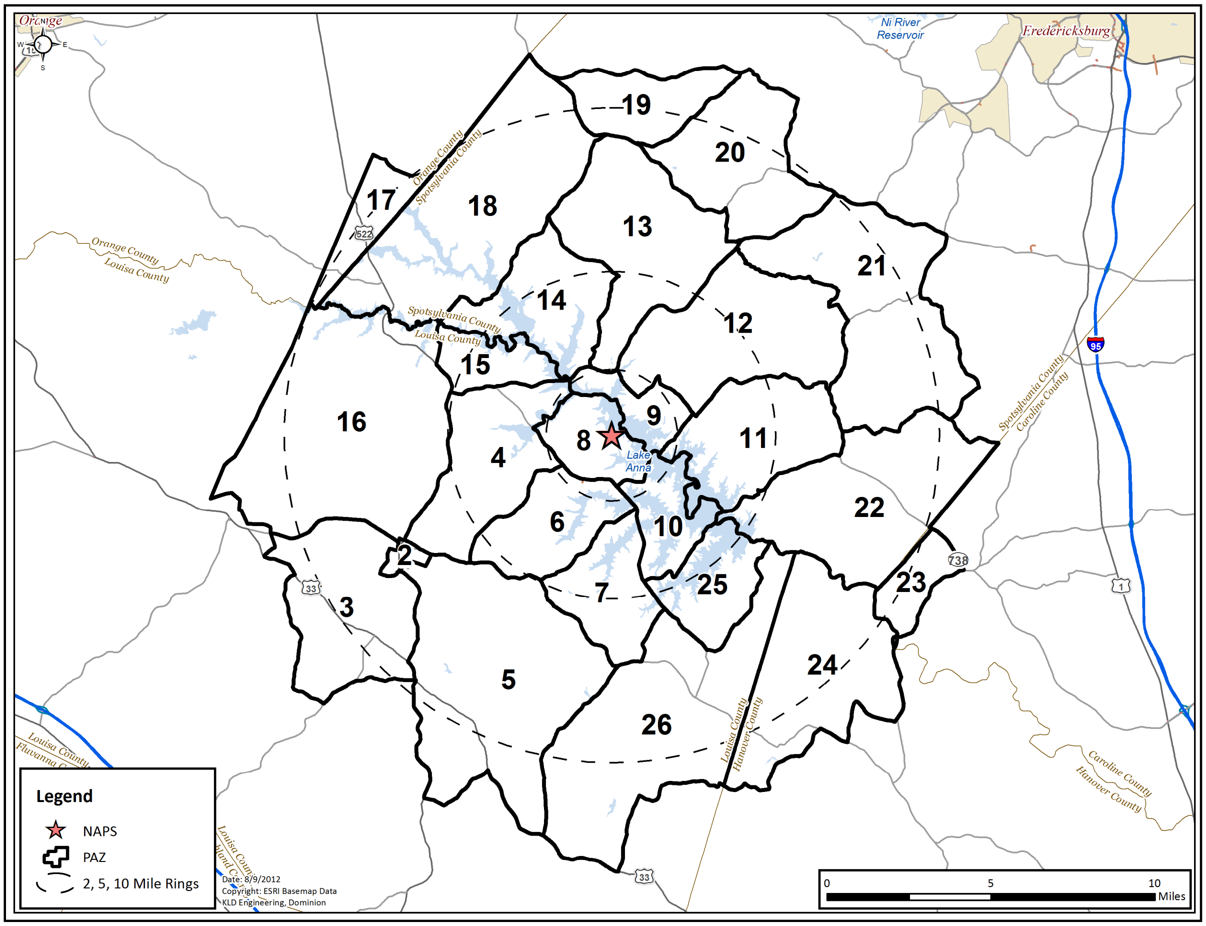
KLD ENGINEERING, P.C.

North Anna Power Station

Development of Evacuation Time Estimates



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November 2012 | **Final Report, Rev. 1** | **KLD TR – 503**

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EXECUTIVE SUMMARY

This report describes the analyses undertaken and the results obtained by a study to develop Evacuation Time Estimates (ETE) for the North Anna Power Station (NAPS) located in Louisa County, Virginia. ETE are part of the required planning basis and provide Dominion and State and local governments with site-specific information needed for Protective Action decision-making.

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

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

Overview of Project Activities

This project began in February, 2012 and extended over a period of 9 months. The major activities performed are briefly described in chronological sequence:

- Attended "kick-off" meetings with Dominion personnel and emergency management personnel representing state and county governments.
- Accessed U.S. Census Bureau data files for the year 2010. Studied Geographical Information Systems (GIS) maps of the area in the vicinity of the NAPS, then conducted a detailed field survey of the highway network.
- Synthesized this information to create an analysis network representing the highway system topology and capacities within the Emergency Planning Zone (EPZ), plus a Shadow Region covering the region between the EPZ boundary and approximately 15 miles radially from the plant.
- Designed and sponsored a telephone survey of residents within the EPZ to gather focused data needed for this ETE study that were not contained within the census database. The survey instrument was reviewed and modified by the licensee and offsite response organization (ORO) personnel prior to the survey (survey from the 2007 COLA was used since EPZ demographics did not significantly change).
- Counties provided school and transportation resources data. Data for transient facilities

was collected through phone calls to specific facilities.

- The traffic demand and trip-generation rates of evacuating vehicles were estimated from the gathered data. The trip generation rates reflected the estimated mobilization time (i.e., the time required by evacuees to prepare for the evacuation trip) computed using the results of the telephone survey of EPZ residents.
- Following federal guidelines, the EPZ is subdivided into 25 Protective Action Zones (PAZ). These PAZ are then grouped within circular areas or "keyhole" configurations (circles plus radial sectors) that define a total of 41 Evacuation Regions.
- The time-varying external circumstances are represented as Evacuation Scenarios, each described in terms of the following factors: (1) Season (Summer, Winter); (2) Day of Week (Midweek, Weekend); (3) Time of Day (Midday, Evening); and (4) Weather (Good, Rain, Snow). One special event scenario involving the Kinetic Triathlon at Lake Anna State Park was considered. One roadway impact scenario was considered wherein a northbound segment of US-522 NB at CR-612 was closed for the duration of the evacuation.
- Staged evacuation was considered for those regions wherein the 2 mile radius and sectors downwind to 5 miles were evacuated.
- As per NUREG/CR-7002, the Planning Basis for the calculation of ETE is:
  - A rapidly escalating accident at the NAPS that quickly assumes the status of General Emergency such that the Advisory to Evacuate is virtually coincident with the siren alert, and no early protective actions have been implemented.
  - While an unlikely accident scenario, this planning basis will yield ETE, measured as the elapsed time from the Advisory to Evacuate until the stated percentage of the population exits the impacted Region, that represent "upper bound" estimates. This conservative Planning Basis is applicable for all initiating events.
- If the emergency occurs while schools are in session, the ETE study assumes that the children will be evacuated by bus directly to Evacuation Assembly Centers (EAC) located outside the EPZ. Parents, relatives, and neighbors are advised to not pick up their children at school prior to the arrival of the buses dispatched for that purpose. The ETE for schoolchildren are calculated separately.
- Evacuees who do not have access to a private vehicle will either ride-share with relatives, friends or neighbors, or be evacuated by buses provided as specified in each of the counties Radiological Emergency Response Plans (RERP). Those in special facilities will likewise be evacuated with public transit, as needed: bus, van, or ambulance, as required. Separate ETE are calculated for the transit-dependent evacuees, for homebound special needs population, and for those evacuated from special facilities.
- Attended final meeting with Dominion personnel and emergency management personnel representing state and county governments to review results and receive comments.

Computation of ETE

A total of 574 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 41 Evacuation Regions to evacuate from that Region, under the circumstances defined for one of the 14 Evacuation Scenarios (41 x 14 = 574). 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 Advisory to Evacuate applies only to those people occupying the specified impacted region. It is assumed that 100 percent of the people within the impacted region will evacuate in response to this Advisory. The people occupying the remainder of the EPZ outside the impacted region may be advised to take shelter.

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

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

The computational procedure is outlined as follows:

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

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

The use of a public outreach (information) program to emphasize the need for evacuees to minimize the time needed to prepare to evacuate (secure the home, assemble needed clothes, medicines, etc.) should also be considered.

Traffic Management

This study references the comprehensive traffic management plans provided by Louisa, Spotsylvania, Orange, Caroline, and Hanover Counties, and identifies critical intersections.

Selected Results

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

- Figure 6-1 displays a map of the NAPS EPZ showing the layout of the 25 PAZ that comprise, in aggregate, the EPZ.
- Table 3-1 presents the estimates of permanent resident population in each PAZ based on the 2010 Census data.
- Table 6-1 defines each of the 41 Evacuation Regions in terms of their respective groups of PAZ.
- Table 6-2 lists the Evacuation Scenarios.
- Tables 7-1 and 7-2 are compilations of ETE. These data are the times needed to clear the indicated regions of 90 and 100 percent of the population occupying these regions, respectively. These computed ETE include consideration of mobilization time and of estimated voluntary evacuations from other regions within the EPZ and from the Shadow Region.
- Tables 7-3 and 7-4 present ETE for the 2-mile region for un-staged and staged evacuations for the 90th and 100th percentiles, respectively.
- Table 8-7 presents ETE for the schoolchildren in good weather.
- Table 8-11 presents ETE for the transit-dependent population in good weather.
- Figure H-8 presents an example of an Evacuation Region (Region R08) to be evacuated under the circumstances defined in Table 6-1. Maps of all regions are provided in Appendix H.

Conclusions

- General population ETE were computed for 574 unique cases – a combination of 41 unique Evacuation Regions and 14 unique Evacuation Scenarios. Table 7-1 and Table 7-2 document these ETE for the 90th and 100th percentiles. These ETE range from 1:45 (hr:min) to 3:45 at the 90th percentile.
- Inspection of Table 7-1 and Table 7-2 indicates that the ETE for the 100th percentile are significantly longer than those for the 90th percentile. This is the result of the long trip generation "tail". As these stragglers mobilize, the aggregate rate of egress slows since many vehicles have already left the EPZ. Towards the end of the process, relatively few evacuation routes service the remaining demand. See Figures 7-7 through 7-20.

- Inspection of Table 7-3 and Table 7-4 indicates that a staged evacuation provides no benefits to evacuees from within the 2 mile region and unnecessarily delays the evacuation of those beyond 2 miles (compare Regions R02 and R04 through R15 with Regions R29 through R41, respectively, in Tables 7-1 and 7-2). See Section 7.6 for additional discussion.
- Comparison of Scenarios 9 (winter, weekend, midday) and 13 (winter, weekend, midday, special event) in Table 7-1 indicates that the special event does not materially affect the ETE. See Section 7.5 for additional discussion.
- Comparison of Scenarios 1 and 14 in Table 7-1 indicates that the roadway closure – a northbound section of US-522 NB at CR-612 – does not have a significant impact on the 90th or 100th percentile ETE. Sufficient reserve capacity exists on CR-612 to service the additional evacuating traffic demand. See Section 7.5 for additional discussion.
- There is minimal traffic congestion within the EPZ. All congestion within the EPZ clears by 2 hours and 10 minutes after the Advisory to Evacuate (earlier for winter cases). See Section 7.3 and Figures 7-3 through 7-6.
- Separate ETE were computed for schools, the one medical facility, transit-dependent persons and homebound special needs persons. The average single-wave ETE for these facilities are within a similar range as the general population ETE at the 90th percentile. See Section 8.
- Table 8-5 indicates that there are enough buses and wheelchair vans available to evacuate the entire transit-dependent population within the EPZ in a single wave, if transportation resources are shared by the counties. However, if for any reason transportation resources could not be shared, then Spotsylvania County would require a second wave for two of their schools in order to evacuate all schoolchildren. The second-wave ETE for schools do exceed the general population ETE at the 90th percentile. Mutual aid agreements with neighboring counties and assistance from the state could be used to address the shortfall in bus resources (See Section 8.4).
- The general population ETE at the 90th percentile is insensitive to reductions in the base trip generation time of 5½ hours. The general population ETE at the 100th percentile, however, closely mirrors trip generation time. See Table M-1.
- The general population ETE is insensitive to the voluntary evacuation of vehicles in the Shadow Region. Tripling the shadow evacuation percentage results in no change in the 90th percentile ETE. See Table M-2.
- An increase in permanent resident population of 150% or more, or a decrease in population of 85% or more results in ETE changes which meet the criteria for updating ETE between decennial Censuses. See Section M.3.
- The additional employees present during an outage concurrent with construction of the New Unit 3, does not affect the ETE, with the exception of the 90th percentile ETE for the 2-mile region, which decreased by 5 minutes. See Section M.4.

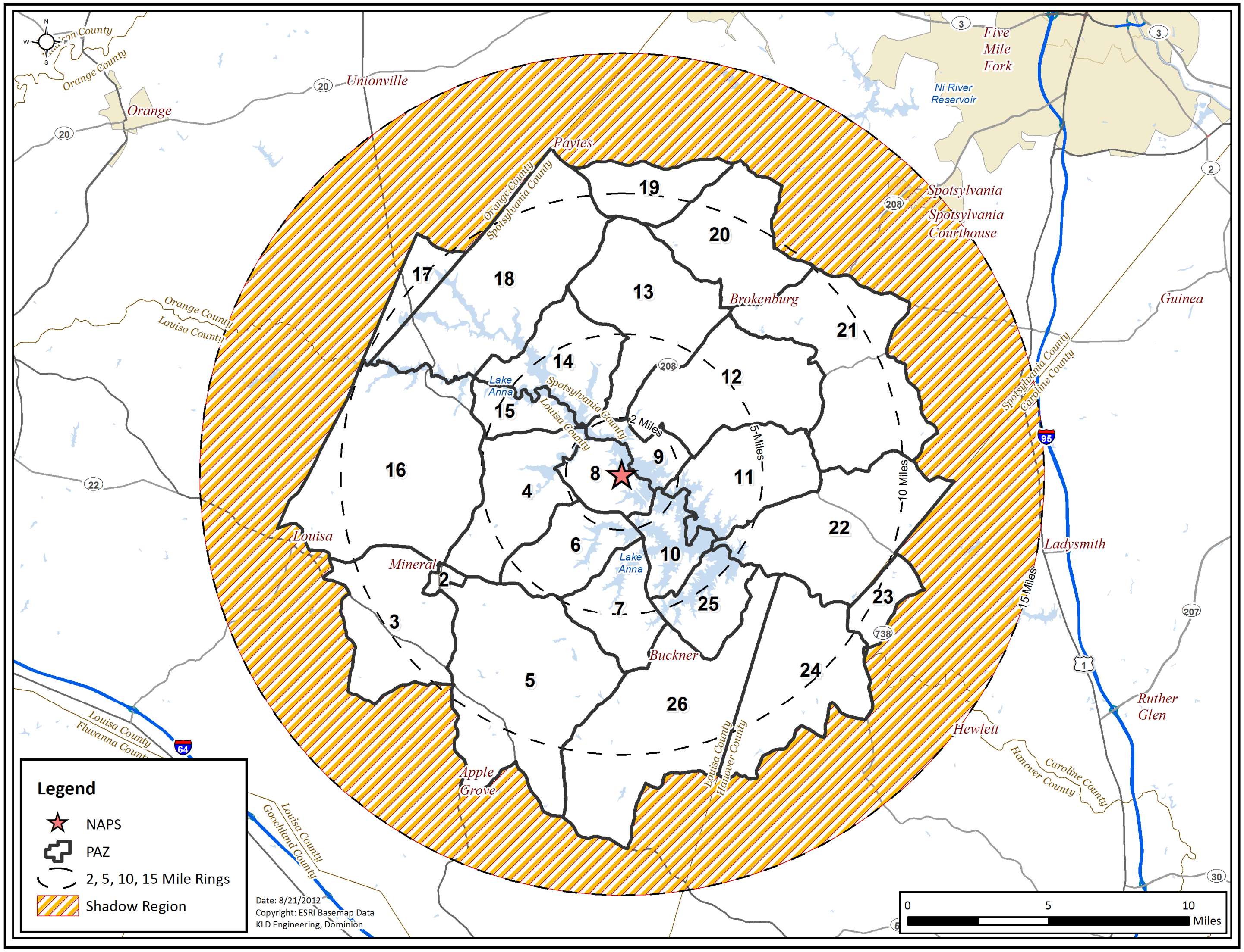

Figure 6-1. NAPS EPZ PAZ

Table 3-1. EPZ Permanent Resident Population

PAZ	2000 Population	2008 Population (Estimated)[1]	2010 Population
2	418	645	466
3	1,241	1,843	1,490
4	837	1,842	1,107
5	1,331	1,740	1,472
6	308	727	484
7	318	939	484
8	287	885	409
9	117	426	203
10	245	1,151	429
11	740	1,345	981
12	1,222	1,467	1,561
13	991	1,312	1,364
14	541	1,719	803
15	451	1,589	697
16	1,138	2,153	1,601
17	50	223	144
18	1,664	3,624	2,416
19	246	352	383
20	894	1,025	1,026
21	1,901	2,125	2,232
22	1,355	1,639	1,538
23	263	341	260
24	716	989	946
25	312	902	464
26	1,729	2,420	2,242
TOTAL	**19,315**	**33,423**	**25,202**
EPZ Population Growth:		**2000-2010**	**30.48%**
EPZ Population Difference:		**2008-2010**	**-24.60%**

Notes: 1 - 2008 COLA ETE – Resident address points within each county (except Caroline County) were provided by VDEM. Average household size from telephone survey (2.57) was used to determine 2008 EPZ population. 2000 Census projected to 2008 using county growth rate was used for Caroline County.

Table 6-1. Description of Evacuation Regions

Region	Description	Site PAR Description	Protection Action Zone (PAZ)																								
			2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
R01	2-Mile Radius	2- Mile Radius					x		x	x	x																
R02	5-Mile Radius	5-Mile Radius			x		x	x	x	x	x	x	x	x	x	x										x	
R03	Full EPZ	Full EPZ	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Evacuate 2-Mile Radius and Downwind to 5 Miles																											
Region	**Wind Direction Toward:**	**Site PAR Description**	**Protection Action Zone (PAZ)**																								
			2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
R04	N, NNE	349° - 33°					x		x	x	x		x	x	x												
R05	NE	34° - 56°					x		x	x	x	x	x	x													
R06	ENE, E	57° - 101°					x		x	x	x	x	x														
R07	ESE	102° - 123°					x		x	x	x	x														x	
R08	SE	124° - 146°					x	x	x	x	x	x														x	
R09	SSE, S	147° - 191°					x	x	x	x	x															x	
R10	SSW	192° - 213°					x	x	x	x	x																
R11	SW	214° - 236°			x		x	x	x	x	x																
R12	WSW	237° - 258°			x		x		x	x	x																
R13	W	259°- 281°			x		x		x	x	x					x											
R14	WNW, NW	282° - 326°			x		x		x	x	x				x	x											
R15	NNW	327° - 349°					x		x	x	x			x	x	x											
Evacuate 5-Mile Radius and Downwind to the EPZ Boundary																											
Region	**Wind Direction Toward:**	**Site PAR Description**	**Protection Action Zone (PAZ)**																								
			2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
R16	N	349° - 11°			x		x	x	x	x	x	x	x	x	x	x			x	x	x					x	
R17	NNE	12° - 33°			x		x	x	x	x	x	x	x	x	x	x			x	x	x	x				x	
R18	NE	34° - 56°			x		x	x	x	x	x	x	x	x	x	x				x	x	x				x	
R19	ENE	57° - 78°			x		x	x	x	x	x	x	x	x	x	x					x	x	x			x	
R20	E	79° - 101°			x		x	x	x	x	x	x	x	x	x	x						x	x	x		x	
R21	ESE	102° - 123°			x		x	x	x	x	x	x	x	x	x	x						x	x	x	x	x	x
R22	SE	124° - 146°			x		x	x	x	x	x	x	x	x	x	x							x	x	x	x	x
R23	SSE, S	147° - 191°			x	x	x	x	x	x	x	x	x	x	x	x									x	x	x
R24	SSW	192° - 213°		x	x	x	x	x	x	x	x	x	x	x	x	x										x	x

Region	Description	Site PAR Description	Protection Action Zone (PAZ)																								
			2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
R25	SW, WSW	214° - 258°	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x									x	
R26	W	259° - 281°	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x							x	
R27	WNW, NW	282° - 326°			x		x	x	x	x	x	x	x	x	x	x	x	x	x							x	
R28	NNW	327° - 349°			x		x	x	x	x	x	x	x	x	x	x		x	x	x						x	
Staged Evacuation - 2-Mile Radius Evacuates, then Evacuate Downwind to 5 Miles																											
Region	**Wind Direction Toward:**	**Site PAR Description**	**Protection Action Zone (PAZ)**																								
			2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
R29	-	5-Mile Radius			x		x	x	x	x	x	x	x	x	x	x										x	
R30	N, NNE	349° - 33°					x		x	x	x		x	x	x												
R31	NE	34° - 56°					x		x	x	x	x	x	x													
R32	ENE, E	57° - 101°					x		x	x	x	x	x														
R33	ESE	102° - 123°					x		x	x	x	x														x	
R34	SE	124° - 146°					x	x	x	x	x	x														x	
R35	SSE, S	147° - 191°					x	x	x	x	x															x	
R36	SSW	192° - 213°					x	x	x	x	x																
R37	SW	214° - 236°			x		x	x	x	x	x																
R38	WSW	237° - 258°			x		x		x	x	x																
R39	W	259°- 281°			x		x		x	x	x					x											
R40	WNW, NW	282° - 326°			x		x		x	x	x				x	x											
R41	NNW	327° - 349°					x		x	x	x			x	x	x											

Shelter-in-Place until 90% ETE for R01, then Evacuate | PAZ Shelter-in-Place | PAZ Evacuate

Table 6-2. Evacuation Scenario Definitions

Scenario	Season[1]	Day of Week	Time of Day	Weather	Special
1	Summer	Midweek	Midday	Good	None
2	Summer	Midweek	Midday	Rain	None
3	Summer	Weekend	Midday	Good	None
4	Summer	Weekend	Midday	Rain	None
5	Summer	Midweek, Weekend	Evening	Good	None
6	Winter	Midweek	Midday	Good	None
7	Winter	Midweek	Midday	Rain	None
8	Winter	Midweek	Midday	Snow	None
9	Winter	Weekend	Midday	Good	None
10	Winter	Weekend	Midday	Rain	None
11	Winter	Weekend	Midday	Snow	None
12	Winter	Midweek, Weekend	Evening	Good	None
13	Winter	Weekend	Midday	Good	Kinetic Triathlon at Lake Anna State park
14	Summer	Midweek	Midday	Good	Roadway Impact – One Segment of US-522 NB will be Closed

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

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

	Summer		Summer		Summer	Winter			Winter			Winter	Winter	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	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	Snow	Good Weather	Rain	Snow	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region, 5-Mile Region, and EPZ														
R01	2:25	2:25	1:45	1:45	1:45	2:30	2:30	3:20	1:50	1:50	2:50	1:50	1:50	2:30
R02	2:25	2:25	1:50	1:50	1:50	2:30	2:35	3:25	1:50	1:50	2:55	1:55	1:50	2:30
R03	2:35	2:35	2:00	2:00	2:00	2:40	2:40	3:30	2:00	2:00	3:05	2:00	2:00	2:35
2-Mile Region and Keyhole to 5 Miles														
R04	2:20	2:20	1:45	1:45	1:45	2:30	2:30	3:15	1:50	1:50	2:55	1:50	1:50	2:20
R05	2:25	2:25	1:50	1:50	1:50	2:30	2:30	3:20	1:50	1:50	2:55	1:50	1:50	2:25
R06	2:25	2:25	1:50	1:50	1:50	2:25	2:25	3:15	1:50	1:50	2:55	1:50	1:50	2:25
R07	2:20	2:20	1:50	1:50	1:50	2:25	2:25	3:10	1:50	1:50	2:55	1:50	1:50	2:25
R08	2:20	2:20	1:50	1:50	1:50	2:25	2:25	3:15	1:50	1:50	2:55	1:50	1:50	2:25
R09	2:15	2:20	1:50	1:50	1:50	2:25	2:25	3:10	1:50	1:50	2:55	1:50	1:50	2:20
R10	2:15	2:15	1:50	1:50	1:50	2:20	2:20	3:05	1:50	1:50	2:50	1:50	1:50	2:20
R11	2:20	2:20	1:50	1:50	1:50	2:25	2:25	3:15	1:50	1:50	2:55	1:50	1:50	2:25
R12	2:15	2:20	1:50	1:50	1:50	2:20	2:25	3:10	1:50	1:50	2:50	1:50	1:50	2:20
R13	2:20	2:20	1:45	1:50	1:50	2:25	2:25	3:10	1:50	1:50	2:55	1:50	1:50	2:20
R14	2:15	2:15	1:45	1:45	1:45	2:25	2:25	3:15	1:50	1:50	2:50	1:50	1:50	2:20
R15	2:15	2:15	1:45	1:45	1:45	2:25	2:25	3:15	1:50	1:50	2:50	1:50	1:50	2:20
5-Mile Region and Keyhole to EPZ Boundary														
R16	2:30	2:30	1:55	1:55	1:50	2:35	2:35	3:25	1:55	1:55	3:00	1:55	1:55	2:30
R17	2:30	2:35	1:55	1:55	1:55	2:35	2:40	3:30	1:55	1:55	3:00	1:55	1:55	2:35
R18	2:30	2:30	1:50	1:55	1:55	2:35	2:35	3:30	1:55	1:55	3:00	1:55	1:55	2:35
R19	2:30	2:35	1:55	1:55	1:55	2:35	2:35	3:30	1:55	1:55	3:00	1:55	1:55	2:35
R20	2:30	2:35	1:55	1:55	1:55	2:35	2:40	3:30	1:55	1:55	3:00	1:55	1:55	2:35
R21	2:35	2:35	2:00	2:05	2:05	2:40	2:40	3:30	2:00	2:00	3:00	2:00	2:00	2:35
R22	2:30	2:35	2:00	2:00	2:05	2:35	2:40	3:30	1:55	1:55	3:00	1:55	1:55	2:35
R23	2:30	2:30	2:00	2:00	2:00	2:35	2:35	3:30	1:55	1:55	3:00	1:55	1:55	2:35

	Summer		Summer		Summer	Winter			Winter			Winter	Winter	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	Snow	Good Weather	Rain	Snow	Good Weather	Special Event	Roadway Impact
R24	2:30	2:30	1:50	1:55	1:55	2:35	2:35	3:25	1:55	1:55	3:00	1:55	1:55	2:35
R25	2:30	2:30	1:55	1:55	1:55	2:35	2:35	3:25	1:55	1:55	3:00	1:55	1:55	2:35
R26	2:30	2:30	1:50	1:50	1:50	2:35	2:35	3:25	1:55	1:55	3:00	1:55	1:55	2:30
R27	2:25	2:30	1:50	1:50	1:50	2:35	2:35	3:25	1:55	1:55	2:55	1:55	1:55	2:30
R28	2:30	2:30	1:55	1:55	1:50	2:35	2:35	3:25	1:55	1:55	2:55	1:55	1:55	2:30
Staged Evacuation - 2-Mile Region and Keyhole to 5 Miles														
R29	2:55	2:55	2:10	2:10	2:10	2:55	2:55	3:45	2:10	2:15	3:30	2:10	2:10	2:55
R30	2:55	2:55	2:10	2:10	2:10	2:55	2:55	3:45	2:15	2:15	3:30	2:15	2:15	2:55
R31	2:55	2:55	2:15	2:15	2:15	2:55	2:55	3:45	2:15	2:15	3:30	2:15	2:15	2:55
R32	2:50	2:50	2:10	2:10	2:10	2:50	2:55	3:40	2:10	2:10	3:25	2:10	2:10	2:50
R33	2:50	2:50	2:05	2:05	2:05	2:50	2:50	3:35	2:05	2:05	3:25	2:05	2:05	2:50
R34	2:50	2:50	2:05	2:05	2:05	2:50	2:50	3:40	2:05	2:10	3:25	2:05	2:05	2:50
R35	2:45	2:45	2:05	2:05	2:05	2:50	2:50	3:35	2:05	2:10	3:25	2:05	2:05	2:50
R36	2:45	2:45	2:05	2:05	2:05	2:45	2:45	3:30	2:05	2:05	3:20	2:05	2:05	2:45
R37	2:45	2:50	2:05	2:05	2:05	2:50	2:50	3:35	2:05	2:05	3:20	2:05	2:05	2:50
R38	2:45	2:45	2:05	2:05	2:05	2:45	2:45	3:35	2:05	2:05	3:20	2:05	2:05	2:45
R39	2:45	2:50	2:05	2:05	2:05	2:50	2:50	3:35	2:05	2:05	3:20	2:05	2:05	2:50
R40	2:50	2:50	2:05	2:05	2:05	2:50	2:50	3:40	2:05	2:10	3:25	2:05	2:05	2:50
R41	2:50	2:50	2:05	2:05	2:05	2:50	2:50	3:40	2:05	2:05	3:25	2:05	2:05	2:50

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

	Summer		Summer		Summer	Winter			Winter			Winter	May	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	Snow	Good Weather	Rain	Snow	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region, 5-Mile Region, and EPZ														
R01	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R02	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R03	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
2-Mile Region and Keyhole to 5 Miles														
R04	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R05	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R06	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R07	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R08	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R09	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R10	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R11	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R12	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R13	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R14	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R15	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
5-Mile Region and Keyhole to EPZ Boundary														
R16	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
R17	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
R18	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
R19	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
R20	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
R21	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
R22	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
R23	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40

	Summer		Summer		Summer	Winter			Winter			Winter	May	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	Snow	Good Weather	Rain	Snow	Good Weather	Special Event	Roadway Impact
R24	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
R25	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
R26	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
R27	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
R28	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
Staged Evacuation - 2-Mile Region and Keyhole to 5 Miles														
R29	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R30	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R31	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R32	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R33	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R34	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R36	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R37	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R38	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R39	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R40	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R41	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35

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

	Summer		Summer		Summer	Winter			Winter			Winter	Winter	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region and 5-Mile Region														
R01	2:25	2:25	1:45	1:45	1:45	2:30	2:30	3:20	1:50	1:50	2:50	1:50	1:50	2:25
R02	2:25	2:25	1:45	1:50	1:50	2:35	2:35	3:25	1:50	1:50	2:55	1:50	1:50	2:25
Unstaged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R04	2:25	2:25	1:45	1:45	1:50	2:30	2:30	3:20	1:50	1:50	2:55	1:50	1:50	2:25
R05	2:25	2:25	1:45	1:45	1:50	2:30	2:30	3:20	1:50	1:50	2:55	1:50	1:50	2:25
R06	2:25	2:25	1:45	1:45	1:45	2:30	2:30	3:20	1:50	1:50	2:50	1:50	1:50	2:25
R07	2:25	2:25	1:45	1:45	1:45	2:30	2:30	3:20	1:50	1:50	2:50	1:50	1:50	2:25
R08	2:25	2:25	1:45	1:45	1:50	2:35	2:35	3:25	1:50	1:50	2:55	1:50	1:50	2:25
R09	2:25	2:25	1:45	1:45	1:50	2:30	2:30	3:25	1:50	1:50	2:55	1:50	1:50	2:25
R10	2:25	2:25	1:45	1:45	1:50	2:30	2:30	3:25	1:50	1:50	2:55	1:50	1:50	2:25
R11	2:25	2:25	1:45	1:45	1:50	2:35	2:35	3:25	1:50	1:50	2:55	1:50	1:50	2:25
R12	2:25	2:25	1:45	1:45	1:45	2:30	2:30	3:20	1:50	1:50	2:50	1:50	1:50	2:25
R13	2:25	2:25	1:45	1:45	1:45	2:30	2:30	3:20	1:50	1:50	2:50	1:50	1:50	2:25
R14	2:25	2:25	1:45	1:45	1:45	2:30	2:30	3:20	1:50	1:50	2:50	1:50	1:50	2:25
R15	2:25	2:25	1:45	1:45	1:50	2:30	2:30	3:20	1:50	1:50	2:55	1:50	1:50	2:25
Staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R29	2:45	2:45	2:00	2:00	2:00	2:45	2:45	3:35	2:00	2:00	3:15	2:00	2:00	2:45
R30	2:40	2:40	1:55	1:55	2:00	2:45	2:45	3:30	2:00	2:00	3:15	2:00	2:00	2:40
R31	2:40	2:40	1:55	1:55	1:55	2:45	2:45	3:30	2:00	2:00	3:15	2:00	2:00	2:40
R32	2:35	2:40	1:55	1:55	1:55	2:40	2:40	3:30	2:00	2:00	3:10	2:00	2:00	2:35
R33	2:35	2:40	1:55	1:55	1:55	2:40	2:40	3:30	2:00	2:00	3:10	2:00	2:00	2:35
R34	2:40	2:45	2:00	2:00	2:00	2:45	2:45	3:30	2:00	2:00	3:15	2:00	2:00	2:40
R35	2:45	2:45	2:00	2:00	2:00	2:45	2:45	3:30	2:00	2:00	3:15	2:00	2:00	2:45
R36	2:45	2:45	2:00	2:00	2:00	2:45	2:45	3:30	2:00	2:00	3:15	2:00	2:00	2:45
R37	2:45	2:45	2:00	2:00	2:00	2:45	2:45	3:35	2:00	2:00	3:15	2:00	2:00	2:45

	Summer		Summer		Summer	Winter			Winter			Winter	Winter	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather	Special Event	Roadway Impact
R38	2:40	2:40	2:00	2:00	2:00	2:45	2:45	3:30	2:00	2:00	3:15	2:00	2:00	2:40
R39	2:40	2:40	2:00	2:00	2:00	2:45	2:45	3:30	2:00	2:00	3:15	2:00	2:00	2:40
R40	2:40	2:40	2:00	2:00	2:00	2:45	2:45	3:30	2:00	2:00	3:15	2:00	2:00	2:40
R41	2:40	2:40	1:55	1:55	2:00	2:45	2:45	3:30	2:00	2:00	3:15	2:00	2:00	2:40

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

	Summer		Summer		Summer	Winter			Winter			Winter	May	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region and 5-Mile Region														
R01	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R02	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
Unstaged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R04	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R05	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R06	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R07	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R08	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R09	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R10	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R11	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R12	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R13	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R14	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R15	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
Staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R29	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R30	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R31	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R32	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R33	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R34	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R35	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R36	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R37	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30

	Summer		Summer		Summer	Winter			Winter			Winter	May	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather	Special Event	Roadway Impact
R38	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R39	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R40	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R41	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30

Table 8-7. School Evacuation Time Estimates – Good Weather

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to EAC (mi.)	Travel Time from EPZ Bdry to EAC (min)	ETE to EAC (hr:min)
LOUISA COUNTY SCHOOLS									
Louisa County High School	90	15	3.7	45.0	5	**1:50**	8.3	11	**2:05**
Louisa County Middle School	90	15	3.4	45.0	5	**1:50**	8.3	11	**2:05**
Mineral Christian Preschool	90	15	4.8	45.0	7	**1:55**	8.3	11	**2:10**
Thomas Jefferson Elementary School	90	15	1.5	45.0	3	**1:50**	8.6	11	**2:05**
SPOTSYLVANIA COUNTY SCHOOLS									
Berkeley Elementary School	90	15	2.1	44.7	3	**1:50**	8.0	11	**2:05**
Livingston Elementary School	90	15	9.1	45.0	13	**2:00**	8.3	11	**2:10**
Post Oak Middle School	90	15	3.4	45.0	5	**1:50**	8.3	11	**2:05**
Spotsylvania High School	90	15	3.2	44.2	5	**1:50**	8.0	11	**2:05**
Spotsylvania High School - Governor's School	90	15	3.2	44.2	5	**1:50**	8.0	11	**2:05**
					Maximum for EPZ:	**2:00**		**Maximum:**	**2:10**
					Average for EPZ:	**1:55**		**Average:**	**2:10**

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

		One-Wave							Two-Wave					
Route Number	Bus Number	Mobilization (min)	Route Length (miles)	Speed (mph)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)	Distance to EAC (miles)	Travel Time to EAC (min)	Unload (min)	Driver Rest (min)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)
1	1	105	12.6	45.0	17	30	**2:35**	8.2	11	5	10	41	30	**4:15**
2	1	105	17.4	38.9	27	30	**2:45**	8.2	11	5	10	50	30	**4:35**
3	1	105	20.2	44.6	27	30	**2:45**	8.2	11	5	10	51	30	**4:35**
4	1	105	15.3	45.0	20	30	**2:35**	8.2	11	5	10	45	30	**4:20**
5	1	105	13.0	45.0	17	30	**2:35**	8.9	12	5	10	43	30	**4:15**
6	1	105	25.5	45.0	34	30	**2:50**	8.5	11	5	10	59	30	**4:50**
7	1	105	19.8	45.0	26	30	**2:45**	12.1	16	5	10	56	30	**4:45**
8	1	105	32.2	45.0	43	30	**3:00**	8.2	11	5	10	67	30	**5:05**
9	1	105	22.8	45.0	30	30	**2:45**	8.2	11	5	10	55	30	**4:40**
10	1	105	26.3	40.2	39	30	**2:55**	8.2	11	5	10	61	30	**4:55**
11	1	105	17.3	45.0	23	30	**2:40**	9.5	13	5	10	49	30	**4:30**
12	1	105	27.6	45.0	37	30	**2:55**	8.3	11	5	10	61	30	**4:55**
13	1	105	17.0	44.8	23	30	**2:40**	8.3	11	5	10	47	30	**4:25**
14	1	105	36.6	45.0	49	30	**3:05**	13.5	18	5	10	80	30	**5:30**
15	1	105	17.5	45.0	23	30	**2:40**	8.3	11	5	10	48	30	**4:25**
16	1	105	23.2	44.5	31	30	**2:50**	7.8	10	5	10	55	30	**4:45**
17	1	105	9.5	43.0	13	30	**2:30**	7.8	10	5	10	36	30	**4:05**
18	1	105	30.5	45.0	41	30	**3:00**	13.5	18	5	10	72	30	**5:15**
19	1	105	18.5	45.0	25	30	**2:40**	13.5	18	5	10	56	30	**4:40**
20	1	105	29.2	45.0	39	30	**2:55**	13.5	18	5	10	70	30	**5:10**
21	1	105	10.7	45.0	14	30	**2:30**	14.8	20	5	10	47	30	**4:25**
22	1	105	5.1	45.0	7	30	**2:25**	12.6	17	5	10	31	30	**4:00**
23	1	105	7.7	45.0	10	30	**2:25**	13.4	18	5	10	38	30	**4:10**
24	1	105	8.0	35.5	13	30	**2:30**	13.4	18	5	10	41	30	**4:15**
25	1	105	7.2	45.0	10	30	**2:25**	12.7	17	5	10	36	30	**4:05**
						Maximum ETE:	**3:05**						**Maximum ETE:**	**5:30**
						Average ETE:	**2:45**						**Average ETE:**	**4:35**

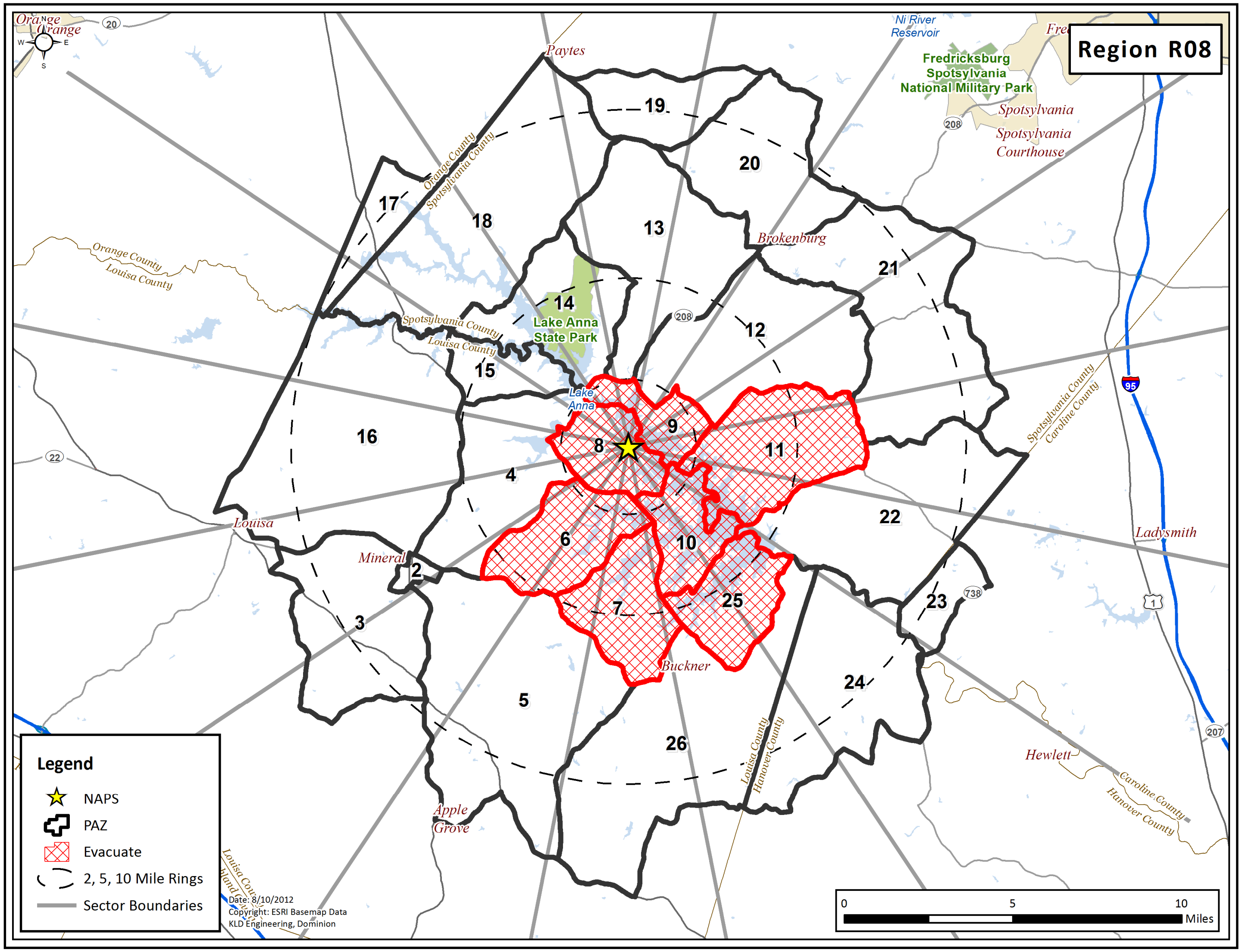

Figure H-8. Region R08

1 INTRODUCTION

This report describes the analyses undertaken and the results obtained by a study to develop Evacuation Time Estimates (ETE) for the North Anna Power Station (NAPS), located in Louisa County, Virginia. ETE provide State and local governments with site-specific information needed for Protective Action decision-making.

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

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

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

Table 1-1. Stakeholder Interaction

<table>
<tr><th>Stakeholder</th><th>Nature of Stakeholder Interaction</th></tr>
<tr><td>Dominion</td><td>Meetings to define data requirements and set up contacts with local government agencies. Obtain NAPS emergency plan. Final meeting to discuss results.</td></tr>
<tr><td>Louisa County Emergency Management / Fire & EMS</td><td rowspan="5">Meetings to define data requirements. Obtain special facility data. Final meeting to discuss results.</td></tr>
<tr><td>Spotsylvania County Emergency Management / Fire & EMS</td></tr>
<tr><td>Caroline County Emergency Management / Fire & EMS</td></tr>
<tr><td>Orange County Emergency Management / Fire & EMS</td></tr>
<tr><td>Hanover County Emergency Management / Fire & EMS</td></tr>
<tr><td>Virginia Department of Emergency Management</td><td>Meetings to define data requirements and set up contacts with local government agencies. Obtain county emergency plans, population data, GIS data and special facility data. Final meeting to discuss results.</td></tr>
</table>

1.1 Overview of the ETE Process

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

1. Information Gathering:
    a. Defined the scope of work in discussions with representatives from Dominion.
    b. Attended meetings with emergency planners from Louisa County EMA, Spotsylvania County EMA, Orange County EMA, Caroline County EMA and Hanover County EMA to identify issues to be addressed and resources available.
    c. Conducted a detailed field survey of the highway system and of area traffic conditions within the Emergency Planning Zone (EPZ) and Shadow Region.
    d. Obtained demographic data from the 2010 census and Virginia Department of Emergency Management.
    e. Re-analyzed results of the 2007 telephone survey and supplemented existing data with results from the Surry Power Station (SPS) telephone survey.
    f. Conducted a data collection effort to identify and describe schools, special facilities, major employers, transportation providers, and other important information.
2. Estimated distributions of Trip Generation times representing the time required by various population groups (permanent residents, employees, and transients) to prepare (mobilize) for the evacuation trip. These estimates are primarily based upon the random sample telephone survey.
3. Defined Evacuation Scenarios. These scenarios reflect the variation in demand, in trip generation distribution and in highway capacities, associated with different seasons, day of week, time of day and weather conditions.
4. Reviewed the existing traffic management plan to be implemented by local and state police in the event of an incident at the plant. Traffic control is applied at specified Traffic Control Points (TCP) located within the EPZ.
5. Used existing PAZ to define evacuation regions. The EPZ is partitioned into 25 PAZ along jurisdictional and geographic boundaries. "Regions" are groups of contiguous PAZ for which ETE are calculated. The configurations of these Regions reflect wind direction and the radial extent of the impacted area. Each Region, other than those that approximate circular areas, approximates a "key-hole section" within the EPZ as recommended by NUREG/CR-7002.
6. Estimated demand for transit services for persons at "Special Facilities" and for transit-dependent persons at home.
7. Prepared the input streams for the DYNEV II system.
    a. Estimated the evacuation traffic demand, based on the available information

derived from Census data, and from data provided by local and state agencies, Dominion and from the telephone survey.

b. Applied the procedures specified in the 2010 Highway Capacity Manual (HCM[1]) to the data acquired during the field survey, to estimate the capacity of all highway segments comprising the evacuation routes.

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

d. Calculated the evacuating traffic demand for each Region and for each Scenario.

e. Specified selected candidate destinations for each “origin” (location of each “source” where evacuation trips are generated over the mobilization time) to support evacuation travel consistent with outbound movement relative to the location of the NAPS.

8. Executed the DYNEV II model to determine optimal evacuation routing and compute ETE for all residents, transients and employees (“general population”) with access to private vehicles. Generated a complete set of ETE for all specified Regions and Scenarios.

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

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

1.2 The North Anna Power Station Location

The North Anna Power Station is located approximately 40 miles northwest of Richmond, Virginia. The Emergency Planning Zone (EPZ) consists of parts of Louisa, Spotsylvania, Orange, Caroline and Hanover Counties in Virginia. Figure 1-1 displays the area surrounding the NAPS. This map identifies the communities in the area and the major roads.

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

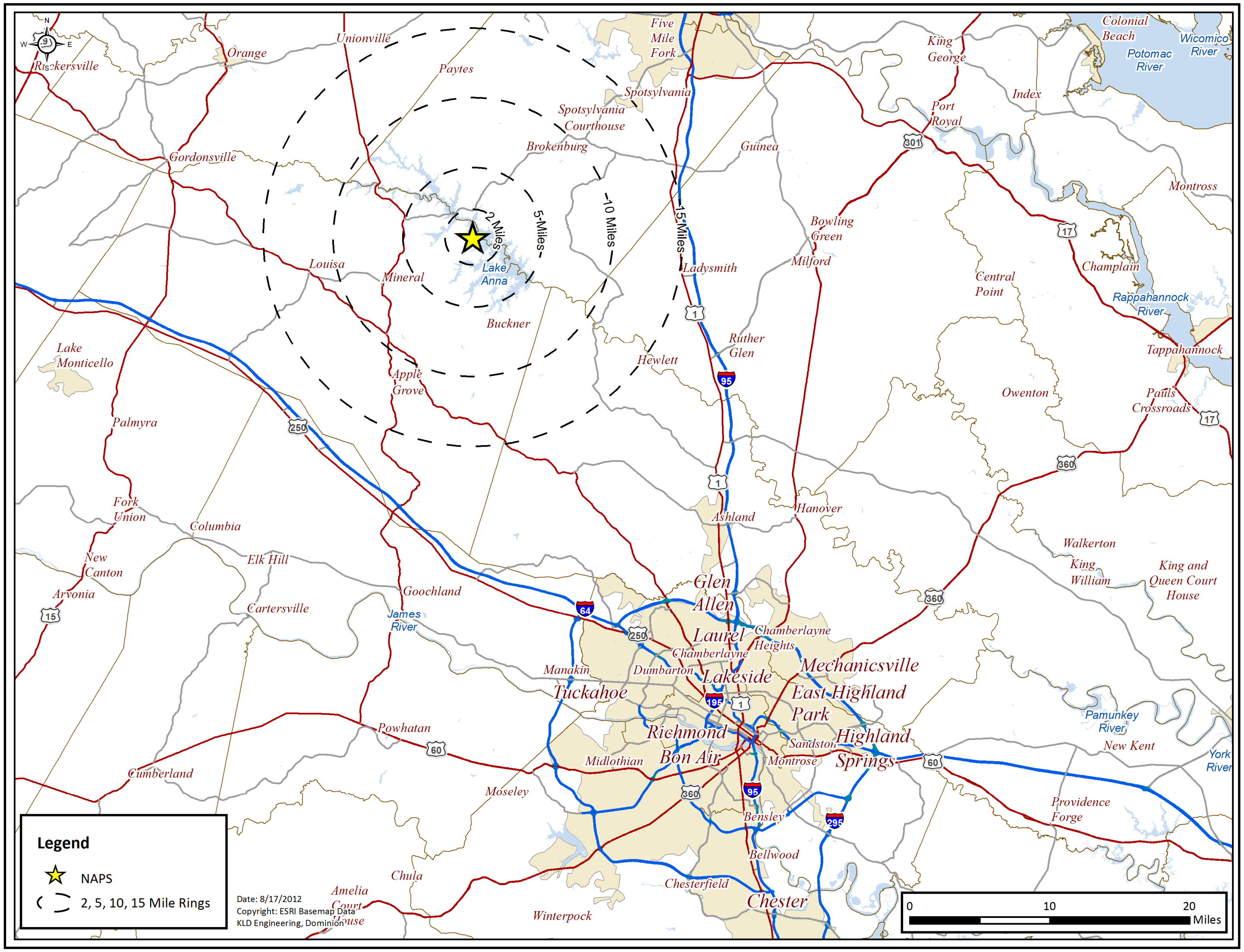

Figure 1-1. North Anna Power Station Location

1.3 Preliminary Activities

These activities are described below.

Field Surveys of the Highway Network

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

Table 1-2. Highway Characteristics

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

Video and audio recording equipment were used to capture a permanent record of the highway infrastructure. No attempt was made to meticulously measure such attributes as lane width and shoulder width; estimates of these measures based on visual observation and recorded images were considered appropriate for the purpose of estimating the capacity of highway sections. For example, Exhibit 15-7 in the HCM indicates that a reduction in lane width from 12 feet (the "base" value) to 10 feet can reduce free flow speed (FFS) by 1.1 mph – not a material difference – for two-lane highways. Exhibit 15-30 in the HCM shows little sensitivity for the estimates of Service Volumes at Level of Service (LOS) E (near capacity), with respect to FFS, for two-lane highways.

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

As documented on page 15-5 of the HCM 2010, the capacity of a two-lane highway is 1700 passenger cars per hour in one direction. For freeway sections, a value of 2250 vehicles per hour per lane is assigned, as per Exhibit 11-17 of the HCM 2010. The road survey has identified several segments which are characterized by adverse geometrics on two-lane highways which are reflected in reduced values for both capacity and speed. These estimates are consistent with the service volumes for LOS E presented in HCM Exhibit 15-30. These links may be identified by reviewing Appendix K. Link capacity is an input to DYNEV II which computes the ETE. Further discussion of roadway capacity is provided in Section 4 of this report.

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

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

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

Telephone Survey

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

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

Computing the Evacuation Time Estimates

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

Analytical Tools

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

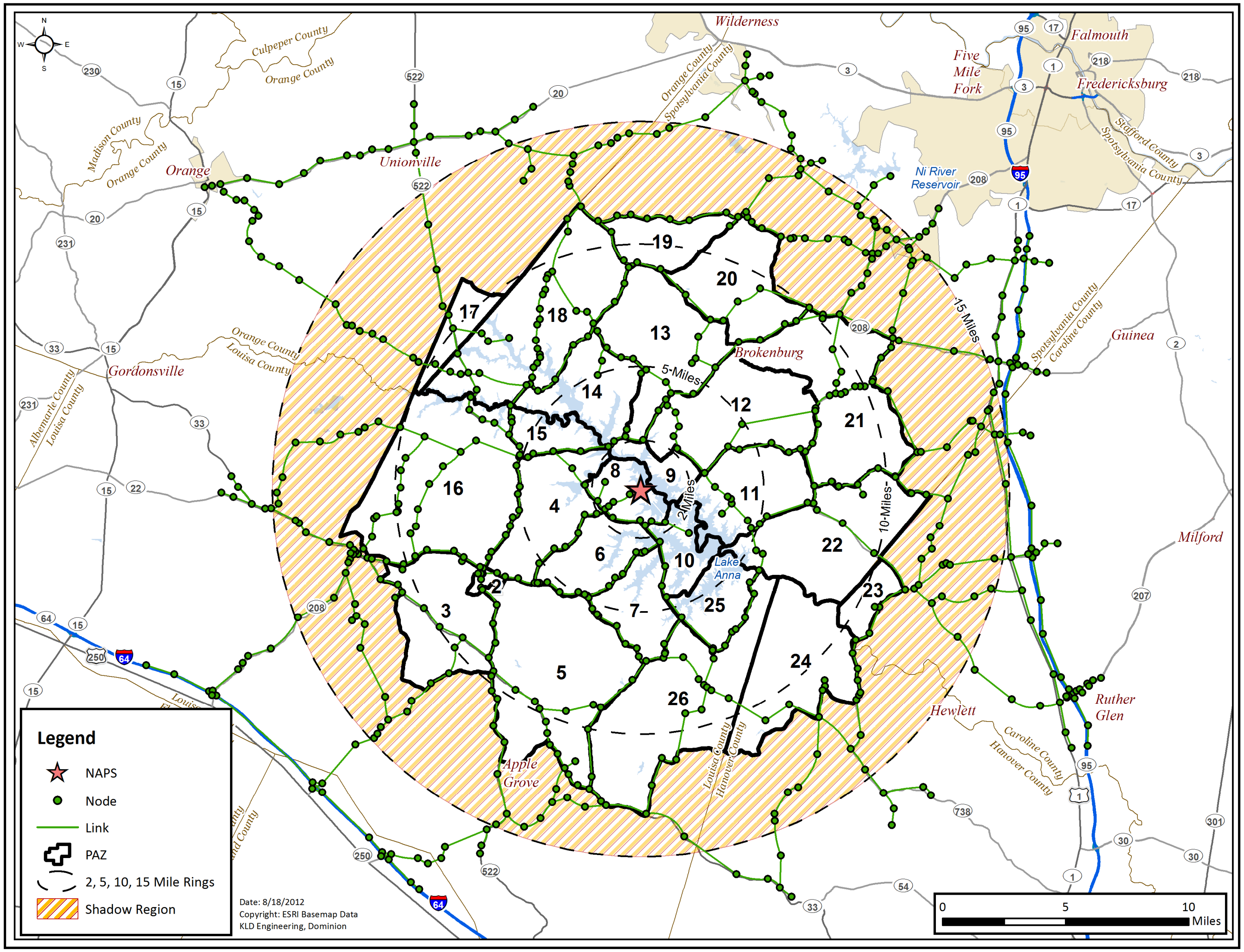

Figure 1-2. NAPS Link-Node Analysis Network

DYNEV II consists of four sub-models:

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

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

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

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

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

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

The evacuation analysis procedures are based upon the need to:

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

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 2008 study (Revision 1 of the 2007 COLA). The major factors contributing to the differences between the ETE values obtained in this study and those of the previous study can be summarized as follows:

- A decrease in permanent resident population (-24.6% between 2008 estimated population with 2010 Census).
- A decrease in the estimated number of transients in the EPZ.
- An increase in the level of detail of the link-node representation of the roadway network.
- Advances in the model have led to improvement in the ability to model the County TCP.

Table 1-3. ETE Study Comparisons

Topic	Previous ETE Study	Current ETE Study
Resident Population Basis	ArcGIS Software using county specific address shapefiles. 71.4% population growth between 2000 Census and estimated 2008 population. Population = 33,423	ArcGIS Software using 2010 US Census blocks; area ratio method used. Population = 25,202
Resident Population Vehicle Occupancy	2.57 persons/household, 1.42 evacuating vehicles/household yielding: 1.81 persons/vehicle	2.57 persons/household, 1.42 evacuating vehicles/household yielding: 1.81 persons/vehicle.
Employee Population	Employees treated as separate population group. Employee estimates based on information provided about major employers in EPZ. 1.03employees/vehicle based on phone survey results.	Employee estimates based on information provided and phone call made to major employers in the EPZ. 1.04[2] employees per vehicle based on telephone survey results. Employees = 788
Transit-Dependent Population	Estimates based upon U.S. Census data and the results of the telephone survey. A total of 478 people who do not have access to a vehicle, requiring 16 buses to evacuate.	Estimates based upon U.S. Census data and the results of the telephone survey. A total of 360 people who do not have access to a vehicle, requiring 12 buses to evacuate. An additional 191 homebound special needs persons needed special transportation to evacuate (171 required a bus, 20 required a wheelchair-accessible vehicle).

[2] Current study added park and ride commuters into the calculation for employee vehicle occupancy.

Topic	Previous ETE Study	Current ETE Study
Transient Population	Transient estimates based on data provided by the counties within the EPZ and through phone calls to the facilities. Transients = 10,438	Transient estimates based upon phone calls made to facilities, supplemented by observations of the facilities during the road survey and from aerial photography. Transients = 5,273 at recreational facilities and hotels + 1,724 seasonal residents = 6,997 total.
Special Facilities Population	No special facilities within the EPZ	Special facility population based upon phone call made to the one facility. Current census = 23 Buses Required = 1 Wheelchair Van Required = 1
School Population	School population based on data provided by the counties within the EPZ. School enrollment = 6,859 Vehicles originating at schools = 127	School population based on data provided by the counties within the EPZ, supplemented with 2011-2012 enrollment data from a Virginia State website. School enrollment = 6,427 Buses required = 113
Voluntary evacuation from within EPZ in areas outside region to be evacuated	50 percent of population within the outer portion of the region; 35 percent, in annular ring between the outer portion and the EPZ boundary (See Figure 2-1).	20 percent of the population within the EPZ, but not within the Evacuation Region (see Figure 2-1)
Shadow Evacuation	30% of people outside of the EPZ, within the shadow area (See Figure 7-2).	20% of people outside of the EPZ within the Shadow Region (See Figure 7-2).
Network Size	635 Links; 487 Nodes (See Figure 1-2).	856 links; 665 nodes (See Figure 1-2).
Roadway Geometric Data	Field surveys conducted in 2007. Major intersections were video archived. GIS shape-files of signal locations and roadway characteristics created during road survey. Road capacities based on 2000 HCM.	Field surveys conducted in February 2012. Roads and intersections were video archived. Road capacities based on 2010 HCM.
School Evacuation	Direct evacuation to designated Evacuation Assembly Center.	Direct evacuation to designated Evacuation Assembly Center.
Ridesharing	Assumed 50 percent of transit dependent persons will evacuate with a neighbor or friend.	Assumed 50 percent of transit dependent persons will evacuate with a neighbor or friend.

Topic	Previous ETE Study	Current ETE Study
Trip Generation for Evacuation	Trip generation curves based on residential telephone survey of specific pre-trip mobilization activities: Residents with commuters returning leave between 30 minutes and 5 hours; for snow scenarios this increases to between 30 minutes and 6 hours. Residents without commuters returning leave between 15 minutes and 4 hours; for snow scenarios this increases to between 15 minutes and 5 hours. Employees and transients leave between 15 minutes and 3 hours. All times measured from the Advisory to Evacuate.	Trip generation curves based on based on residential telephone survey of specific pre-trip mobilization activities: Residents with commuters returning leave between 30 and 330 minutes. Residents without commuters returning leave between 10 and 270 minutes. Employees and transients leave between 10 and 150 minutes. All times measured from the Advisory to Evacuate.
Weather	Normal, Rain, or Snow. The capacity and free flow speed of all links in the network are reduced by 10% in the event of rain and 20% for snow.	Normal, Rain, or Snow. The capacity and free flow speed of all links in the network are reduced by 10% in the event of rain and 20% for snow.
Modeling	IDYNEV System: TRAD and PCDYNEV.	DYNEV II System – Version 4.0.8.0
Special Events	Two considered – Construction of a new unit at NAPS with and without refueling of the operating units.	The Kinetic Triathlon Special Event Population = 1,100 additional transients.
Evacuation Cases	27 Regions (central sector wind direction and each adjacent sector technique used) and 14 Scenarios producing 378 unique cases.	41 Regions (central sector wind direction and each adjacent sector technique used) and 14 Scenarios producing 574 unique cases.
Evacuation Time Estimates Reporting	ETE reported for 50th, 90th, 95th, and 100th percentile population. Results presented by Region and Scenario.	ETE reported for 90^{th} and 100^{th} percentile population. Results presented by Region and Scenario.
Evacuation Time Estimates for the entire EPZ, 90^{th} percentile	Winter Weekday Midday, Good weather = 2:50 Summer Weekend Midday, Good weather = 3:00	Winter Weekday Midday, Good Weather = 2:40 Summer Weekend, Midday, Good Weather = 2:00

2 STUDY ESTIMATES AND ASSUMPTIONS

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

2.1 Data Estimates

1. Population estimates are based upon Census 2010 data.
2. Estimates of employees who reside outside the EPZ and commute to work within the EPZ are based upon data provided by Dominion and data obtained from a telephone call to the other major employer in the EPZ, Tri-Dim Filters.
3. Population estimates at special facilities are based on available data from county emergency management departments and from phone calls to specific facilities.
4. Roadway capacity estimates are based on field surveys and the application of the Highway Capacity Manual 2010.
5. Population mobilization times are based on a statistical analysis of data acquired from a random sample telephone survey of EPZ residents (see Section 5 and Appendix F).
6. The relationship between resident population and evacuating vehicles is developed from the telephone survey. Average values of 2.57 persons per household and 1.42 evacuating vehicles per household are used. The relationship between persons and vehicles for transients and employees is as follows:
    a. Employees: 1.04 employees per vehicle (telephone survey results) for all major employers.
    b. Recreational areas: Vehicle occupancy varies based upon data gathered from local transient facilities.
    c. Special Events: Kinetic Triathlon at Lake Anna State Park includes 1,100 additional transients traveling in 249 vehicles, equating to an occupancy of 4.4 people/vehicle.

2.2 Study Methodological Assumptions

1. ETE are presented for the evacuation of the 90th and 100th percentiles of population for each Region and for each Scenario. The percentile ETE is defined as the elapsed time from the Advisory to Evacuate issued to a specific Region of the EPZ, to the time that Region is clear of the indicated percentile of evacuees. A Region is defined as a group of PAZ that is issued an Advisory to Evacuate. A scenario is a combination of circumstances, including time of day, day of week, season, and weather conditions.
2. The ETE are computed and presented in tabular format and graphically, in a format compliant with NUREG/CR-7002.
3. Evacuation movements (paths of travel) are generally outbound relative to the plant to the extent permitted by the highway network. All major evacuation routes are used in the analysis.
4. Regions are defined by the underlying "keyhole" or circular configurations as specified in Section 1.4 of NUREG/CR-7002. These Regions, as defined, display irregular boundaries reflecting the geography of the PAZ included within these underlying configurations.
5. As indicated in Figure 2-2 of NUREG/CR-7002, 100% of people within the impacted "keyhole" evacuate. 20% of those people within the EPZ, not within the impacted keyhole, will voluntarily evacuate. 20% of those people within the Shadow Region will voluntarily evacuate. See Figure 2-1 for a graphical representation of these evacuation percentages. Sensitivity studies explore the effect on ETE of increasing the percentage of voluntary evacuees in the Shadow Region (see Appendix M).
6. A total of 14 "Scenarios" representing different temporal variations (season, time of day, day of week) and weather conditions are considered. These Scenarios are outlined in Table 2-1.
7. Scenario 14 considers the closure of a northbound segment of US-522 north of the intersection with CR-612.
8. The models of the I-DYNEV System were recognized as state of the art by the Atomic Safety & Licensing Board (ASLB) in past hearings. (Sources: Atomic Safety & Licensing Board Hearings on Seabrook and Shoreham; Urbanik[1]). The models have continuously been refined and extended since those hearings and were independently validated by a consultant retained by the NRC. The new DYNEV II model incorporates the latest technology in traffic simulation and in dynamic traffic assignment.

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

Table 2-1. Evacuation Scenario Definitions

Scenario	Season[2]	Day of Week	Time of Day	Weather	Special
1	Summer	Midweek	Midday	Good	None
2	Summer	Midweek	Midday	Rain	None
3	Summer	Weekend	Midday	Good	None
4	Summer	Weekend	Midday	Rain	None
5	Summer	Midweek, Weekend	Evening	Good	None
6	Winter	Midweek	Midday	Good	None
7	Winter	Midweek	Midday	Rain	None
8	Winter	Midweek	Midday	Snow	None
9	Winter	Weekend	Midday	Good	None
10	Winter	Weekend	Midday	Rain	None
11	Winter	Weekend	Midday	Snow	None
12	Winter	Midweek, Weekend	Evening	Good	None
13	Winter	Weekend	Midday	Good	Kinetic Triathlon at Lake Anna State Park
14	Summer	Midweek	Midday	Good	Roadway Impact – One Segment of US-522 NB will be Closed

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

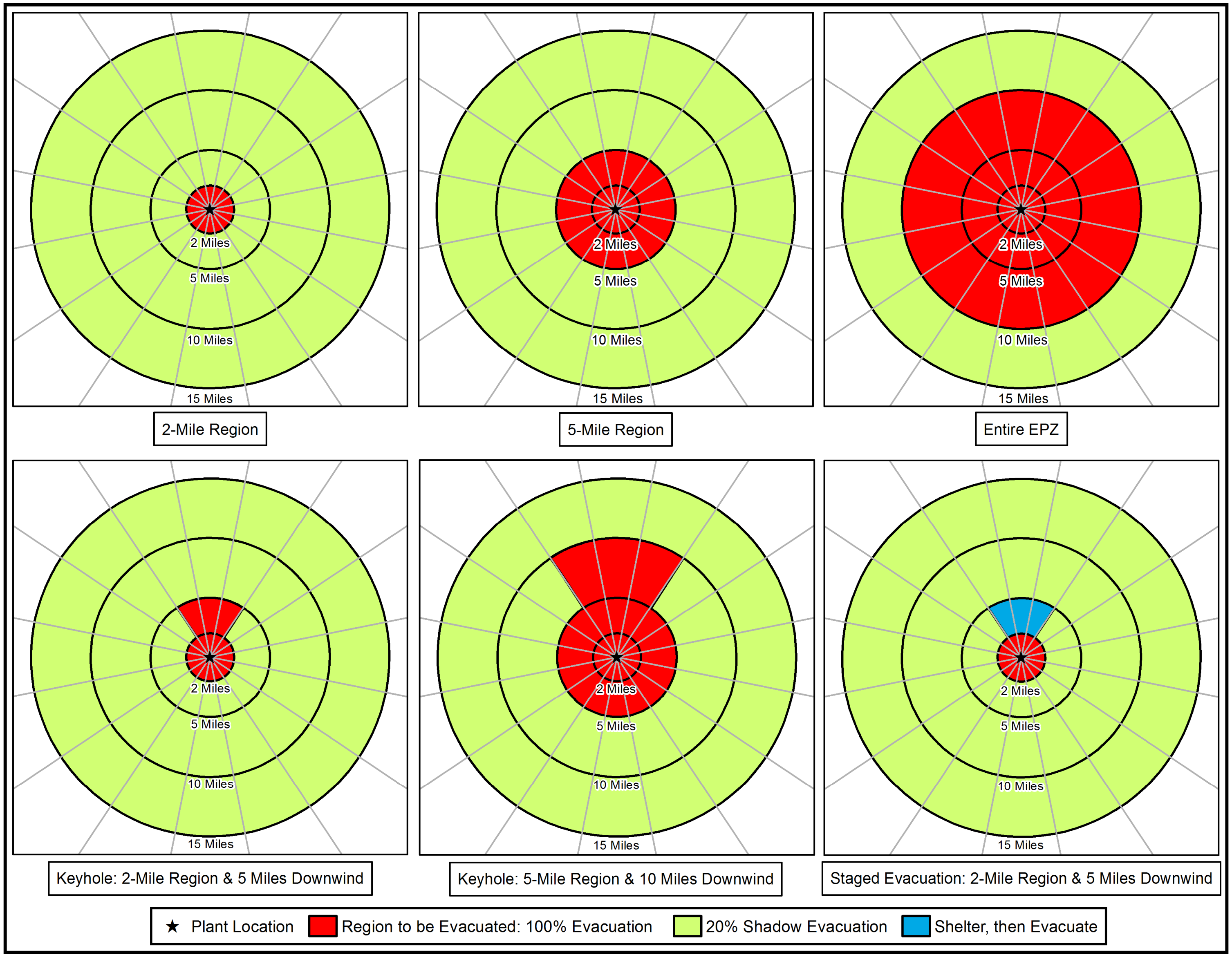

Figure 2-1. Voluntary Evacuation Methodology

2.3 Study Assumptions

1. The Planning Basis Assumption for the calculation of ETE is a rapidly escalating accident that requires evacuation, and includes the following:
    a. Advisory to Evacuate is announced coincident with the siren notification.
    b. Mobilization of the general population will commence within 15 minutes after siren notification.
    c. ETE are measured relative to the Advisory to Evacuate.
2. It is assumed that everyone within the group of PAZ forming a Region that is issued an Advisory to Evacuate will, in fact, respond and evacuate in general accord with the planned routes.
3. 59 percent of the households in the EPZ have at least 1 commuter; 61 percent of those households with commuters will await the return of a commuter before beginning their evacuation trip, based on the telephone survey results. Therefore 36 percent (59% x 61% = 36%) of EPZ households will await the return of a commuter, prior to beginning their evacuation trip.
4. The ETE will also include consideration of "through" (External-External) trips during the time that such traffic is permitted to enter the evacuated Region. "Normal" traffic flow is assumed to be present within the EPZ at the start of the emergency.
5. Access Control Points (ACP) will be staffed within approximately 120 minutes following the siren notifications, to divert traffic attempting to enter the EPZ. Earlier activation of ACP locations could delay returning commuters. It is assumed that no through traffic will enter the EPZ after this 120 minute time period.
6. Traffic Control Points (TCP) within the EPZ will be staffed over time, beginning at the Advisory to Evacuate. Their number and location will depend on the Region to be evacuated and resources available. The objectives of these TCP are:
    a. Facilitate the movements of all (mostly evacuating) vehicles at the location.
    b. Discourage inadvertent vehicle movements towards the plant.
    c. Provide assurance and guidance to any traveler who is unsure of the appropriate actions or routing.
    d. Act as local surveillance and communications center.
    e. Provide information to the emergency operations center (EOC) as needed, based on direct observation or on information provided by travelers.

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

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

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

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[3] Institute for Environmental Studies, University of Toronto, THE MISSISSAUGA EVACUATION FINAL REPORT, June 1981. The report indicates that 6,600 people of a transit-dependent population of 8,600 people shared rides with other residents; a ride share rate of 76% (Page 5-10).

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

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

Table 2-2. Model Adjustment for Adverse Weather

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

3 DEMAND ESTIMATION

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

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

Appendix E presents much of the source material for the population estimates. Our primary source of population data, the 2010 Census, however, is not adequate for directly estimating some transient groups.

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

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

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

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

Analysis of the population characteristics of the North Anna Power Station EPZ indicates the need to identify three distinct groups:

- Permanent residents - people who are year round residents of the EPZ.
- Transients - people who reside outside of the EPZ who enter the area for a specific purpose (shopping, recreation) and then leave the area.
- Seasonal residents – people who are residents of the EPZ during the summer months but are not included in the permanent resident census numbers.
- Employees - people who reside outside of the EPZ and commute to businesses within the EPZ on a daily basis.

Estimates of the population and number of evacuating vehicles for each of the population groups are presented for each PAZ and by polar coordinate representation (population rose). The NAPS EPZ is subdivided into 25 PAZ. The EPZ is shown in Figure 3-1.

3.1 Permanent Residents

The primary source for estimating permanent population is the latest U.S. Census data. The average household size (2.57 persons/household – See Figure F-1) and the number of evacuating vehicles per household (1.42 vehicles/household – See Figure F-8) were adapted from the telephone survey results.

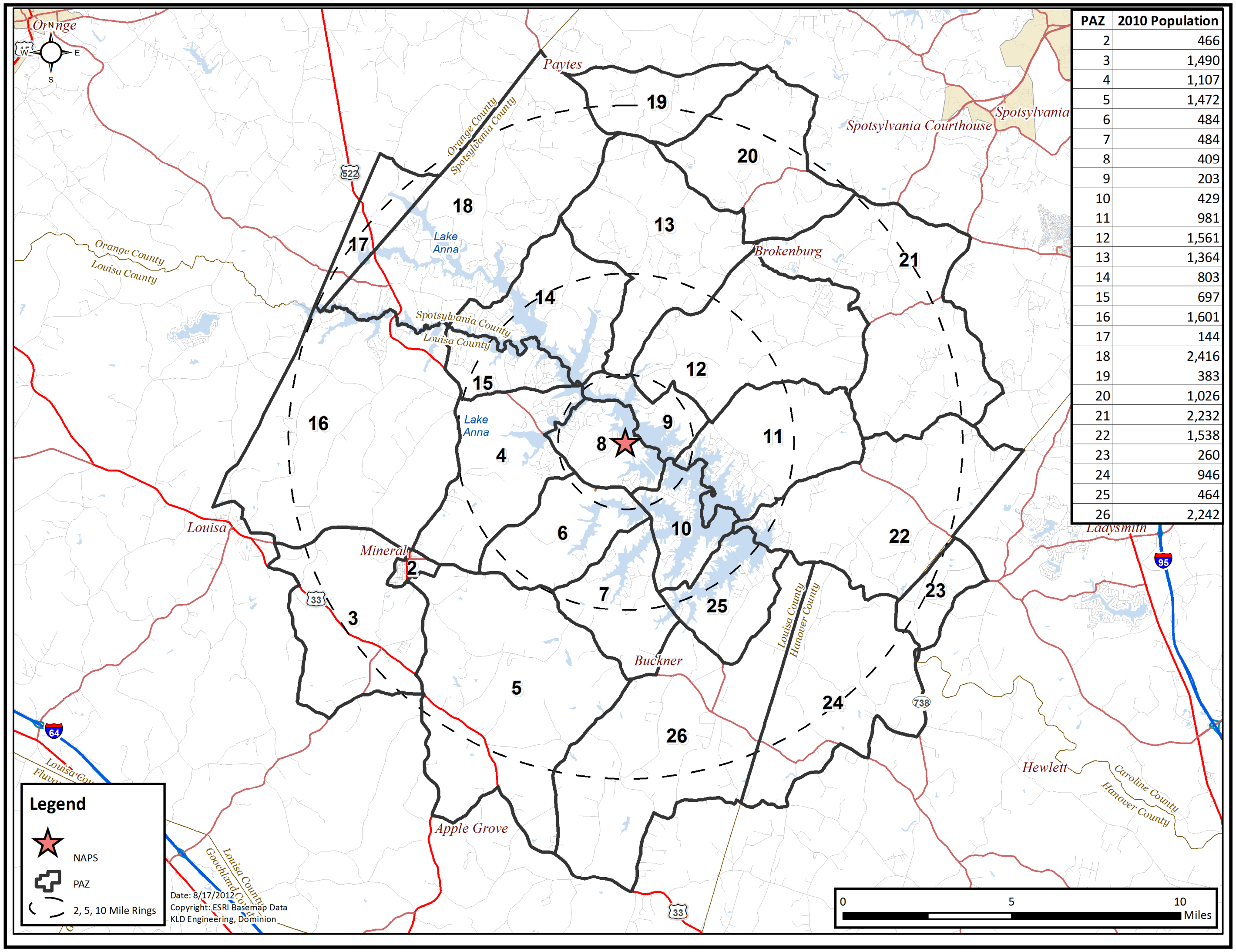
Population estimates are based upon Census 2010 data. The estimates are created by cutting the census block polygons by the PAZ and EPZ boundaries. A ratio of the original area of each census block and the updated area (after cutting) is multiplied by the total block population to estimate what the population is within the EPZ. This methodology assumes that the population is evenly distributed across a census block. Table 3-1 provides the permanent resident population within the EPZ, by PAZ based on this methodology.

The year 2010 permanent resident population is divided by the average household size and then multiplied by the average number of evacuating vehicles per household in order to estimate number of vehicles. Permanent resident population and vehicle estimates are presented in 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 NAPS. This "rose" was constructed using GIS software.

It can be argued that this estimate of permanent residents overstates, somewhat, the number of evacuating vehicles, especially during the summer. It is certainly reasonable to assert that some portion of the population would be on vacation during the summer and would travel elsewhere. A rough estimate of this reduction can be obtained as follows:

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

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



PAZ	2010 Population
2	466
3	1,490
4	1,107
5	1,472
6	484
7	484
8	409
9	203
10	429
11	981
12	1,561
13	1,364
14	803
15	697
16	1,601
17	144
18	2,416
19	383
20	1,026
21	2,232
22	1,538
23	260
24	946
25	464
26	2,242

Figure 3-1. NAPS EPZ

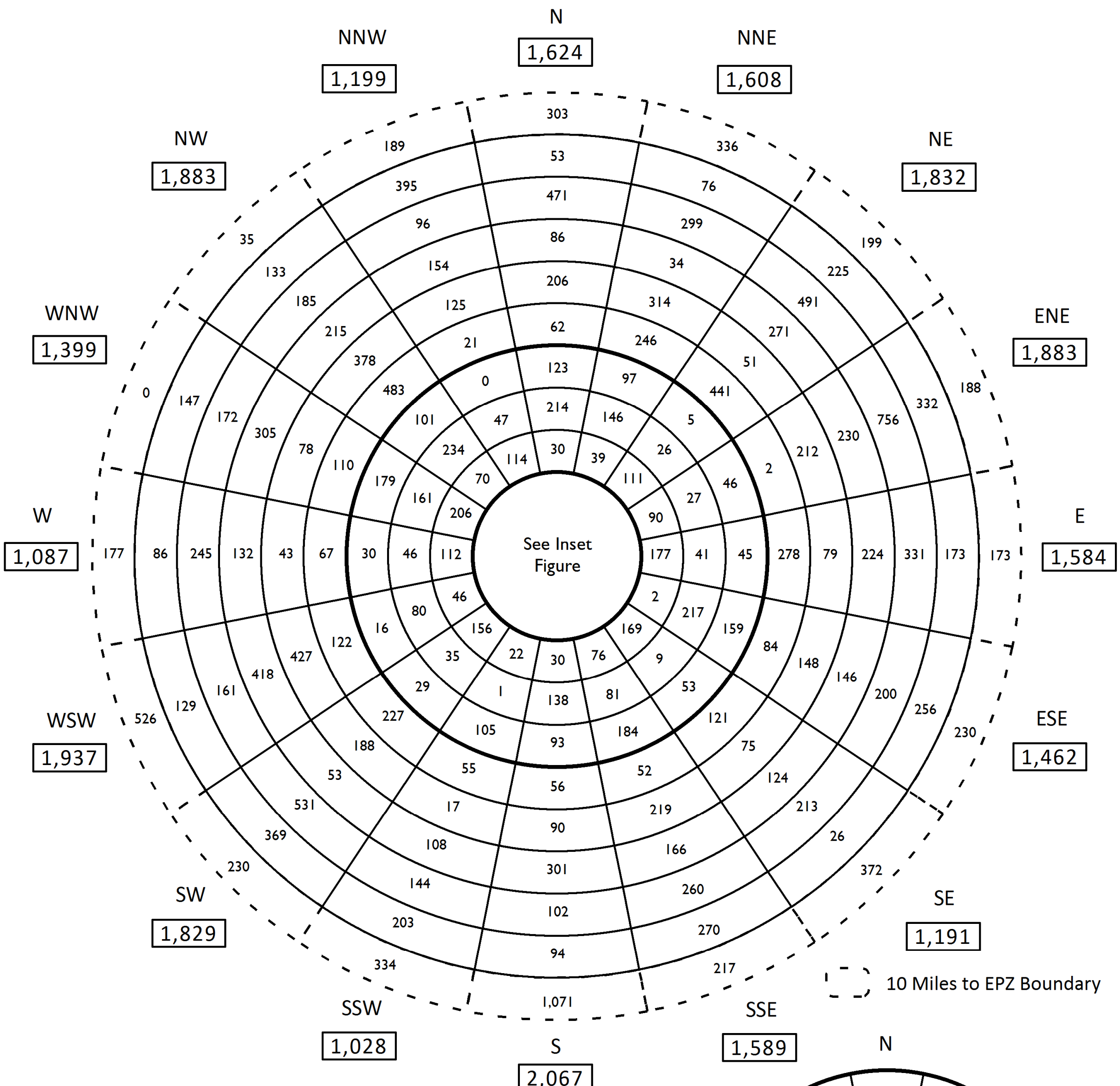
Table 3-1. EPZ Permanent Resident Population

PAZ	2000 Population	2008 Population (Estimated)[1]	2010 Population
2	418	645	466
3	1,241	1,843	1,490
4	837	1,842	1,107
5	1,331	1,740	1,472
6	308	727	484
7	318	939	484
8	287	885	409
9	117	426	203
10	245	1,151	429
11	740	1,345	981
12	1,222	1,467	1,561
13	991	1,312	1,364
14	541	1,719	803
15	451	1,589	697
16	1,138	2,153	1,601
17	50	223	144
18	1,664	3,624	2,416
19	246	352	383
20	894	1,025	1,026
21	1,901	2,125	2,232
22	1,355	1,639	1,538
23	263	341	260
24	716	989	946
25	312	902	464
26	1,729	2,420	2,242
TOTAL	**19,315**	**33,423**	**25,202**
EPZ Population Growth:		**2000-2010**	**30.48%**
EPZ Population Difference:		**2008-2010**	**-24.60%**

Notes: 1 - 2008 COLA ETE – Resident address points within each county (except Caroline County) were provided by VDEM. Average household size from telephone survey (2.57) was used to determine 2008 EPZ population. 2000 Census projected to 2008 using county growth rate was used for Caroline County.

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

PAZ	2010 Population	2010 Resident Vehicles
2	466	259
3	1,490	826
4	1,107	613
5	1,472	817
6	484	266
7	484	267
8	409	228
9	203	113
10	429	236
11	981	543
12	1,561	861
13	1,364	754
14	803	444
15	697	385
16	1,601	889
17	144	79
18	2,416	1,333
19	383	212
20	1,026	568
21	2,232	1,239
22	1,538	818
23	260	144
24	946	525
25	464	257
26	2,242	1,239
TOTAL	**25,202**	**13,915**



Resident Population

Miles	Subtotal by Ring	Cumulative Total
0 - 1	12	12
1 - 2	724	736
2 - 3	1,450	2,186
3 - 4	1,503	3,689
4 - 5	1,265	4,954
5 - 6	2,427	7,381
6 - 7	2,650	10,031
7 - 8	2,967	12,998
8 - 9	4,657	17,655
9 - 10	2,967	20,622
10 - EPZ	4,580	25,202
	Total:	25,202

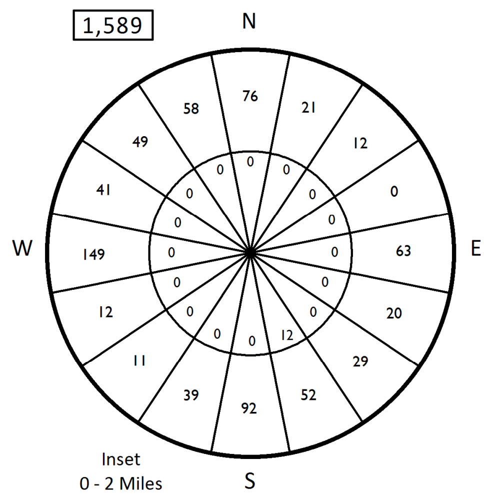
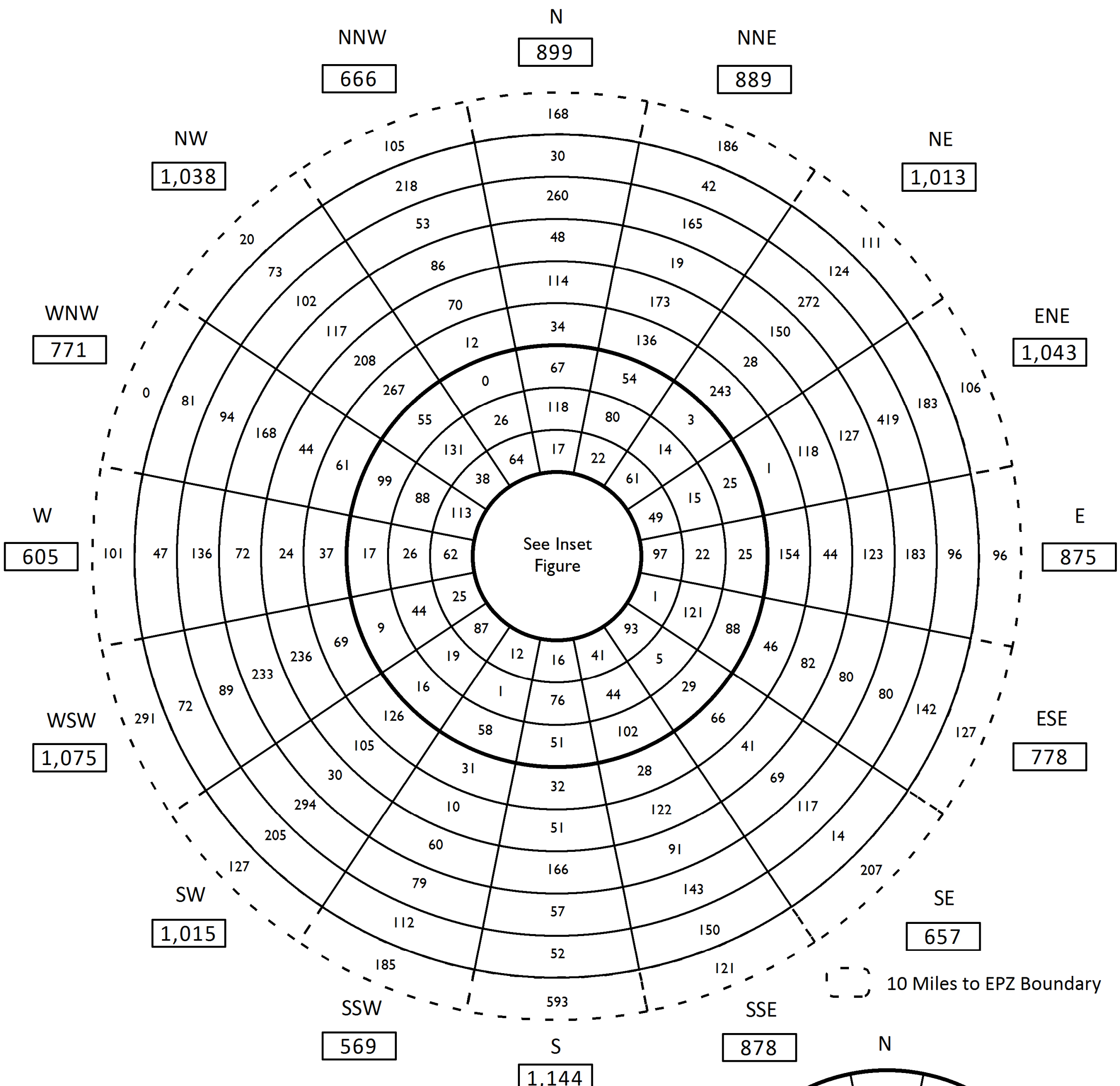


Figure 3-2. Permanent Resident Population by Sector



Resident Vehicles

Miles	Subtotal by Ring	Cumulative Total
0 - 1	7	7
1 - 2	402	409
2 - 3	798	1,207
3 - 4	830	2,037
4 - 5	698	2,735
5 - 6	1,343	4,078
6 - 7	1,470	5,548
7 - 8	1,639	7,187
8 - 9	2,543	9,730
9 - 10	1,641	11,371
10 - EPZ	2,544	13,915
	Total:	13,915

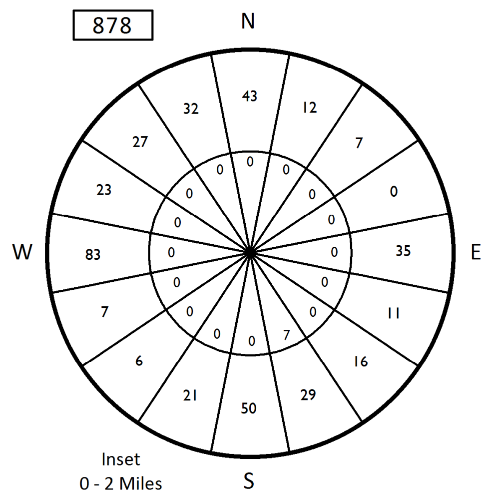


Figure 3-3. Permanent Resident Vehicles by Sector

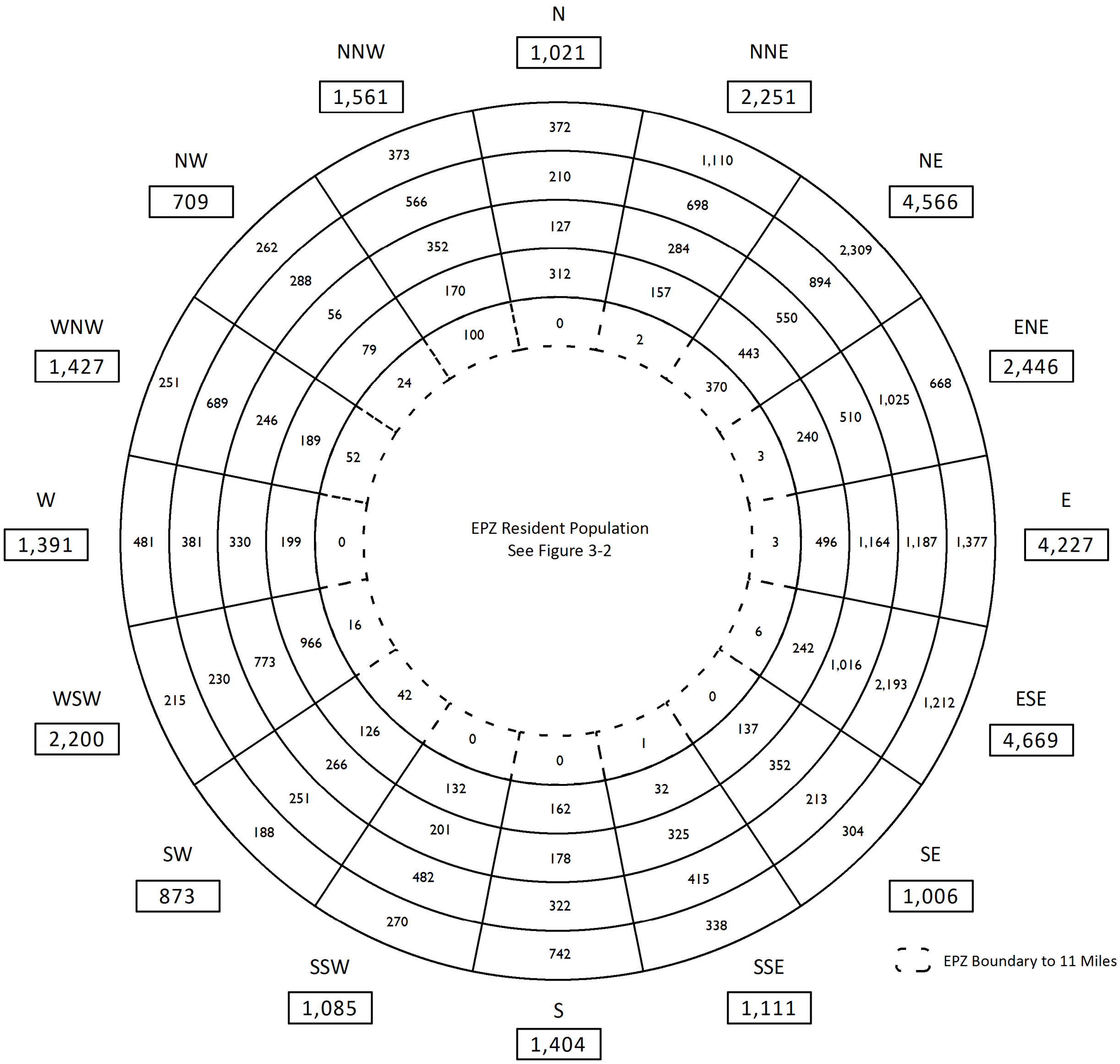
3.2 Shadow Population

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

Shadow population characteristics (household size, evacuating vehicles per household, mobilization time) are assumed to be the same as that for the EPZ permanent resident population. Table 3-3, Figure 3-4, and Figure 3-5 present estimates of the shadow population and vehicles, by sector.

Table 3-3. Shadow Population and Vehicles by Sector

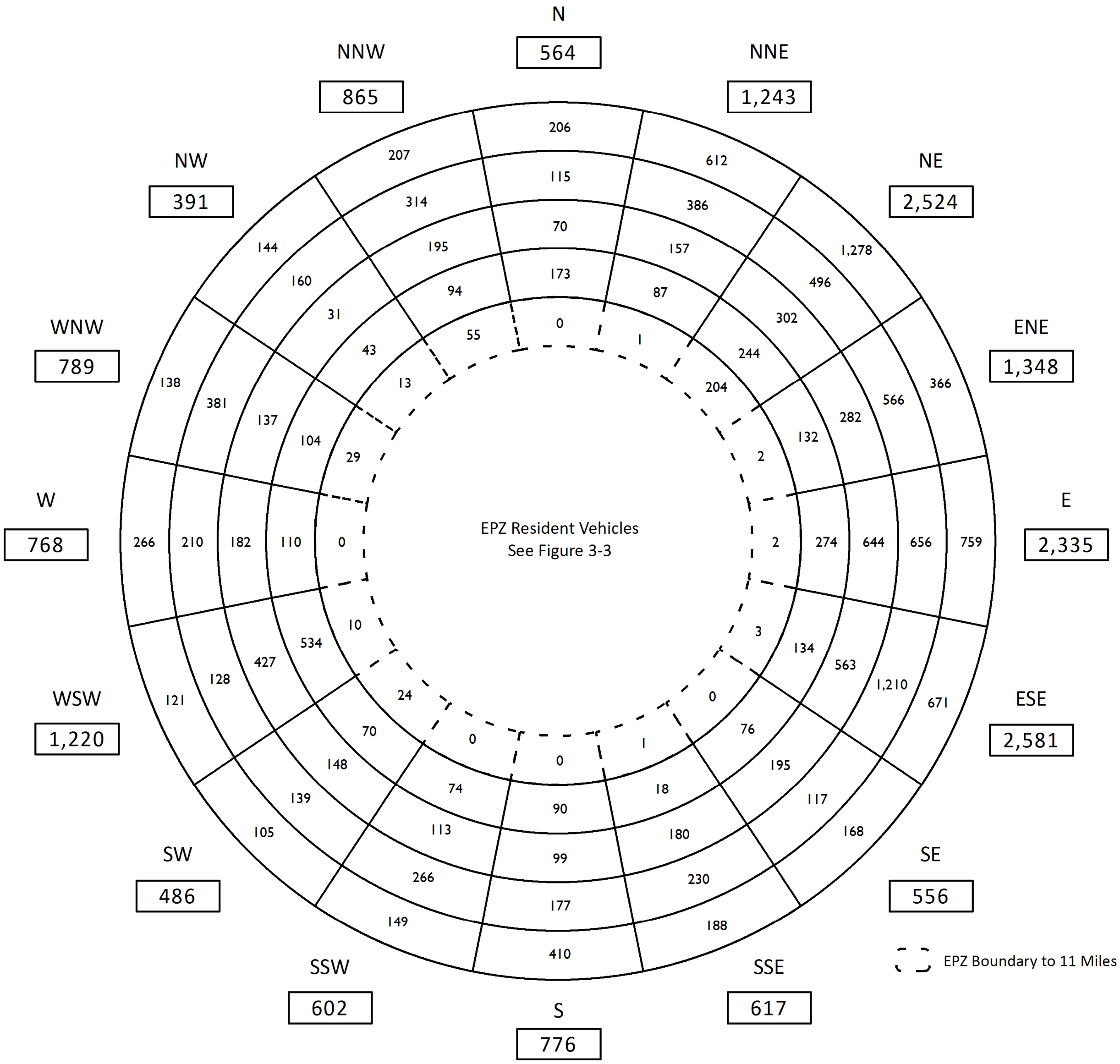
Sector	Population	Evacuating Vehicles
N	1,021	564
NNE	2,251	1,243
NE	4,566	2,524
ENE	2,446	1,348
E	4,227	2,335
ESE	4,669	2,581
SE	1,006	556
SSE	1,111	617
S	1,404	776
SSW	1,085	602
SW	873	486
WSW	2,200	1,220
W	1,391	768
WNW	1,427	789
NW	709	391
NNW	1,561	865
TOTAL	**31,947**	**17,665**



Shadow Population

Miles	Subtotal by Ring	Cumulative Total
EPZ - 11	619	619
11 - 12	4,082	4,701
12 - 13	6,730	11,431
13 - 14	10,044	21,475
14 - 15	10,472	31,947
	Total:	31,947

Figure 3-4. Shadow Population by Sector



Shadow Vehicles

Miles	Subtotal by Ring	Cumulative Total
EPZ - 11	344	344
11 - 12	2,257	2,601
12 - 13	3,725	6,326
13 - 14	5,551	11,877
14 - 15	5,788	17,665
	Total:	17,665

Figure 3-5. Shadow Vehicles by Sector

3.3 Transient Population

Transient population groups are defined as those people (who are not permanent residents, nor commuting employees) who enter the EPZ for a specific purpose (shopping, recreation). Transients may spend less than one day or stay overnight at camping facilities, hotels and motels. The NAPS EPZ has a number of areas and facilities that attract transients, including:

- Campgrounds
- State Parks
- Marinas
- Lodging Facilities
- Seasonal Summer Homes on Lake Anna

Data were gathered through phone calls placed to individual facilities within the EPZ. Data from the 2008 ETE report (Revision 1 of the 2007 COLA) was used for facilities where data was unable to be collected.

There are two campgrounds within the EPZ. Phone calls were made to determine the number of campsites, peak occupancy and the number of vehicles and people per campsite for each facility. Data from the 2008 ETE report was used for Christopher Run Campground in Mineral. A total of 2,298 transients and 899 vehicles are assigned to campgrounds in the EPZ.

Data gathered from Lake Anna State Park were used to estimate the number of transients and evacuating vehicles at this facility. A total of 1,920 transients and 480 vehicles are assigned to this facility.

There are seven marinas within the EPZ. Phone calls were made to determine the peak season and peak daily attendance. These data were used to estimate the number of transients and evacuating vehicles at each of these facilities. Data from the 2008 ETE report was used for High Point Marina. A total of 994 transients and 456 vehicles are assigned to this facility.

There are four lodging facilities (all smaller hotels/bed and breakfasts) within the EPZ. Phone calls were made to determine the number of rooms, percentage of occupied rooms at peak times and the number of people and vehicles per room for each facility. These data were used to estimate the number of transients and evacuating vehicles at each of these facilities. Data from the 2008 ETE report was used for Rockland Farm Retreat. A total of 61 transients and 44 vehicles are assigned to lodging facilities in the EPZ.

Appendix E summarizes the transient data that was estimated for the EPZ. Table E-4 presents the number of transients visiting marinas within the EPZ, Table E-5 presents the number of transients at visiting campground within the EPZ, Table E-6 presents the number of transients visiting State Parks within the EPZ and Table E-7 presents the number of transients visiting lodging facilities within the EPZ.

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

The methodology behind calculating the seasonal population involves using 2010 Census Block data. Each Census Block includes information regarding the number of vacant and occupied households. Using this Census data, an average vacant household percentage (23%) was calculated for the entire NAPS EPZ.

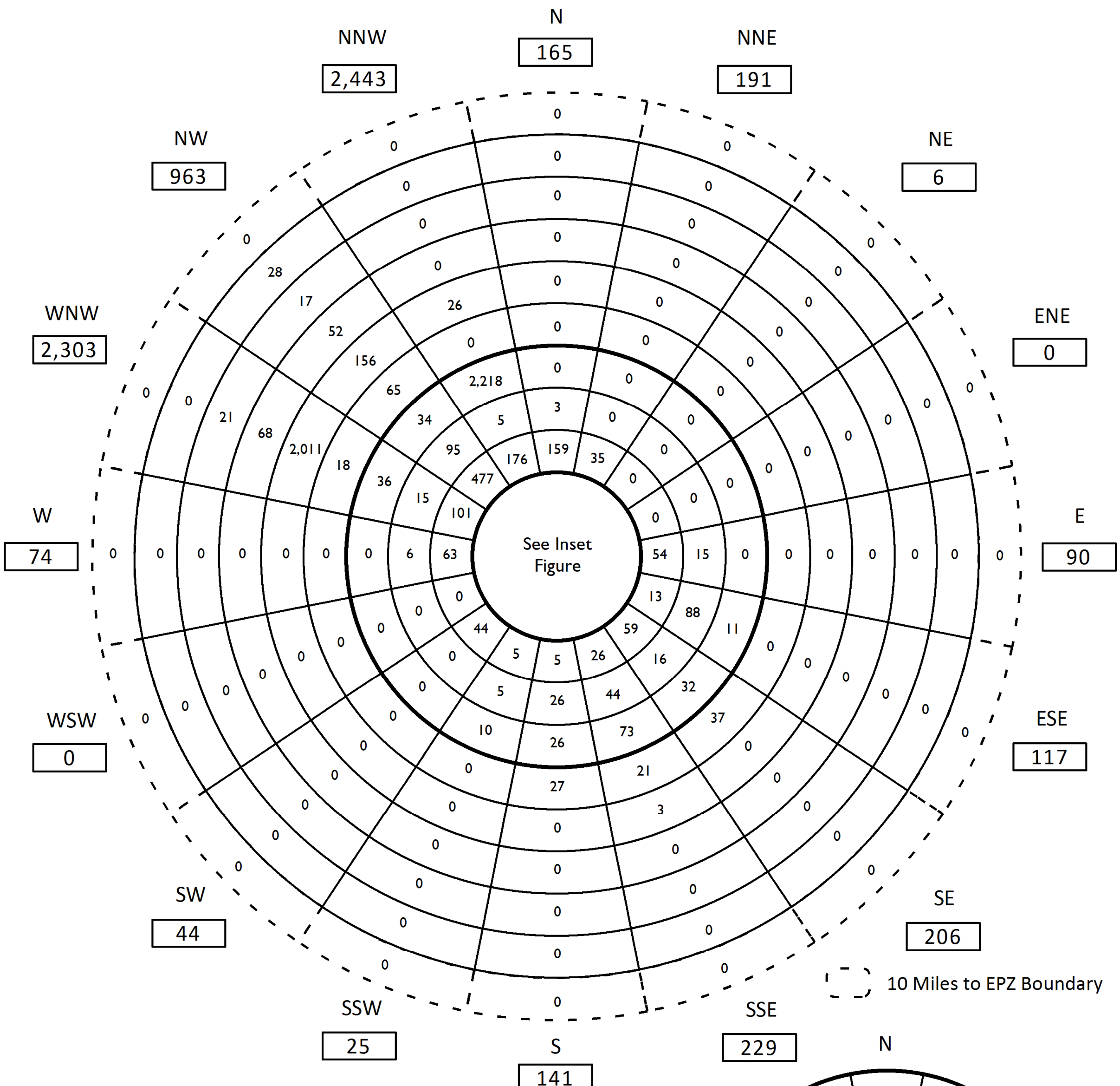
It is assumed that seasonal residents will be renting homes near the Lake Anna shoreline. Using only those Census blocks that are within one-half mile of the shoreline, the number of seasonal homes will be calculated. In order to normalize the data, the average vacant household percentage for the entire EPZ (23%) was subtracted from the percent vacancy for each individual census block. To determine the seasonal population, the remaining households from the analysis are considered to be seasonal households. An average household size of 2.57 persons per household is used to determine the seasonal transient population, and 1.42 evacuating vehicles per seasonal household is used to determine the number of seasonal transient vehicles. These numbers are adapted from the telephone survey results (see Appendix F).

It is estimated that there is an additional seasonal population of 1,724 transients traveling in 922 vehicles within the NAPS EPZ. Factoring in seasonal transients, there are a total of 6,997 (5,273+1,724) transients traveling in 2,801 vehicles (1,879+922) within the NAPS EPZ. These numbers are included in Table 3-4 as well as Figure 3-6 and Figure 3-7.

Table 3-4 presents 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.

Table 3-4. Summary of Transients and Transient Vehicles

PAZ	Transients	Transient Vehicles	Seasonal Transients	Seasonal Transient Vehicles
2	0	0	0	0
3	0	0	0	0
4	0	0	165	87
5	0	0	0	0
6	0	0	72	40
7	0	0	102	54
8	0	0	213	118
9	150	100	36	16
10	0	0	231	125
11	58	24	128	68
12	167	58	3	1
13	27	27	0	0
14	2,773	831	104	56
15	0	0	262	145
16	2,000	800	74	38
17	0	0	5	3
18	98	39	197	103
19	0	0	0	0
20	0	0	0	0
21	0	0	0	0
22	0	0	8	4
23	0	0	0	0
24	0	0	0	0
25	0	0	124	64
26	0	0	0	0
TOTAL	**5,273**	**1,879**	**1,724**	**922**



Transients

Miles	Subtotal by Ring	Cumulative Total
0 - 1	5	5
1 - 2	467	472
2 - 3	1,217	1,689
3 - 4	318	2,007
4 - 5	2,440	4,447
5 - 6	168	4,615
6 - 7	2,196	6,811
7 - 8	120	6,931
8 - 9	38	6,969
9 - 10	28	6,997
10 - EPZ	0	6,997
	Total:	6,997

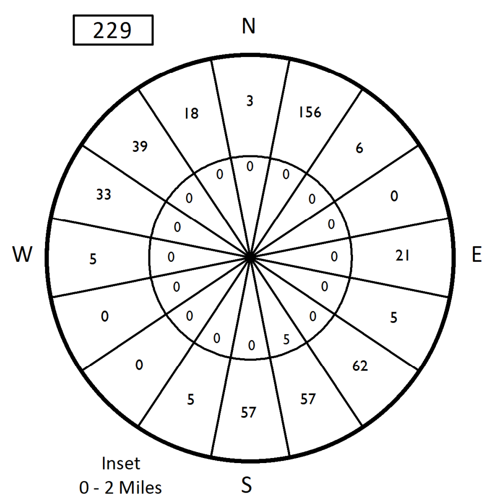
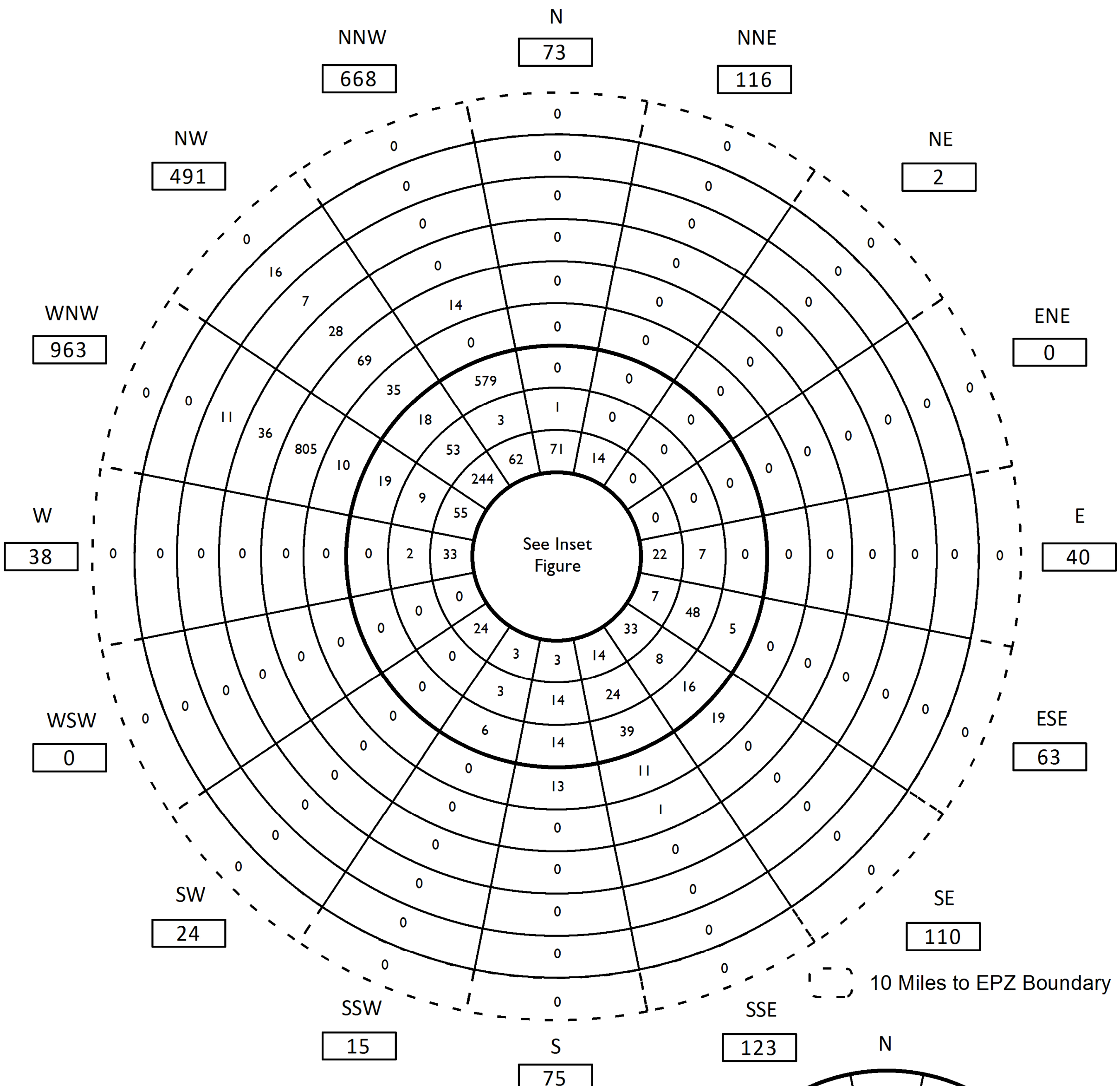


Figure 3-6. Transient Population by Sector



Transient Vehicles

Miles	Subtotal by Ring	Cumulative Total
0 - 1	3	3
1 - 2	270	273
2 - 3	585	858
3 - 4	172	1,030
4 - 5	696	1,726
5 - 6	88	1,814
6 - 7	889	2,703
7 - 8	64	2,767
8 - 9	18	2,785
9 - 10	16	2,801
10 - EPZ	0	2,801
	Total:	2,801

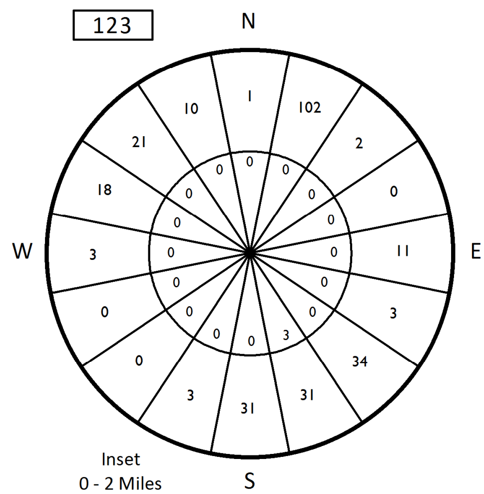


Figure 3-7. Transient Vehicles by Sector

3.4 Employees

Employees who work within the EPZ fall into two categories:

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

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

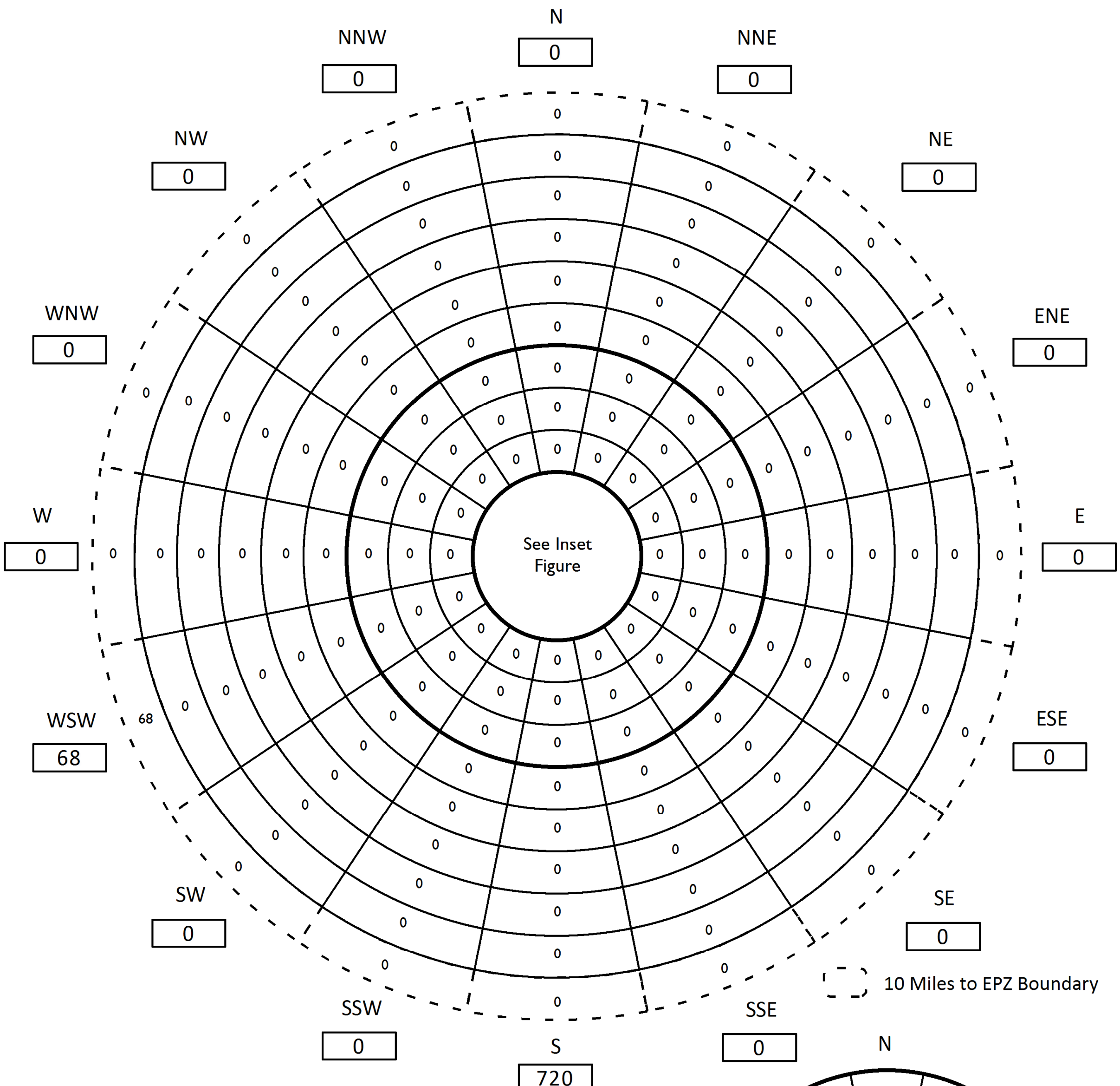
There are two major employers within the EPZ, North Anna Power Station and Tri-Dim Filters. Data provided by Dominion and a phone call made to Tri-Dim Filters were used to estimate the number of employees commuting into the EPZ.

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

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

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

PAZ	Employees	Employee Vehicles
2	0	0
3	68	65
4	0	0
5	0	0
6	0	0
7	0	0
8	720	692
9	0	0
10	0	0
11	0	0
12	0	0
13	0	0
14	0	0
15	0	0
16	0	0
17	0	0
18	0	0
19	0	0
20	0	0
21	0	0
22	0	0
23	0	0
24	0	0
25	0	0
26	0	0
TOTAL	**788**	**757**



Employees

Miles	Subtotal by Ring	Cumulative Total
0 - 1	720	720
1 - 2	0	720
2 - 3	0	720
3 - 4	0	720
4 - 5	0	720
5 - 6	0	720
6 - 7	0	720
7 - 8	0	720
8 - 9	0	720
9 - 10	0	720
10 - EPZ	68	788
	Total:	788

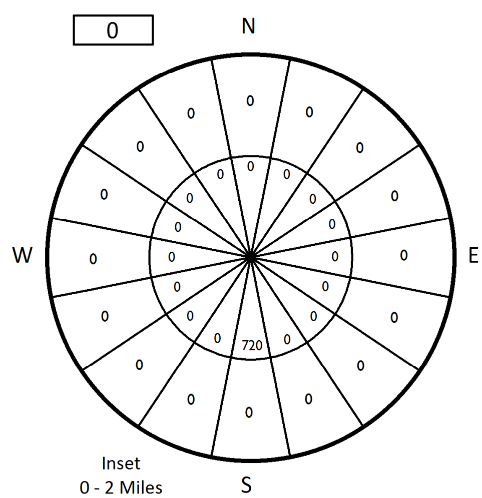
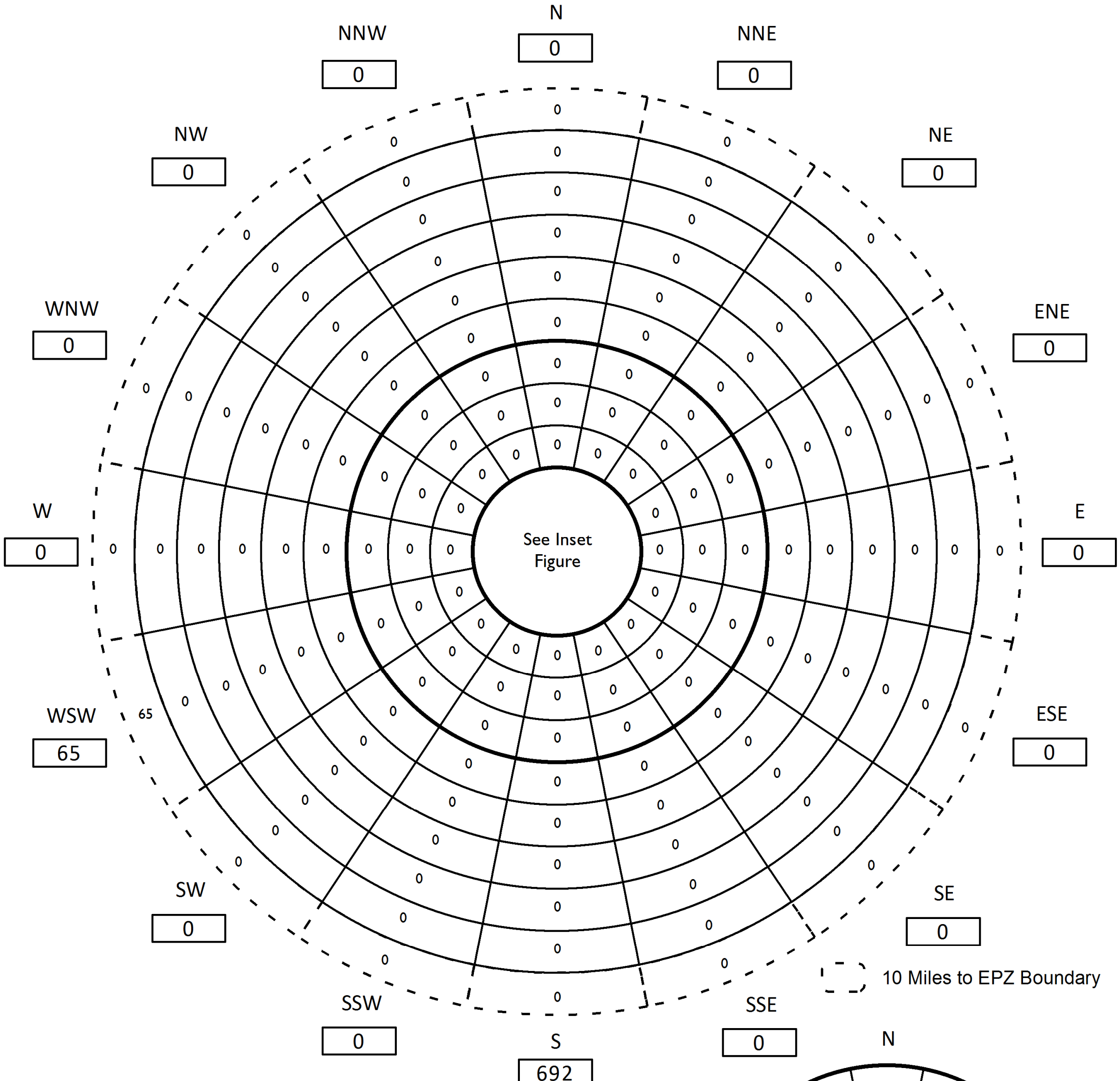


Figure 3-8. Employee Population by Sector



Employee Vehicles

Miles	Subtotal by Ring	Cumulative Total
0 - 1	692	692
1 - 2	0	692
2 - 3	0	692
3 - 4	0	692
4 - 5	0	692
5 - 6	0	692
6 - 7	0	692
7 - 8	0	692
8 - 9	0	692
9 - 10	0	692
10 - EPZ	65	757
	Total:	757

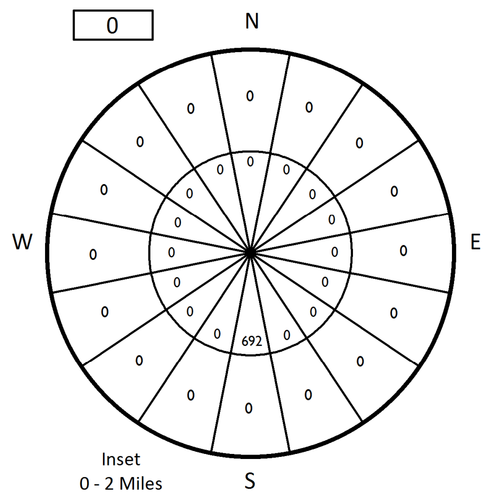


Figure 3-9. Employee Vehicles by Sector

3.5 Medical Facilities

A phone call was made to gather data for the one medical facility within the EPZ. Table E-2 in Appendix E summarizes the data gathered. Section 8 details the evacuation of medical facilities and their patients. The number and type of evacuating vehicles that need to be provided depend on the patients' state of health. It is estimated that buses can transport up to 30 people; and wheelchair vans, up to 4 people.

3.6 Total Demand in Addition to Permanent Population

Vehicles will be traveling through the EPZ (external-external trips) at the time of an accident. After the Advisory to Evacuate is announced, these through-travelers will also evacuate. These through vehicles are assumed to travel on major routes traversing the study area – US-1, Interstate-95 and Interstate-64. It is assumed that this traffic will continue to enter the study area during the first 120 minutes following the Advisory to Evacuate.

Average Annual Daily Traffic (AADT) data was obtained from VDOT[1] to estimate the number of vehicles per hour on the aforementioned routes. The AADT was multiplied by the K-Factor (obtained from VDOT), which is the proportion of the AADT on a roadway segment or link during the design hour, resulting in the design hour volume (DHV). The design hour is usually the 30th highest hourly traffic volume of the year, measured in vehicles per hour (vph). The DHV is then multiplied by the D-Factor (obtained from HCM 2010), which is the proportion of the DHV occurring in the peak direction of travel (also known as the directional split). The resulting values are the directional design hourly volumes (DDHV), and are presented in Table 3-6, for each of the routes considered. The DDHV is then multiplied by 2 hours (access control points – ACP – are assumed to be activated at 120 minutes after the advisory to evacuate) to estimate the total number of external vehicles loaded on the analysis network. As indicated, there are 13,550 vehicles entering the study area as external-external trips prior to the activation of access control and the diversion of this traffic. This number is reduced by 60% for evening scenarios (Scenarios 5 and 12) as discussed in Section 6.

3.7 Special Event

One special event (Scenario 13) is considered for the ETE study – the Kinetic Triathlon at Lake Anna State Park, which occurs annually on the second weekend in May. Data was gathered by calling the facility. This event attracts an additional 1,100 transients to the park, traveling in approximately 249 vehicles.

These vehicles are all loaded at the park and are included in Table 6-4 under Special Events. The special event vehicle trips were generated utilizing the same mobilization distributions as for transients. Public transportation is not provided for this event and was not considered in the special event analysis.

[1] http://www.virginiadot.org/info/2010_traffic_data.asp

Table 3-6. NAPS EPZ External Traffic

Upstream Node	Downstream Node	Road Name	Direction	VDOT[1] AADT	K-Factor[1]	D-Factor[2]	Hourly Volume	External[3] Traffic
8330	330	I-64	EB	14,000	0.1374	0.5	962	1,924
8329	329	I-64	WB	14,000	0.1237	0.5	866	1,732
8152	152	I-95	NB	44,000	0.1034	0.5	2,275	4,550
8146	146	I-95	SB	43,000	0.1012	0.5	2,176	4,352
8303	303	US-1	NB	5,300	0.0936	0.5	248	496
8265	265	US-1	SB	5,300	0.0936	0.5	248	496
							TOTAL	**13,550**

Notes: 1 - Virginia Department of Transportation (VDOT), 2010

2 - HCM 2010

3 - Interstate-64 and Interstate-95 are outside of the Shadow Region and only a small portion of US-1 resides in the Shadow Region

3.8 Summary of Demand

A summary of population and vehicle demand is provided in Table 3-7 and Table 3-8, respectively. This summary includes all population groups described in this section. Additional population groups – transit-dependent, special facility and school population – are described in greater detail in Section 8. A total of 46,186 people and 34,835 vehicles are considered in this study.

Table 3-7. Summary of Population Demand

PAZ	Residents	Transit-Dependent	Transients	Seasonal Transients	Employees	Special Facilities	Schools	Shadow Population	External Traffic	Total
2	466	7	0	0	0	0	60	0	0	533
3	1,490	21	0	0	68	23	3,010	0	0	4,612
4	1,107	16	0	165	0	0	0	0	0	1,288
5	1,472	21	0	0	0	0	597	0	0	2,090
6	484	7	0	72	0	0	0	0	0	563
7	484	7	0	102	0	0	0	0	0	593
8	409	6	0	213	720	0	0	0	0	1,348
9	203	3	150	36	0	0	0	0	0	392
10	429	6	0	231	0	0	0	0	0	666
11	981	14	58	128	0	0	0	0	0	1,181
12	1,561	22	167	3	0	0	444	0	0	2,197
13	1,364	19	27	0	0	0	0	0	0	1,410
14	803	11	2,773	104	0	0	0	0	0	3,691
15	697	10	0	262	0	0	0	0	0	969
16	1,601	23	2,000	74	0	0	0	0	0	3,698
17	144	2	0	5	0	0	0	0	0	151
18	2,416	34	98	197	0	0	0	0	0	2,745
19	383	5	0	0	0	0	0	0	0	388
20	1,026	15	0	0	0	0	0	0	0	1,041
21	2,232	32	0	0	0	0	2,316	0	0	4,580
22	1,538	22	0	8	0	0	0	0	0	1,568
23	260	4	0	0	0	0	0	0	0	264
24	946	14	0	0	0	0	0	0	0	960
25	464	7	0	124	0	0	0	0	0	595
26	2,242	32	0	0	0	0	0	0	0	2,274
Shadow	0	0	0	0	0	0	0	6,389	0	6,389
Total	**25,202**	**360**	**5,273**	**1,724**	**788**	**23**	**6,427**	**6,389**	**0**	**46,186**

Notes: - 20% Percent Shadow population evacuation. Refer to Figure 2-1 for additional information.
- Special Facilities column only consists of JABA Adult Daycare
- School population total includes enrollment for Jouett Elementary School, even though it shelters-in-place.

Table 3-8. Summary of Vehicle Demand

PAZ	Residents	Transit-Dependent	Transients	Seasonal Transients	Employees	Special Facilities	Schools	Shadow Population	External Traffic	Total
2	259	2	0	0	0	0	2	0	0	263
3	826	2	0	0	65	3	116	0	0	1,012
4	613	2	0	87	0	0	0	0	0	702
5	817	2	0	0	0	0	0	0	0	819
6	266	2	0	40	0	0	0	0	0	308
7	267	2	0	54	0	0	0	0	0	323
8	228	2	0	118	692	0	0	0	0	1,040
9	113	2	100	16	0	0	0	0	0	231
10	236	2	0	125	0	0	0	0	0	363
11	543	2	24	68	0	0	0	0	0	637
12	861	2	58	1	0	0	14	0	0	936
13	754	2	27	0	0	0	0	0	0	783
14	444	2	831	56	0	0	0	0	0	1,333
15	385	2	0	145	0	0	0	0	0	532
16	889	2	800	38	0	0	0	0	0	1,729
17	79	2	0	3	0	0	0	0	0	84
18	1,333	2	39	103	0	0	0	0	0	1,477
19	212	2	0	0	0	0	0	0	0	214
20	568	2	0	0	0	0	0	0	0	570
21	1,239	2	0	0	0	0	94	0	0	1,335
22	818	2	0	4	0	0	0	0	0	824
23	144	2	0	0	0	0	0	0	0	146
24	525	2	0	0	0	0	0	0	0	527
25	257	2	0	64	0	0	0	0	0	323
26	1,239	2	0	0	0	0	0	0	0	1,241
Shadow	0	0	0	0	0	0	0	3,533	13,550	17,083
Total	**13,915**	**50**	**1,879**	**922**	**757**	**3**	**226**	**3,533**	**13,550**	**34,835**

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

4 ESTIMATION OF HIGHWAY CAPACITY

The ability of the road network to service vehicle demand is a major factor in determining how rapidly an evacuation can be completed. The capacity of a road is defined as the maximum hourly rate at which persons or vehicles can reasonably be expected to traverse a point or uniform section of a lane of roadway during a given time period under prevailing roadway, traffic and control conditions, as stated in the 2010 Highway Capacity Manual (HCM 2010).

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

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

This distinction is illustrated in Exhibit 11-17 of the HCM 2010. As indicated there, the SV varies with Free Flow Speed (FFS), and LOS. The SV is calculated by the DYNEV II simulation model, based on the specified link attributes, FFS, capacity, control device and traffic demand.

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

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

These factors are considered during the road survey and in the capacity estimation process; some factors have greater influence on capacity than others. For example, lane and shoulder width have only a limited influence on Base Free Flow Speed (BFFS[1]) according to Exhibit 15-7 of the HCM. Consequently, lane and shoulder widths at the narrowest points were observed during the road survey and these observations were recorded, but no detailed measurements of lane or shoulder width were taken. Horizontal and vertical alignment can influence both FFS and capacity. The estimated FFS were measured using the survey vehicle’s speedometer and observing local traffic, under free flow conditions. Capacity is estimated from the procedures of

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

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

As discussed in Section 2.3, it is necessary to adjust capacity figures to represent the prevailing conditions during inclement weather. Based on limited empirical data, weather conditions such as rain reduce the values of free speed and of highway capacity by approximately 10 percent. Over the last decade new studies have been made on the effects of rain on traffic capacity. These studies indicate a range of effects between 5 and 20 percent depending on wind speed and precipitation rates. As indicated in Section 2.3, we employ a reduction in free speed and in highway capacity of 10 percent and 20 percent for rain and snow, respectively.

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

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

4.1 Capacity Estimations on Approaches to Intersections

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

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

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

where:

$Q_{cap,m}$ = Capacity of a single lane of traffic on an approach, which executes movement, m, upon entering the intersection; vehicles per hour (vph)

h_m = Mean queue discharge headway of vehicles on this lane that are executing movement, m; seconds per vehicle

G = Mean duration of GREEN time servicing vehicles that are executing movement, m, for each signal cycle; seconds

L = Mean "lost time" for each signal phase servicing movement, m; seconds

C = Duration of each signal cycle; seconds

P_m = Proportion of GREEN time allocated for vehicles executing movement, m, from this lane. This value is specified as part of the control treatment.

m = The movement executed by vehicles after they enter the intersection: through, left-turn, right-turn, and diagonal.

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

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

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:

$$h_m \geq h_{sat}$$

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

That is, the turn-movement-specific discharge headways are always greater than, or equal to the saturation discharge headway for through vehicles. These headways (or its inverse equivalent, "saturation flow rate"), may be determined by observation or using the procedures of the HCM 2010.

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

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

4.2 Capacity Estimation along Sections of Highway

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

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

The value of V_F can be expressed as:

$$V_F = R \times Capacity$$

where:

R = Reduction factor which is less than unity

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

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

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

The estimated value of capacity is based primarily upon the type of facility and on roadway geometrics. Sections of roadway with adverse geometrics are characterized by lower free-flow speeds and lane capacity. Exhibit 15-30 in the Highway Capacity Manual was referenced to estimate saturation flow rates. The impact of narrow lanes and shoulders on free-flow speed and on capacity is not material, particularly when flow is predominantly in one direction as is the case during an evacuation.

The procedure used here was to estimate "section" capacity, V_E, based on observations made traveling over each section of the evacuation network, based on the posted speed limits and travel behavior of other motorists and by reference to the 2010 HCM. The DYNEV II simulation model determines for each highway section, represented as a network link, whether its capacity would be limited by the "section-specific" service volume, V_E, or by the intersection-specific capacity. For each link, the model selects the lower value of capacity.

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

4.3 Application to the North Anna Power Station Study Area

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

> 2010 Highway Capacity Manual (HCM)
> Transportation Research Board
> National Research Council
> Washington, D.C.

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

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

Each of these classifications will be discussed.

4.3.1 Two-Lane Roads

Ref: HCM Chapter 15

Two lane roads comprise the majority of highways within the EPZ. The per-lane capacity of a two-lane highway is estimated at 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 3200 pc/h. The HCM procedures then estimate Level of Service (LOS) and Average Travel Speed. The DYNEV II simulation model accepts the specified value of capacity as input and computes average speed based on the time-varying demand: capacity relations.

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

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

4.3.2 Multi-Lane Highway

Ref: HCM Chapter 14

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

4.3.3 Freeways

Ref: HCM Chapters 10, 11, 12, 13

Chapter 10 of the HCM 2010 describes a procedure for integrating the results obtained in Chapters 11, 12 and 13, which compute capacity and LOS for freeway components. Chapter 10 also presents a discussion of simulation models. The DYNEV II simulation model automatically performs this integration process.

Chapter 11 of the HCM 2010 presents procedures for estimating capacity and LOS for “Basic Freeway Segments". Exhibit 11-17 of the HCM 2010 presents capacity vs. free speed estimates, which are provided below.

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

The inputs to the simulation model are highway geometrics, free-speeds and capacity based on field observations. The simulation logic calculates actual time-varying speeds based on demand: capacity relationships. A conservative estimate of per-lane capacity of 2250 pc/h is adopted for this study for freeways, as shown in Appendix K.

Chapter 12 of the HCM 2010 presents procedures for estimating capacity, speed, density and LOS for freeway weaving sections. The simulation model contains logic that relates speed to demand volume: capacity ratio. The value of capacity obtained from the computational procedures detailed in Chapter 12 depends on the "Type" and geometrics of the weaving segment and on the "Volume Ratio" (ratio of weaving volume to total volume).

Chapter 13 of the HCM 2010 presents procedures for estimating capacities of ramps and of "merge" areas. There are three significant factors to the determination of capacity of a ramp-freeway junction: The capacity of the freeway immediately downstream of an on-ramp or immediately upstream of an off-ramp; the capacity of the ramp roadway; and the maximum flow rate entering the ramp influence area. In most cases, the freeway capacity is the controlling factor. Values of this merge area capacity are presented in Exhibit 13-8 of the HCM 2010, and depend on the number of freeway lanes and on the freeway free speed. Ramp capacity is presented in Exhibit 13-10 and is a function of the ramp free flow speed. The DYNEV II simulation model logic simulates the merging operations of the ramp and freeway traffic in accord with the procedures in Chapter 13 of the HCM 2010. If congestion results from an excess of demand relative to capacity, then the model allocates service appropriately to the two entering traffic streams and produces LOS F conditions (The HCM does not address LOS F explicitly).

4.3.4 Intersections

Ref: HCM Chapters 18, 19, 20, 21

Procedures for estimating capacity and LOS for approaches to intersections are presented in Chapter 18 (signalized intersections), Chapters 19, 20 (un-signalized intersections) and Chapter 21 (roundabouts). The complexity of these computations is indicated by the aggregate length of these chapters. The DYNEV II simulation logic is likewise complex.

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

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

4.4 Simulation and Capacity Estimation

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

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

This statement succinctly describes the analyses required to determine traffic operations across an area encompassing an EPZ operating under evacuation conditions. The model utilized for this study, DYNEV II, is further described in Appendix C. It is essential to recognize that simulation models do not replicate the methodology and procedures of the HCM – they *replace* these procedures by describing the complex interactions of traffic flow and computing Measures of Effectiveness (MOE) detailing the operational performance of traffic over time and by location. The DYNEV II simulation model includes some HCM 2010 procedures only for the purpose of estimating capacity.

All simulation models must be calibrated properly with field observations that quantify the performance parameters applicable to the analysis network. Two of the most important of these are: (1) Free flow speed (FFS); and (2) saturation headway, h_{sat}. The first of these is estimated by direct observation during the road survey; the second is estimated using the concepts of the HCM 2010, as described earlier. These parameters are listed in Appendix K, for each network link.

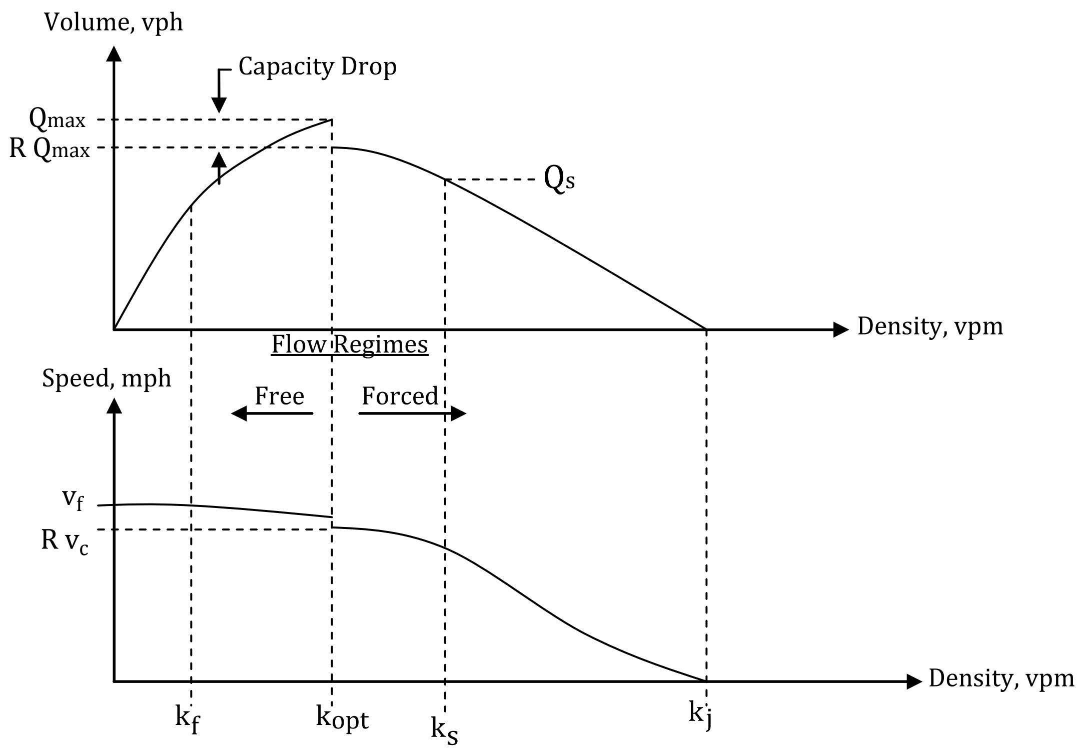


Figure 4-1. Fundamental Diagrams

5 ESTIMATION OF TRIP GENERATION TIME

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

5.1 Background

In general, an accident at a nuclear power plant is characterized by the following Emergency Classification Levels (see Appendix 1 of NUREG 0654 for details):

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

At each level, the Federal guidelines specify a set of Actions to be undertaken by the Licensee, and by State and Local offsite authorities. As a Planning Basis, we will adopt a conservative posture, in accordance with Section 1.2 of NUREG/CR-7002, that a rapidly escalating accident will be considered in calculating the Trip Generation Time. We will assume:

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

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

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

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

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

The notification process consists of two events:

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

The population within the EPZ is dispersed over an area of 384 square miles and is engaged in a wide variety of activities. It must be anticipated that some time will elapse between the transmission and receipt of the information advising the public of an accident.

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

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

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

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

5.2 Fundamental Considerations

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

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

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

Associated with each sequence of events are one or more activities, as outlined below:

Table 5-1. Event Sequence for Evacuation Activities

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

These relationships are shown graphically in Figure 5-1.

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

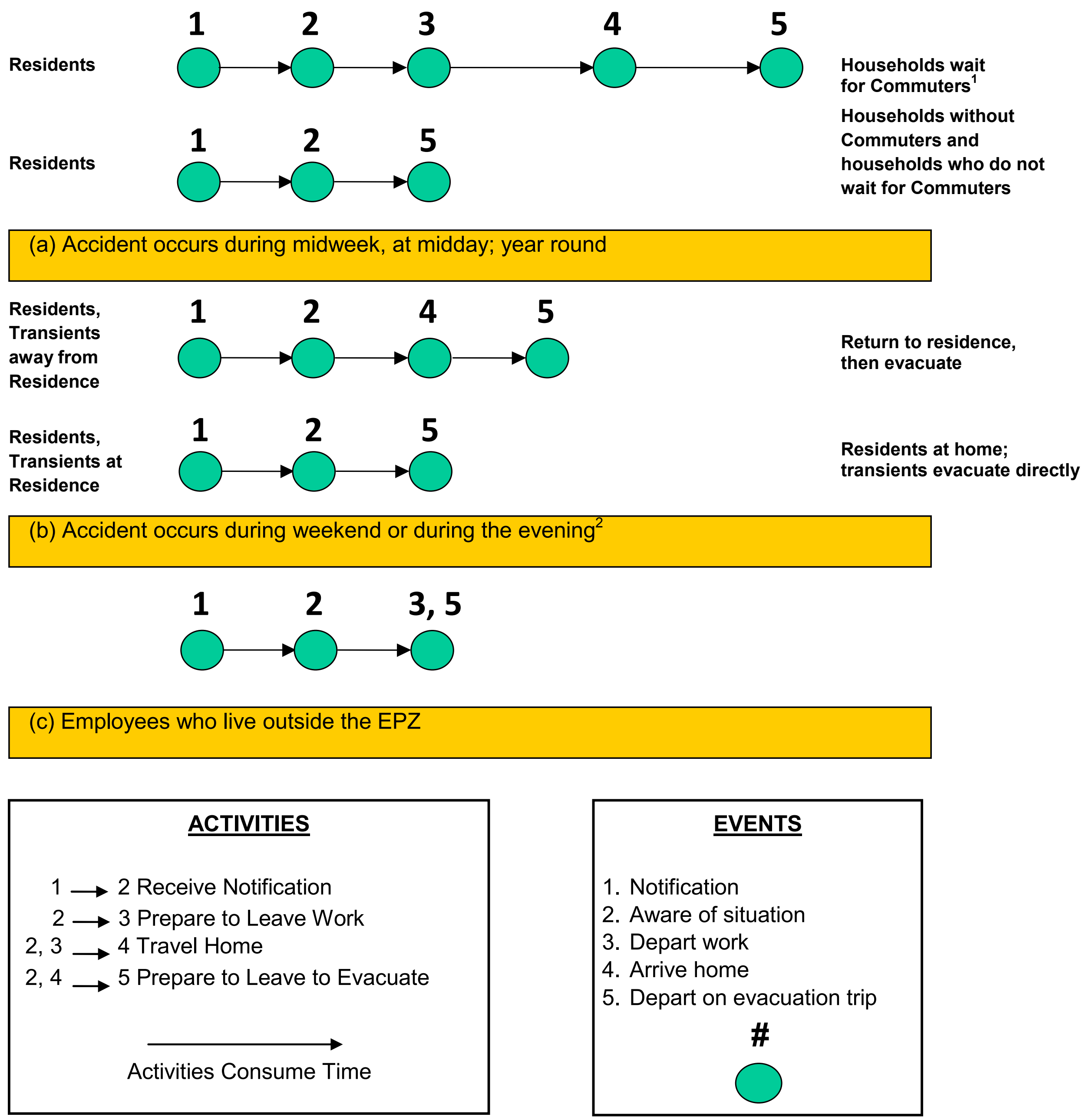
As such, a completed Activity changes the 'state' of an individual (e.g. the activity, 'travel home' changes the state from 'depart work' to 'arrive home'). Therefore, an Activity can be described as an 'Event Sequence'; the elapsed times to perform an event sequence vary from one person to the next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

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

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

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

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



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

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

5.3 Estimated Time Distributions of Activities Preceding Event 5

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

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

In accordance with the 2012 Federal Emergency Management Agency (FEMA) Radiological Emergency Preparedness Program Manual, 100% of the population is notified within 45 minutes. It is assumed (based on the presence of sirens within the EPZ) that 87 percent of those within the EPZ will be aware of the accident within 30 minutes with the remainder notified within the following 15 minutes. The notification distribution is given below:

Table 5-2. Time Distribution for Notifying the Public

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

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

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

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

Elapsed Time (Minutes)	Cumulative Percent Employees Leaving Work	Elapsed Time (Minutes)	Cumulative Percent Employees Leaving Work
0	0%	45	86%
5	29%	50	86%
10	39%	55	87%
15	50%	60	93%
20	57%	75	97%
25	61%	90	98%
30	76%	105	99%
35	77%	120	100%
40	78%	-	-

NOTE: The survey data was normalized to distribute the "Don't know" response. That is, the sample was reduced in size to include only those households who responded to this question. The underlying assumption is that the distribution of this activity for the "Don't know" responders, if the event takes place, would be the same as those responders who provided estimates.

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

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

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

Elapsed Time (Minutes)	Cumulative Percent Returning Home	Elapsed Time (Minutes)	Cumulative Percent Returning Home
0	0%	45	79%
5	4%	50	81%
10	10%	55	81%
15	22%	60	89%
20	34%	75	94%
25	39%	90	97%
30	54%	105	99%
35	58%	120	100%
40	64%	-	-

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

Distribution No. 4, Prepare to Leave Home: Activity 2, 4 $\rightarrow$ 5

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

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

Elapsed Time (Minutes)	Cumulative Percent Ready to Evacuate
0	0%
15	31%
30	60%
45	68%
60	80%
75	91%
90	92%
105	93%
120	96%
135	98%
150	98%
165	98%
180	99%
195	100%

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

Distribution No. 5, Snow Clearance Time Distribution

Inclement weather scenarios involving snowfall must address the time lags associated with snow clearance. It is assumed that snow equipment is mobilized and deployed during the snowfall to maintain passable roads. The general consensus is that the snow-plowing efforts are generally successful for all but the most extreme blizzards when the rate of snow accumulation exceeds that of snow clearance over a period of many hours.

Consequently, it is reasonable to assume that the highway system will remain passable – albeit at a lower capacity – under the vast majority of snow conditions. Nevertheless, for the vehicles to gain access to the highway system, it may be necessary for driveways and employee parking lots to be cleared to the extent needed to permit vehicles to gain access to the roadways. These clearance activities take time; this time must be incorporated into the trip generation time distributions. These data are provided by those households which responded to the Surry 2012 telephone survey. This distribution is plotted in Figure 5-2 and listed in Table 5-6.

Note that those respondents (33%) who answered that they would not take time to clear their driveway were assumed to be ready immediately at the start of this activity. Essentially they would drive through the snow on the driveway to access the roadway and begin their evacuation trip.

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

Elapsed Time (Minutes)	Cumulative Percent Completing Snow Removal
0	33%
15	42%
30	69%
45	73%
60	84%
75	91%
90	92%
105	92%
120	95%
135	97%
150	97%
165	97%
180	100%

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

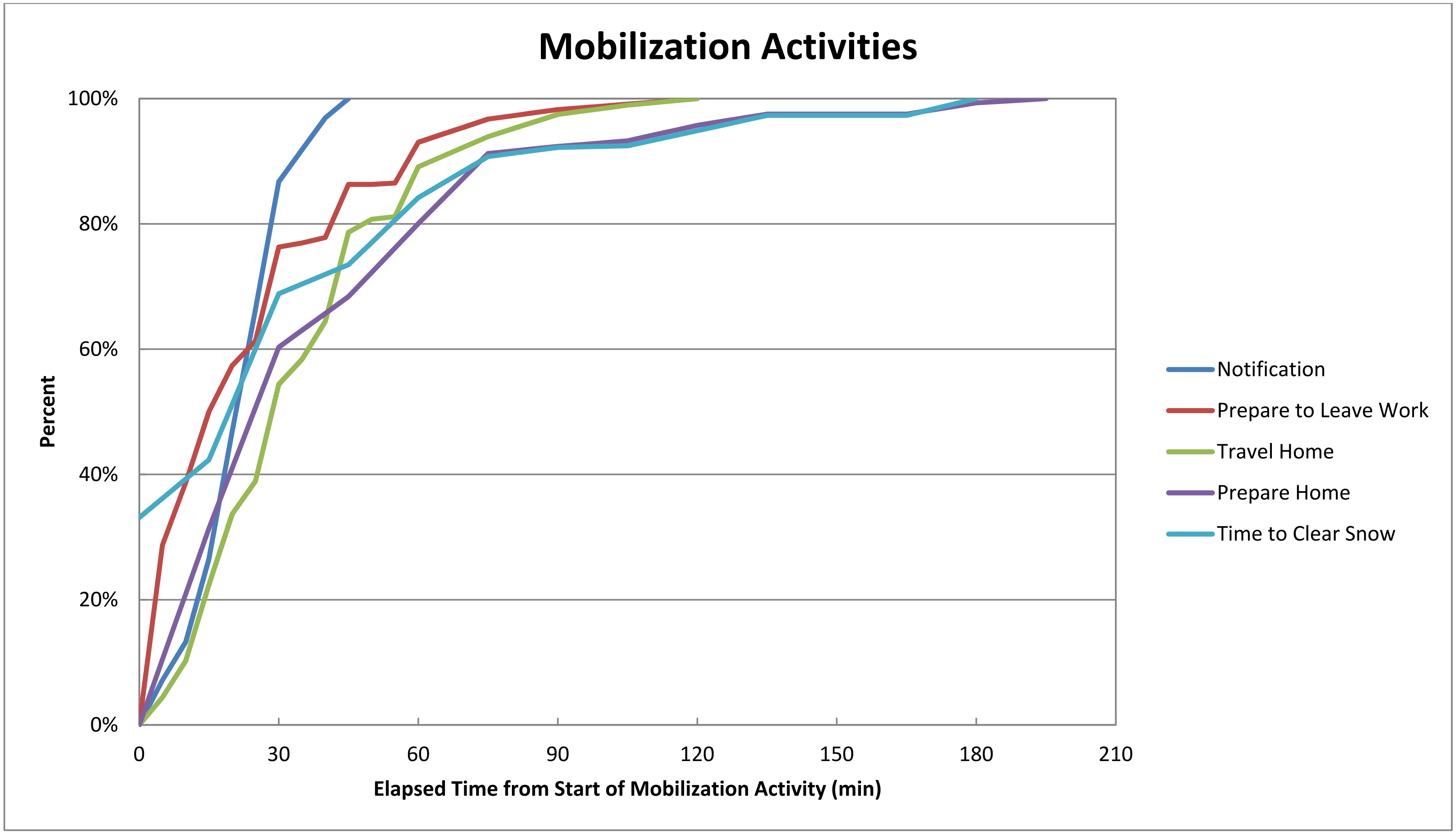


Figure 5-2. Evacuation Mobilization Activities

5.4 Calculation of Trip Generation Time Distribution

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

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

Table 5-7. Mapping Distributions to Events

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

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

Table 5-8. Description of the Distributions

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

5.4.1 Statistical Outliers

As already mentioned, some portion of the survey respondents answer "don't know" to some questions or choose to not respond to a question. The mobilization activity distributions are based upon actual responses. But, it is the nature of surveys that a few numeric responses are inconsistent with the overall pattern of results. An example would be a case in which for 500 responses, almost all of them estimate less than two hours for a given answer, but 3 say "four hours" and 4 say "six or more hours".

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

In assessing outliers, there are three alternates to consider:

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

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

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

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

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

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

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

2) The individual mobilization activities (prepare to leave work, travel home, prepare home, clear snow) are reviewed for outliers, and then the overall trip generation distributions are created (see Figure 5-1, Table 5-7, Table 5-8);

3) Outliers can be eliminated either because the response reflects a special population (e.g. special needs, transit dependent) or lack of realism, because the purpose is to estimate trip generation patterns for personal vehicles;

4) To eliminate outliers,
    a) the mean and standard deviation of the specific activity are estimated from the responses,
    b) the median of the same data is estimated, with its position relative to the mean noted,
    c) the histogram of the data is inspected, and
    d) all values greater than 3.5 standard deviations are flagged for attention, taking special note of whether there are gaps (categories with zero entries) in the histogram display.

    In general, only flagged values more than 4 standard deviations from the mean are allowed to be considered outliers, with gaps in the histogram expected.

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

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

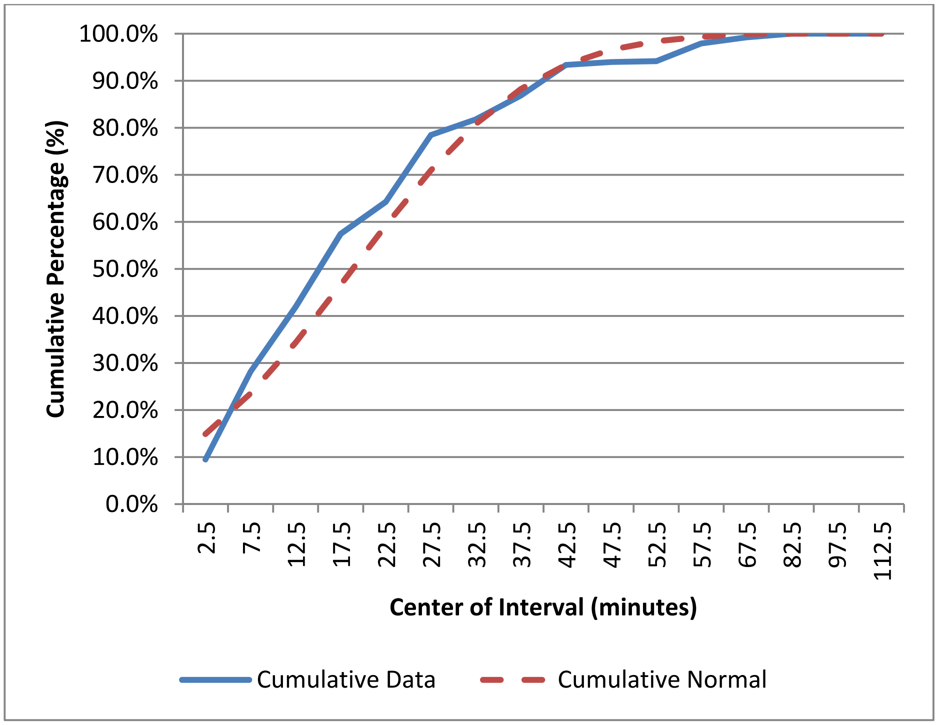


Figure 5-3. Comparison of Data Distribution and Normal Distribution

6) In particular, the cumulative distribution differs from the normal distribution in two key aspects, both very important in loading a network to estimate evacuation times:

- Most of the real data is to the left of the "normal" curve above, indicating that the network loads faster for the first 80-85% of the vehicles, potentially causing more (and earlier) congestion than otherwise modeled;
- The last 10-15% of the real data "tails off" slower than the comparable "normal" curve, indicating that there is significant traffic still loading at later times.

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

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

This is done by using the data sets and distributions under different scenarios (e.g. commuter returning, no commuter returning, no snow or snow in each). In general, these are additive, using weighting based upon the probability distributions of each element; Figure 5-4 presents the combined trip generation distributions designated A, C, D, E and F. These distributions are presented on the same time scale. (As discussed earlier, the use of strictly additive activities is a conservative approach, because it makes all activities sequential – preparation for departure follows the return of the commuter; snow clearance follows the preparation for departure, and so forth. In practice, it is reasonable that some of these activities are done in parallel, at least to some extent – for instance, preparation to depart begins by a household member at home while the commuter is still on the road.)

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

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

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

5.4.2 Staged Evacuation Trip Generation

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

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

Assumptions

1. The population in the shadow region beyond the EPZ boundary, extending to approximately 15 miles radially from the plant, will react as they do for all non-staged evacuation scenarios. That is 20% of these households will elect to evacuate with no shelter delay.

2. The EPZ population in PAZ beyond 5 miles will react as does the population in the 2 to 5 mile region; that is they will first shelter, then evacuate after the 90th percentile ETE for the 2 mile region.
3. The transient population will not be expected to stage their evacuation because of the limited sheltering options available to people who may be at parks, on a beach, or at other venues. Also, notifying the transient population of a staged evacuation would prove difficult.
4. Employees will also be assumed to evacuate without first sheltering.

Procedure

1. Trip generation for population groups in the 2 mile region will be as computed based upon the results of the telephone survey and analysis.
2. Trip generation for the population subject to staged evacuation will be formulated as follows:
    a. Identify the 90th percentile evacuation time for the PAZ comprising the two mile region. This value, T_{Scen}^*, is obtained from simulation results. It will become the time at which the region being sheltered will be told to evacuate for each scenario.
    b. The resultant trip generation curves for staging are then formed as follows:
        i. The non-shelter trip generation curve is followed until a maximum of 20% of the total trips are generated (to account for shelter non-compliance).
        ii. No additional trips are generated until time T_{Scen}^*
        iii. Following time T_{Scen}^*, the balance of trips are generated:
            1. by stepping up and then following the non-shelter trip generation curve (if T_{Scen}^* is $\leq$ max trip generation time) or
            2. by stepping up to 100% (if T_{Scen}^* is > max trip generation time)
    c. Note: This procedure implies that there may be different staged trip generation distributions for different scenarios. NUREG/CR-7002 uses the statement "approximately 90th percentile" as the time to end staging and begin evacuating. The value of T_{Scen}^* is 2:30 for weekday non-snow scenarios and 3:15 for weekday snow scenarios. The value of T_{Scen}^* is 1:45 for weekend non-snow scenarios and 3:00 for weekend snow scenarios. The reason for the difference between weekday and weekend scenarios is that for midweek, midday cases, approximately 65% of the vehicles within the 2-mile region are those of employees and transients, whereas the percentage is lower for weekend and evening cases. These population groups mobilize faster than the general population and therefore the 90th percentile ETE will be lower for cases with a higher percentage of employees and transients.
3. Staged trip generation distributions are created for the following population groups:
    a. Residents with returning commuters
    b. Residents without returning commuters
    c. Residents with returning commuters and snow conditions

d. Residents without returning commuters and snow conditions

Figure 5-5 presents the staged trip generation distributions for both residents with and without returning commuters; the 90th percentile two-mile evacuation time is 150 minutes for weekday non-snow, 195 minutes for weekday snow, 105 minutes for weekend non-snow, and 180 minutes for weekend snow scenarios. At the 90th percentile evacuation time, 20% of the population (who normally would have completed their mobilization activities for an un-staged evacuation) advised to shelter has nevertheless departed the area. These people do not comply with the shelter advisory. Also included on the plot are the trip generation distributions for these groups as applied to the regions advised to evacuate immediately.

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

Table 5-10 provides the trip generation histograms for staged evacuation, weekday scenarios and Table 5-11 provides the trip generation histograms for staged evacuation, weekend scenarios.

5.4.3 Trip Generation for Waterways and Recreational Areas

The Louisa County Radiological Emergency Response Plan states that the Sheriff's Office, assisted by Fire and Rescue, is responsible for implementing evacuations, including campgrounds, Lake Anna, and other areas. As stated in the Spotsylvania and Louisa County RERP, additional help is available as necessary, to assist in the warning of persons on Lake Anna, from the State Department of Game and Inland Fisheries.

As indicated in Table 5-2, this study assumes 100% notification in 45 minutes. Table 5-9 indicates that all transients will have mobilized within 2 hours and 30 minutes. It is assumed that this 2.5 hour timeframe is sufficient time for boaters, campers and other transients to return to their vehicles and begin their evacuation trip.

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

Time Period	Duration (Min)	Percent of Total Trips Generated Within Indicated Time Period					
		Employees (Distribution A)	Transients (Distribution A)	Residents with Commuters (Distribution C)	Residents Without Commuters (Distribution D)	Residents With Commuters Snow (Distribution E)	Residents Without Commuters Snow (Distribution F)
1	15	5%	5%	0%	2%	0%	1%
2	30	53%	53%	2%	41%	1%	17%
3	30	29%	29%	14%	31%	6%	28%
4	15	7%	7%	13%	10%	7%	12%
5	15	3%	3%	13%	7%	9%	11%
6	15	2%	2%	14%	2%	11%	8%
7	30	1%	1%	20%	3%	21%	9%
8	15	0%	0%	7%	1%	9%	3%
9	15	0%	0%	5%	1%	7%	3%
10	15	0%	0%	4%	0%	7%	1%
11	15	0%	0%	2%	1%	5%	2%
12	60	0%	0%	5%	1%	11%	4%
13	60	0%	0%	1%	0%	5%	1%
14	60	0%	0%	0%	0%	1%	0%
15	600	0%	0%	0%	0%	0%	0%

NOTE:

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

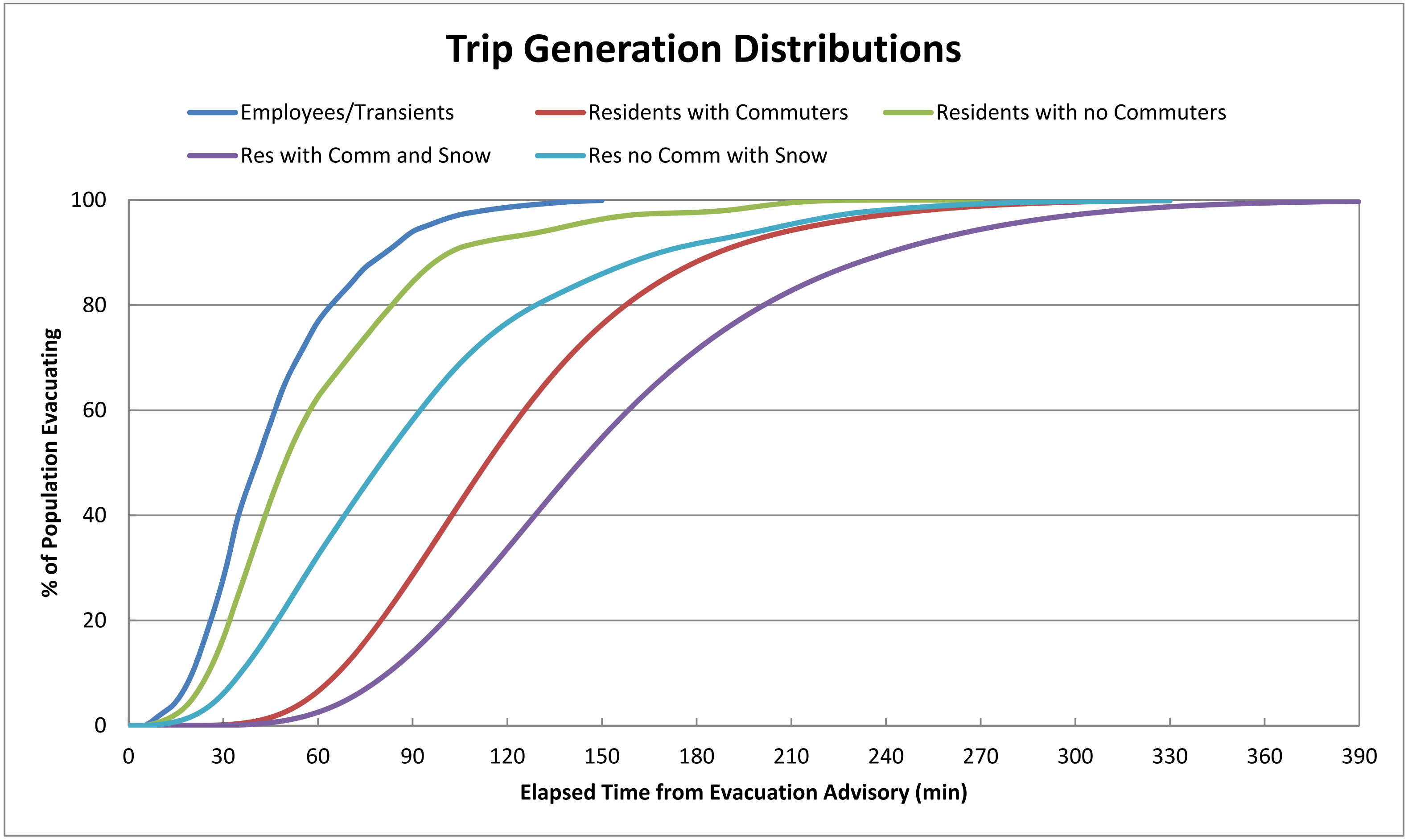


Figure 5-4. Comparison of Trip Generation Distributions

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

Time Period	Duration (Min)	Percent of Total Trips Generated Within Indicated Time Period*			
		Residents with Commuters Weekday (Distribution C)	Residents Without Commuters Weekday (Distribution D)	Residents With Commuters Weekday-Snow (Distribution E)	Residents Without Commuters Weekday-Snow (Distribution F)
1	15	0%	0%	0%	0%
2	30	0%	9%	0%	4%
3	30	3%	6%	1%	5%
4	15	3%	2%	2%	3%
5	15	2%	1%	2%	2%
6	15	3%	1%	2%	1%
7	30	4%	0%	4%	2%
8	15	68%	78%	2%	1%
9	15	5%	1%	1%	0%
10	15	4%	0%	2%	1%
11	15	2%	1%	67%	76%
12	60	5%	1%	11%	4%
13	60	1%	0%	5%	1%
14	60	0%	0%	1%	0%
15	600	0%	0%	0%	0%

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

Table 5-11. Trip Generation Histograms for the EPZ Population for Staged Evacuation, Weekend

Time Period	Duration (Min)	Percent of Total Trips Generated Within Indicated Time Period*			
		Residents with Commuters Weekend (Distribution C)	Residents Without Commuters Weekend (Distribution D)	Residents With Commuters Weekend-Snow (Distribution E)	Residents Without Commuters Weekend-Snow (Distribution F)
1	15	0%	0%	0%	0%
2	30	0%	9%	0%	4%
3	30	3%	6%	1%	5%
4	15	3%	2%	2%	3%
5	15	2%	1%	2%	2%
6	15	48%	75%	2%	1%
7	30	20%	3%	4%	2%
8	15	7%	1%	2%	1%
9	15	5%	1%	1%	0%
10	15	4%	0%	64%	75%
11	15	2%	1%	5%	2%
12	60	5%	1%	11%	4%
13	60	1%	0%	5%	1%
14	60	0%	0%	1%	0%
15	600	0%	0%	0%	0%

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

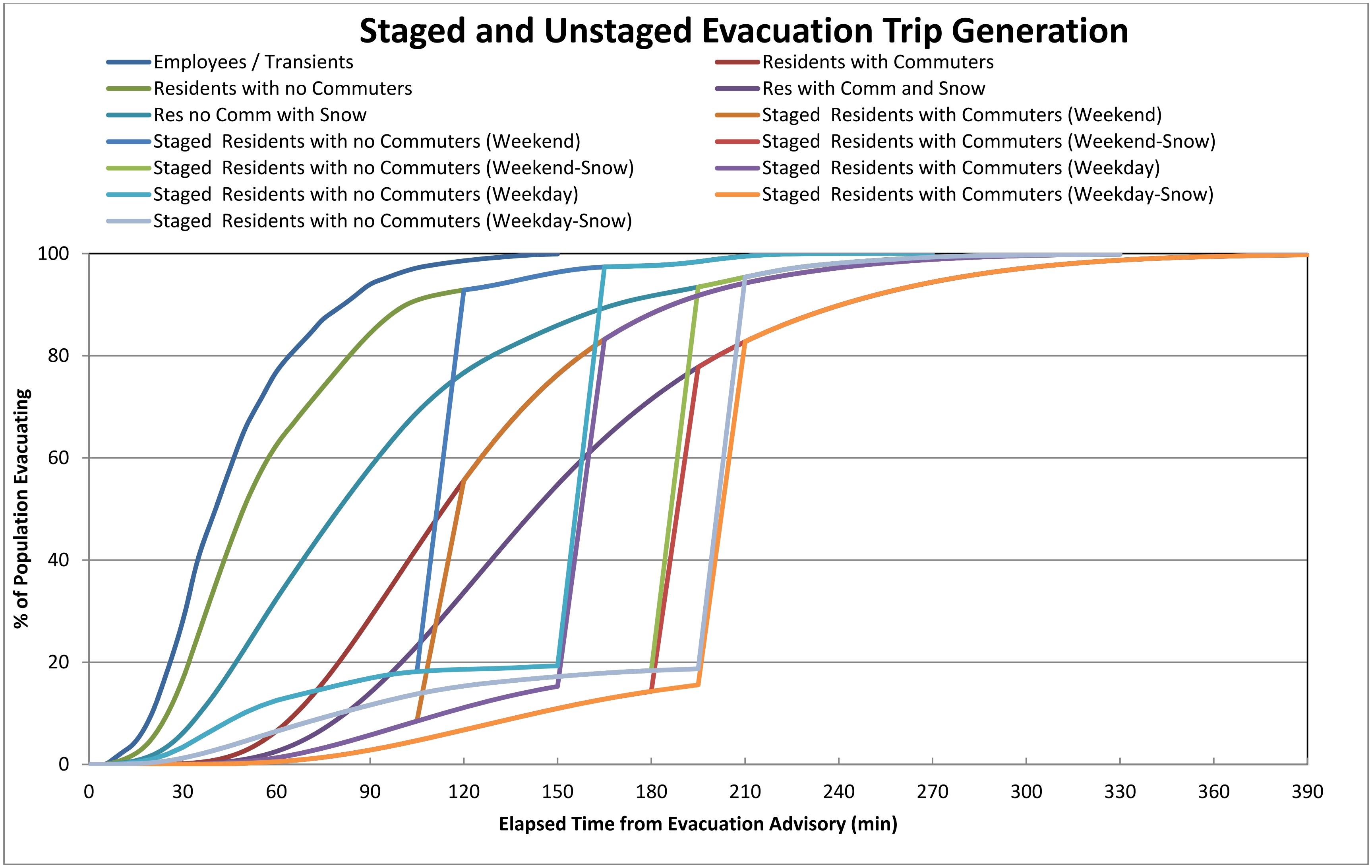


Figure 5-5. Comparison of Staged and Unstaged Trip Generation Distributions in the 2 to 5 Mile Region

6 DEMAND ESTIMATION FOR EVACUATION SCENARIOS

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

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

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

A total of 41 Regions were defined which encompass all the groupings of PAZ 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 guidance. The central sector coincides with the wind direction. These sectors extend to 5 miles from the plant (Regions R04 through R15) or to the EPZ boundary (Regions R16 through R28). Regions R01, R02 and R03 represent evacuations of circular areas with radii of 2, 5 and 10 miles, respectively. Regions R29 through R41 are identical to Regions R02 and R04 through R15, respectively; however, those PAZ 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 41 x 14 = 574 evacuation cases. Table 6-2 is a description of all Scenarios.

Each combination of region and scenario implies a specific population to be evacuated. Table 6-3 presents the percentage of each population group estimated to evacuate for each scenario. Table 6-4 presents the vehicle counts for each scenario for an evacuation of Region R03 – the entire EPZ.

The vehicle estimates presented in Section 3 are peak values. These peak values are adjusted depending on the scenario and region being considered, using scenario and region specific percentages, such that the average population is considered for each evacuation case. The scenario percentages are presented in Table 6-3, while the regional percentages are provided in Table H-1 and H-2. The percentages presented in Table 6-3 were determined as follows:

The number of residents with commuters during the week (when workforce is at its peak) is equal to the product of 59% (the number of households with at least one commuter) and 61% (the number of households with a commuter that would await the return of the commuter prior to evacuating). See assumption 3 in Section 2.3. It is estimated for weekend and evening scenarios that 10% of households with returning commuters will have a commuter at work during those times.

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

Transient activity is estimated to be at its peak during summer weekends and less (69%) during the week. As shown in Appendix E, there is a moderate amount of lodging and campgrounds offering overnight accommodations in the EPZ; and an almost equal amount of parks and marinas where evening transient activity is very low; thus, transient activity is estimated to be – 56% during summer evening hours and 14% for winter evening hours. Transient activity on winter weekends is estimated to be 26%.

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

As noted in the shadow footnote to Table 6-3, the shadow percentages are computed using a base of 20% (see assumption 5 in Section 2.2); to include the employees within the shadow region who may choose to evacuate, the voluntary evacuation is multiplied by a scenario-specific proportion of employees to permanent residents in the shadow region. For example, using the values provided in Table 6-4 for Scenario 1, the shadow percentage is computed as follows:

$$20\% \times \left(1 + \frac{727}{8{,}895 + 5{,}020}\right) = 21\%$$

One special event (Scenario 13) is considered for the ETE study – Kinetics Triathlon at Lake Anna State Park. Thus, the special event traffic is 100% evacuated for Scenario 13, and 0% for all other scenarios. This special event includes an additional 249 vehicles being loaded at the State Park, as shown in the Special Events column in Table 6-4.

It is estimated that summer school enrollment is approximately 10% of enrollment during the regular school year for summer, midweek, midday scenarios. School is not in session during weekends and evenings, thus no buses for schoolchildren are needed under those circumstances. As discussed in Section 7, schools are in session during the winter season, midweek, midday and 100% of buses will be needed under those circumstances. Transit buses for the transit-dependent population are set to 100% for all scenarios as it is assumed that the transit-dependent population is present in the EPZ for all scenarios.

External traffic is estimated to be reduced by 60% during evening scenarios and is 100% for all other scenarios.

Table 6-1. Description of Evacuation Regions

Region	Description	Site PAR Description	Protection Action Zone (PAZ)																								
			2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
R01	2-Mile Radius	2- Mile Radius					x		x	x	x																
R02	5-Mile Radius	5-Mile Radius			x		x	x	x	x	x	x	x	x	x	x										x	
R03	Full EPZ	Full EPZ	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Evacuate 2-Mile Radius and Downwind to 5 Miles																											
Region	**Wind Direction Toward:**	**Site PAR Description**	**Protection Action Zone (PAZ)**																								
			2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
R04	N, NNE	349° - 33°					x		x	x	x		x	x	x												
R05	NE	34° - 56°					x		x	x	x	x	x	x													
R06	ENE, E	57° - 101°					x		x	x	x	x	x														
R07	ESE	102° - 123°					x		x	x	x	x														x	
R08	SE	124° - 146°					x	x	x	x	x	x														x	
R09	SSE, S	147° - 191°					x	x	x	x	x															x	
R10	SSW	192° - 213°					x	x	x	x	x																
R11	SW	214° - 236°			x		x	x	x	x	x																
R12	WSW	237° - 258°			x		x		x	x	x																
R13	W	259°- 281°			x		x		x	x	x					x											
R14	WNW, NW	282° - 326°			x		x		x	x	x				x	x											
R15	NNW	327° - 349°					x		x	x	x			x	x	x											
Evacuate 5-Mile Radius and Downwind to the EPZ Boundary																											
Region	**Wind Direction Toward:**	**Site PAR Description**	**Protection Action Zone (PAZ)**																								
			2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
R16	N	349° - 11°			x		x	x	x	x	x	x	x	x	x	x			x	x	x					x	
R17	NNE	12° - 33°			x		x	x	x	x	x	x	x	x	x	x			x	x	x	x				x	
R18	NE	34° - 56°			x		x	x	x	x	x	x	x	x	x	x				x	x	x				x	
R19	ENE	57° - 78°			x		x	x	x	x	x	x	x	x	x	x					x	x	x			x	
R20	E	79° - 101°			x		x	x	x	x	x	x	x	x	x	x						x	x	x		x	
R21	ESE	102° - 123°			x		x	x	x	x	x	x	x	x	x	x						x	x	x	x	x	x
R22	SE	124° - 146°			x		x	x	x	x	x	x	x	x	x	x							x	x	x	x	x
R23	SSE, S	147° - 191°			x	x	x	x	x	x	x	x	x	x	x	x									x	x	x
R24	SSW	192° - 213°		x	x	x	x	x	x	x	x	x	x	x	x	x										x	x
R25	SW, WSW	214° - 258°	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x									x	

Region	Description	Site PAR Description	Protection Action Zone (PAZ)																							
			2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
R26	W	259° - 281°	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x							x	
R27	WNW, NW	282° - 326°			x		x	x	x	x	x	x	x	x	x	x	x	x	x							x	
R28	NNW	327° - 349°			x		x	x	x	x	x	x	x	x	x	x		x	x	x						x	
Staged Evacuation - 2-Mile Radius Evacuates, then Evacuate Downwind to 5 Miles																											
Region	**Wind Direction Toward:**	**Site PAR Description**	**Protection Action Zone (PAZ)**																							
			2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
R29	-	5-Mile Radius			x		x	x	x	x	x	x	x	x	x	x										x	
R30	N, NNE	349° - 33°					x		x	x	x		x	x	x												
R31	NE	34° - 56°					x		x	x	x	x	x	x													
R32	ENE, E	57° - 101°					x		x	x	x	x	x														
R33	ESE	102° - 123°					x		x	x	x	x														x	
R34	SE	124° - 146°					x	x	x	x	x	x														x	
R35	SSE, S	147° - 191°					x	x	x	x	x															x	
R36	SSW	192° - 213°					x	x	x	x	x																
R37	SW	214° - 236°			x		x	x	x	x	x																
R38	WSW	237° - 258°			x		x		x	x	x																
R39	W	259°- 281°			x		x		x	x	x					x											
R40	WNW, NW	282° - 326°			x		x		x	x	x				x	x											
R41	NNW	327° - 349°					x		x	x	x			x	x	x											

Shelter-in-Place until 90% ETE for R01, then Evacuate | PAZ Shelter-in-Place | PAZ Evacuate

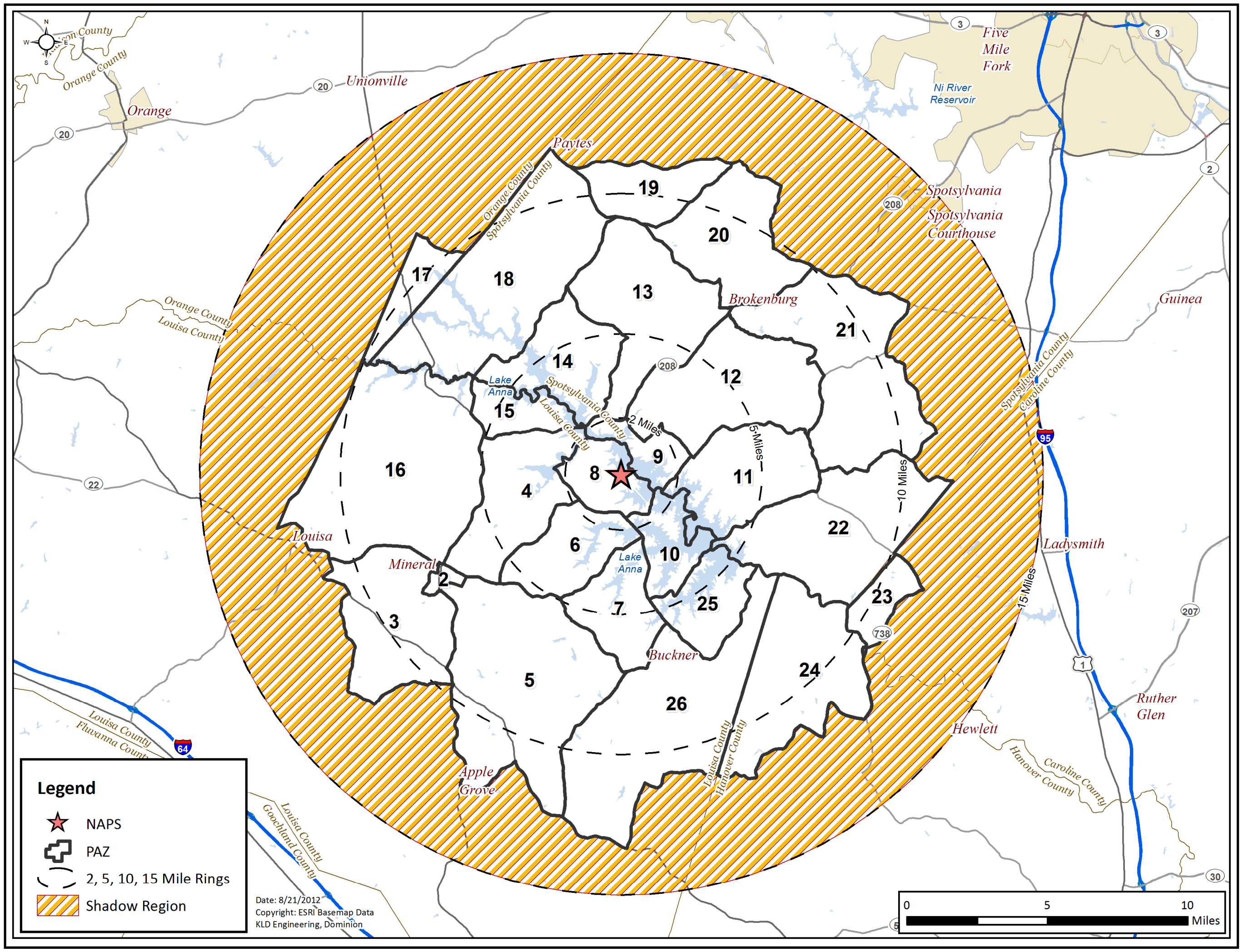


Figure 6-1. NAPS EPZ PAZ

Table 6-2. Evacuation Scenario Definitions

Scenario	Season[1]	Day of Week	Time of Day	Weather	Special
1	Summer	Midweek	Midday	Good	None
2	Summer	Midweek	Midday	Rain	None
3	Summer	Weekend	Midday	Good	None
4	Summer	Weekend	Midday	Rain	None
5	Summer	Midweek, Weekend	Evening	Good	None
6	Winter	Midweek	Midday	Good	None
7	Winter	Midweek	Midday	Rain	None
8	Winter	Midweek	Midday	Snow	None
9	Winter	Weekend	Midday	Good	None
10	Winter	Weekend	Midday	Rain	None
11	Winter	Weekend	Midday	Snow	None
12	Winter	Midweek, Weekend	Evening	Good	None
13	Winter	Weekend	Midday	Good	Kinetic Triathlon at Lake Anna State park
14	Summer	Midweek	Midday	Good	Roadway Impact – One Segment of US-522 NB will be Closed

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

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

Scenario	Households With Returning Commuters	Households Without Returning Commuters	Employees	Transients	Seasonal Transients	Shadow	Special Events	School Buses	Transit Buses	External Through Traffic
1	36%	64%	96%	69%	100%	21%	0%	10%	100%	100%
2	36%	64%	96%	69%	100%	21%	0%	10%	100%	100%
3	4%	96%	10%	100%	100%	20%	0%	0%	100%	100%
4	4%	96%	10%	100%	100%	20%	0%	0%	100%	100%
5	4%	96%	10%	56%	100%	20%	0%	0%	100%	40%
6	36%	64%	100%	15%	0%	21%	0%	100%	100%	100%
7	36%	64%	100%	15%	0%	21%	0%	100%	100%	100%
8	36%	64%	100%	15%	0%	21%	0%	100%	100%	100%
9	4%	96%	10%	26%	0%	20%	0%	0%	100%	100%
10	4%	96%	10%	26%	0%	20%	0%	0%	100%	100%
11	4%	96%	10%	26%	0%	20%	0%	0%	100%	100%
12	4%	96%	10%	14%	0%	20%	0%	0%	100%	40%
13	4%	96%	10%	26%	0%	20%	100%	0%	100%	100%
14	36%	64%	96%	69%	100%	21%	0%	10%	100%	100%

Resident Households with Commuters .... Households of EPZ residents who await the return of commuters prior to beginning the evacuation trip.
Resident Households with No Commuters .. Households of EPZ residents who do not have commuters or will not await the return of commuters prior to beginning the evacuation trip.
Employees.. EPZ employees who live outside the EPZ
Transients .... People who are in the EPZ at the time of an accident for recreational or other (non-employment) purposes.
Shadow .... Residents and employees in the shadow region (outside of the EPZ) who will spontaneously decide to relocate during the evacuation. The basis for the values shown is a 20% relocation of shadow residents along with a proportional percentage of shadow employees.
Special Events .... Additional vehicles in the EPZ due to the identified special event.
School and Transit Buses .... Vehicle-equivalents present on the road during evacuation servicing schools and transit-dependent people (1 bus is equivalent to 2 passenger vehicles).
External Through Traffic .... Traffic on interstates/freeways and major arterial roads at the start of the evacuation. This traffic is stopped by access control approximately 2 hours after the evacuation begins.

Table 6-4. Vehicle Estimates by Scenario

Scenario	Households With Returning Commuters	Households Without Returning Commuters	Employees	Transients	Seasonal Transients	Shadow	Special Events	School Buses	Transit Buses	External Through Traffic	Total Scenario Vehicles
1	5,020	8,895	727	1,297	922	3,718	-	23	50	13,550	34,202
2	5,020	8,895	727	1,297	922	3,718	-	23	50	13,550	34,202
3	502	13,413	76	1,879	922	3,552	-	-	50	13,550	33,944
4	502	13,413	76	1,879	922	3,552	-	-	50	13,550	33,944
5	502	13,413	76	1,052	922	3,552	-	-	50	5,420	24,987
6	5,020	8,895	757	282	-	3,725	-	226	50	13,550	32,505
7	5,020	8,895	757	282	-	3,725	-	226	50	13,550	32,505
8	5,020	8,895	757	282	-	3,725	-	226	50	13,550	32,505
9	502	13,413	76	489	-	3,552	-	-	50	13,550	31,632
10	502	13,413	76	489	-	3,552	-	-	50	13,550	31,632
11	502	13,413	76	489	-	3,552	-	-	50	13,550	31,632
12	502	13,413	76	263	-	3,552	-	-	50	5,420	23,276
13	502	13,413	76	489	-	3,552	249	-	50	13,550	31,181
14	5,020	8,895	727	1,297	922	3,718	-	23	50	13,550	34,202

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 41 regions within the NAPS EPZ and the 14 Evacuation Scenarios discussed in Section 6.

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

7.1 Voluntary Evacuation and Shadow Evacuation

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

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

Figure 7-2 presents the area identified as the Shadow Region. This region extends radially from the plant to cover a region between the EPZ boundary and approximately 15 miles. The population and number of evacuating vehicles in the Shadow Region were estimated using the same methodology that was used for permanent residents within the EPZ (see Section 3.1). As discussed in Section 3.2, it is estimated that a total of 31,947 people reside in the Shadow Region; 20 percent of them would evacuate. See Table 6-4 for the number of evacuating vehicles from the Shadow Region.

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

7.2 Staged Evacuation

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

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

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

See Section 5.4.2 for additional information on staged evacuation.

7.3 Patterns of Traffic Congestion during Evacuation

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

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

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

Highway "links" which experience LOS F at the indicated times are delineated in these Figures by a red line; all others are lightly indicated.

At 30 minutes after the ATE, evacuees are beginning to mobilize. As shown in Figure 7-3, moderate traffic develops along SR-700 as employees evacuate from the plant.

At 50 minutes after the ATE, Figure 7-4 shows that there is no congestion within 5 miles of the plant. The town of Louisa experiences moderate levels of traffic (LOS D and LOS E) in the shadow, and congestion (LOS F) is exhibited on CR-601 northbound in the town of Granite Springs at the EPZ boundary. This congestion is due to the presence of a stop sign at the junction of CR-601 and CR-606. The intersections of SR 658 and SR 715 south of Beaverdam and US 522 and CR 612 also exhibit congestion due to the evacuation of seasonal summer residents on Lake Anna. The congestion at these two locations is due to the presence of stop-sign control.

At 1 hour and 30 minutes after the ATE, congestion has cleared on CR-601 in Granite Springs and CR 612 approaching US 522, as shown in Figure 7-5. Traffic has dissipated in the town of Louisa and congestion is still exhibited at the junction of SR 658 and SR 715.

At 2 hour and 10 minutes after the ATE, Figure 7-6 shows that traffic has subsided in the town of Louisa and the EPZ is completely clear of congestion. The last remnants of congestion, located outside of the Shadow Region at the junction of US 33 and SR 715 clears at 2 hours and 20 minutes after the ATE.

7.4 Evacuation Rates

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

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

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

7.5 Evacuation Time Estimate (ETE) Results

Table 7-1 through Table 7-2 present the ETE values for all 41 Evacuation Regions and all 14 Evacuation Scenarios. Table 7-3 through Table 7-4 present the ETE values for the 2-Mile region for both staged and un-staged keyhole regions downwind to 5 miles. They are organized as follows:

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

The animation snapshots described above reflect the ETE statistics for the concurrent (un-staged) evacuation scenarios and regions, which are displayed in Figure 7-3 through Figure 7-6. There is minimal traffic congestion within the EPZ, which results in ETE values which reflect mobilization time.

The 90th percentile ETE for weekday (non-snow) scenarios are approximately 45 minutes longer than weekend scenarios. As shown in Table 6-4, the ratio of households with returning commuters to that of employees and transients is approximately 5 to 10 times greater for weekdays compared with weekends. As shown in Figure 5-4, 90 percent of residents with commuters mobilize in about 185 minutes, whereas 90 percent of employees and transients mobilize in about 85 minutes. These factors lead to 90 percent of the population clearing the EPZ sooner in the weekend scenario.

The 100th percentile ETE for all Regions and for all Scenarios are the same values as the mobilization times, due to the fact that there is essentially no congestion within the EPZ and traffic is free-flowing prior to the end of mobilization, as is displayed in Figure 7-6.

Comparison of Scenarios 9 and 13 in Table 7-1 indicates that the special event, the Kinetic Triathlon at Lake Anna State Park (see Section 3.7), has no impact on the ETE at the 90th or 100th percentile. The results indicate there is sufficient reserve capacity to accommodate the additional special event vehicles.

Comparison of Scenarios 1 and 14 in Table 7-1 indicates that the roadway closure – one segment of US-522 northbound at CR-612 – increases the 90th percentile by at most 5 minutes and has no effect on the100th percentile ETE – not a significant impact. US-522 never experiences traffic congestion, and sufficient reserve capacity exists on CR-612 to service the additional evacuating traffic demand diverted from US-522.

7.6 Staged Evacuation Results

Table 7-3 and Table 7-4 present a comparison of the ETE compiled for the concurrent (un-staged) and staged evacuation studies. Note that Regions R29 through R41 are the same geographic areas as Regions R02 and R04 through R15, respectively.

To determine whether the staged evacuation strategy is worthy of consideration, one must show that the ETE for the 2 Mile region can be reduced without significantly affecting the region between 2 miles and 5 miles. As shown by Table 7-3 and Table 7-4, no benefit is gained from staging the evacuation; staging the evacuation to attempt to reduce congestion within the 5-mile area provides no benefits to evacuees from within the 2-mile region and unnecessarily delays the evacuation of those beyond 2 miles. The staged 90th percentile ETE, shown in Table 7-3, are generally 15 minutes longer than a concurrent evacuation. This results from vehicles evacuating from the 2 to 5-mile region passing through the 2-mile region to evacuate, primarily along SR-208 and CR-601.

While failing to provide assistance to evacuees from within 2 miles of the NAPS, staging produces a negative impact on the ETE for those evacuating from within the 5-mile area. A comparison of ETE between Regions, R29 through R41 with R02 and R04 through R15, respectively, reveals that staging retards the 90th percentile evacuation time for those in the 2 to 5-mile area by up to 35 minutes for non-snow cases (see Table 7-1). This extending of ETE is due to the delay in beginning the evacuation trip, experienced by those who shelter, plus the effect of the trip-generation "spike" (significant volume of traffic beginning the evacuation trip at the same time) that follows their eventual ATE, in creating congestion within the EPZ area beyond 2 miles.

In summary, the staged evacuation protective action strategy provides no benefits to evacuees from within 2 miles and adversely impacts many evacuees located beyond 2 miles from the NAPS. This fact is implied by the lack of congestion within 5 miles of the plant, as displayed in Figure 7-4.

7.7 Guidance on Using ETE Tables

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

1. Identify the applicable **Scenario**:
    - Season
        - Summer
        - Winter (also Autumn and Spring)
    - Day of Week

- Midweek
- Weekend
- Time of Day
  - Midday
  - Evening
- Weather Condition
  - Good Weather
  - Rain
  - Snow
- Special Event
  - Kinetic Triathlon at Lake Anna State Park
  - Road Closure (A segment on US-522 as explained in Section 2.2)
- Evacuation Staging
  - No, Staged Evacuation is not considered
  - Yes, Staged Evacuation is considered

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

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

2. With the desired percentile ETE and Scenario identified, now identify the **Evacuation Region**:
   - Determine the projected azimuth direction of the plume (coincident with the wind direction). This direction is expressed in terms of compass orientation: towards 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 (Region R02, R04 through R15)
     - To EPZ Boundary (Regions R03, R16 through R28)
   - Enter Table 7-5 and identify the applicable group of candidate Regions based on the

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

3. Determine the **ETE Table based on the percentile selected. Then, for the Scenario** identified in Step 1 and the **Region** identified in Step 2, proceed as follows:
   - The columns of Table 7-1 are labeled with the Scenario numbers. Identify the proper column in the selected Table using the Scenario number defined in Step 1.
   - Identify the row in this table that provides ETE values for the Region identified in Step 2.
   - The unique data cell defined by the column and row so determined contains the desired value of ETE expressed in Hours:Minutes.

<u>Example</u>

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

- Sunday, August 10th at 4:00 AM.
- It is raining.
- Wind direction is toward the northeast (NE).
- Wind speed is such that the distance to be evacuated is judged to be a 5-mile radius and downwind to 10 miles (to EPZ boundary).
- The desired ETE is that value needed to evacuate 90 percent of the population from within the impacted Region.
- A staged evacuation is not desired.

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

1. Identify the Scenario as summer, weekend, evening and raining. Entering Table 7-1, it is seen that there is no match for these descriptors. However, the clarification given above assigns this combination of circumstances to Scenario 4.
2. Enter Table 7-5 and locate the Region described as "Evacuate 5-Mile Radius and Downwind to the EPZ Boundary" for wind direction toward the NE and read Region R18 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 R18. This data cell is in column (4) and in the row for Region R18; it contains the ETE value of **1:55**.

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

	Summer		Summer		Summer	Winter			Winter			Winter	Winter	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	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	Snow	Good Weather	Rain	Snow	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region, 5-Mile Region, and EPZ														
R01	2:25	2:25	1:45	1:45	1:45	2:30	2:30	3:20	1:50	1:50	2:50	1:50	1:50	2:30
R02	2:25	2:25	1:50	1:50	1:50	2:30	2:35	3:25	1:50	1:50	2:55	1:55	1:50	2:30
R03	2:35	2:35	2:00	2:00	2:00	2:40	2:40	3:30	2:00	2:00	3:05	2:00	2:00	2:35
2-Mile Region and Keyhole to 5 Miles														
R04	2:20	2:20	1:45	1:45	1:45	2:30	2:30	3:15	1:50	1:50	2:55	1:50	1:50	2:20
R05	2:25	2:25	1:50	1:50	1:50	2:30	2:30	3:20	1:50	1:50	2:55	1:50	1:50	2:25
R06	2:25	2:25	1:50	1:50	1:50	2:25	2:25	3:15	1:50	1:50	2:55	1:50	1:50	2:25
R07	2:20	2:20	1:50	1:50	1:50	2:25	2:25	3:10	1:50	1:50	2:55	1:50	1:50	2:25
R08	2:20	2:20	1:50	1:50	1:50	2:25	2:25	3:15	1:50	1:50	2:55	1:50	1:50	2:25
R09	2:15	2:20	1:50	1:50	1:50	2:25	2:25	3:10	1:50	1:50	2:55	1:50	1:50	2:20
R10	2:15	2:15	1:50	1:50	1:50	2:20	2:20	3:05	1:50	1:50	2:50	1:50	1:50	2:20
R11	2:20	2:20	1:50	1:50	1:50	2:25	2:25	3:15	1:50	1:50	2:55	1:50	1:50	2:25
R12	2:15	2:20	1:50	1:50	1:50	2:20	2:25	3:10	1:50	1:50	2:50	1:50	1:50	2:20
R13	2:20	2:20	1:45	1:50	1:50	2:25	2:25	3:10	1:50	1:50	2:55	1:50	1:50	2:20
R14	2:15	2:15	1:45	1:45	1:45	2:25	2:25	3:15	1:50	1:50	2:50	1:50	1:50	2:20
R15	2:15	2:15	1:45	1:45	1:45	2:25	2:25	3:15	1:50	1:50	2:50	1:50	1:50	2:20
5-Mile Region and Keyhole to EPZ Boundary														
R16	2:30	2:30	1:55	1:55	1:50	2:35	2:35	3:25	1:55	1:55	3:00	1:55	1:55	2:30
R17	2:30	2:35	1:55	1:55	1:55	2:35	2:40	3:30	1:55	1:55	3:00	1:55	1:55	2:35
R18	2:30	2:30	1:50	1:55	1:55	2:35	2:35	3:30	1:55	1:55	3:00	1:55	1:55	2:35
R19	2:30	2:35	1:55	1:55	1:55	2:35	2:35	3:30	1:55	1:55	3:00	1:55	1:55	2:35
R20	2:30	2:35	1:55	1:55	1:55	2:35	2:40	3:30	1:55	1:55	3:00	1:55	1:55	2:35
R21	2:35	2:35	2:00	2:05	2:05	2:40	2:40	3:30	2:00	2:00	3:00	2:00	2:00	2:35
R22	2:30	2:35	2:00	2:00	2:05	2:35	2:40	3:30	1:55	1:55	3:00	1:55	1:55	2:35
R23	2:30	2:30	2:00	2:00	2:00	2:35	2:35	3:30	1:55	1:55	3:00	1:55	1:55	2:35

	Summer		Summer		Summer	Winter			Winter			Winter	Winter	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	Snow	Good Weather	Rain	Snow	Good Weather	Special Event	Roadway Impact
R24	2:30	2:30	1:50	1:55	1:55	2:35	2:35	3:25	1:55	1:55	3:00	1:55	1:55	2:35
R25	2:30	2:30	1:55	1:55	1:55	2:35	2:35	3:25	1:55	1:55	3:00	1:55	1:55	2:35
R26	2:30	2:30	1:50	1:50	1:50	2:35	2:35	3:25	1:55	1:55	3:00	1:55	1:55	2:30
R27	2:25	2:30	1:50	1:50	1:50	2:35	2:35	3:25	1:55	1:55	2:55	1:55	1:55	2:30
R28	2:30	2:30	1:55	1:55	1:50	2:35	2:35	3:25	1:55	1:55	2:55	1:55	1:55	2:30
Staged Evacuation - 2-Mile Region and Keyhole to 5 Miles														
R29	2:55	2:55	2:10	2:10	2:10	2:55	2:55	3:45	2:10	2:15	3:30	2:10	2:10	2:55
R30	2:55	2:55	2:10	2:10	2:10	2:55	2:55	3:45	2:15	2:15	3:30	2:15	2:15	2:55
R31	2:55	2:55	2:15	2:15	2:15	2:55	2:55	3:45	2:15	2:15	3:30	2:15	2:15	2:55
R32	2:50	2:50	2:10	2:10	2:10	2:50	2:55	3:40	2:10	2:10	3:25	2:10	2:10	2:50
R33	2:50	2:50	2:05	2:05	2:05	2:50	2:50	3:35	2:05	2:05	3:25	2:05	2:05	2:50
R34	2:50	2:50	2:05	2:05	2:05	2:50	2:50	3:40	2:05	2:10	3:25	2:05	2:05	2:50
R35	2:45	2:45	2:05	2:05	2:05	2:50	2:50	3:35	2:05	2:10	3:25	2:05	2:05	2:50
R36	2:45	2:45	2:05	2:05	2:05	2:45	2:45	3:30	2:05	2:05	3:20	2:05	2:05	2:45
R37	2:45	2:50	2:05	2:05	2:05	2:50	2:50	3:35	2:05	2:05	3:20	2:05	2:05	2:50
R38	2:45	2:45	2:05	2:05	2:05	2:45	2:45	3:35	2:05	2:05	3:20	2:05	2:05	2:45
R39	2:45	2:50	2:05	2:05	2:05	2:50	2:50	3:35	2:05	2:05	3:20	2:05	2:05	2:50
R40	2:50	2:50	2:05	2:05	2:05	2:50	2:50	3:40	2:05	2:10	3:25	2:05	2:05	2:50
R41	2:50	2:50	2:05	2:05	2:05	2:50	2:50	3:40	2:05	2:05	3:25	2:05	2:05	2:50

Table 7-2. Time to Clear the Indicated Area of *__100__* Percent of the Affected Population

	Summer		Summer		Summer	Winter			Winter			Winter	May	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	Snow	Good Weather	Rain	Snow	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region, 5-Mile Region, and EPZ														
R01	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R02	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R03	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
2-Mile Region and Keyhole to 5 Miles														
R04	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R05	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R06	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R07	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R08	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R09	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R10	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R11	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R12	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R13	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R14	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R15	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
5-Mile Region and Keyhole to EPZ Boundary														
R16	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
R17	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
R18	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
R19	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
R20	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
R21	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
R22	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
R23	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40

	Summer		Summer		Summer	Winter			Winter			Winter	May	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	Snow	Good Weather	Rain	Snow	Good Weather	Special Event	Roadway Impact
R24	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
R25	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
R26	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
R27	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
R28	5:40	5:40	5:40	5:40	5:40	5:40	5:40	6:40	5:40	5:40	6:40	5:40	5:40	5:40
Staged Evacuation - 2-Mile Region and Keyhole to 5 Miles														
R29	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R30	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R31	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R32	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R33	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R34	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R36	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R37	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R38	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R39	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R40	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35
R41	5:35	5:35	5:35	5:35	5:35	5:35	5:35	6:35	5:35	5:35	6:35	5:35	5:35	5:35

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

	Summer		Summer		Summer	Winter			Winter			Winter	Winter	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region and 5-Mile Region														
R01	2:25	2:25	1:45	1:45	1:45	2:30	2:30	3:20	1:50	1:50	2:50	1:50	1:50	2:25
R02	2:25	2:25	1:45	1:50	1:50	2:35	2:35	3:25	1:50	1:50	2:55	1:50	1:50	2:25
Unstaged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R04	2:25	2:25	1:45	1:45	1:50	2:30	2:30	3:20	1:50	1:50	2:55	1:50	1:50	2:25
R05	2:25	2:25	1:45	1:45	1:50	2:30	2:30	3:20	1:50	1:50	2:55	1:50	1:50	2:25
R06	2:25	2:25	1:45	1:45	1:45	2:30	2:30	3:20	1:50	1:50	2:50	1:50	1:50	2:25
R07	2:25	2:25	1:45	1:45	1:45	2:30	2:30	3:20	1:50	1:50	2:50	1:50	1:50	2:25
R08	2:25	2:25	1:45	1:45	1:50	2:35	2:35	3:25	1:50	1:50	2:55	1:50	1:50	2:25
R09	2:25	2:25	1:45	1:45	1:50	2:30	2:30	3:25	1:50	1:50	2:55	1:50	1:50	2:25
R10	2:25	2:25	1:45	1:45	1:50	2:30	2:30	3:25	1:50	1:50	2:55	1:50	1:50	2:25
R11	2:25	2:25	1:45	1:45	1:50	2:35	2:35	3:25	1:50	1:50	2:55	1:50	1:50	2:25
R12	2:25	2:25	1:45	1:45	1:45	2:30	2:30	3:20	1:50	1:50	2:50	1:50	1:50	2:25
R13	2:25	2:25	1:45	1:45	1:45	2:30	2:30	3:20	1:50	1:50	2:50	1:50	1:50	2:25
R14	2:25	2:25	1:45	1:45	1:45	2:30	2:30	3:20	1:50	1:50	2:50	1:50	1:50	2:25
R15	2:25	2:25	1:45	1:45	1:50	2:30	2:30	3:20	1:50	1:50	2:55	1:50	1:50	2:25
Staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R29	2:45	2:45	2:00	2:00	2:00	2:45	2:45	3:35	2:00	2:00	3:15	2:00	2:00	2:45
R30	2:40	2:40	1:55	1:55	2:00	2:45	2:45	3:30	2:00	2:00	3:15	2:00	2:00	2:40
R31	2:40	2:40	1:55	1:55	1:55	2:45	2:45	3:30	2:00	2:00	3:15	2:00	2:00	2:40
R32	2:35	2:40	1:55	1:55	1:55	2:40	2:40	3:30	2:00	2:00	3:10	2:00	2:00	2:35
R33	2:35	2:40	1:55	1:55	1:55	2:40	2:40	3:30	2:00	2:00	3:10	2:00	2:00	2:35
R34	2:40	2:45	2:00	2:00	2:00	2:45	2:45	3:30	2:00	2:00	3:15	2:00	2:00	2:40
R35	2:45	2:45	2:00	2:00	2:00	2:45	2:45	3:30	2:00	2:00	3:15	2:00	2:00	2:45
R36	2:45	2:45	2:00	2:00	2:00	2:45	2:45	3:30	2:00	2:00	3:15	2:00	2:00	2:45
R37	2:45	2:45	2:00	2:00	2:00	2:45	2:45	3:35	2:00	2:00	3:15	2:00	2:00	2:45

	Summer		Summer		Summer	Winter			Winter			Winter	Winter	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather	Special Event	Roadway Impact
R38	2:40	2:40	2:00	2:00	2:00	2:45	2:45	3:30	2:00	2:00	3:15	2:00	2:00	2:40
R39	2:40	2:40	2:00	2:00	2:00	2:45	2:45	3:30	2:00	2:00	3:15	2:00	2:00	2:40
R40	2:40	2:40	2:00	2:00	2:00	2:45	2:45	3:30	2:00	2:00	3:15	2:00	2:00	2:40
R41	2:40	2:40	1:55	1:55	2:00	2:45	2:45	3:30	2:00	2:00	3:15	2:00	2:00	2:40

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

	Summer		Summer		Summer	Winter			Winter			Winter	May	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Region	Midday		Midday		Evening	Midday			Midday			Evening	Evening	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Snow	Good Weather	Rain	Snow	Good Weather	Special Event	Roadway Impact
Entire 2-Mile Region and 5-Mile Region														
R01	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R02	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
Unstaged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R04	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R05	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R06	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R07	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R08	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R09	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R10	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R11	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R12	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R13	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R14	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R15	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
Staged Evacuation - 2-Mile Region and Keyhole to 5-Miles														
R29	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R30	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R31	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R32	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R33	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R34	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R35	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R36	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R37	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30

	Summer		Summer		Summer	Winter			Winter			Winter	May	Summer
	Midweek		Weekend		Midweek Weekend	Midweek			Weekend			Midweek Weekend	Weekend	Midweek
Scenario:	**(1)**	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**
Region	**Midday**		**Midday**		**Evening**	**Midday**			**Midday**			**Evening**	**Evening**	**Midday**
	Good Weather	**Rain**	**Good Weather**	**Rain**	**Good Weather**	**Good Weather**	**Rain**	**Snow**	**Good Weather**	**Rain**	**Snow**	**Good Weather**	**Special Event**	**Roadway Impact**
R38	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R39	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R40	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30
R41	5:30	5:30	5:30	5:30	5:30	5:30	5:30	6:30	5:30	5:30	6:30	5:30	5:30	5:30

Table 7-5. Description of Evacuation Regions

Region	Description	Site PAR Description	Protection Action Zone (PAZ)																								
			2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
R01	2-Mile Radius	2- Mile Radius					x		x	x	x																
R02	5-Mile Radius	5-Mile Radius			x		x	x	x	x	x	x	x	x	x	x										x	
R03	Full EPZ	Full EPZ	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Evacuate 2-Mile Radius and Downwind to 5 Miles																											
Region	**Wind Direction Toward:**	**Site PAR Description**	**Protection Action Zone (PAZ)**																								
			2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
R04	N, NNE	349° - 33°					x		x	x	x		x	x	x												
R05	NE	34° - 56°					x		x	x	x	x	x	x													
R06	ENE, E	57° - 101°					x		x	x	x	x	x														
R07	ESE	102° - 123°					x		x	x	x	x														x	
R08	SE	124° - 146°					x	x	x	x	x	x														x	
R09	SSE, S	147° - 191°					x	x	x	x	x															x	
R10	SSW	192° - 213°					x	x	x	x	x																
R11	SW	214° - 236°			x		x	x	x	x	x																
R12	WSW	237° - 258°			x		x		x	x	x																
R13	W	259°- 281°			x		x		x	x	x					x											
R14	WNW, NW	282° - 326°			x		x		x	x	x				x	x											
R15	NNW	327° - 349°					x		x	x	x			x	x	x											
Evacuate 5-Mile Radius and Downwind to the EPZ Boundary																											
Region	**Wind Direction Toward:**	**Site PAR Description**	**Protection Action Zone (PAZ)**																								
			2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
R16	N	349° - 11°			x		x	x	x	x	x	x	x	x	x	x			x	x	x					x	
R17	NNE	12° - 33°			x		x	x	x	x	x	x	x	x	x	x			x	x	x	x				x	
R18	NE	34° - 56°			x		x	x	x	x	x	x	x	x	x	x				x	x	x				x	
R19	ENE	57° - 78°			x		x	x	x	x	x	x	x	x	x	x					x	x	x			x	
R20	E	79° - 101°			x		x	x	x	x	x	x	x	x	x	x						x	x	x		x	
R21	ESE	102° - 123°			x		x	x	x	x	x	x	x	x	x	x						x	x	x	x	x	x
R22	SE	124° - 146°			x		x	x	x	x	x	x	x	x	x	x							x	x	x	x	x
R23	SSE, S	147° - 191°			x	x	x	x	x	x	x	x	x	x	x	x									x	x	x
R24	SSW	192° - 213°		x	x	x	x	x	x	x	x	x	x	x	x	x										x	x
R25	SW, WSW	214° - 258°	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x									x	
R26	W	259° - 281°	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	x							x	

Region	Description	Site PAR Description	Protection Action Zone (PAZ)																								
			2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
R27	WNW, NW	282° - 326°			x		x	x	x	x	x	x	x	x	x	x	x	x	x							x	
R28	NNW	327° - 349°			x		x	x	x	x	x	x	x	x	x	x		x	x	x						x	
Staged Evacuation - 2-Mile Radius Evacuates, then Evacuate Downwind to 5 Miles																											
Region	**Wind Direction Toward:**	**Site PAR Description**	**Protection Action Zone (PAZ)**																								
			2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
R29	-	5-Mile Radius			x		x	x	x	x	x	x	x	x	x	x										x	
R30	N, NNE	349° - 33°					x		x	x	x		x	x	x												
R31	NE	34° - 56°					x		x	x	x	x	x	x													
R32	ENE, E	57° - 101°					x		x	x	x	x	x														
R33	ESE	102° - 123°					x		x	x	x	x														x	
R34	SE	124° - 146°					x	x	x	x	x	x														x	
R35	SSE, S	147° - 191°					x	x	x	x	x															x	
R36	SSW	192° - 213°					x	x	x	x	x																
R37	SW	214° - 236°			x		x	x	x	x	x																
R38	WSW	237° - 258°			x		x		x	x	x																
R39	W	259°- 281°			x		x		x	x	x					x											
R40	WNW, NW	282° - 326°			x		x		x	x	x				x	x											
R41	NNW	327° - 349°					x		x	x	x			x	x	x											

Shelter-in-Place until 90% ETE for R01, then Evacuate | PAZ Shelter-in-Place | PAZ Evacuate

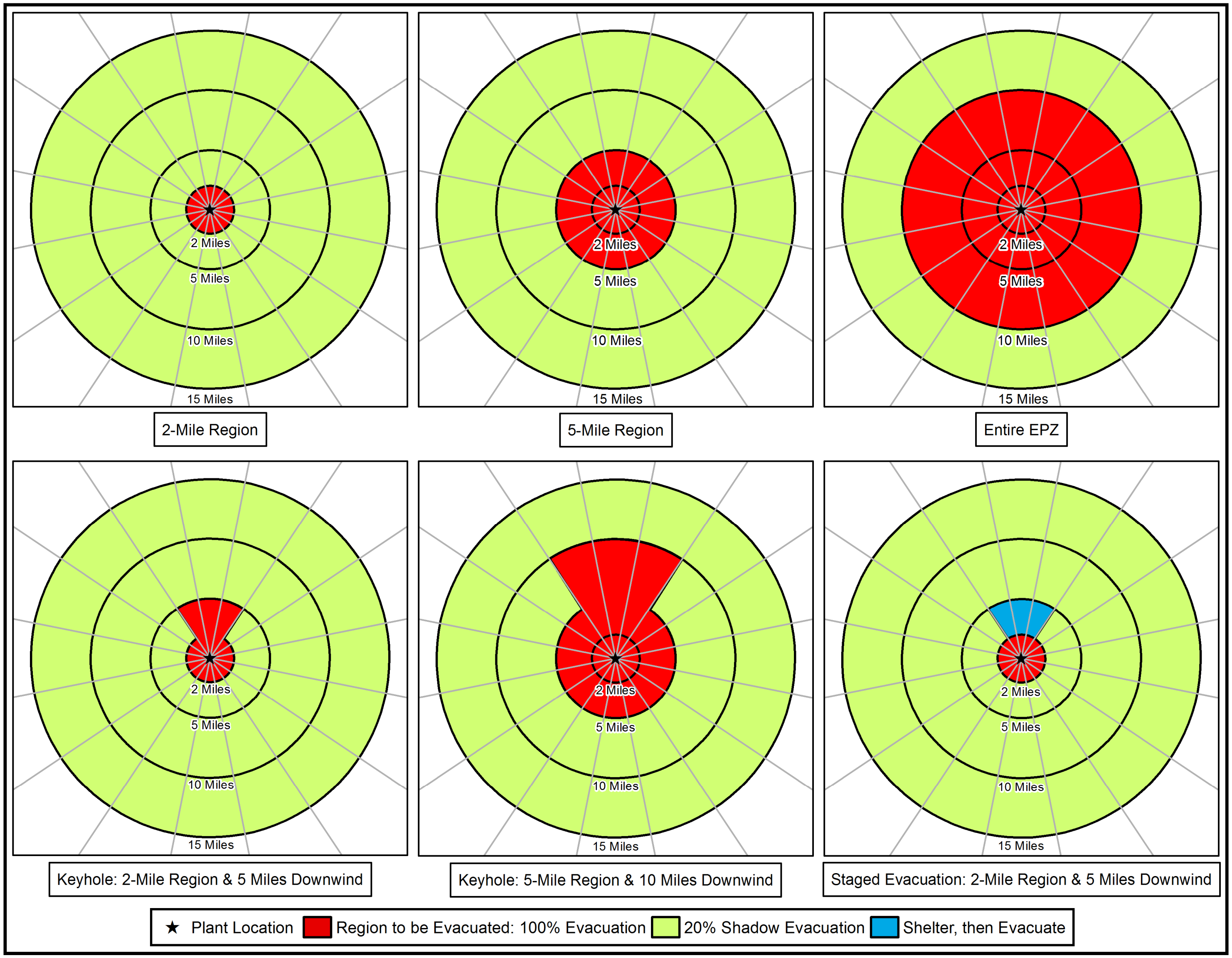


Figure 7-1. Voluntary Evacuation Methodology

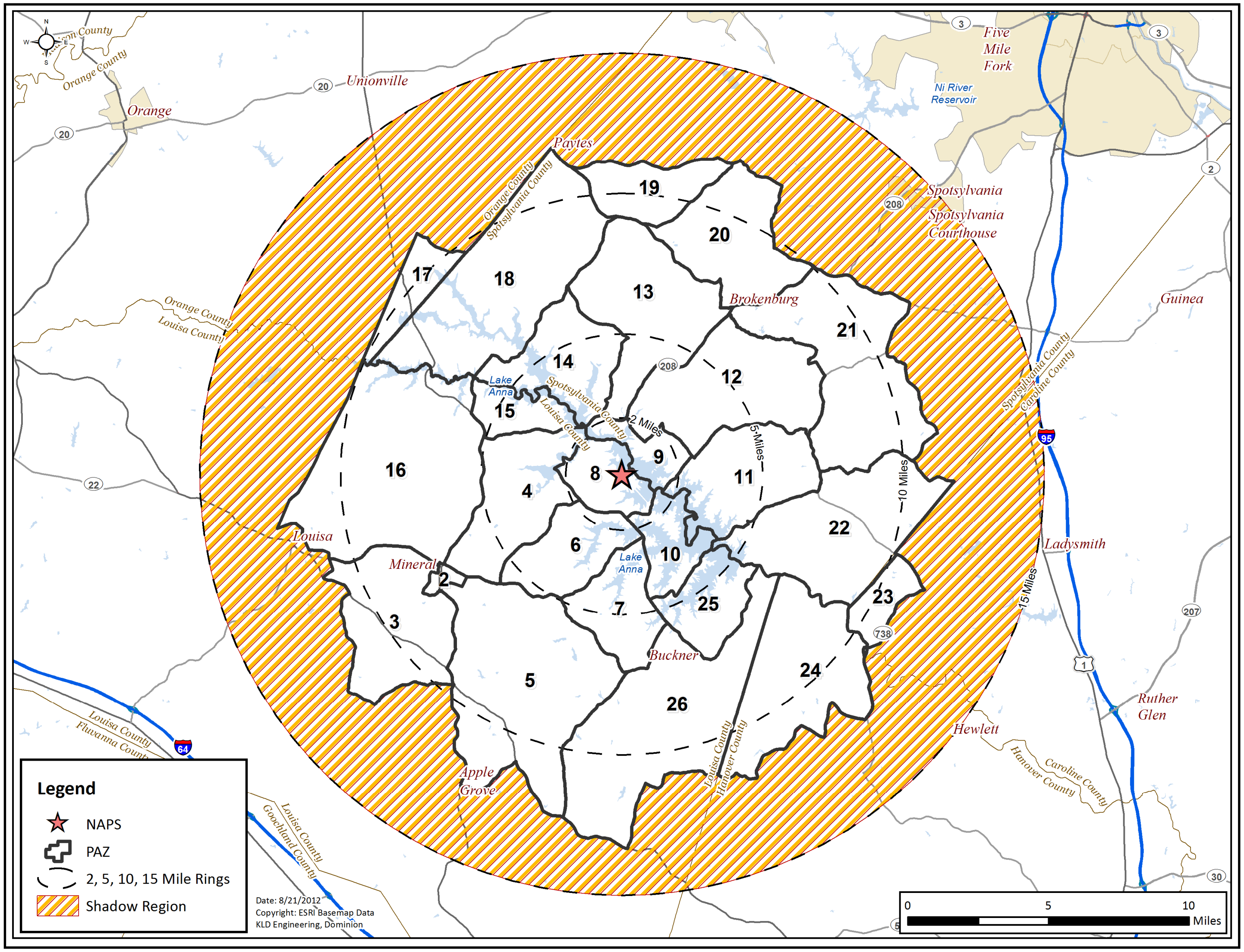


Figure 7-2. NAPS Shadow Region

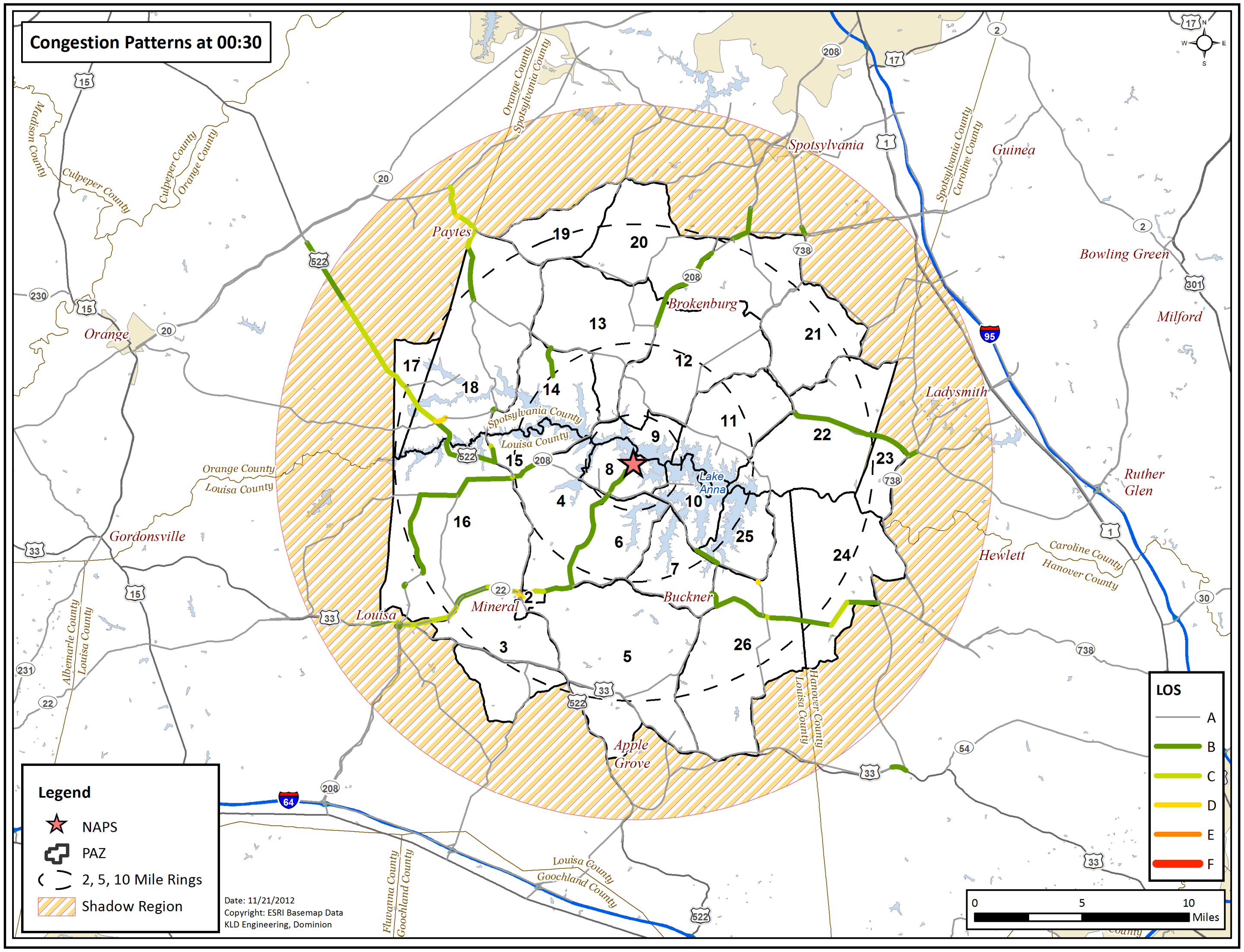


Figure 7-3. Congestion Patterns at 30 Minutes after the Advisory to Evacuate

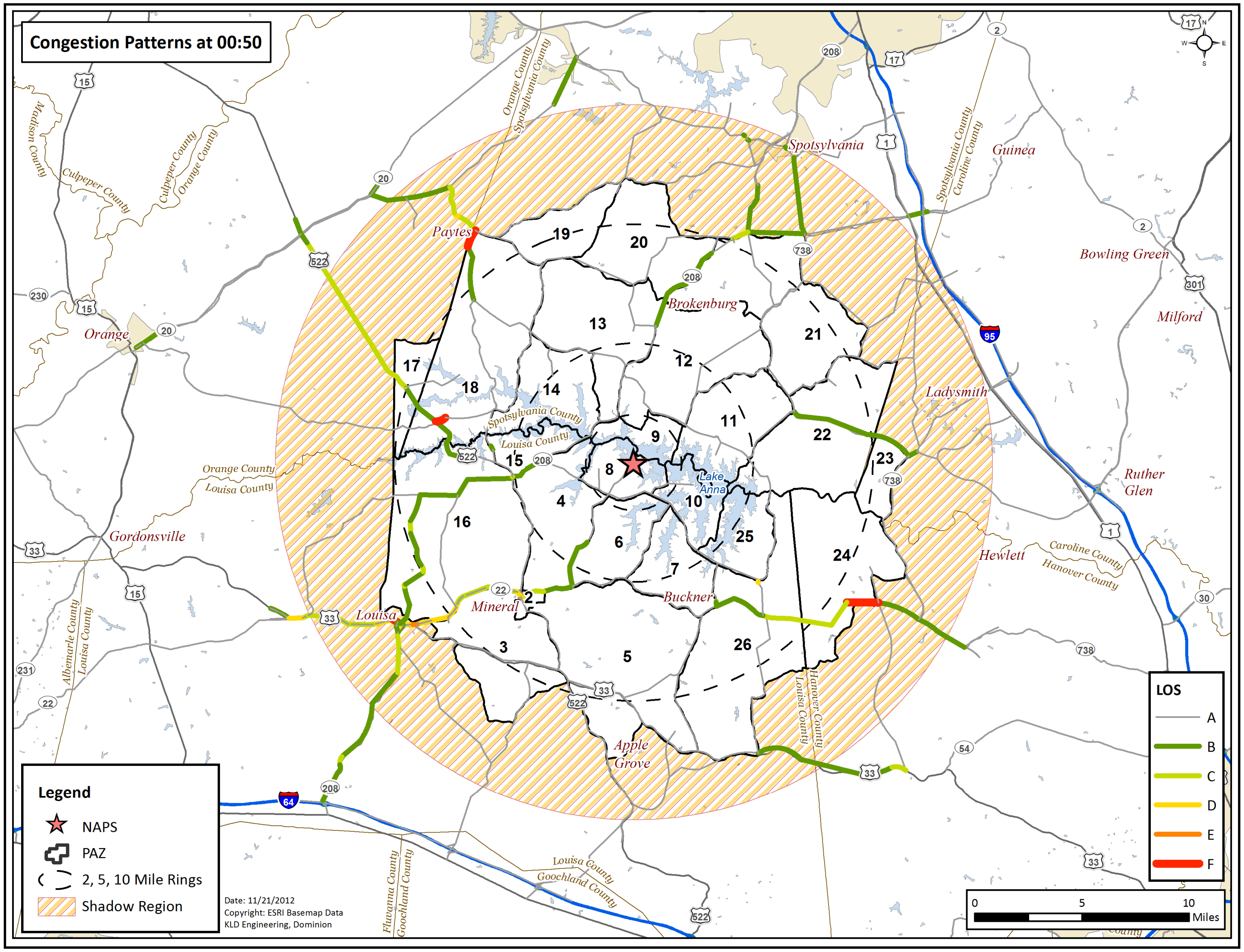


Figure 7-4. Congestion Patterns at 50 Minutes after the Advisory to Evacuate

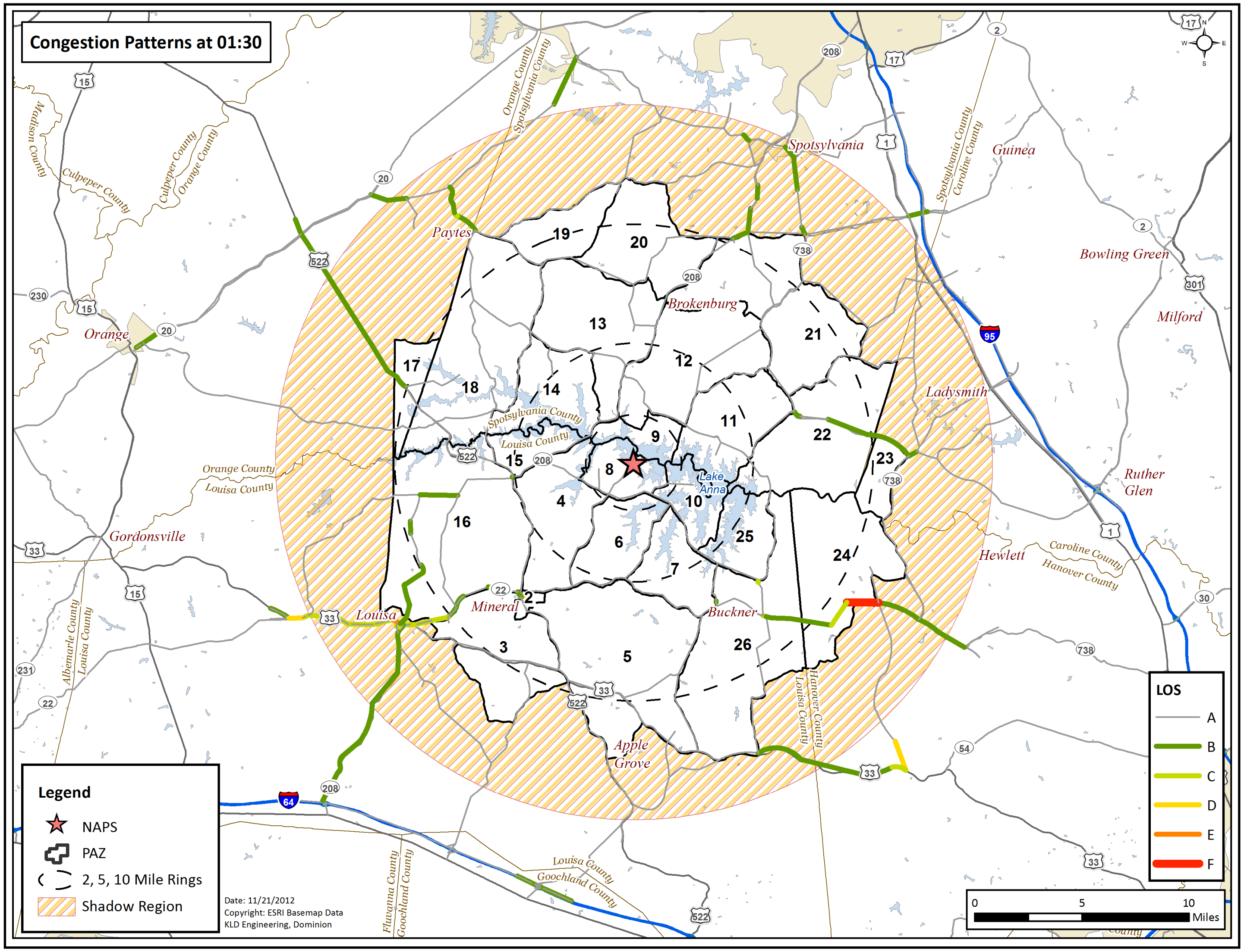


Figure 7-5. Congestion Patterns at 1 Hour 30 Minutes after the Advisory to Evacuate

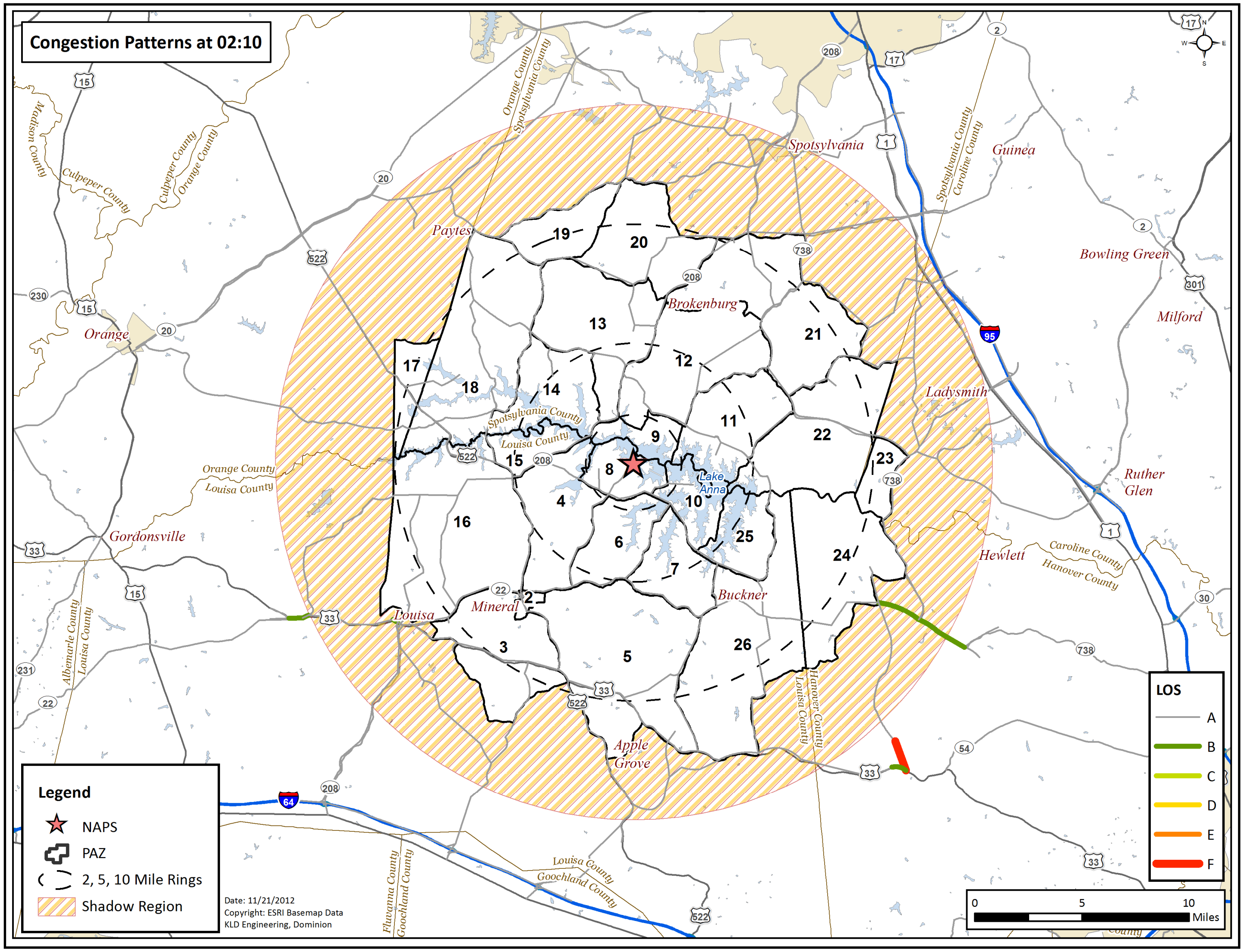


Figure 7-6. Congestion Patterns at 2 Hours 10 Minutes after the Advisory to Evacuate

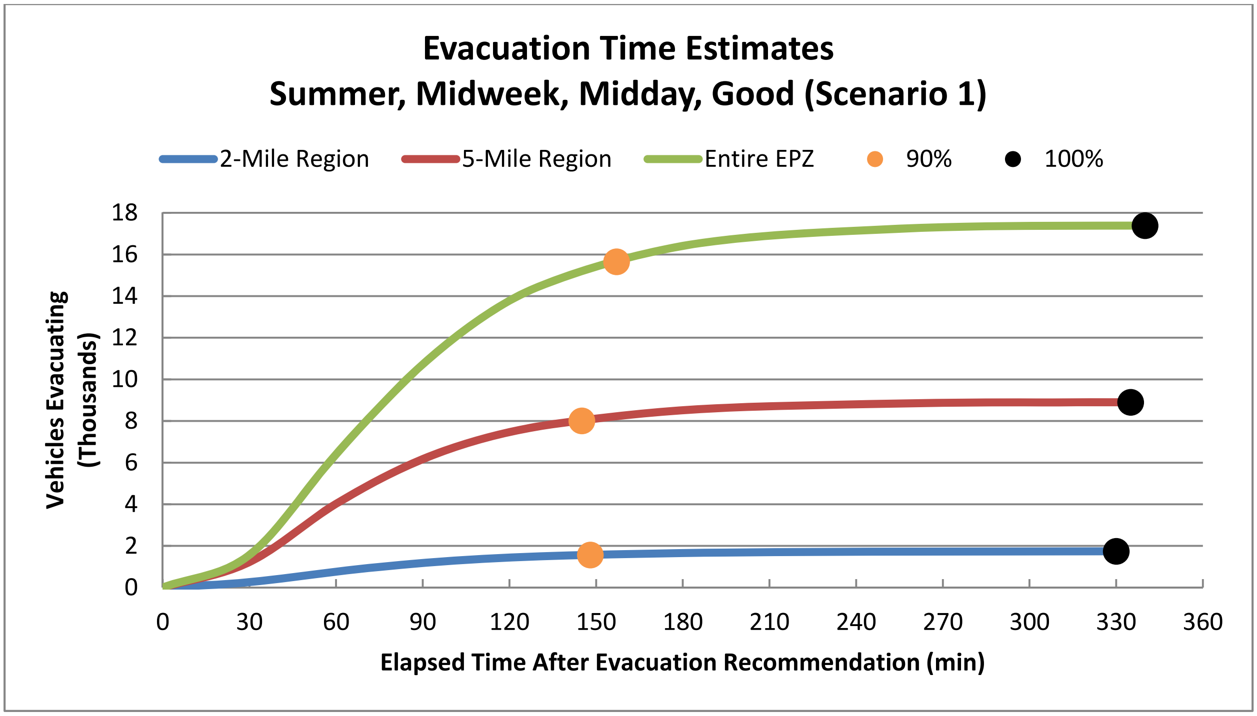


Figure 7-7. Evacuation Time Estimates - Scenario 1 for Region R03

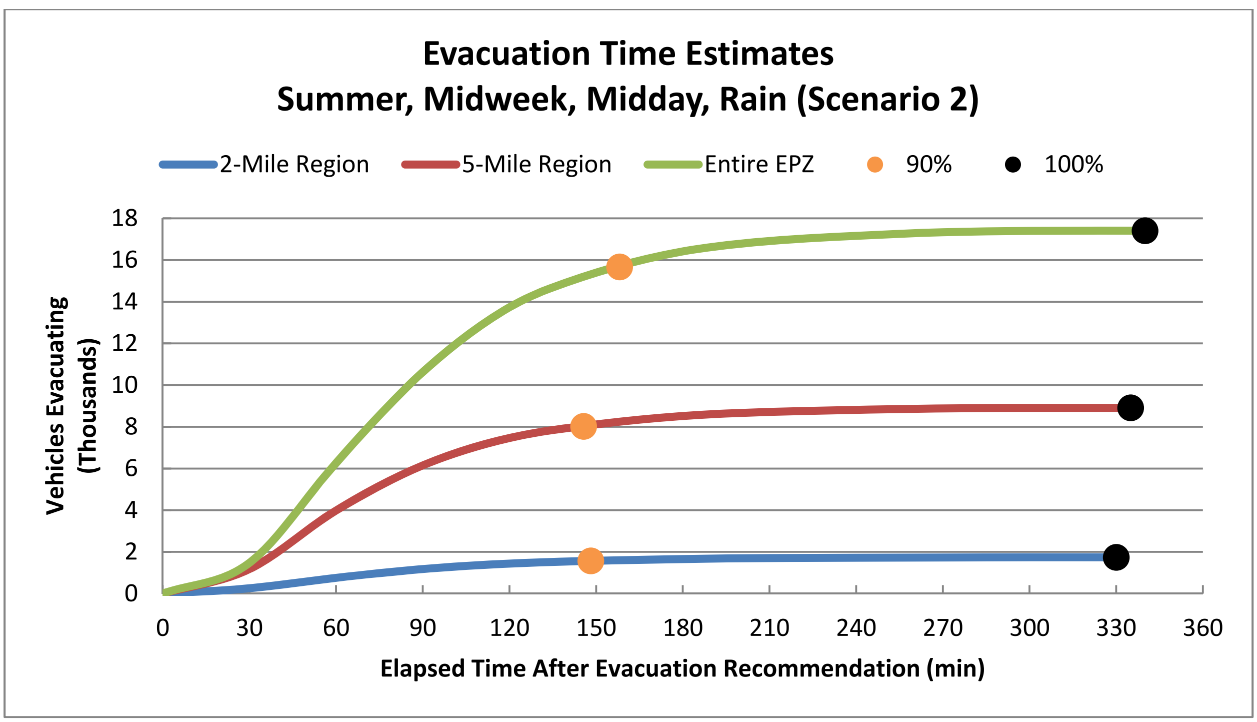


Figure 7-8. Evacuation Time Estimates - Scenario 2 for Region R03

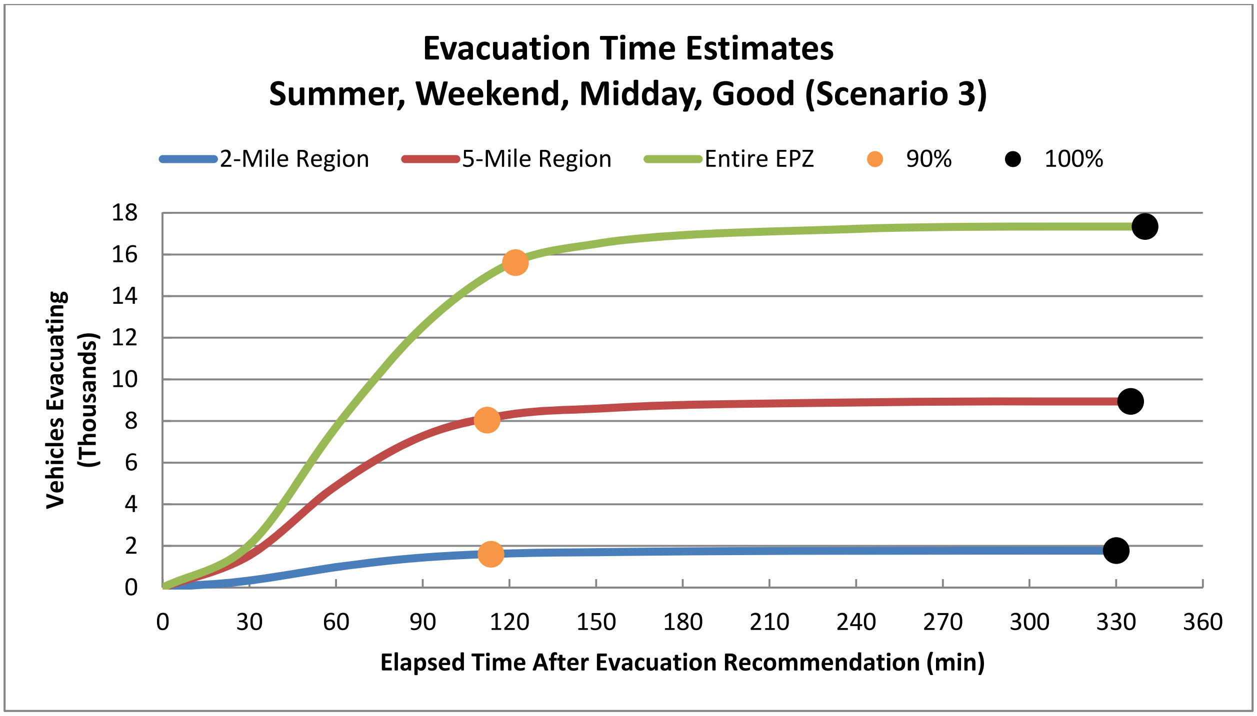


Figure 7-9. Evacuation Time Estimates - Scenario 3 for Region R03

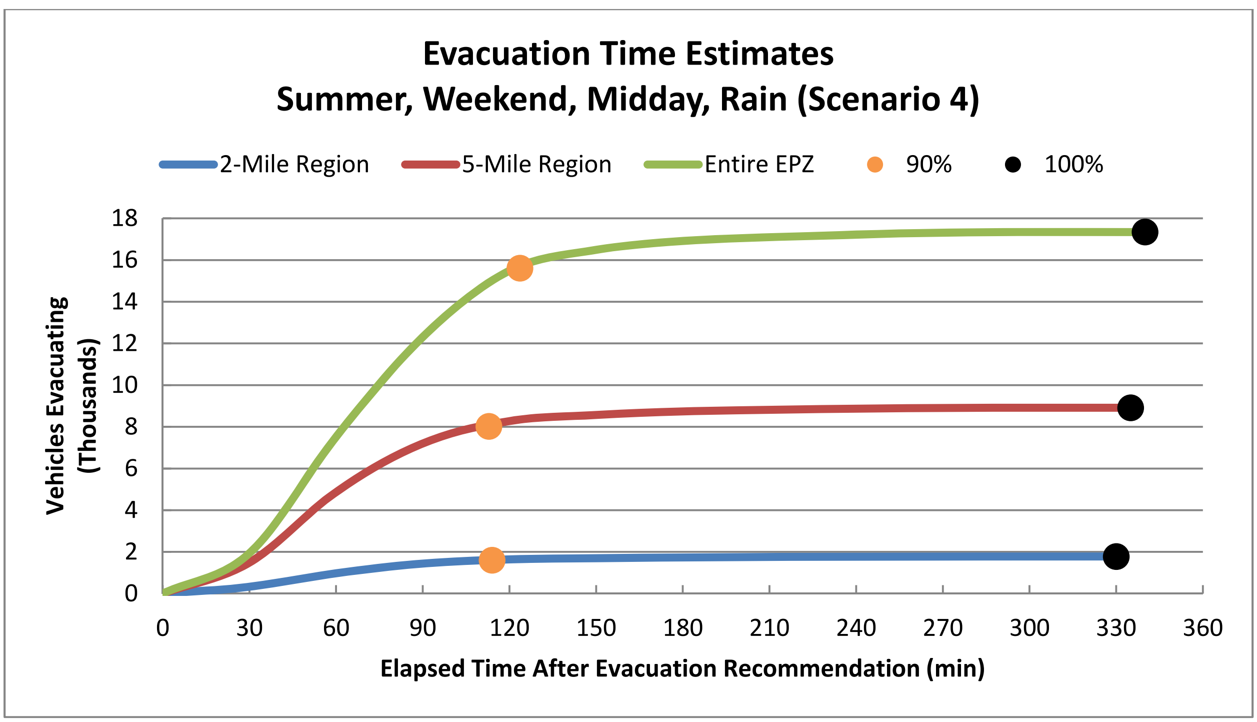


Figure 7-10. Evacuation Time Estimates - Scenario 4 for Region R03

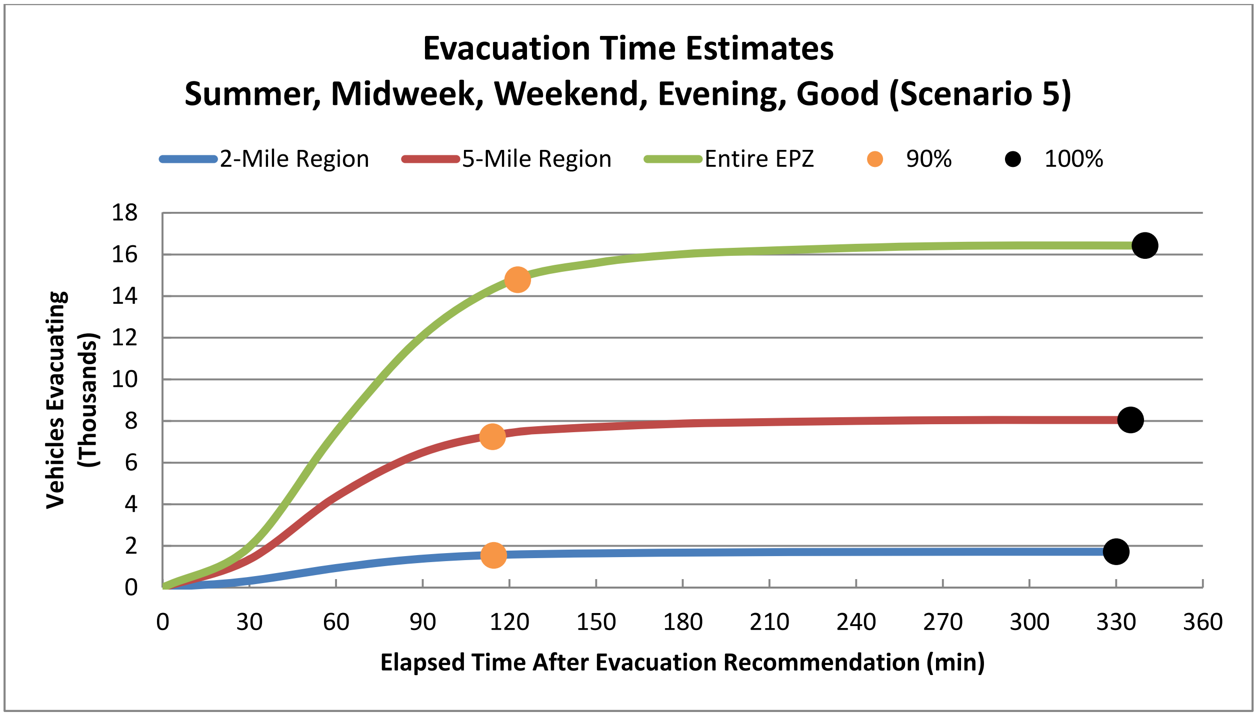


Figure 7-11. Evacuation Time Estimates - Scenario 5 for Region R03

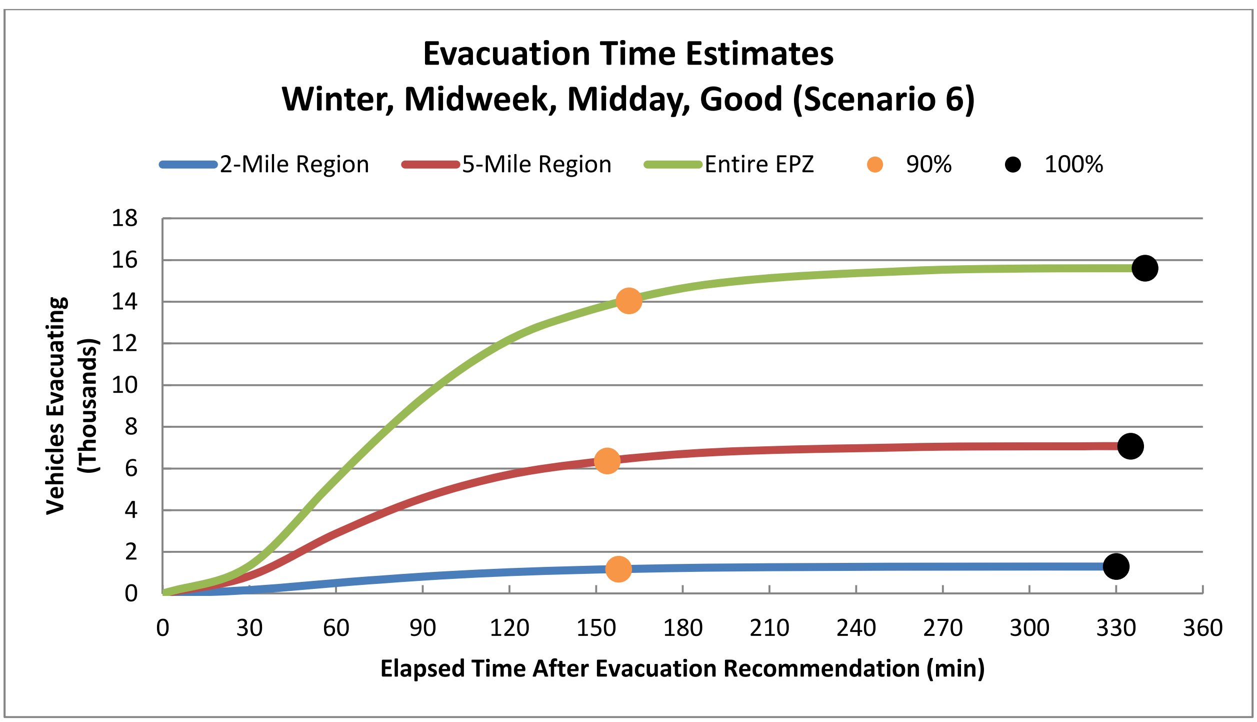


Figure 7-12. Evacuation Time Estimates - Scenario 6 for Region R03

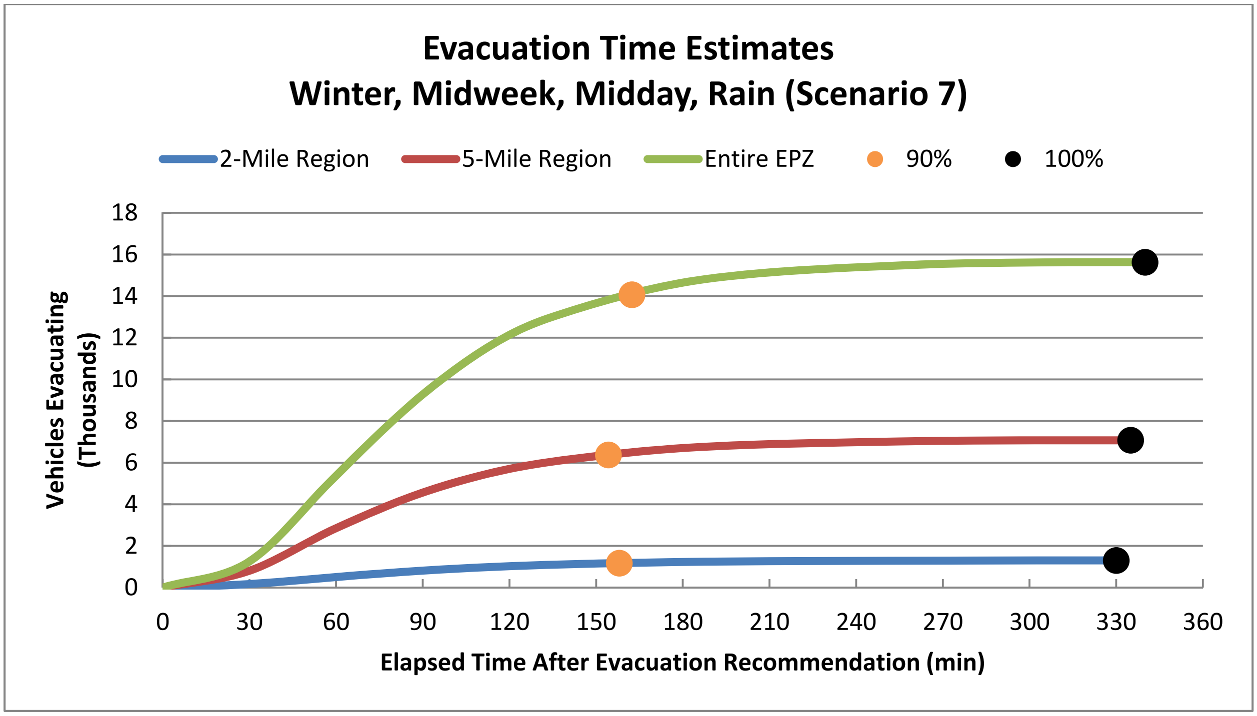


Figure 7-13. Evacuation Time Estimates - Scenario 7 for Region R03

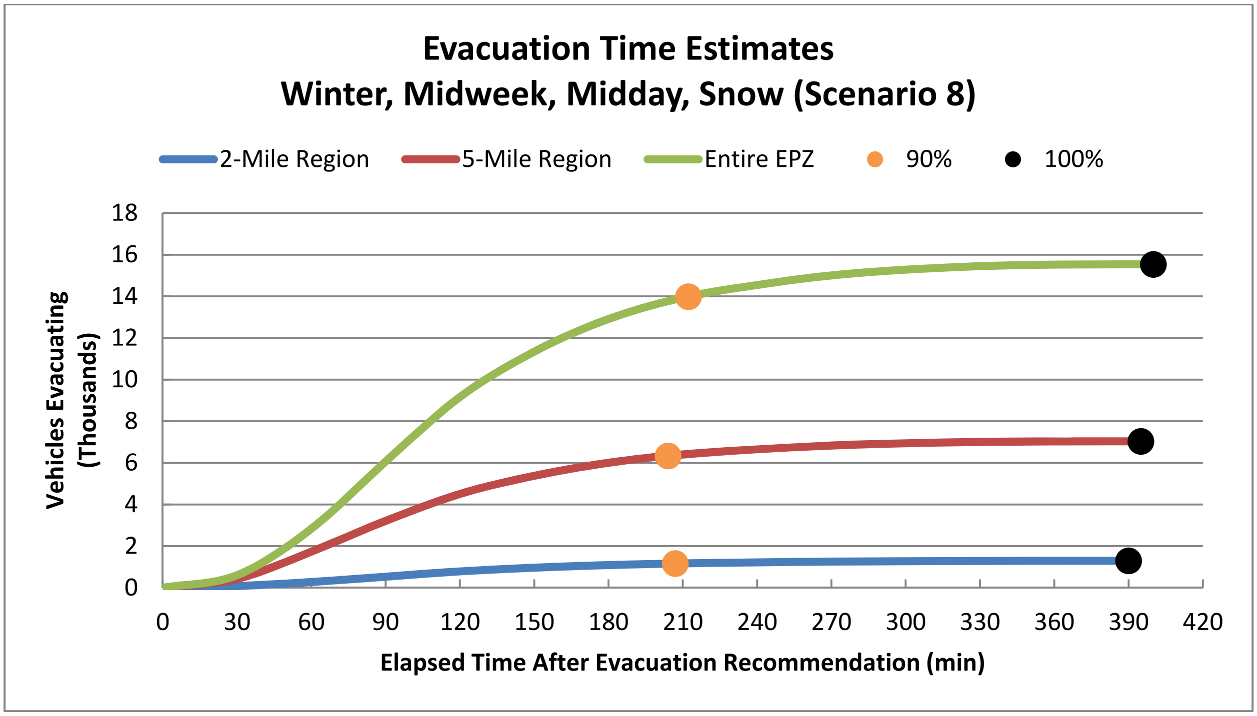


Figure 7-14. Evacuation Time Estimates - Scenario 8 for Region R03

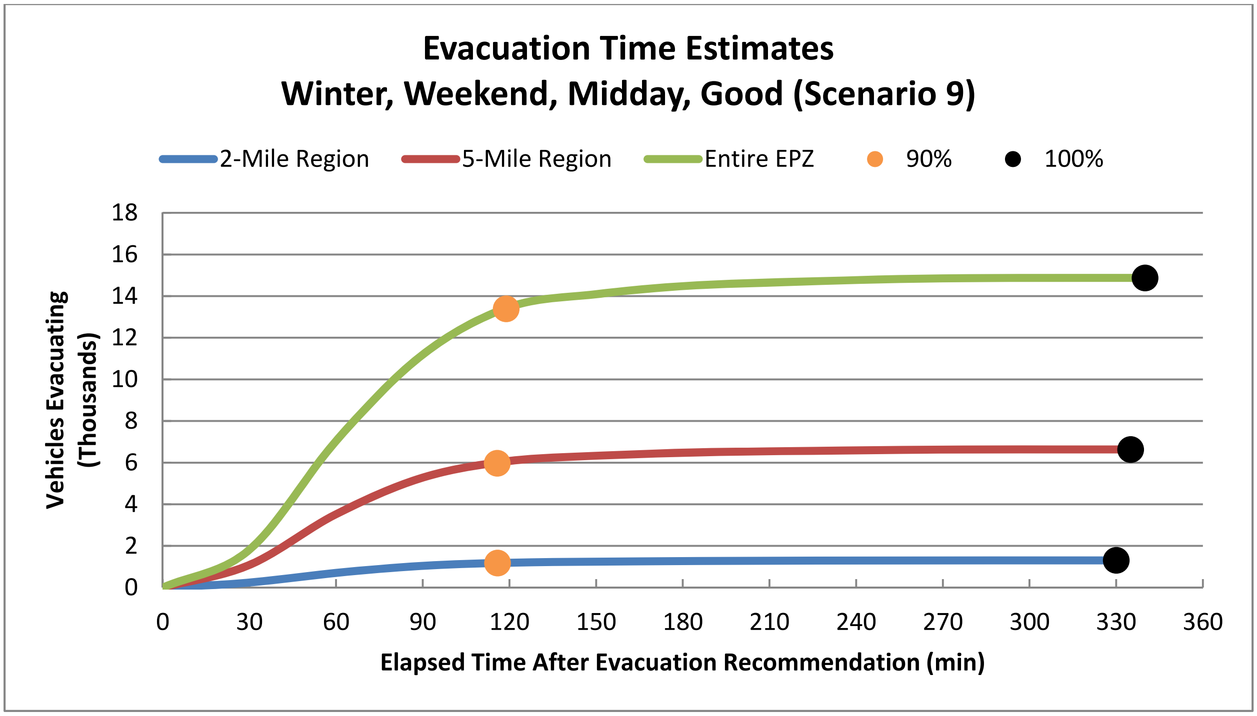


Figure 7-15. Evacuation Time Estimates - Scenario 9 for Region R03

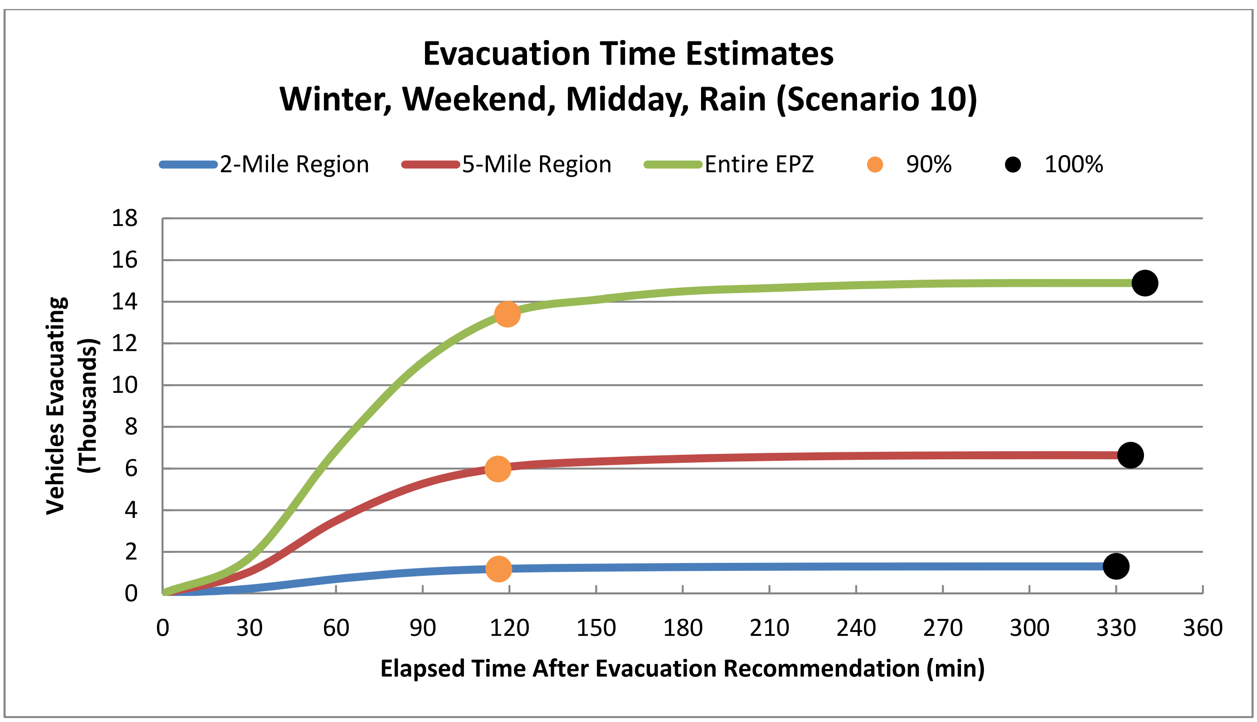


Figure 7-16. Evacuation Time Estimates - Scenario 10 for Region R03

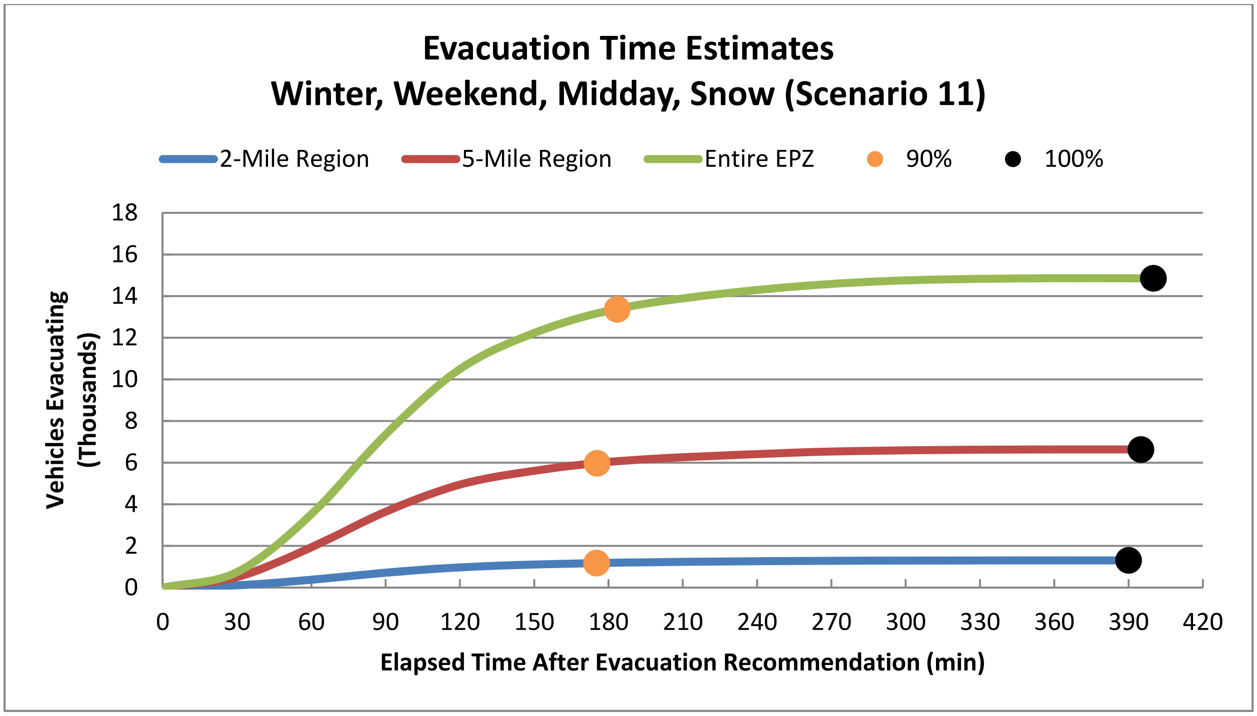


Figure 7-17. Evacuation Time Estimates - Scenario 11 for Region R03

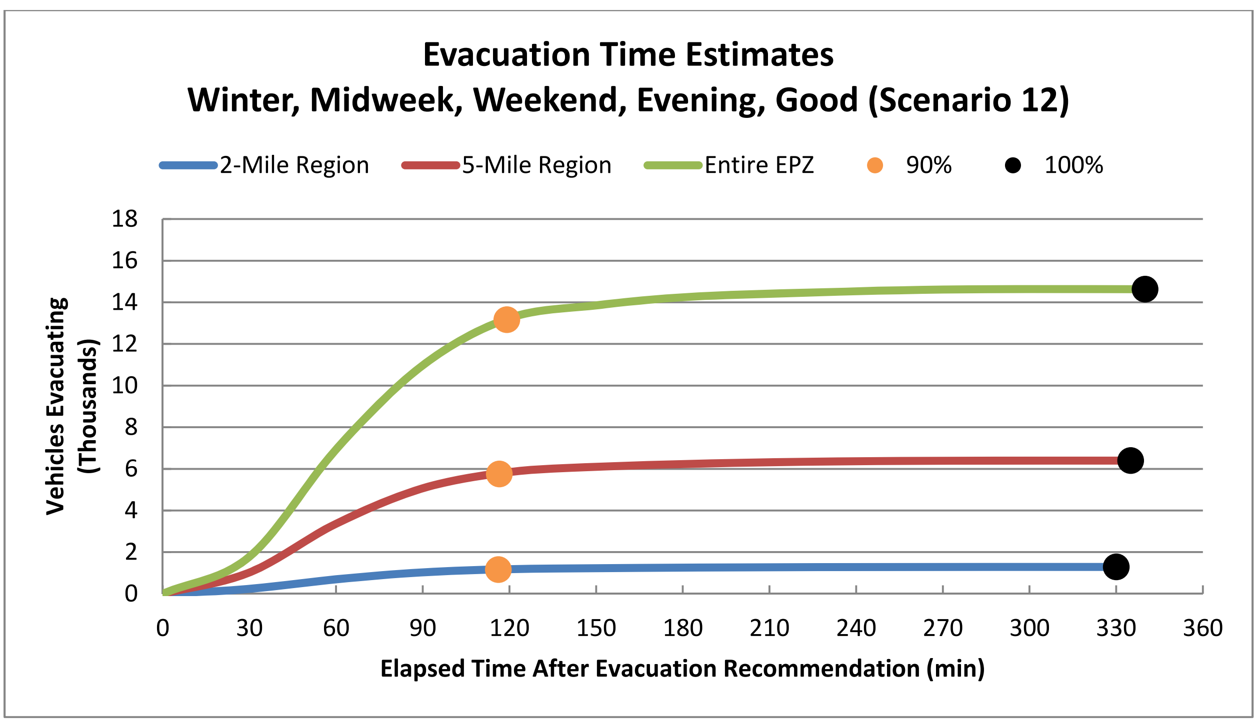


Figure 7-18. Evacuation Time Estimates - Scenario 12 for Region R03

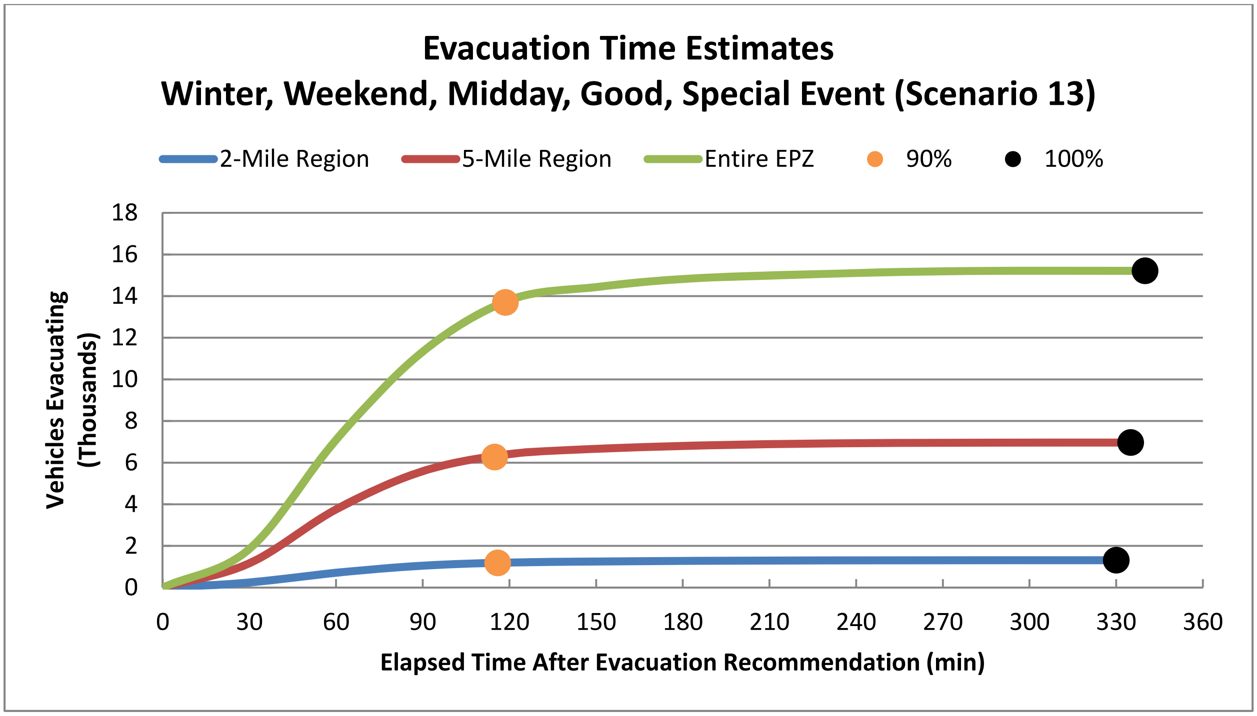


Figure 7-19. Evacuation Time Estimates - Scenario 13 for Region R03

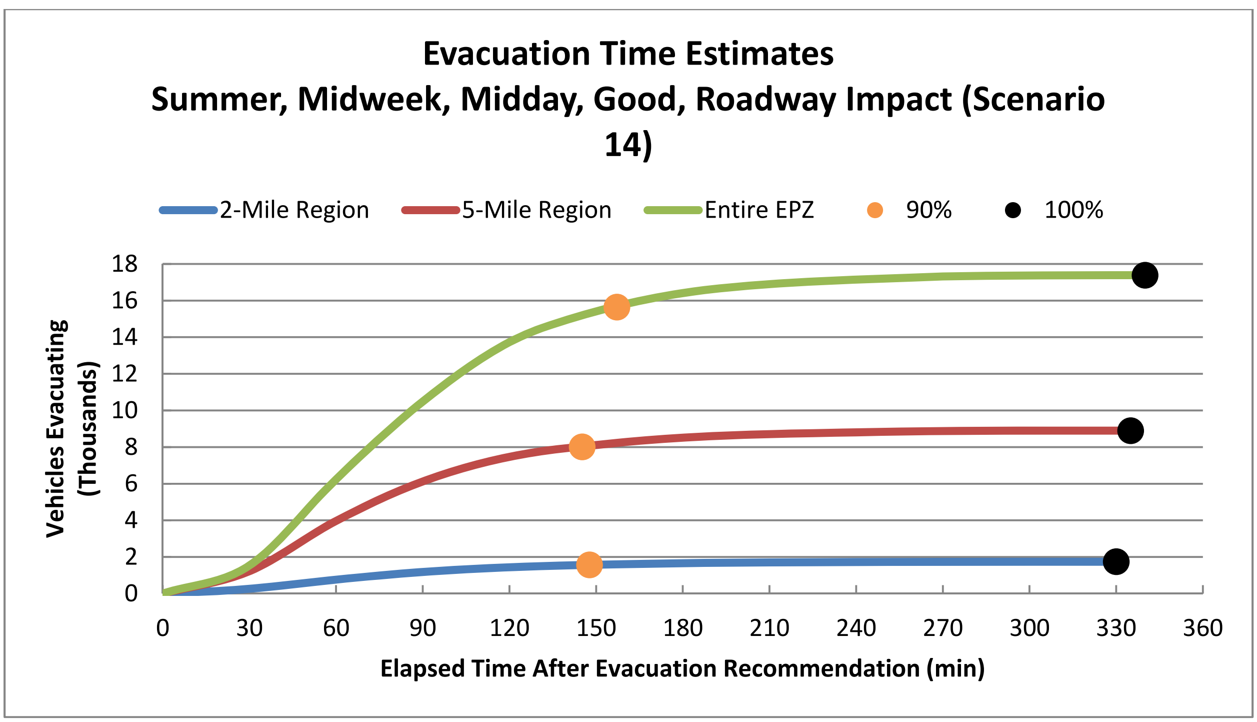


Figure 7-20. Evacuation Time Estimates - Scenario 14 for Region R03

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 for transit vehicles. The demand for transit service reflects the needs of three population groups: (1) residents with no vehicles available; (2) residents of special facilities such as schools, medical facilities; and (3) homebound special needs population.

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

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

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

These activities consume time. Based on discussion with the offsite agencies, it is estimated that school bus mobilization time will average approximately 90 minutes extending from the Advisory to Evacuate, to the time when buses first arrive at the facility to be evacuated.

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

The procedure for computing transit-dependent ETE is to:

- Estimate demand for transit service
- Estimate time to perform all transit functions
- Estimate route travel times to the EPZ boundary and to the EAC

8.1 Transit Dependent People Demand Estimate

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

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

In the latter group, the vehicle(s) may be used by a commuter(s) who does not return (or is not expected to return) home to evacuate the household.

Table 8-1 presents estimates of transit-dependent people. Note:

- Estimates of persons requiring transit vehicles include schoolchildren. For those evacuation scenarios where children are at school when an evacuation is ordered, separate transportation is provided for the schoolchildren. The actual need for transit vehicles by residents is thereby less than the given estimates. However, estimates of transit vehicles are not reduced when schools are in session.
- It is reasonable and appropriate to consider that many transit-dependent persons will evacuate by ride-sharing with neighbors, friends or family. For example, nearly 80 percent of those who evacuated from Mississauga, Ontario who did not use their own cars, shared a ride with neighbors or friends. Other documents report that approximately 70 percent of transit dependent persons were evacuated via ride sharing. **We will adopt a conservative estimate that 50 percent of transit dependent persons will ride share, in accordance with NUREG/CR-7002.**

The estimated number of bus trips needed to service transit-dependent persons is based on an estimate of average bus occupancy of 30 persons at the conclusion of the bus run. Transit vehicle seating capacities typically equal or exceed 60 children on average (roughly equivalent to 40 adults). If transit vehicle evacuees are two thirds adults and one third children, then the number of “adult seats” taken by 30 persons is 20 + (2/3 x10) = 27. On this basis, the average load factor anticipated is (27/40) x 100 = 68 percent. Thus, if the actual demand for service exceeds the estimates of Table 8-1 by 50 percent, the demand for service can still be accommodated by the available bus seating capacity.

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

Table 8-1 indicates that transportation must be provided for 360 people. Therefore, a total of **12 bus runs** are required to transport this population to EAC. While only 12 buses are needed from a capacity perspective, the county emergency plans collectively identify 25 different bus routes used to evacuate transit-dependent persons. This study will assume one bus is dispatched on each route resulting in a total of 25 buses to service the transit-dependent population in the NAPS EPZ.

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 NAPS 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

$$P = 9{,}806 \times [0.022 \times 1.50 + 0.154 \times (1.85 - 1) \times 0.59 \times 0.39 + 0.411 \times (2.47 - 2) \times (0.59 \times 0.39)^2] = 9{,}806 \times 0.0733 = 719$$

$$B = (0.5 \times P) \div 30 = 12$$

These calculations are explained as follows:

- All members (1.50 avg.) of households (HH) with no vehicles (2.2%) will evacuate by public transit or ride-share. The term 9,806 (number of households) x 0.022 x 1.50 accounts for these people.
- The members of HH with 1 vehicle away (15.4%), who are at home, equal (1.85-1). The number of HH where the commuter will not return home is equal to (9,806 x 0.154 x 0.59 x 0.39), as 59% of EPZ households have a commuter, 39% 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 (41.1%), who are at home, equal (2.47 – 2). The number of HH where neither commuter will return home is equal to 9,806 x 0.411 x $(0.59 \times 0.39)^2$. The number of persons who will evacuate by public transit or ride-share is equal to the product of these two terms (the last term is squared to represent the probability that neither commuter will return).
- Households with 3 or more vehicles are assumed to have no need for transit vehicles.
- The total number of persons requiring public transit is the sum of such people in HH with no vehicles, or with 1 or 2 vehicles that are away from home.

The estimate of transit-dependent population in Table 8-1 far exceeds the number of registered transit-dependent persons in the EPZ as provided by the counties (discussed below in Section 8.5). This is consistent with the findings of NUREG/CR-6953, Volume 2, in that a large majority of the transit-dependent population within the EPZs of U.S. nuclear plants does not register with their local emergency response agency.

8.2 School Population – Transit Demand

Table 8-2 presents the school population and transportation requirements for the direct evacuation of all schools within the EPZ for the 2011-2012 school year. All schools in the NAPS EPZ are located in either Spotsylvania or Louisa County. Spotsylvania County student enrollment was provided by the local county emergency management agency and Louisa County student enrollment was obtained from a Virginia State website provided by VDEM. The column in Table 8-2 entitled "Buses Required" specifies the number of buses required for each school under the following set of assumptions and estimates:

- No students will be picked up by their parents prior to the arrival of the buses.
- While many high school students commute to school using private automobiles (as discussed in Section 2.4 of NUREG/CR-7002), the estimate of buses required for school evacuation do not consider the use of these private vehicles.
- Bus capacity, expressed in students per bus, is set to 70 for primary schools and 50 for middle and high schools.
- Those staff members who do not accompany the students will evacuate in their private vehicles.
- No allowance is made for student absenteeism, typically 3 percent daily.

Louisa County emergency management agency indicated that Jouett Elementary School, which is located beyond 10 miles from the NAPS, will shelter-in-place. Therefore, 0 buses are required to evacuate this facility (see Table 8-2).

It is recommended that the counties in the EPZ introduce procedures whereby the schools are contacted prior to the dispatch of buses from the depot, to ascertain the current estimate of students to be evacuated. In this way, the number of buses dispatched to the schools will reflect the actual number needed. The need for buses would be reduced by any high school students who have evacuated using private automobiles (if permitted by school authorities). Those buses originally allocated to evacuate schoolchildren that are not needed due to children being picked up by their parents, can be gainfully assigned to service other facilities or those persons who do not have access to private vehicles or to ride-sharing.

Table 8-3 presents a list of the EAC for each evacuating school in the EPZ. Students will be transported to these centers where they will be subsequently retrieved by their respective families.

8.3 Medical Facility Demand

Table 8-4 presents the census for the one medical facility in the EPZ. 23 people have been identified as living in, or being treated in, this facility. The current census for this facility was obtained by making a phone call to the facility. The data includes the number of ambulatory and wheelchair-bound patients at the facility.

The transportation requirements for the medical facility population are also presented in Table 8-4. The number of wheelchair van runs is determined by assuming that 4 patients can be accommodated per wheelchair van trip and the number of bus runs estimated assumes 30 ambulatory patients per trip.

8.4 Evacuation Time Estimates for Transit Dependent People

EPZ bus resources are assigned to evacuating schoolchildren (if school is in session at the time of the ATE) as the first priority in the event of an emergency. In the event that the allocation of buses dispatched from the depots to the various facilities and to the bus routes is somewhat "inefficient", or if there is a shortfall of available drivers, then there may be a need for some buses to return to the EPZ from the EAC after completing their first evacuation trip, to complete a "second wave" of providing transport service to evacuees. For this reason, the ETE for the transit-dependent population will be calculated for both a one wave transit evacuation and for two waves. Of course, if the impacted Evacuation Region is other than R03 (the entire EPZ), then there will likely be ample transit resources relative to demand in the impacted Region and this discussion of a second wave would likely not apply.

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

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

Activity: Mobilize Drivers (A→B→C)

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

Activity: Board Passengers (C→D)

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

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

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

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

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

Assigning reasonable estimates:

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

Then, P ≈ 1 minute per stop. Allowing 30 minutes pick-up time per bus run implies 30 stops per run, for good weather. It is assumed that bus acceleration and speed will be less in rain; total loading time is 40 minutes per bus in rain, 50 minutes in snow.

Activity: Travel to EPZ Boundary (D→E)

School Evacuation

Transportation resources available were provided by the EPZ county emergency management agencies and are summarized in Table 8-5. Also included in the table are the number of each type of transportation vehicle needed to evacuate schools, medical facilities, transit-dependent population and homebound special needs (discussed below in Section 8.5). These numbers indicate there are sufficient resources available to evacuate everyone in a single wave, if transportation resources are shared by the counties. While Louisa County has sufficient resources to evacuate each of their schools in a single wave, Spotsylvania County does not, and would require a second wave to evacuate all schoolchildren if no other resources could be made available.

The buses servicing the schools are ready to begin their evacuation trips at 105 minutes after the advisory to evacuate – 90 minutes mobilization time plus 15 minutes loading time – in good weather. The UNITES software discussed in Section 1.3 was used to define bus routes along the most likely path from a school being evacuated to the EPZ boundary, traveling toward the appropriate school EAC. This is done in UNITES by interactively selecting the series of nodes from the school to the EPZ boundary. Each bus route is given an identification number and is written to the DYNEV II input stream. DYNEV computes the route length and outputs the average speed for each 5 minute interval, for each bus route. The specified bus routes are documented in Table 8-6 (refer to the maps of the link-node analysis network in Appendix K for node locations). Data provided by DYNEV during the appropriate timeframe depending on the mobilization and loading times (i.e., 100 to 105 minutes after the advisory to evacuate for good weather) were used to compute the average speed for each route, as follows:

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

The average speed computed (using this methodology) for the buses servicing each of the schools in the EPZ is shown in Table 8-7 through Table 8-9 for school evacuation, and in Table 8-11 through Table 8-13 for the transit vehicles evacuating transit-dependent persons, which are discussed later. The travel time to the EPZ boundary was computed for each bus using the computed average speed and the distance to the EPZ boundary along the most likely route out of the EPZ. The travel time from the EPZ boundary to the EAC was computed assuming an average speed of 45 mph, 41 mph, and 36 mph for good weather, rain and snow, respectively. Speeds were reduced in Table 8-7 through Table 8-9 and Table 8-14 through Table 8-17 to 45 mph (41 mph for rain – 10% decrease – and 36 mph for snow – 20% decrease) for those calculated bus speeds which exceed 45 mph, as the school bus speed limit is 45 mph for roadways in Virginia where the maximum posted speed limit is 55 mph.

Table 8-7 (good weather), Table 8-8 (rain) and Table 8-9 (snow) present the following evacuation time estimates (rounded up to the nearest 5 minutes) for schools in the EPZ: (1) The elapsed time from the Advisory to Evacuate until the bus exits the EPZ; and (2) The elapsed time until the bus reaches the EAC. The evacuation time out of the EPZ can be computed as the sum of times associated with Activities A→B→C, C→D, and D→E (For example: 90 min + 15 + 5 = 1:50 for Post Oak Middle School, with good weather). The evacuation time to the EAC is determined by adding the time associated with Activity E→F (discussed below), to this EPZ evacuation time.

Evacuation of Transit-Dependent Population

The buses dispatched from the depots to service the transit-dependent evacuees will be scheduled so that they arrive at their respective routes after their passengers have completed their mobilization. As shown in Figure 5-4 (Residents with no Commuters), 90 percent of the evacuees will complete their mobilization when the buses will begin their routes, approximately 105 minutes after the Advisory to Evacuate.

Those buses servicing the transit-dependent evacuees will first travel along their pick-up routes, then proceed out of the EPZ to their respective EAC. Transit-dependent bus routes are defined in each of the counties Radiological Emergency Response Plan (RERP). Spotsylvania County has 10 bus routes that are shown graphically in Figure 8-2. Louisa County has 10 bus routes that are shown graphically in Figure 8-3. Hanover and Orange County have 2 bus routes each and Caroline County has 1 bus route, all of which are shown graphically in Figure 8-4. Details of the routes servicing the EPZ are described in Table 8-10. As discussed in Section 8.1, this study assumes 25 buses are used to service the transit-dependent population within the EPZ. It is assumed, for good weather conditions, that buses can mobilize and begin picking up evacuees within 105 minutes (i.e. when 90 percent of the residents without commuters are ready to begin their trip). Longer mobilization times of 115 minutes and 125 minutes are used for rain and snow, respectively.

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

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

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

For example, the ETE for the Bus Route 1 – Spotsylvania County 1 - is computed as 105 + 17 + 30 = 2:35 for good weather (rounded up to nearest 5 minutes). Here, 17 minutes is the time to travel 12.6 miles at 45 mph, the average speed output by the model for this route starting at 105 minutes. The ETE for a second wave (discussed below) is presented in the event there is a shortfall of available buses or bus drivers, as previously discussed.

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

The distances from the EPZ boundary to the EAC are measured using GIS software along the most likely route from the EPZ exit point to the EAC. The EAC are mapped in Figure 10-1. For a one-wave evacuation, this travel time outside the EPZ does not contribute to the ETE. For a two-wave evacuation, the ETE for buses must be considered separately, since it could exceed the ETE for the general population. Assumed bus speeds of 45 mph, 41 mph, and 36 mph for good weather, rain, and snow, respectively, will be applied for this activity for buses servicing the transit-dependent population.

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

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

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

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

The second-wave ETE for Bus Route 1 is computed as follows for good weather:

- Bus arrives at EAC at 2:46 in good weather (2:35 to exit EPZ + 11 minute travel time to EAC).
- 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: 11 minutes (equal to travel time to EAC) + 13 minutes (equal to travel time to start of route, i.e., 10 miles[1] @ 45 mph) + 17 minutes (equal to travel time for second route, i.e., 12.6 miles @ 45 mph) = 41 minutes
- Bus completes pick-ups along route: 30 minutes.
- Bus exits EPZ at time 2:35 + 0:11 + 0:15 + 0:41 + 0:30 = 4:15 (rounded up to nearest 5 minutes) after the Advisory to Evacuate.

Table 8-5 indicates that there are enough buses available to evacuate the entire school population within the EPZ, if transportation resources are shared by the counties. However, if for any reason transportation resources could not be shared, then Spotsylvania County would require a second-wave evacuation for two of their schools in order to transport all schoolchildren out of the EPZ. A second-wave ETE example is computed as follows for Post Oak Middle School in good weather:

- School buses arrive at the EAC at 2:01 (1:50 to exit the EPZ + 11 minute travel time) in good weather (see Table 8-7).
- Bus discharges passengers (5 minutes) and driver takes a 10-minute rest: 15 minutes.
- Bus returns to EPZ and drives back to the school: 11 minutes (equal to travel time to EAC for good weather - 8.3 miles @ 45 mph) + 4 minutes (equal to travel time to start of route - 3.4 miles @ 45 mph) = 16 minutes. 45 mph is the assumed inbound speed for travel from the EAC back to the school.
- Loading Time: 15 minutes.
- Travel to EPZ Boundary: 5 minutes (3.3 miles @ 44.5 mph). 44.5 mph is the average speed along the route from the school at 2 hours and 50 minutes.

ETE: 2:01 + 0:15 + 0:16 + 0:15 + 0:05 = 2:55 (rounded up to nearest 5 minutes) after the Advisory to Evacuate. Therefore, a second wave evacuation would require an additional 1 hour and 10 minutes relative to a single wave evacuation. As shown in Table 8-5, Louisa County has excess transportation resources. Mutual aid agreements with neighboring counties and assistance from the state could be used to address the shortfall in bus resources.

[1] Some transit-dependent bus routes have lengths in excess of 10 miles, as the buses circulate the EPZ to pick up individuals. It was conservatively assumed that buses could take a more direct path of travel from the EPZ boundary to the start of route - a maximum distance of 10 miles.

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

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

Evacuation of Medical Facilities

The bus operations for this group are similar to those for school evacuation except:

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

Table 8-4 indicates that 1 bus run and 1 wheelchair van run are needed to service the one medical facility in the EPZ. According to Table 8-5, the counties can collectively provide 235 buses, 13 wheelchair accessible vans and 27 ambulances. Thus, there are sufficient resources to evacuate the ambulatory and wheelchair bound persons from this JABA Adult Daycare facility in a single wave.

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

Table 8-14 through Table 8-16 summarize the ETE for this medical facility for good weather, rain, and snow. . Average speeds output by the model for Scenario 6 (Scenario 7 for rain and Scenario 8 for snow) Region 3, capped at 45 mph (41 mph for rain and 36 mph for snow), are used to compute travel time to EPZ boundary. The travel time to the EPZ boundary is computed by dividing the distance of 1.7 miles 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 to the nearest 5 minutes. The calculation of ETE for the JABA Adult Daycare with 21 ambulatory residents during good weather is:

ETE: 90 + 21 x 1 + 2 = 113 min. or 1:55 rounded to the nearest 5 minutes.

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

8.5 Special Needs Population

Based on data provided by the counties, there are an estimated 185 homebound special needs people within the Louisa County portion of the EPZ and 6 people within the Caroline County portion of the EPZ who require transportation assistance to evacuate. Spotsylvania County indicated that they do not keep a list of transit-dependent and special needs persons; Orange County does not have any persons requiring transportation assistance and no special needs population information was available for Hanover County. Caroline County indicated that they have 5 ambulatory and 1 wheelchair-bound individual. Details on the number of ambulatory, wheelchair-bound and bedridden people were not available for Louisa County. It is assumed that the percentage of ambulatory (90%) and wheelchair-bound (10%) are similar to the average percentages between Caroline County and the one medical facility in Louisa County (JABA Adult Daycare). This results in 166 ambulatory persons and 19 wheelchair-bound persons for Louisa County, and a total of 171 ambulatory and 20 wheelchair-bound persons for the entire EPZ.

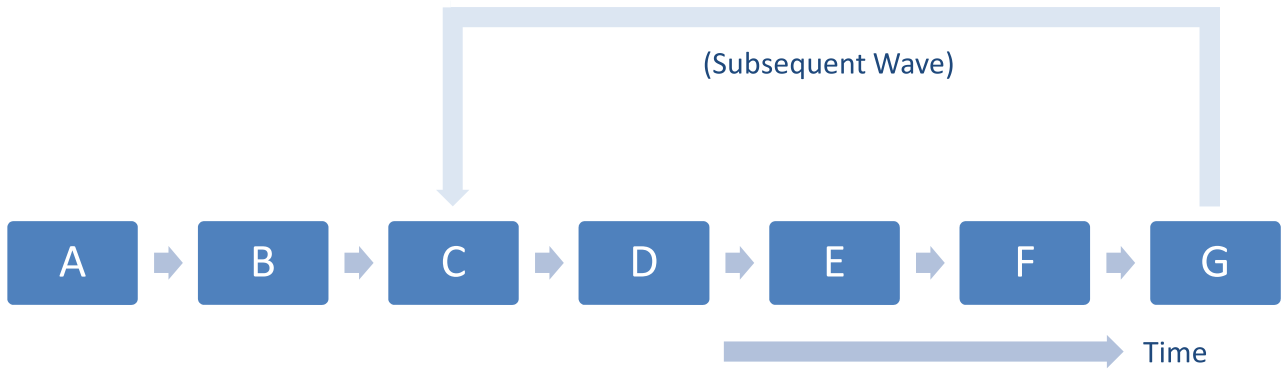
ETE for Homebound Special Needs Persons

Table 8-17 summarizes the ETE for homebound special needs people. The table is categorized by type of vehicle required and then broken down by weather condition. The table takes into consideration the deployment of multiple vehicles to reduce the number of stops per vehicle. It is conservatively assumed that ambulatory and wheelchair bound special needs households are spaced 3 miles apart and bedridden households are spaced 5 miles apart. Van and bus speeds approximate 20 mph between households and ambulance speeds approximate 30 mph in good weather (10% slower in rain, 20% slower in snow). Mobilization times of 90 minutes were used (100 minutes for rain, and 110 minutes for snow). The last HH is assumed to be 5 miles from the EPZ boundary, and the network-wide average speed, capped at 45 mph (41 mph for rain and 36 mph for snow), after the last pickup is used to compute travel time. ETE is computed by summing mobilization time, loading time at first household, travel to subsequent households, loading time at subsequent households, and travel time to EPZ boundary. All ETE are rounded to the nearest 5 minutes.

For example, assuming no more than one special needs person per HH implies that 171 ambulatory households need to be serviced. While only 6 buses are needed from a capacity perspective, if 25 buses are deployed to service these special needs HH, then each would require about 7 stops. The following outlines the ETE calculations:

1. Assume 25 buses are deployed, each with about 7 stops, to service a total of 171 HH.
2. The ETE is calculated as follows:
    a. Buses arrive at the first pickup location: 90 minutes
    b. Load HH members at first pickup: 5 minutes
    c. Travel to subsequent pickup locations: 6 @ 9 minutes = 54 minutes
    d. Load HH members at subsequent pickup locations: 6 @ 5 minutes = 30 minutes
    e. Travel to EPZ boundary: 7 minutes (5 miles @ 45 mph).

ETE: 90 + 5 + 54 + 30 + 7 = 3:10 rounded up to the nearest 5 minutes



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

Figure 8-1. Chronology of Transit Evacuation Operations

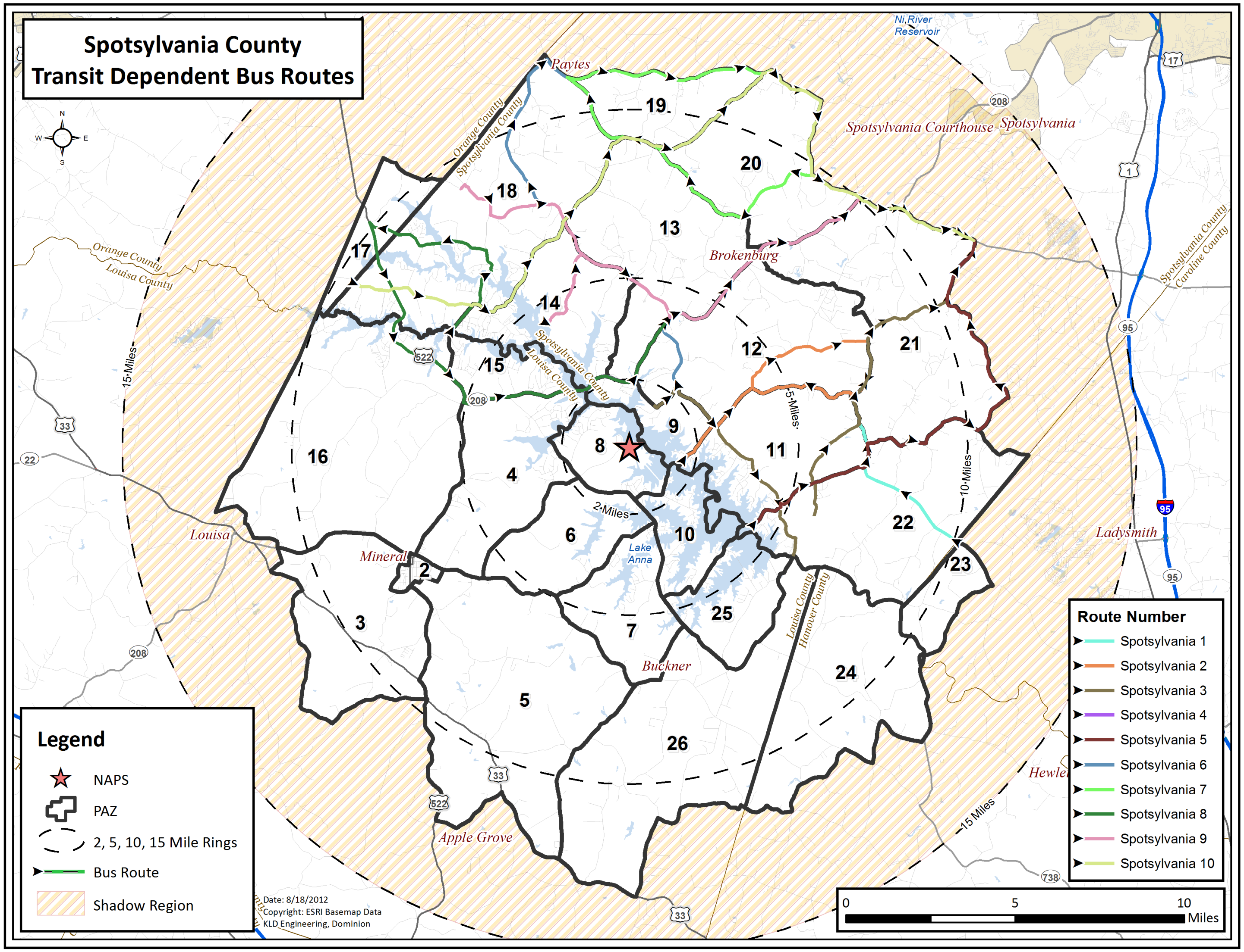


Figure 8-2. Transit-Dependent Bus Routes – Spotsylvania County

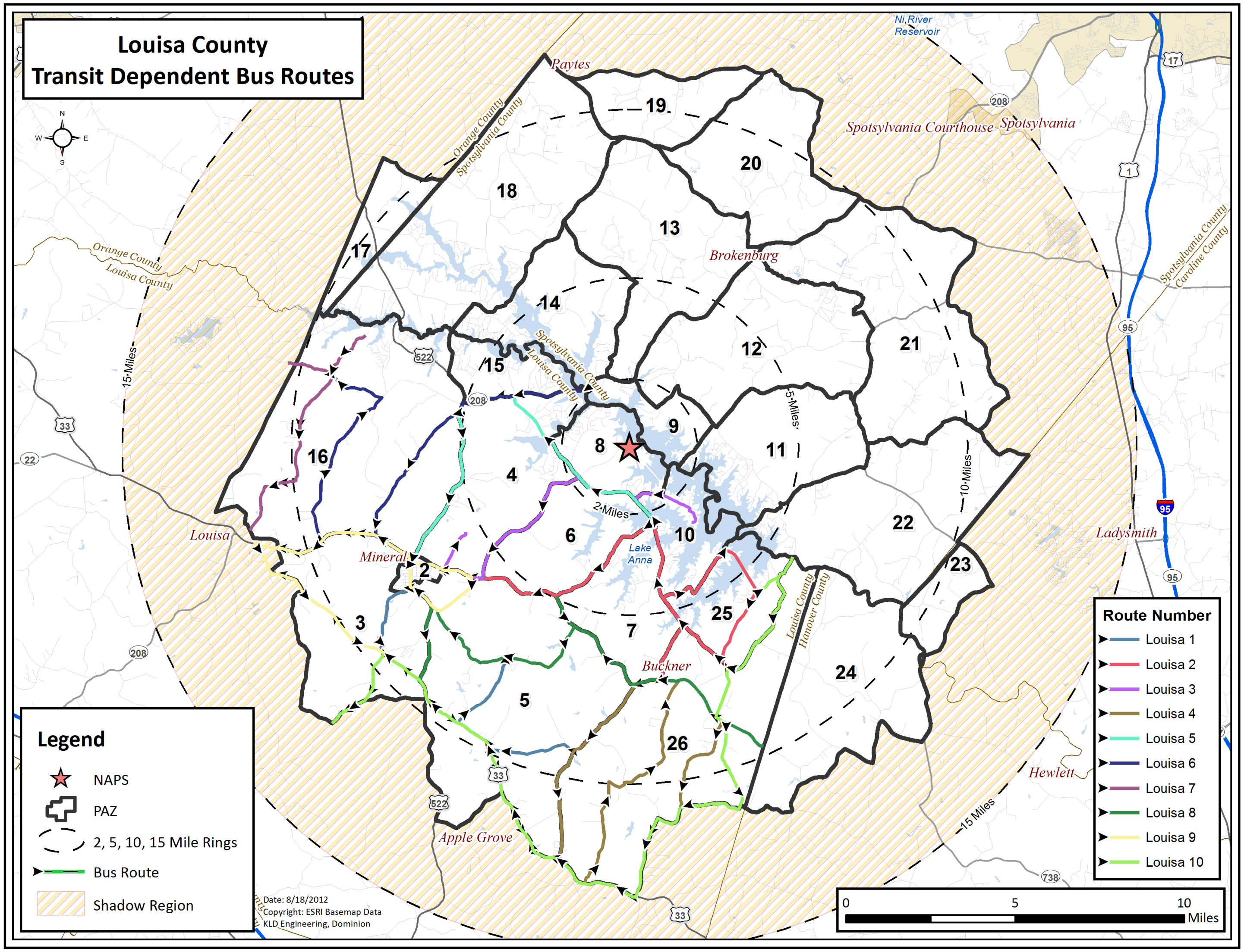


Figure 8-3. Transit-Dependent Bus Routes – Louisa County

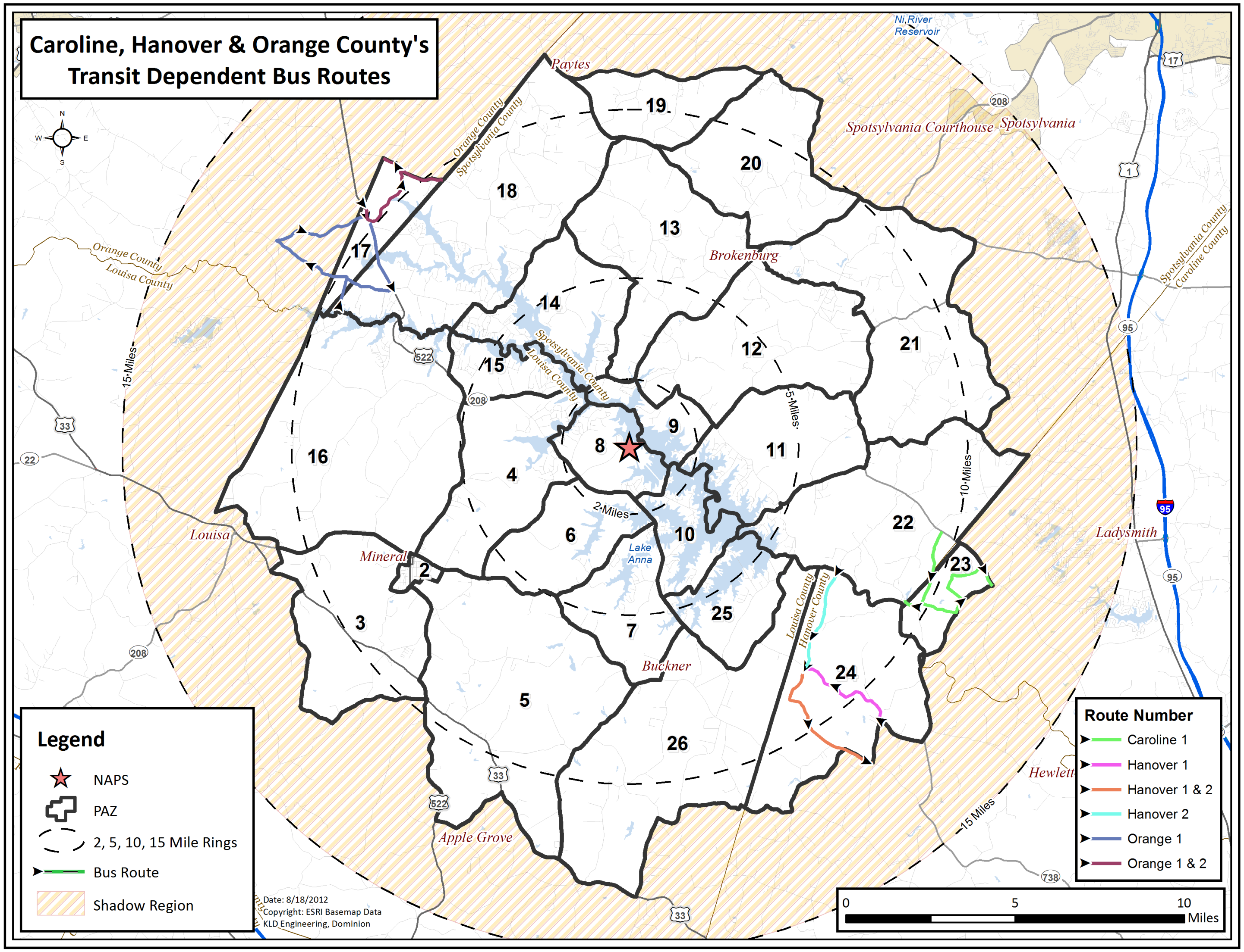


Figure 8-4. Transit-Dependent Bus Routes – Caroline, Hanover, Orange County

Table 8-1. Transit-Dependent Population Estimates

2010 EPZ Population	Survey Average HH Size with Indicated No. of Vehicles			Estimated No. of Households	Survey Percent HH with Indicated No. of Vehicles			Survey Percent HH with Commuters	Survey Percent HH with Non-Returning Commuters	Total People Requiring Transport	Estimated Ridesharing Percentage	People Requiring Public Transit	Percent Population Requiring Public Transit
	0	1	2		0	1	2						
25,202	1.50	1.85	2.47	9,806	2.2%	15.4%	41.1%	59%	39%	719	50%	360	1.4%

Table 8-2. School Population Demand Estimates

PAZ	School Name	Enrollment	Buses Required
2	Mineral Christian Preschool	60	1
3	Thomas Jefferson Elementary School	545	8
3	Louisa County High School	1,392	28
3	Louisa County Middle School	1,073	22
5	Jouett Elementary School[1]	597	0
12	Livingston Elementary School	444	7
21	Berkeley Elementary School	326	5
21	Post Oak Middle School	752	16
21	Spotsylvania High School	1,118	23
21	Spotsylvania High School - Governor's School	120	3
	TOTAL:	**6,427**	**113**

[1] School will shelter-in-place

Table 8-3. Evacuation Assembly Centers

School	Evacuation Assembly Center (EAC)
Livingston Elementary School	Courtland High School
Post Oak Middle School	Courtland High School
Berkeley Elementary School	Massaponax High School
Spotsylvania High School	Massaponax High School
Spotsylvania High School - Governor's School	Massaponax High School
Louisa County High School	Moss-Nuckols Elementary School
Louisa County Middle School	Moss-Nuckols Elementary School
Mineral Christian Preschool	Moss-Nuckols Elementary School
Thomas Jefferson Elementary School	Moss-Nuckols Elementary School
Jouett Elementary School	Shelter-in-Place

Table 8-4. Medical Facility Transit Demand

PAZ	Facility Name	Municipality	Cap-acity	Current Census	Ambu-latory	Wheel-chair Bound	Bed-ridden	Bus Runs	Wheel-chair Van Runs	Ambulance
LOUISA COUNTY MEDICAL FACILITIES										
3	JABA Adult Daycare	Louisa	N/A	23	21	2	0	1	1	0
		Louisa County Subtotal:	***-***	***23***	***21***	***2***	***0***	***1***	***1***	***0***
		TOTAL:	**-**	**23**	**21**	**2**	**0**	**1**	**1**	**0**

Table 8-5. Summary of Transportation Resources

Transportation Resource	Buses	Vans	Wheelchair Buses	Wheelchair Vans	Ambulances
Resources Available					
Louisa County	107	-	-	7	14
Caroline County	81	-	-	6	13
Berkeley Elementary School	9	-	-	-	-
Livingston Elementary School	10	-	-	-	-
Post Oak Middle School	12	-	-	-	-
Spotsylvania High School	15	-	-	-	-
Mineral Christian Preschool	1	-	-	-	-
TOTAL:	**235**	**0**	**0**	**13**	**27**
Resources Needed					
Schools (Table 8-2):	113	-	-	-	-
Medical Facilities (Table 8-4):	1	-	-	1	-
Transit-Dependent Population (Table 8-10):	25	-	-	-	-
Homebound Special Needs (Section 8.5):	6	-	-	5	-
TOTAL TRANSPORTATION NEEDS:	**145**	**0**	**0**	**6**	**0**

Notes:
- Spotsylvania County has a combined 46 buses, however, need a total of 54 buses to evacuate all students
- Post Oak Middle School has 12 buses and need 16 buses to evacuate all schoolchildren
- Spotsylvania High School has 15 buses and need 26 buses to evacuate the High School and Governor's School
- Louisa County needs 58 buses to evacuate all schoolchildren

Table 8-6. Bus Route Descriptions

Bus Route Number	Description	Nodes Traversed from Route Start to EPZ Boundary
1	Spotsylvania County 1 - Transit Route	108, 406, 107, 390, 389, 388, 106, 588, 383, 587, 586, 585, 584, 583, 582, 387, 386, 105, 10
2	Spotsylvania County 2 - Transit Route	399, 400, 490, 388, 106, 588, 383, 587, 586, 585, 584, 583, 582, 387, 386, 105, 10
3	Spotsylvania County 3 - Transit Route	153, 399, 398, 555, 397, 392, 393, 394, 619, 395, 396, 108, 406, 107, 390, 389, 388, 106, 588, 383, 587, 586, 585, 584, 583, 582, 387, 386, 105, 10
4	Spotsylvania County 4 - Transit Route	203, 5, 283, 160, 6, 276, 171, 7, 378, 377, 174, 8, 497, 9, 10
5	Spotsylvania County 5 - Transit Route	394, 619, 395, 396, 108, 406, 107, 390, 389, 388, 106, 588, 383, 587, 586, 585, 584, 583, 582, 387, 386, 105, 10
6	Spotsylvania County 6 - Transit Route	158, 159, 556, 557, 160, 6, 144, 622, 141, 140, 71, 559, 74, 79, 91, 96, 99, 100, 21
7	Spotsylvania County 7 - Transit Route	23, 489, 104, 103, 22, 192, 458, 21
9	Spotsylvania County 9 - Transit Route	72, 558, 71, 140, 141, 622, 144, 6, 276, 171, 7, 378, 377, 174, 8, 497, 9, 10
10	Spotsylvania County 10 - Transit Route	136, 130, 125, 74, 486, 101, 102, 103, 22, 192, 458, 21
11	Louisa County 1 - Transit Route	163, 80, 313
12	Louisa County 2 - Transit Route	37, 604, 60, 248, 271, 272, 273, 59, 600, 274, 58, 281, 601, 602, 434, 57, 603, 56, 48, 335, 305, 517, 63, 64, 312, 342, 182, 519
13	Louisa County 3 - Transit Route	36, 433, 428, 429, 430, 431, 432, 434, 57, 603, 56, 48, 335, 305, 517, 63, 64, 312, 342, 182, 519
14	Louisa County 4 - Transit Route	81, 278, 92, 93, 539
15	Louisa County 5 - Transit Route	36, 199, 607, 321, 4, 347, 348, 511, 3, 510, 299, 345, 346, 344, 343, 46, 298, 47, 513, 297, 48, 335, 305, 517, 63, 64, 312, 342, 182, 519
16	Louisa County 6 - Transit Route	447, 228, 227, 525, 524, 522, 222, 521, 520, 221, 220, 219
17	Louisa County 7 - Transit Route	510, 241, 447, 228, 227, 525, 524, 522, 222, 521, 520, 221, 220, 219
18	Louisa County 8 - Transit Route	81, 278, 92, 93, 539
19	Louisa County 9 - Transit Route	163, 165, 188, 81, 278, 92, 93, 539
20	Louisa County 10 - Transit Route	81, 278, 92, 93, 539
21	Orange County 1 - Transit Route	35, 14, 482, 239, 240

Bus Route Number	Description	Nodes Traversed from Route Start to EPZ Boundary
22	Orange County 2 - Transit Route	482, 239, 240
23	Hanover County 1 - Transit Route	438, 546, 547, 41
24	Hanover County 2 - Transit Route	154, 41, 439
25	Caroline County 1 - Transit Route	110, 111, 112
50	Thomas Jefferson Elementary School	163, 80, 313
51	Louisa County High School	516, 517, 63, 64, 312, 342, 182, 519
52	Louisa County Middle School	517, 63, 64, 312, 342, 182, 519
54	Livingston Elementary School	171, 7, 378, 377, 174, 8, 497, 9, 10
55	Post Oak Middle School	497, 9, 10
56	Berkeley Elementary School	582, 387, 386, 105, 10
57	Spotsylvania High School, Spotsylvania High School – Governor's School	581, 497, 9, 10
58	Mineral Christian Preschool	297, 48, 335, 305, 517, 63, 64, 312, 342, 182, 519
70	JABA Adult Daycare	518, 342, 182

Notes: - Transit route labels match counties RERP (from ESF #6, Mass Care Procedure)

- Jouett Elementary School not included since it shelters-in-place

Table 8-7. School Evacuation Time Estimates - Good Weather

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to EAC (mi.)	Travel Time from EPZ Bdry to EAC (min)	ETE to EAC (hr:min)
LOUISA COUNTY SCHOOLS									
Louisa County High School	90	15	3.7	45.0	5	**1:50**	8.3	11	**2:05**
Louisa County Middle School	90	15	3.4	45.0	5	**1:50**	8.3	11	**2:05**
Mineral Christian Preschool	90	15	4.8	45.0	7	**1:55**	8.3	11	**2:10**
Thomas Jefferson Elementary School	90	15	1.5	45.0	3	**1:50**	8.6	11	**2:05**
SPOTSYLVANIA COUNTY SCHOOLS									
Berkeley Elementary School	90	15	2.1	44.7	3	**1:50**	8.0	11	**2:05**
Livingston Elementary School	90	15	9.1	45.0	13	**2:00**	8.3	11	**2:10**
Post Oak Middle School	90	15	3.4	45.0	5	**1:50**	8.3	11	**2:05**
Spotsylvania High School	90	15	3.2	44.2	5	**1:50**	8.0	11	**2:05**
Spotsylvania High School - Governor's School	90	15	3.2	44.2	5	**1:50**	8.0	11	**2:05**
					Maximum for EPZ:	**2:00**		**Maximum:**	**2:10**
					Average for EPZ:	**1:55**		**Average:**	**2:10**

Table 8-8. School Evacuation Time Estimates - Rain

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to EAC (mi.)	Travel Time from EPZ Bdry to EAC (min)	ETE to EAC (hr:min)
LOUISA COUNTY SCHOOLS									
Louisa County High School	100	20	3.7	41.0	6	**2:10**	8.3	12	**2:25**
Louisa County Middle School	100	20	3.4	41.0	5	**2:05**	8.3	12	**2:20**
Mineral Christian Preschool	100	20	4.8	41.0	8	**2:10**	8.3	12	**2:25**
Thomas Jefferson Elementary School	100	20	1.5	41.0	3	**2:05**	8.6	13	**2:20**
SPOTSYLVANIA COUNTY SCHOOLS									
Berkeley Elementary School	100	20	2.1	40.4	4	**2:05**	8.0	12	**2:20**
Livingston Elementary School	100	20	9.1	41.0	14	**2:15**	8.3	12	**2:30**
Post Oak Middle School	100	20	3.4	40.3	6	**2:10**	8.3	12	**2:25**
Spotsylvania High School	100	20	3.2	39.0	5	**2:05**	8.0	12	**2:20**
Spotsylvania High School - Governor's School	100	20	3.2	39.0	5	**2:05**	8.0	12	**2:20**
					Maximum for EPZ:	**2:15**		**Maximum:**	**2:30**
					Average for EPZ:	**2:10**		**Average:**	**2:25**

Table 8-9. School Evacuation Time Estimates - Snow

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to EAC (mi.)	Travel Time from EPZ Bdry to H.S. (min)	ETE to EAC (hr:min)
LOUISA COUNTY SCHOOLS									
Louisa County High School	110	25	3.7	36.0	7	**2:25**	8.3	14	**2:40**
Louisa County Middle School	110	25	3.4	36.0	6	**2:25**	8.3	14	**2:40**
Mineral Christian Preschool	110	25	4.8	36.0	9	**2:25**	8.3	14	**2:40**
Thomas Jefferson Elementary School	110	25	1.5	36.0	3	**2:20**	8.6	14	**2:35**
SPOTSYLVANIA COUNTY SCHOOLS									
Berkeley Elementary School	110	25	2.1	36.0	4	**2:20**	8.0	13	**2:35**
Livingston Elementary School	110	25	9.1	36.0	16	**2:35**	8.3	14	**2:50**
Post Oak Middle School	110	25	3.4	35.9	6	**2:25**	8.3	14	**2:40**
Spotsylvania High School	110	25	3.2	35.2	6	**2:25**	8.0	13	**2:40**
Spotsylvania High School - Governor's School	110	25	3.2	35.2	6	**2:25**	8.0	13	**2:40**
					Maximum for EPZ:	**2:35**		**Maximum:**	**2:50**
					Average for EPZ:	**2:25**		**Average:**	**2:40**

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

Route	No. of Buses	Route Description	Length (mi.)
1	1	Spotsylvania County 1 - pick up residents in PAZ 11, 12, 21, 22	12.6
2	1	Spotsylvania County 2 - pick up residents in PAZ 11, 12, 21	17.4
3	1	Spotsylvania County 3 - pick up residents in PAZ 9, 11, 12, 22	20.2
4	1	Spotsylvania County 4 - pick up residents in PAZ 9, 11, 12, 13, 20, 21	15.3
5	1	Spotsylvania County 5 - pick up residents in PAZ 11, 21, 22	13.0
6	1	Spotsylvania County 6 - pick up residents in PAZ 12, 13, 14, 18	25.5
7	1	Spotsylvania County 7 - pick up residents in PAZ 13, 18, 19	19.8
8	1	Spotsylvania County 8 - pick up residents in PAZ 14, 18	32.2
9	1	Spotsylvania County 9 - pick up residents in PAZ 13, 14, 18	22.8
10	1	Spotsylvania County 10 - pick up residents in PAZ 13, 14, 18, 20	26.3
11	1	Louisa County 1 - pick up residents in PAZ 3, 5	17.3
12	1	Louisa County 2 - pick up residents in PAZ 6, 7, 10, 25	27.6
13	1	Louisa County 3 - pick up residents in PAZ 4, 6, 8, 10	17.0
14	1	Louisa County 4 - pick up residents in PAZ 5, 7, 26	36.6
15	1	Louisa County 5 - pick up residents in PAZ 2, 4, 8, 10, 15, 16	17.5
16	1	Louisa County 6 - pick up residents in PAZ 4, 8, 15, 16	23.2
17	1	Louisa County 7 - pick up residents in PAZ 15, 16	9.5
18	1	Louisa County 8 - pick up residents in PAZ 3, 5, 7, 26	30.5
19	1	Louisa County 9 - pick up residents in PAZ 2, 3, 5, 16	18.5
20	1	Louisa County 10 - pick up residents in PAZ 3	29.2
21	1	Orange County 1 - pick up residents in PAZ 17	10.7
22	1	Orange County 2 - pick up residents in PAZ 17	5.1
23	1	Hanover County 1 - pick up residents in PAZ 24	7.7
24	1	Hanover County 2 - pick up residents in PAZ 24	8.0
25	1	Caroline County 1 - pick up residents in PAZ 23	7.2
Total:	**25**		

Notes: - Transit route names taken from counties RERP (from ESF #6, Mass Care Procedure)

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

Route Number	Bus Number	One-Wave						Two-Wave						
		Mobilization (min)	Route Length (miles)	Speed (mph)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)	Distance to EAC (miles)	Travel Time to EAC (min)	Unload (min)	Driver Rest (min)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)
1	1	105	12.6	45.0	17	30	**2:35**	8.2	11	5	10	41	30	**4:15**
2	1	105	17.4	38.9	27	30	**2:45**	8.2	11	5	10	50	30	**4:35**
3	1	105	20.2	44.6	27	30	**2:45**	8.2	11	5	10	51	30	**4:35**
4	1	105	15.3	45.0	20	30	**2:35**	8.2	11	5	10	45	30	**4:20**
5	1	105	13.0	45.0	17	30	**2:35**	8.9	12	5	10	43	30	**4:15**
6	1	105	25.5	45.0	34	30	**2:50**	8.5	11	5	10	59	30	**4:50**
7	1	105	19.8	45.0	26	30	**2:45**	12.1	16	5	10	56	30	**4:45**
8	1	105	32.2	45.0	43	30	**3:00**	8.2	11	5	10	67	30	**5:05**
9	1	105	22.8	45.0	30	30	**2:45**	8.2	11	5	10	55	30	**4:40**
10	1	105	26.3	40.2	39	30	**2:55**	8.2	11	5	10	61	30	**4:55**
11	1	105	17.3	45.0	23	30	**2:40**	9.5	13	5	10	49	30	**4:30**
12	1	105	27.6	45.0	37	30	**2:55**	8.3	11	5	10	61	30	**4:55**
13	1	105	17.0	44.8	23	30	**2:40**	8.3	11	5	10	47	30	**4:25**
14	1	105	36.6	45.0	49	30	**3:05**	13.5	18	5	10	80	30	**5:30**
15	1	105	17.5	45.0	23	30	**2:40**	8.3	11	5	10	48	30	**4:25**
16	1	105	23.2	44.5	31	30	**2:50**	7.8	10	5	10	55	30	**4:45**
17	1	105	9.5	43.0	13	30	**2:30**	7.8	10	5	10	36	30	**4:05**
18	1	105	30.5	45.0	41	30	**3:00**	13.5	18	5	10	72	30	**5:15**
19	1	105	18.5	45.0	25	30	**2:40**	13.5	18	5	10	56	30	**4:40**
20	1	105	29.2	45.0	39	30	**2:55**	13.5	18	5	10	70	30	**5:10**
21	1	105	10.7	45.0	14	30	**2:30**	14.8	20	5	10	47	30	**4:25**
22	1	105	5.1	45.0	7	30	**2:25**	12.6	17	5	10	31	30	**4:00**
23	1	105	7.7	45.0	10	30	**2:25**	13.4	18	5	10	38	30	**4:10**
24	1	105	8.0	35.5	13	30	**2:30**	13.4	18	5	10	41	30	**4:15**
25	1	105	7.2	45.0	10	30	**2:25**	12.7	17	5	10	36	30	**4:05**
						Maximum ETE:	**3:05**						**Maximum ETE:**	**5:30**
						Average ETE:	**2:45**						**Average ETE:**	**4:35**

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

		One-Wave							Two-Wave					
Route Number	Bus Number	Mobilization (min)	Route Length (miles)	Speed (mph)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)	Distance to EAC (miles)	Travel Time to EAC (min)	Unload (min)	Driver Rest (min)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)
1	1	115	12.6	41.0	18	40	**2:55**	8.2	12	5	10	44	40	**4:50**
2	1	115	17.4	36.2	29	40	**3:05**	8.2	12	5	10	53	40	**5:05**
3	1	115	20.2	41.0	30	40	**3:05**	8.2	12	5	10	55	40	**5:10**
4	1	115	15.3	41.0	22	40	**3:00**	8.2	12	5	10	48	40	**4:55**
5	1	115	13.0	41.0	19	40	**2:55**	8.9	13	5	10	45	40	**4:50**
6	1	115	25.5	41.0	37	40	**3:15**	8.5	12	5	10	63	40	**5:30**
7	1	115	19.8	41.0	29	40	**3:05**	12.1	18	5	10	60	40	**5:20**
8	1	115	32.2	41.0	47	40	**3:25**	8.2	12	5	10	72	40	**5:45**
9	1	115	22.8	41.0	33	40	**3:10**	8.2	12	5	10	59	40	**5:20**
10	1	115	26.3	37.2	42	40	**3:20**	8.2	12	5	10	67	40	**5:35**
11	1	115	17.3	41.0	25	40	**3:00**	9.5	14	5	10	52	40	**5:05**
12	1	115	27.6	40.9	40	40	**3:15**	8.3	12	5	10	66	40	**5:30**
13	1	115	17.0	40.8	25	40	**3:00**	8.3	12	5	10	50	40	**5:00**
14	1	115	36.6	41.0	54	40	**3:30**	13.5	20	5	10	87	40	**6:15**
15	1	115	17.5	41.0	26	40	**3:05**	8.3	12	5	10	51	40	**5:05**
16	1	115	23.2	40.1	35	40	**3:10**	7.8	11	5	10	59	40	**5:20**
17	1	115	9.5	38.6	15	40	**2:50**	7.8	11	5	10	39	40	**4:40**
18	1	115	30.5	41.0	45	40	**3:20**	13.5	20	5	10	78	40	**5:55**
19	1	115	18.5	41.0	27	40	**3:05**	13.5	20	5	10	60	40	**5:20**
20	1	115	29.2	41.0	43	40	**3:20**	13.5	20	5	10	76	40	**5:55**
21	1	115	10.7	41.0	16	40	**2:55**	14.8	22	5	10	51	40	**5:05**
22	1	115	5.1	41.0	8	40	**2:45**	12.6	18	5	10	33	40	**4:35**
23	1	115	7.7	41.0	11	40	**2:50**	13.4	20	5	10	41	40	**4:50**
24	1	115	8.0	33.1	14	40	**2:50**	13.4	20	5	10	44	40	**4:50**
25	1	115	7.2	41.0	11	40	**2:50**	12.7	19	5	10	39	40	**4:45**
						Maximum ETE:	**3:30**						**Maximum ETE:**	**6:15**
						Average ETE:	**3:05**						**Average ETE:**	**5:15**

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

		One-Wave							Two-Wave						
Route Number	Bus Number	Mobilization (min)	Route Length (miles)	Speed (mph)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)	Distance to EAC (miles)	Travel Time to EAC (min)	Unload (min)	Driver Rest (min)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)
1	1	125	12.6	36.0	21	50	**3:20**	8.2	14	5	10	48	50	**5:30**
2	1	125	17.4	32.5	32	50	**3:30**	8.2	14	5	10	56	50	**5:45**
3	1	125	20.2	36.0	34	50	**3:30**	8.2	14	5	10	61	50	**5:50**
4	1	125	15.3	36.0	26	50	**3:25**	8.2	14	5	10	52	50	**5:40**
5	1	125	13.0	36.0	22	50	**3:20**	8.9	15	5	10	50	50	**5:30**
6	1	125	25.5	36.0	42	50	**3:40**	8.5	14	5	10	70	50	**6:10**
7	1	125	19.8	36.0	33	50	**3:30**	12.1	20	5	10	66	50	**6:05**
8	1	125	32.2	36.0	54	50	**3:50**	8.2	14	5	10	81	50	**6:30**
9	1	125	22.8	36.0	38	50	**3:35**	8.2	14	5	10	65	50	**6:00**
10	1	125	26.3	33.7	47	50	**3:45**	8.2	14	5	10	73	50	**6:20**
11	1	125	17.3	36.0	29	50	**3:25**	9.5	16	5	10	58	50	**5:45**
12	1	125	27.6	36.0	46	50	**3:45**	8.3	14	5	10	73	50	**6:20**
13	1	125	17.0	35.9	28	50	**3:25**	8.3	14	5	10	56	50	**5:40**
14	1	125	36.6	36.0	61	50	**4:00**	13.5	22	5	10	97	50	**7:05**
15	1	125	17.5	36.0	29	50	**3:25**	8.3	14	5	10	56	50	**5:40**
16	1	125	23.2	35.8	39	50	**3:35**	7.8	13	5	10	66	50	**6:00**
17	1	125	9.5	34.6	17	50	**3:15**	7.8	13	5	10	42	50	**5:15**
18	1	125	30.5	36.0	51	50	**3:50**	13.5	22	5	10	87	50	**6:45**
19	1	125	18.5	36.0	31	50	**3:30**	13.5	22	5	10	67	50	**6:05**
20	1	125	29.2	36.0	49	50	**3:45**	13.5	22	5	10	84	50	**6:40**
21	1	125	10.7	36.0	18	50	**3:15**	14.8	25	5	10	56	50	**5:45**
22	1	125	5.1	36.0	9	50	**3:05**	12.6	21	5	10	36	50	**5:10**
23	1	125	7.7	36.0	13	50	**3:10**	13.4	22	5	10	45	50	**5:25**
24	1	125	8.0	29.3	16	50	**3:15**	13.4	22	5	10	48	50	**5:35**
25	1	125	7.2	36.0	12	50	**3:10**	12.7	21	5	10	43	50	**5:20**
						Maximum ETE:	**4:00**						**Maximum ETE:**	**7:05**
						Average ETE:	**3:30**						**Average ETE:**	**5:55**

Table 8-14. Medical Facility Evacuation Time Estimates - Good Weather

Medical Facility	Patient	Mobilization (min)	Loading Rate (min per person)	People	Total Loading Time (min)	Dist. To EPZ Bdry (mi)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
JABA Adult Daycare	Ambulatory	90	1	21	21	1.7	2	**1:55**
	Wheelchair bound	90	5	2	10	1.7	2	**1:45**
							Maximum ETE:	**1:55**
							Average ETE:	**1:50**

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

Medical Facility	Patient	Mobilization (min)	Loading Rate (min per person)	People	Total Loading Time (min)	Dist. To EPZ Bdry (mi)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
JABA Adult Daycare	Ambulatory	100	1	21	21	1.7	2	**2:05**
	Wheelchair bound	100	5	2	10	1.7	2	**1:55**
							Maximum ETE:	**2:05**
							Average ETE:	**2:00**

Table 8-16. Medical Facility Evacuation Time Estimates - Snow

Medical Facility	Patient	Mobilization (min)	Loading Rate (min per person)	People	Total Loading Time (min)	Dist. To EPZ Bdry (mi)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
JABA Adult Daycare	Ambulatory	115	1	21	21	1.7	3	**2:20**
	Wheelchair bound	115	5	2	10	1.7	3	**2:10**
							Maximum ETE:	**2:20**
							Average ETE:	**2:15**

Table 8-17. Homebound Special Needs Population Evacuation Time Estimates

Vehicle Type	People Requiring Vehicle	Vehicles deployed	Stops	Weather Conditions	Mobilization Time (min)	Loading Time at 1st Stop (min)	Travel to Subsequent Stops (min)	Total Loading Time at Subsequent Stops (min)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
Buses	171	25	7	Normal	90	5	54	30	7	**3:10**
				Rain	100		60		7	**3:25**
				Snow	110		66		8	**3:40**
Wheelchair Vans	20	8	3	Normal	90	5	18	10	7	**2:10**
				Rain	100		20		7	**2:25**
				Snow	110		22		8	**2:35**
									Maximum ETE:	**3:40**
									Average ETE:	**2:55**

9 TRAFFIC MANAGEMENT STRATEGY

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

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

The functions to be performed in the field are:

1. <u>Facilitate</u> evacuating traffic movements that safely expedite travel out of the 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 en route to perform an important activity.

The implementation of a plan <u>must</u> also be flexible enough for the application of sound judgment by the traffic guide.

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

1. The existing TCP and ACP identified by the offsite agencies in their existing emergency plans serve as the basis of the traffic management plan, as per NUREG/CR-7002.
2. Computer analysis of the evacuation traffic flow environment (see Figures 7-3 through 7-6).

    This analysis identifies the best routing and those critical intersections that experience pronounced congestion. Any critical intersections that are not identified in the existing offsite plans are suggested as additional TCPs and ACPs.
3. The existing TCP and ACP, and how they were applied in this study, are discussed in Appendix G.

4. Prioritization of TCP and ACP.

   Application of traffic and access control at some TCPs and ACPs will have a more pronounced influence on expediting traffic movements than at other TCPs and ACPs. For example, TCPs controlling traffic originating from areas in close proximity to the power plant could have a more beneficial effect on minimizing potential exposure to radioactivity than those TCPs located far from the power plant. As shown in Figures 7-3 through 7-6, traffic congestion is concentrated between the towns of Mineral and Louisa. Those existing TCP and ACP in this area, especially along SR-618 westbound towards Mineral and SR-208/SR-22 westbound at the Louisa town line, should be considered top priority when assigning personnel and equipment for traffic and access control.

The use of Intelligent Transportation Systems (ITS) technologies (if available) can reduce manpower and equipment needs, while still facilitating the evacuation process. Dynamic Message Signs (DMS) can be placed within the EPZ to provide information to travelers regarding traffic conditions, route selection, and assistance center information. DMS can also be placed outside of the EPZ to warn motorists to avoid using routes that may conflict with the flow of evacuees away from the power plant. Highway Advisory Radio (HAR) can be used to broadcast information to evacuees en route through their vehicle stereo systems. Automated Traveler Information Systems (ATIS) can also be used to provide evacuees with information. Internet websites can provide traffic and evacuation route information before the evacuee begins their trip, while on board navigation systems (GPS units), cell phones, and pagers can be used to provide information en route. These are only several examples of how ITS technologies can benefit the evacuation process. Consideration should be given that ITS technologies be used to facilitate the evacuation process, and any additional signage placed should consider evacuation needs.

The ETE analysis treated all controlled intersections that are existing TCP or ACP locations in the offsite agency plans for an evacuation of the entire EPZ as being controlled by actuated signals.

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

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

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

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

10 EVACUATION ROUTES

Evacuation routes are comprised of two distinct components:

- Routing from a PAZ being evacuated to the boundary of the Evacuation Region and thence out of the EPZ.
- Routing of transit-dependent evacuees from the EPZ boundary to Evacuation Assembly Centers.

Evacuees will select routes within the EPZ in such a way as to minimize their exposure to risk. This expectation is met by the DYNEV II model routing traffic away from the location of the plant, to the extent practicable. The DTRAD model satisfies this behavior by routing traffic so as to balance traffic demand relative to the available highway capacity to the extent possible. See Appendices B through D for further discussion.

The routing of transit-dependent evacuees from the EPZ boundary to Evacuation Assembly Centers (EAC) is designed to minimize the amount of travel outside the EPZ, from the points where these routes cross the EPZ boundary.

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

It is assumed that all school evacuees will be taken to the appropriate EAC and subsequently picked up by parents or guardians. Transit-dependent evacuees are transported to the nearest EAC for each county. This study does not consider the transport of evacuees from EAC to congregate care centers, if the counties do make the decision to relocate evacuees.

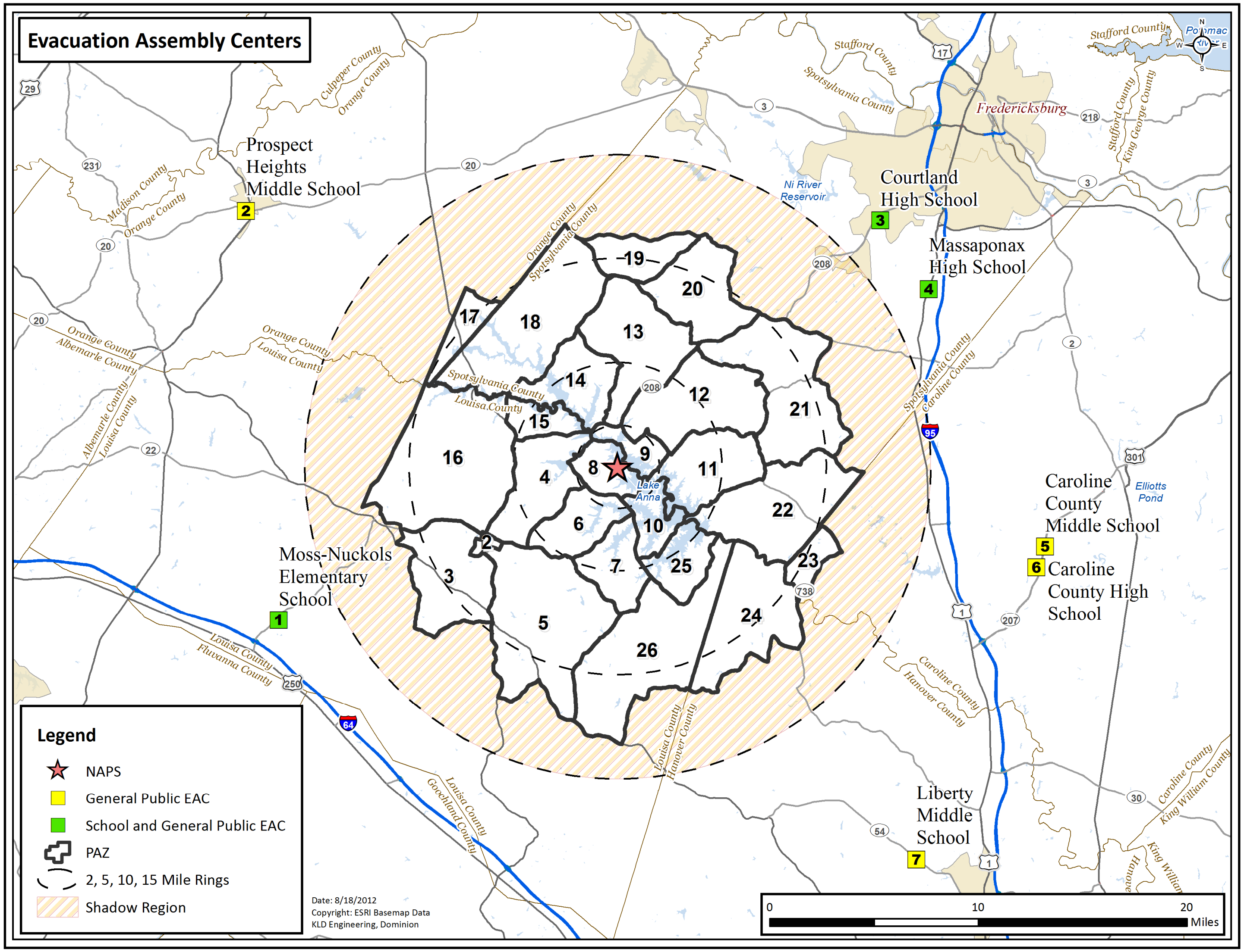


Figure 10-1. General Population and School Evacuation Assembly Centers

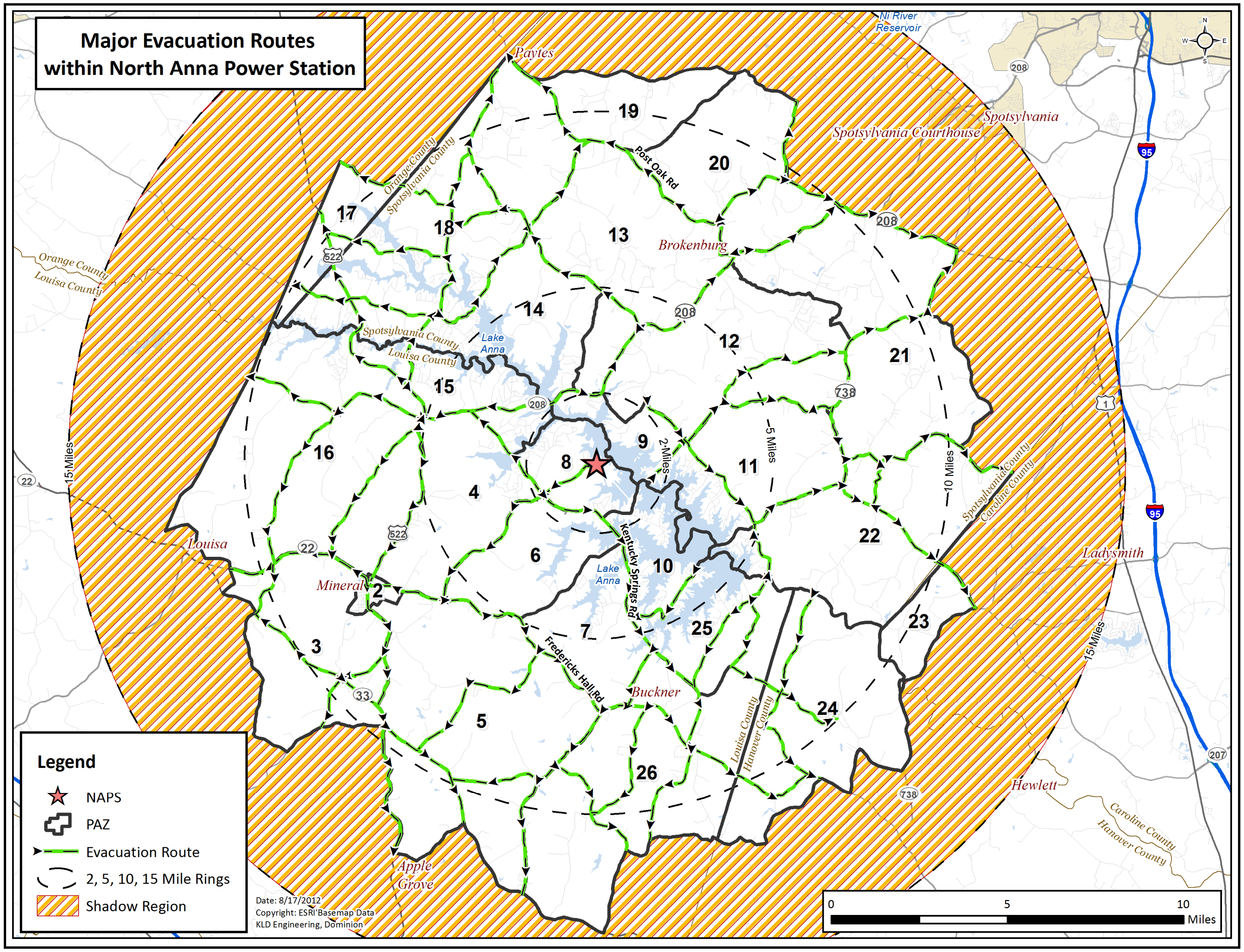


Figure 10-2. Major Evacuation Routes

11 SURVEILLANCE OF EVACUATION OPERATIONS

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

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

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

Tow Vehicles

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

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

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

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

12 CONFIRMATION TIME

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

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

The confirmation process should start at about 2¾ hours after the Advisory to Evacuate, which is when approximately 90 percent of resident evacuees have completed their mobilization activities (see Table 5-9). At this time, virtually all evacuees will have departed on their respective trips and the local telephone system will be largely free of traffic.

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

If this method is indeed used by the offsite agencies, consideration should be given to maintain a list of telephone numbers within the EPZ in the (EOC) at all times. Such a list could be purchased from vendors and could be periodically updated. As indicated above, the confirmation process should not begin until 2¾ hours after the Advisory to Evacuate, to ensure that households have had enough time to mobilize. This 2¾-hour timeframe will enable telephone operators to arrive at their workplace, obtain a call list and prepare to make the necessary phone calls.

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

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

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

Problem Definition

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

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

Given:

- No. of households plus other facilities, N, within the EPZ (est.) = 9,900
- Est. proportion, F, of households that will not evacuate = 0.20
- Allowable error margin, e: 0.05
- Confidence level, α: 0.95 (implies A = 1.96)

Applying Table 10 of cited reference,

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

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

Finite population correction:

$$n_F = \frac{nN}{n + N - 1} = 299$$

Thus, some 300 telephone calls will confirm that approximately 20 percent of the population has not evacuated. If only 10 percent of the population does not comply with the Advisory to Evacuate, then the required sample size, n_F = 211.

Est. Person Hours to complete 300 telephone calls

Assume:

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

Person Hours:

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

13 RECOMMENDATIONS

The following recommendations are offered:

1. Examination of the general population ETE in Section 7 shows that the ETE for 100 percent of the population is generally 2 ½ to 3 ½ hours longer than for 90 percent of the population. Specifically, the additional time needed for the last 10 percent of the population to evacuate can be as much as double the time needed to evacuate 90 percent of the population. This non-linearity reflects the fact that these relatively few stragglers require significantly more time to mobilize (i.e. prepare for the evacuation trip) than their neighbors. This leads to two recommendations:
   a. The public outreach (information) program should emphasize the need for evacuees to minimize the time needed to prepare to evacuate (secure the home, assemble needed clothes, medicines, etc.).
   b. The decision makers should reference Table 7-1 which list the time needed to evacuate 90 percent of the population, when preparing recommended protective actions, as per NUREG/CR-7002 guidance.
2. Staged evacuation is not recommended because it is not beneficial due to the low population within the 2 and 5-mile regions of the plant and the lack of traffic congestion within these regions.
3. Counties should implement procedures whereby schools are contacted prior to dispatch of buses from the depots to get an accurate count of students needing transportation and the number of buses required (See Section 8).
4. Table 8-5 indicates that there are enough buses and wheelchair vans available to evacuate the entire transit-dependent population within the EPZ in a single wave, if transportation resources are shared by the counties. However, if for any reason transportation resources could not be shared, then Spotsylvania County would require a second wave for two of their schools in order to evacuate all schoolchildren. The second-wave ETE for schools do exceed the general population ETE at the 90th percentile. Mutual aid agreements with neighboring counties and assistance from the state could be used to address the shortfall in bus resources (See Section 8.4).
5. Intelligent Transportation Systems (ITS) such as Dynamic Message Signs (DMS), Highway Advisory Radio (HAR), Automated Traveler Information Systems (ATIS), etc. should be used to facilitate the evacuation process (See Section 9). The placement of additional signage should consider evacuation needs.
6. Counties/State should establish strategic locations to position tow trucks provided with gasoline containers in the event of a disabled vehicle during the evacuation process (see Section 11) and should encourage gas stations to remain open during the evacuation.
7. Counties/State should establish a system/procedure to confirm that the Advisory to Evacuate (ATE) is being adhered to (see the approach suggested by KLD in Section 12). Should the approach recommended by KLD in Section 12 be used, consideration should be given to keep a list of telephone numbers within the EPZ in the Emergency Operations Center (EOC) at all times.

APPENDIX A

Glossary of Traffic Engineering Terms

A. GLOSSARY OF TRAFFIC ENGINEERING TERMS

Table A-1. Glossary of Traffic Engineering Terms

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

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

APPENDIX B

DTRAD: Dynamic Traffic Assignment and Distribution Model

B. DYNAMIC TRAFFIC ASSIGNMENT AND DISTRIBUTION MODEL

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

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

Overview of Integrated Distribution and Assignment Model

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

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

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

Interfacing the DYNEV Simulation Model with DTRAD

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

DTRAD Description

DTRAD is the DTA module for the DYNEV II System.

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

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

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

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

  where c_a is the generalized cost for link a, and α, β, and γ are cost coefficients for link travel time, distance, and supplemental cost, respectively. Distance and supplemental costs are defined as invariant properties of the network model, while travel time is a dynamic property dictated by prevailing traffic conditions. The DYNEV simulation model computes travel times on all edges in the network and DTRAD uses that information to constantly update the costs of paths. The route choice decision model in the next simulation iteration uses these updated values to adjust the route choice behavior. This way, traffic demands are dynamically re-assigned based on time dependent conditions. The interaction between the DTRAD traffic assignment and DYNEV II simulation models is depicted in Figure B-1. Each round of interaction is called a Traffic Assignment Session (TA session). A TA session is composed of multiple iterations, marked as loop B in the figure.

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

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

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

  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 = 15 miles, the outer distance of the shadow region. Note that the supplemental cost, s_a, of link, a, is (high, low), if its downstream node, n, is (near, far from) the power plant.

Network Equilibrium

In 1952, John Wardrop wrote:

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

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

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

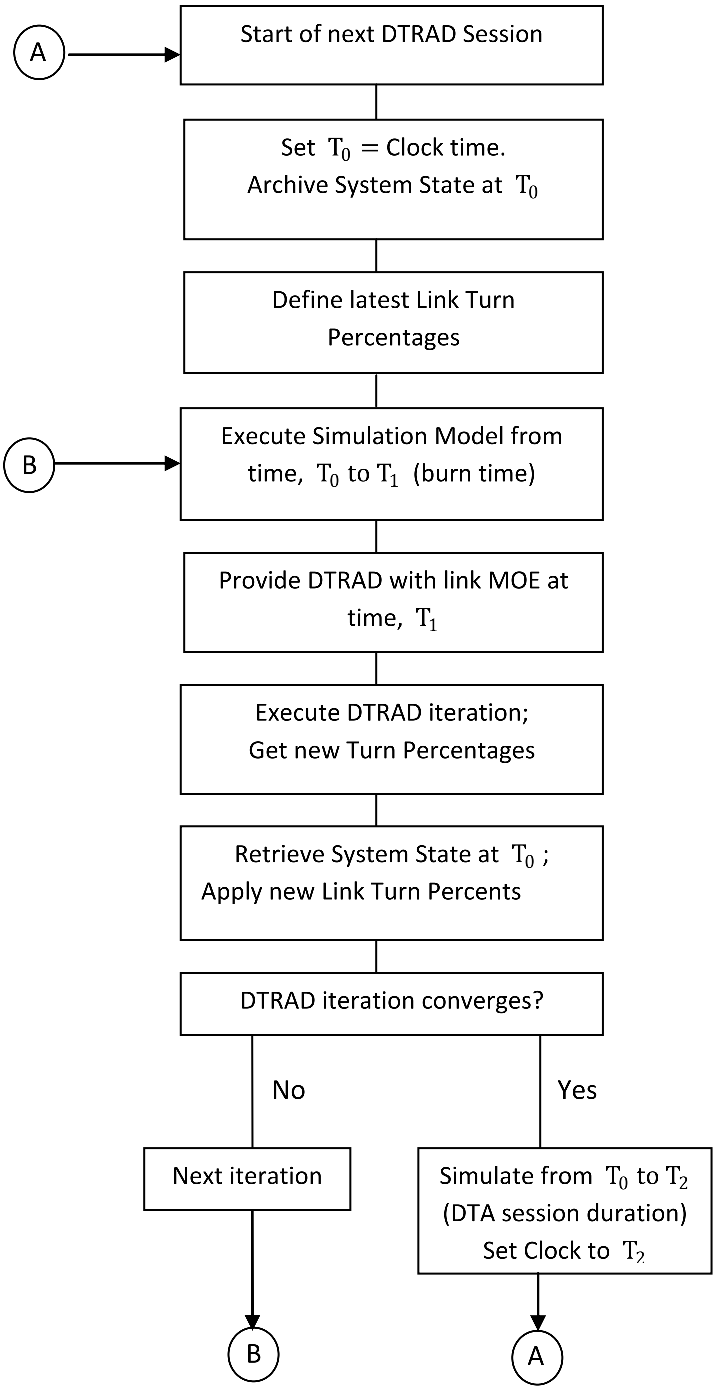


Figure B-1. Flow Diagram of Simulation-DTRAD Interface

APPENDIX C

DYNEV Traffic Simulation Model

C. DYNEV TRAFFIC SIMULATION MODEL

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

Model Features Include:

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

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

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

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

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

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

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

HIGHWAY NETWORK

- Links defined by upstream and downstream node numbers
- Link lengths
- Number of lanes (up to 9) and channelization
- Turn bays (1 to 3 lanes)
- Destination (exit) nodes
- Network topology defined in terms of downstream nodes for each receiving link
- Node Coordinates (X,Y)
- Nuclear Power Plant Coordinates (X,Y)

GENERATED TRAFFIC VOLUMES

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

TRAFFIC CONTROL SPECIFICATIONS

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

DRIVER'S AND OPERATIONAL CHARACTERISTICS

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

DYNAMIC TRAFFIC ASSIGNMENT

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

INCIDENTS

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

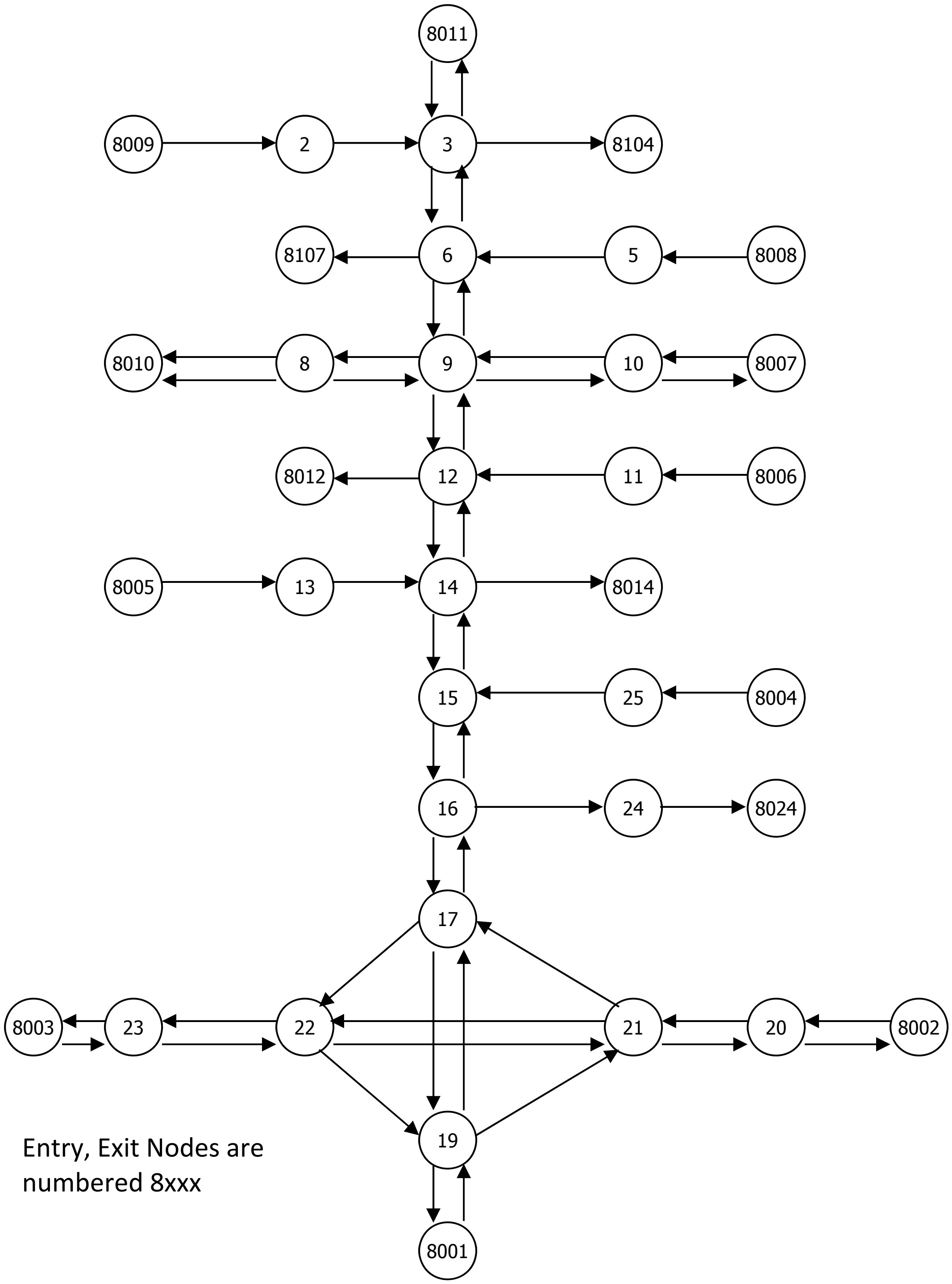


Figure C-1. Representative Analysis Network

C.1 Methodology

C.1.1 The Fundamental Diagram

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

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

C.1.2 The Simulation Model

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

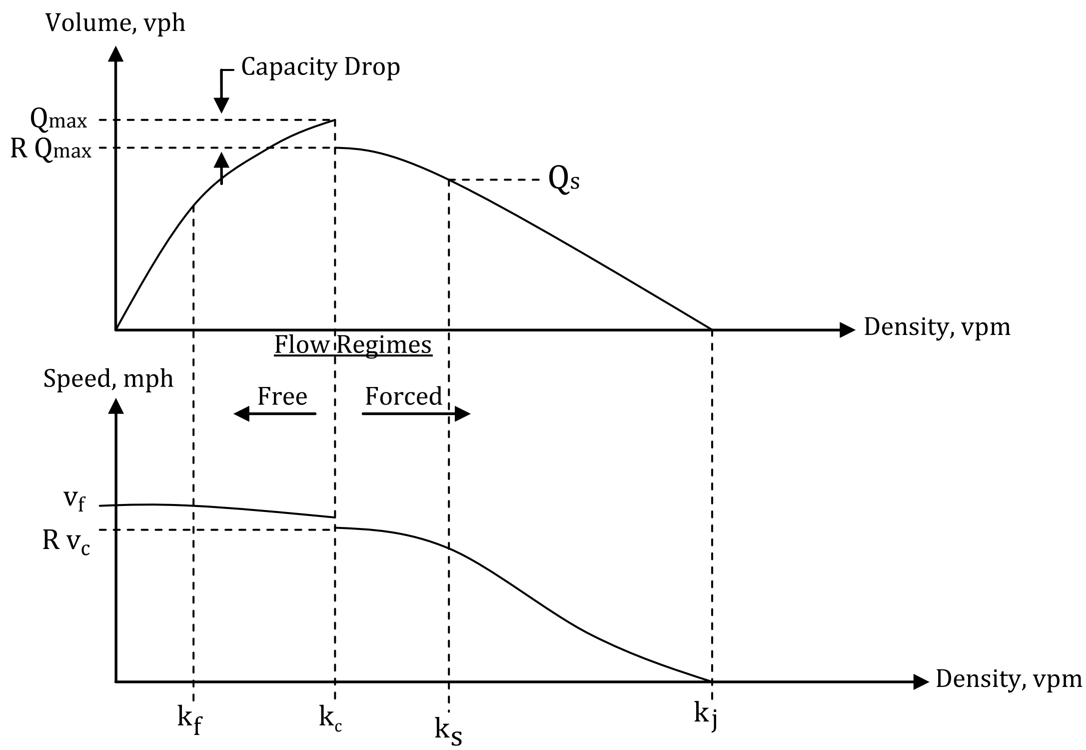


Figure C-2. Fundamental Diagrams

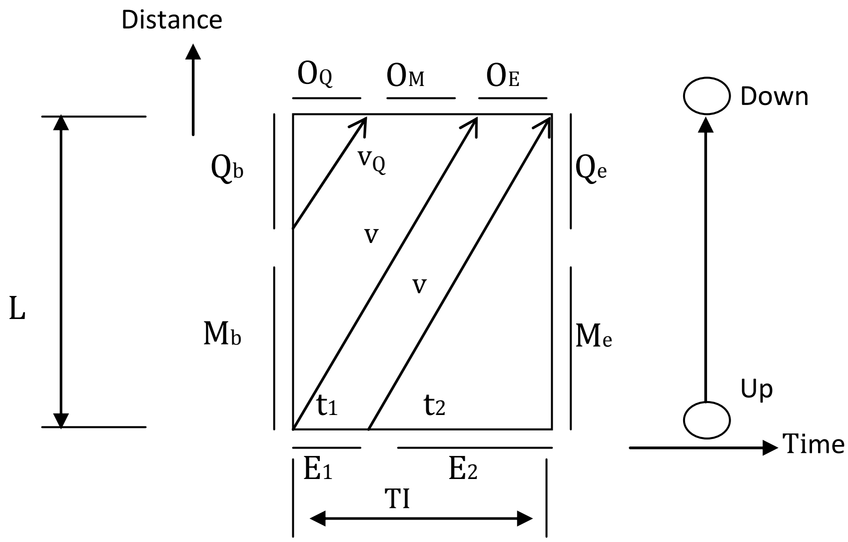


Figure C-3. A UNIT Problem Configuration with t_1 > 0

Table C-3. Glossary

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

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

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

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

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

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

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

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

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

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

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

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

$Q'_e = E_1 - O_E$

If $Q'_e > 0$, then

Calculate Q_e , M_e with Algorithm A

Else

$Q_e = 0$, $M_e = E_2$

End if

Else $(t_1 = 0)$

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

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

End if

9. Else $(M_b > RCap)$

$O_E = 0$

If $t_1 > 0$, then

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

Calculate Q_e and M_e using Algorithm A

10. Else $(t_1 = 0)$

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

If $M_d > RCap$, *then*

$O_M = RCap$

$Q'_e = M_d - O_M$

Apply Algorithm A to calculate Q_e and M_e

Else

$O_M = M_d$

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

End if

End if

End if

End if

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

where k_b = density at the beginning of the TI

k_e = density at the end of the TI

k_m = density at the mid-point of the TI

All values of density apply only to the moving vehicles.

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

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

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

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

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

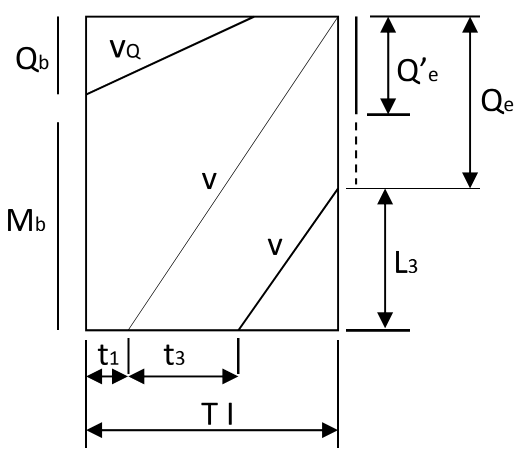
The number of excess vehicles that cause spillback is: $SB = Q_e + M_e - \frac{(L-W) \cdot LN}{L_v}$, where W is the width of the upstream intersection. To prevent spillback, meter the outflow from the feeder approaches and from the source flow, S, during this TI by the amount, SB. That is, set

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

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

Algorithm A

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



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

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

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

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

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

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

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

C.1.3 Lane Assignment

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

C.2 Implementation

C.2.1 Computational Procedure

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

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

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

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

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

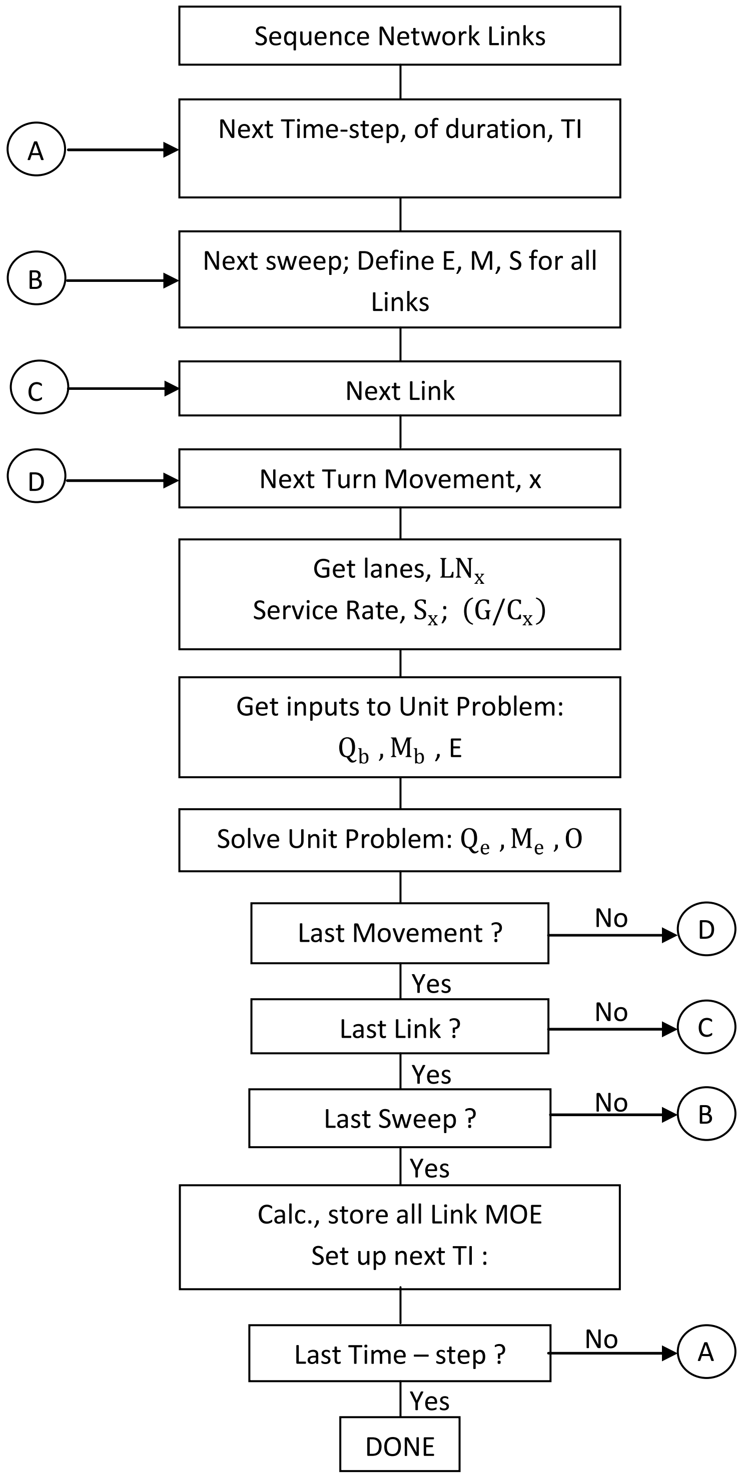


Figure C-4. Flow of Simulation Processing (See Glossary: Table C-3)

C.2.2 Interfacing with Dynamic Traffic Assignment (DTRAD)

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

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

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

Additional details are presented in Appendix B.

APPENDIX D

Detailed Description of Study Procedure

D. DETAILED DESCRIPTION OF STUDY PROCEDURE

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

Step 1

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

Step 2

2010 Census block information was obtained in GIS format. This information was used to estimate the resident population within the EPZ and Shadow Region and to define the spatial distribution and demographic characteristics of the population within the study area. Employee and transient data were obtained from local/state emergency management agencies and from phone calls to transient facilities. Information concerning schools, medical and other types of special facilities within the EPZ was obtained from county sources, augmented by telephone contacts with the identified facilities.

Step 3

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

Step 4

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

Step 5

A telephone survey of households within the EPZ was conducted (in 2007) to identify household dynamics, trip generation characteristics, and evacuation-related demographic information of the EPZ population. This information was used to determine important study factors including the average number of evacuating vehicles used by each household, and the time required to perform pre-evacuation mobilization activities.

Step 6

A computerized representation of the physical roadway system, called a link-node analysis network, was developed using the UNITES software developed by KLD. Once the geometry of the network was completed, the network was calibrated using the information gathered during the road survey (Step 4). Estimates of highway capacity for each link and other link-specific characteristics were introduced to the network description. Traffic signal timings were input accordingly. The link-node analysis network was imported into a GIS map. 2010 Census data were overlaid in the map, and origin centroids where trips would be generated during the evacuation process were assigned to appropriate links.

Step 7

The EPZ is subdivided into 25 PAZ. Based on wind direction and speed, Regions (groupings of PAZ) that may be advised to evacuate, were developed.

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

Step 8

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

Step 9

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

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

Step 10

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

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

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

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

Step 11

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

Step 12

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

Step 13

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

Step 14

The prototype evacuation case was used as the basis for generating all region and scenario-specific evacuation cases to be simulated. This process was automated through the UNITES user interface. For each specific case, the population to be evacuated, the trip generation distributions, the highway capacity and speeds, and other factors are adjusted to produce a customized case-specific data set.

Step 15

All evacuation cases are executed using the DYNEV II System to compute ETE. Once results were available, quality control procedures were used to assure the results were consistent, dynamic routing was reasonable, and traffic congestion/bottlenecks were addressed properly.

Step 16

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

Step 17

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

Step 18

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

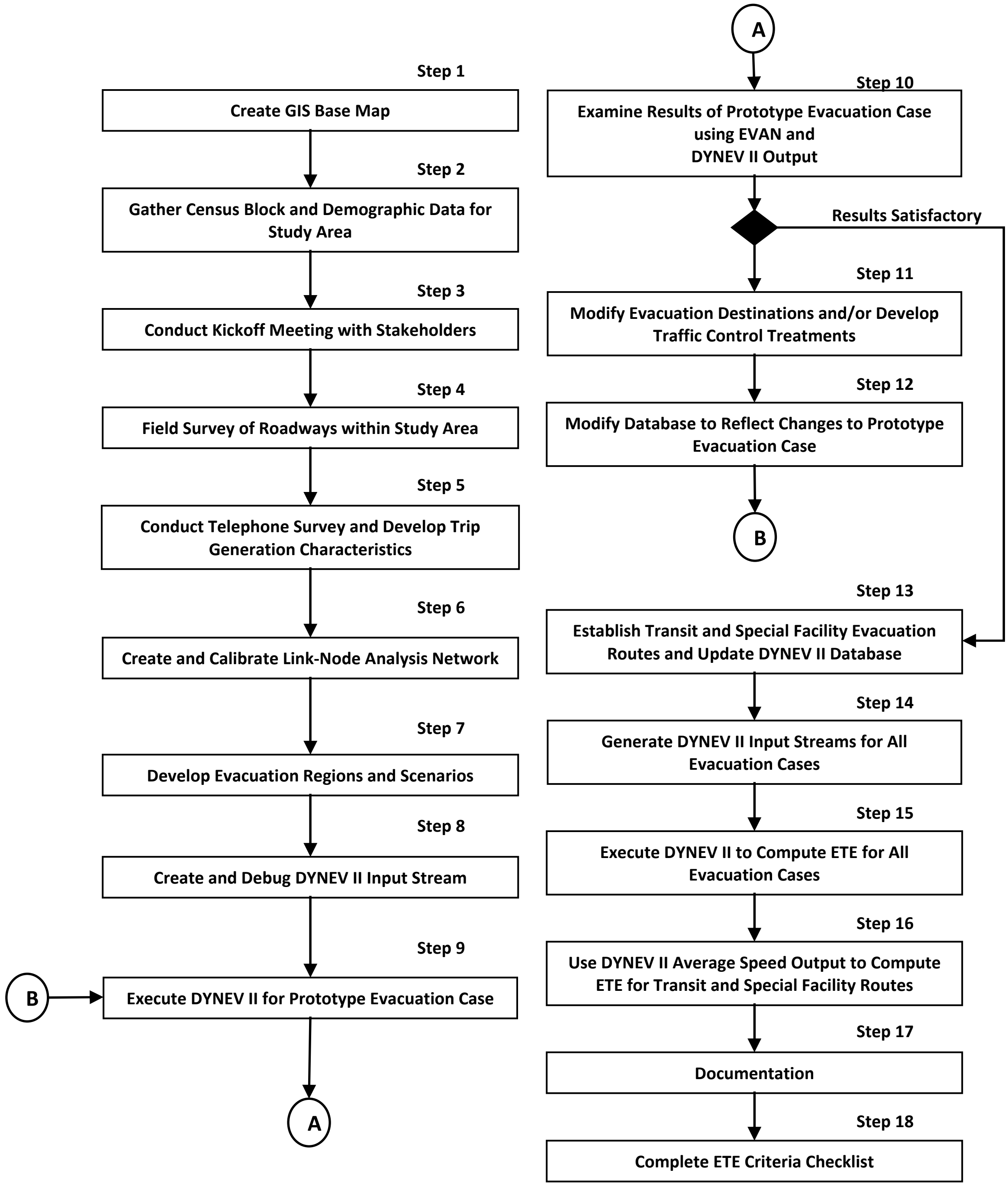


Figure D-1. Flow Diagram of Activities

APPENDIX E

Special Facility Data

E. SPECIAL FACILITY DATA

The following tables list population information, as of August 2012, for special facilities that are located within the NAPS EPZ. Special facilities are defined as schools, day care centers, hospitals and other medical care facilities. Transient population data is included in the tables for recreational areas and lodging facilities. Summer seasonal transients along the shores of Lake Anna were determined using 2010 US Census data and are not discussed in this section; Section 3.3 provides information for this transient population group. Employment data is included in the tables for major employers. Each table is grouped by county. The location of the facility is defined by its straight-line distance (miles) and direction (magnetic bearing) from the center point of the plant. Maps of each school and day care center, medical facility, major employer, recreational area and lodging facility are also provided.

Table E-1. Schools and Preschools within the EPZ

PAZ	Distance (miles)	Dire-ction	School Name	Street Address	Municipality	Phone	Enroll-ment	Staff
LOUISA COUNTY								
2	7.2	WSW	Mineral Christian Preschool[1]	51 Louisa Ave	Mineral	N/A	60	9
3	10.5	WSW	Thomas Jefferson Elementary School[1,2]	1782 Jefferson Hwy	Louisa	(540) 967-0492	545	124
3	7.8	WSW	Louisa County High School[1]	757 Davis Hwy	Louisa	(540) 894-5436	1,392	170
3	7.9	WSW	Louisa County Middle School[1]	1009 Davis Hwy	Mineral	(540) 894-5457	1,073	119
5	11.6	SSW	Jouett Elementary School[1,3]	315 Jouett School Rd	Mineral	(540) 872-3931	597	102
						Louisa County Subtotals:	*3,667*	*524*
SPOTSYLVANIA COUNTY								
12	5.2	NNE	Livingston Elementary	6057 Courthouse Rd	Spotsylvania	(540) 895-5101	444	65
21	10.3	ENE	Berkeley Elementary	5979 Partlow Road	Spotsylvania	(540) 582-5141	326	70
21	9.7	NE	Post Oak Middle School	6959 Courthouse Rd	Spotsylvania	(540) 582-7517	752	122
21	10.1	NE	Spotsylvania High School	6975 Courthouse Rd	Spotsylvania	(540) 582-3882	1,118	163
21	10.1	NE	Spotsylvania High School-Governor's School	6975 Courthouse Rd	Spotsylvania	(540) 582-3882	120	7
						Spotsylvania County Subtotals:	*2,760*	*427*
						TOTAL:	**6,427**	**951**

[1] Staff data obtained from 2008 ETE report (Revision 1 of the 2007 COLA) for Louisa County Schools.
[2] Students enrolled at Thomas Jefferson Elementary School currently attend classes at Trevilians Elementary School (outside the EPZ), due to damages from the August 2011 earthquake, and will return to the address provided above once reconstruction of the school is complete.
[3] School shelters-in-place.

Table E-2. Medical Facilities within the EPZ

PAZ	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Phone	Cap-acity	Current Census	Ambul-atory Patients	Wheel-chair Patients	Bed-ridden Patients
LOUISA COUNTY											
3	10.5	WSW	JABA Adult Daycare	522 Industrial Dr #B	Louisa	(434) 817-5222	N/A	23	21	2	0
						Louisa County Subtotals:	-	*23*	*21*	*2*	*0*
						TOTAL:	**-**	**23**	**21**	**2**	**0**

Table E-3. Major Employers within the EPZ

PAZ	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Phone	Employees (max shift)	% Non-EPZ	Employees (Non EPZ)
LOUISA COUNTY									
3	10.3	WSW	Tri-Dim Filters	93 Industrial Drive	Louisa	(540) 967-2600	135	50%	68
8	0.0	-	North Anna Power Station	State Hwy 700 & State Hwy 652	Mineral	(804) 237-2883	800	90%	720
						Louisa County Subtotals:	*935*	-	*788*
						TOTAL:	**935**	**-**	**788**

Table E-4. Marinas within the EPZ

PAZ	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Phone	Transients	Vehicles
SPOTSYLVANIA COUNTY								
9	1.4	NNE	Lake Anna Marina	4303 Boggs Dr	Bumpass	(540) 895-5555	150	100
11	2.1	E	Duke's Creek Marina	3831 Breaknock Rd	Bumpass	(540) 895-5065	46	18
12	2.0	N	Sturgeon Creek Marina	5107 Courthouse Rd	Spotsylvania	(540) 895-5095	132	44
12	2.2	NNE	Rocky Branch Marina	5153 Courthouse Rd	Spotsylvania	(540) 895-5475	35	14
14	2.3	NNW	Anna Point Marina	13701 Anna Point Ln	Mineral	(540) 895-5900	151	50
14	2.2	NW	High Point Marina[1]	4634 Courthouse Rd	Mineral	(540) 895-5249	390	195
18	6.7	NW	Hunter's Landing	6320 Belmont Rd. (Route 719)	Mineral	(540) 854-5725	90	35
						Spotsylvania County Subtotals:	*994*	*456*
						TOTAL:	**994**	**456**

[1] Data obtained from 2008 ETE report (Revision 1 of the 2007 COLA)

Table E-5. Campgrounds within the EPZ

PAZ	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Phone	Transients	Vehicles
LOUISA COUNTY								
16	6.0	WNW	Christopher Run Campground[1]	7149 Zachary Taylor Hwy	Mineral	(540) 894-4744	2,000	800
						Louisa County Subtotals:	*2,000*	*800*
SPOTSYLVANIA COUNTY								
14	4.0	NNW	Lake Anna State Park	6800 Lawyers Rd	Spotsylvania	(540) 854-5503	298	99
						Spotsylvania County Subtotals:	*298*	*99*
						TOTAL:	**2,298**	**899**

[1] Data obtained from 2008 ETE report (Revision 1 of the 2007 COLA)

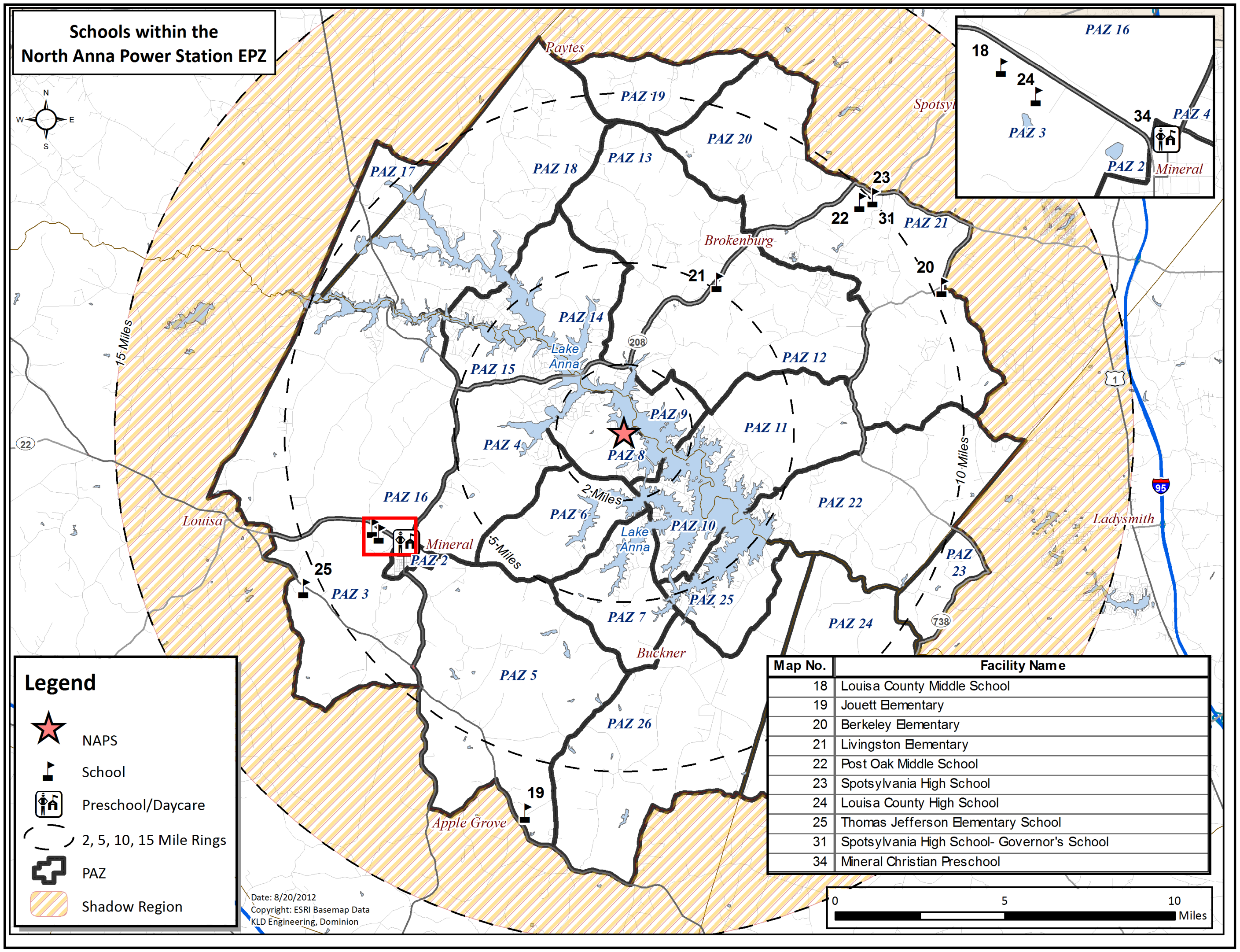
Table E-6. State Parks within the EPZ

PAZ	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Phone	Transients	Vehicles
SPOTSYLVANIA COUNTY								
14	4.0	NNW	Lake Anna State Park	6800 Lawyers Rd	Spotsylvania	(540) 854-5503	1,920	480
						Spotsylvania County Subtotals:	*1,920*	*480*
						TOTAL:	**1,920**	**480**

Table E-7. Lodging Facilities within the EPZ

PAZ	Distance (miles)	Dire-ction	Facility Name	Street Address	Municipality	Phone	Transients	Vehicles
SPOTSYLVANIA COUNTY								
11	3.2	E	Rockland Farm Retreat[1]	3609 Lewiston Rd	Bumpass	(540) 895-5098	12	6
13	2.3	N	Lake Anna Lodge	5152 Courthouse Rd	Spotsylvania	(540) 895-5844	27	27
14	2.2	NNW	The Lighthouse Inn	4634 Courthouse Rd	Mineral	(540) 895-5249	14	7
18	6.6	NW	Littlepage Bed & Breakfast	15701 Monrovia Rd	Mineral	(540) 854-9861	8	4
						Spotsylvania County Subtotals:	*61*	*44*
						TOTAL:	**61**	**44**

[1] Data obtained from 2008 ETE report (Revision 1 of the 2007 COLA)



Map No.	Facility Name
18	Louisa County Middle School
19	Jouett Elementary
20	Berkeley Elementary
21	Livingston Elementary
22	Post Oak Middle School
23	Spotsylvania High School
24	Louisa County High School
25	Thomas Jefferson Elementary School
31	Spotsylvania High School- Governor's School
34	Mineral Christian Preschool

Figure E-1. Schools and Preschools within the EPZ

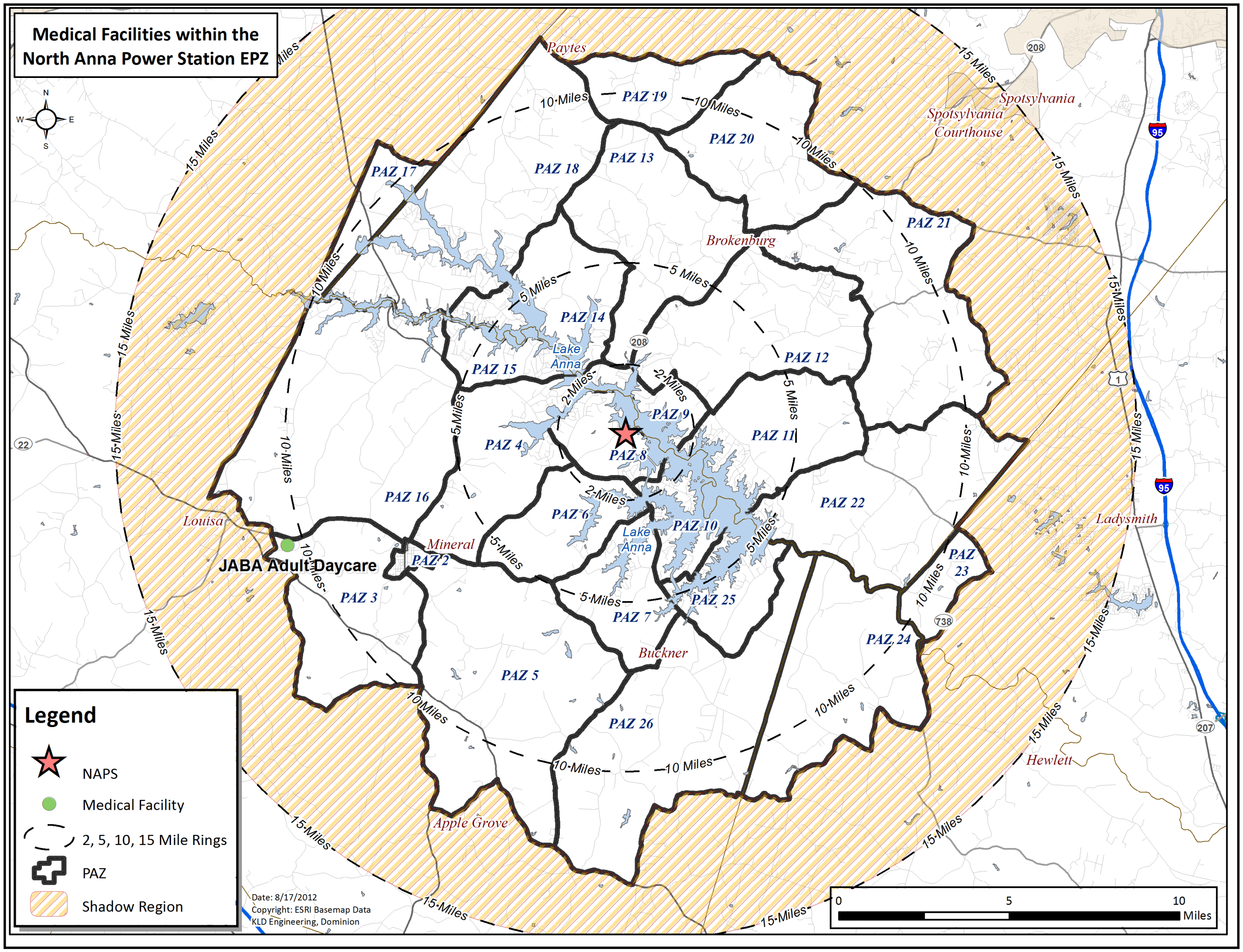


Figure E-2. Medical Facilities within the EPZ

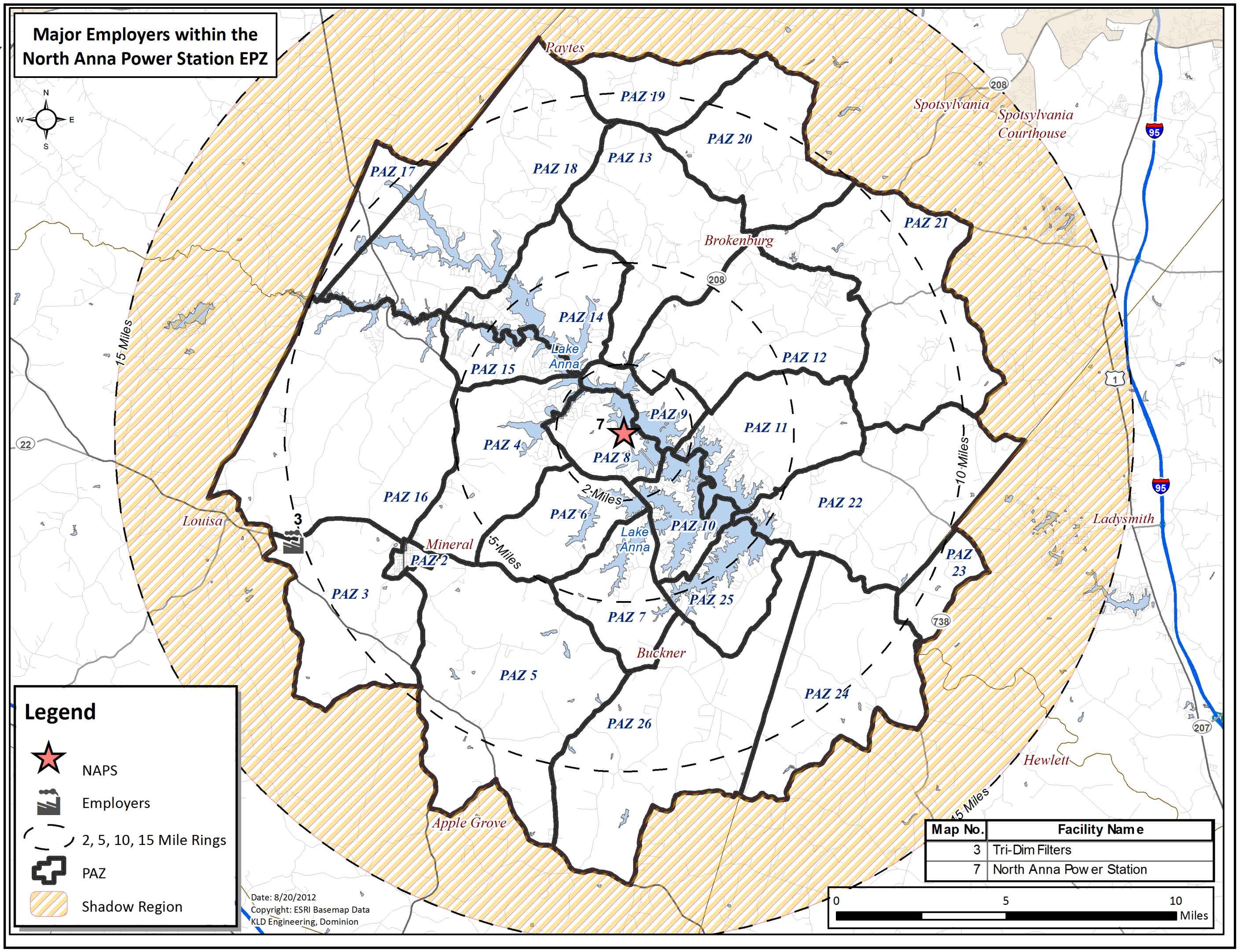


Figure E-3. Major Employers within the EPZ

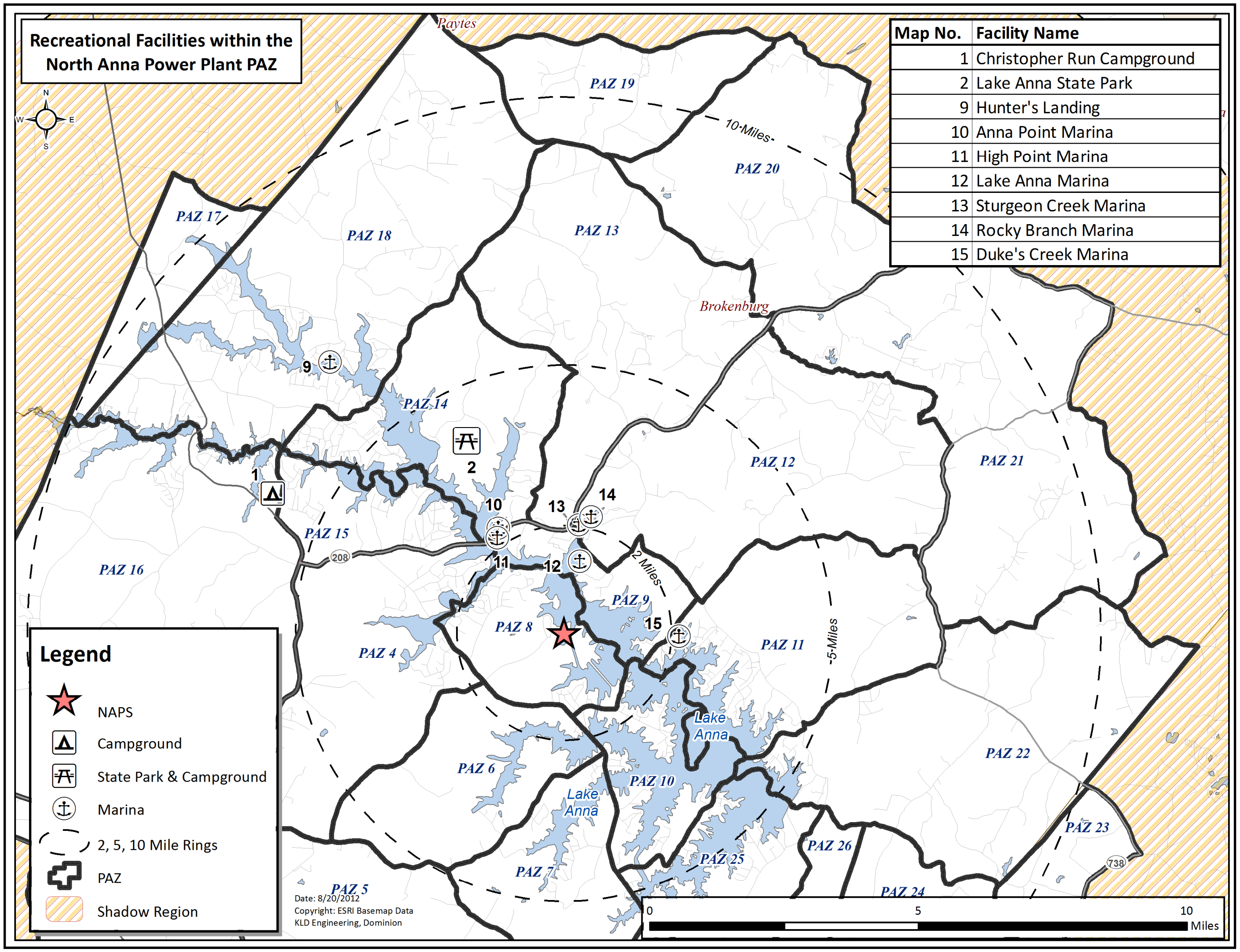
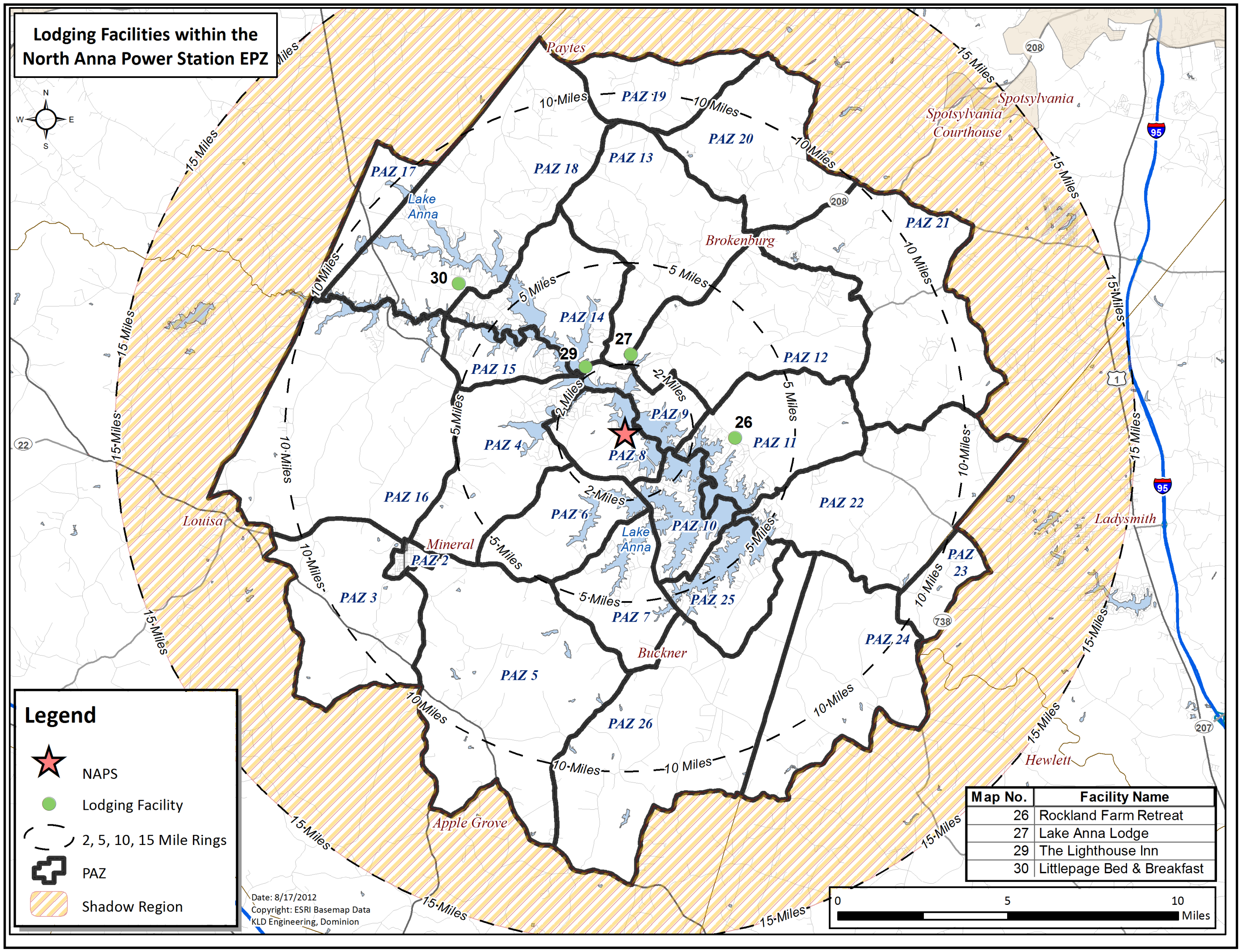


Figure E-4. Marinas, Campgrounds and State Parks within the EPZ



Map No.	Facility Name
26	Rockland Farm Retreat
27	Lake Anna Lodge
29	The Lighthouse Inn
30	Littlepage Bed & Breakfast

Figure E-5. Lodging within the EPZ

APPENDIX F

Telephone Survey

F. TELEPHONE SURVEY

F.1 Introduction

The development of evacuation time estimates for the North Anna Power Station 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 telephone survey of a representative sample of the EPZ population. The survey is designed to elicit information from the public concerning family demographics and estimates of response times to well defined events. The design of the survey includes a limited number of questions of the form "What would you do if …?" and other questions regarding activities with which the respondent is familiar ("How long does it take you to …?")

F.2 Survey Instrument and Sampling Plan

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

Following the completion of the instrument, a sampling plan was developed. A sample size of approximately 550 **completed** survey forms yields results with a sampling error of ±4.15% at the 95% confidence level. The sample must be drawn from the EPZ population. Consequently, a list of zip codes in the EPZ was developed using GIS software. This list is shown in Table F-1. Along with each zip code, an estimate of the population and number of households in each area was determined by overlaying Census data and the EPZ boundary, again using GIS software. The proportional number of desired completed survey interviews for each area was identified, as shown in Table F-1. Note that the average household size computed in Table F-1 was an estimate for sampling purposes and was not used in the ETE study.

The completed survey adhered to the sampling plan.

Table F-1. NAPS Telephone Survey Sampling Plan

Zip Code	Population within EPZ (2000)[1]	Households	Required Sample
22534	2,061	696	52
22546	4	1	0
22553*	4,894	1,731	131
22567	45	18	1
22960	308	122	9
23015	1,446	499	38
23024	3,674	1,447	109
23093	1,448	563	42
23117	5,621	2,222	168
Total	**19,501**	**2,222**	**550**
		Average Household Size:	**2.67**

*Note: The Postal Code 22553 was subdivided (into 22553 and 22551) between 2009 and 2010; the relevant portion is now zip code 22551.

The survey discussed herein was performed in 2007. The EPZ population has increased by about 30 percent (5,887 people) between the 2000 and 2010 Census (see Section 3.1). In the intervening period, the distribution pattern of population within the EPZ has not changed, nor has the nature of the EPZ. Consequently, the use of 2007 telephone survey sampling plan and results can be justified.

Four of the questions listed in this Appendix were not asked in the 2007 survey; therefore the

[1] EPZ population used in 2007 COLA

results from the 2012 Surry Power Station telephone survey are presented. Of these questions, only one (about snow removal time) is used in the calculation of ETE.

F.3 Survey Results

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

A review of the survey instrument reveals that several questions have a "don't know" (DK) or "refused" entry for a response. It is accepted practice in conducting surveys of this type to accept the answers of a respondent who offers a DK response for a few questions or who refuses to answer a few questions. To address the issue of occasional DK/refused responses from a large sample, the practice is to assume that the distribution of these responses is the same as the underlying distribution of the positive responses. In effect, the DK/refused responses are ignored and the distributions are based upon the positive data that is acquired.

F.3.1 Household Demographic Results

Household Size

Figure F-1 presents the distribution of household size within the EPZ. The average household contains 2.57 people. The estimated household size (2.68 persons) used to determine the survey sample (Table F-1) was drawn from Census data. The close agreement between the average household size obtained from the survey and from the Census is an indication of the reliability of the survey.

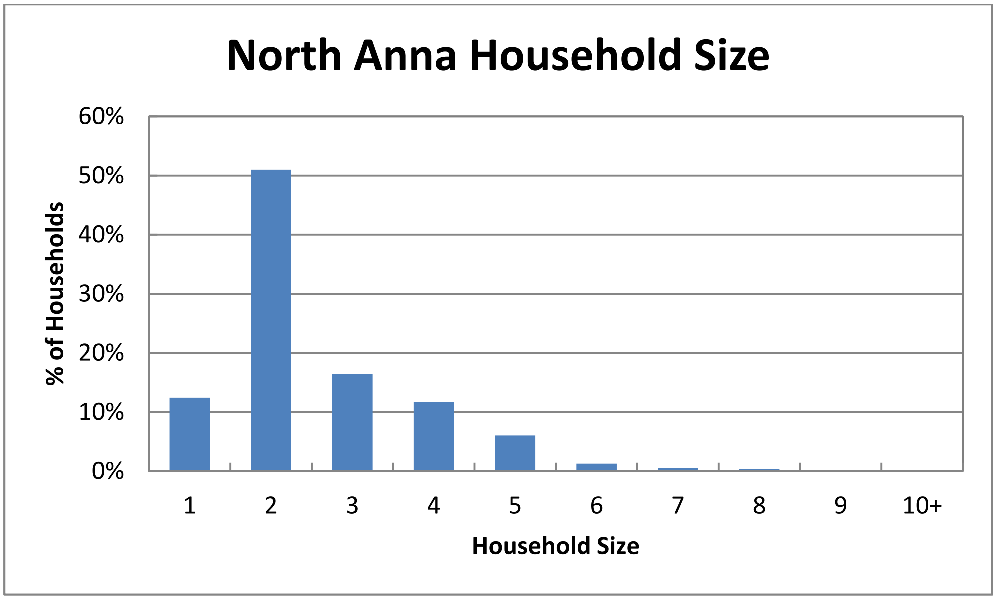


Figure F-1. Household Size in the EPZ

<u>Automobile Ownership</u>

The average number of automobiles available per household in the EPZ is 2.48. It should be noted that approximately 2.2 percent of households do not have access to an automobile. The distribution of automobile ownership is presented in Figure F-2. Figure F-3 and Figure F-4 present the automobile availability by household size. Note that the majority of households without access to a car are single person households. As expected, nearly all households of 2 or more people have access to at least one vehicle.

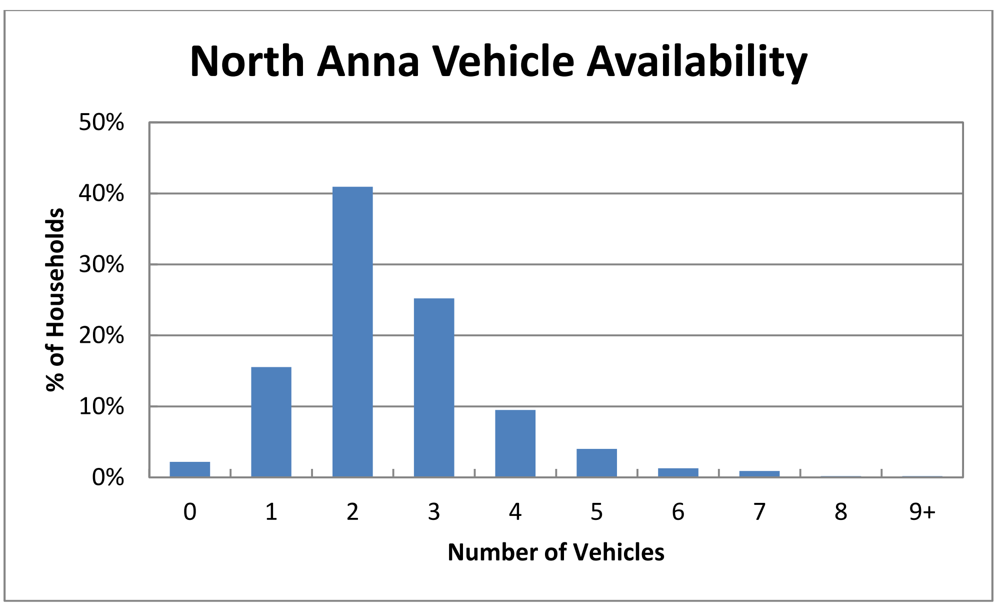


Figure F-2. Household Vehicle Availability

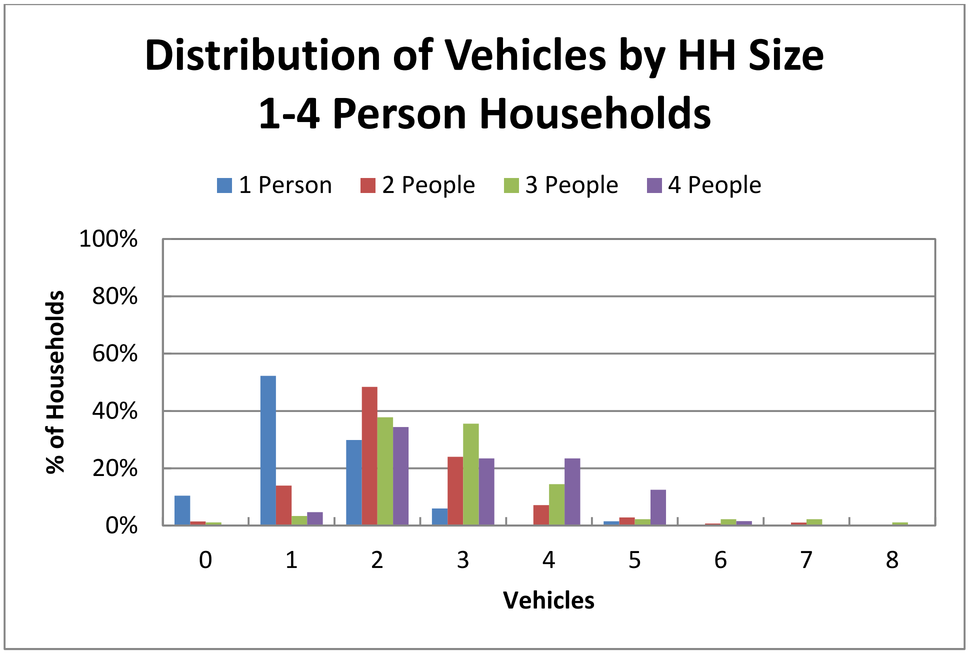


Figure F-3. Vehicle Availability - 1 to 5 Person Households

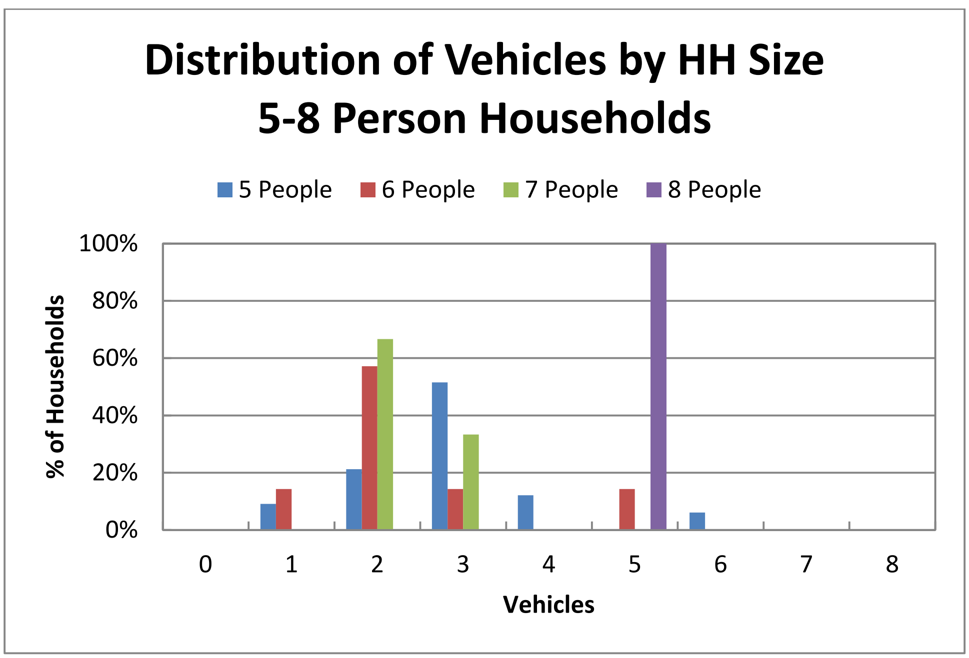


Figure F-4. Vehicle Availability - 6 to 9+ Person Households

Ridesharing

85% of the households surveyed (who do not own a vehicle) responded that they would share a ride with a neighbor, relative, or friend if a car was not available to them when advised to evacuate in the event of an emergency. Note, however, that only those households with no access to a vehicle – 20 total out of the sample size of 500 – answered this question. Thus, the results are not statistically significant. As such, the NRC recommendation of 50% ridesharing is used throughout this study. Figure F-5 presents this response.

The 2007 telephone survey did not include this question; therefore these results were taken from the 2012 telephone survey conducted for the Surry Power Station, which is located approximately 85 miles southeast of the North Anna Power Station.

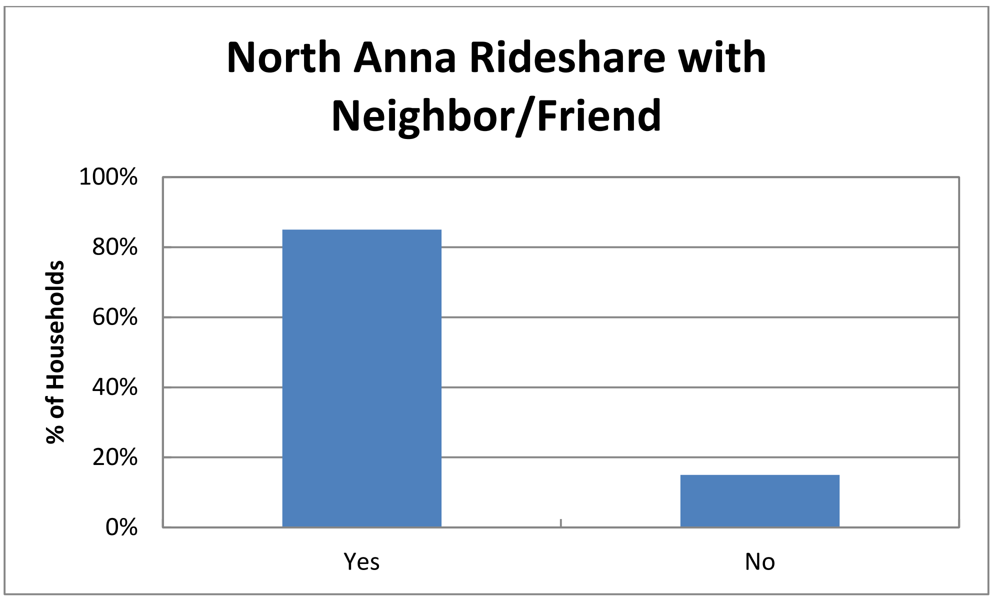


Figure F-5. Household Ridesharing Preference

Commuters

Figure F-6 presents the distribution of the number of commuters in each household. Commuters are defined as household members who travel to work or college on a daily basis. The data shows an average of 0.94 commuters in each household in the EPZ, and 59% of households have at least one commuter.

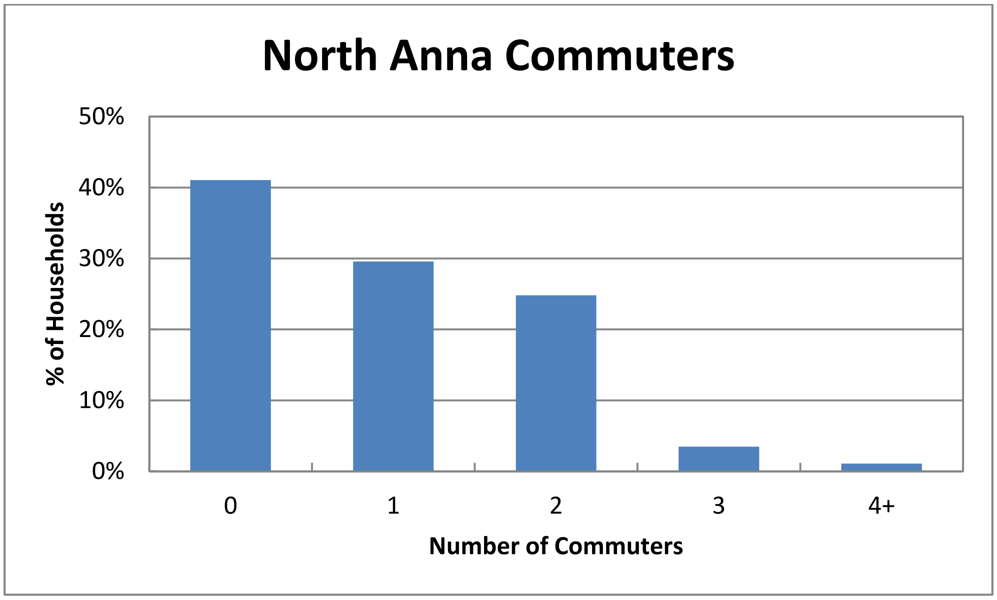


Figure F-6. Commuters in Households in the EPZ

Commuter Travel Modes

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

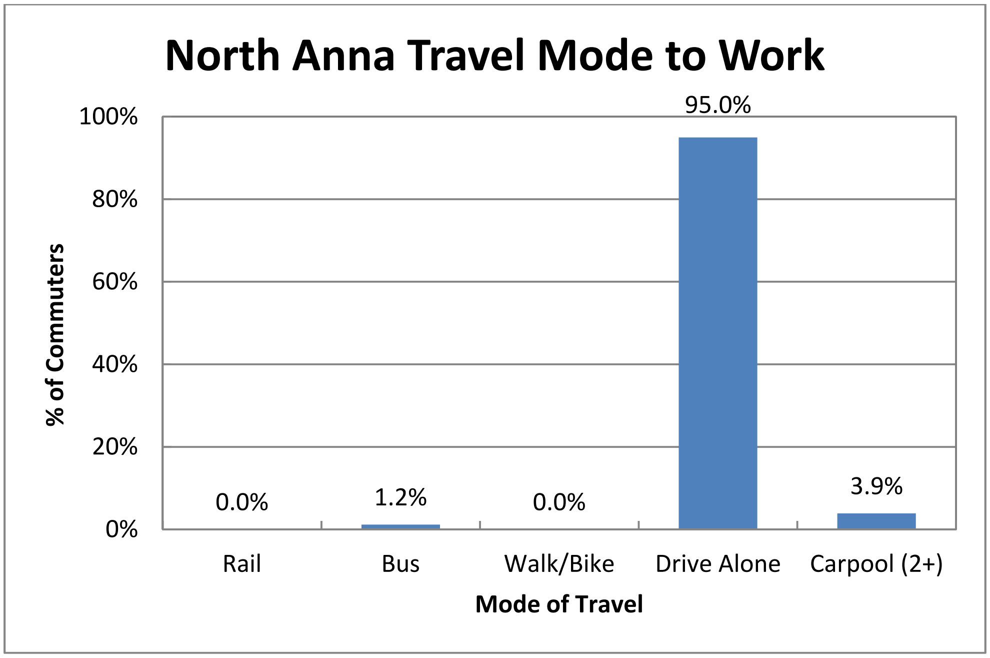


Figure F-7. Modes of Travel in the EPZ

F.3.2 Evacuation Response

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

"How many of the vehicles would your household use during an evacuation?" The response is shown in Figure F-8. On average, evacuating households would use 1.42 vehicles.

"Would your family await the return of other family members prior to evacuating the area?" Of the survey participants who responded, 61 percent said they would await the return of other family members before evacuating and 39 percent indicated that they would not await the return of other family members.

"If you had a household pet, would you take your pet with you if you were asked to evacuate the area?" Based on the responses to the survey, 79 percent of households have a family pet. Of the households with pets, 83 percent of them indicated that they would take their pets with them, as shown in Figure F-9.

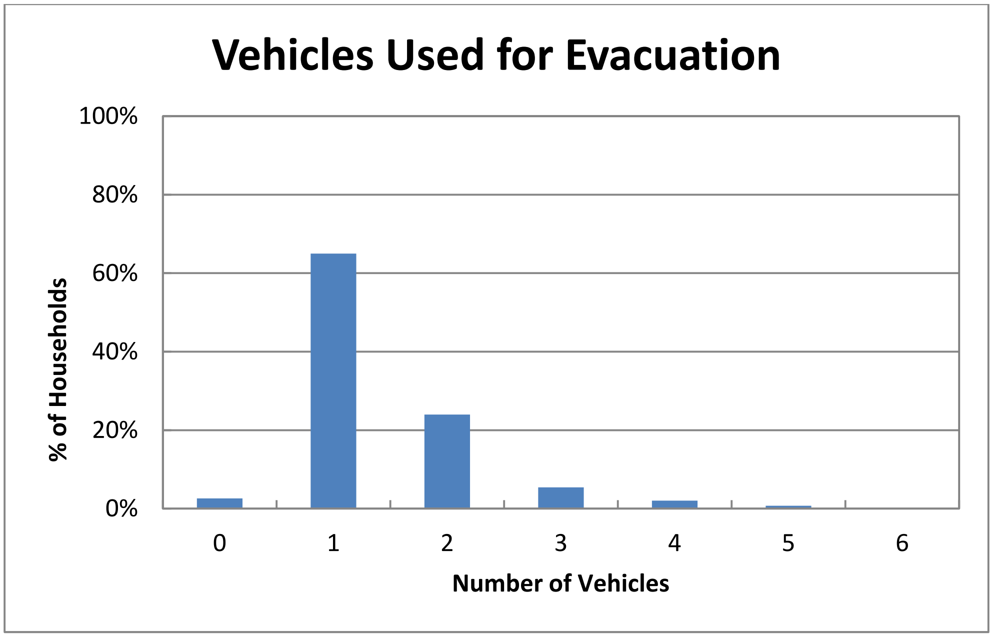


Figure F-8. Number of Vehicles Used for Evacuation

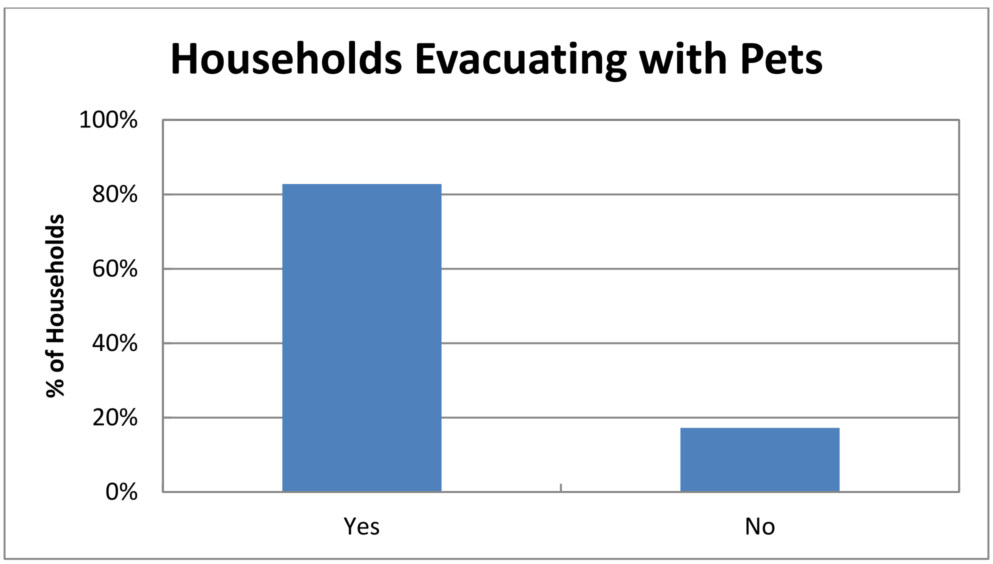


Figure F-9. Households Evacuating with Pets

"Emergency officials advise you to take shelter at home in an emergency. Would you?" This question is designed to elicit information regarding compliance with instructions to shelter in place. The results indicate that 81 percent of households who are advised to shelter in place would do so; the remaining 19 percent would choose to evacuate the area. Note the baseline ETE study assumes 20 percent of households will not comply with the shelter advisory, as per Section 2.5.2 of NUREG/CR-7002. Thus, the data obtained above is in good agreement with the federal guidance. The 2007 telephone survey did not include this question; these results are from the 2012 Surry Power Station telephone survey.

"Emergency officials advise you to take shelter at home now in an emergency and possibly evacuate later while people in other areas are advised to evacuate now. Would you?" This question is designed to elicit information specifically related to the possibility of a staged evacuation. That is, asking a population to shelter in place now and then to evacuate after a specified period of time. Results indicate that 74 percent of households would follow instructions and delay the start of evacuation until so advised, while the balance of 26 percent would choose to begin evacuating immediately. The 2007 telephone survey did not include this question; these results are from the 2012 Surry Power Station telephone survey.

F.3.3 Time Distribution Results

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

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

"How long does it take the commuter to complete preparation for leaving work?" Figure F-10 presents the cumulative distribution; in all cases, the activity is completed by about 120 minutes. 86 percent can leave within 45 minutes.

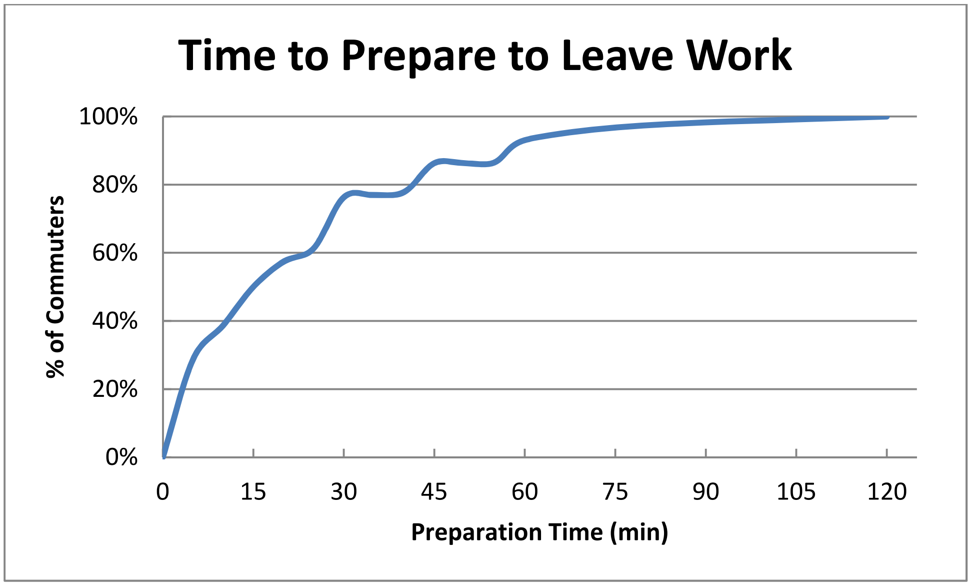


Figure F-10. Time Required to Prepare to Leave Work/School

"How long would it take the commuter to travel home?" Figure F-11 presents the work to home travel time for the EPZ. About 89 percent of commuters can arrive home within about 60 minutes of leaving work; all within 120 minutes.

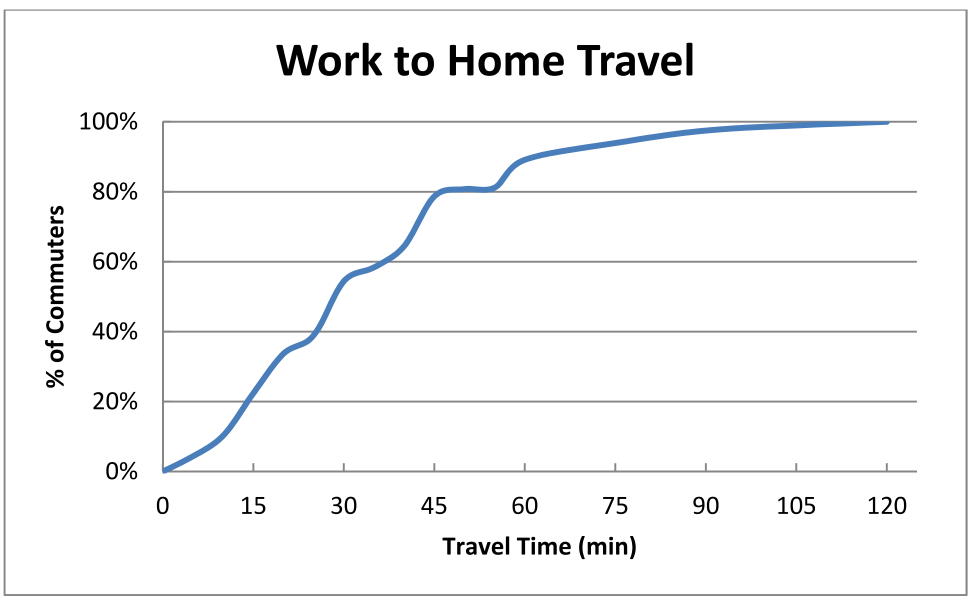


Figure F-11. Work to Home Travel Time

"How long would it take the family to pack clothing, secure the house, and load the car?" Figure F-12 presents the time required to prepare for leaving on an evacuation trip. In many ways this activity mimics a family's preparation for a short holiday or weekend away from home. Hence, the responses represent the experience of the responder in performing similar activities.

The distribution shown in Figure F-12 has a long "tail." About 91 percent of households can be ready to leave home within 75 minutes; the remaining households require up to an additional two hours.

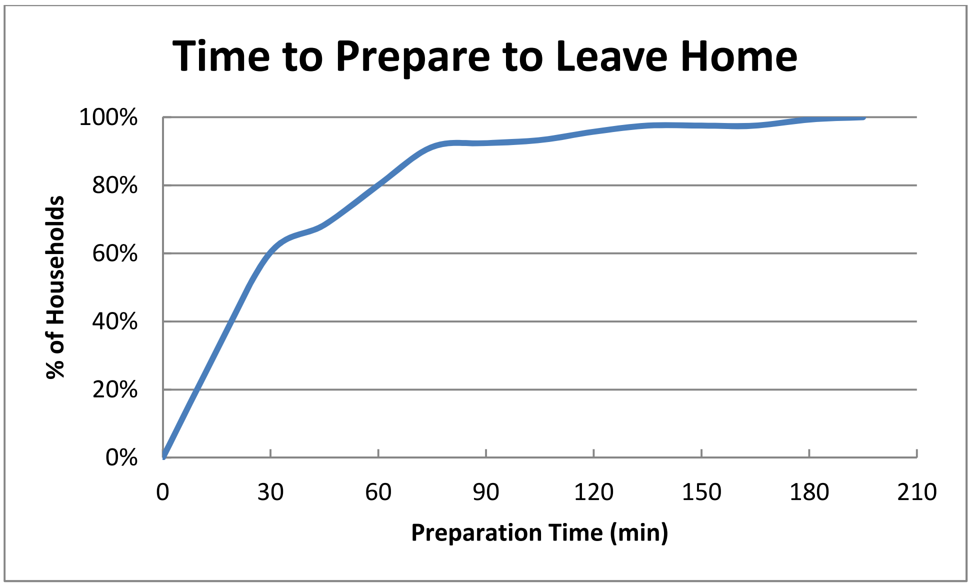


Figure F-12. Time to Prepare Home for Evacuation

"How long would it take you to clear 6 to 8 inches of snow from your driveway?" During adverse, snowy weather conditions, an additional activity must be performed before residents can depart on the evacuation trip. Although snow scenarios assume that the roads and highways have been plowed and are passable (albeit at lower speeds and capacities), it may be necessary to clear a private driveway prior to leaving the home so that the vehicle can access the street. Figure F-13 presents the time distribution for removing 6 to 8 inches of snow from a driveway. The time distribution for clearing the driveway has a long tail; about 91 percent of driveways are passable within 75 minutes. The last driveway is cleared three hours after the start of this activity. Note that those respondents (33%) who answered that they would not take time to clear their driveway were assumed to be ready immediately at the start of this activity. Essentially they would drive through the snow on the driveway to access the roadway and begin their evacuation trip.

The 2007 telephone survey did not include this question; these results are from the 2012 Surry Power Station telephone survey.

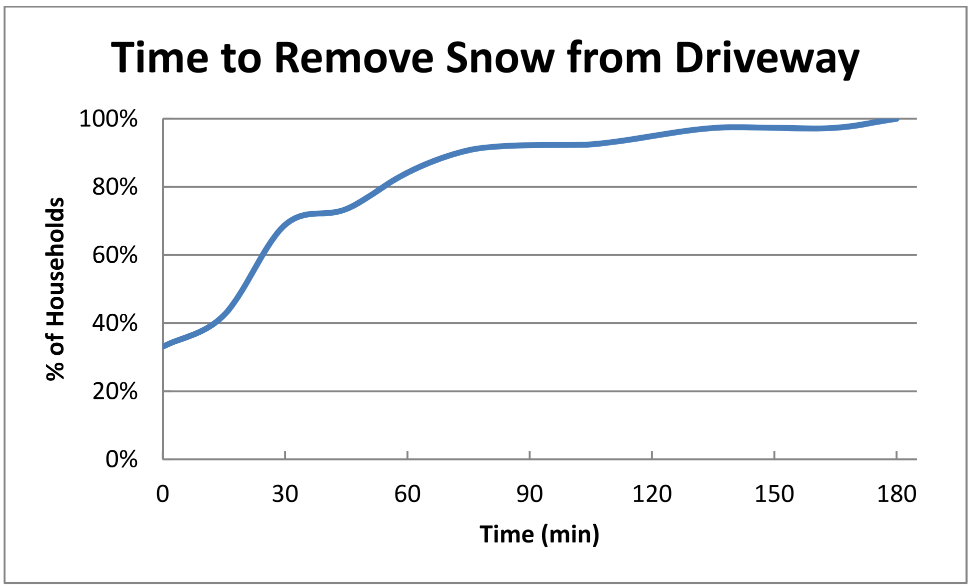


Figure F-13. Time to Clear Driveway of 6"-8" of Snow

F.4 Conclusions

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

ATTACHMENT A

Telephone Survey Instrument

Survey Instrument

Hello, my name is _______________ and I'm working on a survey being made for [insert marketing firm name] designed to identify local travel patterns in your area. The information obtained will be used in a traffic engineering study and in connection with an update of the county's emergency response plans. Your participation in this survey will greatly enhance the county's emergency preparedness program.

COL.1 Unused
COL.2 Unused
COL.3 Unused
COL.4 Unused
COL.5 Unused

Sex COL. 8
1 Male
2 Female

INTERVIEWER: ASK TO SPEAK TO THE HEAD OF HOUSEHOLD OR THE SPOUSE OF THE HEAD OF HOUSEHOLD. (Terminate call if not a residence)
IF ASKED FOR MORE INFORMATION ABOUT THE SURVEY, REFERENCE THE POSTCARD MAILED FROM KLD ASSOCIATES.

DO NOT ASK:

1. Record exchange number. To Be Determined

COL. 9-11

---

2. In total, how many cars, or other vehicles are usually available to the household? (DO NOT READ ANSWERS.)

COL.12
1 ONE
2 TWO
3 THREE
4 FOUR
5 FIVE
6 SIX
7 SEVEN
8 EIGHT
9 NINE OR MORE
0 ZERO (NONE)
X REFUSED

---

3. How many people usually live in this household? (DO NOT READ ANSWERS.)

COL.13	COL.14
1 ONE	0 TEN
2 TWO	1 ELEVEN
3 THREE	2 TWELVE
4 FOUR	3 THIRTEEN
5 FIVE	4 FOURTEEN
6 SIX	5 FIFTEEN
7 SEVEN	6 SIXTEEN
8 EIGHT	7 SEVENTEEN
9 NINE	8 EIGHTEEN
	9 NINETEEN OR MORE
	X REFUSED

4. How many children living in this household go to local public, private, or parochial schools? (DO NOT READ ANSWERS.)

COL.15
0 ZERO
1 ONE
2 TWO
3 THREE
4 FOUR
5 FIVE
6 SIX
7 SEVEN
8 EIGHT
9 NINE OR MORE
X REFUSED

5. How many people in the household commute to a job, or to college, at least 4 times a week?

COL.16	SKIP TO
0 ZERO	Q. 11
1 ONE	Q. 6
2 TWO	Q. 6
3 THREE	Q. 6
4 FOUR OR MORE	Q. 6
5 DON'T KNOW/REFUSED	Q. 11

INTERVIEWER: For each person identified in Question 5, ask Questions 6, 7, 8, and 9.

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

	Commuter #1 COL.17	Commuter #2 COL.18	Commuter #3 COL.19	Commuter #4 COL.20
Rail	1	1	1	1
Bus	2	2	2	2
Walk/Bicycle	3	3	3	3
Driver Car/Van	4	4	4	4
Park & Ride (Car/Rail, Xpress_bus)	5	5	5	5
Driver Carpool-2 or more people	6	6	6	6
Passenger Carpool-2 or more people	7	7	7	7
Taxi	8	8	8	8
Refused	9	9	9	9

7. What is the name of the city, town or community in which Commuter #1 works or attends school? (REPEAT QUESTION FOR EACH COMMUTER.) (FILL IN ANSWER.)

COMMUTER #1			COMMUTER #2			COMMUTER #3			COMMUTER #4		
City/Town		State	City/Town		State	City/Town		State	City/Town		State
COL.21	COL.22	COL.23	COL.24	COL.25	COL.26	COL.27	COL.28	COL.29	COL.30	COL.31	COL.32
0	0	0	0	0	0	0	0	0	0	0	0
1	1	1	1	1	1	1	1	1	1	1	1
2	2	2	2	2	2	2	2	2	2	2	2
3	3	3	3	3	3	3	3	3	3	3	3
4	4	4	4	4	4	4	4	4	4	4	4
5	5	5	5	5	5	5	5	5	5	5	5
6	6	6	6	6	6	6	6	6	6	6	6
7	7	7	7	7	7	7	7	7	7	7	7
8	8	8	8	8	8	8	8	8	8	8	8
9	9	9	9	9	9	9	9	9	9	9	9

8. How long would it take Commuter #1 to travel home from work or college?
(REPEAT QUESTION FOR EACH COMMUTER.) (DO NOT READ ANSWERS.)

COMMUTER #1

COL.33
1 5 MINUTES OR LESS
2 6-10 MINUTES
3 11-15 MINUTES
4 16-20 MINUTES
5 21-25 MINUTES
6 26-30 MINUTES
7 31-35 MINUTES
8 36-40 MINUTES
9 41-45 MINUTES

COL.34
1 46-50 MINUTES
2 51-55 MINUTES
3 56 - 1 HOUR
4 OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
5 BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
6 BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
7 BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
8 OVER 2 HOURS (SPECIFY _____)
9
0
X DON'T KNOW/REFUSED

COMMUTER #2

COL.35
1 5 MINUTES OR LESS
2 6-10 MINUTES
3 11-15 MINUTES
4 16-20 MINUTES
5 21-25 MINUTES
6 26-30 MINUTES
7 31-35 MINUTES
8 36-40 MINUTES
9 41-45 MINUTES

COL.36
1 46-50 MINUTES
2 51-55 MINUTES
3 56 - 1 HOUR
4 OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
5 BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
6 BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
7 BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
8 OVER 2 HOURS (SPECIFY _____)
9
0
X DON'T KNOW/REFUSED

COMMUTER #3

COL.37
1 5 MINUTES OR LESS
2 6-10 MINUTES
3 11-15 MINUTES
4 16-20 MINUTES
5 21-25 MINUTES
6 26-30 MINUTES
7 31-35 MINUTES
8 36-40 MINUTES
9 41-45 MINUTES

COL.38
1 46-50 MINUTES
2 51-55 MINUTES
3 56 - 1 HOUR
4 OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
5 BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
6 BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
7 BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
8 OVER 2 HOURS (SPECIFY _____)
9
0
X DON'T KNOW/REFUSED

COMMUTER #4

COL.39
1 5 MINUTES OR LESS
2 6-10 MINUTES
3 11-15 MINUTES
4 16-20 MINUTES
5 21-25 MINUTES
6 26-30 MINUTES
7 31-35 MINUTES
8 36-40 MINUTES
9 41-45 MINUTES

COL.40
1 46-50 MINUTES
2 51-55 MINUTES
3 56 - 1 HOUR
4 OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
5 BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
6 BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
7 BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
8 OVER 2 HOURS (SPECIFY _____)
9
0
X DON'T KNOW/REFUSED

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

COMMUTER #1

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

COMMUTER #2

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

COMMUTER #3

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

COMMUTER #4

COL. 47		COL. 48	
1	5 MINUTES OR LESS	1	46-50 MINUTES
2	6-10 MINUTES	2	51-55 MINUTES
3	11-15 MINUTES	3	56 - 1 HOUR
4	16-20 MINUTES	4	OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES
5	21-25 MINUTES	5	BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES
6	26-30 MINUTES	6	BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES
7	31-35 MINUTES	7	BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS
8	36-40 MINUTES	8	OVER 2 HOURS (SPECIFY _____)
9	41-45 MINUTES	9	
		0	
		X	DON'T KNOW/REFUSED

10. When the commuters are away from home, is there a vehicle at home that is available for evacuation during any emergency?

Col. 49
1 Yes
2 No
3 Don't Know/Refused

11. Would you await the return of family members prior to evacuating the area?

Col. 50
1 Yes
2 No
3 Don't Know/Refused

12. How many of the vehicles that are usually available to the household would your family use during an evacuation? (DO NOT READ ANSWERS.)

COL.51
1 ONE
2 TWO
3 THREE
4 FOUR
5 FIVE
6 SIX
7 SEVEN
8 EIGHT
9 NINE OR MORE
0 ZERO (NONE)
X REFUSED

13. How long would it take the family to pack clothing, secure the house, load the car, and complete preparations prior to evacuating the area? (DO NOT READ ANSWERS.)

COL.52
1 LESS THAN 15 MINUTES
2 15-30 MINUTES
3 31-45 MINUTES
4 46 MINUTES - 1 HOUR
5 1 HOUR TO 1 HOUR 15 MINUTES
6 1 HOUR 16 MINUTES TO 1 HOUR 30 MINUTES
7 1 HOUR 31 MINUTES TO 1 HOUR 45 MINUTES
8 1 HOUR 46 MINUTES TO 2 HOURS
9 2 HOURS TO 2 HOURS 15 MINUTES
0 2 HOURS 16 MINUTES TO 2 HOURS 30 MINUTES
X 2 HOURS 31 MINUTES TO 2 HOURS 45 MINUTES
Y 2 HOURS 46 MINUTES TO 3 HOURS

COL.53
1 3 HOURS TO 3 HOURS 15 MINUTES
2 3 HOURS 16 MINUTES TO 3 HOURS 30 MINUTES
3 3 HOURS 31 MINUTES TO 3 HOURS 45 MINUTES
4 3 HOURS 46 MINUTES TO 4 HOURS
5 4 HOURS TO 4 HOURS 15 MINUTES
6 4 HOURS 16 MINUTES TO 4 HOURS 30 MINUTES
7 4 HOURS 31 MINUTES TO 4 HOURS 45 MINUTES
8 4 HOURS 46 MINUTES TO 5 HOURS
9 5 HOURS TO 5 HOURS 15 MINUTES
0 5 HOURS 16 MINUTES TO 5 HOURS 30 MINUTES
X 5 HOURS 31 MINUTES TO 5 HOURS 45 MINUTES
Y 5 HOURS 46 MINUTES TO 6 HOURS

COL.54
1 DON'T KNOW

14. Would you take household pets with you if you were asked to evacuate the area?

Col. 58
1 Yes
2 No
3 Don't Know/Refused

Thank you very much. ______________________________________
(TELEPHONE NUMBER CALLED)

For Additional information: If requested, **ask what county they reside in** and provide the appropriate number from the list below:

Contact your County Emergency Management Office:

COUNTY	PHONE NUMBER
Caroline	(804)633-4357
Hanover	(804)365-6140
Louisa	(540)967-1234
Orange	(540)672-1235
Spotsylvania	(540)582-7115

APPENDIX G

Traffic Management Plan

G. TRAFFIC MANAGEMENT PLAN

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

These plans were reviewed and the TCP were modeled accordingly.

G.1 Traffic Control Points

As discussed in Section 9, traffic control points at intersections (which are controlled) are modeled as actuated signals. If an intersection has a pre-timed signal, stop, or yield control, and the intersection is identified as a traffic control point, the control type was changed to an actuated signal in the DYNEV II system. Table K-2 provides the control type and node number for those nodes which are controlled. If the existing control was changed due to the point being a Traffic Control Point, the control type is indicated as a TCP in Table K-2.

Figure G-1 maps the TCP identified in the county emergency plans for a full EPZ evacuation. Theses TCP would be manned during evacuation by traffic guides who would direct evacuees in the proper direction and facilitate the flow of traffic through the intersections.

G.2 Access Control Points

It is assumed that ACP will be established within 2 hours of the advisory to evacuate to discourage through travelers from using major through routes which traverse the study area. As discussed in Section 3.7, external traffic was only considered on three routes which traverse the study area – Interstate-95, Interstate-64 and US-1 – in this analysis. The generation of these external trips ceased at 2 hours after the advisory to evacuate in the simulation.

Figure G-2 maps the ACP identified in the county emergency plans which would be in affect during the evacuation of the full EPZ. These ACP are concentrated on roadways giving access to the EPZ. Theses ACP would be manned during an evacuation by traffic guides who would direct evacuees in the proper direction away from NAPS and facilitate the flow of traffic through the intersections.

This study did not identify any additional intersections that should be identified as TCP or ACP.

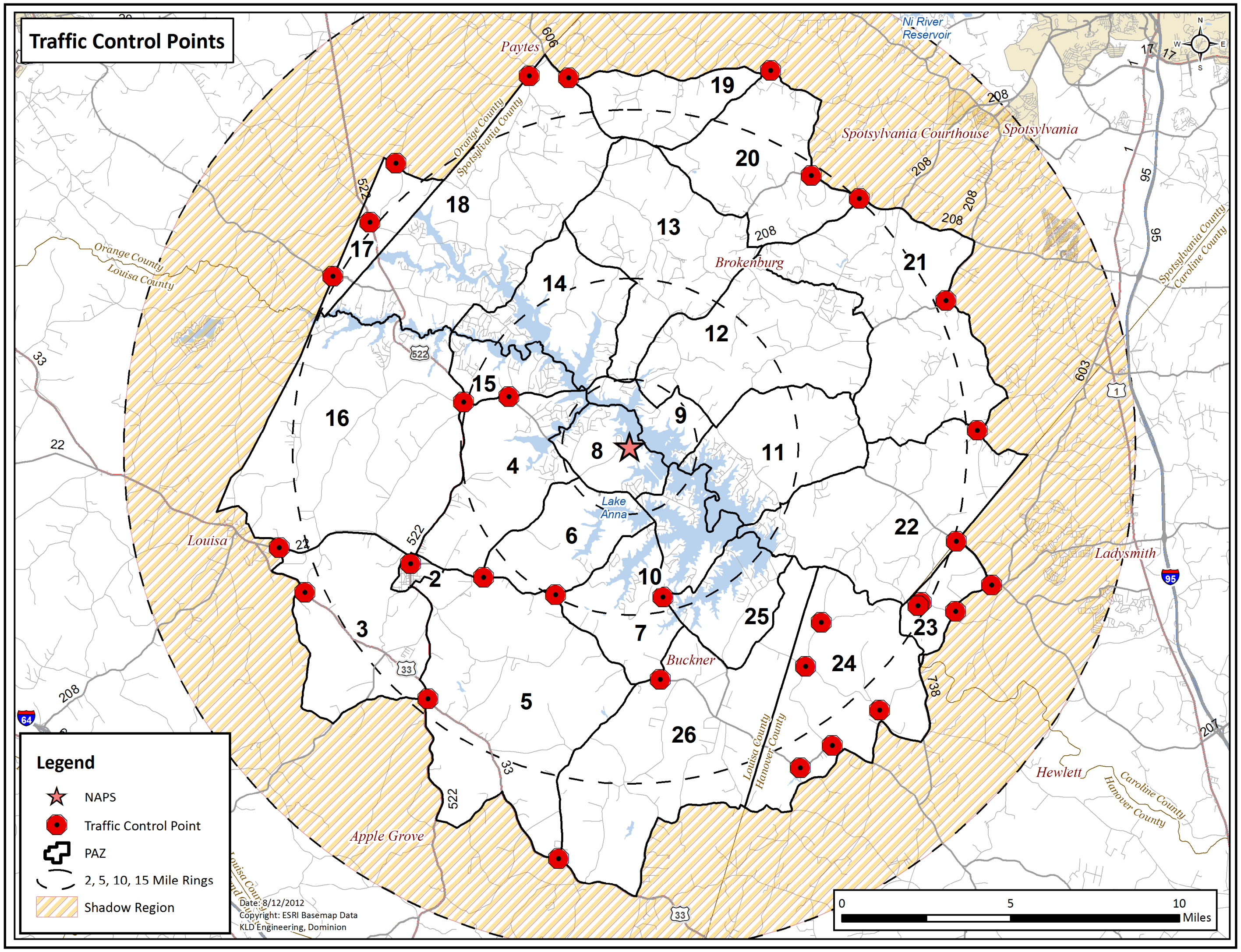


Figure G-1. Traffic Control Points for the NAPS Site

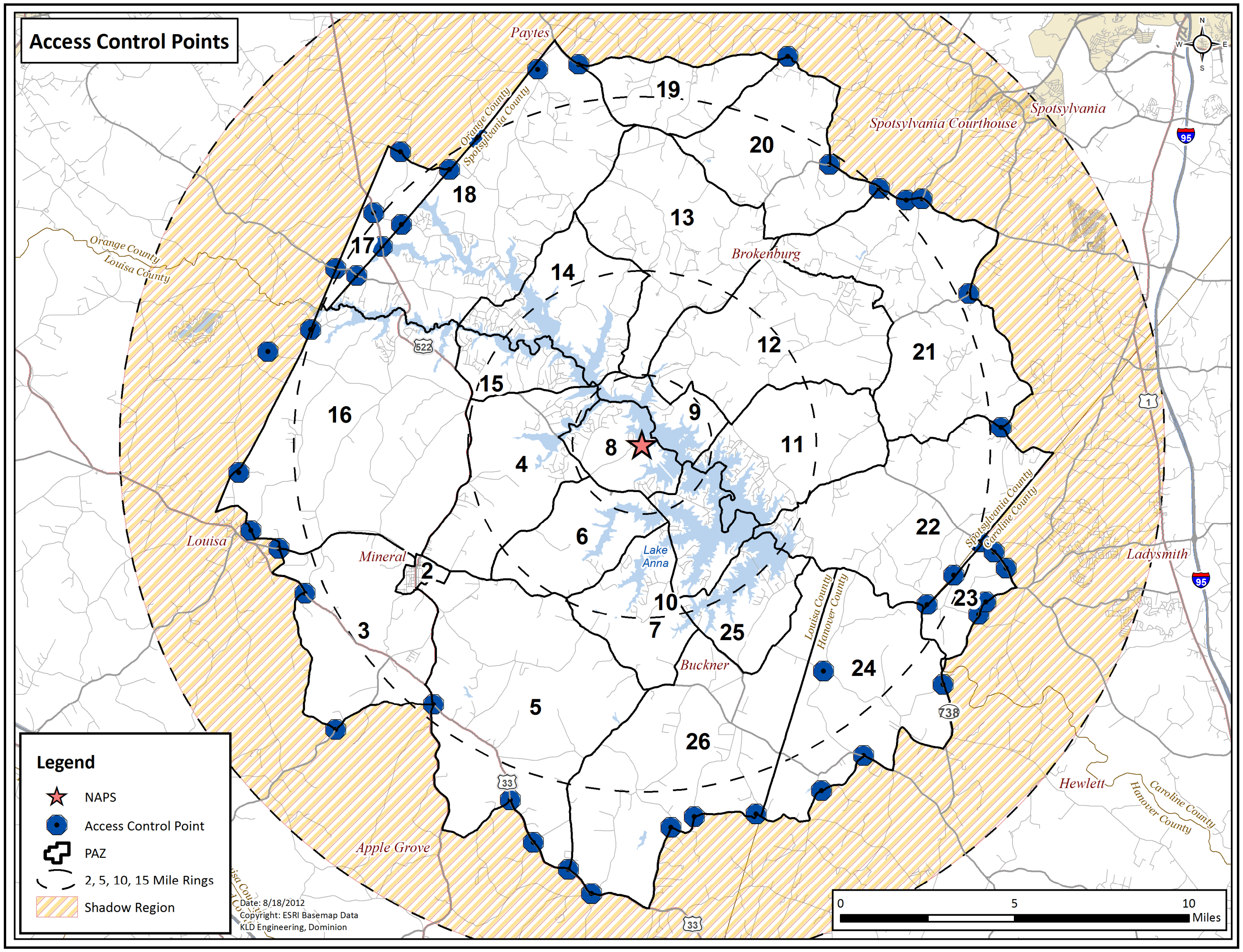


Figure G-2. Access Control Points for the NAPS Site

APPENDIX H

Evacuation Regions

H EVACUATION REGIONS

This appendix presents the evacuation percentages for each Evacuation Region (Table H-1) and maps of all Evacuation Regions. The percentages presented in Table H-1 are based on the methodology discussed in assumption 5 of Section 2.2 and shown in Figure 2-1.

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

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

Region	Description	Site PAR Description	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Basic Regions																											
			Protection Action Zone (PAZ)																								
R01	2-Mile Radius	2-Mile Radius	20%	20%	20%	20%	100%	20%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R02	5-Mile Radius	5-Mile Radius	20%	20%	100%	20%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	100%	20%
R03	Full EPZ	Full EPZ	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Evacuate 2-Mile Radius and Downwind to 5 Miles																											
Region	**Wind Direction Toward:**	**Site PAR Description**	**Protection Action Zone (PAZ)**																								
			2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
R04	N, NNE	349° - 33°	20%	20%	20%	20%	100%	20%	100%	100%	100%	20%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R05	NE	34° - 56°	20%	20%	20%	20%	100%	20%	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R06	ENE, E	57° - 101°	20%	20%	20%	20%	100%	20%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R07	ESE	102° - 123°	20%	20%	20%	20%	100%	20%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	100%	20%
R08	SE	124° - 146°	20%	20%	20%	20%	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	100%	20%
R09	SSE, S	147° - 191°	20%	20%	20%	20%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	100%	20%
R10	SSW	192° - 213°	20%	20%	20%	20%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R11	SW	214° - 236°	20%	20%	100%	20%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R12	WSW	237° - 258°	20%	20%	100%	20%	100%	20%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R13	W	259°-281°	20%	20%	100%	20%	100%	20%	100%	100%	100%	20%	20%	20%	20%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R14	WNW, NW	282° - 326°	20%	20%	100%	20%	100%	20%	100%	100%	100%	20%	20%	20%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R15	NNW	327° - 349°	20%	20%	20%	20%	100%	20%	100%	100%	100%	20%	20%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
Evacuate 5-Mile Radius and Downwind to the EPZ Boundary																											
Region	**Wind Direction Toward:**	**Site PAR Description**	**Protection Action Zone (PAZ)**																								
			2	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**
R16	N	349° - 11°	20%	20%	100%	20%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	20%	20%	100%	100%	100%	20%	20%	20%	20%	100%	20%
R17	NNE	12° - 33°	20%	20%	100%	20%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	20%	20%	100%	100%	100%	100%	20%	20%	20%	100%	20%
R18	NE	34° - 56°	20%	20%	100%	20%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	20%	20%	20%	100%	100%	100%	20%	20%	20%	100%	20%
R19	ENE	57° - 78°	20%	20%	100%	20%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	100%	100%	100%	20%	20%	100%	20%
R20	E	79° - 101°	20%	20%	100%	20%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	100%	100%	100%	20%	100%	20%
R21	ESE	102° - 123°	20%	20%	100%	20%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	100%	100%	100%	100%	100%	100%
R22	SE	124° - 146°	20%	20%	100%	20%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	100%	100%	100%	100%	100%
R23	SSE, S	147° - 191°	20%	20%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	100%	100%	100%
R24	SSW	192° - 213°	20%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	100%	100%
R25	SW, WSW	214° - 258°	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	100%	20%
R26	W	259° - 281°	100%	100%	100%	20%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	100%	20%
R27	WNW, NW	282° - 326°	20%	20%	100%	20%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	100%	20%
R28	NNW	327° - 349°	20%	20%	100%	20%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	20%	100%	100%	100%	20%	20%	20%	20%	20%	100%	20%

Table H-2. Percent of PAZ Population Evacuating for Each Staged Region

Staged Evacuation - 2-Mile Radius Evacuates, then Evacuate Downwind to 5 Miles																											
Region	Wind Direction Toward:	Site PAR Description	Protection Action Zone (PAZ)																								
			2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
R29	-	5-Mile Radius	20%	20%	100%	20%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	100%	20%
R30	N, NNE	349° - 33°	20%	20%	20%	20%	100%	20%	100%	100%	100%	20%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R31	NE	34° - 56°	20%	20%	20%	20%	100%	20%	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R32	ENE, E	57° - 101°	20%	20%	20%	20%	100%	20%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R33	ESE	102° - 123°	20%	20%	20%	20%	100%	20%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	100%	20%
R34	SE	124° - 146°	20%	20%	20%	20%	100%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	100%	20%
R35	SSE, S	147° - 191°	20%	20%	20%	20%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	100%	20%
R36	SSW	192° - 213°	20%	20%	20%	20%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R37	SW	214° - 236°	20%	20%	100%	20%	100%	100%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R38	WSW	237° - 258°	20%	20%	100%	20%	100%	20%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R39	W	259°- 281°	20%	20%	100%	20%	100%	20%	100%	100%	100%	20%	20%	20%	20%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R40	WNW, NW	282° - 326°	20%	20%	100%	20%	100%	20%	100%	100%	100%	20%	20%	20%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%
R41	NNW	327° - 349°	20%	20%	20%	20%	100%	20%	100%	100%	100%	20%	20%	100%	100%	100%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%	20%

Shelter-in-Place until 90% ETE for R01, then Evacuate[1] | PAZ(s) Shelter-in-Place | PAZ(s) Evacuate

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

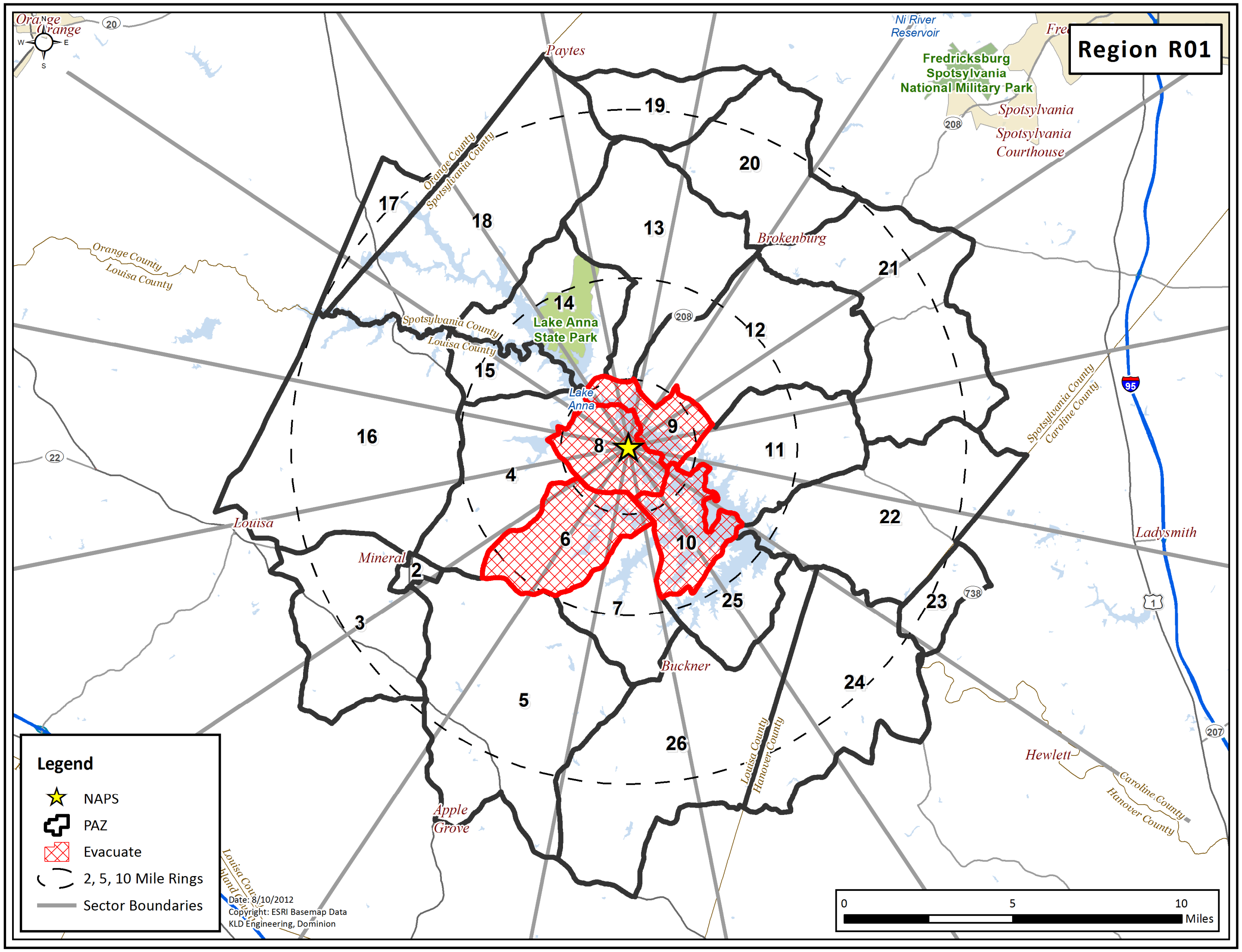


Figure H-1. Region R01

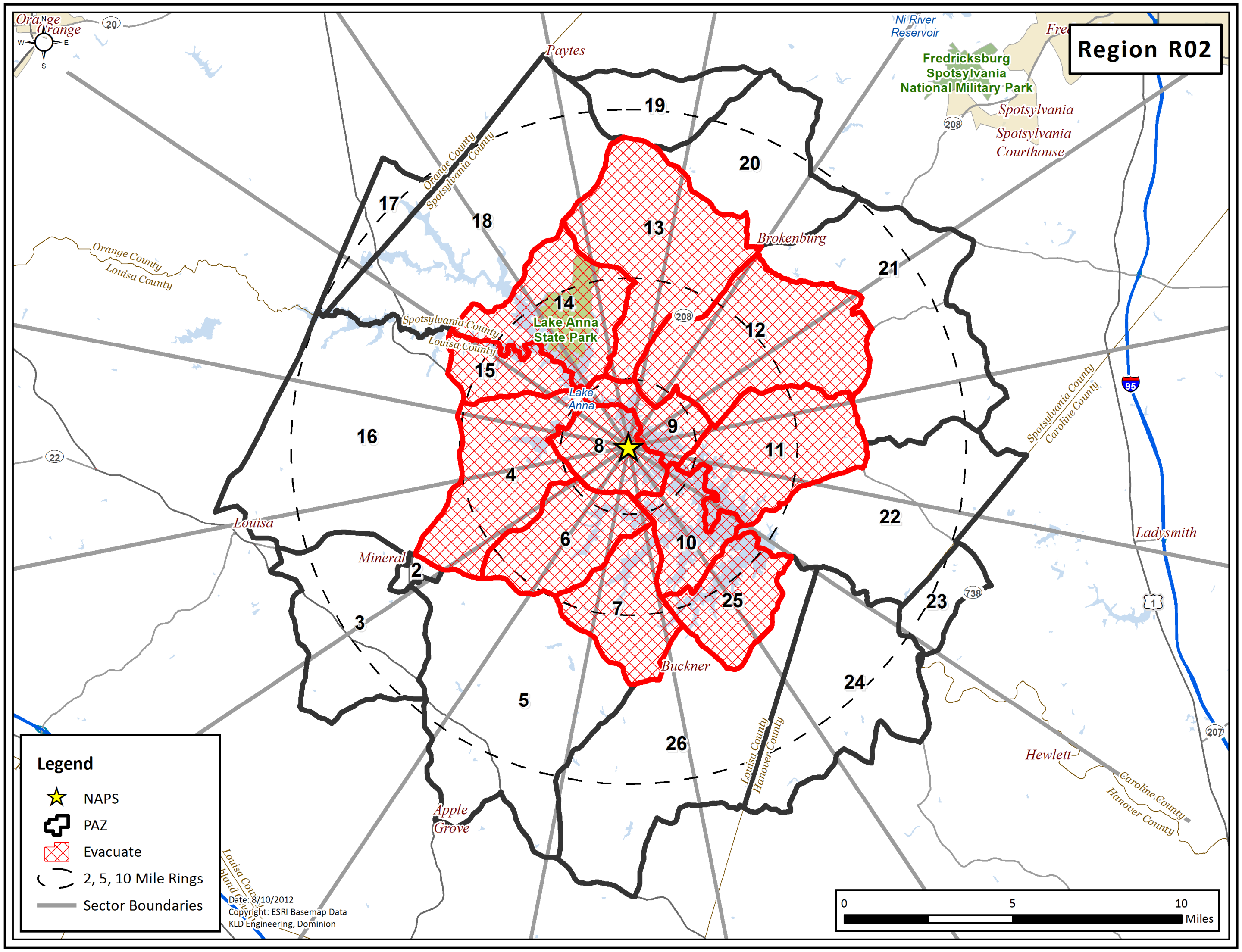


Figure H-2. Region R02

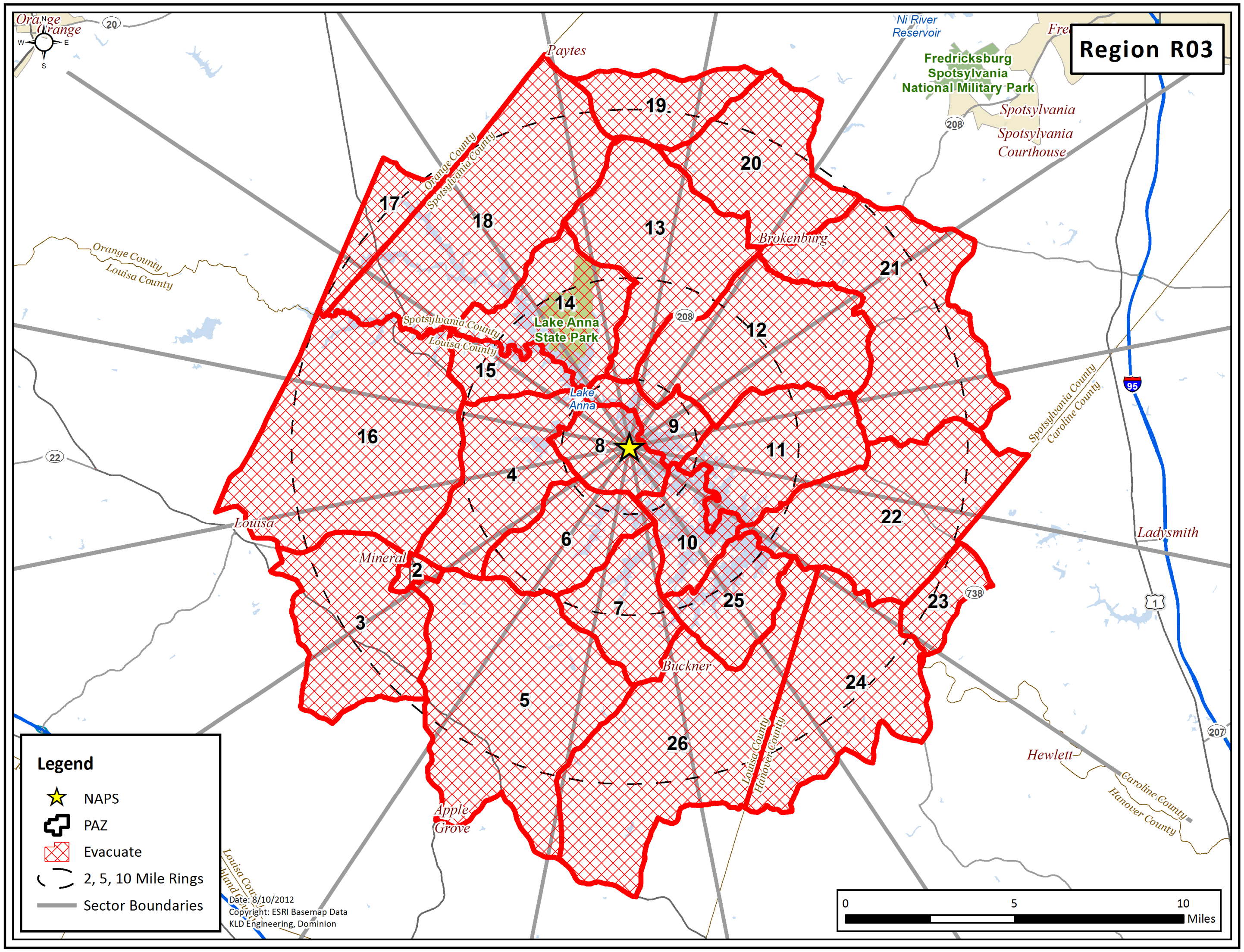


Figure H-3. Region R03

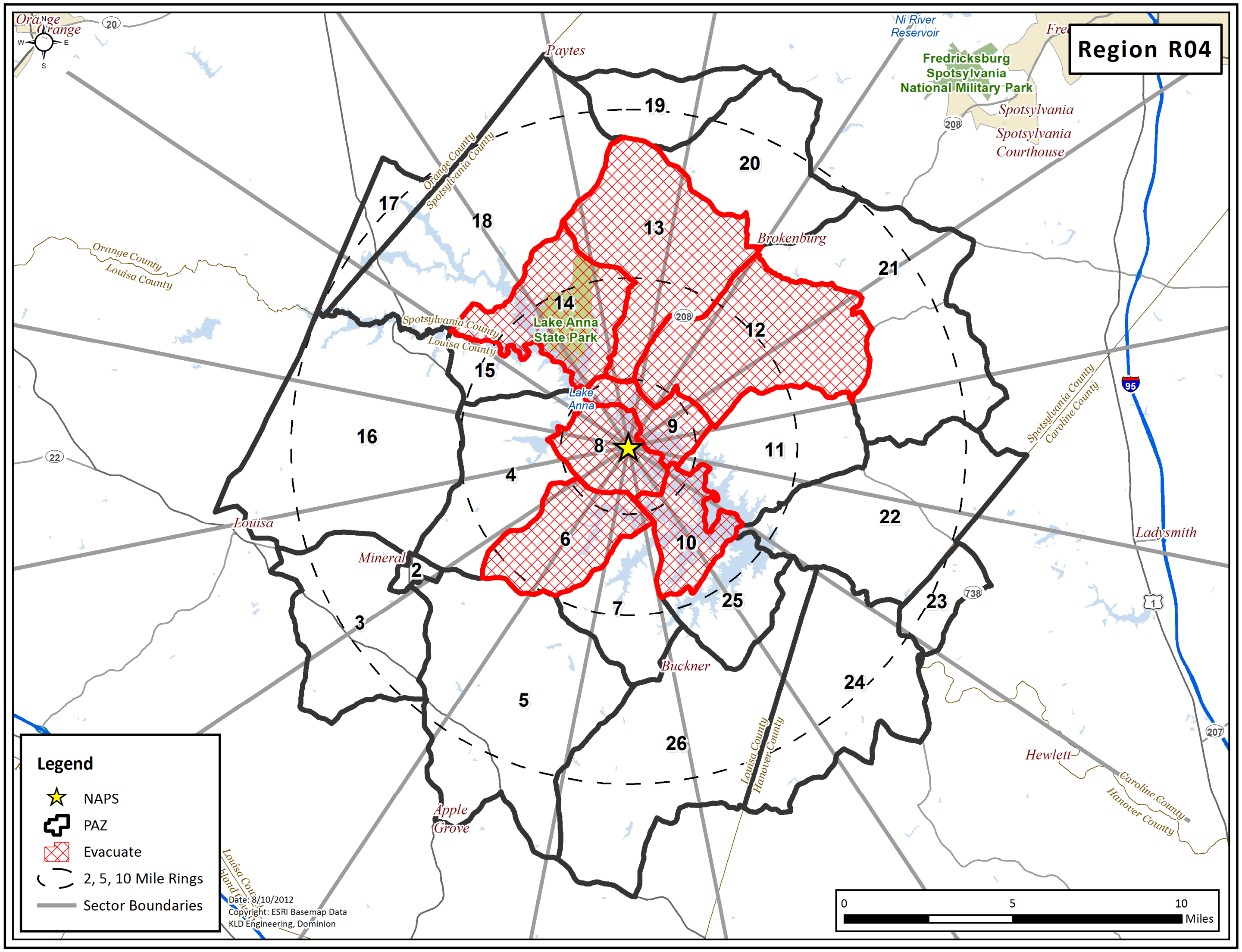


Figure H-4. Region R04

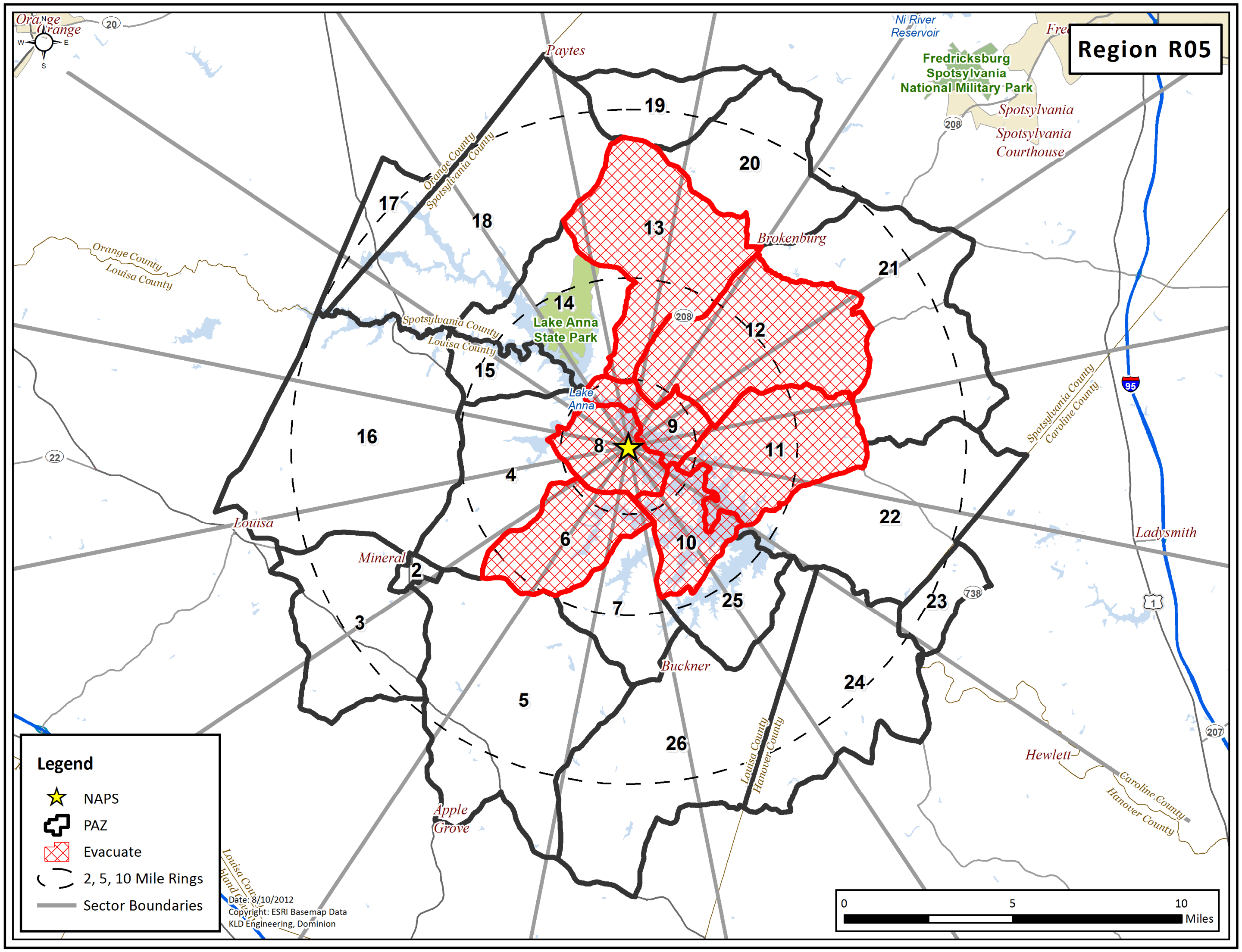


Figure H-5. Region R05

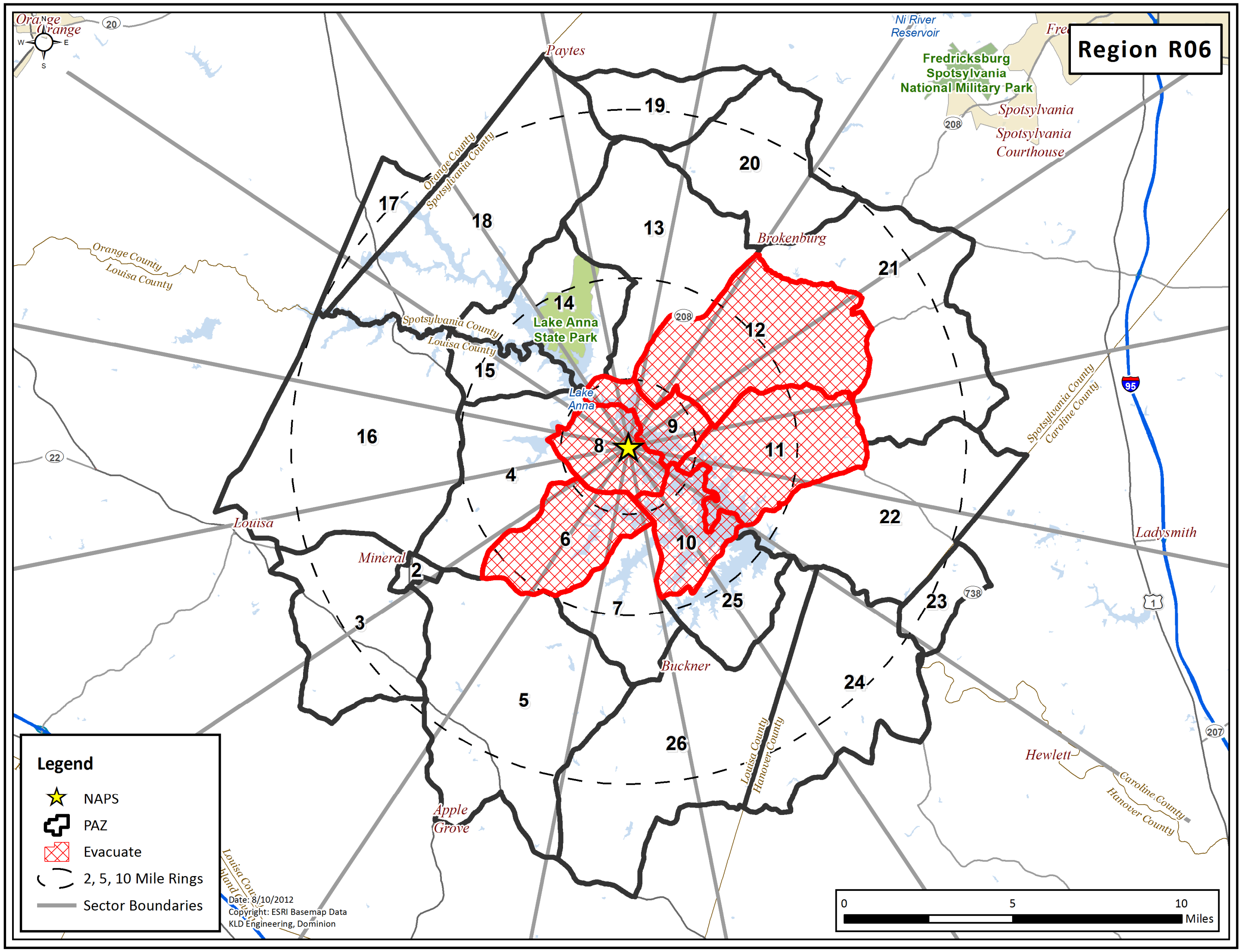


Figure H-6. Region R06

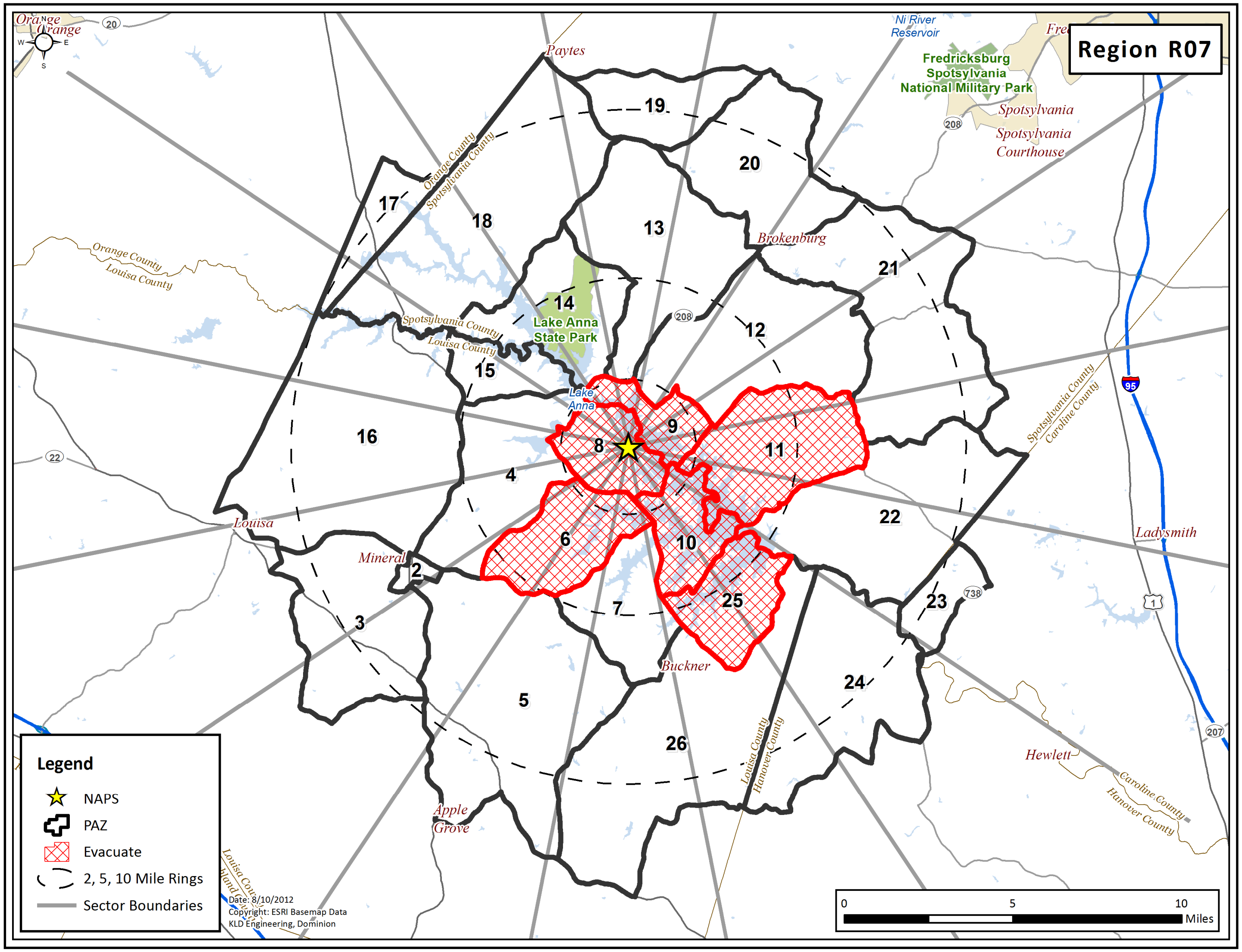


Figure H-7. Region R07

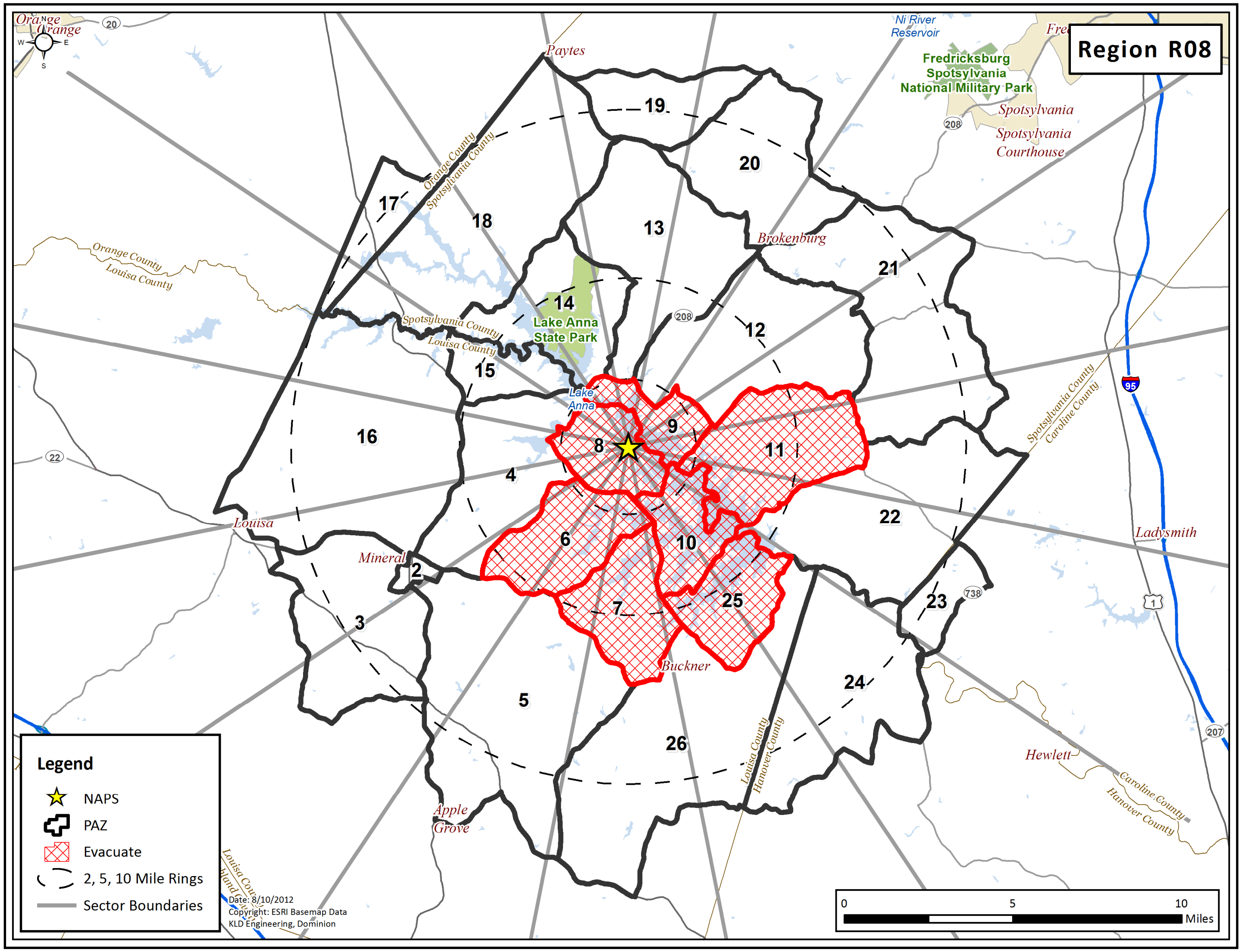


Figure H-8. Region R08

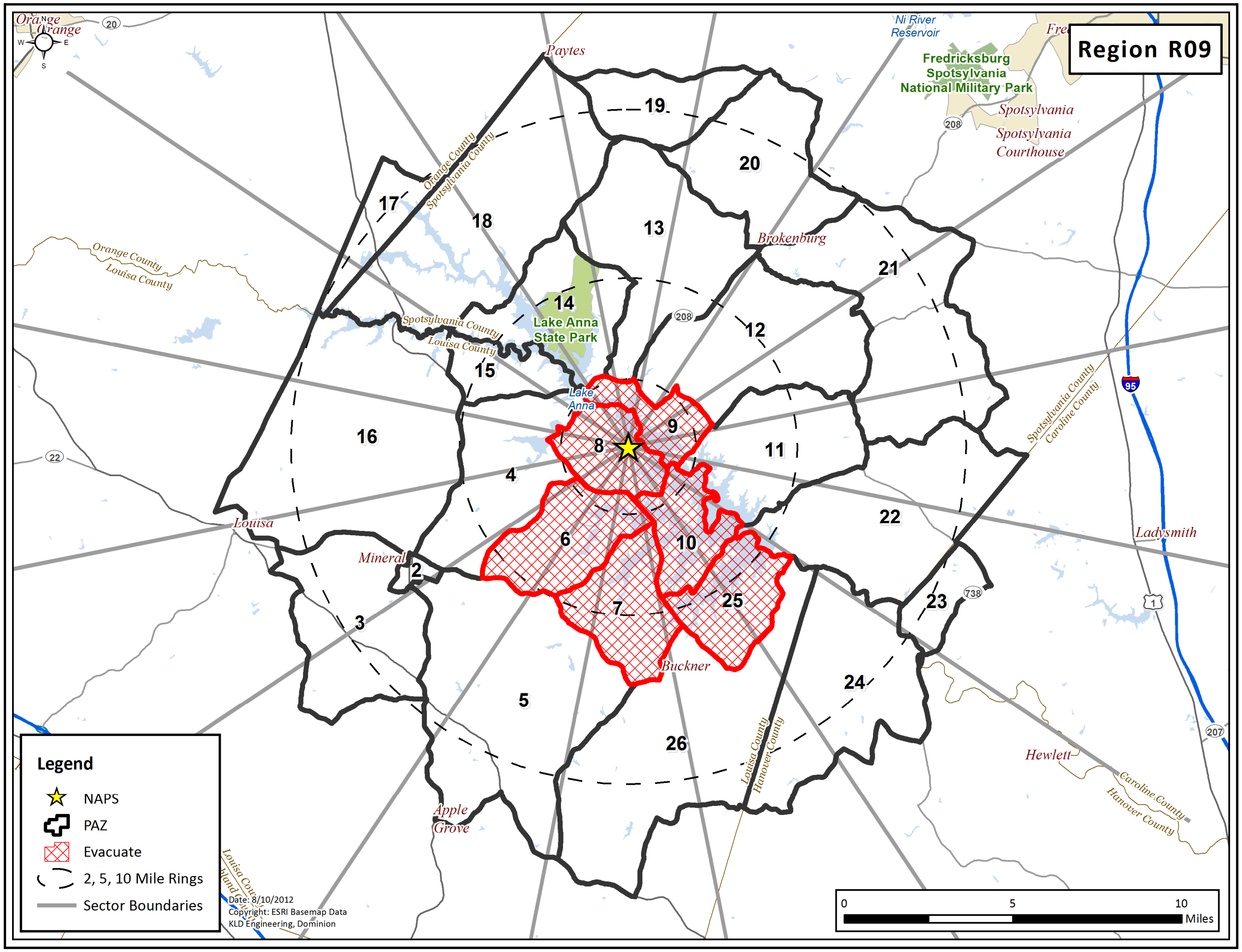


Figure H-9. Region R09

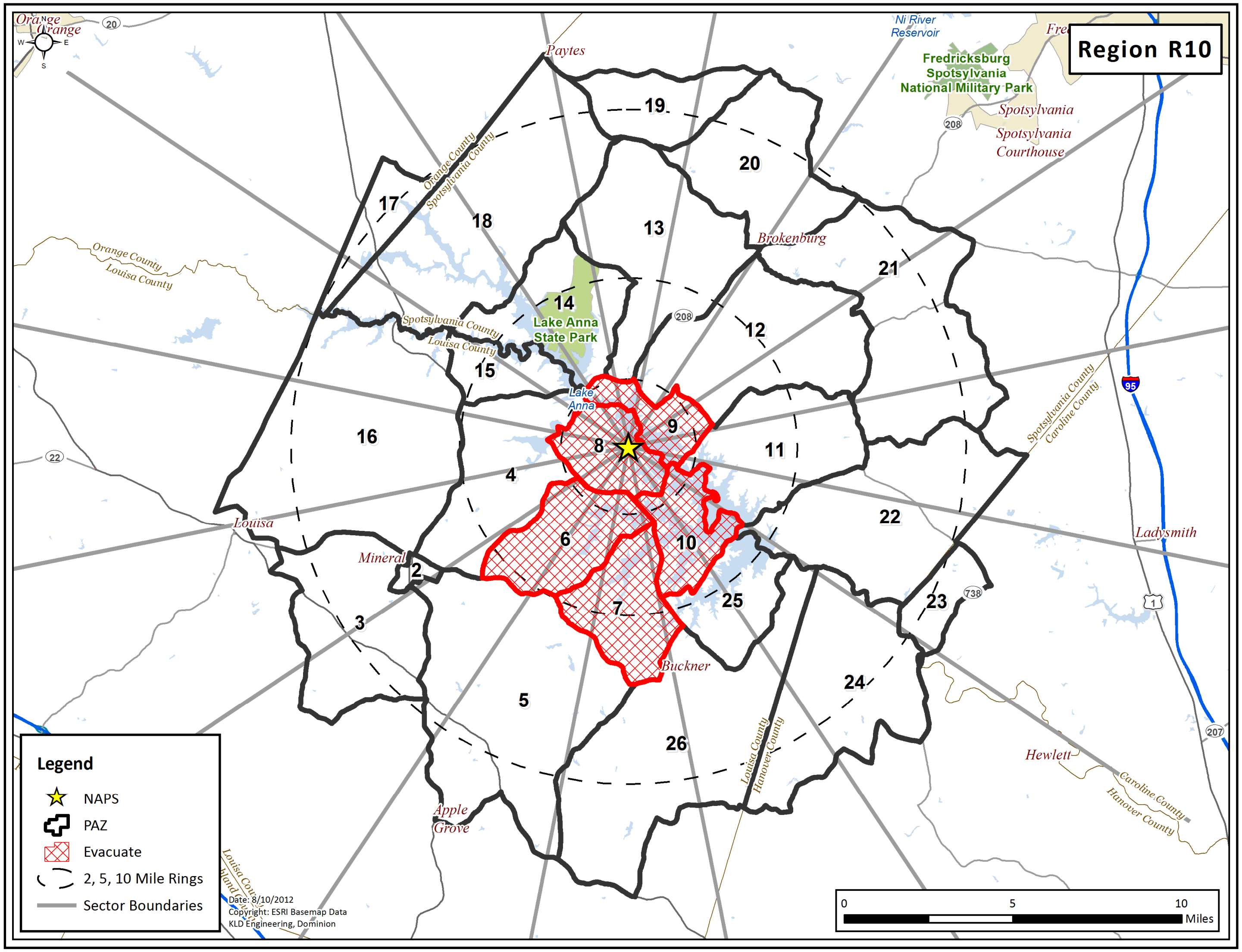


Figure H-10. Region R10

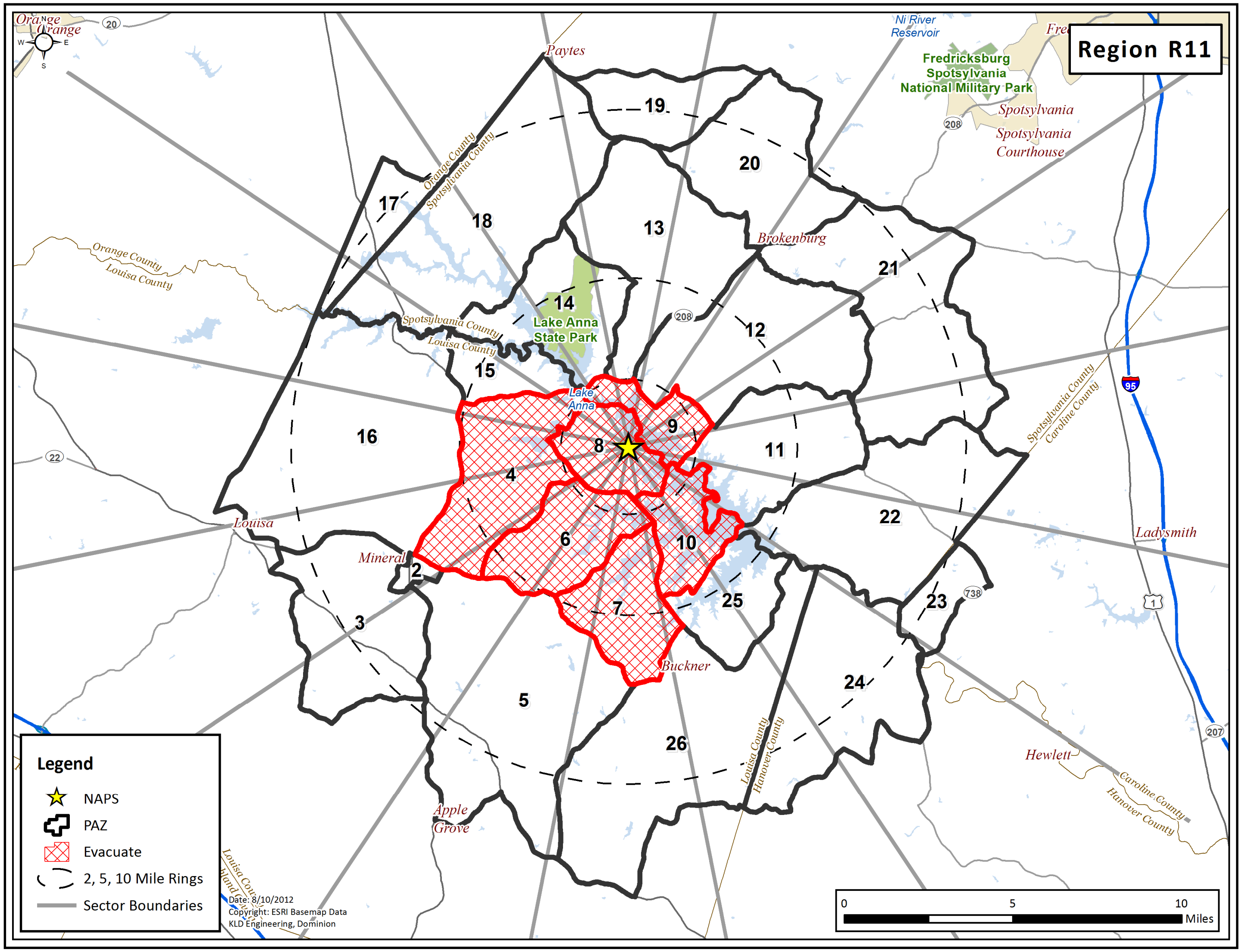


Figure H-11. Region R11

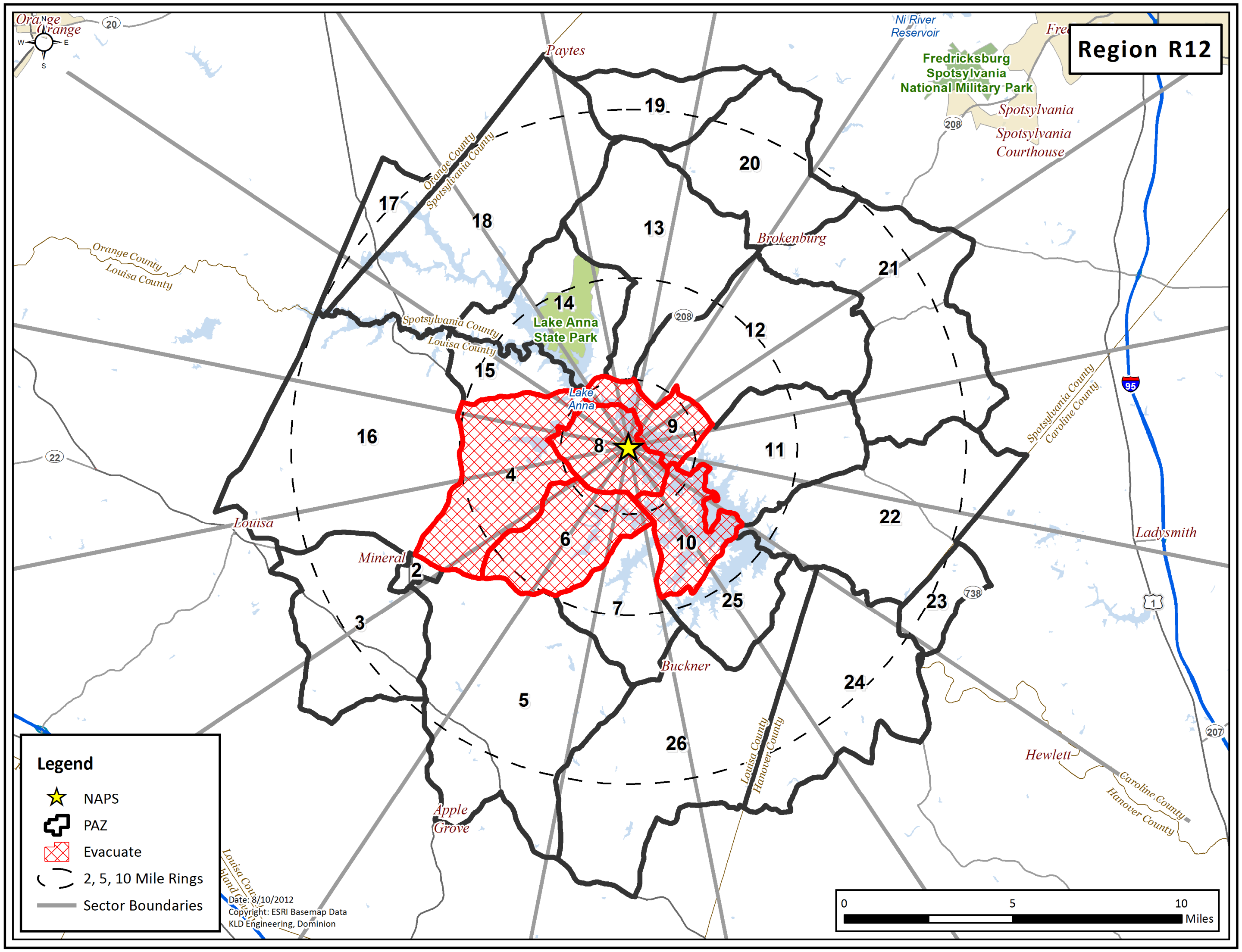


Figure H-12. Region R12

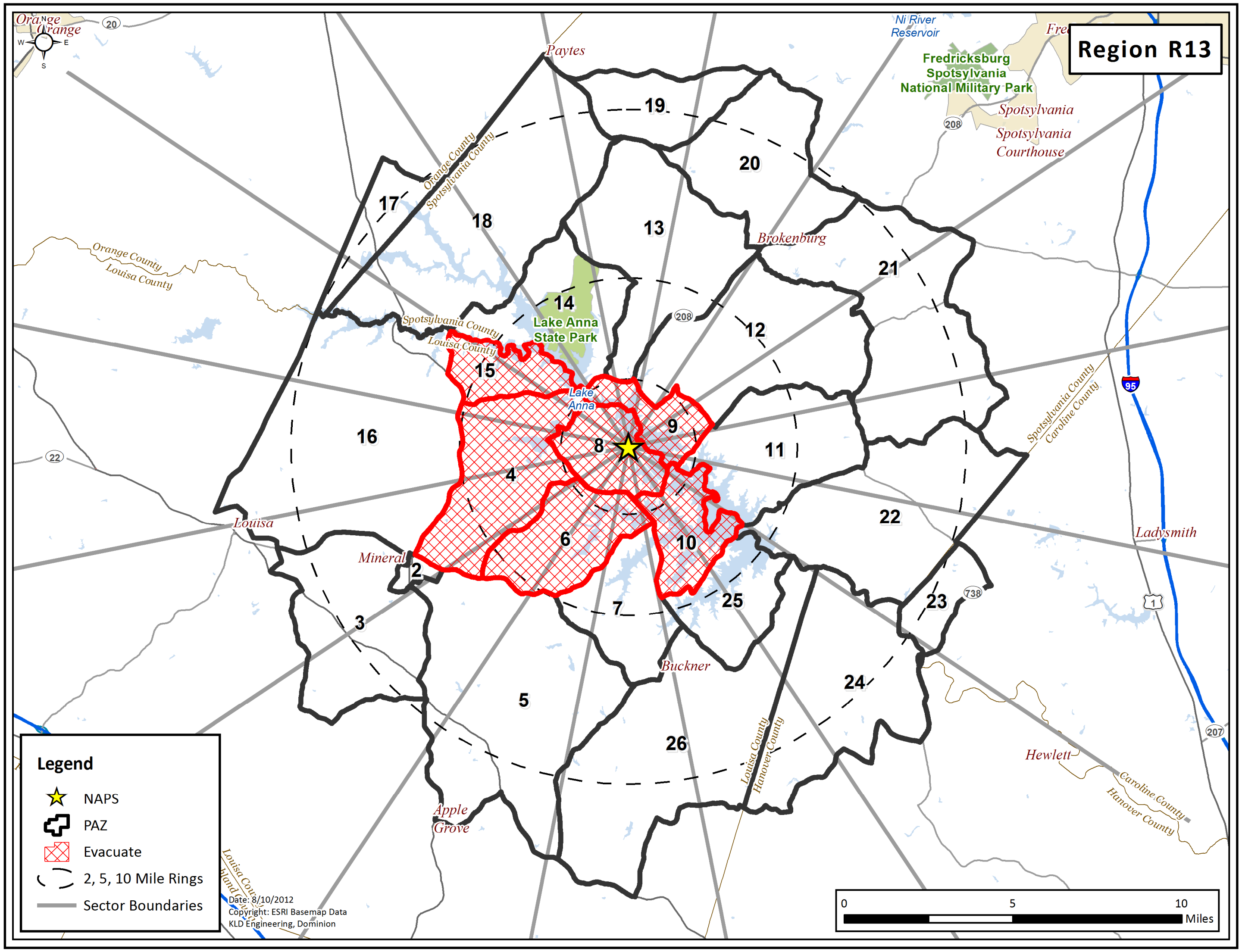


Figure H-13. Region R13

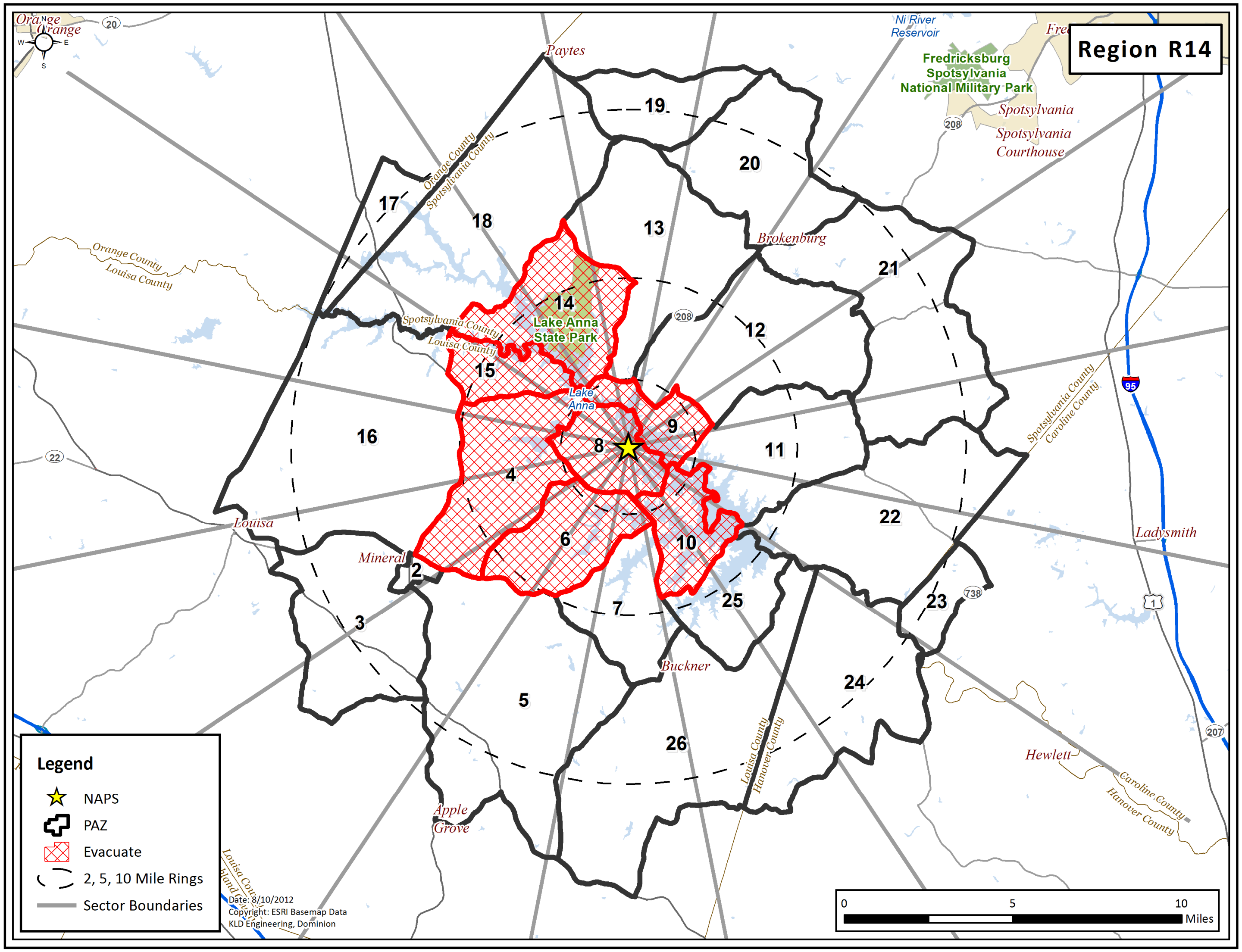


Figure H-14. Region R14

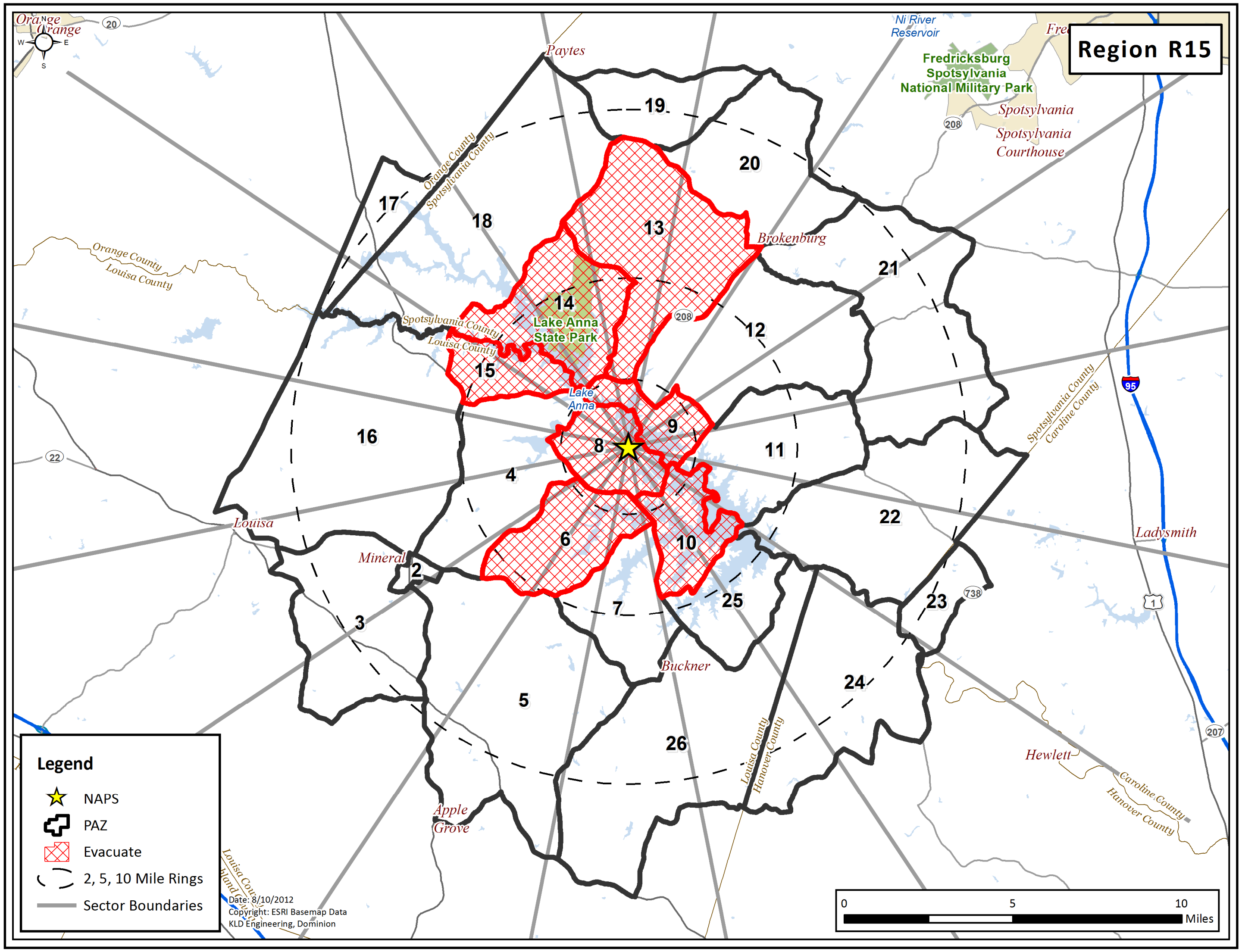


Figure H-15. Region R15

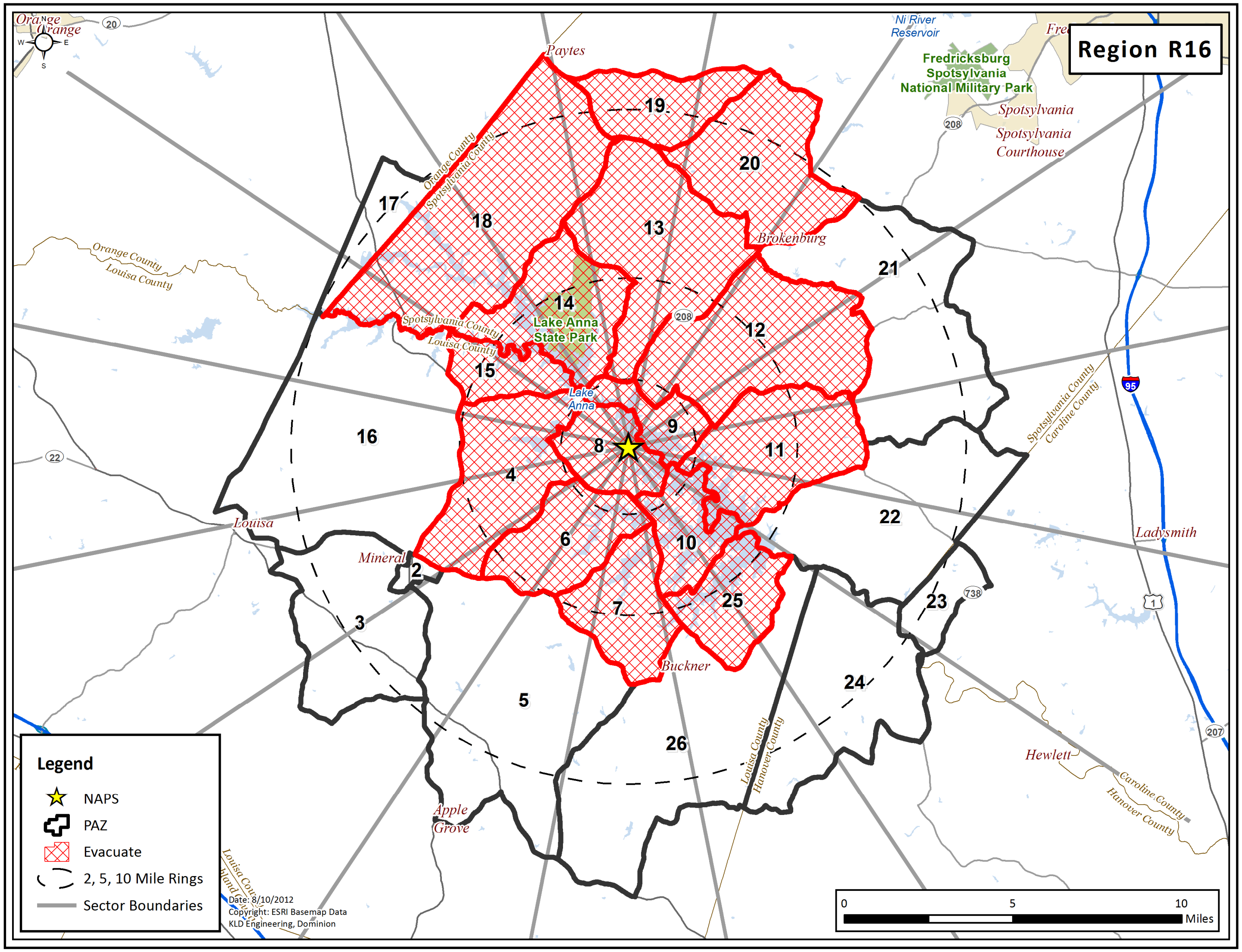


Figure H-16. Region R16

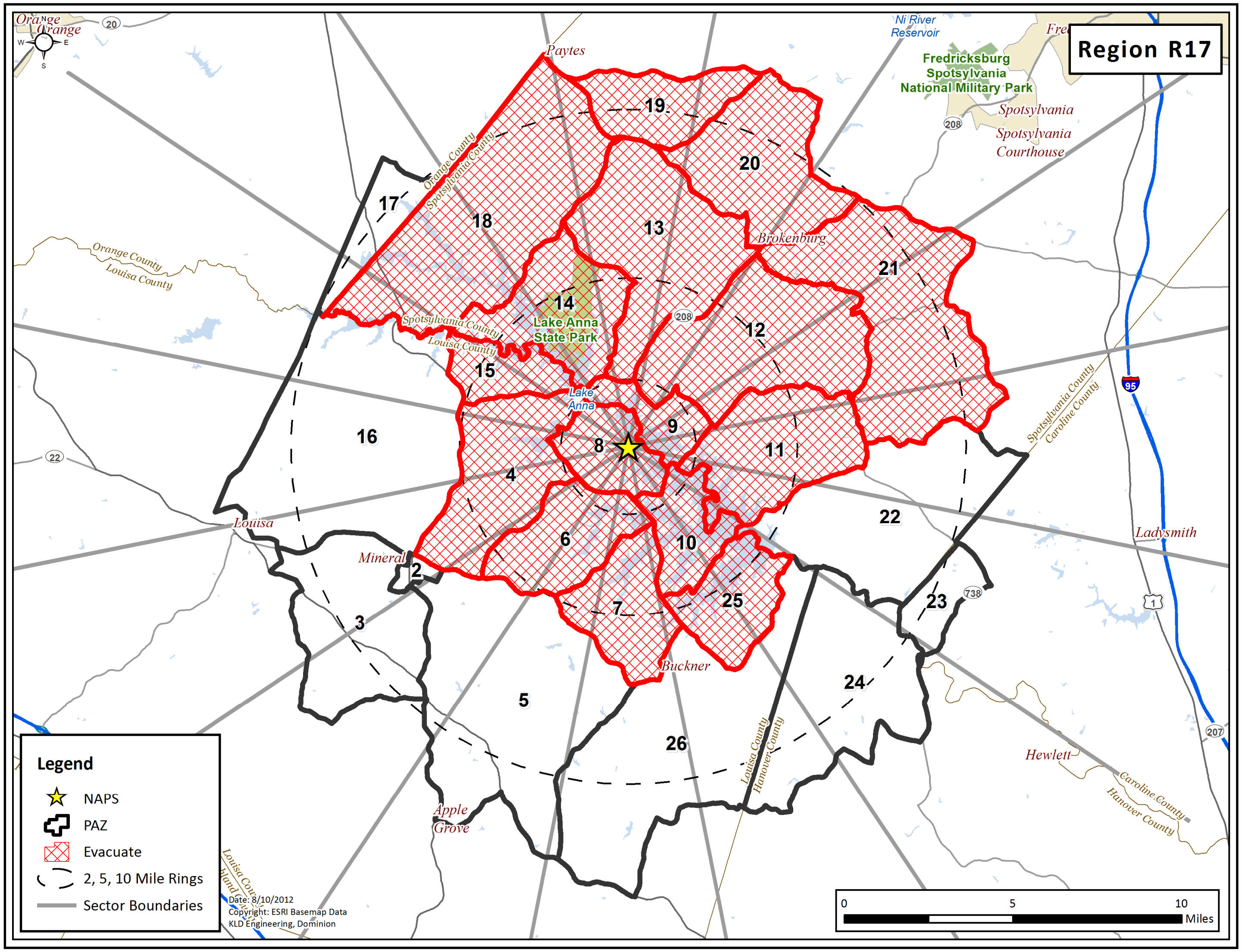


Figure H-17. Region R17

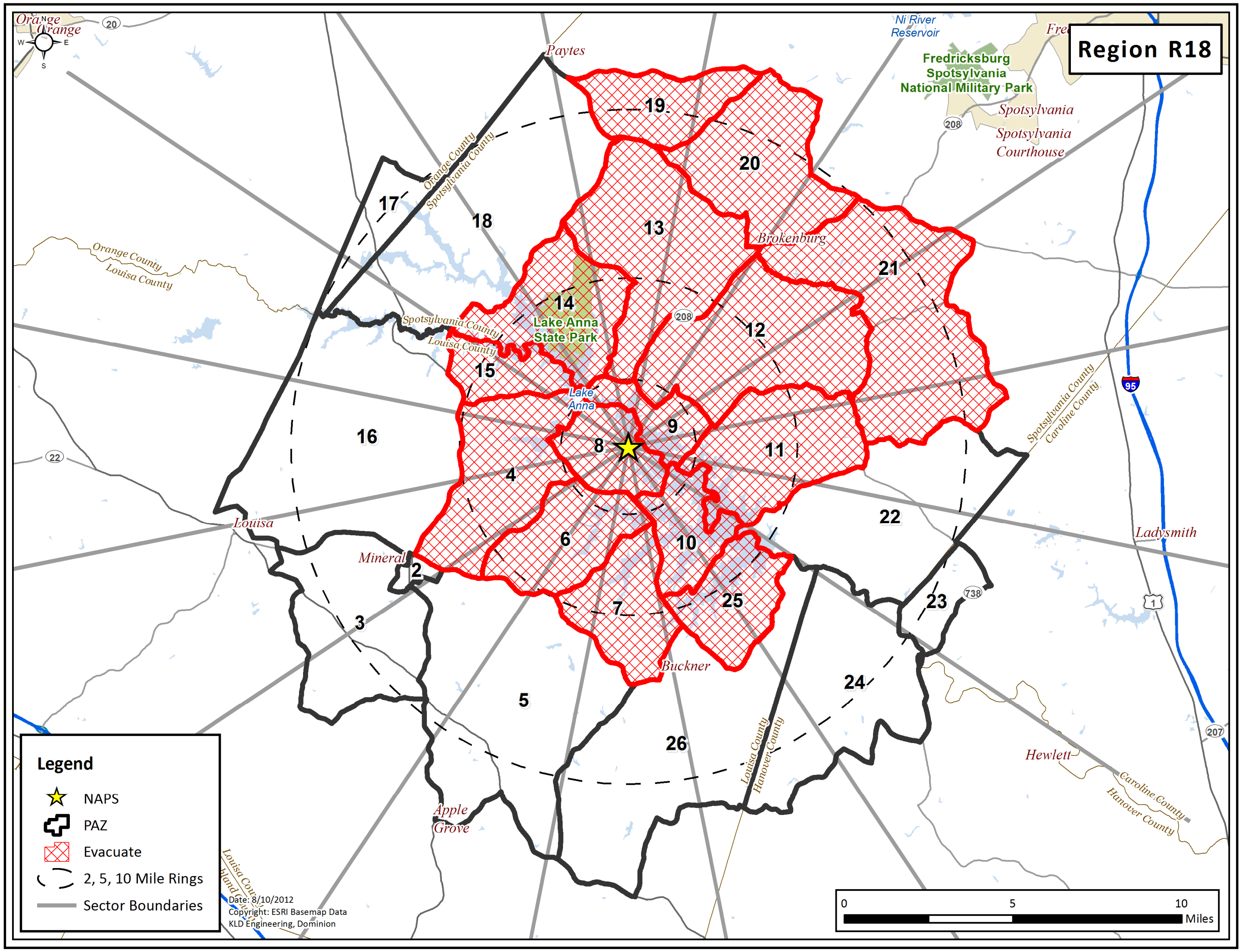


Figure H-18. Region R18

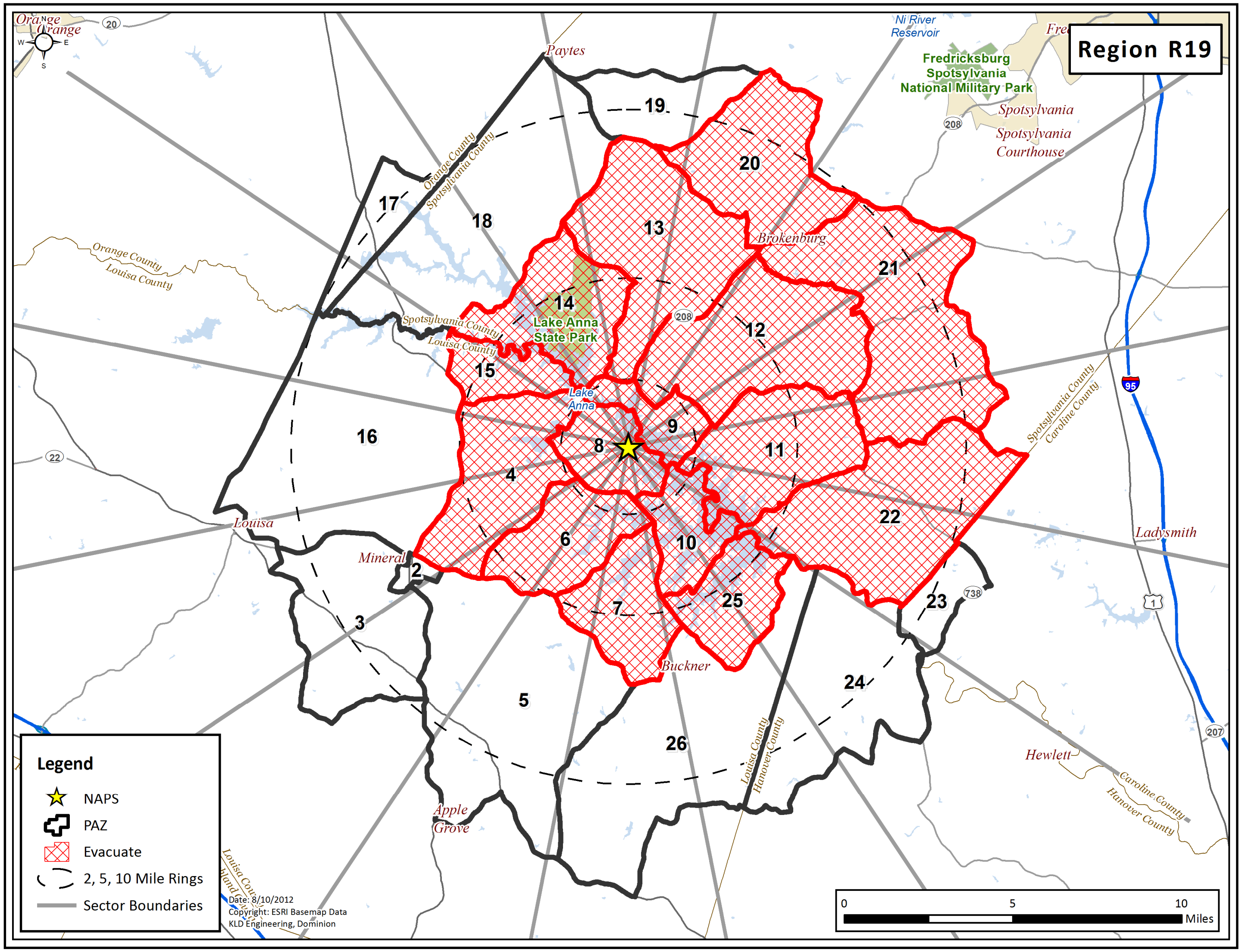


Figure H-19. Region R19

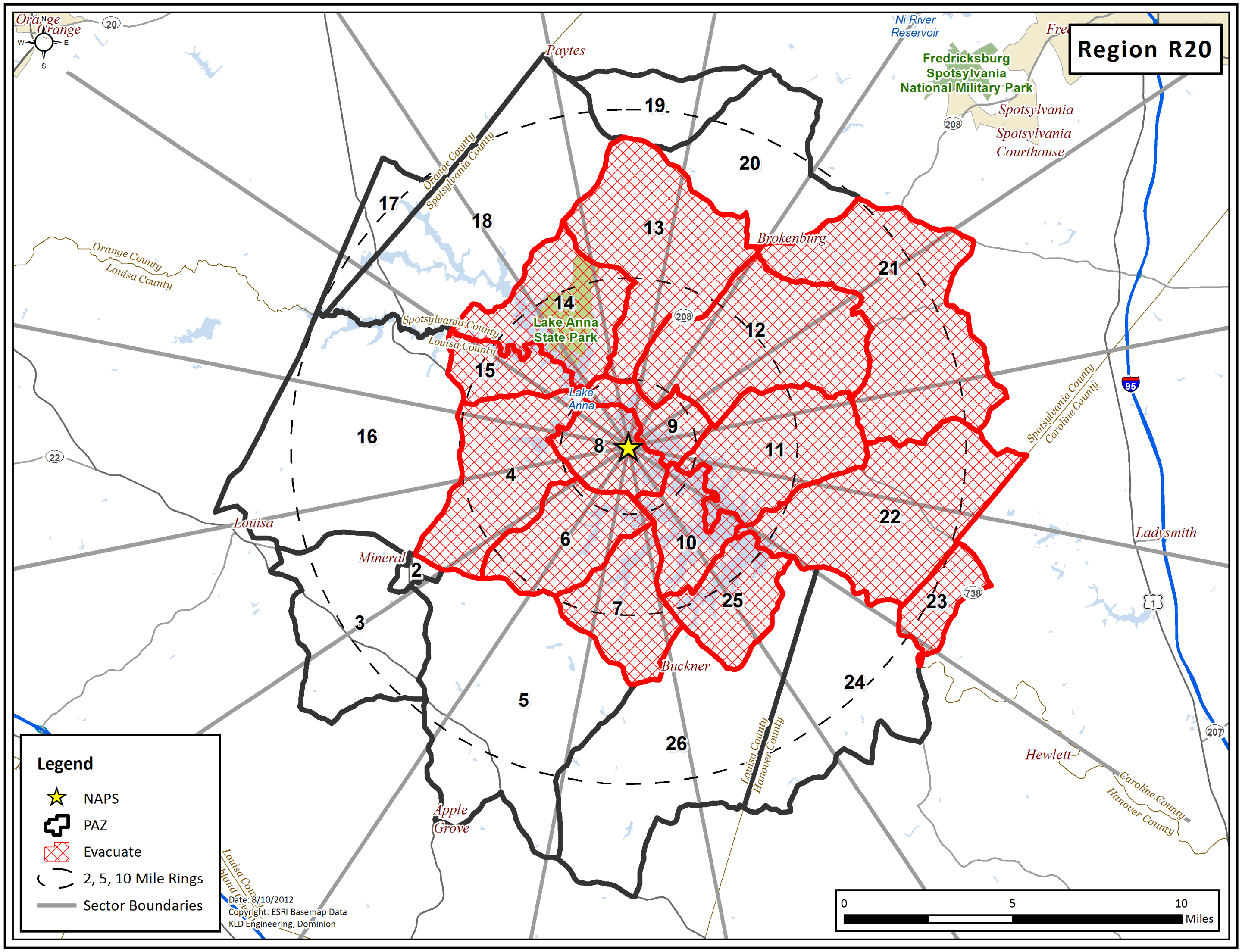


Figure H-20. Region R20

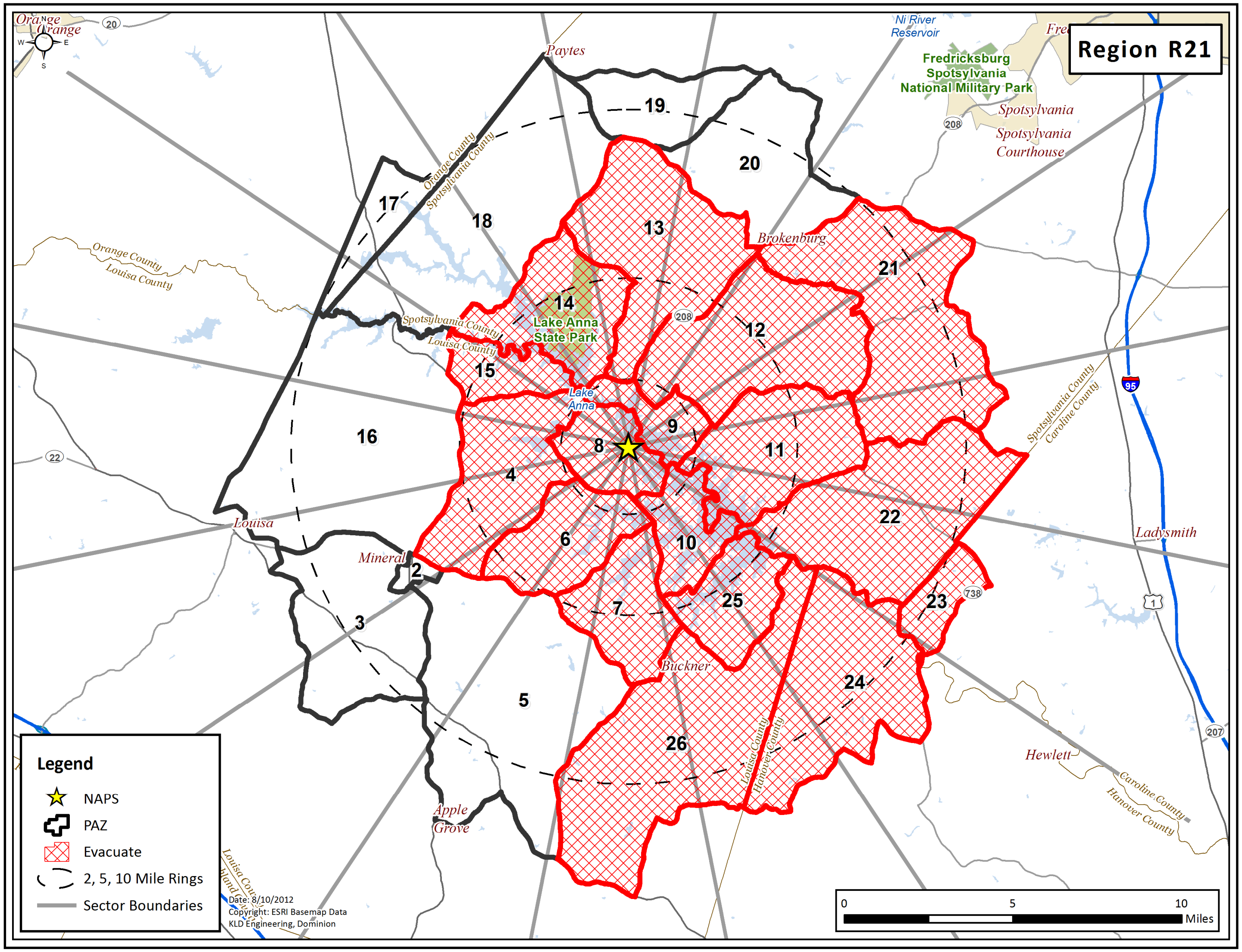


Figure H-21. Region R21

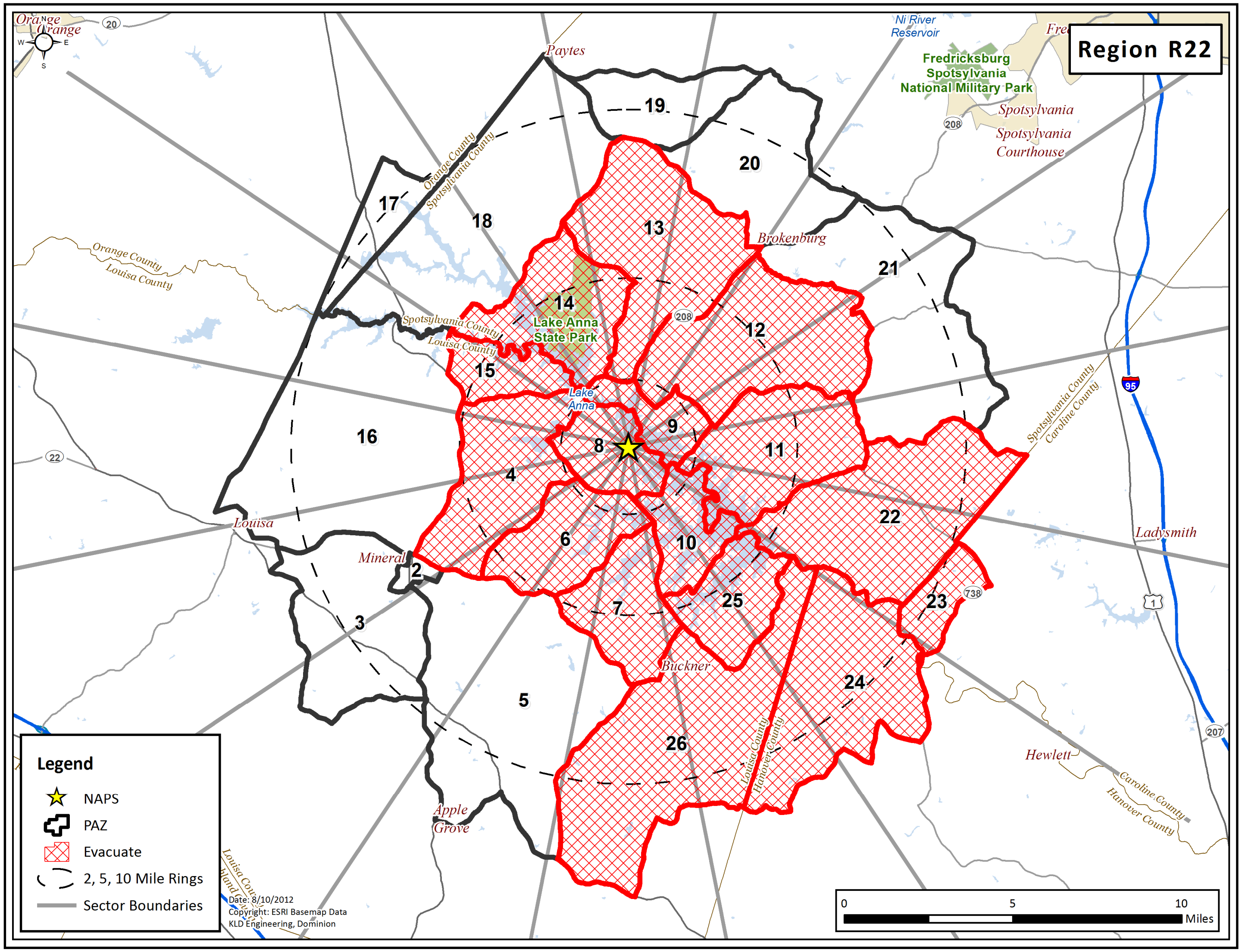


Figure H-22. Region R22

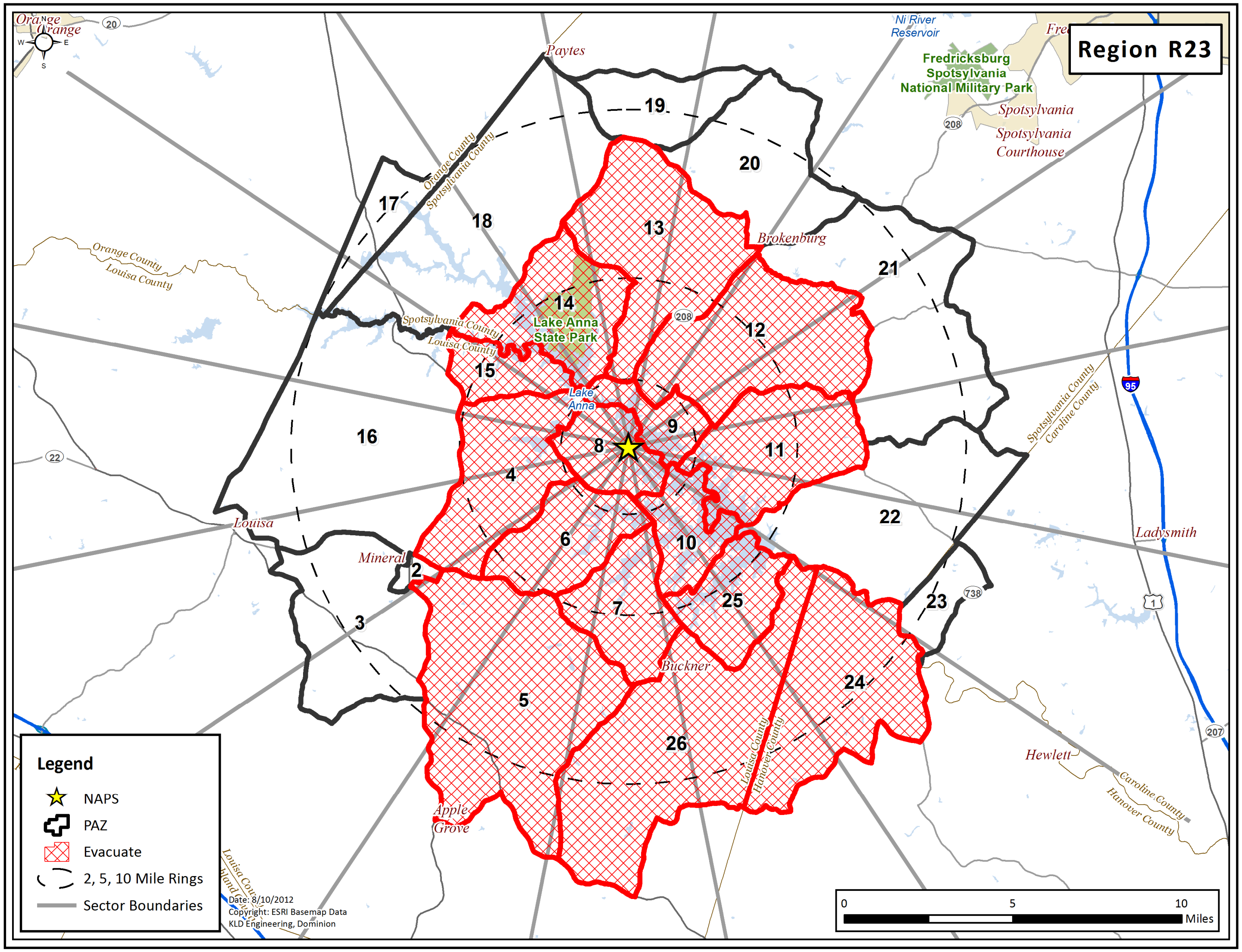


Figure H-23. Region R23

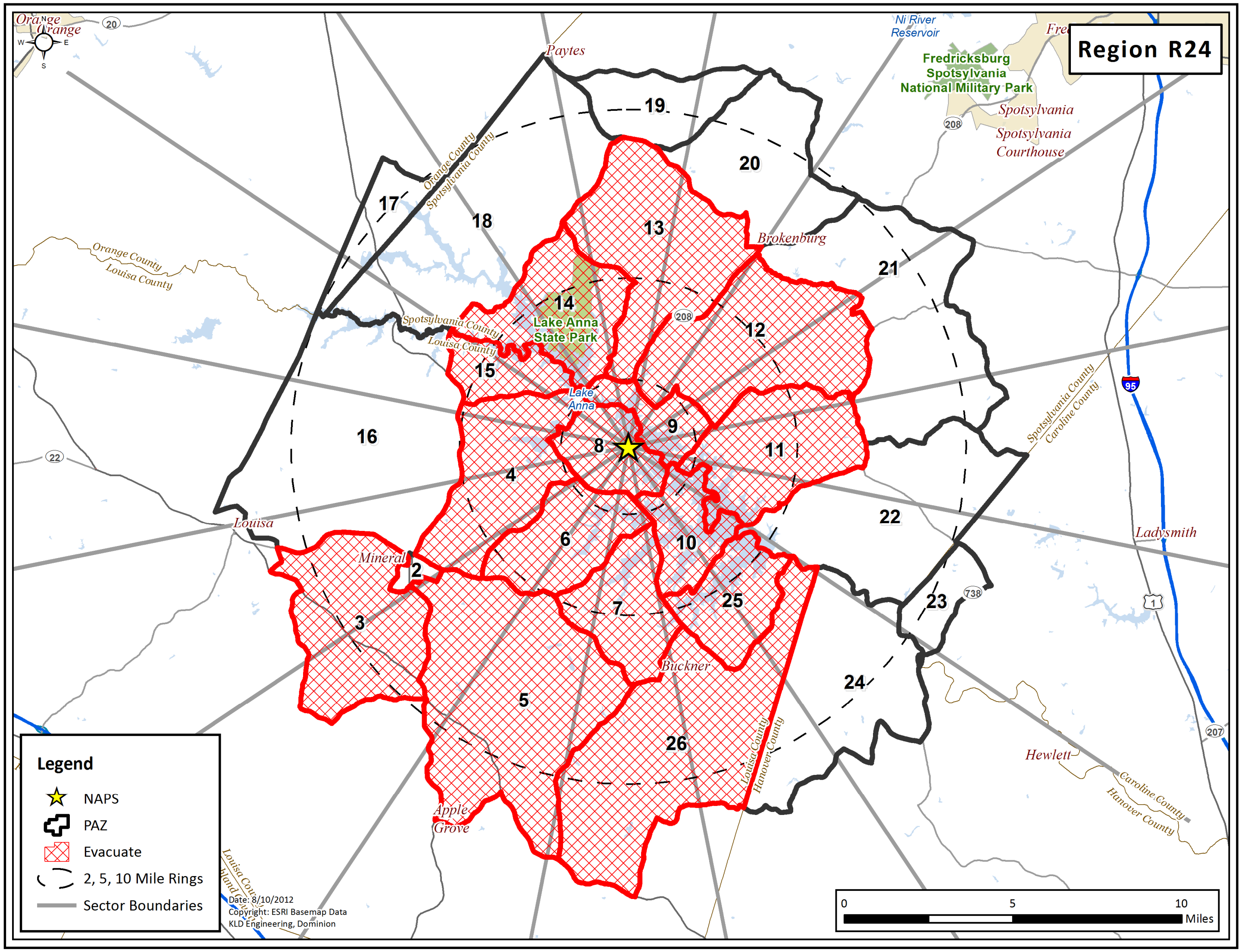


Figure H-24. Region R24

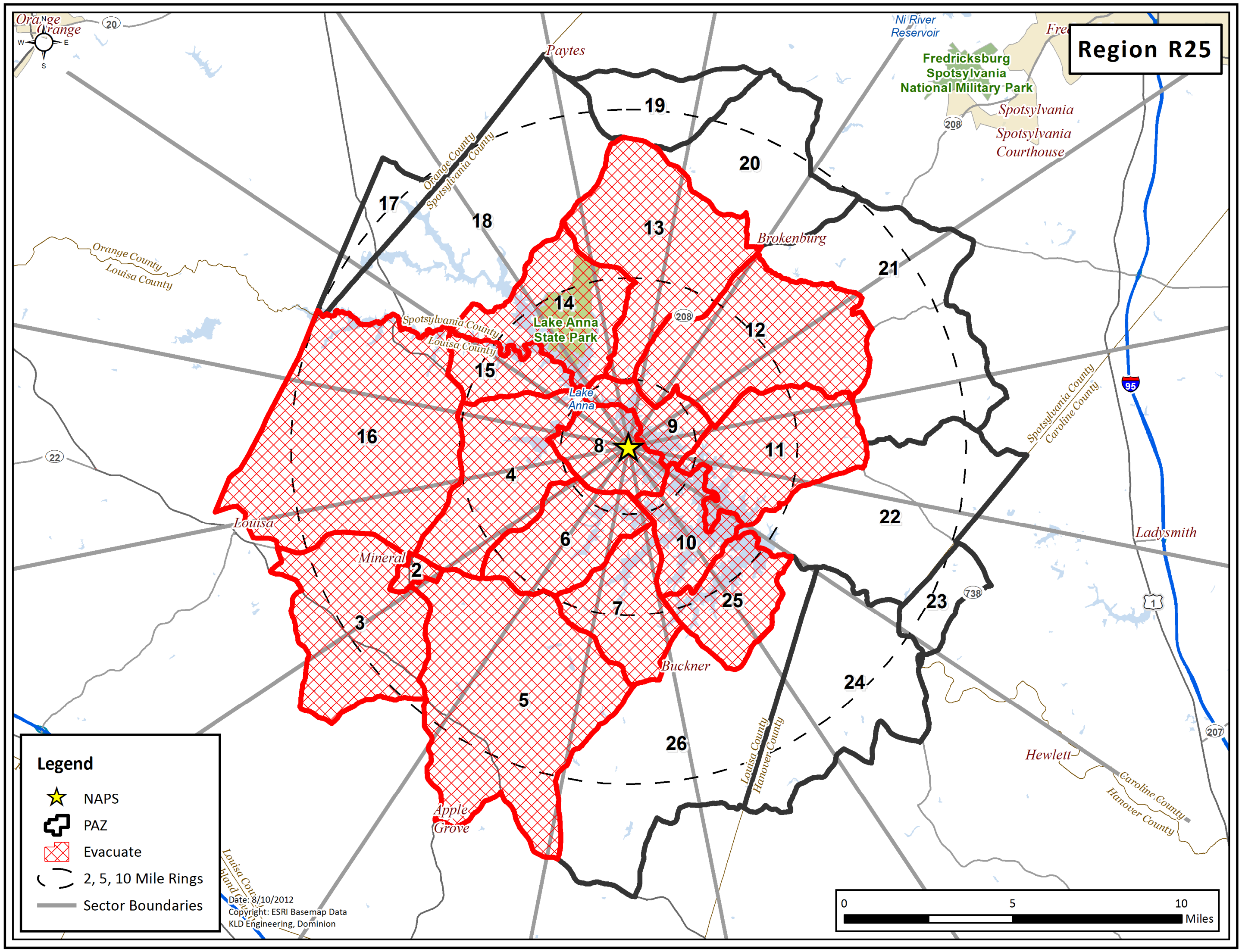


Figure H-25. Region R25

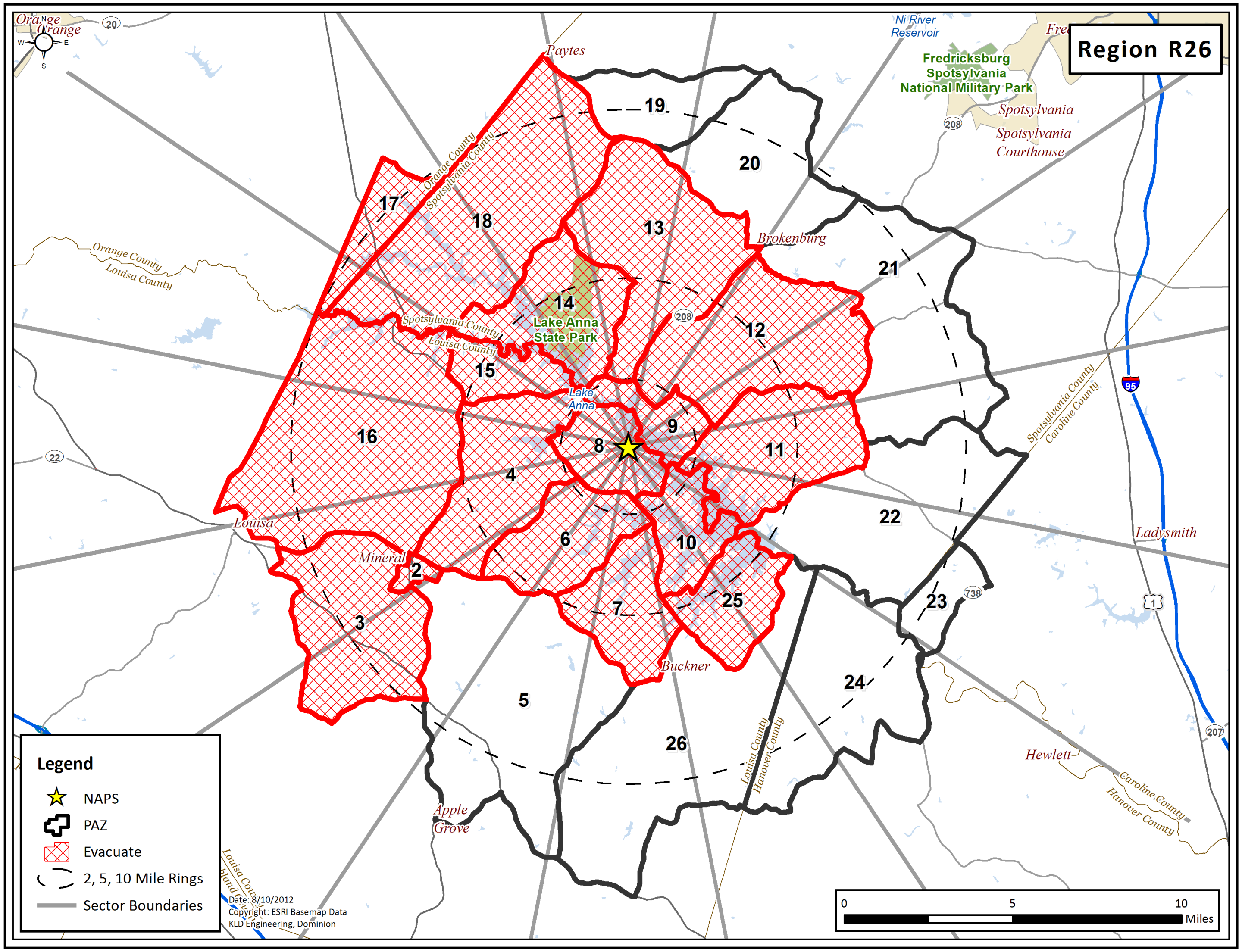


Figure H-26. Region R26

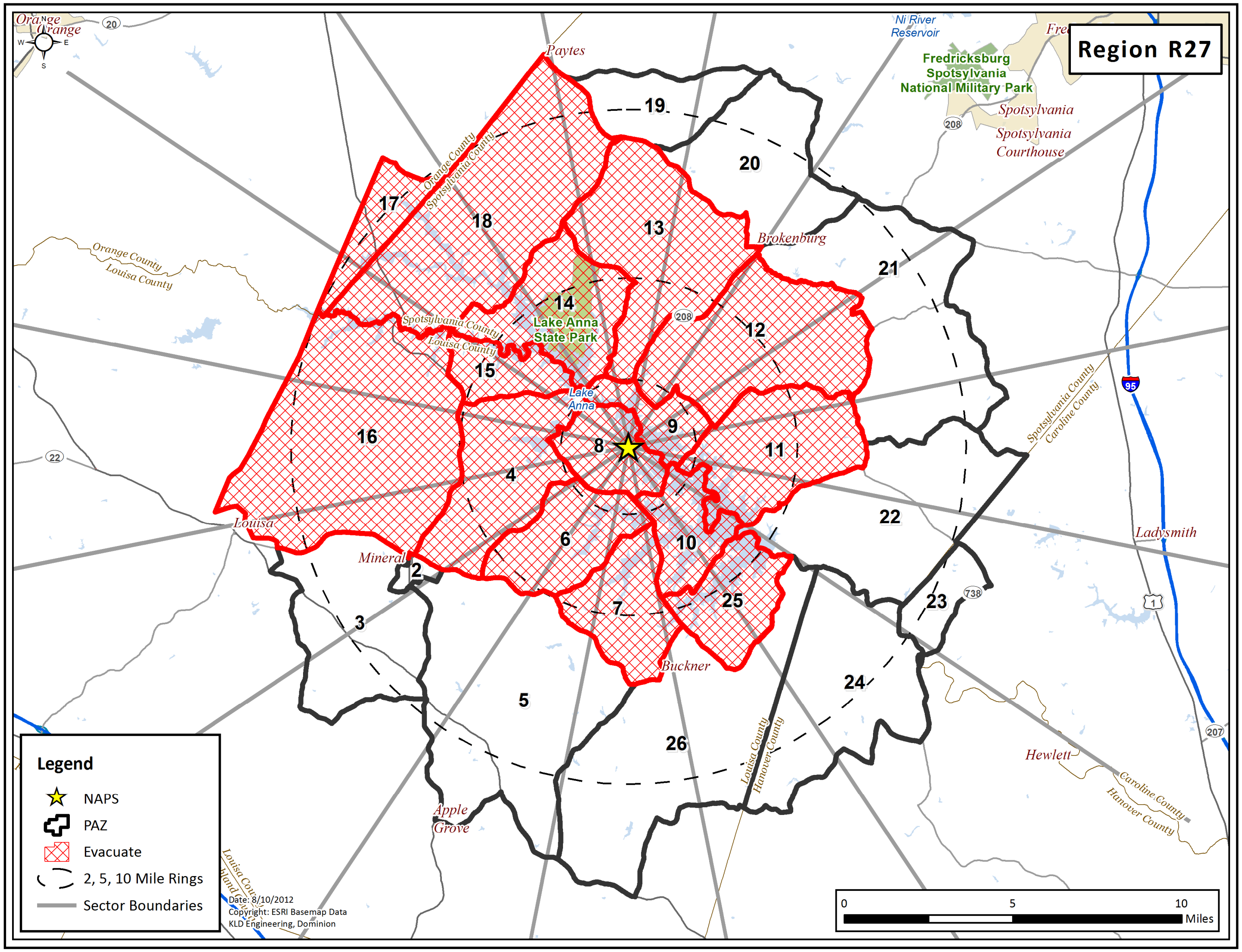


Figure H-27. Region R27

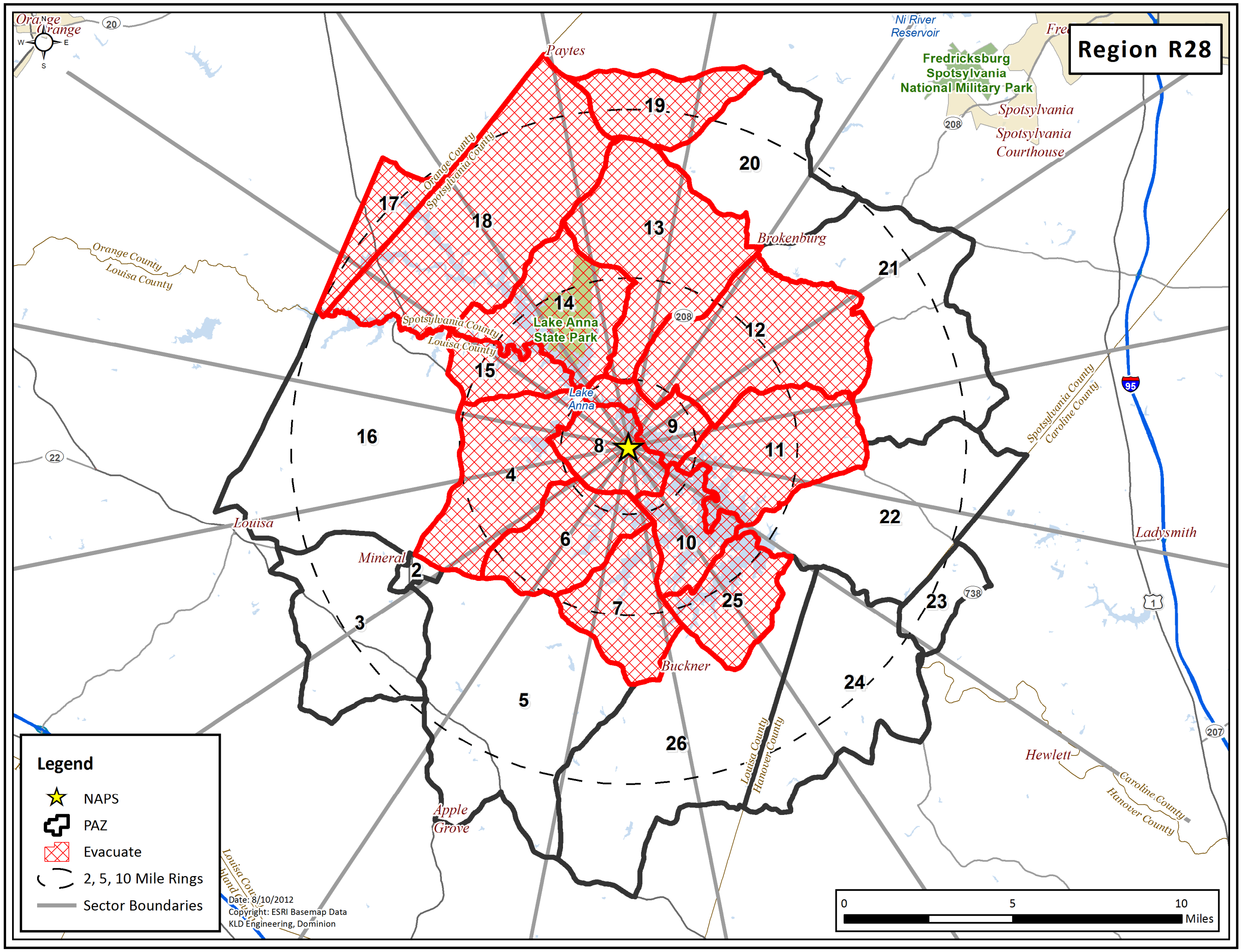


Figure H-28. Region R28

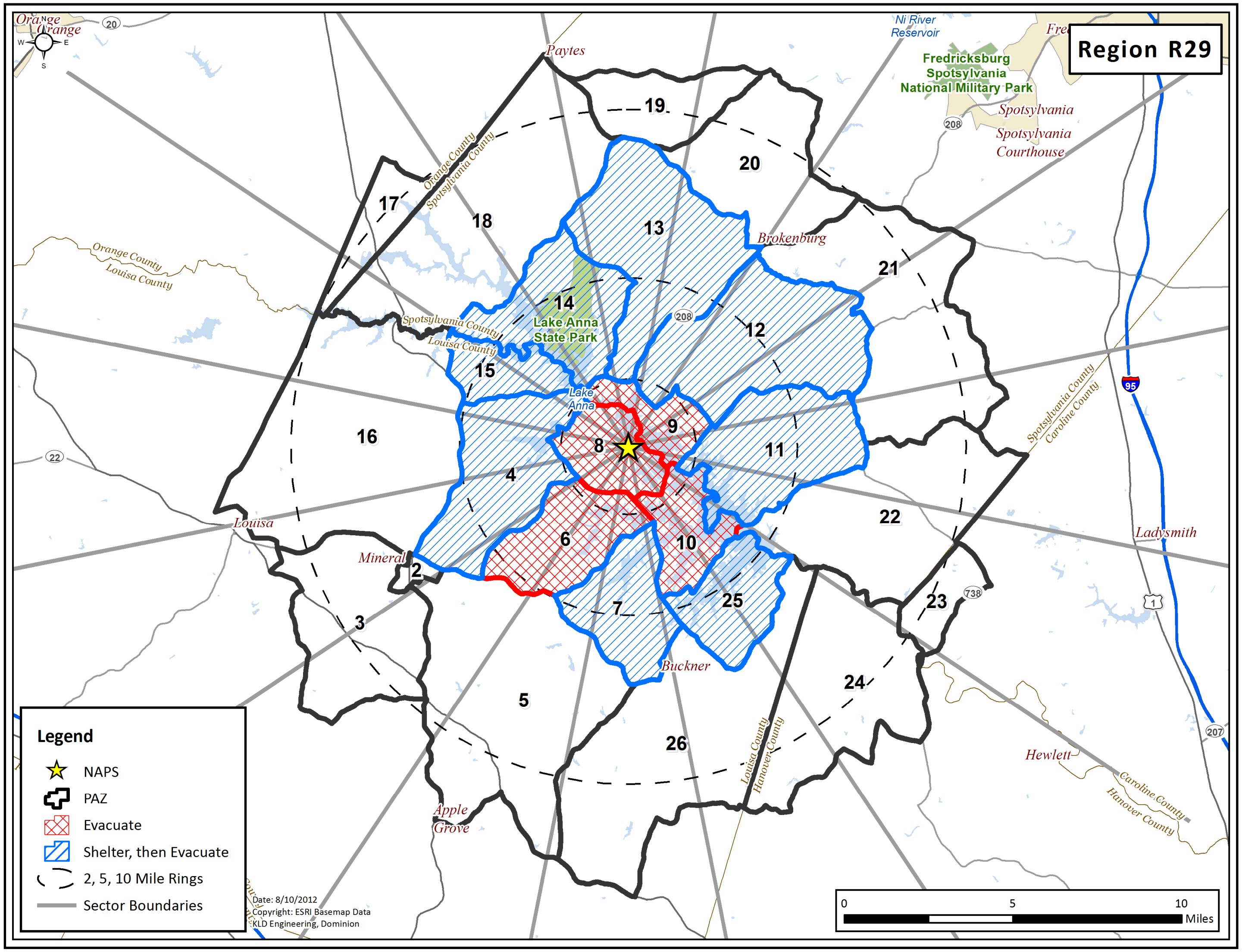


Figure H-29. Region R29

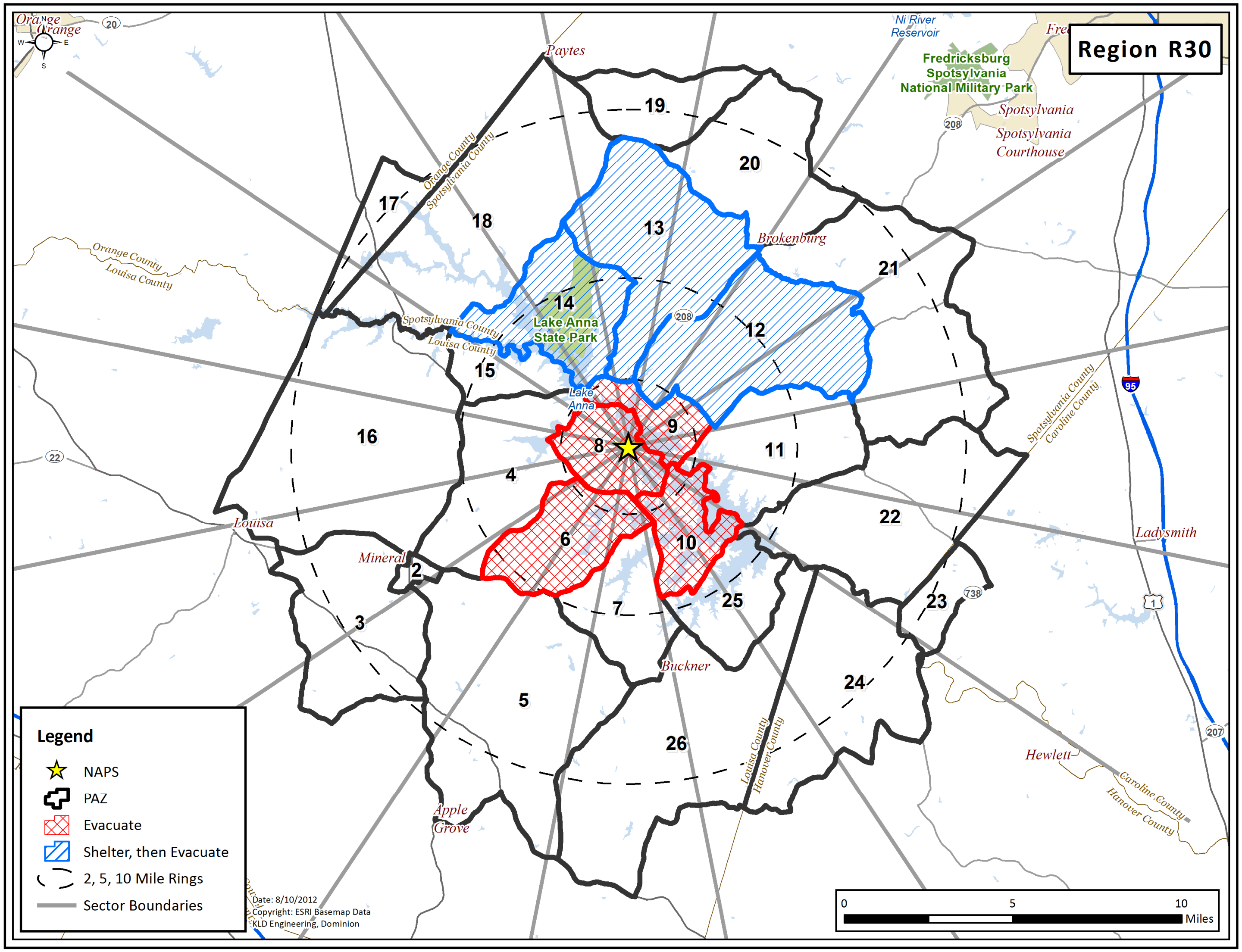


Figure H-30. Region R30

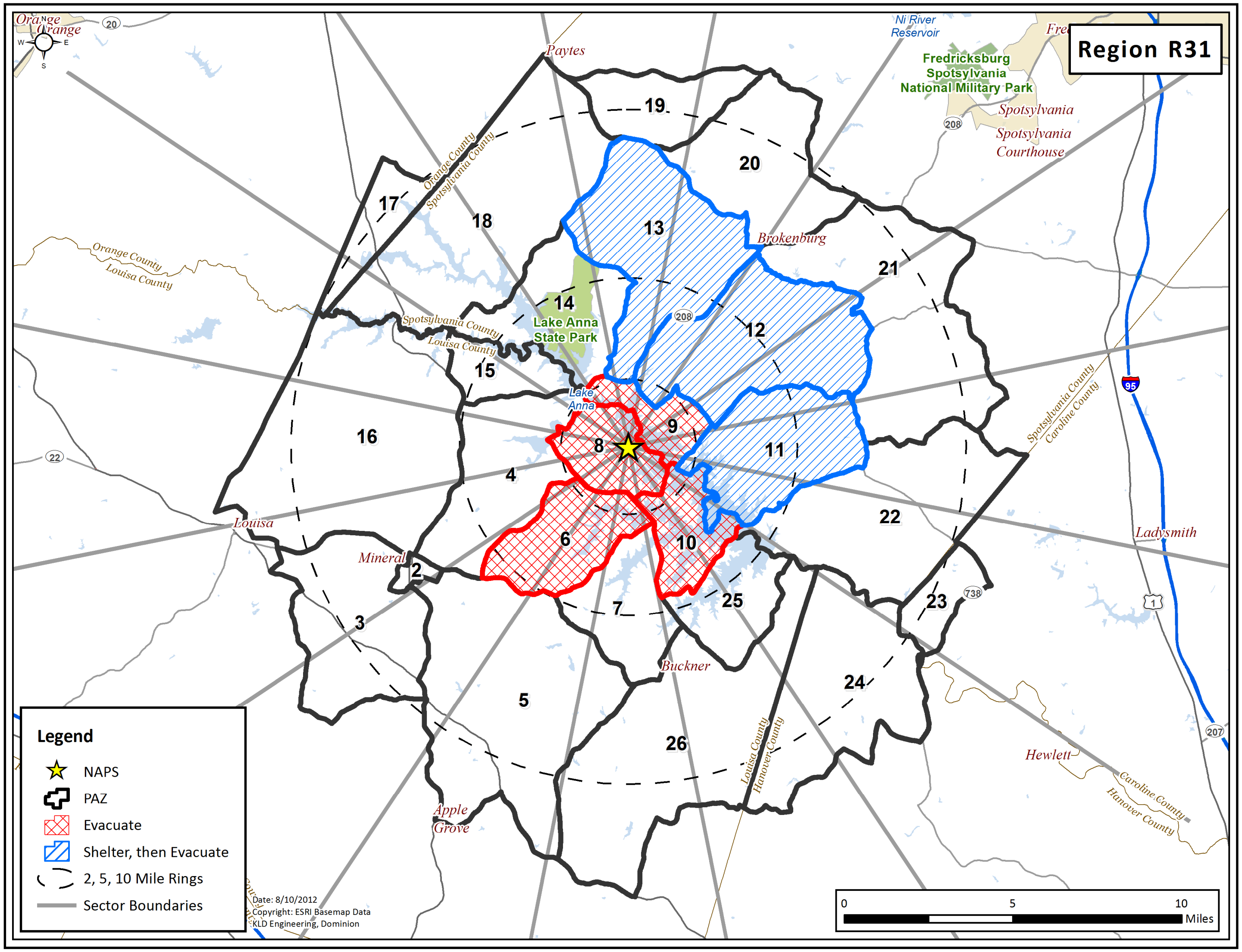


Figure H-31. Region R31

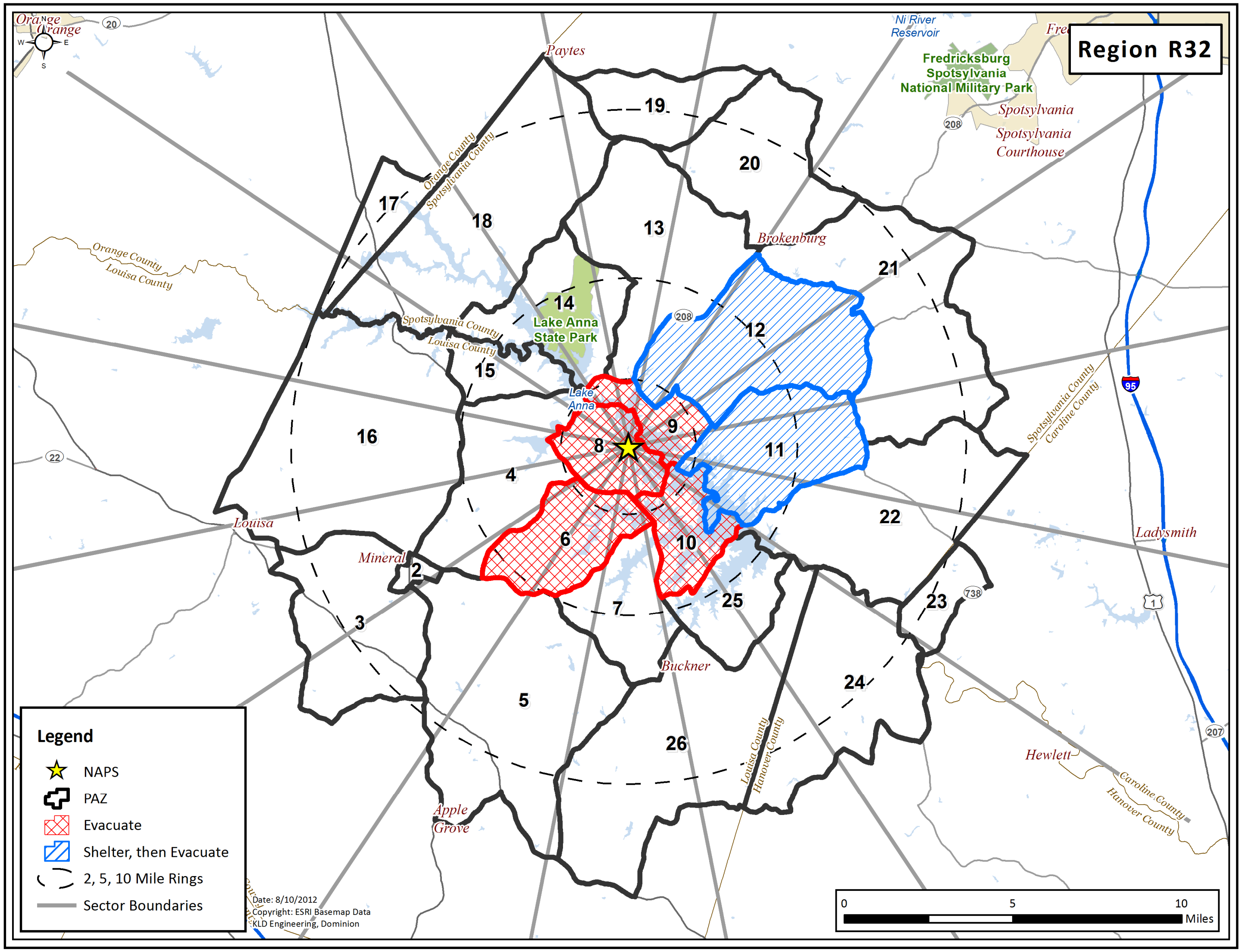


Figure H-32. Region R32

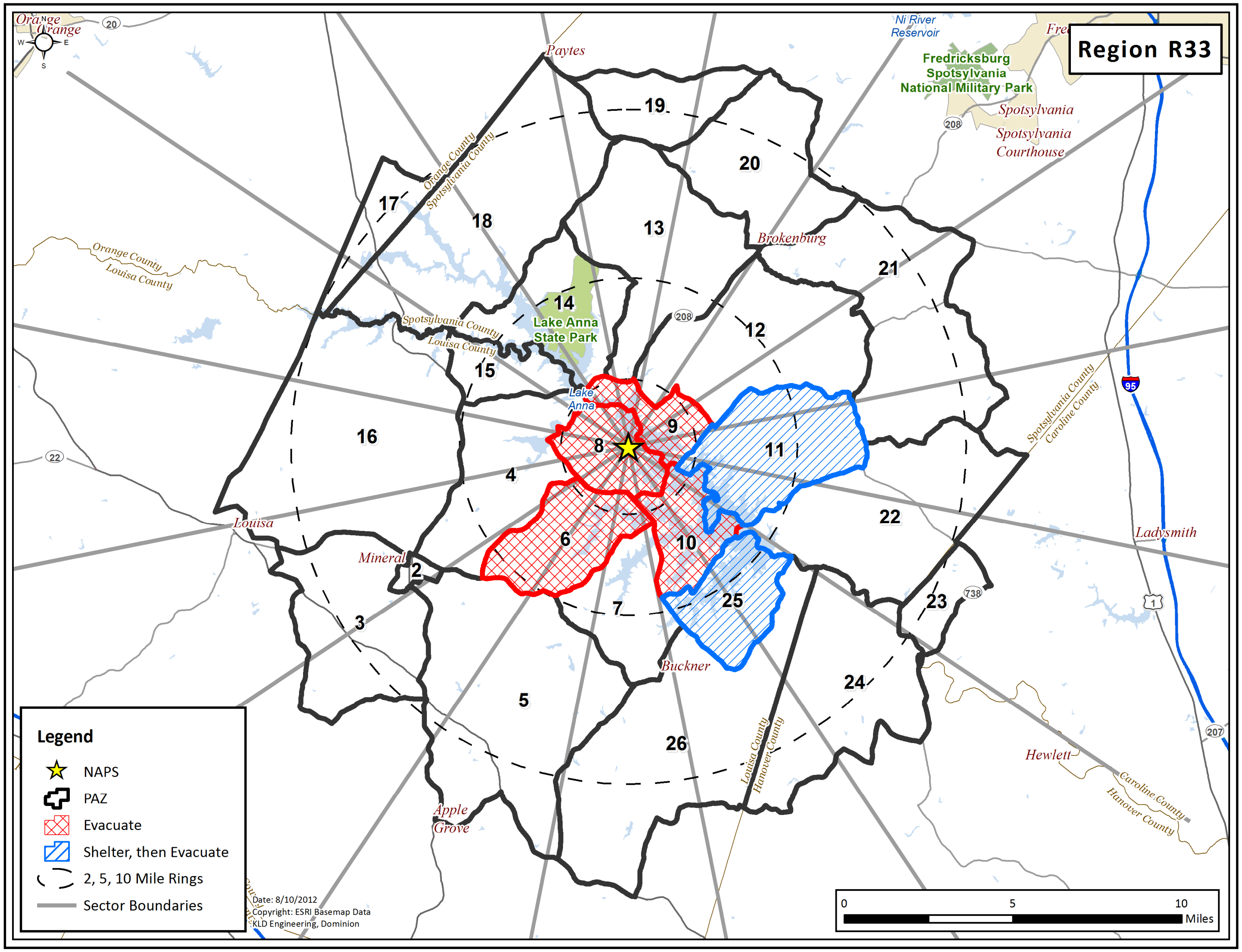


Figure H-33. Region R33

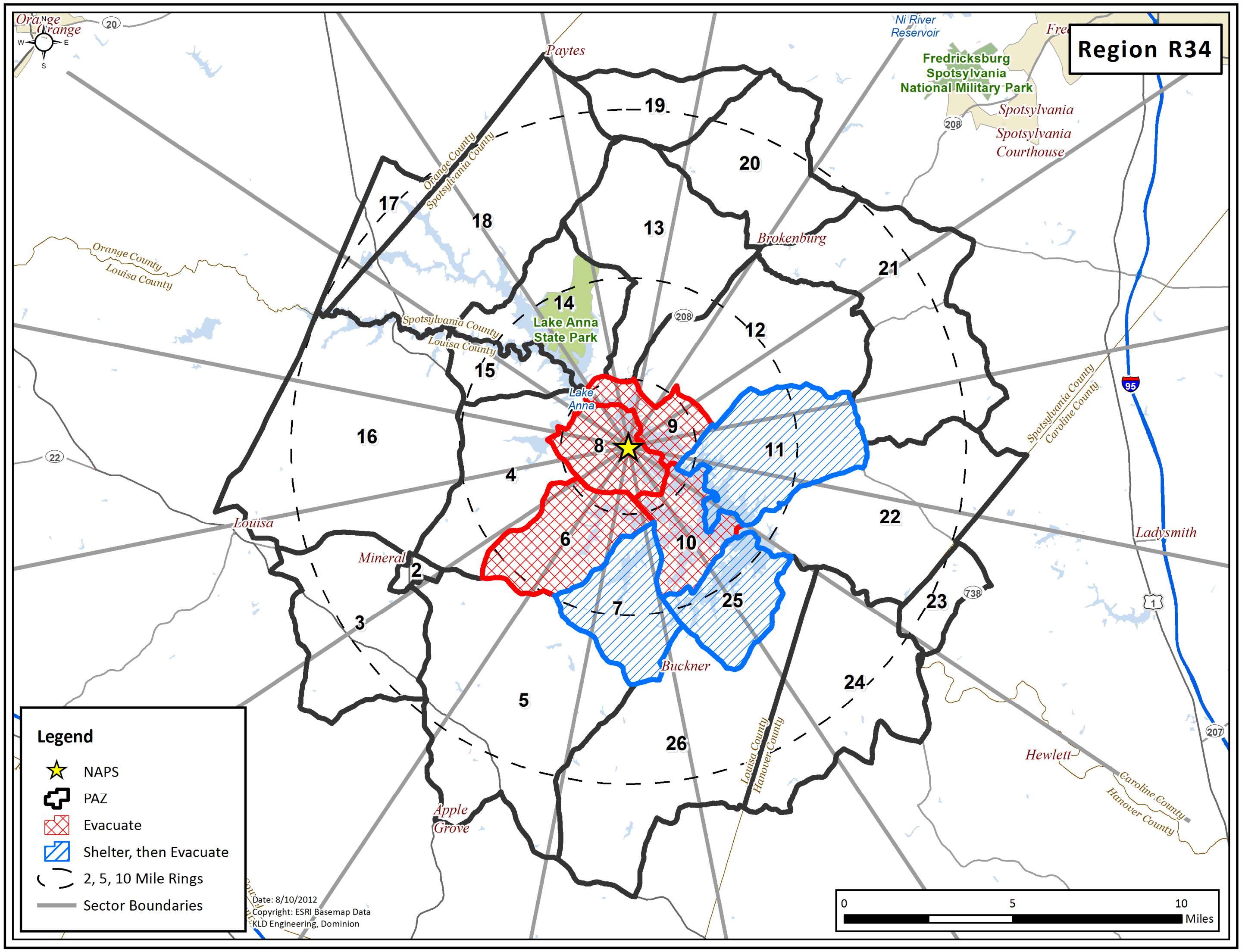


Figure H-34. Region R34

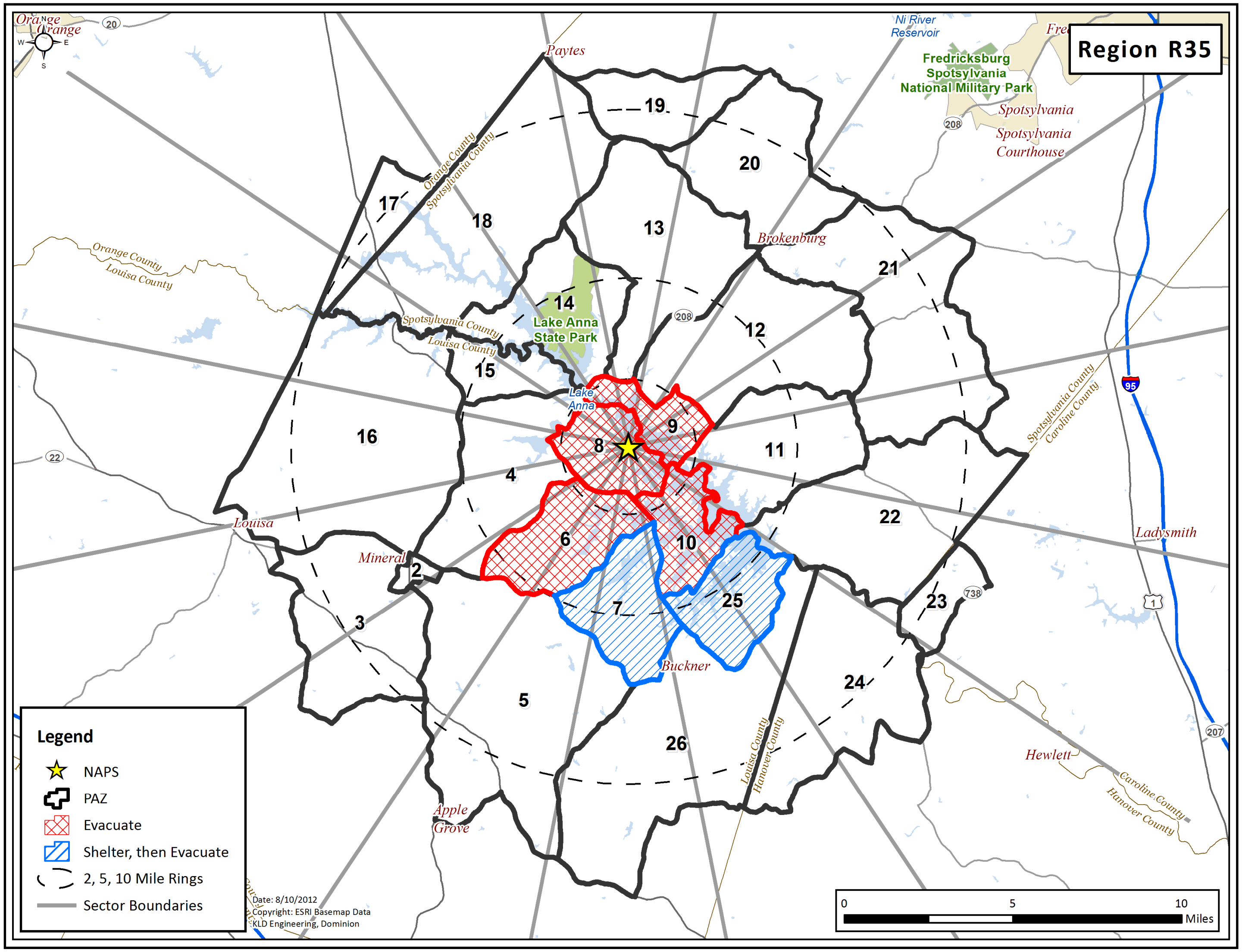


Figure H-35. Region R35

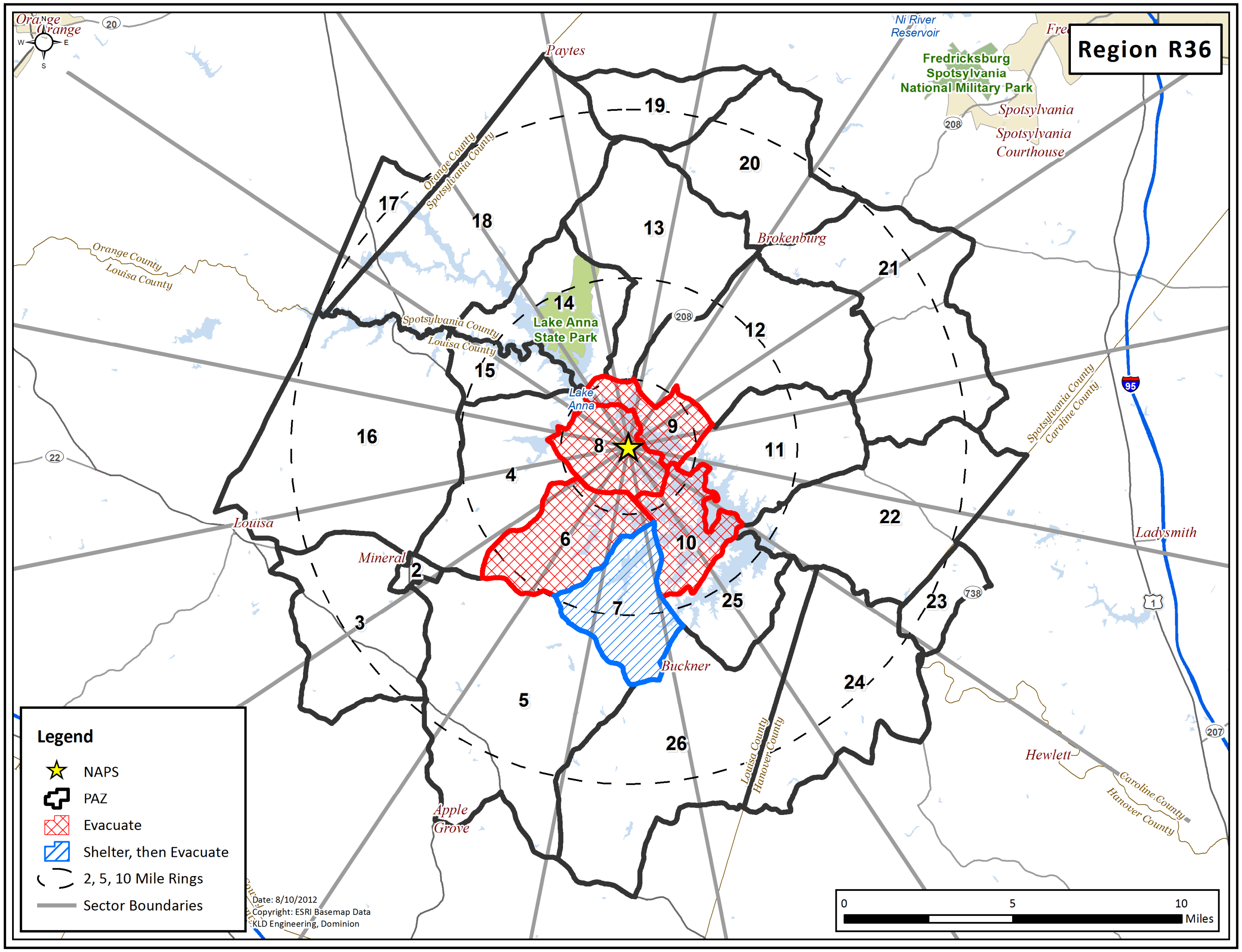


Figure H-36. Region R36

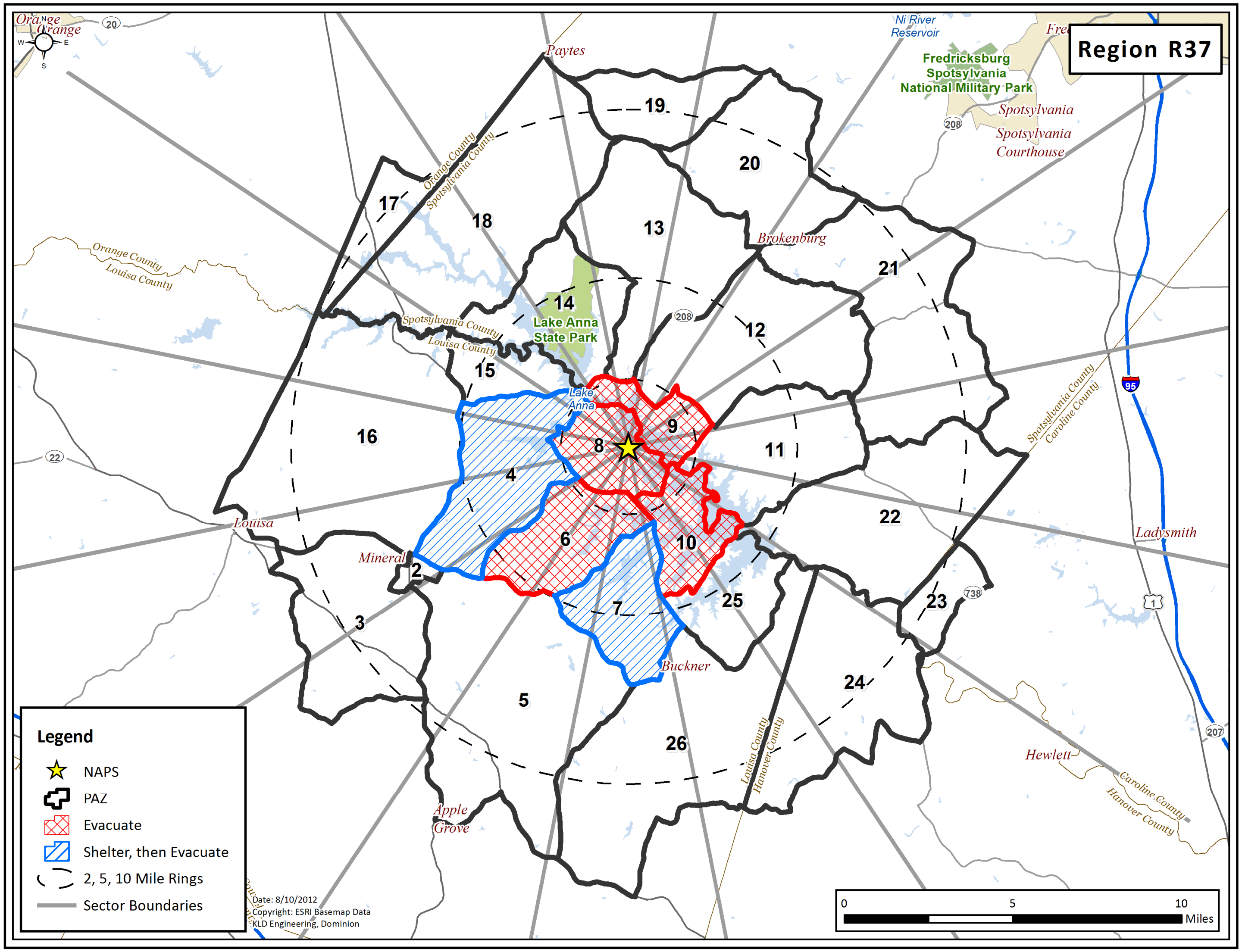


Figure H-37. Region R37

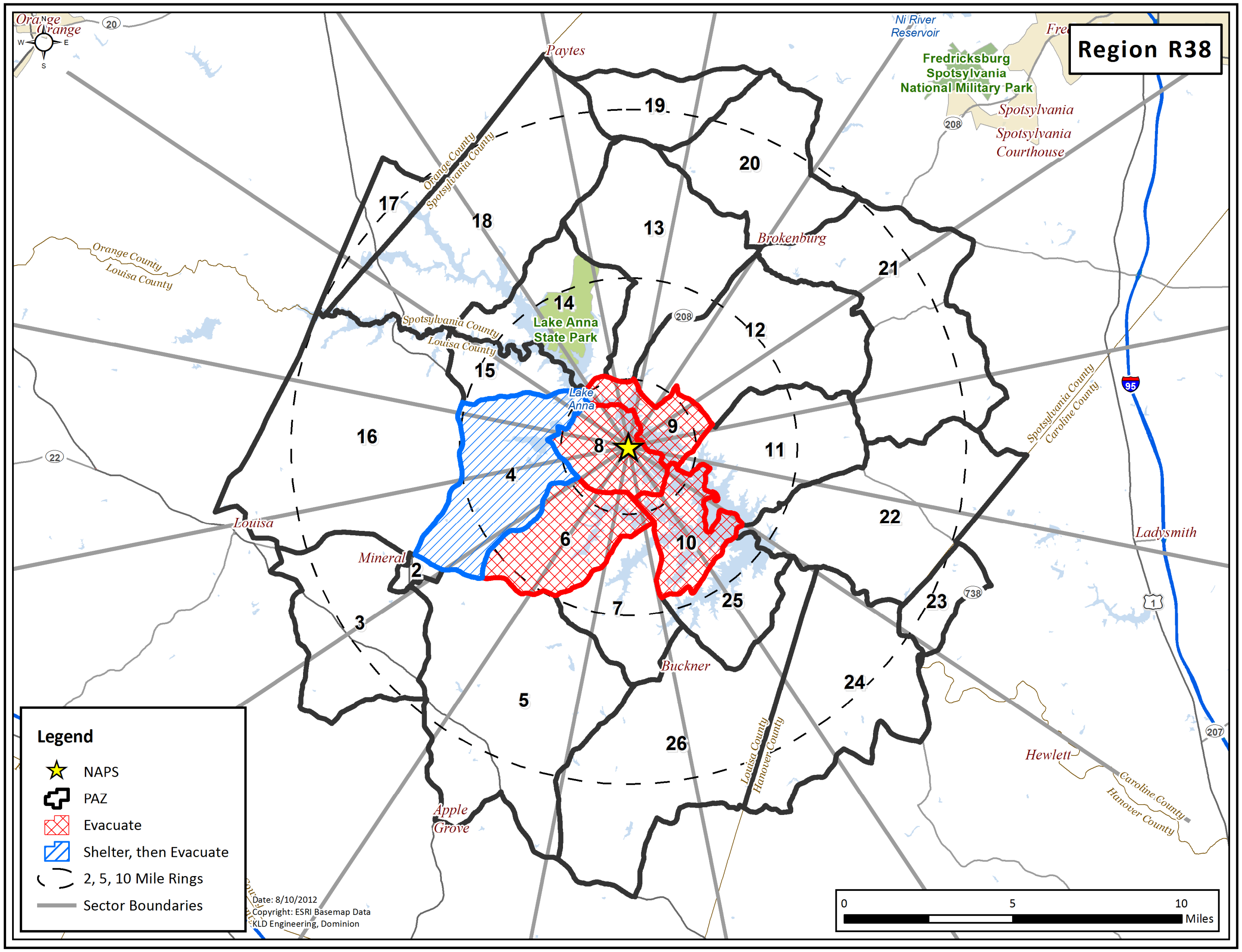


Figure H-38. Region R38

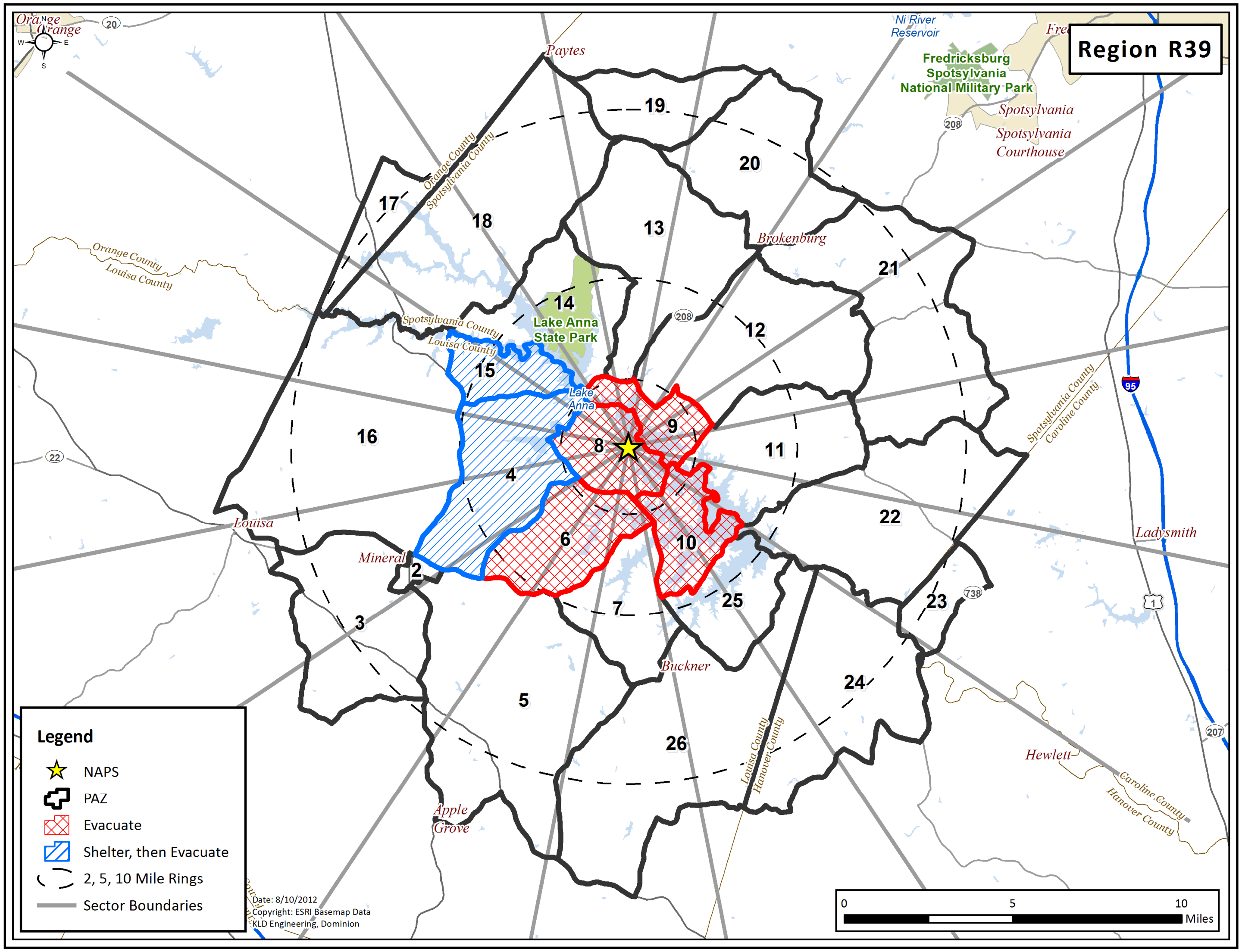


Figure H-39. Region R39

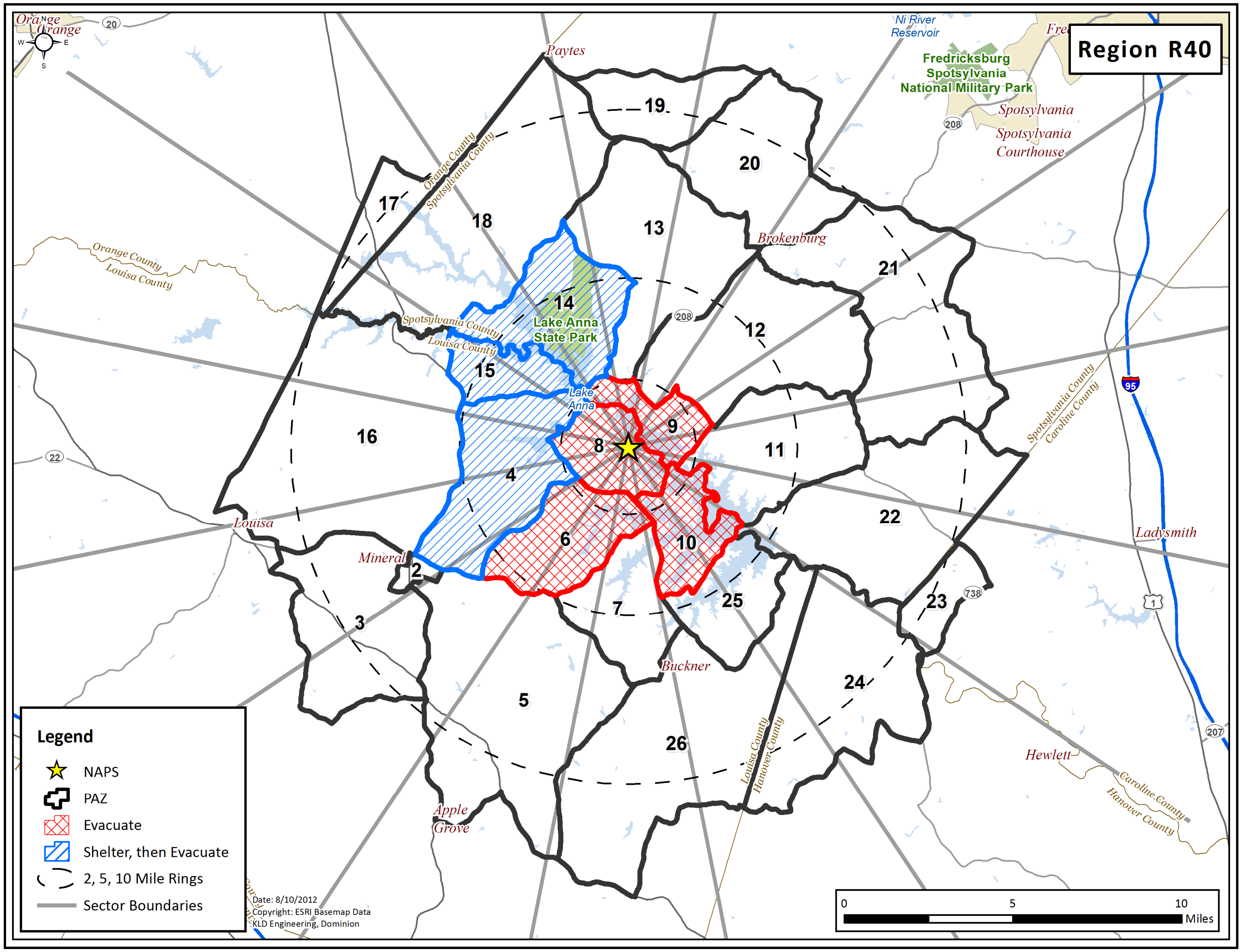


Figure H-40. Region R40

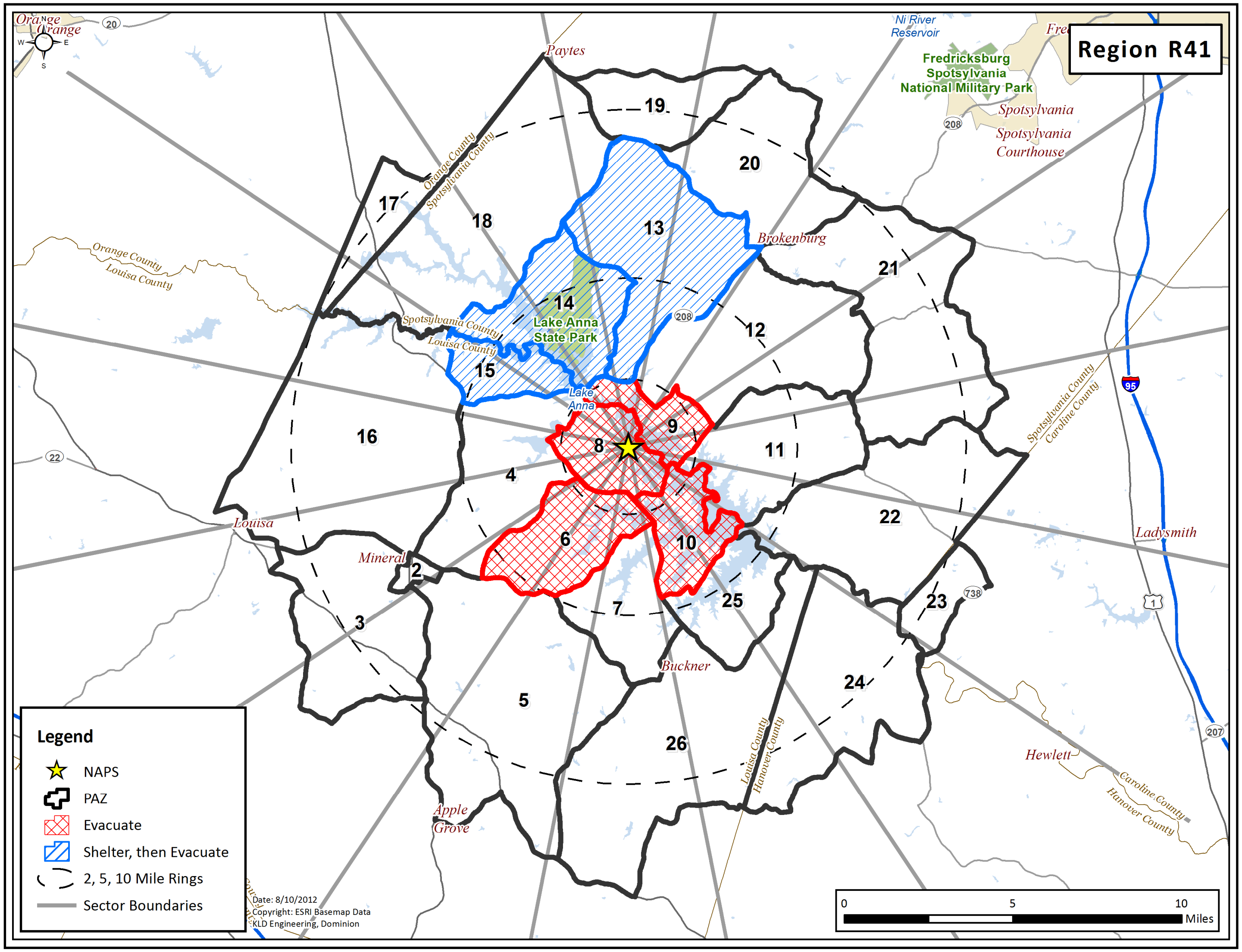


Figure H-41. Region R41

APPENDIX J

Representative Inputs to and Outputs from the DYNEV II System

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

This appendix presents data input to and output from the DYNEV II System. Table J-1 provides the volume and queues for the ten highest volume signalized intersections in the study area. A residual queue, existing at the start of the RED signal indication, indicates that the demand could not be entirely served by the GREEN phase. No residual queue indicates that the traffic movement is under-saturated (i.e., not congested) throughout the duration of evacuation. Refer to Table K-2 and the figures in Appendix K for a map showing the geographic location of each intersection.

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

Table J-3 provides network–wide statistics (average travel time, average speed and number of vehicles) for an evacuation of the entire EPZ (Region R03) for each scenario. As expected, rain and snow reduce the average speed and increase the average travel time; for example compare the winter Scenarios 6, 7 and 8. The roadway impact and special event scenarios have slower average speeds than their equivalent normal conditions scenarios.

Table J-4 provides statistics (average speed and travel time) for the major evacuation routes – US 522, SR 208, SR 738 and US 33 – 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 essentially no congestion in the EPZ throughout the duration of the evacuation. As such, the average speeds on the main evacuation routes are essentially unaffected.

Table J-5 provides the number of vehicles discharged and the cumulative percent of total vehicles discharged for each link exiting the analysis network, for an evacuation of the entire EPZ (Region R03) under Scenario 1 conditions. Refer to Table K-1 and the figures in Appendix K for a map showing the geographic location of each link.

Figure J-1 through Figure J-14 plot the trip generation time versus the ETE for each of the 14 Scenarios considered. The distance between the trip generation and ETE curves is the travel time. Plots of trip generation versus ETE are indicative of the level of traffic congestion during evacuation. For low population density sites, the curves are close together, indicating short travel times and minimal traffic congestion. For higher population density sites, the curves are farther apart indicating longer travel times and the presence of traffic congestion. As seen in Figure J-1 through Figure J-14, the curves are close together as a result of the minimal traffic congestion in the EPZ, which was discussed in detail in Section 7.3.

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

Node	Location	Intersection Control	Approach (Up Node)	Total Volume (Veh)	Max. Turn Queue (Veh)
288	US 1 & CR 606	Actuated	289	1,196	0
			12	863	0
			261	699	0
			TOTAL	2,758	-
166	US 33 & SR 628/Rosewood Ave	Actuated	170	109	0
			66	1,338	0
			219	1,245	0
			TOTAL	2,692	-
127	US 1 & SR 639	Actuated	126	798	0
			133	953	0
			134	903	0
			TOTAL	2,654	-
2	US 522 and SR 20	Actuated	194	638	0
			195	1,895	0
			198	107	0
			TOTAL	2,640	-
9	Lake Anna Pkwy & SR 208	TCP Actuated	497	1,690	0
			385	762	0
			TOTAL	2,452	-
66	US33/SR 22 & SR 208/Courthouse Rd	Actuated	65	2,168	0
			166	161	0
			168	18	0
			TOTAL	2,347	-
170	US 33 & Courthouse Sq	Actuated	67	0	0
			166	1,526	0
			180	811	0
			TOTAL	2,337	-
65	SR 208/SR 22 & US 33	Actuated	519	1,973	0
			313	136	0
			66	0	0
			TOTAL	2,109	-
264	US 1 & CR 608	Actuated	263	1,102	0
			265	498	0
			255	493	0
			TOTAL	2,093	-
302	US 1 & SR 207/SR 658	Actuated	287	420	0
			117	973	0
			613	0	0
			303	501	0
			TOTAL	1,894	-

Table J-2. Sample Simulation Model Input

Link Number	Vehicles Entering Network on this Link	Directional Preference	Destination Nodes	Destination Capacity
81	44	SW	8070	1,698
			8073	1,698
			8330	4,500
125	80	S	8444	3,315
549	130	E	8169	3,810
			8146	6,750
			8226	3,810
801	295	N	8225	1,698
			8306	1,698
			8238	1,698
51	15	NW	8016	1,698
			8231	1,698
			8214	1,698
532	79	NE	8146	6,750
			8143	1,698
			8167	1,698
632	88	S	8444	3,315
124	20	S	8330	4,500
			8329	4,500
			8187	1,698
334	31	NW	8016	1,698
			8231	1,698
			8214	1,698
609	85	NE	8226	3,810
			8225	1,698
			8306	1,698

Table J-3. Selected Model Outputs for the Evacuation of the Entire EPZ (Region R03)

Scenario	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Network-Wide Average Travel Time (Min/Veh-Mi)	1.1	1.2	1.2	1.3	1.3	1.0	1.1	1.3	1.1	1.2	1.3	1.2	1.1	1.1
Network-Wide Average Speed (mph)	56.1	50.9	50.1	46.1	46.9	58.2	52.7	46.9	56.4	51.2	47.2	51.7	55.3	54.4
Total Vehicles Exiting Network	36,413	36,626	36,264	36,456	26,199	34,594	34,798	34,869	33,733	33,945	34,043	24,364	34,086	36,412

Table J-4. Average Speed (mph) and Travel Time (min) for Major Evacuation Routes (Region R03, Scenario 1)

		Elapsed Time (hours)									
		1		2		3		4		5	
Route Name	Length (miles)	Speed (mph)	Travel Time (min)	Speed	Travel Time	Speed	Travel Time	Speed	Travel Time	Speed	Travel Time
US 522 NB from SR 208	7.2	57.2	7.6	59.1	7.4	58.7	7.4	58.8	7.4	60.0	7.2
US 522 SB from Mineral	7.4	51.8	8.5	52.2	8.4	52.5	8.4	54.2	8.1	54.2	8.1
SR 208/SR 22 WB from Mineral	4.2	51.4	4.9	53.2	4.7	53.5	4.7	53.6	4.7	53.6	4.7
SR 208/Courthouse Rd EB from CR 601	10.8	52.2	12.4	53.1	12.2	52.7	12.3	53.6	12.1	55.9	11.6
SR 738/Partlow Rd NB from CR 657	8.2	46.1	10.6	46.3	10.6	47.0	10.4	47.1	10.4	48.1	10.2
SR 738/Partlow Rd SB from CR 657	6.0	48.8	7.3	48.2	7.4	48.1	7.5	48.4	7.4	49.3	7.3
US 33 EB from SR 768	14.3	58.9	14.6	58.9	14.6	59.1	14.5	59.9	14.3	60.0	14.3

Table J-5. Simulation Model Outputs at Network Exit Links for Region R03, Scenario 1

EPZ Exit Link	Elapsed Time (hours)				
	1	2	3	4	5
	Cumulative Vehicles Discharged by the Indicated Time				
	Cumulative Percent of Vehicles Discharged by the Indicated Time				
4	400	1,004	1,225	1,290	1,311
	3.40	3.55	3.54	3.59	3.60
22	346	852	1,027	1,081	1,099
	2.94	3.01	2.97	3.01	3.02
30	160	471	625	676	693
	1.36	1.67	1.80	1.88	1.90
31	102	369	491	516	523
	0.87	1.30	1.42	1.43	1.44
36	49	165	232	254	260
	0.41	0.58	0.67	0.71	0.71
38	188	539	711	769	785
	1.60	1.90	2.05	2.14	2.16
47	303	918	1,145	1,206	1,224
	2.57	3.24	3.31	3.35	3.36
65	209	560	749	800	816
	1.78	1.98	2.16	2.23	2.24
66	188	524	709	753	768
	1.60	1.85	2.05	2.09	2.11
80	129	324	412	438	447
	1.10	1.15	1.19	1.22	1.23
102	440	1,162	1,471	1,553	1,580
	3.75	4.10	4.25	4.32	4.34
103	205	542	716	779	797
	1.75	1.91	2.07	2.17	2.19
209	199	555	698	727	736
	1.69	1.96	2.02	2.02	2.02
304	2,361	4,803	5,492	5,510	5,516
	20.07	16.97	15.86	15.32	15.16
350	124	362	461	484	493
	1.06	1.28	1.33	1.35	1.36
356	130	447	578	605	613
	1.11	1.58	1.67	1.68	1.68
358	35	111	147	155	159
	0.30	0.39	0.42	0.43	0.44

EPZ Exit Link	Elapsed Time (hours)				
	1	2	3	4	5
	Cumulative Vehicles Discharged by the Indicated Time				
	Cumulative Percent of Vehicles Discharged by the Indicated Time				
371	287	783	1,107	1,216	1,251
	2.44	2.77	3.20	3.38	3.44
375	2,282	4,697	5,396	5,425	5,432
	19.40	16.59	15.58	15.09	14.93
407	1,144	2,675	3,061	3,118	3,135
	9.73	9.45	8.84	8.67	8.62
425	228	613	885	982	1,013
	1.94	2.16	2.55	2.73	2.78
456	1,175	2,837	3,270	3,338	3,357
	9.99	10.02	9.44	9.28	9.23
599	186	566	859	918	937
	1.58	2.00	2.48	2.55	2.58
600	436	1,185	1,551	1,659	1,693
	3.71	4.19	4.48	4.61	4.65
734	402	1,080	1,394	1,480	1,510
	3.42	3.82	4.02	4.12	4.15
788	52	162	216	231	235
	0.44	0.57	0.62	0.64	0.65

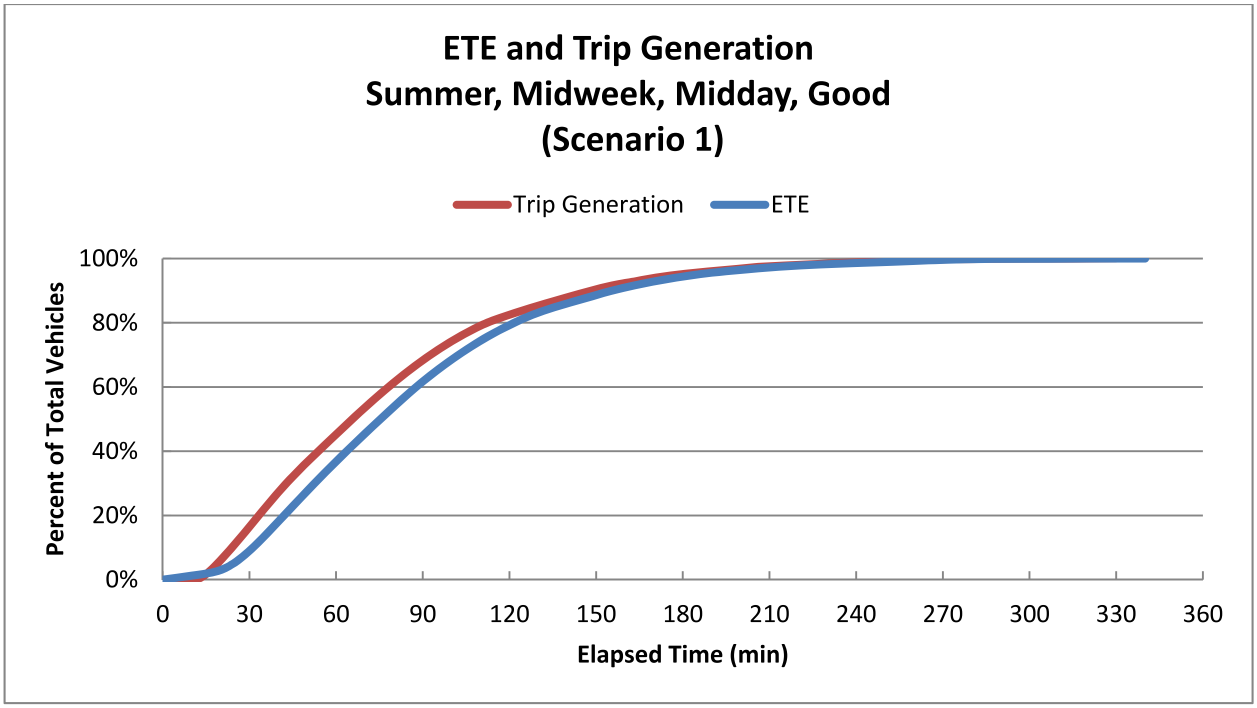


Figure J-1. ETE and Trip Generation: Summer, Midweek, Midday, Good Weather (Scenario 1)

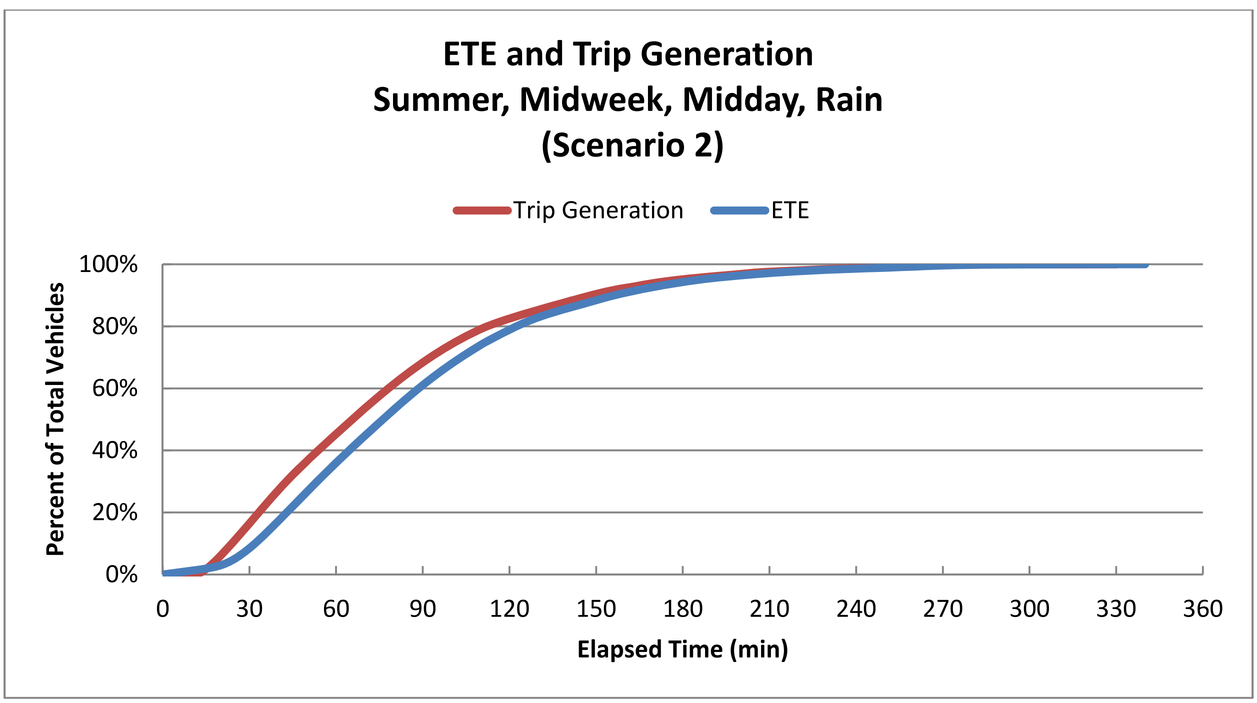


Figure J-2. ETE and Trip Generation: Summer, Midweek, Midday, Rain (Scenario 2)

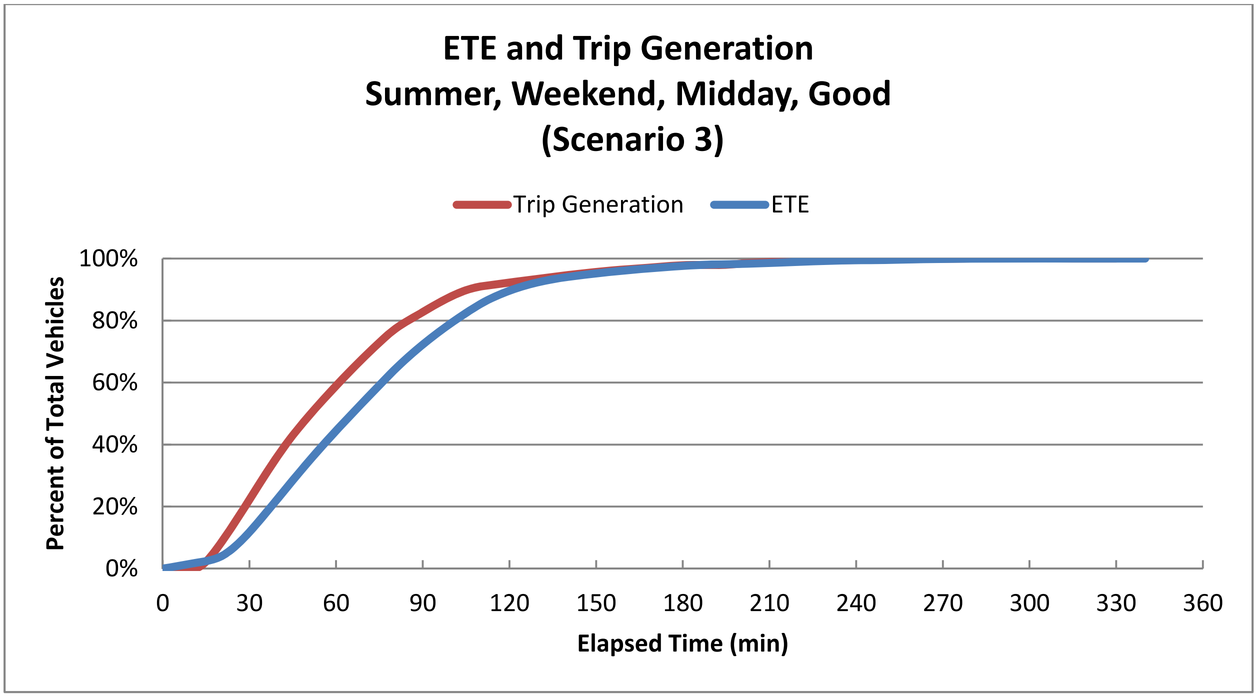


Figure J-3. ETE and Trip Generation: Summer, Weekend, Midday, Good Weather (Scenario 3)

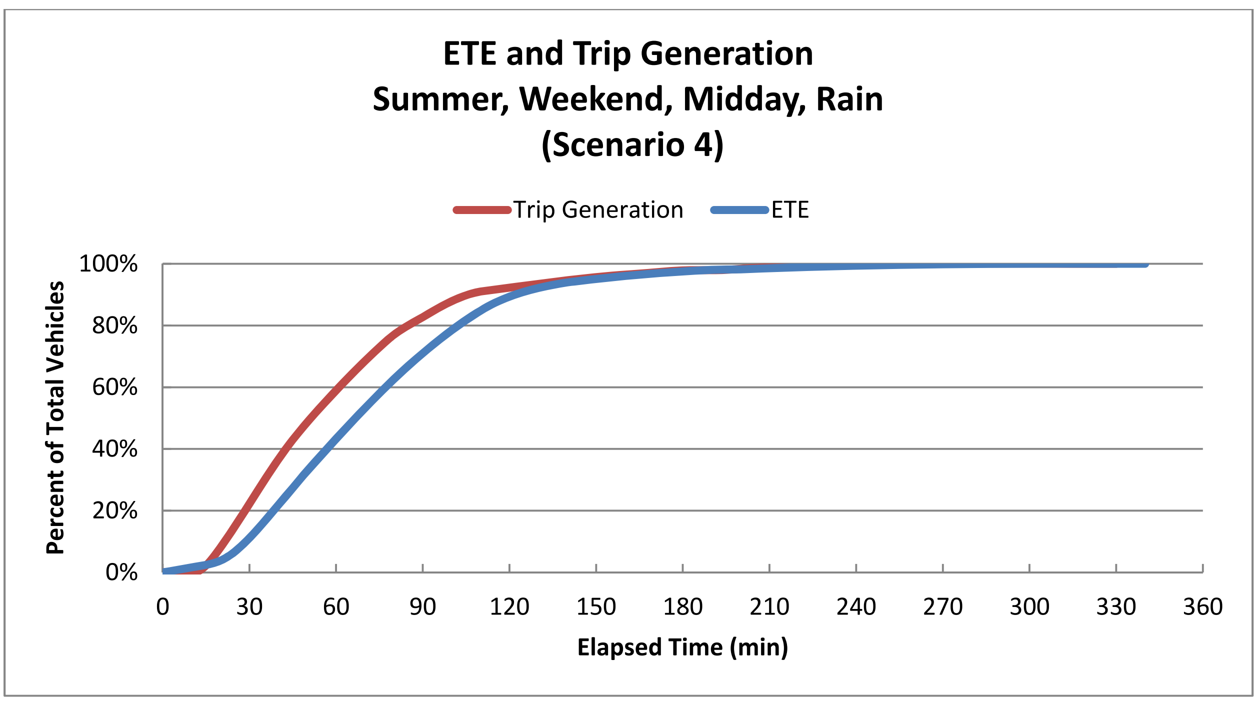


Figure J-4. ETE and Trip Generation: Summer, Weekend, Midday, Rain (Scenario 4)

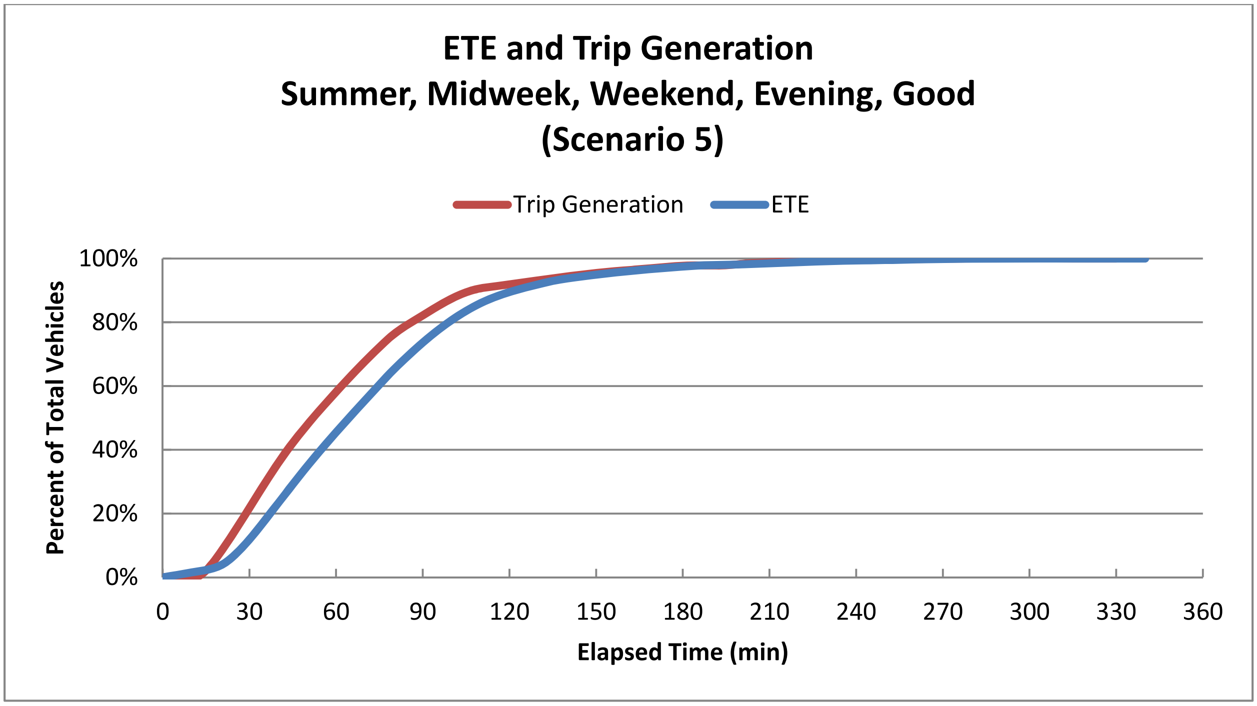


Figure J-5. ETE and Trip Generation: Summer, Midweek, Weekend, Evening, Good Weather (Scenario 5)

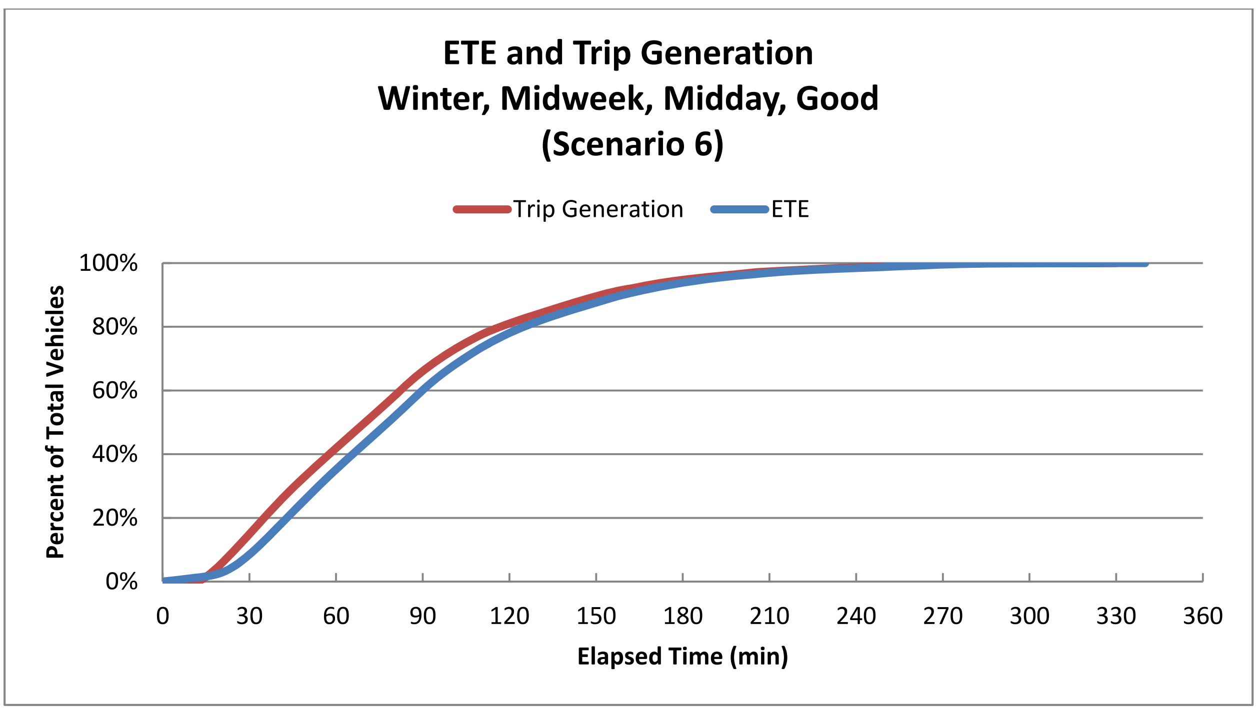


Figure J-6. ETE and Trip Generation: Winter, Midweek, Midday, Good Weather (Scenario 6)

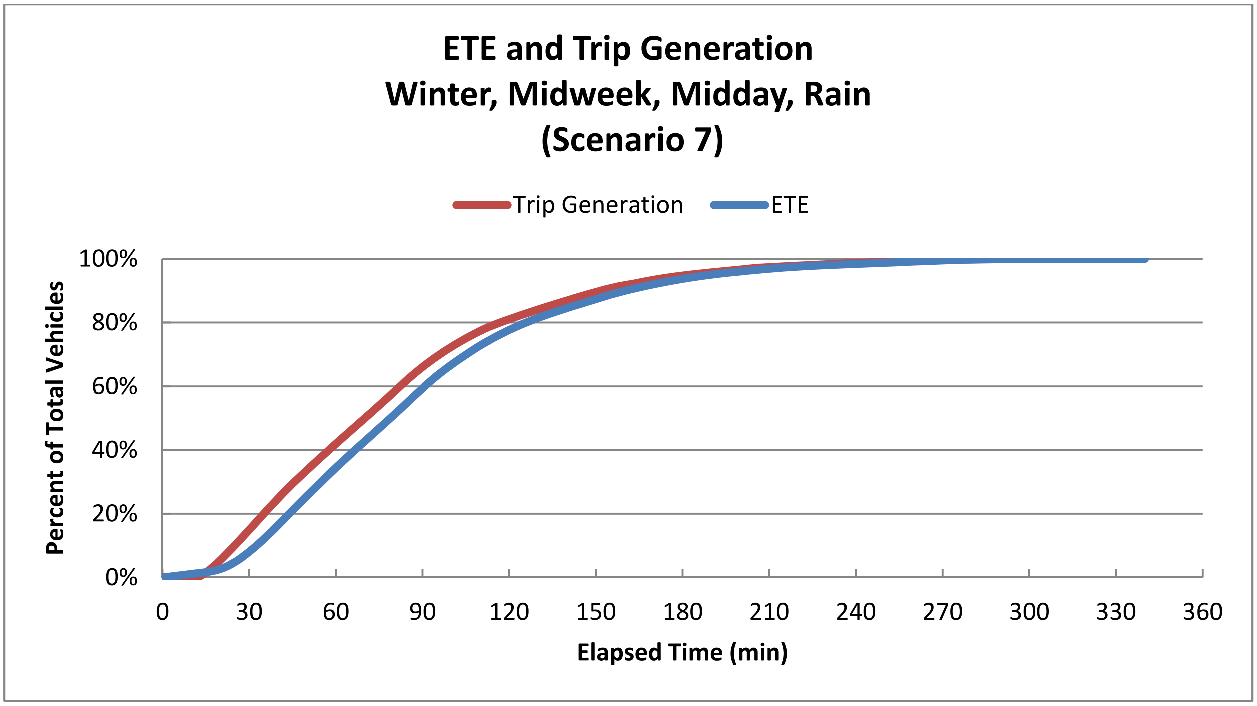


Figure J-7. ETE and Trip Generation: Winter, Midweek, Midday, Rain (Scenario 7)

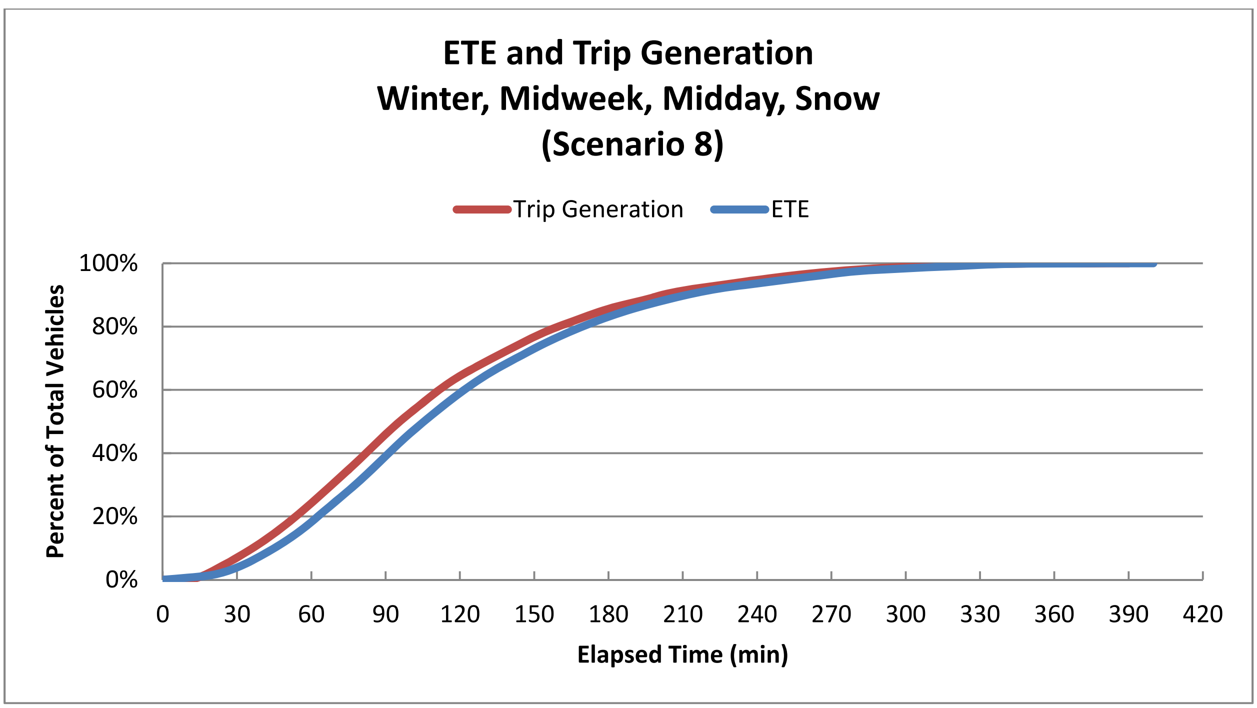


Figure J-8. ETE and Trip Generation: Winter, Midweek, Midday, Snow (Scenario 8)

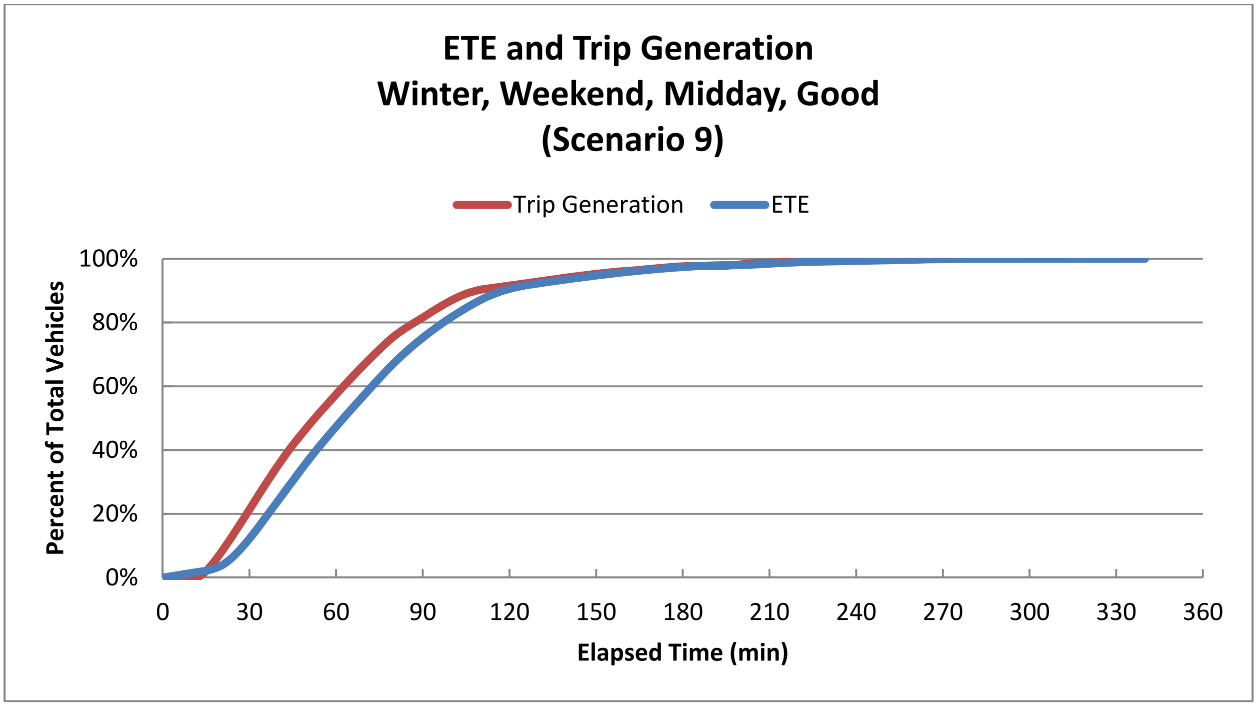


Figure J-9. ETE and Trip Generation: Winter, Weekend, Midday, Good Weather (Scenario 9)

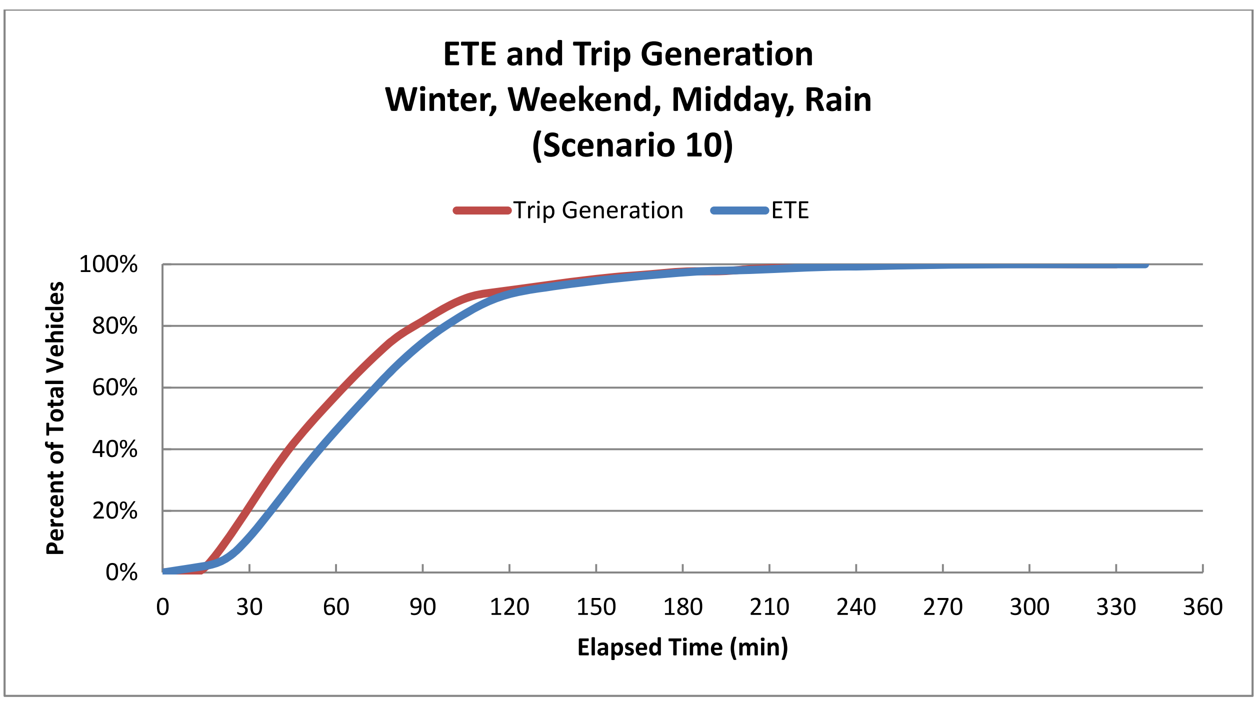


Figure J-10. ETE and Trip Generation: Winter, Weekend, Midday, Rain (Scenario 10)

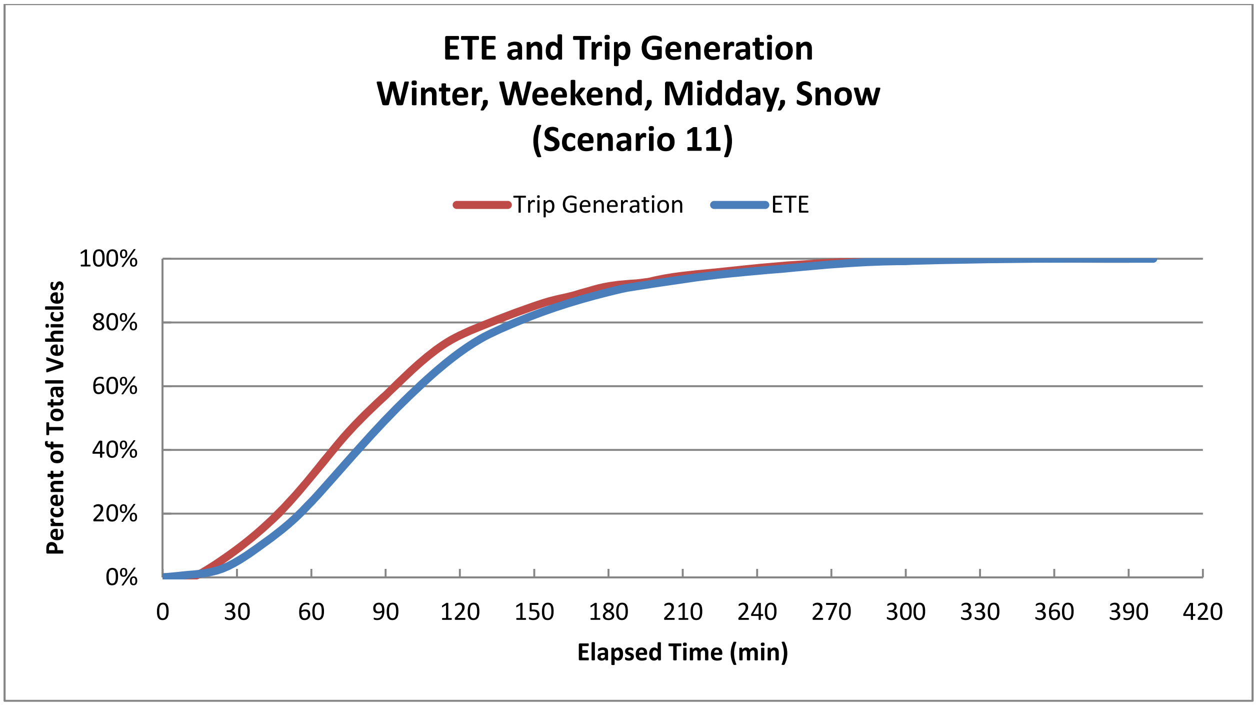


Figure J-11. ETE and Trip Generation: Winter, Weekend, Midday, Snow (Scenario 11)

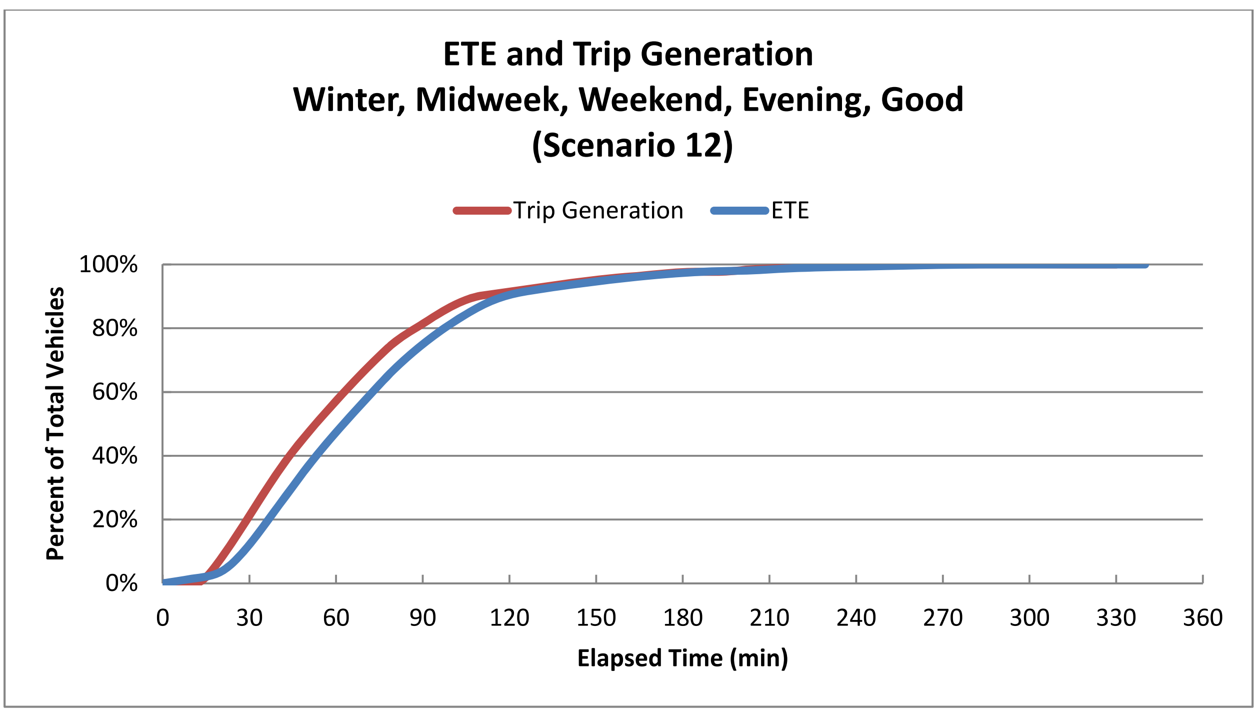


Figure J-12. ETE and Trip Generation: Winter, Midweek, Weekend, Evening, Good Weather (Scenario 12)

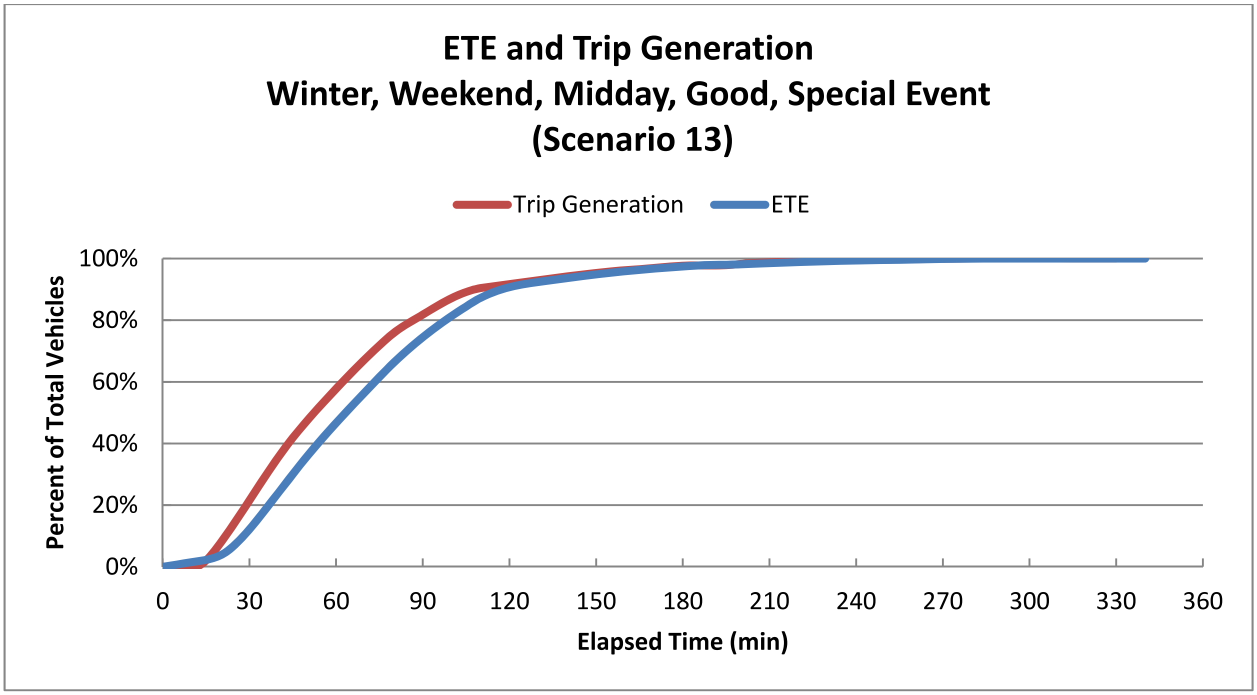


Figure J-13. ETE and Trip Generation: Summer, Weekend, Evening, Good Weather, Special Event (Scenario 13)

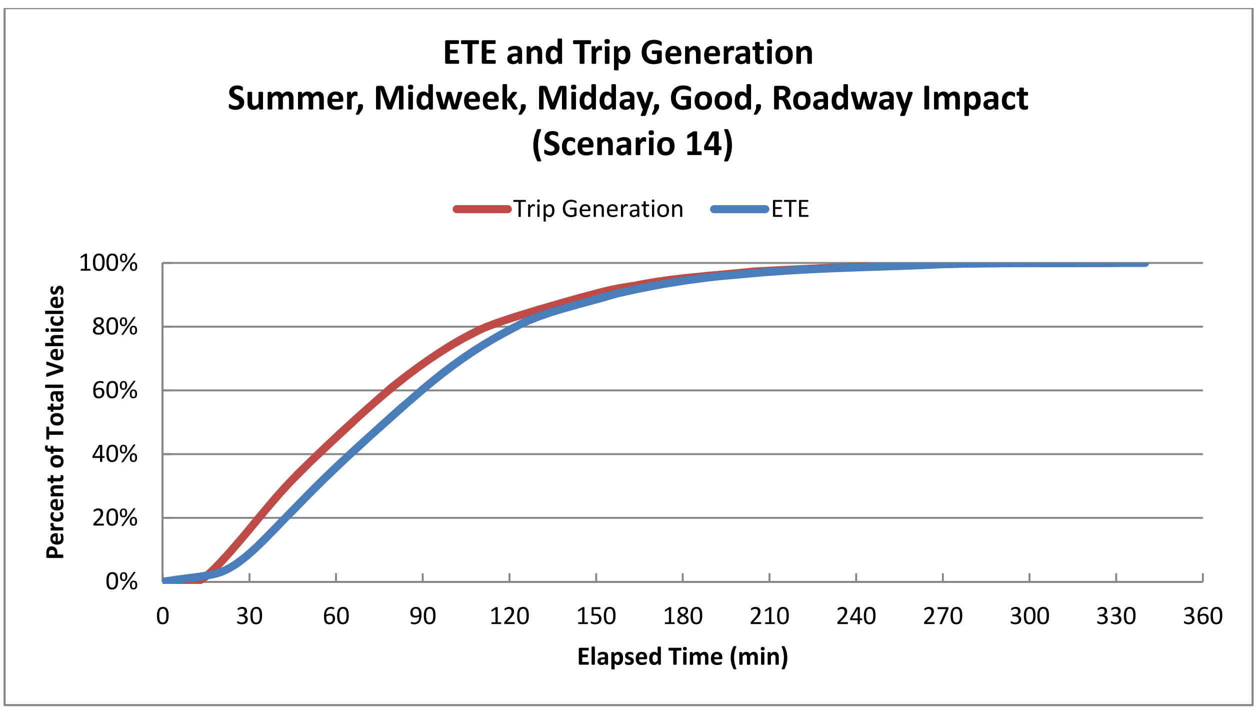


Figure J-14. ETE and Trip Generation: Summer, Midweek, Midday, Good Weather, Roadway Impact (Scenario 14)

APPENDIX K

Evacuation Roadway Network

K. EVACUATION ROADWAY NETWORK

As discussed in Section 1.3, a link-node analysis network was constructed to model the roadway network within the study area. Figure K-1 provides an overview of the link-node analysis network. The figure has been divided up into 37 more detailed figures (Figure K-2 through Figure K-38) which show each of the links and nodes in the network.

The analysis network was calibrated using the observations made during the field survey conducted in February 2012. Table K-1 lists the characteristics of each roadway section modeled in the ETE analysis. Each link is identified by its road name and the upstream and downstream node numbers. The geographic location of each link can be observed by referencing the grid map number provided in Table K-1. The roadway type identified in Table K-1 is based on the following criteria:

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

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

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

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

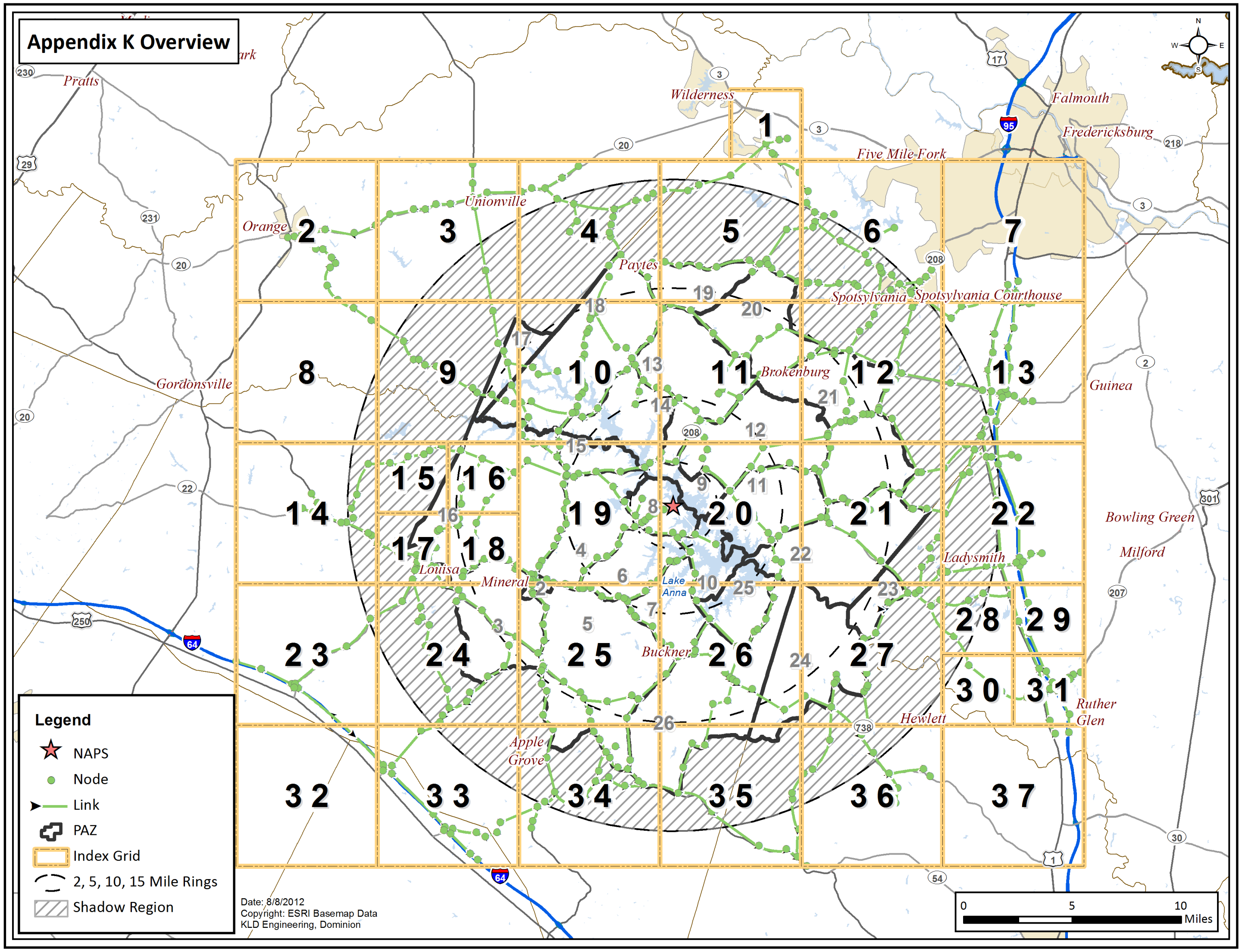


Figure K-1. NAPS Link-Node Analysis Network

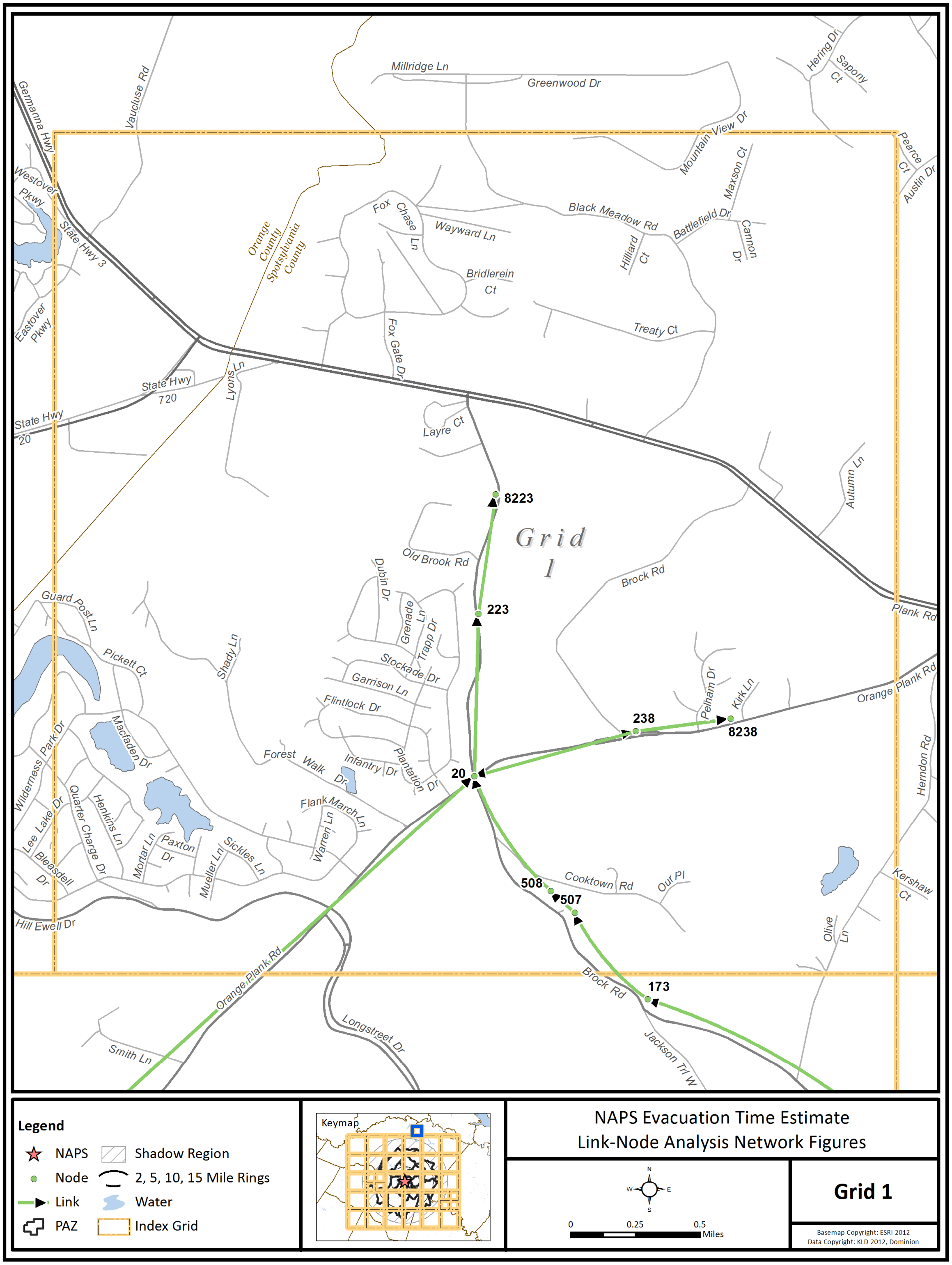


Figure K-2. Link-Node Analysis Network – Grid 1

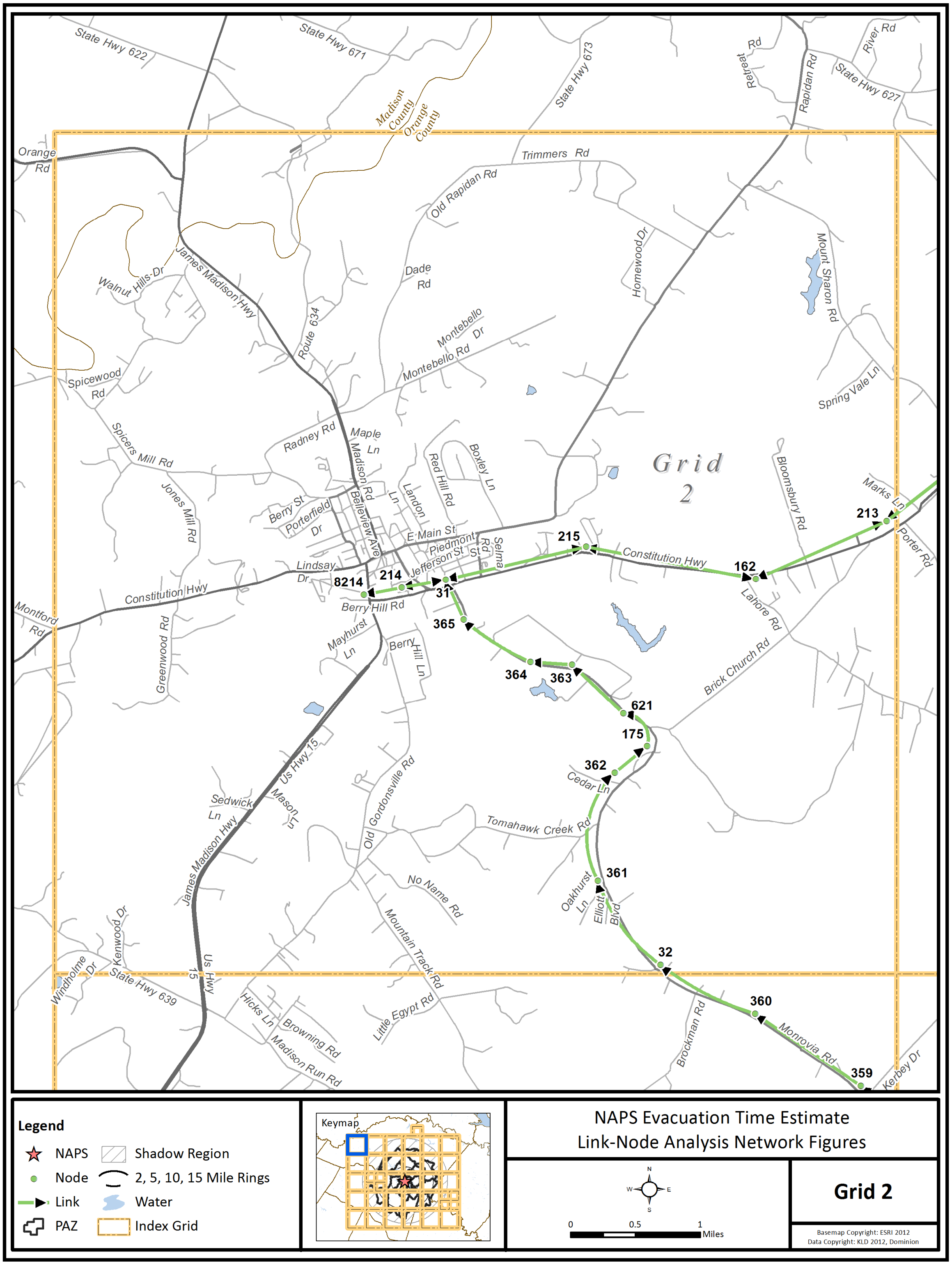


Figure K-3. Link-Node Analysis Network – Grid 2

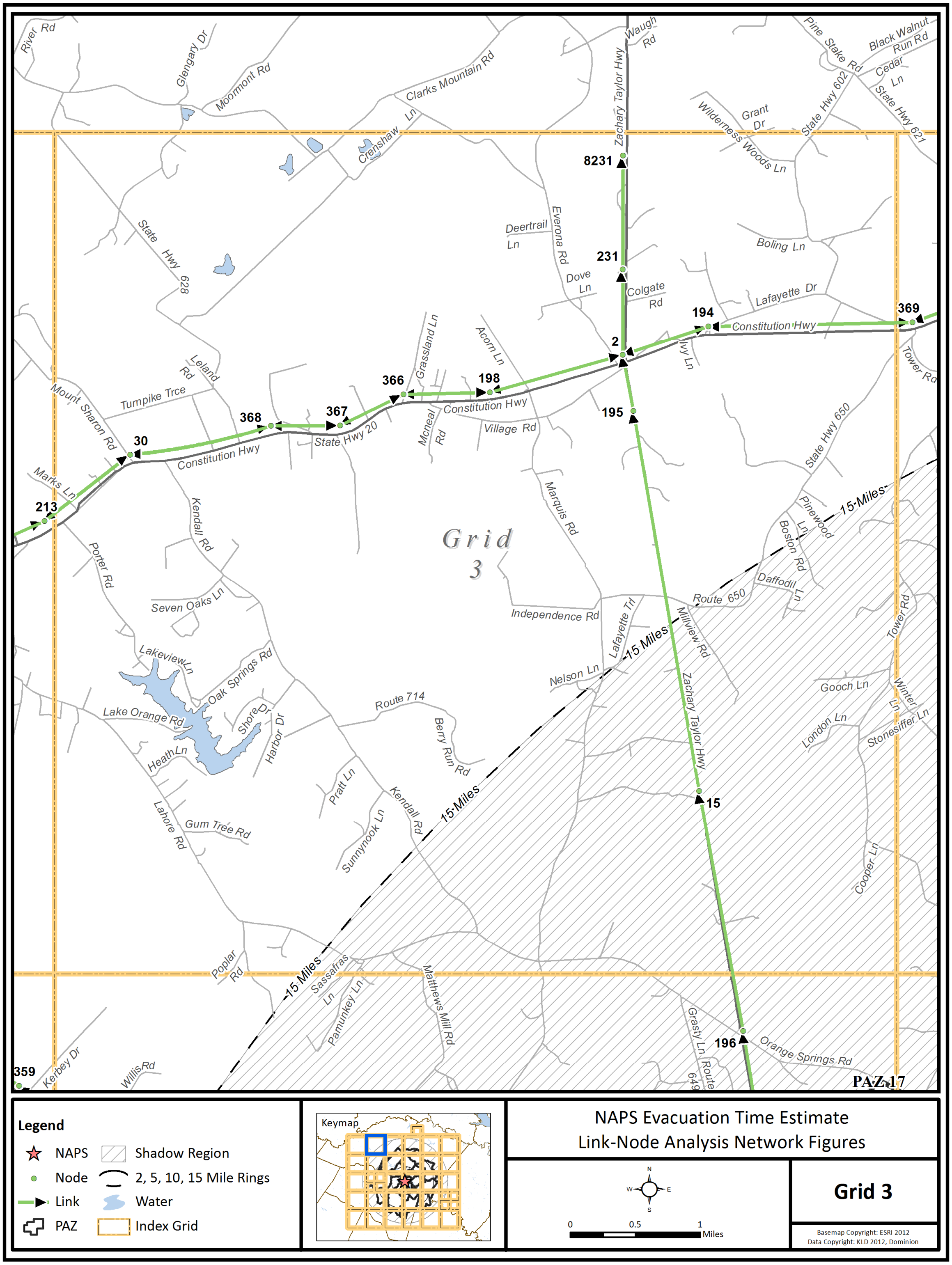


Figure K-4. Link-Node Analysis Network – Grid 3

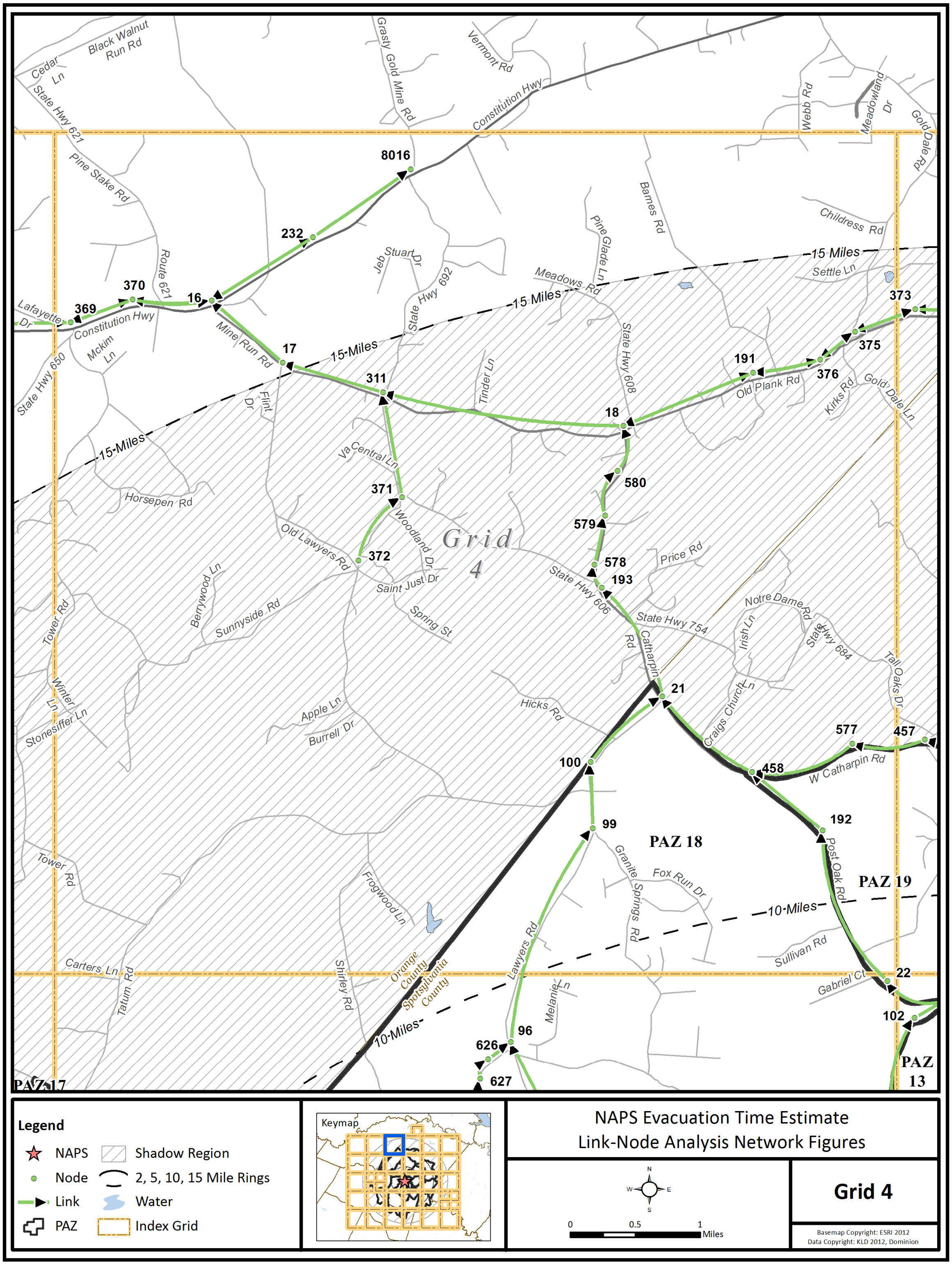


Figure K-5. Link-Node Analysis Network – Grid 4

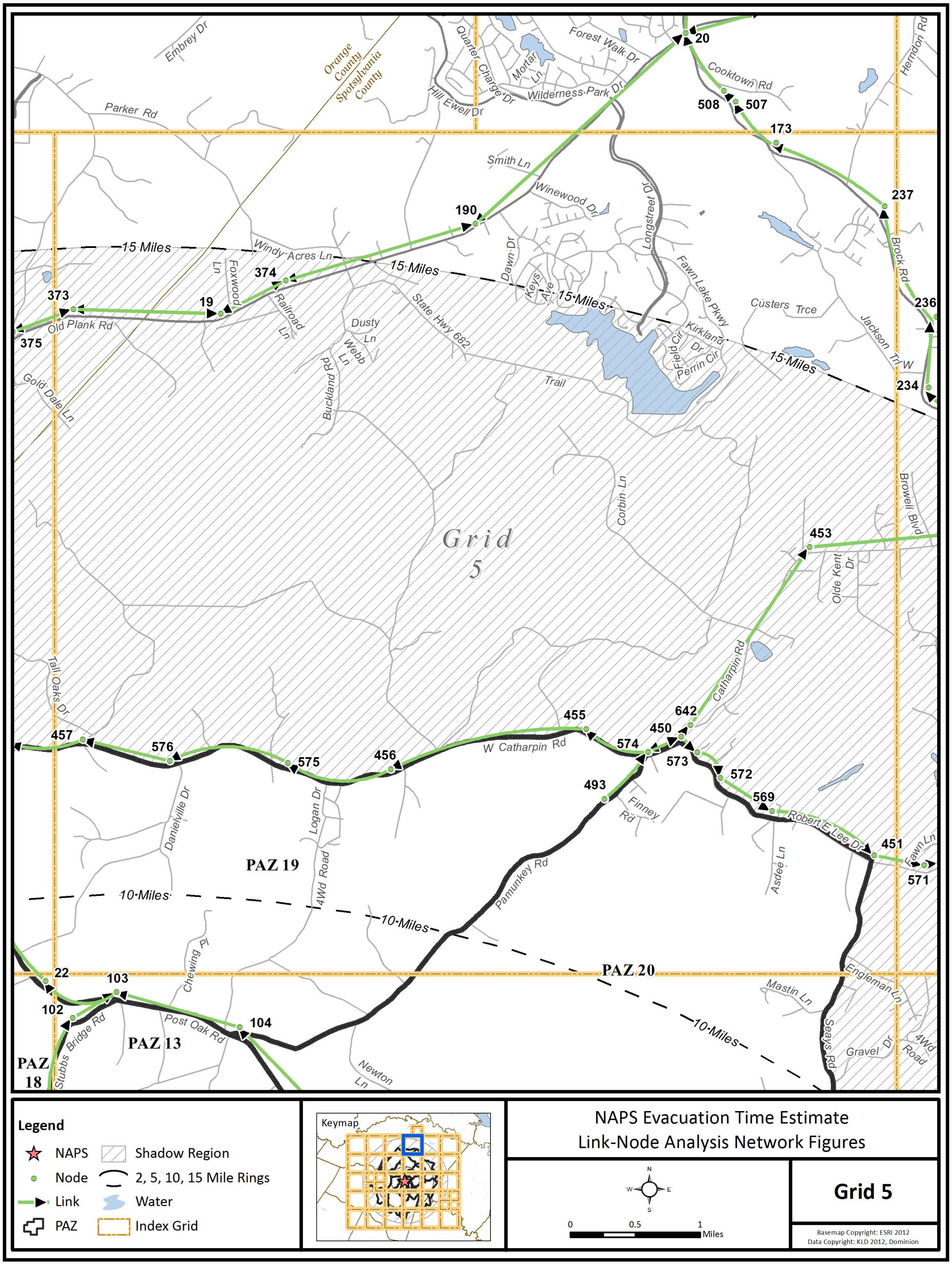


Figure K-6. Link-Node Analysis Network – Grid 5

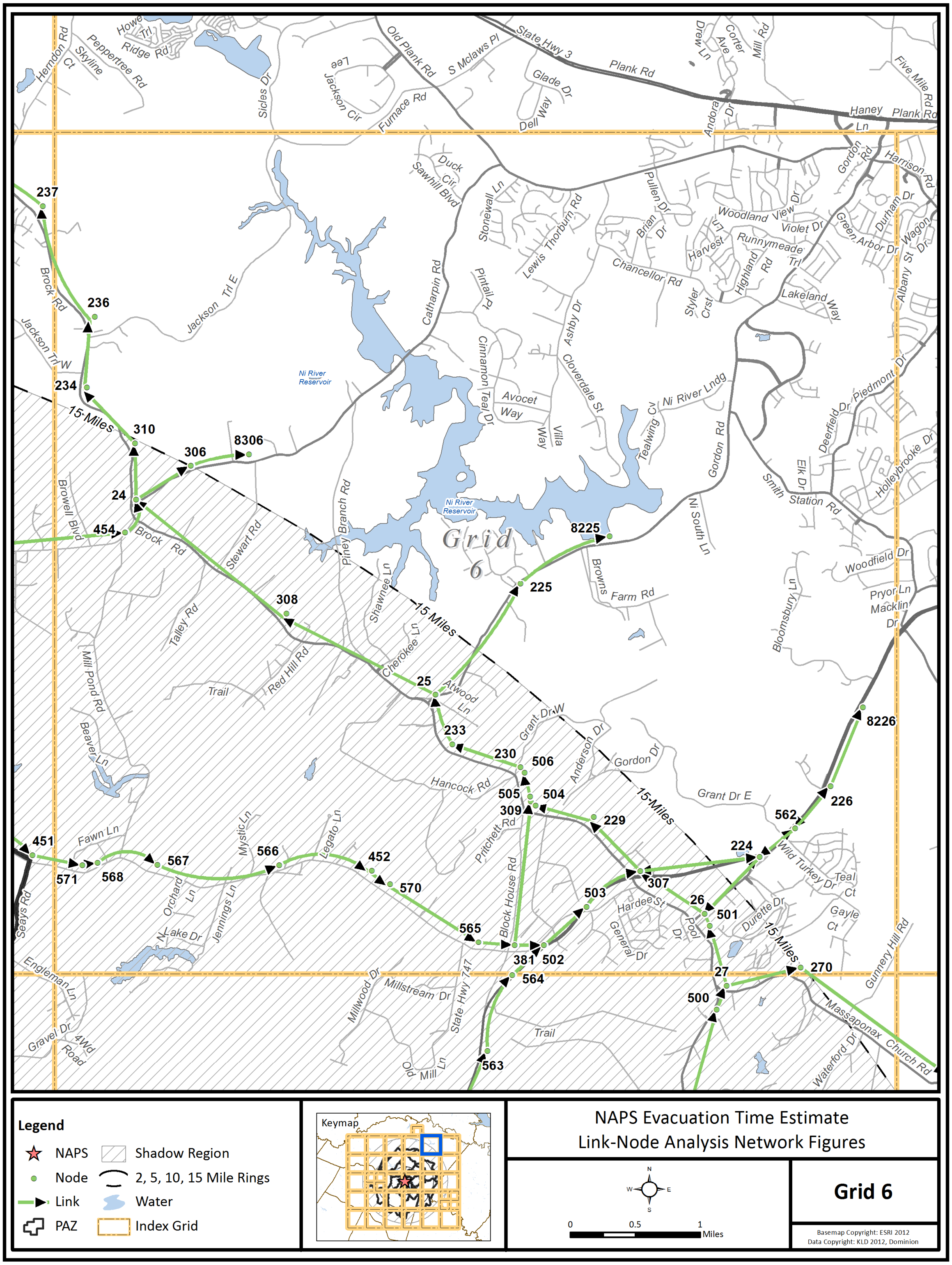


Figure K-7. Link-Node Analysis Network – Grid 6

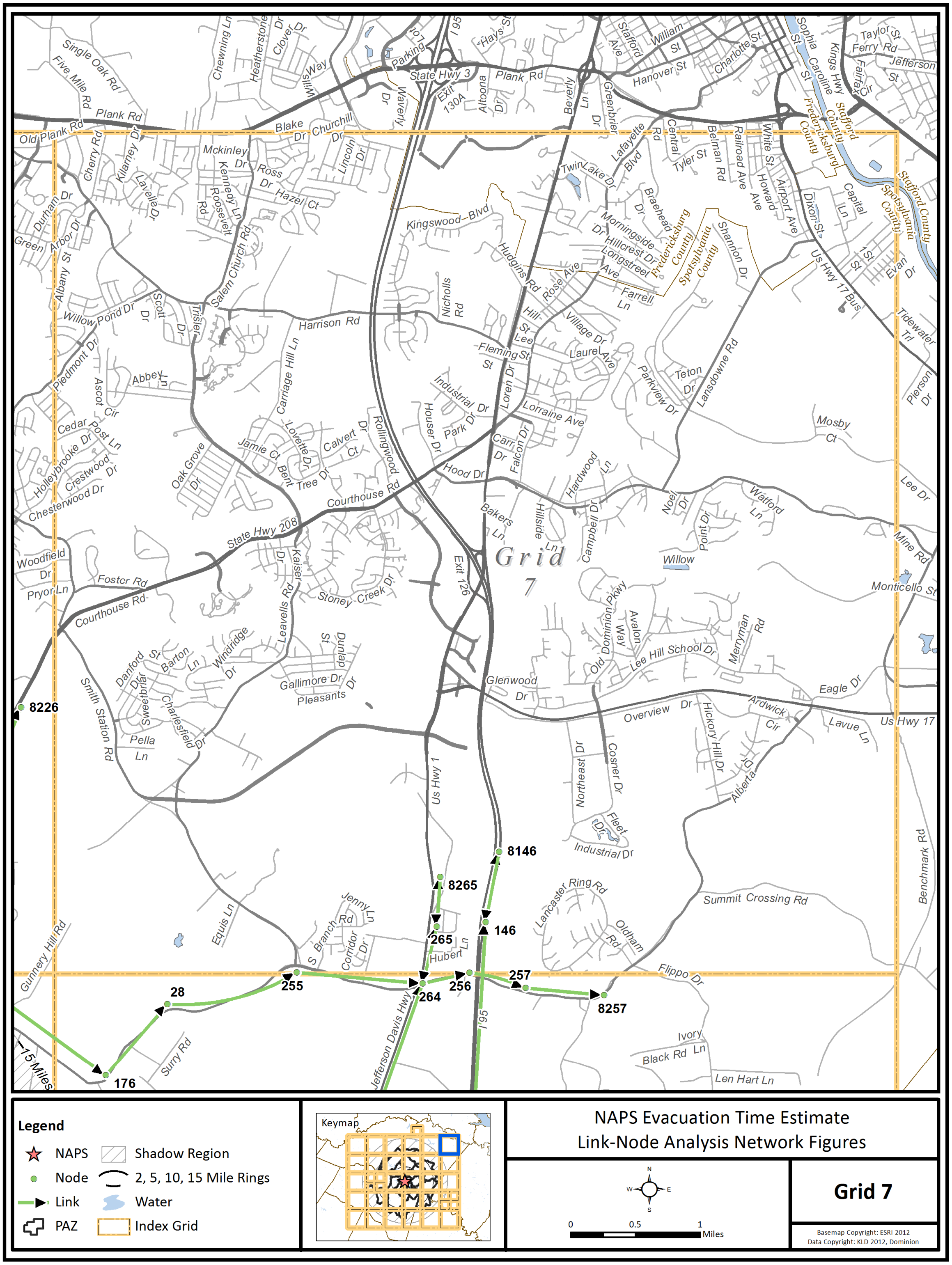


Figure K-8. Link-Node Analysis Network – Grid 7

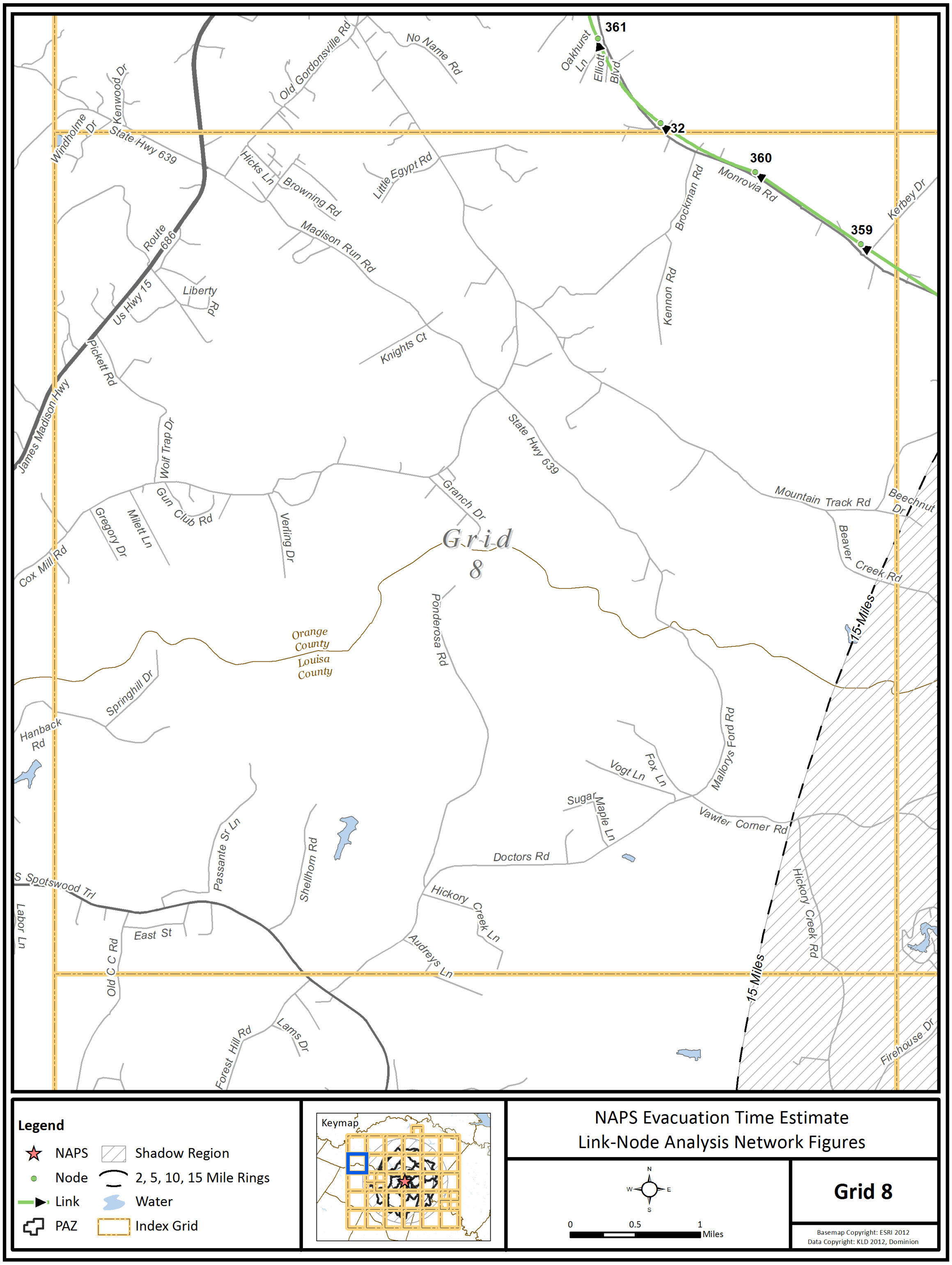


Figure K-9. Link-Node Analysis Network – Grid 8

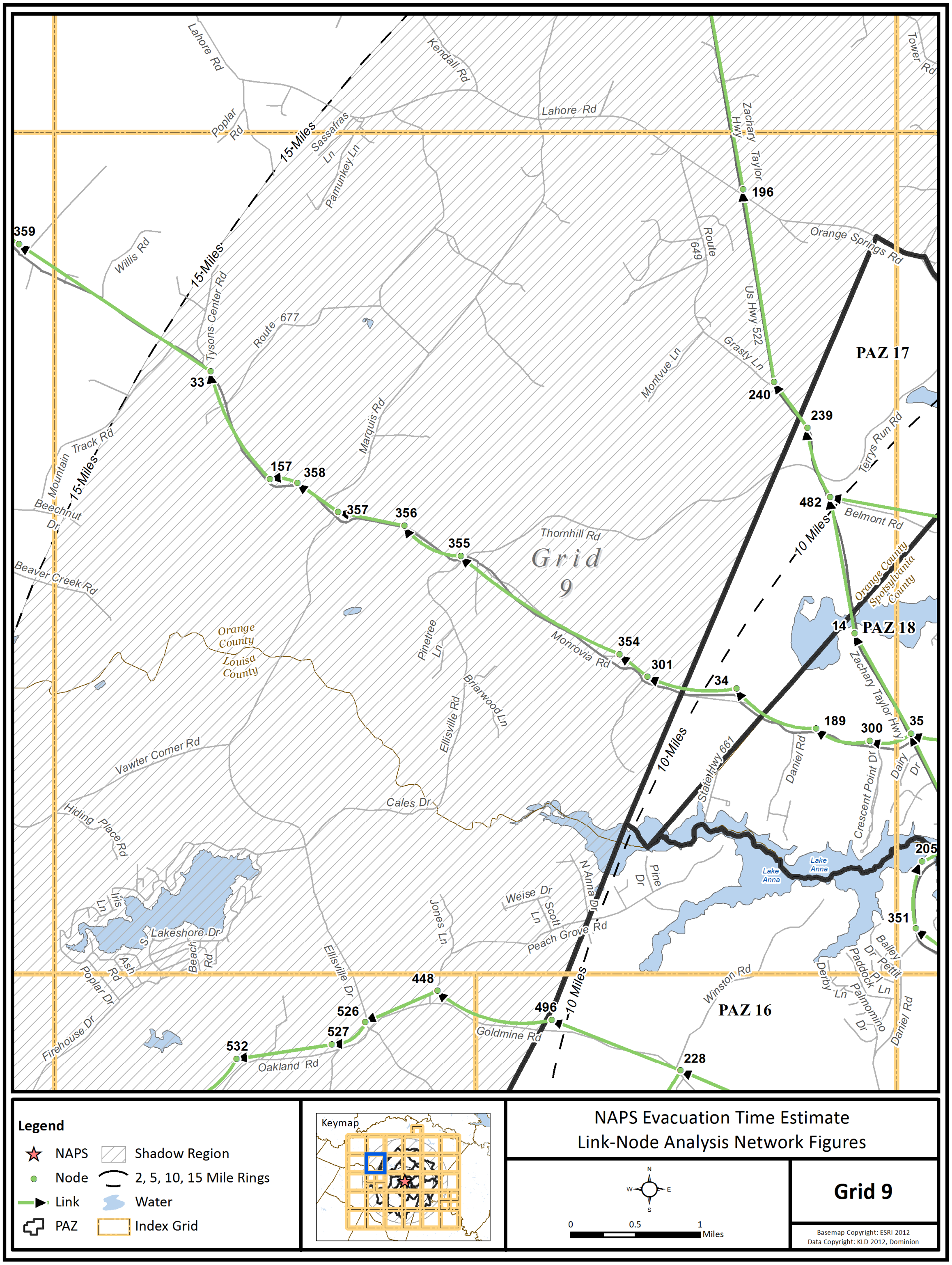


Figure K-10. Link-Node Analysis Network – Grid 9

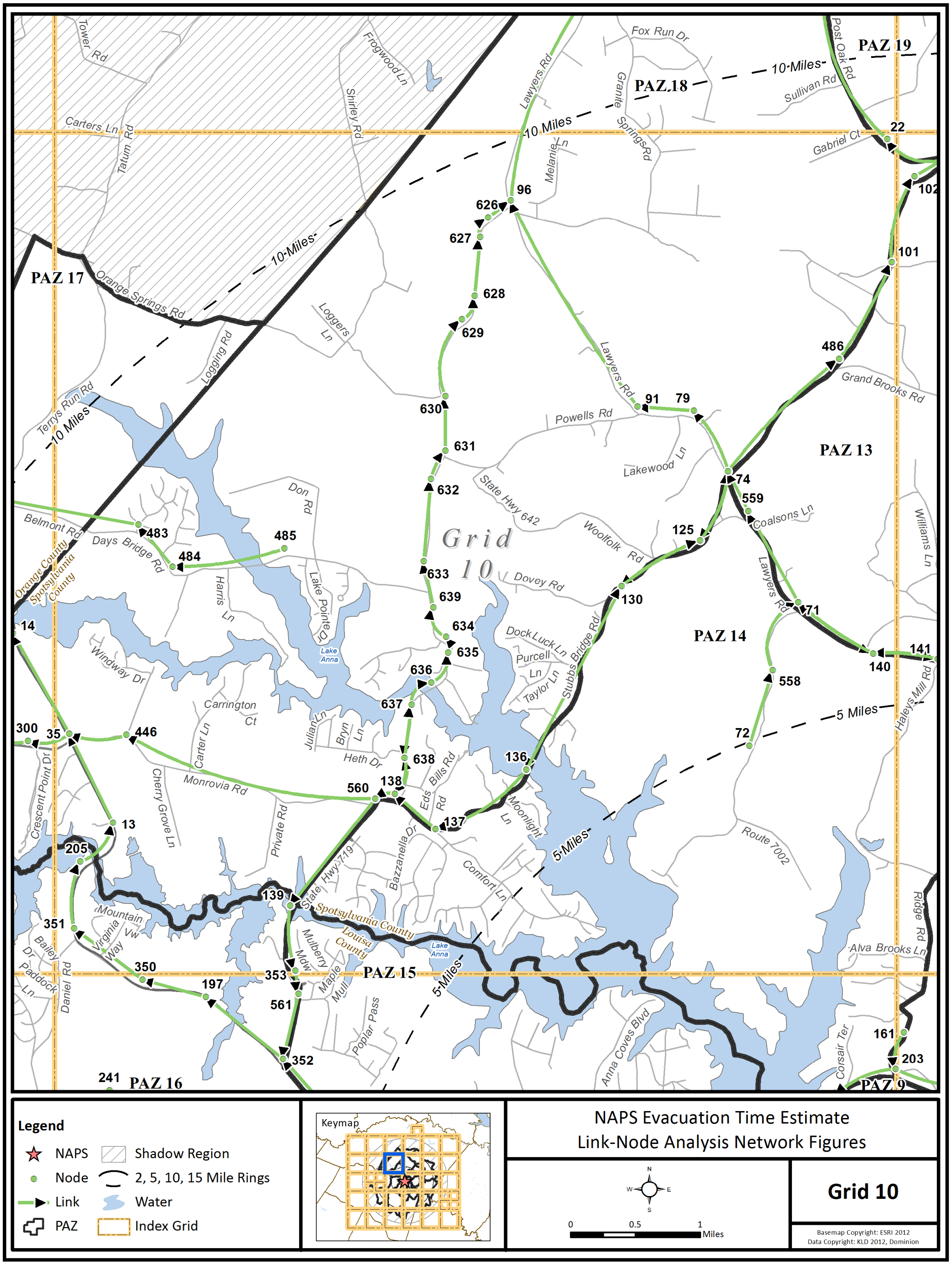


Figure K-11. Link-Node Analysis Network – Grid 10

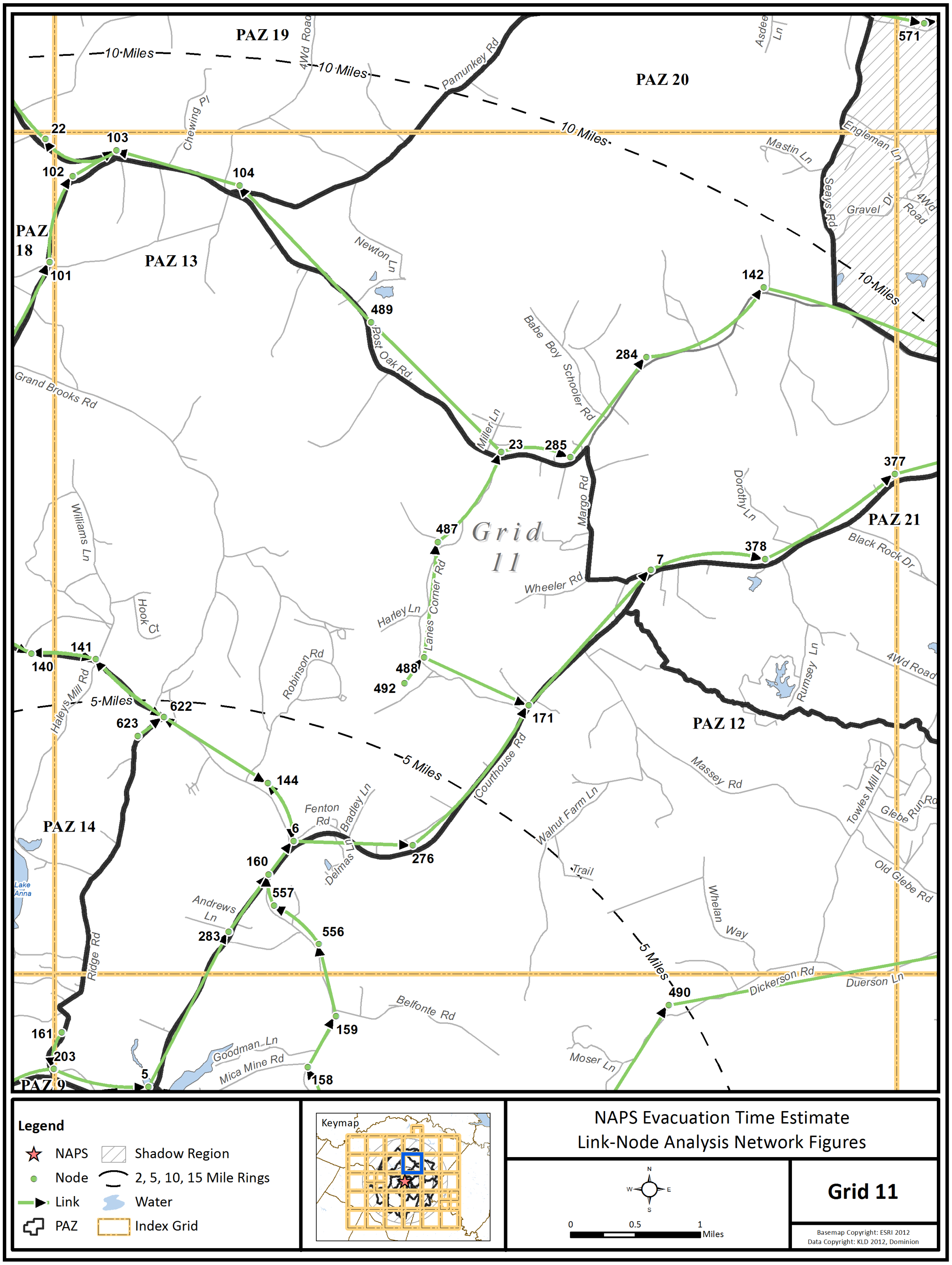


Figure K-12. Link-Node Analysis Network – Grid 11

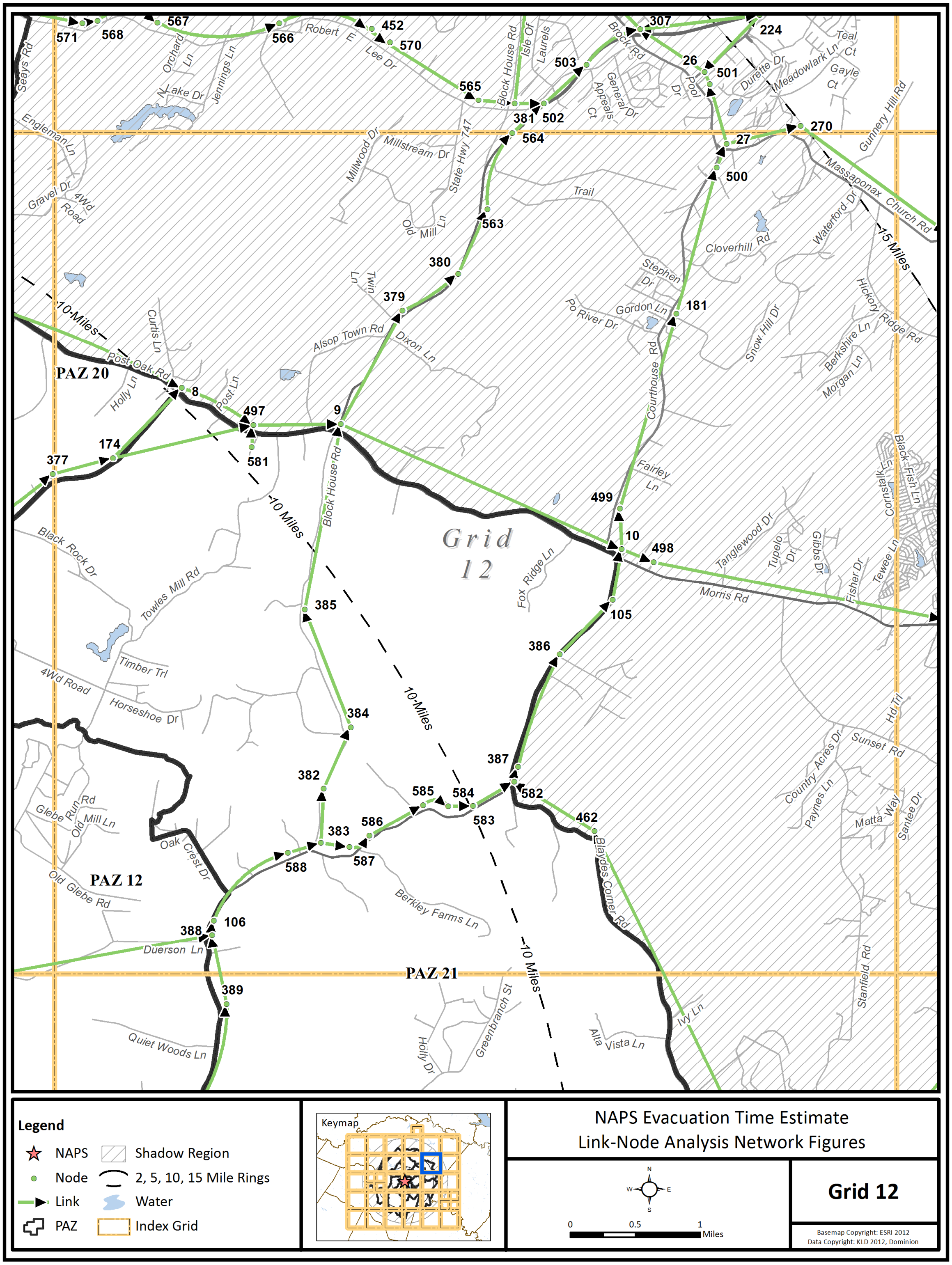


Figure K-13. Link-Node Analysis Network – Grid 12

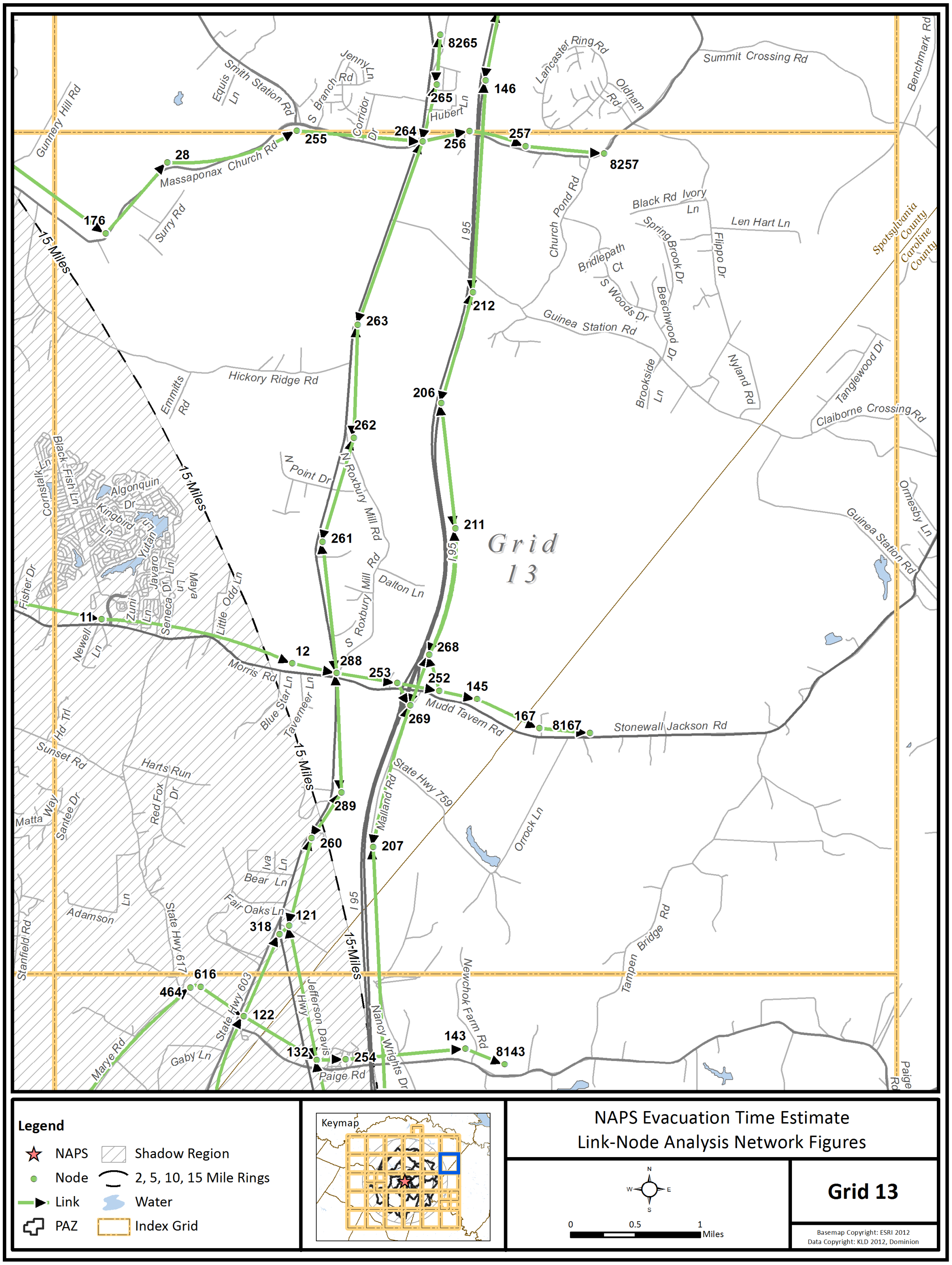


Figure K-14. Link-Node Analysis Network – Grid 13

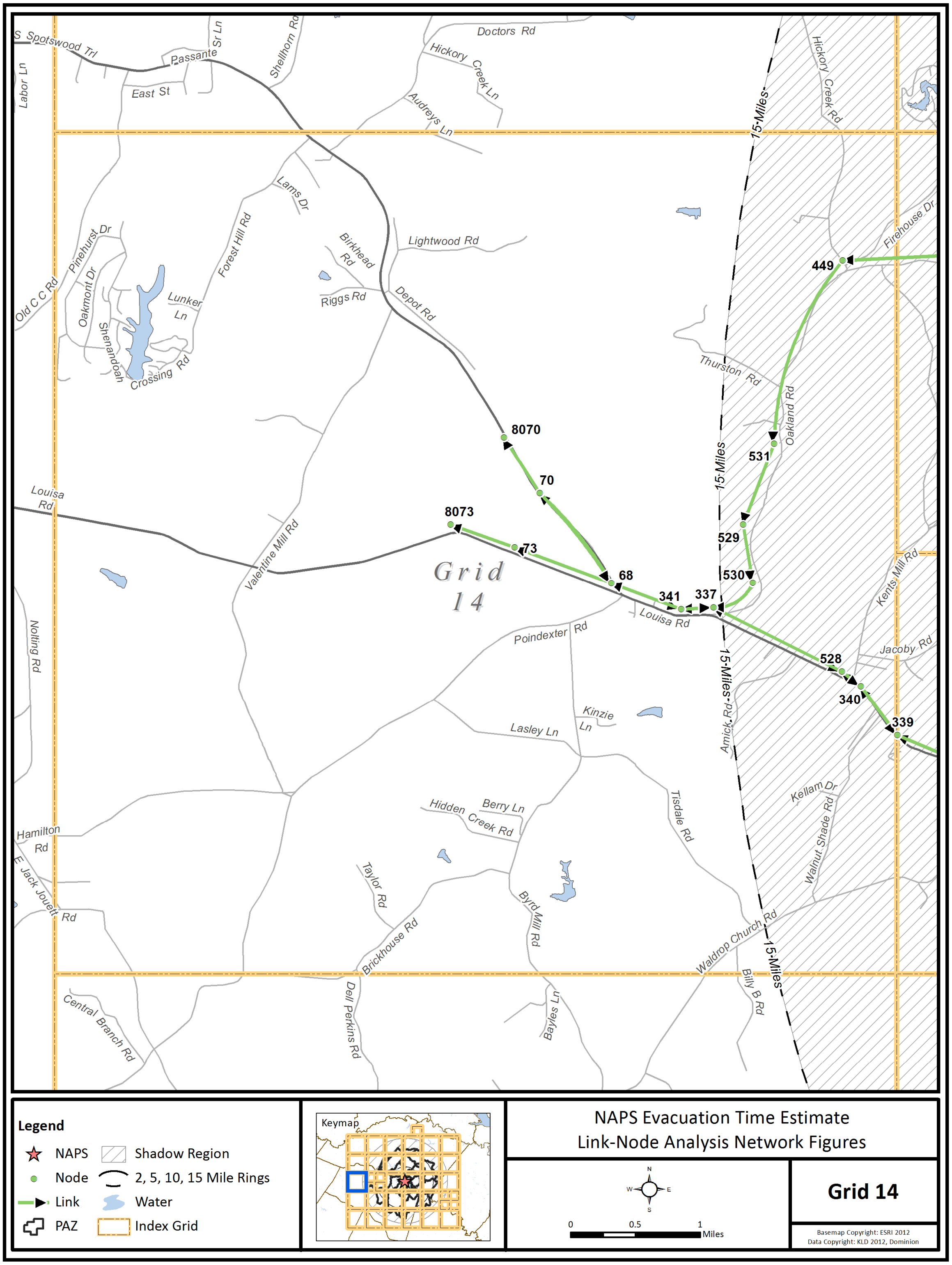


Figure K-15. Link-Node Analysis Network – Grid 14

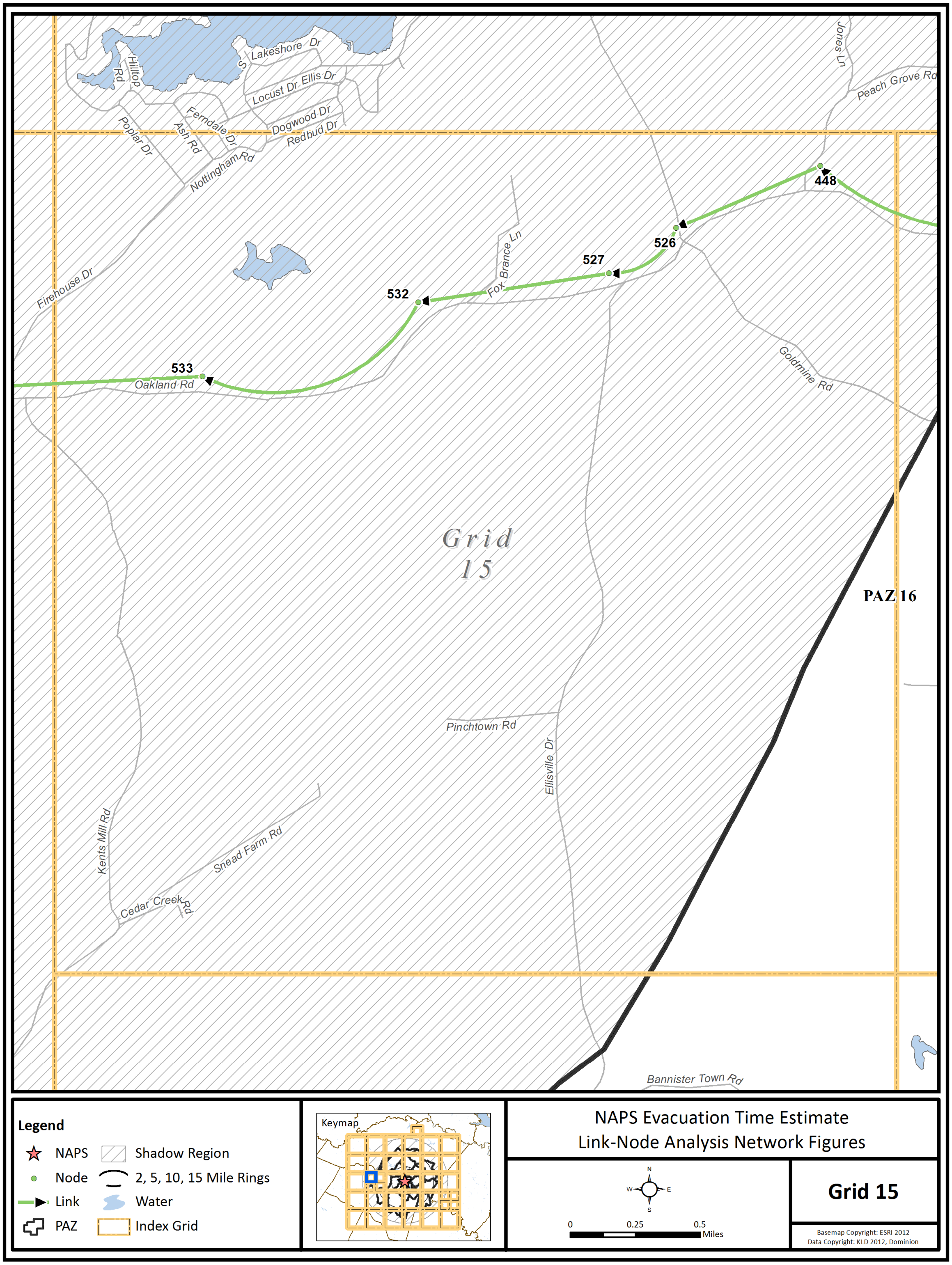


Figure K-16. Link-Node Analysis Network – Grid 15

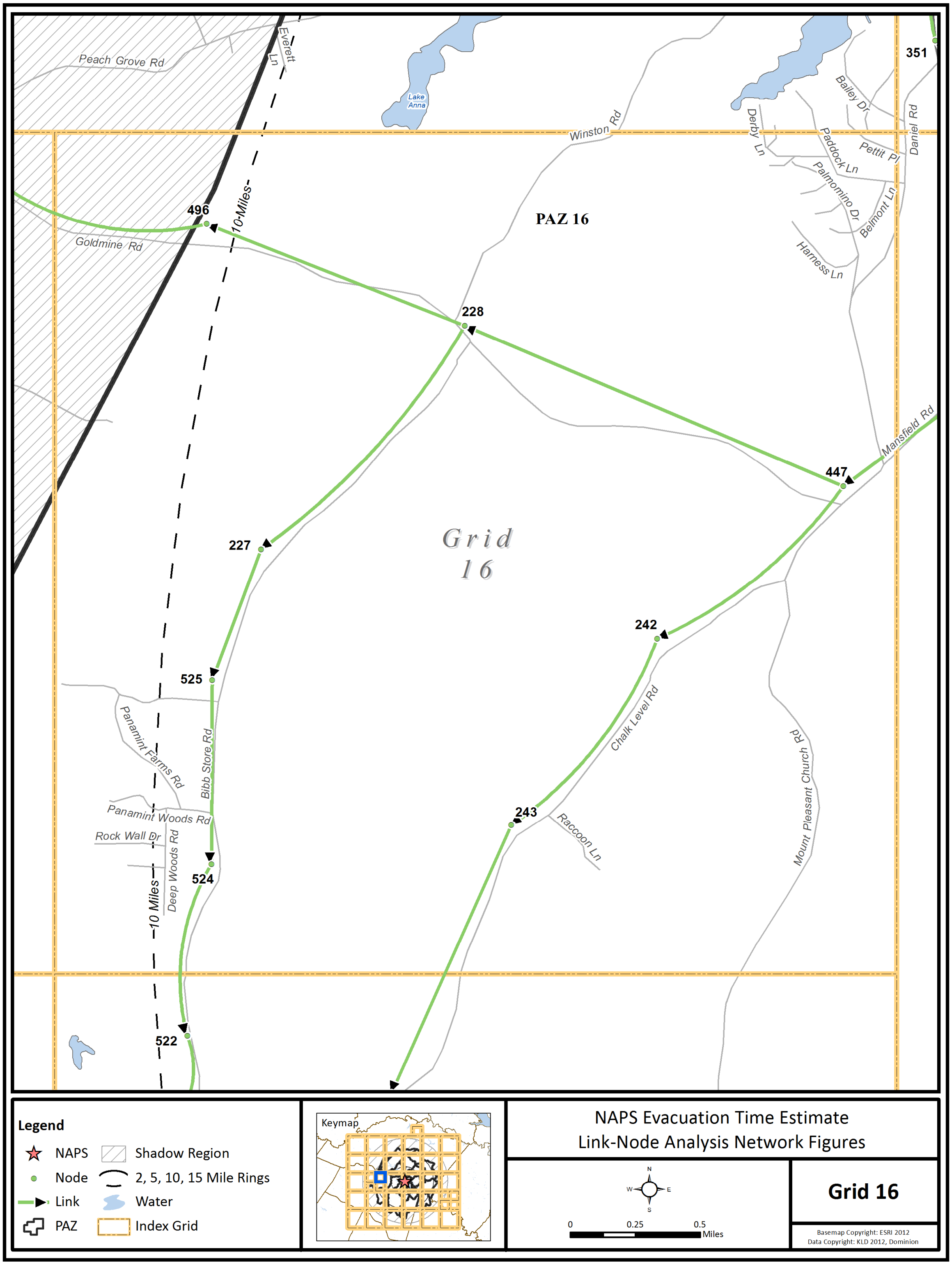


Figure K-17. Link-Node Analysis Network – Grid 16

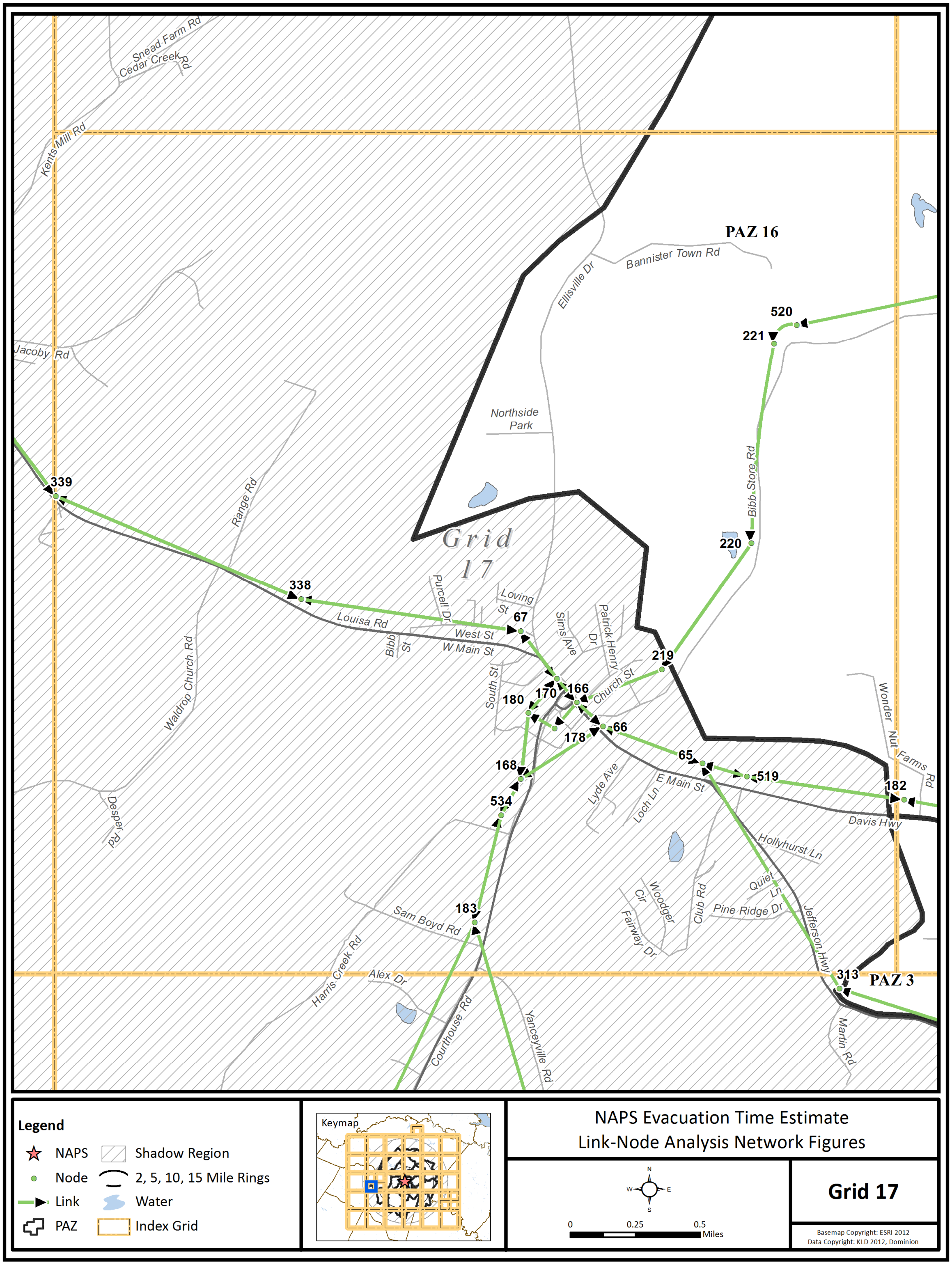


Figure K-18. Link-Node Analysis Network – Grid 17

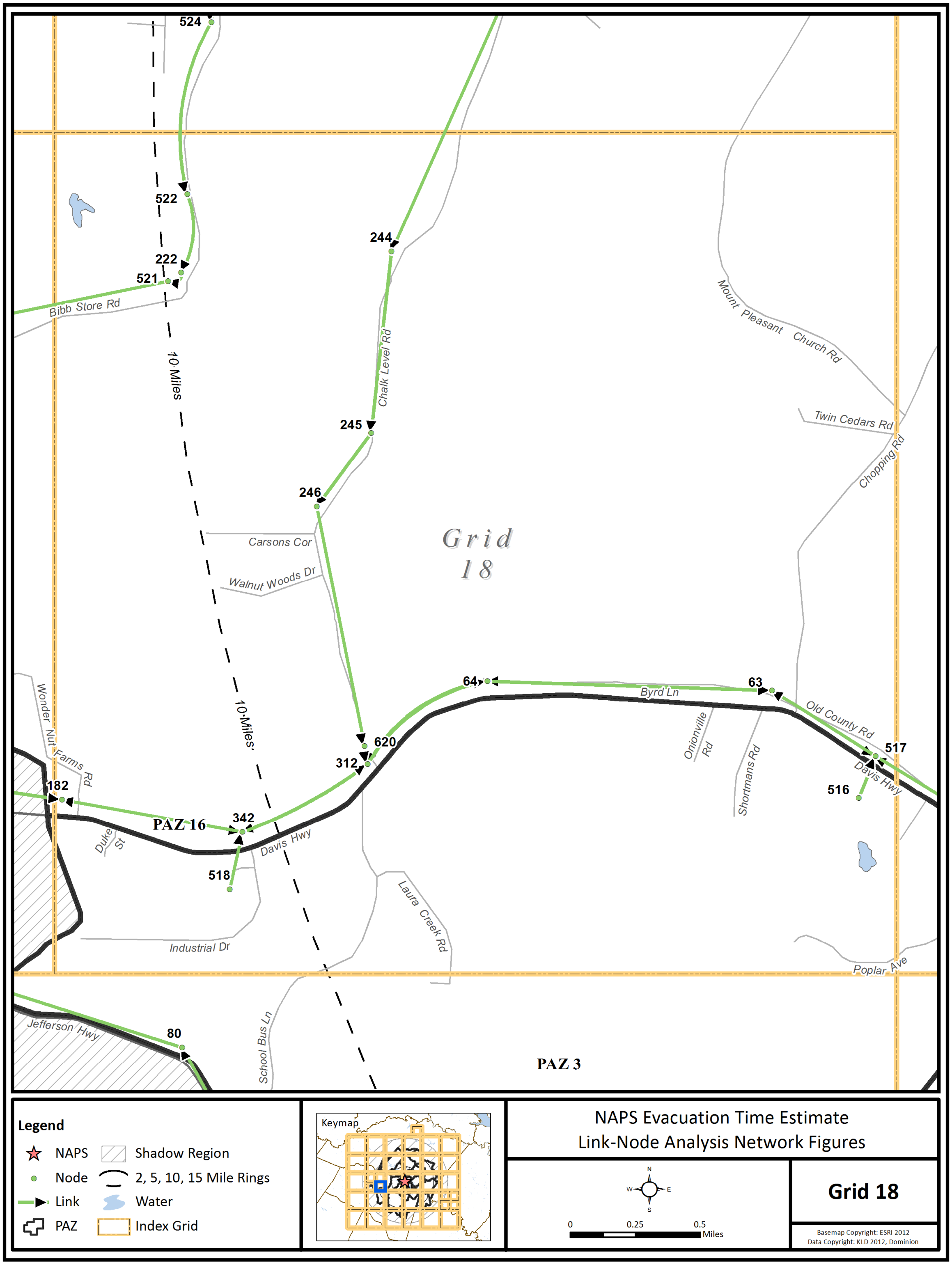


Figure K-19. Link-Node Analysis Network – Grid 18

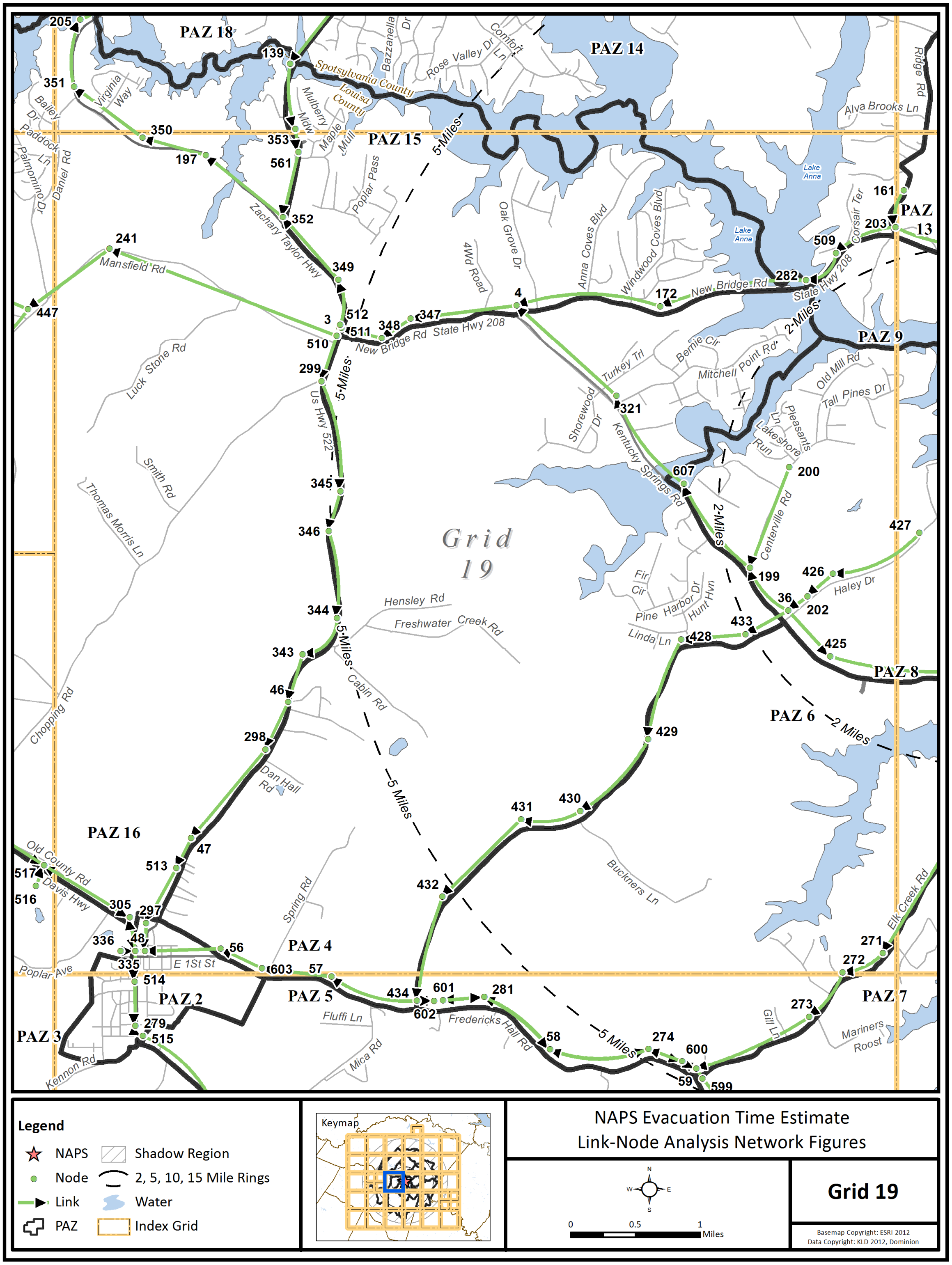


Figure K-20. Link-Node Analysis Network – Grid 19

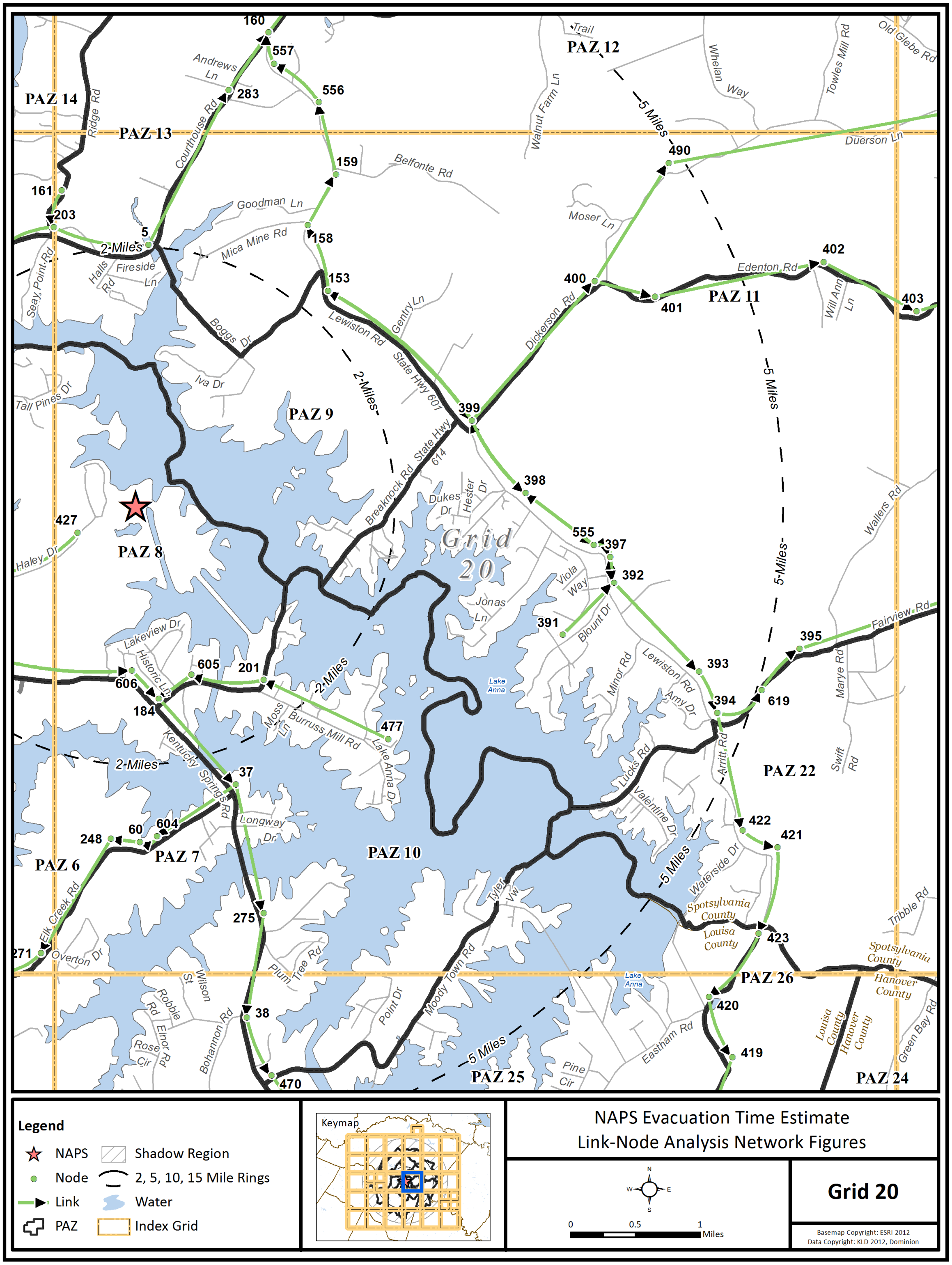


Figure K-21. Link-Node Analysis Network – Grid 20

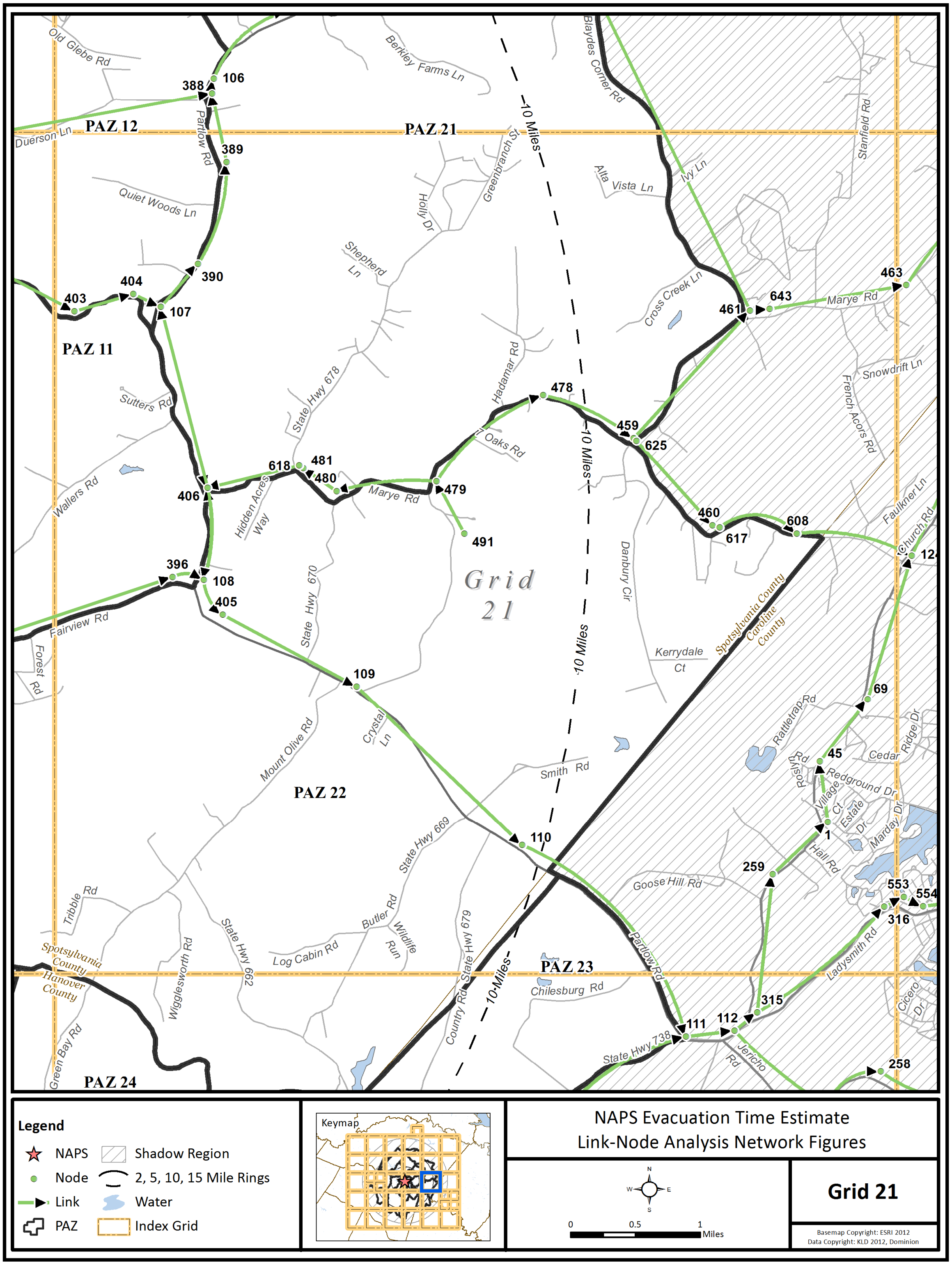


Figure K-22. Link-Node Analysis Network – Grid 21

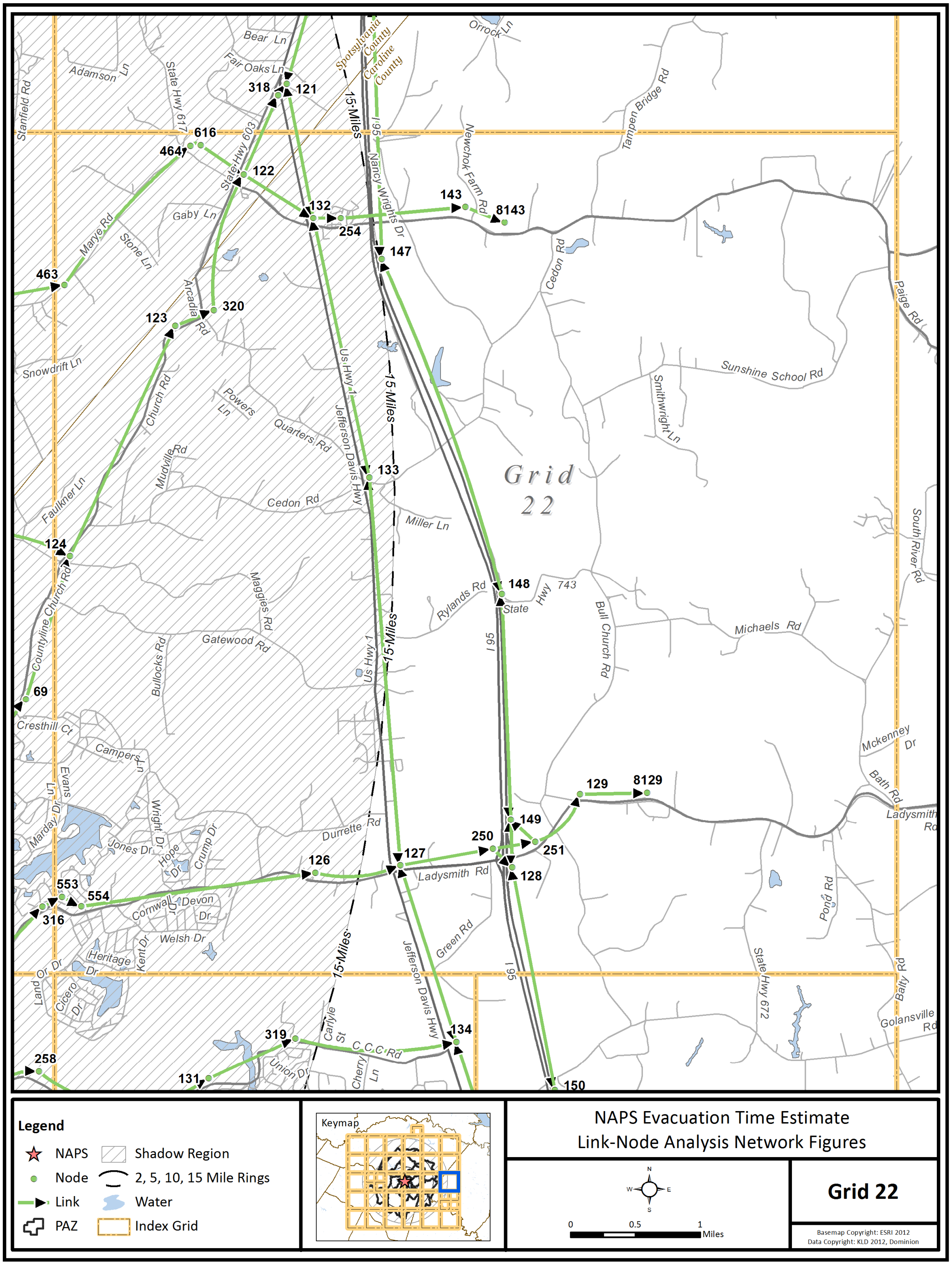


Figure K-23. Link-Node Analysis Network – Grid 22

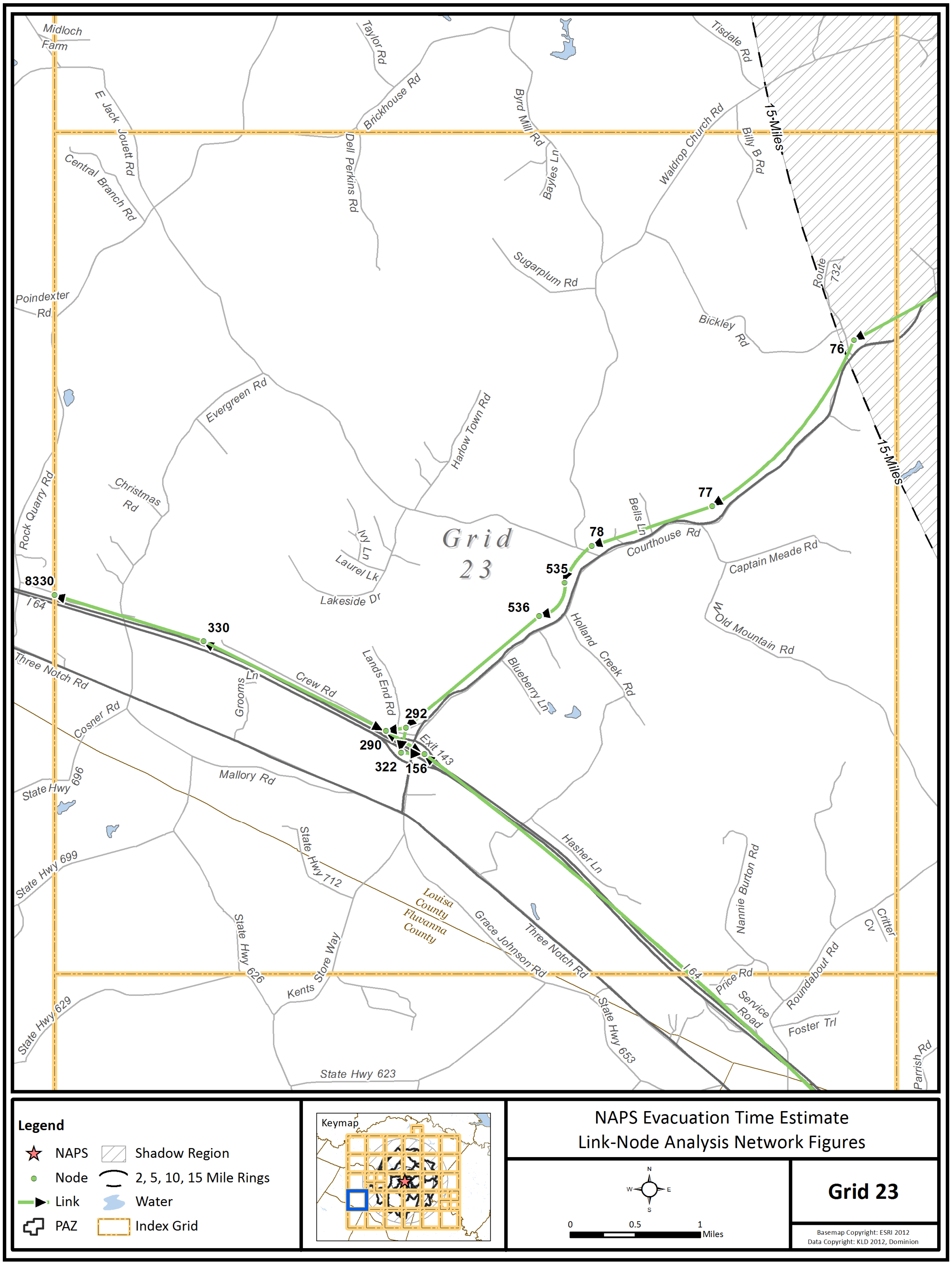


Figure K-24. Link-Node Analysis Network – Grid 23

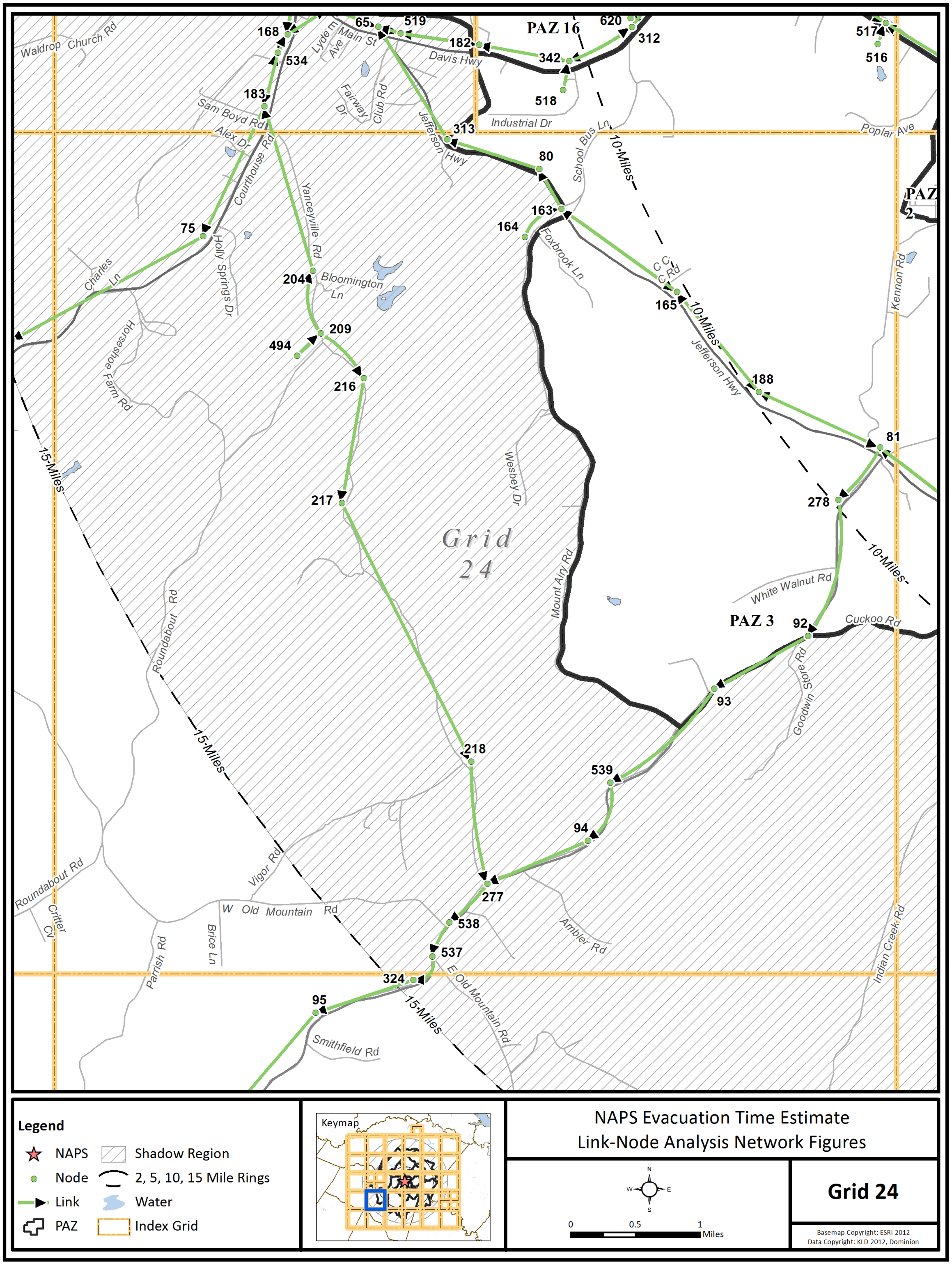


Figure K-25. Link-Node Analysis Network – Grid 24

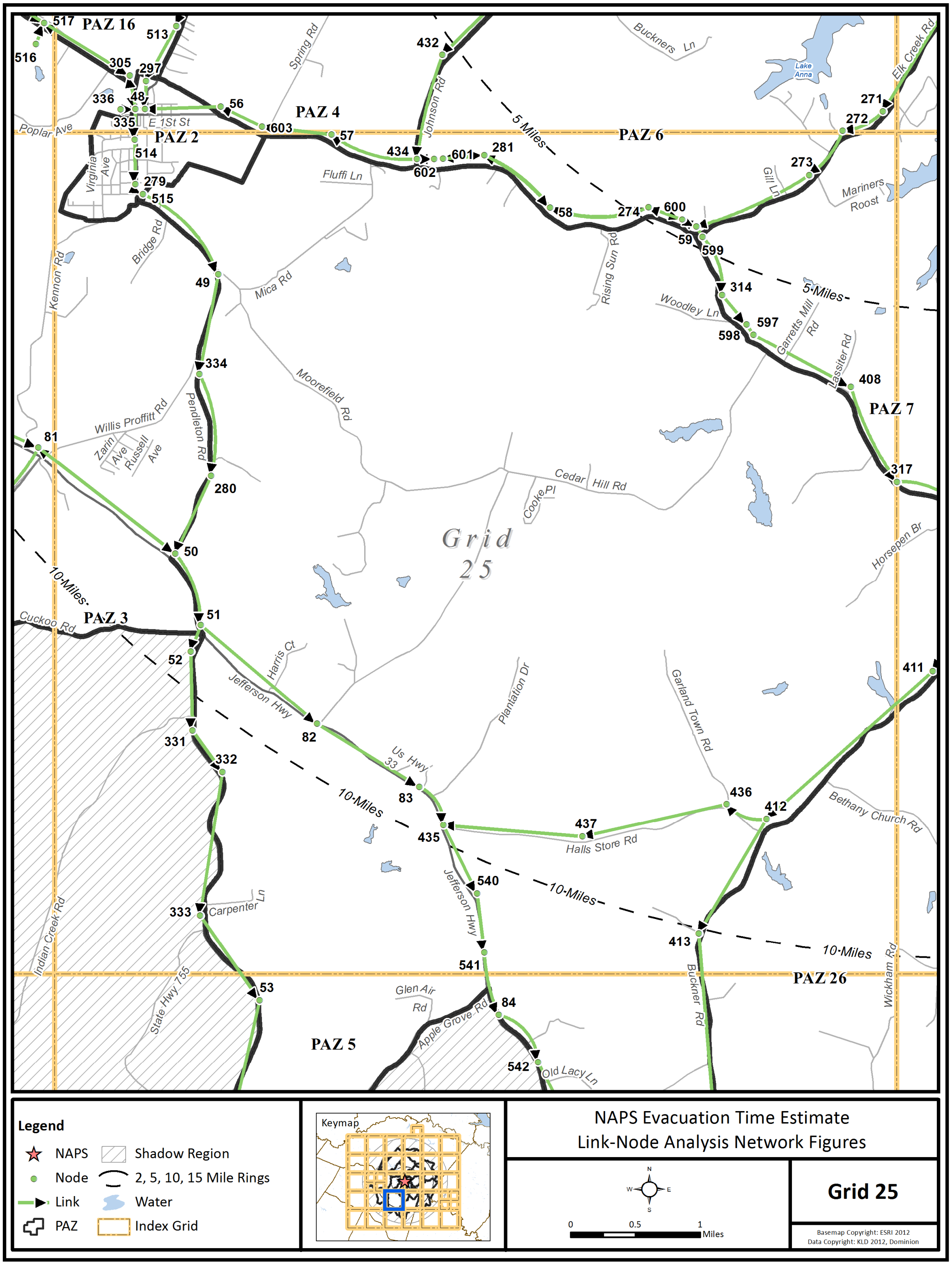


Figure K-26. Link-Node Analysis Network – Grid 25

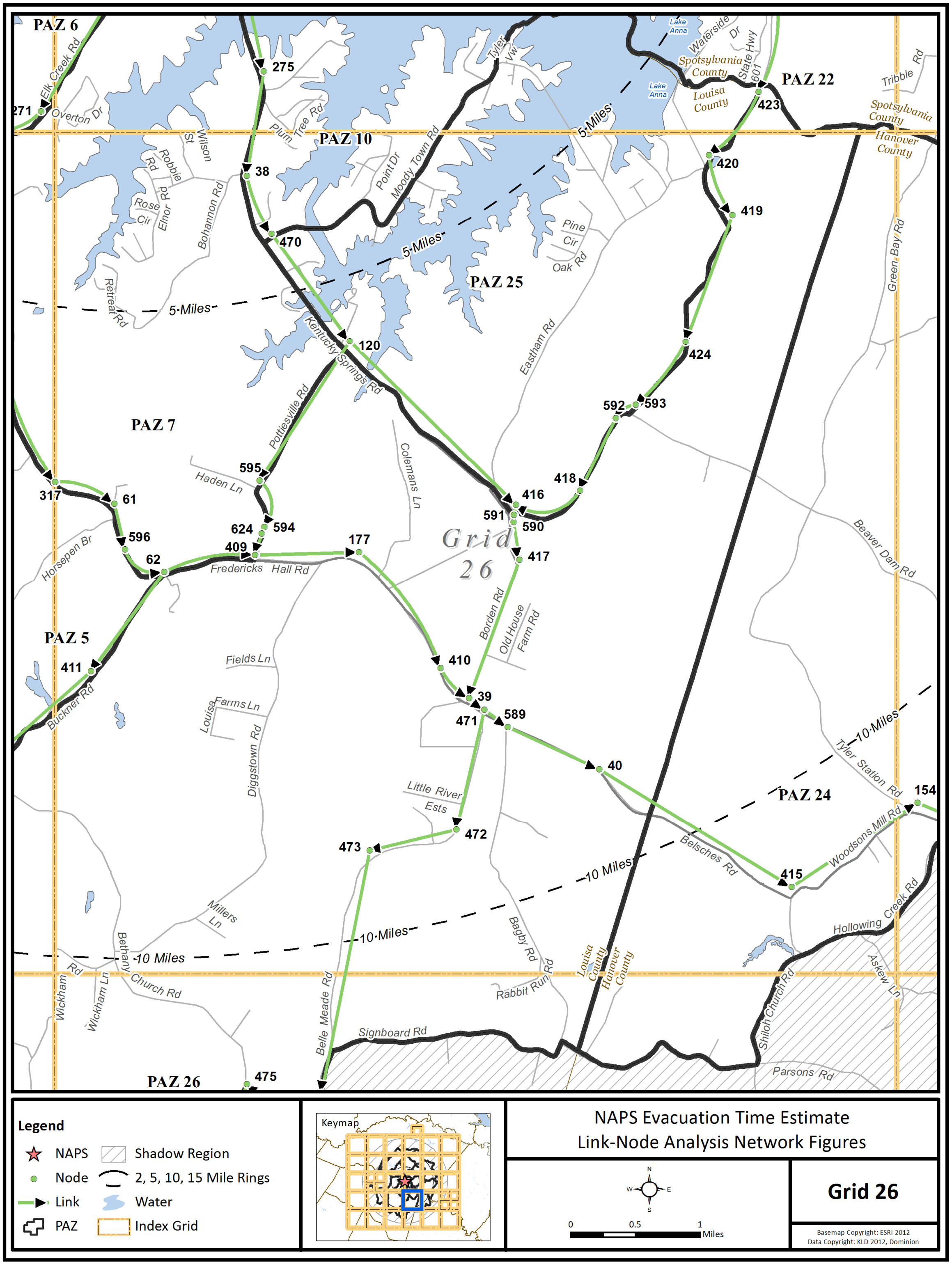


Figure K-27. Link-Node Analysis Network – Grid 26

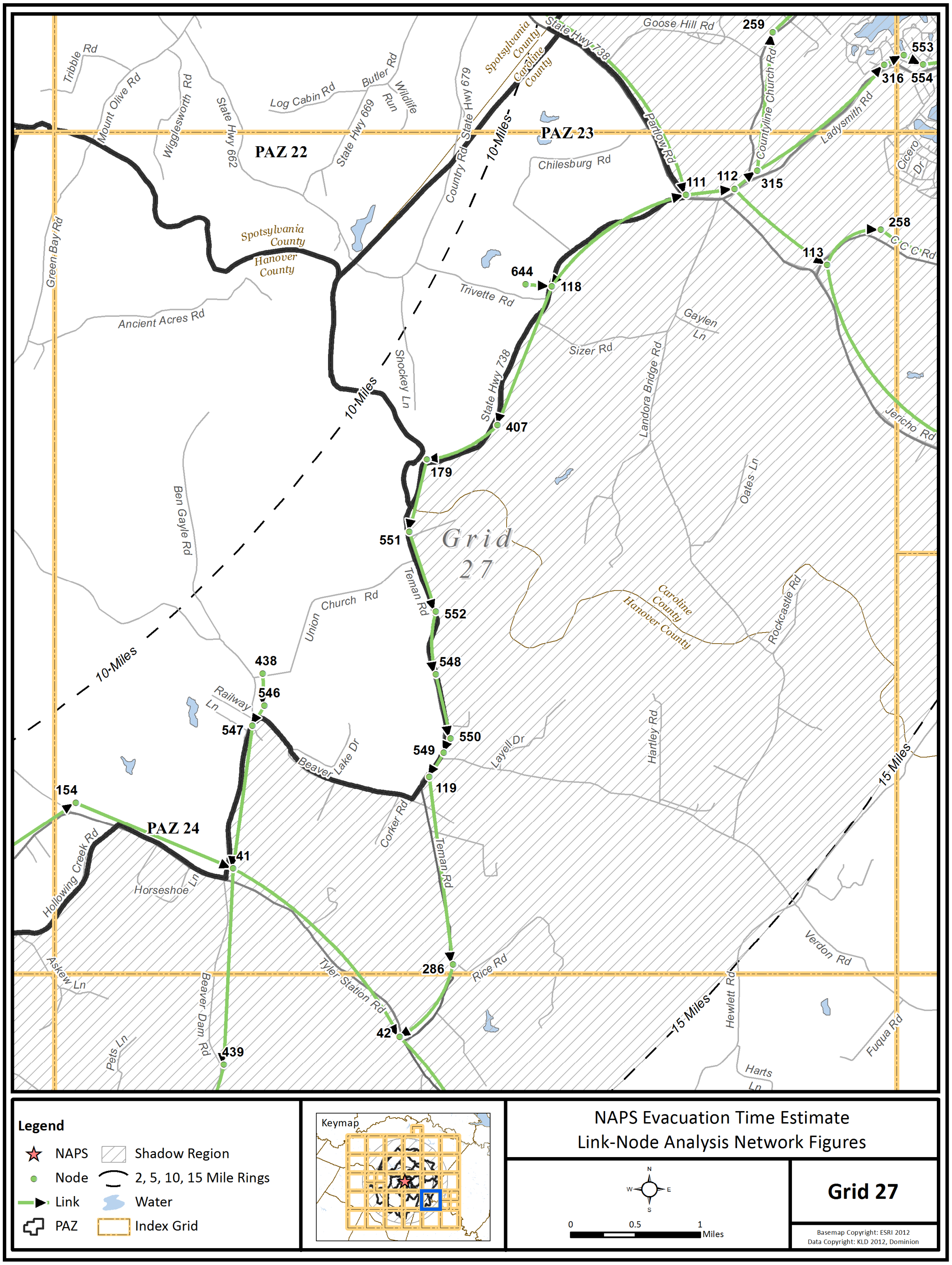


Figure K-28. Link-Node Analysis Network – Grid 27

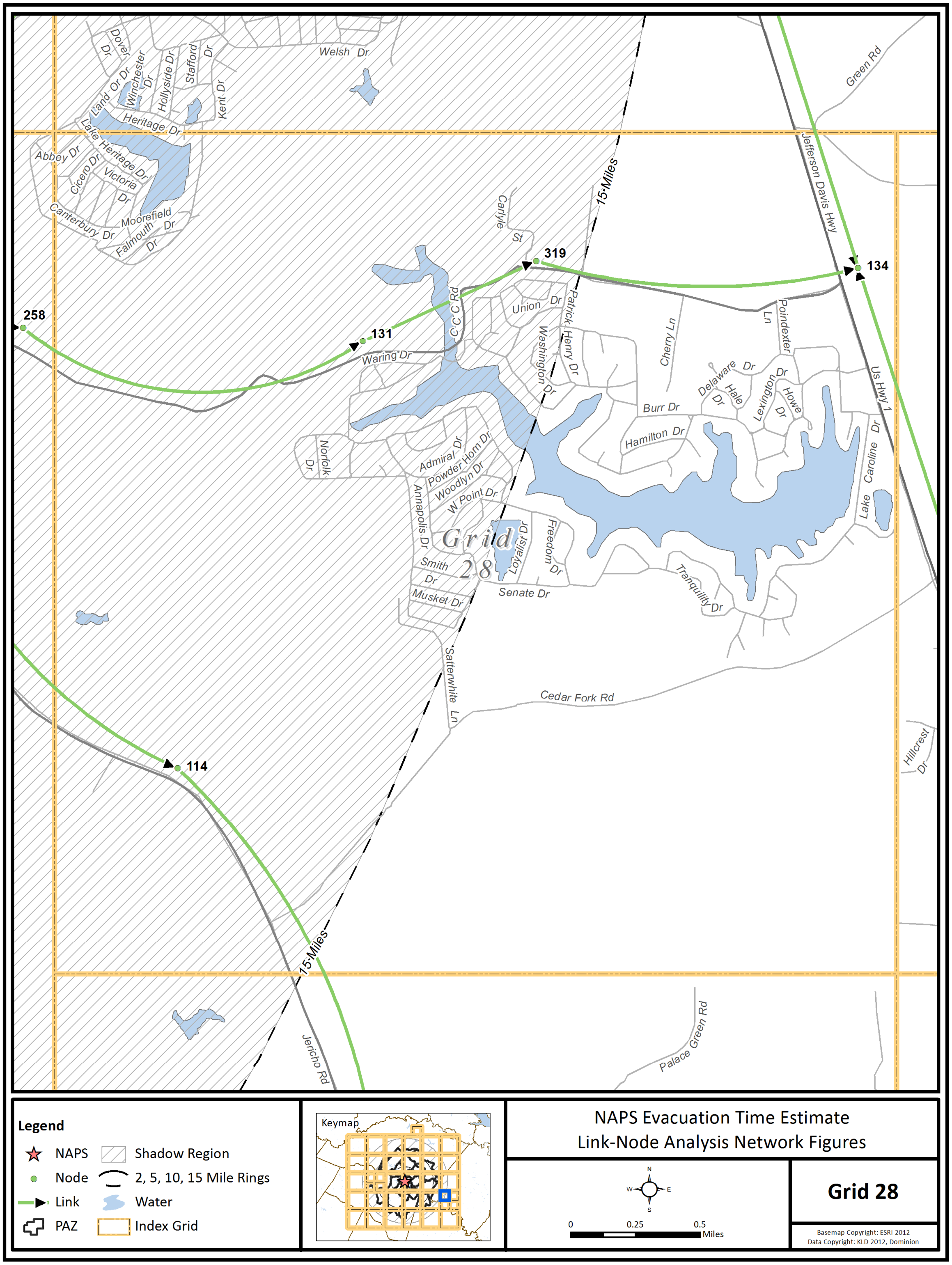


Figure K-29. Link-Node Analysis Network – Grid 28

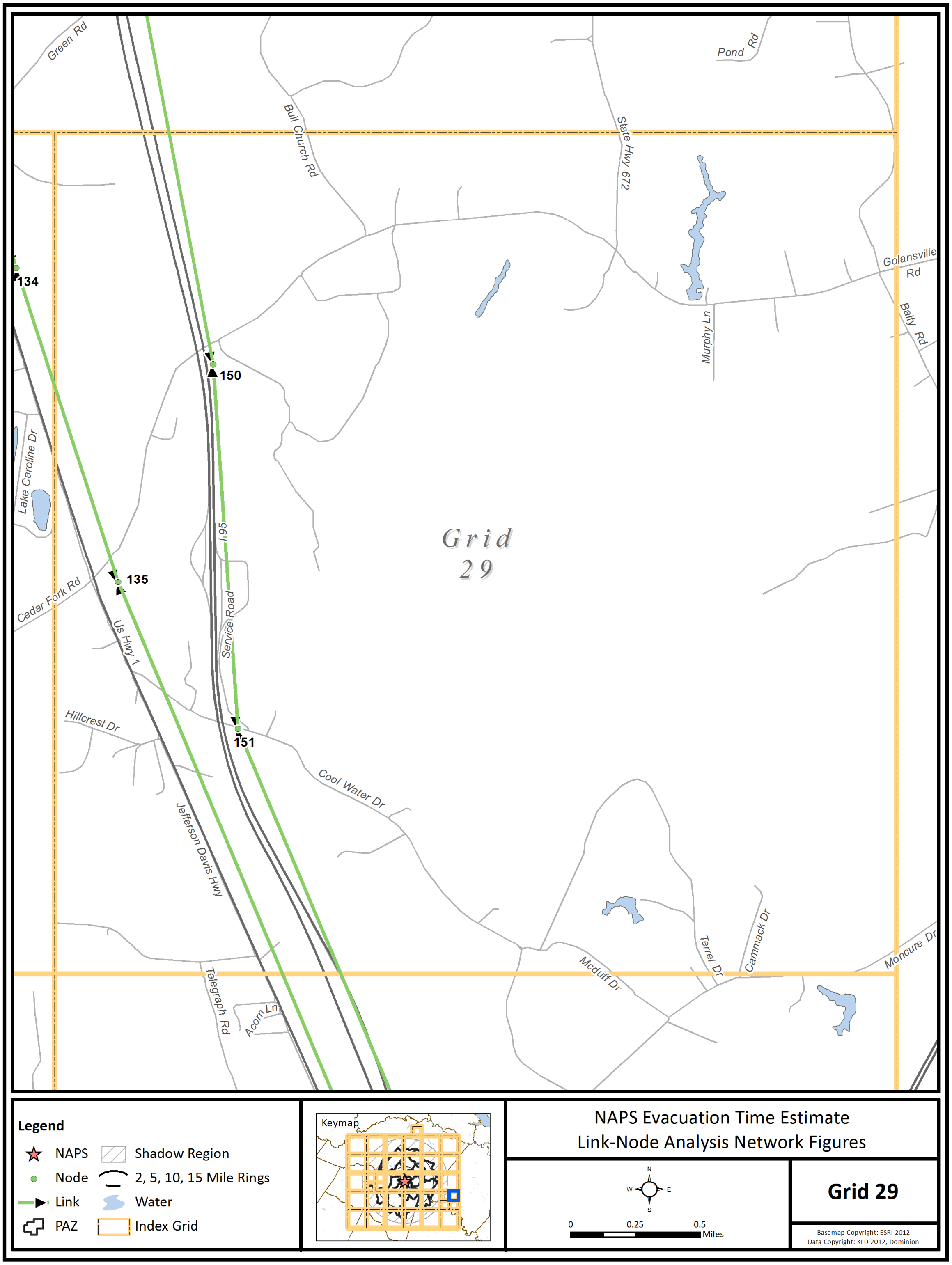


Figure K-30. Link-Node Analysis Network – Grid 29

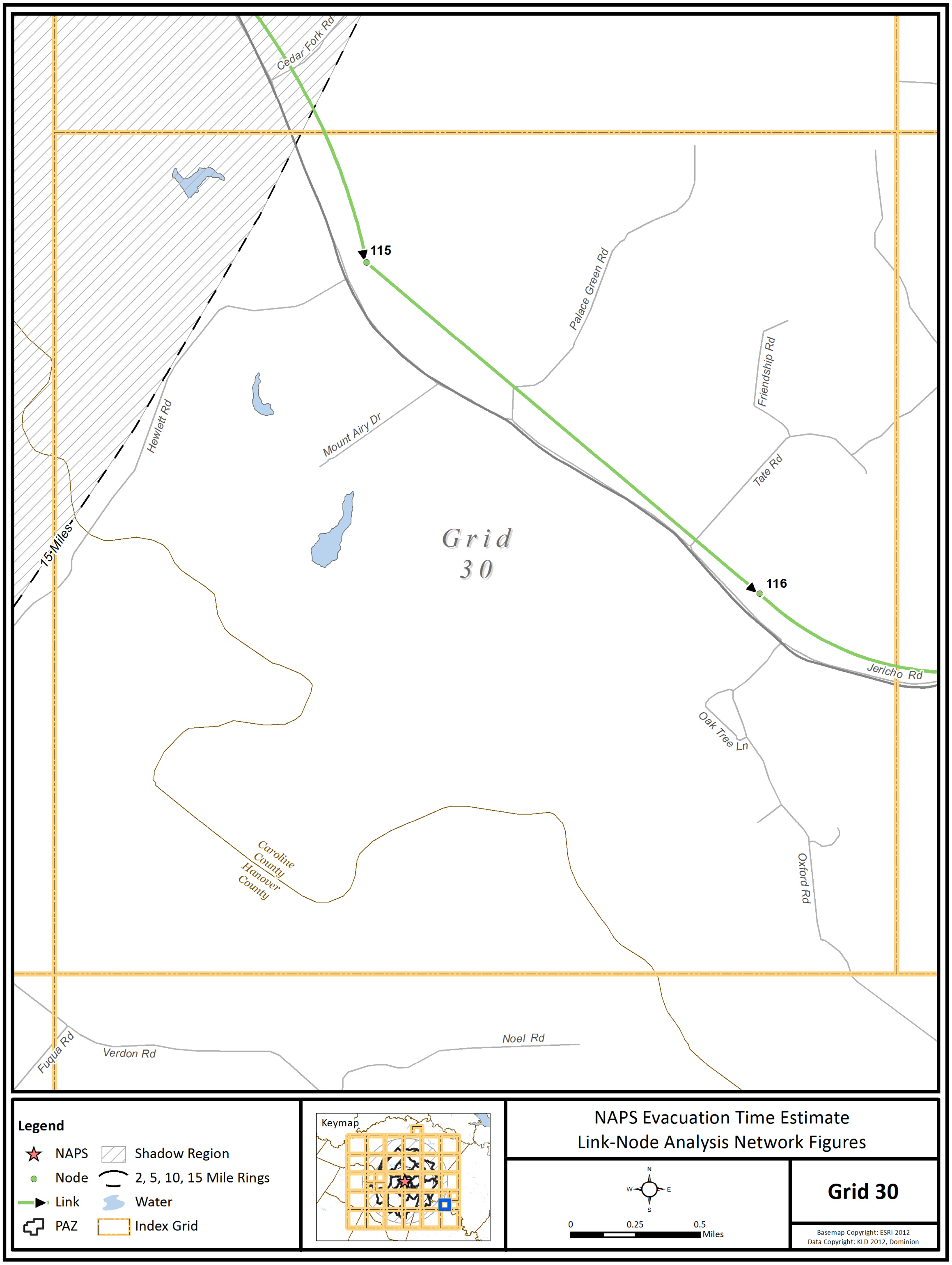


Figure K-31. Link-Node Analysis Network – Grid 30

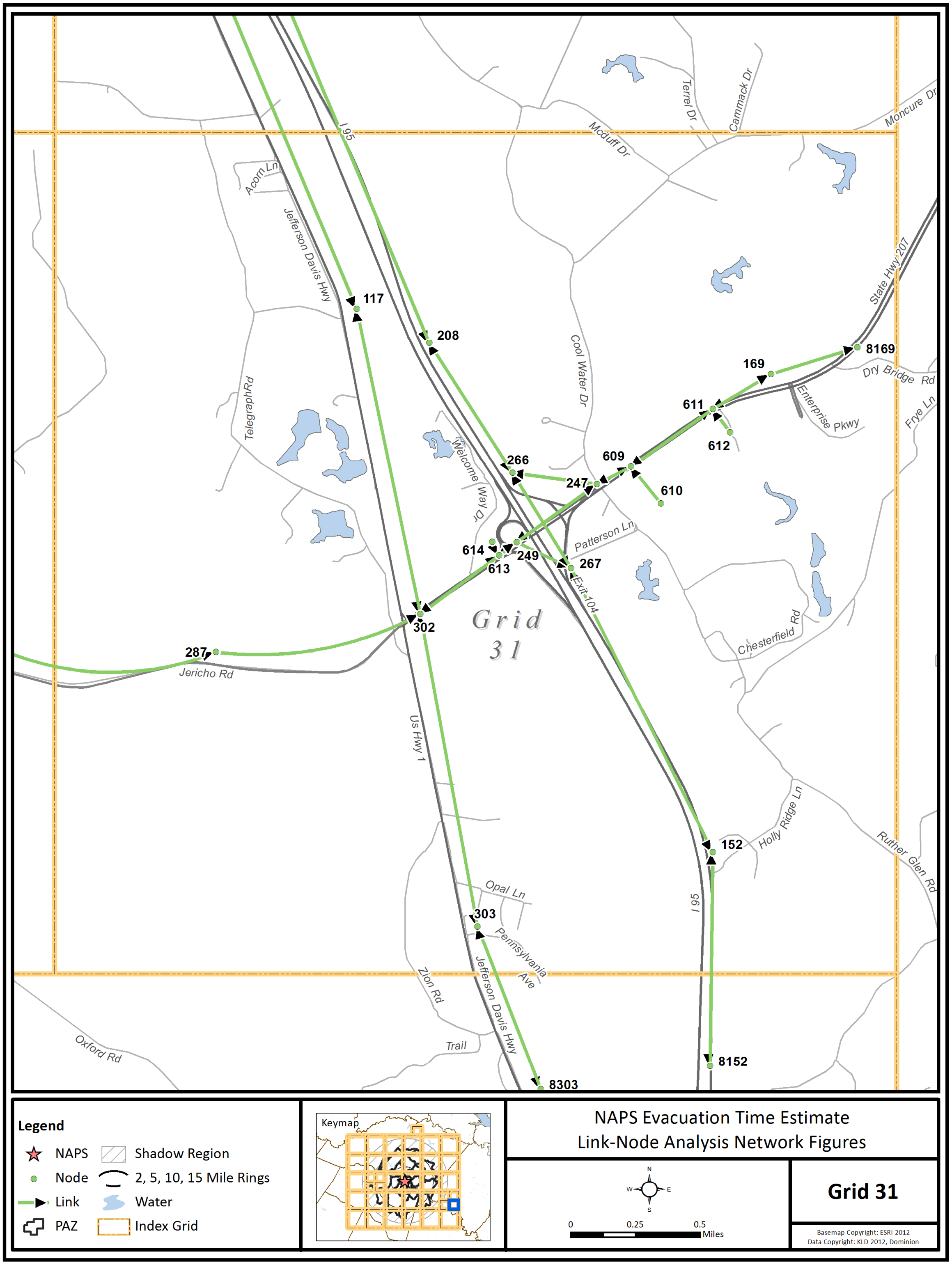


Figure K-32. Link-Node Analysis Network – Grid 31

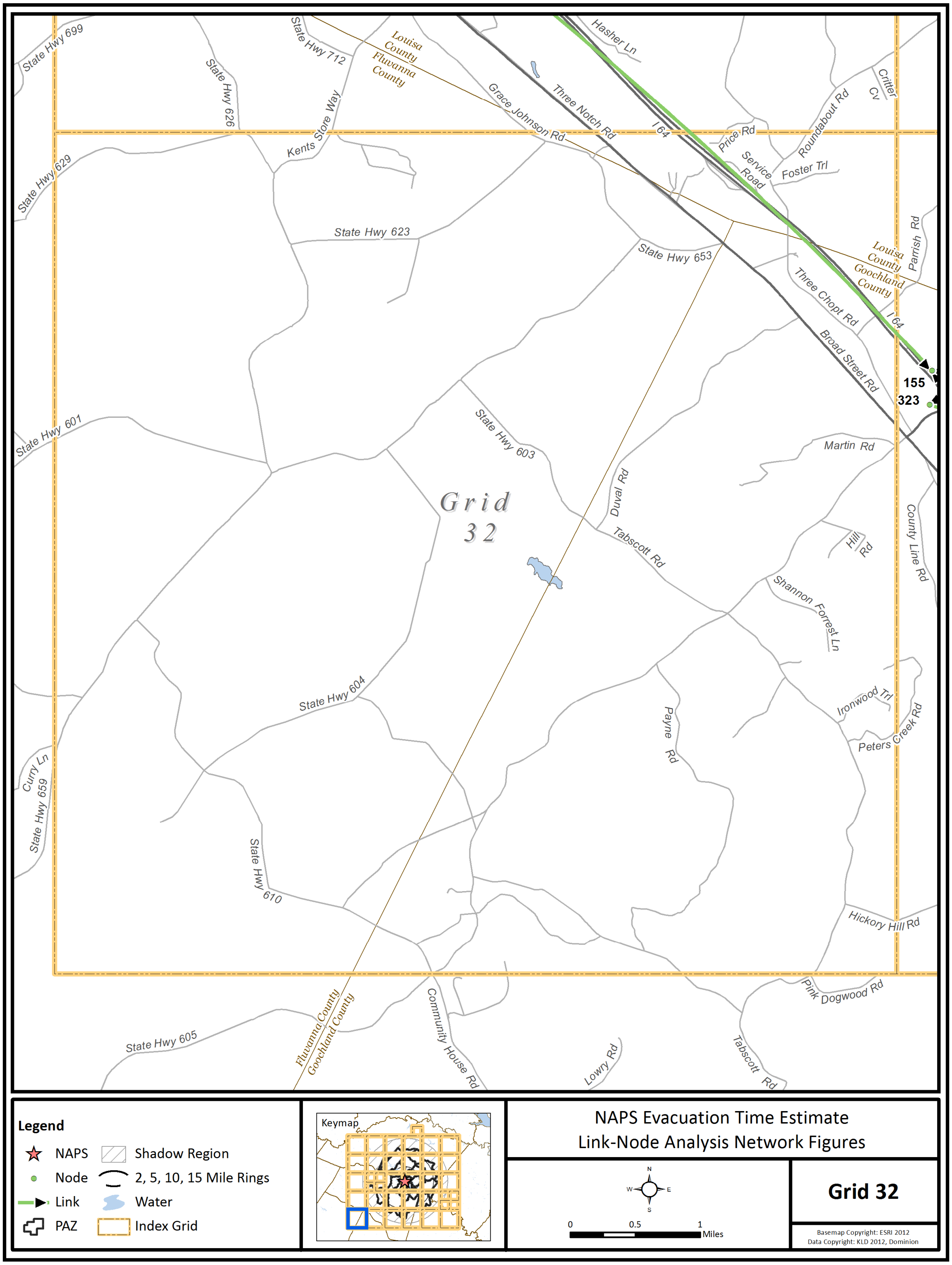


Figure K-33. Link-Node Analysis Network – Grid 32

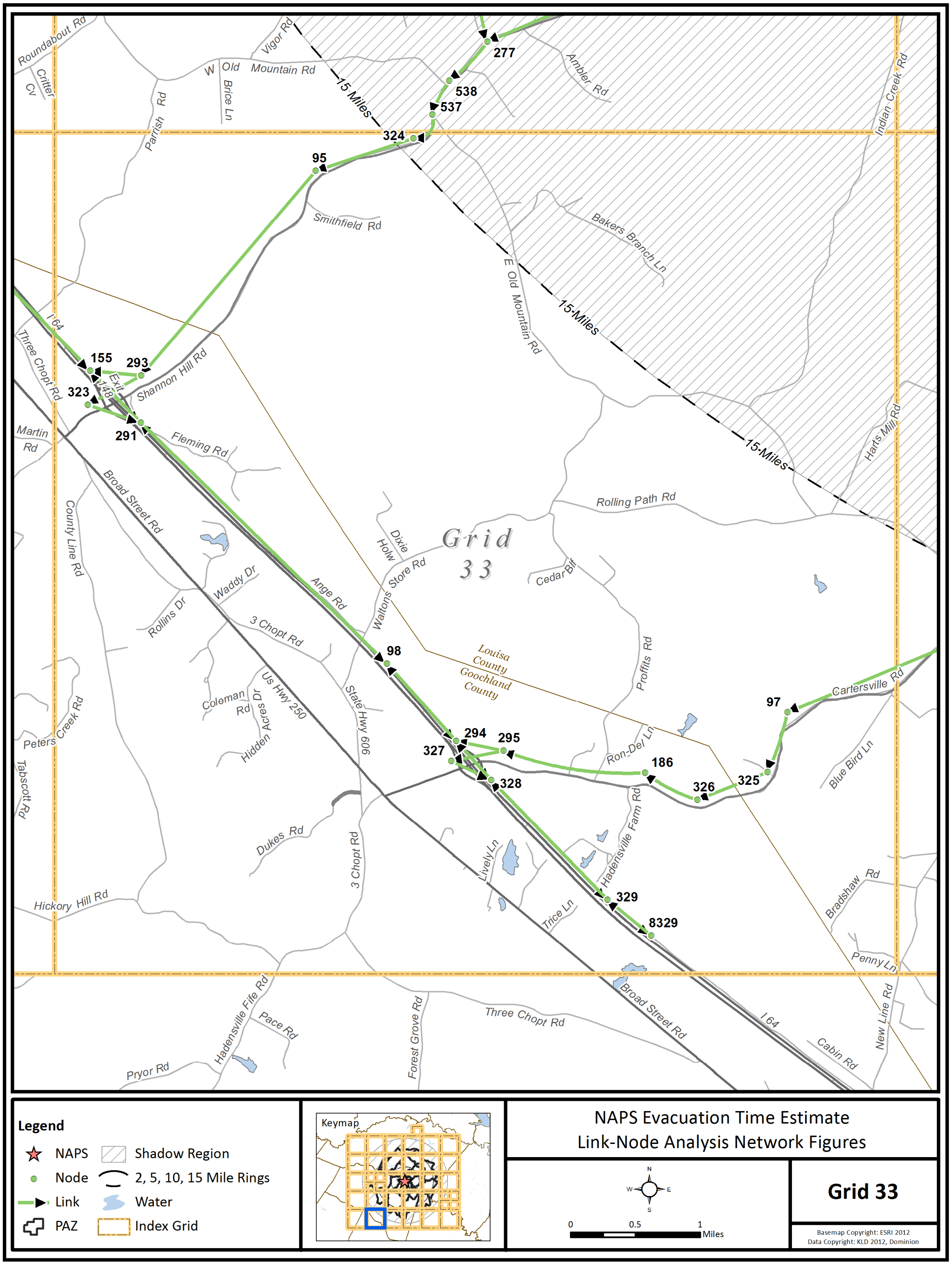


Figure K-34. Link-Node Analysis Network – Grid 33

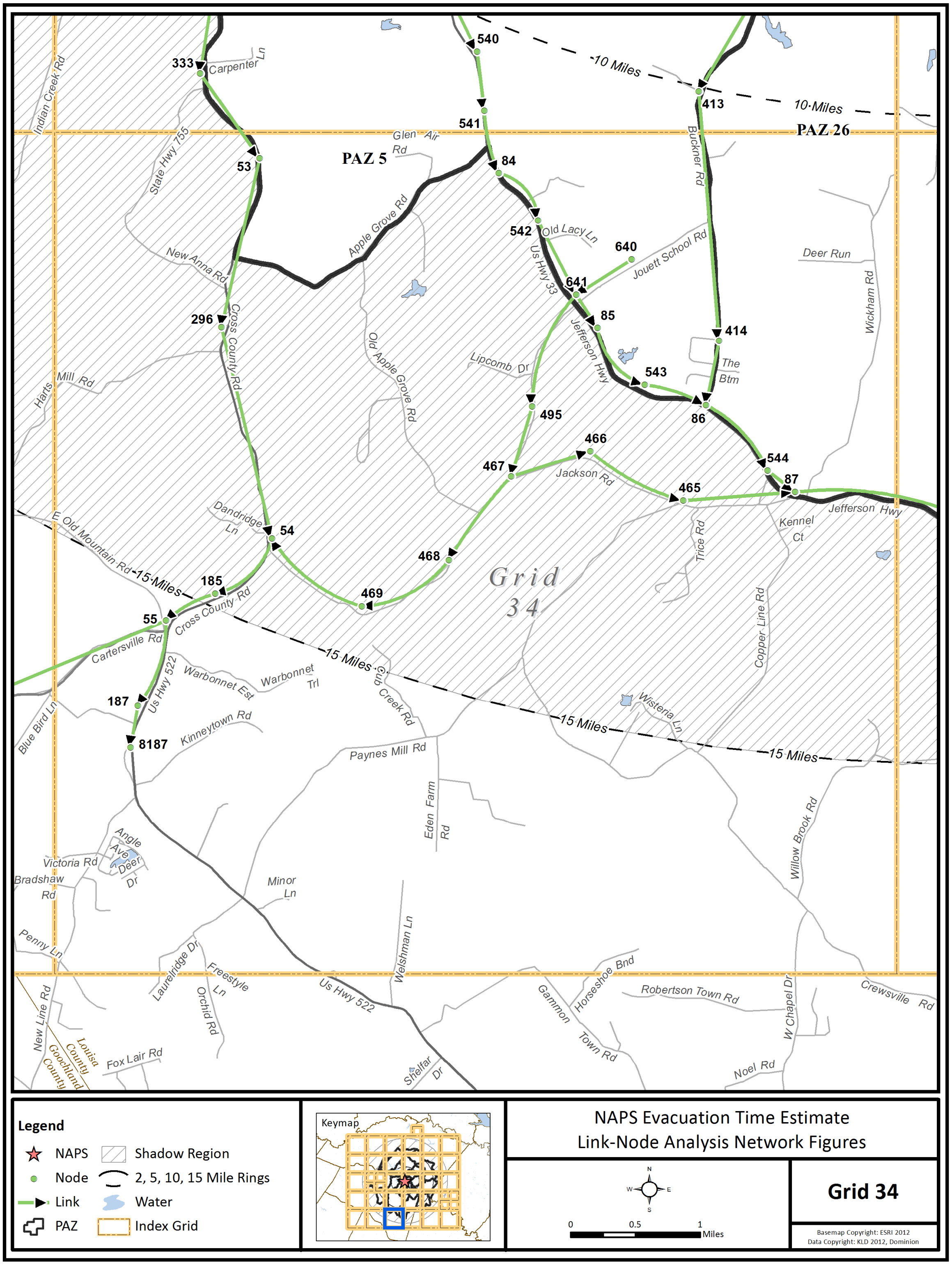


Figure K-35. Link-Node Analysis Network – Grid 34

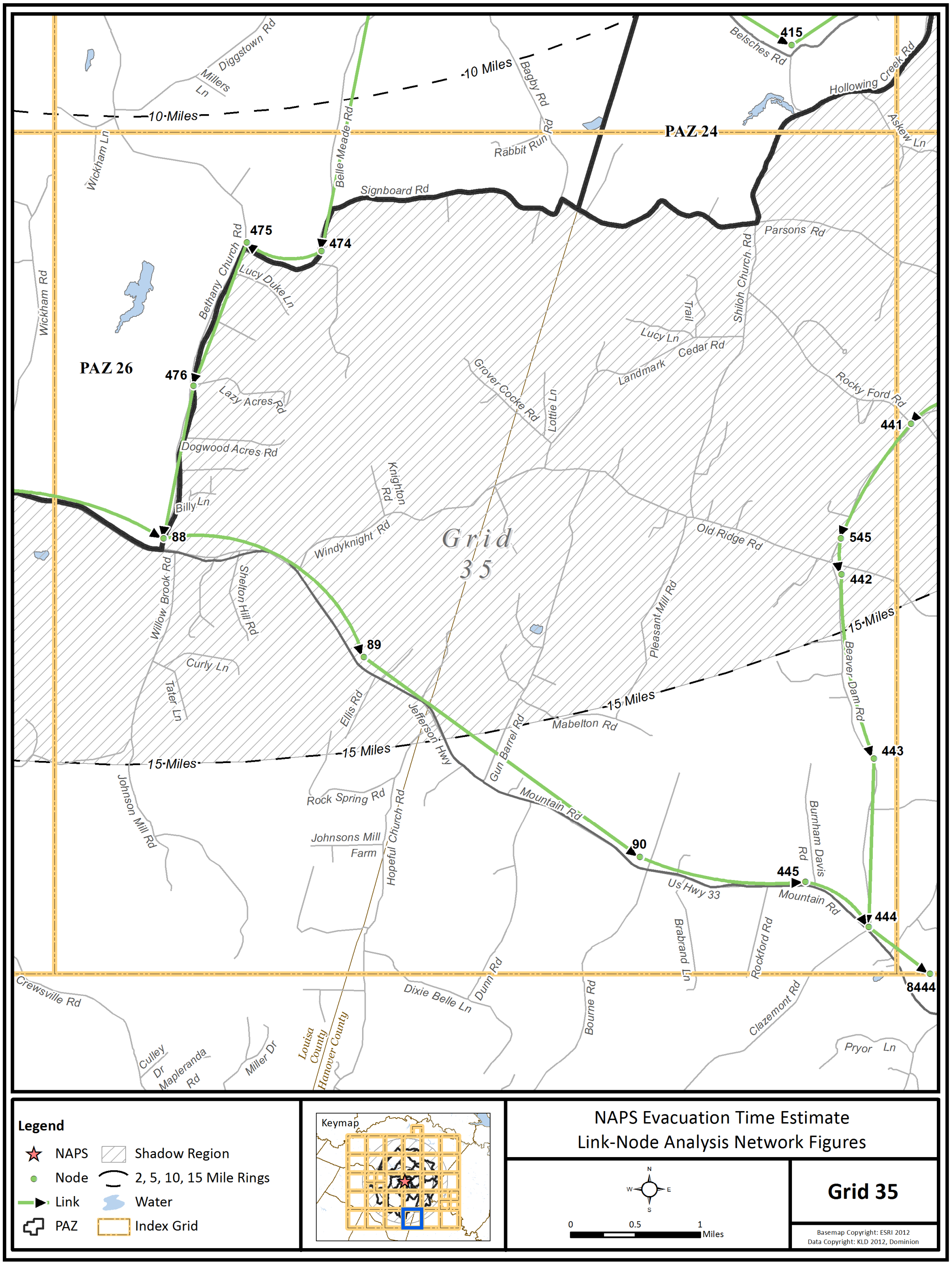


Figure K-36. Link-Node Analysis Network – Grid 35

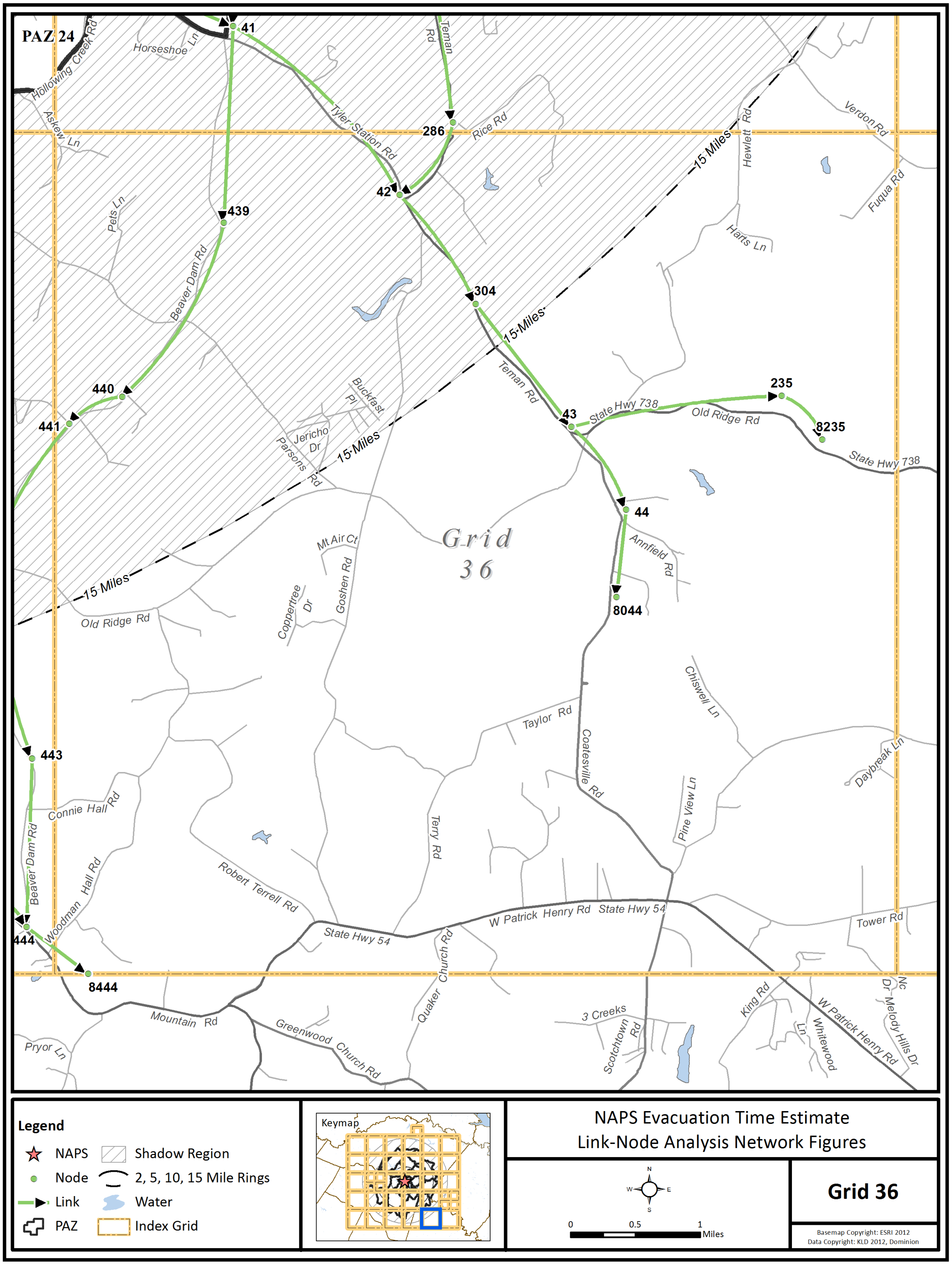


Figure K-37. Link-Node Analysis Network – Grid 36

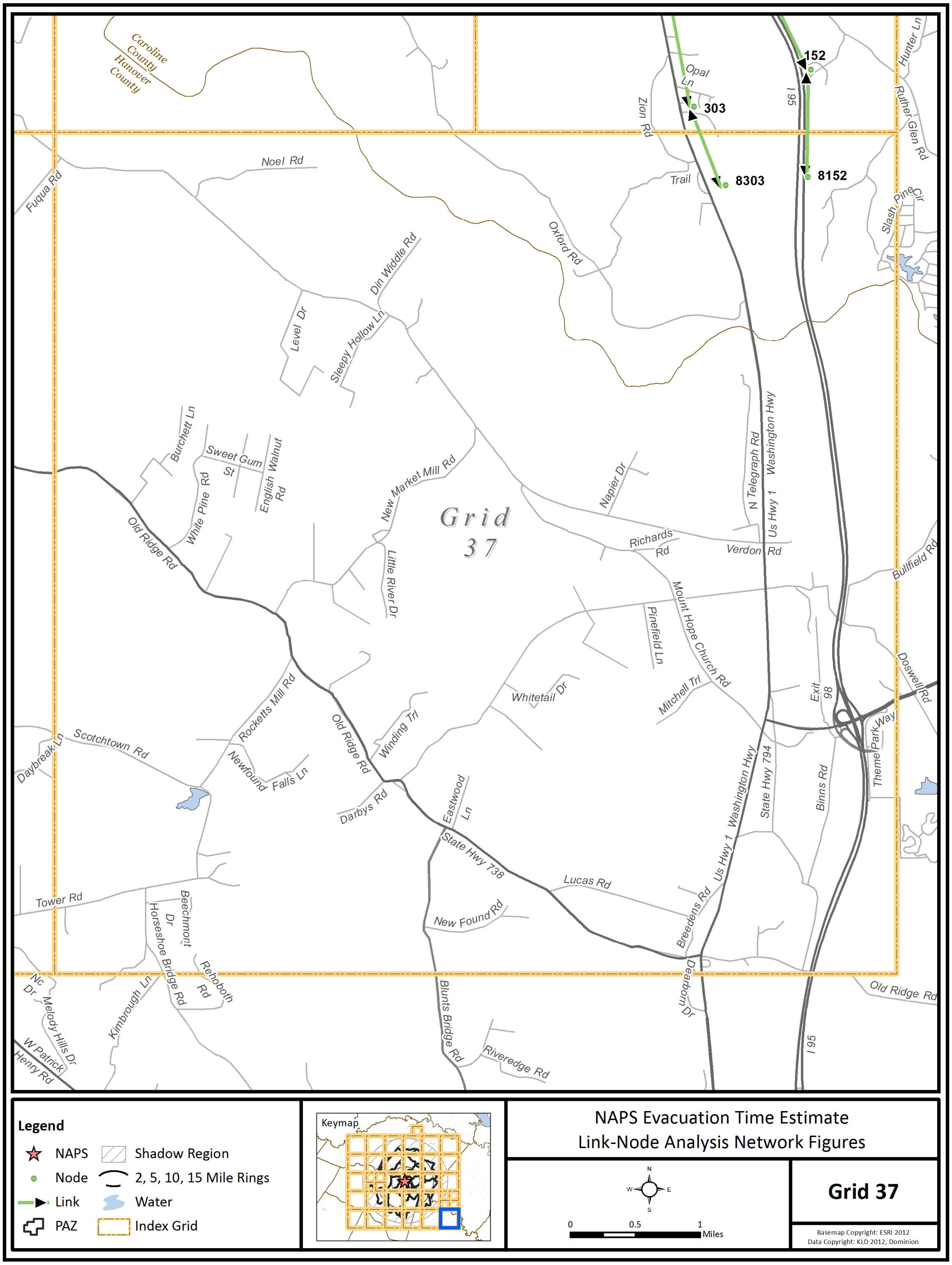


Figure K-38. Link-Node Analysis Network – Grid 37

Table K-1. Evacuation Roadway Network Characteristics

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
1	1	45	SR 603	COLLECTOR	2517	1	10	0	1700	55	21
2	2	194	SR 20	COLLECTOR	3683	1	12	3	1700	50	3
3	2	198	SR 20	COLLECTOR	5624	1	11	2	1700	60	3
4	2	231	US 522	COLLECTOR	3473	1	12	1	1700	60	3
5	3	510	US 522	COLLECTOR	351	1	12	1	1700	60	19
6	3	512	US 522	COLLECTOR	111	1	12	1	1700	60	19
7	4	347	SR 208	COLLECTOR	4353	1	12	1	1700	60	19
8	5	283	SR 208	COLLECTOR	7131	1	12	1	1700	60	20
9	6	144	CR 601	COLLECTOR	2655	1	11	0	1700	55	11
10	6	276	SR 208	COLLECTOR	5122	1	12	1	1700	60	11
11	7	378	SR 208	COLLECTOR	4774	1	12	1	1700	60	11
12	8	497	CR 606	COLLECTOR	3296	1	11	0	1750	50	12
13	9	10	SR 208	COLLECTOR	12530	1	12	1	1750	50	12
14	9	379	LAKE ANNA PKWY	COLLECTOR	5265	1	12	0	1700	45	12
15	10	498	CR 606	COLLECTOR	1409	1	12	0	1700	40	12
16	10	499	SR 208	COLLECTOR	1642	1	12	0	1700	40	12
17	11	12	CR 606	COLLECTOR	8027	1	12	0	1700	55	13
18	12	288	CR 606	COLLECTOR	1849	1	12	0	1750	40	13
19	13	35	US 522	COLLECTOR	4037	1	12	1	1700	60	10
20	14	482	US 522	COLLECTOR	5636	1	12	1	1750	60	9
21	15	195	US 522	COLLECTOR	15727	1	12	1	1700	60	3
22	16	232	SR 20	COLLECTOR	4864	1	12	3	1700	60	4
23	16	370	SR 20	COLLECTOR	3236	1	12	3	1700	60	4
24	17	16	SR 621	COLLECTOR	3855	1	10	0	1700	50	4

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
25	18	191	SR 621	COLLECTOR	5721	1	10	0	1700	50	4
26	18	311	SR 621	COLLECTOR	9916	1	10	0	1700	50	4
27	19	373	CR 621	COLLECTOR	6009	1	10	0	1700	50	5
28	19	374	CR 621	COLLECTOR	2969	1	10	0	1700	50	5
29	20	190	CR 621	COLLECTOR	11577	1	10	0	1700	50	1
30	20	223	CR 613	COLLECTOR	3304	1	12	0	1700	50	1
31	20	238	CR 621	COLLECTOR	3408	1	10	0	1700	50	1
32	21	193	CR 606	COLLECTOR	5144	1	11	0	1700	50	4
33	22	192	CR 606	COLLECTOR	6859	1	11	0	1700	50	4
34	23	285	CR 606	COLLECTOR	2892	1	11	0	1700	50	11
35	23	489	CR 606	COLLECTOR	7531	1	11	0	1700	50	11
36	24	306	CR 612	COLLECTOR	2615	1	10	0	1700	45	6
37	24	310	CR 613	COLLECTOR	2306	1	12	0	1700	50	6
38	25	225	CR 627	COLLECTOR	5717	1	12	2	1700	45	6
39	25	308	CR 613	COLLECTOR	6944	1	12	0	1700	50	6
40	26	224	SR 208 BUS	LOCAL ROADWAY	3232	1	12	4	1750	25	6
41	26	307	CR 613	COLLECTOR	3141	1	12	0	1750	40	6
42	27	270	CR 608	COLLECTOR	3107	1	12	0	1700	45	12
43	27	501	SR 208	COLLECTOR	2544	1	12	0	1700	40	6
44	28	255	CR 608	COLLECTOR	5503	1	12	0	1700	45	13
45	30	213	SR 20	COLLECTOR	4416	1	11	2	1700	60	3
46	30	368	SR 20	COLLECTOR	5866	1	11	2	1700	60	3
47	31	214	SR 20	COLLECTOR	1827	1	11	2	1700	40	2
48	31	215	SR 20	COLLECTOR	5871	1	11	2	1700	40	2
49	32	361	CR 612	COLLECTOR	4349	1	10	0	1700	60	2

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
50	33	359	CR 612	COLLECTOR	9382	1	10	0	1700	60	9
51	34	301	CR 612	COLLECTOR	3718	1	10	0	1700	40	9
52	35	14	US 522	COLLECTOR	4699	1	12	1	1700	60	9
53	35	300	CR 612	COLLECTOR	1778	1	10	0	1700	40	9
54	36	199	SR 652	COLLECTOR	2394	1	12	0	1700	55	19
55	36	425	SR 652	COLLECTOR	2528	1	12	0	1700	50	19
56	36	433	SR 700	COLLECTOR	1984	1	11	0	1700	45	19
57	37	275	SR 652	COLLECTOR	5368	1	12	0	1700	50	20
58	37	604	SR 614	COLLECTOR	3849	1	10	0	1700	50	20
59	38	470	SR 652	COLLECTOR	2594	1	12	0	1700	50	26
60	39	471	SR 618	COLLECTOR	795	1	10	0	1700	45	26
61	40	415	SR 618	COLLECTOR	9198	1	10	0	1700	50	26
62	41	42	SR 658	COLLECTOR	9779	1	11	0	1700	40	27
63	41	439	SR 715	COLLECTOR	8043	1	12	1	1700	45	27
64	42	304	SR 738	COLLECTOR	5436	1	11	0	1700	50	36
65	43	44	SR 671	COLLECTOR	4091	1	11	0	1700	50	36
66	43	235	SR 738	COLLECTOR	8685	1	11	0	1700	50	36
67	45	69	SR 603	COLLECTOR	3183	1	10	0	1700	55	21
68	46	298	US 522	COLLECTOR	2149	1	12	1	1700	60	19
69	47	513	US 522	COLLECTOR	1364	1	12	1	1700	60	19
70	48	335	E 1ST ST	LOCAL ROADWAY	388	1	12	0	1750	20	19
71	49	334	US 522	COLLECTOR	4170	1	12	1	1700	60	25
72	50	51	US 33	COLLECTOR	3158	1	12	1	1700	60	25
73	50	81	US 33	COLLECTOR	7058	1	12	1	1700	60	25
74	51	52	US 522	COLLECTOR	1149	1	12	0	1700	45	25

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
75	51	82	US 33	COLLECTOR	6216	1	12	1	1700	60	25
76	52	331	US 522	COLLECTOR	3233	1	12	0	1700	45	25
77	53	296	US 522	COLLECTOR	7046	1	12	0	1700	60	34
78	54	185	US 522	COLLECTOR	3375	1	12	0	1700	60	34
79	55	97	SR 629	COLLECTOR	9753	1	11	0	1700	45	34
80	55	187	US 522	COLLECTOR	3716	1	12	0	1700	60	34
81	56	48	E 1ST ST	LOCAL ROADWAY	3092	1	10	0	1575	35	19
82	57	603	SR 618	COLLECTOR	2855	1	10	0	1700	50	19
83	58	274	SR 618	COLLECTOR	4111	1	10	0	1700	45	25
84	58	281	SR 618	COLLECTOR	3463	1	10	0	1700	45	25
85	59	599	SR 618	COLLECTOR	498	1	10	0	1575	35	25
86	59	600	SR 618	COLLECTOR	645	1	10	0	1575	35	25
87	60	248	SR 614	COLLECTOR	1190	1	10	0	1700	50	20
88	61	596	SR 618	COLLECTOR	1902	1	10	0	1700	50	26
89	62	409	SR 618	COLLECTOR	3810	1	10	0	1750	50	26
90	62	411	SR 609	COLLECTOR	5040	1	9	0	1700	45	26
91	63	64	SR 208	COLLECTOR	5804	1	12	1	1700	60	18
92	63	517	SR 208	COLLECTOR	2503	1	12	1	1700	50	18
93	64	63	SR 208	COLLECTOR	5804	1	12	1	1700	60	18
94	64	312	SR 208	COLLECTOR	3057	1	12	1	1700	60	18
95	65	66	SR 208	COLLECTOR	2156	1	12	1	1750	35	17
96	65	519	SR 208	COLLECTOR	949	1	12	1	1575	35	17
97	66	65	SR 208	COLLECTOR	2156	1	12	1	1750	35	17
98	66	166	US 33	COLLECTOR	724	1	12	1	1750	30	17
99	66	168	SR 208	COLLECTOR	1987	1	12	1	1700	45	17

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
100	67	170	US 33	COLLECTOR	1219	1	12	4	1750	30	17
101	67	338	US 33	COLLECTOR	4520	1	12	1	1700	45	17
102	68	70	US 33	COLLECTOR	4690	1	11	0	1700	55	14
103	68	73	SR 22	COLLECTOR	4198	1	11	0	1700	45	14
104	68	341	US 33	COLLECTOR	3041	1	11	1	1700	55	14
105	69	124	SR 603	COLLECTOR	6115	1	10	0	1700	55	21
106	70	68	US 33	COLLECTOR	4684	1	11	0	1700	55	14
107	71	140	CR 601	COLLECTOR	3717	1	11	0	1700	55	10
108	71	559	CR 601	COLLECTOR	4229	1	11	0	1700	60	10
109	72	558	STATE PARK LN	LOCAL ROADWAY	3223	1	10	0	1575	35	10
110	74	79	CR 601	COLLECTOR	2875	1	9	0	1700	45	10
111	74	125	CR 612	COLLECTOR	3075	1	10	0	1700	40	10
112	74	486	CR 612	COLLECTOR	6467	1	10	0	1700	40	10
113	75	76	SR 208	COLLECTOR	8873	1	12	1	1700	60	24
114	76	77	SR 208	COLLECTOR	9019	1	12	1	1700	60	23
115	77	78	SR 208	COLLECTOR	5191	1	12	1	1700	60	23
116	78	535	SR 208	COLLECTOR	1888	1	12	1	1700	45	23
117	79	91	CR 601	COLLECTOR	2322	1	9	0	1700	45	10
118	80	313	US 33	COLLECTOR	3951	1	12	1	1700	45	24
119	81	50	US 33	COLLECTOR	7058	1	12	1	1700	60	25
120	81	188	US 33	COLLECTOR	5432	1	12	1	1700	60	24
121	81	278	SR 605	COLLECTOR	2761	1	11	1	1700	50	24
122	82	83	US 33	COLLECTOR	4896	1	12	1	1700	60	25
123	83	435	US 33	COLLECTOR	1935	1	12	1	1700	60	25
124	84	542	US 33	COLLECTOR	2672	1	12	1	1700	60	34

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
125	85	543	US 33	COLLECTOR	3159	1	12	1	1700	60	34
126	86	544	US 33	COLLECTOR	3738	1	12	1	1700	60	34
127	87	88	US 33	COLLECTOR	8916	1	12	1	1700	60	35
128	88	89	US 33	COLLECTOR	10277	1	12	1	1700	60	35
129	89	90	US 33	COLLECTOR	13893	1	12	1	1700	60	35
130	90	445	US 33	COLLECTOR	6892	1	12	1	1700	60	35
131	91	96	CR 601	COLLECTOR	9884	1	11	0	1700	50	10
132	92	93	SR 605	COLLECTOR	4387	1	11	1	1700	60	24
133	93	539	SR 605	COLLECTOR	5768	1	11	1	1700	60	24
134	94	277	SR 605	COLLECTOR	4456	1	11	1	1700	60	24
135	95	293	SR 605	COLLECTOR	10964	1	11	1	1700	60	33
136	96	99	CR 601	COLLECTOR	9442	1	11	0	1700	50	4
137	97	325	SR 629	COLLECTOR	2564	1	11	0	1575	35	33
138	98	291	I-64	FREEWAY	14035	2	12	10	2250	75	33
139	98	294	I-64	FREEWAY	4235	2	12	10	2250	75	33
140	99	100	CR 601	COLLECTOR	2706	1	11	0	1700	50	4
141	100	21	CR 601	COLLECTOR	3980	1	11	0	1700	50	4
142	101	102	CR 612	COLLECTOR	3696	1	10	0	1700	40	10
143	102	103	CR 612	COLLECTOR	2074	1	10	0	1700	40	11
144	103	22	CR 606	COLLECTOR	3273	1	11	0	1700	50	11
145	104	103	CR 606	COLLECTOR	5217	1	11	0	1700	50	11
146	105	10	SR 738	COLLECTOR	2118	1	11	0	1750	50	12
147	106	588	SR 738	COLLECTOR	4229	1	11	0	1700	50	12
148	107	390	SR 738	COLLECTOR	2299	1	11	0	1700	50	21
149	107	406	SR 738	COLLECTOR	7642	1	11	0	1700	50	21

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
150	108	405	SR 738	COLLECTOR	1655	1	11	0	1700	40	21
151	108	406	SR 738	COLLECTOR	3781	1	11	0	1700	50	21
152	109	110	SR 738	COLLECTOR	9332	1	11	0	1700	50	21
153	110	111	SR 738	COLLECTOR	10608	1	11	0	1750	50	21
154	111	112	SR 639	COLLECTOR	1997	1	10	0	1700	50	27
155	111	118	SR 738	COLLECTOR	6747	1	11	0	1750	55	27
156	112	113	SR 658	COLLECTOR	4899	1	11	0	1700	55	27
157	112	315	SR 639	COLLECTOR	1191	1	10	0	1700	50	27
158	113	114	SR 658	COLLECTOR	9548	1	11	0	1700	55	27
159	113	258	SR 683	COLLECTOR	2796	1	8	0	1700	40	27
160	114	115	SR 658	COLLECTOR	8053	1	11	0	1700	55	28
161	115	116	SR 658	COLLECTOR	10193	1	11	0	1700	55	30
162	116	287	SR 658	COLLECTOR	6568	1	11	0	1700	55	31
163	117	135	US 1	MINOR ARTERIAL	12571	2	12	2	1900	60	29
164	117	302	US 1	MINOR ARTERIAL	6268	2	12	2	1750	60	31
165	118	111	SR 738	COLLECTOR	6754	1	11	0	1750	55	27
166	118	407	SR 738	COLLECTOR	6078	1	11	0	1700	55	27
167	119	286	SR 738	COLLECTOR	7719	1	11	0	1700	45	27
168	120	416	SR 652	COLLECTOR	9511	1	12	0	1700	50	26
169	120	595	SR 650	COLLECTOR	6780	1	10	0	1700	40	26
170	121	132	US 1	MINOR ARTERIAL	5589	2	12	2	1900	60	22
171	121	260	US 1	MINOR ARTERIAL	3686	2	12	2	1900	60	13
172	122	132	SR 605	COLLECTOR	3455	1	11	0	1700	40	22
173	122	318	CR 603	COLLECTOR	3656	1	10	0	1700	45	22
174	123	320	SR 603	COLLECTOR	1698	1	10	0	1700	55	22

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
175	124	123	SR 603	COLLECTOR	10327	1	10	0	1700	55	22
176	125	74	CR 612	COLLECTOR	3066	1	10	0	1700	40	10
177	125	130	CR 612	COLLECTOR	3715	1	10	0	1700	40	10
178	126	127	SR 639	COLLECTOR	3646	1	10	0	1750	50	22
179	127	133	US 1	MINOR ARTERIAL	15821	2	12	2	1900	60	22
180	127	134	US 1	MINOR ARTERIAL	7464	2	12	2	1900	60	22
181	127	250	SR 639	COLLECTOR	3712	1	10	0	1700	50	22
182	128	149	I-95	FREEWAY	1942	3	12	12	2250	75	22
183	128	150	I-95	FREEWAY	9282	3	12	12	2250	75	29
184	130	125	CR 612	COLLECTOR	3717	1	10	0	1700	40	10
185	130	136	CR 612	COLLECTOR	8426	1	10	0	1700	40	10
186	131	319	SR 683	COLLECTOR	4002	1	8	0	1700	40	28
187	132	121	US 1	MINOR ARTERIAL	5589	2	12	2	1900	60	22
188	132	133	US 1	MINOR ARTERIAL	10875	2	12	2	1900	60	22
189	132	254	SR 605	COLLECTOR	1187	1	11	0	1700	40	22
190	133	127	US 1	MINOR ARTERIAL	15821	2	12	2	1750	60	22
191	133	132	US 1	MINOR ARTERIAL	10875	2	12	2	1900	60	22
192	134	127	US 1	MINOR ARTERIAL	7464	2	12	2	1750	60	22
193	134	135	US 1	MINOR ARTERIAL	6786	2	12	2	1900	60	29
194	135	117	US 1	MINOR ARTERIAL	12571	2	12	2	1900	60	29
195	135	134	US 1	MINOR ARTERIAL	6786	2	12	2	1900	60	29
196	136	130	CR 612	COLLECTOR	8426	1	10	0	1700	40	10
197	136	137	CR 612	COLLECTOR	4504	1	10	0	1700	40	10
198	137	138	CR 612	COLLECTOR	2194	1	10	0	1700	40	10
199	138	560	CR 612	COLLECTOR	850	1	10	0	1350	30	10

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
200	138	638	CR 719	COLLECTOR	1609	1	10	0	1700	40	10
201	139	353	SR 719	COLLECTOR	2691	1	11	0	1700	50	10
202	140	71	CR 601	COLLECTOR	3716	1	11	0	1700	55	10
203	140	141	CR 601	COLLECTOR	2650	1	11	0	1700	55	11
204	141	140	CR 601	COLLECTOR	2653	1	11	0	1700	55	11
205	141	622	CR 601	COLLECTOR	3654	1	11	0	1700	55	11
206	142	8	CR 606	COLLECTOR	11391	1	11	0	1750	50	12
207	144	6	CR 601	COLLECTOR	2660	1	11	0	1700	55	11
208	144	622	CR 601	COLLECTOR	5015	1	11	0	1700	55	11
209	145	167	CR 606	COLLECTOR	2804	1	12	0	1700	45	13
210	146	212	I-95	FREEWAY	8652	3	12	12	2250	75	13
211	147	148	I-95	FREEWAY	14471	3	12	12	2250	75	22
212	147	207	I-95	FREEWAY	10424	3	12	12	2250	75	22
213	148	147	I-95	FREEWAY	14471	3	12	12	2250	75	22
214	148	149	I-95	FREEWAY	9252	3	12	12	2250	75	22
215	149	128	I-95	FREEWAY	1942	3	12	12	2250	75	22
216	149	148	I-95	FREEWAY	9252	3	12	12	2250	75	22
217	150	128	I-95	FREEWAY	9282	3	12	12	2250	75	29
218	150	151	I-95	FREEWAY	7390	3	12	12	2250	75	29
219	151	150	I-95	FREEWAY	7390	3	12	12	2250	75	29
220	151	208	I-95	FREEWAY	10054	3	12	12	2250	75	29
221	152	267	I-95	FREEWAY	6522	3	12	12	2250	75	31
222	153	158	CR 601	COLLECTOR	2811	1	10	0	1700	50	20
223	153	399	CR 601	COLLECTOR	7950	1	10	0	1700	50	20
224	154	41	SR 658	COLLECTOR	7017	1	9	0	1700	40	27

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
225	155	156	I-64	FREEWAY	27925	2	12	10	2250	75	23
226	155	291	I-64	FREEWAY	2954	2	12	10	2250	75	33
227	156	155	I-64	FREEWAY	27926	2	12	10	2250	75	23
228	156	290	I-64	FREEWAY	1828	2	12	10	2250	75	23
229	157	33	CR 612	COLLECTOR	5083	1	10	0	1700	60	9
230	158	159	CR 601	COLLECTOR	2378	1	10	0	1700	50	20
231	159	556	CR 601	COLLECTOR	3028	1	10	0	1700	50	20
232	160	6	SR 208	COLLECTOR	1696	1	12	1	1700	60	11
233	161	203	CR 655	COLLECTOR	1583	1	9	0	1700	45	19
234	162	213	SR 20	COLLECTOR	5821	1	11	2	1700	60	2
235	162	215	SR 20	COLLECTOR	7051	1	11	2	1700	60	2
236	163	80	US 33	COLLECTOR	1859	1	12	1	1700	60	24
237	163	165	US 33	COLLECTOR	5802	1	12	1	1700	60	24
238	164	163	MT AIRY RD	COLLECTOR	1969	1	9	0	1700	40	24
239	165	163	US 33	COLLECTOR	5802	1	12	1	1700	60	24
240	165	188	US 33	COLLECTOR	5281	1	12	1	1700	60	24
241	166	66	US 33	COLLECTOR	724	1	12	1	1750	30	17
242	166	170	US 33	COLLECTOR	634	1	12	4	1750	30	17
243	166	178	ROSEWOOD AVE	LOCAL ROADWAY	708	1	12	0	1125	25	17
244	168	66	SR 208	COLLECTOR	1987	1	12	1	1750	45	17
245	168	534	SR 208	COLLECTOR	844	1	12	1	1700	45	17
246	169	611	SR 207	MINOR ARTERIAL	1378	2	12	4	1750	50	31
247	170	67	US 33	COLLECTOR	1219	1	12	4	1350	30	17
248	170	166	US 33	COLLECTOR	634	1	12	4	1750	30	17
249	170	180	COURTHOUSE SQ	LOCAL ROADWAY	916	1	12	4	1125	25	17

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
250	171	7	SR 208	COLLECTOR	7451	1	12	1	1700	60	11
251	172	4	SR 208	COLLECTOR	5946	1	12	1	1750	60	19
252	173	507	CR 613	COLLECTOR	2335	1	12	0	1700	50	1
253	174	8	SR 208	COLLECTOR	4005	1	12	1	1750	50	12
254	174	497	LAKE ANNA PKWY	COLLECTOR	5873	1	12	10	1750	60	12
255	175	621	CR 612	COLLECTOR	1871	1	10	0	1700	40	2
256	176	28	CR 608	COLLECTOR	3844	1	12	0	1700	45	13
257	177	410	SR 618	COLLECTOR	5843	1	10	0	1700	50	26
258	178	180	WOOLFOLK AVE	LOCAL ROADWAY	621	1	12	0	1125	25	17
259	179	551	SR 738	COLLECTOR	3020	1	11	0	1700	45	27
260	180	168	ELM AVE	LOCAL ROADWAY	1346	1	12	4	1700	40	17
261	180	170	COURTHOUSE SQ	LOCAL ROADWAY	916	1	12	4	1750	25	17
262	181	500	SR 208	COLLECTOR	6178	1	12	0	1700	55	12
263	182	342	SR 208	COLLECTOR	3755	1	12	1	1700	50	18
264	182	519	SR 208	COLLECTOR	3235	1	12	1	1700	45	17
265	183	75	SR 208	COLLECTOR	5863	1	12	1	1700	60	24
266	183	534	SR 208	COLLECTOR	2252	1	12	1	1700	60	17
267	184	37	SR 652	COLLECTOR	4708	1	12	0	1700	50	20
268	185	55	US 522	COLLECTOR	2298	1	12	0	1700	60	34
269	186	295	SR 629	COLLECTOR	5871	1	11	0	1700	45	33
270	188	81	US 33	COLLECTOR	5432	1	12	1	1700	60	24
271	188	165	US 33	COLLECTOR	5281	1	12	1	1700	60	24
272	189	34	CR 612	COLLECTOR	3766	1	10	0	1700	40	9
273	190	20	CR 621	COLLECTOR	11577	1	10	0	1700	50	1
274	190	374	CR 621	COLLECTOR	8069	1	10	0	1700	60	5

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
275	191	18	SR 621	COLLECTOR	5721	1	10	0	1700	50	4
276	191	376	SR 621	COLLECTOR	2790	1	10	0	1700	50	4
277	192	458	CR 606	COLLECTOR	3742	1	11	0	1750	50	4
278	193	578	CR 606	COLLECTOR	1043	1	11	0	1575	35	4
279	194	2	SR 20	COLLECTOR	3683	1	12	3	1750	50	3
280	194	369	SR 20	COLLECTOR	8316	1	12	3	1700	50	3
281	195	2	US 522	COLLECTOR	2325	1	12	1	1750	60	3
282	196	15	US 522	COLLECTOR	9953	1	12	1	1700	60	3
283	197	350	US 522	COLLECTOR	2669	1	12	1	1700	60	19
284	198	2	SR 20	COLLECTOR	5624	1	11	2	1750	45	3
285	198	366	SR 20	COLLECTOR	3531	1	11	2	1700	60	3
286	199	607	SR 652	COLLECTOR	4396	1	12	0	1700	55	19
287	200	199	CENTERVILLE RD	LOCAL ROADWAY	4397	1	9	0	1700	40	19
288	201	605	SR 614	COLLECTOR	2987	1	12	0	1700	40	20
289	202	36	SR 700	COLLECTOR	982	2	11	0	1700	60	19
290	203	5	SR 208	COLLECTOR	3960	1	12	1	1700	60	20
291	203	509	SR 208	COLLECTOR	2705	1	12	1	1700	60	19
292	204	183	SR 646	COLLECTOR	7005	1	10	0	1700	40	24
293	205	13	US 522	COLLECTOR	2161	1	12	1	1700	60	10
294	206	211	I-95	FREEWAY	5135	3	12	12	2250	75	13
295	206	212	I-95	FREEWAY	4706	3	12	12	2250	75	13
296	207	147	I-95	FREEWAY	10424	3	12	12	2250	75	22
297	207	269	I-95	FREEWAY	5962	3	12	12	2250	75	13
298	208	151	I-95	FREEWAY	10054	3	12	12	2250	75	29
299	208	266	I-95	FREEWAY	3146	3	12	12	2250	75	31

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
300	209	204	SR 646	COLLECTOR	2676	1	10	0	1700	40	24
301	209	216	SR 646	COLLECTOR	2568	1	10	0	1700	40	24
302	211	206	I-95	FREEWAY	5135	3	12	12	2250	75	13
303	211	268	I-95	FREEWAY	5303	3	12	12	2250	75	13
304	212	146	I-95	FREEWAY	8652	3	12	12	2250	75	13
305	212	206	I-95	FREEWAY	4706	3	12	12	2250	75	13
306	213	30	SR 20	COLLECTOR	4416	1	11	2	1700	60	3
307	213	162	SR 20	COLLECTOR	5821	1	11	2	1700	60	2
308	214	31	SR 20	COLLECTOR	1827	1	11	2	1700	40	2
309	215	31	SR 20	COLLECTOR	5871	1	11	2	1700	40	2
310	215	162	SR 20	COLLECTOR	7051	1	11	2	1700	60	2
311	216	217	SR 646	COLLECTOR	5206	1	10	0	1700	40	24
312	217	218	SR 646	COLLECTOR	11844	1	10	0	1700	40	24
313	218	277	SR 646	COLLECTOR	5035	1	10	0	1700	40	24
314	219	166	SR 628	COLLECTOR	1856	1	10	0	1750	30	17
315	220	219	SR 628	COLLECTOR	3156	1	10	0	1700	50	17
316	221	220	SR 628	COLLECTOR	4095	1	10	0	1700	50	17
317	222	521	SR 628	COLLECTOR	430	1	10	0	1350	30	18
318	224	26	SR 208 BUS	LOCAL ROADWAY	3232	1	12	4	1750	25	6
319	224	307	SR 208	MINOR ARTERIAL	4910	1	12	0	1750	50	6
320	224	562	SR 208	MINOR ARTERIAL	1854	2	12	0	1900	50	6
321	226	562	SR 208	MINOR ARTERIAL	2251	2	12	0	1900	60	6
322	227	525	SR 628	COLLECTOR	2846	1	10	0	1700	40	16
323	228	227	SR 628	COLLECTOR	6204	1	10	0	1700	50	16
324	228	496	SR 613	COLLECTOR	5651	1	11	0	1700	50	16

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
325	229	504	CR 613	COLLECTOR	2328	1	12	0	1700	50	6
326	230	233	CR 613	COLLECTOR	2926	1	12	0	1700	50	6
327	232	16	SR 20	COLLECTOR	4864	1	12	3	1700	60	4
328	233	25	CR 613	COLLECTOR	2148	1	12	0	1700	50	6
329	234	236	CR 613	COLLECTOR	2897	1	12	0	1700	50	6
330	236	237	CR 613	COLLECTOR	5098	1	12	0	1700	50	6
331	237	173	CR 613	COLLECTOR	5255	1	12	0	1700	50	5
332	238	20	CR 621	COLLECTOR	3408	1	10	0	1700	50	1
333	239	240	US 522	COLLECTOR	2304	1	12	1	1700	60	9
334	240	196	US 522	COLLECTOR	7960	1	12	1	1700	60	9
335	241	447	SR 613	COLLECTOR	4135	1	12	0	1700	45	19
336	242	243	SR 625	COLLECTOR	4886	1	12	0	1700	45	16
337	243	244	SR 625	COLLECTOR	6056	1	12	0	1700	40	16
338	244	245	SR 625	COLLECTOR	3724	1	12	0	1700	40	18
339	245	246	SR 625	COLLECTOR	1866	1	12	0	1700	40	18
340	246	620	SR 625	COLLECTOR	4978	1	12	0	1700	45	18
341	247	249	SR 207	MINOR ARTERIAL	2014	2	12	4	1900	50	31
342	247	266	I-95 ON-RAMP FROM SR 207	FREEWAY RAMP	1624	1	12	4	1700	50	31
343	247	609	SR 207	MINOR ARTERIAL	783	2	12	4	1750	50	31
344	248	271	SR 614	COLLECTOR	5473	1	10	0	1700	50	20
345	249	247	SR 207	MINOR ARTERIAL	2014	2	12	4	1900	50	31
346	249	267	I-95 ON-RAMP FROM SR 207	FREEWAY RAMP	1365	1	12	4	1700	50	31
347	249	613	SR 207	MINOR ARTERIAL	449	1	12	4	1750	50	31

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
348	250	128	I-95 ON-RAMP FROM SR 639	FREEWAY RAMP	1171	1	12	6	1700	50	22
349	250	251	SR 639	COLLECTOR	1750	1	10	0	1700	50	22
350	251	129	SR 639	COLLECTOR	2756	1	10	0	1700	50	22
351	251	149	I-95 ON-RAMP FROM SR 639	FREEWAY RAMP	1348	1	12	6	1700	50	22
352	252	145	CR 606	COLLECTOR	1587	1	12	0	1700	45	13
353	252	268	I-95 ON-RAMP FROM CR 606	FREEWAY RAMP	1523	1	12	4	1700	50	13
354	253	252	CR 606	COLLECTOR	1736	1	12	0	1700	45	13
355	253	269	I-95 ON-RAMP FROM CR 606	FREEWAY RAMP	1066	1	12	4	1700	50	13
356	254	143	SR 605	COLLECTOR	4898	1	11	0	1700	40	22
357	255	264	CR 608	COLLECTOR	5147	1	12	0	1750	45	13
358	256	257	CR 608	COLLECTOR	2381	1	12	0	1700	45	13
359	258	131	SR 683	COLLECTOR	7384	1	8	0	1700	40	28
360	259	1	SR 603	COLLECTOR	3108	1	10	0	1700	55	21
361	260	121	US 1	MINOR ARTERIAL	3686	2	12	2	1900	60	13
362	260	289	US 1	MINOR ARTERIAL	2220	2	12	2	1900	60	13
363	261	262	US 1	MINOR ARTERIAL	4422	2	12	2	1900	60	13
364	261	288	US 1	MINOR ARTERIAL	5381	2	12	2	1750	60	13
365	262	261	US 1	MINOR ARTERIAL	4422	2	12	2	1900	60	13
366	262	263	US 1	MINOR ARTERIAL	4621	2	12	2	1900	60	13
367	263	262	US 1	MINOR ARTERIAL	4621	2	12	2	1900	60	13
368	263	264	US 1	MINOR ARTERIAL	7912	2	12	2	1750	60	13
369	264	256	CR 608	COLLECTOR	1953	1	12	0	1700	45	13

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
370	264	263	US 1	MINOR ARTERIAL	7912	2	12	2	1900	60	13
371	264	265	US 1	MINOR ARTERIAL	2404	2	12	2	1900	60	7
372	265	264	US 1	MINOR ARTERIAL	2404	2	12	2	1750	60	7
373	266	208	I-95	FREEWAY	3146	3	12	12	2250	75	31
374	266	267	I-95	FREEWAY	2285	3	12	12	2250	75	31
375	267	152	I-95	FREEWAY	6522	3	12	12	2250	75	31
376	267	266	I-95	FREEWAY	2285	3	12	12	2250	75	31
377	268	211	I-95	FREEWAY	5320	3	12	12	2250	75	13
378	268	269	I-95	FREEWAY	2220	3	12	12	2250	75	13
379	269	207	I-95	FREEWAY	5961	3	12	12	2250	75	13
380	269	268	I-95	FREEWAY	2220	3	12	12	2250	75	13
381	270	176	CR 608	COLLECTOR	7427	1	12	0	1700	45	12
382	271	272	SR 614	COLLECTOR	1855	1	10	0	1700	50	19
383	272	273	SR 614	COLLECTOR	2285	1	10	0	1700	50	25
384	273	59	SR 614	COLLECTOR	5084	1	10	0	1750	50	25
385	274	58	SR 618	COLLECTOR	4100	1	10	0	1700	45	25
386	274	600	SR 618	COLLECTOR	1471	1	10	0	1700	45	25
387	275	38	SR 652	COLLECTOR	4328	1	12	0	1700	50	20
388	276	171	SR 208	COLLECTOR	7438	1	12	1	1700	60	11
389	277	538	SR 605	COLLECTOR	2227	1	11	1	1700	60	24
390	278	92	SR 605	COLLECTOR	5823	1	11	1	1700	50	24
391	279	515	US 522	COLLECTOR	542	1	12	1	1350	30	25
392	280	50	US 522	COLLECTOR	3475	1	12	1	1700	60	25
393	281	58	SR 618	COLLECTOR	3454	1	10	0	1700	45	25
394	281	601	SR 618	COLLECTOR	1683	1	10	0	1700	45	25

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
395	282	172	SR 208	COLLECTOR	6084	1	12	1	1700	60	19
396	283	160	SR 208	COLLECTOR	2845	1	12	1	1700	60	11
397	284	142	CR 606	COLLECTOR	5743	1	11	0	1700	50	11
398	285	284	CR 606	COLLECTOR	5125	1	11	0	1700	50	11
399	286	42	SR 738	COLLECTOR	3760	1	11	0	1575	35	36
400	287	302	SR 658	COLLECTOR	4363	1	11	0	1750	55	31
401	288	253	CR 606	COLLECTOR	2496	1	12	0	1700	45	13
402	288	261	US 1	MINOR ARTERIAL	5381	2	12	2	1900	60	13
403	288	289	US 1	MINOR ARTERIAL	4875	2	12	0	1900	55	13
404	289	260	US 1	MINOR ARTERIAL	2220	2	12	2	1900	60	13
405	289	288	US 1	MINOR ARTERIAL	4875	2	12	0	1750	55	13
406	290	156	I-64	FREEWAY	1828	2	12	10	2250	75	23
407	290	330	I-64	FREEWAY	8286	2	12	10	2250	75	23
408	291	98	I-64	FREEWAY	14035	2	12	10	2250	75	33
409	291	155	I-64	FREEWAY	2954	2	12	10	2250	75	33
410	292	290	I-64 ON-RAMP FROM SR 208	FREEWAY RAMP	829	1	12	2	1700	50	23
411	292	322	SR 208	COLLECTOR	1033	1	12	1	1700	55	23
412	293	155	I-64 ON-RAMP FROM SR 605	FREEWAY RAMP	2083	1	12	6	1700	50	33
413	293	323	SR 605	COLLECTOR	2480	1	11	1	1700	40	33
414	294	98	I-64	FREEWAY	4235	2	12	10	2250	75	33
415	294	328	I-64	FREEWAY	2139	2	12	10	2250	75	33
416	295	294	I-64 ON-RAMP FROM SR 629	FREEWAY RAMP	1966	1	12	6	1700	50	33
417	295	327	SR 629	COLLECTOR	2172	1	11	0	1700	40	33

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
418	296	54	US 522	COLLECTOR	8870	1	12	0	1700	60	34
419	297	48	US 522	COLLECTOR	1150	1	15	0	1575	35	19
420	298	47	US 522	COLLECTOR	4717	1	12	1	1700	60	19
421	299	345	US 522	COLLECTOR	4595	1	12	1	1700	65	19
422	300	189	CR 612	COLLECTOR	2340	1	10	0	1700	40	9
423	301	354	CR 612	COLLECTOR	1465	1	10	0	1700	40	9
424	302	117	US 1	MINOR ARTERIAL	6268	2	12	2	1900	60	31
425	302	303	US 1	MINOR ARTERIAL	6581	2	12	2	1900	60	31
426	302	613	SR 207	MINOR ARTERIAL	1885	2	12	4	1750	50	31
427	303	302	US 1	MINOR ARTERIAL	6581	2	12	2	1750	60	31
428	304	43	SR 738	COLLECTOR	6358	1	11	0	1700	50	36
429	305	335	SR 208	COLLECTOR	1405	1	12	1	1750	40	19
430	305	517	SR 208	COLLECTOR	4082	1	12	1	1700	50	19
431	307	224	SR 208	MINOR ARTERIAL	4911	2	12	0	1750	50	6
432	307	229	CR 613	COLLECTOR	2888	1	12	0	1700	50	6
433	308	24	CR 613	COLLECTOR	7694	1	12	0	1700	50	6
434	309	505	CR 613	COLLECTOR	214	1	12	0	1575	35	6
435	310	234	CR 613	COLLECTOR	2975	1	12	0	1700	50	6
436	311	17	SR 621	COLLECTOR	4267	1	10	0	1700	50	4
437	312	64	SR 208	COLLECTOR	3048	1	12	1	1700	60	18
438	312	342	SR 208	COLLECTOR	2911	1	12	1	1700	50	18
439	313	65	US 33	COLLECTOR	5376	1	12	4	1750	40	17
440	314	598	SR 618	COLLECTOR	1554	1	10	0	1700	40	25
441	315	259	SR 603	COLLECTOR	5689	1	10	0	1700	55	21
442	315	316	SR 639	COLLECTOR	6769	1	10	0	1700	50	21

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
443	316	553	SR 639	COLLECTOR	903	1	10	0	1700	40	21
444	317	61	SR 618	COLLECTOR	2645	1	10	0	1700	50	26
445	318	121	CR 603	COLLECTOR	527	1	10	0	1700	40	13
446	319	134	SR 683	COLLECTOR	6767	1	8	0	1700	40	28
447	320	122	CR 603	COLLECTOR	5737	1	10	0	1700	50	22
448	321	4	SR 652	COLLECTOR	5497	1	12	0	1750	55	19
449	322	156	I-64 ON-RAMP FROM SR 208	FREEWAY RAMP	957	1	12	2	1700	50	23
450	323	291	I-64 ON-RAMP FROM SR 605	FREEWAY RAMP	2285	1	12	6	1700	50	33
451	324	95	SR 605	COLLECTOR	4207	1	11	1	1700	60	33
452	325	326	SR 629	COLLECTOR	3078	1	11	0	1575	35	33
453	326	186	SR 629	COLLECTOR	2413	1	11	0	1700	45	33
454	327	328	I-64 ON-RAMP FROM SR 629	FREEWAY RAMP	1810	1	12	6	1700	50	33
455	328	294	I-64	FREEWAY	2139	2	12	10	2250	75	33
456	328	329	I-64	FREEWAY	6800	2	12	10	2250	75	33
457	329	328	I-64	FREEWAY	6800	2	12	10	2250	75	33
458	330	290	I-64	FREEWAY	8286	2	12	10	2250	75	23
459	331	332	US 522	COLLECTOR	2086	1	12	0	1700	45	25
460	332	333	US 522	COLLECTOR	5980	1	12	0	1700	45	25
461	333	53	US 522	COLLECTOR	4258	1	12	0	1700	60	25
462	334	280	US 522	COLLECTOR	4260	1	12	1	1700	60	25
463	335	305	SR 208	COLLECTOR	1405	1	12	1	1700	40	19
464	335	514	US 522	COLLECTOR	1248	1	16	1	1700	40	19
465	336	335	E 1ST ST	LOCAL ROADWAY	611	1	12	0	1750	35	19

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
466	337	341	US 33	COLLECTOR	1320	1	12	4	1700	55	14
467	337	528	US 33	COLLECTOR	5859	1	12	1	1700	60	14
468	338	67	US 33	COLLECTOR	4520	1	12	1	1700	45	17
469	338	339	US 33	COLLECTOR	5422	1	12	1	1700	60	17
470	339	338	US 33	COLLECTOR	5422	1	12	1	1700	60	17
471	339	340	US 33	COLLECTOR	2480	1	12	1	1700	60	14
472	340	339	US 33	COLLECTOR	2480	1	12	1	1700	60	14
473	340	528	US 33	COLLECTOR	987	1	12	1	1700	55	14
474	341	68	US 33	COLLECTOR	3041	1	11	1	1700	55	14
475	341	337	US 33	COLLECTOR	1320	1	12	4	1700	55	14
476	342	182	SR 208	COLLECTOR	3746	1	12	1	1700	50	18
477	342	312	SR 208	COLLECTOR	2912	1	12	1	1700	50	18
478	343	46	US 522	COLLECTOR	2046	1	12	1	1700	60	19
479	344	343	US 522	COLLECTOR	2216	1	12	1	1700	60	19
480	345	346	US 522	COLLECTOR	1696	1	12	1	1700	65	19
481	346	344	US 522	COLLECTOR	3587	1	12	1	1700	60	19
482	347	348	SR 208	COLLECTOR	1425	1	12	1	1700	60	19
483	348	511	SR 208	COLLECTOR	1689	1	12	1	1700	45	19
484	349	352	US 522	COLLECTOR	3414	1	12	1	1700	60	19
485	350	351	US 522	COLLECTOR	3508	1	12	1	1700	60	10
486	351	205	US 522	COLLECTOR	2772	1	12	1	1700	60	10
487	352	197	US 522	COLLECTOR	4037	1	12	1	1700	60	19
488	353	561	SR 719	COLLECTOR	1042	1	11	0	1575	35	19
489	354	355	CR 612	COLLECTOR	7630	1	10	0	1700	40	9
490	355	356	CR 612	COLLECTOR	2707	1	10	0	1700	50	9

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
491	356	357	CR 612	COLLECTOR	2756	1	10	0	1700	40	9
492	357	358	CR 612	COLLECTOR	2037	1	10	0	1700	40	9
493	358	157	CR 612	COLLECTOR	1143	1	10	0	1700	40	9
494	359	360	CR 612	COLLECTOR	5214	1	10	0	1700	60	8
495	360	32	CR 612	COLLECTOR	4362	1	10	0	1700	60	8
496	361	362	CR 612	COLLECTOR	4745	1	10	0	1700	50	2
497	362	175	CR 612	COLLECTOR	1711	1	10	0	1700	40	2
498	363	364	CR 612	COLLECTOR	1706	1	10	0	1700	40	2
499	364	365	CR 612	COLLECTOR	3231	1	10	0	1700	40	2
500	365	31	CR 612	COLLECTOR	1787	1	10	0	1700	40	2
501	366	198	SR 20	COLLECTOR	3531	1	11	2	1700	60	3
502	366	367	SR 20	COLLECTOR	2878	1	11	2	1700	60	3
503	367	366	SR 20	COLLECTOR	2878	1	11	2	1700	60	3
504	367	368	SR 20	COLLECTOR	2819	1	11	2	1700	60	3
505	368	30	SR 20	COLLECTOR	5867	1	11	2	1700	60	3
506	368	367	SR 20	COLLECTOR	2819	1	11	2	1700	60	3
507	369	194	SR 20	COLLECTOR	8316	1	12	3	1700	50	3
508	369	370	SR 20	COLLECTOR	2695	1	12	3	1700	60	4
509	370	16	SR 20	COLLECTOR	3243	1	12	3	1700	60	4
510	370	369	SR 20	COLLECTOR	2695	1	12	3	1700	60	4
511	371	311	SR 692	COLLECTOR	4359	1	10	0	1700	50	4
512	372	371	SR 692	COLLECTOR	3224	1	10	0	1700	40	4
513	373	19	CR 621	COLLECTOR	6009	1	10	0	1700	50	5
514	373	375	SR 621	COLLECTOR	2628	1	10	0	1700	50	4
515	374	19	CR 621	COLLECTOR	2969	1	10	0	1700	50	5

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
516	374	190	CR 621	COLLECTOR	8069	1	10	0	1700	60	5
517	375	373	SR 621	COLLECTOR	2628	1	10	0	1700	50	4
518	375	376	SR 621	COLLECTOR	1816	1	10	0	1700	50	4
519	376	191	SR 621	COLLECTOR	2791	1	10	0	1700	50	4
520	376	375	SR 621	COLLECTOR	1816	1	10	0	1700	50	4
521	377	174	SR 208	COLLECTOR	2545	1	12	1	1700	60	12
522	378	377	SR 208	COLLECTOR	6324	1	12	1	1700	60	11
523	379	380	LAKE ANNA PKWY	COLLECTOR	2726	1	12	0	1700	55	12
524	380	563	LAKE ANNA PKWY	COLLECTOR	2892	1	12	0	1700	55	12
525	381	309	CR 648	COLLECTOR	5910	1	12	0	1700	45	6
526	381	502	CR 648	COLLECTOR	1180	1	11	0	1750	40	6
527	382	384	CR 648	COLLECTOR	2715	1	10	0	1700	45	12
528	383	382	CR 648	COLLECTOR	2215	1	10	0	1700	45	12
529	383	587	SR 738	COLLECTOR	1181	1	11	0	1700	40	12
530	384	385	CR 648	COLLECTOR	5167	1	10	0	1700	45	12
531	385	9	CR 648	COLLECTOR	7707	1	10	0	1750	45	12
532	386	105	SR 738	COLLECTOR	3094	1	11	0	1700	50	12
533	387	386	SR 738	COLLECTOR	4900	1	11	0	1700	50	12
534	388	106	SR 738	COLLECTOR	602	1	11	0	1700	50	12
535	389	388	SR 738	COLLECTOR	2897	1	11	0	1700	50	12
536	390	389	SR 738	COLLECTOR	4364	1	11	0	1700	50	21
537	391	392	BRENT'S LANDING RD	LOCAL ROADWAY	2978	1	10	0	1700	40	20
538	392	393	CR 601	COLLECTOR	5011	1	10	0	1700	50	20
539	392	397	CR 601	COLLECTOR	1052	1	10	0	1700	50	20

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
540	393	394	CR 601	COLLECTOR	1862	1	10	0	1700	50	20
541	394	422	CR 601	COLLECTOR	4897	1	10	0	1575	35	20
542	394	619	CR 622	COLLECTOR	2228	1	10	0	1700	45	20
543	395	396	CR 622	COLLECTOR	9238	1	10	0	1700	50	21
544	396	108	CR 622	COLLECTOR	1338	1	10	0	1700	50	21
545	397	392	CR 601	COLLECTOR	1052	1	10	0	1700	50	20
546	397	555	CR 601	COLLECTOR	975	1	10	0	1700	40	20
547	398	399	CR 601	COLLECTOR	3721	1	10	0	1700	50	20
548	398	555	CR 601	COLLECTOR	3482	1	10	0	1700	50	20
549	399	153	CR 601	COLLECTOR	7959	1	10	0	1700	50	20
550	399	398	CR 601	COLLECTOR	3715	1	10	0	1700	50	20
551	399	400	CR 614	COLLECTOR	7566	1	9	0	1700	40	20
552	400	401	CR 657	COLLECTOR	2537	1	9	0	1700	40	20
553	400	490	CR 614	COLLECTOR	5679	1	9	0	1700	40	20
554	401	402	CR 657	COLLECTOR	7017	1	9	0	1700	40	20
555	402	403	CR 657	COLLECTOR	4280	1	9	0	1700	40	20
556	403	404	CR 657	COLLECTOR	2494	1	9	0	1700	40	21
557	404	107	CR 657	COLLECTOR	1237	1	9	0	1700	40	21
558	405	109	SR 738	COLLECTOR	6204	1	11	0	1700	50	21
559	406	107	SR 738	COLLECTOR	7642	1	11	0	1700	50	21
560	406	108	SR 738	COLLECTOR	3774	1	11	0	1700	50	21
561	407	179	SR 738	COLLECTOR	3256	1	11	0	1700	45	27
562	408	317	SR 618	COLLECTOR	4330	1	10	0	1700	50	25
563	409	177	SR 618	COLLECTOR	4248	1	10	0	1700	50	26
564	410	39	SR 618	COLLECTOR	1702	1	10	0	1700	50	26

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
565	411	412	SR 609	COLLECTOR	9079	1	9	0	1700	45	25
566	412	413	SR 609	COLLECTOR	5465	1	9	0	1700	45	25
567	412	436	SR 612	COLLECTOR	1809	1	9	0	1700	40	25
568	413	414	SR 609	COLLECTOR	10254	1	9	0	1700	45	34
569	414	86	SR 609	COLLECTOR	2670	1	9	0	1750	40	34
570	415	154	SR 680	COLLECTOR	6182	1	10	0	1700	40	26
571	416	591	SR 601	COLLECTOR	421	1	10	0	1700	40	26
572	417	39	SR 701	COLLECTOR	6002	1	10	0	1700	50	26
573	418	416	SR 601	COLLECTOR	2939	1	10	0	1700	45	26
574	419	424	SR 601	COLLECTOR	5498	1	10	0	1700	40	26
575	420	419	SR 601	COLLECTOR	2649	1	10	0	1700	40	26
576	421	423	CR 601	COLLECTOR	3646	1	10	0	1700	40	20
577	422	421	CR 601	COLLECTOR	1600	1	10	0	1575	35	20
578	423	420	SR 601	COLLECTOR	3338	1	10	0	1700	40	20
579	424	593	SR 601	COLLECTOR	3294	1	10	0	1700	40	26
580	425	606	SR 652	COLLECTOR	5918	1	12	0	1700	50	20
581	426	202	SR 700	COLLECTOR	1391	1	11	0	1700	60	19
582	427	426	SR 700	COLLECTOR	3995	1	11	0	1700	60	19
583	428	429	SR 700	COLLECTOR	4310	1	11	0	1700	45	19
584	429	430	SR 700	COLLECTOR	4062	1	11	0	1700	45	19
585	430	431	SR 700	COLLECTOR	2486	1	11	0	1700	45	19
586	431	432	SR 700	COLLECTOR	4505	1	11	0	1700	45	19
587	432	434	SR 700	COLLECTOR	4382	1	11	0	1750	45	19
588	433	428	SR 700	COLLECTOR	2631	1	11	0	1700	45	19
589	434	57	SR 618	COLLECTOR	3692	1	10	0	1700	50	25

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
590	434	602	SR 618	COLLECTOR	698	1	10	0	1700	45	25
591	435	540	US 33	COLLECTOR	3115	1	12	1	1700	60	25
592	436	437	SR 612	COLLECTOR	6028	1	9	0	1700	40	25
593	437	435	SR 612	COLLECTOR	5683	1	9	0	1700	40	25
594	438	546	SR 715	COLLECTOR	1310	1	12	0	1575	35	27
595	439	440	SR 715	COLLECTOR	8312	1	12	1	1700	60	36
596	440	441	SR 715	COLLECTOR	2471	1	12	1	1700	60	36
597	441	545	SR 715	COLLECTOR	5503	1	12	1	1700	60	35
598	442	443	SR 715	COLLECTOR	7673	1	12	1	1700	60	35
599	443	444	SR 715	COLLECTOR	6864	1	12	1	1700	60	35
600	445	444	US 33	COLLECTOR	3263	1	12	1	1700	40	35
601	446	35	CR 612	COLLECTOR	2377	1	10	0	1700	40	10
602	447	228	SR 613	COLLECTOR	8380	1	12	0	1700	40	16
603	447	242	SR 625	COLLECTOR	4955	1	12	0	1700	40	16
604	448	526	SR 613	COLLECTOR	3212	1	11	0	1700	50	15
605	449	531	SR 613	COLLECTOR	8105	1	11	0	1700	50	14
606	450	573	CR 608	COLLECTOR	927	1	11	0	1700	40	5
607	450	574	CR 608	COLLECTOR	1477	1	12	0	1700	50	5
608	450	642	CR 612	COLLECTOR	611	1	10	0	1700	40	5
609	451	571	CR 608	COLLECTOR	2088	1	11	0	1700	50	6
610	452	570	CR 608	COLLECTOR	1007	1	11	0	1700	55	6
611	453	454	CR 612	COLLECTOR	6445	1	10	0	1700	40	5
612	454	24	CR 612	COLLECTOR	1531	1	10	0	1700	40	6
613	455	456	CR 608	COLLECTOR	8205	1	12	0	1700	50	5
614	456	575	CR 608	COLLECTOR	4389	1	12	0	1700	50	5

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
615	457	577	CR 608	COLLECTOR	3009	1	12	0	1700	50	4
616	458	21	CR 606	COLLECTOR	4826	1	12	0	1700	50	4
617	459	461	CR 605	COLLECTOR	7046	1	10	0	1700	40	21
618	459	625	CR 604	COLLECTOR	163	1	9	0	1700	40	21
619	460	617	CR 604	COLLECTOR	346	1	9	0	1125	25	21
620	461	462	CR 647	COLLECTOR	14625	1	9	0	1700	40	21
621	461	643	CR 605	COLLECTOR	807	1	10	0	1700	40	21
622	462	582	CR 647	COLLECTOR	3847	1	9	0	1750	40	12
623	463	464	CR 605	COLLECTOR	7668	1	10	0	1700	40	22
624	464	616	CR 605	COLLECTOR	444	1	10	0	1125	25	22
625	465	87	SR 601	COLLECTOR	4568	1	11	0	1700	40	34
626	466	465	SR 658	COLLECTOR	4327	1	10	0	1700	40	34
627	467	466	SR 658	COLLECTOR	3392	1	10	0	1700	40	34
628	467	468	SR 648	COLLECTOR	4251	1	11	0	1700	40	34
629	468	469	SR 648	COLLECTOR	4124	1	11	0	1700	40	34
630	469	54	SR 648	COLLECTOR	4678	1	11	0	1700	40	34
631	470	120	SR 652	COLLECTOR	5407	1	12	0	1700	50	26
632	471	472	SR 701	COLLECTOR	5004	1	10	0	1700	40	26
633	471	589	SR 618	COLLECTOR	1181	1	10	0	1700	45	26
634	472	473	SR 701	COLLECTOR	3635	1	10	0	1700	40	26
635	473	474	SR 701	COLLECTOR	10097	1	10	0	1700	40	26
636	474	475	SR 701	COLLECTOR	3223	1	10	0	1700	40	35
637	475	476	SR 655	COLLECTOR	6231	1	10	0	1700	40	35
638	476	88	SR 655	COLLECTOR	6340	1	10	0	1700	40	35
639	477	201	BURRUSS MILL RD	COLLECTOR	5638	1	10	0	1700	40	20

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
640	478	459	CR 605	COLLECTOR	4109	1	10	0	1700	40	21
641	479	478	CR 605	COLLECTOR	5690	1	10	0	1700	40	21
642	479	480	CR 605	COLLECTOR	4097	1	10	0	1700	40	21
643	480	481	CR 605	COLLECTOR	1656	1	10	0	1700	40	21
644	481	618	CR 605	COLLECTOR	220	1	10	0	1125	25	21
645	482	239	US 522	COLLECTOR	3007	1	12	1	1700	60	9
646	483	482	CR 719	COLLECTOR	6282	1	10	0	1750	40	10
647	484	483	CR 719	COLLECTOR	2193	1	10	0	1700	40	10
648	485	484	CR 719	COLLECTOR	4637	1	10	0	1700	40	10
649	486	101	CR 612	COLLECTOR	4486	1	10	0	1700	40	10
650	487	23	CR 659	COLLECTOR	4545	1	10	0	1700	40	11
651	488	171	CR 659	COLLECTOR	4782	1	10	0	1700	40	11
652	488	487	CR 659	COLLECTOR	4762	1	10	0	1700	40	11
653	489	104	CR 606	COLLECTOR	7727	1	11	0	1700	50	11
654	490	388	CR 614	COLLECTOR	16136	1	9	0	1700	40	11
655	491	479	CR 658	COLLECTOR	2411	1	9	0	1700	40	21
656	492	488	HARLEY LN	COLLECTOR	1305	1	9	0	1700	40	11
657	493	574	CR 612	COLLECTOR	2621	1	12	0	1350	30	5
658	494	209	SR 604	COLLECTOR	1333	1	8	0	1700	40	24
659	495	467	SR 648	COLLECTOR	2993	1	11	0	1700	40	34
660	496	448	SR 613	COLLECTOR	4968	1	11	0	1700	50	16
661	497	9	LAKE ANNA PKWY	COLLECTOR	3561	1	12	1	1750	50	12
662	498	11	CR 606	COLLECTOR	12047	1	12	0	1700	55	12
663	499	181	SR 208	COLLECTOR	8338	1	12	0	1700	55	12
664	500	27	SR 208	COLLECTOR	1050	1	12	0	1700	40	12

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
665	501	26	SR 208	COLLECTOR	538	1	12	0	1750	35	6
666	502	503	LAKE ANNA PKWY	MINOR ARTERIAL	2374	2	12	6	1900	60	6
667	503	307	LAKE ANNA PKWY	MINOR ARTERIAL	2692	2	12	6	1750	60	6
668	504	309	CR 613	COLLECTOR	256	1	12	0	1575	35	6
669	505	506	CR 613	COLLECTOR	986	1	12	0	1700	50	6
670	506	230	CR 613	COLLECTOR	290	1	12	0	1575	35	6
671	507	508	CR 613	COLLECTOR	691	1	12	0	1700	40	1
672	508	20	CR 613	COLLECTOR	2837	1	12	0	1700	50	1
673	509	282	SR 208	COLLECTOR	1772	1	12	1	1700	60	19
674	510	241	SR 613	COLLECTOR	9914	1	12	0	1700	40	19
675	510	299	US 522	COLLECTOR	1967	1	12	1	1700	65	19
676	511	3	SR 208	COLLECTOR	101	1	12	4	1700	45	19
677	511	512	SR 208	COLLECTOR	145	1	12	0	1350	30	19
678	512	349	US 522	COLLECTOR	1868	1	12	1	1700	60	19
679	513	297	US 522	COLLECTOR	2555	1	12	1	1700	40	19
680	514	279	US 522	COLLECTOR	1805	1	12	1	1700	40	25
681	515	49	US 522	COLLECTOR	4596	1	12	1	1700	50	25
682	516	517	BUS GARAGE RD	LOCAL ROADWAY	915	1	11	0	1350	30	18
683	517	63	SR 208	COLLECTOR	2503	1	12	1	1700	50	18
684	517	305	SR 208	COLLECTOR	4082	1	12	1	1700	50	19
685	518	342	INDUSTRIAL DR	LOCAL ROADWAY	1220	1	11	0	1700	40	18
686	519	65	SR 208	COLLECTOR	947	1	12	1	1750	35	17
687	519	182	SR 208	COLLECTOR	3233	1	12	1	1700	45	17
688	520	221	SR 628	COLLECTOR	656	1	10	0	1575	35	17
689	521	520	SR 628	COLLECTOR	4439	1	10	0	1700	50	18

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
690	522	222	SR 628	COLLECTOR	1642	1	10	0	1575	35	18
691	524	522	SR 628	COLLECTOR	3610	1	10	0	1700	50	16
692	525	524	SR 628	COLLECTOR	3757	1	10	0	1700	50	16
693	526	527	SR 613	COLLECTOR	1739	1	11	0	1700	40	15
694	527	532	SR 613	COLLECTOR	3929	1	11	0	1700	50	15
695	528	337	US 33	COLLECTOR	5859	1	12	1	1700	60	14
696	528	340	US 33	COLLECTOR	989	1	12	1	1700	55	14
697	529	530	SR 613	COLLECTOR	2392	1	11	0	1700	50	14
698	530	337	SR 613	COLLECTOR	2006	1	11	0	1350	30	14
699	531	529	SR 613	COLLECTOR	3533	1	11	0	1700	50	14
700	532	533	SR 613	COLLECTOR	5097	1	11	0	1700	50	15
701	533	449	SR 613	COLLECTOR	5211	1	11	0	1700	50	15
702	534	168	SR 208	COLLECTOR	844	1	12	1	1700	45	17
703	534	183	SR 208	COLLECTOR	2252	1	12	1	1700	60	17
704	535	536	SR 208	COLLECTOR	1865	1	12	1	1700	50	23
705	536	292	SR 208	COLLECTOR	7090	1	12	1	1700	55	23
706	537	324	SR 605	COLLECTOR	1461	1	11	1	1700	45	24
707	538	537	SR 605	COLLECTOR	1564	1	11	1	1700	45	24
708	539	94	SR 605	COLLECTOR	2692	1	11	1	1700	45	24
709	540	541	US 33	COLLECTOR	2437	1	12	1	1700	60	25
710	541	84	US 33	COLLECTOR	2617	1	12	1	1700	60	34
711	542	641	US 33	COLLECTOR	3398	1	12	1	1700	60	34
712	543	86	US 33	COLLECTOR	2648	1	12	1	1750	60	34
713	544	87	US 33	COLLECTOR	1423	1	12	1	1700	60	34
714	545	442	SR 715	COLLECTOR	1479	1	12	1	1700	50	35

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
715	546	547	SR 715	COLLECTOR	960	1	12	1	1575	35	27
716	547	41	SR 715	COLLECTOR	5858	1	12	1	1700	60	27
717	548	550	SR 738	COLLECTOR	2690	1	11	0	1700	45	27
718	549	119	SR 738	COLLECTOR	1136	1	11	0	1700	45	27
719	550	549	SR 738	COLLECTOR	651	1	11	0	1125	25	27
720	551	552	SR 738	COLLECTOR	3429	1	11	0	1700	55	27
721	552	548	SR 738	COLLECTOR	2576	1	11	0	1700	40	27
722	553	554	SR 639	COLLECTOR	878	1	10	0	1700	50	22
723	554	126	SR 639	COLLECTOR	9644	1	10	0	1700	50	22
724	555	397	CR 601	COLLECTOR	949	1	10	0	1700	40	20
725	555	398	CR 601	COLLECTOR	3496	1	10	0	1700	50	20
726	556	557	CR 601	COLLECTOR	2444	1	10	0	1700	50	11
727	557	160	CR 601	COLLECTOR	1305	1	10	0	1700	50	11
728	558	71	STATE PARK LN	LOCAL ROADWAY	3301	1	10	0	1575	35	10
729	559	74	CR 601	COLLECTOR	1832	1	11	0	1700	50	10
730	560	139	SR 719	COLLECTOR	5574	1	11	0	1700	50	10
731	560	446	CR 612	COLLECTOR	10582	1	10	0	1700	40	10
732	561	352	SR 719	COLLECTOR	2728	1	11	0	1700	50	19
733	562	224	SR 208	MINOR ARTERIAL	1854	2	12	0	1750	50	6
734	562	226	SR 208	MINOR ARTERIAL	2251	2	12	0	1900	60	6
735	563	564	LAKE ANNA PKWY	MINOR ARTERIAL	3340	2	12	4	1900	55	12
736	564	502	LAKE ANNA PKWY	MINOR ARTERIAL	1768	2	12	4	1750	55	6
737	565	381	CR 608	COLLECTOR	1484	1	11	0	1700	50	6
738	566	452	CR 608	COLLECTOR	3837	1	11	0	1700	55	6
739	567	566	CR 608	COLLECTOR	5094	1	11	0	1700	55	6

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
740	568	567	CR 608	COLLECTOR	2663	1	11	0	1700	50	6
741	569	451	CR 608	COLLECTOR	4643	1	11	0	1700	50	5
742	570	565	CR 608	COLLECTOR	4341	1	11	0	1700	50	6
743	571	568	CR 608	COLLECTOR	653	1	11	0	1700	45	6
744	572	569	CR 608	COLLECTOR	2500	1	11	0	1700	40	5
745	573	572	CR 608	COLLECTOR	1532	1	11	0	1575	35	5
746	574	450	CR 608	COLLECTOR	1477	1	12	0	1700	50	5
747	574	455	CR 608	COLLECTOR	2775	1	12	0	1700	50	5
748	575	576	CR 608	COLLECTOR	4988	1	12	0	1700	50	5
749	576	457	CR 608	COLLECTOR	3649	1	12	0	1700	50	5
750	577	458	CR 608	COLLECTOR	4376	1	12	0	1750	50	4
751	578	579	SR 608	COLLECTOR	2035	1	11	0	1700	50	4
752	579	580	SR 608	COLLECTOR	2008	1	11	0	1700	50	4
753	580	18	SR 608	COLLECTOR	1951	1	11	0	1700	50	4
754	581	497	SPOTSYLVANIA SCHOOL RD	LOCAL ROADWAY	904	1	12	0	1750	30	12
755	582	387	SR 738	COLLECTOR	679	1	11	0	1700	40	12
756	583	582	SR 738	COLLECTOR	1941	1	11	0	1750	50	12
757	584	583	SR 738	COLLECTOR	1055	1	11	0	1700	40	12
758	585	584	SR 738	COLLECTOR	1141	1	11	0	1700	40	12
759	586	585	SR 738	COLLECTOR	2520	1	11	0	1700	50	12
760	587	586	SR 738	COLLECTOR	1001	1	11	0	1700	40	12
761	588	383	SR 738	COLLECTOR	1412	1	11	0	1700	40	12
762	589	40	SR 618	COLLECTOR	4115	1	10	0	1700	50	26
763	590	417	SR 701	COLLECTOR	1544	1	10	0	1700	40	26

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
764	591	590	SR 601	COLLECTOR	293	1	10	0	675	15	26
765	592	418	SR 601	COLLECTOR	3305	1	10	0	1700	40	26
766	593	592	SR 601	COLLECTOR	1010	1	10	0	1125	25	26
767	594	624	SR 650	COLLECTOR	282	1	10	0	1125	25	26
768	595	594	SR 650	COLLECTOR	2078	1	10	0	1700	40	26
769	596	62	SR 618	COLLECTOR	1997	1	10	0	1700	40	26
770	597	408	SR 618	COLLECTOR	4513	1	10	0	1700	50	25
771	598	597	SR 618	COLLECTOR	552	1	10	0	900	20	25
772	599	314	SR 618	COLLECTOR	2549	1	10	0	1700	50	25
773	600	59	SR 618	COLLECTOR	648	1	10	0	1750	35	25
774	600	274	SR 618	COLLECTOR	1469	1	10	0	1700	45	25
775	601	281	SR 618	COLLECTOR	1681	1	10	0	1700	45	25
776	601	602	SR 618	COLLECTOR	369	1	10	0	1350	30	25
777	602	434	SR 618	COLLECTOR	698	1	10	0	1750	45	25
778	602	601	SR 618	COLLECTOR	369	1	10	0	1350	30	25
779	603	56	SR 618	COLLECTOR	1861	1	10	0	1700	40	19
780	604	60	SR 614	COLLECTOR	847	1	10	0	1575	35	20
781	605	184	SR 614	COLLECTOR	1652	1	12	0	1700	40	20
782	606	184	SR 652	COLLECTOR	1581	1	12	0	1700	50	20
783	607	321	SR 652	COLLECTOR	4579	1	12	0	1700	55	19
784	608	124	SR 604	COLLECTOR	4840	1	9	0	1700	40	21
785	609	247	SR 207	MINOR ARTERIAL	778	2	12	4	1900	50	31
786	609	611	SR 207	MINOR ARTERIAL	2041	2	12	4	1750	50	31
787	610	609	SR 652	COLLECTOR	967	1	11	2	1750	45	31
788	611	169	SR 207	MINOR ARTERIAL	1378	2	12	4	1900	50	31

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
789	611	609	SR 207	MINOR ARTERIAL	2041	2	12	4	1750	50	31
790	612	611	RUTHER GLEN RD	LOCAL ROADWAY	589	1	11	2	1750	45	31
791	613	249	SR 207	MINOR ARTERIAL	449	3	12	4	1900	50	31
792	613	302	SR 207	MINOR ARTERIAL	1885	1	12	4	1750	50	31
793	614	613	SR F-160	LOCAL ROADWAY	308	1	10	0	1750	30	31
794	616	122	CR 605	COLLECTOR	2129	1	10	0	1700	40	22
795	617	608	CR 604	COLLECTOR	3438	1	9	0	1700	40	21
796	618	406	CR 605	COLLECTOR	3843	1	10	0	1700	40	21
797	619	395	CR 622	COLLECTOR	2293	1	10	0	1700	45	20
798	620	312	SR 625	COLLECTOR	373	1	12	0	1350	30	18
799	621	363	CR 612	COLLECTOR	2882	1	10	0	1700	40	2
800	622	141	CR 601	COLLECTOR	3658	1	11	0	1700	55	11
801	622	144	CR 601	COLLECTOR	5015	1	11	0	1700	55	11
802	623	622	CR 655	COLLECTOR	1320	1	9	0	1700	45	11
803	624	409	SR 650	COLLECTOR	911	1	10	0	1750	40	26
804	625	460	CR 604	COLLECTOR	4640	1	9	0	1700	40	21
805	626	96	CR 652	COLLECTOR	1169	1	10	0	1700	50	10
806	627	626	CR 652	COLLECTOR	936	1	10	0	1700	50	10
807	628	627	CR 652	COLLECTOR	2399	1	10	0	1700	50	10
808	629	628	CR 652	COLLECTOR	1147	1	10	0	1700	50	10
809	630	629	CR 652	COLLECTOR	3402	1	10	0	1700	50	10
810	631	630	CR 652	COLLECTOR	2211	1	10	0	1700	50	10
811	632	631	CR 652	COLLECTOR	1311	1	10	0	1700	50	10
812	633	632	CR 652	COLLECTOR	3358	1	10	0	1700	50	10
813	634	639	CR 652	COLLECTOR	1426	1	10	0	1700	40	10

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
814	635	634	CR 652	COLLECTOR	723	1	10	0	1700	40	10
815	636	635	CR 652	COLLECTOR	1482	1	10	0	1700	40	10
816	637	636	CR 719	COLLECTOR	1362	1	10	0	1700	40	10
817	637	638	CR 719	COLLECTOR	2175	1	10	0	1700	50	10
818	638	138	CR 719	COLLECTOR	1576	1	10	0	1700	40	10
819	638	637	CR 719	COLLECTOR	2175	1	10	0	1700	50	10
820	639	633	CR 652	COLLECTOR	1931	1	10	0	1700	50	10
821	640	641	SR 648	COLLECTOR	2679	1	11	0	1700	40	34
822	641	85	US 33	COLLECTOR	1609	1	12	1	1700	60	34
823	641	495	SR 648	COLLECTOR	4990	1	11	0	1700	40	34
824	642	453	CR 612	COLLECTOR	8798	1	10	0	1700	40	5
825	643	463	CR 605	COLLECTOR	5653	1	10	0	1700	40	21
826	644	118	TRIVETTE RD	LOCAL ROADWAY	1063	1	11	0	1700	40	27
827	8146	146	I-95	FREEWAY	2911	3	12	12	2250	75	7
828	8152	152	I-95	FREEWAY	4365	3	12	12	2250	75	31
829	8265	265	US 1	MINOR ARTERIAL	2025	2	12	2	1900	60	7
830	8303	303	US 1	MINOR ARTERIAL	3508	2	12	2	1900	60	37
831	8329	329	I-64	FREEWAY	2307	2	12	10	2250	75	33
Exit Link	235	8235	SR 738	COLLECTOR	2514	1	11	0	1700	50	36
Exit Link	257	8257	CR 608	COLLECTOR	3207	1	12	0	1700	45	13
Exit Link	146	8146	I-95	FREEWAY	2911	3	12	12	2250	75	7
Exit Link	152	8152	I-95	FREEWAY	4365	3	12	12	2250	75	31
Exit Link	169	8169	SR 207	MINOR ARTERIAL	1848	2	12	4	1900	50	31
Exit Link	44	8044	SR 671	COLLECTOR	3596	1	11	0	1700	50	36
Exit Link	226	8226	SR 208	MINOR ARTERIAL	3464	2	12	0	1900	60	6

Link #	Up-Stream Node	Down-Stream Node	Roadway Name	Roadway Type	Length (ft.)	No. of Lanes	Lane Width (ft.)	Shoulder Width (ft.)	Saturation Flow Rate (pcphpl)	Free Flow Speed (mph)	Grid Number
Exit Link	70	8070	US 33	COLLECTOR	2710	1	11	0	1700	55	14
Exit Link	73	8073	SR 22	COLLECTOR	2764	1	11	0	1700	45	14
Exit Link	129	8129	SR 639	COLLECTOR	2735	1	10	0	1700	50	22
Exit Link	143	8143	SR 605	COLLECTOR	1727	1	11	0	1700	40	22
Exit Link	167	8167	STONEWALL JACKSON RD	COLLECTOR	2067	1	12	0	1700	45	13
Exit Link	187	8187	US 522	COLLECTOR	1747	1	12	0	1700	60	34
Exit Link	223	8223	CR 613	COLLECTOR	2456	1	12	0	1700	50	1
Exit Link	225	8225	CR 627	COLLECTOR	4169	1	12	2	1700	45	6
Exit Link	231	8231	US 522	COLLECTOR	4645	1	12	1	1700	60	3
Exit Link	232	8016	SR 20	COLLECTOR	4855	1	12	3	1700	60	4
Exit Link	238	8238	CR 621	COLLECTOR	1957	1	10	0	1700	50	1
Exit Link	444	8444	US 33	COLLECTOR	3161	1	12	1	1700	40	36
Exit Link	265	8265	US 1	MINOR ARTERIAL	2025	2	12	2	1900	60	7
Exit Link	303	8303	US 1	MINOR ARTERIAL	3508	2	12	2	1900	60	37
Exit Link	214	8214	SR 20	COLLECTOR	1575	1	11	2	1700	40	2
Exit Link	329	8329	I-64	FREEWAY	2307	2	12	10	2250	75	33
Exit Link	330	8330	I-64	FREEWAY	6358	2	12	10	2250	75	23
Exit Link	306	8306	CR 612	COLLECTOR	2435	1	10	0	1700	45	6

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

Node	X Coordinate (ft)	Y Coordinate (ft)	Control Type	Grid Map Number
2	11638749	6780690	Actuated	3
3	11661508	6713177	TCP Uncontrolled	19
4	11668745	6714072	TCP Actuated	19
8	11723737	6745023	TCP Actuated	12
9	11730212	6743549	TCP Actuated	12
10	11741662	6738461	Actuated	12
16	11656309	6782910	Stop	4
18	11673093	6777797	Stop	4
20	11709946	6793806	Stop	1
21	11674684	6766769	Stop	4
23	11702430	6742414	Stop	11
24	11721873	6774782	Stop	6
26	11745039	6757906	Actuated	6
31	11597219	6771531	Stop	2
35	11650509	6730923	Stop	10
36	11679813	6701623	Stop	19
39	11701123	6663747	Stop	26
41	11725824	6656802	Stop	27
42	11732613	6649926	Stop	36
48	11653592	6687743	Stop	19
50	11654831	6669639	Stop	25
51	11655864	6666710	TCP Uncontrolled	25
54	11658771	6635919	Stop	34
56	11656682	6687839	Yield	19
59	11676068	6682941	TCP Actuated	25
65	11628791	6691103	Actuated	17
66	11626770	6691855	Actuated	17
68	11603959	6702751	Stop	14
71	11680218	6736288	Stop	10
86	11676467	6641362	TCP Actuated	34
87	11680097	6637805	Stop	34
88	11688666	6635927	Stop	35
96	11668513	6752671	Stop	10
100	11671767	6764094	TCP Uncontrolled	4
103	11686750	6754700	Stop	11
107	11722882	6714017	Stop	21
108	11724634	6702878	Stop	21

Node	X Coordinate (ft)	Y Coordinate (ft)	Control Type	Grid Map Number
111	11744285	6684255	TCP Actuated	27
112	11746267	6684497	Yield	27
118	11738815	6680524	TCP Actuated	27
121	11762334	6723100	Stop	13
122	11760583	6719400	Stop	22
124	11753489	6703852	Stop	22
127	11766960	6691244	Actuated	22
132	11763409	6717612	Stop	22
134	11769248	6684033	Stop	28
138	11663780	6728480	Stop	10
154	11719411	6659480	TCP Uncontrolled	27
160	11692947	6725191	Stop	11
163	11636244	6683679	Stop	24
166	11626237	6692346	Actuated	17
168	11625093	6690789	Stop	17
170	11625830	6692831	Actuated	17
171	11703556	6732071	Stop	11
180	11625245	6692126	Stop	17
182	11632902	6690365	TCP Uncontrolled	18
183	11624147	6687863	Stop	17
184	11688468	6698039	Stop	20
199	11678258	6703372	Stop	19
203	11684194	6717239	Stop	19
209	11626438	6678615	Stop	24
219	11627968	6693016	TCP Uncontrolled	17
224	11747296	6760219	Actuated	6
264	11767872	6755060	Actuated	13
277	11633233	6656172	Stop	24
288	11764372	6733405	Actuated	13
302	11777484	6659827	Actuated	31
307	11742420	6759640	Actuated	6
309	11737965	6762487	Stop	6
311	11663295	6779158	Stop	4
312	11639128	6691088	Yield	18
335	11653204	6687739	TCP Actuated	19
337	11608123	6701758	Stop	14
342	11636576	6689704	Stop	18
352	11659216	6717658	Stop	19

Node	X Coordinate (ft)	Y Coordinate (ft)	Control Type	Grid Map Number
355	11632154	6738156	Stop	9
497	11726651	6743506	Actuated	12
502	11738487	6756614	Actuated	6
512	11661550	6713280	Yield	19
517	11649482	6691247	Stop	18
641	11671165	6645863	Stop	34
526	11628255	6719167	Stop	15
546	11727108	6663426	Stop	27
574	11708424	6764505	Stop	5
582	11737280	6728970	TCP Actuated	12
593	11707918	6675692	Stop	26
609	11781777	6662831	Actuated	31
611	11783446	6664006	Actuated	31
613	11779090	6661023	Actuated	31
625	11742263	6708539	Stop	21
381	11737307	6756614	Stop	6
388	11724972	6722711	Stop	12
406	11724788	6706617	Stop	21
409	11692400	6669583	TCP Actuated	26
415	11714279	6656033	TCP Uncontrolled	26
416	11703038	6671616	Stop	26
434	11664681	6685714	TCP Actuated	25
435	11665757	6658568	Stop	25
444	11717412	6620093	Stop	35
448	11631193	6720438	TCP Uncontrolled	15
450	11709766	6765122	TCP Uncontrolled	5
458	11678340	6763683	TCP Actuated	4
459	11742148	6708654	TCP Uncontrolled	21
465	11675541	6637461	Stop	34
467	11668518	6638441	Stop	34
470	11693069	6682652	TCP Uncontrolled	26
475	11692070	6647984	TCP Uncontrolled	35
482	11647208	6740563	TCP Actuated	9
488	11699294	6734031	Stop	11

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

APPENDIX L

Protective Action Zone (PAZ) Boundaries

L. PROTECTIVE ACTION ZONE BOUNDARIES

PAZ 1 Not in Use

PAZ 2 County: Louisa

Defined as the area within the following boundary: Town of Mineral

PAZ 3 County: Louisa

Defined as the area within the following boundary: north by Routes 22 and 208, east by Routes 33, 522 and Mineral Town line, south by Routes 605 and 643, west by Routes 644, 33 and Louisa Town line

PAZ 4 County: Louisa

Defined as the area within the following boundary: north by Route 208, east by Lake Anna, Contrary Creek and Routes 652 and 700, south by Routes 618 and 667, west by Routes 208 and 522

PAZ 5 County: Louisa

Defined as the area within the following boundary: north by Route 618 and Mineral Town line, east by Route 609, south by Routes 33 and 657, west by Route 522

PAZ 6 County: Louisa

Defined as the area within the following boundary: north by Route 652, east by Route 614, south by Route 618, west by Route 700

PAZ 7 County: Louisa

Defined as the area within the following boundary: north by Route 652, east by Route 650, south by Route 618, west by Route 614

PAZ 8 County: Louisa

Defined as the area within the following boundary: northeast by Lake Anna, southeast by Route 614, northwest by Contrary Creek, southwest by Route 652

PAZ 9 County: Spotsylvania

Defined as the area within the following boundary: north by Routes 713 and 601, east by Route 614, south by Lake Anna, west by Route 208

PAZ 10 County: Louisa

Defined as the area within the following boundary: north by Lake Anna, east by Lake Anna and Route 622, south by Route 622, west by Routes 652 and 614

PAZ 11 County: Spotsylvania

Defined as the area within the following boundary: north by Route 657, east by Routes 738 and 622, south by Route 622, west by Lake Anna and Route 614

PAZ 12 County: Spotsylvania

Defined as the area within the following boundary: north by Bluff Run and Glebe Run, east by Route 738 and Oak Crest Drive, south by Routes 657, 614, 601 and 713, west by Route 208

PAZ 13 County: Spotsylvania

Defined as the area within the following boundary: north by Route 606, east by Routes 208 and 650, south by Route 208, west by Routes 601, 612 and 655

PAZ 14 County: Spotsylvania

Defined as the area within the following boundary: north by Route 601, east by Route 655, south by Lake Anna, west by Routes 612 and 719

PAZ 15 County: Louisa

Defined as the area within the following boundary: north by Lake Anna, east by Lake Anna, south by Route 208, west by Routes 522 and 719

PAZ 16 County: Louisa

Defined as the area within the following boundary: north by Lake Anna, east by Routes 719 and 522/208, south by Routes 22, 208 and Louisa Town line, west by Colonial Pipeline

PAZ 17 County: Orange

Defined as the area within the following boundary: north by Routes 653 and 629, east by Orange/Spotsylvania County line, south by Orange/Louisa County line (North Anna River), west by Colonial Pipeline

PAZ 18 County: Spotsylvania

Defined as the area within the following boundary: north by Routes 606 and 608, east by Routes 612 and 719, south by Spotsylvania/Louisa County line (North Anna River), west by Spotsylvania/Orange County line

PAZ 19 County: Spotsylvania

Defined as the area within the following boundary: north by Route 608, east by Route 612, south by Route 606, west by Route 606

PAZ 20 County: Spotsylvania

Defined as the area within the following boundary: north by Route 608, east by Routes 606 and 649, south by Route 208, west by Routes 606, 612 and 650

PAZ 21 County: Spotsylvania

Defined as the area within the following boundary: north by Routes 208 and 606, east by Routes 647 and 738, south by Route 605, west by Bluff Run, Glebe Run, Oak Crest Drive and Route 738

PAZ 22 County: Spotsylvania

Defined as the area within the following boundary: north by Routes 604 and 605, east by Spotsylvania/Caroline County line, south by North Anna River, west by Routes 622 and 738

PAZ 23 County: Caroline

Defined as the area within the following boundary: north by Route 738, east by Route 738, south by North Anna River, west by Spotsylvania/Caroline County line

PAZ 24 County: Hanover

Defined as the area within the following boundary: north by North Anna River, east by Route 738, south by Routes 608, 658, 680, 715, 729, 739 and 800, west by Hanover/Louisa County line

PAZ 25 County: Louisa

Defined as the area within the following boundary: north by North Anna River, east by Route 601, south by Route 652, west by Route 622

PAZ 26 County: Louisa

Defined as the area within the following boundary: north by North Anna River, east by Hanover/Louisa County line, south by Routes 33, 608, 655 and 701, west by Routes 601, 609, 650 and 652

APPENDIX M

Evacuation Sensitivity Studies

M. EVACUATION SENSITIVITY STUDIES

This appendix presents the results of a series of sensitivity analyses. These analyses are designed to identify the sensitivity of the ETE to changes in some base evacuation conditions.

M.1 Effect of Changes in Trip Generation Times

A sensitivity study was performed to determine whether changes in the estimated trip generation time have an effect on the ETE for the entire EPZ. Specifically, if the tail of the mobilization distribution were truncated (i.e., if those who responded most slowly to the Advisory to Evacuate, could be persuaded to respond much more rapidly), how would the ETE be affected? The case considered was Scenario 6, Region 3; a winter, midweek, midday, good weather evacuation of the entire EPZ. Table M-1 presents the results of this study.

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

Trip Generation Period	Evacuation Time Estimate for Entire EPZ	
	90th Percentile	100th Percentile
3 Hours 30 Minutes	2:40	3:45
4 Hours 30 Minutes	2:40	4:40
5 Hours 30 Minutes (Base)	2:40	5:40

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

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

A sensitivity study was conducted to determine the effect on ETE of changes in the percentage of people who decide to relocate from the Shadow Region. The case considered was Scenario 6, Region 3; a winter, midweek, midday, good weather evacuation for the entire EPZ. The movement of people in the Shadow Region has the potential to impede vehicles evacuating from an Evacuation Region within the EPZ. Refer to Sections 3.2 and 7.1 for additional information on population within the shadow region.

Table M-2 presents the evacuation time estimates for each of the cases considered. The results show that the ETE is not impacted by shadow evacuation from 0% to 20%. Tripling the shadow percentage has no effect on ETE. Note, the telephone survey results presented in Appendix F indicate that 19% of households would elect to evacuate if advised to shelter. Thus, the base assumption of 20% non-compliance suggested in NUREG/CR-7002 is valid.

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

Percent Shadow Evacuation	Evacuating Shadow Vehicles	Evacuation Time Estimate for Entire EPZ	
		90th Percentile	100th Percentile
0	0	2:40	5:40
15	2,650	2:40	5:40
20 (Base)	3,533	2:40	5:40
60	10,599	2:40	5:40

M.3 Effect of Changes in EPZ Resident Population

A sensitivity study was conducted to determine the effect on ETE of changes in the resident population within the EPZ. As population in the EPZ 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 EPZ, changes in population will cause the demand side of the equation to change. The sensitivity study was conducted using the following planning assumptions:

1. The change in population within the EPZ was treated parametrically. The percent population change was varied between +100% and -85%. 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 remained fixed; the presence of new roads 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 good weather scenario which yielded the highest ETE values was selected as the case to be considered in this sensitivity study (Scenario 6).

Table M-3 presents the results of the sensitivity study. Section IV of Appendix E to 10 CFR Part 50, and NUREG/CR-7002, Section 5.4, require licensees to provide an updated ETE analysis to the NRC when a population increase within the EPZ causes ETE values (for the 2-Mile Region, 5-Mile Region or entire EPZ) to increase by 25 percent or 30 minutes, whichever is less. Note that all of the base ETE values are greater than 2 hours; 25 percent of the base ETE is always greater than 30 minutes. Therefore, 30 minutes is the lesser and is the criterion for updating.

Those percent population changes which result in ETE changes greater than 30 minutes are highlighted in red below – a 150% increase or 85% decrease in the EPZ population. Dominion will have to estimate the EPZ population on an annual basis. If the EPZ population increases by 150% or more, or decreases by 85% or more, an updated ETE analysis will be needed.

Table M-3. ETE Variation with Population Change

EPZ Resident Population	Base	Population Change			Base	Population Change		
		100%	135%	150%		-40%	-70%	-85%
	25,202	50,404	59,225	63,005	25,202	15,122	7,561	3,781
ETE for 90th Percentile								
Region	Base	Population Change			Base	Population Change		
		100%	135%	150%		-40%	-70%	-85%
2-MILE	2:30	2:35	2:40	2:40	2:30	2:25	2:10	**1:55**
5-MILE	2:30	2:35	2:40	2:40	2:30	2:25	2:15	**1:55**
FULL EPZ	2:40	2:50	3:00	**3:10**	2:40	2:35	2:30	**2:10**
ETE for 100th Percentile								
Region	Base	Population Change			Base	Population Change		
		100%	135%	150%		-40%	-70%	-85%
2-MILE	5:30	5:30	5:30	5:30	5:30	5:30	5:30	5:30
5-MILE	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35
FULL EPZ	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40

M.4 Effect of an Outage at the NAPS with Construction of New Unit 3

A sensitivity study was conducted to determine the effect on ETE from having an outage at the NAPS, concurrent with construction of the new unit. Outages may occur in spring (March/April) or fall (September/October) and typically last between 25 and 35 days. Data obtained from emergency management personnel at NAPS indicate there are an additional 900 employees (with a maximum shift of 450 employees) and an additional 150 Dominion/supplemental personnel per day for the Unit 3 construction project, resulting in a total of 600 additional employees. Using a vehicle occupancy factor of 1.04 obtained from the telephone survey, there are a total of 577 additional vehicles present at the plant during an outage.

ETE results shown in Table M-4 compare the outage to Scenario 6; a winter, midweek, midday, good weather evacuation of the 2-mile, 5-mile and full EPZ. Results indicate that the ETE are not affected by the additional plant employees, with the exception of the 90th percentile ETE for the 2-mile region, which decreased by 5 minutes. The decrease in the 90th percentile ETE is attributable to employees mobilizing at a quicker rate than the general population.

Table M-4. Evacuation Time Estimates for Outage

Region	Scenario 6 (Base)		Outage with Construction of New Unit 3	
	90th Percentile	100th Percentile	90th Percentile	100th Percentile
2-MILE	2:30	5:30	2:25	5:30
5-MILE	2:30	5:35	2:30	5:35
FULL EPZ	2:40	5:40	2:40	5:40

APPENDIX N

ETE Criteria Checklist

N. ETE CRITERIA CHECKLIST

Table N-1. ETE Review Criteria Checklist

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

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
e. Methods used to address data uncertainties should be described.	Yes	Section 3 – avoid double counting Section 5, Appendix F – 4.15% sampling error at 95% confidence interval for telephone survey
1.2 Assumptions		
a. The planning basis for the ETE includes the assumption that the evacuation should be ordered promptly and no early protective actions have been implemented.	Yes	Section 2.3 – Assumption 1 Section 5.1
b. Assumptions consistent with Table 1-2, "General Assumptions," of NUREG/CR-7002 should be provided and include the basis to support their use.	Yes	Sections 2.2, 2.3
1.3 Scenario Development		
a. The ten scenarios in Table 1-3, Evacuation Scenarios, should be developed for the ETE analysis, or a reason should be provided for use of other scenarios.	Yes	Tables 2-1, 6-2
1.3.1 Staged Evacuation		
a. A discussion should be provided on the approach used in development of a staged evacuation.	Yes	Sections 5.4.2, 7.2
1.4 Evacuation Planning Areas		
a. A map of EPZ with emergency response planning areas (ERPAs) should be included.	Yes	Figure 6-1
b. A table should be provided identifying the ERPAs considered for each ETE calculation by downwind direction in each sector.	Yes	Table 6-1

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
c. A table similar to Table 1-4, "Evacuation Areas for a Staged Evacuation Keyhole," of NUREG/CR-7002 should be provided and includes the complete evacuation of the 2, 5, and 10 mile areas and for the 2 mile area/5 mile keyhole evacuations.	Yes	Table 7-5
2.0 Demand Estimation		
a. Demand estimation should be developed for the four population groups, including permanent residents of the EPZ, transients, special facilities, and schools.	Yes	Permanent residents, employees, transients – Section 3, Appendix E Special facilities, schools – Section 8, Appendix E
2.1 Permanent Residents and Transient Population		
a. The US Census should be the source of the population values, or another credible source should be provided.	Yes	Section 3.1
b. Population values should be adjusted as necessary for growth to reflect population estimates to the year of the ETE.	Yes	2010 used as the base year for analysis. No growth of population necessary.
c. A sector diagram should be included, similar to Figure 2-1, "Population by Sector," of NUREG/CR-7002, showing the population distribution for permanent residents.	Yes	Figure 3-2
2.1.1 Permanent Residents with Vehicles		
a. The persons per vehicle value should be between 1 and 2 or justification should be provided for other values.	Yes	1.81 persons per vehicle – Table 1-3
b. Major employers should be listed.	Yes	Appendix E – Table E-3
2.1.2 Transient Population		

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

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

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
c. The number of wheelchair and bed-bound individuals should be provided.	Yes	Section 3.5 Table E-2
d. An estimate of the number and capacity of vehicles needed to support the evacuation of the facility should be provided.	Yes	Section 8.3 Table 8-4
e. The logistics for mobilizing specially trained staff (e.g., medical support or security support for prisons, jails, and other correctional facilities) should be discussed when appropriate.	Yes	Sections 8.3, 8.4
2.4 Schools		
a. A list of schools including name, location, student population, and transportation resources required to support the evacuation, should be provided. The source of this information should be provided.	Yes	Table 8-2 Section 8.2
b. Transportation resources for elementary and middle schools should be based on 100% of the school capacity.	Yes	Table 8-2
c. The estimate of high school students who will use their personal vehicle to evacuate should be provided and a basis for the values used should be discussed.	Yes	Section 8.2
d. The need for return trips should be identified if necessary.	Yes	There are sufficient resources to evacuate schools in a single wave if transportation resources are shared between counties. However, Section 8.4 and Figure 8-1 discuss the potential for a multiple wave evacuation.

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
2.5.1 Special Events		
a. A complete list of special events should be provided and includes information on the population, estimated duration, and season of the event.	Yes	Section 3.7 Section 6
b. The special event that encompasses the peak transient population should be analyzed in the ETE.	Yes	Section 3.7
c. The percent of permanent residents attending the event should be estimated.	Yes	Section 3.7
2.5.2 Shadow Evacuation		
a. A shadow evacuation of 20 percent should be included for areas outside the evacuation area extending to 15 miles from the NPP.	Yes	Section 2.2 – Assumption 5 Figure 2-1 Section 3.2
b. Population estimates for the shadow evacuation in the 10 to 15 mile area beyond the EPZ are provided by sector.	Yes	Section 3.2 Figure 3-4 Table 3-3
c. The loading of the shadow evacuation onto the roadway network should be consistent with the trip generation time generated for the permanent resident population.	Yes	Section 5 – Table 5-9
2.5.3 Background and Pass Through Traffic		

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

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
d. Calculations for a representative roadway segment should be provided.	Yes	Section 4
e. A legible map of the roadway system that identifies node numbers and segments used to develop the ETE should be provided and should be similar to Figure 3-1, "Roadway Network Identifying Nodes and Segments," of NUREG/CR-7002.	Yes	Appendix K, Figures K-1 through K-38 present the entire link-node analysis network at a scale suitable to identify all links and nodes
3.2 Capacity Analysis		
a. The approach used to calculate the roadway capacity for the transportation network should be described in detail and identifies factors that should be expressly used in the modeling.	Yes	Section 4
b. The capacity analysis identifies where field information should be used in the ETE calculation.	Yes	Section 1.3, Section 4
3.3 Intersection Control		
a. A list of intersections should be provided that includes the total number of intersections modeled that are unsignalized, signalized, or manned by response personnel.	Yes	Appendix K, Table K-2
b. Characteristics for the 10 highest volume intersections within the EPZ are provided including the location, signal cycle length, and turn lane queue capacity.	Yes	Table J-1
c. Discussion should be provided on how signal cycle time is used in the calculations.	Yes	Section 4.1, Appendix C.
3.4 Adverse Weather		

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

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
a. Permanent residents are assumed to evacuate from their homes but are not assumed to be at home at all times. Trip generation time includes the assumption that a percentage of residents will need to return home prior to evacuating.	Yes	Section 5 discusses trip generation for households with and without returning commuters. Table 6-3 presents the percentage of households with returning commuters and the percentage of households either without returning commuters or with no commuters. Appendix F presents the percent households who will await the return of commuters.
b. Discussion should be provided on the time and method used to notify transients. The trip generation time discusses any difficulties notifying persons in hard to reach areas such as on lakes or in campgrounds.	Yes	Section 5.4.3
c. The trip generation time accounts for transients potentially returning to hotels prior to evacuating.	Yes	Section 5 Figure 5-1
d. Effect of public transportation resources used during special events where a large number of transients should be expected should be considered.	Yes	Section 3.7
e. The trip generation time for the transient population should be integrated and loaded onto the transportation network with the general public.	Yes	Section 5 Table 5-9
4.1.2 Transit Dependent Residents		

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
a. If available, existing plans and bus routes should be used in the ETE analysis. If new plans should be developed with the ETE, they have been agreed upon by the responsible authorities.	Yes	Section 8.4 – pages 8-7, 8-8. Pre-established bus routes were used as defined in each of the counties RERP– see Figures 8-2, 8-3, 8-4, Table 8-10.
b. Discussion should be included on the means of evacuating ambulatory and non-ambulatory residents.	Yes	Section 8.4
c. The number, location, and availability of buses, and other resources needed to support the demand estimation should be provided.	Yes	Section 8.4 Table 8-5
d. Logistical details, such as the time to obtain buses, brief drivers, and initiate the bus route should be provided.	Yes	Section 8.4 Figure 8-1
e. Discussion should identify the time estimated for transit dependent residents to prepare and travel to a bus pickup point, and describes the expected means of travel to the pickup point.	Yes	Section 8.4
f. The number of bus stops and time needed to load passengers should be discussed.	Yes	Section 8.4
g. A map of bus routes should be included.	Yes	Figures 8-2, 8-3, 8-4
h. The trip generation time for non-ambulatory persons includes the time to mobilize ambulances or special vehicles, time to drive to the home of residents, loading time, and time to drive out of the EPZ should be provided.	Yes	Section 8.4

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
i. Information should be provided to supports analysis of return trips, if necessary.	Yes	Section 8.4 Figure 8-1 Tables 8-11, 8-12, 8-13
4.1.3 Special Facilities		
a. Information on evacuation logistics and mobilization times should be provided.	Yes	Section 8-4 Tables 8-14, 8-15, 8-16
b. Discussion should be provided on the inbound and outbound speeds.	Yes	Sections 8.4
c. The number of wheelchair and bed-bounds individuals should be provided, and the logistics of evacuating these residents should be discussed.	Yes	Section 8-4 Tables 8-14, 8-15, 8-16
d. Time for loading of residents should be provided	Yes	Section 8.4
e. Information should be provided that indicates whether the evacuation can be completed in a single trip or if additional trips should be needed.	Yes	Section 8.4 Tables 8-4, 8-5
f. If return trips should be needed, the destination of vehicles should be provided.	Yes	Return trips are not needed.
g. Discussion should be provided on whether special facility residents are expected to pass through the reception center prior to being evacuated to their final destination.	Yes	Section 8.4
h. Supporting information should be provided to quantify the time elements for the return trips.	Yes	Return trips are not needed.
4.1.4 Schools		

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
a. Information on evacuation logistics and mobilization time should be provided.	Yes	Section 8.4
b. Discussion should be provided on the inbound and outbound speeds.	Yes	School bus routes are presented in Table 8-6. School bus speeds are presented in Tables 8-7 (good weather), 8-8 (rain) and 8-9 (snow). Outbound speeds are defined as the minimum of the evacuation route speed and the State school bus speed limit. Inbound speeds are limited to the State school bus speed limit.
c. Time for loading of students should be provided.	Yes	Tables 8-7, 8-8, 8-9 Discussion in Section 8.4
d. Information should be provided that indicates whether the evacuation can be completed in a single trip or if additional trips are needed.	Yes	Section 8.4 – page 8-6 Table 8-2, 8-5
e. If return trips are needed, the destination of school buses should be provided.	Yes	Table 8-3
f. If used, reception centers should be identified. Discussion should be provided on whether students are expected to pass through the reception center prior to being evacuated to their final destination.	Yes	Table 8-3. Students are evacuated to Evacuation Assembly Centers (EAC) where they will be picked up by parents or guardians.

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
g. Supporting information should be provided to quantify the time elements for the return trips.	Yes	Return trips are needed for two of the schools. Tables 8-7, 8-8 and 8-9 provide time needed to arrive at the EAC, which could be used to compute a second wave evacuation. Example calculation is done in Section 8-4 – page 8-9
4.2 ETE Modeling		
a. General information about the model should be provided and demonstrates its use in ETE studies.	Yes	DYNEV II (Ver. 4.0.8.0) Section 1.3 Table 1-3 Appendix B and Appendix C
b. If a traffic simulation model is not used to conduct the ETE calculation, sufficient detail should be provided to validate the analytical approach used. All criteria elements should have been met, as appropriate.	No	Not applicable as a traffic simulation model was used.
4.2.1 Traffic Simulation Model Input		
a. Traffic simulation model assumptions and a representative set of model inputs should be provided.	Yes	Appendices B and C describe the simulation model assumptions and algorithms Table J-2
b. A glossary of terms should be provided for the key performance measures and parameters used in the analysis.	Yes	Appendix A Tables C-1, C-2

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
4.2.2 Traffic Simulation Model Output		
a. A discussion regarding whether the traffic simulation model used must be in equilibration prior to calculating the ETE should be provided.	Yes	Appendix B
b. The minimum following model outputs should be provided to support review: 1. Total volume and percent by hour at each EPZ exit node. 2. Network wide average travel time. 3. Longest queue length for the 10 intersections with the highest traffic volume. 4. Total vehicles exiting the network. 5. A plot that provides both the mobilization curve and evacuation curve identifying the cumulative percentage of evacuees who have mobilized and exited the EPZ. 6. Average speed for each major evacuation route that exits the EPZ.	Yes	1. Table J-5. 2. Table J-3. 3. Table J-1. 4. Table J-3. 5. Figures J-1 through J-14 (one plot for each scenario considered). 6. Table J-4. Network wide average speed also provided in Table J-3.
c. Color coded roadway maps should be provided for various times (i.e., at 2, 4, 6 hrs., etc.) during a full EPZ evacuation scenario, identifying areas where long queues exist including level of service (LOS) "E" and LOS "F" conditions, if they occur.	Yes	Figures 7-3 through 7-6
4.3 Evacuation Time Estimates for the General Public		
a. The ETE should include the time to evacuate 90% and 100% of the total permanent resident and transient population	Yes	Tables 7-1, 7-2

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
b. The ETE for 100% of the general public should include all members of the general public. Any reductions or truncated data should be explained.	Yes	Section 5.4.1 – truncating survey data to eliminate statistical outliers Table 7-2 – 100th percentile ETE for general public
c. Tables should be provided for the 90 and 100 percent ETEs similar to Table 4-3, "ETEs for Staged Evacuation Keyhole," of NUREG/CR-7002.	Yes	Tables 7-3, 7-4
d. ETEs should be provided for the 100 percent evacuation of special facilities, transit dependent, and school populations.	Yes	Section 8.4 Tables 8-7, 8-8, 8-9 Tables 8-11, 8-12, 8-13, 8-14, 8-15, 8-16
5.0 Other Considerations		
5.1 Development of Traffic Control Plans		
a. Information that responsible authorities have approved the traffic control plan used in the analysis should be provided.	Yes	Section 9, Appendix G
b. A discussion of adjustments or additions to the traffic control plan that affect the ETE should be provided.	Yes	Appendix G
5.2 Enhancements in Evacuation Time		
a. The results of assessments for improvement of evacuation time should be provided.	Yes	Section 13 Appendix M
b. A statement or discussion regarding presentation of enhancements to local authorities should be provided.	Yes	Results of the ETE study were formally presented to local authorities at the final project meeting. Recommended enhancements were discussed.

NRC Review Criteria	Criterion Addressed in ETE Analysis	Comments
5.3 State and Local Review		
a. A list of agencies contacted and the extent of interaction with these agencies should be discussed.	Yes	Table 1-1
b. Information should be provided on any unresolved issues that may affect the ETE.	Yes	There are no outstanding issues.
5.4 Reviews and Updates		
a. A discussion of when an updated ETE analysis is required to be performed and submitted to the NRC.	Yes	Appendix M, Section M.3
5.5 Reception Centers and Congregate Care Center		
a. A map of congregate care centers and reception centers should be provided.	Yes	Figure 10-1
b. If return trips are required, assumptions used to estimate return times for buses should be provided.	Yes	Section 8.4 discusses a multi-wave evacuation procedure. Figure 8-1
c. It should be clearly stated if it is assumed that passengers are left at the reception center and are taken by separate buses to the congregate care center.	Yes	Section 2.3 – Assumption 7h Section 10

Technical Reviewer ________________________________ Date __________________________

Supervisory Review ________________________________ Date __________________________