Tennessee Valley Authority, 1101 Market Street, Chattanooga, TN 37402

CNL-16-104

June 10, 2016

10 CFR 2.101
10 CFR 52.15

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

Clinch River Nuclear Site
NRC Project No. 785

Subject: Submittal of Evacuation Time Estimate Report in Support of Early Site Permit Application for Clinch River Nuclear Site

Reference: Letter from TVA to NRC, CNL-16-081, "Application for Early Site Permit for Clinch River Nuclear Site," dated May 12, 2016

In the referenced letter, Tennessee Valley Authority (TVA) submitted an application for an early site permit for the Clinch River Nuclear (CRN) Site in Oak Ridge, TN. In addition to the contents of the application, TVA is also providing the enclosed Evacuation Time Estimate (ETE) Report. The ETE Report is being provided in support of the NRC staff's determination that there is no significant impediment to the development of an emergency plan at the CRN Site that cannot be mitigated or eliminated, pursuant to 10 CFR 52.18.

There are no new regulatory commitments associated with this submittal. If any additional information is needed, please contact Dan Stout at (423) 751-7642.

I declare under penalty of perjury that the foregoing is true and correct. Executed on this 10th day of June 2016.

Respectfully,

J. W. Shea
Vice President, Nuclear Licensing

Enclosure

cc: See Page 2

D113
NRO

Enclosure:

Evacuation Time Estimate Report, Revision 0

cc (without enclosure):

Executive Director of Operations
Regional Administrator, Region II
Deputy Executive Director for Reactor and Preparedness Programs
Director, Office of New Reactor Licensing
Director, Office of New Reactors
Branch Chief, Division of New Reactor Licensing
Project Manager, Division of New Reactor Licensing
Project Manager, Division of New Reactor Licensing
Project Manager, Division of New Reactor Licensing
Acting Assistant Secretary, Office of Nuclear Energy, Department of Energy
Deputy Assistant Secretary, Nuclear Reactor Technologies, Department of Energy
Light Water Reactor Technologies, Department of Energy
Program Manager, Licensing Technical Support Program, Department of Energy
Project Manager, Licensing Technical Support Program, Department of Energy
Regulatory Specialist, Eastern Regulatory Field Office, Nashville District,
U.S. Army Corp of Engineers

Tennessee Valley Authority

Clinch River Nuclear Site

Early Site Permit Application

Part 5B

Evacuation Time Estimate Report

Revision 0

September 2015

ABSTRACT

The evacuation time estimate (ETE) detailed in this report is an analysis of the time required to evacuate the Plume Exposure Pathway Emergency Planning Zone (EPZ) for the Clinch River Nuclear (CRN) Site. The CRN Site is a proposed Small Modular Reactor (SMR) project on 1200 acres of land adjacent to the Clinch River arm of the Watts Bar Reservoir, south of the U.S. Department of Energy Oak Ridge Reservation (DOE/OR), within the City of Oak Ridge, in Roane County, Tennessee. The CRN Emergency Plan considers the unique plant design and margins to safety afforded by a SMR design, while maintaining emergency preparedness at appropriate levels to protect the health and safety of the public. For the proposed CRN Site, the EPZ is an area encompassing an approximate 2 mile radius around the proposed reactor center point location. NUREG/CR-7002, "Criteria for Development of Evacuation Time Estimate Studies" (NUREG/CR-7002), provides guidance for the development of ETEs. The guidance provided in NUREG/CR-7002 can be used to demonstrate compliance with the ETE analysis development required by the NRC in Section IV of Appendix E to Title 10 of the Code of Federal Regulation (CFR) Part 50 (10 CFR 50) and serves as a template for the development of this ETE study. Typically, the ETE is used to inform protective action decision-making and may also be used to assist offsite authorities in development of traffic management plans to support an evacuation. For purposes of the CRN Site Early Site Permit Application (ESPA), the ETE also serves to satisfy the requirements of 10 CFR 52.17(b)(1), which states that the site safety analysis report identify physical characteristics of the proposed site, such as egress limitations from the area surrounding the site, that could pose a significant impediment to the development of emergency plans and if physical impediments are identified, the application must identify measures that would, when implemented, mitigate or eliminate the significant impediment.. Consistent with guidance, this ETE has been developed to provide the time to evacuate 90 percent and 100 percent of the total population of the EPZ. The 90 percent ETE provides the evacuation times that would typically be used to support protective action recommendations and decision-making.

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EXECUTIVE SUMMARY

This report describes the analyses undertaken to develop evacuation time estimates (ETE) for the Clinch River Nuclear (CRN) Site, and the associated results. The Clinch River Property consists of 1200 acres adjacent to the Clinch River arm of the Watts Bar Reservoir, south of the U.S. Department of Energy Oak Ridge Reservation (DOE/OR), within the City of Oak Ridge, in Roane County, Tennessee that is proposed to be used as the location to construct and operate a Small Modular Reactor (SMR) project.

Part 5 of the Early Site Permit Application (ESPA) being submitted for the CRN Site includes two (2) Emergency Plans (Part 5A and Part 5B) for review by the NRC. Part 5A will address a site boundary plume exposure pathway Emergency Planning Zone (EPZ) and Part 5B addresses a 2-Mile plume exposure pathway EPZ. The final EPZ size will be determined at the time the Combined License Application (COLA) is submitted. For purposes of the CRN Site ESPA, the ETE serves to satisfy the requirements of 10 CFR 52.17(b)(1), which states that the site safety analysis report identify physical characteristics of the proposed site, such as egress limitations from the area surrounding the site, that could pose a significant impediment to the development of emergency plans and if physical impediments are identified, the application must identify measures that would, when implemented, mitigate or eliminate the significant impediment. This ETE did not identify physical characteristics of the proposed site that could pose a significant impediment to the development of emergency plans.

In the event the site boundary EPZ is selected for the CRN Site, the Tennessee Valley Authority (TVA) has proposed an exemption from the requirements to perform an ETE and an update to this ETE will not be necessary.

The Clinch River Emergency Plan considers the unique plant design and margins to safety afforded by a SMR design, while maintaining emergency preparedness at appropriate levels to protect the health and safety of the public. The ETE are calculations of the time necessary to evacuate the Plume Exposure Pathway Emergency Planning Zone (EPZ), which is an area encompassing an approximate 2 mile radius around the proposed reactor center point location. The exact size and configuration of the EPZ surrounding the CRN Site was developed in relation to local emergency response needs and capabilities as they are affected by such conditions as demography, topography, land characteristics, access routes and jurisdictional

boundaries. Of particular interest in the development of CRN Site plume exposure pathway EPZ is the overlapping emergency planning zone for the DOE/OR.

Section IV of Appendix E to Title 10 of the Code of Federal Regulation (CFR) Part 50 (10 CFR 50) requires that an analysis of the time required to evacuate be provided for various sectors and distances within the EPZ for transient and permanent residents. Consistent with Supplement 3, "Guidance for Protective Action Strategies," of NUREG-0654/FEMA-REP-1, Rev. 1, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants" (NUREG-0654), the Protective Action Recommendation for an EPZ encompassing an area of approximately 2 miles surrounding the CRN Site would be consistent throughout the EPZ. Therefore, the use of various sectors and distances within the EPZ is not appropriate for the CRN Site and this ETE only considers an evacuation of the entire EPZ reflecting the effects of seasonal variations, day-of-the-week, and adverse weather conditions. Based on the data obtained from the 2010 U.S. Census, projected to 2015, there are 856 permanent residents within the EPZ of the proposed CRN Site.

The ETE is primarily used to inform protective action decision-making and may also be used to assist in development of traffic management plans to support an evacuation, if deemed necessary by offsite response organizations (OROs). The ETE is used as an information tool, and therefore, no minimum evacuation time must be achieved. The guidance in NUREG-0654 Evaluation Criterion J.10, provides additional information regarding the use of ETE results. ETE are used by OROs when making offsite protective action decisions. This report was prepared based on guidance provided in NUREG/CR-7002, "Criteria for Development of Evacuation Time Estimate Studies" (NUREG/CR-7002).

This report provides details on the process used for the development of ETEs for two population segments, including:

1. Permanent residents and transient population.
2. Transit dependent permanent residents.

There are no school populations located within the EPZ.

This report also provides details on the development of the evacuation demand considered in the ETE, preparation activities associated with development of the ETE, and the use of traffic simulation modeling. Other considerations included in this ETE analysis include:

- A shadow evacuation extending to 15 miles from the CRN Site assumes that 20% of the public outside the boundary of the EPZ to a distance of 15 miles from the CRN Site would spontaneously evacuate.
- Lack of existing emergency preparedness programs and evacuation plans, including:
  - The absence of existing registration programs for people with disabilities and those with access and functional needs who do not reside in special facilities.
  - The absence of existing evacuation routes.
  - The absence of existing traffic control plans.
- Verification of the future commitment of resources, such as buses and ambulances.
- Consideration of the evacuation tail.
- Future ETE updates related to a Combined License Application.

This report includes a discussion of INTEGRATION, the traffic simulation model used in performance of the ETE and a summary of the key inputs, assumptions, outputs, and computational process associated with the simulation. The INTEGRATION software is listed in the U.S. Department of Transportation's (DOT) "Evacuation Management Operations (EMO) Modeling Assessment: Transportation Modeling Inventory," developed to support selection of an appropriate model for use in evacuation analyses (Reference 1).

NUREG/CR-7002 establishes the need to include a 20 percent shadow evacuation in the analysis. A shadow evacuation is defined as an evacuation of people from areas outside an officially declared evacuation zone. The shadow population is considered in this analysis to account for any effect of people from the EPZ boundary to 15 miles impeding the evacuation of those under evacuation orders. According to the 2010 U.S. Census data, projected to the year 2015, there are approximately 186,500 permanent residents within 15 miles of the proposed CRN Site.

The EPZ is sparsely populated with no major commercial facilities. There are no schools, correctional facilities, licensed day care facilities, nursing home facilities or major retail facilities located in the EPZ.

To summarize the results of this ETE, Table 4.13 of this report depicts evacuation times for nine scenarios (the tenth scenario is for peak construction which is not considered) and provides evacuation times for 90% of the affected population. As shown in Table 4.13, the shortest evacuation time is 1 hour and 40 minutes and the longest evacuation time is 2 hours and 17 minutes.

Similarly, Table 4.14 depicts evacuation times for 100% of the affected population. As shown in Table 4.14, the shortest evacuation time is 3 hours and 1 minute and the longest evacuation time is 3 hours and 52 minutes.

ACRONYMS AND ABBREVIATIONS

AADT	Annual Average Daily Traffic
AASHTO	American Association of State Highway and Transportation Officials
ACP	Access Control Point
ANS	Alert and Notification System
CFR	Code of Federal Regulation
COLA	Combined License Application
CRN	Clinch River Nuclear
DBE	Design Basis Event
DOE/OR	U.S. Department of Energy Oak Ridge Reservation
DOT	Department of Transportation
EAS	Emergency Alert System
EMO	Evacuation Management Operations
EPZ	Plume Exposure Pathway Emergency Planning Zone
ER	Environmental Report
ERPA	Emergency Response Planning Area
ESP	Early Site Permit
ESPA	Early Site Permit Application
ETE	Evacuation Time Estimate
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
GIS	Geographic Information Systems
HCM	Highway Capacity Manual
LOS	Level of Service
MOE	Measures of Effectiveness
O-D	Origin-Destination
ORO	Offsite Response Organization
SMR	Small Modular Reactor
TCP	Traffic Control Point
TEMA	Tennessee Emergency Management Agency
TVA	Tennessee Valley Authority
U.S.	United States
VTTI	Virginia Tech Transportation Institute

PREFACE

NUREG/CR-7002, "Criteria for Development of Evacuation Time Estimate Studies" (NUREG/CR-7002), provides guidance for the development of Evacuation Time Estimates (ETE). It also identifies the importance of using approved emergency response plans and existing traffic control information to reflect the expected response actions during an emergency. This report describes the analyses undertaken to develop ETE for the populace located within the Plume Exposure Pathway Emergency Planning Zone (EPZ) of the Clinch River Nuclear (CRN) Site, and the associated results.

Section 1 provides an introduction to the ETE, describes the characteristics of the EPZ, establishes general assumptions, and identifies the evacuation scenarios evaluated in this analysis. Section 2 provides details considered in developing demand estimates for permanent residents and transients, transit dependent populations, special facilities, schools, special events and quantifying a shadow evacuation. Section 3 describes the approach for evaluating the roadway capacity and establishes values for use in adverse weather calculations. Section 4 discusses the process for developing trip generation times and provides details on information included in traffic simulation modeling. Section 5 identifies other considerations including the need for development of a traffic control plan, potential enhancements to the ETE, and State and local review. Appendix A of the document provides characteristics for the roadways in the roadway network and Appendix B includes ETE review criteria contained in Appendix B of NUREG/CR-7002.

The ETE is primarily used by State and local governments to inform protective action decision-making and may also be used to assist in the future development of traffic management plans to support an evacuation, if deemed necessary by offsite response organizations. The ETE is used as an informational tool, and therefore, no minimum evacuation time must be achieved.

1.0 INTRODUCTION

The Clinch River Nuclear (CRN) Site is the location of a proposed Small Modular Reactor (SMR) nuclear power plant project adjacent to the Clinch River arm of the Watts Bar Reservoir, south of the U.S. Department of Energy Oak Ridge Reservation (DOE/OR), within the City of Oak Ridge, in Roane County, Tennessee. To account for the possibility of an emergency at the CRN Site, a hypothetical, unplanned release of radioactive materials is considered. This report describes the analyses undertaken to develop evacuation time estimates (ETE) for the populace located within the EPZ of the proposed nuclear power plant site, and the associated results. The ETE analysis is an emergency planning tool that assesses, in an organized and systematic fashion, the feasibility of taking protective measures for the population in the area surrounding a nuclear power plant. For purposes of the CRN Site ESPA, the ETE serves to satisfy the requirements of 10 CFR 52.17(b)(1), which states that the site safety analysis report identify physical characteristics of the proposed site, such as egress limitations from the area surrounding the site, that could pose a significant impediment to the development of emergency plans and if physical impediments are identified, the application must identify measures that would, when implemented, mitigate or eliminate the significant impediment.

The ETE also provides a tool for offsite response organizations (OROs) to use in preplanning as well as protective action decision making should a radiological release requiring offsite protective action decisions occur. The ETE may also be used to assist in development of future traffic management plans to support an evacuation, as deemed appropriate by OROs. The ETE is used as a decision-making tool, and therefore, no minimum evacuation time must be achieved.

Section IV of Appendix E to Title 10 of the Code of Federal Regulation (CFR) Part 50 (10 CFR 50) requires that an analysis of the time required to evacuate be provided for various sectors and distances within the EPZ for transient and permanent residents. Consistent with Supplement 3, "Guidance for Protective Action Strategies," of NUREG-0654/FEMA-REP-1, Rev. 1, "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants" (NUREG-0654), the Protective Action Recommendation for an EPZ encompassing an area of approximately 2 miles surrounding the CRN Site is expected to be consistent throughout the EPZ. Therefore, the use of various sectors and distances within the EPZ is not appropriate for the CRN Site and this ETE only

considers an evacuation of the entire EPZ reflecting the effects of seasonal variations, day-of-the-week, and adverse weather conditions. This report was prepared considering the ETE guidance provided in NUREG/CR-7002, "Criteria for Development of Evacuation Time Estimate Studies" (NUREG/CR-7002).

Roane County is located in southeastern Tennessee, encompasses 395 square miles, and has a population of approximately 54,000 residents distributed between five incorporated municipalities and its unincorporated areas. Kingston, the County seat, is located approximately 7 miles west-southwest of the proposed CRN Site. The Clinch River surrounds the CRN Site to the east, south and west. The county boundary is closest to the CRN Site approximately 3 miles to the east of the CRN Site.

The CRN Site is a proposed SMR nuclear power plant site. The CRN Emergency Plan considers the unique plant design and margins to safety afforded by a SMR design, while maintaining emergency preparedness at appropriate levels to protect the health and safety of the public. For the proposed CRN Site, the EPZ is an area encompassing an approximate 2 mile radius around the proposed reactor center point location. The EPZ encompasses sparsely populated areas and a portion of the DOE/OR. No major employment areas of the DOE/OR lie within the EPZ.

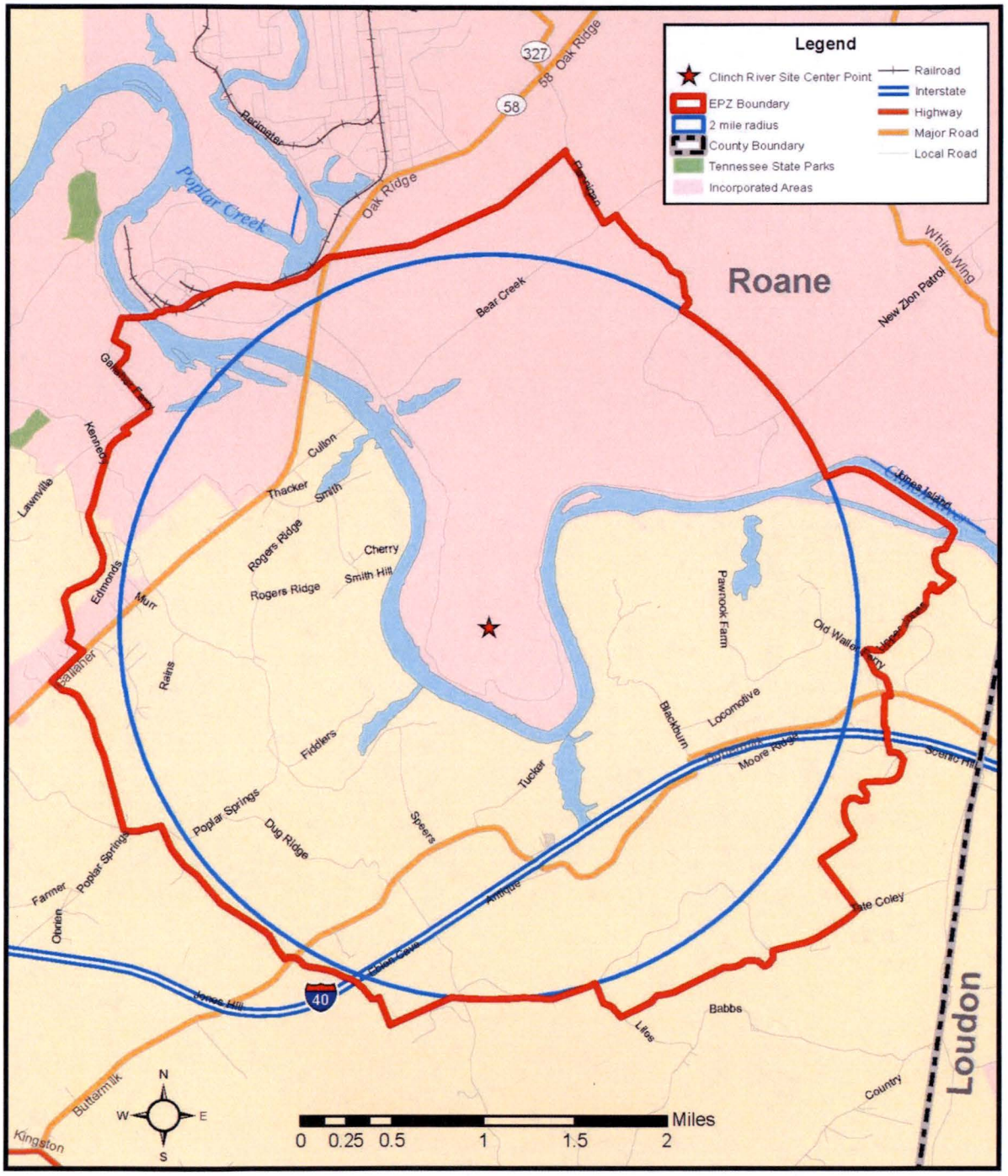
According to the U.S. Census 2010 data, projected to the year 2015, there are 856 permanent residents within the EPZ of the CRN Site. According to the 2010 U.S. Census data, projected to the year 2015, there are approximately 186,500 permanent residents within 15 miles of the proposed CRN Site. The EPZ is sparsely populated with no major commercial facilities. There are no schools, correctional facilities, licensed day care facilities, nursing home facilities or major retail facilities located in the EPZ.

Interstate 40 (I-40), located in the southeastern portion of the EPZ, is the primary east-west traffic route in the vicinity of the proposed CRN Site. I-40 crosses the EPZ boundary approximately 2 miles east and 2 miles south-southwest of the proposed CRN Site. Tennessee State Route 58 (Highway 58), located in the northwestern portion of the EPZ, is the primary north-south traffic route in the vicinity of the proposed CRN Site. Highway 58 crosses the EPZ boundary approximately 2 miles west and 2 miles north-northwest of the proposed CRN Site. Numerous local roads are found throughout the EPZ. Figure 1.1 illustrates the area surrounding

the proposed CRN Site and includes the roadway network, population centers, jurisdictional boundaries, and significant topographical features in the area.

Interstate 75 (I-75), although outside of the EPZ, is a major traffic route intersecting with I-40 approximately 7 miles east of the proposed CRN Site.

Figure 1.1 CRN Site Vicinity Map



The traffic simulation model INTEGRATION, used in performance of this ETE study, is a microscopic traffic assignment and simulation software that is well-suited for performance of ETEs for nuclear power plants. The INTEGRATION software calculates a number of Measures of Effectiveness (MOEs), which are addressed by NUREG/CR-7002 and it is listed in the U.S. Department of Transportation's (DOT) "Evacuation Management Operations (EMO) Modeling Assessment: Transportation Modeling Inventory," (Reference 1) developed to support selection of an appropriate model for use in evacuation analyses.

INTEGRATION performs traffic simulations by tracking the movement of individual vehicles every 1/10 of a second. The INTEGRATION model computes a number of MOEs, including the network efficiency. This model has been validated against state-of-the-art delay estimation procedures using queuing theory and shockwave analysis and against standard traffic flow theory and has been utilized for the evaluation of real-life applications.

The key parameters gathered on the roadway segments include the length of roadway segment, the number of lanes on each segment, type of roadway intersection control (stop sign, yield sign, etc.), lane striping (left turn only, shared through and right turn, etc.), free-flow speed, base saturation flow rate, jam density, and speed-at-capacity. Additional details regarding the traffic simulation model utilized in this study are included in Section 4.2.

Table 1.1 Evacuation Time Estimate Summary Information

ETE Element	Current ETE*
Permanent Residents	
Total EPZ permanent resident population	856
Vehicle ratio (people / evacuating vehicle)	1.7
Evacuating vehicles per household	1.3
Transit Dependent Population	
Total transit dependent population	35
Number of buses	3
Number of ambulances	2
Transient Population	
Average transient population	99
Peak Transient population	197
Special Facilities	
Total population	52
Number of buses	0
Number of ambulances	0
Schools	**Not Applicable**
Total population	-
Total capacity	-
Number of buses	-
Capacity (each bus)	-
Shadow Evacuation	
Percent Estimated	20%
Special Event	**Not Applicable**
Population	-
Location	-
Duration	-
Other Elements	
Adverse Weather	Summer – Rain Winter – Snow/Ice
Evacuation Model	INTEGRATION
Scenarios	10
Assumptions	See Table 1.2

* A previous ETE has not been performed for the proposed CRN Site.

1.1. Approach

A meeting regarding the development of the ETE was conducted at the Tennessee Emergency Management Agency (TEMA) in Knoxville, Tennessee on January 9, 2014 and was attended by representatives of state and local emergency management and law enforcement agencies, local elected officials and representatives from various state and local government agencies and private-sector support organizations. The purpose of the meeting was to present the process used for developing the ETE for the proposed CRN Site and outline associated data and information needs that would be used as inputs in the ETE analysis. The meeting included a detailed discussion of the ETE process including the methods used to collect data (roadway survey, telephone survey and data collection forms).

Following the meeting, a detailed field survey of the EPZ roadway network was conducted to validate existing mapping and to obtain characteristics of the primary roadways in the EPZ. Roadway characteristics obtained during the field survey include:

- Number of lanes
- Lane width
- Intersection configuration
- Lane channelization and striping
- Geometrics (curves and lengths)
- Posted and actual speeds
- Abutting land use
- Traffic control devices
- Unusual characteristics

The detailed field survey was video archived for reference purposes during subsequent development of the INTEGRATION model network.

A random telephone survey of households within the EPZ and surrounding area to 10 miles from the CRN Site was conducted to interview a statistically representative sample of residents. The telephone survey resulted in interviews with 604 households and was designed to obtain information related to household demographics and the commuting habits of residents. This information was used to identify factors affecting the evacuee trip generation time (mobilization time) as well as other data to be used in the ETE analyses, including average household size, vehicles per household, vehicle occupancy and an estimate of the number of transit-dependent residents. The mobilization time is the major component of the total ETE when the EPZ population density is low and there is minimal traffic congestion, as is the case for the CRN Site. The telephone survey provides a statistical confidence interval of plus or minus 4% at the 95% level of confidence and is a sound, documented basis for the trip generation times needed to develop the calculated ETEs.

NUREG/CR-7002 defines the transient population as tourists, shoppers, employees, etc., who do not reside within the EPZ and other people temporarily visiting the EPZ (Reference 4). Hotel, motel, and campground occupancy rates peak during the summer months and during special events in the area. A survey of the transient facilities was conducted to obtain information regarding the number of transients and vehicles expected at these locations. The survey was designed to obtain information related to the number of units at each facility, average yearly occupancy, average number of persons per occupied unit and average number of vehicles per occupied unit. The survey was used to estimate peak attendance at transient facilities. There are no hotels/motels and 1 campground/RV park within the EPZ. This facility is addressed in greater detail in Section 2.1.2.

One special facility, the Kingston Academy, currently exists within the EPZ. The Kingston Academy is a Psychiatric Residential Treatment Facility with living quarters and a capacity of 52 children between the ages of 5 and 17. The facility provides residential treatment and day treatment services. Special facilities are addressed in Section 2.3.

Data related to major employers (more than 50 total employees) provided in the CRN Site Early Site Permit Application (ESPA) Environmental Report (ER) was evaluated for use in development of this ETE. Major employers within the EPZ are addressed in Section 2.5.

There are no schools, correctional facilities, licensed day care facilities, nursing home facilities or major commercial or retail facilities located in the EPZ.

1.2. Assumptions

According to NUREG/CR-7002, the planning basis for the ETE includes the assumption that a rapidly escalating emergency is underway, an evacuation is ordered promptly by emergency management officials and no early protective actions have been implemented (Reference 4).

A 2-mile EPZ is evaluated in this ETE analysis and is included among the regulatory exemptions requested in the CRN Site ESPA.

Development of potential exemptions for SMRs is based on various design and analysis considerations. Specifically, the SMR licensing basis events (or Design Basis Events, DBEs) are expected to have small and delayed source term releases that will result in predicted on- and off-site radiation doses significantly lower than those considered in the bases for existing nuclear power plant emergency planning requirements. For Beyond DBEs, analyses would need to conclude that the slow progression rate of postulated severe event scenarios provides sufficient time to initiate appropriate mitigating actions to protect the health and safety of the public.

The following table, Table 1.2, General Assumptions, provides assumptions that the NRC included in NUREG/CR-7002 and additional assumptions considered in development of the ETE, as appropriate for the CRN Site. The telephone survey discussed in Section 2.2 of this report provides information on vehicle usage. Those assumptions that are used exclusively within individual sections of this report are addressed and discussed in the applicable section. Assumptions used, beyond those explicitly accepted by NRC in published guidance, are supported by available technical reports, telephone survey data, documented communications, and other sources. Scenario-specific assumptions are addressed in section 1.3 of this report.

Table 1.2 General Assumptions

1	The ETE is measured from the time that the advisory to evacuate is issued to the public within the EPZ (e.g., initial emergency alert system (EAS) broadcast.
2	Mobilization of the public begins after initial notification and includes all preparation activities (time for commuters to leave work, time for commuters to travel home, time to prepare the house)
3	Evacuation time ends when the last vehicle has exited the EPZ.
4	Background traffic is on the roadway when initial notification occurs and stops entering the EPZ upon establishment of Access Control Points at 90 minutes following the advisory to evacuate.
5	A 50% capacity is appropriate for buses used in the evacuation of the transit dependent population.
6	Shadow evacuation of 20% of the public occurs from the outside boundary of the EPZ to a distance of 15 miles from the CRN Site.
7	Permanent residents will evacuate using local roads.
8	All daytime scenarios assume 90% of the commuters are at work. All evening scenarios assume 10% of the commuters are at work. All weekend scenarios assume 10% of the commuters are at work.
9	Telephone survey results indicate the following: • The average household contains 2.2 persons. • The average household has 2.2 vehicles. • 1.3 vehicles/household would be used during an evacuation

1.3. Scenario Development

As suggested in NUREG/CR-7002, the evacuation scenarios presented in Table 1.3, below, were modeled to reflect the effects of seasonal variations, day-of-the-week, adverse weather, special events, roadway impacts and the peak construction workforce at the proposed CRN site on the ETE (Reference 4). These scenarios were developed to identify combinations of variables and events to provide ETE under varying conditions to support protective action decisions and to provide a range of potential evacuation situations dependent on site-specific considerations.

Table 1.3 Evacuation Scenarios

Scenario	Season	Day	Time	Weather
1	Summer	Midweek	Daytime	Normal
2	Summer	Midweek	Daytime	Adverse*
3	Summer	Weekend	Daytime	Normal
4	Summer	Midweek and Weekend	Evening	Normal
5	Winter	Midweek	Daytime	Normal
6	Winter	Midweek	Daytime	Adverse*
7	Winter	Weekend	Daytime	Normal
8	Winter	Midweek and Weekend	Evening	Normal
9	Roadway Impact	Midweek	Daytime	Normal
10	Peak Construction	Midweek	Daytime	Normal

* See Table 3.1

A description of each scenario used in the study is provided below.

Scenario # 1 – Summer Midweek Daytime (Normal Weather): This scenario represents a typical normal weather daytime period when permanent residents are generally dispersed within the EPZ performing daily activities and major work places are at typical daytime levels. This scenario includes assumptions that schools are closed and hotel and motel facilities are occupied at peak levels. The scenario assumes that 1/4 of the transients are in the EPZ for a single night and 3/4 are staying multiple nights. It is further assumed that 1/4 of the multiple

night transients remain in hotel rooms and/or campgrounds during the day and 3/4 are participating in recreational activities within the EPZ. It is further assumed that 1/2 of the 3/4 (3/8 of total transient population within the EPZ) will return to their lodging facilities to retrieve belongings.

Scenario # 2 – Summer Midweek Daytime (Adverse Weather): This scenario represents an adverse weather daytime period when permanent residents are generally dispersed within the EPZ performing daily activities and major work places are at typical daytime levels. This scenario includes assumptions that permanent residents will evacuate from their place of residence; schools are closed and hotel and motel facilities are occupied at peak levels. The scenario assumes that 1/4 of the transients are in the EPZ for a single night and 3/4 are staying multiple nights. Due to adverse weather, it is assumed that 1/2 of multiple night transients remain in hotel rooms and/or campgrounds and 1/2 are participating in recreational activities within the EPZ. Of the 1/2 that are participating in recreational activities within the EPZ, it is assumed that 1/2 (1/4 of total transient population within the EPZ) will return to their lodging facilities to retrieve belongings.

Scenario # 3 – Summer Weekend Daytime (Normal Weather): This scenario represents a typical normal weather weekend period when permanent residents are both at home and dispersed within the EPZ performing typical summer weekend activities. This scenario includes assumptions that permanent residents will evacuate from their place of residence; schools are closed and students are at home or with their families; work places are staffed at typical weekend levels and hotel and motel facilities are occupied at peak summer weekend levels. The scenario assumes that 1/4 of the transients are in the EPZ for a single night and 3/4 are staying multiple nights. It is further assumed that 1/4 of the multiple night transients remain in hotel rooms and/or campgrounds during the day and 3/4 are participating in recreational activities within the EPZ. It is further assumed that 1/2 of the 3/4 (3/8 of total transient population within the EPZ) will return to their lodging facilities to retrieve belongings.

Scenario # 4 – Summer Midweek and Weekend Evening (Normal Weather): This scenario represents a typical normal weather midweek and weekend evening period when permanent residents are generally at home with fewer dispersed within the EPZ performing evening activities. This scenario includes assumptions that permanent residents will evacuate from their place of residence; schools are closed and students are at home; work places are staffed at

typical evening levels; hotel and motel facilities are occupied at peak summer levels and all transients are at their lodging facilities.

Scenario # 5 – Winter Midweek Daytime (Normal Weather): This scenario represents a typical normal weather weekday period during the winter when school is in session, permanent residents are generally dispersed within the EPZ performing daily activities and major work places are at typical daytime levels. This scenario includes assumptions that students will evacuate directly from the schools and hotel and motel facilities are occupied at 50% of the peak summertime levels. The scenario assumes that 1/4 of the transients are in the EPZ for a single night and 3/4 are staying multiple nights. It is further assumed that 1/4 of the multiple night transients remain in hotel rooms and/or campgrounds during the day and 3/4 are participating in recreational activities within the EPZ. It is further assumed that 1/2 of the 3/4 (3/8 of total transient population within the EPZ) will return to their lodging facilities to retrieve belongings.

Scenario # 6 – Winter Midweek Daytime (Adverse Weather): This scenario represents an adverse weather weekday period during the winter when school is in session, permanent residents are generally dispersed within the EPZ performing daily activities and major work places are at typical daytime levels. This scenario includes assumptions that students will evacuate directly from the schools; work places are fully staffed at typical daytime levels and hotel and motel facilities are occupied at average levels. The scenario assumes that 1/4 of the transients are in the EPZ for a single night and 3/4 are staying multiple nights. Due to adverse weather, it is assumed that 1/2 of multiple night transients remain in hotel rooms and/or campgrounds and 1/2 are participating in recreational activities within the EPZ. Of the 1/2 that are participating in recreational activities within the EPZ, it is assumed that 1/2 (1/4 of total transient population within the EPZ) will return to their lodging facilities to retrieve belongings.

Scenario # 7 – Winter Weekend Daytime (Normal Weather): This scenario reflects a typical normal weather winter weekend period when permanent residents are both at home and dispersed within the EPZ. This scenario includes assumptions that schools are closed and students are at home; work places are staffed at typical weekend levels; and hotel and motel facilities are occupied at average weekend levels. The scenario assumes that 1/4 of the transients are in the EPZ for a single night and 3/4 are staying multiple nights. It is further assumed that 1/4 of the multiple night transients remain in hotel rooms and/or campgrounds

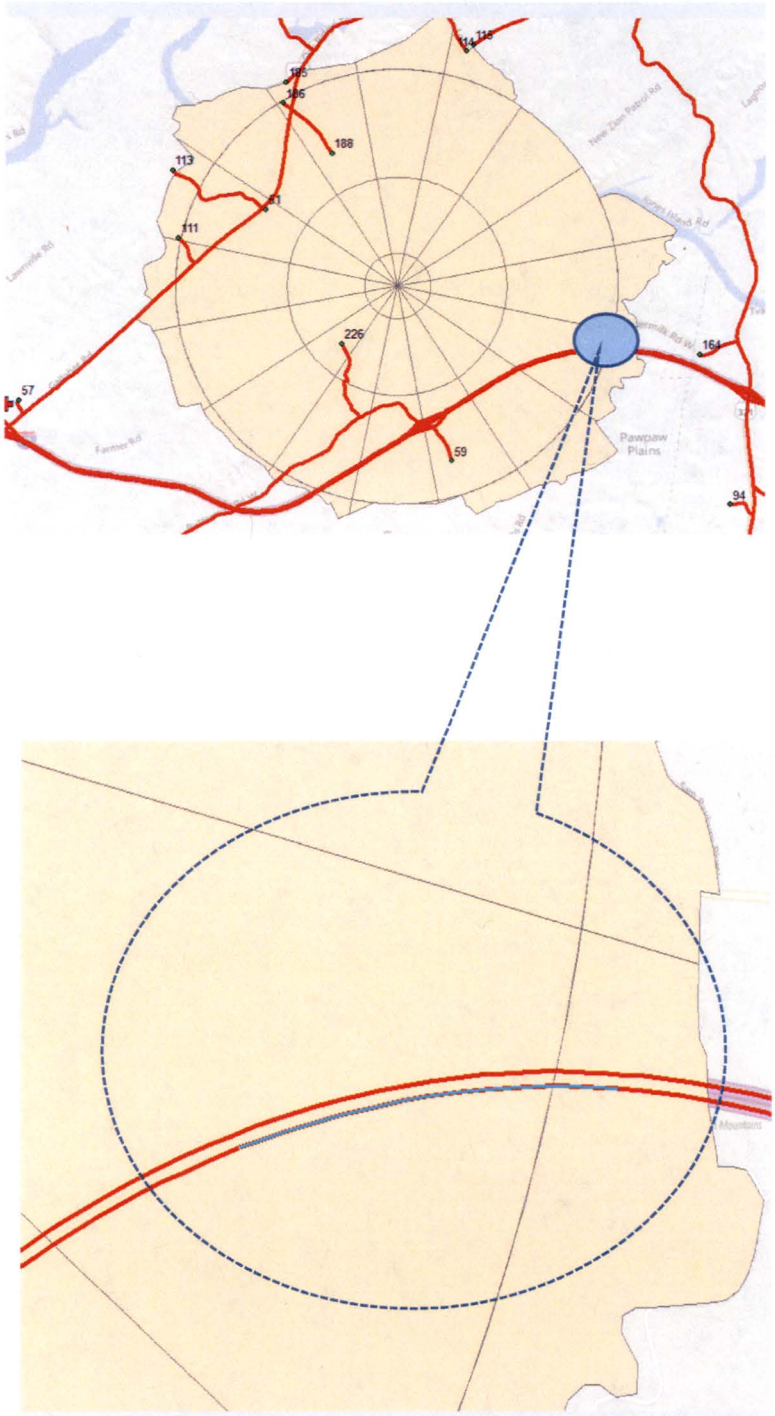
during the day and 3/4 are participating in recreational activities within the EPZ. It is further assumed that 1/2 of the 3/4 (3/8 of total transient population within the EPZ) will return to their lodging facilities to retrieve belongings.

Scenario # 8 – Winter Midweek and Weekend Evening (Normal Weather): This scenario reflects a typical normal weather midweek and weekend evening period when permanent residents are home and the work force is at a nighttime level. This scenario includes assumptions that schools are closed and students are at home; work places are staffed at typical nighttime levels; and hotel and motel facilities are occupied at average winter levels and all transients are at their lodging facilities.

Scenario # 9 – Roadway Impact Summer Midweek Daytime (Normal Weather): The intent of this scenario is to represent a variety of conditions that may impact a roadway segment such as construction, flooding, vehicle accidents, etc. The roadway impact scenario assumes that during a summer midweek normal weather daytime scenario, one section of an eastbound lane of I-40 is shut down near the EPZ boundary, resulting in a reduction in capacity. All assumptions included in Scenario #1 are included in this scenario. This analysis is conducted to understand the potential impact of such an event and to support the development of a traffic control plan by identifying areas where OROs may want to consider additional emergency planning such as the pre-positioning of response vehicles (e.g., tow trucks). The ETE for this scenario is not typically used in protective action recommendations or decision-making.

Figure 1.2 illustrates the location of the roadway impact scenario.

Figure 1.2 Location of Roadway Impact Scenario



Scenario # 10 – Peak Construction Midweek Daytime (Normal): This scenario represents a typical normal weather midweek daytime period when the peak number of construction workers are on-site and permanent residents are generally dispersed within the EPZ performing daily activities and major work places are at typical daytime levels. Up to 2,700 construction workers would be required during the peak phase of construction activities for a Small Modular Reactor plant at the Site. Peak plant staff is expected to be 500 employees. Construction workers and plant staff are expected to commute because there are no provisions for housing at the Site. A site plan detailing road access to the Site has not been finalized. Therefore, it was assumed that driveway access to and from the Site would be along Bear Creek Road. This scenario includes assumptions that schools are closed and hotel and motel facilities are occupied at peak levels. Assumptions related to the transient population are identical to Scenario #1. The existing roadway system was used for this scenario and no roadway improvements were considered. According to the census data in the area, the overall permanent population increasing rate from 2015 to 2024 is estimated to be 2.64%. Permanent resident and shadow populations were extrapolated to 2024 for this scenario.

1.3.1. Staged and Keyhole Evacuation

NUREG/CR-7002 addresses the use of staged and traditional keyhole evacuations when making protective action decisions. Evacuation research has shown that implementation of a staged evacuation can be more beneficial to the public health and safety than the traditional keyhole evacuation (Reference 2). However, NUREG/CR-7002 was developed considering an EPZ size of an approximately 10-mile radius, where the benefits of a staged and traditional keyhole evacuations may be realized, given site-specific characteristics.

In a typical (NUREG/CR-7002) staged evacuation, evacuation times for the 0-2 mile and the 2-5 mile portions of a 10-mile EPZ are calculated separately to support a staged evacuation protective action decision (i.e., evacuation of the 0-2 mile zone, followed by subsequent evacuation of the 2-5 mile zone). Because this ETE analysis for the CRN Site considers an EPZ encompassing an approximate 2 mile radius around the proposed reactor center point location, staged and traditional keyhole evacuations are not appropriate for the CRN Site and have not been considered in this analysis. Instead, this analysis considers an evacuation of the entire EPZ for each evacuation scenario. Based on the data obtained from the 2010 U.S.

Census, projected to 2015, there are 856 permanent residents within the EPZ of the proposed CRN site.

1.4. Emergency Response Planning Areas

As described in NUREG/CR-7002, conduct of the ETE typically requires consideration of discreet planning areas within the EPZ, referred to as Emergency Response Planning Areas (ERPAs) (Reference 4). ERPAs are defined as local areas within the EPZ for which emergency response information is provided. The establishment of ERPAs within an EPZ enables protective action recommendations and decisions to be made at the ERPA level. With a 2-mile EPZ, during an emergency at the CRN Site, protective actions will be implemented consistently throughout the EPZ. For this reason, development of ERPA within the EPZ are not necessary and ERPA are not considered in this analysis. Based on the characteristics of the EPZ for the proposed CRN Site, ETEs were developed for the complete evacuation of the entire EPZ for each evacuation scenario considered.

The permanent resident and transient populations for the EPZ are discussed in Section 2 of this report.

2.0 DEMAND ESTIMATION

This section of the ETE report details the process for developing an estimate of the number of people to be evacuated from the EPZ. The demand estimation includes permanent residents, transients, individuals with special needs, and any other members of the public in the EPZ at the time an evacuation is ordered. The potential exists for counting individuals in more than one of these groups (i.e., EPZ resident may also be counted as an employee or transient). To avoid double-counting permanent residents, and as a result, overestimating the number of evacuating vehicles, the percent of permanent residents of the EPZ assumed to be at parks, shopping, places of employment or other locations within the EPZ is identified in appropriate sections of this ETE report. Demographic data obtained from the U.S. Census 2010 (projected to 2015), a random telephone survey of permanent residents in the EPZ and surrounding area, and assumptions detailed throughout this ETE report, have been used to estimate the number of people and vehicles considered in the ETE. Demand estimates for the following population groups have been considered separately and account for all of the public in the EPZ:

- Permanent Residents and Transient Population (with access to a vehicle during an evacuation).
- Transit Dependent Permanent Residents (without access to a vehicle or dependent on help from outside the home to evacuate).
- Special Facility Residents (Residents of or those confined to nursing homes, jails, assisted living centers, hospitals, etc.).
- Schools (Public and private educational facilities).

Estimates of the population and number of evacuating vehicles for each of these population groups have been developed separately and are described in the following sections.

2.1. Permanent Residents and Transient Population

The permanent resident population has been estimated using Census block data obtained from the U.S. Census 2010 and is projected to 2015 for this analysis. To determine the permanent resident population, the block data was loaded directly into geographic information systems (GIS) software and the permanent resident population and number of households were

calculated based on polar coordinate representation (population rose). The EPZ permanent residents, by sector, is presented in Table 2.1. Table 2.1 includes residents in the "2 to EPZ Boundary" to reflect those areas where the EPZ extends irregularly beyond a 2-mile radius. The EPZ permanent resident population, the number of households and the number of evacuating vehicles are presented in Table 2.2. The permanent resident population is illustrated by sector in Figure 2.1.

Table 2.1 Permanent Resident Population By Sector

Distance	Direction	2015 Population
1	N	0
1	NNE	0
1	NE	5
1	ENE	8
1	E	8
1	ESE	6
1	SE	8
1	SSE	7
1	S	13
1	SSW	13
1	SW	13
1	WSW	15
1	W	17
1	WNW	21
1	NW	19
1	NNW	0
2	N	0
2	NNE	0
2	NE	0
2	ENE	8
2	E	13
2	ESE	38
2	SE	41

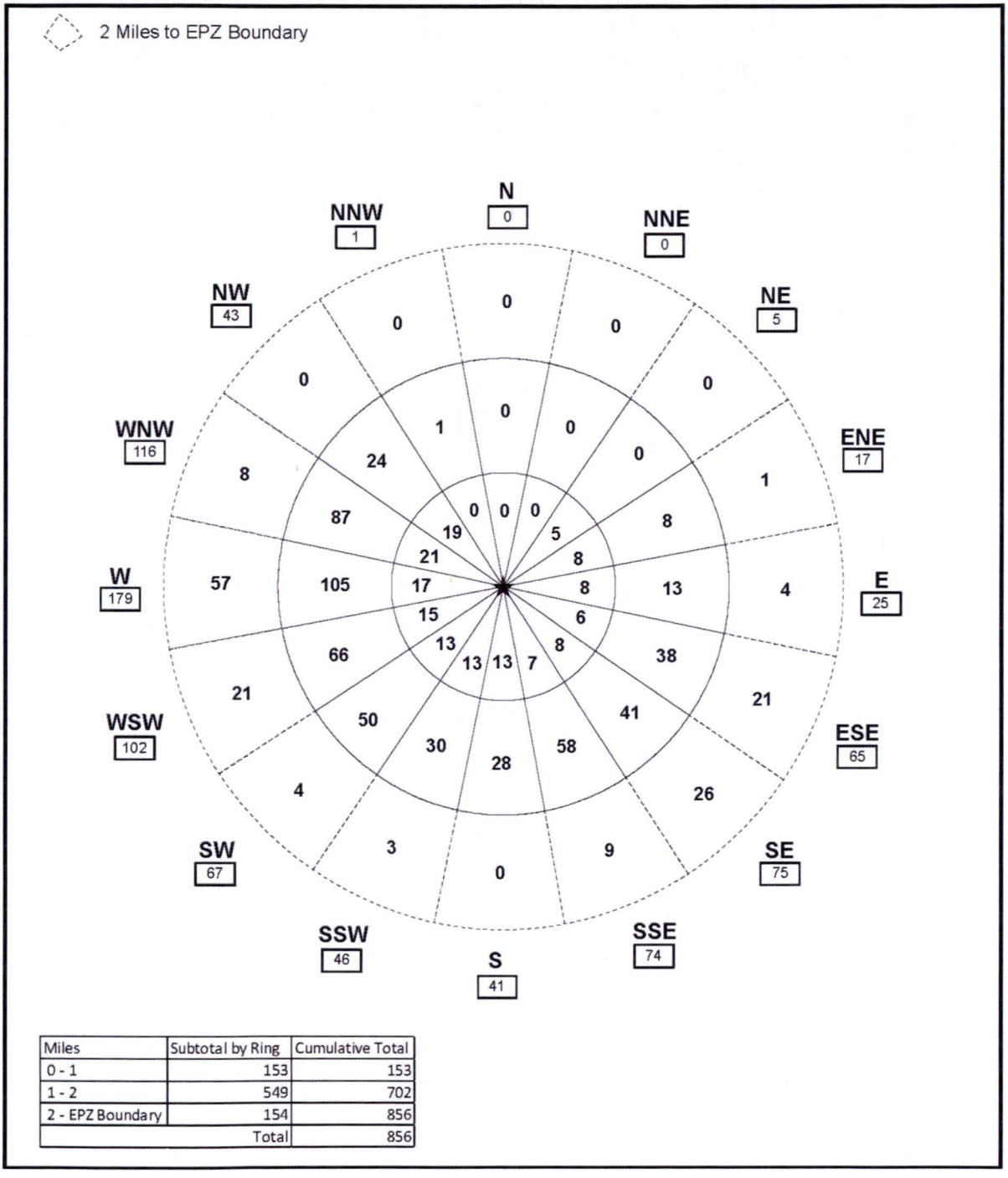
Distance	Direction	2015 Population
2	SSE	58
2	S	28
2	SSW	30
2	SW	50
2	WSW	66
2	W	105
2	WNW	87
2	NW	24
2	NNW	1
2 to EPZ Boundary	N	0
2 to EPZ Boundary	NNE	0
2 to EPZ Boundary	NE	0
2 to EPZ Boundary	ENE	1
2 to EPZ Boundary	E	4
2 to EPZ Boundary	ESE	21
2 to EPZ Boundary	SE	26
2 to EPZ Boundary	SSE	9
2 to EPZ Boundary	S	0
2 to EPZ Boundary	SSW	3
2 to EPZ Boundary	SW	4
2 to EPZ Boundary	WSW	21
2 to EPZ Boundary	W	57
2 to EPZ Boundary	WNW	8
2 to EPZ Boundary	NW	0
2 to EPZ Boundary	NNW	0
	TOTAL	**856**

Table 2.2 Permanent Resident Population and Evacuating Vehicles

EPZ Population	Households*	Evacuating Vehicles*
856	389	506

* Estimated assuming 2.2 persons per household and 1.3 evacuating vehicles per household as determined by the random telephone survey of households within the EPZ and surrounding area. This results in an estimate of 1.7 people per evacuating vehicle.

Figure 2.1 Permanent Resident Population by Sector



Miles	Subtotal by Ring	Cumulative Total
0 - 1	153	153
1 - 2	549	702
2 - EPZ Boundary	154	856
	Total	856

The transient population is defined as those people temporarily visiting the area and includes tourists, shoppers and employees who work in the EPZ but do not reside in the EPZ.

Estimates of the size of the transient population were obtained and used to determine the associated number of evacuating vehicles. A listing of transient population facilities and special event data was obtained through a combination of internet research and questionnaires, and interviews with facility representatives. Data gathering surveys focused on acquiring the number of hotel/motel rooms and campsites at each transient facility within the EPZ; the typical number of guests in each hotel/motel room and campsite and the average number of vehicles per hotel/motel room/campsite. The number of transients at these facilities was estimated based on the information obtained.

The average EPZ household size of 2.2 persons per household was applied to the transient population to determine the number of transient units. Transients are assumed to evacuate at the same value as the EPZ population, 1.7 people per evacuating vehicle. Section 2.1.2 provides estimates of the peak transient population presented by facility type. The peak transient population is illustrated by sector in Figure 2.2.

Table 2.3 Peak Transient Population By Sector

Distance	Direction	2015 Population
1	N	0
1	NNE	0
1	NE	0
1	ENE	0
1	E	0
1	ESE	0
1	SE	0
1	SSE	0
1	S	197
1	SSW	0
1	SW	0
1	WSW	0
1	W	0
1	WNW	0
1	NW	0
1	NNW	0
2	N	0
2	NNE	0
2	NE	0
2	ENE	0
2	E	0
2	ESE	0
2	SE	0
2	SSE	0
2	S	0
2	SSW	0
2	SW	0
2	WSW	0
2	W	0
2	WNW	0

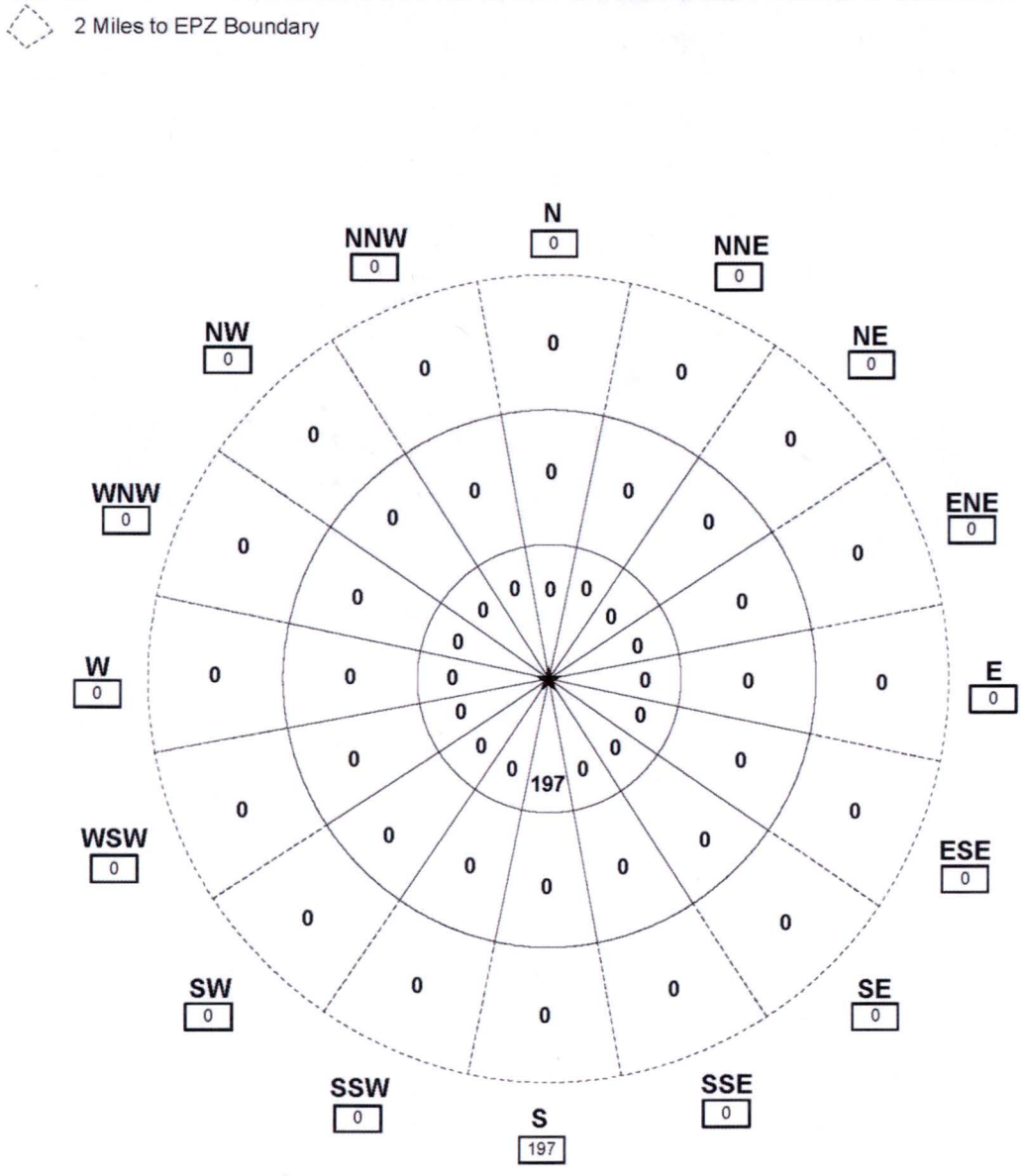
Distance	Direction	2015 Population
2	NW	0
2	NNW	0
2 to EPZ Boundary	N	0
2 to EPZ Boundary	NNE	0
2 to EPZ Boundary	NE	0
2 to EPZ Boundary	ENE	0
2 to EPZ Boundary	E	0
2 to EPZ Boundary	ESE	0
2 to EPZ Boundary	SE	0
2 to EPZ Boundary	SSE	0
2 to EPZ Boundary	S	0
2 to EPZ Boundary	SSW	0
2 to EPZ Boundary	SW	0
2 to EPZ Boundary	WSW	0
2 to EPZ Boundary	W	0
2 to EPZ Boundary	WNW	0
2 to EPZ Boundary	NW	0
2 to EPZ Boundary	NNW	0
	TOTAL	**197**

Table 2.4 Peak Transient Population and Evacuating Vehicles

Transient Population	Evacuating Vehicles*
197	116

* Estimated assuming 1.7 persons per evacuating vehicle as determined by the random telephone survey of households within the EPZ and surrounding area.

Figure 2.2 Peak Transient Population by Sector



Miles	Subtotal by Ring	Cumulative Total
0 - 1	197	197
1 - 2	0	197
2 - EPZ Boundary	0	197
	Total	197

2.1.1. Permanent Residents with Vehicles

The estimated number of evacuating vehicles per household (1.3) was adapted from the results of the random telephone survey of the households in the EPZ and surrounding area. These data, along with the estimated number of households in the EPZ were used to calculate the number of evacuating vehicles provided in Table 2.1 in the following manner:

EV = Evacuating Vehicles

HH = Household

$$\text{Evacuating Vehicles} = HH \times {}^{EV}/_{HH}$$

As an example, Evacuating Vehicles:

$$= 389 \times {}^{1.3}/_{HH}$$

= 506 Evacuating Vehicles

The actual need for permanent resident vehicles is thereby less than the given estimate. However, the estimate of permanent resident vehicles is not reduced to account for schoolchildren outside of the EPZ at the time of an evacuation.

2.1.2. Transient Population

Transient population groups are defined as those people who are not permanent residents and who enter the EPZ for a specific purpose (camping, recreation, etc.). Transients may spend less than one day in the EPZ or they may stay overnight or longer at camping facilities, hotels and motels. The only transient facility in the EPZ identified during development of the ETE is a campground located approximately one mile south of the CRN Site. Based on information obtained from the facility's website, the facility has approximately 90 campsites. This facility is discussed in greater detail below.

Hotels and Motels

There are no hotels or motels that have been identified within the EPZ.

Campgrounds

There is 1 campground/RV park within the EPZ. Soaring Eagle Campground is located approximately 1 mile south of the proposed CRN Site with approximately 90 campsites/RV parking spots. Figure 2.3 illustrates the location of the campground.

Figure 2.3 Transient Facilities Location Map

This facility is assumed to be at capacity during the summer scenarios, including during the Smokin' the Water 4th of July Celebration discussed in Section 2.5.1. Assuming 2.2 people per

campsite (equivalent to the EPZ persons per household), the peak attendance at the campground is estimated as 197 people evacuating in 116 vehicles (assuming 1.7 persons per evacuating vehicle). Based on the small permanent resident population within the EPZ and the relatively small transient population associated with this single facility, the impact of double counting any permanent EPZ residents that may be at this facility is minimal. Therefore, no permanent EPZ residents are assumed to be at this facility. A summary of the transient facility population is included in Table 2.5.

Table 2.5 Summary of Transient Facility Populations

Distance (miles) (from CRN Site)	Direction	Facility	Municipality	Campsites	Population	Vehicles
1	South	Soaring Eagle Campground	Lenoir City	90	197	116

2.2. Transit Dependent Permanent Residents

Transit-dependent permanent residents are those residents within the EPZ who do not have access to a vehicle or are dependent on help from outside the home to evacuate. Schoolchildren would typically be included as a segment of the transit dependent permanent resident population. However, as described in Section 2.4, there are no schools located within the EPZ. The estimated number of transit-dependent permanent residents was adapted from the results of the random telephone survey of the households in the EPZ and surrounding area. In addition to households that do not own a vehicle, consideration was also given to those households with 1 or 2 vehicles identified by the telephone survey. Calculations related to households with 0, 1 or 2 vehicles available during an evacuation are described below.

0-Vehicle Households

The telephone survey indicated that 2% of the households in the EPZ do not own a vehicle. As indicated in Table 2.2, there are an estimated 389 households located in the EPZ; resulting in approximately 8 households without access to a vehicle during an evacuation. The telephone survey also indicates that of those households with no vehicles available for evacuation, the average household size is 1.2 people per household. This translates to approximately 10

people (8 x 1.2) in 0-vehicle households that would not have access to a vehicle during an evacuation, assuming all households residents are home at the time an evacuation is ordered.

1-Vehicle Households

The results of the telephone survey indicate that approximately 21.8% of the households in the EPZ have 1 vehicle. The telephone survey also indicated that 42% of households in the EPZ have a commuter and 26.4% of commuters would not return home prior to evacuating. The telephone survey also indicates that of those households with 1 vehicle available for evacuation, the average household size is 1.48 people per household. This results in approximately 10 households (389 X 0.218 x 0.42 x 0.264) or 5 people (10 x (1.48 – 1)) (considering the commuter is away with the vehicle) in 1-vehicle households would not have access to a vehicle during an evacuation.

2-Vehicle Households

The results of the telephone survey indicate that approximately 43.8% of the households in the EPZ have 2 vehicles. The telephone survey also indicated that 42% of households in the EPZ have a commuter and 26.4% of commuters would not return home prior to evacuating. The telephone survey also indicates that of those households with 2 vehicles available for evacuation, the average household size is 2.18 people per household. This results in approximately 2 households (389 X 0.438 x $(0.42 \times 0.264)^2$) or 1 person (2 x (2.18 – 2)) (considering both commuters are away with both vehicles) in 2-vehicle households would not have access to a vehicle during an evacuation.

3 or More-Vehicle Households

The telephone survey indicates that of those households with 3 or more vehicles available for evacuation, the average household size is 2.58 people per household. Because the average household size is less than the number of vehicles available to the household, it is assumed that households with 3 or more vehicles will always have a vehicle available at home for evacuation during an emergency.

Transit-Dependent Ridesharing

As discussed in NUREG/CR-7002, it is recognized that a portion of the transit-dependent population will rideshare during an evacuation, leaving the area with friends, neighbors, or relatives, and it is acceptable to assume that up to 50 percent of residents without vehicles will rideshare (Reference 4). This value is based on results of a national telephone survey conducted of EPZ residents (Reference 2) which indicate more than 50 percent of residents would offer a ride to individuals waiting for transportation. Empirical data obtained from the widely studied Mississauga, Canada evacuation in 1979 (Reference 3) also supports a value of 50 percent. Roane County emergency management officials agreed that a value of 50 percent was acceptable for this study. As a result, it is estimated that 9 people in 0-, 1-, and 2-vehicle households will require transit assistance during an evacuation. The number of transit-dependent permanent residents in 0, 1, and 2-vehicle households in the EPZ is summarized in Table 2.6.

Homebound Special Needs Population

A subset of transit dependent residents includes people with disabilities and those with access and functional needs that live independent of a special facility. During development of the ETE, attempts were made to obtain data from Roane County to determine the demand for transit resources to accommodate homebound special needs individuals. Information on households with residents dependent on specialized transportation, such as wheelchair vans or ambulances, could not be provided by Roane County. However, as described in NUREG/CR-7002, a recent telephone survey of residents living within EPZs in the U.S. found that 6% of respondents said they, or someone in their household, would need assistance to evacuate (Reference 4). NUREG/CR-7002 cited NUREG/CR-6953, Vol. II, SAND2007-4195P, "Review of NUREG-0654, Supplement 3, 'Criteria for Protective Action Recommendations for Severe Accidents – Focus Groups and Telephone Survey,'" October 2008 (Reference 2), as the source of this information. Because of the absence of information related to households with residents dependent on specialized transportation, it is assumed that 85% of special needs individuals requiring transportation are ambulatory and capable of being transported via buses. It is further assumed that 10% of special needs individuals requiring transportation are wheelchair bound, not capable of walking short distances, and require transportation via wheelchair bus and 5% of special needs individuals requiring transportation are bedridden and require transportation via

ambulance. It is further assumed that there are no more than 1 special needs individuals per household.

Based on the total permanent resident population of 856 within the EPZ of the CRN Site, it is estimated that approximately 24 households in the EPZ would house a special needs individual requiring assistance during an evacuation. Based on the assumptions above that 85% of special needs individuals are ambulatory (21 persons) 10% are wheelchair bound (3 persons) and 5% are bedridden (2 persons) it is estimated that a total of 26 homebound special needs individuals will be evacuated. Because the locations of these individuals is unknown, it is estimated that 2 buses will service those individuals that are ambulatory. Additionally, 1 wheelchair bus will service the wheelchair bound individuals and 2 ambulances will service the bedridden individuals. The number of transit-dependent permanent residents in a special needs situation is summarized in Table 2.6.

2.3. Special Facility Residents

Special facility residents are those who reside in special facilities and are dependent upon facility personnel or emergency medical services vehicles for transportation in an emergency. This includes, but is not limited to, institutions such as hospitals, nursing homes, and correctional facilities. The presence of special facilities was researched during development of the ETE and it was determined that one facility, the Kingston Academy, currently exists within the EPZ.

The Kingston Academy is a Psychiatric Residential Treatment Facility with living quarters and a capacity of 52 children between the ages of 5 and 17. The facility provides residential treatment and day treatment services. For this ETE, it is assumed the facility is at 90% capacity when an evacuation is ordered and the facility is ready to evacuate 75 minutes (60 minutes to prepare + 15 minutes to load vehicles) after the order to evacuate is issued. This results in an evacuation of approximately 47 residents from this facility. Because of the type of facility, it is assumed that all residents of the Kingston Academy are ambulatory. The number of transit-dependent residents in special facilities is summarized in Table 2.6.

Table 2.6 Summary of Transit Dependent Residents

Facility/Situation	Population Requiring Evacuation	Evacuating Vehicles
Permanent Residents Without Access to Vehicle		**Buses**
0-Vehicle Households	5	1
1-Vehicle Households	3	
2-Vehicle Households	1	
Homebound Special Needs Population (Including all members of household)		**Various**
Ambulatory Patients	21	2 Buses
Wheelchair Bound	3	1 Wheelchair Bus
Bedridden	2	2 Ambulances
Special Facility Residents		**Various**
Kingston Academy	47	3 facility vans
Total	**82**	3 buses 1 wheelchair bus 2 ambulances 3 facility vans

2.4. Schools

The presence of schools was researched during development of the ETE and it was determined that no schools currently exist within the EPZ.

2.5. Other Demand Estimate Considerations

Demand estimates have also been considered for EPZ employees; a peak transients population during a special event just outside the EPZ; a shadow evacuation of 20% of the permanent resident population outside of the EPZ extending to 15 miles from the proposed CRN Site; and for background and pass through traffic within the EPZ. A summary of the shadow evacuation population and vehicles are included in Tables 2.8 and 2.9.

Employees

In addition to the demand estimates for permanent resident and transient populations described above, demand estimates were also considered for people who work in the EPZ. There are two categories of people who work in the EPZ:

1. Those who live and work in the EPZ.
2. Those who live outside the EPZ and commute to jobs within the EPZ.

Those of the first category are already counted as part of the permanent resident population and previously accounted for in the demand estimate. In order to estimate the number of people who live outside the EPZ and commute to jobs within the EPZ, the presence of major employers in the vicinity of the CRN Site (50 or more employees) was researched during development of the ESPA ER and was evaluated for use in development of this ETE report. It was determined that two major employers exist within the EPZ. Information on the major employers is included in Table 2.7.

Table 2.7 Major Employers in the EPZ

Distance (miles)	Direction	Facility Name	Location	Employees	Employees per Vehicle	Evacuating Vehicles*
0.95	SW	Kingston Academy	Kingston	150	1	36
0.75	WSW	Duratek	Kingston	300	1	71
					Total	107

* Assume 90% of employees are at work when the order to evacuate is issued and 26.4% of employees evacuate directly from their place of employment (based on the results of the telephone survey). The remainder of the employees return home and are included in the permanent resident EPZ population.

2.5.1. Special Events

Special events within an EPZ and can attract large numbers of transients for short periods of time. Special events could include Fourth of July celebrations, holiday parades, professional and amateur sporting events, or any number of activities that bring large populations into the

EPZ. These events frequently define the peak tourist population that is to be included in the ETE study (Reference 5).

Kingston, Tennessee hosts the Smokin' the Water 4th of July Celebration (http://www.kingstonparks.com/Fourth%20of%20July%20-%20Smokin%20the%20Water.htm) each year with activities centered on the Kingston waterfront at Watts Bar Lake, approximately 10 miles west of the CRN Site and 8 miles outside the EPZ. The event is typically a one-day event, and features a floating parade, drag boat and raft races, children's activities, a classic car show, commercial and craft vendors and fireworks. It is assumed that this event will result in peak tourist populations at transient facilities within the EPZ. This peak tourist population is considered in the Scenario #4 described in Section 1.3. Based on the small permanent resident population in the EPZ, it is assumed that all permanent residents remain in the EPZ during this event and no reduction in permanent resident population is considered.

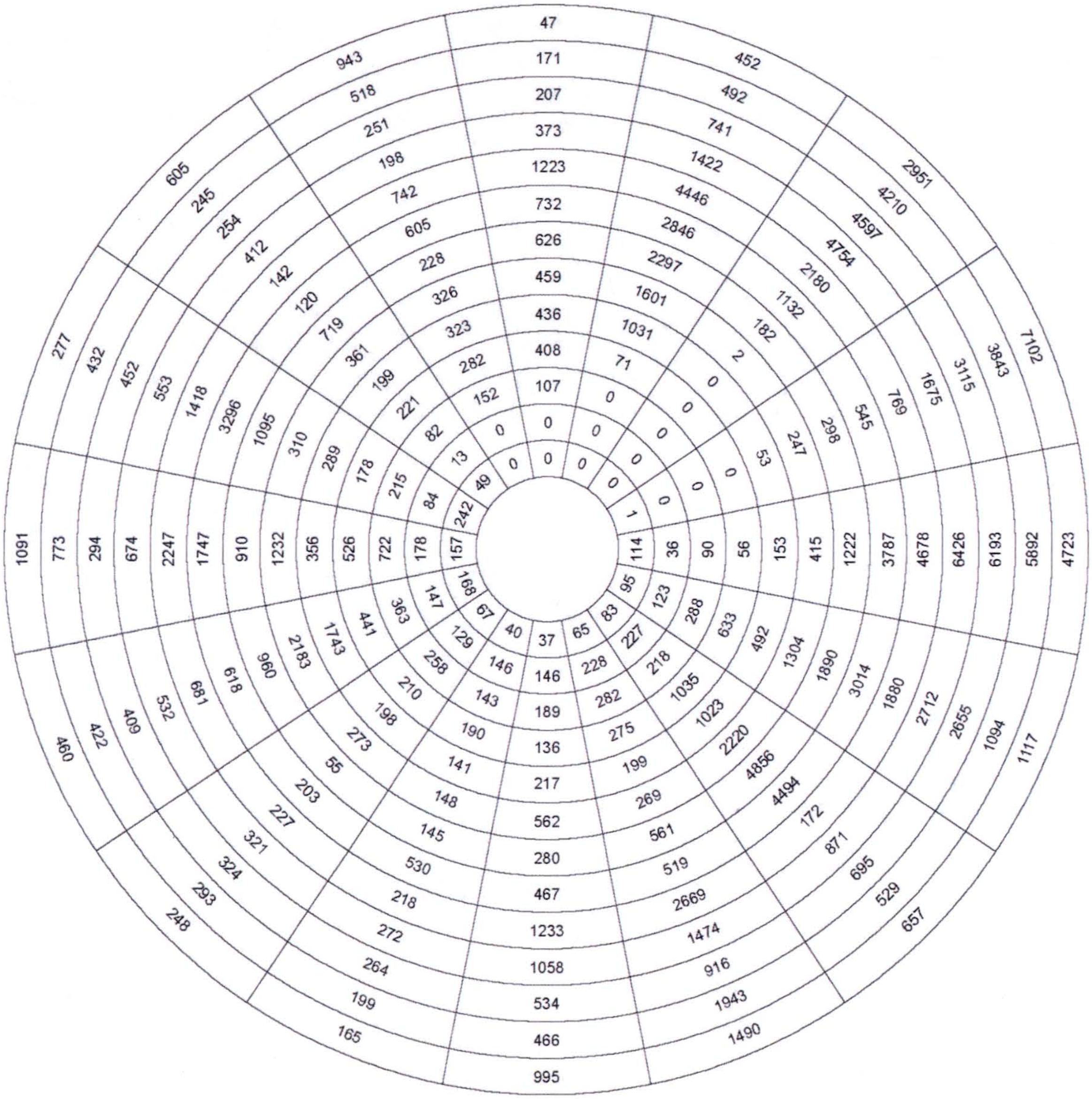
2.5.2. Shadow Evacuation

A shadow evacuation is defined as an evacuation of people from areas outside an officially declared evacuation zone. The shadow population is considered in this analysis because the additional traffic generated has the potential to impede the evacuation of those in the EPZ under evacuation orders. Shadow evacuations were considered in developing the demand estimation because of the additional traffic typically generated during an evacuation and its potential to affect the ETE. Consistent with NRC guidance, a shadow evacuation of 20% of the permanent resident population was assumed to occur in areas outside of the EPZ for all cases extending to 15 miles from the CRN Site. Shadow population was determined based on U.S. Census 2010 data, projected to 2015. As noted in Table 1.2, the area outside the EPZ is assumed to have a shadow evacuation of 20% of the permanent resident population.

According to the Census data, projected to 2015, there are 186,500 permanent residents living within 15 miles of the CRN Site. It is assumed that the trip generation times for the shadow evacuation onto the roadway network is consistent with the trip generation times for the permanent resident population within the EPZ.

Figure 2.4 illustrates the permanent resident population by sector, at 1-mile increments from the EPZ boundary to 15 miles from the CRN Site.

Figure 2.4 Population Estimates for the Shadow Evacuation Area



2.5.3. Background and Pass-Through Traffic

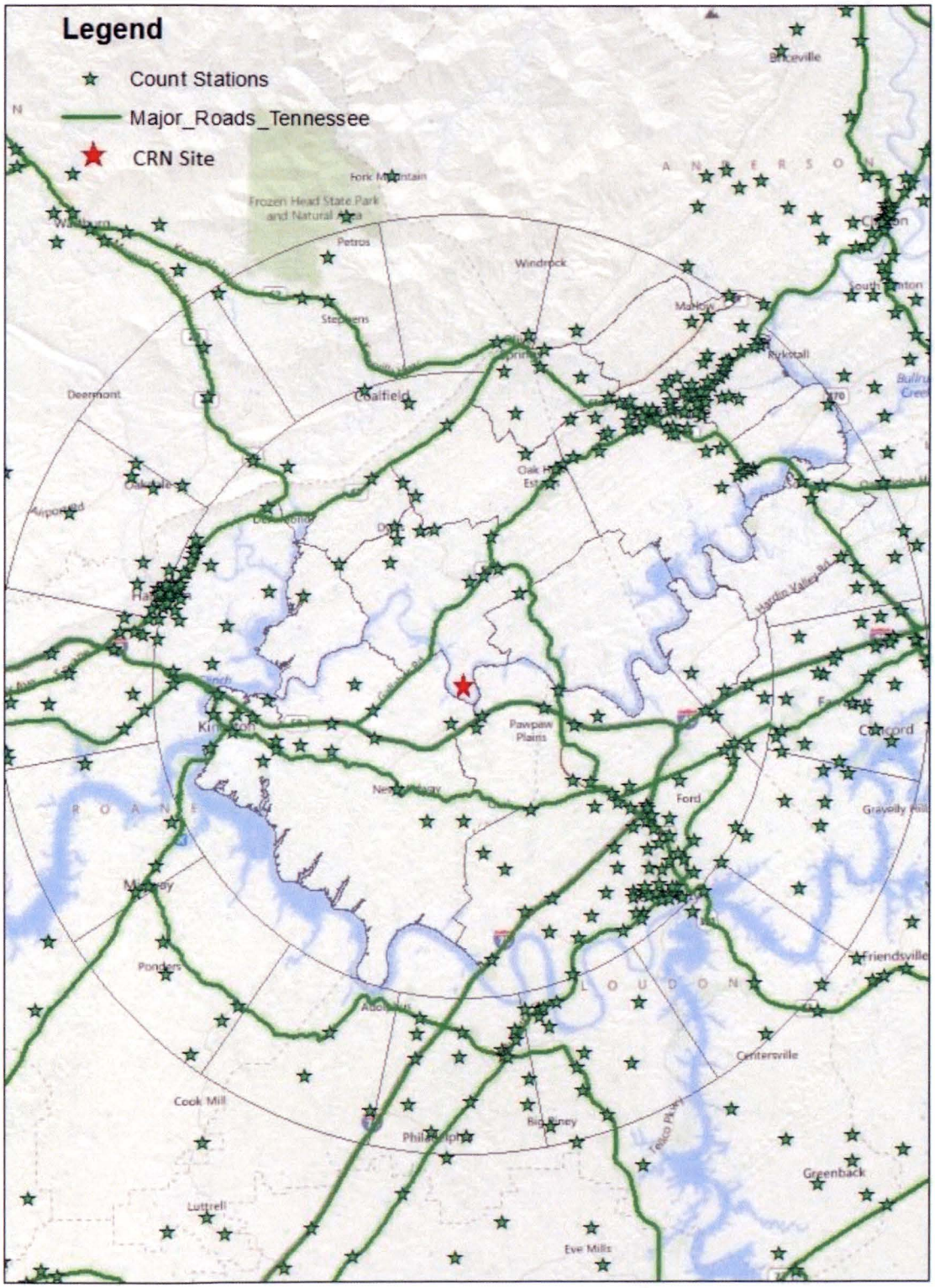
Background and pass-through traffic will exist within the EPZ at the time an order to evacuate is issued. Background traffic is that traffic on the roadways when the initial notification to evacuate occurs and consists of both permanent residents and transients. Pass-through traffic includes

vehicles that enter the EPZ roadway network and exit the EPZ prior to the establishment of Access Control Points (ACPs).

QUEENSOD, software developed by Virginia Tech Transportation Institute (VTTI), was used to estimate the background and pass-through traffic. Because origin-destination (O-D) demand data is not readily available and difficult to obtain unless a large scale O-D survey is conducted, a method is needed to estimate demand by readily available data, such as traffic count data. QUEENSOD is a model for estimating origin-destination traffic demands based on observed link traffic flows, observed link turning movement counts, link travel times and, potentially, additional information on drivers' route choices. QUEENSOD iteratively minimizes errors between observed link volumes to estimated link flow using Least Relative Error model and generates an O-D matrix.

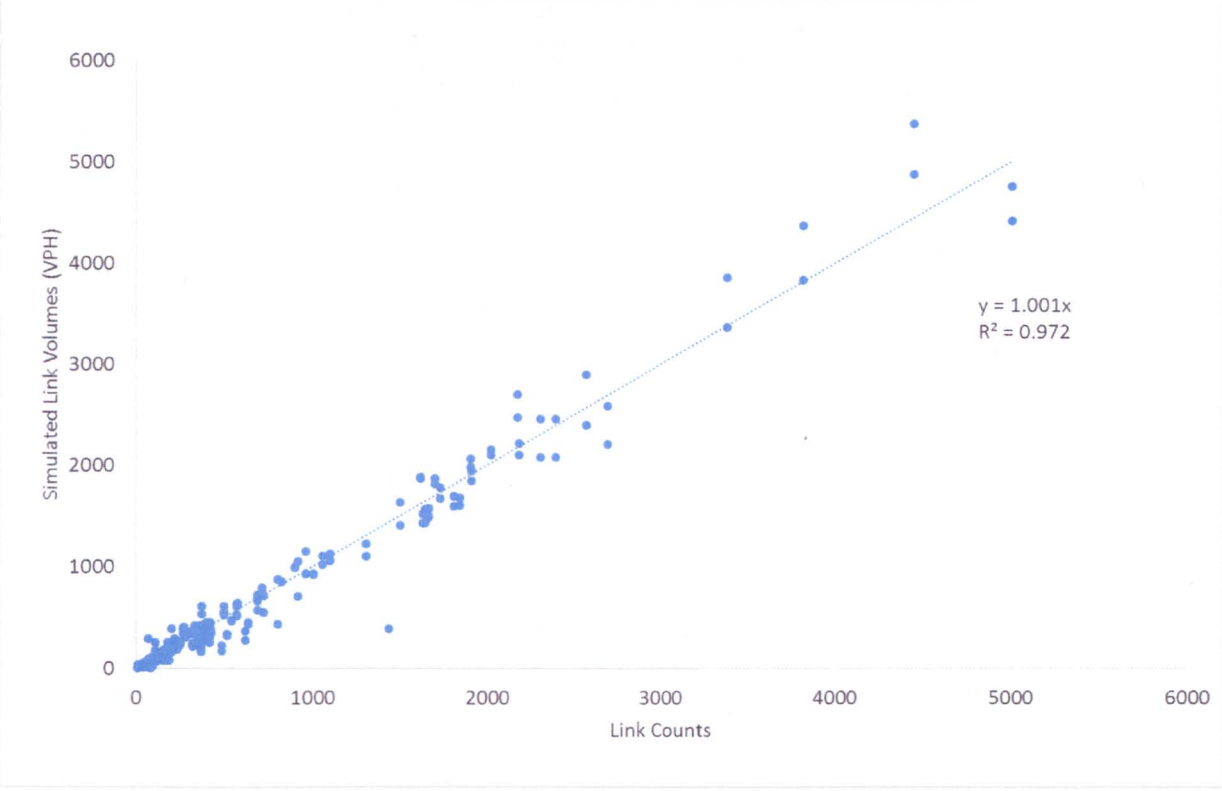
Pass-through traffic, used as input data in the ETE simulations, was determined based on the latest published traffic statistics, provided by the Tennessee Department of Transportation (http://www.tdot.state.tn.us/traffichistory). Annual Average Daily Traffic (AADT) on road sections of the State Highways and Local Federal-Aid roads are included on each of the major roadways within the EPZ. The count station, or specific location on a roadway where traffic count surveys are conducted, and the roadway network in the vicinity of the CRN Site are shown in Figure 2.3.

Figure 2.5 Roadway Network in the Vicinity of the CRN Site



To validate the results of QUEENSOD, the output of the QUEENSOD, the O-D matrix, is used in INTEGRATION as input demand file. The simulation is then run and the link traffic counts are recorded and calibrated against the observed traffic count data. The figure below shows the relationship between the observed link volumes versus the simulation volume. As evidenced by the following figure, the results from QUEENSOD accurately replicate the known network demands. The coefficient of determination R^2 (a statistical measure of how close the data are to the fitted regression line) is very close to 1.

Figure 2.6 Network Demand Validation



The background and pass-through traffic volume is estimated, and the calibration verified, for each scenario with consideration given to the effects of seasonal variations, day-of-the-week, adverse weather and other factors.

It is assumed that ACPs would be staffed within approximately 90 minutes of the advisory to evacuate. Activation of ACPs prior to 90 minutes could delay commuters returning from areas outside of the EPZ. Therefore, for purposes of this analysis, it is assumed that ACPs will be

established at 90 minutes following the advisory to evacuate. It is also assumed that no vehicles will enter the EPZ after ACPs have been established. The establishment of ACPs at 90 minutes following the advisory to evacuate has been confirmed with OROs.

From the time an evacuation order is issued until 90 minutes after the order is issued, background traffic begins to diminish as evacuating traffic begins to exit the EPZ and the establishment of ACPs prevent inbound traffic from entering the EPZ. The evacuating traffic begins to increase at the rate of the time distributions related to the trip generation times (see section 4.1). The background and pass-through traffic stops entering the EPZ 90 minutes after the order to evacuate is issued.

2.6. Summary of Demand Estimation

A total of 10 Scenarios were evaluated for an evacuation of the full EPZ. As previously described, the use of various sectors and distances within the EPZ is not appropriate for the CRN Site and this ETE only considers an evacuation of the entire EPZ reflecting the effects of seasonal variations, day-of-the-week, and adverse weather conditions resulting in a total of 10 unique evacuation cases. Each scenario results in a specific population to be evacuated. Table 2.8 provides a summary of the total populations used in the analysis for each scenario for an evacuation of the EPZ. Table 2.9 provides a summary of the total number of vehicles, by population group (permanent residents, transients, transit dependent residents, shadow population, background and pass-through), for each scenario for an evacuation of the EPZ and represents the input values used in the traffic simulation modeling.

Table 2.8 Total Population Considered for Each Scenario

Scenario	Permanent Residents	Transient Population	Transit Dependent Permanent Residents	Special Facilities	Major Employers	Shadow Population	Total Population
1	856	185	35	47	107	37,126	38,356
2	856	173	35	47	107	37,126	38,344
3	856	185	35	47	12	37,126	38,261
4	856	197	35	47	12	37,126	38,273
5	856	92	35	47	107	37,126	38,263
6	856	87	35	47	107	37,126	38,258
7	856	92	35	47	12	37,126	38,168
8	856	99	35	47	12	37,126	38,175
9	856	185	35	47	107	37,126	38,356
10*	879	190	128	47	2,810	38,091	42,053

* Peak Construction - Permanent Resident population and Shadow population have been extrapolated to the Year 2024, which is when the construction workforce will be at its peak. Major employer data includes projected construction employees at the CRN Site.

Table 2.9 Total Vehicles Considered for Each Scenario

Scenario	Permanent Resident Vehicles	Transient Vehicles	Transit Dependent Permanent Resident Vehicles	Schools	Major Employers	Shadow Population	Background and Pass-through Traffic	Total Vehicles
1	658	109	6	0	107	21,206	45,069	67,155
2	658	102	6	0	107	22,246	45,069	68,188
3	658	109	6	0	12	21,985	36,055	58,825
4	658	116	6	0	12	21,985	22,535	45,312
5	658	54	6	0	107	22,247	45,069	68,141
6	658	51	6	0	107	22,246	45,069	68,137
7	658	54	6	0	12	21,985	36,055	58,770
8	658	58	6	0	12	21,985	22,535	45,254
9	658	109	6	0	107	22,246	45,069	68,195
10*	675	112	7	0	2,810	22,820	46,241	72,665

* Peak Construction - Permanent Resident population and Shadow population have been extrapolated to the Year 2024, which is when the construction workforce will be at its peak. Major employer data includes projected construction employees at the CRN Site.

3.0 ROADWAY CAPACITY

In conjunction with the development of the traffic network in the vicinity of the CRN Site, an estimate of roadway capacity is required. Roadway capacity is defined as the maximum rate at which vehicles can be expected to traverse a section of roadway during a given time period under prevailing roadway, traffic, weather, and control conditions. The capacity analysis in this study has been performed using the application of processes and equations established in the U.S. Department of Transportation's Highway Capacity Manual (HCM) (Reference 6). The (LOS), as defined in the HCM, provides a quality measure of the traffic operational conditions of a roadway and is designated as 'A' for free flow operating conditions through 'F' for congested operating conditions.

The roadway network in the vicinity of the CRN Site consists of the following three primary categories of roads:

1. Two-lane Local Roads - Various local and residential streets are located within the city limits of Oak Ridge and Roane County.

2. State Roads (Highway 58) - The portion of Highway 58 traversing the EPZ begins at an interchange with I-40 west-southwest of the CRN Site, then heads northeast, crossing the EPZ boundary 2 miles west of the CRN Site. Highway 58 continues northeast, before turning north and exiting the EPZ, 2 miles north-northwest of the CRN Site.

3. Freeways (I-40) - I-40 is the primary east-west route through the EPZ and crosses the EPZ boundary 2 miles east and 2 miles south-southwest of the CRN Site.

The following sections discuss the methods used in this study to determine roadway capacity.

3.1. Roadway Characteristics

Roadway characteristics were obtained from an ArcGIS network file, which is imbedded in the raw calibrated data obtained from the data provider. Roadway characteristics, such as number of lanes, lengths, and free flow speed were extracted from the network file and exported to simulation input files. Table 3.1 provides the definition of free flow speed based on functional class. There are six functional classes in the CRN Site area according to the definition of the roadway databases. Speed at capacity and jam density were then designed according to

suggestions from the HCM. Based on field surveys, such roadway characteristics were further adjusted and calibrated to reflect real situations. The roadways included in the ETE analysis are primarily functional class 2 to 5 in the vicinity of the CRN Site.

Table 3.1 Free Flow Speed by Functional Class

Function Class	Free Flow Speed (mph)	Speed at Capacity (mph)	Capacity (Veh/Hour/Lane)	Jam Density (Veh/Mile/Lane)
1	80	65	2,400	240
2	65	50	2,400	240
3	55	45	2,300	240
4	45	35	2,250	240
5	30	25	2,100	240
6	20	15	1,900	240

Figures 3.1 through 3.4 illustrate the roadway system, including links and nodes used in the analysis. A link is defined as a segment of roadway between two nodes. A node is an identification designator used to connect links in a roadway network model or to apply input data onto the network. Nodes are at intersections, ramps, etc., and contain characteristics such as traffic control and may be used as input points to assign loading of vehicles. Links are identified using blue text and nodes are identified as boxes with accompanying black text identifiers in Figures 3.1 through 3.4.

Characteristics for the roadways in the roadway network, including nodes, links and loading input information are included in Appendix A.

Figure 3.1 Evacuation Network Map

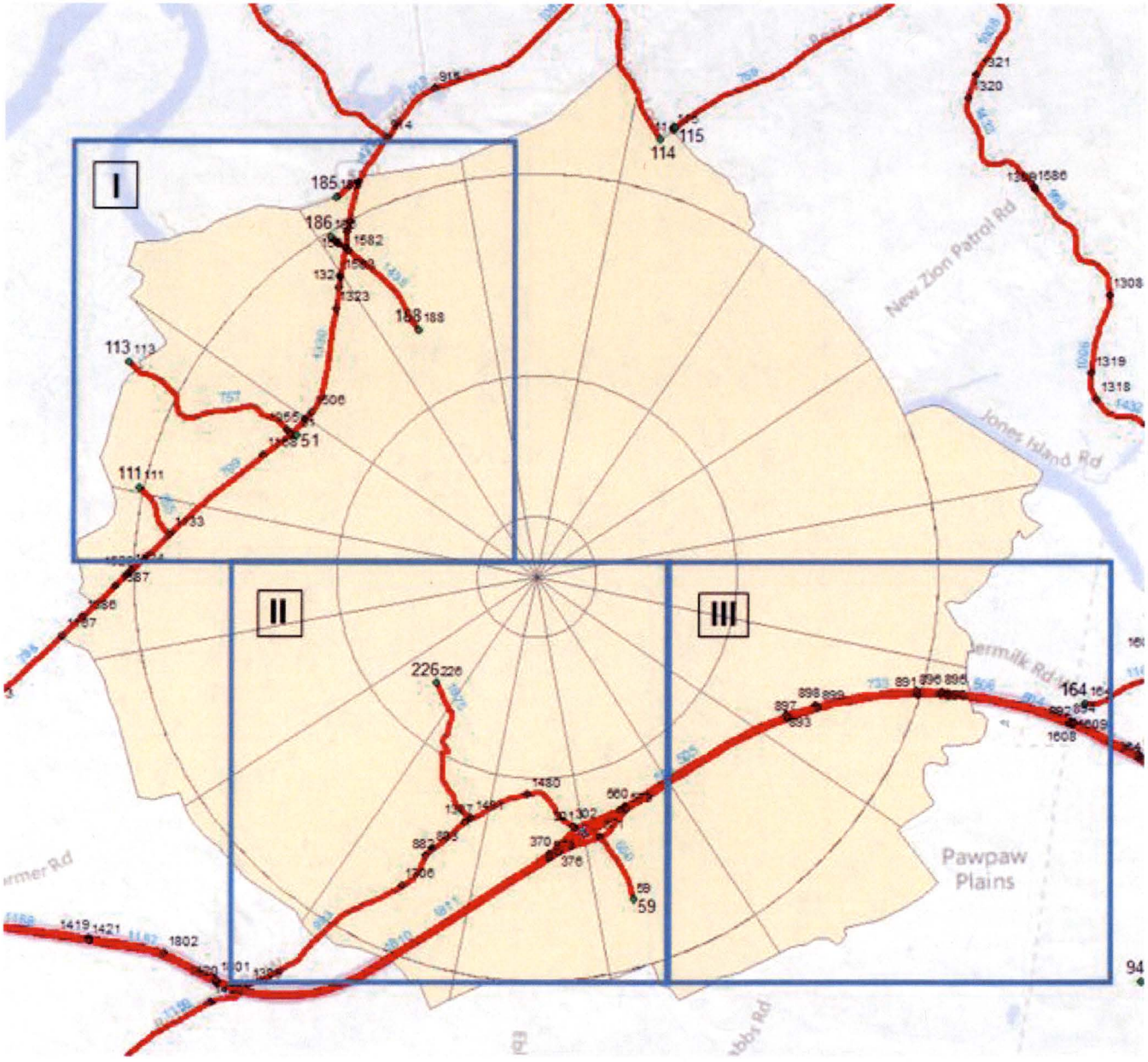


Figure 3.2 Evacuation Network Map – Grid I

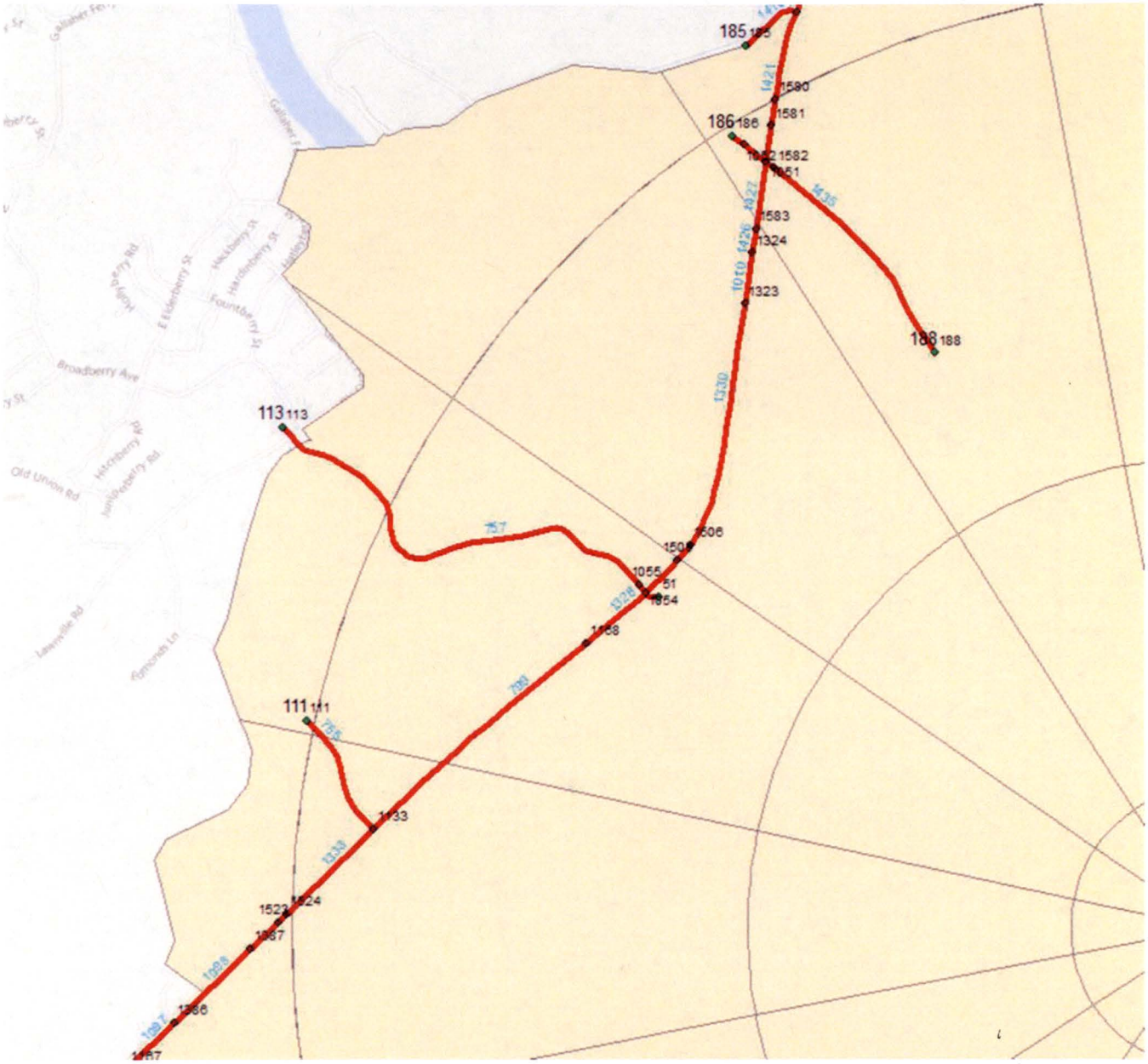
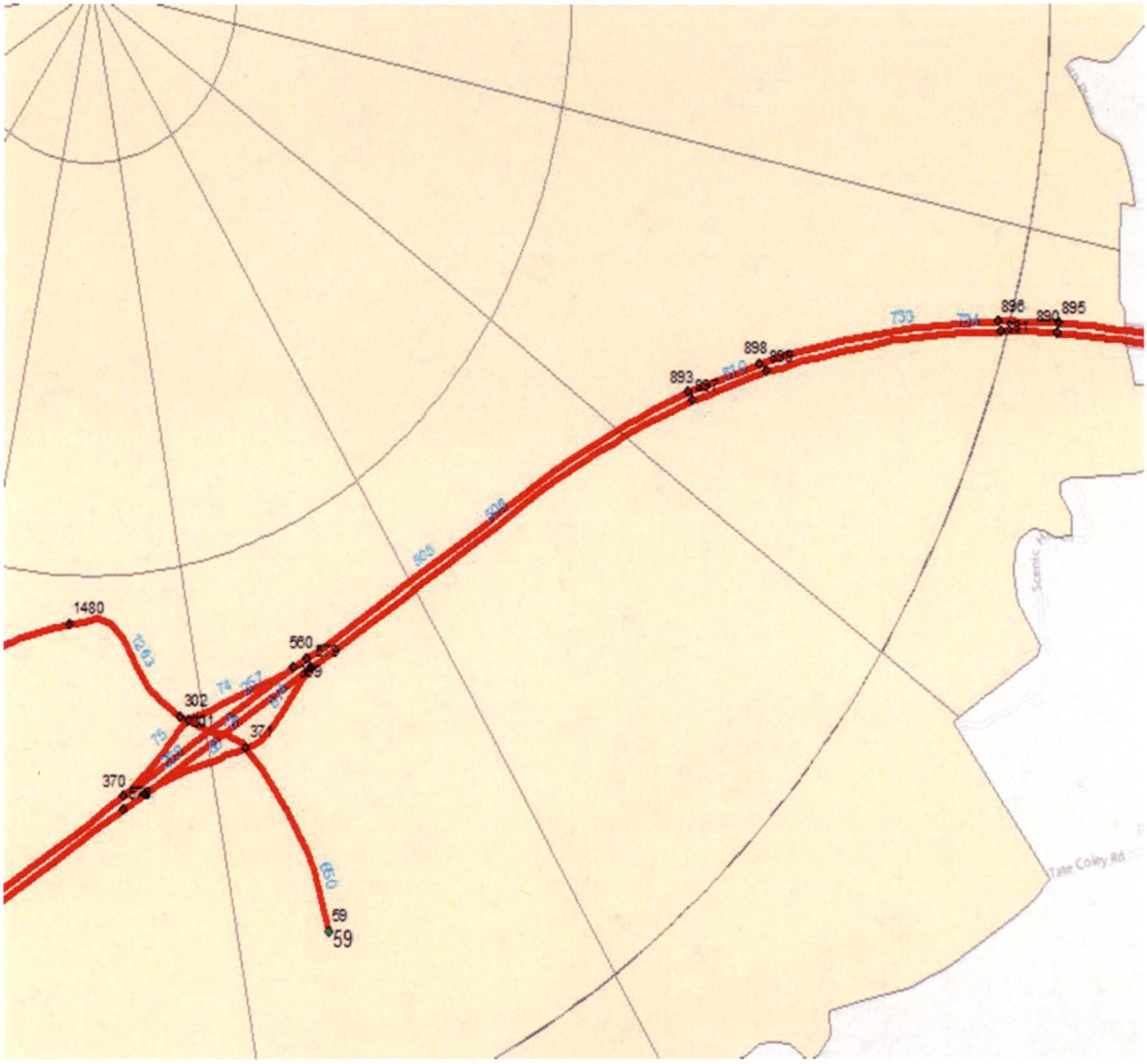


Figure 3.3 Evacuation Network Map – Grid II

Figure 3.4 Evacuation Network Map – Grid III



3.2. Capacity Analysis

Although the majority of the parameters for the road network that are input variables for the simulation are imported from the GIS database providers, local adjustments were conducted to ensure the accuracy of variables. The principles used for adjusting the variables are based on the HCM and the Green Book (A Policy on Geometric Design of Highways and Streets from AASHTO) (Reference 7).

The capacity of a road, according to the HCM, is the maximum sustainable hourly flow rate at which vehicles can reasonably traverse a point during a given time period under prevailing roadway, traffic, and control conditions (Reference 6).

According to the HCM, the factors affecting capacity of a roadway include design speed, number of lanes, the width of the lanes, shoulder, geometrical features (horizontal and vertical curves), traffic compositions as well as some other environment factors, such as weather, visual obstruction of the roadway, etc (Reference 6). These factors need to be incorporated into the simulation environment such that the simulation will be able to reflect the real traffic status, especially during the process of evacuation when congestion is possible in the network.

The capacity of the roadway is defined according to the recommendations by the HCM. The roads in the vicinity of the CRN Site are divided into the six functional classes based on the features of the roads, including hierarchy in the network, traffic load, serving environment, design speed, etc. The capacity of each class is defined in Table 3.1. The capacity in Table 3.1 is the description of network under perfect traffic conditions. As described in Section 3.4, a reduction in capacity is considered for ETE scenarios 2 and 6, considering adverse weather conditions.

3.3. Intersections Control

Similar to the roadway capacity, intersection capacity is determined by multiple factors such as roadway geometrics, lane width, and number of lanes, etc. In addition, because intersections are the meeting point of two or more roads and they are usually controlled by traffic lights or other traffic control methodologies (stop signs or yield signs), the capacity at intersections will also be affected by the cycle length of the traffic signal, green time, turning movements, the

conflicting traffic, and other factors. It is important to reflect the prevailing intersection control treatments in the simulation such that the real traffic conditions should be replicated.

The underlying rules and parameters adopted by INTEGRATION at intersections, such as left and right turn gap acceptance, acceleration rate, discharge headway, and driver behavior during yellow light et al., are constructed in accordance with the recommendations from the HCM and are calibrated in-field.

The intersection traffic control data in the CRN Site area were obtained from two major sources. Traffic signal timing data, including cycle length and phases, were requested from local town or county traffic agencies. Field survey data provided supplemental information for certain intersections. Stop signs and yield signs controlled intersections are identified from Google street view images. Data are then coded into an input file for INTEGRATION and are calibrated to field observations in terms of travel speeds and counts. Because the data obtained from local transportation agency is incomplete, estimation of cycle lengths and split of the signal is conducted based on the locations of the intersections where the signal data are not available. The rules for estimation are based on geographic locations and road class resemblance. A similar traffic signal timing plan at an adjacent intersection of the same road class in the area was adopted for intersections where the data are not available. Because it is not uncommon for traffic control personnel to direct traffic and override the existing traffic signal plans resulting in improvement in the capacity of the intersections during an evacuation, the simulation optimizes the cycle lengths and offset times at a frequency of 5 minutes.

Characteristics for the intersections, including control summaries and signal files, are included in Appendix A.

3.4. Adverse Weather

According to the HCM, during adverse weather the capacity and free flow speed of the roadway will be impaired (Reference 6). Table 3.2 illustrates the capacity drop and free flow speed reduction on freeways suggested by research conducted during previous studies.

Table 3.2 Speed Reductions in Inclement Weather

Condition	Percent Capacity Reduction	Percent Speed Reduction
Heavy Rain	10% - 18%	5% - 17%
Heavy Snow/Ice	20% - 28%	20% - 35%

The reduction in capacity and speed is calculated based on several factors including pavement condition, terrain, roadway functional class, and other factors. In accordance with the guidance presented in NUREG/CR-7002, the following roadway capacity and speed reduction factors were adopted for use in Scenarios 2 and 6, respectively (Reference 4). The values in Table 3.3 for heavy rain and snow are derived from Chapter 22 of the HCM, Exhibit 22-7 and the Federal Highway Administration (FHWA) study, "Identifying and Assessing Key Weather-Related Parameters and Their Impacts on Traffic Operations Using Simulation" (Reference 8).

Table 3.3 Weather Capacity Factors

Scenario	Season	Weather Condition	Roadway Capacity	Speed
2	Summer	Heavy Rain	90%	85%
6	Winter	Heavy Snow/Ice	85%	65%

Based on the location of Clinch River and data obtained from NOAA (http://www.srh.noaa.gov/mrx/?n=oqtclimate) indicating average annual snowfall of 6.6 inches and 3 days per year with greater than 1" of snow, the winter adverse weather scenario (Scenario 6) considers ice as the limiting winter adverse weather condition and there is no effect on mobilization based on the need for snow removal from roadways or driveways.

4.0 DEVELOPMENT OF EVACUTION TIMES

Evacuation times are estimated for 90% and 100% of the evacuating vehicles to exit the EPZ boundary. A total of 10 scenarios were simulated in various weather, season, time, and network conditions to reflect the traffic conditions when the evacuation order is issued. Development of the evacuation times considered preparation activities, including the time to receive the notification and time to prepare to evacuate.

4.1. Trip Generation Time

A random telephone survey of households within the EPZ was used to identify factors affecting the evacuee trip generation time (mobilization time) as well as other data to be used in the ETE analyses. The mobilization time is the major component of the total ETE when the EPZ population density is low and there is minimal traffic congestion, as is the case for the CRN Site. The telephone survey provides a sound, documented basis for the trip generation times needed to develop the calculated ETEs.

With respect to trip generation time, the telephone survey was used to obtain data related to whether or not commuters would return home or evacuate directly from work; how long it would take commuters to travel home; and how long it would take to complete preparations at home and at work prior to evacuation. The data obtained from the telephone survey related to trip generation time is summarized in Tables 4.4, 4.5, and 4.6.

The evacuation trips consists of a sequence of events and activities. Each event (other than the notification alert) occurs at an instant of time, while activities are accomplished in series or parallel, over a period of time. The relevant events associated with the public's preparation for the evacuation trip are presented in Table 4.1. One or more activities are associated with each sequence of events as shown in Table 4.2.

Table 4.1 Trip Generation Evacuation Events

Event	Description
1	Notification to public
2	Awareness of incident
3	Leave work/facility
4	Arrive home/residence
5	Leave to evacuate

Table 4.2 Trip Generation Evacuation Activities

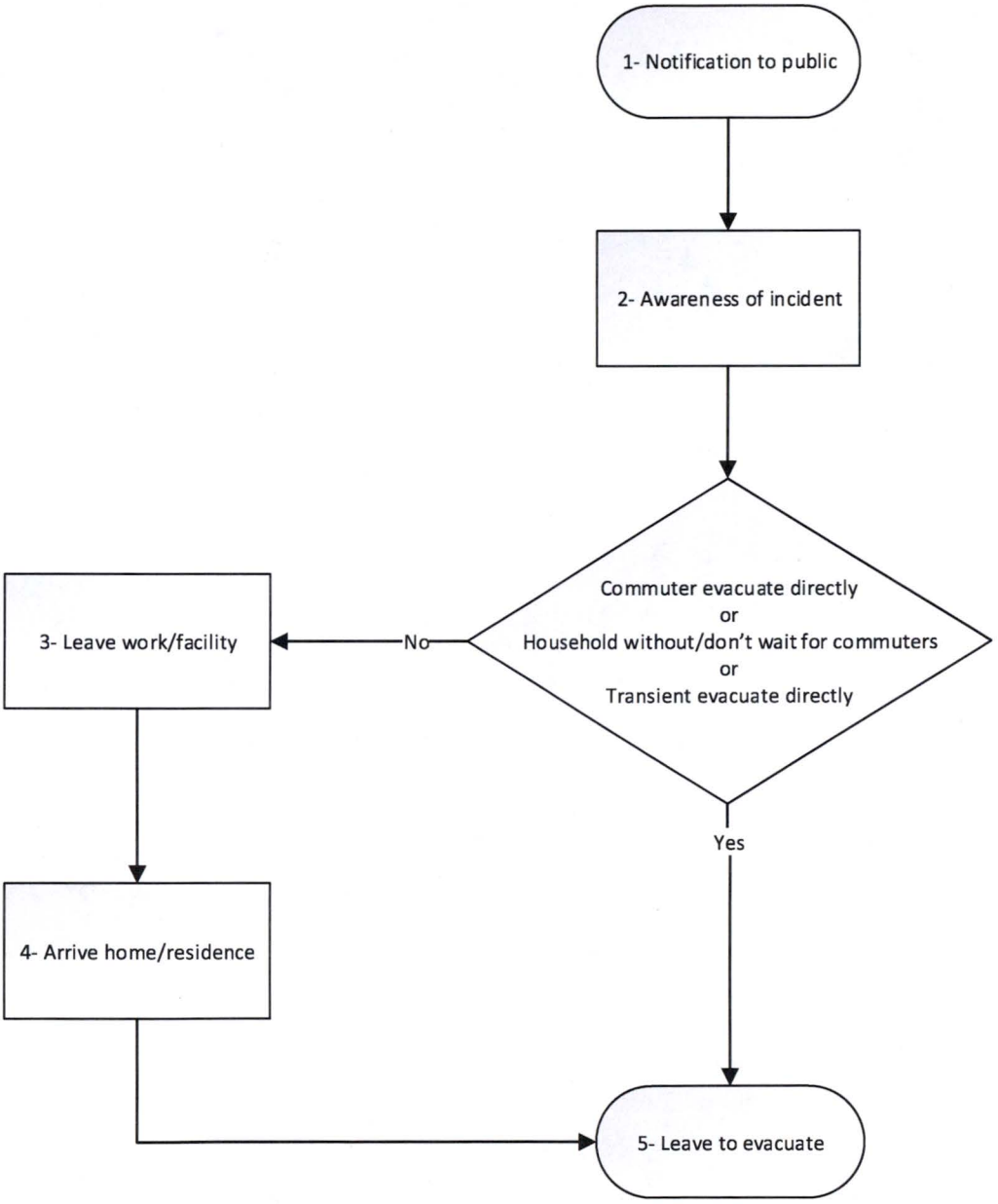
Activity	Description	Event Sequence
1	Receive notification	1 → 2
2	Prepare to leave work/facility	2 → 3
3	Travel home/residence	3 → 4
4	Prepare to leave to evacuate	2,4 → 5

The Trip Generation Time (the total elapsed time from Event 1 to 5) is dependent on the scenario and will vary from one household to another. Factors affecting the trip generation time include, but are not limited to the following:

- A commuter may or may not return home prior to evacuating.
- Households with a vehicle available for evacuation may or may not wait for a commuter to return home prior to evacuating.
- Transients within the EPZ may evacuate immediately without returning to their residence (With respect to transients, residence refers to their hotel, motel or campground.).

The flow chart included as Figure 4.1 indicates the relationship of events and activities preceding the evacuation trip.

Figure 4.1 Flow Chart of Events and Activities Preceding the Evacuation Trip



Estimated Time Distributions of Activities Preceding the Evacuation Trip

The time distribution of an event is obtained by "summing" the time distributions of all prior contributing activities.

NUREG-0654/FEMA-REP-1 Appendix 3 (as amended by Supplement 4), 44 CFR 350.5(a), and Section V, Part A of the Federal Emergency Management Agency (FEMA) Radiological Emergency Preparedness (REP) Program Manual (FEMA P-1028) (Reference 9), discuss Alert and Notification System (ANS) design objectives. The minimum acceptable design objectives for coverage by an ANS is the capability for providing an alert signal and beginning an informational or instructional message to the population in the EPZ within 15 minutes and providing protective action recommendations, if appropriate. The coverage of essentially 100% of the population in the EPZ who may not have received the initial notification must occur within 45 minutes. Based on the regulatory requirements and guidance in FEMA P-1028, the notification distribution used in this analysis is provided in Table 4.3.

Table 4.3 Notification Time Distribution

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

It is assumed following notification and evacuation order, most businesses within the EPZ will shut down and most employees would leave work quickly and that residents dispersed within the EPZ performing daily activities will travel home. Table 4.4 shows the preparation time distribution to leave work/facility (Activity 2) from data obtained by those households that

responded to the telephone survey. This distribution is applicable for all commuters (those going home prior to evacuating, those evacuating directly from work, or those living outside the EPZ) and for residents to leave stores, restaurant, parks, and other locations within the EPZ. Notification of the transient population is assumed to occur at the same time distribution as permanent residents. Those transients in campgrounds within the EPZ will receive an alert via the ANS.

Table 4.4 Prepare to Leave Work/Facility Time Distribution

Elapsed Time (Minutes)	Cumulative Percentage
0	0%
10	79.6%
15	86.1%
20	91.2%
30	96.5%
40	97.3%
50	98.4%
60	98.9%
120	99.5%
180	99.7%
240	100.0%

The time distribution to travel home (Activity 3) for commuters/residents after leaving work/facility was obtained from those who responded to the telephone survey and is provided in Table 4.5. This distribution is applicable for transients going back to residence to begin the evacuation trip.

Table 4.5 Travel to Home/Residence Time Distribution

Elapsed Time (Minutes)	Cumulative Percentage
0	0.0%
5	11.5%
10	24.9%
15	39.1%
20	51.7%
25	60.1%
30	78.3%
35	82.0%
40	89.0%
45	93.3%
50	94.6%
55	94.6%
60	97.1%
75	97.9%
90	99.2%
105	99.2%
120	99.5%
150	99.5%
180	99.5%
210	99.7%
240	99.7%
300	100.0%

The preparation time distribution for households to leave home (Activity 4) to begin the evacuation trip was obtained from those who responded to the telephone survey, under different time scenarios (daytime, nighttime, and weekend) and is included in Table 4.6. This distribution is also applicable for transients preparing at their residence to begin the evacuation trip.

Table 4.6 Prepare to Leave Home/Residence Time Distribution

Elapsed Time (Minutes)	Cumulative Percentage		
	Daytime	Night time	Weekends
0	0.0%	0.0%	0.0%
15	40.9%	38.4%	39.7%
30	59.4%	57.9%	58.9%
45	81.5%	81.1%	81.3%
60	89.4%	88.6%	89.1%
75	94.4%	93.2%	94.0%
90	94.5%	93.7%	94.2%
105	95.0%	94.7%	95.2%
120	96.5%	96.2%	96.7%
135	98.5%	98.2%	98.8%
150	98.7%	98.3%	99.0%
165	98.8%	98.7%	99.0%
180	99.2%	98.8%	99.2%
195	99.3%	99.0%	99.3%
210	99.3%	99.0%	99.3%
225	99.3%	99.2%	99.3%
240	99.5%	99.3%	99.5%
255	99.7%	99.5%	99.7%
270	99.7%	99.5%	99.7%
285	99.7%	99.5%	99.7%
300	99.7%	99.5%	99.7%
315	99.7%	99.5%	99.7%
330	99.7%	99.5%	99.7%
345	99.7%	99.5%	99.7%
360	99.7%	99.5%	99.7%
420	100.0%	100.0%	100.0%

Calculation of Trip Generation Time Distribution

To compute the trip generation times, new time distributions (A, B, C, and D) are formed by applying a summing algorithm repeatedly to calculate the time distribution of an event that is dependent on two or more sequential activities. Table 4.7 shows the summing procedure and a description of each of the final trip generation distributions.

Table 4.7 Trip Generation Distributions Description

Distribution	Description	Activities Sequence
A	Time distribution of commuters evacuate directly, employees live outside the EPZ, and transients evacuate directly.	1 + 2
B	Time distribution of commuters/transients arriving home/residence.	1+2+3
C	Time distribution of residents wait for commuters and transients arriving residence to begin the evacuation trip.	1+2+3+4
D	Time distribution of residents without/do not wait for commuters and transients at residence to begin the evacuation trip.	1+4

The trip generation distributions describe the activities that take place before the evacuation trips begin. Distribution B is embedded within Distribution C because those residents are awaiting the return of the commuter and transients arriving at their residence before beginning their evacuation.

Statistical Outliers

Some of the numeric responses are inconsistent with the overall pattern of results because the response either may be unrealistic or reflects a special population that need to be classified in a different population subgroup. These outliers may be valid responses that must be considered or unrepresentative and has to be dropped from the sample. To eliminate outliers:

a) Mean and standard deviation of the specific activity are estimated from the responses.

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

c) The histogram of the data is inspected and all values greater than 3.5 standard deviations from the mean are flagged and either considered as a valid response or dropped from the sample.

d) All values greater than 4 standard deviations from the mean are considered outliers and dropped from the sample.

e) Repeat steps "a" to "d".

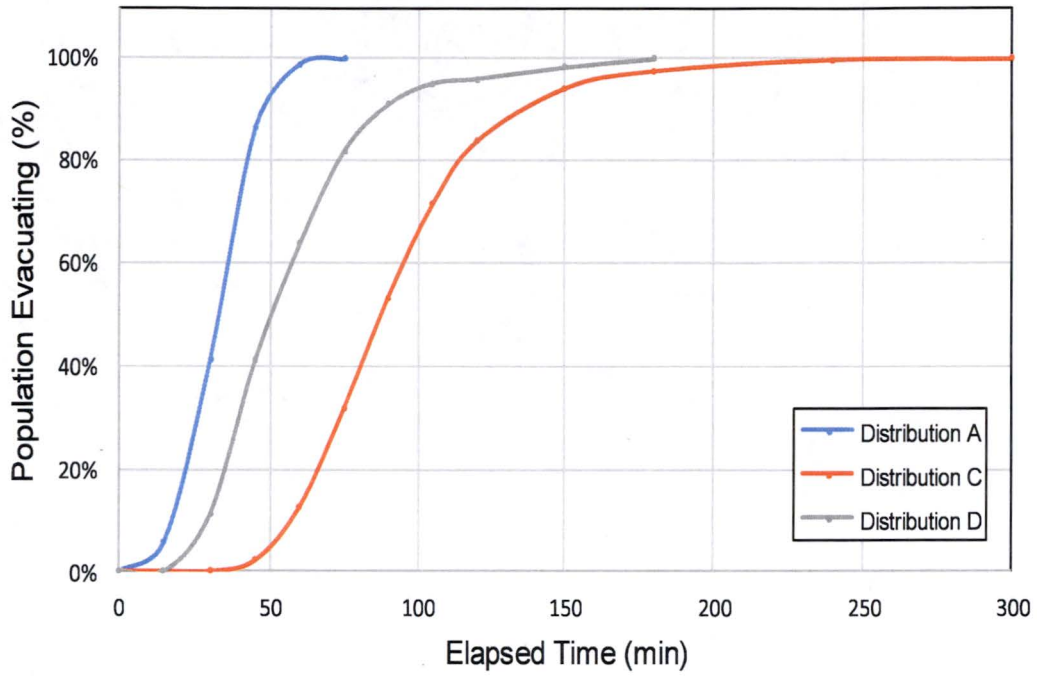
Mobilization Time Distributions

The overall (or total) mobilization distributions are constructed using the different mobilization activities modeled. This is done by using the data sets and distributions under different scenarios (e.g. households with/without commuters, households that wait/don't wait for commuters, commuters/transients evacuate directly, commuters/transients returning to home/residence prior to evacuating) according to the flow chart presented in Figure 4.1. The mobilization times obtained under different scenarios are used as direct inputs to the simulation model that lead to the ETE. Table 4.8 shows the trip generation distributions A, C, and D on the same time scale (elapsed time) and Figure 4.2 presents a comparison for the trip generation time distributions for the daytime scenarios.

Table 4.8 Trip Generation Distributions (Daytime)

Elapsed Time (Minutes)	Trip Generation Distributions (Daytime)					
	Distribution A		Distribution C		Distribution D	
	Population %	Cumulative %	Population %	Cumulative %	Population %	Cumulative %
0	0.0%	0.0%	0.00%	0.00%	0.00%	0.00%
15	5.8%	5.8%	0.00%	0.00%	0.00%	0.00%
30	35.5%	41.3%	0.00%	0.00%	11.21%	11.21%
45	45.4%	86.7%	2.11%	2.11%	29.99%	41.20%
60	12.4%	99.1%	10.53%	12.64%	22.73%	63.92%
75	0.9%	100.0%	19.09%	31.73%	18.04%	81.96%
90			21.65%	53.38%	9.11%	91.07%
105			18.10%	71.47%	4.12%	95.19%
120			12.28%	83.76%	0.89%	96.08%
150			10.44%	94.20%	2.25%	98.33%
180			3.45%	97.65%	1.67%	100.00%
240			2.30%	99.94%		
300			0.06%	100.00%		

Figure 4.2 Trip Generation Distributions Comparison (Daytime)



Using the same methodology, the trip generation time distributions A, C, and D for the nighttime and weekend scenarios were developed and are shown in Tables 4.9 and 4.10, respectively. Figures 4.3 and 4.4 present the comparison for the trip generation distributions.

Table 4.9 Trip Generation Distributions (Nighttime)

Elapsed Time	Trip Generation Distributions (Nighttime)					
	Distribution A		Distribution C		Distribution D	
	Population %	Cumulative %	Population %	Cumulative %	Population %	Cumulative %
0	0.0%	0.0%	0.00%	0.00%	0.00%	0.00%
15	5.8%	5.8%	0.00%	0.00%	0.00%	0.00%
30	35.5%	41.3%	0.00%	0.00%	10.56%	10.56%
45	45.4%	86.7%	1.98%	1.98%	28.85%	39.41%
60	12.4%	99.1%	10.04%	12.02%	23.40%	62.81%
75	0.9%	100.0%	18.62%	30.64%	18.80%	81.61%
90			21.70%	52.34%	8.90%	90.51%
105			18.40%	70.73%	3.96%	94.46%
120			12.40%	83.14%	1.19%	95.65%
150			10.59%	93.73%	2.67%	98.33%
180			3.83%	97.55%	1.67%	100.00%
240			2.39%	99.94%		
300			0.06%	100.00%		

Figure 4.3 Trip Generation Distributions Comparison (Nighttime)

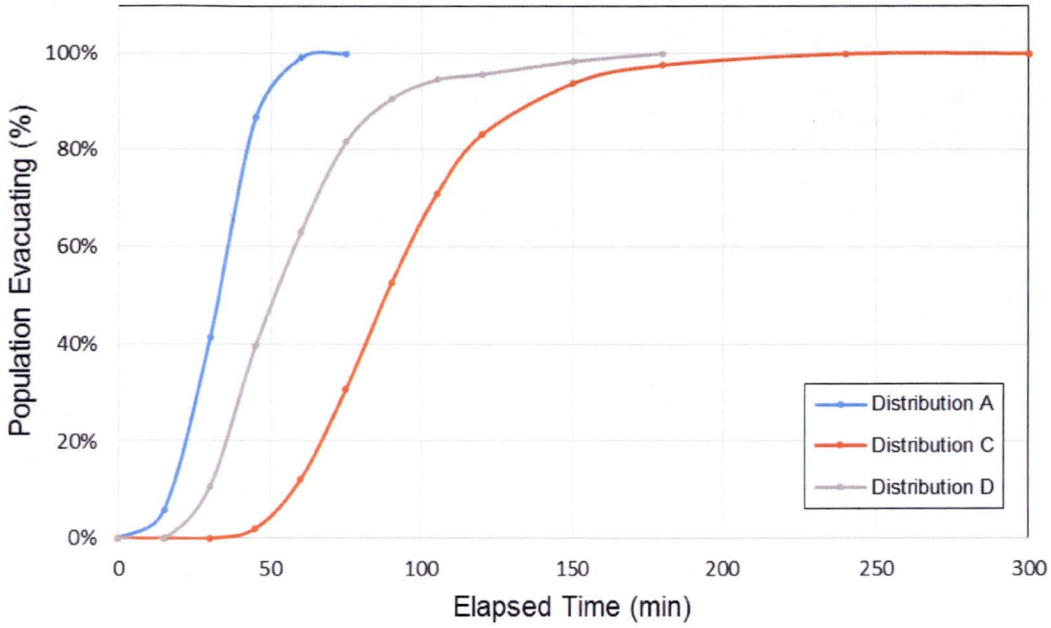
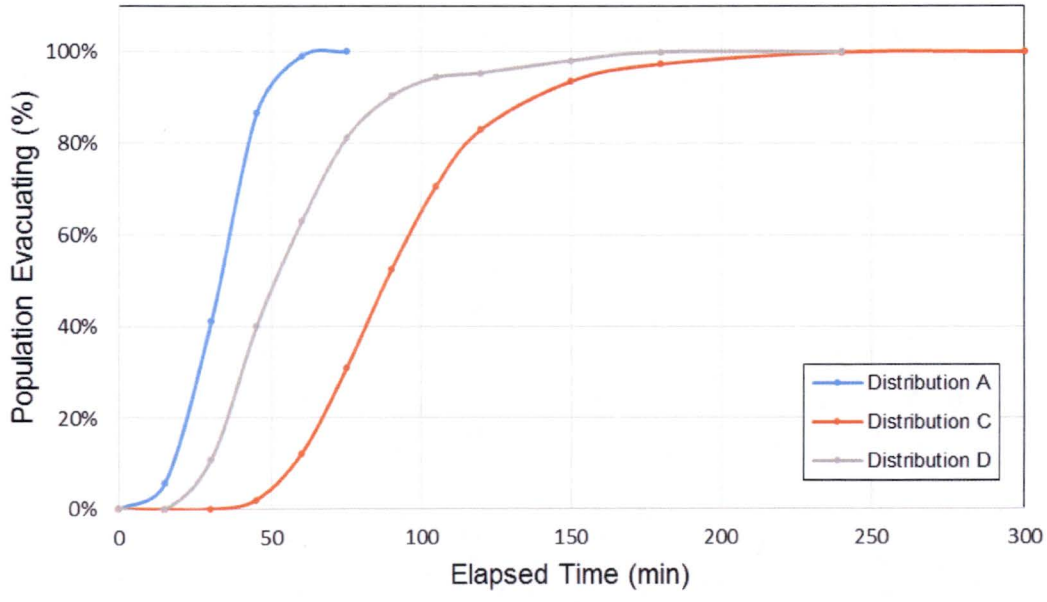


Table 4.10 Trip Generation Distributions (Weekend)

Elapsed Time	Trip Generation Distributions (Weekend)					
	Distribution A		Distribution C		Distribution D	
	Population %	Cumulative %	Population %	Cumulative %	Population %	Cumulative %
0	0.0%	0.0%	0.00%	0.00%	0.00%	0.00%
15	5.8%	5.8%	0.00%	0.00%	0.00%	0.00%
30	35.5%	41.3%	0.00%	0.00%	10.84%	10.84%
45	45.4%	86.7%	2.04%	2.04%	29.32%	40.15%
60	12.4%	99.1%	10.24%	12.28%	22.95%	63.11%
75	0.9%	100.0%	18.78%	31.06%	18.19%	81.29%
90			21.55%	52.61%	9.01%	90.30%
105			18.12%	70.73%	4.08%	94.38%
120			12.28%	83.01%	1.02%	95.40%
150			10.52%	93.53%	2.65%	98.05%
180			3.78%	97.30%	1.93%	99.98%
240			2.62%	99.93%	0.02%	100.00%
300			0.07%	100.00%		

Figure 4.4 Trip Generation Distributions Comparison (Weekend)



4.1.1. Permanent Residents and Transient Population

Permanent residents are household residents, residents in special facilities, residents in medical facilities, employees at work, and children at schools within the EPZ. Census data were used to generate residential population and the population is distributed to zones of the network based on spatial locations. Major employers in the area were also geocoded and spatially associated with zones. The total number of employees is dependent on time of day and time of week. It is assumed that each employee commutes to work separately.

The transient population refers to people staying in a hotel, motel or a campground. According to different scenarios, the total transient population and locations which they are at varies by weather, time of day and time of year. The total number of transient population is divided into three groups: 1) Transients in their residence when the order to evacuate is received and will evacuate directly from hotel/model/campground; 2) Transients away from their residence when the order to evacuate is issued, but will return to their residence prior to evacuating; 3) Transients away from their residence when the order to evacuate is issued that will evacuate directly from where they are. The first two groups are assigned to the corresponding zones where the hotel/motel/campground are located. The third group of transient population is distributed evenly within the EPZ.

Assumptions regarding transients are scenario-specific and are detailed in each scenario described in Section 1.3.

4.1.2. Transit Dependent Permanent Residents

Transit-dependent permanent residents are those residents within the EPZ who do not have access to a vehicle or are dependent on help from outside the home to evacuate. The estimated number of transit-dependent permanent residents was adapted from the results of the random telephone survey of the households in the EPZ and surrounding area and are described in detail in Section 2.2 and Table 2.6. It is estimated that buses would be available to pick up transit dependent residents approximately 120 minutes (obtain drivers, brief drivers and mobilize to bus routes) after the order to evacuate and that would allow individuals to make their way to a bus route.

A subset of transit dependent residents includes people with disabilities and those with access and functional needs that live independent of a special facility. Information was requested from Roane County regarding residents who need assistance during an evacuation, but none was provided.

Because local emergency management agencies were not able to provide information regarding special needs individuals requiring assistance during an evacuation in the EPZ, the total number of vehicles needed was estimated as described in Section 2.2 and evenly distributed across the EPZ.

It is assumed that ambulances required to evacuate special needs individuals are capable of mobilizing to the home, loading the patient and begin the evacuation within 30 minutes of the evacuation order.

Table 4.11 Evacuation of Transit Dependent Individuals

Scenario	Summer				Winter				Summer	
	Midweek		Weekend	Midweek Weekend	Midweek		Weekend	Midweek Weekend	Midweek	Midweek
	1	2	3	4	5	6	7	8	9	10*
	Daytime		Daytime	Evening	Daytime		Daytime	Evening	Daytime	
	Normal Weather	Adverse Weather	Normal Weather	Normal Weather	Normal Weather	Adverse Weather	Normal Weather	Normal Weather	Normal Weather	
Full EPZ	2:11	2:11	2:10	2:11	2:11	2:12	2:11	2:11	2:11	2:36

Times presented in Hours:Minutes
* Peak Construction Scenario

4.1.3. Special Facilities

The presence of special facilities was researched during development of the ETE and it was determined that one facility, the Kingston Academy, currently exists within the EPZ. The Kingston Academy is a Psychiatric Residential Treatment Facility with living quarters and a capacity of 52 children between the ages of 5 and 17. The facility provides residential treatment and day treatment services. For this ETE, it is assumed the facility is at 90% capacity when an evacuation is ordered and the facility is ready to evacuate 75 minutes (60 minutes to prepare + 15 minutes to load vehicles) after the order to evacuate is issued. This results in an evacuation of approximately 47 residents from this facility. The number of transit-dependent residents in special facilities is summarized in Table 2.6.

Information on evacuation of the Kingston Academy is provided in Table 4.12.

Table 4.12 ETEs for Special Facility Populations

Facility	Population	Number/Types of Vehicles	Mobilization Time (minutes)	Loading Time (minutes)	Distance to EPZ Boundary (miles)	Outbound Travel Speed (mph)	Travel Time to EPZ Boundary (minutes)	ETE (hr:min)
Kingston Academy	47	3 Vans	75	15	2.58	45.32	3.416	1:19

4.2. Evacuation Time Estimate Modeling

This Section of the report includes a discussion of INTEGRATION, the traffic simulation model used in performance of the ETE and a summary of the key inputs, assumptions, outputs, and computational process associated with the simulation. INTEGRATION is a microscopic traffic assignment and simulation program with broad applicability to traffic simulation activities well-suited for performance of ETEs for nuclear power plants. The INTEGRATION software calculates a number of Measures of Effectiveness (MOEs) which are addressed by NUREG/CR-7002. The INTEGRATION software is listed in the U.S. Department of Transportation's (DOT) "Evacuation Management Operations (EMO) Modeling Assessment: Transportation Modeling Inventory," developed to support selection of an appropriate model for use in evacuation analyses (Reference 1).

INTEGRATION is an integrated simulation and traffic assignment model that performs traffic simulations by tracking the movement of individual vehicles every 1/10 of a second. This allows detailed analyses of lane-changing movements and shock wave propagations. It also permits considerable flexibility in representing spatial and temporal variations in traffic conditions. The model also estimates the expected number of vehicle crashes using a time-based crash prediction model.

The INTEGRATION model computes a number of MOEs, including the network efficiency. Efficiency evaluation of highway alternatives involves computing the average speed and vehicle delay. The average vehicle speed is computed as the average of all vehicle speeds, where the vehicle speed is computed as the trip distance divided by the trip duration. This model has been validated against state-of-the-art delay estimation procedures using queuing theory and shockwave analysis and against standard traffic flow theory and has been utilized for the evaluation of real-life applications.

The calibration of the INTEGRATION software entails two calibration efforts, namely calibration of the traffic demand and calibration of the network supply. The calibration of the traffic demand involves the use of the telephone survey results to construct a time-varying origin-destination (O-D) table. Different O-D demands were constructed for the different scenarios that were identified in Section 1.3. The second calibration effort entails calibrating four roadway parameters: saturation flow rate; free-flow speed; speed-at-capacity; and jam density.

4.2.1. Traffic Simulation Model Input

Input files of INTEGRATION include files defining the topological relationship of the network, traffic control information and traffic demand data. The input files of the simulation include:

- Node File
- Link File
- Demand File
- Signal File
- Incident File
- Other supplemental Files

The final network generated includes 1,824 nodes, 252 zones, and 3,312 links. Lane striping file is also included to define turning movements assigned to each lane at intersections.

4.2.2. Traffic Simulation Model Output

INTEGRATION is flexible regarding simulation outputs and is capable of providing output files by network link, by vehicle, and by time sequences. At an aggregated level, INTEGRATION is capable of providing output results as: average vehicle stops/delays; total vehicles existing in the network; travel time/distance by vehicle class; volume/capacity ratio; and others. At individual link or vehicle level, INTEGRATION is capable of providing output results as: Starting/ending time by vehicle and/or by link; link flow; link average travel speed; and queues on link, etc. Because the goal of the ETE is to estimate the time needed for the public to move out of the area of concern, the output file needed includes time and location information for each evacuating vehicle. By setting each evacuation vehicle as a probe vehicle, the appropriate output file records the trajectories of each vehicle. Data recorded in the output file are link and vehicle based. Once a vehicle exits a link, a record is written to the output file documenting time, trip ID, O-D, link ID, and vehicle speed. The data in the output file is then aggregated to calculate the travel time for each evacuating vehicle exiting the EPZ boundary by identifying the link ID at the boundary of the EPZ.

4.3. Evacuation Time Estimates for the General Public

The output file provides a vehicle probe listing which chronicles the completion of each link a vehicle probe traverses. Every evacuating vehicle is marked as a probe in the simulation for

ETE. Two types of records can be produced, namely record type 11 and 21. Record type 11 is produced only once for each link and is generated at the time the vehicle departs the link. Record type 21, in contrast, is produced every second the vehicle is on the link.

To compute the evacuation time, the following steps are adopted:

1. The phone survey asked questions such as whether or not the respondents will be at work, if yes, will they return home before evacuating, and how long will they need to prepare to evacuate. Such data are aggregated to develop trip generation times as described in Section 4.1. Several time distributions are generated to describe the time people need to prepare to evacuate. Such distributions are statistically aggregated to obtain the overall patterns of the time needed to prepare to evacuate.

2. The simulation starts with a 45 minute background traffic simulation to ensure equilibration prior to initiating the ETE simulation.

3. Following this 45 minute period, the background traffic gradually decreases and traffic volumes start to convert into evacuation traffic as INTEGRATION begins to generate and load vehicles into the network based on the trip generation time distribution.

4. At 90 minutes the background traffic will stop entering the network.

5. The simulation continues to simulate each vehicle's movement and traffic condition in the network.

6. The output file records the trajectory of each vehicle and information such as origin, destination, starting time, and arrival time, etc.

7. The road links at the boundary of the EPZs are used to identify occurrence of each vehicle on the links. The travel time on such links are divided into 2 parts proportional on the length of the section of that link located within and out of the boundary.

8. The time spent traveling is documented and aggregated. The ETE is estimated for 90% and 100% of the vehicle exiting the EPZs.

The ETE for the evacuation of the general public are provided in Tables 4.13 and 4.14.

Table 4.13 ETEs for Evacuation of the General Public (90% of the Affected Population)

Scenario	Summer				Winter				Summer	
	Midweek		Weekend	Midweek Weekend	Midweek		Weekend	Midweek Weekend	Midweek	Midweek
	1	2	3	4	5	6	7	8	9	10*
	Daytime		Daytime	Evening	Daytime		Daytime	Evening	Daytime	
	Normal Weather	Adverse Weather	Normal Weather	Normal Weather	Normal Weather	Adverse Weather	Normal Weather	Normal Weather	Normal Weather	
Full EPZ	2:09	2:09	1:45	1:40	2:16	2:17	1:44	1:40	2:09	3:38

Times presented in Hours:Minutes
* Peak Construction Scenario

Table 4.14 ETEs for Evacuation of the General Public (100% of the Affected Population)

Scenario	Summer				Winter				Summer	
	Midweek		Weekend	Midweek Weekend	Midweek		Weekend	Midweek Weekend	Midweek	Midweek
	1	2	3	4	5	6	7	8	9	10*
	Daytime		Daytime	Evening	Daytime		Daytime	Evening	Daytime	
	Normal Weather	Adverse Weather	Normal Weather	Normal Weather	Normal Weather	Adverse Weather	Normal Weather	Normal Weather	Normal Weather	
Full EPZ	3:43	3:43	3:05	3:03	3:52	3:52	3:10	3:01	3:43	4:07

Times presented in Hours:Minutes
* Peak Construction Scenario

5.0 OTHER CONSIDERATIONS

The preceding sections describe the methodology and approach to calculating the ETE. In addition to the calculation of an ETE, there are other considerations that need to be addressed in this and future ETE studies. These considerations, as appropriate, are described below.

5.1. Development of Traffic Control Plans

In the event of an evacuation of the EPZ, OROs would establish ACPs and Traffic Control Points (TCPs) as necessary to support the evacuation. It is assumed that ACPs can be staffed within approximately 90 minutes of the advisory to evacuate. Activation of ACPs prior to 90 minutes could delay commuters returning from areas outside of the EPZ. Therefore, it is recommended that ACPs be established 90 minutes following an advisory to evacuate to allow commuters sufficient time to return home and prepare for an evacuation.

ACPs should be established as follows to restrict in-bound traffic flow toward the CRN Site:

1. Prior to 45 minutes after the evacuation order is issued, background and pass-through traffic is running normally in the network.

2. From the time an evacuation order is issued until 90 minutes after the order is issued, background traffic begins to diminish as traffic exits the EPZ and the ACPs begin to prevent inbound traffic from entering the EPZ. The evacuating traffic begins to increase at the rate of the time distribution to get ready (see section 4.1).

3. The background and pass-through traffic stops entering the EPZ 90 minutes after the evacuation order is issued.

Based on the low population of the EPZ, the limited number of vehicles involved in the evacuation, the relative simplicity of the roadway network within the EPZ, and the absence of congestion observed during the traffic simulation modeling, the need to develop more detailed traffic control plans to support an evacuation is not considered necessary at this time. As future ETE studies are conducted additional consideration should be given to the need for a more detailed traffic control plan based on future potential changes to the roadway network, the potential for increased populations within the EPZ and the potential for increased congestion observed during traffic simulation modeling.

5.2. Enhancements in Evacuation Time

Guidance presented in NUREG/CR-7002 suggests that an evaluation of potential enhancements that could reduce the evacuation time be limited to those roadways or intersections of the EPZ that impact the ETE the greatest (Reference 4). These evaluations typically include intersections and roadways that experience LOS F conditions for some period of time. Based on the absence of congestion observed during the traffic simulation modeling, the need to develop enhancements that may reduce evacuation times would have little, if any, benefit. As future ETE studies are conducted, additional consideration should be given to the need for enhancements that may reduce evacuation times.

5.3. State and Local Review

State and local authorities were involved in the development of the ETE. Interactions began with a kick-off meeting in Knoxville in January 2014 during which the regulatory requirements, the process used to develop the ETE and the associated data and information needs were discussed. The meeting was attended by representatives of the following State and local agencies and private sector support organizations:

- Tennessee Emergency Management Agency
- Tennessee Highway Patrol
- Roane County Office of Emergency Services and Homeland Security
- Anderson County Office of Emergency Management and Homeland Security
- Loudon County Mayor
- Loudon County Homeland Security and Emergency Management Agency
- Loudon County Sheriff's Office
- Knox County Emergency Management Agency
- Knox County Sheriff's Office
- Knox County Engineering

- City of Oak Ridge Fire Department
- Kingston Police Department
- Lenoir City Fire Department
- Rural/Metro of East Tennessee
- American Red Cross of East Tennessee

Following the kick-off meeting, a telephone survey instrument was prepared and provided to the TEMA for review and comment, resulting in several modifications. Each agency approved of the instrument prior to initiating the telephone survey.

TEMA and Roane County provided assistance with completing data collection related to the permanent resident and transient populations, schools, major employers, transportation resources, transit-dependent residents and hotels, motels and campgrounds in the EPZ.

5.4. Reviews and Updates

Details related to updating this ETE are included in Sections 5.6 and 5.7 of this report.

5.5. Reception Centers and Congregate Care Centers

The specific locations of reception centers have not yet been identified. Because of the absence of a school population and the limited number of transit-dependent permanent residents, it is not anticipated that multiple trips will be necessary to evacuate the transit dependent population. Therefore the location of these facilities and the logistics of offloading passengers will not impact return trips to the EPZ or the evacuation time.

5.6. New Reactors

Part 5 of the Early Site Permit Application (ESPA) being submitted for the CRN Site includes two (2) Emergency Plans (Part 5A and Part 5B) for review by the NRC. Part 5A will address a site boundary Emergency Planning Zone (EPZ) and Part 5B addresses a 2-Mile EPZ. The final EPZ size will be determined at the time the Combined License Application (COLA) is submitted. This ETE is prepared in support of the 2-Mile EPZ Emergency Plan. In the event the site boundary EPZ is selected for the CRN Site, the Tennessee Valley Authority (TVA) has

proposed an exemption from the requirements to perform an ETE and an update to this ETE will not be necessary.

Because the CRN Site is a greenfield site, as described in NUREG/CR-7002, emergency response plans are not in place, evacuation plans have not been approved and tested by local authorities and the locations of congregate care and reception centers have not been established. These conditions necessitate that the development of the ETE analysis be coordinated with the development of the emergency response program being prepared during the licensing phase (Reference 4). For the CRN Site, development of the offsite emergency response program will occur beginning with the development of the COLA. In the event a 2-mile EPZ is selected, assumptions used in the ETE must be consistent with the assumptions and proposed resources and infrastructure identified within the emergency response plan to provide an accurate ETE. An ETE update for the COLA is expected to be developed based on the most recent decennial census data projected to the year the license application will be submitted.

5.7. Early Site Permits

This ETE was developed in support of the CRN Site ESPA. The ETE serves to satisfy the requirements of 10 CFR 52.17(b)(1), which states that the site safety analysis report identify physical characteristics of the proposed site, such as egress limitations from the area surrounding the site, that could pose a significant impediment to the development of emergency plans and if physical impediments are identified, the application must identify measures that would, when implemented, mitigate or eliminate the significant impediment. This ETE did not identify physical characteristics of the proposed site that could pose a significant impediment to the development of emergency plans.

As described in Section 5.6 and in Section 5.7 of NUREG/CR-7002, data and information is expected to be updated, as appropriate, to ensure up-to-date information is used to develop the ETE when the COLA is submitted.

6.0 GLOSSARY

Count Station - Specific location on a roadway where traffic count surveys are conducted.

Demand Estimation – The total number of evacuees by population group including vehicles.

Emergency Response Planning Areas (ERPAs) – Defined areas that constitute the EPZ and for which emergency response plans have been developed. These areas are typically defined by geographic or political boundaries to support emergency response planning and may also be referred to as subareas, protective action areas, or other local terminology.

Evacuation Tail – A small portion of the population that takes a longer time to evacuate than the rest of the general public and is the last to leave the evacuation area. The tail generally conforms to about the last 10 percent of the population.

Keyhole Evacuation – An evacuation of the 2-mile radius around an NPP and the downwind sectors forming a keyhole configuration.

Link – A segment of roadway between two nodes.

Loading Curve – The rate at which vehicles are entered onto the roadway network.

Measure of Effectiveness (MOE) – Statistics used to describe performance. As applied in this document, these include output data that provide key performance characteristics of the roadway network and the evacuation time.

Node – An identification designator used to connect links in a roadway network model or to apply input data onto the network. Nodes are at intersections, ramps, etc., and contain characteristics such as traffic control and may be used as input points to assign loading of vehicles.

Permanent Resident – All people having a residence in the area.

Roadway Capacity – The maximum rate at which vehicles can be reasonably expected to traverse a point or uniform section of roadway during a given time period under prevailing conditions.

Shadow Evacuation – Evacuation of persons from areas outside any officially declared evacuation zone.

Special Event – An activity where large transient populations are present for a limited period of time.

Special Facilities – Facilities where residents are confined or dependent upon facility personnel for transportation, including nursing homes, assisted living centers, hospitals, jails, prisons, and other similar facilities.

Staged Evacuation – A protective action where one area is ordered to evacuate while adjacent areas are ordered to shelter in place until ordered to evacuate.

Transient Population – Tourists, shoppers, employees, etc., who do not reside within the EPZ, and other people temporarily visiting the EPZ.

Trip Generation Time – Time elapsed for each population group from when the evacuation order was disseminated until the time when the evacuation trip actually begins (e.g., when the car leaves the driveway).

7.0 REFERENCES

1. U.S. Department of Transportation's (DOT) "Evacuation Management Operations (EMO) Modeling Assessment: Transportation Modeling Inventory," June 2008

2. Nuclear Regulatory Commission (NRC). NUREG/CR-6953, Vol. II, SAND2007-4195P, "Review of NUREG-0654, Supplement 3, 'Criteria for Protective Action Recommendations for Severe Accidents – Focus Groups and Telephone Survey,'" October 2008.

3. Institute for Environmental Studies (IES), University of Toronto. "The Mississauga Evacuation Final Report," June 1981.

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5. Nuclear Regulatory Commission (NRC). NUREG-0654/FEMA-REP-1, Rev. 1. "Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants," November 1980.

6. Transportation Research Board (TRB). "Highway Capacity Manual." National Research Council, Washington, DC, 2010.

7. American Association of State Highway and Transportation Officials (AASHTO). "A Policy on Geometric Design of Highways and Streets." AASHTO, Washington, DC, 2011.

8. Federal Highway Administration (FHWA). "Identifying and Assessing Key Weather- Related Parameters and Their Impacts on Traffic Operations Using Simulation." U.S. Department of Transportation. Publication No. FHWA-HRT-04-131. September 2004.

9. Federal Emergency Management Agency (FEMA). "Radiological Emergency Preparedness Program Manual." FEMA-P-1028. January 2015.

Appendices

Appendix A Roadway Network Characteristics

Appendix B Evacuation Time Estimate Evaluation Criteria Checklist

Appendix C Traffic Simulation Model Inputs and Outputs

Appendix A – Roadway Network Characteristics

Table A.1 Node Input File

Node ID	X-Coordinate	Y-Coordinate	Node Category	Node Attribute
51	221.805	241.105	1	-51
59	248.935	203.993	1	-59
111	209.333	236.852	1	-111
185	224.818	260.019	1	-185
186	224.391	256.883	1	-186
188	231.454	249.464	1	-188
226	232.948	221.259	1	-226
301	244.246	209.738	4	0
302	243.991	209.856	4	0
369	247.79	211.173	4	0
370	242.104	207.672	4	0
371	246.2	209.016	4	0
376	242.807	207.75	4	0
560	248.192	211.435	4	0
578	242.109	207.328	4	0
579	248.349	211.205	4	0
882	232.1	207.485	4	0
883	232.605	208.059	4	0
890	273.447	220.325	4	0
891	271.605	220.361	4	0
893	261.13	218.709	4	0
895	273.497	220.582	4	0
896	271.483	220.625	4	0
897	261.233	218.477	4	0
898	263.51	219.481	4	0
899	263.712	219.274	4	0
1051	225.561	255.992	4	0
1052	224.793	256.579	4	0
1054	221.324	241.242	4	0

Node ID	X-Coordinate	Y-Coordinate	Node Category	Node Attribute
1055	221.076	241.515	4	0
1133	211.705	233.162	4	0
1167	203.114	224.989	4	0
1168	219.167	239.52	4	0
1306	230.115	205.111	4	0
1307	235.216	210.188	4	0
1323	224.818	251.153	4	0
1324	225.079	252.877	4	0
1386	204.759	226.558	4	0
1387	207.392	229.064	4	0
1480	240.31	212.359	4	0
1481	235.771	210.486	4	0
1505	222.462	242.359	4	0
1506	222.913	242.888	4	0
1523	208.361	229.979	4	0
1524	208.655	230.261	4	0
1579	226.595	261.191	4	0
1580	225.887	258.139	4	0
1581	225.748	257.227	4	0
1582	225.826	255.774	4	0
1583	225.21	253.711	4	0

Table A.2 Link Input File

Link ID	From	To	Length	Speed Limit (mph)	Capacity	Number of Lanes	Density (V/KM/Lane)	Signal	First Phase Releasing	First Releasing Direction	Second Phase	Second Releasing Direction
17	301	302	0.028	45	1900	1	150	0	0	0	0	0
74	369	301	0.382	55	1900	1	150	-67	2	111	0	0
75	301	370	0.298	45	1900	1	150	0	0	0	0	0
76	371	301	0.212	45	1900	1	150	-67	1	111	0	0
80	376	371	0.363	55	1900	1	150	-68	2	111	0	0
239	560	369	0.048	80	2000	2	150	0	0	0	0	0
257	369	370	0.668	80	2000	2	150	0	0	0	0	0
258	578	376	0.082	80	2000	2	150	0	0	0	0	0
259	376	579	0.653	80	2000	2	150	0	0	0	0	0
495	882	883	0.077	45	1900	1	150	0	0	0	0	0
503	891	890	0.184	80	2000	2	150	0	0	0	0	0
504	890	892	1.046	80	2000	2	150	0	0	0	0	0
505	893	560	1.487	80	2000	2	150	0	0	0	0	0
506	894	895	1.047	80	2000	2	150	0	0	0	0	0
507	895	896	0.202	80	2000	2	150	0	0	0	0	0
508	579	897	1.482	80	2000	2	150	0	0	0	0	0
509	898	893	0.25	80	2000	2	150	0	0	0	0	0
510	897	899	0.26	80	2000	2	150	0	0	0	0	0
637	1051	1052	0.097	30	1900	1	150	0	0	0	0	0
639	51	1054	0.051	30	1900	1	150	10001	0	0	0	0

Link ID	From	To	Length	Speed Limit (mph)	Capacity	Number of Lanes	Density (V/KM/Lane)	Signal	First Phase Releasing	First Releasing Direction	Second Phase	Second Releasing Direction
640	1054	1055	0.037	30	1900	1	150	0	0	0	0	0
650	59	371	0.58	30	1900	1	150	-68	1	111	0	0
733	896	898	0.808	80	2000	2	150	0	0	0	0	0
734	899	891	0.799	80	2000	2	150	0	0	0	0	0
755	1133	111	0.45	30	1900	1	150	0	0	0	0	0
757	1055	113	1.566	30	1900	1	150	0	0	0	0	0
798	913	1167	0.803	55	1900	1	150	0	0	0	0	0
799	1133	1168	0.981	55	1900	1	150	0	0	0	0	0
874	371	579	0.313	45	1900	1	150	0	0	0	0	0
993	1305	1306	1.469	45	1900	1	150	0	0	0	0	0
994	1306	882	0.319	45	1900	1	150	0	0	0	0	0
995	883	1307	0.338	45	1900	1	150	0	0	0	0	0
1010	1323	1324	0.174	55	1900	1	150	0	0	0	0	0
1097	1167	1386	0.227	55	1900	1	150	0	0	0	0	0
1098	1386	1387	0.363	55	1900	1	150	0	0	0	0	0
1263	302	1480	0.49	45	1900	1	150	0	0	0	0	0
1264	1481	1480	0.495	45	1900	1	150	0	0	0	0	0
1265	1307	1481	0.063	45	1900	1	150	0	0	0	0	0
1303	1505	1506	0.07	55	1900	1	150	0	0	0	0	0
1328	1168	1054	0.276	55	1900	1	150	0	0	0	0	0
1329	1054	1505	0.16	55	1900	1	150	0	0	0	0	0

Link ID	From	To	Length	Speed Limit (mph)	Capacity	Number of Lanes	Density (V/KM/Lane)	Signal	First Phase Releasing	First Releasing Direction	Second Phase	Second Releasing Direction
1330	1506	1323	0.855	55	1900	1	150	0	0	0	0	0
1331	1387	1523	0.133	55	1900	1	150	0	0	0	0	0
1332	1523	1524	0.041	55	1900	1	150	0	0	0	0	0
1333	1524	1133	0.421	55	1900	1	150	0	0	0	0	0
1419	185	1579	0.223	30	1900	1	150	10001	0	0	0	0
1420	1052	186	0.05	30	1900	1	150	0	0	0	0	0
1421	1580	1579	0.315	55	1900	1	150	0	0	0	0	0
1422	1579	914	0.429	55	1900	1	150	0	0	0	0	0
1423	1581	1580	0.092	55	1900	1	150	0	0	0	0	0
1424	1051	1581	0.125	55	1900	1	150	0	0	0	0	0
1425	1582	1051	0.034	30	1900	1	150	10001	0	0	0	0
1426	1324	1583	0.084	55	1900	1	150	0	0	0	0	0
1427	1583	1051	0.231	55	1900	1	150	0	0	0	0	0
1435	188	1582	0.856	30	1900	1	150	0	0	0	0	0
1810	1420	578	2.983	80	2000	2	150	0	0	0	0	0
1811	370	1801	2.983	80	2000	2	150	0	0	0	0	0
1875	1481	226	1.273	30	1900	1	150	0	0	0	0	0
1925	302	301	0.028	45	1900	1	150	-67	1	111	0	0
1945	301	371	0.212	45	1900	1	150	-68	1	111	0	0
2224	883	882	0.077	45	1900	1	150	0	0	0	0	0
2348	1052	1051	0.097	30	1900	1	150	10001	0	0	0	0

Link ID	From	To	Length	Speed Limit (mph)	Capacity	Number of Lanes	Density (V/KM/Lane)	Signal	First Phase Releasing	First Releasing Direction	Second Phase	Second Releasing Direction
2350	1054	51	0.051	30	1900	1	150	0	0	0	0	0
2351	1055	1054	0.037	30	1900	1	150	10001	0	0	0	0
2361	371	59	0.58	30	1900	1	150	0	0	0	0	0
2454	111	1133	0.45	30	1900	1	150	10001	0	0	0	0
2456	113	1055	1.566	30	1900	1	150	0	0	0	0	0
2495	1167	913	0.803	55	1900	1	150	0	0	0	0	0
2496	1168	1133	0.981	55	1900	1	150	0	0	0	0	0
2567	579	371	0.313	45	1900	1	150	0	0	0	0	0
2682	1306	1305	1.469	45	1900	1	150	0	0	0	0	0
2683	882	1306	0.319	45	1900	1	150	0	0	0	0	0
2684	1307	883	0.338	45	1900	1	150	0	0	0	0	0
2696	1324	1323	0.174	55	1900	1	150	0	0	0	0	0
2762	1386	1167	0.227	55	1900	1	150	0	0	0	0	0
2763	1387	1386	0.363	55	1900	1	150	0	0	0	0	0
2903	1480	302	0.49	45	1900	1	150	0	0	0	0	0
2904	1480	1481	0.495	45	1900	1	150	0	0	0	0	0
2905	1481	1307	0.063	45	1900	1	150	0	0	0	0	0
2942	1506	1505	0.07	55	1900	1	150	0	0	0	0	0
2967	1054	1168	0.276	55	1900	1	150	0	0	0	0	0
2968	1505	1054	0.16	55	1900	1	150	0	0	0	0	0
2969	1323	1506	0.855	55	1900	1	150	0	0	0	0	0

Link ID	From	To	Length	Speed Limit (mph)	Capacity	Number of Lanes	Density (V/KM/Lane)	Signal	First Phase Releasing	First Releasing Direction	Second Phase	Second Releasing Direction
2970	1523	1387	0.133	55	1900	1	150	0	0	0	0	0
2971	1524	1523	0.041	55	1900	1	150	0	0	0	0	0
2972	1133	1524	0.421	55	1900	1	150	0	0	0	0	0
3052	1579	185	0.223	30	1900	1	150	0	0	0	0	0
3053	186	1052	0.05	30	1900	1	150	0	0	0	0	0
3054	1579	1580	0.315	55	1900	1	150	0	0	0	0	0
3055	914	1579	0.429	55	1900	1	150	0	0	0	0	0
3056	1580	1581	0.092	55	1900	1	150	0	0	0	0	0
3057	1581	1051	0.125	55	1900	1	150	0	0	0	0	0
3058	1051	1582	0.034	30	1900	1	150	0	0	0	0	0
3059	1583	1324	0.084	55	1900	1	150	0	0	0	0	0
3060	1051	1583	0.231	55	1900	1	150	0	0	0	0	0
3068	1582	188	0.856	30	1900	1	150	0	0	0	0	0
3353	226	1481	1.273	30	1900	1	150	10001	0	0	0	0

Table A.3 Intersection Control Type Counts

Intersection Control Type	# of Intersections
Traffic Light	2
Stop Signs	7
Yield Signs	0

Table A.4 Intersection Control Summaries

Node ID	X-Coordinate	Y-Coordinate	Control Type	Notes
301	244.246	209.738	Traffic Light	T-intersection
371	246.2	209.016	Traffic Light	T-intersection
1051	225.561	255.992	Stop Sign	2-way
1054	221.324	241.242	Stop Sign	2-way
1133	211.705	233.162	Stop Sign	1-way
1481	235.771	210.486	Stop Sign	1-way
1579	226.595	261.191	Stop Sign	1-way

Table A.5 Summary of Signalized Intersections

Signal ID	Initial Cycle Time (sec)	Minimum Cycle Length (sec)	Maximum Cycle Length (sec)	Signal Offset	Number Phases	Green Time 1 (sec)	Inter Green Time 1 (sec)	Green Time 2 (sec)	Inter Green Time 2 (sec)	Green Time 3 (sec)	Inter Green Time 3 (sec)	Optimization Frequency (sec)
67	75	65	85	0	3	10	5	14	6	34.5	5.5	300
68	75	65	85	-3	3	10	5	14	6	34.5	5.5	300

Times listed in Seconds (sec).

Appendix B – Evacuation Time Estimate Review Criteria Checklist

Table B.1 – Evacuation Time Estimate Review Criteria Checklist

	Criterion Addressed in ETE Analysis (Yes/No)	Comments
1.0 Introduction		
a. The emergency planning zone (EPZ) and surrounding area should be described.	Yes	Section 1.0 Figure 1.1
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 1.1
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 1.1
b. Sources of demographic data for schools, special facilities, large employers, and special events should be identified.	Yes	
c. Discussion should be presented on use of traffic control plans in the analysis.	Yes	
d. Traffic simulation models used for the analyses should be identified by name and version.	Yes	
e. Methods used to address data uncertainties should be described.	Yes	
1.2 Assumptions		
a. The planning basis for the ETE includes the assumption that the evacuation is ordered promptly and no early protective actions have been implemented.	Yes	Section 1.2
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	Section 1.2 Table 1.2
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	Section 1.3 Table 1.3

	Criterion Addressed in ETE Analysis (Yes/No)	Comments
1.3.1 Staged Evacuation		
a. A discussion should be provided on the approach used in development of a staged evacuation.	No	Because this ETE analysis for the CRN Site considers an EPZ encompassing an approximate 2 mile radius around the proposed reactor center point location, staged and traditional keyhole evacuations are not appropriate for the CRN Site and have not been considered in this analysis. Instead this analysis considers an evacuation of the entire EPZ for each evacuation scenario. Refer to Section 1.3.1
1.4 Evacuation Planning Areas		
a. A map of the EPZ with emergency response planning areas (ERPAs) should be included.	No	The EPZ is an area encompassing an approximate 2 mile radius around the proposed reactor center point location. During an emergency at the CRN Site, protective actions will be implemented consistently throughout the EPZ. For this reason, development of ERPA within the EPZ are not necessary to support site-specific protective action recommendation logic (i.e., staged or keyhole based on wind direction) and ERPA are not considered in this analysis. Refer to Section 1.4 Figure 1.1
b. A table should be provided identifying the ERPAs considered for each ETE calculation by downwind direction in each sector.	No	
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.	No	
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	Section 2.0
2.1 Permanent Residents and Transient Population		
a. The US Census should be the source of the population values, or another	Yes	Section 2.1

	Criterion Addressed in ETE Analysis (Yes/No)	Comments
credible source should be provided.		
b. Population values should be adjusted as necessary for growth to reflect population estimates to the year of the ETE.	Yes	
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 2.1
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	Section 2.1
b. Major employers should be listed.	Yes	Section 2.5 Table 2.7
2.1.2 Transient Population		
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	Section 2.1.1 Table 2.5
b. The average population during the season should be used, itemized and totaled for each scenario.	Yes	Table 2.5
c. The percent of permanent residents assumed to be at facilities should be estimated.	Yes	Section 2.1.2
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	Section 2.1.2
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 2.2
2.2 Transit Dependent Permanent Residents		
a. The methodology used to determine the number of transit dependent residents should be discussed	Yes	Section 2.2
b. Transportation resources needed to evacuate this group should be quantified.	Yes	Section 2.2

	Criterion Addressed in ETE Analysis (Yes/No)	Comments
c. The county/local evacuation plans for transit dependent residents should be used in the analysis.	No	A county/local evacuation plan for transit-dependent residents does not currently exist.
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 2.2
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 2.2
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	Section 2.2
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	Table 2.6
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	Section 2.3 Table 2.6
b. A discussion should be provided on how special facility data was obtained.	Yes	Section 2.3
c. The number of wheelchair and bed-bound individuals should be provided.	Yes	Section 2.3
d. An estimate of the number and capacity of vehicles needed to support the evacuation of the facility should be provided.	Yes	Table 2.6
e. The logistics for mobilizing specially trained staff (e.g., medical support or security support for prisons, jails, and other correctional facilities) should be discussed when appropriate.	Yes	Section 2.3
2.4 Schools		
a. A list of schools including name, location, student population, and transportation resources required to support the evacuation, should be	No	Not Applicable

	Criterion Addressed in ETE Analysis (Yes/No)	Comments
provided. The source of this information should be provided.		The presence of schools was researched during development of the ETE and it was determined that no schools currently exist within the EPZ. Refer to Section 2.4
b. Transportation resources for elementary and middle schools are based on 100% of the school capacity.	No	
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 provided	No	
d. The need for return trips should be identified if necessary.	No	
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	There were no special events identified that take place within the EPZ. However, it is assumed that the Smokin' the Water 4th of July Celebration in Kingston, Tennessee would result in a peak transient population within the EPZ. Based on the small permanent resident population in the EPZ, it is assumed that all permanent residents remain in the EPZ during this event and no reduction in permanent resident population is considered. Refer to Section 2.5.1
b. The special event that encompasses the peak transient population should be analyzed in the ETE.	Yes	
c. The percent of permanent residents attending the event should be estimated.	Yes	
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 2.5.2
b. Population estimates for the shadow evacuation in the 10 to 15 mile area beyond the EPZ are provided by sector.	No	Based on the reduced EPZ size, the population estimates are available by sector from the EPZ boundary out to 15 miles was considered in the ETE. Refer to Section 2.5.2
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 2.5.2

	Criterion Addressed in ETE Analysis (Yes/No)	Comments
2.5.3 Background and Pass Through Traffic		
a. The volume of background traffic and pass-through traffic should be based on the average daytime traffic. Values may be reduced for nighttime scenarios.	Yes	Section 2.5.3 Table 2.9
b. Pass-through traffic should be assumed to have stopped entering the EPZ about two hours after the initial notification.	No	An estimate of 90 minutes is used in this analysis.
2.6 Summary of Demand Estimation		
a. A summary table should be provided that identifies the total populations and total vehicles used in the analysis for permanent residents, transients, transit dependent residents, special facilities, schools, shadow population, and pass-through demand used in each scenario.	Yes	Table 2.8 Table 2.9
3.0 Roadway Capacity		
a. The method(s) used to assess roadway capacity should be discussed.	Yes	Section 3.0
3.1 Roadway Characteristics		
a. A field survey of key routes within the EPZ has been conducted.	Yes	Section 3.1
b. Information should be provided describing the extent of the survey, and types of information gathered and used in the analysis.	Yes	Section 3.1
c. A table similar to that in Appendix A, "Roadway Characteristics," of NUREG/CR-7002 should be provided.	Yes	Appendix A
d. Calculations for a representative roadway segment should be provided.	Yes	Appendix A
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	Figure 3.1
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 are expressly used in the modeling.	Yes	Section 3.2
b. The capacity analysis identifies where field information should be used in the ETE calculation.	Yes	Section 3.2

	Criterion Addressed in ETE Analysis (Yes/No)	Comments
3.3 Intersection Control		
a. A list of intersections should be provided that includes the total numbers of intersections modeled that are unsignalized, signalized, or manned by response personnel.	Yes	Section 3.3
b. Characteristics for the 10 highest volume intersections within the EPZ are provided including the location, signal cycle length, and turn lane queue capacity.		
c. Discussion should be provided on how time signal cycle is used in the calculations.	Yes	Section 3.3
3.4 Adverse Weather		
a. The adverse weather condition should be identified and the effect of adverse weather on mobilization should be considered.	Yes	Section 3.4
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 3.3
c. The study identifies assumptions for snow removal on streets and driveways, when applicable.	Yes	Section 3.4
4.0 Development of Evacuation Times		
4.1 Trip Generation Times		
a. The process used to develop trip generation times should be identified.	Yes	Section 4.1
b. When telephone surveys are used, the scope of the survey, area of the survey, number of participants, and statistical relevance should be provided.	Yes	Section 1.1
c. Data obtained from telephone surveys should be summarized.	Yes	Table 1.2 Section 2.2 Table 4.4 Table 4.5 Table 4.6
d. The trip generation time for each population group should be developed from site specific information.	Yes	Section 4.1

	Criterion Addressed in ETE Analysis (Yes/No)	Comments
4.1.1 Permanent Resident and Transient Population		
a. Permanent residents are assumed to evacuate from their homes but are not assumed to be at home at all times. Trip generation time includes the assumption that a percentage of residents will need to return home prior to evacuating.	Yes	Section 4.1
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 4.1
c. The trip generation time accounts for transients potentially returning to hotels prior to evacuating.	Yes	Section 4.1
d. Effect of public transportation resources used during special events where a large number of transients are expected should be considered.	No	Not applicable. Refer to Section 2.5.1.
e. The trip generation time for the transient population should be integrated and loaded onto the transportation network with the general public.	Yes	Section 4.1
4.1.2 Transit Dependent Residents		
a. If available, existing plans and bus routes are used in the ETE analysis. If new plans are developed with the ETE, they should have been agreed upon by the responsible authorities.	No	Not applicable.
b. Discussion should be included on the means of evacuating ambulatory and non-ambulatory residents.	Yes	Section 4.1.2 Section 2.2
c. The number, location and availability of buses, and other resources needed to support the demand estimation are provided.	Yes	Section 4.1.2
d. Logistical details, such as the time to obtain buses, brief drivers and initiate the bus route are provided.	Yes	Section 4.1.2
e. Discussion should identify the time estimated for transit dependent residents to prepare and then travel to a bus pickup point, and describes the expected means of travel to the pickup point.	Yes	Section 4.1.2
f. The number of bus stops and time needed to load passengers should be discussed.	No	Refer to Section 4.1.2

	Criterion Addressed in ETE Analysis (Yes/No)	Comments
g. A map of bus routes should be included.	Yes	4.1.2
h. The trip generation time for non-ambulatory persons includes the time to mobilize ambulances or special vehicles, time to drive to the home of residents, loading time, and time to drive out of the EPZ should be provided.	Yes	Section 4.1.2
i. Information should be provided to support analysis of return trips, if necessary.	No	No return trips are necessary.
4.1.3 Special Facilities		
a. Information on evacuation logistics and mobilization times should be provided.	Yes	Section 2.3 Table 4.11
b. Discussion should be provided on the inbound and outbound speeds.	Yes	Table 4.11
c. The number of wheelchair and bed-bound individuals should be provided, and the logistics of evacuating these residents should be discussed.	Yes	Section 2.3
d. Time for loading of residents should be provided.	Yes	Table 4.11
e. Information should be provided that indicates whether the evacuation can be completed in a single trip or if additional trips are needed.	Yes	Section 2.3
f. If return trips are needed, the destination of vehicles should be provided.	No	No return trips are necessary.
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.	No	Not applicable as no return trips are necessary.
h. Supporting information should be provided to quantify the time elements for the return trips.	No	Not applicable as no return trips are necessary.
4.1.4 Schools		
a. Information on evacuation logistics and mobilization times should be provided.	No	Not Applicable The presence of schools was researched during development of the ETE and it was determined that no schools currently exist within the EPZ.
b. Discussion should be provided on the inbound and outbound speeds.	No	
c. Time for loading of students should be provided.	No	
d. Information should be provided that indicates whether the evacuation can	No	

	Criterion Addressed in ETE Analysis (Yes/No)	Comments
be completed in a single trip or if additional trips are needed.		Refer to Section 2.4
e. If return trips are needed, the destination of school buses should be provided.	No	
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.	No	
g. Supporting information should be provided to quantify the time elements for the return trips.	No	
4.2 ETE Modeling		
a. General information about the model should be provided and demonstrates its use in ETE studies.	Yes	Section 4.2
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
4.2.1 Traffic Simulation Model Input		
a. Traffic simulation model assumptions and a representative set of model inputs should be provided.	Yes	Section 4.2.1 Appendix A
b. A glossary of terms should be provided for the key performance measures and parameters used in the analysis.	Yes	Section 6.0
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	Section 4.3
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.	Yes	Section 4.2.2 Appendix C

	Criterion Addressed in ETE Analysis (Yes/No)	Comments
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.		
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	Appendix A
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	Table 4.13 Table 4.14
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	Statistical outliers related to trip generation time are addressed in Section 4.1
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.	No	Because this ETE analysis for the CRN Site considers an EPZ encompassing an approximate 2 mile radius around the proposed reactor center point location, staged and traditional keyhole evacuations are not appropriate for the CRN Site and have not been considered in this analysis. Instead this analysis considers an evacuation of the entire EPZ for each evacuation scenario. Refer to Section 1.3.1
d. ETEs should be provided for the 100 percent evacuation of special facilities, transit dependent, and school populations.	Yes	Table 4.11 Table 4.12
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.	No	Not Applicable

	Criterion Addressed in ETE Analysis (Yes/No)	Comments
b. A discussion of adjustments or additions to the traffic control plan that affect the ETE should be provided.	No	Based on the low population of the EPZ, the limited number of vehicles involved in the evacuation, the relative simplicity of the roadway network within the EPZ, and the absence of congestion observed during the traffic simulation modeling, the need to develop more detailed traffic control plans to support an evacuation is not considered necessary at this time.
5.2 Enhancements in Evacuation Time		
a. The results of assessments for improvement of evacuation time should be provided.	No	Based on the absence of congestion observed during the traffic simulation modeling, the need to develop enhancements that may reduce evacuation times would have little, if any, benefit.
b. A statement or discussion regarding presentation of enhancements to local authorities should be provided.		
5.3 State and Local Review		
a. A list of agencies contacted and the extent of interaction with these agencies should be discussed.	Yes	Section 5.3
b. Information should be provided on any unresolved issues that may affect the ETE.	No	Not Applicable
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	Section 5.6 Section 5.7
5.5 Reception Centers and Congregate Care Centers		
a. A map of congregate care centers and reception centers should be provided.	No	The specific locations of reception centers have not yet been identified.
b. If return trips are required, assumptions used to estimate return times for buses should be provided.	No	Because of the absence of a school population and the limited number of transit-dependent permanent residents, it is not anticipated that multiple trips will be necessary to evacuate the transit dependent population.
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	No	It is not anticipated that multiple trips will be necessary to evacuate the transit dependent

	Criterion Addressed in ETE Analysis (Yes/No)	Comments
center.		population. Therefore, the logistics of offloading passengers will not impact return trips to the EPZ or the evacuation time.

Appendix C – Traffic Simulation Model Inputs and Outputs

Table C.1 Loading Curves

Time Period	Duration (Min)	Scenario									
		1	2	3	4	5	6	7	8	9	10
1	15	10	9	5	0	7	7	2	0	10	167
2	15	66	64	89	79	56	53	79	72	66	275
3	15	111	109	210	209	96	95	195	192	111	245
4	15	106	108	158	172	98	97	151	158	106	244
5	15	137	139	131	144	131	132	124	134	137	303
6	15	142	142	77	77	138	138	71	72	142	316
7	15	117	116	41	40	112	112	39	36	117	291
8	15	76	75	19	17	74	73	15	16	76	252
9	15	39	38	18	20	29	29	20	17	39	214
10	15	33	33	16	12	41	41	12	12	33	214
11	15	11	11	5	7	9	9	7	4	11	193
12	15	11	11	10	8	13	13	8	9	11	187
13	15	3	3	1	0	5	5	1	0	3	182
14	15	5	5	2	1	2	2	0	0	5	186
15	15	3	3	0	1	4	3	0	0	3	182
16	15	4	4	0	0	4	4	2	1	4	141
17	15	0	0	0	0	0	0	0	0	0	0
18	15	0	0	0	0	0	0	0	0	0	0
19	15	0	0	0	0	0	0	0	0	0	0
20	15	0	0	0	0	1	1	0	0	0	0

Table C.2 Data Input by Zone

Zones	Scenario									
	1	2	3	4	5	6	7	8	9	10
226	308	300	275	250	293	288	263	250	308	312
51	341	334	279	251	330	325	267	251	341	349
59	203	213	205	262	175	179	174	203	203	208
186	10	11	12	10	11	11	10	9	10	12
188	10	10	9	12	11	11	10	10	10	2709
111	10	11	11	11	11	11	10	10	10	12

Table C.3 Destination Nodes and Capacities

Destination	Capacities	Destination	Capacities	Destination	Capacities
180	3800	201	1900	219	1900
134	1900	27	1900	98	1900
216	1900	227	7600	25	1900
139	3800	209	3800	174	1900
223	1900	147	1900	129	1900
23	3800	125	1900	119	1900
167	1900	22	4000	197	1900
33	1900	132	4000	221	1900
166	1900	215	1900	225	8000

Table C.4 Exiting Number of Vehicles by Hour by Exiting Node

Time (Hour)		Exiting Link	Exiting Node	Scenario									
From	To			1	2	3	4	5	6	7	8	9	10
0	1	2495	913	135	128	179	152	120	115	162	153	135	636
0	1	504	892	43	52	104	141	34	37	88	111	43	45
0	1	1811	1801	94	86	159	131	82	74	144	134	94	97
1	2	2495	913	183	184	102	102	186	184	104	100	183	868
1	2	504	892	128	128	83	105	110	111	72	79	126	129
1	2	1811	1801	171	170	97	103	165	166	100	99	171	170
2	3	2495	913	39	38	20	20	38	39	22	17	39	752
2	3	504	892	28	29	17	16	26	27	13	13	30	30
2	3	1811	1801	37	38	16	14	40	42	18	16	37	39
3	4	2495	913	6	7	1	1	7	8	1	0	6	726
3	4	504	892	4	4	1	0	5	4	1	0	4	4
3	4	1811	1801	6	6	3	2	6	6	1	1	6	6
4	5	2495	913	0	0	0	0	1	1	0	0	0	90
4	5	504	892	0	0	0	0	0	0	0	0	0	0
4	5	1811	1801	0	0	0	0	0	0	0	0	0	0

Table C.5 Exiting Percentage of Vehicles by Hour by Exiting Node

Time (Hour)		Exiting Link	Exiting Node	Scenario									
From	To			1	2	3	4	5	6	7	8	9	10
0	1	2495	913	15.4%	14.7%	22.9%	19.3%	14.6%	14.1%	22.3%	21.2%	15.4%	17.7%
0	1	504	892	4.9%	6.0%	13.3%	17.9%	4.1%	4.5%	12.1%	15.4%	4.9%	1.3%
0	1	1811	1801	10.8%	9.9%	20.3%	16.6%	10.0%	9.1%	19.8%	18.5%	10.8%	2.7%
1	2	2495	913	20.9%	21.1%	13.0%	13.0%	22.7%	22.6%	14.3%	13.8%	20.9%	24.2%
1	2	504	892	14.6%	14.7%	10.6%	13.3%	13.4%	13.6%	9.9%	10.9%	14.4%	3.6%
1	2	1811	1801	19.6%	19.5%	12.4%	13.1%	20.1%	20.4%	13.8%	13.7%	19.6%	4.7%
2	3	2495	913	4.5%	4.4%	2.6%	2.5%	4.6%	4.8%	3.0%	2.4%	4.5%	20.9%
2	3	504	892	3.2%	3.3%	2.2%	2.0%	3.2%	3.3%	1.8%	1.8%	3.4%	0.8%
2	3	1811	1801	4.2%	4.4%	2.0%	1.8%	4.9%	5.2%	2.5%	2.2%	4.2%	1.1%
3	4	2495	913	0.7%	0.8%	0.1%	0.1%	0.9%	1.0%	0.1%	0.0%	0.7%	20.2%
3	4	504	892	0.5%	0.5%	0.1%	0.0%	0.6%	0.5%	0.1%	0.0%	0.5%	0.1%
3	4	1811	1801	0.7%	0.7%	0.4%	0.3%	0.7%	0.7%	0.1%	0.1%	0.7%	0.2%
4	5	2495	913	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	2.5%
4	5	504	892	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
4	5	1811	1801	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table C.6 Network-Wide Travel Time (Minutes)

Scenario									
1	2	3	4	5	6	7	8	9	10
2.57	2.99	2.59	2.57	2.57	3.90	2.59	2.59	2.84	9.22

Table C.7 Total Vehicles Exiting the Network

Time Period	Duration (Min)	Scenario									
		1	2	3	4	5	6	7	8	9	10
1	15	9	8	5	0	6	6	2	0	9	167
2	15	51	53	72	66	46	39	66	56	51	275
3	15	109	105	186	187	94	92	171	164	110	245
4	15	103	100	179	171	90	89	155	178	102	244
5	15	134	132	132	154	133	129	136	132	134	303
6	15	141	146	78	85	137	138	82	82	141	316
7	15	119	119	47	51	112	112	42	44	119	291
8	15	88	85	25	20	79	82	16	20	88	252
9	15	44	45	19	22	35	38	25	18	44	214
10	15	33	31	17	11	44	39	11	12	33	214
11	15	15	18	8	9	14	20	8	7	15	193
12	15	12	11	9	8	11	11	9	9	12	187
13	15	4	5	3	1	8	9	1	0	4	182
14	15	4	4	2	1	1	1	0	0	4	186
15	15	4	3	0	1	5	4	0	0	4	182
16	15	4	5	0	0	4	4	2	1	4	141
17	15	0	0	0	0	0	0	0	0	0	0
18	15	0	0	0	0	0	0	0	0	0	0
19	15	0	0	0	0	0	0	0	0	0	0
20	15	0	0	0	0	1	1	0	0	0	0
Total		874	870	782	787	820	814	726	723	874	3592

Figure C.1 Mobilization and Evacuation Curves

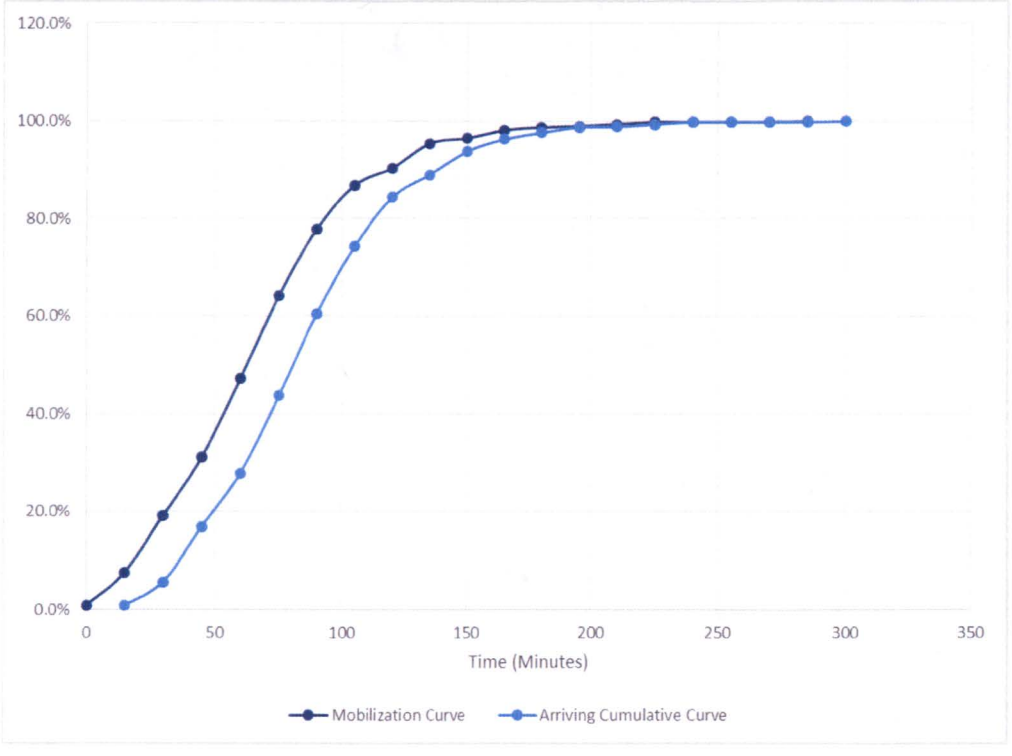
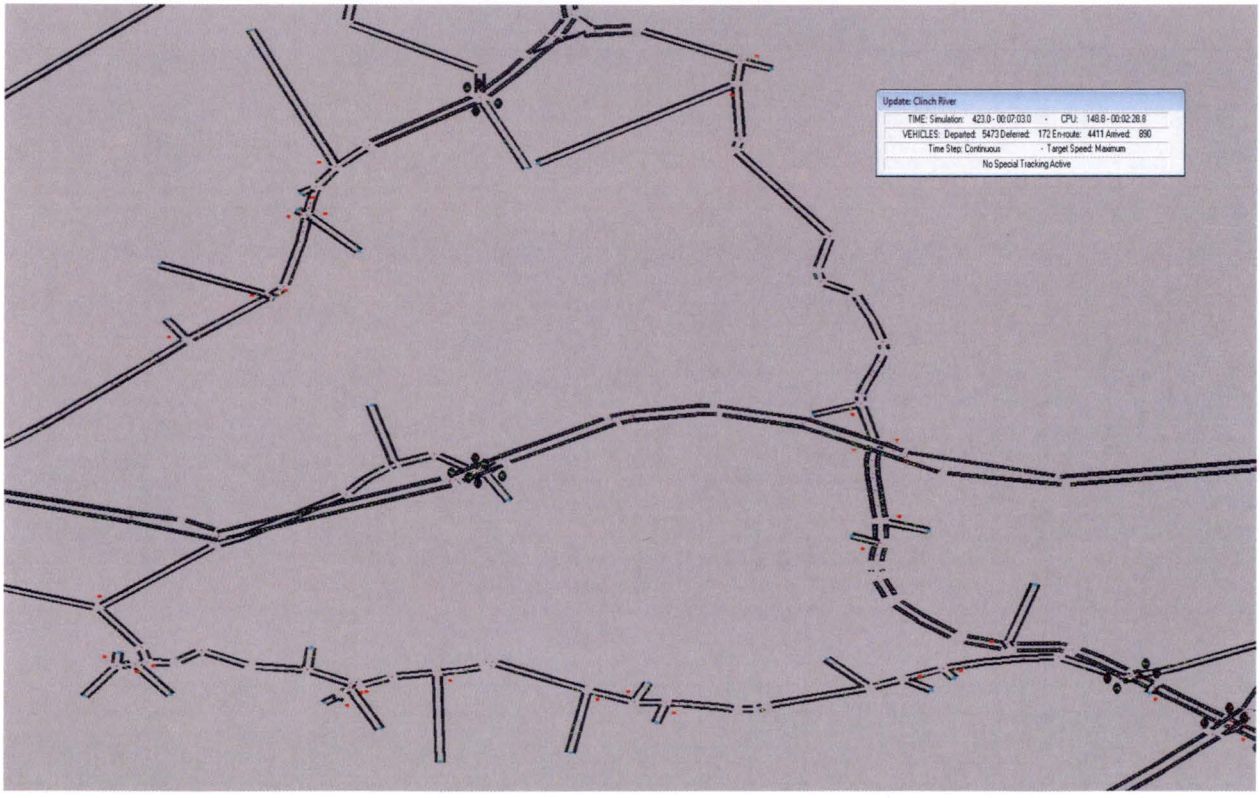


Table C.8 Average Speeds for Major Evacuation Routes (mph)

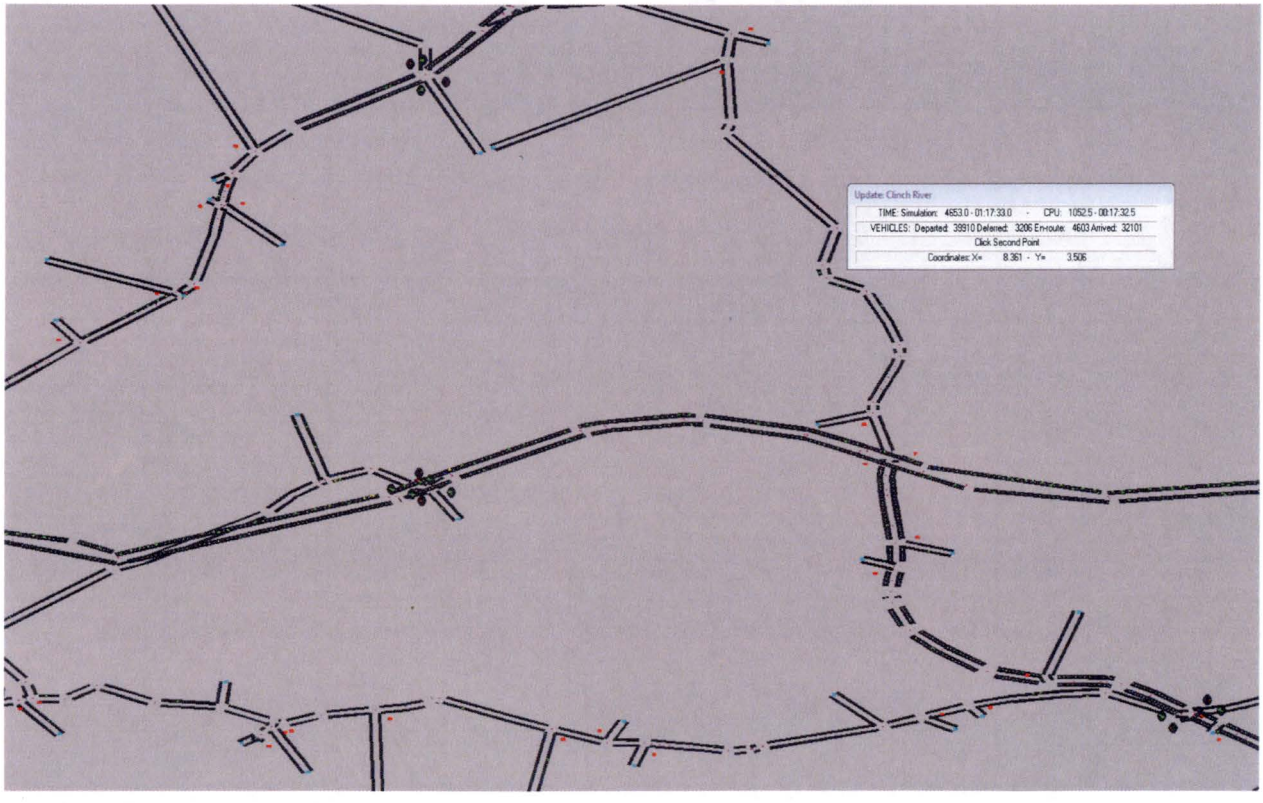
Route	Scenario									
	1	2	3	4	5	6	7	8	9	10
Route 58	49	42	50	50	49	32	50	50	49	48
I-40	63	54	63	63	63	41	63	63	63	63

Figure C.2 Time Lapse Simulation Graphics

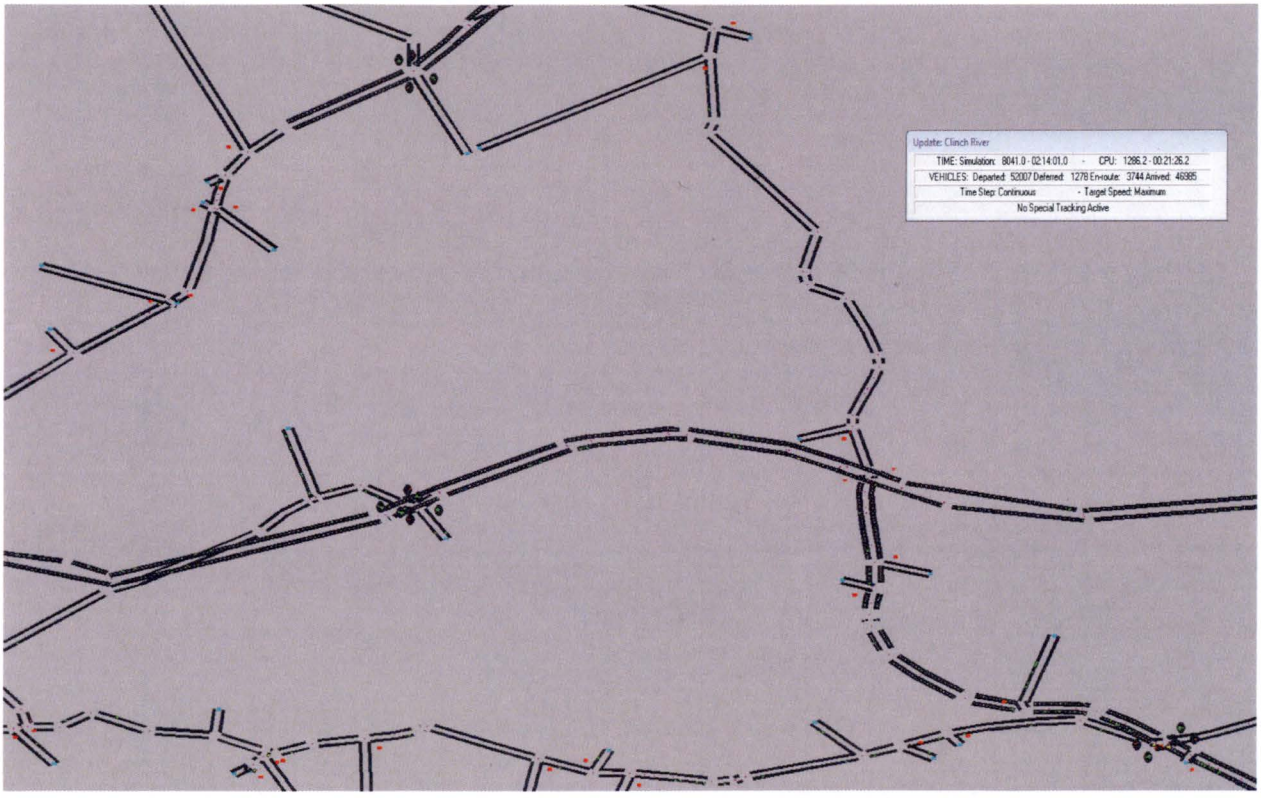
Simulation Screenshot 1 – Background Traffic



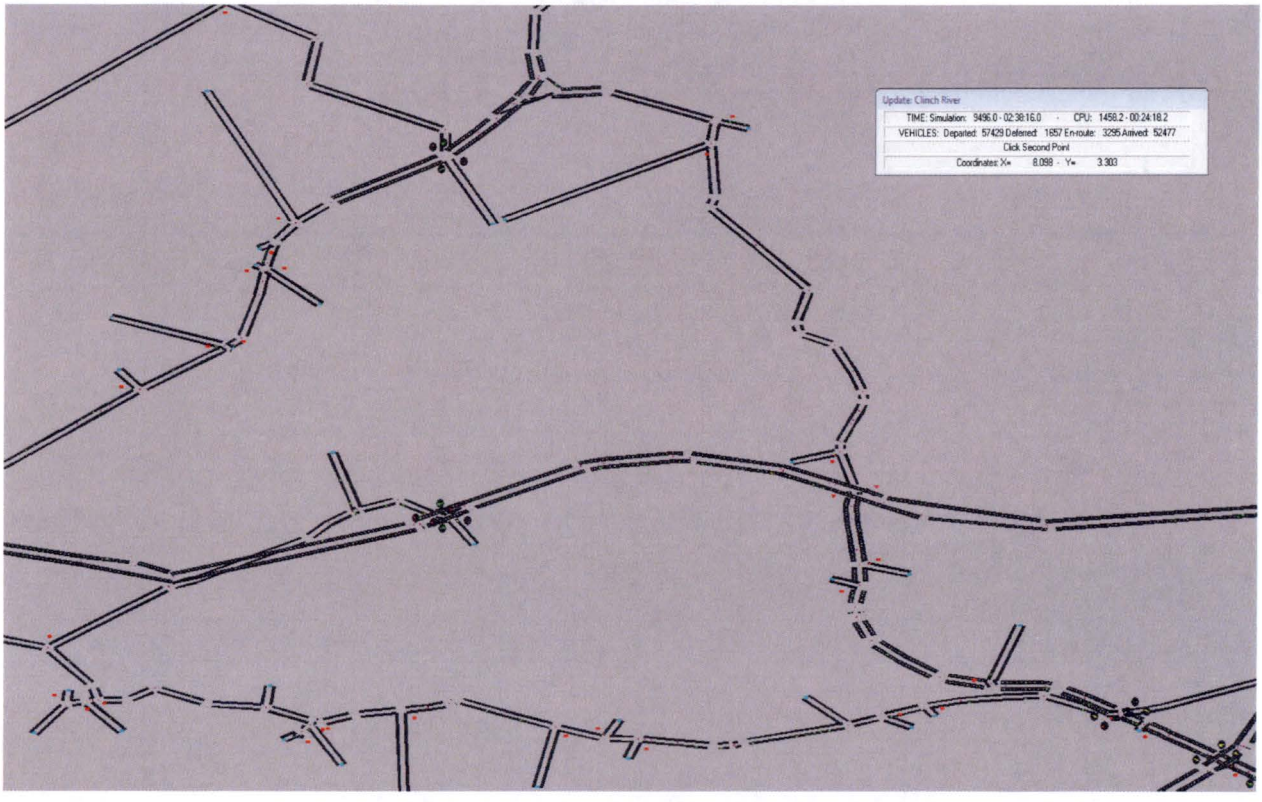
Simulation Screenshot 2 - ~ 30 minutes after Order to Evacuate



Simulation Screenshot 3 - ~ 90 minutes after Order to Evacuate



Simulation Screenshot 4 - ~ 115 minutes after Order to Evacuate



Simulation Screenshot - ~ 3 hours after Order to Evacuate