



Tennessee Valley Authority, 1101 Market Street, LP 5A, Chattanooga, Tennessee 37402-2801

January 12, 2009

10 CFR 52.79

U.S. Nuclear Regulatory Commission  
ATTN: Document Control Desk  
Washington, D.C. 20555

In the Matter of )  
Tennessee Valley Authority )

Docket No. 52-014 and 52-015

BELLEFONTE COMBINED LICENSE APPLICATION – RESPONSE TO REQUEST FOR  
ADDITIONAL INFORMATION – EVACUATION TIME ESTIMATE

- References:
- 1) Letter from Brian C. Anderson (NRC) to Andrea L. Sterdis (TVA), Request for Additional Information Letter No. 069 Related to SRP Section 13.03 for the Bellefonte Units 3 and 4 Combined License Application, dated July 11, 2008.
  - 2) Letter from Andrea L. Sterdis (TVA) to Document Control Desk (NRC), Response to Request for Additional Information Letter No. 069, Evacuation Time Estimate for the Bellefonte Units 3 and 4 Combined License Application, dated August 8, 2008.
  - 3) Letter from Jack A. Bailey (TVA) to Document Control Desk (NRC), Response to Request for Additional Information Letter No. 069, Evacuation Time Estimate for the Bellefonte Units 3 and 4 Combined License Application, dated September 17, 2008.

This letter provides the Tennessee Valley Authority's (TVA) supplemental response to the Nuclear Regulatory Commission's (NRC) request for additional information (RAI) items included in Reference 1.

A supplemental response to the NRC request in Reference 1 is addressed in the enclosure which also identifies any associated changes to be made in a future revision of the BLN application.

If you should have any questions, please contact Thomas Spink at 1101 Market Street, LP5A, Chattanooga, Tennessee 37402-2801, by telephone at (423) 751-7062, or via email at [tespink@tva.gov](mailto:tespink@tva.gov).

D085  
NRC

Document Control Desk

Page 2

January 12, 2009

I declare under penalty of perjury that the foregoing is true and correct.

Executed on this 12<sup>th</sup> day of Jan, 2009.

A handwritten signature in black ink, appearing to read "Andrea Sterdis". The signature is fluid and cursive, with the first name "Andrea" and last name "Sterdis" clearly distinguishable.

Andrea L. Sterdis

Manager, New Nuclear Licensing and Industry Affairs  
Nuclear Generation Development & Construction

Enclosure

cc: See Page 3

Document Control Desk

Page 3

January 12, 2009

cc: (w/Enclosure)

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Enclosure  
TVA letter dated January 12, 2009  
RAI Responses

Responses to NRC Request for Additional Information letter No. 069 dated July 11, 2008  
(18 pages, including this list)

Subject: SRP Section 13.03 for the Bellefonte Units 3 and 4 Combined License Application

<u>RAI Number</u>	<u>Date of TVA Response</u>
13.03-01	August 8, 2008, Reference 2
13.03-02	August 8, 2008, Reference 2
13.03-03	August 8, 2008, Reference 2
13.03-04	August 8, 2008, Reference 2
13.03-05	August 8, 2008, Reference 2
13.03-06	August 8, 2008, Reference 2, Supplemented September 17, 2008,
Reference 3	
13.03-07	August 8, 2008, Reference 2
13.03-08	August 8, 2008, Reference 2, Supplemented with this letter – see
following pages	
13.03-09	August 8, 2008, Reference 2
13.03-10	August 8, 2008, Reference 2, Supplemented with this letter – see
following pages	
13.03-11	August 8, 2008, Reference 2; Supplemented with this letter – see
following pages	
13.03-12	August 8, 2008, Reference 2, Supplemented with this letter – see
following pages	
13.03-13	August 8, 2008, Reference 2, Supplemented with this letter – see
following pages	
13.03-14	August 8, 2008, Reference 2
13.03-15	August 8, 2008, Reference 2
13.03-16	August 8, 2008, Reference 2, Supplemented with this letter – see
following pages	

<u>Associated Additional Attachments / Enclosures</u>	<u>Pages Included</u>
Attachment 13.03-01A, revised	33
Attachment 13.03-12A	13

**NRC Letter Dated: July 11, 2008**

**NRC Review of Final Safety Analysis Report**

**NRC RAI NUMBER: 13.03-08**

ETE-9: Emergency planning zone

SRP Acceptance Criterion 17

Regulatory Basis: 10 CFR Part 50, Appendix E.IV., introductory paragraph; Appendix 4 to NUREG-0654

(a) Provide the basis for the population used to calculate the shadow evacuation vehicles identified in Table 6-4, "Vehicle Estimates by Scenario." Explain how the shadow population percentages included in Table 6-4 were developed.

(b) Provide map(s) that show the locations of all the special facilities identified in Appendix E, "Special Facility Data," with respect to ERPA boundaries. Also, discuss the inclusion of Bridgeport, AL, as an assumed reception center in Figure 10-1, "Assumed General Population Reception Centers," compared to the assumed reception centers in Table 8-3, "Assumed School Reception Centers." Discuss the impact on the BLN ETE of the reception centers being other than the assumed ones. Are these the same facilities as referred to as relocation centers in section J.8., "Evacuation Time Estimates," in the BLN Emergency Plan?

**BLN RAI ID: 2649**

**BLN RESPONSE:**

(a) Response was previously provided (Reference 2).

(b) The Tables in Appendix E indicate the ERPA, the radial distance from the plant, and the direction from the plant of each special facility within the EPZ. Supplement 1 to the Bellefonte ETE Report provides GIS maps as Figures E-1 through E-4 indicating the geographical location of the special facilities. There were no specific locations designated as reception/relocation centers at the time the ETE were computed, and the results are not sensitive to this assumption. Therefore, it was assumed that reception centers would be located in nearby cities outside of the EPZ, as they would have the resources necessary to service evacuees. The location of the reception centers has an impact on the travel time from the EPZ boundary to the reception center provided in Table 8-5. This travel time is included in the estimation of "second-wave" ETE; therefore, second-wave ETE are impacted by the reception center location. This travel time was estimated by measuring the distance from the school to the center of the assumed reception center city, along the most likely route of travel.

The general population in the northern portion of the EPZ (ERPAs 2, 3, 6, 7, 8, and 12) will evacuate to Bridgeport, Alabama as shown in Figure 10-1. There are no schools in these ERPAs, as indicated in Table 8-2; therefore, Bridgeport is not used as a reception center for school evacuees.

As indicated above, the locations of reception/relocation centers are not designated. Specific facilities are subject to further detailed planning by the State and Counties, which will be completed prior to fuel load. Accordingly, the ETE discusses default locations for reception centers identified in Section 8.2: Bridgeport, Huntsville, and Ft. Payne. Section 8.4 indicates the assumed location for reception centers as the center of each of these three cities.

The time to evacuate the schools in the EPZ reported in Section 8 of the ETE is the time to clear the EPZ boundary. Therefore, location of reception centers for this purpose is irrelevant.

However, the ETE considers the use of school buses for evacuation of transit-dependent people. This requires the buses to return to the EPZ after evacuating the school children. The return trip time estimate is based on the assumed location of the reception center where the evacuated schoolchildren are taken. The choice of the city center as a surrogate for an actual reception center was agreed upon with State and County emergency management agencies, as documented by the State and County executing certification letters provided in Appendix 7 of the COL Emergency Plan. This approach satisfies their need to understand an estimate of the time for buses to become available for a second-wave or transit-dependent evacuation. The following was considered in initially recommending the use of the city-center in the absence of specific reception center locations:

- Huntsville is the nearest large city to Jackson County. Reception centers are typically chosen in public schools or other large municipal buildings. TVA expects that locations on the eastern side of the city would be considered in preference to routing evacuees across the city or even to the center of the city. Therefore, the use of city center for the Huntsville surrogate reception center location provides a conservative approach to calculating the ETE.
- Bridgeport is conservatively chosen to host a reception center to the north of the EPZ. Bridgeport is a small town with a population of less than 3,000 and land area of a little over 3 square miles. Extending the distance from the center of town to an extreme border would have minimal impact on return time for school buses.
- Additionally, relocation of school children is most likely to be to the North Jackson High School located in Stevenson, which is approximately 10 miles closer to the center of the EPZ than Bridgeport. Identification of a specific reception center will not be decided until Jackson County devotes resources to further development of the emergency plans prior to fuel load.
- Ft. Payne is located to the east of the EPZ. The selection of the city center for the surrogate location of a reception center for school evacuees recognizes that it is unlikely that a reception center requiring evacuees to traverse the entire city would be selected. Alternative locations, closer to Henagar, are more likely to be identified and chosen. One example is the Northeast Alabama Community College campus near Rainsville, which is significantly closer to Henagar than is Ft. Payne. The choice of the center of Ft. Payne provides DeKalb County with useful information for future planning associated with school and transit-dependent evacuation from Henagar.

This response is PLANT-SPECIFIC.

#### **ASSOCIATED BLN COL APPLICATION REVISIONS:**

COLA Part 5, EP, ETE will be updated to provide GIS maps as Figures E-1 through E-4. The change was previously provided (Reference 2) and is also provided in the enclosed Supplement 1, Revision 1 to the Bellefonte ETE Report which is included as Attachment 13.03-01A, revised.

#### **ASSOCIATED ATTACHMENTS/ENCLOSURES:**

Enclosure  
TVA letter dated January 12, 2009  
RAI Responses

Attachment 13.03-01A, revised (see response to RAI 13.03-01).

**NRC Letter Dated: July 11, 2008**

**NRC Review of Final Safety Analysis Report**

**NRC RAI NUMBER: 13.03-10**

ETE-11: Evacuation roadway network

SRP Chapter 13.3 Acceptance Criterion 17

Regulatory Basis: 10 CFR Part 50, Appendix E.IV., introductory paragraph; Appendix 4 to NUREG-0654

(a) Provide a map or maps that include the nodes and numbering identified in Appendix K, "Evacuation Roadway Network Characteristics." The ERPA boundaries should also be indicated on the map(s). The existing node network on Figure 1.2, "Bellefonte Link-node Analysis Network," appears to have considerably fewer segments and nodes in the north and northwest region as compared to the rest of the EPZ. The populations in this area are comparable to those in the south and southeast regions. Discuss how the number of nodes in the north and northwest region adequately represent the roadway network.

What width was used for a "Full Lane" in Appendix K? Discuss whether lane widths were measured during the field survey, and if they were one consistent width.

**BLN RAI ID: 2650**

**BLN RESPONSE:**

(a) Given the number of nodes, a 48 inch by 36 inch PDF file of Figure 1-2, exported at a resolution of 400 dpi from the original GIS file, has been provided with Supplement 1, to the Bellefonte ETE Report. The node numbers (from Appendix K) are labeled in the map. The link-node analysis network is developed by modeling all major evacuation routes within the EPZ and Shadow Region. Figure 3-1 shows that there are several major evacuation routes in the south and southeast sectors – State Highway 35, State Highway 71 and State Highway 40. There is, however, only one major evacuation route servicing the north and northwest sectors – US Highway 72. Also, Figure 3-6 indicates that the population in the south and southeast regions is more than 3 times that of the population in the north and northwest sectors.

The NW, NNW and N sectors of the network are home to about 1,830 persons (1,090 vehicles), as shown in Figures 3-2 and 3-3. This area is about 19% of the EPZ, but is less than 6% of the population within the EPZ. This area vehicle population can be serviced in about 40 minutes on a single rural road. The analysis network provided in this area is robust, given the 3+ hours of mobilization time. As is evident from Figures 7-3 through 7-6, there is not a hint of congestion in this area. Consequently, it is believed that the link-node representation is certainly adequate to document the flow of vehicles leaving this area of the EPZ.

In Appendix K, the term "full lanes" is used to identify the number of lanes that extends over the entire length of the roadway segment or link; it does not pertain to lane width. Many network links are widened with additional lanes near the downstream intersection (e.g., left-turn bays, right-turn bays, additional through lanes). These additional lanes are all properly represented by the input stream for the I-DYNEV system, but they are not full lanes.

Lane widths certainly do vary from one link to the next and even within one link, as do other features such as shoulder width, grade, and horizontal curvature. Consistent with NUREG-

Enclosure  
TVA letter dated January 12, 2009  
RAI Responses

0654/FEMA-REP-1, Appendix 4, Section III B, the estimation of capacity (expressed as saturation flow rate in the fifth column of the table in Appendix K) is based on the narrowest section of the roadway segment. The free-flow speed shown in Appendix K is based upon observation of traffic movements during the field survey; these estimates do not necessarily comport with the speed advisory signing. Lane widths were observed but not measured during the field survey.

As indicated in response 13.03-11(c), roadway characteristics were evaluated qualitatively, not quantitatively. Response 13.03-11(c) has been revised to eliminate any inconsistency with this response.

This response is PLANT-SPECIFIC.

**ASSOCIATED BLN COL APPLICATION REVISIONS:**

COLA Part 5, EP, ETE will be updated to reflect a change to Figure 1-2. The change was previously provided (Reference 2) and is also provided in the enclosed Supplement 1, Revision 1 to the Bellefonte ETE Report which is included as Attachment 13.03-01A, revised.

**ASSOCIATED ATTACHMENTS/ENCLOSURES:**

Attachment 13.03-01A, revised (see response to RAI 13.03-01).

**NRC Letter Dated: July 11, 2008**

**NRC Review of Final Safety Analysis Report**

**NRC RAI NUMBER: 13.03-11**

ETE-12: Roadway segment characteristics

SRP Chapter 13.3 Acceptance Criterion 17

Regulatory Basis: 10 CFR Part 50, Appendix E.IV., introductory paragraph; Appendix 4 to NUREG-0654

(a) Subsection "Field Surveys of the Highway Network," of Section 1.3, "Preliminary Activities," states that unusual roadway characteristics were identified in the field survey including: narrow bridges, sharp curves, poor pavement, flood warning signs, inadequate delineations, etc. Identify where these locations occur. Explain how this information was used in the ETE calculations.

(b) Section 4, "Estimation of Highway Capacity," states that the two lane roadway capacity is 1700 passenger cars per hour (pc/hr) as identified in Chapter 20 of the HCM. Chapter 20 of the HCM does identify 1700 pc/hr as the capacity of a two lane roadway, but only if the roadway meets the base conditions of Chapter 12. Clarify whether the field survey confirmed that lane widths are greater than or equal to 12 feet, shoulder widths are wider than or equal to 6 feet, and there are no other impediments to through traffic as described in Chapter 12 of the HCM.

(c) Clarify what value was used for lane width in Appendix K. Identify where the narrowest roadway sections exist within the roadway network and explain how this was factored into the ETE calculation.

**BLN RAI ID: 2651**

**BLN RESPONSE:**

(a) Response was previously provided (Reference 2).

(b) Response was previously provided (Reference 2).

(c) Roadway characteristics were evaluated qualitatively, not quantitatively. Physical measurements of roadway widths were not taken. The number of "full lanes" on each roadway was observed during the road survey, along with a qualitative description of the lane width – narrow lanes or wide lanes. Downward adjustments to the capacity estimate (as described in the response to NRC RAI No. 13.03-11(b)) were made to those roadways with narrow lanes. The number of "full lanes" input for each link is summarized in Appendix K of the ETE report. The responses to NRC RAI No. 13.03-11(a) and (b) describe the use of the roadway characteristics observed during the road survey in preparing the input streams to the I-DYNEV system used to compute ETE.

This response is PLANT-SPECIFIC.

**ASSOCIATED BLN COL APPLICATION REVISIONS:**

No COLA revisions have been identified associated with this response.

Enclosure  
TVA letter dated January 12, 2009  
RAI Responses

**ASSOCIATED ATTACHMENTS/ENCLOSURES:**

None

**NRC Letter Dated: July 11, 2008**

**NRC Review of Final Safety Analysis Report**

**NRC RAI NUMBER: 13.03-12**

ETE-13: Reporting format

SRP Chapter 13.3 Acceptance Criterion 17

Regulatory Basis: 10 CFR Part 50, Appendix E.IV., introductory paragraph; Appendix 4 to NUREG-0654

(a) Discuss why there is only a 15% reduction in highway capacity and free flow speed during ice conditions.

(b) Explain why there is no increase in ETE time in Table 7-1D, "Time to Clear the Indicated Area of 100 Percent of the Affected Population," due to adverse weather for Evacuation Region 03 Summer Weekend, when there is an increase in time for the same Evacuation Region 03 in Table 7-1C "Time to Clear the Indicated Area of 95 Percent of the Affected Population."

(c) Section 7.3, "Evacuation Rates," states that the ETE should not be distorted to account for "laggards". Clarify whether the ETE results presented in Table 7-1D actually includes 100% of the population or whether the evacuation tail was truncated and "laggards" were not included. Also, in Appendix F, "Telephone Survey," Figure F-11, "Time to Prepare Home for Evacuation," indicates that 6 hours are required as the maximum time needed for the last individuals to prepare to evacuate. They must then travel out of the EPZ. Table 7-1D indicates the longest evacuation time is 4.5 hours. Explain how the data in Figure F-11 were used in the development of the ETE, that is, how it can take up to 6 hours to prepare for evacuation but that all evacuations are complete after 4.5 hours.

(d) Regarding Table 6-3, "Percent of Population Groups for Various Scenarios," explain the need for school buses in scenarios 3, 4, 9 and 10, which are weekend scenarios.

**BLN RAI ID: 2652**

**BLN RESPONSE:**

(a) Footnote 4 to the table on ETE Page 2-7 cites a study, conducted by M. Agarwal, et. al, which was performed to assess the impact of adverse weather conditions on freeway speeds and capacities. This report can be found on the web at [http://www.ctre.iastate.edu/reports/weather\\_impacts.pdf](http://www.ctre.iastate.edu/reports/weather_impacts.pdf) (accessed 12/12/2008). Although the footnote appears only in the "Rain" row of the table, the study assessed the impact of both rain and snow of varying intensities. The study indicated that light rain resulted in highway capacity reductions of 5-17%. Speed reductions ranged from 2% to 7%, depending on the intensity of the rain. With regard to snow, the study indicated that snow resulted in highway capacity reductions of 6% to 27%, depending on the intensity of the snow. Speed reductions associated with snowfall ranged from 7% to 15%, depending on the intensity of the snowfall. Note that heavy snowfall would be a very rare event at the proposed site location.

Also, a typographical error was identified in footnote 4 in the ETE report; the title of the reference should be, "Impact of Weather on Urban Freeway Traffic Flow Characteristics and Facility Capacity." This error has been corrected in Supplement 1, Revision 1 to the Bellefonte ETE Report, which is included as Attachment 13.03-01A.

Enclosure  
TVA letter dated January 12, 2009  
RAI Responses

Obviously, it is possible to conceive of weather conditions that would reduce highway capacity and speed to very low levels. However, the ETE is used primarily as a planning tool for state and local emergency planning and response personnel. If state and local emergency response personnel determined that highway conditions rendered evacuation inadvisable, then one would expect decision-makers to recommend alternative protective actions, such as shelter-in-place.

(b) Response was previously provided (Reference 2).

(c) Response was previously provided (Reference 2). The supplemental material provided in the following paragraph supports the previous response.

A statistical analysis on the mobilization distributions was performed to quantify a "confidence band" about the distribution. This band serves as the basis for establishing the point in time where the long tail should be truncated. In this instance, the mobilization time is estimated to extend over a period of 4 hours, as shown in Table 5-8. Although a small percentage of the population indicated, via the telephone survey, that their mobilization time may extend out as long as six hours, the vehicles for this population were loaded into the evacuation network at four hours to provide a conservative estimate of the vehicle flow within the roadway network. A procedure has been developed to identify truncation points for the mobilization time distributions. Vehicles beyond these points have their trip generation times advanced to the intervals preceding the truncation points such that all vehicles are included in the ETE. The technical development of this procedure is provided as Attachment 13.03-12A to this response.

(d) Response was previously provided (Reference 2).

This response is PLANT-SPECIFIC.

**ASSOCIATED BLN COL APPLICATION REVISIONS:**

COLA Part 5, EP, ETE will be updated to reflect a change to Footnote 4 to the table on ETE Page 2-7. The change is provided in the enclosed Supplement 1, Revision 1 to the Bellefonte ETE Report, Revision 1, which is included as Attachment 13.03-01A.

**ASSOCIATED ATTACHMENTS/ENCLOSURES:**

Attachment 13.03-01A, revised (see response to RAI 13.03-01).

Attachment 13.03-12A

**NRC Letter Dated: July 11, 2008**

**NRC Review of Final Safety Analysis Report**

**NRC RAI NUMBER: 13.03-013**

ETE-14: Methodology

SRP Chapter 13.3 Acceptance Criterion 17

Regulatory Basis: 10 CFR Part 50, Appendix E.IV., introductory paragraph; Appendix 4 to NUREG-0654

(a) The unnumbered table with column headings "Event Number" and "Event Description" on page 5-4 of the BLN ETE differs from the legend in Figure 5-1, "Events and Activities Preceding the Evacuation Trip." The legend in Figure 5-1 appears to agree with the text that follows. Event numbers (page 5-4) evidently lead to Event Sequences in Table 5-1, "Event Sequence for Evacuation Activities," associated with Activities, each of which is associated with a numbered time distribution. The numbers 1-5 in the legend of Figure 5-1 do not correspond to the numbers 1-5 in the unnumbered table on page 5-4, but rather to the activities in Table 5-1, even though there are only 4 activities in that table and there are 5 numbers in Figure 5-1. In the four headings beginning "Time Distribution...", Activities seem to be associated with a numerical sequence such as 1 & 2, whereas in Table 5-1 activities are associated with distribution numbers and event sequences, neither of which match the numerical sequences in the "Time Distribution..." headers. Some items associated with numbers are events, others are either mislabeled or are intervals between events (sometimes called "evacuation activities" or "activities" in the BLN ETE). The word "activity" has a different meaning in the legend of Figure 5-1 than it has in the caption of Figure 5-1. Explain why the methodology as presented leads to valid evacuation time estimates, or clarify and eliminate ambiguities in the text, tables, and figures of Section 5, "Estimation of Trip Generation Time."

(b) The example in Section 7, "General Population Evacuation Time estimates (ETE)," states that the distance to be evacuated is judged to be 10 miles. Step number 2 of the example then states to enter Table 7-2 and locate the group entitled "evacuate 5-mile ring and downwind to EPZ boundary." There is no Table 7-2. Clarify whether Table 7-1 on page 7-13 should read Table "7-2."

(c) Discuss the assumptions used in developing the ETes for the non car-owning public with respect to any special services that may be needed to serve the non-ambulatory population subgroup.

(d) Section 8.4, "Evacuation Time Estimates for Transport-dependent People," states that buses should be dispatched for transit-dependent people after those people have mobilized and are in a position to board the buses. Explain how the time estimate for mobilizing these buses was derived. Explain how the time needed for local authorities to inform the transit dependent public of the time at which buses should be expected to arrive was incorporated into the ETE analysis.

(e) Identify the time required to notify and mobilize drivers. Identify the time required to evacuate these special needs individuals, including travel times, loading/unloading, and return trips if needed.

(f) Explain how the inbound travel speed and time is calculated considering that buses must traverse traffic control points.

(g) Provide a basis for the assumption that the speed for buses is 30 mph as indicated in Section 8.4. According to the HCM 2000, when stopping and loading twice per mile are included, speeds

of 15 mph would be more realistic. Clarify how these speeds can be achieved when buses are mixed with evacuating traffic and traveling through multiple traffic control points. Clarify how many stops the buses are expected to make along each route identified in Figure 8-2, "Proposed Transit-dependent Bus Routes." Clarify how long a bus is expected to wait for individuals at the bus stops.

(h) Provide the basis for unloading a bus in 5 minutes as shown in Table 8.7A, "Transit-dependent Evacuation Time Estimates - Good Weather."

(i) Explain why it takes 172 minutes for the bus to arrive at the reception center in Table 8.7A but it only takes 36 minutes to return to the EPZ to start the new route. Explain why an aggregate total ETE value is not provided for the two waves. Also, clarify these same issues for Table 8.7B.

(j) Tables 8-5A, "School Evacuation Time Estimates - Good Weather," and 8-5B, "School Evacuation Time Estimates - Rain," indicate school bus speeds of 40 to 45 miles per hour. Inbound buses would have to slow down to traverse the traffic control at intersections. Explain how speeds were established for buses going against traffic until they reach their destination. Discuss how this range of speeds takes into account interactions with evacuation traffic and travel through multiple traffic control points.

(k) Discuss the numbers of individuals and time needed to shut down industrial equipment for major employers such as those listed in table titled, "Bellefonte EPZ: Major Employers (As of April, 2007)," on page E-6. Explain how these individuals and the time needed to shut down equipment are considered in the BLN ETE analysis.

(l) Table 8-8A, "Evacuation Time Estimates for Ambulatory Evacuees from Special Facilities - Good Weather," and Table 8-8B, "Evacuation Time Estimates for Ambulatory Evacuees from Special Facilities - Rain," provides time estimates for ambulatory evacuees. However, there is no discussion or quantification of the number of non-ambulatory evacuees. Non-ambulatory evacuees would include individuals that must be transported by ambulance with medical assistance. Discuss whether there are any non-ambulatory individuals at the special facilities identified in the above tables, and if there are, explain how their transport is considered in the ETE analysis.

(m) The table of day care centers in Appendix E, "Special Facility Data," of the BLN ETE analysis lists five day care centers. A brief review of the local telephone book identified at least six other day care centers within the plume exposure pathway EPZ. Discuss how the day care centers were identified and whether the number of day care centers identified in the BLN ETE analysis should be revised and the analysis revised accordingly.

(n) Table 8-2, "School Population Demand Estimates," appears to be missing some local schools such as the Skyline High School, Cumberland Presbyterian preschool, Macedonia school and possibly others. Explain the method used to identify all of the schools within the plume exposure pathway EPZ. Clarify whether additional schools need to be considered in the BLN ETE analysis. Also, in Table 8-2, there is an estimate of two buses needed for the Epruett Center of Technology and Jackson County Alternative School. However, there is no estimate of enrollment for these schools. Explain why two buses are adequate when most of the schools in the list require four or more buses.

(o) Section 8, "Transit-dependent and Special Facility Evacuation Time Estimates," indicates bus speeds of 30 miles per hour (mph) for buses. Explain how these buses can travel 30 mph when Figure 7-5, "Congestion Patterns at 2 Hours After the Advisory to Evacuate," shows congestion on these roadways during this timeframe. Clarify how the congestion indicated on Figures 7-4 thru 7-6 affects the speed of the buses.

Enclosure  
TVA letter dated January 12, 2009  
RAI Responses

(p) Table 8-7A, "Transit-dependent Evacuation Time Estimates - Good Weather," indicates a pick up time of 15 minutes for transit-dependent bus runs. Section 8.4, "Evacuation Time Estimates for transit dependent People," states that 15 minutes are needed when multiple stops are made. Clarify whether 15 minutes should be used as an average for each stop or whether 15 minutes is the total amount of time that the buses are stopped. Considering that Routes 1 and 4 are both longer than 24 miles, identify the estimated number of stops on each route.

**BLN RAI ID: 2653**

**BLN RESPONSE:**

- (a) Response was previously provided (Reference 2).
- (b) Response was previously provided (Reference 2).
- (c) Response was previously provided (Reference 2).
- (d) Response was previously provided (Reference 2).
- (e) Response was previously provided (Reference 2).
- (f) As indicated in ETE Section 8.4, ETE were calculated for both one-wave and two-wave bus evacuations. Following the mobilization time, bus transit times of 30 minutes, for good weather, and 35 minutes, for adverse weather, were assumed. It is expected that traffic control points, if established, would be established in a manner that does not interfere with the movement of inbound buses.

State and County emergency management agencies have not yet developed detailed procedures for implementing traffic control recommendations associated with a Bellefonte emergency response. These procedures would be expected to include specific methods to allow returning school buses access through traffic control points and how this information is communicated to the traffic guides assigned to affected traffic control points.

Recommendations in the ETE recognize the need for facilitating emergency vehicles re-entering the EPZ following an evacuation order. Section 9 of the ETE provides three examples of some of the legitimate reasons for a driver to prefer a direction other than that indicated. The example applicable to school buses returning for a second trip is included: "The driver may be an emergency worker en route to perform an important activity." The ETE goes on to say, "The implementation of a [traffic management] plan must also be flexible enough for the application of sound judgment by the traffic guide." This section of the ETE reflects that the traffic management strategy was developed in consultation with emergency management and law enforcement personnel. Specifically, "Trained personnel who are experienced in controlling traffic and who are familiar with the likely traffic patterns have reviewed these control tactics."

The key for the TCP intersection schematics presented in Appendix G of the ETE report indicates that cones are spaced to "discourage traffic but allow passage." The barricades used in TCPs 5-1, 5-2 and 11-13 to prevent the flow of traffic northbound on US Highway 72 have been changed to cones so as to allow the flow of buses evacuating school children and the transit-dependent population. The manpower/equipment needs for each intersection schematic are updated accordingly. Table G-1, which summarizes the manpower/equipment needs, is also updated. The revised schematics and Table G-1 are included in Supplement 1, Revision 1 to the Bellefonte ETE Report, which is included as Attachment 13.03-01A.

- (g) Based on observations of traffic movement during the road survey and the fact that the buses will be traveling counter to the evacuating flow with no stops for passengers, an average speed of 30 mph was estimated. The TCPs, as discussed elsewhere, are created to facilitate and guide evacuating traffic – not to impede their progress. It is reasonable to expect that incoming buses will have their travel expedited by the personnel at the TCP, rather than hindered. Local officials in Jackson and DeKalb Counties agreed with this estimate as reflected by their acceptance of the ETE documented by the Certification Letters provided in Appendix 7 of the Bellefonte COL Emergency Plan.

As documented in Tables 8-7, a pickup time of 15 minutes is allocated for each route run. This estimate for pickup time is based on the reasonable assumption that each bus will, on average, contain 30 passengers. It is further assumed that passengers will form groups with an average of 2 persons per group which translates into 15 bus stops per run. The delay associated with each stop, which includes slowing, stopping, boarding, seating and then accelerating, is calculated at less than 1 minute. Thus, a total of 15 stops at 1 minute each yields a total pickup time of 15 minutes.

The RAI comment to the effect that the effective average speed of the bus is impacted by these pickups is, of course, correct. For example, the longest route, Route 1, which is 24.9 miles long, is estimated to have a total route travel time of  $50 + 15 = 65$  minutes. Therefore, the average bus speed along this route is 23 mph. For a shorter route, such as Route 3, which is 17.3 miles long, the total travel time is 50 minutes which translates into an average speed of 20.8 mph. Thus, the shorter the route, the more frequent the bus stops and the lower the effective average speed.

The number and locations of bus stops along the routes is not a requirement for the ETE. These implementation specifics, if any stops are designated, are the responsibility of the county emergency management plan. Appendix 7 of the Bellefonte COL Emergency Plan includes formally executed letters certifying State and local officials' commitment to support of future emergency planning efforts.

The effect of traffic control points on the speed of busses returning to the EPZ is discussed in the response to RAI 13.03-13(f), above.

(h) Response was previously provided (Reference 2).

(i) Response was previously provided (Reference 2).

(j) As stated on the top of page 8-9, the assumed speeds are 30 mph on local roads and 50 mph on major routes such as US Route 72. This inbound travel runs counter to the evacuation flow and the distance from the reception center to the EPZ boundary is, by definition, outside the EPZ; consequently, they would encounter few, if any TCPs along this inbound road. As discussed the response to (g), above, TCP activities are specifically designed to expedite travel rather than hinder it.

The effect of traffic control points on the speed of busses returning to the EPZ is discussed in the response to RAI 13.03-13(f), above.

(k) Response was previously provided (Reference 2).

(l) Response was previously provided (Reference 2).

(m) Response was previously provided (Reference 2).

(n) Response was previously provided (Reference 2).

(o) Response was previously provided (Reference 2).

(p) Response was previously provided (Reference 2).

This response is PLANT-SPECIFIC.

**ASSOCIATED BLN COL APPLICATION REVISIONS:**

Enclosure  
TVA letter dated January 12, 2009  
RAI Responses

COLA Part 5, EP, ETE will be updated to include:

- 1) Updated and corrected tables and figures in ETE Section 5, including explanatory text,
- 2) Corrected ETE Table 7-2,
- 3) Supplemented and corrected Section 8.3 and Table 8-4,
- 4) Supplemented and corrected Table 8-2 and table on page E-3,
- 5) Revised Table G-1, and
- 6) Revised schematics for TCPs 5-1, 5-2, and 11-13.

These changes are provided in the enclosed Supplement 1, Revision 1 to the Bellefonte ETE Report which is included as Attachment 13.03-01A.

**ASSOCIATED ATTACHMENTS/ENCLOSURES:**

Attachment 13.03-01A, revised (see response to RAI 13.03-01).

Enclosure  
TVA letter dated January 12, 2009  
RAI Responses

**NRC Letter Dated: July 11, 2008**

**NRC Review of Final Safety Analysis Report**

**NRC RAI NUMBER: 13.03-16**

ETE-17: Review of the ETE

SRP Chapter 13.3 Acceptance Criterion 17

Regulatory Basis: 10 CFR Part 50, Appendix E.IV., introductory paragraph; Appendix 4 to NUREG-0654

Provide additional information on the involvement of state and county emergency planners and local and state police. (a) Clarify whether state and local organizations involved in emergency response reviewed the entire ETE plan or just the traffic control plan. (b) Clarify whether state and local organizations provided any comments. Include any comments and resolution of such comments in the ETE document. (c) Clarify whether State and Local emergency response agencies concurred with the Traffic Control Point and Access Control Point selection and arrangements in the ETE.

**BLN RAI ID: 2654**

**BLN RESPONSE:**

At the beginning of the ETE project, State and local emergency management officials and law enforcement personnel participated in a presentation in which the ETE, including its inputs, processes, outputs, and uses, was discussed. During the course of the project, personnel developing the ETE contacted State and local officials to obtain their input on critical questions regarding State and local procedures and practices that might affect the ETE. These same personnel provided a draft ETE report to State and local officials, who were invited to attend a presentation to discuss the initial results and to obtain their comments on the entire ETE.

On May 30, 2007, TVA met with the following organizations to review a draft of the Bellefonte ETE:

- Alabama Emergency Management Agency
- Alabama Department of Health/Office of Radiation Control
- Jackson County Emergency Management Agency
- DeKalb County Emergency Management Agency
- Jackson County Sheriff's Office
- Alabama State Troopers
- Scottsboro Police Department
- Hollywood Police Department
- DeKalb County Sheriff's Office
- Scottsboro Fire Department
- DeKalb-Henagar Fire Department
- City of Henagar
- Jackson County Engineering
- DeKalb County Engineering

During the May 30, 2007 meeting, the police agencies were requested to review the traffic management plan as discussed in Section 9 and Appendix G of the ETE report and provide

Enclosure  
TVA letter dated January 12, 2009  
RAI Responses

feedback. On June 21, 2007, the Jackson County Emergency Management Agency provided comments from the Scottsboro Police Department on the Traffic Control Points and Access Control Points in their jurisdiction. Several comments on traffic control points were provided by the Scottsboro Police Department and resolved during the meeting. The agreed upon resolution to these comments was incorporated in the final version of the ETE Report submitted with Part 5 of the COLA. This report was subsequently presented to the State and County Emergency Management Agencies.

Following resolution of comments, the ETE was provided to affected state and local emergency management agencies. Appendix 7 of the Bellefonte COL Emergency Plan includes formally executed letters certifying State and local government agency review of the ETE Report (which included the Traffic Management Plan) and committing to supporting future development of emergency plans.

Comments on the draft ETE provided by state and local personnel have not been submitted with the final ETE. These comments addressed issues related to the draft ETE and have been satisfactorily addressed as indicated by the certification letters provided in Appendix 7 of the Bellefonte COL Emergency Plan. Provision of certification letters as required by 10 CFR Part 52 provides adequate documentation of State and local agency review of the COL Emergency Plan and ETE obviating the need for submittal of these comments as suggested by Appendix 4 of NUREG-0654/FEMA-REP-1.

This response is PLANT-SPECIFIC.

**ASSOCIATED BLN COL APPLICATION REVISIONS:**

No COLA revisions have been identified associated with this response.

**ASSOCIATED ATTACHMENTS/ENCLOSURES:**

None

**Attachment 13.03-01A**

**Supplement 1 to the Bellefonte ETE Report**  
(32 pages including this cover sheet)

**Revision 1**

**Attachment 13.03-012A**

**Procedure for Estimating the Mobilization Curve Based Upon Survey Data**  
(13 pages including this cover sheet)

# Supplement 1

## Bellefonte Evacuation Time Estimate

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### Page 1-9:

- The figure was requested in an electronic file for NRC review of details.

### Page 2-5

- Corrected Section 2.3, Assumption 5 as follows: "Access Control Points (ACP) will be staffed within approximately 90 minutes following the siren notifications, to divert traffic attempting to enter the EPZ. Earlier activation of ACP locations would delay returning commuters. It is assumed that no vehicles will enter the EPZ after this 90 minute time period."

### Page 2-7:

- Under Item 9, corrected the table entries for Ice from "85%" to "80%".
- Revise footnote 4 to read "Agarwal, M. et. Al. Impacts of Weather on Urban Freeway Traffic Flow Characteristics and Facility Capacity, Proceedings of the 2005 Mid-Continent Transportation Research Symposium, August, 2005."

### Page 3-4, Figure 3-1:

- Updated figure by adding county boundaries to the map, labeling Jackson and DeKalb Counties, and adding county boundary to the legend. See updated figure provided in this Errata Sheet.

### Page 3-10:

- Added supplemental information to the bottom of the page after the discussion of hotels and motels. "Jackson County Fair. This fair is held annually in Scottsboro in mid-September and attracts a peak population of 9,000 persons from outside the EPZ, traveling in 3600 vehicles. Because this event extends over only 5 days, these estimates are not included in Table 3-3 or in Figures 3-4 and 3-5."

### Page 3-16, Figure 3-6:

- Corrected by moving the figure "806" for the ESE, 9-10 mile cell to the ESE, 10-EPZ boundary cell. Corrected the table summarizing employees in the lower left corner of the Figure accordingly. See corrected figure provided in this Errata Sheet.

### Page 3-17, Figure 3-7:

- Corrected by moving the figure "783" for the ESE, 9-10 mile cell to the ESE, 10-EPZ boundary cell. Corrected the table summarizing employee vehicles in the lower left corner of the Figure accordingly. See corrected figure provided in this Errata Sheet.

# Supplement 1

## Bellefonte Evacuation Time Estimate

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### Page 3-18:

- Corrected the final section "Total Demand in Addition to Permanent Population" to read: "It is assumed that this traffic will continue to enter the EPZ during the first 90 minutes following the Advisory to Evacuate. We assume 300 vehicles per lane per hour; external-external trips have been loaded northbound and southbound on U.S. Highway 72, which are two lanes in each direction. Therefore, we estimate approximately 1,800 vehicles enter the EPZ as external-external trips during the 90 minutes following the Advisory to Evacuate."

### Page 5-4:

- Corrected the Event Description for Event 3 by deleting "to return home" from the Event Description.
- Corrected the descriptions of "Events" and "Activities" as follows: Added two bullets to the bottom of the page. Bullet 1: "An Event is a 'state' that exists at a point in time (e.g., depart work, arrive home)." Bullet 2: "An Activity is a 'process' that takes place over some elapsed time (e.g., prepare to leave work, travel home)."
- Provided clarification of "Events" and "Activities" as follows: Added a paragraph after the 2 bullets, reading: "As such, an Activity changes the 'state' of an individual (e.g. the activity, 'travel home' changes the state from 'depart work' to 'arrive home'). Therefore, an Activity can be described as an 'Event Sequence'; the elapsed times to perform an event sequence varies from one person to the next and are described as statistical distributions on the following pages."

### Page 5-5:

- Corrected the 5<sup>th</sup> column of Table 5-1 as follows: Change "Prepare to leave for evacuation trip" to "Prepare to leave to evacuate."

### Page 5-7:

- Corrected Figure 5-1 to agree with the text on Page 5-5. See corrected figure provided in this Errata Sheet.

### Page 5-8:

- Corrected title of Table 5-3 to "Time Distribution for Employees to Prepare to Leave Work."

### Page 5-9:

- Corrected title of Table 5-4 to "Time Distribution for Commuters to Travel Home."

### Page 5-10:

## **Supplement 1**

### **Bellefonte Evacuation Time Estimate**

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- Corrected title of Table 5-5 to "Time Distribution for Population to Prepare to Evacuate."

**Page 5-11:**

- Corrected "Notification" to "Receive Notification" in legend for Figure 5-2.
- Corrected "Prepare Home" to "Prepare to Leave Home to Evacuate" in legend for Figure 5-2.

# **Supplement 1**

## **Bellefonte Evacuation Time Estimate**

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### Page 5-13:

- Clarified the description of Distribution B in Table 5-7 by adding "(Event 4)."
- Clarified the description of Distribution C in Table 5-7 by adding "(Event 5)."
- Clarified the description of Distribution D in Table 5-7 by adding "(Event 5)."

### Page 6-5:

- Corrected the final note under Table 6-3 to indicate that traffic entering the EPZ is stopped by the Access Control Points at 90 minutes following the Advisory to Evacuate.

### Page 7-1:

- Supplemented information provided on shadow evacuation by adding the following sentence to the last paragraph: "The permanent resident population estimates are 20,953 persons and 12,393 vehicles within this region."

### Page 7-13:

- Corrected title of table to "Table 7-2. Description of Evacuation Regions."

### Pages 8-6 and 8-7, Section 8.3:

- Supplemented and corrected information provided on special facility populations as follows: Deleted all text under Section 8.3 and added the following text:  
"Table 8-4 presents the census of special facilities in the EPZ as of October, 2007. Approximately 344 people have been identified as living in, or being treated in, these facilities. This census also indicates the number of wheelchair-bound people and the number of bed-ridden people. The transportation requirements for this group are also presented. The number of ambulance runs is determined by assuming that 2 patients can be accommodated per ambulance trip and the number of bus runs estimated assumes 30 ambulatory patients per trip. Wheelchair buses and vans are often scarce; however, regular buses can be used to transport wheelchair bound patients. Patients would occupy the front portion of the bus and their wheelchairs would be folded and stacked in the back of the bus. Staff at the medical facility would assist the patients in boarding the buses. The capacity of wheelchair buses assumes 15 patients per trip."

## **Supplement 1**

### **Bellefonte Evacuation Time Estimate**

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Page 8-12, Emergency Medical Services (EMS) Vehicles:

- Supplemented available information on evacuation of non-ambulatory persons as follows: Paragraph 1 – deleted "Data on the number of bed-ridden patients was not available, but several ambulance trips will likely be needed for an evacuation of the entire EPZ.", and added "A total of 18 ambulance runs (Table 8-4) are anticipated for an evacuation of the entire EPZ."

# **Supplement 1**

## **Bellefonte Evacuation Time Estimate**

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### Page 8-15, Table 8-2:

- 1<sup>st</sup> Row – “Epruett” corrected to “Ernest Pruett”
- N/A for Ernest Pruett enrollment corrected to 230.
- N/A for Ernest Pruett staff corrected to 26.
- Bus Runs Required for Ernest Pruett corrected from 2 to 5.
- N/A for Jackson County Alternative School enrollment corrected to 20.
- N/A for Jackson County Alternative School staff corrected to 2.
- Bus Runs Required for Jackson County Alternative School corrected from 2 to 0\*.
- The totals for Jackson County have been corrected to 4,911, 346, and 84 for enrollment, staff, and bus runs required, respectively.
- The EPZ totals have been corrected to 5,252, 370, and 91 for enrollment, staff, and bus runs required, respectively.
- Deleted “N/A – Not Available; \*Assumed number of buses needed” and added “\*Students provide their own transportation”.
- See corrected Table 8-2 provided in this Errata Sheet.

### Page 8-15, Table 8-3:

- “Epruett” corrected to “Ernest Pruett”

### Page 8-16, Table 8-4:

- Updated table by deleting “The Home Place” – phones have been disconnected, no internet record of the facility.
- Corrected table entries by grouping “Highlands Medical Center” and “Jackson County Nursing Home”. They are both included under the Jackson County Health Authority and they share an address.
- “North Jackson Nursing Home” corrected to “Cumberland Health and Rehabilitation” – name recently changed.
- Deleted “Staff” column.

### Page 8-16, Table 8-4 (cont.):

- Supplemented information by adding columns for: “Current Census”, “Ambulatory”, “Wheelchair Bound”, “Bed-ridden”, “Ambulance Runs”, “Wheelchair Bus Runs”, and “Bus Runs”.

# Supplement 1

## Bellefonte Evacuation Time Estimate

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### Page 8-16, Table 8-4 (cont):

- Data updated for the columns "Capacity", "Current Census", "Ambulatory", "Wheelchair Bound", "Bed-ridden", "Ambulance Runs", "Wheelchair Bus Runs", and "Bus Runs" for each facility as follows:
  - Cloverdale Healthcare: 141, 138, 58, 52, 28, 14, 4, 2.
  - Highlands Medical Center & Jackson County Nursing Home: 170, 70, 32\*, 31\*, 7\*, 4, 3, 2.
  - Mountain Lakes Behavioral Healthcare: All columns merged and "Outpatient Only" indicated.
  - Cumberland Health and Rehabilitation: 100, 91, 21, 70, 0, 0, 5, 1.
  - Rosewood Manor: 32, 30, 30, 0, 0, 0, 0, 1.
  - Southern Estates Assisted Living: 16, 15, 15, 0, 0, 0, 0, 1.
- Corrected entry for "EPZ Totals" and added "Jackson County and EPZ Totals:"
- Updated columns for Jackson County and EPZ Totals: 459, 344, 156, 35, 18, 12, 7.
- Updated by deleting "N/A = Not Available".
- Updated by deleting "\*\*Details about number of bed ridden, wheel-chair bound, and ambulatory residents not provided."
- Updated table by adding "\*\*Details about number of bed ridden, wheel-chair bound, and ambulatory residents were not available for this facility. The average percentage of bed ridden (10%), wheel-chair bound (45%), and ambulatory patients (45%) found using the totals for the EPZ were used to estimate the census for this facility."
- See updated Table 8-4 provided in this Errata Sheet.

### Page E-2:

- Updated date in heading from "April, 2007" to "October, 2007".
- "Epruett" corrected to "Ernest Pruett"
- N/A for Ernest Pruett enrollment corrected to 455\*.
- N/A for Ernest Pruett staff corrected to 26.
- Updated consistent with other changes by adding \*\* after "Jackson County Alternative School" under "School Name" column.
- ~~○ N/A for Jackson County Alternative School enrollment corrected to 20.~~
- ~~○ N/A for Jackson County Alternative School staff corrected to 2.~~

# Supplement 1

## Bellefonte Evacuation Time Estimate

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### Page E-2 (cont):

- N/A for Jackson County Alternative School enrollment corrected to 20.
- N/A for Jackson County Alternative School staff corrected to 2.
- Totals for enrollment and staff corrected to 5,477 and 370, respectively.
- Updated by deleting "N/A = Data Not Available" below table.
- Updating by deleting "\*\*The numbers provided were found using Internet searches, County specific data was not provided."
- Updated by adding "\*\*These students are split up amongst morning and afternoon sessions."
- Updated by adding "\*\*\*Students provide their own transportation."
- See updated table on page 10 provided in this Errata Sheet.

### Page E-3:

- Supplemented by adding Figure E-1, a GIS map of all schools within the BLN EPZ. See supplemental figure provided in this Errata Sheet.

### Page E-4:

- Corrected by moving former Page E-3 to this location.
- Updated by adding "Cumberland Presbyterian Preschool" to the list of Day Care Centers. See updated table provided in this Errata Sheet.

### Page E-5:

- Corrected by moving former Page E-4 to this location.
- Updated date in heading from "April, 2007" to "October, 2007".
- Updated by deleting "The Home Place" entry.
- Corrected by combining "Highlands Medical Center" and "Jackson County Nursing Home" entries.
- Updated by changing "North Jackson Nursing Home" to "Cumberland Health and Rehabilitation".
- Corrected phone number for Highlands Medical Center and Jackson County Nursing Home to (256) 259-4444.
- Updated capacity for Highlands Medical Center and Jackson County Nursing Home from N/A to 170.
- Corrected by merging "Capacity" and "Employees" columns for Mountain Lakes Behavioral Healthcare and indicated "Outpatient\*\*".

## **Supplement 1**

### **Bellefonte Evacuation Time Estimate**

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Page E-5 (cont):

- Updated capacity for Rosewood manor from N/A to 32.
- Updated capacity for Southern Estates Assisted Living from N/A to 16.

# Supplement 1

## Bellefonte Evacuation Time Estimate

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~~o~~ Page E-5 (cont):

- o Updated employees for the following:
  - Cloverdale Healthcare Inc. – 175
  - Highlands Medical Center & Jackson County Nursing Home – 650
  - Rosewood Manor – 25
  - Southern Estates Assisted Living – 4
- o Updated by adding “\*This facility is for outpatients only” below the table.
- o See updated table ~~on~~ provided in this Errata Sheet.

Page E-6:

- o Supplemented by adding Figure E-2, a GIS map of all day care centers and medical facilities within the BLN EPZ. See supplemental figure provided in this Errata Sheet.

Page E-7:

- o Corrected by moving former Page E-5 to this location.

Page E-8:

- o Corrected by moving former Page E-6 to this location.
- o Updated address for Witt Heat Transfer Products to “201 Thomas French Dr.”
- o Corrected the Distance and Direction for Polymer Industries as they were in the wrong columns.
- o See updated table of major employers on page 12 of this memo.

Page E-9:

- o Supplemented by adding Figure E-3, a GIS map of all major employers within the BLN EPZ. See supplemental figure provided in this Errata Sheet.

Page E-10:

- o Updated the title of the State Parks & Overnight Camps table to “Transient Attractions (As of April 2007).”
- o Corrected by adding The Unclaimed Baggage Center to the list of Transient Attractions
- ~~o Corrected by moving Pages E-7 and E-8 to this location.~~
- ~~o Updated the title of the hotels table to “Lodging Facilities (As of July 2008).”~~

# Supplement 1

## Bellefonte Evacuation Time Estimate

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### Page E-10 (cont):

- Corrected by moving Pages E-7 and E-8 to this location.
- Updated the title of the hotels table to "Lodging Facilities (As of July 2008)."
- Corrected the "Counry" to "County" in the address for Creekstone Lodge.
- Updated by adding Econo Lodge & Suites to the list of Hotels.
- Updated by adding Scottsboro Days Inn to the list of Hotels.
- See updated tables provided in this Errata Sheet.

### Page E-11:

- Supplemented by adding ~~Added~~ Figure E-4, a GIS map of all lodging facilities and transient attractions within the BLN EPZ. See supplemental figure provided in this Errata Sheet.

### Page G-4:

- Revised the number of cones and barricades needed for TCP ID 11-13 to 12 and 14, respectively.
- Revised the number of cones and barricades needed for TCP ID 5-01 to 9 and 0, respectively.
- Revised the number of cones and barricades needed for TCP ID 5-02 to 6 and 10, respectively.
- Revised the number of cones and barricades needed for Jackson County to 177 and 58, respectively.
- Revised the number of cones and barricades needed for the entire EPZ to 180 and 58, respectively.
- See updated table provided in this Errata Sheet.

### Page G-6:

- Replaced barricades on USHY 72 with cones.
- Permitted access to Scottsboro High School.
- Updated the manpower/equipment estimates accordingly.
- See updated figure provided in this Errata Sheet.

### Page G-7:

- Replaced barricades on USHY 72 with cones.

# Supplement 1

## Bellefonte Evacuation Time Estimate

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### Page G-7 (cont.):

- Updated the manpower/equipment estimates accordingly.
- See updated figure provided in this Errata Sheet.

### Page G-22:

- Replaced barricades on USHY 72 with cones.
- Updated the manpower/equipment estimates accordingly.
- See updated figure provided in this Errata Sheet.

### Page I-2:

- Supplemented by adding a sentence to the end of the first paragraph, reading: "The permanent resident population estimates are 20,953 persons and 12,393 vehicles within this region."

### Page 1-9:

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~~The figure was requested in an electronic file for NRC review of details.~~

# Supplement 1

## Bellefonte Evacuation Time Estimate

Table 8-2. School Population Demand Estimates							
ERPA	Distance (miles)	Direction	School Name	Municipality	Enrollment	Staff	Bus Runs Required
<b>Jackson County Schools</b>							
1	2.0	WNW	Ernest Pruett Center of Technology	Hollywood	230*	26	5
1	2.3	WNW	Hollywood Elementary School	Hollywood	205	17	3
1	2.7	WNW	Jackson County Alternative School	Hollywood	20	2	0**
4	4.9	ESE	Pisgah High School	Pisgah	564	35	11
5	6.1	WSW	Brownwood Elementary School	Scottsboro	391	29	6
5	5.3	WSW	Scottsboro High School	Scottsboro	719	51	14
9	9.1	E	Rosalie Elementary School	Pisgah	308	22	4
10	7.5	S	Dutton Elementary School	Dutton	270	18	4
10	9.6	SSW	Section High School	Section	558	36	11
11	7.1	WSW	Caldwell Elementary School	Scottsboro	430	30	6
11	7.7	SW	Collins Elementary School	Scottsboro	455	29	7
11	7.8	WSW	Scottsboro Junior High School	Scottsboro	467	29	9
11	9.6	SW	Thurston T Nelson Elementary School	Scottsboro	294	22	4
<i>Jackson County Totals:</i>					<b>4,911</b>	<b>346</b>	<b>84</b>
<b>DeKalb County Schools</b>							
13	10.5	ESE	Henagar Junior High School	Henagar	341	24	7
<i>DeKalb County Totals:</i>					<b>341</b>	<b>24</b>	<b>7</b>
<b>EPZ Totals:</b>					<b>5,252</b>	<b>370</b>	<b>91</b>

\*There are 455 students enrolled at this school, split amongst morning and afternoon sessions.

\*\*Students provide their own transportation

# Supplement 1

## Bellefonte Evacuation Time Estimate

**Table 8-4. Special Facility Transit Demand**

ERPA	Distance (miles)	Direction	Facility Name	Municipality	Capacity	Current Census	Ambulatory	Wheel-chair Bound	Bed-ridden	Ambulance Runs	Wheel-chair Bus Runs	Bus Runs
<b>Jackson County</b>												
11	7.8	WSW	Cloverdale Healthcare Inc.	Scottsboro	141	138	58	52	28	14	4	2
11	7.8	WSW	Highlands Medical Center & Jackson County Nursing Home	Scottsboro	170	70	32*	31*	7*	4	3	2
11	7.8	WSW	Mountain Lakes Behavioral Healthcare	Scottsboro	Outpatient Only							
11	6.2	SW	Cumberland Health and Rehabilitation	Scottsboro	100	91	21	70	0	0	5	1
11	7.6	SW	Rosewood Manor	Scottsboro	32	30	30	0	0	0	0	1
11	9.2	SW	Southern Estates Assisted Living	Scottsboro	16	15	15	0	0	0	0	1
<b>Jackson County and EPZ Totals:</b>					<b>459</b>	<b>344</b>	<b>156</b>	<b>153</b>	<b>35</b>	<b>18</b>	<b>12</b>	<b>7</b>

\*Details about number of bed ridden, wheel-chair bound, and ambulatory residents were not available for this facility. The average percentage of bed ridden (10%), wheel-chair bound (45%), and ambulatory patients (45%) found using the totals for the EPZ were used to estimate the census for this facility.

# Supplement 1

## Bellefonte Evacuation Time Estimate

Bellefonte EPZ: Schools (As of October, 2007)								
ERPA	Distance (miles)	Direction	School Name	Street Address	Municipality	Phone	Enrollment	Staff
<b>JACKSON COUNTY</b>								
1	2.0	WNW	Ernest Pruett Center of Technology	29490 US Highway 72	Hollywood	(256) 574-6079	230*	26
1	2.3	WNW	Hollywood Elementary School	6369 County Road 33	Hollywood	(256) 574-2054	205	17
1	2.7	WNW	Jackson County Alternative School**	594 County Road 42	Hollywood	(256) 574-6446	20	2
4	4.9	ESE	Pisgah High School	60 Metcalf St	Pisgah	(256) 451-3241	564	35
5	6.1	WSW	Brownwood Elementary School	305 Bingham St	Scottsboro	(256) 218-2400	391	29
5	5.3	WSW	Scottsboro High School	25053 John T Reid Pkwy	Scottsboro	(256) 218-2300	719	51
9	9.1	E	Rosalie Elementary School	162 County Road 355	Pisgah	(256) 451-3616	308	22
10	7.5	S	Dutton Elementary School	180 Main St.	Dutton	(256) 228-4265	270	18
10	9.6	SSW	Section High School	141 AL Hwy 71	Section	(256) 228-6718	558	36
11	7.1	WSW	Caldwell Elementary School	905 S Market St	Scottsboro	(256) 218-2500	430	30
11	7.7	SW	Collins Elementary School	102 Legion Dr	Scottsboro	(256) 218-2700	455	29
11	7.8	WSW	Scottsboro Junior High School	1601 Jefferson St	Scottsboro	(256) 218-2300	467	29
11	9.6	SW	Thurston T Nelson Elementary School	202 Ida Moody Rd	Scottsboro	(256) 218-2600	294	22
<b>DEKALB COUNTY</b>								
13	10.5	ESE	Henagar Junior High School	85 Woodview Rd	Henagar	(256) 657-4483	341	24
<b>Total:</b>							<b>5,252</b>	<b>370</b>

\*There are 455 students enrolled at this school, split amongst morning and afternoon sessions.

\*\*Students provide their own transportation.

# Supplement 1

## Bellefonte Evacuation Time Estimate

Bellefonte EPZ: Day Care Centers (As of April 2007)								
ERPA	Distance (miles)	Direction	Name	Street Address	Municipality	Phone	Enrollment	Employees
<b>JACKSON COUNTY</b>								
11	7.1	WSW	Tiny Tot Day Care	827 South Market St	Scottsboro	(256) 574-1483	49	8
11	6.6	WSW	Cumberland Presbyterian Preschool	315 South Kyle St	Scottsboro	(256) 259-0542	84	N/A
11	6.7	WSW	First Baptist Learning Center	215 South Andrews Street	Scottsboro	(256) 574-1012	55	N/A
11	7.3	WSW	First United Methodist	1105 South Broad St	Scottsboro	(256) 574-4051	46	14
11	9.3	SW	Kids Kingdom	3517 South Broad St	Scottsboro	(256) 259-3044	58	5
<b>DEKALB COUNTY</b>								
13	11.6	ESE	Kids Patch	19976 Al Highway 75	Henagar	(256) 657-4187	40	8
<b>Total:</b>							<b>332</b>	<b>35</b>

N/A = Data not Available

Bellefonte EPZ: Medical Facilities & Nursing Homes (As of October 2007)										
ERPA	Distance (miles)	Dir- ection	Facility Name	Street Address	Municipality	County	Phone	Cap- acity	Empl- oyees	
11	7.8	WSW	Cloverdale Healthcare Inc	412 Cloverdale Rd	Scottsboro	Jackson	(256) 259-1505	141	175	
11	7.8	WSW	Highlands Medical Center & Jackson County Nursing Home	380 Woods Cove Rd	Scottsboro	Jackson	(256) 259-4444	170	650	
11	7.8	WSW	Mountain Lakes Behavioral Healthcare	508 Gregory Street	Scottsboro	Jackson	(256) 259-1774	Outpatient*		
11	6.2	SW	Cumberland Health and Rehabilitation	47065 US Highway 72	Scottsboro	Jackson	(256) 437-7260	100	N/A	
11	7.6	SW	Rosewood Manor	1513 County Park Rd	Scottsboro	Jackson	(256) 574-4800	32	25	
11	9.2	SW	Southern Estates Assisted Living	212 East Stewart Road	Scottsboro	Jackson	(256) 574-4202	16	4	
Total:								459	854	

\*This facility is for outpatients only.

# Supplement 1

## Bellefonte Evacuation Time Estimate

Bellefonte EPZ: Major Employers (As of April 2007)							
ERPA	Distance (miles)	Dir- ection	Facility Name	Street Address	Municipality	Phone	Empl- oyees
<b>JACKSON COUNTY</b>							
1	-	-	Bellefonte Nuclear Power Plant*	TBD	Hollywood	TBD	750
1	1.8	WNW	Great Western, LLC**	30290 US Highway 72	Hollywood	(256) 259-1079	60
5	5.9	SW	Home Depot	24635 John T Reid Pkwy	Scottsboro	(256) 572-1000	N/A
5	4.9	WSW	Maples Industries, Inc.**	2210 Moody Ridge Rd	Scottsboro	(256) 259-1327	2,128
5	3.8	WSW	Scottsboro Coca Cola Bottling Co.**	26921 John T. Reid Pkwy	Scottsboro	(256) 259-0505	88
9	8.6	SE	Storey Trucking Company**	1420 County Road 422	Scottsboro	(256) 657-3283	130
11	9.9	SW	Associated Pharmacies**	211 Lonnie Crawford Blvd	Scottsboro	(256) 574-6819	55
11	11.3	SW	Crown Machinery**	262 Harbor Dr	Scottsboro	(256) 218-3045	30
11	7.5	WSW	Lozier Corporation**	401 Taylor St	Scottsboro	(256) 259-6100	472
11	11.1	SW	Mason & Dixon Lines**	330 Industrial Park Dr	Scottsboro	(256) 259-6719	200
11	9.9	SW	Maverick Transportation, LLC**	215 Lonnie Crawford Blvd	Scottsboro	(256) 259-3400	130
11	11.3	SW	Meteor Express, Inc.**	875 Harbor Dr	Scottsboro	(256) 218-3000	100
11	9.9	SW	NCI Manufacturing, Inc.**	209 Lonnie Crawford Blvd	Scottsboro	(256) 259-2105	57
11	6.5	WSW	Patrick Lumber Company, Inc.**	615 East Willow St	Scottsboro	(256) 259-2211	45
11	11.3	SW	Performance Fibers, Inc.**	7526 Roy Owens Blvd	Scottsboro	(256) 574-7200	38
11	11.1	SW	Polyamide High-Performance, Inc.**	7526 Alabama Hwy 79	Scottsboro	(256) 218-4004	79
11	10.1	SW	Sanoh America, Inc.**	103 Thomas French Dr	Scottsboro	(256) 575-0100	195
11	11.3	SW	Sunrise Express, Inc.**	388 Industrial Park Dr	Scottsboro	(256) 575-0014	80
11	11.1	SW	Valley Industries**	140 Mack Morris Dr	Scottsboro	(256) 259-3636	31
11	10.1	SW	Wenzel Metal Spinning, Inc.**	208 Lonnie Crawford Blvd	Scottsboro	(256) 259-0239	41
11	10.1	SW	Witt Heat Transfer Products**	201 Thomas French Dr	Scottsboro	(256) 259-7400	304
<b>DEKALB COUNTY</b>							
13	10.1	ESE	Polymer Industries**	10526 Alabama Highway 40	Henagar	(256) 657-5197	100
<b>Total:</b>							<b>5,113</b>

# Supplement 1

## Bellefonte Evacuation Time Estimate

Bellefonte EPZ: Transient Attractions (As of April 2007)									
ERPA	Distance (miles)	Direction	Facility Name	Street Address	Municipality	County	Phone	Persons	Total Vehicles
11	7.5	SW	Jackson County Park	2302 County Park Rd	Scottsboro	Jackson	(256) 574-4719	1,500	612
11	9.9	SW	Crawford Mobile Home/RV Park	4370 South Broad St	Scottsboro	Jackson	(256) 574-5366	28	14
11	12.7	SW	Goose Pond Colony Campsite	417 Ed Hembree Dr	Scottsboro	Jackson	(256) 574-5353	450	200
11	7.4	WSW	Unclaimed Baggage Center	509 W Willow St	Scottsboro	Jackson	(256) 259-1525	254	100
<b>Total:</b>								<b>2,232</b>	<b>926</b>

Bellefonte EPZ: Lodging Facilities (As of July 2008)									
ERPA	Distance (miles)	Direction	Facility Name	Street Address	Municipality	County	Phone	Persons	Vehicles
2	3.1	NNE	Creekstone Lodge	355 County Rd.213	Hollywood	Jackson	(256) 574-1462	48	24
11	6.3	SW	Best Value Inn	46 Micah Way	Scottsboro	Jackson	(256) 259-4300	96	48
11	6.2	WSW	Budget Inn	101 Tupelo Drive	Scottsboro	Jackson	(256) 674-3163	36	18
11	7.2	SW	Comfort Inn	23518 John T Reid Parkway	Scottsboro	Jackson	(256) 594-6740	122	61
11	5.9	WSW	Econo Lodge & Suites*	1401 E Willow St	Scottsboro	Jackson	(256) 574-1010	208	104
11	12.7	SW	Goose Pond Colony	417 Ed Hembree Dr	Scottsboro	Jackson	(256) 574-5353	24	12
11	6.9	WSW	J & W Motel	206 W Willow St	Scottsboro	Jackson	(256) 574-2330	20	20
11	6.3	SW	Jameson Inn	208 Micah Way	Scottsboro	Jackson	(256) 574-6666	61	61
11	6.4	WSW	Liberty Inn	907 E Willow St	Scottsboro	Jackson	(256) 574-1730	60	30
11	11.7	WSW	Scottsboro Days Inn*	1106 John T Reid Parkway	Scottsboro	Jackson	(256) 574-1212	144	72
<b>Total:</b>								<b>819</b>	<b>450</b>

\*These hotels were not originally identified by the County. Scottsboro Days Inn is just within the EPZ, while the Econo Lodge & Suites is centrally located in Scottsboro. No change in ETE is anticipated for the additional 176 transient vehicles present at these facilities during peak times. Therefore, Table 3-3, Figures 3-4 and 3-5, the discussion of hotels on Page 3-10 and the Transient Vehicle Totals in Table 6-4 do not reflect these data.

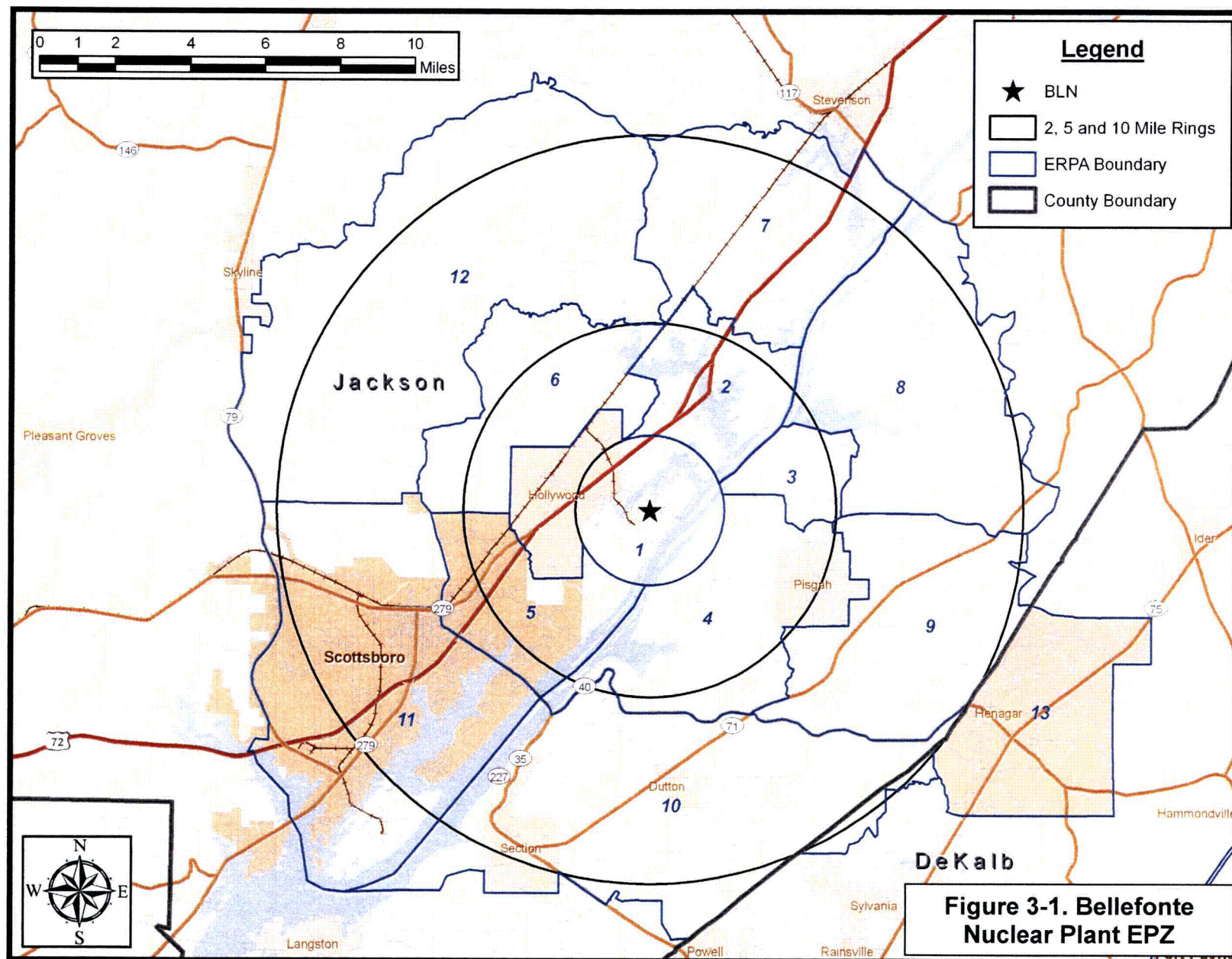
# Supplement 1

## Bellefonte Evacuation Time Estimate

Table G-1 Traffic Control Point Summary						
TCP ID	Town	Intersection Location	Priority	# of Guides	# of Cones	# of Barricades
<b>JACKSON COUNTY</b>						
1-01	Hollywood	U.S. Hwy 72 & County Rd 33 (Bellefonte Rd)	1	2	0	22
11-01	Scottsboro	State Hwy 279 & State Hwy 35	1	4	6	4
11-02	Scottsboro	State Hwy 35 & U.S. Hwy 72 (S) Ramps	1	3	12	2
11-03	Scottsboro	State Hwy 35 & U.S. Hwy 72 (N) Ramps	1	3	6	4
11-06	Scottsboro	State Hwy 35 & State Hwy 279 (Broad St)	1	2	6	0
11-13	Scottsboro	U.S. Hwy 72 & County Park Rd	1	3	12	14
11-14	Scottsboro	State Hwy 279 & State Hwy 72 (S) Ramps	1	2	6	2
11-15	Scottsboro	State Hwy 35 & State Hwy 79	1	2	6	0
11-16	Scottsboro	State Hwy 79 & State Hwy 279	1	2	18	0
11-17	Scottsboro	State Hwy 79 & U.S. Hwy 72	1	4	9	0
5-01	Scottsboro	U.S. Hwy 72 & Entrance to Scottsboro High School	2	2	9	0
10-01	Dutton	State Hwy 40 & State Hwy 71	2	1	9	0
10-02	Section	State Hwy 35 & State Hwy 71	2	2	6	0
11-05	Scottsboro	State Hwy 35 & Market St	2	2	9	0
11-07	Scottsboro	State Hwy 35 & Houston St	2	2	9	0
11-08	Scottsboro	State Hwy 35 & Cedar St	2	2	6	0
5-02	Scottsboro	U.S. Hwy 72 & Entrance to Walmart Shopping Center	3	3	6	10
11-04	Scottsboro	State Hwy 35 & Entrance to Home Depot	3	3	15	0
11-09	Scottsboro	State Hwy 279 & Charlotte Ave	3	1	6	0
11-10	Scottsboro	State Hwy 279 & Parks Ave	3	1	3	0
11-11	Scottsboro	State Hwy 279 & Cecil St	3	2	9	0
11-12	Scottsboro	State Hwy 279 & Legion St	3	2	9	0
<b>Total Equipment/Manpower for Jackson County:</b>				<b>50</b>	<b>177</b>	<b>58</b>
<b>DEKALB COUNTY</b>						
13-01	Henagar	State Hwy 40 & State Hwy 75	1	1	3	0
<b>Total Equipment/Manpower for DeKalb County:</b>				<b>1</b>	<b>3</b>	<b>0</b>
<b>TOTAL EQUIPMENT/MANPOWER FOR ENTIRE EPZ:</b>				<b>51</b>	<b>180</b>	<b>58</b>

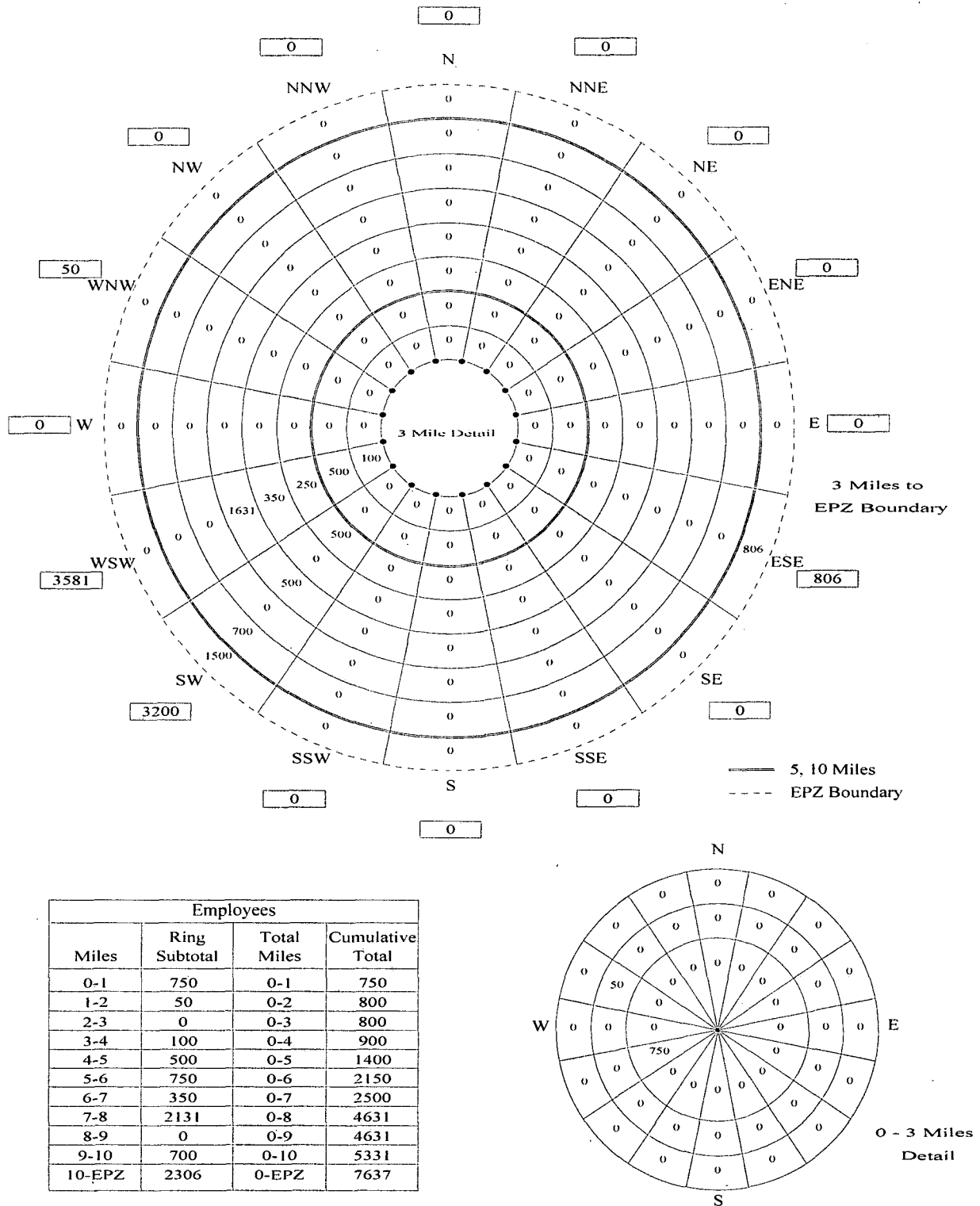
# Supplement 1

## Bellefonte Evacuation Time Estimate



# Supplement 1

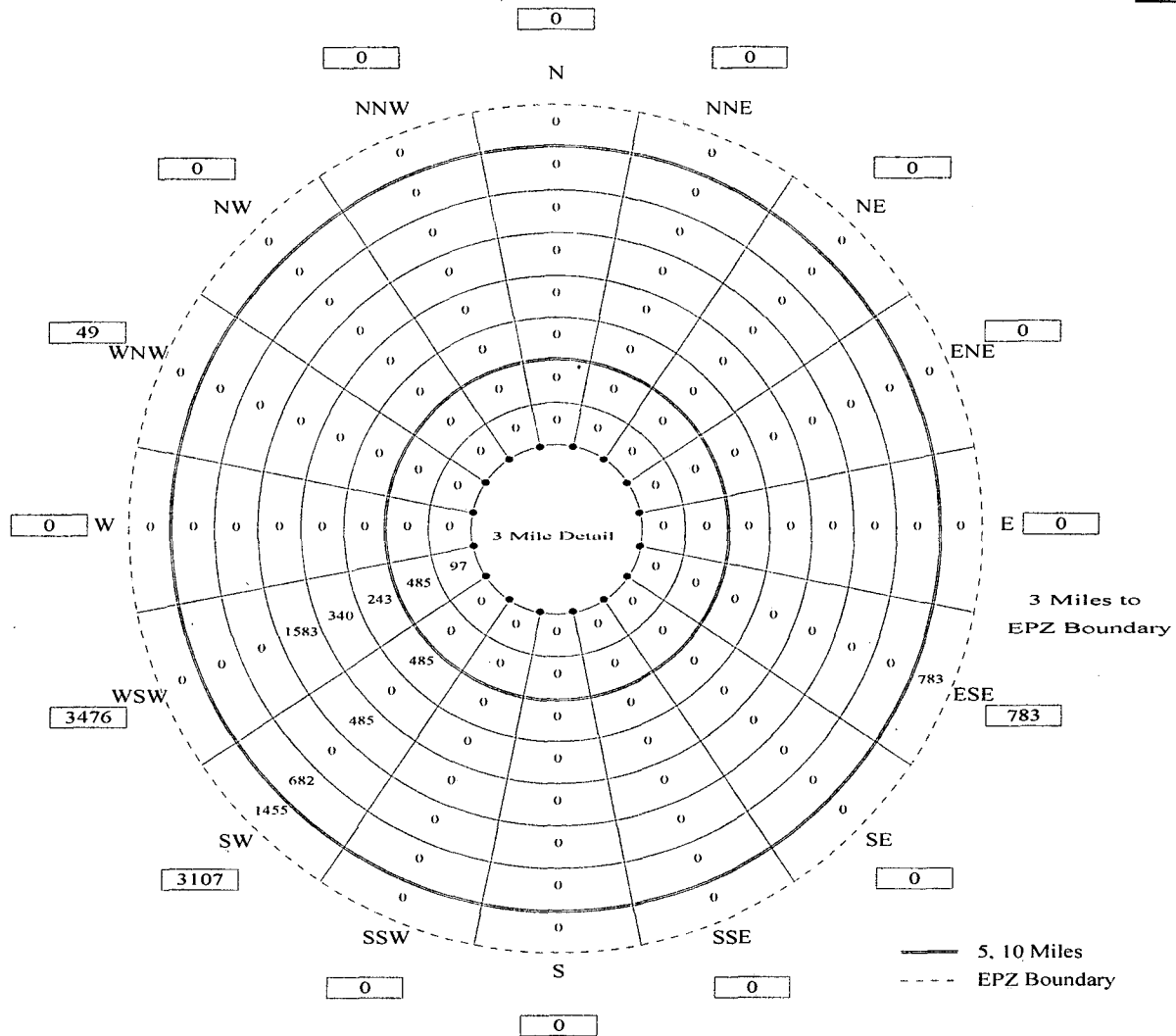
## Bellefonte Evacuation Time Estimate



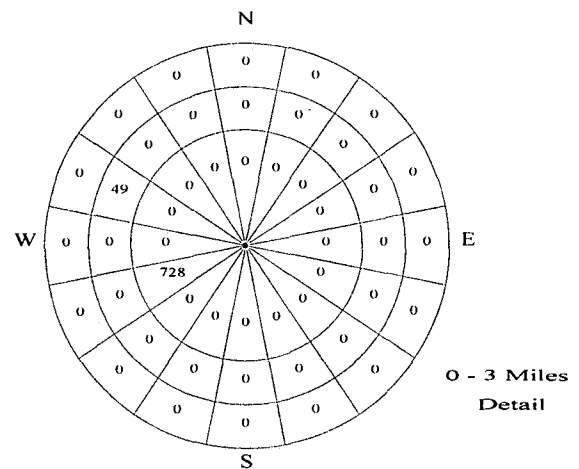
**Figure 3-6. Employee Population by Sector**

# Supplement 1

## Bellefonte Evacuation Time Estimate



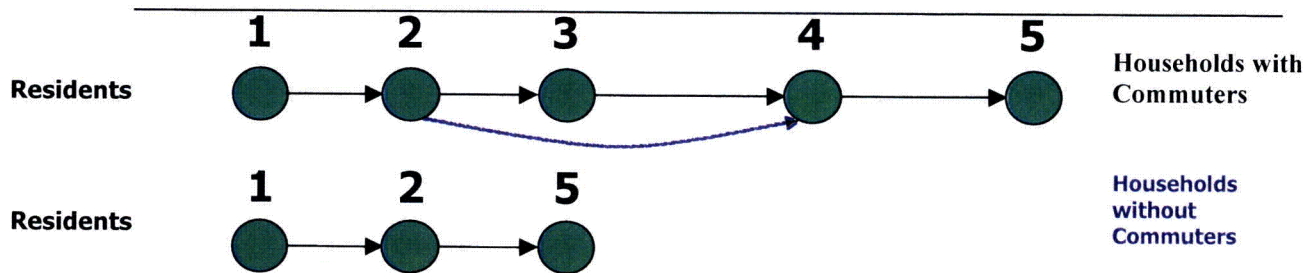
Employee Vehicles			
Miles	Ring Subtotal	Total Miles	Cumulative Total
0-1	728	0-1	728
1-2	49	0-2	777
2-3	0	0-3	777
3-4	97	0-4	874
4-5	485	0-5	1359
5-6	728	0-6	2087
6-7	340	0-7	2427
7-8	2068	0-8	4495
8-9	0	0-9	4495
9-10	682	0-10	5177
10-EPZ	2238	0-EPZ	7415



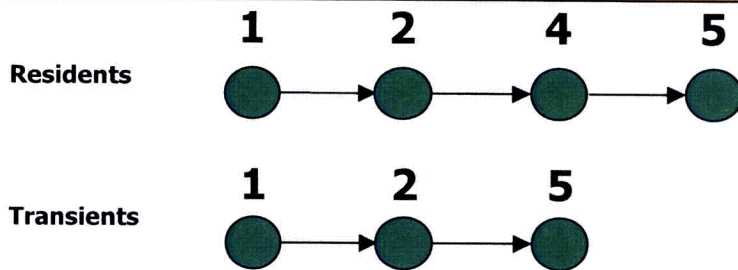
**Figure 3-7. Employee Vehicles by Sector**

# Supplement 1

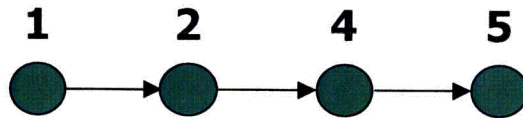
## Bellefonte Evacuation Time Estimate



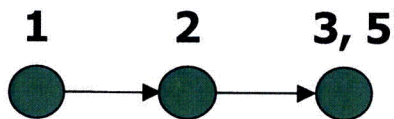
(a) Accident occurs during midweek, at midday; year round



(b) Accident occurs during weekend, at midday; summer season



(c) Accident occurs in the evening; non-summer season



(d) Employees who live outside the EPZ

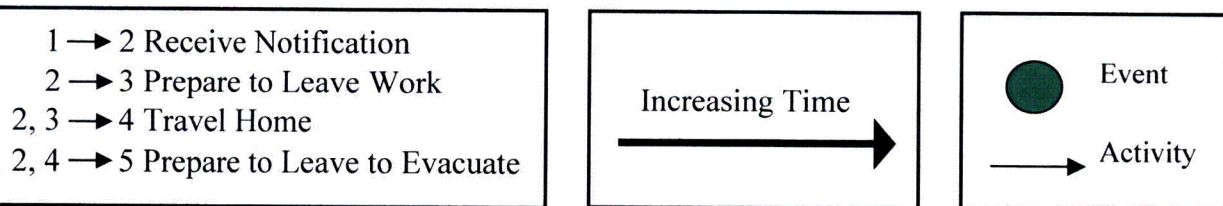
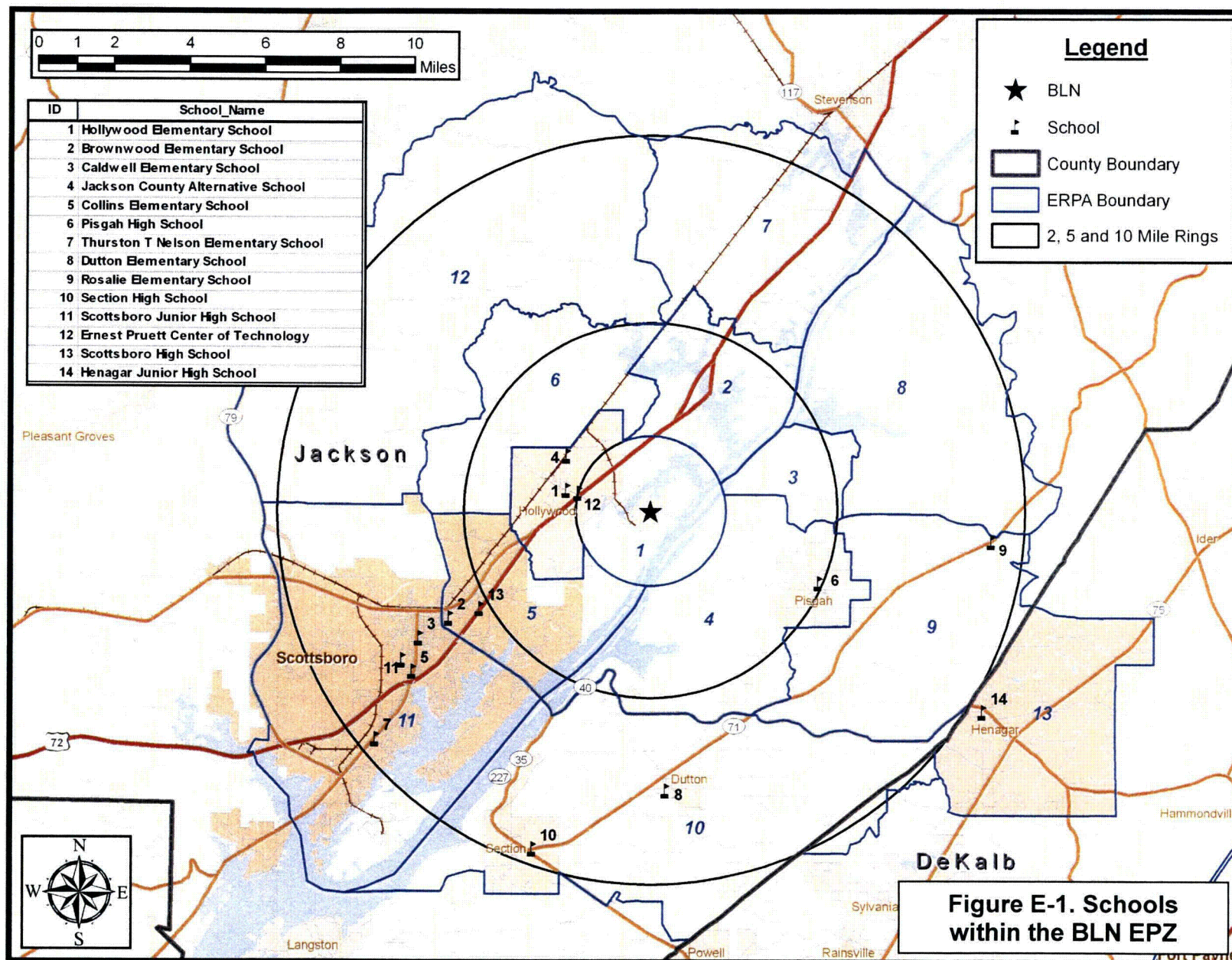


Figure 5-1. Events and Activities Preceding the Evacuation Trip

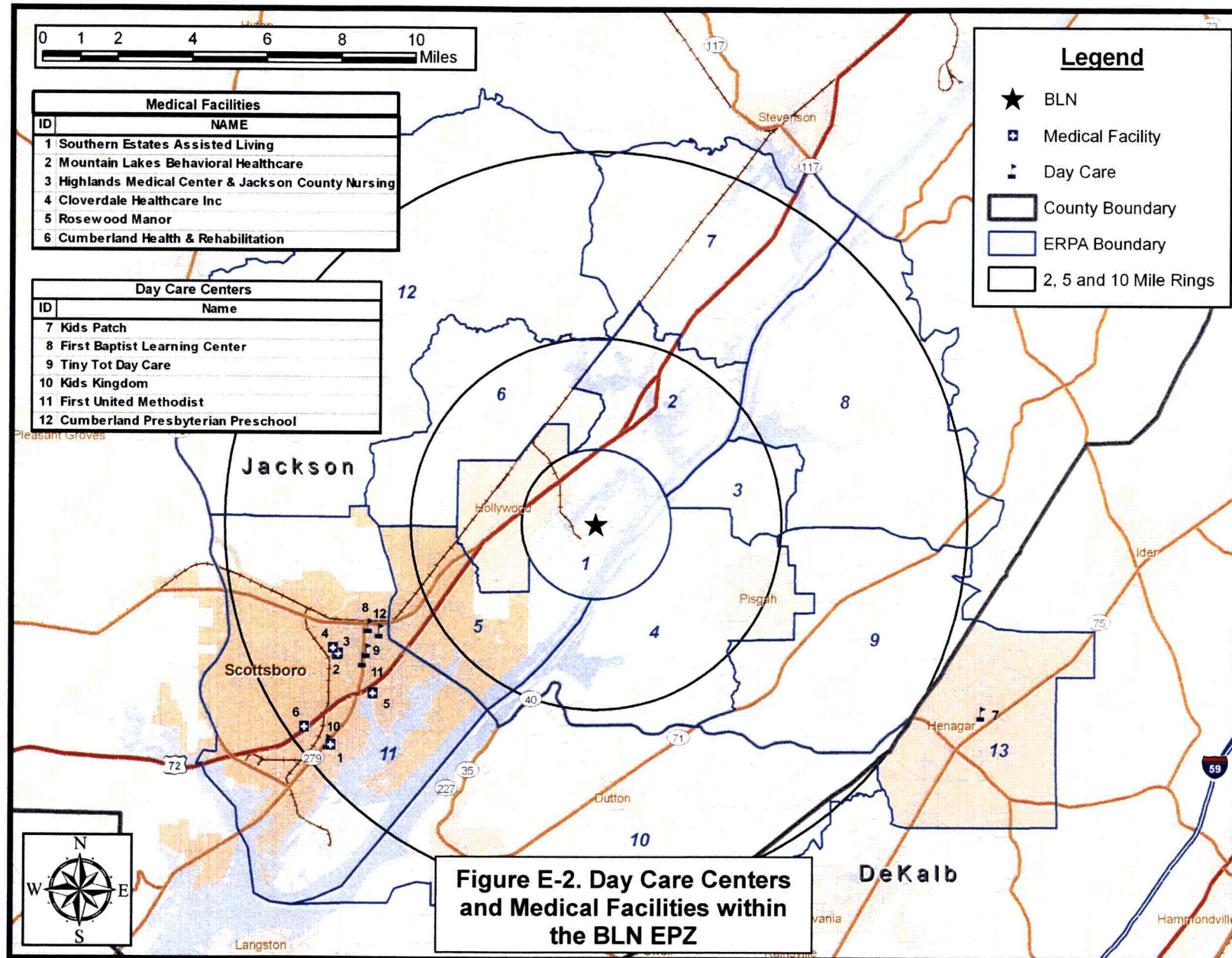
# Supplement 1

## Bellefonte Evacuation Time Estimate



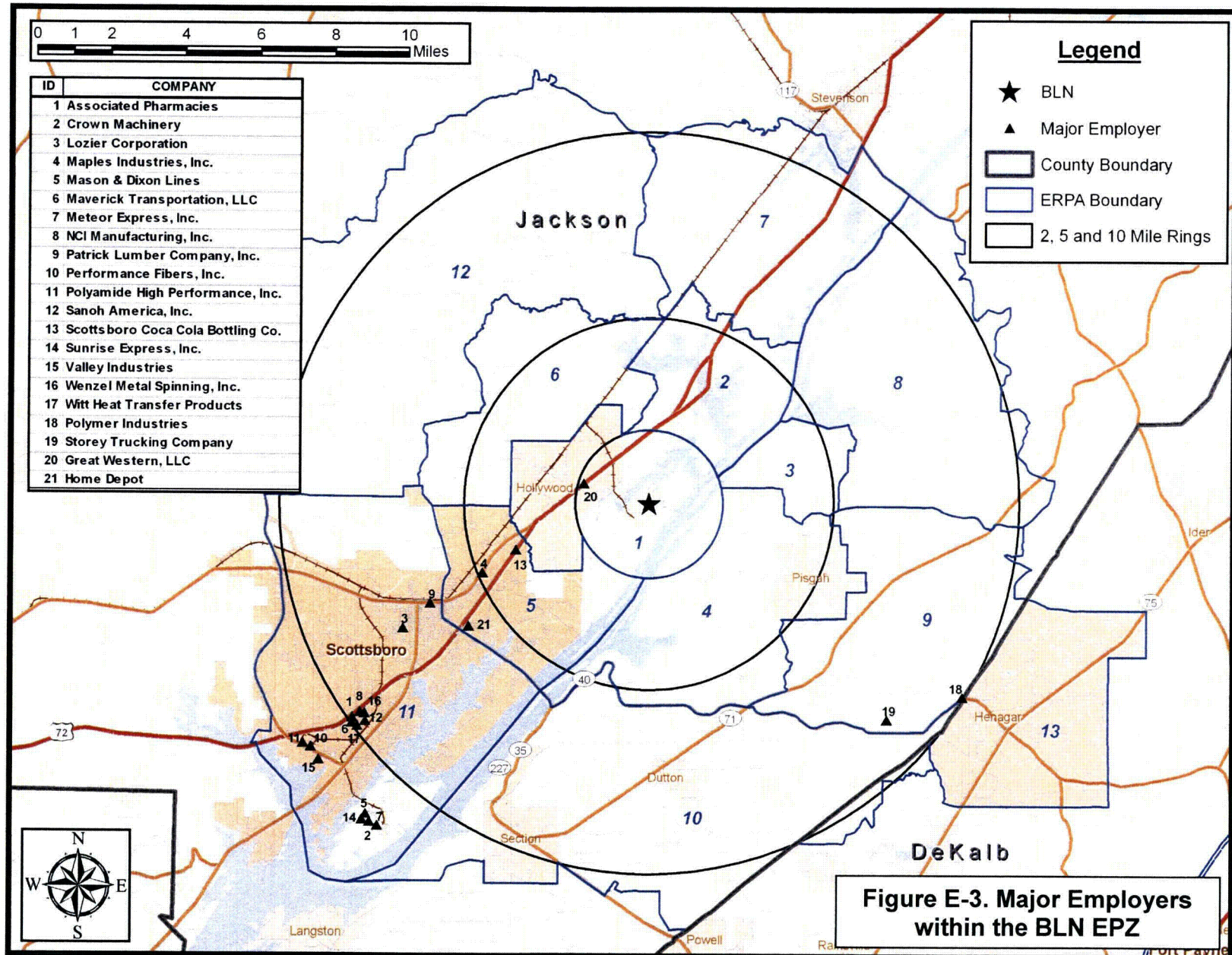
# Supplement 1

## Bellefonte Evacuation Time Estimate



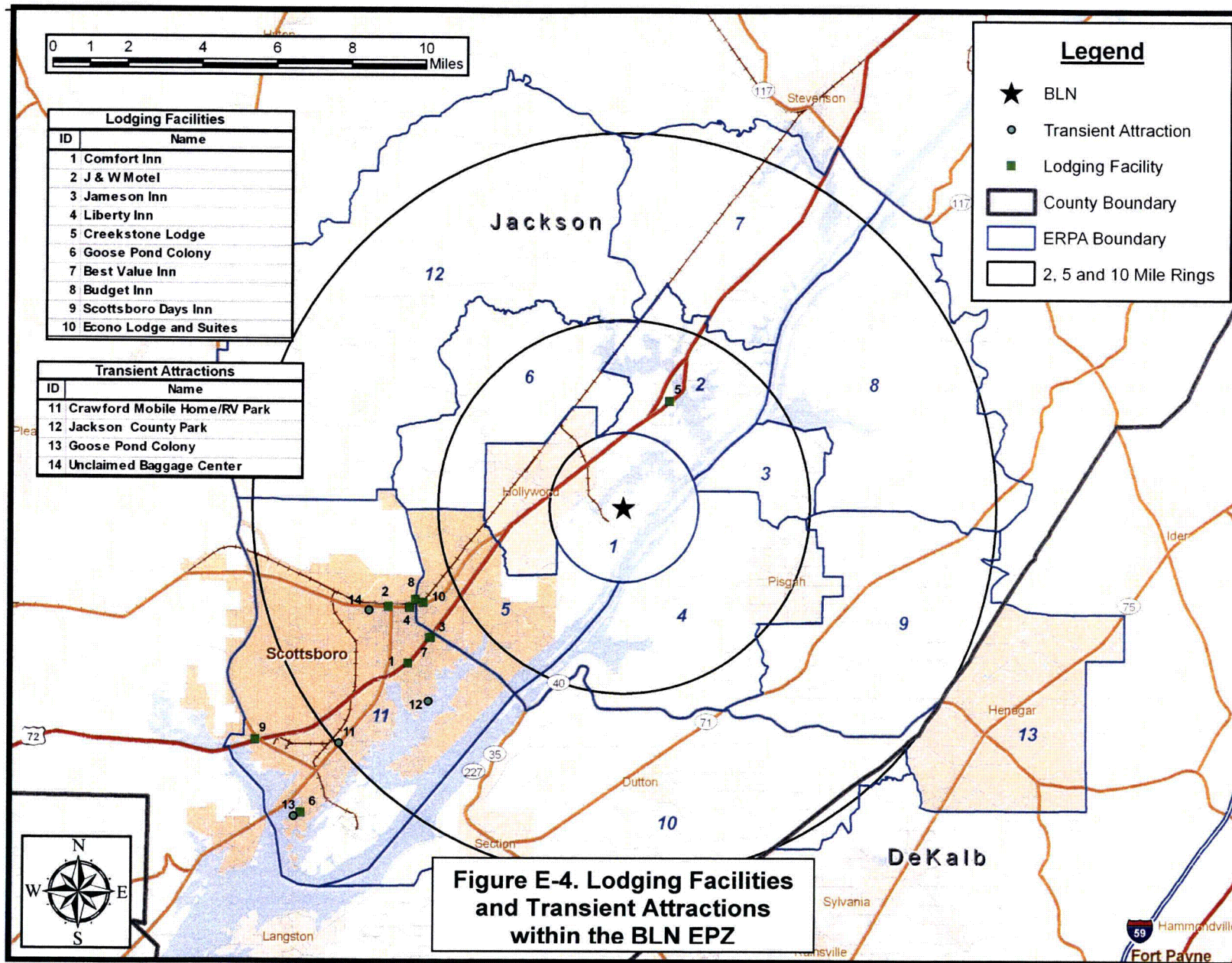
# Supplement 1

## Bellefonte Evacuation Time Estimate



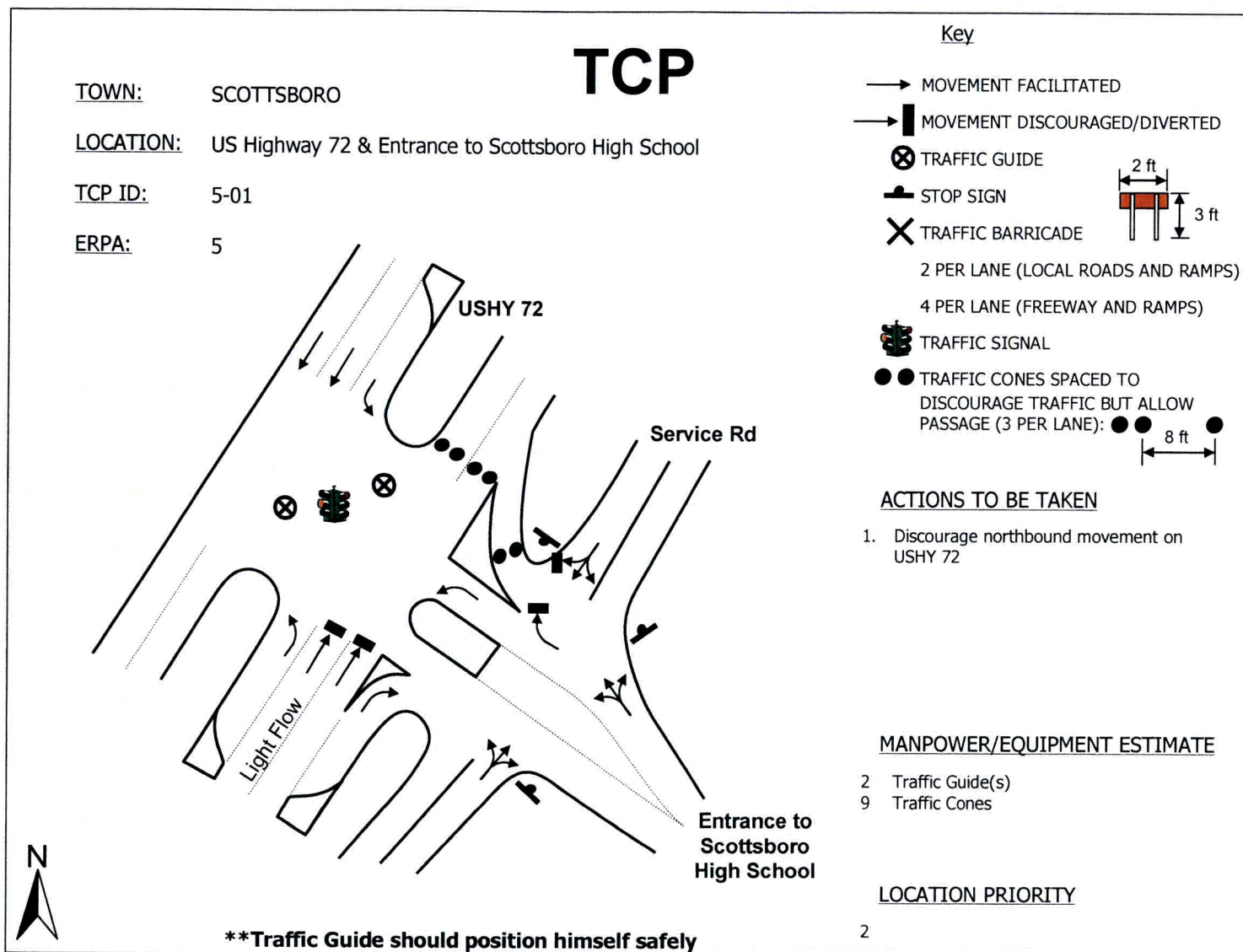
# Supplement 1

## Bellefonte Evacuation Time Estimate



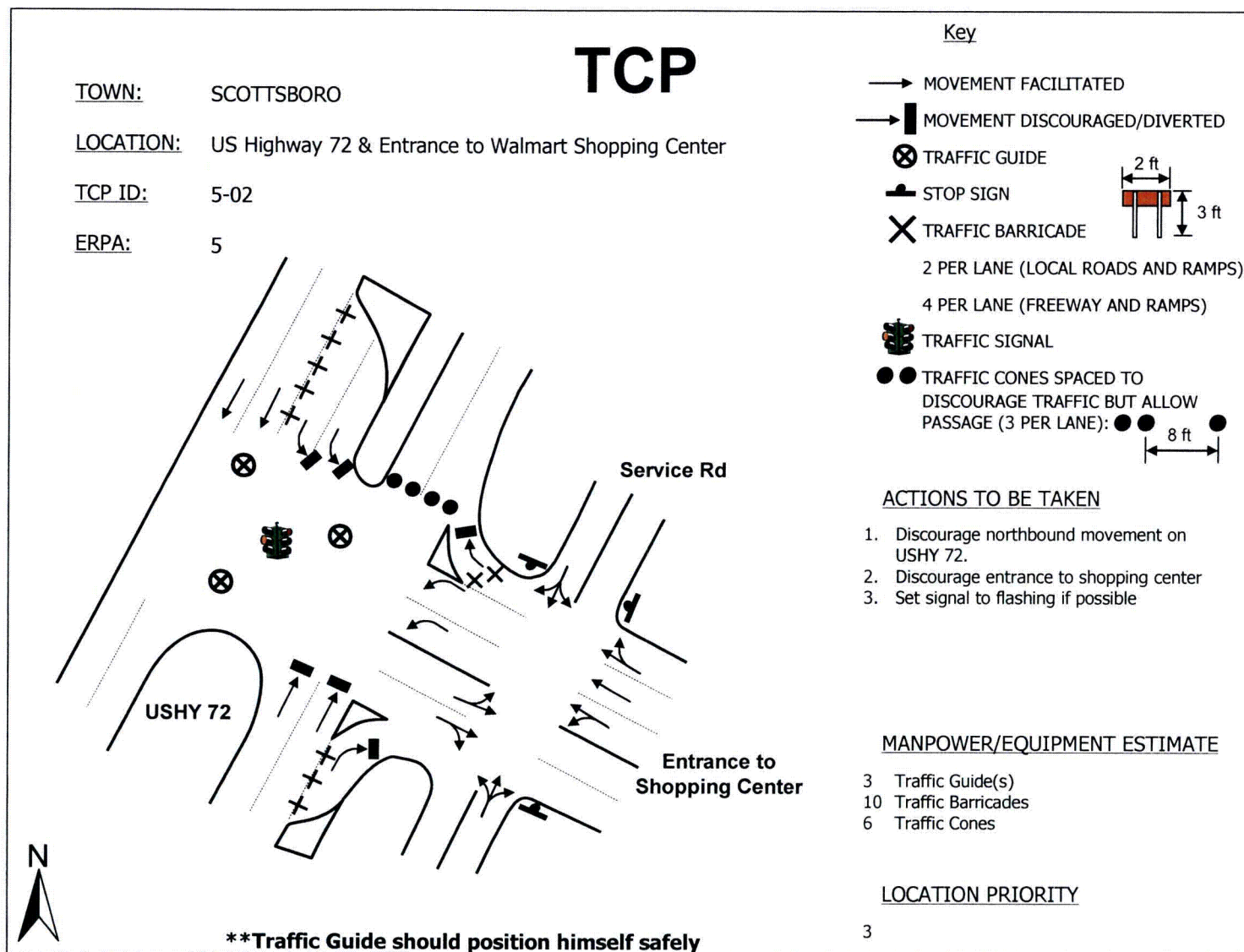
# Supplement 1

## Bellefonte Evacuation Time Estimate



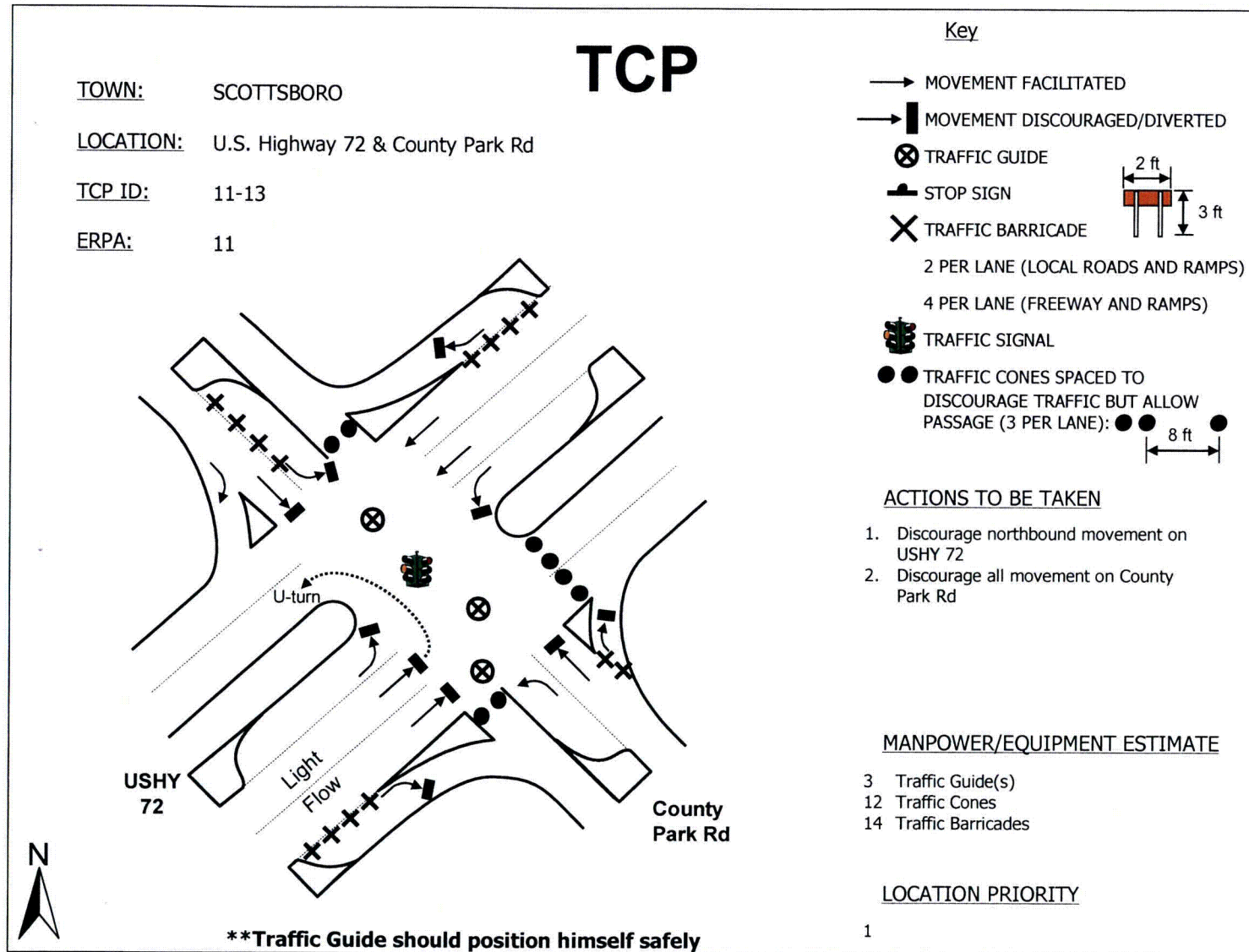
# Supplement 1

## Bellefonte Evacuation Time Estimate



# Supplement 1

## Bellefonte Evacuation Time Estimate



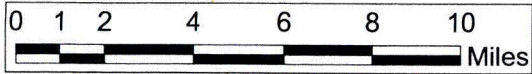
**Supplement 1**  
**Bellefonte Evacuation Time Estimate**

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Figure 1-2

Bellefonte Link Nodes Analysis Network

(Attached)



## Legend

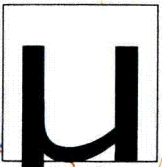
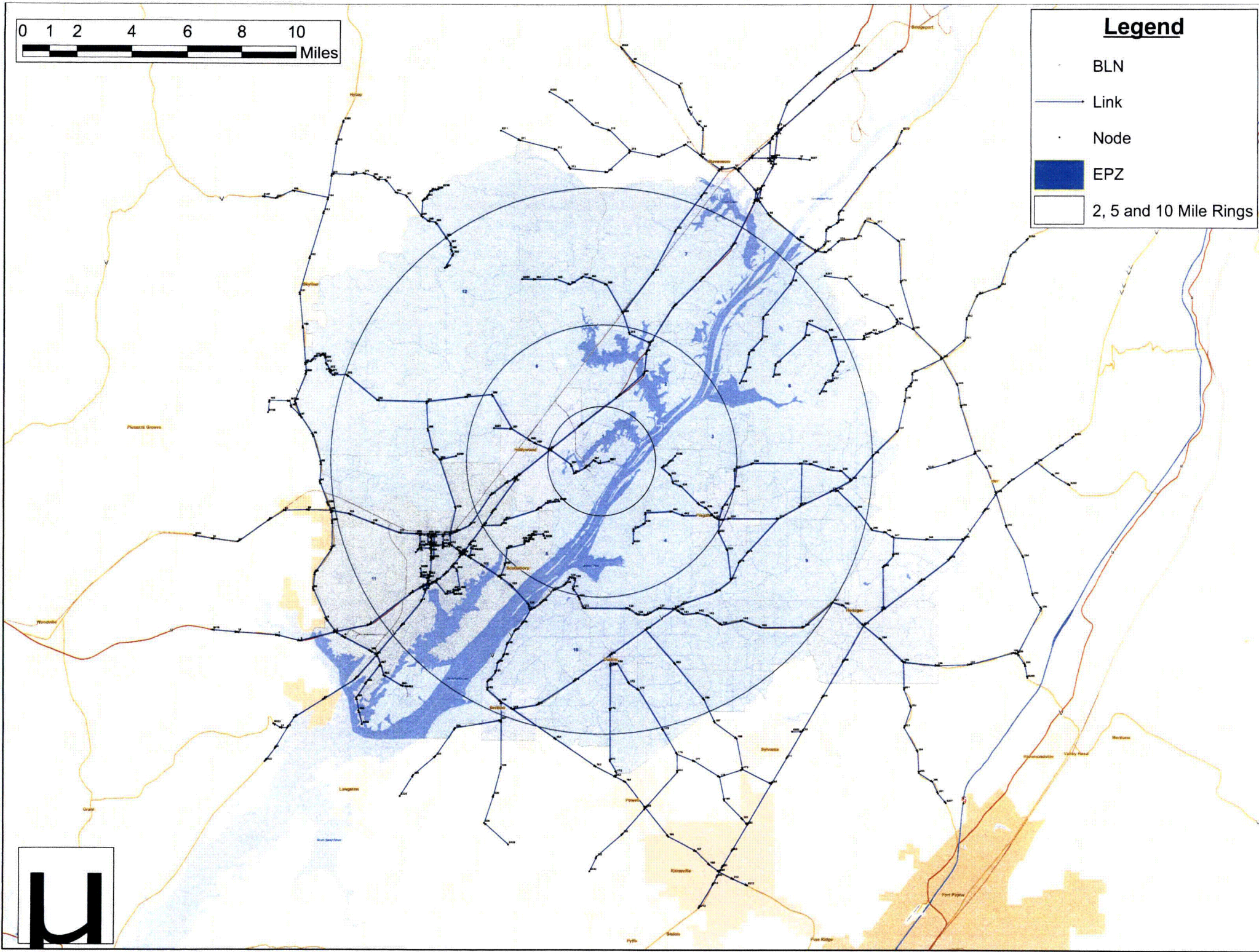
BLN

Link

Node

EPZ

2, 5 and 10 Mile Rings



**Attachment 13.03-012A**

**Procedure for Estimating the Mobilization Curve Based Upon Survey Data**  
(13 pages including this cover sheet)

## PROCEDURE FOR ESTIMATING MOBILIZATION CURVE BASED UPON SURVEY DATA

The mobilization time data is obtained from a telephone survey, often with  $N = 500$  to 1000 samples. The cumulative distribution or cumulative histogram can be plotted from the survey results.

Experience shows that the best fit pattern to the data is often a cumulative exponential distribution, shifted by  $T_0$  minutes. For instance, refer to Figure 1, which shows a hypothetical case in which

The population begins to leave only after  $t = T_0 = 20$  minutes, and then follows the exponential distribution, and almost all are gone by  $T_0 + T_1 = 320$  minutes.

Because this single-regime model is the most common in practice, this procedure addresses this case first. It also lays the basis for the additional cases.

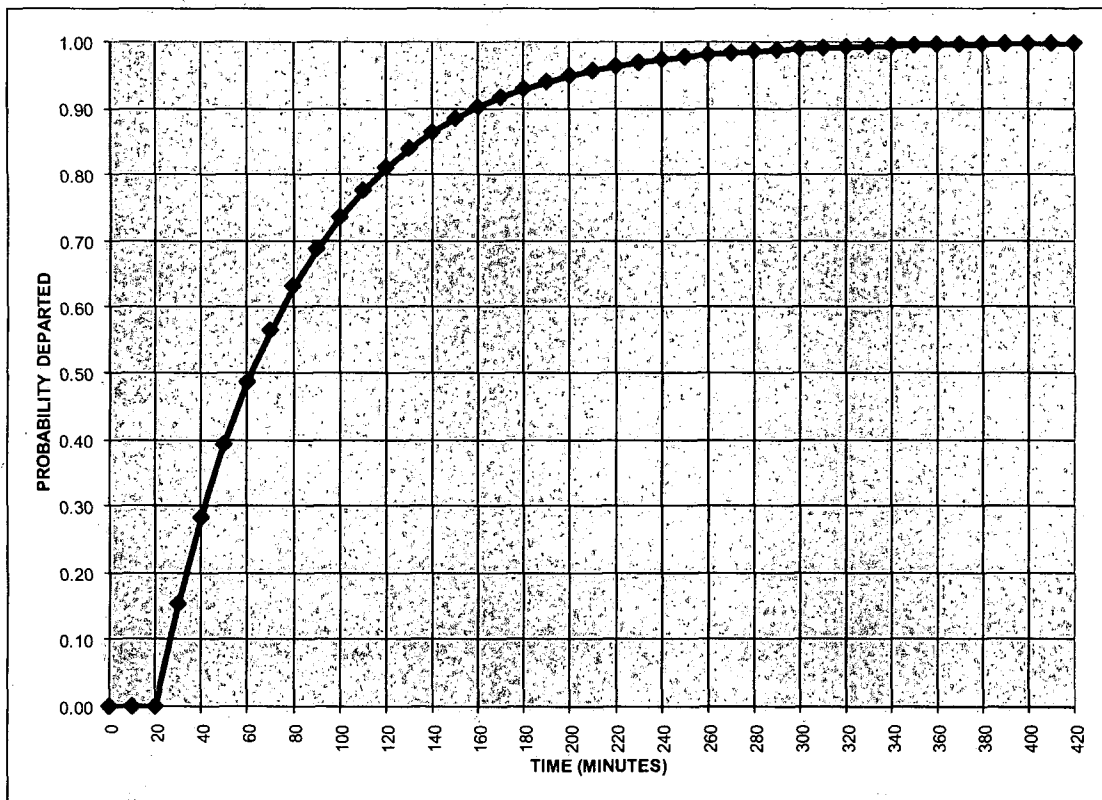


Figure 1: Common Representation of Underlying Behavior

The form of the relation shown in Figure 1 is

$$\left. \begin{aligned} P_R(\text{departure time} \leq t) = F(t) &= \{1 - e^{-(t-T_0)/\tau}\} \text{ for } t \geq T_0 \\ &= 0 \text{ for } t < T_0 \end{aligned} \right\} \quad (1)$$

where  $P_R$  indicates the cumulative probability of a departure, “ $t$ ” is any given time and “ $\tau$ ” is a constant referred to as the “time constant”.

The relation can also be read as “the percentage of vehicles departed by time ‘ $t$ ’”.

The relation can also be expressed as shown in Figure 2, namely as the probability density function of a departure at time “ $t$ ”. In this form, the relation is

$$f(t) = (1/\tau) e^{-(t-T_0)/\tau} \text{ for } t \geq T_0, = 0 \text{ else} \quad (2)$$

This can be read as “the relative probability of departing at time ‘ $t$ ’”. The probability of departing in the interval  $\{t, t + \Delta t\}$  is approximately  $p(t) \simeq f(t) \Delta t$ .

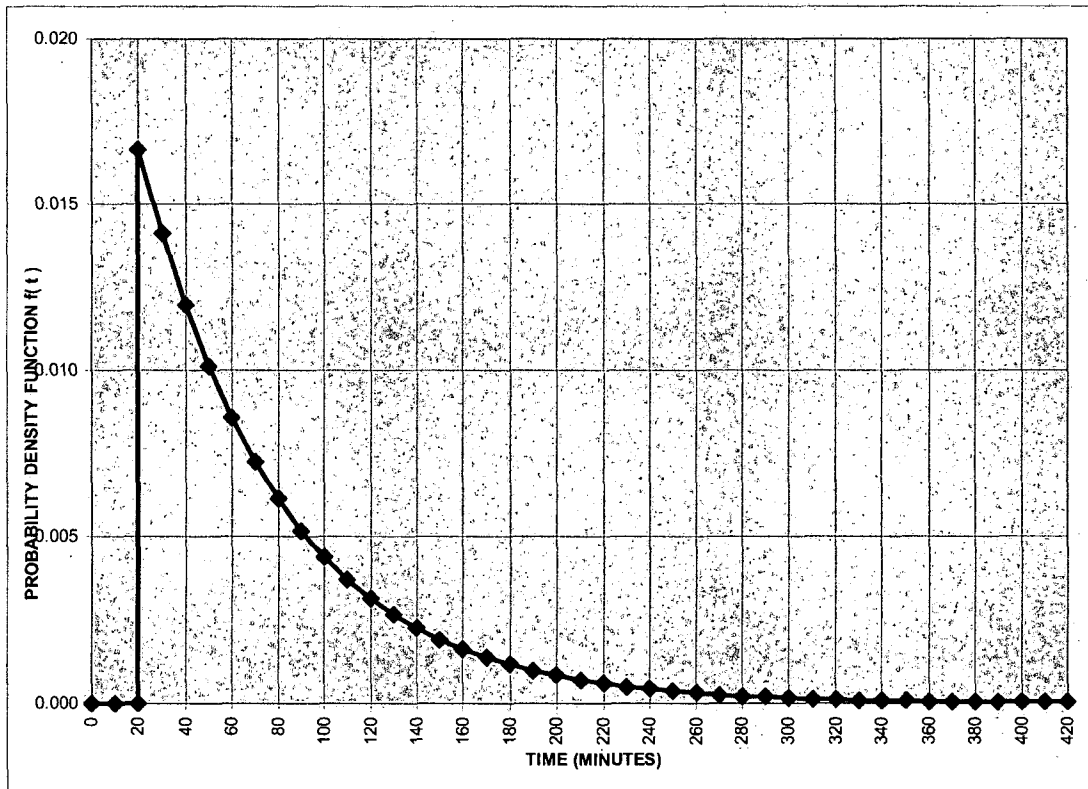


Figure 2: The probability density function  $f(t)$  Related to Figure 1

## Estimating $T_0$

The problem of estimating these curves from data is divided into two estimations: (1) estimate the time  $T_0$  and (2) estimate the parameter  $\tau$ . There are various methods for doing this. Based upon the sample sizes and the number of sampling intervals used in the survey, it has proven effective to

- Select a value of  $T_0$
- Estimate  $\tau$  based upon methods described in this document
- Iterate as needed

In practice, the choice of  $T_0$  has been clear from the plot of the survey results.

For the remainder of this document, given an initial choice of  $T_0$ , you are to shift all the data (or data categories) by subtracting  $T_0$ . The net effect of this is to create a version of Figure 2 with the curve starting at  $t = 0$  rather than  $t = T_0$ .

## Time Constant and Settling Time

In linear systems, it is common to say that the exponential curve has essentially settled to zero when either four or five time constants have passed. In fact,

$$e^{-(4/\tau)} = e^{-4} = 0.018 \text{ or } 1.8\% \text{ of the original signal strength}$$

$$e^{-(5/\tau)} = e^{-5} = 0.007 \text{ or } 0.7\% \text{ of the original signal strength}$$

Focus on the purpose of the analysis, which is to estimate “ $\tau$ ”. The (shifted) Figure 2 curve is idealized. When inspecting data and conceptually sketching a curve through the cumulative plot of the data, it is quite feasible to identify the “ $4\tau$ ” level of 98.2% of the data to the left (i.e. 1.8% remaining) whereas identifying the “ $5\tau$ ” level with 99.3% of the data generally proves elusive due to the presence of outliers in the data. Therefore, while recognizing that the curve truly settles in  $5\tau$ , this procedure calibrates  $\tau$  based upon the 98.2% level.

**Therefore, as a key element of this procedure is to identify “ $\tau$ ”, you will seek to establish the point at which the 1.8% threshold is passed in plots such as Figure 2, or the 98.2% threshold is passed in plots such as Figure 1 (shifted, in both cases).**

**The identification may be done by reference to the cumulative data plot (usually aggregated by category, from the survey) or by reference to a smooth exponential curve through that data.**

For clarity:

**time constant** is the constant “ $\tau$ ” shown in Equations 1 and 2. If the exponential relation is written in the form  $e^{-A t}$ , then  $\tau = 1 / A$ .

**settling time** is generally taken as five time constants. If the exponential relation is written in the form  $e^{-A t}$ , then the settling time to the 1.8% level is  $4 / A$ .

In either Figures 1 or 2, it is easy to estimate by inspection that the settling time to the  $4\tau$  level is about 260 seconds from the graph, including the  $T_0$  component. Therefore, the “time constant” is  $\tau = (260-20)/4 = 60$  and  $A = 1/60$ . A later section in this document will give guidance by which to estimate “ $\tau$ ”, for more difficult cases.

Note that the exponential curve never reaches zero, but approaches zero asymptotically. The concept behind using this curve is that “essentially everyone” has departed by five time constants. In the ETE application, this defines the 100<sup>th</sup> percentile.

Other percentiles (50<sup>th</sup>, 90<sup>th</sup>, 95<sup>th</sup>) can be found on the basis of entering Figure 1 on the vertical at the desired percentile and reading the corresponding time “ $t$ ”. The same can be achieved by solving Equation 1 for “ $t$ ”, given the percentile set on the left hand side of Equation 1.

From basic probability theory, it is known that the mean of the exponential distribution equals “ $1 / A$ ” or “ $\tau$ ” (that is, one time constant). Let us formalize the procedure as:

**Method 1** is estimating the settling time to the  $4\tau$  level by inspection as described above, and arriving at the estimated time constant “ $\tau$ ”.

**Method 2** for estimating the time constant is making it equal to the

$$\{ (\text{estimated mean mobilization time}) - T_0 \}$$

computed from the observations (i.e. samples) obtained. It may be necessary to do this by using the centers of the categories, given the method of data collection and recording.

With the analytic form of the curve thus determined, the curve can be plotted on the same display as the data, and any major anomalies can be identified.

A “major anomaly” would be a cumulative analytic curve that has the data systematically lying to one side or the other of the analytic curve, which is drawn in the form of Equation 1. This would imply that the shifted exponential form is not a satisfactory representation of the data.

As an example, consider the hypothetical data shown in Table 1, along with the computation of the estimated mean and estimated variance contained therein.

**Table 1: Estimation of {(Mean Mobilization Time) –  $T_0$ }**

minutes

CATEGORIES

FROM CATEGORY OBSERVATIONS

Cat #	FROM	TO	Observed
1	0	30	228
2	30	60	149
3	60	90	88
4	90	120	47
5	120	150	42
6	150	180	12
7	180	210	8
8	210	240	5
9	240	270	6
10	270	END	5
			590

EST MEAN	EST STD
3420	51300
6705	301725
6600	495000
4935	518175
5670	765450
1980	326700
1560	304200
1125	253125
1530	390150
1425	406125
34950	3811950

590 observations **6472** est variance

**59.2** deduced mean **80.4** est std

**6.5** for conf bound  
on mean

With 95% confidence, mean is estimated  
to be between **52.7** minutes  
and **65.7** minutes

The estimated time constant is therefore 59.2 minutes, given the particular sample used for this computation.

Note that the 95% confidence bound range on this estimate of the mean is from 52.7 to 65.7 minutes. A hypothesis that the mean is any value in this range would not be rejected<sup>1</sup>.

*Because the data tends to be aggregated into groups due to the survey (stated ranges are checked by the interviewer, rather than interviewee estimate of minutes, it is not necessarily true that Method 1 is markedly better than Method 2. Rather, the two results should be compared for reasonableness.*

Should there be a clear anomaly, one can expect the underlying hypothesis to be rejected in the next section.

<sup>1</sup> Indeed, for this illustration within this procedure, the true mean of the distribution that generated the “data” was 60 minutes. Normally, of course, this would not be known and the above estimate would be the best available.

### A Goodness-of-Fit Test for the Hypothesized Curve

The hypothesis to be tested is that the underlying probability density function (pdf) is as described in Equation 2, with the constant “ $\tau$ ” or “A” determined by Methods 1 or 2 or an alternative method (described herein). **In practice, one is to use Method 1 as the preferred method.** *Should an analyst recommend another choice, it is to be discussed with the senior analyst and the QC Officer.*

The statistical test to be used is chi-square goodness-of-fit test. A level of significance of  $\alpha = 0.05$  will be used.

The procedure calls for the data to be divided into at least 5 categories, generally such that the shape of the curve to be calibrated is retained. More than 5 categories are preferred. The category widths need not be equal.

A number of standard statistical packages (e.g. SPSS, StatGraphics, MiniTab) contain the chi-square goodness of fit test. It can also be done on a spreadsheet.

Refer to Table 2, which shows the results of a hypothetical set of survey data. The KLD spreadsheet accompanying this procedure was used. Note that:

- 1) There are at least five categories and at least 5 samples per category;
- 2) The last category is open-ended;
- 3) The categories are selected such that the “expected” bars do not obscure the fact that they represent the exponential distribution;
- 4) While the “observed” differs from the “expected”, it is within the range of natural variability for the number of samples and categories, so that the conclusion *in this illustration* is “**do not reject the hypothesis**”.

With that decision reached, one then proceeds to use the exponential distribution as descriptive of the phenomenon being modeled (e.g. the mobilization times). For the purpose of identifying where the sample distribution may be truncated.

**Table 2: Chi-Square Test on the Mobilization Distribution Above  $T_0$**

**CHI-SQUARE TEST ON EXPONENTIAL DISTRIBUTION OF MOBILIZATION TIMES**

time constant =  minutes

LEVEL OF SIGNIFICANCE =

Cat #	CATEGORIES		PROB WITH EXP DIST
	FROM	TO	
1	0	<b>30</b>	0.393
2	30	<b>60</b>	0.239
3	60	<b>90</b>	0.145
4	90	<b>120</b>	0.088
5	120	<b>150</b>	0.053
6	150	<b>180</b>	0.032
7	180	<b>210</b>	0.020
8	210	<b>240</b>	0.012
9	240	<b>270</b>	0.007
10	270	END	0.011

	Expected	Observed	CHI-SQ
1	232	<b>228</b>	0.074
2	141	<b>149</b>	0.477
3	85	<b>88</b>	0.079
4	52	<b>47</b>	0.445
5	31	<b>42</b>	3.564
6	19	<b>12</b>	2.613
7	12	<b>8</b>	1.095
8	7	<b>5</b>	0.576
9	4	<b>6</b>	0.719
10	7	<b>5</b>	0.369
	590		<b>10.011</b> COMPUTED

Decision Point =   
with  $\alpha$  above and  $df = \{\text{\#categories} - 1\}$

HYPOTHESIS: UNDERLYING DISTRIBUTION IS  
EXPONENTIAL, WITH PARAMETERS SHOWN

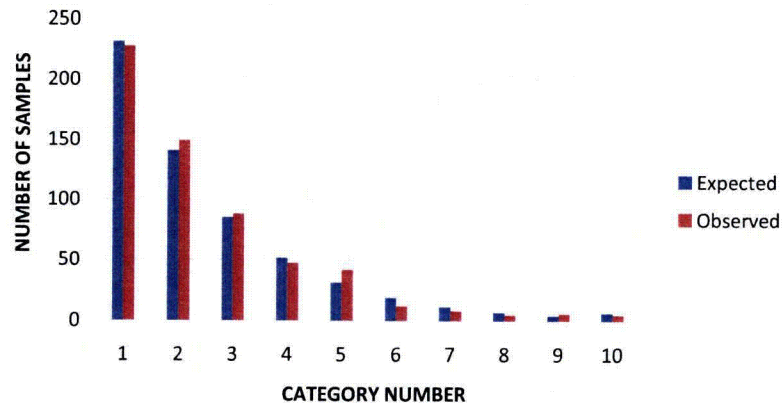
**CONCLUSION**

**DO NOT REJECT HYPOTHESIS**

**Implication: use the exponential relation**

**Notes**

- 1 # categories  $\geq 5$ , # samples per category  $\geq 5$
- 2 categories need not be equal span (range)
- 3 expected distribution should follow hypothesized curve, namely exponential (do not aggregate too much, particularly where curve changes quickly)
- 4 this spreadsheet starts with 10 categories, with the first nine each 1/2 of a time constant wide. The user can modify the red bold category ends, and can change the number of categories



### Another Graphical Display, Involving the Natural Logarithm

It is interesting that if one takes the natural logarithm of both sides of Equation 2, the result is a linear relation, namely

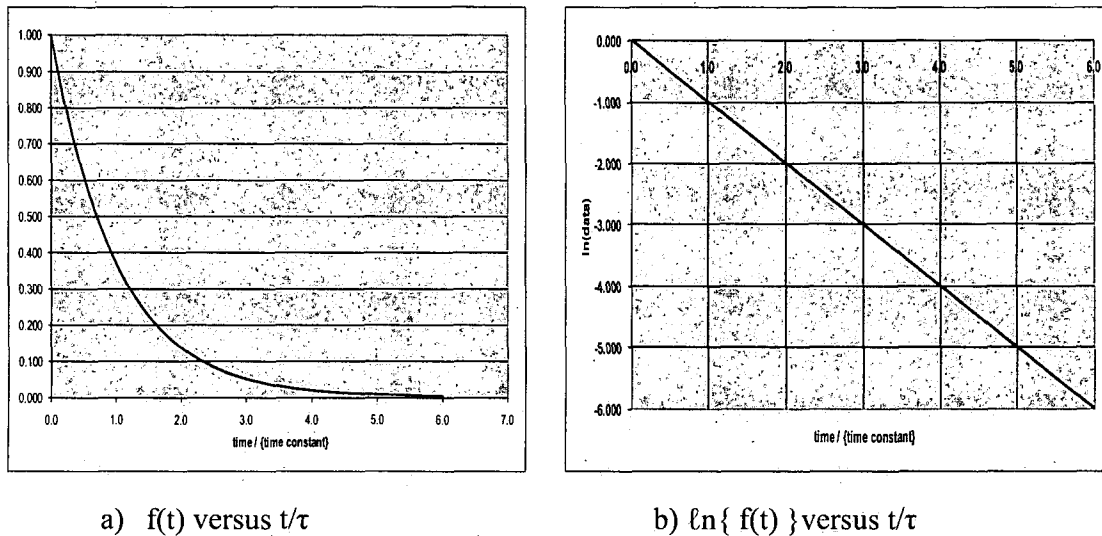
$$\ln\{f(t)\} = -\{t/\tau\} + \ln\{1/\tau\}$$

or

$$\ln\{f(t)\} = a + b t \quad (3)$$

where “b” is actually “-A” or “-1 /  $\tau$ ”

Refer to Figure 3 for an illustration of how Equation 2 and 3 would plot, normalized to  $(t/\tau)$ , which is the same as saying plotting for  $\tau = 1$  just for illustration<sup>2</sup>.



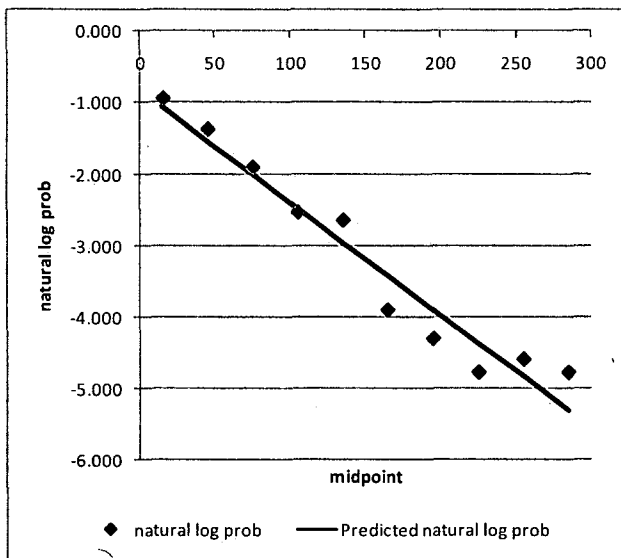
**Figure 3: Plot of Exponential Function**

Figure 4 shows the logarithmic plot of the “data” from Table 1, with the trend line from the data. The “trend line” obtained in Excel is in fact the same as that resulting from a linear regression. If one does the regression using Data Analysis tools in Excel, the result is

$$\text{Estimated time constant} = 60.2 \pm 11.7 \text{ minutes}$$

For present purposes, let us define the use of the regression line in this format as **Method 3** for arriving at an estimate of the time constant.

<sup>2</sup> At one time, it was common to use semi-log paper to plot this, with the scale on the paper taking care of the logarithmic conversion.



midpoint	natural log prob
15	-0.951
45	-1.376
75	-1.903
105	-2.530
135	-2.642
165	-3.895
195	-4.301
225	-4.771
255	-4.588
285	-4.771

**Figure 4: Plot of the Table 1 “Data” in Logarithm Form for the Percent by Category**

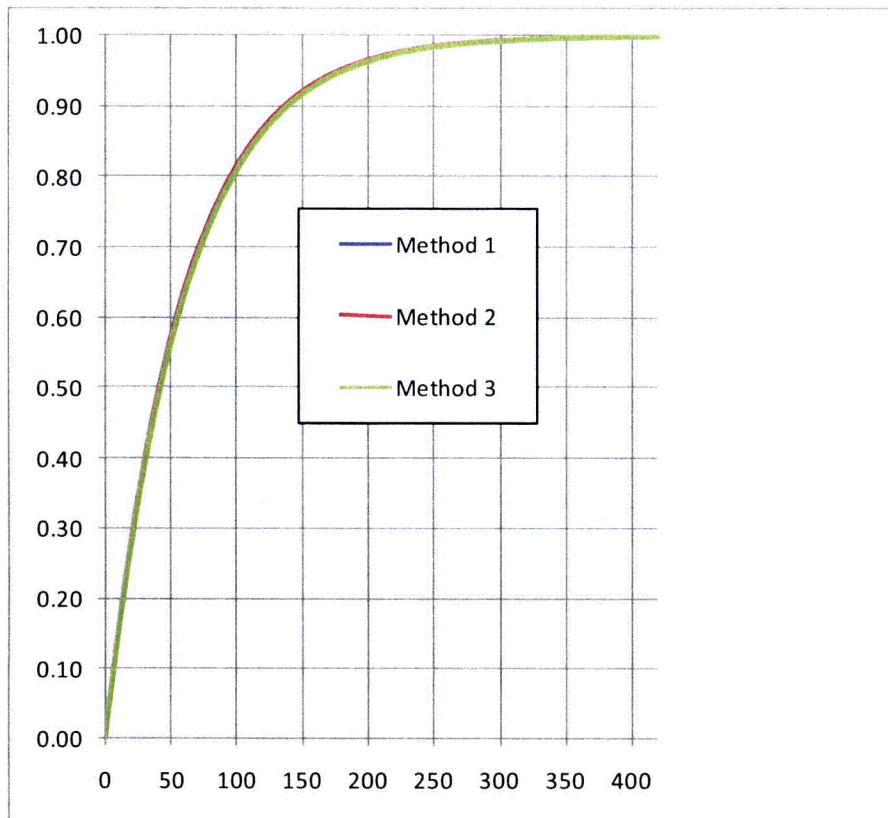
This is rather consistent with the Method 2 estimate of  $59.2 \pm 6.5$  minutes.

Comparing the three “methods” side-by-side, Figure 5 shows a negligible difference in the results, at least on a visual scale. The analyst is to use Method 1, but as this illustration demonstrates, the other methods yield comparable results, with no more than  $\pm 2\%$  on the 50<sup>th</sup> percentile and  $\pm 1\%$  at the 90<sup>th</sup>, 95<sup>th</sup>, or 99<sup>th</sup> percentiles. This is well within the natural variability of the statistics, given the number of samples and the inherent variability in the population. Consider Table 3, as an illustration.

**Table 3: Percentile Results, for Different Methods**

Percentiles indicated, in minutes			
	Method 1	Method 2	Method 3
50th	42	41	42
90th	138	136	139
95th	180	178	180
99th	271	271	273

Note: Add  $T_0 = 20$  minutes for actual mobilization times



**Figure 5: Comparison of Three Methods of Estimating  $\tau$**

### Insights and Guidance for the Analyst

- 1) Method 1 is to be used as the default method. If another method is considered, it must be discussed with the senior analyst and reviewed by the quality control officer.
- 2) Given the natural variability in the data and the survey sample sizes, any differences shown herein are within the expected variability of the results.
- 3) Table 3 illustrates the variability that may arise, in terms of percentile values of the mobilization distribution. As shown in Figure 3, the numbers that appear somewhat different in Table 3 have little practical impact in Figure 5.
- 4) All of the analysis and methods have focused on the most common model of a homogeneous population mobilizing. If there were more complex models (see the next section), the problem can be subdivided into “regimes” and the above

techniques applied within each regime. Because this is not as common, the analyst should review such cases with the senior analyst and quality control officer when they occur.

- 5) Note that the “outlying” points typical of survey responses may shift the mean somewhat, but not in a major way. The methods used do not depend on the outliers as much as on the 98.2% level or the mean. That is, good estimates of the major percentiles can be obtained from the underlying curve, as illustrated in Figure 5.
- 6) In reviewing work, the analyst may find that the mobilization curve is not continued past the 95<sup>th</sup> percentile or that it is sketched unevenly (poorly) past that point. Fortunately, as cited in #5, the time constant  $\tau$  (whether estimated by Methods 1, 2, or 3) is the prime determinant of the curve and of the key percentiles.
- 7) The goodness-of-fit test is intended to assure that the hypothesis of an underlying exponential distribution is plausible. If it is not, the analyst can expect the result of “reject hypothesis” in the analysis illustrated in Table 2.
- 8) Indeed, if the data in the Figure 4 display is done at the time of the goodness-of-fit test, the analyst can then expect the data to not appear randomly distributed about the trend line. In particular, a range that has the values on only one side – notably toward the end – may represent a more complex underlying model.

The conclusion in #8 occurs infrequently, and the senior analyst should then be involved, with a review by the QC officer expected.

### Other Model Forms

Three variations may occur, as illustrated in Figures 6, 7, and 8:

- Figure 6 shows a 2-regime model in which there are two distinct groups *that can be discerned* in the data. For instance, Group 1 may start to leave immediately and follow the basic model pattern. Group 2 may start some time later (due to returns home, etc) and then follow a shifted exponential, perhaps with a different time constant. The curve may also be shifted at  $t = 0$ .
- Figure 7 shows a 3-regime model in which there are three distinct groups *that can be discerned* in the data. The curve may also be shifted at  $t = 0$ .
- Figure 8 shows a delayed curve with a smooth rise (shown compared to the dashed basic model with  $T_0 = 0$ ).

If and when the data displays these unexpected multi-regime patterns, the senior analyst is to be involved, and a special analysis is to be documented and submitted to the QC officer.

--end--

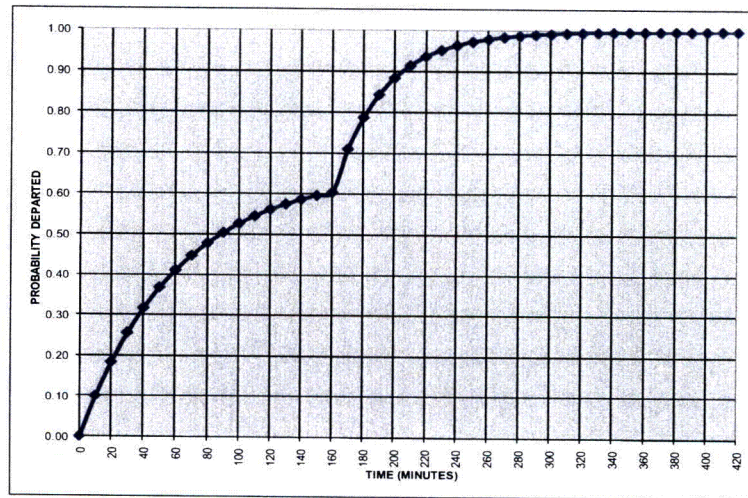


Figure 6: 2-regime model

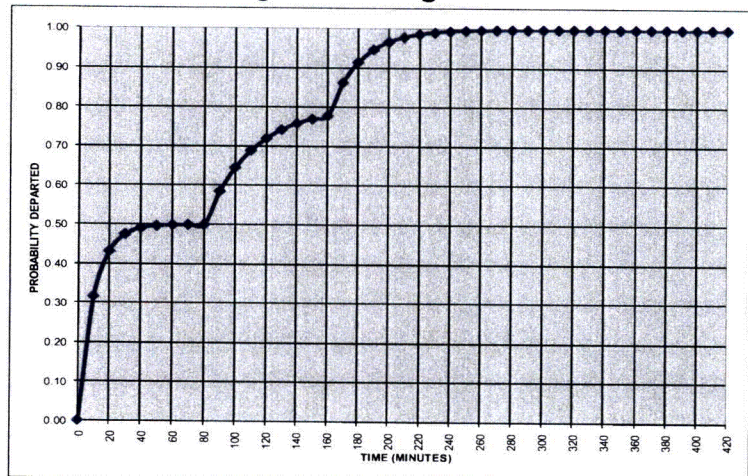


Figure 7: 3-regime model

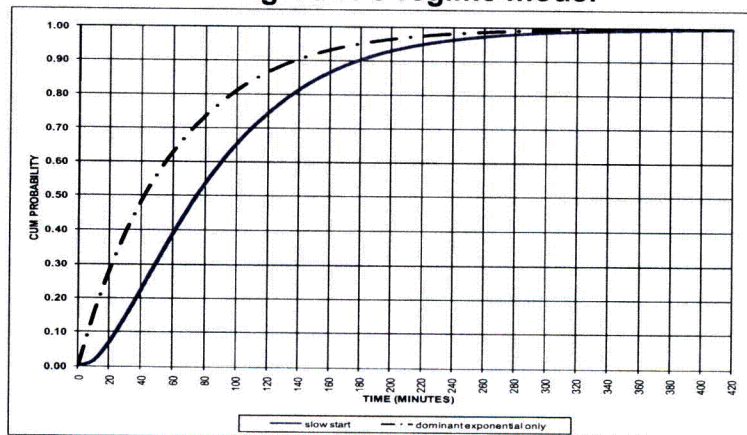


Figure 8: delayed initiation model, compared to basic model