

## APPENDIX I

### Evacuation Sensitivity Studies

## APPENDIX I: EVACUATION SENSITIVITY STUDIES

A sensitivity study was performed to determine whether changes in the estimated trip generation time have an effect upon the evacuation time estimate for the entire EPZ. The case considered was Scenario 1, Region 3; a summer, midweek, midday, good weather evacuation for the entire EPZ. Table I-1 presents the results of this study.

<b>Table I-1. Evacuation Time Estimates for Trip Generation Sensitivity Study</b>			
<b>Trip Generation Period</b>	<b>Evacuation Time Estimate</b>		
	<b>2-Mile Region</b>	<b>5-Mile Region</b>	<b>Entire EPZ</b>
3 Hours	3:00	3:10	4:10
4 Hours (Base)	4:00	4:05	4:20
5 Hours	5:00	5:05	5:10

The results confirm the importance of accurately estimating the trip generation times. The evacuation time estimates closely mirror the values for the time the last evacuation trip is generated, except for the entire EPZ with a 3 hour trip generation. This is due to significant traffic congestion in Gaffney during an evacuation, which persists for 4 hours, as indicated in Section 7. The results for the 5 hour trip generation indicate that programs to educate the public and encourage them toward faster responses for a radiological emergency can enhance county emergency planning programs.

A sensitivity study was conducted to determine the effects on Evacuation Time Estimates (ETE) of changes in the percentage of people who decide to relocate from the Shadow Region. The movement of people in the shadow region has the potential to impede vehicles evacuating from an Evacuation Region within the EPZ.

Table I-2 presents the evacuation time estimates for each of these cases. The ETE for the 2 mile and 5 mile Regions do not change as the percentage of people who decide to relocate from areas within the shadow region increases from 15% to 60%. The Entire EPZ, however, does change as the percentage of shadow evacuees varies. The ETE for the Entire EPZ increases by 20 minutes as the percent of shadow evacuees changes from 30% to 60%. The roads within and leading out of Gaffney are highly congested during an evacuation. The additional shadow vehicles outside of Gaffney further delay those trying to evacuate.

<b>Table I-2. Evacuation Time Estimates for Shadow Sensitivity Study</b>			
<b>Percent Shadow Evacuation</b>	<b>Evacuation Time Estimate</b>		
	<b>2-Mile Region</b>	<b>5-Mile Region</b>	<b>Entire EPZ</b>
15	4:00	4:05	4:10
30 (Base)	4:00	4:05	4:20
60	4:00	4:05	4:40

A sensitivity study was conducted to determine the effects on ETE of changes in the average number of evacuating vehicles per household. The value used as a base condition (1.44 evacuating vehicles per household) was obtained from the responses to the telephone survey of EPZ resident households. This number represents the average of all responses.

York County expressed concern that its residents would use all available vehicles during an evacuation. The average vehicle ownership for the EPZ is 2.08 vehicles per household (Appendix F). This number was used for this sensitivity study to measure the effect on ETE of EPZ residents using all available vehicles during an evacuation. Scenario 1, Region 3 is also used for this study.

Table I-3 presents the evacuation time estimates for each of these cases. The ETE is unchanged for the 2-Mile Region as the vehicle utilization increases from 1.44 vehicles per household to 2.08 vehicles per household. The total vehicles evacuated for the Entire EPZ increases by approximately 30%. This significant increase in evacuating vehicles further compounds the congestion within Gaffney and results in an increase in the ETE of 1 hour, 5 minutes for the 5-Mile Region, and 1 hour, 10 minutes for the Entire EPZ.

<b>Table I-3. Evacuation Time Estimates for Evacuating Vehicles per Household Sensitivity Study</b>				
<b>Evacuating Vehicles per Household</b>	<b>Total Vehicles Evacuated</b>	<b>Evacuation Region</b>		
		<b>2-Mile Region (R01)</b>	<b>5-Mile Region (R02)</b>	<b>Entire EPZ (R03)</b>
1.44	42,312	4:00	4:05	4:20
2.08	54,381	4:00	5:10	5:30

A sensitivity study was conducted to determine the effect of traffic control tactics on the ETE. The traffic signals in the PC-DYNEV simulation were modeled as demand responsive signals; as the traffic varies on the routes approaching the signal, the traffic signal changes to service the approaching traffic. This mimics fully actuated signal control and also reflects the technique that would be used by a traffic guide when directing traffic – the majority of the green time is allotted to the approach with the highest demand.

Theoretically, the worst case scenario, in the event the traffic signals fail to operate properly or none of the TCP are manned, the signals will present even amounts of green time to the competing traffic streams, a 50-50 signal cycle split. Sensitivity studies were performed to compare the ETE for a 50-50 signal cycle split and for a 75-25 signal cycle split (with the major evacuation route receiving 75% of the green time), with the ETE computed on the basis of traffic responsive signal settings. Table I-4 indicates that the worst case scenario (50-50 cycle split) adds 20 minutes to the ETE for an evacuation of the full EPZ for a summer, midweek, midday scenario, while the 75-25 split adds only 10 minutes to the ETE. The majority of the traffic congestion is in Gaffney which is beyond the 5 mile boundary which explains why the 2-mile and 5-mile regions are not impacted by the signal cycle split, but the Entire EPZ is.

These results indicate that if the signals fail to operate properly, the manning of all traffic control points outlined in Appendix G will at best reduce the ETE by 20 minutes. Regardless of signal operations, traffic control guides should man key intersections throughout the EPZ to serve as fixed point surveillance for accidents or other problems that may arise during the evacuation which could reduce capacity and extend the ETE. Traffic control guides also provide needed route guidance to those evacuees who may not be familiar with the area and the roadway system (i.e., transients), and to those residents who are uncertain of the proper direction of travel.

<b>Table I-4. Evacuation Time Estimates for Signal Splits Sensitivity Study</b>			
<b>Signal Cycle Split (major route – minor route)</b>	<b>Evacuation Region</b>		
	<b>2-Mile Region (R01)</b>	<b>5-Mile Region (R02)</b>	<b>Entire EPZ (R03)</b>
50 – 50	4:00	4:05	4:40
75 – 25	4:00	4:05	4:30
Traffic Responsive (Base)	4:00	4:05	4:20

Two additional sensitivity studies were performed to measure the effect on ETE for Special Events that cause an increase in the total vehicle demand within the EPZ – The Revolutionary War Reenactment at Kings Mountain National Military Park and a Gaffney High School football game.

The Revolutionary War Reenactment at Kings Mountain National Military Park takes place each year in October. Actors dressed in Revolutionary War uniforms recreate battle scenes on the site of the actual Kings Mountain battle. York County Office of Emergency Management (OEM) estimates that 1,000 transients attend the reenactment each year. We assume 2 people per vehicle resulting in an additional 500 vehicles in the evacuation traffic stream. Although the reenactment takes place in October after the summer has ended, we use a summer, weekend scenario as the basis for this study. This scenario was chosen because Kings Mountain State Park has its peak transient attendance on weekends during the summer. Vehicles evacuating from the national portion of the park may be delayed by those evacuating the state portion of the park. Table I-5 indicates that the ETE is not affected by the additional transients present for the reenactment.

The Gaffney High School football team plays its games at William K. Brumbach Stadium (“The Reservation”), which is actually located at the Gaffney Middle School. Games are typically on Friday evenings. Based on information provided by Cherokee County OEM, attendance at the games is typically 5,000 or more people, with as many as 13,000 people attending the more popular games. We assume 13,000 fans, 50% of which are EPZ residents. We further assume that there are 2 fans per vehicle. Thus, there are 6,500 non-EPZ residents attending the game, evacuating in 2,167 vehicles. Fans park in the parking lot at the middle school, along Chandler Drive south of the school and on the other roads within the area; the vehicles for the football game were loaded on to the analysis network accordingly. A winter (school in session) weekend/evening scenario with good weather (Scenario 11) was used for this study. The resident with commuters trip generation (Table 5-8) was used for permanent residents in ERPA H-2 in this study to account for the additional mobilization time needed for those attending the game to travel from the school back home and then prepare for the evacuation trip. Table I-5 indicates that the ETE increases by 50 minutes for the entire EPZ, while the 2 mile and 5 mile regions are not affected.

Table I-5. Evacuation Time Estimates for Special Events Sensitivity Study				
Event	Total Vehicles Evacuated	Evacuation Region		
		2-Mile Region (R01)	5-Mile Region (R02)	Entire EPZ (R03)
Summer, Weekend, Good Weather (Scenario 3)				
Revolutionary War Reenactment	39,870	3:00	3:20	4:20
Base	39,370	3:00	3:20	4:20
Winter, Weekend/Evening, Good Weather (Scenario 11)				
Gaffney High School Football Game	34,141	3:00	3:30	5:00
Base	31,961	3:00	3:30	4:10