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FINAL DRAFT

AN EVALUATION OF THE EVACUATION TIME ESTIMATES SUBMITTED BY THE LICENSEE FOR THE PILGRIM II NUCLEAR POWER STATION

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EVALUATION OF PILGRIM II EVACUATION TIME ESTIMATES

Introduction

On February 18th and 19th, Matthew P. Moeller, Scientist, Pacific Northwest Laboratory, and Thomas Urbanik II, Traffic Engineer, Texas Institute of Transportation, conducted an on-site evaluation of the transportation network around the Pilgrim II Plant. The analysis included driving all major roadways in the EPZ to record the number of lanes, nominal speed, intersecting roadways, and condition of each segment. In addition, observations and radar tests were made of important routes and intersections. As a result of this work, M. P. Moeller and T. Urbanik II were able to devise a system of evacuation paths for the population within the EPZ. This evacuation network was used as input for the calculation of evacuation time estimates.

Method

Data on the population density and distribution within the Pilgrim II EPZ were taken from the HMM Associates' Document No. 79-048 for the peak population case. A total of 115,095 individuals are represented. They comprise the permanent residents, seasonal residents, and peak transient populations for the area. Because the peak population for the Pilgrim II EPZ is expected to occur during a summer weekend, factories and schools were assumed to be closed during the evacuation.

The computer model CLEAR (Calculates Logical Evacuation and Response) was used to simulate the evacuation process for the purpose of calculating evacuation time estimates for the Pilgrim II EPZ. M. P. Moeller, author of the code, prepared the input data and ran the calculations. The following assumpcions were made for or by the CLEAR model:

1. Peak Population occurs in f[illegible] weather on summer weekerd with no schools or factorie[illegible] open.

2. Peak Population is: All permanent residents at home;
   Seasonal units full;
   All transient facilities at capacity.

3. Double Counting was used; i.e., many persons at beaches are permanent residents, seasonal residents, or transients.

4. Auto Occupancy: Three persons per vehicle.

5. Free Flow Rate: 1700 vehicles per lane-hour at vehicle speeds between 55 and 15 mph.

6. Minimum speed for any roadway segment is 15 mph when vehicle population is at or exceeds density at which traffic jams begin ("jam density").

7. Average vehicle length is 5.68 m.

8. Minimum effective vehicle length is 14.20 m at 15 mph.
9. Warning time is 30 minutes.

10. A staggered delay between notification and departure (preparation time) results in gradual loading of the populations onto the evacuation network. Ninety minutes is the maximum preparation time. Population departure rates used are as follows:

    10% of peak population departure by 22.5 minutes.
    32.5% of peak population departure by 45.0 minutes.
    77.5% of peak population departure by 77.5 minutes.
    100% of peak population departure by 90 minutes.

11. Peak population distribution by sector (see Appendix A).

12. Initial population assigned to a roadway segment is proportional to length of the roadway segment.

13. Pre-planned evacuation routes are devised for populations within the EPZ based upon field analysis and evaluation.

14. Route 3 (North and South) has two lanes in the direction of the evacuation, all other roadway segments are one lane in width.

15. People not within the planned EPZ boundaries would not choose to evacuate during the EPZ evacuation. This includes the population of Cape Cod.

16. Evacuation times are calculated for the area within a 10-mile radius and for the EPZ described by the licensee. However, the transportation network and evacuation process was simulated to include major intersections up to twenty miles from the Pilgrim II Plant. The area which includes these major intersections is called the "extended EPZ" in this report. The time required for the EPZ population to exit the extended EPZ is also calculated.

17. The network was empty at the beginning of the evacuation, e.g., non-resident or non-transient cars on network and normal traffic on Route 3 between Boston and Cape Cod was not simulated.

18. Population assumptions:

Kingston - 85% of the population lives within 10 miles
15% of the population lives outside the EPZ.

Carver - 8,000 permanent residents of which 1/3 live within the EPZ (east of Route 58).

Duxbury - 75% of the population lives within 10 miles
25% of the population lives outside the EPZ.

19. The priority for the advancement of vehicle at intersections is modelled according to the relative demands of each intersecting route.

20. The EPZ and extended EPZ are as shown in Appendix B.

Results

The evacuation time estimates calculated by PNL are as follows:

EVACUATION TIME ESTIMATES
FOR PEAK POPULATION CASE (MINUTES)

	Area	Licensee (HMM Associates)*	CLEAR (PNL)**
1.	360° 2 Miles	70	145
2.	360° 5 Miles		160
3.	360° 10 miles		225
4.	360° EPZ	345	295
5.	360° Extended EPZ		410
6.	North 2 Miles		120
8.	North 10 Miles	120	160
9.	North EPZ	180	295
10.	North Extended EPZ		330
11.	West 2 Miles		120
12.	West 5 Miles	200	160
13.	West 10 Miles		160
14.	West EPZ	240	200
15.	South 2 Miles		145
16.	South 5 Miles	150	160
17.	South 10 Miles	160	185
18.	South EPZ	160	185
19.	South Extended EPZ		410

* Instantaneous departure.
** Staggered departure over 90 minutes.

Discussion

The CLEAR model estimated evacuation time based on a conservative scenario. In effect, this means that the majority of the Plymouth population would evacuate via Route 3, either north or south. Consequently, the evacuation time estimates for the north and south sectors are larger than that for the west sector.

It is apparent from the estimates submitted by the licensee that the evacuation scenario devised by HMM Associates resulted in a higher percentage of the Plymouth population utilizing evacuation routes to the west than the scenario used for the CLEAR calculations. As expected, therefore, the evacuation time estimates calculated by HMM Associates are larger in the west sector then in the north or south sectors.

As is apparent from the table of evacuation times, estimates were calculated for several Emergency Planning Zones. Both the HMM Associates model and CLEAR calculated evacuation time estimates for the population within the ten mile radius. Although the population figure is determined for a ten mile radius, an EPZ for a plant may extend beyond ten miles to include potentially critical routes or intersections or to include geographical or political boundaries.

For the Pilgrim II plant, HMM Associates defined an EPZ which included several areas beyond ten miles. When reviewing the EPZ for the CLEAR calculations, it was determined that several intersections which could significantly effect the evacuation process lay beyond the EPZ defined by HMM Associates. As a result, an EPZ was planned for the CLEAR calculation to include these critical intersections. The analysis of this EPZ, labeled as the extended EPZ, proved beneficial in providing new information on this previously undefined problem area.

The omission of a critical bottleneck might leave the evacuation time estimates reported by the licensee open to some criticism. The problem area, approximately 11.5 miles from the Pilgrim Plant, is the rotary at the intersection of Route 3, Route 6, immediately north of the Sagamore Bridge which spans the Cape Cod canal. In the present analysis, it is assumed that the rotary will accept one lane of traffic at 15 mph. The effect of a segment with relatively minimal speed and capacity is to cause major traffic jams and delays. Furthermore, it is possible that vehicles backed up in a queue from this rotary will be within ten miles of the Pilgrim Plant. Consequently, the fact that calculations performed by HMM Associates did not address this major intersection which effects the evacuation of the Pilgrim II EPZ could cause difficulties for local government officials who might attempt to carry out an evacuation based on the estimates submitted by the licensee.

The input to the CLEAR code assumes that traffic evacuating through the rotary bottleneck is not impeded by traffic existing from Cape Cod. The management of Cape Cod traffic must be decided by state or local government officials. The present analysis assumes that there is no northbound traffic on the Sagamore Bridge during the evacuation. If this were determined to be

unrealistic, the evacuation routings could be revised to eliminate all or most outbound traffic on Route 3. Furthermore, such rerouting would probably reduce the 410 minute estimate for the population of the extended EPZ.

Conclusions

The results of calculations using the CLEAR model indicate that the evacuation times submitted by the Boston Edison Company for the EPZ surrounding the Pilgrim II Nuclear Power Station are realistic. The evacuation time estimates submitted by the licensee do not, however, reflect the effects of a major bottleneck 11.5 miles south of Pilgrim II. Evacuation time estimates calculated by CLEAR for an extended EPZ which include this bottleneck reveals such problems should be explicitly analyzed in the evacuation times estimates submitted by the licensee.

Potential delays caused by this critical rotary intersection may be reduced by rerouting evacuation traffic to the north and west. It is quite possible that such routings were, in fact, used by the licensee. Hence, the PNL estimates of 295 to 410 minutes are comparable to the estimate of 345 minutes submitted by the licensee for the evacuation of the EPZ.

Further studies of the important intersections within the extended EPZ are recommended prior to inclusion of the evacuation time estimates into emergency evacuation procedures.

Refereces

[1] M. P. Moeller and A. E. Desrosiers, "CLEAR - A Gener.: Transportation Network Model for the Calculation of Evacuation Time Estimates," PNL-3770 (in preparation).

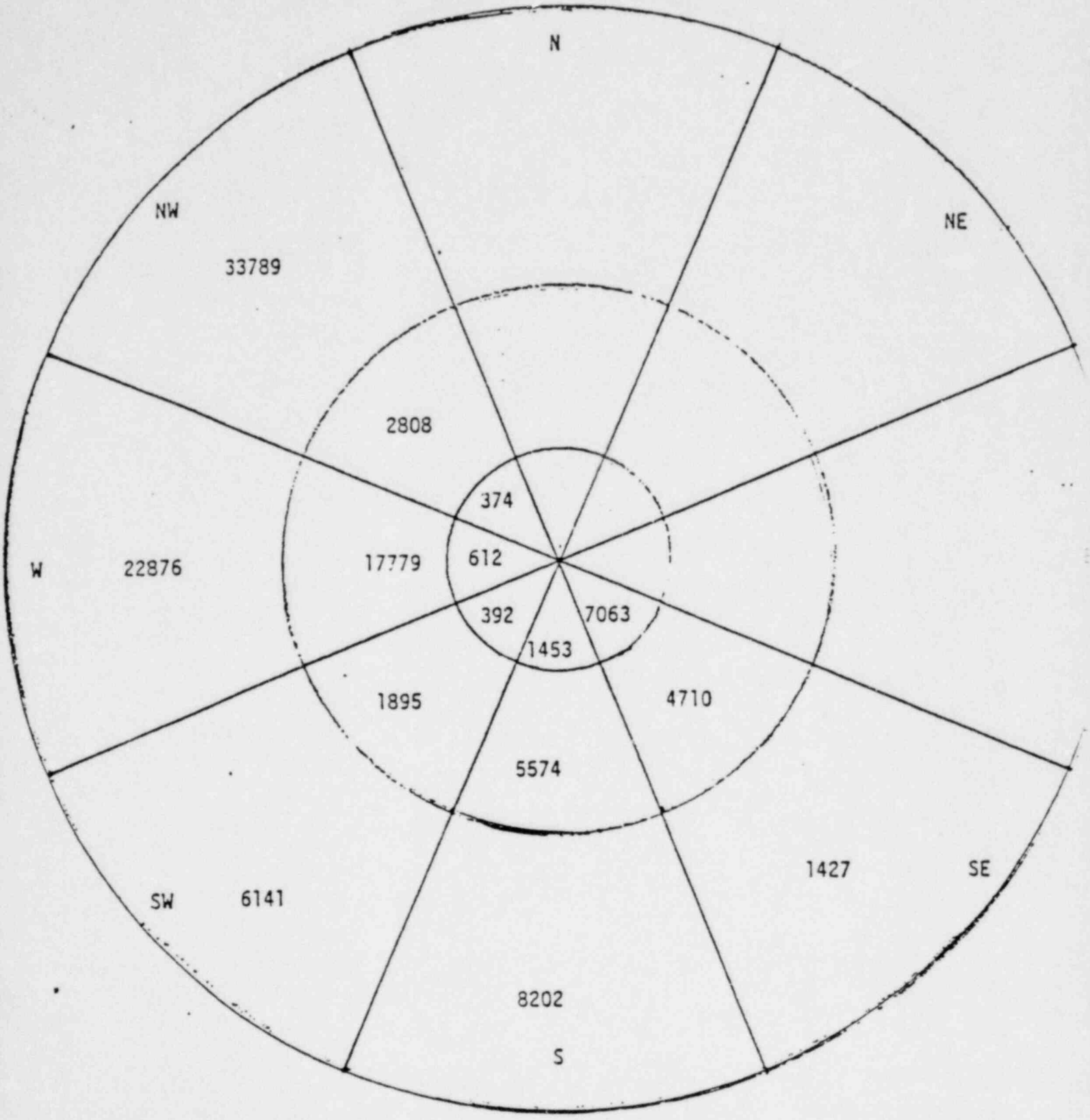
[2] T. Urbanik, A. Desrosiers, M. Lindell, C. Schuller, "Analysis of Techniques for Estimating Evacuation Times for Emergency Planning Zones, NUREG/CR-1745, BHARC-40L/80-0L7, November 1980.

PILGRIM NUCLEAR POWER STATION

EVACCC POPULATION DATA

Appendix A

TYPE: PEAK POPULATION



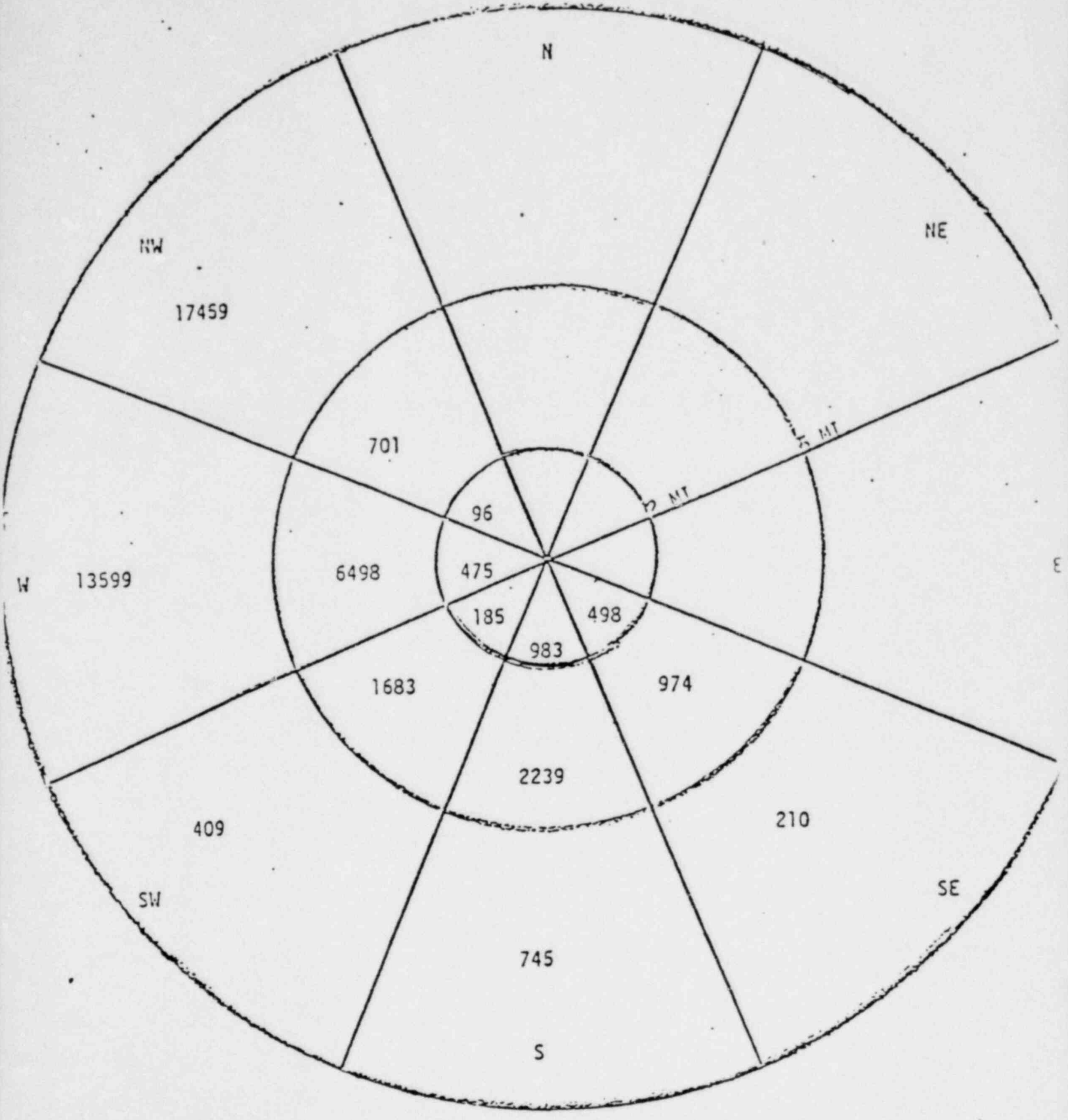
0 - 2 MILES: 9894
2 - 5 MILES: 32766
5 - 10 MILES: 72435

TOTAL: 115,095

PILGRIM NUCLEAR POWER STATION

EVACCC POPULATION DATA

TYPE: PERMANENT POPULATION



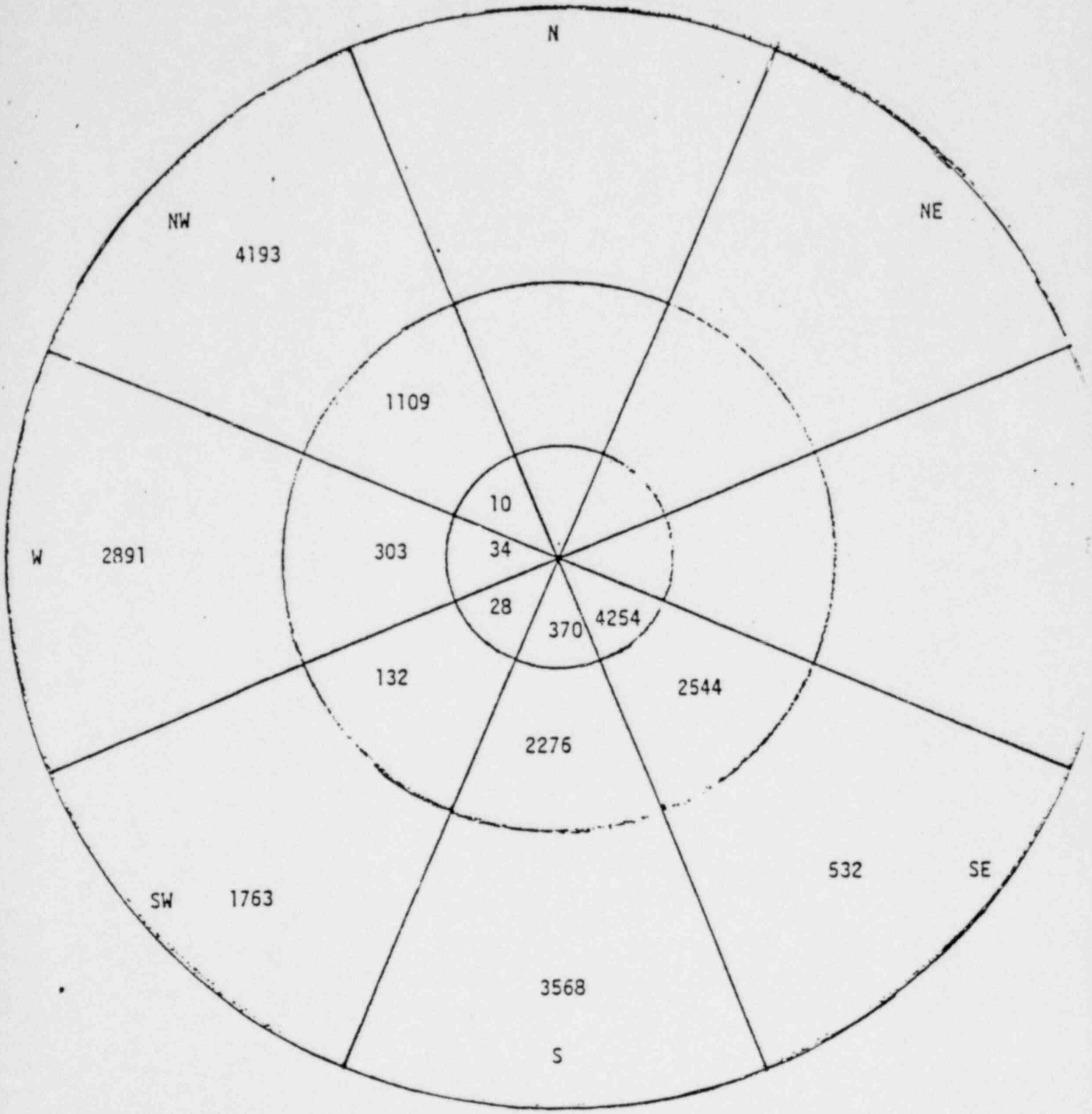
TOTAL: 46,754

0- 2 MILES: 2237
2- 5 MILES: 12095

PILGRIM NUCLEAR POWER STATION

EVACCC POPULATION DATA

TYPE: SEASONAL POPULATION



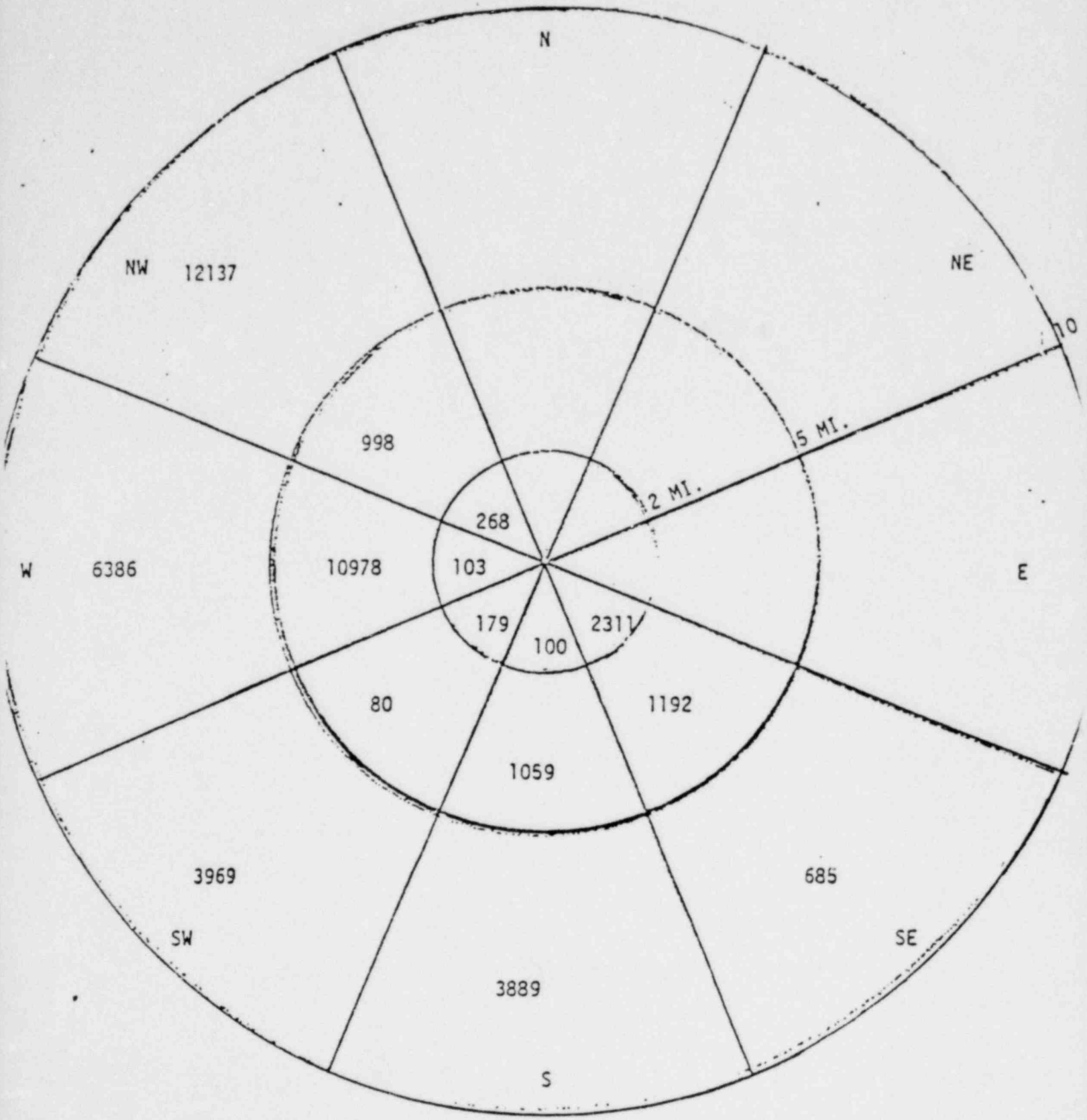
0 - 2 MILES: 12947
2 - 5 MILES: 6364
5 - 10 MILES: 4696

TOTAL: 24,007

PHILIPPINE NUCLEAR POWER STATION

EVACCC POPULATION DATA

TYPE: PEAK TRANSIENT POPULATION

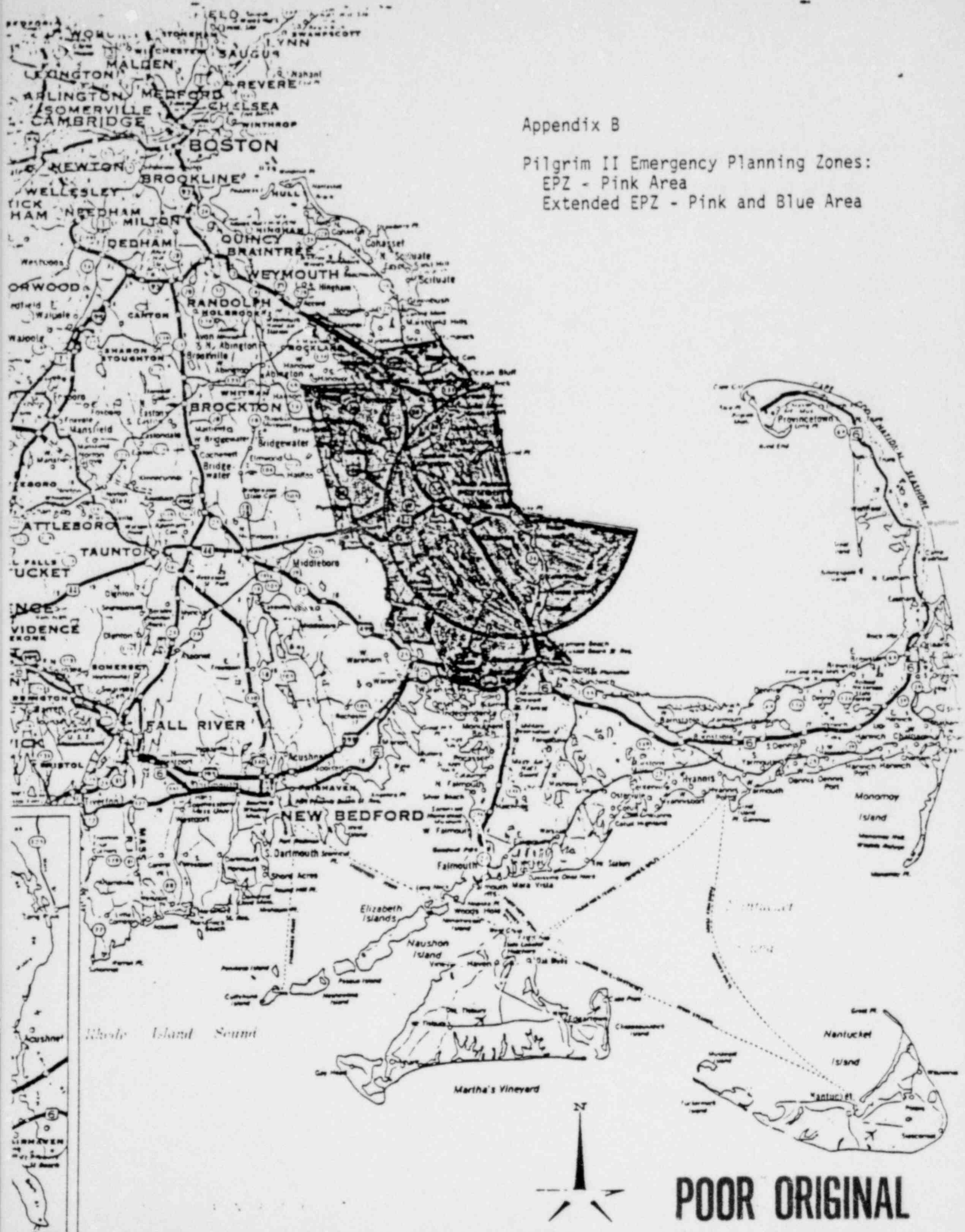


TOTAL: 44,334

0- 2 MILES: 2961
2- 5 MILES: 14307
5-10 MILES: 27066

Appendix B

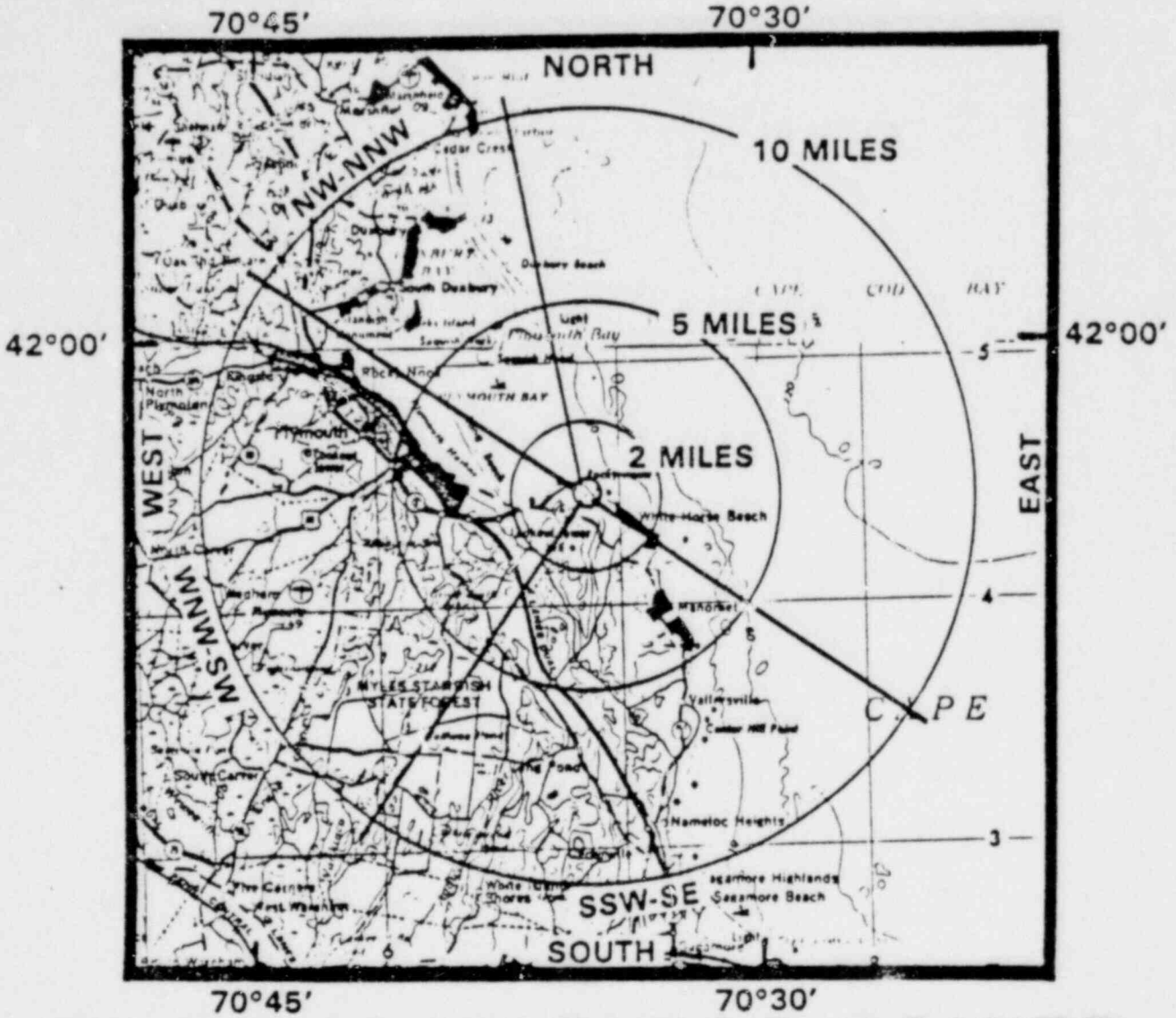
Pilgrim II Emergency Planning Zones:
EPZ - Pink Area
Extended EPZ - Pink and Blue Area



Appendix C

10-MILE RADIUS EMERGENCY PLANNING MAP

U.S. NUCLEAR REGULATORY COMMISSION - 1980



PILGRIM NUCLEAR POWER STATION MASSACHUSETTS

Scale 1:250,000

CONTOUR INTERVAL 100 FEET
WITH SUPPLEMENTARY CONTOURS AT 50 FOOT INTERVALS