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Dominion Energy

August 2, 2022

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

Serial No. 22-186
VCS LIC/HK/Rev 0
Docket No. 50-395
License No. NPF-12

DOMINION ENERGY SOUTH CAROLINA (DESC)
VIRGIL C. SUMMER NUCLEAR STATION (VCSNS) UNIT 1
10 CFR 50, APPENDIX E, EVACUATION TIME ESTIMATES

Pursuant to 10 CFR 50, Appendix E, Section IV, Paragraph 4, Dominion Energy South Carolina (DESC) submits the enclosed evacuation time estimate (ETE) studies for Virgil C. Summer Nuclear Station (VCSNS).

Should you have any questions, please contact Mr. Robert Williamson at (803) 345-4464.

Sincerely,

George Lippard
Site Vice President
V.C. Summer Nuclear Station

Enclosure

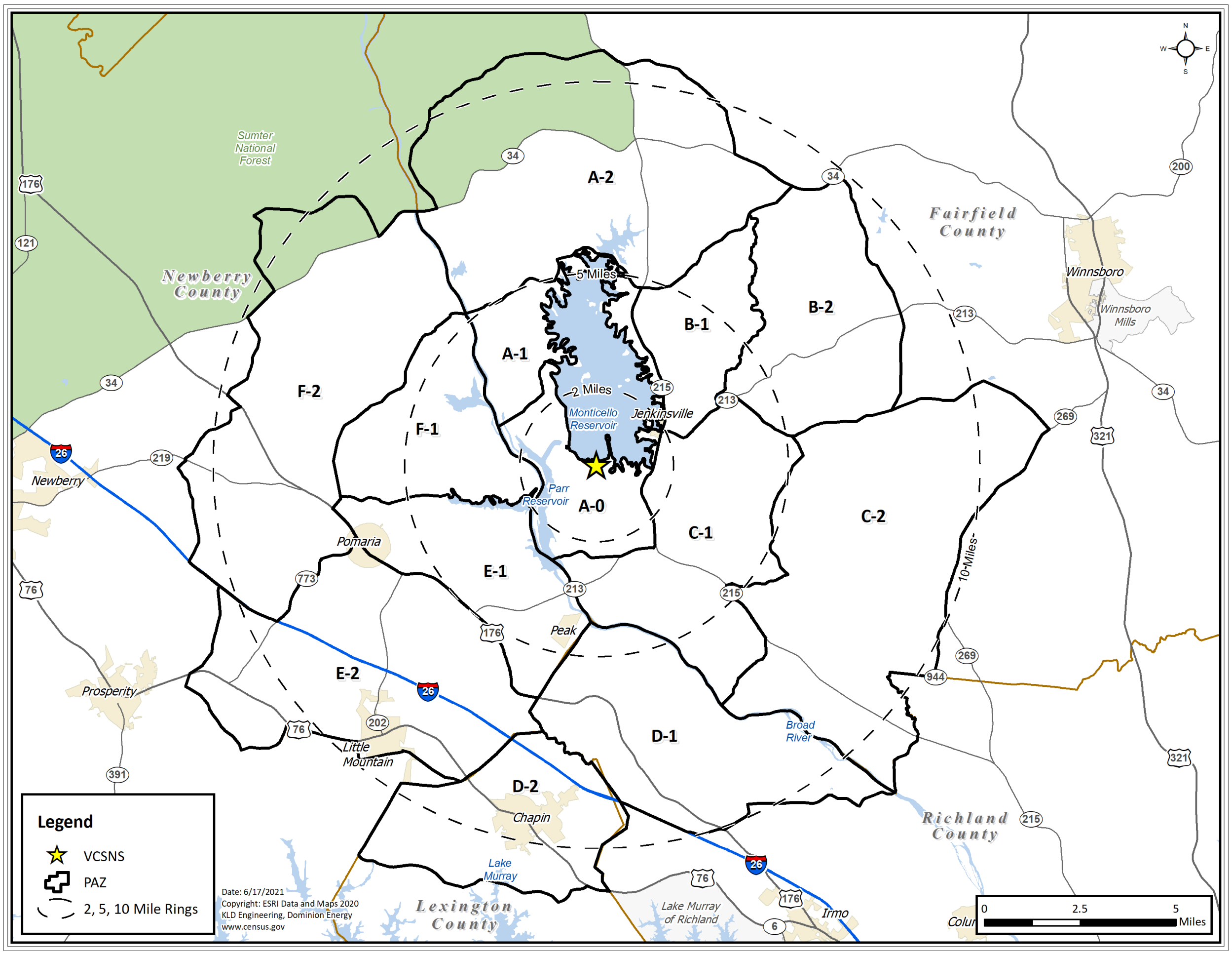
Commitments contained in this letter: None

cc: (Without Enclosures Unless Indicated)
G. J. Lindamood – Santee Cooper
L. Dudes – NRC Region II
G. Miller – NRC Project Mgr.
NRC Resident Inspector

VC Summer Nuclear Station

Development of Evacuation Time Estimates

EP-100 Appendix 5



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May 05, 2022 **Final Report, Rev. 0** **KLD TR – 1232**

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ACRONYM LIST

Table 1. Acronym List

ACRONYM	DEFINITION
AADT	Average Annual Daily Traffic
ANS	Alert and Notification System
ASLB	Atomic Safety and Licensing Board
ATE	Advisory to Evacuate
ATIS	Automated Traveler Information Systems
BFFS	Base Free Flow Speed
CR	County Road
COVID-19	Coronavirus Disease 2019
D	Destination
DDHV	Directional Design Hourly Volume
DHV	Design Hour Volume
DMS	Dynamic Message Sign
DTA	Dynamic Traffic Assignment
DTRAD	Dynamic Traffic Assignment and Distribution
DYNEV	Dynamic Network Evacuation
EAS	Emergency Alert System
EB	Eastbound
EPZ	Emergency Planning Zone
EPFAQ	Emergency Planning Frequently Asked Question
ETE	Evacuation Time Estimate
EVAN	Evacuation Animator
FEMA	Federal Emergency Management Agency
FFS	Free Flow Speed
FHWA	Federal Highway Administration
GIS	Geographic Information System
HAR	Highway Advisory Radio
HCM	Highway Capacity Manual
HH	Household
I-	Interstate
ITS	Intelligent Transportation Systems
LOS	Level of Service
MOE	Measures of Effectiveness
mph	Miles Per Hour
MUTCD	Manual On Uniform Traffic Control Devices
MTC	Manual Traffic Control
NB	Northbound
NRC	United States Nuclear Regulatory Commission
O	Origin
O-D	Origin-Destination
ORO	Offsite Response Organization

ACRONYM	DEFINITION
PAR	Protective Action Recommendation
PAZ	Protective Action Zone
pcphpl	passenger car per hour per lane
PSL	Path-Size-Logit
QDF	Queue Discharge Flow
RC	Reception Center
SB	Southbound
SR	State Route
SV	Service Volume
TA	Traffic Assignment
TACP	Traffic and Access Control Point
TD	Trip Distribution
TI	Time Interval
TMP	Traffic Management Plan
UNITES	Unified Transportation Engineering System
USDOT	United States Department of Transportation
US	US Highway
VCSNS	VC Summer Nuclear Station
vph	Vehicles Per Hour
vpm	Vehicles Per Minute
WB	Westbound

EXECUTIVE SUMMARY

This report describes the analyses undertaken and the results obtained by a study to develop Evacuation Time Estimates (ETE) for the VC Summer Nuclear Station (VCSNS) site located in Fairfield County, South Carolina. ETE are part of the required planning basis and provide Dominion 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.
- 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.

Project Activities

This project began in February, 2021 and extended over a period of about 14 months. The major activities performed are briefly described in chronological sequence:

- Conducted a virtual kick-off meeting with Dominion Energy personnel and emergency management personnel representing state and county governments.
- Accessed U.S. Census Bureau data files for the year 2020.
- Obtained the estimates of employees who reside outside the Emergency Planning Zone (EPZ) and commute to work within the EPZ from Dominion Energy and phone calls directly to General Information Services. (The percent of non-EPZ is from the previous study, as current data was not available.)
- Studied Geographic Information Systems (GIS) maps of the area in the vicinity of the VCSNS, 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.
- Conducted a random-sample online demographic survey of residents within the EPZ, to gather focused data needed for this ETE study, that were not contained within the census database. The survey instrument was reviewed and modified by the licensee and offsite response organization (ORO) personnel prior to the survey.

- A data needs matrix (requesting data) was provided to Dominion Energy and the OROs at the kick-off meeting. The data for major employers, transients, and special facilities (schools, licensed day care centers, medical facility) gathered for the 2012 ETE study were reviewed and either confirmed or updated accordingly by the OROs. If updated information was not provided and could not be obtained from online sources/phone calls directly to the facility, data gathered in the 2012 ETE study was assumed still accurate 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 existing 13 Protective Action Zones (PAZ) within the EPZ were grouped within circular areas or "keyhole" configurations (circles plus radial sectors) that define a total of 33 Evacuation Regions (numbered R01 through R33).
- 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, Ice). One special scenario, Labor Day Parade in Chapin, was considered. One roadway impact scenario was considered wherein a single lane was closed on eastbound Interstate (I)-26 from Columbia Avenue (Exit 91) to State Route 60 (Exit 102A/B) for the duration of the evacuation.
- Staged evacuation was considered for those regions where 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 VCSNS 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 Alert and Notification System (ANS).
    - 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 or licensed day care centers are in session, the ETE study assumes that the school/day care children will be evacuated by bus directly to reception centers located outside the EPZ and will be subsequently picked up by parents or legal guardians. No children at these facilities will be picked up by parents or relatives prior to the arrival of the buses. The ETE for children at these facilities 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 by the counties in the EPZ. Those in special facilities will likewise be evacuated by bus, wheelchair transport vehicle, 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 Generations of Chapin (a medical facility).
- Attended "final" virtual meeting with Dominion Energy personnel and the OROs to present results of the study.

Computation of ETE

A total of 462 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 33 Evacuation Regions to evacuate from that Region, under the circumstances defined for one of the 14 Evacuation Scenarios (33 x 14 = 462). 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 evacuate "voluntarily". 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 between 2-Mile Region and 5 miles 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, during a staged evacuation.

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 90^{th} percentile ETE has been identified as the value that should be considered when making protective action decisions because the 100^{th} 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 comprehensive existing traffic management plans provided by the counties within the EPZ, and the South Carolina Operational Radiological Emergency Response Plan (Site Specific Plan, Part 3). Due to the limited traffic congestion within the EPZ, no additional traffic and access control points have been identified as a result of this study. Refer to Section 9 and Appendix G.

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 PAZ based on the 2020 Census data.
- Table 6-1 defines each of the 33 Evacuation Regions in terms of their respective groups of PAZ.
- 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, the ETE for Regions R02 and R04 through R11 are compared to Regions R25 through R33, respectively, in Table 7-1 and Table 7-2.
- Table 7-3 and Table 7-4 present the ETE for the 2-Mile Region, when evacuating additional PAZs downwind to 5 miles for un-staged and staged evacuations for the 90^{th} and 100^{th} percentile ETE, respectively.
- Table 8-2 presents the ETE for the children at schools and licensed day care centers in good weather.
- Table 8-5 presents the ETE for the transit-dependent population in good weather.
- Table 8-8 presents ETE for the medical facility population (Generations of Chapin) in good weather.

- Figure 6-1 displays a map of the VCSNS EPZ showing the layout of the 13 PAZs that comprise, in aggregate, the EPZ.
- Figure H-7 presents an example of an Evacuation Region (Region R07) to be evacuated under the circumstances defined in Table 6-1. Maps of all regions are provided in Appendix H.

<u>Conclusions</u>

- General population ETE were computed for 462 unique cases – a combination of 33 unique Evacuation Regions and 14 unique Evacuation Scenarios. Tables 7-1 and 7-2 document these ETE for the 90^{th} and 100^{th} percentiles. The 90^{th} percentile ETE range from 2:05 (hr:min) to 3:15. The 100^{th} percentile ETE range from 5:00 to 5:10 and are dictated by trip mobilization of residents (i.e., the time it takes to prepare to evacuate plus the time to travel to the EPZ boundary).
- The comparison of Table 7-1 and 7-2 indicate that the 100^{th} percentile ETE are significantly longer than those for the 90^{th} 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 7-7 through 7-20.
- The population centers of Chapin (PAZ D-2), White Rock and Irmo in the Shadow Region display the most congestion during the evacuation for Scenario 1 (summer, midweek, midday with good weather conditions) for the full EPZ. US Highway (US) 76 eastbound (just north of Irmo), exhibits the last of the traffic congestion within the EPZ. All congestion within the EPZ clears by 2 hours and 40 minutes after the ATE. See Section 7.3 and Figures 7-3 through 7-6.
- The comparison of Scenarios 3 (summer, weekend, midday with good weather) and 13 (summer, weekend, midday, special event) in Table 7-1 and in Table 7-2 indicate that the Special Event – Labor Day Parade in Chapin – has no impact to the 90^{th} and 100^{th} percentile ETEs. See Section 7.5 for additional discussion.
- The comparison of Scenarios 1 and 14 in Table 7-1 and in Table 7-2 indicate that the roadway impact (a single lane closure on I-26 eastbound) has no impact on the 90^{th} percentile ETE for all Regions except for Region R03 and Regions R18 through R22. During an evacuation of Region R03 and Regions R18 through R22, the 90^{th} percentile ETE increases at most by 40 minutes. There is no impact to the 100^{th} percentile ETE. See Section 7.5 for additional information.
- Inspection of Table 7-3 and Table 7-4 indicate 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 (compare Regions R02, R04 through R11 with Region R25 through R33, respectively, in Tables 7-1 and 7-2). A comparison of ETE between these similar regions reveals that staging increases the ETE for those in the 2 to 5-mile area by at most 30 minutes (see Table 7-1) for the 90^{th} percentile ETE and has no impact on the 100^{th} percentile ETE. The increase in the 90^{th} percentile ETE is due to the evacuating vehicles, beyond the 2-Mile Region, sheltering and delaying the start of their

evacuation. See Section 7.6 for additional discussion. Staged evacuation is not recommended for the VCSNS EPZ.

- Separate ETE were computed for schools, licensed day care centers, medical facility (Generation in Chapin), transit-dependent persons, and access and/or functional needs persons. The average (single-wave) ETE for schools and licensed day care centers, transit dependent people and medical facility (Generations of Chapin) are at most 50 minutes less than the 90th percentile ETE for Region R03 for the general population during Scenario 6 (winter, midweek, midday with good weather) conditions except for the 90th percentile ETE for the access and/or functional needs population. The average single-wave 90th percentile ETE for the access and/or functional needs population is 1 hour and 10 minutes greater than the 90th percentile ETE for the general population. See Section 8.
- Table 8-1 indicates that there are sufficient transportation resources available to evacuate the school and licensed day care center, transit dependent people, patients, and access and/or functional needs population within the EPZ in a single wave. As such, second wave ETE would likely not apply for this site. A second wave ETE is presented for the transit dependent people in the event there is a shortfall of available buses or bus drivers. See Section 8.
- A reduction or addition of base trip generation time by an hour impacts the 90th percentile ETE by 15 to 30 minutes and the 100th percentile ETE by 1 hour, since trip generation time within the EPZ dictates 100th percentile ETE. See Appendix M.1 and Table M-1.
- The general population ETE is minimally impacted when reducing the voluntary evacuation of vehicles in the Shadow Region. The 90th and 100th percentile ETE are significantly impacted to increases in the shadow evacuation percentage. For example, the 90th percentile and 100th percentile ETE increases by 1 hour 30 minutes and 1 hours and 15 minutes, respectively, during an evacuation of the entire (100%) Shadow Region. See Appendix M and Table M-2.
- An increase in permanent resident population (EPZ plus Shadow Region) of 62% or greater result in an increase in the longest 90th percentile ETE by 30 minutes for the full EPZ (Regions R03), which meets the federal criterion for performing a fully updated ETE study between decennial Censuses. See Appendix M.3 and Table M-3.

Table 3-1. EPZ Permanent Resident Population

PAZ	2010 Population	2020 Population
A-0	220	178
A-1	395	363
A-2	618	538
B-1	341	242
B-2	382	307
C-1	411	362
C-2	1,515	1,338
D-1	2,214	3,217
D-2	3,908	4,987
E-1	536	482
E-2	1,997	2,130
F-1	202	241
F-2	1,436	1,469
EPZ TOTAL	**14,175**	**15,854**
EPZ Population Growth (2010-2020):		**11.84%**

Table 6-1. Description of Evacuation Regions

Region	Description	Wind Degree From	A-0	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2	E-1	E-2	F-1	F-2
Radial Regions															
Region	**Description**	**Wind Degree From**	**PAZ**												
R01	2-Mile Region	0° - 359°	X												
R02	5-Mile Region	0° - 359°	X	X		X		X				X		X	
R03	Full EPZ	0° - 359°	X	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 Degree From**	**A-0**	**A-1**	**A-2**	**B-1**	**B-2**	**C-1**	**C-2**	**D-1**	**D-2**	**E-1**	**E-2**	**F-1**	**F-2**
R04	S, SSW	168.8° - 213.8°	X	X		X									
R05	SW, WSW	213.8° - 258.8°	X	X		X		X							
R06	W	258.8° - 281.3°	X			X		X							
R07	WNW, NW	281.3° - 326.3°	X					X							
R08	NNW, N	326.3° - 11.3°	X					X				X			
R09	NNE, NE	11.3° - 56.3°	X									X			
R10	ENE, E	56.3° - 101.3°	X									X		X	
R11	ESE, SE, SSE	101.3° - 168.8°	X	X										X	
Evacuate 2-Mile Region and Downwind to the EPZ Boundary															
Region	**Wind Direction From**	**Wind Degree From**	**A-0**	**A-1**	**A-2**	**B-1**	**B-2**	**C-1**	**C-2**	**D-1**	**D-2**	**E-1**	**E-2**	**F-1**	**F-2**
R12	S	168.8° - 191.3°	X	X	X	X									
R13	SSW	191.3° - 213.8°	X	X	X	X	X								
R14	SW	213.8° - 236.3°	X	X	X	X	X	X							
R15	WSW	236.3° - 258.8°	X	X		X	X	X	X						
R16	W	258.8° - 281.3°	X			X	X	X	X						
R17	WNW, NW	281.3° - 326.3°	X					X	X	X					
R18	NNW	326.3° - 348.8°	X					X	X	X	X	X			
R19	N	348.8° - 11.3°	X					X		X	X	X	X		
R20	NNE	11.3° - 33.8°	X							X	X	X	X		
R21	NE	33.8° - 56.3°	X								X	X	X		X
R22	ENE, E	56.3° - 101.3°	X									X	X	X	X
R23	ESE	101.3° - 123.8°	X	X										X	X
R24	SE, SSE	123.8° - 168.8°	X	X	X									X	X
PAZ(s) Evacuate					PAZ(s) Shelter-in-Place										
Staged Evacuation - 2-Mile Region Evacuates, then Evacuate Downwind to 5 Miles															
Region	**Wind Direction From**	**Wind Degree From**	**A-0**	**A-1**	**A-2**	**B-1**	**B-2**	**C-1**	**C-2**	**D-1**	**D-2**	**E-1**	**E-2**	**F-1**	**F-2**
R25	5-Mile Region	0° - 359°	X	X		X		X				X		X	
R26	S, SSW	168.8° - 213.8°	X	X		X									
R27	SW, WSW	213.8° - 258.8°	X	X		X		X							
R28	W	258.8° - 281.3°	X			X		X							
R29	WNW, NW	281.3° - 326.3°	X					X							
R30	NNW, N	326.3° - 11.3°	X					X				X			
R31	NNE, NE	11.3° - 56.3°	X									X			
R32	ENE, E	56.3° - 101.3°	X									X		X	
R33	ESE, SE, SSE	101.3° - 168.8°	X	X										X	
PAZ(s) Evacuate				PAZ(s) Shelter-in-Place				Shelter-in-Place until 90% ETE for R01, then Evacuate							

Table 6-2. Evacuation Scenario Definitions

Scenarios	Season[1]	Day of Week	Time of Day	Weather	Special
1	Summer	Midweek	Midday	Good	None
2	Summer	Midweek	Midday	Rain	None
3	Summer	Weekend	Midday	Good	None
4	Summer	Weekend	Midday	Rain	None
5	Summer	Midweek, Weekend	Evening	Good	None
6	Winter	Midweek	Midday	Good	None
7	Winter	Midweek	Midday	Rain	None
8	Winter	Midweek	Midday	Ice	None
9	Winter	Weekend	Midday	Good	None
10	Winter	Weekend	Midday	Rain	None
11	Winter	Weekend	Midday	Ice	None
12	Winter	Midweek, Weekend	Evening	Good	None
13	Summer	Weekend	Midday	Good	Special Event: Labor Day Parade in Chapin
14	Summer	Midweek	Midday	Good	Roadway Impact: Lane Closure on I-26 Eastbound

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

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

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

	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**	**Ice**	**Good Weather**	**Rain**	**Ice**	**Good Weather**	**Special Event**	**Roadway Impact**
Staged Evacuation - 2-Mile Region Evacuates, then Evacuate Downwind to 5 Miles														
R25	3:00	3:00	2:55	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	2:55	3:00
R26	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00
R27	3:00	3:05	3:00	3:00	3:00	3:00	3:05	3:05	3:00	3:00	3:00	3:00	3:00	3:00
R28	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00
R29	2:55	3:00	3:00	3:00	3:00	2:55	2:55	3:00	3:00	3:00	3:00	3:00	3:00	2:55
R30	2:55	2:55	2:55	2:55	3:00	2:55	2:55	2:55	2:55	2:55	2:55	3:00	2:55	2:55
R31	2:50	2:50	2:50	2:50	2:55	2:50	2:55	2:55	2:50	2:50	2:55	3:00	2:50	2:50
R32	2:55	2:55	2:55	2:55	3:00	2:55	2:55	2:55	2:55	2:55	2:55	3:00	2:55	2:55
R33	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00

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	Ice	Good Weather	Rain	Ice	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region, 5-Mile Region, and EPZ														
R01	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R02	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R03	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
Evacuate 2-Mile Region and Downwind to 5 Miles														
R04	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R06	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R07	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R08	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R09	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R10	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R11	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
Evacuate 2-Mile Region and Downwind to the EPZ Boundary														
R12	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R13	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R14	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R15	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R16	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R17	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R18	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R19	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R20	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R21	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R22	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R23	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R24	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10

	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**	**Ice**	**Good Weather**	**Rain**	**Ice**	**Good Weather**	**Special Event**	**Roadway Impact**
Staged Evacuation - 2-Mile Region Evacuates, then Evacuate Downwind to 5 Miles														
R25	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R26	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R27	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R28	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R29	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R30	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R31	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R32	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R33	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05

Table 7-3. Staged Evacuation Results - Time to Clear *90* Percent of the 2-Mile 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	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Ice	Good Weather	Rain	Ice	Good Weather	Special Event	Roadway Impact
Un-staged Evacuation - 2-Mile Region and 5-Mile Region														
R01	2:05	2:10	2:35	2:35	2:35	2:05	2:05	2:05	2:35	2:35	2:35	2:35	2:35	2:05
R02	2:20	2:20	2:40	2:40	2:40	2:15	2:15	2:15	2:40	2:40	2:40	2:40	2:40	2:20
Un-staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R04	2:05	2:10	2:35	2:35	2:35	2:05	2:05	2:05	2:35	2:35	2:35	2:35	2:35	2:05
R05	2:15	2:15	2:40	2:40	2:40	2:15	2:15	2:15	2:40	2:40	2:40	2:40	2:40	2:15
R06	2:15	2:15	2:40	2:40	2:40	2:15	2:15	2:15	2:40	2:40	2:40	2:40	2:40	2:15
R07	2:15	2:20	2:40	2:40	2:40	2:15	2:15	2:15	2:40	2:40	2:40	2:40	2:40	2:15
R08	2:15	2:20	2:40	2:40	2:40	2:15	2:15	2:15	2:40	2:40	2:40	2:40	2:40	2:15
R09	2:05	2:10	2:35	2:35	2:35	2:05	2:05	2:05	2:35	2:35	2:35	2:35	2:35	2:05
R10	2:05	2:10	2:35	2:35	2:35	2:05	2:05	2:05	2:35	2:35	2:35	2:35	2:35	2:05
R11	2:05	2:10	2:35	2:35	2:35	2:05	2:05	2:05	2:35	2:35	2:35	2:35	2:35	2:05
Staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R25	2:35	2:35	2:55	2:55	2:55	2:35	2:35	2:35	2:55	2:55	2:55	2:55	2:55	2:35
R26	2:10	2:15	2:40	2:40	2:40	2:10	2:10	2:10	2:40	2:40	2:40	2:40	2:40	2:10
R27	2:35	2:35	2:55	2:55	2:55	2:35	2:35	2:35	2:55	2:55	2:55	2:55	2:55	2:35
R28	2:35	2:35	2:55	2:55	2:55	2:35	2:35	2:35	2:55	2:55	2:55	2:55	2:55	2:35
R29	2:35	2:35	2:55	2:55	2:55	2:35	2:35	2:35	2:55	2:55	2:55	2:55	2:55	2:35
R30	2:35	2:35	2:55	2:55	2:55	2:35	2:35	2:35	2:55	2:55	2:55	2:55	2:55	2:35
R31	2:10	2:15	2:40	2:40	2:40	2:10	2:10	2:10	2:40	2:40	2:40	2:40	2:40	2:10
R32	2:10	2:15	2:40	2:40	2:40	2:10	2:10	2:10	2:40	2:40	2:40	2:40	2:40	2:10
R33	2:10	2:15	2:40	2:40	2:40	2:10	2:10	2:10	2:40	2:40	2:40	2:40	2:40	2:10

Table 7-4. Staged Evacuation Results - Time to Clear *100* Percent of the 2-Mile 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	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Ice	Good Weather	Rain	Ice	Good Weather	Special Event	Roadway Impact
Un-staged Evacuation - 2-Mile Region and 5-Mile Region														
R01	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R02	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
Un-staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R04	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R05	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R06	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R07	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R08	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R09	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R10	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R11	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
Staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R25	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R26	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R27	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R28	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R29	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R30	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R31	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R32	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R33	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00

Table 8-2. School and Licensed Day Care Center Evacuation Time Estimates - Good Weather

School and Licensed Day Care Center	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 R.C. (mi.)	Travel Time from EPZ Bdry to R.C. (min)	ETA to R.C. (hr:min)
FAIRFIELD COUNTY									
McCrorey-Liston School Of Technology	120	15	8.2	45.0	11	**2:30**	6.8	10	**2:40**
Kelly Miller Elementary School	120	15	1.4	44.1	2	**2:20**	6.9	10	**2:30**
McCrorey-Liston Child Development Center	120	15	8.2	45.0	11	**2:30**	6.8	10	**2:40**
Kelly Miller Child Development Center	120	15	1.4	44.1	2	**2:20**	6.9	10	**2:30**
Jacqueline Wylie	Evacuated by Private Vehicles								
Jackie Chappell									
LEXINGTON COUNTY									
Chapin High School	90	15	4.8	45.0	7	**1:55**	9.8	14	**2:10**
Crooked Creek Park Afterschool Program	90	15	2.5	27.5	6	**1:55**	10.5	14	**2:10**
Chapin Intermediate School	90	15	2.5	27.5	6	**1:55**	10.5	14	**2:10**
Chapin Elementary School	90	15	2.5	24.8	6	**1:55**	10.4	14	**2:05**
Mt Horeb Lutheran Church	90	15	4.7	45.0	7	**1:55**	9.7	13	**2:05**
Elaine Alewine	90	15	4.7	45.0	7	**1:55**	9.7	13	**2:05**
Abner Montessori School/Chapin Children's Center	90	15	4.7	45.0	7	**1:55**	9.7	13	**2:10**
Chapin Baptist Child Development Center	90	15	2.5	27.5	6	**1:55**	10.5	14	**2:10**
Chapin United Methodist Church Preschool	90	15	5.6	45.0	8	**1:55**	9.8	14	**2:10**
Inez's Childcare Center	90	15	5.6	45.0	8	**1:55**	9.8	14	**2:10**
NEWBERRY COUNTY									
Little Mountain Elementary[2]	90	15	8.2	45.0	11	**2:00**	6.0	9	**2:10**
Little Angels Daycare	90	15	7.1	45.0	10	**1:55**	6.0	9	**2:05**
Mid-Carolina High School	90	15	2.0	41.9	3	**1:50**	2.3	4	**1:55**
Mid-Carolina Middle School	90	15	2.0	41.9	3	**1:50**	2.3	4	**1:55**

[2] The ETE computation represents the children at the Little Mountain Elementary school and the licensed day care center provided at this facility.

School and Licensed Day Care Center	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 R.C. (mi.)	Travel Time from EPZ Bdry to R.C. (min)	ETA to R.C. (hr:min)
Pomaria-Garmany Elementary[3]	90	15	4.7	45.0	7	**1:55**	7.3	10	**2:05**
RICHLAND COUNTY									
Chapin Middle School	90	15	1.5	38.0	3	**1:50**	34.1	46	**2:40**
Academy for Success	90	15	1.5	38.0	3	**1:50**	34.1	46	**2:40**
Spring Hill High School	90	15	1.5	38.0	3	**1:50**	34.1	46	**2:40**
The Center for Advanced Technical Studies	90	15	1.5	38.0	3	**1:50**	34.1	46	**2:40**
Sally Becker	Evacuated by Private Vehicles								
					Maximum for EPZ:	**2:30**		**Maximum:**	**2:40**
					Average for EPZ:	**2:00**		**Average:**	**2:20**

[3] The ETE computation represents the children at the Pomaria-Garmany Elementary School and the licensed day care center provided at this facility.

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

PAZ Serviced	Number of Buses	One-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)
A-0, B-1, B-2	1	60	10.0	45.0	13	30	**1:45**	6.9	9	5	10	36	30	**3:15**
A-1, A-2	1	60	13.0	45.0	17	30	**1:50**	6.9	9	5	10	44	30	**3:30**
C-1, C-2	1	60	14.3	45.0	19	30	**1:50**	6.9	9	5	10	47	30	**3:35**
D-1	1	150	6.7	45.0	9	30	**3:10**	30.9	41	5	10	59	30	**5:35**
D-2	1	150	4.8	45.0	6	30	**3:10**	10.5	14	5	10	27	30	**4:40**
E-1, E-2, F-1, F-2	1	150	11.4	45.0	15	30	**3:15**	5.2	7	5	10	37	30	**4:45**
						Maximum ETE:	**3:15**						**Maximum ETE:**	**5:35**
						Average ETE:	**2:30**						**Average ETE:**	**4:15**

Table 8-8. Generations of Chapin 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)	Speed (mph)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
LEXINGTON COUNTY									
Generations of Chapin	Ambulatory	90	1	29	29	5.3	45.0	7	**2:10**
	Wheelchair bound - Bus	90	5	25	25	5.3	45.0	7	**2:55**
								Maximum ETE:	**2:55**
								Average ETE:	**2:35**

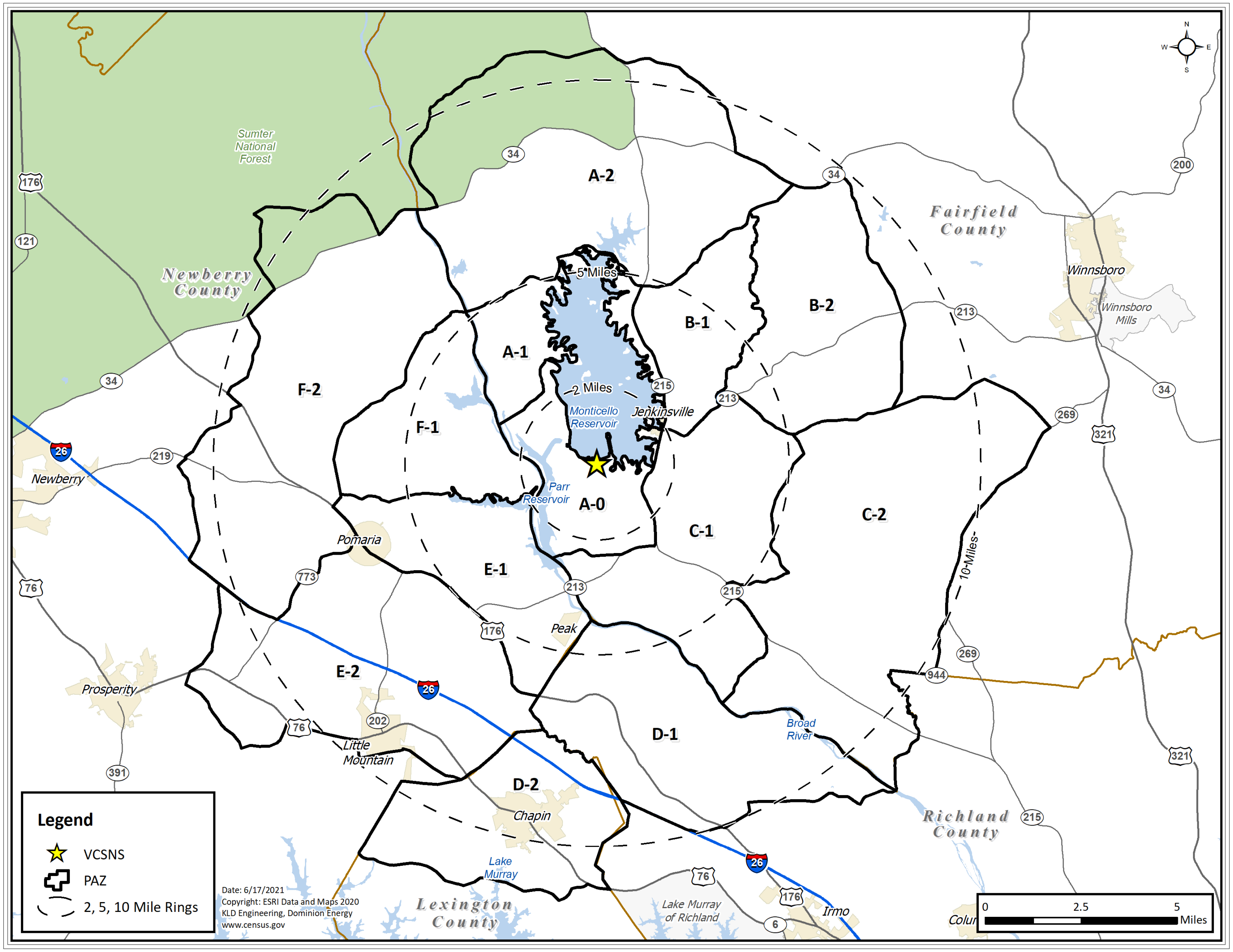

Figure 6-1. VCSNS EPZ Protective Action Zones

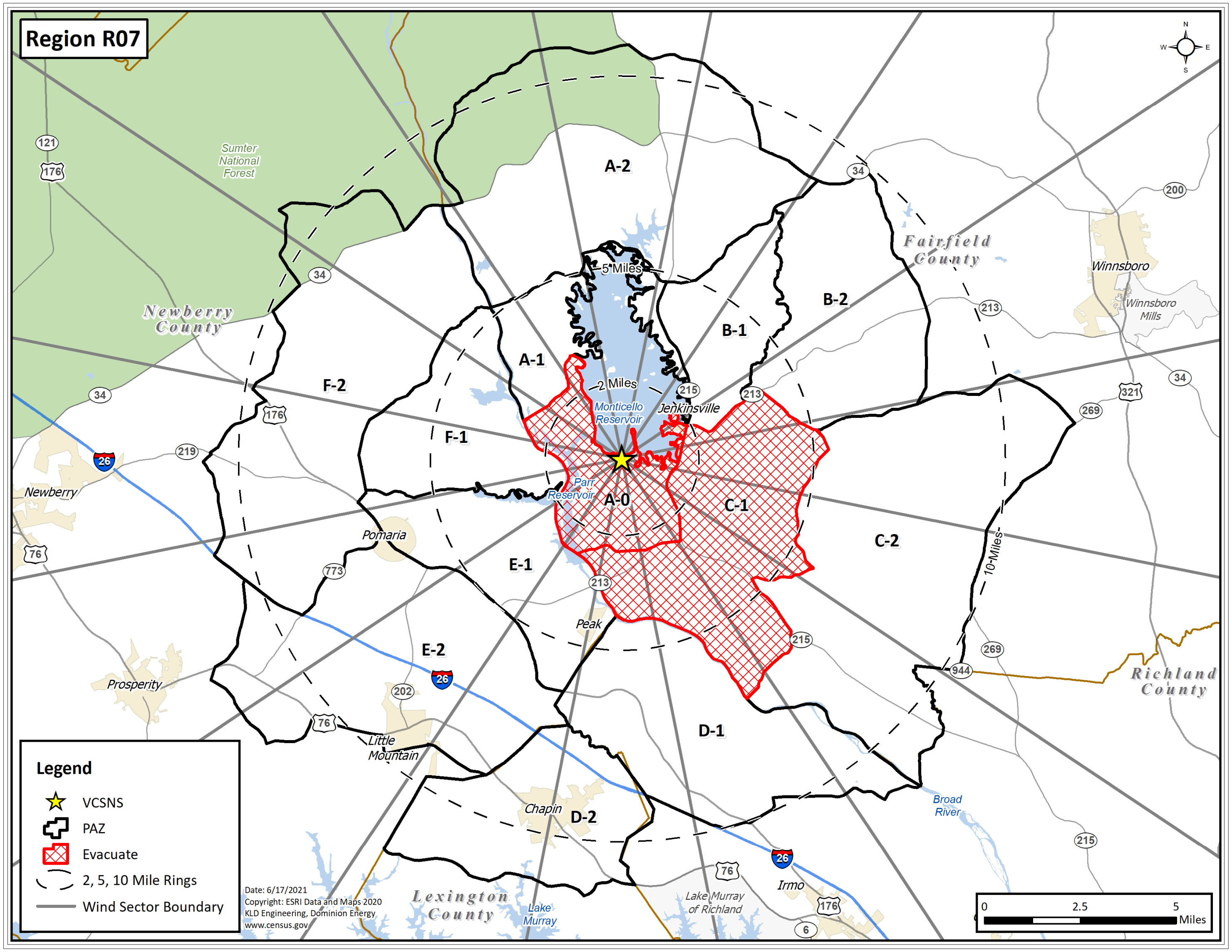

Figure H-7. Region R07

1 INTRODUCTION

This report describes the analyses undertaken and the results obtained by a study to develop Evacuation Time Estimates (ETE) for the VC Summer Nuclear Station (VCSNS), located in Fairfield County, South Carolina. This ETE study provides Dominion 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 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 Dominion Energy.
   b. Attended a project kick-off meeting with personnel from Dominion Energy, the Fairfield, Lexington, Richland, and Newberry Counties, and South Carolina State government 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) and Shadow Region.
   d. Reviewed existing county and state Emergency Operations Plans.
   e. Conducted a random sample demographic survey of EPZ residents.
   f. Obtained demographic data from the 2020 Census.
   g. Conducted a data collection effort to identify and describe special facilities (i.e., schools/day cares and medical facilities), major employers, access and/or

functional needs populations, 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 random sample 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 control is applied at specified Traffic and Access Control Points (TACP) located within the study area. See Section 9 and Appendix G.
5. Used existing Protective Action Zones (PAZ) to define Evacuation Regions. The EPZ is partitioned into 13 PAZs along jurisdictional and geographic boundaries. "Regions" are groups of contiguous PAZs 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, licensed day care centers, medical facility, 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, Dominion Energy and from the demographic survey.
    b. Applied the procedures specified in the 2016 Highway Capacity Manual (HCM 2016[1]) to the data acquired during the field survey, to estimate the capacities of all highway segments comprising the evacuation routes.
    c. 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.
    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

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

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, licensed day care centers, and Generations of Chapin), for the transit-dependent population and for the access and/or functional needs population.

1.2 The VC Summer Nuclear Station Location

The VCSNS is located on the southern shoreline of Monticello Reservoir, in Jenkinsville, Fairfield County, South Carolina. The site is approximately 17 miles west-southwest of Winnsboro, 18 miles east of Newberry, and 25 miles northwest of Columbia. The EPZ consists of parts of Fairfield Lexington Newberry, and Richland Counties in South Carolina. Figure 1-1 displays the area surrounding VCSNS. This map also identifies the major population centers, and the major roads in the area, and the location of the plant relative to Winnsboro, Newberry, and Columbia.

The EPZ is predominantly rural in nature, with a permanent resident population of 15,854. It is characterized by gently rolling terrain and has good primary and secondary paved roads. There are no major concentrations of population within the EPZ, except for Chapin. Transient attraction within the EPZ includes Monticello Reservoir, Parr Reservoir, and Broad River.

1.3 Preliminary Activities

These activities are described below.

Field Surveys of the Highway Network

In 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 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 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 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. TACPs 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 and aerial imagery were used to calibrate the analysis network.

Demographic Survey

An online demographic survey was performed in 2021 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.

Developing 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 the DYNEV II System, such as LOS, vehicles discharged, average speed, and percent of vehicles evacuated. 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-486, dated April 2012, Rev 5). The 90th percentile ETE for the full EPZ for Scenario 1 (summer, midweek, midday with good weather) and Scenario 6 (winter, midweek, midday with good weather) increased by 20 minutes and 25 minutes, respectively, 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 increased by 15 minutes for all the scenarios. (See Table 1-3 final rows.)

The major factors contributing to the increase in ETE values obtained in this study and those of the previous study can be summarized as follows:

- The permanent resident population in the EPZ has increased by 11.8%. This population increase results in in additional resident evacuating vehicles, which can increase the ETE.
- The permanent resident population in the Shadow Region increased by 16.1%. This population increase results in significantly more vehicles evacuating in the Shadow Region, which reduces the available roadway capacity for EPZ evacuees which can increase the ETE.
- Household size within the study area decreased from 2010 to the current survey (2.68 vs 2.52-persons/household); resulting in additional resident evacuating vehicles. The number of resident vehicles increased by 21.6% compared to previous ETE study, due to

the increase in resident population (discussed above) and overall reduction in household size, which can increase ETE.

- The number of transient population and school enrollment significantly increased by 58.7%, compared to the previous study. This results in additional evacuating vehicles within the study area, which can increase the ETE.
- Note that in the previous study, major employers were considered those with 50 or more total employees, while this study considered employers with 200 or more employees working in a single shift as major employers, as per the NUREG/CR-7002, Rev. 1 guidance. As such, the number of fast mobilizing employees commuting into the EPZ decreased significantly (34.6%), which results in a decrease in vehicle demand, potentially decreasing the 100th percentile ETE (see Table 1-3) but increasing the 90th percentile ETE, as it will take longer to reach an evacuation of 90% of the general population.
- Trip generation times increased by at most 60 minutes for the permanent resident (without commuter) population based on the data collected from the demographic survey. As a result, vehicles are generated over a longer period of time which can decrease local congestion decreasing the 90th percentile ETE. This trip generation increase is directly correlated with the increase of the 100th percentile ETE for all scenarios. As discussed in Section 7, there is minimal to no congestion within the EPZ and all congestion clears prior to the end of the trip generation time for an evacuation of the entire EPZ (Region R03) during summer, midweek, midday with good weather conditions (Scenario 1). As such, the 100th percentile ETE is dictated by the time needed to mobilize (plus a 10-minute travel time to the EPZ boundary).

The majority of the factors, discussed above, that can increase ETE outweigh those that can decrease the ETE, thereby explaining why the 90th percentile and the 100th percentile ETEs for the full EPZ increased for all scenarios in this study, relative to the 2012 ETE Study.

Table 1-1. Stakeholder Interaction

Stakeholder	Nature of Stakeholder Interaction
Dominion Energy	Attended kick-off meeting to define project methodology and data requirements. Set up contacts with local government agencies. Provided recent VCSNS employee data. Reviewed and approved all project. Engaged in the ETE development and was informed of the study results. Attended final meeting where the ETE study results were presented.
Fairfield County Emergency Management, Lexington County Department of Emergency Services, Newberry County Emergency Management, Richland County Services Department (ESD)	Attended Kick-off meeting to discuss the project methodology, key project assumptions and to define data needs. Provided emergency plans and traffic management plans. Provided/confirmed special facility data, transient data and special event 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.
South Carolina Emergency Management Division	Attended Kick-off meeting to define methodology and data requirements. Provided recent emergency plans (South Carolina Operational Radiological Emergency Response Plan, SCORERP Part 3) and Basic Plan. Reviewed and approved all project assumptions and was informed of the study results. Reviewed and approved draft report. Attended final meeting where the ETE study results were presented.

Table 1-2. Highway Characteristics

- Number of lanes
- Lane width
- Shoulder type & width
- Interchange geometrics
- 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 = 14,175 Vehicles = 7,892	ArcGIS software using 2020 US Census blocks; area ratio method used. Population = 15,854 Vehicles = 9,595
Resident Population Vehicle Occupancy	2.68 persons/household, 1.49 evacuating vehicles/household yielding: 1.80 persons/vehicle	2.52 persons/household, 1.53 evacuating vehicles/household yielding: 1.65 persons/vehicle.
Employee Population	Employees treated as separate population group. Employee estimates based on information provided by county emergency management offices about major employers in EPZ. 1.01 employees/vehicle is estimated based on phone survey results. Employees = 1,158 Vehicles = 1,143	Employee estimates are based on the information by Dominion Energy and phone calls directly to General Information Services and supplemented by previous study data . The values of 1.09 employees per vehicle based on demographic survey results. Employees = 757 Vehicles = 694
Transit-Dependent Population	Defined as households with 0 vehicles + households with 1 vehicle with commuters who do not return home + households with 2 vehicles with commuters who do not return home. Telephone surveys results used to estimate transit dependent population (See Table 8-1).	Estimates based upon U.S. Census data and the results of the Demographic survey. A total of 215 people who do not have access to a vehicle, requiring 6 buses to evacuate. An additional 91 homebound special needs persons need special transportation to evacuate (37 require a bus, 43 require a wheelchair-accessible bus, 3 require a wheelchair-accessible van, and 8 require an ambulance).
Transient Population	Phone calls to recreational facilities. Transients = 121 Vehicles = 53	Transient estimates are based on information provided by the counties within the EPZ the, and the previous ETE study (confirmed or updated by the counties), supplemented by internet searches and phone calls to specific facilities where data was missing. Transients = 561 Vehicles = 425
Special Facilities Population	Medical facility population based on information provided by Lexington County. Medical Facility (Generations of Chapin) Current census = 48 Buses Required = 1 Wheelchair Bus Required = 1 Ambulances Required = 2	Medical facility population based on information provided by Lexington County. Medical Facility (Generations of Chapin) Current census = 54 Buses Required = 1 Wheelchair Bus Required = 2 Ambulances Required = 0

Topic	Previous ETE Study	Current ETE Study
School Population	School population was based on information provided by local county emergency management agencies. School enrollment = 6,027 Buses required = 102 (204 vehicle)	School population based on information provided by each county within the EPZ and the previous ETE study (confirmed or updated by the counties), supplemented by internet searches and phone calls to specific facilities where data was missing. School and licensed day care center enrollment = 9,195 Buses required = 154 (308 vehicle)
Voluntary evacuation from within EPZ in areas outside region to be evacuated	20 percent of the population within the EPZ, but not within the Evacuation Region (see Figure 2-1).	20 percent of the population within the EPZ, but not within the evacuation region (see Figure 2-1)
Shadow Evacuation/ Population	20% of people outside of the EPZ within the Shadow Region (see Figure 7-2). 20% Population = 10,333 20% Vehicles = 5,747	20% of people outside of the EPZ within the Shadow Region (see Figure 7-2). 20% Population = 12,001 20% Vehicles = 7,250
Network Size	1,295 Links; 944 Nodes.	1,543 Links ; 1,155 Nodes.
Roadway Geometric Data	Field surveys conducted in May 2011. Major intersections were video archived. GIS shape-files of signal locations and roadway characteristics created during road survey. Road capacities based on HCM 2010.	Field surveys conducted in February 2021. Roads and intersections were video archived. Road capacities based on HCM 2016.
School Evacuation	Direct evacuation to designated Reception Center/Host School.	Direct evacuation to designated Reception Center (Host School).
Ridesharing	50 percent of transit-dependent persons will evacuate with a neighbor or friend.	About 82 percent of transit-dependent persons will evacuate with a neighbor or friend based on the 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 45 and 285 minutes. Residents without commuters returning leave between 15 and 180 minutes. 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 60 and 300 minutes. Residents without commuters returning leave between 30 and 240 minutes. Employees and transients leave between 15 and 105 minutes. All times measured from the Advisory to Evacuate.

Topic	Previous ETE Study	Current ETE Study
Weather	Normal, Rain, or Ice. The capacity and free flow speed of all links in the network are reduced by 10% in the event of rain and 20% for ice.	Normal, Rain, or Ice. The capacity and free flow speed of all links in the network are reduced by 10% in the event of rain and 20% for ice.
Modeling	DYNEV II System - Version 4.0.0.0	DYNEV II System – Version 4.0.21.0
Special Events	New plant construction workforce during peak construction year with an outage at Unit 1. Special Event Population = 4,200 additional employees during construction of new plant. Special Event Vehicles = 4,158	Labor Day Parade in Chapin, Lexington County Special Event Population = 5,000 additional transients in Chapin during Labor Day Parade. Special Event Vehicles = 1,984
Evacuation Cases	30 Regions (central sector wind direction and each adjacent sector technique used) and 14 Scenarios producing 420 unique cases	33 regions (central sector wind direction and each adjacent sector technique used) and 14 scenarios producing 462 unique cases.
Staged Evacuation	Evacuation of 2-Mile Region with sheltering of 2-5 Mile Region followed by 2-5 mile evacuation when 2-Mile Region evacuation is 90% complete	Evacuation of 2-Mile Region with sheltering of 2-5 Mile Region followed by 2 to 5-Mile evacuation when 2-Mile Region evacuation is 90% complete. Region 25 through Region 33 are staged evacuation.
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.
Evacuation Time Estimates for the entire EPZ, 90th percentile	Summer Midweek Midday Good weather = 2:25 Rain = 2:25 Winter Midweek Midday Good weather = 2:25 Rain = 2:25 Ice = 2:25	Summer Midweek Midday Good weather = 2:45 Rain = 2:50 Winter Midweek Midday Good weather = 2:50 Rain = 2:50 Ice = 2:50
Evacuation Time Estimates for the entire EPZ, 100th percentile	Summer Midweek Midday Good weather = 4:55 Rain = 4:55 Winter Midweek Midday Good weather = 4:55 Rain = 4:55 Ice = 4:55	Summer Midweek Midday Good weather = 5:10 Rain = 5:10 Winter Midweek Midday Good weather = 5:10 Rain = 5:10 Ice = 5:10

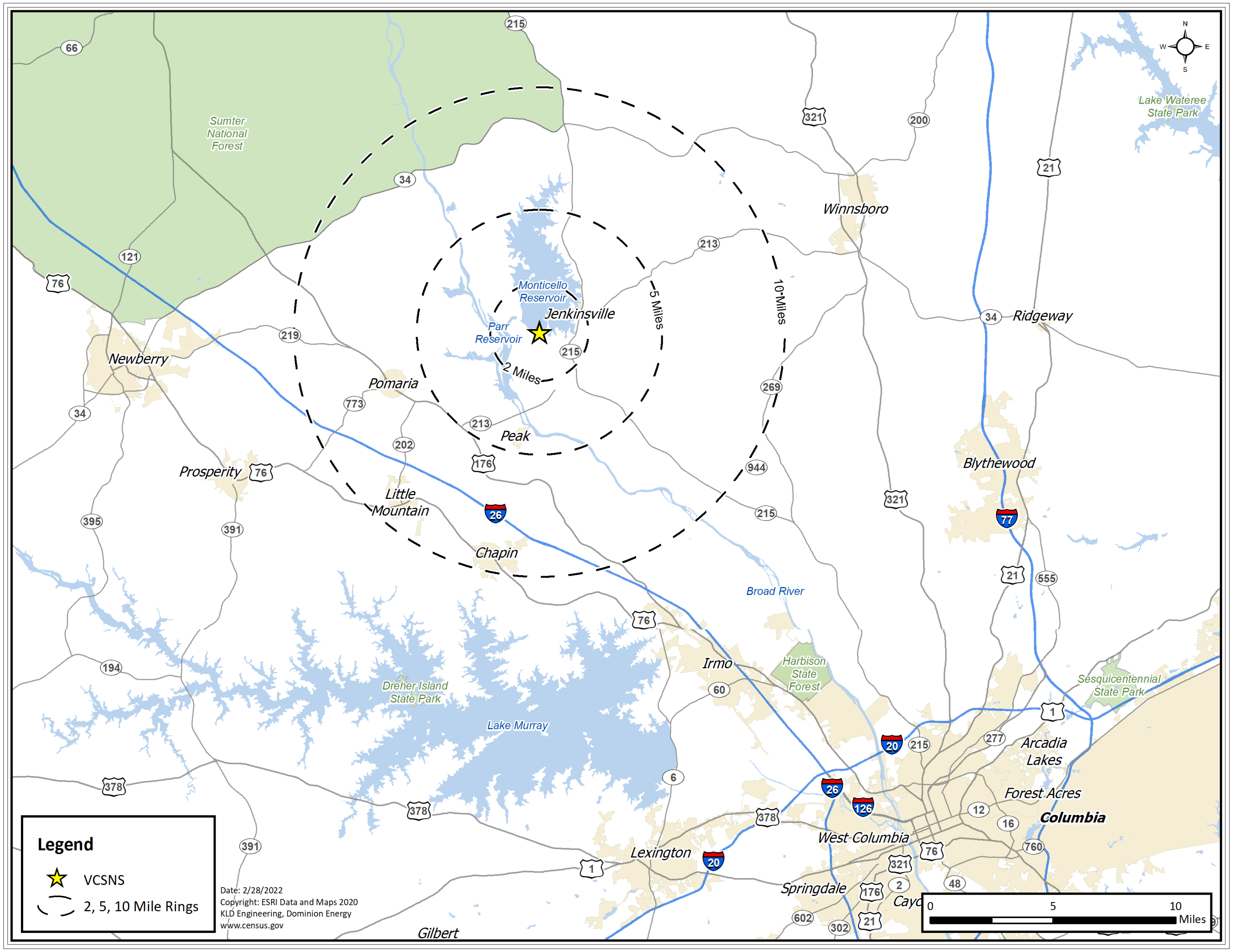

Figure 1-1. VCSNS Site Location

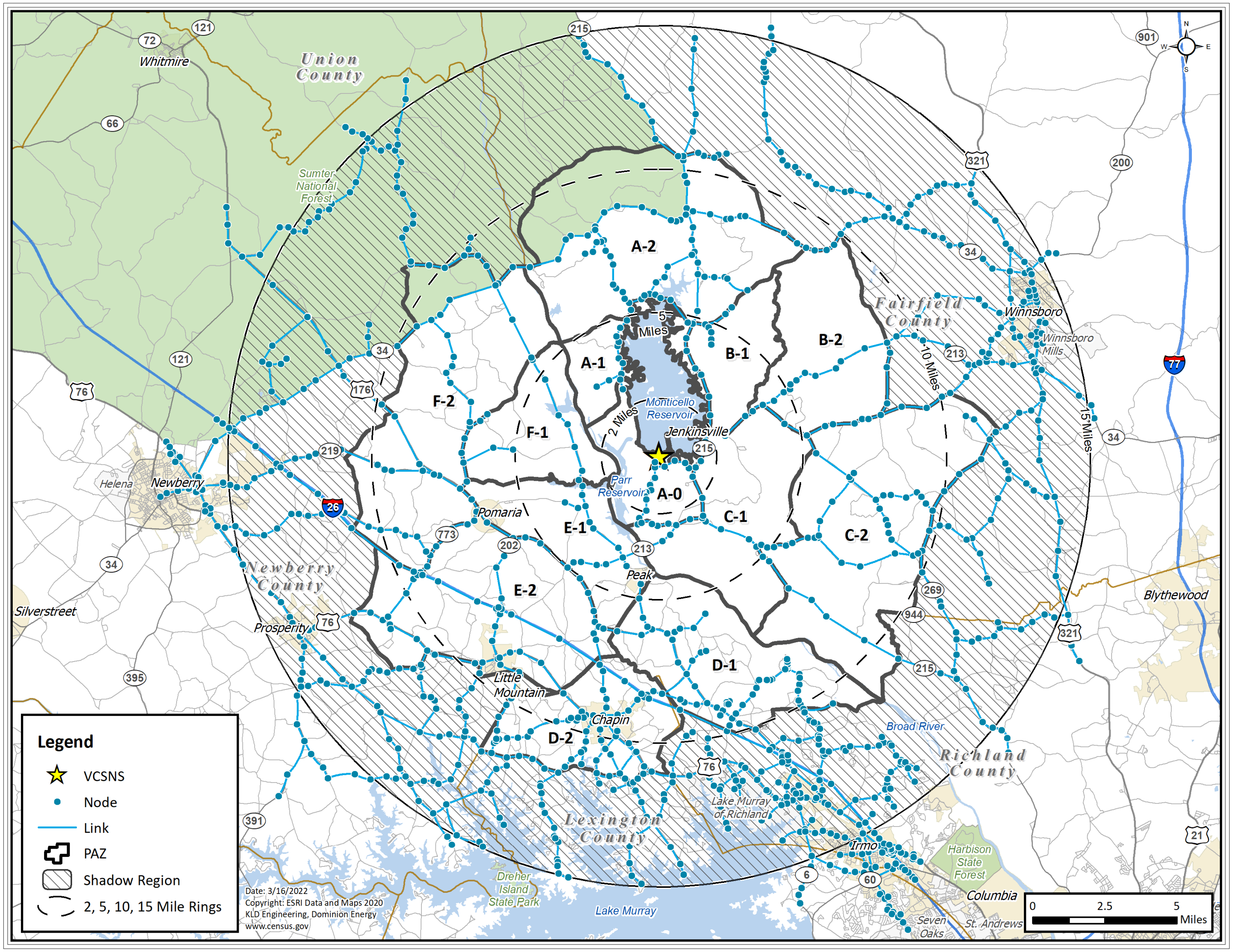

Figure 1-2. VCSNS Link-Node Analysis Network

2 STUDY ESTIMATES AND ASSUMPTIONS

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

2.1 Data Estimate Assumptions

1. The permanent resident population 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 Protective Action Zone (PAZ) boundaries. It is assumed that the population is evenly distributed across a census block in order to employ the area ratio method (see Section 3.1).
2. Estimates of employees who reside outside the Emergency Planning Zone (EPZ) and commute to work within the EPZ are based upon data provided by Dominion Energy, the counties within the EPZ, phone calls to facilities, and the old data from the previous study, where data was not available (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[2], State Office of the Department of Social Services, and the previous ETE study (confirmed or updated by the counties), supplemented by internet searches and phone calls to specific facilities where data was missing.
4. The relationship between permanent resident population and evacuating vehicles was based on the results of the recent, random-sample demographic survey (see Appendix F). Average values of 2.52 persons per household (Figure F-1) and 1.53 evacuating vehicles per household (Figure F-10) are used for permanent resident population.
5. On average, the relationship between persons and vehicles for transients (see Section 3.3) and the special event (see Section 3.9) are as follows:
    a. Parks: 2.17 people per vehicle
    b. Campgrounds: 1.19 people per vehicle
    c. Marinas: 2.59 people per vehicle.
    d. Golf Course: 1.35 people per vehicle
    e. Special Events: 2.52 people per vehicle (the average household size)
    f. Where data was not provided, the average household size is assumed to be the vehicle occupancy rate for transient facilities.
6. Employee vehicle occupancies are based on the results of the demographic survey. The value of 1.09 employees per vehicle is used in the study (See Figure F-7). In addition, it is assumed there are two people per carpool, on average.

[1] www.census.gov
[2] https://nces.ed.gov/ccd/schoolsearch/index.asp

7. The maximum bus speed assumed within the EPZ is 45 mph, based on South Carolina state laws[3] for buses and average posted speed limits on roadways within the EPZ.

8. Roadway capacity estimates are based on field surveys performed in 2021 (verified by aerial imagery), and the application of the Highway Capacity Manual 2016.

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[4] (as per NRC guidance):
    a. Advisory to Evacuate (ATE) is announced coincident with the Alert and Notification System (ANS).
    b. Mobilization of the general population will commence within 15 minutes after the notification from the ANS.
    c. The ETE are measured relative to the ATE.

2. The center-point of the plant is located at the center of the containment building 34°17'54.6"N, 81°18'54.4"W.

3. The DYNEV II[5] (Dynamic Network EVacuation) macroscopic simulation model 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 PAZ 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 PAZs 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.

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[3] https://www.scstatehouse.gov/code/t59c067.php

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

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

[5] 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.

9. The 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 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 include consideration of “through” (External-External) trips during the time that such traffic is permitted to enter the evacuated Region (see Section 3.10).
11. This study does not assume that roadways are empty at the start of the first time period. Rather, there is a 45-minute 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 3.11).
12. To account for boundary conditions beyond the study area, this study assumed a 25 percent (%) 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 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.

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 (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, approximately 60% of the households in the EPZ have at least 1 commuter (see Figure F-6); 58% of those households with commuters will await the return of a commuter before beginning their evacuation trip (see Figure F-11). Therefore, 35% (60% x 58% = 34.8%, rounded up to 35%) 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, approximately 82% of the transit-dependent population will rideshare.
2. Transit vehicles are used to transport those without access to private vehicles:
    a. Schools and licensed day care centers
        i. If schools are in session, transport (buses) will evacuate students directly to the designated Reception Centers.
        ii. Buses will evacuate children at licensed day care centers within the EPZ, as needed.
        iii. For the schools and licensed day care centers 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. Children at schools and licensed day care centers, if in session, are given priority in assigning transit vehicles.
    b. Medical Facilities (Generations of Chapin)
        i. Buses, vans, passenger cars, wheelchair accessible buses (special needs bus), wheelchair vans and ambulances will evacuate patients at medical facilities within the EPZ, as needed.
        ii. The percent breakdown of ambulatory, wheelchair bound and bedridden patients from the 2012 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. 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. 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.
    d. Analysis of the number of required round-trips (“waves”) of evacuating transit vehicles is presented.
    e. 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 primary schools/licensed day care centers and 50 students per bus for middle/intermediate/high schools
    b. Ambulatory transit-dependent persons and medical facility patients = 30 persons per bus

   c. Vans = 8 persons per van
   d. Ambulances = 2 bedridden persons (includes advanced and basic life support)
   e. Wheelchair vans = 4 wheelchair bound persons
   f. Wheelchair buses = 15 wheelchair bound persons

4. Transit vehicles mobilization times, which are considered in ETE calculations:
   a. School/licensed day care center buses arrive at these facilities to be evacuated within 120 minutes of the ATE in Fairfield County and 90 minutes of the ATE, for the Counties of Lexington, Newberry and Richland.
   b. Transit-dependent buses are mobilized when approximately 86% of residents with no commuters have completed their mobilization at about 150 minutes of the ATE, for all counties within the EPZ except for Fairfield County, where 60 minutes of the ATE are used. If necessary, multiple waves of buses will be utilized to gather transit dependent people who mobilize more slowly.
   c. Vehicles will arrive at medical centers to be evacuated within 90 minutes of the ATE
   d. Ambulances and wheelchair transport vehicles within Fairfield County, arrives at medical facilities or at homes of the access and/or functional needs population within 180 minutes and 60 minutes, respectively.

5. Transit Vehicle loading times:
   a. School and licensed day care center buses are loaded in 15 minutes.
   b. Transit Dependent buses require 1 minute of loading time per passenger.
   c. Buses for medical facilities and the access and/or functional needs population require 1 minute of loading time per ambulatory passenger.
   d. Wheelchair transport vehicles require 5 minutes of loading time per passenger.
   e. Ambulances are loaded in 15 minutes per bedridden passenger.
   f. Concurrent loading on multiple buses/transit vehicles is assumed.

6. It is assumed that 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 (TACPs) as defined in the approved county and state emergency plans are considered in the ETE analysis, as per NRC guidance. See Table G-1 in Appendix G.

2. The TACPs are assumed to be staffed approximately 120 minutes after the ATE, as per NRC guidance. Earlier activation of the TACP locations could delay returning commuters. 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. Labor Day Parade in Chapin, Lexington County, located in PAZ D-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 of the top 5 highest volume roadways must be closed or one lane outbound on a freeway must be closed for a roadway impact scenario. This study considers the closure of one lane on Interstate (I)-26 Eastbound from Columbia Avenue (Exit 91) to State Route (SR) 60 (Exit 102A/B) for the roadway impact scenario – Scenario 14.
2. Two types of adverse weather scenarios are considered. Rain may occur for either winter or summer scenarios; ice occurs in winter scenarios only. It is assumed that the rain or ice begins earlier or at about the same time the evacuation advisory is issued. No weather-related reduction in the number of transients who may be present in the EPZ is assumed. It is assumed that the appropriate agencies are clearing/treating the roads as they would normally during ice storms, and the roads are passable albeit at lower speeds and capacities.
3. Adverse weather scenarios affect roadway capacity and the free flow highway speeds. In accordance with Table 3-1 of Revision 1 to NUREG/CR-7002, this study assumes a 10% and 20% reduction in speed and capacity for rain and ice, respectively. These factors are shown in Table 2-2.
4. It is assumed that employment is reduced slightly (4% reduction) in the summer for vacations.
5. It is also assumed that 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 and ice, respectively. It is assumed that loading times are 5 minutes and 10 minutes longer in rain and ice, respectively. Refer to Table 2-2.
6. 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 PAZs 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 PAZs forming a Region that is issued an ATE will, in fact, respond and evacuate in general accord with the planned routes.
7. Due to the irregular shapes of the PAZs, there are instances where a small portion of a PAZ (a "sliver") is within the keyhole and the population within that small portion is low (less than 500 people or 10% of the PAZ population, whichever is less). Under those circumstances, the PAZ is not included in the Region so as to not evacuate large

numbers of people outside of the keyhole for a small number of people that are actually in the keyhole, unless otherwise stated in the Protective Action Recommendation (PAR) document.

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 R25 through R33 in Table 6-1.

Table 2-1. Evacuation Scenario Definitions

Scenarios	Season[6]	Day of Week	Time of Day	Weather	Special
1	Summer	Midweek	Midday	Good	None
2	Summer	Midweek	Midday	Rain	None
3	Summer	Weekend	Midday	Good	None
4	Summer	Weekend	Midday	Rain	None
5	Summer	Midweek, Weekend	Evening	Good	None
6	Winter	Midweek	Midday	Good	None
7	Winter	Midweek	Midday	Rain	None
8	Winter	Midweek	Midday	Ice	None
9	Winter	Weekend	Midday	Good	None
10	Winter	Weekend	Midday	Rain	None
11	Winter	Weekend	Midday	Ice	None
12	Winter	Midweek, Weekend	Evening	Good	None
13	Summer	Weekend	Midday	Good	Special Event: Labor Day Parade in Chapin
14	Summer	Midweek	Midday	Good	Roadway Impact: Lane Closure on I-26 Eastbound[7]

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 Transit Vehicles
Rain	90%	90%	No Effect	10-minute increase	5-minute increase
Ice	80%	80%	No Effect	20-minute increase	10-minute increase
*Adverse weather capacity and speed values are given as a percentage of good weather conditions. Roads are assumed to be passable.					

[6] 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).
[7] A single lane on I-26 will be closed in the eastbound direction from Columbia Avenue (Exit 91) to SR 60 (Exit 102A/B).

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 (e.g., resident, employee, transient, special facilities, etc.).
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 VCSNS 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 Protective Action Zone (PAZ) and by polar coordinate representation (population rose). The VCSNS EPZ is subdivided into 13 PAZ. The PAZ 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 (2.52 persons/household was obtained from the 2021 demographic survey - See Appendix F, Sub-section F.3.1). The number of evacuating vehicles per household (1.53 vehicles/household – See Appendix F, Sub-section F.3.2) was adapted from the demographic survey results.

The permanent resident population is estimated by cutting the census block polygons by the PAZ 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 PAZ, for 2010 and for 2020 (based on the methodology above). As indicated, the permanent resident population within the EPZ has increased by 11.84% since the 2010 Census.

To estimate the number of vehicles, the 2020 Census permanent resident population is divided by the average household size (2.52 persons/household) and multiplied by the average number of evacuating vehicles per household (1.53 vehicles/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 VCSNS. 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. 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 Figure 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 VCSNS 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 (i.e., shopping, recreation). Transients may spend less than one day or stay overnight at camping facilities. Data for transient facilities was based on the data received from the counties within the EPZ and the previous ETE study (confirmed to be still accurate by the counties). The average transient vehicle occupancy rates vary by facility from 0.6 persons per vehicle to 2.7 persons per vehicle. Note, recreational vehicles (RVs) at campgrounds are treated as 2 vehicles due to their larger size and more sluggish operating characteristics.

As shown in the maps in Appendix E, the VCSNS EPZ has a number of total of fourteen areas and facilities that attract transients, including Monticello Reservoir, Parr Reservoir, and Broad River that offer hunting, fishing, and boating. There is also some camping along the Broad River. Nine recreational areas, all of which offer picnicking and seven of which have boat ramps, are located in the EPZ near the Monticello and Parr Reservoirs. The remaining five areas and facilities are campgrounds, golf courses and parks within the EPZ. The transient facilities within the VCSNS EPZ are summarized as follows:

- Campgrounds – 427 transients and 360 vehicles; an average of 1.19 transients per vehicle
- Golf Courses – 27 transients and 20 vehicles; an average of 1.35 transients per vehicle
- Marinas – 57 transients and 22 vehicles; an average of 2.59 transients per vehicle
- Parks – 50 transients and 23 vehicles; an average of 2.17 transients per vehicle

Table E-5 in Appendix E summarizes the transient data that was estimated for the VCSNS EPZ. In total, there are 561 transients, evacuating in 425 vehicles (an average of 1.32 transients per vehicle) in the EPZ during peak times. Table 3-4 presents the transient population and transient vehicle estimates by PAZ. 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.

There are two major employers within the VCSNS EPZ: VC Summer Nuclear Station and General Information Services. The information of these two facilities is shown in Table E-4 in Appendix E. 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. As such, the employers with less than 200 employees (during the maximum shift) are not considered in this study. The total number of employees into the EPZ is based upon data provided by Dominion Energy and phone calls to

General Information Services. The percent of employees commuting in the EPZ was obtained from Dominion Energy for VC Summer Nuclear Station and the old data from the previous study was used for General Information Services.

To estimate the evacuating employee vehicles, a vehicle occupancy rate of 1.09 employees per vehicle obtained from the demographic survey (see Appendix F, sub-section F.3.1) was used for the major employers. Table 3-5 presents employee and vehicle estimates commuting into the EPZ by PAZ. Figure 3-8 and Figure 3-9 present these data by sector.

3.5 Medical Facilities

The VCSNS EPZ has only one medical facility – Generations of Chapin. The capacity, current census and general information for Generations of Chapin was provided by Lexington County. Table E-3 in Appendix E summarizes the data gathered. Table 3-6 presents the census of the Generations of Chapin. A total of 54 people has been identified as living in or being treated at Generations of Chapin. As per data provided by Lexington County, there are 29 ambulatory patients and 25 patients requiring wheelchair transport.

The transportation requirements for the medical facility population are also presented in Table 3-6. The number and type of evacuating vehicles that need to be provided depend on the patients' state of health. It is estimated that buses can transport up to 30 people; wheelchair buses up to 15 people; and ambulances, up to 2 people. One bus and two wheelchair buses are required to evacuate the medical facility population, as shown in Table 3-6. Buses are represented as two passenger vehicles in the ETE simulations due to their larger size and more sluggish operating characteristics.

3.6 Schools and Licensed Day Care Centers

School and licensed day care center population and transportation requirements for the direct evacuation of all schools and licensed day care centers within the EPZ for the 2020-2021 school year are presented in Table 3-7 and Table 3-8, respectively. This information was provided by local county emergency management agencies. This was supplemented with the National Center for Education Statistics[1], State Office of the Department of Social Services, the previous ETE study, and phone calls to specific facilities where data was missing. The column in Table 3-7and 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.
- 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. All high school students except some students at Chapin High School and Spring Hill High School will use school buses to evacuate. Discussions with Chapin High School and Spring Hill High School officials indicate they would permit students who drive to

[1] https://nces.ed.gov/

school to evacuate using their personal vehicles. This approach conforms to that cited in Section 2.4 of NUREG/CR-7002, Rev. 1.

- Students at Chapin High School and Spring Hill High School who evacuate using private vehicles will drive home and unite with their parents/family and then evacuate together using the average evacuating vehicles per household obtained from the demographic survey.
- Bus capacity, expressed in students per bus, is set to 70 for primary schools/licensed day care centers and 50 for middle/intermediate 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.

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.

School buses are represented as two vehicles in the ETE simulation due to their larger size and more sluggish operating characteristics.

3.7 Transit Dependent Population Demand Estimate

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 3-9 presents estimates of transit-dependent people. Note:

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

cars, shared a ride with neighbors or friends. Other documents report that approximately 70 percent of transit dependent persons were evacuated via ride sharing. **Based on the results of the demographic survey, approximately 82% 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 (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 3-9 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 3-9 indicates that transportation must be provided for 40 people. Therefore, a total of 2 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 PAZs to pick up transit dependent people, **6 bus runs** are used in the ETE calculations, see Sections 8.1 and 10 for further discussion. These buses are represented as two vehicles in the ETE simulations due to their larger size and more sluggish operating characteristics.

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

$$P = 6{,}291 \times [0.147 \times (1.61 - 1) \times 0.597 \times 0.416 + 0.457 \times (2.42 - 2) \times (0.597 \times 0.416)^2]\ = 215$$

$$B = [(1 - 0.82) \times P] \div 30 = (0.18 \times 215) \div 30 \approx 2$$

These calculations 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 approximate number of HH is 6,291.
- No HH indicated that they did not have access to a vehicle.
- The members of HH with 1 vehicle away (14.7%), who are at home, equal (1.61 - 1). The number of HH where the commuter will not return home is equal to (6,291 x

0.147 x 0.61 x 0.597 x 0.416), as 59.7% of EPZ households have a commuter 41.6% 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 (45.7%), who are at home, equal (2.42 – 2). The number of HH where neither commuter will return home is equal to 6,291 x 0.457 x 0.42 x $(0.597 \times 0.416)^2$. 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.

3.8 Access and/or Functional Needs Population

Based on data provided by the counties within the EPZ, there are an estimated 45 access and/or functional needs people within the Richland County, 24 people within the Newberry County, 14 people within the Lexington County, and 8 people within the Fairfield County who are within the EPZ and require transportation assistance to evacuate.

Details on the number of ambulatory, wheelchair-bound and bedridden people were received from Lexington and Fairfield County directly. The breakdown of the type of access and/or functional needs population within Richland and Newberry Counties was not available. It is assumed that the percent breakdown used for Lexington and Fairfield Counties will be used for Richland and Newberry Counties as well. This results in 37 ambulatory persons, 46 wheelchair-bound persons and 8 bedridden persons for a total access and/or functional needs population of 91 people. A total of 5 buses (capacity of 30 ambulatory persons per bus), 6 wheelchair buses (capacity of 15 wheelchair bound persons per wheelchair bus), 1 wheelchair van (capacity of 4 wheelchair bound persons per van) and 4 ambulances (capacity 2 bedridden persons per ambulance) for a total number of 16 vehicles deployed. Table 3-10 shows the total number of people registered for access and/or functional needs by type of need. The table also estimates the number of transportation resources needed to evacuate these people in a timely manner. Buses and wheelchair buses needed to evacuate the special needs population are represented as two vehicles in the ETE simulations due to their larger size and more sluggish operating characteristics.

3.9 Special Events

Several special events were discussed through emails with VCSNS and the OROs. The events that were considered include:

- Events at Baltic Circle – 1,000 attendees
- The 10k Charity Run at Palmetto Trail – Several hundred participants
- Dutch For Football Game (outside of the EPZ) – 1,000 to 3,000 attendees
- Labor Day Parade in Chapin – 10,000 attendees
- Event at Mid-Carolina Middle and High Schools – No attendance data provided.

Based on discussions with VCSNS and OROs, the Labor Day Parade in Chapin, Lexington County, located in PAZ D-2, was chosen as the special event (for Scenario 13) in accordance with NUREG/CR-7002, Rev. 1, because it has the largest transient population. This event occurs annually in September on Labor Day.

Based on the data received from Lexington County, the total attendance for the event is approximately 10,000 people. It is estimated that 50% of these people are local residents and were subtracted out to avoid double counting. This results in 5,000 people who are additional transients present in the EPZ during the Labor Day Parade. It was assumed that families travel to the event as a household unit in a single vehicle; and based on the demographic survey the average household size of 2.52 was used as the vehicle occupancy, which results in 1,984 (5,000/2.52 = 1,984) vehicles.

Temporary road closures are used for the parade portion of the festival, but all roadways could be quickly re-opened in the event of an emergency. It is assumed that the roads would be re-opened by the time transients at the event gather their belongings and return to their vehicles to begin their evacuation trip. Vehicles were loaded at the General Information Services parking lot and at local streets near the event for this scenario. Public transportation to transport attendees to parking lots are not provided and are not considered as part of this study.

3.10 External Traffic

Vehicles will be traveling through the EPZ (external-external trips) 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 Highway (US) 76, US 176, and US 321, as well as Interstate (I)-26. 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 from 2019 was obtained from the South Carolina Department of Transportation website[2] to estimate the number of vehicles per hour (vph) on the aforementioned routes. The 2020 AADT data was available, but it was not used in this study due to the significant decrease in traffic on these highways caused by the Coronavirus Disease 2019 (COVID-19) pandemic. 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 3-11, for each of the routes considered. The DDHV is then multiplied by 2 hours since traffic and access control points (TACPs) are assumed to be activated at 120 minutes after the ATE, to estimate the total number of external vehicles loaded on the analysis network. As indicated, there are 11,944 vehicles entering the EPZ as external-external trips prior to the activation of the TACP and the diversion of this

[2] https://scdot.maps.arcgis.com/apps/MinimalGallery/index.html?appid=7420aa1f39d84400a6d7e8cdaacc89cd#

traffic. This number is reduced by 60% for evening scenarios (Scenarios 5 and 12), as discussed in Section 6.

3.11 Background Traffic

Section 5 discusses the time needed for the people in the EPZ to mobilize and begin their evacuation trips. As shown in Table 5-8, 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 15^{th} 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 a 45-minute 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 2,523 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 1 (summer, midweek, midday, with good weather) conditions.

3.12 Summary of Demand

A summary of population and vehicle demand is summarized in Table 3-12 and Table 3-13, respectively. This summary includes all population groups described in this section. A total of 43,462 people and 32,218 vehicles are considered in this study.

Table 3-1. EPZ Permanent Resident Population

PAZ	2010 Population	2020 Population
A-0	220	178
A-1	395	363
A-2	618	538
B-1	341	242
B-2	382	307
C-1	411	362
C-2	1,515	1,338
D-1	2,214	3,217
D-2	3,908	4,987
E-1	536	482
E-2	1,997	2,130
F-1	202	241
F-2	1,436	1,469
EPZ TOTAL	**14,175**	**15,854**
EPZ Population Growth (2010-2020):		**11.84%**

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

PAZ	2020 Population	2020 Resident Vehicles
A-0	178	108
A-1	363	221
A-2	538	327
B-1	242	148
B-2	307	185
C-1	362	219
C-2	1,338	811
D-1	3,217	1,956
D-2	4,987	3,001
E-1	482	291
E-2	2,130	1,290
F-1	241	147
F-2	1,469	891
EPZ TOTAL	**15,854**	**9,595**

Table 3-3. Shadow Population and Vehicles by Sector

Sector	2020 Population	Evacuating Vehicles
N	191	116
NNE	58	36
NE	833	508
ENE	6,204	3,706
E	1,063	646
ESE	915	555
SE	5,168	3,141
SSE	22,074	13,279
S	11,302	6,865
SSW	5,238	3,177
SW	1,556	945
WSW	2,256	1,363
W	2,047	1,245
WNW	916	553
NW	81	49
NNW	104	64
TOTAL	**60,006**	**36,248**

Table 3-4. Summary of Transients and Transient Vehicles

PAZ	Transients	Transient Vehicles
A-0	0	0
A-1	44	17
A-2	27	10
B-1	12	20
B-2	0	0
C-1	0	0
C-2	350	240
D-1	0	0
D-2	12	10
E-1	65	100
E-2	25	18
F-1	26	10
F-2	0	0
EPZ TOTAL	**561**	**425**

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

PAZ	Employees	Employee Vehicles
A-0	286	262
A-1	0	0
A-2	0	0
B-1	0	0
B-2	0	0
C-1	0	0
C-2	0	0
D-1	0	0
D-2	471	432
E-1	0	0
E-2	0	0
F-1	0	0
F-2	0	0
EPZ TOTAL	**757**	**694**

Table 3-6. Medical Facility Transit Demand

PAZ	Facility Name	Munici-pality	Capacity	Current Census	Ambu-latory	Wheel-chair Bound	Bed-ridden	Bus Runs	Wheel-chair Bus Runs	Ambulance Runs
LEXINGTON COUNTY, SC										
D-2	Generations of Chapin	Chapin	64	54	29	25	0	1	2	0
Lexington County Subtotal:			*64*	*54*	*29*	*25*	*0*	*1*	*2*	*0*
TOTAL:			**64**	**54**	**29**	**25**	**0**	**1**	**2**	**0**

Table 3-7. School Population Demand Estimates

PAZ	Schools	Enrollment	Buses Required
FAIRFIELD COUNTY			
A-2	McCrorey-Liston School of Technology	135	2
C-2	Kelly Miller Elementary School	221	4
	Fairfield County Subtotal:	*356*	*6*
LEXINGTON COUNTY			
D-2	Chapin High School[3]	1,552	18
D-2	Crooked Creek Park Afterschool Program	45	1
D-2	Chapin Intermediate School	811	17
D-2	Chapin Elementary School	874	13
	Lexington County Subtotal:	*3,282*	*49*
NEWBERRY COUNTY			
E-2	Little Mountain Elementary	428	7
E-2	Mid-Carolina High School	738	15
E-2	Mid-Carolina Middle School	557	12
F-2	Pomaria-Garmany Elementary	347	5
	Newberry County Subtotal:	*2,070*	*39*
RICHLAND COUNTY			
D-1	Chapin Middle School	976	20
D-1	Academy for Success	125	3
D-1	Spring Hill High School[3]	1,135	12
D-1	The Center for Advanced Technical Studies	313	7
	Richland County Subtotal:	*2,549*	*42*
	SCHOOLS TOTAL:	**8,257**	**136**

[3] There are 700 and 550 high school students that drive to Chapin High School and Spring Hill High School, respectively. Discussions with high school officials indicate they would permit students to evacuate the school using their personal vehicles. The remaining 852 students at Chapin High School and 585 students at Spring Hill High School will require buses to evacuate.

Table 3-8. Licensed Day Care Centers Population Demand Estimates

PAZ	Licensed Day Care Centers	Enrollment	Buses Required
FAIRFIELD COUNTY			
A-2	McCrorey-Liston Child Development Center	20	1
B-2	Jacqueline Wylie[4]	6	0
B-2	Jackie Chappell[4]	6	0
C-2	Kelly Miller Child Development Center	40	1
	Fairfield County Subtotal:	*72*	*2*
LEXINGTON COUNTY			
D-2	Mt Horeb Lutheran Church	70	1
D-2	Elaine Alewine	6	1
D-2	Abner Montessori School/Chapin Children's Center	246	4
D-2	Chapin Baptist Child Development Center	332	5
D-2	Chapin United Methodist Church Preschool	50	1
D-2	Inez's Childcare Center	52	1
	Lexington County Subtotal:	*756*	*13*
NEWBERRY COUNTY			
E-2	Little Angels Daycare	44	1
E-2	Little Mountain Elementary	20	1
F-2	Pomaria-Garmany Elementary	40	1
	Newberry County Subtotal:	*104*	*3*
RICHLAND COUNTY			
D-1	Sally Becker[4]	6	0
	Richland County Subtotal:	*6*	*0*
	DAY CARE CENTERS TOTAL:	**938**	**18**

[4] Children from Jacqueline Wylie ,Jackie Chappell, and Sally Becker day care centers will be transported by personal vehicles and a bus is not provided.

Table 3-9. Transit-Dependent Population Estimates

2020 EPZ Population	Survey Average HH Size with Indicated No. of Vehicles			Estimated No. of Households	Survey Percent HH with Indicated No. of Vehicles			Survey Percent HH with Commuters	Survey Percent HH with Non-Returning Commuters	Total People Requiring Transport	Estimated Ridesharing Percentage	People Requiring Public Transit	Percent Population Requiring Public Transit
	0	1	2		0	1	2						
15,854	0	1.61	2.42	6,291	0	14.7%	45.7%	59.7%	41.6%	215	82%	40	0.3%

Table 3-10. Access and/or Functional Needs Demand Summary

Population Group	Population	Vehicles deployed
RICHLAND, NEWBERRY, AND LEXINGTON COUNTIES		
Ambulatory	37	5 buses
Wheelchair Bound	35	5 wheelchair buses
	3	1 wheelchair van
Bedridden	8	4 ambulances
FAIRFIELD COUNTY		
Wheelchair Bound	8	1 wheelchair buses
Total:	**91**	**16**

Table 3-11. VCSNS EPZ External Traffic

Upstream Node	Downstream Node	Road Name	Direction	SCDOT AADT[5]	K-Factor[6]	D-Factor[6]	Hourly Volume	External Traffic
8363	363	I-26	Eastbound (EB)	53,200	0.091	0.50	2,421	4,842
8824	824	I-26	Westbound (WB)	53,200	0.091	0.50	2,421	4,842
8401	401	US-176	Eastbound (EB)[7]	4,700	0.136	0.25	160	320
8827	827	US-176	Westbound (WB)	4,700	0.136	0.50	320	640
8813	957	US-76	Eastbound (EB)	4,700	0.136	0.25	160	320
8664	664	US-321	Northbound (NB)	3,600	0.136	0.50	245	490
8470	470	US-321	Southbound (SB)	3,600	0.136	0.50	245	490
							TOTAL:	**11,944**

[5] 2019 Traffic Counts. https://scdot.maps.arcgis.com/apps/MinimalGallery/index.html?appid=7420aa1f39d84400a6d7e8cdaacc89cd#
[6] HCM 2016
[7] AADT for US-176 is assumed equal to AADT for US-76

Table 3-12. Summary of Population Demand[8]

PAZ	Residents	Transit-Dependent	Transients	Employees	Special Facilities	Schools and Day Care Centers	Special Event	Shadow Population[9]	External Traffic	Total
A-0	178	2	0	286	0	0	0	0	0	466
A-1	363	2	44	0	0	0	0	0	0	409
A-2	538	0	27	0	0	155	0	0	0	720
B-1	242	0	12	0	0	0	0	0	0	254
B-2	307	0	0	0	0	12	0	0	0	319
C-1	362	4	0	0	0	0	0	0	0	366
C-2	1,338	0	350	0	0	261	0	0	0	1,949
D-1	3,217	8	0	0	0	2,555	0	0	0	5,780
D-2	4,987	13	12	471	54	4,038	5,000	0	0	14,575
E-1	482	11	65	0	0	0	0	0	0	558
E-2	2,130	0	25	0	0	1,787	0	0	0	3,942
F-1	241	0	26	0	0	0	0	0	0	267
F-2	1,469	0	0	0	0	387	0	0	0	1,856
Shadow Region	0	0	0	0	0	0	0	12,001	0	12,001
Total	**15,854**	**40**	**561**	**757**	**54**	**9,195**	**5,000**	**12,001**	**0**	**43,462**

[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 3-13. Summary of Vehicle Demand[10]

PAZ	Residents	Transit-Dependent[11]	Transients	Employees	Medical Facility[11]	Schools and Day Care Centers[11]	Special Event	Shadow Population[12]	External Traffic	Total
A-0	108	2	0	262	0	0	0	0	0	372
A-1	221	2	17	0	0	0	0	0	0	240
A-2	327	0	10	0	0	6	0	0	0	343
B-1	148	0	20	0	0	0	0	0	0	168
B-2	185	0	0	0	0	0	0	0	0	185
C-1	219	2	0	0	0	0	0	0	0	221
C-2	811	0	240	0	0	10	0	0	0	1,061
D-1	1,956	2	0	0	0	84	0	0	0	2,042
D-2	3,001	2	10	432	6	124	1,984	0	0	5,559
E-1	291	2	100	0	0	0	0	0	0	393
E-2	1,290	0	18	0	0	72	0	0	0	1,380
F-1	147	0	10	0	0	0	0	0	0	157
F-2	891	0	0	0	0	12	0	0	0	903
Shadow Region	0	0	0	0	0	0	0	7,250	11,944	19,194
Total	**9,595**	**12**	**425**	**694**	**6**	**308**	**1,984**	**7,250**	**11,944**	**32,218**

[10] 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.
[11] Buses (including transit-dependent buses, wheelchair buses, school/day care center buses) represented as two passenger vehicles. Refer to Section 8 for additional information.
[12] Shadow vehicles has been reduced to 20%. Refer to Figure 2-1 for additional information.

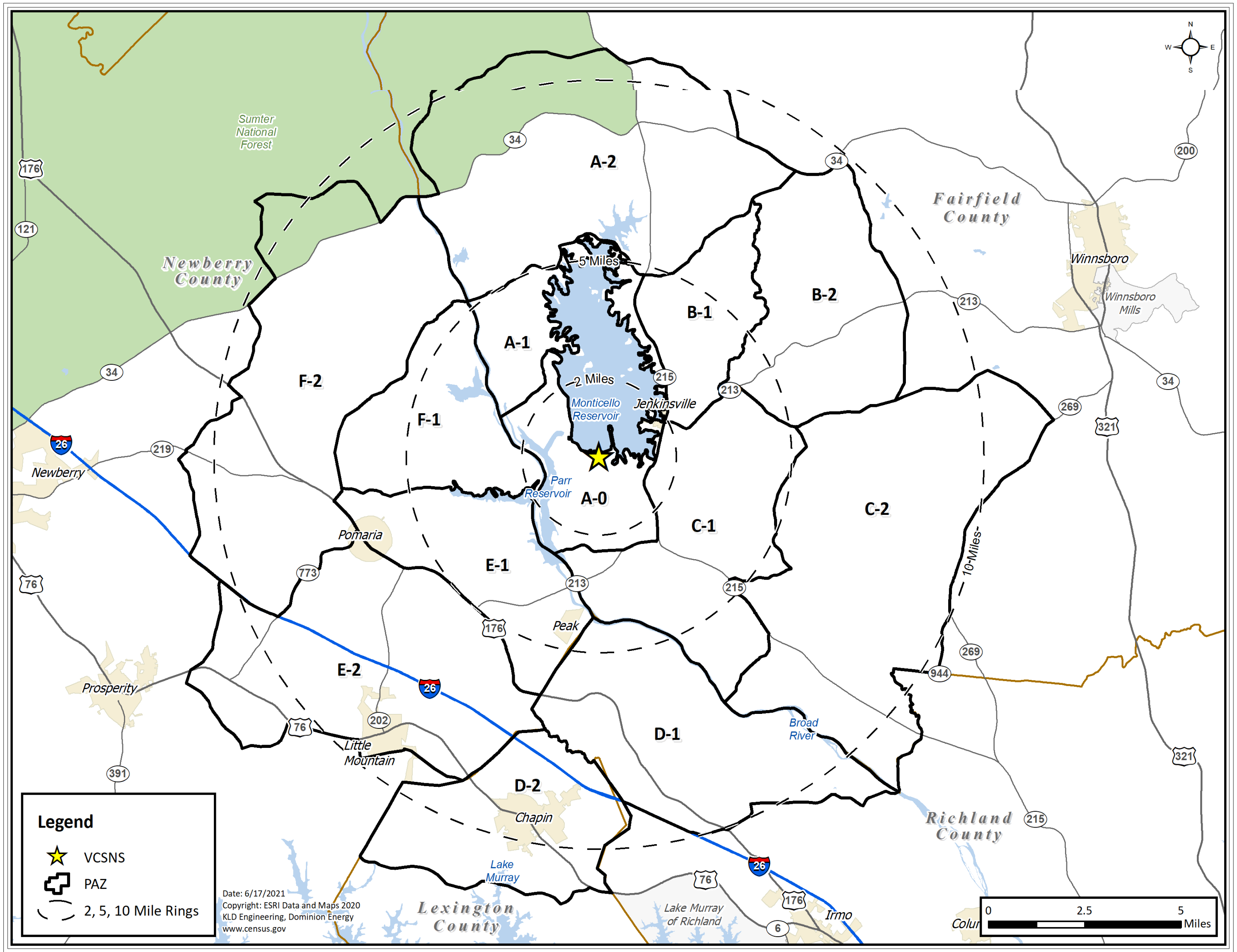
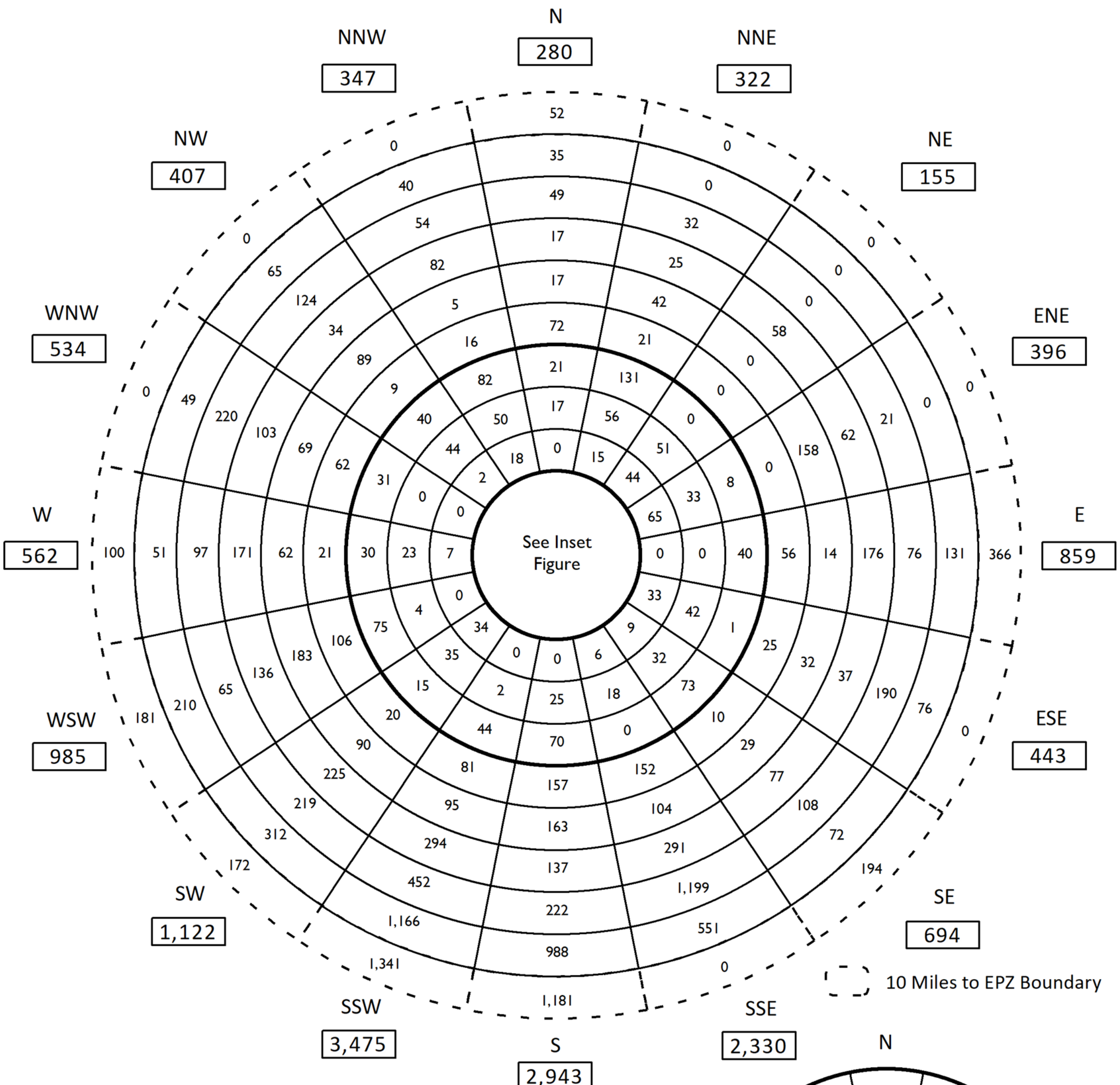


Figure 3-1. PAZ Comprising the VCSNS EPZ



2020 Permanent Resident Population

Miles	Subtotal by Ring	Cumulative Total
0 - 1	25	25
1 - 2	157	182
2 - 3	233	415
3 - 4	432	847
4 - 5	661	1,508
5 - 6	808	2,316
6 - 7	1,152	3,468
7 - 8	1,925	5,393
8 - 9	3,128	8,521
9 - 10	3,746	12,267
10 - EPZ	3,587	15,854
	Total:	15,854

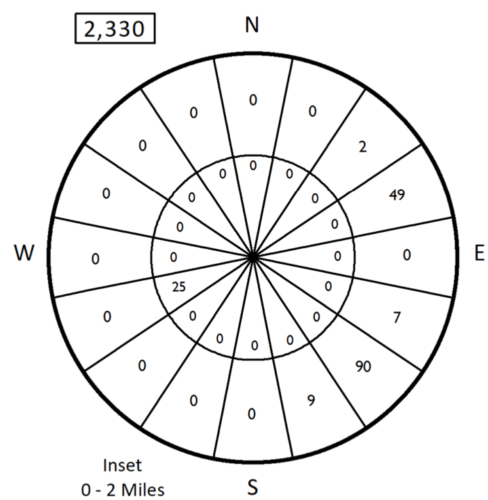
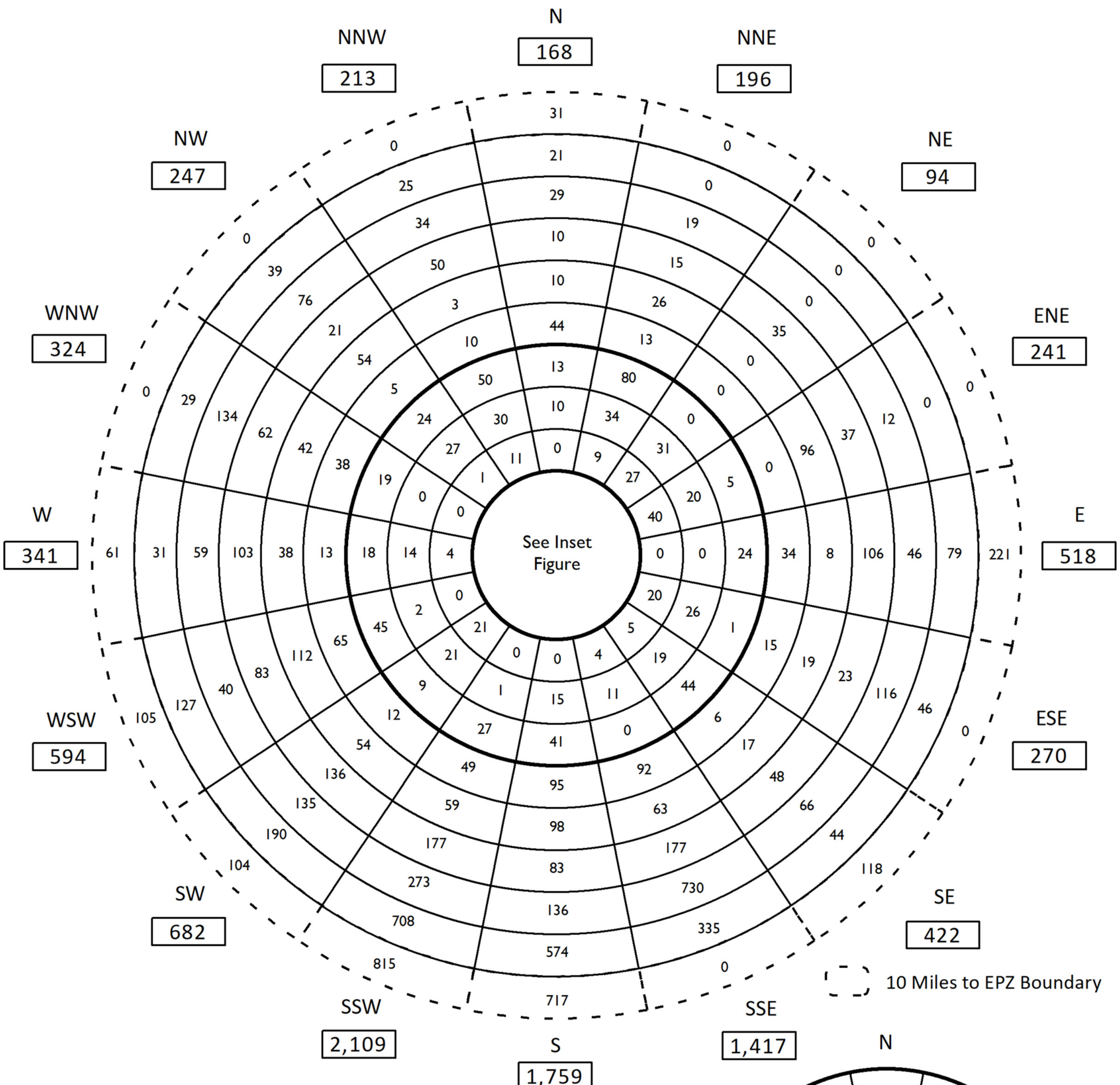


Figure 3-2. Permanent Resident Population by Sector



Resident Vehicles

Miles	Subtotal by Ring	Cumulative Total
0 - 1	15	15
1 - 2	96	111
2 - 3	142	253
3 - 4	261	514
4 - 5	400	914
5 - 6	491	1,405
6 - 7	699	2,104
7 - 8	1,166	3,270
8 - 9	1,905	5,175
9 - 10	2,248	7,423
10 - EPZ	2,172	9,595
	Total:	9,595

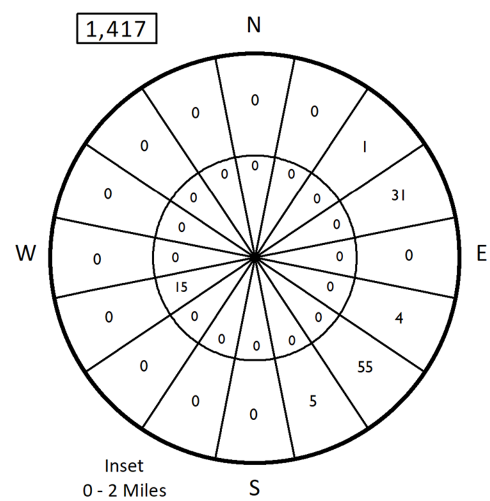
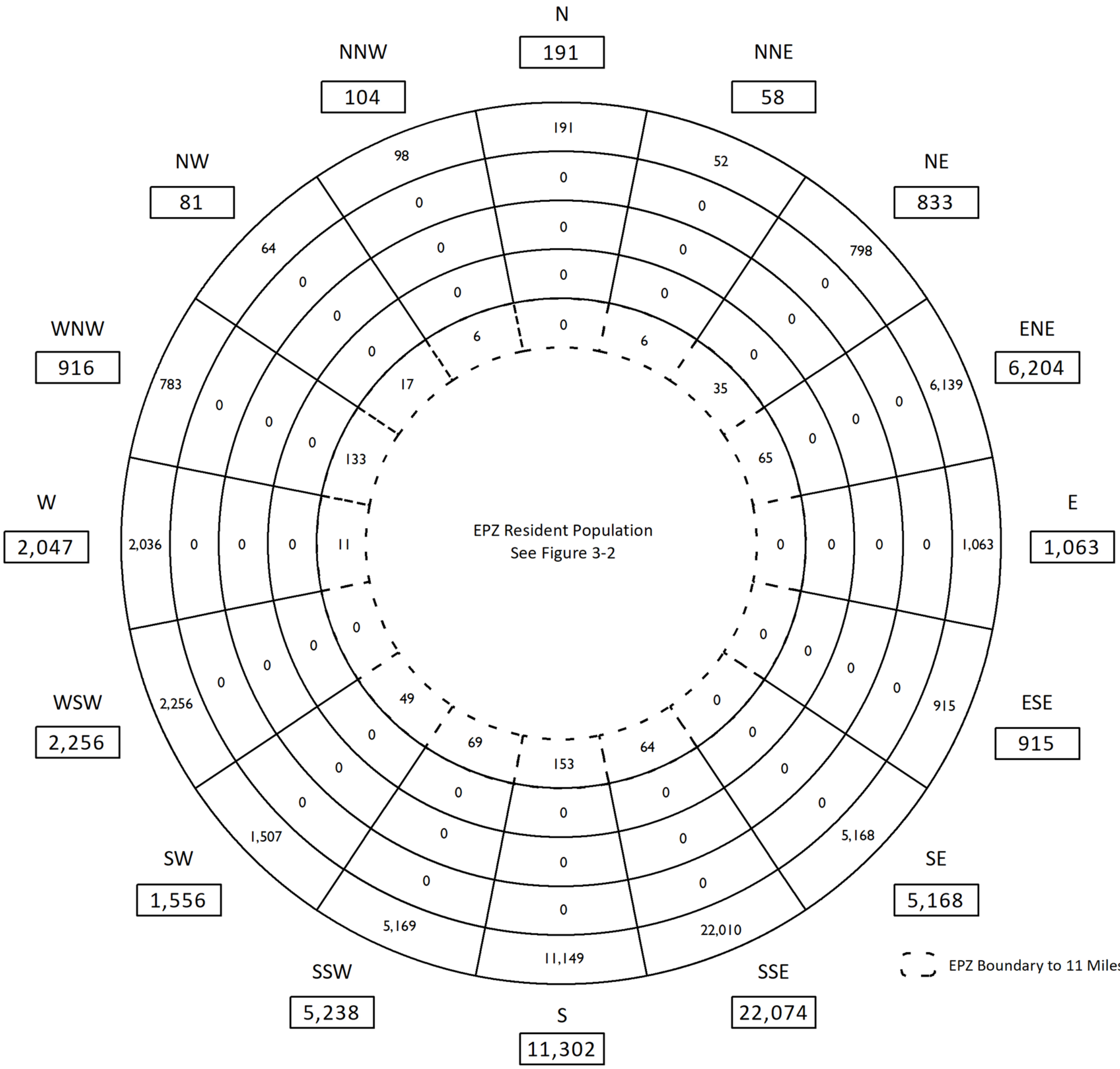


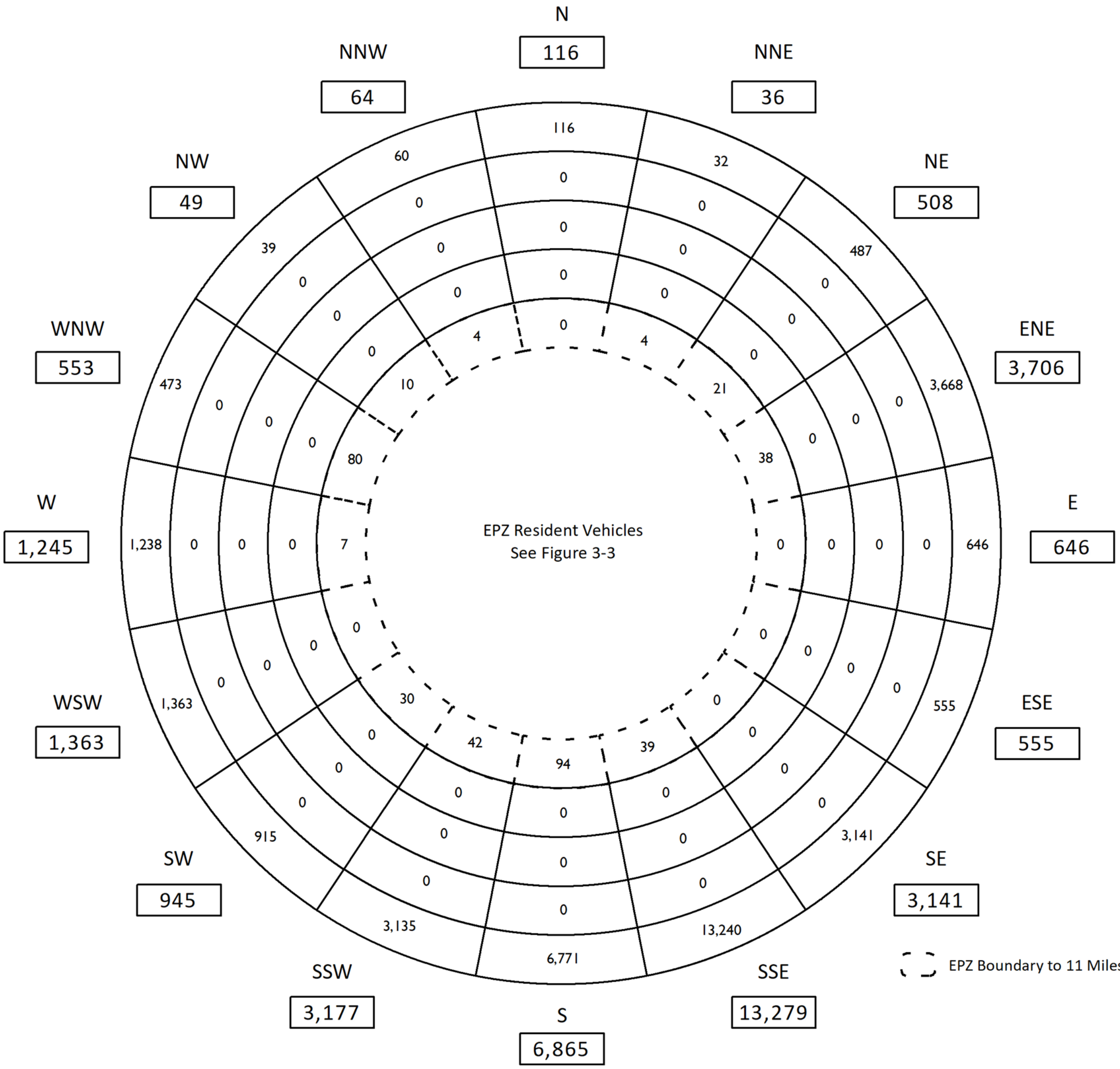
Figure 3-3. Permanent Resident Vehicles by Sector



2020 Shadow Population

Miles	Subtotal by Ring	Cumulative Total
EPZ - 11	608	608
11 - 12	0	608
12 - 13	0	608
13 - 14	0	608
14 - 15	59,398	60,006
	Total:	60,006

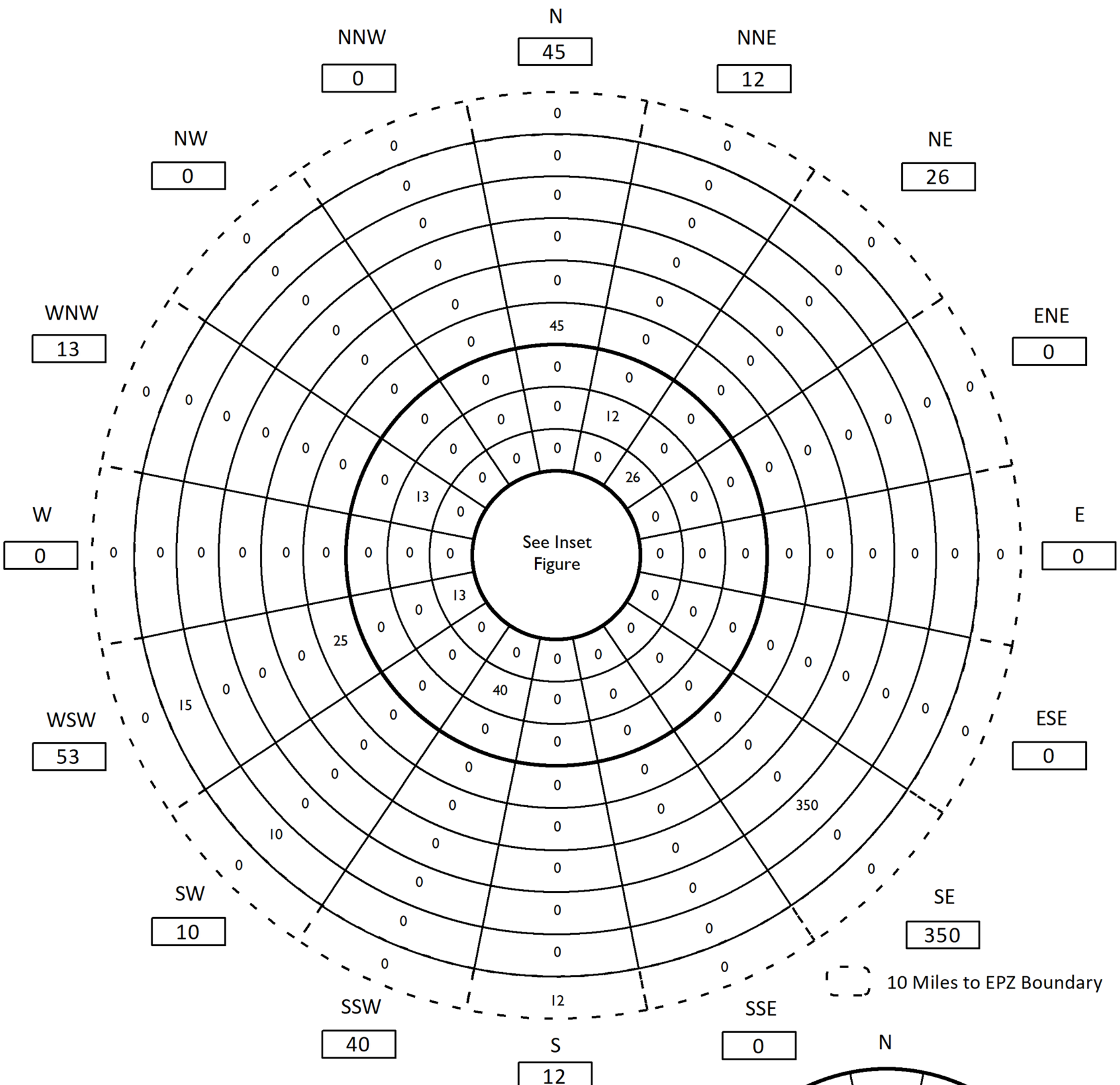
Figure 3-4. Shadow Population by Sector



Shadow Vehicles

Miles	Subtotal by Ring	Cumulative Total
EPZ - 11	369	369
11 - 12	0	369
12 - 13	0	369
13 - 14	0	369
14 - 15	35,879	36,248
	Total:	36,248

Figure 3-5. Shadow Vehicles by Sector



Transients

Miles	Subtotal by Ring	Cumulative Total
0 - 1	0	0
1 - 2	0	0
2 - 3	39	39
3 - 4	65	104
4 - 5	0	104
5 - 6	70	174
6 - 7	0	174
7 - 8	0	174
8 - 9	350	524
9 - 10	25	549
10 - EPZ	12	561
	Total:	561

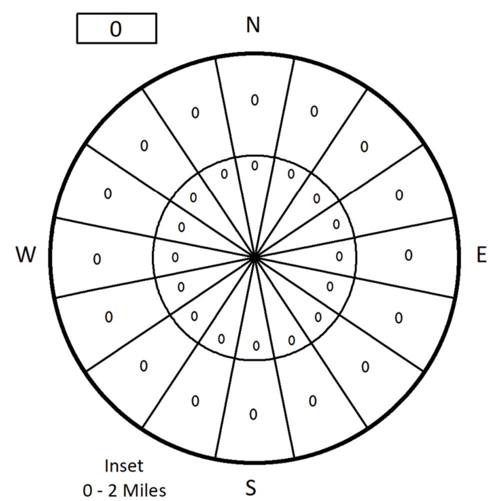
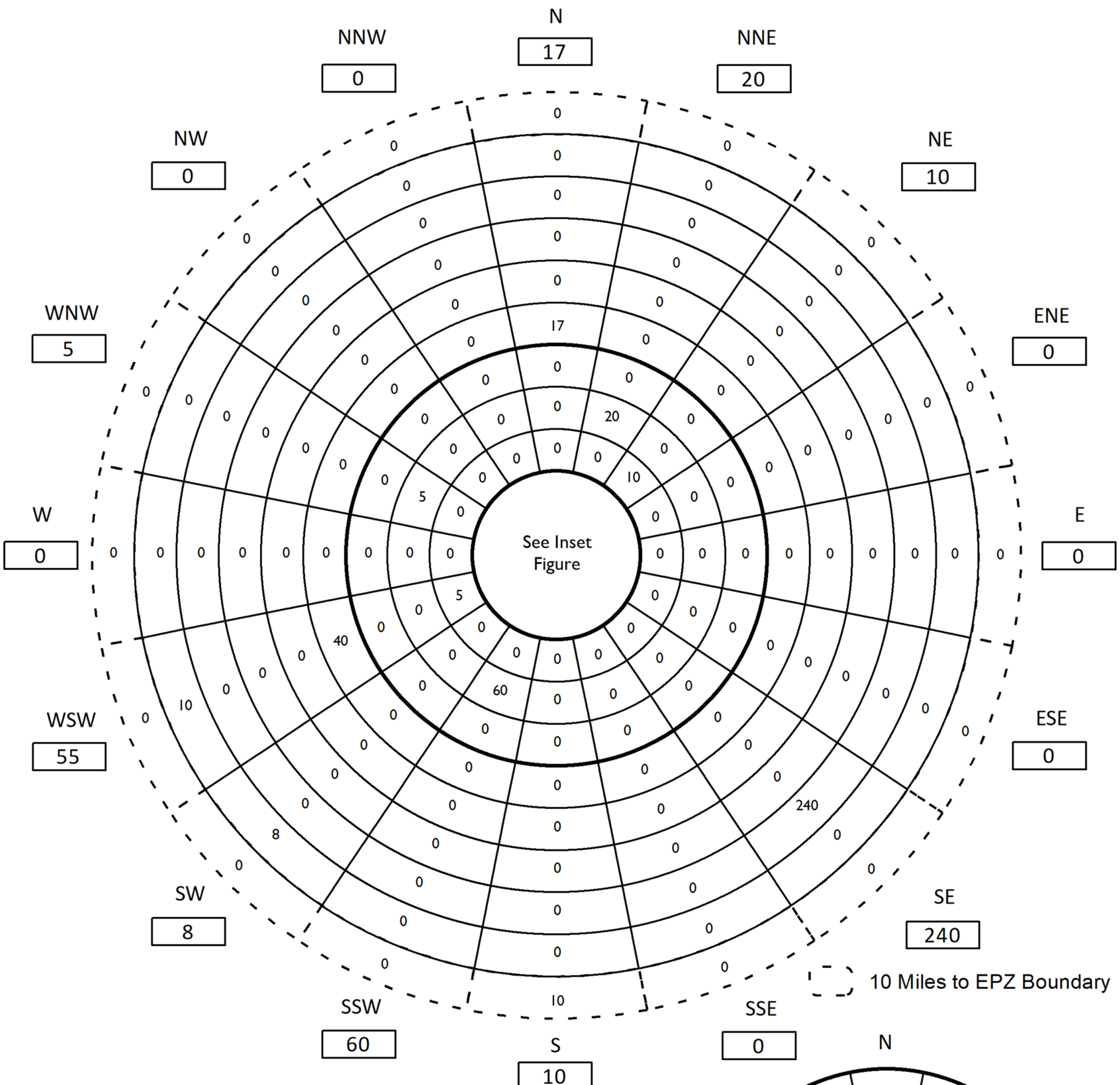


Figure 3-6. Transient Population by Sector



Transient Vehicles

Miles	Subtotal by Ring	Cumulative Total
0 - 1	0	0
1 - 2	0	0
2 - 3	15	15
3 - 4	85	100
4 - 5	0	100
5 - 6	57	157
6 - 7	0	157
7 - 8	0	157
8 - 9	240	397
9 - 10	18	415
10 - EPZ	10	425
	Total:	425

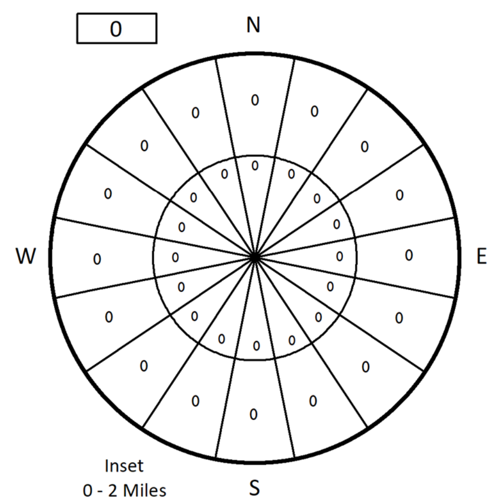
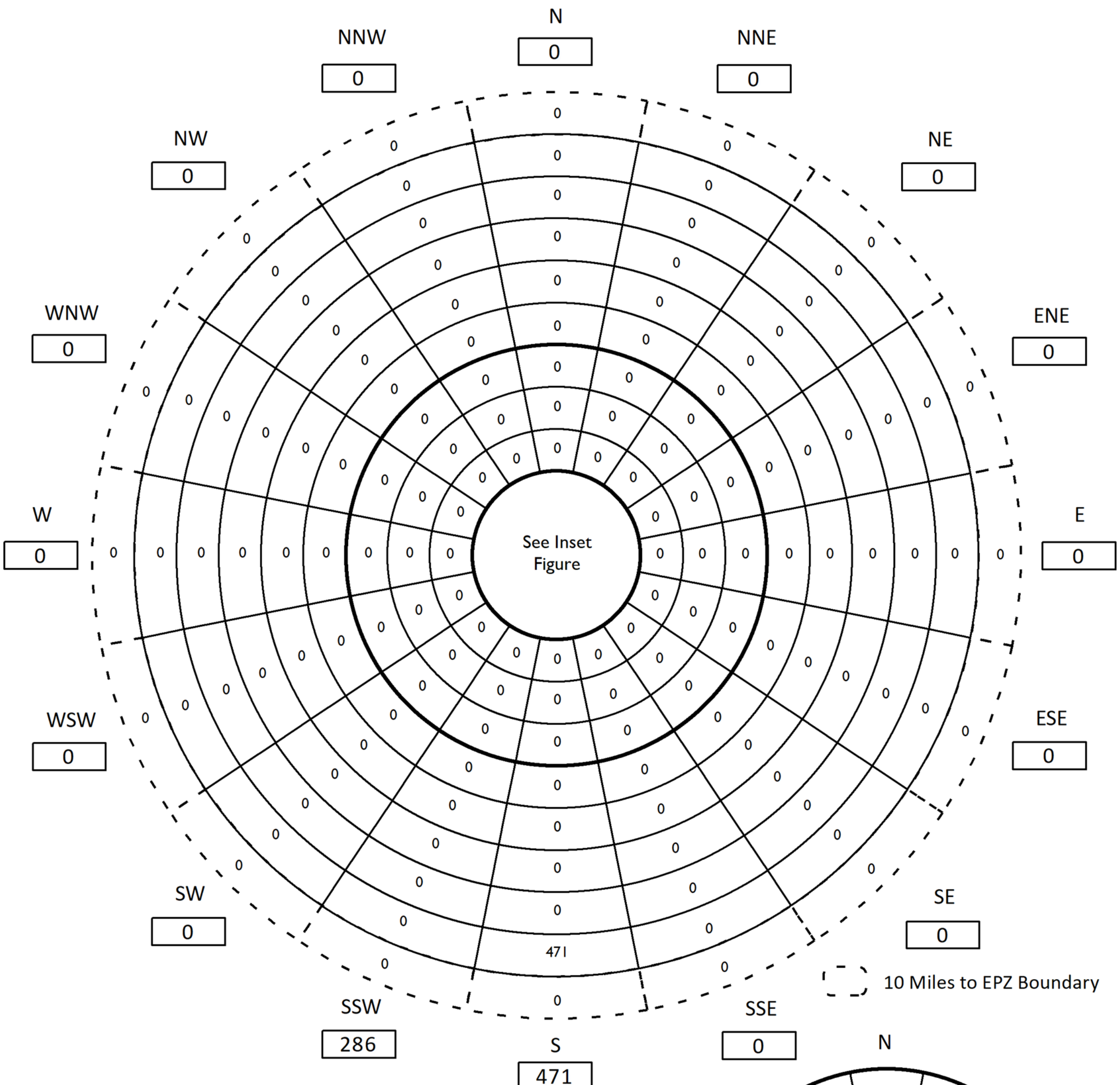


Figure 3-7. Transient Vehicles by Sector



Employees

Miles	Subtotal by Ring	Cumulative Total
0 - 1	286	286
1 - 2	0	286
2 - 3	0	286
3 - 4	0	286
4 - 5	0	286
5 - 6	0	286
6 - 7	0	286
7 - 8	0	286
8 - 9	0	286
9 - 10	471	757
10 - EPZ	0	757
	Total:	757

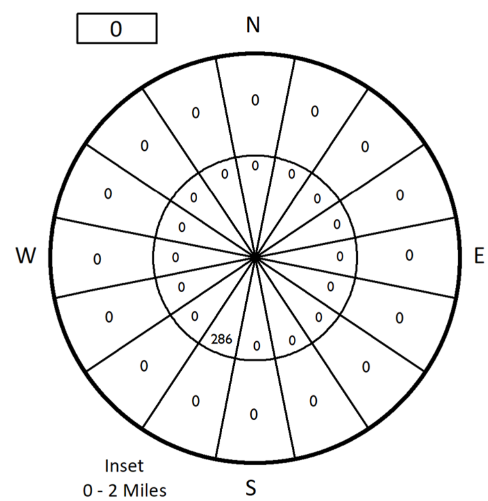
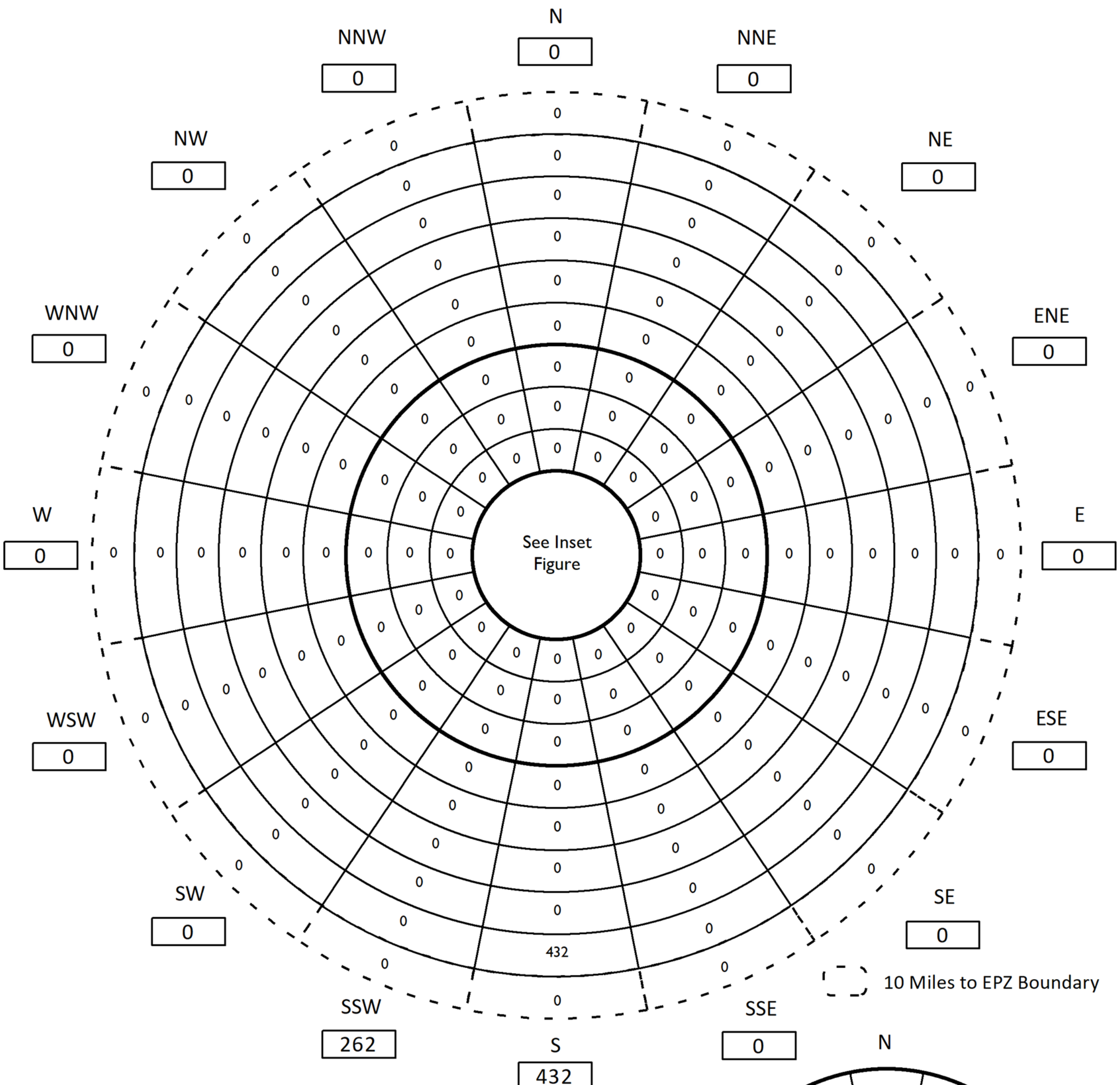


Figure 3-8. Employee Population by Sector



Employee Vehicles

Miles	Subtotal by Ring	Cumulative Total
0 - 1	262	262
1 - 2	0	262
2 - 3	0	262
3 - 4	0	262
4 - 5	0	262
5 - 6	0	262
6 - 7	0	262
7 - 8	0	262
8 - 9	0	262
9 - 10	432	694
10 - EPZ	0	694
	Total:	694

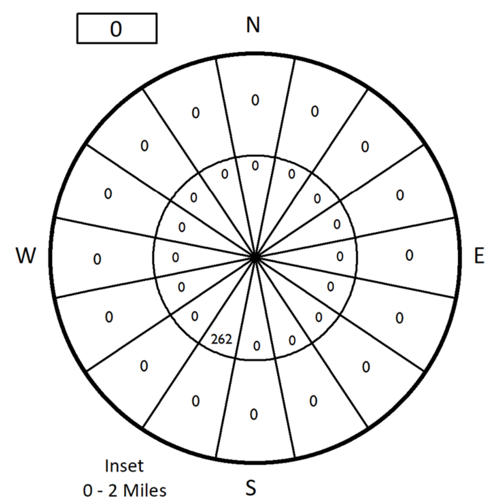


Figure 3-9. Employee Vehicles by Sector

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, a 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, 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 2016. 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

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

lane or shoulder width were taken. Horizontal and vertical alignment can influence both FFS and capacity. The estimated FFS were measured using the survey vehicle's speedometer and observing local traffic, under free flow conditions. Free flow speeds ranged from 10 mph to 75 mph in the study area. Capacity is estimated from the procedures of the HCM 2016. For example, HCM 2016 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, weather conditions such as rain reduce the values of free-flow speed and of highway capacity by approximately 10 percent. Over the last decade new studies have been made on the effects of rain on traffic capacity. These studies indicate a range of effects between 5 and 20 percent depending on wind speed and precipitation rates. As indicated in Section 2.6 we employ a reduction in free speed and in highway capacity of 10 percent and 20 percent for rain and ice, 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. 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 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

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

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 VCSNS 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 below.

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 2016 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 is a mathematical representation of an assumed set of conditions using the best available knowledge and understanding of traffic flow and available inputs. Simulation should not be assumed to be a prediction of what will happen under any event because a real evacuation can be impacted by an infinite number of things – many of which will differ from these test cases – and many others cannot be taken into account with the tools available.

4.5 Boundary 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 outside the study area and the fact that the evacuating traffic volume will be more significant than the competing traffic volume at any downstream signalized intersections, thereby warranting a more significant percentage (75% in this case) of the signal green time.

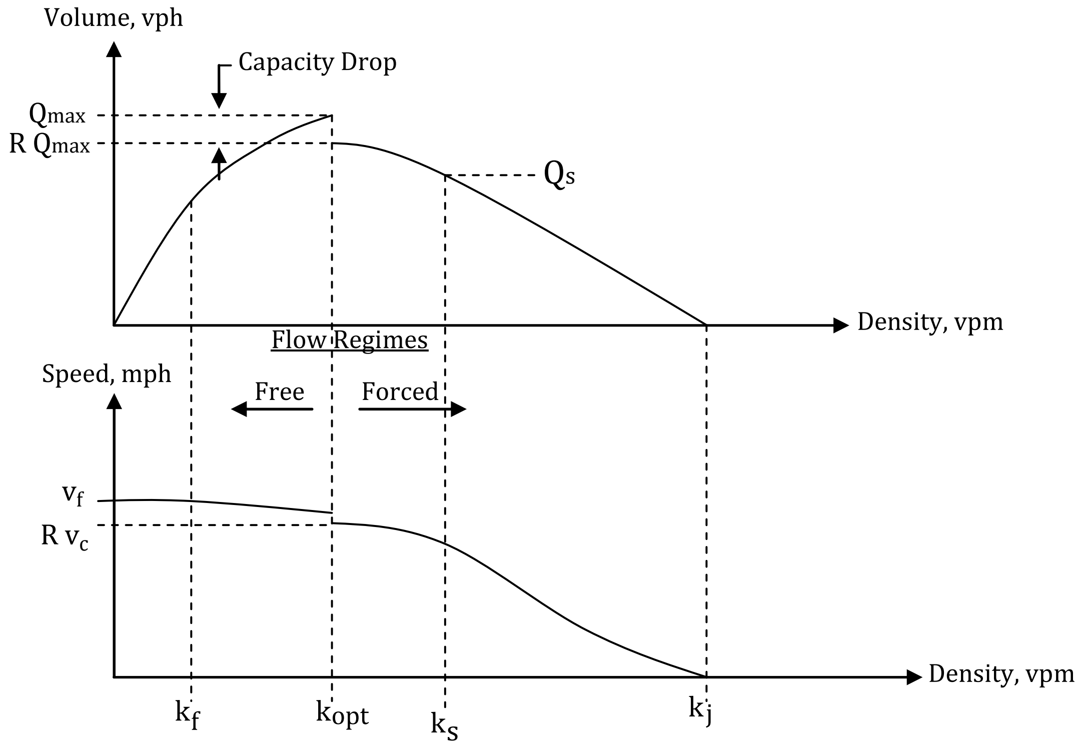


Figure 4-1. Fundamental Diagrams

5 ESTIMATION OF TRIP GENERATION TIME

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

5.1 Background

In general, an accident at a nuclear power plant is characterized by the following Emergency 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 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 - Alert and Notification System (ANS).
2. Mobilization of the general population will commence within 15 minutes after the - notification from the ANS.
3. The ETE are measured relative to the ATE.

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

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

It is likely that a longer time will elapse between the various classes of an emergency. For example, suppose one hour elapses from the - Wireless Emergency Alert (in the form of text messages with unique tones and vibration) 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 Wireless Emergency Alert. In addition, many will engage in preparation activities to evacuate, in anticipation that an Advisory will be broadcasted. Thus,

the time needed to complete the mobilization activities and the number of people remaining to evacuate the EPZ after the ATE, will both be somewhat less than the estimates presented in this report. Consequently, the ETE presented in this report are higher than the actual evacuation time, if this hypothetical situation were to take place.

The notification process consists of two events:

1. Transmitting information using the alert and notification systems (ANS) available within the EPZ (e.g. Integrated Public Alert and Warning System-Wireless Emergency Alert (IPAWS-WEA), Emergency Alert System (EAS) broadcasts in radio (WCOS-FM 97.5, WTCB-FM 106.7, WLTR-FM 91.3) and televisions/News Media, loudspeakers and horns).
2. Receiving and correctly interpreting the information that is transmitted.

The population within the EPZ is dispersed over an area of approximately 316 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 ANS 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 surveys of the EPZ residents. Such a demographic survey was conducted in February 2021 in support of this ETE study for this site. Appendix F discusses the survey sampling plan, the number of completed surveys 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 ETE to extend 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 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 (i.e., depart work, arrive home)
- An Activity is a 'process' that takes place over some elapsed time (i.e., prepare to leave work, travel home)

As such, a completed Activity changes the 'state' of an individual (i.e., 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) 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, 2019 Federal Emergency Management Agency (FEMA) Radiological Emergency Preparedness (REP) Program Manual Part V Section B.1 Bullet 3 states, "Notification methods will be established to ensure coverage within 45 minutes of essentially 100% of the population within the entire plume exposure pathway EPZ who may not have received the initial notification."

Given the federal regulations and guidance, and the presence of the ANS within the EPZ, it is assumed that 87 percent of those within the EPZ will be aware of the accident within 30 minutes with the remainder notified within the following 15 minutes. The notification distribution is provided in Table 5-2. The distribution is plotted in Figure 5-2.

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

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

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

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

Distribution No. 4, Prepare to Leave Home: Activity 2, 4 $\rightarrow$ 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.

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 5-6 presents the summing procedure to arrive at each designated distribution.

Table 5-7 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 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) are reviewed for outliers, and then the overall trip generation distributions are created (see Figure 5-1, Table 5-6, Table 5-7);

3) Outliers can be eliminated either because the response reflects a special population (e.g., access and/or functional 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 3.0 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 3.5 standard deviations from the mean are allowed to be considered outliers, with gaps in the histogram expected. Values more than 3.3 standard deviations from the mean were removed for Distribution 4 (Prepare to Leave Home).

   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). In general, these are additive, using weighting based upon the probability distributions of each element; Figure 5-4 presents the combined trip generation distributions for each population group considered. These distributions are presented on the same time scale. (As discussed earlier, the use of strictly additive activities is a conservative approach, because it makes all activities sequential – travel home from work follows preparation to leave work, preparation for departure follows the return of the commuter, 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 and D, properly displaced with respect to one another, are tabulated in Table 5-8 (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. Protective Action Zones (PAZs) comprising the 2-Mile Region are advised to evacuate immediately.
2. PAZs 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 to prepare 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. The population between the 5-Mile Region Boundary to EPZ boundary shelters in place.
6. Non-compliance with the shelter recommendation is the same as the shadow evacuation percentage of 20%.

Assumptions

1. The EPZ population in PAZs in the 2 to 5-Mile Region will shelter-in-place and then evacuate after the 90th percentile ETE for the 2-Mile Region, 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, at campgrounds, 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 PAZs comprising the 2-Mile Region. This value, T_{Scen}^*, is obtained from simulation results is scenario-specific. It will become the time at which the region being sheltered will be told to evacuate for each scenario.
    b. The resultant trip generation curves for staging are then formed as follows:
        i. The non-shelter trip generation curve is followed until a maximum of 20% of the total trips are generated (to account for shelter non-compliance).
        ii. No additional trips are generated until time T_{Scen}^*
        iii. Following time T_{Scen}^*, the balance of trips are generated:
            1. by stepping up and then following the non-shelter trip generation curve (if T_{Scen}^* is $\leq$ max trip generation time) or
            2. by stepping up to 100% (if T_{Scen}^* is > max trip generation time)

c. Note: This procedure implies that there may be different staged trip generation distributions for different scenarios, however, that was not the case for this site. NUREG/CR-7002, Rev. 1, uses the statement “approximately 90th percent” as the time to end staging and begin evacuating. The value of T_{Scen}^* is 2:25 for all scenarios (see Region R01 in Table 7-1).

3. Staged trip generation distributions are created for the following population groups:
   a. Residents with returning commuters
   b. Residents without returning commuters

Figure 5-5 and Table 5-9 present the staged trip generation distributions for both residents with and without returning commuters and employees/transients; the 90th percentile 2-Mile Region evacuation time is 145 minutes for all scenarios, on average. At T_{Scen}^*, approximately 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 15 minutes. After T_{Scen}^*+ 15, the remainder of evacuation trips are generated in accordance with the un-staged trip generation distribution.

Figure 5-5 and Table 5-9 provides the trip generation for staged evacuation.

5.4.3 Trip Generation for Waterways and Recreational Areas

The Basic Plan (December 2020), South Carolina Operational Radiological Emergency Response Plan (SCORERP), indicates that the South Carolina Department of Natural Resources (SCDNR) will coordinate the clearance of all lakes and waterways within the 10-mile EPZ.

The VCSNS Site Specific plan (December 2020), Part 3 of the SCORERP states that the SCDNR will “alert persons boating or fishing on Lake Monticello along portions of the Broad River. SCDNR officers will initiate alert and clearing efforts on the lake and river as needed.”

As discussed in Section 2.3, this study assumes a rapidly escalating general emergency. As indicated in Table 5-2, this study assumes 100% notification in 45 minutes which is consistent with the FEMA REP Manual. Table 5-8 indicates that all transients will have mobilized within 1 hour and 45 minutes. It is assumed that this timeframe is sufficient time for boaters, campers and other transients to return to their vehicles or campground facilities, pack their belongings 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

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%

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%	35	88.7%
5	27.4%	40	92.0%
10	47.3%	45	94.2%
15	65.8%	50	94.7%
20	75.1%	55	95.1%
25	77.2%	60	99.2%
30	85.6%	75	100%

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	40	80.6%
5	3.3%	45	89.9%
10	10.3%	50	94.6%
15	23.3%	55	96.7%
20	36.7%	60	98.4%
25	49.5%	75	99.6%
30	60.2%	90	100%
35	70.7%		

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	120	82.3%
15	3.1%	135	91.6%
30	18.4%	150	92.0%
45	32.6%	165	93.3%
60	52.3%	180	94.9%
75	66.7%	195	99.1%
90	72.3%	210	99.3%
105	75.4%	225	100%

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

Table 5-6. 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

Table 5-7. 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).

Table 5-8. Trip Generation Histograms for the EPZ Population for Un-Staged Evacuation[1]

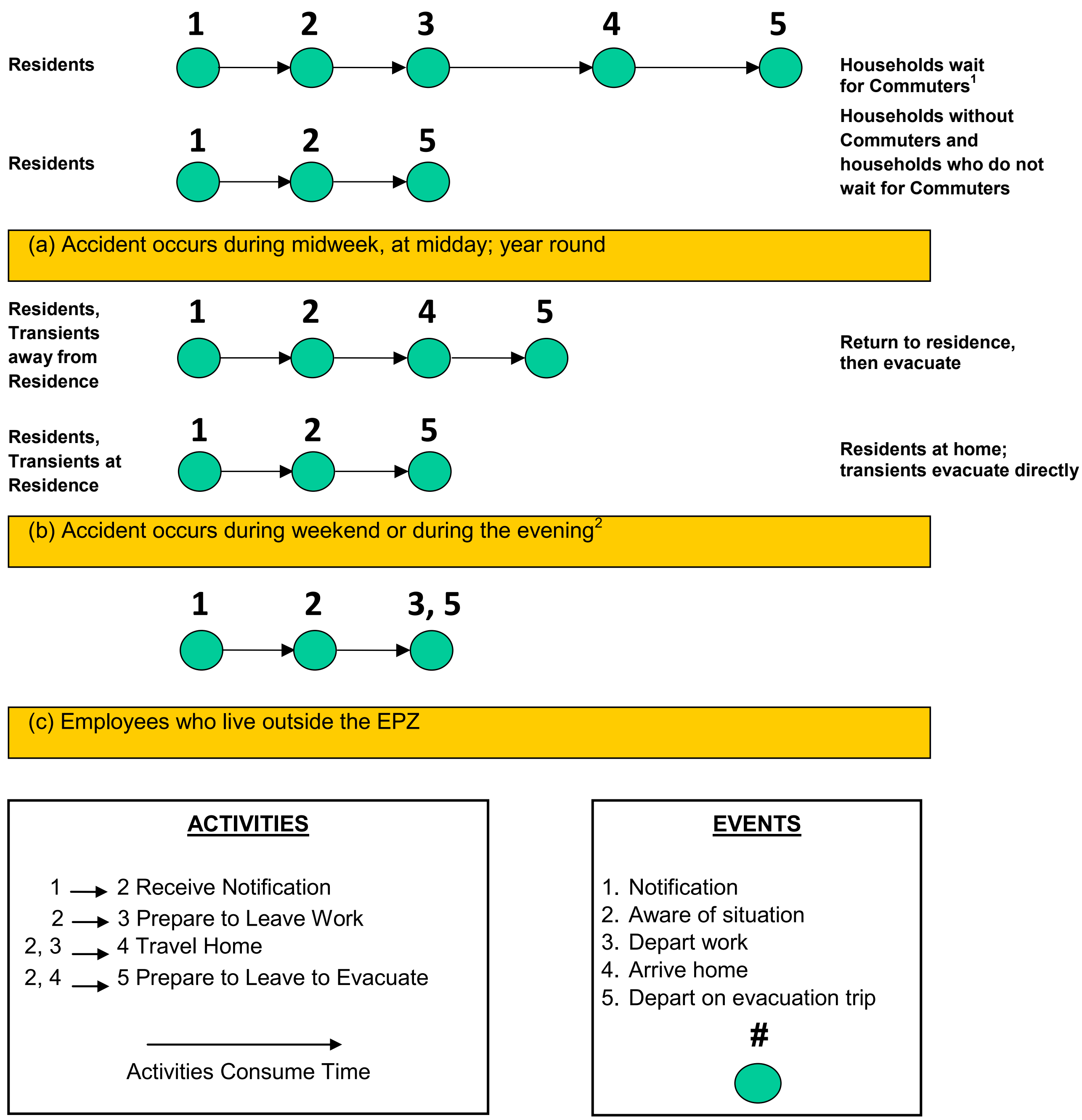
Time Period	Duration (Min)	Percent of Total Trips Generated Within Indicated Time Period			
		Employees (Distribution A)	Transients (Distribution A)	Residents with Commuters (Distribution C)	Residents Without Commuters (Distribution D)
1	15	5%	5%	0%	0%
2	15	29%	29%	0%	2%
3	15	37%	37%	0%	9%
4	15	17%	17%	2%	14%
5	15	7%	7%	4%	17%
6	15	4%	4%	8%	16%
7	15	1%	1%	12%	10%
8	15	0%	0%	14%	6%
9	30	0%	0%	23%	12%
10	30	0%	0%	15%	7%
11	30	0%	0%	10%	4%
12	30	0%	0%	6%	3%
13	30	0%	0%	4%	0%
14	30	0%	0%	2%	0%
15	600	0%	0%	0%	0%

[1] Shadow vehicles are loaded onto the analysis network (Figure 1-2) using Distribution C for good weather. Special event vehicles are loaded using Distribution A.

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

Time Period	Duration (Min)	Percent of Total Trips Generated Within Indicated Time Period[2]	
		Residents with Commuters (Distribution C)	Residents Without Commuters (Distribution D)
1	15	0%	0%
2	15	0%	0%
3	15	0%	2%
4	15	0%	3%
5	15	1%	3%
6	15	2%	4%
7	15	2%	2%
8	15	3%	1%
9	30	23%	26%
10	30	47%	52%
11	30	10%	4%
12	30	6%	3%
13	30	4%	0%
14	30	2%	0%
15	600	0%	0%

[2] Trip Generation for Employees and Transients (see Table 5-8) 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

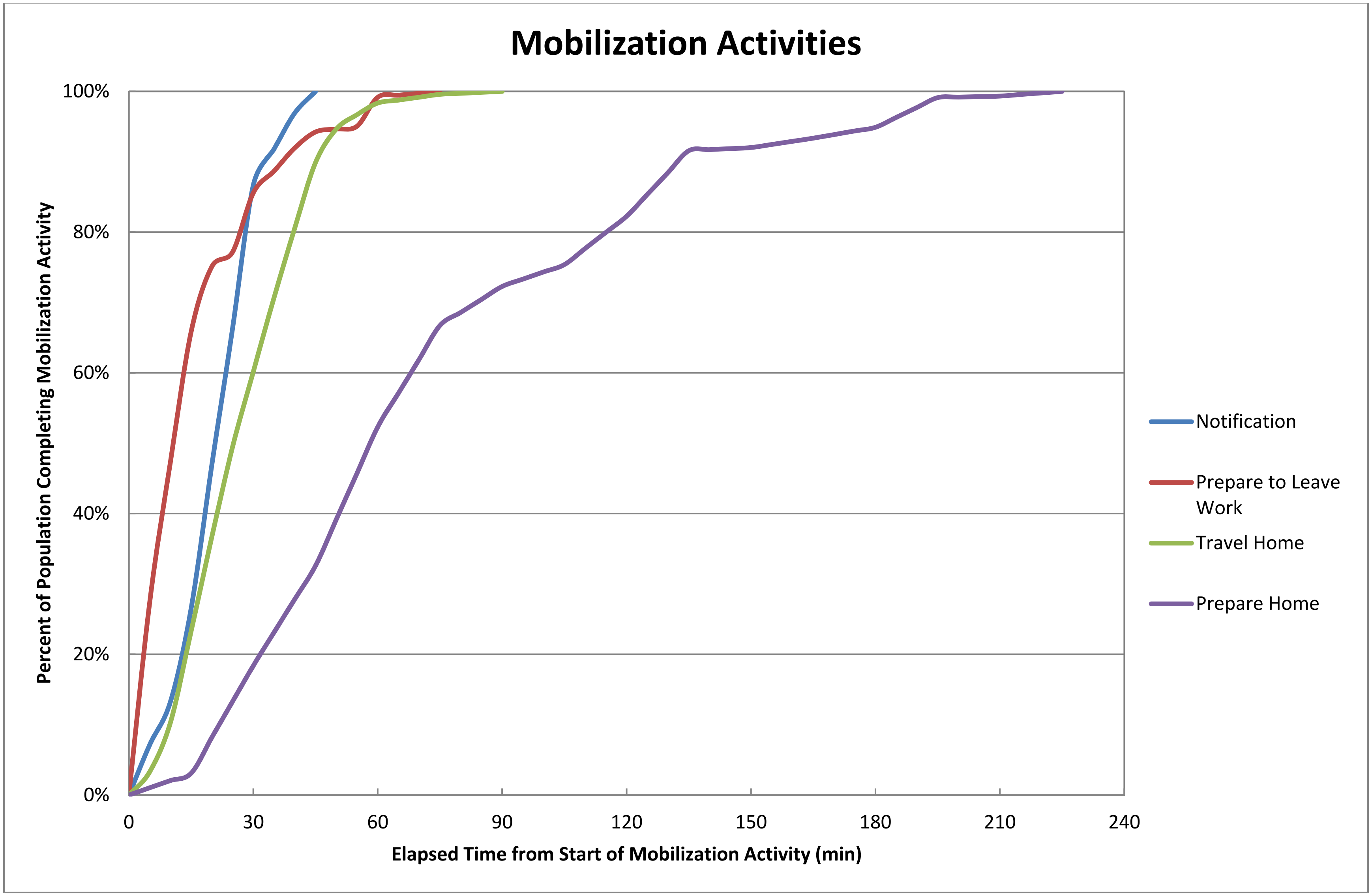


Figure 5-2. Time Distributions for Evacuation Mobilization Activities

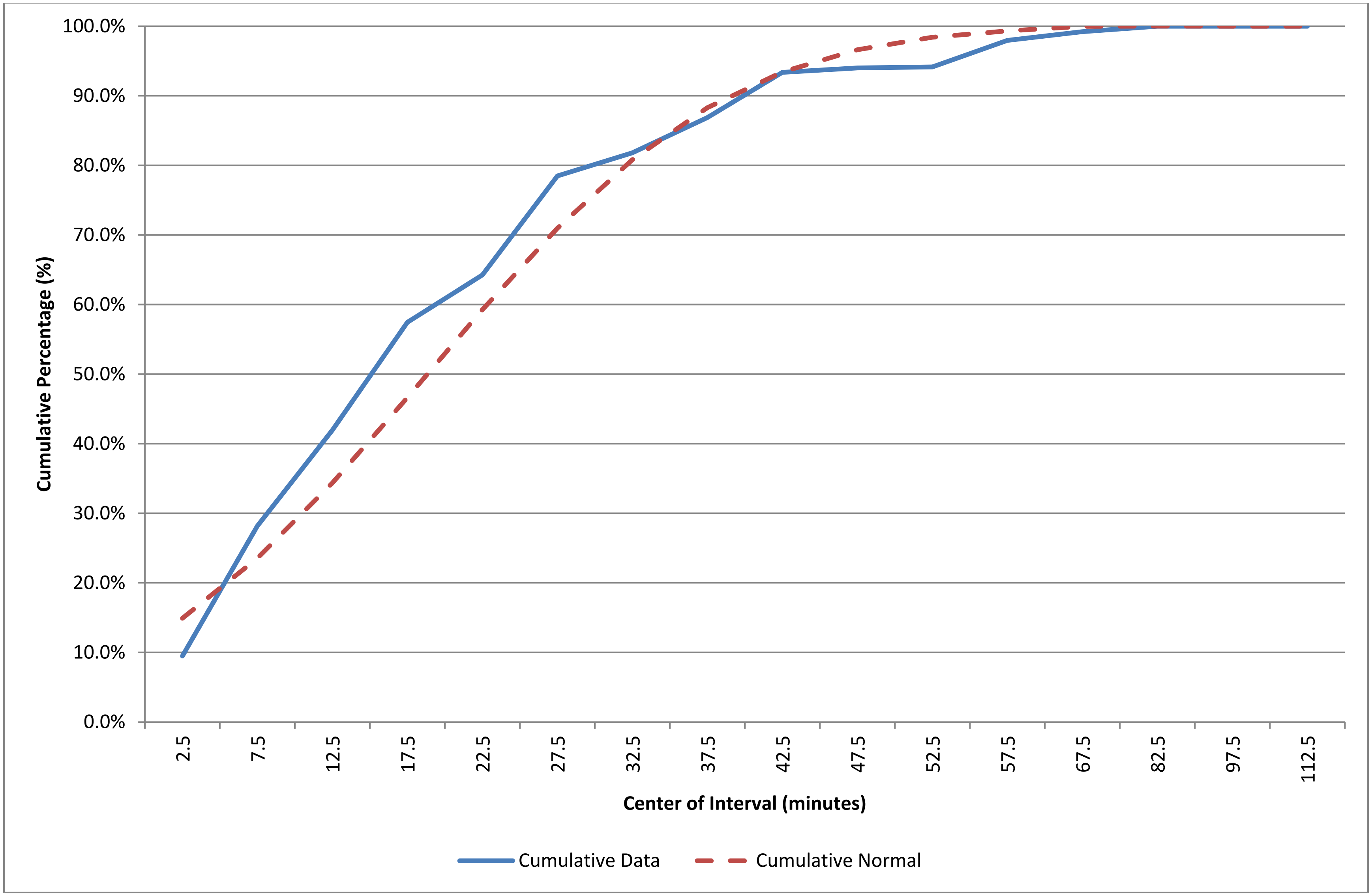


Figure 5-3. Comparison of Data Distribution and Normal Distribution

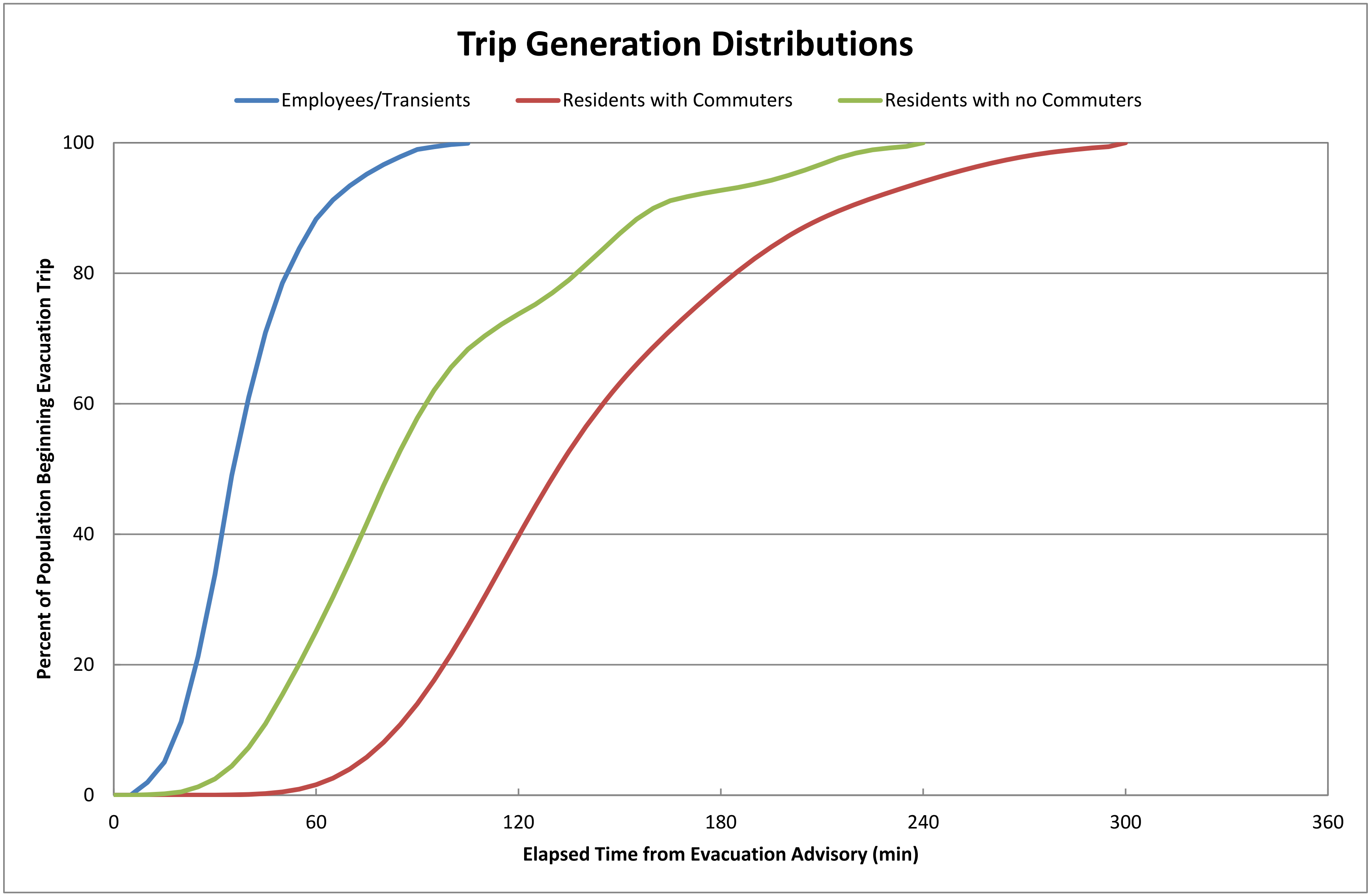


Figure 5-4. Comparison of Trip Generation Distributions

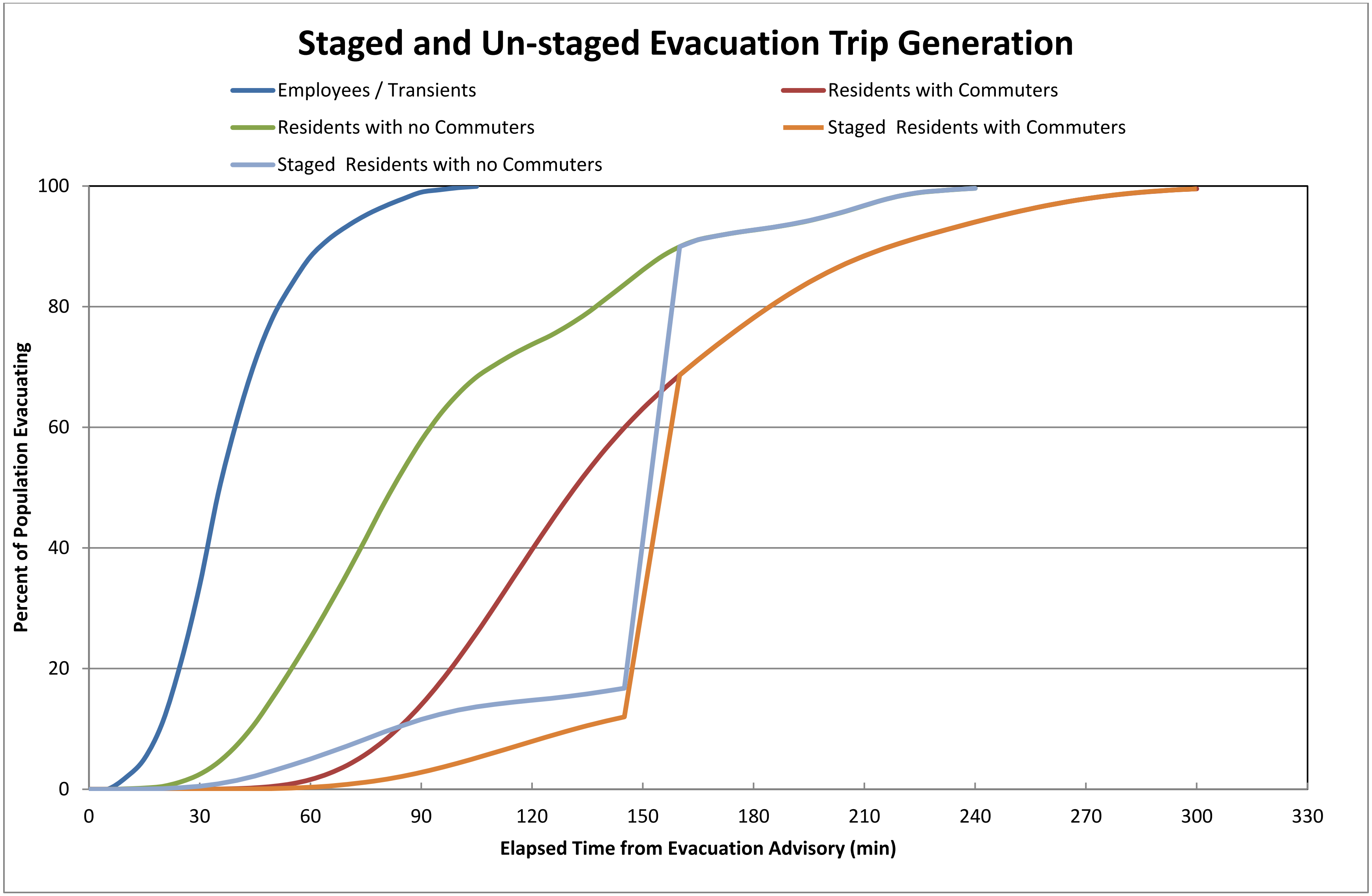


Figure 5-5. Comparison of Staged and Un-staged Trip Generation Distributions in the 2 to 5-Mile Region

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 Protective Action Zones (PAZs), that forms either a "keyhole" sector-based area, or a circular area within the Emergency Planning Zone (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 33 Regions were identified which encompass all the groupings of PAZs considered. These Regions are defined in Table 6-1. The PAZ 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 R24).

Regions R01, R02, and R03 represent evacuations of circular areas with radii of 2, 5 and 10 miles, respectively. Regions R25 through R33 are geographically identical to Region R02 and Regions R04 through R11, respectively; however, those PAZs 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 14 x 33 = 462 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 group and the vehicle estimates presented in Section 3 and 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 35%, which is the product of 60% (the number of households with at least one commuter – see Figure F-6) and 58.4% (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 (35%) will have a commuter at work during those times, or approximately 3% (10% x 35% = 3.5%, rounded to 3%) 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 (70%) during the week. As shown in Appendix E, Table E-5, the majority of transients use campgrounds offering overnight accommodations in the EPZ, offset by the other transit facilities in which evening use is minimal; thus, transient activity is estimated to be relatively high during the summer hours – 75% for evening. The recreational areas in the EPZ (shown in Table E-5) are predominantly outdoors and will be frequented more often during the summer than the winter. As a result, transient activity during winter weekends is estimated to be 30% and less during the week (15%). Since nearly all parks and marinas are closed during the evenings in the winter, transient activity is estimated to be 20%.

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:

$$20\% \times \left(1 + \frac{666}{3{,}338 + 6{,}257}\right) = 21\%$$

One special event – Labor Day Parade in Chapin – was considered as Scenario 13, during the summer, weekend, midday, with good weather. Thus, the special event traffic is 100% evacuated for Scenario 13 and 0% for all other scenarios.

Schools and licensed day care centers are in session during the winter season, midweek, midday and 100% of buses will be needed under those circumstances. It is estimated that summer school enrollment is approximately 10% of enrollment during the regular school year for summer, midweek, midday scenarios. School is not in session during weekends and evening, thus no buses to evacuate school/day care children are needed under those circumstances.

Buses for the transit-dependent population and patients at Generations of Chapin are set to 100% for all scenarios as it is assumed that the transit-dependent population and Generations of Chapin patients are present in the EPZ for all scenarios.

External traffic is estimated to be 100% for all midday scenarios, while it is significantly less (40%) during the evening scenarios.

Table 6-1. Description of Evacuation Regions

Region	Description	Wind Degree From	A-0	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2	E-1	E-2	F-1	F-2
Radial Regions															
R01	2-Mile Region	0° - 359°	X												
R02	5-Mile Region	0° - 359°	X	X		X		X				X		X	
R03	Full EPZ	0° - 359°	X	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 Degree From**	**A-0**	**A-1**	**A-2**	**B-1**	**B-2**	**C-1**	**C-2**	**D-1**	**D-2**	**E-1**	**E-2**	**F-1**	**F-2**
R04	S, SSW	168.8° - 213.8°	X	X		X									
R05	SW, WSW	213.8° - 258.8°	X	X		X		X							
R06	W	258.8° - 281.3°	X			X		X							
R07	WNW, NW	281.3° - 326.3°	X					X							
R08	NNW, N	326.3° - 11.3°	X					X				X			
R09	NNE, NE	11.3° - 56.3°	X									X			
R10	ENE, E	56.3° - 101.3°	X									X		X	
R11	ESE, SE, SSE	101.3° - 168.8°	X	X										X	
Evacuate 2-Mile Region and Downwind to the EPZ Boundary															
Region	**Wind Direction From**	**Wind Degree From**	**A-0**	**A-1**	**A-2**	**B-1**	**B-2**	**C-1**	**C-2**	**D-1**	**D-2**	**E-1**	**E-2**	**F-1**	**F-2**
R12	S	168.8° - 191.3°	X	X	X	X									
R13	SSW	191.3° - 213.8°	X	X	X	X	X								
R14	SW	213.8° - 236.3°	X	X	X	X	X	X							
R15	WSW	236.3° - 258.8°	X	X		X	X	X	X						
R16	W	258.8° - 281.3°	X			X	X	X	X						
R17	WNW, NW	281.3° - 326.3°	X					X	X	X					
R18	NNW	326.3° - 348.8°	X					X	X	X	X	X			
R19	N	348.8° - 11.3°	X					X		X	X	X	X		
R20	NNE	11.3° - 33.8°	X							X	X	X	X		
R21	NE	33.8° - 56.3°	X								X	X	X		X
R22	ENE, E	56.3° - 101.3°	X									X	X	X	X
R23	ESE	101.3° - 123.8°	X	X										X	X
R24	SE, SSE	123.8° - 168.8°	X	X	X									X	X
PAZ(s) Evacuate						PAZ(s) Shelter-in-Place									
Staged Evacuation - 2-Mile Region Evacuates, then Evacuate Downwind to 5 Miles															
Region	**Wind Direction From**	**Wind Degree From**	**A-0**	**A-1**	**A-2**	**B-1**	**B-2**	**C-1**	**C-2**	**D-1**	**D-2**	**E-1**	**E-2**	**F-1**	**F-2**
R25	5-Mile Region	0° - 359°	X	X		X		X				X		X	
R26	S, SSW	168.8° - 213.8°	X	X		X									
R27	SW, WSW	213.8° - 258.8°	X	X		X		X							
R28	W	258.8° - 281.3°	X			X		X							
R29	WNW, NW	281.3° - 326.3°	X					X							
R30	NNW, N	326.3° - 11.3°	X					X				X			
R31	NNE, NE	11.3° - 56.3°	X									X			
R32	ENE, E	56.3° - 101.3°	X									X		X	
R33	ESE, SE, SSE	101.3° - 168.8°	X	X										X	
PAZ(s) Evacuate				PAZ(s) Shelter-in-Place				Shelter-in-Place until 90% ETE for R01, then Evacuate							

Table 6-2. Evacuation Scenario Definitions

Scenarios	Season[1]	Day of Week	Time of Day	Weather	Special
1	Summer	Midweek	Midday	Good	None
2	Summer	Midweek	Midday	Rain	None
3	Summer	Weekend	Midday	Good	None
4	Summer	Weekend	Midday	Rain	None
5	Summer	Midweek, Weekend	Evening	Good	None
6	Winter	Midweek	Midday	Good	None
7	Winter	Midweek	Midday	Rain	None
8	Winter	Midweek	Midday	Ice	None
9	Winter	Weekend	Midday	Good	None
10	Winter	Weekend	Midday	Rain	None
11	Winter	Weekend	Midday	Ice	None
12	Winter	Midweek, Weekend	Evening	Good	None
13	Summer	Weekend	Midday	Good	Special Event: Labor Day Parade in Chapin
14	Summer	Midweek	Midday	Good	Roadway Impact: Lane Closure on I-26 Eastbound

[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	School Buses	Medical Facility	Transit Buses	External Through Traffic
1	35%	65%	96%	70%	21%	0%	10%	100%	100%	100%
2	35%	65%	96%	70%	21%	0%	10%	100%	100%	100%
3	3%	97%	10%	100%	20%	0%	0%	100%	100%	100%
4	3%	97%	10%	100%	20%	0%	0%	100%	100%	100%
5	3%	97%	10%	75%	20%	0%	0%	100%	100%	40%
6	35%	65%	100%	15%	21%	0%	100%	100%	100%	100%
7	35%	65%	100%	15%	21%	0%	100%	100%	100%	100%
8	35%	65%	100%	15%	21%	0%	100%	100%	100%	100%
9	3%	97%	10%	30%	20%	0%	0%	100%	100%	100%
10	3%	97%	10%	30%	20%	0%	0%	100%	100%	100%
11	3%	97%	10%	30%	20%	0%	0%	100%	100%	100%
12	3%	97%	10%	20%	20%	0%	0%	100%	100%	40%
13	3%	97%	10%	100%	20%	100%	0%	100%	100%	100%
14	35%	65%	96%	70%	21%	0%	10%	100%	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.
School, Medical, and Transit Buses .... Vehicle-equivalents present on the road during evacuation servicing schools, licensed day care centers (except those evacuated in personal passenger vehicles), medical facility, and transit-dependent people (1 bus is equivalent to 2 passenger vehicles).
External Through Traffic .... Traffic passing through the EPZ on interstates/freeways and major arterial roads 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]

Scenarios	Residents with Commuters	Residents without Commuters	Employees	Transients	Shadow	Special Event	School Buses[3]	Medical Facility	Transit Buses	External Traffic	Total Scenario Vehicles
1	3,337	6,258	666	298	7,612	0	31	6	12	11,944	30,164
2	3,337	6,258	666	298	7,612	0	31	6	12	11,944	30,164
3	334	9,261	69	425	7,250	0	0	6	12	11,944	29,301
4	334	9,261	69	425	7,250	0	0	6	12	11,944	29,301
5	334	9,261	69	319	7,250	0	0	6	12	4,778	22,029
6	3,337	6,258	694	64	7,612	0	308	6	12	11,944	30,235
7	3,337	6,258	694	64	7,612	0	308	6	12	11,944	30,235
8	3,337	6,258	694	64	7,612	0	308	6	12	11,944	30,235
9	334	9,261	69	128	7,250	0	0	6	12	11,944	29,004
10	334	9,261	69	128	7,250	0	0	6	12	11,944	29,004
11	334	9,261	69	128	7,250	0	0	6	12	11,944	29,004
12	334	9,261	69	85	7,250	0	0	6	12	4,778	21,795
13	334	9,261	69	425	7,250	1,984	0	6	12	11,944	31,285
14	3,337	6,258	666	298	7,612	0	31	6	12	11,944	30,164

[2] Vehicle estimates are for an evacuation of the entire EPZ (Region R03).
[3] The school bus estimates do not include the personal passenger vehicles from Jacqueline Wylie ,Jackie Chappell, and Sally Becker day care centers, as they are already considered in the general population.

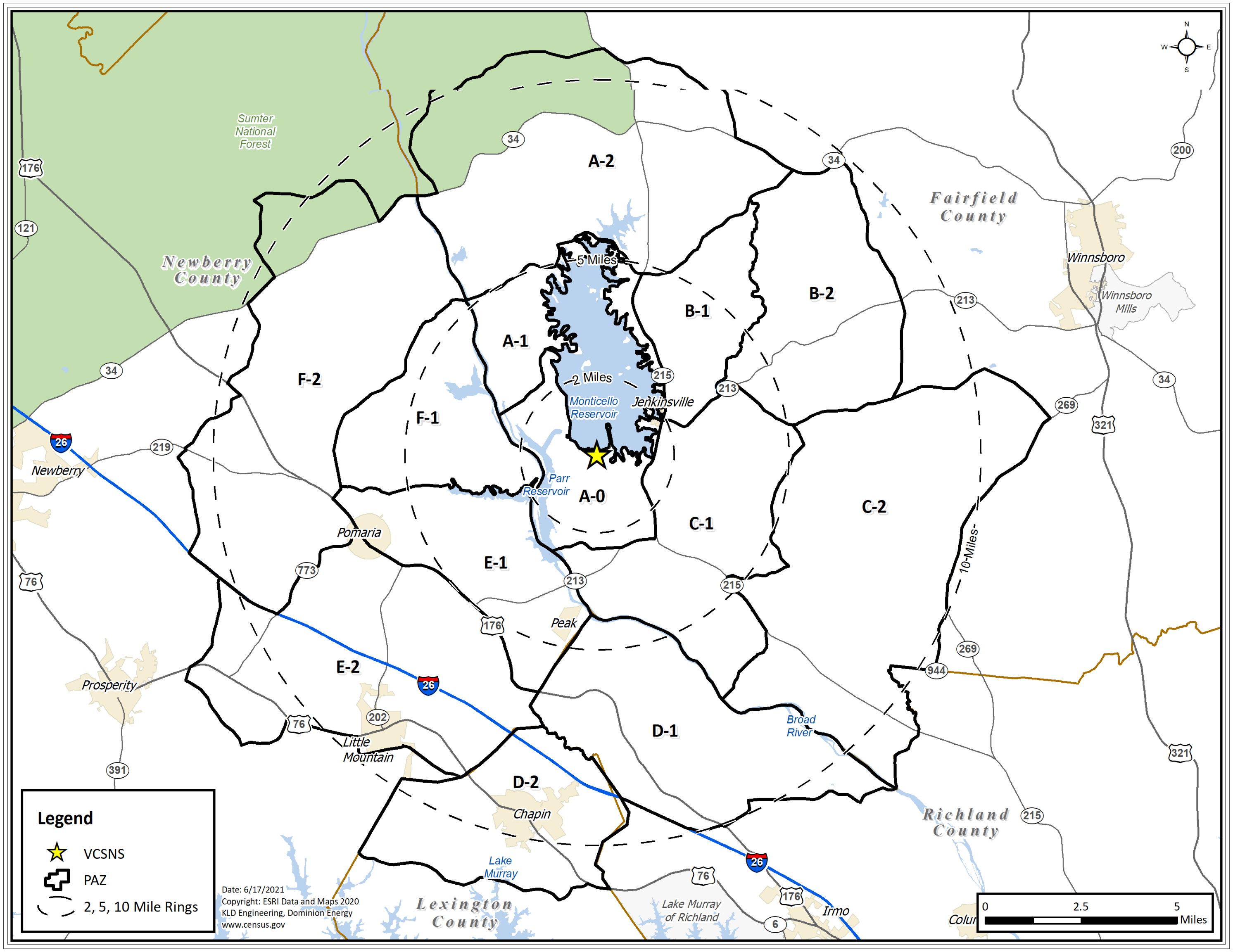


Figure 6-1. Protective Action Zones Comprising the VCSNS EPZ

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 33 Evacuation Regions within the VC Summer Nuclear Station (VCSNS) Emergency Planning Zone (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 Protective Action Zones (PAZs) 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 VCSNS EPZ addresses the issue of voluntary evacuees in the manner shown in Figure 7-1. Within the EPZ, 20% of permanent residents located in PAZs outside of the Evacuation Region who are not advised to evacuate, are assumed to elect to evacuate. Similarly, it is assumed that 20% of the 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 60,006 permanent residents 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 (see Section 3.10), traveling away from the plant location, has the potential for impeding evacuating vehicles from within the Evacuation Region. All ETE calculations include this shadow traffic movement.

7.2 Staged Evacuation

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

1. PAZs comprising the 2-Mile Region are advised to evacuate immediately.

2. PAZs 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 begin evacuating when approximately 90% of those originally within the 2-Mile Region evacuate crosses the 2-Mile Region boundary.
5. The population between the 5-Mile Region boundary to EPZ boundary shelters in place.
6. Non-compliance with the shelter recommendation is the same as the shadow evacuation percentage of 20%.

See Section 5.4.2 for additional information on staged evacuation.

7.3 Patterns of Traffic Congestion during Evacuation

Figure 7-3 through Figure 7-6 illustrate the patterns of traffic congestion (or absence of congestion) that arise for the case when the entire EPZ (Region R03) is advised to evacuate during the summer, midweek, midday period under good weather conditions (Scenario 1).

Traffic congestion, as the term is used here, is defined as Level of Service (LOS) F. LOS F is defined as follows (HCM 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. These include measures such as the back of queue and the identification of the specific intersection approaches or system elements experiencing LOS F conditions.

All highway "links" which experience LOS F are delineated in these figures by a thick red line; all others are lightly indicated.

At 35 minutes after the ATE, Figure 7-3 displays the developing congestion within the population centers of Chapin (PAZ D-2), White Rock and Irmo in the Shadow Region. In addition, minimal delays (LOS B and LOS C) are located on Highway US (US) 76 and Interstate

(I)-26 as external traffic continues before Traffic and Access Control Points (TACP) are established. A stop sign exists at the intersection of Bradham Avenue and County Road (CR) 215, causing minimal delays (LOS B) within the 2-Mile Region, as plant employees and some permanent residents without commuters access CR 215, which clears 15 minutes later at 50 minutes after the ATE. At this time, approximately 41% of employees/transients and 2% of permanent residents without commuters have mobilized and 14% of evacuees have successfully evacuated the EPZ.

At 1 hour and 35 minutes after the ATE, Figure 7-4 displays significant congestion (LOS F) along US 76 eastbound within White Rock, and north of Irmo, as additional evacuees from PAZ D-2 and the Shadow Region begin evacuating. Significant congestion also occurs on State Road S-40-286 southbound as evacuees approach a signalized intersection to gain access to US 76 eastbound. Minimal congestion (LOS C) exists on US 176 as vehicles access on-ramps (which acts as bottlenecks) to I-26. Congestion (LOS D) is now visible on State Route (SR) 6 as evacuees on US 76 choose SR 6 as an alternate evacuation route. I-26 within the EPZ operates at LOS B and LOS C except at the on-ramp locations. US 76 westbound displays some delays (LOS B) as the speed limits reduce from 55 mph to 35 mph, when entering the population center of Prosperity. At this time, approximately 66% of evacuees have mobilized and 55% of evacuees have successfully evacuated the EPZ.

At 2 hours and 40 minutes after the ATE, the congestion within the EPZ area clears and is now operating at a LOS A, as shown in Figure 7-5. Therefore, any evacuees who depart after this time encounters no traffic congestion or delays within the EPZ. Congestion has cleared on I-26 but delays exist as vehicles try to access I-26 from US 176 and SR 60/Lake Murray Road. Significant congestion (LOS F) persists within the Shadow Region on portions of US 76 southeast of White Rock and US 176 northwest of Irmo, as more permanent residents begin to evacuate and are further delayed by approaching a signalized intersection with N Woodrow Street. Minor delays continue on US 76 westbound within Prosperity. At this time, approximately 92% of evacuees have mobilized and 89% of evacuees have successfully evacuated the EPZ.

At 3 hours and 50 minutes after the ATE, approximately 99% of evacuees have mobilized and 98% of evacuees have successfully evacuated the EPZ. This indicates that the trip generation plus the time to travel to the EPZ boundary (5 hours and 10 minutes) is dictating the 100^{th} percentile ETE. Figure 7-6 displays the last of the congestion (LOS B) which exists only on US 76 just north of Irmo (within the Shadow Region), which clears 15 minutes later at 4 hours and 5 minutes after the ATE.

7.4 Evacuation Rates

Evacuation is a continuous process, as implied by Figure 7-7 through Figure 7-20. 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 7-7 through Figure 7-20, there is typically a long "tail" to these distributions due to the mobilization and not congestion (low population demand). 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 and Table 7-2 present the ETE values for all 33 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 the 2-Mile Region with both Concurrent and Staged Evacuations of additional PAZs downwind in the keyhole Region.
7-4	The 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 PAZs downwind in the keyhole Region.

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 7-6. There is no traffic congestion within the EPZ except along US 76 located in PAZ D-2, northwest of Irma and on Bradham Avenue within PAZ A-0, which results in ETE values which parallel the mobilization time; this is reflected in the ETE statistics:

- The 2-Mile Region (Region R01) consists of mostly plant employee vehicles and a small percentage (1.1%) of permanent resident vehicles. The congestion within this region is mostly based on the plant employees and some permanent residents evacuating on Bradham Boulevard, to gain access to CR 215. Even though employees mobilize quickly (within 105 minutes), the permanent residents with commuters take much longer to mobilize (300 minutes), as shown in Figure 5-4. As such, the 90th percentile ETE for the 2-Mile Region (R01) ranges between 2:05 (hours:minutes) and 2:35 for all scenarios, which mimics the combination of the quick mobilizing employees and the slow mobilizing permanent residents with commuters.
- The 5-Mile Region (Region R02) has no congestion within the Region (except the delays within the 2-Mile Region, already discussed above). Region R02 consists of 26.7% transient/employee vehicles and 7.3% permanent resident vehicles (i.e., higher than Region R01), which increases the mobilization time (see Figure 5-4 – mobilization time is longer for permanent residents than for employees/transients). As a result, the 90th percentile ETE for Region R02 ranges between 2:35 and 2:50.
- The 90th percentile ETE for the full EPZ (Region R03) are up to 25 minutes longer than for Region R02. The 90th percentile ETE ranges between 2:35 and 3:15 for all scenarios.
- The 100th percentile ETE for all Regions and Scenarios parallel mobilization time, as the minimal congestion within the EPZ dissipates (no speed and capacity reductions exist) after 2 hours and 40 minutes after the ATE, as displayed in Figure 7-6 and discussed in Section 7.3. The 100th percentile ETE ranges from 5:00 to 5:10 (mobilization time plus 10 minutes to travel out of the EPZ).

Comparison of Scenarios 3 and 13 in Table 7-1 and Table 7-2 indicate that the Special Event – Labor Day Parade in Chapin – has no impact to the 90th percentile ETEs. The additional 1,984 transient vehicles considered for the special event will increase congestion and the number of transients locally in Chapin, Lexington County, but due to the excess capacity to service the additional evacuating demand, traffic congestion within the EPZ still clears before the trip generation (plus the travel time to the EPZ boundary). As a result, the 100th percentile ETE are not impacted by the special event.

Comparison of Scenarios 1 and 14 in Table 7-1 and Table 7-2 indicate that the roadway impact – a single lane closure on I-26 eastbound from the interchange with Columbia Avenue (Exit 91) to the interchange with SR 60 (Exit 102A/B) has no impact on the 90th percentile ETE for all Regions except for Region R03 and Regions R18 through R22. During an evacuation of Region R03 and Regions R18 through R22, the 90th percentile ETE increases at most by 40 minutes. Minor congestion is visible on I-26 eastbound or from roads accessing I-26 within PAZ D-2 and/or PAZ E-1 as well as outside of the EPZ. As such, the closure of a single lane on I-26 eastbound reduces the roadway capacity, prolonging traffic congestion. There is no impact to the 100th percentile ETE, as the trip generation (plus the travel time to the EPZ boundary) dictates the 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 results. Note that Regions R25 through R33 are geographically identical to Regions R02 and Regions 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 is to show that the ETE for the 2-Mile Region can be significantly reduced (30 minutes or 25%, whichever is less) without significantly impacting people beyond the regions between 2 miles and 5 miles. As shown in Table 7-3 and Table 7-4, the 90^{th} percentile ETE for the 2-Mile Region remains the same or increases by at most 30 minutes when a staged evacuation is implemented for all Scenarios. As discussed in Section 7.3 and shown in Figure 7-3 through Figure 7-6, there is little to no congestion between the 2-Mile Region and 5-Mile Region. For the 2-Mile Region, the 100^{th} percentile ETE remains the same, as the trip generation (plus the travel time to the EPZ boundary) dictates the ETE.

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 R25 through R33, 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 area by at most 30 minutes (see Table 7-1) for the 90^{th} percentile and has no impact on the 100^{th} percentile ETE. The increase in the 90^{th} percentile ETE is due to the 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 or evacuating vehicles. This spike oversaturates evacuation routes, which increases traffic congestion and prolongs ETE.

Therefore, staging evacuation provides no benefits to evacuees within the 2-Mile Region and adversely impacts many evacuees located beyond the 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 90^{th} percentile). The applicable value of ETE within the chosen table may then be identified using the following procedure:

- 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
  - Ice
- Special Event
  - Labor Day Parade in Chapin
- Roadway Impact
  - A single lane closure on I-26 eastbound from Columbia Avenue (Exit 91) to SR 60 (Exit 102A/B).
- Evacuation Staging
  - No, Staged Evacuation is not considered
  - Yes, Staged Evacuation is considered

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

- The conditions of a summer evening (either midweek or weekend) and rain are not explicitly identified in the Tables. For these conditions, Scenarios (2) and (4) apply.
- The conditions of a winter evening (either midweek or weekend) and rain are not explicitly identified in the Tables. For these conditions, Scenarios (7) and (10) for rain apply.
- The conditions of a winter evening (either midweek or weekend) and ice are not explicitly identified in the Tables. For these conditions, Scenarios (8) and (11) for ice apply.
- The seasons are defined as follows:
  - Summer assumes 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 traveling to/from work.

- With the desired percentile ETE and Scenario identified, now identify the **Evacuation Region (Step 2)**:

  - Determine the projected azimuth direction of the plume (coincident with the wind direction). This direction is expressed in terms of compass orientation: from N, NNE, NE, …
  - Determine the distance that the Evacuation Region will extend from the nuclear power plant. The applicable distances and their associated candidate Regions are given below:
    - 2 Miles (Region R01)
    - To 5 Miles (Regions R02, R04 through R11)
    - To EPZ Boundary (Regions R03, R12 through R24)
  - Enter Table 7-5 and identify the applicable group of candidate Regions based on the

distance that the selected Region extends from the plant. Select the Evacuation Region identifier in that row, based on the azimuth direction of the plume, from the first column of the table.

- Determine the **ETE Table** based on the **percentile** selected. Then, for the **Scenario** identified in Step 1 and the **Evacuation Region** identified in Step 2, proceed as follows:
  - The columns of Table 7-1 are labeled with the Scenario numbers. Identify the proper column in the selected table using the Scenario number 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 10:00 PM.
- 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 the EPZ boundary.
- The desired ETE is that value needed to evacuate 90 percent of the population from within the impacted Region
- A staged evacuation is not desired

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

1. Identify the Scenario as summer, weekend, evening and raining. Entering Table 7-1, it is seen that there is no match for these descriptors. However, the clarification given above assigns this combination of circumstances to Scenario 4.
2. Enter Table 7-5 and locate the Region described as “Evacuate 2-Mile Region and Downwind to the EPZ Boundary” for wind direction from the NE and read Region R21 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 R21. This data cell is in column (4) and in the row for Region R21; it contains the ETE value of **2:25**.

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	Ice	Good Weather	Rain	Ice	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region, 5-Mile Region, and EPZ														
R01	2:05	2:10	2:35	2:35	2:35	2:05	2:05	2:05	2:35	2:35	2:35	2:35	2:35	2:05
R02	2:45	2:50	2:35	2:35	2:45	2:50	2:50	2:50	2:35	2:35	2:35	2:45	2:35	2:45
R03	2:45	2:50	2:35	2:35	2:45	2:50	2:50	2:50	2:35	2:35	2:35	2:45	2:35	3:15
Evacuate 2-Mile Region and Downwind to 5 Miles														
R04	2:50	2:50	2:45	2:45	2:45	2:50	2:50	2:50	2:45	2:45	2:45	2:45	2:45	2:50
R05	2:55	2:55	2:45	2:50	2:50	2:55	2:55	2:55	2:50	2:50	2:50	2:50	2:45	2:55
R06	2:50	2:50	2:45	2:45	2:45	2:50	2:50	2:50	2:50	2:50	2:50	2:50	2:45	2:50
R07	2:40	2:40	2:50	2:50	2:50	2:40	2:40	2:40	2:50	2:50	2:50	2:50	2:50	2:40
R08	2:35	2:35	2:25	2:25	2:40	2:35	2:40	2:40	2:30	2:30	2:30	2:45	2:25	2:35
R09	2:25	2:30	2:20	2:25	2:35	2:30	2:30	2:30	2:25	2:25	2:25	2:40	2:20	2:25
R10	2:30	2:35	2:25	2:25	2:40	2:35	2:35	2:35	2:25	2:25	2:30	2:40	2:25	2:30
R11	2:50	2:50	2:40	2:45	2:45	2:50	2:50	2:50	2:45	2:45	2:45	2:45	2:40	2:50
Evacuate 2-Mile Region and Downwind to the EPZ Boundary														
R12	3:00	3:05	2:50	2:55	2:50	3:00	3:05	3:05	2:55	2:55	2:55	2:55	2:50	3:00
R13	3:00	3:05	2:50	2:55	2:55	3:05	3:05	3:05	2:55	2:55	2:55	2:55	2:50	3:00
R14	3:05	3:05	2:55	2:55	2:55	3:05	3:05	3:05	2:55	2:55	2:55	2:55	2:55	3:05
R15	3:00	3:00	2:45	2:45	2:45	3:00	3:00	3:05	2:50	2:50	2:50	2:50	2:45	3:00
R16	2:55	2:55	2:45	2:45	2:45	3:00	3:00	3:00	2:50	2:50	2:50	2:50	2:45	2:55
R17	3:00	3:00	2:45	2:45	2:50	3:00	3:00	3:00	2:45	2:45	2:45	2:50	2:45	3:00
R18	2:30	2:35	2:20	2:25	2:40	2:35	2:35	2:40	2:20	2:25	2:25	2:40	2:20	3:10

	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	Ice	Good Weather	Rain	Ice	Good Weather	Special Event	Roadway Impact
R19	2:35	2:40	2:25	2:25	2:40	2:35	2:40	2:45	2:25	2:25	2:30	2:40	2:25	3:15
R20	2:35	2:40	2:25	2:25	2:40	2:35	2:40	2:45	2:25	2:25	2:30	2:40	2:25	3:15
R21	2:35	2:35	2:20	2:25	2:40	2:35	2:35	2:35	2:20	2:25	2:25	2:40	2:20	3:10
R22	2:15	2:20	2:10	2:15	2:25	2:15	2:20	2:20	2:10	2:15	2:15	2:25	2:10	2:35
R23	2:15	2:15	2:10	2:15	2:20	2:15	2:15	2:20	2:10	2:15	2:15	2:20	2:10	2:15
R24	2:15	2:20	2:15	2:15	2:20	2:15	2:20	2:20	2:15	2:15	2:15	2:20	2:15	2:15
Staged Evacuation - 2-Mile Region Evacuates, then Evacuate Downwind to 5 Miles														
R25	3:00	3:00	2:55	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	2:55	3:00
R26	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00
R27	3:00	3:05	3:00	3:00	3:00	3:00	3:05	3:05	3:00	3:00	3:00	3:00	3:00	3:00
R28	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00
R29	2:55	3:00	3:00	3:00	3:00	2:55	2:55	3:00	3:00	3:00	3:00	3:00	3:00	2:55
R30	2:55	2:55	2:55	2:55	3:00	2:55	2:55	2:55	2:55	2:55	2:55	3:00	2:55	2:55
R31	2:50	2:50	2:50	2:50	2:55	2:50	2:55	2:55	2:50	2:50	2:55	3:00	2:50	2:50
R32	2:55	2:55	2:55	2:55	3:00	2:55	2:55	2:55	2:55	2:55	2:55	3:00	2:55	2:55
R33	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00	3:00

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	Ice	Good Weather	Rain	Ice	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region, 5-Mile Region, and EPZ														
R01	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R02	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R03	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
Evacuate 2-Mile Region and Downwind to 5 Miles														
R04	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R06	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R07	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R08	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R09	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R10	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R11	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
Evacuate 2-Mile Region and Downwind to the EPZ Boundary														
R12	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R13	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R14	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R15	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R16	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R17	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R18	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10

	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**	**Ice**	**Good Weather**	**Rain**	**Ice**	**Good Weather**	**Special Event**	**Roadway Impact**
R19	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R20	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R21	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R22	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R23	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
R24	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10	5:10
Staged Evacuation - 2-Mile Region Evacuates, then Evacuate Downwind to 5 Miles														
R25	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R26	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R27	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R28	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R29	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R30	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R31	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R32	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05
R33	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05	5:05

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	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Ice	Good Weather	Rain	Ice	Good Weather	Special Event	Roadway Impact
Un-staged Evacuation - 2-Mile Region and 5-Mile Region														
R01	2:05	2:10	2:35	2:35	2:35	2:05	2:05	2:05	2:35	2:35	2:35	2:35	2:35	2:05
R02	2:20	2:20	2:40	2:40	2:40	2:15	2:15	2:15	2:40	2:40	2:40	2:40	2:40	2:20
Un-staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R04	2:05	2:10	2:35	2:35	2:35	2:05	2:05	2:05	2:35	2:35	2:35	2:35	2:35	2:05
R05	2:15	2:15	2:40	2:40	2:40	2:15	2:15	2:15	2:40	2:40	2:40	2:40	2:40	2:15
R06	2:15	2:15	2:40	2:40	2:40	2:15	2:15	2:15	2:40	2:40	2:40	2:40	2:40	2:15
R07	2:15	2:20	2:40	2:40	2:40	2:15	2:15	2:15	2:40	2:40	2:40	2:40	2:40	2:15
R08	2:15	2:20	2:40	2:40	2:40	2:15	2:15	2:15	2:40	2:40	2:40	2:40	2:40	2:15
R09	2:05	2:10	2:35	2:35	2:35	2:05	2:05	2:05	2:35	2:35	2:35	2:35	2:35	2:05
R10	2:05	2:10	2:35	2:35	2:35	2:05	2:05	2:05	2:35	2:35	2:35	2:35	2:35	2:05
R11	2:05	2:10	2:35	2:35	2:35	2:05	2:05	2:05	2:35	2:35	2:35	2:35	2:35	2:05
Staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R25	2:35	2:35	2:55	2:55	2:55	2:35	2:35	2:35	2:55	2:55	2:55	2:55	2:55	2:35
R26	2:10	2:15	2:40	2:40	2:40	2:10	2:10	2:10	2:40	2:40	2:40	2:40	2:40	2:10
R27	2:35	2:35	2:55	2:55	2:55	2:35	2:35	2:35	2:55	2:55	2:55	2:55	2:55	2:35
R28	2:35	2:35	2:55	2:55	2:55	2:35	2:35	2:35	2:55	2:55	2:55	2:55	2:55	2:35
R29	2:35	2:35	2:55	2:55	2:55	2:35	2:35	2:35	2:55	2:55	2:55	2:55	2:55	2:35
R30	2:35	2:35	2:55	2:55	2:55	2:35	2:35	2:35	2:55	2:55	2:55	2:55	2:55	2:35
R31	2:10	2:15	2:40	2:40	2:40	2:10	2:10	2:10	2:40	2:40	2:40	2:40	2:40	2:10
R32	2:10	2:15	2:40	2:40	2:40	2:10	2:10	2:10	2:40	2:40	2:40	2:40	2:40	2:10
R33	2:10	2:15	2:40	2:40	2:40	2:10	2:10	2:10	2:40	2:40	2:40	2:40	2:40	2:10

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	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Ice	Good Weather	Rain	Ice	Good Weather	Special Event	Roadway Impact
Un-staged Evacuation - 2-Mile Region and 5-Mile Region														
R01	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R02	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
Un-staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R04	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R05	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R06	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R07	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R08	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R09	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R10	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R11	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
Staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R25	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R26	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R27	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R28	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R29	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R30	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R31	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R32	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00
R33	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00	5:00

Table 7-5. Description of Evacuation Regions

Radial Regions															
Region	**Description**	**Wind Degree From**	**PAZ A-0**	**A-1**	**A-2**	**B-1**	**B-2**	**C-1**	**C-2**	**D-1**	**D-2**	**E-1**	**E-2**	**F-1**	**F-2**
R01	2-Mile Region	0° - 359°	X												
R02	5-Mile Region	0° - 359°	X	X		X		X				X		X	
R03	Full EPZ	0° - 359°	X	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 Degree From**	**PAZ A-0**	**A-1**	**A-2**	**B-1**	**B-2**	**C-1**	**C-2**	**D-1**	**D-2**	**E-1**	**E-2**	**F-1**	**F-2**
R04	S, SSW	168.8° - 213.8°	X	X		X									
R05	SW, WSW	213.8° - 258.8°	X	X		X		X							
R06	W	258.8° - 281.3°	X			X		X							
R07	WNW, NW	281.3° - 326.3°	X					X							
R08	NNW, N	326.3° - 11.3°	X					X				X			
R09	NNE, NE	11.3° - 56.3°	X									X			
R10	ENE, E	56.3° - 101.3°	X									X		X	
R11	ESE, SE, SSE	101.3° - 168.8°	X	X										X	
Evacuate 2-Mile Region and Downwind to the EPZ Boundary															
Region	**Wind Direction From**	**Wind Degree From**	**PAZ A-0**	**A-1**	**A-2**	**B-1**	**B-2**	**C-1**	**C-2**	**D-1**	**D-2**	**E-1**	**E-2**	**F-1**	**F-2**
R12	S	168.8° - 191.3°	X	X	X	X									
R13	SSW	191.3° - 213.8°	X	X	X	X	X								
R14	SW	213.8° - 236.3°	X	X	X	X	X	X							
R15	WSW	236.3° - 258.8°	X	X		X	X	X	X						
R16	W	258.8° - 281.3°	X			X	X	X	X						
R17	WNW, NW	281.3° - 326.3°	X					X	X	X					
R18	NNW	326.3° - 348.8°	X					X	X	X	X	X			
R19	N	348.8° - 11.3°	X					X		X	X	X	X		
R20	NNE	11.3° - 33.8°	X							X	X	X	X		
R21	NE	33.8° - 56.3°	X								X	X	X		X
R22	ENE, E	56.3° - 101.3°	X									X	X	X	X
R23	ESE	101.3° - 123.8°	X	X										X	X
R24	SE, SSE	123.8° - 168.8°	X	X	X									X	X
PAZ(s) Evacuate						PAZ(s) Shelter-in-Place									
Staged Evacuation - 2-Mile Region Evacuates, then Evacuate Downwind to 5 Miles															
Region	**Wind Direction From**	**Wind Degree From**	**PAZ A-0**	**A-1**	**A-2**	**B-1**	**B-2**	**C-1**	**C-2**	**D-1**	**D-2**	**E-1**	**E-2**	**F-1**	**F-2**
R25	5-Mile Region	0° - 359°	X	X		X		X				X		X	
R26	S, SSW	168.8° - 213.8°	X	X		X									
R27	SW, WSW	213.8° - 258.8°	X	X		X		X							
R28	W	258.8° - 281.3°	X			X		X							
R29	WNW, NW	281.3° - 326.3°	X					X							
R30	NNW, N	326.3° - 11.3°	X					X				X			
R31	NNE, NE	11.3° - 56.3°	X									X			
R32	ENE, E	56.3° - 101.3°	X									X		X	
R33	ESE, SE, SSE	101.3° - 168.8°	X	X										X	
PAZ(s) Evacuate				PAZ(s) Shelter-in-Place				Shelter-in-Place until 90% ETE for R01, then Evacuate							

Figure 7-1. Voluntary Evacuation Methodology

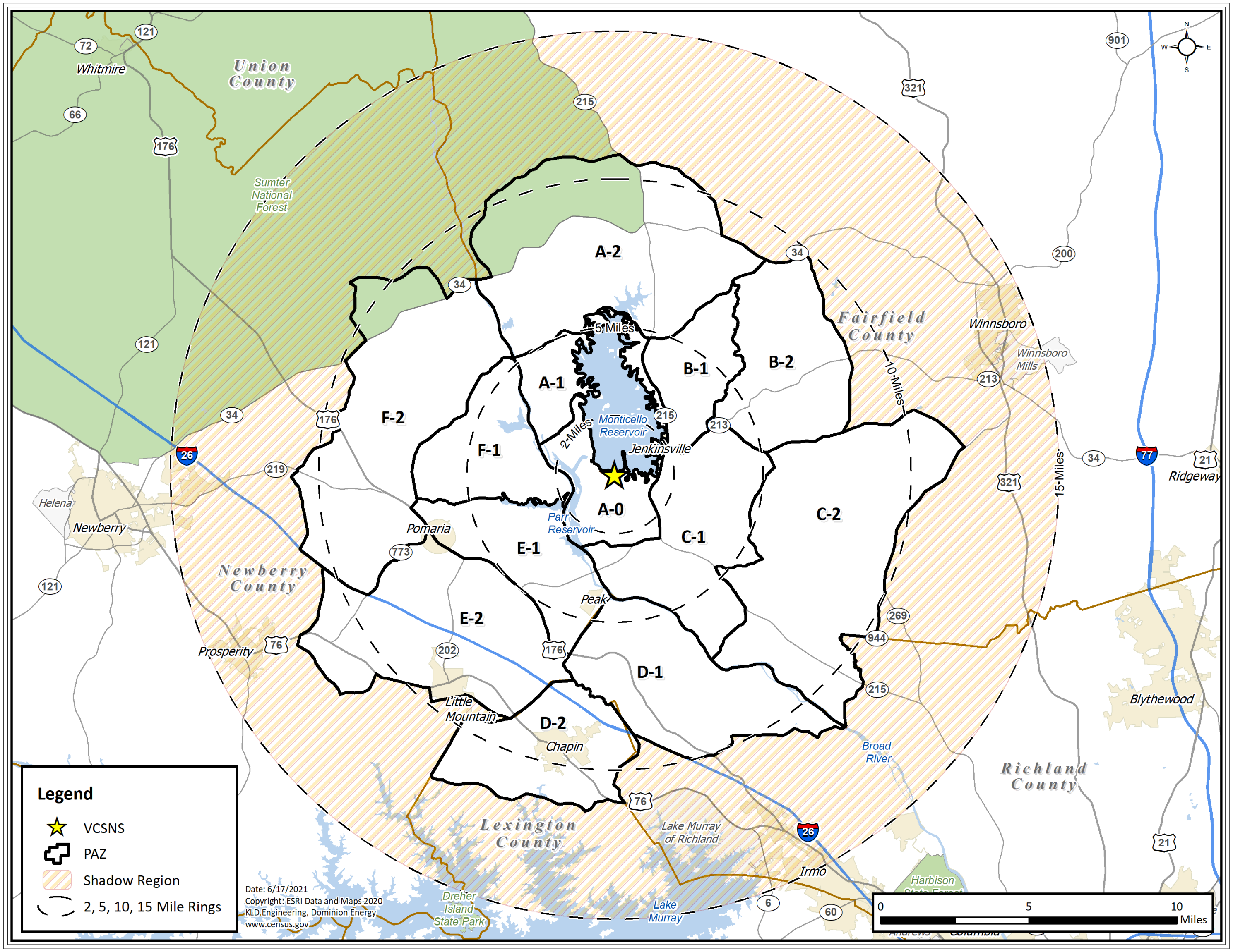


Figure 7-2. VCSNS Shadow Region

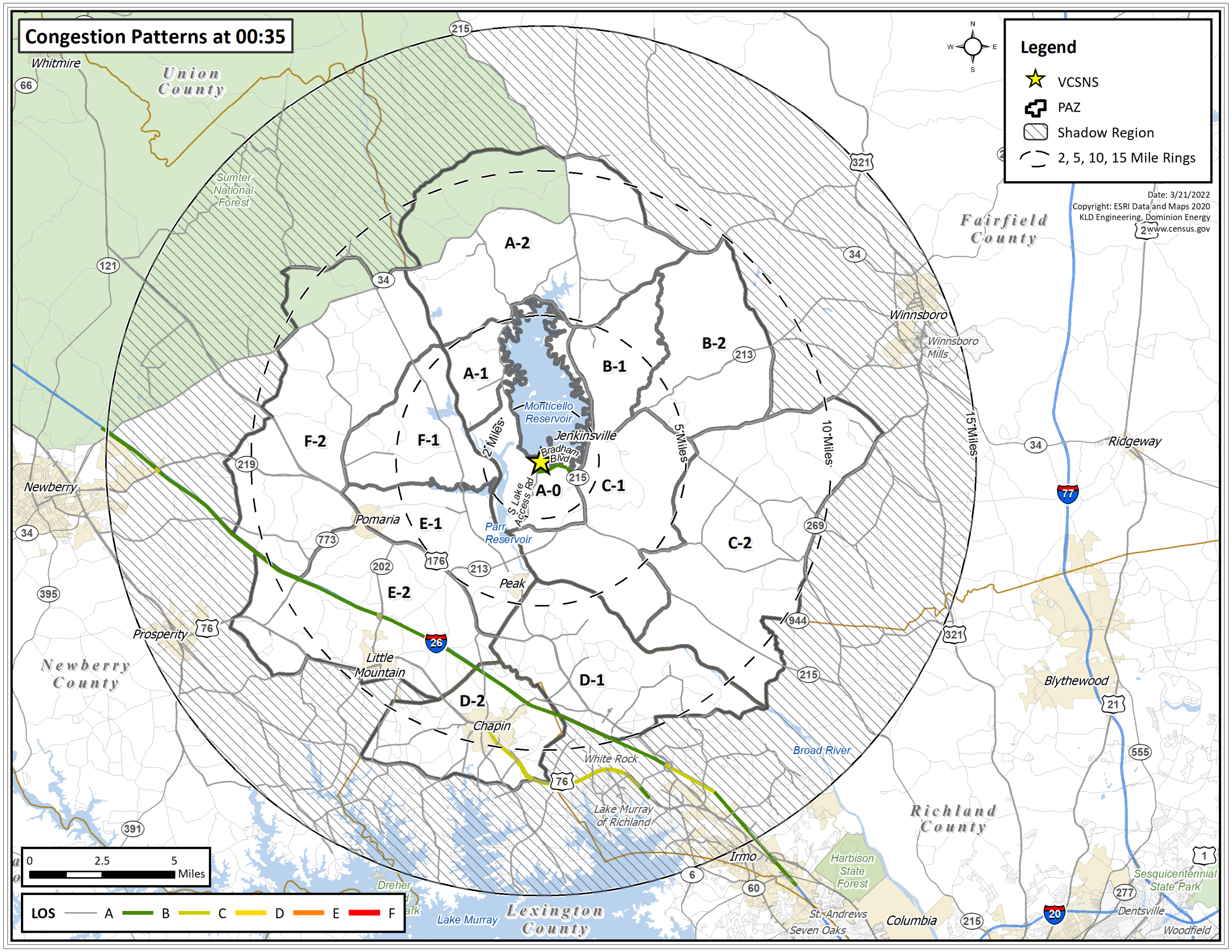


Figure 7-3. Congestion Patterns at 35 Minutes after the Advisory to Evacuate

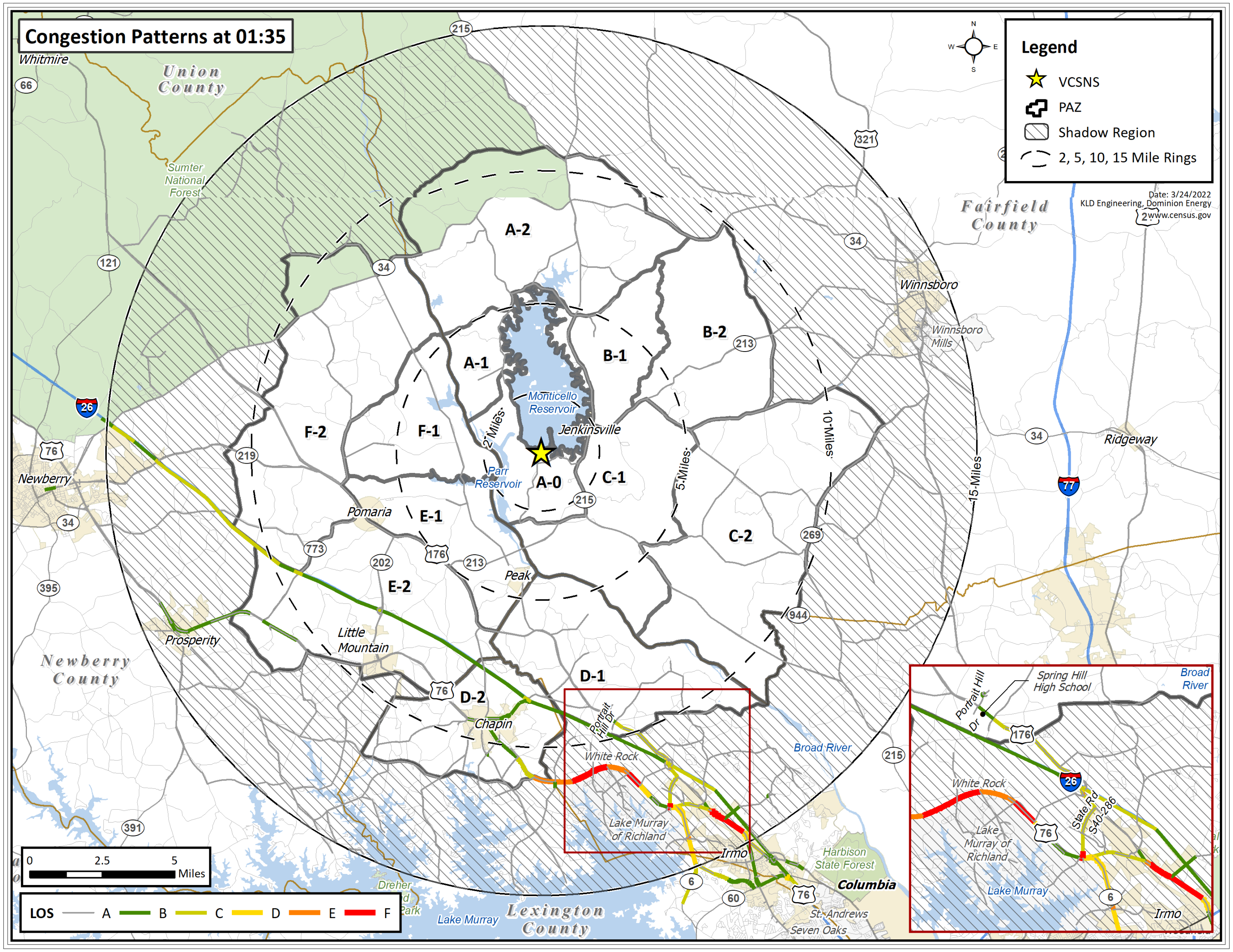


Figure 7-4. Congestion Patterns at 1 Hour and 35 Minutes after the Advisory to Evacuate

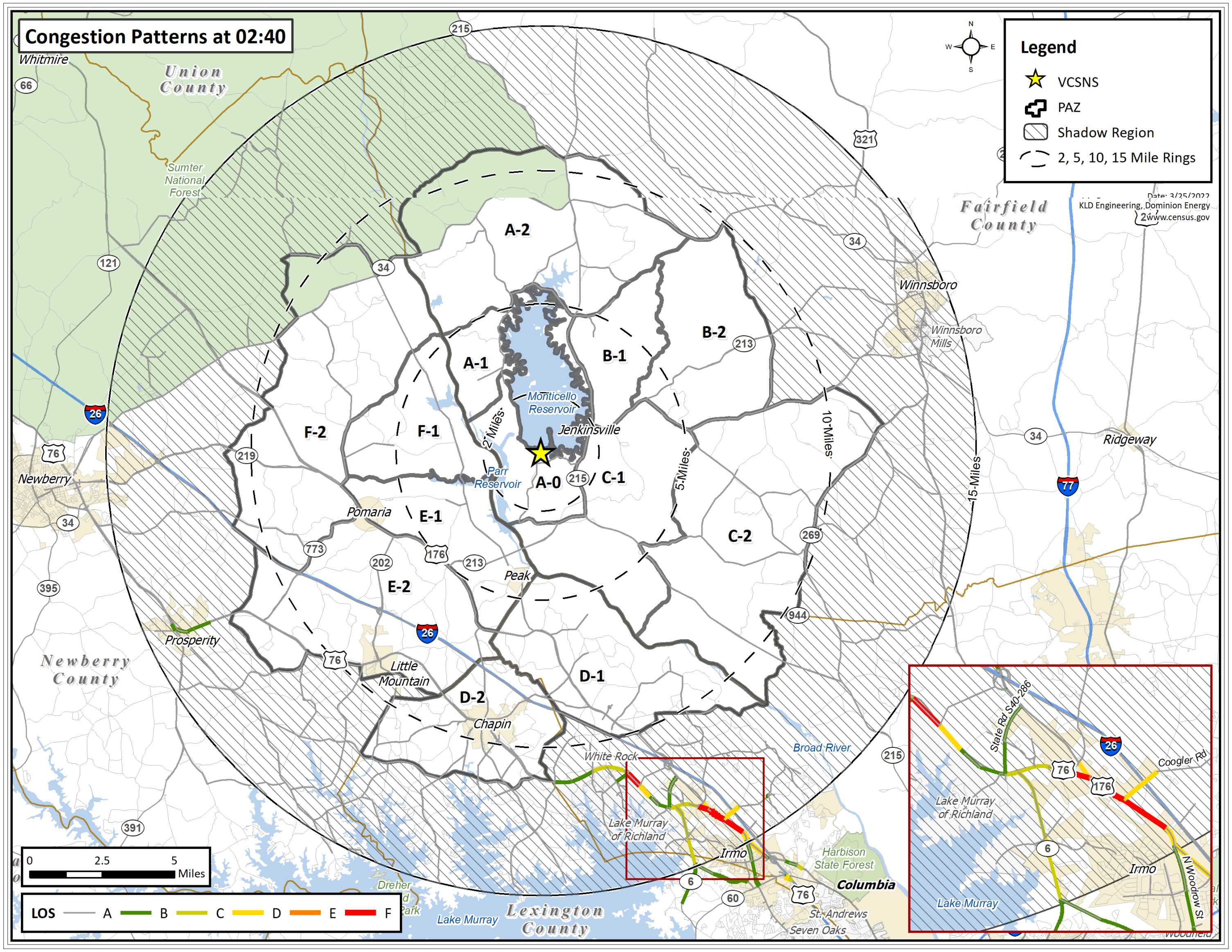


Figure 7-5. Congestion Patterns at 2 Hours and 40 Minutes after the Advisory to Evacuate

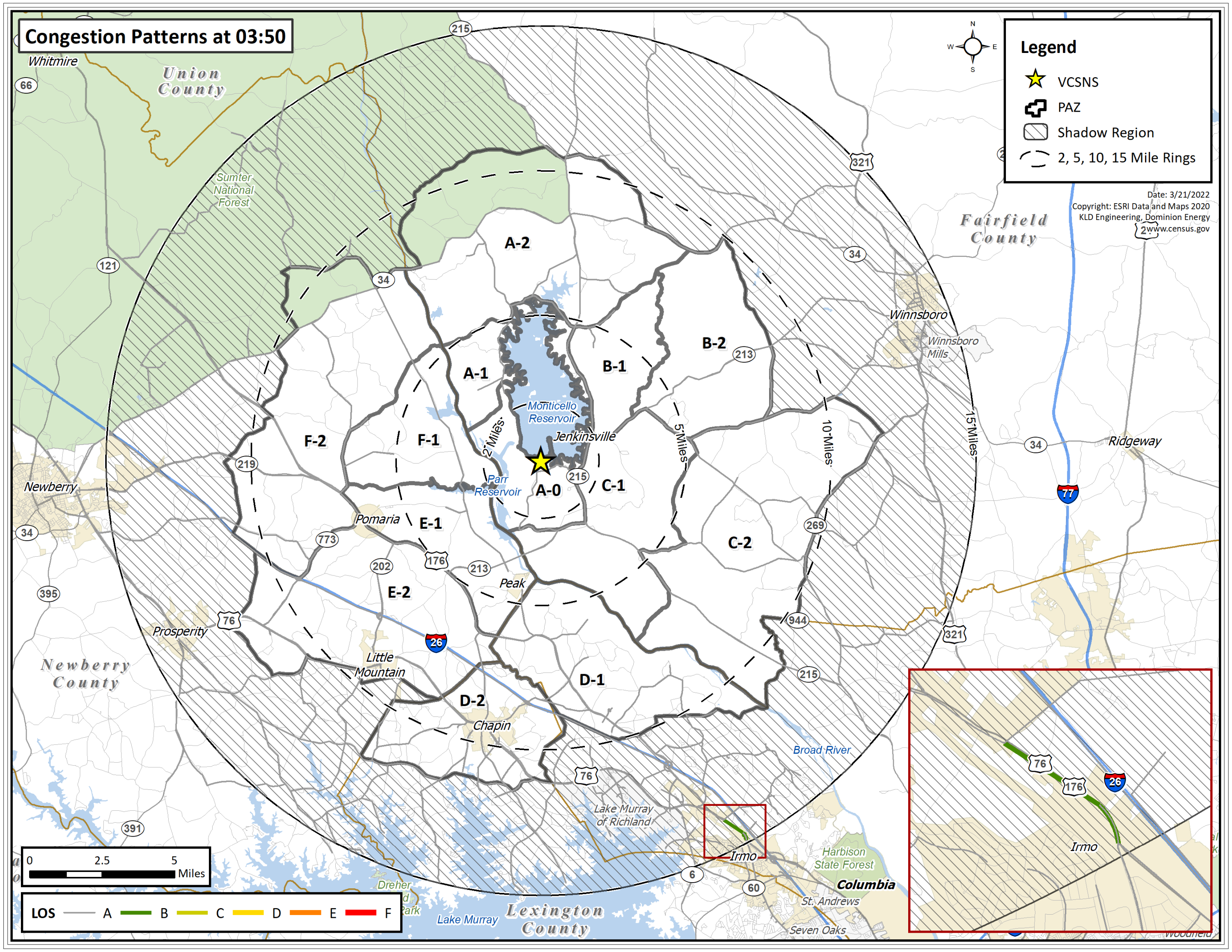


Figure 7-6. Congestion Patterns at 3 Hours and 50 Minutes after the Advisory to Evacuate

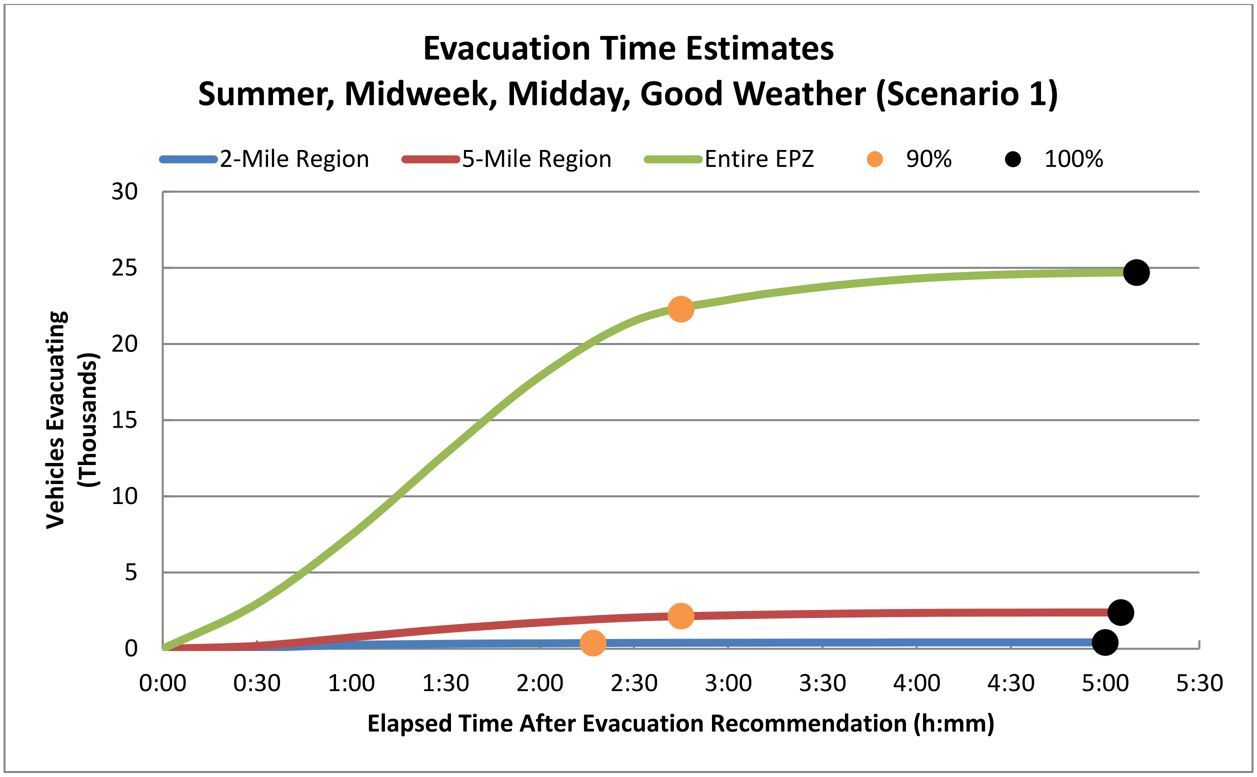


Figure 7-7. Evacuation Time Estimates - Scenario 1 for Region R03

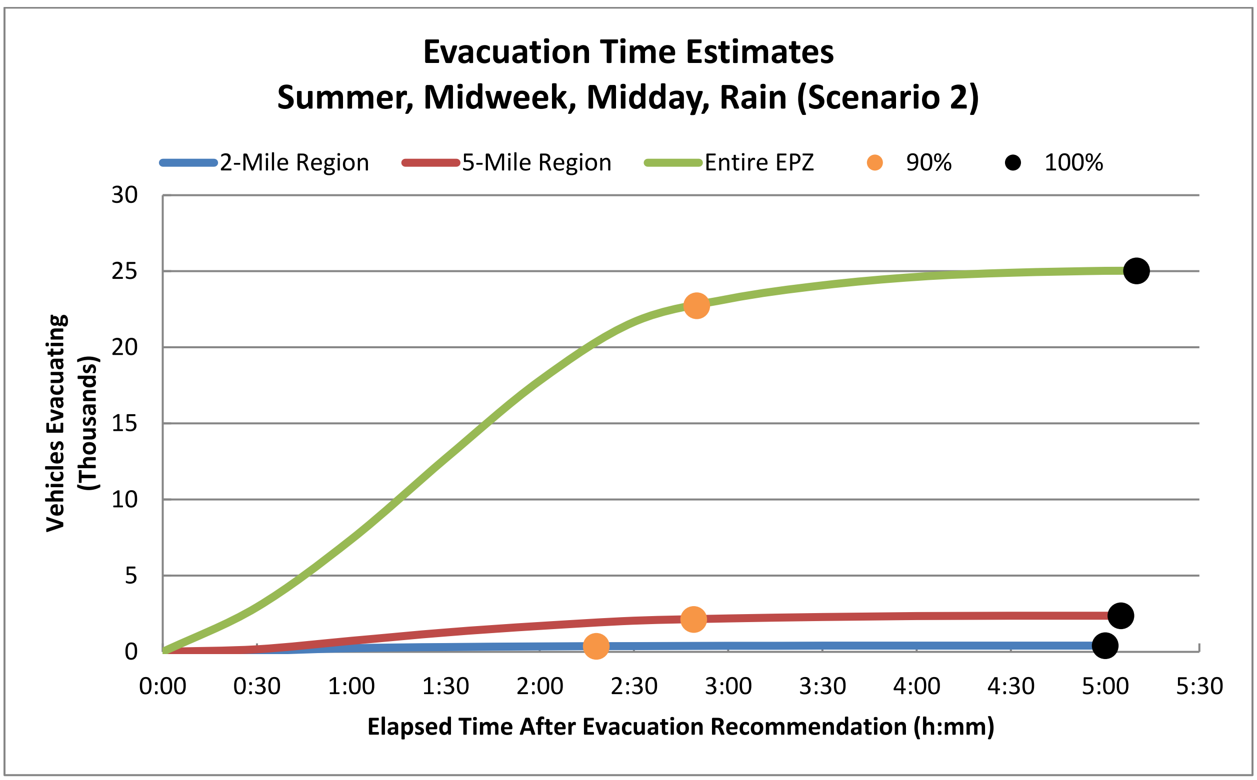


Figure 7-8. Evacuation Time Estimates - Scenario 2 for Region R03

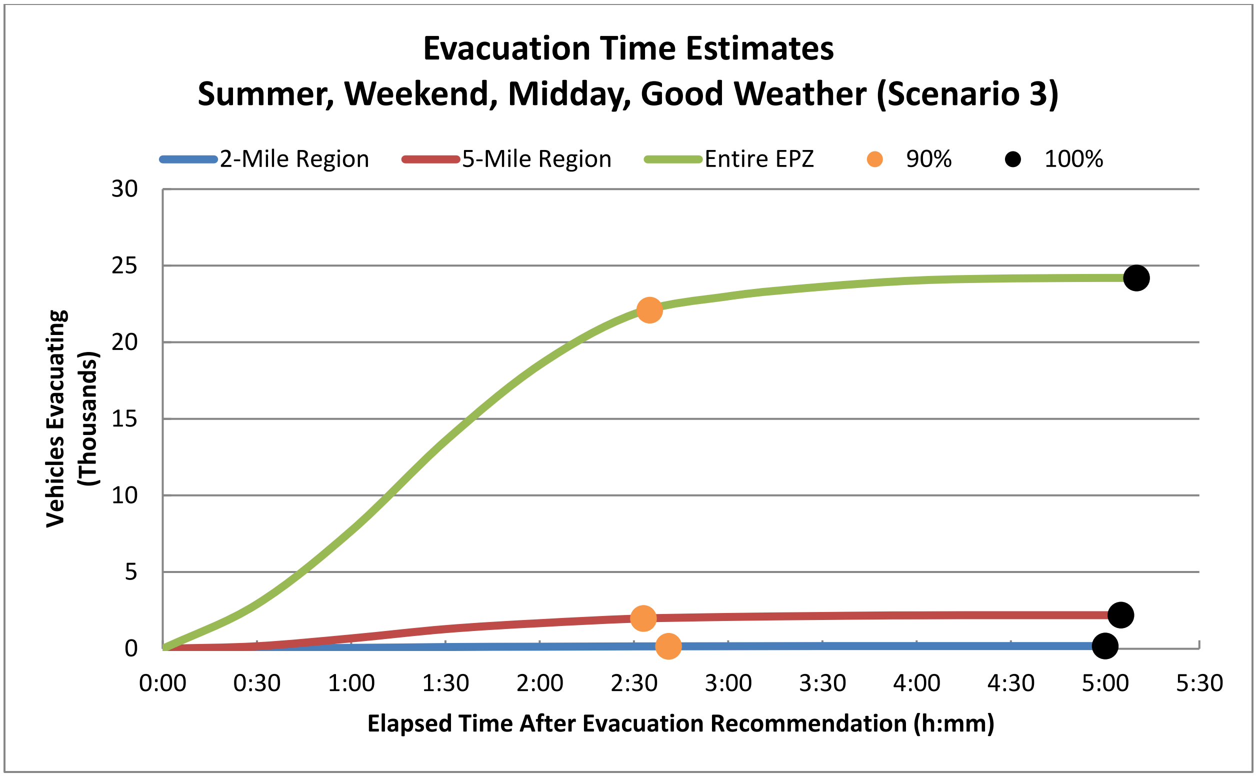


Figure 7-9. Evacuation Time Estimates - Scenario 3 for Region R03

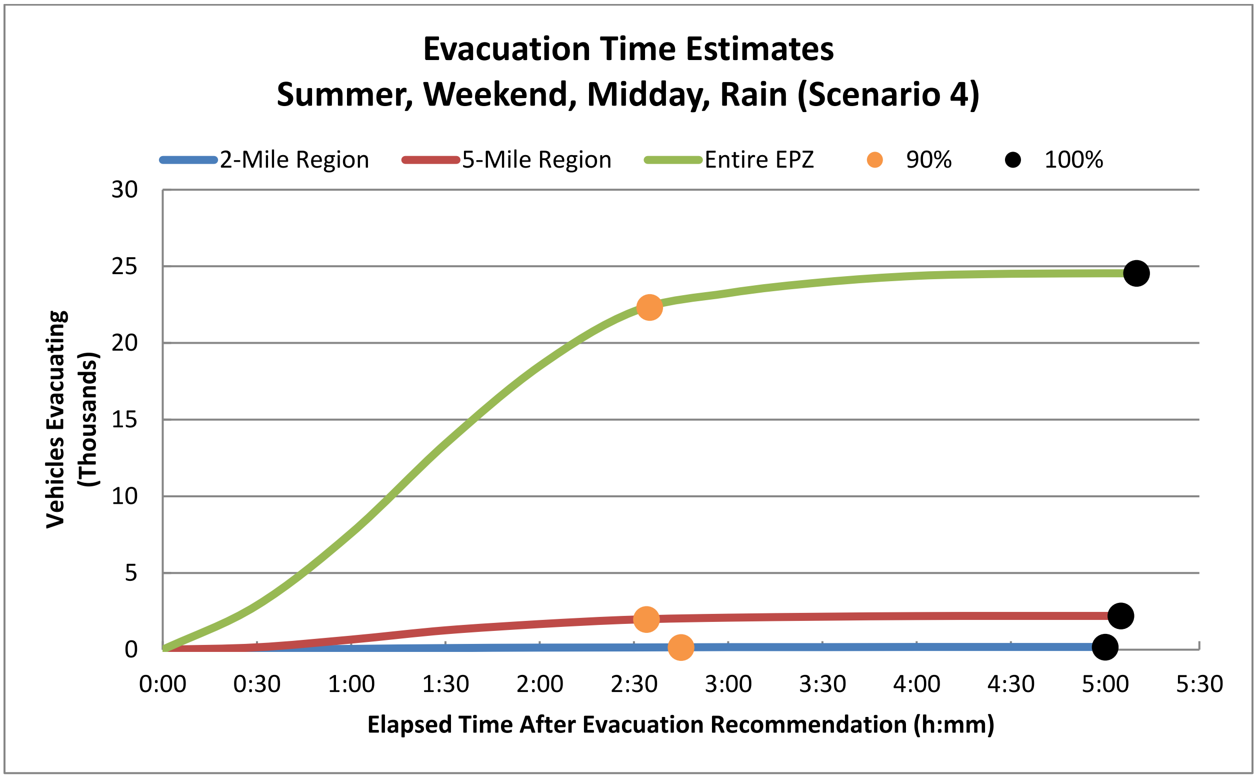


Figure 7-10. Evacuation Time Estimates - Scenario 4 for Region R03

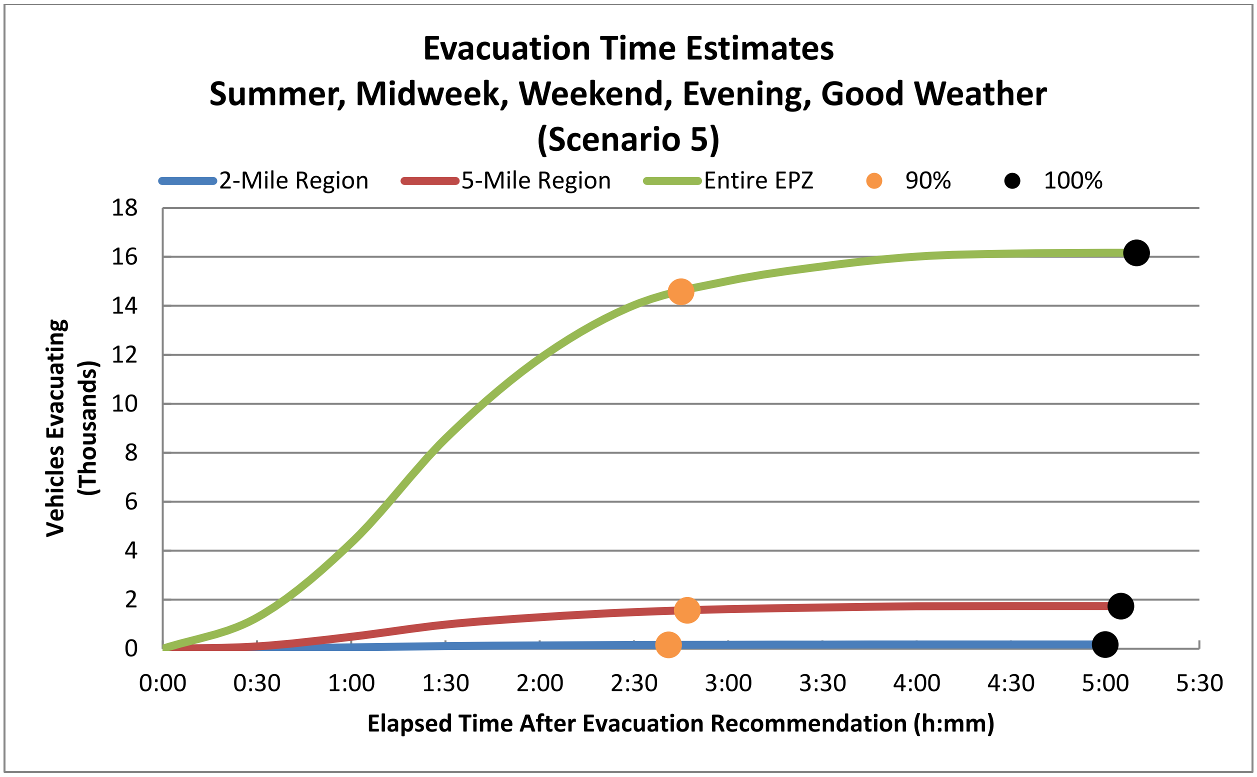


Figure 7-11. Evacuation Time Estimates - Scenario 5 for Region R03

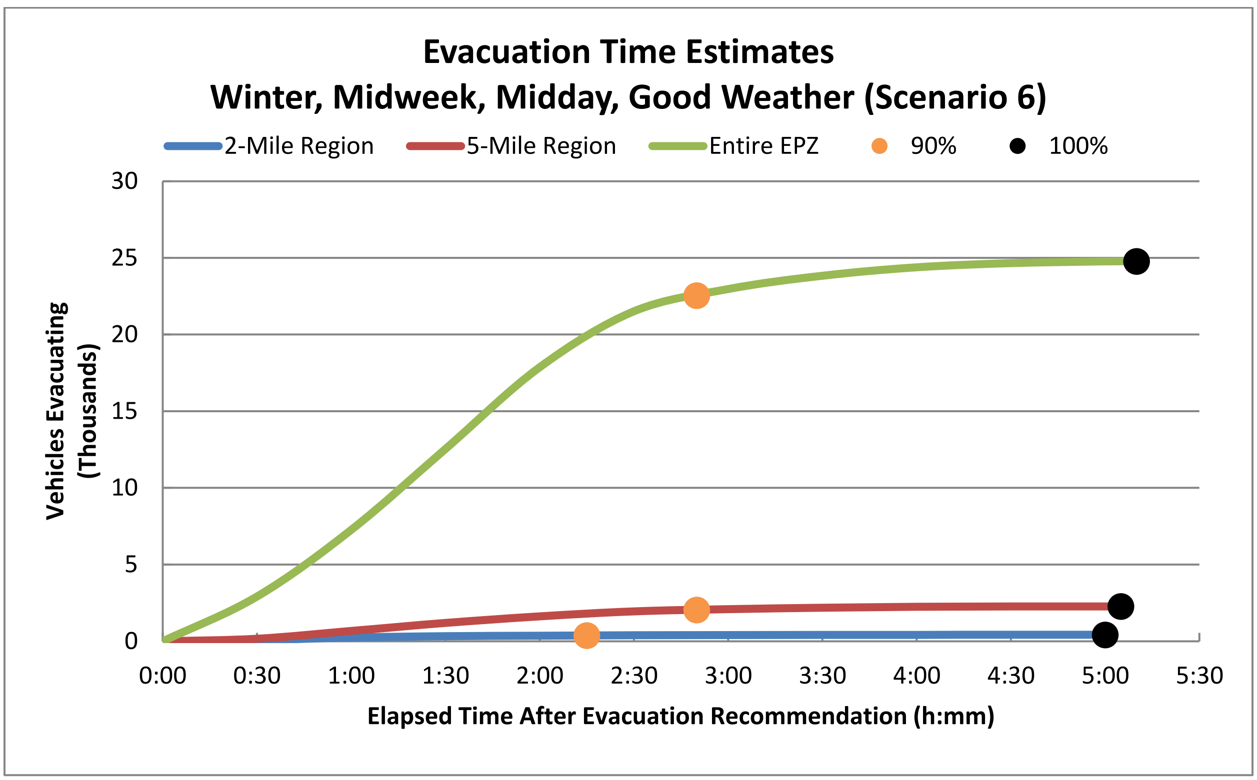


Figure 7-12. Evacuation Time Estimates - Scenario 6 for Region R03

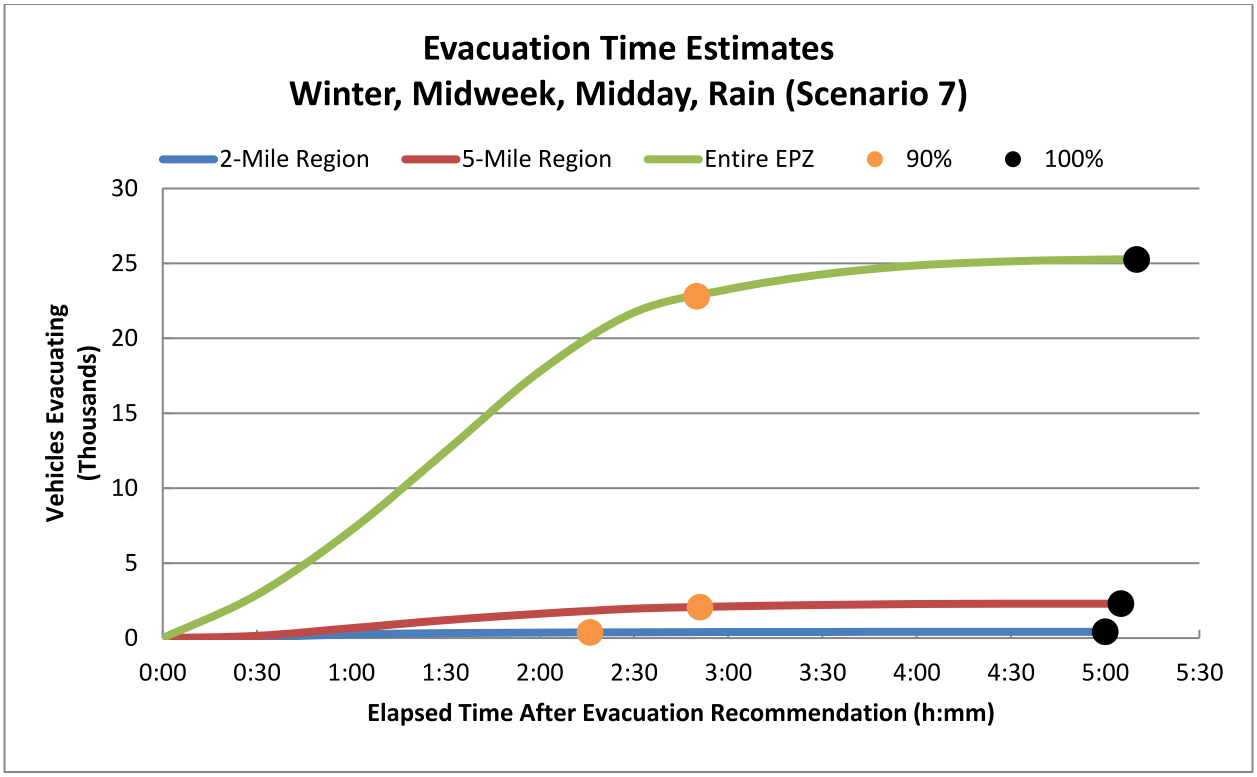


Figure 7-13. Evacuation Time Estimates - Scenario 7 for Region R03

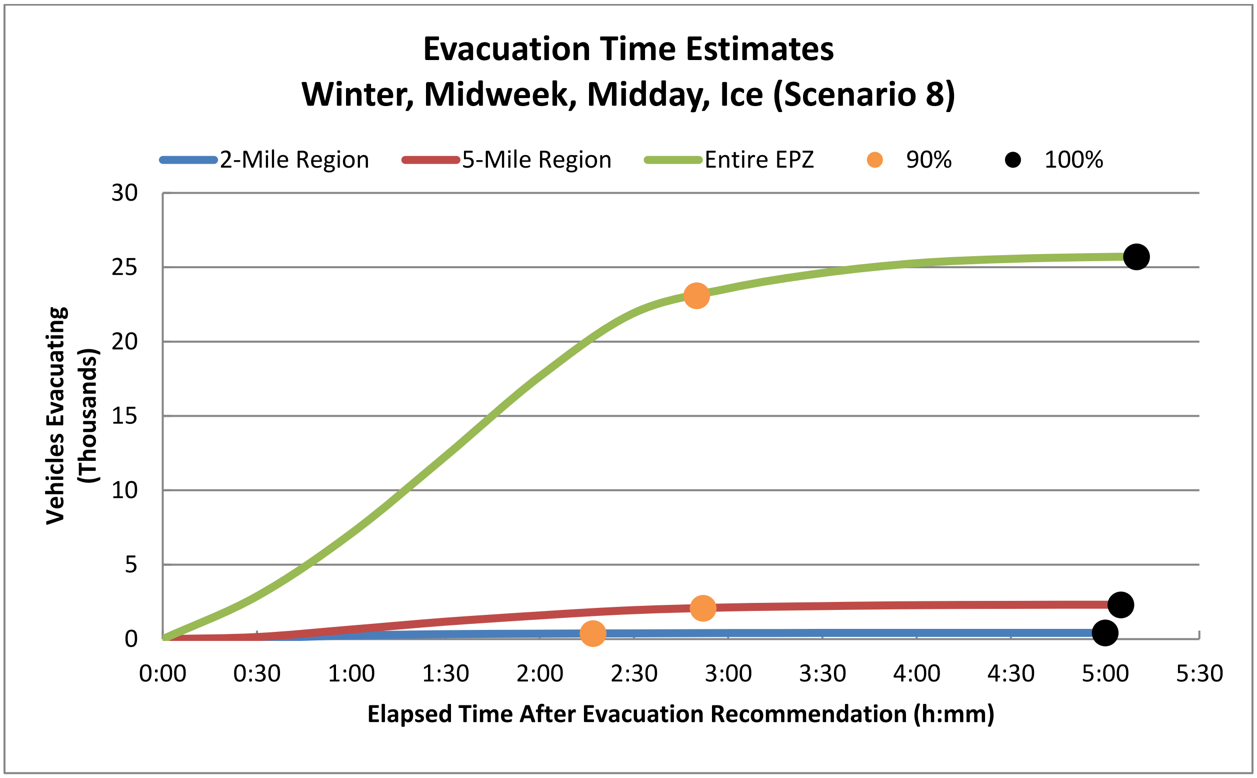


Figure 7-14. Evacuation Time Estimates - Scenario 8 for Region R03

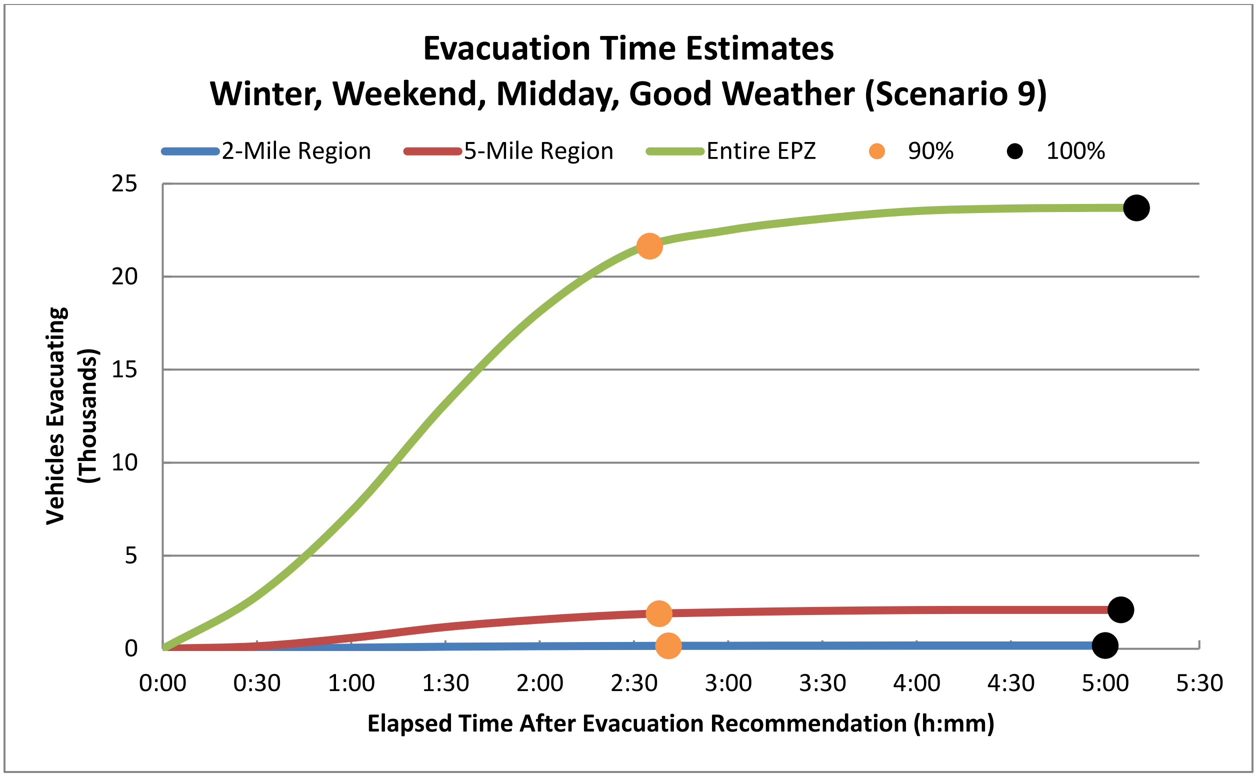


Figure 7-15. Evacuation Time Estimates - Scenario 9 for Region R03

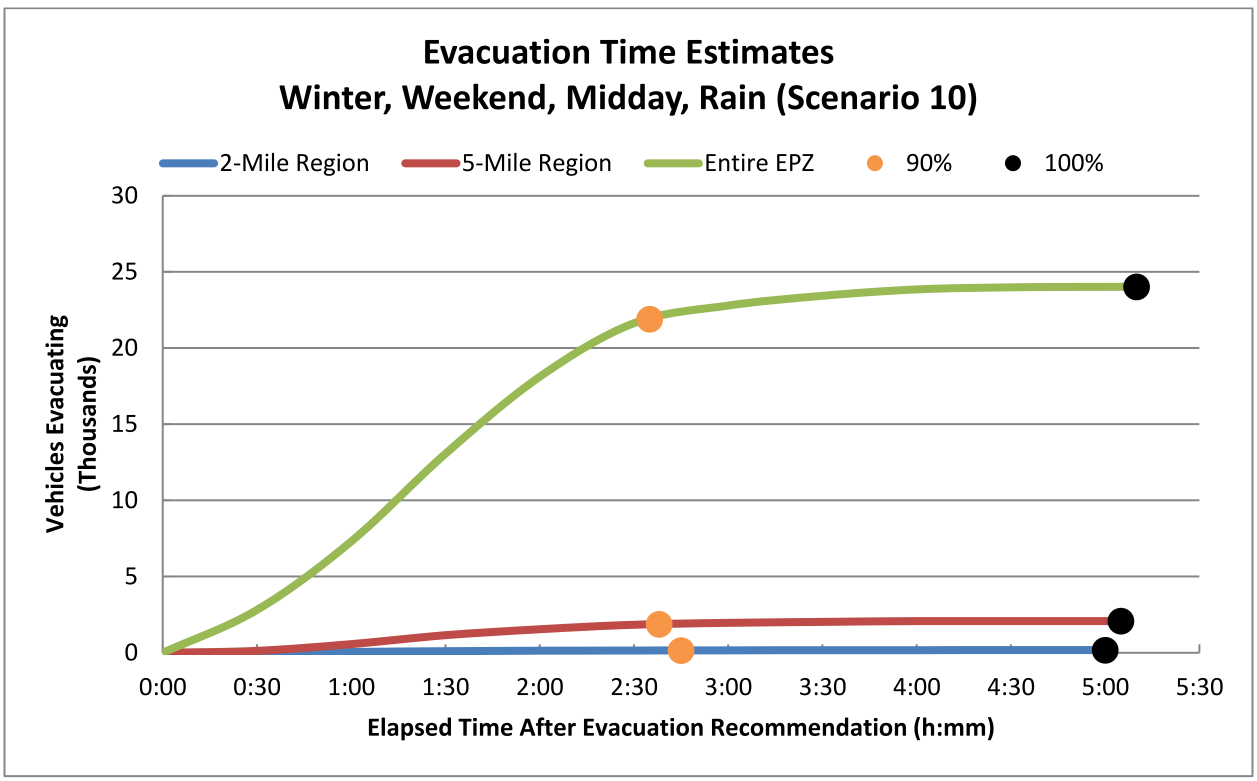


Figure 7-16. Evacuation Time Estimates - Scenario 10 for Region R03

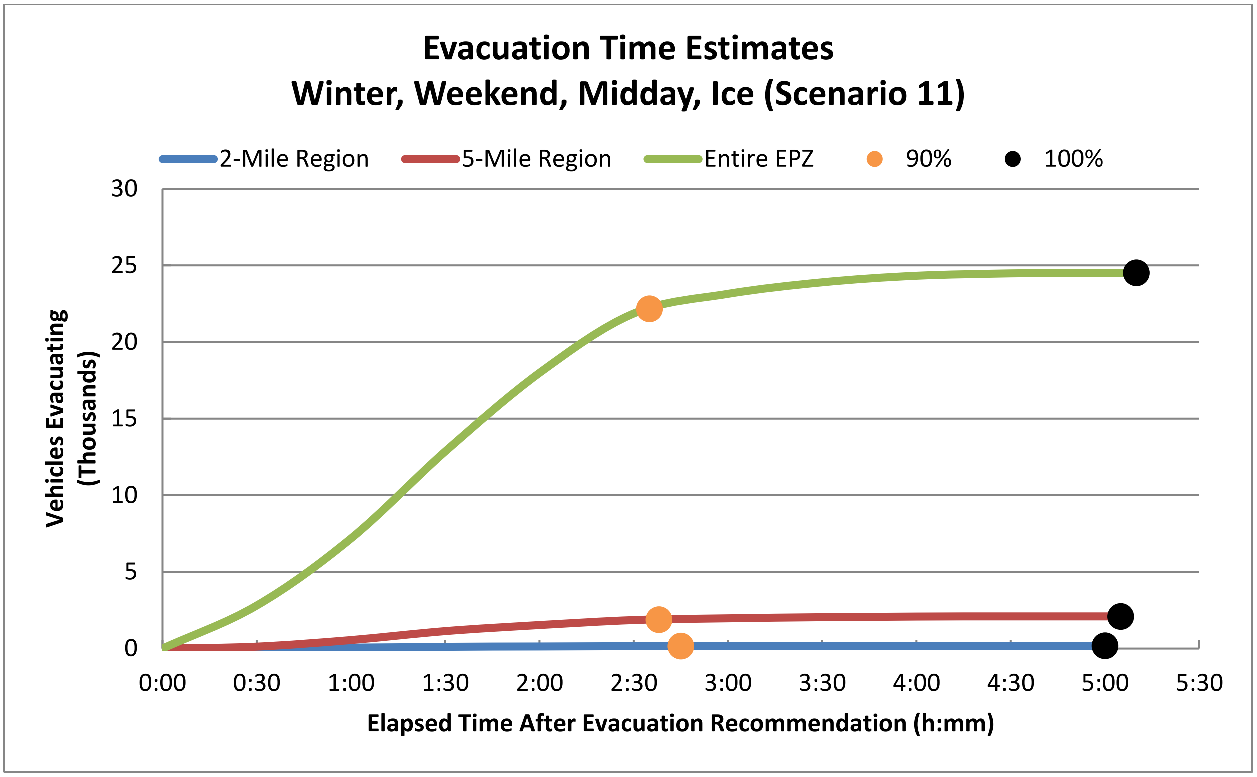


Figure 7-17. Evacuation Time Estimates - Scenario 11 for Region R03

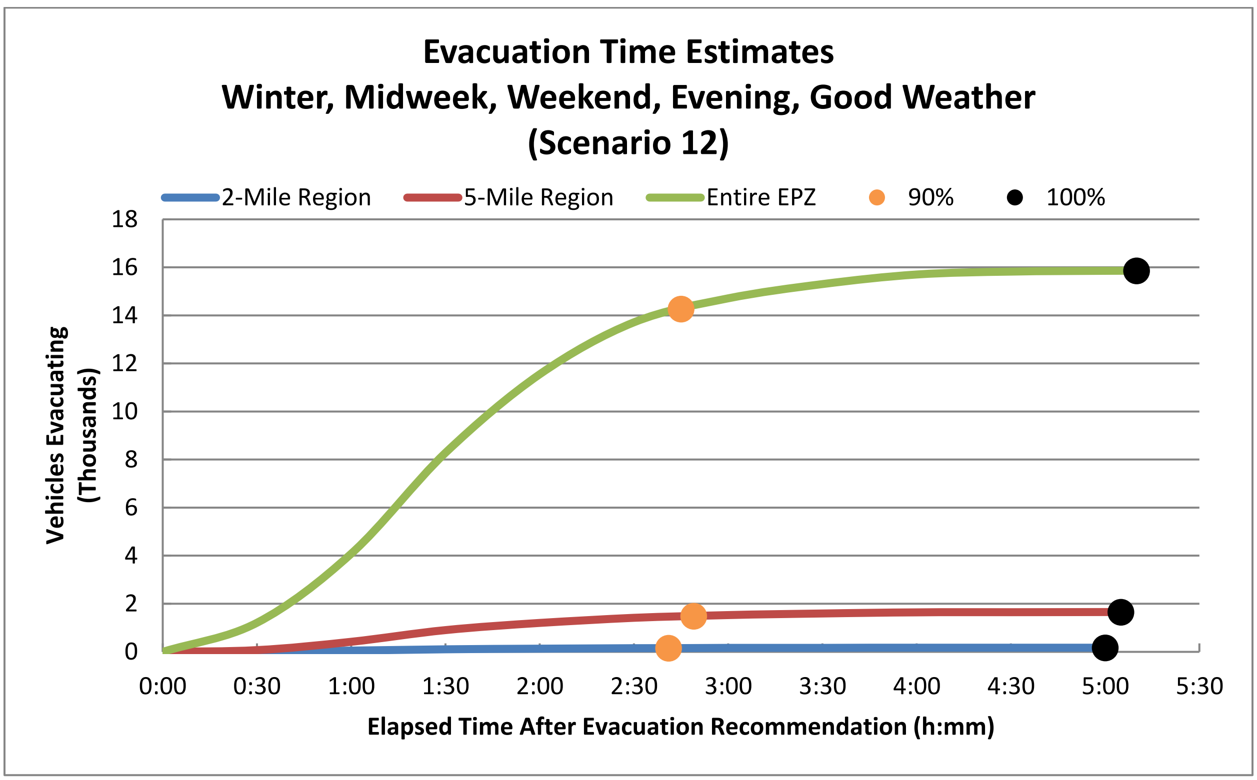


Figure 7-18. Evacuation Time Estimates - Scenario 12 for Region R03

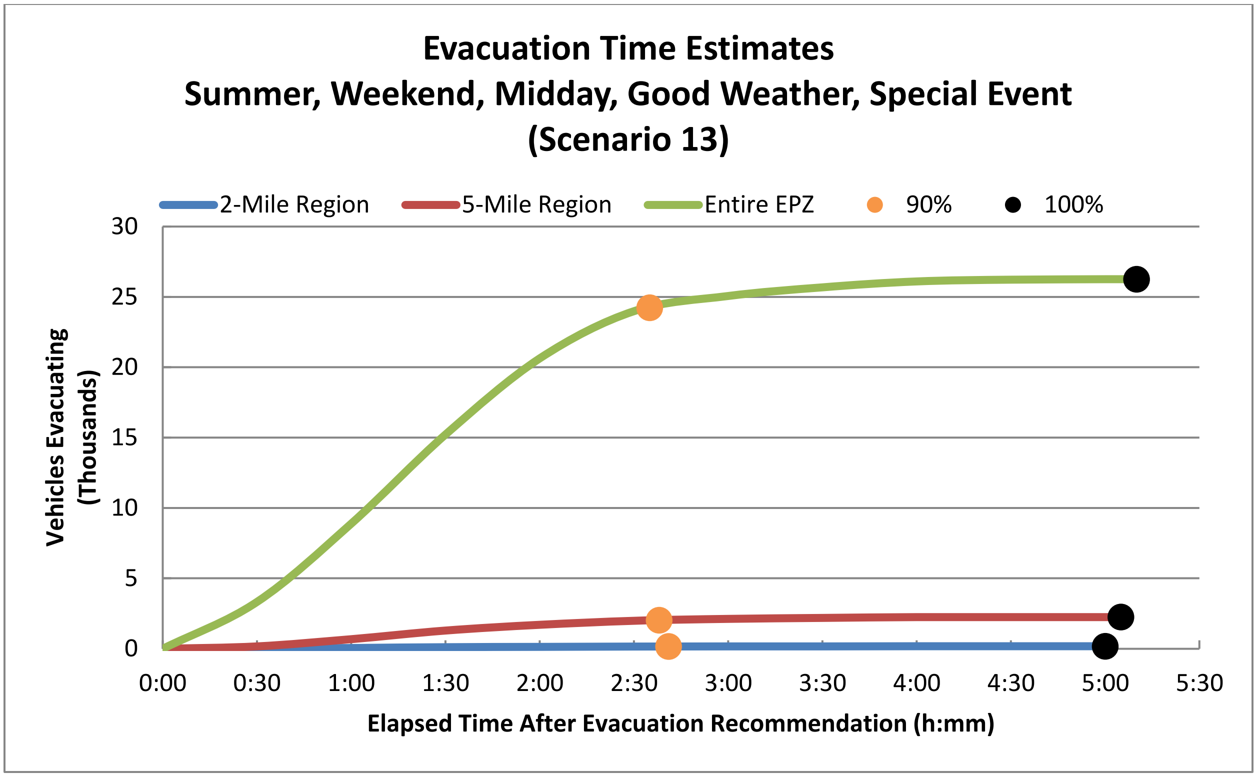


Figure 7-19. Evacuation Time Estimates - Scenario 13 for Region R03

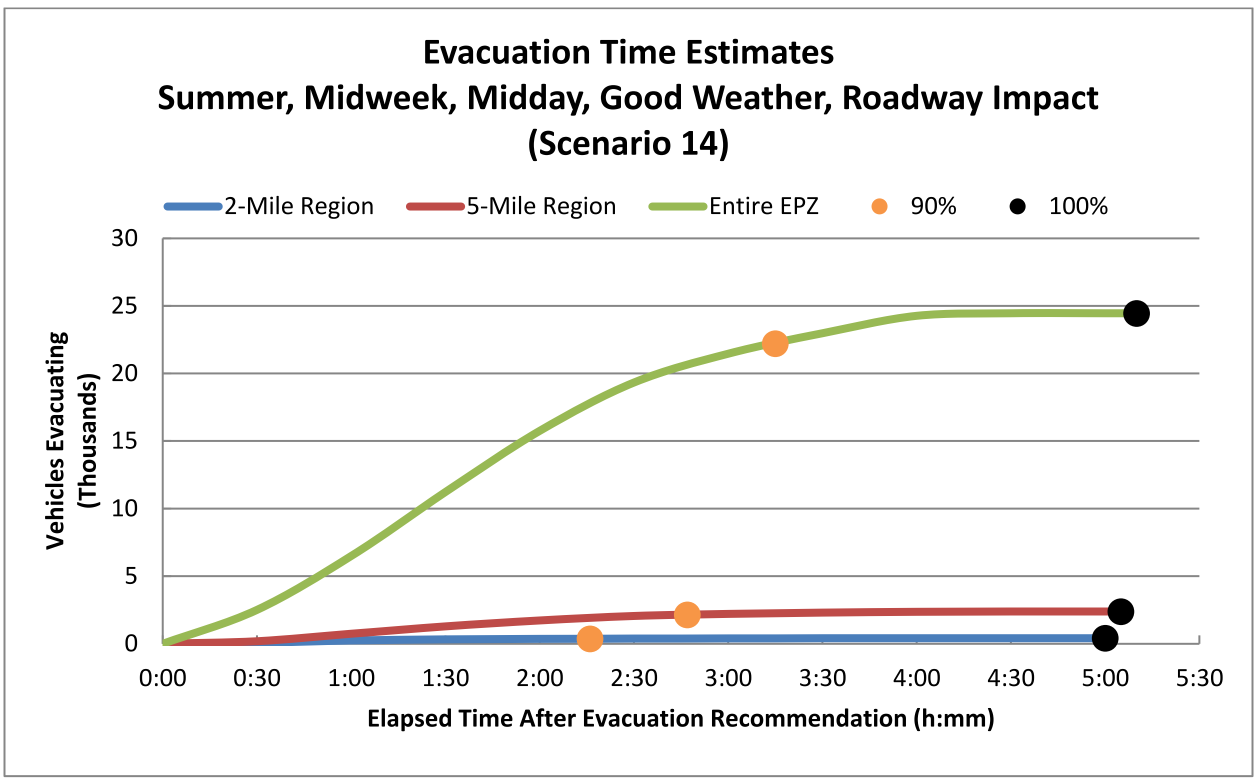


Figure 7-20. Evacuation Time Estimates - Scenario 14 for Region R03

8 TRANSIT-DEPENDENT AND SPECIAL FACILITY EVACUATION TIME ESTIMATES

This section details the analyses applied and the results obtained in the form of 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, licensed day care centers, and medical facility (Generations of Chapin); and
- access and/or functional needs population.

These transit vehicles mix with the general evacuating traffic that is comprised mostly of "passenger cars" (pc's). The presence of each bus 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. An ambulance is 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. Based on discussion with offsite agencies and as discussed in item 4a-d of Section 2.4, it is estimated that bus mobilization time for schools and licensed day care centers (located within Lexington, Newberry and Richland Counties) will average approximately 90 minutes extending from the Advisory to Evacuate (ATE), to the time when buses first arrive at the facility to be evacuated. Bus mobilization time will average approximately 120 minutes after the ATE for schools and licensed day care centers located within the Fairfield County. It is assumed transit dependent buses and access and/or functional needs vehicles are mobilized when about 86% of the residents with no commuters have completed their mobilization activities at 150 minutes after the ATE, for all counties within the EPZ except Fairfield County. In Fairfield County, transit dependent buses are mobilized in 60 minutes after the ATE, while wheelchair transport vehicles and ambulances for access and/or functional needs population are mobilized within 180 minutes and 60 minutes, respectively. Transport vehicles for Generations of Chapin patients will mobilize within 90 minutes of the ATE.

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. Reception center for schools, licensed day care centers, and for general population within each Protective Action Zone (PAZ) are based on the 2022 Emergency Planning Information Calendar (public

information calendar) disseminated to residents of the VC Summer Nuclear Station (VCSNS) Emergency Planning Zone (EPZ). As per public information calendar school children will be taken to the reception center if an evacuation were ordered, and that parents should pick school children up at the reception center. Emergency Alert System (EAS) stations will give information for changes or new instructions.

As discussed in item 2a of Section 2.2, this study assumes a rapidly escalating event. Based on the information provided by the offsite agencies, children at licensed day care centers will be transported by buses or private vehicles. For licensed day care centers that evacuate by private vehicle or staff vehicle (see Table 3-8) no buses are considered to avoid double counting vehicles.

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 schoolchildren, 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 reception centers

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, Licensed Day Care Centers, Transit Dependent People, and Generations of Chapin (Medical Facility)

The EPZ bus resources are assigned to evacuating school children (if schools and licensed day care centers 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 center after completing their first evacuation trip, to complete a "second wave" providing transportation service to evacuees. For this reason, the ETE for the transit-dependent population are calculated for both a one wave transit evacuation and for two waves. The number of available transportation resources were provided by the offsite agencies. Table 8-1 summarizes the capacity of transportation resources. Also included in the table is the transportation resource capacity needed to evacuate schools, licensed day care centers, the transit-dependent population, and the access and/or functional needs (discussed below in Section 8.2). There are sufficient bus resources available to evacuate the school children and transit-dependent population in the EPZ in a single wave. Furthermore, if the impacted Evacuation Region is other than R03 (the entire EPZ), then there will likely be ample transit resources relative to demand in the impacted Region and this discussion of a second wave would likely not apply.

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

Evacuation of Schools and Licensed Day Care Centers

Activity: Mobilize Drivers (A→B→C)

Mobilization time is the elapsed time from the ATE until the time the buses arrive at the school or licensed day care center to be evacuated. As previously stated, it is assumed that for a rapidly escalating radiological emergency with no observable indication before the fact, drivers (within Lexington, Newberry and Richland County) would require 90 minutes to be contacted, to travel to the depot, be briefed, and to travel to the schools or licensed day care centers. Bus mobilization time would be 120 minutes for schools or licensed day care centers located within Fairfield County. Mobilization time is slightly longer in adverse weather – 100 minutes in rain and 110 minutes in ice conditions. For rain and ice cases, mobilization time would be 130 and 140 minutes, respectively for Fairfield County school buses.

Activity: Board Passengers (C→D)

As discussed in Section 2.4 and 2.6, a loading time of 15 minutes for good weather (20 minutes for rain and 25 minutes for ice) for school and licensed day care center buses is used.

Activity: Travel to EPZ Boundary (D→E)

The buses servicing the schools and licensed day care centers (located within Lexington, Newberry and Richland County) 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. Fairfield County school and licensed day care center buses would be ready to begin evacuation trips at 135 minutes after the ATE (120 minutes mobilization time plus 15 minutes loading time). The UNITES software discussed in Section 1.3 was used to define bus routes along the most likely path from a school or licensed day care center being evacuated to the EPZ boundary, traveling toward the appropriate reception center. This is done in UNITES by interactively selecting the series of nodes from the school or licensed day care 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 Section 10 in Table 10-2 (refer to the maps of the link-node analysis network in Appendix K for node locations). Data provided by DYNEV during the appropriate timeframe depending on the mobilization and loading times (i.e., 100 to 105 minutes or 130 to 135 minutes after the ATE for good weather) were used to compute the average speed for each route, as follows:

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

The average speed computed (using this methodology) for the buses servicing each of the schools and licensed day care centers in the EPZ is shown in Table 8-2 through Table 8-4. To comply with state bus speed regulations, the computed speeds are restricted to 45 mph, 40 mph (about 10% decrease), and 35 mph (about 20% decrease) for good weather, rain and ice, 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 Reception Center was computed assuming an average speed of 45 mph, 40 mph, and 35 mph for good weather, rain and ice, respectively.

Table 8-2 (good weather), Table 8-3 (rain), and Table 8-4 (ice) present the following ETEs (rounded up to the nearest 5 minutes) for schools or day care centers 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 Reception Center or Host School.

The evacuation time out of the EPZ can be computed as the sum of times associated with Activities A→B→C, C→D, and D→E (For example: 120 min.+ 15 + 11 = 2:30 rounded to the nearest 5 minutes for McCrorey-Liston School Of Technology - in good weather).

The average ETE for schools and day care centers are 50 minutes less than the 90th percentile ETE for Region R03 for the general population during Scenario 6 conditions (2:50 – 2:00 = 0:50) in good weather. Hence, ETE is not likely to impact protective action decision making.

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

<u>Activity: Travel to Reception Centers (E→F)</u>

The distances from the EPZ boundary to the reception centers are measured using geographic information system (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. Assumed bus speeds of 45 mph, 40 mph, and 35 mph for good weather, rain, and ice, respectively, are applied for this activity for buses servicing the schools and day care centers in the EPZ.

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

A detailed computation of the transit dependent people is discussed in Section 3.7. The total number of transit dependent people per PAZ was determined using a weighted distribution based on population. The number of buses required to evacuate this population was determined by the capacity of 30 people per bus. The PAZs that were determined to have very few transit-dependent person were grouped and a bus route was assigned. The six (6) bus routes utilized in this study were designed by KLD to service a single or group of PAZ. These routes are described in Table 10-1 and mapped in Figure 10-2. Those buses servicing the transit-dependent evacuees will first travel along major evacuation routes, then proceed out of the EPZ. 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 150-minutes bus mobilization time (good weather).

Activity: Mobilize Drivers (A→B→C)

Mobilization time is the elapsed time from the ATE until the time the buses arrive at their designated route. The buses dispatched from the depots to service the transit-dependent evacuees will be scheduled so that they arrive at their respective routes after their passengers have completed their mobilization. As shown in Figure 5-4 (Residents with no Commuters), 86% of the evacuees will complete their mobilization when the buses begin their routes at approximately 150 minutes after the ATE. The residents taking longer to mobilize are assumed to rideshare with a friend or neighbor. Mobilization time is slightly longer in adverse weather – 160 minutes in rain and 170 minutes in ice conditions to account for slower travel speeds and reduced roadway capacity. In Fairfield County, drivers mobilized 60 minutes after the ATE-in good weather; 70 minutes after the ATE in rain and 80 minutes after the ATE in ice condition.

The ETEs for transit trips were developed using both good weather and adverse weather conditions. Each route has one bus that departs at 150 minutes (60 minutes for bus routes within Fairfield County) after the ATE. Table 8-5 (good weather), Table 8-6 (rain), and Table 8-7 (ice) show the ETE breakdown for each step in the transit-dependent evacuation process.

Activity: Board Passengers (C→D)

For multiple stops along a major evacuation 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 resulting in 40 minutes of pick-up time per bus and 50 minutes in ice.

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 and licensed day care center evacuation, where they are restricted to 45 mph, 40 mph, and 35 mph for good weather, rain, and ice, respectively.

Table 8-5 through Table 8-7 present the transit-dependent population ETE for each bus route calculated using the above procedures for good weather, rain, and ice, respectively. For example, the ETE for the bus serviced PAZ D-1 is computed as 150 + 9 + 30 = 3:10 for good weather (rounded to nearest 5 minutes). Here, 9 minutes is the time to travel 6.7 miles at 45.0 mph, the average speed output by the model for this route at 150 minutes.

The average single-wave ETE (2 hours and 30 minutes) for the transit dependent population does not exceed the 90^{th} percentile ETE for the general population for a winter, midweek, midday, good weather scenario (Scenario 6). Hence, ETE is not likely to 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.

Activity: Travel to Reception Centers (E→F)

The distances from the EPZ boundary to the reception centers are measured using geographic information system (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. Assumed bus speeds of 45 mph, 40 mph, and 35 mph for good weather, rain, and ice, respectively, will be applied for this activity for buses servicing the transit-dependent population.

For a second-wave evacuation, the ETE for buses must be considered separately, since it could exceed the ETE for the general population.

Activity: Passengers Leave Bus (F→G)

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

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

The buses assigned to return to the EPZ to perform a “second wave” evacuation of transit-

dependent evacuees will be those that have already evacuated transit-dependent people who mobilized more quickly. The first wave of transit-dependent people depart the bus, and the bus then returns to the EPZ, travels to the start of its route and proceeds to pick up more transit-dependent evacuees along the route. The travel time back to the EPZ is equal to the travel time to the reception center.

The second wave ETE for the bus route servicing PAZ D-2 (for example) is computed as follows for good weather:

- Bus arrives at reception center at 3:24 in good weather (3:10 to exit EPZ + 14-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: 14 minutes (equal to travel time to reception center) + 13 minutes (4.8 miles @ 45 mph [assumed speed since bus is traveling against traffic] + 4.8 miles @ 45 mph [route specific speed output from the model at this time) = 27 minutes
- Bus completes pick-ups along route: 30 minutes.
- Bus exits EPZ at time 3:10 + 0:14 + 0:15 + 0:27 + 0:30 = 4:40 (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 (4 hours and 15 minutes) for a second-wave evacuation of the transit-dependent population is 1 hour and 25 minutes longer than the ETE for the general population at the 90th percentile for an evacuation of the entire EPZ (Region R03) under winter, midweek, midday, good weather conditions (Scenario 6) and could impact protective action decision making.

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

Evacuation of Generations of Chapin

Activity: Mobilize Drivers (A→B→C)

As per Item 4c of Section 2.4, it is assumed that the mobilization time for Generations of Chapin average 90 minutes after the ATE- in good weather, 100 minutes in rain and 110 minutes in ice. 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 facility. 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. Item 3 of Section 2.4 discusses transit vehicle capacities to cap loading times per vehicle type.

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 and licensed day care center evacuation.

Table 8-8 through Table 8-10 summarize the ETE for Generations of Chapin within the EPZ for good weather, rain, and ice. Average speeds output by the model for Scenario 6 (Scenario 7 for rain and Scenario 8 for ice) Region 3, capped at 45 mph (40 mph for rain and 35 mph for ice), 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. All ETE are rounded up to the nearest 5 minutes. For example, the calculation of ETE for The Generations of Chapin with 29 ambulatory residents during good weather is:

ETE: 90 + 1 x 29 + 7 = 130 min. or 2:10 (rounded up to the nearest 5 minutes).

The average ETE for evacuation of Generations of Chapin population is 15 minutes less than the 90^{th} percentile ETE for Region R03 for the general population during Scenario 6 conditions (2:50 – 2:35 = 0:15) in good weather. Hence, ETE is not likely to impact protective action decision making.

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

8.2 ETE for Access and/or Functional Needs Population

Table 8-11 summarizes the ETE for the 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 limitations on driving for access and/or functional needs persons, it is assumed that they will be picked up from their homes. Furthermore, it is conservatively assumed that ambulatory access and/or functional needs households are spaced 3 miles apart and bedridden households are spaced 5 miles apart. Bus speeds approximate 20 mph between households and ambulance speeds approximate 30 mph in good weather (10% slower in rain, 20% slower in ice). Similar to transit dependent evacuees, mobilization times of 150 minutes were used (160 minutes for rain, and 170 minutes for ice) for access and/or functional needs people within Richland, Newberry and Lexington County. As per information provided by Fairfield County, mobilization time of 60 minutes, 70 minutes, and 80 minutes are used for good weather, rain, and ice case, respectively for access and/or function needs population within Fairfield County. Loading times of 1 minute per person are assumed for ambulatory people, 5 minutes per person are assumed for wheelchair bound people, and 15

minutes per person are assumed for bedridden people. For buses evacuating ambulatory access and/or functional needs, the last household is assumed to be 5 miles from the EPZ boundary, and the network-wide average speed, capped at 45 mph (40 mph for rain and 35 mph for ice), is used to compute travel time after the last pickup. 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 up to the nearest 5 minutes.

For example, assuming no more than one access and/or functional need person per HH implies that 37 ambulatory households need to be serviced. While only 2 bus is needed from a capacity perspective, if 5 buses are deployed to service these special needs HH, then each would require 8 stops maximum. For example, the ETE for access and/or functional needs ambulatory people in good weather is computed as follows :

1. Assume 5 buses are deployed, each with about 8 stops, to service a total of 37 HH.
2. The ETE is calculated as follows:
    a. Buses arrive at the first pickup location: 2:30
    b. Load HH members at first pickup: 1 minute
    c. Travel to subsequent pickup locations: (8-1) @ 9 minutes (3 miles at 20 mph) = 63 minutes
    d. Load HH members at subsequent pickup locations: (8-1) @ 1 minutes = 7 minutes
    e. Travel to EPZ boundary: 5 miles @ 45.0 mph (network wide average speed at 3 hours and 40 minutes after the ATE) = 7 minutes

ETE: 2:30 + 1 + 63 + 7 + 7 = 3:50 (rounded up to the nearest 5 minutes)

It is estimated that 4 ambulances will be needed to evacuate the 8 homebound bed-ridden person within the EPZ. As shown in Table 8-1, there are 64 ambulances available within the EPZ and only 4 are required to evacuate the bedridden access and/or functional needs population within the EPZ (see Table 8-1).

For example, the ETE for access and/or functional needs bedridden people in good weather is computed as follows:

1. Ambulance arrives at first household: 150 minutes
2. Loading time at first household: 15 minutes
3. Ambulance travels to second household: 5 miles @ 30 mph = 10 minutes
4. Loading time at second household: 15 minutes
5. Travel time to EPZ boundary: 5 miles @ 45.0 mph (network wide average speed at 3 hours and 10 minutes after the ATE) = 7 minutes

ETE: 150 + 15 + 10 + 15 + 7 = 3:20 (rounded up to the nearest 5 minutes).

The average ETE (4 hours) for a single wave evacuation of the access and/or functional needs population exceeds the general population ETE by 1 hour and 10 minutes at the 90th percentile for an evacuation of the entire EPZ (Region R03), during Scenario 6 conditions and could impact protective action decision making.

Table 8-1. Summary of Transportation Resources

Transportation Resources	Buses	Vans	Wheelchair Buses	Wheelchair Vans	Ambulances
Resources Available					
Chapin Transportation Office	23	0	2	0	0
Dutch Fork Transportation Office	32	0	0	0	0
Irmo Transportation Office	30	0	0	0	0
Special Needs Bus	1	0	17	0	0
Activity Bus	40	0	0	0	0
Newberry County School District	63	3	0	17	16
Kelly Miller Elementary School	0	0	0	0	0
McCrorey-Liston Elementary School	3	0	0	0	0
Generations of Chapin[1]	0	3	0	0	0
Fairfield County Transit	14	0	0	0	0
School District of Fairfield	40	0	0	0	0
Fairfield County EMS	0	0	14	0	11
Medshore Ambulance (by mutual aid)[1]	0	0	0	3	37
Chapin Recreation Center	0	2	0	0	0
Central Midlands Regional Transit Authority (CMRTA)	2	0	0	0	0
TOTAL:	**248**	**8**	**33**	**20**	**64**
Resources Needed					
Schools (Table 3-7):	136	0	0	0	0
Licensed Day Care Centers (Table 3-8):	18	0	0	0	0
Medical Facility (Table 3-6):	1	0	2	0	0
Homebound Access and/or Functional Needs (Section 3-10):	3	0	4	1	4
Transit-Dependent Population (Table 10-1):	6	0	0	0	0
TOTAL TRANSPORTATION NEEDS:	**164**	**0**	**6**	**1**	**4**

[1] Recent transportation resources for this facility were not provided, as such the values shown are from the previous report.

Table 8-2. School and Licensed Day Care Center Evacuation Time Estimates - Good Weather

School and Licensed Day Care Center	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 R.C. (mi.)	Travel Time from EPZ Bdry to R.C. (min)	ETA to R.C. (hr:min)
FAIRFIELD COUNTY									
McCrorey-Liston School Of Technology	120	15	8.2	45.0	11	**2:30**	6.8	10	**2:40**
Kelly Miller Elementary School	120	15	1.4	44.1	2	**2:20**	6.9	10	**2:30**
McCrorey-Liston Child Development Center	120	15	8.2	45.0	11	**2:30**	6.8	10	**2:40**
Kelly Miller Child Development Center	120	15	1.4	44.1	2	**2:20**	6.9	10	**2:30**
Jacqueline Wylie	Evacuated by Private Vehicles								
Jackie Chappell									
LEXINGTON COUNTY									
Chapin High School	90	15	4.8	45.0	7	**1:55**	9.8	14	**2:10**
Crooked Creek Park Afterschool Program	90	15	2.5	27.5	6	**1:55**	10.5	14	**2:10**
Chapin Intermediate School	90	15	2.5	27.5	6	**1:55**	10.5	14	**2:10**
Chapin Elementary School	90	15	2.5	24.8	6	**1:55**	10.4	14	**2:05**
Mt Horeb Lutheran Church	90	15	4.7	45.0	7	**1:55**	9.7	13	**2:05**
Elaine Alewine	90	15	4.7	45.0	7	**1:55**	9.7	13	**2:05**
Abner Montessori School/Chapin Children's Center	90	15	4.7	45.0	7	**1:55**	9.7	13	**2:10**
Chapin Baptist Child Development Center	90	15	2.5	27.5	6	**1:55**	10.5	14	**2:10**
Chapin United Methodist Church Preschool	90	15	5.6	45.0	8	**1:55**	9.8	14	**2:10**
Inez's Childcare Center	90	15	5.6	45.0	8	**1:55**	9.8	14	**2:10**
NEWBERRY COUNTY									
Little Mountain Elementary[2]	90	15	8.2	45.0	11	**2:00**	6.0	9	**2:10**
Little Angels Daycare	90	15	7.1	45.0	10	**1:55**	6.0	9	**2:05**
Mid-Carolina High School	90	15	2.0	41.9	3	**1:50**	2.3	4	**1:55**
Mid-Carolina Middle School	90	15	2.0	41.9	3	**1:50**	2.3	4	**1:55**
Pomaria-Garmany Elementary[3]	90	15	4.7	45.0	7	**1:55**	7.3	10	**2:05**

[2] The ETE computation represents the children at the Little Mountain Elementary school and the licensed day care center provided at this facility.
[3] The ETE computation represents the children at the Pomaria-Garmany Elementary School and the licensed day care center provided at this facility.

School and Licensed Day Care Center	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 R.C. (mi.)	Travel Time from EPZ Bdry to R.C. (min)	ETA to R.C. (hr:min)
RICHLAND COUNTY									
Chapin Middle School	90	15	1.5	38.0	3	**1:50**	34.1	46	**2:40**
Academy for Success	90	15	1.5	38.0	3	**1:50**	34.1	46	**2:40**
Spring Hill High School	90	15	1.5	38.0	3	**1:50**	34.1	46	**2:40**
The Center for Advanced Technical Studies	90	15	1.5	38.0	3	**1:50**	34.1	46	**2:40**
Sally Becker	Evacuated by Private Vehicles								
					Maximum for EPZ:	**2:30**		**Maximum:**	**2:40**
					Average for EPZ:	**2:00**		**Average:**	**2:20**

Table 8-3. School and Licensed Day Care Center Evacuation Time Estimates – Rain

School and Licensed Day Care Center	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 R.C. (mi.)	Travel Time from EPZ Bdry to R.C. (min)	ETA to R.C (hr:min)
FAIRFIELD COUNTY									
McCrorey-Liston School Of Technology	130	25	8.2	40.0	13	**2:50**	6.8	11	**3:05**
Kelly Miller Elementary School	130	25	1.4	40.0	3	**2:40**	6.9	11	**2:55**
McCrorey-Liston Child Development Center	130	25	8.2	40.0	13	**2:50**	6.8	11	**3:05**
Kelly Miller Child Development Center	130	25	1.4	40.0	3	**2:40**	6.9	11	**2:55**
Jacqueline Wylie	Evacuated by Private Vehicles								
Jackie Chappell									
LEXINGTON COUNTY									
Chapin High School	100	25	4.8	40.0	8	**2:15**	9.8	15	**2:30**
Crooked Creek Park Afterschool Program	100	25	2.5	31.6	5	**2:10**	10.5	16	**2:30**
Chapin Intermediate School	100	25	2.5	31.6	5	**2:10**	10.5	16	**2:30**
Chapin Elementary School	100	25	2.5	28.8	6	**2:15**	10.4	16	**2:30**
Mt Horeb Lutheran Church	100	25	4.7	40.0	8	**2:15**	9.7	15	**2:30**
Elaine Alewine	100	25	4.7	40.0	8	**2:15**	9.7	15	**2:30**

School and Licensed Day Care Center	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 R.C. (mi.)	Travel Time from EPZ Bdry to R.C. (min)	ETA to R.C (hr:min)
Abner Montessori School/Chapin Children's Center	100	25	4.7	40.0	8	**2:15**	9.7	15	**2:30**
Chapin Baptist Child Development Center	100	25	2.5	31.6	5	**2:10**	10.5	16	**2:30**
Chapin United Methodist Church Preschool	100	25	5.6	40.0	9	**2:15**	9.8	15	**2:30**
Inez's Childcare Center	100	25	5.6	40.0	9	**2:15**	9.8	15	**2:30**
NEWBERRY COUNTY									
Little Mountain Elementary[4]	100	25	8.2	40.0	13	**2:20**	6.0	10	**2:30**
Little Angels Daycare	100	25	7.1	40.0	11	**2:20**	6.0	10	**2:30**
Mid-Carolina High School	100	25	2.0	38.5	4	**2:10**	2.3	4	**2:15**
Mid-Carolina Middle School	100	25	2.0	38.5	4	**2:10**	2.3	4	**2:15**
Pomaria-Garmany Elementary[5]	100	25	4.7	40.0	8	**2:15**	7.3	11	**2:25**
RICHLAND COUNTY									
Chapin Middle School	100	25	1.5	35.7	3	**2:10**	34.1	52	**3:05**
Academy for Success	100	25	1.5	35.7	3	**2:10**	34.1	52	**3:05**
Spring Hill High School	100	25	1.5	35.7	3	**2:10**	34.1	52	**3:05**
The Center for Advanced Technical Studies	100	25	1.5	35.7	3	**2:10**	34.1	52	**3:05**
Sally Becker	Evacuated by Private Vehicles								
					Maximum for EPZ:	**2:50**		**Maximum:**	**3:05**
					Average for EPZ:	**2:20**		**Average:**	**2:40**

[4] The ETE computation represents the children at the Little Mountain Elementary school and the licensed day care center provided at this facility.
[5] The ETE computation represents the children at the Pomaria-Garmany Elementary School and the licensed day care center provided at this facility.

Table 8-4. School and Licensed Day Care Center Evacuation Time Estimates – Ice

School and Licensed Day Care Center	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 R.C. (mi.)	Travel Time from EPZ Bdry to R.C. (min)	ETA to R.C. (hr:min)
FAIRFIELD COUNTY									
McCrorey-Liston School Of Technology	140	25	8.2	35.0	15	**3:00**	6.8	12	**3:15**
Kelly Miller Elementary School	140	25	1.4	35.0	3	**2:50**	6.9	12	**3:05**
McCrorey-Liston Child Development Center	140	25	8.2	35.0	15	**3:00**	6.8	12	**3:15**
Kelly Miller Child Development Center	140	25	1.4	35.0	3	**2:50**	6.9	12	**3:05**
Jacqueline Wylie	Evacuated by Private Vehicles								
Jackie Chappell									
LEXINGTON COUNTY									
Chapin High School	110	25	4.8	35.0	9	**2:25**	9.8	17	**2:45**
Crooked Creek Park Afterschool Program	110	25	2.5	25.8	6	**2:25**	10.5	18	**2:45**
Chapin Intermediate School	110	25	2.5	25.8	6	**2:25**	10.5	18	**2:45**
Chapin Elementary School	110	25	2.5	23.5	7	**2:25**	10.4	18	**2:40**
Mt Horeb Lutheran Church	110	25	4.7	35.0	9	**2:25**	9.7	17	**2:45**
Elaine Alewine	110	25	4.7	35.0	9	**2:25**	9.7	17	**2:45**
Abner Montessori School/Chapin Children's Center	110	25	4.7	35.0	9	**2:25**	9.7	17	**2:45**
Chapin Baptist Child Development Center	110	25	2.5	25.8	6	**2:25**	10.5	18	**2:45**
Chapin United Methodist Church Preschool	110	25	5.6	35.0	10	**2:25**	9.8	17	**2:45**
Inez's Childcare Center	110	25	5.6	35.0	10	**2:25**	9.8	17	**2:45**
NEWBERRY COUNTY									
Little Mountain Elementary[6]	110	25	8.2	35.0	14	**2:30**	6.0	11	**2:45**
Little Angels Daycare	110	25	7.1	35.0	13	**2:30**	6.0	11	**2:45**
Mid-Carolina High School	110	25	2.0	33.6	4	**2:20**	2.3	4	**2:25**

[6] The ETE computation represents the children at the Little Mountain Elementary school and the licensed day care center provided at this facility.

School and Licensed Day Care Center	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 R.C. (mi.)	Travel Time from EPZ Bdry to R.C. (min)	ETA to R.C. (hr:min)
Mid-Carolina Middle School	110	25	2.0	33.6	4	**2:20**	2.3	4	**2:25**
Pomaria-Garmany Elementary[7]	110	25	4.7	35.0	9	**2:25**	7.3	13	**2:40**
RICHLAND COUNTY									
Chapin Middle School	110	25	1.5	31.8	3	**2:20**	34.1	59	**3:20**
Academy for Success	110	25	1.5	31.8	3	**2:20**	34.1	59	**3:20**
Spring Hill High School	110	25	1.5	31.8	3	**2:20**	34.1	59	**3:20**
The Center for Advanced Technical Studies	110	25	1.5	31.8	3	**2:20**	34.1	59	**3:20**
Sally Becker	Evacuated by Private Vehicles								
					Maximum for EPZ:	**3:00**		**Maximum:**	**3:20**
					Average for EPZ:	**2:30**		**Average:**	**2:55**

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

		One-Wave							Second-Wave					
PAZ Serviced	Number of Buses	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)
A-0, B-1, B-2	1	60	10.0	45.0	13	30	**1:45**	6.9	9	5	10	36	30	**3:15**
A-1, A-2	1	60	13.0	45.0	17	30	**1:50**	6.9	9	5	10	44	30	**3:30**
C-1, C-2	1	60	14.3	45.0	19	30	**1:50**	6.9	9	5	10	47	30	**3:35**
D-1	1	150	6.7	45.0	9	30	**3:10**	30.9	41	5	10	59	30	**5:35**
D-2	1	150	4.8	45.0	6	30	**3:10**	10.5	14	5	10	27	30	**4:40**
E-1, E-2, F-1, F-2	1	150	11.4	45.0	15	30	**3:15**	5.2	7	5	10	37	30	**4:45**
						Maximum ETE:	**3:15**						**Maximum ETE:**	**5:35**
						Average ETE:	**2:30**						**Average ETE:**	**4:15**

[7] The ETE computation represents the children at the Pomaria-Garmany Elementary School and the licensed day care center provided at this facility.

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

PAZ Serviced	Number of Buses	One-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)
A-0, B-1, B-2	1	70	10.0	40.0	15	40	**2:05**	6.9	10	5	10	40	40	**3:50**
A-1, A-2	1	70	13.0	40.0	20	40	**2:10**	6.9	10	5	10	49	40	**4:05**
C-1, C-2	1	70	14.3	40.0	21	40	**2:15**	6.9	10	5	10	53	40	**4:15**
D-1	1	160	6.7	40.0	10	40	**3:30**	30.9	46	5	10	66	40	**6:20**
D-2	1	160	4.8	40.0	7	40	**3:30**	10.5	16	5	10	30	40	**5:15**
E-1, E-2, F-1, F-2	1	160	11.4	40.0	17	40	**3:40**	5.2	8	5	10	42	40	**5:25**
						Maximum ETE:	**3:40**						**Maximum ETE:**	**6:20**
						Average ETE:	**2:55**						**Average ETE:**	**4:55**

Table 8-7. Transit Dependent Evacuation Time Estimates – Ice

PAZ Serviced	Number of Buses	One-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)
A-0, B-1, B-2	1	80	10.0	35.0	17	50	**2:30**	6.9	12	5	10	46	50	**4:35**
A-1, A-2	1	80	13.0	35.0	22	50	**2:35**	6.9	12	5	10	57	50	**4:50**
C-1, C-2	1	80	14.3	35.0	25	50	**2:35**	6.9	12	5	10	61	50	**4:55**
D-1	1	170	6.7	35.0	11	50	**3:55**	30.9	53	5	10	76	50	**7:10**
D-2	1	170	4.8	35.0	8	50	**3:50**	10.5	18	5	10	34	50	**5:50**
E-1, E-2, F-1, F-2	1	170	11.4	35.0	20	50	**4:00**	5.2	9	5	10	48	50	**6:05**
						Maximum ETE:	**4:00**						**Maximum ETE:**	**7:10**
						Average ETE:	**3:15**						**Average ETE:**	**5:35**

Table 8-8. Generations of Chapin 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)	Speed (mph)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
LEXINGTON COUNTY									
Generations of Chapin	Ambulatory	90	1	29	29	5.3	45.0	7	**2:10**
	Wheelchair bound - Bus	90	5	25	25	5.3	45.0	7	**2:55**
								Maximum ETE:	**2:55**
								Average ETE:	**2:35**

Table 8-9. Generations of Chapin Evacuation Time Estimates – Rain

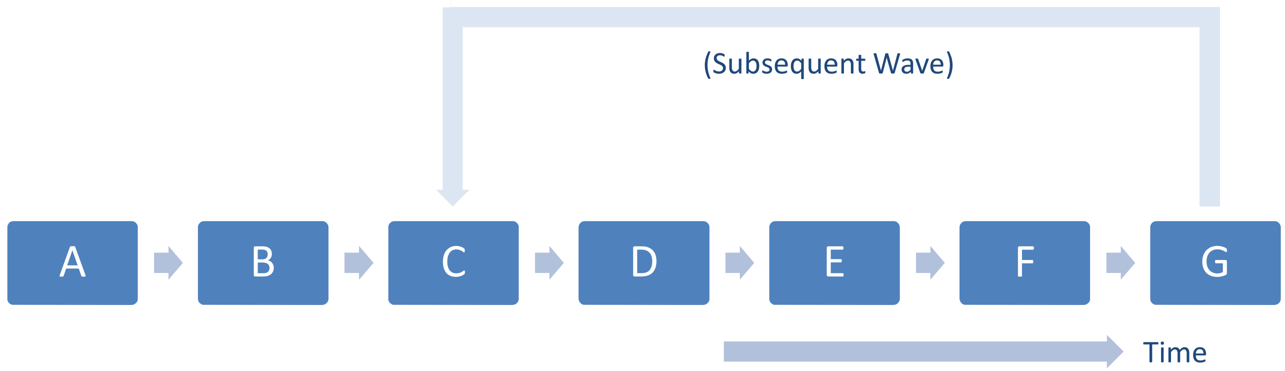
Medical Facility	Patient	Mobilization (min)	Loading Rate (min per person)	People	Total Loading Time (min)	Dist. To EPZ Bdry (mi)	Speed (mph)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
LEXINGTON COUNTY									
Generations of Chapin	Ambulatory	100	1	29	29	5.3	40.0	8	**2:20**
	Wheelchair bound - Bus	100	5	25	25	5.3	40.0	8	**3:05**
								Maximum ETE:	**3:05**
								Average ETE:	**2:45**

Table 8-10. Generations of Chapin Evacuation Time Estimates – Ice

Medical Facility	Patient	Mobilization (min)	Loading Rate (min per person)	People	Total Loading Time (min)	Dist. To EPZ Bdry (mi)	Speed (mph)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
LEXINGTON COUNTY									
Generations of Chapin	Ambulatory	110	1	29	29	5.3	35.0	9	**2:30**
	Wheelchair bound - Bus	110	5	25	25	5.3	35.0	9	**3:15**
								Maximum ETE:	**3:15**
								Average ETE:	**2:55**

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

Vehicle Type	People Requiring Vehicle	Vehicles deployed	Stops per Vehicle	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)
RICHLAND, NEWBERRY, AND LEXINGTON COUNTIES										
Buses	37	5	8	Normal	150	1	63	7	7	**3:50**
				Rain	160		70		7	**4:05**
				Ice	170		77		8	**4:25**
Wheelchair Buses	35	5	7	Normal	150	5	54	30	7	**4:10**
				Rain	160		60		7	**4:25**
				Ice	170		66		8	**4:40**
Wheelchair Vans	3	1	3	Normal	150	5	18	10	7	**3:10**
				Rain	160		20		9	**3:25**
				Ice	170		22		10	**3:40**
Ambulances	8	4	2	Normal	150	15	10	15	7	**3:20**
				Rain	160		11		8	**3:30**
				Ice	170		13		9	**3:45**
FAIRFIELD COUNTY										
Wheelchair Buses	8	1	8	Normal	60	5	54	35	7	**4:10**
				Rain	70		60		10	**4:25**
				Ice	80		66		10	**4:45**
									Maximum ETE:	**4:45**
									Average ETE:	**4:00**



Event	
A	Advisory to Evacuate
B	Bus Dispatched from Depot
C	Bus Arrives at Facility/Pick-up Route
D	Bus Departs for Reception Center
E	Bus Exits Region
F	Bus Arrives at Reception Center
G	Bus Available for “Second Wave” Evacuation Service
Activity	
A→B	Driver Mobilization
B→C	Travel to Facility or to Pick-up Route
C→D	Passengers Board the Bus
D→E	Bus Travels Towards Region Boundary
E→F	Bus Travels Towards Reception Center Outside the EPZ
F→G	Passengers Leave Bus; Driver Takes a Break

Figure 8-1. Chronology of Transit Evacuation Operations

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 this 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. <u>Facilitate</u> evacuating traffic movements that safely expedite travel out of the Emergency Planning Zone (EPZ)
2. <u>Discourage</u> 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 <u>must</u> 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 state and county existing emergency plans 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 offsite agency plans as being controlled by actuated signals. In Appendix G, Table G-1 identifies the number of intersections that were modeled as TACPs.
3. Evacuation simulations were run using DYNEV II to predict traffic congestion during evacuation (see Section 7.3 and Figure 7-3 through Figure 7-6). These simulations help to identify the best routing and critical intersections that experience pronounced 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 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 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.
- Study assumptions 1 through 3 in Section 2.5 discuss TACP staffing schedules and 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 CENTERS

10.1 Evacuation Routes

Evacuation routes are comprised of two distinct components:

- Routing from a Protective Action Zone (PAZ) being evacuated to the boundary of the Evacuation Region and thence out of the Emergency Planning Zone (EPZ).
- Routing of transit-dependent evacuees (schools, licensed day care centers, medical facilities, employees, transients, or permanent residents who do not own or have access to a private vehicle) from the EPZ boundary to reception centers.

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

The routing of transit-dependent evacuees from the EPZ boundary to reception centers is designed to minimize the amount of travel outside the EPZ, from the points where these routes cross the EPZ boundary. The six (6) 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 transit-dependent population within each PAZ along major evacuation routes and then proceed to the reception center assigned in the VC Summer Nuclear Station 2022 Emergency Planning Information Calendar (public information calendar). This does not imply that these exact routes would be used in an emergency. It is assumed that residents will walk along to the nearest major roadway and flag down a passing bus.

Schools, licensed day care centers, and the Generations of Chapin medical facility were routed along the most likely path from the facility being evacuated to the EPZ boundary, traveling toward the appropriate school reception center or host facility.

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

10.2 Reception Centers

According to the current public information calendar to EPZ residents, evacuees from the Counties of Fairfield, Richland, Lexington, and Newberry County will be directed to Fairfield Magnet School for Math and Science, Muller Road Middle School, Crossroads Middle School, and Newberry High School, respectively. Figure 10-3 presents a map showing the general population reception centers. As per 2020 Fairfield County Radiological Emergency Response Plan (Annex Q), Fairfield Central High School is an alternative reception center for Fairfield County evacuees/residents. Transit-dependent evacuees are transported to the appropriate reception center for each county. It is assumed that all special facility evacuees will be taken to the appropriate Reception Centers or host facility.

Table 10-3 presents a list of the school reception centers for each school and day care centers in the EPZ. Reception centers for schools and day care centers are based on the public information calendar. Any day care centers not listed in the public information calendar, was designated based on the county the day care center is located in. It is assumed that all school/day care center evacuees will be taken to the appropriate school reception center and will be subsequently picked up by parents or legal guardians. No children at these facilities will be picked up by parents prior to the arrival of the buses.

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

Bus Route Number	No. of Buses	PAZ (s) Serviced	Route Description	Length (mi.)
1	1	A-0, B-1, and B-2	Head north on State Highway 215 (SH 215), next turn right onto SH 213 northeast bound, then out of the EPZ.	10.0
2	1	A-1 and A-2	Head north on Cole Trestle Road, turn left onto Pearson Road northbound, turn right onto Ladds Road northeast bound, then turn left onto SH 215 northbound, next turn right onto County Route 34 (CR 34) eastbound, then out of the EPZ.	13.0
3	1	C-1 and C-2	Head east on State Road S-20 60, then turn right onto Estes Lane southeast bound, next turn left into SH 269 northbound, then out of the EPZ.	14.3
4	1	D-1	Head southeast on US Highway 176 (US 176), then out of the EPZ.	6.7
5	1	D-2	Head southeast onto US 76, then out of the EPZ.	4.8
6	1	E-1, E-2, F-1, and F-2	Head northwest on US 176, next turn left onto SH 219 west bound, then out of the EPZ.	11.4
Total:	**6**			

Table 10-2. Bus Route Descriptions

Bus Route Number	Description	Nodes Traversed from Route Start to EPZ Boundary
1	PAZ (A-0, B-1, B-2)	4, 5, 1067, 1, 3, 33, 34, 1053, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46
2	PAZ (A-1, A-2)	514, 513, 512, 511, 516, 517, 518, 510, 509, 498, 499, 519, 500, 505, 506, 507, 508, 96, 97, 98, 99, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 2
3	PAZ (C-1, C-2)	1019, 1020, 475, 1031, 476, 497, 669, 670, 671, 1016, 80, 79, 78, 86, 77, 76, 652, 75
4	PAZ (D-1)	1046, 202, 203, 204, 205, 206, 207, 208, 209, 210, 1146, 605, 211, 212
5	PAZ (D-2)	235, 857, 234, 684, 233, 855, 232, 231, 230, 229, 228, 686
6	PAZ (E-1, E-2, F-1, F-2)	996, 201, 200, 199, 198, 197, 175, 192, 193, 194, 195, 196, 307, 308, 309, 317, 332, 318, 333, 319, 320
7	McCrorey-Liston School of Technology McCrorey-Liston Child Development Center	958, 95, 96, 97, 98, 99, 114, 115, 116, 117, 118, 119, 120, 121, 122, 123, 124, 125, 2
8	Kelly Miller Elementary School	654, 652, 75, 74

Bus Route Number	Description	Nodes Traversed from Route Start to EPZ Boundary
	Kelly Miller Child Development Center	
9	Chapin High School	278, 277, 276, 273, 274, 376, 377
10	Crooked Creek Park Afterschool Program	701, 702, 1094, 703, 1096, 1097, 1099, 228, 686
	Chapin Intermediate School	
	Chapin Baptist Child Development Center	
11	Chapin Elementary School	1095, 1094, 703, 1096, 1097, 1099, 228, 686
12	Little Mountain Elementary	767, 239, 284, 283, 876, 298, 877, 282, 1035, 301, 371, 370, 305, 304, 369, 368
13	Mid-Carolina High School	859, 858, 243, 244, 245
	Mid-Carolina Middle School	
14	Pomaria-Garmany Elementary	307, 308, 309, 317, 332, 318, 333, 319, 320
15	Chapin Middle School	210, 1146, 605, 211, 212
	Academy for Success	
	Spring Hill High School	
	The Center for Advanced Technical Studies	
16	Mt Horeb Lutheran Church	267, 278, 277, 276, 273, 274, 376, 377
	Elaine Alewine	
	Abner Montessori School/Chapin Children's Center	
17	Chapin United Methodist Church Preschool	698, 233, 855, 267, 278, 277, 276, 273, 274, 376, 377
	Inez's Childcare Center	
18	Little Angels Daycare	284, 283, 876, 298, 877, 282, 1035, 301, 371, 370, 305, 304, 369, 368
19	Generations of Chapin	267, 278, 277, 276, 273, 274, 376, 377

Table 10-3. School/Licensed Day Care Center Reception Centers

Schools/Licensed Day Care Centers	School Reception Centers
FAIRFIELD COUNTY	
McCrorey-Liston School of Technology	Fairfield Magnet School for Math and Science
Kelly Miller Elementary School	
McCrorey-Liston Child Development Center	
Kelly Miller Child Development Center	
Jacqueline Wylie[1]	White Oak Conference Center
Jackie Chappell[1]	
LEXINGTON COUNTY	
Chapin High School	Crossroads Middle School
Crooked Creek Park Afterschool Program	
Chapin Intermediate School	
Chapin Elementary School	
Mt Horeb Lutheran Church	
Elaine Alewine	
Abner Montessori School/Chapin Children's Center	
Chapin Baptist Child Development Center	
Chapin United Methodist Church Preschool	
Inez's Childcare Center	
NEWBERRY COUNTY	
Little Angels Daycare	Newberry High School
Mid-Carolina High School	Wightman United Methodist Church
Mid-Carolina Middle School	
Little Mountain Elementary[2]	
Pomaria-Garmany Elementary[3]	Central United Methodist Church
RICHLAND COUNTY	
Chapin Middle School	Muller Road Middle School
Academy for Success	
Spring Hill High School	
The Center for Advanced Technical Studies	
Sally Becker[1]	

[1] Children from Jacqueline Wylie ,Jackie Chappell, and Sally Becker daycare centers will be transported by personal vehicles.
[2] This represents the children at the Little Mountain Elementary school and the licensed day care center provided at this facility.
[3] This represents the children Pomaria-Garmany Elementary School and the licensed day care center provided at this facility.

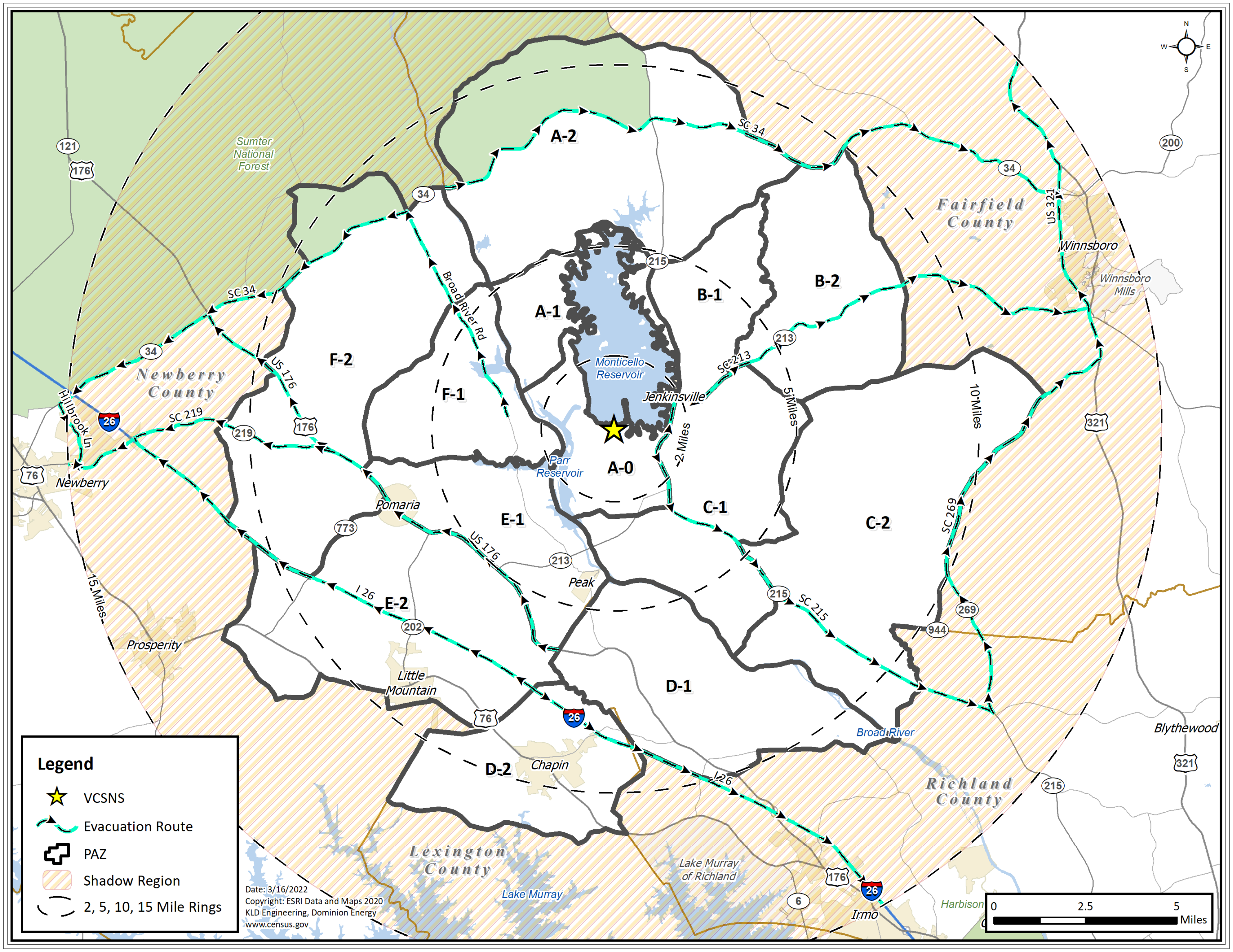


Figure 10-1. Major Evacuation Routes within the VCSNS EPZ

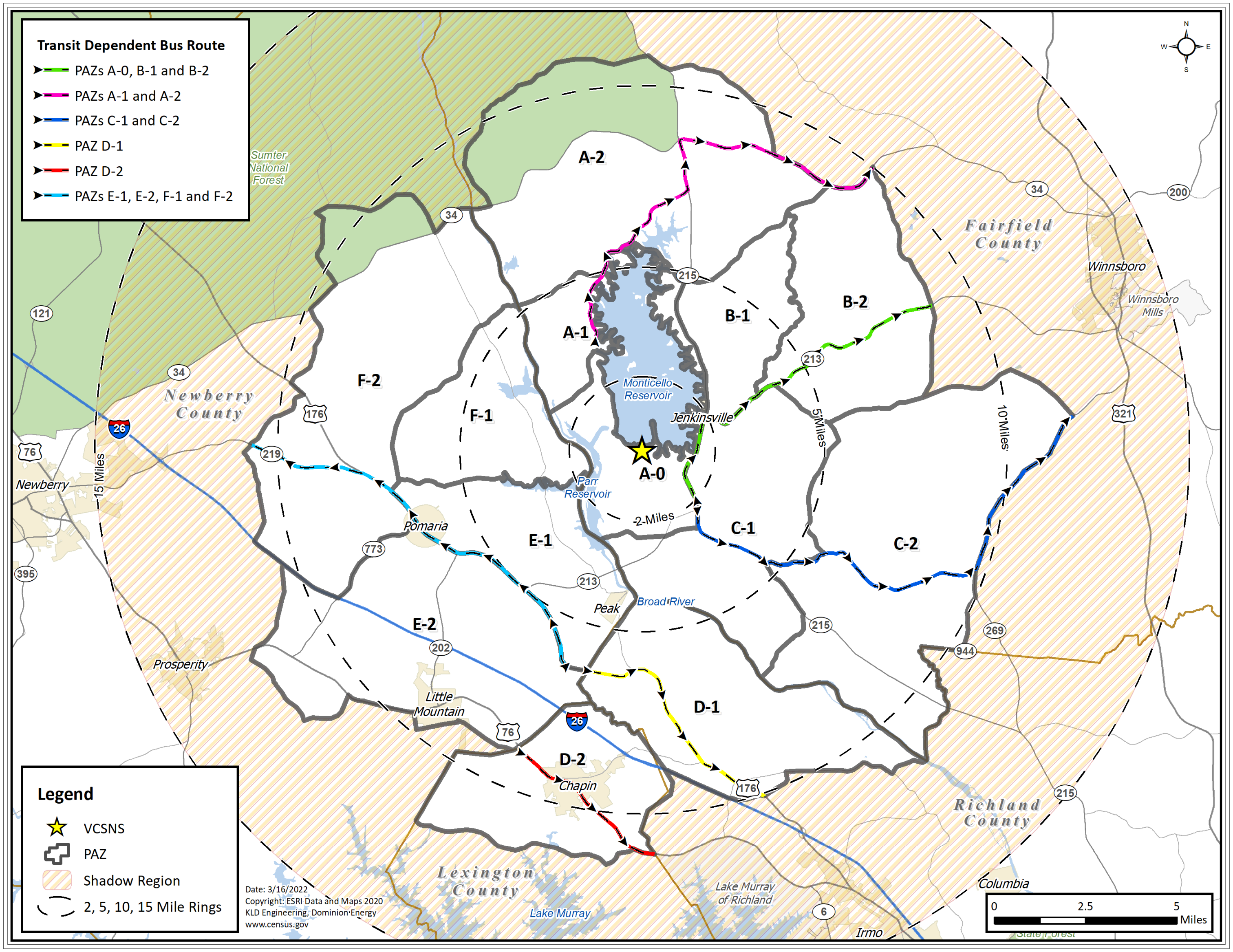


Figure 10-2. Transit-Dependent Bus Routes

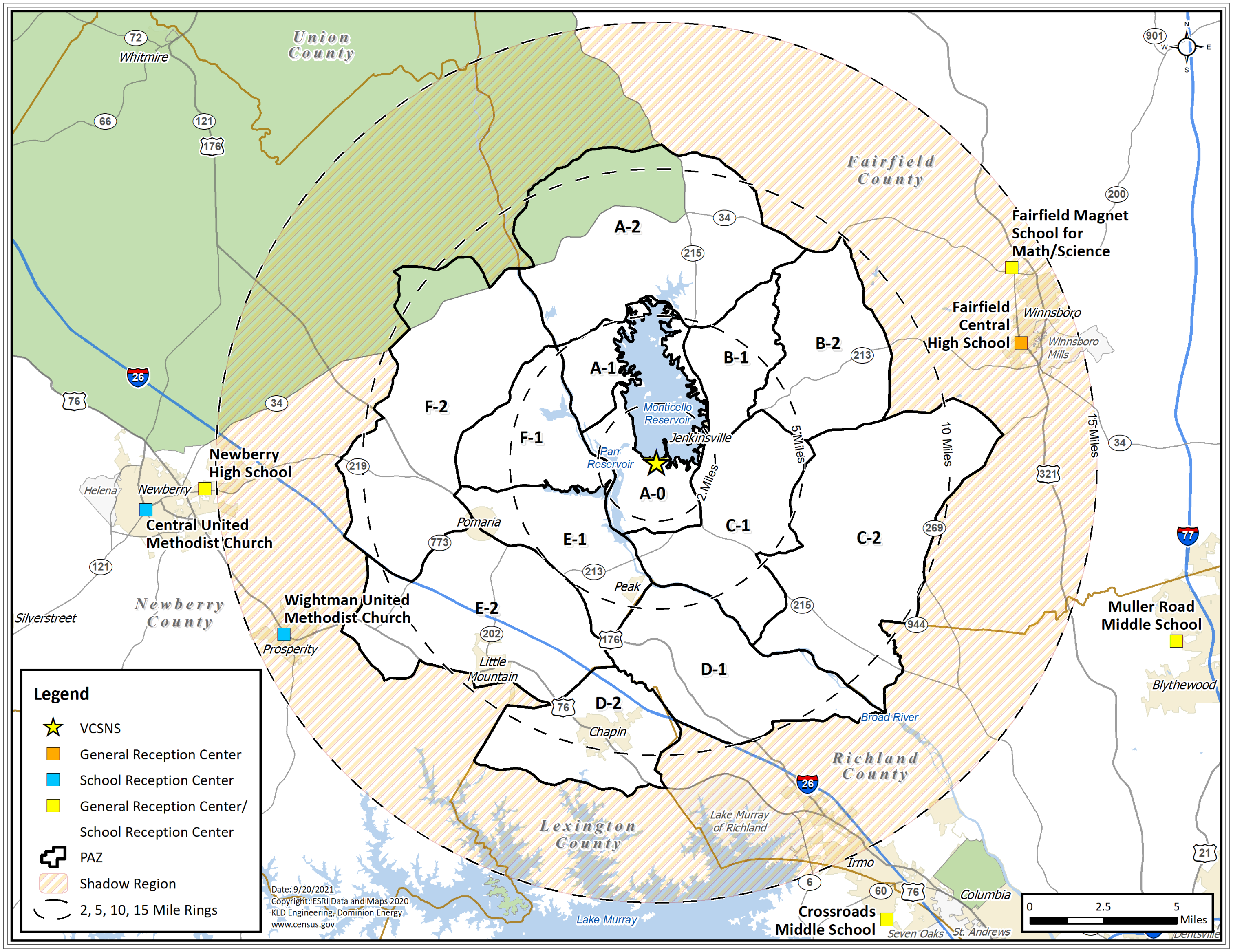


Figure 10-3. General Population Reception and School Reception Centers

APPENDIX A

Glossary of Traffic Engineering Terms

A. GLOSSARY OF TRAFFIC ENGINEERING TERMS

This appendix provides a glossary of traffic engineering terms that are used throughout this report.

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 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 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 (MOE).
Traffic Volume	The number of vehicles that pass over a section of roadway in one direction, expressed in 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 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 DYNEV II System. The DTRAD module implements path-based *Dynamic Traffic Assignment* (DTA) so that time dependent Origin-Destination (O-D) 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 = 12 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.

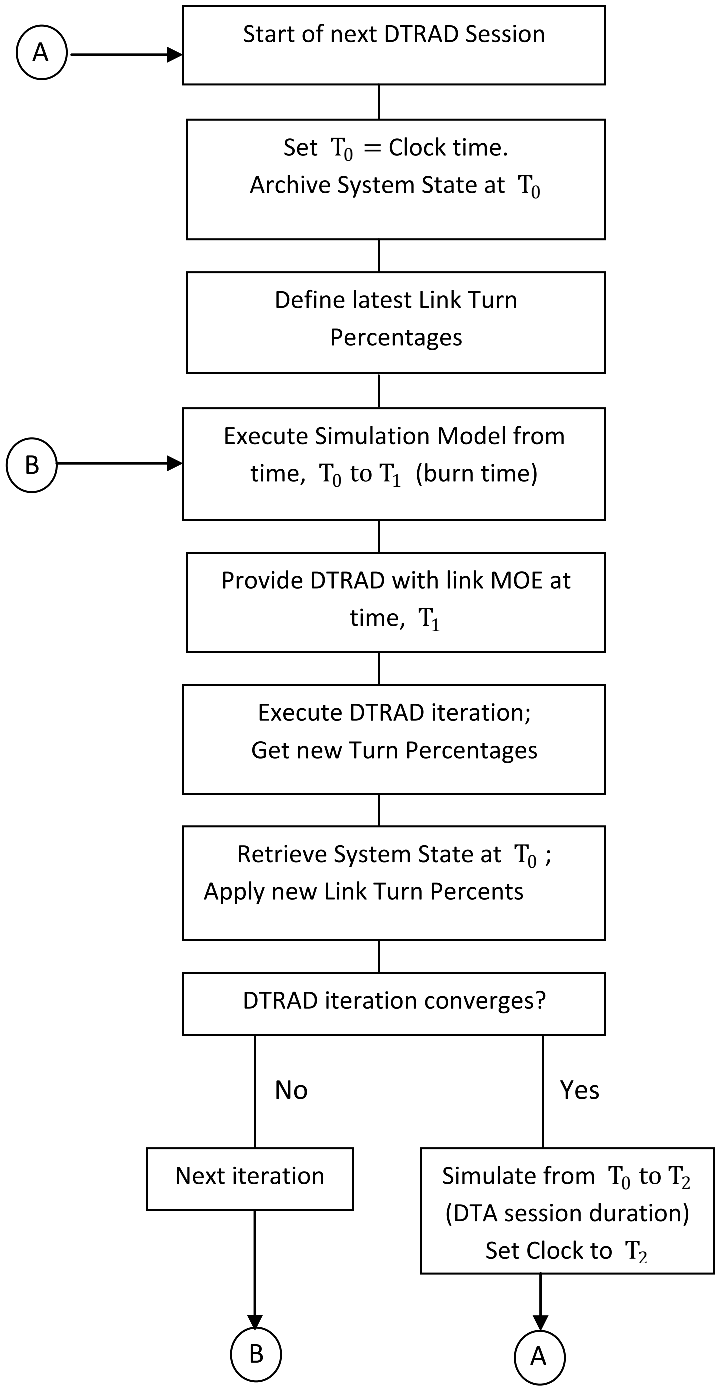


Figure B-1. Flow Diagram of Simulation-DTRAD Interface

APPENDIX C

DYNEV Traffic Simulation Model

C. DYNEV TRAFFIC SIMULATION MODEL

This appendix describes the 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, EVacuation ANimator (EVAN)
- Calculates ETE statistics

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

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

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

C.1 Methodology

C.1.1 The Fundamental Diagram

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

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

C.1.2 The Simulation Model

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

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

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

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

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

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

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

5. If $Q_b \geq Cap$, 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 $(Q_b \prec Cap)$
   $O_Q = Q_b$, $RCap = Cap - O_Q$

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 <u>moving</u> vehicles.

If $|\bar{k}_n - \bar{k}_{n-1}| > \epsilon$ and $n < N$
where N = max number of iterations, and ϵ is a convergence criterion, then

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

End if

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

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

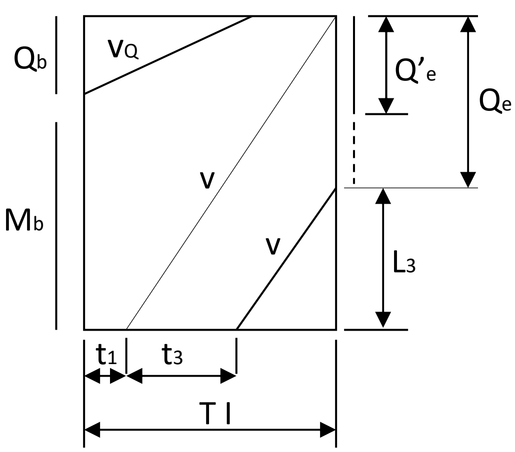
The number of excess vehicles that cause spillback is: $SB = Q_e + M_e - \frac{(L-W)\cdot LN}{L_v}$, where W is the width of the upstream intersection. To prevent spillback, meter the outflow from the feeder approaches and from the source flow, S, during this TI by the amount, SB. That is, set

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

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

Algorithm A

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



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

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

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

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

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

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

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

C.1.3 Lane Assignment

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

C.2 Implementation

C.2.1 Computational Procedure

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

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

Within each sweep, processing solves the "unit problem" for each turn movement on each link. With the turn movement percentages for each link provided by the DTRAD model, an algorithm allocates the number of lanes to each movement serviced on each link. The timing at a signal, if any, applied at the downstream end of the link, is expressed as a G/C ratio, the signal timing needed to define this ratio is an input requirement for the model. The model also has the capability of representing, with macroscopic fidelity, the actions of actuated signals responding to the time-varying competing demands on the approaches to the intersection.

The solution of the unit problem yields the values of the number of vehicles, O, that discharge from the link over the time interval and the number of vehicles that remain on the link at the end of the time interval as stratified by queued and moving vehicles: Q_e 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 MOEs for each link and turn movement for output purposes. It then prepares for the following time interval by defining the values of $\mathrm{Q_b}$ and $\mathrm{M_b}$ for the start of the next TI as being those values of $\mathrm{Q_e}$ and $\mathrm{M_e}$ 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, $[\mathrm{T_0}, \mathrm{T_2}]$, 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, $\mathrm{T_1} \leq \mathrm{T_2}$, which lies within the session duration, $[\mathrm{T_0}, \mathrm{T_2}]$. This "burn time", $\mathrm{T_1} - \mathrm{T_0}$, 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, $\mathrm{T_0}$, and executes until it arrives at the end of the DTRAD session duration at time, $\mathrm{T_2}$. 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 and access 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.

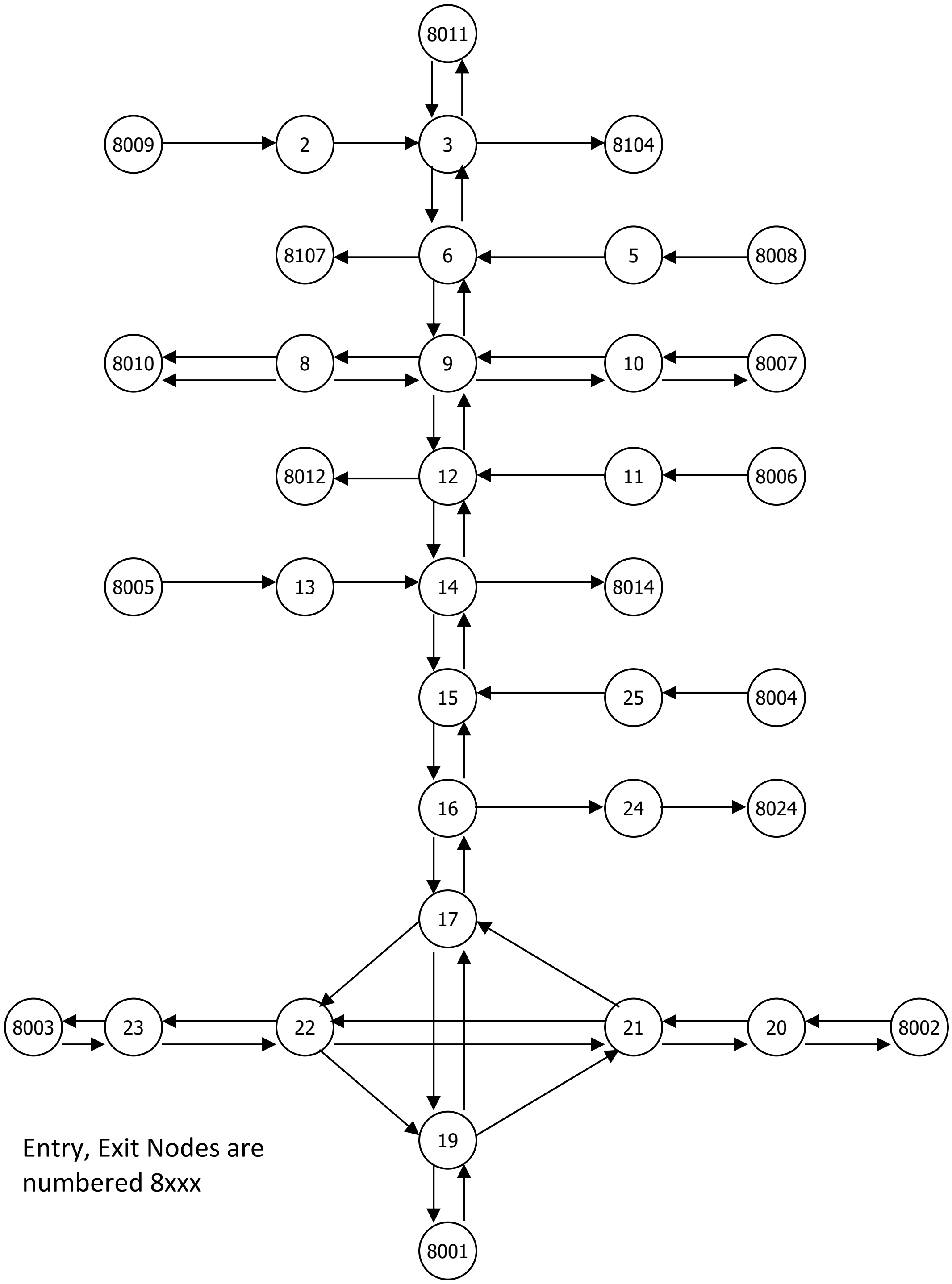


Figure C-1. Representative Analysis Network

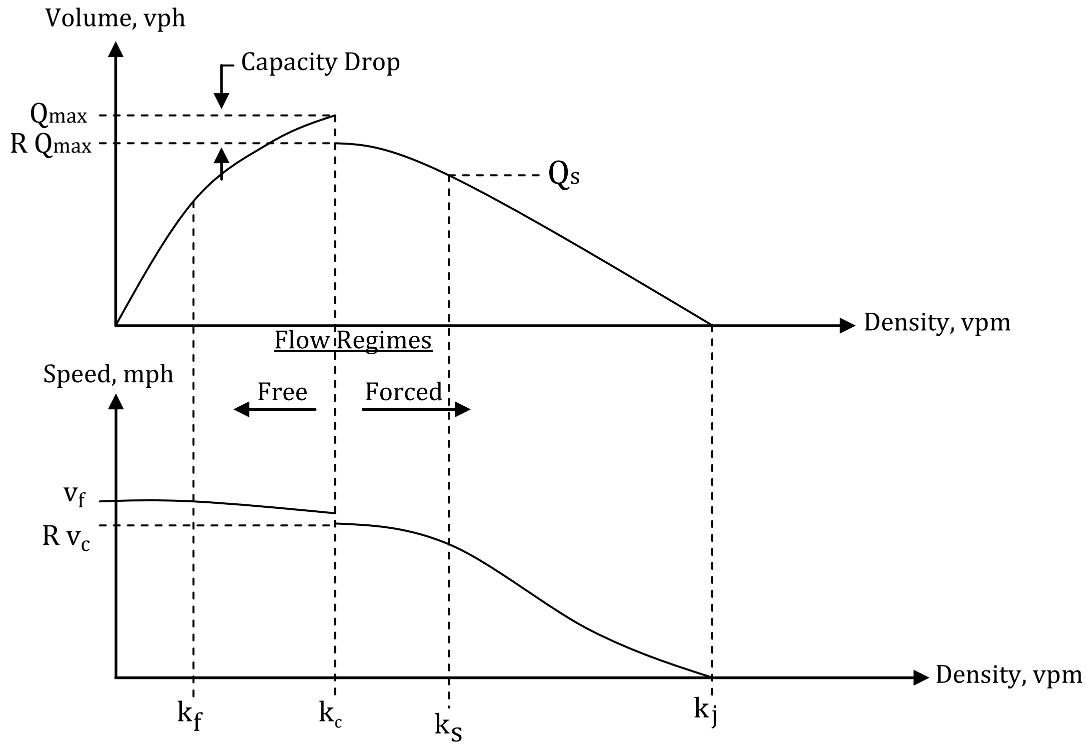


Figure C-2. Fundamental Diagrams

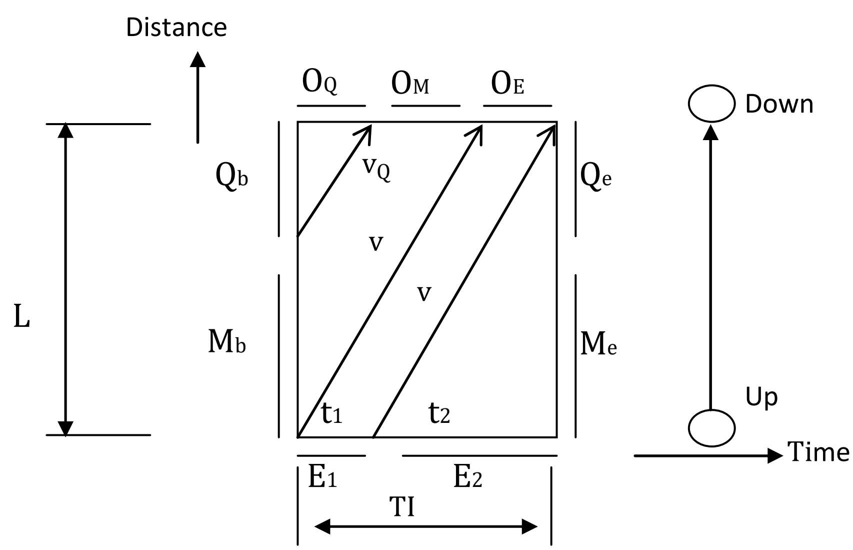


Figure C-3. A UNIT Problem Configuration with $t_1 > 0$

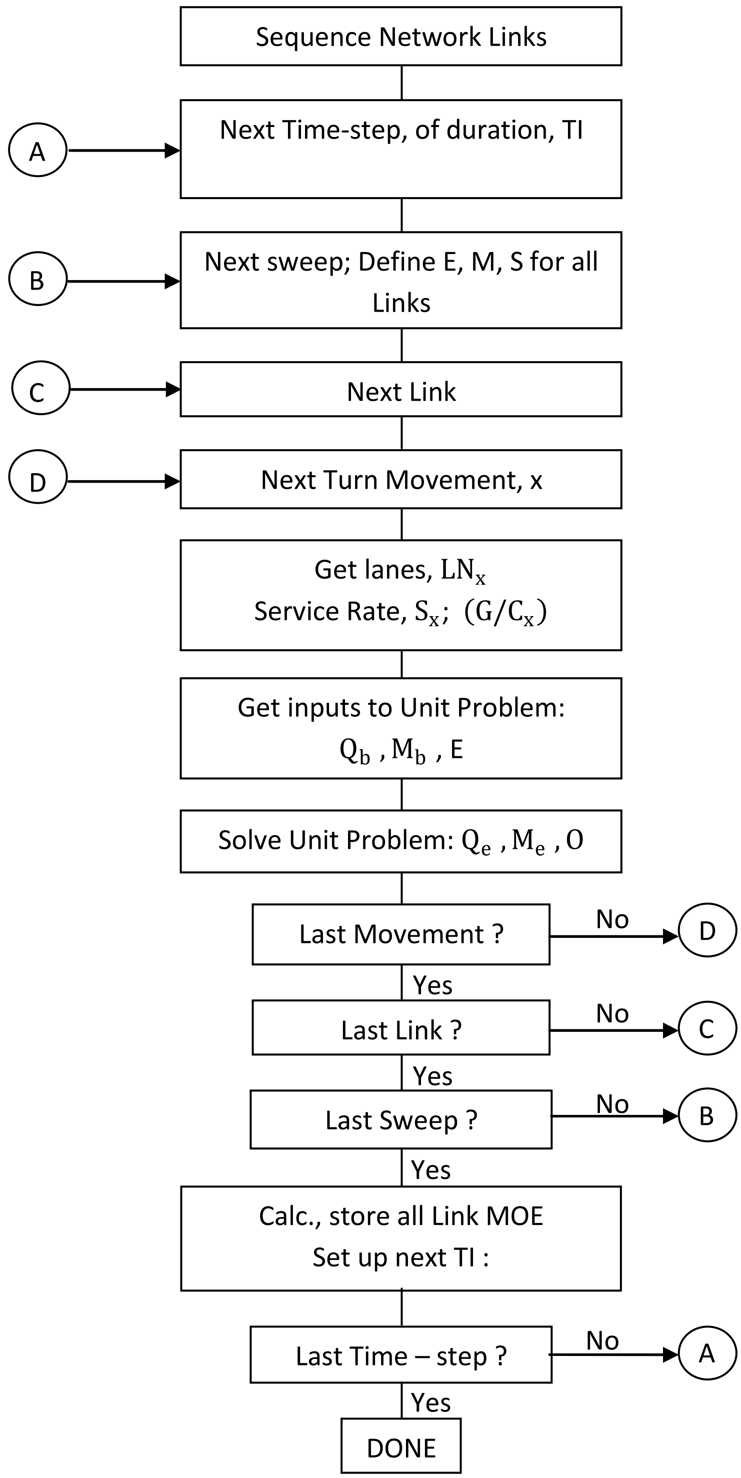


Figure C-4. Flow of Simulation Processing (See Glossary: Table C-3)

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 the 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 and Protective Action Zone (PAZ) boundaries.

Step 2

The 2020 Census block population 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. Data for employees, transients, schools, and other facilities were obtained from Dominion Energy, county emergency management agencies, the National Center for Education Statistics website[1] and personnel at the South Carolina Department of Social Services, and the old data from the previous study, supplemented by internet searches and phone calls to specific facilities where data was missing. In addition, transportation resources available during the emergency were also provided by the counties within the EPZ.

Step 3

A kickoff meeting was conducted with major stakeholders (state and county emergency officials, and on-site and off-site Dominion Energy 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 the state and county emergency officials and the Dominion Energy utility 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.

[1] https://nces.ed.gov/ccd/schoolsearch/index.asp

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 13 PAZs. Based on wind direction and speed, Regions (groupings of PAZs 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 System, 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) 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 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 and for school buses, vans, wheelchair buses and wheelchair 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 model 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.

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, licensed day care centers, Generations of Chapin medical facility, 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.

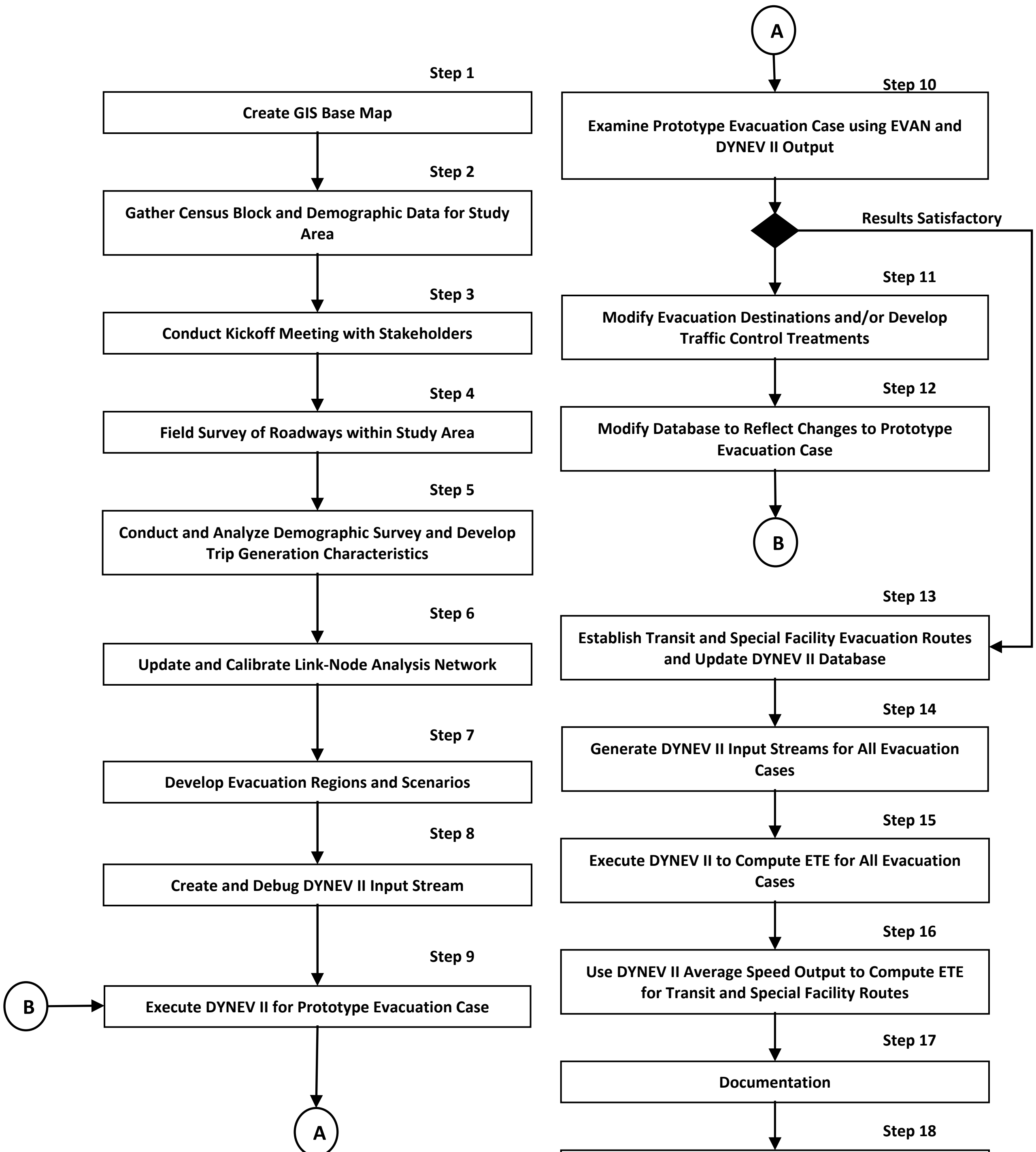


Figure D-1. Flow Diagram of Activities

APPENDIX E

Facility Data

E. FACILITY DATA

The following tables list population information, as of February 2022, for special facilities that are located within the VCSNS EPZ. Special facilities are defined as schools, licensed day care centers, and medical facilities. Transient population data is included in the table for recreational areas (campgrounds, golf courses, marinas, and parks). Employment data are 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), direction (magnetic bearing) from the center point of the plant, and by its PAZ. Maps identifying the location of each special facility, recreational area (campground, golf course, marina, and park), and major employer are also provided.

Table E-1. Schools within the EPZ

PAZ	Distance (miles)	Dire-ction	School Name	Street Address	Municipality	Enroll-ment
FAIRFIELD COUNTY						
A-2	6.4	NNE	McCrorey-Liston School Of Technology	1978 SC-215 S	Blair	135
C-2	11.1	E	Kelly Miller Elementary School	255 Kelly Miller Rd	Winnsboro	221
					Fairfield County Subtotal:	*356*
LEXINGTON COUNTY						
D-2	9.2	S	Chapin High School	300 Columbia Ave	Chapin	1,552
D-2	10.8	S	Crooked Creek Park Afterschool Program	1098 Old Lexington Hwy	Chapin	45
D-2	11.1	S	Chapin Intermediate School	1130 Old Lexington Hwy	Chapin	811
D-2	11.2	S	Chapin Elementary School	940 Old Bush River Rd	Chapin	874
					Lexington County Subtotal:	3,282
NEWBERRY COUNTY						
E-2	9.1	SW	Little Mountain Elementary	692 Mill St	Little Mountain	428
E-2	10.9	WSW	Mid-Carolina High School	6794 US 76	Prosperity	738
E-2	10.9	WSW	Mid-Carolina Middle School	6834 US 76	Prosperity	557
F-2	6.7	WSW	Pomaria-Garmany Elementary	7288 US 176	Pomaria	347
					Newberry County Subtotal:	*2,070*
RICHLAND COUNTY						
D-1	9.2	SSE	Chapin Middle School	11661 Broad River Rd	Chapin	976
D-1	9.4	SSE	Academy for Success	11629 Broad River Rd	Chapin	125
D-1	9.4	SSE	Spring Hill High School	11629 Broad River Rd	Chapin	1,135
D-1	9.5	SSE	The Center for Advanced Technical Studies	916 Mt Vernon Church Rd	Chapin	313
					Richland County Subtotal:	*2,549*
					EPZ TOTAL:	**8,257**

Table E-2. Licensed Day Care Centers within the EPZ

PAZ	Distance (miles)	Dire-ction	School Name	Street Address	Municipality	Enroll-ment
FAIRFIELD COUNTY						
A-2	6.4	NNE	McCrorey-Liston Child Development Center	1978 SC-215 S	Blair	20
B-2	7.9	ENE	Jacqueline Wylie	302 Guess Dr	Winnsboro	6
B-2	8.0	ENE	Jackie Chappell	4303 Jackson Creek Rd	Winnsboro	6
C-2	11.1	E	Kelly Miller Child Development Center	255 Kelly Miller Rd	Winnsboro	40
					Fairfield County Subtotal:	*72*
LEXINGTON COUNTY						
D-2	9.2	S	Mt Horeb Lutheran Church	101 E Boundary St	Chapin	70
D-2	9.3	S	Elaine Alewine	108 E Boundary St	Chapin	6
D-2	9.5	S	Abner Montessori School/Chapin Children's Center	432 E Boundary St	Chapin	246
D-2	9.6	S	Chapin Baptist Child Development Center	950 Old Lexington Hwy	Chapin	332
D-2	9.6	SSW	Chapin United Methodist Church Preschool	415 Lexington Ave	Chapin	50
D-2	9.6	SSW	Inez's Childcare Center	411 Lexington Ave	Chapin	52
					Lexington County Subtotal:	756
NEWBERRY COUNTY						
E-2	8.5	SW	Little Angels Daycare	753 SC-202	Little Mountain	44
E-2	9.1	SW	Little Mountain Elementary	692 Mill St	Little Mountain	20
F-2	6.7	WSW	Pomaria-Garmany Elementary	7288 US 176	Pomaria	40
					Newberry County Subtotal:	*104*
RICHLAND COUNTY						
D-1	8.9	SSE	Sally Becker	2273 Harvestwood Ln	Chapin	6
					Richland County Subtotal:	*6*
					EPZ TOTAL:	**938**

Table E-3. Medical Facilities within the EPZ

PAZ	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Cap-acity	Current Census	Ambul-atory Patients	Wheel-chair Patients	Bed-ridden Patients
LEXINGTON COUNTY										
D-2	9.5	S	Generations of Chapin	431 E Boundary St	Chapin	64	54	29	25	0
Lexington County Subtotal:						*64*	*54*	*29*	*25*	*0*
EPZ TOTAL:						**64**	**54**	**29**	**25**	**0**

Table E-4. Major Employers within the EPZ

PAZ	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Employees (Max Shift)	% Employees Commuting into the EPZ	Employees Commuting into the EPZ	Employee Vehicles Commuting into the EPZ
FAIRFIELD COUNTY									
A-0	-	-	VC Summer Nuclear Station	576 Stairway Rd	Jenkinsville	318	90%	286	262
Fairfield County Subtotal:						*318*	*-*	*286*	*262*
LEXINGTON COUNTY									
D-2	9.5	S	General Information Services	917 Chapin Rd	Chapin	600	78.5%	471	432
Lexington County Subtotal:						*600*	*-*	*471*	*432*
EPZ TOTAL:						**918**	**-**	**757**	**694**

Table E-5. Recreational Areas within the EPZ

PAZ	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Facility Type	Transients	Vehicles
FAIRFIELD COUNTY								
A-1	2.4	NE	Lake Monticello Park	Baltic Cir	Jenkinsville	Park	13	5
A-1	2.6	NE	Monticello Boat Ramp	6773 SC-215	Jenkinsville	Marina	13	5
A-1	5.3	N	99 Boat Ramp	Meadow Lake Rd	Jenkinsville	Marina	5	2
A-1	5.4	N	Unnamed Boat Ramp	Meadow Lake Rd	Jenkinsville	Marina	13	5
A-2	5.7	N	Monticello Recreational Lake Beach	Hemlock Ln	Jenkinsville	Park	27	10
B-1	3.3	NNE	Stonewall RV Park	5693 SC-215	Jenkinsville	Campground	12	20
C-2	8.1	SE	Broad River Campground	16842 SC-215	Winnsboro	Campground	350	240
						Fairfield County Subtotal:	*433*	*287*
LEXINGTON COUNTY								
D-2	11	S	Lake Murray Golf Center	2032 Old Hilton Rd	Chapin	Golf Course	12	10
						Lexington County Subtotal:	*12*	*10*
NEWBERRY COUNTY								
E-1	3.6	SSW	River Road Family Campground	1061 Broad River Rd	Pomaria	Campground	40	60
E-1	5.5	WSW	Gateway Motorhome and RV Park	2688 Peak Rd	Pomaria	Campground	25	40
E-2	9	SW	Rocky Branch Natural Area	State Rd S-36-73	Little Mountain	Park	10	8
E-2	9.2	WSW	Mid Carolina Club Inc	3593 Kibler Bridge Rd	Prosperity	Golf Course	15	10
F-1	2.7	WSW	Cannon's Creek Public Access	Broad River Rd	Pomaria	Marina	13	5
F-1	3.6	WNW	Heller's Creek Boat Ramp	6316 County Rd S-36-28	Pomaria	Marina	13	5
						Newberry County Subtotal:	*116*	*128*
						EPZ TOTAL:	**561**	**425**

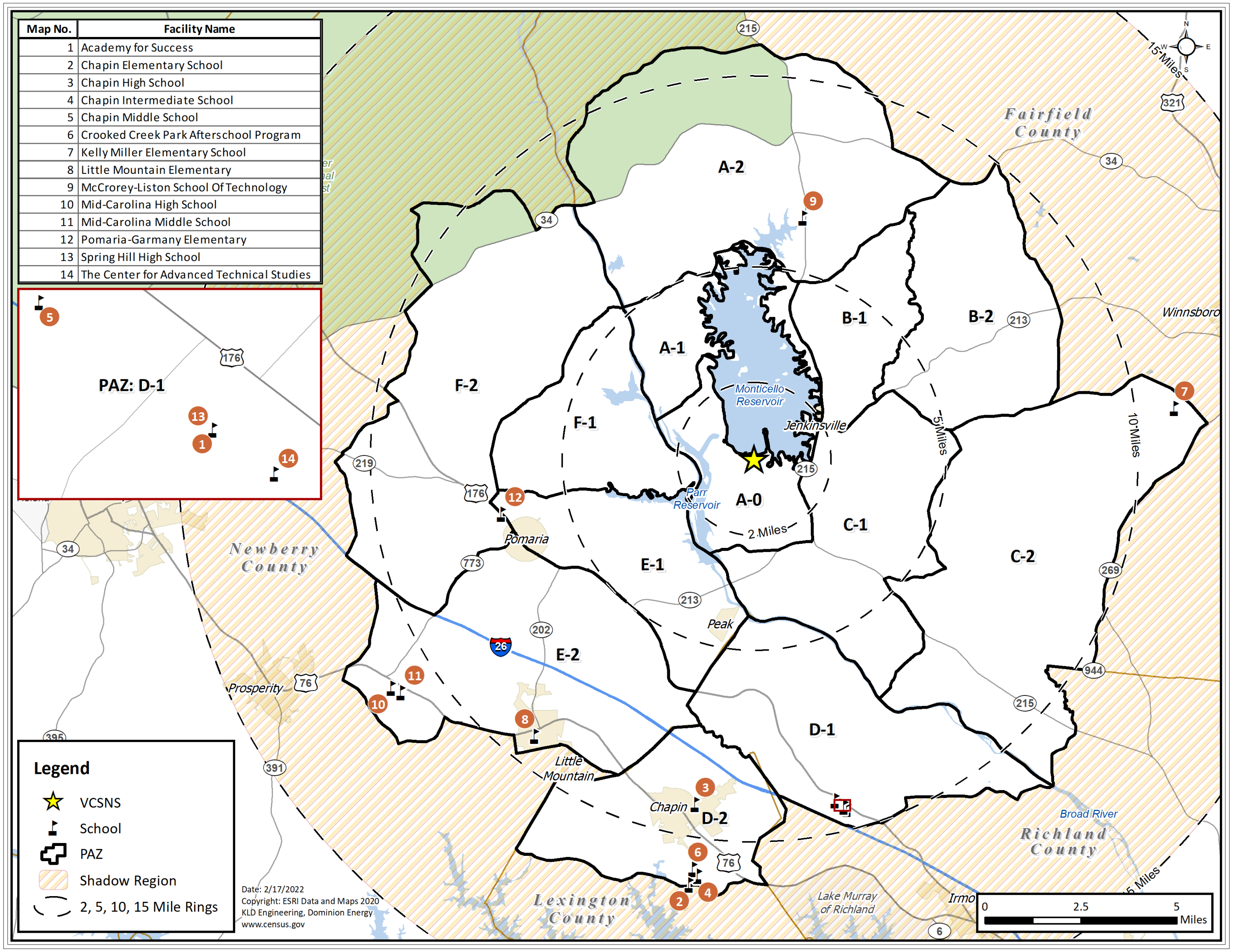
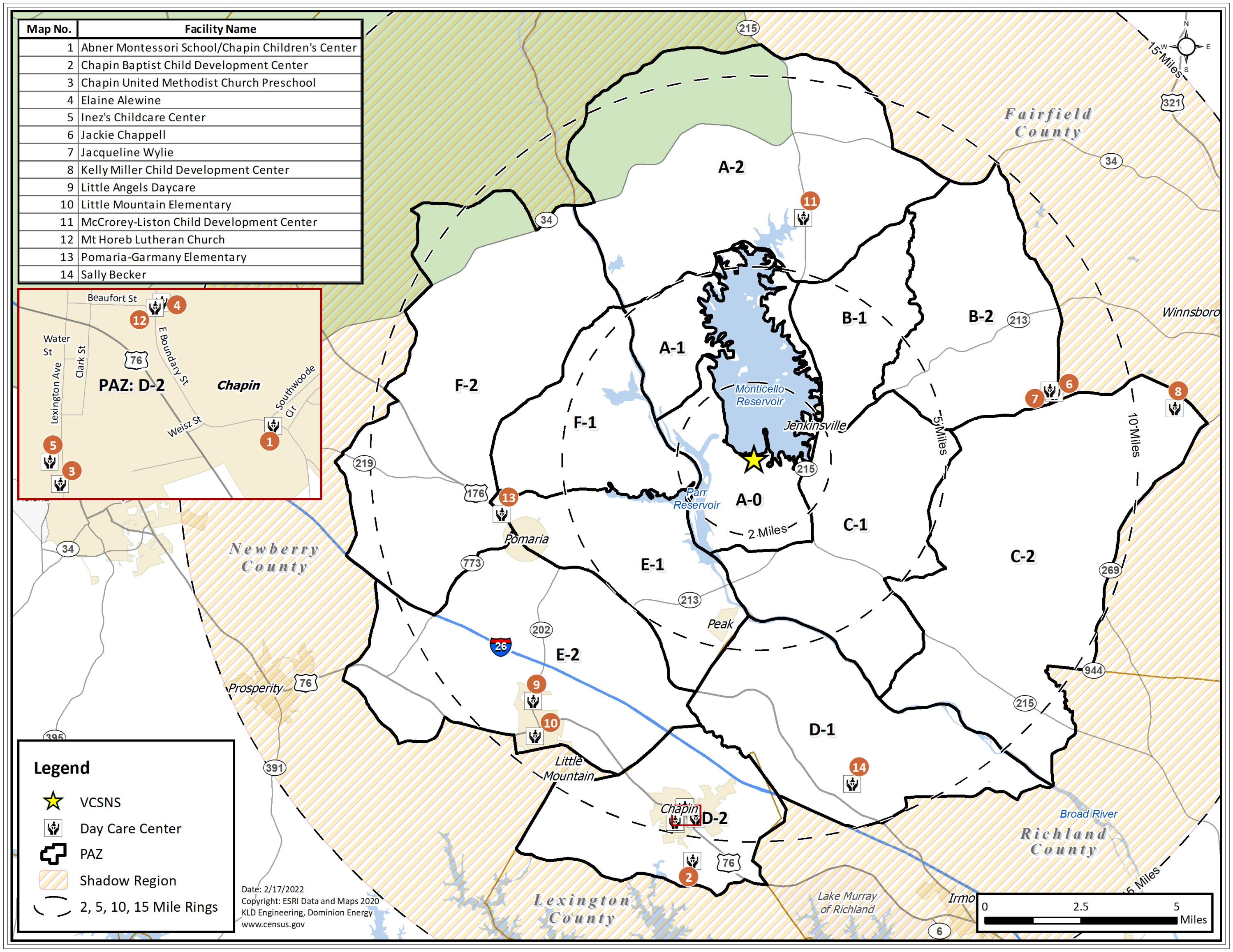


Figure E-1. Schools within the EPZ



Map No.	Facility Name
1	Abner Montessori School/Chapin Children's Center
2	Chapin Baptist Child Development Center
3	Chapin United Methodist Church Preschool
4	Elaine Alewine
5	Inez's Childcare Center
6	Jackie Chappell
7	Jacqueline Wylie
8	Kelly Miller Child Development Center
9	Little Angels Daycare
10	Little Mountain Elementary
11	McCrorey-Liston Child Development Center
12	Mt Horeb Lutheran Church
13	Pomaria-Garmany Elementary
14	Sally Becker

Figure E-2. Licensed Day Care Centers within the EPZ

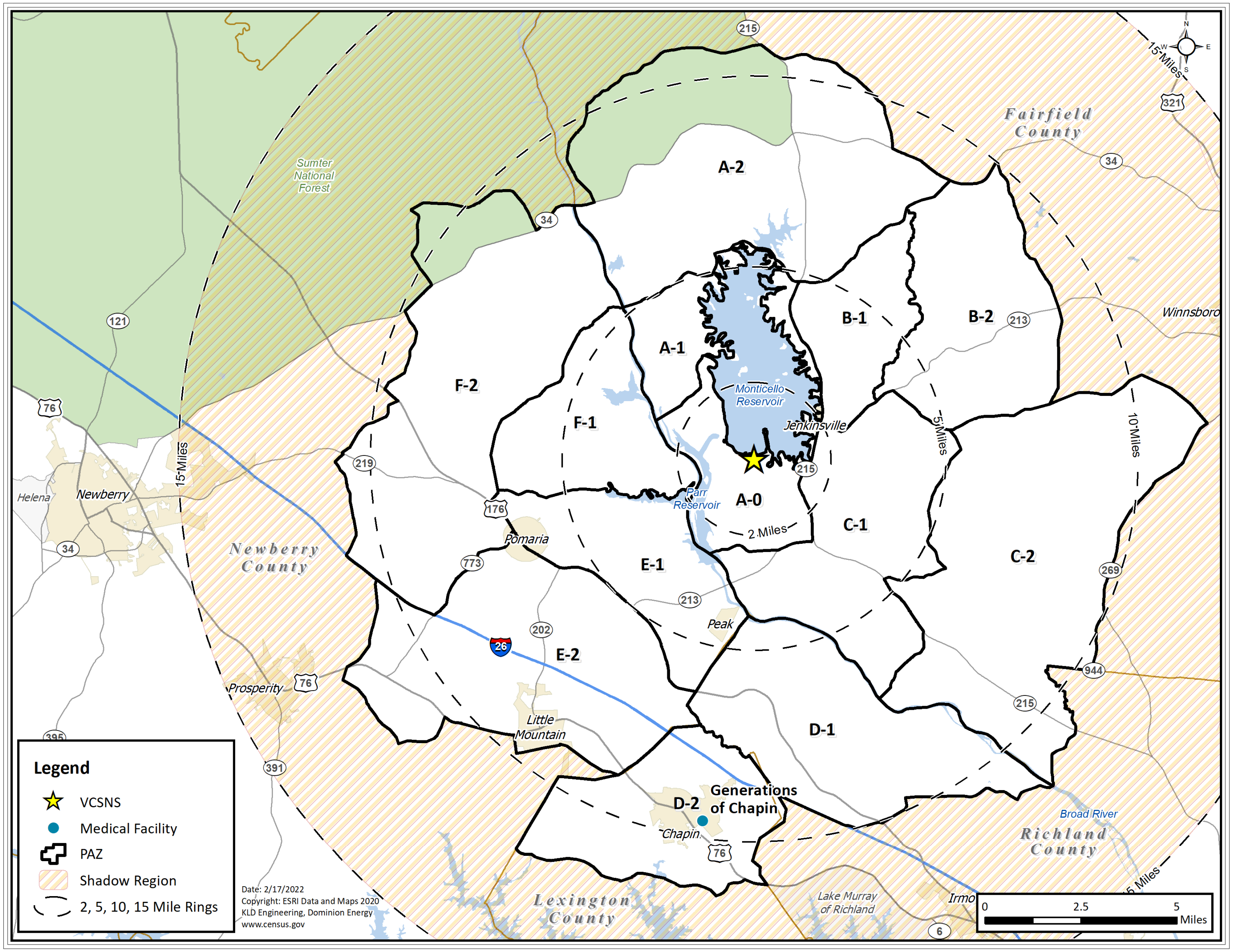


Figure E-3. Medical Facilities within the EPZ

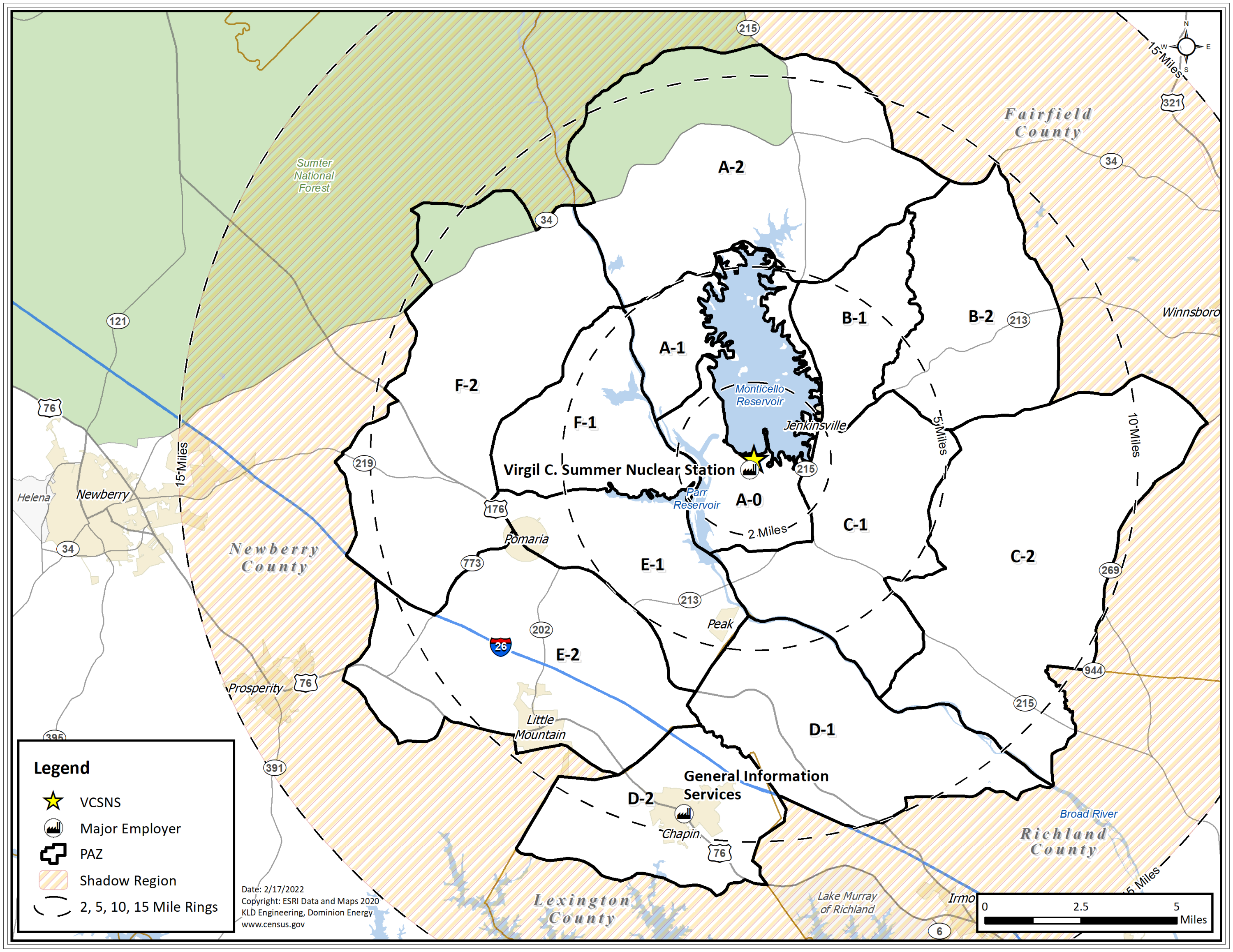
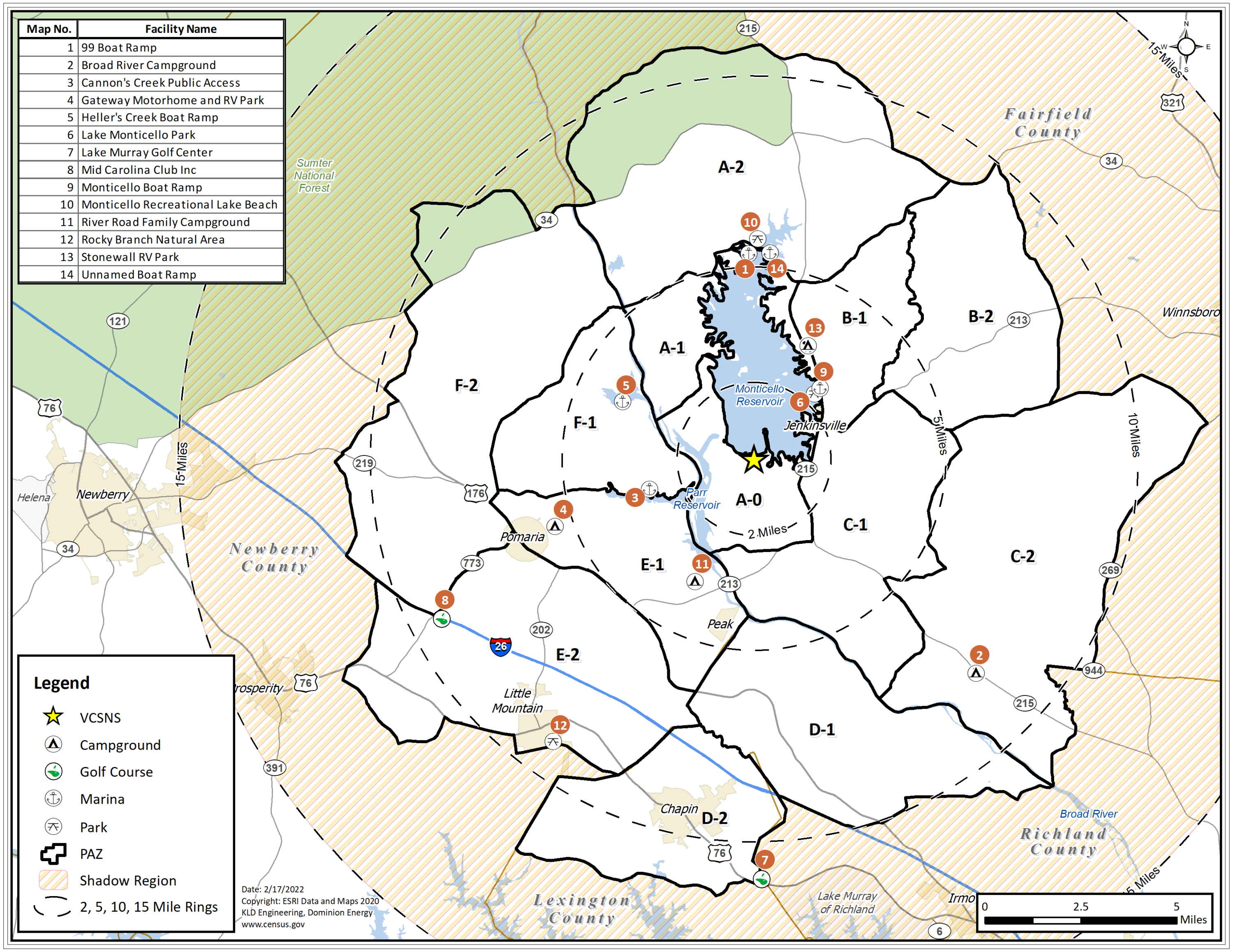


Figure E-4. Major Employers within the EPZ



Map No.	Facility Name
1	99 Boat Ramp
2	Broad River Campground
3	Cannon's Creek Public Access
4	Gateway Motorhome and RV Park
5	Heller's Creek Boat Ramp
6	Lake Monticello Park
7	Lake Murray Golf Center
8	Mid Carolina Club Inc
9	Monticello Boat Ramp
10	Monticello Recreational Lake Beach
11	River Road Family Campground
12	Rocky Branch Natural Area
13	Stonewall RV Park
14	Unnamed Boat Ramp

Figure E-5. Recreational Areas within the EPZ

APPENDIX F

Demographic Survey

F. DEMOGRAPHIC SURVEY

F.1 Introduction

The development of evacuation time estimates for the VC Summer Nuclear Station (VCSNS) Emergency Planning Zone (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 began in February 2021 and the 2020 Census data had not been released, 2010 Census data was used to develop the sampling plan.

A sample size of approximately 437 **completed** survey forms yields results with a sampling error of ±4.50% 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 geographic information system (GIS) software. This list is shown in Table F-1. Along with each zip code, an estimate of the population and number of households in each area was determined by overlaying 2010 Census data and the EPZ boundary, again using GIS software. The proportional number of desired completed survey interviews for each zip code 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 survey exceeded the sampling plan. A total of 481 **completed** samples were obtained corresponding to a sampling error of ±4.27% at the 95% confidence level based on the 2010 Census Data. The number of samples obtained within each zip code is also shown in Table F-1.

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. According to the responses, the average household contains 2.52 people. The estimated average household size from the 2020 Census data is 2.58 people, which is in good agreement with the demographic survey. The percent difference between the 2020 Census data and survey data is 2.33%, which is within the sampling error of 4.27%, as discussed in Section F.2.

Automobile Ownership

The average number of automobiles available per household in the EPZ is 2.43. It should be noted that all households within the EPZ have access to an automobile according to the demographic survey. The distribution of automobile ownership is presented in Figure F-2. Figure F-3 and Figure F-4 present the automobile availability by household size. As expected, all households of 2 or more people have access to at least one vehicle.

Ridesharing

Approximately 82% 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 on a daily basis. The data shows an

average of 1.06 commuters per household in the EPZ, and approximately 60% 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 (89%) of commuters use their private automobiles to travel to work. The data shows an average of 1.09 employees per vehicle, assuming 2 people per vehicle – on average – for carpools.

Impact of Coronavirus Disease 2019 (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. The data shows an average of 0.55 commuters per household were affected by the COVID-19 pandemic. Approximately 32% 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

Figure F-9 presents the distribution of the number of individuals with functional or transportation need. The survey result shows that approximately 7% of households have functional or transportation needs. Of those with functional or transportation needs, about 21% require a bus, about 29% require a medical bus/van, about 32% require a wheelchair accessible vehicle, 15% require an ambulance, and the remaining 3% indicated that they would require other transportation needs.

F.3.2 Evacuation Response

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

"How many vehicles would your household use during an evacuation?" The response is shown in Figure F-10. On average, evacuating households would use 1.53 vehicles.

"Would your family await the return of other family members prior to evacuating the area?" Of the survey participants who responded, 58.4% said they would await the return of other family members before evacuating and 41.6% indicated 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 (stay at home, work or current location) in an emergency because you are not in the area of risk. Would you?" This question is designed to elicit information regarding compliance with instructions to shelter-in-place. The results indicate that nearly 89% of households who are advised to shelter in place would do so; the remaining 11% would choose to evacuate the area.

Note the baseline ETE study assumes 20% of households will not comply with the shelter advisory, as per Section 2.5.2 of NUREG/CR-7002, Rev. 1. Thus, the compliance rate obtained above is relatively higher than the federal guidance. 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-in-place now in an emergency and possibly evacuate later while people in other areas are advised to evacuate now. Would you?" This question is designed to elicit information specifically related to the possibility of a staged evacuation. That is, asking a population to shelter in place now and then to evacuate after a specified period of time. Results indicate that about 73% of households would follow instructions and delay the start of evacuation until so advised, while the other 27% 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. Results show that 48.3% of households indicated that they would evacuate to a friend or relatives' home, 4.9% to a reception center, 16.5% to a hotel, motel or campground, 7.2% to a second or seasonal home, 0.2% of households would not evacuate, and the remaining 22.9% responded other/don't know to this question. The response is shown in Figure F-12.

"If you had a pet and/or animal, would you take your pet and/or animal with you if you were asked to evacuate?" Based on the responses to the survey, about 67% of households have a pet and/or animal. Of the households with pets and/or animals, 22.4% of them indicated that they would take their pets with them to a shelter, 68.4% indicated that they would take their pets somewhere else, and 9.2% would leave their pet at home. The response is shown in Figure F-13. Of the households that would evacuate with their pets, approximately 89% indicated that they have sufficient room in their vehicle to evacuate with their pets/animals and 7% would use a trailer.

"What type of pet(s) and/or animal(s) do you have?" Based on responses from the survey, nearly 83% of households have a household pet (dog, cat, bird, reptile, or fish), about 14% of households have farm animals (horse, chicken, goat, or pig), 2% have other small pets/animals, and 1% have other 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-8, the majority (68%) 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?" Figure F-14 presents the cumulative distribution; in all cases, the activity is completed by about 75 minutes (1 hour and 15 minutes). Approximately 89% can leave within 35 minutes.

"How long would it take the commuter to travel home ?" Figure F-15 presents the work to home travel time for the EPZ. About 90% of commuters can arrive home within about 45 minutes of leaving work; all within 90 minutes (1 hour and 30 minutes).

"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.

About 92% of households can be ready to leave home within 3 hours; the remaining households require up to an additional 1 hour and 15 minutes .

F.4 Conclusions

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

Table F-1. VC Summer Demographic Survey Sampling Plan

Zip Code	EPZ Population (2010)	EPZ Households Within Zip Code (2010)	Desired Samples	Samples Obtained
29015	1,186	415	33	5
29036	4,653	1,814	144	189
29063	747	282	22	48
29065	675	286	23	11
29075	2,098	830	66	50
29108	24	9	1	16
29122	54	27	2	1
29126	1,980	778	62	111
29127	737	296	24	23
29180	2,021	755	60	27
EPZ Total	**14,175**	**5,492**	**437**	**481**
Average HH Size[1]:	**2.58**			

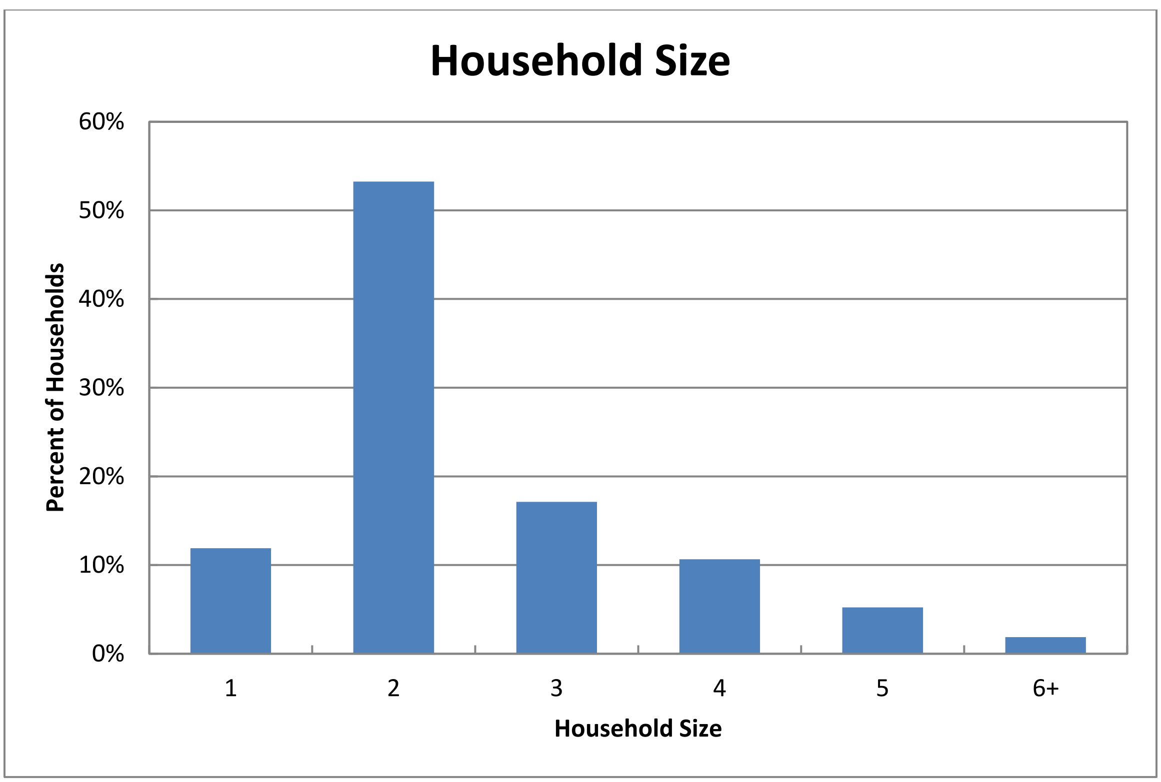


Figure F-1. Household Size in the EPZ

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

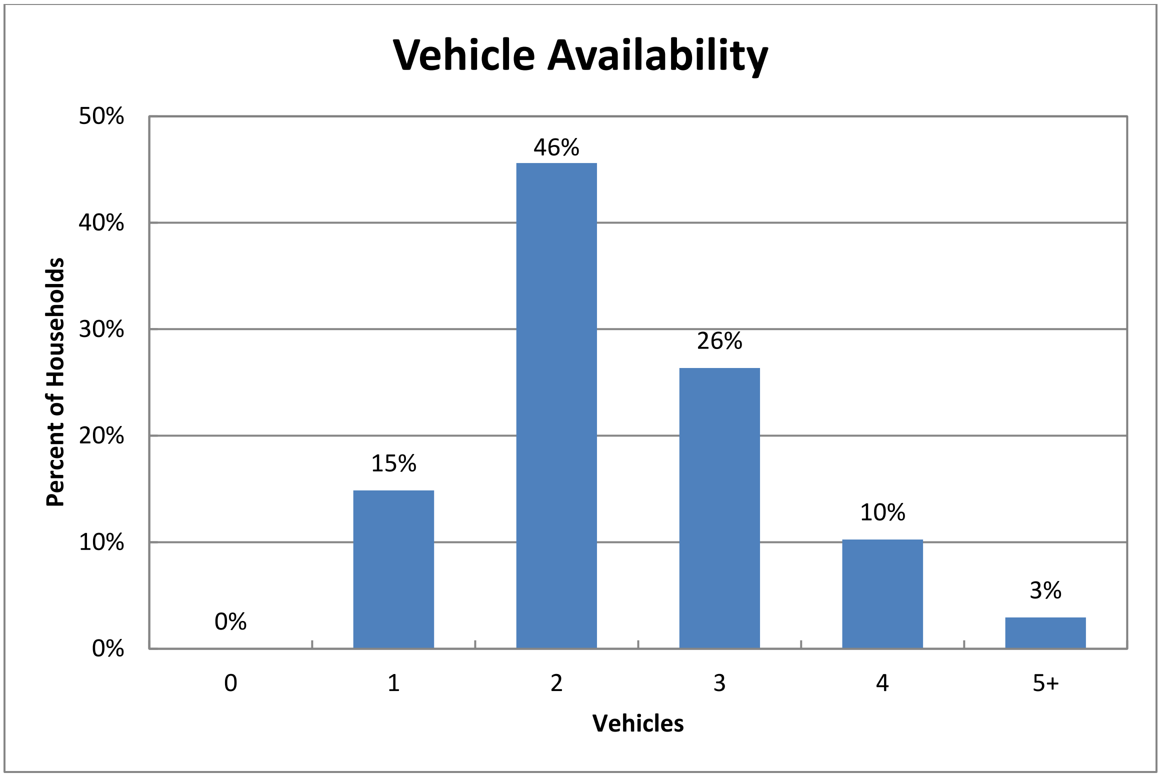


Figure F-2. Vehicle Availability

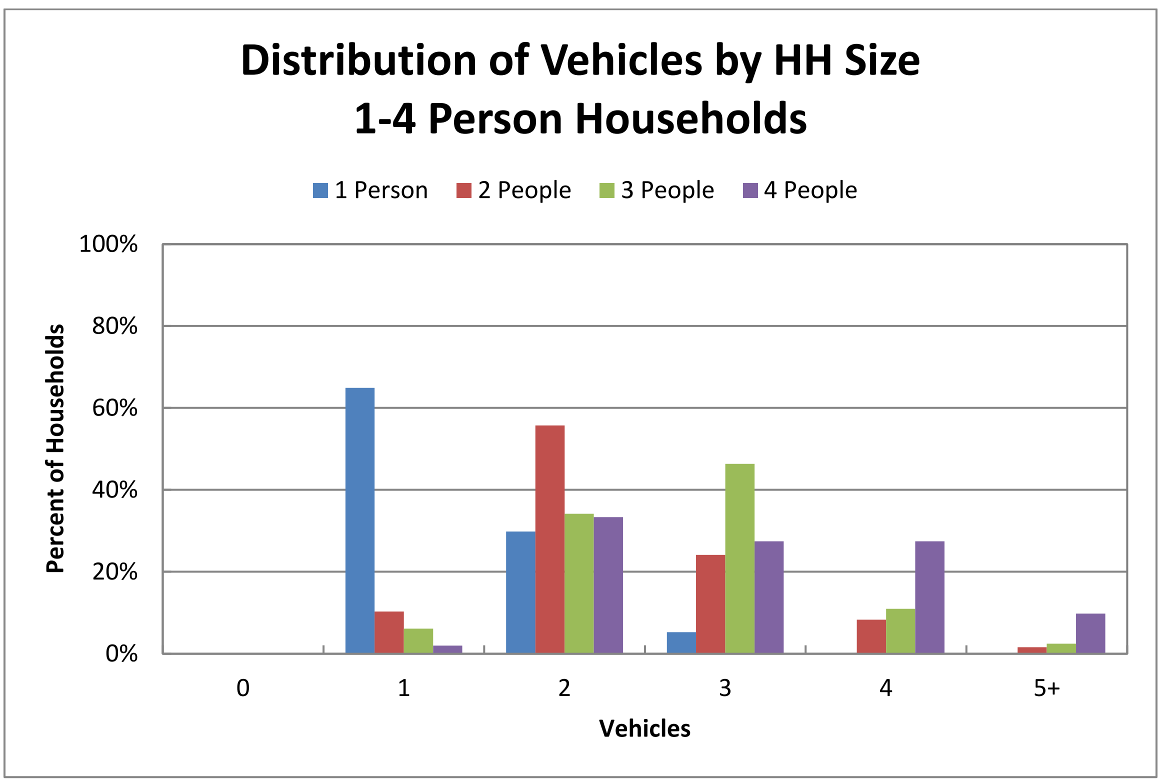


Figure F-3. Vehicle Availability - 1 to 4 Person Households

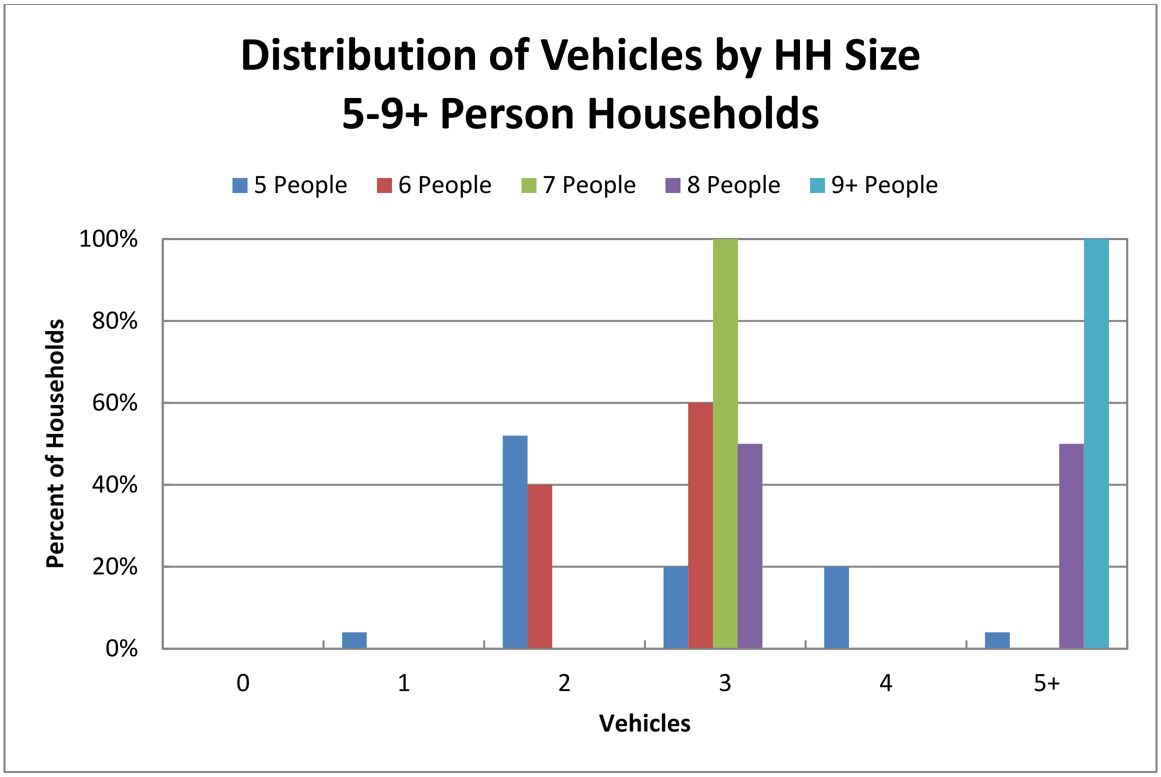


Figure F-4. Vehicle Availability - 5 to 9+ Person Households

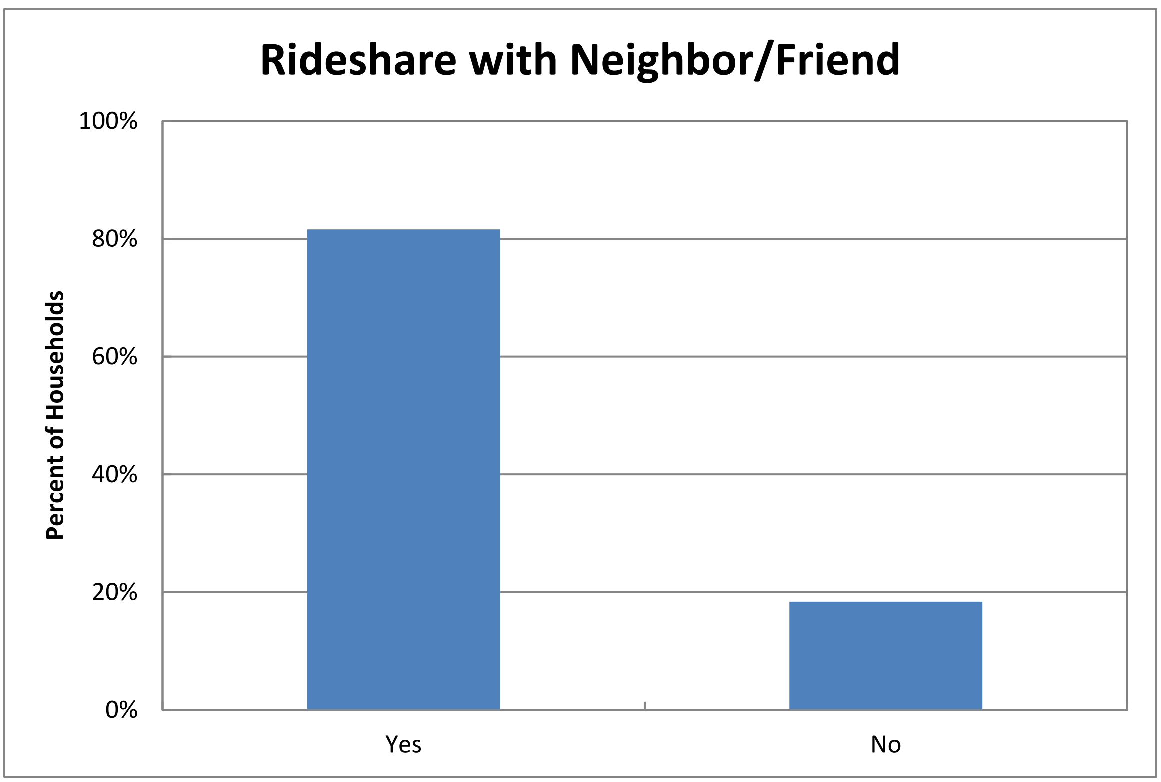


Figure F-5. Household Ridesharing Preference

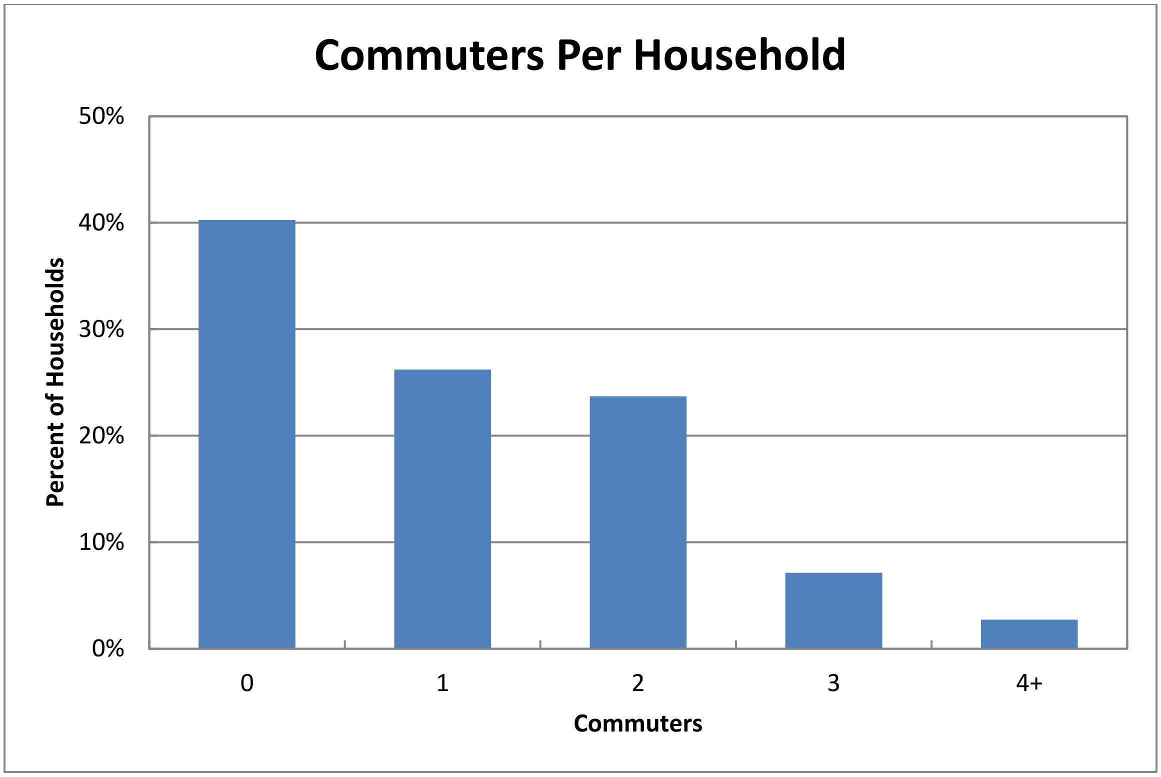


Figure F-6. Commuters per Households in the EPZ

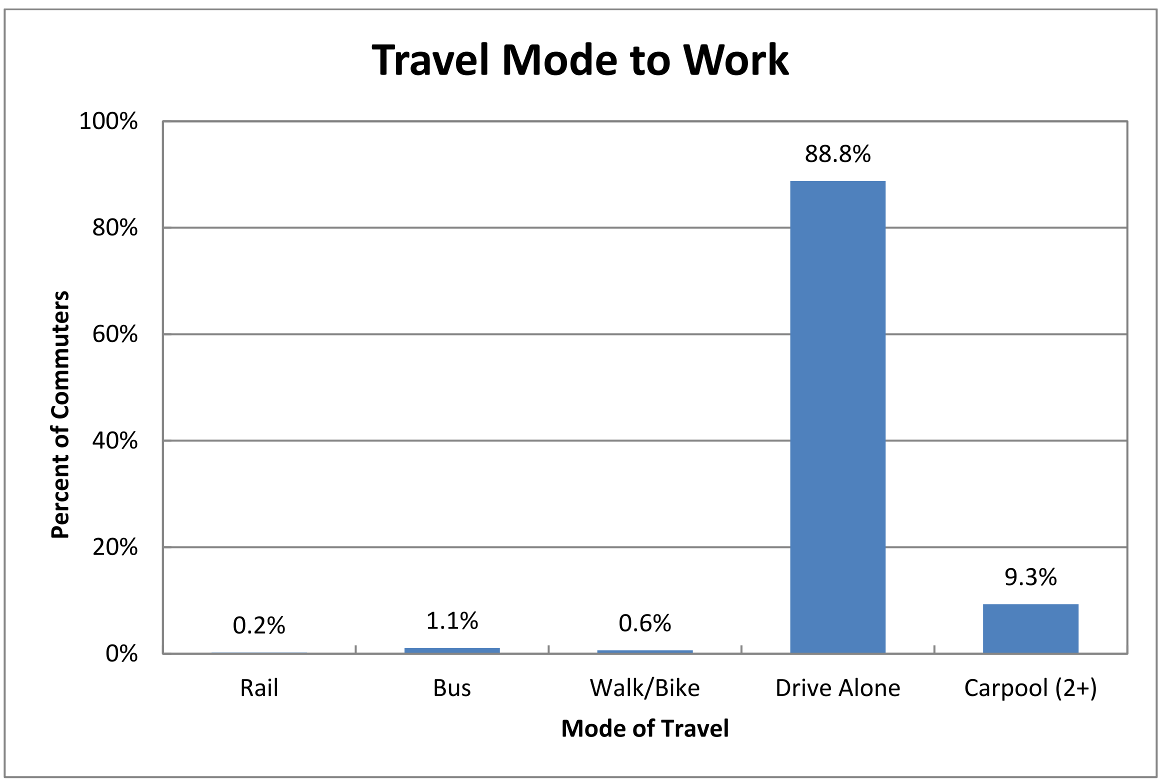


Figure F-7. Modes of Travel in the EPZ

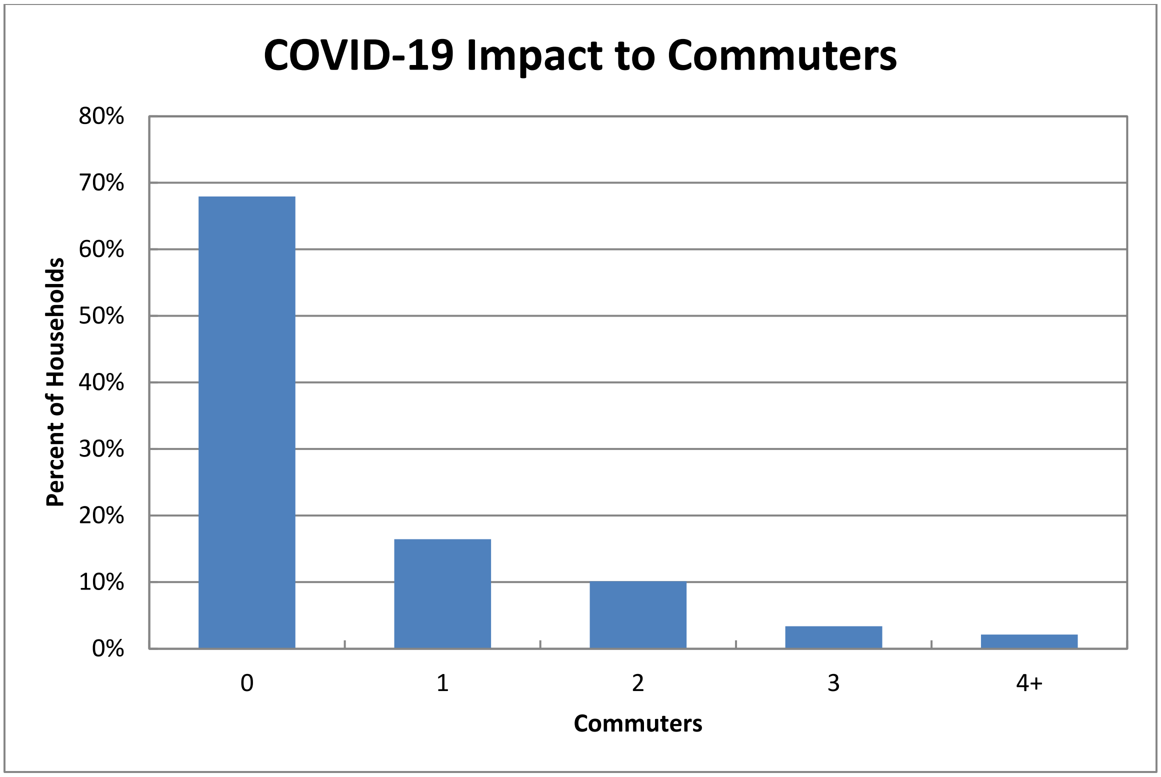


Figure F-8. Commuter Impacted by COVID-19

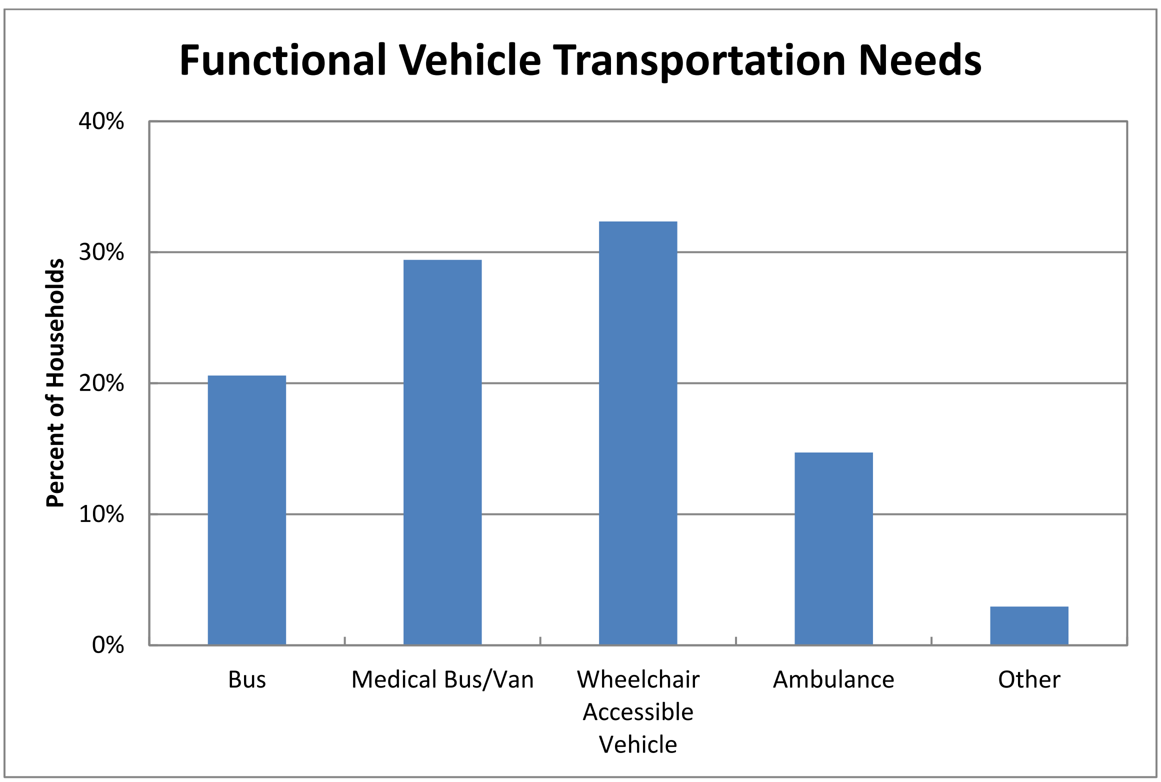


Figure F-9. Households with Functional or Transportation Needs

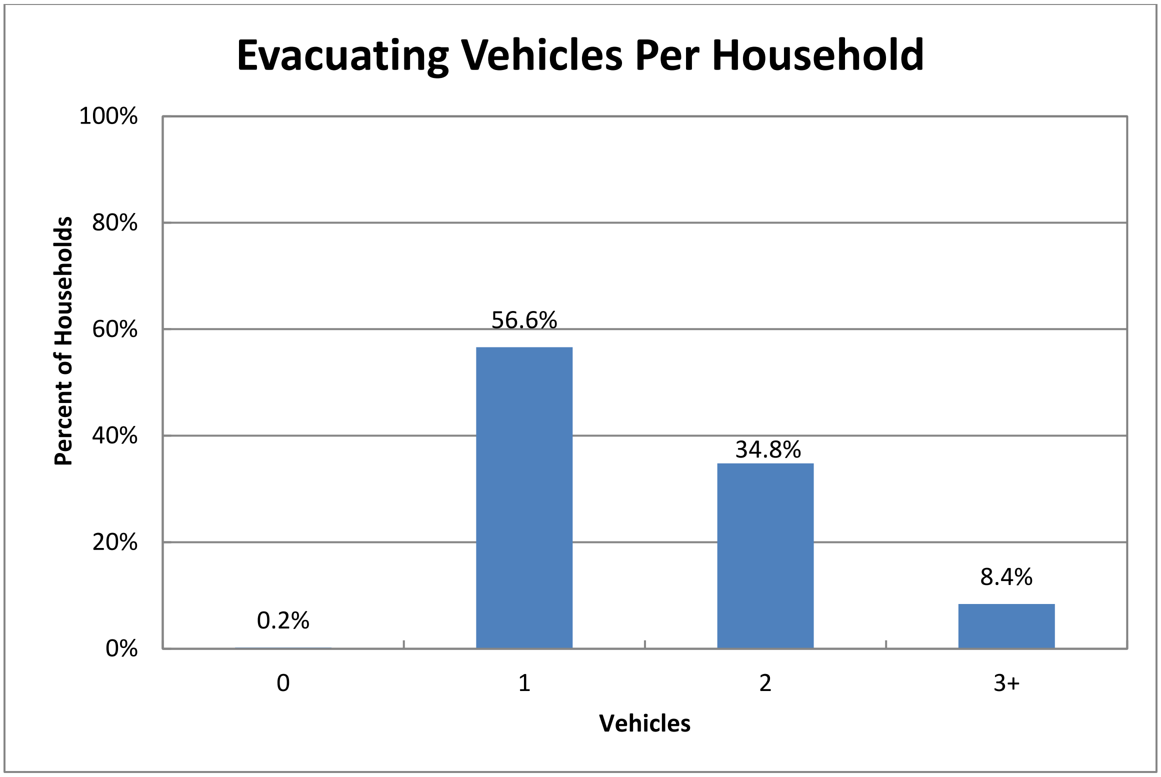


Figure F-10. Number of Vehicles Used for Evacuation

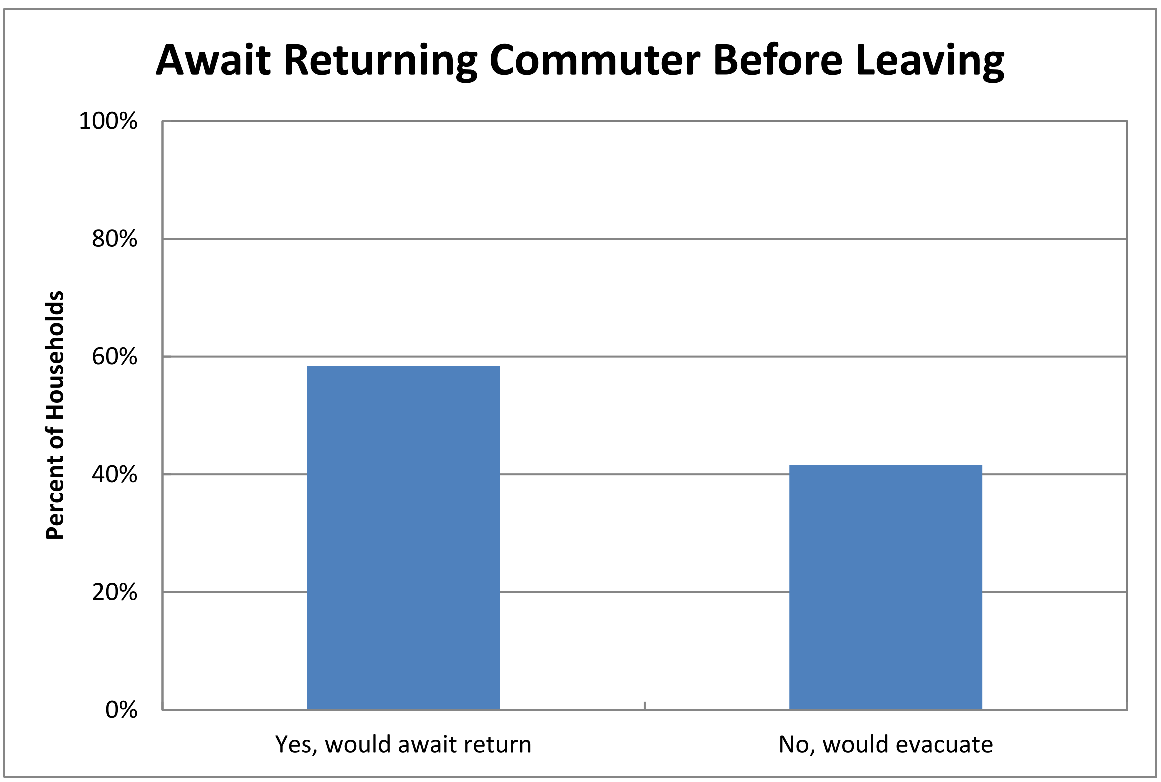


Figure F-11. Percent of Households that Await Returning Commuter Before Evacuating

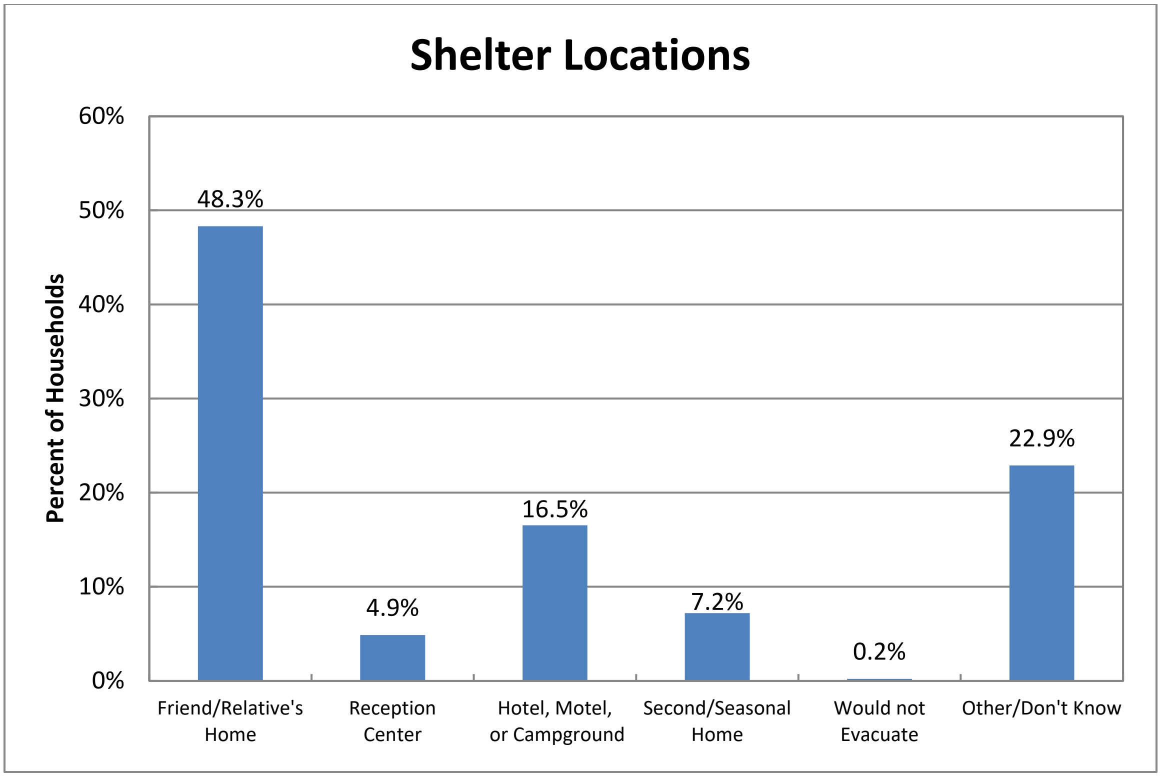


Figure F-12. Study Area Evacuation Destinations

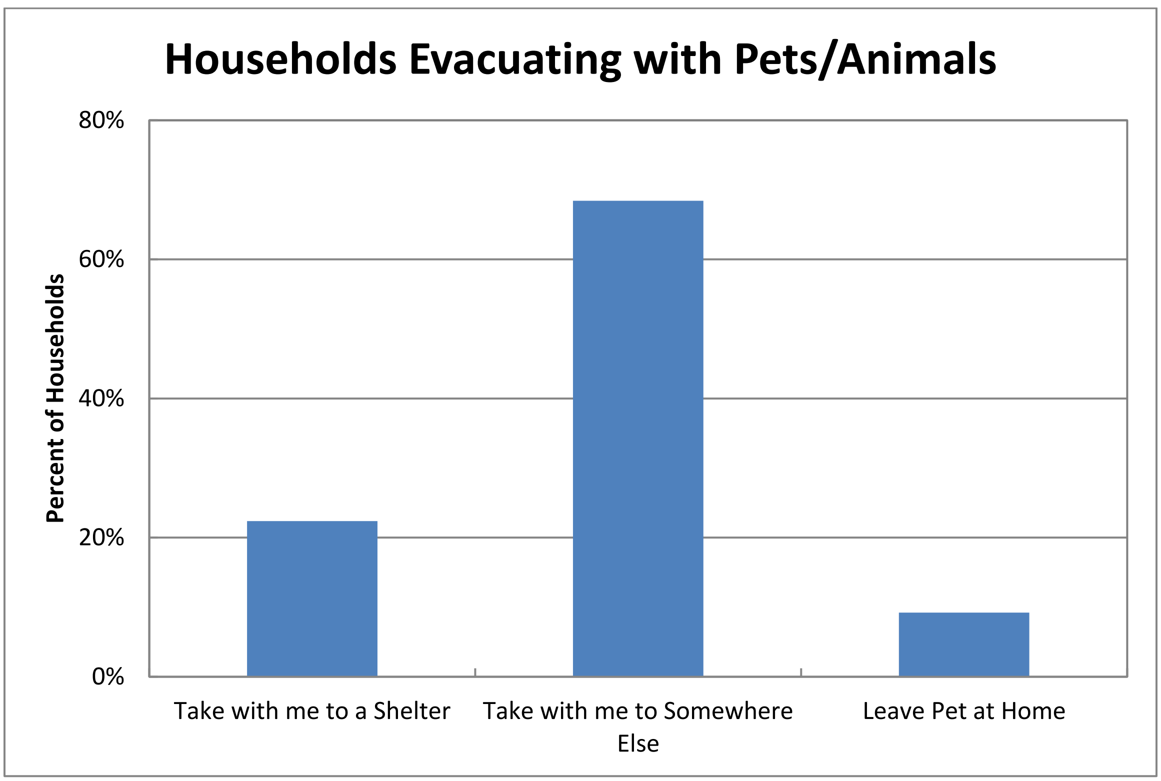


Figure F-13. Households Evacuating with Pets/Animals

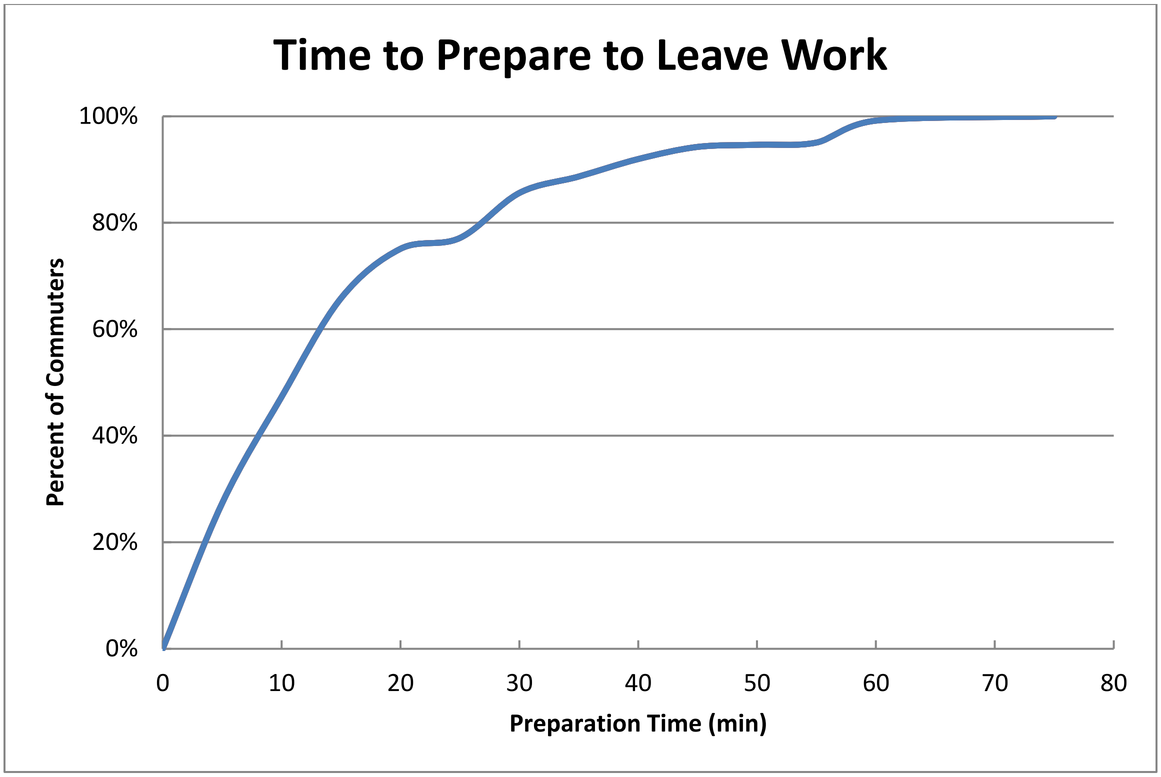


Figure F-14. Time Required to Prepare to Leave Work

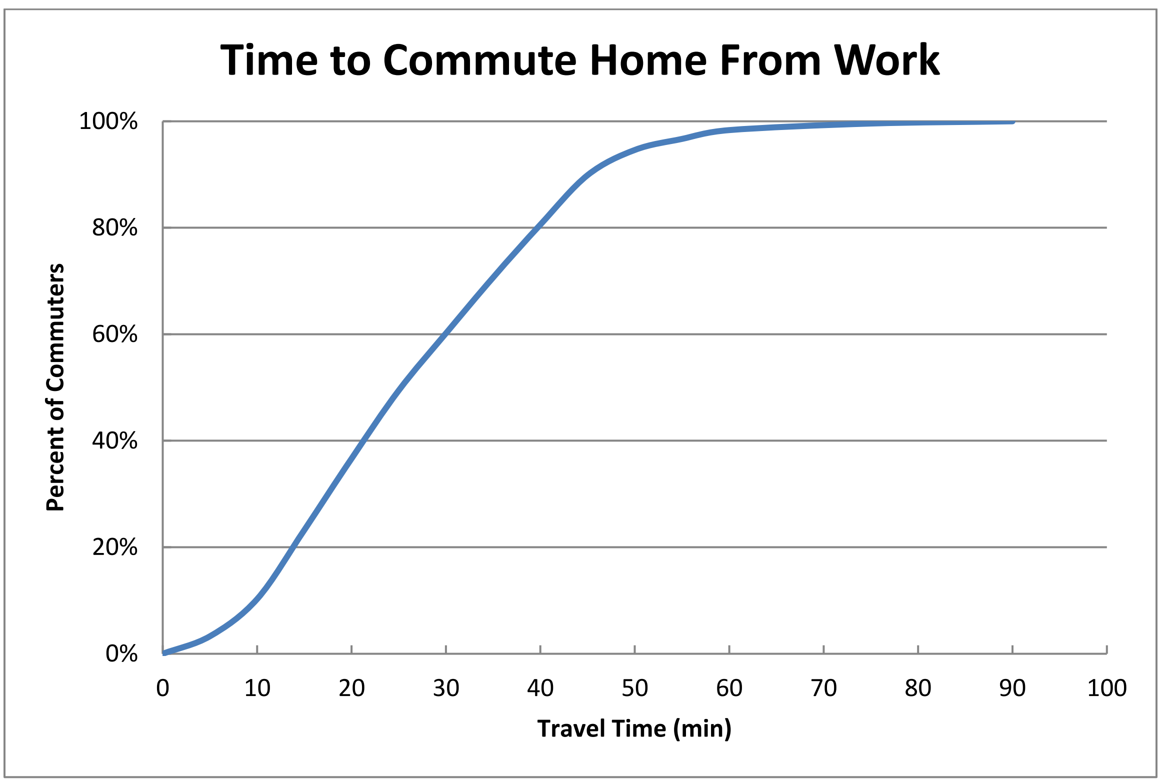


Figure F-15. Work to Home Travel Time

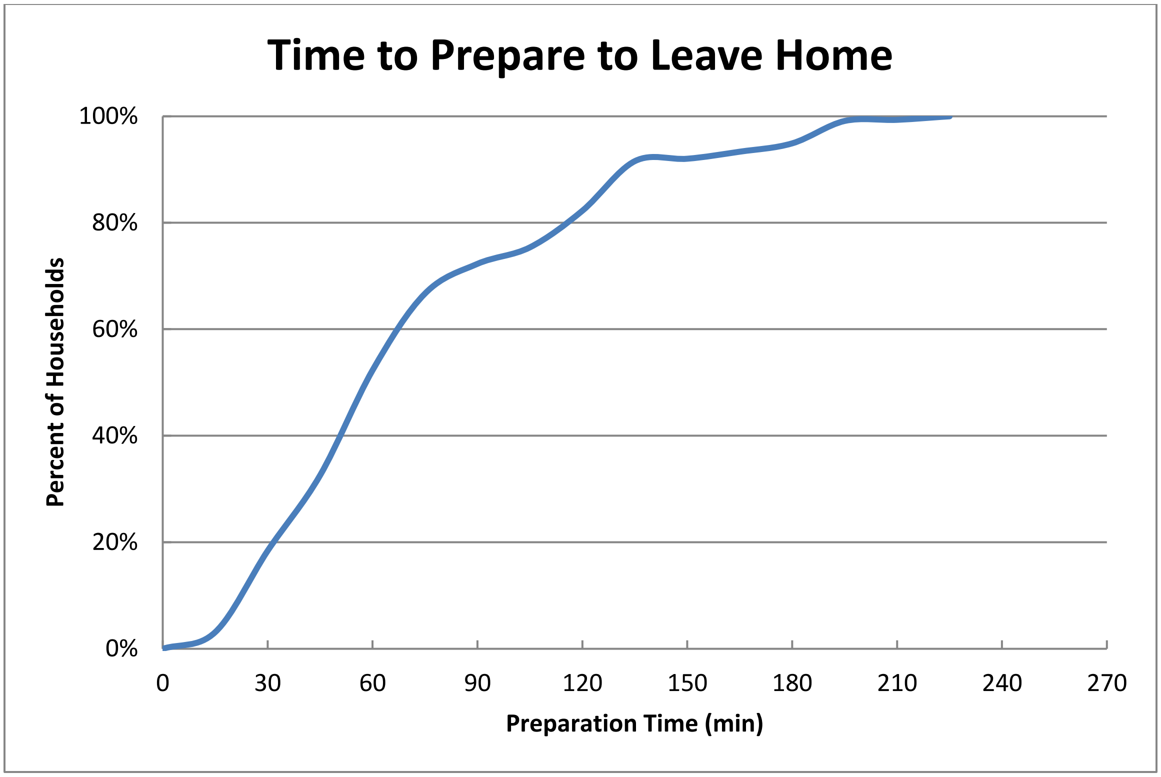


Figure F-16. Preparation Time to Leave Home

ATTACHMENT A

Demographic Survey Instrument

VC Summer Nuclear Station 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 Dominion Energy and local emergency agencies 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*

Skip to question 9

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. 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	◯	◯	◯	◯	◯	◯

56. Specify "Other" Transportation Need Below

57. 13. 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

58. 14A. 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

59. 14B. 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

60. 14C. 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

61. Fill in OTHER answers for question 14C

Pet Questions

62. 15A. Do you have any pet(s) and/or animal(s)?

Mark only one oval.

- ◯ YES
- ◯ NO
- ◯ DECLINE TO STATE

Pet Questions

63. 15B. 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: [ ] ______________________

64.

Mark only one oval.

- ( ) DECLINE TO STATE

Pet Questions

65. 15C. 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

66. 15D. 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 control plans for the Emergency Planning Zone (EPZ) were provided by the offsite response organizations within the EPZ.

The VC Summer Nuclear Station (VCSNS) Site Specific plan (December 2020), Part 3 of the South Carolina Operational Radiological Emergency Response Plan (SCORERP) states that upon declaration of a Site Area Emergency Alert, ESF-16 (Emergency Traffic Management), led by the South Carolina Highway Patrol (SCHP), will coordinate the occupation of designated TACPs with the County Sheriff or chief law enforcement officer within the EPZ.

These Site Specific Plan and county-level emergency plans were reviewed, and the TACPs were modeled accordingly. An analysis of the TACP locations was performed, and it was determined to model the Evacuation Time Estimate (ETE) simulations with existing TACPs that were provided in the approved county and state emergency plans, 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 control type and node number for those nodes which are controlled. 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 MTC points within the study area are mapped as aqua dots in Figure G-1. No additional locations for MTC are suggested in this study.

It is assumed that the TACPs will be established within 120 minutes of the Advisory to Evacuate (ATE) to discourage through travelers from using major through routes which traverse the EPZ. As discussed in Section 3.10, external traffic was considered on Interstate (I)-26, US Highway (US) 76, US 176, and US 321 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 (TMP) were analyzed to determine key locations where MTC would be most useful and can 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 traffic management plans.

Table G-1 shows a list of the controlled intersections that were identified as MTC points in the TMPs that were not previously actuated signals, including the type of control that currently exists at each location. To determine the impact of MTC at these locations, a summer, midweek, midday, good weather scenario (Scenario 1) evacuation of the 2-Mile, 5-Mile and entire EPZ (Region R01, R02, R03) were simulated wherein these intersections were left as is (without MTC). The results are shown in Table G-2. The ETE remained unchanged when compared to the cases wherein these controlled intersections were modeled as actuated signals (with MTC) presented in Section 7 for Scenario 1, Regions R01, R02, and R03. Although localized congestion worsened, there is no change in ETE at both the 90th and 100th percentile when MTC was not present at these intersections. The remaining TACPs at controlled intersections were left as actuated signals in the model and, therefore, had no impact to ETE.

As shown in Figure 7-3 through Figure 7-6, the only area in the EPZ that experiences minimal congestion is Chapin, located within Protective Action Zone (PAZ) D-2. The congestion in Chapin/PAZ D-2 clears by 2 hours and 40 minutes after the ATE. As a result, the TACPs within the EPZ do very little to reduce the 90th percentile ETE as there is very little congestion in the EPZ as a whole.

In addition, congestion within the EPZ clears prior to the completion of the trip generation time (the time to mobilize, plus travel time to EPZ boundary, dictates the 100th percentile ETE); as a result, the MTC has no impact on the 100th percentile ETE.

Although there is no reduction in ETE when MTC is implemented, traffic and access control can be beneficial in the reduction of localized congestion and driver confusion and can be extremely helpful for fixed point surveillance, 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 priority locations when implementing the TMP.

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

Source	TACP Location (Description)	Node Number (See Appendix K)	Type of Control (Prior to being a TACP)
SCORERP Part 3 and County-level Emergency Plans	ST-03: S-215 & Glenn's Bridge Road (Rd)	17	Stop Control
	ST-04: Pearson Rd & Cole Trestle Rd	510	Stop Control
	ST-05: SC-213 & Broad River Rd	172	Stop Control
	FA-01: SC-34 & SC-215	99	Stop Control
	FA-02: SC-34 & US-321 Bypass	138	Pre-Timed Signal
	FA-03: SC-269 & US-321 Bypass	64	Stop Control
	FA-04: SC-213 & US-321	57	Pre-Timed Signal
	LE-01: I-26 & Columbia Avenue	273	Stop Control
	LE-02: US-76 & Crooked Creek Rd	230	Stop Control
	LE-03: Old Lexington Hwy & Murray Lindler Rd	954, 955	Yield Control (Roundabout)
	LE-04: Amicks Ferry Rd & Sandbar Rd	680	Stop Control
	LE-05: Saint Peters Church Rd & Westwoods Dr	781	Stop Control
	NE-01: US-176 & SC-213	175	Stop Control
	NE-04: SC-34 & Broad River Rd	159	Stop Control
	NE-05: US-176 & SC-34	167	Stop Control
	RI-01: Broad River Rd & Mt. Vernon Church Rd	605	Pre-Timed Signal
	RI-02: Broad River Rd & W. Shady Grove Rd	213	Stop Control
	RI-03: Broad River Rd & Shady Grove Rd	612	Pre-Timed Signal
	RI-04: Broad River Rd & Koon Rd	630	Pre-Timed Signal

Table G-2. The ETE with No MTC

Region	Scenario 1					
	90th Percentile ETE			100th Percentile ETE		
	Base	No MTC	Difference	Base	No MTC	Difference
R01 (2-Mile)	2:05	2:05	0:00	5:00	5:00	0:00
R02 (5-Mile)	2:45	2:45	0:00	5:05	5:05	0:00
R03 (Full EPZ)	2:45	2:45	0:00	5:10	5:10	0:00

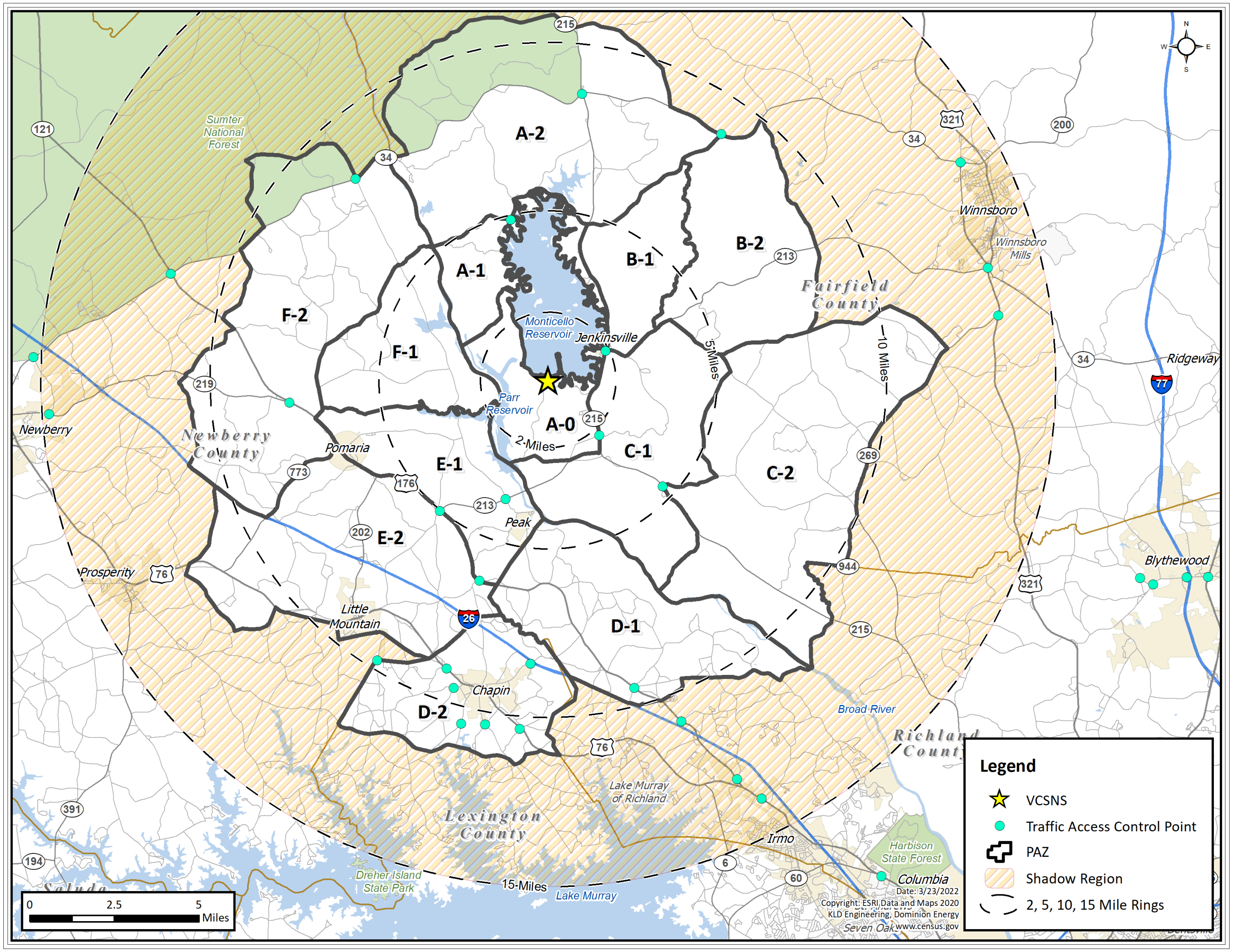


Figure G-1. Traffic and Access Control Points (TACPs) for the VCSNS EPZ

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-33). The percentages presented in Table H-1 are based on the methodology discussed in assumption 7 of Section 2.2 and shown in Figure 2-1.

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

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

Radial Regions															
		Wind Degree	PAZ												
Region	**Description**	**From**	**A-0**	**A-1**	**A-2**	**B-1**	**B-2**	**C-1**	**C-2**	**D-1**	**D-2**	**E-1**	**E-2**	**F-1**	**F-2**
R01	2-Mile Region	0° - 359°	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R02	5-Mile Region	0° - 359°	100%	100%	20%	100%	20%	100%	20%	20%	20%	100%	20%	100%	20%
R03	Full EPZ	0° - 359°	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Evacuate 2-Mile Region and Downwind to 5 Miles															
	Wind Direction	**Wind Degree**	**PAZ**												
Region	**From:**	**From**	**A-0**	**A-1**	**A-2**	**B-1**	**B-2**	**C-1**	**C-2**	**D-1**	**D-2**	**E-1**	**E-2**	**F-1**	**F-2**
R04	S, SSW	168.8° - 213.8°	100%	100%	20%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R05	SW, WSW	213.8° - 258.8°	100%	100%	20%	100%	20%	100%	20%	20%	20%	20%	20%	20%	20%
R06	W	258.8° - 281.3°	100%	20%	20%	100%	20%	100%	20%	20%	20%	20%	20%	20%	20%
R07	WNW, NW	281.3° - 326.3°	100%	20%	20%	20%	20%	100%	20%	20%	20%	20%	20%	20%	20%
R08	NNW, N	326.3° - 11.3°	100%	20%	20%	20%	20%	100%	20%	20%	20%	100%	20%	20%	20%
R09	NNE, NE	11.3° - 56.3°	100%	20%	20%	20%	20%	20%	20%	20%	20%	100%	20%	20%	20%
R10	ENE, E	56.3° - 101.3°	100%	20%	20%	20%	20%	20%	20%	20%	20%	100%	20%	100%	20%
R11	ESE, SE, SSE	101.3° - 168.8°	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	100%	20%
Evacuate 2-Mile Region and Downwind to the EPZ Boundary															
	Wind Direction	**Wind Degree**	**PAZ**												
Region	**From:**	**From**	**A-0**	**A-1**	**A-2**	**B-1**	**B-2**	**C-1**	**C-2**	**D-1**	**D-2**	**E-1**	**E-2**	**F-1**	**F-2**
R12	S	168.8° - 191.3°	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R13	SSW	191.3° - 213.8°	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%
R14	SW	213.8° - 236.3°	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%
R15	WSW	236.3° - 258.8°	100%	100%	20%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%
R16	W	258.8° - 281.3°	100%	20%	20%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%
R17	WNW, NW	281.3° - 326.3°	100%	20%	20%	20%	20%	100%	100%	100%	20%	20%	20%	20%	20%
R18	NNW	326.3° - 348.8°	100%	20%	20%	20%	20%	100%	100%	100%	100%	100%	20%	20%	20%
R19	N	348.8° - 11.3°	100%	20%	20%	20%	20%	100%	20%	100%	100%	100%	100%	20%	20%
R20	NNE	11.3° - 33.8°	100%	20%	20%	20%	20%	20%	20%	100%	100%	100%	100%	20%	20%
R21	NE	33.8° - 56.3°	100%	20%	20%	20%	20%	20%	20%	20%	100%	100%	100%	20%	100%
R22	ENE, E	56.3° - 101.3°	100%	20%	20%	20%	20%	20%	20%	20%	20%	100%	100%	100%	100%
R23	ESE	101.3° - 123.8°	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	100%	100%
R24	SE, SSE	123.8° - 168.8°	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	100%	100%

Staged Evacuation - 2-Mile Region Evacuates, then Evacuate Downwind to 5 Miles															
Region	Wind Direction From:	Wind Degree From	PAZ												
			A-0	A-1	A-2	B-1	B-2	C-1	C-2	D-1	D-2	E-1	E-2	F-1	F-2
R25	5-Mile Region	0° - 359°	100%	100%	20%	100%	20%	100%	20%	20%	20%	100%	20%	100%	20%
R26	S, SSW	168.8° - 213.8°	100%	100%	20%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R27	SW, WSW	213.8° - 258.8°	100%	100%	20%	100%	20%	100%	20%	20%	20%	20%	20%	20%	20%
R28	W	258.8° - 281.3°	100%	20%	20%	100%	20%	100%	20%	20%	20%	20%	20%	20%	20%
R29	WNW, NW	281.3° - 326.3°	100%	20%	20%	20%	20%	100%	20%	20%	20%	20%	20%	20%	20%
R30	NNW, N	326.3° - 11.3°	100%	20%	20%	20%	20%	100%	20%	20%	20%	100%	20%	20%	20%
R31	NNE, NE	11.3° - 56.3°	100%	20%	20%	20%	20%	20%	20%	20%	20%	100%	20%	20%	20%
R32	ENE, E	56.3° - 101.3°	100%	20%	20%	20%	20%	20%	20%	20%	20%	100%	20%	100%	20%
R33	ESE, SE, SSE	101.3° - 168.8°	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	100%	20%
PAZ(s) Evacuate		PAZ(s) Shelter-in-Place			Shelter-in-Place until 90% ETE for R01, then Evacuate										

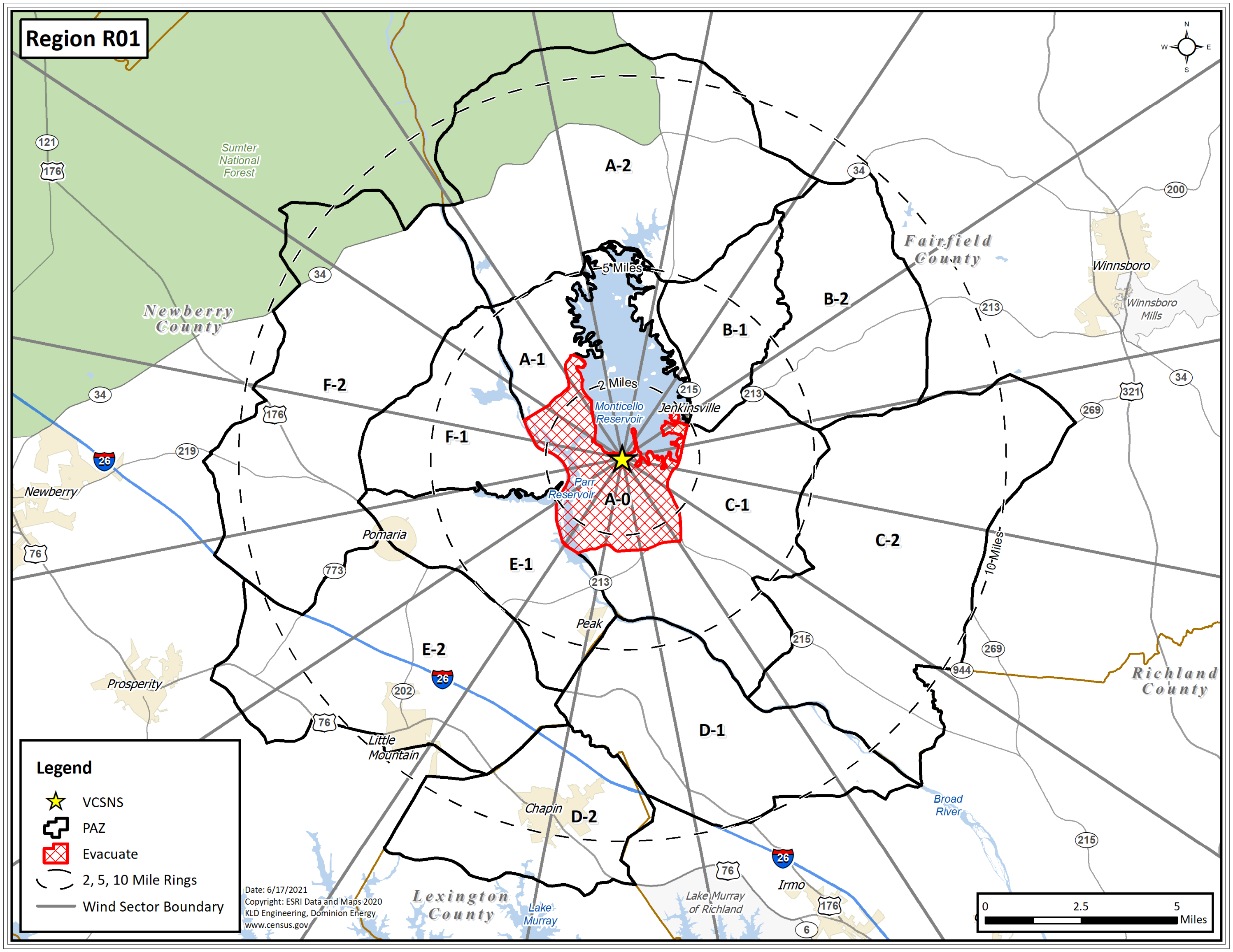


Figure H-1. Region R01

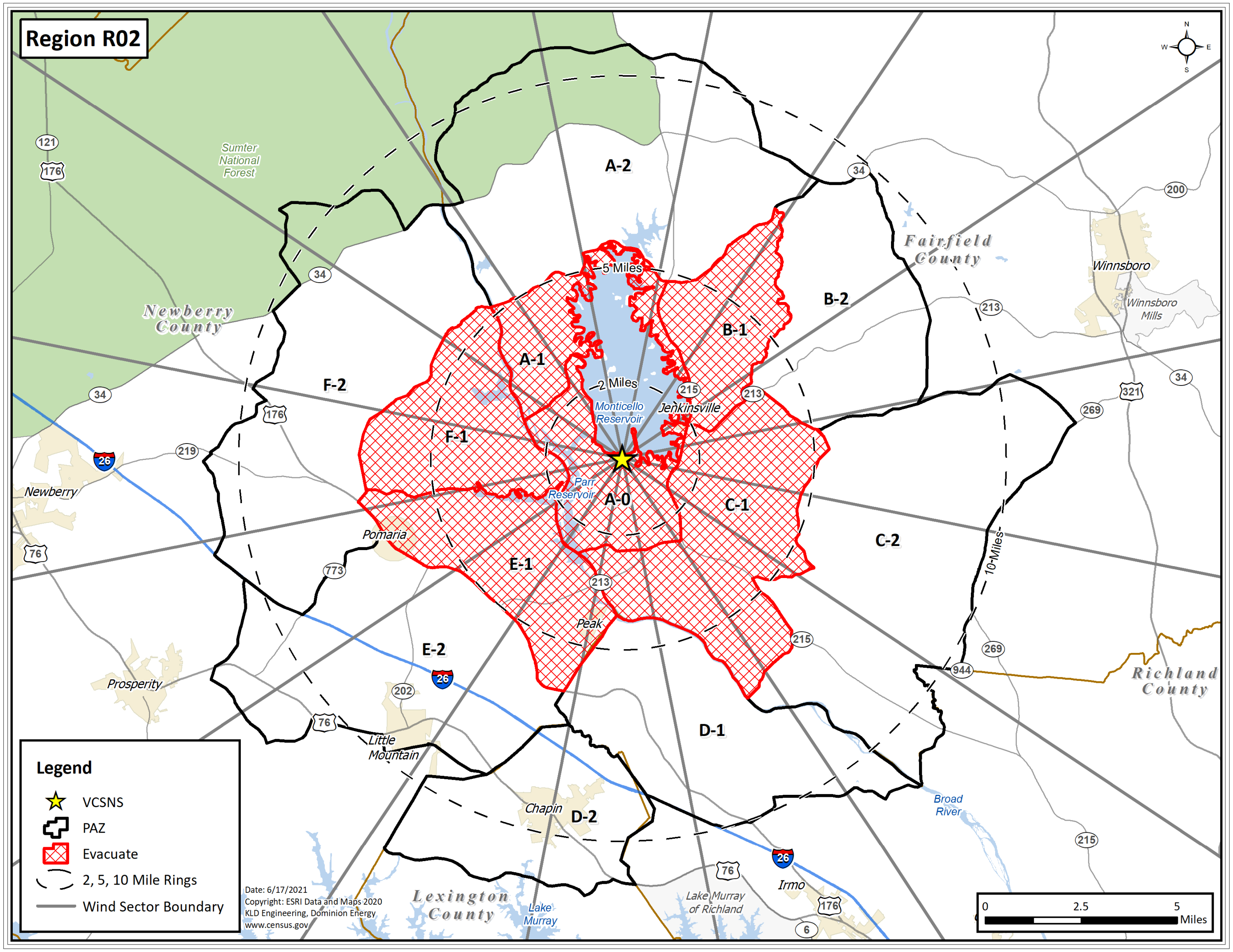


Figure H-2. Region R02

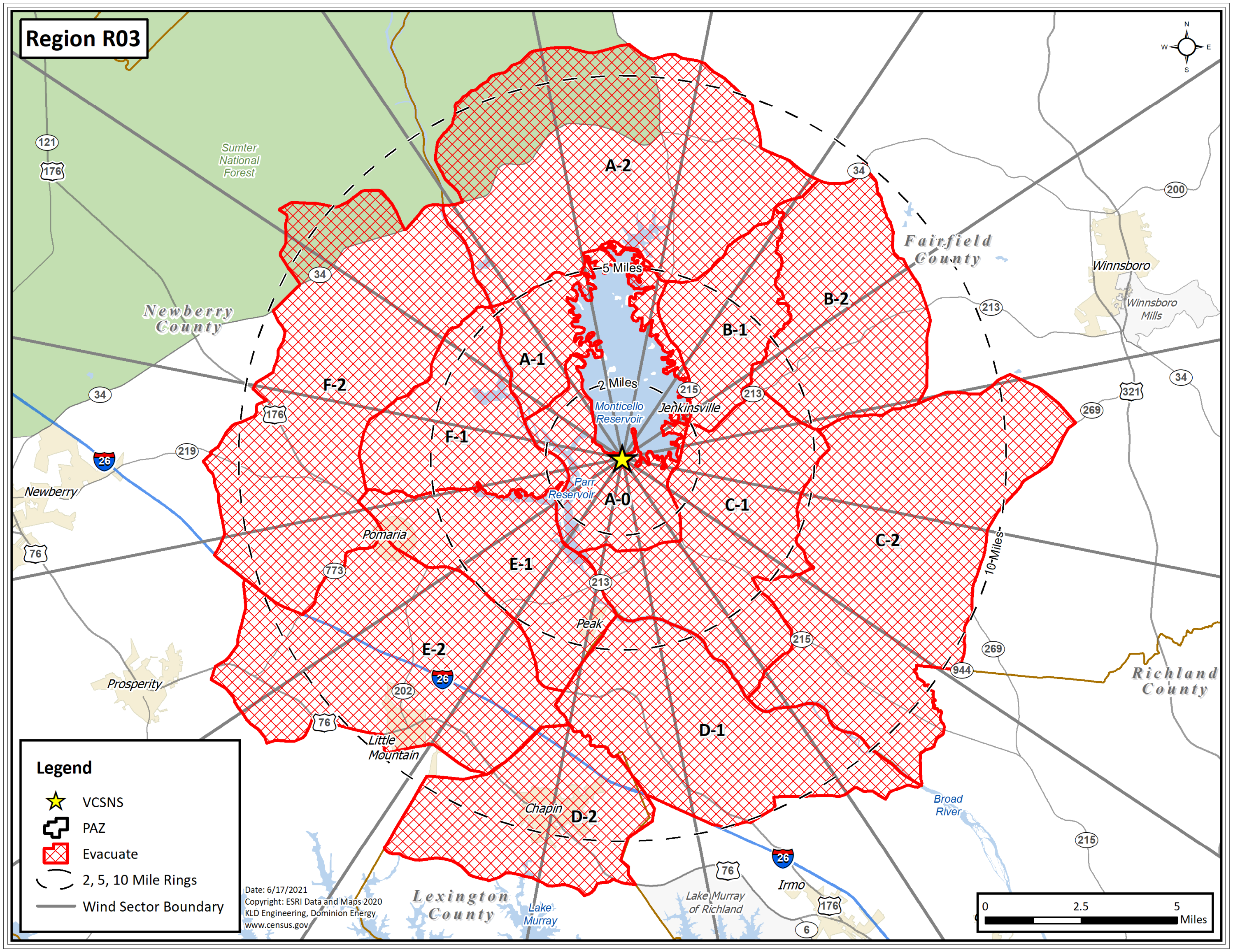


Figure H-3. Region R03

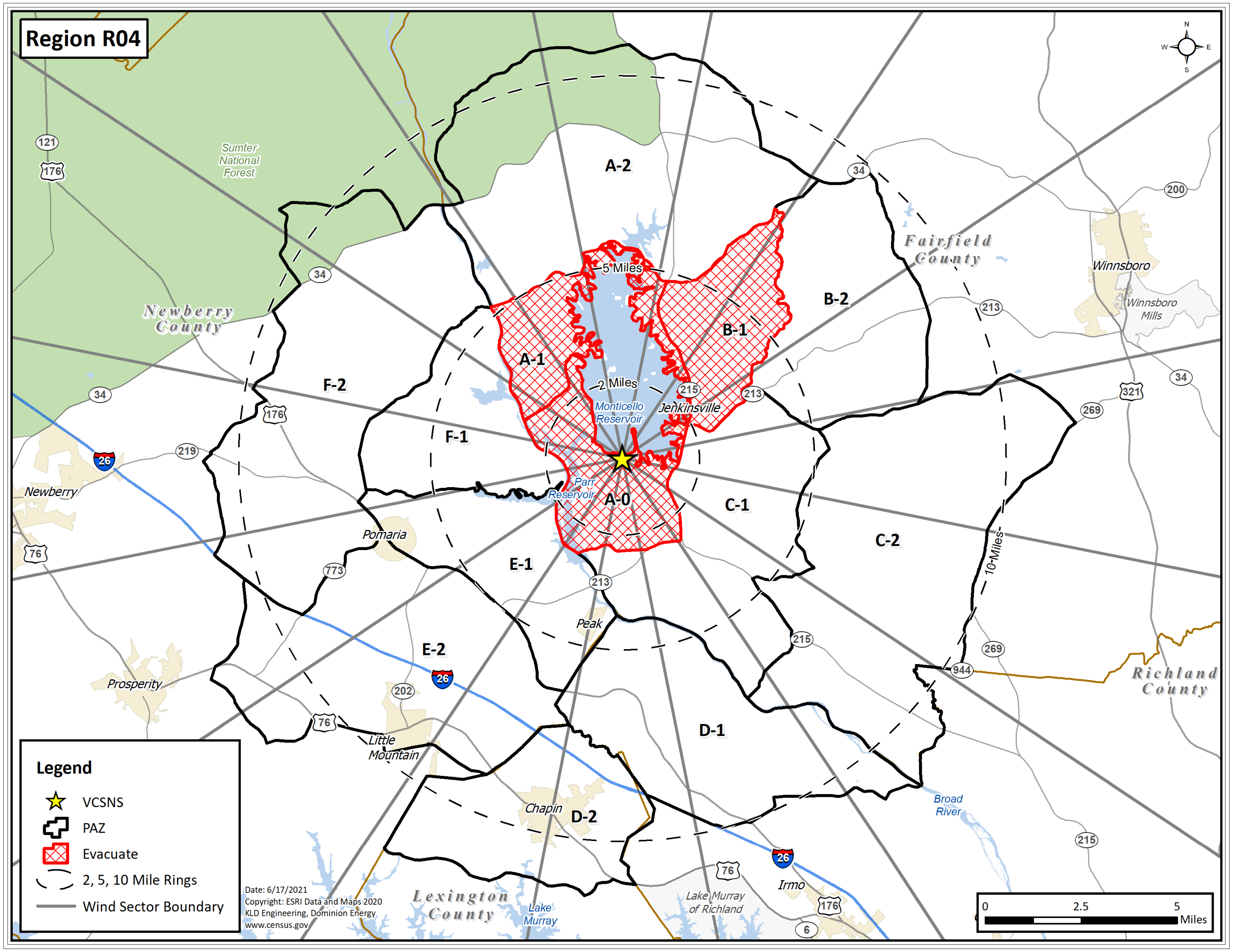


Figure H-4. Region R04

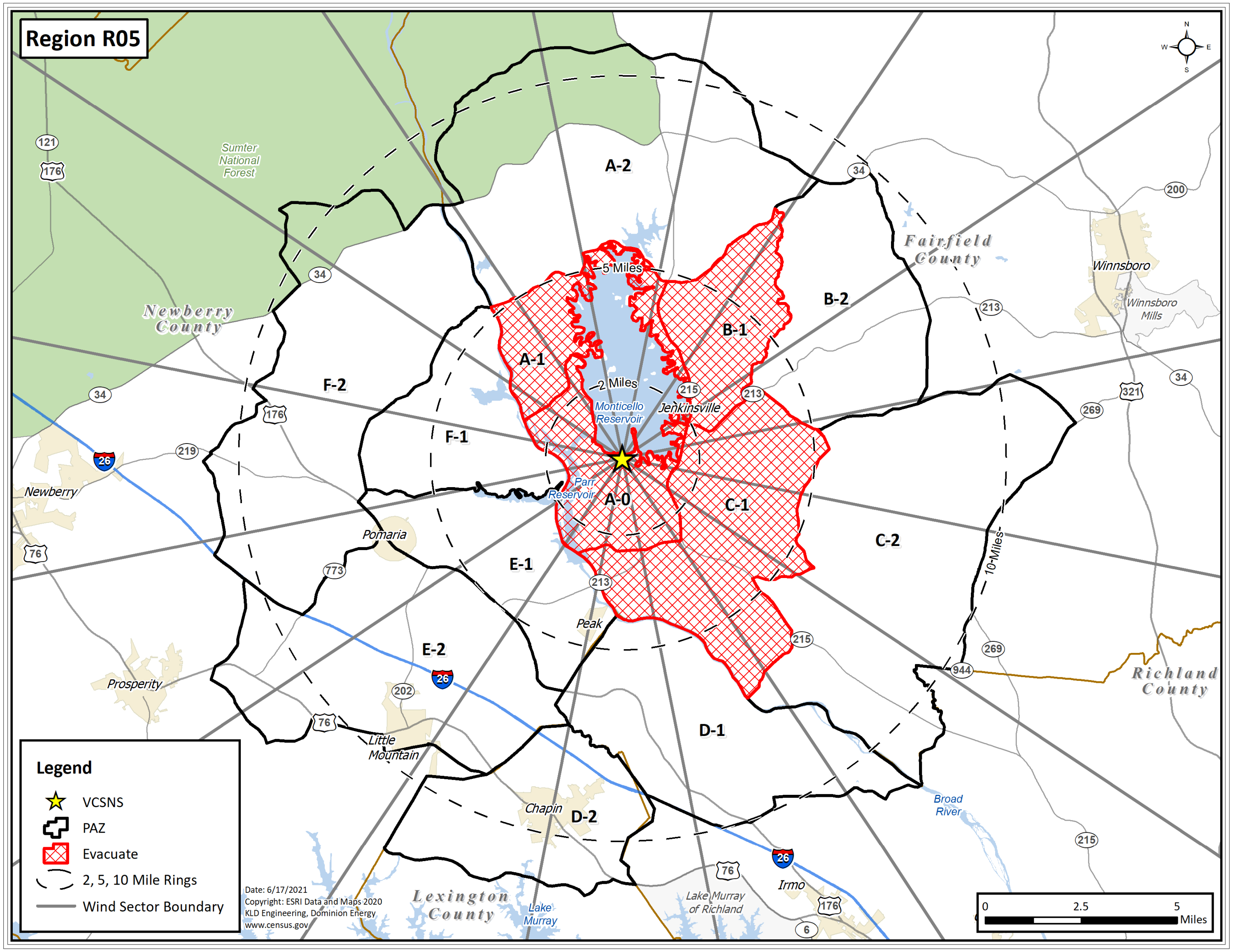


Figure H-5. Region R05

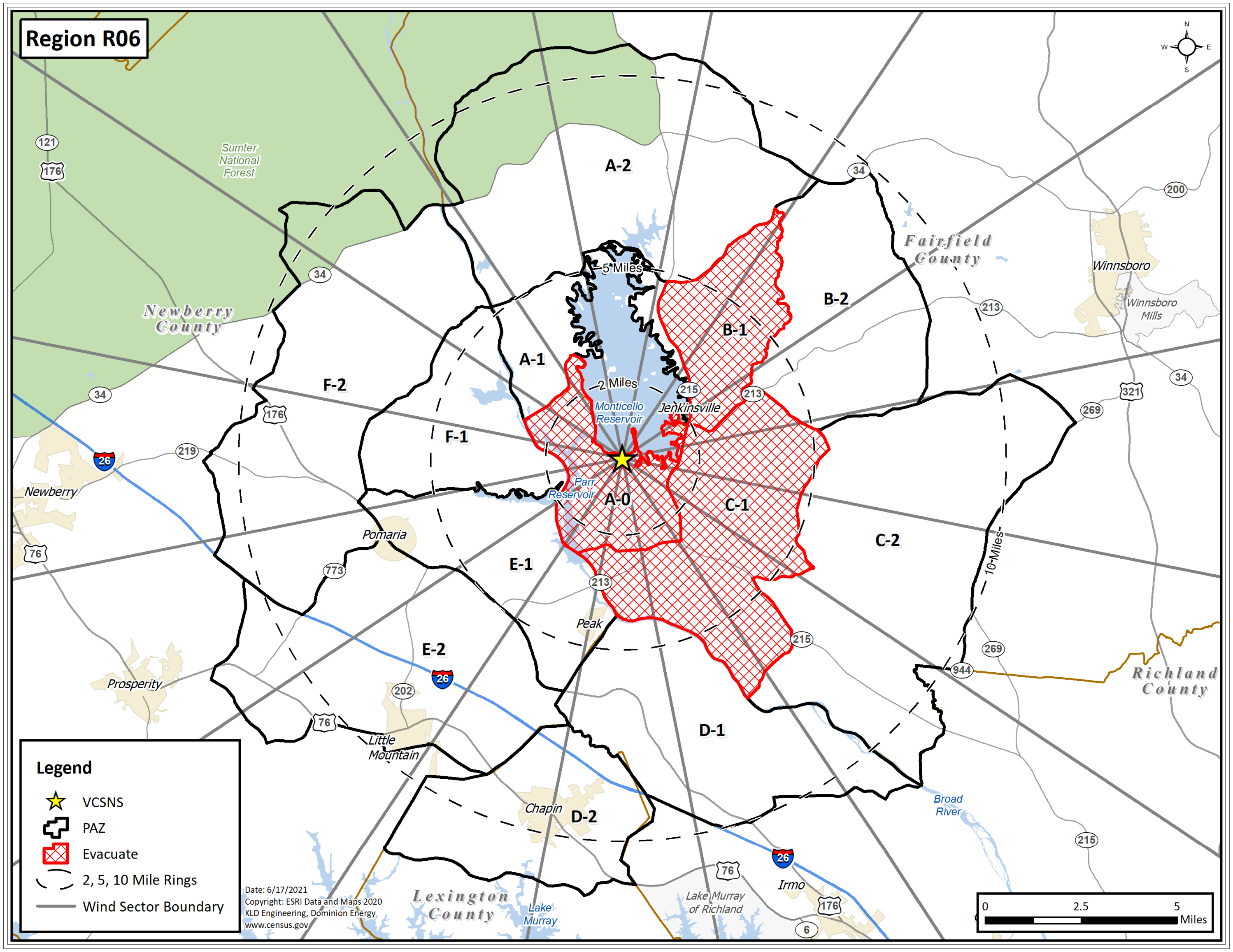


Figure H-6. Region R06

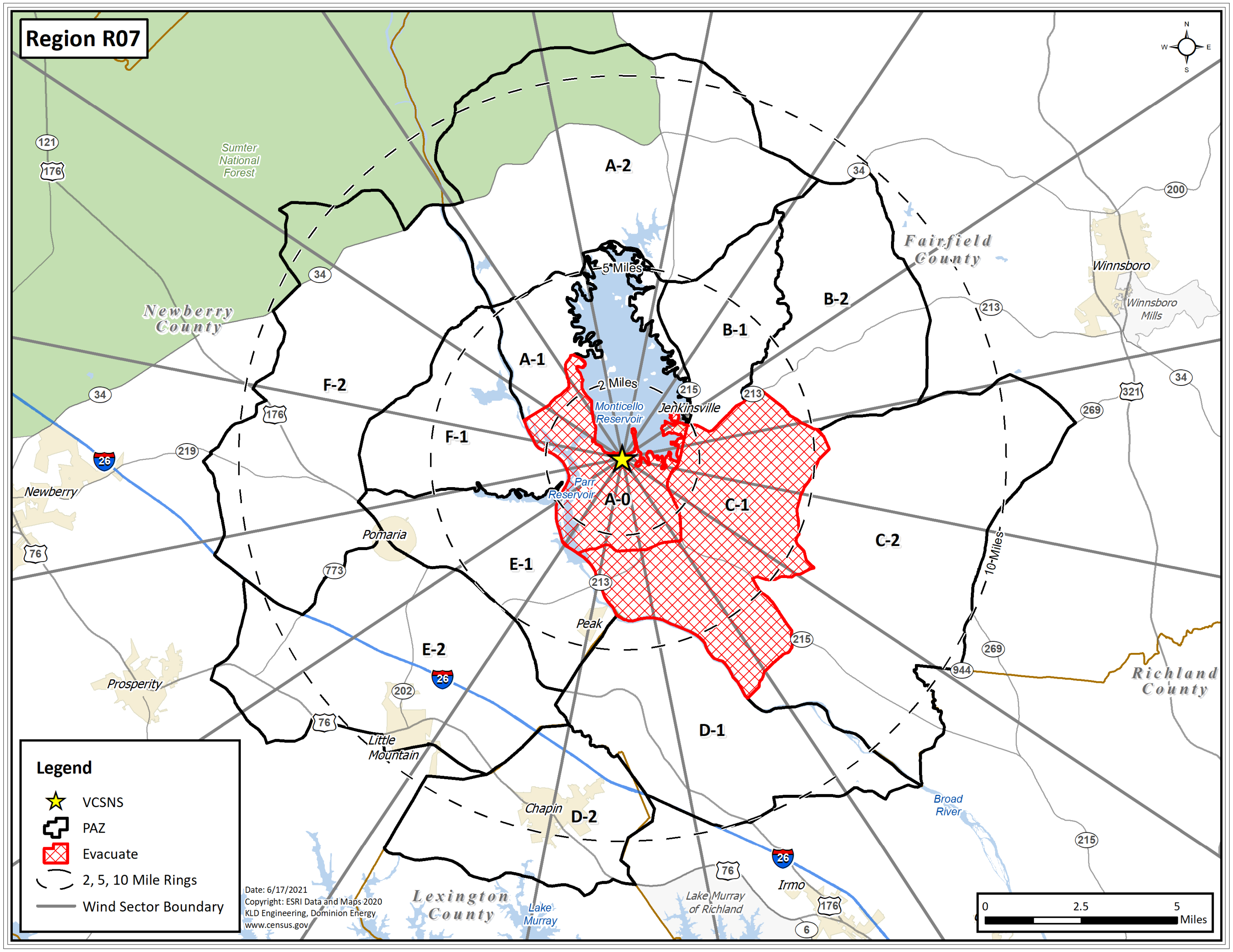


Figure H-7. Region R07

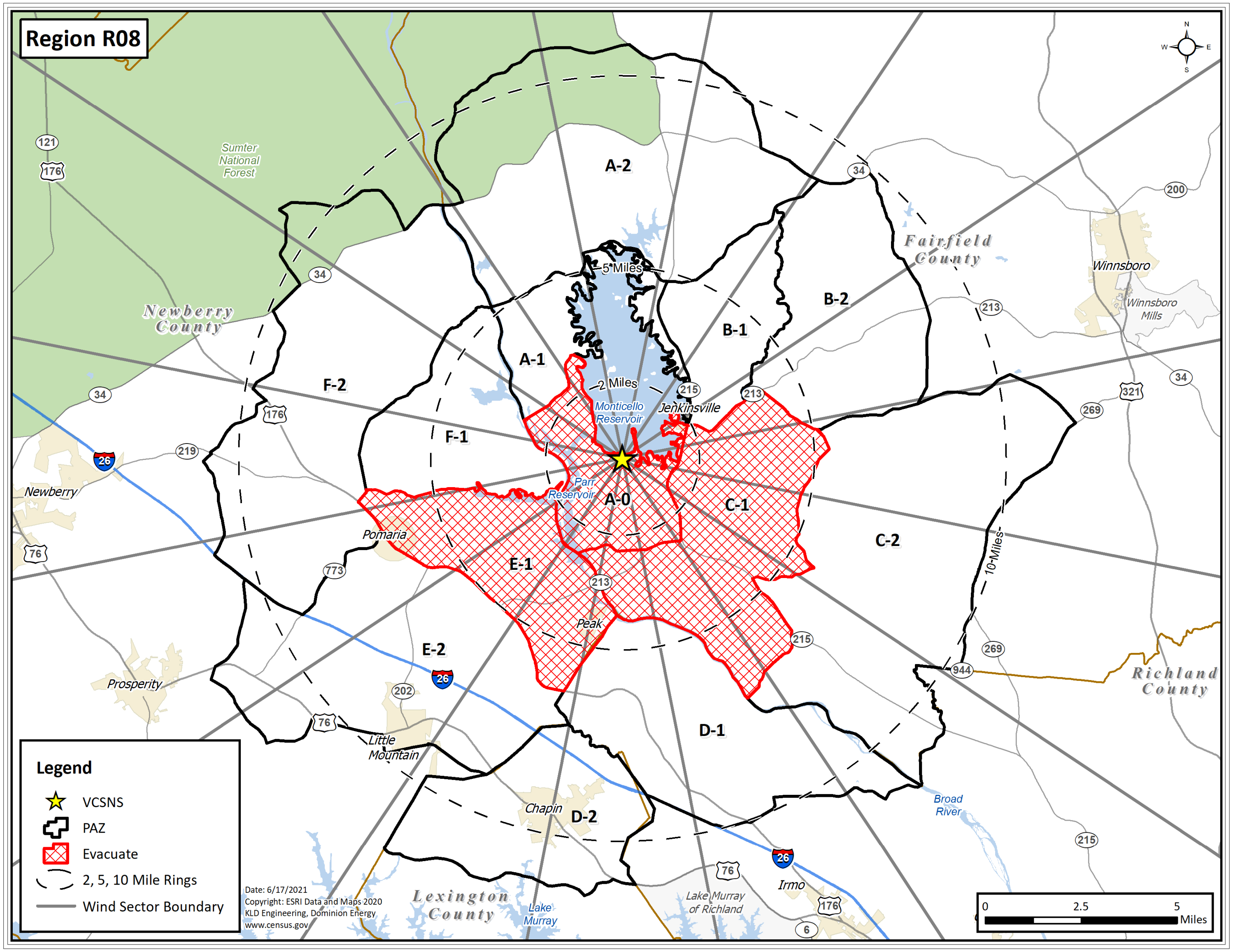


Figure H-8. Region R08

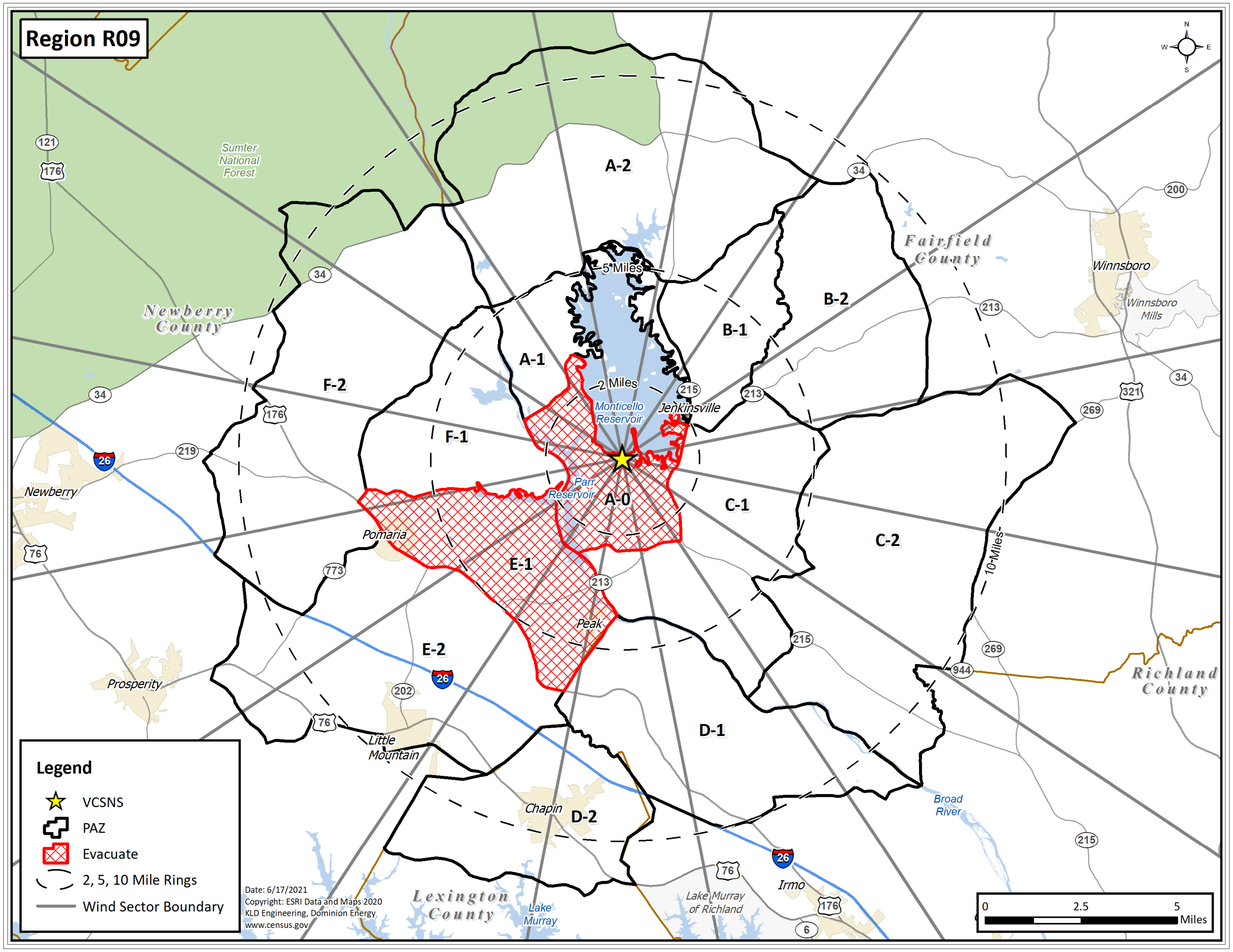


Figure H-9. Region R09

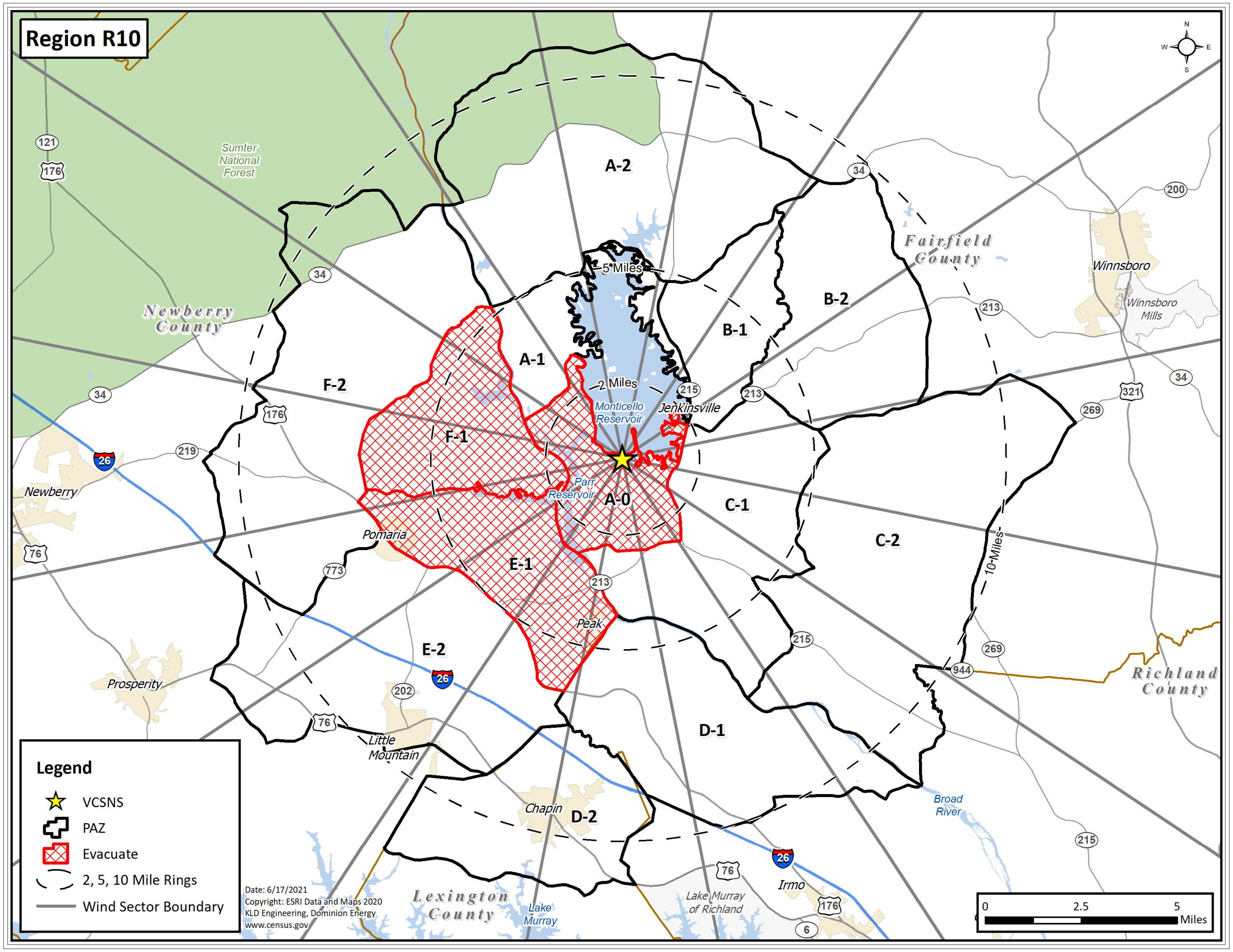


Figure H-10. Region R10

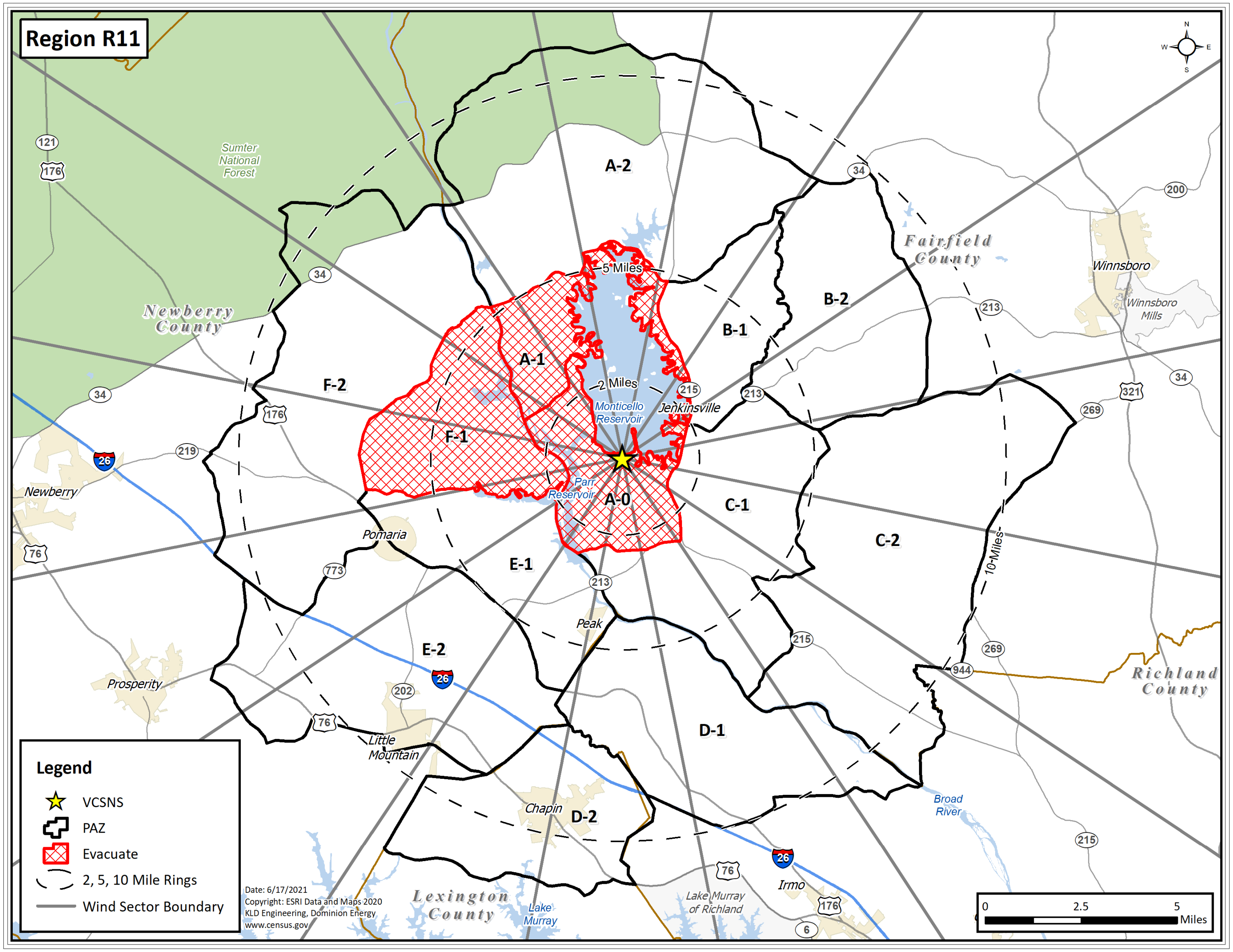


Figure H-11. Region R11

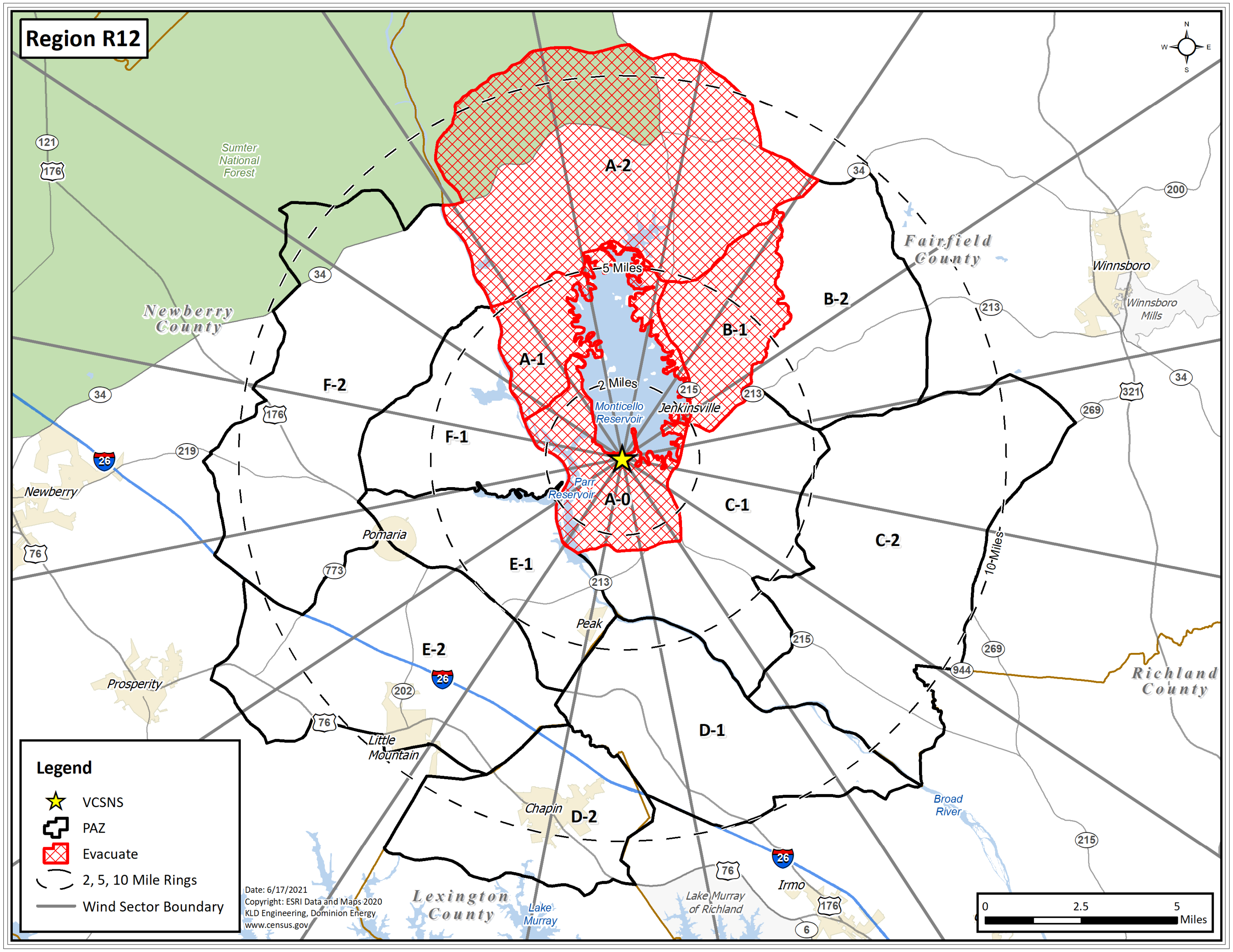


Figure H-12. Region R12

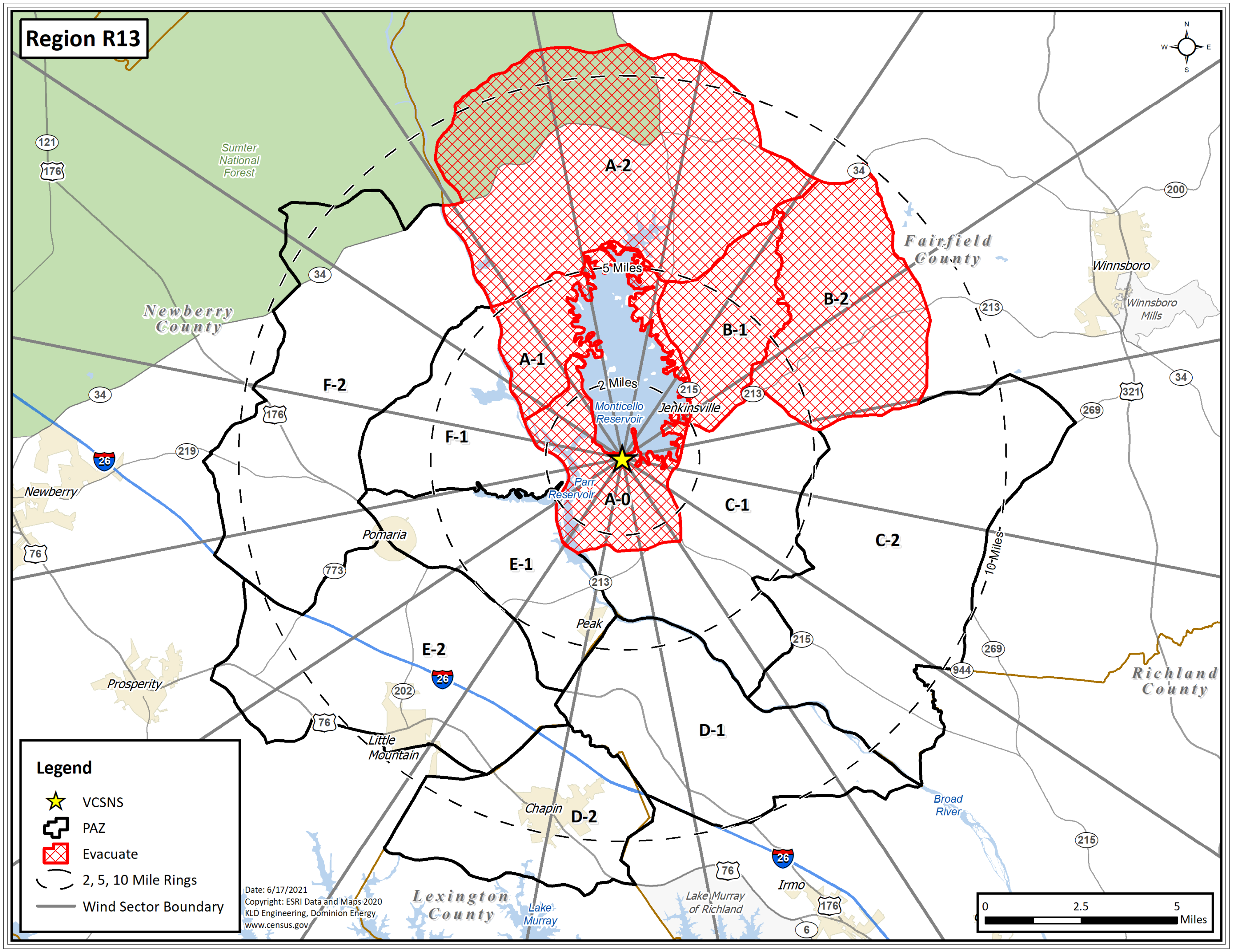


Figure H-13. Region R13

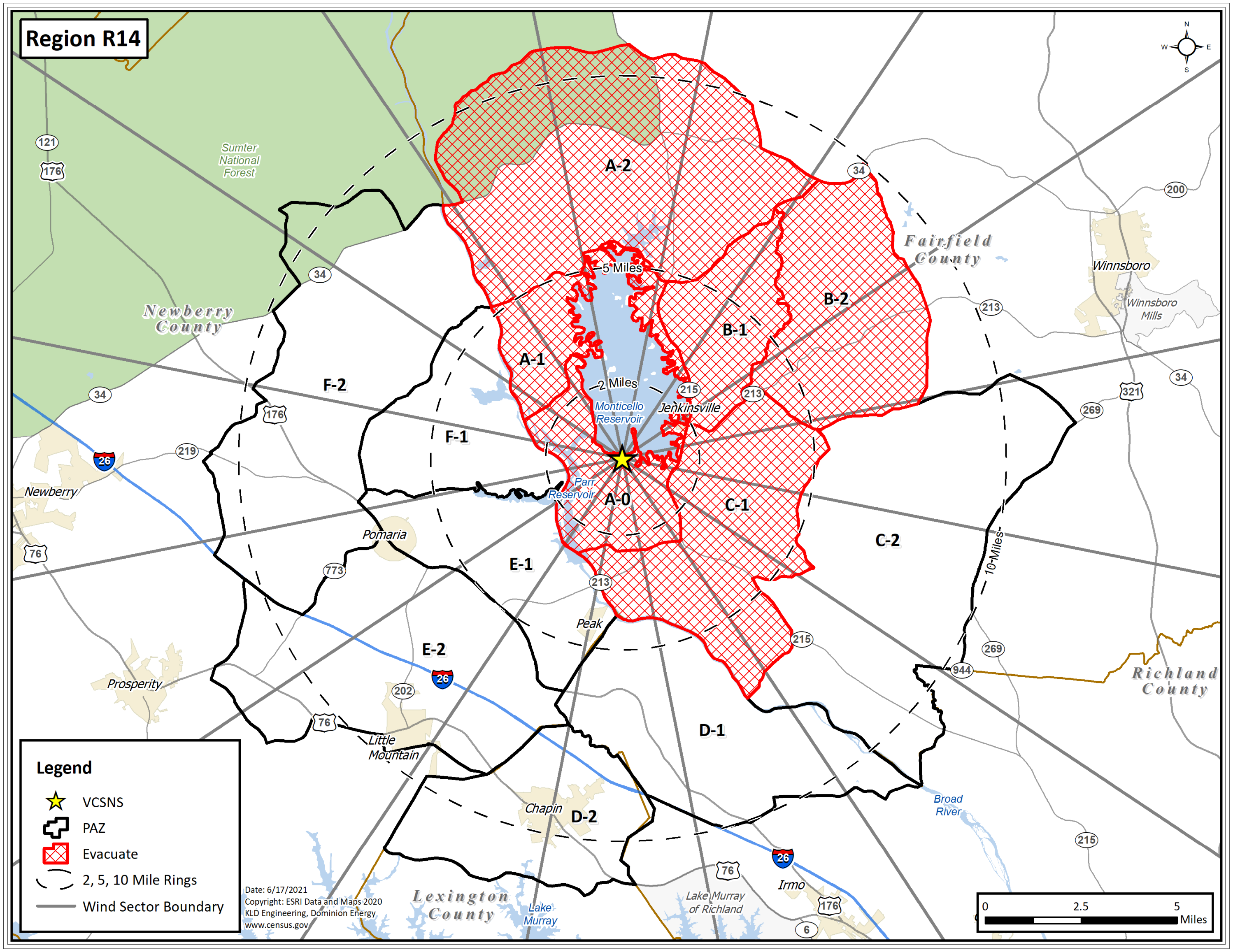


Figure H-14. Region R14

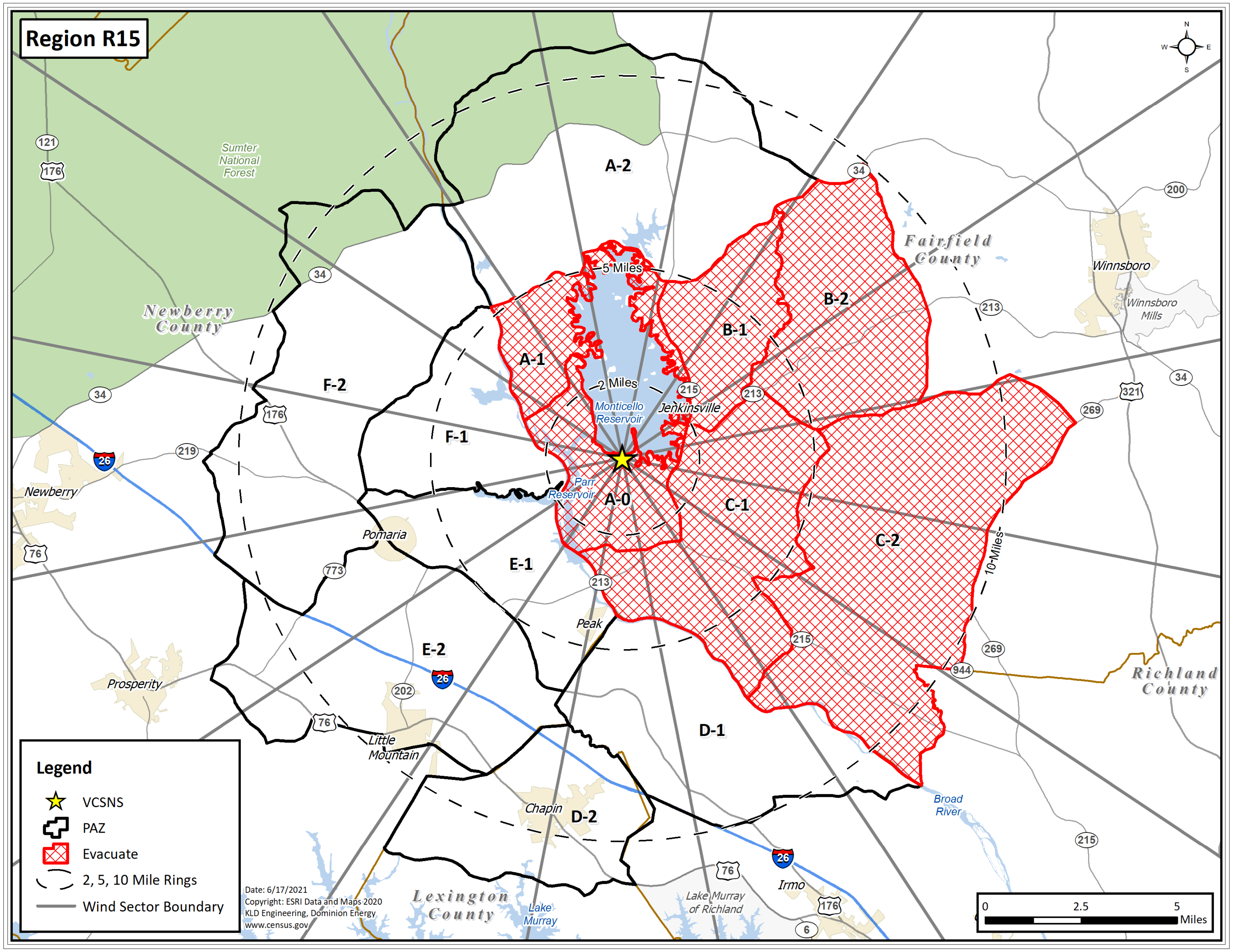


Figure H-15. Region R15

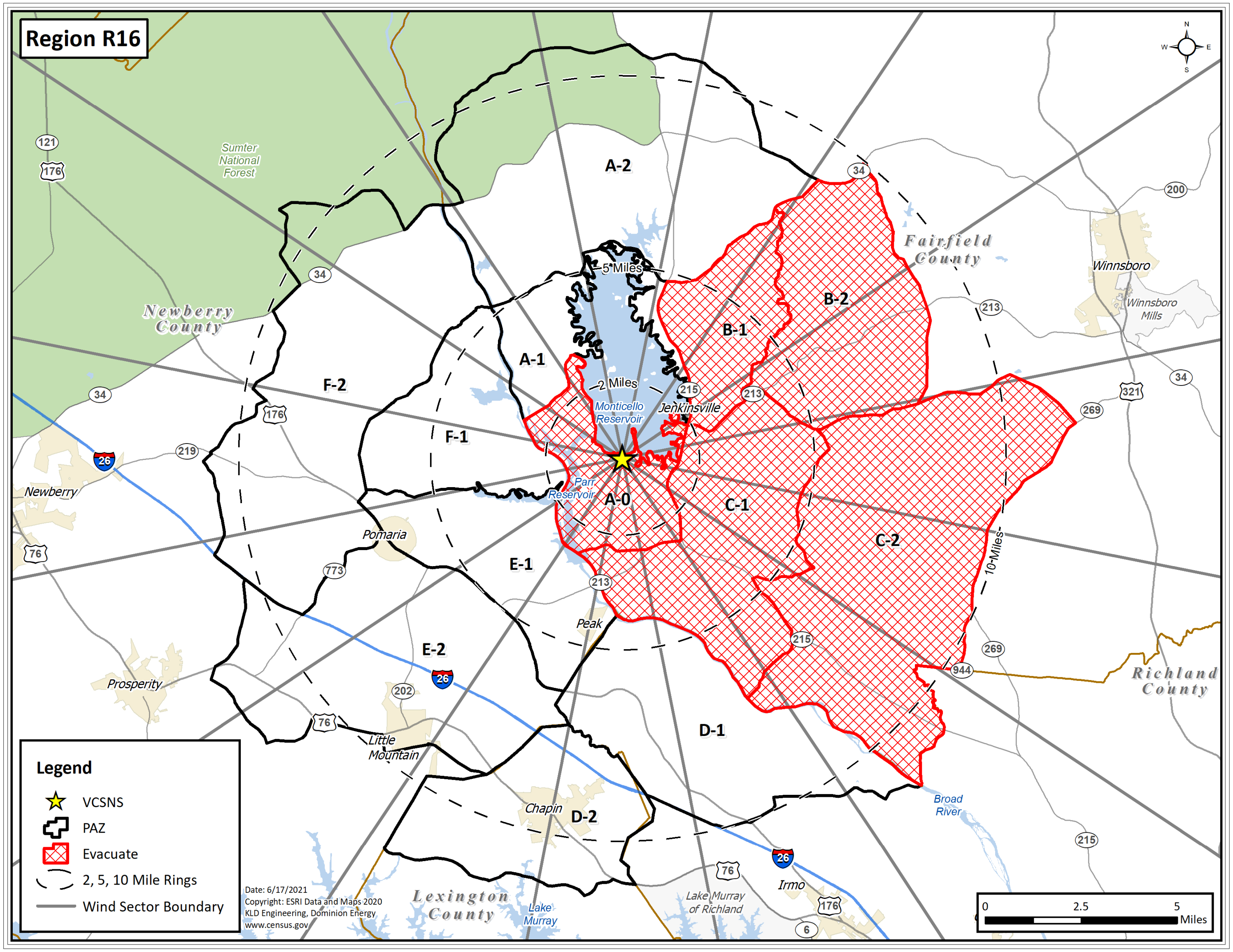


Figure H-16. Region R16

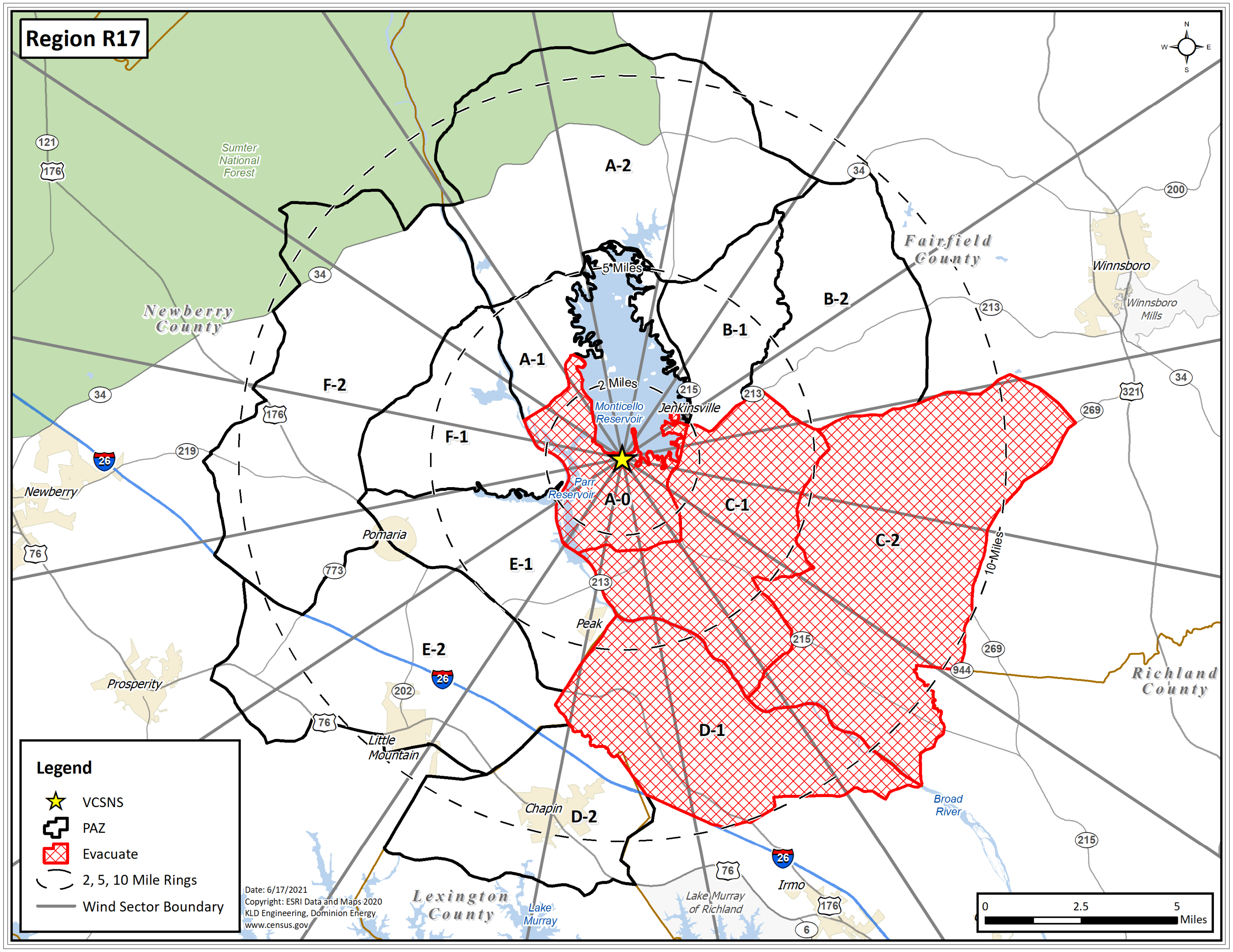


Figure H-17. Region R17

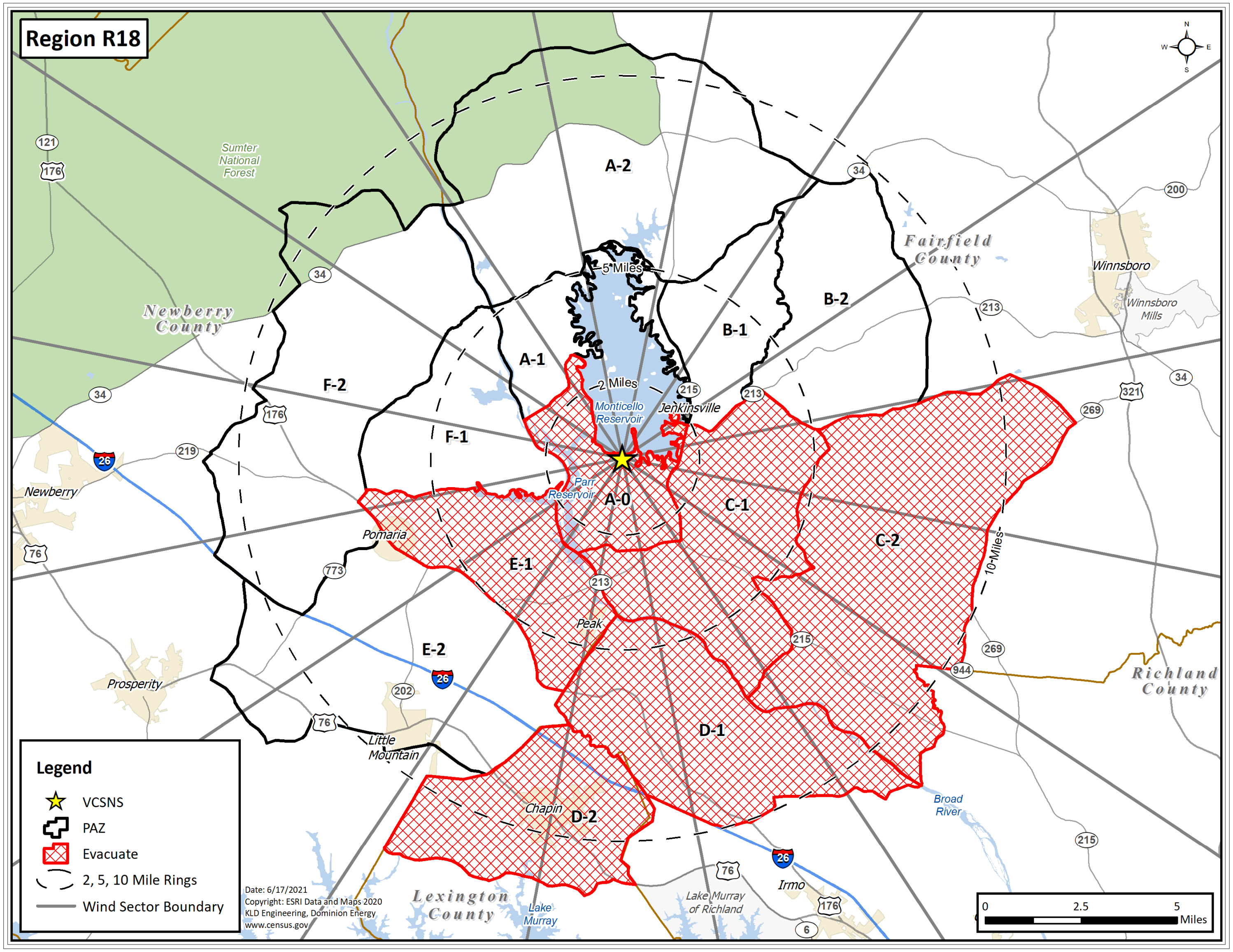


Figure H-18. Region R18

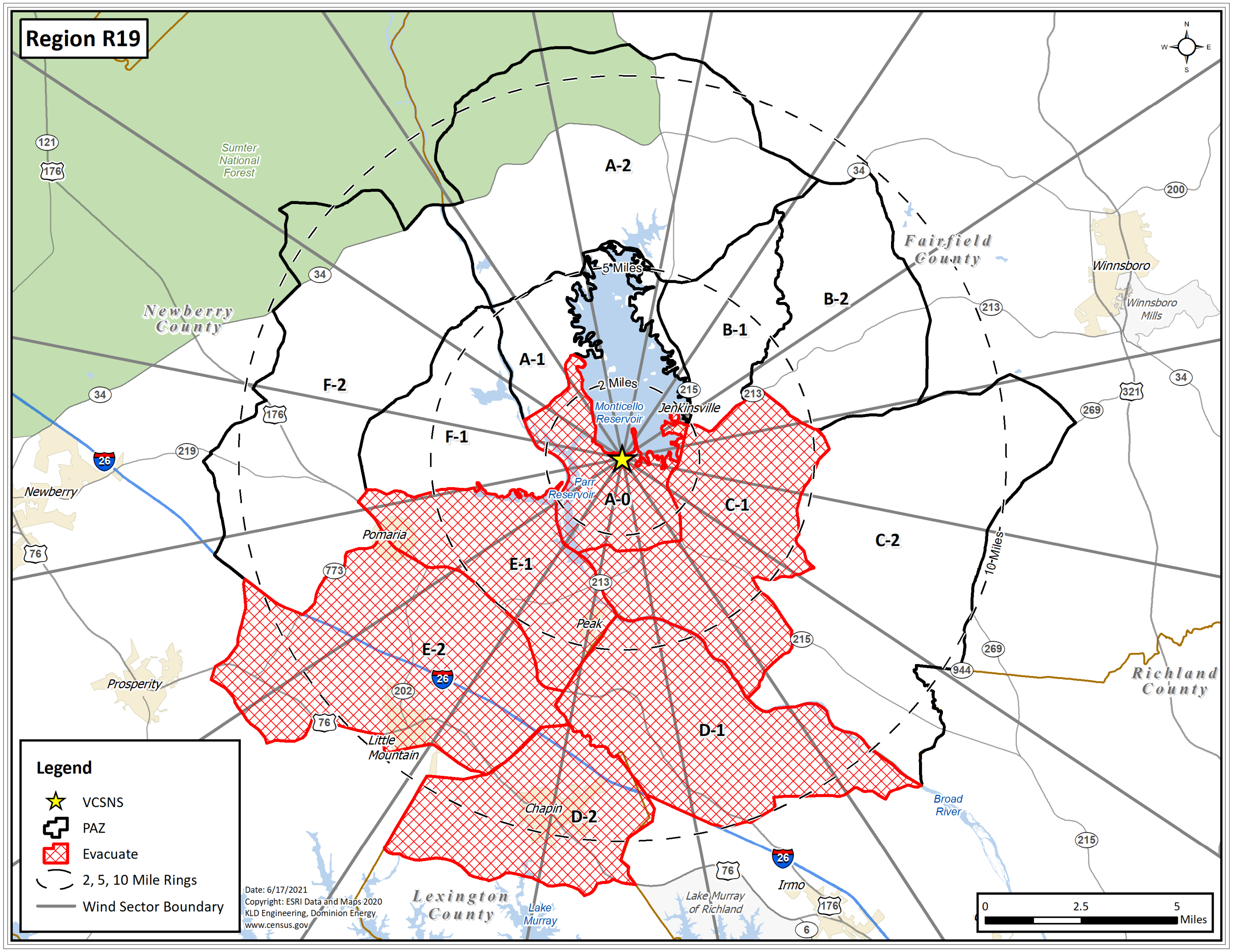


Figure H-19. Region R19

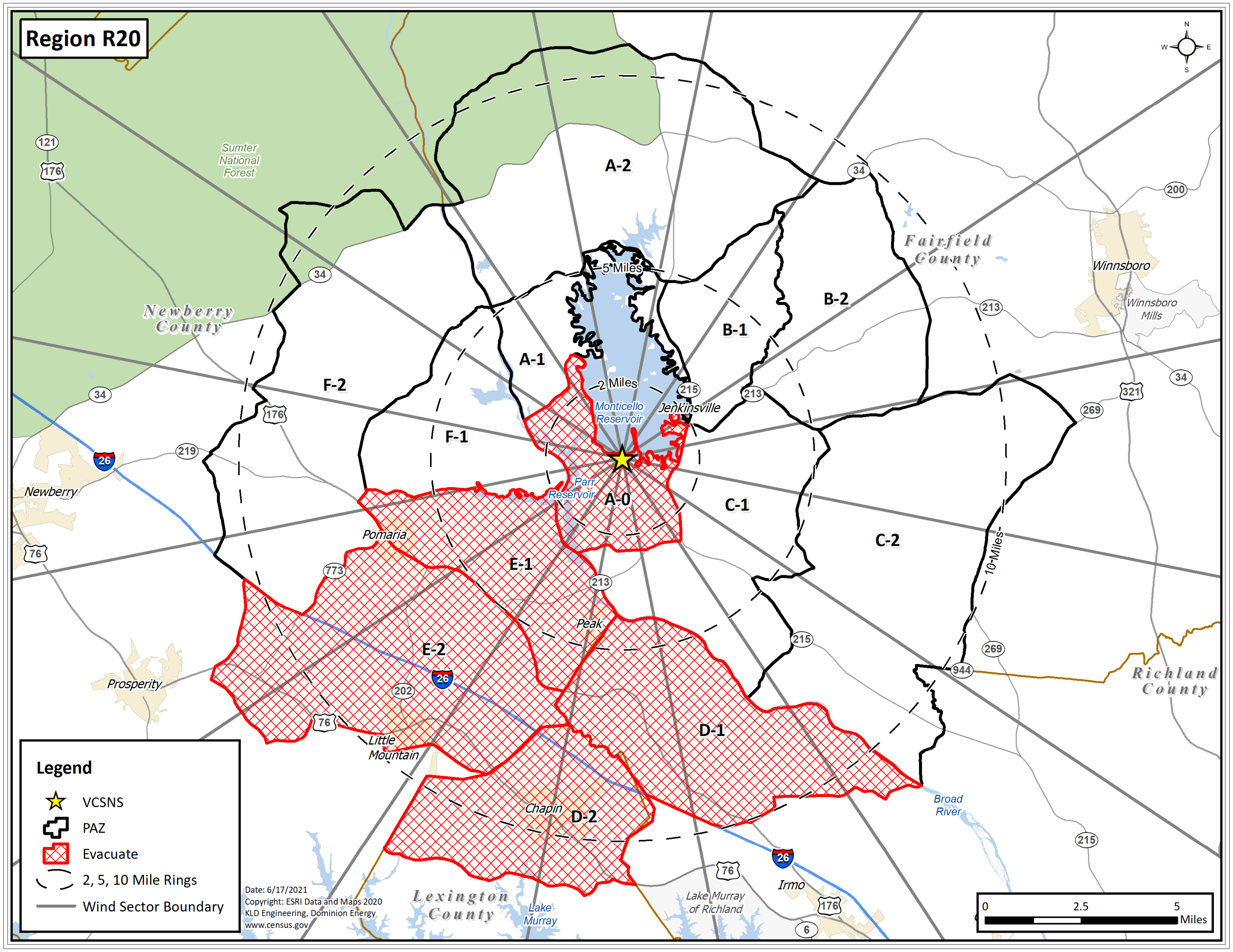


Figure H-20. Region R20

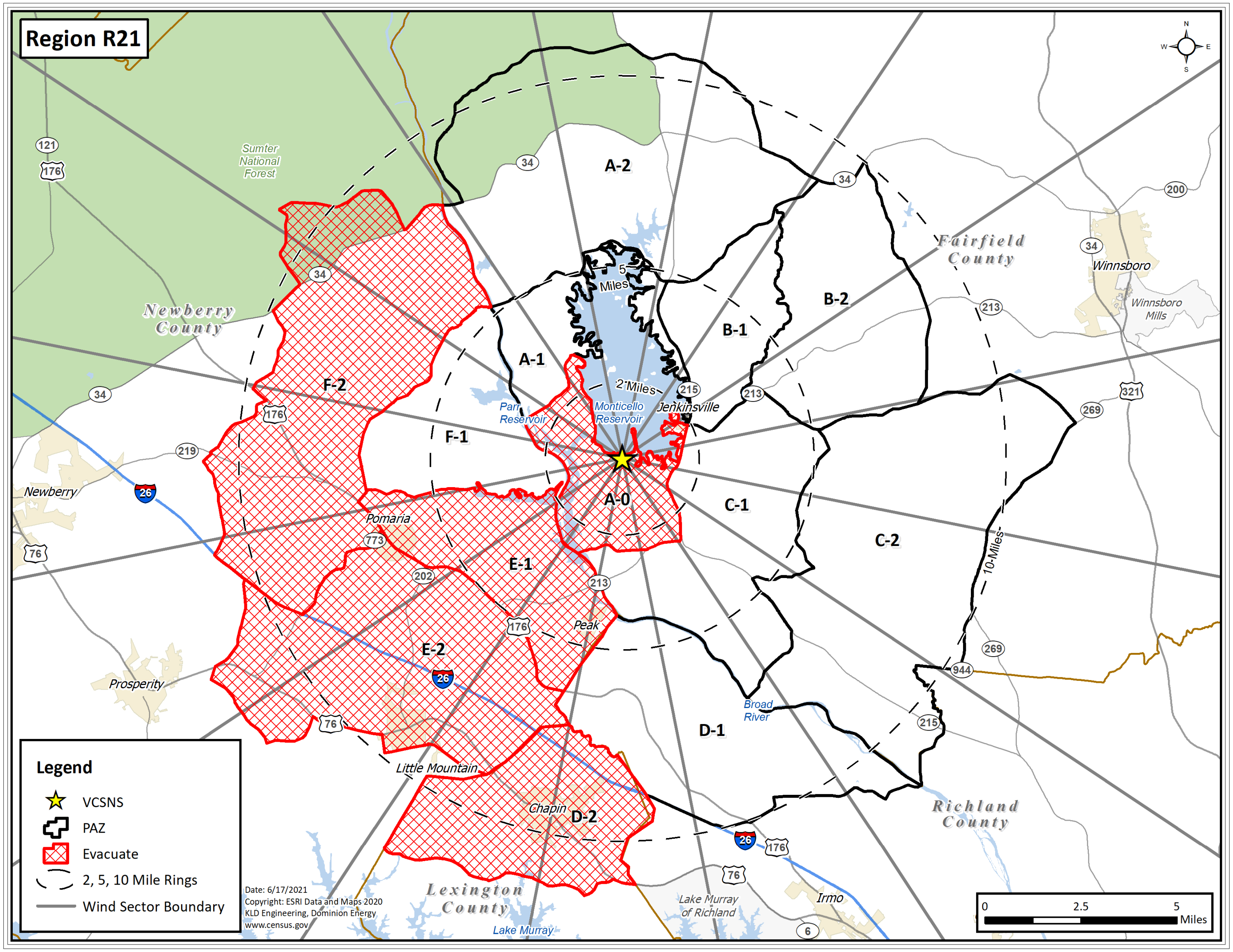


Figure H-21. Region R21

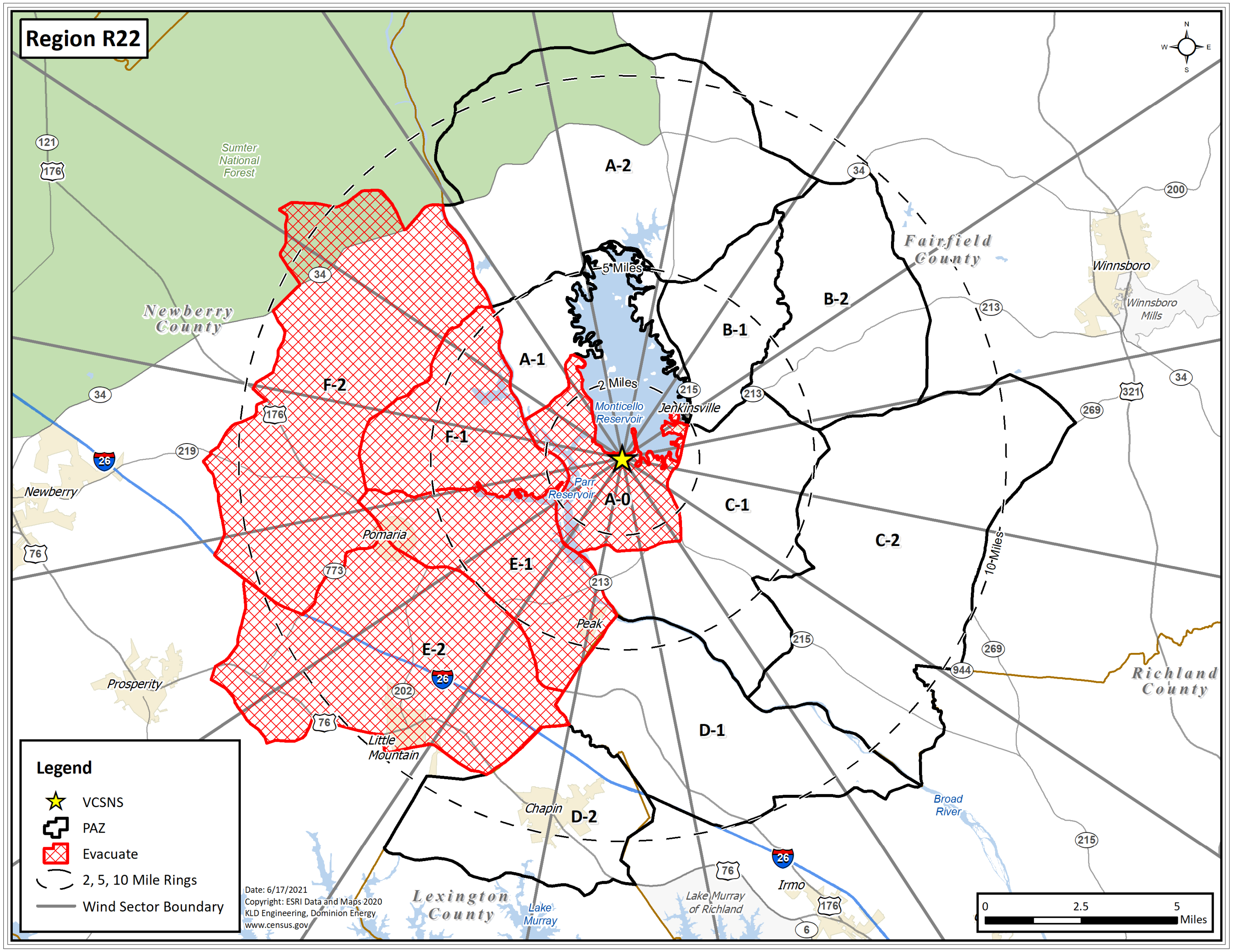


Figure H-22. Region R22

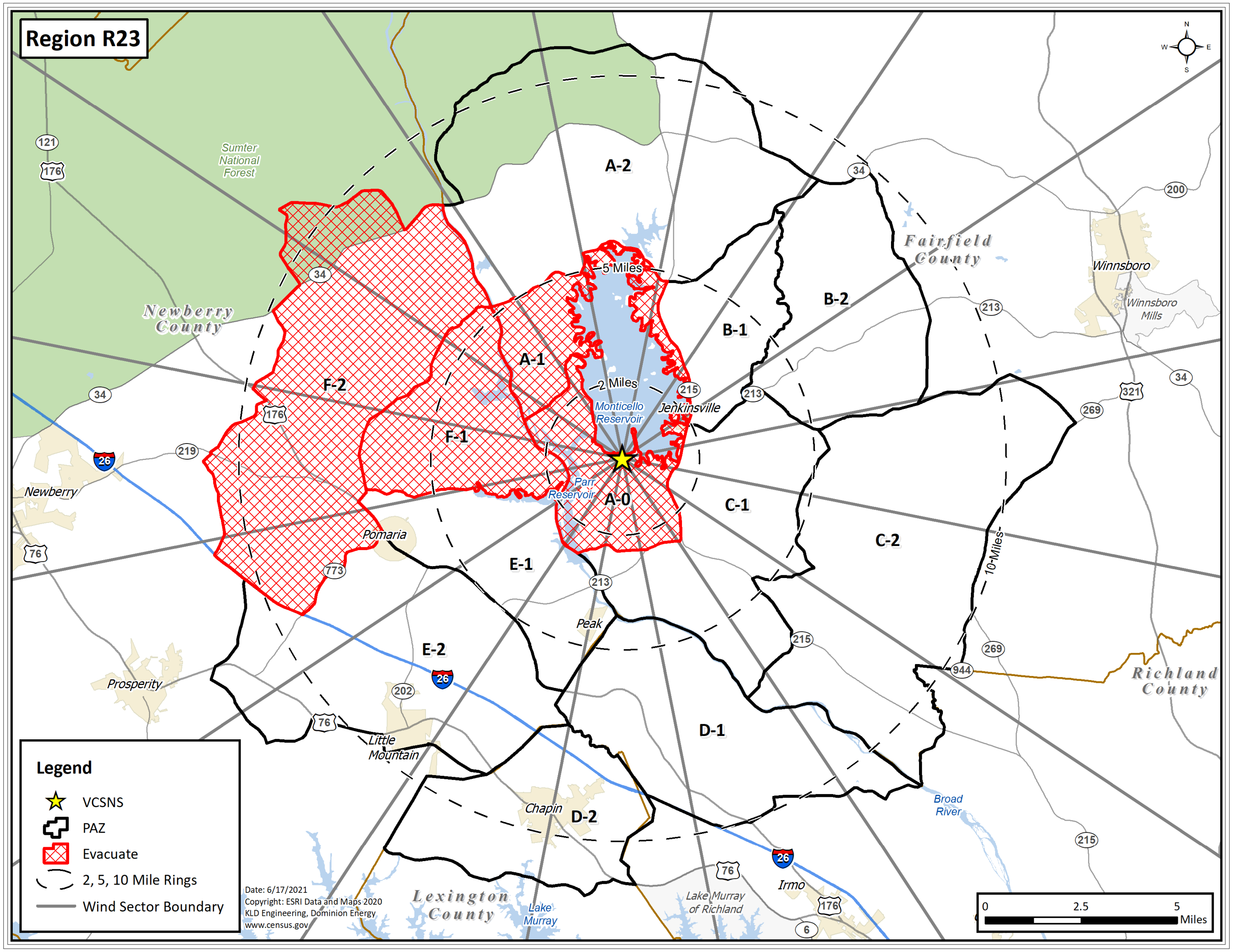


Figure H-23. Region R23

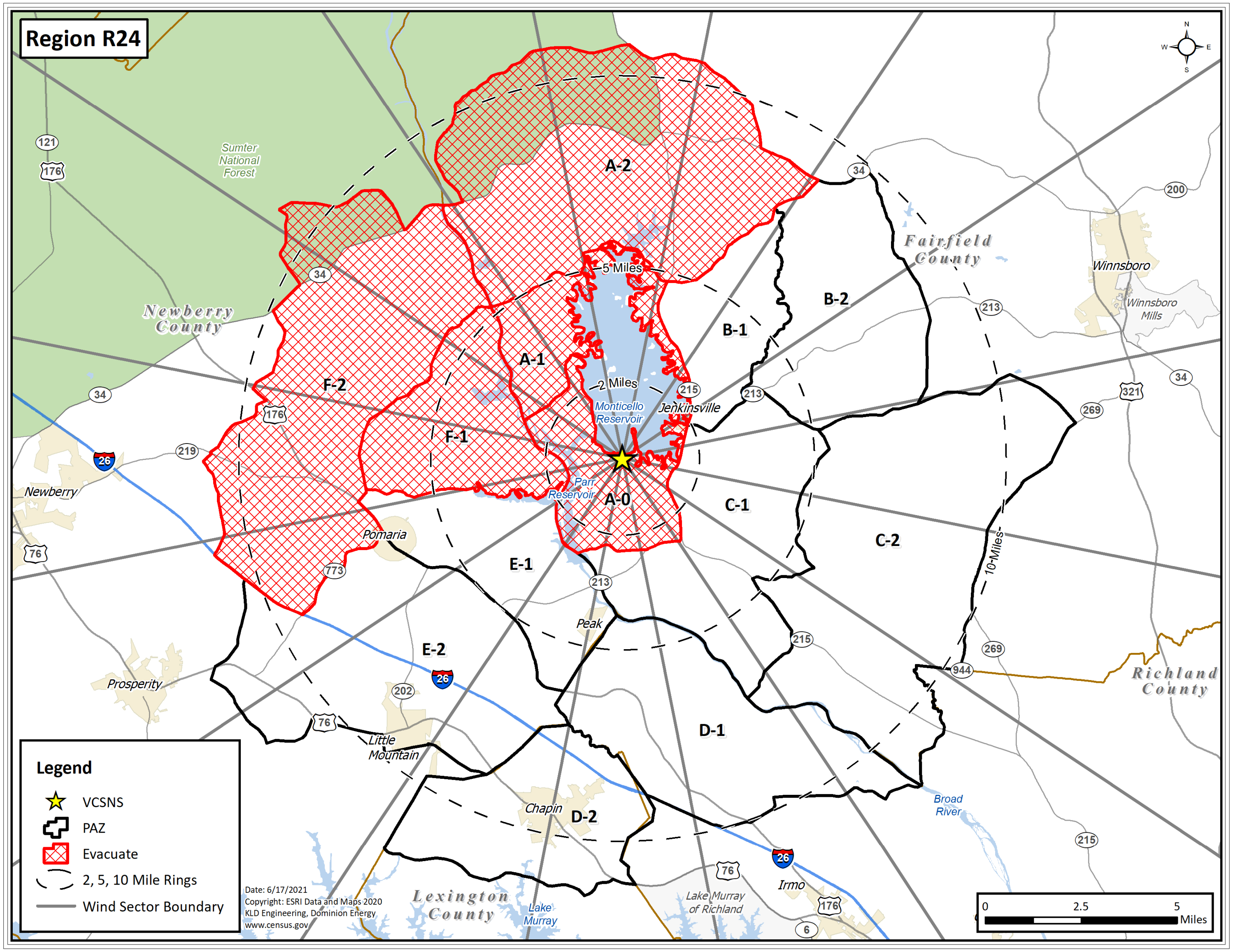


Figure H-24. Region R24

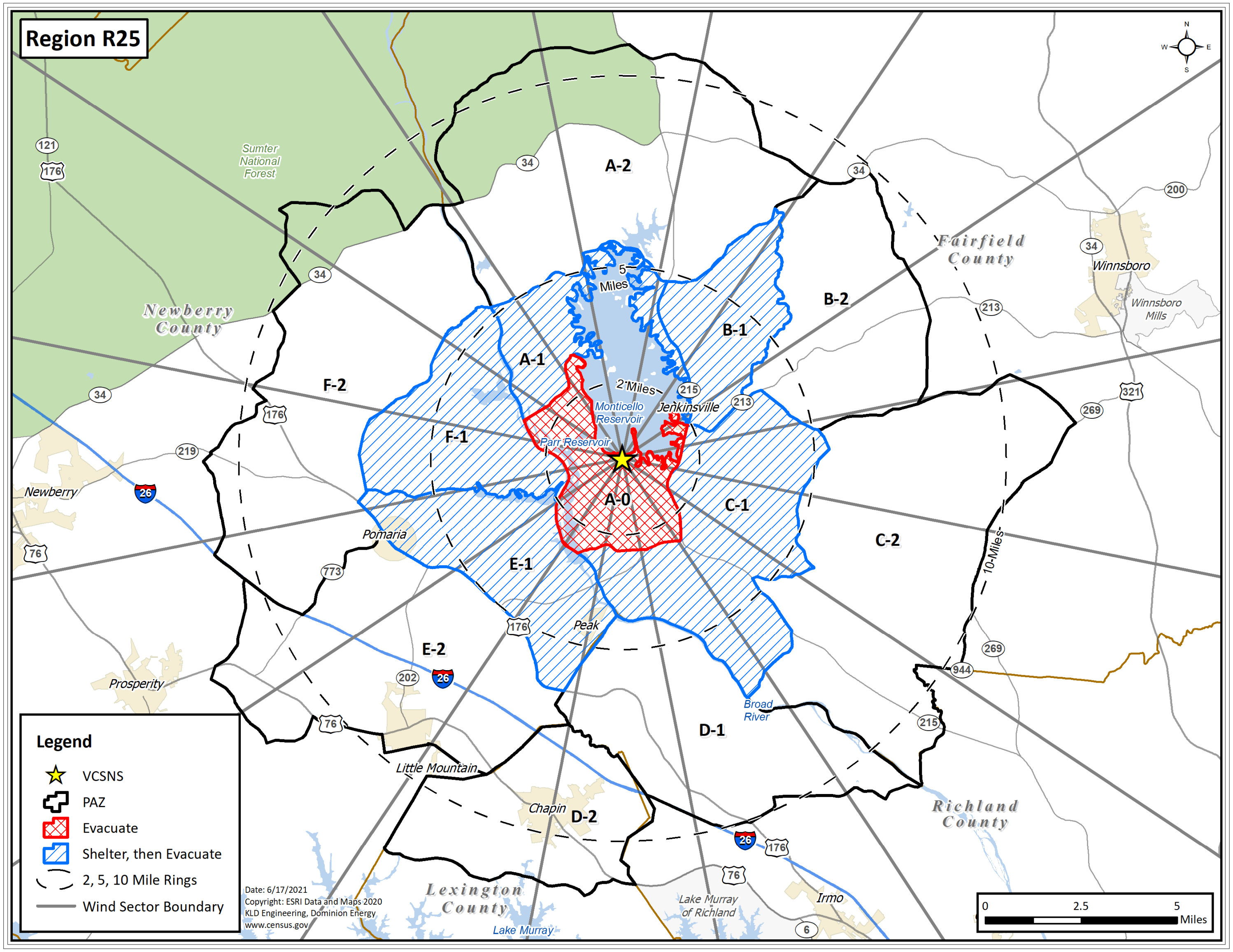


Figure H-25. Region R25

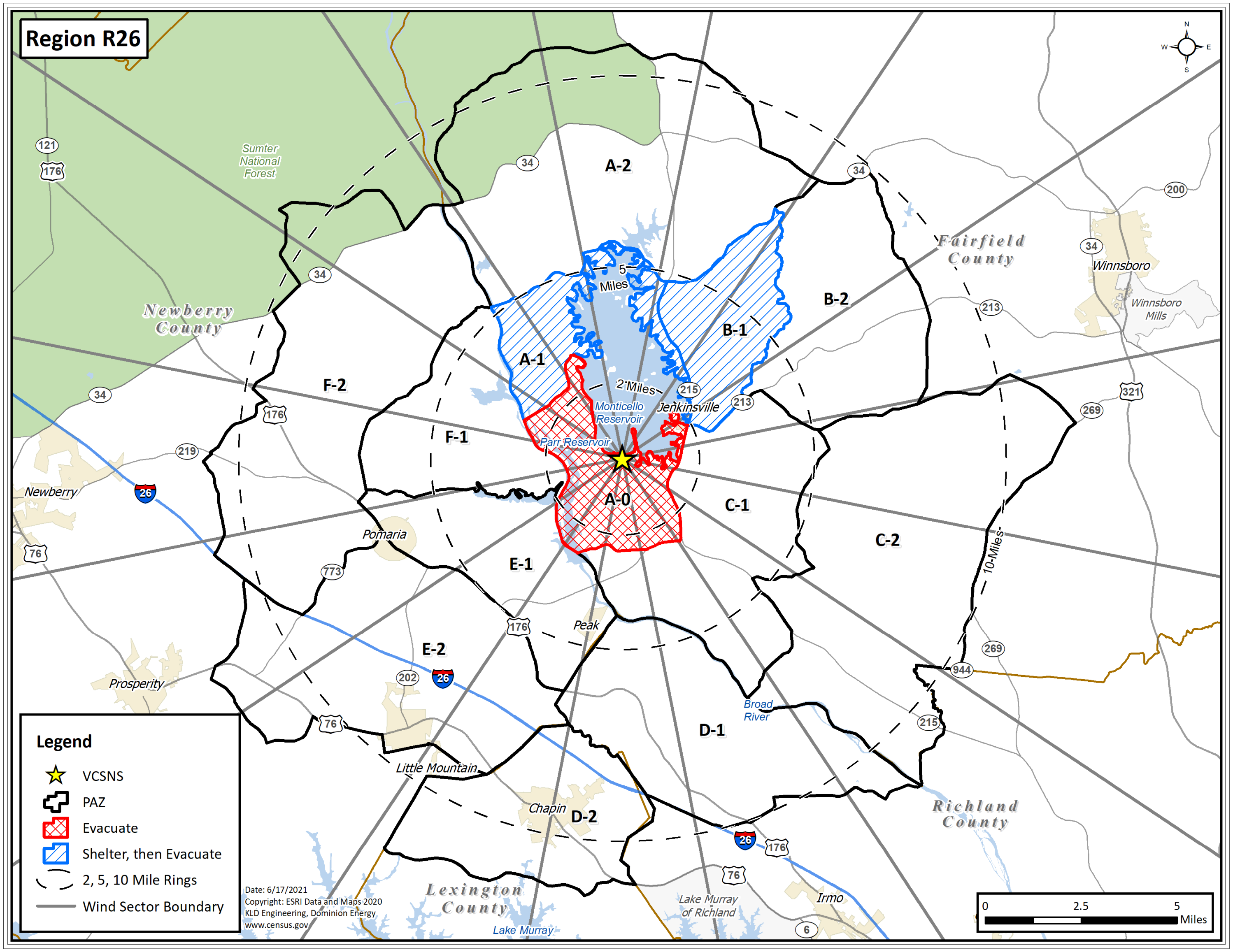


Figure H-26. Region R26

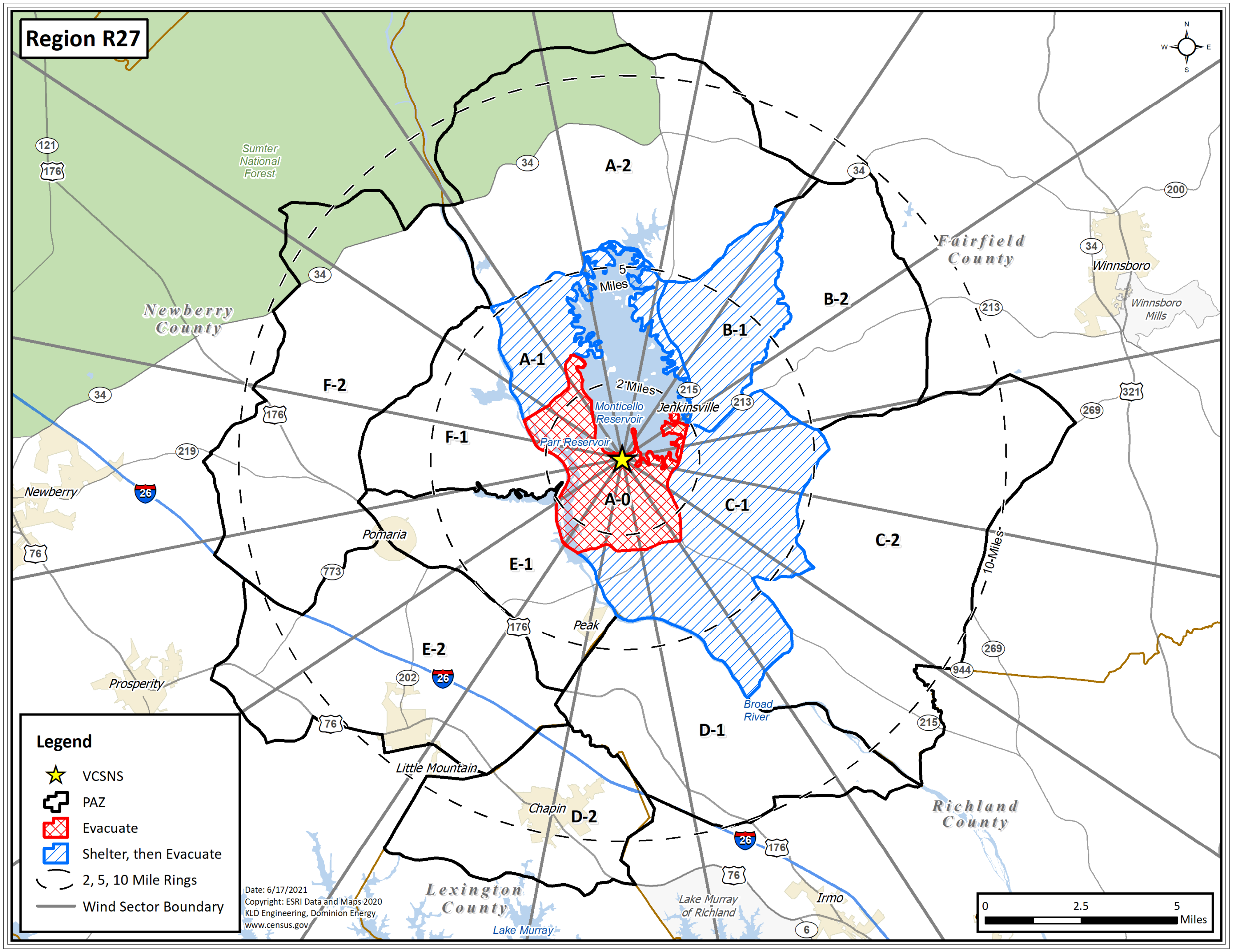


Figure H-27. Region R27

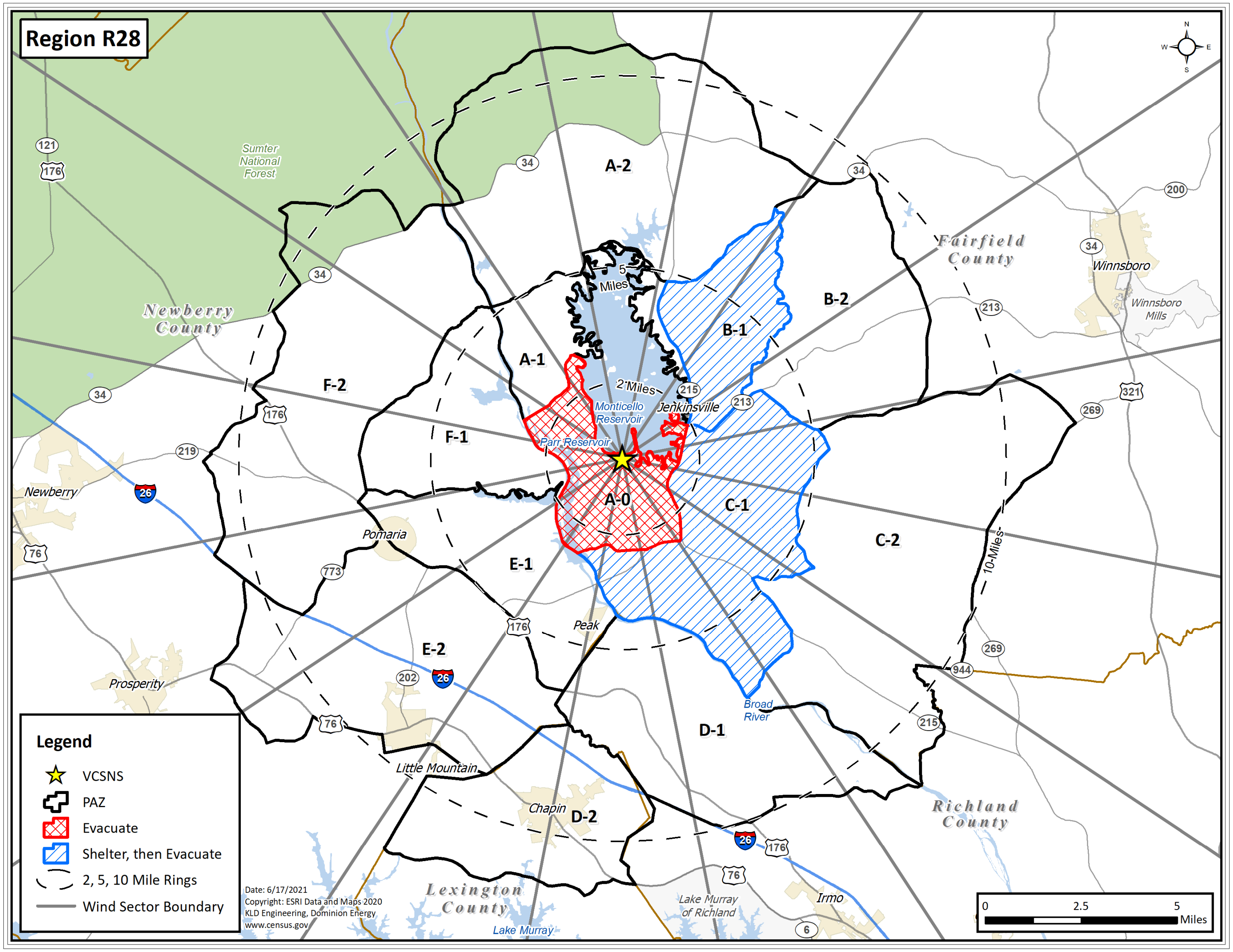


Figure H-28. Region R28

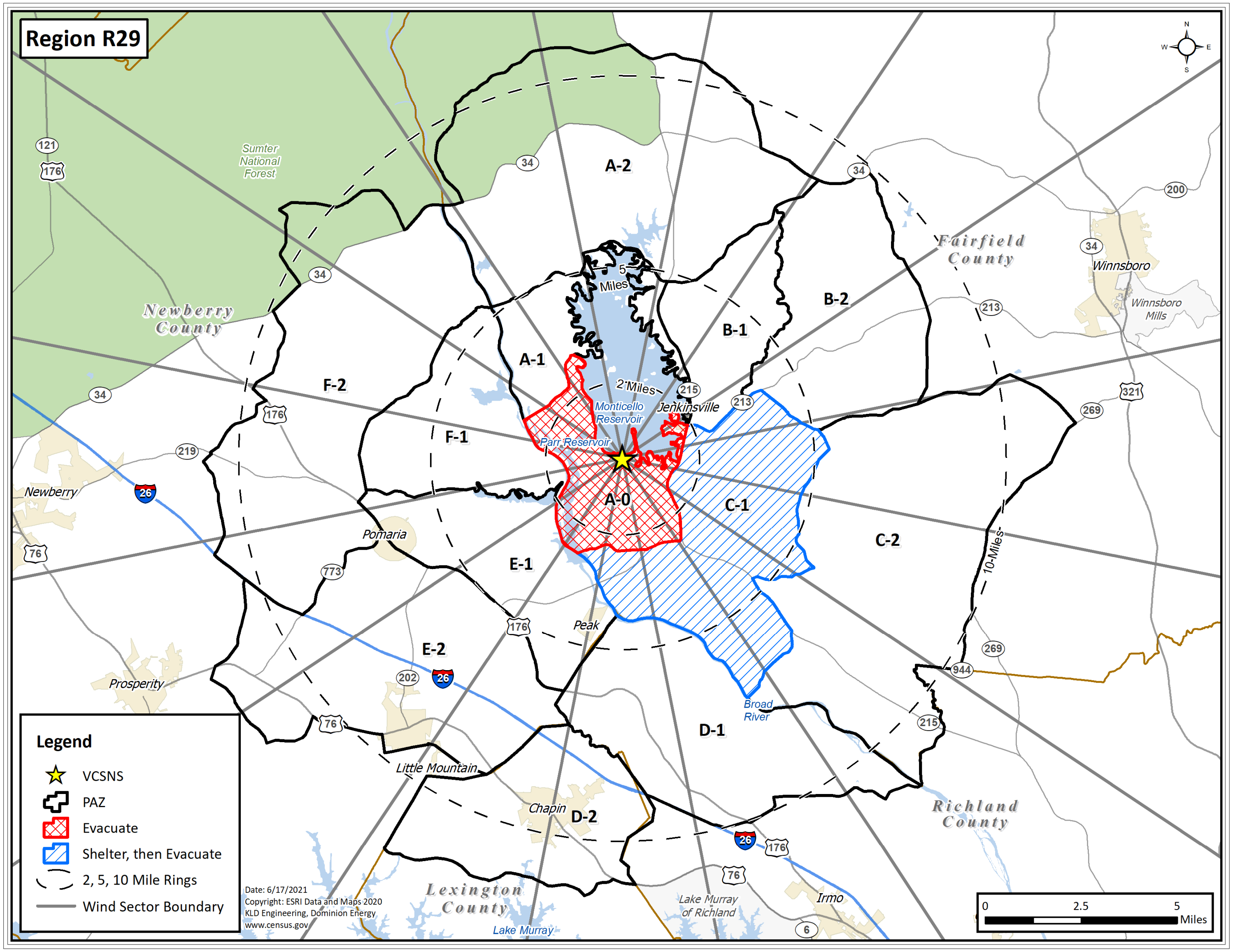


Figure H-29. Region R29

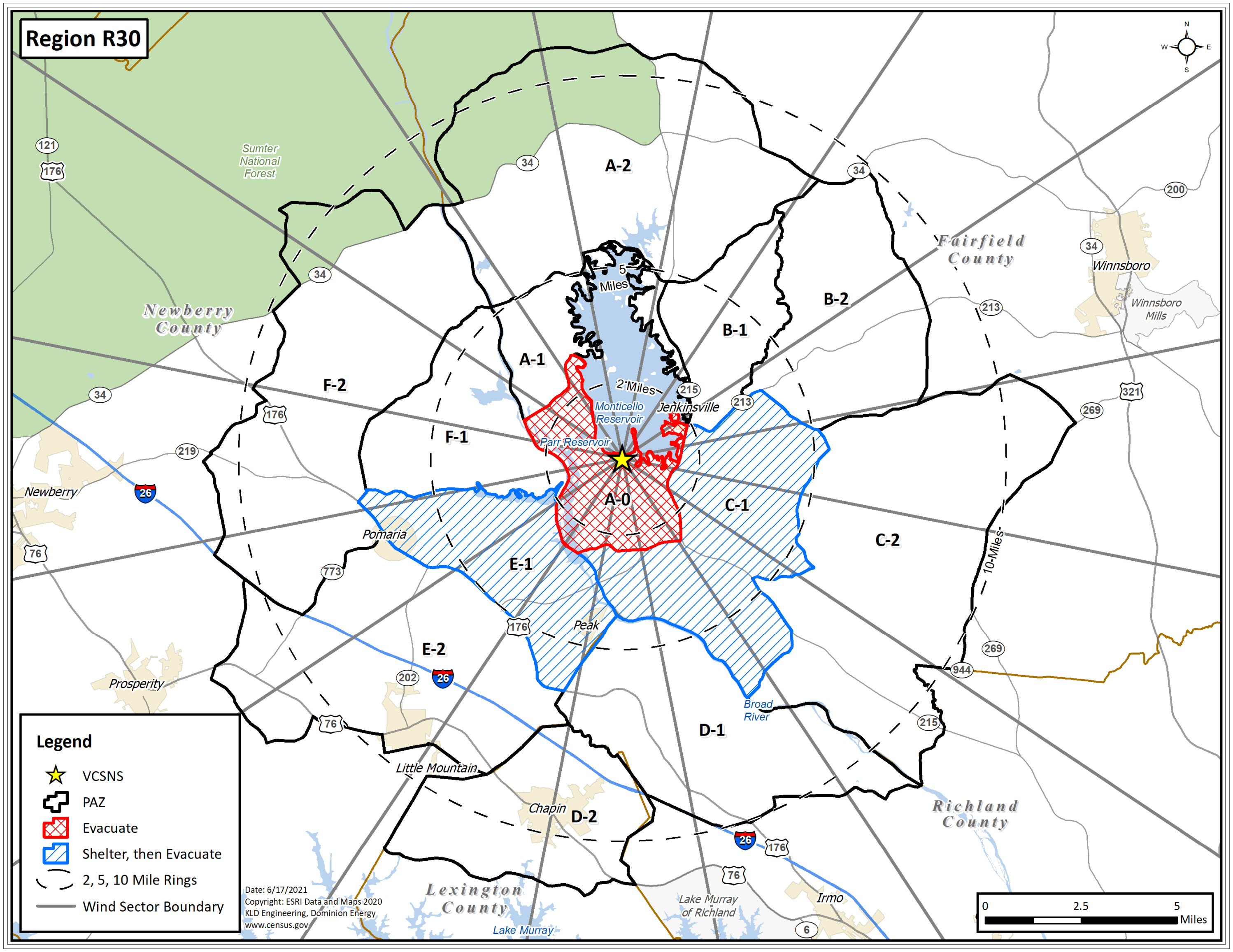


Figure H-30. Region R30

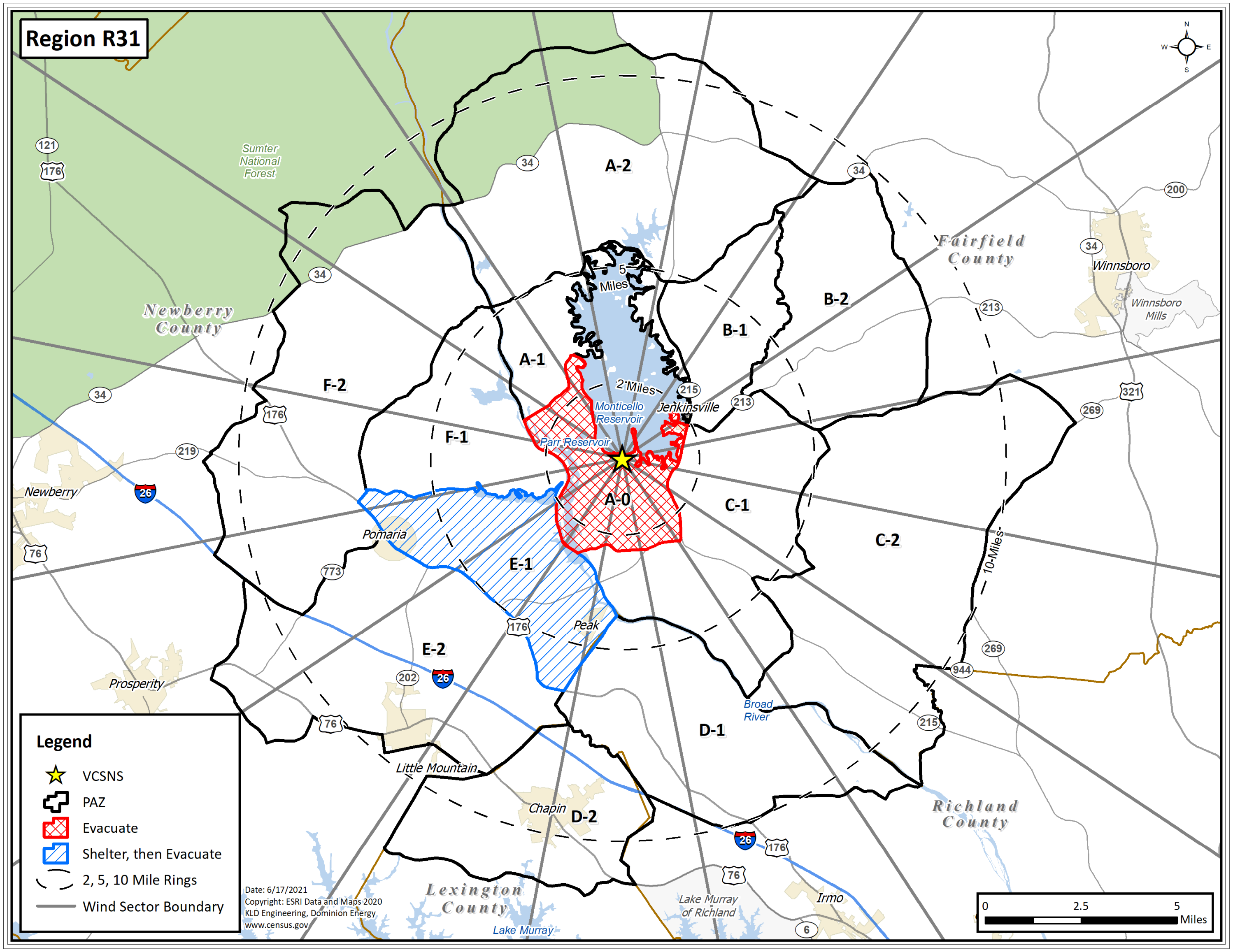


Figure H-31. Region R31

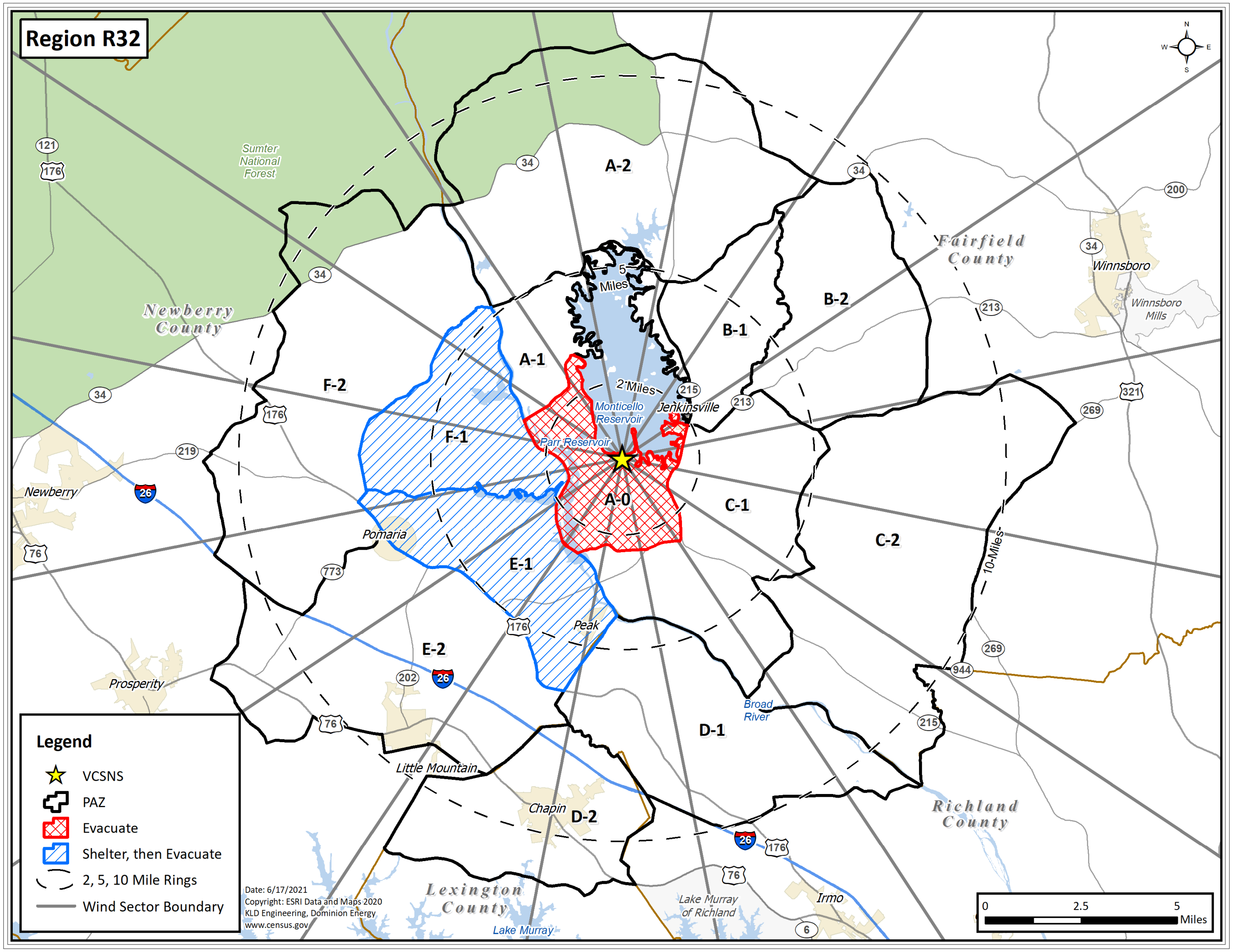


Figure H-32. Region R32

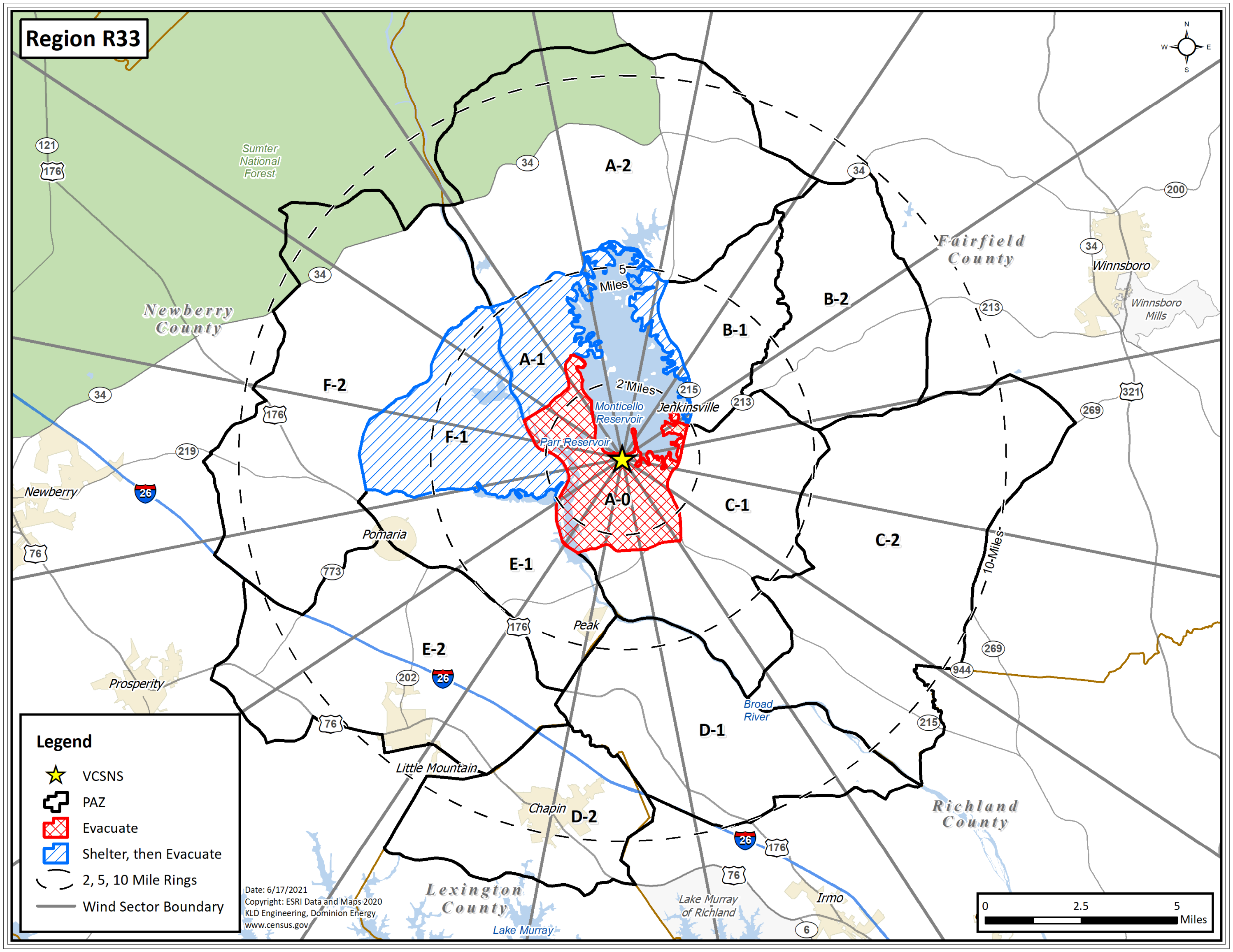


Figure H-33. Region R33

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 347 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 3.21 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 Emergency Planning Zone (EPZ) (Region R03) for each scenario. As expected, Scenarios 8 and 11, which are ice scenarios, exhibit the slowest average speeds, higher delays, and longer average travel times when compared to good weather and rain scenarios.

Table J-3 provides statistics (average speed and travel time) for the major evacuation routes – Interstate (I)- 26, US Highway (US) 176, US 76, and US 321 – 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 7-6, there is minimal to no congestion on I-26, US 321, and US 176 westbound throughout the evacuation, therefore the travel times and speeds are minimally affected. As such, the speeds shown in this table are relatively close to the free-flow speeds. As shown in Figures 7-3 through 7-6, US 76 eastbound and US 176 eastbound are the last two major evacuation routes to clear. As such, the average speeds along these routes are comparably slower (and travel times longer) than I-26, US 321 and US 176 westbound.

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 close together as a result of the limited traffic congestion in the EPZ, which clears at 2 hours and 40 minutes, as 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
729	484	485	83	E	8664	1,700
					8061	1,700
					8141	1,700
854	608	977	206	SE	8391	1,275
					8395	2,850
					8824	6,750
222	175	192	11	SW	8401	1,700
					8363	4,500
					8813	2,850
471	309	313	27	W	8401	1,700
					8363	4,500
					8813	2,850
207	164	165	17	W	8401	1,700
					8363	4,500
					8813	2,850
670	449	447	44	E	8141	1,700
					8470	1,700
909	653	652	31	E	8664	1,700
					8061	1,700
					8141	1,700
1044	758	759	8	SW	8391	1,275
					8395	2,850
					8363	4,500
1329	985	984	141	SE	8395	2,850
					8824	6,750
					8827	1,275

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

Scenario	1	2	3	4	5	6	7
Network-Wide Average Travel Time (Min/Veh-Mi)	1.11	1.25	1.11	1.25	1.14	1.11	1.29
Network-Wide Average Delay Time (Min/Veh-Mi)	0	0.1	0	0.1	0	0	0.1
Network-Wide Average Speed (mph)	54.2	48.1	54.2	48.1	52.5	54.0	46.6
Total Vehicles Exiting Network	32,774	33,042	31,888	32,156	23,099	32,842	33,107
Scenario	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Network-Wide Average Travel Time (Min/Veh-Mi)	1.48	1.09	1.22	1.41	1.14	1.13	1.70
Network-Wide Average Delay Time (Min/Veh-Mi)	0.3	0	0.1	0.2	0	0	1.50
Network-Wide Average Speed (mph)	40.5	54.8	49.4	42.6	52.5	53.0	34.7
Total Vehicles Exiting Network	33,403	31,577	31,842	32,154	22,866	34,024	32,838

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

Elapsed Time (hours)													
		1		2		3		4		5		6	
Route Name	Length (miles)	Speed (mph)	Travel Time (min)	Speed (mph)	Travel Time (min)	Speed (mph)	Travel Time (min)	Speed (mph)	Travel Time (min)	Speed (mph)	Travel Time (min)	Speed (mph)	Travel Time (min)
I-26 EB	29.1	70.5	24.7	69.7	25	71.2	24.5	72	24.2	71.7	24.3	68.7	25.4
I-26 WB	29.1	70.4	24.8	70.4	24.8	71.9	24.3	72	24.2	71.9	24.3	72.1	24.2
US 176 EB	34	53	38.5	45.8	44.6	48	42.5	52.9	38.6	53.4	38.2	54.1	37.7
US 176 WB	34.1	53.7	38	53.8	38	54	37.8	53.8	38	55.4	36.9	55.7	36.7
US 76 EB	29.3	45.8	38.3	39.6	44.4	47.2	37.2	46.5	37.8	45.9	38.3	47.7	36.8
US 321 NB	17.8	52.1	20.5	51.8	20.6	52.3	20.4	52.8	20.2	54.9	19.4	55	19.4
US 321 SB	17.8	51.7	20.6	51.3	20.8	52.2	20.4	53.6	19.9	54.6	19.5	55.2	19.3

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

Roadway Name	Upstream Node	Down stream Node	Elapsed Time (hours)					
			1	2	3	4	5	6
			Cumulative Vehicles Discharged by the Indicated Time					
			Cumulative Percent of Vehicles Discharged by the Indicated Time Interval					
State Route (SR) 215	31	32	207	430	564	623	637	637
			2.90%	2.20%	2.00%	2.00%	2.00%	1.90%
SR 34	60	61	87	362	468	487	494	495
			1.20%	1.80%	1.60%	1.50%	1.50%	1.50%
US 321	71	664	239	674	964	1,081	1,117	1,118
			3.30%	3.40%	3.40%	3.40%	3.40%	3.40%
SR 215	113	111	36	166	225	247	251	251
			0.50%	0.80%	0.80%	0.80%	0.80%	0.80%
I-26	361	363	2,535	5,339	6,572	6,647	6,672	6,673
			35.20%	27.00%	22.90%	20.90%	20.40%	20.40%
US 176/SR 121	400	401	68	273	415	469	484	484
			1.00%	1.40%	1.50%	1.50%	1.50%	1.50%
Tyger River Rd	422	423	4	33	48	53	55	55
			0.10%	0.20%	0.20%	0.20%	0.20%	0.2%
SR S-36-45	425	426	7	54	77	85	87	87
			0.10%	0.30%	0.30%	0.30%	0.30%	0.30%
SR 391	719	720	87	470	920	1,114	1,187	1,189
			1.20%	2.40%	3.20%	3.50%	3.60%	3.60%
SR 34	812	814	77	521	909	1,043	1,086	1,088
			1.10%	2.60%	3.20%	3.30%	3.30%	3.30%
US 76	848	957	226	713	1,173	1,429	1,529	1,532
			3.10%	3.60%	4.10%	4.50%	4.70%	4.70%
US 321	939	470	231	688	1,027	1,179	1,228	1,228
			3.20%	3.50%	3.60%	3.70%	3.80%	3.80%
SR 200	966	141	58	406	616	674	694	694
			0.80%	2.10%	2.10%	2.10%	2.10%	2.10%
US 176	1043	827	239	882	1,623	2,185	2,354	2,357
			3.30%	4.50%	5.70%	6.90%	7.20%	7.20%
I-26	1111	824	2,801	7,369	10,565	11,431	11,636	11,644
			38.90%	37.20%	36.80%	36.00%	35.50%	35.50%
St. Andrews Rd	1143	395	79	420	800	975	1,070	1,071
			1.10%	2.10%	2.80%	3.10%	3.30%	3.30%
SR 6	1156	391	219	990	1,748	2,029	2,167	2,172
			3.00%	5.00%	6.10%	6.40%	6.60%	6.60%

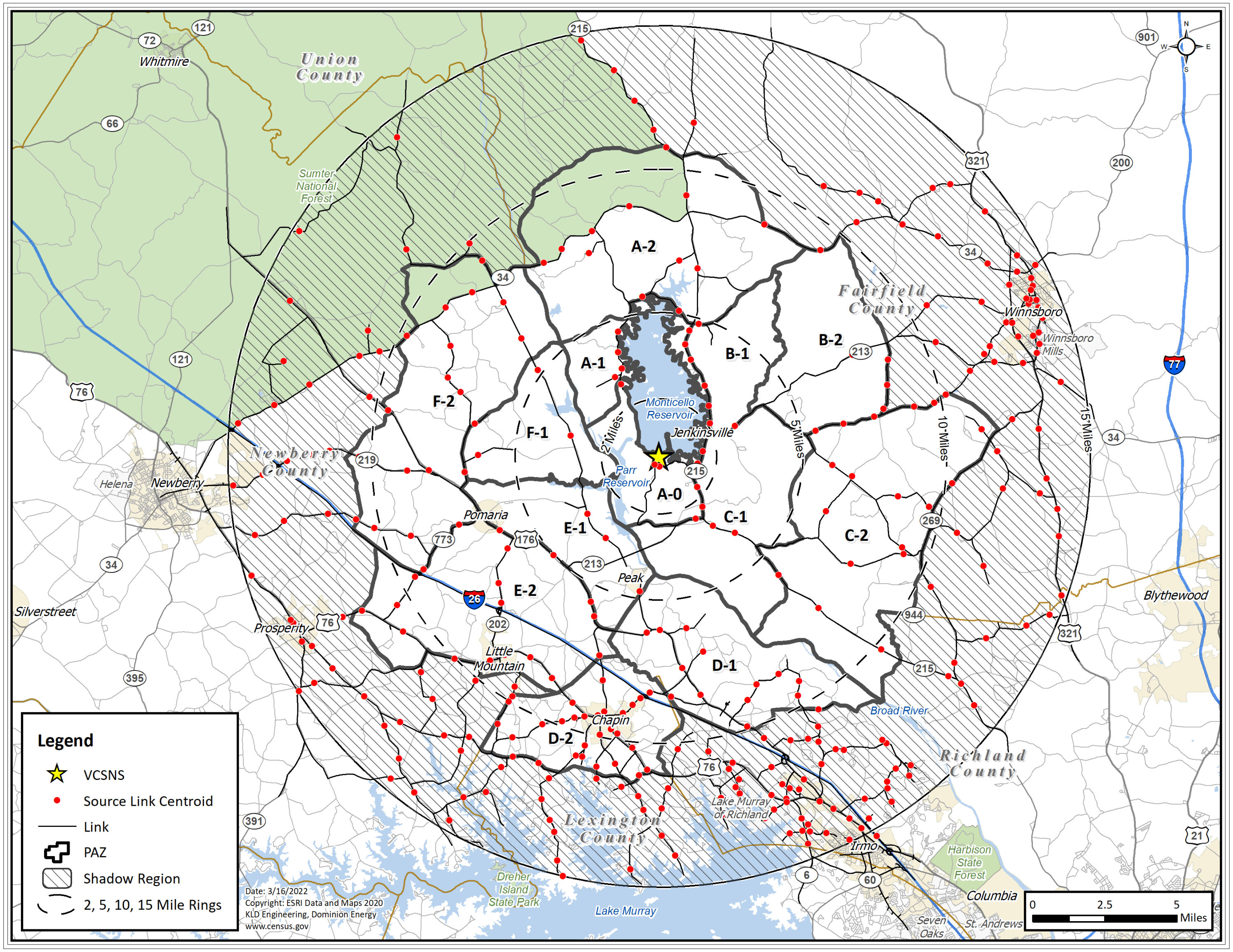


Figure J-1. Network Sources/Origins

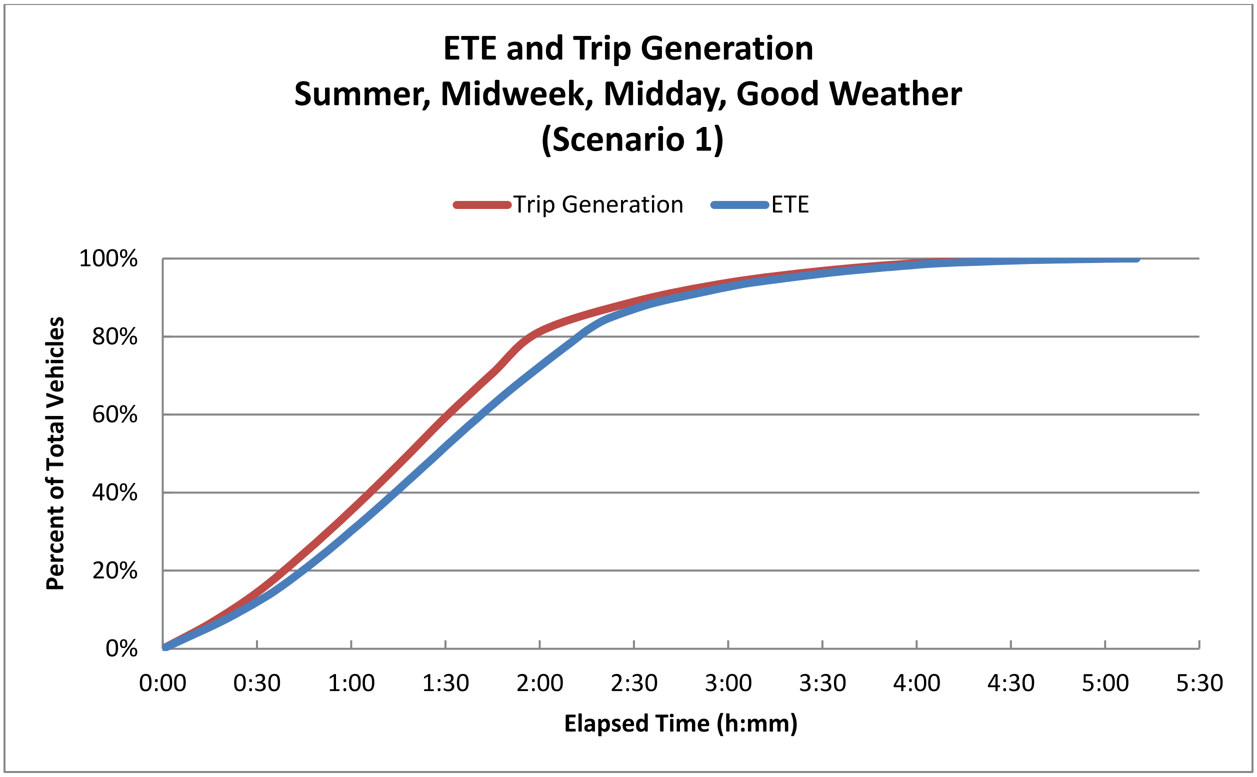


Figure J-2. ETE and Trip Generation: Summer, Midweek, Midday, Good Weather (Scenario 1)

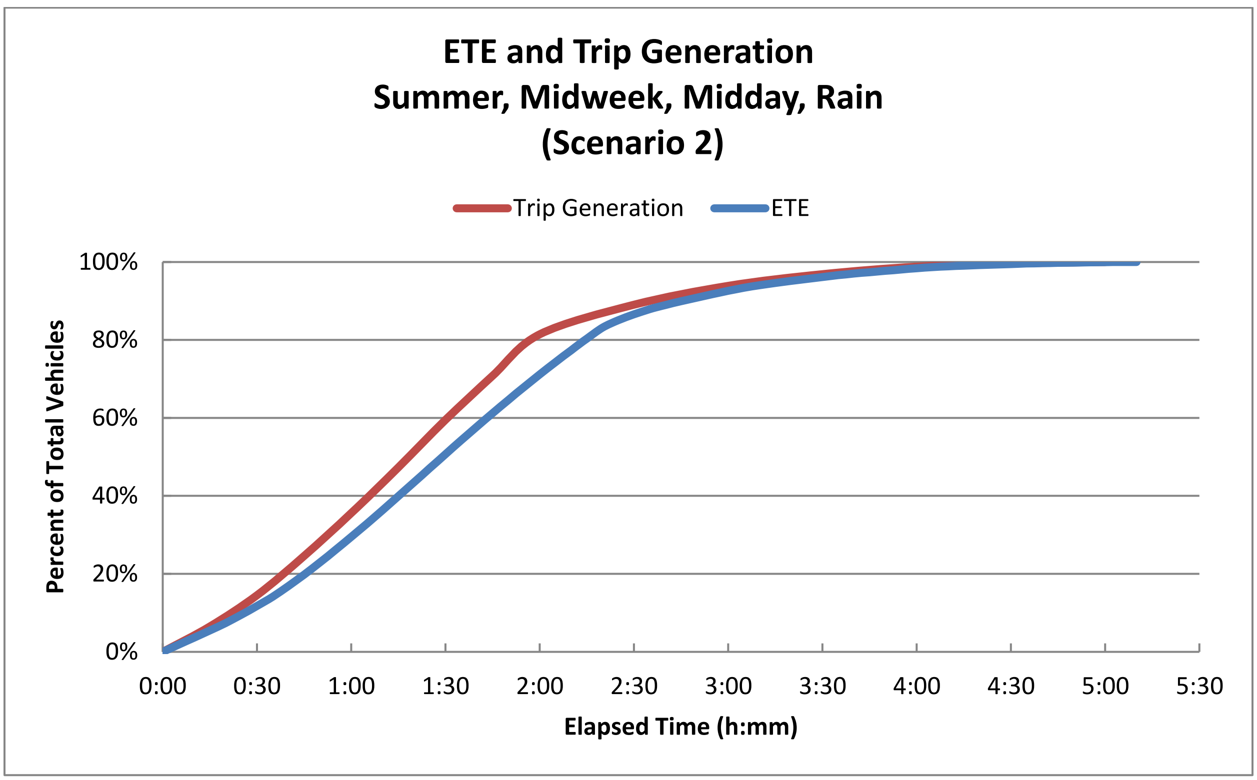


Figure J-3. ETE and Trip Generation: Summer, Midweek, Midday, Rain (Scenario 2)

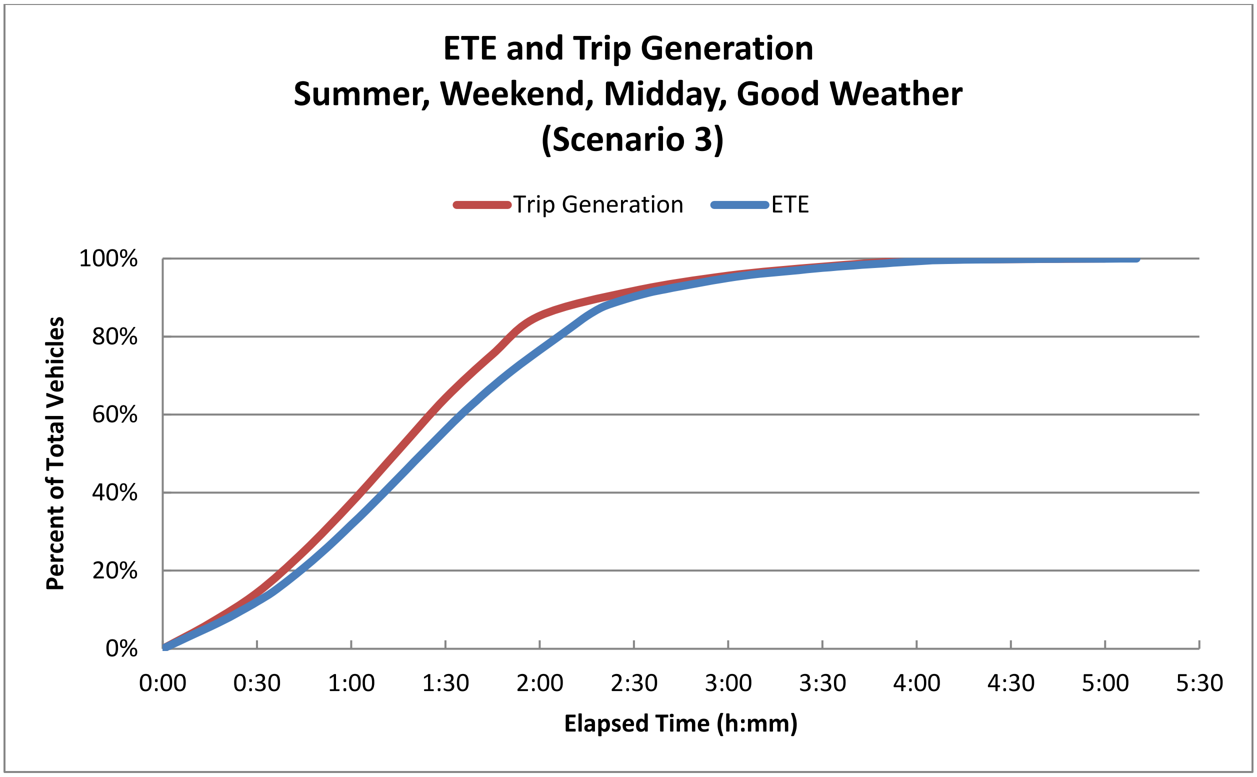


Figure J-4. ETE and Trip Generation: Summer, Weekend, Midday, Good Weather (Scenario 3)

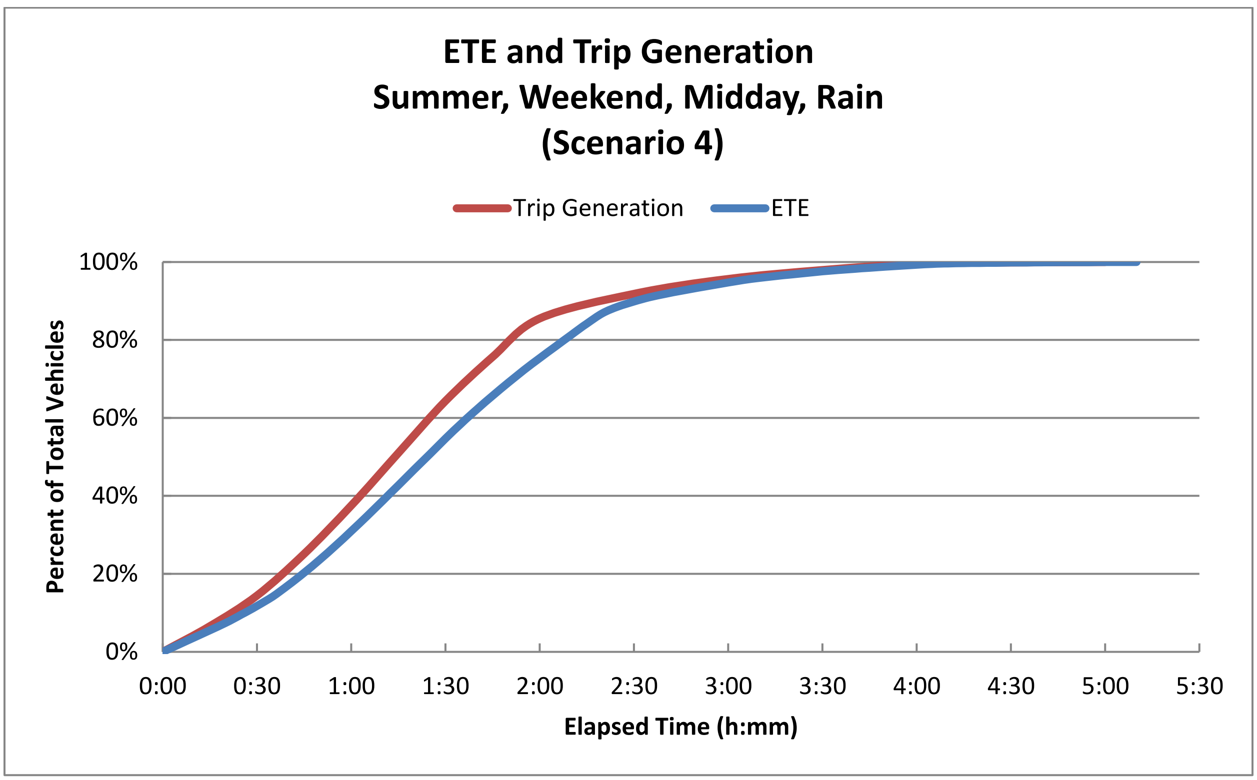


Figure J-5. ETE and Trip Generation: Summer, Weekend, Midday, Rain (Scenario 4)

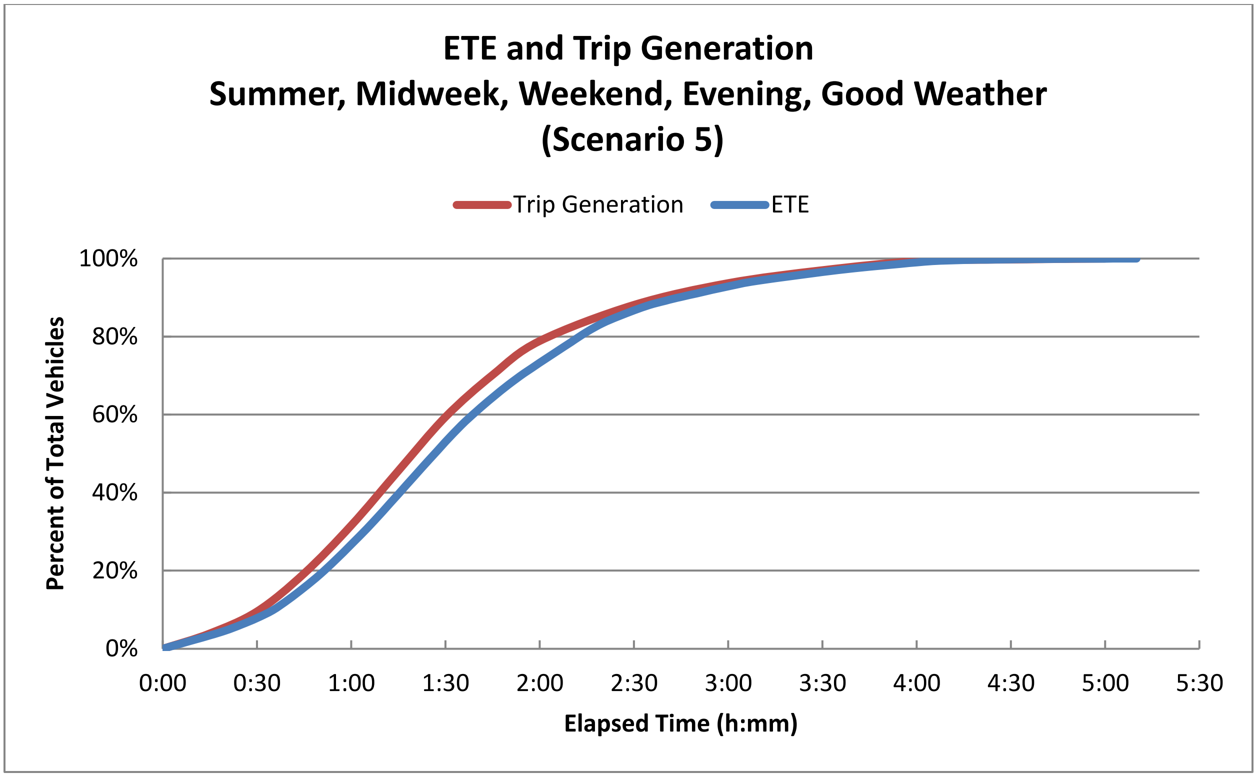


Figure J-6. ETE and Trip Generation: Summer, Midweek, Weekend, Evening, Good Weather (Scenario 5)

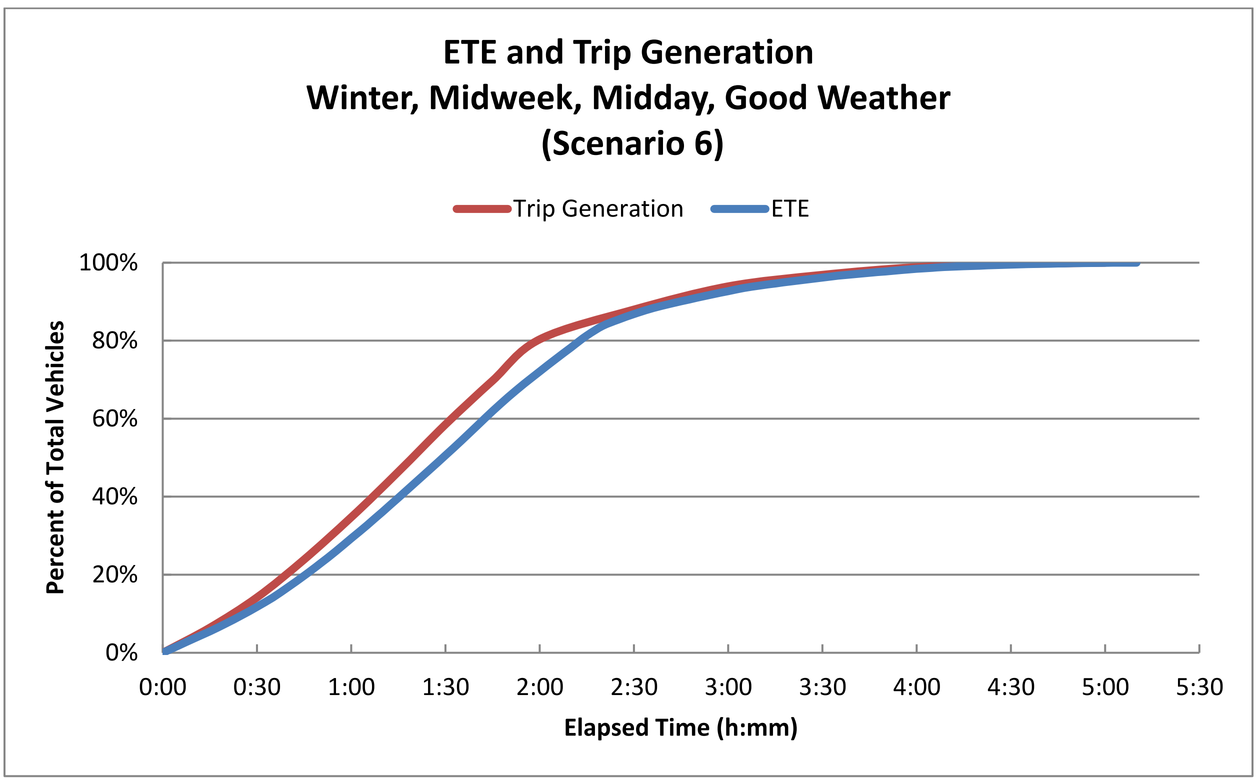


Figure J-7. ETE and Trip Generation: Winter, Midweek, Midday, Good Weather (Scenario 6)

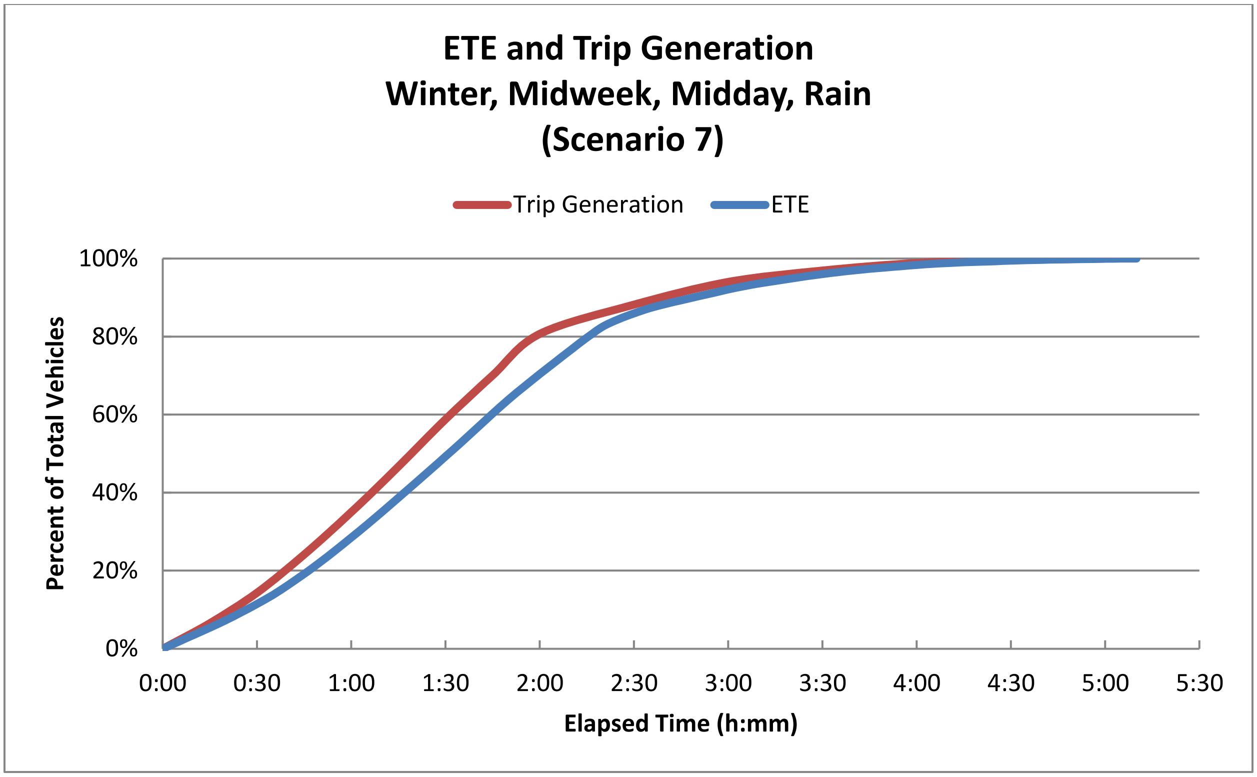


Figure J-8. ETE and Trip Generation: Winter, Midweek, Midday, Rain (Scenario 7)

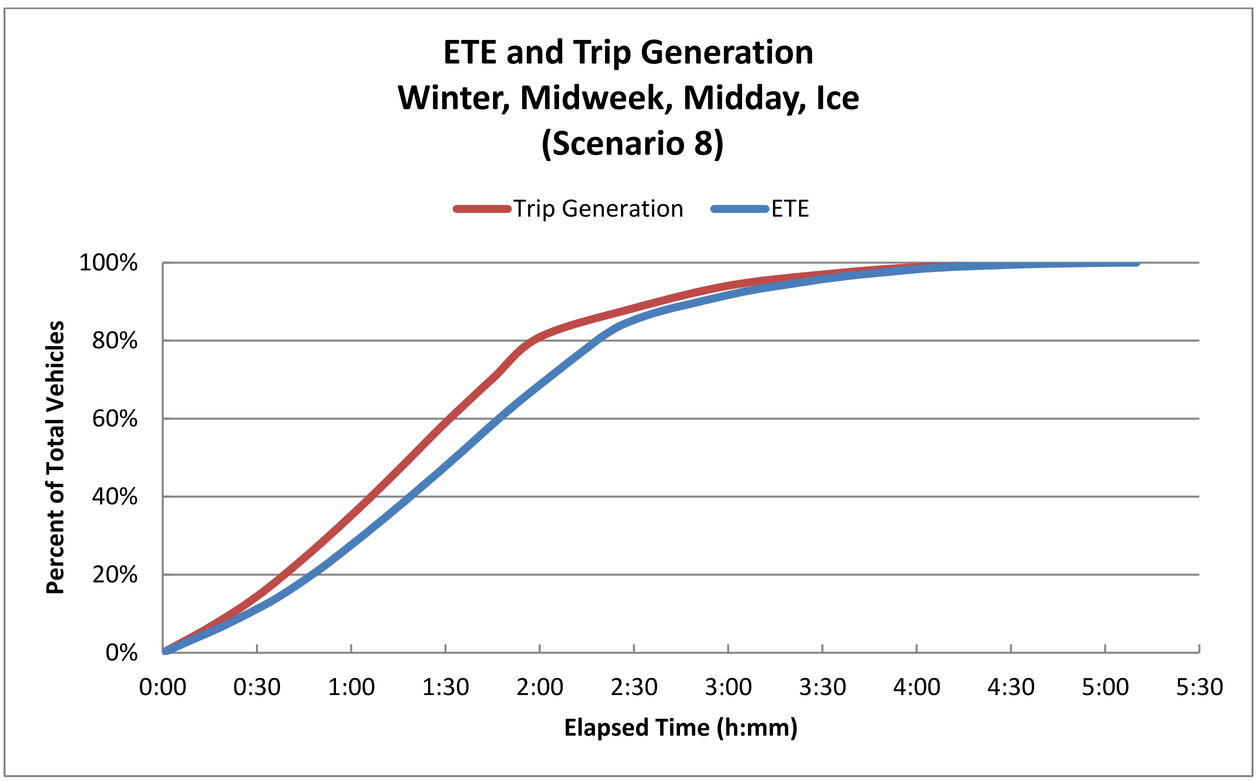


Figure J-9. ETE and Trip Generation: Winter, Midweek, Midday, Ice (Scenario 8)

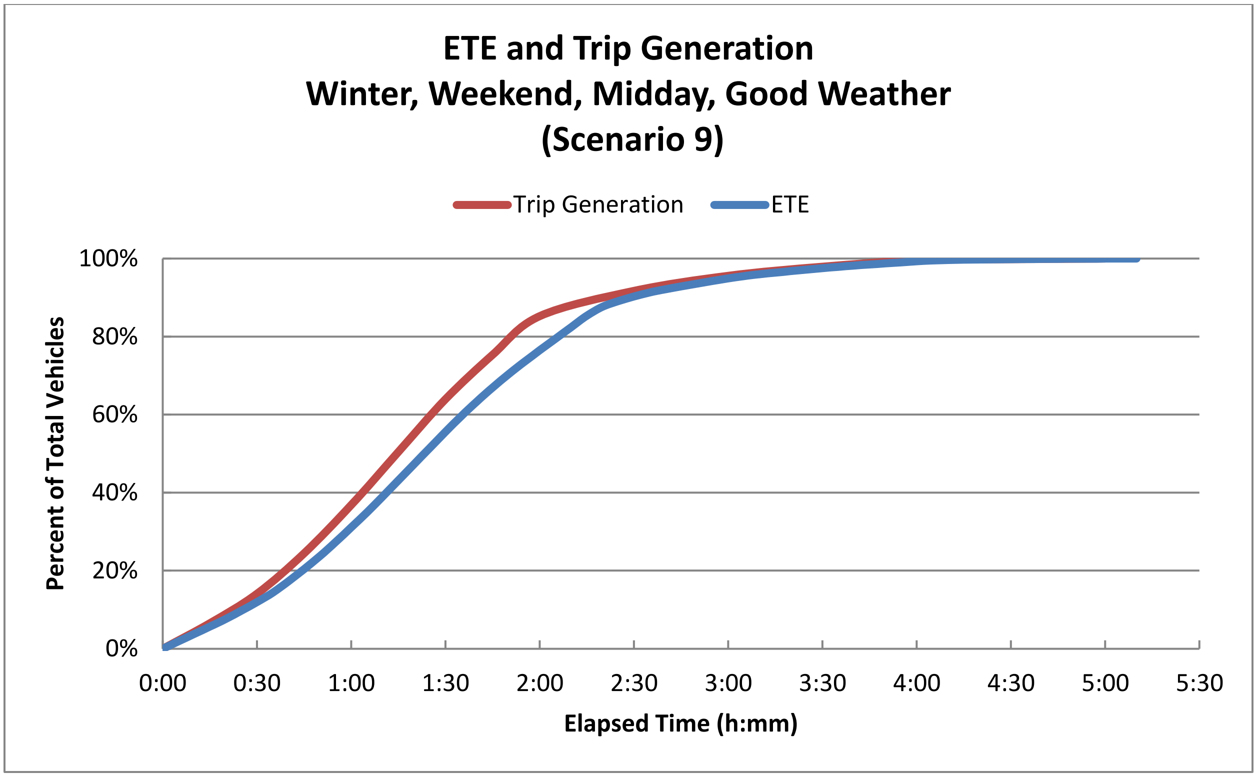


Figure J-10. ETE and Trip Generation: Winter, Weekend, Midday, Good Weather (Scenario 9)

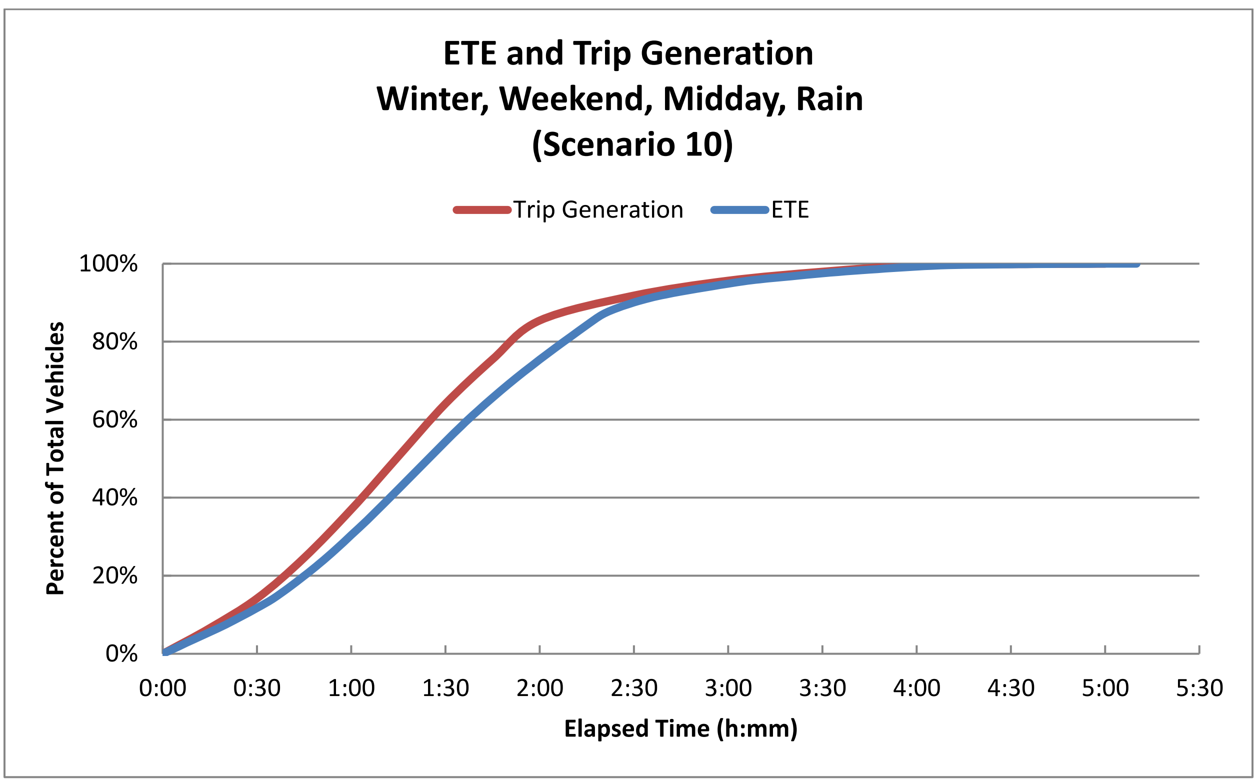


Figure J-11. ETE and Trip Generation: Winter, Weekend, Midday, Rain (Scenario 10)

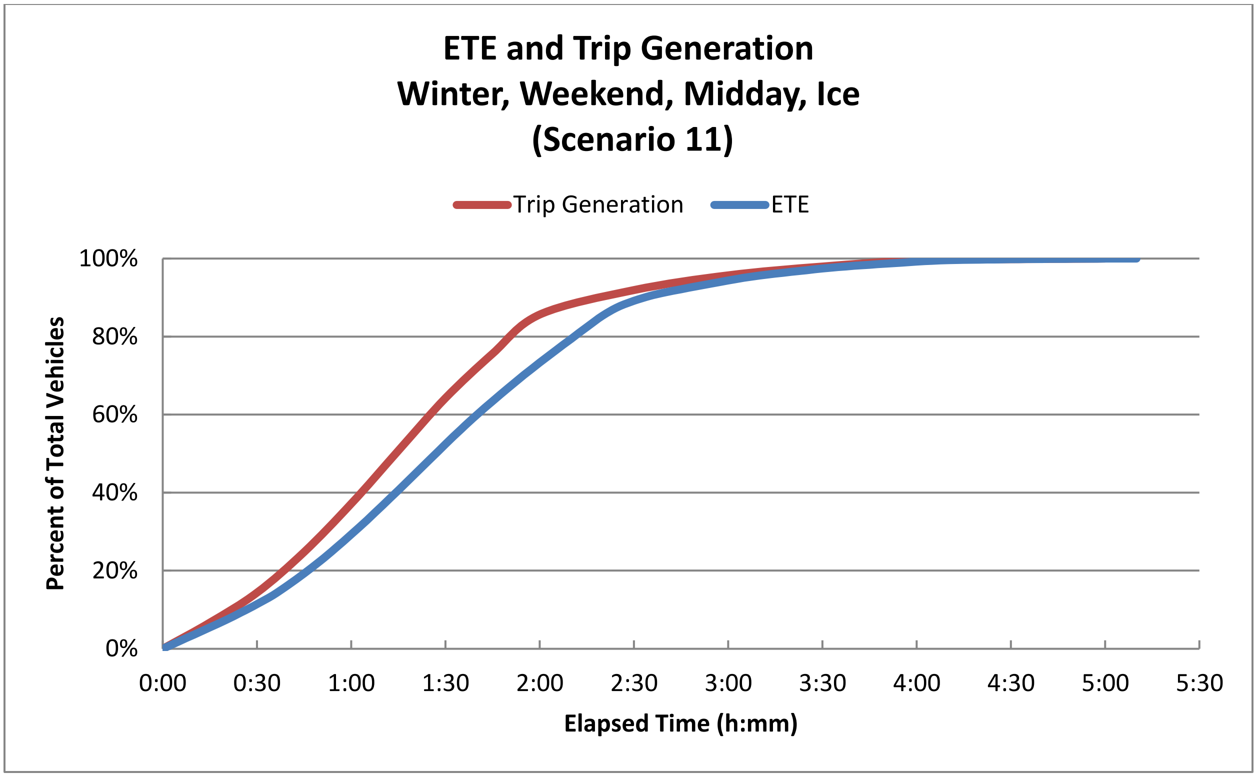


Figure J-12. ETE and Trip Generation: Winter, Weekend, Midday, Ice (Scenario 11)

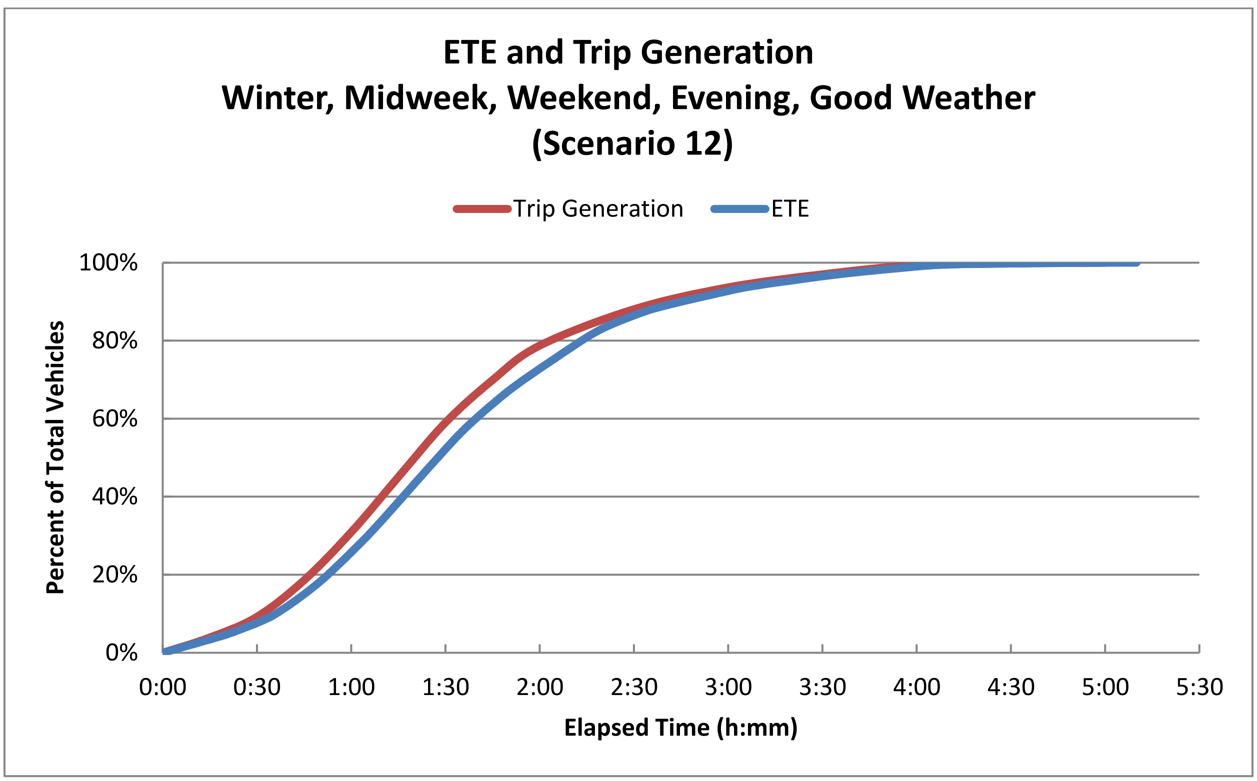


Figure J-13. ETE and Trip Generation: Winter, Midweek, Weekend, Evening, Good Weather (Scenario 12)

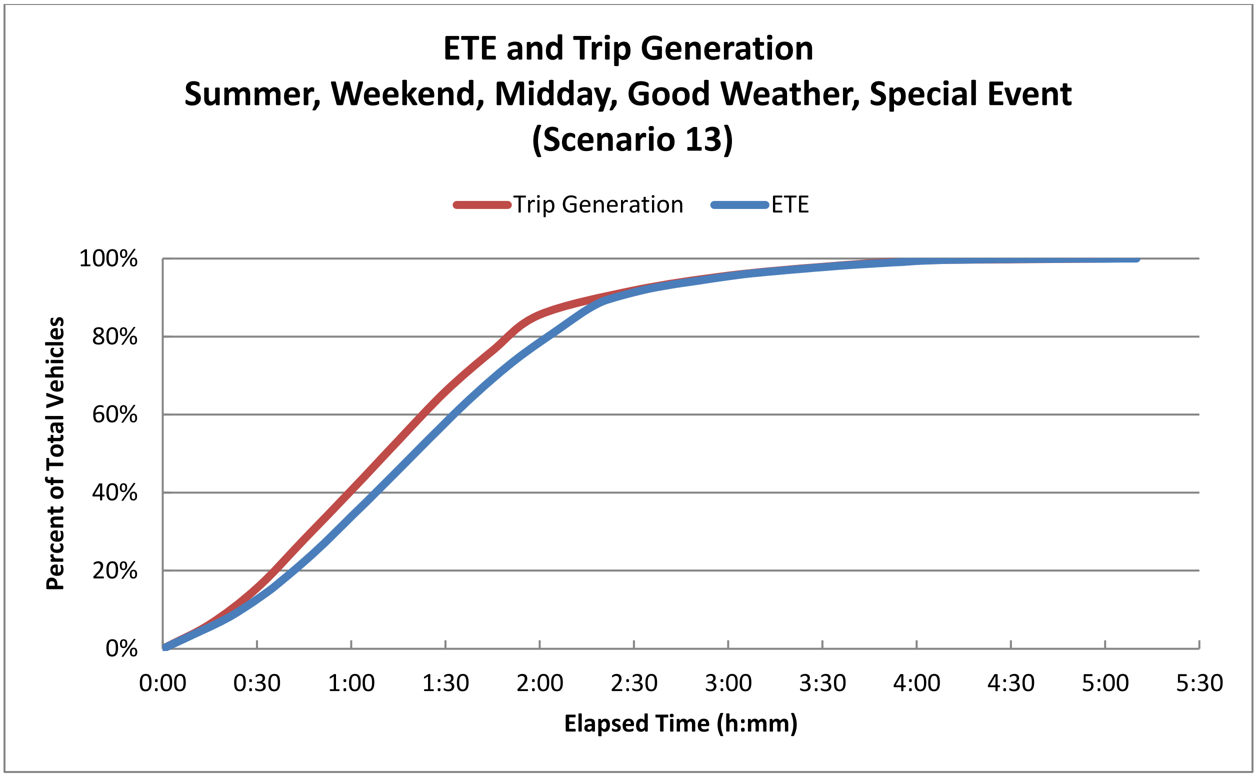


Figure J-14. ETE and Trip Generation: Summer, Weekend, Midday, Good Weather, Special Event (Scenario 13)

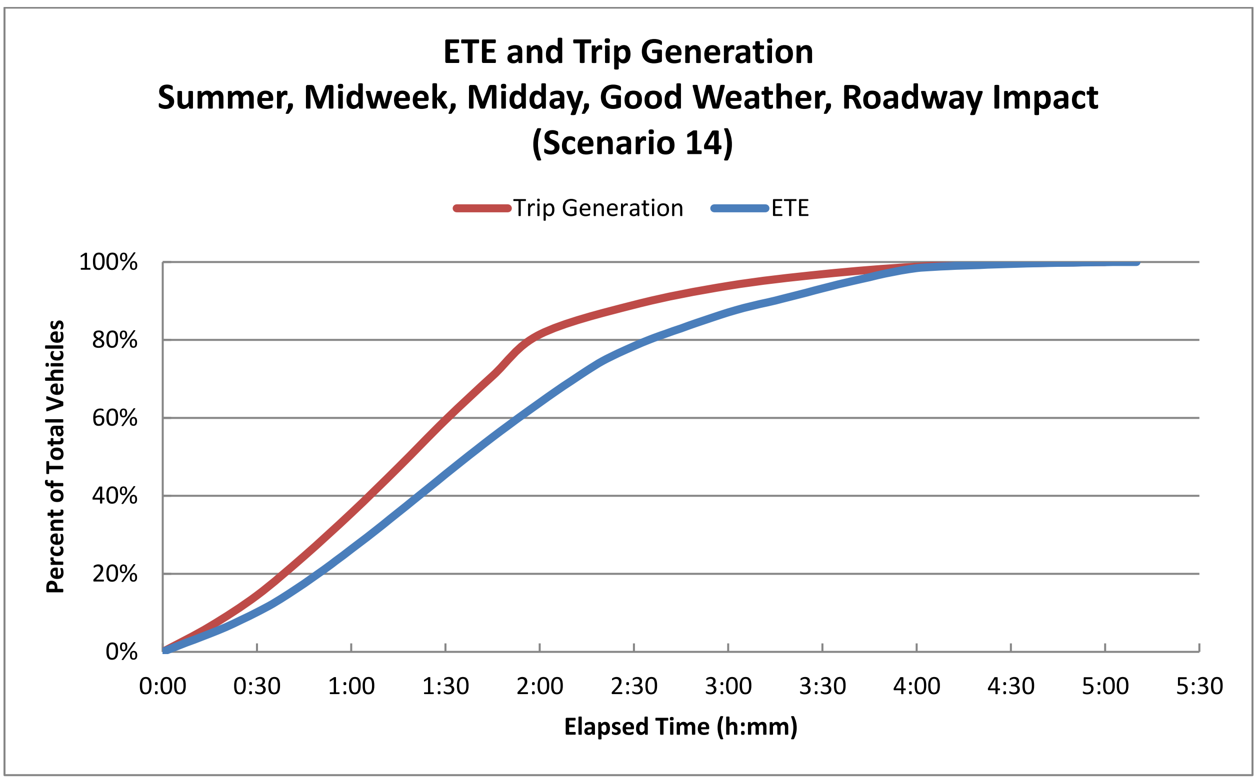


Figure J-15. ETE and Trip Generation: Summer, Midweek, Midday, Good Weather, Roadway Impact (Scenario 14)

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 31 more detailed figures (Figure K-2 through Figure K-32) 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 February 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	942
Pretimed	2
Actuated	52
Stop	123
TACP	24
Yield	12
Total:	**1,155**

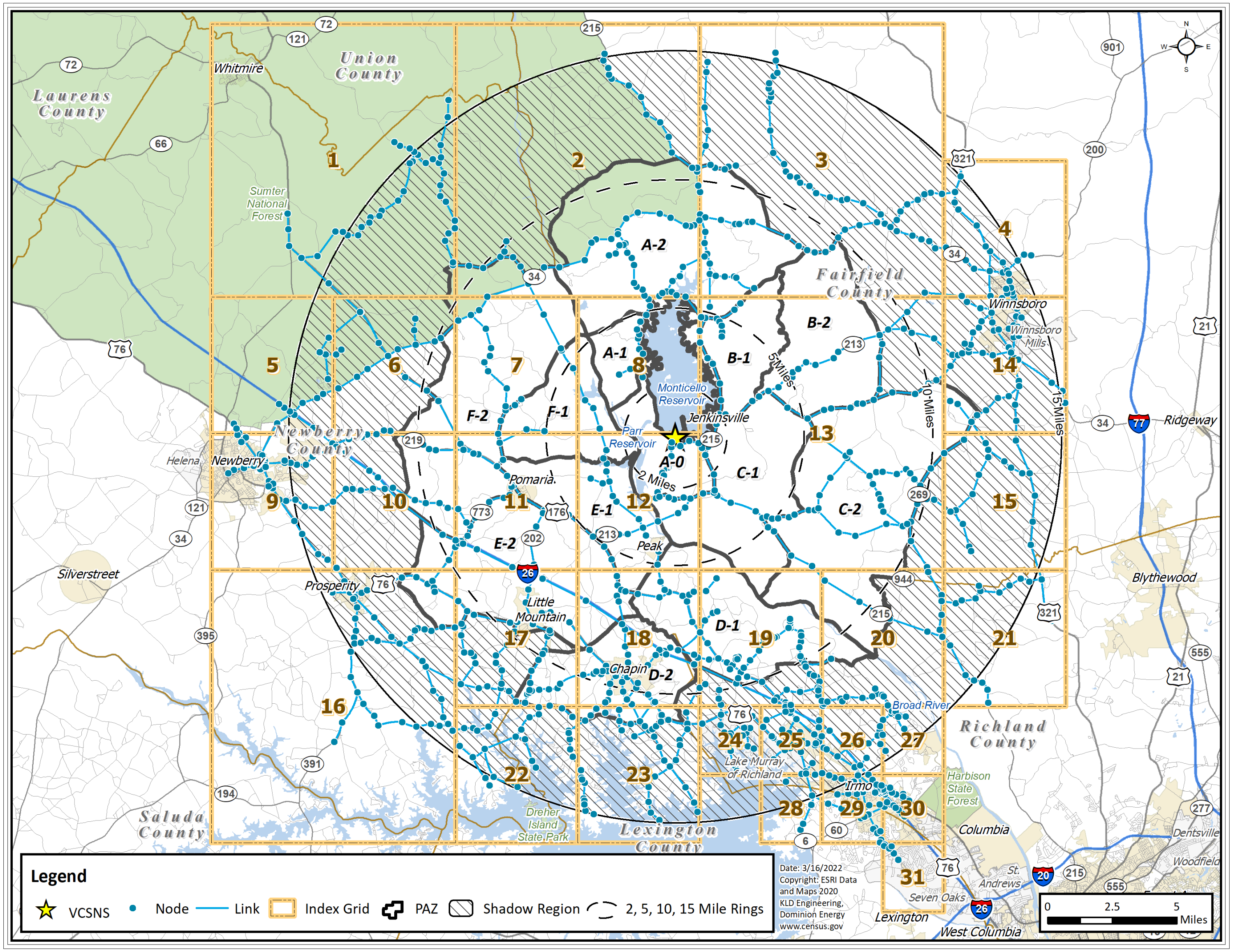


Figure K-1. Overview of Link Node Analysis

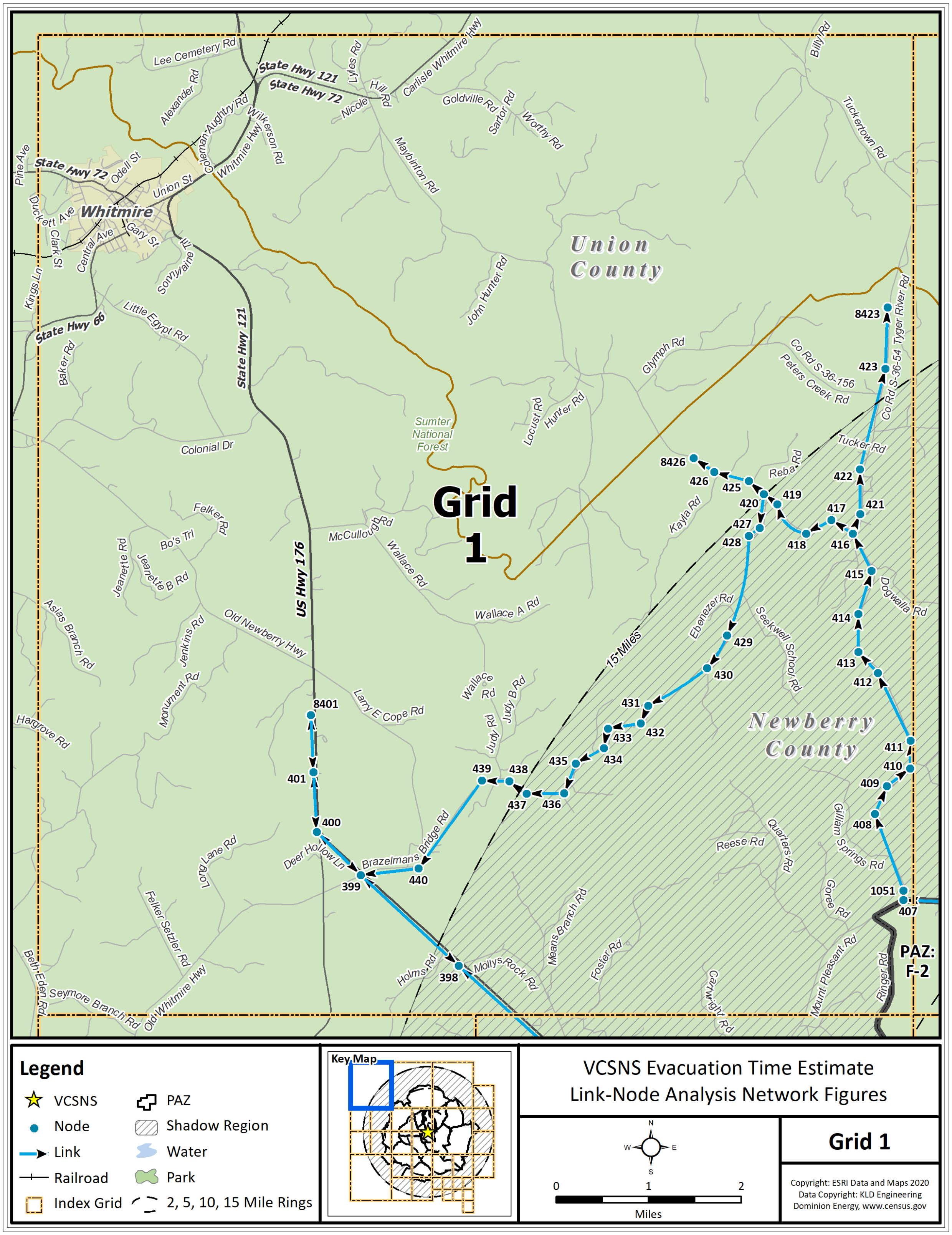


Figure K-2. Grid 1

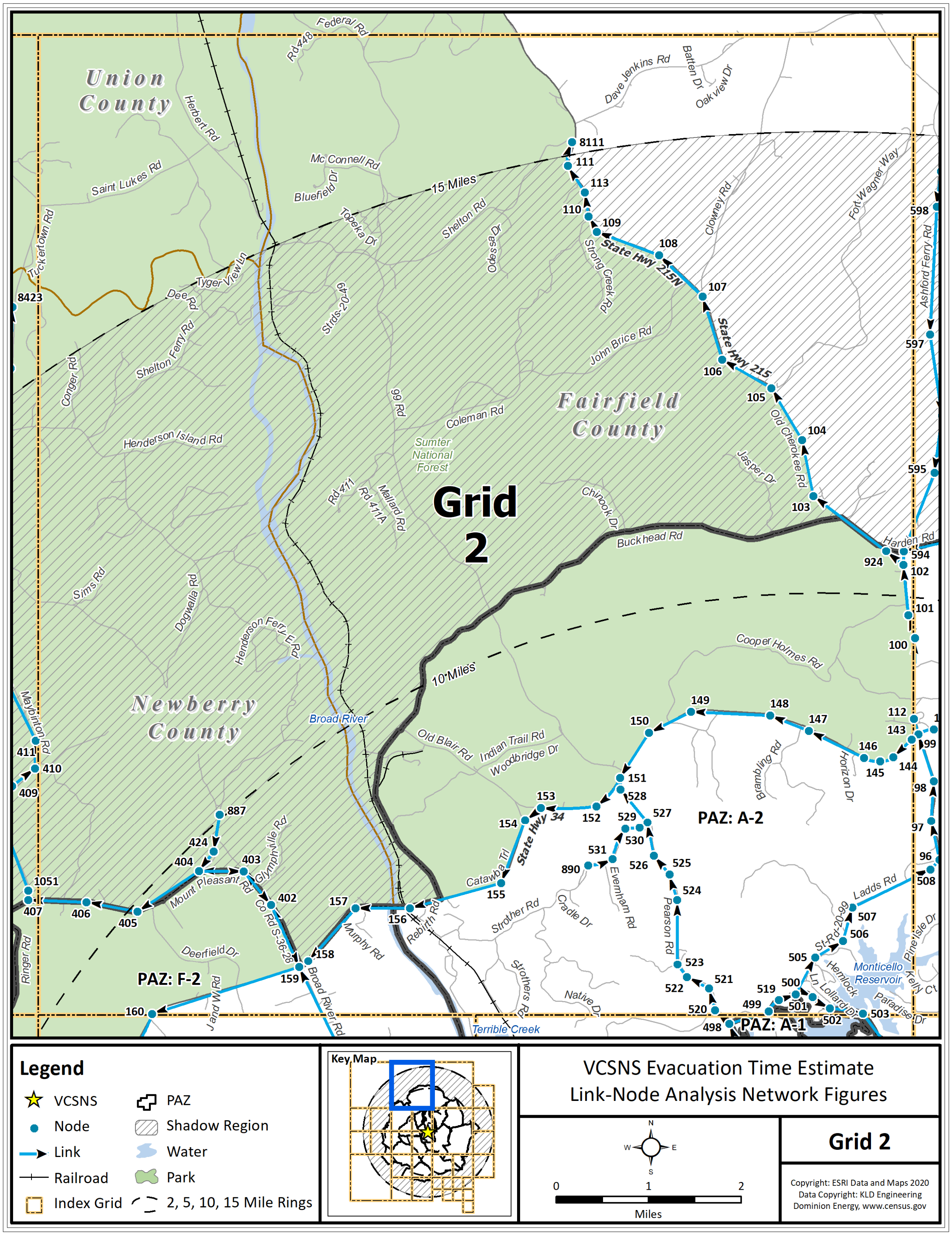


Figure K-3. Grid 2

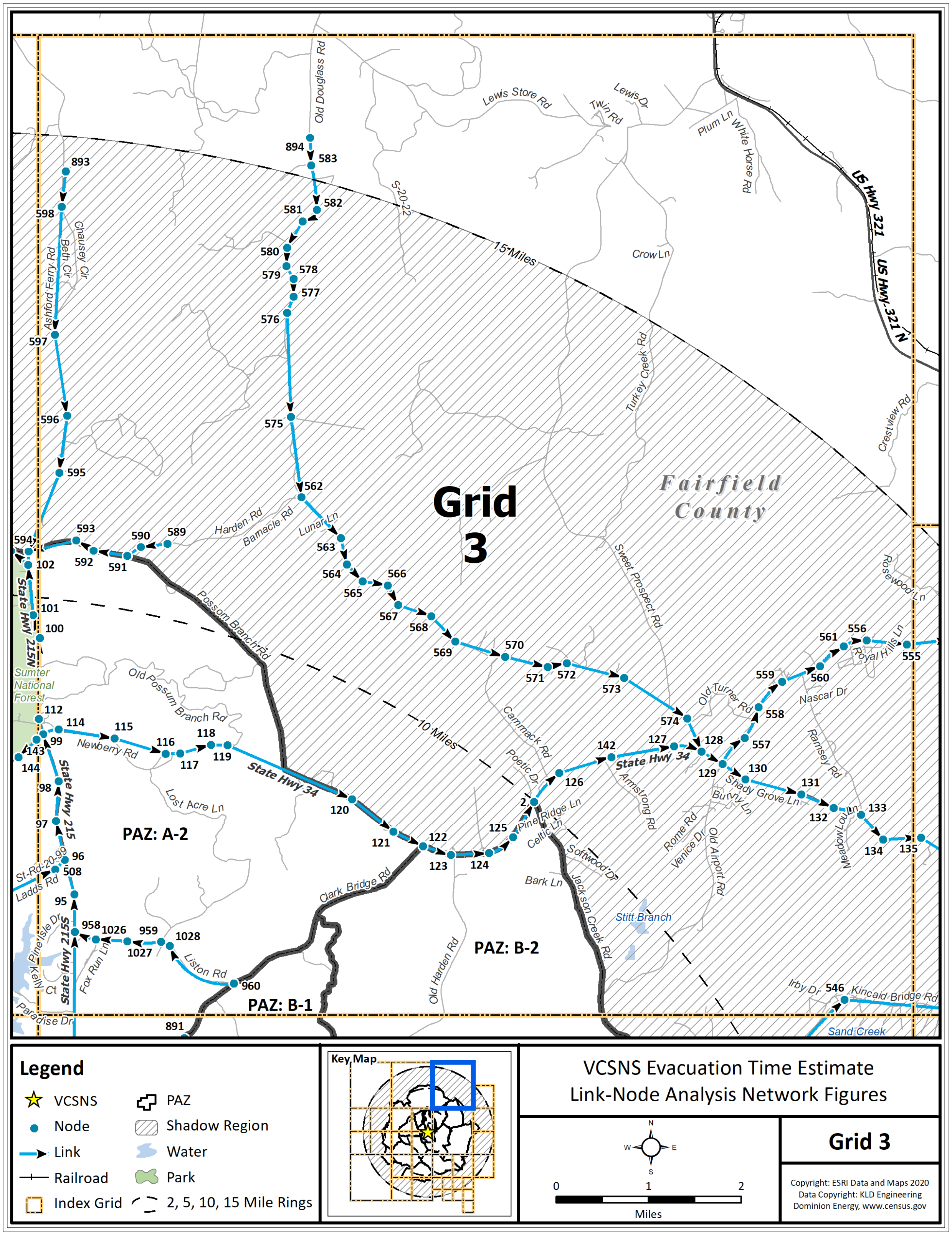


Figure K-4. Grid 3

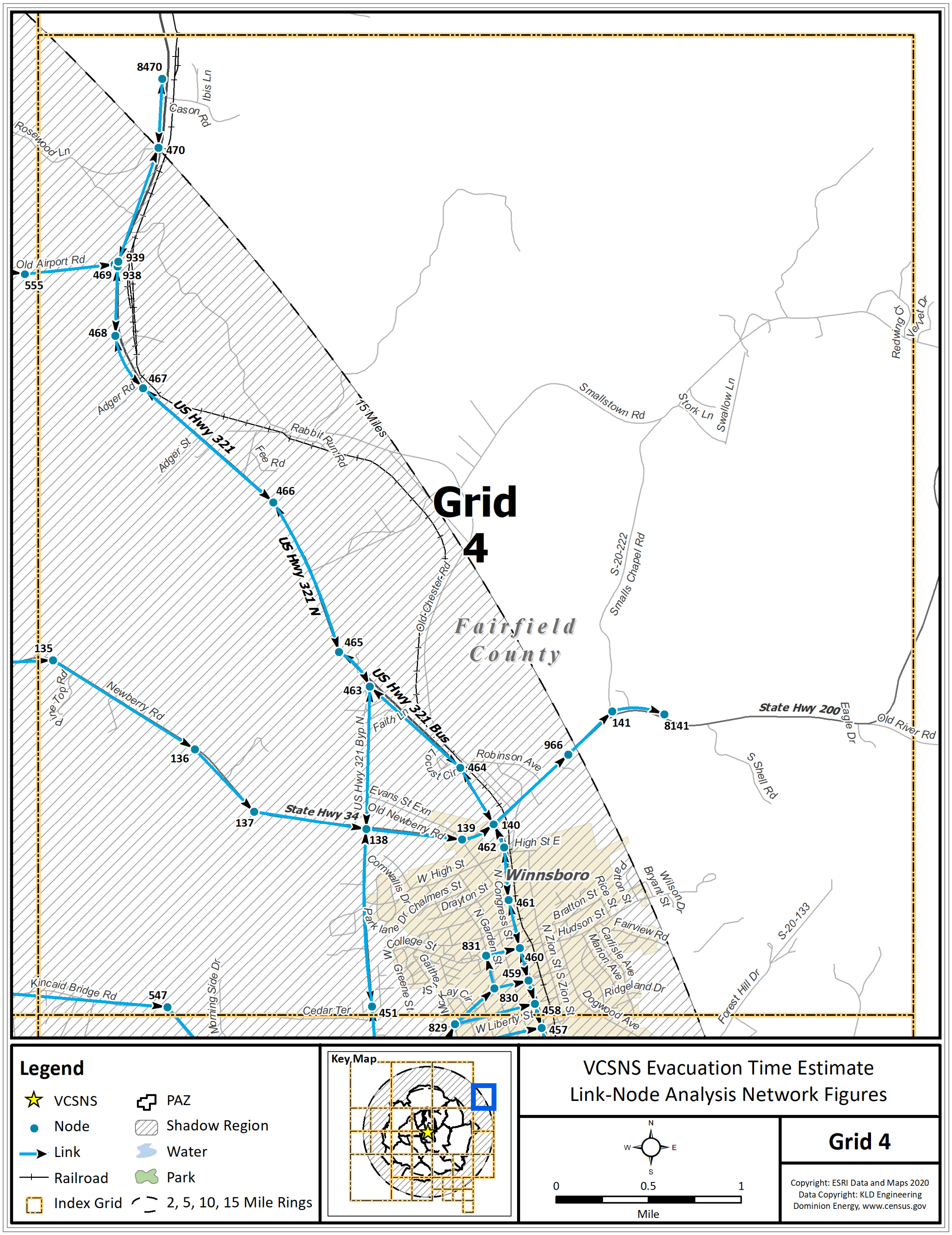


Figure K-5. Grid 4

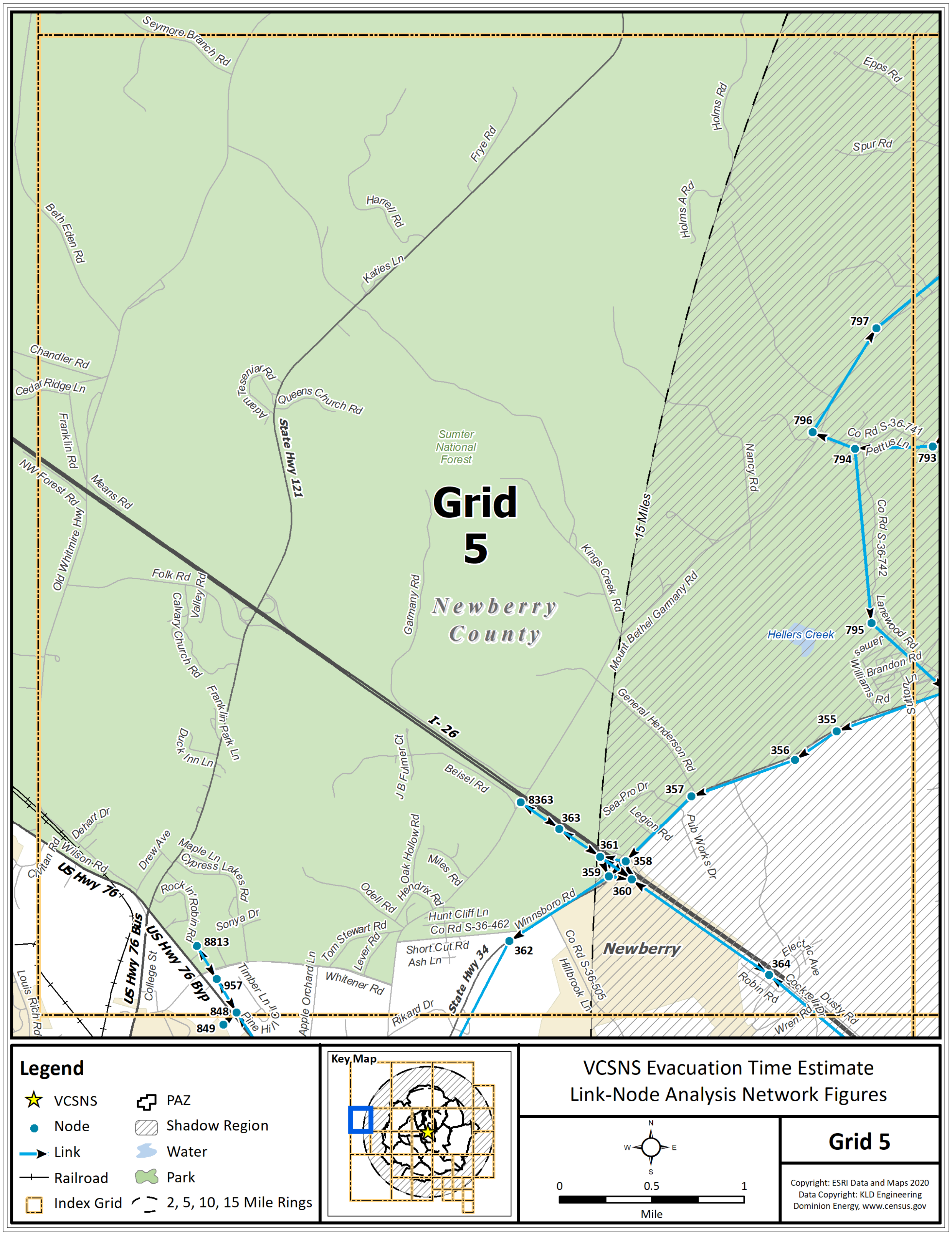
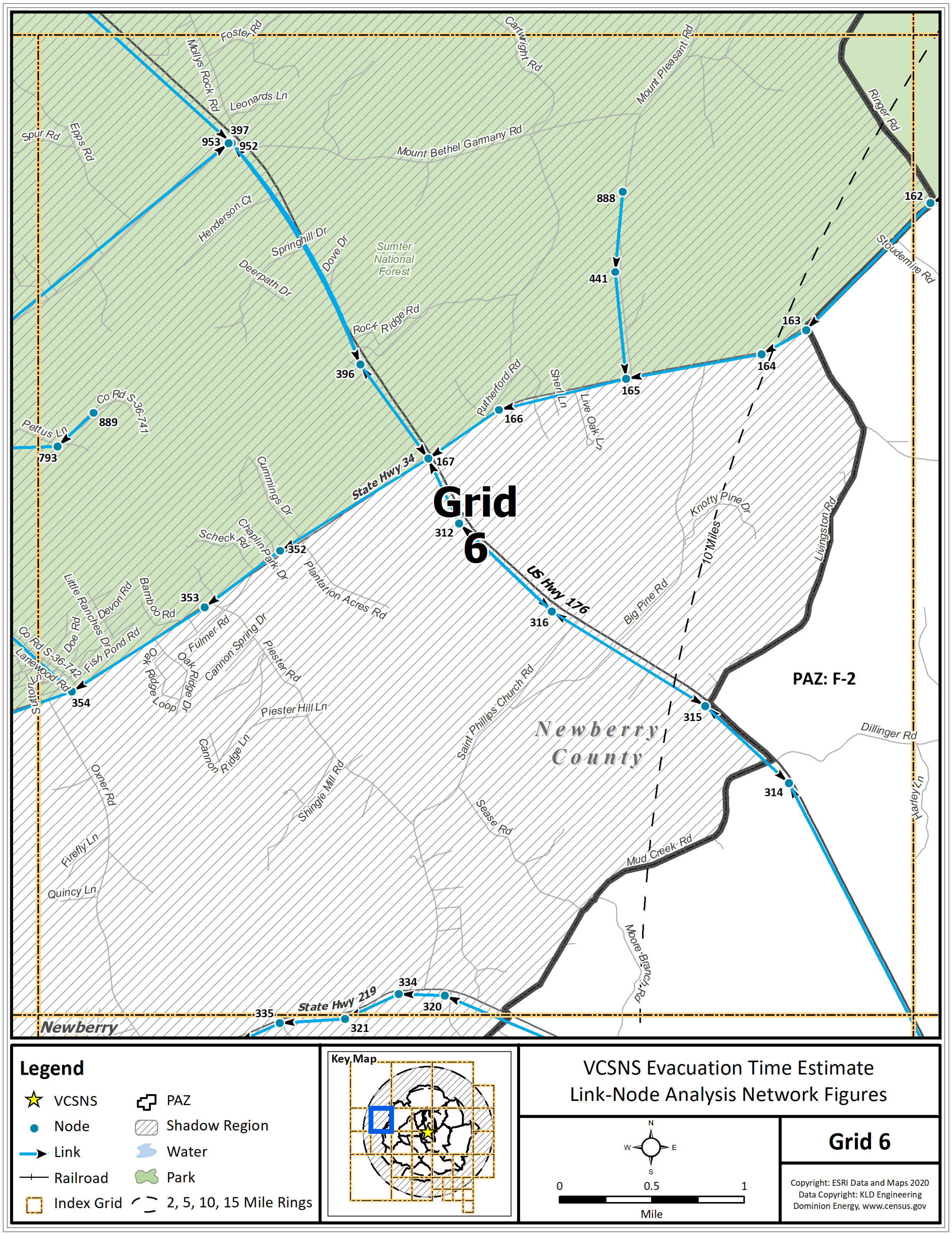


Figure K-6. Grid 5



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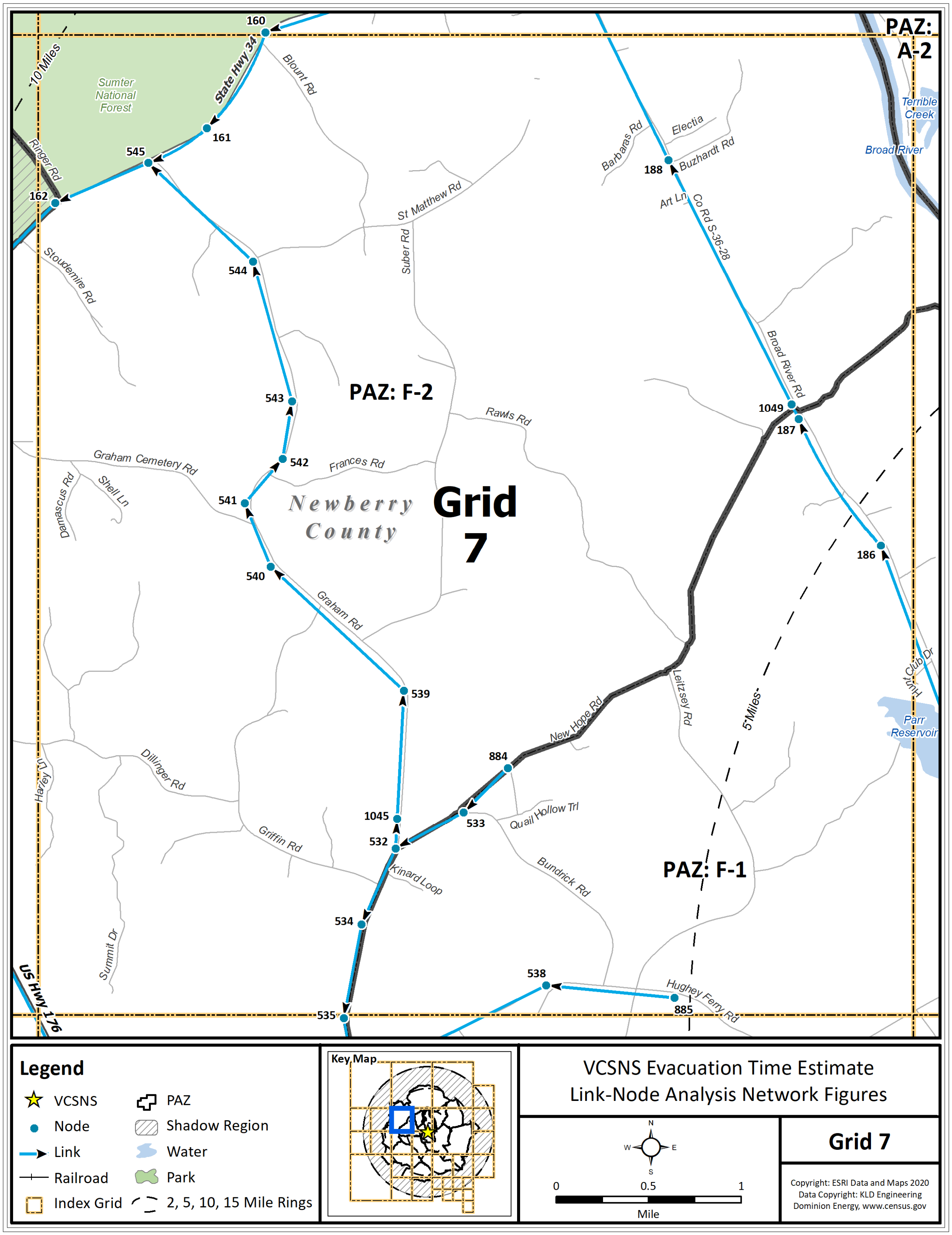

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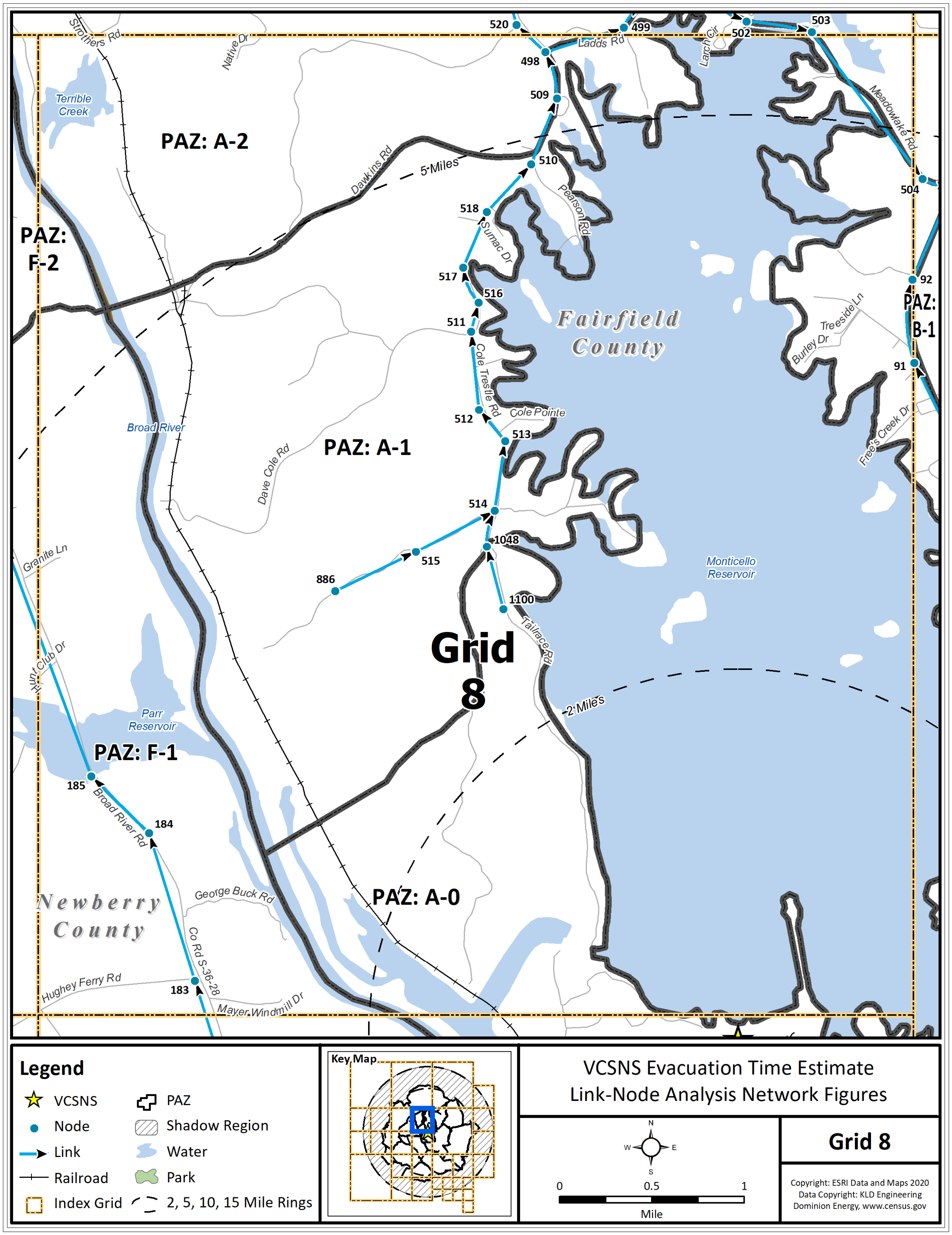


Figure K-9. Grid 8

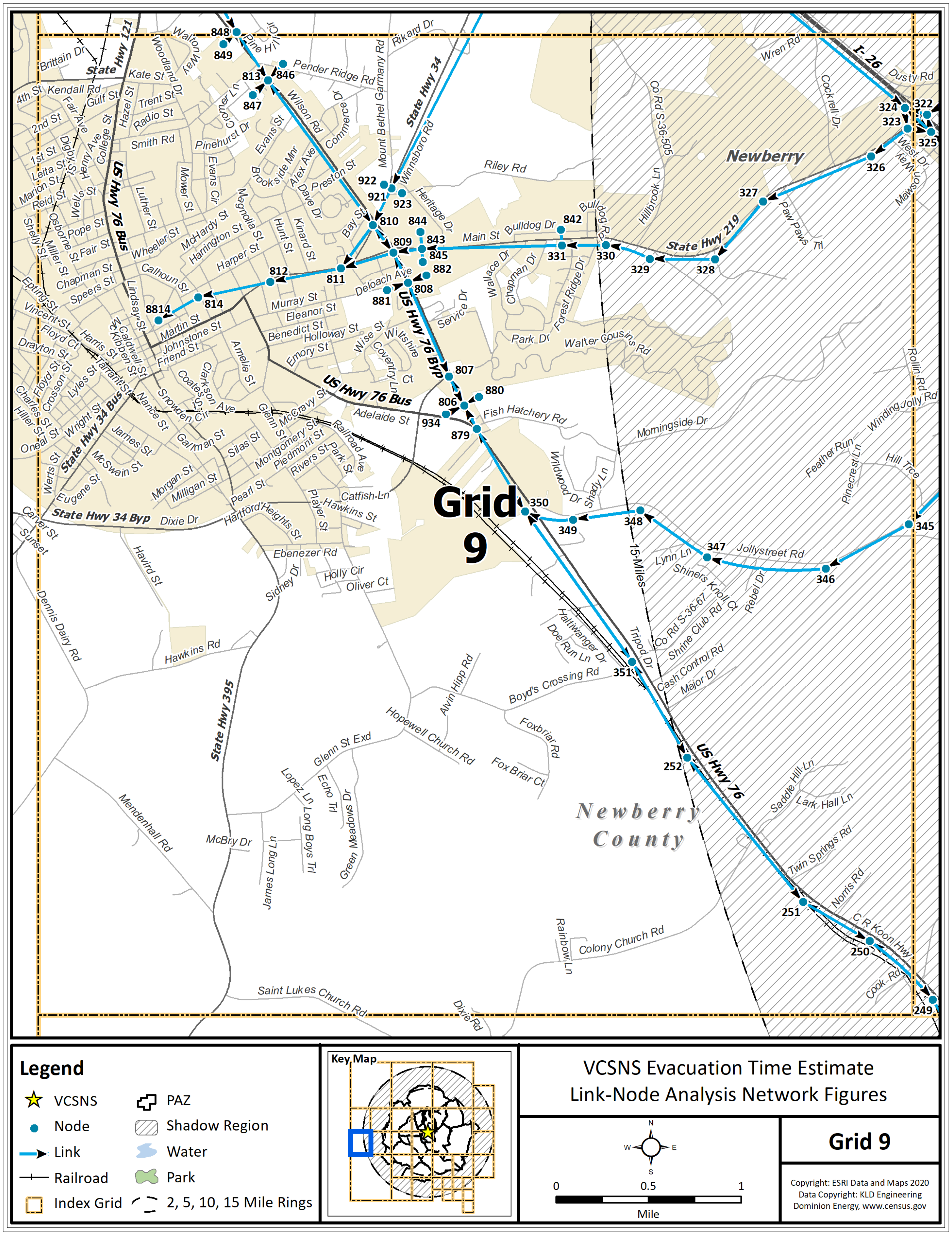


Figure K-10. Grid 9

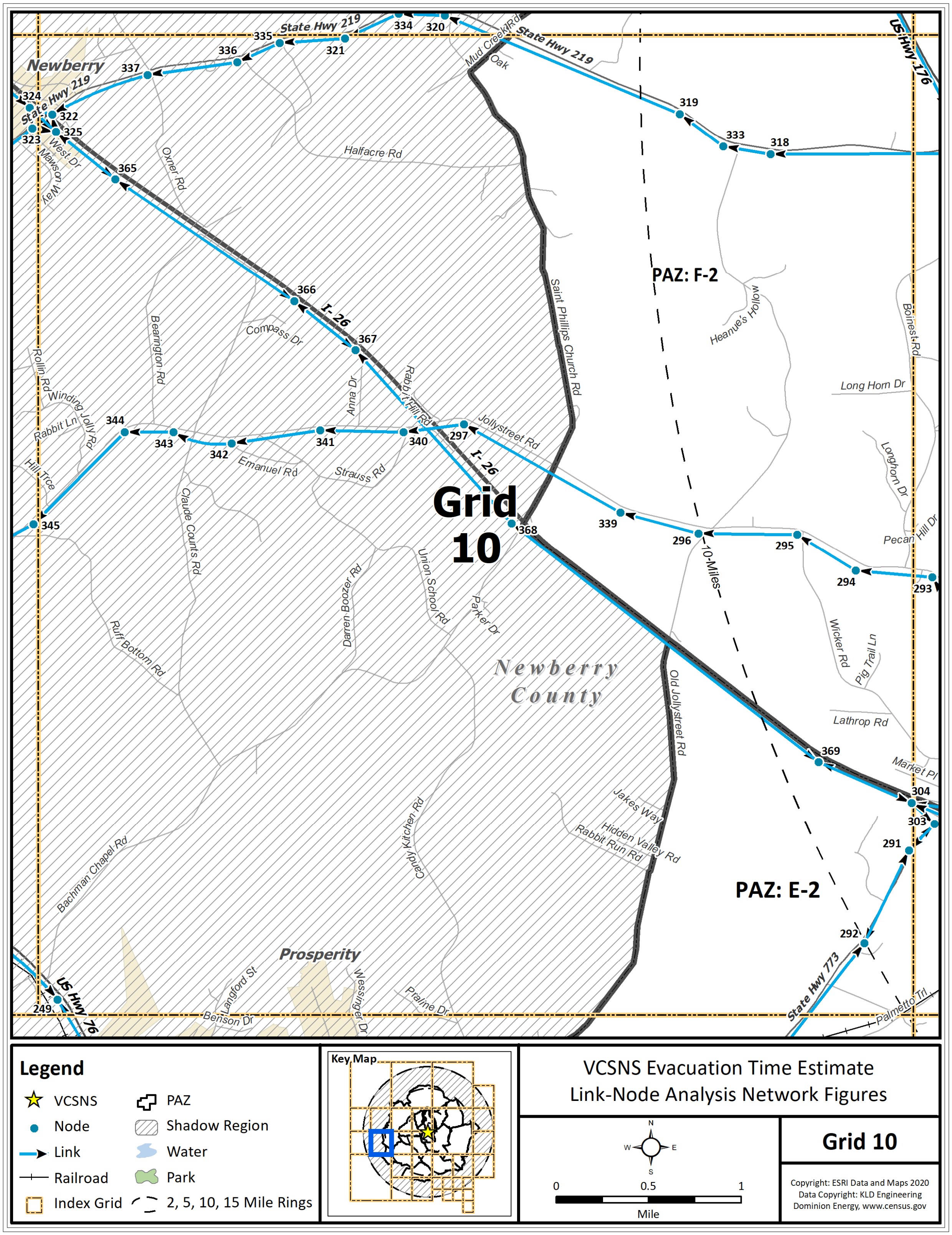


Figure K-11. Grid 10

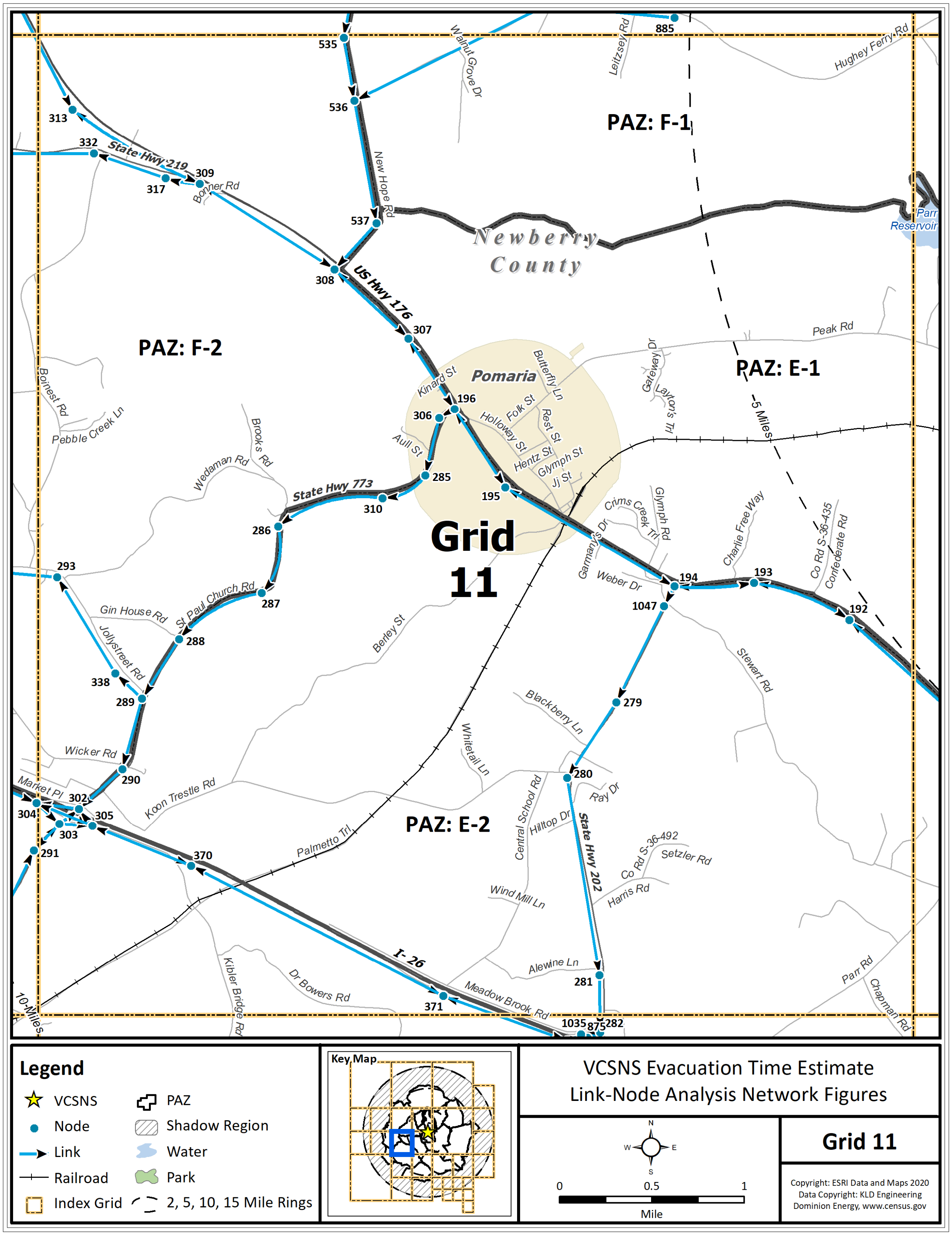
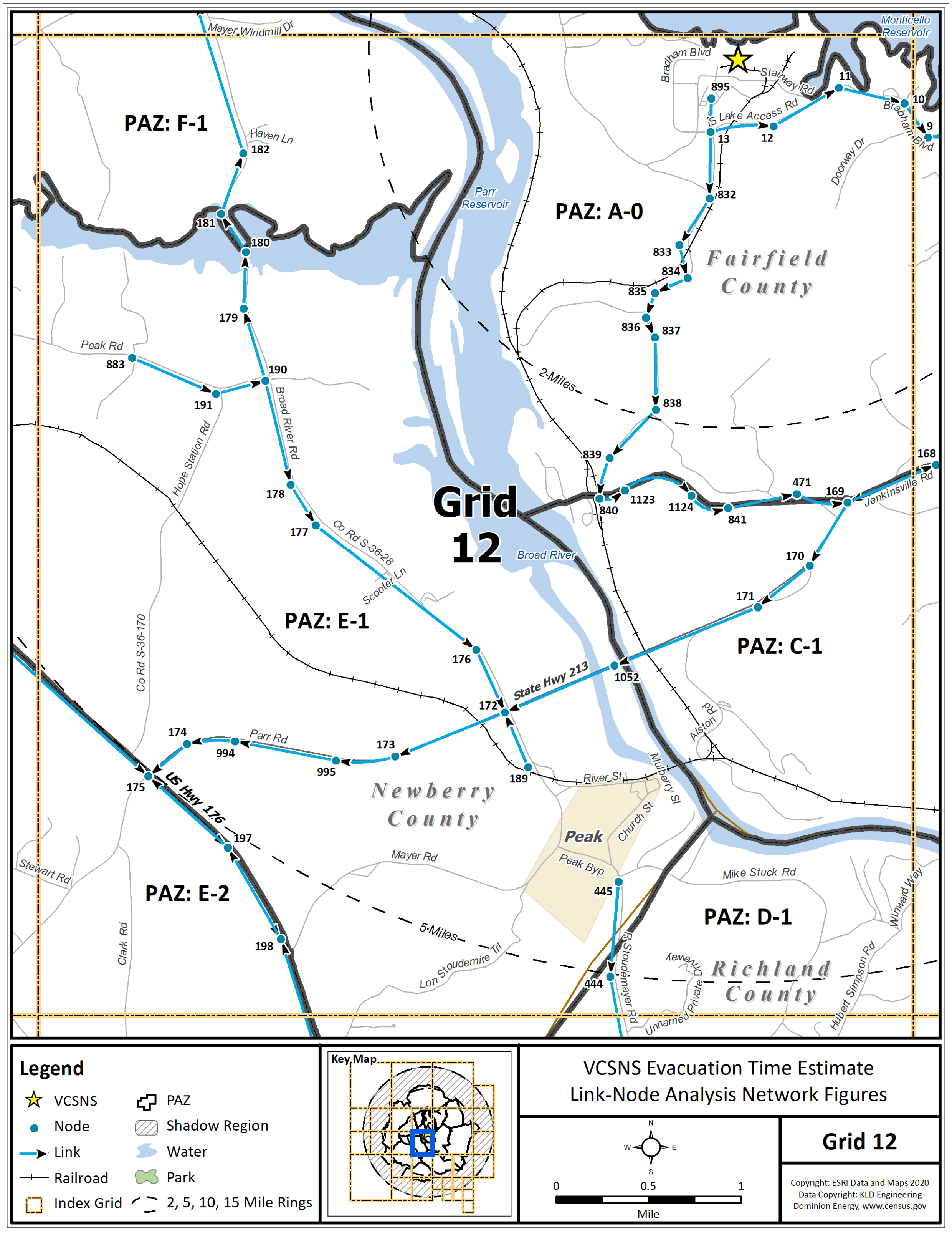


Figure K-12. Grid 11



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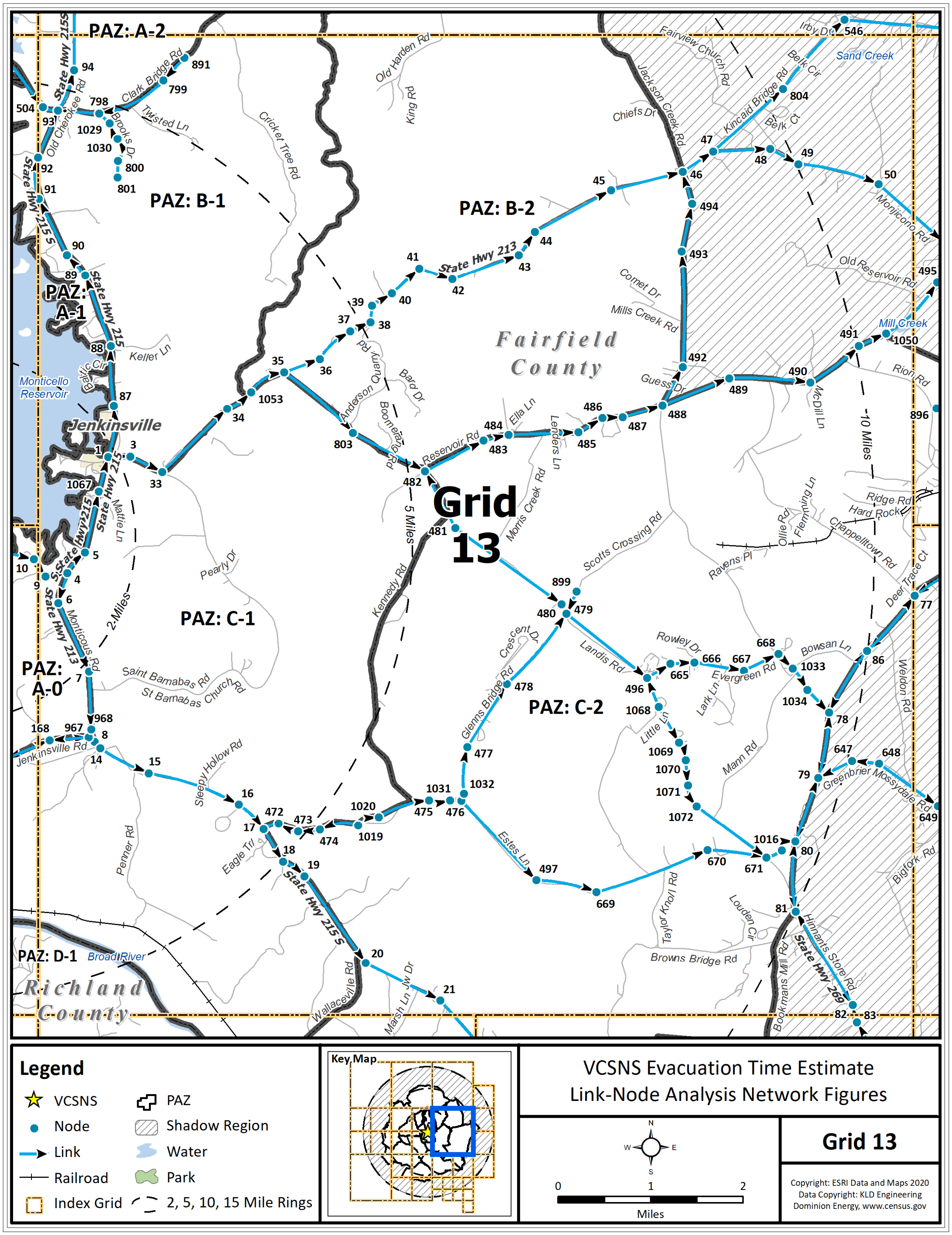


Figure K-14. Grid 13

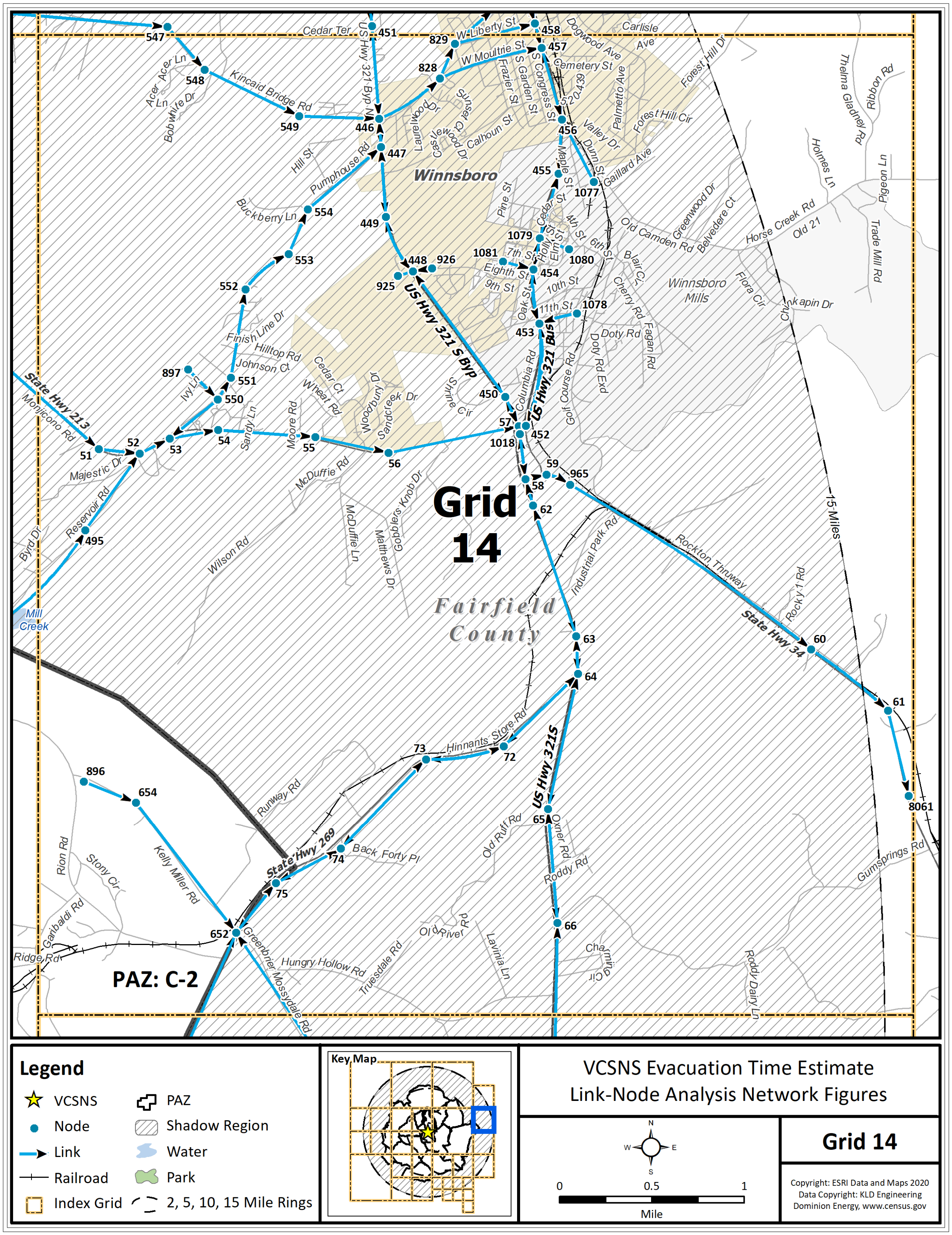


Figure K-15. Grid 14

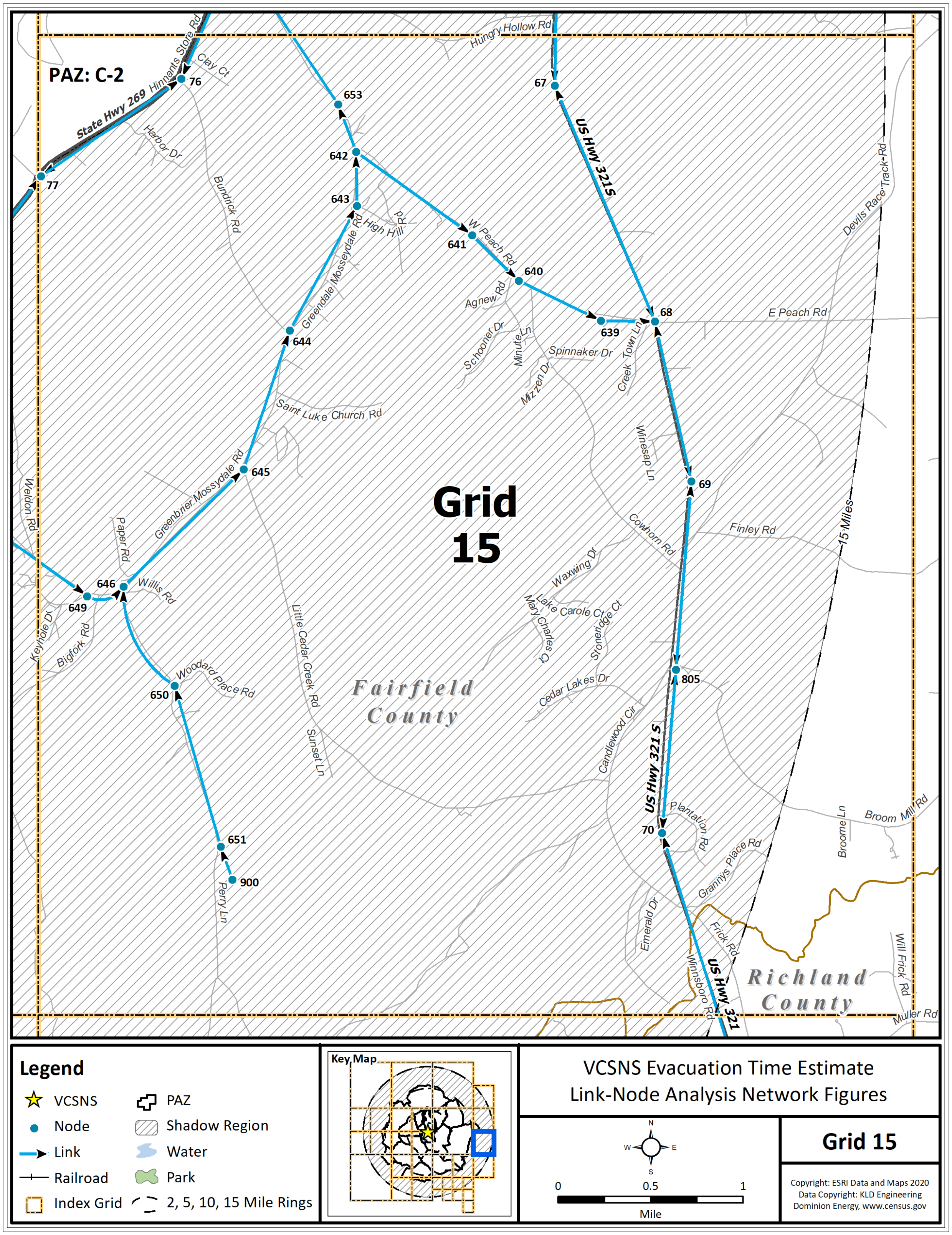


Figure K-16. Grid 15

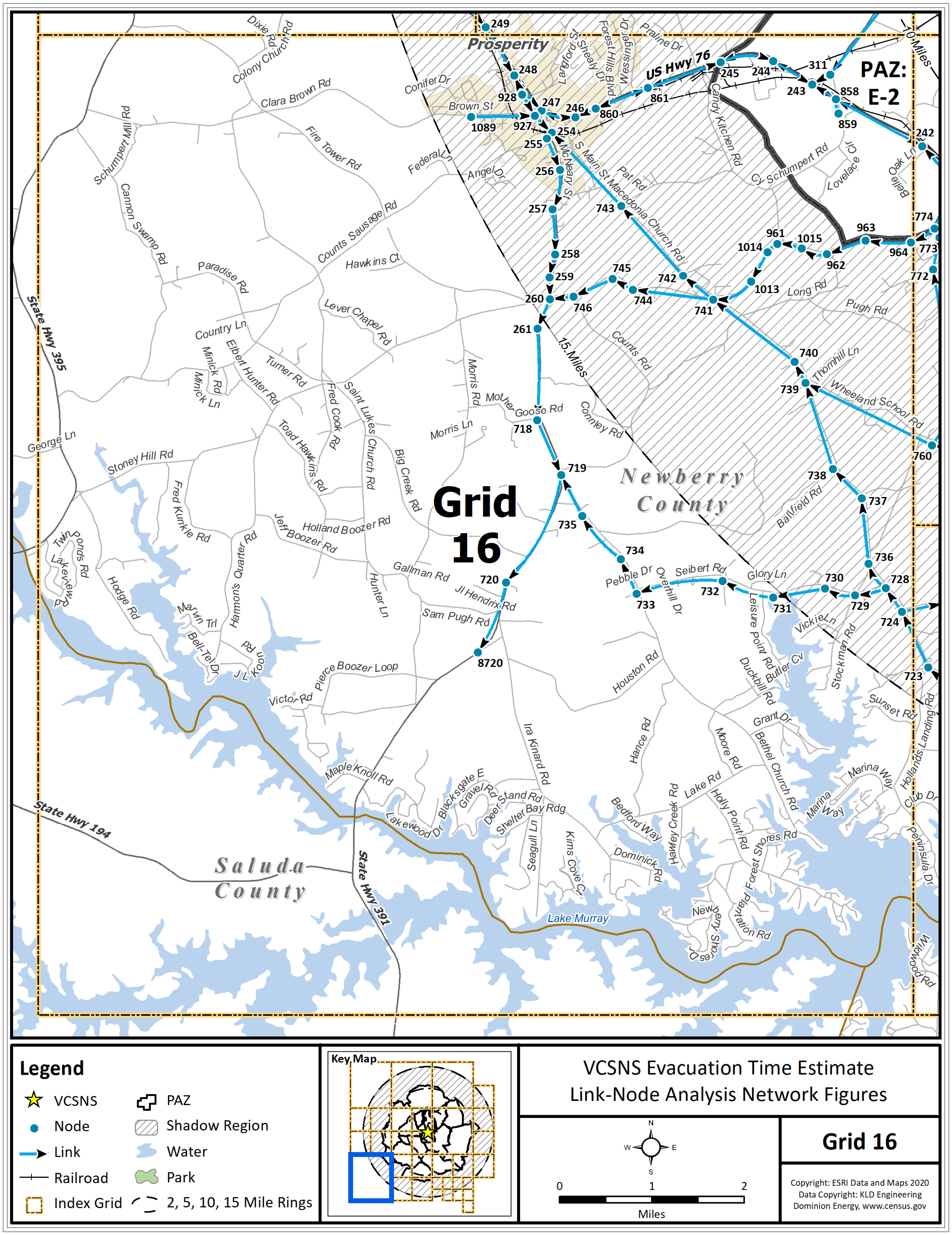


Figure K-17. Grid 16

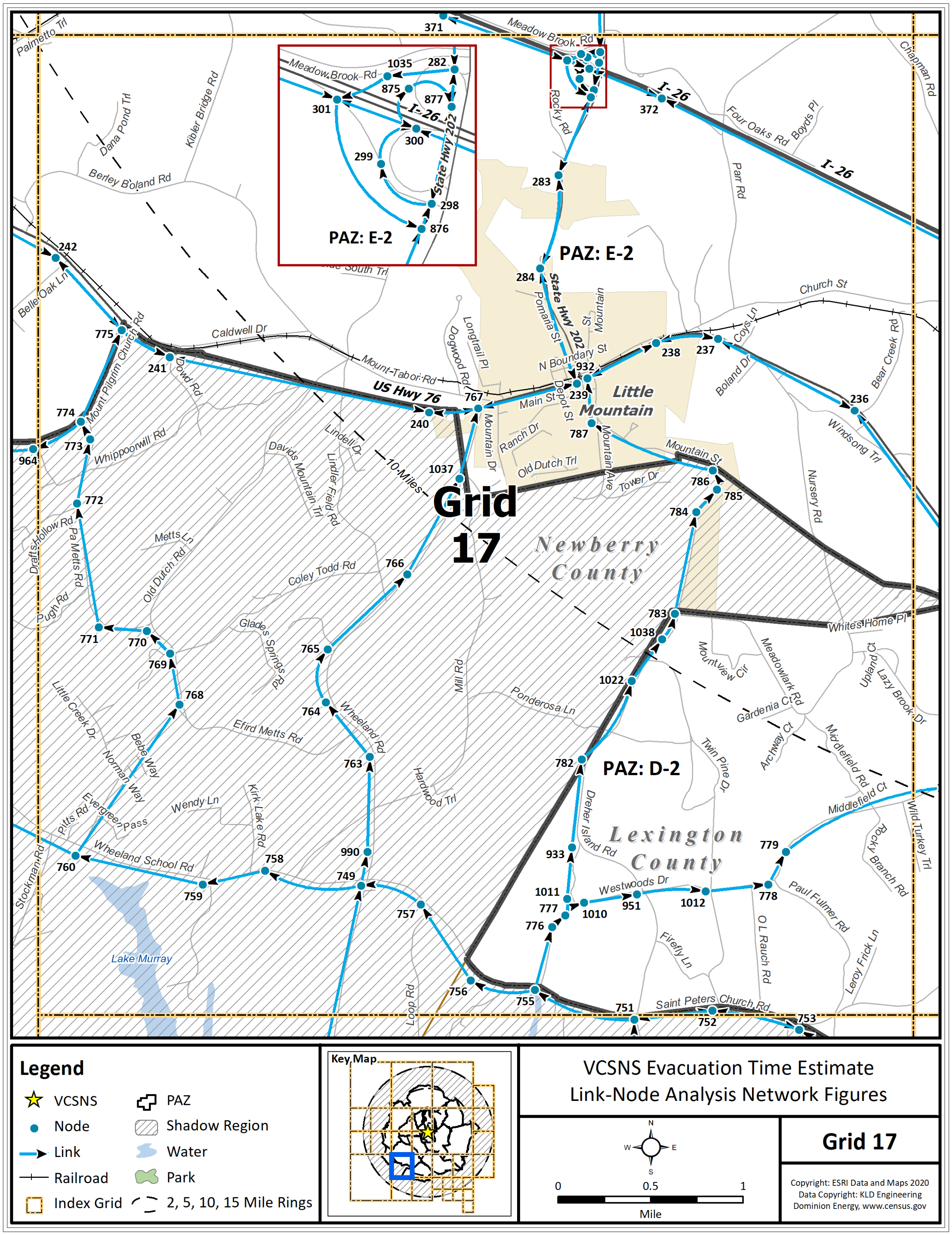


Figure K-18. Grid 17

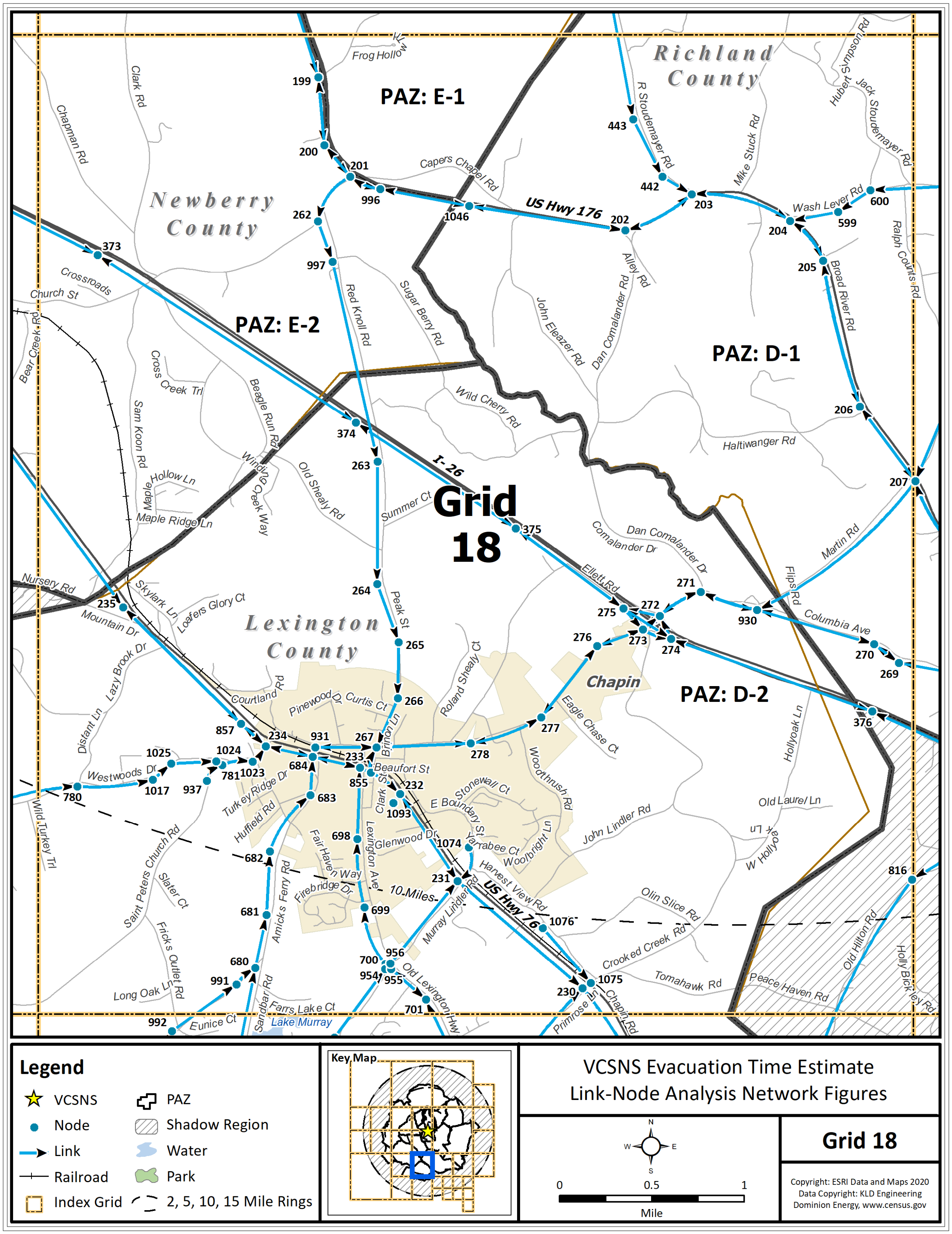
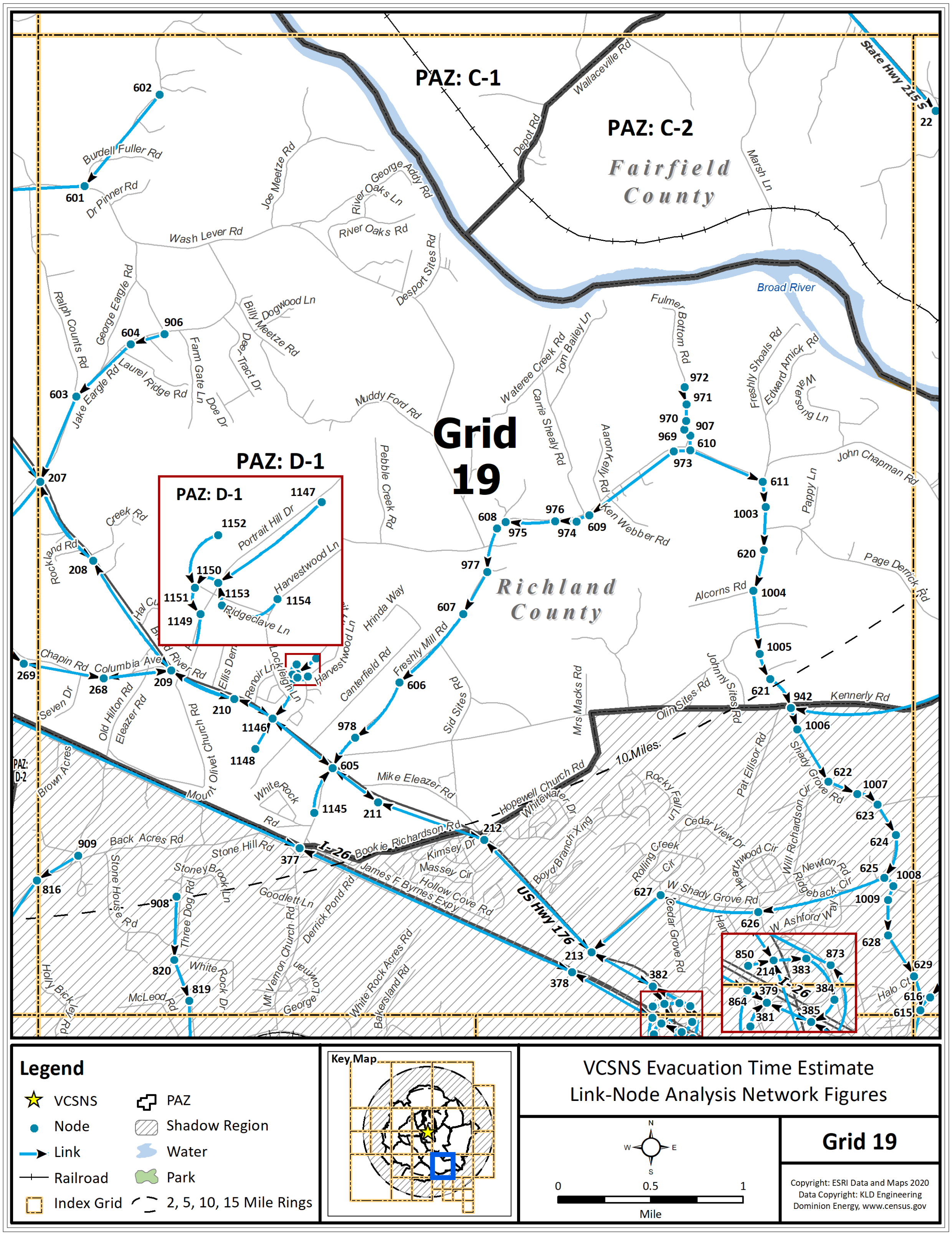


Figure K-19. Grid 18



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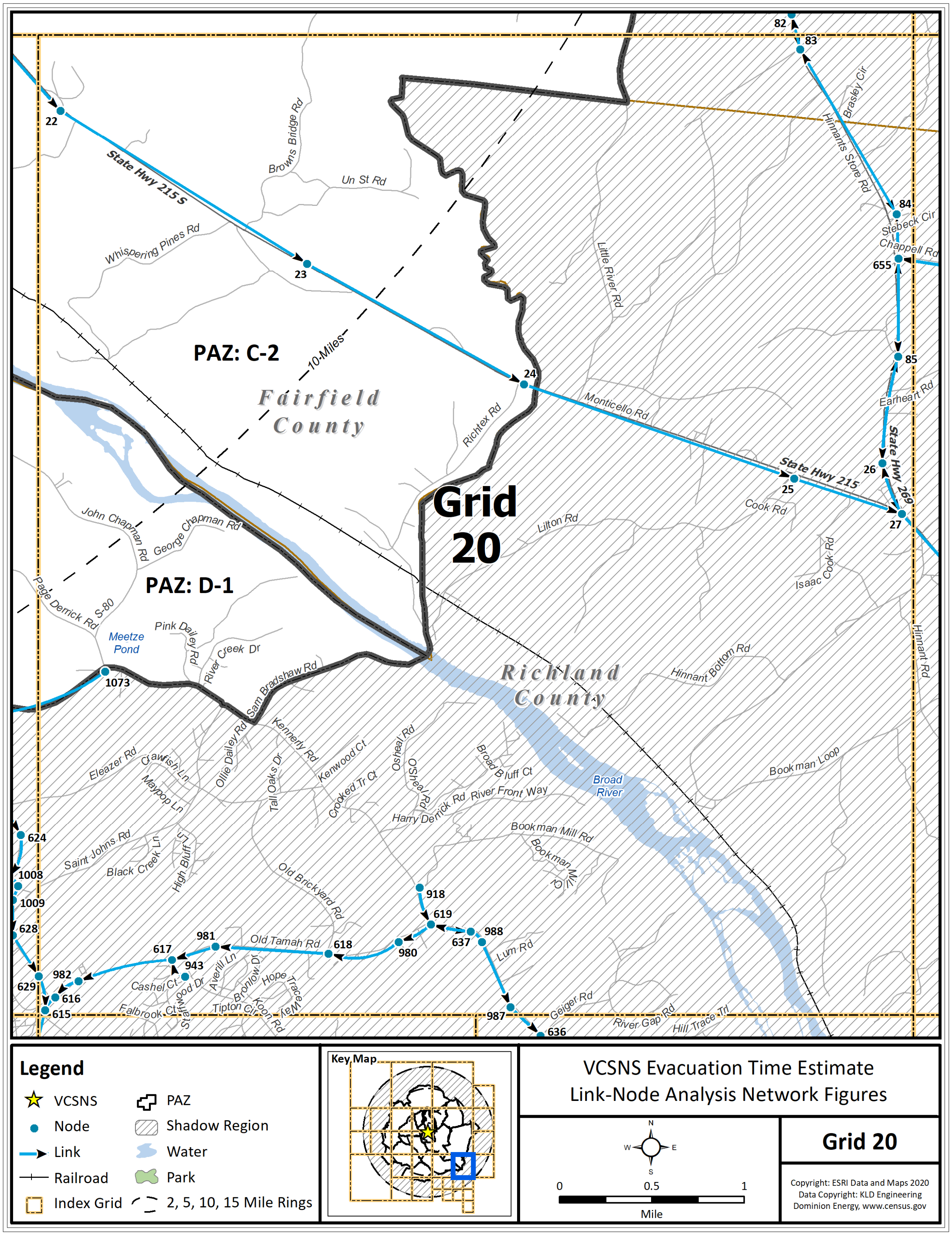

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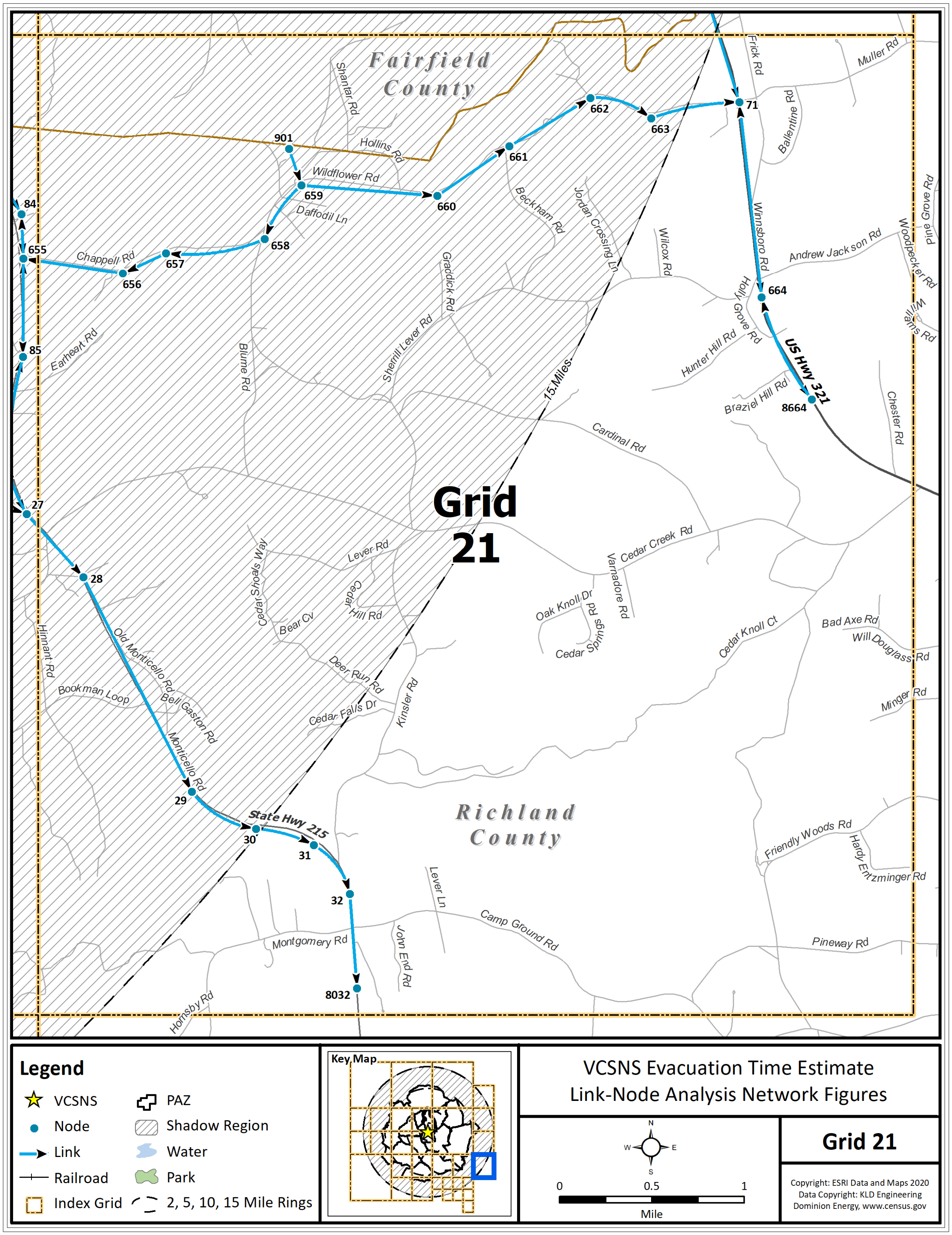

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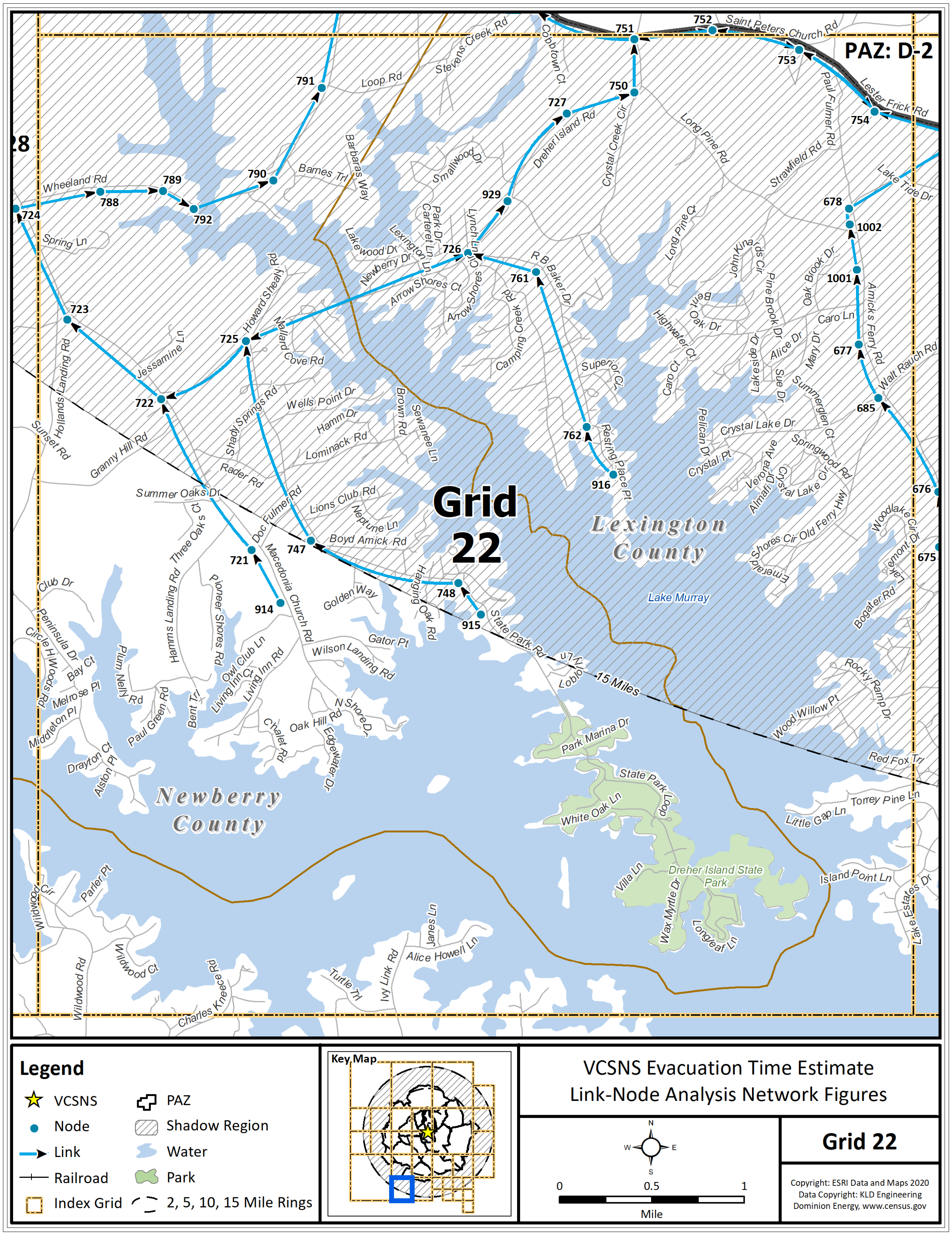

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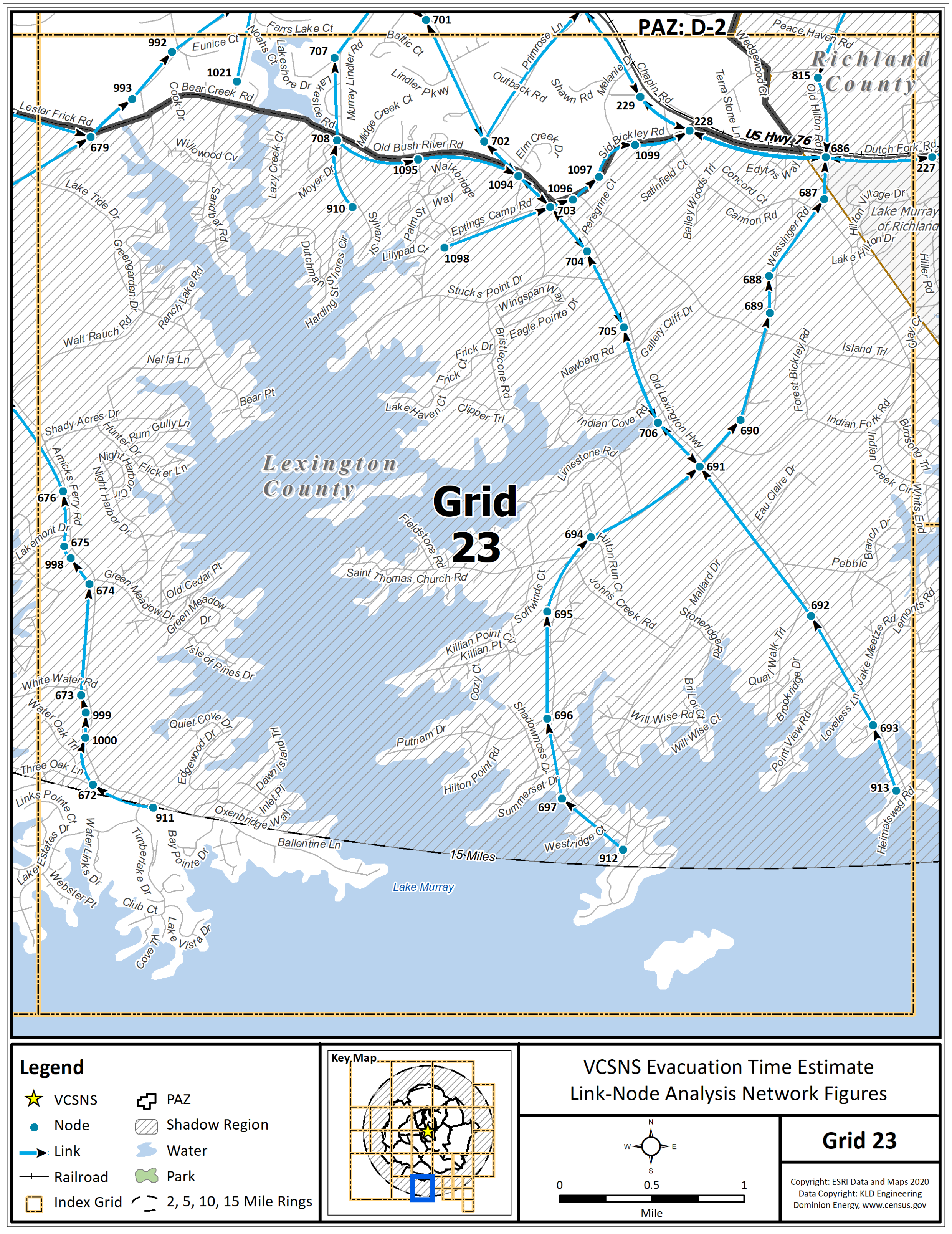

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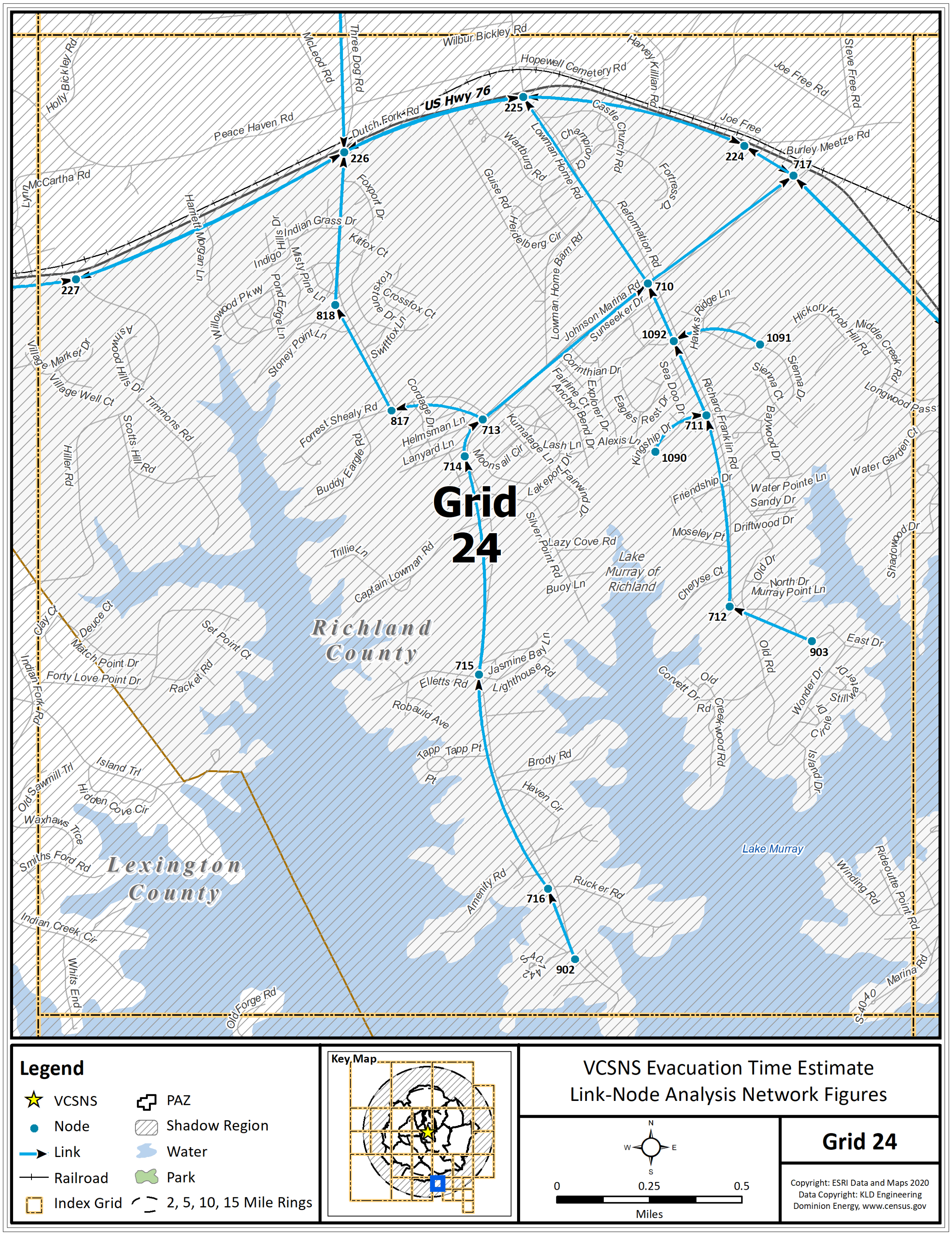

Figure K-25. Grid 24

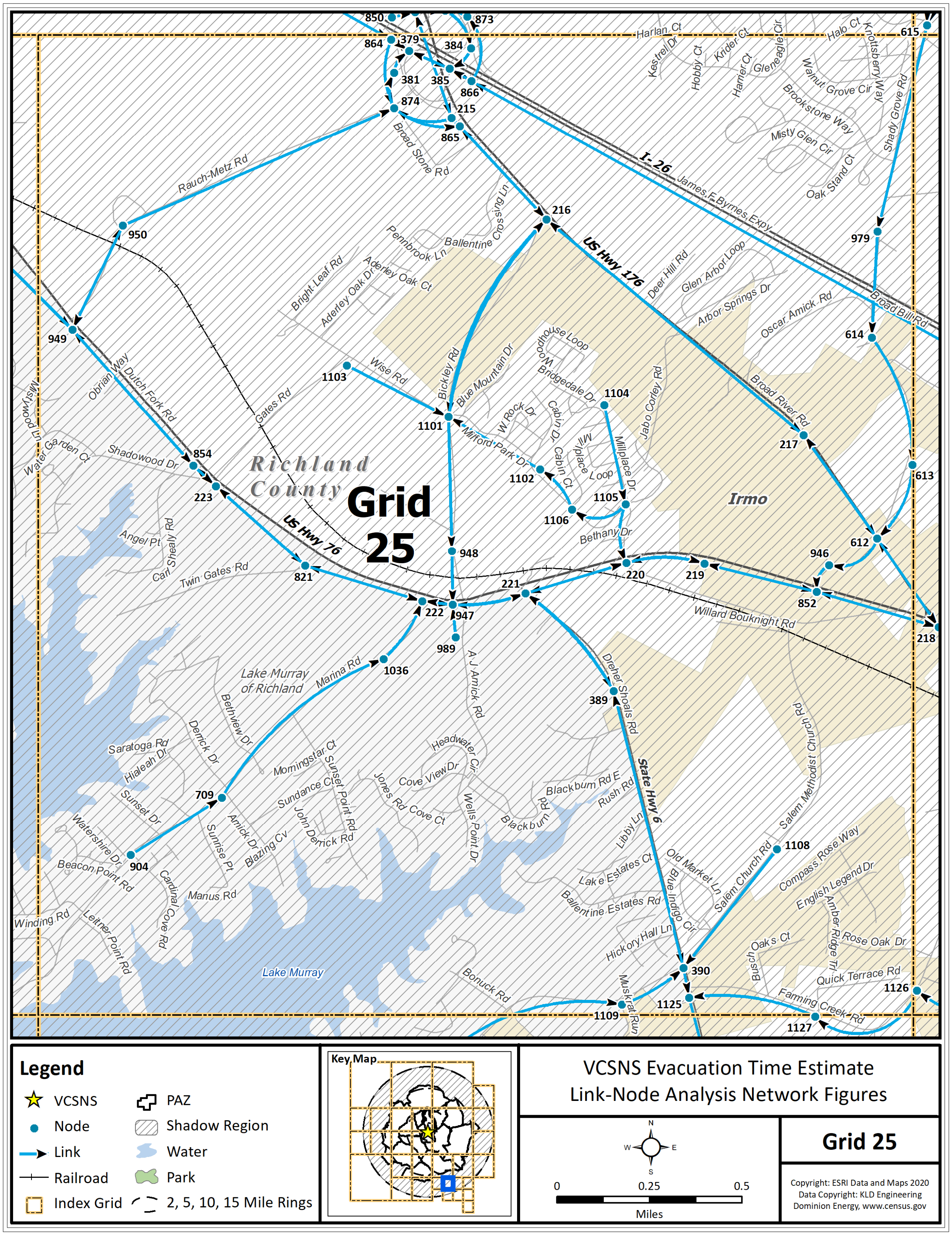

Figure K-26. Grid 25

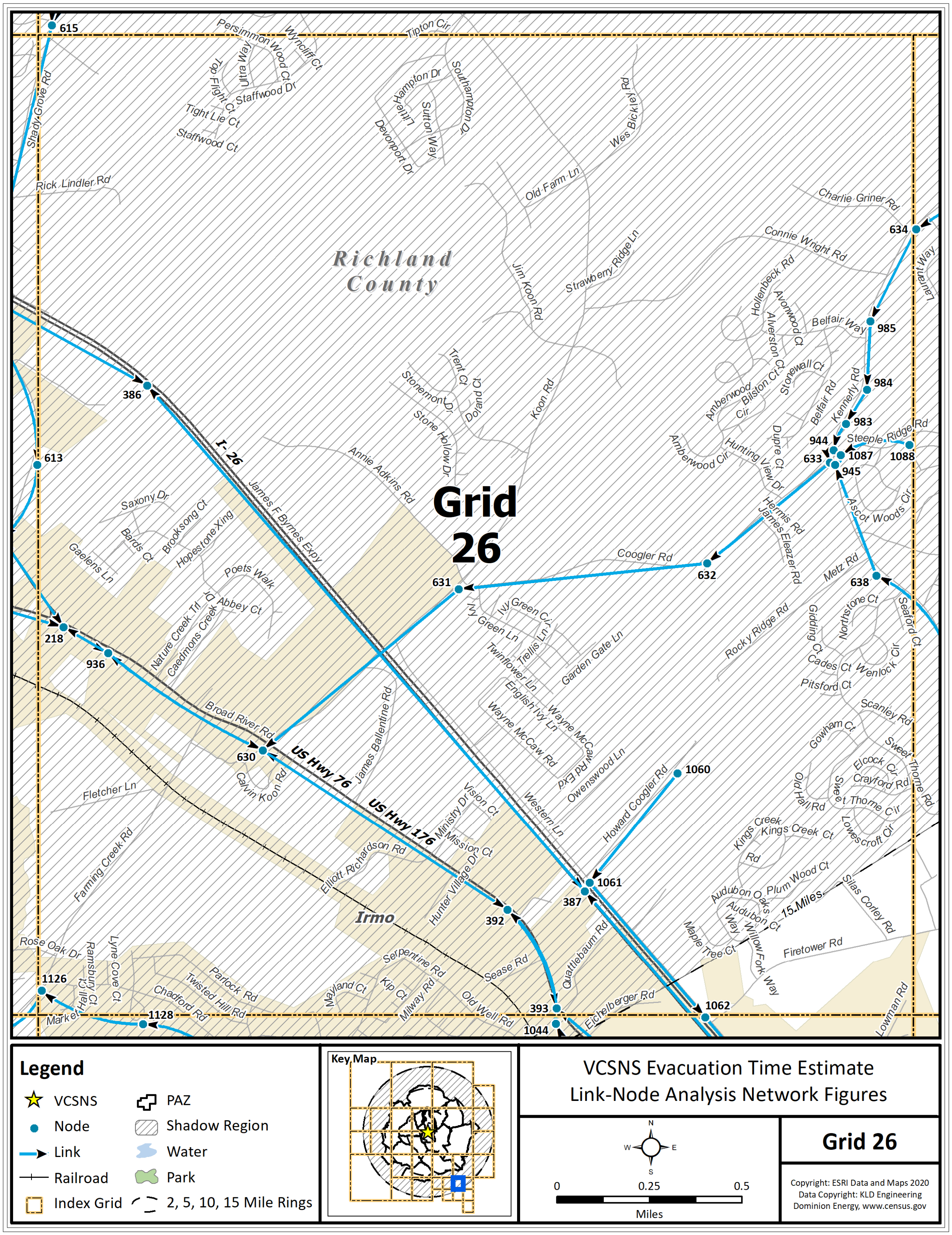

Figure K-27. Grid 26

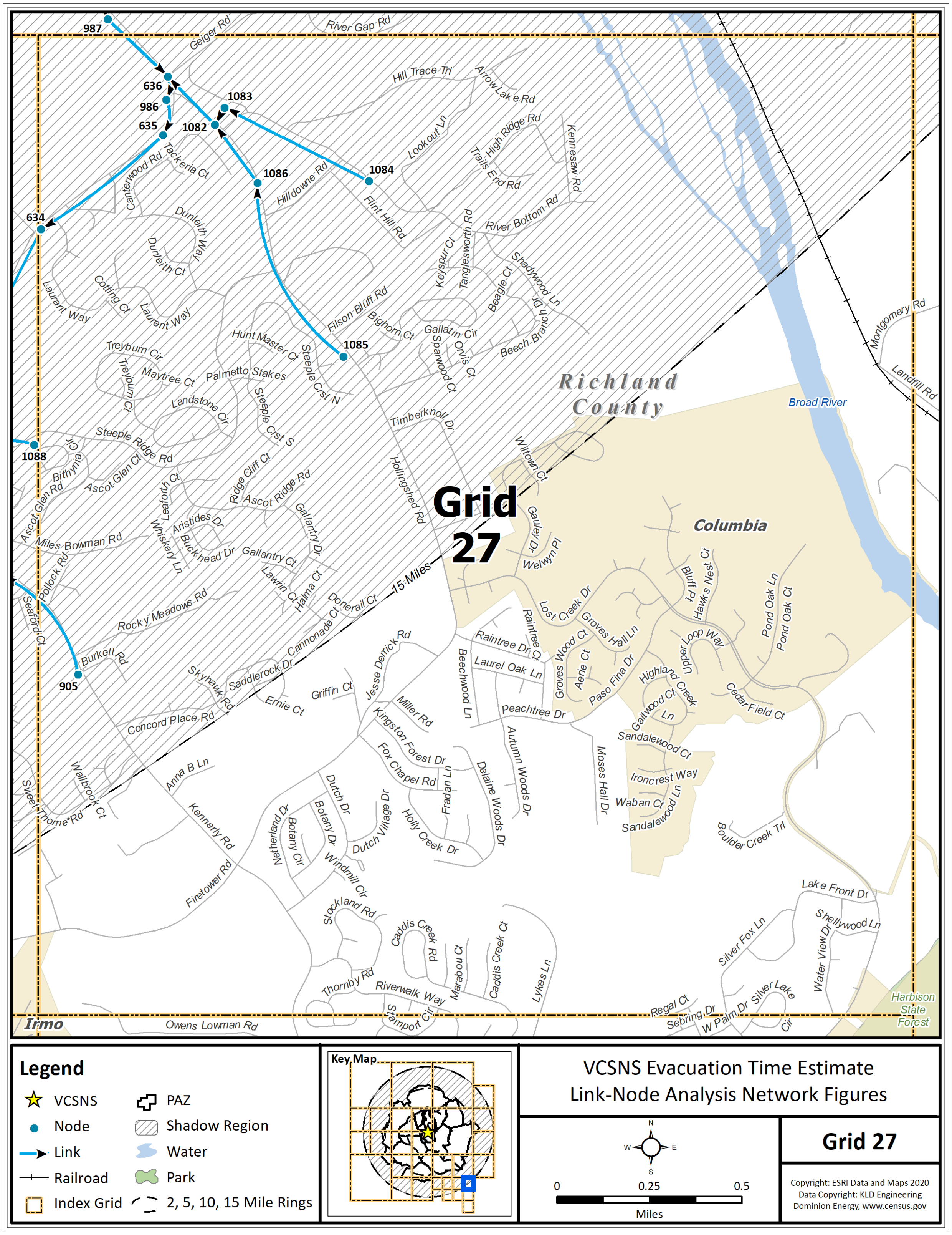

Figure K-28. Grid 27

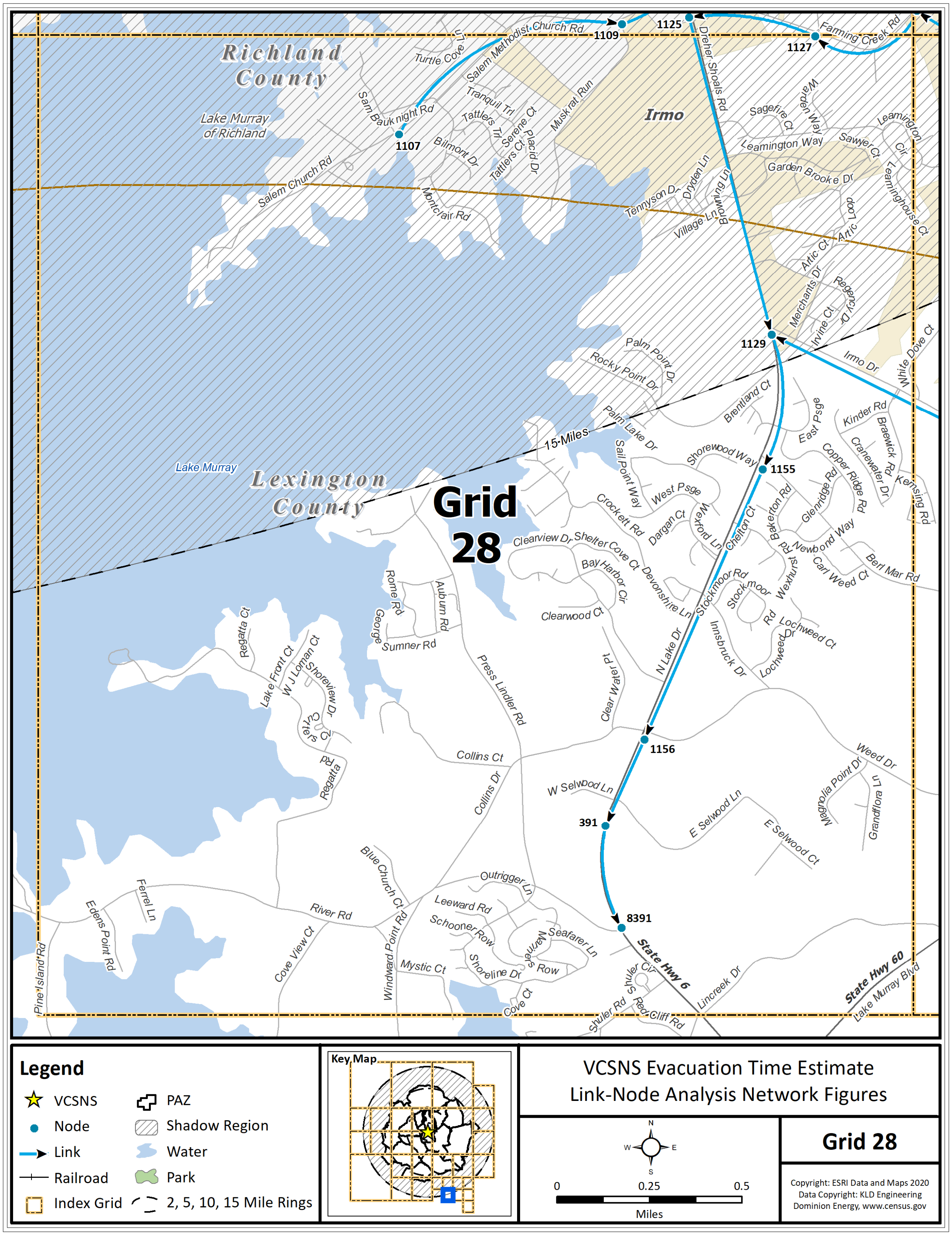

Figure K-29. Grid 28

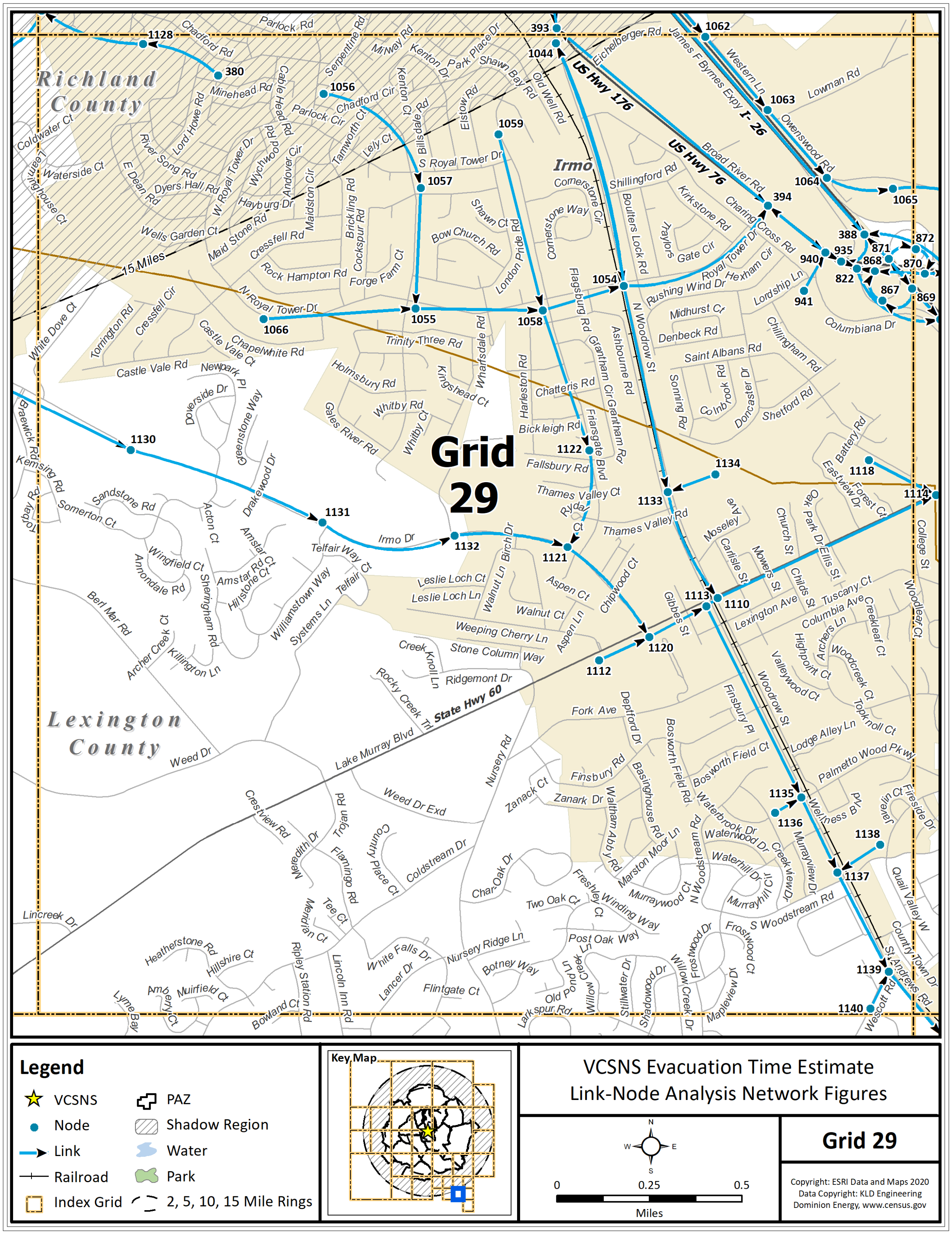

Figure K-30. Grid 29

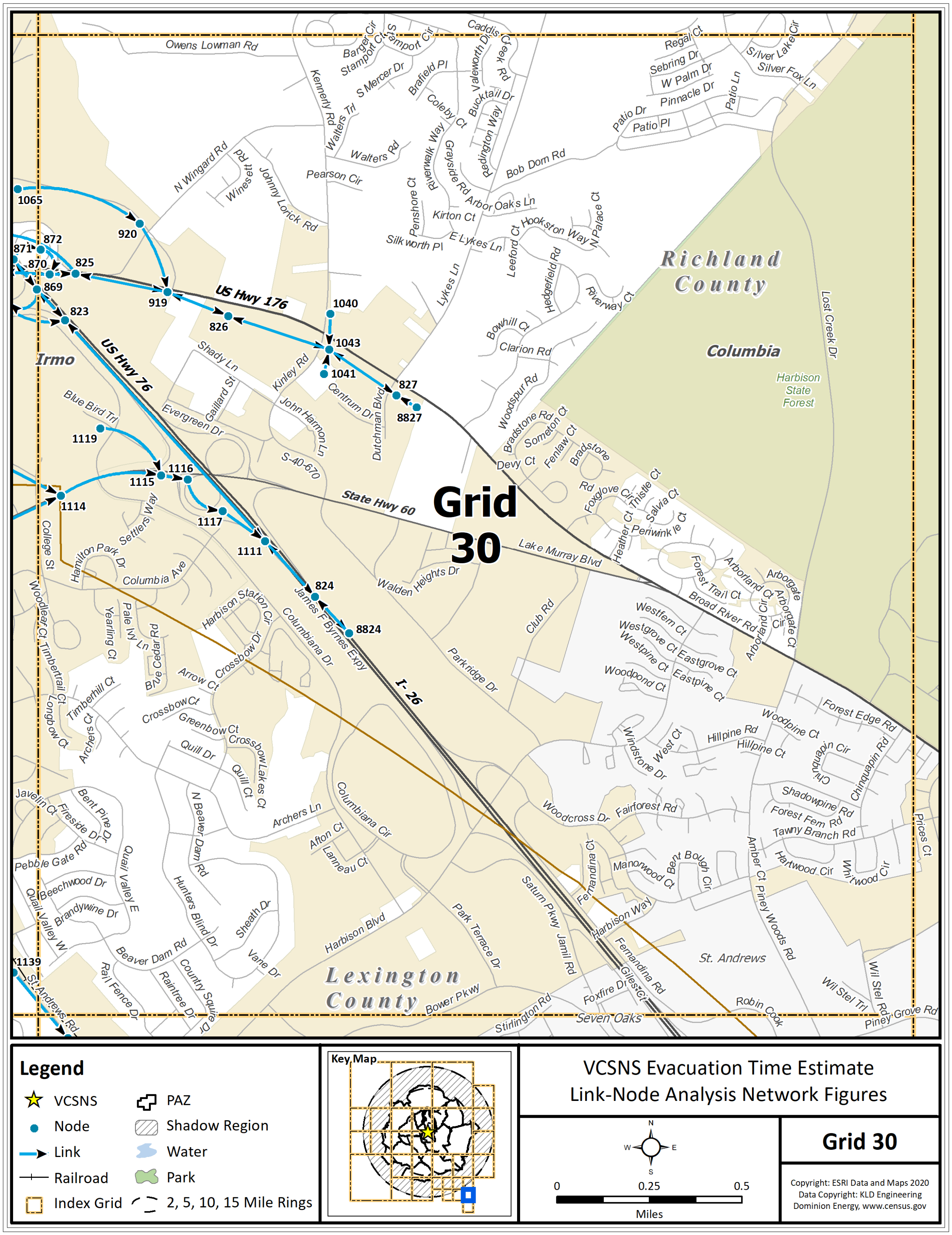

Figure K-31. Grid 30

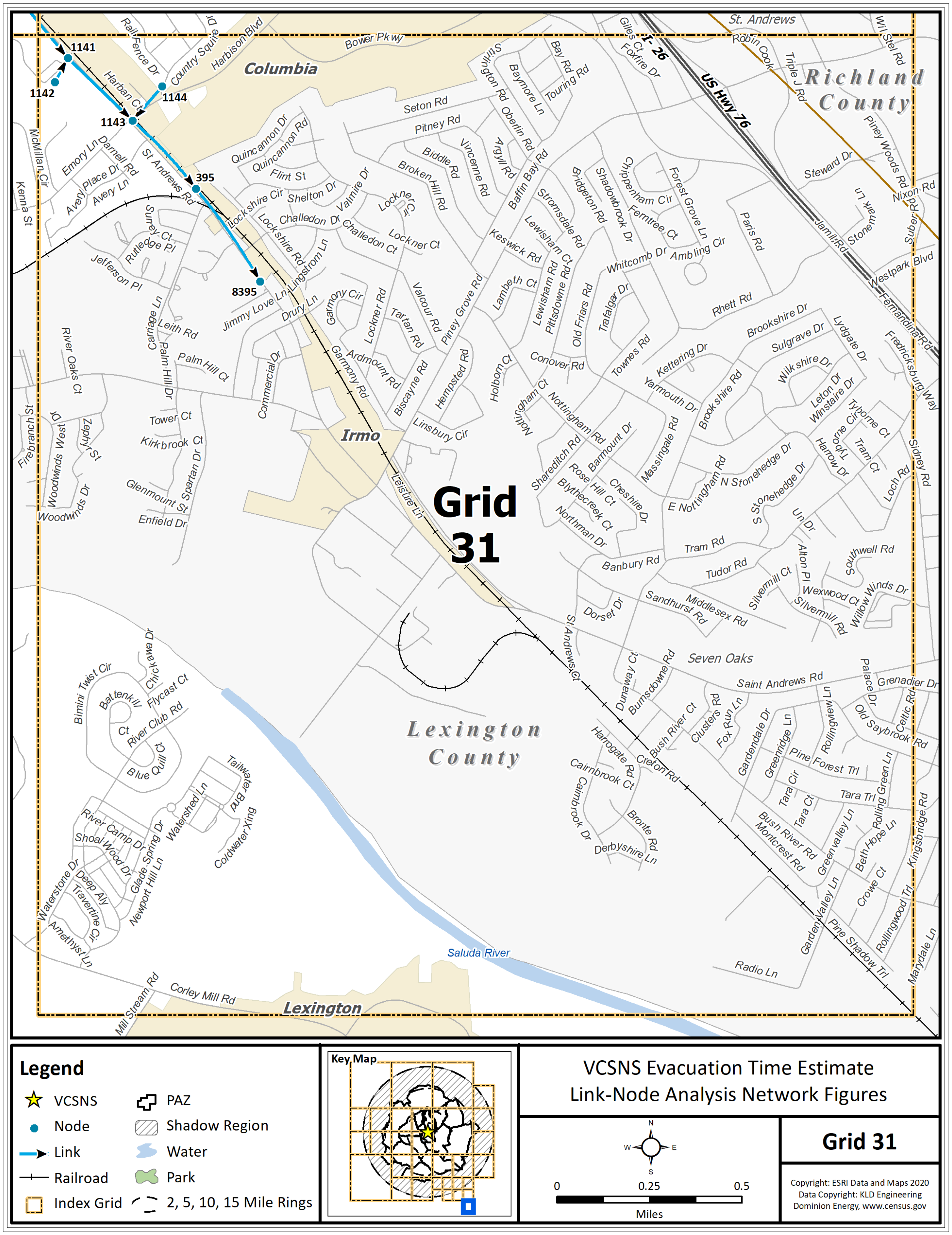

Figure K-32. **Grid 31**

APPENDIX L

Protective Action Zone Boundaries

L. PROTECTIVE ACTION ZONE (PAZ) BOUNDARIES

PAZ A-0 County: Fairfield

Defined as the area within the following boundaries: Within a 2-mile radius of the VCSNS. Bounded on the north by a line from Friendship Church on Cole Trestle Road east across Monticello Reservoir to the northern junction of S-213 and S-215. Bounded on the east by both sides of S-215 back to the Parr Road. Bounded on the south by both sides of Parr Road. Bounded on the west by Broad River, from the Broad River (at a 2-mile radius from VCSNS) along the south side of the dirt extension of Cole Trestle Road, and along the east side of Cole Trestle Road to Friendship Church.

PAZ A-1 County: Fairfield

Defined as the area within the following boundaries: Bounded on the north along the Broad River to Dawkins Road to Meadow Lake Road. Bounded on the east by S-215 to the line south of the town of Monticello. Bounded on the south by a line from south of the Town of Monticello on S-215, due west to Friendship Church; south along Cole Trestle Road. Bounded on the west along dirt road to the Broad River.

PAZ A-2 County: Fairfield

Defined as the area within the following boundaries: Bounded on the north by Buckhead Road. Bounded on the east by Possum Branch Road to S-34, then S-34 east to the junction of S-34 and Clark Bridge Road. Bounded on the south by both sides of Dawkins Road, Meadow Lake Road, and Clark Bridge Road. Bounded on the west by the Broad River.

PAZ B-1 County: Fairfield

Defined as the area within the following boundaries: Bounded on the north by both sides of Clark Bridge Road. Bounded on the east by the Little River. Bounded on the south by both sides of S-213. Bounded on the west by both sides of S-215.

PAZ B-2 County: Fairfield

Defined as the area within the following boundaries: Bounded on the north by both sides of Clark Bridge Road and S-34. Bounded on the east by both sides of Jackson Creek Road. Bounded on the south by both sides of Reservoir Road, Landis Road, and S-213. Bounded on the west by the Little River.

PAZ C-1 <u>County:</u> Fairfield

<u>Defined as the area within the following boundaries:</u> Bounded on the north by both sides of S-213 and Landis Road. Bounded on the east by both sides of Koon Store Road, Glenn's Bridge Road, S-215, and Wallaceville Road. Bounded on the south by the Broad River. Bounded on the west by Parr Road and both sides of S-213 and S-215.

PAZ C-2 <u>County:</u> Fairfield

<u>Defined as the area within the following boundaries:</u> Bounded on the north by both sides of Reservoir Road, Rion Road, and Keller Miller Road to include both Kelly Miller and Greenbriar Schools. Bounded on the east by both sides of S-269 and Bookmans Mill Road, then along the Fairfield County line to the Broad River. Bounded on the south by the Broad River. Bounded on the west by both sides of Wallaceville Road, S-215, Glenn's Bridge Road, Koon Store Road and Landis Road.

PAZ D-1 <u>County:</u> Richland

<u>Defined as the area within the following boundaries:</u> Bounded on the north and east by the Broad River. Bounded on the south by both sides of Kennerly Road, Mt. Vernon Church Road, and I-26. Bounded on the west by the Richland County line.

PAZ D-2 <u>County:</u> Lexington

<u>Defined as the area within the following boundaries:</u> Bounded on the north, west, and east by the Lexington County line. Bounded on the south by US-76 (Chapin Road), Sid Bickley Road, Old Lexington Road including Chapin Elementary School, Old Bush River Road until it ends, across the water to Bear Creek Road, Amicks Ferry Road, Lester Frick Road, and St. Peter's Church Road to the Lexington/Newberry County line.

PAZ E-1 <u>County:</u> Newberry

<u>Defined as the area within the following boundaries:</u> Bounded on the north by Cannons Creek. Bounded on the east by the Broad River. Bounded on the south from Peak (by the Newberry County line) and both sides of Capers Chapel Road. Bounded on the west by both sides of US 176 and the Town of Pomaria and New Hope Road.

PAZ E-2 County: Newberry

Defined as the area within the following boundaries: Bounded on the north by both sides of US-176. Bounded on the east by the Newberry County line. Bounded on the south by both sides of Nursery Road, US-76, the Town of Little Mountain, and US-76 including Mid-Carolina School. Bounded on the west by both sides of Old Jolly Street Road to I-26 then east to S-773 and then north on US -176 to Pomaria.

PAZ F-1 County: Newberry

Defined as the area within the following boundaries: Bounded on the north and east by the Broad River; Bounded on the south by Cannons Creek; Bounded on the west by both sides of New Hope Road.

PAZ F-2 County: Newberry

Defined as the area within the following boundaries: Bounded on the north by both sides of Mt. Pleasant Road, Broad River Road, and S-34. Bounded on the east by the Broad River, both sides of New Hope Road, S-773, and US-176. Bounded on the south by both sides of I-26. Bounded on the west by both sides of Bachman Chapel Road, Mud Creek Road, Livingston Road, and Ringer Road.

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 Emergency Planning Zone (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 1, Region 3; a summer, 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 ETE is reduced by 15 minutes and the 100th percentile ETE are reduced by 1 hour (a significant change), respectively. If evacuees mobilize one hour slower, the 90th and 100th percentile ETE are increased by 30 minutes and 1 hour, respectively – a significant change.

As discussed in Section 7.3, traffic congestion within the EPZ clears (i.e., all highways within EPZ operates at a Level of Service A) at 2 hours and 40 minutes after the ATE, well before the completion of trip generation time. As such, congestion dictates the 100th percentile until 2 hours and 40 minutes after the ATE. After this time, trip generation (plus a 10-minute travel time to the EPZ boundary), dictates the 100th percentile ETE. See Table M-1.

M.2 Effect of Changes in the Number of People in the Shadow Region Who Relocate

A sensitivity study was conducted to determine the effect on ETE due to changes in the percentage of people who decide to relocate from the Shadow Region. The case considered was Scenario 1, Region 3; a summer, 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 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 shadow evacuation (0%) decreases the 90th percentile ETE by 10 minutes while the 100th percentile ETE remain unchanged. Tripling the shadow percentage from 20% to 60% increases the ETE by 40 minutes for the 90th percentile – a significant change, but the 100th percentile ETE remains unchanged. A full evacuation (100%) of the Shadow Region increases the 90th and 100th percentile ETE by 1 hour 30 minutes and 1 hours and 15 minutes, respectively.

Note the demographic survey results presented in Appendix F, indicate that 11% 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 11% shadow and the ETE decreases the 90th percentile ETE by 5 minutes and the 100th percentile ETE remains the same.

The Shadow Region for VCSNS is significantly populated within population centers like Prosperity, and Winnsboro, southwest and northeast of the plant, respectively. In addition, Irmo is also significantly populated (which includes the area of Lake Murray of Richland) and is within close proximity of the EPZ boundary (PAZ D-1 and PAZ D-2). As shown in Figure 7-3 through Figure 7-6, congestion exists within the Shadow Region near Irmo, especially along US Highway (US) 76 eastbound, such that the EPZ evacuees would be delayed during an evacuation trip. Therefore, any additional shadow residents that decide to voluntarily evacuate increase this congestion, delay the egress of EPZ evacuees and prolong ETE.

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 <u>longest 90th percentile ETE</u> (excluding the roadway impact scenario and the special event scenario if it is a one day per year special event).

Thus, the sensitivity study was conducted using the following planning assumptions:

1. The percent change in population within the study area was increased by up to 62%. Changes in population were applied to permanent residents only (as per federal guidance), in both the EPZ area 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 <u>longest 90th percentile ETE</u> values was selected as the case to be considered in this sensitivity study (Scenario 8 – Winter, Midweek, Midday with Ice).

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 for the 2-Mile Region (R01), 5-Mile Region (R02), and for the entire (EPZ) are greater than 2 hours; 25% 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 change greater than or equal to 30 minutes are highlighted red in Table M-3 – a 62% or greater increase in the entire EPZ permanent resident population. Dominion Energy will have to estimate the EPZ population on an annual basis. If the EPZ population increases by 62% or more, an updated ETE analysis will be needed.

M.4 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 an hour impacts the 90th percentile ETE by 15 to 30 minutes and the 100th percentile ETE by 1 hour, since trip generation within the EPZ dictates ETE (Section M.1). Thus, public outreach encouraging evacuees to mobilize more quickly will decrease ETE.
- Increasing the percent shadow evacuation has significant impacts on ETE (Section M.2). As such, 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 (Section M.3) in more evacuating vehicles, which could significantly increase ETE. 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.

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

Trip Generation Period	Evacuation Time Estimate for Entire EPZ	
	90th Percentile	100th Percentile
4 Hours	2:30	4:10
5 Hours (Base)	2:45	5:10
6 Hours	3:15	6:10

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	2:35	5:10
11 (survey)	4,187	2:40	5:10
20 (Base)	7,612	2:45	5:10
40	15,224	3:00	5:10
60	22,836	3:25	5:10
80	30,448	3:50	5:45
100	38,060	4:15	6:25

Table M-3. Evacuation Time Estimates for Variation with Population Change

EPZ and 20% Shadow Permanent Resident Population	Base	Population Change		
		60%	61%	62%
	27,855	44,568	44,847	45,125
ETE (hrs:mins) for the 90th Percentile				
Region	**Base**	**Population Change**		
		60%	**61%**	**62%**
2-MILE	2:05	2:25	2:25	2:25
5-MILE	2:50	3:00	3:00	3:00
FULL EPZ	2:50	3:15	3:15	**3:20**
ETE (hrs:mins) for the 100th Percentile				
Region	**Base**	**Population Change**		
		60%	**61%**	**62%**
2-MILE	5:00	5:00	5:00	5:00
5-MILE	5:05	5:05	5:05	5:05
FULL EPZ	5:10	5:10	5:10	5:10

[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.

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 H-1, 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

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
c. Population values are adjusted as necessary for growth to reflect population estimates to the year of the ETE.	N/A	N/A - 2020 used as the base year of the analysis
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-5
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

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
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
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 3.7
b. The State and local evacuation plans for transit dependent residents are used in the analysis.	Yes	Section 8.1
c. The methodology used to determine the number of people with disabilities and those with access and functional needs who may need assistance and do not reside in special facilities is provided. Data from local/county registration programs are used in the estimate.	Yes	Section 3.8
d. Capacities are provided for all types of transportation resources. Bus seating capacity of 50 percent is used or justification is provided for higher values.	Yes	Item 3 of Section 2.4
e. An estimate of the transit dependent population is provided.	Yes	Section 3.7, Table 3-9, Table 3-10

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
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 3-10, Table 8-1
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.
b. The method of obtaining special facility data is discussed.	Yes	Section 3.5
c. An estimate of the number and capacity of vehicles assumed available to support the evacuation of the facility is provided.	Yes	Table 3-6
d. The logistics for mobilizing specially trained staff (e.g., medical support or security support for prisons, jails, and other correctional facilities) are discussed when appropriate.	Yes	Section 8.1 – under "Evacuation of Generations of Chapin"
2.4 Schools		
a. A list of schools including name, location, student population, and transportation resources required to support the evacuation, is provided. The source of this information should be identified.	Yes	Table 3-7, Table 3-8, Table E-1, Table E-2, Section 3.6
b. Transportation resources for elementary and middle schools are based on 100 percent of the school capacity.	Yes	Section 3.6

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
c. The estimate of high school students who will use personal vehicle to evacuate is provided and a basis for the values used is given.	Yes	Section 3.6
d. The need for return trips is identified.	Yes	Section 8.1- no return trips are needed.
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 3.9
b. The special event that encompasses the peak transient population is analyzed in the ETE.	Yes	Section 3.9
c. The percentage of permanent residents attending the event is estimated.	Yes	Section 3.9
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 5-8 (footnote)

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
2.5.3 Background and Pass Through Traffic		
a. The volume of background traffic and pass-through traffic is based on the average daytime traffic. Values may be reduced for nighttime scenarios.	Yes	Section 3.10 and Section 3.11
b. The method of reducing background and pass-through traffic is described.	Yes	Section 2.2 – Item 10 and 11 Section 2.5 Section 3.10 and Section 3.11 Table 6-3 – External Through Traffic footnote
c. Pass-through traffic is assumed to have stopped entering the EPZ about two (2) hours after the initial notification.	Yes	Section 2.5, 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 3-12, Table 3-13, 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

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
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
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	Item 2 and 3 of Section 2.6

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
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.
d. The effect of adverse weather on mobilization is considered and assumptions for snow removal on streets and driveways are identified, when applicable.	Yes	Item 5 of Section 2.6, Table 2-2; ice, not snow is considered for this site.
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, and Table C-3
4.3 Trip Generation Time		

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
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
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. Item 3 of Section 2.3

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
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 3.9
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 People (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 People (Residents without access to a vehicle)" Section 8.2
c. Logistical details, such as the time to obtain buses, brief drivers and initiate the bus route are used in the analysis.	Yes	Section 8.1, Figure 8-1
d. The estimated time for transit dependent residents to prepare and then travel to a bus pickup point, including the expected means of travel to the pickup point, is described.	Yes	Section 8.1 under "Evacuation of Transit Dependent People (Residents without access to a vehicle)"

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
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	Sections 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
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. f.	Yes	Section 8.1

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
g. 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
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

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
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	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.
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

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
b. The minimum following model outputs for evacuation of the entire EPZ are provided to support review: 1. Evacuee average travel distance and time. 2. Evacuee average delay time. 3. Number of vehicles arriving at each destination node. 4. Total number and percentage of evacuee vehicles not exiting the EPZ. 5. A plot that provides both the mobilization curve and evacuation curve identifying the cumulative percentage of evacuees who have mobilized and exited the EPZ. 6. Average speed for each major evacuation route that exits the EPZ.	Yes	1. Appendix J, Table J-2 2. Table J-2 3. Table J-4 4. None and 0%. 100 percent ETE is based on the time the last vehicle exits the evacuation zone 5. Figures J-2 through J-15 (one plot for each scenario considered) 6. Table J-3
c. Color coded roadway maps are provided for various times (e.g., at 2, 4, 6 hrs.) during a full EPZ evacuation scenario, identifying areas where congestion exists.	Yes	Figure 7-3 through Figure 7-6
4.7 Evacuation Time Estimates for the General Public		
a. The ETE includes the time to evacuate 90 percent and 100 percent of the total permanent resident and transient population.	Yes	Table 7-1 and Table 7-2
b. Termination criteria for the 100 percent ETE are discussed, if not based on the time the last vehicle exits the evacuation zone.	N/A	100 percent ETE is based on the time the last vehicle exits the evacuation zone.

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
c. The ETE for 100 percent of the general public includes all members of the general public. Any reductions or truncated data is explained.	Yes	Section 5.4.1 – truncating survey data to eliminate statistical outliers Table 7-2 – 100th percentile ETE for general population
d. Tables are provided for the 90 and 100 percent ETEs similar to Table 4-3, “ETEs for a Staged Evacuation,” and Table 4-4, “ETEs for a Keyhole Evacuation.”	Yes	Table 7-3 and Table 7-4
e. ETEs are provided for the 100 percent evacuation of special facilities, transit dependent, and school populations.	Yes	Section 8
5.0 Other Considerations		
5.1 Development of Traffic Control Plans		
a. Information that responsible authorities have approved the traffic control plan used in the analysis are discussed.	Yes	Section 9, Appendix G
b. Adjustments or additions to the traffic control plan that affect the ETE is provided.	Yes	Section 9, Appendix G
5.2 Enhancements in Evacuation Time		
a. The results of assessments for enhancing evacuations are provided.	Yes	Appendix M
5.3 State and Local Review		
a. A list of agencies contacted is provided and the extent of interaction with these agencies is discussed.	Yes	Table 1-1

NRC Review Criteria	Addressed in ETE Analysis (Yes/No/NA)	Comments
b. Information is provided on any unresolved issues that may affect the ETE.	Yes	Results of the ETE study were formally presented to state and local agencies at the final project meeting. There were no comments on the draft report and 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