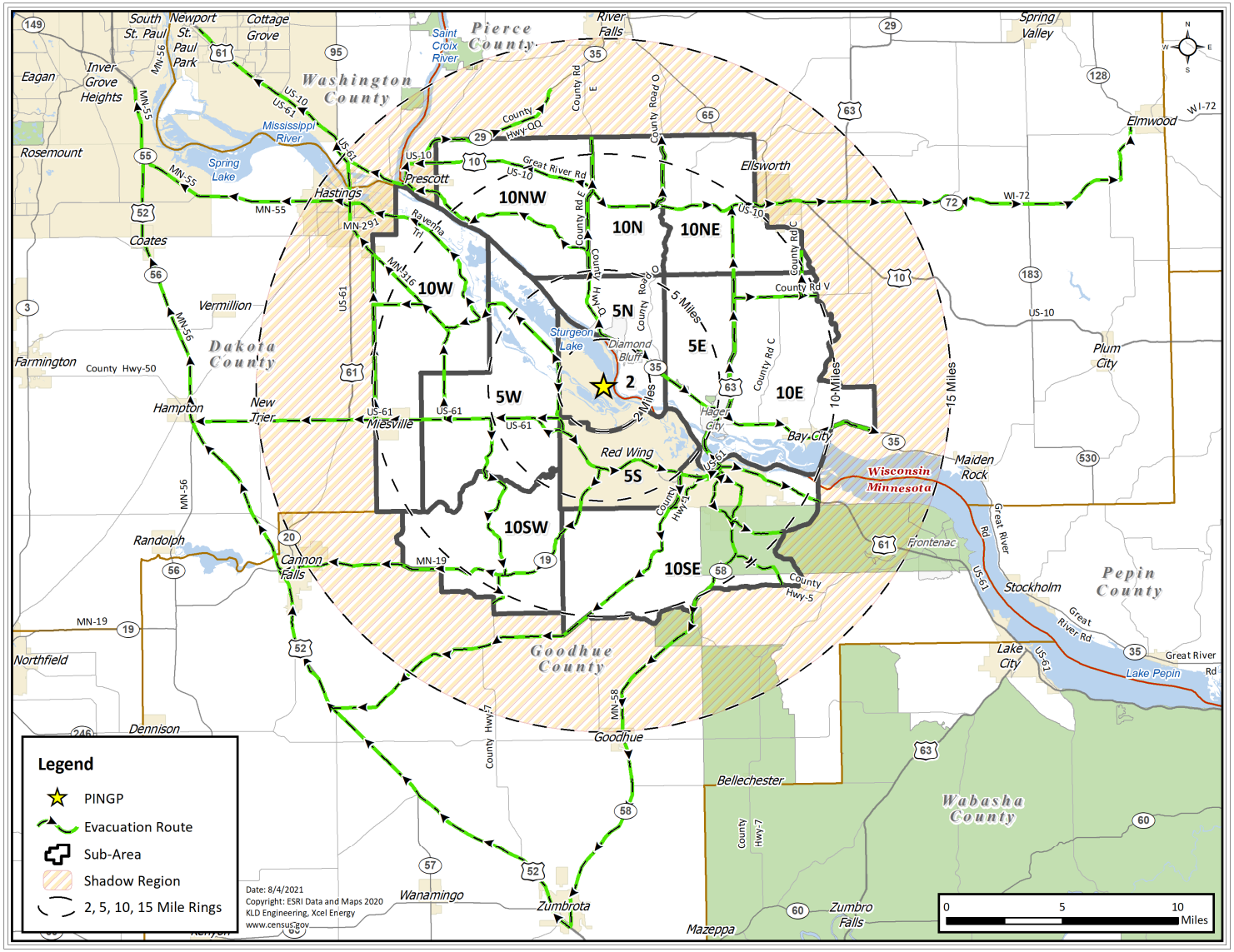


Figure 10-1. Evacuation Route Map

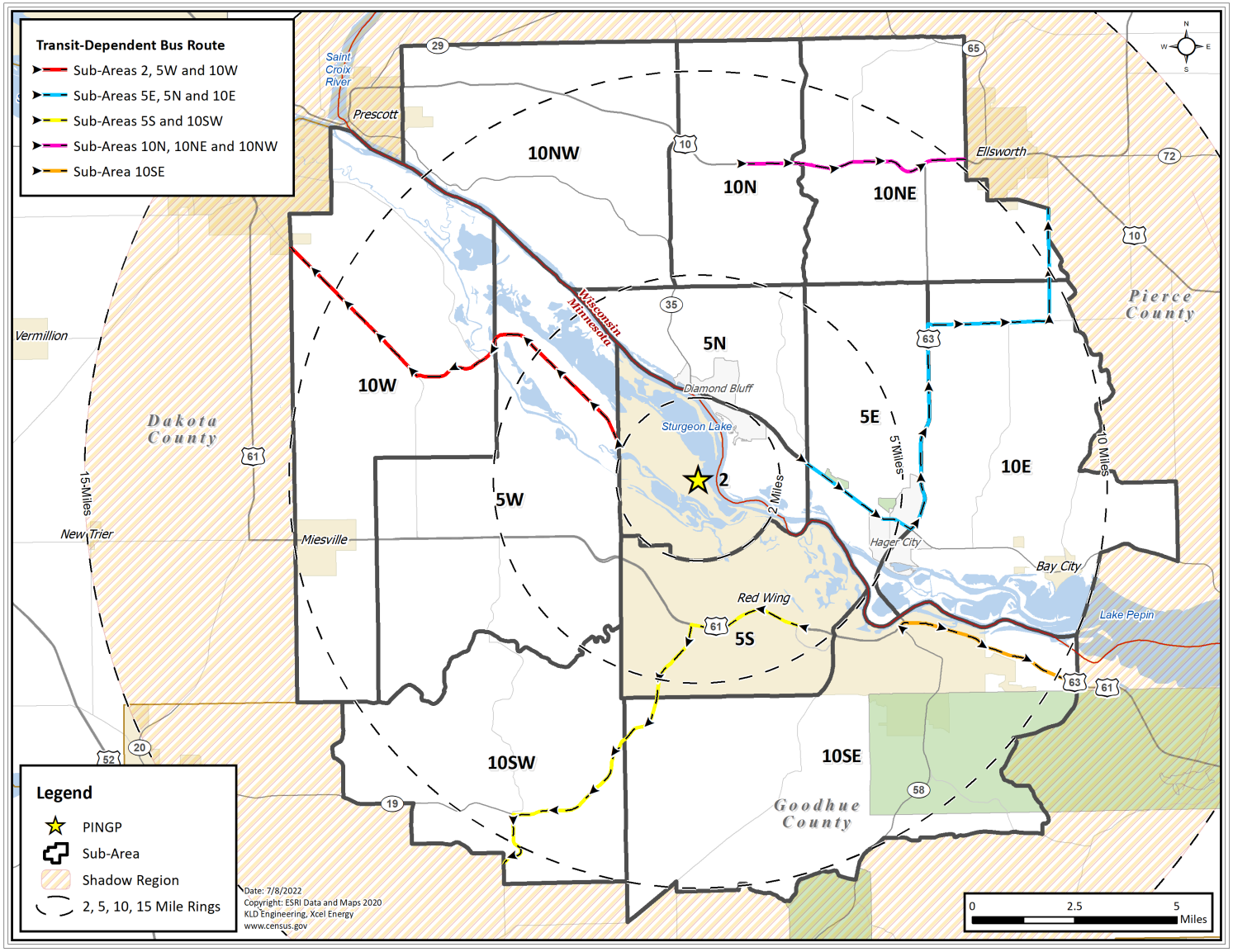


Figure 10-2. PINGP Transit Dependent Bus Routes

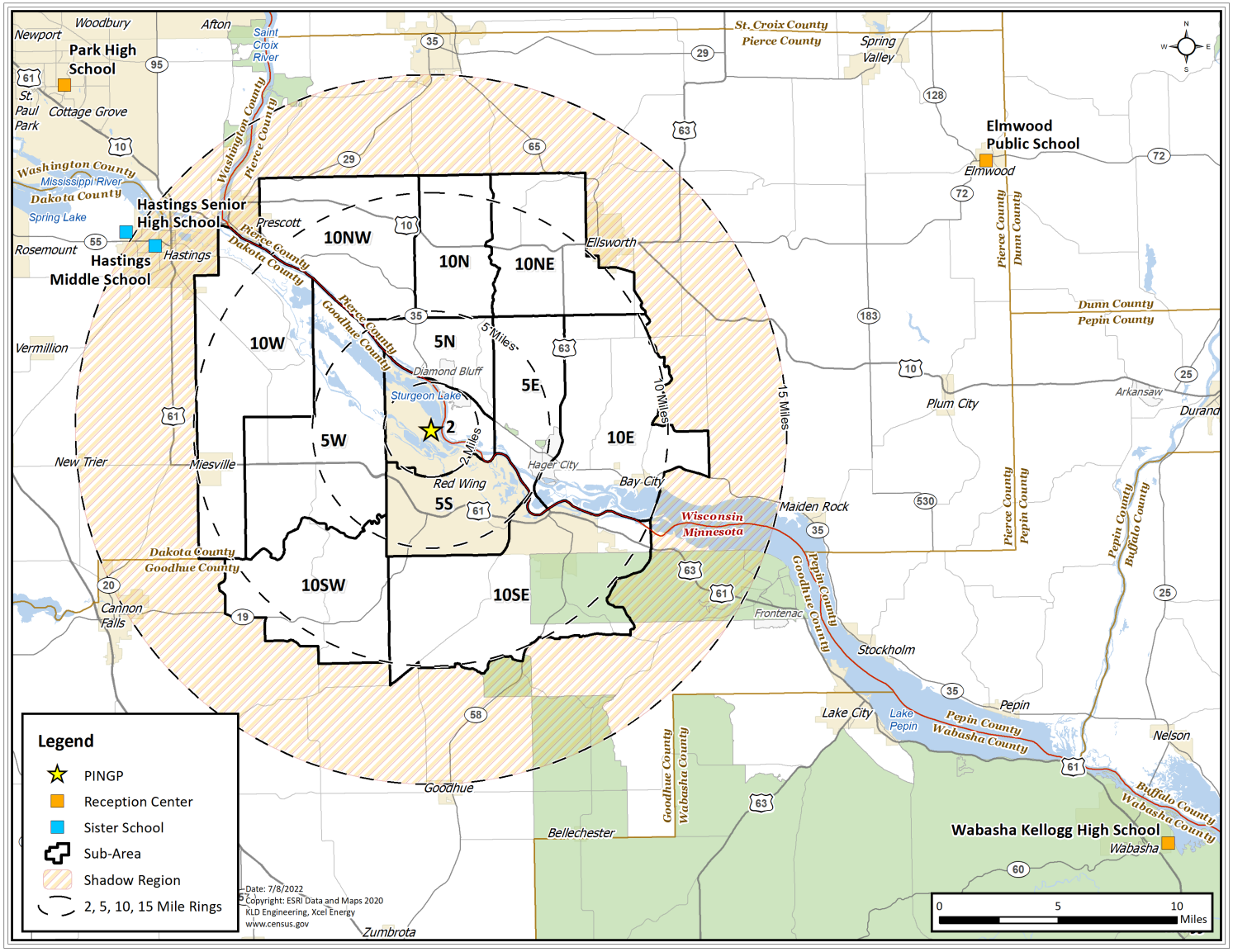


Figure 10-3. General Population Reception Centers and Sister Schools

APPENDIX A

Glossary of Traffic Engineering Terms

A. GLOSSARY OF TRAFFIC ENGINEERING TERMS

Table A-1. Glossary of Traffic Engineering Terms

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

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

APPENDIX B

DTRAD: Dynamic Traffic Assignment and Distribution Model

B. DYNAMIC TRAFFIC ASSIGNMENT AND DISTRIBUTION MODEL

This appendix 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 Emergency Planning Zone (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."

B.1 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.

B.2 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.

B.2.1 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 DYNEV II 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 DTRAD include:

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

- Travel "cost" plays a crucial role in route choice. In DTRAD, path cost is a linear summation of the generalized cost of each link that comprises the path. The generalized cost for a link, a, is expressed as

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

where c_a is the generalized cost for link a, and α, β, and γ are cost coefficients for link travel time, distance, and supplemental cost, respectively. Distance and supplemental costs are defined as invariant properties of the network model, while travel time is a dynamic property dictated by prevailing traffic conditions. The DYNEV simulation model computes travel times on all edges in the network and DTRAD uses that information to constantly update the costs of paths. The route choice decision model in the next simulation iteration uses these updated values to adjust the route choice behavior. This way, traffic demands are dynamically re-assigned based on time dependent conditions. The interaction between the DTRAD traffic assignment and DYNEV II simulation models is depicted in Figure B-1. Each round of interaction is called a Traffic Assignment Session (TA session). A TA session is composed of multiple iterations, marked as loop B in the figure.

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

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

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

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

The value of d_o = 13 miles, the outer distance of the EPZ. Note that the supplemental cost, s_a, of link, a, is (high, low), if its downstream node, n, is (near, far from) the power plant.

B.2.2 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.

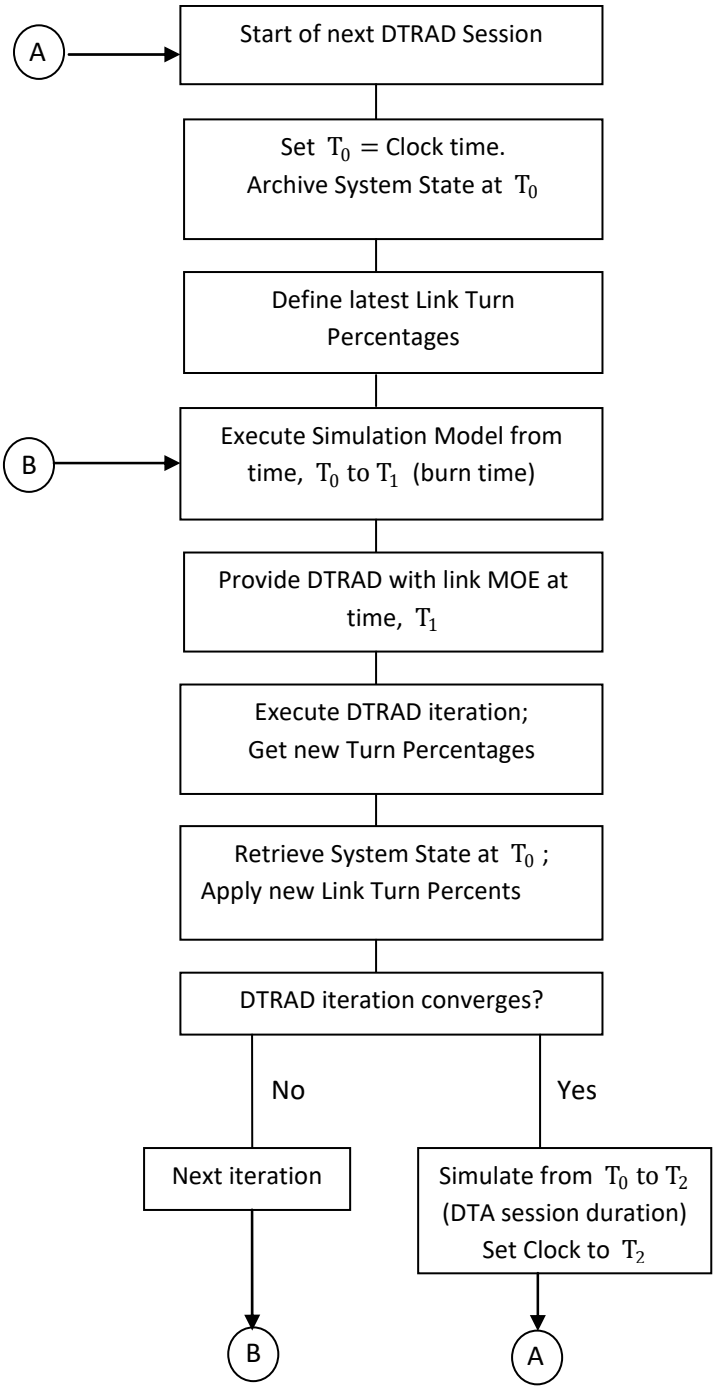


Figure B-1. Flow Diagram of Simulation-DTRAD Interface

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 Dynamic traffic Assignment and Distribution (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 (EVacuation ANimator)
- Calculates ETE statistics

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

To provide an efficient framework for defining these specifications, the physical highway environment is represented as a network. The unidirectional links of the network represent

roadway sections: rural, multi-lane, urban streets or freeways. The nodes of the network generally represent intersections or points along a section where a geometric property changes (e.g. a lane drop, change in grade or free flow speed).

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

C.1 Methodology

C.1.1 The Fundamental Diagram

It is necessary to define the fundamental diagram describing flow-density and speed-density relationships. Rather than "settling for" a triangular representation, a more realistic representation that includes a "capacity drop", (I-R)$Q_{max,}$ at the critical density when flow conditions enter the forced flow regime, is developed and calibrated for each link. This representation, shown in Figure C-2, asserts a constant free speed up to a density, k_f, and then a linear reduction in speed in the range, $k_f \le k \le k_c = 45$ vpm, the density at capacity. In the flow-density plane, a quadratic relationship is prescribed in the range, $k_c < k \le k_s = 95$ 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 moving 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 $0 \le \bar{k} \le \bar{k}_s = 50$. It can be shown that $Q = (0.98 - 0.0056\,\bar{k})\,RQ_{max}$ for $\bar{k}_s \le \bar{k} \le \bar{k}_j$, where $\bar{k}_s = 50$ and $\bar{k}_j = 175$.

C.1.2 The Simulation Model

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

The formulation and the associated logic presented below are designed to solve the unit problem for each sweep over the network (discussed below), for each turn movement serviced on each link that comprises the evacuation network, and for each TI over the duration of the evacuation.

Given = Q_b , M_b , L , TI , E_0 , LN , G/C , h , L_v , R_0 , L_c , E , M

Compute $= O\,, Q_e\,, M_e$
Define $O = O_Q + O_M + O_E$; $E = E_1 + E_2$

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

2. Calculate $v\,(k)$ such that $k \le 130$ using the analytical representations of the fundamental diagram.
   Calculate $Cap = \frac{Q_{max}(TI)}{3600}\ (G/C)\ LN$, in vehicles, this value may be reduced due to metering
   Set $R = 1.0$ if $G/C < 1$ or if $k \le k_c$; 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 $t_1 < 0$, 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 $Q_b \ge Cap$, then
   $O_Q = Cap\,, O_M = O_E = 0$
   If $t_1 > 0$, then
   $Q'_e = Q_b + M_b + E_1 - Cap$
   Else
   $Q'_e = Q_b - Cap$
   End if
   Calculate Q_e and M_e using Algorithm A (below)

6. Else $(Q_b < Cap)$
   $O_Q = Q_b\,,$ $RCap = Cap - O_Q$

7. If $M_b \le RCap$, then

8. If $t_1 > 0\,,$ $O_M = M_b\,, O_E = \min\left(RCap - M_b, \frac{t_1\ Cap}{TI}\right) \ge 0$
   $Q'_e = E_1 - O_E$
   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

$O_M = \text{RCap}\,,\ Q'_e = M_b - O_M + E_1$

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 $M_d > RCap\,,\ then$

$O_M = \text{RCap}$

$Q'_e = M_d - O_M$

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 moving vehicles.

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

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

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

End if

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

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

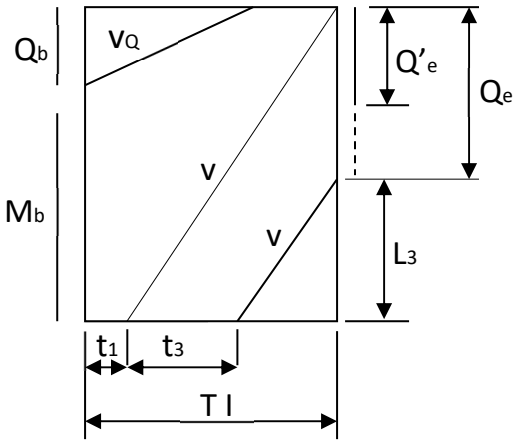
The number of excess vehicles that cause spillback is: $SB = Q_e + M_e - \frac{(L-W)\cdot LN}{L_v}$, where W is the width of the upstream intersection. To prevent spillback, meter the outflow from the feeder approaches and from the source flow, S, during this TI by the amount, SB. That is, set

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

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

Algorithm A

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



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

Define: $L'_e = Q'_e\,\frac{L_v}{LN}$. From the sketch, $L_3 = v(TI - t_1 - t_3) = L - (Q'_e + E_3)\frac{L_v}{LN}$. Substituting $E_3 = \frac{t_3}{TI}\,E$ yields: $-vt_3 + \frac{t_3}{TI}\,E\,\frac{L_v}{LN} = L - v(TI - t_1) - L'_e$. Recognizing that the first two terms on the right hand side cancel, solve for t_3 to obtain:

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

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

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

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

C.1.3 Lane Assignment

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

C.2 Implementation

C.2.1 Computational Procedure

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

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

Within each sweep, processing solves the "unit problem" for each turn movement on each link. With the turn movement percentages for each link provided by the DTRAD model, an algorithm allocates the number of lanes to each movement serviced on each link. The timing at a signal, if any, applied at the downstream end of the link, is expressed as a G/C ratio, the signal timing needed to define this ratio is an input requirement for the model. The model also has the capability of representing, with macroscopic fidelity, the actions of actuated signals responding to the time-varying competing demands on the approaches to the intersection.

The solution of the unit problem yields the values of the number of vehicles, O, that discharge from the link over the time interval and the number of vehicles that remain on the link at the end of the time interval as stratified by queued and moving vehicles: Q_e 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.

C.2.2 Interfacing with Dynamic Traffic Assignment (DTRAD)

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

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

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

Additional details are presented in Appendix B.

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

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

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

HIGHWAY NETWORK

- Links defined by upstream and downstream node numbers
- Link lengths
- Number of lanes (up to 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

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

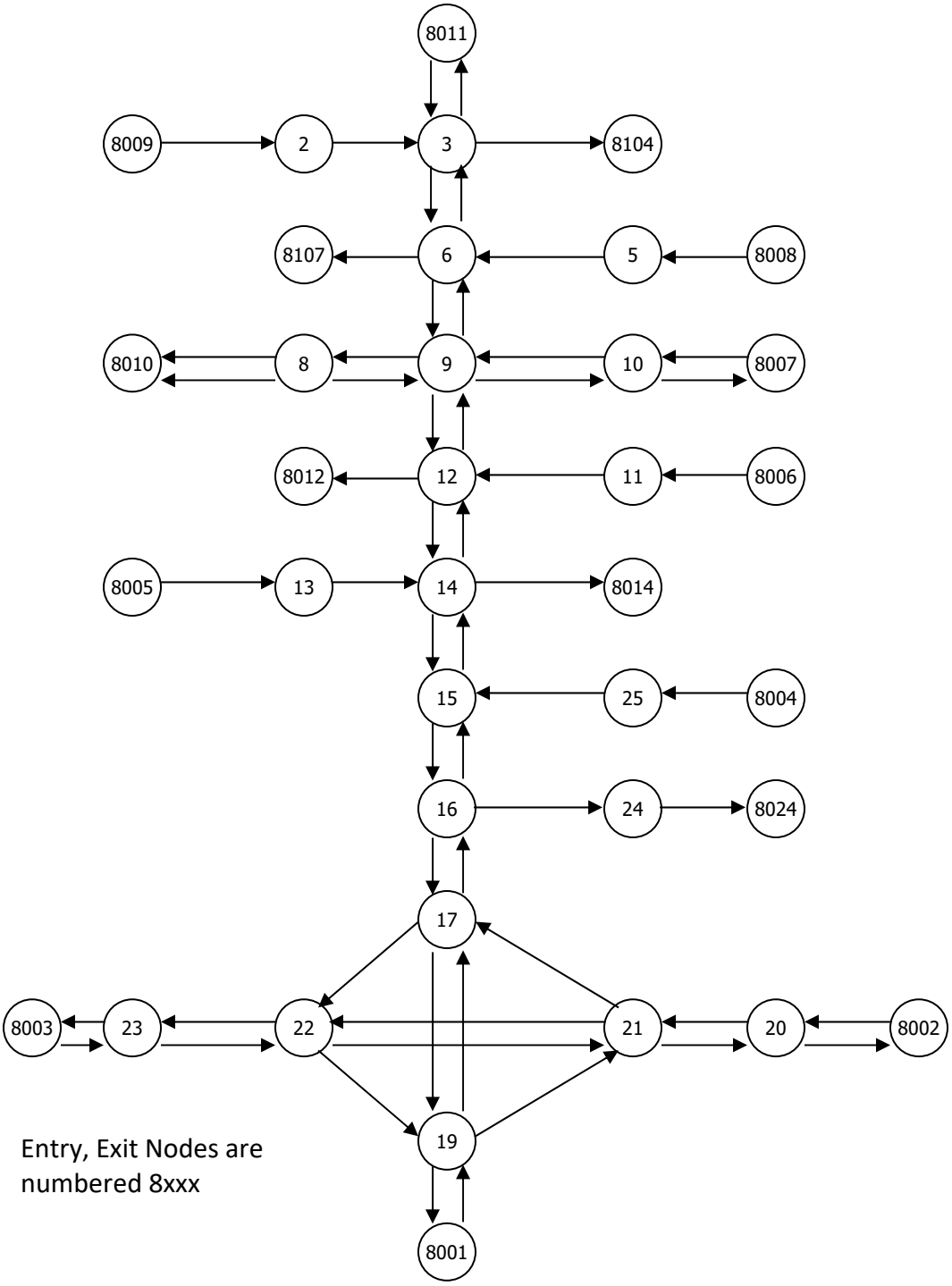


Figure C-1. Representative Analysis Network

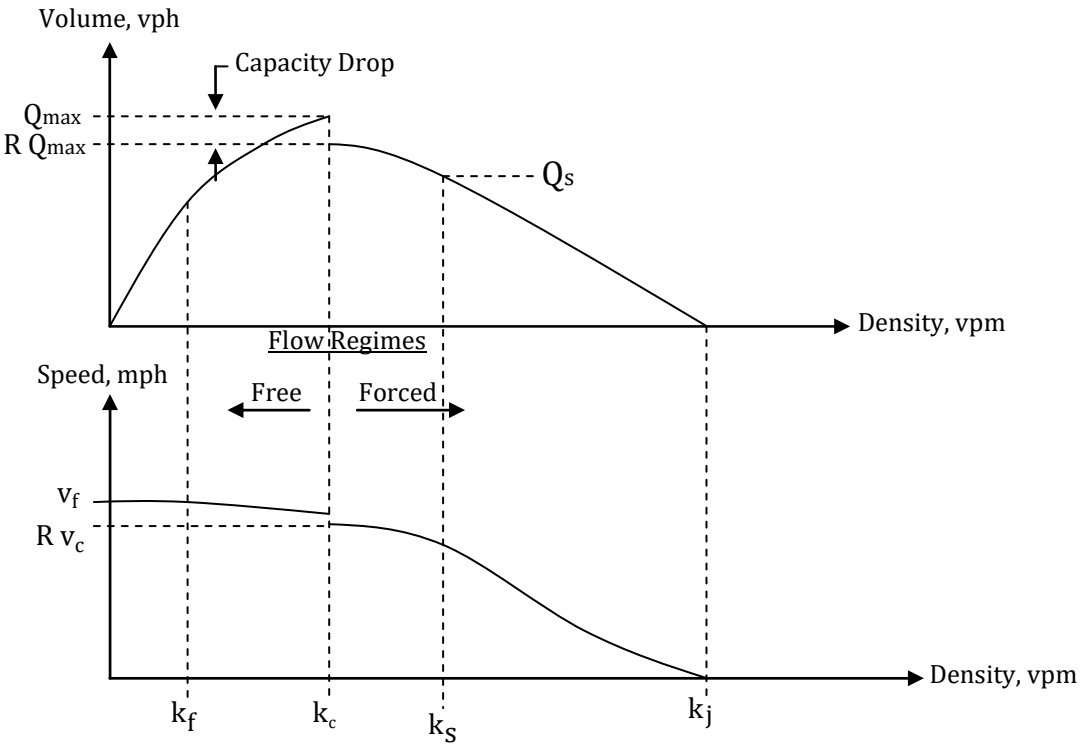


Figure C-2. Fundamental Diagrams

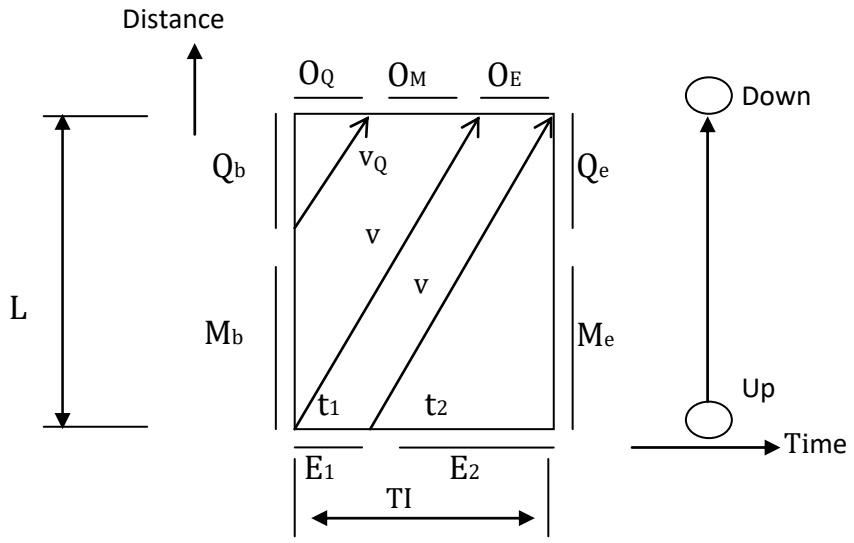


Figure C-3. A UNIT Problem Configuration with $t_1 > 0$

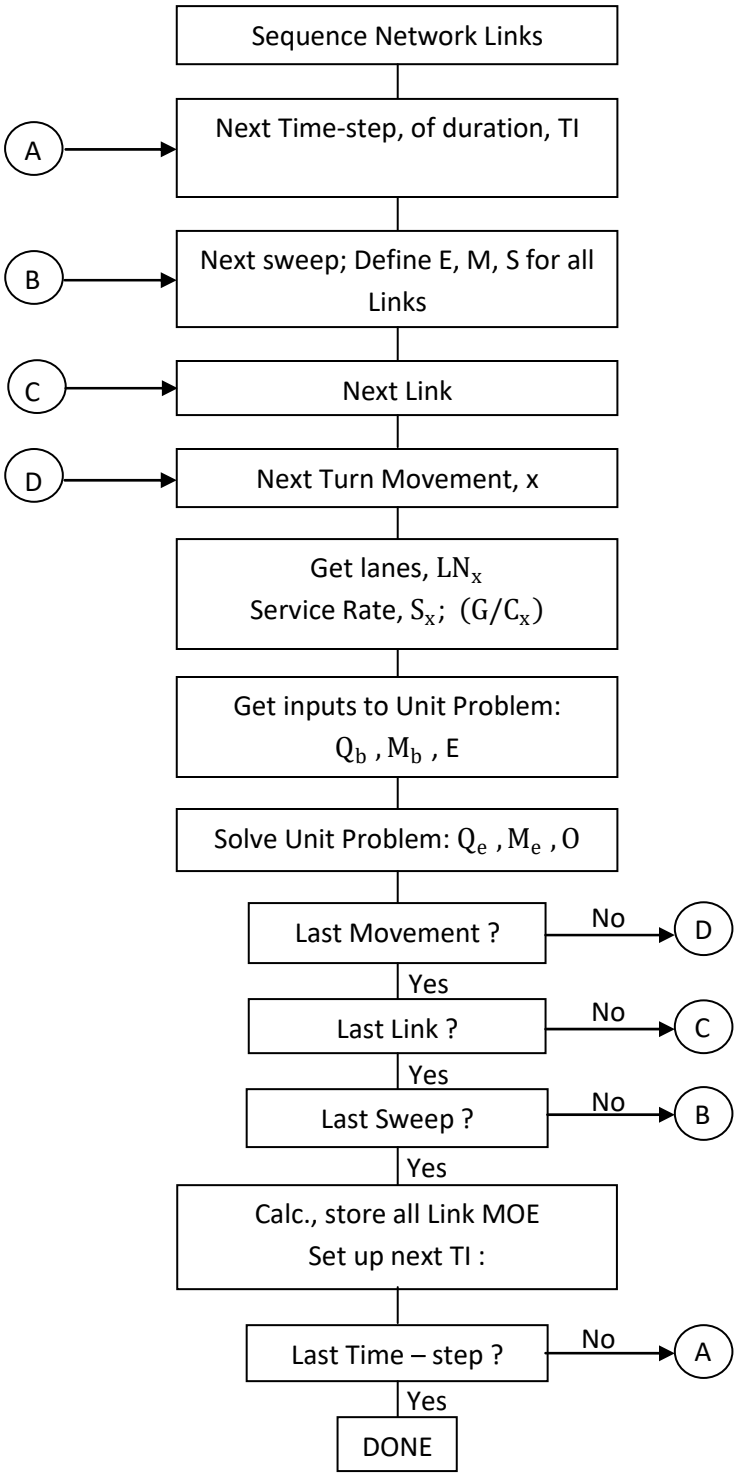


Figure C-4. Flow of Simulation Processing (See Glossary: Table C-3)

APPENDIX D

Detailed Description of Study Procedure

D. DETAILED DESCRIPTION OF STUDY PROCEDURE

This appendix describes the activities that were performed to compute Evacuation Time Estimates (ETE). 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 Emergency Planning Zone (EPZ) boundary information and create a Geographic Information System (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

The 2020 Census block information was obtained in GIS format. This information was used to estimate the permanent resident population within the EPZ and Shadow Region and to define the spatial distribution and demographic characteristics of the population within the study area. Transient, employment, and special facilities data were obtained from Xcel Energy and from the state and county emergency management agencies, and the old data from the previous study which were reviewed and confirmed by the state and county emergency management agencies as still accurate, supplemented by internet searches, where data was missing.

Step 3

A kickoff meeting was conducted with major stakeholders (state and county emergency management officials, and Xcel personnel). 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 (if any exist within the study area), and to make the necessary observations needed to estimate realistic values of roadway capacity. Roadway characteristics were also verified using aerial imagery.

Step 5

A demographic survey of households within the EPZ was conducted to identify household dynamics, trip generation characteristics, and evacuation-related demographic information of

the EPZ population. This information was used to determine important study factors including the average number of evacuating vehicles used by each household, and the time required to perform pre-evacuation mobilization activities.

Step 6

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

Step 7

The EPZ is subdivided into 12 Sub-Areas. Based on wind direction and speed, Regions (groupings of Sub-Areas) that may be advised to evacuate, were developed.

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

Step 8

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

Step 9

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

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

Step 10

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

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

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

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

Step 11

There are many "treatments" available to the user in resolving apparent problems. These treatments range from decisions to reroute the traffic by assigning additional evacuation destinations for one or more sources, imposing turn restrictions where they can produce significant improvements in capacity, changing the control treatment at critical intersections so as to provide improved service for one or more movements, adding minor routes (which are paved and traversable) that were not previously modelled but may assist in an evacuation and increase the available roadway network capacity, 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, school buses, ambulatory buses, wheelchair buses and mini vans, and ambulances 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 are available, quality control procedures are used to assure the results are consistent, dynamic routing is reasonable, and traffic congestion/bottlenecks are addressed properly. Traffic management plans are analyzed, and traffic control points are prioritized, if applicable. Additional analysis is conducted to identify the sensitivity of the ETE to change in some base evacuation conditions and model assumptions.

Step 16

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

Step 17

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

Step 18

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

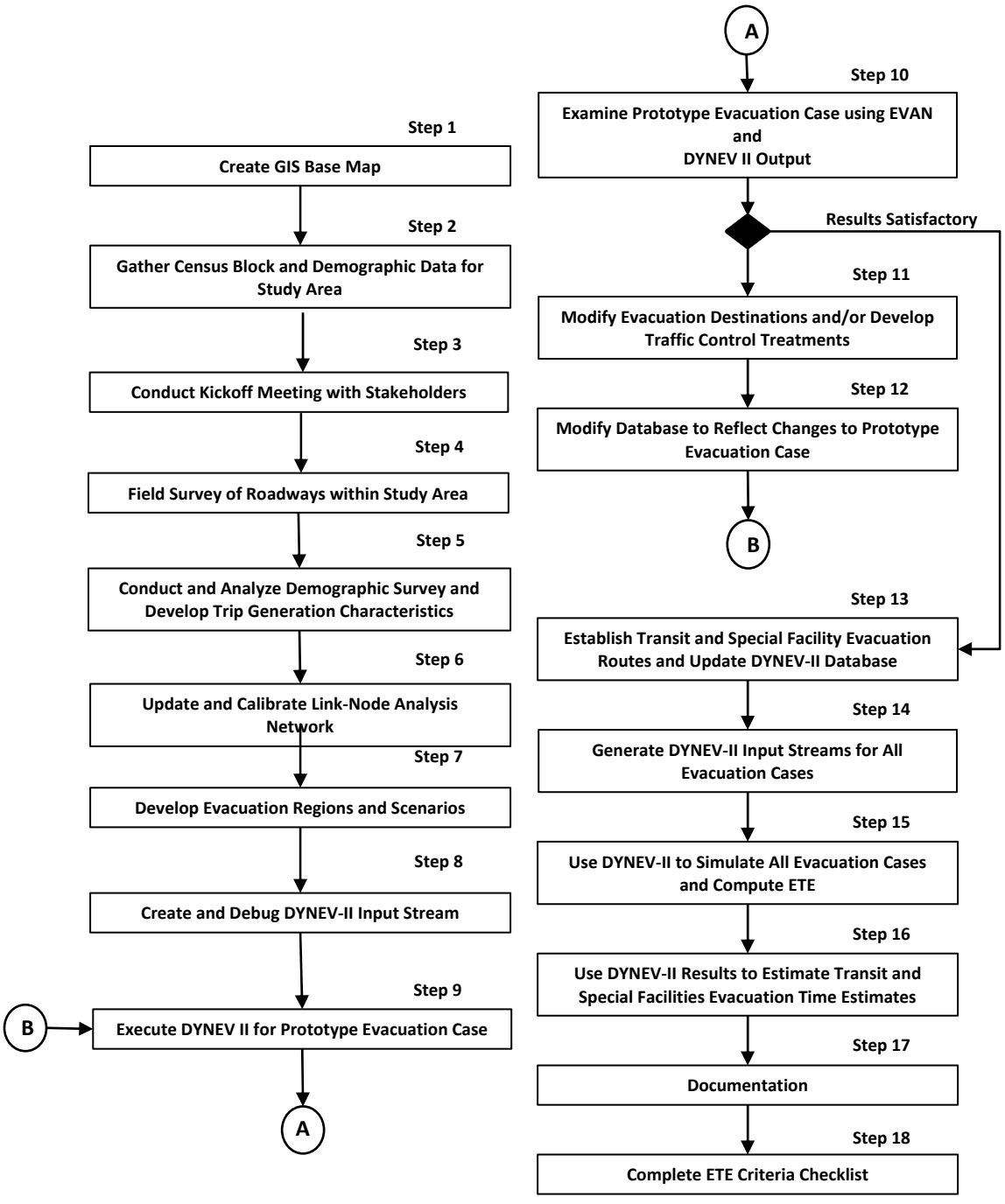


Figure D-1. Flow Diagram of Activities

APPENDIX E

Special Facility Data

E. SPECIAL FACILITY DATA

The following tables list population information, as of June 2022, for special facilities, transient attractions and major employers that are located within the PINGP EPZ. Special facilities are defined as schools, day care centers, medical facilities and correctional facilities. Transient population data is included in the tables for campgrounds, golf courses, marinas, other transient attractions and lodging facilities. Employment data is included in the table for major employers. Each table is grouped by county. The location of the facility is defined by its straight-line distance (miles) and direction (magnetic bearing) from the center point of the plant. Maps of each school and day care center, medical facility, major employer, campground, golf course, marina, other transient attraction, lodging facility and correctional facility are also provided.

Table E-1. Schools and Day Care Centers within the EPZ

Sub-Area	Distance (miles)	Direction	School Name	Street Address	Municipality	Enrollment
DAKOTA COUNTY, MN						
10W	11.4	WNW	Kimmes Kellie Jean	509 Tuttle Dr	Hastings	12
					Dakota County Subtotal:	*12*
GOODHUE COUNTY, MN						
5S	3.5	S	Tower View Alternative High School	154 Tower View Dr	Red Wing	68
5S	3.7	S	Red Cottage Montessori School	5225 US Highway 61 #3	Red Wing	55
5S	3.7	S	Burnside Elementary School	5001 Learning Ln	Red Wing	528
5S	4.8	SSE	Under the Rainbow Child Care	555 Technology Dr	Red Wing	123
10SE	5.8	SE	Jefferson Elementary School	601 Buchanan St	Red Wing	185
10SE	6.1	SE	YMCA Sunshine Corner Preschool	434 Main St	Red Wing	31
10SE	6.3	SE	Learning Circle, Inc.	615 W 5th St	Red Wing	100
10SE	6.3	SE	St. John's Lutheran School	421 E Ave	Red Wing	52
10SE	6.5	SE	Colvill Family Center	269 E 5th St	Red Wing	76
10SE	6.6	SE	Sunnyside Elementary School	1669 Southwood Ave	Red Wing	450
10SE	6.8	SE	Twin Bluff Middle School	2120 Twin Bluff Rd	Red Wing	644
10SE	6.8	SE	Building Blocks Childcare and Learning Center	469 12th St	Red Wing	180
10SE	7.3	SE	His Kids Childcare and Preschool	1811 Bush St	Red Wing	40
10SE	7.4	SE	Eagles Nest Daycare	2237 Patch Ct	Red Wing	12
10SE	8.0	SE	Southeast Minnesota Technical College - Red Wing	308 Pioneer Rd	Red Wing	40
10SE	8.3	SE	Red Wing High School	2451 Eagle Ridge Dr	Red Wing	969
					Goodhue County Subtotal:	*3,553*
					EPZ TOTAL:	**3,565**

Table E-2. Medical Facilities within the EPZ

Sub-Area	Distance (miles)	Direction	Facility Name	Street Address	Municipality	Capacity	Current Census	Ambulatory Patients	Wheelchair Patients	Bedridden Patients
GOODHUE COUNTY, MN										
5S	4.9	SE	Deer Crest	470 Fairview Blvd	Red Wing	81	81	77	4	0
5S	5.1	SE	Mayo Clinic Health System-Red Wing	701 Fairview Blvd	Red Wing	50	18	7	4	7
10SE	5.9	SE	Bay View Nursing & Rehabilitation Center	1412 W 4th St	Red Wing	110	78	50	26	2
10SE	6.1	SE	Loving Residence	1760 Perlich Ave	Red Wing	10	7	5	2	0
10SE	6.1	SE	Potter Ridge Assisted Living	1971 Neal St	Red Wing	53	48	43	2	3
10SE	6.2	SE	The Downtown Plaza	434 W 4th St	Red Wing	190	78	76	2	0
10SE	6.3	SE	Jordan Towers I & II	433 W 4th St	Red Wing	199	159	159	0	0
10SE	8.0	SE	St. Crispin Living Community	213 Pioneer Rd	Red Wing	112	61	16	45	0
10SE	8.3	SE	Valentines Assisted Living	2557 Eagle Ridge Dr	Red Wing	14	13	12	1	0
Goodhue County Subtotal:						*819*	*543*	*445*	*86*	*12*
EPZ TOTAL:						**819**	**543**	**445**	**86**	**12**

Table E-3. Major Employers within the EPZ

Sub-Area	Distance (miles)	Direction	Facility Name	Street Address	Municipality	Employees (Max Shift)	% Employees Commuting into the EPZ	Employees Commuting into the EPZ	Employee Vehicles Commuting into the EPZ
GOODHUE COUNTY, MN									
2	-	-	Prairie Island Nuclear Generating Plant	1717 Wakonade Dr E	Welch	600	52%	312	309
2	1.2	NW	Treasure Island Resort & Casino	5734 Sturgeon Lake Rd	Welch	435	18%	78	77
5S	4.7	S	Norwood Promotional Products	5151 Moundview Dr	Red Wing	320	43%	138	137
10SE	6.1	SE	Red Wing Shoe Co Inc	314 Main St # 2	Red Wing	350	43%	151	150
Goodhue County Subtotal:						*1,705*	-	*679*	*673*
EPZ TOTAL:						**1,705**	-	**679**	**673**

Table E-4. Campgrounds within the EPZ

Sub-Area	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Transients	Vehicles
DAKOTA COUNTY, MN							
10W	10.2	WNW	Greenwood Campground	13797 190th St E	Hastings	174	174
					Dakota County Subtotal:	*174*	*174*
GOODHUE COUNTY, MN							
10SE	9.9	SSE	Hay Creek Campground & Old Western Saloon	31655 Hwy 58 Blvd	Red Wing	600	300
					Goodhue County Subtotal:	*600*	*300*
PIERCE COUNTY, WI							
5E	5.8	SE	Island Campground and Marina	650 825th St	Hager City	216	108
10E	9.2	ESE	Bay City Campground	-	Bay City	118	96
					Pierce County Subtotal:	*334*	*204*
					EPZ TOTAL:	**1,108**	**678**

Table E-5. Golf Courses within the EPZ

Sub-Area	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Transients	Vehicles
DAKOTA COUNTY, MN							
10W	9.5	WSW	Gopher Hills Golf Course	26155 Nicolai Ave	Cannon Falls	60	30
					Dakota County Subtotal:	*60*	*30*
GOODHUE COUNTY, MN							
10SE	6.1	SE	Red Wing Golf Course	1311 W 6th St	Red Wing	172	86
10SE	8.3	ESE	Mississippi National Golf Links	409 Golf Links Dr	Red Wing	96	48
					Goodhue County Subtotal:	*268*	*134*
					EPZ TOTAL:	**328**	**164**

Table E-6. Marinas within the EPZ

Sub-Area	Distance (miles)	Direction	Facility Name	Street Address	Municipality	Transients	Vehicles
GOODHUE COUNTY, MN							
2	1.2	NW	Treasure Island Resort & Casino	5734 Sturgeon Lake Rd	Welch	450	270
10SE	5.7	SE	Ole Miss Marina Gas Dock	-	Red Wing	446	212
10SE	5.8	SE	Red Wing Marina & Boat Rental	918 Levee Rd	Red Wing	221	90
10SE	7.3	ESE	River Valley Marina and Boat Rentals	430 Nymphara Ln	Red Wing	149	61
10SE	7.5	ESE	Ole Miss Marina Colvill Park	507 Nymphara Ln	Red Wing	377	154
					Goodhue County Subtotal:	*1,643*	*787*
PIERCE COUNTY, WI							
5E	5.8	SE	Harbor Restaurant Bar Marina	N673 825th St	Hager City	58	29
5E	5.8	SE	Island Campground and Marina	650 825th St	Hager City	90	45
10E	5.9	SE	Trenton Island Yacht Club	N671 825th St	Hager City	126	63
					Pierce County Subtotal:	*274*	*137*
					EPZ TOTAL:	**1,917**	**924**

Table E-7. Other Transient Attractions within the EPZ

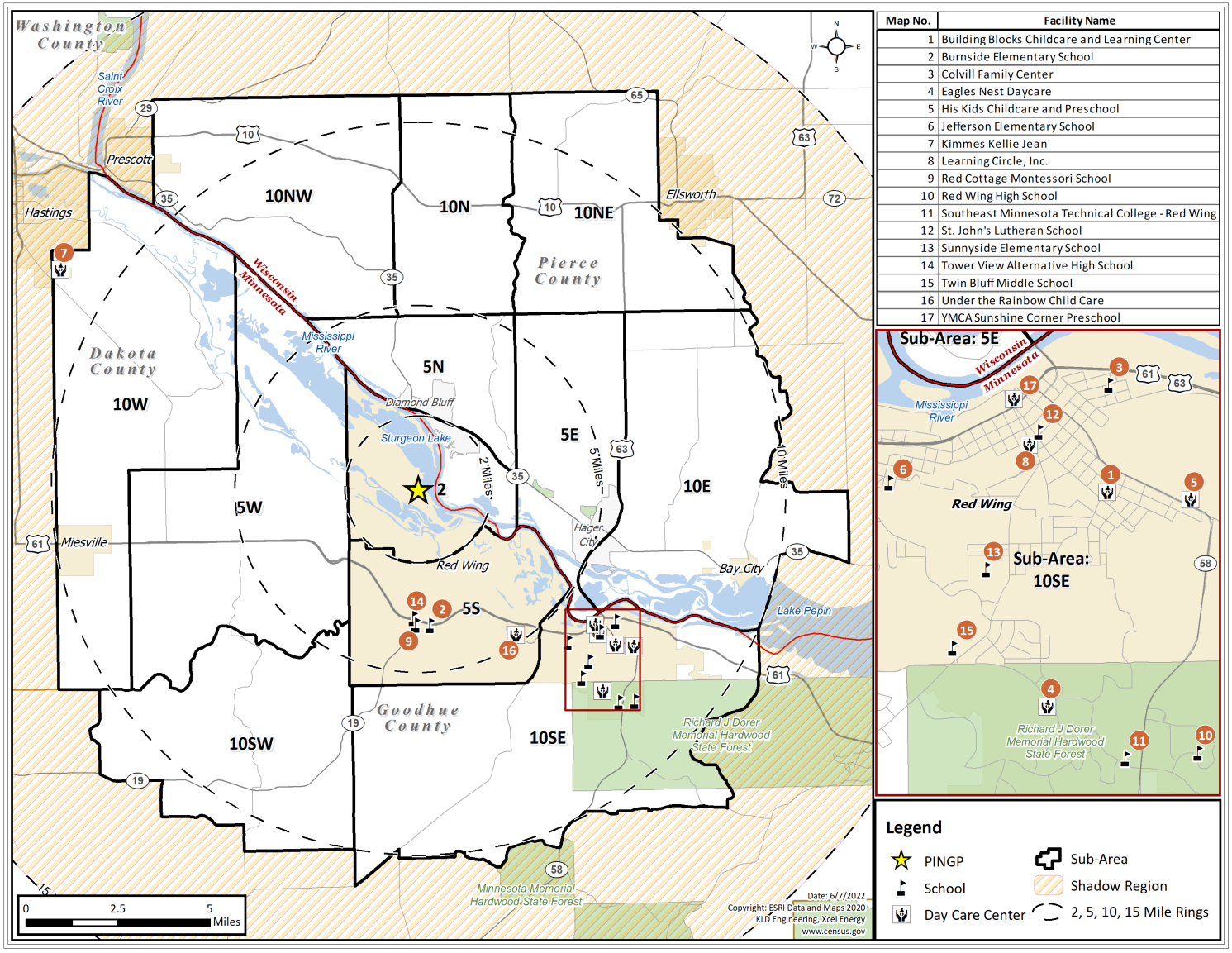
Sub-Area	Distance (miles)	Direction	Facility Name	Street Address	Municipality	Transients	Vehicles
GOODHUE COUNTY, MN							
2	1.2	NW	Treasure Island Resort & Casino	5734 Sturgeon Lake Rd	Welch	5,400	2,842
5S	4.1	SE	Red Wing Mall	160 Tyler Rd N	Red Wing	300	150
10SW	6.3	SW	Welch Village Ski Area	26685 County 7 Blvd	Welch	525	213
					Goodhue County Subtotal:	*6,225*	*3,205*
					EPZ TOTAL:	**6,225**	**3,205**

Table E-8. Lodging Facilities within the EPZ

Sub-Area	Distance (miles)	Direction	Facility Name	Street Address	Municipality	Transients	Vehicles
GOODHUE COUNTY, MN							
5S	3.5	SSE	Country Inn & Suites	4275 Hwy 61 W	Red Wing	220	59
5S	4.0	SSE	Parkway Motel	3425 Hwy 61 W	Red Wing	50	22
10SE	5.1	SE	Super 8	232 Withers Harbor Dr	Red Wing	108	54
10SE	5.3	SE	Rodeway Inn	235 Withers Harbor Dr	Red Wing	61	30
10SE	5.4	SE	Quality Inn & Suites	752 Withers Harbor Dr	Red Wing	250	50
10SE	5.4	SE	AmericInn	1819 Old W Main St	Red Wing	42	21
10SE	5.5	SE	Holiday Inn Express & Suites	1919 Old W Main St	Red Wing	174	71
10SE	5.6	SE	Nichols Inn & Suites	1750 Hwy 61	Red Wing	42	21
10SE	6.1	SE	Candlelight Inn	818 W 3rd St	Red Wing	6	3
10SE	6.1	SE	St. James Hotel	406 Main St	Red Wing	87	43
10SE	6.2	SE	Pratt-Taber Inn	706 W 4th St	Red Wing	6	6
10SE	6.5	SE	Golden Lantern Inn	721 E Ave	Red Wing	9	4
10SE	7.2	ESE	Days Inn	955 E 7th St	Red Wing	81	36
10SE	9.9	ESE	Round Barn Farm	28650 Wildwood Ln	Red Wing	9	5
Goodhue County Subtotal:						*1,145*	*425*
EPZ TOTAL:						**1,145**	**425**

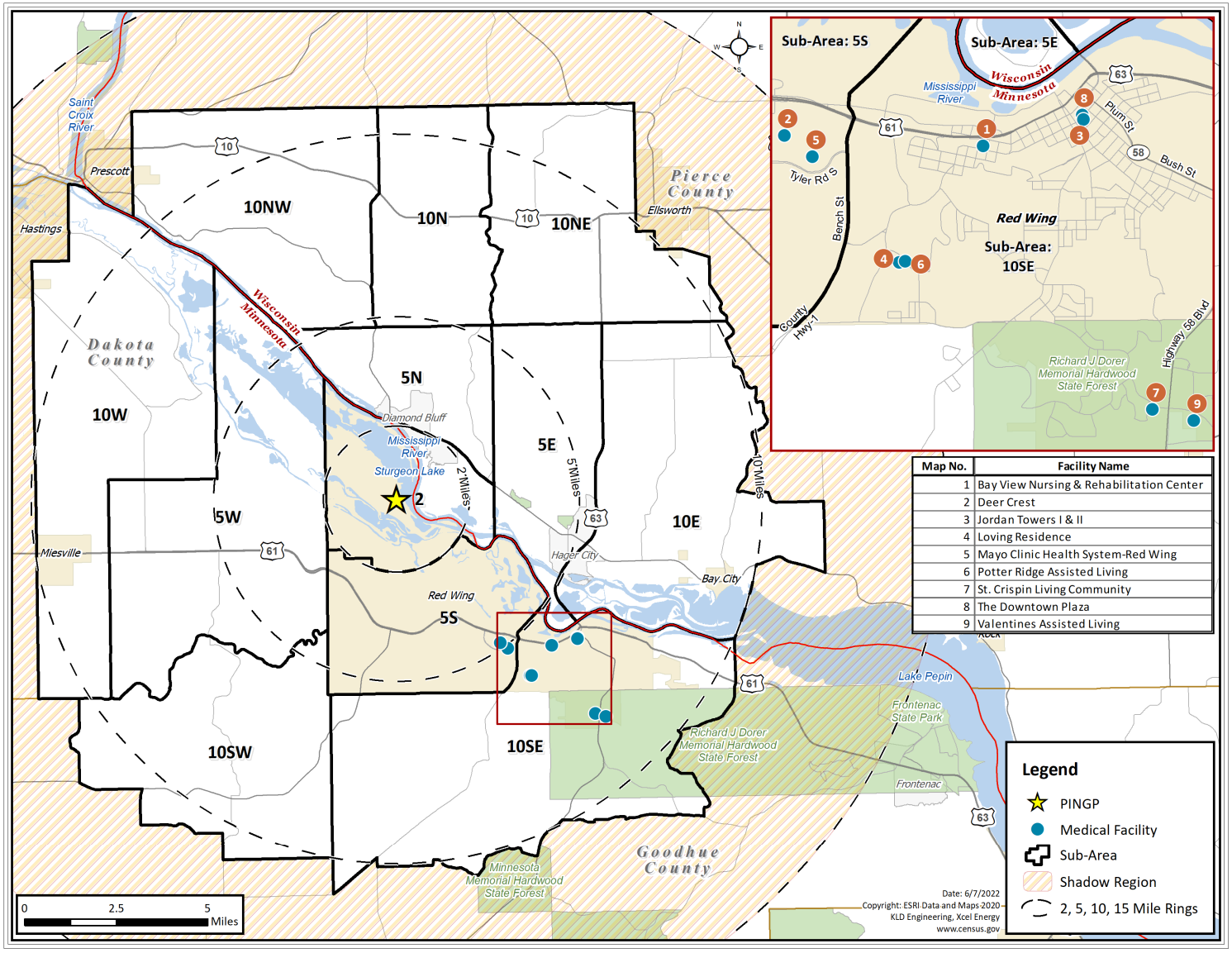
Table E-9. Correctional Facilities within the EPZ

Sub-Area	Distance (miles)	Direction	Facility Name	Street Address	Municipality	Capacity
GOODHUE COUNTY, MN						
10SE	7.9	ESE	Minnesota Correctional Facility - Red Wing	1079 Minnesota 292	Red Wing	200
Goodhue County Subtotal:						*200*
EPZ TOTAL:						**200**



Map No.	Facility Name
1	Building Blocks Childcare and Learning Center
2	Burnside Elementary School
3	Colvill Family Center
4	Eagles Nest Daycare
5	His Kids Childcare and Preschool
6	Jefferson Elementary School
7	Kimmes Kellie Jean
8	Learning Circle, Inc.
9	Red Cottage Montessori School
10	Red Wing High School
11	Southeast Minnesota Technical College - Red Wing
12	St. John's Lutheran School
13	Sunnyside Elementary School
14	Tower View Alternative High School
15	Twin Bluff Middle School
16	Under the Rainbow Child Care
17	YMCA Sunshine Corner Preschool

Figure E-1. Schools and Day Care Centers within the EPZ



Map No.	Facility Name
1	Bay View Nursing & Rehabilitation Center
2	Deer Crest
3	Jordan Towers I & II
4	Loving Residence
5	Mayo Clinic Health System-Red Wing
6	Potter Ridge Assisted Living
7	St. Crispin Living Community
8	The Downtown Plaza
9	Valentines Assisted Living

Figure E-2. Medical Facilities within the EPZ

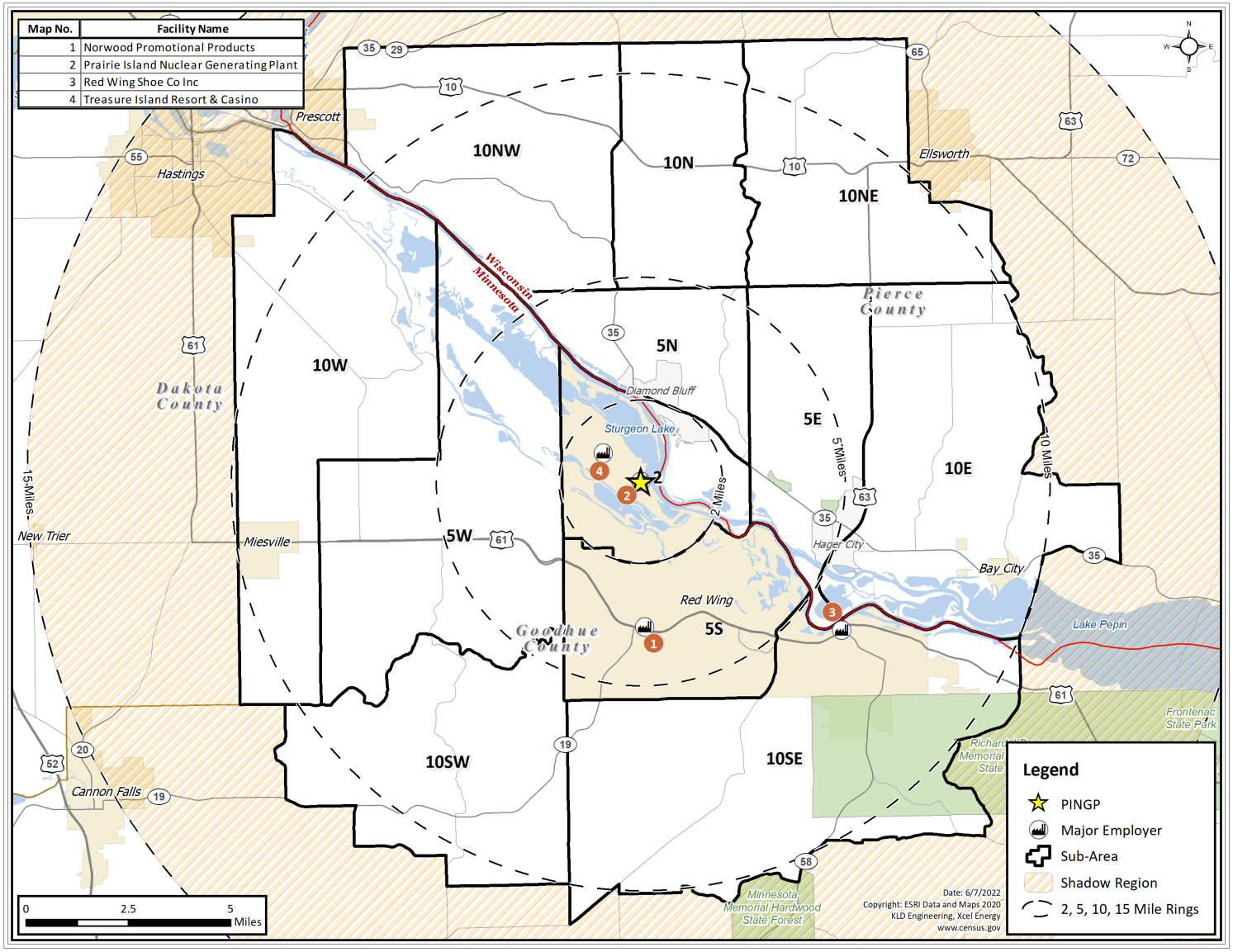


Figure E-3. Major Employers within the EPZ

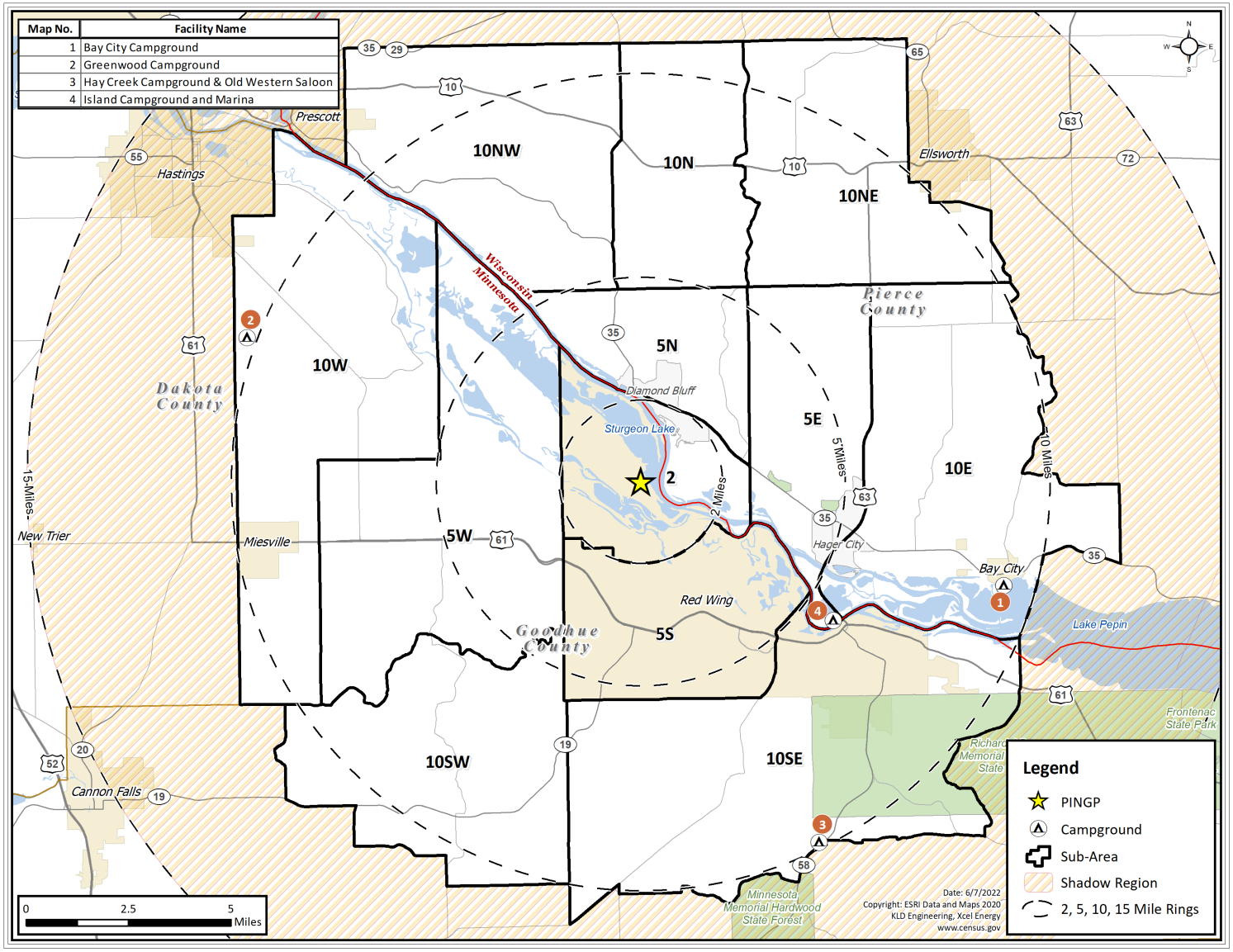


Figure E-4. Campgrounds within the EPZ

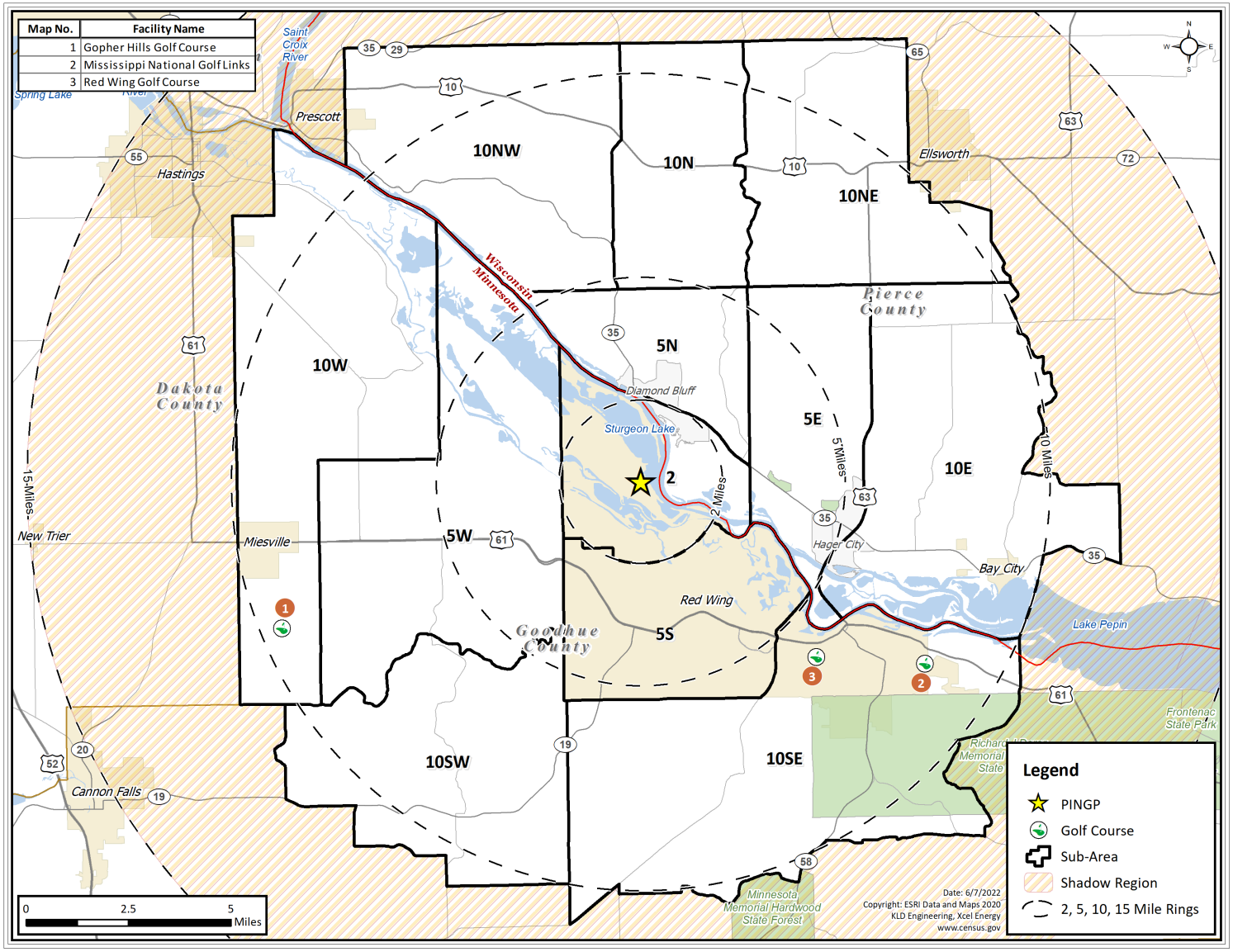


Figure E-5. Golf Courses within the EPZ

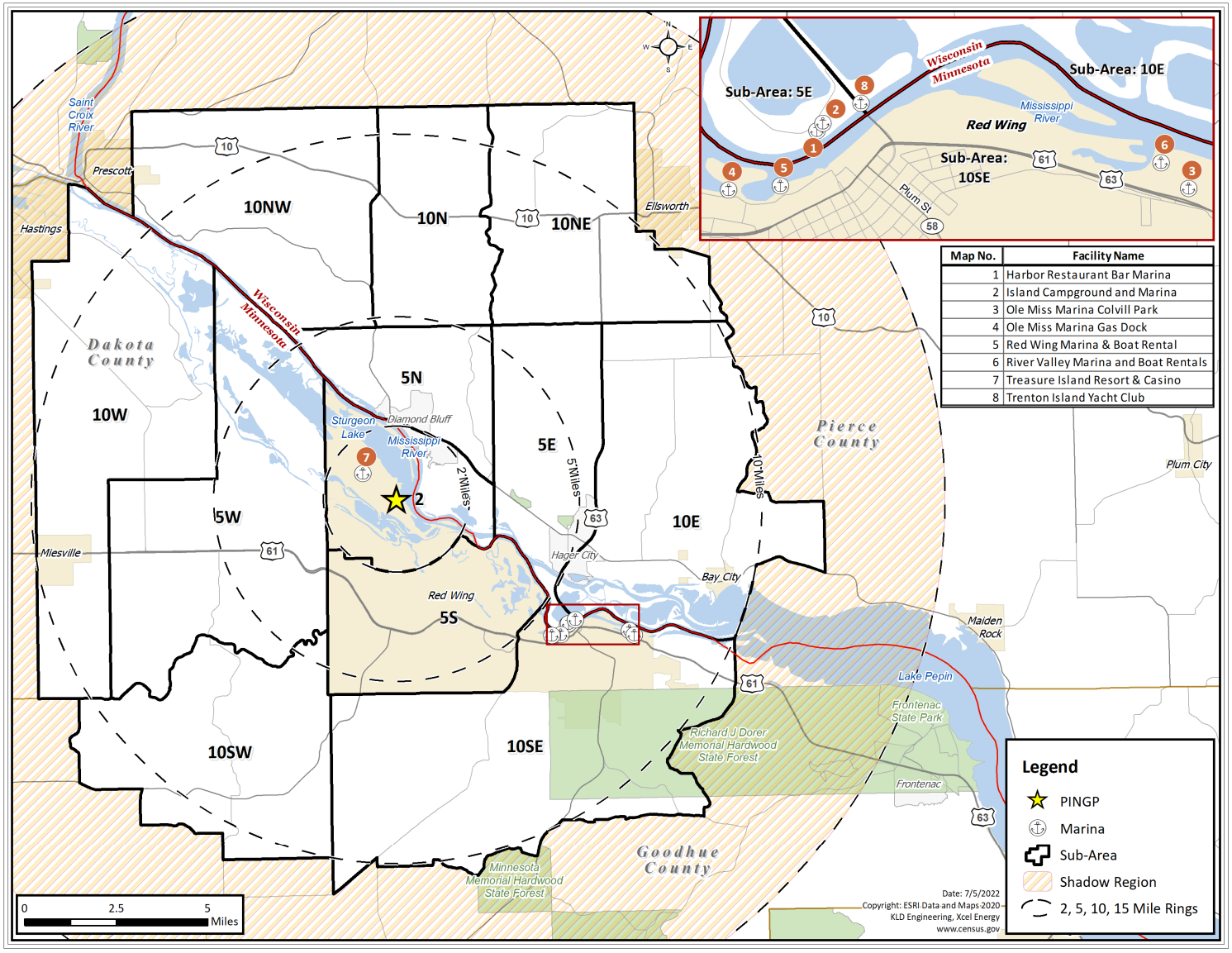


Figure E-6. Marinas within the EPZ

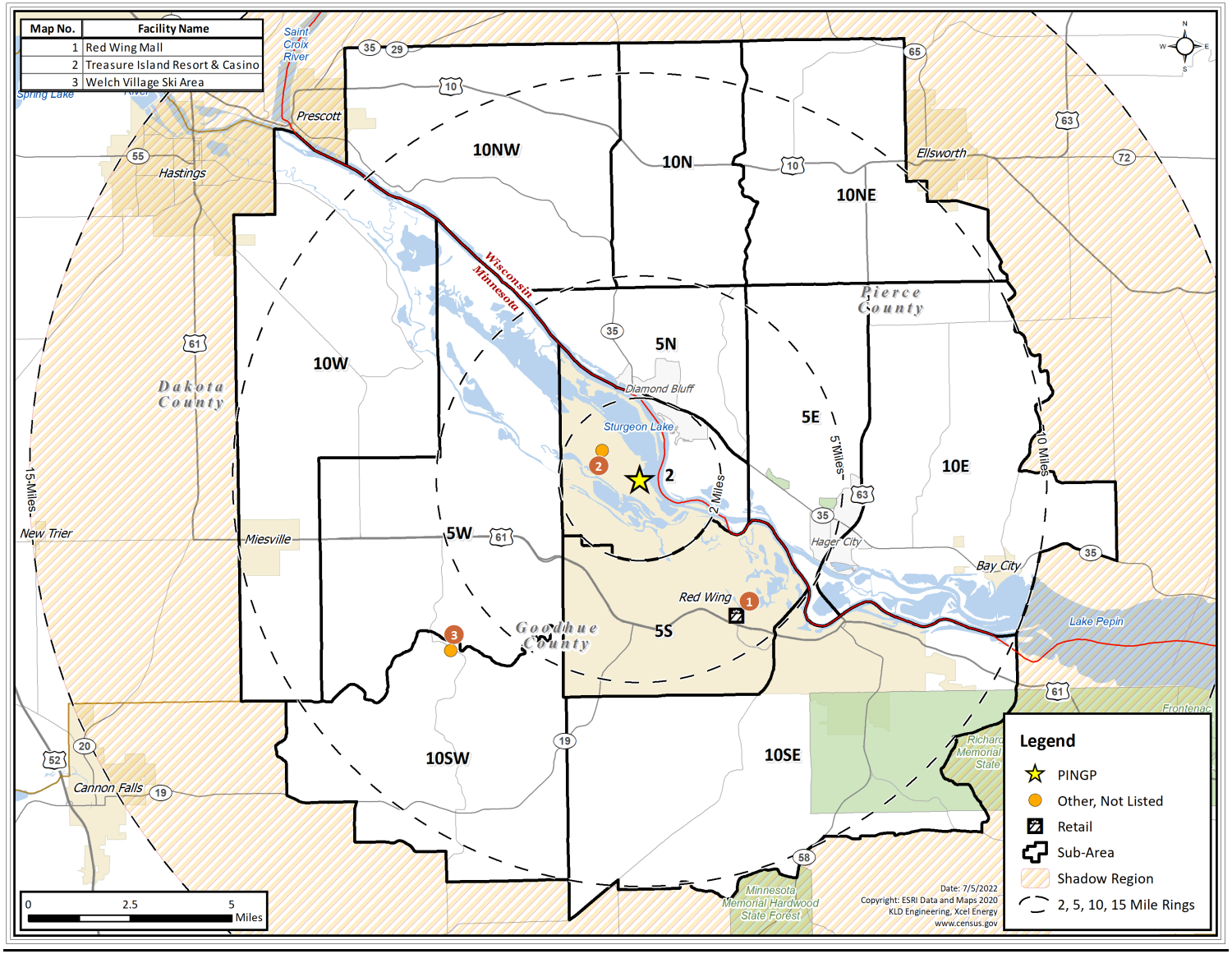


Figure E-7. Other Transient Attractions within the EPZ

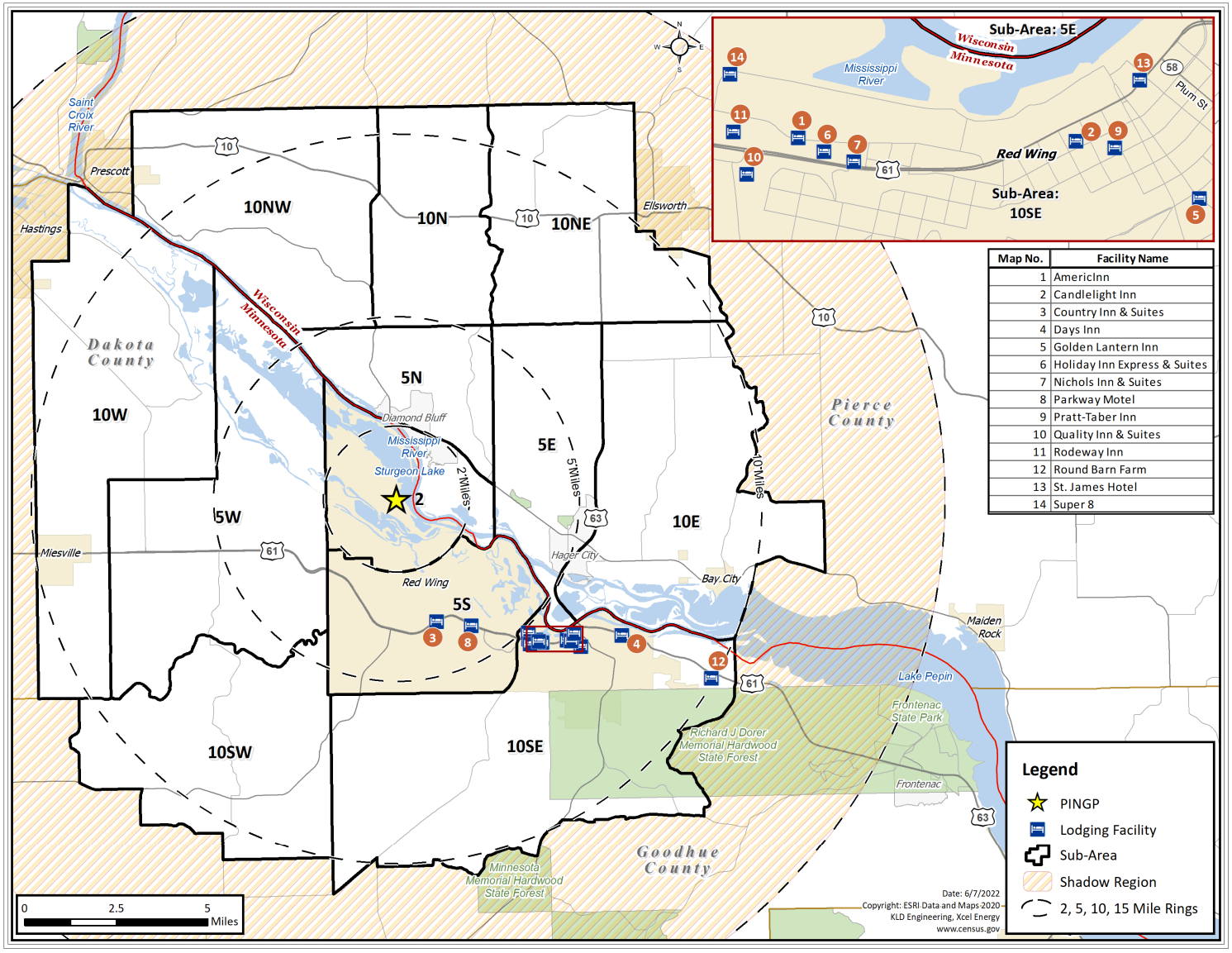


Figure E-8. Lodging Facilities within the EPZ

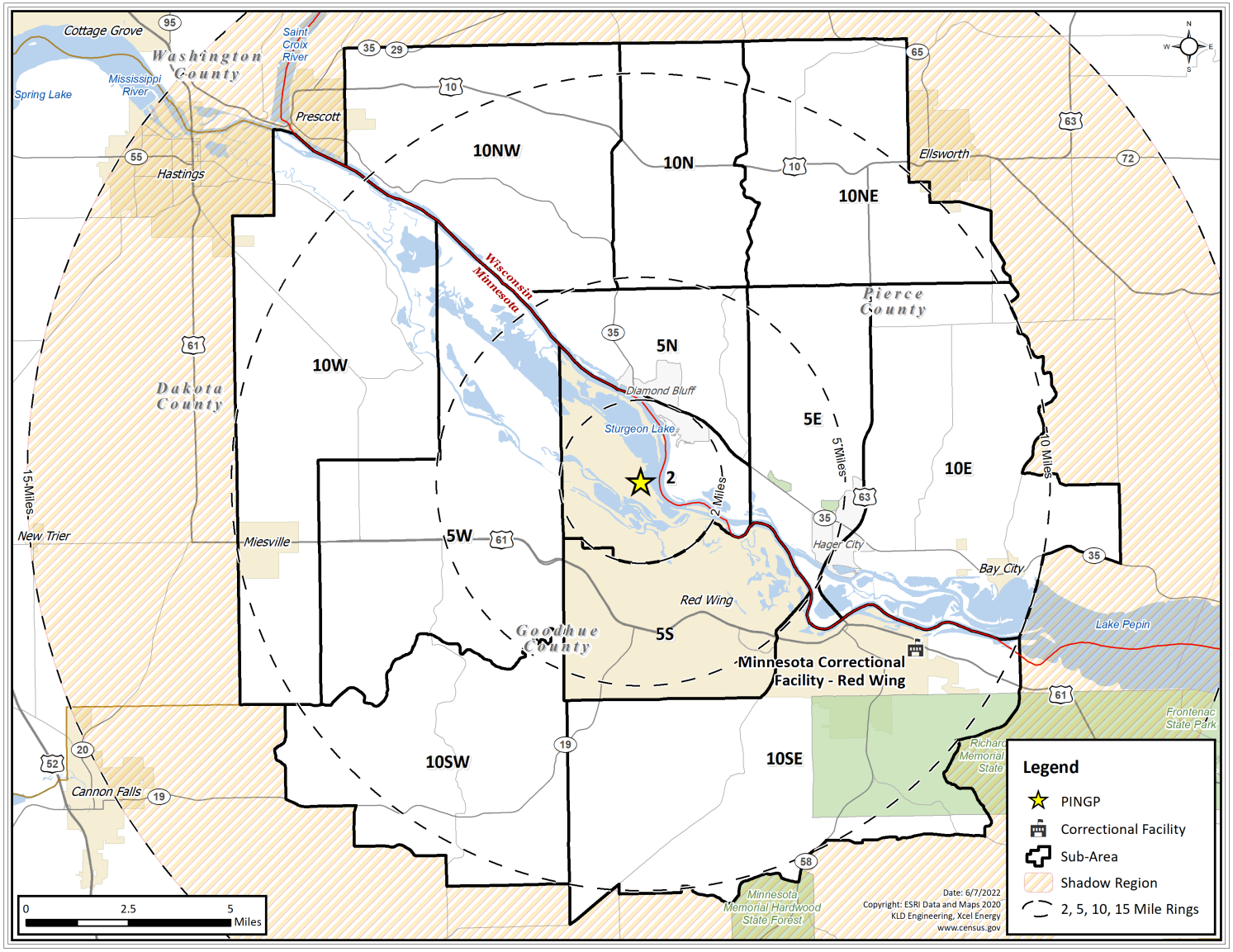


Figure E-9. Correctional Facilities within the EPZ

APPENDIX F

Demographic Survey

F. DEMOGRAPHIC SURVEY

F.1 Introduction

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

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

F.2 Survey Instrument and Sampling Plan

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

Following the completion of the instrument, a sampling plan was developed. Since the demographic survey discussed herein was performed in 2021 prior to the release of the 2020 Census data, the 2010 Census data was used to develop the sampling plan.

A sample size of approximately 457 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 2010 Census data and the EPZ boundary, again using GIS software. The proportional number of desired completed survey interviews for each zip code was identified, as shown in Table F-1.

The results of the survey fell just short of the sampling plan. A total of 426 completed samples within the EPZ were obtained, corresponding to a sampling error of approximately ±4.67% at the 95% confidence level based on the 2020 Census. The number of samples obtained from each zip code is also shown in Table F-1. Despite the number of obtained samples falling short of the sampling plan, the distribution of samples across zip codes aligns with the plan with the majority of samples from zip 55066.

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" or "Decline to State" entry for a response. It is accepted practice in conducting surveys of this type to accept the answers of a respondent who offers a don't know/decline to state response for a few questions or who refuses to answer a few questions. To address the issue of occasional don't know/decline to state responses from a large sample, the practice is to assume that the distribution of these responses is the same as the underlying distribution of the positive responses. In effect, the don't know/decline to state responses are ignored, and the distributions are based upon the positive data that is acquired.

F.3.1 Household Demographic Results

Household Size

Figure F-1 presents the distribution of household size within the EPZ based on the responses to the demographic survey. The average household contains 2.61 people. The estimated average household size from the 2020 Census data is 2.45 people. The difference between the 2020 Census data and survey data is 6.5%, which exceeds the demographic survey's margin of error of 4.67%. This difference was discussed with Xcel Energy, and it was decided that the U.S. Census estimate of 2.45 people per household should be used for this study. This results in a more conservative estimate when determining the number of households and evacuating vehicles. A sensitivity study to determine the impact to ETE of using the survey data was conducted and is documented in Appendix M.

Automobile Ownership

The average number of automobiles available per household in the EPZ is 2.32. It should be noted that less than 1.5% of households within the EPZ do not have access to an automobile, according to the demographic survey. 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.

Ridesharing

The majority (76.6%) of the households surveyed responded that they would share a ride with a neighbor, relative, or friend if a car was not available to them when advised to evacuate in the event of an emergency, as shown in Figure F-5.

Commuters

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 1.31 commuters in each household in the EPZ, and 73.7% of households have at least one commuter.

Impact of COVID-19 on Commuters

Figure F-7 presents the distribution of the number of commuters in each household that were temporarily impacted by the COVID-19 pandemic. The data shows and average of 0.87 commuters per household were affected by the COVID-19 pandemic. Approximately 48% of households indicated someone in their household had a work and/or school commute that was temporarily impacted by the COVID-19 pandemic.

Commuter Travel Modes

Figure F-8 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 1.01 employees per vehicle, assuming 2 people per vehicle – on average – for carpools.

Functional or Transportation Needs

Figure F-9 presents the distribution of the number of individuals with functional or transportation needs. The survey results show that even though a majority of EPZ residents would not require assistance, it is important to note that about 4% of households will. Of those with access and/or functional transportation needs, about 85% of homes require a bus, no home requires a medical bus/van or ambulance, about 11% require a wheelchair accessible vehicle, and about 4% have an unspecified need.

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-10. On average, evacuating households would use 1.43 vehicles.

"Would your family await the return of other family members prior to evacuating the area?" Of the survey participants who responded, 55.1% said they would await the return of other family members before evacuating and 44.9% indicated that they would not await the return of other family members before evacuating, as shown in Figure F-11.

"Emergency officials advise you to shelter-in-place in an emergency because you are not in the area risk. Would you?" This question is designed to elicit information regarding compliance with instructions to shelter-in-place. The results indicate that about 90% of households who are advised to shelter in place would do so; the remaining 10% would choose to evacuate the area, as shown in Figure F-12.

Note the baseline ETE study assumes 20% of households will not comply with the shelter advisory, as per Section 2.5.2 of NUREG/CR-7002, Rev 1. Thus, the non-compliance rate obtained above is considerably lower than the federal guidance recommendation. A sensitivity study was conducted to estimate the impact of shadow evacuation non-compliance of shelter advisory on ETE – see Appendix M.

"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 about 72% of households would follow instructions and delay the start of evacuation until so advised, while the other 28% would choose to begin evacuating immediately, as shown in Figure F-13.

"Emergency officials advise you to evacuate due to an emergency. Where would you evacuate to?" This question is designed to elicit information regarding the destination of evacuees in case of an evacuation. Approximately 50% of households indicated that they would evacuate to a friend or relatives' home, 3% to a reception center, 15% to a hotel, motel or campground, 8% to a second or seasonal home, less than 1% said they would not evacuate, and the remaining 24% answered other/don't know to this question, as shown in Figure F-14.

"If you had a household pet, would you take your pet with you if you were asked to evacuate the area?" Based on the responses to the survey, 65% of households have a family pet or farm animals. Of the households with pets, about 31% of them indicated that they would take their pets with them to a shelter, about 62% indicated that they would take their pets somewhere else and only about 7% would leave their pet at home, as shown in Figure F-15. Of the households that would evacuate with their pets, 94% indicated that they have sufficient room in their vehicle to evacuate with their pet(s)/animal(s) and 3% would use a trailer; the remaining do not have room in their vehicle(s).

"What type of pet(s) and/or animal(s) do you have?" Based on responses from the survey, 84.8% of households have a household pet (dog, cat, bird, reptile, fish, etc.), 9.7% of households have farm animals (horse, chicken, goose, duck, etc.), and 5.5% have other small/large pets/animals.

F.3.3 Time Distribution Results

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

As discussed in Section F.3.1 and shown in Figure F-7, slightly lower than half (48%) of respondents indicated no commuters were impacted by the COVID-19 pandemic; therefore, the results for the time distribution of commuters (time to prepare to leave work/college and time to travel home from work/college) were used as is in this study.

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

"How long does it take the commuter to complete preparation for leaving work or school?" Figure F-16 presents the cumulative distribution; in all cases, the activity is completed by about 50 minutes. Over 95% can leave within 30 minutes.

"How long would it take the commuter to travel home?" Figure F-17 presents the work to home travel time for the EPZ. About 92% of commuters can arrive home within about 45 minutes of leaving work; all within 90 minutes.

"How long would it take the family to pack clothing, secure the house, and load the car?" Figure F-18 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.

Approximately 88% of households can be ready to leave home within 120 minutes; the remaining households require an additional 1 hour and 15 minutes.

"How much time, on average, would it take you to clear 6-8 inches of snow accumulation to move the car from the driveway to begin the evacuation trip assuming the roads are passable?" 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-19 presents the time required to clear the snow accumulation and begin the evacuation trip.

About 95% of households can have their car cleared and the driveway passable within 90 minutes; the remaining households would require up to an additional 1 hour to begin their evacuation trip, as seen in Figure F-19. Note, that those respondents (about 21%) who answered that they wouldn't 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.

F.3.4 Emergency Communications

"At your place of residence, how reliable is your cell phone signal?" This question is designed to elicit information regarding the ability to be notified in case of an evacuation. 88% of households indicated that they have very reliable signal to receive texts and phone calls, 2% indicated that their signal is reliable for text messages only, about 9% indicated that they do not always receive cell communications at their residence, and 1% indicated that they do not have cell service at their residence, as shown in Figure F-20.

"Emergency management officials in your state may send text messages, similar to AMBER Alerts, with emergency directions for the public during a radiological emergency at the Prairie Island Nuclear Plant. How likely would you be to take action on these directions, if you received the message?" This question is designed to elicit information regarding the likelihood of an individual to take action based on emergency management officials' guidelines. About 68% of households indicated that they are highly likely to take action on these directions, 27% indicated

likely, 3% indicated neither likely nor unlikely, 1% indicated unlikely and 1% indicted highly unlikely for them to take action on emergency management officials' directions, as shown in Figure F-21.

"Which of the following emergency communication methods do you think is most likely to alert you at your residence?" This question is designed to elicit information regarding the most efficient way to alert residents within the EPZ. Approximately 68% of households indicated that a text message from emergency officials would be most likely to alert them at their residence, about 27% indicated that a siren sounding near their home would be the most likely method, about 2% indicated an alert broadcast on the TV, about 3% indicated that a phone call/text message from a family member, friend or neighbor, and less than 1% indicated that an alert broadcast on the radio, and/or information on Twitter or Facebook would be the most likely way to alert them at their residence, as shown in Figure F-22.

Table F-1. PINGP Demographic Survey Sampling Plan

Zip Code	EPZ Population (2010)	EPZ Households Within Zip Code (2010)	EPZ Population (2020)	EPZ Households Within Zip Code (2020)	Desired Samples	Samples Obtained
54003	173	71	188	70	3	0
54011	2,402	877	2,364	903	33	26
54014	2,232	895	2,329	967	34	31
54021	1,891	645	2,211	764	24	26
54022	179	66	186	75	2	5
54723	930	378	851	375	14	6
55009	264	101	301	108	4	12
55027	7	2	5	2	0	6
55033	3,037	1,030	2,997	1,061	39	94
55066	17,546	7,423	17,606	7,598	279	210
55089	1,814	664	1,894	699	25	10
Total EPZ	**30,475**	**12,152**	**30,932**	**12,622**	**457**	**426**
Ave HH Size	**2.51**		**2.45**			

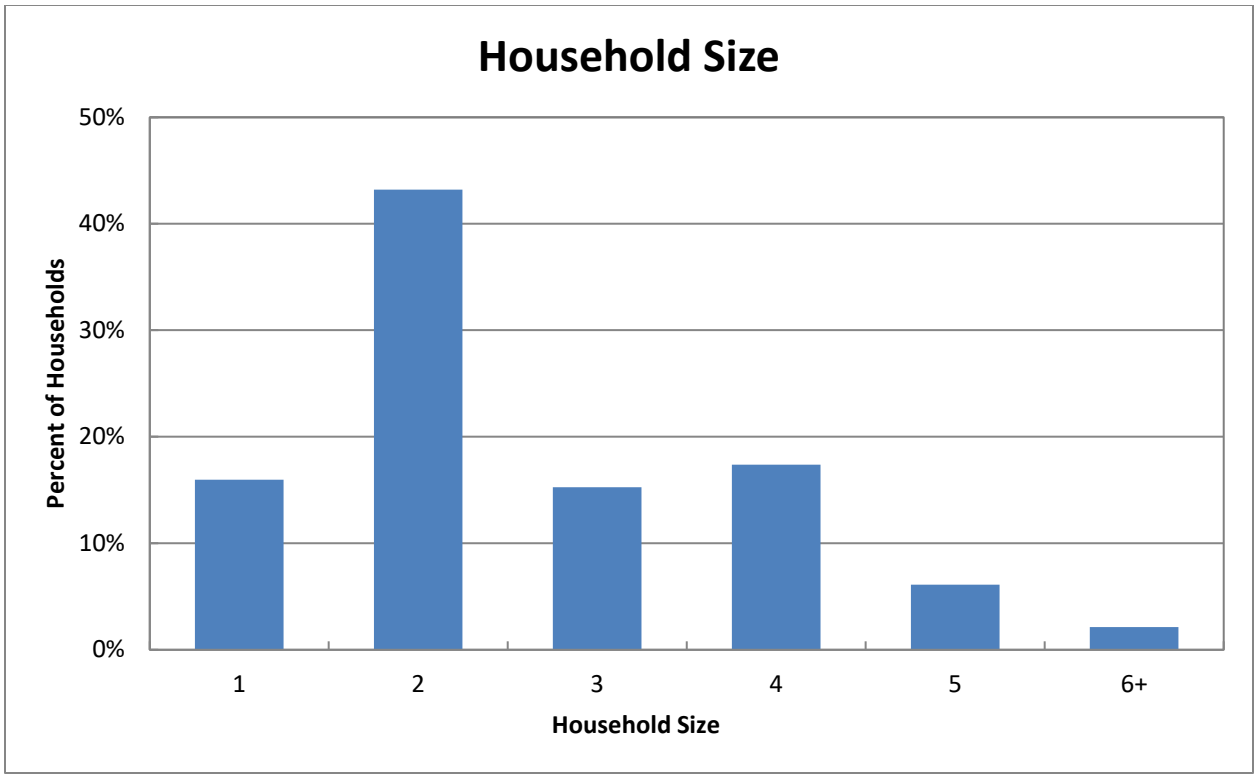


Figure F-1. Household Size in the EPZ

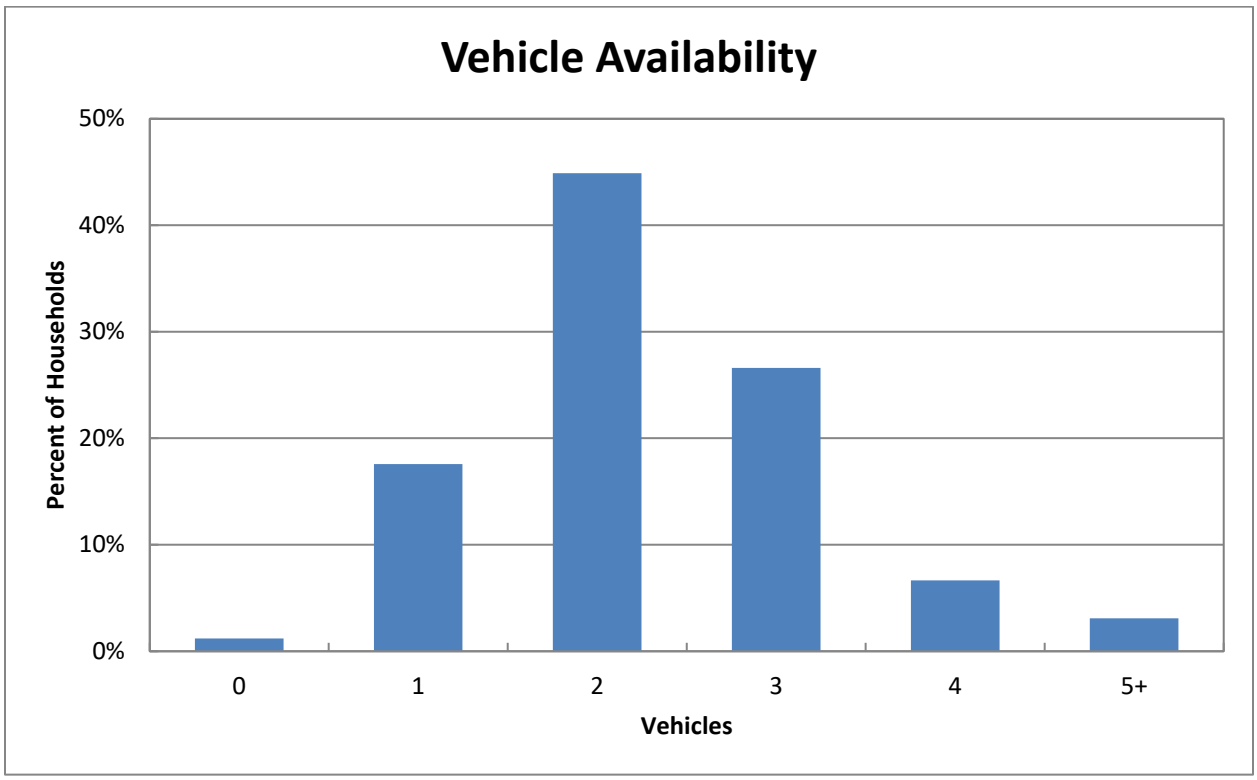


Figure F-2. Household Vehicle Availability

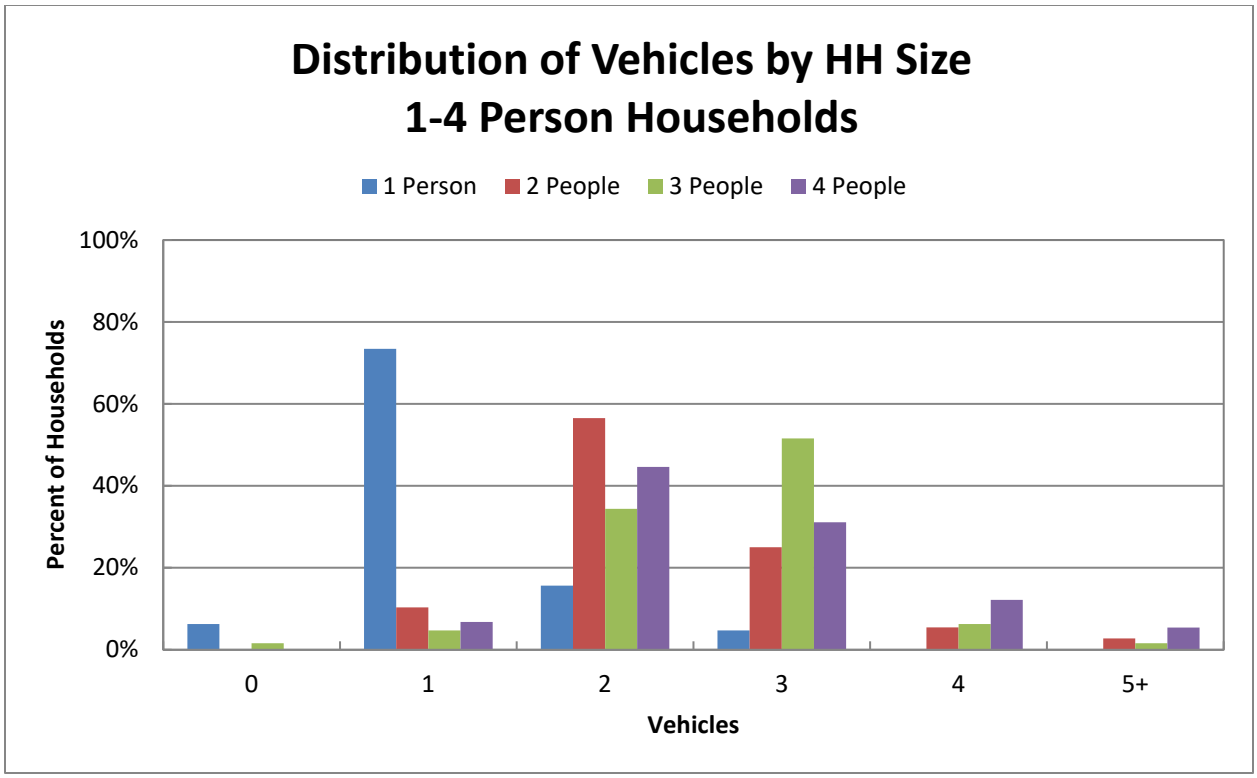


Figure F-3. Vehicle Availability - 1 to 4 Person Households

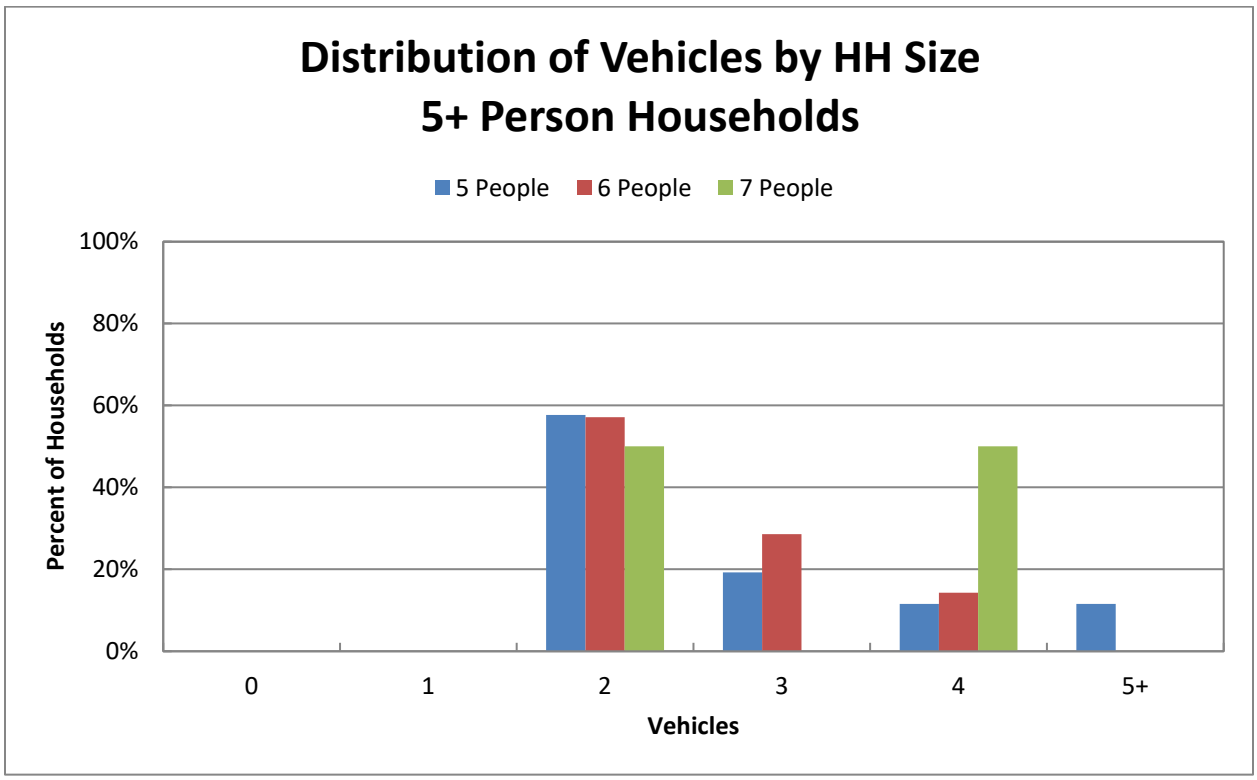


Figure F-4. Vehicle Availability - 5+ Person Households

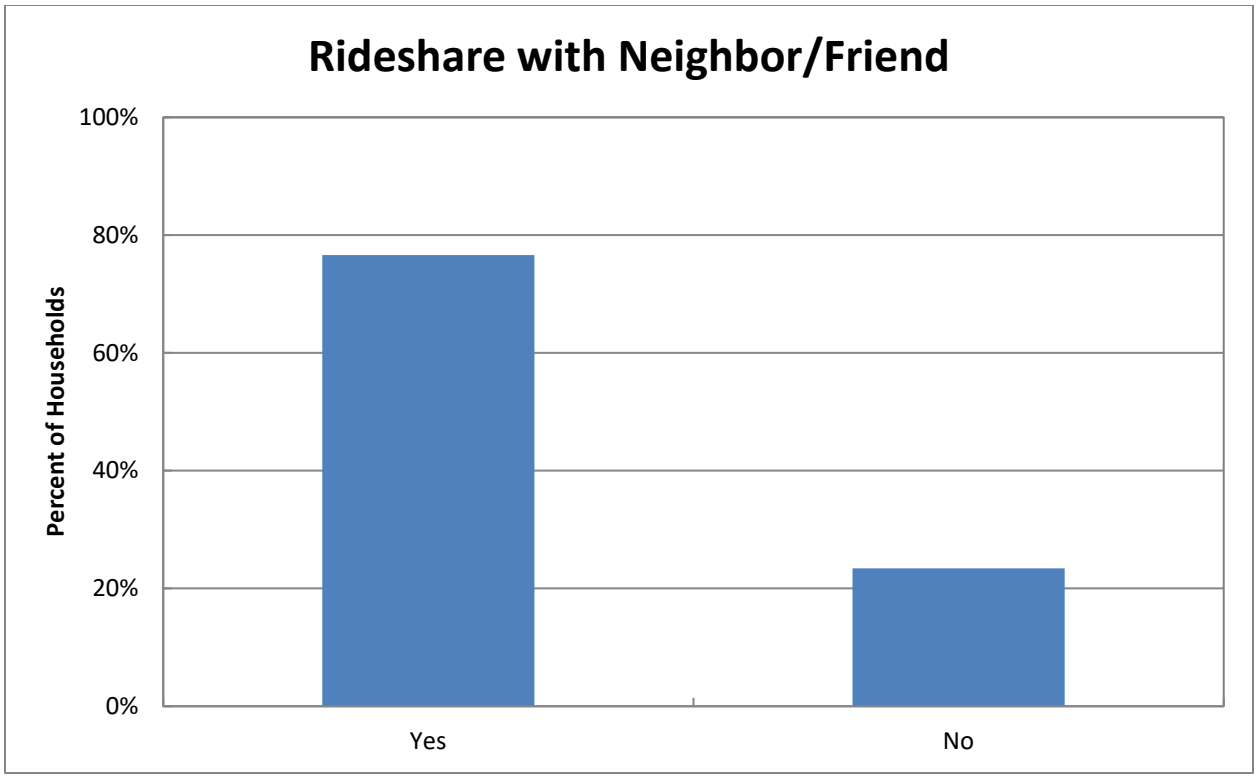


Figure F-5. Household Ridesharing Preference

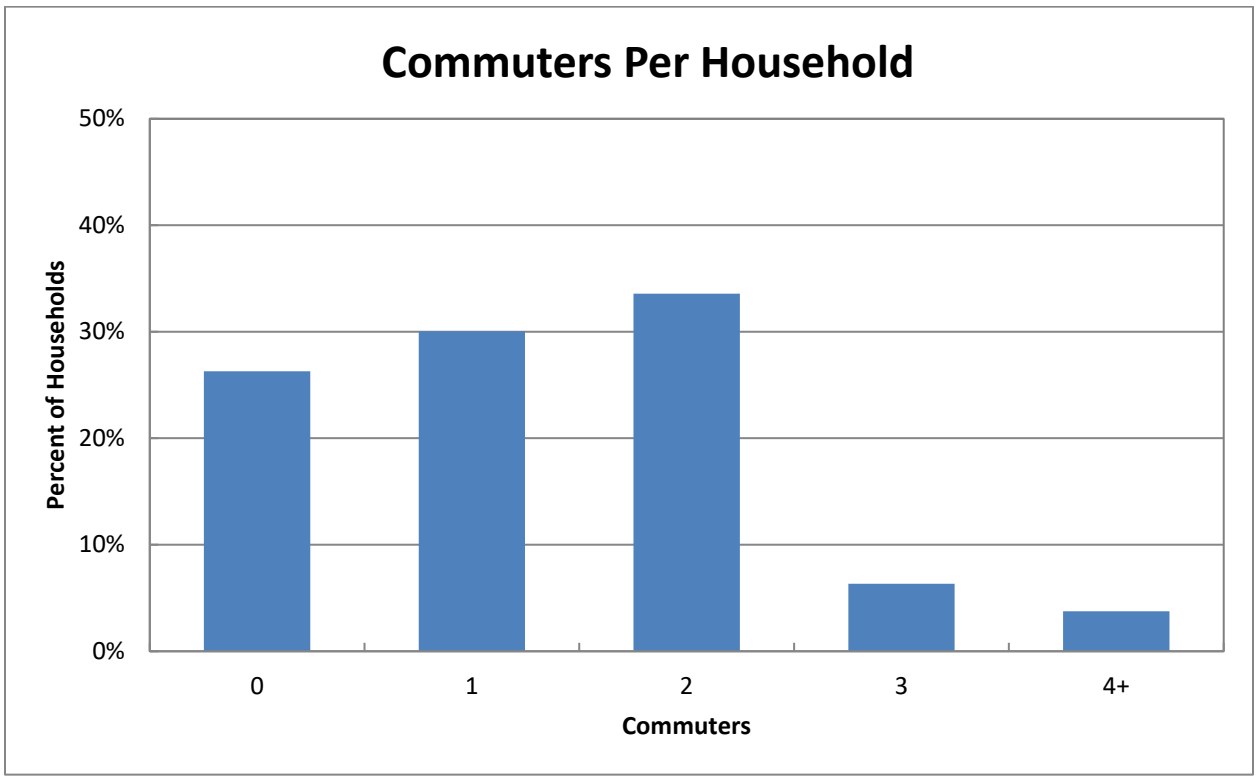


Figure F-6. Commuters in Households in the EPZ

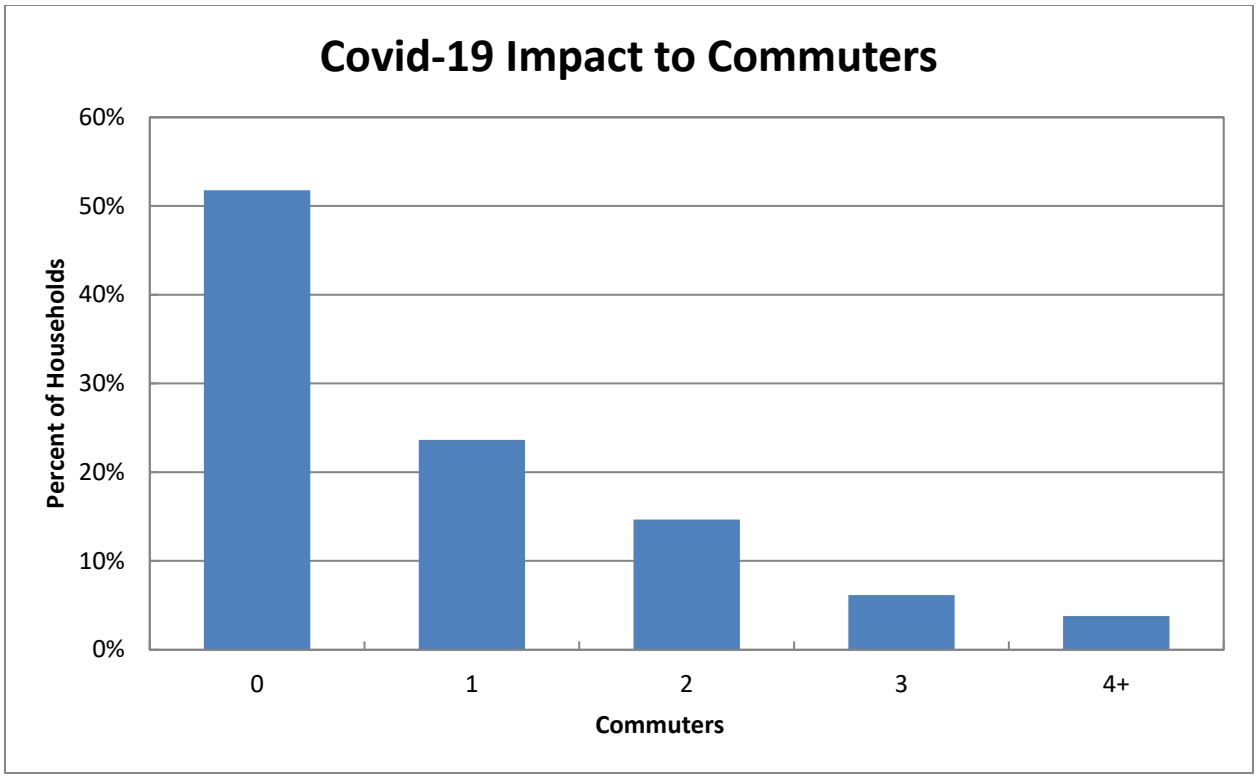


Figure F-7. Impact to Commuters due to the COVID-19 Pandemic

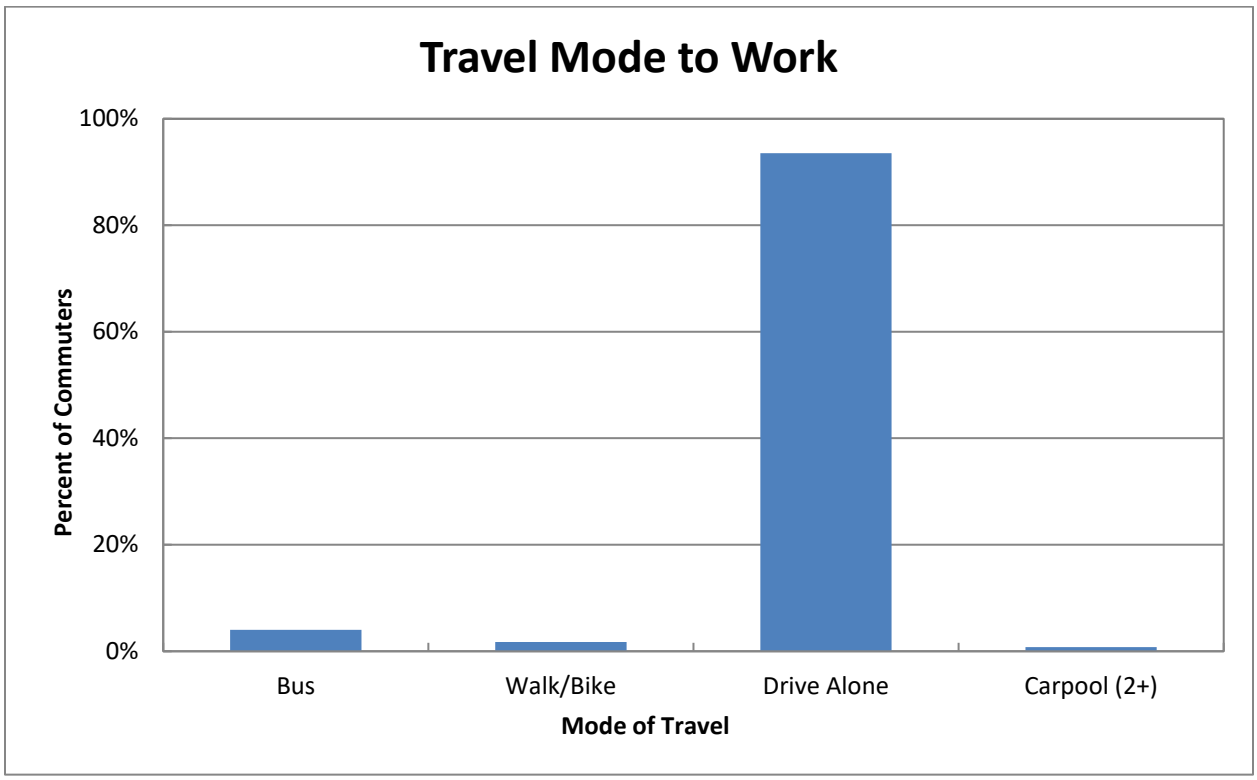


Figure F-8. Modes of Travel in the EPZ

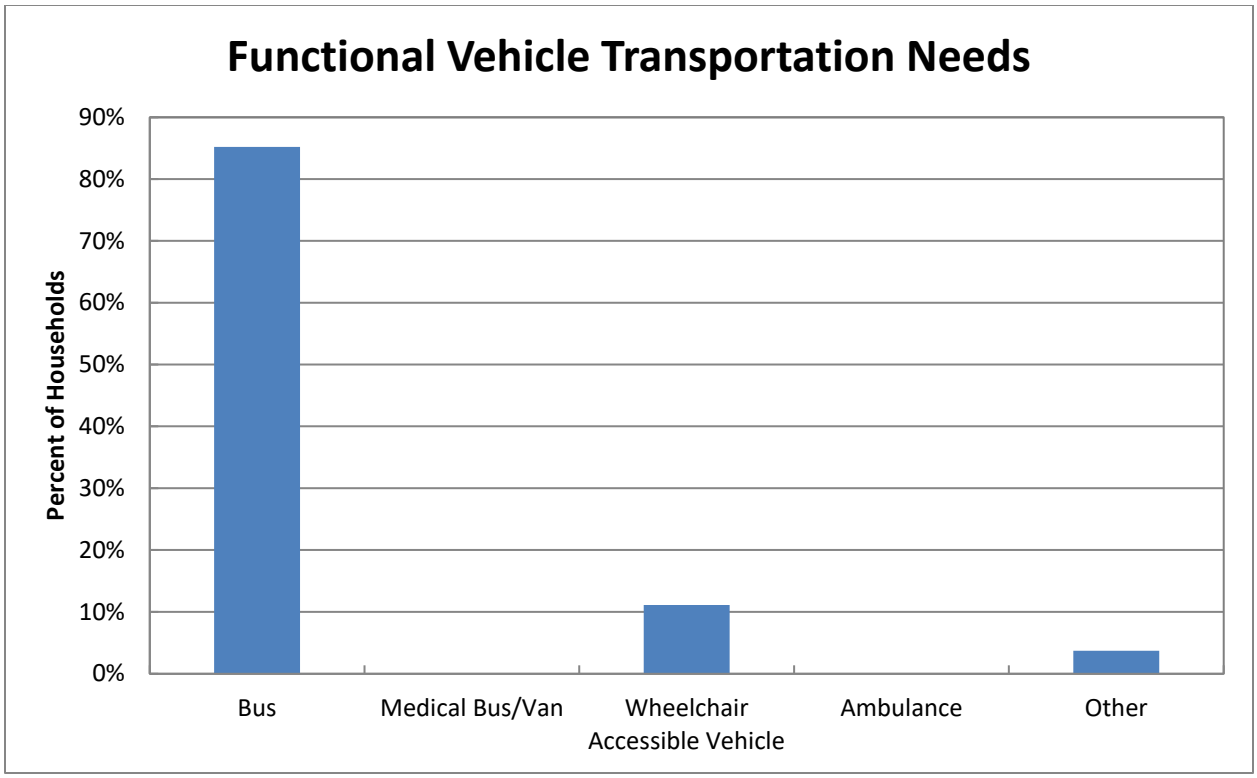


Figure F-9. Households with Functional or Transportation Needs

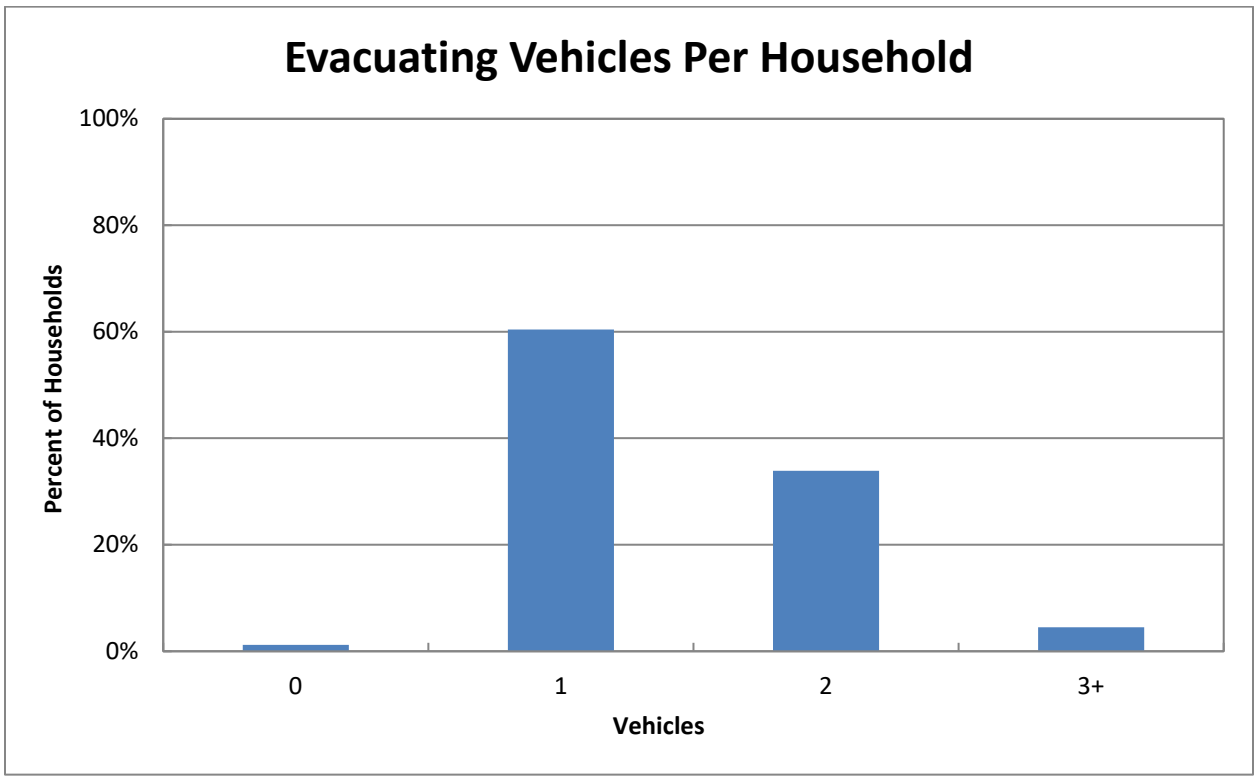


Figure F-10. Number of Vehicles Used for Evacuation

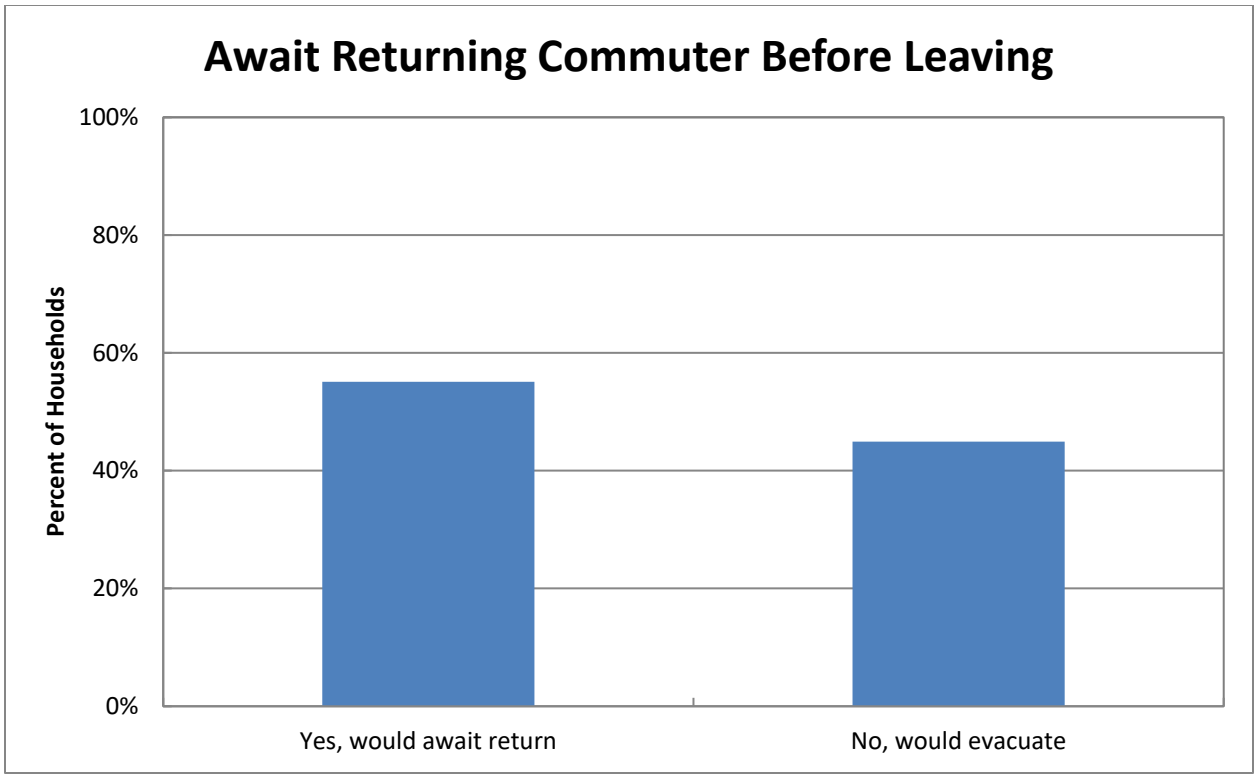


Figure F-11. Percent of Households that Await Returning Commuter Before Leaving

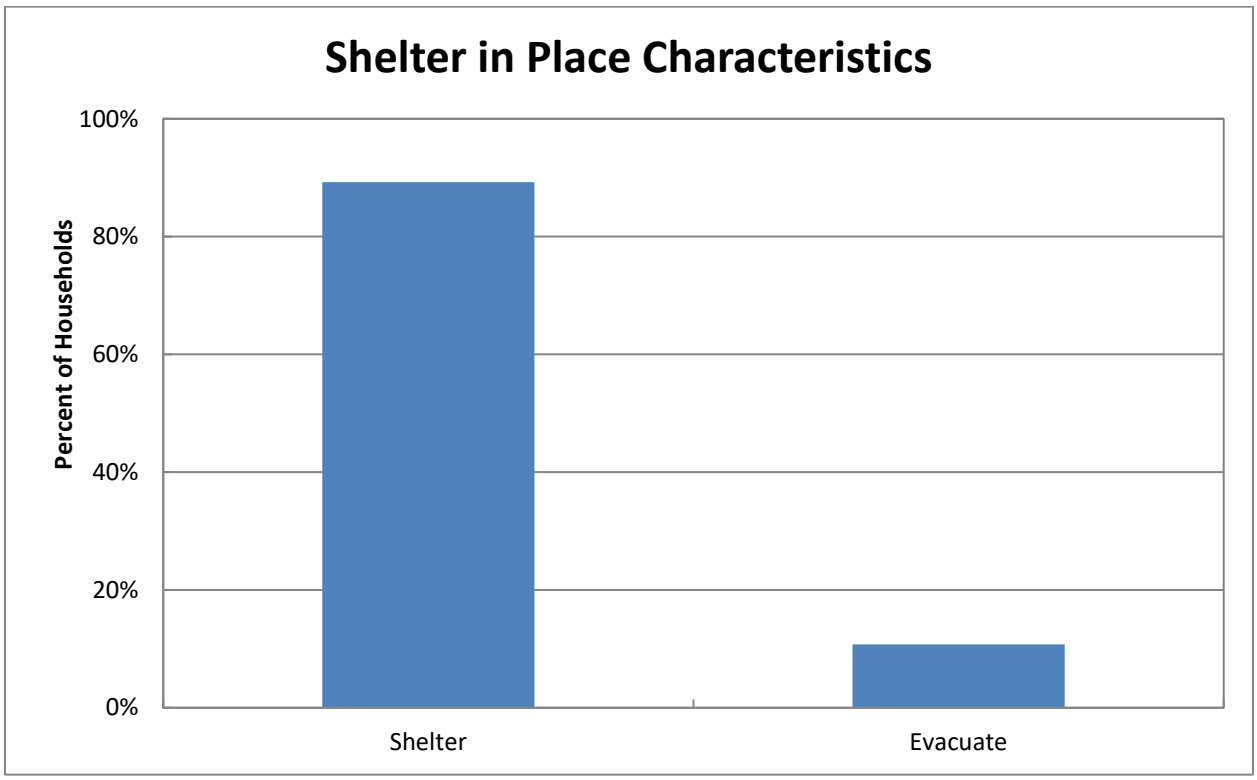


Figure F-12. Shelter-in-Place Characteristics

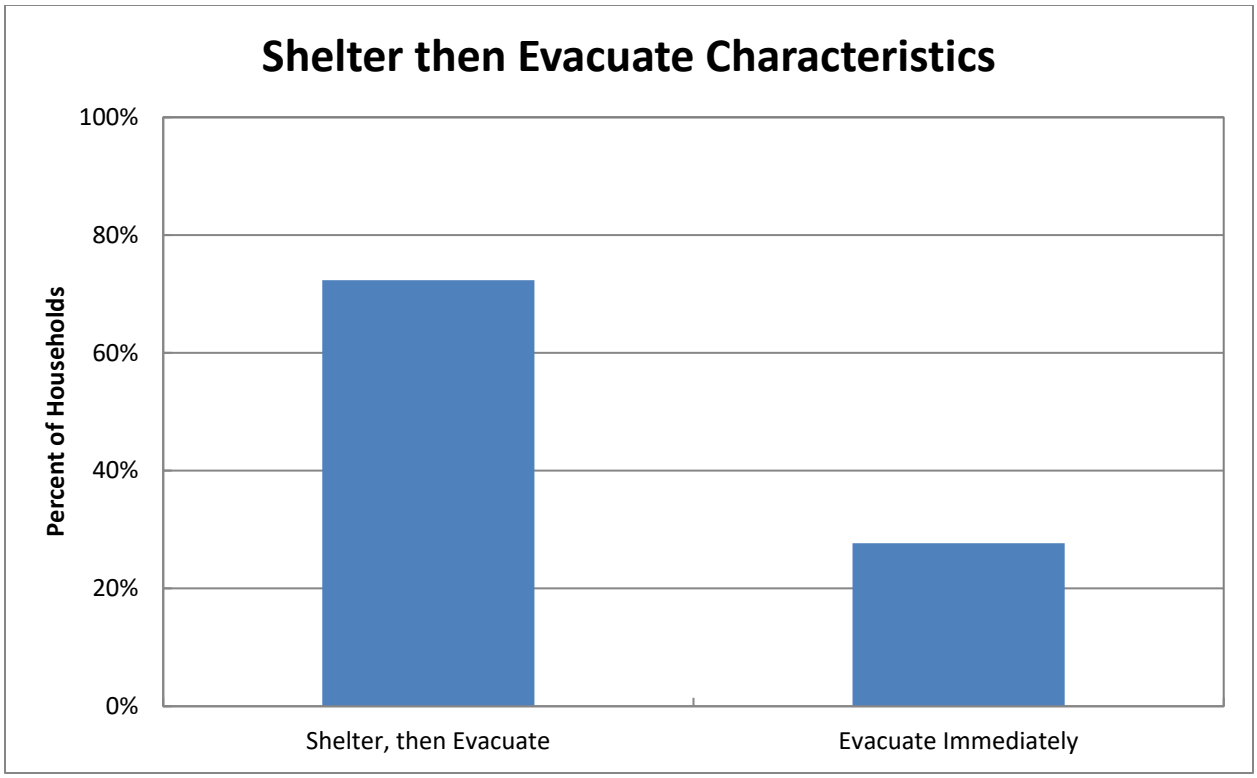


Figure F-13. Shelter then Evacuate Characteristics

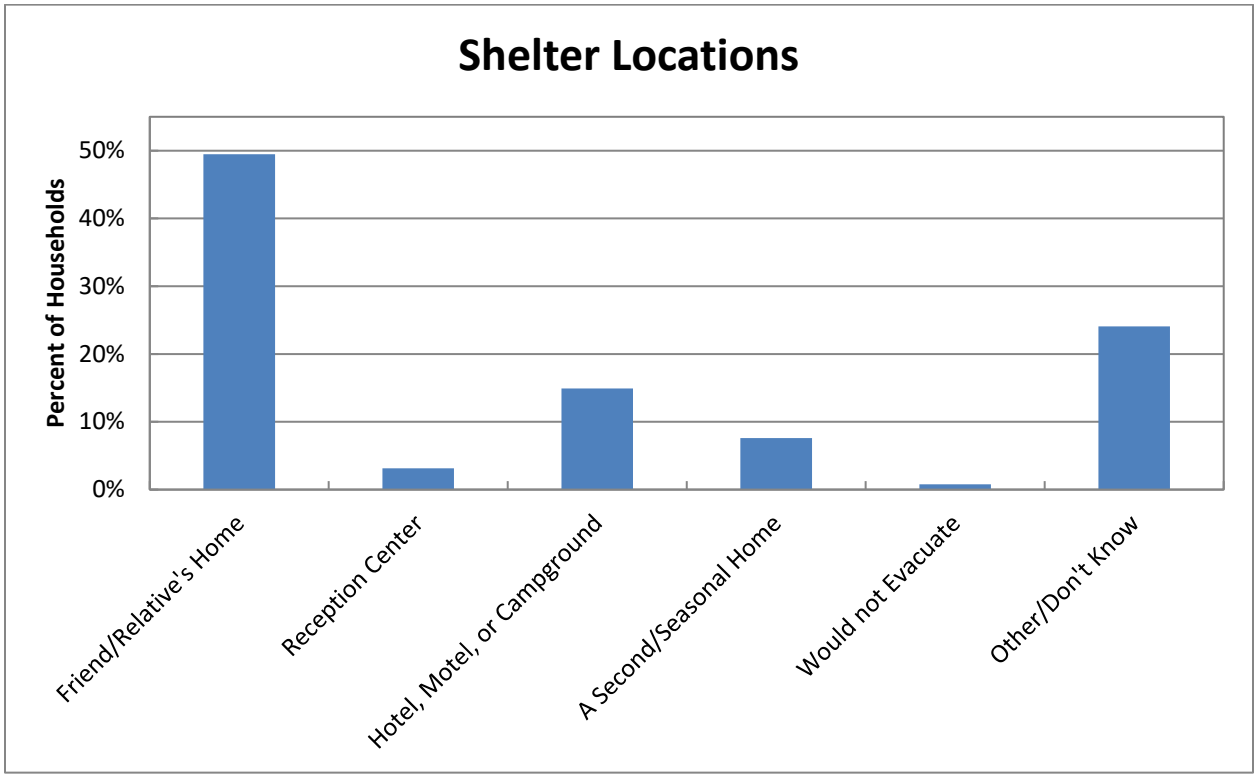


Figure F-14. Study Area Evacuation Destinations

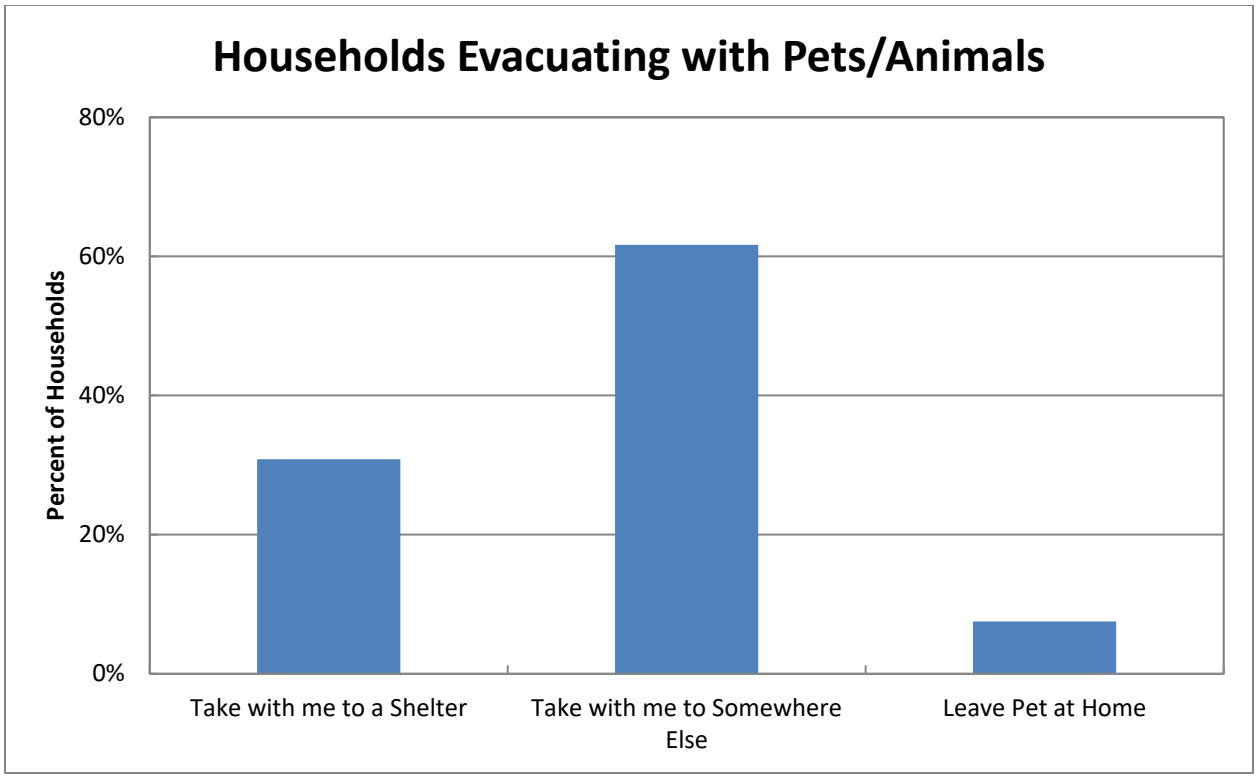


Figure F-15. Households Evacuating with Pets/Animals

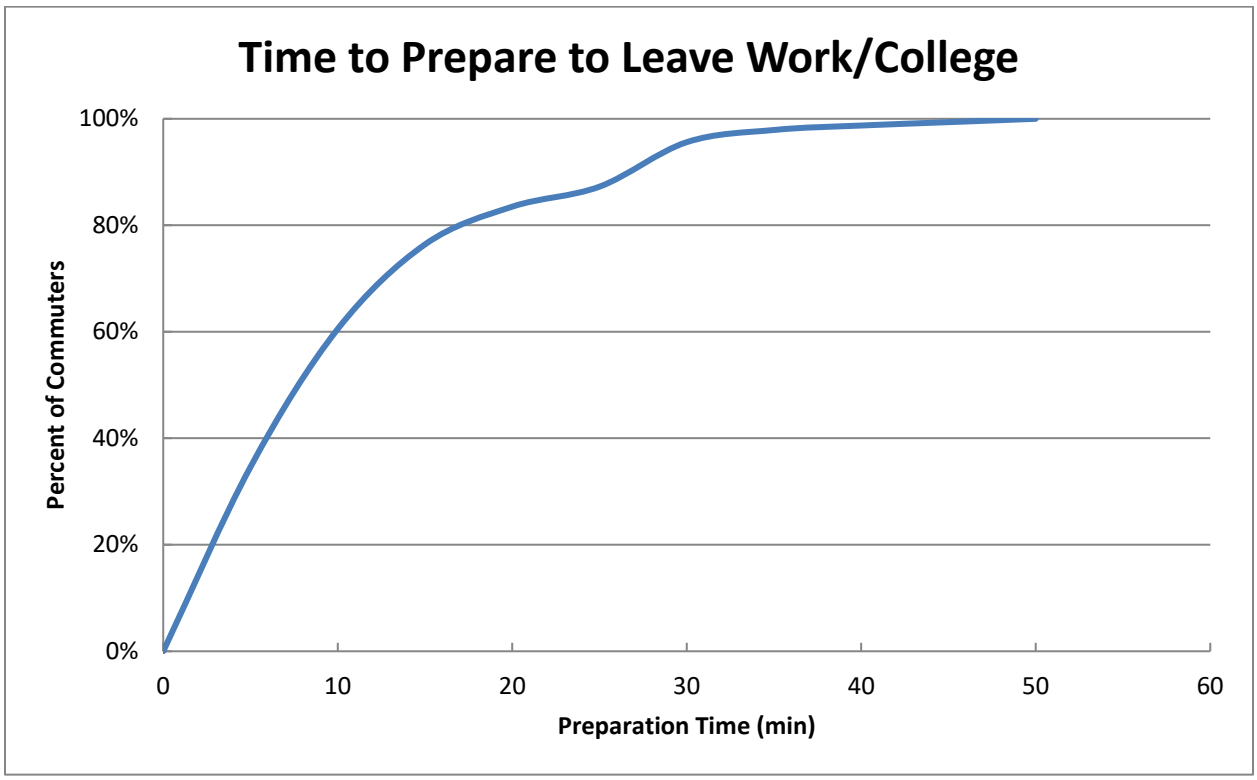


Figure F-16. Time Required to Prepare to Leave Work/College

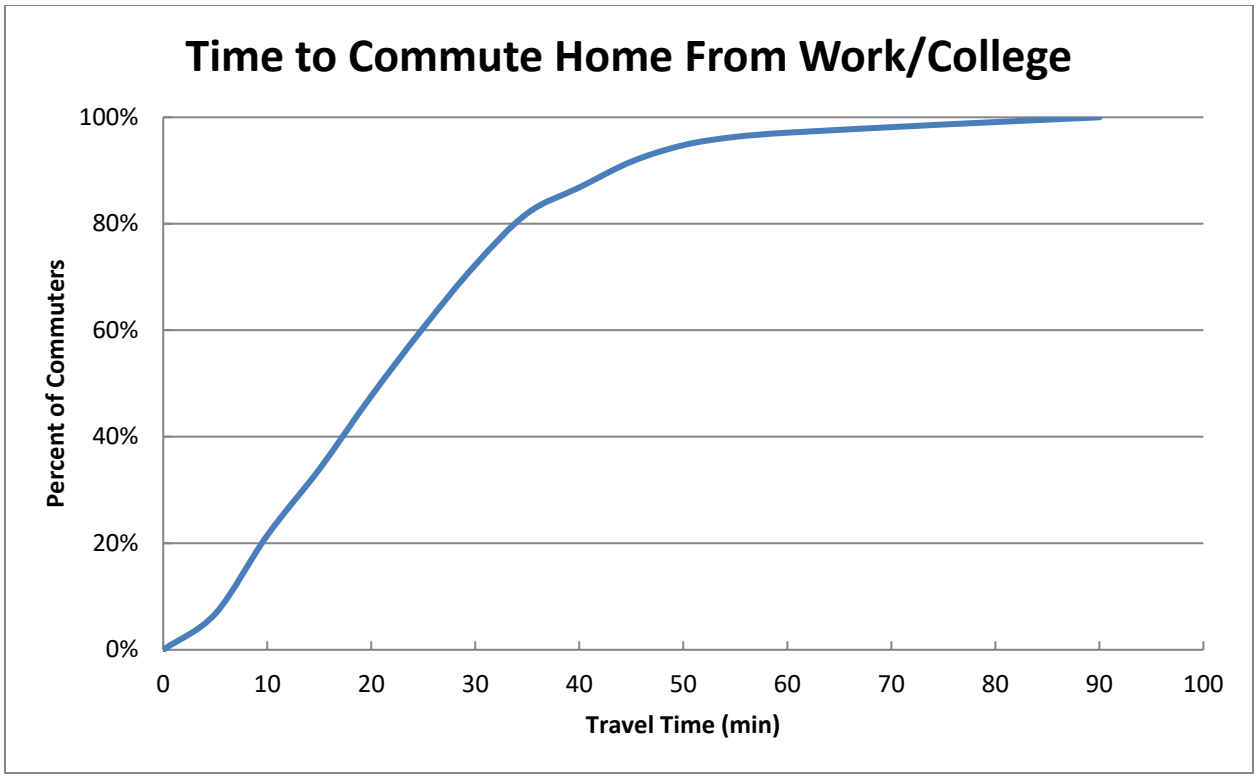


Figure F-17. Work/College to Home Travel Time

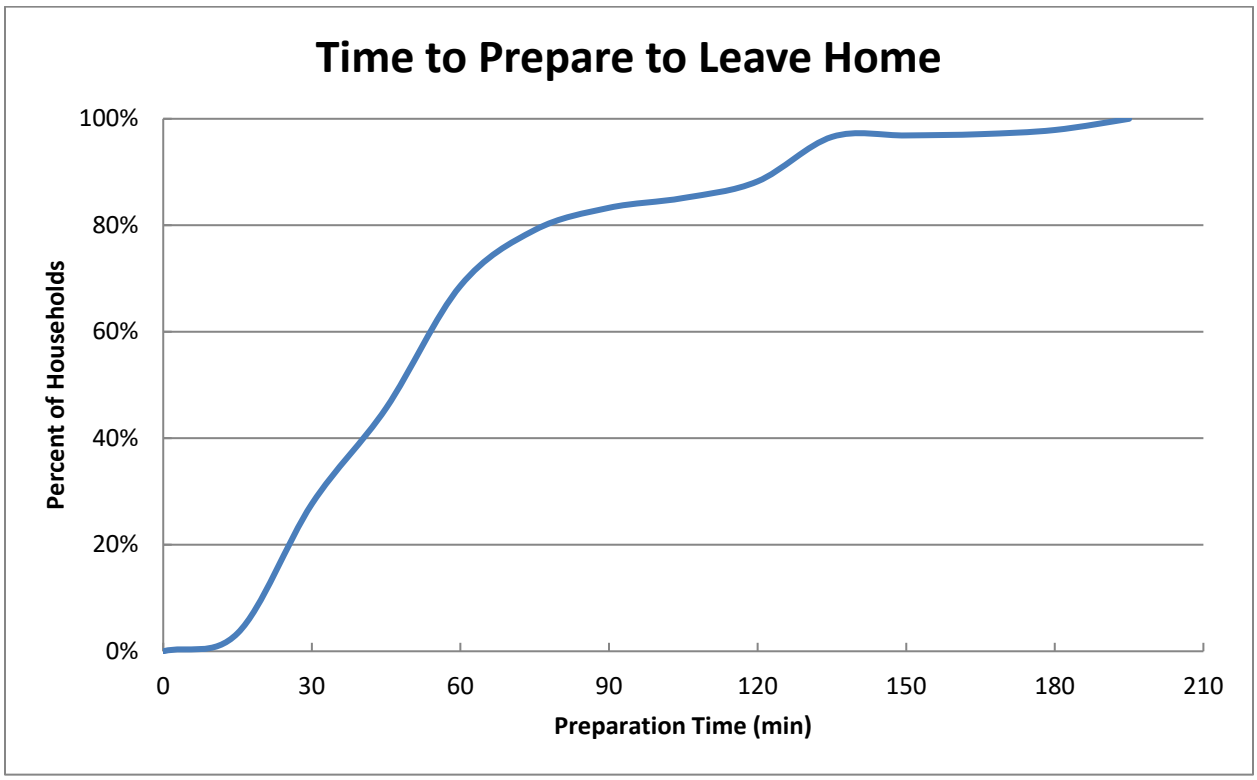


Figure F-18. Time to Prepare Home for Evacuation

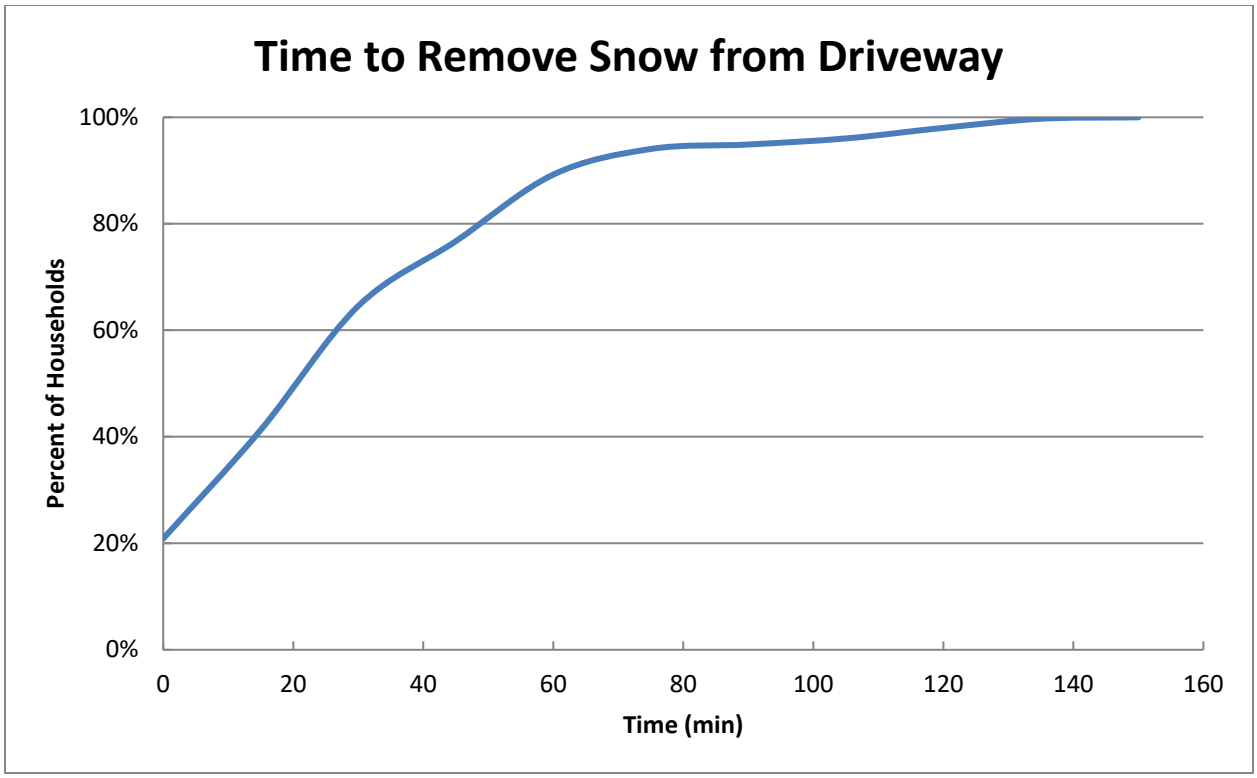


Figure F-19. Time to Remove 6-8 inches of Snow from Driveway

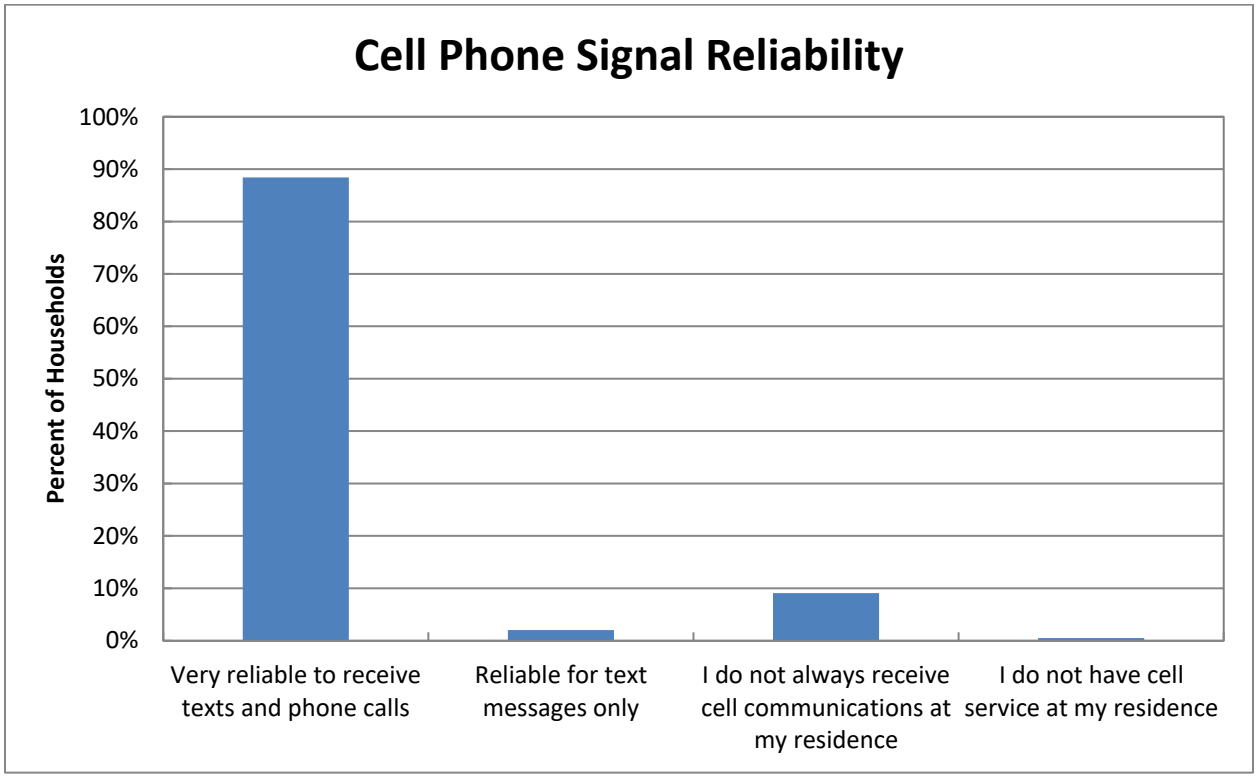


Figure F-20. Cell Phone Signal Reliability

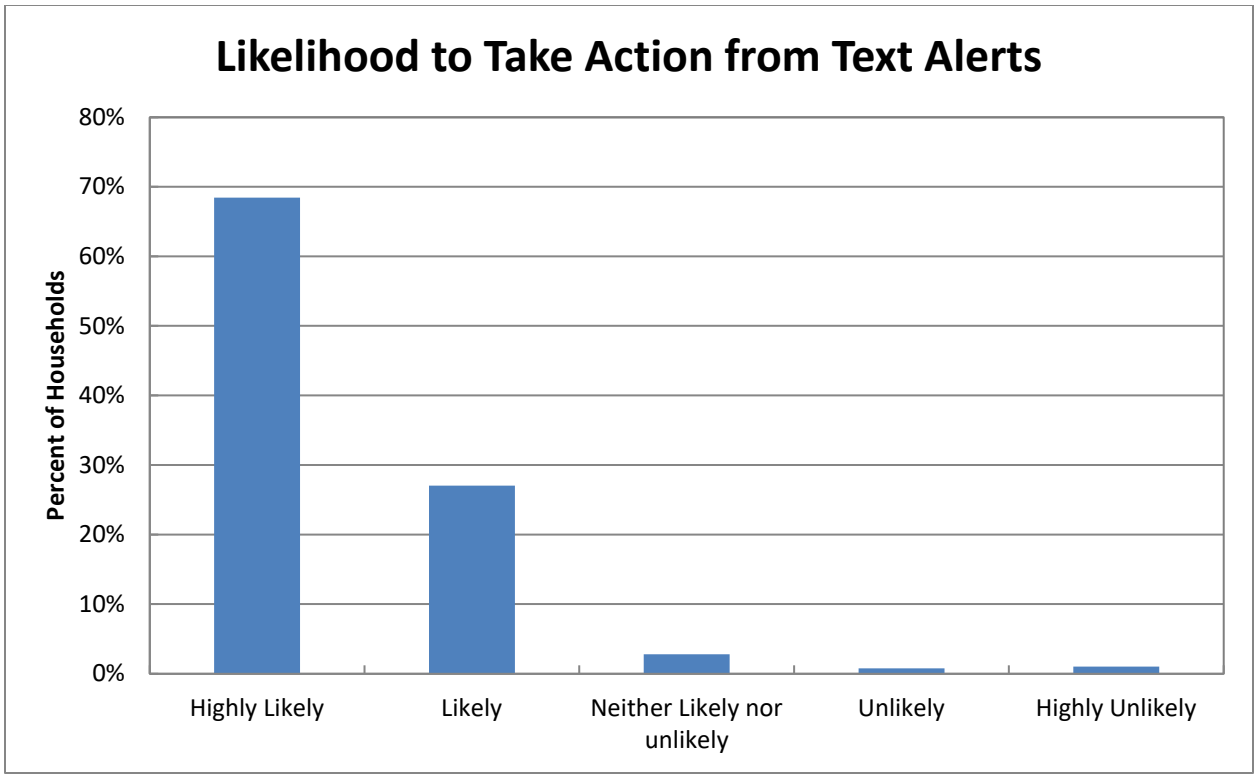


Figure F-21. Likelihood to Take Action Based off Emergency Management Officials Guidelines

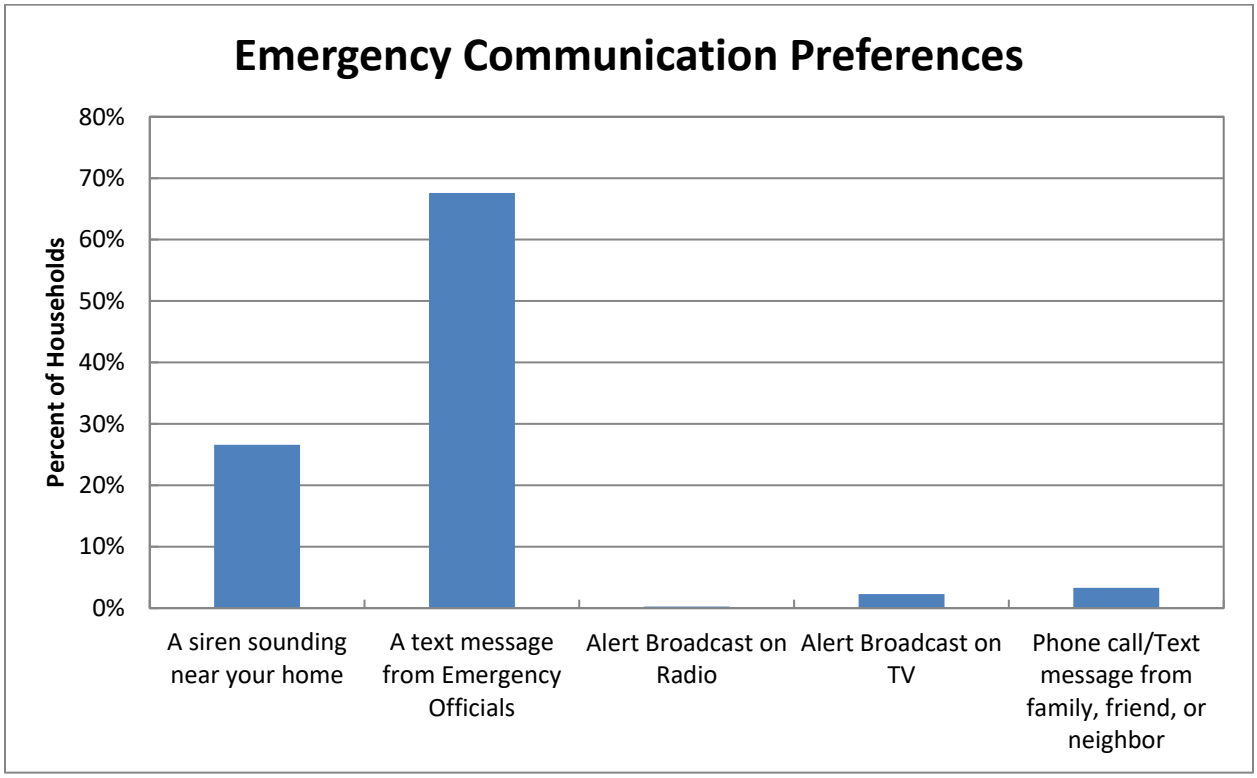


Figure F-22. Emergency Communication Alert

ATTACHMENT A

Demographic Survey Instrument

Prairie Island Nuclear Generating Plant Demographic Survey

* Required

Purpose

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

1. 1. What is your gender?

   Mark only one oval.

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

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

   _____

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

Mark only one oval.

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

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

Mark only one oval.

- YES
- NO
- DECLINE TO STATE

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

Mark only one oval.

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

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

Mark only one oval.

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

Skip to question 7

COVID-19

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

Mark only one oval.

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

Skip to question 8

Commuters

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

Mark only one oval.

- ZERO *Skip to question 53*
- ONE *Skip to question 9*
- TWO *Skip to question 10*
- THREE *Skip to question 11*
- FOUR OR MORE *Skip to question 12*
- DECLINE TO STATE *Skip to question 53*

Mode of Travel

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

Mark only one oval per row.

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

Skip to question 13

Mode of Travel

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

Mark only one oval per row.

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

Skip to question 15

Mode of Travel

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

Mark only one oval per row.

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

Skip to question 19

Mode of Travel

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

Mark only one oval per row.

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

Skip to question 25

Travel Home From Work/College

13. 9-1. How much time on average, would it take Commuter #1 to travel home from work or college?

Mark only one oval.

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

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

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

_____

Skip to question 33

Travel Home From Work/College

15. 9-1. How much time on average, would it take Commuter #1 to travel home from work or college?

Mark only one oval.

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

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

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

_____

17. 9-2. How much time on average, would it take Commuter #2 to travel home from work or college?

Mark only one oval.

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

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

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

_____

Skip to question 35

Travel Home From Work/College

19. 9-1. How much time on average, would it take Commuter #1 to travel home from work or college?

Mark only one oval.

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

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

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

_____

21. 9-2. How much time on average, would it take Commuter #2 to travel home from work or college?

Mark only one oval.

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

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

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

_____

23. 9-3. How much time on average, would it take Commuter #3 to travel home from work or college?

Mark only one oval.

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

24. If Over 2 Hours for Question 9-3, Specify Here

leave blank if your answer for Question 9-3, is under 2 hours.

_____

Skip to question 39

Travel Home From Work/College

25. 9-1. How much time on average, would it take Commuter #1 to travel home from work or college?

Mark only one oval.

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

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

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

_____

27. 9-2. How much time on average, would it take Commuter #2 to travel home from work or college?

Mark only one oval.

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

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

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

_____

29. 9-3. How much time on average, would it take Commuter #3 to travel home from work or college?

Mark only one oval.

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

30. If Over 2 Hours for Question 9-3, Specify Here

leave blank if your answer for Question 9-3, is under 2 hours.

_____

31. 9-4. How much time on average, would it take Commuter #4 to travel home from work or college?

Mark only one oval.

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

32. If Over 2 Hours for Question 9-4, Specify Here

leave blank if your answer for Question 9-4, is under 2 hours.

_____

Skip to question 45

Preparation to leave Work/College

33. 10-1. Approximately how much time would it take Commuter #1 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

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

34. If Over 2 Hours for Question 10-1, Specify Here

leave blank if your answer for Question 10-1, is under 2 hours.

_____

Skip to question 53

Preparation to leave Work/College

35. 10-1. Approximately how much time would it take Commuter #1 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

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

36. If Over 2 Hours for Question 10-1, Specify Here

leave blank if your answer for Question 10-1, is under 2 hours.

_____

37. 10-2. Approximately how much time would it take Commuter #2 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

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

38. If Over 2 Hours for Question 10-2, Specify Here

leave blank if your answer for Question 10-2, is under 2 hours.

_____

Skip to question 53

Preparation to leave Work/College

39. 10-1. Approximately how much time would it take Commuter #1 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

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

40. If Over 2 Hours for Question 10-1, Specify Here

leave blank if your answer for Question 10-1, is under 2 hours.

_____

41. 10-2. Approximately how much time would it take Commuter #2 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

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

42. If Over 2 Hours for Question 10-2, Specify Here

leave blank if your answer for Question 10-2, is under 2 hours.

_____

43. 10-3. Approximately how much time would it take Commuter #3 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

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

44. If Over 2 Hours for Question 10-3, Specify Here

leave blank if your answer for Question 10-3, is under 2 hours.

_____

Skip to question 53

Preparation to leave Work/College

45. 10-1. Approximately how much time would it take Commuter #1 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

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

46. If Over 2 Hours for Question 10-1, Specify Here

leave blank if your answer for Question 10-1, is under 2 hours.

_____

47. 10-2. Approximately how much time would it take Commuter #2 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

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

48. If Over 2 Hours for Question 10-2, Specify Here

leave blank if your answer for Question 10-2, is under 2 hours.

_____

49. 10-3. Approximately how much time would it take Commuter #3 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

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

50. If Over 2 Hours for Question 10-3, Specify Here

leave blank if your answer for Question 10-3, is under 2 hours.

_____

51. 10-4. Approximately how much time would it take Commuter #4 to complete preparation for leaving work or college prior to starting the trip home?

Mark only one oval.

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

52. If Over 2 Hours for Question 10-4, Specify Here

leave blank if your answer for Question 10-4, is under 2 hours.

_____

Skip to question 53

Additional Questions

53. 11. If you were advised by local authorities to evacuate, how much time would it take the household to pack clothing, medications, secure the house, load the car, and complete preparations prior to evacuating the area?

Mark only one oval.

- LESS THAN 15 MINUTES
- 15-30 MINUTES
- 31-45 MINUTES
- 46 MINUTES - 1 HOUR
- 1 HOUR TO 1 HOUR 15 MINUTES
- 1 HOUR 16 MINUTES TO 1 HOUR 30 MINUTES
- 1 HOUR 31 MINUTES TO 1 HOUR 45 MINUTES
- 1 HOUR 46 MINUTES TO 2 HOURS
- 2 HOURS TO 2 HOURS 15 MINUTES
- 2 HOURS 16 MINUTES TO 2 HOURS 30 MINUTES
- 2 HOURS 31 MINUTES TO 2 HOURS 45 MINUTES
- 2 HOURS 46 MINUTES TO 3 HOURS
- 3 HOURS TO 3 HOURS 15 MINUTES
- 3 HOURS 16 MINUTES TO 3 HOURS 30 MINUTES
- 3 HOURS 31 MINUTES TO 3 HOURS 45 MINUTES
- 3 HOURS 46 MINUTES TO 4 HOURS
- 4 HOURS TO 4 HOURS 15 MINUTES
- 4 HOURS 16 MINUTES TO 4 HOURS 30 MINUTES
- 4 HOURS 31 MINUTES TO 4 HOURS 45 MINUTES
- 4 HOURS 46 MINUTES TO 5 HOURS
- 5 HOURS TO 5 HOURS 30 MINUTES
- 5 HOURS 31 MINUTES TO 6 HOURS
- OVER 6 HOURS
- WILL NOT EVACUATE
- DECLINE TO STATE

54. If Over 6 Hours for Question 11, Specify Here

leave blank if your answer for Question 11, is under 6 hours.

55. 12. If there are 6-8 inches of snow on your driveway or curb, would you need to shovel out to evacuate? If yes, how much time, on average, would it take you to clear the 6-8 inches of snow to move the car from the driveway or curb to begin the evacuation trip? Assume the roads are passable.

Mark only one oval.

- LESS THAN 15 MINUTES
- 15-30 MINUTES
- 31-45 MINUTES
- 46 MINUTES – 1 HOUR
- 1 HOUR TO 1 HOUR 15 MINUTES
- 1 HOUR 16 MINUTES TO 1 HOUR 30 MINUTES
- 1 HOUR 31 MINUTES TO 1 HOUR 45 MINUTES
- 1 HOUR 46 MINUTES TO 2 HOURS
- 2 HOURS TO 2 HOURS 15 MINUTES
- 2 HOURS 16 MINUTES TO 2 HOURS 30 MINUTES
- 2 HOURS 31 MINUTES TO 2 HOURS 45 MINUTES
- 2 HOURS 46 MINUTES TO 3 HOURS
- NO, WILL NOT SHOVEL OUT
- OVER 3 HOURS
- DECLINE TO STATE

56. If Over 3 Hours for Question 12, Specify Here

leave blank if your answer for Question 12, is under 3 hours.

57. 13. Please specify the number of people in your household who require Functional or Transportation needs in an evacuation:

Mark only one oval per row.

	0	1	2	3	4	More than 4
Bus						
Medical Bus/Van						
Wheelchair Accessible Vehicle						
Ambulance						
Other						

58. Specify "Other" Transportation Need Below

_____

59. 14. Please choose one of the following:

Mark only one oval.

- I would await the return of household members to evacuate together.
- I would evacuate independently and meet other household members later.
- Decline to State

60. 15A. Emergency officials advise you to shelter-in-place in an emergency because you are not in the area of risk. Would you:

Mark only one oval.

- SHELTER-IN-PLACE
- EVACUATE
- DECLINE TO STATE

61. 15B. Emergency officials advise you to shelter-in-place now in an emergency and possibly evacuate later while people in other areas are advised to evacuate now. Would you:

Mark only one oval.

- SHELTER-IN-PLACE
- EVACUATE
- DECLINE TO STATE

62. 15C. Emergency officials advise you to evacuate due to an emergency. Where would you evacuate to?

Mark only one oval.

- A RELATIVE'S OR FRIEND'S HOME
- A RECEPTION CENTER
- A HOTEL, MOTEL OR CAMPGROUND
- A SECOND/SEASONAL HOME
- WOULD NOT EVACUATE
- DON'T KNOW
- OTHER (Specify Below)
- DECLINE TO STATE

63. Fill in OTHER answers for question 15C

_____

Emergency Communication

64. 16A. At your place of residence, how reliable is your cell phone signal?

Mark only one oval.

- VERY RELIABLE TO RECEIVE TEXTS AND PHONE CALLS
- RELIABLE FOR TEXT MESSAGES ONLY
- I DO NOT ALWAYS RECEIVE CELL COMMUNICATIONS AT MY RESIDENCE
- I DO NOT HAVE CELL SERVICE AT MY RESIDENCE

65. 16B. Emergency management officials in your state may send text messages, similar to AMBER Alerts, with emergency directions for the public during a radiological emergency at Prairie Island Nuclear Generating Plant. How likely would you be to take action on these directions, if you received the message?

Mark only one oval.

- HIGHLY LIKELY
- LIKELY
- NEITHER LIKELY NOR UNLIKELY
- UNLIKELY
- HIGHLY UNLIKELY

66. 16C. Which of the following emergency communication methods do you think is most likely to alert you at your residence?

Mark only one oval.

- A SIREN SOUNDING NEAR YOUR HOME
- A TEXT MESSAGE FROM EMERGENCY OFFICIALS
- ALERT BROADCAST ON RADIO
- ALERT BROADCAST ON TV
- INFORMATION ON TWITTER OR FACEBOOK
- PHONE CALL/TEXT MESSAGE FROM FAMILY, FRIEND, OR NEIGHBOR
- OTHER (Fill in)

67. 16D. Have you opted into your local Emergency Alert and Warning Systems?

Check all that apply.

- [ ] With Residential Phone
- [ ] With Cellular Phone
- [ ] With Email
- [ ] With Text Message
- [ ] Did not opt in
- [ ] Decline to State

Pet Questions

68. 17A. Do you have any pet(s) and/or animal(s)?

Mark only one oval.

- YES
- NO
- DECLINE TO STATE

Pet Questions

69. 17B. What type of pet(s) and/or animal(s) do you have?

Check all that apply.

- DOG
- CAT
- BIRD
- REPTILE
- HORSE
- FISH
- CHICKEN
- GOAT
- PIG
- OTHER SMALL PETS/ANIMALS (Specify Below)
- OTHER LARGE PETS/ANIMALS (Specify Below)
- Other: _____

70.

Mark only one oval.

- DECLINE TO STATE

Pet Questions

71. 17C. What would you do with your pet(s) and/or animal(s) if you had to evacuate?

Mark only one oval.

- ◯ TAKE PET WITH ME TO A SHELTER
- ◯ TAKE PET WITH ME SOMEWHERE ELSE
- ◯ LEAVE PET AT HOME
- ◯ DECLINE TO STATE

Pet Questions

72. 17D. Do you have sufficient room in your vehicle(s) to evacuate with your pet(s) and/or animal(s)?

Mark only one oval.

- ◯ YES
- ◯ NO
- ◯ WILL USE A TRAILER
- ◯ DECLINE TO STATE
- ◯ Other: _____

71. 17C. What would you do with your pet(s) and/or animal(s) if you had to evacuate?

Mark only one oval.

- ◯ TAKE PET WITH ME TO A SHELTER
- ◯ TAKE PET WITH ME SOMEWHERE ELSE
- ◯ LEAVE PET AT HOME
- ◯ DECLINE TO STATE

Pet Questions

72. 17D. Do you have sufficient room in your vehicle(s) to evacuate with your pet(s) and/or animal(s)?

Mark only one oval.

- ◯ YES
- ◯ NO
- ◯ WILL USE A TRAILER
- ◯ DECLINE TO STATE
- ◯ Other: _____

APPENDIX G

Traffic Management Plan

G. TRAFFIC MANAGEMENT PLAN

NUREG/CR-7002, Rev. 1 indicates that the existing Traffic and Access Control Points (TACPs) identified by the offsite agencies should be used in the evacuation simulation modeling. The traffic and access control plans for the Emergency Planning Zone (EPZ) were provided by the counties in the EPZ.

These plans were reviewed, and the TACPs were modeled accordingly. An analysis of the TACP locations was performed, and it was determined to model the ETE simulations with existing TACPs that were provided in the state and county radiological emergency plans, with no additional TACPs.

G.1 Manual Traffic Control

The TACPs are forms of Manual Traffic Control (MTC). As discussed in Section 9, TMC 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 TACP, the control type was changed to an actuated signal in the DYNEV II system, in accordance with Section 3.3 of NUREG/CR-7002, Rev. 1. MTCs at existing actuated traffic signalized intersections were essentially left alone.

Table K-1 provides the number of nodes with each control type in the analysis network. If the existing control was changed due to the point being a TACP, the control type is indicated as "TACP" in Table K-1. The TACPs within the TMP are mapped as green dots in Figure G-1. The TACPs are concentrated along Sub-Area boundaries and would be staffed during evacuation by traffic guides who would direct evacuees in the proper direction away from the plant, facilitate the flow of traffic through the intersections and stop the flow of traffic into the EPZ. No additional locations for MTC are suggested in this study.

It is assumed that the ACPs will be established within 120 minutes of the advisory to evacuate (ATE) to discourage through travelers from using major through routes which traverse the study area. As discussed in Section 3.11, external traffic was considered on US-52 and US-61 in this analysis.

G.2 Analysis of Key TACP Locations

As discussed in Section 5.2 of NUREG/CR-7002, Rev. 1, MTC at intersections could benefit from the ETE analysis. The MTC locations contained within the traffic management plans (TMPs) were analyzed to determine key locations where MTC would be most useful and could be readily implemented. As previously mentioned, signalized intersections that were actuated based on field data collection were essentially left as actuated traffic signals in the model, with modifications to green time allocation as needed. Other controlled intersections (pre-timed signals, stop signs and yield signs) were changed to actuated traffic signals to represent the MTC that would be implemented according to the TMPs.

Table G-1 shows a list of the controlled intersections that were included in the model and that were identified as MTC points in the TMPs that are not at actuated signals, including the type of control that currently exists at each location. To determine the impact of MTC at these locations, a summer, weekend, midday, with good weather scenario (Scenario 3) evacuation of the 2-Mile Region, 5-Mile Region and entire EPZ (Regions R01, R02, and R03, respectively) were simulated wherein these intersections were left as is (without MTC). The results were compared to the results presented in Section 7 and are shown in Table G-2. The 90th percentile ETE significantly increased – 1 hour and 50 minutes, 55 minutes, and 20 minutes increases for Regions R01, R02, and R03, respectively during Scenario 3 conditions – when compared to the base case wherein these controlled intersections were modeled as actuated signals (with MTC). As discussed in Section 7, the trip mobilization dictates the 100th percentile ETE, as a result, the MTC has no impact on the 100th percentile ETE (as shown in Table G-2).

The evacuation animations were compared in the two cases to determine the critical intersections causing the significant change in 90th percentile ETE. One of the 18 intersections (intersection of Sturgeon Lake Rd and CR-18) listed in Table G-1 appeared to be more critical than the rest since the congestion on Sturgeon Lake Rd was significantly worse in the non-MTC animation. There are nearly 3,000 vehicles evacuating along Sturgeon Lake Rd on summer weekends due to employees at the plant and transients at the Treasure Island Resort & Casino (and even more vehicles on summer weekdays). These vehicles can only evacuate along Sturgeon Lake Rd where they meet Prairie Island Blvd/CR-18 at a stop sign. Stop signs can only process about 1,000 vehicles per hour. MTC (or signals) can process about 1,750 vehicles per hour. That's an additional 750 vehicles per hour (or 75% increase in capacity). As a result, this intersection was reverted back to a TACP and a summer, weekend, midday, good weather evacuation of the entire EPZ (Region R03) was simulated again. This intersection was, therefore, labeled as "Priority 1" and is listed as Priority 1 in Table G-1.

Table G-2 displays the results of this case as well labeled as "Priority 1 MTC Locations Only". When comparing the ETE to the base case with MTC, the 90th percentile ETE increased by 10 minutes, 5 minutes, and 5 minutes for Regions R01, R02, and R03, respectively – not a significant change. The 100th percentile ETE remained the same. As a result, this intersection was determined to be the most critical (first priority) with the remainder of the intersections listed in Table G-1 as Priority 2 locations for MTC.

Figure G-2 shows the congestion patterns of the case wherein all TACPs (MTC) are implemented (1), wherein no MTC is implemented (2), and when MTC is implemented at the priority 1 intersection only (3) at 1 hours and 30 minutes after the ATE. The patterns of congestion are similar between the All MTC (1) case and the Priority 1 MTC Only (3) case and both of these cases show less congestion than the No MTC (2) case.

Aside from the priority 1 intersection (Sturgeon Lake Rd and CR-18), the rest of the TACPs are in either less congested locations or in locations with heavy competing movements. When heavy traffic persists in competing directions, MTC provides little to no benefit since both approaches need equal amounts of 'green time'. Although there is no reduction in ETE when the remaining TACPs are implemented, TACPs can be beneficial in the reduction of localized congestion and

driver confusion and can be extremely helpful for fixed point surveillance, amongst other things. Should there be a shortfall of personnel to staff the TACPs, the list of TACPs provided in Table G-1 could be considered as key locations when implementing the TMP in the priority order shown.

Table G-1. List of Key Manual TACP Locations

TACP Number	Node Number	Intersection	Type of Control (Prior to being a TACP)	Priority
GCSO-2	684	Sturgeon Lake Rd & CR-18	Stop Control	1
MSP-8	701	US-61 & CR-18	Stop Control	2
MSP-18	41	US-61 Blvd & CR-21	Stop Control	2
5001	417	SR-35 & 570th Ave	Stop Control	2
5011	523	CR-E & 630th Ave	Stop Control	2
5012	809	CR-E & 620th Ave	Stop Control	2
5015	511	CR-E & US-10	Stop Control	2
5017	801	CR-E & 530th Ave	Stop Control	2
5018	797	CR-E & 521st Ave	Stop Control	2
5028	783	CR-O & 640th Ave	Stop Control	2
5029	793	CR-O & 570th Ave	Stop Control	2
5042	978	SR-35 & 985th St	Stop Control	2
5043	790	SR-35 & 290th Ave	Stop Control	2
5051	455	SR-35 & US-63	Stop Control	2
5057	771	US-63 & 350th Ave	Stop Control	2
5058	482	US-63 & CR-V	Stop Control	2
5071	502	US-10 & 730th St	Stop Control	2
5073	719	SR-65 & 490th Ave	Stop Control	2

Table G-2. ETE with No MTC

Region		Scenario 3								
		90th Percentile ETE					100th Percentile ETE				
	Base (with All MTC)	No MTC	Difference	Priority 1 MTC Locations Only	Difference	Base (with All MTC)	No MTC	Difference	Priority 1 MTC Locations Only	Difference
R01 (2-Mile Region)	2:05	3:50	1:50	2:15	0:10	4:30	4:30	0:00	4:30	0:00
R02 (5-Mile Region)	2:15	3:10	0:55	2:20	0:05	4:35	4:35	0:00	4:35	0:00
R03 (Full EPZ)	2:50	3:10	0:20	2:55	0:05	4:40	4:40	0:00	4:40	0:00

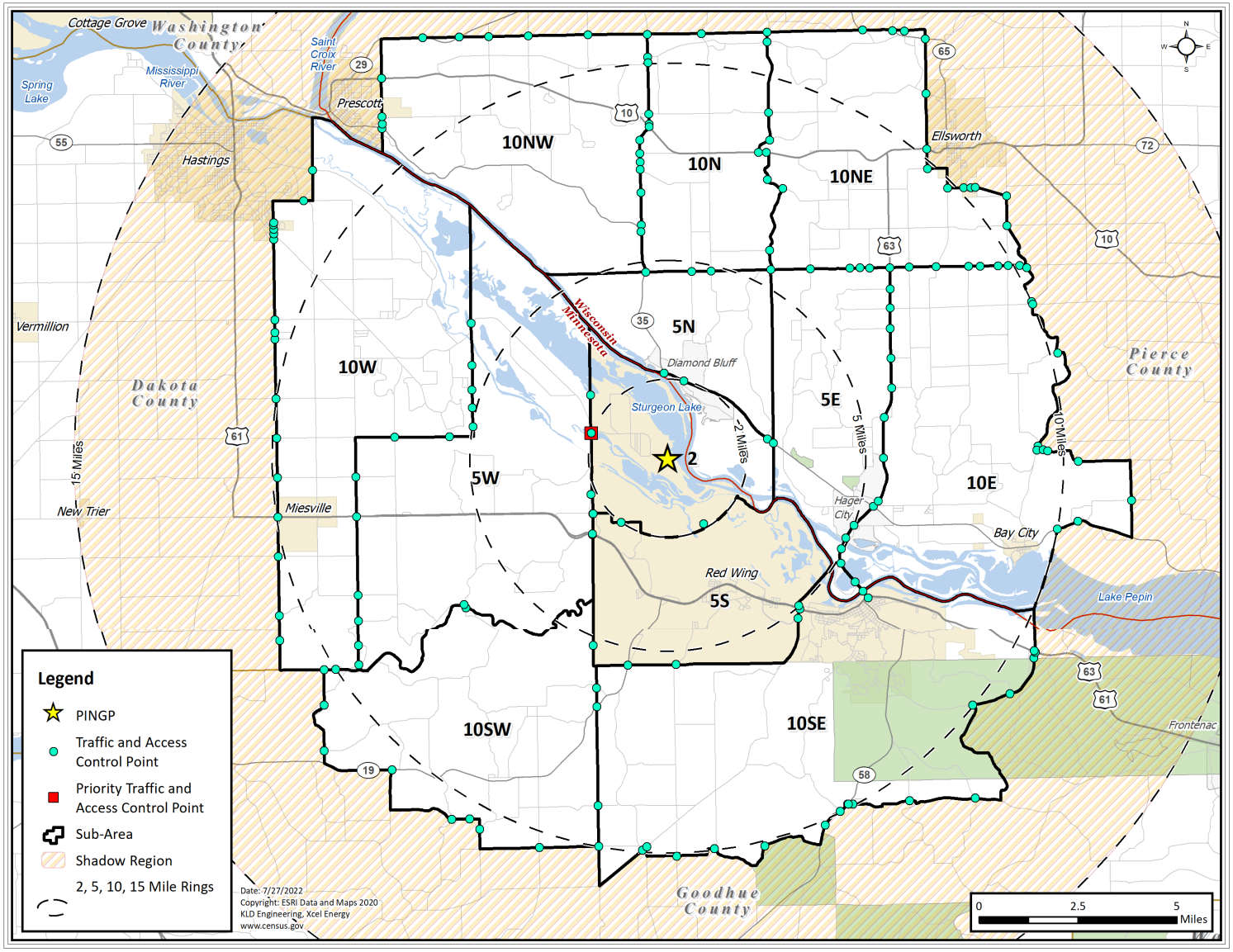


Figure G-1. Traffic and Access Control Points for PINGP

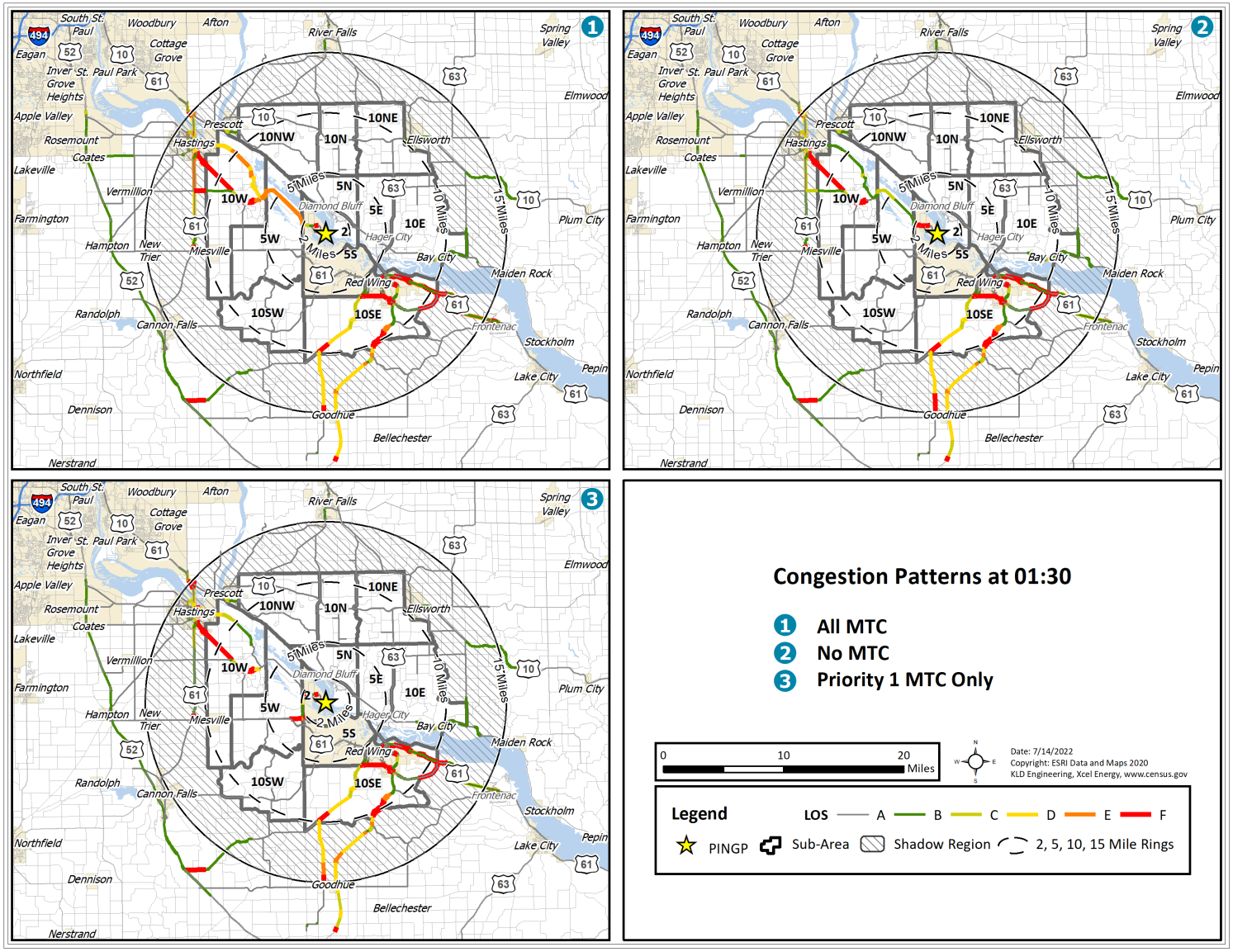


Figure G-2. Comparison of Congestion Patterns at 1 hours and 30 minutes after the ATE

APPENDIX H

Evacuation Regions

H. EVACUATION REGIONS

This appendix presents the evacuation percentages for each Evacuation Region (Table H-1) and maps of all Evacuation Regions (Figure H-1 through Figure H-28). The percentages presented in Table H-1 are based on the methodology discussed in assumption 7 of Section 2.2 and shown in Figure 2-1.

Note the baseline ETE study assumes 20% of households will not comply with the shelter advisory, as per Section 2.5.2 of NUREG/CR-7002, Rev. 1.

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

Radial Regions													
			Sub-Area										
Region	Description	Degrees in PAR	2	5N	5E	5S	5W	10N	10NE	10E	10SE	10SW	10W	10NW
R01	2-Mile Radius	0°-359°	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R02	5-Mile Radius	0°-359°	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%
R03	Full EPZ	0°-359°	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Evacuate 2-Mile Radius and Downwind to 5 Miles													
	Wind Direction		Sub-Area										
Region	From:	Degrees in PAR	2	5N	5E	5S	5W	10N	10NE	10E	10SE	10SW	10W	10NW
R04	NNW, N	326.25°-11.25°	100%	20%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%
R05	NNE, NE, ENE, E	11.25°-101.25°	100%	20%	20%	100%	100%	20%	20%	20%	20%	20%	20%	20%
R06	ESE, SE	101.25°-146.25°	100%	100%	20%	20%	100%	20%	20%	20%	20%	20%	20%	20%
R07	SSE, S, SSW	146.25°-213.75°	100%	100%	100%	20%	100%	20%	20%	20%	20%	20%	20%	20%
R08	SW	213.75°-236.25°	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R09	WSW, W, WNW	236.25°-303.75°	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%
R10	NW	303.75°-326.25°	100%	20%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%
Evacuate 5-Mile Radius and Downwind to the EPZ Boundary													
	Wind Direction		Sub-Area										
Region	From:	Degrees in PAR	2	5N	5E	5S	5W	10N	10NE	10E	10SE	10SW	10W	10NW
R11	N, NNE, NE, ENE	348.75°-78.75°	100%	100%	100%	100%	100%	20%	20%	20%	100%	100%	100%	20%
R12	E	78.75°-101.25°	100%	100%	100%	100%	100%	20%	20%	20%	20%	100%	100%	100%
R13	ESE	101.25°-123.75°	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	100%	100%
R14	SE	123.75°-146.25°	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	100%	100%
R15	SSE	146.25°-168.75°	100%	100%	100%	100%	100%	100%	100%	20%	20%	20%	100%	100%
R16	S	168.75°-191.25°	100%	100%	100%	100%	100%	100%	100%	100%	20%	20%	100%	100%
R17	SSW, SW	191.25°-236.25°	100%	100%	100%	100%	100%	100%	100%	100%	20%	20%	20%	100%
R18	WSW	236.25°-258.75°	100%	100%	100%	100%	100%	100%	100%	100%	100%	20%	20%	20%
R19	W, WNW	258.75°-303.75°	100%	100%	100%	100%	100%	20%	100%	100%	100%	20%	20%	20%
R20	NW, NNW	303.75°-348.75°	100%	100%	100%	100%	100%	20%	20%	100%	100%	100%	20%	20%

Staged Evacuation - 2-Mile Radius Evacuates, then Evacuate Downwind to 5 Miles													
Region	Wind Direction From:	Degrees in PAR	Sub-Area											
			2	5N	5E	5S	5W	10N	10NE	10E	10SE	10SW	10W	10NW
R21	5-Mile Radius	0°-359°	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%
R22	NNW, N	326.25°-11.25°	100%	20%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%
R23	NNE, NE, ENE, E	11.25°-101.25°	100%	20%	20%	100%	100%	20%	20%	20%	20%	20%	20%	20%
R24	ESE, SE	101.25°-146.25°	100%	100%	20%	20%	100%	20%	20%	20%	20%	20%	20%	20%
R25	SSE, S, SSW	146.25°-213.75°	100%	100%	100%	20%	100%	20%	20%	20%	20%	20%	20%	20%
R26	SW	213.75°-236.25°	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R27	WSW, W, WNW	236.25°-303.75°	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%
R28	NW	303.75°-326.25°	100%	20%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%
Sub-Area(s) Evacuate			Sub-Area(s) Shelter-in-Place						Sub-Area(s) Shelter-in-Place until 90% ETE for R01, then Evacuate					

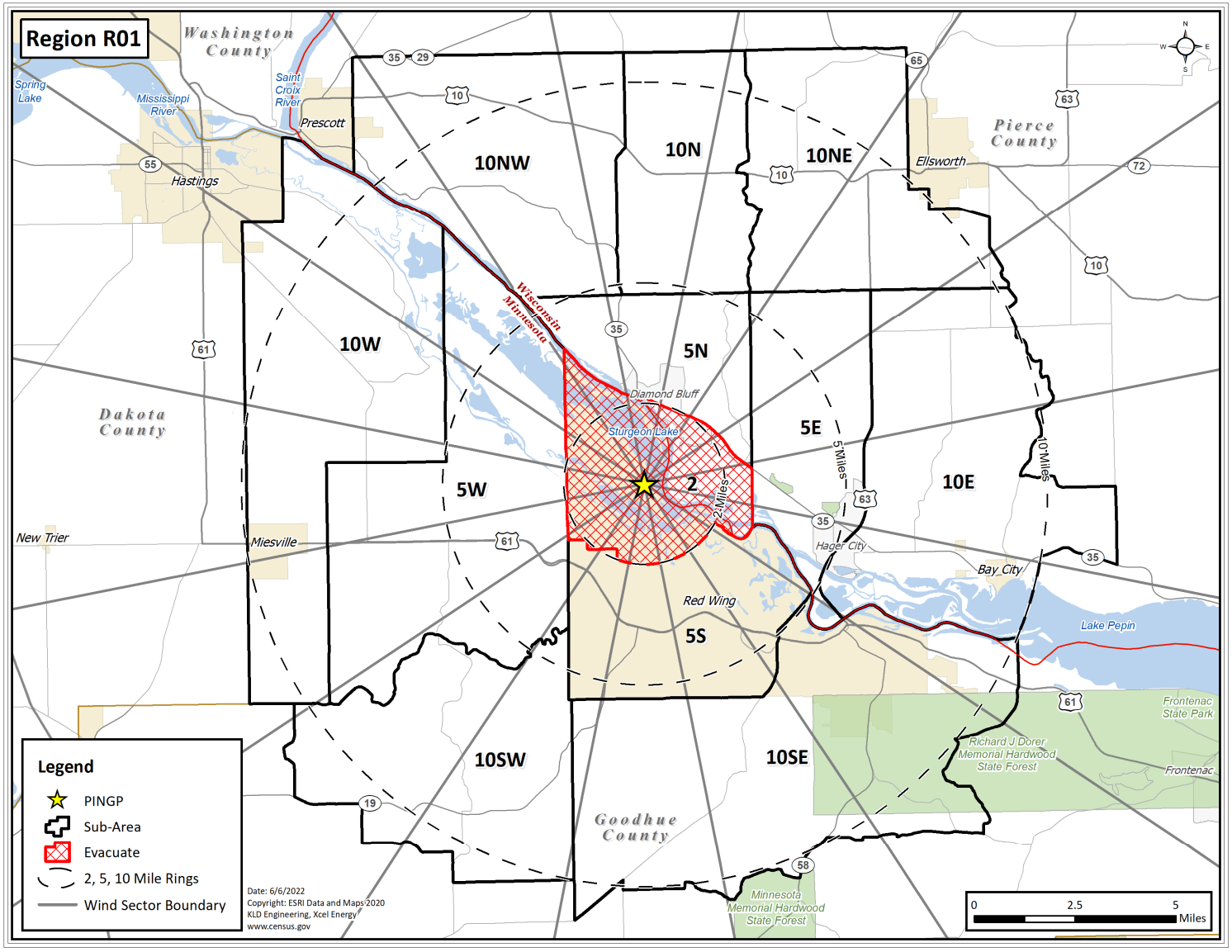


Figure H-1. Region R01

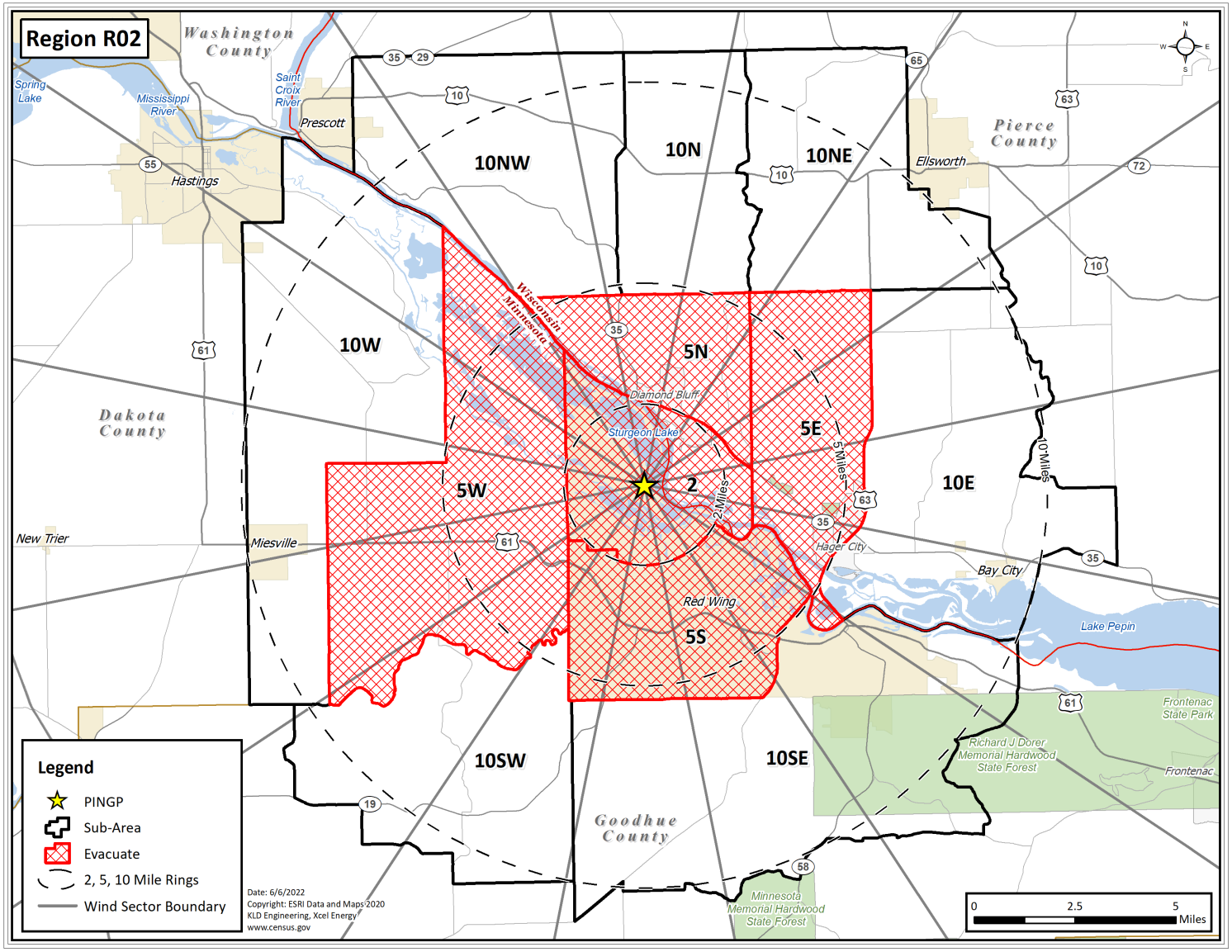


Figure H-2. Region R02

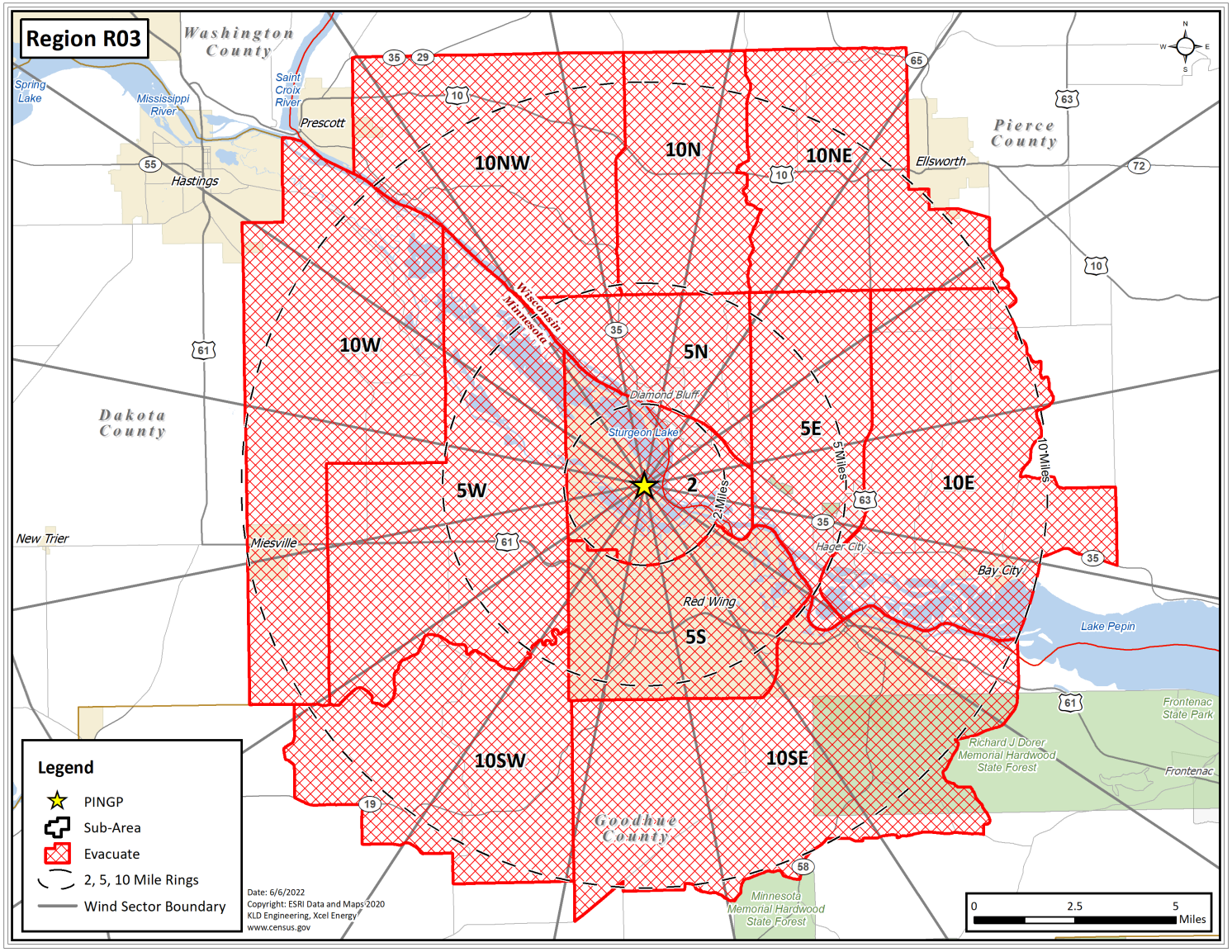


Figure H-3. Region R03

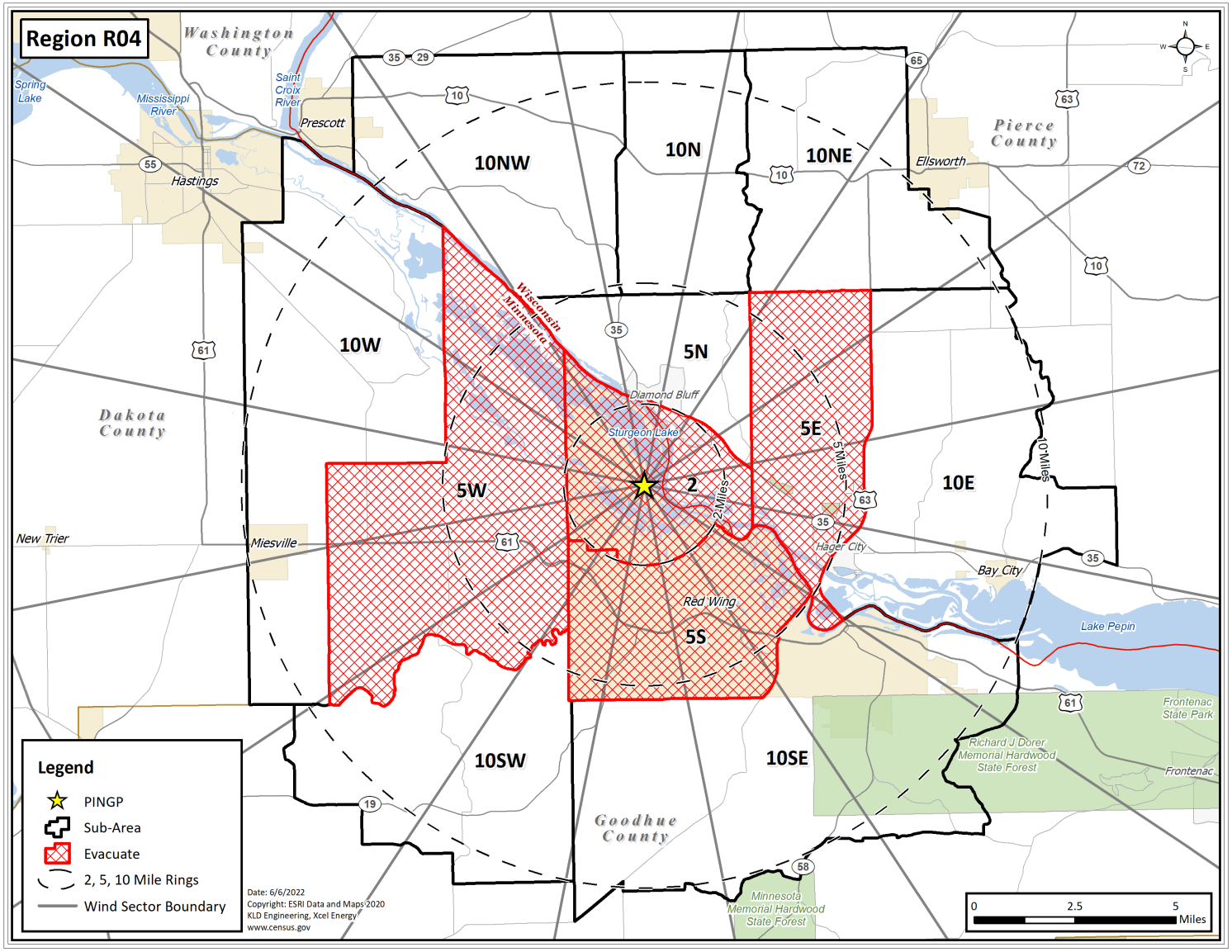


Figure H-4. Region R04

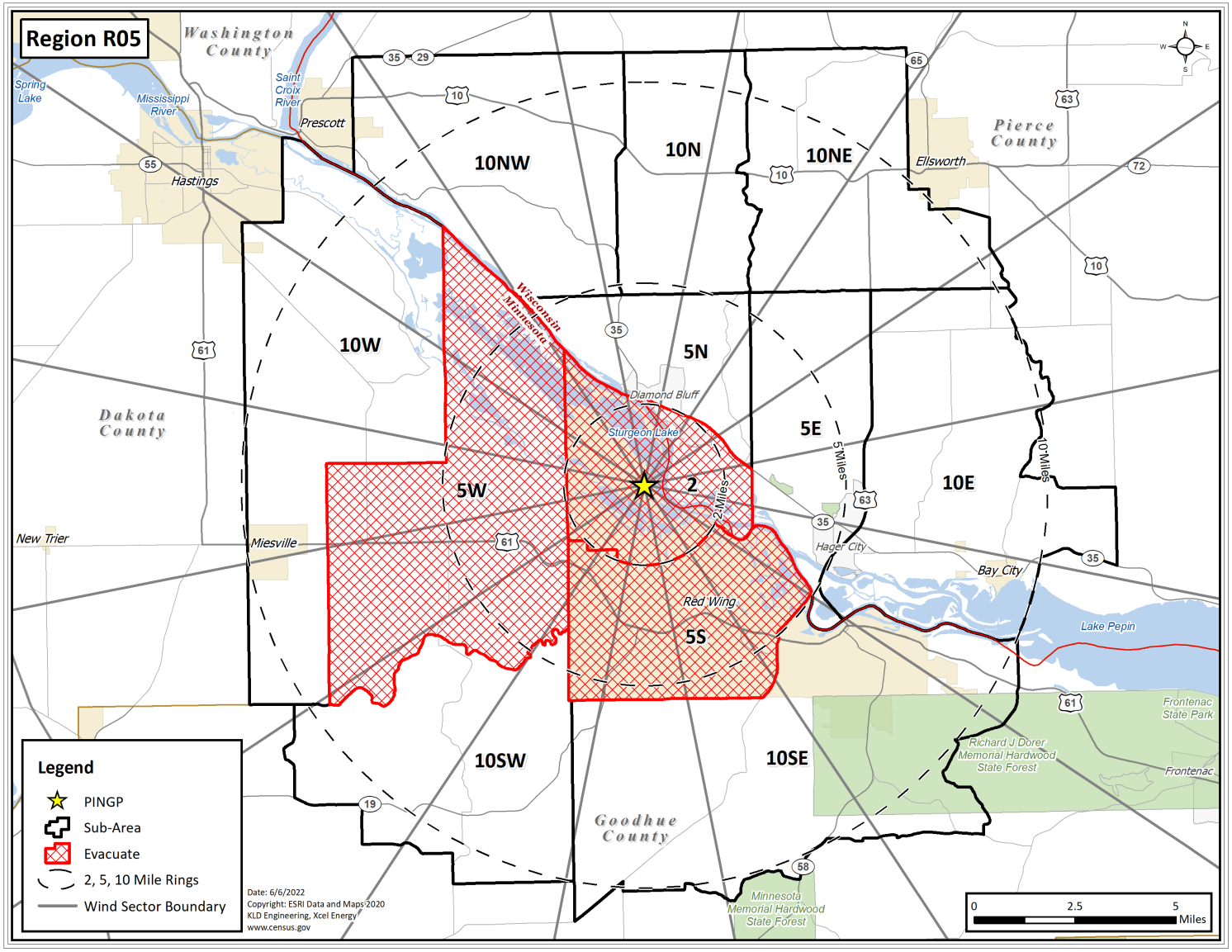


Figure H-5. Region R05

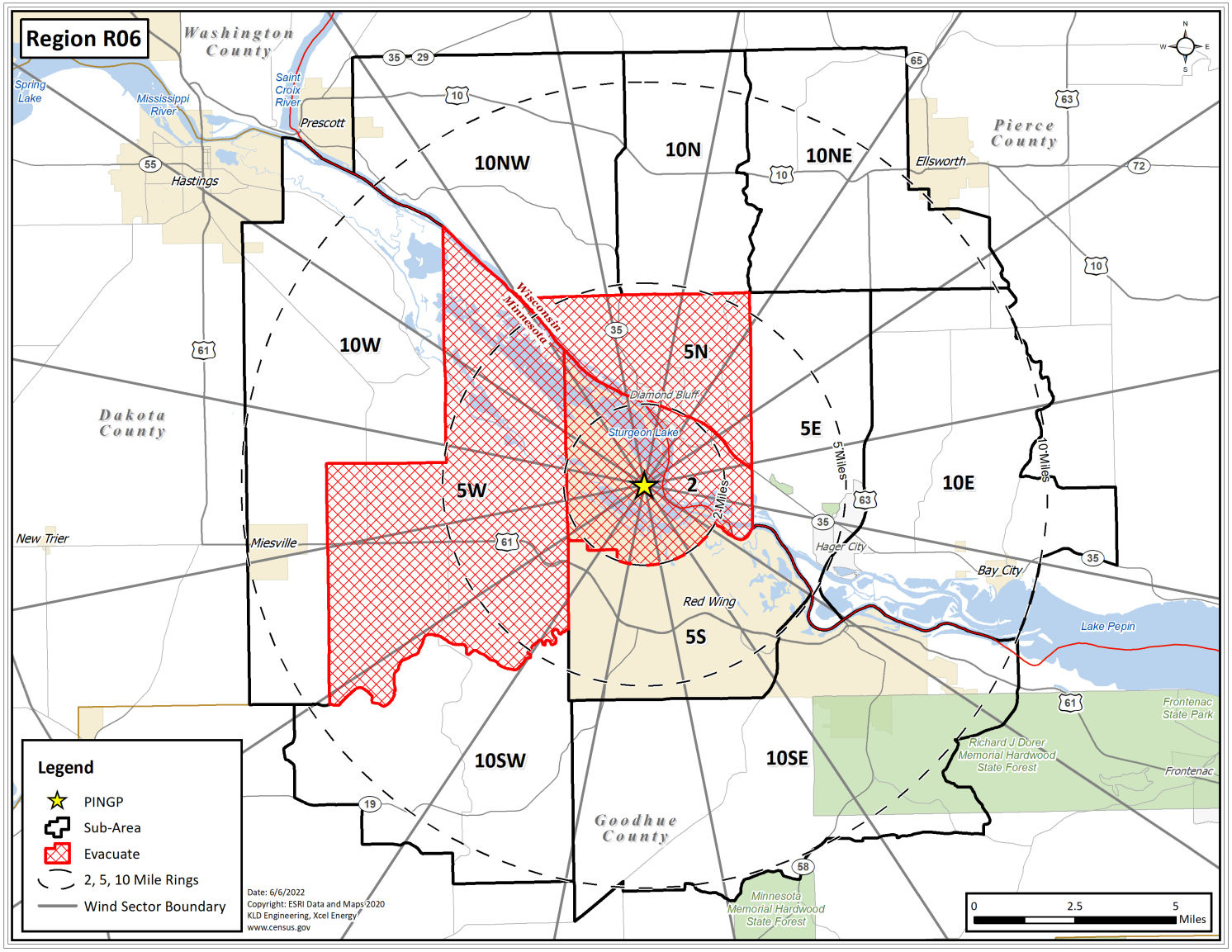


Figure H-6. Region R06

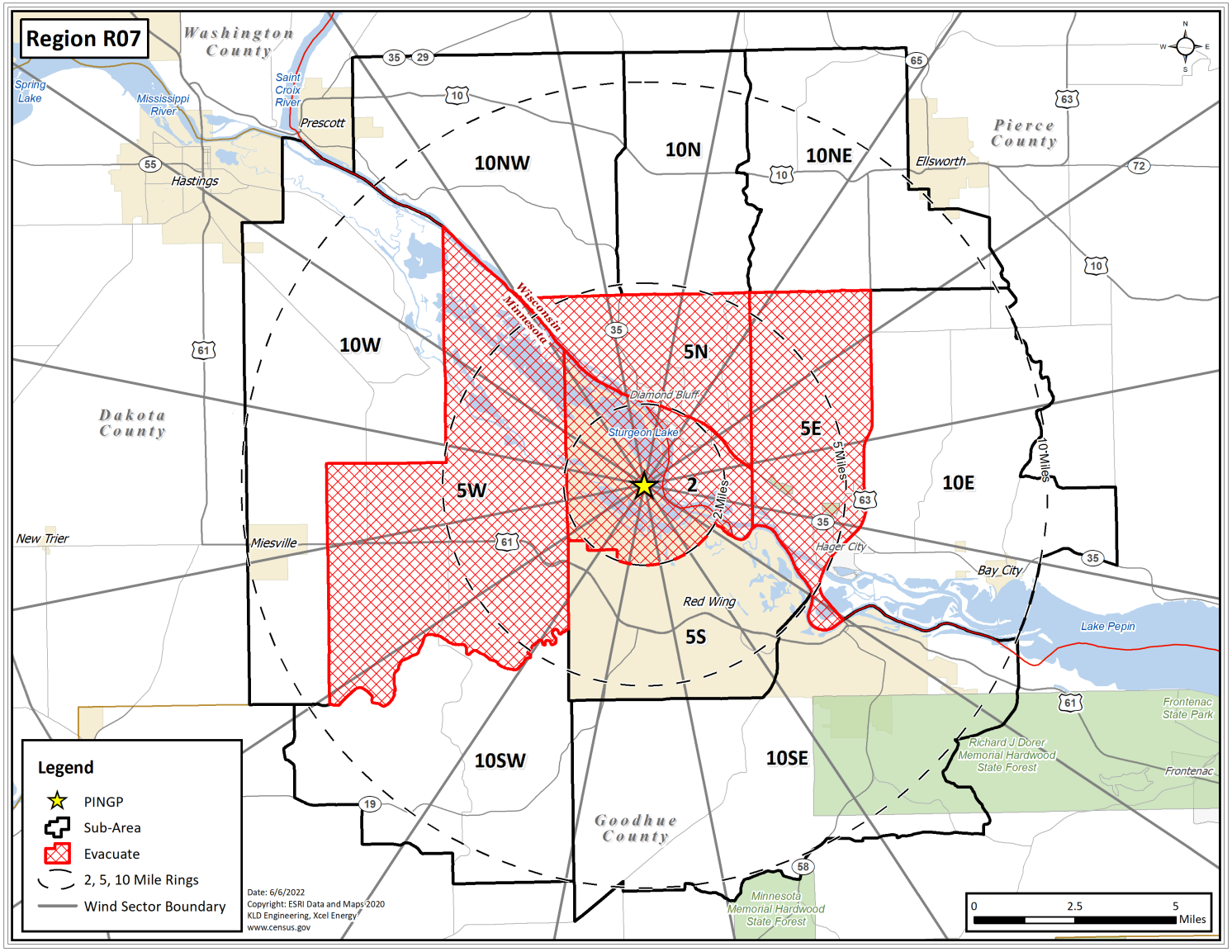


Figure H-7. Region R07

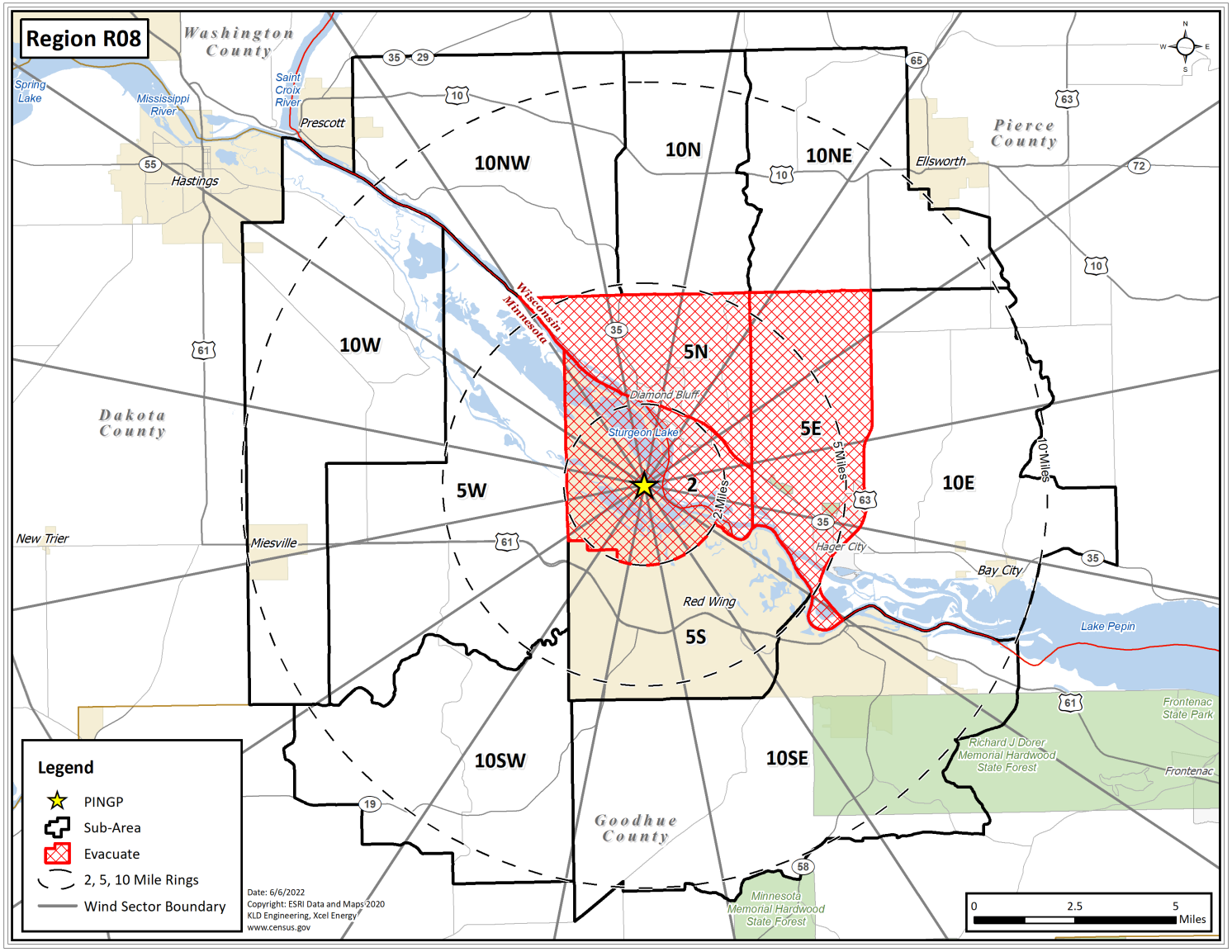


Figure H-8. Region R08

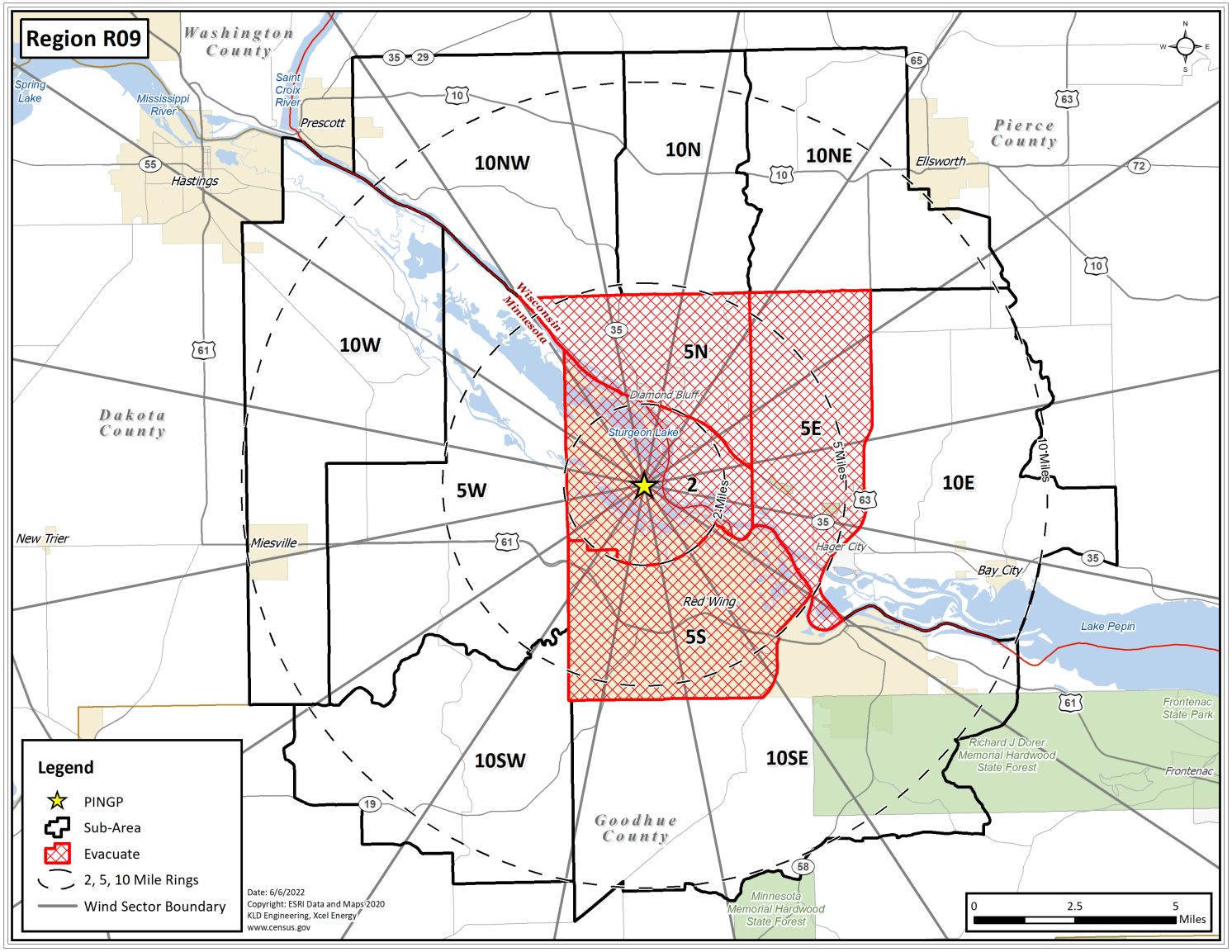


Figure H-9. Region R09

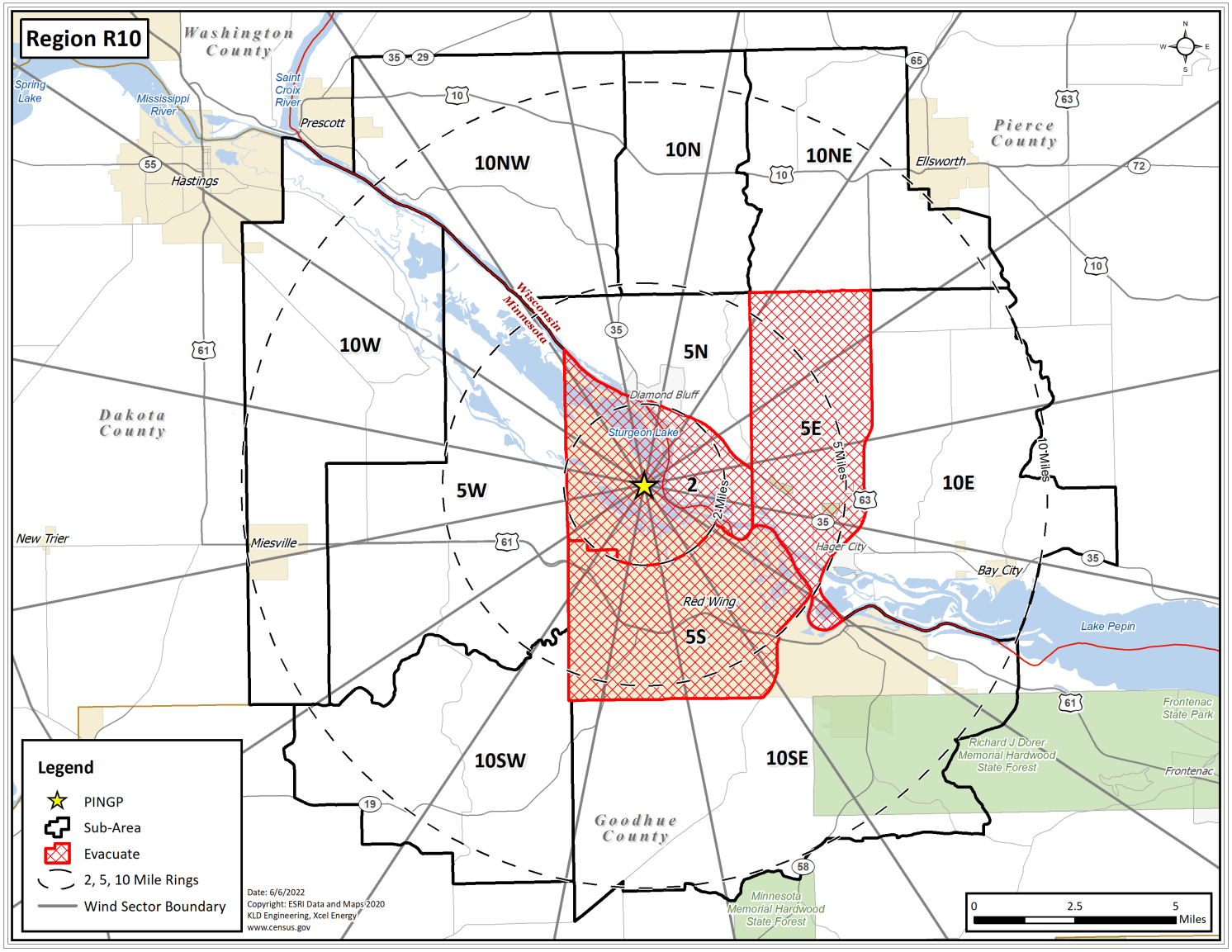


Figure H-10. Region R10

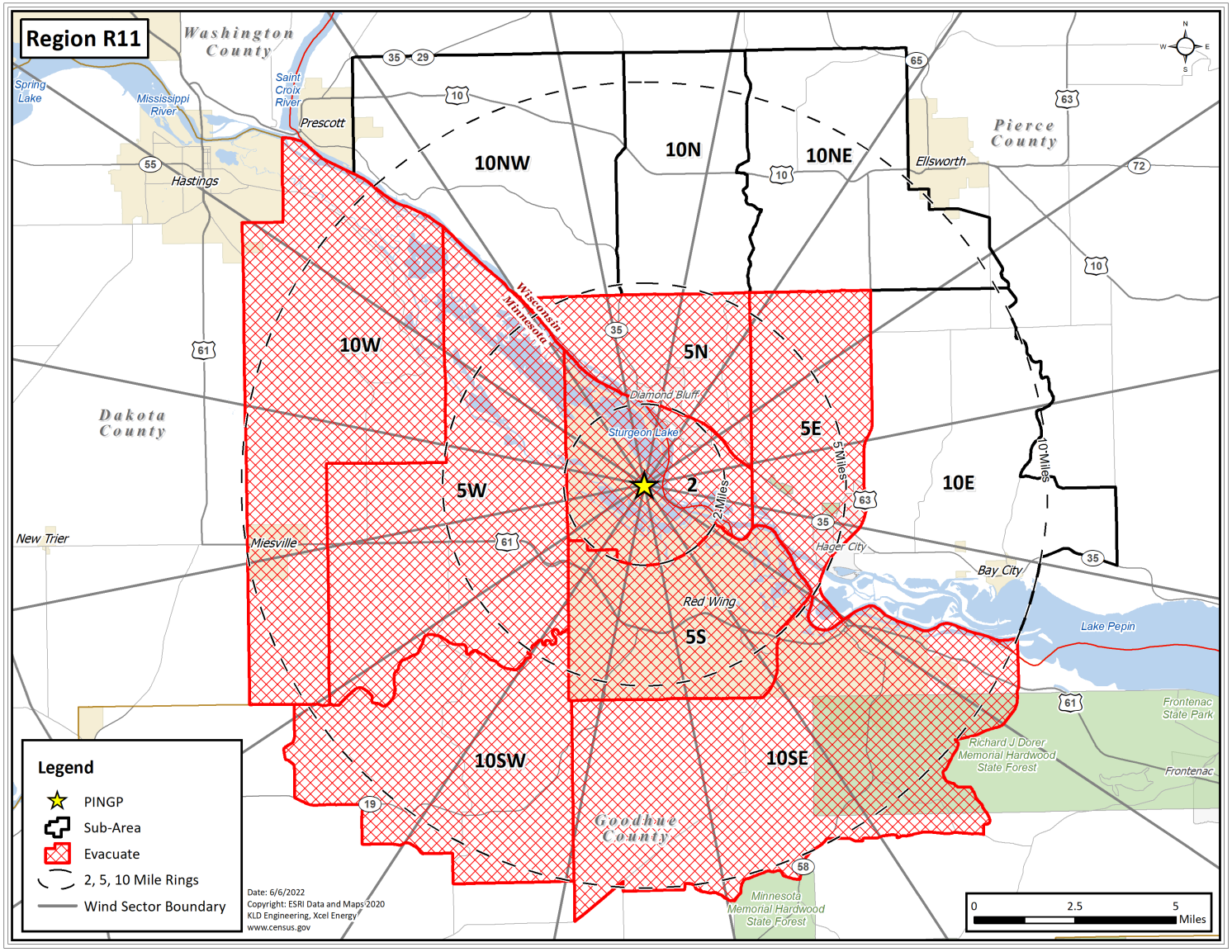


Figure H-11. Region R11

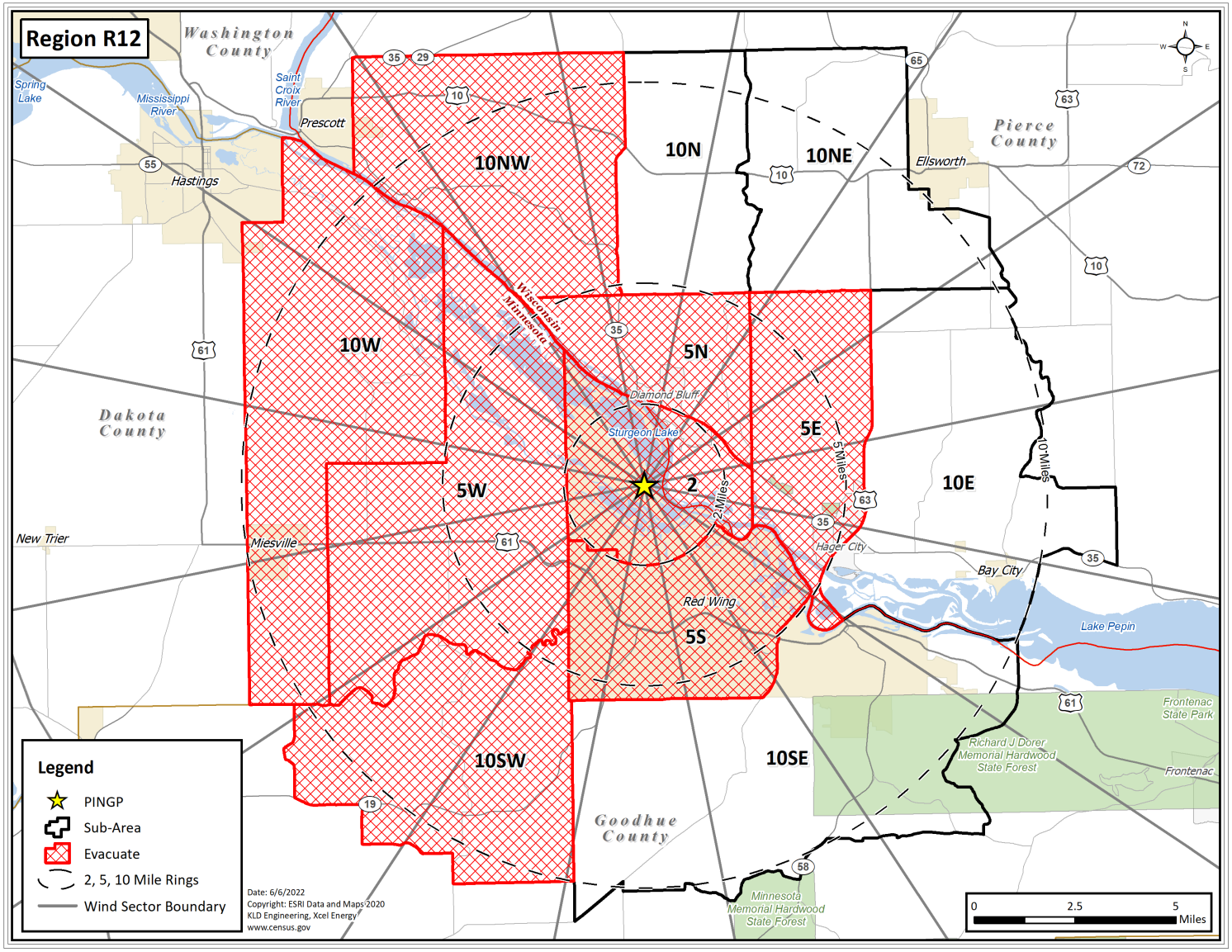


Figure H-12. Region R12

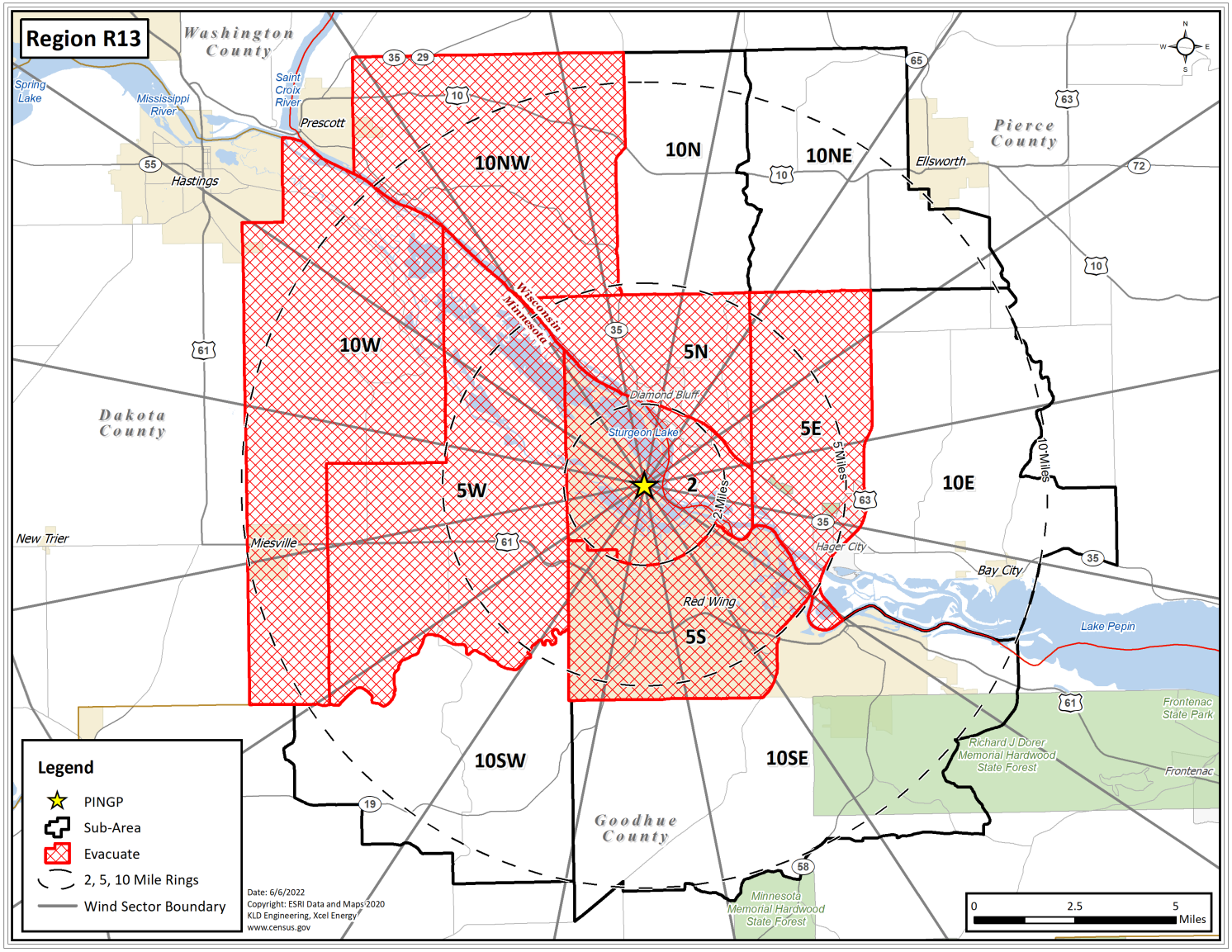


Figure H-13. Region R13

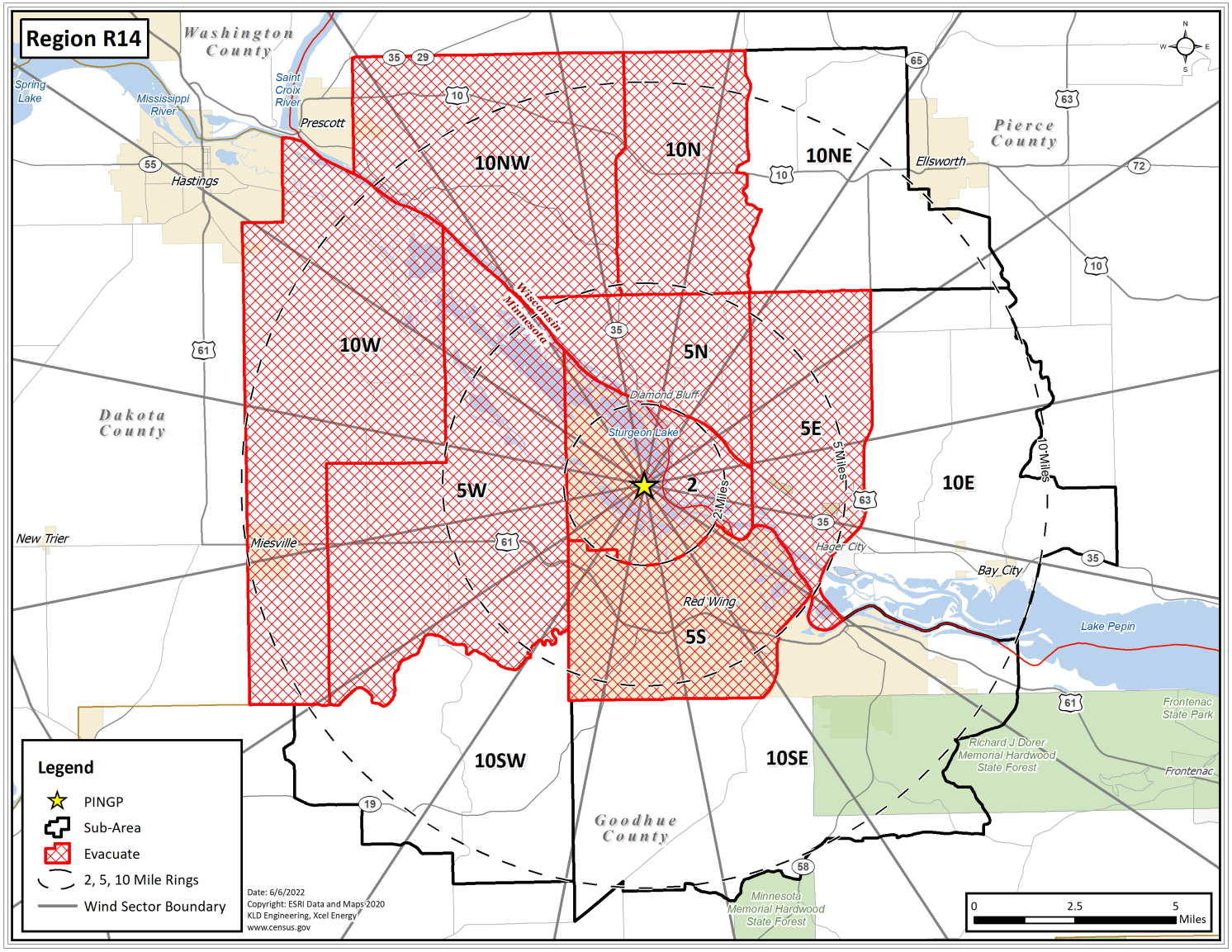


Figure H-14. Region R14

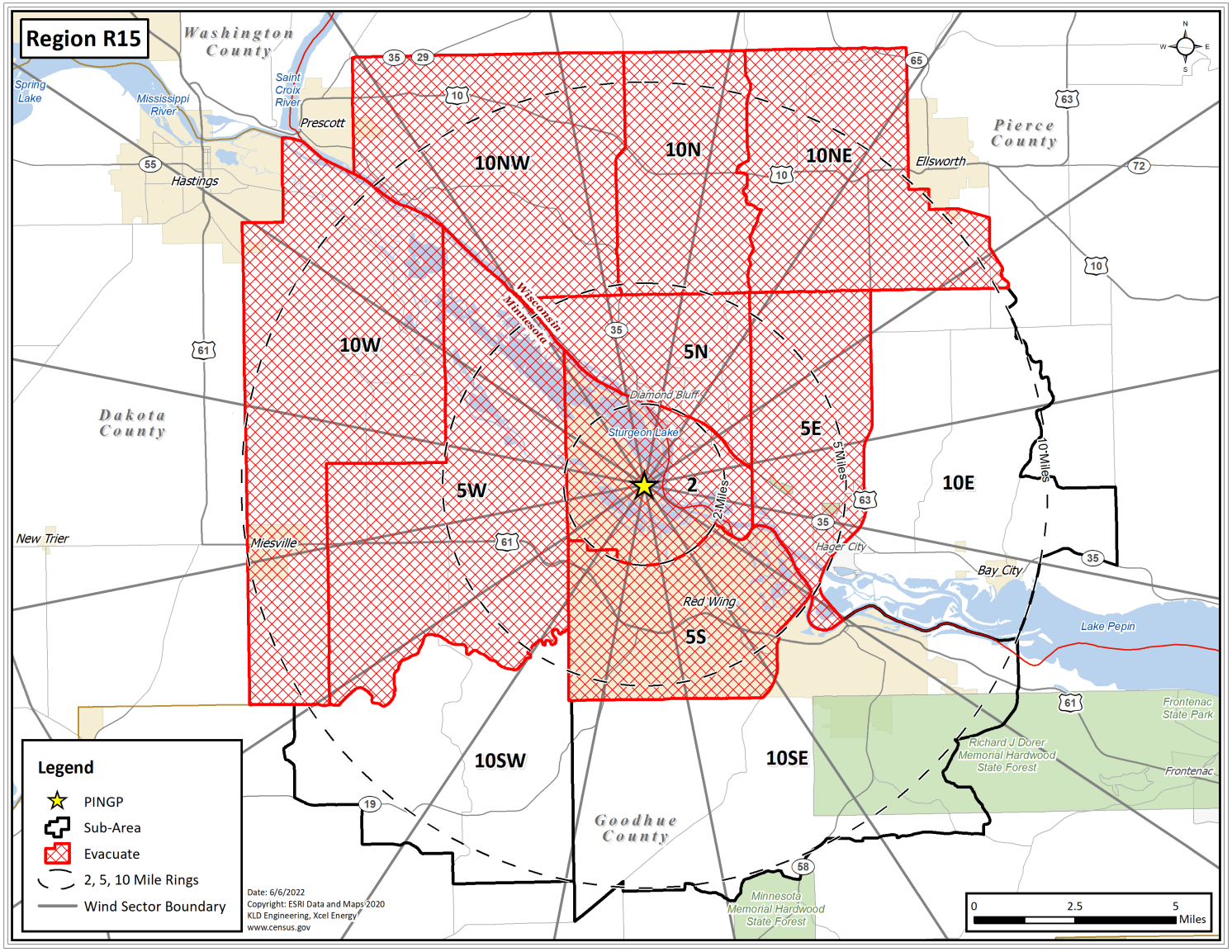


Figure H-15. Region R15

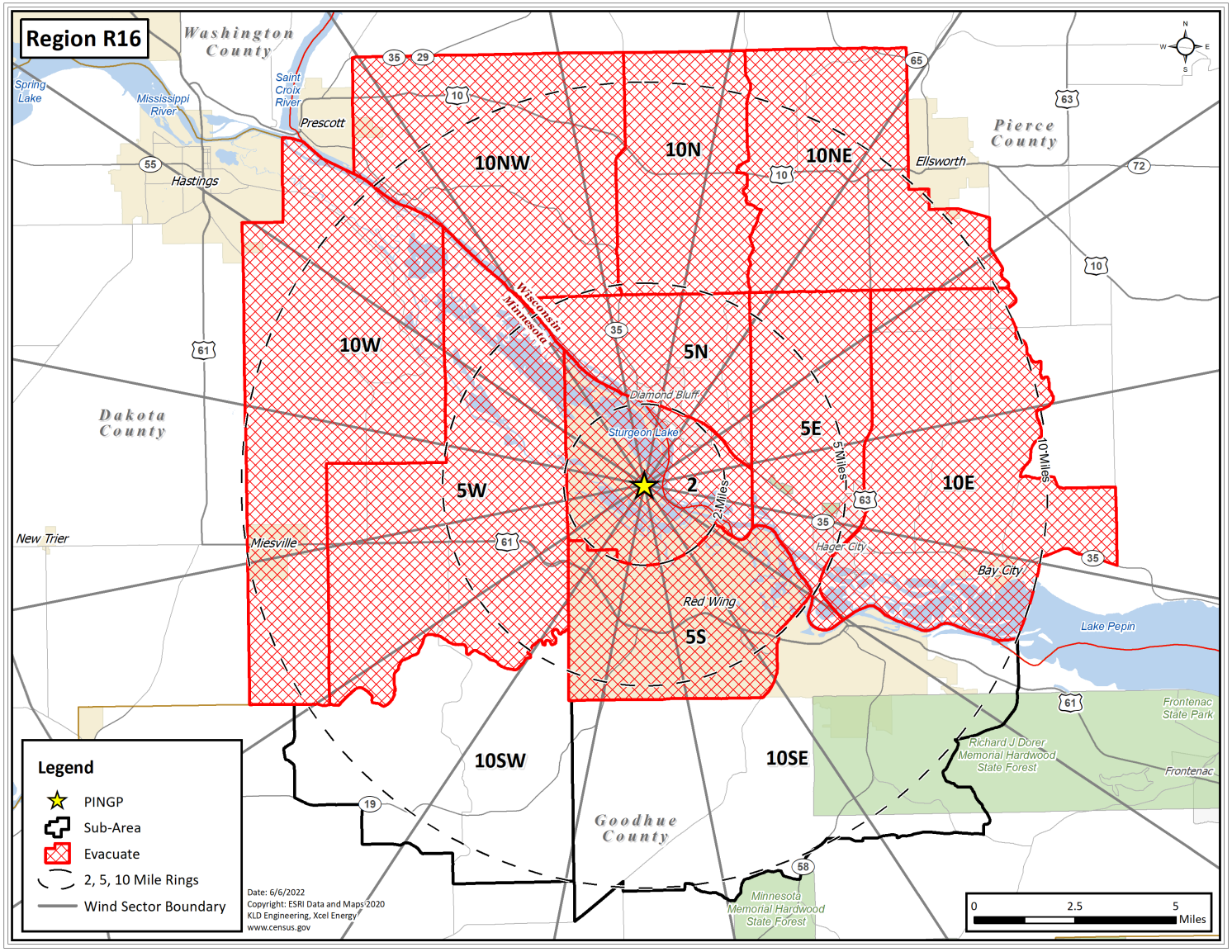


Figure H-16. Region R16

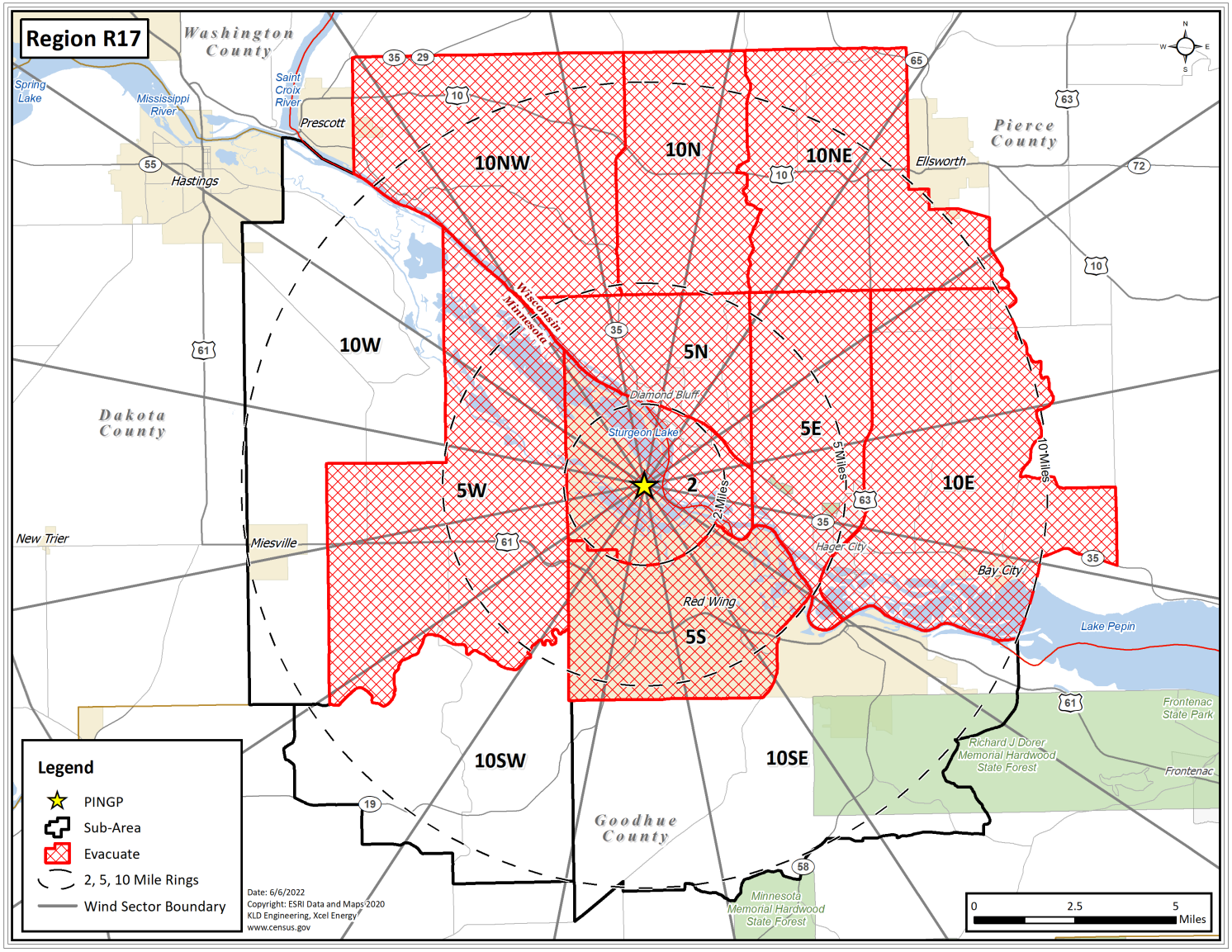


Figure H-17. Region R17

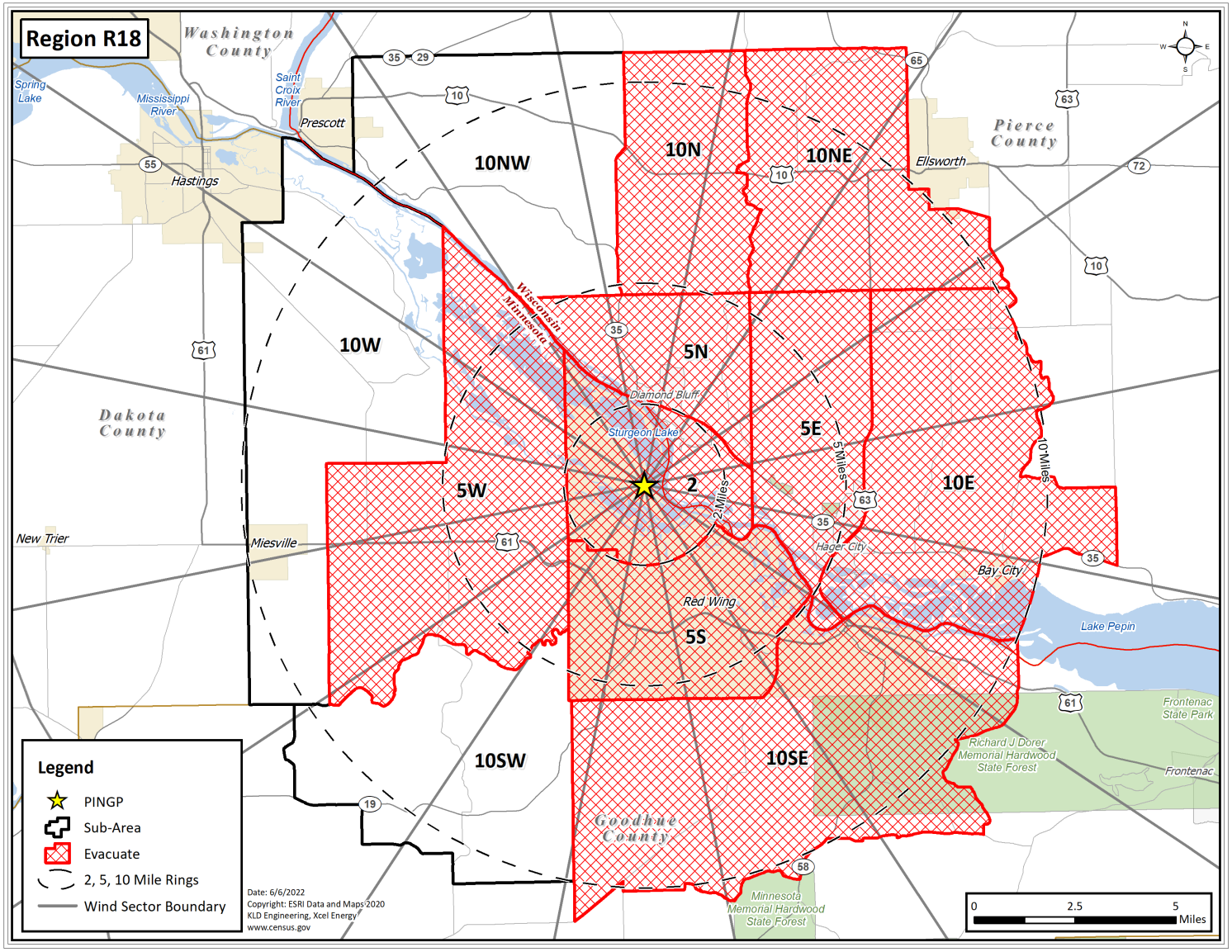


Figure H-18. Region R18

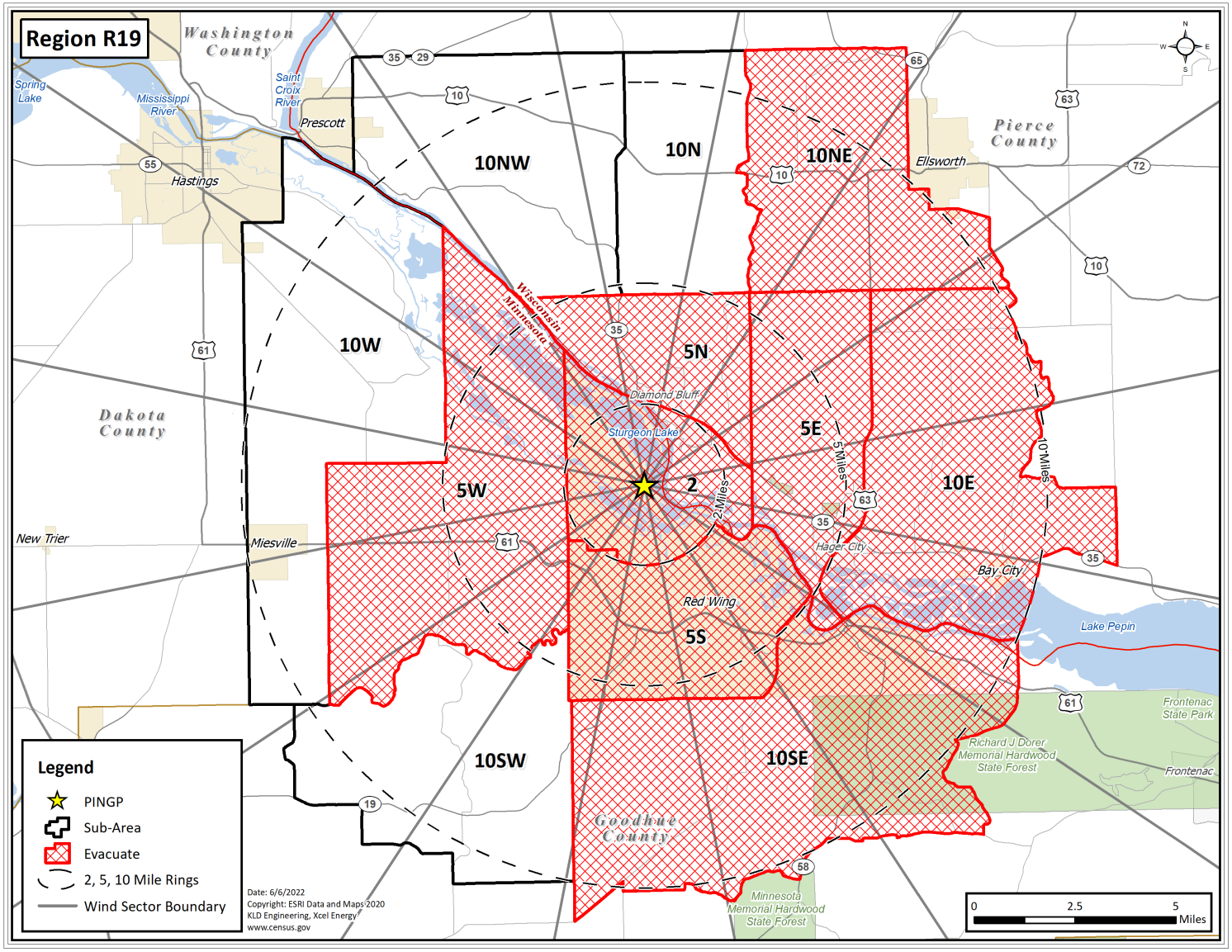


Figure H-19. Region R19

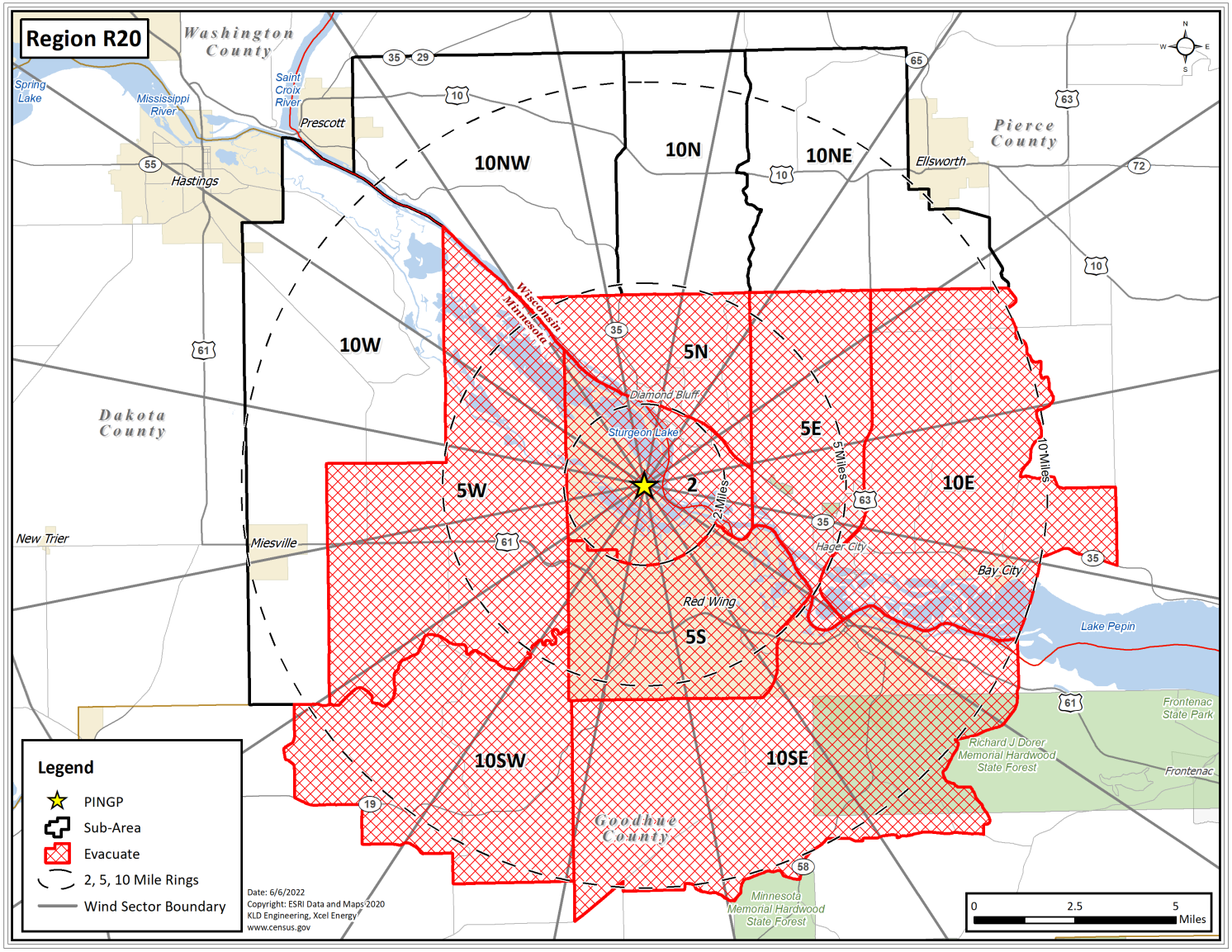


Figure H-20. Region R20

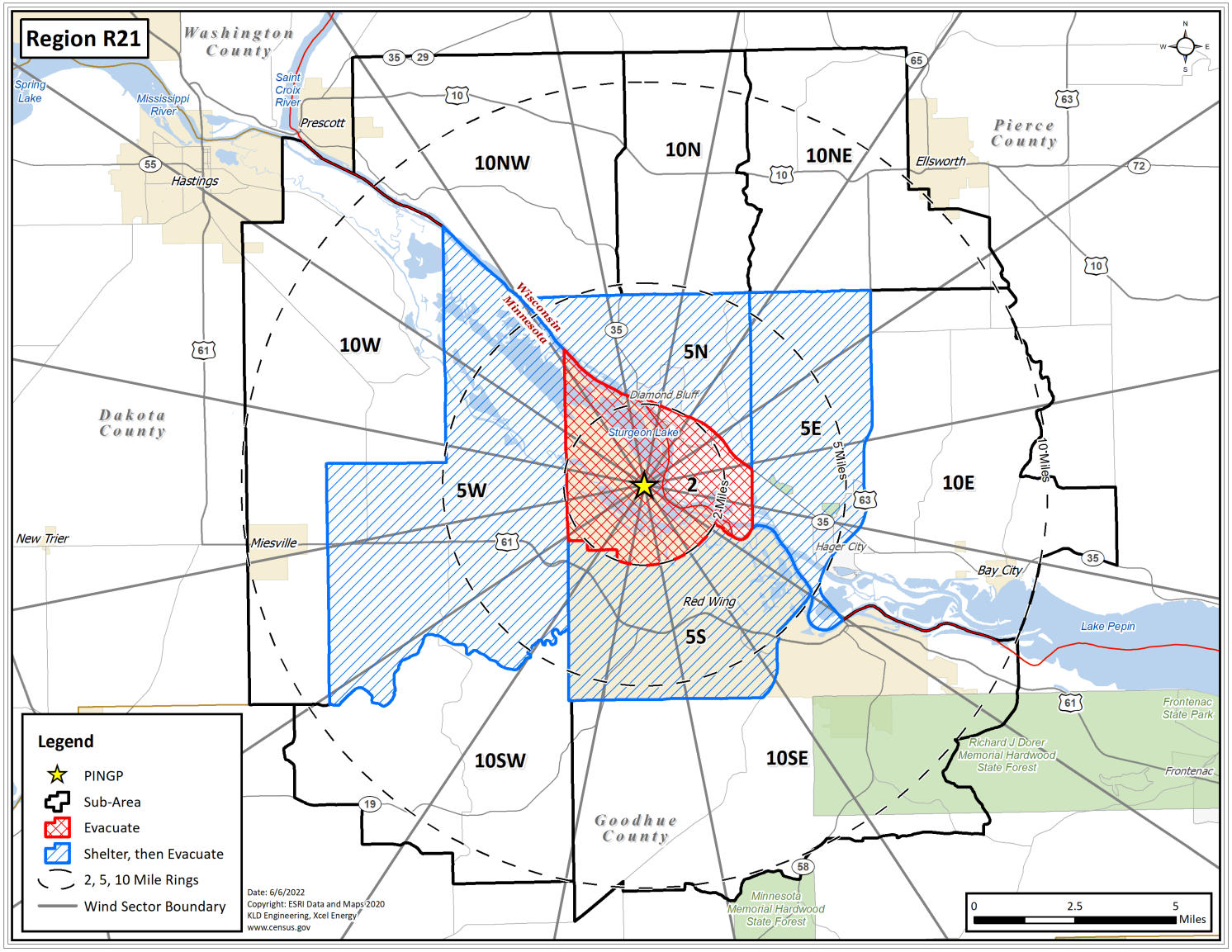


Figure H-21. Region R21

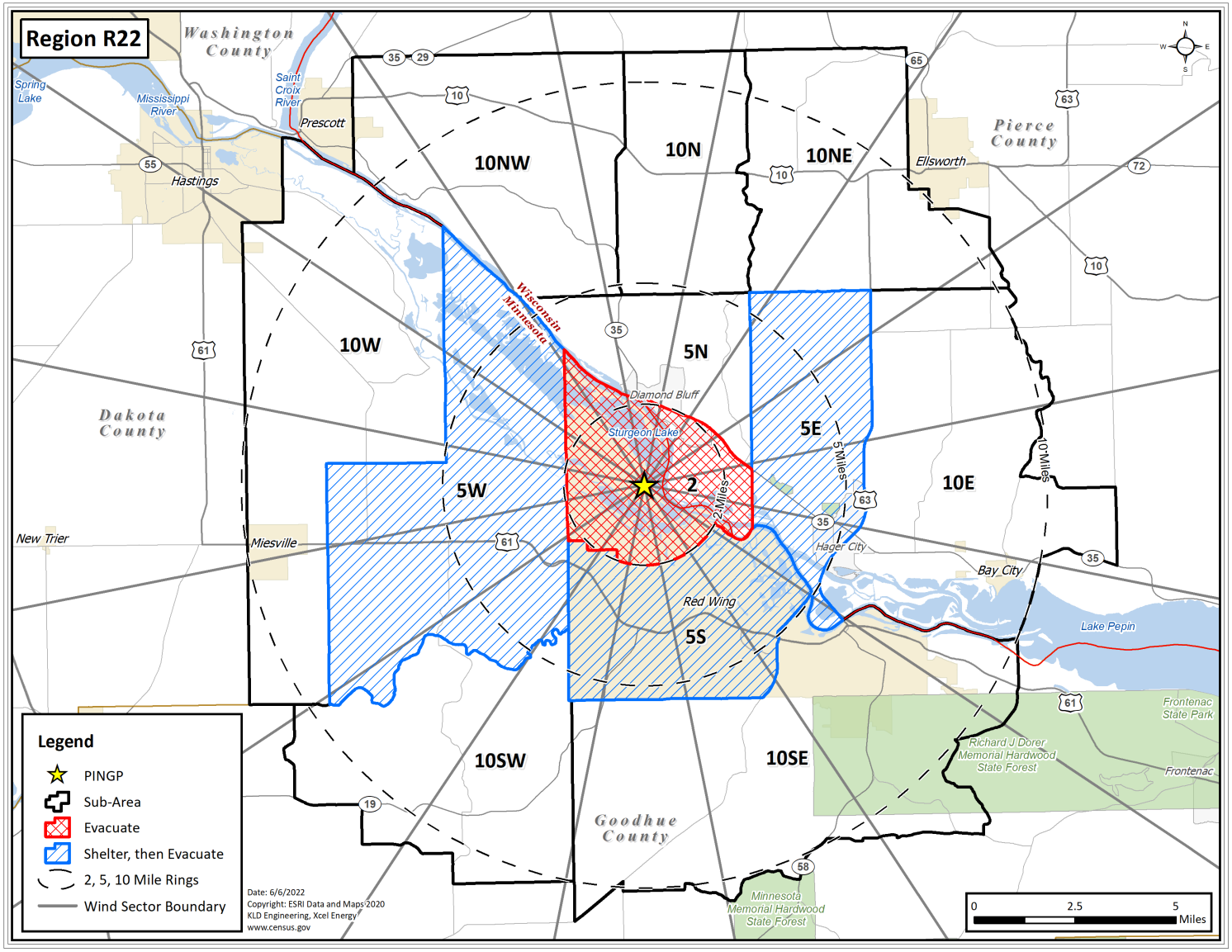


Figure H-22. Region R22

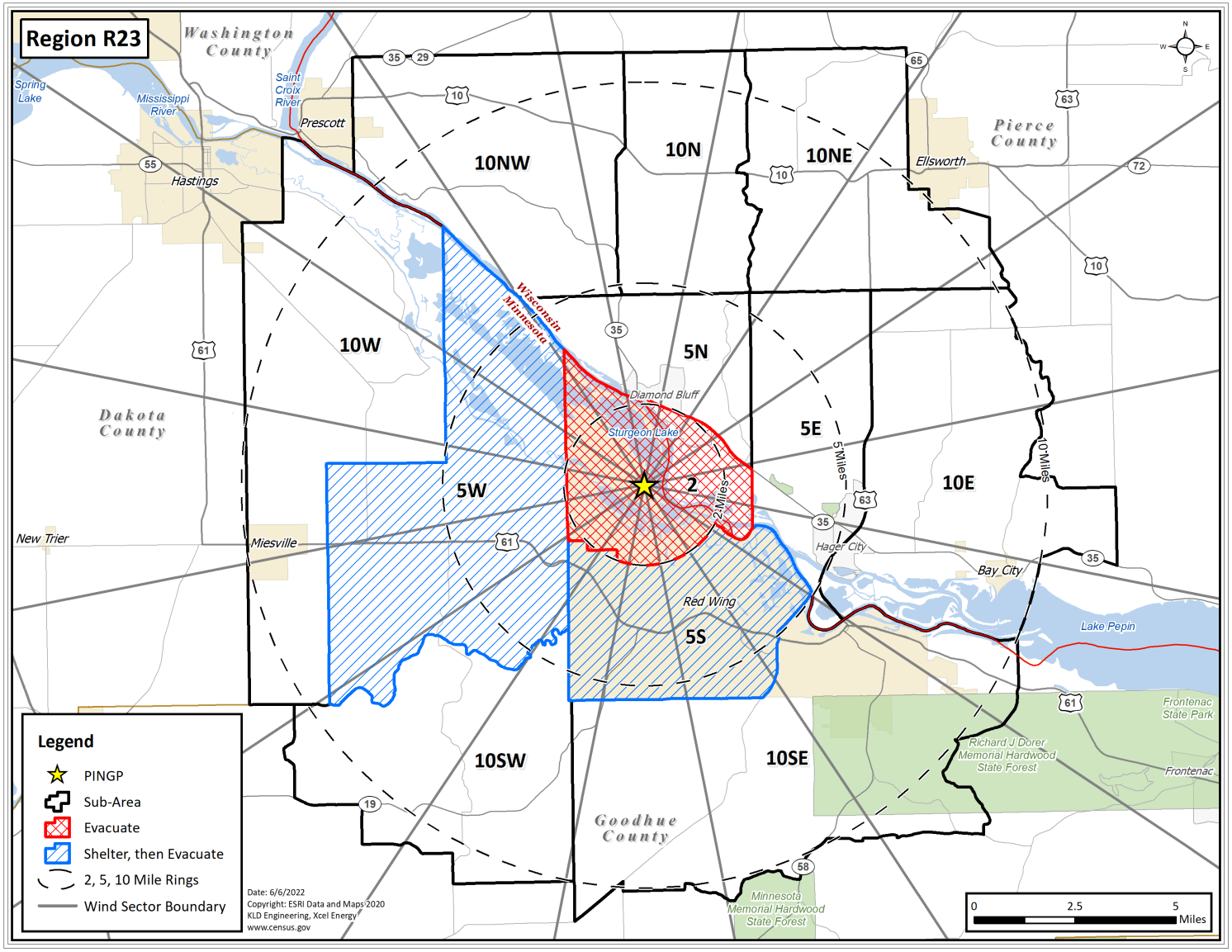


Figure H-23. Region R23

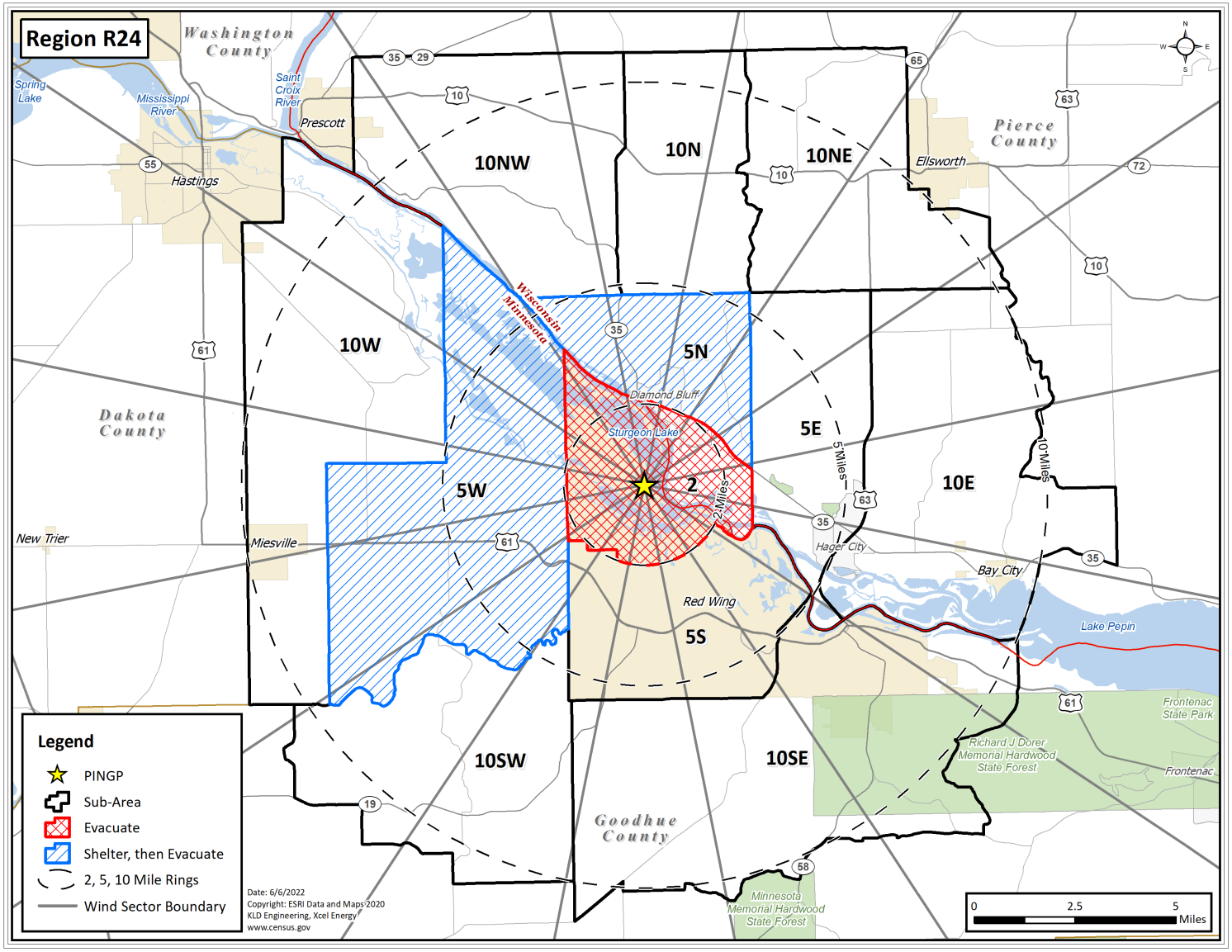


Figure H-24. Region R24

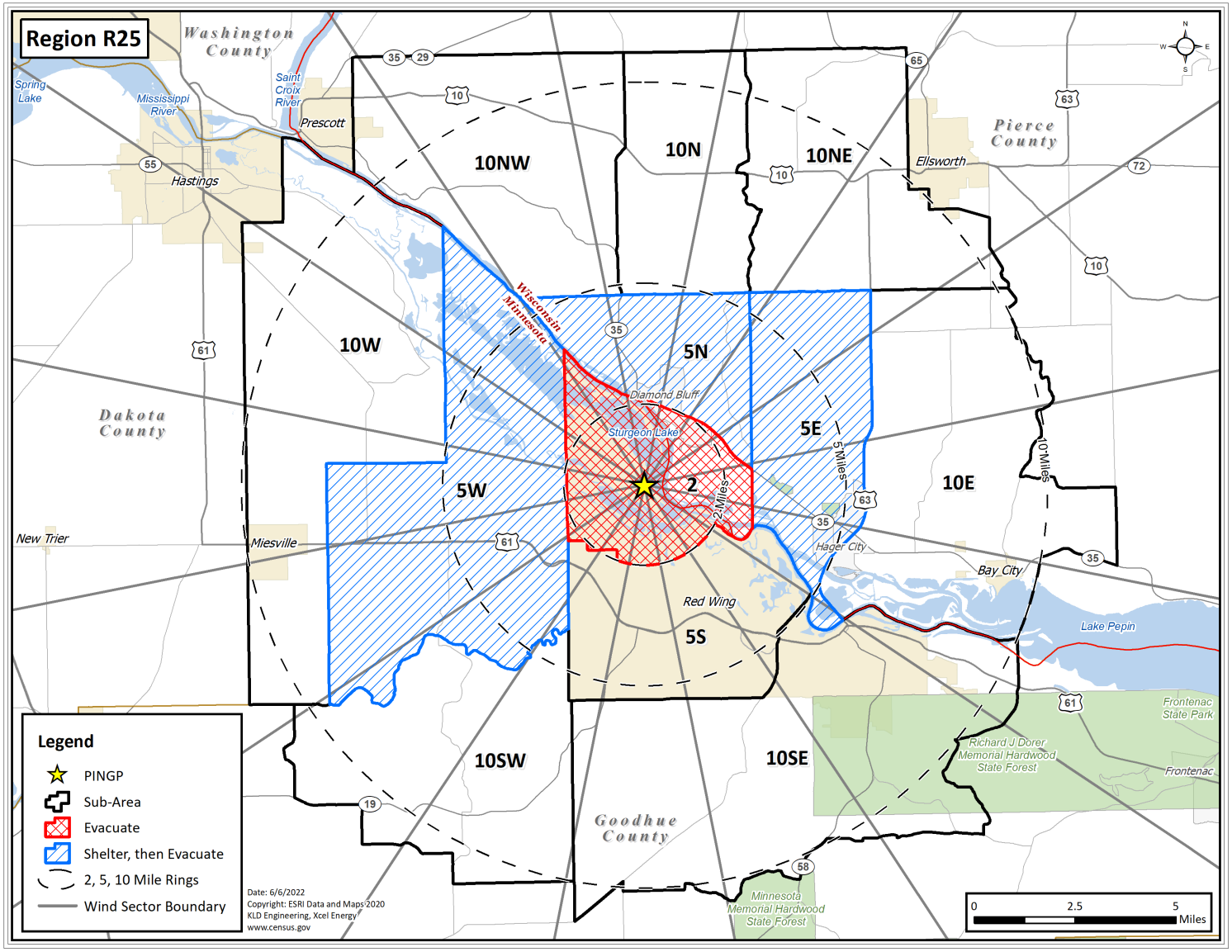


Figure H-25. Region R25

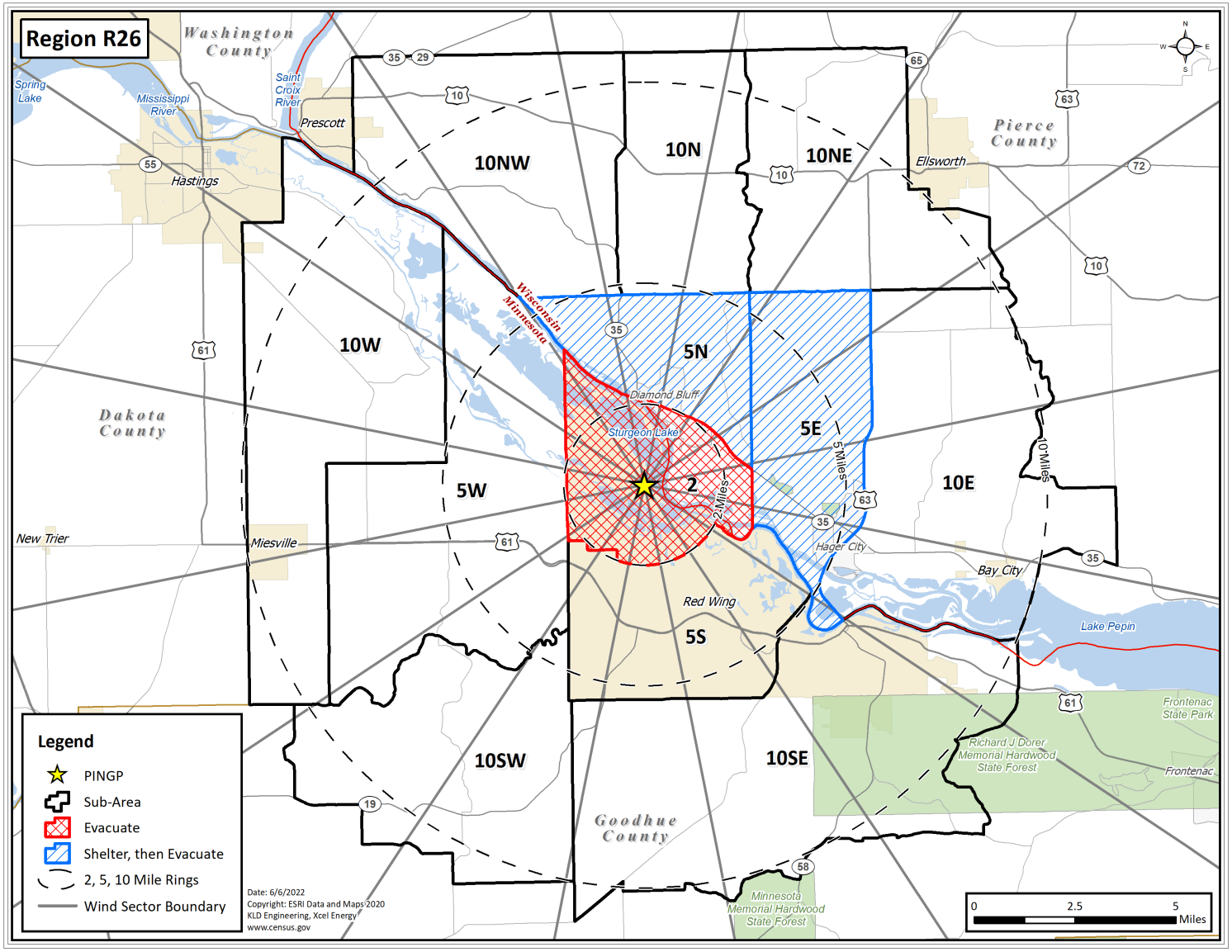


Figure H-26. Region R26

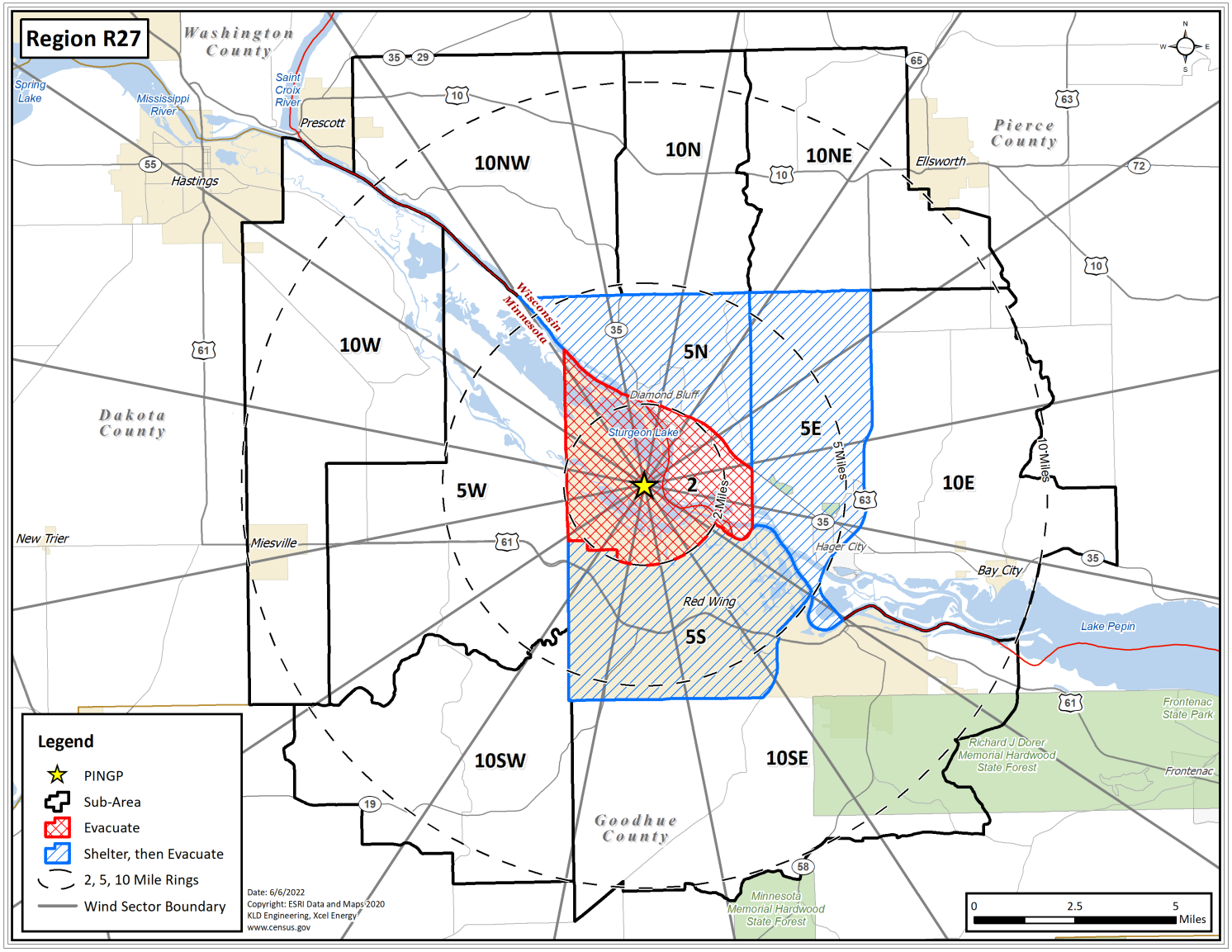


Figure H-27. Region R27

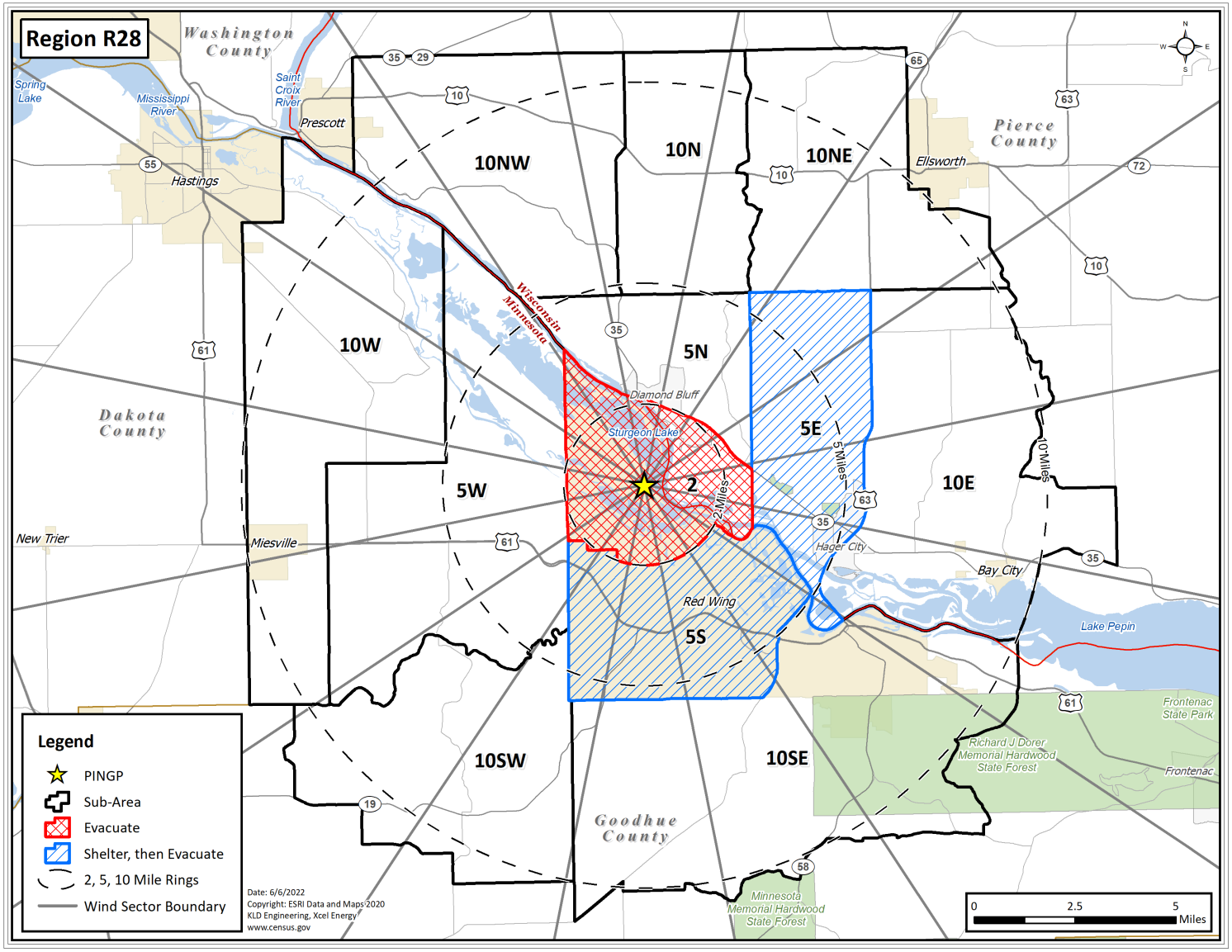


Figure H-28. Region R28

APPENDIX J

Representative Inputs to and Outputs from the DYNEV II System

J. REPRESENTATIVE INPUTS TO AND OUTPUTS FROM THE DYNEV II SYSTEM

This appendix presents data input to and output from the DYNEV II System.

Table J-1 provides source (vehicle loading) and destination information for several roadway segments (links) in the analysis network. In total, there are a total of 285 source links (origins) in the model. The source links are shown as centroid points in Figure J-1. On average, evacuees travel a straight-line distance of 6.18 miles to exit the network.

Table J-2 provides network–wide statistics (average travel time, average delay time[1], average speed and number of vehicles) for an evacuation of the entire EPZ (Region R03) for each scenario. As expected, adverse weather scenarios (Scenarios 2, 4, 7, 8, 10 and 11), exhibit slower average speeds, higher delays, and longer average travel times when compared to the corresponding good weather scenarios. Scenario 13 (special event) has a lower network-wide average speed and higher network-wide average travel time when compared with Scenario 5 (summer, midweek, weekend, evening, good weather). Scenario 14 (roadway impact) has a slightly lower network-wide average travel time and a higher network-wide average speed when compared with Scenario 1 (summer, weekday, midday, good weather). As a segment of US-61 eastbound from US-63 to County 292 Blvd is completely closed, vehicles will make detour by using multiple alternate routes (e.g. SR-58, CR-1) rather than stick with the US-61 eastbound only.

Table J-3 provides statistics (average speed and travel time) for the major evacuation routes – US Route (US)-61, US-63, US-10, SR-58 – for an evacuation of the entire EPZ (Region R03) under Scenario 1 conditions. As discussed in Section 7.3 and shown in Figures 7-3 through 7-7, congestion persists along US-61 southbound and SR-58 southbound during the first 3 hours of the evacuation. As such, the average speeds along these roadways are comparably slower (and travel times longer) during this time.

Table J-4 provides the number of vehicles discharged and the cumulative percent of total vehicles discharged for each link exiting the analysis network, for an evacuation of the entire EPZ (Region R03) under Scenario 1 conditions. Refer to the figures in Appendix K for a map showing the geographic location of each link.

Figure J-2 through Figure J-15 plot the trip generation time versus the ETE for each of the 14 Scenarios considered. The distance between the trip generation and ETE curves is the travel time. Plots of trip generation versus ETE are indicative of the level of traffic congestion during evacuation. For low population density sites, the curves are close together, indicating short travel times and minimal traffic congestion. For higher population density sites, the curves are farther apart indicating longer travel times and the presence of traffic congestion.

As seen in Figure J-2 through Figure J-15, the curves are spatially separated as a result of the traffic congestion within traffic congestion in the EPZ, which was discussed in detail in Section 7.3, but then are close together as a result of the traffic congestion in the EPZ clearing before the completion of the trip generation, which was discussed in detail in Section 7.3.

[1] Computed as the difference of the average travel time and the average ideal travel time under free flow conditions.

Table J-1. Sample Simulation Model Input

Link Number	Upstream Node	Downstream Node	Vehicles Entering Network on this Link	Directional Preference	Destination Nodes	Destination Capacity
675	467	468	28	NE	8474	1,700
					8485	1,700
					8617	1,700
66	31	245	28	SE	8014	900
					8141	1,275
					8048	1,700
1100	840	842	349	SE	8341	3,800
					8617	1,700
					8141	1,275
1321	993	956	116	SE	8341	3,800
					8014	900
					8141	1,275
1004	754	351	208	W	8403	4,500
					8360	3,800
					8620	2,850
54	26	27	73	SE	8341	3,800
					8014	900
					8141	1,275
193	124	219	11	SW	8341	3,800
					8360	3,800
534	375	373	107	NW	8403	4,500
					8360	3,800
					8620	2,850
748	544	543	9	N	8591	4,500
					8662	1,700
					8649	1,700

Table J-2. Selected Model Outputs for the Evacuation of the Entire EPZ (Region R03)

Scenario	1	2	3	4	5	6	7
Network-Wide Average Travel Time (Min/Veh-Mi)	1.9	2.2	2.0	2.4	2.0	1.8	2.1
Network-Wide Average Delay Time (Min/Veh-Mi)	0.8	1.2	1.0	1.3	1.0	0.8	1.1
Network-Wide Average Speed (mph)	31.8	27.3	29.7	25.1	29.8	32.6	28.3
Total Vehicles Exiting Network	38,492	38,711	39,124	39,034	31,328	37,439	37,523
Scenario	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Network-Wide Average Travel Time (Min/Veh-Mi)	2.3	2.0	2.2	2.3	2.0	2.2	1.8
Network-Wide Average Delay Time (Min/Veh-Mi)	1.2	0.9	1.2	1.3	0.9	1.1	0.7
Network-Wide Average Speed (mph)	26.6	30.5	26.8	25.9	30.5	27.4	33.9
Total Vehicles Exiting Network	37,593	37,189	37,215	37,224	30,735	39,960	38,545

Table J-3. Average Speed (mph) and Travel Time (min) for Major Evacuation Routes (Region R03, Scenario 1)

Elapsed Time (hours)											
		1:00		2:00		3:00		4:00		4:40	
Route Name	Length (miles)	Speed (mph)	Travel Time (min)	Speed	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed	Travel Time
US-61 Southbound	12.6	19.9	37.9	15.5	48.6	25.8	29.3	49.7	15.2	56.3	13.4
US-61 Northbound	21.9	53.3	24.7	37.4	35.2	51.7	25.4	54.7	24.0	57.8	22.7
US-63 Northbound	8.4	59.3	8.5	59.6	8.5	60.8	8.3	61.2	8.3	65.0	7.8
US-10 Eastbound	5.7	59.9	5.7	59.7	5.7	59.3	5.7	59.4	5.7	60.9	5.6
SR-58 Southbound	6.3	35.5	10.7	39.3	9.7	47.2	8.1	49.9	7.6	51.7	7.4

Table J-4. Simulation Model Outputs at Network Exit Links for Region R03, Scenario 1

Network Exit Link	Upstream Node	Downstream Node	Elapsed Time (hours)				
			1:00	2:00	3:00	4:00	4:40
			Cumulative Vehicles Discharged by the Indicated Time				
			Cumulative Percent of Vehicles Discharged by the Indicated Time				
US-61 Eastbound	47	48	1,041	2,739	4,311	5,839	6,383
			15%	13%	14%	16%	17%
US-61 Northbound	402	403	922	3,269	5,588	6,425	6,491
			14%	16%	18%	17%	17%
SR-35 Eastbound	473	474	223	717	961	1,033	1,045
			3%	3%	3%	3%	3%
US-10 Eastbound	486	485	161	814	1,169	1,277	1,295
			2%	4%	4%	3%	3%
SR-65 Northbound	580	591	86	703	1,082	1,197	1,218
			1%	3%	3%	3%	3%
US-63 Northbound	607	608	60	403	586	640	648
			1%	2%	2%	2%	2%
SR-72 Eastbound	616	617	97	443	621	679	691
			1%	2%	2%	2%	2%
CR-21 Northbound	648	649	54	343	494	540	549
			1%	2%	2%	1%	1%
CR-F Northbound	661	662	65	456	671	735	748
			1%	2%	2%	2%	2%
US-52 Southbound	725	341	1,558	3,494	4,900	5,735	5,799
			23%	17%	15%	15%	15%
US-52 Northbound	897	896	1,637	3,884	5,948	6,608	6,661
			24%	19%	19%	18%	17%
CR-48 Westbound	914	912	236	830	1,355	1,578	1,598
			3%	4%	4%	4%	4%

Network Exit Link	Upstream Node	Downstream Node	Elapsed Time (hours)				
			1:00	2:00	3:00	4:00	4:40
			Cumulative Vehicles Discharged by the Indicated Time				
			Cumulative Percent of Vehicles Discharged by the Indicated Time				
CR-42 Westbound	916	915	6	142	356	442	445
			0%	1%	1%	1%	1%
CR-6 Southbound	1013	1014	178	659	1,018	1,264	1,291
			3%	3%	3%	3%	3%
SR-58 Southbound	1015	883	437	1,622	2,772	3,585	3,633
			6%	8%	9%	10%	9%

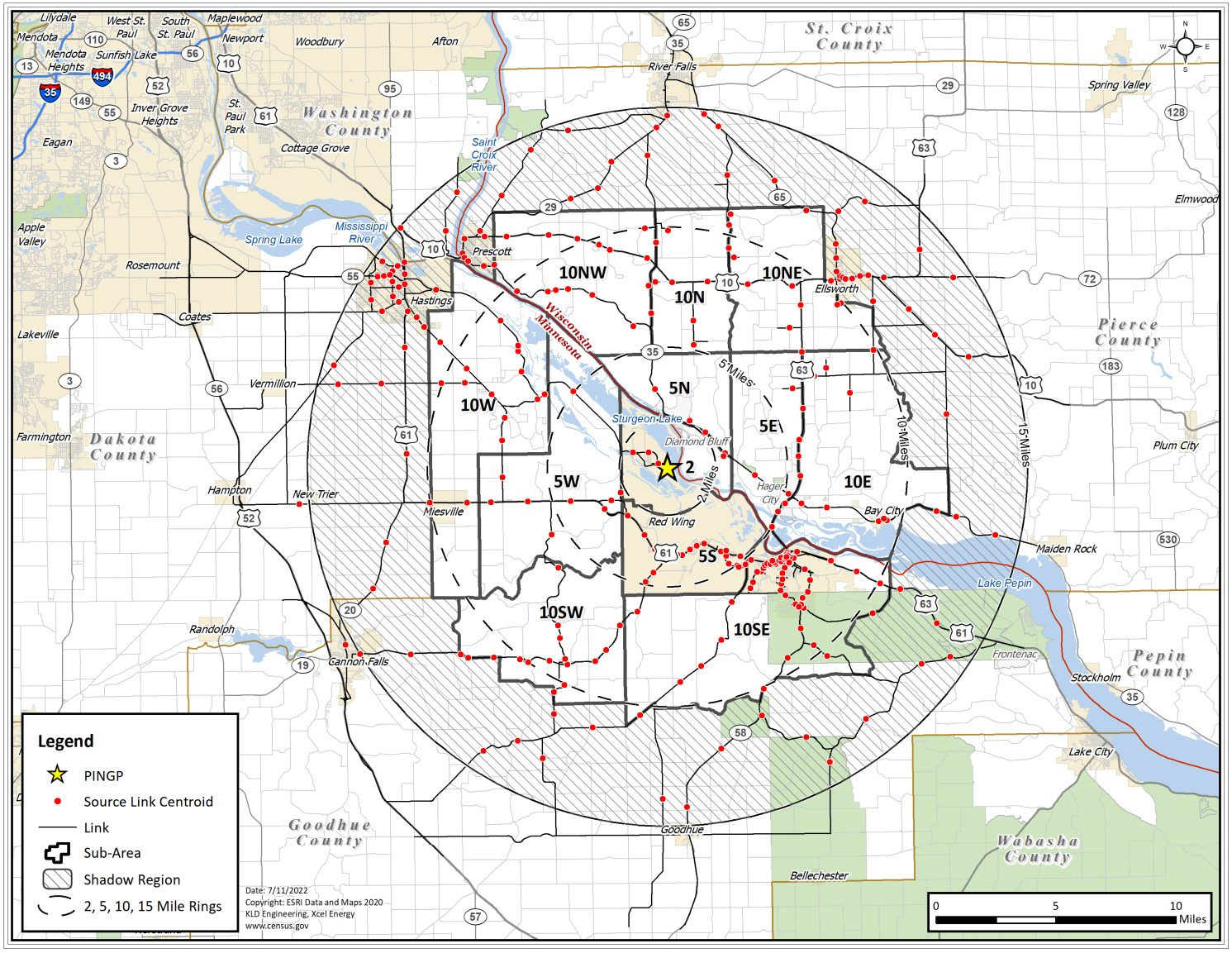


Figure J-1. Network Sources/Origins

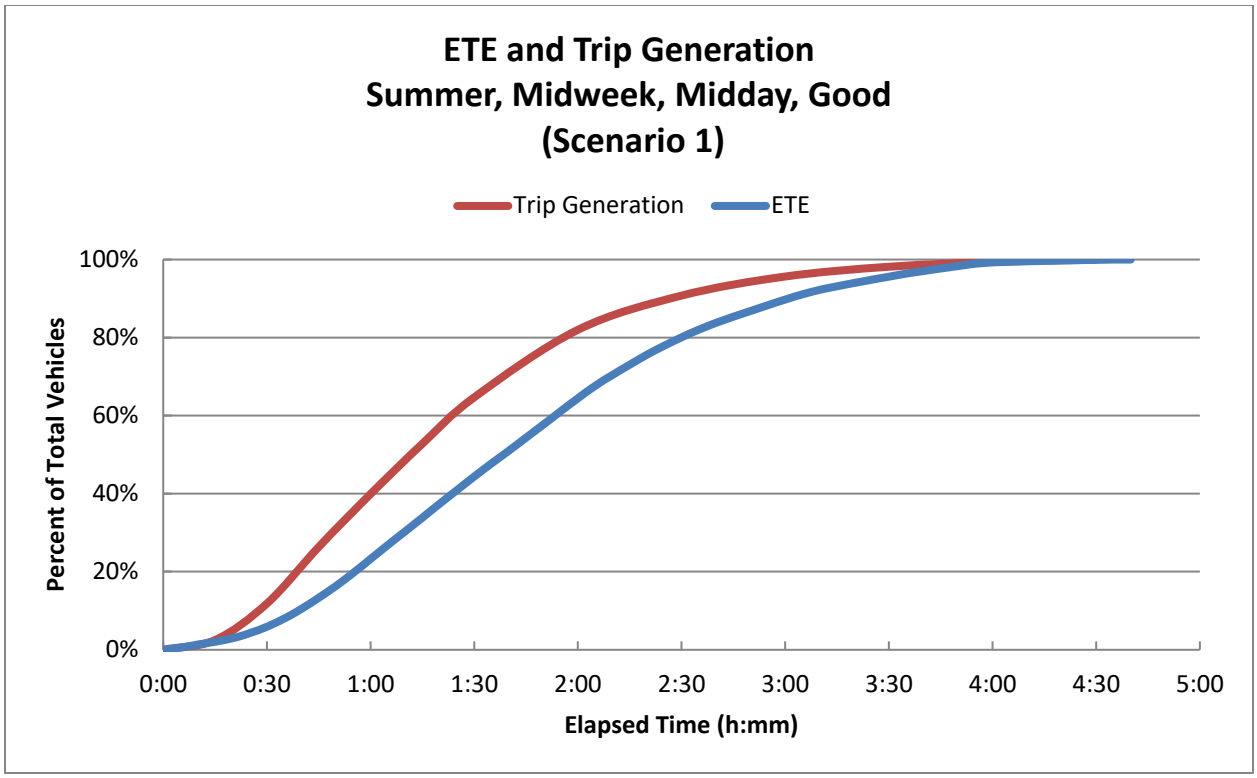


Figure J-2. ETE and Trip Generation: Summer, Midweek, Midday, Good Weather (Scenario 1)

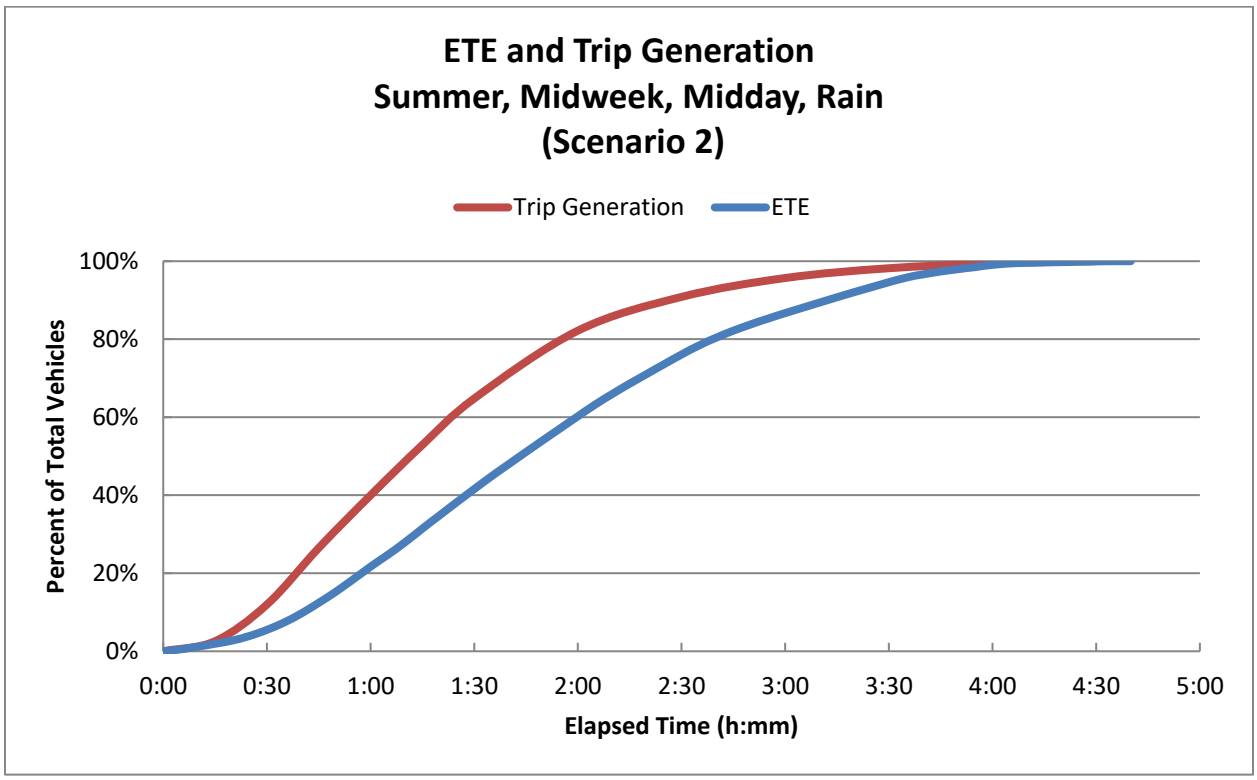


Figure J-3. ETE and Trip Generation: Summer, Midweek, Midday, Rain (Scenario 2)

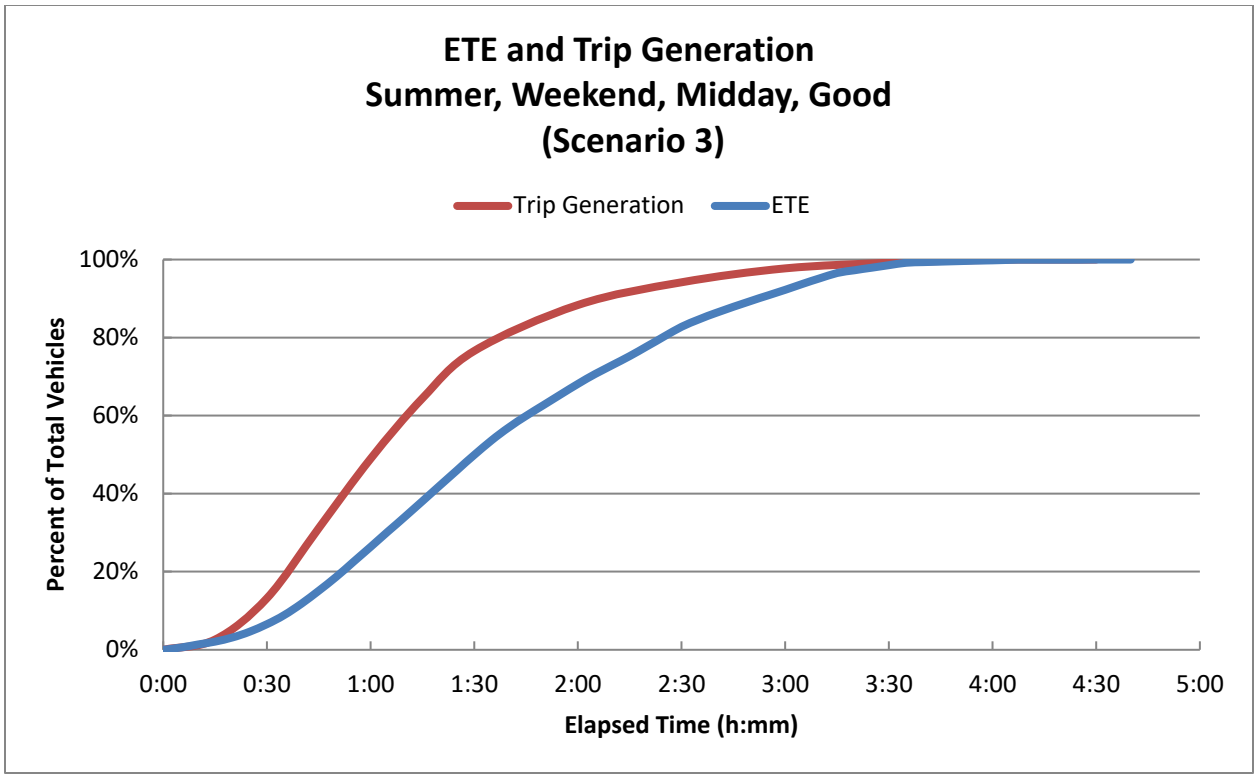


Figure J-4. ETE and Trip Generation: Summer, Weekend, Midday, Good Weather (Scenario 3)

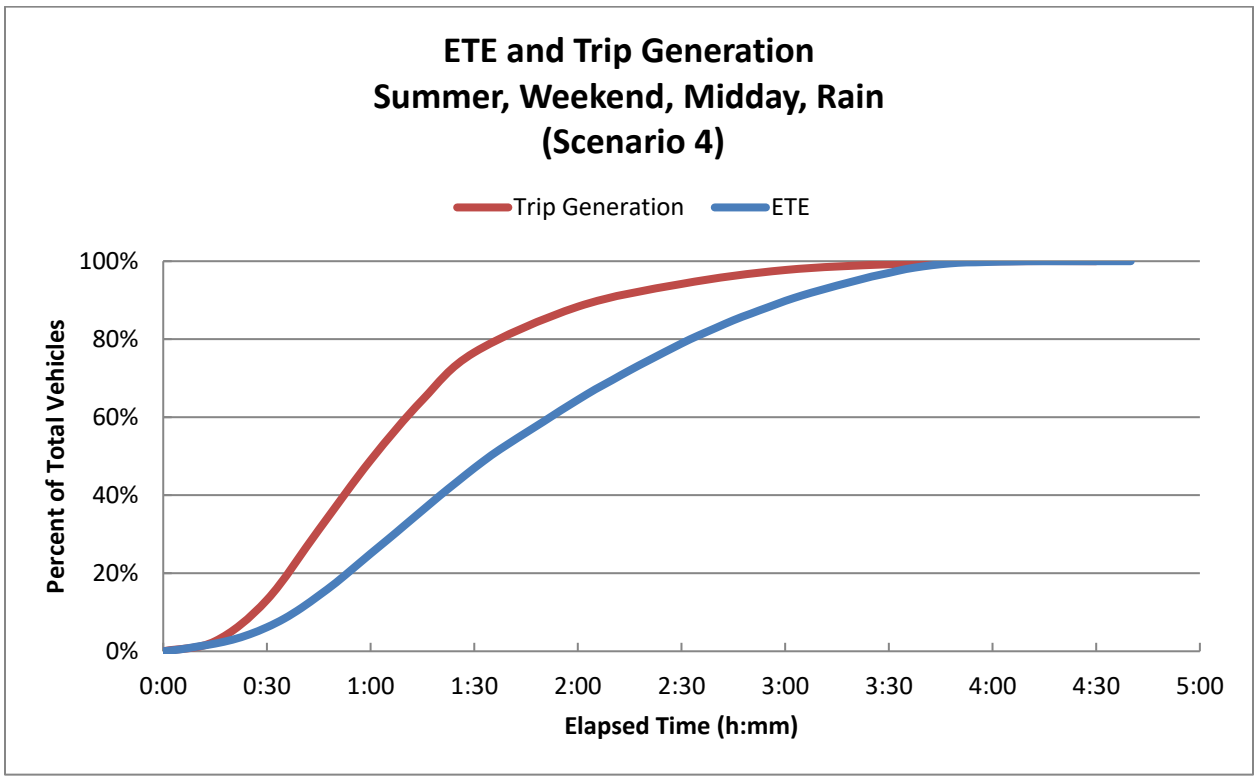


Figure J-5. ETE and Trip Generation: Summer, Weekend, Midday, Rain (Scenario 4)

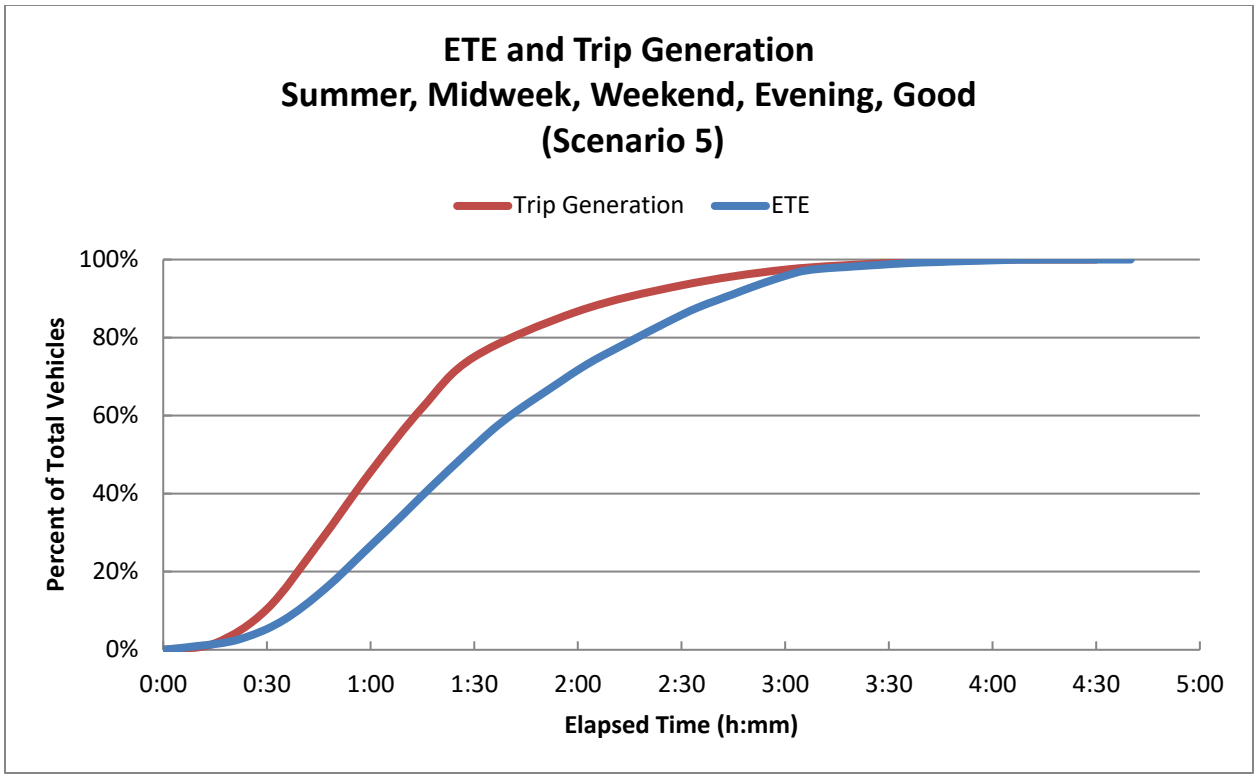


Figure J-6. ETE and Trip Generation: Summer, Midweek, Weekend, Evening, Good Weather (Scenario 5)

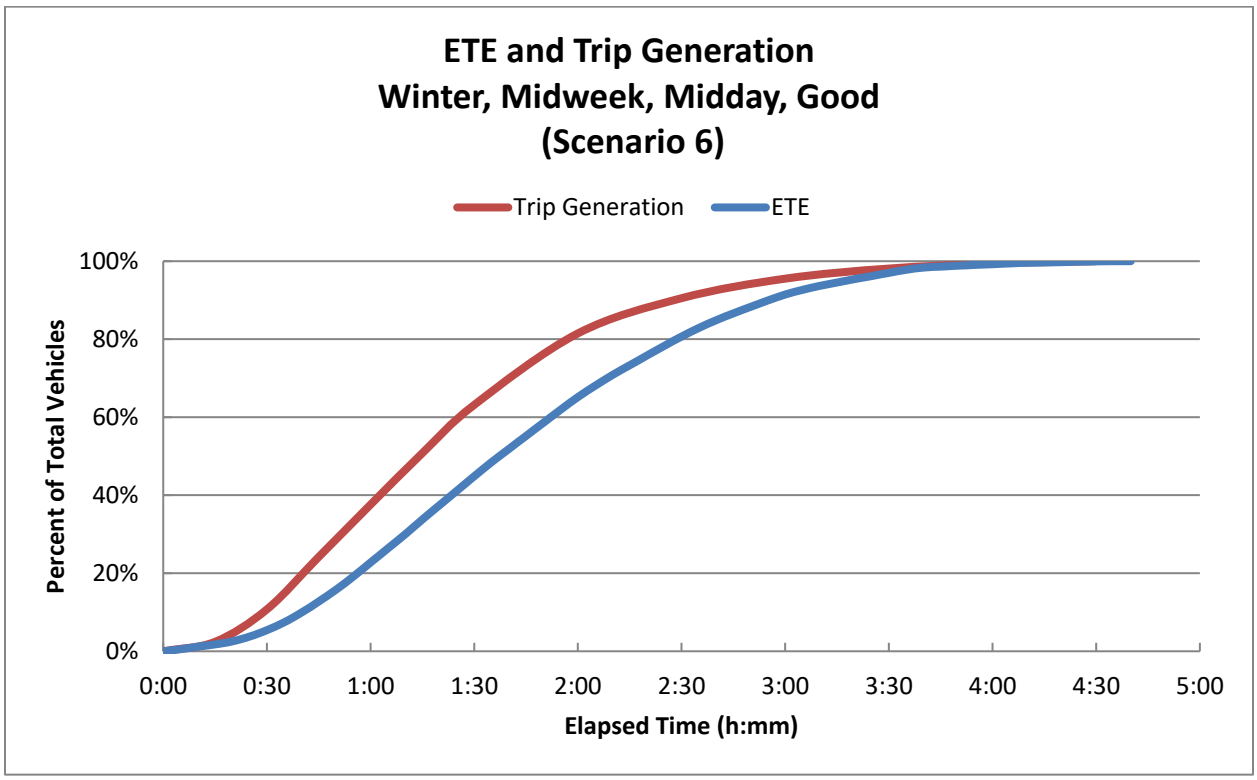


Figure J-7. ETE and Trip Generation: Winter, Midweek, Midday, Good Weather (Scenario 6)

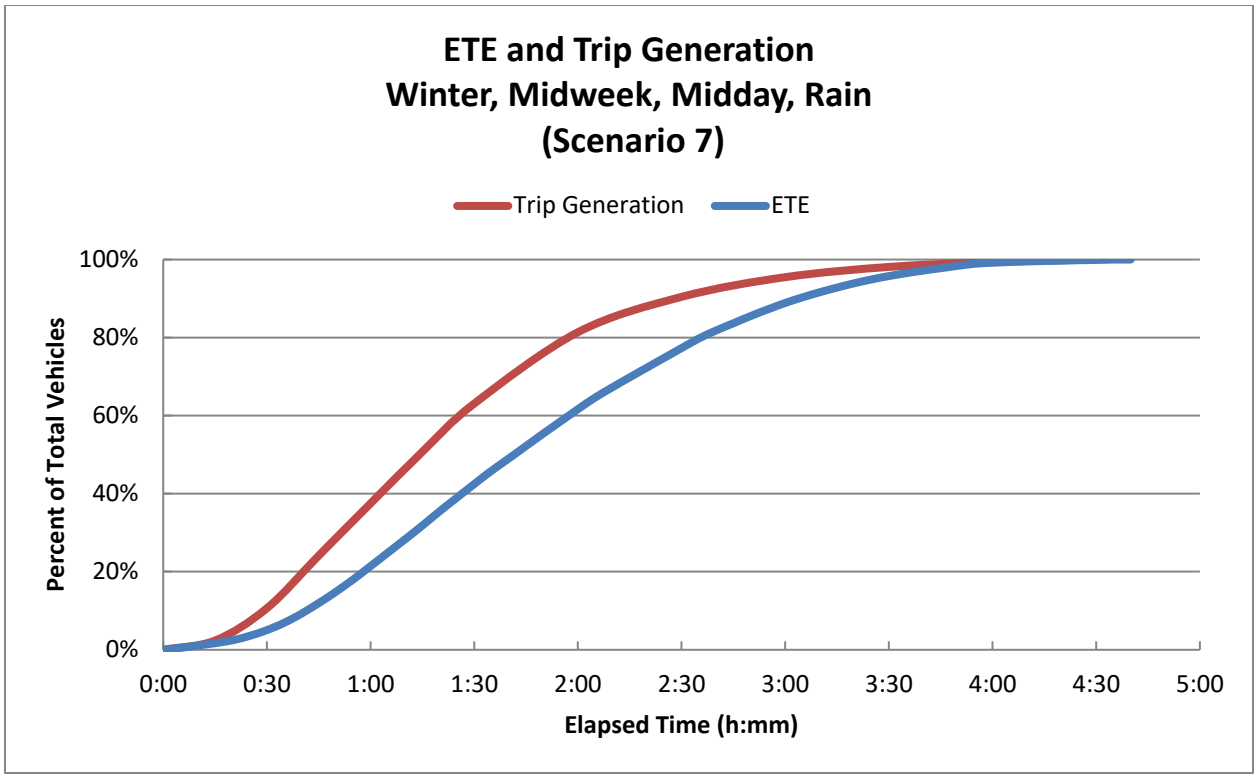


Figure J-8. ETE and Trip Generation: Winter, Midweek, Midday, Rain/Light Snow (Scenario 7)

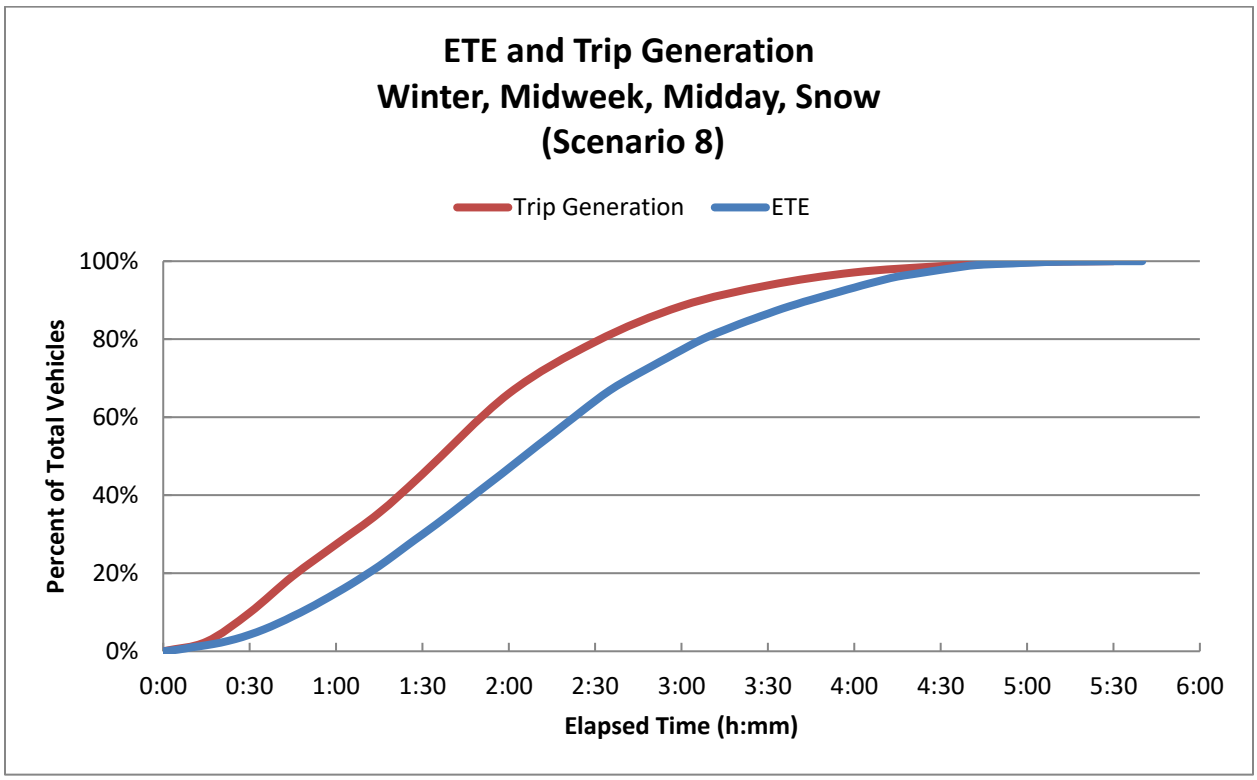


Figure J-9. ETE and Trip Generation: Winter, Midweek, Midday, Heavy Snow (Scenario 8)

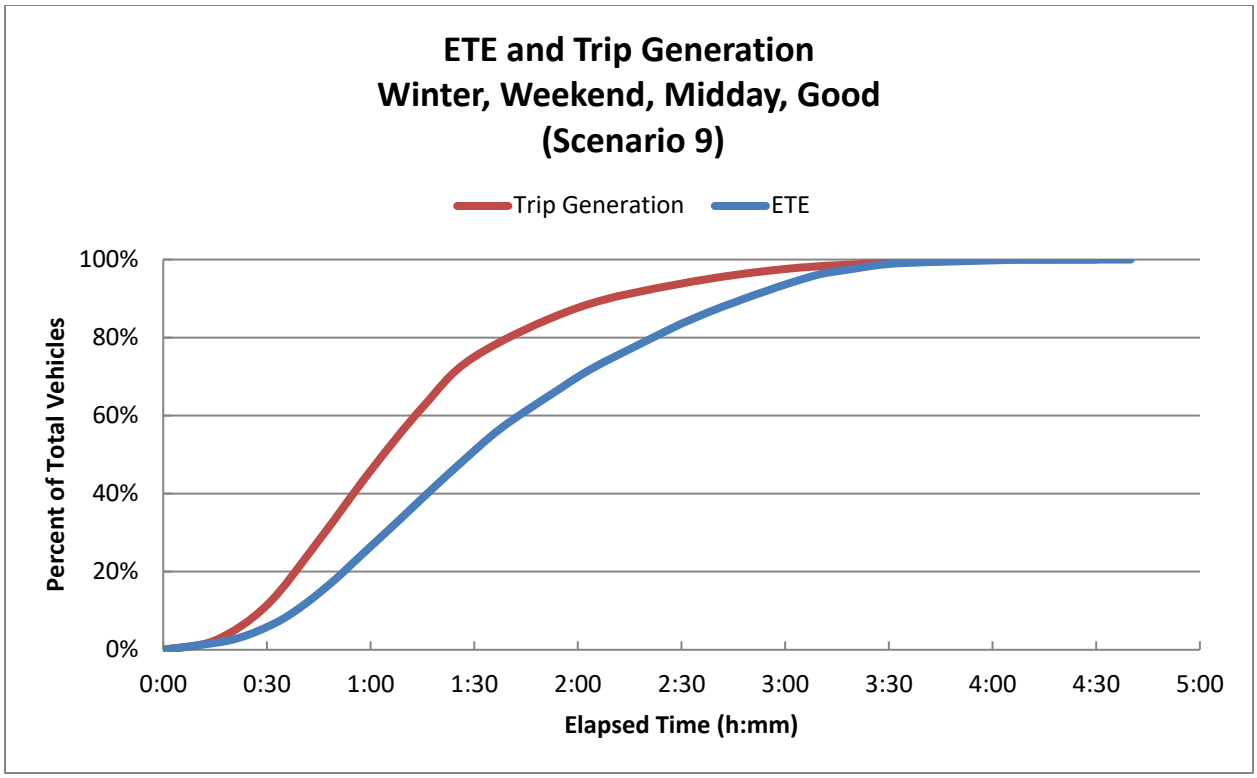


Figure J-10. ETE and Trip Generation: Winter, Weekend, Midday, Good Weather (Scenario 9)

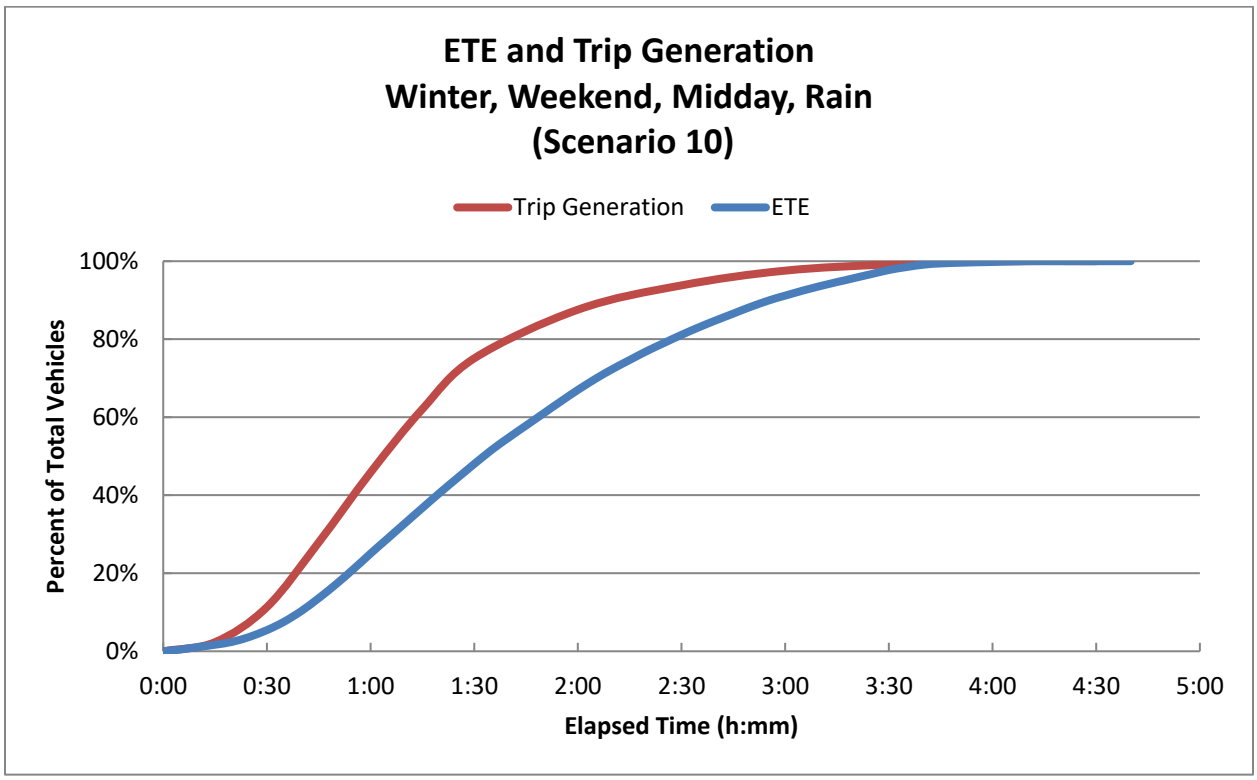


Figure J-11. ETE and Trip Generation: Winter, Weekend, Midday, Rain/Light Snow (Scenario 10)

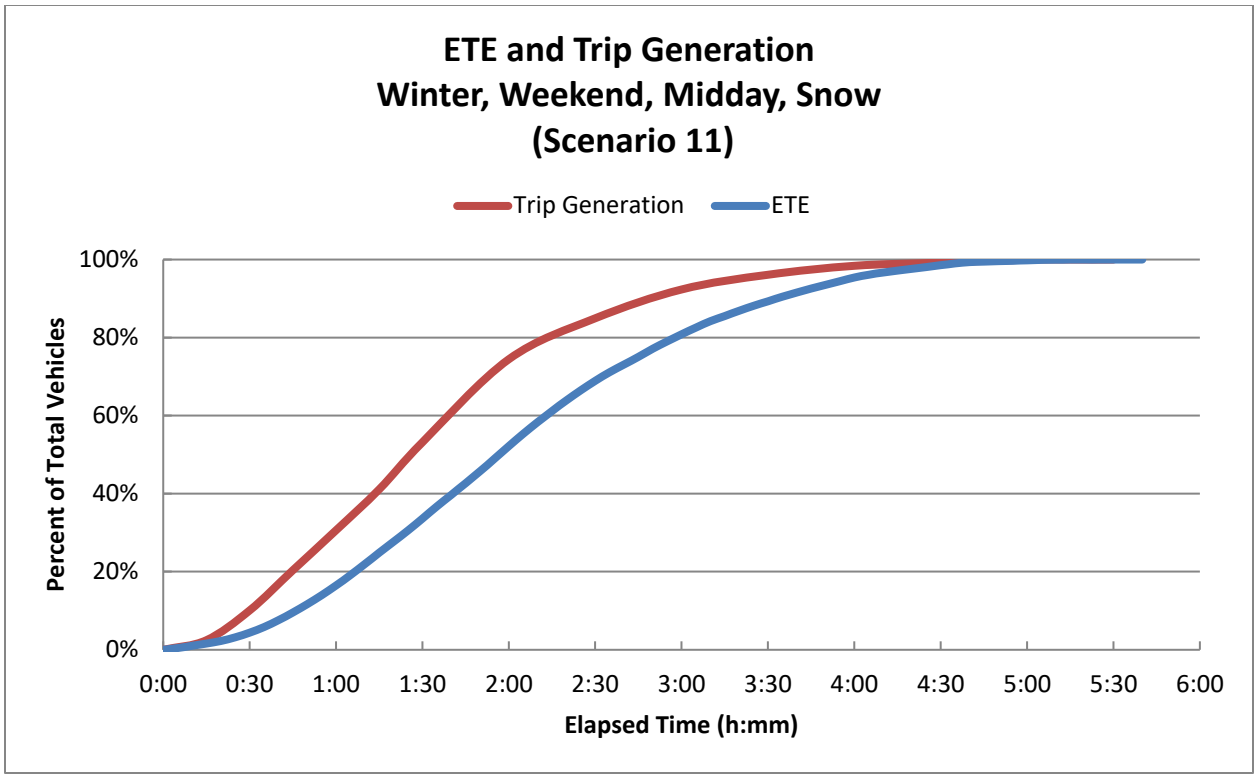


Figure J-12. ETE and Trip Generation: Winter, Weekend, Midday, Heavy Snow (Scenario 11)

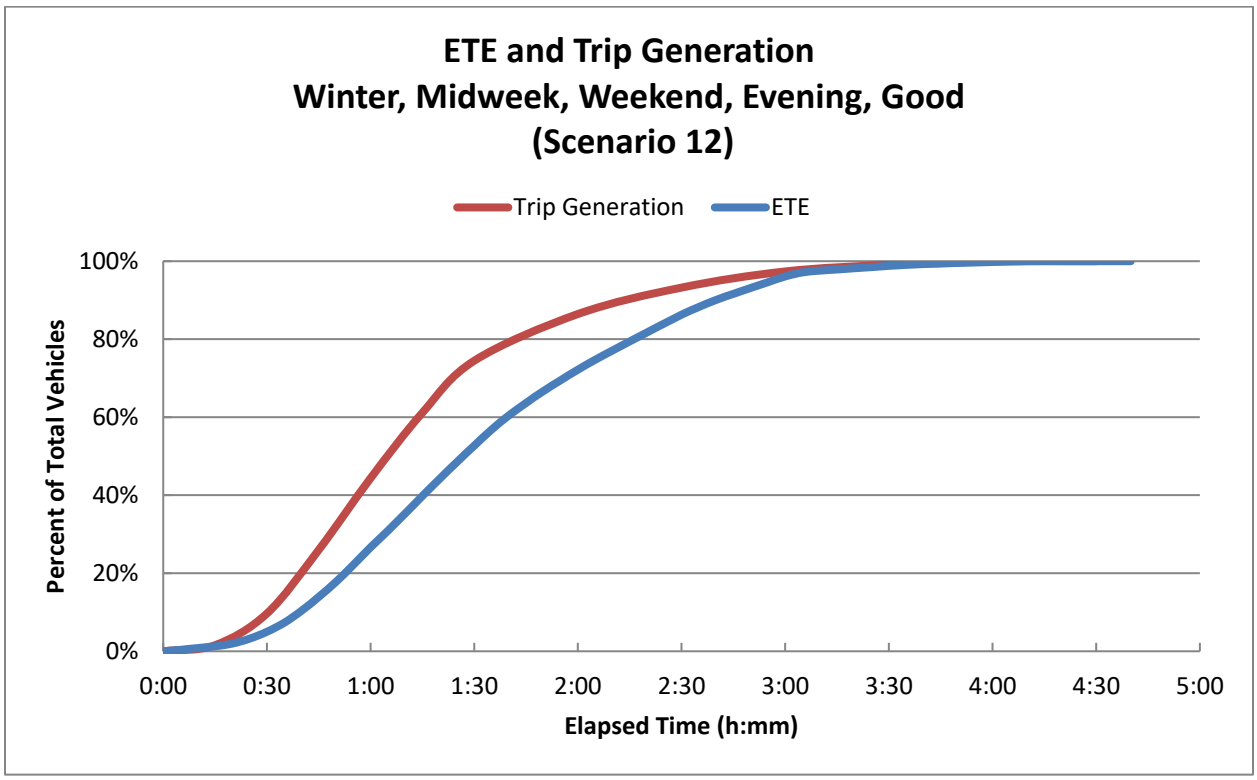


Figure J-13. ETE and Trip Generation: Winter, Midweek, Weekend, Evening, Good Weather (Scenario 12)

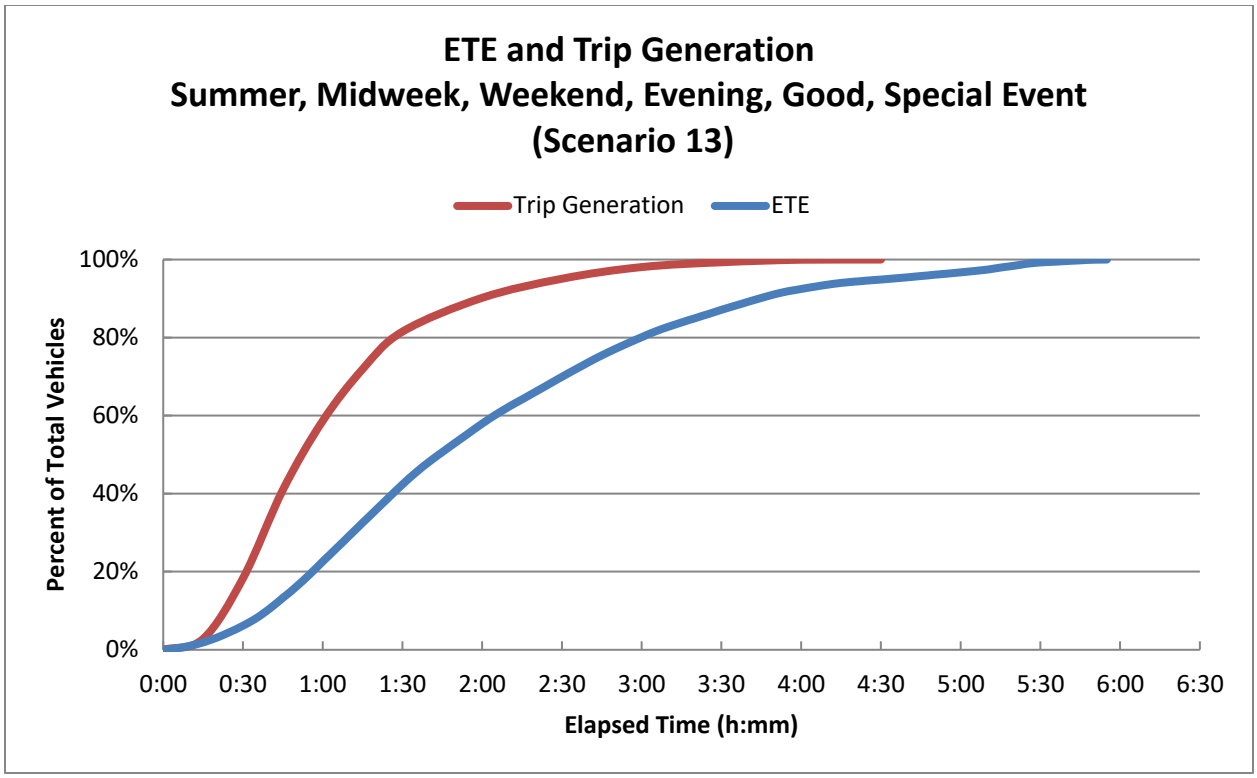


Figure J-14. ETE and Trip Generation: Summer, Midweek, Weekend/Evening, Good Weather, Special Event (Scenario 13)

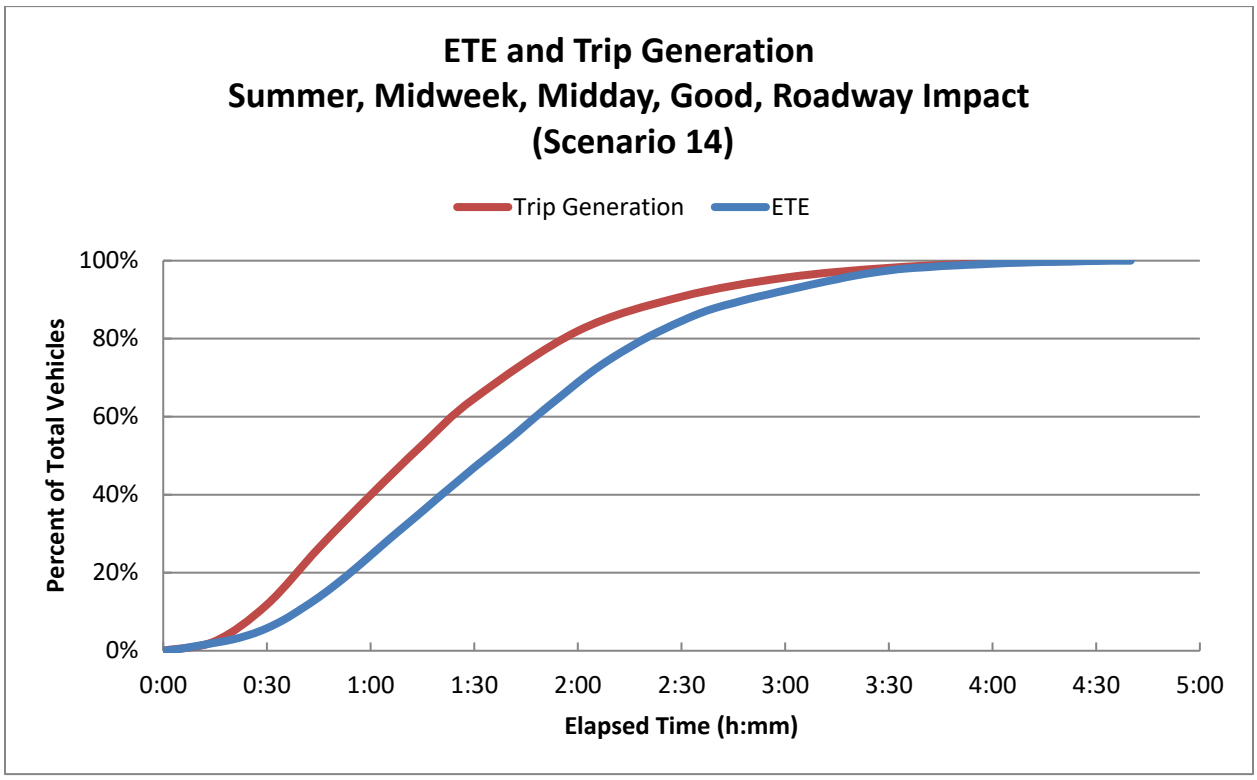


Figure J-15. ETE and Trip Generation: Summer, Midweek, Midday, Good Weather, Roadway Impact (Scenario 14)

APPENDIX K

Evacuation Roadway Network

K. EVACUATION ROADWAY NETWORK

As discussed in Section 1.3, a link-node analysis network was constructed to model the roadway network within the study area. Figure K-1 provides an overview of the link-node analysis network. The figure has been divided up into 49 more detailed figures (Figure K-2 through Figure K-50) which show each of the links and nodes in the network.

The analysis network was calibrated using the observations made during the field surveys conducted in January 2021.

Table K-1 summarizes the number of nodes by the type of control (stop sign, yield sign, pre-timed signal, actuated signal, Traffic and Access Control Point [TACP] and uncontrolled).

Table K-1. Summary of Nodes by the Type of Control

Control Type	Number of Nodes
Uncontrolled	791
Pretimed	4
Actuated	31
Stop	115
TACP	61
Yield	11
Total:	**1,013**

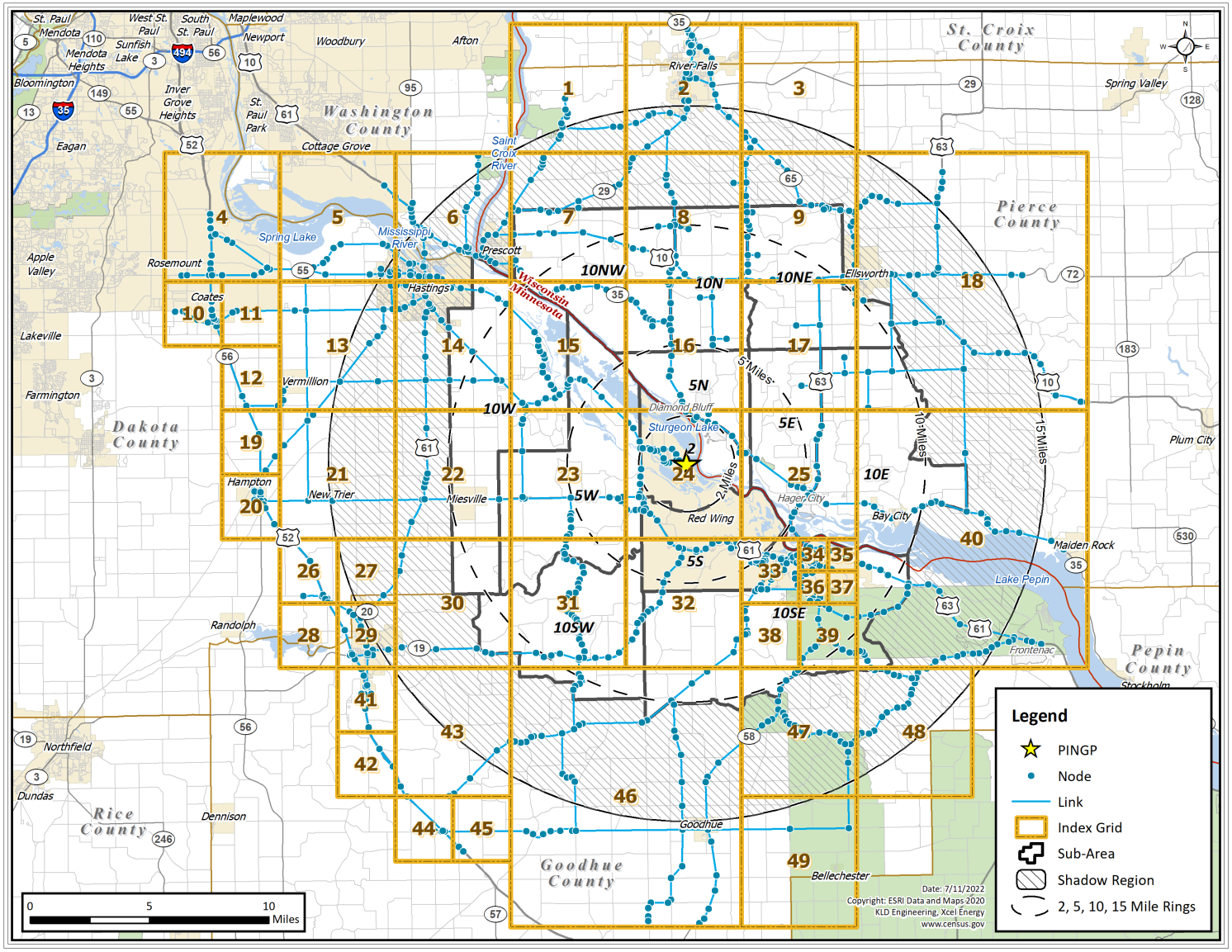


Figure K-1. PINGP Link-Node Analysis Network

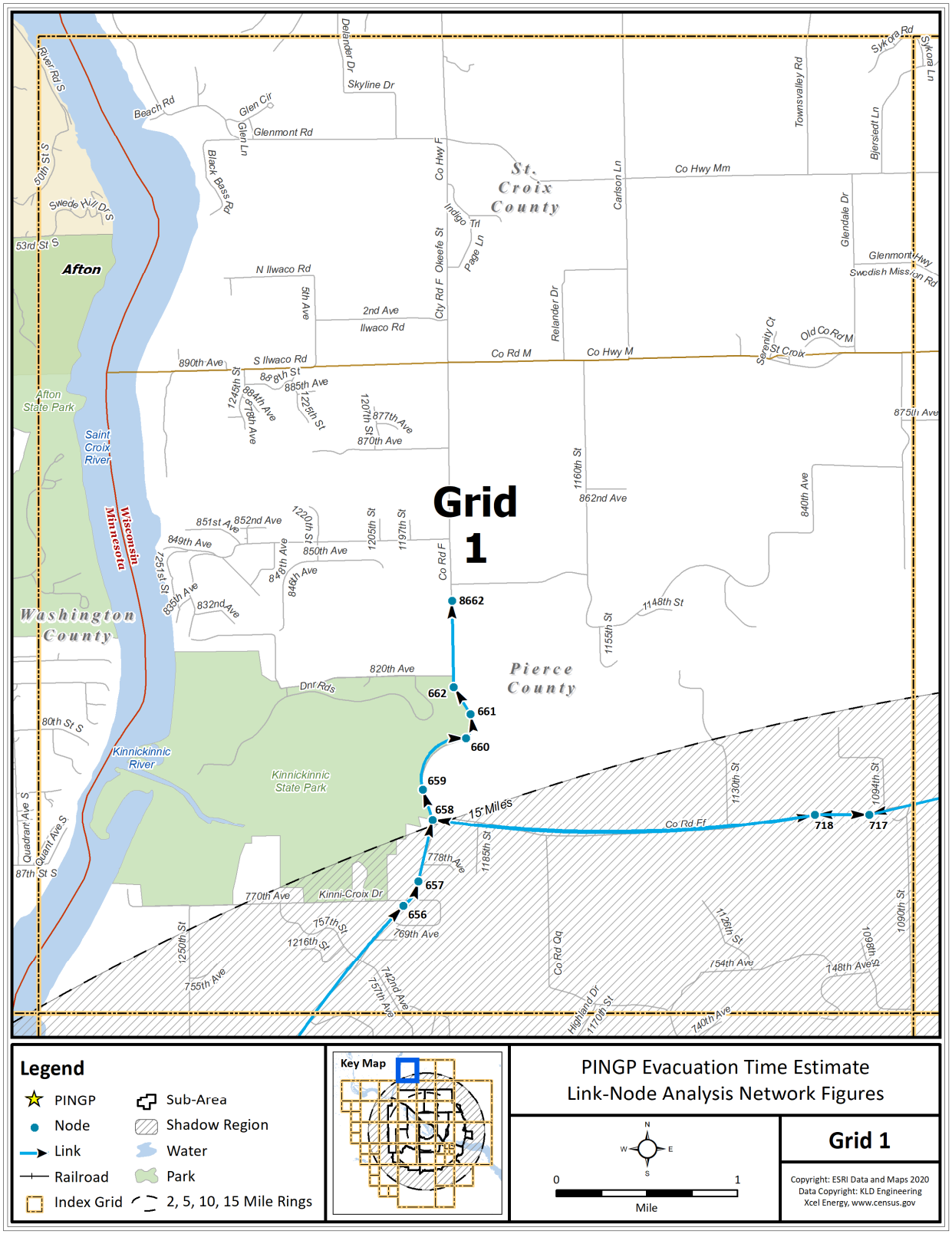


Figure K-2. Link-Node Analysis Network – Grid 1

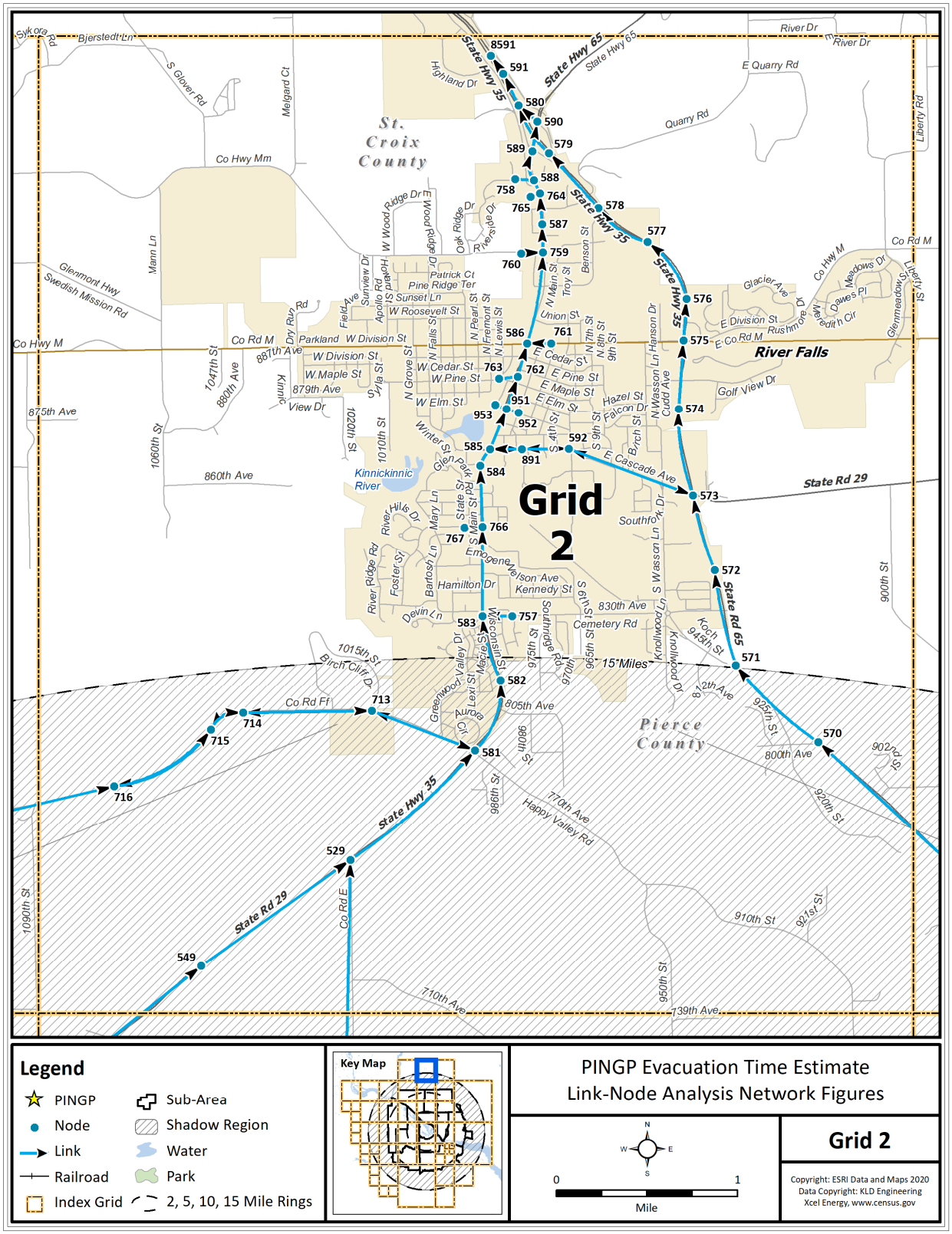


Figure K-3. Link-Node Analysis Network – Grid 2

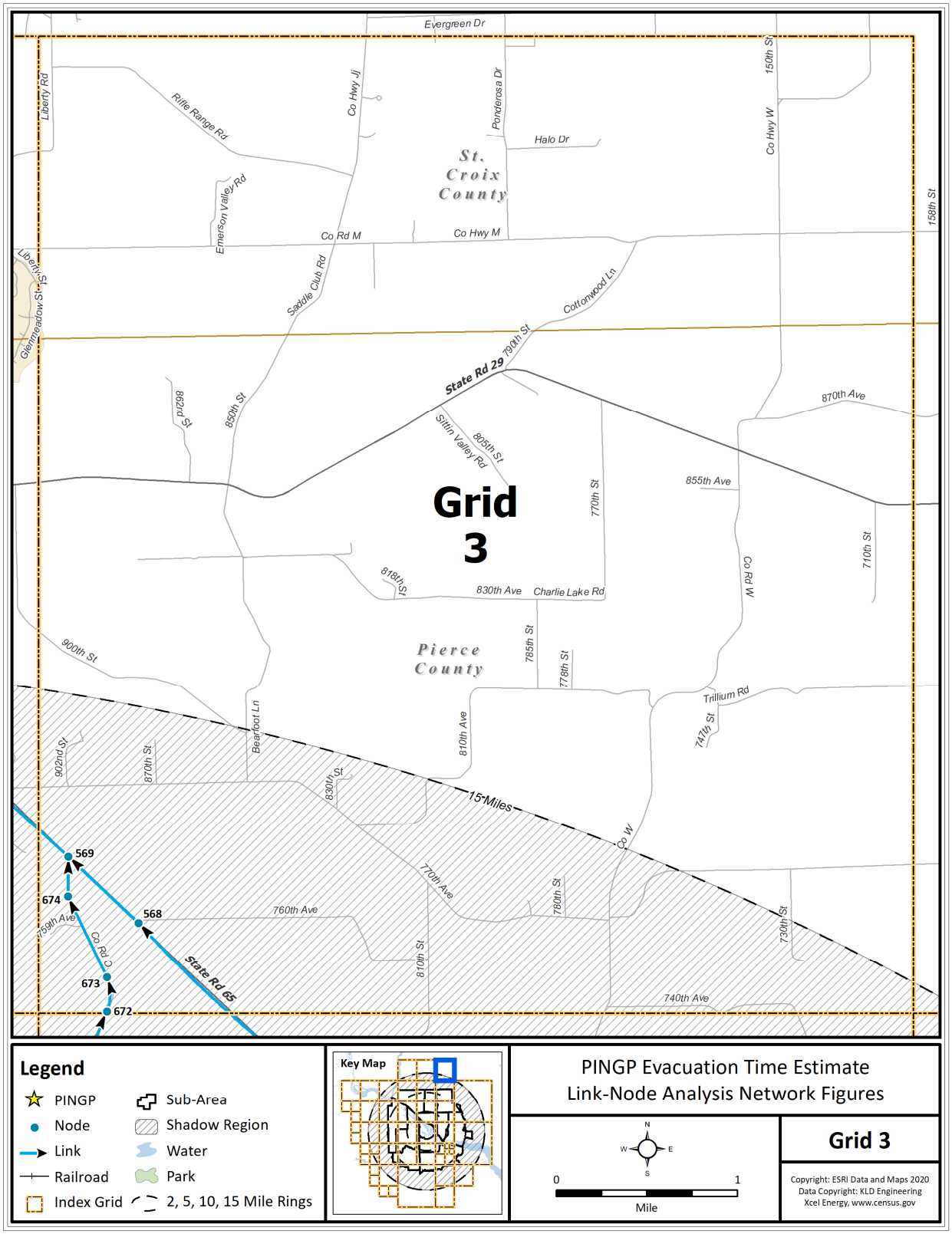


Figure K-4. Link-Node Analysis Network – Grid 3

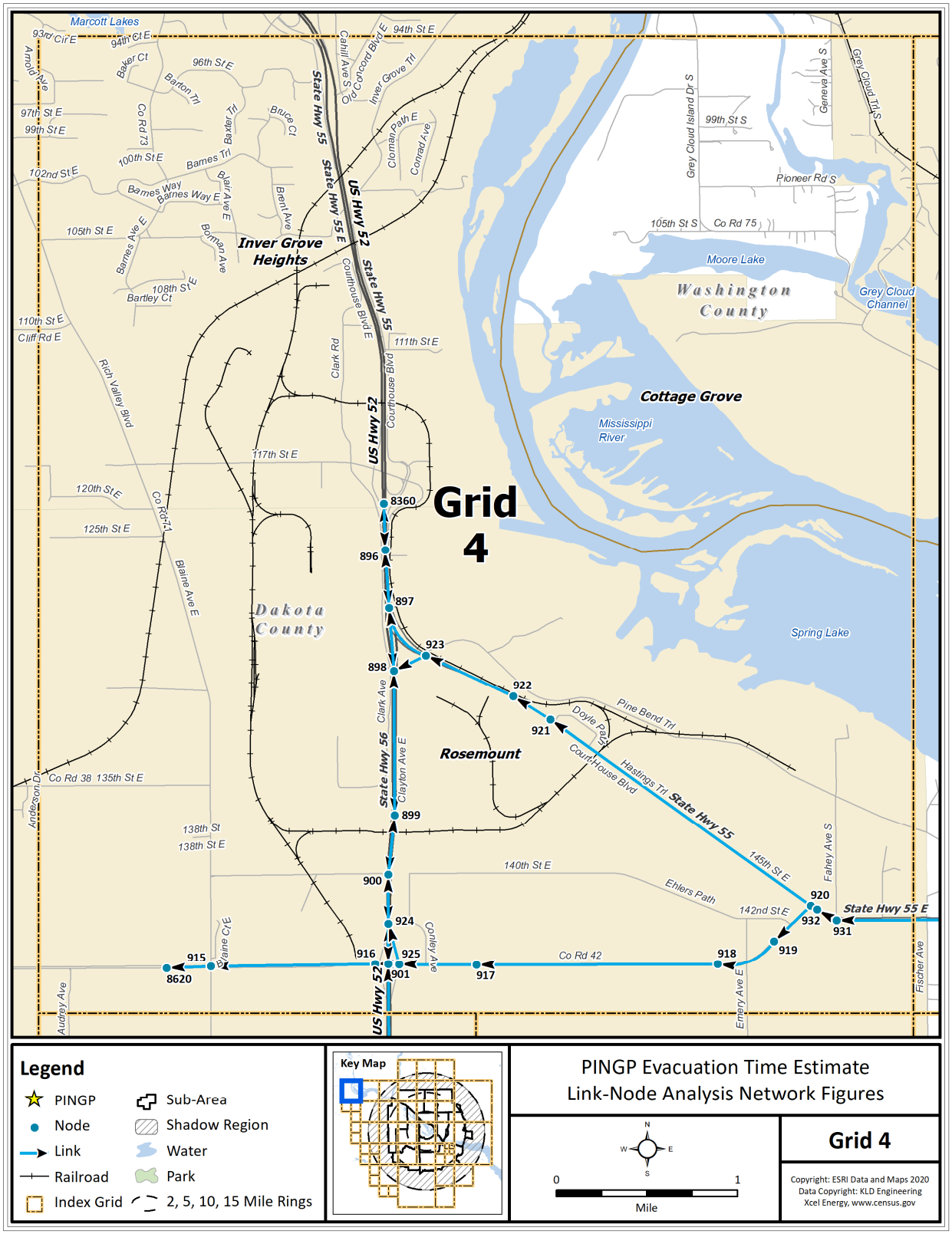


Figure K-5. Link-Node Analysis Network – Grid 4

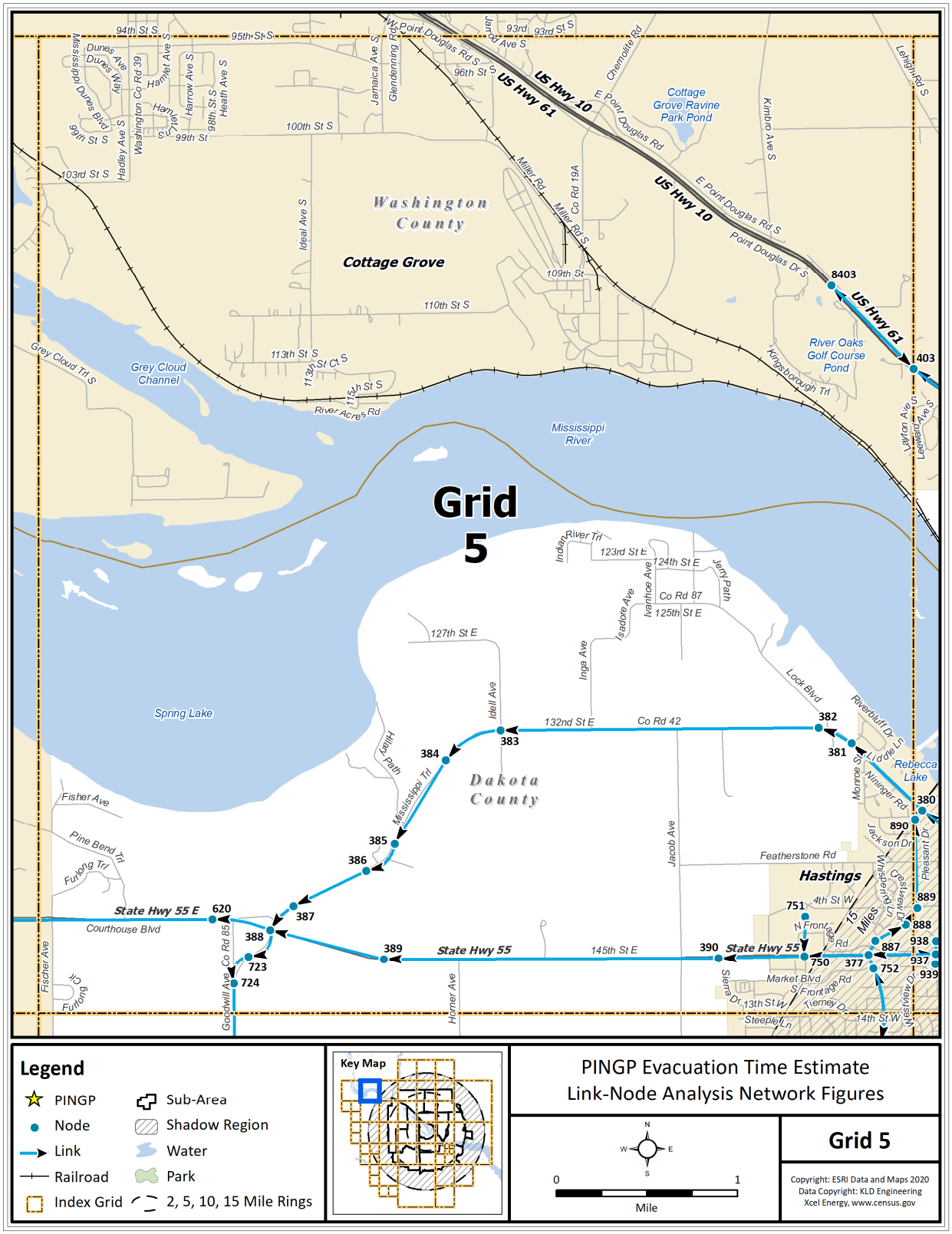


Figure K-6. Link-Node Analysis Network – Grid 5

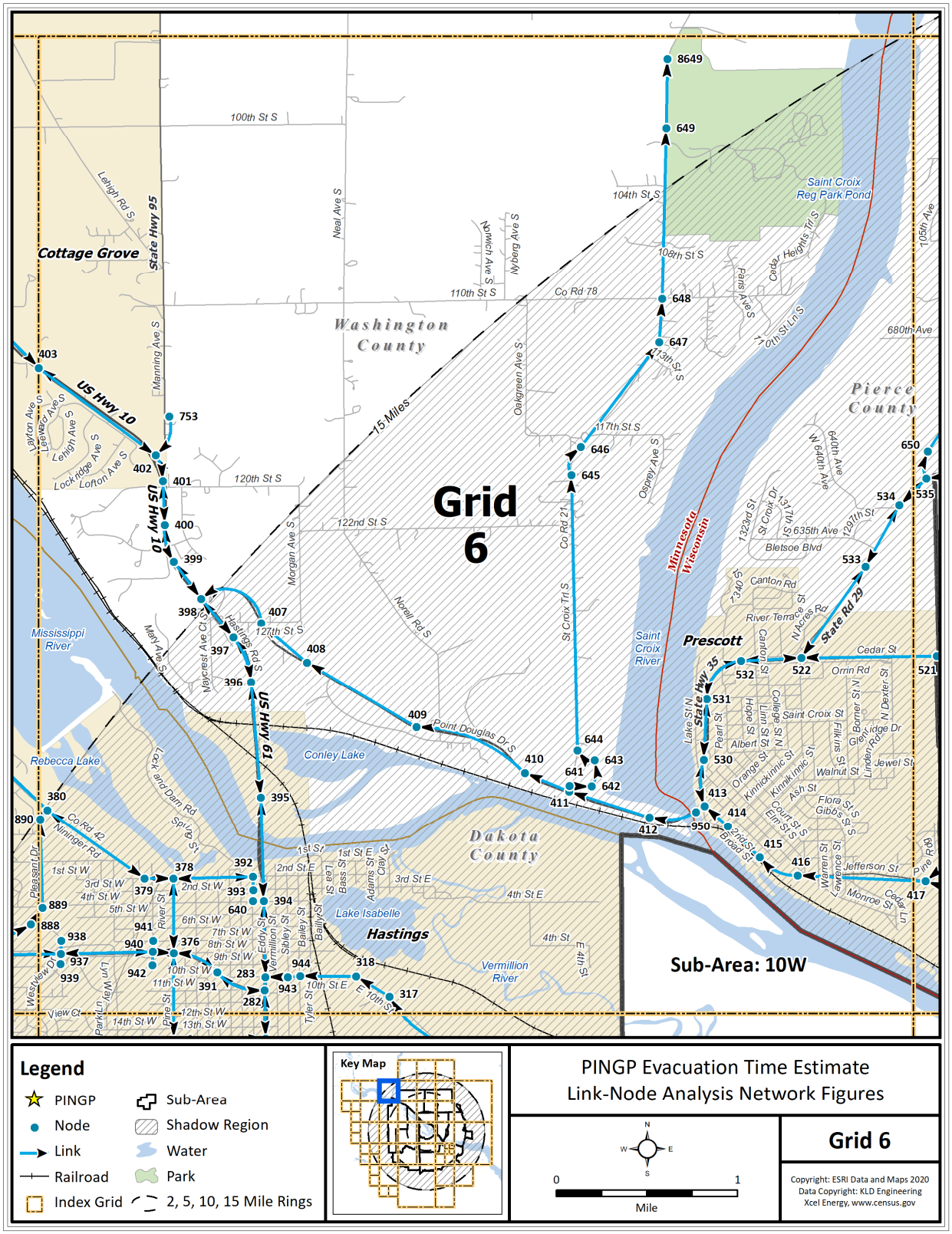


Figure K-7. Link-Node Analysis Network – Grid 6

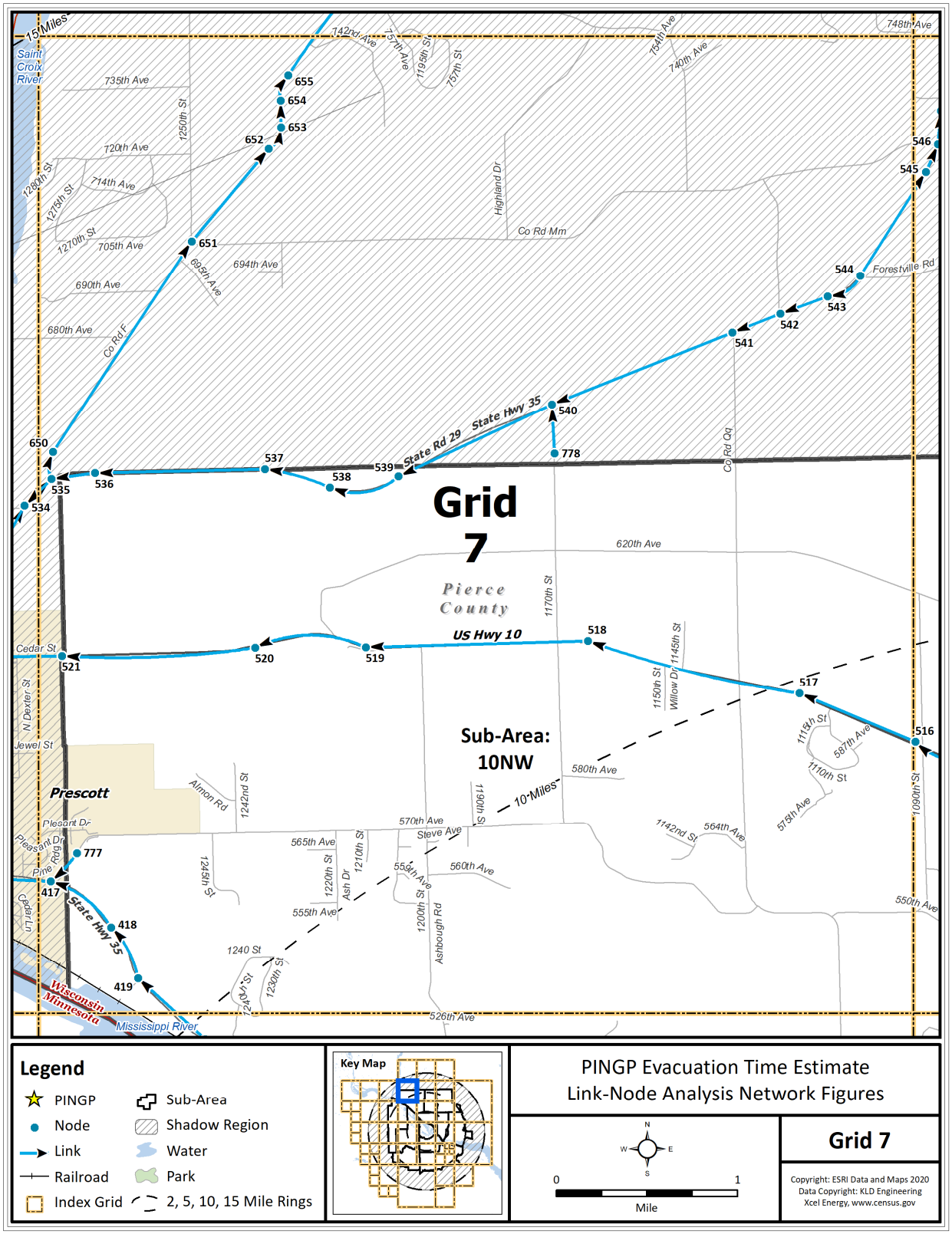


Figure K-8. Link-Node Analysis Network – Grid 7

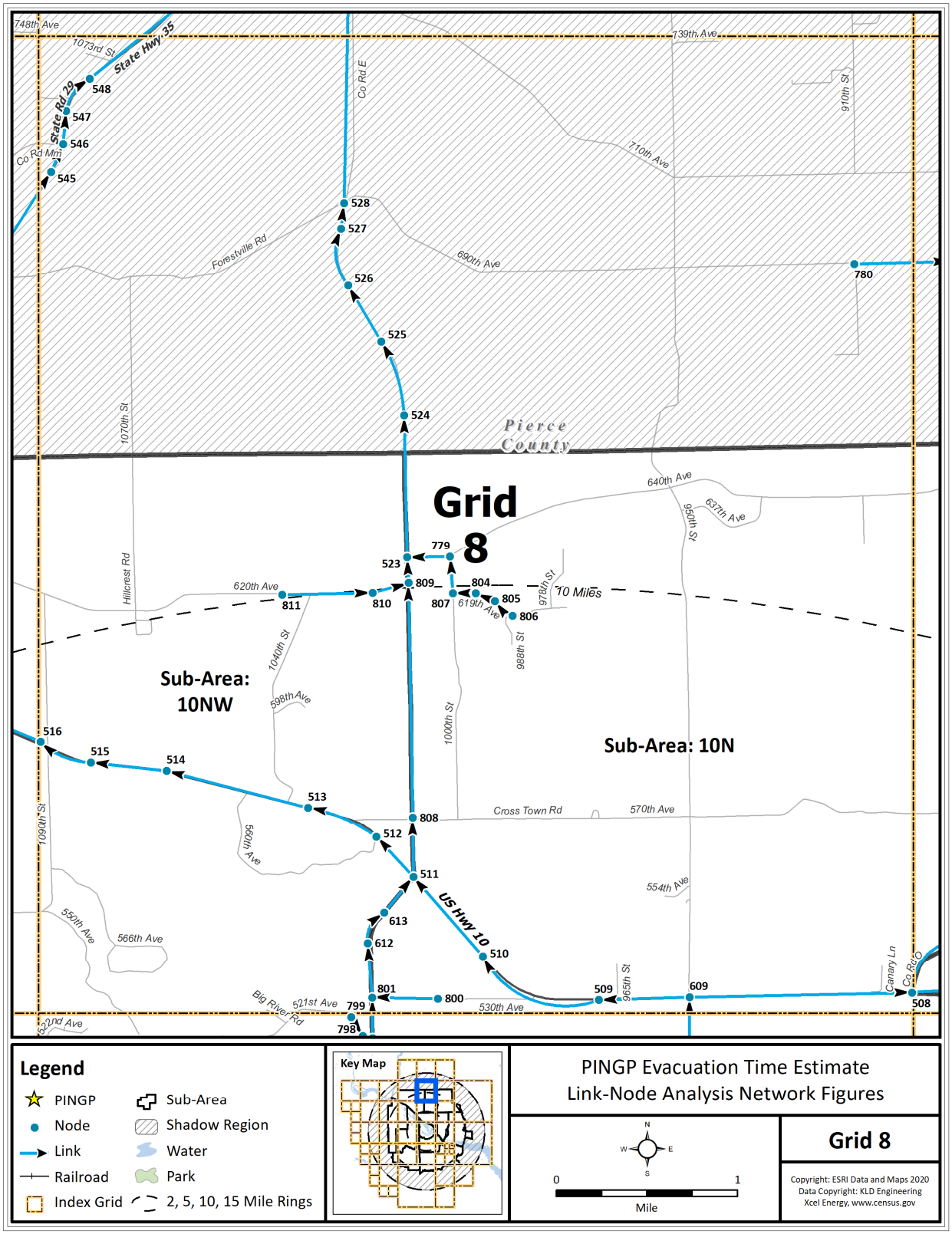


Figure K-9. Link-Node Analysis Network – Grid 8

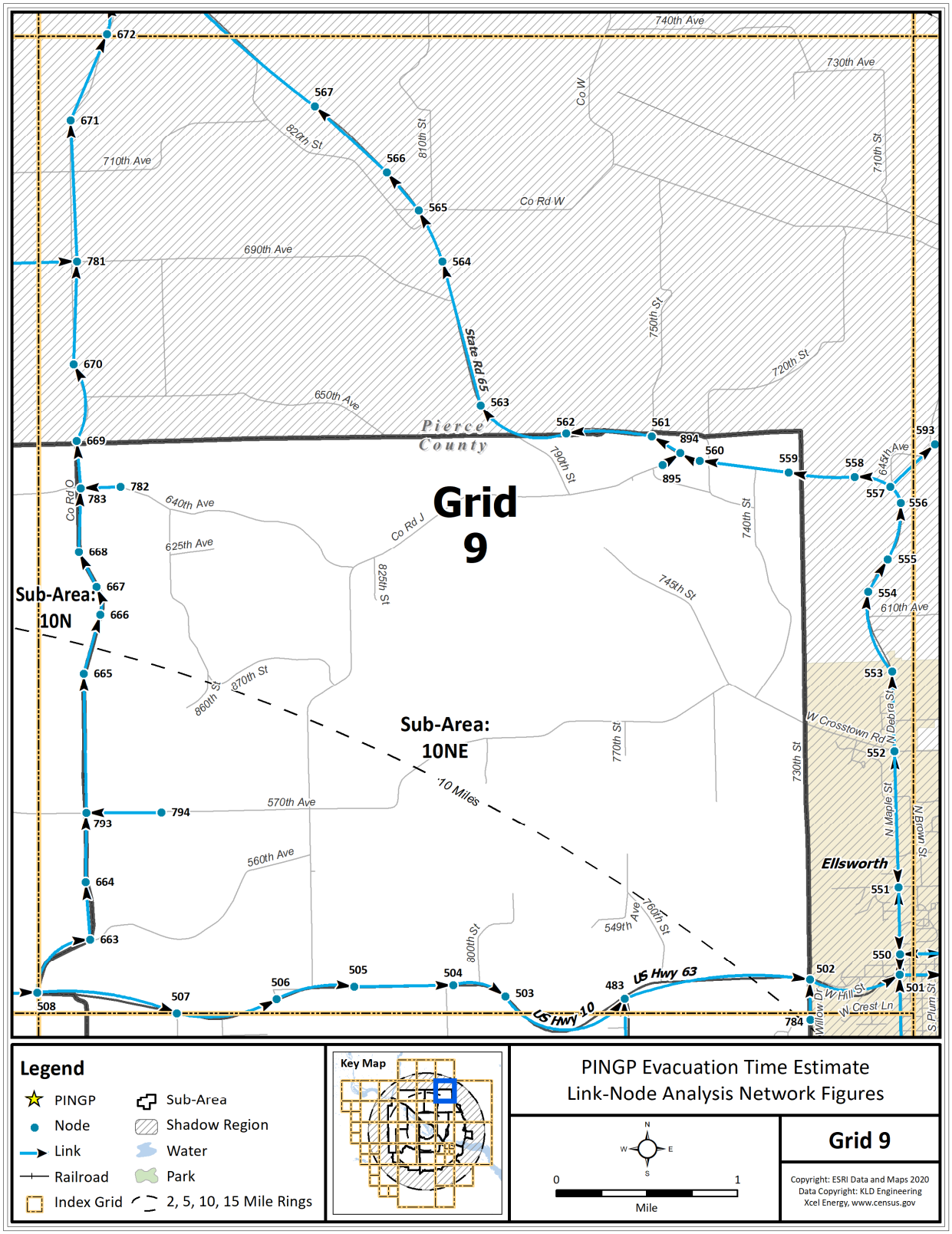


Figure K-10. Link-Node Analysis Network – Grid 9

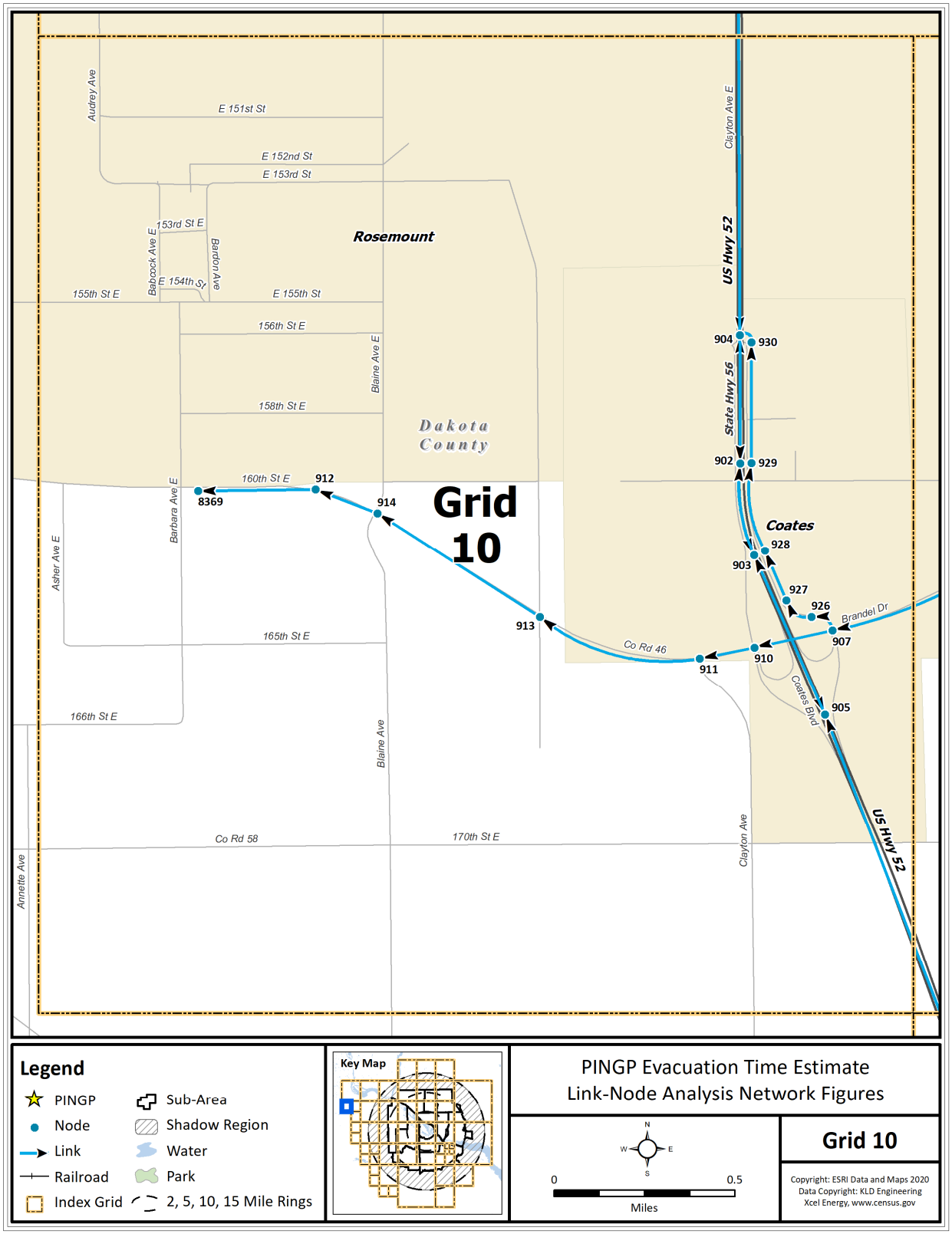


Figure K-11. Link-Node Analysis Network – Grid 10

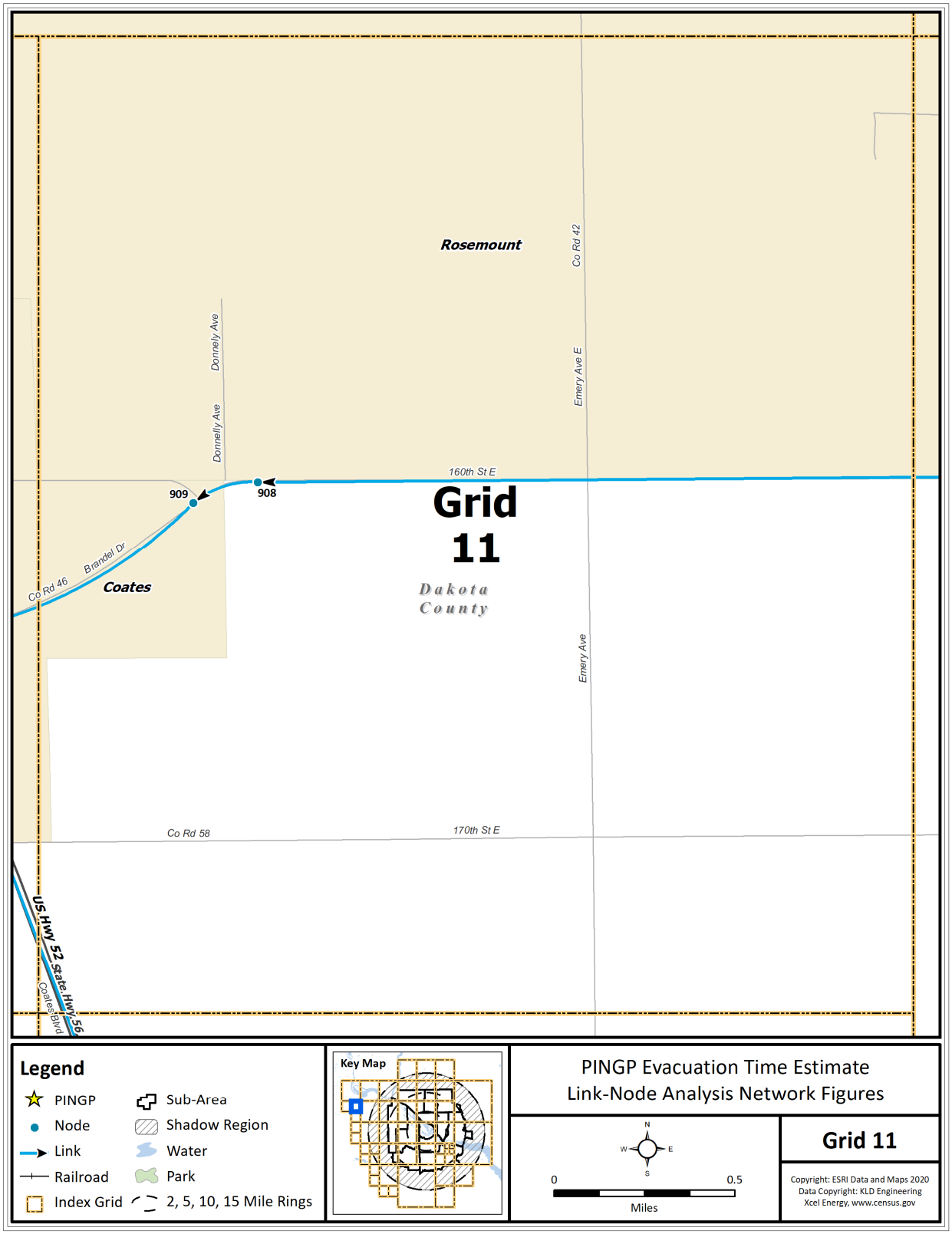


Figure K-12. Link-Node Analysis Network – Grid 11

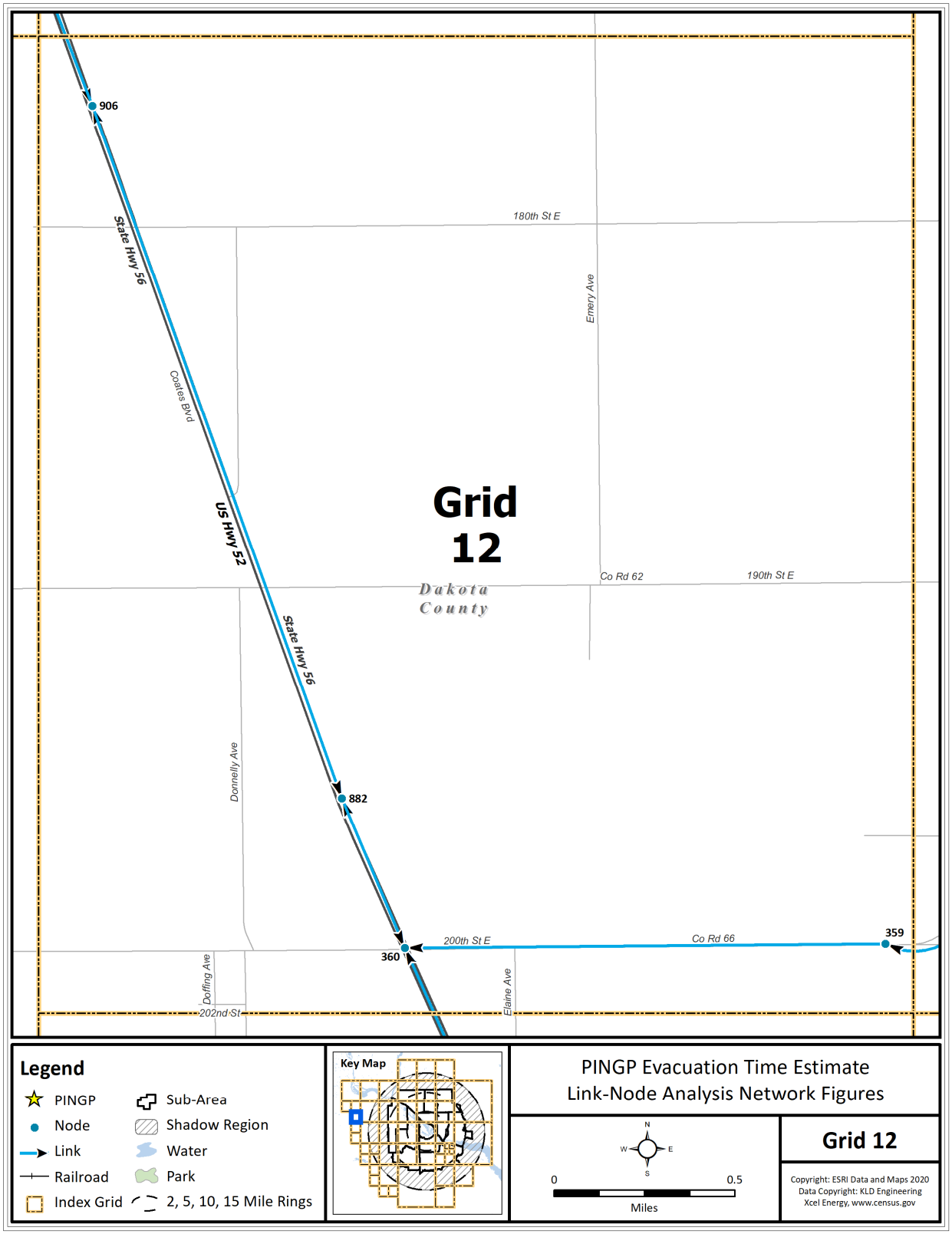


Figure K-13. Link-Node Analysis Network – Grid 12

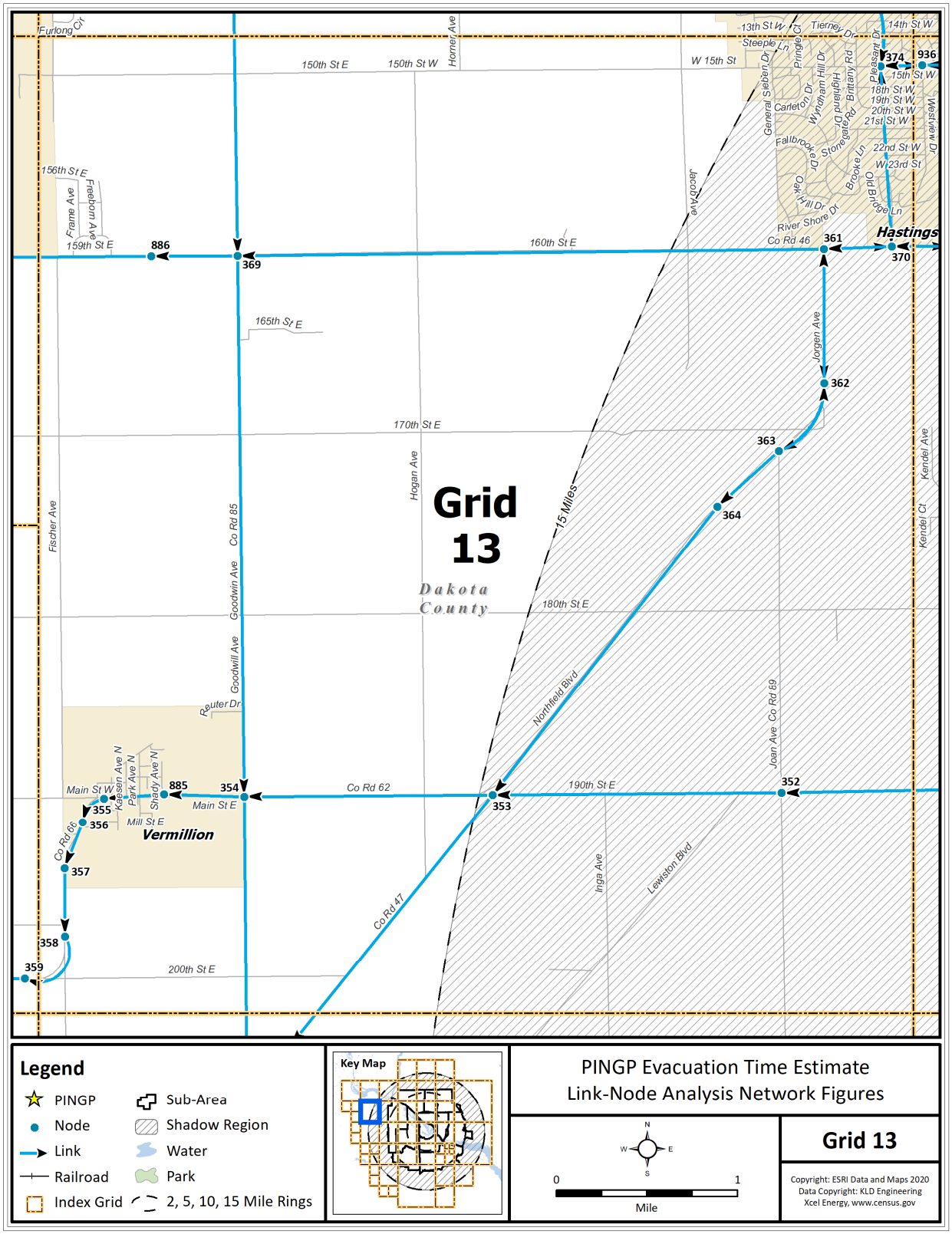


Figure K-14. Link-Node Analysis Network – Grid 13

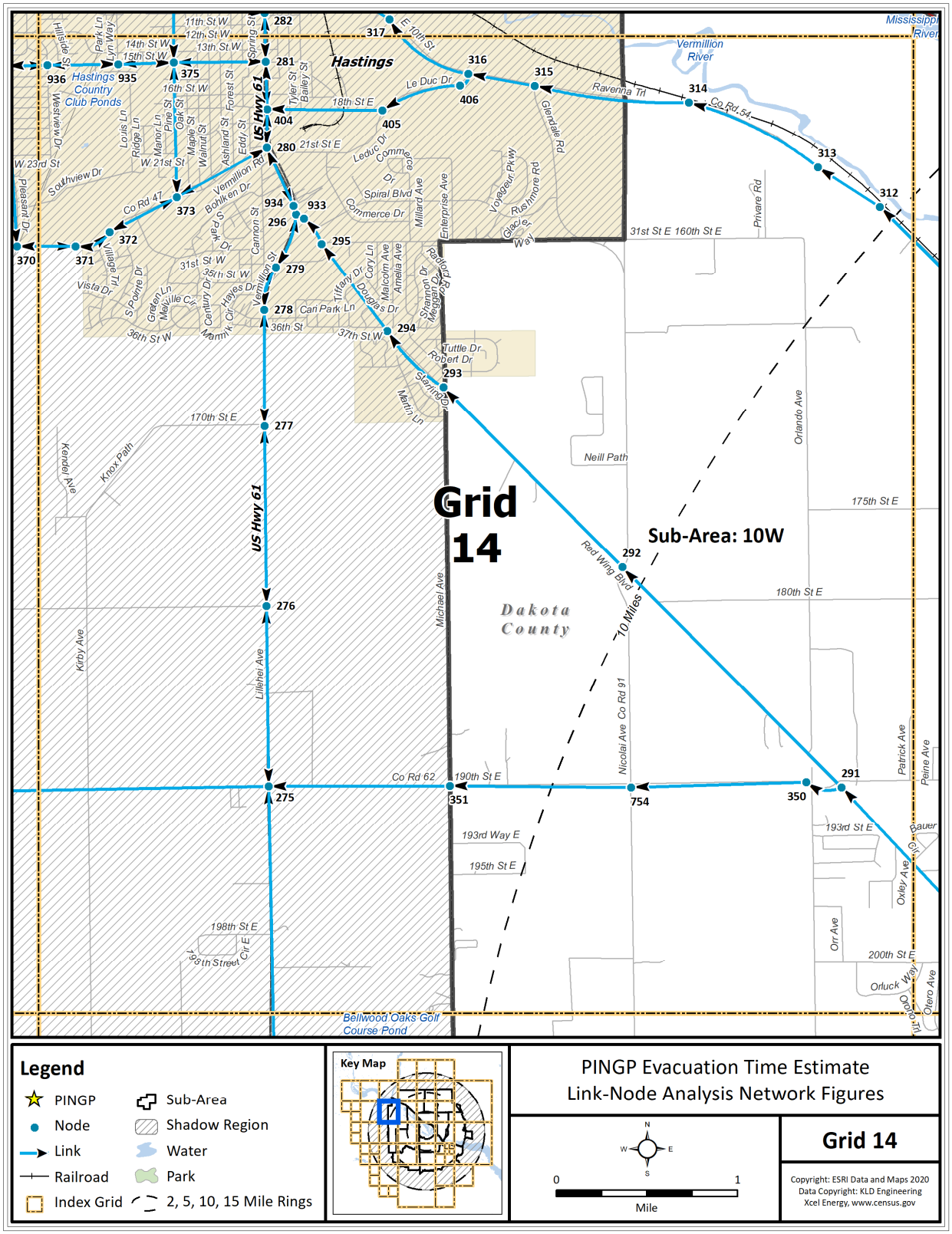


Figure K-15. Link-Node Analysis Network – Grid 14

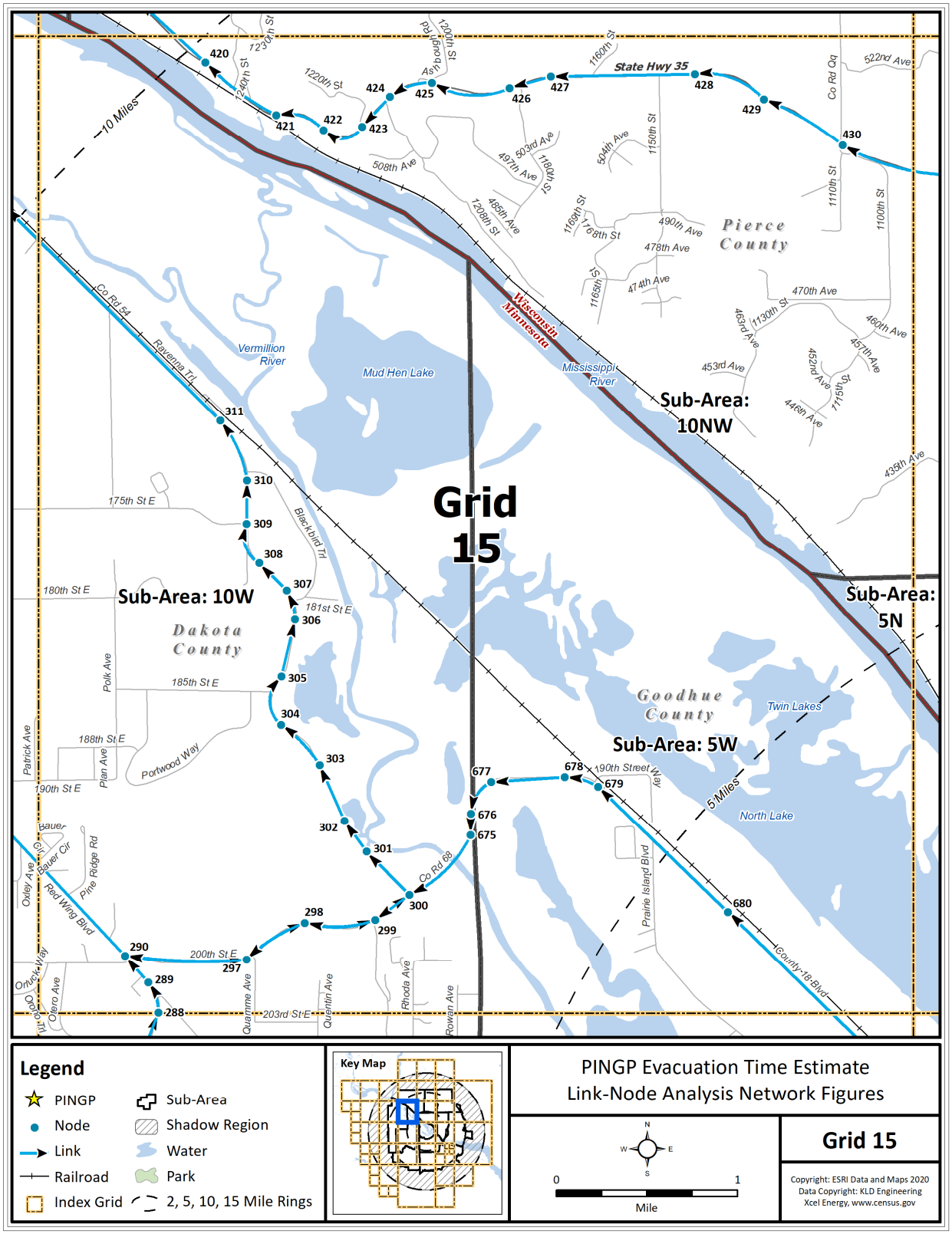


Figure K-16. Link-Node Analysis Network – Grid 15

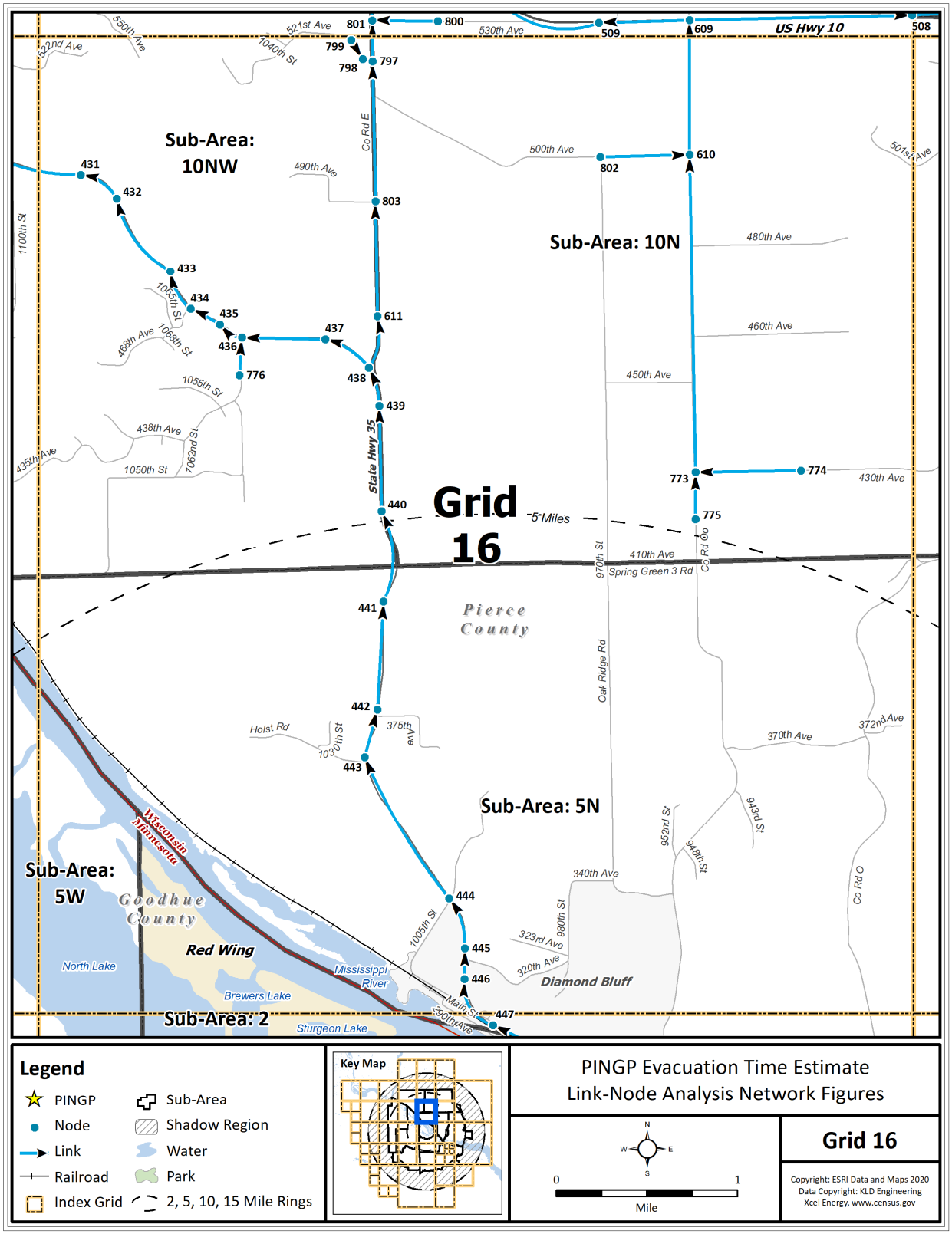


Figure K-17. Link-Node Analysis Network – Grid 16

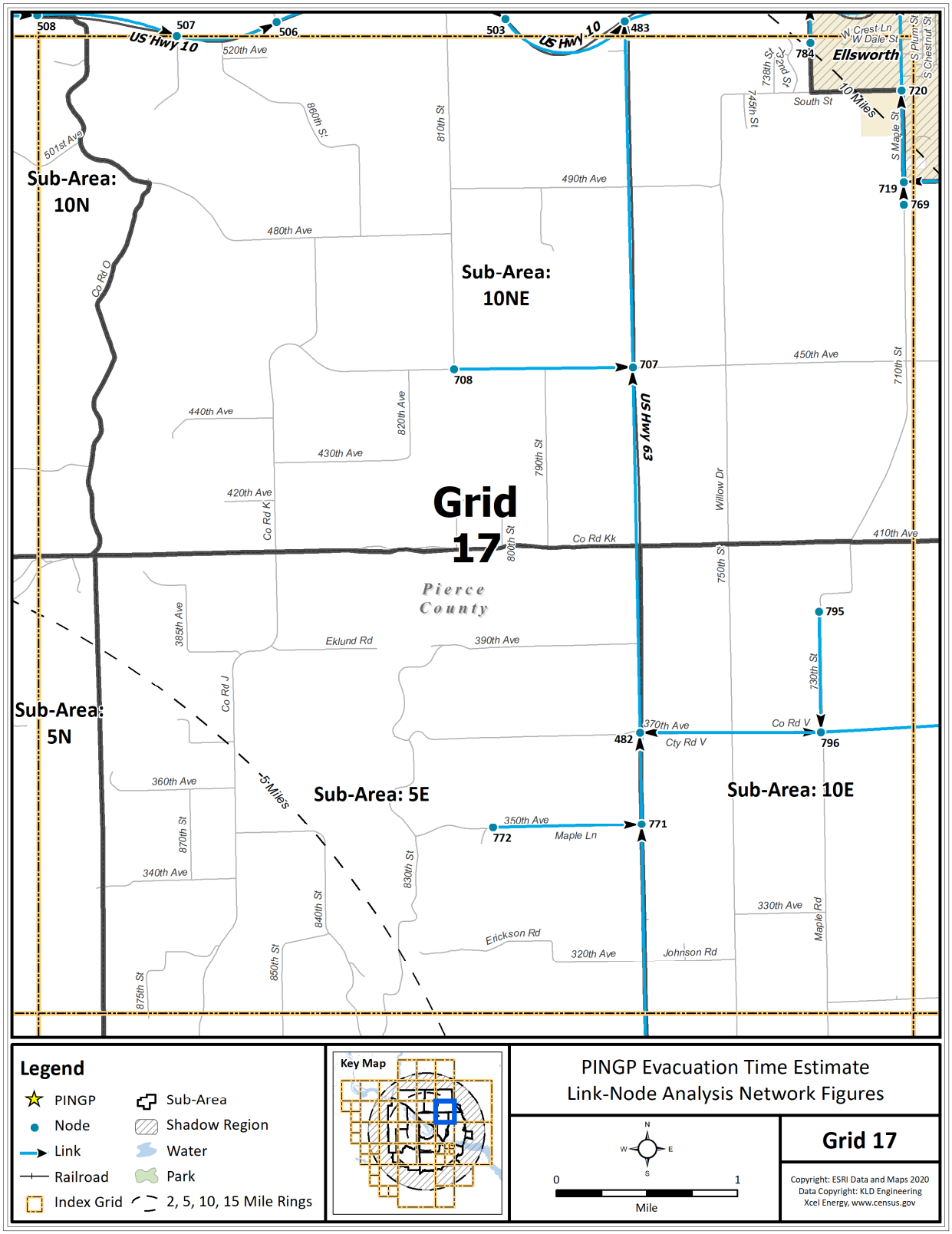


Figure K-18. Link-Node Analysis Network – Grid 17

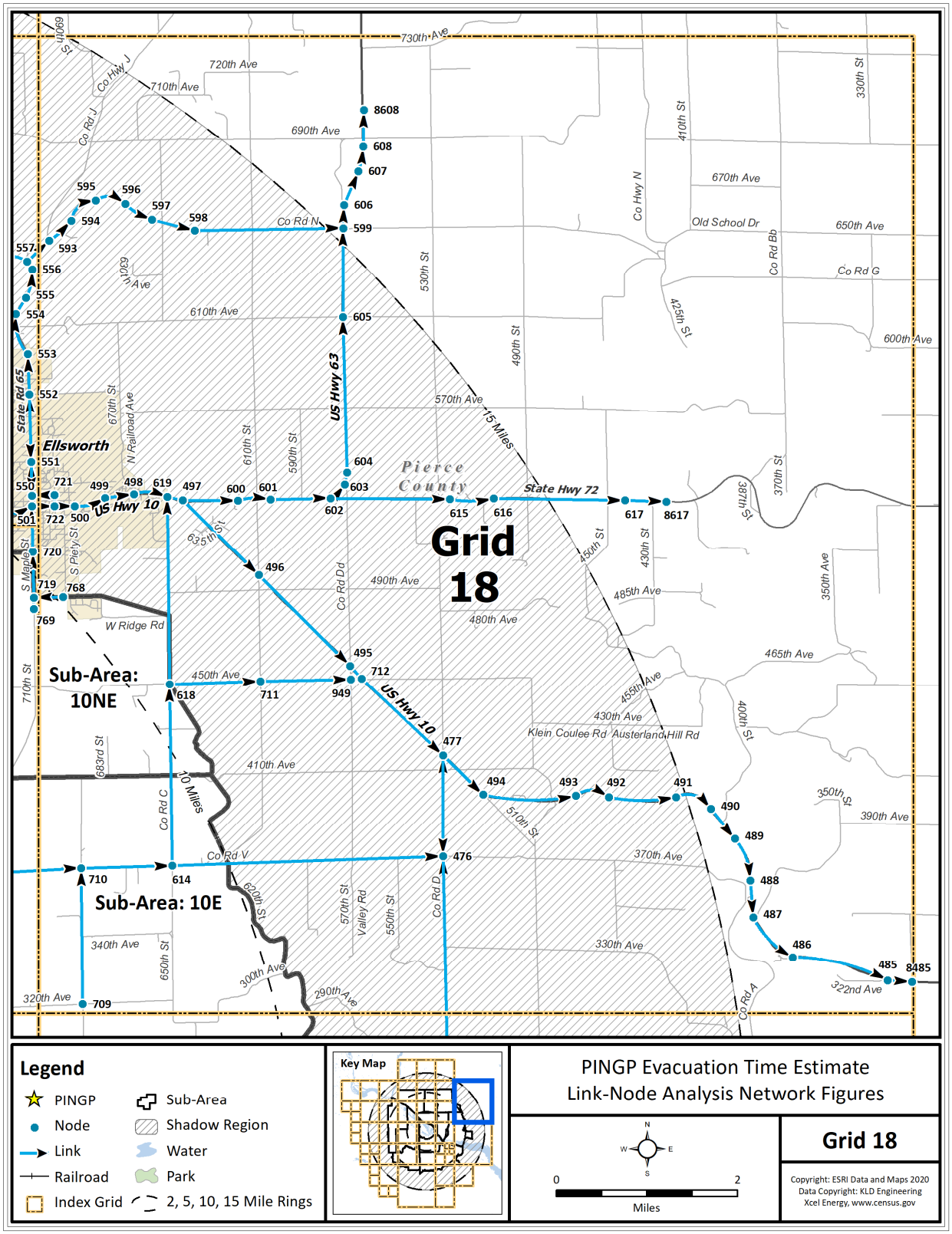


Figure K-19. Link-Node Analysis Network – Grid 18

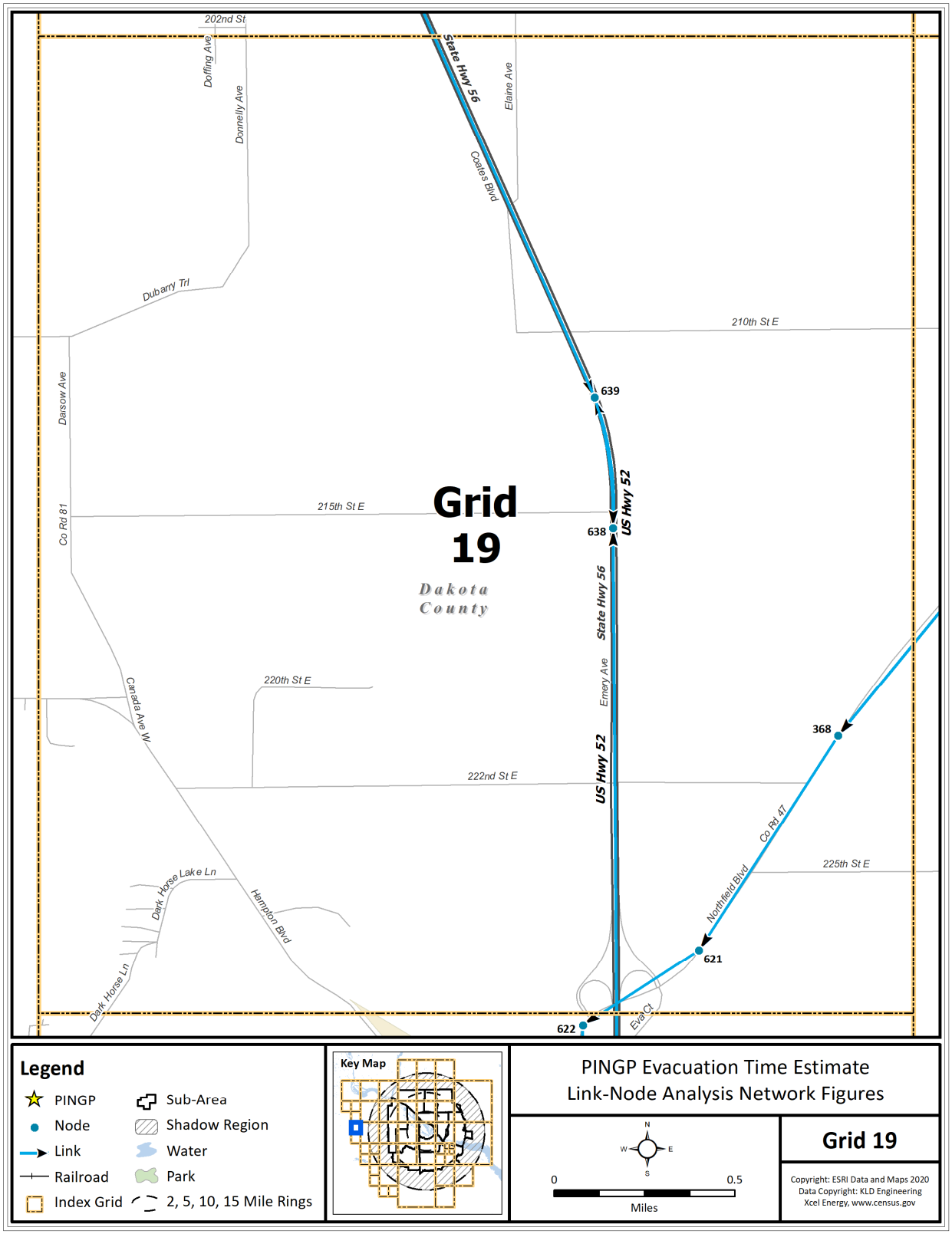


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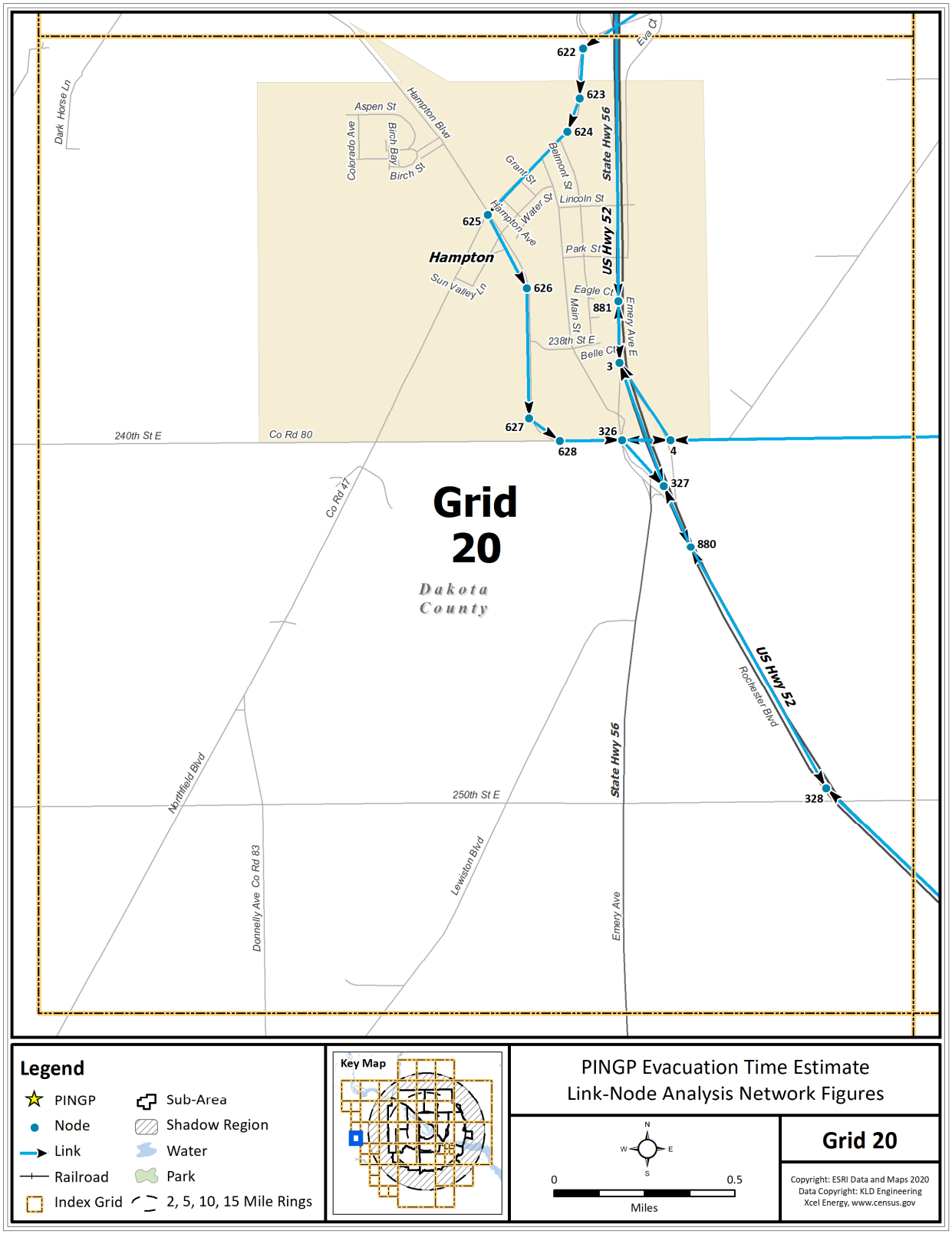


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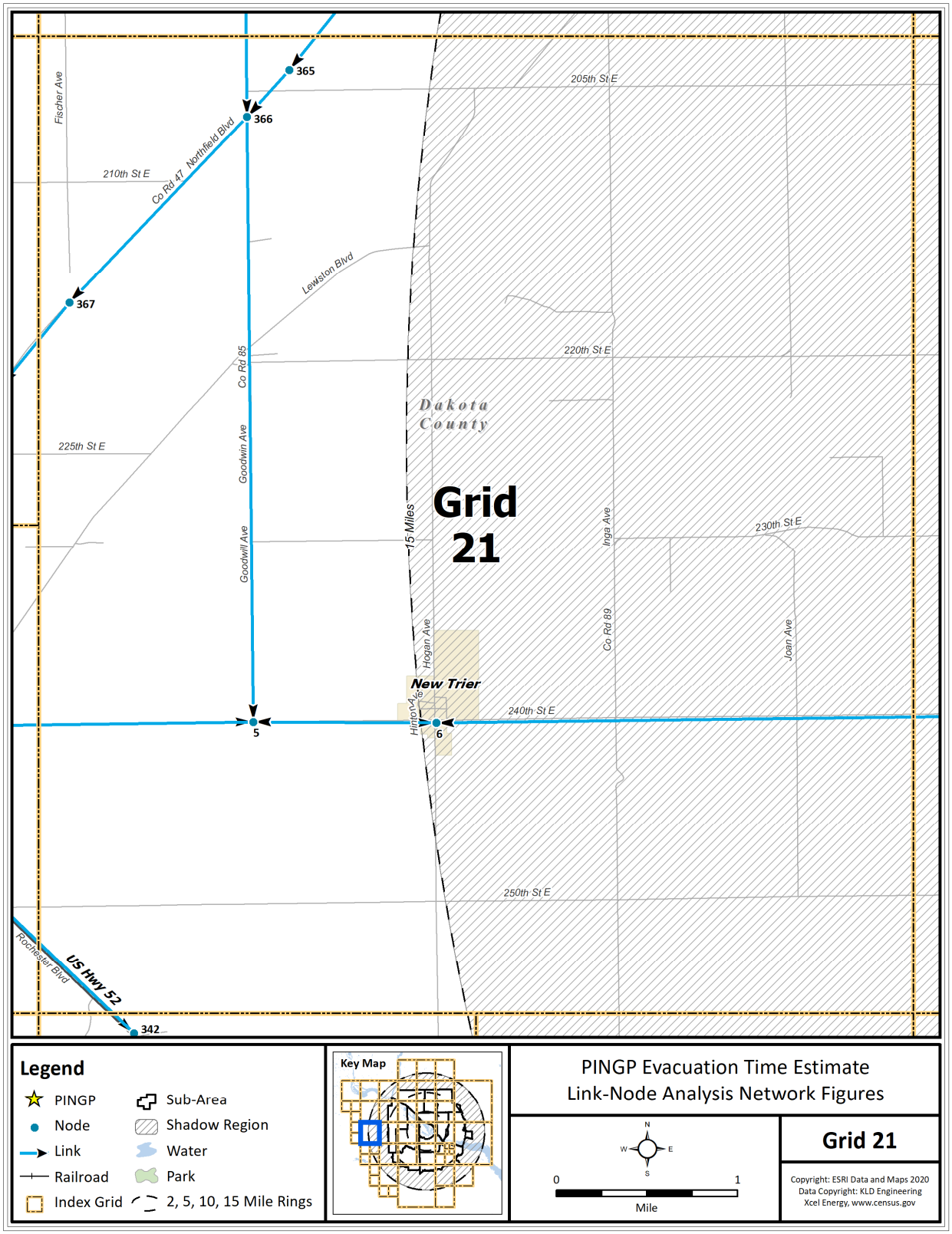


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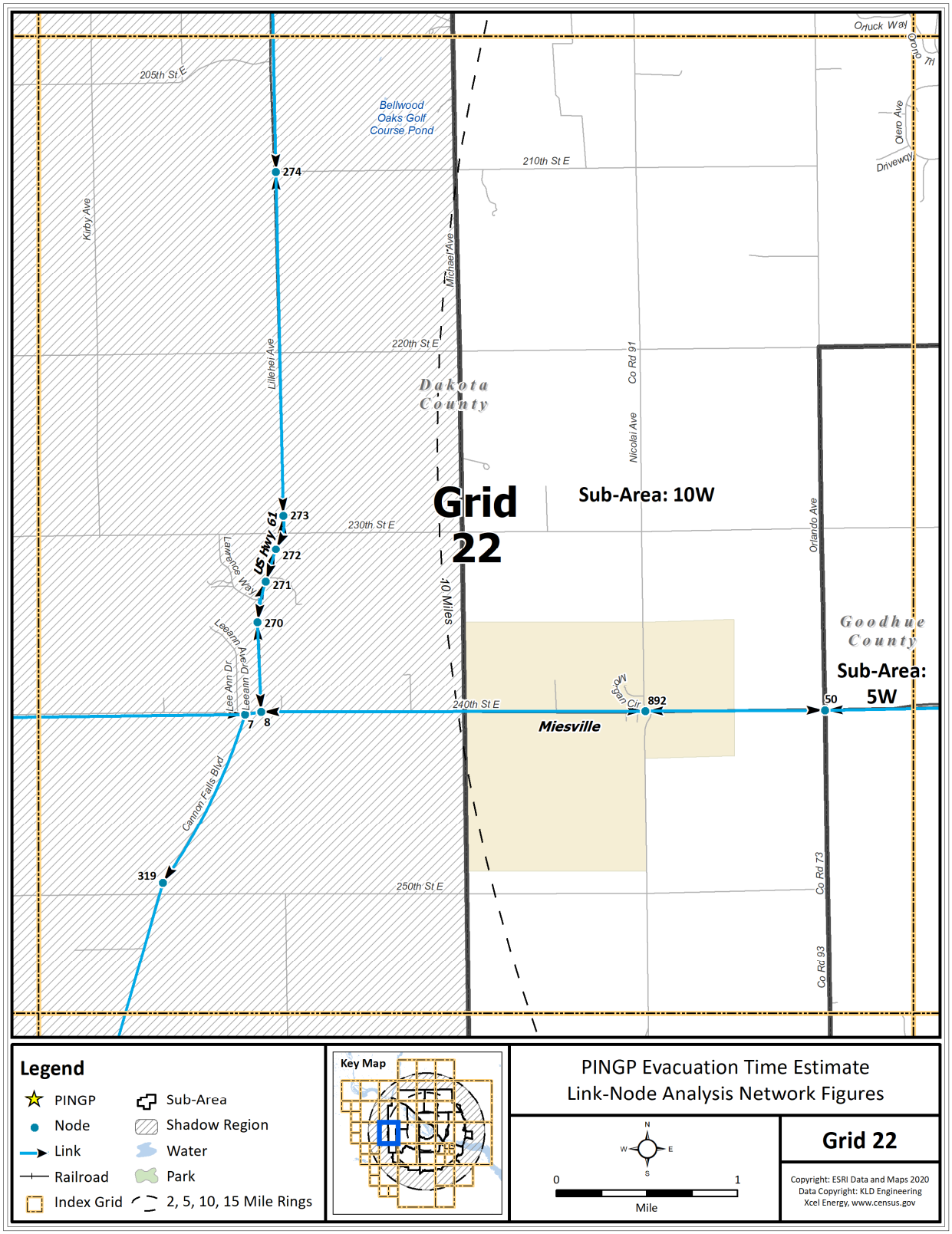


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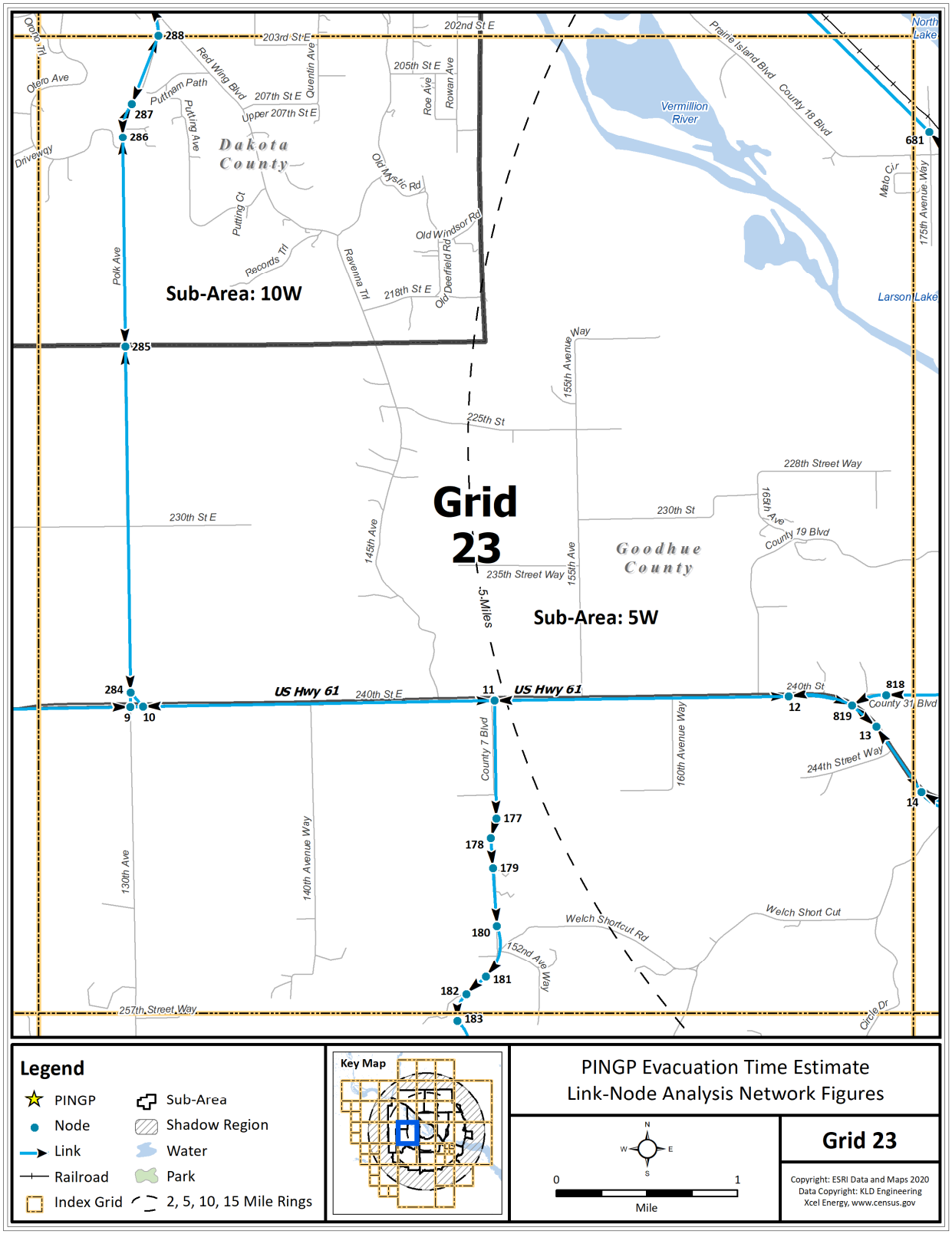


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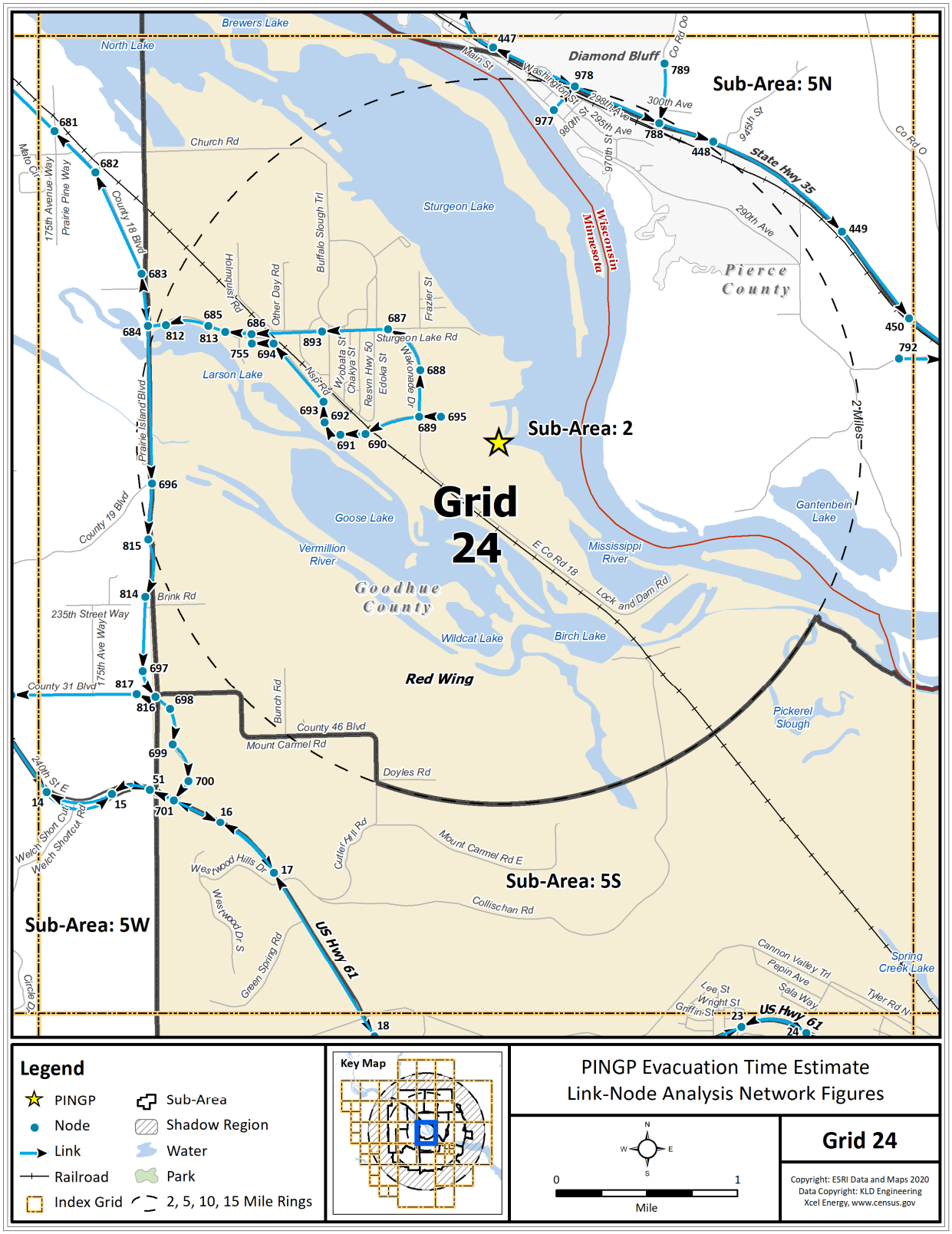


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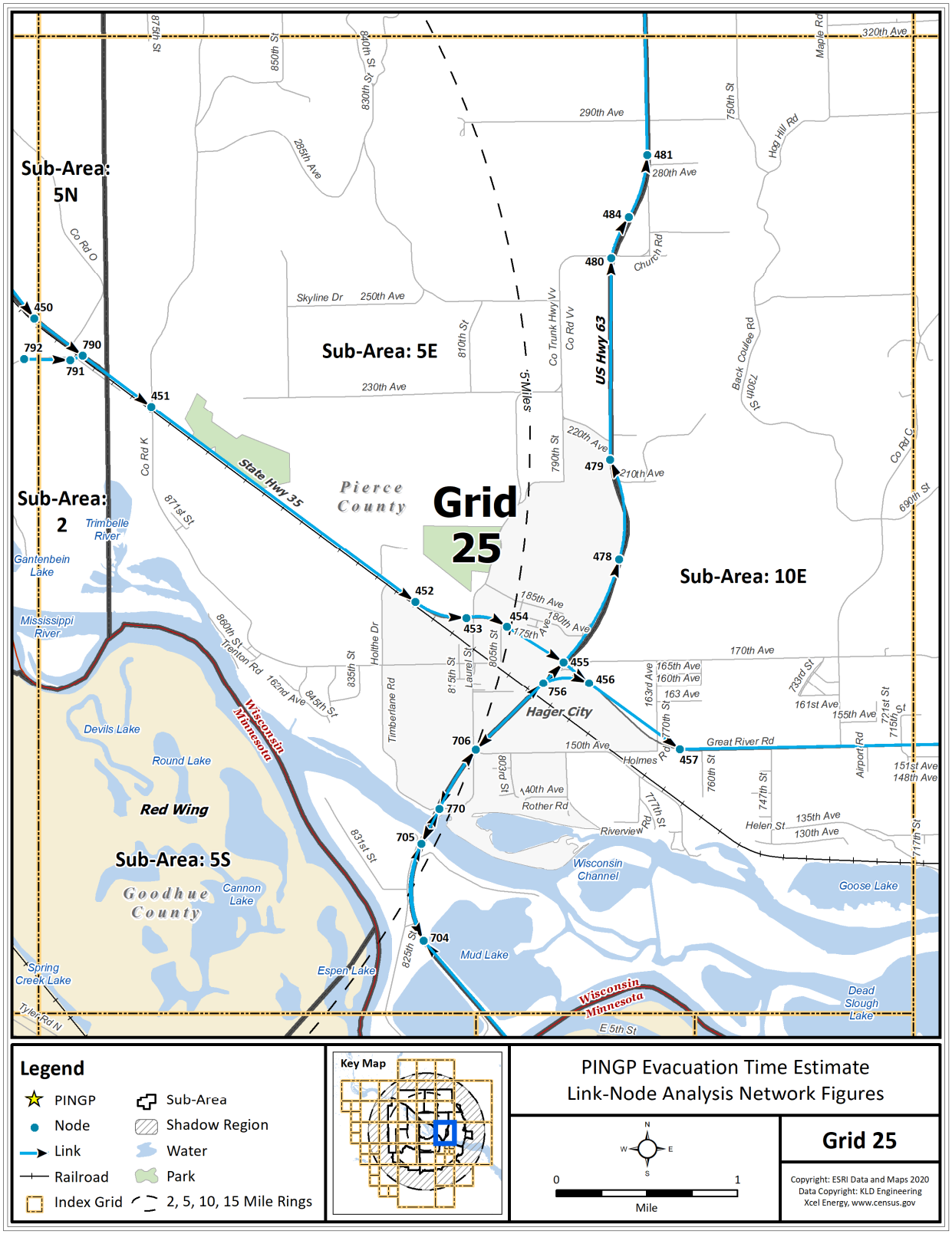


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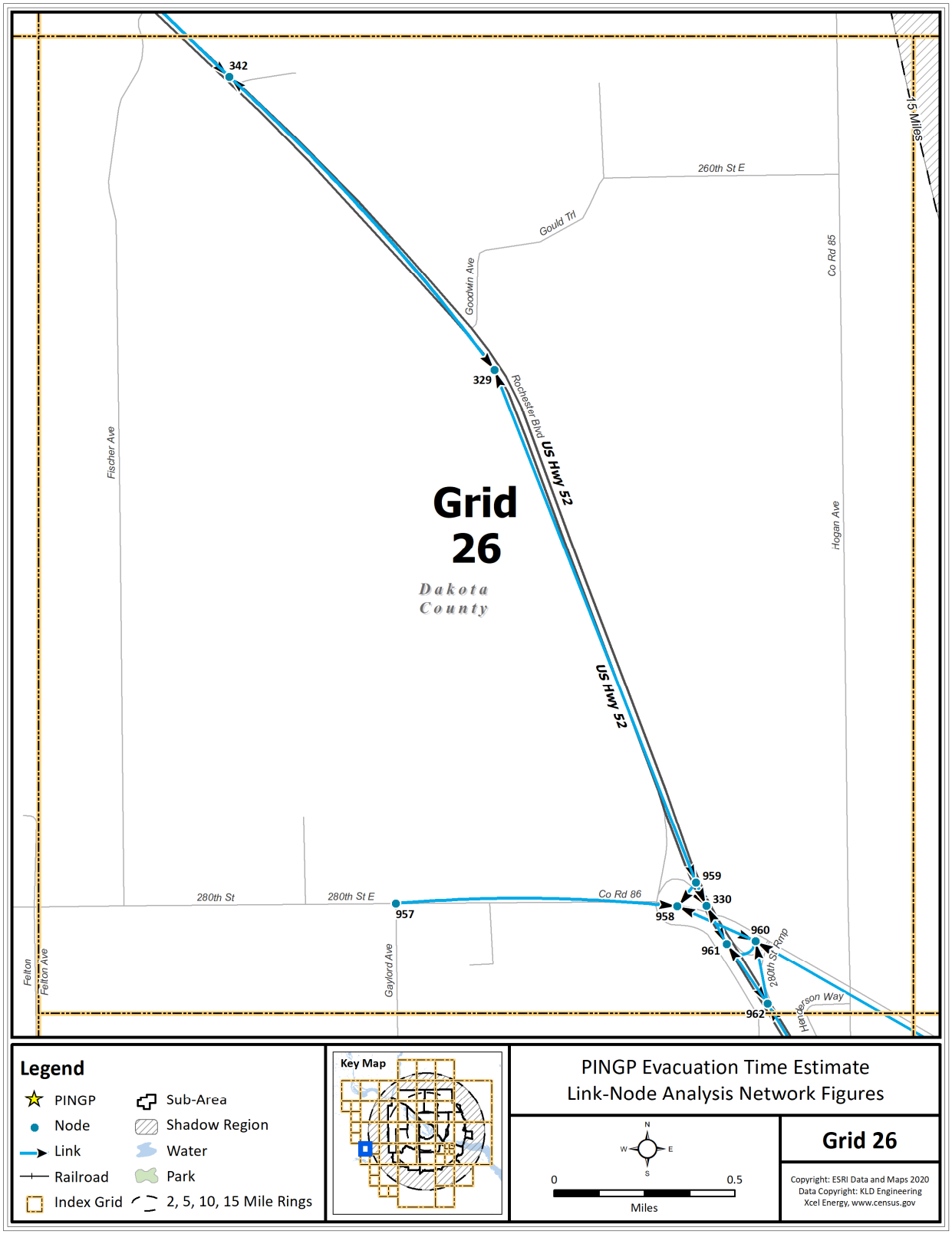


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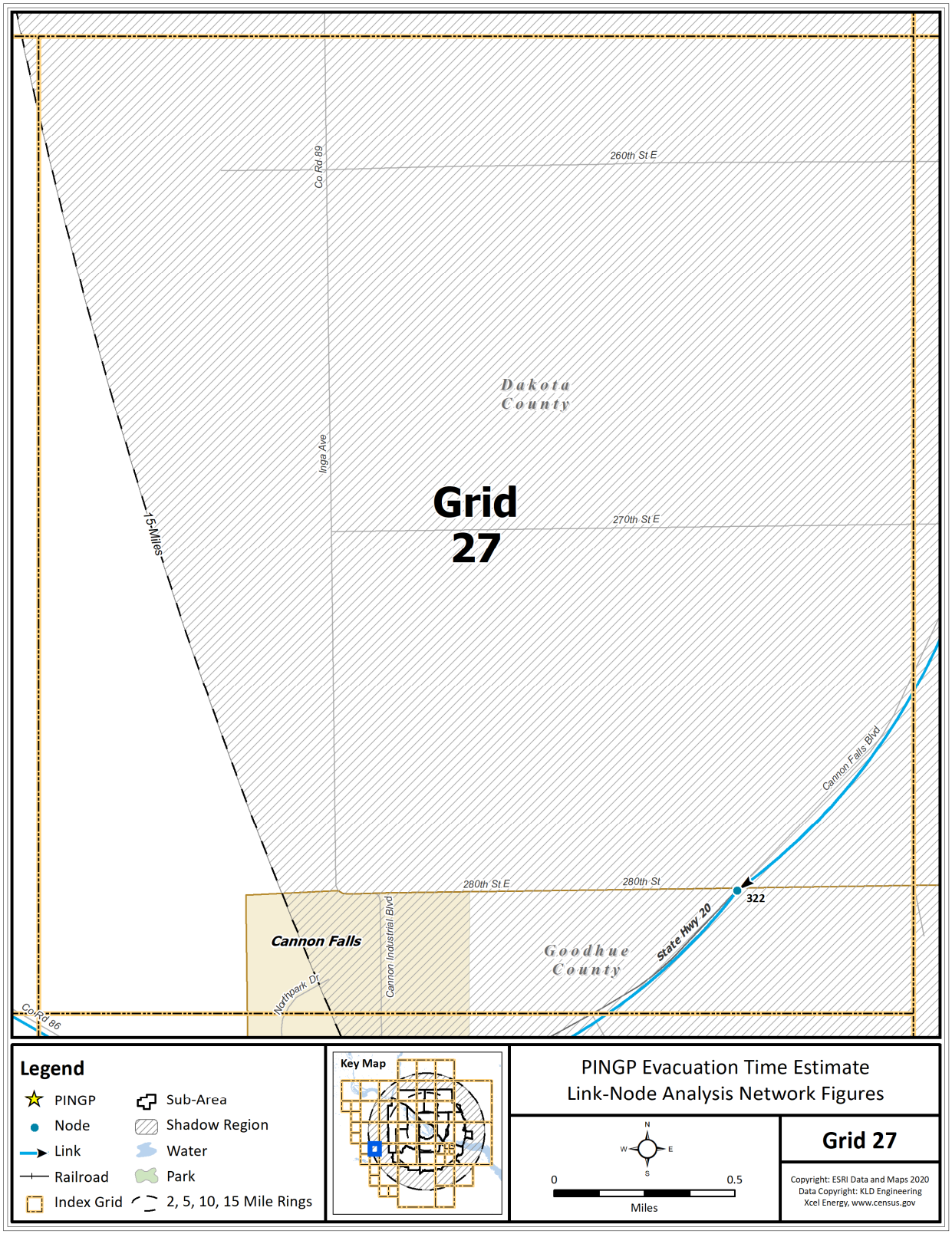


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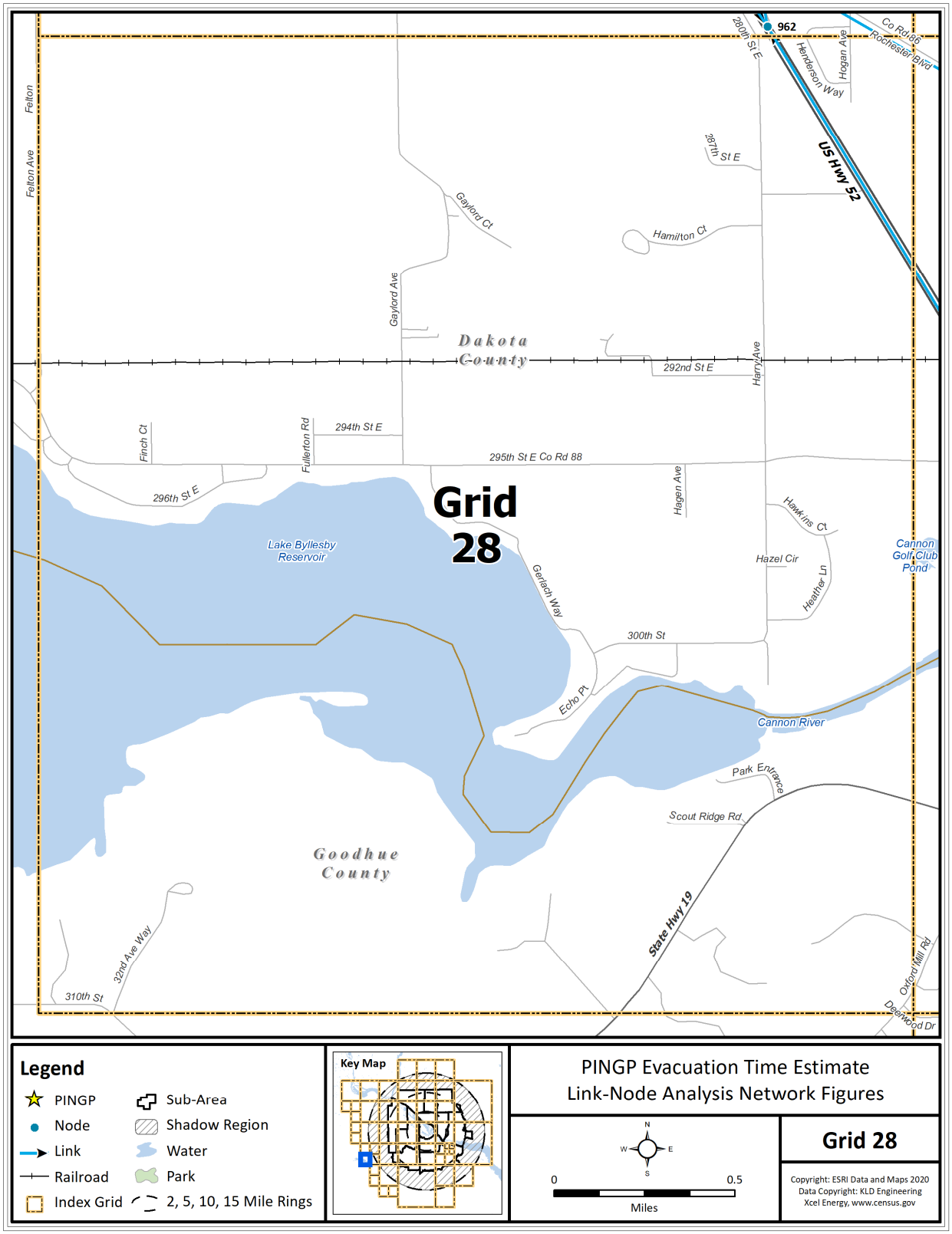


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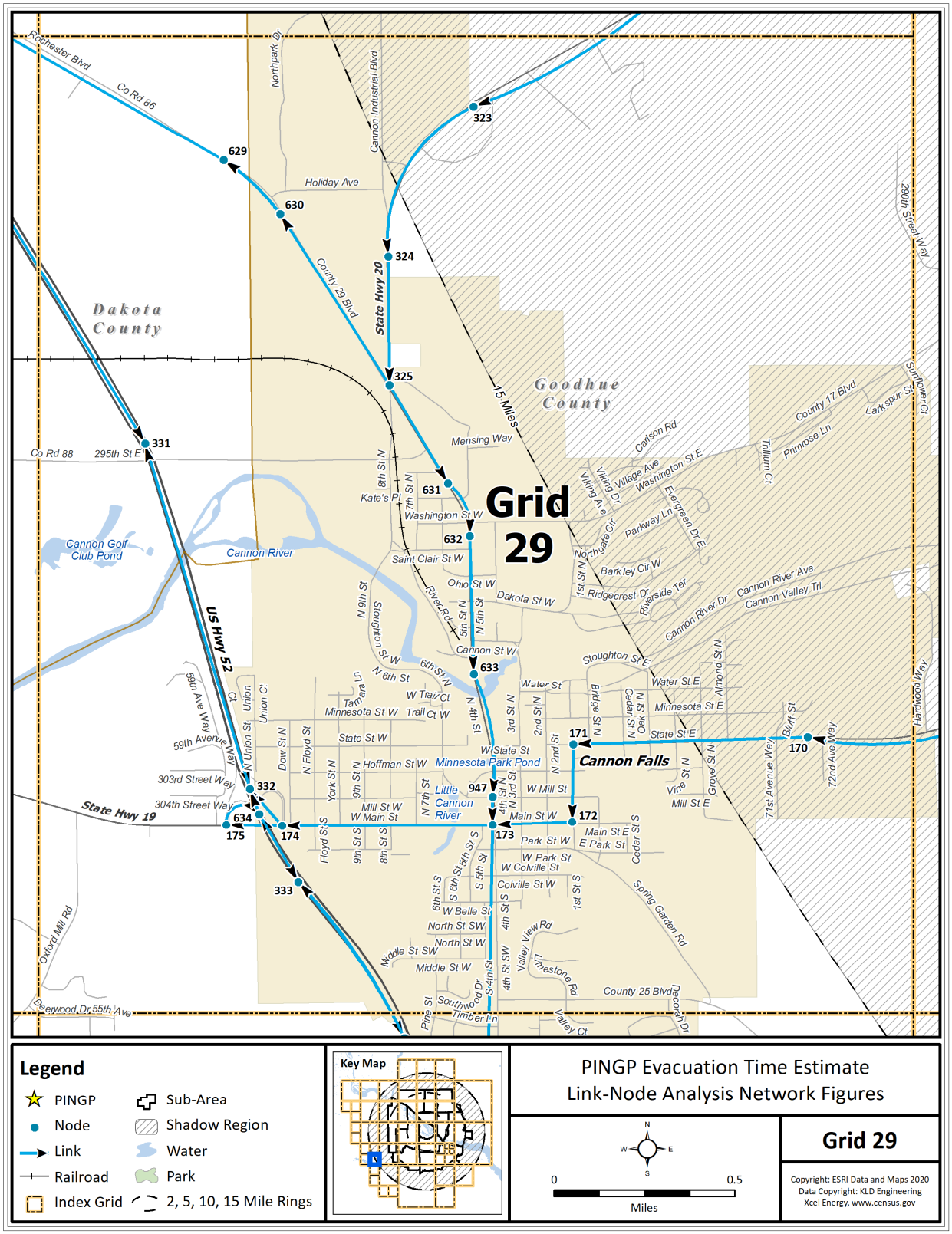


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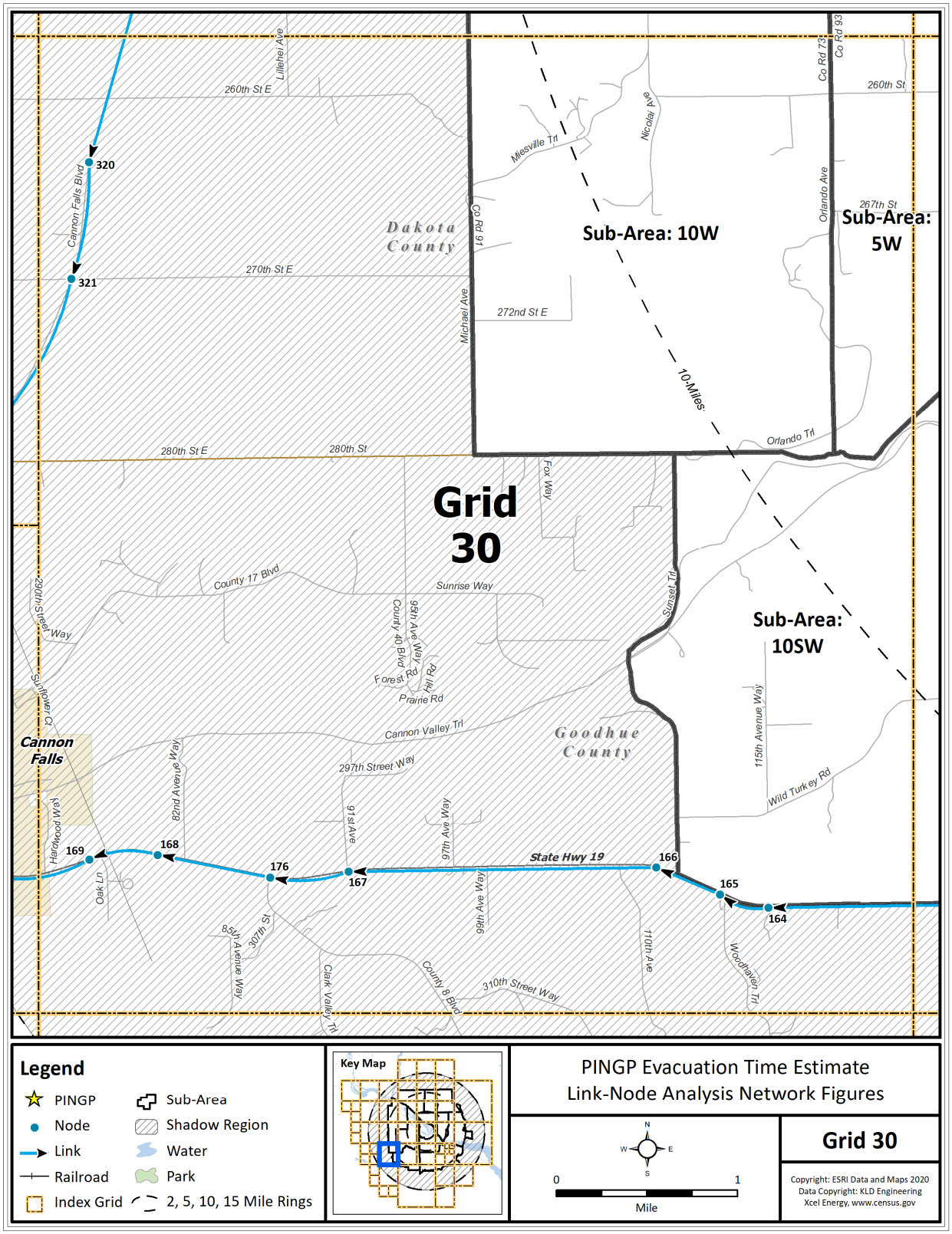


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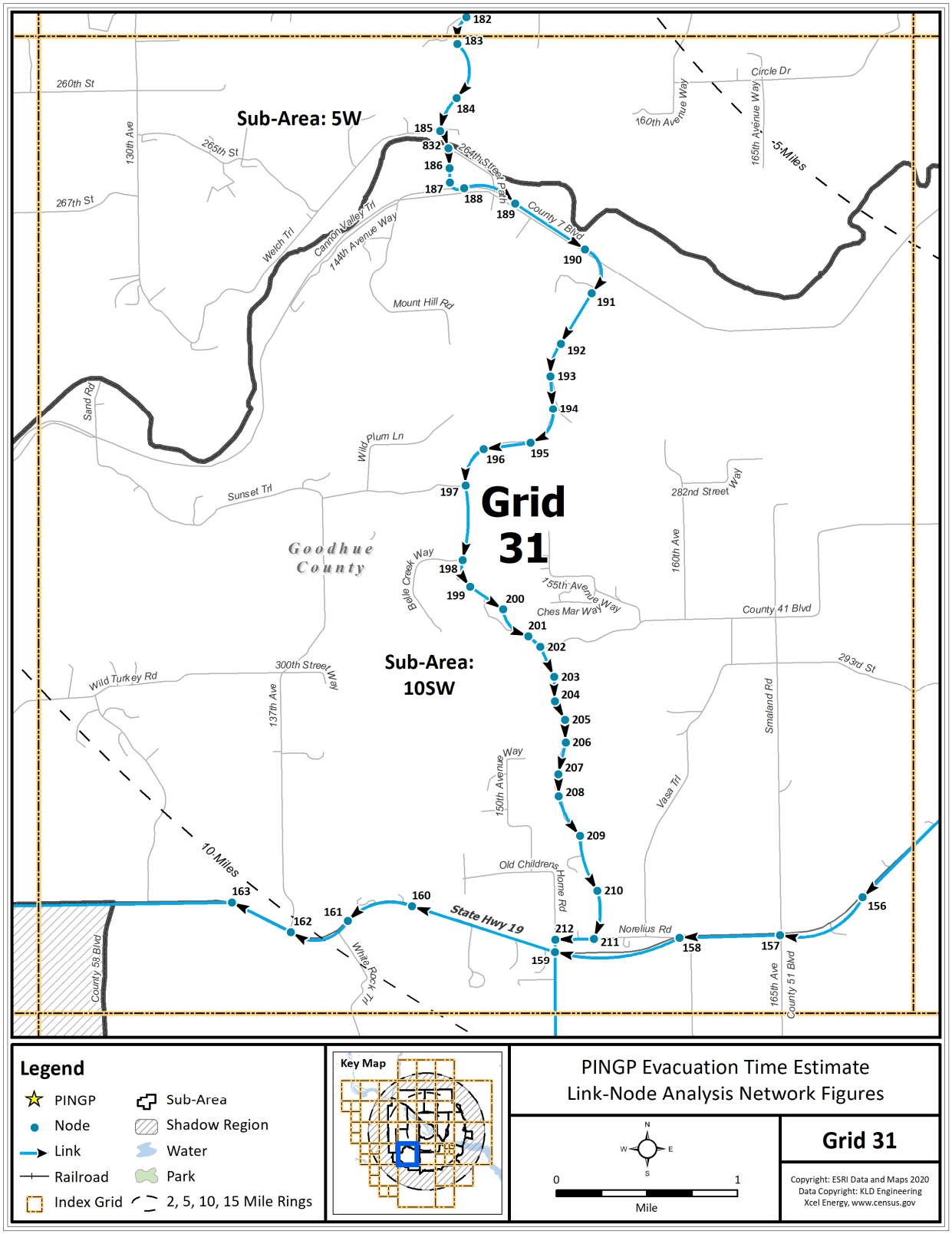


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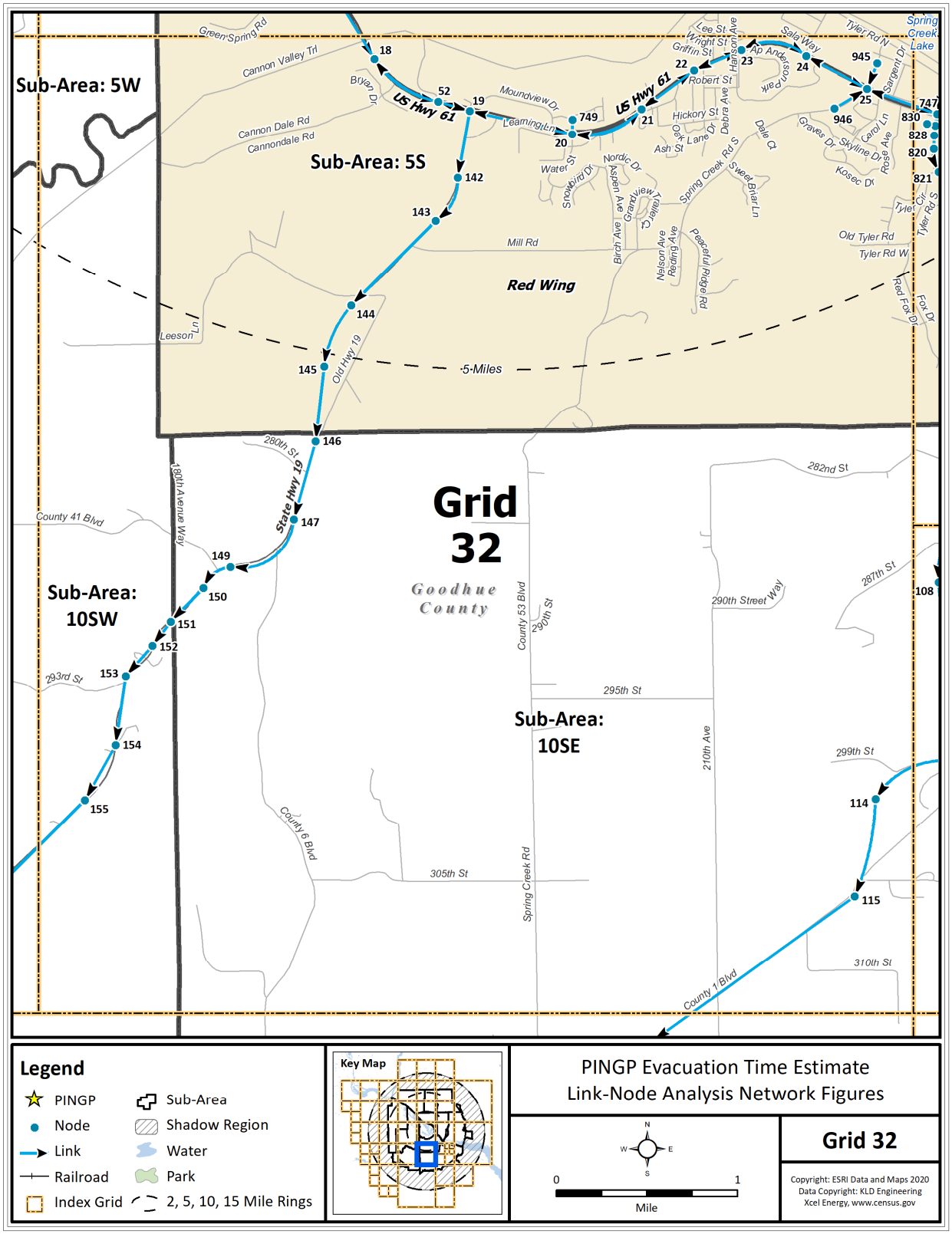


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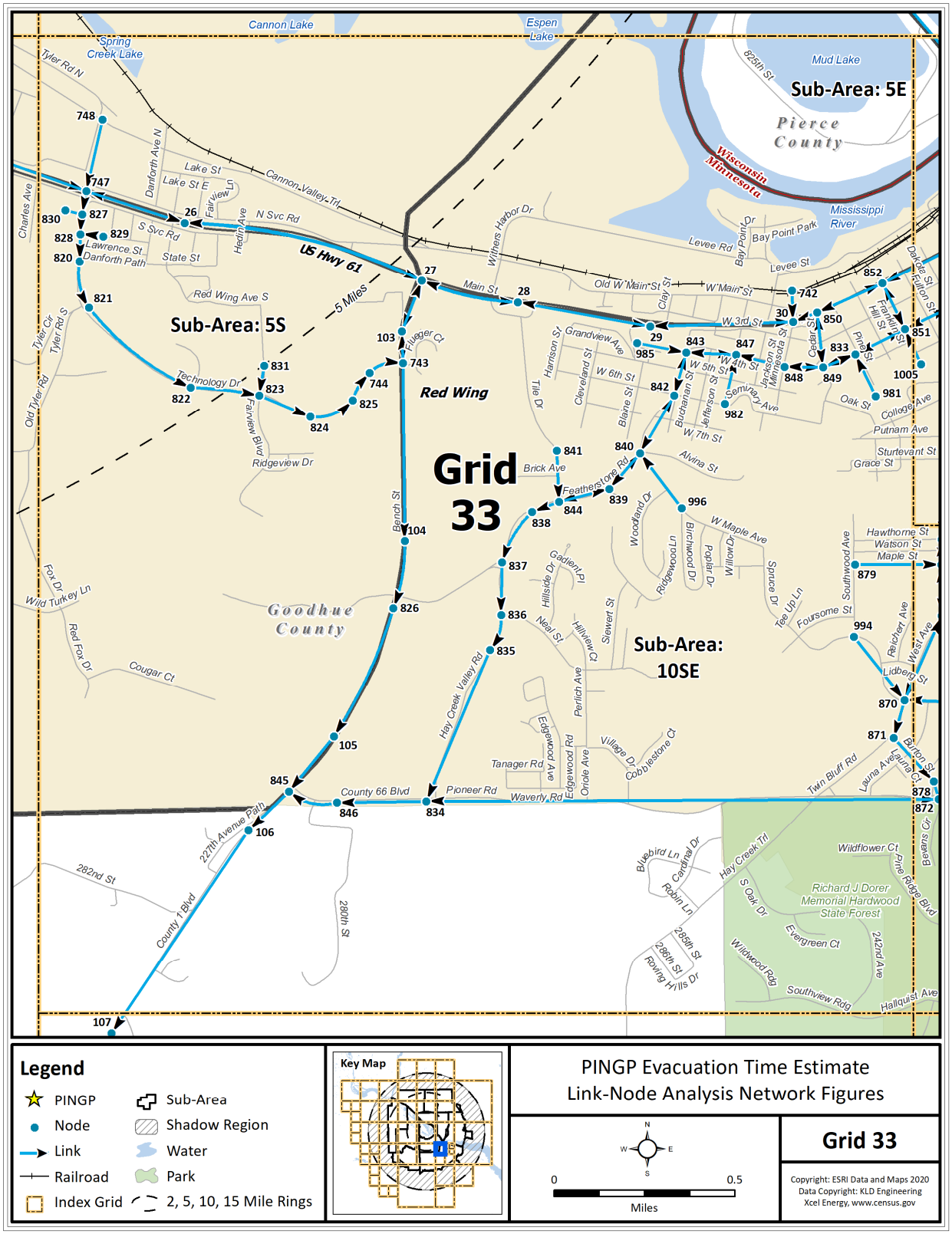


Figure K-34. Link-Node Analysis Network – Grid 33

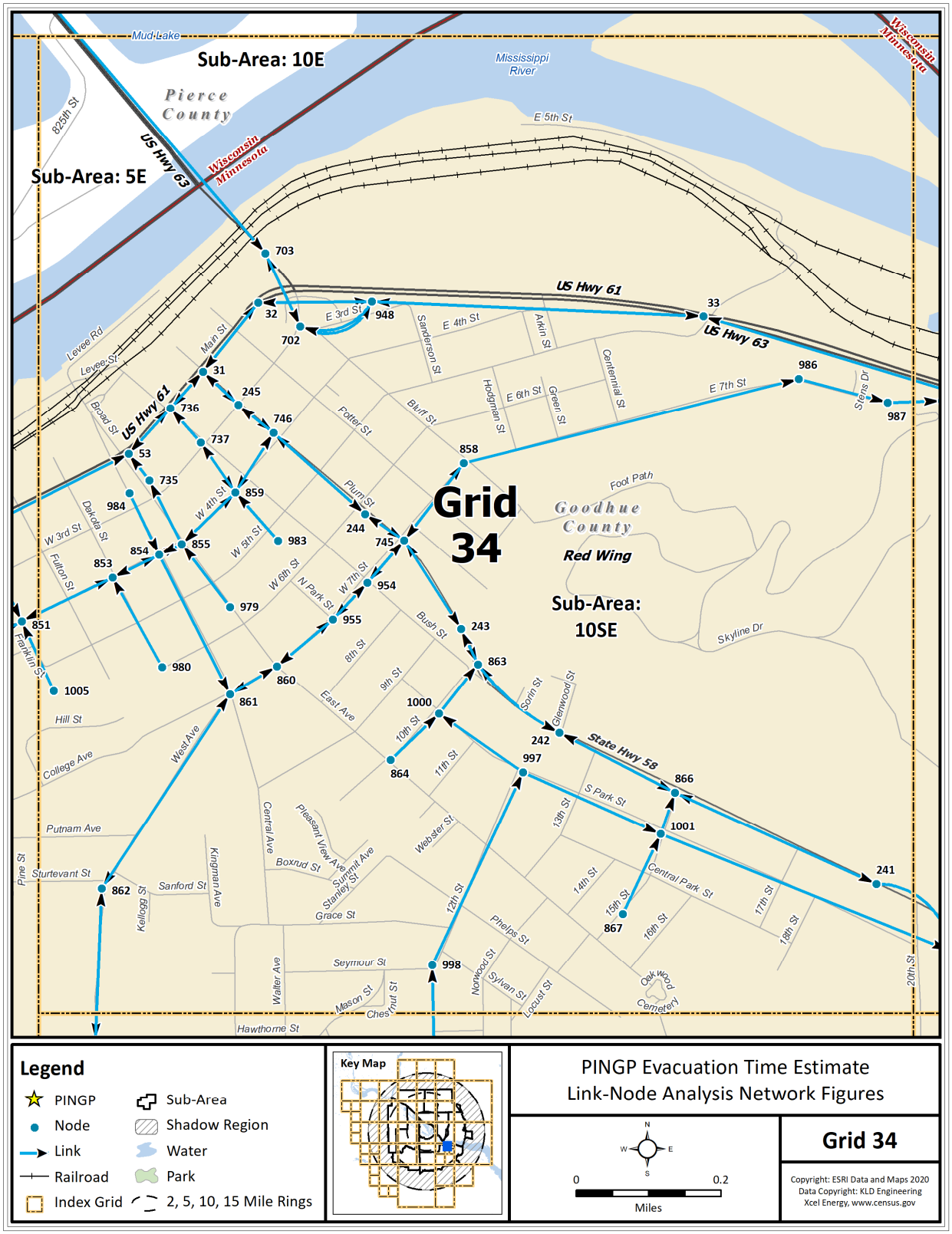


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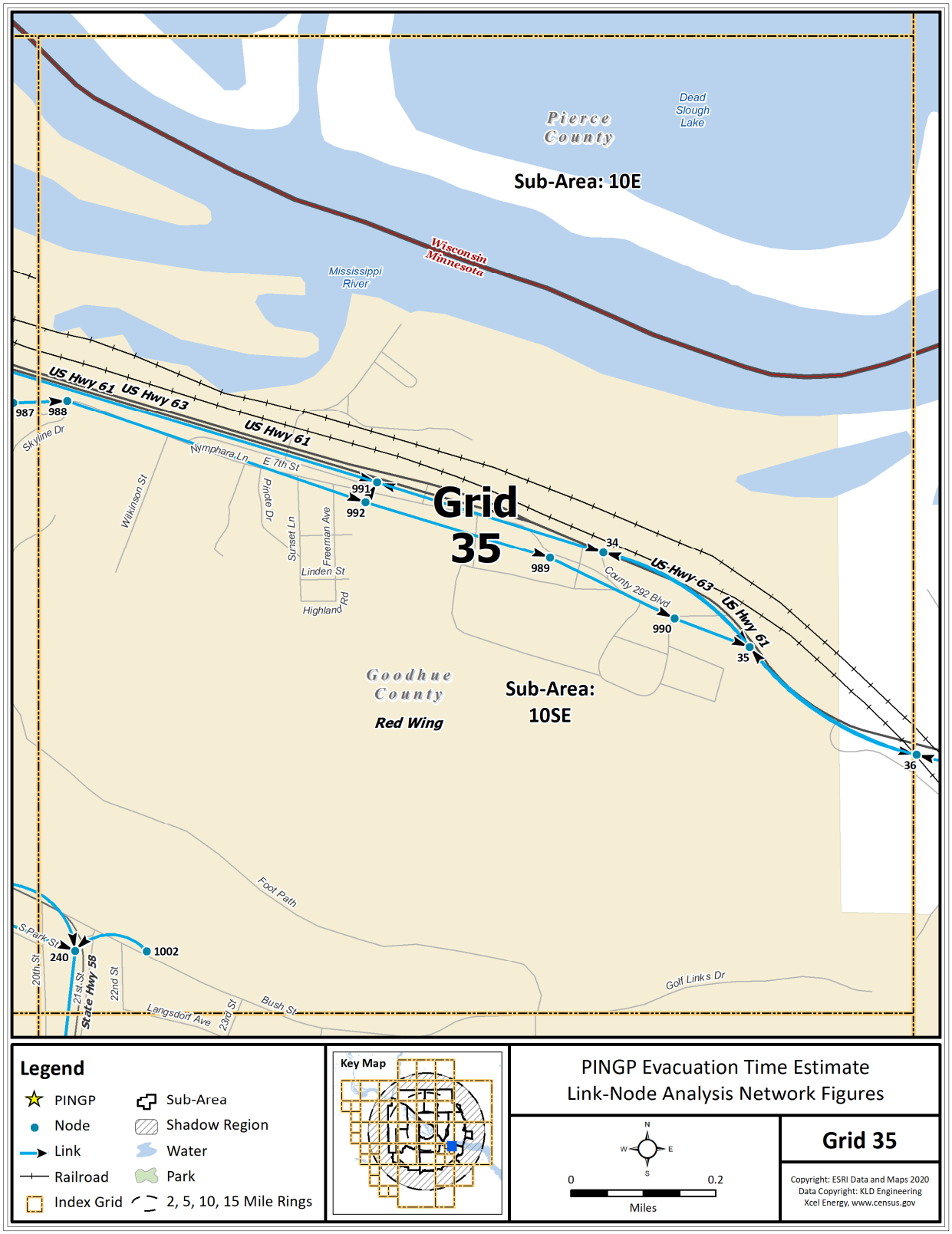


Figure K-36. Link-Node Analysis Network – Grid 35

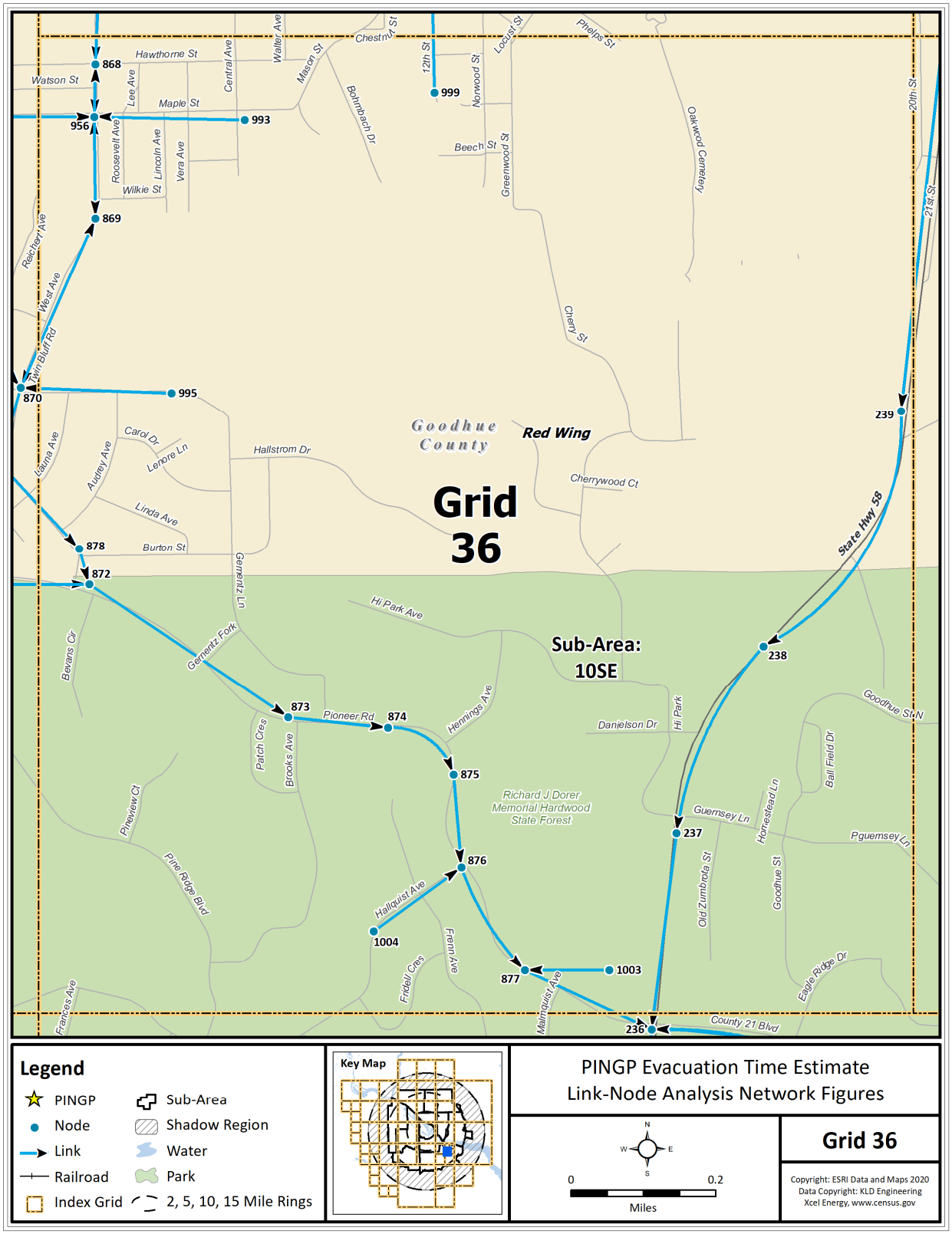


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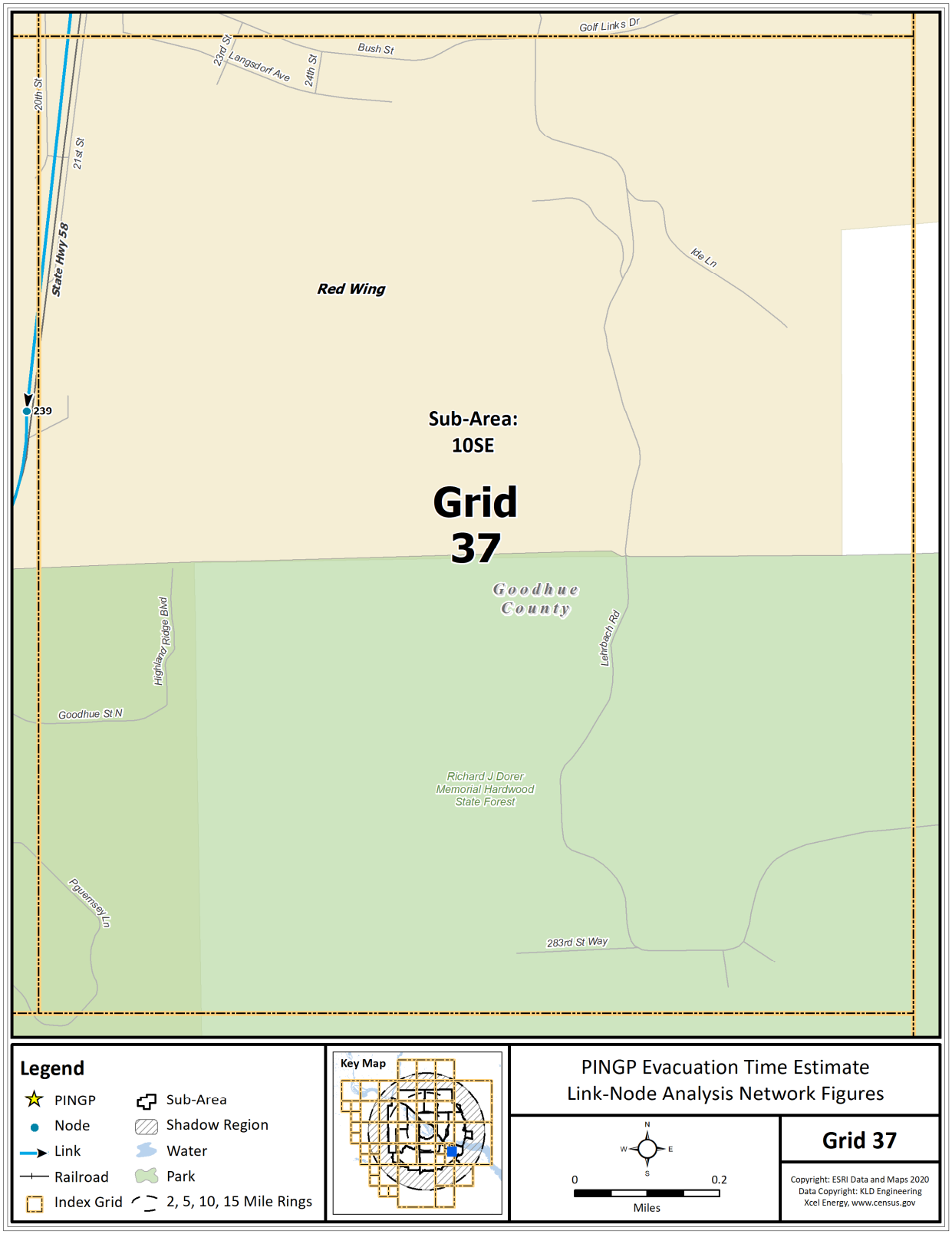


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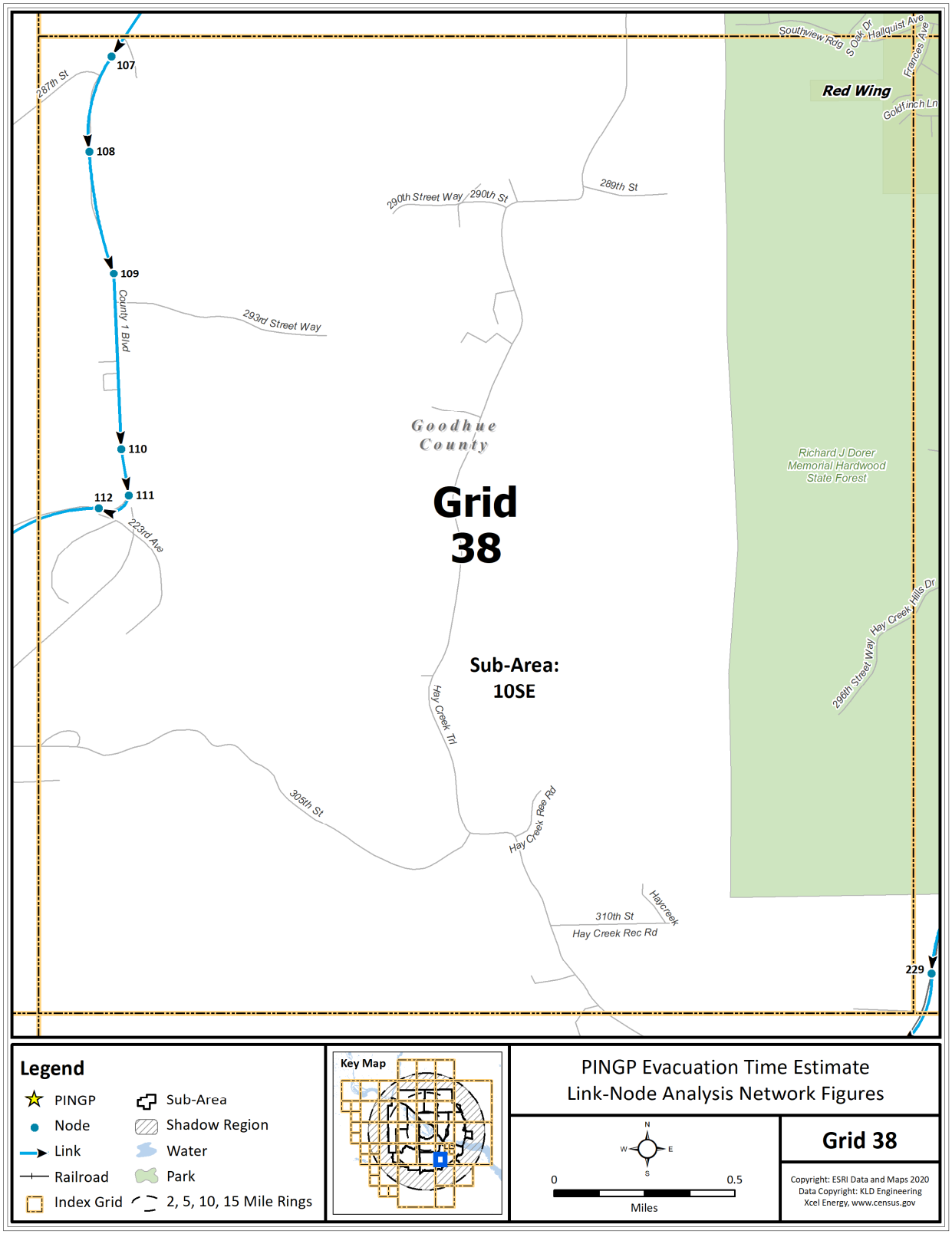


Figure K-39. Link-Node Analysis Network – Grid 38

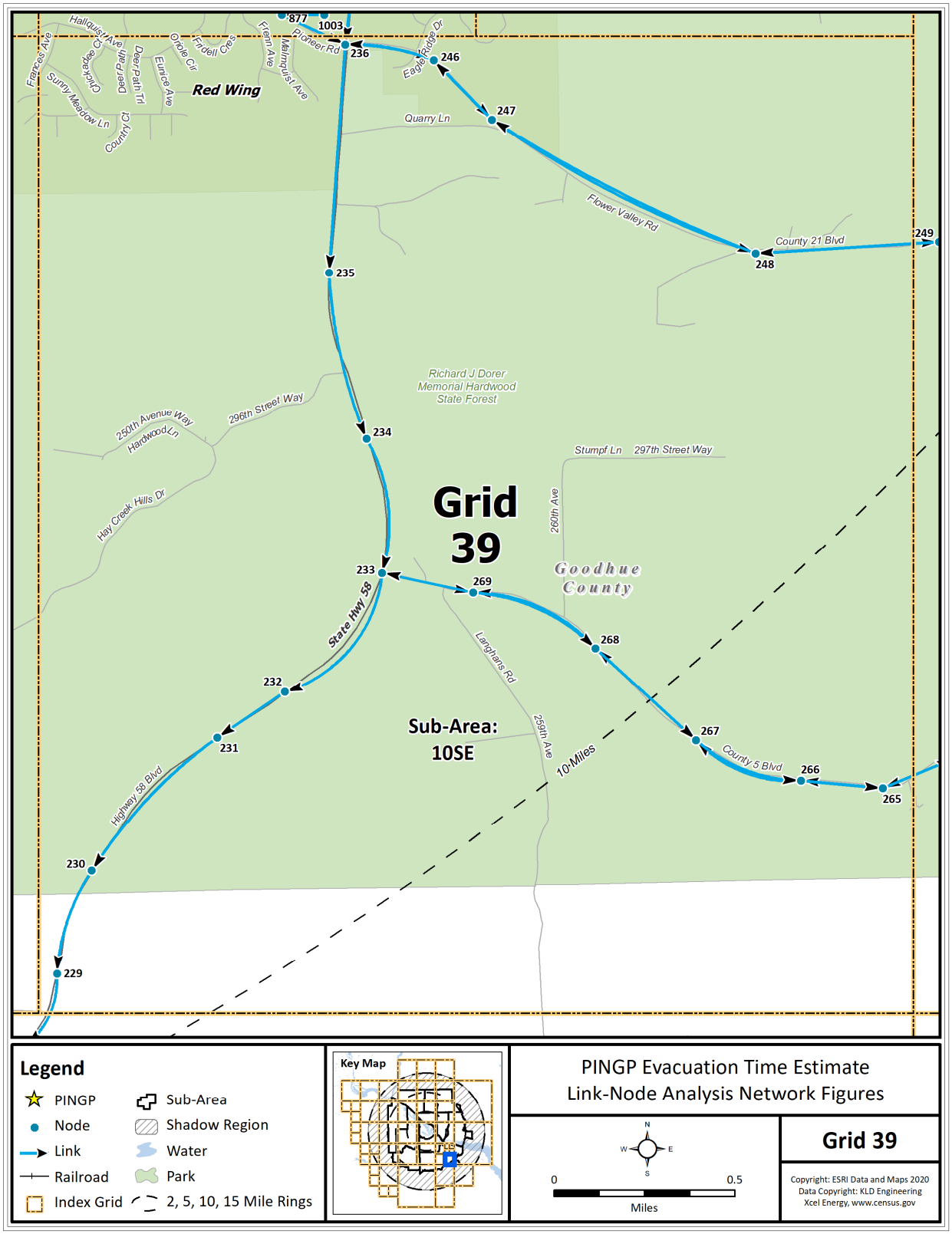


Figure K-40. Link-Node Analysis Network – Grid 39

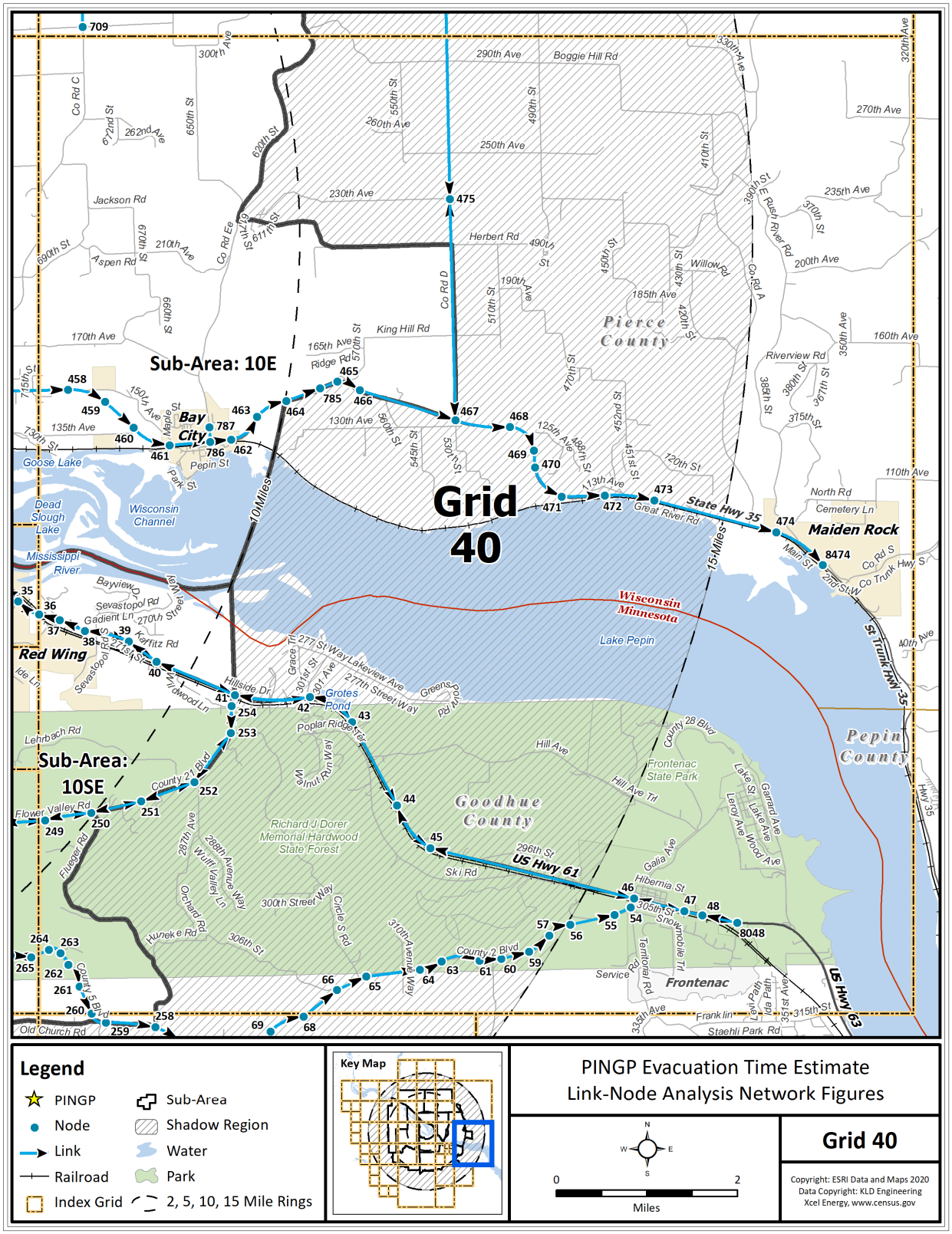


Figure K-41. Link-Node Analysis Network – Grid 40

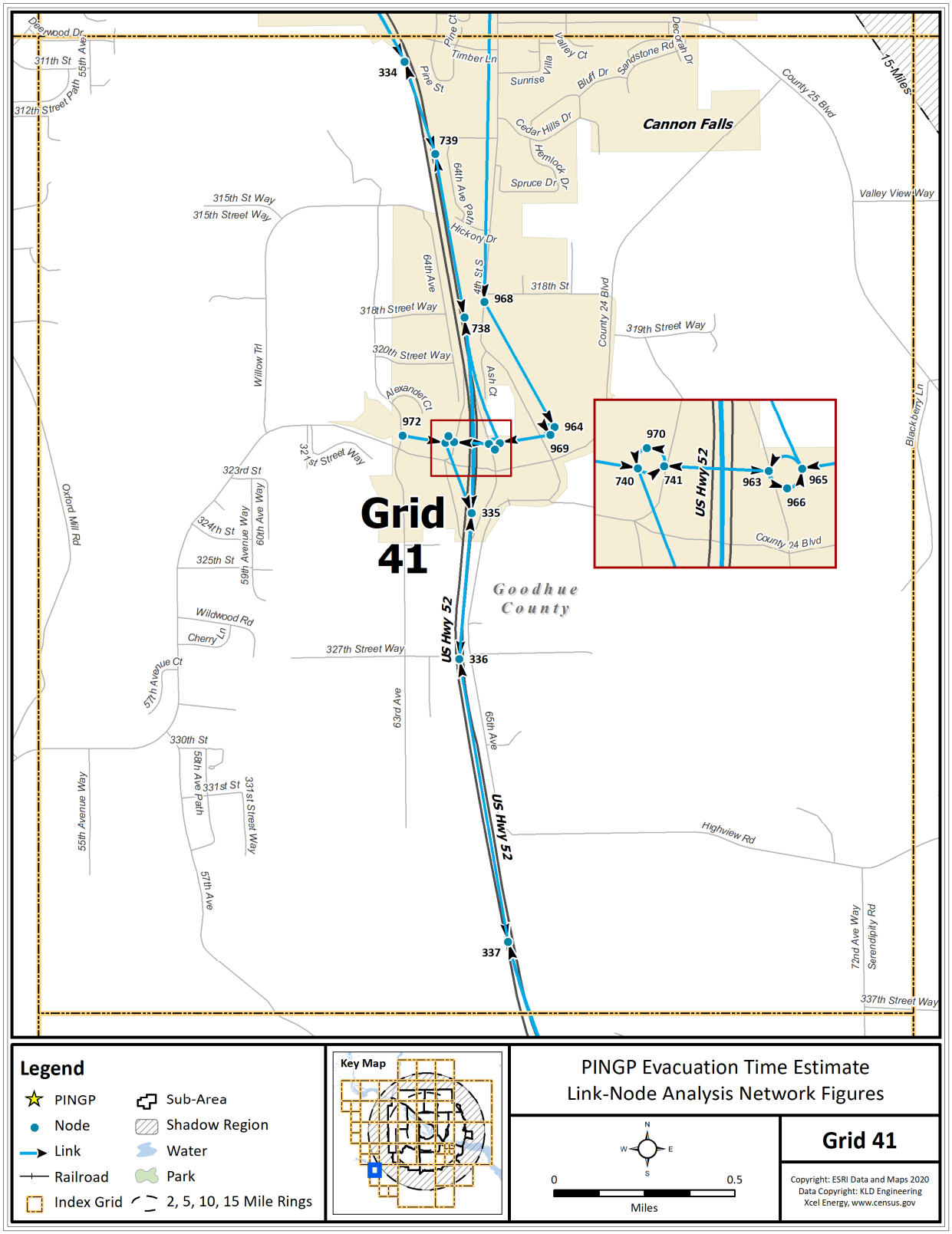


Figure K-42. Link-Node Analysis Network – Grid 41

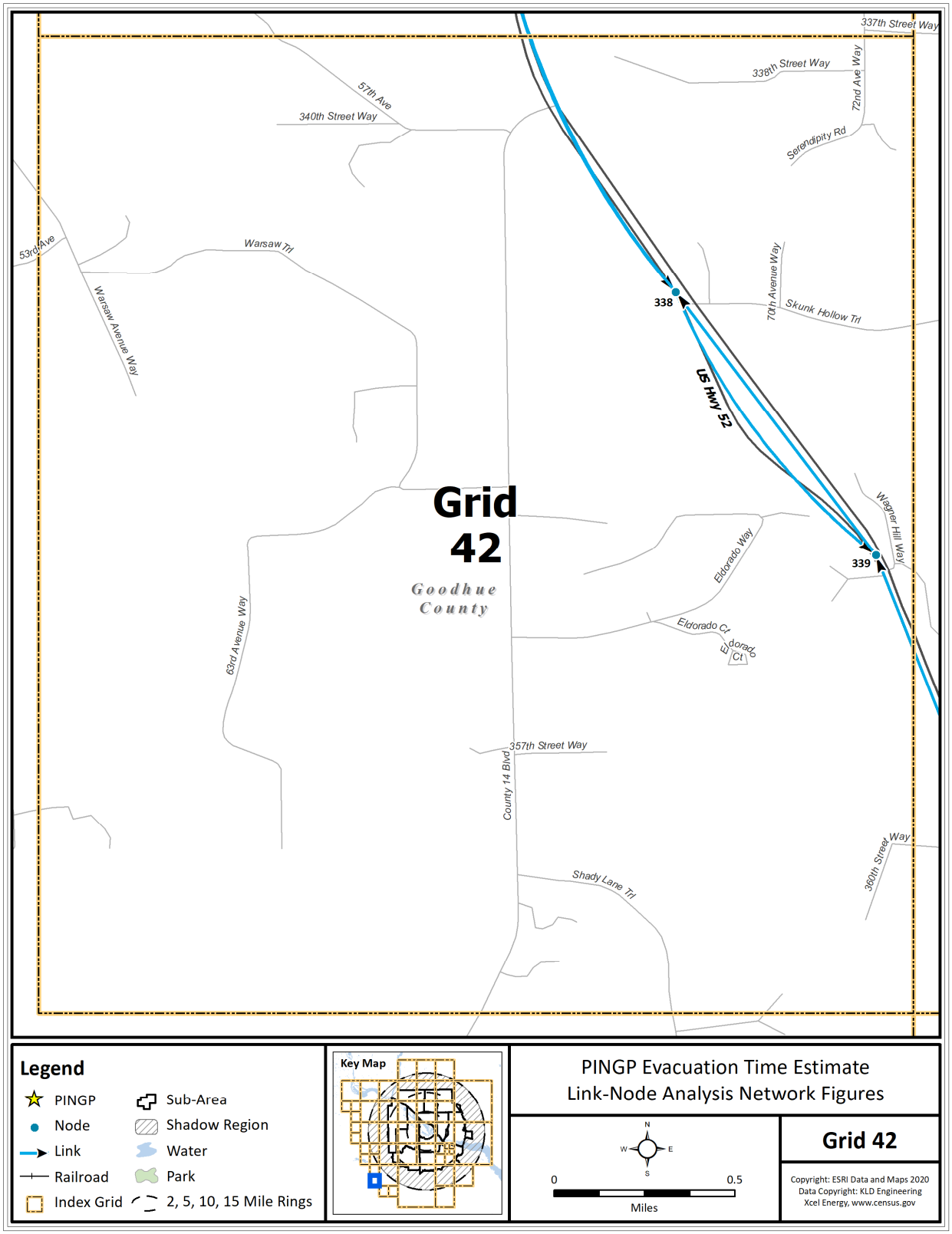


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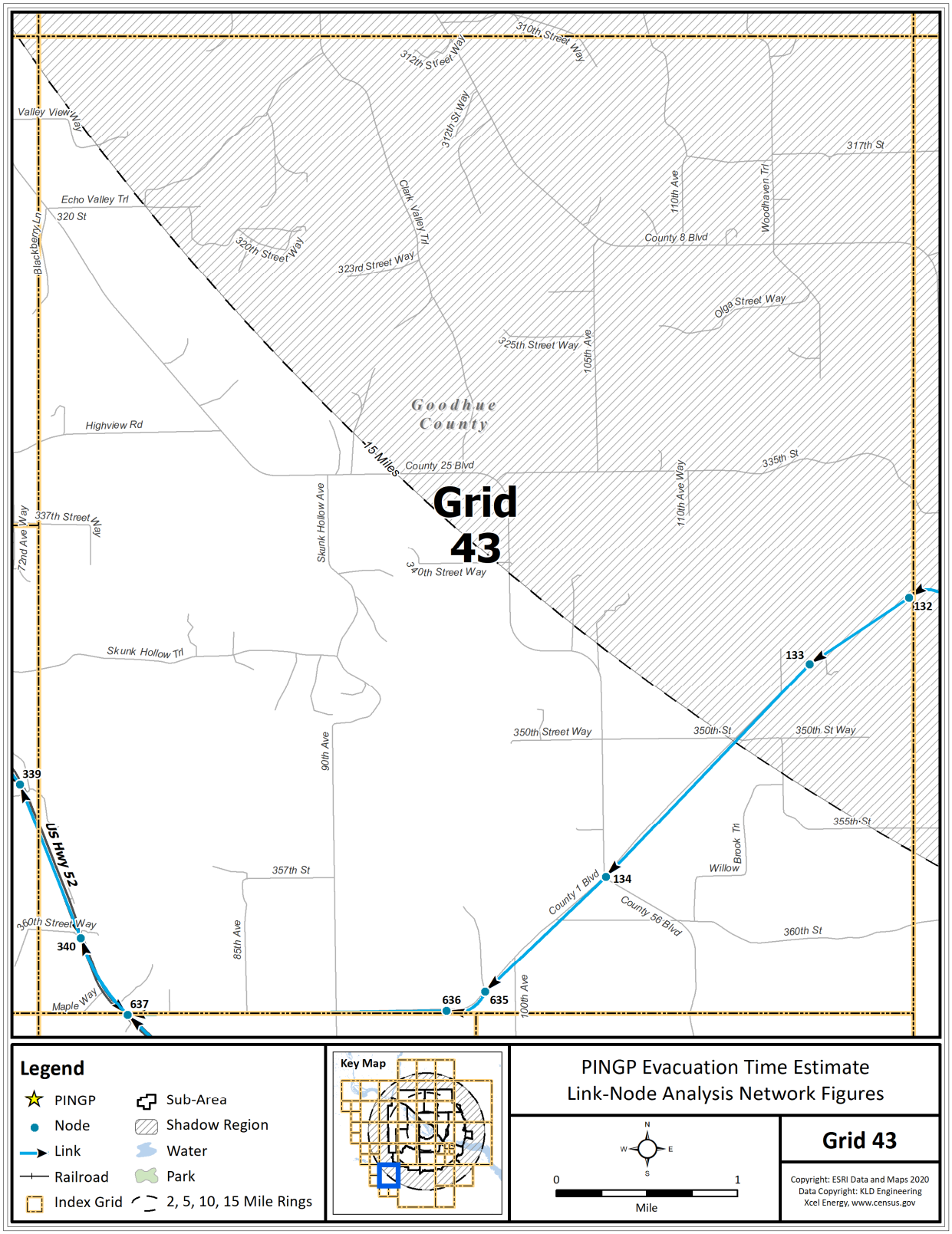


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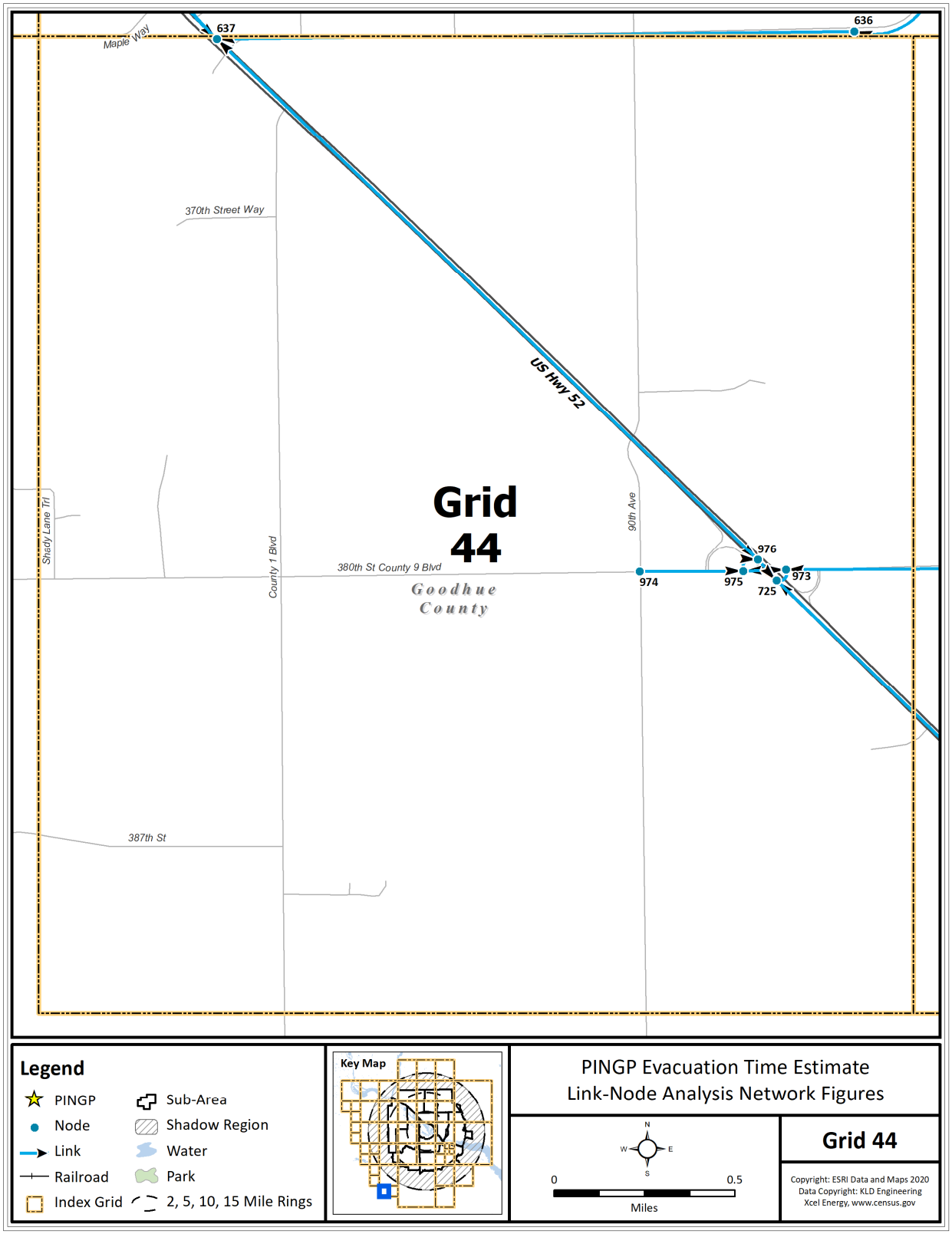


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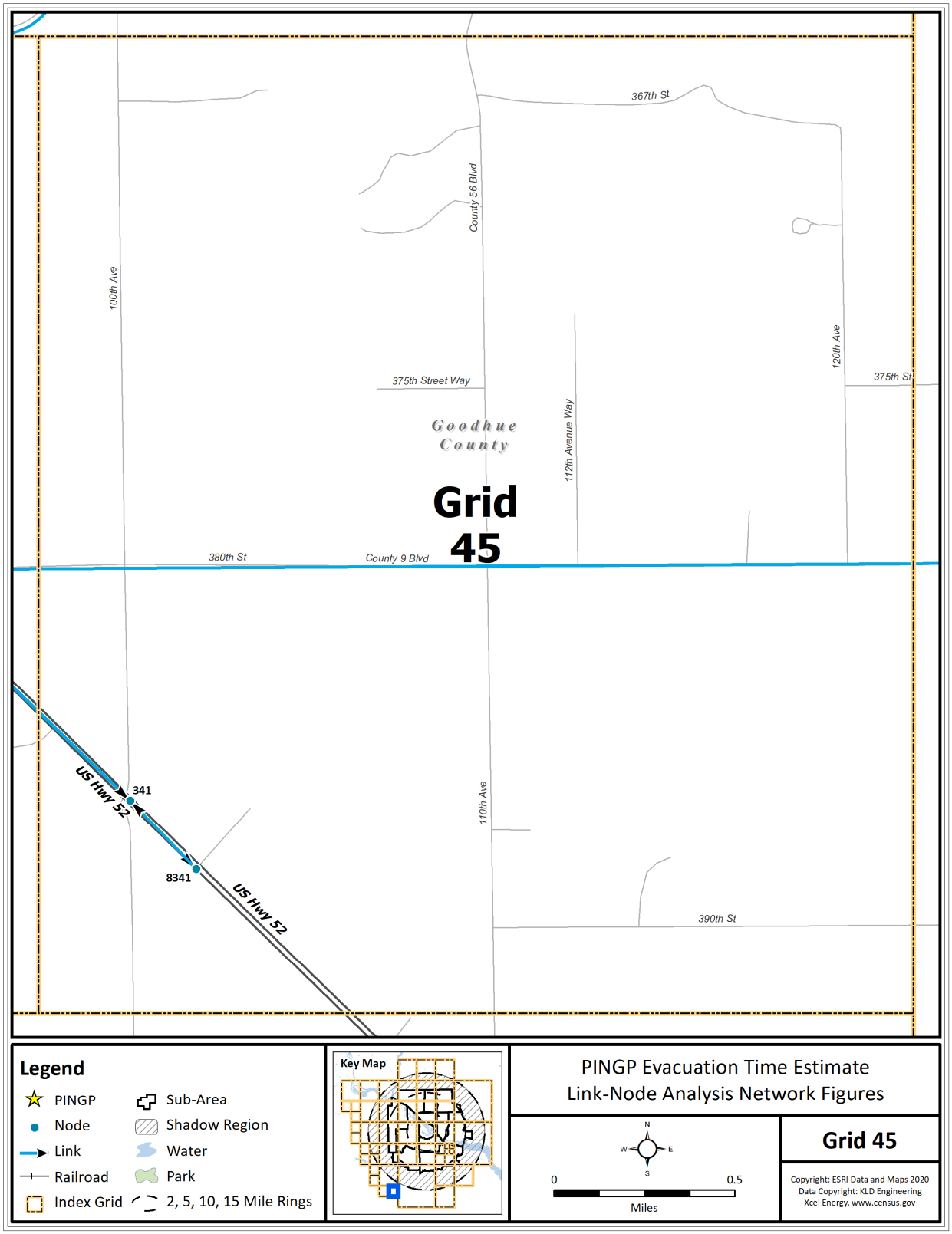


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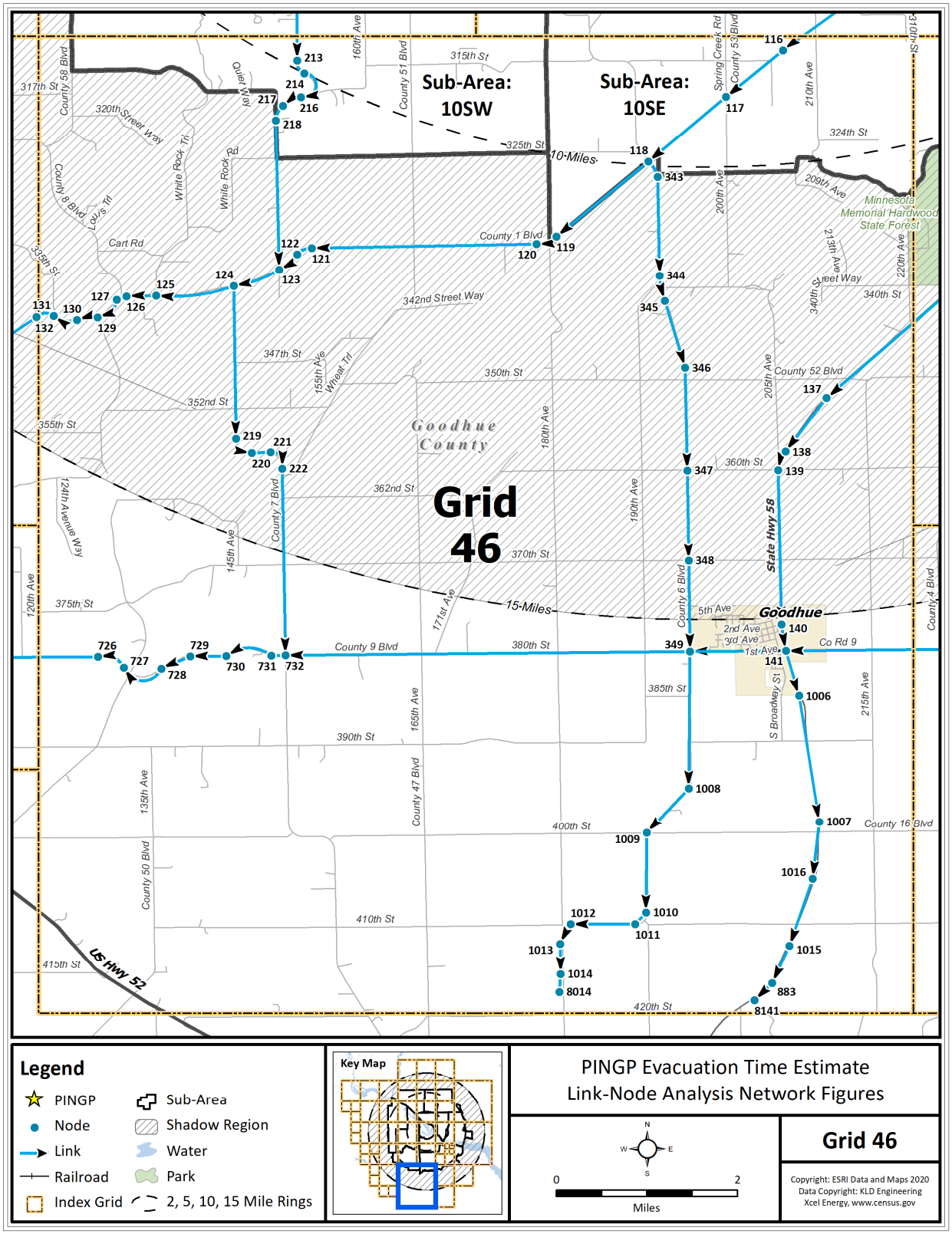


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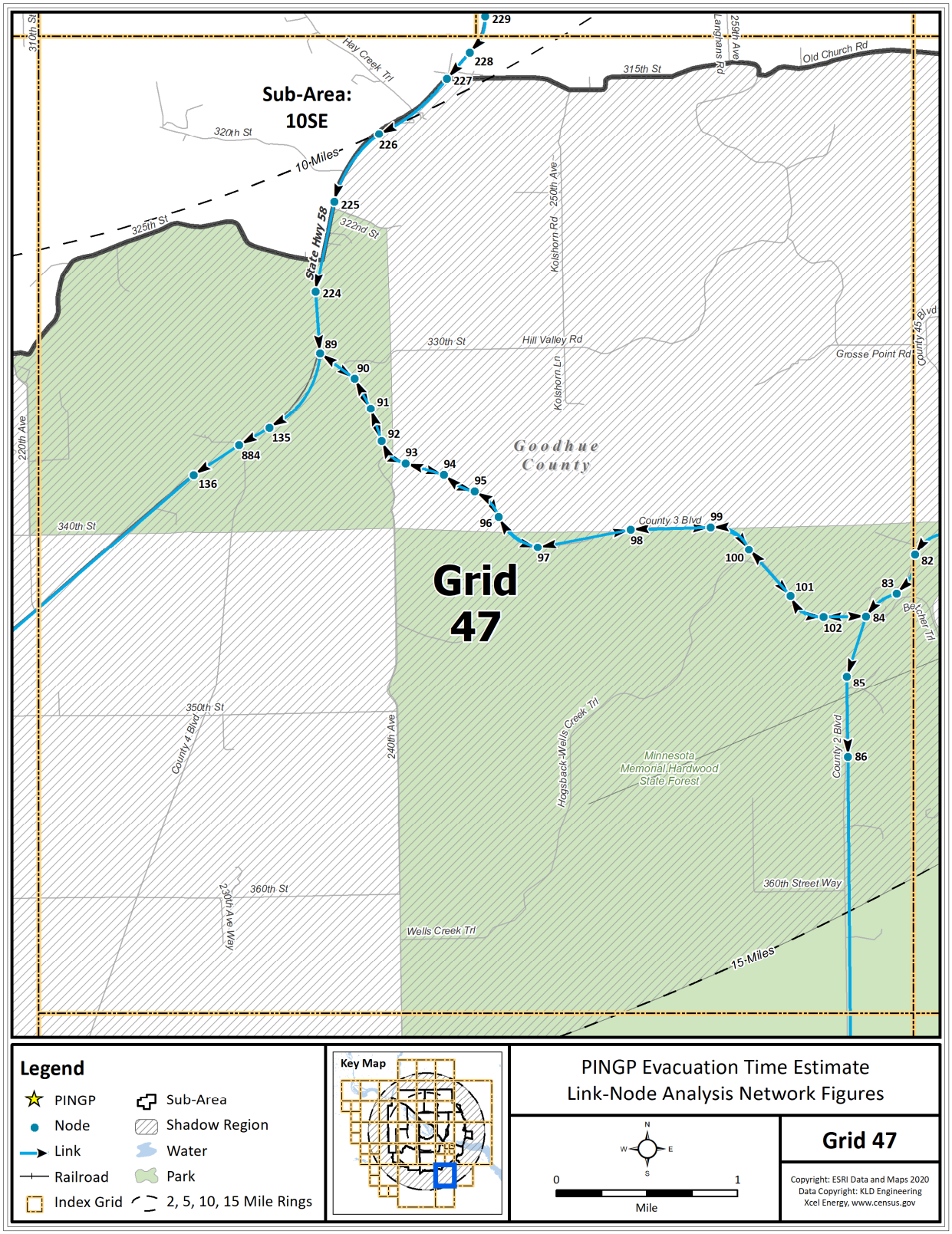


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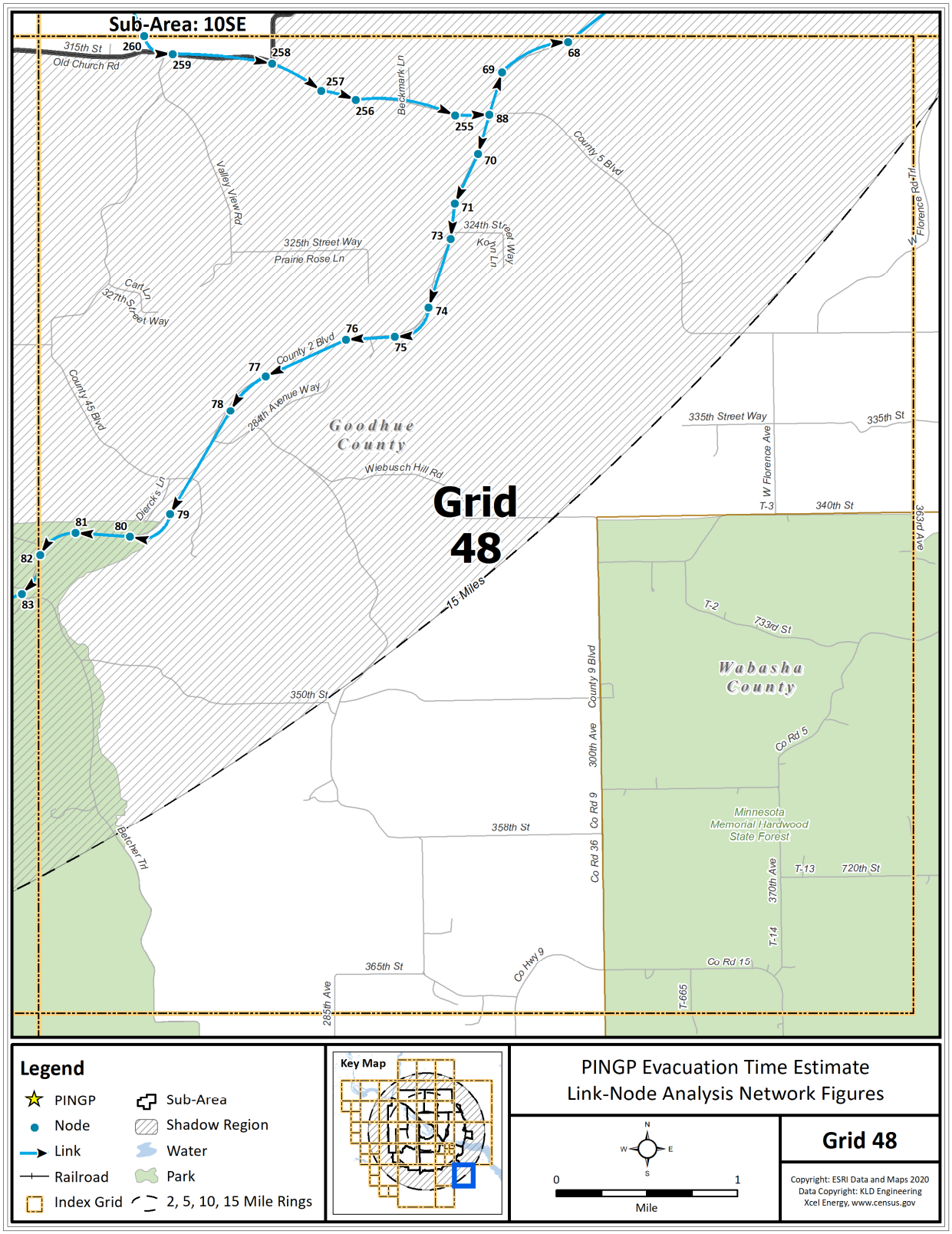


Figure K-49. Link-Node Analysis Network – Grid 48

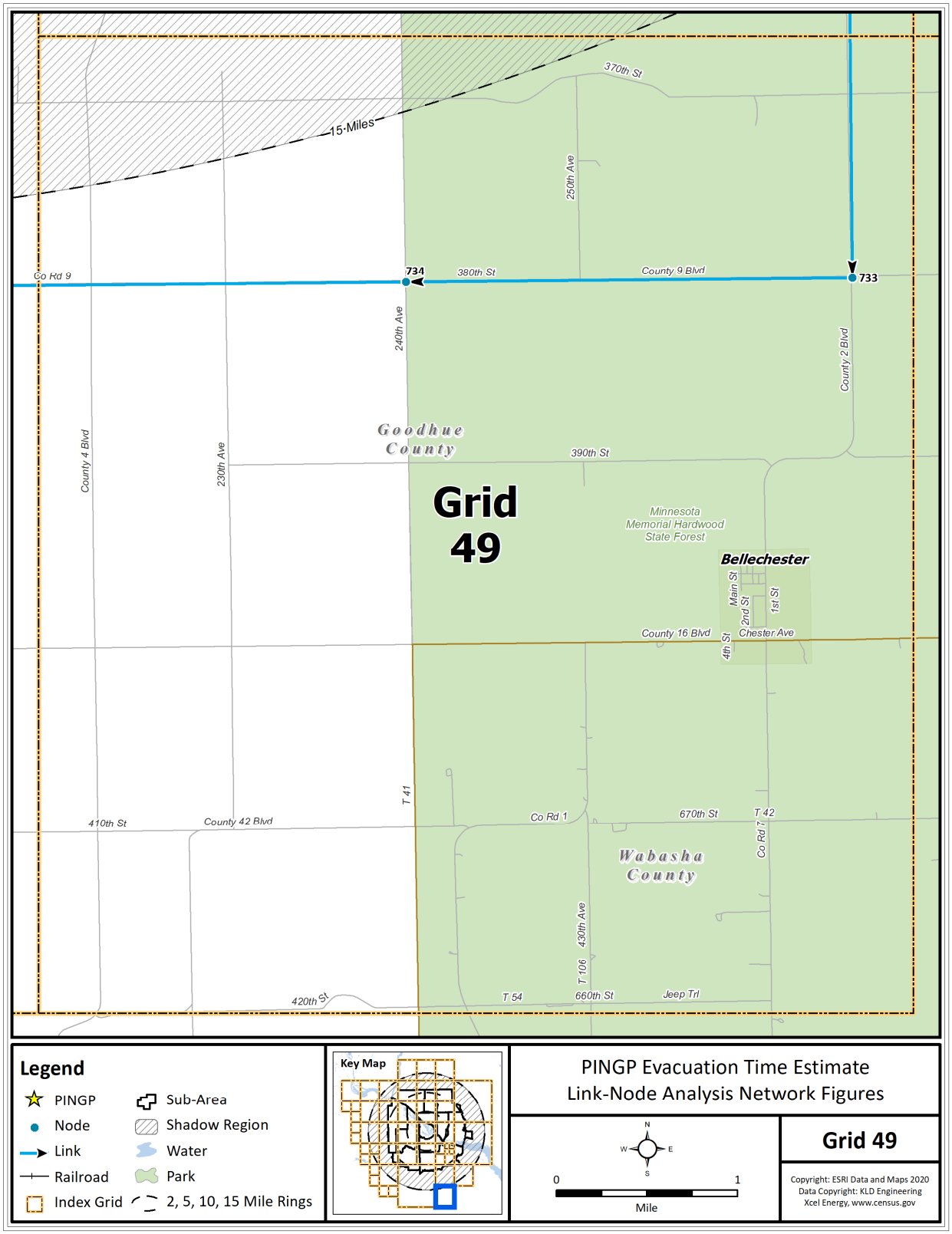


Figure K-50. Link-Node Analysis Network – Grid 49

APPENDIX L

Subarea Boundaries

L. SUB-AREA BOUNDARIES

Subarea 2

Counties: Goodhue and Pierce

Defined as the area within the following boundary: Goodhue County residents in the portion of Red Wing within 2 miles of the Prairie Island Nuclear Generating Plant. This INCLUDES those residents north of County Road 46 and south of the Mississippi River. This INCLUDES the Prairie Island Indian Community but DOES NOT INCLUDE the downtown section of Red Wing. Pierce County residents in the portion of the Town of Diamond Bluff, south of State Highway 35.

Subarea 5N

County: Pierce

Defined as the area within the following boundary: Pierce County residents in the Town of Diamond Bluff north of State Highway 35.

Subarea 5E

County: Pierce

Defined as the area within the following boundary: Pierce County residents in the portions of the Town of Trenton, west of US Highway 63, INCLUDING the Village of Hager City.

Subarea 5S

County: Goodhue

Defined as the area within the following boundary: Goodhue County residents in the portion of Red Wing west of Bench Street (County Road 1). This area DOES NOT INCLUDE the downtown section of Red Wing.

Subarea 5W

County: Goodhue

Defined as the area within the following boundary: Goodhue County residents in all portions of Welch Township, INCLUDING the Village of Welch.

Subarea 10N

County: Pierce

Defined as the area within the following boundary: Pierce County residents in portions of the Town of Oak Grove east of County Road E. Portions of the Town of Trimbelle west of County Road O.

Subarea 10NE

County: Pierce

Defined as the area within the following boundary: Pierce County residents in portions of the Town of Trimbelle east of County Road O. Portions of the Town of Ellsworth west of County Road C. This DOES NOT INCLUDE the Village of Ellsworth.

Subarea 10E County: Pierce

Defined as the area within the following boundary: Pierce County residents in portions of the Town of Trenton east of US Highway 63, and all of the Town of Isabelle, INCLUDING the Village of Bay City. Portions of the Town of Hartland west of 620th Street, south of County Road EE, and west of County Road D.

Subarea 10SE County:

Defined as the area within the following boundary: Goodhue County residents in Red Wing east of Bench Street (County Road 1), INCLUDING the downtown section. Goodhue County residents of Wacouta Township west of Flower Valley Road. Residents of Hay Creek Township west of Flower Valley Road and County Road 45, and north of Old Church Road (315th Street). Residents of Featherstone Township north of State Highway 58 and 325th Street

Subarea 10SW County:

Defined as the area within the following boundary: Goodhue County residents in the portions of Vasa Township north of 325th Street and 315th Street, INCLUDING the village of Vasa. Residents in the northeast corner of Cannon Falls Township north of State Highway 19 and east of Sunset Trail and the Cannon River.

Subarea 10W County:

Defined as the area within the following boundary: Dakota County residents in all of Ravenna Township. Portions of Marshan and Douglas Townships east of County State Aid Highway 91 (Nicolai Avenue) and Michael Avenue, INCLUDING the town of Miesville.

Subarea 10NW County:

Defined as the area within the following boundary: Pierce County residents in portions of the Town of Oak Grove west of County Road E. This DOES NOT INCLUDE the City of Prescott.

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 Evacuation Time Estimates (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 (ATE), could be persuaded to respond much more rapidly), or if the tail were elongated (i.e., spreading out the departure of evacuees to limit the demand during peak times), how would the ETE be affected? The case considered was Scenario 3, Region 3; a summer, weekend, midday, with good weather evacuation of the entire EPZ. Table M-1 presents the results of this study.

If evacuees mobilize one hour quicker, the 90th percentile and 100th percentile ETE is reduced by 5 minutes and 1 hour, respectively – a minimal change for the 90th percentile ETE and a significant change for the 100th percentile ETE. If evacuees mobilize one hour slower, the 90th percentile and 100th percentile ETE increases by 45 minutes and by 1 hour, respectively – a significant change for both of the 90th percentile ETE and the 100th percentile ETE.

As discussed in Section 7.3, traffic congestion persists within the EPZ for about 3 hours and 45 minutes after the ATE, before the completion of trip generation time. As such, congestion dictates the 90th and 100th percentile ETE until 3 hours and 45 minutes after the ATE. After this time, the ETE are dictated by the trip generation (plus a 10-minute travel time to the EPZ boundary).

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 due to changes in the percentage of people who decide to relocate from the Shadow Region. The case considered was Scenario 3, Region 3; a summer, weekend, midday, with good weather evacuation of the entire EPZ. The movement of people in the Shadow Region has the potential to impede vehicles evacuating from an Evacuation Region within the EPZ. Refer to Sections 3.2 and 7.1 for additional information on population within the Shadow Region.

Table M-2 presents the ETE for each of the cases considered. The results show that eliminating (0%) shadow evacuation has no change to the 90th or 100th percentile ETEs. Doubling, tripling and quadrupling the shadow evacuation (80%) or a full shadow evacuation (100%) increases the 90th percentile ETE by 5 – not a significant change. The 100th percentile ETE is not impacted by any changes in the shadow evacuation percentages since it is dictated by the trip generation time.

Note the demographic survey results presented in Appendix F indicate that approximately 10% of households would elect to evacuate if advised to shelter, which differs significantly from the base

assumption of 20% non-compliance suggested in the NUREG/CR-7002, Rev. 1. A sensitivity study was run using 10% shadow evacuation and the results the results indicate there is no impact to the ETE both 90th percentile and 100th percentile ETEs.

The Shadow Region for PINGP is sparsely populated, except for population centers of Hastings, Cannon Falls, Prescott, and Ellsworth, which are all in the northwest. As shown in Figures 7-3 through 7-7, vicinities of Frontenac and Goodhue near the southeast are the last areas to clear of congestion. Therefore, any additional shadow region residents that decide to voluntarily evacuate are easily accommodated by the excess capacity available in the study area to the northwest such that ETE are not impacted.

M.3 Effect of Changes in Permanent Resident Population

A sensitivity study was conducted to determine the effect on ETE due to changes in the permanent resident population within the study area (EPZ plus Shadow Region). As population in the study area changes over time, the time required to evacuate the public may increase, decrease, or remain the same. Since the ETE is related to the demand to capacity ratio present within the study area, changes in population will cause the demand side of the equation to change and could impact ETE.

As per the NRC's response to the Emergency Planning Frequently Asked Question (EPFAQ) 2013-001, the ETE population sensitivity study must be conducted to determine what percentage increase in permanent resident population causes an increase in the 90th percentile ETE of 25% or 30 minutes, whichever is less. The sensitivity study must use the scenario with the longest 90th percentile ETE (excluding the roadway impact scenario and the special event scenario if it is a one day per year special event).

Thus, the sensitivity study was conducted using the following planning assumptions:

1. The percent change in population within the study area was increased by up to 33%. Changes in population were applied to permanent residents only (as per federal guidance), in both the EPZ and the Shadow Region.
2. The transportation infrastructure (as presented in Appendix K) remained fixed; the presence of future proposed roadway changes and/or highway capacity improvements were not considered.
3. The study was performed for the 2-Mile Region (R01), the 5-Mile Region (R02), and the entire EPZ (R03).
4. The scenario (excluding roadway impact and special event) which yielded the longest 90th percentile ETE values was selected as the case to be considered in this sensitivity study (Scenario 8 – winter, midweek, midday, with heavy snow).

Table M-3 presents the results of the sensitivity study. Section IV of Appendix E to 10 CFR Part 50, and NUREG/CR-7002, Rev. 1, Section 5.4, require licensees to provide an updated ETE analysis to the NRC when a population increase within the EPZ causes the longest 90th percentile ETE values (for the 2-Mile Region, 5-Mile Region or entire EPZ) to increase by 25% or 30 minutes, whichever is less. All base ETE values of the aforementioned Regions are greater

than 2 hours; 25 percent of these base ETE is always equal or greater than 30 minutes. Therefore, 30 minutes is the lesser and is the criterion for updating ETE.

Those percent population changes which result in the longest 90th percentile ETE to change greater than or equal to 30 minutes are highlighted in red in Table M-3 – a 33% or greater increase in the full EPZ permanent resident population (includes 20% of the Shadow permanent resident population). Constellation will have to estimate the full EPZ population on an annual basis. If the EPZ population increases by 33% or more, an updated ETE analysis will be needed.

M.4 Effect of Changes in Average Household Size

As discussed in Appendix F, the average household size obtained from the survey contains 2.61 people. The estimated household size from the 2020 Census data is 2.45 people. The difference between the Census data and survey data is 6.5%, which exceeds the survey's margin of error of 4.67%. Upon discussions with Xcel Energy, it was decided that the U.S. Census estimate of 2.45 people per household would be used in this study. A sensitivity study was performed to determine how sensitive the ETE is to changes in the average household size. It should be noted that only resident and shadow vehicles were changed for this sensitivity study. The case considered was Scenario 3, a summer, weekend, midday with good weather evacuation of the 2-Mile Region (R01), 5-Mile Region (R02), and entire EPZ (R03). Table M-4 presents the results of this study.

Increasing the average household size (decreasing the total number of evacuating vehicles) by 6.5% has no impact on both of the 90th percentile and 100th percentile ETE.

M.5 Enhancements in Evacuation Time

This appendix documents sensitivity studies on critical variables that could potentially impact ETE. Possible improvements to ETE are further discussed below:

- Reducing or prolonging the trip generation time significantly impacts the 100th percentile ETE since trip generation dictates ETE for this low population site (Section M.1). Thus, public outreach encouraging evacuees to mobilize more quickly or in a timely manner will decrease ETE.
- Shadow evacuation has no impact on ETE (Section M.2). Nonetheless, public outreach could be considered to inform those people within the EPZ (and potentially beyond the EPZ) that if they are not advised to evacuate, they should not.
- Population growth results in more evacuating vehicles which could significantly increase ETE (Section M.3). Public outreach to inform those people within the EPZ to evacuate as a family in a single vehicle would reduce the number of evacuating vehicles and could reduce ETE or offset the impact of population growth.
- Increasing the average household size (decreasing the total number of evacuating vehicles), has no impact on the 90th percentile ETE and 100th percentile ETE (Appendix M.4).

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

Trip Generation Period	Evacuation Time Estimate for Entire EPZ	
	90th Percentile	100th Percentile
3 hours 30 minutes	2:45	3:40
4 hours 30 minutes (Base)	2:50	4:40
5 hours 30 minutes	3:35	5:40

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

Percent Shadow Evacuation	Evacuating Shadow Vehicles[1]	Evacuation Time Estimate for Entire EPZ	
		90th Percentile	100th Percentile
0	0	2:50	4:40
10	2,245	2:50	4:40
20 (Base)	4,490	2:50	4:40
40	8,980	2:55	4:40
60	13,470	2:55	4:40
80	17,960	2:55	4:40
100	22,450	2:55	4:40

[1] The Evacuating Shadow Vehicles, in Table M-2, represent the residents and employees who will spontaneously decide to relocate during the evacuation. The basis, for the base values shown, is a 20% relocation of shadow residents along with a proportional percentage of shadow employees. See Section 6 for further discussion.

Table M-3. ETE Variation with Population Change

EPZ and 20% Shadow Permanent Resident Population	Base	Population Change		
		31%	32%	33%
	38,716	50,718	51,105	51,492
ETE (hrs:mins) for the 90th Percentile				
Region	Base	Population Change		
		31%	32%	33%
2-MILE	2:05	2:10	2:10	2:10
5-MILE	2:45	2:50	2:50	2:50
FULL EPZ	3:45	4:10	4:10	4:15
ETE for the 100th Percentile				
Region	Base	Population Change		
		31%	32%	33%
2-MILE	5:30	5:30	5:30	5:30
5-MILE	5:35	5:35	5:35	5:35
FULL EPZ	5:40	5:40	5:40	5:40

Table M-4. ETE Results for Change in Average Household Size

EPZ and 20% Shadow Permanent Resident Population	Base Case Average Household Size (2.45 people per household)	Sensitivity Case Average Household Size (2.61 people per household)
	38,716 people	36,343 people
ETE for the 90th Percentile		
Region	Base Case	Sensitivity Case
2-MILE	2:05	2:05
5-MILE	2:15	2:15
FULL EPZ	2:50	2:50
ETE for the 100th Percentile		
Region	Base Case	Sensitivity Case
2-MILE	4:30	4:30
5-MILE	4:35	4:35
FULL EPZ	4:40	4:40

APPENDIX N

ETE Criteria Checklist

N. ETE CRITERIA CHECKLIST

Table N-1. ETE Review Criteria Checklist

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
1.0 Introduction		
a. The emergency planning zone (EPZ) and surrounding area is described.	Yes	Section 1.2
b. A map is included that identifies primary features of the site including major roadways, significant topographical features, boundaries of counties, and population centers within the EPZ.	Yes	Figures 1-1, 3-1, 6-1
c. A comparison of the current and previous ETE is provided including information similar to that identified in Table 1-1, "ETE Comparison."	Yes	Section 1.4, Table 1-3
1.1 Approach		
a. The general approach is described in the report as outlined in Section 1.1, "Approach."	Yes	Section 1.1, Section 1.3, Appendix D
1.2 Assumptions		
a. Assumptions consistent with Table 1-2, "General Assumptions," of NUREG/CR-7002 are provided and include the basis to support use.	Yes	Section 2
1.3 Scenario Development		
a. The scenarios in Table 1-3, "Evacuation Scenarios," are developed for the ETE analysis. A reason is provided for use of other scenarios or for not evaluating specific scenarios.	Yes	Table 2-1, Section 6, Table 6-2

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
1.4 Evacuation Planning Areas		
a. A map of the EPZ with emergency response planning areas (ERPAs) is included.	Yes	Figure 3-1, Figure 6-1
1.4.1 Keyhole Evacuation		
a. A table similar to Table 1-4 "Evacuation Areas for a Keyhole Evacuation", is provided identifying the ERPAs considered for each ETE calculation by downwind direction.	Yes	Table 6-1, Table 7-5, Table H-1
1.4.2 Staged Evacuation		
a. The approach used in development of a staged evacuation is discussed.	Yes	Section 7.2, Section 5.4.2
b. A table similar to Table 1-5, "Evacuation Areas for a Staged Evacuation," is provided for staged evacuations identifying the ERPAs considered for each ETE calculation by downwind direction.	Yes	Table 6-1, Table 7-5, Table 7-3, Table 7-4, Table H-1
2.0 Demand Estimation		
a. Demand estimation is developed for the four population groups (permanent residents of the EPZ, transients, special facilities, and schools).	Yes	Section 3
2.1 Permanent Residents and Transient Population		
a. The U.S. Census is the source of the population values, or another credible source is provided.	Yes	Section 3.1
b. The availability date of the census data is provided.	Yes	Section 3.1
c. Population values are adjusted as necessary for growth to reflect population estimates to the year of the ETE.	N/A	N/A – 2020 Census used as the base year of the analysis

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
d. A sector diagram, similar to Figure 2-1, "Population by Sector," is included showing the population distribution for permanent residents.	Yes	Figure 3-2
2.1.1 Permanent Residents with Vehicles		
a. The persons per vehicle value is between 1 and 3 or justification is provided for other values.	Yes	Section 3.1, Appendix F
2.1.2 Transient Population		
a. A list of facilities that attract transient populations is included, and peak and average attendance for these facilities is listed. The source of information used to develop attendance values is provided.	Yes	Section 3.3, Table E-4, Table E-5, Table E-6, Table E-7, Table E-8
b. Major employers are listed.	Yes	Section 3.4, Table E-3
c. The average population during the season is used, itemized and totaled for each scenario.	Yes	Table 3-4, Table 3-5 and Appendix E itemize the peak transient population and employee estimates. These estimates are multiplied by the scenario specific percentages provided in Table 6-3 to estimate average transient population and employees by scenario – see Table 6-4.
d. The percentage of permanent residents assumed to be at facilities is estimated.	Yes	Section 3.3 and Section 3.4
e. The number of people per vehicle is provided. Numbers may vary by scenario, and if so, reasons for the variation are discussed.	Yes	Section 3.3 and Section 3.4

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
f. A sector diagram is included, similar to Figure 2-1, "Population by Sector", is included showing the population distribution for the transient population.	Yes	Figure 3-6 (transients) and Figure 3-8 (employees)
2.2 Transit Dependent Permanent Residents		
a. The methodology (e.g., surveys, registration programs) used to determine the number of transit dependent residents is discussed.	Yes	Section 3.8
b. The State and local evacuation plans for transit dependent residents are used in the analysis.	Yes	Section 8.1
c. The methodology used to determine the number of people with disabilities and those with access and functional needs who may need assistance and do not reside in special facilities is provided. Data from local/county registration programs are used in the estimate.	Yes	Section 3.9
d. Capacities are provided for all types of transportation resources. Bus seating capacity of 50 percent is used or justification is provided for higher values.	Yes	Item 3 of Section 2.4
e. An estimate of the transit dependent population is provided.	Yes	Section 3.8, Table 3-8, Table 3-9, Table 3-11
f. A summary table showing the total number of buses, ambulances, or other transport assumed available to support evacuation is provided. The quantification of resources is detailed enough to ensure that double counting has not occurred.	Yes	Table 3-9, Table 8-1

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
2.3 Special Facility Residents		
a. Special facilities, including the type of facility, location, and average population, are listed. Special facility staff is included in the total special facility population.	Yes	Table E-2 and Table E-9 list all medical facilities and correctional facility by facility name, location, and average population. Staff estimates were not provided.
b. The method of obtaining special facility data is discussed.	Yes	Section 3.5, Section 3.6
c. An estimate of the number and capacity of vehicles assumed available to support the evacuation of the facility is provided.	Yes	Table 3-6
d. The logistics for mobilizing specially trained staff (e.g., medical support or security support for prisons, jails, and other correctional facilities) are discussed when appropriate.	Yes	Section 8.1 – under "Evacuation of Medical Facilities" and Section 8.2 – under "ETEs for Correctional Facilities"
2.4 Schools		
a. A list of schools including name, location, student population, and transportation resources required to support the evacuation, is provided. The source of this information should be identified.	Yes	Section 3.7, Table 3-7, Table E-1 (schools)
b. Transportation resources for elementary and middle schools are based on 100 percent of the school capacity.	Yes	Section 3.7
c. The estimate of high school students who will use personal vehicle to evacuate is provided and a basis for the values used is given.	Yes	Section 3.7
d. The need for return trips is identified.	Yes	Section 8.1 - no return trips are needed

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
2.5 Other Demand Estimate Considerations		
2.5.1 Special Events		
a. A complete list of special events is provided including information on the population, estimated duration, and season of the event.	Yes	Section 3.10
b. The special event that encompasses the peak transient population is analyzed in the ETE.	Yes	Section 3.10
c. The percentage of permanent residents attending the event is estimated.	Yes	Section 3.10
2.5.2 Shadow Evacuation		
a. A shadow evacuation of 20 percent is included consistent with the approach outlined in Section 2.5.2, "Shadow Evacuation".	Yes	Item 7 of Section 2.2, Figure 2-1 and Figure 7-1, Section 3.2
b. Population estimates for the shadow evacuation in the shadow region beyond the EPZ are provided by sector.	Yes	Section 3.2, Table 3-3, Figure 3-4
c. The loading of the shadow evacuation onto the roadway network is consistent with the trip generation time generated for the permanent resident population.	Yes	Section 5 – Table 5-9 (footnote)
2.5.3 Background and Pass Through Traffic		
a. The volume of background traffic and pass-through traffic is based on the average daytime traffic. Values may be reduced for nighttime scenarios.	Yes	Section 3.11 and Section 3.12

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
b. The method of reducing background and pass-through traffic is described.	Yes	Section 2.2 – Assumptions 10 and 11 Section 2.5 Section 3.11 and Section 3.12 Table 6-3 – External Through Traffic footnote
c. Pass-through traffic is assumed to have stopped entering the EPZ about two (2) hours after the initial notification.	Yes	Section 2.5, Section 3.11
2.6 Summary of Demand Estimation		
a. A summary table is provided that identifies the total populations and total vehicles used in the analysis for permanent residents, transients, transit dependent residents, special facilities, schools, shadow population, and pass-through demand in each scenario.	Yes	Table 3-11, Table 3-12, and Table 6-4
3.0 Roadway Capacity		
a. The method(s) used to assess roadway capacity is discussed.	Yes	Section 4
3.1 Roadway Characteristics		
a. The process for gathering roadway characteristic data is described including the types of information gathered and how it is used in the analysis.	Yes	Section 1.3, Appendix D
b. Legible maps are provided that identify nodes and links of the modeled roadway network similar to Figure A-1, "Roadway Network Identifying Nodes and Links," and Figure A-2, "Grid Map Showing Detailed Nodes and Links."	Yes	Appendix K

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
3.2 Model Approach		
a. The approach used to calculate the roadway capacity for the transportation network is described in detail, and the description identifies factors that are expressly used in the modeling.	Yes	Section 4
b. Route assignment follows expected evacuation routes and traffic volumes.	Yes	Appendix B and Appendix C
c. A basis is provided for static route choices if used to assign evacuation routes.	N/A	Static route choices are not used to assign evacuation routes. Dynamic traffic assignment is used.
d. Dynamic traffic assignment models are described including calibration of the route assignment.	Yes	Appendix B and Appendix C
3.3 Intersection Control		
a. A list that includes the total numbers of intersections modeled that are unsignalized, signalized, or manned by response personnel is provided.	Yes	Table K-1
b. The use of signal cycle timing, including adjustments for manned traffic control, is discussed.	Yes	Section 4, Appendix G
3.4 Adverse Weather		
a. The adverse weather conditions are identified.	Yes	Assumption 2 and 3 of Section 2.6
b. The speed and capacity reduction factors identified in Table 3-1, "Weather Capacity Factors," are used or a basis is provided for other values, as applicable to the model.	Yes	Table 2-2
c. The calibration and adjustment of driver behavior models for adverse weather conditions are described, if applicable.	N/A	Driver behavior is not adjusted for adverse weather conditions.

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
d. The effect of adverse weather on mobilization is considered and assumptions for snow removal on streets and driveways are identified, when applicable.	Yes	Assumption 6 of Section 2.6, Table 2-2
4.0 Development of Evacuation Times		
4.1 Traffic Simulation Models		
a. General information about the traffic simulation model used in the analysis is provided.	Yes	Section 1.3, Table 1-3, Appendix B, Appendix C
b. If a traffic simulation model is not used to perform the ETE calculation, sufficient detail is provided to validate the analytical approach used.	N/A	Not applicable since a traffic simulation model was used.
4.2 Traffic Simulation Model Input		
a. Traffic simulation model assumptions and a representative set of model inputs are provided.	Yes	Section 2, Appendix J
b. The number of origin nodes and method for distributing vehicles among the origin nodes are described.	Yes	Appendix J, Appendix C
c. A glossary of terms is provided for the key performance measures and parameters used in the analysis.	Yes	Appendix A, Table C-1, Table C-3
4.3 Trip Generation Time		
a. The process used to develop trip generation times is identified.	Yes	Section 5
b. When surveys are used, the scope of the survey, area of the survey, number of participants, and statistical relevance are provided.	Yes	Appendix F
c. Data used to develop trip generation times are summarized.	Yes	Appendix F, Section 5

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
d. The trip generation time for each population group is developed from site-specific information.	Yes	Section 5
e. The methods used to reduce uncertainty when developing trip generation times are discussed, if applicable.	N/A	There was no uncertainty when developing trip generation times.
4.3.1 Permanent Residents and Transient Population		
a. Permanent residents are assumed to evacuate from their homes but are not assumed to be at home at all times. Trip generation time includes the assumption that a percentage of residents will need to return home before evacuating.	Yes	Section 5 discusses trip generation for households with and without returning commuters. Table 6-3 presents the percentage of households with returning commuters and the percentage of households either without returning commuters or with no commuters. Appendix F presents the percent households who will await the return of commuters. Section 2.3, Assumption 3
b. The trip generation time accounts for the time and method to notify transients at various locations.	Yes	Section 5
c. The trip generation time accounts for transients potentially returning to hotels before evacuating.	Yes	Section 5, Figure 5-1
d. The effect of public transportation resources used during special events where a large number of transients are expected is considered.	Yes	Section 3.10 There is no provided transportation, considered for the special event.

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
4.3.2 Transit Dependent Permanent Residents		
a. If available, existing and approved plans and bus routes are used in the ETE analysis.	N/A	Established bus routes do not exist. Basic bus routes were developed for the ETE analysis Section 8.1 under "Evacuation of Transit-Dependent Population (Residents without access to a vehicle)"
b. The means of evacuating ambulatory and non-ambulatory residents are discussed.	Yes	Section 8.1 under "Evacuation of Transit-Dependent Population (Residents without access to a vehicle)", Section 8.3
c. Logistical details, such as the time to obtain buses, brief drivers and initiate the bus route are used in the analysis.	Yes	Section 8.1, Figure 8-1
d. The estimated time for transit dependent residents to prepare and then travel to a bus pickup point, including the expected means of travel to the pickup point, is described.	Yes	Section 8.1 under "Evacuation of Transit-Dependent Population (Residents without access to a vehicle)"
e. The number of bus stops and time needed to load passengers are discussed.	Yes	Section 8.1, Table 8-5 though Table 8-7
f. A map of bus routes is included.	Yes	Figure 10-2
g. The trip generation time for non-ambulatory persons including the time to mobilize ambulances or special vehicles, time to drive to the home of residents, time to load, and time to drive out of the EPZ, is provided.	Yes	Section 8.3
h. Information is provided to support analysis of return trips, if necessary.	Yes	Section 8.1 and 8.3

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
4.3.3 Special Facilities		
a. Information on evacuation logistics and mobilization times is provided.	Yes	Section 2.4, Section 8.1, Section 8.2, Table 8-8 through Table 8-10
b. The logistics of evacuating wheelchair and bed bound residents are discussed.	Yes	Section 8.1, Section 8.2, Table 8-8 through Table 8-11
c. Time for loading of residents is provided.	Yes	Section 2.4, Section 8.1, Section 8.2, Table 8-8 through Table 8-11
d. Information is provided that indicates whether the evacuation can be completed in a single trip or if additional trips are needed.	Yes	Section 8.1, Section 8.2,
e. Discussion is provided on whether special facility residents are expected to pass through the reception center before being evacuated to their final destination.	Yes	Section 8.1, Section 8.2,
f. Supporting information is provided to quantify the time elements for each trip, including destinations if return trips are needed.	Yes	Section 8.1, Section 8.2,
4.3.4 Schools		
a. Information on evacuation logistics and mobilization times is provided.	Yes	Section 2.4, Section 8.1, Table 8-2 through Table 8-4
b. Time for loading of students is provided.	Yes	Section 2.4, Section 8.1, Table 8-2 through Table 8-4
c. Information is provided that indicates whether the evacuation can be completed in a single trip or if additional trips are needed.	Yes	Section 8.1

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
d. If used, reception centers should be identified. A discussion is provided on whether students are expected to pass through the reception center before being evacuated to their final destination.	Yes	Section 8.1, Table 10-3
e. Supporting information is provided to quantify the time elements for each trip, including destinations if return trips are needed.	Yes	Section 8.1, Table 8-2 through Table 8-4
4.4 Stochastic Model Runs		
a. The number of simulation runs needed to produce average results is discussed.	N/A	DYNEV does not rely on simulation averages or random seeds for statistical confidence. For DYNEV/DTRAD, it is a mesoscopic simulation and uses dynamic traffic assignment model to obtain the "average" (stable) network work flow distribution. This is different from microscopic simulation, which is monte-carlo random sampling by nature relying on different seeds to establish statistical confidence. Refer to Appendix B for more details.
b. If one run of a single random seed is used to produce each ETE result, the report includes a sensitivity study on the 90 percent and 100 percent ETE using 10 different random seeds for evacuation of the full EPZ under Summer, Midweek, Daytime, Normal Weather conditions.	N/A	

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
4.5 Model Boundaries		
a. The method used to establish the simulation model boundaries is discussed.	Yes	Section 4.5
b. Significant capacity reductions or population centers that may influence the ETE and that are located beyond the evacuation area or shadow region are identified and included in the model, if needed.	Yes	Section 4.5
4.6 Traffic Simulation Model Output		
a. A discussion of whether the traffic simulation model used must be in equilibration prior to calculating the ETE is provided.	Yes	Appendix B
b. The minimum following model outputs for evacuation of the entire EPZ are provided to support review: 1. Evacuee average travel distance and time. 2. Evacuee average delay time. 3. Number of vehicles arriving at each destination node. 4. Total number and percentage of evacuee vehicles not exiting the EPZ. 5. A plot that provides both the mobilization curve and evacuation curve identifying the cumulative percentage of evacuees who have mobilized and exited the EPZ. 6. Average speed for each major evacuation route that exits the EPZ.	Yes	1. Appendix J, Table J-2 2. Table J-2 3. Table J-4 4. None and 0%. 100 percent ETE is based on the time the last vehicle exits the evacuation zone 5. Figures J-2 through J-15 (one plot for each scenario considered) 6. Table J-3
c. Color coded roadway maps are provided for various times (e.g., at 2, 4, 6 hrs.) during a full EPZ evacuation scenario, identifying areas where congestion exists.	Yes	Figure 7-3 through Figure 7-7

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
4.7 Evacuation Time Estimates for the General Public		
a. The ETE includes the time to evacuate 90 percent and 100 percent of the total permanent resident and transient population.	Yes	Table 7-1 and Table 7-2
b. Termination criteria for the 100 percent ETE are discussed, if not based on the time the last vehicle exits the evacuation zone.	N/A	100 percent ETE is based on the time the last vehicle exits the evacuation zone.
c. The ETE for 100 percent of the general public includes all members of the general public. Any reductions or truncated data is explained.	Yes	Section 5.4.1 – truncating survey data to eliminate statistical outliers Table 7-2 – 100th percentile ETE for general population
d. Tables are provided for the 90 and 100 percent ETEs similar to Table 4-3, "ETEs for a Staged Evacuation," and Table 4-4, "ETEs for a Keyhole Evacuation."	Yes	Table 7-3 and Table 7-4
e. ETEs are provided for the 100 percent evacuation of special facilities, transit dependent, and school populations.	Yes	Section 8
5.0 Other Considerations		
5.1 Development of Traffic Control Plans		
a. Information that responsible authorities have approved the traffic control plan used in the analysis are discussed.	Yes	Section 9, Appendix G
b. Adjustments or additions to the traffic control plan that affect the ETE is provided.	Yes	Section 9, Appendix G
5.2 Enhancements in Evacuation Time		
a. The results of assessments for enhancing evacuations are provided.	Yes	Appendix M

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
5.3 State and Local Review		
a. A list of agencies contacted is provided and the extent of interaction with these agencies is discussed.	Yes	Table 1-1
b. Information is provided on any unresolved issues that may affect the ETE.	Yes	Results of the ETE study were formally presented to state and local agencies at the final project meeting. Comments on the draft report were provided and were addressed in the final report. There are no unresolved issues.
5.4 Reviews and Updates		
a. The criteria for when an updated ETE analysis is required to be performed and submitted to the NRC is discussed.	Yes	Appendix M, Section M.3
5.4.1 Extreme Conditions		
a. The updated ETE analysis reflects the impact of EPZ conditions not adequately reflected in the scenario variations.	N/A	This ETE is being updated as a result of the availability of US Census Bureau decennial census data.
5.5 Reception Centers and Congregate Care Center		
a. A map of congregate care centers and reception centers is provided.	Yes	Figure 10-3