From: <Joseph_Hegner@dom.com>
To: <mls3@nrc.gov>
Date: Wed, Nov 5, 2003 9:02 AM
Subject: EP Documents--Fiist of Two

Mike,

My e-mail system informed me that a message I just sent to you a few minutes ago transmitting the two EP documents you'd requested was too big, and it bounced back.

I'm going to send two separate messages, with one document attached to each. This one is the North Anna ETE.

Joe H.

(See attached file: 2001 NAPS ETE Rpt w043003 correction.pdf)

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Subject: EP Documents--Fiist of Two
Creation Date: Wed, Nov 5, 2003 9:01 AM
From: <Joseph_Hegner@dom.com>

Created By: Joseph_Hegner@dom.com

Recipients
nrc.gov
owf4_po.OWFN_DO
MLS3 (Michael Scott)

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owf4_po.OWFN_DO	nrc.gov

Files	Size	Date & Time
MESSAGE	355	Wednesday, November 5, 2003 9:01 AM
2001 NAPS ETE Rpt w043003 correction.pdf	1592944	
Mime.822	2181656	

Options

Expiration Date:	None
Priority:	Standard
Reply Requested:	No
Return Notification:	None
Concealed Subject:	No
Security:	Standard

Innovative Emergency Management®

Evacuation Time Estimates for the North Anna Power Station and Surrounding Jurisdictions

November 2, 2001

IEM/TEC01-220

Prepared By

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EXECUTIVE SUMMARY

Dominion Virginia Power has contracted Innovative Emergency Management, Inc. (IEM) to update the population figures for the 10-mile emergency planning zone (EPZ) surrounding North Anna Power Station (NAPS) in accordance with 2000 Census data. IEM was also contracted to prepare evacuation time estimates (ETEs) that reflect those figures. This document describes the methods used to obtain current population data and to produce the ETEs, and reports the updated population figures, road network information, and evacuation time estimates.

The total permanent resident population within the 10-mile EPZ for North Anna was calculated to be 20,292. This population is broken down by protective action zone (PAZ) and by sector and ring within the report. Significant transient populations identified within the EPZ are concentrated within PAZs 12, 14, and 15 and total approximately 380 persons. Special populations identified within the 10-mile EPZ include 4 industries with greater than 50 employees and 7 schools.

Seven basic geographic evacuation scenarios were modeled under normal and adverse weather conditions. All of the ETEs generated for North Anna are based on peak season nighttime population counts, as these represent the worst case. ETEs for normal weather conditions ranged from 1 hour and 25 minutes to 1 hour and 45 minutes. ETEs for adverse weather conditions ranged from 1 hour and 30 minutes to 1 hour and 45 minutes.

No significant traffic congestion was noted in any of the scenarios evaluated. Therefore, the time required to evacuate was essentially a combination of the time for the public to be warned and mobilized plus the driving time to exit the 10-mile EPZ. Because the network contains sufficient capacity to handle the evacuating public, "bad weather" has only a limited impact on the ETEs for all scenarios.

Based on the data gathered and the results of the evacuation analyses performed, IEM does not believe that any actions need to be taken to improve the evacuation time for the areas within the 10-mile EPZ for North Anna Power Station.

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1.0 INTRODUCTION

The North Anna Power Station (NAPS), located on Lake Anna in Louisa County, consists of two pressurized water nuclear reactors (Units 1 and 2) owned and operated by Dominion Virginia Power. In order to ensure the safety of the public living in the vicinity of the power plant, Dominion Virginia Power must know the number and location of transient and permanent populations within the 10-mile emergency planning zone (EPZ) surrounding NAPS. This information, which is required in the form of a map of population distribution by the US Nuclear Regulatory Commission's (NRC's) NUREG-0654 (Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants), is necessary for state and local emergency management personnel to provide effective direction in the unlikely event of a nuclear emergency. Recalculating these population figures is particularly relevant now that the US Census Bureau has released its population counts for the year 2000.

Dominion Virginia Power has contracted Innovative Emergency Management, Inc. (IEM) to update the population figures for the 10-mile EPZ surrounding North Anna Power Station and to prepare evacuation time estimates (ETEs) that reflect those figures. This document describes the methods used to obtain current population data and to produce the ETEs, and reports the updated population figures, road network information, and evacuation time estimates.

1.1 Site Location

The North Anna Power Station (NAPS) is located in Louisa County on the southern shore of Lake Anna. The land within the plume exposure pathway is divided almost equally by the 17-mile-long lake and its tributaries (the most significant being the North Anna River), with Spotsylvania County north and east of the lake and Louisa County south and west. Spotsylvania and Louisa Counties, along with small portions of Orange County to the northwest, Caroline County to the east-southeast, and Hanover County to the southeast, compose roughly 90% of the plume exposure pathway, the remainder consisting of the lake and its tributaries.

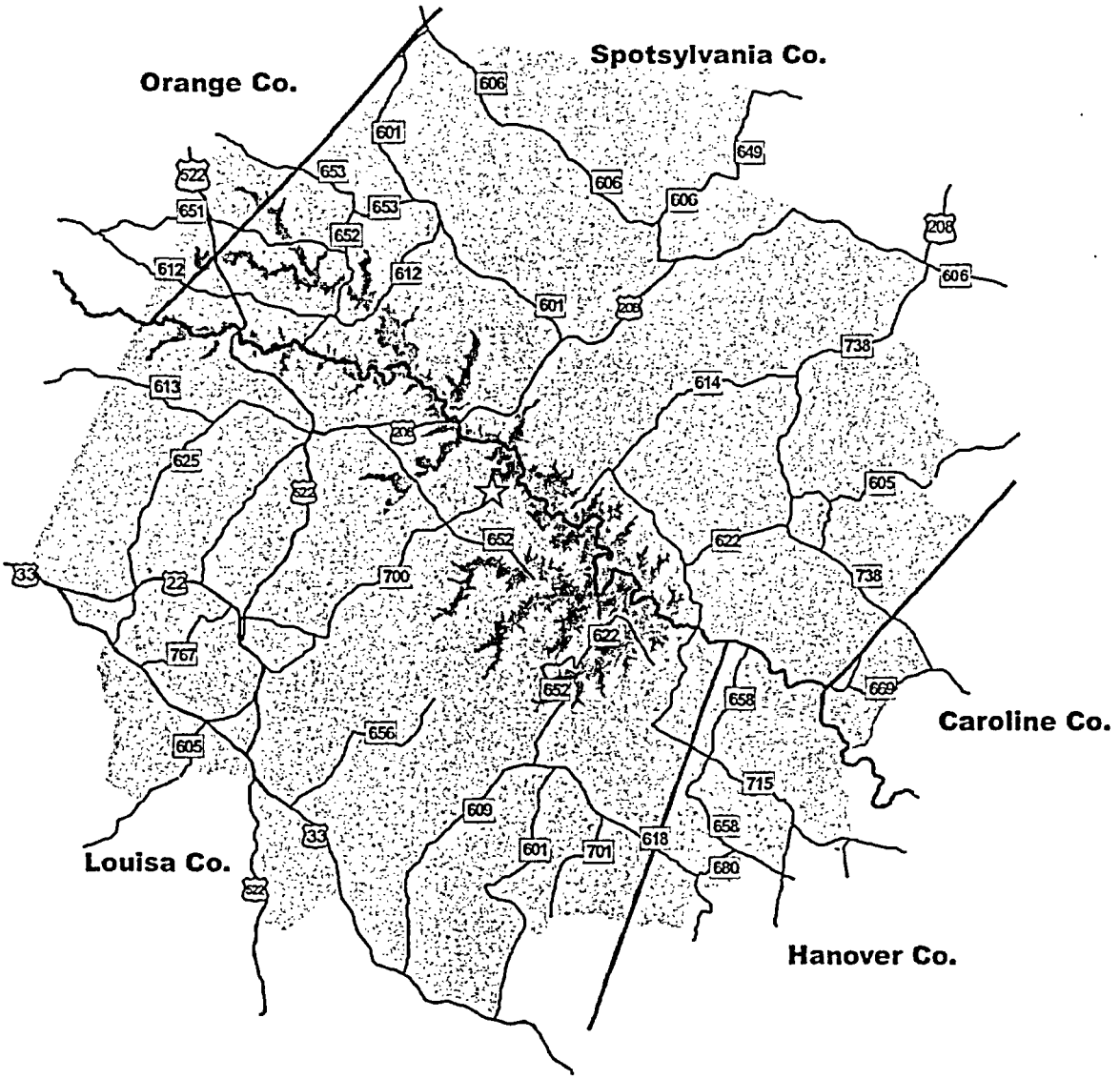


Figure 1: Map of the Area around North Anna Power Station

1.2 Emergency Planning Zone

The Nuclear Regulatory Commission (NRC) requires a division of the 10-mile EPZ into evacuation areas based on concentric rings (referred to as zones) with radii increasing in 1-mile increments and a series of 22.5-degree wedges, or sectors, centered on the zone centers. The sector and ring nomenclature is primarily used by plant personnel to facilitate communication of the area at risk during a real or potential radiological event. Though the 10-mile EPZ is divided into rings with radii ranging from one mile to ten miles, evacuation time estimates are only required for the 2-, 5-, and 10-mile radii circular areas.

To facilitate notification and selection of protective actions for the public, protective action zones (PAZs) have been established within the 10-mile EPZ. This system utilizes prominent physical features, either natural (rivers and lakes) or man-made (roads) to outline the boundaries of each PAZ. The PAZ concept is employed because the zones are readily comprehensible to the area's residents and permits effective dissemination of information and guidance in the event of a radiological emergency.

Twenty-five zones have been established for the NAPS 10-mile EPZ. To the extent feasible, the zones were selected based on existing political boundaries to enhance direction and coordination of the public in the affected area. The demarcation of the zones are roughly 2, 5, and 10 miles from the nuclear facility. This permits flexibility and selectivity in application of protective actions. Figure 2 is a map of the PAZs for NAPS. Attachment 1 contains boundary descriptions of the PAZs within the 10-mile emergency planning zone for NAPS.

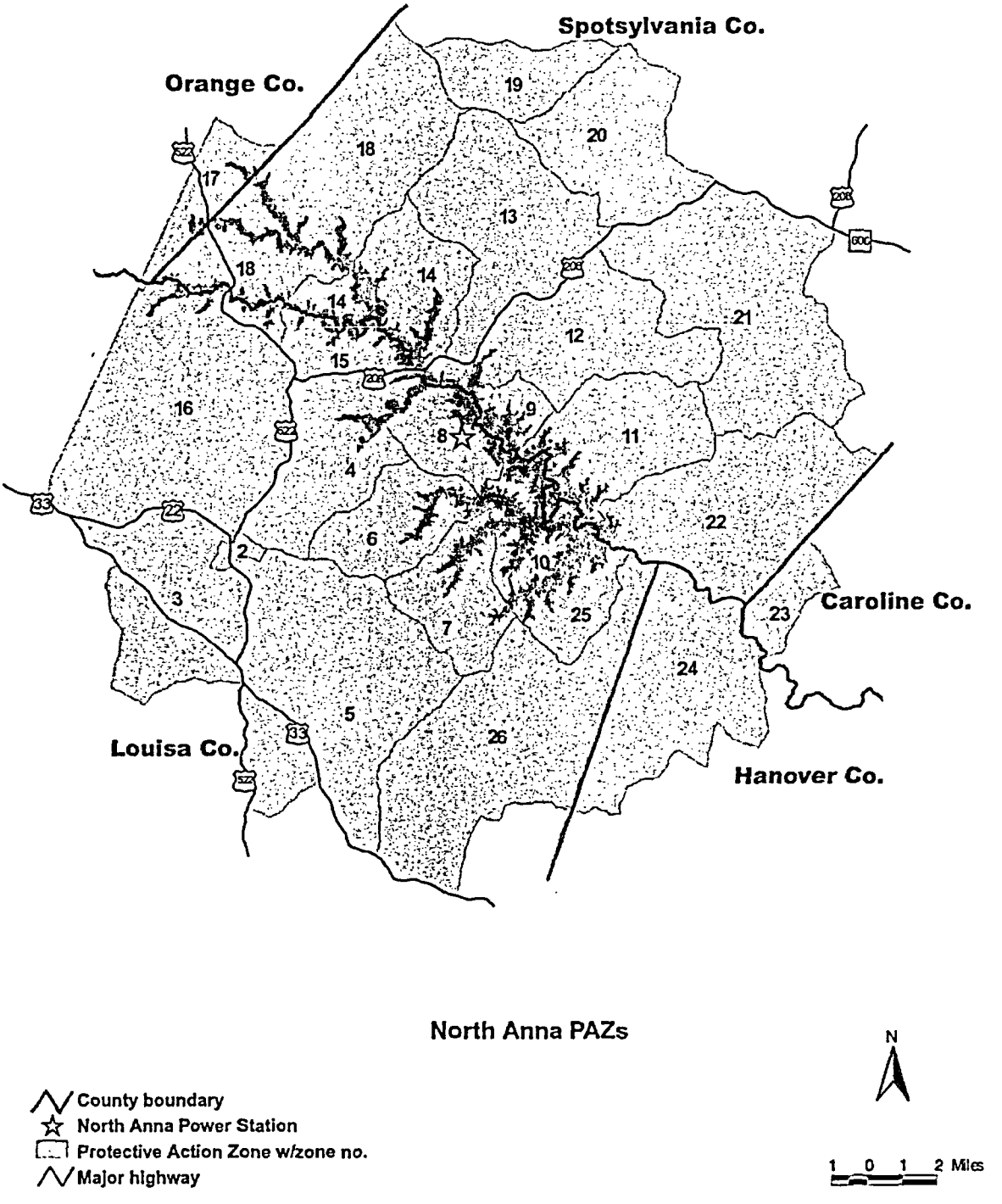


Figure 2: Map of the Protective Action Zones for North Anna Power Station

2.0 POPULATION DATA AND ESTIMATION METHODOLOGY

2.1 *Population Estimation*

IEM identified three population categories within the protective action zones surrounding the North Anna Power Station; as specified in the NUREG-0654, these are: permanent resident population, transient population, and special facility population. Because the power station is located in a densely wooded area, there are no institutional populations within the 10-mile EPZ other than public schools. The majority of the population consists of permanent residents and a varying number of seasonal recreational visitors mainly located on or around the lake.

Population data was derived from the population counts for the year 2000 from the US Census Bureau, business location data obtained from Claritas Corporation, school data from the State of Virginia, and contact with individual facilities. The populations from these sources were assigned to each PAZ designated in the Commonwealth of Virginia Radiological Emergency Plan. These population estimates formed the basis for determining the traffic loading and potential congestion during an evacuation.

2.1.1 Permanent Residents

IEM obtained permanent resident population data from Year 2000 Census. IEM used its geographic information system (GIS) software to process the geographic data and associated population counts for census blocks in each of the counties surrounding the North Anna station. IEM then aggregated these populations over each PAZ to generate a permanent resident population count. Table 1 shows permanent resident population distribution by sector and ring. Table 2 and Figure 3 show permanent resident population distribution by protective action zone. Table 3 shows permanent resident population distribution by county.

Emergency management plans produced by counties and the state include results from recent studies of auto ownership for the population surrounding NAPS. IEM has used a figure for per capita auto ownership derived from these plans and applied it to the current permanent resident population. In addition to permanent resident population information, Table 3 shows household and estimated auto ownership information for the portion of each county that is within the 10-mile EPZ.

Table 1: Permanent Resident Population Distribution Based on 2000 Census Data by Sector and Ring

Sector[1]	Ring[2]	Permanent Resident Population
N	2	18
N	5	265
N	10	585
NNE	2	11
NNE	5	298
NNE	10	853
NE	2	8
NE	5	219
NE	10	872
ENE	2	36
ENE	5	193
ENE	10	1079
E	2	11
E	5	237
E	10	845
ESE	2	37
ESE	5	243
ESE	10	763
SE	2	87
SE	5	103
SE	10	447
SSE	2	37
SSE	5	126
SSE	10	668
S	2	43
S	5	123
S	10	842
SSW	2	62

[1] 22.5° Sectors are designated by compass direction going outward from the plant on the centerline of the sector, e.g., sector from 348.75° to 11.25° is designated "N" for North. Remaining 15 sectors are designated NNE, NE, ENE, E, ESE, SE, SSE, S, and so on.
[2] Rings are defined as the area between two circles of radius 0 and 2 miles, 2 and 5 miles, and 5 and 10 miles.

Sector[1]	Ring[2]	Permanent Resident Population
SSW	5	158
SSW	10	411
SW	2	51
SW	5	120
SW	10	914
WSW	2	18
WSW	5	125
WSW	10	1205
W	2	10
W	5	199
W	10	579
WNW	2	24
WNW	5	236
WNW	10	423
NW	2	27
NW	5	394
NW	10	945
NNW	2	12
NNW	5	141
NNW	10	433

Table 2: Permanent Resident Population Distribution Based on 2000 Census Data by Protective Action Zone (PAZ)

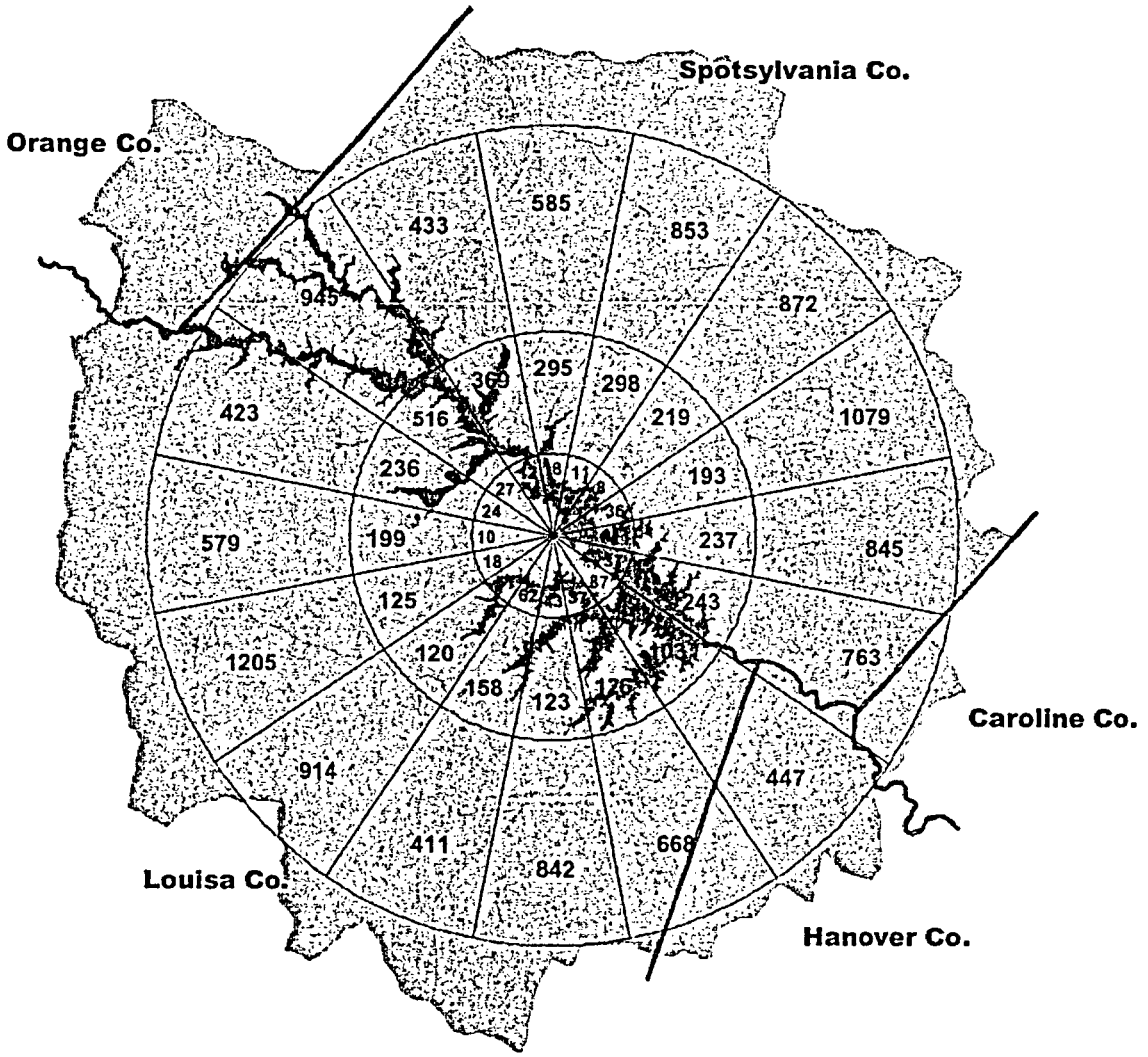
Protective Action Zone[3]	Permanent Resident Population
2	424
3	1257
4	837
5	1331
6	308
7	318
8	289
9	117
10	300
11	740
12	951
13	991
14	541
15	451
16	1589
17	176
18	1664
19	246
20	894
21	2172
22	1355
23	263
24	716
25	253
26	1729

[3] As designated in the Commonwealth of Virginia Radiological Emergency Plan, dated October 2000.

Table 3: Permanent Resident Population Data by County[4]

County	Population	Number of Households	Average Household Size	Non–Auto-Owning Households	Non–Auto-Owning Population
Louisa	9208	4303	2.14	300	643
Spotsylvania	9929	3775	2.63	302	794
Orange	176	63	2.79	10	29
Hanover	716	269	2.66	19	50
Caroline	263	102	2.57	7	19
Total	**20,292**	**8,513**	**2.56**	**639**	**1,535**

[4] This reflects the permanent resident population within the NAPS EPZ in each of the counties listed.



North Anna Sector Populations

Figure 3: Permanent Resident Population Distribution Based on 2000 Census Data by Sector and Ring

2.1.2 Transient Populations

The transient population for the North Anna area (Table 4 and Table 5) is derived from a combination of tourist or recreation populations and employment data. Estimates include employment information available from the Claritas data and, where necessary, contact with individual hotels, motels, and other attractions. These populations were combined with other contributors to daytime population estimations and assigned to loading points in a manner similar to the permanent resident populations. An automobile occupancy rate of 2.5 was used to estimate the number of cars to be evacuated. Further discussion of this is found in Section 3.1.2.

The daytime populations incorporate employment and workforce information, such as county unemployment statistics and special facility populations.

Table 4: Transient Population Distribution by Protective Action Zone (PAZ)

PAZ	Transient Population
12	30
14	228
15	122

Table 5: Transient Population by Sector and Ring

Sector	Ring	Transient Population
N	2-5	30
NNW	2-5	228
NW	2-5	122

2.1.3 Special Facility Population

The special facilities that IEM has identified within the PAZ are shown in Table 6 and Table 7. These include 4 large employers (i.e., industries with more than 50 employees) and 7 schools. The industry population (including the estimates for smaller employers) is not used in the transient population counts, but is included here for informational purposes. The transient population consists mainly of visitors to the lake.

Table 6: Population of Industries with Greater than 50 Employees*

Industry	City	Zone	Day Population
Scale House	Bumpass	26	130
Trade Winds of VA Ltd	Bumpass	7	100
Impac Klearfold Div	Louisa	3	150
Tri-Dim Filter Corp	Louisa	3	180
North Anna Power Station	Mineral	8	1500+[5]

*Transportation assets for industries are assumed to be personal vehicles.

Table 7: School Population and Transportation

School	City	Zone	Day Population	Transportation
Berkeley Elementary	Spotsylvania	21	399	Buses (9 available)
Livingston Elementary	Spotsylvania	12	536	Buses (10 available)
Spotsylvania High	Spotsylvania	21	1466	Buses (15 available)
Jouett Elementary	Bumpass	5	762	Buses (offsite)
Louisa County High	Mineral	3	1331	Buses (offsite)
Louisa County Middle	Mineral	3	1160	Buses (offsite)
Thomas Jefferson Elementary	Louisa	3	817	Buses (offsite)

[5] Information was not available from Claritas. Working population information gathered from Louisa County Office of Economic Development (http://yeslouisa.org/emplyrs.htm).

3.0 ETE DATA AND METHODOLOGY

Evacuation time estimates were developed using ESIM (Evacuation SImulation Model), the core component of the Oak Ridge Evacuation Modeling System (OREMS). OREMS was developed by the Center for Transportation Analysis at Oak Ridge National Laboratory for the Federal Emergency Management Agency and the US Army in support of the Chemical Stockpile Emergency Preparedness Program (CSEPP). OREMS consists of a set of programs used to estimate evacuation time for different events or scenarios (e.g., day vs. night or good vs. bad weather) for user-defined spatial networks. Information provided by OREMS includes evacuation or clearance times, operational characteristics (e.g., average evacuation speed, average distance traveled), points of congestion, and other data necessary to evaluate evacuation plans.

The evacuation network was defined based on the information provided through Dominion Power's public outreach program. This includes the calendars distributed by the company and information available on the company website at http://www.dom.com/operations/station-nuc/emerplan/north_anna_map_frame.html.

The designated routes were driven by IEM to ensure complete and accurate information about the state of the roads, and to evaluate the appropriate selection of routes given the current conditions onsite. This evaluation did not result in any recommended updates to the network.

Population (number of cars) loaded onto the network is based on the data and methods described in Section 2.1. Loading times for the evacuation network are described in Section 3.1.1. Additional details about the methodology are included in the following sections.

3.1 Assumptions

Key assumptions that have a substantial impact on the results of the analysis are detailed in the following sections. Any assumptions associated with the development of population estimates are included in Section 2.1.

3.1.1 Loading of the Evacuation Network

The timing of network loading is derived from data presented in *Evaluating Protective Actions for Chemical Agent Emergencies.*[6] This data was collected during evacuations executed in response to large scale chemical spills, and explicitly incorporates the time required for communication of the warning (warning diffusion) and the time required for an individual to respond to the warning (mobilization). The data collected in this meta-study was based on transient, permanent, and special populations and is therefore appropriate to use as "general" warning diffusion and public mobilization curves for all three

[6] Rogers, G. O., et al., *Evaluating Protective Actions for Chemical Agent Emergencies* (ORNL-6615), Oak Ridge, TN: Oak Ridge National Laboratory, 1990.

population types. The specific timing used for warning diffusion is detailed in Figure 4. Since the curve selected depends on the warning system employed, the siren locations around the site were evaluated and the use of the Siren & EAS (Emergency Alert System) curve was deemed appropriate. Although route alerting is used as a secondary warning measure (per the county emergency response plans), this does not have a significant impact on the speed with which the bulk of the population receives notification. The mobilization curve (Figure 5) is combined with the warning diffusion curve to form a composite loading curve that reflects the actual time distribution of cars loaded on the network. It is important to note that the starting point for this curve is the time at which public notification begins, not the start time of a hypothetical event.

3.1.2 Key Evacuation Parameters

An evacuation is deemed complete when 90% of the affected population (all of those evacuating) have exited the 10-mile EPZ. This is typical for evacuation analyses and serves to prevent the long tail of the distribution (resulting from a small segment of the population being initially non-compliant) from artificially inflating ETEs.

For all scenarios, the evacuation is determined complete when the 10-mile EPZ has been evacuated. Though evacuations of the areas within a 2-mile radius and a 5-mile radius could theoretically be considered complete upon exit from the radius in question, a number of factors support selection of the 10-mile boundary as the exit in all cases:

- The desired ultimate destination for members of the public evacuating in those scenarios is a reception center outside of the 10-mile EPZ
- Unless conditions at the plant resulting in the recommendation of a lesser radius evacuation have stabilized, they may be subject to change
- Except in cases of a severely congested evacuation network, use of the 10-mile EPZ boundary as an exit point results in a conservative, but not overly conservative, ETE

The assumption of user equilibrium is applied to account for local residents' knowledge and use of alternate paths to get to the same destination as specified in the recommended evacuation routes. This recognizes that the evacuating population can and will adjust their routes in response to perceived impedance.

A car occupancy factor of 2.5 is assumed, based on guidance in NUREG-0654, the OREMS 2.50 User's Guide (Rogers, et al., 1990), and standard traffic engineering principles. Because the non-vehicle owning population is a small fraction of the total, and these individuals typically have neighbors with cars, there is no need for special treatment of them in an evacuation analysis.

The capacity of a transportation network depends on weather conditions. The highway capacity manual does not stipulate a methodology for adjusting capacity

due to bad weather conditions (e.g., rain, snow, ice). In this case, IEM perceived that that snow and/or ice are credible bad weather conditions and therefore road capacity should be reduced by 40% to simulate driver response to it. This reduction corresponds to a "worst-case bad weather" condition (i.e., snow and/or ice on the roadway without the benefit of any mitigating actions such as sand or salt).

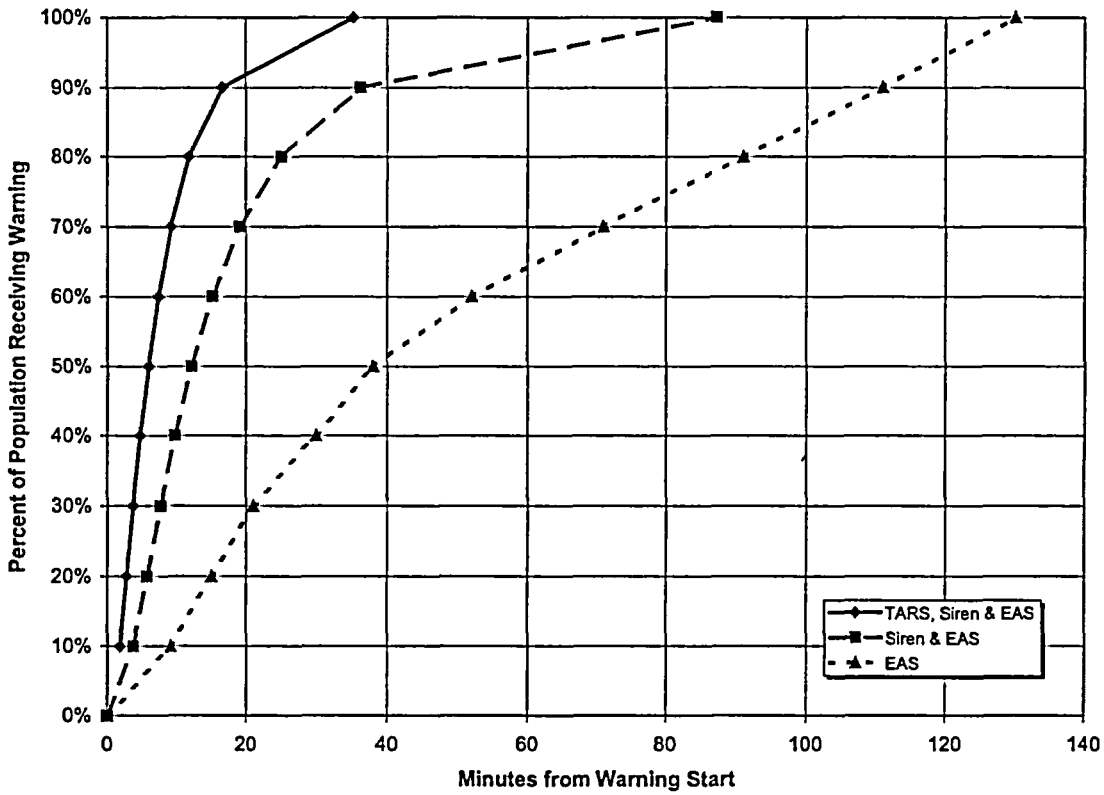


Figure 4: Warning Diffusion for Selected Notification Systems[7]

[7] *Ibid.*

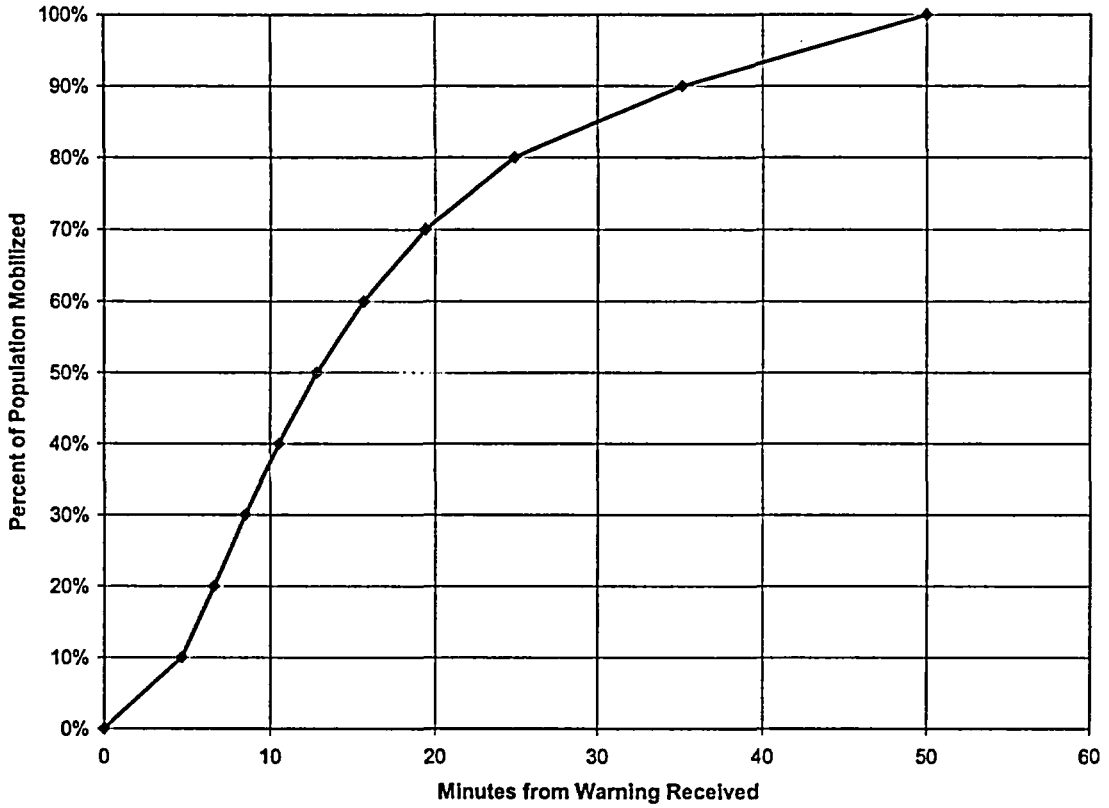


Figure 5: Population Mobilization Times[8]

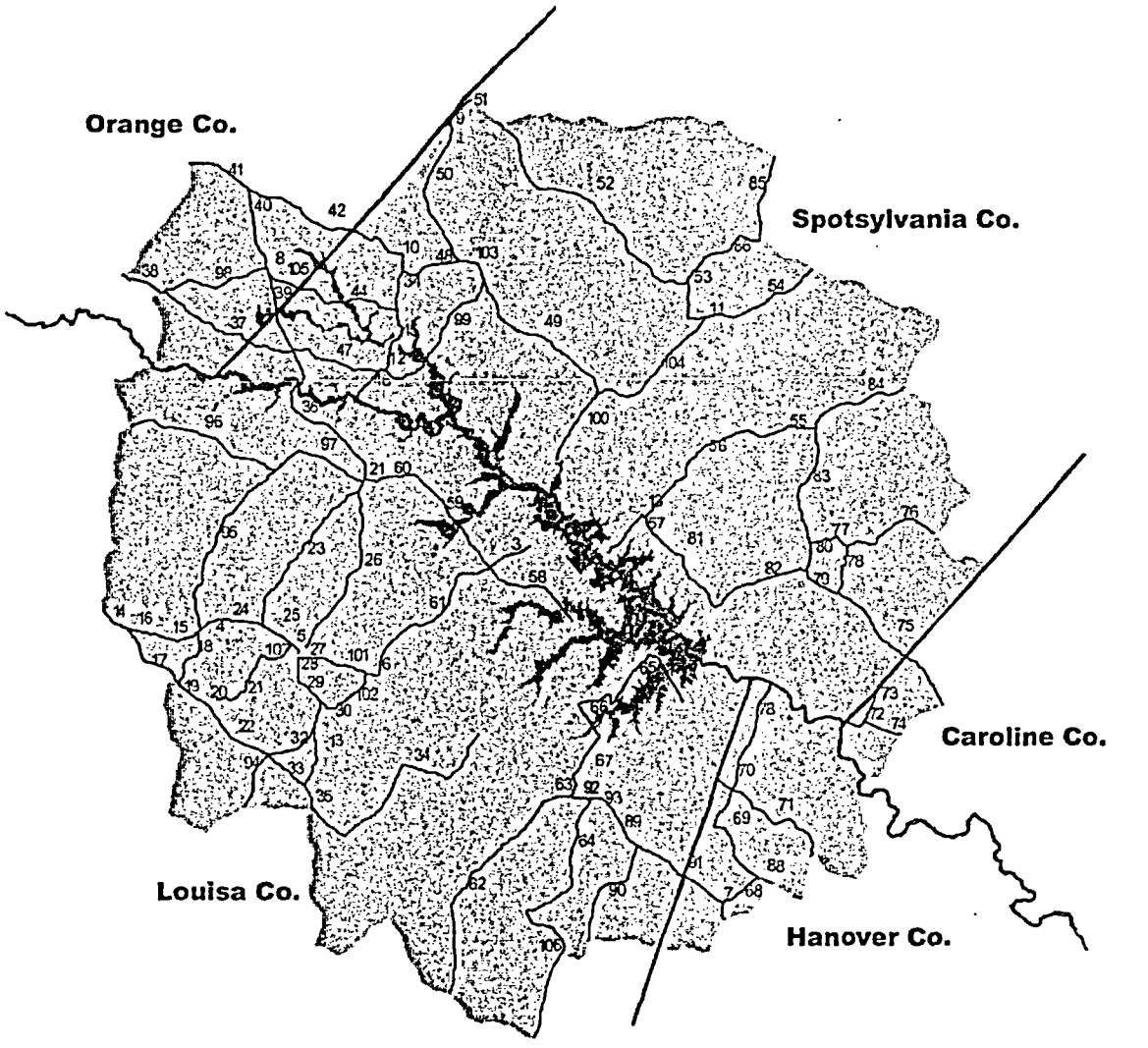
3.2 Evacuation Roadway Network

A complete review was performed of the evacuation roadway network. The evacuation network was developed using published evacuation routes and digital transportation data. To ensure the accuracy of this data, the entire network was verified by traveling each route and collecting detailed information regarding the properties of each link in the network.

The evacuation network for North Anna consists of rural two-lane highways and undivided streets. Most free-flow speeds range from 40 to 55 miles per hour. There is a minimal signalization, with most cross streets controlled by stop and yield signs.

Analysis of evacuation times is provided in Section 4.0. Potential locations for serious congestion on the evacuation network based on the results of the evacuation analyses are discussed in Section 5.0.

[8] *Ibid.*



North Anna Evacuation Routes

N

County boundary
Evacuation Route (w/ link ID)

1 0 1 2 Miles

Figure 6: Evacuation Roadway Network

3.2.1 Roadway Segment Characteristics

The following table identifies road segments by ID as depicted in Figure 6.

Table 8: Roadway Characteristics

Segment ID[9]	Route	Length (miles)	Number of Lanes[10]	Speed Limit	Comments[11]
1	522	0.08	2	55	Turn pocket on link 1 as it turns onto link 97.
2	522	0.27	2	55	
3	700	1.23	2	55	
4	208	0.1	2	35	
5	208	0.3	2	35	
6	618	0.35	2	45	
7	680	0.48	2	45	
8	522	0.15	2	55	
9	651	0.24	2	50	Not divided.
10	652	0.47	2	45	
11	650	0.22	2	35	Not divided.
12	652	0.21	2	45	Not divided.
13	601	0.12	2	45	
14	33	0.86	2	55	
15	208	1.63	2	45	35 mph at 237735 4211892.
16	208	0.38	2	25	Three lanes.
17	33	2.15	2	55	35 mph at 238002 4211112 after entering Louisa Corp. limit.
18	767	1.64	2	45	
19	33	0.9	2	35	
20	767	0.31	2	45	
21	767	1.83	2	45	
22	33	2.21	2	35	
23	623	4.62	2	45	

[9] All links are rural highways.
[10] Total number of through lanes in both directions. Where roadway cross-section is not uniform, section with least number of lanes is indicated here.
[11] Indicates any special conditions that may affect roadway capacity. Locations are identified using UTM coordinates.

Segment ID[9]	Route	Length (miles)	Number of Lanes[10]	Speed Limit	Comments[11]
24	208	1.71	2	55	
25	208	0.95	2	35	
26	522	4.75	2	55	
27	618	0.66	2	45	
28	522	0.65	2	35	
29	522	0.79	2	35	45 mph at 244807 4209825.
30	522	0.69	2	35	
31	522	1.71	2	50	
32	605	1.55	2	50	
33	33	1.33	2	35	
34	656	5.28	2	45	Not divided.
35	33	1.74	2	55	
36	522	4.73	2	55	
37	612	3.95	2	45	Not divided; 35 mph at 242146 4224570.
38	612	1.29	2	45	
39	522	2.13	2	55	
40	522	2.23	2	45	
41	653	1.75	2	55	
42	653	4.78	2	45	Not divided.
43	652	1.07	2	45	
44	719	2.88	2	45	Not divided.
45	652	1.82	2	45	
46	652	0.97	2	45	
47	612	2.5	2	45	Not divided.
48	653	1.63	2	45	Not divided.
49	601	4.56	2	55	
50	601	4.06	2	55	
51	601	0.93	2	55	
52	606	7.37	2	50	45 mph to 259032, 4228143, then 55.
53	650	1.31	2	40	Not divided.
54	208	3.33	2	55	
55	614	1.91	2	45	Not divided.

Segment ID[9]	Route	Length (miles)	Number of Lanes[10]	Speed Limit	Comments[11]
56	614	3.85	2	45	Not divided.
57	614	1.4	2	35	Not divided.
58	652	2.81	2	55	
59	652	3.2	2	55	
60	208	1.42	2	55	
61	700	4.59	2	55	
62	609	6.19	2	55	45 mph and not divided at 252330 4200155
63	618	0.71	2	45	
64	601	3.87	2	40	Not divided.
65	622	4.49	2	45	Not divided.
66	652	1.03	2	55	
67	650	1.85	2	35	
68	680	1.21	2	40	Not divided.
69	658	3.11	2	40	Not divided.
70	715	0.52	2	35	
71	715	3.29	2	35	25 mph at 266732 4203044.
72	669	0.56	2	40	Not divided.
73	679	0.95	2	35	Not divided.
74	669	1.06	2	40	Not divided.
75	738	4.22	2	45	
76	605	2.79	2	40	Link may need to be divided; stop sign at Rt. 658.
77	605	1.12	2	40	
78	670	1.38	2	35	Not divided.
79	738	1.09	2	45	
80	738	0.75	2	45	
81	601	3.08	2	55	
82	622	2.87	2	45	
83	738	3.32	2	45	
84	738	2.87	2	45	
85	649	2.31	2	40	
86	606	2.49	2	55	
87	658	3.08	2	35	Not divided.

Segment ID[9]	Route	Length (miles)	Number of Lanes[10]	Speed Limit	Comments[11]
88	658	0.36	2	40	Not divided.
89	618	1.24	2	45	
90	701	3.19	2	35	Not divided.
91	618	2.8	2	45	
92	618	0.55	2	45	
93	618	0.6	2	45	
94	605	1.57	2	50	
95	625	5.09	2	55	
96	613	4.26	2	55	
97	613	2.77	2	55	
98	651	2.98	2	45	Not divided.
99	612	4.17	2	45	Not divided.
100	208	2.13	2	55	
101	618	1.25	2	45	
102	700	1.84	2	25	
103	601	0.98	2	55	
104	208	3.89	2	55	
105	719	0.89	2	45	Not divided.
106	655	4.12	2	45	Not divided where Rt. 701 intersects.

4.0 ANALYSIS OF EVACUATION TIMES

Because the power station is located in a densely wooded area, there are no institutional populations within the 10-mile EPZ other than public schools (listed in Section 2.1.3). The majority of the population is composed of permanent residents and a varying number of seasonal recreational visitors mainly located on or around the lake. With the waterway limited to seven crossings and only one bridge available at the lower side of the lake, movement is restricted, and in the case of an emergency traffic is more likely to flow away from the power station, rather than across the water. The road network around the facility is adequate to accommodate the flow of vehicular traffic anticipated. The major routes exiting the 10-mile EPZ are U.S. Highways 33, 208, and 522, as well as Routes 719, 612, 614, 601, 658, and 618; all are two-lane paved highways. The primary evacuation roadway network is described in Section 3.2.

4.1 Summary of ETE Results

Seven basic geographic evacuation scenarios were modeled under normal and adverse weather conditions. All of the ETEs generated for North Anna are based on peak season nighttime population counts, as these represent the worst case. With the exception of the schools listed in Table 7, there are no significant special facilities within the North Anna 10-mile EPZ.

Table 9 shows the network clearance times obtained for different regions of the North Anna EPZ. The scenarios evaluated and the results of the evacuation analyses for each are discussed in greater detail in Section 4.2.

Table 9: Summary of Results of Evacuation Time Analysis

Scenario	Total Population Evacuated[12]	Normal Condition ETE	Adverse Condition ETE
10-mile radius	18782	1 hr. 25 min.	1 hr. 30 min.
5-mile radius	6537	1 hr. 35 min.	1 hr. 40 min.
2-mile radius	1837	1 hr. 45 min.	1 hr. 45 min.
Quadrant I	8517	1 hr. 30 min.	1 hr. 35 min.
Quadrant II	8177	1 hr. 30 min.	1 hr. 30 min.
Quadrant III	8137	1 hr. 30 min.	1 hr. 35 min.
Quadrant IV	5995	1 hr. 35 min.	1 hr. 35 min.

4.2 Discussion of Scenario Results

No significant traffic congestion was noted in the analysis of any of the scenarios. Therefore, the time required to evacuate was essentially a combination of the time for the public to be warned and mobilized plus the driving time to exit the 10-mile EPZ. Because the network contains sufficient capacity to handle the evacuating public, "bad weather" has only a limited impact on the ETEs for all scenarios.

Revised Document: Deleted Paragraph April 30, 2003

When comparing the most recent estimates to those from previous studies, some differences may be noted. These differences are a product of the differing methodologies, assumptions, and parameters that were used to model and estimate the evacuation times.

[12] The total population evacuated at the end of evacuation simulations to calculate ETEs is approximately 90% of the population loaded onto the evacuation network during the simulation.

First, there is a difference in the way the populations were estimated and assigned to the network. From a cursory review of the Virginia Tech study, it appears that Census tract data was used. The IEM study used Census block level data, which is of a higher resolution. Also, the Virginia Tech study assumed a uniform population density where tracts did not match PAZ boundaries in order to assign population to the network. This could easily over-estimate population as well as place population inaccurately. The IEM study did not need to make this assumption because of the resolution of the block level data.

Secondly, evacuation time estimates can vary between the studies for a number of reasons. The Virginia Tech study used their proprietary model MASSVAC, while the IEM study used Oak Ridge National Laboratory's Oak Ridge Evacuation Modeling System (OREMS). The Virginia Tech study assumed a constant loading rate; the IEM study used loading rates taken from actual emergency evacuations. In addition, changes in demographics and infrastructure can have significant impact on ETEs. The IEM study considered the demographic situation and infrastructure as they stand now, while the Virginia Tech study was based on data from 1990.

Finally, the IEM study considered the evacuation to be complete when 90% of the evacuating population has exited the 10-mile radius surrounding the facility. It is not clear when the evacuation was considered complete for the Virginia Tech study. This can, however, explain resulting differences in ETEs among scenarios, which may otherwise appear counterintuitive. For example, when the 10-mile radial evacuation starts, much of that population is close to the edge of the evacuating area and can leave the area relatively quickly. For any other evacuation, there may be a larger proportion of the population that has to travel farther or through high congestion to evacuate. This will cause the ETEs for these scenarios to be higher, since we are considering the time it takes 90% of the *evacuating* population to leave the PAZ area.

4.2.1 North Anna Quadrant I

North Anna Quadrant I incorporates zones 8, 9, 11–14, and 18–21. Most of the population in this quadrant is located in zones 18 and 21, both on the periphery of the EPZ. There are no major population concentrations in this quadrant. Approximately 3800 vehicles will attempt to leave the area during an evacuation. The maximum network clearance times in Quadrant I are 1 hour 30 minutes (normal conditions) and 1 hour 35 minutes (adverse conditions).

No routes experience any significant congestion during evacuation of this quadrant.

4.2.2 North Anna Quadrant II

Quadrant II includes most of the zones in Louisa County (6–8, 10, 25, and 26); zones 9, 11, 21, and 22 in Spotsylvania County; zone 23 in Caroline County; and zone 24 in Hanover County. Approximately 3700 vehicles will attempt to leave

the area during an evacuation. The total evacuation times in this quadrant under normal and adverse conditions are 1 hour 30 minutes and 1 hour 30 minutes respectively.

No routes experience any significant congestion during evacuation of this quadrant.

4.2.3 North Anna Quadrant III

Quadrant III includes zones 2–8, 16, and 26, all in Louisa County. This quadrant does include a high population concentration in zone 2, the town of Mineral. Approximately 3650 vehicles will attempt to leave the area during an evacuation. The total evacuation times in this quadrant under normal and adverse conditions are 1 hour 30 minutes and 1 hour 35 minutes respectively.

No routes experience any significant congestion during evacuation of this quadrant.

4.2.4 North Anna Quadrant IV

Quadrant IV has an equal distribution of zones from Louisa (zones 4, 8, 15, 16), Orange (zone 17) and Spotsylvania (zones 14 and 18) Counties. Approximately 2700 vehicles will attempt to leave the area during an evacuation. The total evacuation times in this quadrant under normal and adverse conditions are 1 hour 35 minutes and 1 hour 35 minutes respectively.

No routes experience any significant congestion during evacuation of this quadrant.

4.2.5 North Anna 2-mile, 5-mile, and 10-mile Radii

The North Anna 10-mile radius scenario includes evacuation of all zones within the 10-mile EPZ. Approximately 8400 vehicles will attempt to leave the area during an evacuation. No routes experience any significant congestion during evacuation of this radius.

The 5-mile radius scenario includes evacuation of zones 4, 6–10, 14, 15, and 25, as well as portions of zones 5, 11–13, and 25. Approximately 2900 vehicles will attempt to leave the area during an evacuation. No routes experience any significant congestion during evacuation of this radius.

The 2-mile radius scenario includes evacuation of zones 6, 8, and 9, as well as portions of zones 4, 7, 10, and 11. Approximately 830 vehicles will attempt to leave the area during an evacuation. No routes experience any significant congestion during evacuation of this radius.

The fact that the ETEs for evacuating a 2-mile or 5-mile radius are greater than ETEs for evacuating the 10-mile radius appear to be counterintuitive at first glance. However, the explanation is a simple one. It is due to the interaction of two assumptions in the analysis: 1) that evacuation is considered complete when 90% of the public clears the area; and 2) that a car is considered to have completed the evacuation when it reaches the 10-mile boundary in all cases.

The area between the 5- and 10-mile radii is more populated than the area within the 5-mile radius. Likewise, the area between the 2- and 5-mile radii is more populated than the area within the 2-mile radius. Therefore, a higher percentage of the population begins evacuation of the 10-mile radius closer to the edge of the evacuation exit point, with a lower percentage evacuating the 5-mile radius. The same is true to a greater extent for evacuation of the 10-mile radius versus the 2-mile radius. This results in a shorter time to clear 90% of the population from the 10-mile radius than from the 5-mile or 2-mile radius.

4.3 Estimates for Non–Auto-Owning Population

The non–auto-owning population is largely concentrated in Louisa and Spotsylvania Counties and accounts for approximately 7 to 8 percent of the population in those counties. Given the small fraction of the population involved and the lack of congestion during an evacuation, it is clear that the time to evacuate this portion of the population is driven by the time required to provide transportation. With the public outreach effort that has been undertaken in the area, it is reasonable to expect that the majority of the population requiring transportation will be able to evacuate with neighbors or relatives and will be indistinguishable from the general population during an evacuation.

Any remaining individuals stranded without transportation will be accounted for during the confirmation of evacuation and route alerting via signs to be placed in residents' windows. These signs are distributed in public outreach calendars.

4.4 Estimates for Special Facilities

The only special facilities located within 10 miles of NAPS are the schools identified in Table 7. Since they have evacuation resources immediately available, they have been included with the general population during the evacuation analysis, and share the time estimates for the general population.

It should be noted that schools can typically be expected to evacuate significantly earlier than the general population. As a result of routine fire drills and other emergency drills performed at schools on a regular basis, warning diffusion and mobilization times are typically much better for school populations. During school evacuation drills conducted as part of annual exercises within the Chemical Stockpile Emergency Preparedness (CSEP) Program, schools have demonstrated the ability to load buses and start evacuation within 10–20 minutes following a warning and directions to do so from local emergency management.

4.5 Confirmation of Evacuation

The time required for confirmation of evacuation is dependent on the method employed. The most time-consuming method typically employed is to use ground vehicles, with the time required simply the driving time for each route selected. Given the lack of congestion evident around North Anna, a route alerting or evacuation confirmation effort does not need to wait for the bulk of the evacuation to complete before beginning, significantly reducing the time required.

5.0 RECOMMENDATIONS

The evacuation time estimates summarized in Section 4.0 are relatively low and essentially driven by societal behavior factors, as no areas of congestion were identified during analysis of the evacuation network. This is certainly true when compared to the ETEs for a number of other nuclear power plant sites. Based on this, IEM does not believe that any actions could be taken to *significantly* improve the evacuation time for the areas within the 10-mile EPZ for North Anna Power Station.

In the interest of continuous improvement, there are some potential actions that might be considered by Dominion Virginia Power in an effort to improve the ETEs for North Anna. In general, there are four ways to improve evacuation time:

1) Decrease the time it takes to provide warning to the public
2) Decrease the time it takes for the public to receive the warning and decide to act on it (warning diffusion)
3) Decrease the time it takes for the public to mobilize and start evacuating the area
4) Decrease travel time on the evacuation network

There is probably not much room to improve time to warn the public. However, improvements in this area might be achieved by an increase in focused alert and notification drills conducted with both emergency information communicators at the plant and their corresponding local emergency management agency counterparts responsible for taking plant information and activating public warning systems.

Warning diffusion is directly affected by the alert and notification system in place. NRC-approved sirens, EAS, and route alerting systems are already in place to ensure public warning of residents around North Anna. In accordance with Figure 4, warning diffusion time could be slightly improved by the use of tone alert radios (TARs). However, the cost of installing such a system would likely be high in comparison to the expected benefit, especially given the low ETEs.

Mobilization time is essentially driven by two considerations: knowledge of the emergency response procedures and protective actions, and level of advance preparation to act. Improvement in both areas can be affected by aggressive

public education and outreach efforts. In order to quantify the impact of such an effort, surveys of public knowledge would be required. Even then, quantifying the improvement in mobilization time due to an increase in public knowledge would be difficult.

Finally, travel time is primarily impacted by the conditions on the evacuation network, including any areas prone to congestion during times of heavy travel. As no areas of congestion were identified during the evacuation analyses, there is little or no room for improvement here at the present time. However, this situation could easily change if a large influx of new permanent or transient population is introduced within the 10-mile EPZ without adequate planning and consideration of new roads or modification of existing roads and intersections. Onsite and offsite emergency planners should work closely with local government to ensure that impact on evacuation plans for North Anna are considered as part of the planning and development process.

In conclusion, based on the data gathered and the results of the evacuation analyses performed, IEM does not believe that any actions need to be taken to improve the evacuation time for the areas within the 10-mile EPZ for North Anna Power Station.

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Attachment 1: North Anna Power Station Protective Action Zones (PAZs) and Evacuation Assembly Centers (EACs)[13]

PAZ	County	Consists of	Primary Evacuation Routes	Evacuation Assembly Centers
Zone 1	N/A	Not Being Used	N/A	N/A
Zone 2	Louisa	Town of Mineral	1. Use 618 west and US 522 south 2. Use 208 west, 767 south and US 33 west 3. Use 618 west, US 522 south and 605 south	Trevilians Elementary School Patrick Henry High School
Zone 3	Louisa	Area bounded on the north by Routes 22/208, south by Routes 605 and 643, east by Routes 33/522 and the Mineral town line, and west by Routes 644, 33 and the Louisa town line.	1. Use 767 south and US 33 west	Trevilians Elementary School Patrick Henry High School
Zone 4	Louisa	Area bounded on the north by Route 208, south by Routes 618 and 667, east by Lake Anna, Contrary Creek and Routes 652 and 700, and west by Routes 208/522.	1. Use 613 west 2. Use 522 north and 612 west 3. Use 623 south, 208 west, 767 south and US 33 west	Trevilians Elementary School Patrick Henry High School

[13] From http://www.dom.com/operations/station-nuc/emerplan/paz_routes.html.

PAZ	County	Consists of	Primary Evacuation Routes	Evacuation Assembly Centers
Zone 5	Louisa	Area bounded on the north by Route 618 and Mineral town line, south by Routes 33 and 657, east by Route 609, and west by Route 522.	1. Use 656 south and US 33 west	Trevilians Elementary School Patrick Henry High School
Zone 6	Louisa	Area bounded on the north by Route 652, south by Route 618, east by Route 614, and west by Route 700.	1. Use 700 south and US 522 south 2. Use 700 south, US 522 south and 605 south 3. Use 652 west and 208, 613 west	Trevilians Elementary School Patrick Henry High School
Zone 7	Louisa	Area bounded on the north by Route 652, south by Route 618, east by Route 650, and west by Route 614.	1. Use 650 south, 618 east and 701 south 2. Use 650 south, 618 east, 601 south and 655 south 3. Use 650 south and 618 east 4. Use 650 south, 618 west and 609 south	Trevilians Elementary School Patrick Henry High School
Zone 8	Louisa	Area bounded on the northeast by Lake Anna, northwest by Contrary Creek, southeast by Route 614, and southwest by Route 652.	1. Use 700 south and US 522 south 2. 2.Use 700 south and US 522, 605 south 3. Use 700 south, 618 west and 208 west	Trevilians Elementary School Patrick Henry High School
Zone 9	Spotsylvania	Area bounded on the north by Routes 713 and 601, south by Lake Anna, east by Route 614, and west by Route 208.	1. Use 614 east and 738 north 2. Use 614 east, 601 south, 622 east and 738 south 3. Use 614 east, 657 east, 738 south and 605 east	Courtland High School Chancellor High School

PAZ	County	Consists of	Primary Evacuation Routes	Evacuation Assembly Centers
Zone 10	Louisa	Area bounded on the north by Lake Anna, south by Route 622, east by Lake Anna and Route 622, and west by Routes 652 and 614.	1. Use 622 west, 652 south, 650 south, 618 east and 701 south 2. Use 622 west, 652 south, 650 south, 618 east, 601 south and 655 south 3. Use 622 west, 652 south, 650 south and 618 east	Trevilians Elementary School Patrick Henry High School
Zone 11	Spotsylvania	Area bounded on the north by Route 657, south by Route 622, east by Route 738 and 622, and west by Lake Anna and Route 614.	1. Use 622 east and 738 south 2. Use 622 east, 738 north and 605 east 3. Use 601 south, 715 east and 658 south	Courtland High School Chancellor High School
Zone 12	Spotsylvania	Area bounded on the north by Bluff Run and Glebe Run, south by Routes 657, 614, 601 and 713, east by Route 738 and Oak Crest Drive, and west by Route 208.	1. Use 208 east toward Post Oak 2. Use 614 east and 738 north 3. Use 208 east, 650 north and 606 east	Courtland High School Chancellor High School
Zone 13	Spotsylvania	Area bounded on the north by Route 606, south by Route 208, east by Routes 208 and 650, west by Routes 612, 601 and 655.	1. Use 208 east toward Post Oak 2. Use 601 north and 653 west 3. Use 208 east, 650 north and 606 east	Courtland High School Chancellor High School
Zone 14	Spotsylvania	Area bounded on the north by Route 601, south by Lake Anna, east by Route 655, and west by Routes 612 and 719.	1. Use 612 west 2. Use 612 west, 719 west and US 522 north 3. Use 612 west, and US 522 north	Courtland High School Chancellor High School

PAZ	County	Consists of	Primary Evacuation Routes	Evacuation Assembly Centers
Zone 15	Louisa	Area bounded on the north by Lake Anna, south by Route 208, east by Lake Anna, and west by Routes 522 and 719.	1. Use US 522 north and 612 west 2. Use US 522 north and 719 west 3. Use US 522 north	Trevilians Elementary School Patrick Henry High School
Zone 16	Louisa	Area bounded on the north by Lake Anna, south by Routes 22, 208 and the Louisa town line, east by Routes 719 and 522/208, and west by Colonial Pipeline	1. Use 625 south and 208 west 2. Use 613 west	Trevilians Elementary School Patrick Henry High School
Zone 17	Orange	Area bounded on the north by Routes 653 and 629, south by Orange/Louisa County line (North Anna River), east by Orange/Spotsylvania County line, and west by Colonial Pipeline	1. Use 719 west, 522 north and 651 south 2. Use 719 west and US 522 north	Orange County High School Prospect Heights Middle School
Zone 18	Spotsylvania	Area bounded on the north by Routes 608 and 606, south by Spotsylvania/Louisa County line (North Anna River), east by Routes 612 and 719, and west by Spotsylvania/Orange County line.	1. Use 652 north and 653 west 2. Use 601 north and 651 south 3. Use 719 west and 522 north 4. Use 601 north	Courtland High School Chancellor High School
Zone 19	Spotsylvania	Area bounded on the north by Route 608, south by Route 606, east by Route 612, and west by Route 606.	1. Use 606 west	Courtland High School Chancellor High School
Zone 20	Spotsylvania	Area bounded on the north by Route 608, south by Route 208, east by Routes 649 and 606, and west by Routes 612, 606 and 650.	1. Use 606 west 2. Use 606 east and 649 north	Courtland High School Chancellor High School

PAZ	County	Consists of	Primary Evacuation Routes	Evacuation Assembly Centers
Zone 21	Spotsylvania	Area bounded on the north by Routes 208 and 606, south by Route 605, east by Routes 647 and 738, and west by Bluff Run, Glebe Run, Oak Crest Drive and Route 738.	1. Use 738 north 2. Use 605 east	Courtland High School Chancellor High School
Zone 22	Spotsylvania	Area bounded on the north by Routes 604 and 605, south by North Anna River, east by Spotsylvania/Caroline County line, and west by Routes 622 and 738.	1. Use 738 south 2. Use 670 south and 738 south	Courtland High School Chancellor High School
Zone 23	Caroline	Area bounded on the north by Route 738, south by North Anna River, east by Route 738, and west by Caroline/Spotsylvania County line.	1. Use 679 south and 669 south 2. Use 669 south 3. Use 671 north	Ladysmith Elementary School Ladysmith Primary School
Zone 24	Hanover	Area bounded on the north by North Anna River, south by Routes 608, 680, 729, 658, 715, 739 and 800, east by Route 738, west by Hanover/Louisa County line.	1. Use 658 south 2. Use 715 south 3. Use 658 south, 680 south 4. Use 618 east and 680 south	Liberty Middle School Patrick Henry High School
Zone 25	Louisa	Area bounded on the north by North Anna River, south by Route 652, east by Route 601, and west by Route 622.	1. Use 622 north, 652 south, 650 south, 618 east and 701 south 2. Use 622 north, 652 south, 650 south, 618 east and 601, 655 south 3. Use 622 north, 652 south, 650 south and 618 east	Trevilians Elementary School Patrick Henry High School

PAZ	County	Consists of	Primary Evacuation Routes	Evacuation Assembly Centers
Zone 26	Louisa	Area bounded on the north by North Anna River, south by Routes 33, 655, 701 and 608, east by Louisa/Hanover County line, and west by Routes 609, 650, 652 and 601.	1. Use 618 east and 701 south 2. Use 618 east 3. Use 618 west and 601, 655 south	Trevilians Elementary School Patrick Henry High School