# APPENDIX A

Glossary of Traffic Engineering Terms

## A. GLOSSARY OF TRAFFIC ENGINEERING TERMS

**Table A-1. Glossary of Traffic Engineering Terms**

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

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

## APPENDIX B

DTRAD: Dynamic Traffic Assignment and Distribution Model

## B. DYNAMIC TRAFFIC ASSIGNMENT AND DISTRIBUTION MODEL

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

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

Overview of Integrated Distribution and Assignment Model

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

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

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

Interfacing the DYNEV Simulation Model with DTRAD

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

**DTRAD Description**

DTRAD is the DTA module for the DYNEV II System.

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

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

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

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

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

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

  $s_a = - \beta \ln (p), 0 \leq p \leq 1 ; \beta > 0$

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

  $d_n$ = Distance of node, n, from the plant
  $d_0$ =Distance from the plant where there is zero risk
  $\beta$ = Scaling factor

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

**Network Equilibrium**

In 1952, John Wardrop wrote:

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

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

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

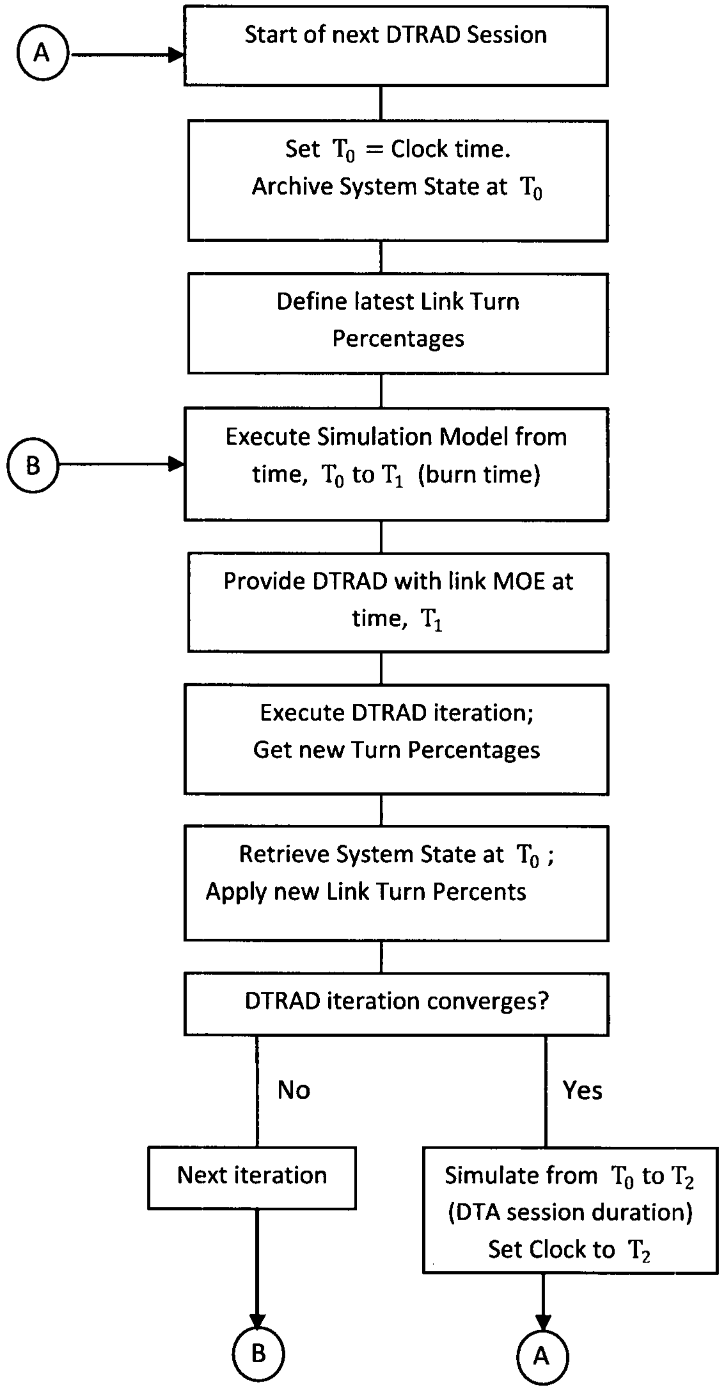



**Figure B-1. Flow Diagram of Simulation-DTRAD Interface**

# APPENDIX C

DYNEV Traffic Simulation Model

# C. DYNEV TRAFFIC SIMULATION MODEL

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

Model Features Include:

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

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

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

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

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

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

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

HIGHWAY NETWORK

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

GENERATED TRAFFIC VOLUMES

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

TRAFFIC CONTROL SPECIFICATIONS

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

DRIVER'S AND OPERATIONAL CHARACTERISTICS

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

DYNAMIC TRAFFIC ASSIGNMENT

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

INCIDENTS

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

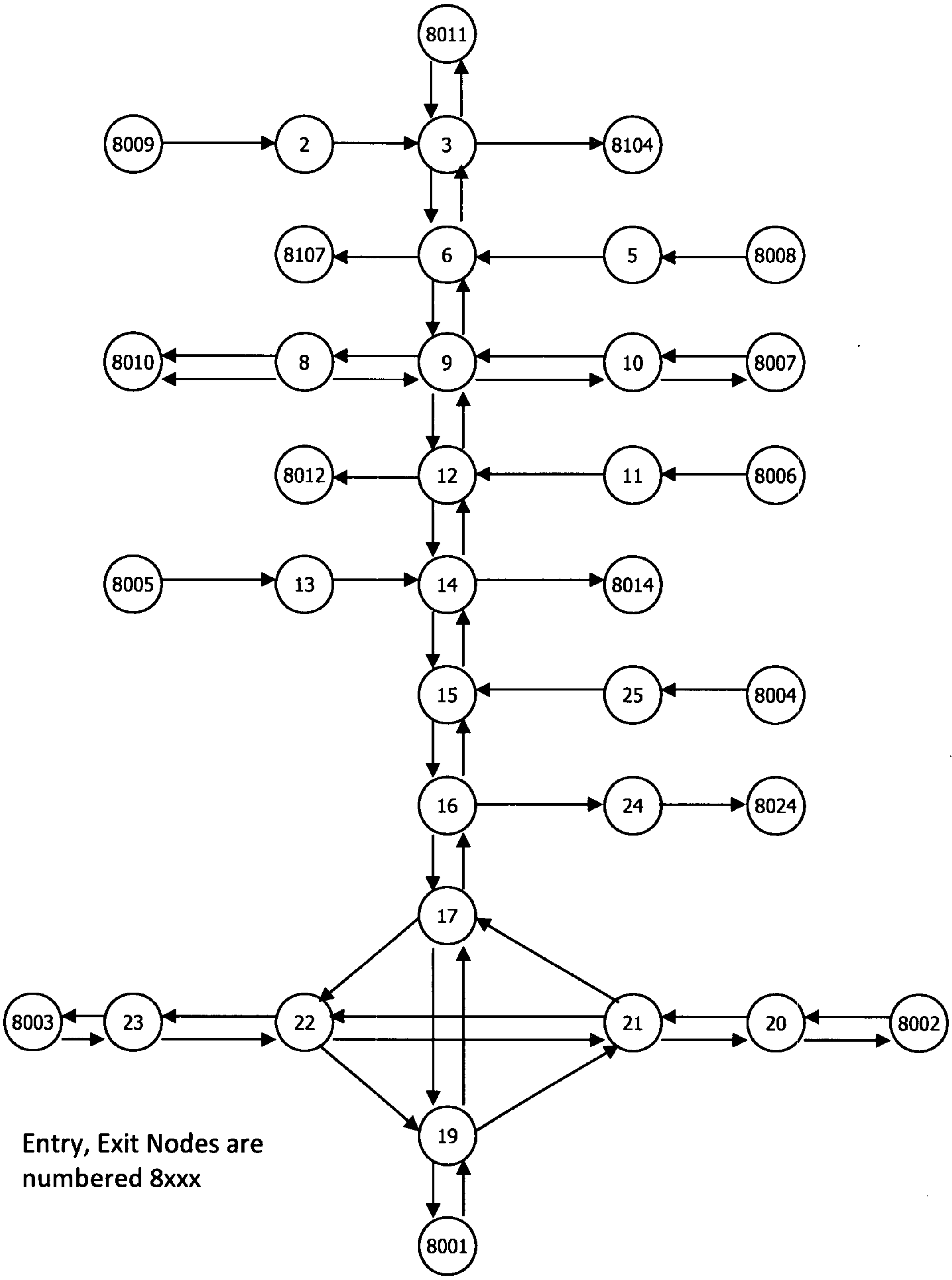



**Figure C-1. Representative Analysis Network**

## C.1 Methodology

### C.1.1 The Fundamental Diagram

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

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

### C.1.2 The Simulation Model

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

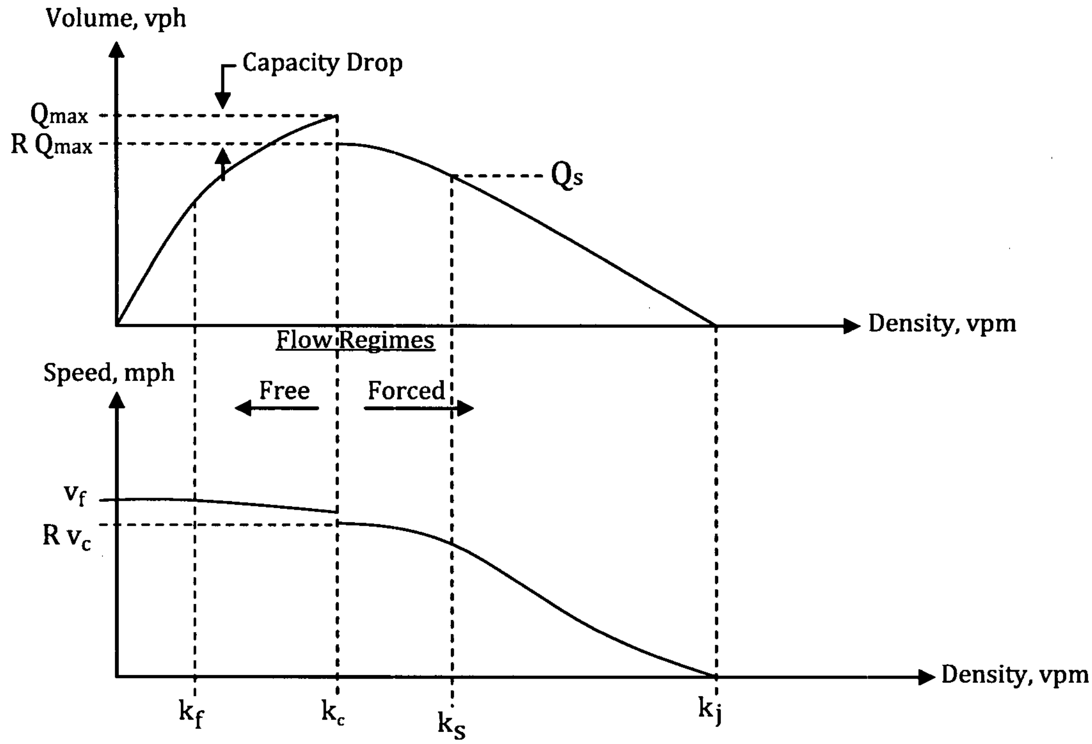



**Figure C-2. Fundamental Diagrams**

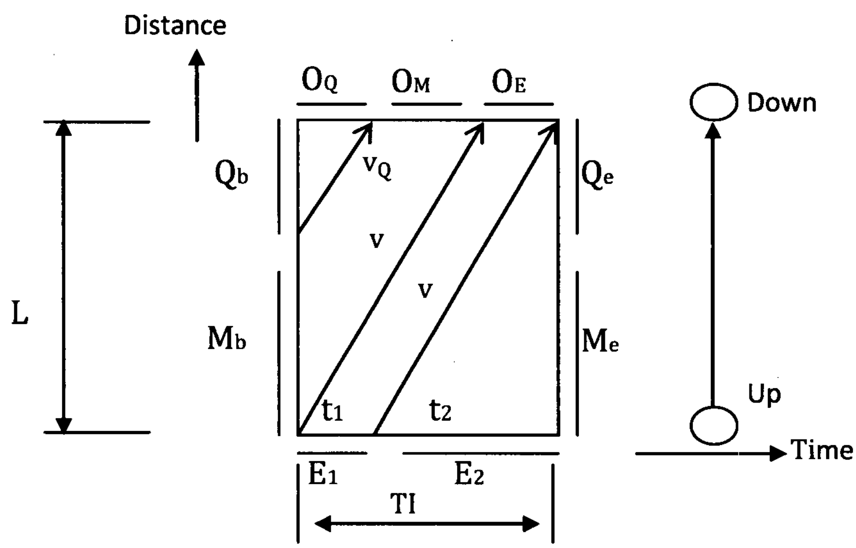



**Figure C-3. A UNIT Problem Configuration with $t_1 > 0$**

**Table C-3. Glossary**

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

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

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

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

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

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

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

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

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

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

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

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

$Q'_e = E_1 - O_E$

If $Q'_e > 0$, then

Calculate $Q_e$, $M_e$ with Algorithm A

Else

$Q_e = 0$, $M_e = E_2$

End if

Else $(t_1 = 0)$

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

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

End if

9. Else $(M_b > RCap)$

$O_E = 0$

If $t_1 > 0$, then

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

Calculate $Q_e$ and $M_e$ using Algorithm A

10. Else $(t_1 = 0)$

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

If $M_d > RCap$, *then*

$O_M = RCap$

$Q'_e = M_d - O_M$

Apply Algorithm A to calculate $Q_e$ and $M_e$

Else

$O_M = M_d$

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

End if

End if

End if

End if

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

where $k_b$ = density at the beginning of the TI

$k_e$ = density at the end of the TI

$k_m$ = density at the mid-point of the TI

All values of density apply only to the <u>moving</u> vehicles.

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

where $N$ = max number of iterations, and $\epsilon$ is a convergence criterion, then

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

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

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

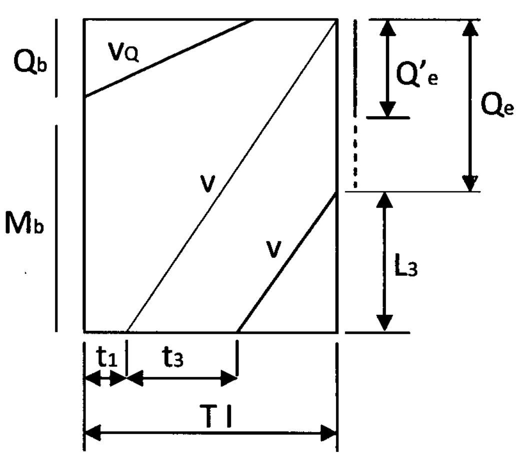
The number of excess vehicles that cause spillback is: $SB = Q_e + M_e - \frac{(L-W)\cdot LN}{L_v}$ , where W is the width of the upstream intersection. To prevent spillback, meter the outflow from the feeder approaches and from the source flow, S, during this TI by the amount, SB. That is, set

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

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

*Algorithm A*

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




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

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

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

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

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

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

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

### C.1.3 Lane Assignment

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

## C.2 Implementation

### C.2.1 Computational Procedure

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

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

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

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

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

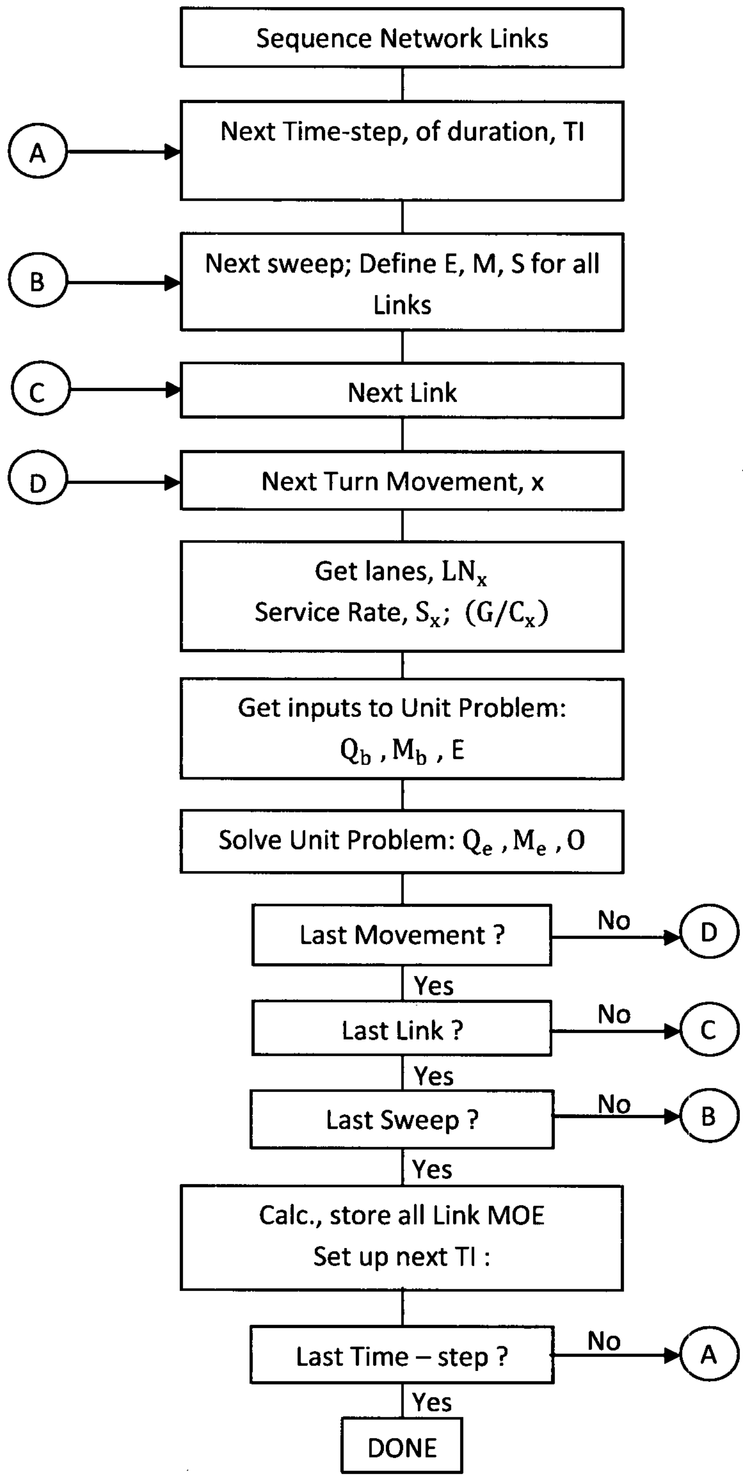



**Figure C-4. Flow of Simulation Processing (See Glossary: Table C-3)**

### C.2.2 Interfacing with Dynamic Traffic Assignment (DTRAD)

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

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

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

Additional details are presented in Appendix B.

## APPENDIX D

Detailed Description of Study Procedure

## D. DETAILED DESCRIPTION OF STUDY PROCEDURE

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

Step 1

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

Step 2

2010 Census block information was obtained in GIS format. This information was used to estimate the resident population within the EPZ and Shadow Region and to define the spatial distribution and demographic characteristics of the population within the study area. Employee data were estimated from phone calls to major employers supplemented with research from the U.S. Census Bureau's Longitudinal Employer-Household Dynamics interactive website[1]. Transient data were obtained from phone calls to the transient attractions. Information concerning schools, medical and other types of special facilities within the EPZ was obtained from county and municipal sources.

Step 3

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

Step 4

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

[1]http://lehdmap.did.census.gov/

Step 5

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

Step 6

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

Step 7

The EPZ is subdivided into 11 Zones. Based on wind direction and speed, Regions (groupings of Zones) that may be advised to evacuate, were developed.

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

Step 8

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

Step 9

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

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

Step 10

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

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

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

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

Step 11

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

Step 12

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

Step 13

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

Step 14

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

Step 15

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

Step 16

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

Step 17

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

Step 18

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

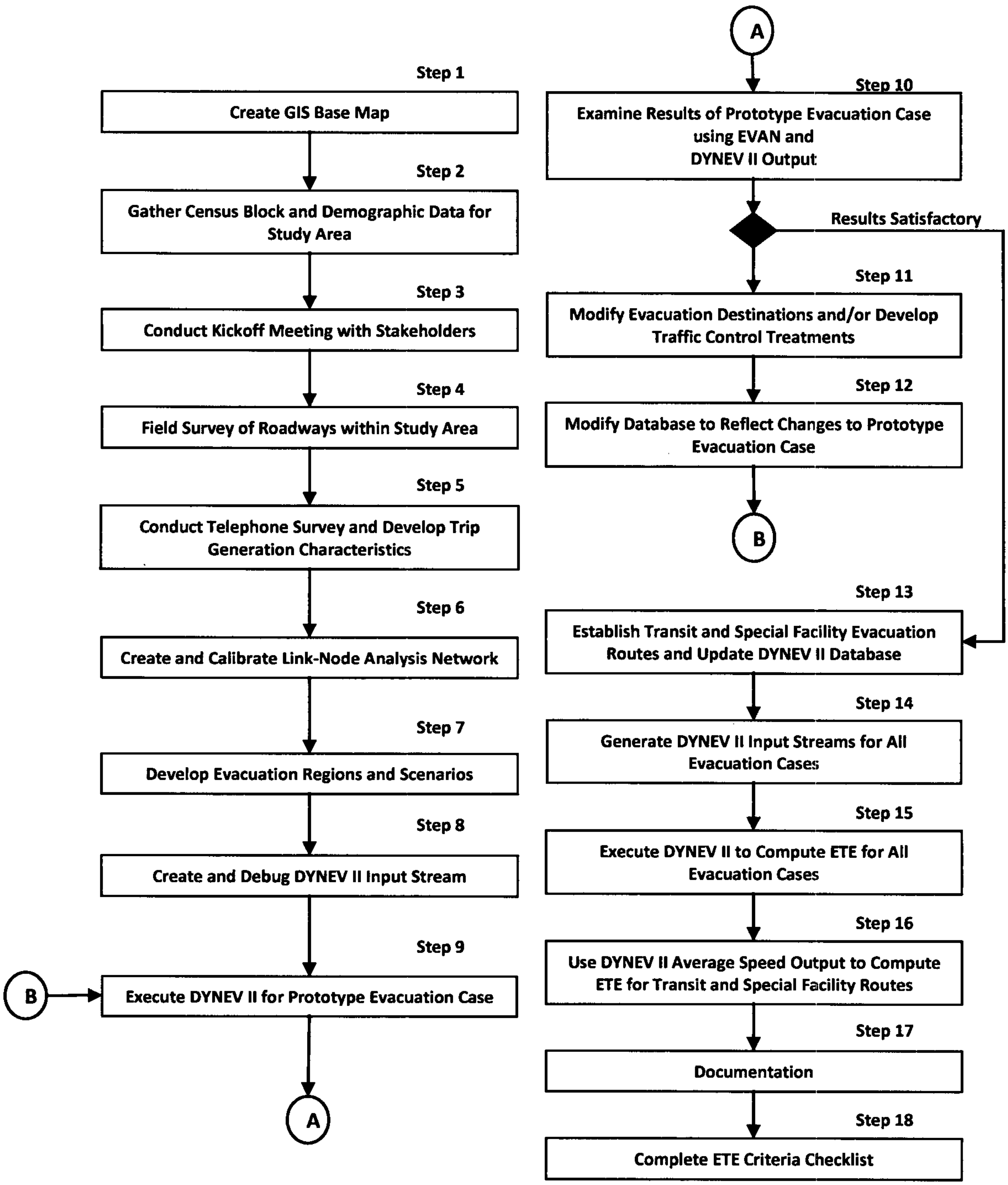



**Figure D-1. Flow Diagram of Activities**

# APPENDIX E

Facility Data

## E. FACILITY DATA

The following tables list population information, as of July 2012, for special facilities, transient attractions and major employers that are located within the Robinson EPZ. Special facilities are defined as schools, day care centers, hospitals and other medical care facilities. Transient population data is included in the tables for recreational areas, lodging facilities and the college. Employment data is included in the tables for major employers. Each table is grouped by county. The location of the facility is defined by its straight-line distance (miles) and direction (magnetic bearing) from the center point of the plant. Maps of each school, day care center, recreational area, lodging facility, and major employer are also provided.

**Table E-1. Schools within the EPZ**

| Zone | Distance (miles) | Dire-ction | School Name | Street Address | Municipality | Phone | Enroll-ment |
|---|---|---|---|---|---|---|---|
| **Chesterfield, SC** | | | | | | | |
| E-2 | 6.8 | NW | McBee Elementary School | 284 East Maple St | McBee | 843-335-8347 | 385 |
| E-2 | 6.9 | NW | McBee High School | 264 East Pine Ave | McBee | 843-335-8251 | 491 |
| E-2 | 7.0 | WNW | McBee Headstart | 168 E Union Church Rd | McBee | 843-335-6506 | NDA* |
| | | | | | | *Chesterfield Subtotals:* | *876* |
| **Darlington, SC** | | | | | | | |
| B-1 | 4.5 | E | Lakeview Baptist Church School | 202 Lakeview Blvd | Hartsville | 843-332-8427 | 61 |
| B-1 | 4.7 | ESE | Carolina Elementary School | 719 West Carolina Ave | Hartsville | 843-383-3112 | 278 |
| B-1 | 4.7 | E | North Hartsville Elementary School | 110 School Dr | Hartsville | 843-383-3115 | 678 |
| B-1 | 5.0 | ESE | First Presbyterian Church School | 213 West Home Ave | Hartsville | 843-332-3622 | 10 |
| B-1 | 5.0 | ESE | Hartsville Middle School | 437 West Carolina Ave | Hartsville | 843-383-3121 | 1,123 |
| B-1 | 5.1 | ESE | 1st Baptist Church Preschool | 104 East Home Ave | Hartsville | 843-332-6571 | 83 |
| B-1 | 5.1 | SE | Hartsville Senior High School | 701 Lewellen Ave | Hartsville | 843-383-3130 | 1,350 |
| B-1 | 5.4 | ESE | Coker College | 300 East College Ave | Hartsville | 843-383-8000 | 875 |
| B-1 | 5.5 | ESE | Washington Street Elementary School | 325 Washington St | Hartsville | 843-383-3141 | 325 |
| B-1 | 5.6 | ESE | Thornwell School for the Arts | 604 East Home Ave | Hartsville | 843-857-3090 | 400 |
| B-1 | 5.7 | ESE | Governor's School for Science & Math | 401 Railroad Ave | Hartsville | 843-383-3900 | 175 |
| B-1 | 5.9 | SE | Southside Early Childhood Center | 1615 Blanding Dr | Hartsville | 843-383-3105 | 410 |
| B-1 | 6.0 | ESE | Eastside Christian Academy | 911 East Home Ave | Hartsville | 843-332-6295 | 35 |
| B-2 | 7.7 | E | Emmanuel Christian School | 1001 N. Marquis Hwy | Hartsville | 843-332-0164 | 363 |
| B-2 | 10.7 | SE | Calvary Christian School | 1812 E. Bobo Newsom Highway | Hartsville | 843-383-6180 | 22 |
| C-1 | 3.3 | SSE | Forest Hills Academy | 317 Forrest Hills Dr | Hartsville | 843-332-7811 | 12 |
| C-1 | 3.4 | SSE | West Hartsville Elementary School | 214 Clyde Road | Hartsville | 843-857-3270 | 172 |
| C-2 | 8.5 | SE | Thomas Hart Academy | 852 Flinns Rd | Hartsville | 843-332-4991 | 140 |
| | | | | | | *Darlington Subtotals:* | *6,512* |
| | | | | | | **TOTAL:** | **7,388** |

**Table E-2. Preschools and Daycares within the EPZ**

| Zone | Distance (miles) | Dire-ction | School Name | Street Address | Municipality | Phone | Enroll-ment |
|---|---|---|---|---|---|---|---|
| Darlington, SC | | | | | | | |
| B-1 | 4.0 | SE | St Luke United Methodist Preschool | 302 Dumlap Dr | Hartsville | 843-383-5169 | 44 |
| B-1 | 4.1 | ENE | Ginger A Shoemake | 122 Wakefield Dr | Hartsville | 843-858-3969 | 6 |
| B-1 | 4.2 | SE | Children's Corner | 143 Gardner Dr | Hartsville | 843-383-6176 | 100 |
| B-1 | 4.3 | E | Evelyn J. Purvis | 536 Davidson St | Hartsville | 843-332-1438 | 6 |
| B-1 | 4.4 | E | A Kidz Place I | 113 Jackson St | Hartsville | 843-332-4004 | 33 |
| B-1 | 4.4 | E | Kids N Me | 521 Johnson St | Hartsville | 843-383-2090 | 35 |
| B-1 | 4.5 | E | Barbara Tyner's Daycare | 408 Bluff Rd | Hartsville | 843-332-7359 | 35 |
| B-1 | 4.6 | E | Sandra Cook | 301 Bluff Road | Hartsville | 843-383-6072 | 6 |
| B-1 | 4.6 | ESE | True Saints Church of God in Christ | 744 W. Carolina Ave | Hartsville | 843-857-9944 | 40 |
| B-1 | 4.7 | SE | Carolina Girls & Barefoot Boys Daycare Center | 843 W. Carolina Ave | Hartsville | 843-917-0207 | 36 |
| B-1 | 4.8 | ESE | Kings Kids Children's Center | 513 W. Carolina Ave | Hartsville | 843-332-8060 | 55 |
| B-1 | 4.8 | SE | Peggy Fairland Bridges | 605 14th St | Hartsville | 843-383-5665 | 12 |
| B-1 | 5.0 | SE | Jill Beckham | 728 Lewellen Ave | Hartsville | 843-332-4545 | 6 |
| B-1 | 5.1 | ESE | First Baptist Weekday Preschool | 104 East Home Ave | Hartsville | 843-878-0455 | 97 |
| B-1 | 5.1 | E | Pure Word Ministries | 430 Society Ave | Hartsville | 843-383-9178 | NDA* |
| B-1 | 5.2 | E | Agnes Scurry | 524 Society Ave | Hartsville | 843-332-4820 | 6 |
| B-1 | 5.3 | ESE | YMCA After School Program[1] | 111 E Carolina Ave | Hartsville | 843-383-4547 | 160 |
| B-1 | 5.4 | E | Thompson's Unique Learning Center | 825 Society Dr | Hartsville | 843-857-9599 | NDA* |
| B-1 | 5.5 | ESE | Thompson Children Learning Center | 516 Elm St | Hartsville | 843-857-9599 | 19 |
| B-1 | 5.6 | ESE | Mary Jean Young | 742 South 6th St | Hartsville | 843-332-2192 | 6 |
| B-1 | 5.6 | ESE | St. Joseph Head Start | 305 Washington St | Hartsville | 843-332-6593 | 212 |
| B-1 | 5.7 | ESE | New Vision - CDC - Magnolia Child Care | 919 S. 6th St | Hartsville | 843-383-2865 | 56 |
| B-1 | 5.9 | ESE | Butler Head Start Center | 1103 C South Sixth St | Hartsville | 843-339-9679 | 120 |

| Zone | Distance (miles) | Dire-ction | School Name | Street Address | Municipality | Phone | Enroll-ment |
|---|---|---|---|---|---|---|---|
| B-1 | 6.1 | ESE | A Kidz Place II | 900 S 4Th St | Hartsville | 843-383-5143 | 62 |
| B-1 | 6.1 | ESE | Kid'N Around | 508 Swift Creek Rd | Hartsville | 843-857-0220 | 29 |
| B-2 | 5.9 | E | Tracy Goodman | 1314 Griggs Circle | Hartsville | 843-383-5411 | 6 |
| B-2 | 9.2 | E | Jeanette Pendergrass | 509 Centerville Rd | Hartsville | 843-857-9302 | 12 |
| B-2 | 9.2 | E | Nazareth Day Care & | 617 Amherst Dr | Hartsville | 843-332-1098 | 28 |
| C-1 | 2.8 | SSE | Susan Watkins | 431 Hawthorne Dr | Hartsville | 843-332-1082 | 12 |
| C-1 | 3.2 | SSE | Linda Kelley | 2541 Highline St | Hartsville | 843-332-3863 | 6 |
| C-1 | 3.3 | SSE | Shelby Perdue | 2532 Stadium Rd | Hartsville | 843-332-2933 | 6 |
| C-1 | 3.8 | SSE | Kelleytown Baptist Church | 2609 Kelleytown Rd | Hartsville | 843-332-8092 | NDA* |
| C-1 | 6.1 | SE | Dale Arthur | 607 Birchleaf Dr | Hartsville | 843-383-6237 | 6 |
| C-2 | 11.2 | SSE | St. John Head Start Center | 207 West Seven Pines Rd | Lamar | 843-332-6593 | 248 |
| C-2 | 11.3 | SSE | Luann Johnson | 223 Philadelphia St | Hartsville | 843-383-3741 | 6 |
| C-2 | 11.7 | SE | Jermika Couplin | 2129 E. Bobo Newsome Highway | Hartsville | 843-332-8699 | 6 |
| D-1 | 2.5 | SW | Patricia Phillips Daycare | 3012 W Old Camden Rd | Hartsville | 843-332-2467 | 13 |
| | | | | | | TOTAL: | 1,530 |

[1] The YMCA After School Program is not a licensed daycare and is exempt from South Carolina DSS licensing requirements.

*NDA = No Data Available

**Table E-3. Medical Facilities within the EPZ**

| Zone | Distance (miles) | Direction | Facility Name | Street Address | Municipality | Phone | Current Census | Ambulatory Patients | Wheelchair Patients | Bedridden Patients |
|---|---|---|---|---|---|---|---|---|---|---|
| **Darlington, SC** | | | | | | | | | | |
| B-1 | 3.3 | SE | Morningside of Hartsville | 1901 W. Carolina Ave | Hartsville | 843-857-0159 | 39 | 34 | 5 | 0 |
| B-1 | 4.8 | SE | Carolina Pines Regional Medical Center | 1304 W. Bobo Newsome Highway | Hartsville | 843-339-2100 | 116 | 81 | 0 | 35 |
| B-1 | 5.0 | SE | Thad E. Saleeby Development Center | 714 Lewellen Ave | Hartsville | 843-332-4104 | 85 | 5 | 0 | 80 |
| B-1 | 6.6 | ESE | Carriage House of Hartsville | 1131 E. Home Ave | Hartsville | 843-383-6990 | 60 | 60 | 0 | 0 |
| B-2 | 7.6 | E | Morrell Memorial Convalescent Center | 900 N. Marquis Hwy | Hartsville | 843-383-5164 | 154 | 34 | 113 | 7 |
| | | | | | | **TOTAL:** | **454** | **214** | **118** | **122** |

**Table E-4. Major Employers within the EPZ**

| Zone | Distance (miles) | Dire-ction | Facility Name | Street Address | Municipality | Phone | Employees (max shift) | % Non-EPZ | Employees (Non EPZ) |
|---|---|---|---|---|---|---|---|---|---|
| **Chesterfield, SC** | | | | | | | | | |
| E-2 | 6.7 | WNW | Talley Metals Technology Inc. | 205 Talley Metal Ln | McBee | 843-335-7540 | 145 | 53.5% | 78 |
| E-2 | 7.0 | WNW | Mar Mac Manufacturing | 884 S Seventh St | McBee | 843-335-5814 | 295 | 53.5% | 158 |
| E-2 | 7.2 | NW | A O Smith Water Products | 25589 U.S. 1 | McBee | 843-335-8281 | 450 | 90% | 315 |
| E-2 | 7.4 | NW | Mar Mac Construction | 334 N 7th St. | McBee | 843-335-5814 | 275 | 53.5% | 147 |
| E-2 | 7.8 | NW | Mc Leod Farms | 25455 U.S. 1 | McBee | 843-335-8611 | 220 | 10% | 22 |
| | | | | | | *Chesterfield Subtotals:* | *1,385* | *-* | *720* |
| **Darlington, SC** | | | | | | | | | |
| A-0 | 0.0 | - | Robinson Nuclear Plant | 3581 W. Entrance Rd | Hartsville | 843-857-1279 | 578 | 50.0% | 289 |
| B-1 | 4.7 | E | North Hartsville Elementary School | 110 School Dr | Hartsville | 843-383-3115 | 70 | 53.5% | 37 |
| B-1 | 4.8 | SE | Carolina Pines Regional Medical Center | 1304 W. Bobo Newsome Hwy | Hartsville | 843-339-2100 | 441 | 53.5% | 161 |
| B-1 | 5.0 | ESE | Hartsville Middle School | 437 W. Carolina Ave | Hartsville | 843-383-3121 | 120 | 53.5% | 64 |
| B-1 | 5.0 | SE | Thad E. Saleeby Development Center | 714 Lewellen Ave | Hartsville | 843-332-4104 | 75 | 53.5% | 40 |
| B-1 | 5.1 | SE | Hartsville Senior High School | 701 Lewellen Ave | Hartsville | 843-383-3130 | 1025 | 53.5% | 548 |
| B-1 | 5.5 | ESE | Washington Street Elementary School | 325 Washington Street | Hartsville | 843-383-3141 | 50 | 53.5% | 27 |
| B-1 | 5.9 | SE | Southside Early Childhood Center | 1615 Blanding Dr | Hartsville | 843-383-3105 | 62 | 53.5% | 33 |
| B-1 | 5.4 | ESE | Coker College | 300 East College Ave | Hartsville | 843-383-8000 | 300 | 53.5% | 94 |
| B-1 | 5.4 | ESE | Sonoco Products Company | 1 N 2nd St | Hartsville | 843-383-7000 | 1,500 | 53.5% | 530 |
| B-1 | 5.6 | ESE | Thornwell School for the Arts | 604 East Home Ave | Hartsville | 843-857-3090 | 50 | 53.5% | 27 |
| B-1 | 5.7 | ESE | Governor's School for Science & Math | 401 Railroad Ave | Hartsville | 843-383-3900 | 56 | 53.5% | 30 |
| B-2 | 6.0 | E | Amspak, Inc. | 1832 North 5th St | Hartsville | 843-332-3314 | 50 | 53.5% | 27 |
| B-1 | 6.0 | ESE | Stingray Boats | 625 Railroad Ave | Hartsville | 843-383-4507 | 240 | 53.5% | 128 |
| B-2 | 6.9 | ESE | JBE, Inc. | 512 Hartland Dr | Hartsville | 843-332-0589 | 80 | 53.5% | 43 |
| C-1 | 4.3 | SE | Anderson Brass Company | 1629 West Bobo Newsom Highway | Hartsville | 843-332-4111 | 85 | 53.5% | 45 |
| C-2 | 7.1 | SSE | RBC Bearings | 2268 S 5th St | Hartsville | 843-332-2691 | 140 | 53.5% | 75 |
| | | | | | | *Darlington Subtotals:* | *4,922* | *-* | *2,198* |
| | | | | | | **TOTAL:** | **6,307** | **-** | **2,918** |

**Table E-5. Recreational Areas and Lodging within the EPZ**

| Zone | Distance (miles) | Dire-ction | Facility Name | Street Address | Municipality | Phone | Transients | Vehicles |
|---|---|---|---|---|---|---|---|---|
| | | | | Darlington, SC | | | | |
| B-1 | 4.9 | ESE | Hartsville Motel | 806 North 5th St | Hartsville | 843-332-6556 | 21 | 21 |
| B-1 | 5.1 | E | Lakeview Motel | 942 North 5th St | Hartsville | 843-332-8145 | 6 | 6 |
| B-1 | 5.4 | ESE | Fairfield Inn Hartsville | 200 South 4th St | Hartsville | 843-332-9898 | 21 | 21 |
| B-1 | 5.9 | ESE | Comfort Inn | 903 South 5th St | Hartsville | 843-383-0110 | 43 | 22 |
| B-1 | 5.3 | ESE | Oak Manor Inn | 314 East Home Ave | Hartsville | 843-383-9553 | 4 | 4 |
| B-1 | 5.4 | ESE | Coker College[1] | 300 East College Ave | Hartsville | 843-383-8000 | 187 | 178 |
| B-2 | 6.6 | ESE | The Landmark Inn | 1301 South 4th Str | Hartsville | 843-332-2611 | 78 | 39 |
| C-2 | 9.1 | SSE | Fox Golf Club | 2433 Tomahawk Rd | Lamar | 843-332-0613 | 20 | 10 |
| | | | | Landings in Darlington Emergency Plans[2] | | | | |
| A-0 | 0.8 | E | Johnson's Landing | Hillview Dr | Hartsville | NA | 0 | 0 |
| A-0 | 1.7 | NNE | Easterling's Landing | Easterling Landing Rd | Hartsville | NA | 0 | 0 |
| B-2 | 5.2 | E | Sonovista Landing | Sonovista Dr | Hartsville | NA | 0 | 0 |
| | | | | | | **TOTAL:** | **380** | **301** |

[1] Coker College commuter students are listed here as their travel patterns are similar to that of a transient. See Section 3.3 for details.

[2] Landings listed in Darlington County Emergency plans considered to be local usage only.

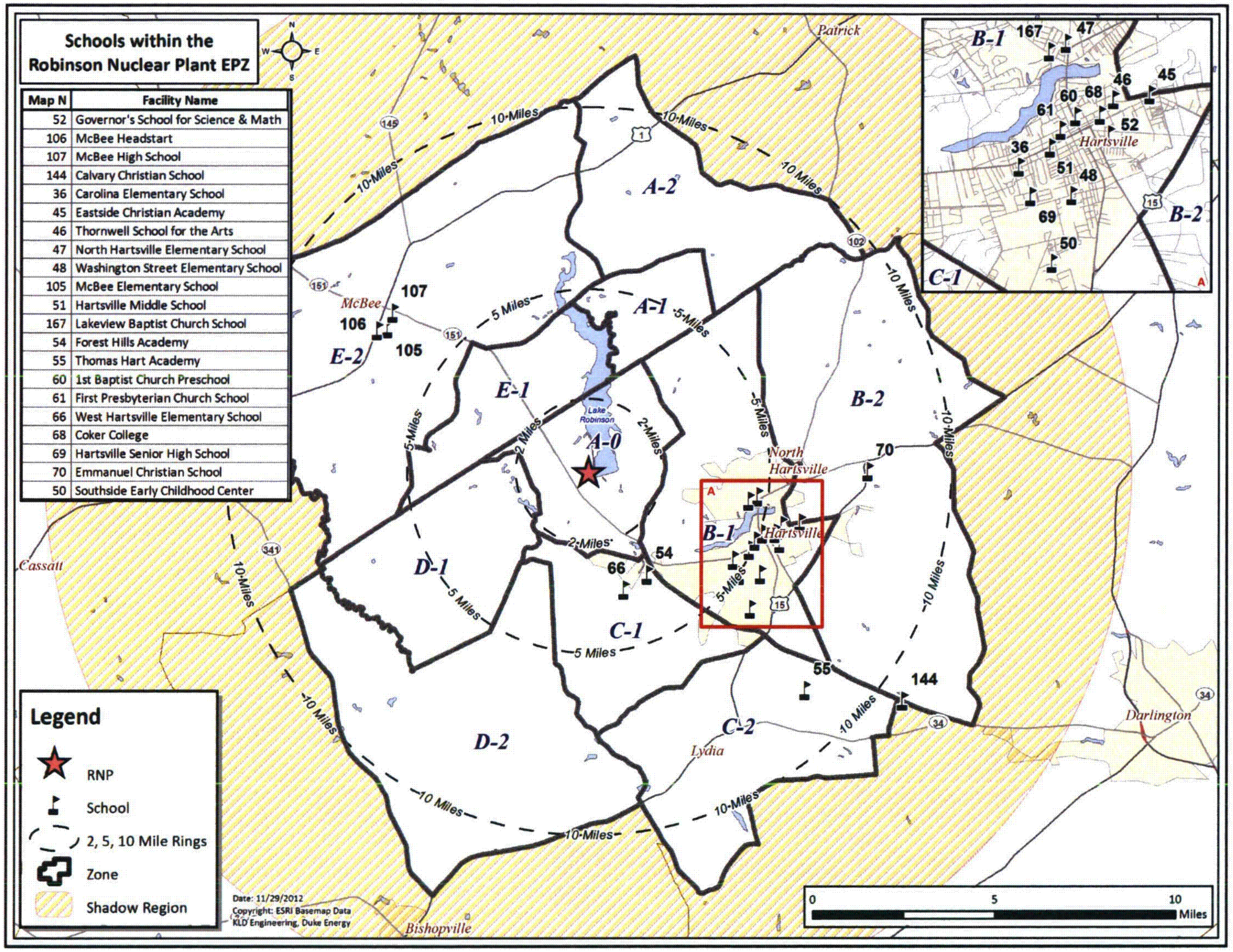
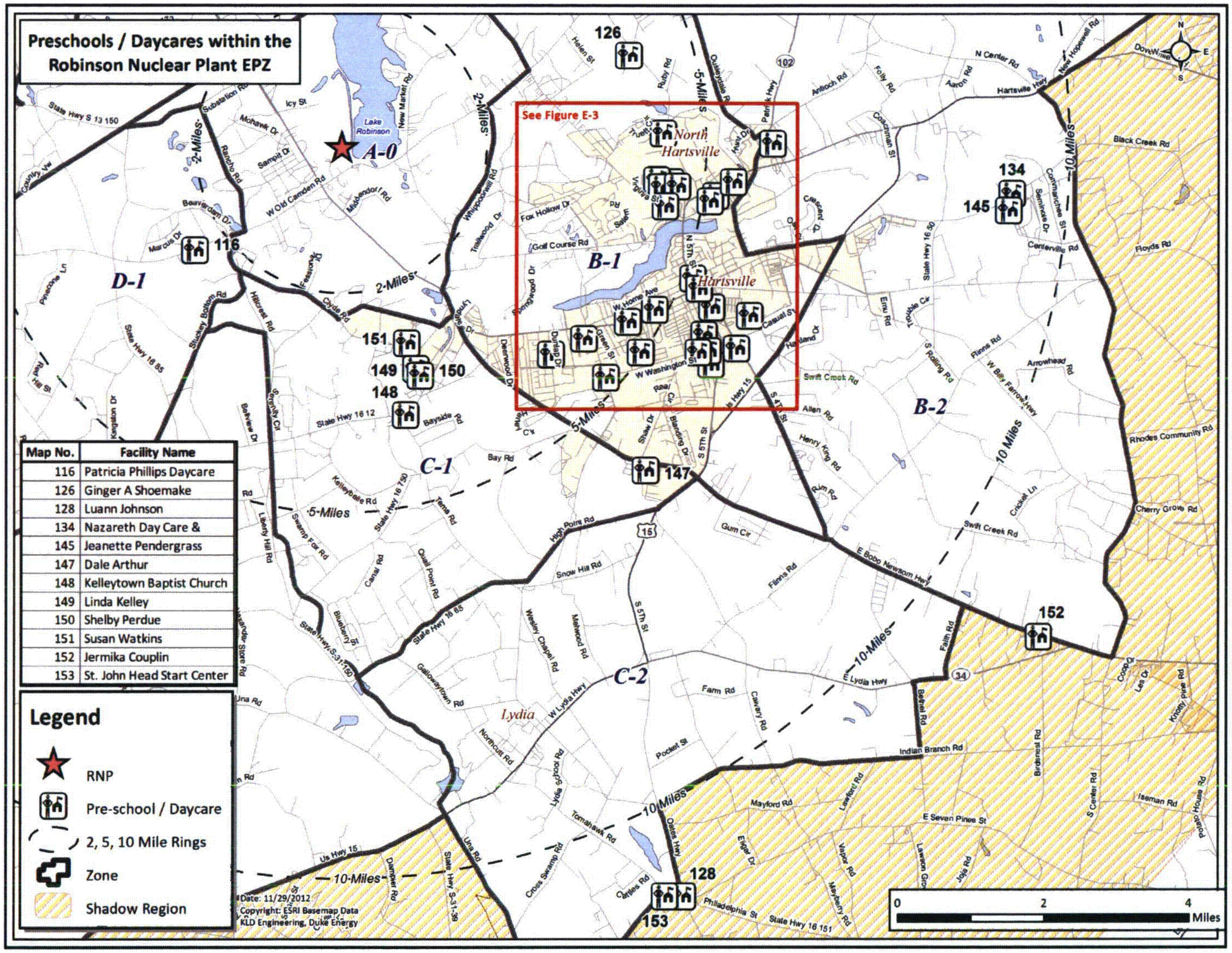



**Figure E-1. Schools within the EPZ**




| Map No. | Facility Name |
|---|---|
| 116 | Patricia Phillips Daycare |
| 126 | Ginger A Shoemake |
| 128 | Luann Johnson |
| 134 | Nazareth Day Care & |
| 145 | Jeanette Pendergrass |
| 147 | Dale Arthur |
| 148 | Kelleytown Baptist Church |
| 149 | Linda Kelley |
| 150 | Shelby Perdue |
| 151 | Susan Watkins |
| 152 | Jermika Couplin |
| 153 | St. John Head Start Center |

**Figure E-2. Preschools / Daycares within the EPZ**

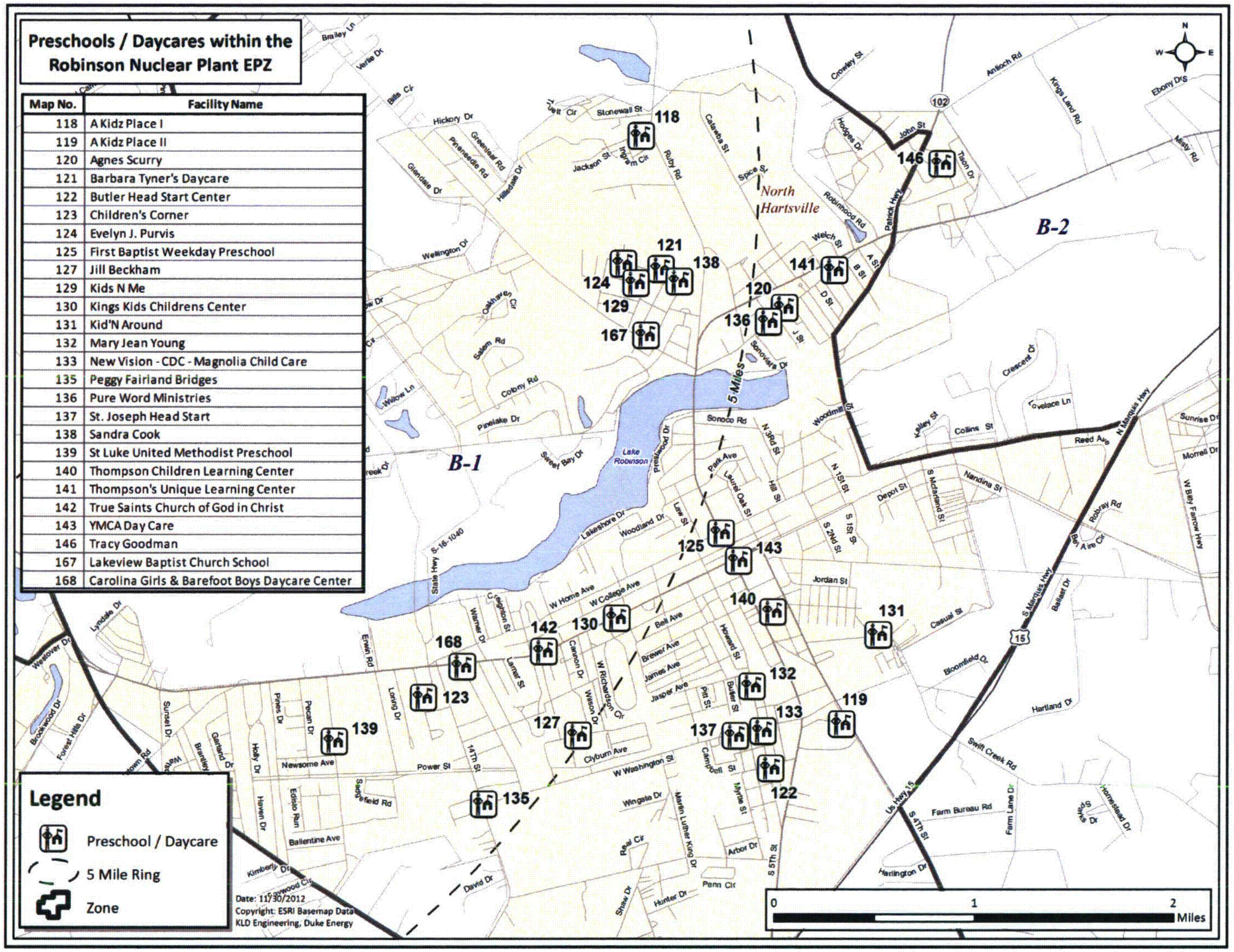
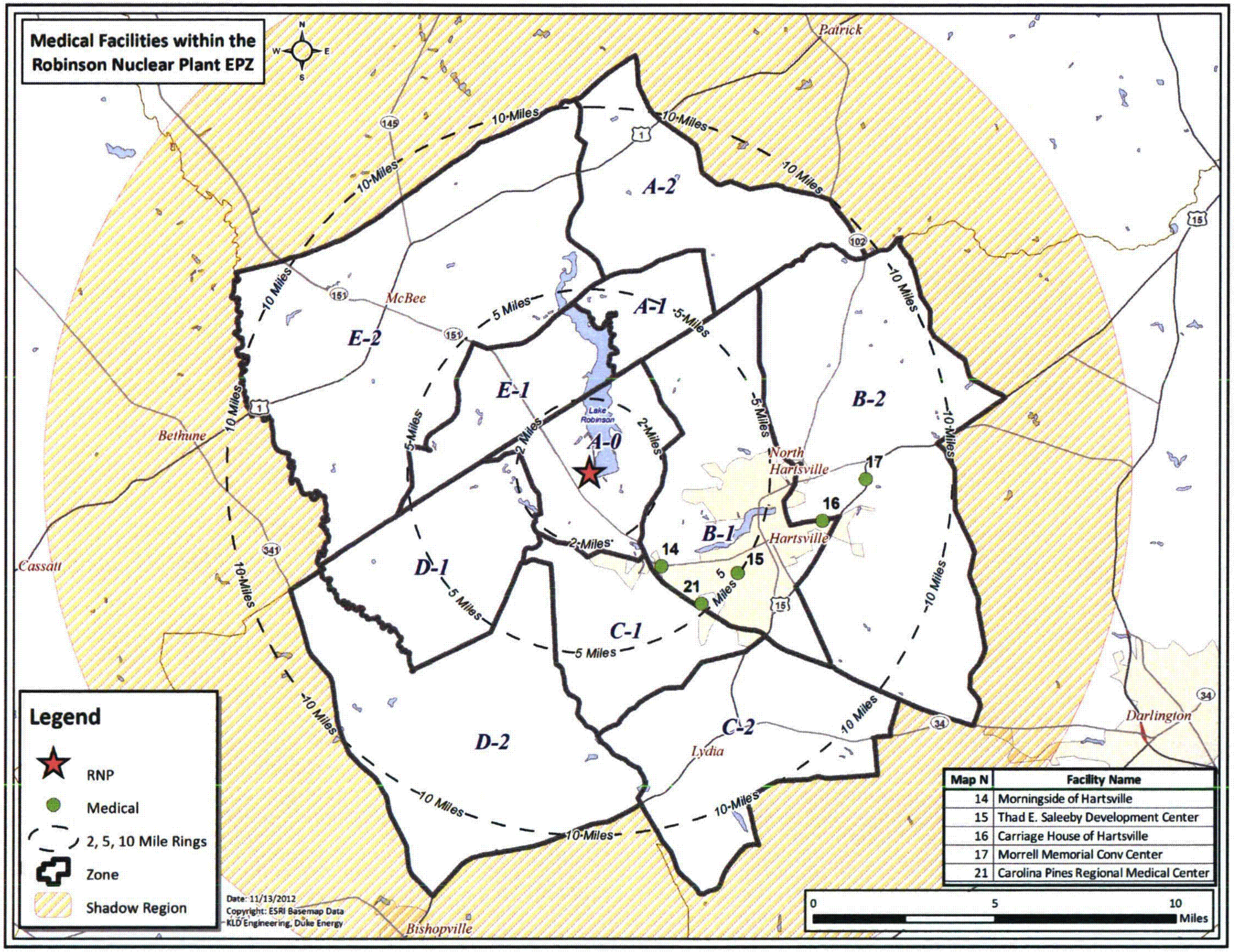
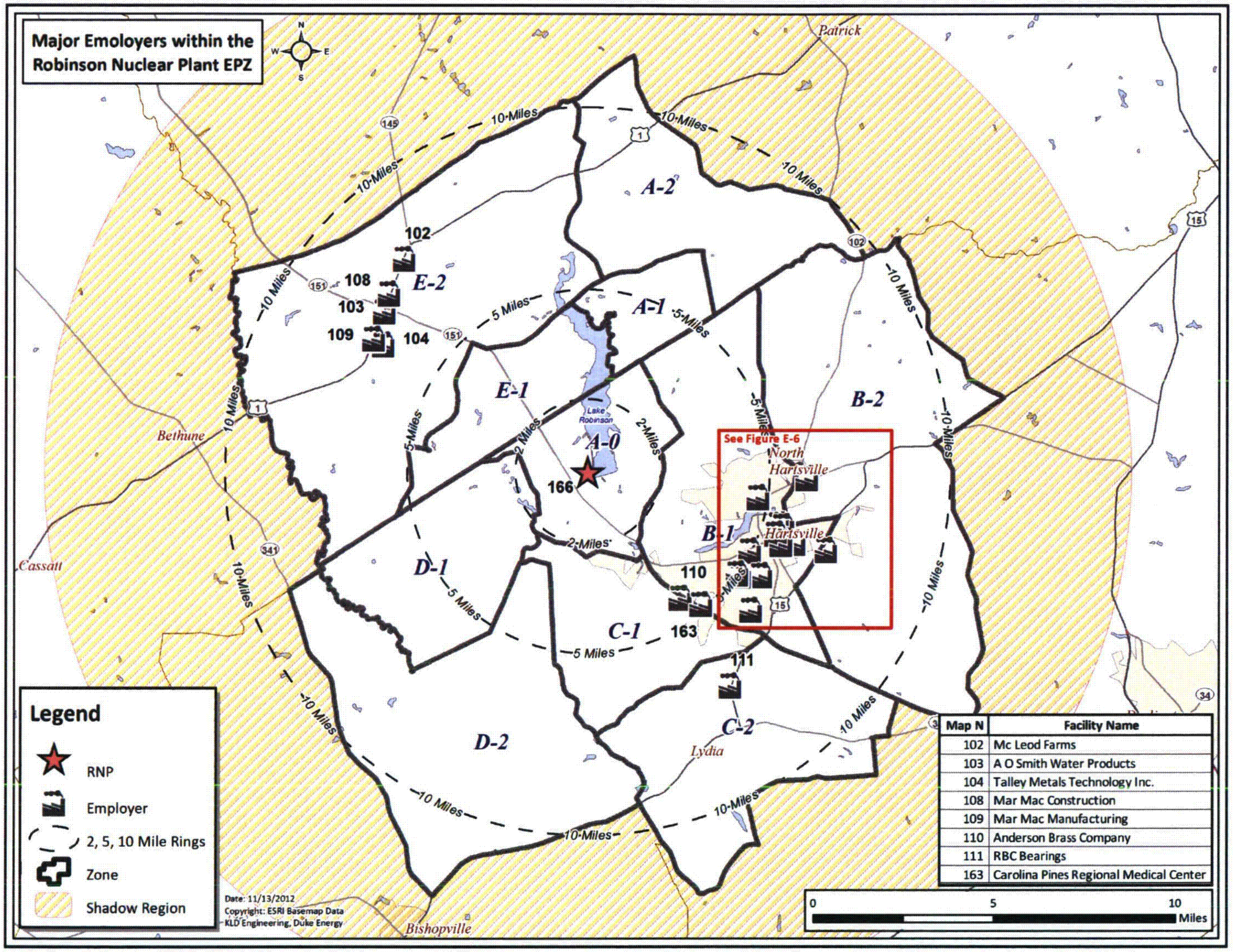



**Figure E-3. Preschools / Daycares within Downtown Hartsville**



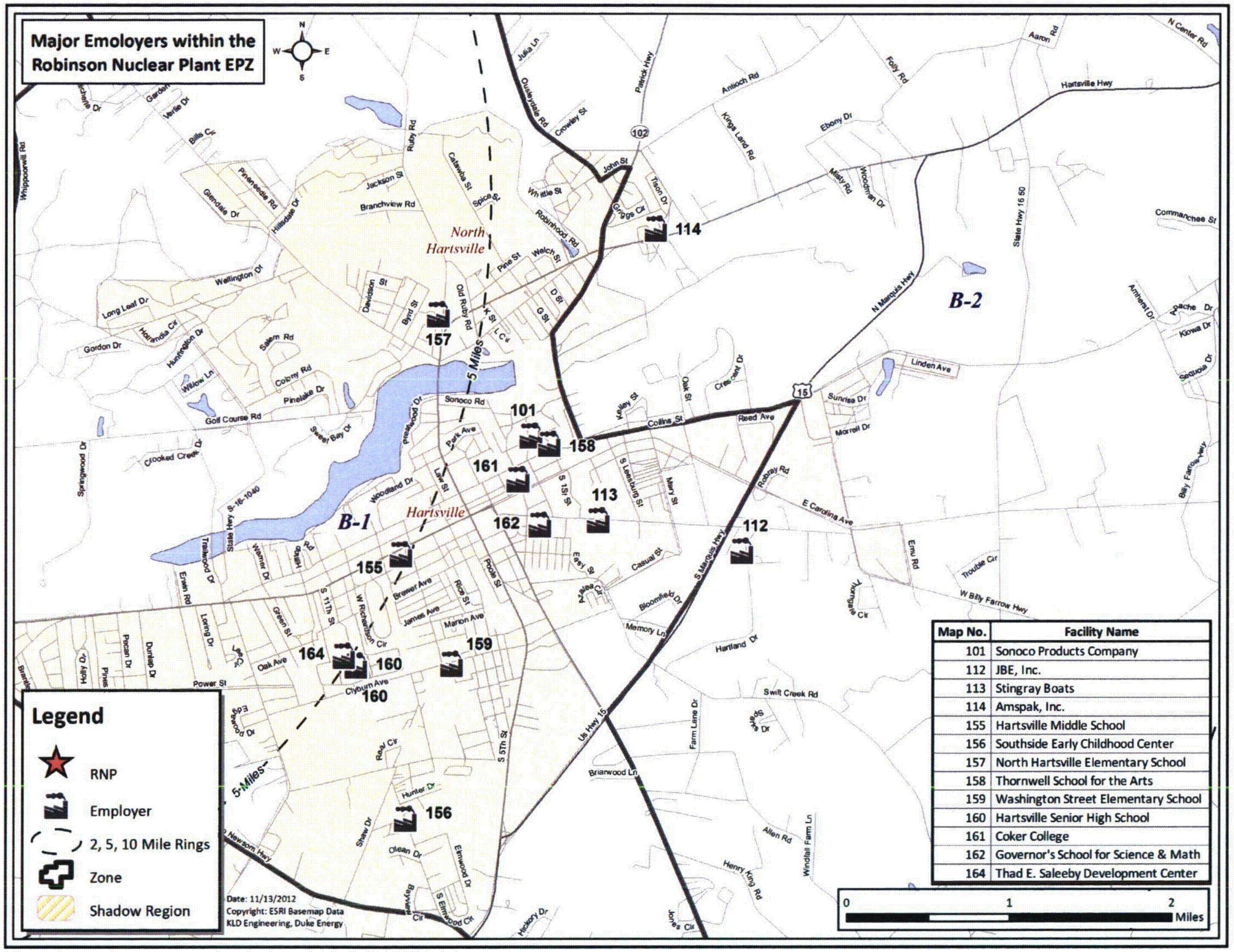

| Map N | Facility Name |
|---|---|
| 14 | Morningside of Hartsville |
| 15 | Thad E. Saleeby Development Center |
| 16 | Carriage House of Hartsville |
| 17 | Morrell Memorial Conv Center |
| 21 | Carolina Pines Regional Medical Center |

**Figure E-4. Medical Facilities within the EPZ**




| Map N | Facility Name |
|---|---|
| 102 | Mc Leod Farms |
| 103 | A O Smith Water Products |
| 104 | Talley Metals Technology Inc. |
| 108 | Mar Mac Construction |
| 109 | Mar Mac Manufacturing |
| 110 | Anderson Brass Company |
| 111 | RBC Bearings |
| 163 | Carolina Pines Regional Medical Center |

**Figure E-5. Major Employers within the EPZ**




| Map No. | Facility Name |
|---|---|
| 101 | Sonoco Products Company |
| 112 | JBE, Inc. |
| 113 | Stingray Boats |
| 114 | Amspak, Inc. |
| 155 | Hartsville Middle School |
| 156 | Southside Early Childhood Center |
| 157 | North Hartsville Elementary School |
| 158 | Thornwell School for the Arts |
| 159 | Washington Street Elementary School |
| 160 | Hartsville Senior High School |
| 161 | Coker College |
| 162 | Governor's School for Science & Math |
| 164 | Thad E. Saleeby Development Center |

**Figure E-6. Major Employers within Downtown Hartsville**

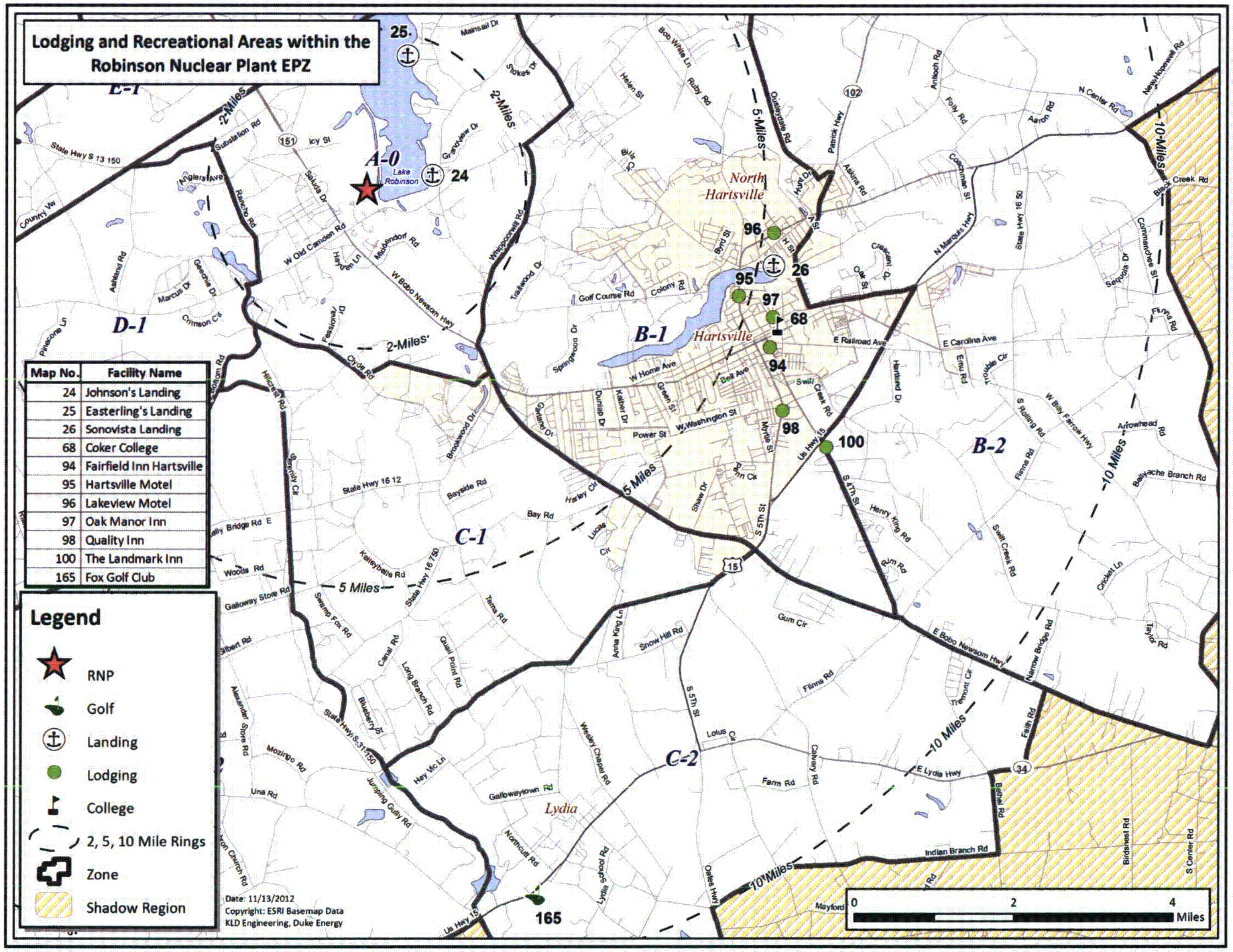



**Figure E-7. Recreational Areas within the EPZ**

## APPENDIX F

Telephone Survey

# F. TELEPHONE SURVEY

## F.1 Introduction

The development of evacuation time estimates for the Robinson Nuclear Plant EPZ requires the identification of travel patterns, car ownership and household size of the population within the EPZ. Demographic information can be obtained from Census data. The use of this data has several limitations when applied to emergency planning. First, the Census data do not encompass the range of information needed to identify the time required for preliminary activities (mobilization) that must be undertaken prior to evacuating the area. Secondly, Census data do not contain attitudinal responses needed from the population of the EPZ and consequently may not accurately represent the anticipated behavioral characteristics of the evacuating populace.

These concerns are addressed by conducting a telephone survey of a representative sample of the EPZ population. The survey is designed to elicit information from the public concerning family demographics and estimates of response times to well defined events. The design of the survey includes a limited number of questions of the form "What would you do if ...?" and other questions regarding activities with which the respondent is familiar ("How long does it take you to ...?")

## F.2 Survey Instrument and Sampling Plan

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

Following the completion of the instrument, a sampling plan was developed. A sample size of approximately 500 **completed** survey forms yields results with a sampling error of ±4.5% at the 95% confidence level. The sample must be drawn from the EPZ population. Consequently, a list of zip codes in the EPZ was developed using GIS software. This list is shown in Table F-1. Along with each zip code, an estimate of the population and number of households in each area was determined by overlaying Census data and the EPZ boundary, again using GIS software. The proportional number of desired completed survey interviews for each area was identified, as shown in Table F-1. Note that the average household size computed in Table F-1 was an estimate for sampling purposes and was not used in the ETE study.

The completed survey adhered to the sampling plan.

**Table F-1. RNP Telephone Survey Sampling Plan**

| Zip Code | Population within EPZ (2010) | Households | Required Sample |
|---|---|---|---|
| 29010 | 929 | 402 | 14 |
| 29069 | 563 | 233 | 8 |
| 29101 | 3,008 | 1,138 | 41 |
| 29540 | 0 | 0 | 0 * |
| 29550 | 31,253 | 12,126 | 436 |
| 29584 | 83 | 28 | 1 |
| | | **Average Household Size:** | **2.57** |
| | | **Total Sample Required:** | **500** |

*Note: Zip code does not have population within the EPZ

## F.3 Survey Results

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

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

### F.3.1 Household Demographic Results

Household Size

Figure F-1 presents the distribution of household size within the EPZ. The average household contains 2.27 people. The estimated household size (2.27 persons) used to determine the survey sample (Table F-1) was drawn from Census data. The close agreement between the average household size obtained from the survey and from the Census is an indication of the reliability of the survey.

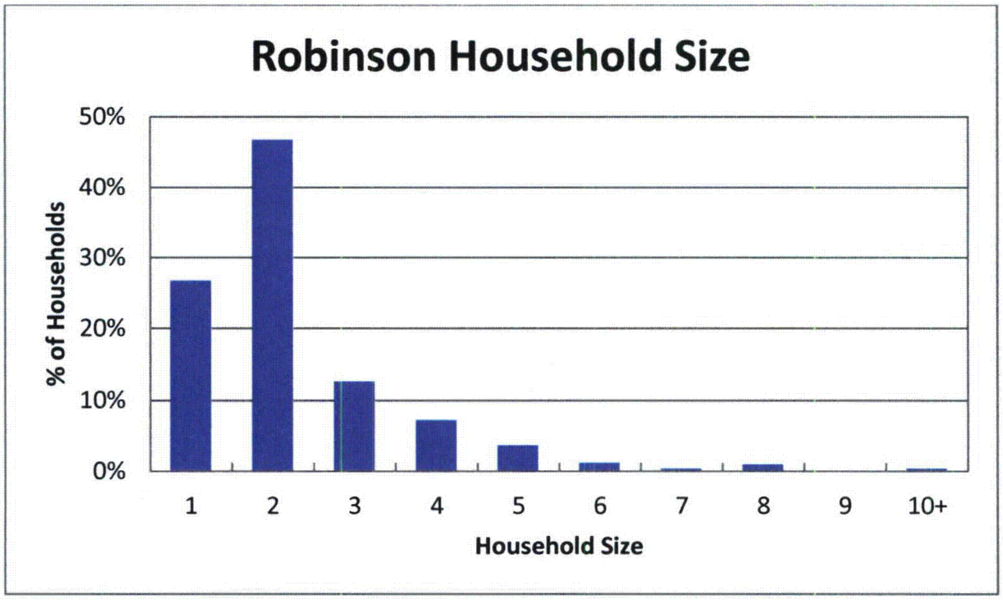



**Figure F-1. Household Size in the EPZ**

Automobile Ownership

The average number of automobiles available per household in the EPZ is 2.01. It should be noted that approximately 7.1 percent of households do not have access to an automobile. The distribution of automobile ownership is presented in Figure F-2. Figure F-3 and Figure F-4 present the automobile availability by household size. Note that the majority of households without access to a car are single person households. As expected, nearly all households of 2 or more people have access to at least one vehicle.

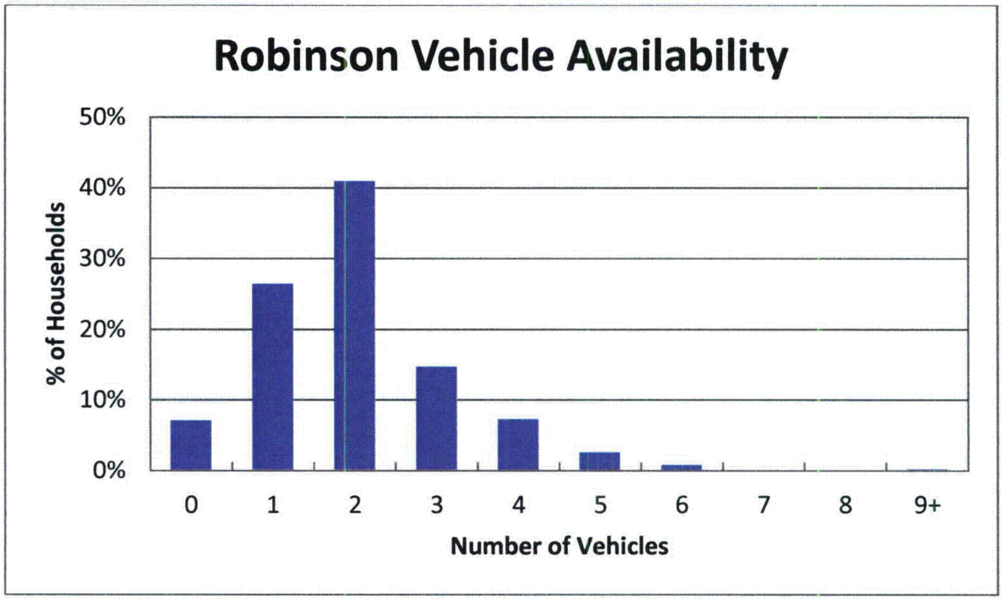



**Figure F-2. Household Vehicle Availability**

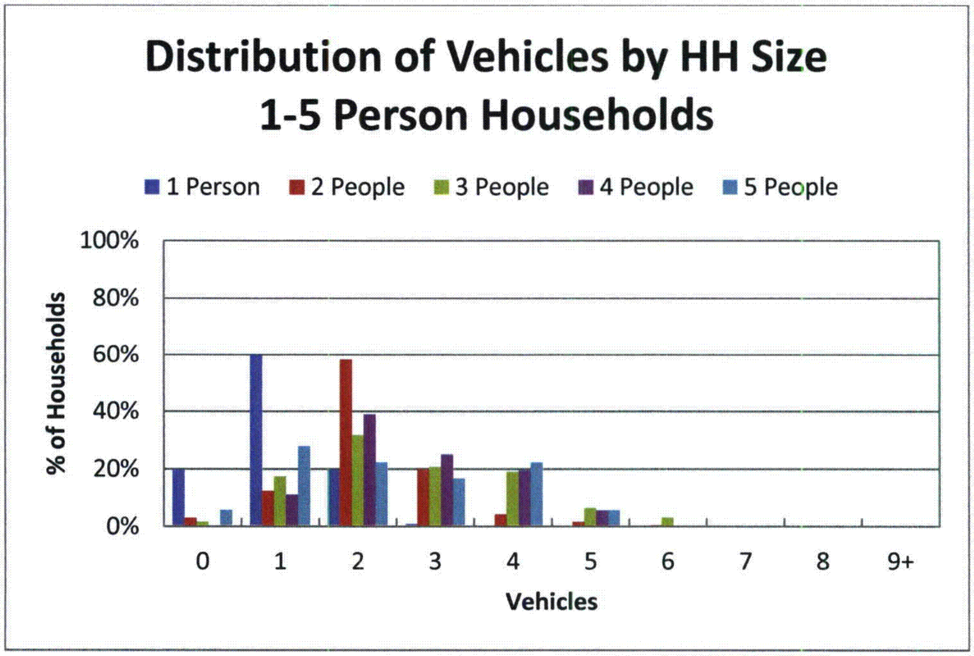



**Figure F-3. Vehicle Availability - 1 to 5 Person Households**

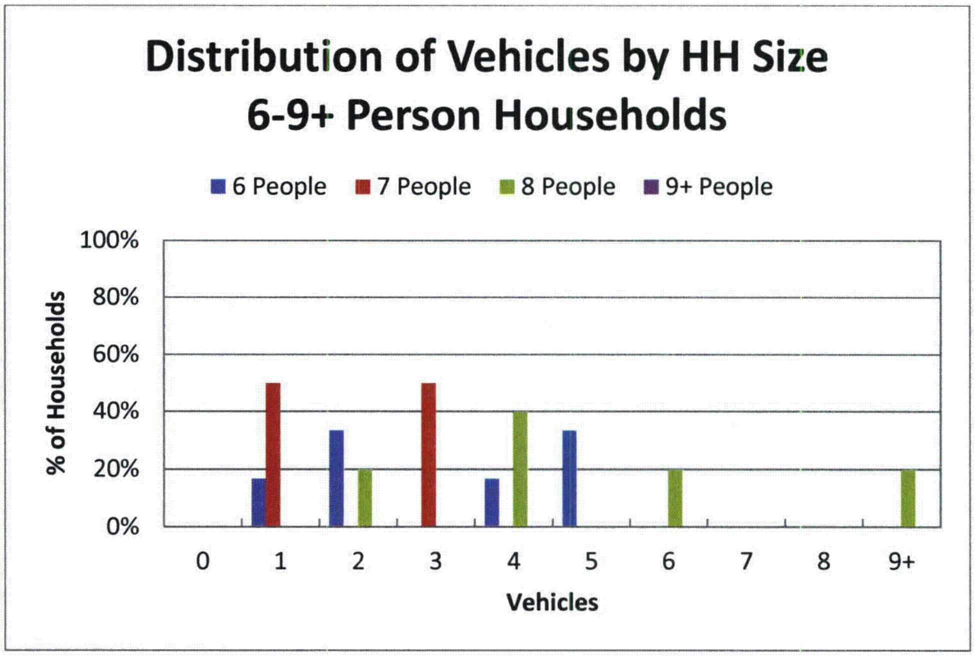



**Figure F-4. Vehicle Availability - 6 to 9+ Person Households**

Ridesharing

86% of the households surveyed who do not own a vehicle responded that they would share a ride with a neighbor, relative, or friend if a car was not available to them when advised to evacuate in the event of an emergency. Note, however, that only those households with no access to a vehicle – 35 total out of the sample size of 500 – answered this question. Thus, the results are not statistically significant. As such, the NRC recommendation of 50% ridesharing is used throughout this study. Figure F-5 presents this response.

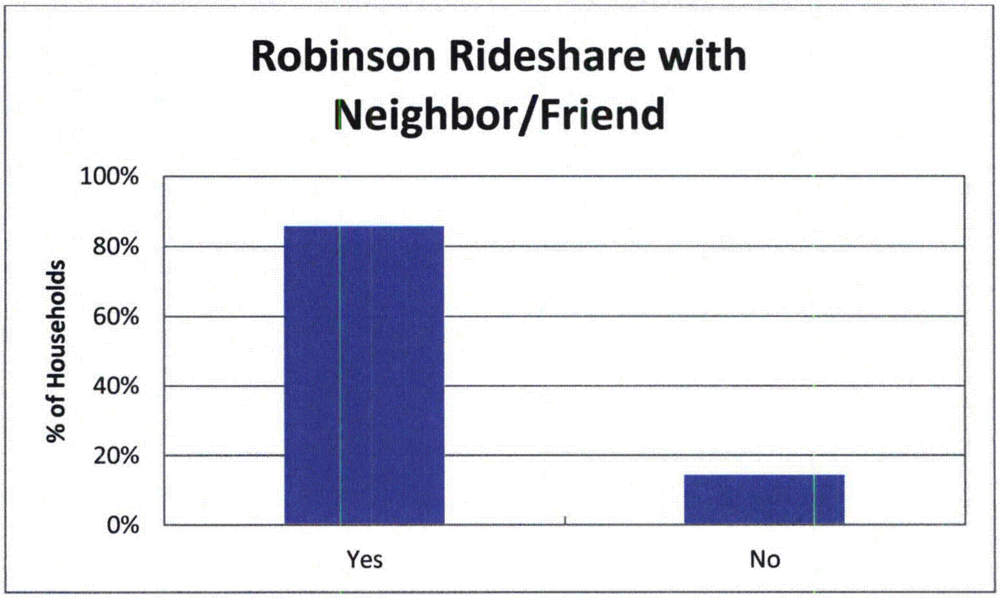



**Figure F-5. Household Ridesharing Preference**

Commuters

Figure F-6 presents the distribution of the number of commuters in each household. Commuters are defined as household members who travel to work or college on a daily basis. The data shows an average of 0.79 commuters in each household in the EPZ, and 48% of households have at least one commuter.

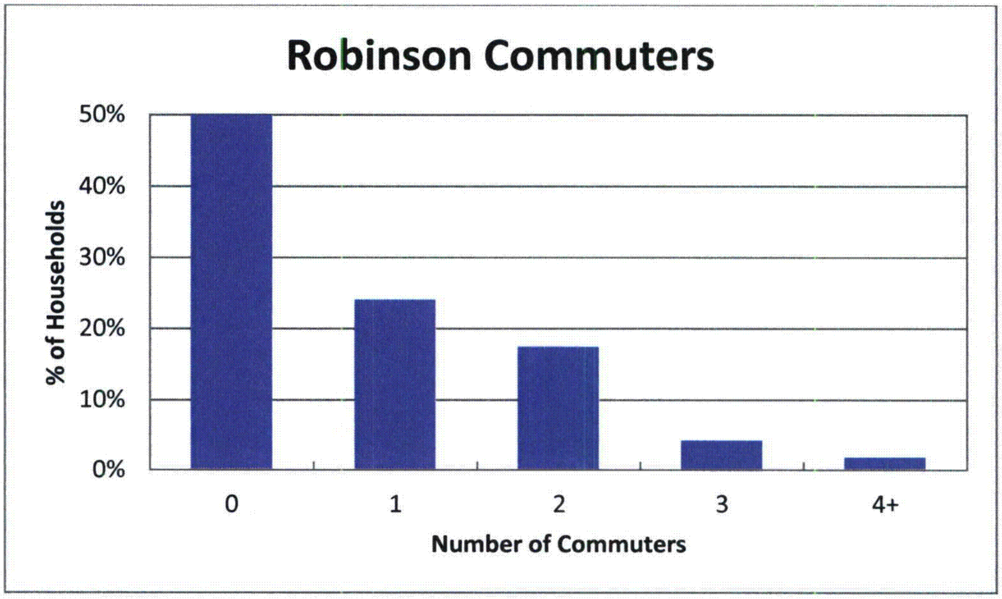



**Figure F-6. Commuters in Households in the EPZ**

Commuter Travel Modes

Figure F-7 presents the mode of travel that commuters use on a daily basis. The vast majority of commuters use their private automobiles to travel to work. The data shows an average of 1.05 employees per vehicle, assuming 2 people per vehicle – on average – for carpools.

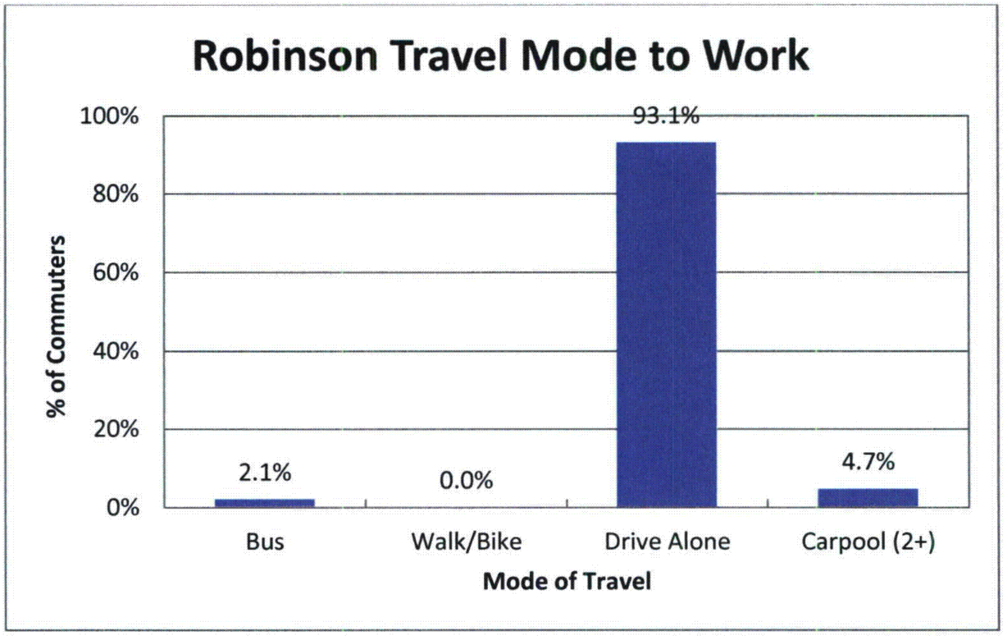



**Figure F-7. Modes of Travel in the EPZ**

### F.3.2 Evacuation Response

Several questions were asked to gauge the population's response to an emergency. These are now discussed[1]:

***"How many of the vehicles would your household use during an evacuation?"*** The response is shown in Figure F-8. On average, evacuating households would use 1.20 vehicles.

***"If you are asked to evacuate, will you wait for all of your household members to return before leaving?"*** Of the survey participants who responded, 55 percent said they would await the return of other family members before evacuating and 45 percent indicated that they would not await the return of other family members.

***"If you have a pet, will you take your pet with you when you leave?"*** Based on the responses to the survey, 66 percent of households have a family pet. Of the households with pets, 84

[1] Some of the questions have been simplified here. To see the exact wording, refer to the survey instrument in Attachment A, at the end of this section.

percent of them indicated that they would take their pets with them, as shown in Figure F-9.

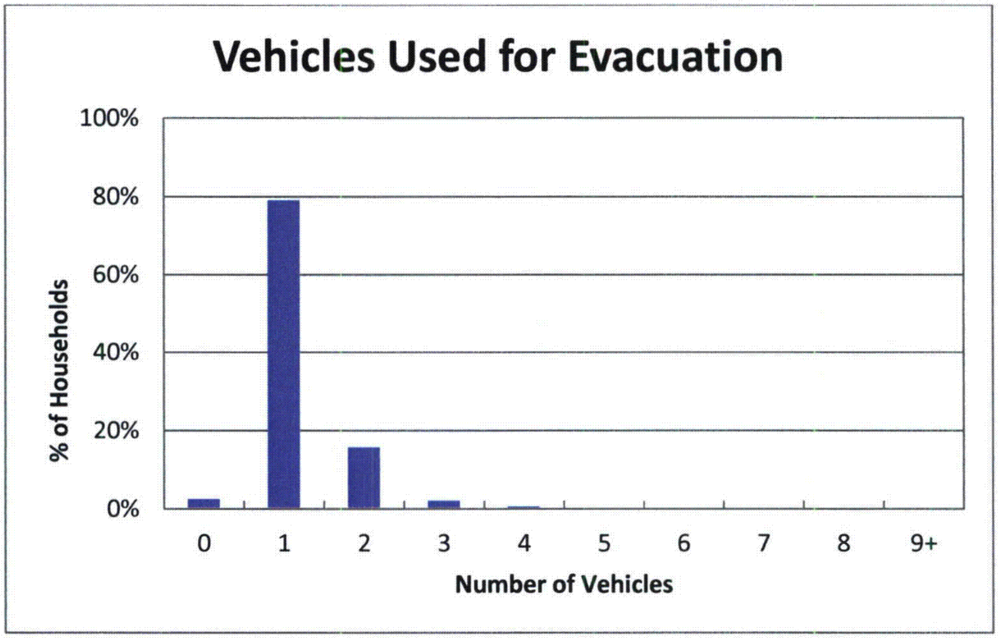



**Figure F-8. Number of Vehicles Used for Evacuation**

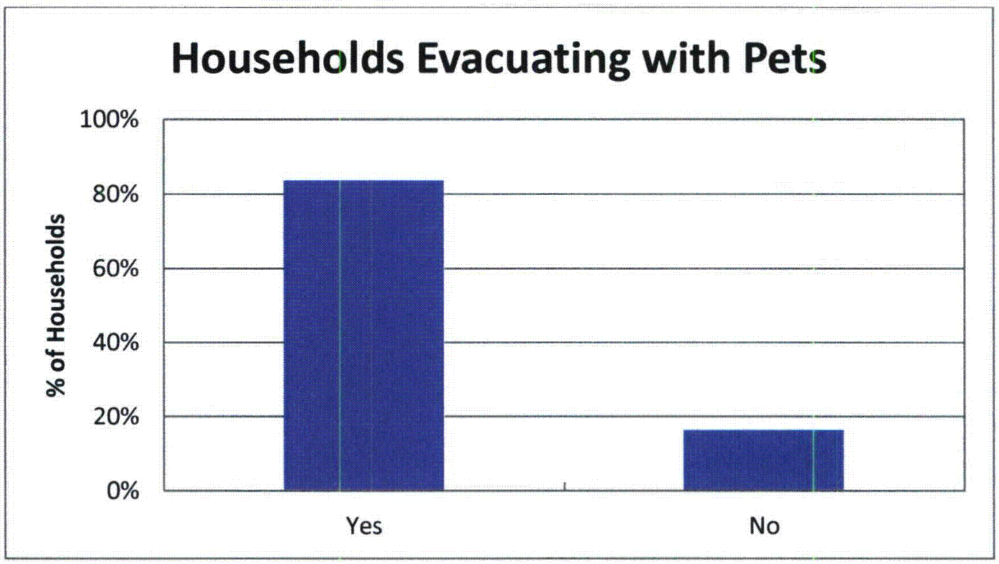



**Figure F-9. Households Evacuating with Pets**

***"Emergency officials advise you to take shelter at home in an emergency. Would you?"*** This question is designed to elicit information regarding compliance with instructions to shelter in place. The results indicate that 86 percent of households who are advised to shelter in place would do so; the remaining 14 percent would choose to evacuate the area. Note the baseline ETE study assumes 20 percent of households will not comply with the shelter advisory, as per Section 2.5.2 of NUREG/CR-7002.

***"Other areas around you have been told to evacuate. You have been told to stay home with the possibility of evacuating later. Will you?"*** This question is designed to elicit information specifically related to the possibility of a staged evacuation. That is, asking a population to shelter in place now and then to evacuate after a specified period of time. Results indicate that 68 percent of households would follow instructions and delay the start of evacuation until so advised, while the balance of 32 percent would choose to begin evacuating immediately.

### F.3.3 Time Distribution Results

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

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

***"How long does it take the commuter to complete preparation for leaving work?"*** Figure F-10 presents the cumulative distribution; in all cases, the activity is completed by about 90 minutes. Approximately ninety percent can leave within 45 minutes.

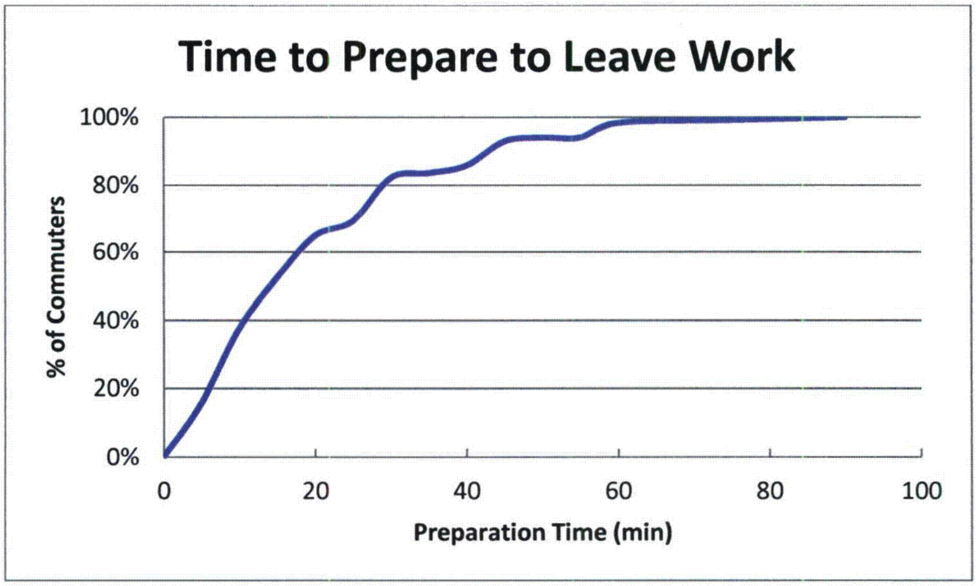



**Figure F-10. Time Required to Prepare to Leave Work/School**

***"How long would it take the commuter to travel home?"*** Figure F-11 presents the work to home travel time for the EPZ. About 80 percent of commuters can arrive home within about 30 minutes of leaving work; nearly all within one hour.

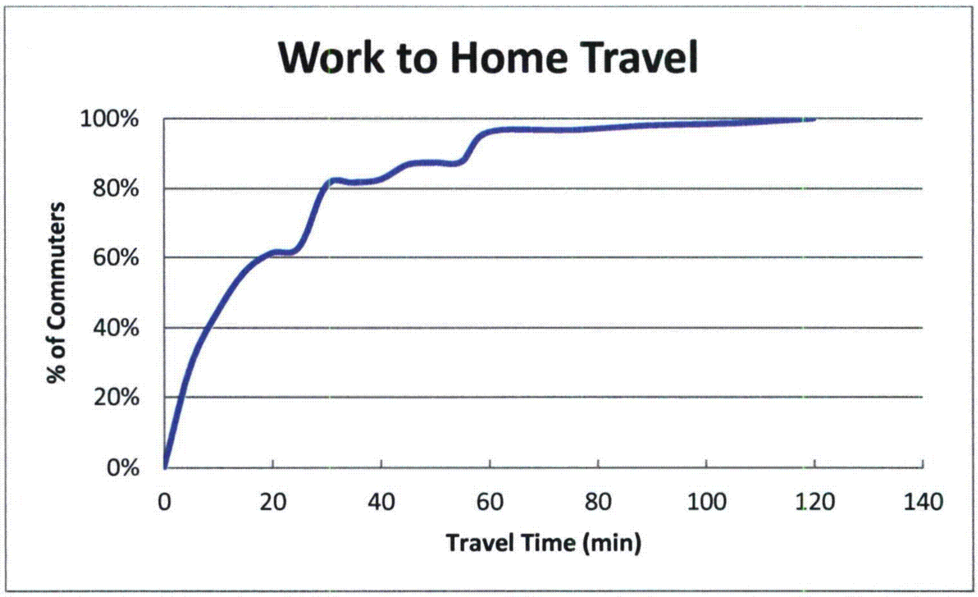



**Figure F-11. Work to Home Travel Time**

***"If you are advised by local authorities to evacuate, how much time will it take your household to prepare to leave? Consider that each of you may need to pack clothes, pack medication, lock the house and load your vehicle(s)?"*** Figure F-12 presents the time required to prepare for leaving on an evacuation trip. In many ways this activity mimics a family's preparation for a short holiday or weekend away from home. Hence, the responses represent the experience of the responder in performing similar activities.

The distribution shown in Figure F-12 has a long "tail." About 90 percent of households can be ready to leave home within 60 minutes; the remaining households require up to an additional hour and fifteen minutes.

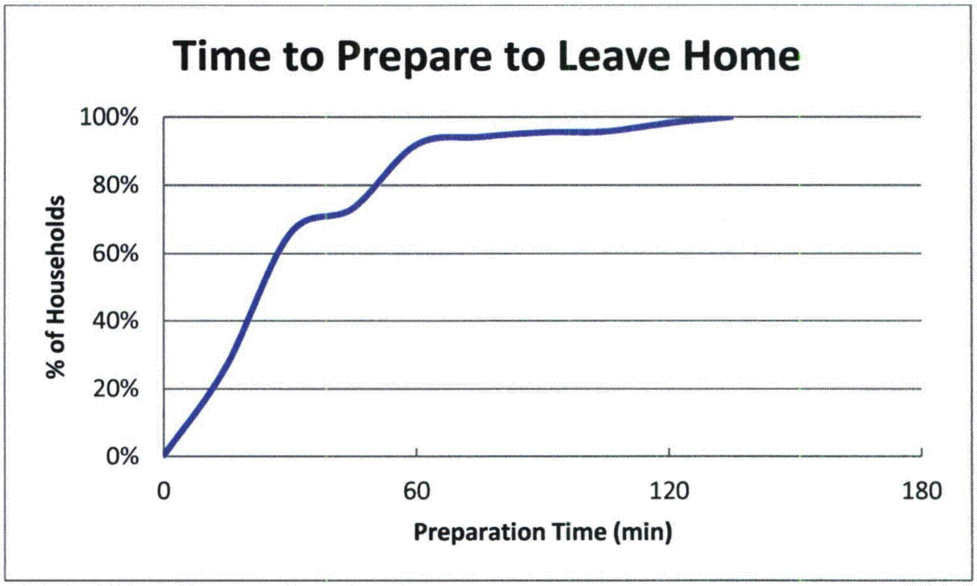



**Figure F-12. Time to Prepare Home for Evacuation**

***" If there is 2-3" of snow on your driveway or curb, would you need to shovel out to evacuate? If yes, how much time, on average, would it take you to clear the 2-3" of snow to move the car from the driveway or curb to begin the evacuation trip? Assume the roads are passable."*** During adverse, snowy weather conditions, an additional activity must be performed before residents can depart on the evacuation trip. Although snow scenarios assume that the roads and highways have been plowed and are passable (albeit at lower speeds and capacities), it may be necessary to clear a private driveway prior to leaving the home so that the vehicle can access the street. Figure F-13 presents the time distribution for removing 6 to 8 inches of snow from a driveway. The time distribution for clearing the driveway has a long tail; about 90 percent of driveways are passable within 45 minutes. The last driveway is cleared three hours after the start of this activity. Note that those respondents (70%) who answered that they would not take time to clear their driveway were assumed to be ready immediately at the start of this activity. Essentially they would drive through the snow on the driveway to access the roadway and begin their evacuation trip.

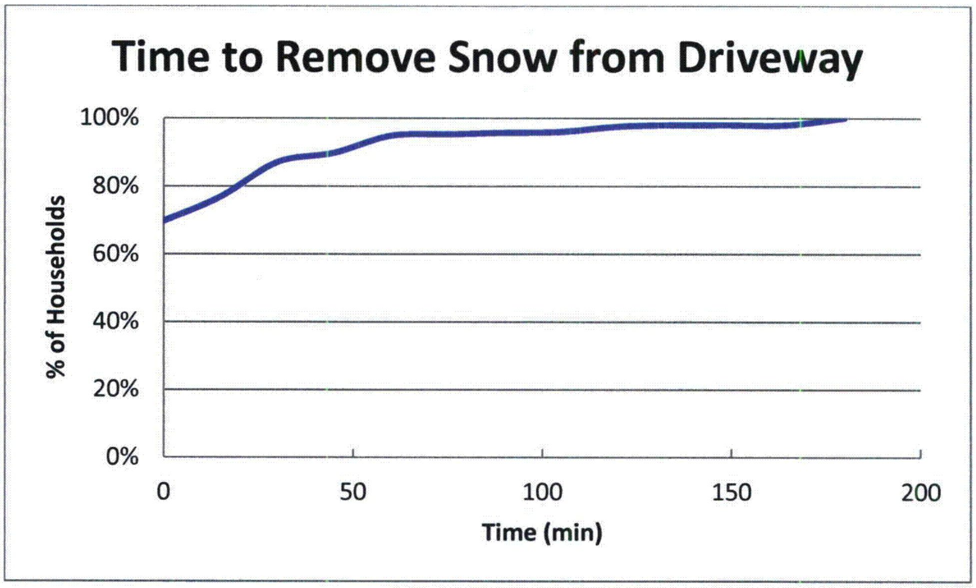



**Figure F-13. Time to Clear Driveway of 2"-3" of Snow**

## F.4 Conclusions

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

# ATTACHMENT A

## Telephone Survey Instrument

# Telephone Survey Instrument

Hello, my name is ________________. I am working on a short survey for your county emergency management agency to understand how residents will behave in an emergency. This information will be shared with your local officials to improve their emergency plans for hazards that may require evacuation. Your responses will be used to verify that plans are up to date and take into consideration the travel arrangements for your household. I will not ask for your name or any other personal information. This survey will take about 10 minutes to complete.

COL. 1 Unused
COL. 2 Unused
COL. 3 Unused
COL. 4 Unused
COL. 5 Unused
Sex COL. 8
1 Male
2 Female

INTERVIEWER: ASK TO SPEAK TO THE HEAD OF HOUSEHOLD OR THE SPOUSE OF THE HEAD OF HOUSEHOLD. (Terminate call if not a residence.)

DO NOT ASK:

| | | | |
|---|---|---|---|
| 1A. | Record area code. To Be Determined | COL. 9-11 | |
| 1B. | Record exchange number. To Be Determined | COL. 12-14 | |
| 2. | What is your zip code? | COL. 15-19 | |
| 3A. | What is the total number of operating vehicles at your house? This includes cars, trucks and motorcycles. It does not include boats or bicycles.<br>(DO NOT READ ANSWERS) | COL. 20<br>1 ONE<br>2 TWO<br>3 THREE<br>4 FOUR<br>5 FIVE<br>6 SIX<br>7 SEVEN<br>8 EIGHT<br>9 NINE OR MORE<br>0 ZERO (NONE)<br>X DON'T KNOW/REFUSED | SKIP TO<br>Q. 4<br>Q. 4<br>Q. 4<br>Q. 4<br>Q. 4<br>Q. 4<br>Q. 4<br>Q. 4<br>Q. 4<br>Q. 3B<br>Q. 3B |
| 3B. | In an emergency, can you get a ride to leave the area with someone close by? | COL. 21<br>1 YES<br>2 NO<br>X DON'T KNOW/REFUSED | |
| 4. | How many people live in this house?<br>(DO NOT READ ANSWERS) | COL. 22<br>1 ONE<br>2 TWO<br>3 THREE<br>4 FOUR<br>5 FIVE | COL. 23<br>0 TEN<br>1 ELEVEN<br>2 TWELVE<br>3 THIRTEEN<br>4 FOURTEEN |

| | | |
|---|---|---|
| | 6 SIX | 5 FIFTEEN |
| | 7 SEVEN | 6 SIXTEEN |
| | 8 EIGHT | 7 SEVENTEEN |
| | 9 NINE | 8 EIGHTEEN |
| | | 9 NINETEEN OR MORE |
| | | X DON'T KNOW/REFUSED |

| | | |
|---|---|---|
| 5. How many people in the house drive to a job or to school/college on a daily basis? | COL. 24 | SKIP TO |
| | 0 ZERO | Q. 9 |
| | 1 ONE | Q. 6 |
| | 2 TWO | Q. 6 |
| | 3 THREE | Q. 6 |
| | 4 FOUR OR MORE | Q. 6 |
| | 5 DON'T KNOW/REFUSED | Q. 9 |

INTERVIEWER: The next 3 questions will be asked about each person that goes to work or school/college.

6. How does *person #1* travel to work or school/college? (REPEAT QUESTION FOR EACH PERSON)

| | Person #1 | Person #2 | Person #3 | Person #4 |
|---|---|---|---|---|
| | COL. 25 | COL. 26 | COL. 27 | COL. 28 |
| Bus | 2 | 2 | 2 | 2 |
| Walk/Bicycle | 3 | 3 | 3 | 3 |
| Drive Alone | 4 | 4 | 4 | 4 |
| Carpool-2 or more people | 5 | 5 | 5 | 5 |
| Don't know/Refused | 6 | 6 | 6 | 6 |

7. When returning home, how much time does it take *person #1* to prepare (get ready) to leave work or school/college? (REPEAT QUESTION FOR EACH PERSON) (DO NOT READ ANSWERS)

| PERSON #1 | | PERSON #2 | |
|---|---|---|---|
| COL. 29 | COL. 30 | COL. 31 | COL. 32 |
| 1 5 MINUTES OR LESS | 1 46-50 MINUTES | 1 5 MINUTES OR LESS | 1 46-50 MINUTES |
| 2 6-10 MINUTES | 2 51-55 MINUTES | 2 6-10 MINUTES | 2 51-55 MINUTES |
| 3 11-15 MINUTES | 3 56 – 1 HOUR | 3 11-15 MINUTES | 3 56 – 1 HOUR |
| 4 16-20 MINUTES | 4 OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES | 4 16-20 MINUTES | 4 OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES |
| 5 21-25 MINUTES | 5 BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES | 5 21-25 MINUTES | 5 BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES |
| 6 26-30 MINUTES | 6 BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES | 6 26-30 MINUTES | 6 BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES |
| 7 31-35 MINUTES | 7 BETWEEN 1 HOUR 46 MINUTES AND 2 | 7 31-35 MINUTES | 7 BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | HOURS | | | | |
| 8 | 36-40 MINUTES | 8 | OVER 2 HOURS (SPECIFY ______) | 8 | 36-40 MINUTES | 8 | OVER 2 HOURS (SPECIFY ______) |
| 9 | 41-45 MINUTES | 9 | | 9 | 41-45 MINUTES | 9 | |
| | | 0 | | | | 0 | |
| | | X | DON'T KNOW /REFUSED | | | X | DON'T KNOW /REFUSED |

PERSON #3 | PERSON #4

| COL. 33 | | COL. 34 | | COL. 35 | | COL. 36 | |
|---|---|---|---|---|---|---|---|
| 1 | 5 MINUTES OR LESS | 1 | 46-50 MINUTES | 1 | 5 MINUTES OR LESS | 1 | 46-50 MINUTES |
| 2 | 6-10 MINUTES | 2 | 51-55 MINUTES | 2 | 6-10 MINUTES | 2 | 51-55 MINUTES |
| 3 | 11-15 MINUTES | 3 | 56 – 1 HOUR | 3 | 11-15 MINUTES | 3 | 56 – 1 HOUR |
| 4 | 16-20 MINUTES | 4 | OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES | 4 | 16-20 MINUTES | 4 | OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES |
| 5 | 21-25 MINUTES | 5 | BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES | 5 | 21-25 MINUTES | 5 | BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES |
| 6 | 26-30 MINUTES | 6 | BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES | 6 | 26-30 MINUTES | 6 | BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES |
| 7 | 31-35 MINUTES | 7 | BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS | 7 | 31-35 MINUTES | 7 | BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS |
| 8 | 36-40 MINUTES | 8 | OVER 2 HOURS (SPECIFY ______) | 8 | 36-40 MINUTES | 8 | OVER 2 HOURS (SPECIFY ______) |
| 9 | 41-45 MINUTES | 9 | | 9 | 41-45 MINUTES | 9 | |
| | | 0 | | | | 0 | |
| | | X | DON'T KNOW /REFUSED | | | X | DON'T KNOW /REFUSED |

8. How much time does it take *person #1* to travel home from work or school/college? (REPEAT QUESTION FOR EACH PERSON) (DO NOT READ ANSWERS)

| PERSON #1 | | | | PERSON #2 | | | |
|---|---|---|---|---|---|---|---|
| COL. 37 | | COL. 38 | | COL. 39 | | COL. 40 | |
| 1 | 5 MINUTES OR LESS | 1 | 46-50 MINUTES | 1 | 5 MINUTES OR LESS | 1 | 46-50 MINUTES |
| 2 | 6-10 MINUTES | 2 | 51-55 MINUTES | 2 | 6-10 MINUTES | 2 | 51-55 MINUTES |
| 3 | 11-15 MINUTES | 3 | 56 – 1 HOUR | 3 | 11-15 MINUTES | 3 | 56 – 1 HOUR |
| 4 | 16-20 MINUTES | 4 | OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES | 4 | 16-20 MINUTES | 4 | OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES |
| 5 | 21-25 MINUTES | 5 | BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES | 5 | 21-25 MINUTES | 5 | BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES |
| 6 | 26-30 MINUTES | 6 | BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES | 6 | 26-30 MINUTES | 6 | BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES |
| 7 | 31-35 MINUTES | 7 | BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS | 7 | 31-35 MINUTES | 7 | BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS |
| 8 | 36-40 MINUTES | 8 | OVER 2 HOURS (SPECIFY ______) | 8 | 36-40 MINUTES | 8 | OVER 2 HOURS (SPECIFY ______) |
| 9 | 41-45 MINUTES | 9 | | 9 | 41-45 MINUTES | 9 | |
| | | 0 | | | | 0 | |
| | | X | DON'T KNOW /REFUSED | | | X | DON'T KNOW /REFUSED |

| PERSON #3 | | | | PERSON #4 | | | |
|---|---|---|---|---|---|---|---|
| COL. 41 | | COL. 42 | | COL. 43 | | COL. 44 | |
| 1 | 5 MINUTES OR LESS | 1 | 46-50 MINUTES | 1 | 5 MINUTES OR LESS | 1 | 46-50 MINUTES |
| 2 | 6-10 MINUTES | 2 | 51-55 MINUTES | 2 | 6-10 MINUTES | 2 | 51-55 MINUTES |
| 3 | 11-15 MINUTES | 3 | 56 – 1 HOUR | 3 | 11-15 MINUTES | 3 | 56 – 1 HOUR |
| 4 | 16-20 MINUTES | 4 | OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES | 4 | 16-20 MINUTES | 4 | OVER 1 HOUR, BUT LESS THAN 1 HOUR 15 MINUTES |
| 5 | 21-25 MINUTES | 5 | BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES | 5 | 21-25 MINUTES | 5 | BETWEEN 1 HOUR 16 MINUTES AND 1 HOUR 30 MINUTES |
| 6 | 26-30 MINUTES | 6 | BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES | 6 | 26-30 MINUTES | 6 | BETWEEN 1 HOUR 31 MINUTES AND 1 HOUR 45 MINUTES |
| 7 | 31-35 MINUTES | 7 | BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS | 7 | 31-35 MINUTES | 7 | BETWEEN 1 HOUR 46 MINUTES AND 2 HOURS |
| 8 | 36-40 MINUTES | 8 | OVER 2 HOURS (SPECIFY ______) | 8 | 36-40 MINUTES | 8 | OVER 2 HOURS (SPECIFY ______) |
| 9 | 41-45 MINUTES | 9 | | 9 | 41-45 MINUTES | 9 | |
| | | 0 | | | | 0 | |
| | | X | DON'T KNOW /REFUSED | | | X | DON'T KNOW /REFUSED |

9. If you are advised by local authorities to evacuate, how much time will it take your household to prepare to leave? Consider that each of you may need to pack clothes, pack medication, lock the house and load your vehicle(s). (DO NOT READ ANSWERS)

COL. 45

1 LESS THAN 15 MINUTES
2 15-30 MINUTES
3 31-45 MINUTES
4 46 MINUTES – 1 HOUR
5 1 HOUR TO 1 HOUR 15 MINUTES
6 1 HOUR 16 MINUTES TO 1 HOUR 30 MINUTES
7 1 HOUR 31 MINUTES TO 1 HOUR 45 MINUTES
8 1 HOUR 46 MINUTES TO 2 HOURS
9 2 HOURS TO 2 HOURS 15 MINUTES
0 2 HOURS 16 MINUTES TO 2 HOURS 30 MINUTES
X 2 HOURS 31 MINUTES TO 2 HOURS 45 MINUTES
Y 2 HOURS 46 MINUTES TO 3 HOURS
Z WILL NOT EVACUATE *(Optional response)*

COL. 46

1 3 HOURS TO 3 HOURS 15 MINUTES
2 3 HOURS 16 MINUTES TO 3 HOURS 30 MINUTES
3 3 HOURS 31 MINUTES TO 3 HOURS 45 MINUTES
4 3 HOURS 46 MINUTES TO 4 HOURS
5 4 HOURS TO 4 HOURS 15 MINUTES
6 4 HOURS 16 MINUTES TO 4 HOURS 30 MINUTES
7 4 HOURS 31 MINUTES TO 4 HOURS 45 MINUTES
8 4 HOURS 46 MINUTES TO 5 HOURS
9 5 HOURS TO 5 HOURS 30 MINUTES
0 5 HOURS 31 MINUTES TO 6 HOURS
X OVER 6 HOURS (SPECIFY _______)

COL. 47

1 DON'T KNOW/REFUSED

10. If there is 2-3" of snow on your driveway or curb, would you need to shovel out to evacuate? If yes, how much time, on average, would it take you to clear the 2-3" of snow to move the car from the driveway or curb to begin the evacuation trip? Assume the roads are passable. (DO NOT READ RESPONSES)

COL. 48

1 LESS THAN 15 MINUTES
2 15-30 MINUTES
3 31-45 MINUTES
4 46 MINUTES – 1 HOUR
5 1 HOUR TO 1 HOUR 15 MINUTES
6 1 HOUR 16 MINUTES TO 1 HOUR 30 MINUTES
7 1 HOUR 31 MINUTES TO 1 HOUR 45 MINUTES
8 1 HOUR 46 MINUTES TO 2 HOURS
9 2 HOURS TO 2 HOURS 15 MINUTES
0 2 HOURS 16 MINUTES TO 2 HOURS 30 MINUTES
X 2 HOURS 31 MINUTES TO 2 HOURS 45 MINUTES
Y 2 HOURS 46 MINUTES TO 3 HOURS
Z NO, WILL NOT SHOVEL OUT

COL. 49

1 OVER 3 HOURS (SPECIFY _______)
2 DON'T KNOW/REFUSED

---

11. If you are asked to evacuate, will you wait for all of your household members to return before leaving? (READ ANSWERS):

A. Yes
B. No.

COL. 50

1 A
2 B
X DON'T KNOW/REFUSED

---

12. How many vehicles will you use to evacuate? (DO NOT READ ANSWERS)

COL. 51

1 ONE
2 TWO
3 THREE
4 FOUR
5 FIVE
6 SIX
7 SEVEN
8 EIGHT
9 NINE OR MORE
0 ZERO (NONE)
X DON'T KNOW/REFUSED

---

13A. Will you stay home if emergency officials advise you to do so? (READ ANSWERS)

A. YES
B. NO

COL. 52

1 A
2 B
X DON'T KNOW/REFUSED

| | | |
|---|---|---|
| 13B. | Other areas around you have been told to evacuate. You have been told to stay home with the possibility of evacuating later. Will you: (READ ANSWERS)<br>A. Stay home as requested or<br>B. Leave the area? | COL. 53<br>1 A<br>2 B<br>X DON'T KNOW/REFUSED |
| 14. | If you have a pet, will you take your pet with you when you leave? (READ ANSWERS) | COL. 54<br>1 DON'T HAVE A PET<br>2 YES<br>3 NO<br>X DON'T KNOW/REFUSED |

Thank you for your help in completing our survey ______________________________

(TELEPHONE NUMBER CALLED)

IF REQUESTED:

For additional information, contact your County Emergency Management Agency during normal business hours.

| County | EMA Phone |
|---|---|
| Chesterfield | (843)-623-3362 |
| Darlington | (843)-398-4450 |
| Lee | (803)-484-5274 |

# APPENDIX G

Traffic Management Plan

# G. TRAFFIC MANAGEMENT PLAN

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

These plans were reviewed and the TCPs and ACPs were modeled accordingly.

## G.1 Traffic Control Points

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

As discussed in Section 7.3, the animation of evacuation traffic conditions indicates several critical intersections which could be bottlenecks during evacuation. These critical intersections were cross-checked with the EPZ county emergency plans. All of the heavily congested intersections within the EPZ except two – Patrick Highway at E. Old Camden Road and Hartsville Highway at E. Old Camden Road – were identified as TCPs in the county plans. The aforementioned intersections have stop control for the side streets and are among the last to clear in the simulation and therefore could be considered for TCPs, should resources be available. However a sensitivity study (see Appendix M) showed that the ETE was not significantly reduced, making neither a first priority if resources are limited.

Figure G-1 maps the TCPs identified in the county emergency plans. The TCPs along SR 151 are particularly important for facilitating the flow of traffic along this major evacuation route.

## G.2 Access Control Points

It is assumed that access control will be established within 2 hours of the advisory to evacuate to discourage through travelers from using major through routes which traverse the EPZ. As discussed in Section 3.7, external traffic was considered on three routes which traverse the EPZ – SR 151, US 1 and US 15 – in this analysis and also on I-20, which passes just inside the 15-mile boundary. The generation of these external trips ceased at 2 hours after the advisory to evacuate in the simulation.

In the existing emergency plans, access control on these roadways is provided primarily by the following TCPs:

- SR 151 – TCP 16G in Darlington and C1 in McBee.
- US 1 – TCP C1 in McBee and C4 in Patrick.
- US 15 – TCP 16E in Society Hill and L1 in Bishopville.
- I-20 – No access control explicitly listed in the County or State RERP for I-20.

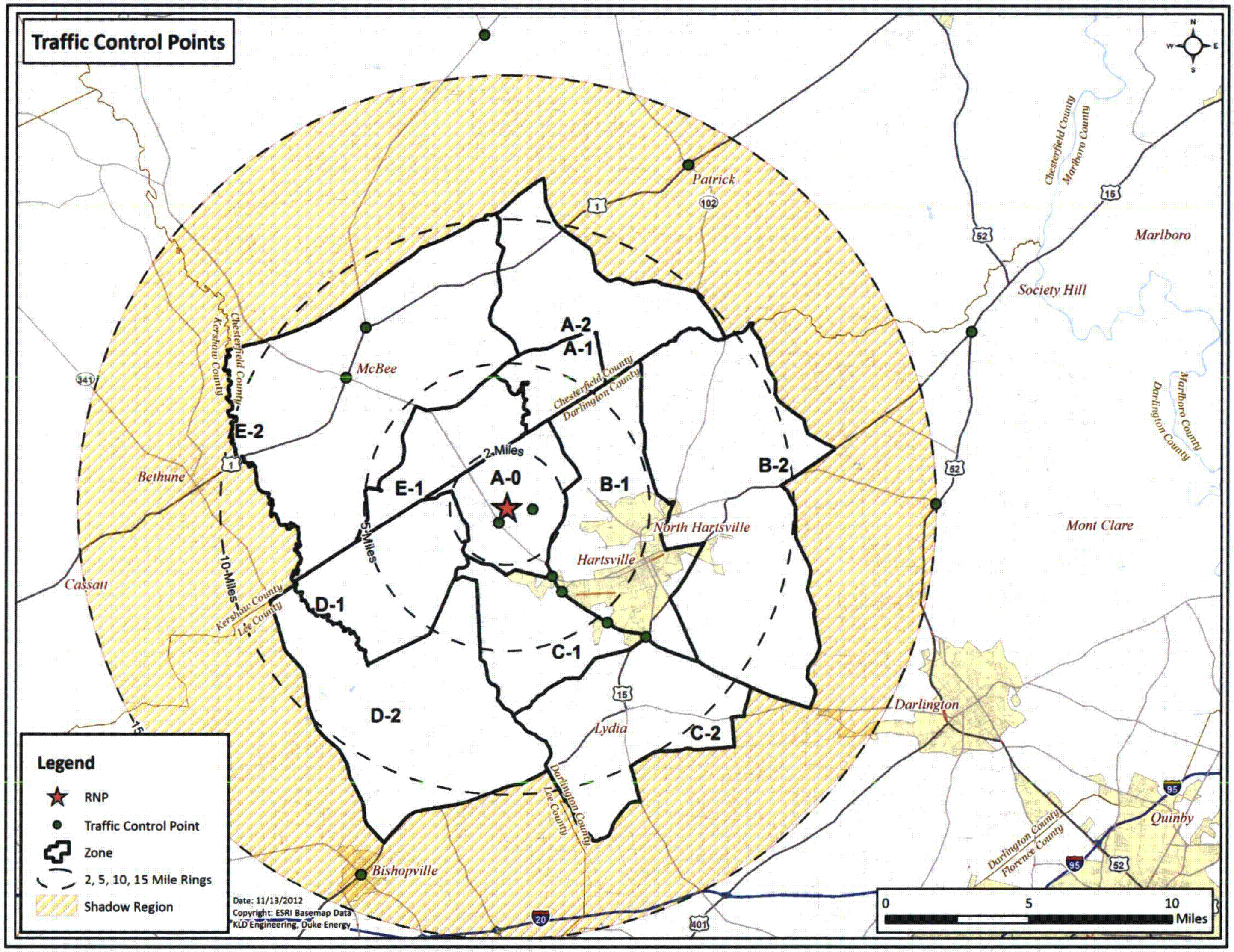



**Figure G-1. Traffic Control Points for the RNP Site**

## H. EVACUATION REGIONS

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

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

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

| Region | Description | Wind Direction From: (Degrees) | Zone | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | A-0 | A-1 | A-2 | B-1 | B-2 | C-1 | C-2 | D-1 | D-2 | E-1 | E-2 |
| **R01** | 2-Mile Ring | N/A | 100% | 20% | 20% | 20% | 20% | 20% | 20% | 20% | 20% | 20% | 20% |
| **R02** | 5-Mile Ring | N/A | 100% | 100% | 20% | 100% | 20% | 100% | 20% | 100% | 20% | 100% | 20% |
| **R03** | Full EPZ | N/A | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% |
| Evacuate 2-Mile Radius and Downwind to 5 Miles | | | | | | | | | | | | | |
| **Region** | **Wind Direction From:** | **Wind Direction From: (Degrees)** | **Zone** | | | | | | | | | | |
| | | | **A-0** | **A-1** | **A-2** | **B-1** | **B-2** | **C-1** | **C-2** | **D-1** | **D-2** | **E-1** | **E-2** |
| **R04** | North | > 328 - <= 015 | 100% | 20% | 20% | 100% | 20% | 100% | 20% | 100% | 20% | 20% | 20% |
| **R05** | Northeast | > 015 - <= 078 | 100% | 20% | 20% | 20% | 20% | 100% | 20% | 100% | 20% | 100% | 20% |
| **R06** | East | > 078 - <= 112 | 100% | 20% | 20% | 20% | 20% | 20% | 20% | 100% | 20% | 100% | 20% |
| **R07** | Southeast | > 112 - <=157 | 100% | 100% | 20% | 20% | 20% | 20% | 20% | 100% | 20% | 100% | 20% |
| **R08** | South | > 157 - <= 202 | 100% | 100% | 20% | 100% | 20% | 20% | 20% | 20% | 20% | 100% | 20% |
| (R08) | Southwest | > 202 - <= 247 | 100% | 100% | 20% | 100% | 20% | 20% | 20% | 20% | 20% | 100% | 20% |
| **R09** | West | > 247 - <= 292 | 100% | 100% | 20% | 100% | 20% | 100% | 20% | 20% | 20% | 20% | 20% |
| **R10** | Northwest | > 292 - <= 328 | 100% | 20% | 20% | 100% | 20% | 100% | 20% | 20% | 20% | 20% | 20% |
| Evacuate 2-Mile Radius and Downwind to the EPZ Boundary | | | | | | | | | | | | | |
| **R11** | North | > 328 - <= 015 | 100% | 20% | 20% | 100% | 100% | 100% | 100% | 100% | 100% | 20% | 20% |
| **R12** | Northeast | > 015 - <= 078 | 100% | 20% | 20% | 20% | 20% | 100% | 100% | 100% | 100% | 100% | 100% |
| **R13** | East | > 078 - <= 112 | 100% | 20% | 20% | 20% | 20% | 20% | 20% | 100% | 100% | 100% | 100% |
| **R14** | Southeast | > 112 - <=157 | 100% | 100% | 100% | 20% | 20% | 20% | 20% | 100% | 20% | 100% | 100% |
| **R15** | South | > 157 - <= 202 | 100% | 100% | 100% | 100% | 100% | 20% | 20% | 20% | 20% | 100% | 100% |
| (R15) | Southwest | > 202 - <= 247 | 100% | 100% | 100% | 100% | 100% | 20% | 20% | 20% | 20% | 100% | 100% |
| **R16** | West | > 247 - <= 292 | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 20% | 20% | 20% | 20% |
| **R17** | Northwest | > 292 - <= 328 | 100% | 20% | 20% | 100% | 100% | 100% | 100% | 20% | 100% | 20% | 20% |

| Evacuate 5-Mile Radius and Downwind to the EPZ Boundary | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Region** | **Wind Direction From:** | **Wind Direction From: (Degrees)** | **Zone** | | | | | | | | | | |
| | | | **A-0** | **A-1** | **A-2** | **B-1** | **B-2** | **C-1** | **C-2** | **D-1** | **D-2** | **E-1** | **E-2** |
| **R18** | North | > 328 - <= 015 | 100% | 100% | 20% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 20% |
| **R19** | Northeast | > 015 - <= 078 | 100% | 100% | 20% | 100% | 20% | 100% | 100% | 100% | 100% | 100% | 100% |
| **R20** | East | > 078 - <= 112 | 100% | 100% | 20% | 100% | 20% | 100% | 20% | 100% | 100% | 100% | 100% |
| **R21** | Southeast | > 112 - <=157 | 100% | 100% | 100% | 100% | 20% | 100% | 20% | 100% | 20% | 100% | 100% |
| **R22** | South | > 157 - <= 202 | 100% | 100% | 100% | 100% | 100% | 100% | 20% | 100% | 20% | 100% | 100% |
| (R22) | Southwest | > 202 - <= 247 | 100% | 100% | 100% | 100% | 100% | 100% | 20% | 100% | 20% | 100% | 100% |
| **R23** | West | > 247 - <= 292 | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 20% | 100% | 100% |
| **R24** | Northwest | > 292 - <= 328 | 100% | 100% | 20% | 100% | 100% | 100% | 100% | 100% | 100% | 100% | 20% |

| Staged Evacuation - 2-Mile Radius Evacuates, then Evacuate Downwind to 5 Miles | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Region** | **Wind Direction From:** | **Wind Direction From: (Degrees)** | **Zone** | | | | | | | | | | |
| | | | **A-0** | **A-1** | **A-2** | **B-1** | **B-2** | **C-1** | **C-2** | **D-1** | **D-2** | **E-1** | **E-2** |
| **R25** | North | > 328 - <= 015 | 100% | 20% | 20% | 100% | 20% | 100% | 20% | 100% | 20% | 20% | 20% |
| **R26** | Northeast | > 015 - <= 078 | 100% | 20% | 20% | 20% | 20% | 100% | 20% | 100% | 20% | 100% | 20% |
| **R27** | East | > 078 - <= 112 | 100% | 20% | 20% | 20% | 20% | 20% | 20% | 100% | 20% | 100% | 20% |
| **R28** | Southeast | > 112 - <=157 | 100% | 100% | 20% | 20% | 20% | 20% | 20% | 100% | 20% | 100% | 20% |
| **R29** | South | > 157 - <= 202 | 100% | 100% | 20% | 100% | 20% | 20% | 20% | 20% | 20% | 100% | 20% |
| (R29) | Southwest | > 202 - <= 247 | 100% | 100% | 20% | 100% | 20% | 20% | 20% | 20% | 20% | 100% | 20% |
| **R30** | West | > 247 - <= 292 | 100% | 100% | 20% | 100% | 20% | 100% | 20% | 20% | 20% | 20% | 20% |
| **R31** | Northwest | > 292 - <= 328 | 100% | 20% | 20% | 100% | 20% | 100% | 20% | 20% | 20% | 20% | 20% |
| **R32** | 5-Mile Ring | N/A | 100% | 100% | 20% | 100% | 20% | 100% | 20% | 100% | 20% | 100% | 20% |

| Zone(s) Shelter-in-Place until 90% ETE for R01, then Evacuate | Zone(s) Shelter-in-Place | Zone(s) Evacuate |
|---|---|---|

**Note:** Regions that are repeated for a different wind direction are written in parentheses

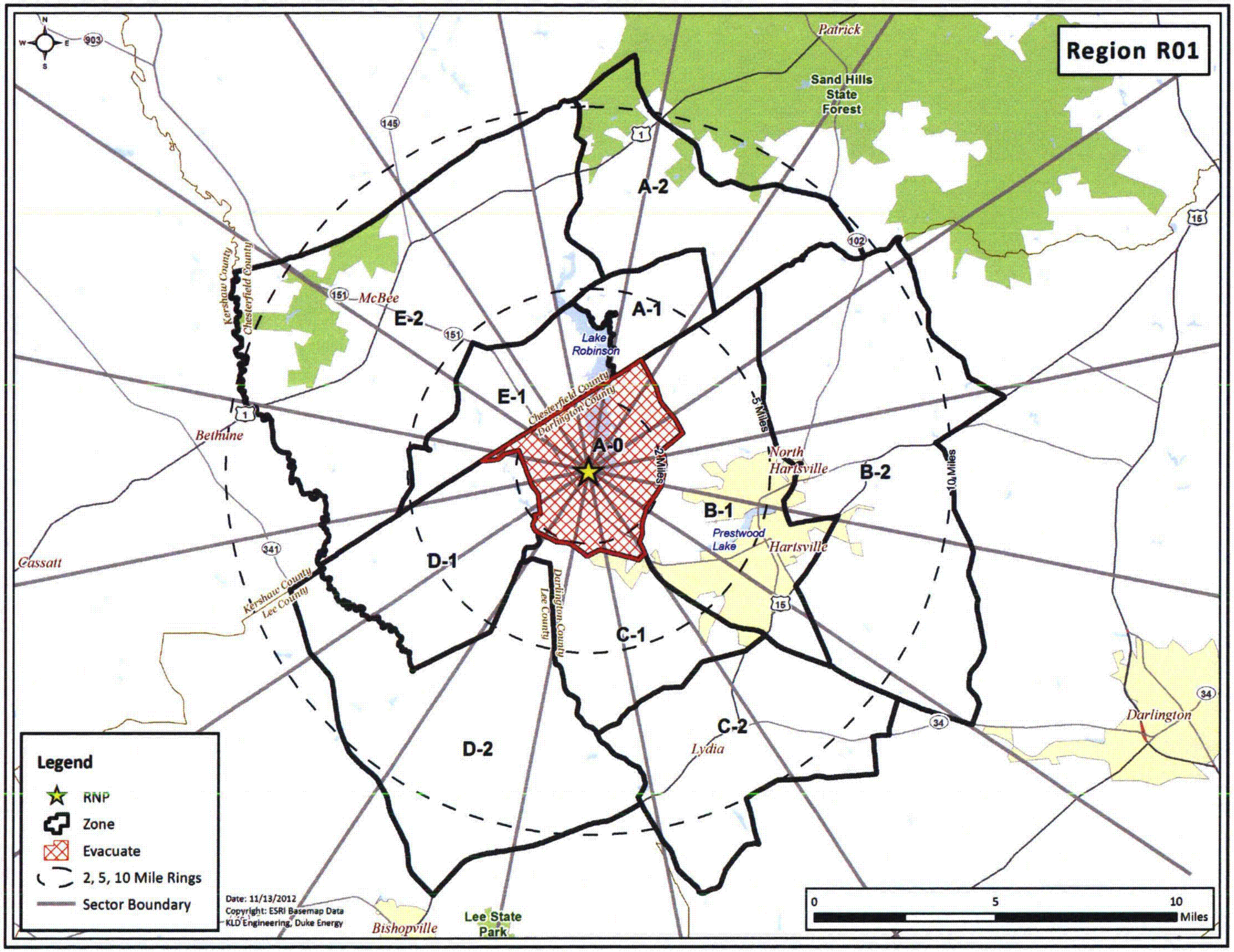



**Figure H-1. Region R01**

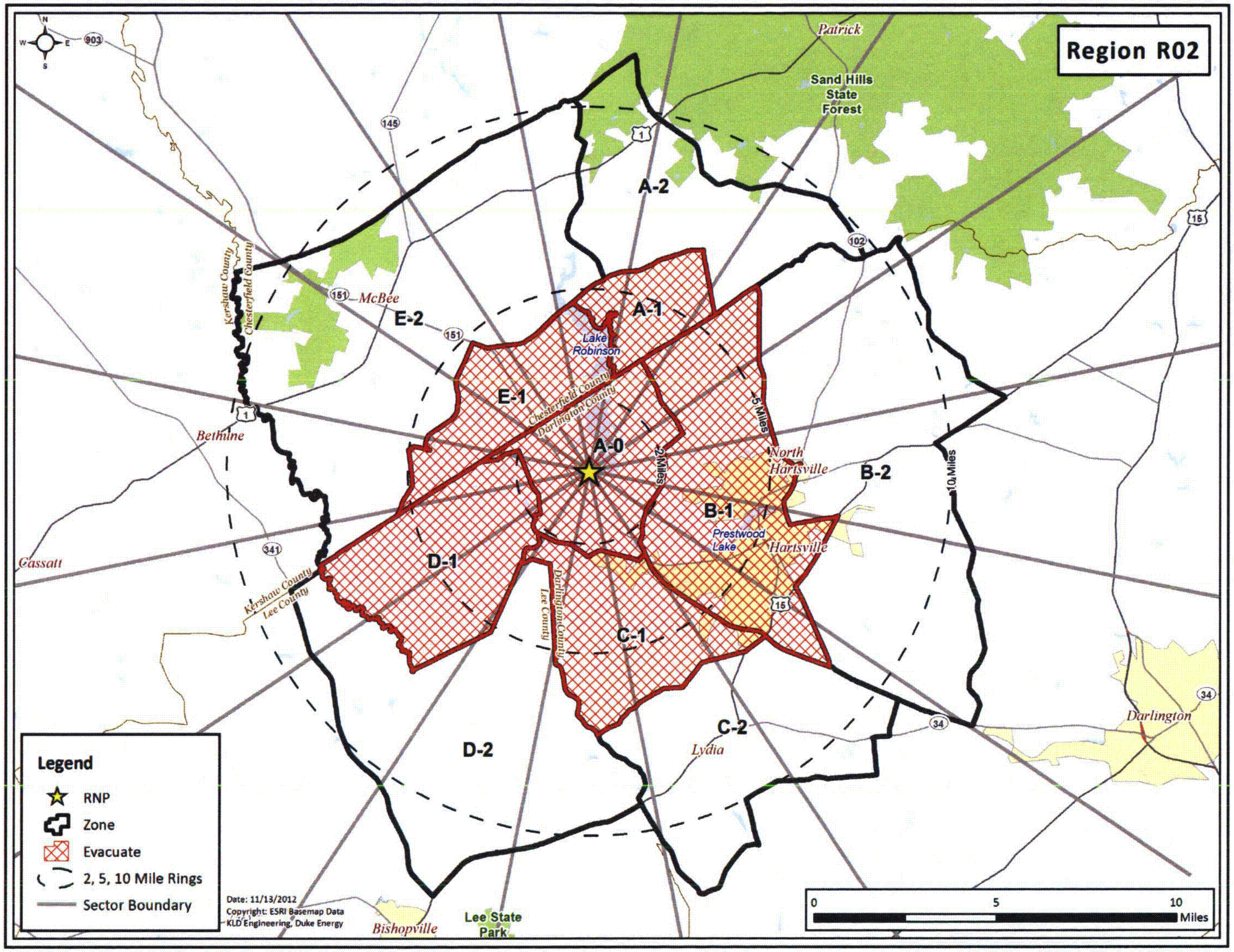



**Figure H-2. Region R02**

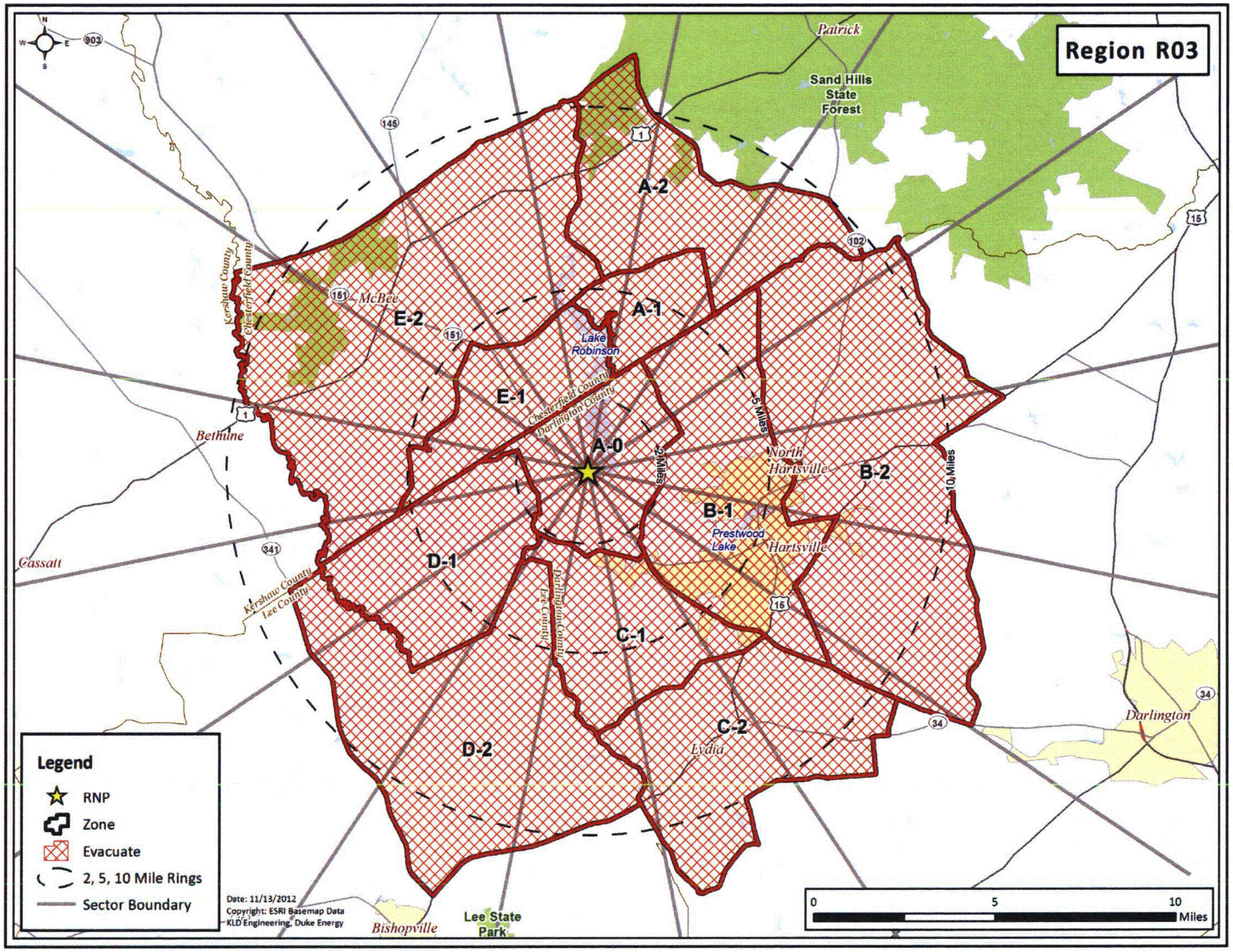



**Figure H-3. Region R03**

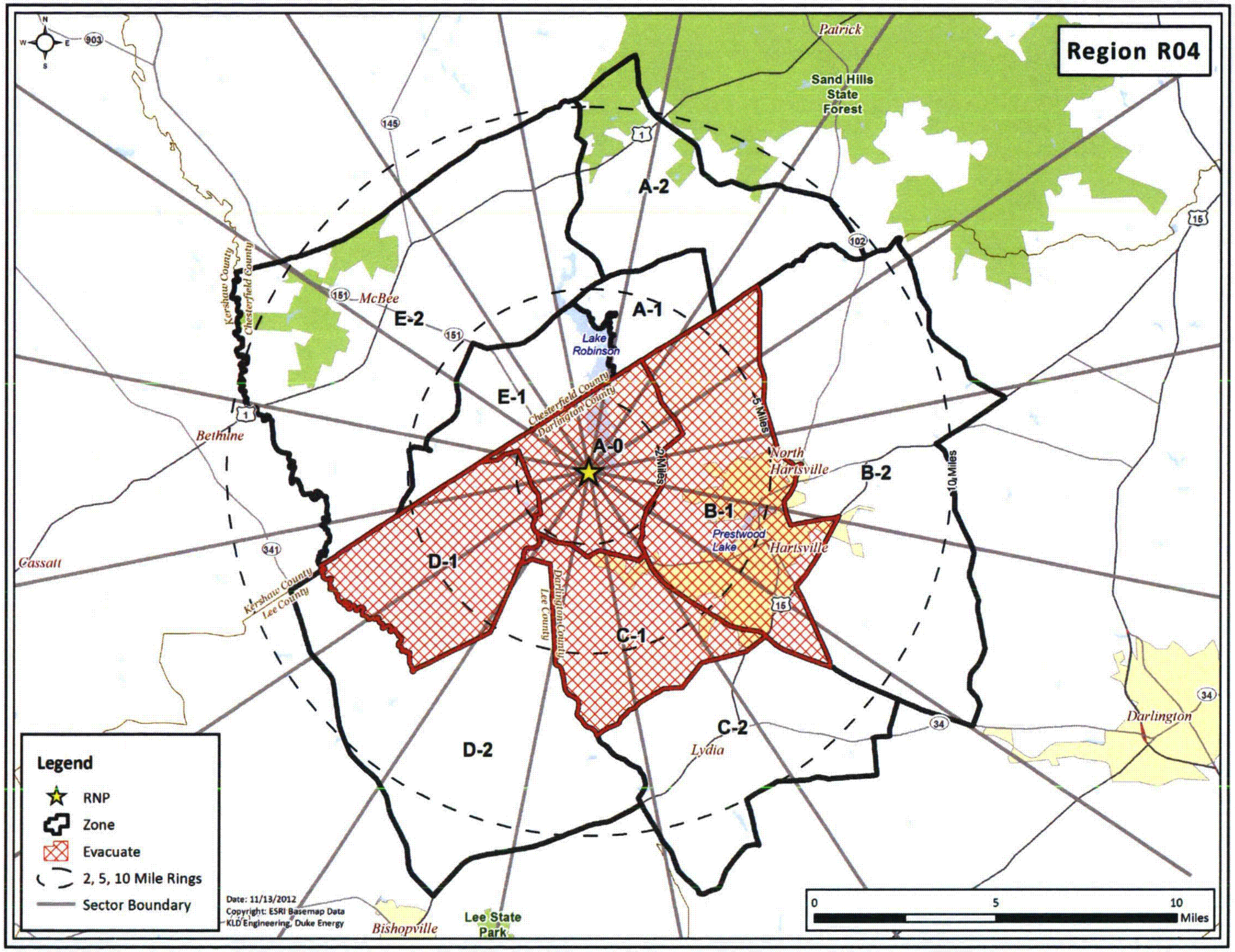



**Figure H-4. Region R04**

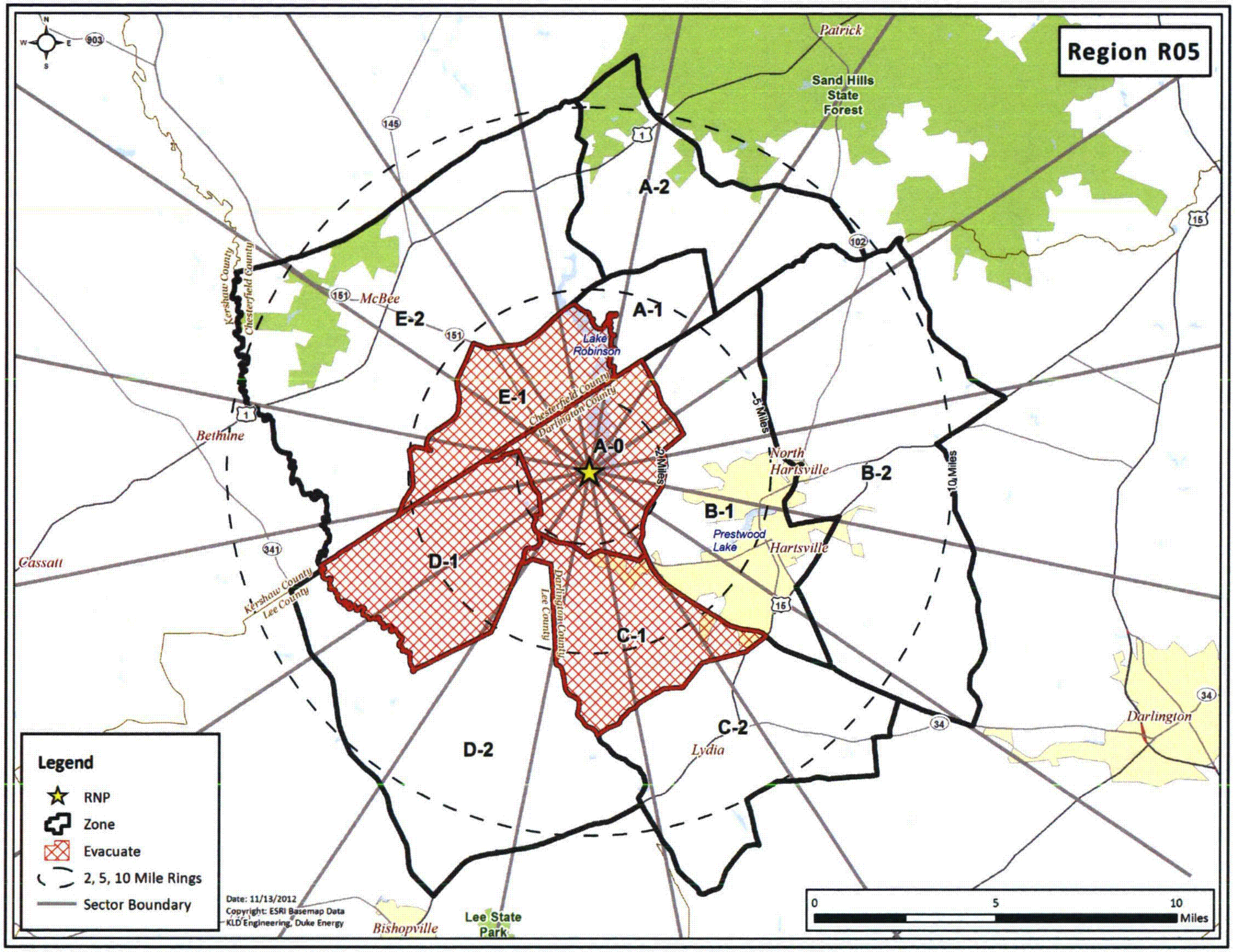



**Figure H-5. Region R05**

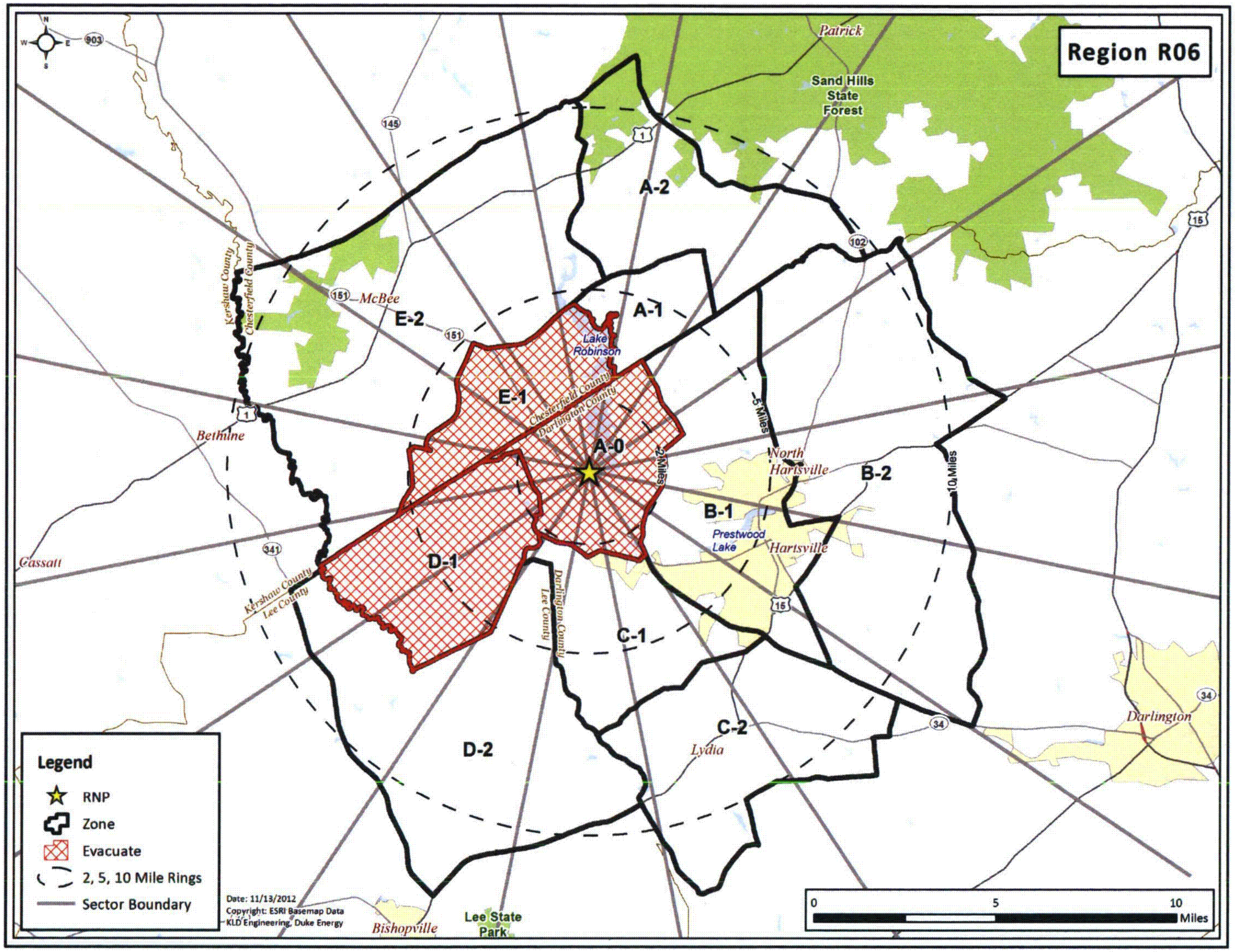



**Figure H-6. Region R06**

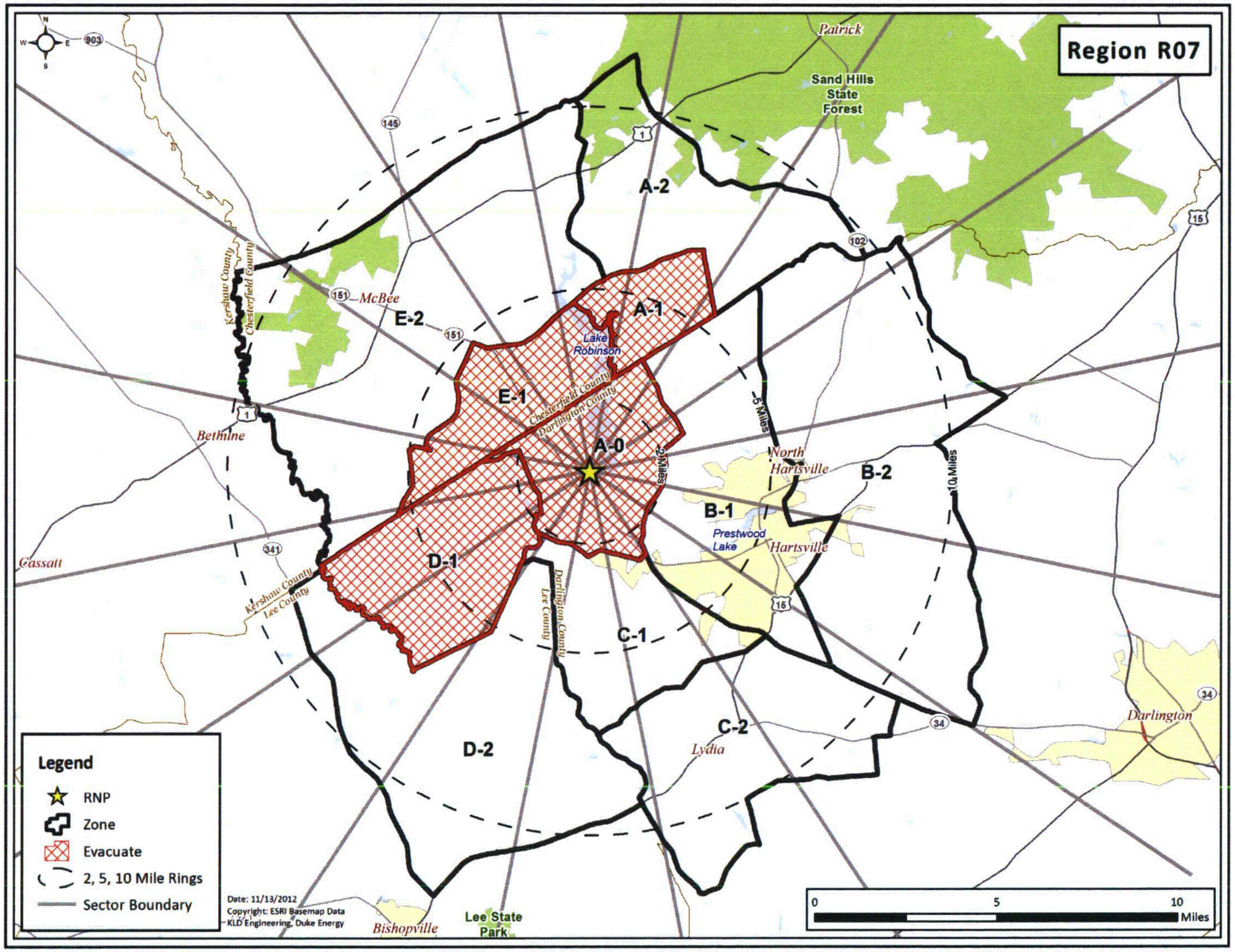



**Figure H-7. Region R07**

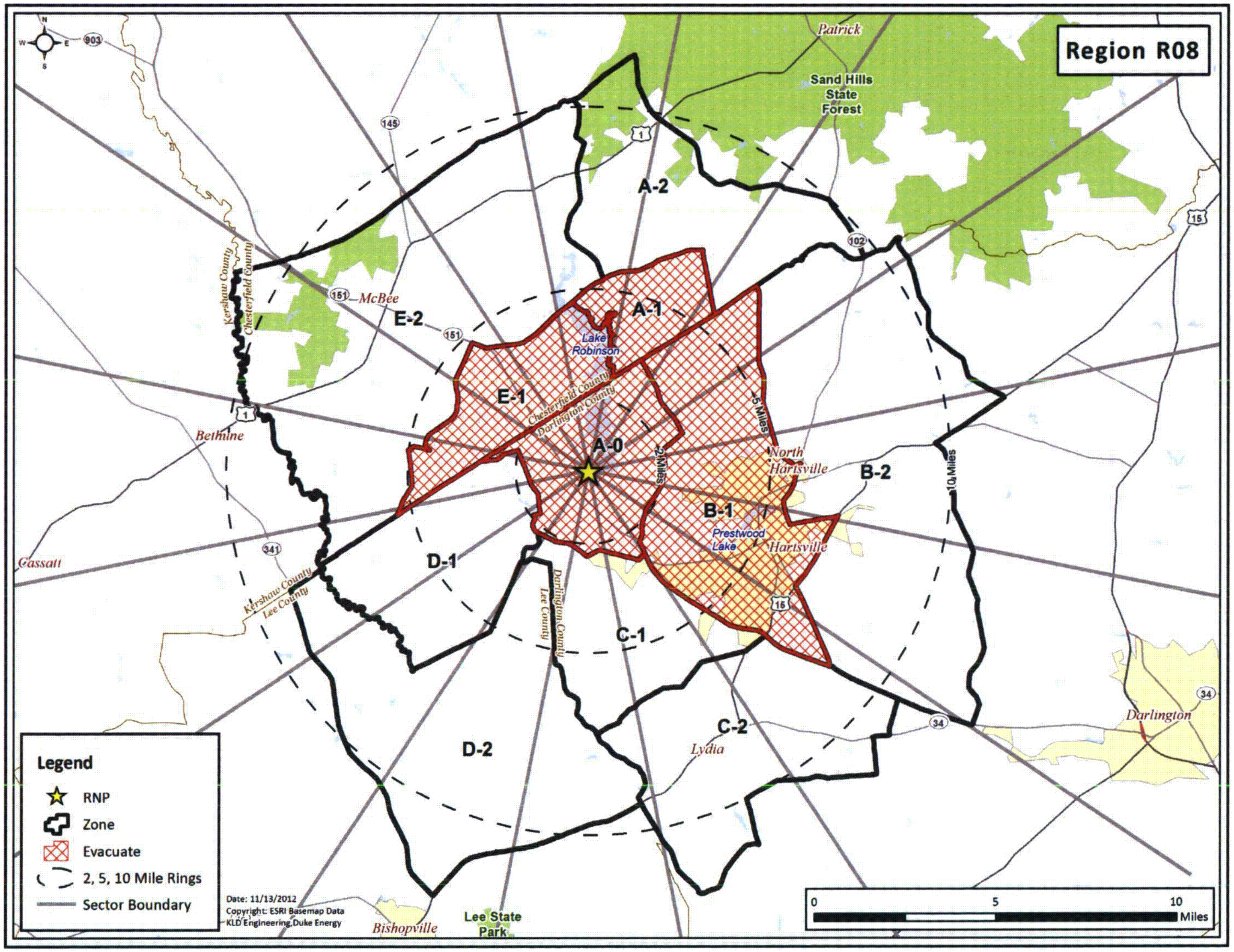



**Figure H-8. Region R08**

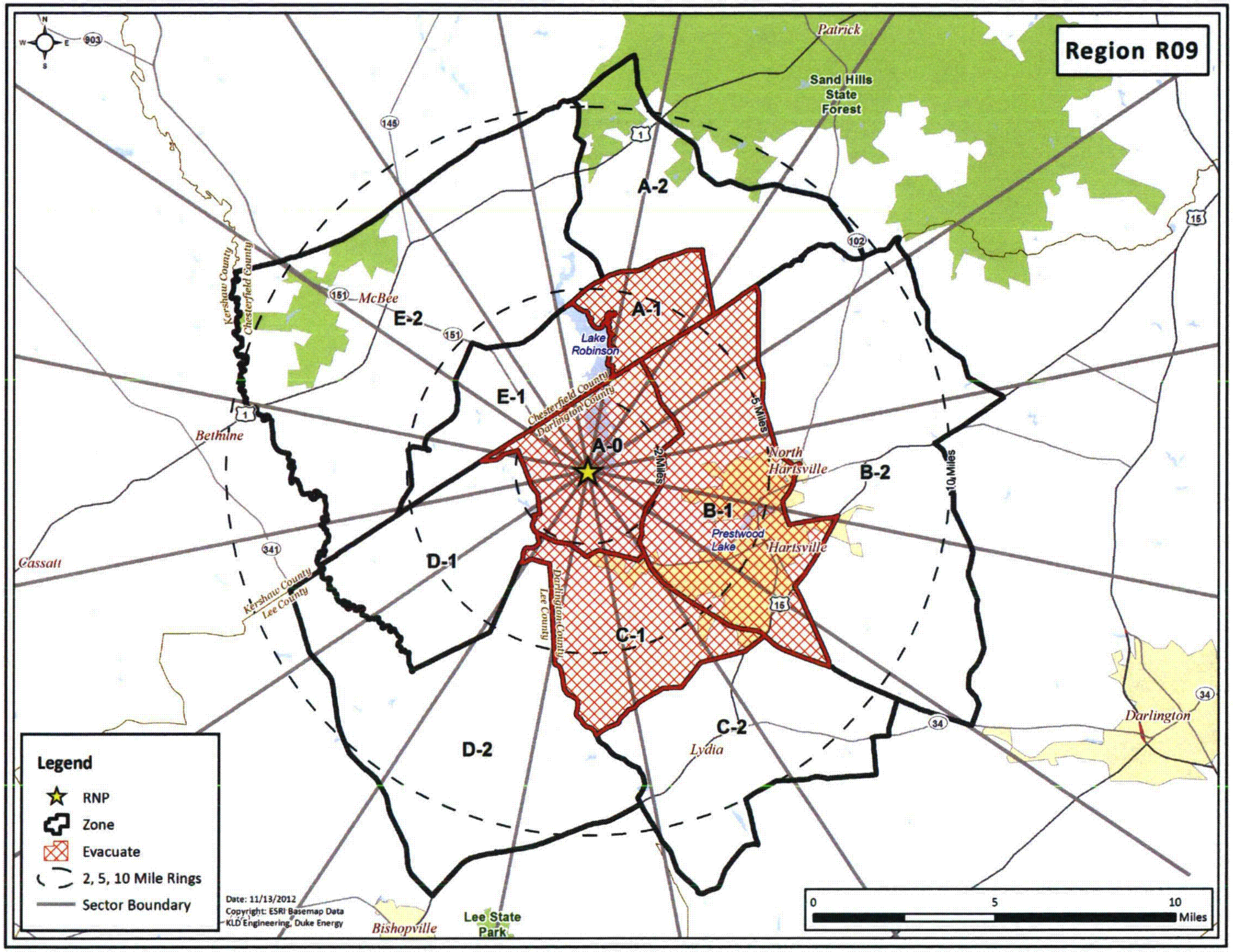



**Figure H-9. Region R09**

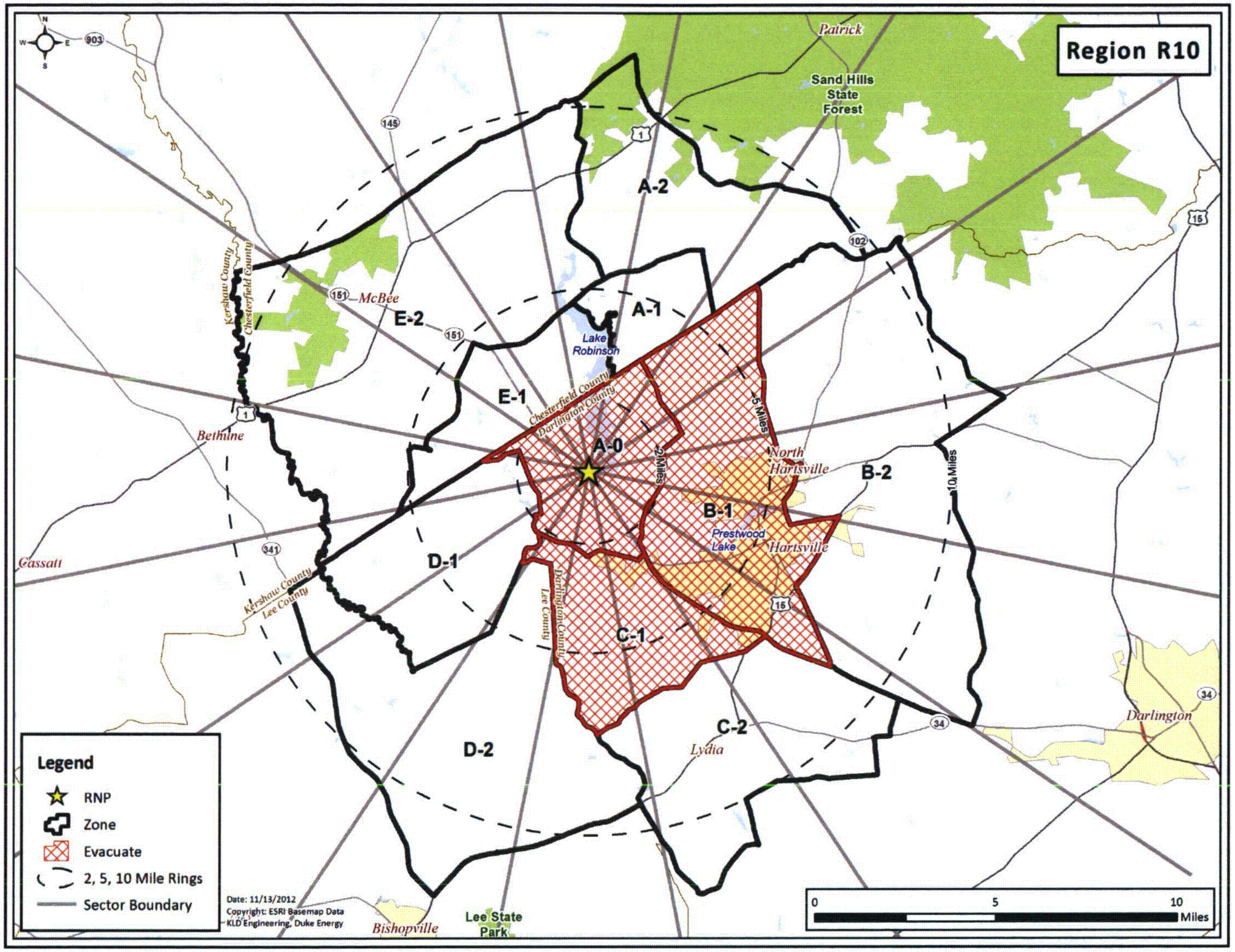



**Figure H-10. Region R10**

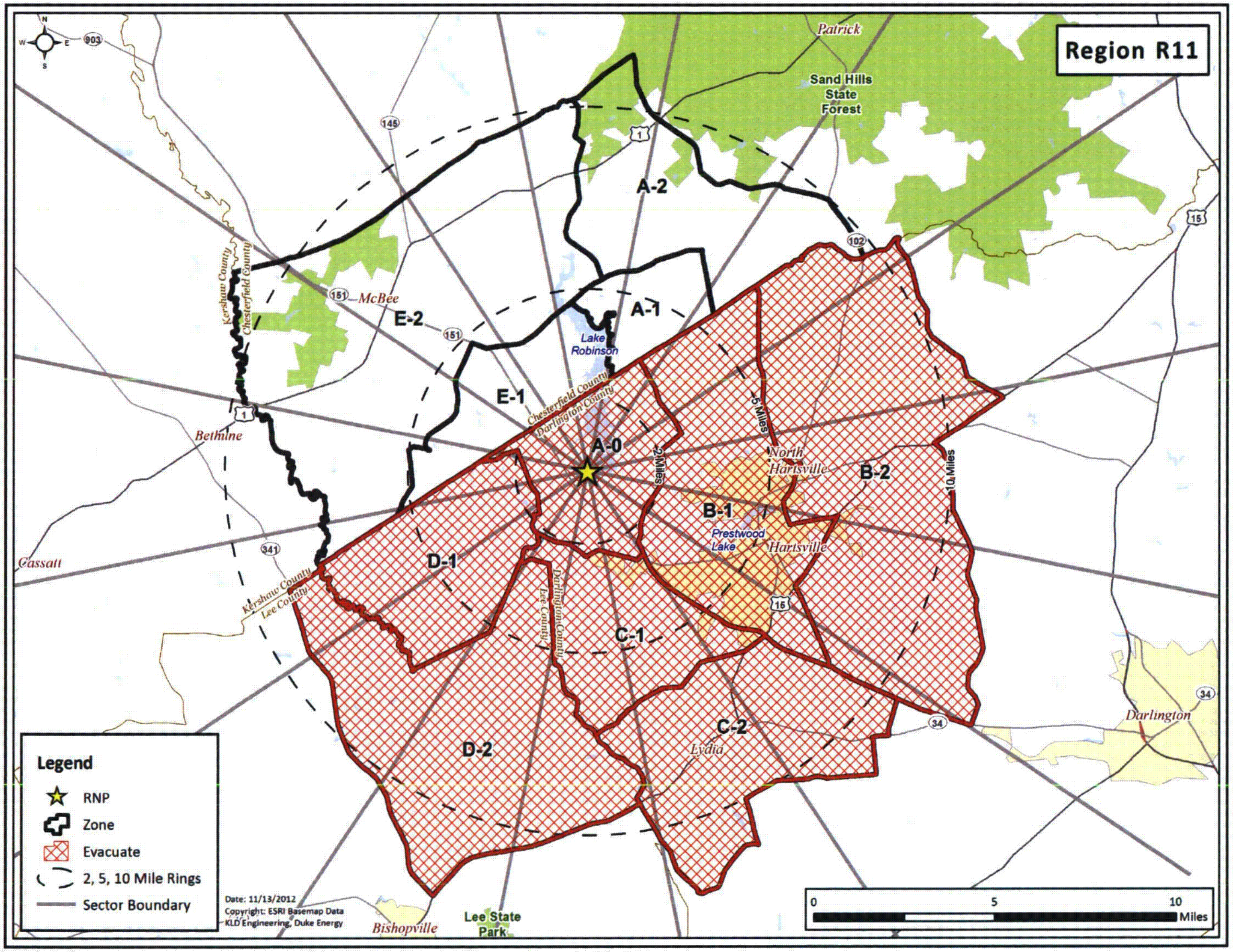



**Figure H-11. Region R11**

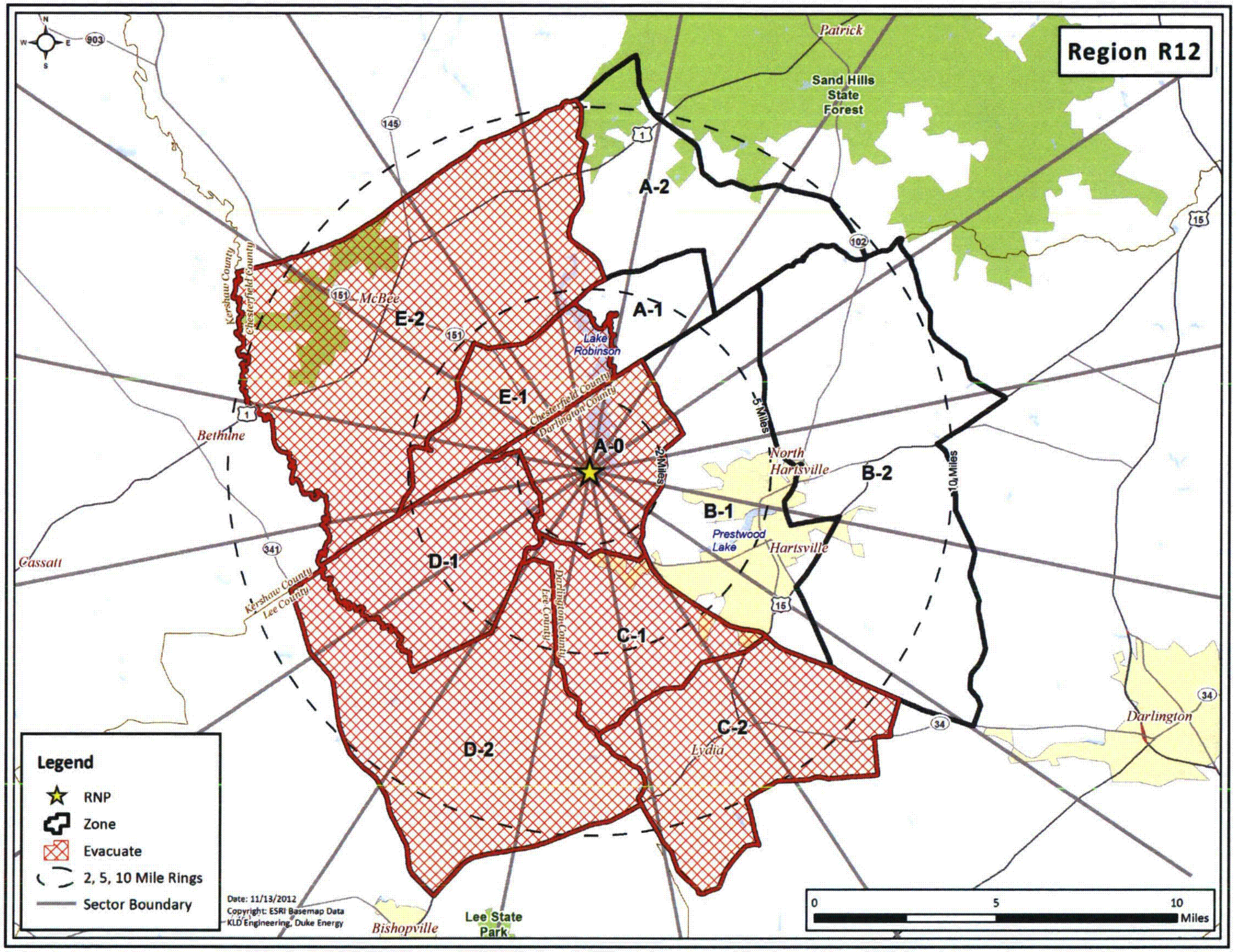



**Figure H-12. Region R12**

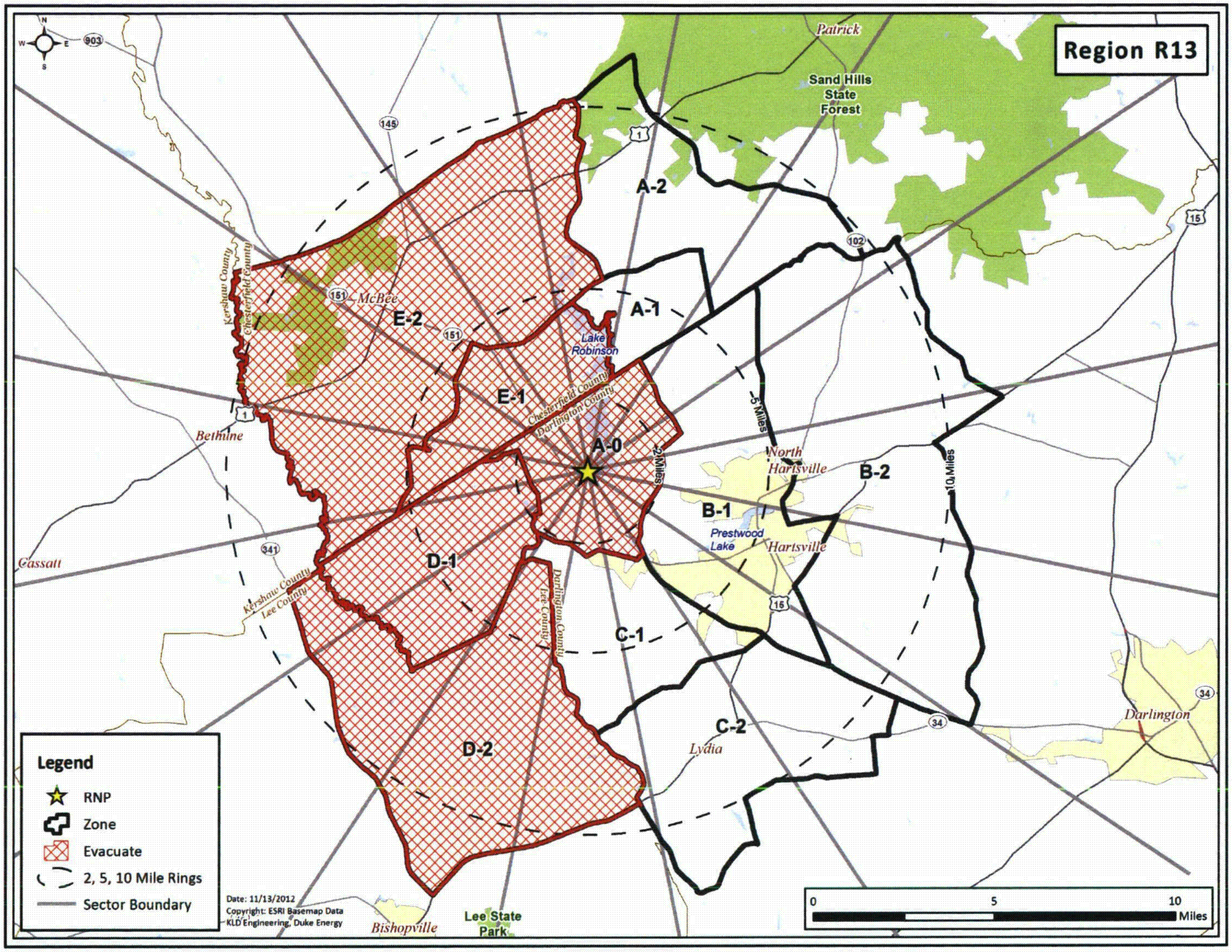



**Figure H-13. Region R13**

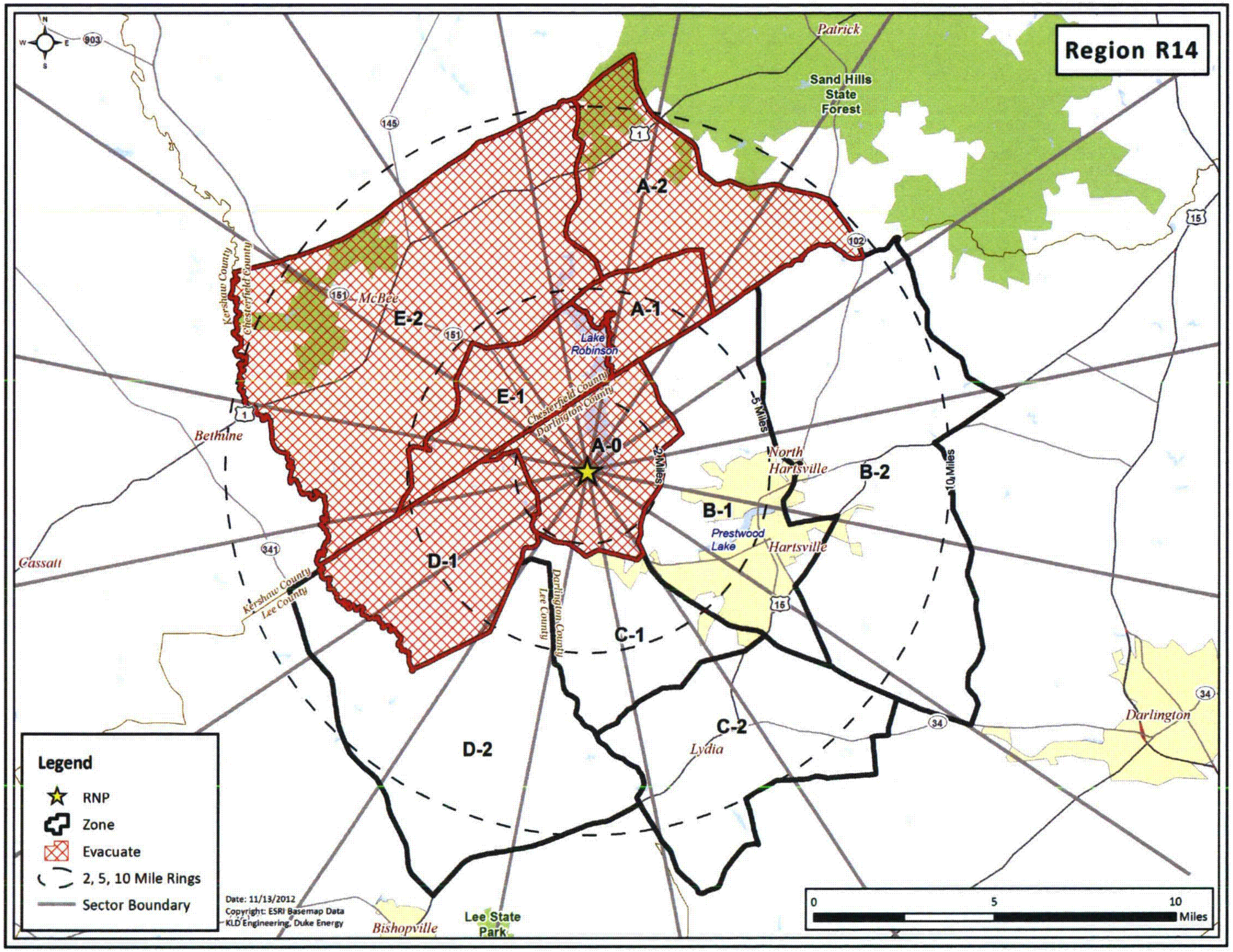



**Figure H-14. Region R14**

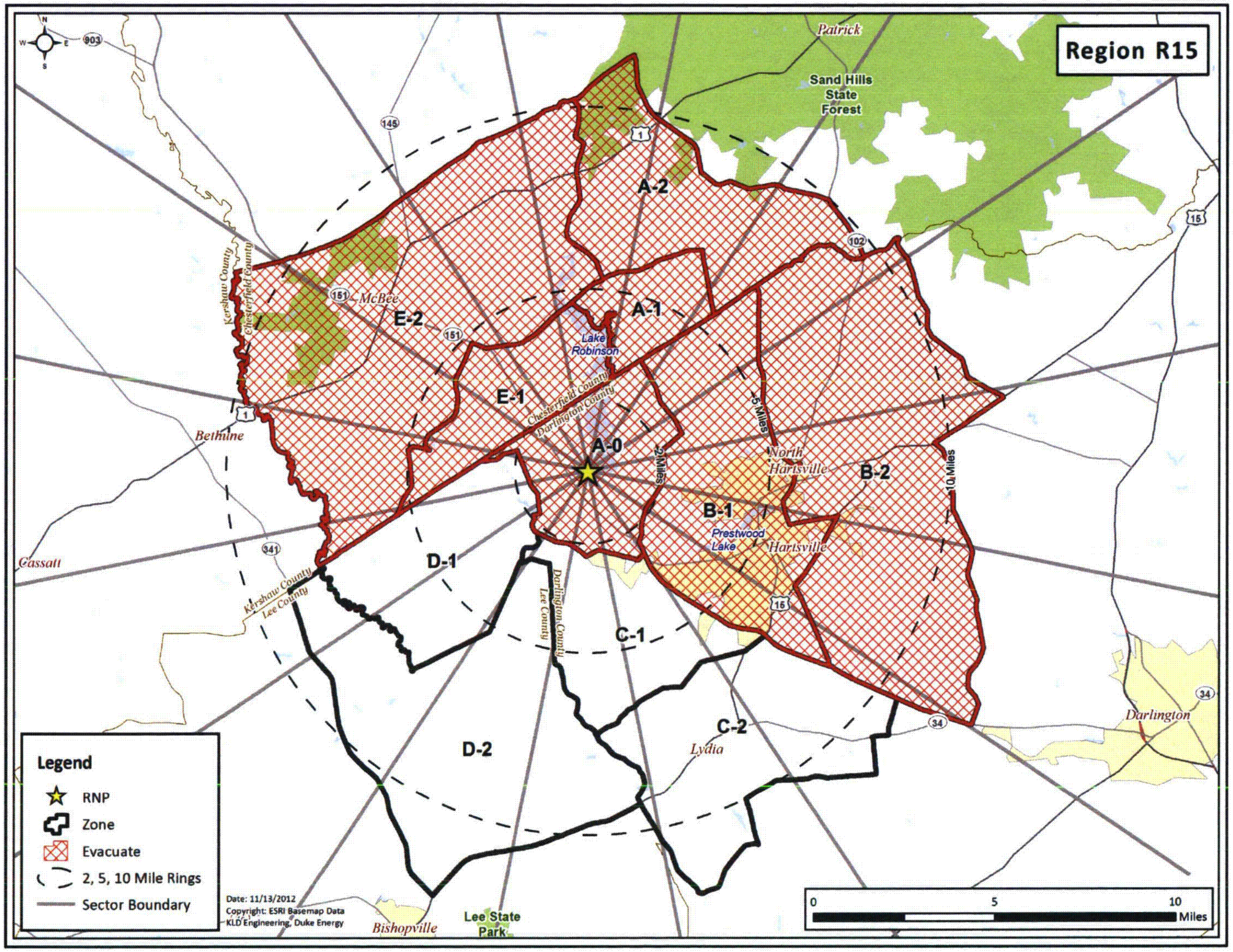



**Figure H-15. Region R15**

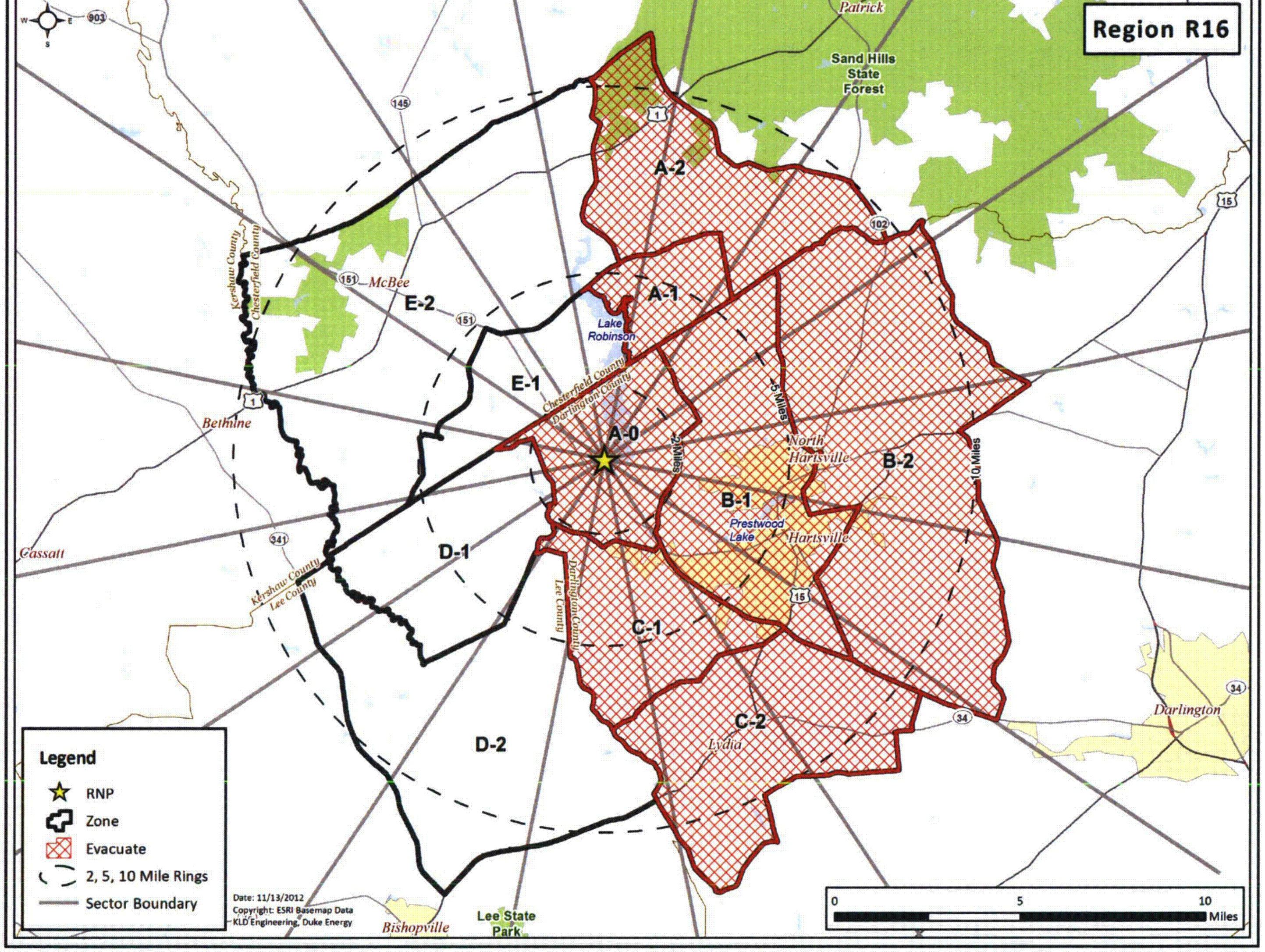



**Figure H-16. Region R16**

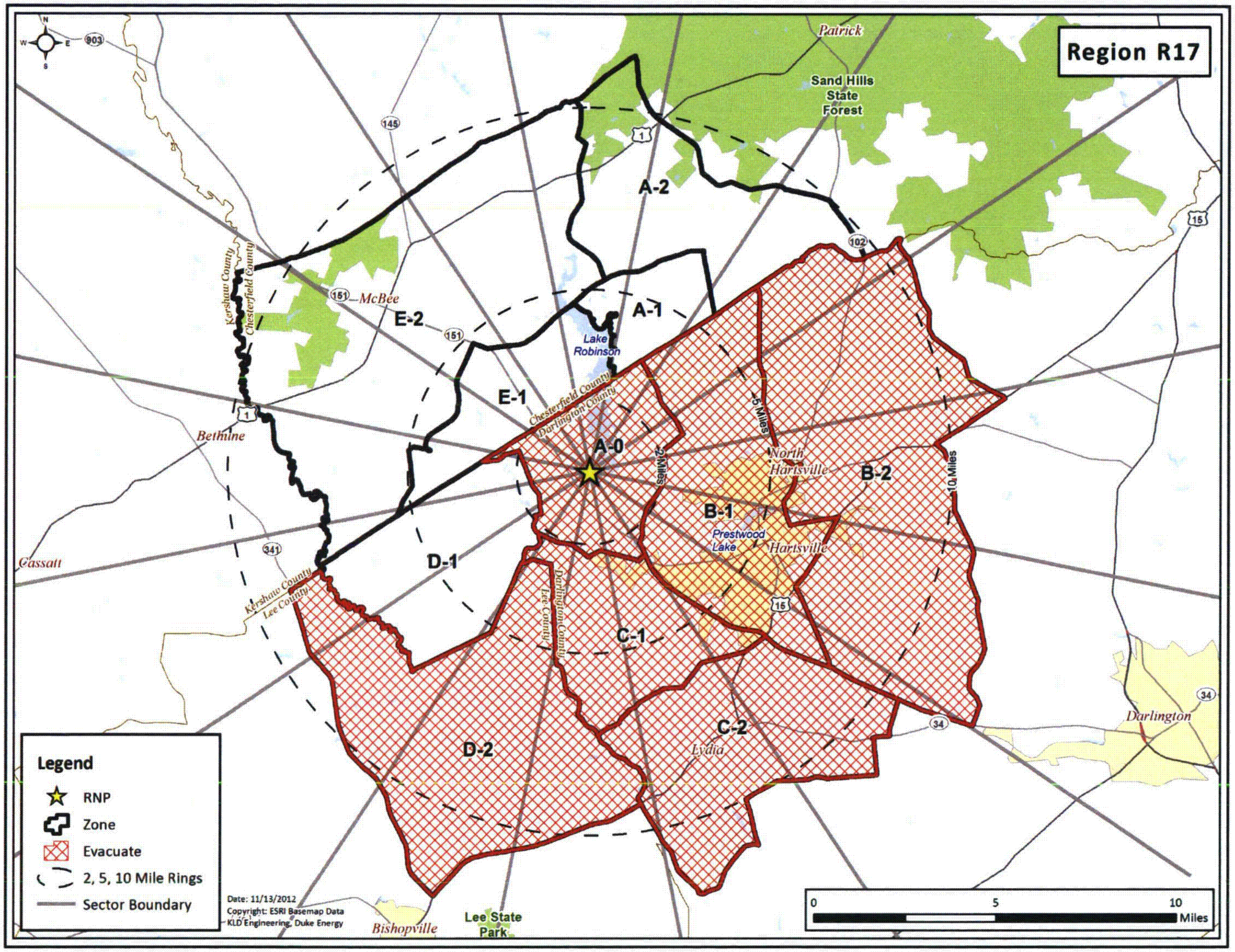



**Figure H-17. Region R17**

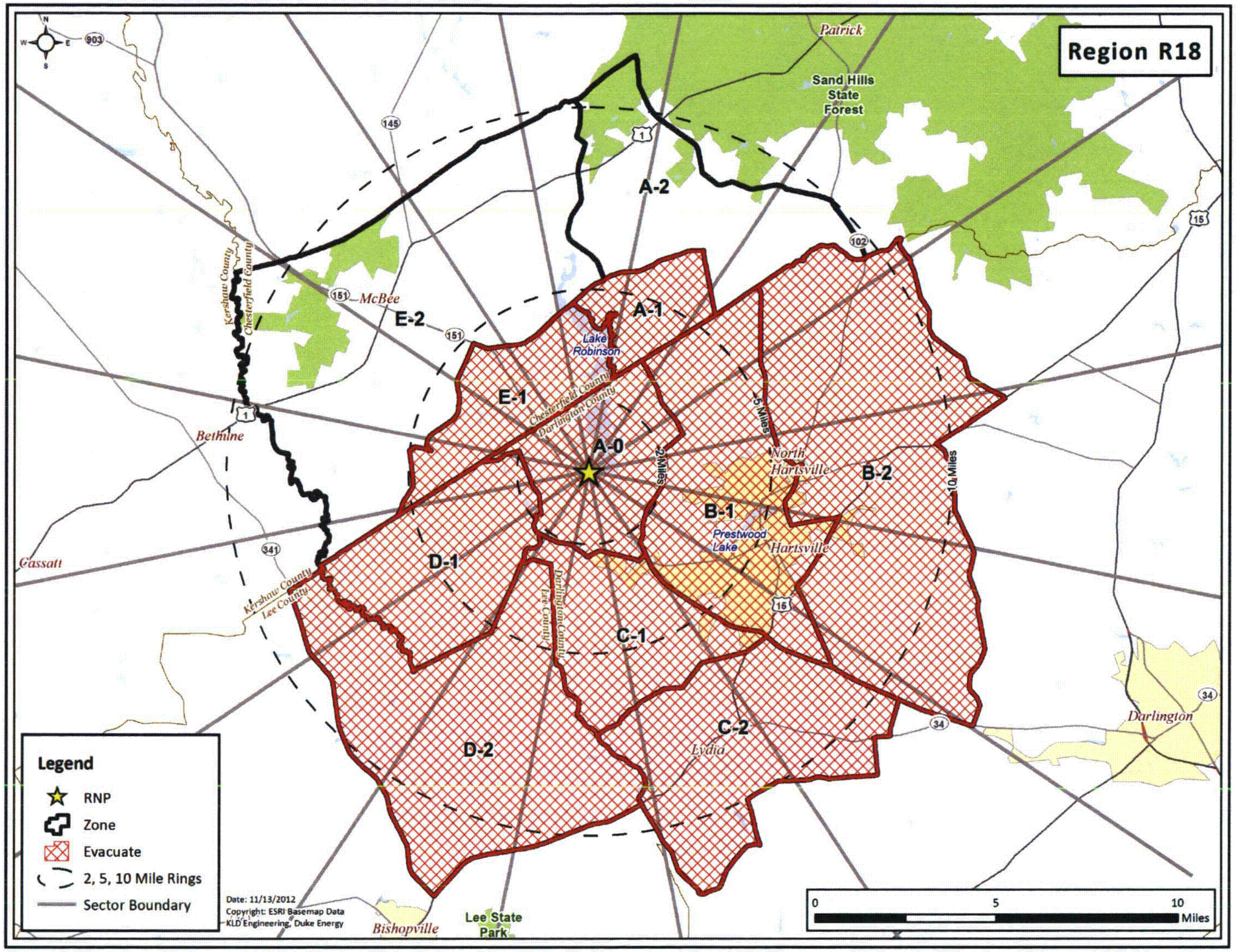



**Figure H-18. Region R18**

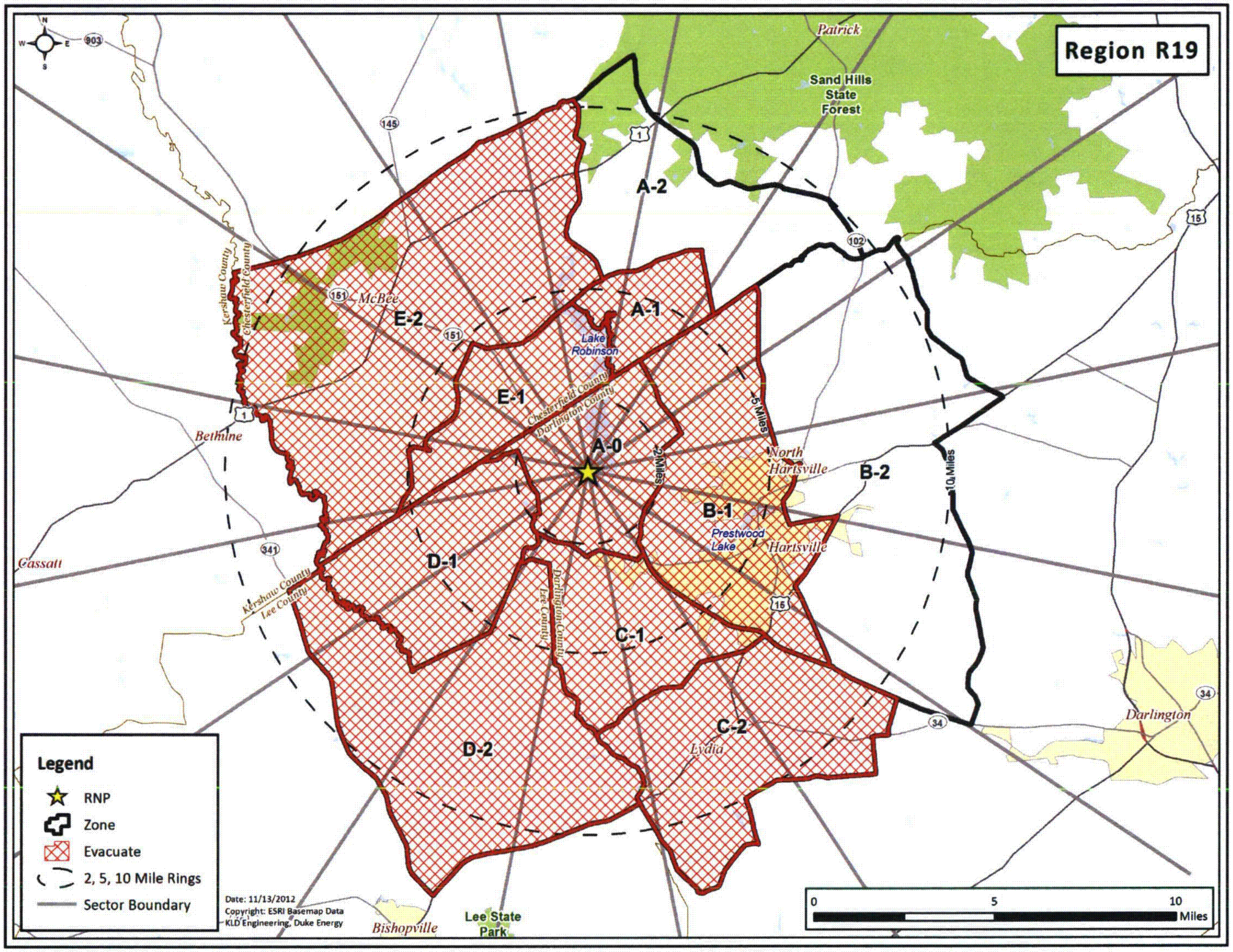



**Figure H-19. Region R19**

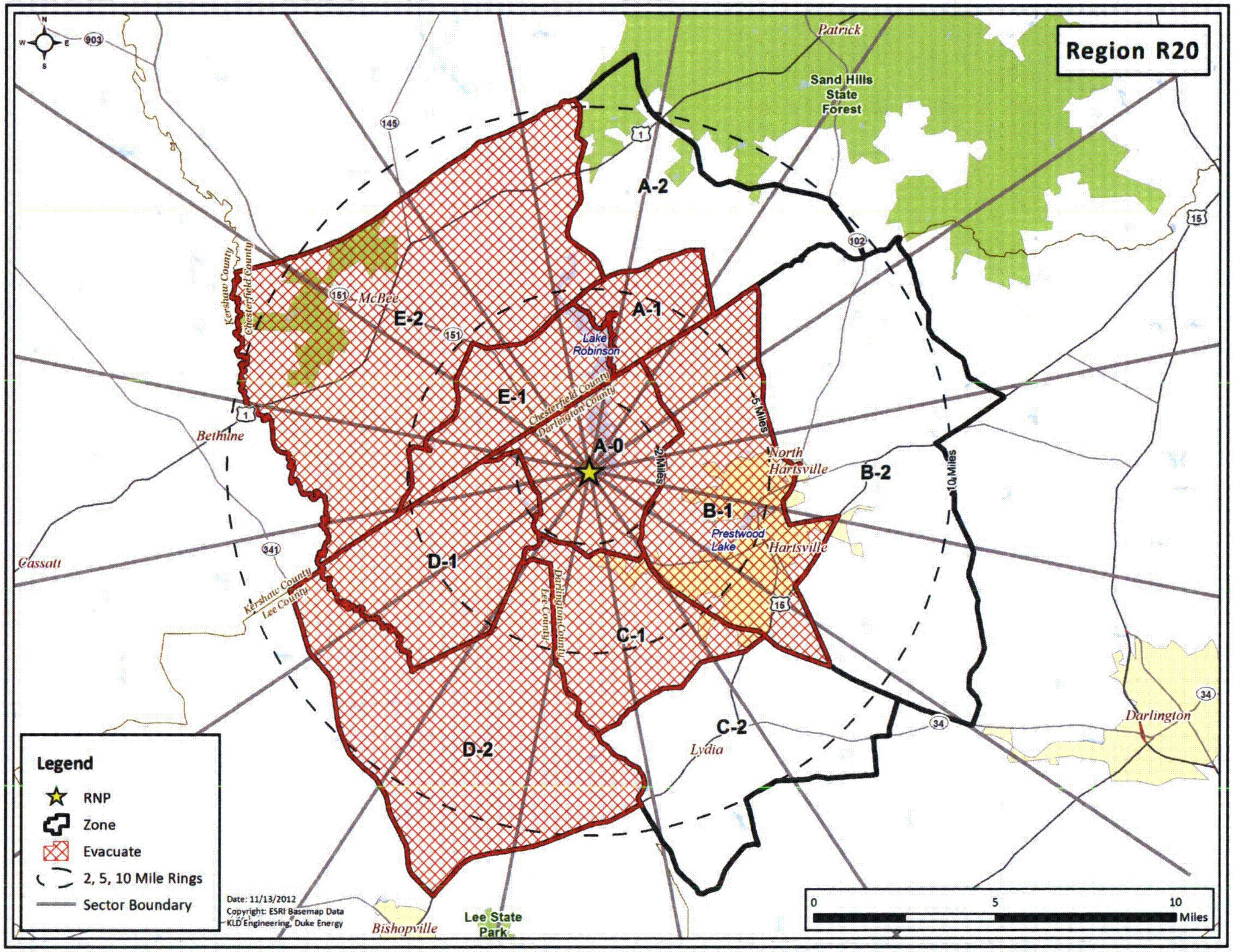



**Figure H-20. Region R20**

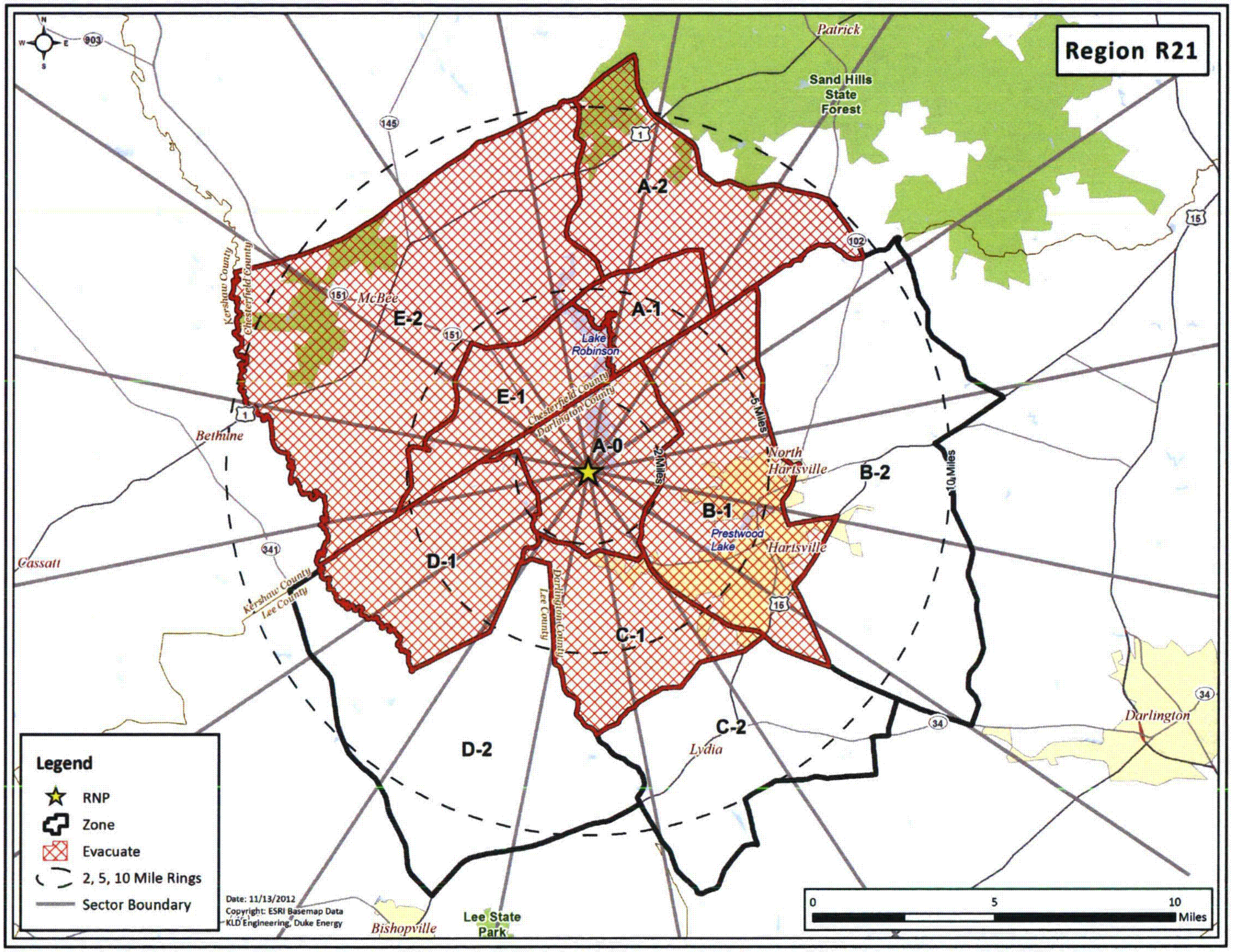



**Figure H-21. Region R21**

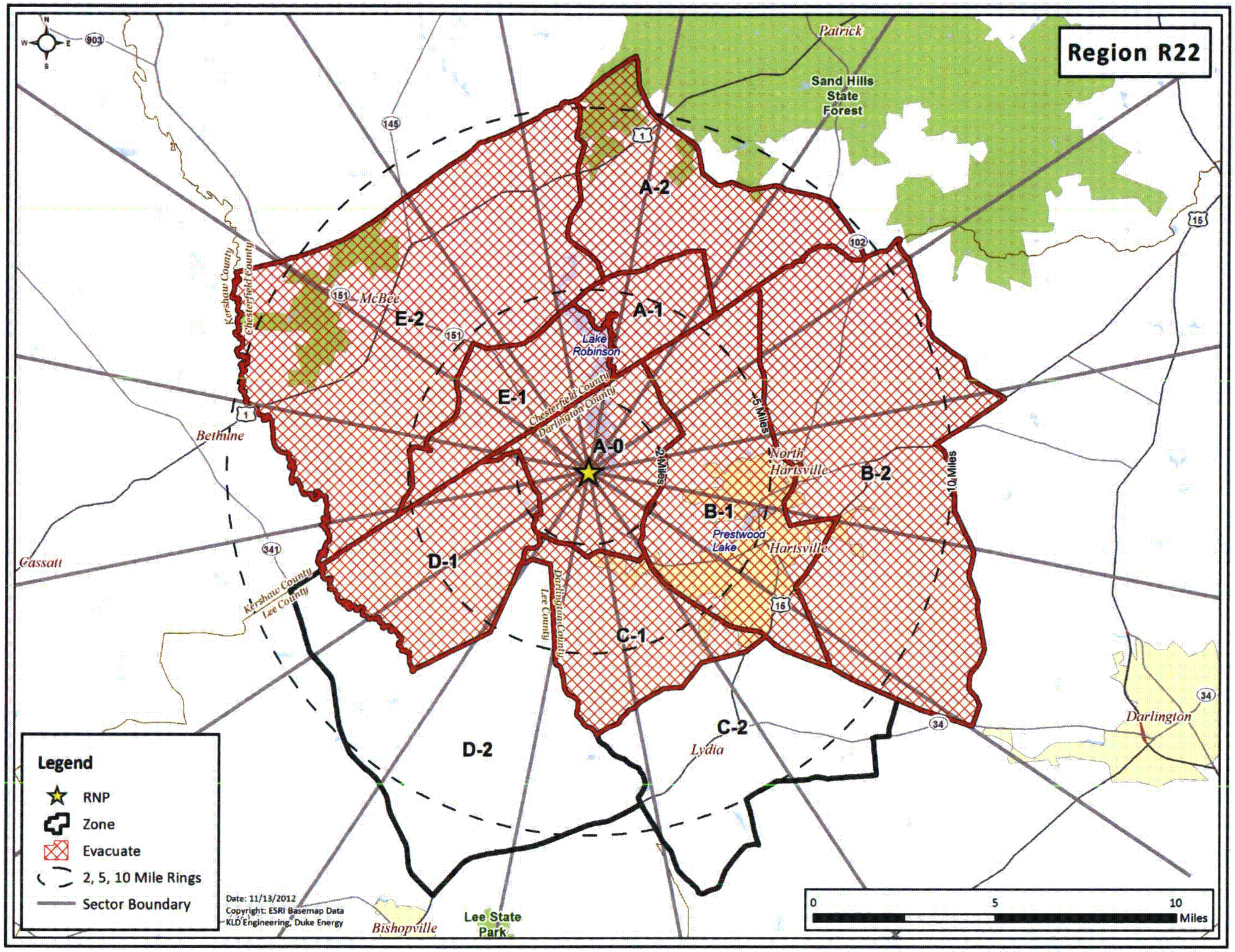



**Figure H-22. Region R22**

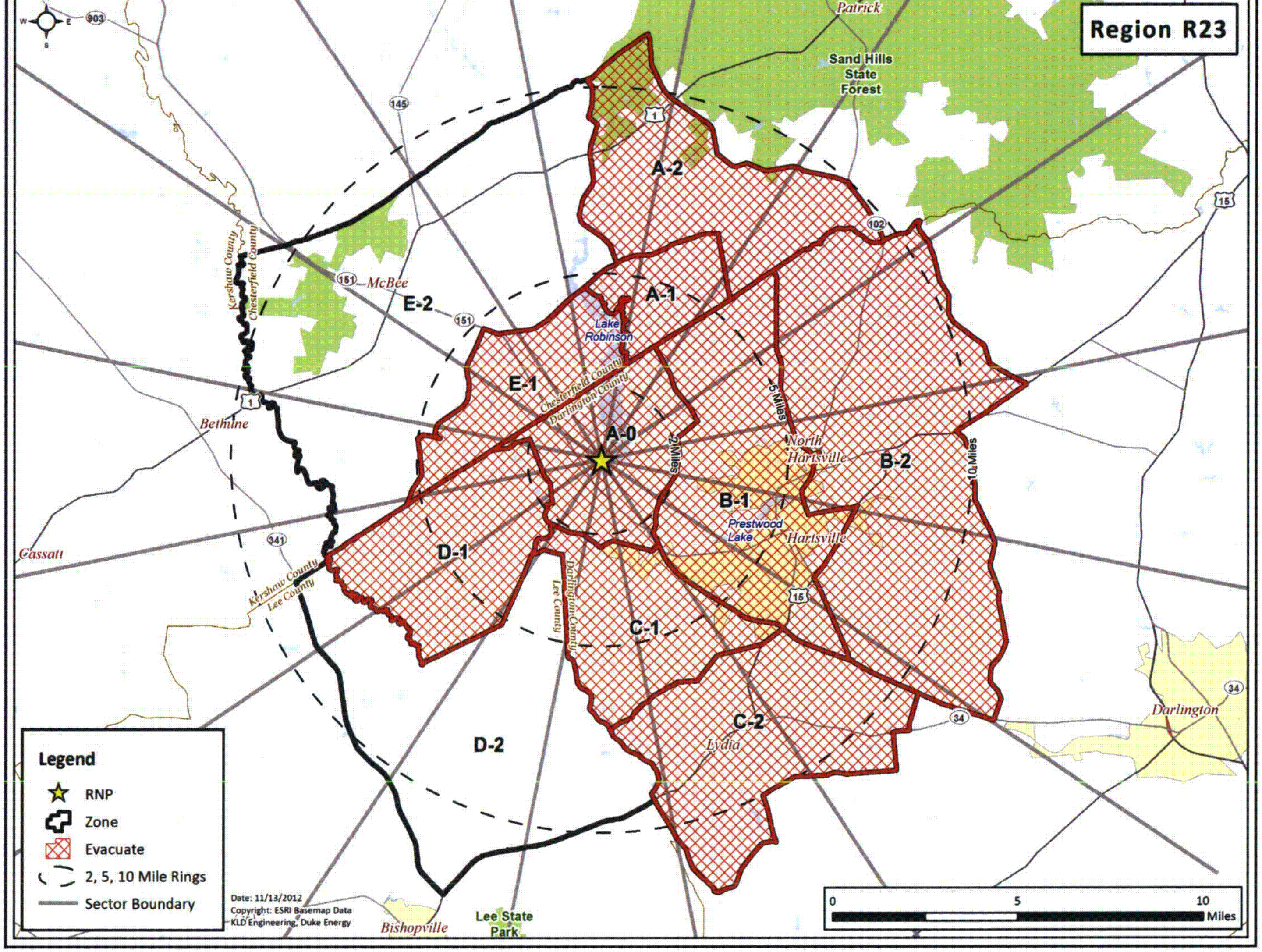



**Figure H-23. Region R23**

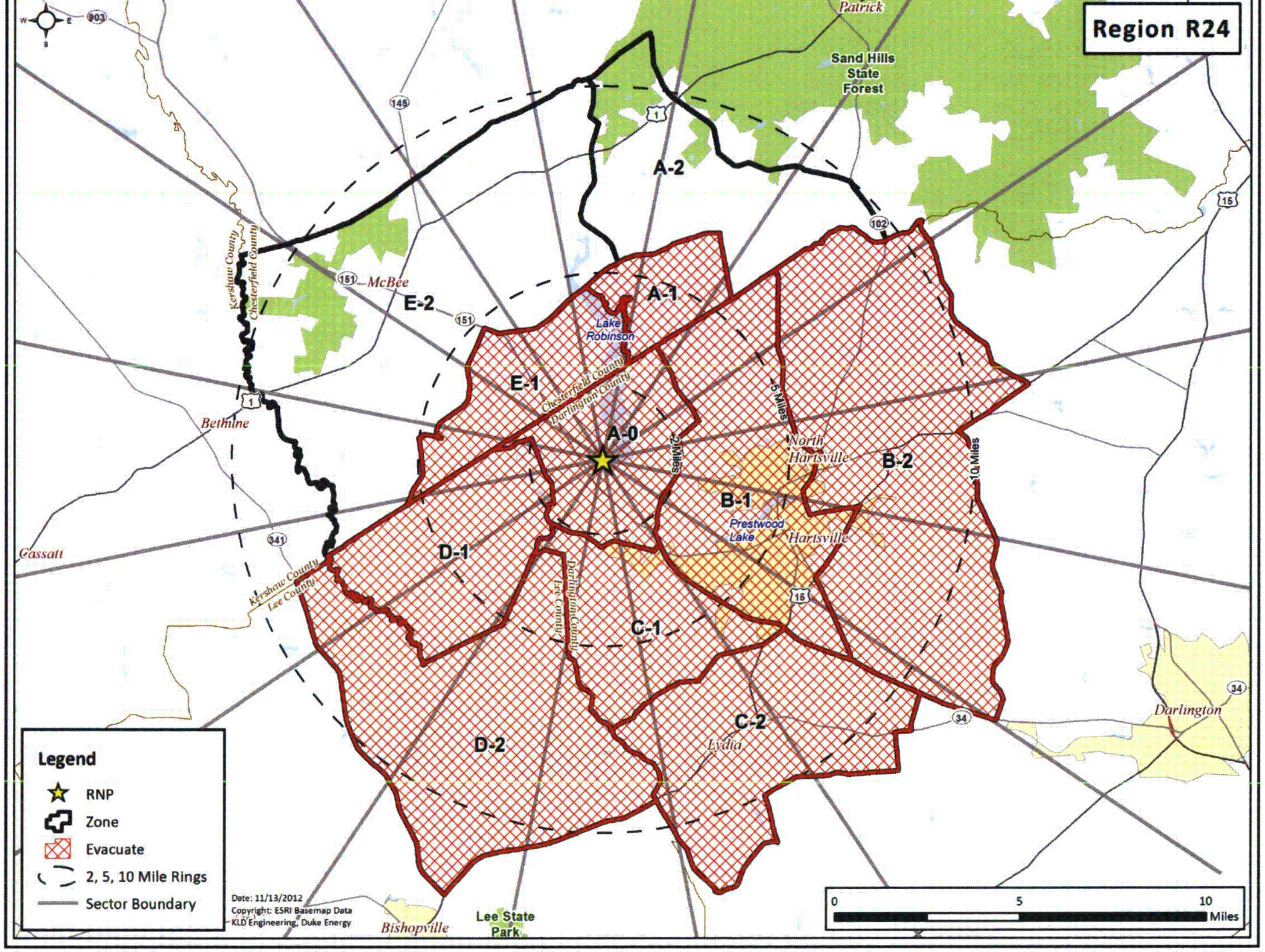



**Figure H-24. Region R24**

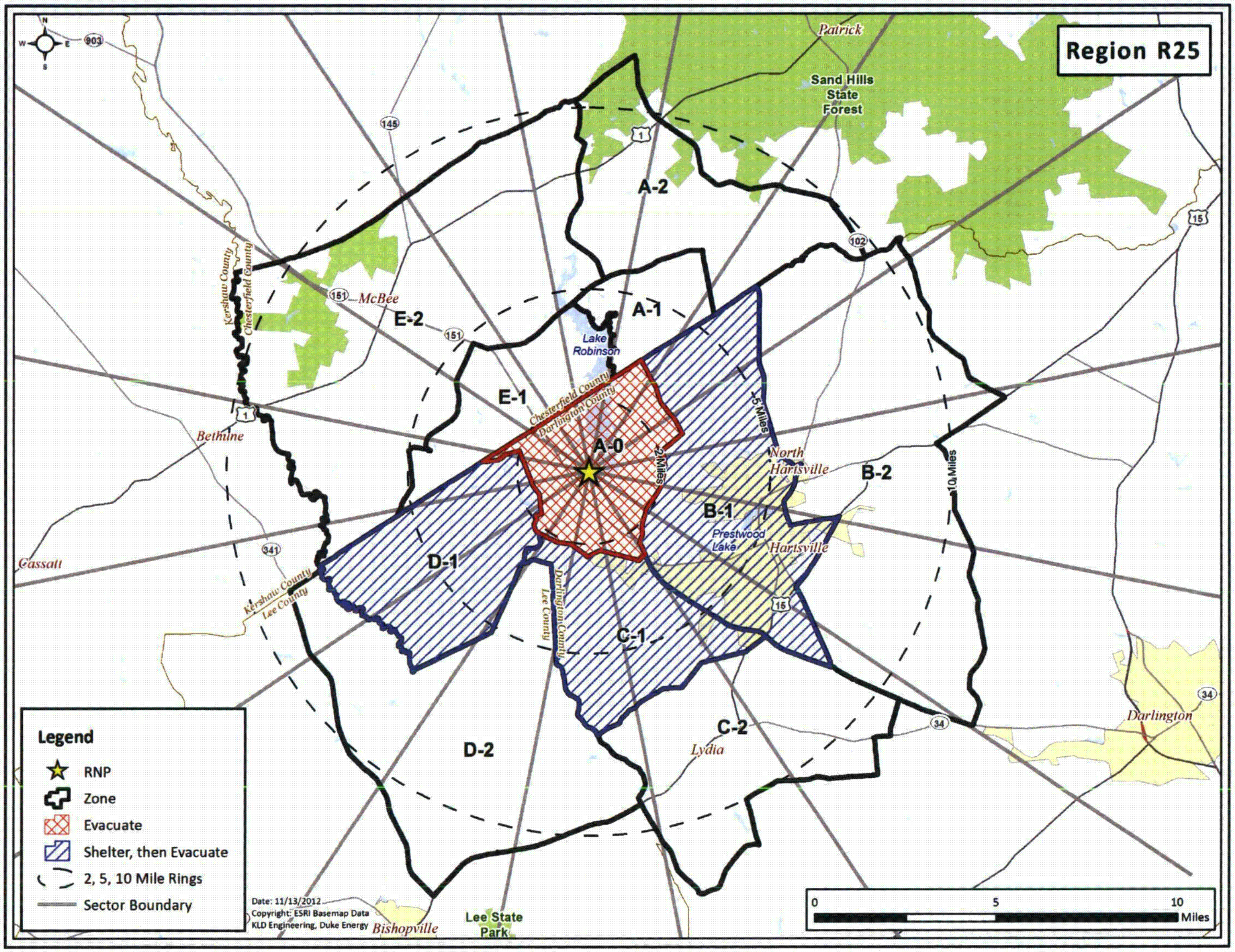



**Figure H-25. Region R25**

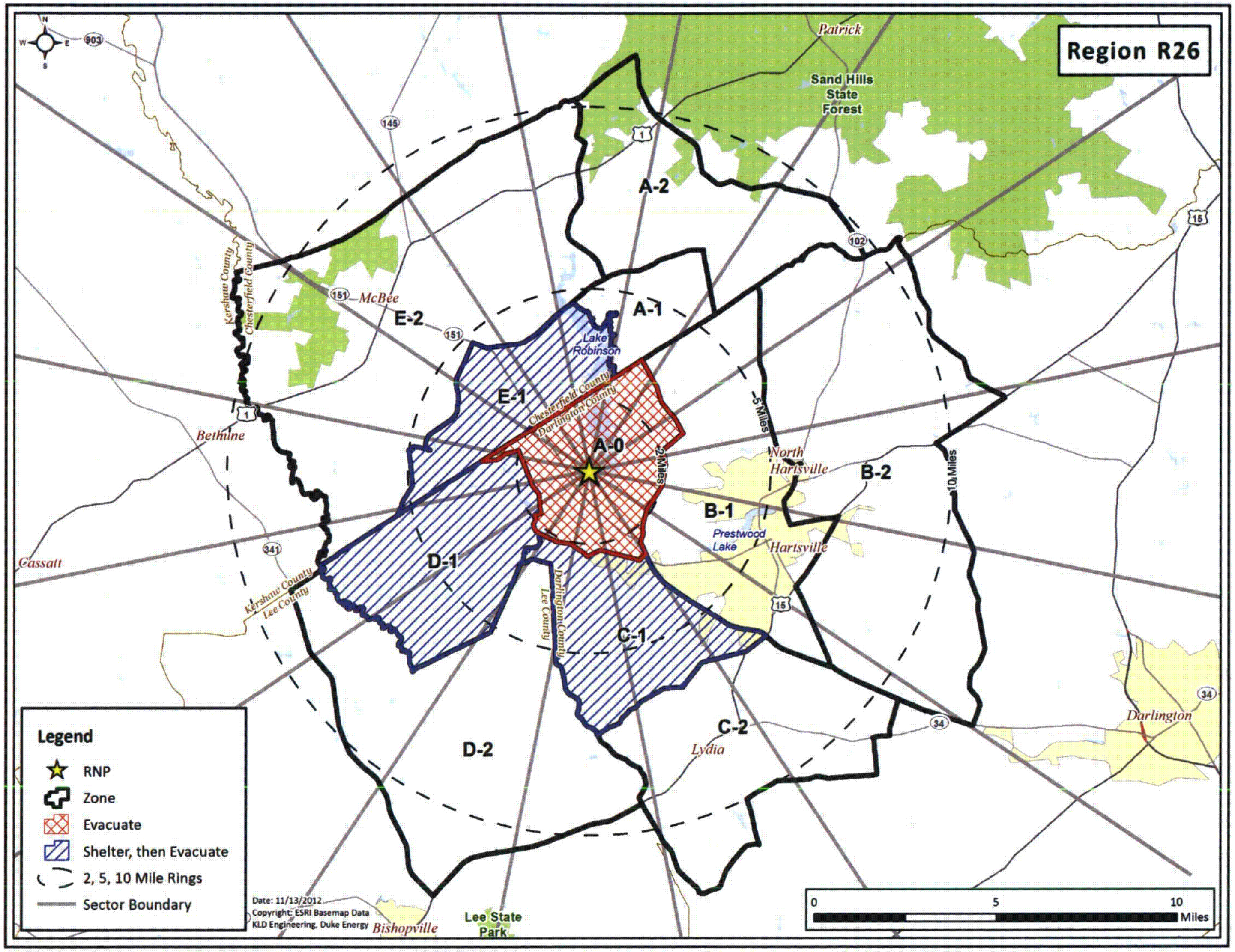



**Figure H-26. Region R26**

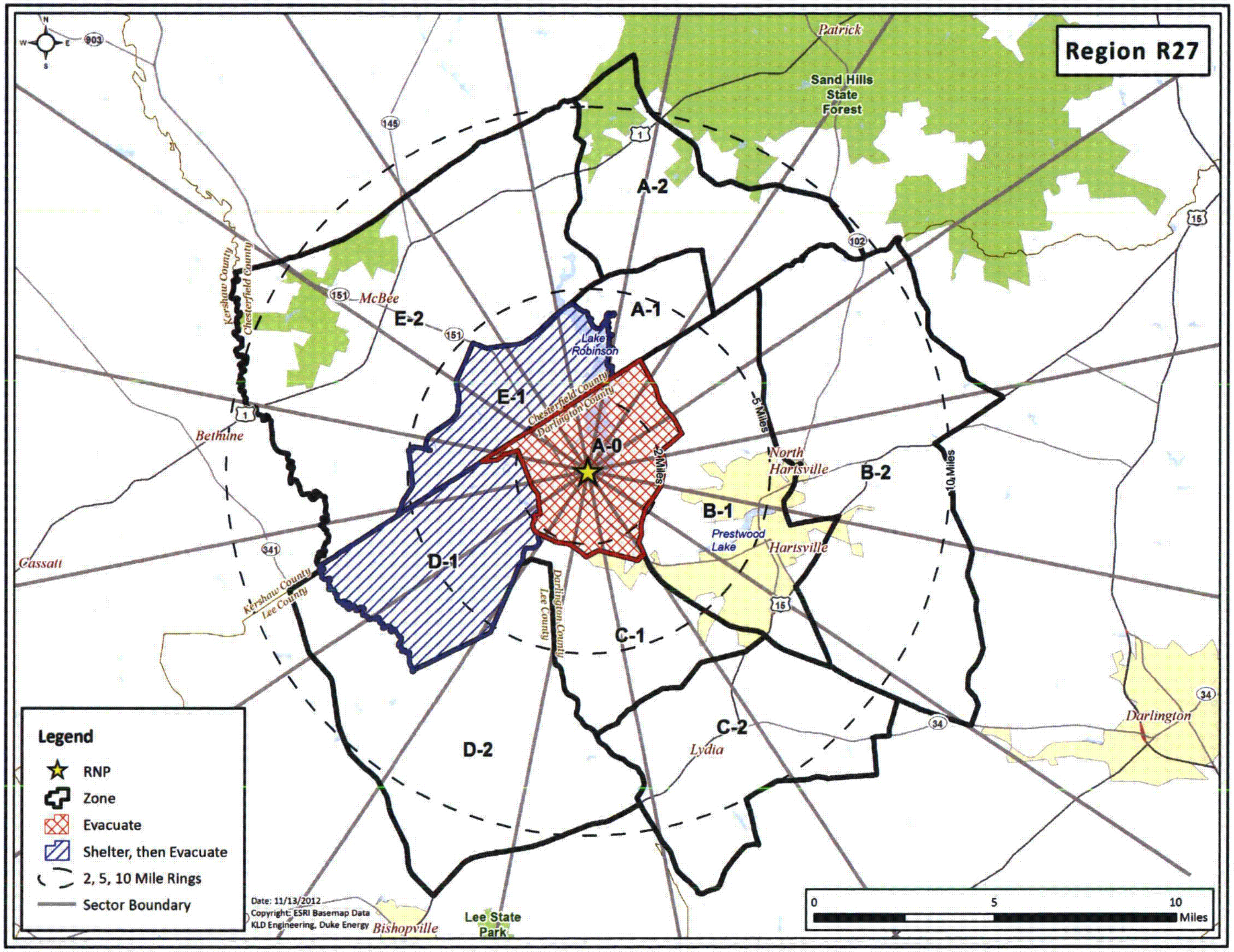



**Figure H-27. Region R27**

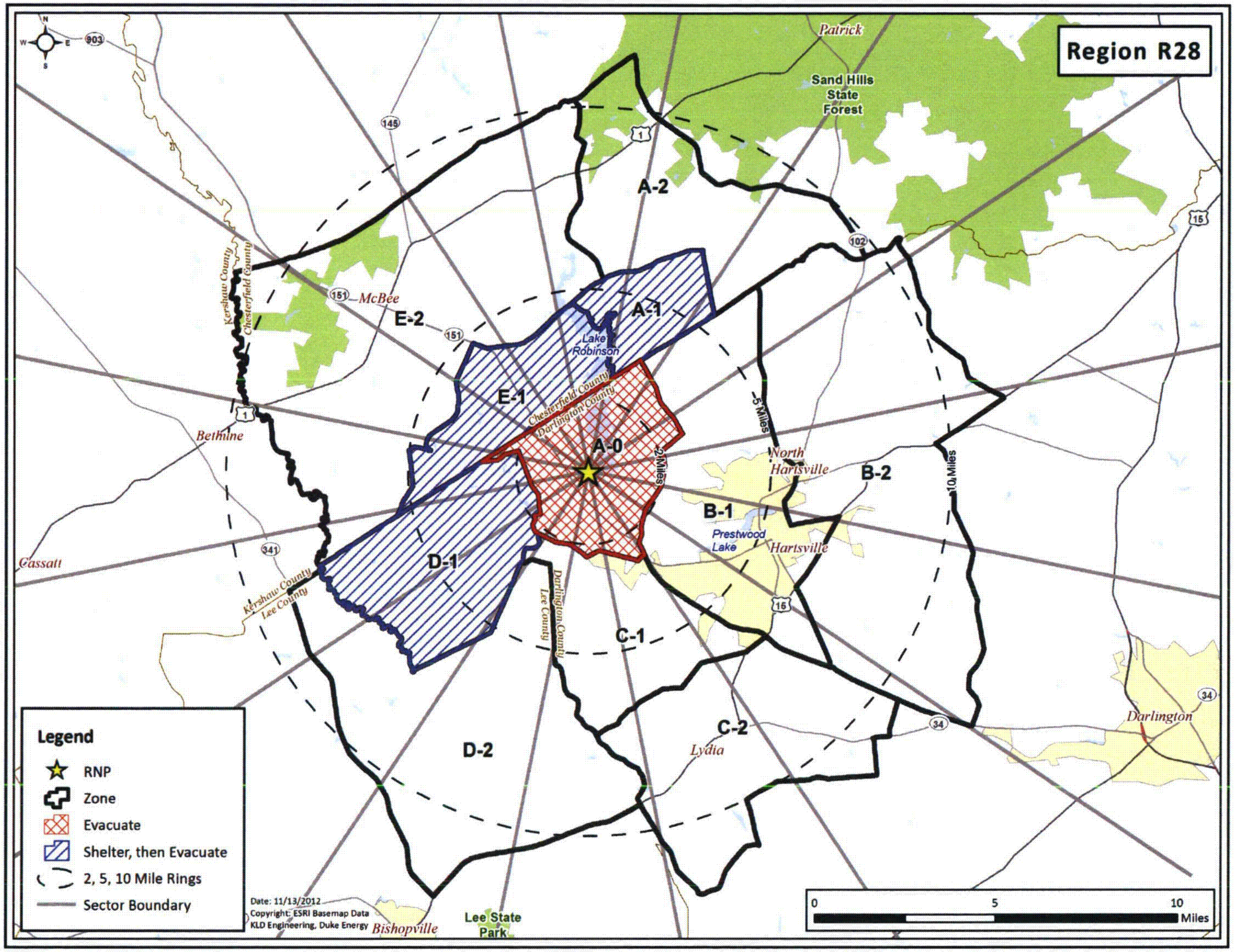



**Figure H-28. Region R28**

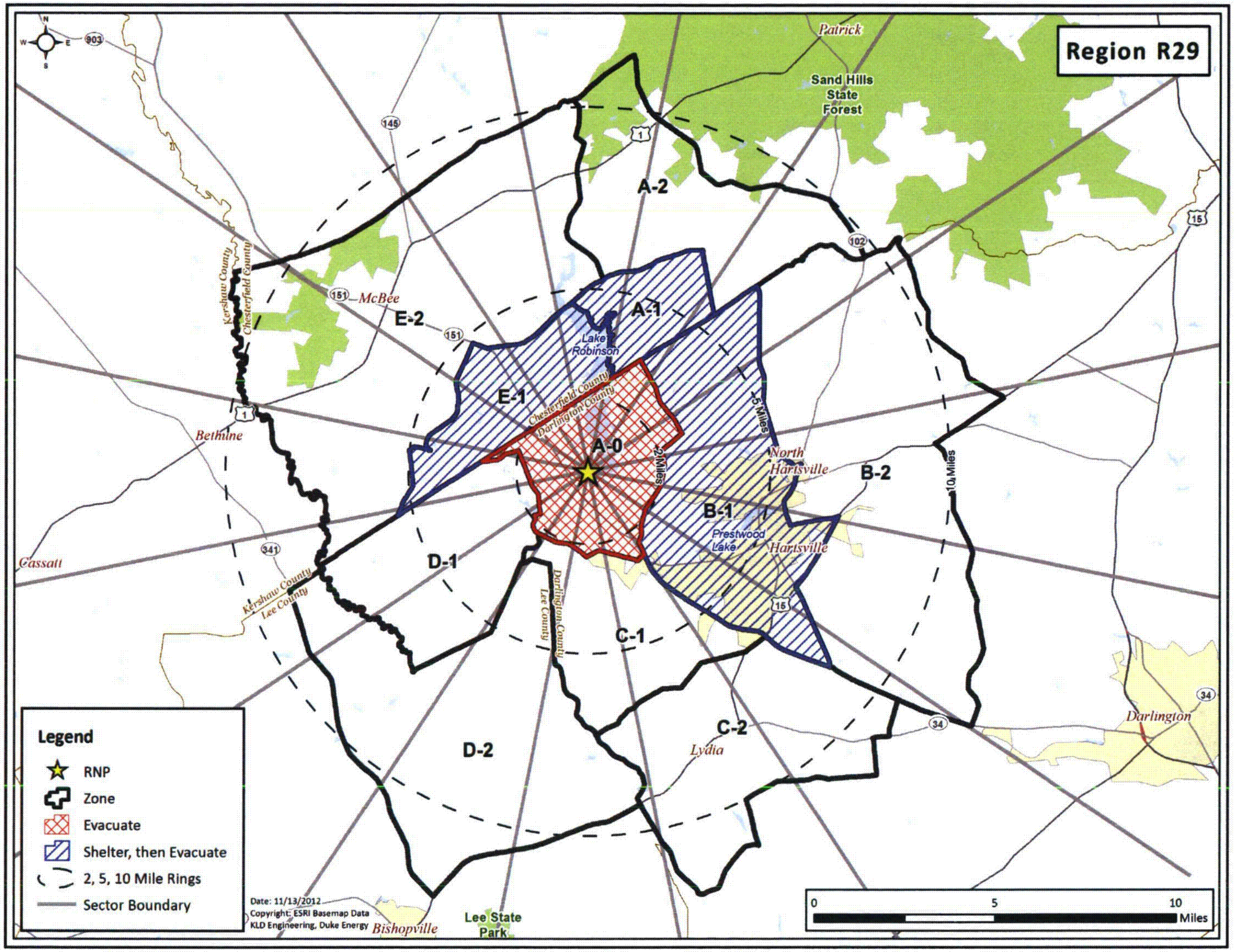



**Figure H-29. Region R29**