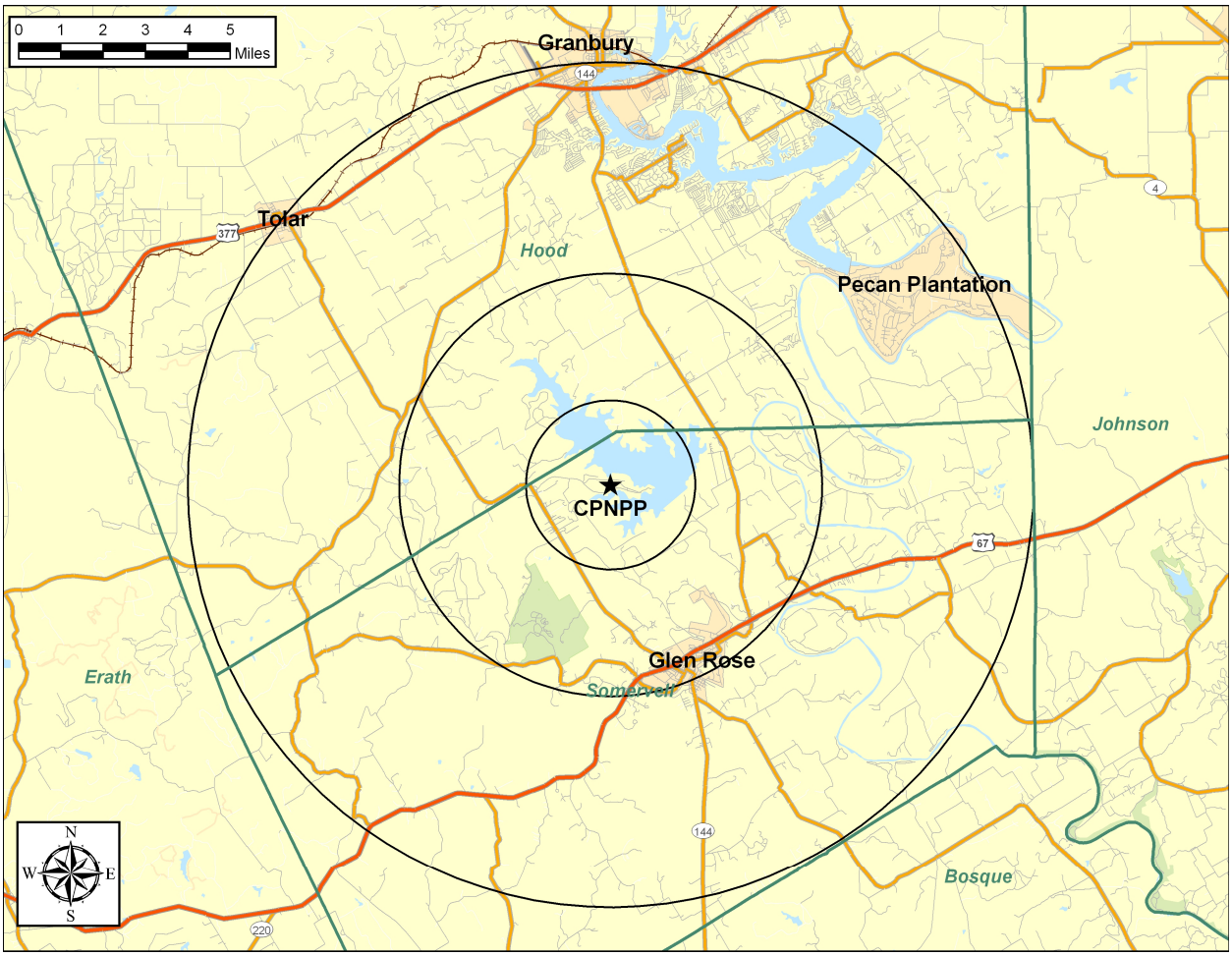
KLD ASSOCIATES, INC.

Comanche Peak Nuclear Power Plant

Development of Evacuation Time Estimates



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EXECUTIVE SUMMARY

This report describes the analyses undertaken and the results obtained by a study to develop Evacuation Time Estimates (ETE) for the Comanche Peak Nuclear Power Plant (CPNPP) located in Somervell County, Texas. ETE are part of the required planning basis and provide CPNPP and State and local governments with site-specific information needed for Protective Action decision-making.

In the performance of this effort, all available prior documentation relevant to ETE was reviewed. Other guidance is provided by documents published by Federal Government agencies. Most important of these are:

- Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants, NUREG 0654/FEMA-REP-1, Rev. 2, November 1980.
- Analysis of Techniques for Estimating Evacuation Times for Emergency Planning Zones, NUREG/CR-1745, November 1980.
- Development of Evacuation Time Estimates for Nuclear Power Plants, NUREG/CR-6863, January 2005.

Overview of Project Activities

This project began in January, 2007 and extended over a period of 15 months. The major activities performed are briefly described in chronological sequence:

- Attended “kick-off” meetings with Luminant Power and Enercon Services personnel and emergency management personnel representing state and local governments.
- Reviewed prior ETE reports prepared for CPNPP and accessed U.S. Census Bureau data files for the year 2000. Studied Geographical Information Systems (GIS) maps of the area in the vicinity of CPNPP, then conducted a field survey of the highway network.
- Synthesized this information to create an analysis network representing the highway system topology and capacities within the Plume Exposure Pathway Emergency Planning Zone (EPZ), plus a “Shadow” area extending 15 miles radially from the plant.
- Designed and sponsored a telephone survey of residents within the EPZ to gather focused data needed for this ETE study that were not contained within the Census database. The survey instrument was reviewed and modified by State and county personnel prior to the survey.
- Data collection forms (provided to the counties at the kickoff meeting) were returned with data pertaining to employment, transients, and special facilities in

each county. Phone calls were placed to recreational, medical, and day care facilities to obtain more detailed information.

- The traffic demand and trip-generation rates of evacuating vehicles were estimated from the gathered data. The trip generation rates reflect the estimated mobilization time (i.e., the time required by evacuees to prepare for the evacuation trip) computed using the results of the telephone survey of EPZ residents.
- Following Federal guidelines, the EPZ is subdivided into 31 Zones. These Zones are then grouped within circular areas or "keyhole" configurations (circles plus radial sectors) that define a total of 63 Evacuation Regions.
- The time-varying external circumstances are represented as Evacuation Scenarios, each described in terms of the following factors: (1) Season (Summer, Winter); (2) Day of Week (Midweek, Weekend); (3) Time of Day (Midday, Evening); and (4) Weather (Good, Rain). Two special Scenarios were considered, one representing a large event occurring at the Texas Amphitheatre, the other involving construction of a new unit at the CPNPP site.
- The Planning Basis for the calculation of ETE is:
  - A rapidly escalating accident at CPNPP that quickly assumes the status of General Emergency such that the Advisory to Evacuate is virtually coincident with the siren alert.
  - While an unlikely accident scenario, this planning basis will yield ETE, measured as the elapsed time from the Advisory to Evacuate until the last vehicle exits the impacted Region, that represent "upper bound" estimates. This conservative Planning Basis is applicable for all initiating events.
- If the emergency occurs while schools are in session, the ETE study assumes that the children will be evacuated by bus directly to specified host schools located outside the EPZ. Parents, relatives, and neighbors are advised to not pick up their children at school prior to the arrival of the buses dispatched for that purpose. The ETE for school children are calculated separately.
- Evacuees who do not have access to a private vehicle will either ride-share with relatives, friends or neighbors, or be evacuated by buses provided as specified in the county evacuation plans. Those in special facilities will likewise be evacuated with public transit, as needed: bus, van, or ambulance, as required. Separate ETE are calculated for the transit-dependent evacuees and for those evacuated from special facilities.

Computation of ETE

A total of 819 ETE were computed for the evacuation of the general public. Each ETE quantifies the aggregate evacuation time estimated for the population within one of the 63 Evacuation Regions to completely evacuate from that Region, under the circumstances defined for one of the 13 Evacuation Scenarios (63 x 13 = 819). Separate ETE are calculated for transit-dependent evacuees, including school children for applicable scenarios.

Except for Region R03, which is the evacuation of the entire EPZ, only a portion of the people within the EPZ would be advised to evacuate. That is, the Advisory to Evacuate applies only to those people occupying the specified impacted region. It is assumed that 100 percent of the people within the impacted region will evacuate in response to this Advisory. The people occupying the remainder of the EPZ outside the impacted region may be advised to take shelter.

The computation of ETE assumes that a portion of the population within the EPZ but outside the impacted Region will elect to "voluntarily" evacuate. In addition, a portion of the population in the "Shadow Region" beyond the EPZ that extends a distance of 15 miles from CPNPP will also elect to evacuate. These voluntary evacuees could impede those who are evacuating from within the impacted region. The impedance that could be caused by voluntary evacuees is considered in the computation of ETE for the impacted region.

The computational procedure is outlined as follows:

- A link-node representation of the highway network is coded. Each link represents a unidirectional length of highway; each node typically represents an intersection or merge point. The capacity of each link is estimated based on the field survey observations and on established procedures.
- The evacuation trips are generated at locations called "zonal centroids" located within the EPZ. The trip generation rates vary over time reflecting the mobilization process, and from one location (centroid) to another depending on population density and on whether a centroid is within, or outside, the impacted area.
- The computer models compute the routing patterns for evacuating vehicles that are compliant with federal guidelines (outbound relative to the location of CPNPP), then simulate the traffic flow movements over space and time. This simulation process estimates the rate that traffic flow exits the impacted region.
- The ETE statistics provide the elapsed times for 50 percent, 90 percent, 95 percent and 100 percent, respectively, of the population within the impacted region, to evacuate from within the impacted region. These statistics are presented in tabular and graphical formats.

Traffic Management

This study includes the development of a comprehensive traffic management plan designed to expedite the evacuation of people from within an impacted region. It is also designed to control access into the EPZ after returning commuters have rejoined their families. **The traffic management plan presented does not supercede existing plans, but provides information that may be considered in updating them**.

The plan is documented in the form of detailed schematics specifying: (1) the directions of evacuation travel to be facilitated, and other traffic movements to be discouraged; (2) the traffic control personnel and equipment needed (cones, barricades) and their deployment; (3) the locations of these "Traffic Control Points" (TCP); (4) the priority assigned to each traffic control point indicating its relative importance and how soon it should be manned relative to others; and (5) the number of traffic control personnel required.

Selected Results

A compilation of selected information is presented on the following pages in the form of Figures and Tables extracted from the body of the report; these are described below.

- Figure 3-1 displays a map of the CPNPP site showing the layout of the 31 Zones that comprise, in aggregate, the Emergency Planning Zone (EPZ).
- Table 3-1 presents the estimates of permanent resident population in each Zone as provided by Enercon Services.
- Table 6-1 defines each of the 63 Evacuation Regions in terms of their respective groups of Zones.
- Table 6-2 lists the 13 Evacuation Scenarios.
- Tables 7-1C and 7-1D are compilations of Evacuation Time Estimates (ETE). These data are the times needed to *clear the indicated regions* of 95 and 100 percent of the population occupying these regions, respectively. These computed ETE include consideration of mobilization time and of estimated voluntary evacuations from other regions within the EPZ and from the Shadow Region. **It is recommended that the ETE for the 95th Percentile of Population (Table 7-1C) be used in making Protective Action Decisions.**
- Table 8-5A presents ETE for the schoolchildren in good weather.
- Table 8-7A presents ETE for the transit-dependent population in good weather.

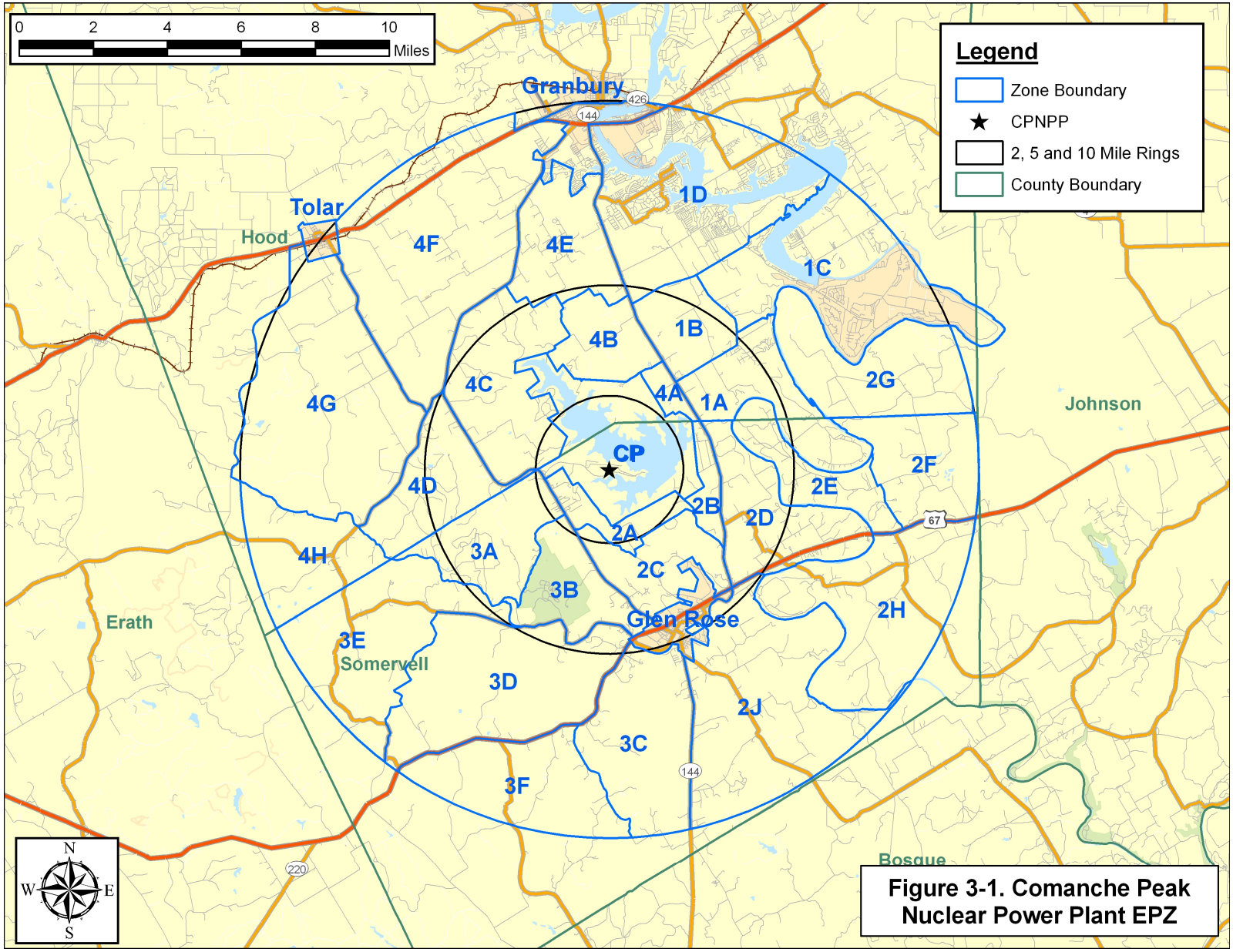


Figure 3-1. Comanche Peak Nuclear Power Plant EPZ

Table 3-1. EPZ Permanent Resident Population by Zone		
Zone	**2000 Population**	**2007 Population**
CP	22	24
1A	607	683
1B	218	245
1C	5,072	5,706
1D	10,017	11,268
2A	300	328
2B	123	134
2C	345	377
2D	575	628
2E	53	58
2F	124	136
2G	27	30
2H	343	375
2J	1,123	1,228
3A	167	182
3B	83	91
3C	303	331
3D	257	281
3E	95	104
3F	208	227
4A	36	40
4B	260	293
4C	238	268
4D	84	95
4E	515	579
4F	1,290	1,451
4G	389	438
4H	59	66
Glen Rose	2,265	2,476
Granbury	4,322	4,862
Tolar	383	431
TOTAL	**29,903**	**33,435**
Population Growth:		**11.8%**

Table 6-1. Description of Evacuation Regions (Page 1 of 2)

Region	Central Sector	Description	ZONE																													
			CP	1A	1B	1C	1D	2A	2B	2C	2D	2E	2F	2G	2H	2J	3A	3B	3C	3D	3E	3F	4A	4B	4C	4D	4E	4F	4G	4H	GLEN ROSE	GRANBURY	TOLAR
R01	-	2 mile ring																														
R02	-	5-mile ring																														
R03	-	Full EPZ																														
Evacuate 2 mile ring and 5 miles downwind (3 Sector Groups)																																
Region	Central Sector	Wind Direction Toward:	ZONE																													
			CP	1A	1B	1C	1D	2A	2B	2C	2D	2E	2F	2G	2H	2J	3A	3B	3C	3D	3E	3F	4A	4B	4C	4D	4E	4F	4G	4H	GLEN ROSE	GRANBURY	TOLAR
R04	A	N																														
R05	B	NNE																														
R06	C	NE																														
R07	D	ENE																														
R08	E	E																														
R09	F	ESE																														
R10	G	SE																														
R11	H, J	SSE, S																														
R12	K	SSW																														
R13	L	SW																														
R14	M	WSW																														
R15	N	W																														
R16	P	WNW																														
R17	Q, R	NW, NNW																														
Evacuate 2 mile ring and downwind to EPZ Boundary (3 Sector Groups)																																
Region	Central Sector	Wind Direction Toward:	ZONE																													
			CP	1A	1B	1C	1D	2A	2B	2C	2D	2E	2F	2G	2H	2J	3A	3B	3C	3D	3E	3F	4A	4B	4C	4D	4E	4F	4G	4H	GLEN ROSE	GRANBURY	TOLAR
R18	A	N																														
R19	B	NNE																														
R20	C	NE																														
R21	D	ENE																														
R22	E	E																														
R23	F	ESE																														
R24	G	SE																														
R25	H	SSE																														
R26	J	S																														
R27	K	SSW																														
R28	L	SW																														
R29	M	WSW																														
R30	N	W																														
R31	P	WNW																														
R32	Q	NW																														
R33	R	NNW																														

Table 6-1. Description of Evacuation Regions (Page 2 of 2)

Evacuate 2 mile ring and 5 miles downwind (5 Sector Groups)

Region	Central Sector	Wind Direction Toward:	ZONE																														
			CP	1A	1B	1C	1D	2A	2B	2C	2D	2E	2F	2G	2H	2J	3A	3B	3C	3D	3E	3F	4A	4B	4C	4D	4E	4F	4G	4H	GLEN ROSE	GRANBURY	TOLAR
R34	A	N	■	■	■			■															■	■	■								
R35	B	NNE	■	■	■			■	■		■	■											■	■	■								
R36	C, D	NE, ENE	■	■	■			■	■		■	■											■	■									
R37	E	E	■	■	■			■	■	■	■	■											■								■		
R38	F	ESE	■	■				■	■	■	■	■																			■		
R39	G	SE	■					■	■	■	■	■						■													■		
R40	H	SSE	■					■	■	■	■							■													■		
R41	J	S	■					■		■							■	■													■		
R42	K	SSW	■					■		■							■	■								■					■		
R43	L	SW	■					■		■							■	■							■	■					■		
R44	M, N	WSW, W	■					■									■	■						■	■	■							
R45	P	WNW	■					■									■							■	■	■							
R46	Q	NW	■					■																■	■	■							
R47	R	NNW	■		■			■															■	■	■								

Evacuate 2 mile ring and downwind to EPZ Boundary (5 Sector Groups)

Region	Central Sector	Wind Direction Toward:	ZONE																														
			CP	1A	1B	1C	1D	2A	2B	2C	2D	2E	2F	2G	2H	2J	3A	3B	3C	3D	3E	3F	4A	4B	4C	4D	4E	4F	4G	4H	GLEN ROSE	GRANBURY	TOLAR
R48	A	N	■	■	■	■	■	■						■									■	■	■		■	■				■	■
R49	B	NNE	■	■	■	■	■	■	■		■	■		■									■	■	■		■	■				■	
R50	C	NE	■	■	■	■	■	■	■		■	■	■	■									■	■			■					■	
R51	D	ENE	■	■	■	■	■	■	■		■	■	■	■	■								■	■									
R52	E	E	■	■	■	■		■	■	■	■	■	■	■	■	■							■								■		
R53	F	ESE	■	■		■		■	■	■	■	■	■	■	■	■			■												■		
R54	G	SE	■					■	■	■	■	■	■		■	■		■		■		■									■		
R55	H	SSE	■					■	■	■	■				■	■		■	■	■		■									■		
R56	J	S	■					■		■					■	■	■	■	■	■	■	■									■		
R57	K	SSW	■					■		■						■	■	■	■	■	■	■				■				■	■		
R58	L	SW	■					■		■							■	■	■	■	■	■			■	■			■	■	■		
R59	M	WSW	■					■									■	■		■	■	■			■	■		■	■	■			■
R60	N	W	■					■									■	■		■	■				■	■		■	■	■			■
R61	P	WNW	■					■									■				■			■	■	■	■	■	■	■			■
R62	Q	NW	■				■	■																■	■	■	■	■	■	■		■	■
R63	R	NNW	■		■	■	■	■															■	■	■		■	■	■			■	■

Table 6-2. Evacuation Scenario Definitions					
Scenario	**Season**	**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	Summer	Weekend	Midday	Good	Event at Amphitheatre
12	Summer	Midweek	Midday	Good	Peak Construction of New Unit (2015)
13	Summer	Weekend	Midday	Good	Fourth of July Celebration in Granbury

Note: Schools are assumed to be in session for the winter season (midweek, midday).

Table 7-1C. Time to Clear the Indicated Area of 95 Percent of The Affected Population (page 1 of 2)

	Summer		Summer		Summer		Winter		Winter		Winter		Summer	Summer	Summer
	Midweek		Weekend		Midweek Weekend		Midweek		Weekend		Midweek Weekend		Weekend	Midweek	Weekend
Scenario:	(1)	(2)	(3)	(4)	(5)	Scenario:	(6)	(7)	(8)	(9)	(10)	Scenario:	(11)	(12)	(13)
Region Wind Toward:	Midday		Midday		Evening	Region Wind Toward:	Midday		Midday		Evening	Region Wind Toward:	Midday	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather		Good Weather	Rain	Good Weather	Rain	Good Weather		Event in Amphitheatre	New Plant Construction	Granbury 4th of July
Entire 2-Mile Region, 5-Mile Region, and EPZ															
R01 2-mile ring	1:40	1:40	1:30	1:30	1:30	R01 2-mile ring	1:40	1:40	1:30	1:30	1:30	R01 2-mile ring	1:30	2:15	1:30
R02 5-mile ring	2:20	2:20	2:10	2:10	2:00	R02 5-mile ring	2:20	2:20	1:50	1:50	1:50	R02 5-mile ring	2:40	2:20	1:50
R03 Entire EPZ	2:50	2:50	2:10	2:20	2:10	R03 Entire EPZ	2:40	2:40	2:10	2:20	2:10	R03 Entire EPZ	2:30	2:40	3:10
2-Mile Ring and Downwind to 5 Miles (3 sector groups)															
R04 N	2:20	2:20	1:50	1:50	2:00	R04 N	2:20	2:20	1:50	1:50	2:00	R04 N	1:50	2:15	1:50
R05 NNE	2:20	2:20	1:50	1:50	1:50	R05 NNE	2:20	2:20	1:50	1:50	1:50	R05 NNE	1:50	2:15	1:50
R06 NE	2:10	2:10	1:50	1:50	1:50	R06 NE	2:10	2:10	1:50	1:50	1:50	R06 NE	1:45	2:15	1:50
R07 ENE	2:10	2:10	1:40	1:50	1:50	R07 ENE	2:10	2:10	1:50	1:50	1:50	R07 ENE	1:45	2:15	1:40
R08 E	2:00	2:00	1:40	1:40	1:50	R08 E	2:00	2:00	1:40	1:40	1:50	R08 E	1:45	2:15	1:40
R09 ESE	2:00	2:00	1:55	2:00	1:45	R09 ESE	2:10	2:10	1:40	1:50	1:50	R09 ESE	2:50	2:15	1:55
R10 SE	2:00	2:00	1:50	2:00	1:40	R10 SE	2:10	2:10	1:40	1:50	1:50	R10 SE	2:50	2:15	1:50
R11 SSE, S	1:50	2:00	1:45	1:50	1:40	R11 SSE, S	2:00	2:00	1:40	1:40	1:40	R11 SSE, S	2:40	2:15	1:45
R12 SSW	2:00	2:00	1:45	1:50	1:40	R12 SSW	2:00	2:00	1:40	1:40	1:40	R12 SSW	2:40	2:15	1:45
R13 SW	1:50	2:00	1:40	1:40	1:40	R13 SW	1:50	2:00	1:40	1:40	1:40	R13 SW	1:40	2:15	1:40
R14 WSW	2:10	2:10	1:40	1:40	1:50	R14 WSW	2:10	2:10	1:40	1:40	1:50	R14 WSW	1:40	2:20	1:40
R15 W	2:10	2:10	1:40	1:40	1:50	R15 W	2:10	2:10	1:40	1:40	1:50	R15 W	1:40	2:15	1:40
R16 WNW	2:10	2:10	1:40	1:40	1:50	R16 WNW	2:10	2:10	1:40	1:40	1:50	R16 WNW	1:40	2:15	1:40
R17 NW, NNW	2:10	2:10	1:40	1:40	1:50	R17 NW, NNW	2:10	2:10	1:40	1:40	1:50	R17 NW, NNW	1:40	2:15	1:40
2-Mile Ring and Downwind to EPZ Boundary (3 sector groups)															
R18 N	2:50	2:50	2:10	2:20	2:10	R18 N	2:50	2:50	2:10	2:20	2:10	R18 N	2:10	2:40	3:15
R19 NNE	2:50	2:50	2:10	2:20	2:10	R19 NNE	2:50	2:50	2:10	2:20	2:10	R19 NNE	2:10	2:40	3:10
R20 NE	2:40	2:40	2:10	2:10	2:10	R20 NE	2:40	2:40	2:10	2:10	2:10	R20 NE	2:10	2:30	2:20
R21 ENE	2:30	2:30	1:50	1:50	2:00	R21 ENE	2:30	2:30	1:50	2:00	2:00	R21 ENE	1:50	2:20	1:50
R22 E	2:30	2:30	1:50	1:50	2:00	R22 E	2:30	2:30	1:50	1:50	2:00	R22 E	1:50	2:20	1:50
R23 ESE	2:10	2:10	2:00	2:10	1:50	R23 ESE	2:10	2:10	1:50	1:55	1:50	R23 ESE	2:40	2:20	2:00
R24 SE	2:10	2:10	2:00	2:10	1:50	R24 SE	2:10	2:20	1:50	1:55	1:50	R24 SE	2:40	2:20	2:00
R25 SSE	2:10	2:10	1:55	2:05	1:50	R25 SSE	2:10	2:10	1:50	1:55	1:50	R25 SSE	2:40	2:30	1:55
R26 S	2:10	2:10	1:55	2:00	1:50	R26 S	2:10	2:10	1:50	1:50	1:50	R26 S	2:40	2:30	1:55
R27 SSW	2:00	2:05	1:50	2:00	1:50	R27 SSW	2:10	2:10	1:50	1:50	1:50	R27 SSW	2:40	2:40	1:50
R28 SW	2:00	2:00	1:40	1:45	1:40	R28 SW	2:00	2:00	1:40	1:40	1:40	R28 SW	1:40	2:25	1:40
R29 WSW	2:10	2:10	1:50	1:50	1:50	R29 WSW	2:20	2:20	1:50	1:50	1:50	R29 WSW	1:50	2:25	1:50
R30 W	2:40	2:40	2:00	2:00	2:10	R30 W	2:40	2:40	2:00	2:00	2:10	R30 W	2:00	2:25	2:10
R31 WNW	2:40	2:40	2:00	2:00	2:10	R31 WNW	2:40	2:40	2:00	2:00	2:10	R31 WNW	2:00	2:25	2:10
R32 NW	2:40	2:40	2:10	2:10	2:10	R32 NW	2:40	2:50	2:10	2:10	2:10	R32 NW	2:10	2:30	2:15
R33 NNW	2:40	2:50	2:10	2:20	2:10	R33 NNW	2:50	2:50	2:10	2:20	2:10	R33 NNW	2:10	2:40	3:20

Table 7-1C. Time to Clear the Indicated Area of 95 Percent of The Affected Population (page 2 of 2)

	Summer		Summer		Summer		Winter		Winter		Winter		Summer	Summer	Summer
	Midweek		Weekend		Midweek Weekend		Midweek		Weekend		Midweek Weekend		Weekend	Midweek	Weekend
Scenario:	(1)	(2)	(3)	(4)	(5)	Scenario:	(6)	(7)	(8)	(9)	(10)	Scenario:	(11)	(12)	(13)
Region Wind Toward:	Midday		Midday		Evening	Region Wind Toward:	Midday		Midday		Evening	Region Wind Toward:	Midday	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather		Good Weather	Rain	Good Weather	Rain	Good Weather		Event in Amphitheatre	New Plant Construction	Granbury 4th of July
2-Mile Ring and Downwind to 5 Miles (5 sector groups)															
R34 N	2:20	2:20	1:50	1:50	2:00	R34 N	2:20	2:20	1:50	1:50	2:00	R34 N	1:50	2:15	1:50
R35 NNE	2:20	2:20	1:50	1:50	1:50	R35 NNE	2:20	2:20	1:50	1:50	1:50	R35 NNE	1:50	2:15	1:50
R36 NE	2:10	2:10	1:50	1:50	1:50	R36 NE	2:10	2:20	1:50	1:50	1:50	R36 NE	1:45	2:15	1:50
R37 ENE	2:10	2:10	1:40	1:50	1:50	R37 ENE	2:20	2:20	1:40	1:50	1:50	R37 ENE	2:10	2:20	1:40
R38 E	2:00	2:00	1:55	2:00	1:50	R38 E	2:10	2:10	1:40	1:50	1:50	R38 E	2:50	2:15	1:55
R39 ESE	2:00	2:00	1:50	2:00	1:45	R39 ESE	2:10	2:10	1:40	1:50	1:40	R39 ESE	2:40	2:15	1:50
R40 SE	2:00	2:00	1:50	1:55	1:40	R40 SE	2:00	2:00	1:40	1:50	1:40	R40 SE	2:50	2:15	1:50
R41 SSE, S	2:00	2:00	1:45	1:50	1:40	R41 SSE, S	2:00	2:00	1:40	1:40	1:40	R41 SSE, S	2:40	2:15	1:45
R42 SSW	2:00	2:00	1:50	1:50	1:40	R42 SSW	2:00	2:10	1:40	1:40	1:40	R42 SSW	2:40	2:20	1:50
R43 SW	2:10	2:10	1:50	1:50	1:40	R43 SW	2:10	2:10	1:40	1:40	1:50	R43 SW	2:40	2:20	1:50
R44 WSW	2:10	2:10	1:40	1:40	1:50	R44 WSW	2:10	2:10	1:40	1:40	1:50	R44 WSW	1:40	2:20	1:40
R45 W	2:20	2:20	1:50	1:50	2:00	R45 W	2:20	2:20	1:50	1:50	2:00	R45 W	1:50	2:20	1:50
R46 WNW	2:20	2:20	1:50	1:50	2:00	R46 WNW	2:20	2:20	1:50	1:50	2:00	R46 WNW	1:50	2:20	1:50
R47 NW, NNW	2:20	2:20	1:50	1:50	2:00	R47 NW, NNW	2:20	2:20	1:50	1:50	2:00	R47 NW, NNW	1:50	2:15	1:50
2-Mile Ring and Downwind to EPZ Boundary (5 sector groups)															
R48 N	2:50	2:50	2:10	2:20	2:10	R48 N	2:50	2:50	2:10	2:20	2:10	R48 N	2:10	2:40	3:20
R49 NNE	2:40	2:40	2:10	2:20	2:10	R49 NNE	2:40	2:50	2:10	2:20	2:10	R49 NNE	2:10	2:40	3:20
R50 NE	2:40	2:40	2:10	2:20	2:10	R50 NE	2:40	2:40	2:10	2:20	2:10	R50 NE	2:10	2:30	3:10
R51 ENE	2:40	2:40	2:10	2:20	2:10	R51 ENE	2:40	2:40	2:10	2:20	2:10	R51 ENE	2:10	2:30	2:30
R52 E	2:30	2:30	2:00	2:10	1:50	R52 E	2:30	2:30	1:50	1:55	1:50	R52 E	2:40	2:20	2:00
R53 ESE	2:20	2:20	2:00	2:00	1:50	R53 ESE	2:30	2:30	1:50	1:55	1:50	R53 ESE	2:40	2:20	2:00
R54 SE	2:10	2:10	2:00	2:10	1:50	R54 SE	2:20	2:20	1:50	1:55	1:50	R54 SE	2:40	2:30	2:00
R55 SSE	2:10	2:10	2:00	2:10	1:50	R55 SSE	2:20	2:20	1:50	1:55	1:50	R55 SSE	2:40	2:30	2:00
R56 S	2:00	2:10	1:55	2:05	1:50	R56 S	2:10	2:10	1:50	1:50	1:50	R56 S	2:50	2:30	1:55
R57 SSW	2:10	2:10	1:55	2:00	1:50	R57 SSW	2:20	2:20	1:50	1:50	1:50	R57 SSW	2:40	2:35	1:55
R58 SW	2:10	2:20	1:50	2:00	1:50	R58 SW	2:20	2:20	1:50	1:50	1:50	R58 SW	2:40	2:40	1:50
R59 WSW	2:30	2:30	1:50	2:00	2:00	R59 WSW	2:30	2:30	2:00	2:00	2:00	R59 WSW	1:50	2:30	2:05
R60 W	2:30	2:30	2:00	2:00	2:00	R60 W	2:30	2:30	2:00	2:00	2:00	R60 W	2:00	2:25	2:10
R61 WNW	2:40	2:40	2:00	2:10	2:10	R61 WNW	2:40	2:40	2:00	2:10	2:10	R61 WNW	2:00	2:30	2:10
R62 NW	2:50	2:50	2:10	2:20	2:10	R62 NW	2:50	2:50	2:10	2:20	2:10	R62 NW	2:10	2:40	3:20
R63 NNW	2:50	2:50	2:10	2:20	2:10	R63 NNW	2:50	2:50	2:10	2:20	2:10	R63 NNW	2:10	2:40	3:20

Table 7-1D. Time to Clear the Indicated Area of 100 Percent of The Affected Population (page 1 of 2)

	Summer		Summer		Summer		Winter		Winter		Winter		Summer	Summer	Summer
	Midweek		Weekend		Midweek Weekend		Midweek		Weekend		Midweek Weekend		Weekend	Midweek	Weekend
Scenario:	(1)	(2)	(3)	(4)	(5)	Scenario:	(6)	(7)	(8)	(9)	(10)	Scenario:	(11)	(12)	(13)
Region Wind Toward:	Midday		Midday		Evening	Region Wind Toward:	Midday		Midday		Evening	Region Wind Toward:	Midday	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather		Good Weather	Rain	Good Weather	Rain	Good Weather		Event in Amphitheatre	New Plant Construction	Granbury 4th of July
Entire 2-Mile Region, 5-Mile Region, and EPZ															
R01 2-mile ring	3:50	3:50	2:50	3:00	3:00	R01 2-mile ring	3:50	3:50	2:50	2:50	3:00	R01 2-mile ring	2:50	3:50	2:50
R02 5-mile ring	4:10	4:10	3:10	3:10	3:10	R02 5-mile ring	4:10	4:10	3:10	3:10	3:10	R02 5-mile ring	3:10	4:10	3:10
R03 Entire EPZ	4:20	4:20	4:00	4:00	4:00	R03 Entire EPZ	4:20	4:20	4:00	4:00	4:00	R03 Entire EPZ	4:00	4:20	4:00
2-Mile Ring and Downwind to 5 Miles (3 sector groups)															
R04 N	4:10	4:10	3:10	3:10	3:00	R04 N	4:00	4:10	3:10	3:10	3:10	R04 N	3:10	4:10	3:10
R05 NNE	4:00	4:10	3:00	3:00	3:10	R05 NNE	4:00	4:10	3:00	3:10	3:00	R05 NNE	3:00	4:00	3:00
R06 NE	4:00	4:00	3:00	3:00	3:10	R06 NE	4:00	4:10	3:10	3:10	3:10	R06 NE	3:00	4:00	3:00
R07 ENE	4:00	4:00	3:00	3:00	3:00	R07 ENE	4:00	4:00	3:00	3:00	3:00	R07 ENE	3:00	4:00	3:00
R08 E	4:00	4:00	3:00	3:00	3:00	R08 E	4:00	4:00	3:00	3:00	3:00	R08 E	3:00	4:00	3:00
R09 ESE	4:00	4:00	3:00	3:00	3:00	R09 ESE	4:00	4:00	3:00	3:00	3:00	R09 ESE	3:00	4:00	3:00
R10 SE	4:00	4:00	3:00	3:00	3:00	R10 SE	4:00	4:00	3:00	3:00	3:00	R10 SE	3:00	4:00	3:00
R11 SSE, S	4:00	4:00	3:00	3:00	3:00	R11 SSE, S	4:00	4:00	2:50	3:00	3:00	R11 SSE, S	3:00	4:00	3:00
R12 SSW	4:00	4:00	3:00	3:00	3:00	R12 SSW	4:00	4:00	2:50	3:00	3:00	R12 SSW	3:00	4:00	3:00
R13 SW	4:00	4:00	3:00	3:10	3:00	R13 SW	4:00	4:00	3:10	3:10	3:00	R13 SW	3:00	4:00	3:00
R14 WSW	4:10	4:10	3:10	3:10	3:10	R14 WSW	4:00	4:10	3:10	3:10	3:10	R14 WSW	3:10	4:10	3:10
R15 W	4:10	4:10	3:10	3:10	3:10	R15 W	4:00	4:10	3:10	3:10	3:10	R15 W	3:10	4:10	3:10
R16 WNW	4:10	4:10	3:10	3:10	3:10	R16 WNW	4:00	4:10	3:10	3:10	3:10	R16 WNW	3:10	4:10	3:10
R17 NW, NNW	4:10	4:10	3:10	3:10	3:10	R17 NW, NNW	4:00	4:10	3:10	3:10	3:10	R17 NW, NNW	3:10	4:10	3:10
2-Mile Ring and Downwind to EPZ Boundary (3 sector groups)															
R18 N	4:10	4:20	4:00	4:00	4:00	R18 N	4:10	4:10	4:00	4:00	4:00	R18 N	4:00	4:10	4:00
R19 NNE	4:10	4:10	4:00	4:00	3:50	R19 NNE	4:10	4:10	4:00	4:00	4:00	R19 NNE	4:00	4:10	4:00
R20 NE	4:10	4:10	3:50	4:00	3:50	R20 NE	4:10	4:10	3:50	4:00	4:00	R20 NE	3:50	4:10	3:50
R21 ENE	4:00	4:00	3:40	3:40	3:40	R21 ENE	4:00	4:00	3:40	3:40	3:40	R21 ENE	3:40	4:00	3:40
R22 E	4:00	4:00	3:40	3:40	3:40	R22 E	4:00	4:00	3:40	3:40	3:40	R22 E	3:40	4:00	3:40
R23 ESE	4:00	4:00	3:00	3:00	3:00	R23 ESE	4:00	4:00	3:00	3:10	3:00	R23 ESE	3:00	4:00	3:00
R24 SE	4:00	4:00	3:00	3:00	3:00	R24 SE	4:00	4:00	3:00	3:10	3:00	R24 SE	3:00	4:00	3:00
R25 SSE	4:00	4:00	3:00	3:10	3:00	R25 SSE	4:10	4:10	3:10	3:10	3:10	R25 SSE	3:10	4:00	3:00
R26 S	4:00	4:00	3:00	3:10	3:00	R26 S	4:00	4:00	3:00	3:00	3:10	R26 S	3:00	4:00	3:00
R27 SSW	4:00	4:00	3:10	3:10	3:00	R27 SSW	4:00	4:10	3:00	3:00	3:00	R27 SSW	3:00	4:00	3:10
R28 SW	4:00	4:10	3:10	3:10	3:10	R28 SW	4:10	4:10	3:10	3:10	3:10	R28 SW	3:10	4:00	3:10
R29 WSW	4:10	4:10	3:10	3:10	3:10	R29 WSW	4:10	4:10	3:10	3:10	3:10	R29 WSW	3:10	4:10	3:10
R30 W	4:10	4:10	3:50	3:50	4:00	R30 W	4:10	4:10	3:50	3:50	3:50	R30 W	3:50	4:10	3:50
R31 WNW	4:20	4:20	3:50	3:50	4:00	R31 WNW	4:10	4:20	3:50	4:00	4:00	R31 WNW	3:50	4:20	3:50
R32 NW	4:20	4:20	3:50	3:50	3:50	R32 NW	4:20	4:20	3:50	4:00	3:50	R32 NW	3:50	4:20	3:50
R33 NNW	4:10	4:20	4:00	4:00	4:00	R33 NNW	4:10	4:20	4:00	4:00	4:00	R33 NNW	4:00	4:20	4:00

Table 7-1D. Time to Clear the Indicated Area of 100 Percent of The Affected Population (page 2 of 2)

	Summer		Summer		Summer		Winter		Winter		Winter		Summer	Summer	Summer
	Midweek		Weekend		Midweek Weekend		Midweek		Weekend		Midweek Weekend		Weekend	Midweek	Weekend
Scenario:	(1)	(2)	(3)	(4)	(5)	Scenario:	(6)	(7)	(8)	(9)	(10)	Scenario:	(11)	(12)	(13)
Region Wind Toward:	Midday		Midday		Evening	Region Wind Toward:	Midday		Midday		Evening	Region Wind Toward:	Midday	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather		Good Weather	Rain	Good Weather	Rain	Good Weather		Event in Amphitheatre	New Plant Construction	Granbury 4th of July
2-Mile Ring and Downwind to 5 Miles (5 sector groups)															
R34 N	4:10	4:10	3:10	3:10	3:10	R34 N	4:00	4:10	3:10	3:10	3:10	R34 N	3:10	4:10	3:10
R35 NNE	4:10	4:10	3:10	3:10	3:10	R35 NNE	4:10	4:10	3:10	3:10	3:10	R35 NNE	3:10	4:10	3:10
R36 NE	4:00	4:00	3:00	3:00	3:10	R36 NE	4:00	4:10	3:10	3:00	3:10	R36 NE	3:00	4:00	3:00
R37 ENE	4:00	4:00	3:00	3:00	3:00	R37 ENE	4:00	4:00	3:00	3:00	3:00	R37 ENE	3:10	4:00	3:00
R38 E	4:00	4:00	3:00	3:00	3:00	R38 E	4:00	4:00	3:00	3:00	3:00	R38 E	3:10	4:00	3:00
R39 ESE	4:00	4:00	3:00	3:00	3:00	R39 ESE	4:00	4:00	3:00	3:00	3:00	R39 ESE	3:10	4:00	3:00
R40 SE	4:00	4:00	3:00	3:00	3:00	R40 SE	4:00	4:00	3:00	3:00	3:00	R40 SE	3:10	4:00	3:00
R41 SSE, S	4:00	4:00	3:00	3:00	3:00	R41 SSE, S	4:00	4:00	3:00	3:00	3:00	R41 SSE, S	3:10	4:00	3:00
R42 SSW	4:00	4:00	3:00	3:00	3:00	R42 SSW	4:00	4:00	3:00	3:00	3:00	R42 SSW	3:10	4:00	3:00
R43 SW	4:00	4:00	3:10	3:00	3:10	R43 SW	4:00	4:00	3:10	3:10	3:10	R43 SW	3:10	4:00	3:10
R44 WSW	4:10	4:10	3:10	3:10	3:10	R44 WSW	4:00	4:10	3:10	3:10	3:10	R44 WSW	3:10	4:10	3:10
R45 W	4:10	4:10	3:10	3:10	3:10	R45 W	4:10	4:10	3:10	3:10	3:10	R45 W	3:10	4:10	3:10
R46 WNW	4:10	4:10	3:10	3:10	3:10	R46 WNW	4:10	4:10	3:10	3:10	3:10	R46 WNW	3:10	4:10	3:10
R47 NW, NNW	4:10	4:10	3:10	3:10	3:10	R47 NW, NNW	4:10	4:10	3:10	3:10	3:10	R47 NW, NNW	3:10	4:10	3:10
2-Mile Ring and Downwind to EPZ Boundary (5 sector groups)															
R48 N	4:10	4:20	4:00	4:00	4:00	R48 N	4:20	4:20	4:00	4:00	4:00	R48 N	4:00	4:10	4:00
R49 NNE	4:10	4:20	4:00	4:00	4:00	R49 NNE	4:10	4:20	4:00	4:00	4:00	R49 NNE	4:00	4:10	4:00
R50 NE	4:10	4:10	4:00	4:00	4:00	R50 NE	4:10	4:10	3:50	4:00	4:00	R50 NE	4:00	4:10	4:00
R51 ENE	4:10	4:10	3:50	4:00	3:50	R51 ENE	4:10	4:10	3:50	4:00	4:00	R51 ENE	3:50	4:10	3:50
R52 E	4:10	4:10	3:40	3:40	3:40	R52 E	4:00	4:10	3:40	3:40	3:40	R52 E	3:40	4:10	3:40
R53 ESE	4:10	4:10	3:40	3:40	3:40	R53 ESE	4:00	4:00	3:40	3:40	3:40	R53 ESE	3:40	4:10	3:40
R54 SE	4:00	4:10	3:00	3:10	3:00	R54 SE	4:00	4:10	3:00	3:10	3:00	R54 SE	3:20	4:00	3:10
R55 SSE	4:00	4:00	3:00	3:10	3:00	R55 SSE	4:10	4:10	3:00	3:10	3:10	R55 SSE	3:20	4:00	3:00
R56 S	4:00	4:00	3:10	3:10	3:10	R56 S	4:10	4:00	3:00	3:10	3:10	R56 S	3:20	4:00	3:10
R57 SSW	4:00	4:10	3:10	3:10	3:10	R57 SSW	4:10	4:10	3:10	3:10	3:10	R57 SSW	3:20	4:00	3:10
R58 SW	4:10	4:10	3:10	3:10	3:10	R58 SW	4:10	4:10	3:10	3:10	3:10	R58 SW	3:20	4:10	3:10
R59 WSW	4:10	4:10	3:50	3:50	3:50	R59 WSW	4:10	4:10	3:50	3:50	3:50	R59 WSW	3:50	4:10	3:50
R60 W	4:20	4:20	3:50	3:50	4:00	R60 W	4:10	4:20	3:50	4:00	3:50	R60 W	3:50	4:20	3:50
R61 WNW	4:20	4:20	3:50	4:00	4:00	R61 WNW	4:20	4:20	3:50	3:50	4:00	R61 WNW	3:50	4:20	3:50
R62 NW	4:10	4:20	4:00	4:00	4:00	R62 NW	4:20	4:20	4:00	4:00	4:00	R62 NW	4:00	4:10	4:00
R63 NNW	4:20	4:20	4:00	4:00	4:00	R63 NNW	4:20	4:20	4:00	4:00	4:00	R63 NNW	4:00	4:20	4:00

Table 8-5A. School Evacuation Time Estimates - Good Weather								
School	Driver Mobilization Time(min)	Loading Time (min)	Dist. to EPZ Bndry (mi.)	Travel Time to EPZ Bndry (min)	ETE (hr:min)	Dist. EPZ Bndry to H.S. (mi.)	Travel Time EPZ Bndry to H.S. (min)	ETE to H.S. (hr:min)
Hood County Schools								
Brawner Intermediate School	60	5	1.8	4	**1:10**	0.5	1	**1:10**
Emma Roberson Elementary School	60	5	1.4	3	**1:10**	0.3	1	**1:10**
Mambrino Elementary School	60	5	5.1	9	**1:15**	6.7	11	**1:25**
Tolar Elementary School	60	5	1.2	3	**1:10**	24	36	**1:45**
Tolar Junior High School	60	5	1.2	3	**1:10**	24	36	**1:45**
Tolar High School	60	5	0.3	1	**1:10**	24	36	**1:45**
Somervell County Schools								
Brazos River Charter School	60	5	3.1	6	**1:15**	13.4	21	**1:35**
Glen Rose Elementary School	60	5	9.2	16	**1:25**	23	35	**2:00**
Glen Rose High School	60	5	8.8	15	**1:20**	23	35	**1:55**
Glen Rose Intermediate School	60	5	9.0	16	**1:25**	23	35	**2:00**
Glen Rose Junior High School	60	5	8.1	14	**1:20**	23	35	**1:55**
Happy Hills Farm	60	5	10.0	17	**1:25**	13	20	**1:45**
				Average for EPZ:	**1:20**		**Average:**	**1:40**

Note: The average speed output by the model of 35.8 mph (Scenario 6, Region 3 at 60 minutes after the Advisory to Evacuate) is used to compute travel time to the EPZ Boundary. The assumed average speed to the Host School is 40 mph.

Table 8-7A. Transit Dependent Evacuation Time Estimates - Good Weather															
		Single Wave					Second Wave								
Route Number	Bus Number	Mobilization (min.)	Route Length (mi.)	Route Travel Time (min.)	Pickup Time (min.)	ETE (hr:min)	Mobilization (min.)	Unload (min.)	Driver Rest (min.)	Return Travel time to EPZ (min.)	Travel Time EPZ to Route Start (min.)	Route Travel Time (min.)	Pickup Time (min.)	ETE (hr:min)	
1	1 - 4	90	10	17	30	2:20	100	5	10	35	0	15	30	3:15	
	5 - 7	105	10	17	30	2:35	100	5	10	35	0	15	30	3:15	
2	1 - 4	90	10	17	30	2:20	100	5	10	38	0	15	30	3:20	
	5 - 7	105	10	17	30	2:35	100	5	10	38	0	15	30	3:20	
3	1 - 3	90	18	31	30	2:35	100	5	10	20	0	27	30	3:15	
	4, 5	105	18	31	30	2:50	100	5	10	20	0	27	30	3:15	
4	1	90	8	14	30	2:15	100	5	10	27	0	12	30	3:15	
Average for EPZ:						**2:30**	**Average for EPZ:**							**3:05**	

1. INTRODUCTION

This report describes the analyses undertaken and the results obtained by a study to update the existing Evacuation Time Estimates (ETE) for the Comanche Peak Nuclear Power Plant (CPNPP), located in Somervell County, Texas. Evacuation time estimates are part of the required planning basis and provide CPNPP, State and local governments with site-specific information needed for Protective Action decision-making.

In the performance of this effort, all available prior documentation relevant to ETE was reviewed.

Other guidance is provided by documents published by Federal Government agencies. Most important of these are:

- Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants, NUREG 0654/FEMA-REP-1, Rev. 2, November 1980.
- Analysis of Techniques for Estimating Evacuation Times for Emergency Planning Zones, NUREG/CR-1745, November 1980.
- Development of Evacuation Time Estimates for Nuclear Power Plants, NUREG/CR-6863, January 2005.

We wish to express our appreciation to all the directors and staff members of the Hood County and Somervell County emergency management agencies and local and state law enforcement and planning agencies, who provided valued guidance and contributed information contained in this report.

1.1 Overview of the ETE Update Process

The following outline presents a brief description of the work effort in chronological sequence:

1. Information Gathering:
   - Defined the scope of work in discussion with representatives of Enercon Services and Luminant Power.
   - Reviewed existing reports describing past evacuation studies.

- Attended meetings with emergency planners from Somervell and Hood Counties to identify issues to be addressed.
- Conducted a detailed field survey of the EPZ highway system and of area traffic conditions.
- Obtained demographic data from Census and state agencies.
- Conducted a random sample telephone survey of EPZ residents.
- Conducted a data collection effort to identify and describe schools, special facilities, major employers, transportation providers, and other important sources of information.

2. Estimated distributions of Trip Generation times representing the time required by various population groups (permanent residents, employees, and transients) to prepare (mobilize) for the evacuation trip. These estimates are primarily based upon the random sample telephone survey.
3. Defined Evacuation Scenarios. These scenarios reflect the variation in demand, trip generation distribution and in highway capacities, associated with different seasons, day of week, time of day and weather conditions.
4. Defined a traffic management strategy. Traffic control is applied at specified Traffic Control Points (TCP) located within the Emergency Planning Zone (EPZ), and at Access Control Points (ACP) located outside the EPZ. Local and state police personnel have reviewed all traffic control plans.
5. Defined Evacuation Areas or Regions. The EPZ is partitioned into Zones which serve as a basis for the ETE analysis presented herein. Evacuation "Regions" are comprised of contiguous Zones for which ETE are calculated. The configuration of these Regions reflects the fact that the wind can take any direction and that the radial extent of the impacted area depends on accident-related circumstances. Each Region, other than those that approximate circular areas, approximates a "key-hole" configuration within the EPZ as required by NUREG/CR-6863.
6. Estimated demand for transit services for persons at "Special Facilities" and for transit-dependent persons at home.
7. Prepared the input streams for the IDYNEV system.
   - Estimated the traffic demand, based on the available information derived from Census data, from prior studies, from data provided by local and state agencies and from the telephone survey.

- Applied the procedures specified in the 2000 Highway Capacity Manual (HCM) to the data acquired during the field survey, to estimate the capacity of all highway segments comprising the evacuation routes.

- Developed the link-node representation of the evacuation network, which is used as the basis for the computer analysis that calculates the ETE.

- Calculated the evacuating traffic demands for each Region and for each Evacuation Scenario. Considered the effects on demand of "voluntary evacuation" and of the "shadow effect".

- Represented the traffic management strategy.

- Specified the candidate destinations of evacuation travel consistent with outbound movement relative to the location of the CPNPP.

- Prepared the input stream for the IDYNEV System.

- Executed the IDYNEV models to provide the estimates of evacuation routing and the ETE.

8. Generated a complete set of ETE for all specified Evacuation Regions and Scenarios.
9. Documented ETE in formats responsive to the cited NUREG reports.
10. Calculated the ETE for all transit activities including those for special facilities (schools, health-related facilities, etc.) and for the transit-dependent.

Steps 4, 7 and 8 are iterated as described in Appendix D.

1.2 The Comanche Peak Nuclear Power Plant Site Location

The Comanche Peak Nuclear Power Plant is located on a peninsula in the Squaw Creek Reservoir, approximately 50 miles southwest of Fort Worth. The Emergency Planning Zone (EPZ) consists of parts of two counties: Hood County and Somervell County. Granbury and Glen Rose are the two main communities in the area, located approximately 10 miles north, and 5 miles south-southeast, respectively, from the plant. The small town of Tolar is located about 10 miles northwest of CPNPP. The Brazos River winds from north to south through both Hood and Somervell Counties. Figure 1-1 displays the area surrounding the CPNPP, including the major roads and county boundaries.

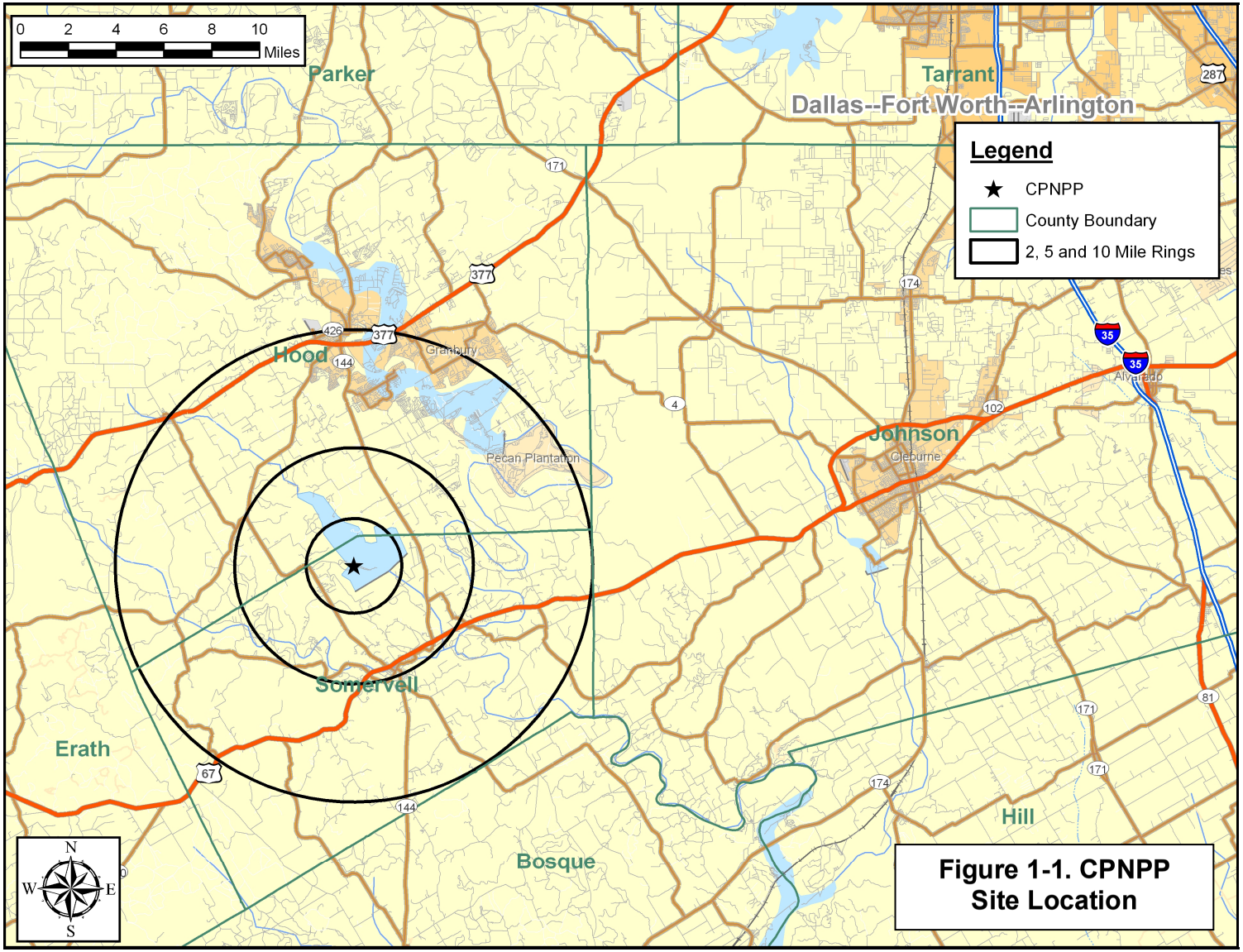


Figure 1-1. CPNPP Site Location

1.3 Preliminary Activities

Since this plan constitutes an update of an existing document, it was necessary to review the prior process and findings. These activities are described below.

Literature Review

KLD Associates was provided with copies of documents describing past studies and analyses leading to the development of emergency plans and of the ETE. We also obtained supporting documents from a variety of sources, which contained information needed to form the database used for conducting evacuation analyses.

Field Surveys of the Highway Network

KLD personnel drove the highway system within the EPZ and the Shadow Region extending 15 miles radially from the CPNPP. The characteristics of each section of highway were recorded. These characteristics include:

• Number of lanes	• Posted speed
• Pavement Width	• Actual free speed
• Shoulder type & width	• Abutting land use
• Intersection configuration	• Control devices
• Lane channelization	• Interchange geometries
• Geometrics: Curves, grades	• Street parking
• Unusual characteristics: Narrow bridges, sharp curves, poor pavement, flood warning signs, inadequate delineations, etc.	

The data were then transcribed; this information was referenced while preparing the input stream for the IDYNEV System. Key highway locations were video archived.

Telephone Survey

A telephone survey was undertaken to gather information needed for the evacuation study. Appendix F presents the survey instrument, the procedures used and tabulations of data compiled from the survey returns.

These data were utilized to develop estimates of vehicle occupancy during an evacuation and to estimate elements of the mobilization process. This database was also referenced to estimate the number of transit-dependent residents.

Developing the Evacuation Time Estimates

The overall study procedure is outlined in Appendix D. Demographic data were obtained from several sources, as detailed later in this report. These data were analyzed and converted into vehicle demand data.

Highway capacity was estimated for each highway segment based on the field surveys and on the principles specified in the 2000 Highway Capacity Manual (HCM[1]). The link-node representation of the physical highway network was developed using Geographic Information System (GIS) mapping software and the observations obtained from the field survey. Figure 1-2 presents the link-node analysis network that was constructed to model the evacuation roadway network in the EPZ and Shadow Region. The detailed figures provided in Appendix K depict the analysis network with directional arrows shown and node numbers provided. The observations made during the field survey were used to calibrate the analysis network.

Analytical Tools

The IDYNEV System that was employed for this study is comprised of several integrated computer models. One of these is the PC-DYNEV (DYnamic Network EVacuation) macroscopic simulation model that was developed by KLD under contract with the Federal Emergency Management Agency (FEMA).

IDYNEV consists of three submodels:

- A macroscopic traffic simulation model (for details, see Appendix C).
- An intersection capacity model (for details, see Highway Research Record No. 772, Transportation Research Board, 1980, papers by Lieberman and McShane & Lieberman).
- A dynamic, node-centric routing model that adjusts the "base" routing in the event of an imbalance in the levels of congestion on the outbound links.

Another model of the IDYNEV System is the TRAD (TRaffic Assignment and Distribution) model. This model integrates an equilibrium assignment model with a trip distribution algorithm to compute origin-destination volumes and paths of travel designed to minimize travel time. For details, see Appendix B.

Still another software product developed by KLD, named UNITES (UNIfied Transportation Engineering System) was used to expedite data entry.

[1] Highway Capacity Manual (HCM2000), Transportation Research Board, National Research Council, 2000.

The procedure for applying the IDYNEV System within the framework of developing an update to an ETE is outlined in Appendix D. Appendix A is a glossary of terms.

The following references provide additional detail on the IDYNEV model:

- NUREG/CR-4873 – Benchmark Study of the I-DYNEV Evacuation Time Estimate Computer Code
- NUREG/CR-4874 – The Sensitivity of Evacuation Time Estimates to Changes in Input Parameters for the I-DYNEV Computer Code

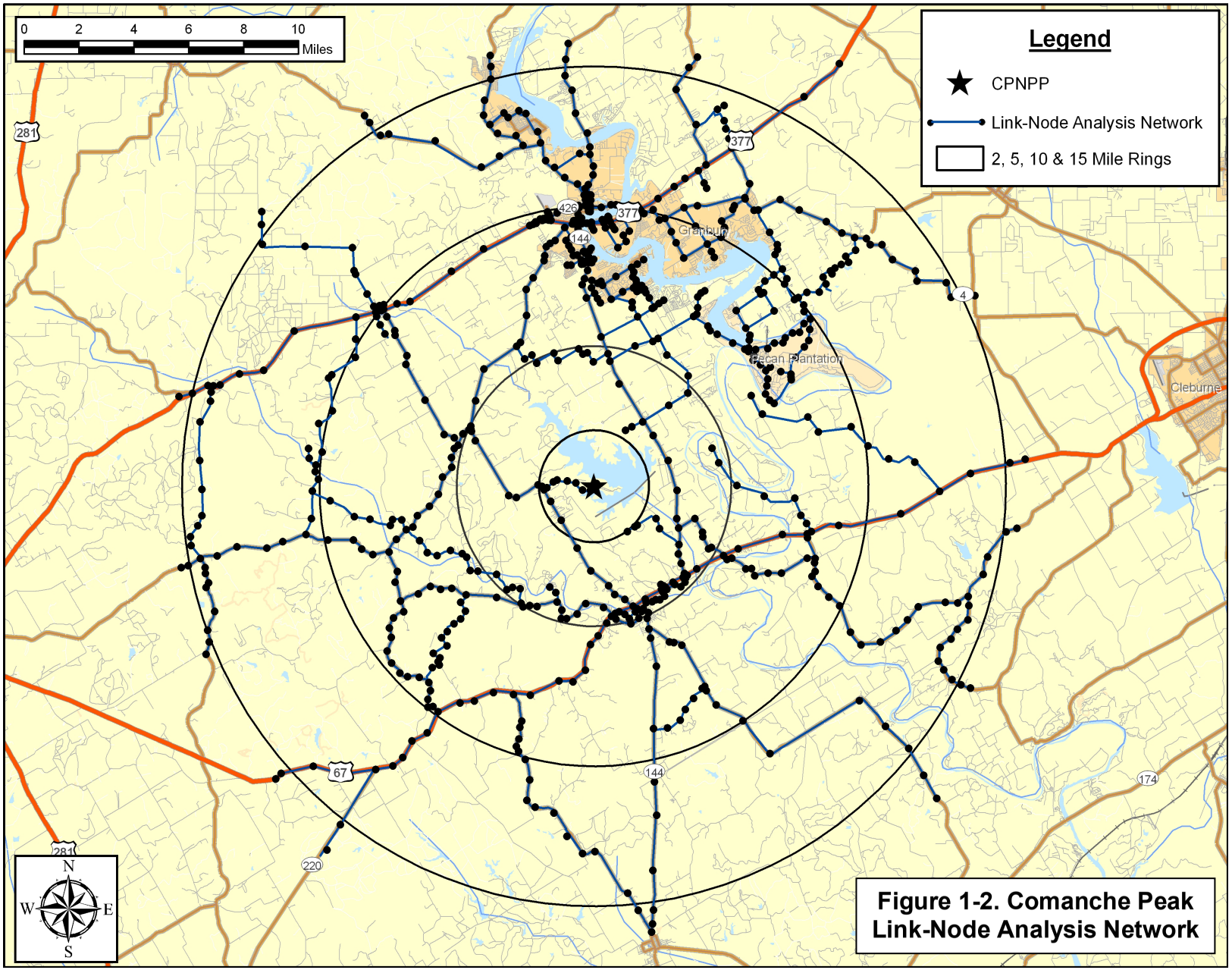


Figure 1-2. Comanche Peak Link-Node Analysis Network

The evacuation analysis procedures are based upon the need to:

- Route traffic along paths of travel that will expedite their travel from their respective points of origin to points outside the EPZ
- Restrict movement toward CPNPP to the extent practicable, and disperse traffic demand so as to avoid focusing demand on a limited number of highways
- Move traffic in directions that are generally outbound, relative to the location of CPNPP.

A set of candidate destination nodes on the periphery of the EPZ is specified for each traffic origin (or centroid) within the EPZ. The TRAD model produces output that identifies the "best" traffic routing, subject to the design conditions outlined above. In addition to this information, rough estimates of travel time are provided, together with turn-movement data required by the PC-DYNEV simulation model.

The simulation model is then executed to provide a detailed description of traffic operations on the evacuation network. This description enables the analyst to identify bottlenecks and to develop countermeasures that are designed to expedite the movement of vehicles. The outputs of this model are the volume of traffic, expressed as vehicles/hour that exit the Evacuation Region along the various highways (links) that cross the Region boundaries. These outputs are exported into a spreadsheet, which are used to generate and document the ETE. Section 7 presents a further description of this process along with the ETE Tables.

As outlined in Appendix D, this procedure consists of an iterative design-analysis-redesign sequence of activities. When properly done, this procedure converges to yield an evacuation plan which best services the evacuating public.

1.4 Comparison with Prior ETE Study

Table 1-1 presents a comparison of the present ETE study with the previous study performed in 2002. The major factors contributing to the differences between the ETE values obtained in this study and those of the previous study can be summarized as follows:

- An increase in permanent resident population.
- Vehicle occupancy and Trip-generation rates are based on the results of a telephone survey of EPZ residents.
- Voluntary and shadow evacuations are considered.
- Many more evacuation cases considered, responsive to NUREG/CR-6863.
- Traffic management plan included.

Table 1-1. ETE Study Comparisons		
Topic	**Treatment**	
	Previous ETE Study	**Current ETE Study**
Resident Population Basis	ArcInfo GIS Software using 2000 US Census blocks; area ratio method used. 2000, 10-mile = 28,258	ArcView GIS Software using 2000 US Census blocks and area ratio method. Population extrapolated to 2007 using block specific population growth rates. 2007 EPZ Population = 33,435
Resident Population Vehicle Occupancy	2.5 people/vehicle based on Census data for Hood County (2.47 persons/household) and Somervell County (2.76 persons/household).	2.21 persons/household, 1.29 evacuating vehicles/household yielding: 1.71 persons/evacuating vehicle.
Employee and Transient Population	Some employees grouped with transient population. Employee and transient estimates based on information available from Claritas data and contact with hotels and other attractions. 2.5 people/vehicle for employees and transients.	Employees treated as separate population group. Employee and transient estimates based on information provided by the counties. 1.02 employees/vehicle based on phone survey results. Transient vehicle occupancy varies.
Voluntary evacuation from within EPZ in areas outside region to be evacuated	Not considered.	50 percent of population within the circular portion of the region; 35 percent, in annular ring between the circle and the EPZ boundary (See Figure 2-1).
Shadow Evacuation	Not considered.	30% of people outside of the EPZ within the Shadow Region (See Figure 7-2).

Table 1-1. ETE Study Comparisons (continued)		
Network Size	143 links; Number of nodes not provided.	1,079 Links; 748 Nodes.
Roadway Geometric Data	Field surveys conducted in 2002 and U.S. Census TIGER data.	Field surveys conducted in 2007. Major intersections were video archived. Signal locations and roadway characteristics recorded. Road capacities based on 2000 HCM.
School Evacuation	Direct evacuation to designated Reception Center/Host School.	Direct evacuation to designated Reception Center/Host School.
Transit Dependent Population	Assumed to evacuate with neighbors or relatives.	Defined as households with 0 vehicles + households with 1 vehicle with commuters who do not return home + households with 2 vehicles with commuters who do not return home. Telephone survey results used to estimate transit dependent population.
Ridesharing	100 percent of transit dependent persons will ride out with a neighbor of friend.	50 percent of transit dependent persons will ride out with a neighbor of friend.
Trip Generation for Evacuation	Trip Generation curves adapted from chemical stockpile evacuation studies. Same distribution used for all population groups; all population is mobilized within 50 minutes.	Based on residential telephone survey of specific pre-trip mobilization activities: Residents with commuters returning leave between 15 and 240 minutes. Residents without commuters returning leave between 0 and 180 minutes. Employees and transients leave between 0 and 120 minutes. All times measured from the Advisory to Evacuate.

Table 1-1. ETE Study Comparisons (continued)		
Traffic and Access Control	Traffic Control recommended for at least 3 locations.	Traffic and Access Control used in all scenarios to facilitate the flow of traffic outbound relative to CPNPP.
Weather	Adverse. The capacity of each link in the network is reduced by 25% for adverse weather.	Normal or Rain. The capacity and free flow speed of all links in the network are reduced by 10% in the event of rain.
Modeling	Evacuation Simulation Model (ESIM) – part of Oak Ridge Evacuation Modeling System (OREMS).	IDYNEV System: TRAD and PC-DYNEV.
Special Events	None considered.	Three considered – Construction of new unit at CPNPP site, a major event at the Texas Amphitheatre and the Fourth of July Celebration in Granbury.
Evacuation Cases	7 Regions: 4 quadrants, 2, 5, and 10-mile rings. 2 Scenarios considered.	63 Regions (central sector wind direction and adjacent sector(s) technique used) and 13 Scenarios producing 819 unique cases.
Evacuation Time Estimates Reporting	ETE reported only for 90th percentile population. Results presented by Region and Scenario.	ETE reported for 50th, 90th, 95th, and 100th percentile population. Results presented by Region and Scenario.
Evacuation Time Estimates for the entire EPZ	90th percentile, Summer Weekday, Good weather = 2:29	Summer Weekday, Midday, Good weather: 100th percentile = 4:20 95th percentile = 2:50 90th percentile = 2:10 50th percentile = 1:10

2. STUDY ESTIMATES AND ASSUMPTIONS

This section presents the estimates and assumptions utilized in the development of the Evacuation Time Estimates (ETE).

2.1 Data Estimates

1. Population estimates are based upon Census 2000 data, projected to year 2007 by Enercon Services using regression analysis on County-specific projections. Estimates of employees who commute into the EPZ to work are based upon employment data obtained from county emergency management offices.
2. Population estimates at special facilities are based on available data from county emergency management offices and additional data obtained though telephone interviews with facility employees.
3. Roadway capacity estimates are based on field surveys and the application of the Highway Capacity Manual 2000[1].
4. Population mobilization times are based on a statistical analysis of data acquired from the telephone survey.
5. The relationship between resident population and evacuating vehicles is developed from the telephone survey; average values of 2.21 persons per household and 1.29 evacuating vehicles per household are used.
6. If facility-specific information concerning vehicle occupancy is not available, the following estimates are used:
   a. Parks/Recreational: 1 vehicle per family (assumed)
   b. Employees: 1.02 employees per vehicle (telephone survey results)
7. ETE are presented for the evacuation of the 100th percentile of population for each Region and for each Scenario, and for the 2-mile, 5-mile and 10-mile distances. ETE are presented in tabular format and graphically, showing the values of ETE associated with the 50th, 90th and 95th percentiles of population. An Evacuation Region is defined as a group of Zones that is issued an Advisory to Evacuate.

[1] Highway Capacity Manual (HCM2000), Transportation Research Board, National Research Council, 2000.

2.2 Study Methodological Assumptions

1. The Evacuation Time is defined as the elapsed time from the Advisory to Evacuate issued to persons within a specific Region of the EPZ, and the time that Region is clear of the indicated percentile of people.

2. The ETE are computed and presented in a format compliant with the guidance in the cited NUREG documentation. The ETE for each evacuation area ("Region" comprised of included Zones) is presented in both statistical and graphical formats.

3. Evacuation movements (paths of travel) are generally outbound relative to the power plant to the extent permitted by the highway network, as computed by the computer models. All available evacuation routes are used in the analysis.

4. Regions are defined by the underlying "keyhole" or circular configurations as specified in NUREG/CR-6863. These Regions, as defined, display irregular boundaries reflecting the geography of the Zones included within these underlying configurations.

5. Voluntary evacuation is considered as indicated in the accompanying Figure 2-1. Within the circle defined by the distance to be evacuated but outside the Evacuation Region, 50 percent of the people not advised to evacuate are assumed to evacuate within the same time-frame. In the annular area between the circle defined by the central "key-hole" of the Evacuation Region and the EPZ boundary, it is assumed that 35 percent of people will voluntarily evacuate. In the area between the EPZ boundary and a 15-mile annular area centered at the plant (the "Shadow Region"), it will be assumed that 30 percent of the people will evacuate voluntarily. Sensitivity studies explore the effect on ETE of increasing the percentage of voluntary evacuees in this area (Appendix I). The basis for our assumptions on voluntary evacuation is testimony proffered by Dennis Miletti, a professor at Colorado State University, and one of the nations top disaster response experts, at Atomic Safety and Licensing Board (ASLB) hearings, which were deemed acceptable. There are limited data pertaining to nuclear evacuations in the United States. The numbers we use for voluntary evacuation are Professor Miletti's best estimates based on his years of experience in evacuation planning and preparedness.

6. The models of the IDYNEV System were recognized as state of the art by Atomic Safety & Licensing Boards (ASLB) in past hearings. (Sources: Atomic Safety & Licensing Board Hearings on Seabrook and Shoreham; Urbanik[2]). The models have continuously been refined and extended since those hearings and have been independently validated by a consultant retained by the NRC.

7. A total of 13 "Scenarios" representing different seasons, time of day, day of week and weather are considered. Three special event scenarios are considered: the peak construction period of a new unit at the CPNPP site, a major event at the Texas Amphitheatre and the Fourth of July Celebration in Granbury. These Scenarios are tabulated below:

Scenario	Season	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	Summer	Weekend	Midday	Good	Event at Amphitheatre
12	Summer	Midweek	Midday	Good	Peak Construction of New Unit (2015)
13	Summer	Weekend	Midday	Good	Fourth of July Celebration in Granbury

[2] Urbanik, T., et. al. Benchmark Study of the I-DYNEV Evacuation Time Estimate Computer Code, NUREG/CR-4873, Nuclear Regulatory Commission, June, 1988

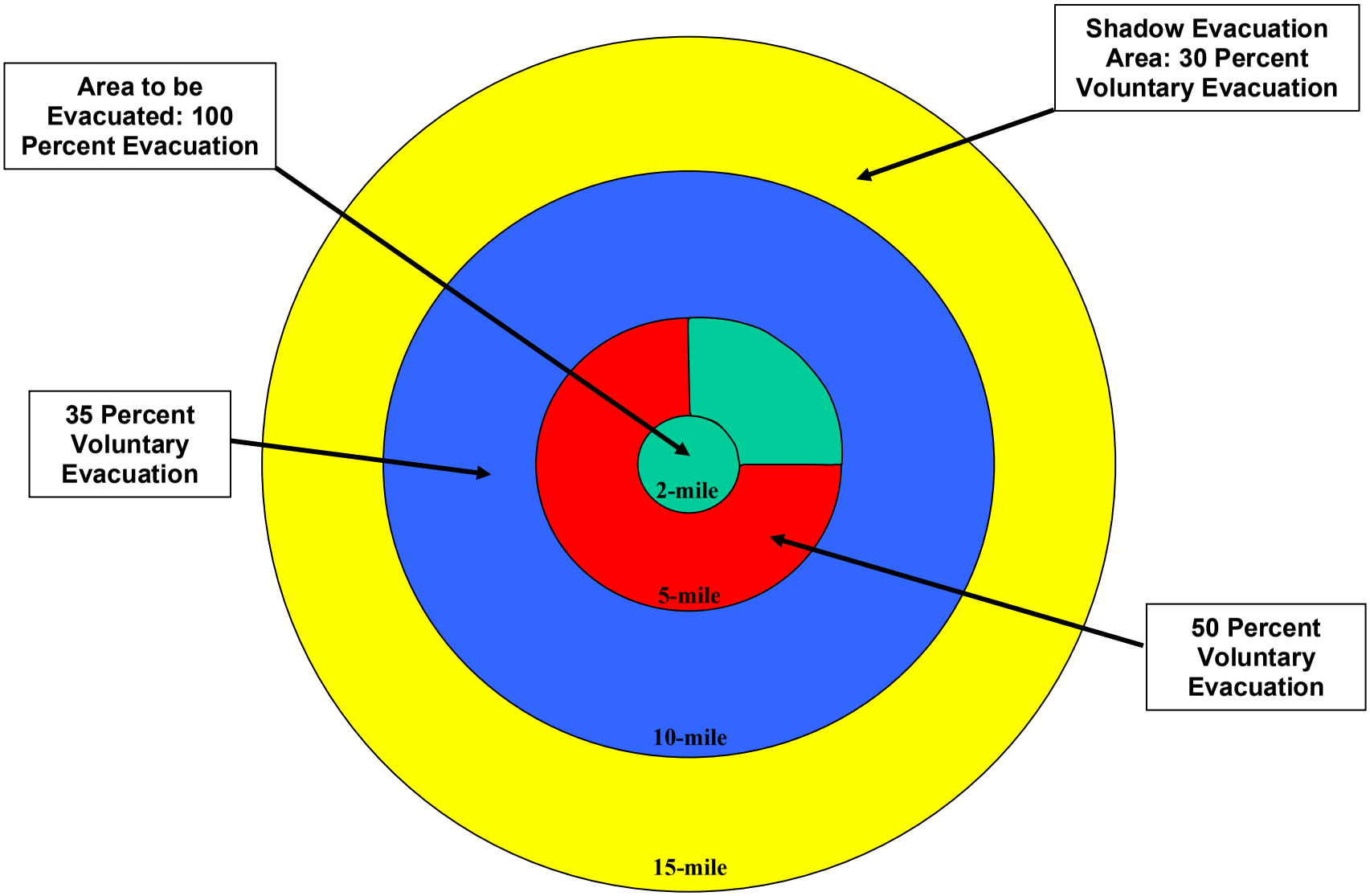


Figure 2-1. Voluntary Evacuation Methodology

2.3 Study Assumptions

1. The Planning Basis Assumption for the calculation of ETE is a rapidly escalating accident that requires evacuation, and includes the following:
   a. Advisory to Evacuate is announced coincident with the siren notification.
   b. Mobilization of the general population will commence within 10 minutes after the Advisory to Evacuate.
   c. ETE are measured relative to the Advisory to Evacuate.
2. It is assumed that everyone within the group of Zones forming a Region that is issued an Advisory to Evacuate will, in fact, respond in general accord with the planned routes.
3. It is further assumed that:
   a. Schools may be evacuated prior to notification of the general public.
   b. 40 percent of the households in the EPZ have at least 1 commuter; 45 percent of those households will await the return of a commuter before beginning their evacuation trip, based on the telephone survey results.
4. The ETE will also include consideration of "through" (External-External) trips during the time that such traffic is permitted to enter the evacuated Region. "Normal" traffic flow is assumed to be present within the EPZ at the start of the emergency.

   The effect of heavy truck traffic on traffic operations during evacuation was determined to be immaterial; therefore the presence of truck traffic is not expressly considered in calculating ETE. However, the buses used to evacuate transit dependent persons from within the EPZ are represented within the modeling process as being equivalent to two passenger car units in calculating the ETE.
5. Access Control Points (ACP) will be staffed within approximately 90 minutes of the siren notifications, to divert traffic attempting to enter the EPZ. Earlier activation of ACP locations could delay returning commuters. It is assumed that no vehicles will enter the EPZ after this 90 minute mobilization time period.
6. Traffic Control Points (TCP) within the EPZ will be staffed over time, beginning at the Advisory to Evacuate. Their number and location will depend on the Region to be evacuated and the resources available. In calculating ETE, it is assumed that drivers will act rationally, travel in the directions identified in the plan (as documented in the public information material), and obey all control devices and traffic guides. The objectives of these TCP are:

a. Facilitate the movements of all (mostly evacuating) vehicles at the location.

b. Discourage inadvertent vehicle movements towards the power station.

c. Provide assurance and guidance to all travelers. This guidance is provided by the deployment of traffic cones and by the use of hand signals by the traffic guides.

d. Act as local surveillance and communications center.

e. Provide information to the emergency operations center (EOC) as needed, based on direct observation or on information provided by travelers.

These TCP serve many useful functions, but are not considered in specifying the inputs to the DYNEV model used to calculate ETE. Consequently, the results presented in Section 7 and in Appendix J are conservative in that they do not reflect an incremental enhancement in traffic performance due to the presence of these TCP. The time needed to mobilize personnel or equipment to staff the TCP will not influence ETE results.

7. Buses will be used to transport those without access to private vehicles:

   a. If schools are in session, transport (buses) will evacuate students directly to the assigned Host Schools.

   b. Medical facilities are required to have a detailed evacuation plan and to provide adequate transportation for all residents. Buses needed to evacuate special facilities are provided through private contracting.

   c. School children, if school is in session, are given priority in assigning transit vehicles.

   d. Bus mobilization time is considered in ETE calculations.

   e. Analysis of the number of required “waves” of transit vehicles used for evacuation is presented.

8. Provisions are made for evacuating the transit-dependent portion of the general population to Reception Centers by bus, based on the assumption that some of these people will ride-share with family, neighbors, and friends, thus reducing the demand for buses. We assume that the percentage of people who rideshare is 50 percent. This assumption is based upon reported experience for other emergencies[3], which cites previous evacuation experience.

[3] Institute for Environmental Studies, University of Toronto, THE MISSISSAUGA EVACUATION FINAL REPORT, June 1981. The report indicates that 6,600 people of a transit-dependent population of 8,600 people shared rides with other residents; a ride share rate of 76% (Page 5-10).

9. One type of adverse weather scenario (rain) is considered; rain may occur for either winter or summer scenarios. It is assumed that the rain begins prior to, or at about the same time the evacuation advisory is issued. No weather-related reduction in the number of transients who may be present in the EPZ is assumed. Adverse weather scenarios affect roadway capacity, free flow highway speeds and the time required to mobilize the general population. The factors assumed for the ETE study are:

Scenario	Highway Capacity*	Free Flow Speed*	Mobilization Time
Rain[4]	90%	90%	No Effect
*Rain capacity and speed values are given as a percentage of good weather conditions. Roads are assumed to be passable.			

10. School buses used to transport students are assumed to have the capacity to transport 70 children per bus for elementary schools, and 50 children per bus for middle and high schools. Transit buses used to transport the transit-dependent general population are assumed to transport an average of 30 people per bus.

11. The goal of the ETE modeling activity is to realistically represent the traffic environment during emergency evacuation conditions. Consistent with this objective, it is assumed that all drivers will respond safely to traffic control regardless of whether that control is implemented by a traffic signal, a stop sign or by traffic control personnel at a TCP. The signal splits input into the model are adjusted to represent realistic human behavior during emergency evacuation based on traffic conditions, but are not treated optimally as though there is expert traffic control personnel controlling the signal at all times. The outcome of this approach to developing ETE estimates is to produce realistic estimates of evacuation time.

[4] Agarwal, M. et. Al. Impacts of Weather on Urban Freeway Traffic Flow Characteristics and Facility Capacity, Proceedings of the 2005 Mid-Continent Transportation Research Symposium, August, 2005.

3. DEMAND ESTIMATION

The estimates of demand, expressed in terms of people and vehicles, constitute a critical element in developing an evacuation plan. These estimates consist of three components:

1. An estimate of population within the Emergency Planning Zone (EPZ), stratified into groups (resident, employee, transient).
2. An estimate, for each population group, of mean occupancy per evacuating vehicle. This estimate is used to determine the number of evacuating vehicles.
3. An estimate of potential double-counting of vehicles.

Appendix E presents much of the source material for the population estimates. Our primary source of population data, the 2000 Census, however, is not adequate for directly estimating some transient groups.

Throughout the year, vacationers and tourists enter the EPZ. These non-residents may dwell within the EPZ for a short period (e.g. a few days or one or two weeks), or may enter and leave within one day. Estimates of the size of these population components must be obtained, so that the associated number of evacuating vehicles can be ascertained.

The potential for double-counting people and vehicles must be addressed. For example:

- A resident who works and shops within the EPZ could be counted as a resident, again as an employee and once again as a shopper.
- A visitor who stays at a hotel and spends time at a park, then goes shopping could be counted three times.

Furthermore, the number of vehicles at a location depends on time of day. For example, motel parking lots may be full at dawn and empty at noon. Similarly, parking lots at area parks, which are full at noon, may be almost empty at dawn. It is clearly wrong to estimate counts of vehicles by simply adding up the capacities of different types of parking facilities, without considering such factors.

Analysis of the population characteristics of the Comanche Peak Nuclear Power Plant (CPNPP) EPZ indicates the need to identify three distinct groups:

- Permanent residents - people who are year-round residents of the EPZ.
- Transients - people who reside outside of the EPZ, who enter the area for a specific purpose (e.g., camping) and then leave the area.
- Commuter-Employees - people who reside outside the EPZ and commute to businesses within the EPZ on a daily basis.

Estimates of the population and number of evacuating vehicles for each of the population groups are presented for each Zone and by polar coordinate representation (population rose). The CPNPP EPZ has been subdivided into 31 Zones as shown in Figure 3-1.

3.1 Permanent Residents

Permanent population data was provided by Enercon Services personnel for the years 2000 and 2007. The population for Year 2007 was estimated using regression analysis. County level population estimates were obtained from the State of Texas for the 2000-2040 timeframe, using the Cohort Component projection method. According to the US Census Bureau website, "in the cohort-component method, the components of population change (fertility, mortality, and net migration) are projected separately for each birth cohort (persons born in a given year). The base population is advanced each year by using projected survival rates and net international migration by single year of age, sex, race, and Hispanic origin. Each year, a new birth cohort is added to the population by applying the projected fertility rates by race and Hispanic origin to the female population. The components of change are individually applied to each of the race/ethnic groups to project the next year's population."

These county level population estimates were curve fitted by linear or least squares regression techniques in Microsoft Excel to compute a linear equation for each county. A regression equation ratio was then computed by dividing the linear equation by the county level Census population estimate for Year 2000. Census Block data were summed by sector (defined by direction and distance from CPNPP) for the Year 2000 using GIS software and then multiplied by the regression equation ratio to estimate the population for Year 2007.

The County population growth between 2000 and 2007, for areas within 15 miles of CPNPP, are as follows:

- Hood, 13%
- Somervell, 10%
- Erath, 12%
- Johnson, 12%
- Bosque, 8%.

The data in Table 3-1 shows that the EPZ population has increased, on average, by 11.8 percent, over the last 7 years.

The average household size (2.21 persons/household) and the number of evacuating vehicles per household (1.29 vehicles/household), adapted from the telephone survey results, were used to estimate the number of evacuating vehicles using the 2007 population.

Permanent resident population and vehicle estimates for 2007 are presented in Table 3-2. Figures 3-2 and 3-3 present the permanent resident population and permanent resident vehicle estimates by sector and distance from the CPNPP.

3.2 Construction

A "special event" scenario (Scenario 12) which represents a typical summer, mid-week, midday with construction workers on-site at the time of the emergency, was considered. The peak construction period – based on discussions with Enercon Services – would be in the year 2015, with workforce estimates of 4,300 workers. An average vehicle occupancy of 1.02 workers per vehicle (adapted from telephone survey results) was used to convert workers to vehicles – 4,202 total vehicles. The existing roadway system was used for the construction scenario; no roadway improvements were considered. Permanent resident population and shadow population were extrapolated to 2015 for this scenario.

Population growth rates by county from Year 2000 to Year 2007 are presented in Section 3.1. These values were applied to each Zone, depending on which county the zone is in. The "CP" Zone is partially in both EPZ counties; a blended growth rate of 11% was used for this Zone. The Shadow Region includes portions of 5 counties; a blended growth rate of 12% was used for this Zone. The Zone specific growth rate was then multiplied by 8/7 in order to compute a growth factor to 2015 from the 2007 population estimate. This growth factor was then applied to each source in the input stream to project evacuating vehicles to 2015.

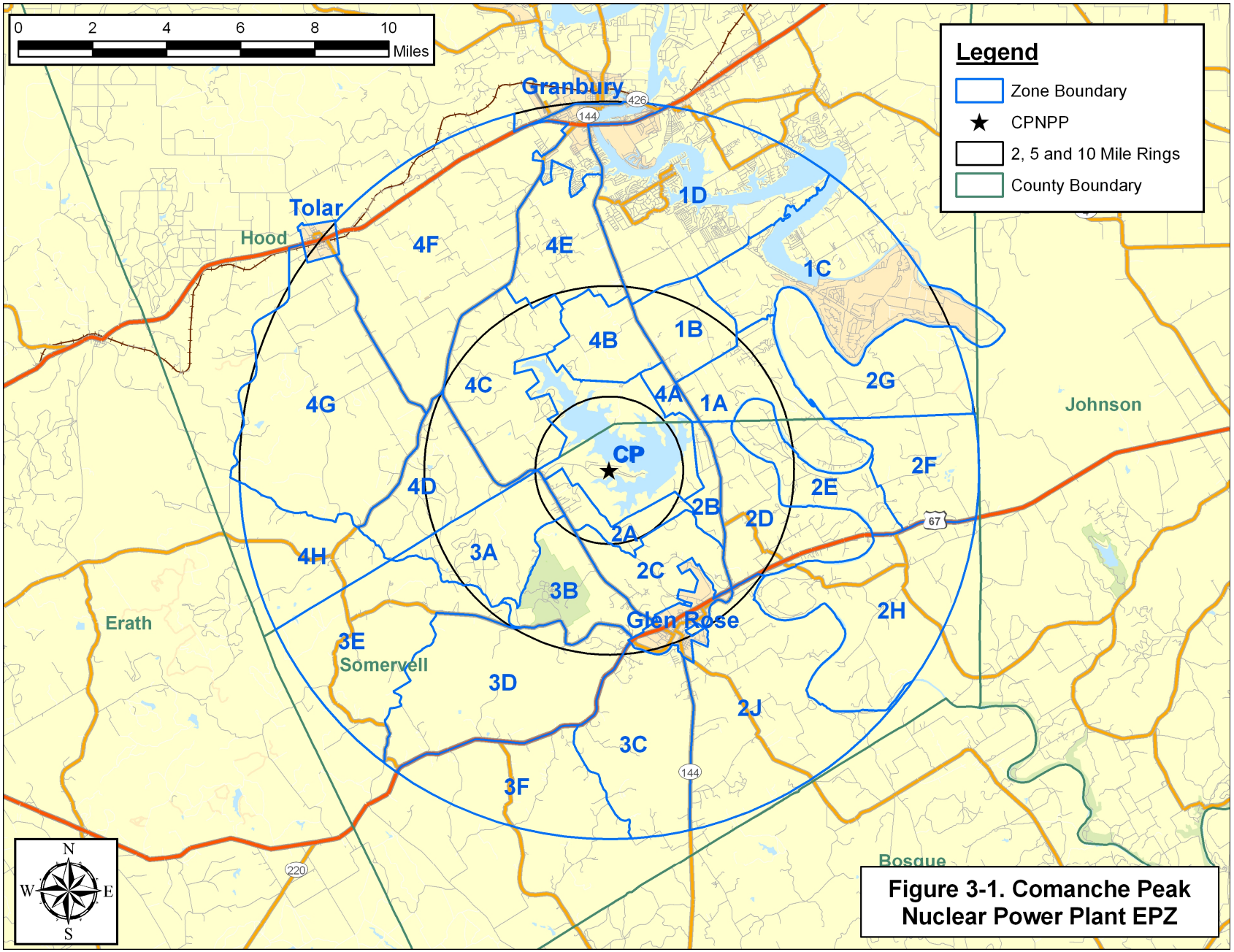
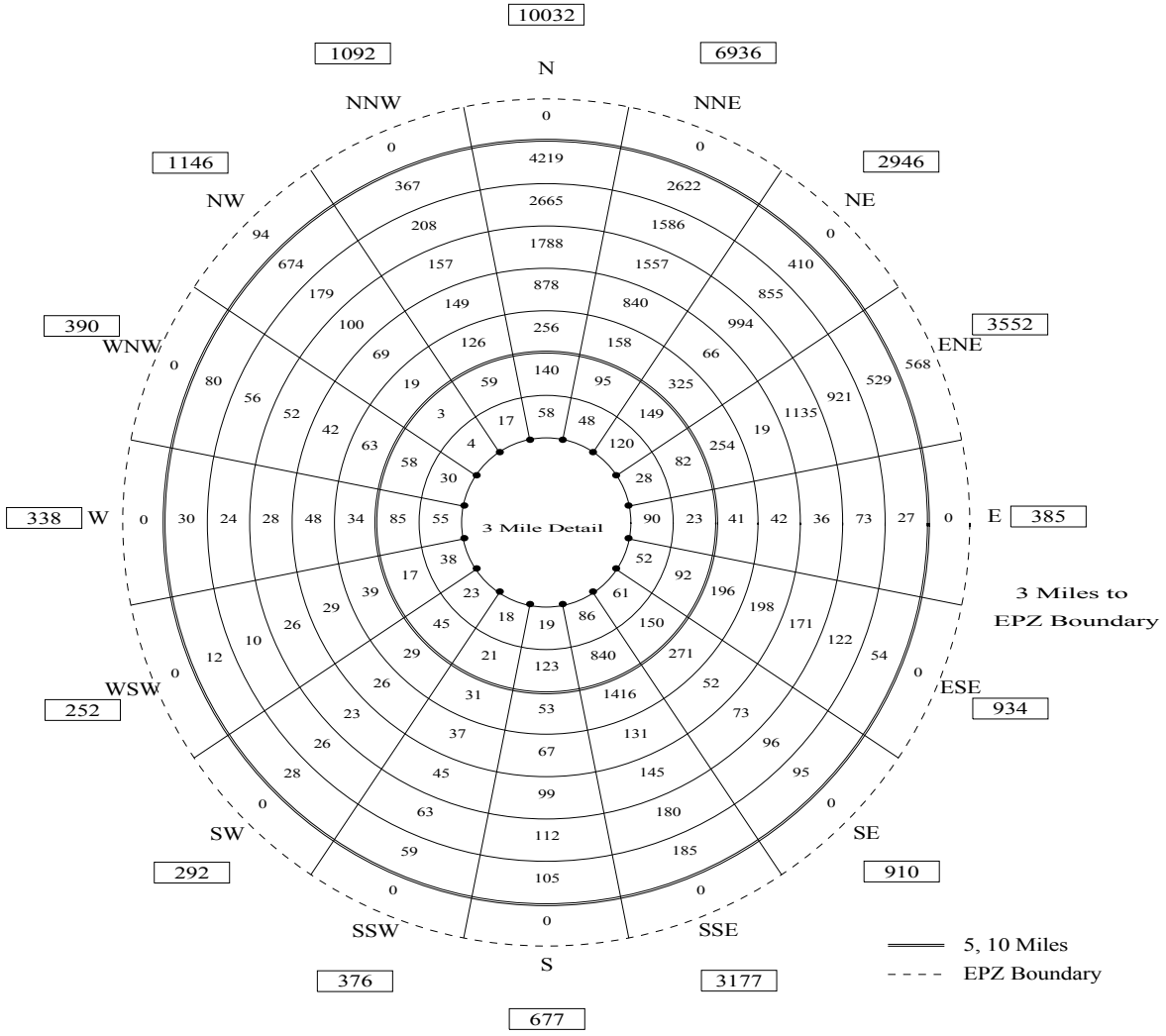


Figure 3-1. Comanche Peak Nuclear Power Plant EPZ

Table 3-1. EPZ Permanent Resident Population by Zone		
Zone	**2000 Population**	**2007 Population**
CP	22	24
1A	607	683
1B	218	245
1C	5,072	5,706
1D	10,017	11,268
2A	300	328
2B	123	134
2C	345	377
2D	575	628
2E	53	58
2F	124	136
2G	27	30
2H	343	375
2J	1,123	1,228
3A	167	182
3B	83	91
3C	303	331
3D	257	281
3E	95	104
3F	208	227
4A	36	40
4B	260	293
4C	238	268
4D	84	95
4E	515	579
4F	1,290	1,451
4G	389	438
4H	59	66
Glen Rose	2,265	2,476
Granbury	4,322	4,862
Tolar	383	431
TOTAL	**29,903**	**33,435**
Population Growth:		**11.8%**

Table 3-2. Permanent Resident Population and Vehicles by Zone		
Zone	**2007 Population**	**2007 Vehicles**
CP	24	14
1A	683	399
1B	245	143
1C	5,706	3,332
1D	11,268	6,577
2A	328	192
2B	134	79
2C	377	220
2D	628	365
2E	58	34
2F	136	80
2G	30	18
2H	375	219
2J	1,228	716
3A	182	106
3B	91	53
3C	331	193
3D	281	164
3E	104	60
3F	227	132
4A	40	23
4B	293	171
4C	268	156
4D	95	56
4E	579	338
4F	1,451	847
4G	438	256
4H	66	39
Glen Rose	2,476	1,445
Granbury	4,862	2,838
Tolar	431	252
TOTAL	**33,435**	**19,517**



Resident Population			
Miles	Ring Subtotal	Total Miles	Cumulative Total
0-1	49	0-1	49
1-2	335	0-2	384
2-3	555	0-3	939
3-4	747	0-4	1686
4-5	1982	0-5	3668
5-6	3311	0-6	6979
6-7	2693	0-7	9672
7-8	6429	0-8	16101
8-9	7176	0-9	23277
9-10	9496	0-10	32773
10-EPZ	662	0-EPZ	33435

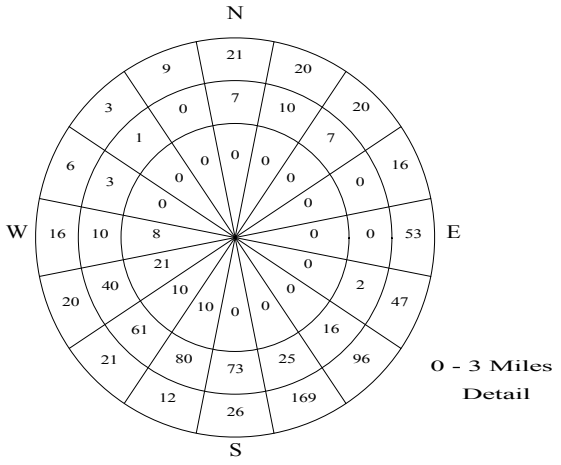
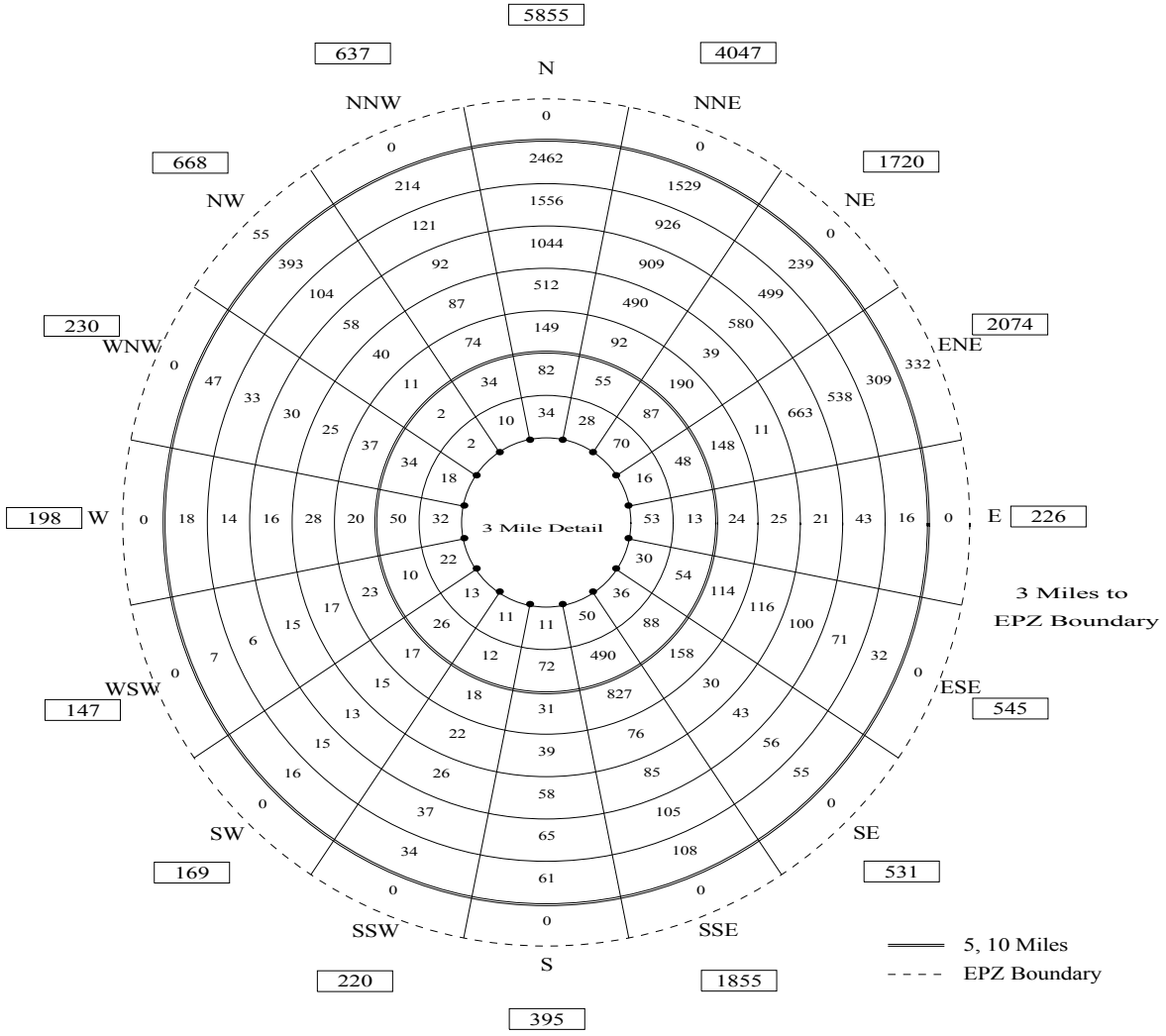


Figure 3-2. Permanent Residents by Sector



Resident Vehicles			
Miles	Ring Subtotal	Total Miles	Cumulative Total
0-1	29	0-1	29
1-2	197	0-2	226
2-3	324	0-3	550
3-4	436	0-4	986
4-5	1157	0-5	2143
5-6	1933	0-6	4076
6-7	1572	0-7	5648
7-8	3753	0-8	9401
8-9	4189	0-9	13590
9-10	5540	0-10	19130
10-EPZ	387	0-EPZ	19517

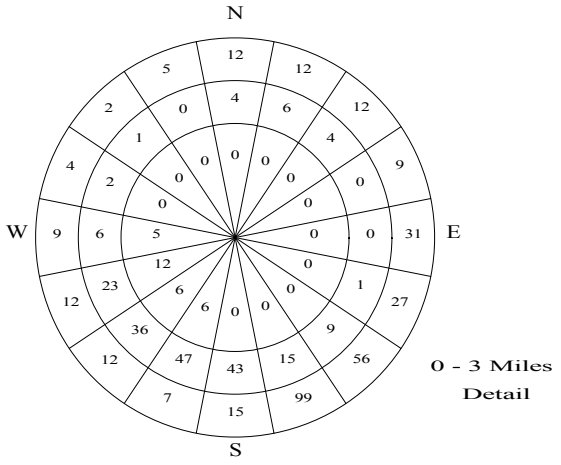


Figure 3-3. Permanent Resident Vehicles by Sector

3.3 Transient Population

Transient population groups are defined as those people who are not permanent residents and who enter the EPZ for a specific purpose (camping, recreation). Transients may spend less than one day or stay overnight or longer at rented apartments, camping facilities, hotels and motels. The Comanche Peak EPZ has several areas that attract a large number of transients, including:

- Somervell County Texas Amphitheatre and Expo Center
- Fossil Rim Wildlife Center
- Riverbend Retreat Center
- Dinosaur Valley State Park
- Dinosaur World
- Tres Rios RV Campground
- Oakdale RV Park
- Glen Lake Methodist Camp
- RV parks, campgrounds, and marinas.

Estimates of the peak attendance at transient facilities were provided by County emergency management offices. Telephone calls and Internet searches were used to obtain more detailed information. The average EPZ household size of 2.21 persons per household was applied to the transient facilities (if specific vehicle usage data were not provided) to estimate the number of transients; one evacuating vehicle per transient family was assumed. The following sections show estimates of transient population, presented by facility type. Table 3-3 summarizes transients by Zone; a detailed breakdown by facility, and a map of all the recreation areas, is provided in Appendix E.

3.3.1 Event Centers, Campsites, and Parks

Somervell County Texas Amphitheatre and Expo Center

Located in Glen Rose, the Expo Center is a multi-purpose event center which hosts a variety of events, such as horse shows, exhibits, concerts, dances, and stage shows. It has a large indoor arena, a show barn, equestrian fields, two outdoor arenas, and a pavilion (multi-purpose area in which portable stalls, cattle pens or an arena can be constructed). It has an exposition hall which may be used for banquets, wedding receptions, and meetings. The Expo Center is used year-round on weekends and weekdays. The combined capacity of the arena, show barn, and banquet hall, is 6,710 people. An average vehicle occupancy of 2.9 people per vehicle was provided, thus 2,314 vehicles were loaded onto the network.

The Texas Amphitheatre is used for special events mostly held on spring, summer, or fall evenings or weekends. It has 3,250 fixed seats but can hold up to 5,000 people with the use of bleachers and standing areas. Facility personnel provided the average number of people per vehicle (3.2); 1,563 vehicles were loaded onto the network for Scenario 11 (special event at amphitheatre) only.

Fossil Rim Wildlife Center

The Fossil Rim Wildlife Center covers 1,800 acres. Visitors can ride their own vehicles along the nine and a half mile tour roadway, or take a guided tour. There are approximately 900 visitors on a peak day. There are 5 lodge-rooms, 7 bunkhouses (for 10-14 people), and 7 cabins (for 2 people) available for overnight stays. The bunkhouses are often used for camp kids (7 minivans were assumed to transport 70 children). All together, 426 Passenger Car Equivalents (PCEs) were loaded onto the network for the Fossil Rim Wildlife Center.

Riverbend Retreat Center

The Riverbend Retreat Center is located on 89 acres adjacent to the Brazos River, southeast of Glen Rose. Visitors can participate in a multitude of sporting and outdoor activities, and/or attend events (year-round) in the indoor meeting and worship areas. Over 25,000 guests were served in camps, retreats, and special events in 2006.

Facilities include:

- An Activity Center Conference Room for up to 100 people
- A Chapel for up to 400 people
- The Riverside Room for up to 400 people
- A Worship/Meeting Center for up to 1,000 people
- 12 cabins and 3 lodges for overnight stays.

It is estimated that a total of 360 vehicles are at the facility during a peak spring or fall day. The Retreat Center hosts numerous 3rd – 12th grade children's camps from May to August; the ETE for camps is computed separately in Chapter 8, since the children are transit dependents (buses or parents drop them off).

Dinosaur Valley State Park

Dinosaur Valley State Park, located just northwest of Glen Rose in Somervell County, is a 1,525 acre, scenic park along the Paluxy River. Nearly 800 people are estimated to be in the park on a peak summer day (358 PCEs).

Dinosaur World

Dinosaur World, which opened in March 2008, is located just south of Dinosaur Valley State Park. Discussions with Dinosaur World staff indicated an average of 60-100 people a day visited during the first week of operation. The majority of visitors are family groups arriving in private vehicles. The following estimates, based on discussions with the staff, were used for the number of transients at Dinosaur World:

- Winter Weekday, 100
- Summer Weekday, 300
- Summer Weekend, 400
- Holiday Weekend, 600.

Tres Rios RV Campground

Located on the banks of the Brazos River, northeast of Glen Rose, Camp Tres Rios hosts musical events, summer camps, and once a year over 5,000 motorcyclists and Vietnam Veterans gather for the Vietnam Veteran Rally. Camp facilities include:

- 290 RV sites
- Cabins
- A swimming pool.

Like many of the local attractions, this park is used year-round; peak usage (excluding children's camps) is 650 people in the summer months, which equates to 294 PCEs assuming 2.21 people (EPZ average household size) per vehicle.

RV Parks, Campgrounds and Marinas

In addition to the campsites within the previously listed facilities, there are 7 RV parks within the EPZ. The largest of these are Pier 144 Marina & RV Park in Hood County, and Cedar Ridge Cabins and RV Park in Somervell County. Both are used year-round.

Pier 144 Marina has 100 boat slips and several RV spaces. The parking lot has an 80 car capacity, but is rarely full. On average there are approximately 120 people and 60 vehicles on site. Cedar Ridge averages 105 people in the summer and 75 in the winter.

3.3.2 Hotels and Motels

There are 13 major hotels (50 or more rooms) and many smaller motels and cottages, and cabins within the EPZ. The peak attendance at the hotels and motels is estimated as 2,176 people evacuating in 993 vehicles.

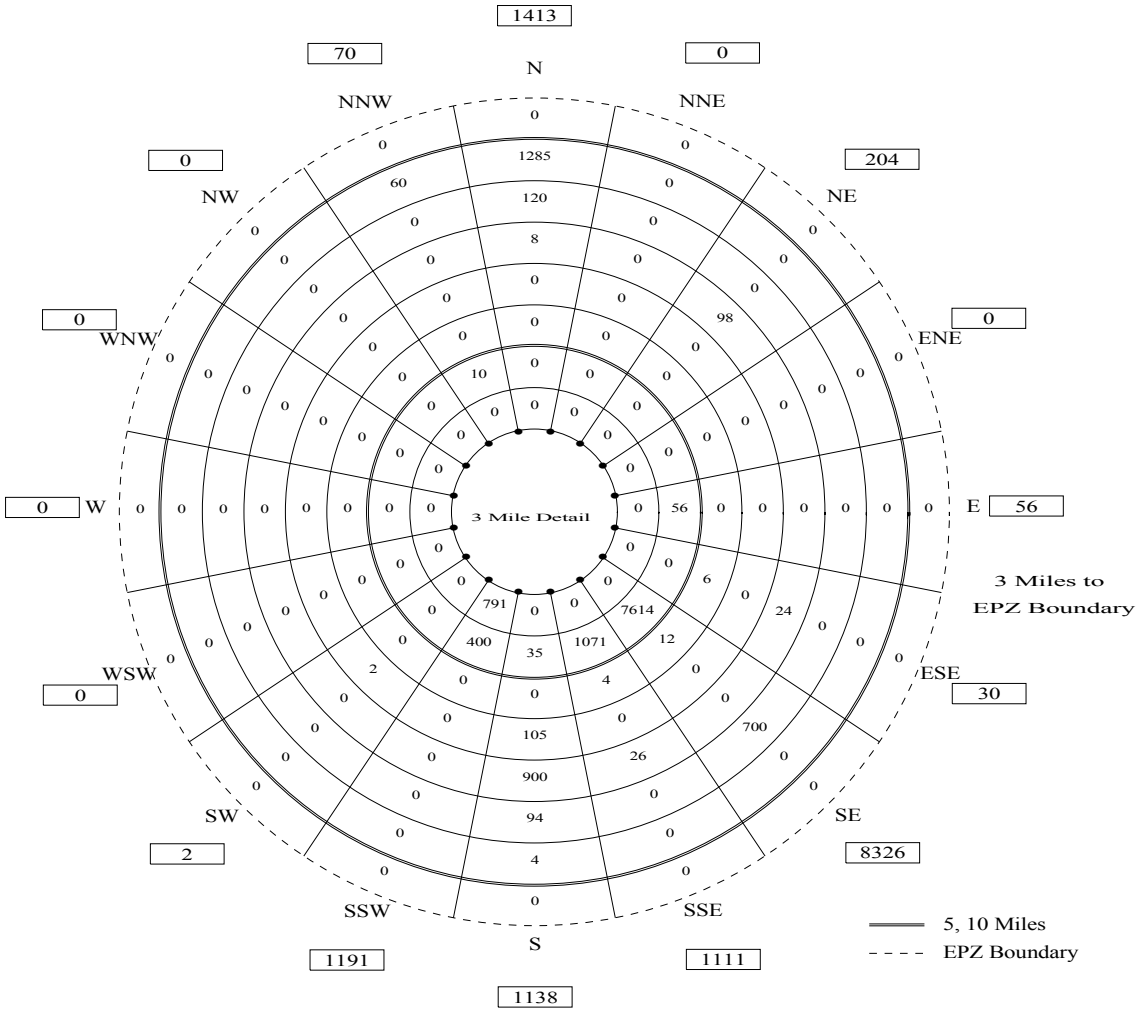
3.3.3 Fourth of July Celebration

Granbury hosts a 4th of July celebration each year, with the center of activity around the courthouse square. The celebration is a two-day event. A parade temporarily closes some roadway sections within the city limits. The number of attendees varies (between 30,000 and 50,000 total for the two-day event), according to the weather and day on which the holiday falls. This study assumes a peak transient population of 25,000 people for the 4th of July celebration. Those people attending the event who are not residents of Granbury drive to the event in private vehicles and park on the street and in nearby shopping center parking lots. Many people stay overnight in the area. A special event (Scenario 13) is considered to compute the ETE during this event. It is assumed for this special event that the residents of Granbury (5,700 people – not all are EPZ residents) walk to the event and that each family travelling into the area arrives in one vehicle. From the telephone survey results, the average household size is estimated to be 2.21 persons. The number of additional transient vehicles evacuating during a peak day under these circumstances is therefore:

$$(25{,}000 - 5{,}700) \div 2.21 = 8{,}733.$$

Following an Advisory to Evacuate, Granbury residents will return home, pack their belongings and then evacuate. It is assumed that the time to return home is negligible; as such, the trip generation is not modified for this special event.

Table 3-3. Summary of Transients by Zone		
Zone	Transients	Transient Vehicles
CP	NO TRANSIENTS	
1A		
1B		
1C	98	44
1D	928	397
2A	NO TRANSIENTS	
2B		
2C	10	5
2D	30	18
2E	56	25
2F	NO TRANSIENTS	
2G		
2H		
2J	1,388	671
3A	NO TRANSIENTS	
3B	1,191	539
3C	NO TRANSIENTS	
3D	117	48
3E	2	1
3F	998	428
4A	106	53
4B	NO TRANSIENTS	
4C	10	5
4D	NO TRANSIENTS	
4E		
4F		
4G		
4H		
Glen Rose	8,062	2,833
Granbury	545	295
Tolar	NO TRANSIENTS	
TOTAL	**13,541**	**5,362**



Transient Population			
Miles	Ring Subtotal	Total Miles	Cumulative Total
0-1	0	0-1	0
1-2	0	0-2	0
2-3	116	0-3	116
3-4	791	0-4	907
4-5	9186	0-5	10093
5-6	22	0-6	10115
6-7	107	0-7	10222
7-8	1056	0-8	11278
8-9	914	0-9	12192
9-10	1349	0-10	13541
10-EPZ	0	0-EPZ	13541

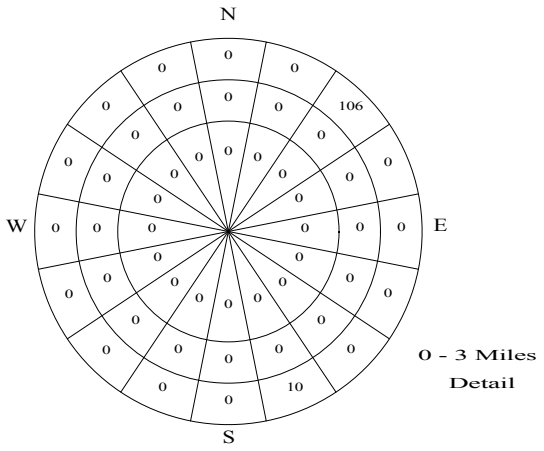
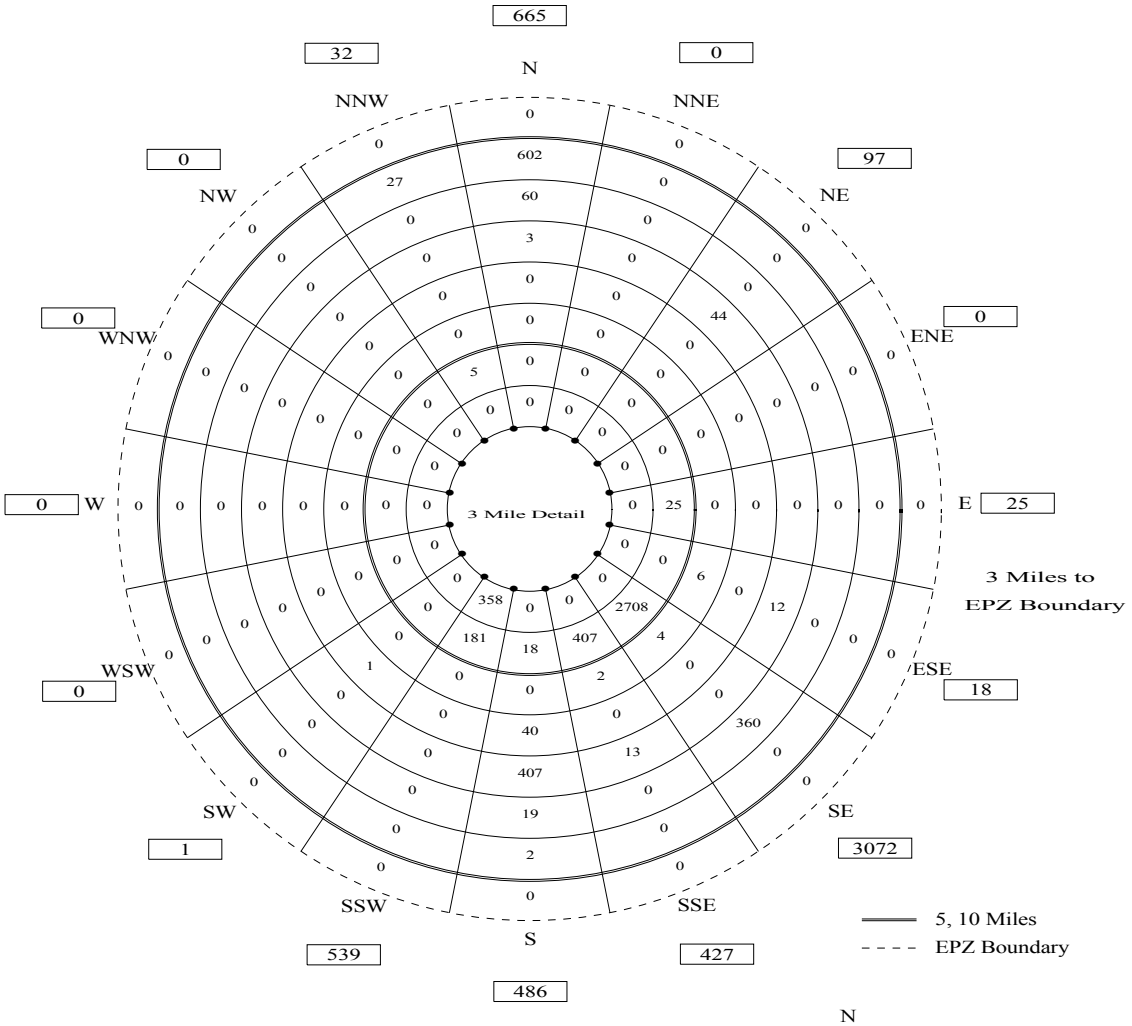


Figure 3-4. Transient Population by Sector



Resident Vehicles			
Miles	Ring Subtotal	Total Miles	Cumulative Total
0-1	0	0-1	0
1-2	0	0-2	0
2-3	58	0-3	58
3-4	358	0-4	416
4-5	3344	0-5	3760
5-6	12	0-6	3772
6-7	41	0-7	3813
7-8	479	0-8	4292
8-9	439	0-9	4731
9-10	631	0-10	5362
10-EPZ	0	0-EPZ	5362

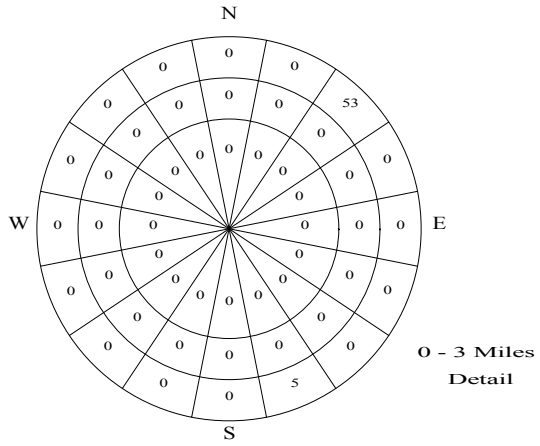


Figure 3-5. Transient Vehicles by Sector

3.4 Employees

Employees who work within the EPZ fall into two categories:

- Those who live and work in the EPZ
- Those who live outside of the EPZ and commute to jobs within the EPZ.

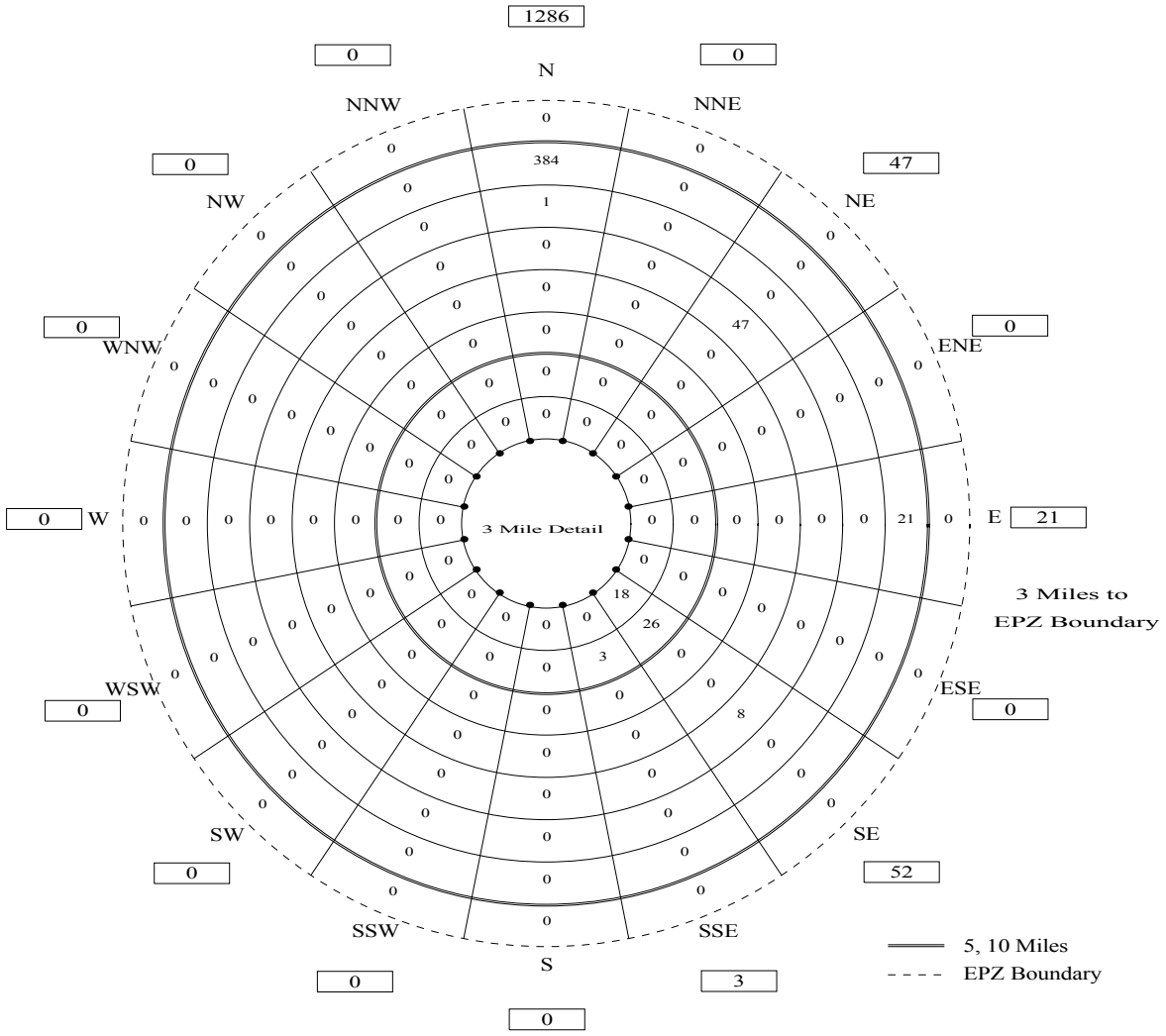
Those of the first category are already counted as part of the permanent resident population. To avoid double counting, we focus on those commuting employees who will evacuate along with the permanent resident population. Data provided by major employers within the EPZ indicates that on average, 43% of employees travel more than 10 miles to work (live outside the EPZ). When a site-specific percentage was not provided, this average value was used to estimate the number of employees commuting into the EPZ to that site.

Data for major employers (more than 50 total employees) in the EPZ was provided by the county offices of emergency management and was supplemented with Internet searches and telephone calls to the employers. The locations of these facilities were mapped using GIS software. The GIS map was overlaid with the evacuation analysis network and employees were loaded onto appropriate links. The map of major employers and commercial properties in the EPZ can be seen in Appendix E.

An occupancy of 1.02 persons per employee-vehicle obtained from the telephone survey was used to determine the number of evacuating employee vehicles.

Table 3-4 presents non-EPZ Resident employee and vehicle estimates by Zone. Figures 3-6 and 3-7 present these data by sector.

Table 3-4. Summary of Non-EPZ Employees by Zone		
Zone	**Total Non-EPZ Employees**	**Employee Vehicles**
CP	901	881
1A	NO EMPLOYEES	
1B		
1C	47	46
1D	255	253
2A	NO EMPLOYEES	
2B		
2C	18	18
2D	13	13
2E	NO EMPLOYEES	
2F	21	21
2G	NO EMPLOYEES	
2H		
2J		
3A		
3B		
3C		
3D		
3E		
3F	8	8
4A	NO EMPLOYEES	
4B		
4C		
4D		
4E		
4F		
4G		
4H		
Glen Rose	16	16
Granbury	130	129
Tolar	NO EMPLOYEES	
TOTAL	**1,409**	**1,385**



Employees			
Miles	Ring Subtotal	Total Miles	Cumulative Total
0-1	901	0-1	901
1-2	0	0-2	901
2-3	0	0-3	901
3-4	18	0-4	919
4-5	29	0-5	948
5-6	0	0-6	948
6-7	0	0-7	948
7-8	55	0-8	1003
8-9	1	0-9	1004
9-10	405	0-10	1409
10-EPZ	0	0-EPZ	1409

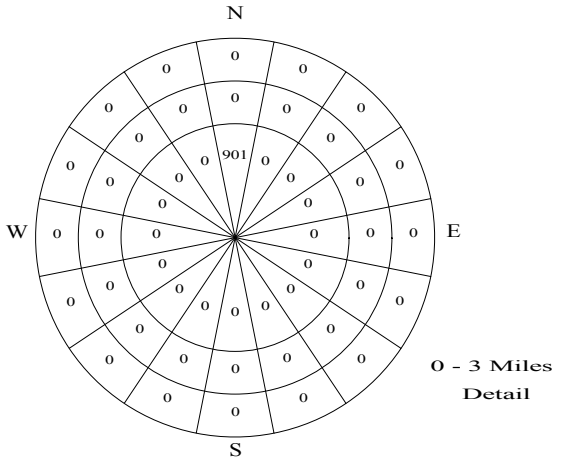
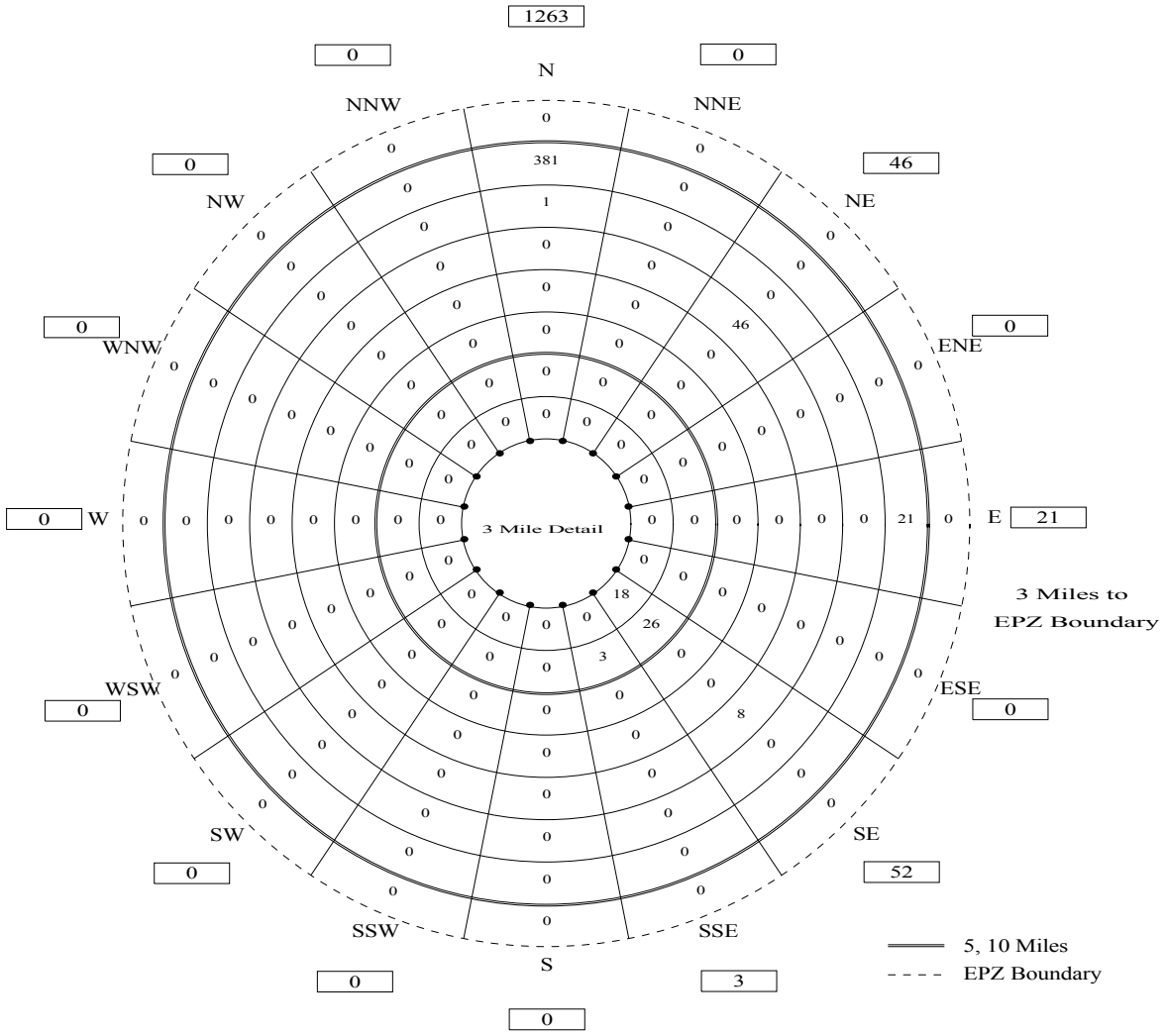


Figure 3-6. Employee Population by Sector



Employee Vehicles			
Miles	Ring Subtotal	Total Miles	Cumulative Total
0-1	881	0-1	881
1-2	0	0-2	881
2-3	0	0-3	881
3-4	18	0-4	899
4-5	29	0-5	928
5-6	0	0-6	928
6-7	0	0-7	928
7-8	54	0-8	982
8-9	1	0-9	983
9-10	402	0-10	1385
10-EPZ	0	0-EPZ	1385

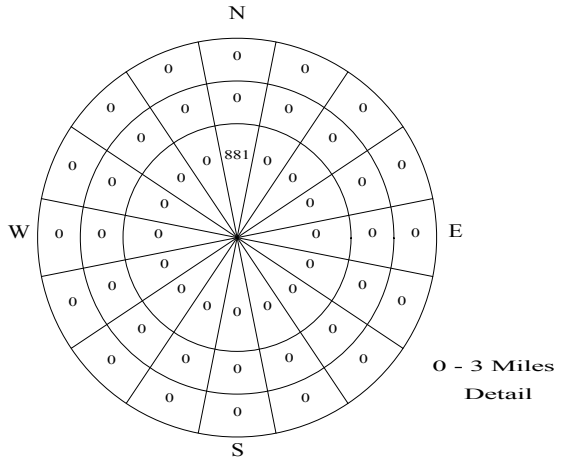


Figure 3-7. Employee Vehicles by Sector

3.5 Medical Facilities

Data request forms were completed for each of the medical facilities within the CPNPP EPZ. Chapter 8 details the evacuation of medical facilities and their patients. The number and type of evacuating vehicles that need to be provided depends on the state of health of the patients. Buses can transport up to 30 people; wheelchair buses, up to 15 people; wheelchair vans, up to 4 people; and ambulances, up to 2 people.

3.6 Pass-Through Demand

Vehicles will be traveling through the EPZ (external-external trips) at the time of an accident. After the Advisory to Evacuate is announced, these through travelers will also evacuate. These through vehicles are assumed to travel on the major routes through the EPZ (e.g. US Hwy 67 and US Hwy 377) and on some minor routes. The loading rates are 300 vehicles per lane per hour for major routes and 100 vehicles per lane per hour for the minor routes. It is assumed that this traffic will continue to enter the EPZ during the first 90 minutes following the Advisory to Evacuate. We estimate approximately 1,700 vehicles per lane per hour enter the EPZ as external-external trips during this period.

Local officials brought attention to the recent increase in truck traffic, largely due to oil discovery drilling in the area. In particular, US Hwy 377, US 67, FM 56 and STHY 144 are affected by this influx of truck traffic. Discussions with local officials indicate that his truck traffic generally has origins and destination outside of the EPZ and would only be passing through the EPZ. It is assumed that the pass-through demand already accounts for this truck traffic.

4. ESTIMATION OF HIGHWAY CAPACITY

The ability of the road network to service vehicle demand is a major factor in determining how rapidly an evacuation can be completed. The capacity of a road is defined as the maximum hourly rate at which persons or vehicles can reasonably be expected to traverse a point or uniform section of a lane of roadway during a given time period under prevailing roadway, traffic and control conditions (From the 2000 Highway Capacity Manual).

In discussing capacity, different operating conditions have been assigned alphabetical designations, A through F, to reflect the range of traffic operational characteristics. These designations have been termed "Levels of Service" (LOS). For example, LOS A connotes free-flow and high-speed operating conditions; LOS F represents a forced flow condition. LOS E describes traffic operating at or near capacity.

Because of the effect of weather on the capacity of a roadway, it is necessary to adjust capacity figures to represent the prevailing conditions during inclement weather. Based on limited empirical data, weather conditions such as heavy rain reduce the values of free speed and of highway capacity by approximately 10 percent. Over the last decade new studies have been made on the effects of rain on traffic capacity. These studies indicate a range of effects between 5 and 20 percent depending on wind speed and precipitation rates.

Estimates of roadway capacity must be determined with great care. Because of its importance, a brief discussion of the major factors that influence highway capacity is presented in this section.

Capacity Estimations on Approaches to Intersections

At-grade intersections are apt to become the first bottleneck locations under local heavy traffic volume conditions. This characteristic reflects the need to allocate access time to the respective competing traffic streams by exerting some form of control. During evacuation, control at critical intersections will often be provided by traffic control personnel assigned for that purpose, whose directions may supersede traffic control devices. The Traffic Management Plan identifies these locations (called Traffic Control Points, TCP) and the management procedures applied.

The per-lane capacity of an approach to a signalized intersection can be expressed (simplistically) in the following form:

$$Q_{cap,m} = \left(\frac{3600}{h_m}\right) \bullet \left[\frac{G-L}{C}\right]_m = \left(\frac{3600}{h_m}\right) \bullet P_m$$

where:

Qcap,m = Capacity of a single lane of traffic on an approach, which executes movement, *m*, upon entering the intersection; vehicles per hour (vph)

h_m = Mean queue discharge headway of vehicles on this lane that are executing movement, *m*; seconds per vehicle

G	=	The mean duration of GREEN time servicing vehicles that are executing movement, m, for each signal cycle; seconds
L	=	The mean "lost time" for each signal phase servicing movement, m; seconds
C	=	The duration of each signal cycle; seconds
P_m	=	The proportion of GREEN time allocated for vehicles executing movement, m, from this lane. This value is specified as part of the control treatment.
m	=	The movement executed by vehicles after they enter the intersection: through, left-turn, right-turn, diagonal.

The turn-movement-specific mean discharge headway h_m, depends in a complex way upon many factors: roadway geometrics, turn percentages, the extent of conflicting traffic streams, the control treatment, and others. A primary factor is the value of "saturation queue discharge headway", h_{sat}, which applies to through vehicles that are not impeded by other conflicting traffic streams. This value, itself, depends upon many factors including motorist behavior. Formally, we can write,

$$h_m = f_m (h_{sat}, F_1, F_2, ...)$$

where:

h_{sat}	=	Saturation discharge headway for through vehicles; seconds per vehicle
F_1, F_2	=	The various known factors influencing h_m
$f_m (\cdot)$	=	Complex function relating h_m to the known (or estimated) values of $h_{sat}, F_1, F_2, \ldots$

The estimation of h_m for specified values of $h_{sat}, F_1, F_2, ...$ is undertaken within the PC-DYNEV simulation model and within the TRAD model by a mathematical model[1]. The resulting values for h_m always satisfy the condition:

$$h_m \geq h_{sat}$$

That is, the turn-movement-specific discharge headways are always greater than, or equal to the saturation discharge headway for through vehicles. These headways (or its inverse equivalent, “saturation flow rate”), may be determined by observation or using the procedures of the Highway Capacity Manual.

1 Lieberman, E., "Determining Lateral Deployment of Traffic on an Approach to an Intersection", McShane, W. & Lieberman, E., "Service Rates of Mixed Traffic on the far Left Lane of an Approach". Both papers appear in Transportation Research Record 772, 1980.

Capacity Estimation Along Sections of Highway

The capacity of highway sections – as distinct from approaches to intersections – is a function of roadway geometrics, traffic composition (e.g. percent heavy trucks and buses in the traffic stream) and, of course, motorist behavior. There is a fundamental relationship which relates service volume (i.e. the number of vehicles serviced within a uniform highway section in a given time period) to traffic density. Figure 4-1 describes this relationship.

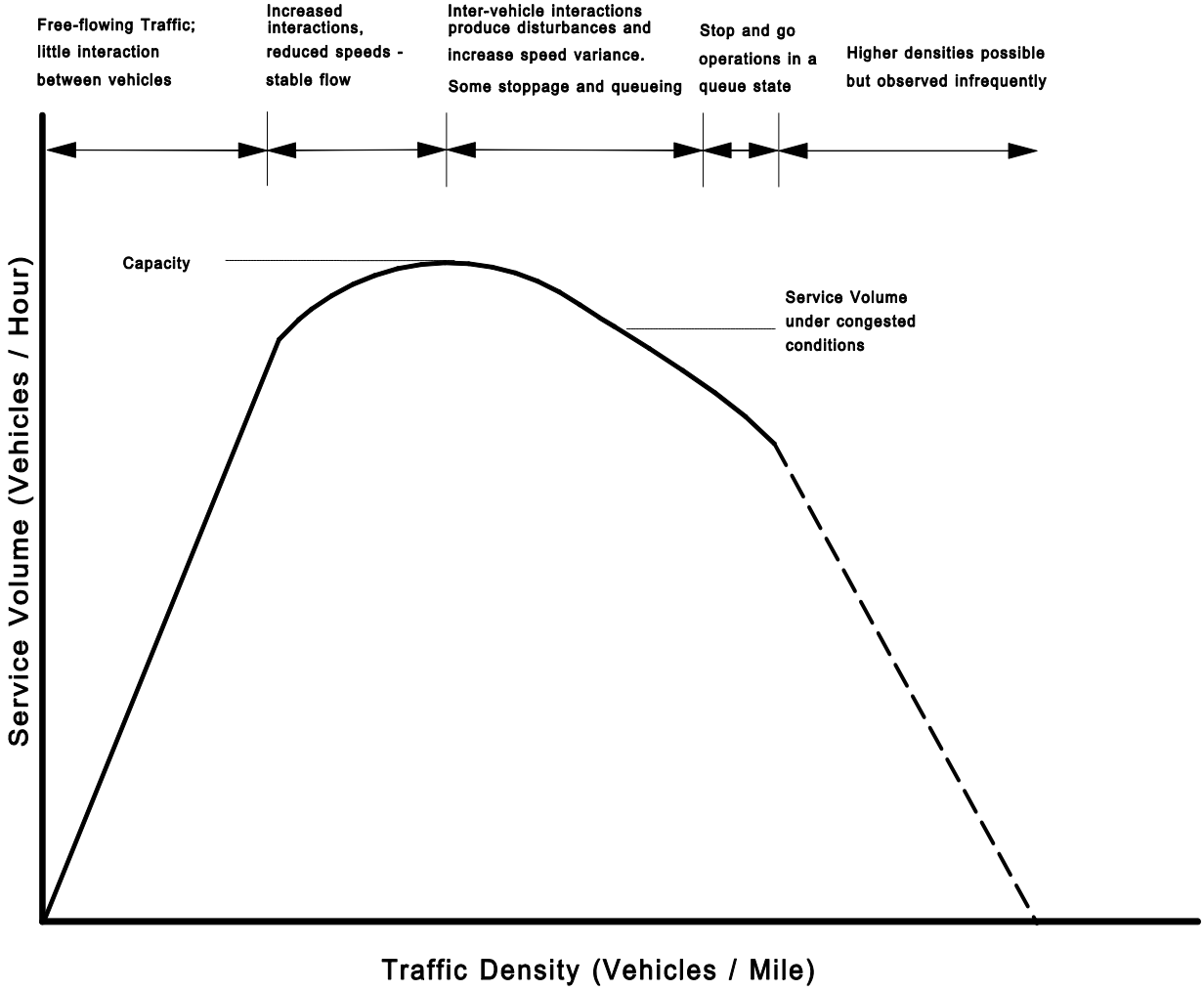


Figure 4-1. Fundamental Relationship between Volume and Density

As indicated, there are two flow regimes: (1) Free Flow (left side of curve); and (2) Forced Flow (right side). In the Free Flow regime, the traffic demand is fully serviced; this service volume increases as demand volume and density increase, until the service volume attains its maximum value, which is the capacity of the highway section. As traffic demand and the resulting highway density increase beyond this "critical" value, the rate at which traffic can be serviced (i.e. the service volume) can actually decline below capacity. Therefore, in order to realistically represent traffic performance during congested conditions (i.e. when demand exceeds capacity), it is necessary to estimate the service volume, V_F, under congested conditions.

The value of V_F can be expressed as:

$$V_F = R \times \text{Capacity}$$

where R = Reduction factor which is less than unity.

Based on empirical data collected on freeways, we have employed a value of R=0.85. It is important to mention that some investigators, on analyzing data collected on freeways, conclude that little reduction in capacity occurs even when traffic is operating at Level of Service, *F*. While there is conflicting evidence on this subject, we adopt a conservative approach and use a value of capacity, V_F, that is applied during LOS F conditions; V_F, is lower than the specified capacity.

The estimated value of capacity is based primarily upon the type of facility and on roadway geometrics. Sections of roadway with adverse geometrics are characterized by lower free-flow speeds and lane capacities.

The procedure used here was to estimate "section" capacity, V_E, based on observations made traveling over each section of the evacuation network, by the posted speed limits and travel behavior of other motorists and by reference to the 2000 Highway Capacity Manual. It was then determined for each highway section, represented as a network link, whether its capacity would be limited by the "section-specific" service volume, V_E, or by the intersection-specific capacity. For each link, the model selects the lower value of capacity.

Application to the Comanche Peak Nuclear Power Plant EPZ

As part of the development of the Comanche Peak Nuclear Power Plant (CPNPP) EPZ traffic network, an estimate of roadway capacity is required. The source material for the capacity estimates presented herein is contained in:

2000 Highway Capacity Manual (HCM)
Transportation Research Board
National Research Council
Washington, D.C.

The highway system in the CPNPP EPZ consists primarily of two categories of roads and, of course, intersections:

1. Two-lane roads: Local, State
2. Multi-lane Highways (at-grade)

Each of these classifications will be discussed.

Two-Lane Roads

Ref: HCM Chapter 20

Two lane roads comprise the majority of highways within the EPZ. The per-lane capacity of a two-lane highway is estimated at 1700 passenger cars per hour (pc/h). This estimate is essentially independent of the directional distribution of traffic volume except that, for extended distances, the two-way capacity will not exceed 3200 pc/h. The HCM procedures then estimate Level of Service (LOS) and Average Travel Speed. The evacuation simulation model accepts the specified value of capacity as input and computes average speed based on the time-varying demand: capacity relations.

Based on the field survey and on expected traffic operations associated with evacuation scenarios:

- Most sections of two-lane roads within the EPZ are classified as “Class I”, with "level terrain"; some are “rolling terrain”.
- “Class II” highways are mostly those within town and city limits.

Multi-Lane Highway

Ref: HCM Chapter 21

Exhibit 21-23 (in the HCM) presents a set of curves that indicates a per-lane capacity of approximately 2100 pc/h, for free-speeds of 55-60 mph. Based on observation, the multi-lane highways outside of urban areas within the EPZ, service traffic with free-speeds in this range. The actual time-varying speeds computed by the simulation model reflect the demand:capacity relationship and the impact of control at intersections.

Intersections

Ref: HCM Chapters 16, 17

Procedures for estimating capacity and LOS for approaches to intersections are presented in Chapters 16 (signalized intersections) and 17 (un-signalized intersections). These are the two longest chapters in the HCM 2000, reflecting the complexity of these procedures. The simulation logic is likewise complex, but different; as stated on page 31-21 of the HCM2000: *“Assumptions and complex theories are used in the simulation model to represent the real-world dynamic traffic environment.”*

5. ESTIMATION OF TRIP GENERATION TIME

Federal Government guidelines (see NUREG 0654, Appendix 4) 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 (Appendix F). We define the sum of these distributions of elapsed times as the Trip Generation Time Distribution.

Background

In general, an accident at a nuclear power plant is characterized by the following Emergency Action Classification Levels (see Appendix 1 of NUREG 0654 for details):

1. Unusual Event
2. Alert
3. Site Area Emergency
4. General Emergency

At each level, the Federal guidelines specify a set of Actions to be undertaken by the Licensee, and by State and Local offsite authorities. As a Planning Basis, we will adopt a conservative posture, in accord with Federal Regulations, that a rapidly escalating accident will be considered in calculating the Trip Generation Time. We will assume:

a. The Advisory to Evacuate will be announced coincident with the emergency notification.
b. Mobilization of the general population will commence up to 10 minutes after the alert notification.
c. Evacuation Time Estimates (ETEs) are measured relative to the Advisory to Evacuate.
d. Schools will be evacuated prior to the Advisory to Evacuate; if circumstances permit.

We emphasize that the adoption of this planning basis is not a representation that these events will occur at Comanche Peak Nuclear Power Plant within the indicated time frame. Rather, these assumptions are necessary in order to:

- Establish a temporal framework for estimating the Trip Generation distribution in the format recommended in Appendix 4 of NUREG 0654.
- Identify temporal points of reference that uniquely define "Clear Time" and ETE.

It is more likely that a longer time will elapse between the various classes of an emergency at CPNPP and that the Advisory to Evacuate is announced somewhat later than the siren alert.

For example, suppose one hour will elapse 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 Emergency Planning Zone (EPZ) will be lower when the Advisory To Evacuate (ATE) is announced, than at the time of the General Emergency. Thus, the time needed to evacuate the EPZ, after the ATE will be less than the estimates presented in this report.

The notification process consists of two events:

- Transmitting information (e.g. using sirens, EAS broadcasts, and loud speakers).
- Receiving and correctly interpreting the information that is transmitted.

The peak population within the EPZ in 2007 approximates 47,000 persons[1] who are deployed over an area of approximately 314 square miles and 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 accident.

The amount of elapsed time will vary from one individual to the next depending 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 NUREG 0654, 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 ETEs may be obtained.

For example, people at home or at work within the EPZ will be notified by siren. 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.

[1] This estimate is for a summer weekend and includes 100% of residents, 100% of transients, and 10% of employees

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-accident condition
2	Awareness of accident situation
3	Depart place of work or elsewhere, to return home
4	Arrive (or be at) home
5	Begin evacuation trip to leave the area.

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

Event Sequence	Activity	Distribution
1 → 2	Public receives notification information	1
2 → 3	Prepare to leave work	2
3 → 4	Travel home*	3
4 → 5	Prepare to leave for evacuation trip	4

*If already at home, this is a null (no-time-consumed) activity.

These relationships are shown graphically in Figure 5-1.

An employee who lives outside the EPZ will follow sequence (c) in 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 sequence (a) in Figure 5-1. 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 sequence (a) in Figure 5-1, regardless of day of week or time of day. Note that event 5, “Leave to

evacuate the area," is conditional either on event 2 or on event 4. For this study, we adopt the conservative posture that all activities will occur in sequence.

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

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.

Estimated Time Distributions of Activities Preceding Event 5

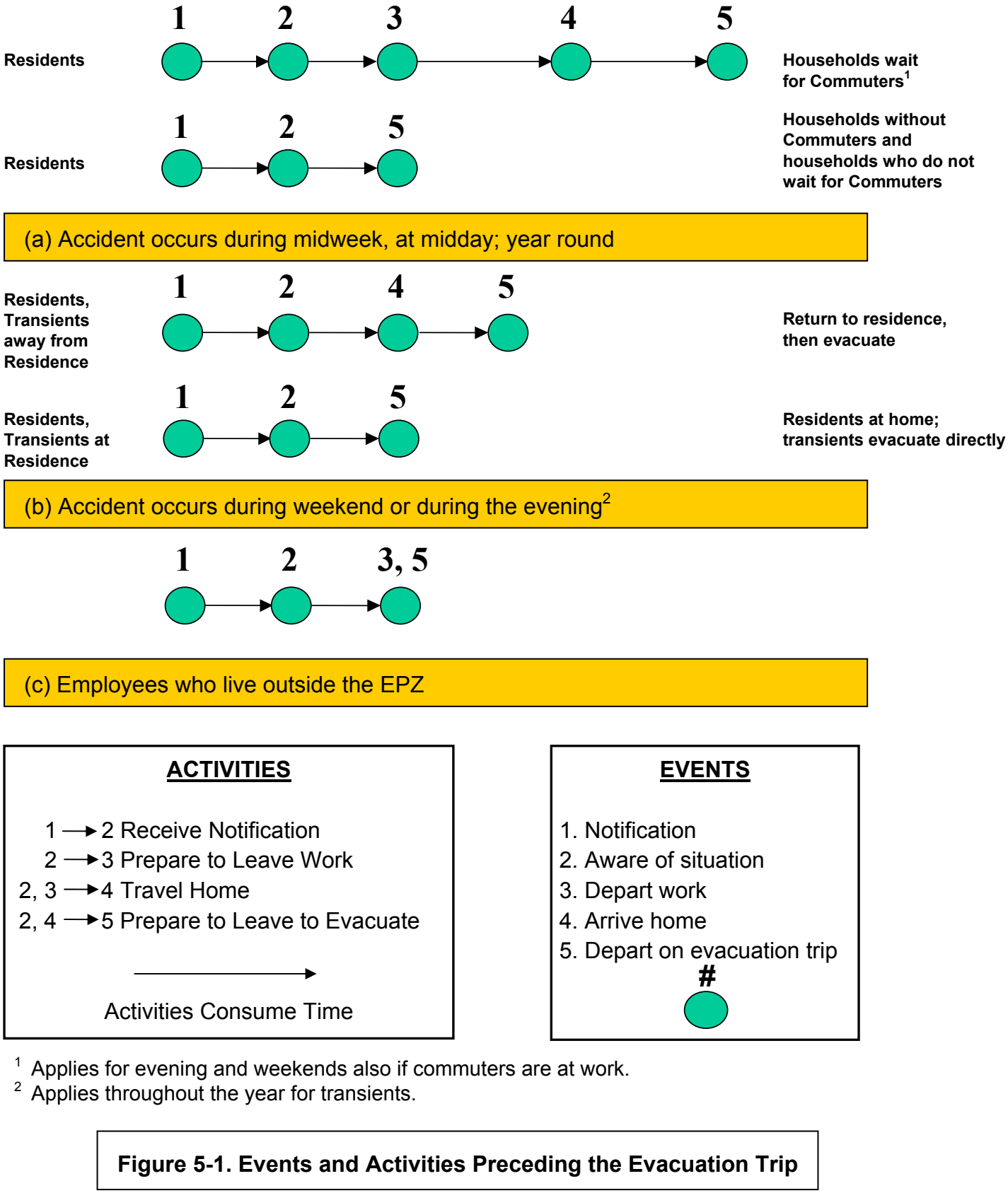
The time distribution of an event is obtained by "summing" the time distributions of all prior contributing activities (This "summing" process is quite different than an algebraic sum since we are operating on distributions, not scalar numbers).

Time Distribution No. 1, Notification Process: Activity 1 $\rightarrow$ 2

It is reasonable to expect that 85 percent of those within the EPZ will be aware of the accident within 30 minutes with the remainder notified within the following 20 minutes. The notification distribution is given below:

Distribution No. 1, Notification Time: Activity 1 $\rightarrow$ 2

Elapsed Time (Minutes)	Percent of Population Notified
0	0
5	7
10	13
15	26
20	46
25	65
30	85
35	90
40	95
45	98
50	100



[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

Distribution No. 2, Prepare to Leave Work: Activity 2 → 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, will also leave quickly since facilities outside the EPZ would remain open and other personnel would remain. Personnel or farmers responsible for equipment would require additional time to secure their facility. The distribution of Activity 2 → 3 reflects data obtained by the telephone survey. This distribution is plotted in Figure 5-2 and listed below.

Elapsed Time (Minutes)	Cumulative Percent Employees Leaving Work
0	0
5	44
10	60
15	68
20	73
25	74
30	84
35	85
40	85
45	87
50	87
55	87
60	95
65	95
70	95
75	98
80	98
85	98
90	98
95	98
100	98
105	98
110	98
115	98
120	100

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

Distribution No. 3, Travel Home: Activity 3 $\rightarrow$ 4

These data are provided directly by the telephone survey. This distribution is plotted in Figure 5-2 and listed below.

Elapsed Time (Minutes)	Cumulative Percent Returning Home
0	0
5	14
10	29
15	46
20	60
25	65
30	77
35	79
40	82
45	87
50	89
55	89
60	91
65	91
70	91
75	93
80	93
85	93
90	96
95	96
100	96
105	97
110	97
115	97
120	98
125	99
130	100

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

Distribution No. 4, Prepare to Leave Home: Activity 2, 4 $\rightarrow$ 5

These data are provided directly by the telephone survey. This distribution is plotted in Figure 5-2 and listed below.

Elapsed Time (Minutes)	Cumulative Pct. Ready to Evacuate
0	0
5	13
10	26
15	39
20	49
25	58
30	68
35	71
40	74
45	78
50	81
55	85
60	88
65	90
70	91
75	93
80	93
85	94
90	94
95	95
100	95
105	95
110	96
115	97
120	97
125	98
130	98
135	99
140	99
145	99
150	100

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

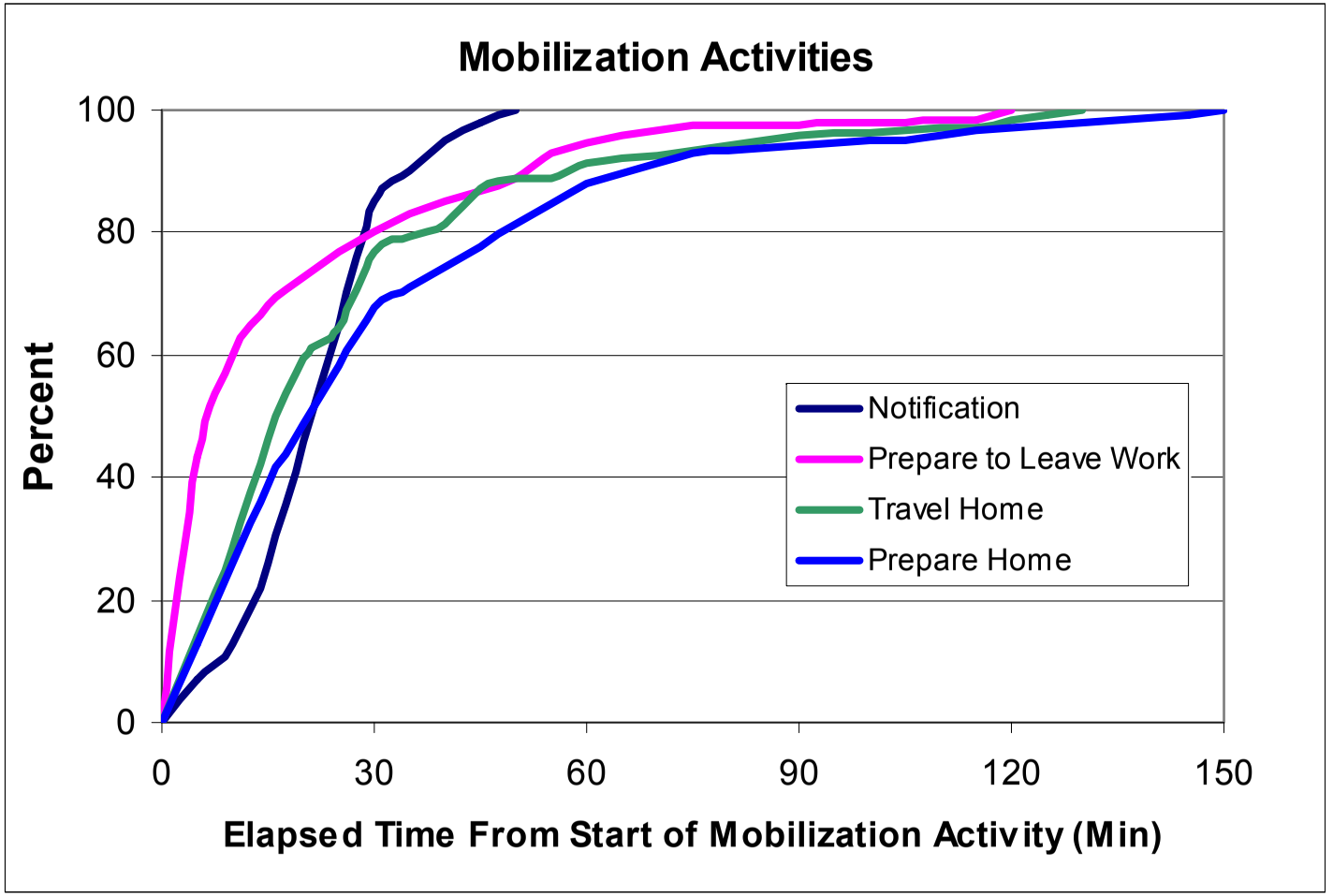


Figure 5-2. Evacuation Mobilization Activities

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. We assume 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.

Apply "Summing" Algorithm To:	**To Obtain:**	**That Defines:**
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

Distributions A through D are described below:

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.
C	Time distribution of residents with commuters leaving home to begin the evacuation trip.
D	Time distribution of residents without commuters returning home to begin the evacuation trip.

As shown in Appendix F, the mobilization activity distributions include outliers – generally, these represent anomalous responses to the survey question. Following standard statistical practice, outliers were identified by (a) computing the estimated mean and standard deviation from the complete set of data, (b) computing value x_{LIMIT} as the mean plus 3.0 standard deviations, above which one expects 0.135% of the observations, (c) inspecting the gap between this limit value and the next-lowest observed value, (d) if that gap is sizable, classify the points above x_{LIMIT} as outliers and eliminate those points from the sample, (e) repeat the process from "a" to "d" until there are no outliers to consider.

The data sets and distributions are then used to construct distributions for the total mobilization times under different scenarios (e.g. commuter returning, no commuter returning). In general, these are additive, using weighting based upon the probability distributions of each element; Figure 5-3 presents the combined trip generation distributions designated A, C and D. These distributions are presented on the same time scale. (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; travel home follows the preparation to leave work, 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.)

Once the mobilization distributions are computed, they are not truncated, but rather used in their tabular form as direct inputs to later computations that lead to the ETE. The PC-DYNEV 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 5-1 (Distribution B, Arrive Home, omitted for clarity). The final time period (9) 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.

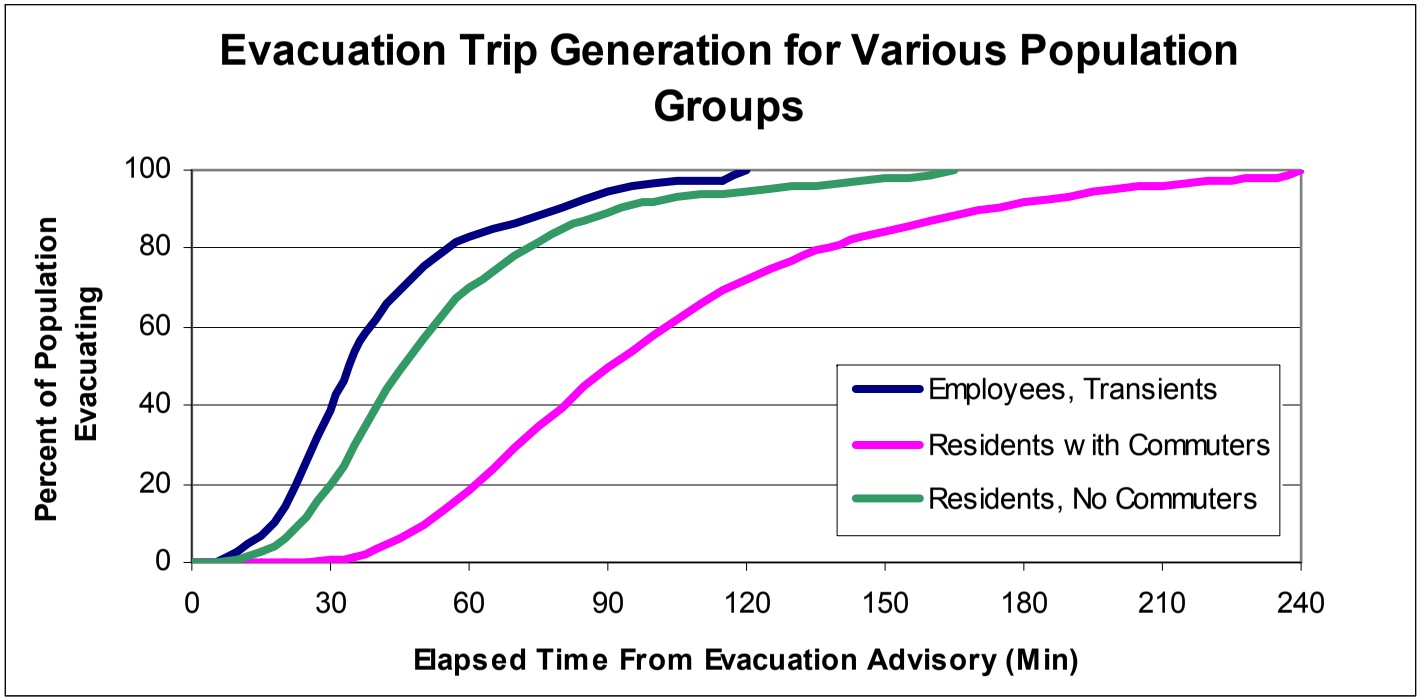


Figure 5-3. Comparison of Trip Generation Distributions

Table 5-1. Trip Generation for the EPZ Population					
Time Period	Duration (Min)	Percent of Total Trips Generated Within Indicated Time Period			
		Residents With Commuters (Distribution C)	Residents Without Commuters (Distribution D)	Employees (Distribution A)	Transients (Distribution A)
1	15	0	2	8	8
2	15	1	18	32	32
3	30	19	50	43	43
4	30	30	20	12	12
5	30	22	5	5	5
6	30	12	3	0	0
7	30	7	2	0	0
8	60	9	0	0	0
9	600	0	0	0	0

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 evacuation 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 total of 63 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 2-mile circular area centered at the Comanche Peak Nuclear Power Plant (CPNPP), and three or five adjoining sectors, each with a central angle of 22.5 degrees. These sectors extend to a distance of 5 miles from CPNPP (Regions R4 to R17 and R34 to R47), or to the EPZ boundary (Regions R18 to R33 and R48 to R63). The azimuth of the central sector defines the orientation of these Regions.

A total of 13 Scenarios were evaluated for all Regions. Thus, there are a total of 13x63=819 evacuation cases. Table 6-2 is a description of all Scenarios. In addition, numerous cases were created to determine the sensitivity of ETE to variations in the mobilization time, the extent of shadow population evacuation, and the impact of the re-opening of Squaw Creek Park on a limited basis to employees, charitable events and eventually to the public. These sensitivity studies are detailed in Appendix I.

Each combination of Region and Scenario implies a specific population to be evacuated. Table 6-3 presents the percentage of each population group assumed to evacuate for each Scenario. Table 6-4 presents the vehicle counts for each Scenario.

Table 6-1. Description of Evacuation Regions (Page 1 of 2)

Region	Central Sector	Description	ZONE																													
			CP	1A	1B	1C	1D	2A	2B	2C	2D	2E	2F	2G	2H	2J	3A	3B	3C	3D	3E	3F	4A	4B	4C	4D	4E	4F	4G	4H	GLEN ROSE	GRANBURY	TOLAR
R01	-	2 mile ring	■					■																									
R02	-	5-mile ring	■	■	■			■	■	■	■	■					■	■					■	■	■	■					■		
R03	-	Full EPZ	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Evacuate 2 mile ring and 5 miles downwind (3 Sector Groups)																																	
Region	Central Sector	Wind Direction Toward:	ZONE																														
			CP	1A	1B	1C	1D	2A	2B	2C	2D	2E	2F	2G	2H	2J	3A	3B	3C	3D	3E	3F	4A	4B	4C	4D	4E	4F	4G	4H	GLEN ROSE	GRANBURY	TOLAR
R04	A	N	■		■			■															■	■	■								
R05	B	NNE	■	■	■			■															■	■									
R06	C	NE	■	■	■			■	■		■	■											■	■									
R07	D	ENE	■	■	■			■	■		■	■											■										
R08	E	E	■	■				■	■		■	■																					
R09	F	ESE	■					■	■	■	■	■																			■		
R10	G	SE	■					■	■	■	■																				■		
R11	H, J	SSE, S	■					■		■								■													■		
R12	K	SSW	■					■		■							■	■													■		
R13	L	SW	■					■									■	■								■							
R14	M	WSW	■					■									■	■							■	■							
R15	N	W	■					■									■								■	■							
R16	P	WNW	■					■																	■	■							
R17	Q, R	NW, NNW	■					■																■	■								
Evacuate 2 mile ring and downwind to EPZ Boundary (3 Sector Groups)																																	
Region	Central Sector	Wind Direction Toward:	ZONE																														
			CP	1A	1B	1C	1D	2A	2B	2C	2D	2E	2F	2G	2H	2J	3A	3B	3C	3D	3E	3F	4A	4B	4C	4D	4E	4F	4G	4H	GLEN ROSE	GRANBURY	TOLAR
R18	A	N	■		■	■	■	■															■	■	■		■	■				■	
R19	B	NNE	■	■	■	■	■	■						■									■	■			■					■	
R20	C	NE	■	■	■	■	■	■	■		■	■		■									■	■									
R21	D	ENE	■	■	■	■		■	■		■	■	■	■									■										
R22	E	E	■	■		■		■	■		■	■	■	■	■																		
R23	F	ESE	■					■	■	■	■	■	■		■	■															■		
R24	G	SE	■					■	■	■	■				■	■			■												■		
R25	H	SSE	■					■		■					■	■		■	■	■		■									■		
R26	J	S	■					■		■						■		■	■	■		■									■		
R27	K	SSW	■					■		■							■	■	■	■	■	■									■		
R28	L	SW	■					■									■	■		■	■	■				■				■			
R29	M	WSW	■					■									■	■		■	■				■	■			■	■			
R30	N	W	■					■									■				■				■	■		■	■	■			
R31	P	WNW	■					■																	■	■		■	■	■			■
R32	Q	NW	■					■																■	■		■	■	■			■
R33	R	NNW	■				■	■																■	■		■	■				■	■

Table 6-1. Description of Evacuation Regions (Page 2 of 2)

Evacuate 2 mile ring and 5 miles downwind (5 Sector Groups)

Region	Central Sector	Wind Direction Toward:	ZONE																													
			CP	1A	1B	1C	1D	2A	2B	2C	2D	2E	2F	2G	2H	2J	3A	3B	3C	3D	3E	3F	4A	4B	4C	4D	4E	4F	4G	4H	GLEN ROSE	GRANBURY	TOLAR
R34	A	N	■	■	■			■															■	■	■								
R35	B	NNE	■	■	■			■	■		■	■											■	■	■								
R36	C, D	NE, ENE	■	■	■			■	■		■	■											■	■									
R37	E	E	■	■	■			■	■	■	■	■											■								■		
R38	F	ESE	■	■				■	■	■	■	■																			■		
R39	G	SE	■					■	■	■	■	■						■													■		
R40	H	SSE	■					■	■	■	■							■													■		
R41	J	S	■					■		■							■	■													■		
R42	K	SSW	■					■		■							■	■								■					■		
R43	L	SW	■					■		■							■	■							■	■					■		
R44	M, N	WSW, W	■					■									■	■							■	■							
R45	P	WNW	■					■									■							■	■	■							
R46	Q	NW	■					■																■	■	■							
R47	R	NNW	■		■			■															■	■	■								

Evacuate 2 mile ring and downwind to EPZ Boundary (5 Sector Groups)

Region	Central Sector	Wind Direction Toward:	ZONE																													
			CP	1A	1B	1C	1D	2A	2B	2C	2D	2E	2F	2G	2H	2J	3A	3B	3C	3D	3E	3F	4A	4B	4C	4D	4E	4F	4G	4H	GLEN ROSE	GRANBURY	TOLAR
R48	A	N	■	■	■	■	■	■						■									■	■	■		■	■				■	■
R49	B	NNE	■	■	■	■	■	■	■		■	■		■									■	■	■		■	■				■	
R50	C	NE	■	■	■	■	■	■	■		■	■	■	■									■	■			■					■	
R51	D	ENE	■	■	■	■	■	■	■		■	■	■	■	■								■	■									
R52	E	E	■	■	■	■		■	■	■	■	■	■	■	■	■							■								■		
R53	F	ESE	■	■		■		■	■	■	■	■	■	■	■	■			■												■		
R54	G	SE	■					■	■	■	■	■	■		■	■		■	■	■		■									■		
R55	H	SSE	■					■	■	■	■				■	■		■	■	■		■									■		
R56	J	S	■					■		■					■	■	■	■	■	■	■	■									■		
R57	K	SSW	■					■		■						■	■	■	■	■	■	■				■				■	■		
R58	L	SW	■					■		■							■	■	■	■	■	■			■	■			■	■	■		
R59	M	WSW	■					■									■	■		■	■	■			■	■		■	■	■			■
R60	N	W	■					■									■	■		■	■				■	■		■	■	■			■
R61	P	WNW	■					■									■				■			■	■	■	■	■	■	■			■
R62	Q	NW	■				■	■																■	■	■	■	■	■	■		■	■
R63	R	NNW	■		■	■	■	■															■	■	■		■	■	■			■	■

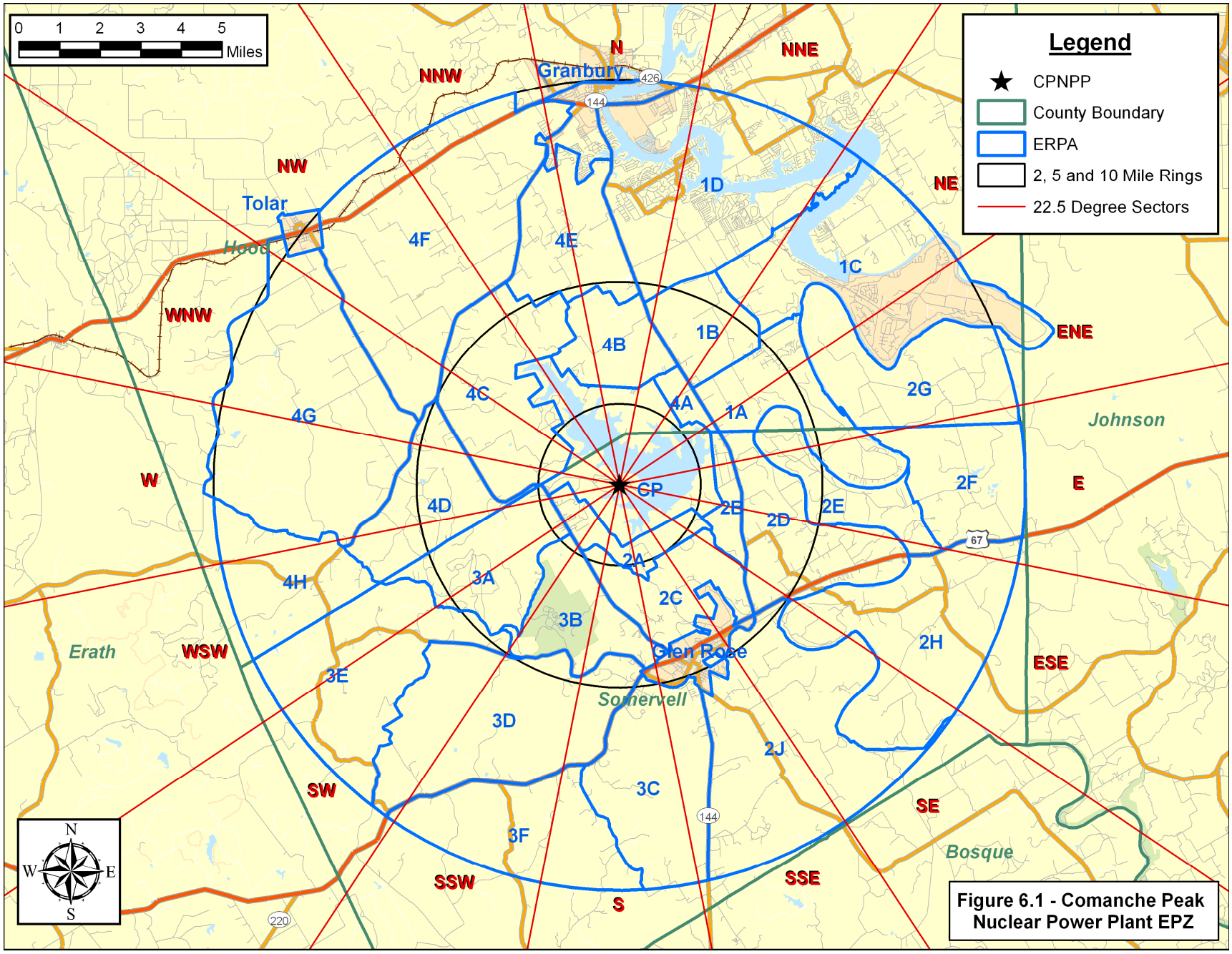


Figure 6.1 - Comanche Peak Nuclear Power Plant EPZ

Table 6-2. Evacuation Scenario Definitions					
Scenario	**Season**	**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	Summer	Weekend	Midday	Good	Event at Amphitheatre
12	Summer	Midweek	Midday	Good	Peak Construction of New Unit (2015)
13	Summer	Weekend	Midday	Good	Fourth of July Celebration in Granbury

Note: Schools are assumed to be in session for the winter season (midweek, midday).

Table 6-3. Percent of Population Groups Evacuating for Various Scenarios									
Scenarios	Residents With Commuters in Household	Residents With No Commuters in Household	Employees	Transients	Shadow	Special Events	School Buses	Transit Buses	External Through Traffic
1	40%	60%	96%	87%	32%	0%	10%	100%	100%
2	40%	60%	96%	87%	32%	0%	10%	100%	100%
3	4%	96%	48%	100%	31%	0%	0%	100%	100%
4	4%	96%	48%	100%	31%	0%	0%	100%	100%
5	4%	96%	10%	81%	30%	0%	0%	100%	60%
6	40%	60%	100%	66%	32%	0%	100%	100%	100%
7	40%	60%	100%	66%	32%	0%	100%	100%	100%
8	4%	96%	50%	76%	31%	0%	0%	100%	100%
9	4%	96%	50%	76%	31%	0%	0%	100%	100%
10	4%	96%	10%	65%	30%	0%	0%	100%	60%
11	4%	96%	48%	100%	31%	100%	0%	100%	100%
12	40%	60%	96%	87%	32%	100%	10%	100%	100%
13	4%	96%	48%	100%	31%	100%	0%	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 of 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 30% relocation of shadow residents along with a proportional percentage of shadow employees. The percentage of shadow employees is computed using the scenario-specific ratio of EPZ employees to residents.

Special Events..... Additional vehicles in the CPNPP EPZ for 3 special cases: when an event is being held at the Texas Amphitheatre, during the construction phase of the new units at the CPNPP site and during the Fourth of July Celebration in Granbury.

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), respectively.

External Through Traffic..... Traffic on local highways and major arterial roads at the start of the evacuation. This traffic is stopped by access control approximately 90 minutes after the evacuation begins.

Table 6-4. Vehicle Estimates By Scenario										
Scenarios	Residents with Commuters	Residents without Commuters	Employees	Transients	Shadow	Special Events	School Buses	Transit Buses	External Traffic	Total Scenario Vehicles
1	7,874	11,643	1,330	4,665	3,475	-	18	40	2,550	31,595
2	7,874	11,643	1,330	4,665	3,475	-	18	40	2,550	31,595
3	787	18,730	665	5,362	3,364	-	-	40	2,550	31,498
4	787	18,730	665	5,362	3,364	-	-	40	2,550	31,498
5	787	18,730	139	4,343	3,276	-	-	40	1,530	28,845
6	7,874	11,643	1,385	3,539	3,484	-	174	40	2,550	30,689
7	7,874	11,643	1,385	3,539	3,484	-	174	40	2,550	30,689
8	787	18,730	693	4,075	3,369	-	-	40	2,550	30,244
9	787	18,730	693	4,075	3,369	-	-	40	2,550	30,244
10	787	18,730	139	3,485	3,276	-	-	40	1,530	27,987
11	787	18,730	665	5,362	3,364	1,563	-	40	2,550	33,061
12*	9,012	13,350	1,330	4,665	3,936	4,202	18	40	2,550	39,103
13	787	18,730	665	5,362	3,364	8,733	-	40	2,550	40,231

***Permanent Resident population and Shadow population have been extrapolated to the Year 2015, which is when the construction workforce will be at its peak.**

7. GENERAL POPULATION EVACUATION TIME ESTIMATES (ETE)

This section presents the current results of the computer analyses using the IDYNEV System described in Appendices B, C and D. These results cover 63 regions within the CPNPP EPZ and the 13 Evacuation Scenarios discussed in Section 6.

The ETE for all Evacuation Cases are presented in Tables 7-1A through 7-1D. These tables present the estimated times to clear the indicated population percentages from the Evacuation Regions for all Evacuation Scenarios. The tabulated values of ETE are obtained from the PC-DYNEV simulation model outputs of vehicles exiting the specified evacuation areas. These data are generated at 10-minute intervals, and then interpolated to the nearest 5 minutes.

7.1 Voluntary Evacuation and Shadow Evacuation

We define "voluntary evacuees" as people who are within the EPZ in Zones located outside the Evacuation Region, for which an Advisory to Evacuate *has not* been issued, yet who nevertheless elect to evacuate. We define "shadow evacuation" as the movement of people from areas *outside* the EPZ for whom no protective action recommendation has been issued. Both voluntary and shadow evacuation are assumed to take place over the same time frame as the evacuation from within the impacted Evacuation Region.

The ETE for the CPNPP addresses the issue of voluntary evacuees as discussed in Section 2.2 and displayed in Figure 7-1 (same as Figure 2-1). Figure 7-2 presents the area identified as the Shadow Evacuation Region. This region extends radially from the boundary of the EPZ to a distance of 15 miles from CPNPP.

Traffic generated within this Shadow Evacuation Region, traveling away from the CPNPP location, has a potential for impeding evacuating vehicles from within the Evacuation Region. We assume that the traffic volumes emitted within the Shadow Evacuation Region correspond to 30 percent of the residents there plus a proportionate number of employees in that region. **All ETE calculations include this shadow traffic movement.**

7.2 Patterns of Traffic Congestion during Evacuation

Figures 7-3 through 7-6 illustrate the patterns of traffic congestion that arise for the case when the entire EPZ (Region R03) is advised to evacuate during the summer, midweek, midday period under good weather conditions (Scenario 1).

Traffic congestion, as the term is used here, is defined as Level of Service (LOS) F. LOS F is defined as follows (2000 HCM):

> Level of Service F is used to define forced or breakdown flow. This condition exists wherever the amount of traffic approaching a point exceeds the amount that can traverse the point. Queues form behind such locations. Operations within the queue are characterized by stop-and-go waves, and they are extremely unstable. Vehicles may progress at reasonable speeds for several hundred feet or more, then be required to stop in a cyclic fashion. Level of Service F is used to describe the operating conditions within the queue, as well as the point of the breakdown. It should be noted, however, that in many cases operating conditions of vehicles or pedestrians discharged from the queue may be quite good. Nevertheless, it is the point at which arrival flow exceeds discharge flow, which causes the queue to form, and Level of Service F is an appropriate designation for such points.

This definition is general and conceptual in nature, and applies primarily to uninterrupted flow. Levels of Service for interrupted flow facilities vary widely in terms of both the user's perception of service quality and the operational variables used to describe them.

All highway "links" which experience LOS F at the indicated times are delineated in these Figures by a red line; all others are lightly indicated. Congestion develops in areas with concentrations of population and at traffic bottlenecks. Figure 7-3 shows the areas of congestion 1 hour after the Advisory to Evacuate (ATE). Congestion exists southbound on US Hwy 377 due to the reduction of speed for traffic entering Tolar. The merge between northbound US Hwy 377 and Business US Hwy 377 also exhibits pronounced congestion. The densely populated areas between Mambrino Hwy and Lake Granbury result in pronounced congestion on the approaches to northbound State Hwy 144. Neri Road was utilized to divert northbound traffic from State Hwy 144 to FM 51 northbound and provide the available capacity on State Hwy 144 to those evacuating from these densely populated areas. In Somervell County, US Hwy 67 also exhibits congestion at 1 hour after the ATE.

Some congestion persists at 2 hours after the ATE (Figure 7-4). The Contrary Creek Road approach to FM 51 northbound is congested within the EPZ, while Cleburne Hwy (FM 4) eastbound and US Hwy 377 are congested outside of the EPZ. By 2 and a half hours after the ATE (Figure 7-5), the only remaining congestion is on FM 4 eastbound, outside the EPZ. Figure 7-6 indicates that by 2 hours and 45 minutes after the ATE, all roadways are free-flowing (LOS A). The absence of congestion on network links (white colored links) implies that traffic demand there has decreased below the roadway capacity for a period of time sufficient to dissipate any traffic queues. It does not necessarily imply that traffic has completely cleared from these roadway sections.

7.3 Evacuation Rates

Evacuation is a continuous process, as implied by Figures 7-3 through 7-6. Another format for displaying the dynamics of evacuation is depicted in Figure 7-7. This plot indicates the rate at which traffic flows out of the indicated areas for the case of an evacuation of the entire EPZ (Region R03) under the indicated conditions. Appendix J presents these plots for all Evacuation Scenarios for Region R03.

As indicated in Figure 7-7, there is typically a long "tail" to these distributions. Vehicles evacuate an area slowly at the beginning, as people respond to the Advisory to Evacuate 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. It is reasonable to expect that some evacuees may delay or lengthen their mobilization activities and evacuate at a later time as a result; these ETE estimates do not (and should not) be distorted to account for these relatively few stragglers.

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 the real world, this ideal is generally unattainable reflecting the variation in population density and in highway capacity over the EPZ.

7.4 Guidance on Using ETE Tables

Tables 7-1A through 7-1D present the ETE values for all 63 Evacuation Regions and all 13 Evacuation Scenarios. They are organized as follows:

Table	Contents
7-1A	ETE represents the elapsed time required for 50 percent of the population within a Region, to evacuate from that Region.
7-1B	ETE represents the elapsed time required for 90 percent of the population within a Region, to evacuate from that Region.
7-1C	ETE represents the elapsed time required for 95 percent of the population within a Region, to evacuate from that Region.
7-1D	ETE represents the elapsed time required for 100 percent of the population within a Region, to evacuate from that Region.

The user first determines the percentile of population for which the ETE is sought. The applicable value of ETE within the chosen Table may then be identified using the following procedure:

1. Identify the applicable **Scenario**:
    - The Season
        - Summer (schools not in session)
        - Winter (also Autumn and Spring)
    - The Day of Week
        - Midweek (work-day)
        - Weekend, Holiday
    - The Time of Day
        - Midday (work and commuting hours)
        - Evening
    - Weather Condition
        - Good Weather
        - Rain
    - Special Event (if any)
        - Event at the Amphitheatre
        - New Plant Construction
        - Fourth of July Celebration in Granbury

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 Tables 7-1A through 7-1D. For these conditions, Scenario (4) applies.
- The conditions of a winter evening (either midweek or weekend) and rain are not explicitly identified in Tables 7-1A through 7-1D. For these conditions, Scenario (9) applies.
- The seasons are defined as follows:
  - Summer implies that public schools are not in session.
  - Winter, Spring and Autumn imply that public schools are in session.
- Time of Day: Midday implies the time over which most commuters are at work.

2. With the Scenario (and column in the Table) 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 CPNPP. The applicable distances and their associated candidate Regions are given below:
     - 2 Miles (Region R01)
     - 5 Miles (Regions R02, R04 through R17, and R34 through R47)
     - to EPZ Boundary (Regions R03, R18 through R33, and R48 through R63)
   - Enter Table 7-2 and identify the applicable candidate Region based on the wind direction and on the distance that the selected Region extends from CPNPP. Select the Evacuation Region identifier in that row from the first column of the Table.

3. Determine the **ETE for the Scenario** identified in Step 1 and the Region identified in Step 2, 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 determined 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 northeast (NE).
- Wind speed and plume extent, are such that the distance to be evacuated is judged to be 10 miles (to EPZ boundary) with a width of 5 sectors (112.5 degrees).
- The desired ETE is that value needed to evacuate 95 percent of the population from within the impacted Region.

Table 7-1C is applicable because the 95th-percentile population is desired. Proceed as follows:

1. Identify the Scenario as summer, weekend, evening and raining. Entering Table 7-1C, 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 7-2 and locate the group entitled "2-Mile Ring and Downwind to EPZ Boundary (5 Sector Groups)". Under "Wind Direction Toward:", identify the NE (northeast) azimuth and read REGION R50 in the first column of that row.
3. Enter Table 7-1C to locate the data cell containing the value of ETE for Scenario 4 and Region R50. This data cell is in column (4) and in the row for Region R50; it contains the ETE value of **2:20.**

Table 7-1A. Time to Clear the Indicated Area of 50 Percent of The Affected Population (page 1 of 2)

	Summer		Summer		Summer		Winter		Winter		Winter		Summer	Summer	Summer
	Midweek		Weekend		Midweek Weekend		Midweek		Weekend		Midweek Weekend		Weekend	Midweek	Weekend
Scenario:	(1)	(2)	(3)	(4)	(5)	Scenario:	(6)	(7)	(8)	(9)	(10)	Scenario:	(11)	(12)	(13)
Region Wind Toward:	Midday		Midday		Evening	Region Wind Toward:	Midday		Midday		Evening	Region Wind Toward:	Midday	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather		Good Weather	Rain	Good Weather	Rain	Good Weather		Event in Amphitheatre	New Plant Construction	Granbury 4th of July
Entire 2-Mile Region, 5-Mile Region, and EPZ															
R01 2-mile ring	0:45	0:45	0:45	0:45	0:45	R01 2-mile ring	0:45	0:45	0:45	0:45	0:45	R01 2-mile ring	0:45	1:10	0:45
R02 5-mile ring	1:00	1:00	0:55	1:00	0:55	R02 5-mile ring	1:00	1:00	0:55	0:55	0:55	R02 5-mile ring	1:05	1:10	0:55
R03 Entire EPZ	1:10	1:15	1:05	1:10	1:05	R03 Entire EPZ	1:10	1:15	1:05	1:10	1:05	R03 Entire EPZ	1:10	1:20	1:25
2-Mile Ring and Downwind to 5 Miles (3 sector groups)															
R04 N	0:55	0:55	0:55	0:55	0:55	R04 N	0:55	0:55	0:55	0:55	0:55	R04 N	0:55	1:10	0:55
R05 NNE	0:55	0:55	0:50	0:55	0:55	R05 NNE	0:55	0:55	0:50	0:55	0:55	R05 NNE	0:50	1:10	0:50
R06 NE	0:55	0:55	0:50	0:55	0:50	R06 NE	0:55	0:55	0:50	0:55	0:55	R06 NE	0:55	1:05	0:50
R07 ENE	0:55	0:55	0:50	0:50	0:50	R07 ENE	0:55	0:55	0:50	0:50	0:50	R07 ENE	0:55	1:05	0:50
R08 E	0:50	0:50	0:50	0:50	0:50	R08 E	0:50	0:55	0:50	0:50	0:50	R08 E	0:55	1:05	0:50
R09 ESE	0:55	1:00	0:55	1:00	0:55	R09 ESE	0:55	0:55	0:55	0:55	0:50	R09 ESE	1:05	1:10	0:55
R10 SE	0:55	1:00	0:55	1:00	0:55	R10 SE	0:55	0:55	0:55	0:55	0:50	R10 SE	1:05	1:10	0:55
R11 SSE, S	0:55	0:55	0:55	0:55	0:50	R11 SSE, S	0:50	0:50	0:50	0:50	0:50	R11 SSE, S	1:00	1:05	0:55
R12 SSW	0:55	0:55	0:55	0:55	0:50	R12 SSW	0:50	0:50	0:50	0:50	0:50	R12 SSW	1:00	1:05	0:55
R13 SW	0:50	0:50	0:50	0:50	0:50	R13 SW	0:50	0:50	0:50	0:50	0:50	R13 SW	0:50	1:10	0:50
R14 WSW	0:55	0:55	0:50	0:55	0:50	R14 WSW	0:55	0:55	0:50	0:55	0:55	R14 WSW	0:50	1:10	0:50
R15 W	0:55	0:55	0:55	0:55	0:55	R15 W	0:55	0:55	0:55	0:55	0:55	R15 W	0:55	1:10	0:55
R16 WNW	0:55	0:55	0:55	0:55	0:55	R16 WNW	0:55	0:55	0:55	0:55	0:55	R16 WNW	0:55	1:10	0:55
R17 NW, NNW	0:55	0:55	0:55	0:55	0:55	R17 NW, NNW	0:55	0:55	0:55	0:55	0:55	R17 NW, NNW	0:55	1:10	0:55
2-Mile Ring and Downwind to EPZ Boundary (3 sector groups)															
R18 N	1:10	1:15	1:05	1:10	1:05	R18 N	1:10	1:15	1:05	1:10	1:05	R18 N	1:05	1:15	1:30
R19 NNE	1:10	1:10	1:05	1:05	1:05	R19 NNE	1:10	1:10	1:05	1:05	1:05	R19 NNE	1:05	1:15	1:25
R20 NE	1:05	1:05	1:00	1:00	1:00	R20 NE	1:05	1:05	1:00	1:00	1:00	R20 NE	1:00	1:10	1:05
R21 ENE	1:00	1:00	0:55	0:55	0:55	R21 ENE	1:00	1:00	0:55	0:55	0:55	R21 ENE	0:55	1:05	0:55
R22 E	1:00	1:00	0:55	0:55	0:55	R22 E	1:00	1:00	0:55	0:55	0:55	R22 E	0:55	1:05	0:55
R23 ESE	1:00	1:00	1:00	1:00	0:55	R23 ESE	1:00	1:00	0:55	1:00	0:55	R23 ESE	1:05	1:10	1:00
R24 SE	1:00	1:00	1:00	1:00	0:55	R24 SE	1:00	1:00	0:55	1:00	0:55	R24 SE	1:05	1:10	1:00
R25 SSE	1:05	1:05	1:00	1:05	1:00	R25 SSE	1:00	1:05	1:00	1:00	0:55	R25 SSE	1:05	1:15	1:00
R26 S	1:00	1:05	1:00	1:05	0:55	R26 S	0:55	1:00	0:55	1:00	0:50	R26 S	1:05	1:15	1:00
R27 SSW	1:00	1:00	1:00	1:00	0:55	R27 SSW	0:55	1:00	0:55	1:00	0:50	R27 SSW	1:05	1:10	1:00
R28 SW	0:55	1:00	0:55	0:55	0:55	R28 SW	0:55	1:00	0:55	0:55	0:55	R28 SW	0:55	1:15	0:55
R29 WSW	1:00	1:00	0:55	0:55	0:55	R29 WSW	1:00	1:00	0:55	0:55	0:55	R29 WSW	0:55	1:15	0:55
R30 W	1:05	1:05	1:00	1:00	1:00	R30 W	1:05	1:05	1:00	1:00	1:00	R30 W	1:00	1:15	1:05
R31 WNW	1:05	1:05	1:00	1:00	1:00	R31 WNW	1:05	1:05	1:00	1:00	1:00	R31 WNW	1:00	1:15	1:05
R32 NW	1:05	1:05	1:00	1:00	1:00	R32 NW	1:05	1:05	1:00	1:00	1:00	R32 NW	1:00	1:15	1:05
R33 NNW	1:10	1:15	1:05	1:10	1:05	R33 NNW	1:10	1:15	1:05	1:10	1:05	R33 NNW	1:05	1:15	1:35

Table 7-1A. Time to Clear the Indicated Area of 50 Percent of The Affected Population (page 2 of 2)

	Summer		Summer		Summer		Winter		Winter		Winter		Summer	Summer	Summer
	Midweek		Weekend		Midweek Weekend		Midweek		Weekend		Midweek Weekend		Weekend	Midweek	Weekend
Scenario:	(1)	(2)	(3)	(4)	(5)	Scenario:	(6)	(7)	(8)	(9)	(10)	Scenario:	(11)	(12)	(13)
Region Wind Toward:	Midday		Midday		Evening	Region Wind Toward:	Midday		Midday		Evening	Region Wind Toward:	Midday	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather		Good Weather	Rain	Good Weather	Rain	Good Weather		Event in Amphitheatre	New Plant Construction	Granbury 4th of July
2-Mile Ring and Downwind to 5 Miles (5 sector groups)															
R34 N	1:00	1:00	0:55	0:55	0:55	R34 N	1:00	1:00	0:55	0:55	0:55	R34 N	0:55	1:10	0:55
R35 NNE	0:55	1:00	0:55	0:55	0:55	R35 NNE	0:55	1:00	0:55	0:55	0:55	R35 NNE	0:55	1:10	0:55
R36 NE	0:55	0:55	0:50	0:55	0:50	R36 NE	0:55	0:55	0:50	0:55	0:55	R36 NE	0:55	1:05	0:50
R37 ENE	0:55	0:55	0:55	0:55	0:50	R37 ENE	0:55	0:55	0:50	0:55	0:50	R37 ENE	0:55	1:05	0:55
R38 E	0:55	1:00	0:55	1:00	0:55	R38 E	0:55	0:55	0:55	0:55	0:50	R38 E	1:05	1:10	0:55
R39 ESE	0:55	0:55	0:55	1:00	0:55	R39 ESE	0:55	0:55	0:50	0:55	0:50	R39 ESE	1:05	1:10	0:55
R40 SE	0:55	0:55	0:55	1:00	0:55	R40 SE	0:55	0:55	0:50	0:55	0:50	R40 SE	1:05	1:10	0:55
R41 SSE, S	0:55	0:55	0:50	0:55	0:50	R41 SSE, S	0:50	0:55	0:50	0:50	0:50	R41 SSE, S	1:00	1:05	0:50
R42 SSW	0:55	0:55	0:55	0:55	0:50	R42 SSW	0:55	0:55	0:50	0:50	0:50	R42 SSW	1:00	1:05	0:55
R43 SW	0:55	0:55	0:55	0:55	0:50	R43 SW	0:55	0:55	0:50	0:55	0:50	R43 SW	1:00	1:05	0:55
R44 WSW	0:55	0:55	0:50	0:55	0:50	R44 WSW	0:55	0:55	0:50	0:55	0:55	R44 WSW	0:50	1:10	0:50
R45 W	1:00	1:00	0:55	0:55	0:55	R45 W	1:00	1:00	0:55	0:55	0:55	R45 W	0:55	1:15	0:55
R46 WNW	1:00	1:00	0:55	0:55	0:55	R46 WNW	1:00	1:00	0:55	0:55	0:55	R46 WNW	0:55	1:15	0:55
R47 NW, NNW	0:55	1:00	0:55	0:55	0:55	R47 NW, NNW	0:55	1:00	0:55	0:55	0:55	R47 NW, NNW	0:55	1:10	0:55
2-Mile Ring and Downwind to EPZ Boundary (5 sector groups)															
R48 N	1:10	1:15	1:05	1:10	1:05	R48 N	1:10	1:15	1:05	1:10	1:05	R48 N	1:05	1:15	1:30
R49 NNE	1:05	1:10	1:05	1:05	1:05	R49 NNE	1:10	1:10	1:05	1:05	1:05	R49 NNE	1:05	1:15	1:25
R50 NE	1:05	1:10	1:00	1:05	1:00	R50 NE	1:05	1:10	1:00	1:05	1:00	R50 NE	1:05	1:15	1:20
R51 ENE	1:05	1:05	1:00	1:00	1:00	R51 ENE	1:05	1:05	1:00	1:00	1:00	R51 ENE	1:00	1:10	1:05
R52 E	1:00	1:05	1:00	1:00	0:55	R52 E	1:00	1:00	0:55	1:00	0:55	R52 E	1:00	1:10	1:00
R53 ESE	1:00	1:05	1:00	1:00	0:55	R53 ESE	1:00	1:00	0:55	1:00	0:55	R53 ESE	1:00	1:10	1:00
R54 SE	1:05	1:05	1:00	1:05	1:00	R54 SE	1:00	1:05	1:00	1:00	0:55	R54 SE	1:05	1:15	1:00
R55 SSE	1:05	1:05	1:00	1:05	1:00	R55 SSE	1:00	1:05	1:00	1:00	0:55	R55 SSE	1:05	1:15	1:00
R56 S	1:00	1:05	1:00	1:05	0:55	R56 S	1:00	1:00	0:55	1:00	0:55	R56 S	1:10	1:15	1:00
R57 SSW	1:00	1:05	1:00	1:05	0:55	R57 SSW	1:00	1:00	0:55	1:00	0:55	R57 SSW	1:05	1:15	1:00
R58 SW	1:00	1:05	1:00	1:00	0:55	R58 SW	1:00	1:00	0:55	1:00	0:55	R58 SW	1:05	1:15	1:00
R59 WSW	1:00	1:05	1:00	1:00	0:55	R59 WSW	1:00	1:05	0:55	1:00	0:55	R59 WSW	1:00	1:15	1:00
R60 W	1:05	1:05	1:00	1:00	1:00	R60 W	1:05	1:05	1:00	1:00	1:00	R60 W	1:00	1:15	1:00
R61 WNW	1:05	1:05	1:00	1:00	1:00	R61 WNW	1:05	1:10	1:00	1:00	1:00	R61 WNW	1:00	1:15	1:05
R62 NW	1:10	1:15	1:05	1:10	1:05	R62 NW	1:10	1:15	1:05	1:10	1:05	R62 NW	1:05	1:20	1:35
R63 NNW	1:10	1:15	1:05	1:10	1:05	R63 NNW	1:10	1:15	1:05	1:10	1:05	R63 NNW	1:05	1:15	1:30

Table 7-1B. Time to Clear the Indicated Area of 90 Percent of The Affected Population (page 1 of 2)

	Summer		Summer		Summer		Winter		Winter		Winter		Summer	Summer	Summer
	Midweek		Weekend		Midweek Weekend		Midweek		Weekend		Midweek Weekend		Weekend	Midweek	Weekend
Scenario:	(1)	(2)	(3)	(4)	(5)	Scenario:	(6)	(7)	(8)	(9)	(10)	Scenario:	(11)	(12)	(13)
Region Wind Toward:	Midday		Midday		Evening	Region Wind Toward:	Midday		Midday		Evening	Region Wind Toward:	Midday	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather		Good Weather	Rain	Good Weather	Rain	Good Weather		Event in Amphitheatre	New Plant Construction	Granbury 4th of July
Entire 2-Mile Region, 5-Mile Region, and EPZ															
R01 2-mile ring	1:25	1:25	1:20	1:20	1:25	R01 2-mile ring	1:25	1:25	1:20	1:20	1:25	R01 2-mile ring	1:20	2:05	1:20
R02 5-mile ring	1:50	1:50	1:40	1:50	1:35	R02 5-mile ring	1:50	1:50	1:35	1:40	1:30	R02 5-mile ring	2:20	2:10	1:40
R03 Entire EPZ	2:10	2:15	2:00	2:05	1:55	R03 Entire EPZ	2:10	2:20	1:55	2:00	1:55	R03 Entire EPZ	2:10	2:25	2:50
2-Mile Ring and Downwind to 5 Miles (3 sector groups)															
R04 N	1:50	1:50	1:30	1:35	1:35	R04 N	1:50	1:50	1:30	1:35	1:35	R04 N	1:30	2:05	1:30
R05 NNE	1:50	1:50	1:30	1:30	1:30	R05 NNE	1:50	1:50	1:30	1:30	1:30	R05 NNE	1:30	2:05	1:30
R06 NE	1:50	1:50	1:30	1:30	1:30	R06 NE	1:50	1:50	1:30	1:30	1:30	R06 NE	1:35	2:05	1:30
R07 ENE	1:40	1:40	1:30	1:30	1:30	R07 ENE	1:40	1:40	1:30	1:30	1:30	R07 ENE	1:35	2:05	1:30
R08 E	1:40	1:40	1:30	1:30	1:30	R08 E	1:40	1:40	1:30	1:30	1:30	R08 E	1:35	2:05	1:30
R09 ESE	1:45	1:50	1:45	1:50	1:35	R09 ESE	1:40	1:40	1:35	1:40	1:30	R09 ESE	2:20	2:05	1:45
R10 SE	1:45	1:50	1:40	1:50	1:35	R10 SE	1:40	1:40	1:35	1:40	1:30	R10 SE	2:20	2:05	1:40
R11 SSE, S	1:40	1:40	1:35	1:40	1:30	R11 SSE, S	1:40	1:40	1:25	1:30	1:25	R11 SSE, S	2:20	2:05	1:35
R12 SSW	1:40	1:40	1:35	1:40	1:30	R12 SSW	1:40	1:40	1:25	1:30	1:25	R12 SSW	2:20	2:05	1:35
R13 SW	1:30	1:30	1:25	1:25	1:25	R13 SW	1:30	1:30	1:25	1:25	1:25	R13 SW	1:25	2:10	1:25
R14 WSW	1:40	1:40	1:30	1:30	1:30	R14 WSW	1:40	1:40	1:30	1:30	1:30	R14 WSW	1:30	2:10	1:30
R15 W	1:40	1:40	1:30	1:30	1:30	R15 W	1:40	1:40	1:30	1:30	1:30	R15 W	1:30	2:10	1:30
R16 WNW	1:40	1:40	1:30	1:30	1:30	R16 WNW	1:40	1:40	1:30	1:30	1:30	R16 WNW	1:30	2:10	1:30
R17 NW, NNW	1:40	1:40	1:30	1:30	1:30	R17 NW, NNW	1:40	1:40	1:30	1:30	1:30	R17 NW, NNW	1:30	2:05	1:30
2-Mile Ring and Downwind to EPZ Boundary (3 sector groups)															
R18 N	2:10	2:20	1:55	2:00	1:55	R18 N	2:20	2:20	1:55	2:00	1:55	R18 N	1:55	2:15	3:00
R19 NNE	2:10	2:20	1:55	2:00	1:55	R19 NNE	2:10	2:20	1:55	2:00	1:55	R19 NNE	1:55	2:15	2:50
R20 NE	2:10	2:10	1:50	1:55	1:50	R20 NE	2:10	2:10	1:50	1:55	1:50	R20 NE	1:50	2:10	2:10
R21 ENE	2:00	2:00	1:35	1:35	1:35	R21 ENE	2:00	2:00	1:35	1:40	1:35	R21 ENE	1:40	2:05	1:35
R22 E	2:00	2:00	1:35	1:35	1:35	R22 E	2:00	2:00	1:35	1:35	1:35	R22 E	1:40	2:05	1:35
R23 ESE	1:50	1:55	1:45	1:50	1:40	R23 ESE	1:50	1:50	1:35	1:40	1:35	R23 ESE	2:20	2:10	1:45
R24 SE	1:50	1:55	1:45	1:50	1:40	R24 SE	1:50	1:50	1:35	1:40	1:35	R24 SE	2:20	2:10	1:45
R25 SSE	1:50	1:55	1:45	1:55	1:35	R25 SSE	1:50	1:50	1:35	1:45	1:35	R25 SSE	2:20	2:15	1:45
R26 S	1:45	1:55	1:45	1:55	1:35	R26 S	1:50	1:50	1:35	1:40	1:30	R26 S	2:10	2:15	1:45
R27 SSW	1:45	1:50	1:45	1:50	1:35	R27 SSW	1:45	1:50	1:35	1:40	1:30	R27 SSW	2:20	2:20	1:45
R28 SW	1:40	1:40	1:35	1:35	1:30	R28 SW	1:40	1:45	1:30	1:35	1:30	R28 SW	1:35	2:15	1:35
R29 WSW	1:50	1:50	1:35	1:35	1:35	R29 WSW	1:50	1:50	1:35	1:35	1:35	R29 WSW	1:35	2:15	1:35
R30 W	2:00	2:10	1:40	1:40	1:40	R30 W	2:10	2:10	1:40	1:40	1:40	R30 W	1:40	2:10	1:55
R31 WNW	2:10	2:10	1:40	1:40	1:40	R31 WNW	2:10	2:10	1:40	1:40	1:40	R31 WNW	1:40	2:15	2:00
R32 NW	2:10	2:10	1:40	1:40	1:40	R32 NW	2:10	2:10	1:40	1:40	1:40	R32 NW	1:40	2:15	2:00
R33 NNW	2:10	2:20	1:55	2:05	2:00	R33 NNW	2:10	2:20	1:55	2:05	2:00	R33 NNW	1:55	2:15	3:00

Table 7-1B. Time to Clear the Indicated Area of 90 Percent of The Affected Population (page 2 of 2)

	Summer		Summer		Summer		Winter		Winter		Winter		Summer	Summer	Summer
	Midweek		Weekend		Midweek Weekend		Midweek		Weekend		Midweek Weekend		Weekend	Midweek	Weekend
Scenario:	(1)	(2)	(3)	(4)	(5)	Scenario:	(6)	(7)	(8)	(9)	(10)	Scenario:	(11)	(12)	(13)
Region Wind Toward:	Midday		Midday		Evening	Region Wind Toward:	Midday		Midday		Evening	Region Wind Toward:	Midday	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather		Good Weather	Rain	Good Weather	Rain	Good Weather		Event in Amphitheatre	New Plant Construction	Granbury 4th of July
2-Mile Ring and Downwind to 5 Miles (5 sector groups)															
R34 N	1:50	1:50	1:35	1:35	1:35	R34 N	1:50	1:50	1:35	1:35	1:35	R34 N	1:35	2:05	1:35
R35 NNE	1:50	1:50	1:30	1:35	1:35	R35 NNE	1:50	1:50	1:30	1:35	1:35	R35 NNE	1:35	2:05	1:30
R36 NE	1:50	1:50	1:30	1:30	1:30	R36 NE	1:50	1:50	1:30	1:30	1:30	R36 NE	1:35	2:05	1:30
R37 ENE	1:40	1:50	1:35	1:35	1:30	R37 ENE	1:50	1:50	1:30	1:30	1:30	R37 ENE	1:40	2:05	1:35
R38 E	1:45	1:50	1:45	1:50	1:35	R38 E	1:40	1:40	1:35	1:40	1:30	R38 E	2:20	2:05	1:45
R39 ESE	1:45	1:50	1:40	1:50	1:35	R39 ESE	1:40	1:40	1:35	1:40	1:30	R39 ESE	2:20	2:05	1:40
R40 SE	1:40	1:50	1:40	1:45	1:35	R40 SE	1:40	1:40	1:30	1:40	1:30	R40 SE	2:20	2:05	1:40
R41 SSE, S	1:40	1:40	1:35	1:40	1:30	R41 SSE, S	1:40	1:40	1:25	1:30	1:25	R41 SSE, S	2:20	2:05	1:35
R42 SSW	1:40	1:40	1:35	1:40	1:30	R42 SSW	1:40	1:40	1:30	1:30	1:30	R42 SSW	2:20	2:05	1:35
R43 SW	1:40	1:45	1:35	1:40	1:30	R43 SW	1:40	1:40	1:30	1:30	1:30	R43 SW	2:10	2:05	1:35
R44 WSW	1:40	1:40	1:30	1:30	1:30	R44 WSW	1:40	1:40	1:30	1:30	1:30	R44 WSW	1:30	2:10	1:30
R45 W	1:50	1:50	1:35	1:35	1:35	R45 W	1:50	1:50	1:35	1:35	1:35	R45 W	1:35	2:10	1:35
R46 WNW	1:50	1:50	1:35	1:35	1:35	R46 WNW	1:50	1:50	1:35	1:35	1:35	R46 WNW	1:35	2:10	1:35
R47 NW, NNW	1:50	1:50	1:30	1:35	1:35	R47 NW, NNW	1:50	1:50	1:30	1:35	1:35	R47 NW, NNW	1:30	2:05	1:30
2-Mile Ring and Downwind to EPZ Boundary (5 sector groups)															
R48 N	2:20	2:20	2:00	2:05	1:55	R48 N	2:20	2:20	2:00	2:05	1:55	R48 N	2:00	2:20	3:00
R49 NNE	2:10	2:20	1:55	2:00	1:55	R49 NNE	2:10	2:20	1:55	2:00	1:55	R49 NNE	1:55	2:15	3:00
R50 NE	2:10	2:10	1:50	2:00	1:50	R50 NE	2:10	2:15	1:50	2:00	1:50	R50 NE	1:50	2:15	2:50
R51 ENE	2:10	2:10	1:50	2:00	1:50	R51 ENE	2:10	2:10	1:50	2:00	1:50	R51 ENE	1:50	2:10	2:10
R52 E	2:00	2:00	1:45	1:50	1:40	R52 E	2:00	2:00	1:40	1:40	1:35	R52 E	2:10	2:10	1:45
R53 ESE	2:00	2:00	1:45	1:50	1:40	R53 ESE	2:00	2:00	1:40	1:40	1:35	R53 ESE	2:10	2:10	1:45
R54 SE	1:55	2:00	1:50	2:00	1:40	R54 SE	1:50	1:55	1:40	1:45	1:35	R54 SE	2:20	2:15	1:50
R55 SSE	1:55	2:00	1:50	2:00	1:40	R55 SSE	1:50	1:50	1:40	1:45	1:35	R55 SSE	2:20	2:15	1:50
R56 S	1:50	1:55	1:45	1:55	1:35	R56 S	1:50	1:50	1:35	1:45	1:30	R56 S	2:25	2:15	1:45
R57 SSW	1:50	1:55	1:45	1:55	1:35	R57 SSW	1:50	1:50	1:35	1:40	1:30	R57 SSW	2:10	2:20	1:45
R58 SW	1:50	1:55	1:45	1:50	1:35	R58 SW	1:50	1:50	1:35	1:40	1:30	R58 SW	2:10	2:20	1:45
R59 WSW	2:00	2:00	1:40	1:40	1:40	R59 WSW	2:00	2:00	1:40	1:40	1:40	R59 WSW	1:40	2:15	1:50
R60 W	2:00	2:00	1:40	1:40	1:40	R60 W	2:00	2:00	1:40	1:40	1:40	R60 W	1:40	2:15	1:55
R61 WNW	2:10	2:10	1:40	1:40	1:40	R61 WNW	2:10	2:10	1:40	1:40	1:40	R61 WNW	1:40	2:15	2:00
R62 NW	2:10	2:20	2:00	2:05	2:00	R62 NW	2:20	2:20	2:00	2:05	2:00	R62 NW	2:00	2:20	3:00
R63 NNW	2:20	2:20	2:00	2:05	1:55	R63 NNW	2:20	2:20	2:00	2:05	1:55	R63 NNW	2:00	2:20	3:00

Table 7-1C. Time to Clear the Indicated Area of 95 Percent of The Affected Population (page 1 of 2)

	Summer		Summer		Summer		Winter		Winter		Winter		Summer	Summer	Summer
	Midweek		Weekend		Midweek Weekend		Midweek		Weekend		Midweek Weekend		Weekend	Midweek	Weekend
Scenario:	(1)	(2)	(3)	(4)	(5)	Scenario:	(6)	(7)	(8)	(9)	(10)	Scenario:	(11)	(12)	(13)
Region Wind Toward:	Midday		Midday		Evening	Region Wind Toward:	Midday		Midday		Evening	Region Wind Toward:	Midday	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather		Good Weather	Rain	Good Weather	Rain	Good Weather		Event in Amphitheatre	New Plant Construction	Granbury 4th of July
Entire 2-Mile Region, 5-Mile Region, and EPZ															
R01 2-mile ring	1:40	1:40	1:30	1:30	1:30	R01 2-mile ring	1:40	1:40	1:30	1:30	1:30	R01 2-mile ring	1:30	2:15	1:30
R02 5-mile ring	2:20	2:20	2:10	2:10	2:00	R02 5-mile ring	2:20	2:20	1:50	1:50	1:50	R02 5-mile ring	2:40	2:20	1:50
R03 Entire EPZ	2:50	2:50	2:10	2:20	2:10	R03 Entire EPZ	2:40	2:40	2:10	2:20	2:10	R03 Entire EPZ	2:30	2:40	3:10
2-Mile Ring and Downwind to 5 Miles (3 sector groups)															
R04 N	2:20	2:20	1:50	1:50	2:00	R04 N	2:20	2:20	1:50	1:50	2:00	R04 N	1:50	2:15	1:50
R05 NNE	2:20	2:20	1:50	1:50	1:50	R05 NNE	2:20	2:20	1:50	1:50	1:50	R05 NNE	1:50	2:15	1:50
R06 NE	2:10	2:10	1:50	1:50	1:50	R06 NE	2:10	2:10	1:50	1:50	1:50	R06 NE	1:45	2:15	1:50
R07 ENE	2:10	2:10	1:40	1:50	1:50	R07 ENE	2:10	2:10	1:50	1:50	1:50	R07 ENE	1:45	2:15	1:40
R08 E	2:00	2:00	1:40	1:40	1:50	R08 E	2:00	2:00	1:40	1:40	1:50	R08 E	1:45	2:15	1:40
R09 ESE	2:00	2:00	1:55	2:00	1:45	R09 ESE	2:10	2:10	1:40	1:50	1:50	R09 ESE	2:50	2:15	1:55
R10 SE	2:00	2:00	1:50	2:00	1:40	R10 SE	2:10	2:10	1:40	1:50	1:50	R10 SE	2:50	2:15	1:50
R11 SSE, S	1:50	2:00	1:45	1:50	1:40	R11 SSE, S	2:00	2:00	1:40	1:40	1:40	R11 SSE, S	2:40	2:15	1:45
R12 SSW	2:00	2:00	1:45	1:50	1:40	R12 SSW	2:00	2:00	1:40	1:40	1:40	R12 SSW	2:40	2:15	1:45
R13 SW	1:50	2:00	1:40	1:40	1:40	R13 SW	1:50	2:00	1:40	1:40	1:40	R13 SW	1:40	2:15	1:40
R14 WSW	2:10	2:10	1:40	1:40	1:50	R14 WSW	2:10	2:10	1:40	1:40	1:50	R14 WSW	1:40	2:20	1:40
R15 W	2:10	2:10	1:40	1:40	1:50	R15 W	2:10	2:10	1:40	1:40	1:50	R15 W	1:40	2:15	1:40
R16 WNW	2:10	2:10	1:40	1:40	1:50	R16 WNW	2:10	2:10	1:40	1:40	1:50	R16 WNW	1:40	2:15	1:40
R17 NW, NNW	2:10	2:10	1:40	1:40	1:50	R17 NW, NNW	2:10	2:10	1:40	1:40	1:50	R17 NW, NNW	1:40	2:15	1:40
2-Mile Ring and Downwind to EPZ Boundary (3 sector groups)															
R18 N	2:50	2:50	2:10	2:20	2:10	R18 N	2:50	2:50	2:10	2:20	2:10	R18 N	2:10	2:40	3:15
R19 NNE	2:50	2:50	2:10	2:20	2:10	R19 NNE	2:50	2:50	2:10	2:20	2:10	R19 NNE	2:10	2:40	3:10
R20 NE	2:40	2:40	2:10	2:10	2:10	R20 NE	2:40	2:40	2:10	2:10	2:10	R20 NE	2:10	2:30	2:20
R21 ENE	2:30	2:30	1:50	1:50	2:00	R21 ENE	2:30	2:30	1:50	2:00	2:00	R21 ENE	1:50	2:20	1:50
R22 E	2:30	2:30	1:50	1:50	2:00	R22 E	2:30	2:30	1:50	1:50	2:00	R22 E	1:50	2:20	1:50
R23 ESE	2:10	2:10	2:00	2:10	1:50	R23 ESE	2:10	2:10	1:50	1:55	1:50	R23 ESE	2:40	2:20	2:00
R24 SE	2:10	2:10	2:00	2:10	1:50	R24 SE	2:10	2:20	1:50	1:55	1:50	R24 SE	2:40	2:20	2:00
R25 SSE	2:10	2:10	1:55	2:05	1:50	R25 SSE	2:10	2:10	1:50	1:55	1:50	R25 SSE	2:40	2:30	1:55
R26 S	2:10	2:10	1:55	2:00	1:50	R26 S	2:10	2:10	1:50	1:50	1:50	R26 S	2:40	2:30	1:55
R27 SSW	2:00	2:05	1:50	2:00	1:50	R27 SSW	2:10	2:10	1:50	1:50	1:50	R27 SSW	2:40	2:40	1:50
R28 SW	2:00	2:00	1:40	1:45	1:40	R28 SW	2:00	2:00	1:40	1:40	1:40	R28 SW	1:40	2:25	1:40
R29 WSW	2:10	2:10	1:50	1:50	1:50	R29 WSW	2:20	2:20	1:50	1:50	1:50	R29 WSW	1:50	2:25	1:50
R30 W	2:40	2:40	2:00	2:00	2:10	R30 W	2:40	2:40	2:00	2:00	2:10	R30 W	2:00	2:25	2:10
R31 WNW	2:40	2:40	2:00	2:00	2:10	R31 WNW	2:40	2:40	2:00	2:00	2:10	R31 WNW	2:00	2:25	2:10
R32 NW	2:40	2:40	2:10	2:10	2:10	R32 NW	2:40	2:50	2:10	2:10	2:10	R32 NW	2:10	2:30	2:15
R33 NNW	2:40	2:50	2:10	2:20	2:10	R33 NNW	2:50	2:50	2:10	2:20	2:10	R33 NNW	2:10	2:40	3:20

Table 7-1C. Time to Clear the Indicated Area of 95 Percent of The Affected Population (page 2 of 2)

	Summer		Summer		Summer		Winter		Winter		Winter		Summer	Summer	Summer
	Midweek		Weekend		Midweek Weekend		Midweek		Weekend		Midweek Weekend		Weekend	Midweek	Weekend
Scenario:	(1)	(2)	(3)	(4)	(5)	Scenario:	(6)	(7)	(8)	(9)	(10)	Scenario:	(11)	(12)	(13)
Region Wind Toward:	Midday		Midday		Evening	Region Wind Toward:	Midday		Midday		Evening	Region Wind Toward:	Midday	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather		Good Weather	Rain	Good Weather	Rain	Good Weather		Event in Amphitheatre	New Plant Construction	Granbury 4th of July
2-Mile Ring and Downwind to 5 Miles (5 sector groups)															
R34 N	2:20	2:20	1:50	1:50	2:00	R34 N	2:20	2:20	1:50	1:50	2:00	R34 N	1:50	2:15	1:50
R35 NNE	2:20	2:20	1:50	1:50	1:50	R35 NNE	2:20	2:20	1:50	1:50	1:50	R35 NNE	1:50	2:15	1:50
R36 NE	2:10	2:10	1:50	1:50	1:50	R36 NE	2:10	2:20	1:50	1:50	1:50	R36 NE	1:45	2:15	1:50
R37 ENE	2:10	2:10	1:40	1:50	1:50	R37 ENE	2:20	2:20	1:40	1:50	1:50	R37 ENE	2:10	2:20	1:40
R38 E	2:00	2:00	1:55	2:00	1:50	R38 E	2:10	2:10	1:40	1:50	1:50	R38 E	2:50	2:15	1:55
R39 ESE	2:00	2:00	1:50	2:00	1:45	R39 ESE	2:10	2:10	1:40	1:50	1:40	R39 ESE	2:40	2:15	1:50
R40 SE	2:00	2:00	1:50	1:55	1:40	R40 SE	2:00	2:00	1:40	1:50	1:40	R40 SE	2:50	2:15	1:50
R41 SSE, S	2:00	2:00	1:45	1:50	1:40	R41 SSE, S	2:00	2:00	1:40	1:40	1:40	R41 SSE, S	2:40	2:15	1:45
R42 SSW	2:00	2:00	1:50	1:50	1:40	R42 SSW	2:00	2:10	1:40	1:40	1:40	R42 SSW	2:40	2:20	1:50
R43 SW	2:10	2:10	1:50	1:50	1:40	R43 SW	2:10	2:10	1:40	1:40	1:50	R43 SW	2:40	2:20	1:50
R44 WSW	2:10	2:10	1:40	1:40	1:50	R44 WSW	2:10	2:10	1:40	1:40	1:50	R44 WSW	1:40	2:20	1:40
R45 W	2:20	2:20	1:50	1:50	2:00	R45 W	2:20	2:20	1:50	1:50	2:00	R45 W	1:50	2:20	1:50
R46 WNW	2:20	2:20	1:50	1:50	2:00	R46 WNW	2:20	2:20	1:50	1:50	2:00	R46 WNW	1:50	2:20	1:50
R47 NW, NNW	2:20	2:20	1:50	1:50	2:00	R47 NW, NNW	2:20	2:20	1:50	1:50	2:00	R47 NW, NNW	1:50	2:15	1:50
2-Mile Ring and Downwind to EPZ Boundary (5 sector groups)															
R48 N	2:50	2:50	2:10	2:20	2:10	R48 N	2:50	2:50	2:10	2:20	2:10	R48 N	2:10	2:40	3:20
R49 NNE	2:40	2:40	2:10	2:20	2:10	R49 NNE	2:40	2:50	2:10	2:20	2:10	R49 NNE	2:10	2:40	3:20
R50 NE	2:40	2:40	2:10	2:20	2:10	R50 NE	2:40	2:40	2:10	2:20	2:10	R50 NE	2:10	2:30	3:10
R51 ENE	2:40	2:40	2:10	2:20	2:10	R51 ENE	2:40	2:40	2:10	2:20	2:10	R51 ENE	2:10	2:30	2:30
R52 E	2:30	2:30	2:00	2:10	1:50	R52 E	2:30	2:30	1:50	1:55	1:50	R52 E	2:40	2:20	2:00
R53 ESE	2:20	2:20	2:00	2:00	1:50	R53 ESE	2:30	2:30	1:50	1:55	1:50	R53 ESE	2:40	2:20	2:00
R54 SE	2:10	2:10	2:00	2:10	1:50	R54 SE	2:20	2:20	1:50	1:55	1:50	R54 SE	2:40	2:30	2:00
R55 SSE	2:10	2:10	2:00	2:10	1:50	R55 SSE	2:20	2:20	1:50	1:55	1:50	R55 SSE	2:40	2:30	2:00
R56 S	2:00	2:10	1:55	2:05	1:50	R56 S	2:10	2:10	1:50	1:50	1:50	R56 S	2:50	2:30	1:55
R57 SSW	2:10	2:10	1:55	2:00	1:50	R57 SSW	2:20	2:20	1:50	1:50	1:50	R57 SSW	2:40	2:35	1:55
R58 SW	2:10	2:20	1:50	2:00	1:50	R58 SW	2:20	2:20	1:50	1:50	1:50	R58 SW	2:40	2:40	1:50
R59 WSW	2:30	2:30	1:50	2:00	2:00	R59 WSW	2:30	2:30	2:00	2:00	2:00	R59 WSW	1:50	2:30	2:05
R60 W	2:30	2:30	2:00	2:00	2:00	R60 W	2:30	2:30	2:00	2:00	2:00	R60 W	2:00	2:25	2:10
R61 WNW	2:40	2:40	2:00	2:10	2:10	R61 WNW	2:40	2:40	2:00	2:10	2:10	R61 WNW	2:00	2:30	2:10
R62 NW	2:50	2:50	2:10	2:20	2:10	R62 NW	2:50	2:50	2:10	2:20	2:10	R62 NW	2:10	2:40	3:20
R63 NNW	2:50	2:50	2:10	2:20	2:10	R63 NNW	2:50	2:50	2:10	2:20	2:10	R63 NNW	2:10	2:40	3:20

Table 7-1D. Time to Clear the Indicated Area of 100 Percent of The Affected Population (page 1 of 2)

	Summer		Summer		Summer		Winter		Winter		Winter		Summer	Summer	Summer
	Midweek		Weekend		Midweek Weekend		Midweek		Weekend		Midweek Weekend		Weekend	Midweek	Weekend
Scenario:	(1)	(2)	(3)	(4)	(5)	Scenario:	(6)	(7)	(8)	(9)	(10)	Scenario:	(11)	(12)	(13)
Region Wind Toward:	Midday		Midday		Evening	Region Wind Toward:	Midday		Midday		Evening	Region Wind Toward:	Midday	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather		Good Weather	Rain	Good Weather	Rain	Good Weather		Event in Amphitheatre	New Plant Construction	Granbury 4th of July
Entire 2-Mile Region, 5-Mile Region, and EPZ															
R01 2-mile ring	3:50	3:50	2:50	3:00	3:00	R01 2-mile ring	3:50	3:50	2:50	2:50	3:00	R01 2-mile ring	2:50	3:50	2:50
R02 5-mile ring	4:10	4:10	3:10	3:10	3:10	R02 5-mile ring	4:10	4:10	3:10	3:10	3:10	R02 5-mile ring	3:10	4:10	3:10
R03 Entire EPZ	4:20	4:20	4:00	4:00	4:00	R03 Entire EPZ	4:20	4:20	4:00	4:00	4:00	R03 Entire EPZ	4:00	4:20	4:00
2-Mile Ring and Downwind to 5 Miles (3 sector groups)															
R04 N	4:10	4:10	3:10	3:10	3:00	R04 N	4:00	4:10	3:10	3:10	3:10	R04 N	3:10	4:10	3:10
R05 NNE	4:00	4:10	3:00	3:00	3:10	R05 NNE	4:00	4:10	3:00	3:10	3:00	R05 NNE	3:00	4:00	3:00
R06 NE	4:00	4:00	3:00	3:00	3:10	R06 NE	4:00	4:10	3:10	3:10	3:10	R06 NE	3:00	4:00	3:00
R07 ENE	4:00	4:00	3:00	3:00	3:00	R07 ENE	4:00	4:00	3:00	3:00	3:00	R07 ENE	3:00	4:00	3:00
R08 E	4:00	4:00	3:00	3:00	3:00	R08 E	4:00	4:00	3:00	3:00	3:00	R08 E	3:00	4:00	3:00
R09 ESE	4:00	4:00	3:00	3:00	3:00	R09 ESE	4:00	4:00	3:00	3:00	3:00	R09 ESE	3:00	4:00	3:00
R10 SE	4:00	4:00	3:00	3:00	3:00	R10 SE	4:00	4:00	3:00	3:00	3:00	R10 SE	3:00	4:00	3:00
R11 SSE, S	4:00	4:00	3:00	3:00	3:00	R11 SSE, S	4:00	4:00	2:50	3:00	3:00	R11 SSE, S	3:00	4:00	3:00
R12 SSW	4:00	4:00	3:00	3:00	3:00	R12 SSW	4:00	4:00	2:50	3:00	3:00	R12 SSW	3:00	4:00	3:00
R13 SW	4:00	4:00	3:00	3:10	3:00	R13 SW	4:00	4:00	3:10	3:10	3:00	R13 SW	3:00	4:00	3:00
R14 WSW	4:10	4:10	3:10	3:10	3:10	R14 WSW	4:00	4:10	3:10	3:10	3:10	R14 WSW	3:10	4:10	3:10
R15 W	4:10	4:10	3:10	3:10	3:10	R15 W	4:00	4:10	3:10	3:10	3:10	R15 W	3:10	4:10	3:10
R16 WNW	4:10	4:10	3:10	3:10	3:10	R16 WNW	4:00	4:10	3:10	3:10	3:10	R16 WNW	3:10	4:10	3:10
R17 NW, NNW	4:10	4:10	3:10	3:10	3:10	R17 NW, NNW	4:00	4:10	3:10	3:10	3:10	R17 NW, NNW	3:10	4:10	3:10
2-Mile Ring and Downwind to EPZ Boundary (3 sector groups)															
R18 N	4:10	4:20	4:00	4:00	4:00	R18 N	4:10	4:10	4:00	4:00	4:00	R18 N	4:00	4:10	4:00
R19 NNE	4:10	4:10	4:00	4:00	3:50	R19 NNE	4:10	4:10	4:00	4:00	4:00	R19 NNE	4:00	4:10	4:00
R20 NE	4:10	4:10	3:50	4:00	3:50	R20 NE	4:10	4:10	3:50	4:00	4:00	R20 NE	3:50	4:10	3:50
R21 ENE	4:00	4:00	3:40	3:40	3:40	R21 ENE	4:00	4:00	3:40	3:40	3:40	R21 ENE	3:40	4:00	3:40
R22 E	4:00	4:00	3:40	3:40	3:40	R22 E	4:00	4:00	3:40	3:40	3:40	R22 E	3:40	4:00	3:40
R23 ESE	4:00	4:00	3:00	3:00	3:00	R23 ESE	4:00	4:00	3:00	3:10	3:00	R23 ESE	3:00	4:00	3:00
R24 SE	4:00	4:00	3:00	3:00	3:00	R24 SE	4:00	4:00	3:00	3:10	3:00	R24 SE	3:00	4:00	3:00
R25 SSE	4:00	4:00	3:00	3:10	3:00	R25 SSE	4:10	4:10	3:10	3:10	3:10	R25 SSE	3:10	4:00	3:00
R26 S	4:00	4:00	3:00	3:10	3:00	R26 S	4:00	4:00	3:00	3:00	3:10	R26 S	3:00	4:00	3:00
R27 SSW	4:00	4:00	3:10	3:10	3:00	R27 SSW	4:00	4:10	3:00	3:00	3:00	R27 SSW	3:00	4:00	3:10
R28 SW	4:00	4:10	3:10	3:10	3:10	R28 SW	4:10	4:10	3:10	3:10	3:10	R28 SW	3:10	4:00	3:10
R29 WSW	4:10	4:10	3:10	3:10	3:10	R29 WSW	4:10	4:10	3:10	3:10	3:10	R29 WSW	3:10	4:10	3:10
R30 W	4:10	4:10	3:50	3:50	4:00	R30 W	4:10	4:10	3:50	3:50	3:50	R30 W	3:50	4:10	3:50
R31 WNW	4:20	4:20	3:50	3:50	4:00	R31 WNW	4:10	4:20	3:50	4:00	4:00	R31 WNW	3:50	4:20	3:50
R32 NW	4:20	4:20	3:50	3:50	3:50	R32 NW	4:20	4:20	3:50	4:00	3:50	R32 NW	3:50	4:20	3:50
R33 NNW	4:10	4:20	4:00	4:00	4:00	R33 NNW	4:10	4:20	4:00	4:00	4:00	R33 NNW	4:00	4:20	4:00

Table 7-1D. Time to Clear the Indicated Area of 100 Percent of The Affected Population (page 2 of 2)

	Summer		Summer		Summer		Winter		Winter		Winter		Summer	Summer	Summer
	Midweek		Weekend		Midweek Weekend		Midweek		Weekend		Midweek Weekend		Weekend	Midweek	Weekend
Scenario:	(1)	(2)	(3)	(4)	(5)	Scenario:	(6)	(7)	(8)	(9)	(10)	Scenario:	(11)	(12)	(13)
Region Wind Toward:	Midday		Midday		Evening	Region Wind Toward:	Midday		Midday		Evening	Region Wind Toward:	Midday	Midday	Midday
	Good Weather	Rain	Good Weather	Rain	Good Weather		Good Weather	Rain	Good Weather	Rain	Good Weather		Event in Amphitheatre	New Plant Construction	Granbury 4th of July
2-Mile Ring and Downwind to 5 Miles (5 sector groups)															
R34 N	4:10	4:10	3:10	3:10	3:10	R34 N	4:00	4:10	3:10	3:10	3:10	R34 N	3:10	4:10	3:10
R35 NNE	4:10	4:10	3:10	3:10	3:10	R35 NNE	4:10	4:10	3:10	3:10	3:10	R35 NNE	3:10	4:10	3:10
R36 NE	4:00	4:00	3:00	3:00	3:10	R36 NE	4:00	4:10	3:10	3:00	3:10	R36 NE	3:00	4:00	3:00
R37 ENE	4:00	4:00	3:00	3:00	3:00	R37 ENE	4:00	4:00	3:00	3:00	3:00	R37 ENE	3:10	4:00	3:00
R38 E	4:00	4:00	3:00	3:00	3:00	R38 E	4:00	4:00	3:00	3:00	3:00	R38 E	3:10	4:00	3:00
R39 ESE	4:00	4:00	3:00	3:00	3:00	R39 ESE	4:00	4:00	3:00	3:00	3:00	R39 ESE	3:10	4:00	3:00
R40 SE	4:00	4:00	3:00	3:00	3:00	R40 SE	4:00	4:00	3:00	3:00	3:00	R40 SE	3:10	4:00	3:00
R41 SSE, S	4:00	4:00	3:00	3:00	3:00	R41 SSE, S	4:00	4:00	3:00	3:00	3:00	R41 SSE, S	3:10	4:00	3:00
R42 SSW	4:00	4:00	3:00	3:00	3:00	R42 SSW	4:00	4:00	3:00	3:00	3:00	R42 SSW	3:10	4:00	3:00
R43 SW	4:00	4:00	3:10	3:00	3:10	R43 SW	4:00	4:00	3:10	3:10	3:10	R43 SW	3:10	4:00	3:10
R44 WSW	4:10	4:10	3:10	3:10	3:10	R44 WSW	4:00	4:10	3:10	3:10	3:10	R44 WSW	3:10	4:10	3:10
R45 W	4:10	4:10	3:10	3:10	3:10	R45 W	4:10	4:10	3:10	3:10	3:10	R45 W	3:10	4:10	3:10
R46 WNW	4:10	4:10	3:10	3:10	3:10	R46 WNW	4:10	4:10	3:10	3:10	3:10	R46 WNW	3:10	4:10	3:10
R47 NW, NNW	4:10	4:10	3:10	3:10	3:10	R47 NW, NNW	4:10	4:10	3:10	3:10	3:10	R47 NW, NNW	3:10	4:10	3:10
2-Mile Ring and Downwind to EPZ Boundary (5 sector groups)															
R48 N	4:10	4:20	4:00	4:00	4:00	R48 N	4:20	4:20	4:00	4:00	4:00	R48 N	4:00	4:10	4:00
R49 NNE	4:10	4:20	4:00	4:00	4:00	R49 NNE	4:10	4:20	4:00	4:00	4:00	R49 NNE	4:00	4:10	4:00
R50 NE	4:10	4:10	4:00	4:00	4:00	R50 NE	4:10	4:10	3:50	4:00	4:00	R50 NE	4:00	4:10	4:00
R51 ENE	4:10	4:10	3:50	4:00	3:50	R51 ENE	4:10	4:10	3:50	4:00	4:00	R51 ENE	3:50	4:10	3:50
R52 E	4:10	4:10	3:40	3:40	3:40	R52 E	4:00	4:10	3:40	3:40	3:40	R52 E	3:40	4:10	3:40
R53 ESE	4:10	4:10	3:40	3:40	3:40	R53 ESE	4:00	4:00	3:40	3:40	3:40	R53 ESE	3:40	4:10	3:40
R54 SE	4:00	4:10	3:00	3:10	3:00	R54 SE	4:00	4:10	3:00	3:10	3:00	R54 SE	3:20	4:00	3:10
R55 SSE	4:00	4:00	3:00	3:10	3:00	R55 SSE	4:10	4:10	3:00	3:10	3:10	R55 SSE	3:20	4:00	3:00
R56 S	4:00	4:00	3:10	3:10	3:10	R56 S	4:10	4:00	3:00	3:10	3:10	R56 S	3:20	4:00	3:10
R57 SSW	4:00	4:10	3:10	3:10	3:10	R57 SSW	4:10	4:10	3:10	3:10	3:10	R57 SSW	3:20	4:00	3:10
R58 SW	4:10	4:10	3:10	3:10	3:10	R58 SW	4:10	4:10	3:10	3:10	3:10	R58 SW	3:20	4:10	3:10
R59 WSW	4:10	4:10	3:50	3:50	3:50	R59 WSW	4:10	4:10	3:50	3:50	3:50	R59 WSW	3:50	4:10	3:50
R60 W	4:20	4:20	3:50	3:50	4:00	R60 W	4:10	4:20	3:50	4:00	3:50	R60 W	3:50	4:20	3:50
R61 WNW	4:20	4:20	3:50	4:00	4:00	R61 WNW	4:20	4:20	3:50	3:50	4:00	R61 WNW	3:50	4:20	3:50
R62 NW	4:10	4:20	4:00	4:00	4:00	R62 NW	4:20	4:20	4:00	4:00	4:00	R62 NW	4:00	4:10	4:00
R63 NNW	4:20	4:20	4:00	4:00	4:00	R63 NNW	4:20	4:20	4:00	4:00	4:00	R63 NNW	4:00	4:20	4:00

Table 7-2. Description of Evacuation Regions (Page 1 of 2)

Region	Central Sector	Description	ZONE																													
			CP	1A	1B	1C	1D	2A	2B	2C	2D	2E	2F	2G	2H	2J	3A	3B	3C	3D	3E	3F	4A	4B	4C	4D	4E	4F	4G	4H	GLEN ROSE	GRANBURY	TOLAR
R01	-	2 mile ring	■					■																									
R02	-	5-mile ring	■	■	■			■	■	■	■	■					■	■					■	■	■	■					■		
R03	-	Full EPZ	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

Evacuate 2 mile ring and 5 miles downwind (3 Sector Groups)

Region	Central Sector	Wind Direction Toward:	ZONE																													
			CP	1A	1B	1C	1D	2A	2B	2C	2D	2E	2F	2G	2H	2J	3A	3B	3C	3D	3E	3F	4A	4B	4C	4D	4E	4F	4G	4H	GLEN ROSE	GRANBURY	TOLAR
R04	A	N	■		■			■															■	■	■								
R05	B	NNE	■	■	■			■															■	■									
R06	C	NE	■	■	■			■	■		■	■											■	■									
R07	D	ENE	■	■	■			■	■		■	■											■										
R08	E	E	■	■				■	■		■	■																					
R09	F	ESE	■					■	■	■	■	■																			■		
R10	G	SE	■					■	■	■	■																				■		
R11	H, J	SSE, S	■					■		■								■													■		
R12	K	SSW	■					■		■							■	■													■		
R13	L	SW	■					■									■	■								■							
R14	M	WSW	■					■									■	■							■	■							
R15	N	W	■					■									■								■	■							
R16	P	WNW	■					■																	■	■							
R17	Q, R	NW, NNW	■																					■	■								

Evacuate 2 mile ring and downwind to EPZ Boundary (3 Sector Groups)

Region	Central Sector	Wind Direction Toward:	ZONE																													
			CP	1A	1B	1C	1D	2A	2B	2C	2D	2E	2F	2G	2H	2J	3A	3B	3C	3D	3E	3F	4A	4B	4C	4D	4E	4F	4G	4H	GLEN ROSE	GRANBURY	TOLAR
R18	A	N	■		■	■	■	■															■	■	■		■	■				■	
R19	B	NNE	■	■	■	■	■	■						■									■	■			■					■	
R20	C	NE	■	■	■	■	■	■	■		■	■		■									■	■									
R21	D	ENE	■	■	■	■		■	■		■	■	■	■									■										
R22	E	E	■	■		■		■	■		■	■	■	■	■																		
R23	F	ESE	■					■	■	■	■	■	■		■	■																■	
R24	G	SE	■					■	■	■	■				■	■			■													■	
R25	H	SSE	■					■		■					■	■		■	■	■		■									■		
R26	J	S	■					■		■						■		■	■	■		■									■		
R27	K	SSW	■					■		■							■	■	■	■	■	■									■		
R28	L	SW	■					■									■	■		■	■	■				■				■			
R29	M	WSW	■					■									■	■		■	■				■	■			■				
R30	N	W	■					■									■				■				■	■		■	■	■			
R31	P	WNW	■					■																	■	■		■	■	■			■
R32	Q	NW	■					■																■	■		■	■	■				■
R33	R	NNW	■				■	■																■	■		■	■				■	■

Table 7-2. Description of Evacuation Regions (Page 2 of 2)

Evacuate 2 mile ring and 5 miles downwind (5 Sector Groups)

Region	Central Sector	Wind Direction Toward:	ZONE																													
			CP	1A	1B	1C	1D	2A	2B	2C	2D	2E	2F	2G	2H	2J	3A	3B	3C	3D	3E	3F	4A	4B	4C	4D	4E	4F	4G	4H	GLEN ROSE	GRANBURY	TOLAR
R34	A	N	■	■	■			■															■	■	■								
R35	B	NNE	■	■	■			■	■		■	■											■	■	■								
R36	C, D	NE, ENE	■	■	■			■	■		■	■											■	■									
R37	E	E	■	■	■			■	■	■	■	■											■								■		
R38	F	ESE	■	■				■	■	■	■	■																			■		
R39	G	SE	■					■	■	■	■	■						■													■		
R40	H	SSE	■					■	■	■	■							■													■		
R41	J	S	■					■		■							■	■													■		
R42	K	SSW	■					■		■							■	■								■					■		
R43	L	SW	■					■		■							■	■							■	■					■		
R44	M, N	WSW, W	■					■									■	■							■	■							
R45	P	WNW	■					■									■							■	■	■							
R46	Q	NW	■					■																	■	■							
R47	R	NNW	■		■			■															■	■	■								

Evacuate 2 mile ring and downwind to EPZ Boundary (5 Sector Groups)

Region	Central Sector	Wind Direction Toward:	ZONE																													
			CP	1A	1B	1C	1D	2A	2B	2C	2D	2E	2F	2G	2H	2J	3A	3B	3C	3D	3E	3F	4A	4B	4C	4D	4E	4F	4G	4H	GLEN ROSE	GRANBURY	TOLAR
R48	A	N	■	■	■	■	■	■						■									■	■	■		■	■				■	■
R49	B	NNE	■	■	■	■	■	■	■		■	■		■									■	■	■		■	■				■	
R50	C	NE	■	■	■	■	■	■	■		■	■	■	■									■	■			■					■	■
R51	D	ENE	■	■	■	■	■	■	■		■	■	■	■	■								■	■									
R52	E	E	■	■	■	■		■	■	■	■	■	■	■	■	■							■								■		
R53	F	ESE	■	■		■		■	■	■	■	■	■	■	■	■			■												■		
R54	G	SE	■					■	■	■	■	■	■		■	■		■	■	■		■									■		
R55	H	SSE	■					■	■	■	■				■	■		■	■	■		■									■		
R56	J	S	■					■		■					■	■	■	■	■	■	■	■									■		
R57	K	SSW	■					■		■						■	■	■	■	■	■	■				■				■	■		
R58	L	SW	■					■		■							■	■	■	■	■	■			■	■			■	■	■		
R59	M	WSW	■					■									■	■		■	■	■			■	■		■	■	■			■
R60	N	W	■					■									■	■		■	■				■	■		■	■	■			■
R61	P	WNW	■					■									■				■			■	■	■	■	■	■	■			■
R62	Q	NW	■				■	■																■	■	■	■	■	■	■		■	■
R63	R	NNW	■		■	■	■	■															■	■	■		■	■	■			■	■

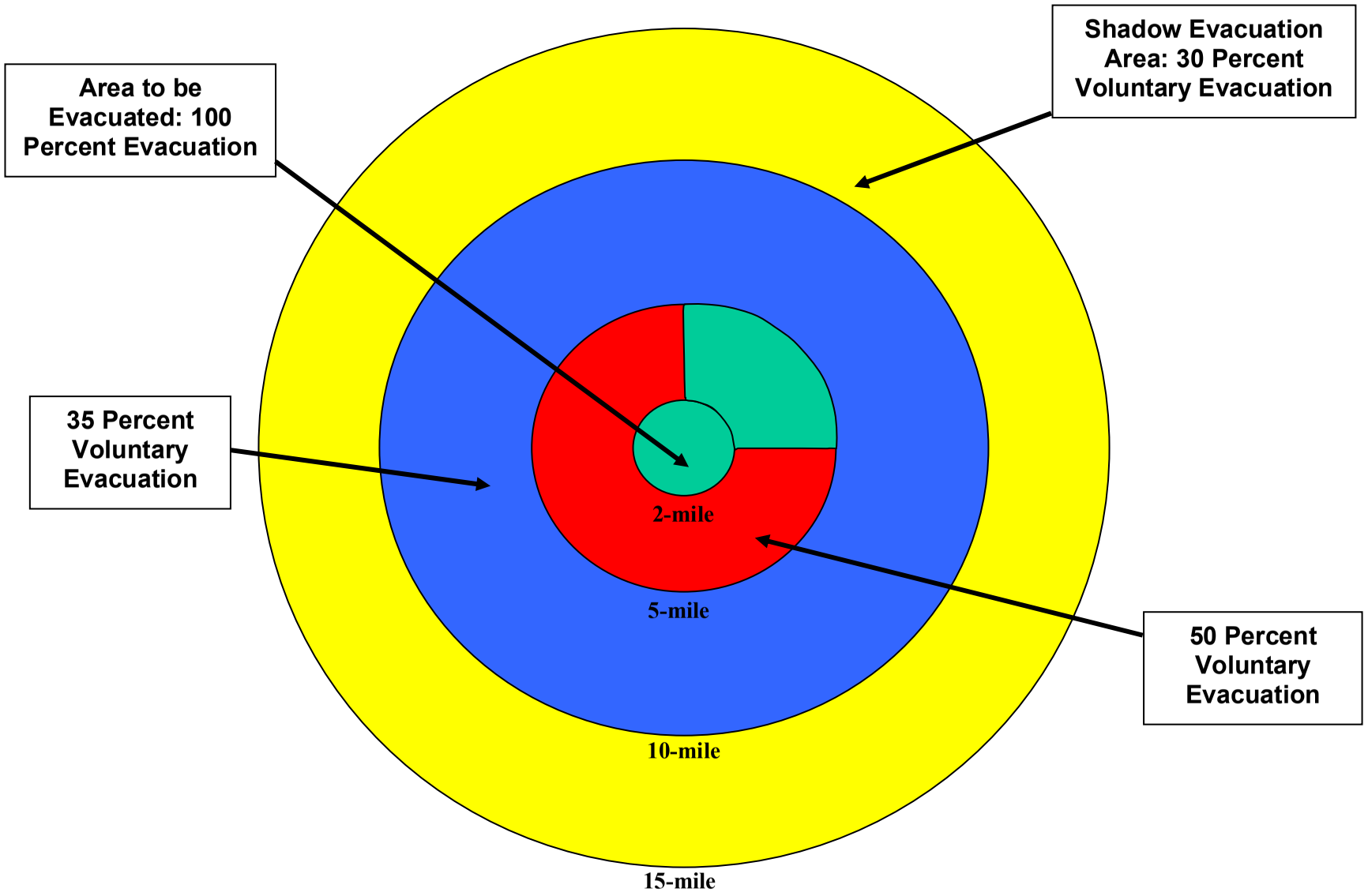


Figure 7-1. Assumed Evacuation Response

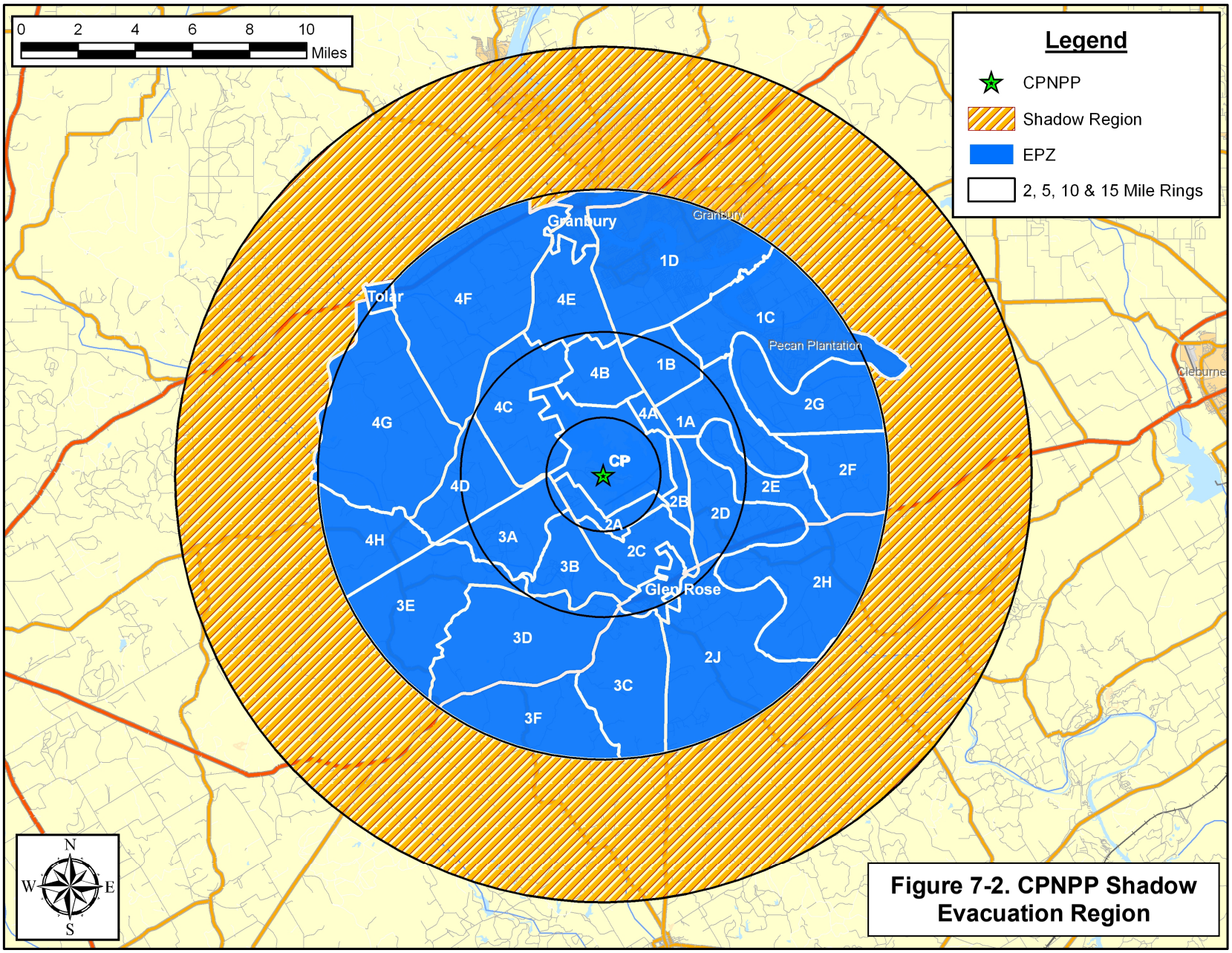


Figure 7-2. CPNPP Shadow Evacuation Region

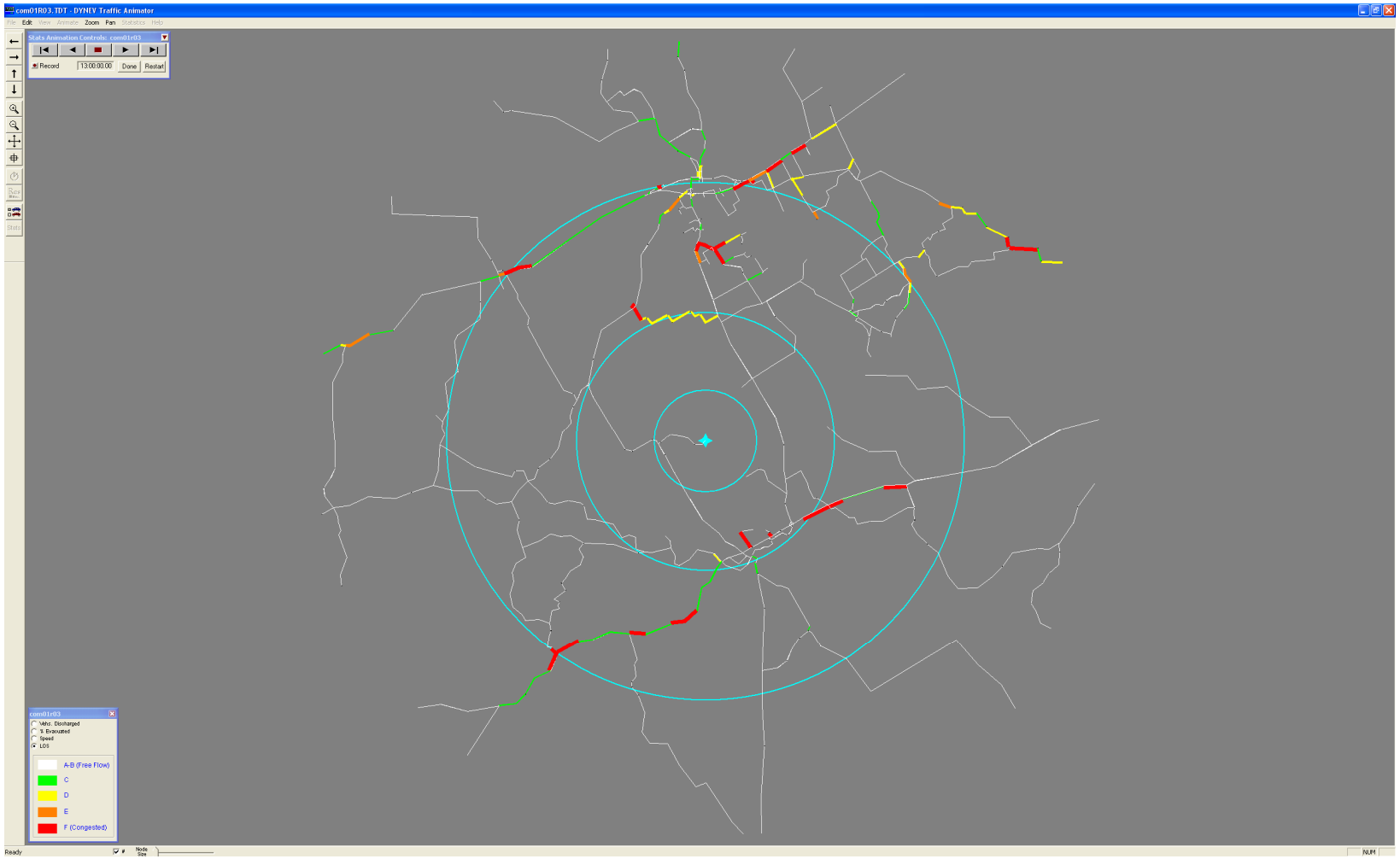


Figure 7-3 Congestion Patterns at 1 Hour after the Advisory to Evacuate

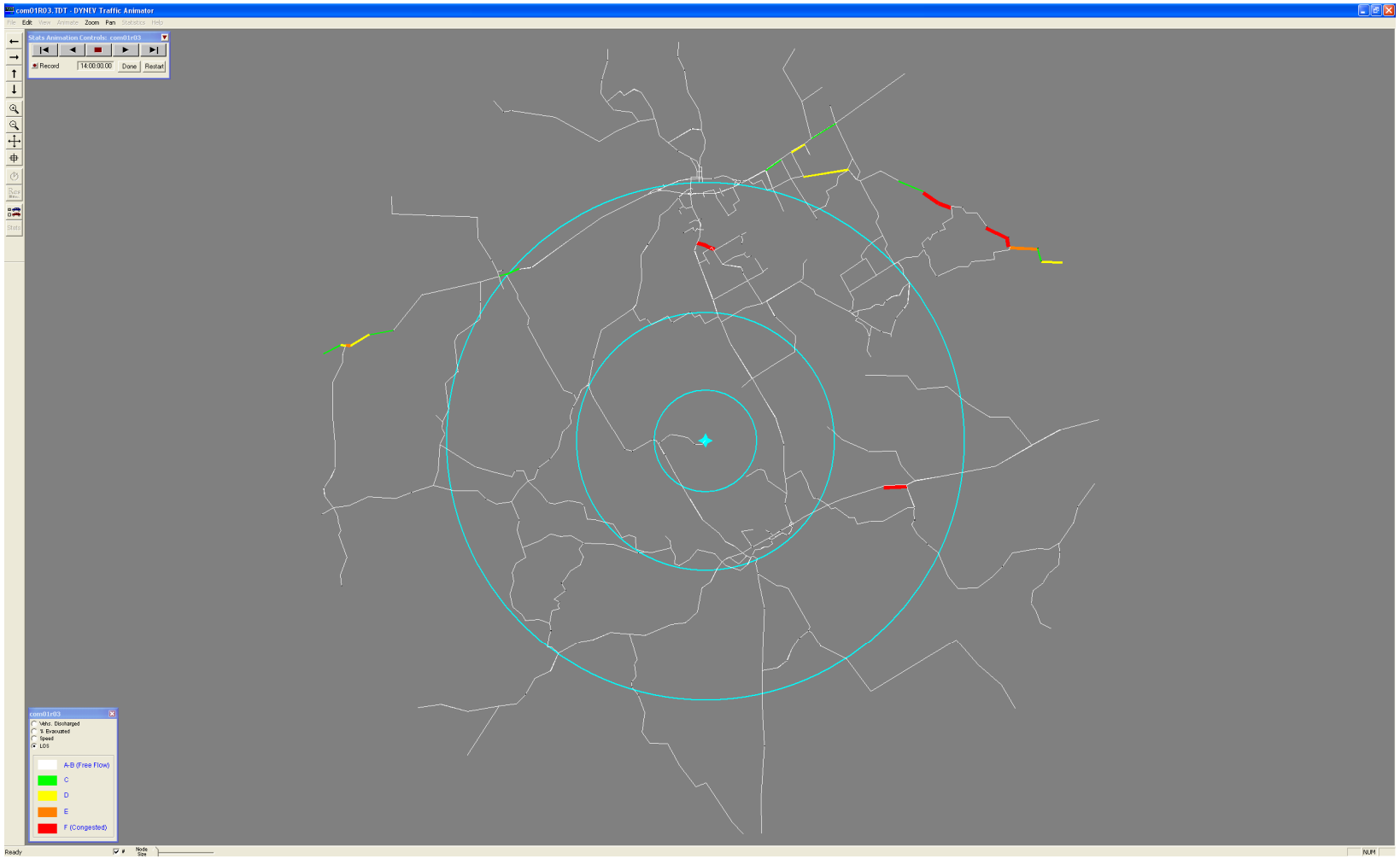


Figure 7-4 Congestion Patterns at 2 Hours after the Advisory to Evacuate

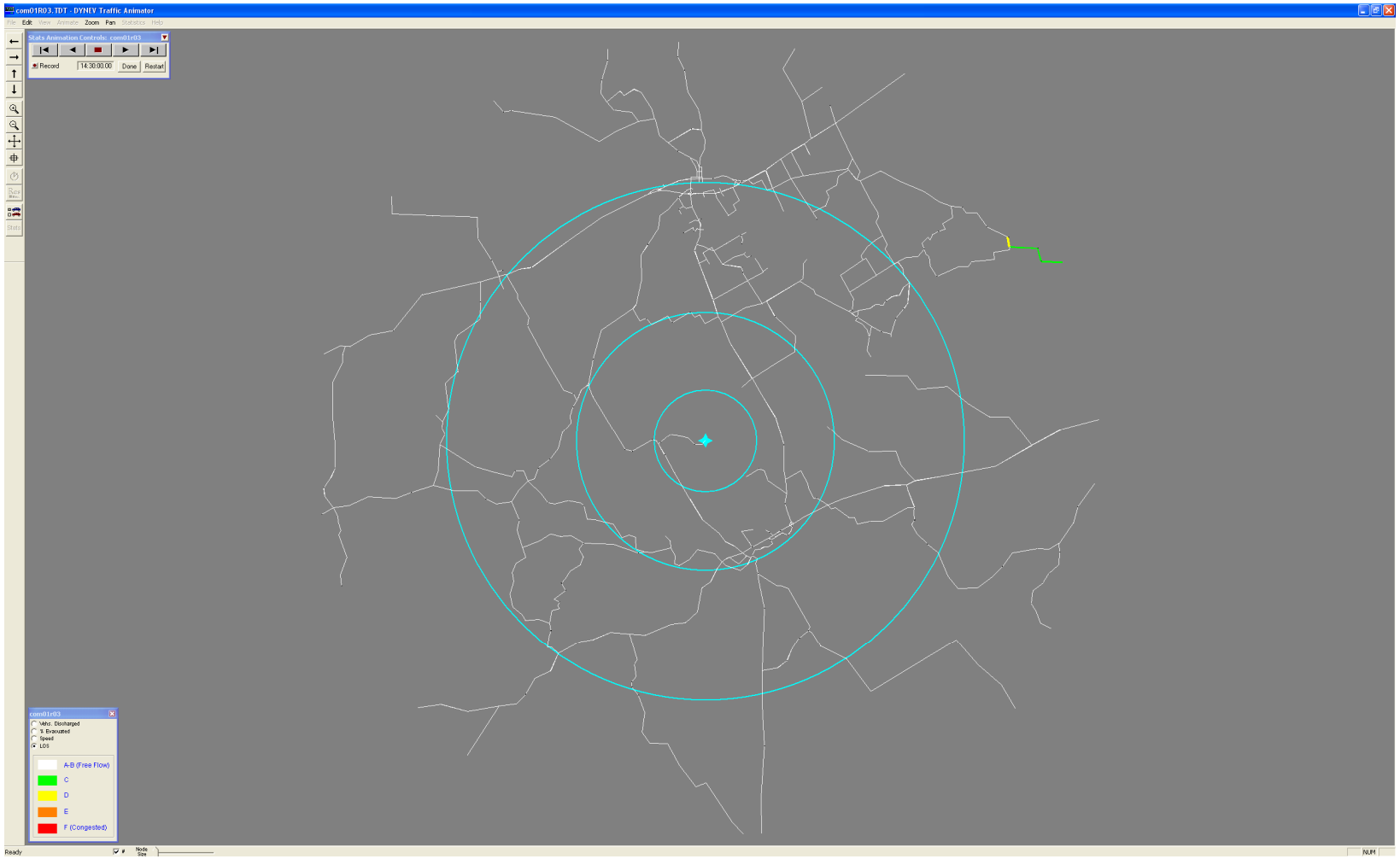


Figure 7-5 Congestion Patterns at 2 Hours and 30 Minutes after the Advisory to Evacuate

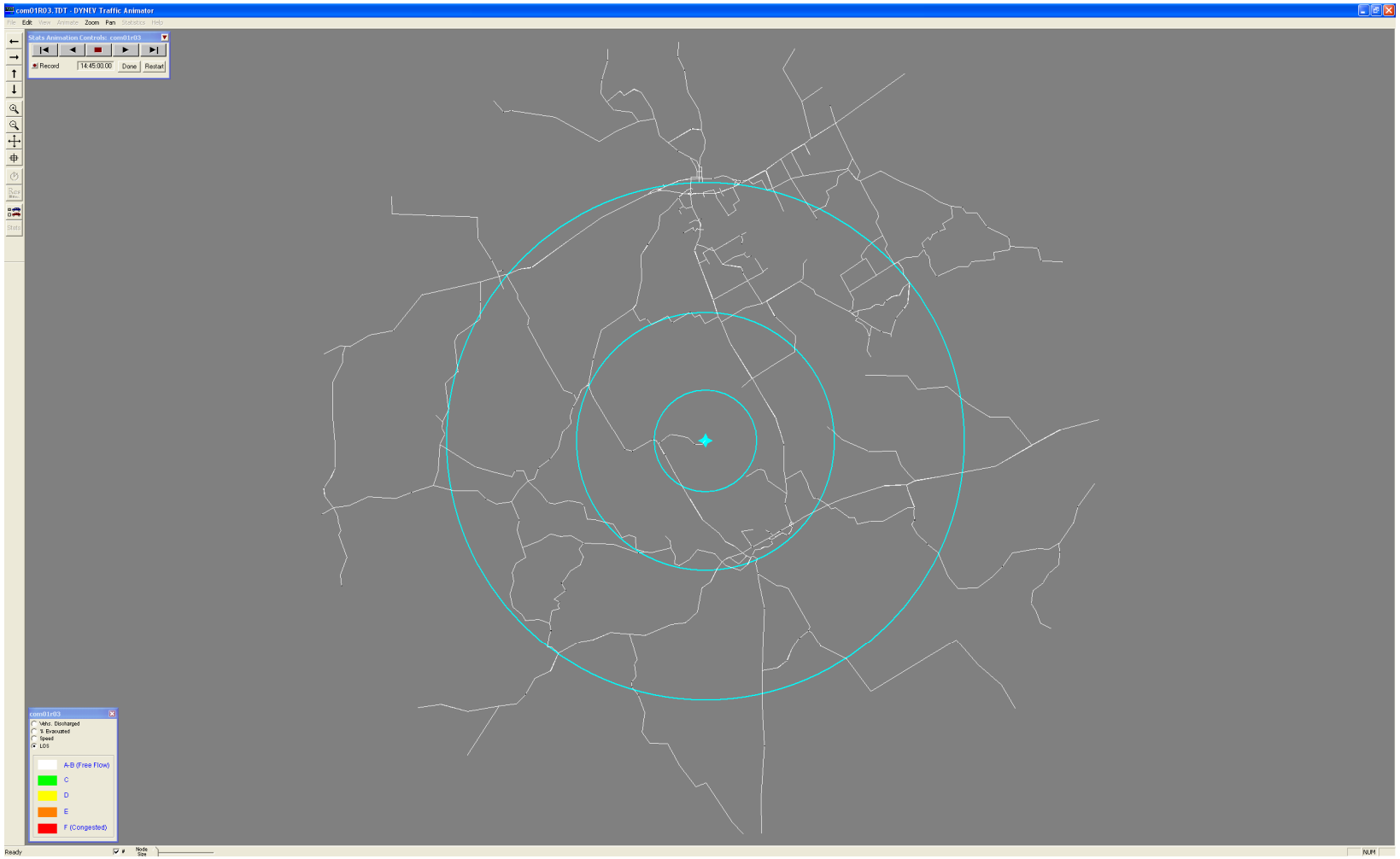


Figure 7-6 Congestion Patterns at 2 Hours and 45 Minutes after the Advisory to Evacuate

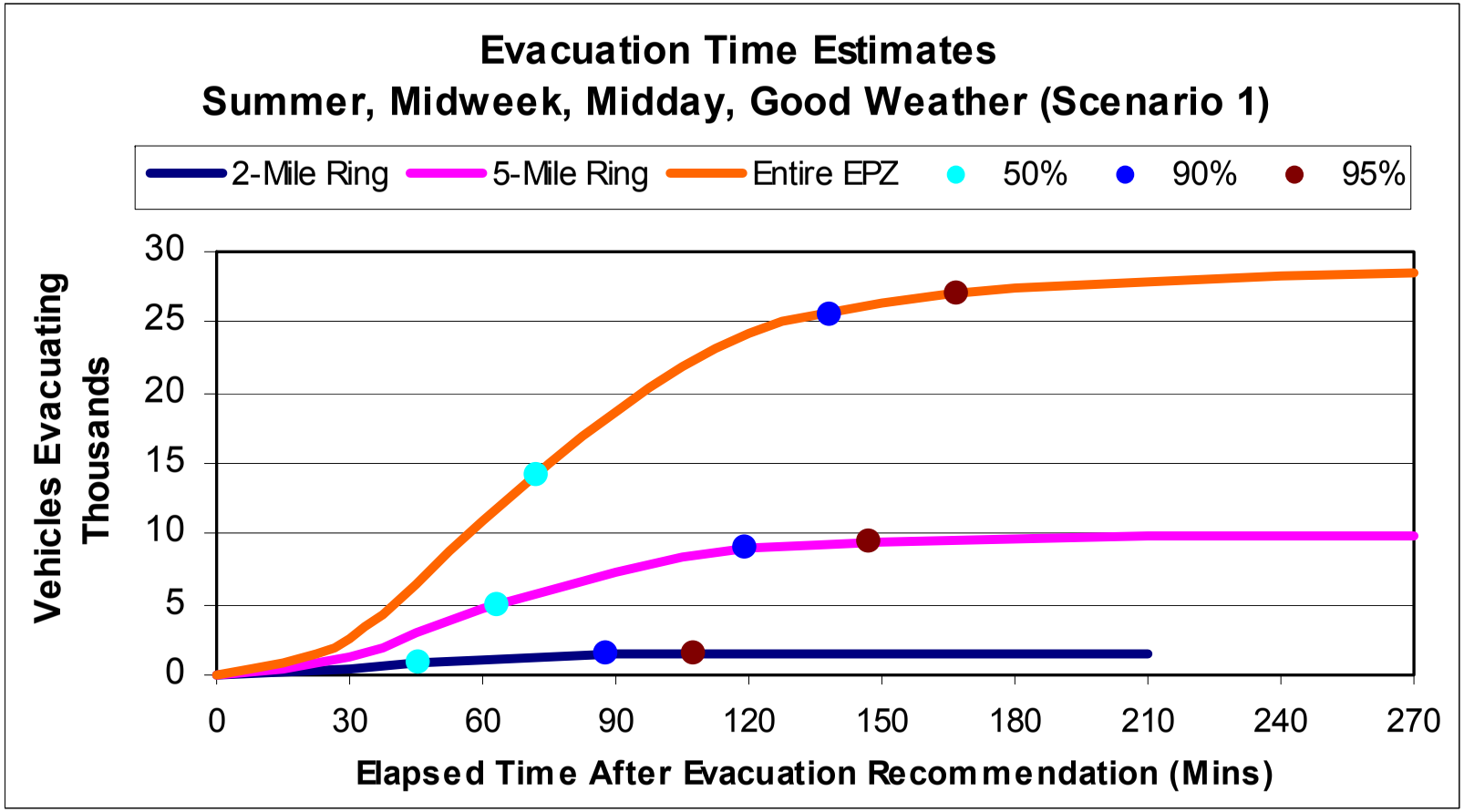


Figure 7-7. Evacuation Time Estimates for CPNPP Summer, Midweek, Midday, Good Weather Evacuation of Region R03 (Entire EPZ)

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). The demand for transit service reflects the needs of two population groups: (1) residents, employees, and transients with no vehicles available; and (2) residents of special facilities such as schools, health-support facilities, institutions and child-care facilities.

These transit vehicles merge into and become a part of the general evacuation traffic environment 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 larger 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. Granbury and Glen Rose school districts station buses on or close to school property when school is in session, thereby reducing the school bus mobilization time. Glen Rose schools have sufficient buses for a single wave evacuation. Granbury schools have a large number of buses plus vans, and will receive additional buses from Aledo Independent School District (ISD) in order to evacuate their schools in a single wave. A conservative estimate of 60 minutes is used for mobilization of school buses.

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 family members is universally prevalent during emergencies and should be anticipated in the planning process. Many emergency plans, however, call for parents to pick up children at host schools to speed the evacuation of the school children in the event that buses need to return to the EPZ and evacuate transit dependents or special facilities. We provide estimates of buses under the assumption that no children will be picked up at school by their parents as an upper bound estimate of the transit vehicles needed.

The procedure is:

- Estimate demand for transit service
- Estimate time to perform all transit functions
- Estimate route travel times to the EPZ boundary and to the host schools.

8.1 Transit-Dependent People - Demand Estimate

The calculations that follow provide a reasonable estimate for the number of transit dependent people in the EPZ during regular working hours. This estimate includes those people who may be transit dependent because a commuter in the household is using the only available vehicle to travel to work outside the EPZ.

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 school children. For those evacuation scenarios where children are at school when an evacuation is advised, separate transportation is provided for the school children. The actual need for transit vehicles by residents is thereby less than the given estimates. However, we will not reduce our estimates of transit vehicles since it would add to the complexity of the implementation procedures.
- 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.**

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 (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.

Table 8-1 indicates that transportation must be provided for 593 people. Therefore, a total of 20 bus runs are required to transport this population to Reception Centers.

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 Comanche Peak EPZ:

$$P = 15{,}129 \times (0.035 \times 1.10 + 0.275 \times (1.53 - 1) \times 0.40 \times 0.55 + 0.492 \times (2.33 - 2) \times (0.40 \times 0.55)^2)$$

$$P = 15{,}129 * (0.0783) = 1{,}185$$

$$B = (0.5 \times P) \div 30 = 20$$

These calculations are explained as follows:

- All members (1.10 avg.) of households (HH) with no vehicles (3.5%) will evacuate by public transit or ride-share. The term 15,129 (number of households) x 0.035 x 1.10, accounts for these people.
- The members of HH with 1 vehicle away (27.5%), who are at home, equal (1.53-1). The number of HH where the commuter will not return home is equal to (15,129 x 0.275 x 0.40 x 0.55), as 40% of EPZ households have a commuter, 55% 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 (49.2%), who are at home, equal (2.33 – 2). The number of HH where neither commuter will return home is equal to 15,129 x 0.492 x $(0.40 \times 0.55)^2$. The number of persons who will evacuate by public transit or ride-share is equal to the product of these two terms.
- 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.

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. The column in Table 8-2 entitled “Bus Runs 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.
- 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 which is in the neighborhood of 3 percent, daily.

Some parents will likely pick up their children at school, although they are asked to pick children up at the host schools. Those buses originally allocated to evacuate school children 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 host schools for each school in the EPZ. Those students not picked up by their parents, will be transported to these facilities where they will be subsequently retrieved by their respective families. In the event of an emergency, the Emergency Operations Center will determine which host schools will be used; buses will be routed accordingly. For the purpose of obtaining an ETE estimate, it is assumed that Glen Rose and Tolar schools go to Stephenville Junior High School and Granbury Schools go to Cleburne High School.

8.3 Special Facility Demand

Table 8-4 presents the census of special facilities in the EPZ as of September, 2007. Approximately 729 people have been identified as living in, or being treated in, these facilities. This census also indicates the number of wheelchair-bound people and the number of bed-ridden people. In the unlikely event that all the facilities need to be provided transportation, Table 8-4 shows the number of buses and wheel chair vehicles that would be needed. The number of bus runs estimated assumes 30 ambulatory patients per trip. Wheelchair buses can transport 15 patients while wheel chair vans can transport 4 patients. It is estimated that 20 buses, 7 wheelchair vans, 18 wheelchair buses, and 30 ambulances are needed to evacuate special facilities.

Each special facility has an evacuation plan, as required by law. Some facilities have contracts with transportation providers for transporting patients in the event of an emergency. It is recommended that the counties implement procedures whereby special facilities are contacted in an emergency to assess their transportation needs.

8.4 Summer Camps and Retreats – Transit Demand

There are several recreational areas within the EPZ that host summer camps, weekend camps, and frequent public events. The families and individuals who visit these recreational areas in their personal vehicles are included as transients. However, in the case of a summer camp or weekend retreat, people arrive in buses, which subsequently depart. It is prudent to calculate an ETE for these transit dependents.

Assumption 10 in Section 2.3 states that school buses have a capacity of 50 children per bus for middle and high schools. Based on the age ranges provided for the facilities below, a capacity estimate of 50 children per bus is appropriate. The following summarizes the peak population at the summer camps and retreats in the EPZ, and the number of buses and bus drivers needed to evacuate these facilities:

- Camp Arrowhead – approximately 270 children (ages 6-17), 6 buses and bus drivers needed
- Riverbend Retreat – as many as 700 children (ages 8-17), 14 buses and bus drivers needed
- Camp Tres Rios – as many as 700 children (ages 11-17), 14 buses and bus drivers needed
- Steven's Ranch – as many as 250 children, 5 buses and bus drivers needed
- Glen Lake Methodist Camp – approximately 100 children, 2 buses and bus drivers needed

Since these camps and retreats operate in the summer or on weekends, when school is not in session, school buses and drivers in the area will be available to evacuate the transients at each facility.

8.5 Evacuation Time Estimates for Transit-Dependent People

Schools are given first priority for bus resources in the event of an emergency at CPNPP. School buses will be used to evacuate transit dependents if additional buses remain after an adequate number of buses have been dispatched to each school. If there are not adequate buses to service the school and the transit dependent population in a single wave, a "second wave" of transportation must be provided. After transporting the children to the host schools, buses will return to the EPZ, to complete this "second wave". The ETE will be calculated for both a one wave transit evacuation and for two waves (Table 8-7). Of course, if the Evacuation Region is other than R03 (the entire EPZ), then adequate transit resources will likely be available to evacuate all transit dependents in a single wave.

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 rain. 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 60 minutes to be contacted, be briefed, and to travel to the facility being evacuated. Drivers of first-wave buses servicing transit dependents would likely require 90 minutes to be contacted, to travel to the depot, be briefed, and to travel to the start of their pickup route. Mobilization time is slightly longer – 65 and 95 minutes, respectively– when raining.

Activity: Board Passengers (C→D)

Studies have shown that passengers can board a bus at headways of 2-4 seconds (Ref. HCM2000 Page 27-27). Therefore, the total dwell time to service passengers boarding a bus to capacity at a single stop (e.g., at a school) is about 5 minutes. A loading time of 10 minutes will be used for rain scenarios. For multiple stops along a pick-up route we must allow for the additional delay associated with stopping and starting at each pick-up point. This additional delay to service passengers expands this estimate of (cumulative) boarding time to 30 minutes in good weather, and 35 minutes in rain.

Activity: Travel to EPZ Boundary (D→E)

The distance from a facility to the EPZ boundary is measured using Geographical Information Systems (GIS) software along the most likely route out of the EPZ. The travel times to the EPZ boundary are based on evacuation speeds computed by the model. For example, the model indicates that the average speed for an evacuation of the full EPZ under Scenario 6 (winter [school in session], good weather conditions) at 90 minutes (mobilization time for transit-dependents) is 35 mph, while the average speed for an evacuation of the full EPZ under Scenario 7 conditions (winter, rain) is 26 mph.

Activity: Travel to Reception Centers/Host Schools (E→F)

The distances from the EPZ boundary to the host schools and Reception Centers, are also measured using GIS software along the most likely route from the EPZ to the host school. 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 public. The travel time from the EPZ boundary to the Reception Center was computed assuming an average speed

of 40 mph and 35 mph for good weather and rain, respectively, as higher speeds are expected outside of the evacuation region.

Activity: Passengers Leave Bus (F→G)

Passengers can de-board within 5 minutes. The driver takes a 10 minute break.

Activity: Bus Returns to Route for Second Wave Evacuation (G→C)

The buses assigned to return to the EPZ to perform a "second wave" evacuation of transit-dependent evacuees will be school buses from either the Stephenville or Cleburne host school, whichever is closer to the assigned route. The travel time back to the EPZ boundary and to the beginning of the bus route is calculated using distances estimated from GIS and a travel speed of 40 mph (35 mph in the rain). The bus then travels its route and picks up transit-dependent evacuees along the route.

School Evacuation

Based on information provided by Hood and Somervell Counties, Granbury ISD has 102 buses, 11 Special Education buses and 12 Vans for the evacuation of school children; additional buses will be provided by Aledo ISD, if needed. Glen Rose ISD has 33 buses on campus with an estimated mobilization time of less than 30 minutes, and Happy Hills Farm has 2 buses and 6 vans. Comparison of the bus resources available with the buses required (See Table 8-2) indicates that sufficient transportation resources are available to evacuate the school children in a single wave.

Tables 8-5A (good weather) and 8-5B (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 Host School. The evacuation time out of the EPZ can be computed as the sum of travel times associated with Activities A→B→C, C→D, and D→E (For example: 60 min. + 5 + 4 = 1:09, rounded to 1:10, for Brawner Intermediate School, with good weather). The evacuation time to the Host School is determined by adding the time associated with Activity E→F (discussed above), 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 activities. As indicated in Section 5 (Table 5-1), 94 percent of the evacuees will have completed their mobilization activities when the first buses will begin their routes, 90 minutes after the Advisory to Evacuate.

Those buses servicing the transit-dependent evacuees will travel along their pick-up routes, then proceed out of the EPZ. The proposed bus routes to service the transit dependent people in the Comanche Peak EPZ are described in detail on pages 8-8 and 8-9. Table 8-6 summarizes the bus routes, while Figure 8-2 maps the proposed bus pick-up routes. These routes are used to compute ETE for the transit-dependent population. **It is not necessary for the counties to use these exact routes in the event of an emergency**. It is recommended that the counties identify the transit dependent population within their jurisdiction and develop routes that efficiently service those people.

Table 8-7 presents the transit-dependent population ETE for each route obtained using the above procedures. The second wave ETE should be referenced if sufficient buses are not available for a single wave evacuation. As previously mentioned, the buses used to provide a second wave of evacuation for the transit-dependent population are the buses used to evacuate the schools, as they will be the earliest resources available. Thus, the mobilization time of these buses is the average ETE for school buses to arrive at the host schools (see Table 8-5).

Analysis of Bus Route Operations for Transit Dependent Population

The following bus routes are suggested based on the estimates of transit dependent residents in Section 8.1. The most efficient path for the buses to take and the exact number of buses needed will vary according to the temporal conditions when an evacuation is advised. For example, during the weekend, there is a greater likelihood that all household vehicles will be home and available for evacuation purposes; therefore, fewer buses will likely be needed. Hood and Somervell Counties are best qualified to create incident-specific routes, based on the resources available and the severity of the emergency.

Route 1

Buses on this route will travel southbound on US Hwy 377, circulate minor streets as necessary to pick up evacuees living in Granbury, and then continue to the Reception Center in Stephenville. The first 4 buses assigned to this route will begin their trip 90 minutes after the ATE; another 3 buses bus will follow after 15 minutes. The route travel time is approximately 17 minutes, with 30 additional minutes allocated for pickups. The last bus trip will begin at 1:45 after the ATE and exit the EPZ at 2:35.

Route 2

Buses on this route will travel northbound on US Hwy 377, circulate minor streets as necessary to pick up evacuees living in Granbury, and then continue to the Reception Center in Cleburne. The first 4 buses assigned to this route will begin their trip 90 minutes after the ATE; another 3 buses bus will follow after 15 minutes. The route travel time is approximately 17 minutes, with 30 additional minutes allocated for pickups. The last bus trip will begin at 1:45 after the ATE and exit the EPZ at 2:35.

Route 3

Buses on this route will travel WB along US Hwy 67, and circulate minor streets as necessary to pick up evacuees living in the Glen Rose area, and then continue to the Reception Center in Stephenville. The first 3 buses will begin their trip at 90 minutes after the ATE; another 2 will follow after 15 minutes. The route travel time is 31 minutes, with 30 additional minutes needed for pickups. The last bus will exit the EPZ at 2:50.

Route 4

The bus on this route will pick up evacuees living within the Pecan Plantation, and then travel northbound out of the EPZ. The bus will begin its trip at 90 minutes after the ATE and exit the EPZ at 2:15.

The ETE for good weather for all routes and buses are given in Table 8-7A. Table 8-7B provides the ETE for rain.

Evacuation of Ambulatory Persons from Special Facilities

The bus operations for this group are similar to those for school evacuation except:

- Buses are assigned on the basis of 30 patients per bus to allow for staff to accompany the patients.
- The passenger loading time will be longer, at approximately one minute per patient, to account for the time to move patients from inside the facility to the vehicles. For those facilities with more than 30 ambulatory patients, it is assumed that buses load concurrently and that loading time is equal to 30 minutes for the entire facility.

It is estimated that mobilization time averages 90 minutes. In the event there is a shortfall of transit vehicles for a single wave evacuation, the buses used to evacuate schools will have to return to evacuate the special facilities. The school ETE to the Reception Centers is 1:40 (hr:min) on average, and 20 to 40 minutes of additional inbound travel time to the special facility from the Reception Center would be required. It follows, therefore, that about forty-five minutes should be added to the calculated ETE for special facilities, in the event they are evacuated as a “second wave”.

All of the medical facilities are located within Granbury or Glen Rose, with the exception of one small facility in Tolar. It is estimated that buses will have to travel 4 miles, on average, to leave the EPZ. The average speed output by the model at 90 minutes for Region 3, Scenario 6 is 35 mph; thus, travel time out of the EPZ is 7 minutes.

Courtyards at Lake Granbury has 60 ambulatory patients and requires 2 buses for evacuation. As noted above, buses will load concurrently; thus, loading time is 30 minutes for the facility. The ETE for this facility is:

ETE: 90 + 30 + 7 = 127 min. or 2:10 rounded up (2:55 for “second wave”).

Table 8-4 indicates that 18 wheelchair bus runs and 7 wheelchair van runs are needed for the entire EPZ. Wheelchair buses and vans are often scarce; however, regular buses can be used to transport wheelchair bound patients. Patients would occupy the front portion of the bus and their wheelchairs would be folded and stacked in the back of the bus. Loading times are estimated at 5 minutes per wheelchair bound person as staff will have to assist them on the bus. For example, the ETE for the wheelchair bound at Granbury Gables is:

ETE: 90 + 23 x 5 + 7 = 3:32.

The first and second wave ETEs for special facilities do not exceed the ETE for the general population.

Emergency Medical Services (EMS) Vehicles

The previous discussion focused on transit operations for ambulatory persons residing at medical facilities within the Evacuation Region. It is also necessary to provide transit services for non-ambulatory persons who do not – or cannot – have access to private vehicles. Based on the data provided in Table 8-4, a total of 30 ambulance runs are needed to evacuate all of the bed ridden patients in the EPZ, assuming 2 people per ambulance.

Based on the ambulance resource information provided in Table 8-9, it is estimated that 30 minutes, on average, will be needed to mobilize the needed 30 ambulances and travel to the medical facilities. Loading times are conservatively estimated as 30 minutes. As with the buses transporting ambulatory patients, ambulances will have to travel 4 miles, on average, to leave the EPZ. The average speed output by the model at 1 hour for Scenario 6 (Region 3 evacuation) is 35.8 mph; thus, travel time out of the EPZ is 7 minutes. The ETE for ambulances is: 30 + 30 + 7 = 1:10 (rounded up to the nearest 5 minutes).

If a second wave evacuation is necessary, 10 ambulances can be mobilized to evacuate patients within 15 minutes of the ATE, based on the ambulance resource information provided in Table 8-9. These 10 ambulances can evacuate patients in 55 minutes and travel to a host facility by 1:30 following the ATE. Allowing 10 minutes to unload, 15 minutes driver rest time, and 35 minutes return travel to the EPZ, these ambulances will arrive at a facility for a second wave evacuation at 2:30 following the ATE. As stated above, ambulance loading times are conservatively estimated as 30 minutes and ambulances will have to travel 4 miles, on average, to leave the EPZ. The average speed output by the model at 3 hours for Scenario 6 (Region 3 evacuation) is 48.2 mph; thus, travel time out of the EPZ is 5 minutes. This results in an ETE of 3:05 for a second wave ambulance evacuation, if necessary.

Summer Camps and Retreats

The peak camp season is when schools are not in session, thus buses will not be needed to evacuate schools. In addition, some camps have made arrangements with transportation providers for buses to be provided in the event of an emergency. For these reasons, Table 8-8 only presents a single wave ETE for camps as bus resources will likely be sufficient. The bus mobilization time is estimated as 90 minutes. The buses are assumed to travel to the nearest Reception Center, which is in Cleburne. The average speed output by the model, 90 minutes after the ATE for Scenario 1 (summer, midweek, midday), Region 3, is 32.2 mph; this speed is used to compute travel times to the EPZ boundary. After exiting the EPZ, a speed of 40 mph is assumed. The ETEs range from 1:40 to 1:55, which is well below the ETE for the general population.

Somervell County Jail

The Somervell County Jail is located in Glen Rose approximately 4 miles from the power plant. If an evacuation of the facility is advised, school buses will be used. The route used to exit the EPZ will depend on the extent of the emergency and the wind direction. For this analysis the evacuating buses are assumed to travel the quickest route out of the EPZ, which is eastbound on US Highway 67. The need for security will largely dictate the number of buses required to transport the [up to] 57 inmates and accompanying corrections officers out of the EPZ. If the jail was filled to capacity, 3 buses would be required; for the current (August 2007) occupancy of 32 inmates, 2 buses would be required.

It is reasonable to estimate the arrival of these buses at 2:30 after the Advisory to Evacuate. This estimate reflects the 1:40 required to evacuate schoolchildren, 15 minutes for de-boarding and a break for the driver, followed by travel time (22 miles from Cleburne) to Somervell County Jail at an assumed average speed of 40 mph.

To maintain security, it is expected that both buses will evacuate in a single group (or convoy) with an escort of law enforcement vehicles. It is estimated that each bus can be boarded and secured in 10 minutes. It is reasonable to assume that 2 buses can be loaded in parallel, consistent with the need to maintain order and security.

For Scenario 6 (winter), Region 3 (entire EPZ), the average speed output by the model at approximately 2:30 after the Advisory to Evacuate is 48 mph. The distance to the EPZ boundary is 8 miles; it will take approximately 10 minutes to travel out of the EPZ.

The ETE for Somervell County Jail is:

Mobilize the buses:	2:30
Board the Inmates:	0:10
Travel out of EPZ:	0:10
ETE	**2:50**

8.6 Evacuation of Homebound Special Needs Population

The following special needs registration data were provided by representatives from the offices of emergency management for the EPZ counties:

Somervell County – 32 special needs persons requiring transportation:

- 0 bedridden
- 6 wheelchair bound
- 26 ambulatory

Hood County – 51 special needs persons requiring transportation:

- 0 bedridden
- 4 wheelchair bound
- 47 ambulatory

As discussed in Section 8.3, buses can transport up to 30 persons, wheelchair buses can transport 15 persons, and wheelchair vans can transport 4 persons.

ETE for Special Needs Persons

Buses

Assuming no more than one special needs person per household (HH) implies that 73 households need to be serviced. If 9 buses are deployed to service these special needs HH, then they each would require about 8 stops, on average. The following outlines the ETE calculations:

1. Assume 9 buses are deployed, each with approximately 8 stops, to service a total of 73 HH.

2. The buses evacuating school children would subsequently be deployed to service special needs persons.

    a. Buses arrive at the school reception center at 1:40 (see Table 8-5A)

    b. Discharge passengers and driver rests: 5 + 15 = 20 minutes

    c. Travel to EPZ, to first pickup: 35 minutes (average of travel time from EPZ boundary to reception center in Table 8-5A)

d. Load HH members at first pick up: 5 minutes

e. Travel to next pickup locations: 7 @ 6 minutes = 42 minutes

f. Load HH members: 7 @ 5 minutes = 35 minutes

g. Travel to EPZ boundary at free speed from last pickup (assume 8 miles @ 40 mph – EPZ is clear of congestion at this time): 12 minutes

ETE: 1:40 + 20 + 35 + 5 + 42 + 35 + 12 = 4:10

Rain ETE: 2:00 + 20 + 43 + 5 + 49 + 35 + 14 = 4:50

The estimated travel time between pickups is based on a distance of 2 miles @ 20 mph = 6 minutes. If planned properly, the pickup locations for each bus run should be clustered within the same general area. The travel time to the EPZ to the first pickup in rain is 43 minutes (average of travel time from EPZ Boundary to reception center in Table 8-5B). It is further assumed that travel speeds are 10% lower in rain – travel time to the EPZ boundary at free speed from last pickup requires 14 minutes (8 miles @ 36 mph) in rain and that travel time between pickups is 7 minutes (2 miles @ 18 mph). All ETE are rounded up to the nearest 5 minutes.

If school is not in session, then the first pickup would occur at 90 minutes and …

ETE: 90 + 5 + 42 + 35 + 15 = 3:10

Rain ETE: 100 + 5 + 49 + 35 + 18 = 3:30

Travel to EPZ boundary: 8 miles @ 30 mph at 2:55 in good weather, 8 miles @ 27 mph at 3:10 in rain.

The average household size in the EPZ is 2.21 persons according to Figure F-1 of the ETE report. Assuming all HH members travel with the disabled person yields 8 x 2.21 = 18 persons per bus.

From the perspective of bus capacity, fewer buses could be deployed. For example, 6 buses, each servicing 12 HH could accommodate 2.21 x 12 = 27 people, but the additional 4 stops would add 4 x (6 + 5) = 44 minutes to the ETE.

Wheel-Chair Vans

Based on a wheelchair van capacity of 4 wheelchairs per trip, 3 wheelchair vans are needed to evacuate the 10 wheelchair bound persons within the EPZ. Assuming one special needs person per household, each wheelchair van will service about 4 households. It is conservatively assumed that the households are spaced 5 miles apart and that van speeds approximate those of school buses = 20 mph between households.

a. Assumed mobilization time for wheelchair van resources to arrive at first household: 1:30

b. Loading time at first household: 15 minutes

c. Travel to next household: 3 @ 15 minutes (5 miles @ 20 mph) = 45 minutes

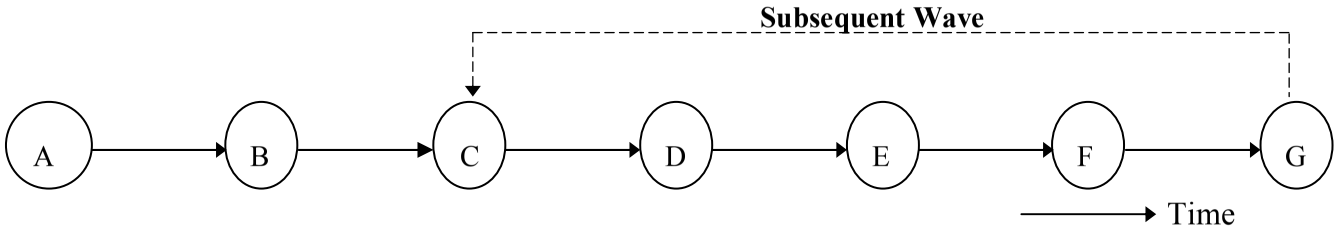
d. Loading time: 3 @ 15 minutes = 45 minutes

e. Wheelchair van travel time to EPZ boundary at 3:15: 5 miles @ 20 mph = 15 minutes

   ETE: 1:30 + 15 + 45 + 45 + 15 = 3:30

   Rain ETE: 1:40 + 15 + 51 + 45 + 17 = 3:50

   It is assumed that mobilization is 10 minutes longer in rain = 1:40. Travel speeds are 10% lower in rain; thus, travel time is 5 miles @ 18 mph = 17 minutes.



Event

A	Advisory to Evacuate
B	Bus Dispatched from Depot
C	Bus Arrives at Facility/Pick-up Route
D	Bus Departs for Reception Center/Host School
E	Bus Exits Region
F	Bus Arrives at Reception Center/Host School
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/Host School Outside the EPZ.
F→G	Passengers Leave Bus; Driver Takes a Break

Figure 8-1. Chronology of Transit Evacuation Operations

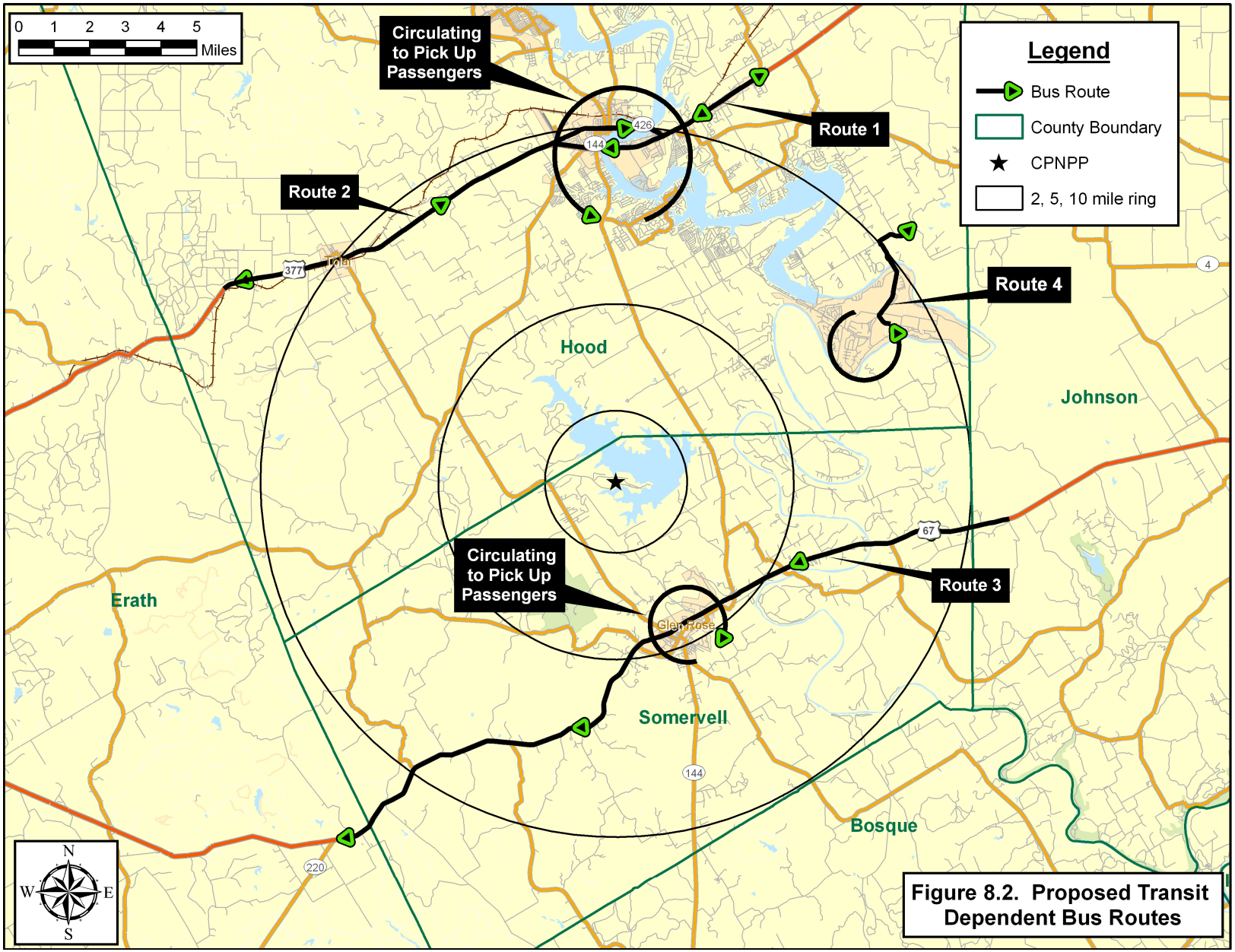


Figure 8.2. Proposed Transit Dependent Bus Routes

Table 8-1. Transit Dependent Population Estimates														
Facility Name	2007 EPZ Population	Survey Average Household Size With Indicated No. of Vehicles			Estimated Number of Households	Survey Percent Households With			Survey Percent Households With Commuters	Survey Percent Households With Non-Returning Commuters	Total People Requiring Transport	Estimated Ridesharing Percentage	People Requiring Public Transit	Percent of Population Requiring Public Transit
		0	1	2		0 Vehicle	1 Vehicle	2 Vehicle						
Comanche Peak Nuclear Power Plant	33,435	1.10	1.53	2.33	15,129	3.5%	27.5%	49.2%	40%	55%	1,185*	50%	593	1.8%

*See Section 8.1 for detailed calculation.

Table 8-2. School Population Demand Estimates							
Zone	**Distance (miles)**	**Direction**	**School Name**	**Municipality**	**Enroll-ment**	**Staff**	**Bus Runs Required**
Hood County							
1C	6.9	NE	Mambrino Elementary School	Granbury	630	77	9
4G	10.3	WNW	Tolar High School	Tolar	620	75	13
Granbury	9	N	Brawner Intermediate School	Granbury	412	51	9
Granbury	8.9	N	Emma Roberson Elementary School	Granbury	642	59	10
TOL	9.8	NW	Tolar Elementary School	Tolar	260	30	4
TOL	9.8	NW	Tolar Junior High School	Tolar	150	15	3
				Hood County Totals:	*2,714*	*307*	*48*
Somervell County							
2D	3.1	E	Happy Hills Farm	Granbury	120	100	3
2H	8.5	ESE	Brazos River Charter School	Nemo	160	15	4
3C	5.3	S	Glen Rose Junior High School	Glen Rose	389	55	8
Glen Rose	4.8	SSE	Glen Rose Elementary School	Glen Rose	413	66	6
Glen Rose	4.7	SSE	Glen Rose High School	Glen Rose	500	90	10
Glen Rose	4.9	SSE	Glen Rose Intermediate School	Glen Rose	385	55	8
				Somervell County Totals:	*1,967*	*381*	*39*
				EPZ Totals:	**4,681**	**688**	**87**

Table 8-3. Host Schools		
Facility	**Zone**	**Host School**
High Schools		
Brazos River Charter School	2H	Cleburne High School
Tolar High School	4G	Stephenville Junior High School
Glen Rose High School	Glen Rose	Stephenville Junior High School
Middle/ Intermediate Schools		
Glen Rose Intermediate School	Glen Rose	Stephenville Junior High School
Glen Rose Junior High School	Glen Rose	Stephenville Junior High School
Brawner Intermediate School	Granbury	Granbury Middle School
Tolar Junior High School	Tolar	Stephenville Junior High School
Elementary Schools		
Glen Rose Elementary School	Glen Rose	Stephenville Junior High School
Emma Roberson Elementary School	Granbury	Crossland 9th Grade Center
Mambrino Elementary School	Granbury	Acton Middle School
Tolar Elementary School	Tolar	Stephenville Junior High School
Other Schools		
Happy Hills Farm	2D	Cleburne High School

Table 8-4. Special Facility Transit Demand											
ZONE	Facility Name	Municipality	Capacity	Current Census	Ambulatory	Wheelchair Bound	Bedridden	Ambulance Runs	Wheelchair Bus Runs	Wheelchair Van Runs	Bus Runs
HOOD COUNTY											
1D	Acorn Run Manor	Granbury	2	2	2	0	0	Facility owned vehicle			
1D	Courtyards at Lake Granbury	Granbury	112	112	60	52	0	0	3	2	2
1D	Southern Concepts	Granbury	6	6	6	0	0	Facility owned van			
4F	Granbury Villa Nursing Center	Granbury	93	81	41	30	10	5	2	0	2
4F	Victoria's Place	Granbury	19	18	18	0	0	0	0	0	1
Granbury	Gables	Granbury	77	77	54	23	0	0	2	0	2
Granbury	Granbury Care Center*	Granbury	178	170	91	65	14	7	4	2	4
Granbury	Lake Granbury Medical Center	Granbury	59	25	8	9	8	4	1	0	1
Granbury	Southern Concepts	Granbury	6	6	6	0	0	0	0	0	1
Granbury	Southern Concepts Day Activity Center	Granbury	20	20	19	1	0	0	0	1	1
Granbury	Southern Concepts*	Granbury	3	2	2	0	0	Facility owned van			
Tolar	Southern Concepts	Tolar	6	6	6	0	0	0	0	0	1
SOMERVELL COUNTY											
Glen Rose	Cherokee Rose Manor	Glen Rose	102	70	10	45	15	8	3	0	1
Glen Rose	Glen Rose Medical Center Hospital*	Glen Rose	16	16	9	6	1	1	0	2	1
Glen Rose	Glen Rose Medical Center Nursing Home*	Glen Rose	118	118	64	45	9	5	3	0	3
		Total:	**817**	**729**	**396**	**276**	**57**	**30**	**18**	**7**	**20**

*For these facilities, the breakdown of patients into ambulatory, wheelchair-bound, and bedridden is not available. The average percent in each category, calculated from those facilities which had data available, is applied.

Table 8-5A. School Evacuation Time Estimates - Good Weather								
School	**Driver Mobilization Time(min)**	**Loading Time (min)**	**Dist. to EPZ Bndry (mi.)**	**Travel Time to EPZ Bndry (min)**	**ETE (hr:min)**	**Dist. EPZ Bndry to H.S. (mi.)**	**Travel Time EPZ Bndry to H.S. (min)**	**ETE to H.S. (hr:min)**
Hood County Schools								
Brawner Intermediate School	60	5	1.8	4	**1:10**	0.5	1	**1:10**
Emma Roberson Elementary School	60	5	1.4	3	**1:10**	0.3	1	**1:10**
Mambrino Elementary School	60	5	5.1	9	**1:15**	6.7	11	**1:25**
Tolar Elementary School	60	5	1.2	3	**1:10**	24	36	**1:45**
Tolar Junior High School	60	5	1.2	3	**1:10**	24	36	**1:45**
Tolar High School	60	5	0.3	1	**1:10**	24	36	**1:45**
Somervell County Schools								
Brazos River Charter School	60	5	3.1	6	**1:15**	13.4	21	**1:35**
Glen Rose Elementary School	60	5	9.2	16	**1:25**	23	35	**2:00**
Glen Rose High School	60	5	8.8	15	**1:20**	23	35	**1:55**
Glen Rose Intermediate School	60	5	9.0	16	**1:25**	23	35	**2:00**
Glen Rose Junior High School	60	5	8.1	14	**1:20**	23	35	**1:55**
Happy Hills Farm	60	5	10.0	17	**1:25**	13	20	**1:45**
				Average for EPZ:	**1:20**		**Average:**	**1:40**

Note: The average speed output by the model of 35.8 mph (Scenario 6, Region 3 at 60 minutes after the ATE) is used to compute travel time to the EPZ Boundary. The assumed average speed to the Host School is 40 mph.

Table 8-5B. School Evacuation Time Estimates - Rain								
School	Driver Mobilization Time(min)	Loading Time (min)	Dist. to EPZ Bndry (mi.)	Travel Time to EPZ Bndry (min)	ETE (hr:min)	Dist. EPZ Bndry to H.S. (mi.)	Travel Time EPZ Bndry to H.S. (min)	ETE to H.S. (hr:min)
Hood County Schools								
Brawner Intermediate School	65	10	1.8	4	**1:20**	0.5	1	**1:20**
Emma Roberson Elementary School	65	10	1.4	3	**1:20**	0.3	1	**1:20**
Mambrino Elementary School	65	10	5.1	11	**1:30**	6.7	12	**1:40**
Tolar Elementary School	65	10	1.2	3	**1:20**	24	42	**2:00**
Tolar Junior High School	65	10	1.2	3	**1:20**	24	42	**2:00**
Tolar High School	65	10	0.3	1	**1:20**	24	42	**2:00**
Somervell County Schools								
Brazos River Charter School	65	10	3.1	7	**1:25**	13.4	23	**1:45**
Glen Rose Elementary School	65	10	9.2	19	**1:35**	22	38	**2:15**
Glen Rose High School	65	10	8.8	18	**1:35**	23	40	**2:15**
Glen Rose Intermediate School	65	10	9.0	18	**1:35**	23	40	**2:15**
Glen Rose Junior High School	65	10	8.1	17	**1:35**	23	40	**2:15**
Happy Hills Farm	65	10	10.0	20	**1:35**	13	23	**2:00**
				Average for EPZ:	**1:30**		**Average:**	**2:00**

Note: The average speed output by the model of 30.1 mph (Scenario 7, Region 3 at 60 minutes after the ATE) is used to compute travel time to the EPZ Boundary. The assumed average speed to the Host School is 35 mph.

Table 8-6. Summary of Transit Dependent Bus Routes		
Route Number	**Number of Buses**	**Route Description**
1	7	US Hwy 377 SB, circulate Granbury; exit via US Hwy 377 SB.
2	7	US Hwy 377 NB, circulate Granbury; exit via US Hwy 377 NB.
3	5	US Hwy 67 WB, circulate Glen Rose; exit via US Hwy 67 WB.
4	1	FM 4, circulate Pecan Plantation, return to FM 4.

Table 8-7A. Transit Dependent Evacuation Time Estimates - Good Weather														
		Single Wave					Second Wave							
Route Number	Bus Number	Mobilization (min.)	Route Length (mi.)	Route Travel Time (min.)	Pickup Time (min.)	ETE (hr:min)	Mobilization (min.)	Unload (min.)	Driver Rest (min.)	Return Travel time to EPZ (min.)	Travel Time EPZ to Route Start (min.)	Route Travel Time (min.)	Pickup Time (min.)	ETE (hr:min)
1	1 - 4	90	10	17	30	2:20	100	5	10	35	0	15	30	3:15
	5 - 7	105	10	17	30	2:35	100	5	10	35	0	15	30	3:15
2	1 - 4	90	10	17	30	2:20	100	5	10	38	0	15	30	3:20
	5 - 7	105	10	17	30	2:35	100	5	10	38	0	15	30	3:20
3	1 - 3	90	18	31	30	2:35	100	5	10	20	0	27	30	3:15
	4, 5	105	18	31	30	2:50	100	5	10	20	0	27	30	3:15
4	1	90	8	14	30	2:15	100	5	10	27	0	12	30	3:05
Average for EPZ:						**2:30**	**Average for EPZ:**							**3:15**

Table 8-7B. Transit Dependent Evacuation Time Estimates - Rain														
		Single Wave					Second Wave							
Route Number	Bus Number	Mobilization (min.)	Route Length (mi.)	Route Travel Time (min.)	Pickup Time (min.)	ETE (hr:min)	Mobilization (min.)	Unload (min.)	Driver Rest (min.)	Return Travel time to EPZ (min.)	Travel Time EPZ to Route Start (min.)	Route Travel Time (min.)	Pickup Time (min.)	ETE (hr:min)
1	1 - 4	95	10	23	35	2:35	120	5	10	39	0	15	35	3:45
	5 - 7	110	10	23	35	2:50	120	5	10	39	0	15	35	3:45
2	1 - 4	95	10	23	35	2:35	120	5	10	43	0	15	35	3:50
	5 - 7	110	10	23	35	2:50	120	5	10	43	0	15	35	3:50
3	1 - 3	95	18	41	35	2:55	120	5	10	22	0	27	35	3:40
	4, 5	110	18	41	35	3:10	120	5	10	22	0	27	35	3:40
4	1	95	8	18	35	2:30	120	5	10	31	0	12	35	3:35
Average for EPZ:						**2:45**	**Average for EPZ:**							**3:45**

Table 8-8A. Camp Evacuation Time Estimates - Good Weather								
Facility	Driver Mobilization Time(min)	Loading Time (min)	Dist. to EPZ Bndry (mi.)	Travel Time to EPZ Bndry (min)	ETE (hr:min)	Dist. EPZ Bndry to R.C. (mi.)	Travel Time EPZ Bndry to RC (min)	ETE to R.C. (hr:min)
Somervell County								
Camp Arrowhead	90	5	7	14	**1:50**	13	20	**2:10**
Camp Tres Rios	90	5	7	14	**1:50**	14	21	**2:10**
Glen Lake Methodist Camp	90	5	8.5	16	**1:55**	14	21	**2:15**
Riverbend Retreat Center	90	5	3.5	7	**1:45**	23	35	**2:20**
Steven's Ranch	90	5	2.5	5	**1:40**	18	27	**2:10**
				Average for EPZ:	**1:50**		**Average:**	**2:15**

Table 8-8B. Camp Evacuation Time Estimates - Rain								
Facility	Driver Mobilization Time(min)	Loading Time (min)	Dist. to EPZ Bndry (mi.)	Travel Time to EPZ Bndry (min)	ETE (hr:min)	Dist. EPZ Bndry to R.C. (mi.)	Travel Time EPZ Bndry to RC (min)	ETE to R.C. (hr:min)
Somervell County								
Camp Arrowhead	100	10	7	17	**2:10**	13	23	**2:30**
Camp Tres Rios	100	10	7	17	**2:10**	14	24	**2:35**
Glen Lake Methodist Camp	100	10	8.5	21	**2:15**	14	24	**2:35**
Riverbend Retreat Center	100	10	3.5	9	**2:00**	23	40	**2:40**
Steven's Ranch	100	10	2.5	7	**2:00**	18	31	**2:30**
				Average for EPZ:	**2:10**		**Average:**	**2:35**

Table 8-9. Ambulance Resources			
Name	**Ambulances**	**Estimated Mobilization Time (min)**	
Granbury Hood County EMS	4	10	
Pecan Plantation EMS	3	15	
Erath County EMS	3	30	
Stephenville Fire Dept.	2	30	
LifeCare EMS, Parker County	5	20	
CareFlite, Johnson County	4	20	
Benbrook Fire Dept.	1	30	
MedStart, Tarrant County	8	45-60*	
Crowley Fire Dept.	1	30-45*	
Northern Bosque County	1	30	
Somervell County	3	15	
TOTAL:	**35**	**Weighted Average**	**29.9**

*Weighted average computed using the upper bound of this range.

9. TRAFFIC MANAGEMENT STRATEGY

This section presents the current 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).
- Traffic Control Devices to assist these personnel in the performance of their tasks. These devices should comply with the guidance of 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 (also available online). Applicable devices include, with reference to the MUTCD:
    - Traffic Barriers: Chapter 6F, section 6F.61, 62 and Figure 6F-4.
    - Traffic Cones: Chapter 3F and section 6F.56.
    - Signs: Chapter 2I.
- A plan that defines all 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 serve to expedite travel out of the EPZ along routes that the analysis has found to be most effective.
2. Discourage traffic movements that permit evacuating vehicles to travel in a direction which takes them significantly closer to the power plant, or which interferes with the efficient flow of other evacuees.

We employ the terms "facilitate" and "discourage" 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 preliminary to evacuating.
- An evacuating driver may be taking a detour from the evacuation route in order 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 strategy is the outcome of the following process:

1. A field survey of these critical locations.

   The schematics describing traffic control, which are presented in Appendix

G, are based on data collected during field surveys, upon large-scale maps, and on overhead photos.

2. Computer analysis of the evacuation traffic flow environment.
   This analysis identifies the best routing and those locations that experience pronounced congestion.
3. Consultation with emergency management and law enforcement personnel.
   Trained personnel who are experienced in controlling traffic and are aware of the likely evacuation traffic patterns have extensively reviewed these control tactics.
4. Prioritization of TCPs.
   Application of traffic control at some TCPs will have a more pronounced influence on expediting traffic movements than at other TCPs. For example, TCPs controlling traffic originating from areas in close proximity to the power plant could have a more beneficial effect on minimizing potential exposure to radioactivity than those TCPs located far from the power plant. Thus, during the mobilization of personnel to respond to the emergency situation, those TCPs which are assigned a higher priority, should be manned earlier. These priorities have been developed in conjunction with county emergency management representatives and law enforcement personnel.

The control tactic at each TCP is presented in each schematic that appears in Appendix G.

The use of Intelligent Transportation Systems (ITS) technologies can reduce manpower and equipment needs, while still facilitating the evacuation process. Dynamic Message Signs (DMS) can be placed within the EPZ to provide information to travelers regarding traffic conditions, route selection, and Reception Center information. DMS can also be placed outside of the EPZ to warn motorists to avoid using routes that may conflict with the flow of evacuees away from the nuclear power plant. Highway Advisory Radio (HAR) can be used to broadcast information to evacuees en route through their vehicle stereo systems. Automated Traveler Information Systems (ATIS) can also be used to provide evacuees with information. Internet websites can provide traffic and evacuation route information before the evacuee begins his trip, while on board navigation systems (GPS units), cell phones, and pagers can be used to provide information en route. These are only several examples of how ITS technologies can benefit the evacuation process.

Chapter 2I of the MUTCD presents guidance on Emergency Management signing. Specifically, the Evacuation Route sign, EM-1 on page 2I -3, with the word “Hurricane” removed, could be installed selectively within the EPZ, if considered advisable by local and state authorities. Similar comments apply to sign EM-3 which identifies TCP locations.

As discussed in Section 2.3, these TCP are not credited in calculating the ETE results. Access control points (ACP) are deployed near the periphery of the EPZ to divert "through" trips. The ETE calculations reflect the assumptions that all "external-external" trips are interdicted after 90 minutes have elapsed after the advisory to evacuate (ATE).

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

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 Emergency Planning Zone (EPZ).
- Routing of evacuees from the EPZ boundary to the Reception Centers.

Evacuees should be routed within the EPZ in such a way as to *minimize their exposure to risk*. This primary requirement is met by routing traffic to move *away* from the location of the Comanche Peak Nuclear Power Plant, to the extent practicable, and by delineating evacuation routes that expedite the movement of evacuating vehicles. This latter objective is addressed by developing evacuation routes to achieve a balancing of traffic demand relative to the available highway capacity to the extent possible, subject to satisfying the primary requirement noted above. This is achieved by carefully specifying candidate destinations for all origin centroids where evacuation trips are generated, and applying the TRAD model effectively. See Appendices A-D for further discussion.

Figure 10-1 presents a map showing the general population Reception Centers. The major evacuation routes for the two counties within the EPZ are presented in Figures 10-2 and 10-3.

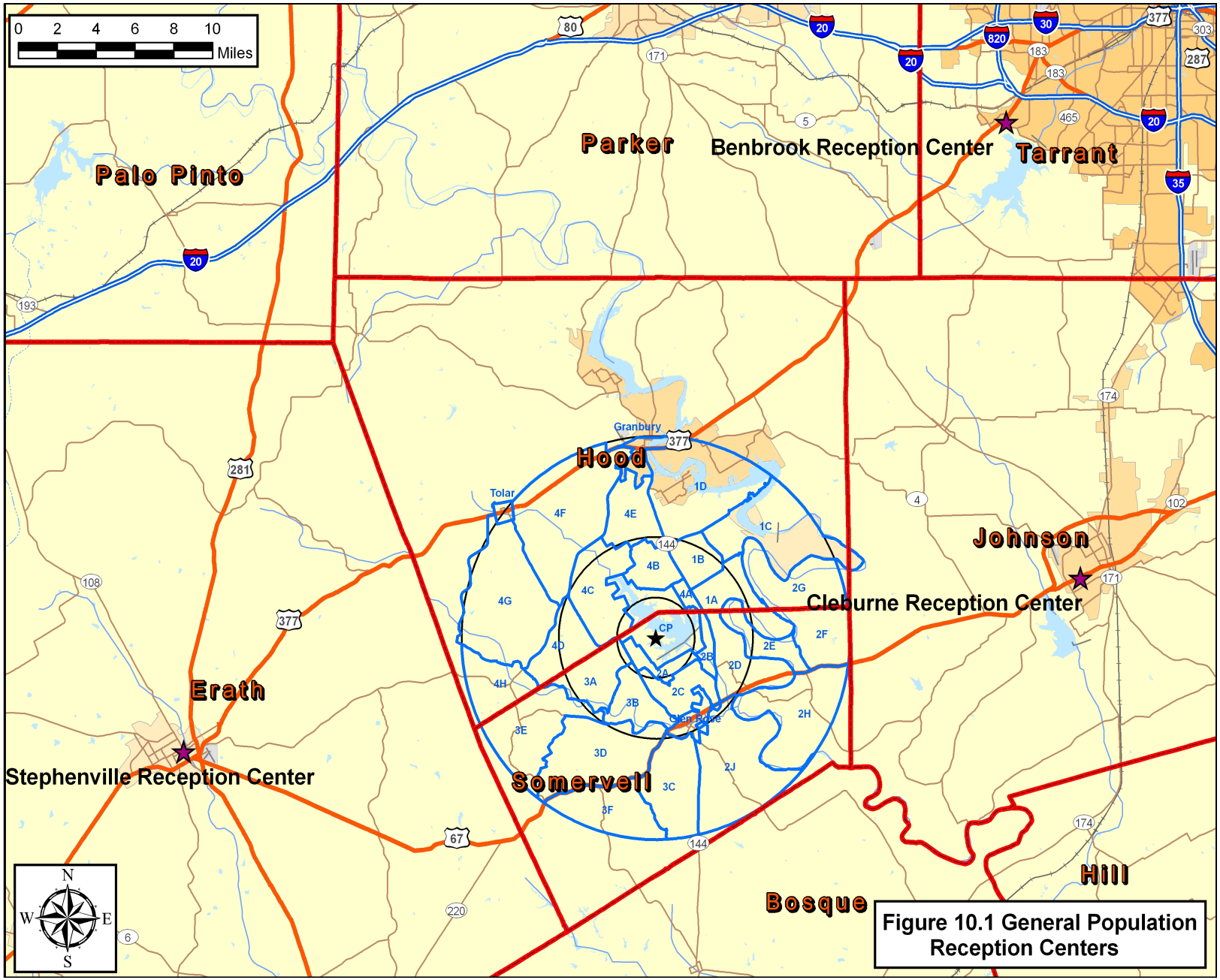


Figure 10.1 General Population Reception Centers

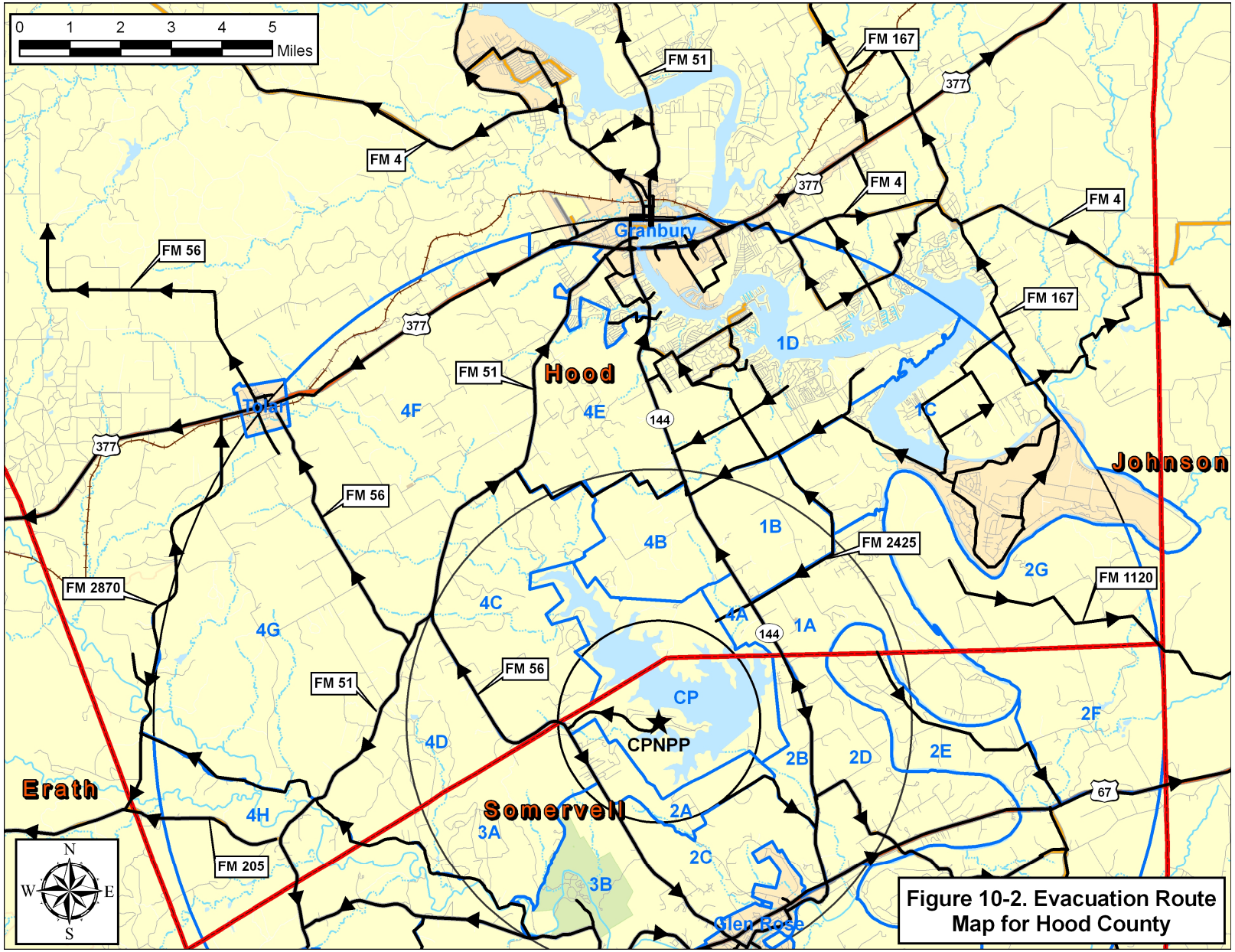


Figure 10-2. Evacuation Route Map for Hood County

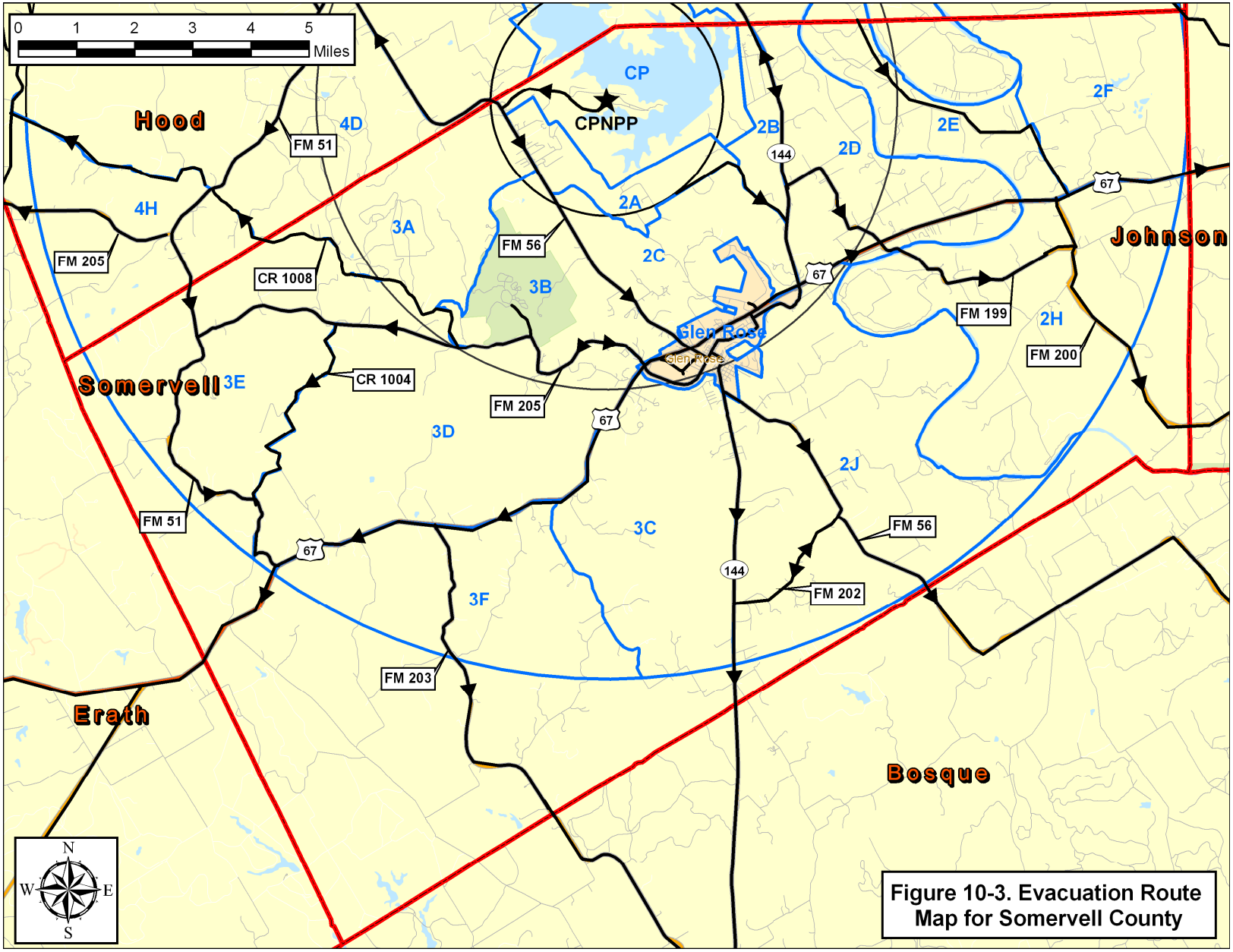


Figure 10-3. Evacuation Route Map for Somervell County

11. SURVEILLANCE OF EVACUATION OPERATIONS

There is a need for surveillance of traffic operations during the evacuation. There is also a need to clear any blockage of roadways arising from accidents or vehicle disablement. Surveillance can take several forms.

1. Traffic control personnel, located at Traffic Control and Access Control Points, provide fixed-point surveillance.
2. Ground patrols may be undertaken along well-defined paths to ensure coverage of those highways that serve as major evacuation routes.
3. Aerial surveillance of evacuation operations may also be conducted using helicopter or fixed-wing aircraft.
4. Cellular phone calls (if cellular coverage exists) from motorists may also provide direct field reports of road blockages.

These concurrent surveillance procedures are designed to provide coverage of the entire EPZ as well as the area around its periphery. It is the responsibility of the Counties to support an emergency response system that can receive messages from the field and be in a position to respond to any reported problems in a timely manner. This coverage should quickly identify, and expedite the response to, any blockage caused by a disabled vehicle.

Tow Vehicles

In a low-speed traffic environment, any vehicle disablement is likely to arise due to a low-speed collision, mechanical failure or the exhausting of its fuel supply. In any case, the disabled vehicle can be pushed onto the shoulder, thereby restoring traffic flow. Past experience in other emergencies indicates that evacuees who are leaving an area often perform activities such as pushing a disabled vehicle to the side of the road without prompting.

While the need for tow vehicles is expected to be low under the circumstances described above, it is still prudent to be prepared for such a need. Tow trucks with a supply of gasoline may be deployed at strategic locations within, or just outside, the EPZ. These locations should be selected so that:

1. They permit access to key, heavily loaded, evacuation routes.
2. Responding tow trucks would most likely travel counter-flow relative to evacuating traffic.

12. CONFIRMATION TIME

It is necessary to confirm that the evacuation process is effective in the sense that the public is complying with the advisory to evacuate. Although Hood and Somervell Counties may use their own procedures for confirmation, we suggest an alternative or complementary approach.

The procedure we suggest employs a stratified random sample and a telephone survey. The size of the sample is dependent on the expected number of households that do not comply with the advisory to evacuate. We believe it is reasonable to assume, for the purpose of estimating sample size that at least 80 percent of the population within the EPZ will comply with the advisory to evacuate. On this basis, an analysis could be undertaken (see Table 12-1) to yield an estimated sample size of approximately 300.

The confirmation process should start at about 3 hours after the advisory to evacuate, which is when 90 percent of evacuees have completed their mobilization activities. At this time, virtually all evacuees will have departed on their respective trips and the local telephone system will be largely free of traffic.

As indicated in Table 12-1, approximately 7-1/2 person hours are needed to complete the telephone survey. If six people are assigned to this task, each dialing a different set of telephone exchanges (e.g., each person can be assigned a different set of Zones), then the confirmation process will extend over a time frame of about 75 minutes. Thus, the confirmation should be completed approximately when the evacuated area is cleared. Of course, fewer people would be needed for this survey if the Evacuation Region were only a portion of the EPZ. Use of modern automated computer controlled dialing equipment can significantly reduce the manpower requirements and the time required to undertake this type of confirmation survey.

Should the number of telephone responses (i.e., people still at home) exceed 20 percent, then the telephone survey should be repeated after an hour's interval until the confirmation process is completed.

TABLE 12-1
ESTIMATED NUMBER OF TELEPHONE CALLS REQUIRED
FOR CONFIRMATION OF EVACUATION

Problem Definition

Estimate number of phone calls, n, needed to ascertain the proportion, F of households that have not evacuated.

Reference: Burstein, H., Attribute Sampling, McGraw Hill, 1971

Given:

No. of households plus other facilities, N, within the EPZ (est.) = 15,200
Est. proportion, F, of households that have not evacuated = 0.20
Allowable error margin, e: 0.05
Confidence level, α: 0.95 (implies A = 1.96)

Applying Table 10 of cited reference,

$$p = F + e = 0.25;\ q = 1 - p = 0.75$$

$$n = \frac{A^2 pq + e}{e^2} = 308$$

Finite population correction:

$$n_F = \frac{nN}{n + N - 1} = 302$$

Thus, some 300 telephone calls will confirm that approximately 20 percent of the population has not evacuated. If only 10 percent of the population does not comply with the advisory to evacuate, then the required sample size, n_F = 212.

Est. Person Hours to complete 300 telephone calls

Assume: Time to dial using touch-tone (random selection of listed numbers): 30 seconds
Time for 6 rings (no answer): 36 seconds
Time for 4 rings plus short conversation: 60 sec.
Interval between calls: 20 sec.

Person Hours: 300[30+20+0.8(36)+0.2(60)]/3600 = 7.6