UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before The Atomic Safety And Licensing Board

In the Matter of
Entergy Corporation
Pilgrim Nuclear Power Station
License Renewal Application

Docket # 50-293-LR

June 20, 2007

DECLARATION OF BRUCE A. EGAN, SC.D., CCM, IN SUPPORT OF PILGRIM WATCH'S RESPONSE OPPOSING ENTERGY'S MOTION FOR SUMMARY DISPOSTION OF PILGRIM WATCH CONTENTION 3

I, Bruce A. Egan prepared the attached document; and declare that under penalty of perjury that it is true and correct to the best of my understanding.

Bruce A. Egan

DECLARATION OF BRUCE A. EGAN, Sc.D., CCM

1. I am President of Egan Environmental Inc., an environmental consulting company based in Beverly, MA. My educational and professional experience is summarized in the Curriculum Vitae attached to this Declaration.
2. I earned an AB degree from Harvard College in 1961 and a S.M. degree in Engineering and Applied Physics from the Harvard Graduate School of Arts and Sciences in 1962. Between 1962 and 1964, I continued to take graduate level engineering courses while I was employed full time by Harvard University as Engineer-in-Charge of their undergraduate instructional laboratories. I then worked for four years for The National Committee for Fluid Dynamic Films making educational films for graduate level students. I earned a second Masters (S.M, 1969) and a Doctorate (Sc. D., 1972), in Environmental Health Sciences from the Harvard School of Public Health. To support my doctoral thesis topic on Numerical Modeling of Urban Air Pollutions Transport Phenomena, I cross registered at MIT for courses in Meteorology.
3. Before starting my own company in 1998, I was Vice President and Technical Director at Woodward Clyde Consultants and, before that, Senior Vice President and Chief Scientist at the ENSR Corporation. I have over 35 years of experience as a manager and an environmental scientist on projects involving the development and application of atmospheric dispersion models to complex topographic situations including mountainous terrain, and coastal settings. Clients for my work have been in the power production, oil and gas industries, chemical industry, pulp and paper and other industries, trade associations, government agencies at both federal and state levels, universities, environmental groups and law firms. Much of my work relies upon my training and experience with air pollution meteorology and air quality models as they are applied to permitting and compliance demonstrations for regulatory applications. However in the context of the issues regarding this reply to a motion for a Summary Disposition, I note that I have also performed accident and consequence analyses for Risk Management Plans and modeling for both hypothetical and actual accidental release scenarios involved in litigation. I am the co-author of book providing guidance on compliance with EPA's Risk Management Program under the Clean Air Act.
4. I have been an active member of the American Meteorological Society (AMS) for over thirty five years and have served on their committees relating to air pollution and meteorology. I am a Certified Consulting Meteorologist (Number 196) of the AMS. I am also an elected Fellow of the AMS. I have been an active member of the Air and Waste Management Association (AWMA) for over three decades and have served on their Editorial Board and on several of their committees. I am also an elected Fellow of the AWMA.
5. I am familiar with Pilgrim Watch Contention 3 which, as admitted by the Licensing Board asserts that "Applicant's SAMA analysis for the Pilgrim Plant is deficient in that the input data concerning (1) evacuation times, (2) economic consequences, and (3) meteorological patterns are incorrect, resulting in incorrect

conclusions about the costs versus benefits of possible mitigation alternatives, such that further analysis is called for."

6. In this Declaration, I will address Pilgrim Watch Contention 3 because having representative meteorological patterns is a foundation element for air quality dispersion modeling, for developing credible evacuation plans, estimating realistic evacuation times and in assessing the cost versus benefits of possible mitigation efforts.
7. Dispersion models rely upon the adequacy of the input meteorological data to represent the important air flow regimes. The field of dispersion modeling has developed rapidly since models were first routinely used in regulatory applications in the 1960 s and early 1970s. The Clean Air Act Amendments of 1977 created further reliance on atmospheric dispersion models for the establishment of emission limits for new industrial sources seeking licenses and permits under the Clean Air Act. The US EPA and other groups initiated research program to improve the science of dispersion models and the US EPA began to establish performance measures for models and to provide guidance and recommendations for the testing and adoption of improved models in permit applications. The result was further advancement in modeling methods that have persisted to the current decade. Specifically, very significant improvements have been made in the parameterization of the atmospheric boundary layer wind profiles, temperature profiles and variations of turbulent mixing rates with height above the ground surface. As a result of the Clean Air Amendments of 1977, The US EPA has been instrumental in encouraging and supporting the development of improved models including those defined as guideline models AERMOD and CALPUFF (EPA, 2005). AERMOD includes highly sophisticated algorithms for including spatial variations of the ground surface parameters of roughness lengths, surface albedo and the Bowen ratio into the parameterizations of wind and turbulence levels as a function of height. CALPUFF has the added features of allowing spatially variable wind fields. These models are now routinely used for regulatory applications and for risk assessments.
8. Even more advanced prognostic dispersion models have been developed for other applications including forecasting of sports events and real time model for weather forecasting and air quality predictions. For example, the MM5 meteorology model was used as a real time forecast model for predicting wind and dispersion conditions in last years winter Olympics.
9. Similar improvements to the model parameterizations have not been required for models used by the NRC for applications to the permitting of nuclear power plants. The MAACS2 code is based upon a straight line, steady state Gaussian plume equation that assumes that meteorological conditions are steady in time and uniform spatially across the study region for each time period of simulation. It does not allow consideration for the fact that the winds for a given time period may be spatially varying. For example, the wind speeds and directions over the ocean and over the land near the Pilgrim Nuclear Power Station (PNPS) are assumed to be the same. Thus the presences of sea breeze circulations which dramatically alter air flow patterns are ignored by the model. As discussed later, the nearby presence of the ocean greatly affect atmospheric dispersion processes

and is of great importance to estimating the consequences in terms of human lives and health effects of any radioactive releases from the facility.

10. The sea breeze circulation is well documented (Slade, 1968, Houghton, 1985, Watts, 1994, Simpson, 1994).The pressure differences that result in the development of a sea breeze essentially start over the land area well after sunrise. Along a coast, the sun heats the land surfaces faster than water surfaces. The warmer air above the land is more buoyant and initially rises vertically. The resulting lower pressure over the land draws air horizontally in from surrounding areas. Near a coast, the air over the water is cooler and denser and is drawn in to replace the rising air. This horizontal flow represents the advent of the sea breeze. The air starting to flow over the land is cooler than the air aloft and like any dense gas tends to resist upward vertical motions and prefers to pass around a terrain obstacle rather than up and over it. The density difference also suppresses turbulence that would mix the air vertically. As this air flows over the rougher and warmer land, an internal boundary layer is created which grows in height within the land bound sea breeze flow. Further inland the flow slows and warms and creates a return flow aloft which flows much more gently back out over the ocean to complete the overall circulations. Thus, the presence of a sea breeze circulation changes the wind directions, wind speeds and turbulence intensities both spatially and temporally through out its entire area of influence. The classic reference *Meteorology and Atomic Energy*, (Section 2-3.5) (Slade, 1968) succinctly comments on the importance of sea breeze circulations as "The sea breeze is important to diffusion studies at seaside locations because of the associated changes in atmospheric stability, turbulence and transport patterns. Moreover its almost daily occurrence at many seaside locations during the warmer seasons results in significant differences in diffusion climatology over rather short distances."
11. Egan Environmental Inc. was the prime contractor to the Massachusetts Department of Public Health for a modeling study of the effects of sea breeze circulations on air quality on Cape Cod. (Egan Environmental, 2002). Upper Cape Cod is surrounded on three sides by water bodies and can have very complicated air flow fields. We lead a team of researchers familiar with the MM5 meteorology model and with CALPUFF, SCIPUFF and other trajectory models which can be driven by the time and spatially varying wind fields computed by meteorological flow models. We performed analyses for elevated emissions from two different power plants, emissions from vehicular traffic along roadways and emissions from ground level area type sources. The model was able to simulate the main features and effects of sea breeze circulations including the occurrence of converging sea breezes from multiple coast lines. The modeling effort is an example of the advanced capabilities that have been developed for complex flow situations generally and for sea breeze flows specifically. The methodologies are amenable to both diagnostic and real time prognostic applications.
12. I have reviewed the report (Spengler and Keeler, 1988) documenting and describing meteorological conditions in the vicinity of the Pilgrim Nuclear Power Plant. This work is relevant to the issue of the need for more extensive

meteorological measurements in the vicinity of the power plant. I support their analysis of sea breeze effects and their general recommendations.

13. Comments on items in the Declaration of Kevin R. O'Kula:

Item 7: The claim that MACCS2 is a state-of-the-art computer model is not correct. MACCS2 does not rely upon or utilize the most current understandings of boundary layer meteorological parameterizations such as those adopted by the current US EPA in the models AERMOD OR CALPUFF (EPA,2005)

Item 14: The Gaussian plume model employed in the PNPS MACCS2 model may be the standard for NRC but it is not the basis for advanced modeling used by other regulatory agencies within the US. It is not appropriate for the PNPS coastal location.

Item 15: With the rapid advancement of computers and software in the past decade, computational time should not be a major factor in the choice of a dispersion model used for non real time applications. My experience is that most dispersion model runs require that multiple years of hour by hour meteorological data be used, that computations for hundreds of receptors locations be made and that source inventories sometimes include hundreds to thousands of sources which may have to be broken down to even larger numbers of individual point or area type sources for computational reasons. Many models also use multiple runs using 'bootstrap' techniques to generate statistical bounds on the model predicted values. Other modeling groups have not found similar applications "simply impracticable"

Item 16: This declaration seems to state that randomly chosen meteorological conditions would give the same results as inputting meteorological conditions as a function of time. This is an erroneous concept with real meteorology which does not generally behave in a random manner.
In order to take into account meteorological conditions 'as a function of time' a model must process the meteorological data sequentially with time. A common phenomenon in weather data analysis is the role of persistence of combinations of meteorological events over periods of hours to many days. The probability that the next hour's meteorology will be similar to the previous hour's or that tomorrows weather will be like today's is fairly high and certainly not random or independent of what happened in the previous time period . It also matters from an air quality point of view if winds are very low and dispersion very small for several hours in a row. To accommodate the real role of persistence in dispersion modeling EPA requires sequential modeling for all averaging times from 3 hour averages to annual averages.

Items 17, 18 and 19: The fact that a model may seem to be conservative in particular applications or in limited data comparisons does not mean that the model is better or should be recommended for an application. Models can be conservative but have incorrect simulations of the underlying physics. Similarly, sensitivity studies do not add useful information if the primary model is flawed.

Item 20: There are several misleading statements in this statement.
First, the statement that the meteorological data collected at the PNPS site would reflect the occurrence of the sea breeze in terms of wind speeds and direction is not necessarily true. As described earlier, the sea breeze is highly temporally and spatially dependent. A measurement at a single station will not provide sufficient information to allow one to project how an accidental release of a hazardous material would travel. One needs supplemental information, preferably in terms of additional meteorological stations. For example a wind sensor located low along the coastline could provide an early warning of the onset of the sea breeze. Another met station further inland could confirm the strength and direction of the sea breeze event. More data would allow the implications of the sea breeze to be even better understood. Measurement data from one station will definitely not suffice to define the sea breeze.
Secondly, the contention that the sea breeze is 'generally beneficial in dispersing the plume and in decreasing doses' is incorrect. If a sea breeze were to not develop under conditions that they normally would develop, the air flow at the PNPS would be offshore, over the ocean, and be much more beneficial to the adjacent shoreline communities. It is in fact the presence of a sea breeze flow that would transport a release inland that is the greatest danger. Thus contrary to the implications of this declaration, the development of a sea breeze flow is the common meteorological condition that must be most closely monitored at the PNPS.
Thirdly, this statement reflects a misconception that the sea breeze is "generally a highly beneficial phenomena that disperses and dilutes the plume concentration and thereby lowers the projected doses downwind from the release point ". If the same meteorological conditions that are conducive to the development of a sea breeze at a coastal site (strong solar insolation, low synoptic scale winds), were to occur at a non coastal site, vertical thermals would develop at somewhat random locations. To the extent that they develop over a pollution source, these thermals would carry contaminants aloft and away from the population living at ground level. In contrast, at a coastal site, the sea breeze would draw contaminants across the land and inland subjecting the population to potentially larger doses.
These misconceptions are important because they reveal a lack of appreciation of the importance of sea breeze flows on coastal community population exposures and on the need to obtain and properly use sufficient meteorological data in emergency response planning.

14. Dispersion models used for developing evacuation plans or in implementing evacuation plans need to provide realistic projections of expected ambient air concentrations and dosages that the public might be subjected to.
While for many regulatory applications of models, especially to support licensing applications, modelers may rely on being conservative in the sense of over predicting expected concentrations, models used for emergency planning or evacuation purposes must be based upon good science and provide realistic assessments of where and for how long exposures to the public might take place.

Thus important decisions about when population groups should be evacuated from any given area and for what population groups shelter-in–place options should be recommended, need to rely upon highly competent atmospheric dispersion simulation methodologies.

15. Under current NRC regulations, the Emergency Planning Zone (EPZ) concerned with plume exposure inhalation risk pathways is defined by a ten mile radius centered on the release point. The first 5 miles radius of that zone is an area where complete evacuation may be mandated. The area from 5 miles out to 10 miles consists of wedge shaped areas defined on the basis of a single wind direction observation at the power plant site. The above discussions about sea breeze flow means that a single measurement point would not necessarily be indicative of the actual flow further inland. A state-of-the-art system could be designed that would utilize real time multi station meteorological data in conjunction with a real time meteorological flow model that could predict the expected plume trajectory in real time.

16. My analysis supports Pilgrim Watch's contention has relied upon incorrect meteorological assumptions and models and this has caused it to draw incorrect conclusions about the costs versus benefits of possible mitigation alternatives

References.

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Simpson, J. E., 1994: Sea Breeze and Local Winds. Cambridge University Press Cambridge, UK.

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