5 ESTIMATION OF TRIP GENERATION TIME

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

5.1 Background

As a Planning Basis, a conservative posture has been adopted, in accordance with Section 1.2 of NUREG/CR-7002, that a rapidly escalating event will be considered in calculating the Trip Generation Time. It is assumed that:

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

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

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

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

The notification process consists of two events:

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

The population within the EPZ is dispersed over a land area of approximately 170 square miles and is engaged in a wide variety of activities. It must be anticipated that some time will elapse between the transmission and receipt of the information advising the public of an emergency event.

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

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

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

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

5.2 Fundamental Considerations

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

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

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

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

Table 5-1. Event Sequence for Evacuation Activities

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

These relationships are shown graphically in Figure 5-1.

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

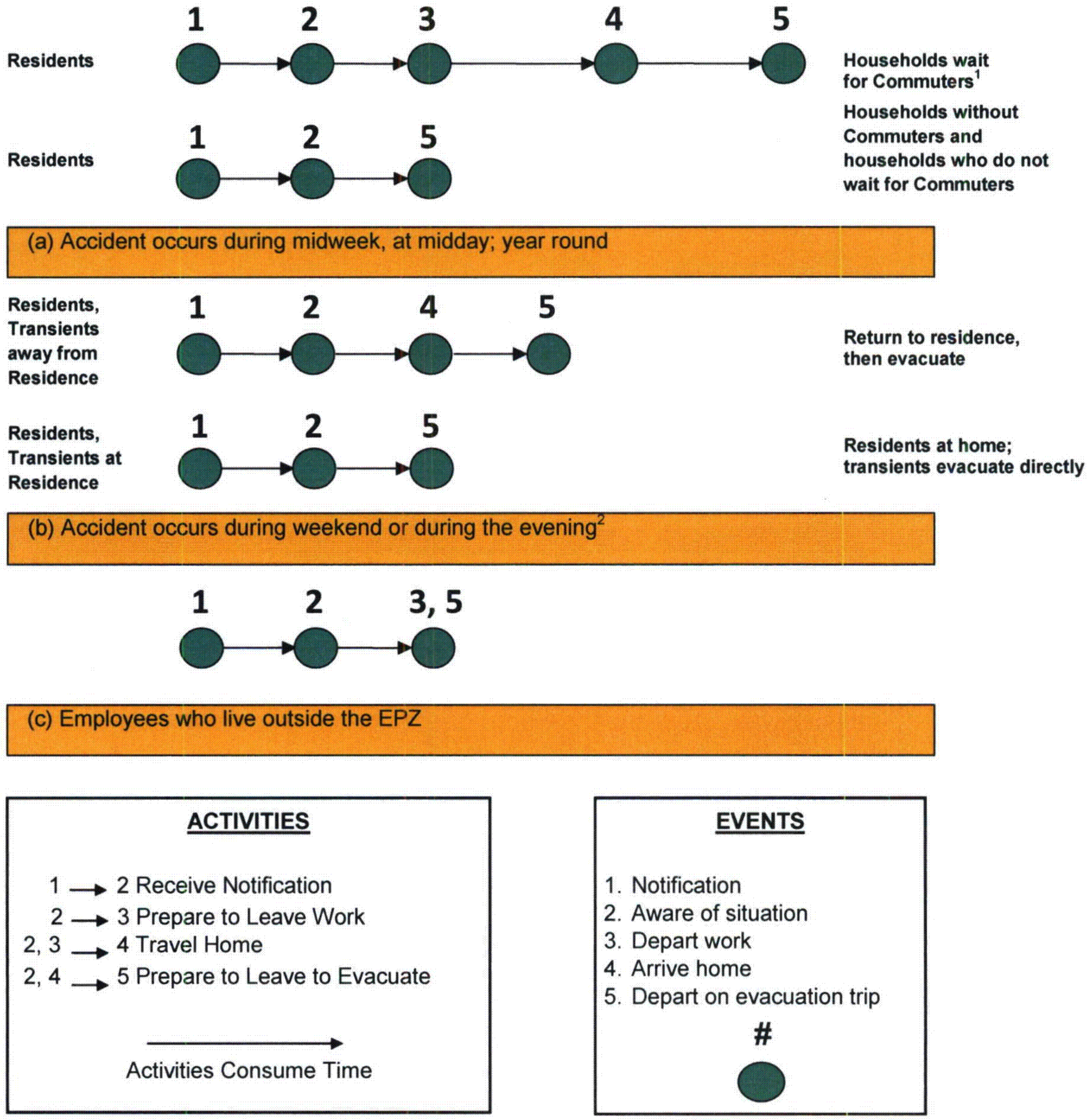
As such, a completed Activity changes the 'state' of an individual (e.g. the activity, 'travel home' changes the state from 'depart work' to 'arrive home'). Therefore, an Activity can be described as an 'Event Sequence'; the elapsed times to perform an event sequence vary from one person to the next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

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

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

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

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



[1] Applies for evening and weekends also if commuters are at work.

[2] Applies throughout the year for transients.

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

5.3 Estimated Time Distributions of Activities Preceding Event 5

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

<u>Time Distribution No. 1, Notification Process: Activity 1 → 2</u>

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

Table 5-2. Time Distribution for Notifying the Public

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

Distribution No. 2, Prepare to Leave Work: Activity 2 $\rightarrow$ 3

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

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

Elapsed Time (Minutes)	Cumulative Percent Employees Leaving Work	Elapsed Time (Minutes)	Cumulative Percent Employees Leaving Work
0	0%	40	89%
5	43%	45	91%
10	60%	50	91%
15	70%	55	91%
20	74%	60	99%
25	74%	75	99%
30	87%	90	100%
35	89%		

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

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

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

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

Elapsed Time (Minutes)	Cumulative Percent Returning Home	Elapsed Time (Minutes)	Cumulative Percent Returning Home
0	0%	45	89%
5	12%	50	89%
10	27%	55	89%
15	46%	60	96%
20	60%	75	97%
25	65%	90	99%
30	81%	105	99%
35	82%	120	100%
40	85%		

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

Distribution No. 4, Prepare to Leave Home: Activity 2, 4 → 5

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

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

Elapsed Time (Minutes)	Cumulative Percent Ready to Evacuate
0	0%
15	14%
30	46%
45	55%
60	73%
75	81%
90	83%
105	84%
120	89%
135	94%
150	94%
165	94%
180	97%
195	98%
210	98%
225	98%
240	100%

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

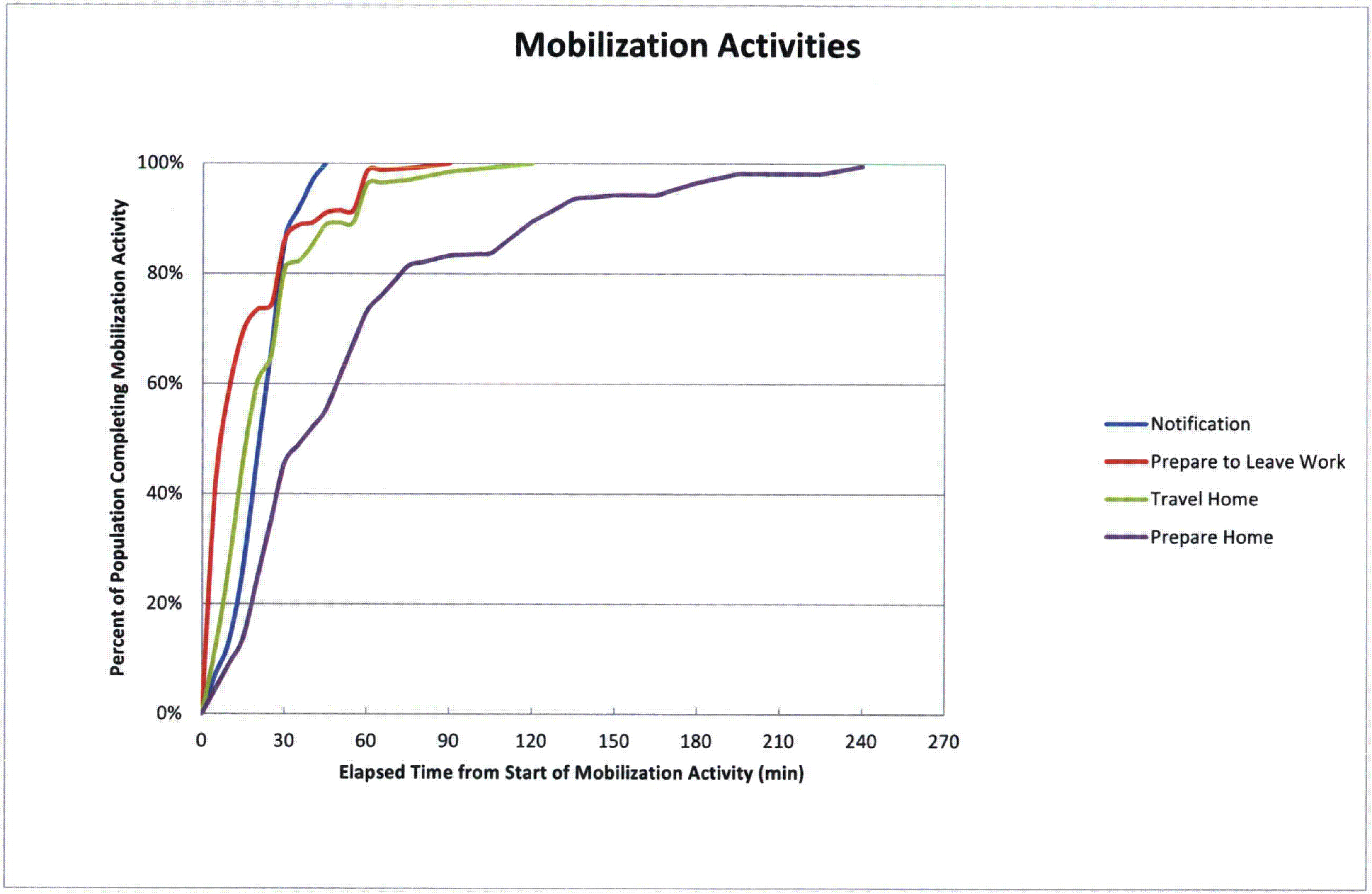


Figure 5-2. Evacuation Mobilization Activities

5.4 Calculation of Trip Generation Time Distribution

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

To calculate the time distribution of an event that is dependent on two sequential activities, it is necessary to "sum" the distributions associated with these prior activities. The distribution summing algorithm is applied repeatedly as shown to form the required distribution. As an outcome of this procedure, new time distributions are formed; we assign "letter" designations to these intermediate distributions to describe the procedure. Table 5-6 presents the summing procedure to arrive at each designated distribution.

Table 5-6. Mapping Distributions to Events

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

Table 5-7 presents a description of each of the final trip generation distributions achieved after the summing process is completed.

Table 5-7. Description of the Distributions

Distribution	Description
A	Time distribution of commuters departing place of work (Event 3). Also applies to employees who work within the EPZ who live outside, and to Transients within the EPZ.
B	Time distribution of commuters arriving home (Event 4).
C	Time distribution of residents with commuters who return home, leaving home to begin the evacuation trip (Event 5).
D	Time distribution of residents without commuters returning home, leaving home to begin the evacuation trip (Event 5).

5.4.1 Statistical Outliers

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

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

In assessing outliers, there are three alternates to consider:

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

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

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

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

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

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

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

2) The individual mobilization activities (prepare to leave work, travel home, prepare home) are reviewed for outliers, and then the overall trip generation distributions are created (see Figure 5-1, Table 5-6, Table 5-7);

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

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

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

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

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

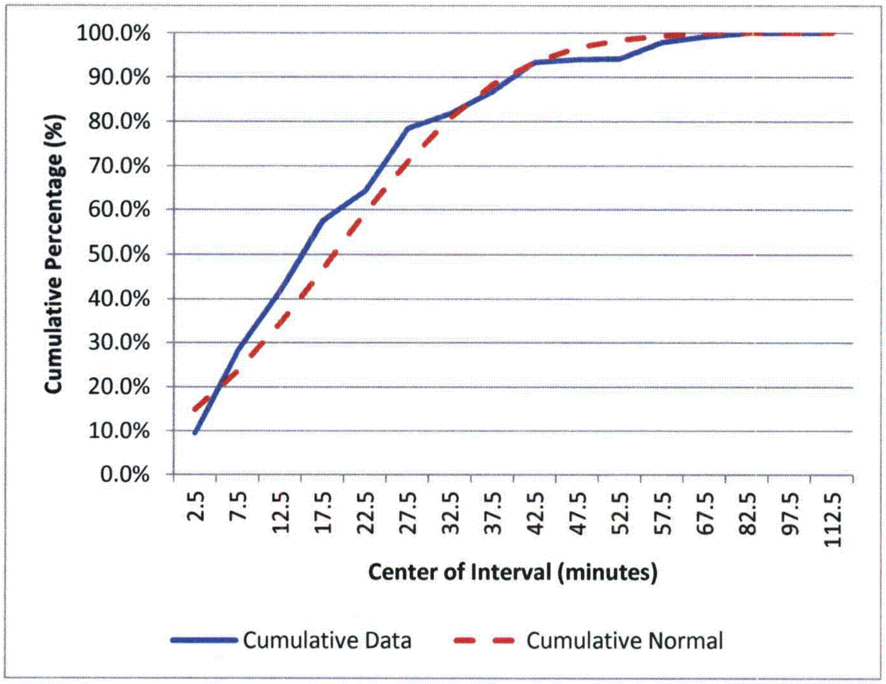


Figure 5-3. Comparison of Data Distribution and Normal Distribution

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

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

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

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

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

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

The DYNEV II simulation model is designed to accept varying rates of vehicle trip generation for each origin centroid, expressed in the form of histograms. These histograms, which represent Distributions A, C, and D properly displaced with respect to one another, are tabulated in Table 5-8 (Distribution B, Arrive Home, omitted for clarity).

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

5.4.2 Staged Evacuation Trip Generation

As defined in NUREG/CR-7002, staged evacuation consists of the prompt evacuation of the 2 mile region, while those beyond 2 miles shelter-in-place. As discussed in Section 6, the CRNP EPZ always evacuates at least the 5 mile radius. Thus this study considers staged evacuation based on a 5 mile prompt evacuation as discussed below:

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

<u>Assumptions</u>

1. The EPZ population in zones beyond 5 miles will first shelter, then evacuate after the 90^{th} percentile ETE for the 5 mile region.
2. The population in the shadow region beyond the EPZ boundary, extending to approximately 15 miles radially from the plant, will react as they do for all non-staged evacuation scenarios. That is 20% of these households will elect to evacuate with no shelter delay.
3. The transient population will not be expected to stage their evacuation because of the limited sheltering options available to people who may be at parks, on a beach, or at other venues. Also, notifying the transient population of a staged evacuation would prove difficult.
4. Employees will also be assumed to evacuate without first sheltering.

<u>Procedure</u>

1. Trip generation for population groups in the 5 mile region will be as computed based upon the results of the telephone survey and analysis.
2. Trip generation for the population subject to staged evacuation will be formulated as follows:
   a. Identify the 90^{th} percentile evacuation time for Zone 1 that is within the five mile region. This value, T_{Scen}^*, is obtained from simulation results. It will become the time at which the region being sheltered will be told to evacuate for each scenario.
   b. The resultant trip generation curves for staging are then formed as follows:

i. The non-shelter trip generation curve is followed until a maximum of 20% of the total trips are generated (to account for shelter non-compliance).
ii. No additional trips are generated until time T_{Scen}^*
iii. Following time T_{Scen}^*, the balance of trips are generated:
    1. by stepping up and then following the non-shelter trip generation curve (if T_{Scen}^* is $\leq$ max trip generation time) or
    2. by stepping up to 100% (if T_{Scen}^* is > max trip generation time)

c. Note: This procedure implies that there may be different staged trip generation distributions for different scenarios. NUREG/CR-7002 uses the statement "approximately 90th percentile" as the time to end staging and begin evacuating. The value of T_{Scen}^* is 2:00 for all scenarios.

3. Staged trip generation distributions are created for the following population groups:
    a. Residents with returning commuters
    b. Residents without returning commuters

Figure 5-5 presents the staged trip generation distributions for both residents with and without returning commuters; the 90th percentile five-mile evacuation time is 135 minutes for good weather. At the 90th percentile evacuation time, 20% of the population (who normally would have completed their mobilization activities for an un-staged evacuation) advised to shelter has nevertheless departed the area. These people do not comply with the shelter advisory. Also included on the plot are the trip generation distributions for these groups as applied to the regions advised to evacuate immediately.

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

Table 5-9 provides the trip generation for staged evacuation.

5.4.3 Trip Generation for Offshore Areas and Waterways

Section III, Appendix 4 of the Citrus County Radiological Emergency Preparedness Plan states the following:

A. Boat traffic evacuated from the off shore areas within the 10-mile EPZ, (Gulf of Mexico and the Crystal River), will be directed to remove their boats at one of three boat ramps, depending on which ramp their vehicles are parked at. Boaters will be directed to either the Fort Island Trail, County boat landing at the Gulf Beach, Fort Island Trail Park, County boat landing on the Crystal River and the boat landing below the east side of the Cross Florida Barge Canal bridge. Transportation to public shelters for those without vehicles should be provided as necessary by school buses or County Transit.

B. Boaters in the Withlacoochee River will be directed to a boat ramp as coordinated with the Emergency Management Director or designee and FWC.

C. Boaters in the Ozello waterways will be directed to a boat ramp as coordinated with the Emergency Management Director or designee and FWC.

As indicated in Table 5-2, this study assumes 100% notification in 45 minutes. Table 5-8 indicates that all transients will have mobilized within 1 hour and 45 minutes. It is assumed that this 1 hour and 45 minute timeframe is sufficient time for boaters, campers and other transients to return to their vehicles and begin their evacuation trip.

Table 5-8. Trip Generation Histograms for the EPZ Population for Unstaged Evacuation

Time Period	Duration (Min)	Percent of Total Trips Generated Within Indicated Time Period			
		Employees (Distribution A)	Transients (Distribution A)	Residents with Commuters (Distribution C)	Residents Without Commuters (Distribution D)
1	15	7%	7%	0%	1%
2	15	33%	33%	0%	8%
3	15	32%	32%	2%	19%
4	15	15%	15%	8%	21%
5	15	6%	6%	12%	14%
6	15	5%	5%	14%	13%
7	15	1%	1%	14%	6%
8	15	1%	1%	12%	2%
9	15	0%	0%	9%	3%
10	15	0%	0%	6%	4%
11	30	0%	0%	10%	3%
12	30	0%	0%	5%	3%
13	60	0%	0%	6%	3%
14	60	0%	0%	2%	0%
15	600	0%	0%	0%	0%

NOTE:

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

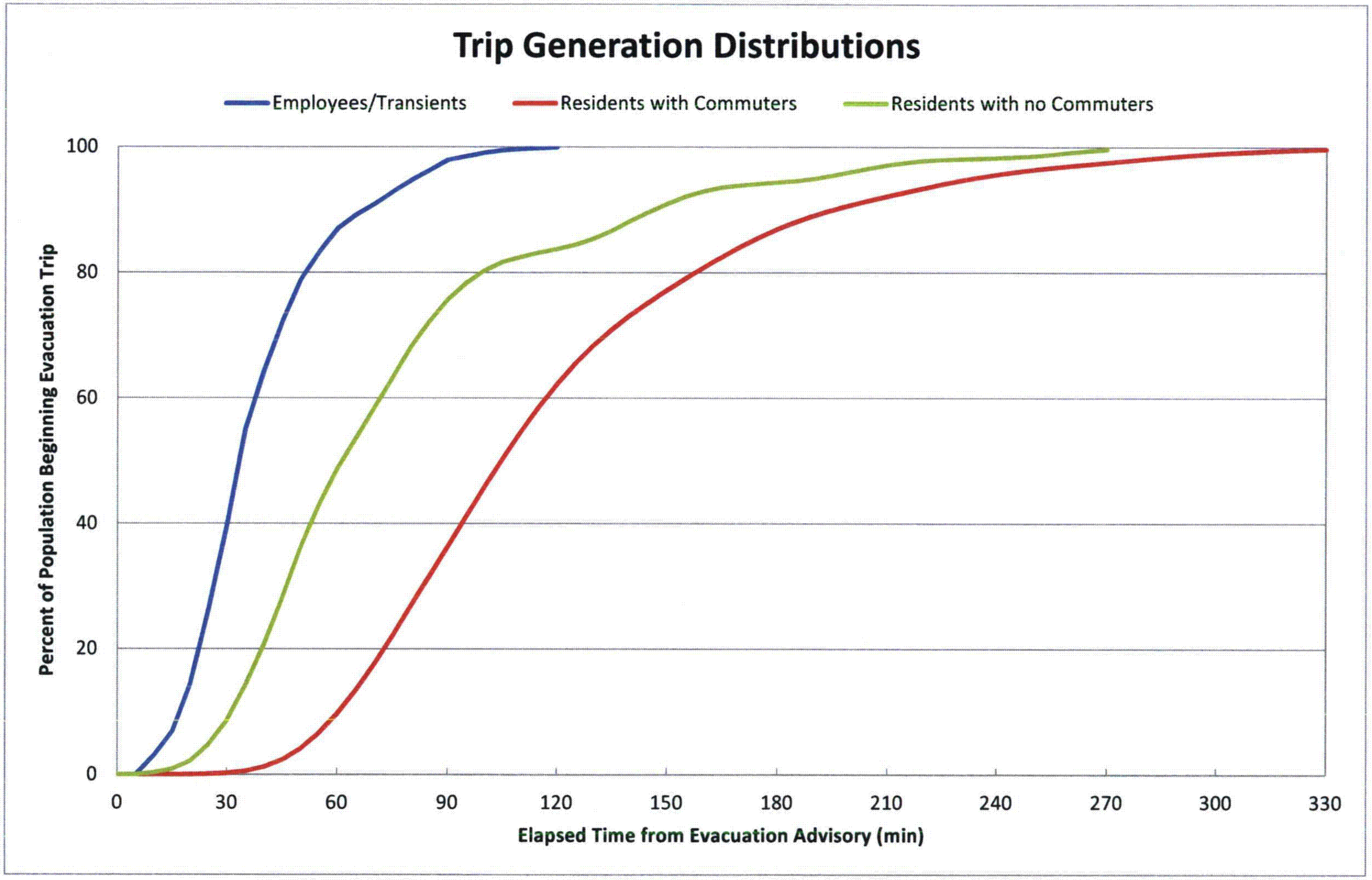


Figure 5-4. Comparison of Trip Generation Distributions

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

Time Period	Duration (Min)	Percent of Total Trips Generated Within Indicated Time Period*	
		Residents with Commuters (Distribution C)	Residents Without Commuters (Distribution D)
1	15	0%	0%
2	15	0%	2%
3	15	0%	4%
4	15	2%	4%
5	15	2%	3%
6	15	3%	2%
7	15	3%	1%
8	15	2%	1%
9	15	2%	0%
10	15	63%	74%
11	30	10%	3%
12	30	5%	3%
13	60	6%	3%
14	60	2%	0%
15	600	0%	0%

*Trip Generation for Employees and Transients (see Table 5-8) is the same for Unstaged and Staged Evacuation.

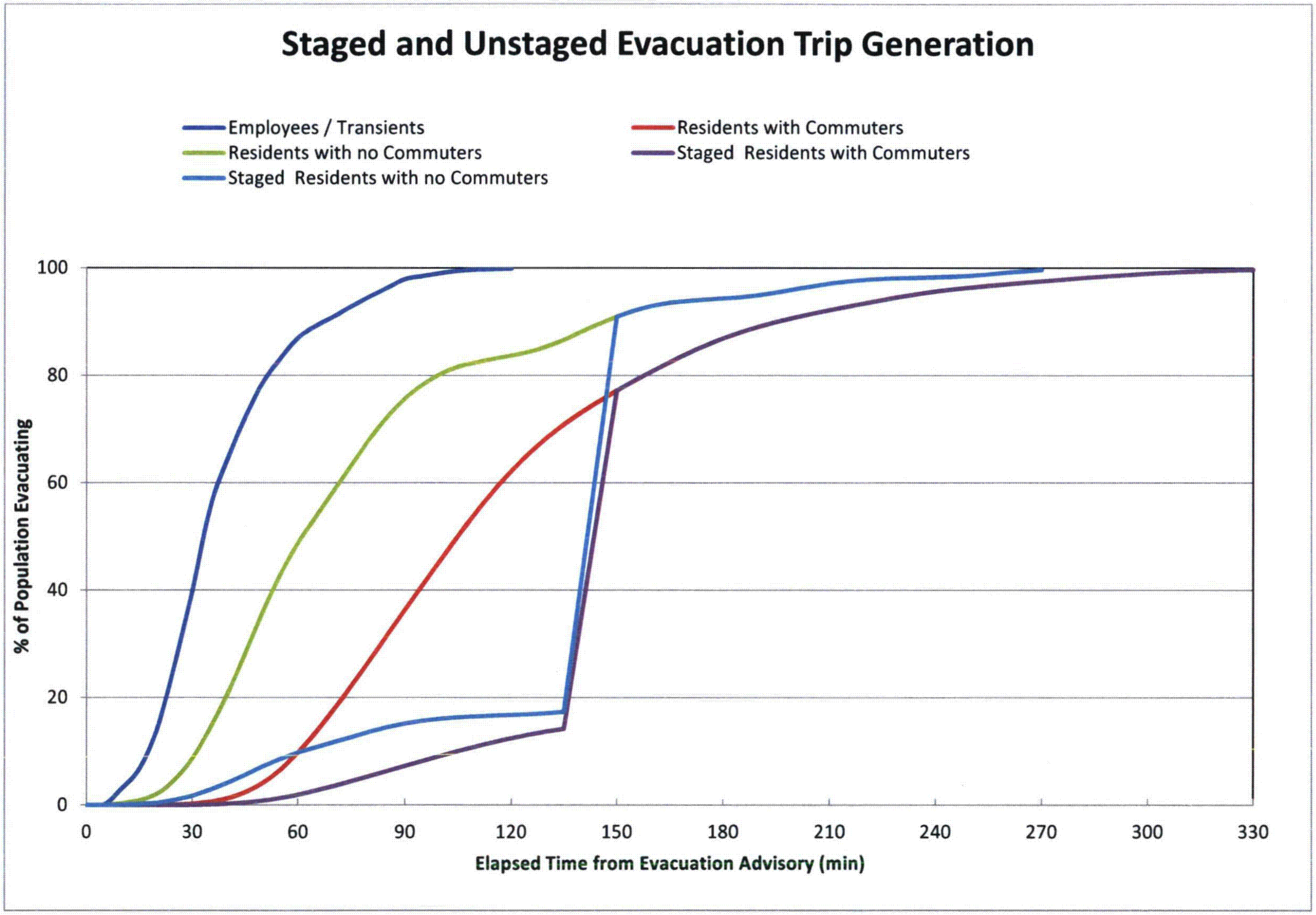


Figure 5-5. Comparison of Staged and Unstaged Trip Generation Distributions in the 5 mile to EPZ Boundary

6 DEMAND ESTIMATION FOR EVACUATION SCENARIOS

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

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

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

A description of each scenario is provided below:

1. **Summer Midweek Midday (normal):** This scenario represents a typical normal weather daytime period when permanent residents are generally dispersed within the EPZ performing daily activities and major work places are at typical daytime levels. This scenario includes assumptions that permanent residents will evacuate from their place of residence; summer school is in session; hotel and motel facilities are occupied at average summer levels; and recreational facilities are at average summer daytime levels.
2. **Summer Midweek Midday (adverse):** This scenario represents an adverse weather daytime period when permanent residents are generally dispersed within the EPZ performing daily activities and major work places are at typical daytime levels. This scenario includes assumptions that permanent residents will evacuate from their place of residence; summer schools are in session; hotel and motel facilities are occupied at average summer levels; and recreational facilities are at average summer daytime levels.
3. **Summer Weekend Midday (normal):** This scenario represents a typical normal weather weekend period when permanent residents are both at home and dispersed within the EPZ performing typical summer weekend activities. This scenario includes assumptions that permanent residents will evacuate from their place of residence; schools are closed and students are at home or with their families; work places are staffed at typical weekend levels; hotel and motel facilities are occupied at average summer weekend levels; and recreational facilities are at average summer weekend levels.
4. **Summer Weekend Midday (adverse):** This scenario represents an adverse weather weekend period when permanent residents are both at home and dispersed within the EPZ performing typical summer weekend activities. This scenario includes assumptions that permanent residents will evacuate from their place of residence; schools are closed and students are at home or with their families; work places are staffed at typical weekend levels; hotel and motel facilities are occupied at average

summer weekend levels; and recreational facilities are at average summer weekend levels.

5. **Summer Midweek and Weekend Evening (normal):** This scenario represents a typical normal weather midweek and weekend evening period when permanent residents are generally at home with fewer dispersed within the EPZ performing evening activities. This scenario includes assumptions that permanent residents will evacuate from their place of residence; schools are closed and students are at home; work places are staffed at typical evening levels; hotel and motel facilities are occupied at average summer levels; and recreational facilities are at average summer evening levels. External traffic is reduced.
6. **Winter Midweek Midday (normal):** This scenario represents a typical normal weather weekday period during the winter when school is in session and the work force is at a full daytime level. This scenario includes assumptions that permanent residents will evacuate from their place of residence; students will evacuate directly from the schools; work places are fully staffed at typical daytime levels; hotel and motel facilities are occupied at average winter levels; and recreational facilities are at winter daytime levels.
7. **Winter Midweek Midday (adverse):** This scenario represents an adverse weather weekday period during the winter when school is in session and the work force is at a full daytime level. This scenario includes assumptions that permanent residents will evacuate from their place of residence; students will evacuate directly from the schools; work places are fully staffed at typical daytime levels; hotel and motel facilities are occupied at average winter levels; and recreational facilities are at winter daytime levels.
8. **Winter Weekend Midday (normal):** This scenario reflects a typical normal weather winter weekend period when permanent residents are both at home and dispersed within the EPZ, and the work force is at a weekend level. This scenario includes assumptions that permanent residents will evacuate from their place of residence; schools are closed and students are at home; work places are staffed at typical weekend levels; hotel and motel facilities are occupied at average winter weekend levels and recreational facilities are at winter weekend levels.
9. **Winter Weekend Midday (adverse):** This scenario reflects an adverse weather winter weekend period when permanent residents are both at home and dispersed within the EPZ, and the work force is at a weekend level. This scenario includes assumptions that permanent residents will evacuate from their place of residence; schools are closed and students are at home; work places are staffed at typical weekend levels; hotel and motel facilities are occupied at average winter weekend levels and recreational facilities are at winter weekend levels.
10. **Winter Midweek and Weekend Evening (normal):** This scenario reflects a typical normal midweek and weekend evening period when permanent residents are home and the work force is at a nighttime level. This scenario includes assumptions that permanent residents will evacuate from their place of residence; schools are closed

and students are at home; work places are staffed at typical nighttime levels; hotel and motel facilities are occupied at average winter levels; and recreational facilities are at winter evening levels.

11. **Special Event (normal):** This scenario reflects a special event (Manatee Fest) where peak tourist populations are present within the EPZ. Assumptions made reflect the timeframe in which the special event occurs (Winter, Weekend, Midday). The population attending the event considers both transients and permanent EPZ residents who may be in attendance to avoid double-counting residents. The remaining permanent resident percentage, those not attending the event, will be assumed to evacuate from their residence. Work places will be staffed at typical levels; hotel and motel facilities are occupied at peak special event levels; and recreational facilities are at appropriate levels based on the event and time of year.
12. **Roadway Impact Summer Midweek Midday (normal):** The intent of this scenario is to represent a variety of conditions that may impact a roadway segment such as construction, flooding, vehicle accidents, etc. The roadway impact scenario assumes that during a summer midweek normal weather daytime scenario, one southbound lane on U.S. 19 is closed.

A total of 7 Regions were defined which encompass all the groupings of zones considered. These Regions are defined in Table 6-1. The zone configurations are identified in Figure 6-1. Each keyhole sector-based area consists of a central circle centered at the power plant, and three adjoining sectors, each with a central angle of 22.5 degrees, as per NUREG/CR-7002 guidance. The central sector coincides with the wind direction. These sectors extend to 5 miles from the plant (Region R01) or to the EPZ boundary (Regions R02 through R07). Regions R01 and R02 represent evacuations of circular areas with radii of 5 and 10 miles, respectively. Regions R05 through R07 are identical to Regions R03, R02 and R04, respectively; however, those zones between 5 miles and the EPZ Boundary are staged until 90% of the 5-mile region (Region R01) has evacuated.

A total of 12 Scenarios were evaluated for all Regions. Thus, there are a total of 7x12=84 evacuation cases. Table 6-2 provides a description of all Scenarios.

Each combination of region and scenario implies a specific population to be evacuated. Table 6-3 presents the percentage of each population group estimated to evacuate for each scenario. Table 6-4 presents the vehicle counts for each scenario for an evacuation of Region R02 – the entire EPZ.

The population and vehicle estimates presented in Section 3 are peak values. These peak values are adjusted depending on the scenario and region being considered, using scenario and region specific percentages; the scenario percentages are presented in Table 6-3, while the regional percentages are provided in Table H-1. The percentages presented in Table 6-3 were determined as follows:

The number of residents with commuters during the week (when workforce is at its peak) is equal to the product of 37% (the number of households with at least one commuter) and 50% (the number of households with a commuter that would await the return of the commuter prior to evacuating). See assumption 3 in Section 2.3. It is estimated for weekend and evening scenarios that 10% of households with commuters will have a commuter at work during those times.

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

Transient activity is estimated to be at its peak during winter weekends and less (75%) during the week. As shown in Appendix E, there is a significant amount of lodging and campgrounds offering overnight accommodations in the EPZ; thus, transient activity is estimated to be high during evening hours – 75% for winter and 15% for summer. Transient activity on summer weekends is estimated to be 15%.

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

$$20\% \times \left(1 + \frac{1{,}716}{2{,}186 + 9{,}692}\right) = 23\%$$

One special event – Manatee Fest – was considered as Scenario 11. Thus, the special event traffic is 100% evacuated for Scenario 11, and 0% for all other scenarios.

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

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

Table 6-1. Description of Evacuation Regions

Region	Description	Zone		
		1	2	3
R01	5-Mile Radius	x		
R02	Full EPZ	x	x	x
Evacuate 5-Mile Radius and Downwind to the EPZ Boundary				
Region	Wind Direction Towards:	Zone		
		1	2	3
R03	NW, NNW, N, NNE	x		x
N/A	NE, ENE	See Region R02		
R04	E, ESE, SE, SSE, S	x	x	
N/A	SSW, SW, WSW, W, WNW	Refer to Region R01		
Staged Evacuation - 5-Mile Radius Evacuates, then Evacuate Downwind to 10 Miles				
Region	Wind Direction Towards:	Zone		
		1	2	3
R05	NW, NNW, N, NNE	x		x
R06	NE, ENE	x	x	x
R07	E, ESE, SE, SSE, S	x	x	
N/A	SSW, SW, WSW, W, WNW	See Region R01		
Shelter-in-Place until 90% ETE for R01, then Evacuate		Zone(s) Shelter-in-Place	Zone(s) Evacuate	

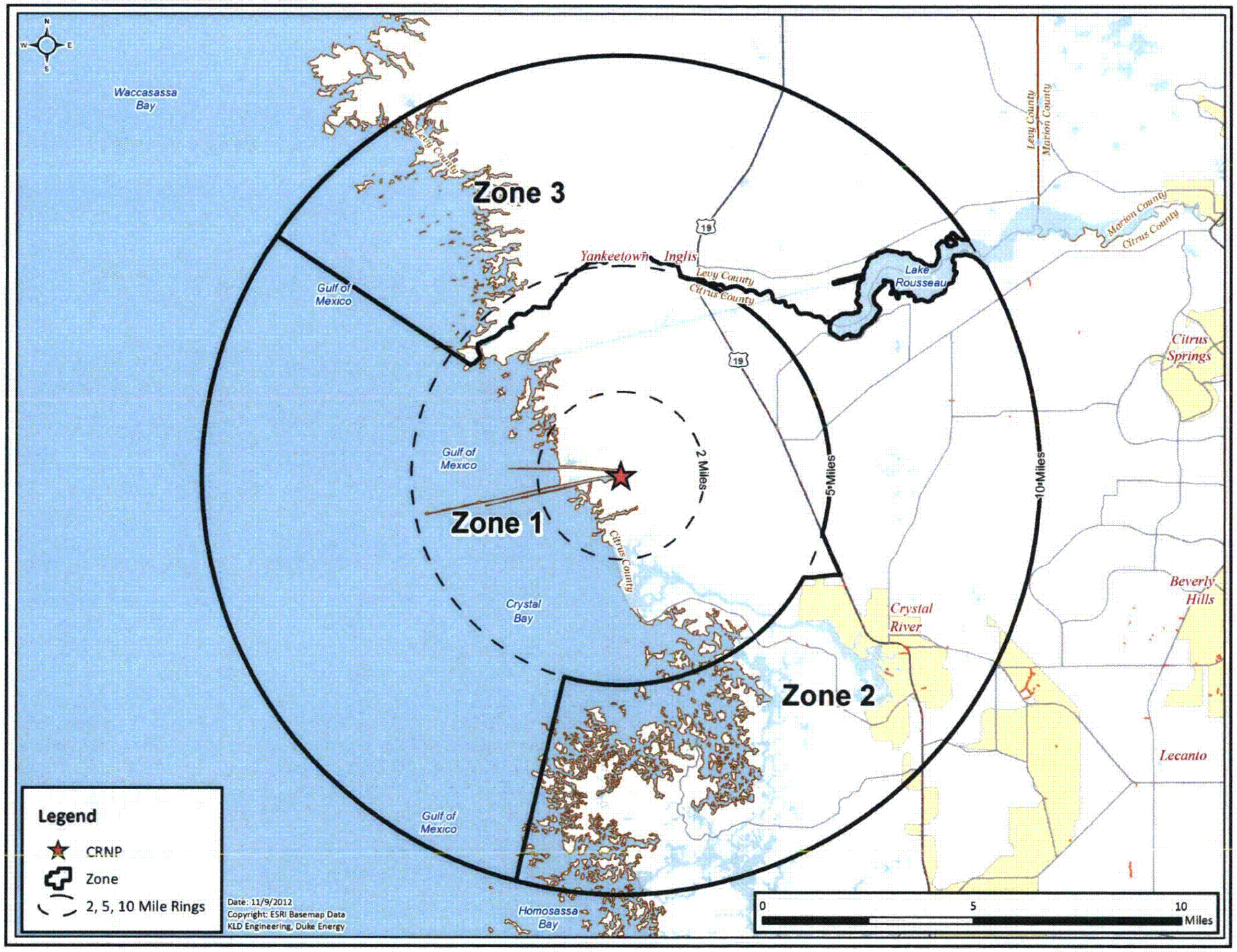


Figure 6-1. CRNP EPZ Zones

Table 6-2. Evacuation Scenario Definitions

Scenarios	Season[1]	Day of Week	Time of Day	Weather	Special
1	Summer	Midweek	Midday	Good	None
2	Summer	Midweek	Midday	Rain	None
3	Summer	Weekend	Midday	Good	None
4	Summer	Weekend	Midday	Rain	None
5	Summer	Midweek, Weekend	Evening	Good	None
6	Winter	Midweek	Midday	Good	None
7	Winter	Midweek	Midday	Rain	None
8	Winter	Weekend	Midday	Good	None
9	Winter	Weekend	Midday	Rain	None
10	Winter	Midweek, Weekend	Evening	Good	None
11	Winter	Weekend	Midday	Good	Special Event – Manatee Fest
12	Summer	Midweek	Midday	Good	Roadway Impact Closure of one southbound lane on U.S. 19

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

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

Scenario	Households With Returning Commuters	Households Without Returning Commuters	Employees	Transients	Shadow	Special Events	School Buses	Transit Buses	External Through Traffic
1	18%	82%	96%	10%	23%	0%	10%	100%	100%
2	18%	82%	96%	10%	23%	0%	10%	100%	100%
3	2%	98%	10%	15%	20%	0%	0%	100%	100%
4	2%	98%	10%	15%	20%	0%	0%	100%	100%
5	2%	98%	10%	15%	20%	0%	0%	100%	40%
6	18%	82%	100%	75%	23%	0%	100%	100%	100%
7	18%	82%	100%	75%	23%	0%	100%	100%	100%
8	2%	98%	10%	100%	20%	0%	0%	100%	100%
9	2%	98%	10%	100%	20%	0%	0%	100%	100%
10	2%	98%	10%	75%	20%	0%	0%	100%	40%
11	2%	98%	10%	100%	20%	100%	0%	100%	100%
12	18%	82%	96%	10%	23%	0%	10%	100%	100%

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

Table 6-4. Vehicle Estimates by Scenario

Scenario	Households With Returning Commuters	Households Without Returning Commuters	Employees	Transients	Shadow	Special Events	School Buses	Transit Buses	External Through Traffic	Total Scenario Vehicles
1	2,186	9,692	1,716	245	6,341	-	13	28	2,196	22,417
2	2,186	9,692	1,716	245	6,341	-	13	28	2,196	22,417
3	219	11,659	179	367	5,624	-	-	28	2,196	20,272
4	219	11,659	179	367	5,624	-	-	28	2,196	20,272
5	219	11,659	179	367	5,624	-	-	28	878	18,954
6	2,186	9,692	1,788	1,836	6,374	-	131	28	2,196	24,231
7	2,186	9,692	1,788	1,836	6,374	-	131	28	2,196	24,231
8	219	11,659	179	2,448	5,624	-	-	28	2,196	22,353
9	219	11,659	179	2,448	5,624	-	-	28	2,196	22,353
10	219	11,659	179	1,836	5,624	-	-	28	878	20,423
11	219	11,659	179	2,448	5,624	1,731	-	28	2,196	26,680
12	2,186	9,692	1,716	245	6,341	-	13	28	2,196	22,417

Note: Vehicle estimates are for an evacuation of the entire EPZ (Region R02)

7 GENERAL POPULATION EVACUATION TIME ESTIMATES (ETE)

This section presents the ETE results of the computer analyses using the DYNEV II System described in Appendices B, C and D. These results cover 7 regions within the CRNP EPZ and the 12 Evacuation Scenarios discussed in Section 6.

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

7.1 Shadow Evacuation

"Shadow evacuees" are people within 15 miles of the CRNP for which an Advisory to Evacuate has not been issued, yet who elect to evacuate. Shadow evacuation is assumed to take place over the same time frame as the evacuation from within the impacted Evacuation Region.

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

Figure 7-2 presents the area identified as the Shadow Region. This region extends radially from the plant to cover a region between the EPZ boundary and approximately 15 miles. The population and number of evacuating vehicles in the Shadow Region were estimated using the same methodology that was used for permanent residents within the EPZ (see Section 3.1). As discussed in Section 3.2, it is estimated that a total of 42,938 people reside in the Shadow Region; 20 percent of them would evacuate. See Table 6-4 for the number of evacuating vehicles from the Shadow Region.

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

7.2 Staged Evacuation

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

1. Zone 1 comprising the 5 mile region is advised to evacuate immediately.
2. Zones 2 and 3, extending from 5 miles to the EPZ Boundary, are advised to shelter in-place while the five mile region is cleared.

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

See Section 5.4.2 for additional information on staged evacuation.

7.3 Patterns of Traffic Congestion during Evacuation

Figure 7-3 through Figure 7-6 illustrate the patterns of traffic congestion that arise for the case when the entire EPZ (Region R02) is advised to evacuate during the winter, midweek, midday period under good weather conditions (Scenario 6).

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

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

All highway "links" which experience LOS F are delineated in these figures by a thick red line; all others are lightly indicated. Congestion develops rapidly around concentrations of population and traffic bottlenecks. Figure 7-3 displays the developing congestion within the population center of Crystal River just 35 minutes after the Advisory to Evacuate (ATE). Congestion also exists on West Power Line St as employees from the Crystal River Energy Complex begin to evacuate. US-19/98, through Crystal River which is also servicing external traffic, is displaying high traffic demand (LOS D and higher).

At 1 hour after the ATE, Figure 7-4 displays fully developed congestion within Crystal River. The heaviest congestion exists along US-19/98, as this route is still servicing external traffic trips.

CR-488 is experiencing LOS E as evacuees approach Dunnellon. The five mile ring is essentially clear of congestion as almost all employees at the Crystal River Energy Complex have already mobilized to evacuate. Evacuees traveling south out of Crystal River are now utilizing Lecanto Hwy as an alternative to US-19/98. The confluence of these evacuees with shadow evacuees has caused congestion to materialize at the intersection of Lecanto Hwy and W Grover Cleveland Blvd just beyond the shadow area.

At 2 hours and 10 minutes after the ATE, Figure 7-5 shows that the EPZ is essentially clear of congestion and the last remnants of congestion persists within the shadow region at the intersection of W Grover Cleveland Blvd and S Lecanto Hwy.

At 3 hours and 30 minutes after the ATE, Figure 7-6 shows the congestion at the intersection of W Grover Cleveland and S Lecanto Hwy is the last area to clear.

All congestion clears before the trip generation time of 5:30 (See Section 5); thus, the ETE for the 100th percentile evacuation is dictated by the trip generation time. The 90th percentile ETE should be considered when making protective action decisions, in order to avoid the long tail of the 100th percentile ETE. This observation is consistent with the findings of NUREG/CR-6953, Volume 2.

7.4 Evacuation Rates

Evacuation is a continuous process, as implied by Figure 7-7 through Figure 7-18. These figures indicate the rate at which traffic flows out of the indicated areas for the case of an evacuation of the full EPZ (Region R02) under the indicated conditions. One figure is presented for each scenario considered.

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

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

7.5 Evacuation Time Estimate (ETE) Results

Table 7-1 and Table 7-2 present the ETE values for all 7 Evacuation Regions and all 12 Evacuation Scenarios. Table 7-3 and Table 7-4 present the ETE values for the 5-Mile region for both staged and un-staged keyhole regions downwind to the EPZ boundary. The tables are organized as follows:

Table	Contents
7-1	ETE represents the elapsed time required for 90 percent of the population within a Region, to evacuate from that Region. All Scenarios are considered, as well as Staged Evacuation scenarios.
7-2	ETE represents the elapsed time required for 100 percent of the population within a Region, to evacuate from that Region. All Scenarios are considered, as well as Staged Evacuation scenarios.
7-3	ETE represents the elapsed time required for 90 percent of the population within the 5-mile Region, to evacuate from that Region with both Concurrent and Staged Evacuations.
7-4	ETE represents the elapsed time required for 100 percent of the population within the 5-mile Region, to evacuate from that Region with both Concurrent and Staged Evacuations.

The animation snapshots described above reflect the ETE statistics for the concurrent (un-staged) evacuation scenarios and regions, which are displayed in Figure 7-3 through Figure 7-6. Most of the congestion is located in Zone 2 which is beyond the 5-mile area; this is reflected in the ETE statistics:

- The 90^{th} percentile ETE for Region R01 (5 mile region) ranges between 2:10 (hr:min) and 2:15
- The 90^{th} percentile ETE for Regions R02 (full EPZ) and R03 – R04 (which extend to the EPZ boundary) are approximately 10 to 20 minutes longer.

The 100^{th} percentile ETE for all Regions and for all Scenarios are the same values as the mobilization times. This fact implies that the congestion within the EPZ dissipates prior to the end of mobilization, as is displayed in Figure 7-6.

Comparison of Scenarios 8 and 11 in Table 7-1 indicates that the Special Event – Manatee Fest – does not have a significant impact on the ETE for the 90^{th} percentile with increases only up to 5 minutes. The additional 1,731 vehicles present for the special event are able to evacuate without having a significant impact on ETE. The special event also has no impact on the 100^{th} percentile ETE.

Comparison of Scenarios 1 and 12 in Table 7-1 indicates that the roadway closure – one lane southbound on US 19/98 from W Power line St to the edge of the Shadow Region at the intersection with West Mckinley St. – does have a material impact on 90^{th} percentile ETE for keyhole regions which include Zone 2, with increases of up to 20 minutes. Wind toward the south and east carries the plume over the City of Crystal River. When the City of Crystal River evacuates, many evacuees are routed onto US 19/98 southbound. With one lane closed on US

19/98 southbound, the capacity of US 19/98 is reduced to half, increasing congestion and prolonging ETE. The roadway closure has no effect on regions which do not involve the evacuation of the City of Crystal River.

The results of the roadway impact scenario indicate that events such as adverse weather or traffic accidents which close a lane on US 19/98 could impact ETE. State and local police could consider traffic management tactics such as using the shoulder of the roadway as a travel lane or re-routing of traffic along other evacuation routes to avoid overwhelming US 19/98. All efforts should be made to remove the blockage on US 19/98, particularly within the first 2 hours of the evacuation.

NUREG/CR-7002 recommends that the ETE study consider potential enhancements that could improve ETE. According to the Institute of Nuclear Power Operations (INPO) timeline for the March 2011 accident at the Fukushima Daiichi Power Station, nearly 18 hours elapsed between the loss of power at the site and the first release to the atmosphere. The 90th percentile ETE for an evacuation of the entire EPZ (Region R02) is less than 3 hours for all scenarios. The possible countermeasures to reduce ETE are:

- Reduce the number of vehicles on the road by educating the public to use fewer vehicles to evacuate. This is very difficult to implement as evacuees are unlikely to leave a significant economic asset such as a personal vehicle behind.
- Use contraflow or reverse-laning. This technique is so manpower and equipment intensive, 90 percent of evacuees will have already left the EPZ by the time contraflow is established. As such, ETE benefits would be minimal. Also, contraflow is a significant liability in that vehicles are traveling the wrong way on a road. Most offsite agencies are hesitant to use contraflow for this reason alone.
- Identify special treatments at critical intersections – i.e. if northbound and eastbound are both viable evacuation directions from the plant, cones and barricades could be used to channelize the intersection such that one traffic stream is directed northbound and the other eastbound to eliminate any vehicle conflict at the intersection and keep the intersection flowing continuously. This is also manpower and equipment dependent and will have little impact on ETE.

No enhancements are recommended for this site. The 90th percentile ETE are significantly less than the elapsed time before a release during the recent nuclear accident in Japan. Significant manpower and equipment would be needed to implement potential enhancements. The time needed to secure needed personnel and equipment would offset any potential ETE benefits.

7.6 Staged Evacuation Results

Table 7-3 and Table 7-4 present a comparison of the ETE compiled for the concurrent (un-staged) and staged evacuation studies. Note that Regions R05 through R07 are the same geographic areas as Regions R03, R02 and R04, respectively.

To determine whether the staged evacuation strategy is worthy of consideration, one must show that the ETE for the 5 Mile region can be reduced without significantly affecting the region between 5 miles and the EPZ boundary. In all cases, as shown in these tables, the ETE for the 5 mile region is unchanged when a staged evacuation is implemented. The reason for this is that the congestion within the 5-mile area does not extend upstream to the extent that it penetrates to within 5 miles of the CRNP. Therefore, staging the evacuation to sharply reduce congestion within the EPZ provides no benefits to evacuees from within the 5 mile region and unnecessarily delays the evacuation of those beyond 5 miles.

While failing to provide assistance to evacuees from within 5 miles of the CRNP, staging produces a negative impact on the ETE for Regions including Zones 1, 2, and 3 or Zones 1 and 2 for Scenario 11 (Special Event) at the 90th percentile with slight increases of 5 minutes. As stated in Assumption 3 in Section 5.4.2, transient population will not be expected to stage their evacuation because of the limited sheltering options available. This slight increase in ETE is due to the delay in beginning the evacuation trip, experienced by those who shelter, plus the effect of the trip-generation "spike" (significant volume of traffic beginning the evacuation trip at the same time) that follows their eventual ATE, in creating congestion within the EPZ area beyond 5 miles.

In summary, the staged evacuation protective action strategy provides no benefits and slightly increases ETE for evacuees located beyond 5 miles from the CRNP.

7.7 Guidance on Using ETE Tables

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

1. Identify the applicable **Scenario**:
   - Season
     - Summer
     - Winter (also Autumn and Spring)
   - Day of Week
     - Midweek
     - Weekend
   - Time of Day
     - Midday
     - Evening
   - Weather Condition
     - Good Weather
     - Rain
   - Special Event
     - Manatee Fest
     - Road Closure (Southbound lane on US 19/98 closed starting from W Power Line St to the edge of the shadow region at the intersection with West McKinley St)
   - Evacuation Staging

- No, Staged Evacuation is not considered
- Yes, Staged Evacuation is considered

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

- The conditions of a summer evening (either midweek or weekend) and rain are not explicitly identified in the Tables. For these conditions, Scenarios (2) and (4) apply.
- The conditions of a winter evening (either midweek or weekend) and rain are not explicitly identified in the Tables. For these conditions, Scenarios (7) and (9) for rain apply.
- The seasons are defined as follows:
  - Summer assumes that public schools are not in session.
  - Winter (includes Spring and Autumn) considers that public schools are in session.
- Time of Day: Midday implies the time over which most commuters are at work or are travelling to/from work.

2. With the desired percentile ETE and Scenario identified, now identify the **Evacuation Region**:
   - Determine the projected azimuth direction of the plume (coincident with the wind direction). This direction is expressed in terms of compass orientation: towards N, NNE, NE, ...
   - Determine the distance that the Evacuation Region will extend from the nuclear power plant. The applicable distances and their associated candidate Regions are given below:
     - 5 Miles (Region R01)
     - To EPZ Boundary (Regions R02, through R07)
   - Enter Table 7-5 and identify the applicable group of candidate Regions based on the distance that the selected Region extends from the CRNP. Select the Evacuation Region identifier in that row, based on the azimuth direction of the plume, from the first column of the Table.
3. Determine the **ETE Table** based on the **percentile** selected. Then, for the **Scenario** identified in Step 1 and the **Region** identified in Step 2, proceed as follows:
   - The columns of Table 7-1 are labeled with the Scenario numbers. Identify the proper column in the selected Table using the Scenario number defined in Step 1.
   - Identify the row in this table that provides ETE values for the Region identified in Step 2.
   - The unique data cell defined by the column and row so determined contains the desired value of ETE expressed in Hours:Minutes.

Example

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

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

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

1. Identify the Scenario as summer, weekend, evening and raining. Entering Table 7-1, it is seen that there is no match for these descriptors. However, the clarification given above assigns this combination of circumstances to Scenario 4.
2. Enter Table 7-5 and locate the Region described as "Evacuate 5-Mile Radius and Downwind to the EPZ Boundary" for wind direction toward the NE (from the SW) and read Region R03 in the first column of that row.
3. Enter Table 7-1 to locate the data cell containing the value of ETE for Scenario 4 and Region R17. This data cell is in column (4) and in the row for Region R03; it contains the ETE value of **2:20**.

Table 7-1. Time to Clear the Indicated Area of _90_ Percent of the Affected Population

	Summer		Summer		Summer	Winter		Winter		Winter	Winter	Summer
	Midweek		Weekend		Midweek Weekend	Midweek		Weekend		Midweek Weekend	Weekend	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Region	Midday		Midday		Evening	Midday		Midday		Evening	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Good Weather	Rain	Good Weather	Special Event	Roadway Impact
Entire 5-Mile Region, and EPZ												
R01	2:10	2:15	2:15	2:15	2:15	2:10	2:10	2:10	2:15	2:10	2:10	2:10
R02	2:30	2:30	2:25	2:25	2:25	2:25	2:30	2:20	2:20	2:20	2:25	2:45
5-Mile Region and Keyhole to EPZ Boundary												
R03	2:20	2:20	2:20	2:20	2:20	2:20	2:20	2:15	2:20	2:20	2:15	2:20
R04	2:30	2:30	2:20	2:25	2:25	2:25	2:25	2:20	2:20	2:20	2:25	2:50
Staged Evacuation - 5-Mile Region and Keyhole to EPZ Boundary												
R05	2:35	2:35	2:35	2:40	2:40	2:35	2:35	2:35	2:35	2:40	2:35	2:35
R06	3:10	3:10	3:10	3:15	3:10	3:10	3:10	3:10	3:10	3:10	3:05	3:20
R07	3:10	3:15	3:10	3:15	3:15	3:10	3:10	3:10	3:15	3:15	3:10	3:25

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

	Summer		Summer		Summer	Winter		Winter		Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek		Weekend		Midweek Weekend	Weekend	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Region	Midday		Midday		Evening	Midday		Midday		Evening	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Good Weather	Rain	Good Weather	Special Event	Roadway Impact
Entire 5-Mile Region, and EPZ												
R01	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35
R02	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40
5-Mile Region and Keyhole to EPZ Boundary												
R03	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40
R04	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40
Staged Evacuation - 5-Mile Region and Keyhole to EPZ Boundary												
R05	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40
R06	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40
R07	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40	5:40

Table 7-3. Time to Clear 90 Percent of the 5-Mile Area within the Indicated Region

	Summer		Summer		Summer	Winter		Winter		Winter	Winter	Summer
	Midweek		Weekend		Midweek Weekend	Midweek		Weekend		Midweek Weekend	Weekend	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Region	Midday		Midday		Evening	Midday		Midday		Evening	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Good Weather	Rain	Good Weather	Special Event	Roadway Impact
Unstaged Evacuation - 5-Mile Region and Keyhole to EPZ Boundary												
R01	2:10	2:15	2:15	2:15	2:15	2:10	2:10	2:10	2:15	2:10	2:10	2:10
R02	2:10	2:15	2:15	2:15	2:15	2:10	2:10	2:10	2:15	2:10	2:15	2:15
R03	2:10	2:15	2:15	2:15	2:15	2:10	2:10	2:10	2:15	2:10	2:10	2:10
R04	2:10	2:15	2:15	2:15	2:15	2:10	2:10	2:10	2:15	2:10	2:15	2:15
Staged Evacuation - 5-Mile Region and Keyhole to EPZ Boundary												
R05	2:10	2:15	2:15	2:15	2:15	2:10	2:10	2:10	2:15	2:10	2:10	2:10
R06	2:10	2:15	2:15	2:15	2:15	2:10	2:10	2:10	2:15	2:10	2:15	2:15
R07	2:10	2:15	2:15	2:15	2:15	2:10	2:10	2:10	2:15	2:10	2:15	2:15

Table 7-4. Time to Clear *100* Percent of the 5-Mile Area within the Indicated Region

	Summer		Summer		Summer	Winter		Winter		Winter	Summer	Summer
	Midweek		Weekend		Midweek Weekend	Midweek		Weekend		Midweek Weekend	Weekend	Midweek
Scenario:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Midday		Midday		Evening	Midday		Midday		Evening	Midday	Midday
Region	Good Weather	Rain	Good Weather	Rain	Good Weather	Good Weather	Rain	Good Weather	Rain	Good Weather	Special Event	Roadway Impact
Unstaged Evacuation - 5-Mile Region and Keyhole to EPZ Boundary												
R01	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35
R02	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35
R03	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35
R04	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35
Staged Evacuation - 5-Mile Region and Keyhole to EPZ Boundary												
R05	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35
R06	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35
R07	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35	5:35

Table 7-5. Description of Evacuation Regions

Region	Description	Zone 1	Zone 2	Zone 3
R01	5-Mile Radius	x		
R02	Full EPZ	x	x	x
Evacuate 5-Mile Radius and Downwind to the EPZ Boundary				
Region	**Wind Direction Towards:**	**1**	**2**	**3**
R03	NW, NNW, N, NNE	x		x
N/A	NE, ENE	See Region R02		
R04	E, ESE, SE, SSE, S	x	x	
N/A	SSW, SW, WSW, W, WNW	Refer to Region R01		
Staged Evacuation - 5-Mile Radius Evacuates, then Evacuate Downwind to 10 Miles				
Region	**Wind Direction Towards:**	**1**	**2**	**3**
R05	NW, NNW, N, NNE	x		x
R06	NE, ENE	x	x	x
R07	E, ESE, SE, SSE, S	x	x	
N/A	SSW, SW, WSW, W, WNW	See Region R01		

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

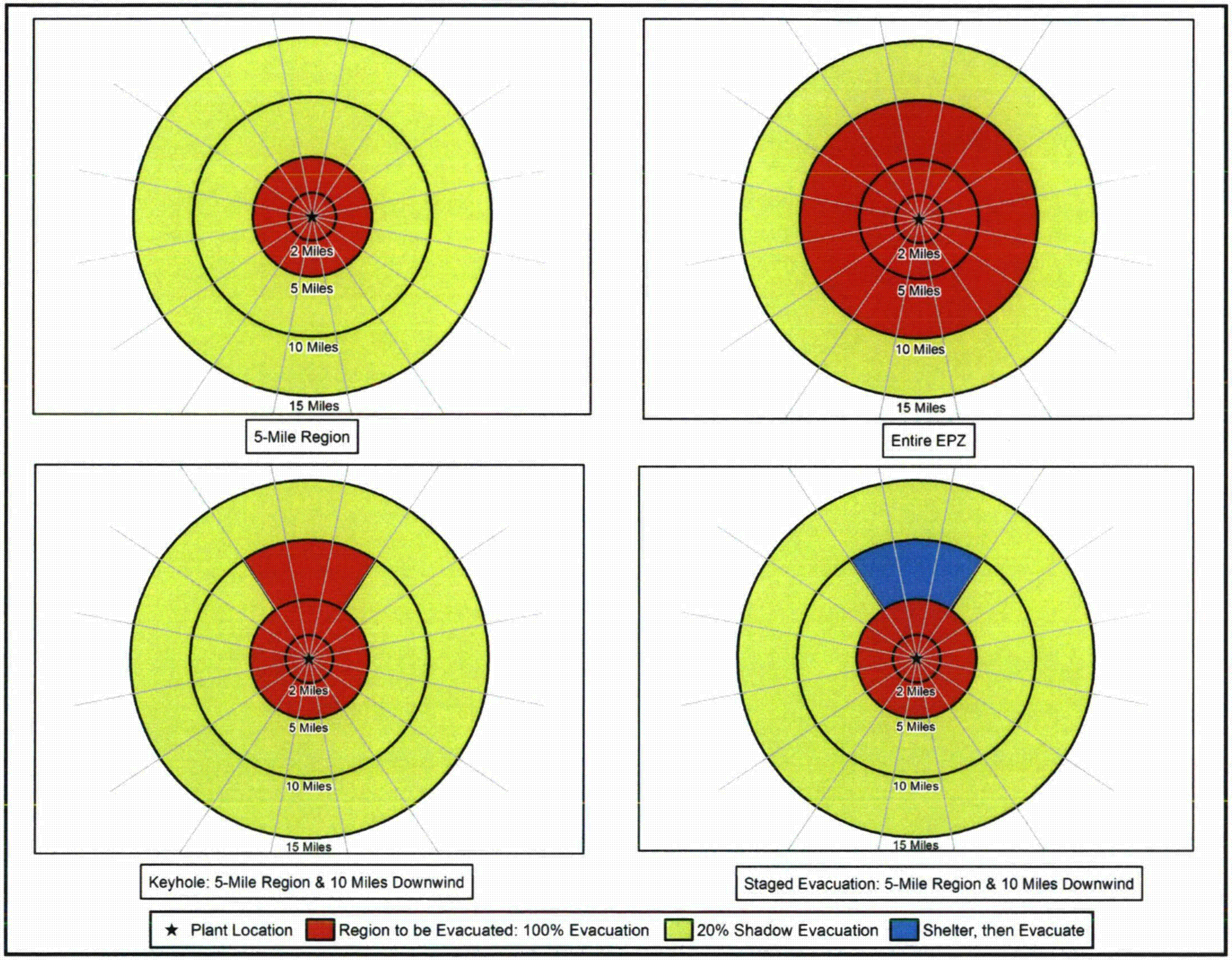


Figure 7-1. Shadow Evacuation Methodology

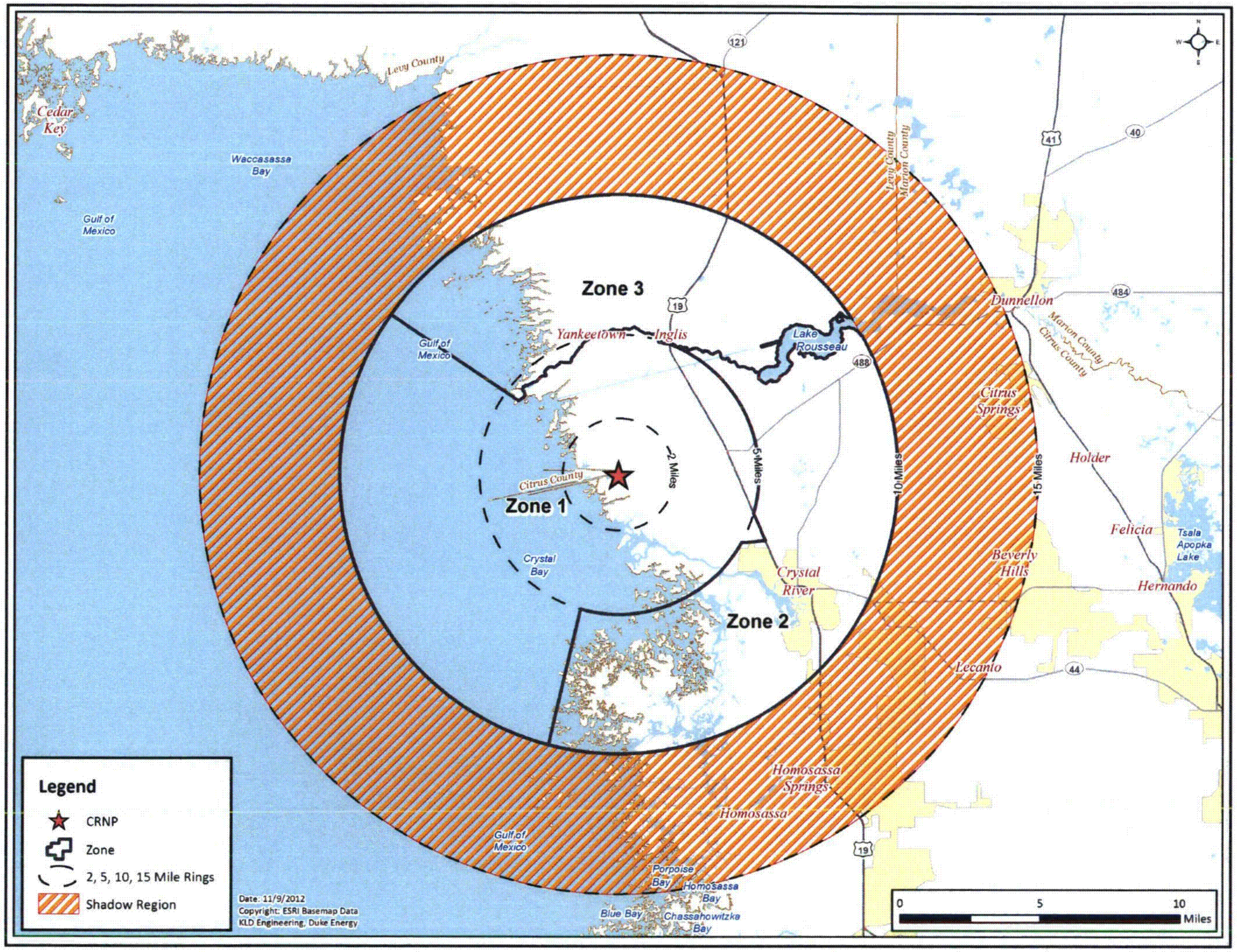


Figure 7-2. CRNP Shadow Region

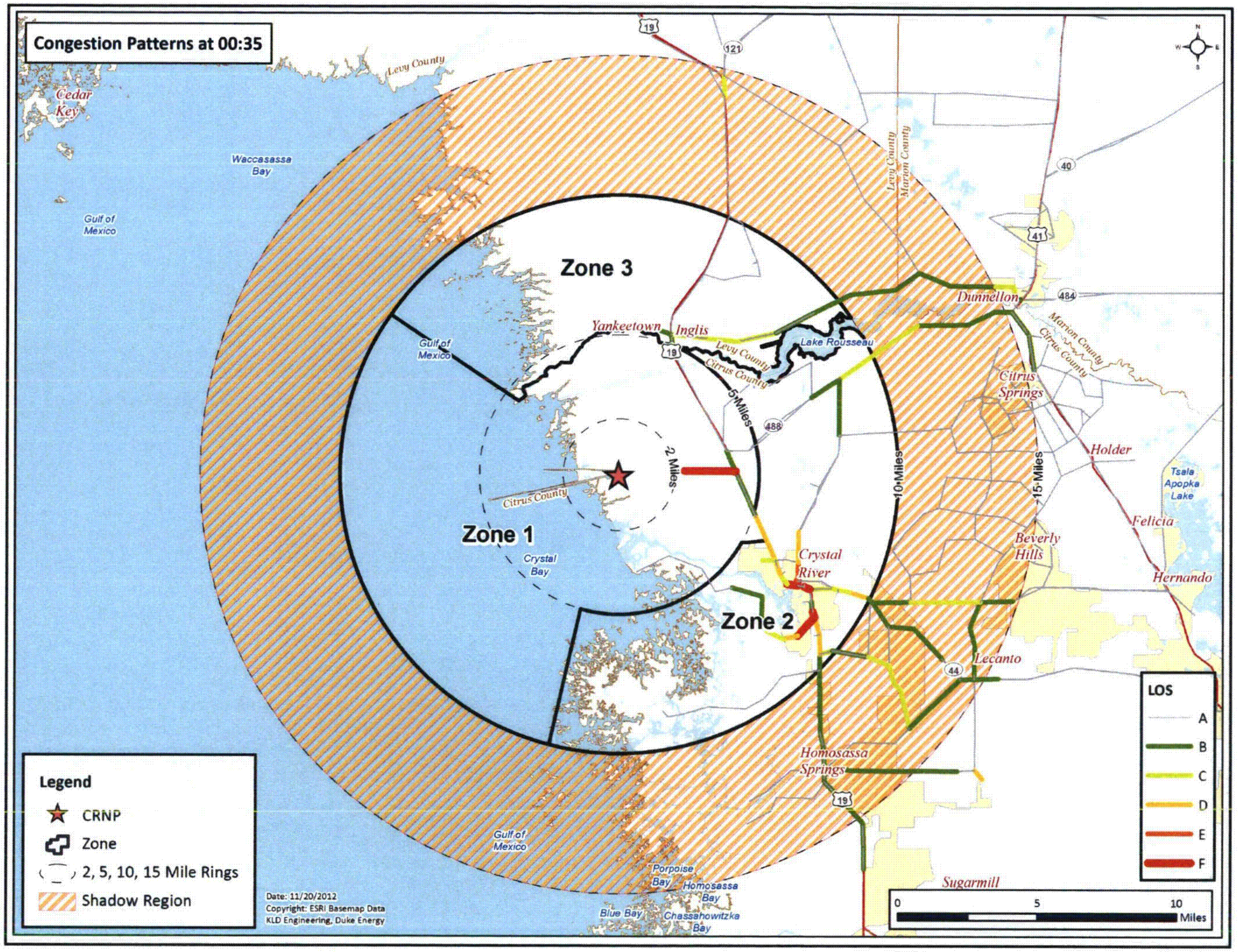


Figure 7-3. Congestion Patterns at 35 Minutes after the Advisory to Evacuate

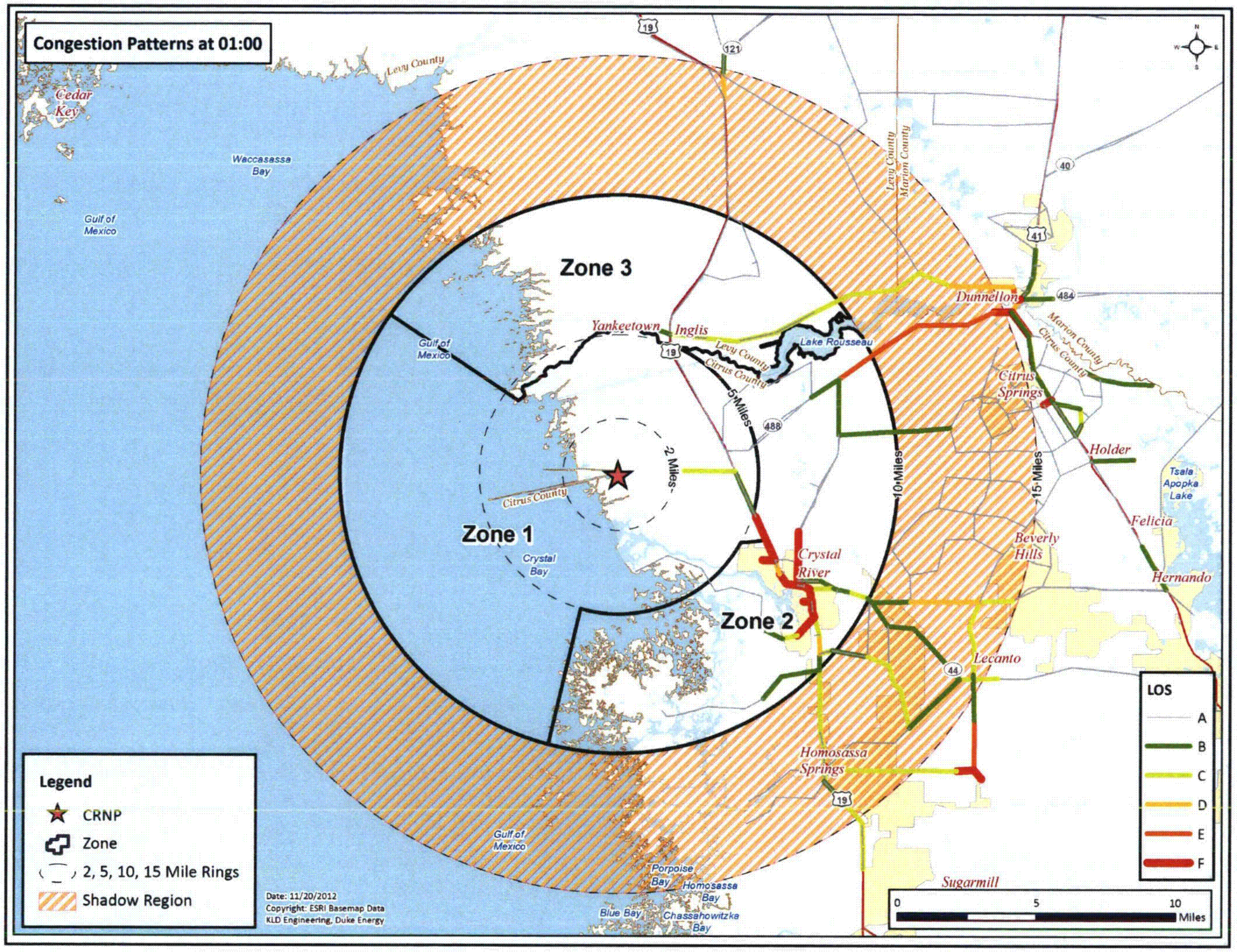


Figure 7-4. Congestion Patterns at 1 Hour after the Advisory to Evacuate

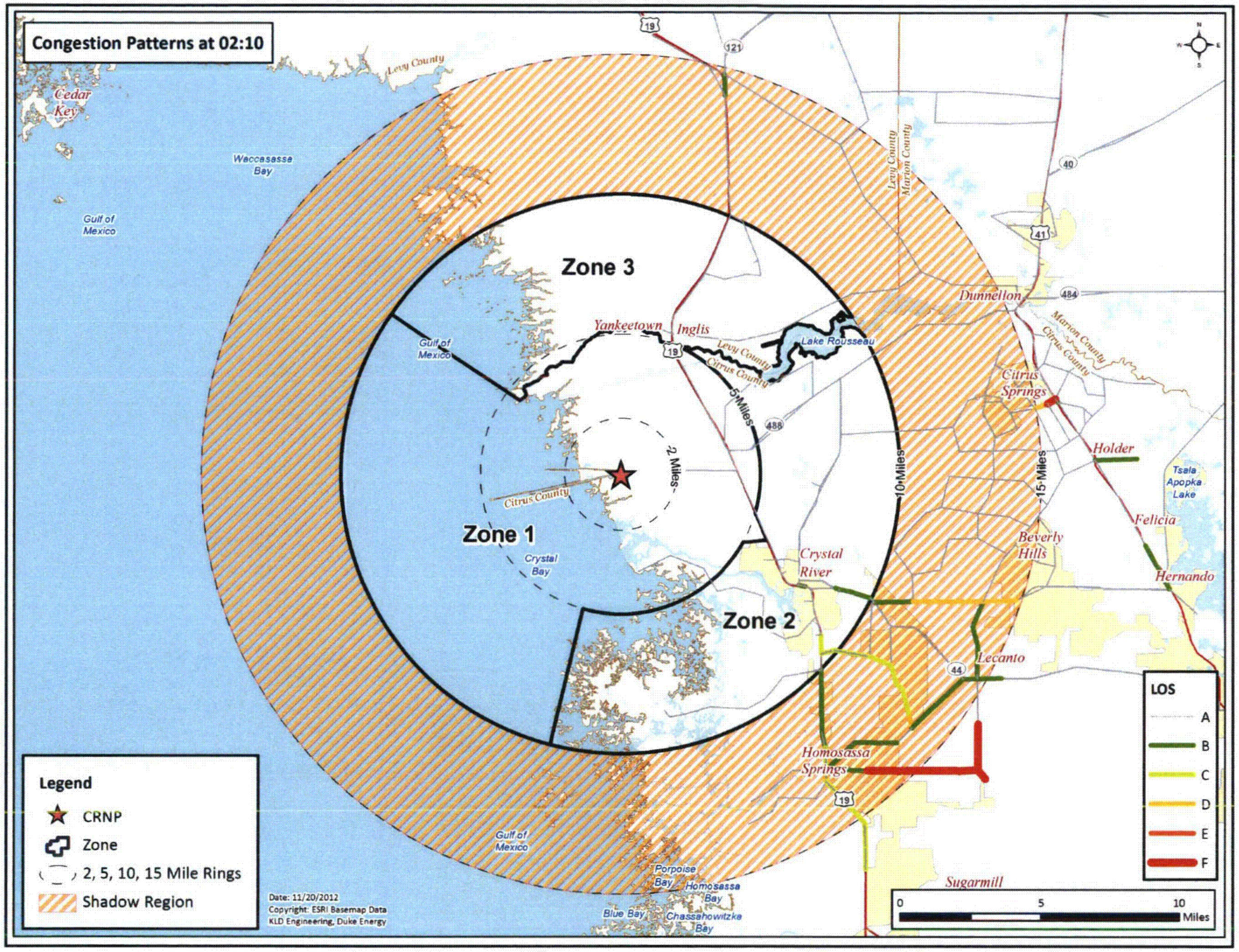


Figure 7-5. Congestion Patterns at 2 Hours and 10 Minutes after the Advisory to Evacuate

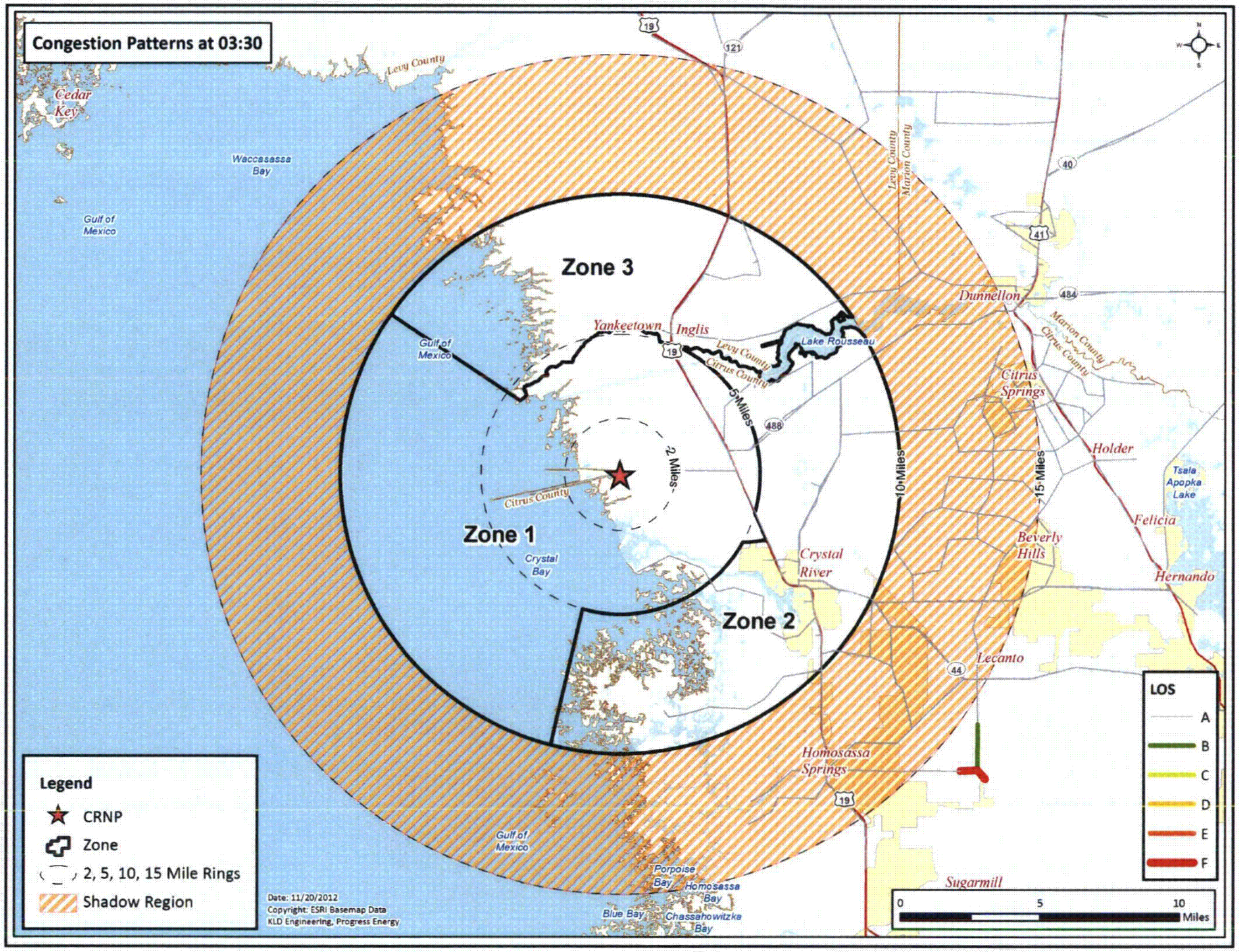


Figure 7-6. Congestion Patterns at 3 Hours and 30 Minutes after the Advisory to Evacuate

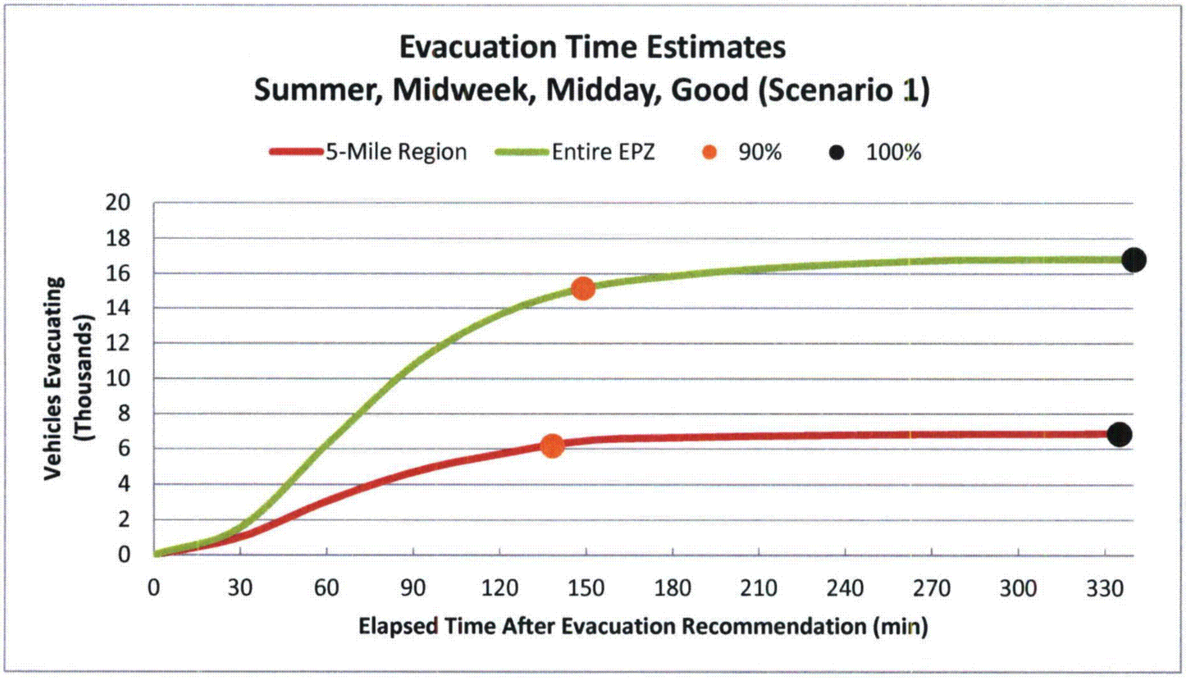


Figure 7-7. Evacuation Time Estimates - Scenario 1 for Region R02

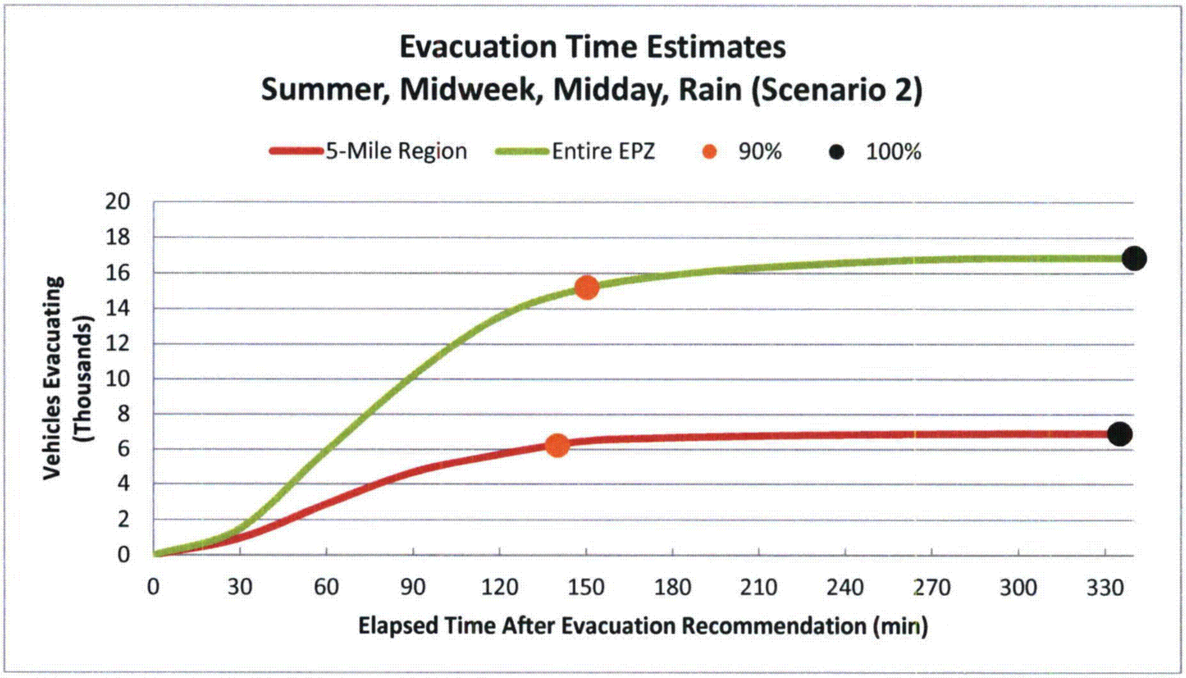


Figure 7-8. Evacuation Time Estimates - Scenario 2 for Region R02

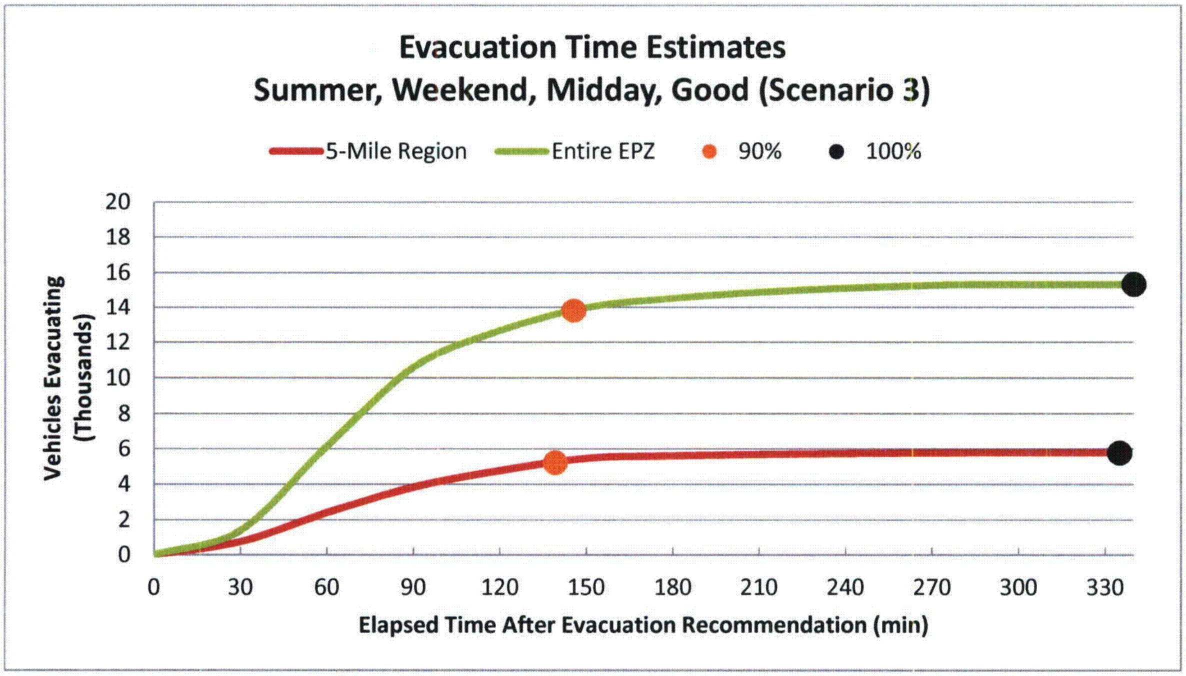


Figure 7-9. Evacuation Time Estimates - Scenario 3 for Region R02

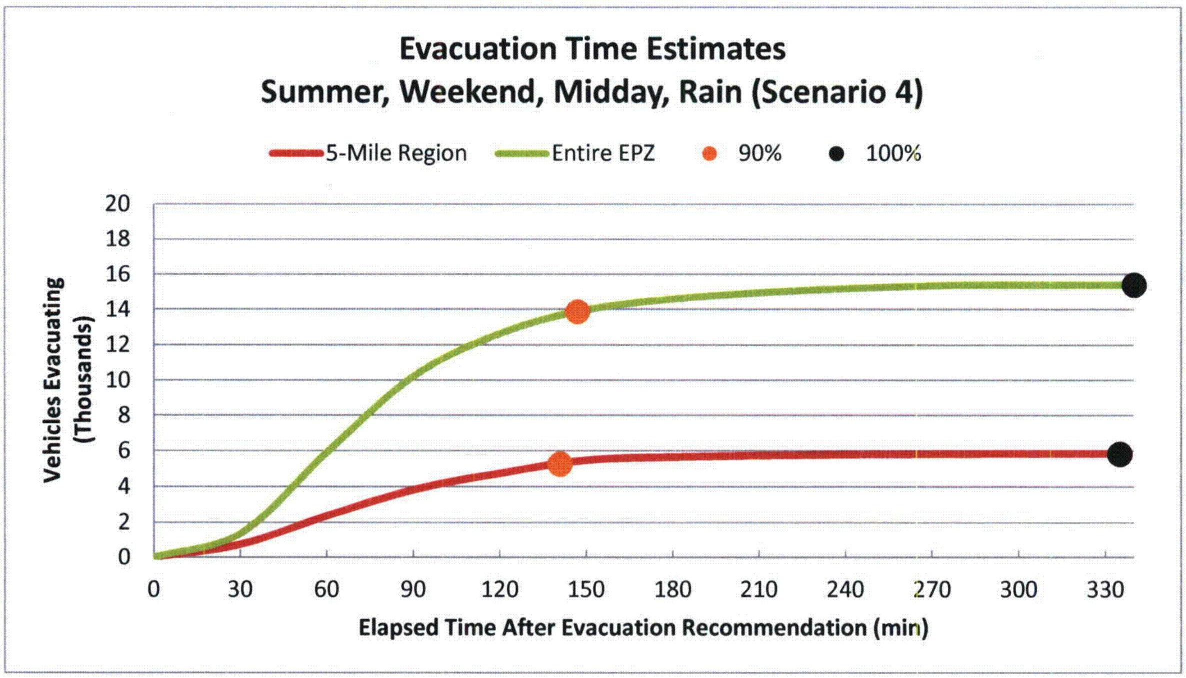


Figure 7-10. Evacuation Time Estimates - Scenario 4 for Region R02

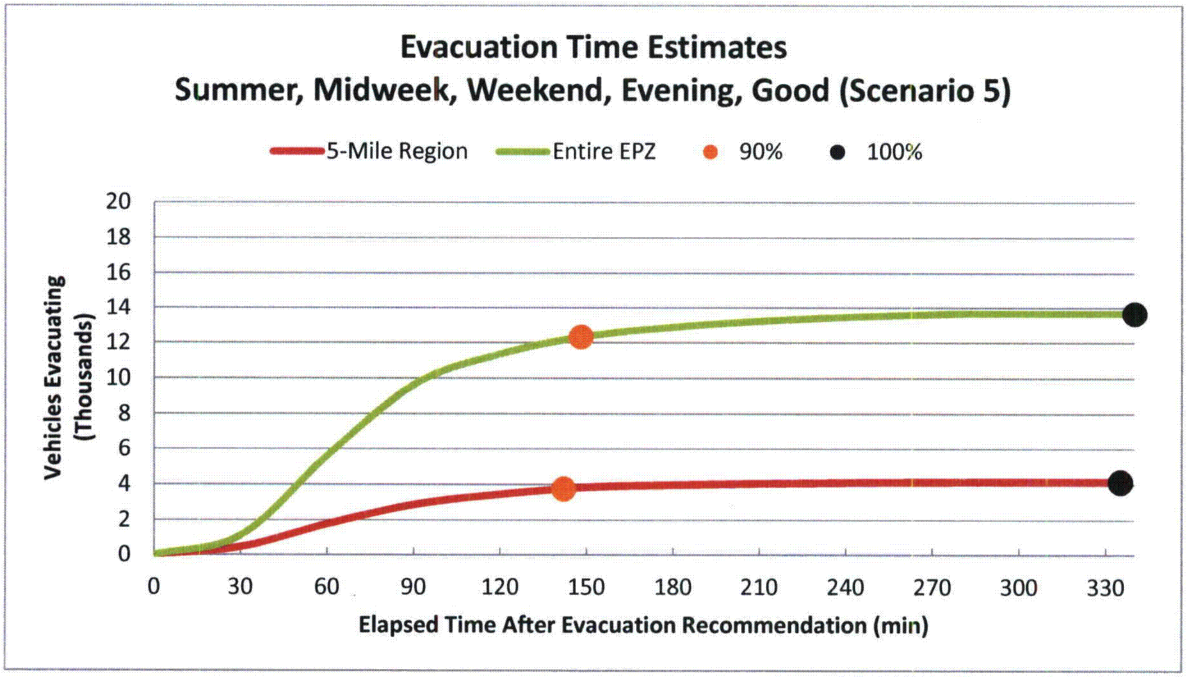


Figure 7-11. Evacuation Time Estimates - Scenario 5 for Region R02

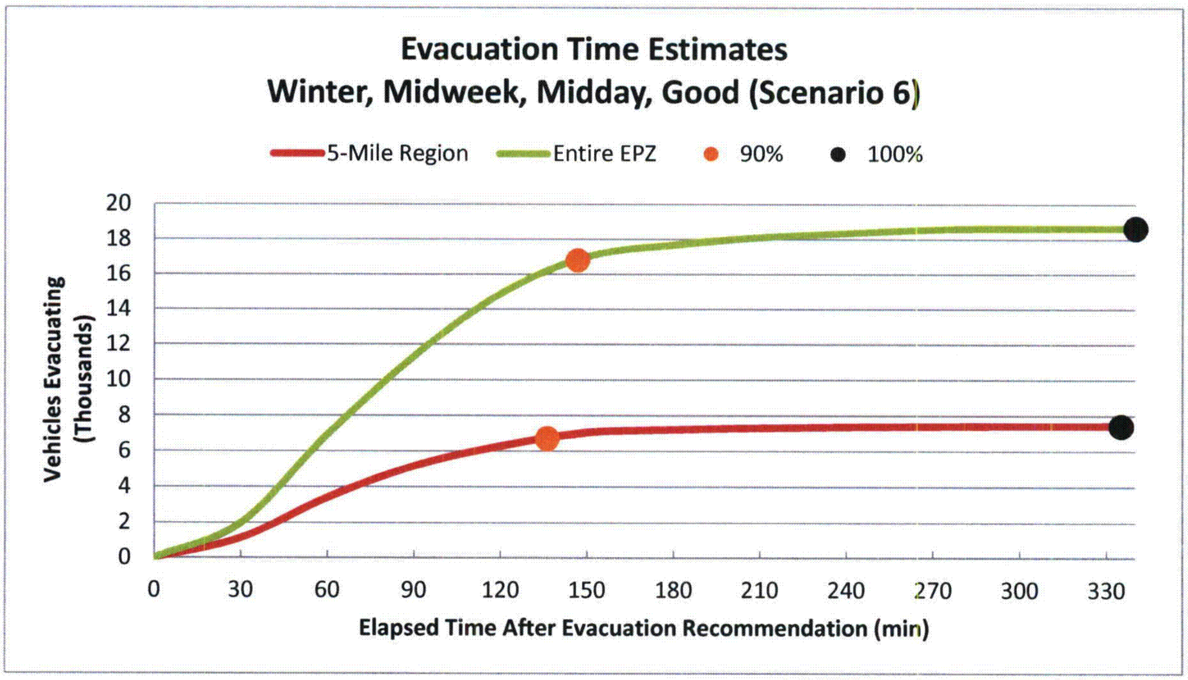


Figure 7-12. Evacuation Time Estimates - Scenario 6 for Region R02

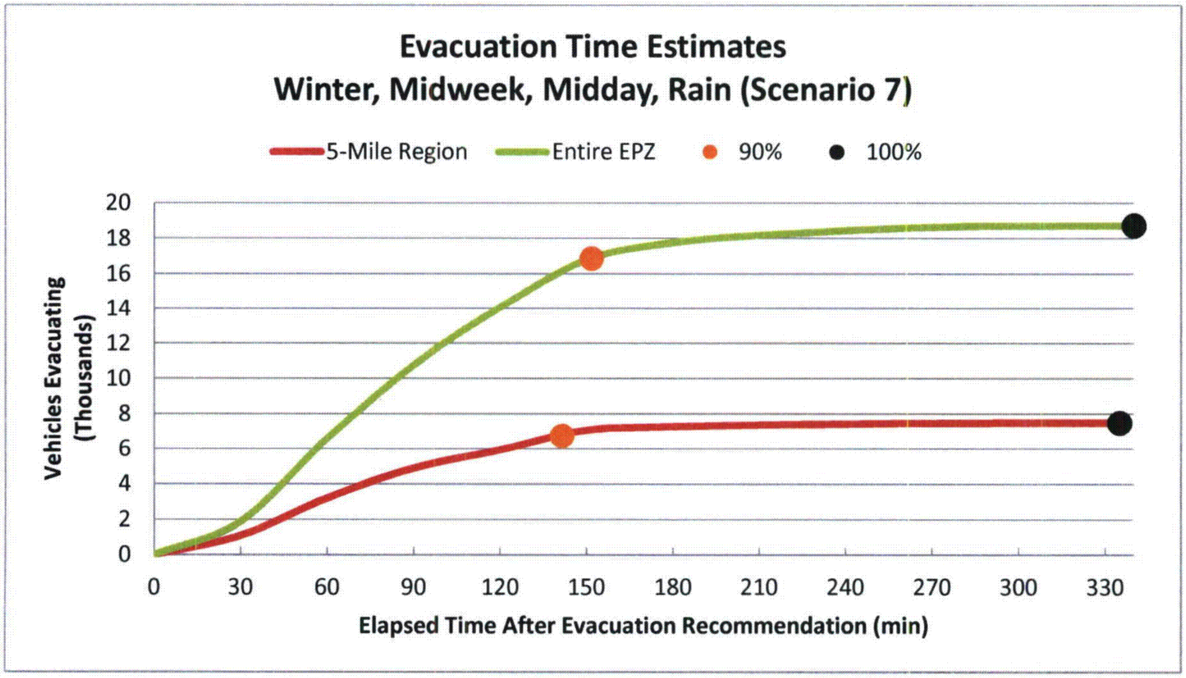


Figure 7-13. Evacuation Time Estimates - Scenario 7 for Region R02

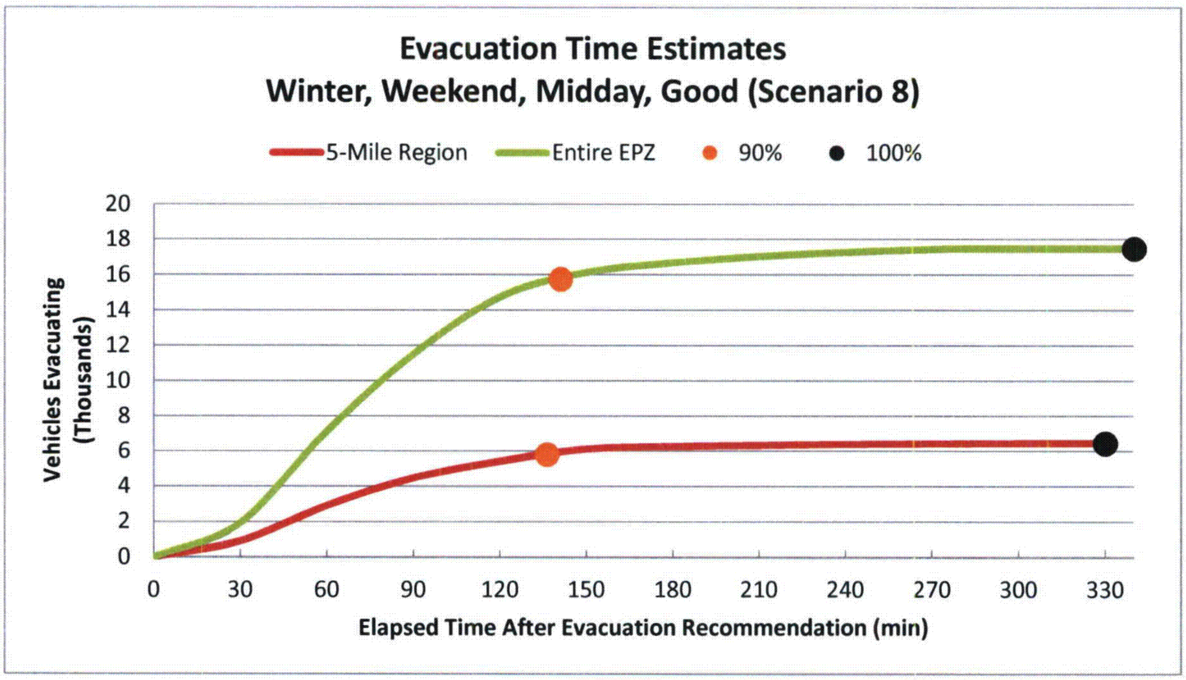


Figure 7-14. Evacuation Time Estimates - Scenario 8 for Region R02

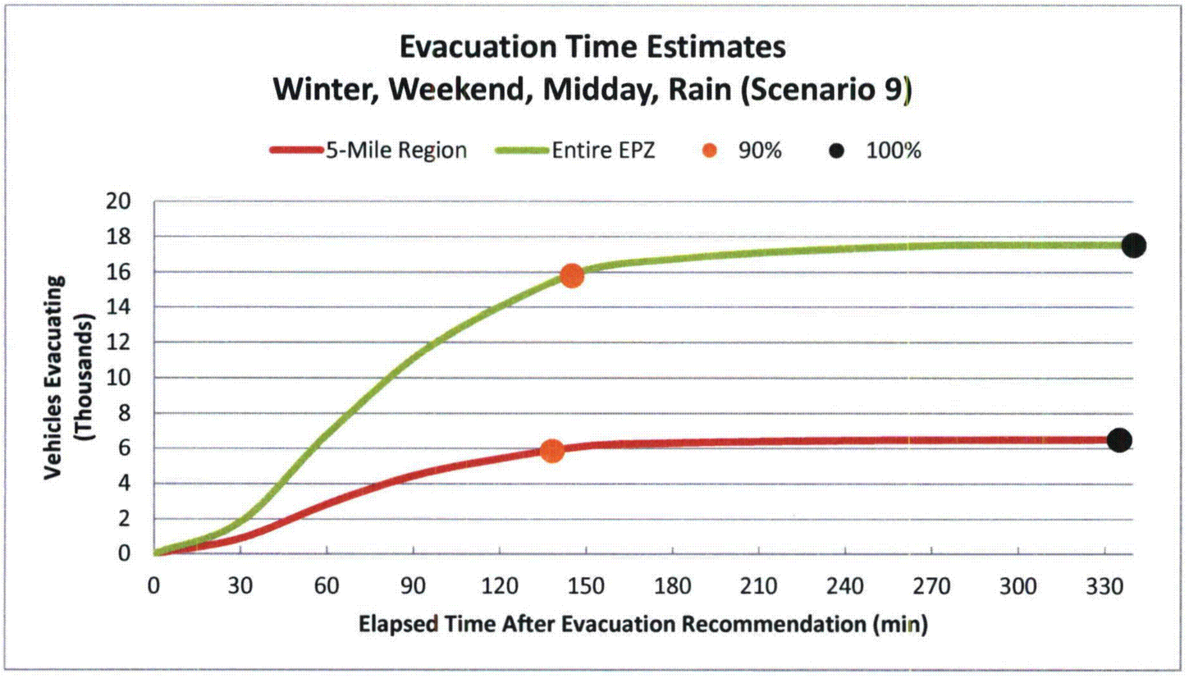


Figure 7-15. Evacuation Time Estimates - Scenario 9 for Region R02

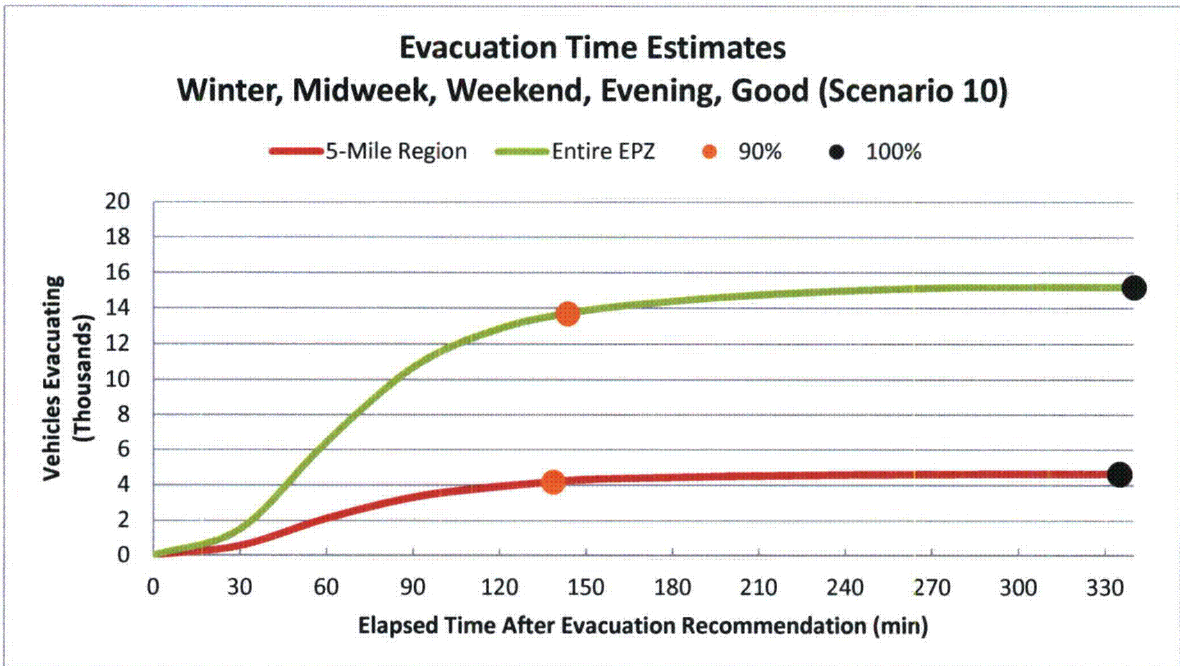


Figure 7-16. Evacuation Time Estimates - Scenario 10 for Region R02

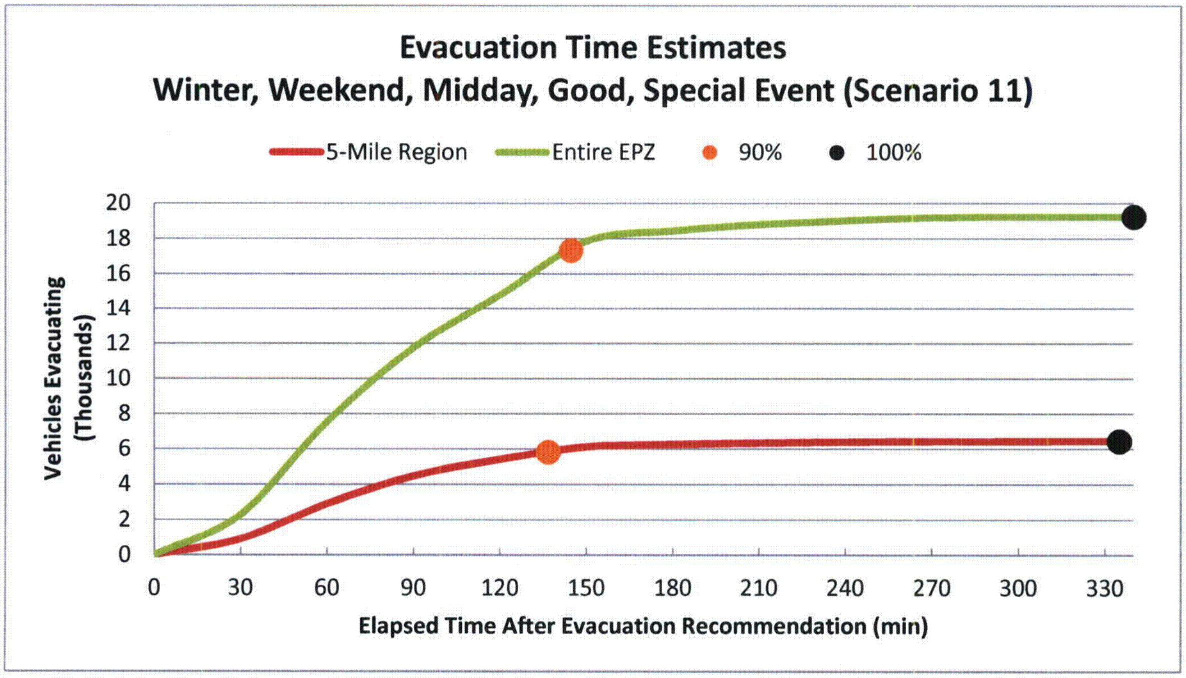


Figure 7-17. Evacuation Time Estimates - Scenario 11 for Region R02

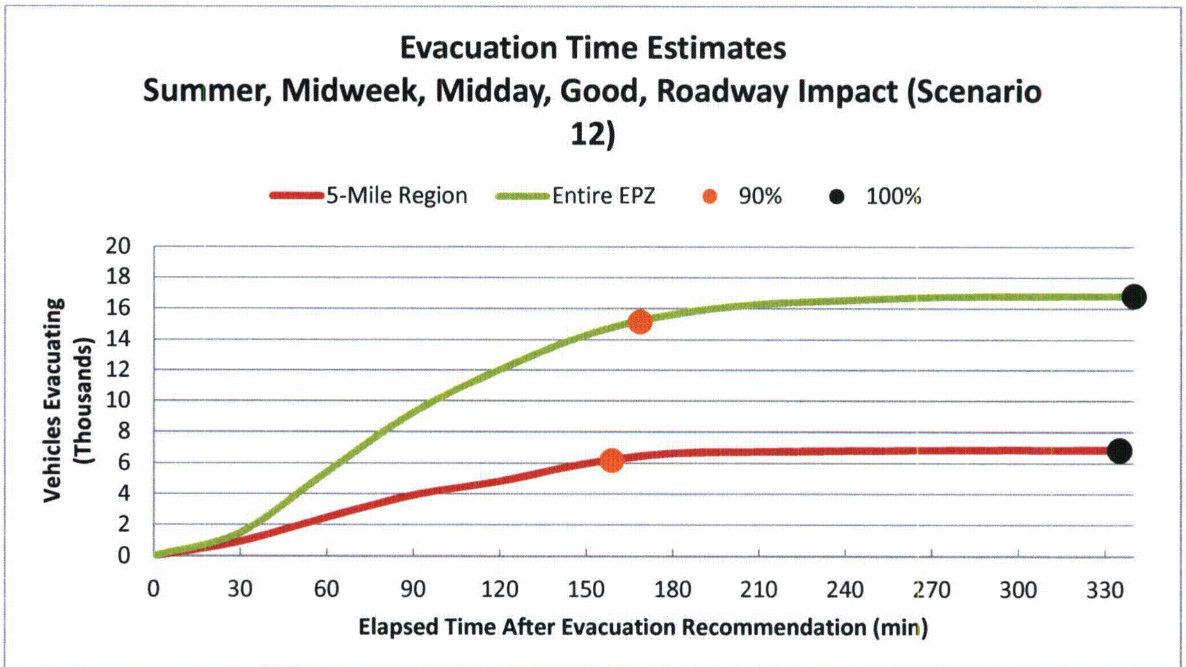


Figure 7-18. Evacuation Time Estimates - Scenario 12 for Region R02

8 TRANSIT-DEPENDENT AND SPECIAL FACILITY EVACUATION TIME ESTIMATES

This section details the analyses applied and the results obtained in the form of evacuation time estimates for transit vehicles (buses, ambulances, and wheelchair transport vehicles). The demand for transit service reflects the needs of three population groups: (1) residents with no vehicles available; (2) residents of special facilities such as schools, and medical facilities; and (3) homebound functional needs population.

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

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

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

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

During this mobilization period, other mobilization activities are taking place. One of these is the action taken by parents, neighbors, relatives and friends to pick up children from school prior to the arrival of buses, so that they may join their families. Virtually all studies of evacuations have concluded that this "bonding" process of uniting families is universally prevalent during emergencies and should be anticipated in the planning process. The current public information disseminated to residents of the CRNP EPZ indicates that schoolchildren will be evacuated to relocation schools at emergency action levels of Site Area Emergency or higher, and that parents should pick schoolchildren up the appropriate relocation school. As discussed in Section 2, this study assumes a rapidly escalating event at the plant wherein evacuation is ordered promptly and no early protective actions have been implemented. Therefore, children are evacuated to relocation schools. Picking up children at school could add to traffic congestion at the schools, delaying the departure of the buses evacuating schoolchildren, which may have to return in a subsequent "wave" to the EPZ to evacuate the transit-dependent population. This report provides estimates of buses under the assumption that no children will be picked up by their parents (in accordance with NUREG/CR-7002), to present an upper bound estimate of buses required. It is assumed that children at day-care centers are picked up by parents or guardians and that the time to perform this activity is included in the trip generation times discussed in Section 5.

The procedure for computing transit-dependent ETE is to:

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

8.1 Transit Dependent People Demand Estimate

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

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

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

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

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

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

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

Table 8-1 indicates that transportation must be provided for 404 people. Therefore, a total of **14 bus runs** are required to transport this population to evacuation shelters.

To illustrate this estimation procedure, we calculate the number of persons, P, requiring public transit or ride-share, and the number of buses, B, required for the CRNP EPZ:

$$P = No. of\ HH \times \sum_{i=0}^{n} \{(\%\ HH\ with\ i\ vehicles) \times [(Average\ HH\ Size) - i]\} \times A^i C^i$$

Where,

A = Percent of households with commuters

C = Percent of households who will not await the return of a commuter

$$P = 8{,}846 \times [0.0242 \times 2.00 + 0.3677 \times (1.58 - 1) \times 0.37 \times 0.50 + 0.4343 \times (2.23 - 2) \times (0.37 \times 0.50)^2] = 8{,}846 \times 0.0913 = 807$$

$$B = (0.5 \times 807) \div 30 = 14$$

These calculations are explained as follows:

- All members (2.00 avg.) of households (HH) with no vehicles (2.42%) will evacuate by public transit or ride-share. The term 8,846 (number of households) x 0.0242 x 2.00, accounts for these people.
- The members of HH with 1 vehicle away (36.77%), who are at home, equal (1.58-1). The number of HH where the commuter will not return home is equal to (8,846 x 0.3677 x 0.58 x 0.50 x .37), as 37% of EPZ households have a commuter, 50% of which would not return home in the event of an emergency. The number of persons who will evacuate by public transit or ride-share is equal to the product of these two terms.
- The members of HH with 2 vehicles that are away (43.43%), who are at home, equal (2.23 – 2). The number of HH where neither commuter will return home is equal to 8,846 x 0.4343 x 0.23 x $(0.37 \times 0.50)^2$. The number of persons who will evacuate by public transit or ride-share is equal to the product of these two terms (the last term is squared to represent the probability that neither commuter will return).
- Households with 3 or more vehicles are assumed to have no need for transit vehicles.
- The total number of persons requiring public transit is the sum of such people in HH with no vehicles, or with 1 or 2 vehicles that are away from home.

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

8.2 School Population – Transit Demand

Table 8-2 presents the school population and transportation requirements for the direct evacuation of all schools within the EPZ for the 2011-2012 school year. This information was provided by the local county emergency management agencies. The column in Table 8-2 entitled "Buses Required" specifies the number of buses required for each school under the following set of assumptions and estimates:

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

Implementation of a process to confirm individual school transportation needs prior to bus dispatch may improve bus utilization. In this way, the number of buses dispatched to the schools will reflect the actual number needed. The need for buses would be reduced by any high school students who have evacuated using private automobiles (if permitted by school authorities). Those buses originally allocated to evacuate schoolchildren that are not needed due to children being picked up by their parents, can be gainfully assigned to service other facilities or those persons who do not have access to private vehicles or to ride-sharing.

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

8.3 Medical Facility Demand

Table 8-4 presents the census of medical facilities in the EPZ. 438 people have been identified as living in, or being treated in, these facilities. The capacity and current census for each facility were provided by the county emergency management agencies. This data includes the number of ambulatory, wheelchair-bound, and bedridden patients at each facility.

The transportation requirements for the medical facility population are also presented in Table 8-4. The number of ambulance runs is determined by assuming that 2 patients can be accommodated per ambulance trip; the number of wheelchair bus runs assumes 15 wheelchairs per trip and the number of bus runs estimated assumes 30 ambulatory patients per trip.

8.4 Evacuation Time Estimates for Transit Dependent People

EPZ bus resources are assigned to evacuating schoolchildren (if school is in session at the time of the ATE) as the first priority in the event of an emergency. In the event that the allocation of buses dispatched from the depots to the various facilities and to the bus routes is somewhat inefficient, or if there is a shortfall of available drivers, then there may be a need for some buses to return to the EPZ from the reception center after completing their first evacuation trip, to complete a "second wave" of providing transport service to evacuees. For this reason, the ETE for the transit-dependent population was calculated for both a one wave transit evacuation and for two waves. Of course, if the impacted Evacuation Region is other than R02 (the entire EPZ), then there will likely be ample transit resources relative to demand in the impacted Region and this discussion of a second wave would likely not apply.

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

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

Activity: Mobilize Drivers (A→B→C)

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

Activity: Board Passengers (C→D)

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

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

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

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

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

Assigning reasonable estimates:

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

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

Activity: Travel to EPZ Boundary (D→E)

School Evacuation

Transportation resources available were provided by the EPZ county emergency management agencies and are summarized in Table 8-5. Also included in the table are the capacities needed to evacuate schools, medical facilities, transit-dependent, and homebound functional needs (discussed below in Section 8.5). These numbers indicate there is sufficient capacity available to evacuate everyone in a single wave, with the exception of the wheelchair-bound population within the EPZ, which requires two waves of wheelchair accessible transportation.

The buses servicing the schools are ready to begin their evacuation trips at 105 minutes after the advisory to evacuate – 90 minutes mobilization time plus 15 minutes loading time – in good weather. According to Levy County, buses are located on site which reduced mobilization time to 0 minutes. Therefore, the buses servicing Yankeetown School are ready to begin their evacuation trip at 15 minutes after the advisory to evacuate – 0 minutes mobilization time plus 15 minutes loading time. The UNITES software discussed in Section 1.3 was used to define bus routes along the most likely path from a school being evacuated to the EPZ boundary, traveling toward the appropriate relocation school. This is done in UNITES by interactively selecting the series of nodes from the school to the EPZ boundary. Each bus route is given an identification number and is written to the DYNEV II input stream. DYNEV computes the route length and outputs the average speed for each 5 minute interval, for each bus route. The specified bus routes are documented in Table 8-6 (refer to the maps of the link-node analysis network in Appendix K for node locations). Data provided by DYNEV during the appropriate timeframe depending on the mobilization and loading times (i.e., 100 to 105 minutes after the advisory to evacuate for good weather) were used to compute the average speed for each route, as follows:

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

The average speed computed (using this methodology) for the buses servicing each of the schools in the EPZ is shown in Table 8-7 and Table 8-8 for school evacuation, in Table 8-10 and Table 8-11 for the transit vehicles evacuating transit-dependent persons (which are discussed later) and in Table 8-12 and

Table 8-13 for vehicles evacuating medical facilities (which are also discussed later). The travel time to the EPZ boundary was computed for each bus using the computed average speed and the distance to the EPZ boundary along the most likely route out of the EPZ. The travel time from the EPZ boundary to the Evacuation Shelter was computed assuming an average speed of 45 mph and 40 mph for good weather and rain, respectively. Speeds were reduced in Table 8-7 through Table 8-8 and in Table 8-10 through Table 8-11 to 55 mph (50 mph for rain – 10% decrease) for those calculated bus speeds which exceed 55 mph, as the school bus speed limit for Florida is 55 mph.

Table 8-7 (good weather) and Table 8-8 (rain) present the following evacuation time estimates (rounded up to the nearest 5 minutes) for schools in the EPZ: (1) The elapsed time from the Advisory to Evacuate until the bus exits the EPZ; and (2) The elapsed time until the bus reaches the Relocation School. The evacuation time out of the EPZ can be computed as the sum of times associated with Activities A→B→C, C→D, and D→E (For example: 90 min + 15 + 11 = 2:00 for the Academy of Environmental Science, with good weather, rounded up to the nearest 5 minutes). The evacuation time to the Relocation School is determined by adding the time associated with Activity E→F (discussed below), to this EPZ evacuation time.

Evacuation of Transit-Dependent Population

The buses dispatched from the depots to service the transit-dependent evacuees will be scheduled so that they arrive at their respective routes after their passengers have completed their mobilization. As shown in Figure 5-4 (Residents with no Commuters), 90 percent of the evacuees will complete their mobilization when buses for Zones 1 and 3 begin their routes, approximately 135 minutes after the Advisory to Evacuate. Zone 2 has a high transit-dependent population and requires more buses than any other zone (Table 8-9). Eleven of the 14 buses are required to service Zone 2, and they are dispatched earlier when 80% of the evacuees will complete their mobilization, at 120 minutes after the Advisory to Evacuate. The start of service on this route is separated by a 5 minute headway, as shown in Table 8-10 and Table 8-11. The use of bus headways ensures that those people who take longer to mobilize will be picked up. Mobilization time is 10 minutes longer in rain to account for slower travel speeds and reduced roadway capacity.

Those buses servicing the transit-dependent evacuees will first travel along their pick-up routes, then proceed out of the EPZ. The county emergency plans do not define bus routes to service the EPZ. The 3 bus routes shown graphically in Figure 8-2 and described in Table 8-9 were designed as part of this study to service the major population centers through each zone. It is assumed that residents will walk to and congregate along these routes to flag buses, and that they can arrive within the 135 minute bus mobilization time (good weather).

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

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

Table 8-10 and Table 8-11 present the transit-dependent population evacuation time estimates for each bus route calculated using the above procedures for good weather and rain, respectively.

For example, the ETE for the bus route servicing Zone 1 is computed as 135 + 16 + 30 = 3:05 for good weather (rounded up to nearest 5 minutes). Here, 16 minutes is the time to travel 12.7 miles at 46.9 mph, the average speed output by the model for this route starting at 135 minutes. The ETE for a second wave (discussed below) is presented in the event there is a shortfall of available buses or bus drivers, as previously discussed.

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

The distances from the EPZ boundary to the evacuation shelters are measured using GIS software along the most likely route from the EPZ exit point to the evacuation shelter. The evacuation shelters are mapped in Figure 10-1. For a one-wave evacuation, this travel time outside the EPZ does not contribute to the ETE. For a two-wave evacuation, the ETE for buses must be considered separately, since it could exceed the ETE for the general population. Assumed bus speeds of 45 mph and 40 mph for good weather and rain, respectively, will be applied for this activity for buses servicing the transit-dependent population.

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

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

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

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

The second-wave ETE for the bus route servicing zone 1 is computed as follows for good weather:

- Bus arrives at evacuation shelter at 3:24 in good weather (3:05 to exit EPZ + 19 minute travel time to evacuation shelter).
- Bus discharges passengers (5 minutes) and driver takes a 10-minute rest: 15 minutes.
- Bus returns to EPZ and completes second route: 19 minutes (equal to travel time to reception center) + 15 minutes (12.7 miles @ 50.6 mph) = 34 minutes
- Bus completes pick-ups along route: 30 minutes.
- Bus exits EPZ at time 3:05 + 0:19 + 0:15 + 0:34 + 0:30 = 4:45 (rounded up to nearest 5 minutes) after the Advisory to Evacuate.

The ETE for the completion of the second wave for all transit-dependent bus routes are provided in Table 8-10 and Table 8-11. The average ETE for a two-wave evacuation of transit-dependent people exceeds the ETE for the general population at the 90th percentile.

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

Evacuation of Medical Facilities

The evacuation of these facilities is similar to school evacuation except:

- Buses are assigned on the basis of 30 patients to allow for staff to accompany the patients. Wheelchair buses can accommodate 15 patients, and ambulances can accommodate 2 patients.
- Loading times of 1 minute, 5 minutes, and 15 minutes per patient are assumed for ambulatory patients, wheelchair bound patients, and bedridden patients, respectively.

Table 8-4 indicates that 192 ambulatory persons, 222 people needing a wheelchair, and 24 people requiring an ambulance are located at the medical facilities in the EPZ. According to Table 8-5, the counties can collectively provide transportation to accommodate 5,106 ambulatory persons, 170 people needing a wheelchair, and 75 people needing an ambulance. Thus, there are sufficient resources from a capacity standpoint to evacuate the ambulatory and bedridden persons from the medical facilities in a single wave, but a two-wave evacuation is needed to evacuate wheelchair-bound patients.

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

Table 8-12 and Table 8-13 summarize the ETE for medical facilities within the EPZ for good weather and rain. Loading times of 1 minute, 5 minutes, and 15 minutes are assumed for ambulatory patients, wheelchair bound patients, and bedridden patients, respectively. Average speeds output by the model for Scenario 6 (Scenario 7 for rain) Region R02, capped at 55 mph (50 mph for rain), are used to compute travel time to EPZ boundary. The travel time to the EPZ boundary is computed by dividing the distance to the EPZ boundary by the average travel speed. The ETE is the sum of the mobilization time, total passenger loading time, and travel time out of the EPZ. Concurrent loading on multiple buses, wheelchair buses/vans, and ambulances is assumed such that the maximum loading times for buses, wheelchair buses/vans and ambulances are 30, 75 and 30 minutes, respectively. All ETE are rounded to the nearest 5 minutes. For example, the calculation of ETE for the Seven Rivers Regional Medical Center with 60 ambulatory residents during good weather is:

ETE: 90 + 30 x 1 + 14 = 135 min. or 2:15 rounded up to the nearest 5 minutes.

The following outlines the ETE calculations for a second wave for wheelchair bound patients:

a. ETE to the EPZ boundary (average wheelchair-bound ETE from Table 8-12): 2:35
b. The host facilities for the medical facilities in the EPZ are located, on average, 27 miles beyond the EPZ boundary. It is therefore estimated that it takes 36 minutes to travel to the host facility from the EPZ boundary at 45 mph.
c. Bus discharges passengers: 57 minutes (average Total Loading Time from Table 8-12)
d. Driver takes a 10 minute rest
e. Travel time back to EPZ: 36 minutes
f. Travel time from EPZ to the medical facility: 5 minutes (4 miles on average @ assumed 45 mph – EPZ is now clear of congestion)
g. Loading time: 57 minutes
h. Travel time from medical facility to EPZ boundary: 5 minutes (4 miles on average @ assumed 45 mph – EPZ is now clear of congestion)

ETE: 2:35 + 0:36 + 0:57 + 0:10 + 0:36 + 0:05 + 0:57 + 0:05 = 6:05 after the Advisory to Evacuate (rounded up to nearest 5 minutes).

Therefore, a second wave evacuation for wheelchair-accessible buses would require an additional 3 hours and 25 minutes relative to a single wave evacuation.

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

8.5 Functional Needs Population

The county emergency management agencies have a registry for homebound functional needs persons. Based on data provided by the counties, there are an estimated 34 homebound special needs people within the Citrus County portion of the EPZ and 12 people within the Levy County portion of the EPZ who require transportation assistance to evacuate. Of the 34 homebound functional needs people within Citrus County, 24 are ambulatory, 7 are wheelchair-bound, and

3 are bedridden. Of the 12 homebound functional needs people in Levy County, 6 are ambulatory, 4 are wheelchair bound, and 2 are bedridden.

It is assumed latchkey children are considered within the homebound functional needs population. Latchkey children are defined by NUREG/CR-7002 as children within households that are unsupervised and will need transportation. No data was received on the number of latchkey children within the EPZ. If transportation was required to pick up these children, they would receive an ETE comparable to that of the ETE for homebound functional needs persons.

ETE for Homebound Functional Needs Persons

Table 8-14 summarizes the ETE for homebound functional needs people. The table is categorized by type of vehicle required and then broken down by weather condition. The table takes into consideration the deployment of multiple vehicles to reduce the number of stops per vehicle. It is conservatively assumed that ambulatory and wheelchair bound functional needs households are spaced 3 miles apart and bedridden households are spaced 5 miles apart. Bus speeds approximate 20 mph between households and ambulance speeds approximate 30 mph in good weather (10% slower in rain). Mobilization times of 90 minutes were used (100 minutes for rain). The last HH is assumed to be 5 miles from the EPZ boundary, and the network-wide average speed, capped at 55 mph (50 mph for rain), after the last pickup is used to compute travel time. ETE is computed by summing mobilization time, loading time at first household, travel to subsequent households, loading time at subsequent households, and travel time to EPZ boundary. All ETE are rounded to the nearest 5 minutes.

For example, assuming no more than one functional needs person per HH implies that 30 ambulatory households need to be serviced. While only 1 bus is needed from a capacity perspective, if 5 buses are deployed to service these functional needs HH, then each would require about 6 stops. The following outlines the ETE calculations:

1. Assume 5 buses are deployed, each with about 6 stops, to service a total of 30 HH.
2. The ETE is calculated as follows:
    a. Buses arrive at the first pickup location: 90 minutes
    b. Load HH members at first pickup: 5 minutes
    c. Travel to subsequent pickup locations: 5 @ 9 minutes = 45 minutes
    d. Load HH members at subsequent pickup locations: 5 @ 5 minutes = 25 minutes
    e. Travel to EPZ boundary: 8 minutes (5 miles @ 38.4 mph).

   ETE: 90 + 5 + 45 + 25 + 8 = 2:55 (rounded to the nearest 5 minutes)

As noted in the footnote to Table 8-5, Citrus County Community Services/Support Services has primary responsibility for the safe movement of those people on the functional needs list during an evacuation. This transportation provider has sufficient capacity to evacuate all of the wheelchair bound individuals within the EPZ in a single wave. Other transportation providers have sufficient reserve capacity to evacuate the homebound population in a single wave.

(Subsequent Wave)

Event	
A	Advisory to Evacuate
B	Bus Dispatched from Depot
C	Bus Arrives at Facility/Pick-up Route
D	Bus Departs for Reception Center
E	Bus Exits Region
F	Bus Arrives at Reception Center/Host Facility
G	Bus Available for "Second Wave" Evacuation Service
Activity	
A→B	Driver Mobilization
B→C	Travel to Facility or to Pick-up Route
C→D	Passengers Board the Bus
D→E	Bus Travels Towards Region Boundary
E→F	Bus Travels Towards Reception Center Outside the EPZ
F→G	Passengers Leave Bus; Driver Takes a Break

Figure 8-1. Chronology of Transit Evacuation Operations

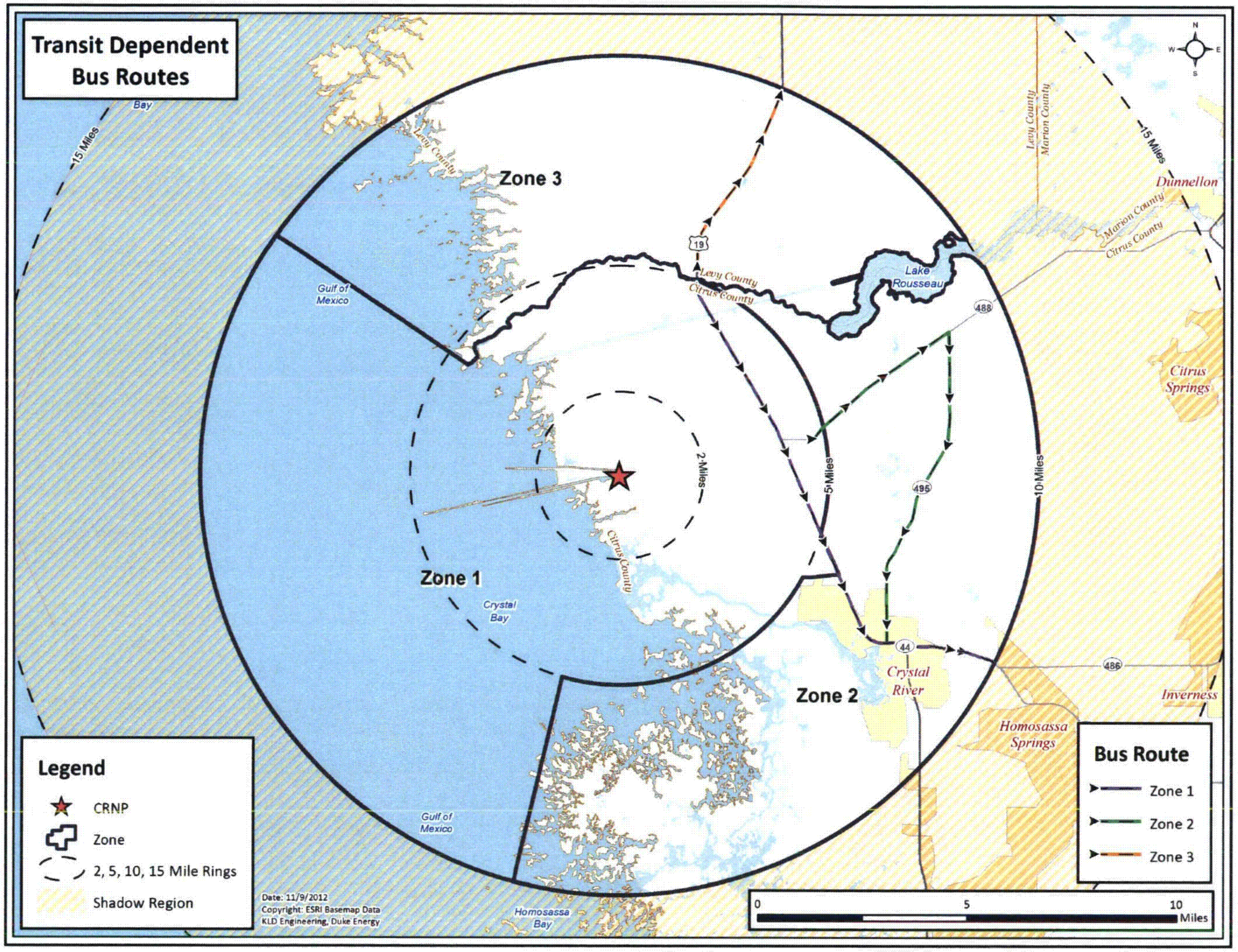


Figure 8-2. Transit-Dependent Bus Routes

Table 8-1. Transit-Dependent Population Estimates

2010 EPZ Population	Survey Average HH Size with Indicated No. of Vehicles			Estimated No. of Households	Survey Percent HH with Indicated No. of Vehicles			Survey Percent HH with Commuters	Survey Percent HH with Non-Returning Commuters	Total People Requiring Transport	Estimated Ridesharing Percentage	People Requiring Public Transit	Percent Population Requiring Public Transit
	0	1	2		0	1	2						
18,400	2.00	1.58	2.23	8,846	2.42%	36.77%	43.43%	37%	50%	807	50%	404	2.2%

Table 8-2. School Population Demand Estimates

Zone	School Name	Enrollment	Buses Required
1	Academy of Environmental Science	102	3
2	Ark Angels Christian Preschool	63	1
2	Crystal River High School	1,207	25
2	Crystal River Middle School	811	17
2	Crystal River Preschool[1]	215	4
2	Crystal River Primary School	622	9
2	Marine Science Station	64	2
3	Yankeetown School	225	5
	TOTAL:	**3,309**	**66**

[1]Evacuates using 3 buses and 1 van

Table 8-3. Relocation Schools

School	Relocation School
Yankeetown School	Bronson High School
Academy of Environmental Science	Citrus High School
Crystal River High School	
Crystal River Middle School	Citrus Springs Middle School
Ark Angels Christian Preschool	First United Methodist Church of Inverness
Crystal River Preschool	
Crystal River Primary School	Inverness Middle School
Marine Science Station	

Table 8-4. Medical Facility Transit Demand

Zone	Facility Name	Municipality	Cap-acity	Current Census	Ambu-latory	Wheel-chair Bound	Bed-ridden	Bus Runs	Wheel-chair Bus Runs	Ambulance
CITRUS COUNTY MEDICAL FACILITIES										
1	Crystal Gem Manor Assisted Living	Crystal River	70	60	53	7	0	2	1	0
1	Seven Rivers Regional Medical Center	Crystal River	128	110	60	35	15	2	3	8
2	Cedar Creek Assisted Living	Crystal River	72	45	25	20	0	1	2	0
2	Crystal River Health & Rehab	Crytsal River	136	100	13	84	3	1	6	2
2	Cypress Cove Care Center	Crystal River	120	111	30	75	6	1	5	3
2	Tender Loving Hospitality	Crystal River	12	12	11	1	0	1	1	0
		Citrus County Subtotal:	***538***	***438***	***192***	***222***	***24***	***8***	***18***	***13***
		TOTAL:	**538**	**438**	**192**	**222**	**24**	**8**	**18**	**13**

Table 8-5. Summary of Transportation Resources

Transportation Resource	Ambulatory Capacity	Wheelchair Capacity	Bedridden Capacity
Resources Available			
Nature Coast EMS	0	0	32
Nature Coast Transit	293	71	7
Citrus County Transit	352	47	0
Levy County School Bus	517	0	7
Dash Transport	42	18	7
Mercy Transport	32	12	0
Levy County EMS	0	0	22
Tender Loving Hospitality	8	0	0
Cedar Creek Assisted Living	34	0	0
Citrus County School Board	3,828	22	0
Citrus County Community Services/Support Services[1]	0	11	0
TOTAL:	**5,106**	**181**	**75**
Resources Needed			
Schools (Table 8-2):	3,309	0	0
Medical Facilities (Table 8-4):	192	222	24
Transit-Dependent Population (Table 8-1):	404	0	0
Homebound Functional Needs (Section 8.5):	30	11	5
TOTAL TRANSPORTATION NEEDS:	**3,935**	**233**	**29**

[1]Citrus County Community Services/Support Services has primary responsibility for the safe movement of those people on the functional needs list during an evacuation.

Table 8-6. Bus Route Descriptions

Bus Route Number	Description	Nodes Traversed from Route Start to EPZ Boundary
1	Academy of Environmental Science	333, 332, 55, 54, 53, 52, 37, 7, 346, 8, 9, 47, 343, 340, 341
2	Crystal River High School	9, 47, 343, 340, 341
3	Crystal River Middle School	41, 40, 10, 89, 9, 47, 343, 340, 341
4	Crystal River Primary School	55, 54, 53, 52, 37, 7, 346, 8, 9, 47, 343, 340, 341, 43
5	Marine Science Station	334, 333, 332, 55, 54, 53, 52, 37, 7, 346, 8, 9, 47, 343, 340, 341
7	Yankeetown School	70, 19, 20, 259, 21, 22, 23, 24
8	Ark Angels Christian Preschool	41, 40, 10, 89, 9, 47, 343, 340, 341
9	Crystal River Preschool	8, 9, 47, 343, 340, 341
11	Cedar Creek Assisted Living	11, 10, 89, 9, 47, 343, 340, 341
12	Crystal River Health & Rehab	47, 343, 340, 341
13	Cypress Cove Care Center	7, 6, 5, 4
14	Tender Loving Hospitality	9, 47, 343, 340, 341
15	Crystal Gem Manor Assisted Living	14, 58, 13, 345, 12, 11, 10, 89, 9, 47, 343, 340, 341
16	Transit-dependent bus route servicing Zone 1	18, 63, 17, 16, 15, 14, 58, 13, 345, 12, 11, 10, 89, 9, 47, 343, 340, 341
17	Transit-dependent bus route servicing Zone 2	95, 60, 99, 100, 101, 102, 62, 103, 41, 40, 10, 89, 9, 47, 343, 340, 341
18	Transit-dependent bus route servicing Zone 3	19, 20, 259, 21, 22, 23, 24
19	Seven Rivers Regional Medical Center	14, 58, 13, 345, 12, 11, 10, 89, 9, 8, 346, 7, 6, 5

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

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to R.S. (mi.)	Travel Time from EPZ Bdry to R.S. (min)	ETE to R.S. (hr:min)
CITRUS COUNTY SCHOOLS									
Academy of Environmental Science	90	15	9.2	52.9	11	**2:00**	15.1	21	**2:20**
Ark Angels Christian Preschool	90	15	3.8	14.9	16	**2:05**	15.8	22	**2:25**
Crystal River High School	90	15	2.4	49.0	3	**1:50**	15.1	21	**2:10**
Crystal River Middle School	90	15	3.1	14.1	14	**2:00**	11.0	15	**2:15**
Crystal River Preschool	90	15	2.5	48.6	4	**1:50**	15.8	22	**2:15**
Crystal River Primary School	90	15	9.2	53.9	11	**2:00**	15.6	21	**2:20**
Marine Science Station	90	15	9.0	52.2	11	**2:00**	15.6	21	**2:20**
LEVY COUNTY SCHOOLS									
Yankeetown School	0[1]	15	5.6	55.0	7	**0:25**	31.5	42	**1:05**
					Maximum for EPZ:	**2:05**		**Maximum:**	**2:25**
					Average for EPZ:	**1:50**		**Average:**	**2:10**

[1]According to Levy County, buses are located on site and do not require any time to mobilize.

Table 8-8. School Evacuation Time Estimates – Rain

School	Driver Mobilization Time (min)	Loading Time (min)	Dist. To EPZ Bdry (mi)	Average Speed (mph)	Travel Time to EPZ Bdry (min)	ETE (hr:min)	Dist. EPZ Bdry to R.S. (mi.)	Travel Time from EPZ Bdry to H.S. (min)	ETE to R.S. (hr:min)
CITRUS COUNTY SCHOOLS									
Academy of Environmental Science	100	20	9.2	47.6	12	**2:15**	15.1	23	**2:35**
Ark Angels Christian Preschool	100	20	3.8	13.0	18	**2:20**	15.8	24	**2:45**
Crystal River High School	100	20	2.4	44.2	4	**2:05**	15.1	23	**2:30**
Crystal River Middle School	100	20	3.1	12.6	15	**2:15**	11.0	17	**2:35**
Crystal River Preschool	100	20	2.5	43.9	4	**2:05**	15.8	24	**2:30**
Crystal River Primary School	100	20	9.2	48.8	12	**2:15**	15.6	24	**2:40**
Marine Science Station	100	20	9.0	46.0	12	**2:15**	15.6	24	**2:40**
LEVY COUNTY SCHOOLS									
Yankeetown School	0[1]	20	5.6	50.0	7	**0:30**	31.5	48	**1:15**
					Maximum for EPZ:	**2:20**		**Maximum:**	**2:45**
					Average for EPZ:	**2:00**		**Average:**	**2:30**

[1]According to Levy County, buses are located on site and do not require any time to mobilize.

Table 8-9. Summary of Transit-Dependent Bus Routes

Route	No. of Buses	Route Description	Length (mi.)
1	1	Picks up transit-dependents in Zone 1 along US-19/98	12.7
2	11	Picks up transit-dependents in Zone 2 along CR-488, CR-495, and SR-44	14.7
3	2	Picks up transit-dependents in Zone 3 along US-19/98	4.8
Total:	**14**		

Table 8-10. Transit-Dependent Evacuation Time Estimates - Good Weather

Route Number	Bus Number	One-Wave: Mobilization (min)	Route Length (miles)	Route Speed (mph)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)	Distance to E.S. (miles)	Two-Wave: Travel Time to E.S. (min)	Unload (min)	Driver Rest (min)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)
1	1	135	12.7	46.9	16	30	**3:05**	14.2	19	5	10	34	30	**4:45**
2	1, 2	120	14.7	48.8	18	30	**2:50**	14.2	19	5	10	35	30	**4:30**
	3, 4	125	14.7	53.0	17	30	**2:55**	14.2	19	5	10	35	30	**4:35**
	5, 6	130	14.7	54.8	16	30	**3:00**	14.2	19	5	10	35	30	**4:40**
	7, 8	135	14.7	55.0	16	30	**3:05**	14.2	19	5	10	35	30	**4:45**
	9, 10	140	14.7	54.5	16	30	**3:10**	14.2	19	5	10	35	30	**4:50**
	11	145	14.7	54.4	16	30	**3:15**	14.2	19	5	10	35	30	**4:55**
3	1, 2	135	4.8	55.0	5	30	**2:55**	32.5	43	5	10	49	30	**5:15**
						Maximum ETE:	**3:15**						**Maximum ETE:**	**5:15**
						Average ETE:	**3:05**						**Average ETE:**	**4:50**

Table 8-11. Transit-Dependent Evacuation Time Estimates - Rain

		One-Wave							Two-Wave					
Route Number	Bus Number	Mobilization (min)	Route Length (miles)	Route Speed (mph)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)	Distance to E.S. (miles)	Travel Time to E.S. (min)	Unload (min)	Driver Rest (min)	Route Travel Time (min)	Pickup Time (min)	ETE (hr:min)
1	1	145	12.7	35.8	21	40	**3:30**	14.2	21	5	10	39	40	**5:25**
2	1, 2	130	14.7	37.4	24	40	**3:15**	14.2	21	5	10	39	40	**5:15**
	3, 4	135	14.7	40.7	22	40	**3:20**	14.2	21	5	10	39	40	**5:20**
	5, 6	140	14.7	44.0	20	40	**3:20**	14.2	21	5	10	39	40	**5:20**
	7, 8	145	14.7	45.6	19	40	**3:25**	14.2	21	5	10	39	40	**5:25**
	9, 10	150	14.7	47.7	18	40	**3:30**	14.2	21	5	10	39	40	**5:30**
	11	155	14.7	48.8	18	40	**3:35**	14.2	21	5	10	39	40	**5:35**
3	1, 2	145	4.8	50.0	6	40	**3:15**	32.5	49	5	10	54	40	**5:55**
						Maximum ETE:	**3:35**						**Maximum ETE:**	**5:55**
						Average ETE:	**3:25**						**Average ETE:**	**5:30**

Table 8-12. Medical Facility Evacuation Time Estimates - Good Weather

Medical Facility	Patient	Mobilization (min)	Loading Rate (min per person)	People	Total Loading Time (min)	Dist. To EPZ Bdry (mi)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
Seven Rivers Regional Medical Center	Ambulatory	90	1	60	30	7.6	14	**2:15**
	Wheelchair bound	90	5	35	75	7.6	10	**2:55**
	Bedridden	90	15	15	30	7.6	14	**2:15**
Cedar Creek Assisted Living	Ambulatory	90	1	25	25	2.9	10	**2:05**
	Wheelchair bound	90	5	20	75	2.9	5	**2:50**
Crystal Gem Manor Assisted Living	Ambulatory	90	1	53	30	8.0	13	**2:15**
	Wheelchair bound	90	5	7	35	8.0	11	**2:20**
Crystal River Health & Rehab	Ambulatory	90	1	13	13	1.5	2	**1:45**
	Wheelchair bound	90	5	84	75	1.5	2	**2:50**
	Bedridden	90	15	3	30	1.5	2	**2:05**
Cypress Cove Care Center	Ambulatory	90	1	30	30	2.5	4	**2:05**
	Wheelchair bound	90	5	75	75	2.5	3	**2:50**
	Bedridden	90	15	6	30	2.5	4	**2:05**
Tender Loving Hospitality	Ambulatory	90	1	11	11	1.9	2	**1:45**
	Wheelchair bound	90	5	1	5	1.9	2	**1:40**
							Maximum ETE:	**2:55**
							Average ETE:	**2:20**

Table 8-13. Medical Facility Evacuation Time Estimates – Rain

Medical Facility	Patient	Mobilization (min)	Loading Rate (min per person)	People	Total Loading Time (min)	Dist. To EPZ Bdry (mi)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
Seven Rivers Regional Medical Center	Ambulatory	100	1	60	30	7.6	20	**2:30**
	Wheelchair bound	100	5	35	75	7.6	11	**3:10**
	Bedridden	100	15	15	30	7.6	20	**2:30**
Cedar Creek Assisted Living	Ambulatory	100	1	25	25	2.9	11	**2:20**
	Wheelchair bound	100	5	20	75	2.9	5	**3:00**
Crystal Gem Manor Assisted Living	Ambulatory	100	1	53	30	8.0	21	**2:35**
	Wheelchair bound	100	5	7	35	8.0	20	**2:35**
Crystal River Health & Rehab	Ambulatory	100	1	13	13	1.5	2	**1:55**
	Wheelchair bound	100	5	84	75	1.5	2	**3:00**
	Bedridden	100	15	3	30	1.5	2	**2:15**
Cypress Cove Care Center	Ambulatory	100	1	30	30	2.5	4	**2:15**
	Wheelchair bound	100	5	75	75	2.5	3	**3:00**
	Bedridden	100	15	6	30	2.5	4	**2:15**
Tender Loving Hospitality	Ambulatory	100	1	11	11	1.9	3	**1:55**
	Wheelchair bound	100	5	1	5	1.9	3	**1:50**
							Maximum ETE:	**3:10**
							Average ETE:	**2:30**

Table 8-14. Homebound Functional Needs Population Evacuation Time Estimates

Vehicle Type	People Requiring Vehicle	Vehicles deployed	Stops	Weather Conditions	Mobilization Time (min)	Loading Time at 1st Stop (min)	Travel to Subsequent Stops (min)	Total Loading Time at Subsequent Stops (min)	Travel Time to EPZ Boundary (min)	ETE (hr:min)
Buses	30	5	6	Normal	90	5	45	25	8	**2:55**
				Rain	100		50		9	**3:10**
Wheelchair Buses	11	5	3	Normal	90	5	18	10	8	**2:15**
				Rain	100		20		9	**2:25**
Ambulances	5	3	2	Normal	90	15	10	15	8	**2:20**
				Rain	100		11		9	**2:30**
									Maximum ETE:	**3:10**
									Average ETE:	**2:35**

9 TRAFFIC MANAGEMENT STRATEGY

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

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

The functions to be performed in the field are:

1. Facilitate evacuating traffic movements that safely expedite travel out of the EPZ.
2. Discourage traffic movements that move evacuating vehicles in a direction which takes them significantly closer to the power plant, or which interferes with the efficient flow of other evacuees.

The terms "facilitate" and "discourage" are employed rather than "enforce" and "prohibit" to indicate the need for flexibility in performing the traffic control function. There are always legitimate reasons for a driver to prefer a direction other than that indicated. For example:

- A driver may be traveling home from work or from another location, to join other family members prior to evacuating.
- An evacuating driver may be travelling to pick up a relative, or other evacuees.
- The driver may be an emergency worker en route to perform an important activity.

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

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

1. The existing TCPs and ACPs identified by the offsite agencies in their existing emergency plans serve as the basis of the traffic management plan, as per NUREG/CR-7002.
2. The existing TCPs and ACPs and how they were applied in this study are discussed in Appendix G.
3. Computer analysis of the evacuation traffic flow environment (see Figures 7-3 through 7-6). As discussed in Section 7.3, congestion within the EPZ is essentially clear by 2 hours and 5 minutes after the ATE. Congestion (LOS F) is isolated to the intersection with West Power Line St and U.S 19/98 and along U.S 19/98 through the city of Crystal River. Based on the limited traffic congestion within the EPZ, no additional TCPs or ACPs are identified as a result of this study. The existing traffic management plans are adequate.

The ETE analysis treated all controlled intersections that are existing TCP locations in the offsite agency plans as being controlled by actuated signals.

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

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

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

10 EVACUATION ROUTES

Evacuation routes are comprised of two distinct components:

- Routing from a zone being evacuated to the boundary of the Evacuation Region and thence out of the EPZ.
- Routing of transit-dependent evacuees from the EPZ boundary to evacuation shelters.

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

The routing of transit-dependent evacuees from the EPZ boundary to evacuation shelters is designed to minimize the amount of travel outside the EPZ, from the points where these routes cross the EPZ boundary.

Figure 10-1 presents a map showing the evacuation shelters and relocation schools for evacuees. The major evacuation routes for the EPZ are presented in Figure 10-2.

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

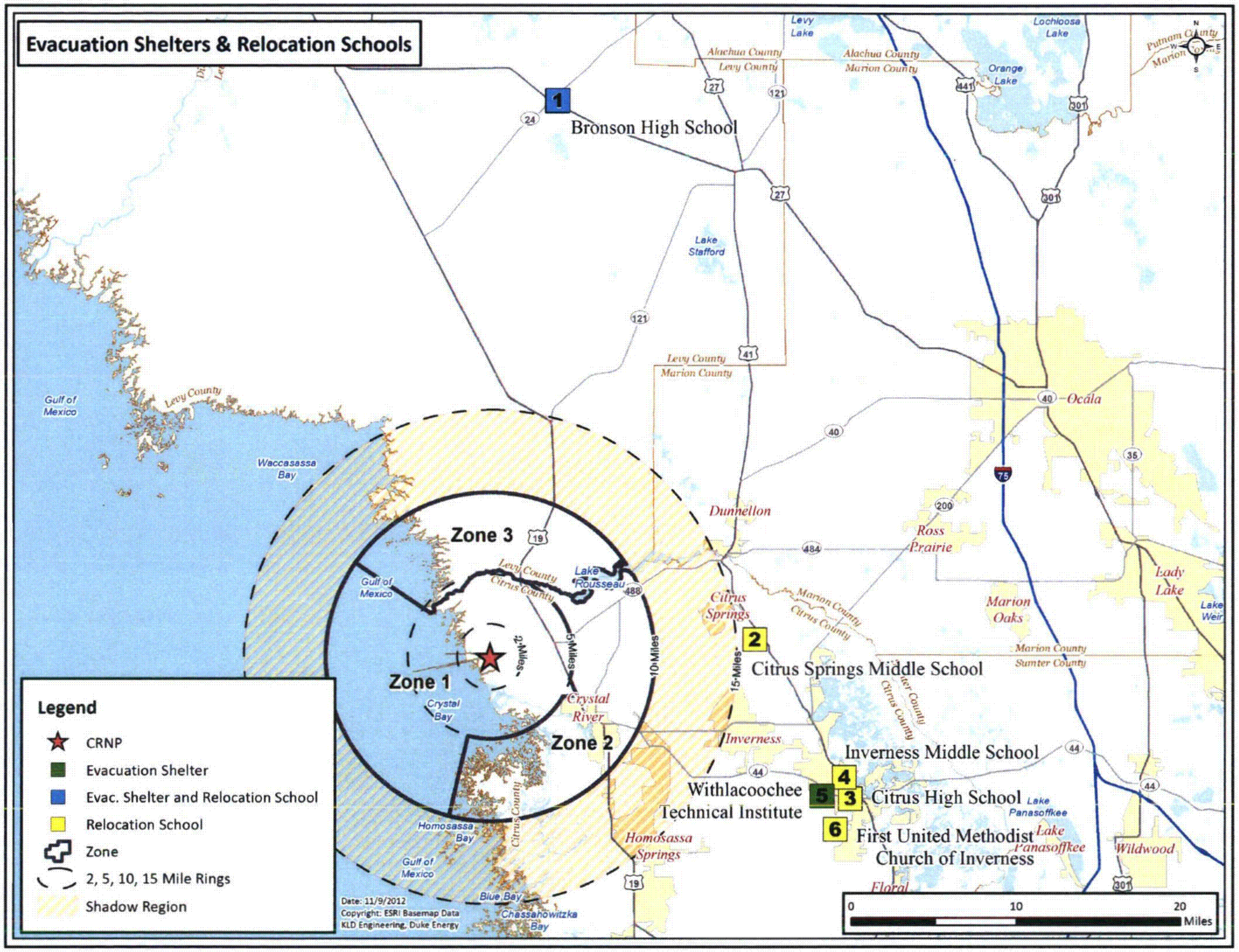


Figure 10-1. Evacuation Shelters and Relocation Schools

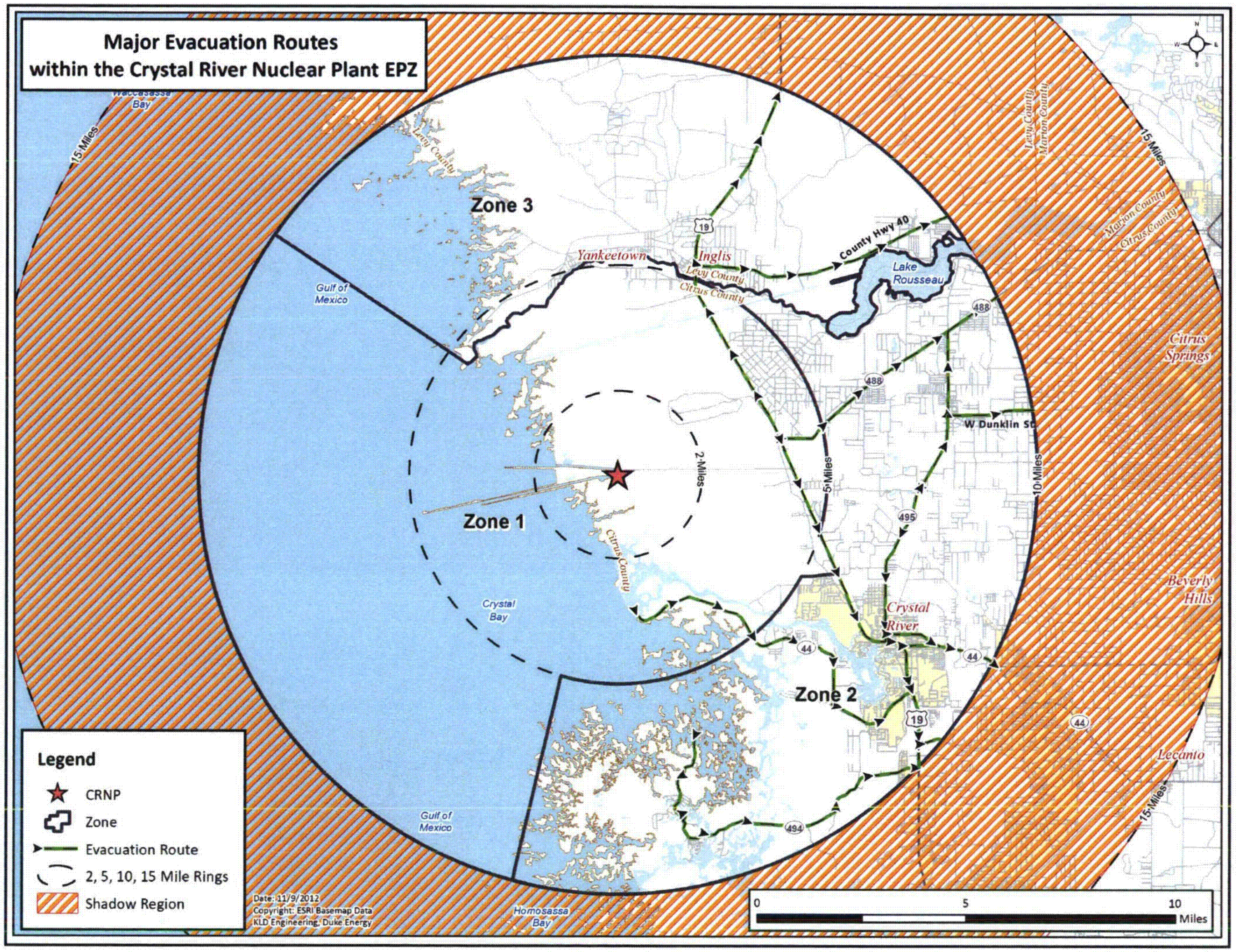


Figure 10-2. Evacuation Route Map

APPENDIX A

Glossary of Traffic Engineering Terms

A. GLOSSARY OF TRAFFIC ENGINEERING TERMS

Table A-1. Glossary of Traffic Engineering Terms

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

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

APPENDIX B

DTRAD: Dynamic Traffic Assignment and Distribution Model

B. DYNAMIC TRAFFIC ASSIGNMENT AND DISTRIBUTION MODEL

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

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

Overview of Integrated Distribution and Assignment Model

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

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

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

Interfacing the DYNEV Simulation Model with DTRAD

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

DTRAD Description

DTRAD is the DTA module for the DYNEV II System.

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

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

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

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

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

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

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

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

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

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

Network Equilibrium

In 1952, John Wardrop wrote:

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

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

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

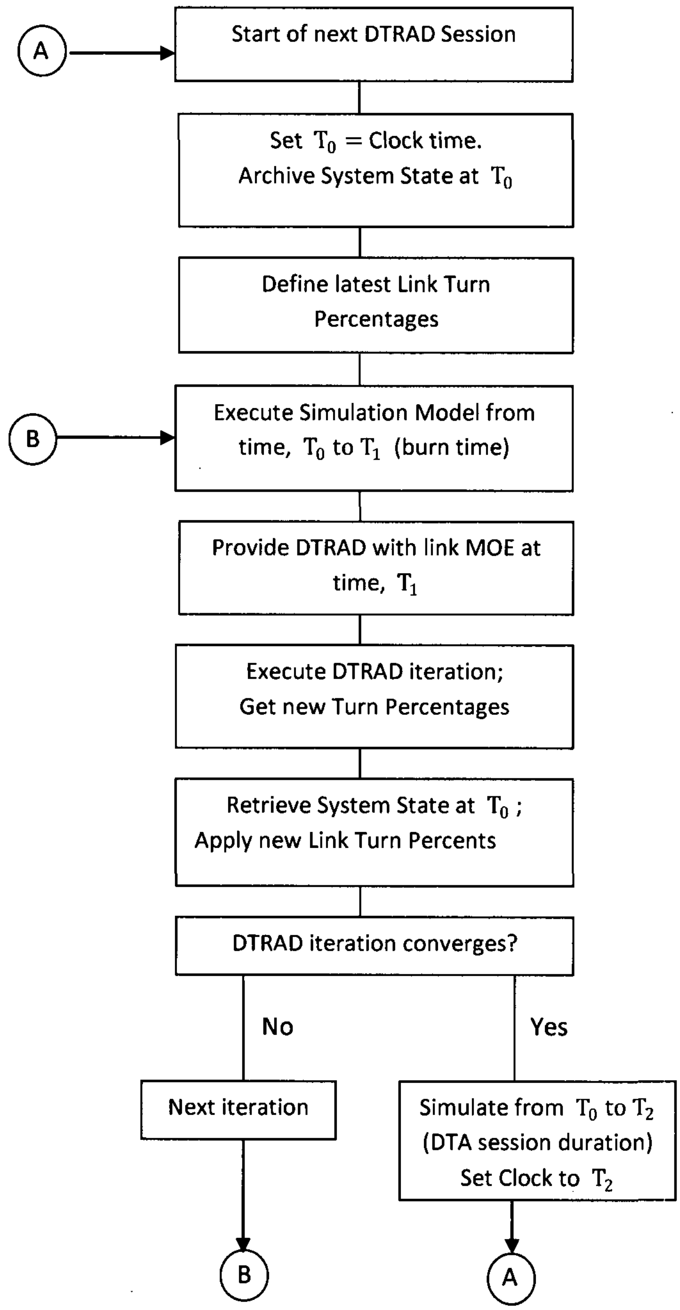


Figure B-1. Flow Diagram of Simulation-DTRAD Interface

APPENDIX C

DYNEV Traffic Simulation Model

C. DYNEV TRAFFIC SIMULATION MODEL

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

Model Features Include:

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

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

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

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

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

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

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

HIGHWAY NETWORK

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

GENERATED TRAFFIC VOLUMES

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

TRAFFIC CONTROL SPECIFICATIONS

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

DRIVER'S AND OPERATIONAL CHARACTERISTICS

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

DYNAMIC TRAFFIC ASSIGNMENT

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

INCIDENTS

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

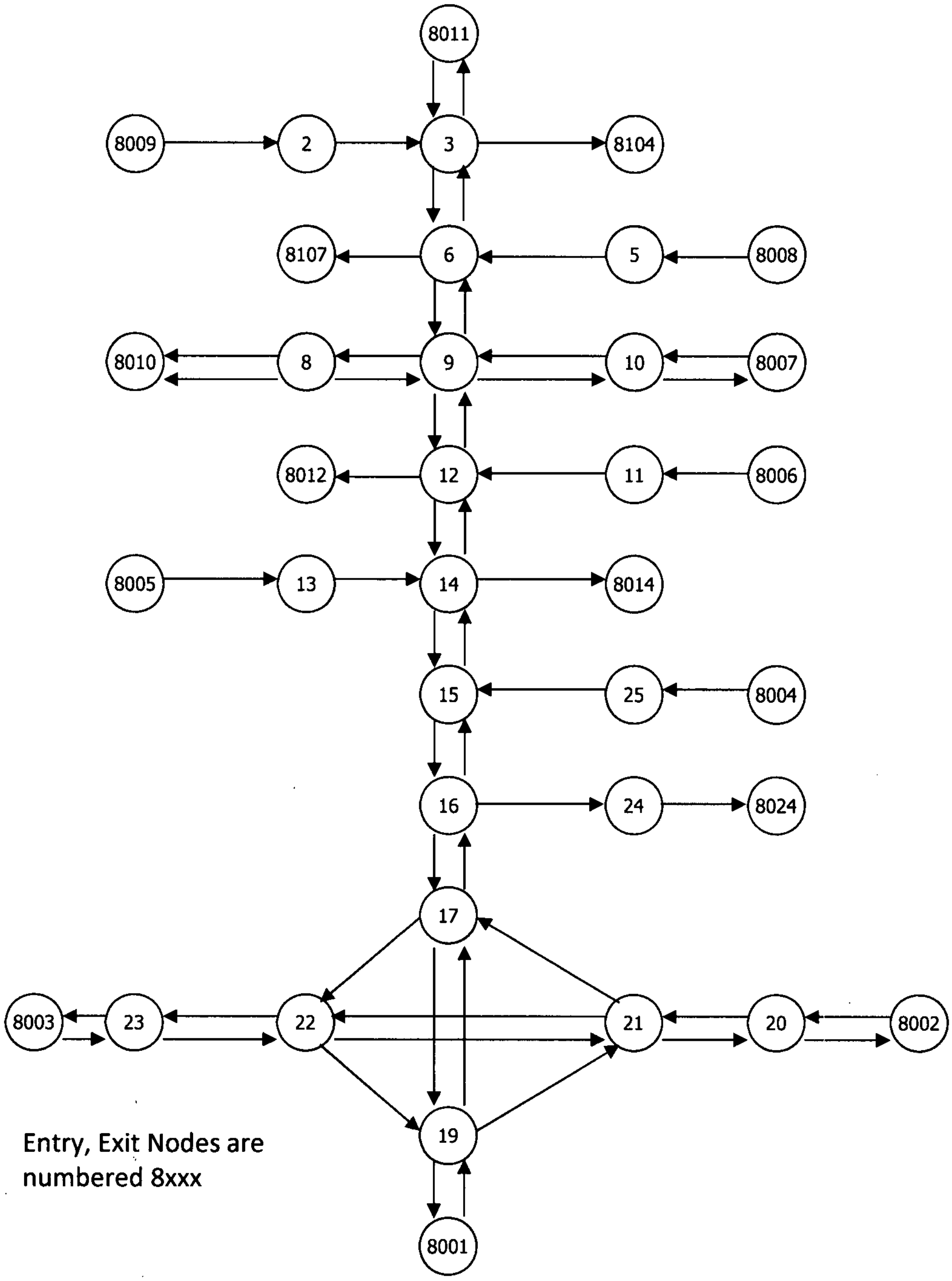


Figure C-1. Representative Analysis Network

C.1 Methodology

C.1.1 The Fundamental Diagram

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

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

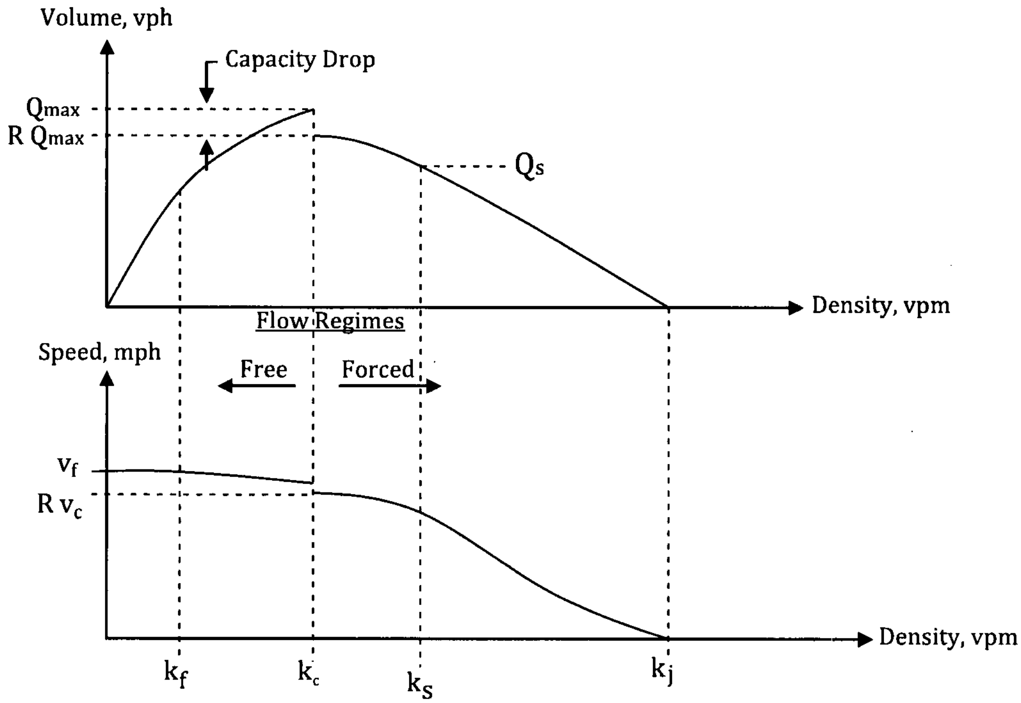


Figure C-2. Fundamental Diagrams

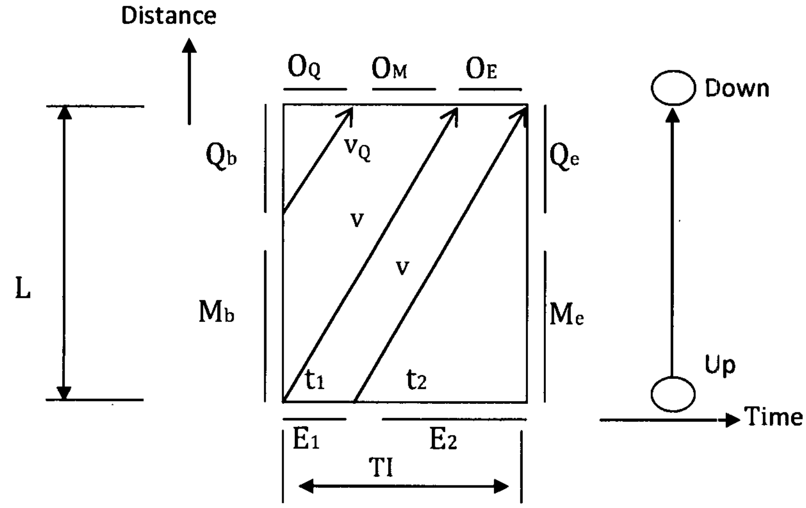


Figure C-3. A UNIT Problem Configuration with $t_1 > 0$

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 <u>moving</u> 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 <u>moving</u> vehicles on the link.
v_Q	The mean speed of the last vehicle in a queue that discharges from the link within the TI. This speed differs from the mean speed of moving vehicles, v.
W	The width of the intersection in feet. This is the difference between the link length which extends from stop-bar to stop-bar and the block length.

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

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

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

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

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

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

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

6. Else $(Q_b < Cap)$
   $O_Q = Q_b$, $RCap = Cap - O_Q$

7. If $M_b \leq RCap$, then

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

$Q'_e = E_1 - O_E$

If $Q'_e > 0$, then

Calculate Q_e, M_e with Algorithm A

Else

$Q_e = 0$, $M_e = E_2$

End if

Else $(t_1 = 0)$

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

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

End if

9. Else $(M_b > RCap)$

$O_E = 0$

If $t_1 > 0$, then

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

Calculate Q_e and M_e using Algorithm A

10. Else $(t_1 = 0)$

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

If $M_d > RCap$, *then*

$O_M = RCap$

$Q'_e = M_d - O_M$

Apply Algorithm A to calculate Q_e and M_e

Else

$O_M = M_d$

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

End if

End if

End if

End if

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

where k_b = density at the beginning of the TI

k_e = density at the end of the TI

k_m = density at the mid-point of the TI

All values of density apply only to the moving vehicles.

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

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

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

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

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

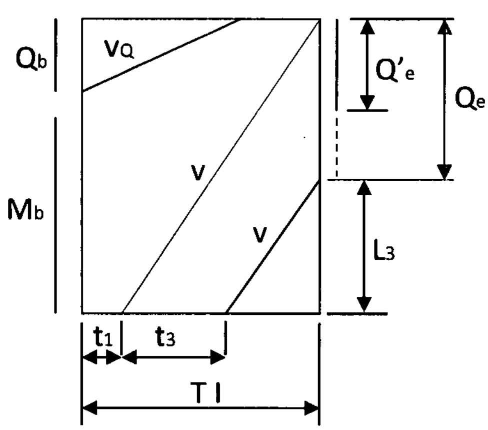
The number of excess vehicles that cause spillback is: $SB = Q_e + M_e - \frac{(L-W) \cdot LN}{L_v}$, where W is the width of the upstream intersection. To prevent spillback, meter the outflow from the feeder approaches and from the source flow, S, during this TI by the amount, SB. That is, set

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

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

Algorithm A

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



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

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

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

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

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

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

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

C.1.3 Lane Assignment

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

C.2 Implementation

C.2.1 Computational Procedure

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

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

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

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

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

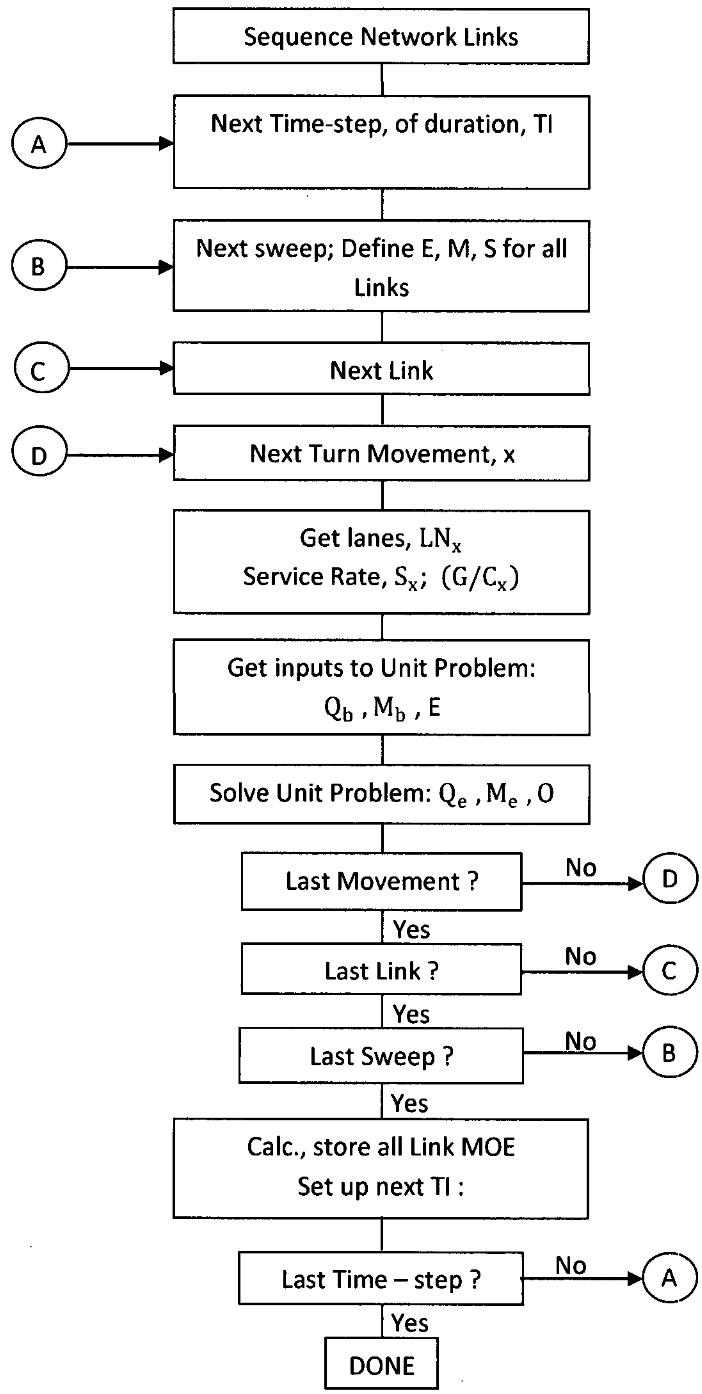


Figure C-4. Flow of Simulation Processing (See Glossary: Table C-3)

C.2.2 Interfacing with Dynamic Traffic Assignment (DTRAD)

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

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

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

Additional details are presented in Appendix B.

APPENDIX D

Detailed Description of Study Procedure

D. DETAILED DESCRIPTION OF STUDY PROCEDURE

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

Step 1

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

Step 2

2010 Census block information was obtained in GIS format. This information was used to estimate the resident population within the EPZ and Shadow Region and to define the spatial distribution and demographic characteristics of the population within the study area. Employee, Transient, School, and Medical facility data were provided by the county in which the facility resides.

Step 3

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

Step 4

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

Step 5

A telephone survey of households within the EPZ was conducted 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 3 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.

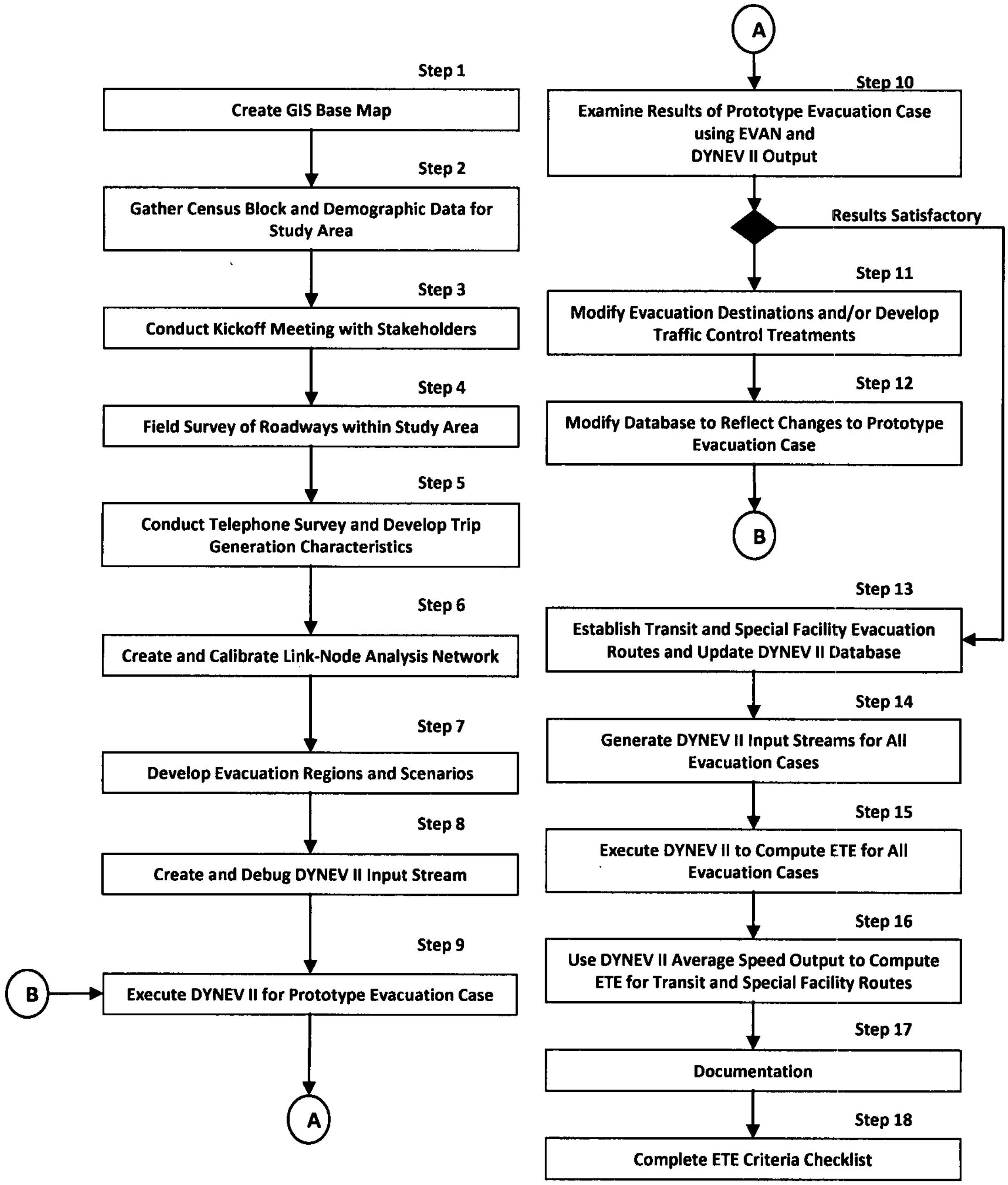


Figure D-1. Flow Diagram of Activities