UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
Entergy Nuclear Generation Co. and	)	
Entergy Nuclear Operations, Inc.	)	Docket No. 50-293-LR
	)	
	)	
(Pilgrim Nuclear Power Station)	)	

NRC STAFF'S PROPOSED FINDINGS OF FACT AND CONCLUSIONS OF LAW, AND ORDER IN THE FORM OF AN INITIAL DECISION

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March 4, 2011

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I. INTRODUCTION

1. This initial decision rules on the outstanding remanded issues in this 10 C.F.R. Part 2, Subpart L proceeding concerning the contention challenging the Entergy Nuclear Generation Co. and Entergy Nuclear Operations, Inc. (collectively, "Entergy" or "Applicant") application for renewal of the operating license for the Pilgrim Nuclear Power Station ("Pilgrim") in Plymouth, Massachusetts. The proposed renewal would authorize the facility to operate 20 years beyond its current operating license expiration date of June 8, 2012. Intervenor Pilgrim Watch sponsored a contention challenging the Applicant's use of meteorological data in developing Pilgrim's Severe Accident Mitigation Alternatives ("SAMA") analysis. The Board modified and admitted this contention.

2. After considering all of the evidence in this proceeding, we find that the record shows, contrary to Pilgrim Watch's contention as admitted by the Board and remanded by the Commission, that the Nuclear Regulatory Commission staff ("Staff") has met its burden of showing that the meteorological modeling in the Pilgrim SAMA analysis is adequate and

reasonable to satisfy NEPA, and that accounting for the meteorological patterns and atmospheric transport modeling issues of concern to Pilgrim Watch, on their own and in combination, could not credibly alter the Pilgrim SAMA analysis conclusions on which SAMAs are potentially cost-beneficial to implement.

II. BACKGROUND

A. Procedural History

3. On January 25, 2006, Entergy filed an application to renew its operating license for Pilgrim.[1]

4. The NRC published a notice of receipt of the application on February 6, 2006.[2] In response to the subsequent notice of docketing of the application and notice of opportunity for a hearing published in the *Federal Register*,[3] Pilgrim Watch filed a petition to intervene in this matter on May 25, 2006, submitting five contentions for consideration.[4] On May 26, 2006, the Attorney General for Massachusetts also filed a petition to intervene containing one contention.[5]

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[1] Entergy Nuclear Operations, Inc., License Renewal Application – Pilgrim Nuclear Power Station (January 25, 2006) (Agencywide Documents and Access Management System ("ADAMS") Accession No. ML060300028).

[2] Entergy Nuclear Operations, Inc.; Notice of Receipt and Availability of Application for Renewal of Pilgrim Nuclear Power Station Facility Operating License No. DPR–35 for an Additional 20-Year Period, 71 Fed. Reg. 6,101 (Feb. 6, 2006).

[3] Entergy Nuclear Operations, Inc., Pilgrim Nuclear Power Station; Notice of Acceptance for Docketing of the Application and Notice of Opportunity for Hearing Regarding Renewal of Facility Operating License No. DPR–35 for an Additional 20-Year Period, 71 Fed. Reg. 15,222 (Mar. 27, 2006).

[4] Request for Hearing and Petition to Intervene by Pilgrim Watch (May 25, 2006).

[5] Massachusetts Attorney General's Request for a Hearing and Petition for Leave to Intervene with Respect to Entergy Nuclear Operations Inc.'s Application for Renewal of the Pilgrim Nuclear Power (continued. . .)

5. In LBP-06-23, 64 NRC 257 (2006), we rejected the Massachusetts Attorney General's petition to intervene[6] but granted that of Pilgrim Watch, admitting two of Pilgrim Watch's proposed contentions.[7] The first of these contentions, designated Contention 1, concerned the aging management program for buried pipes and tanks containing radioactively contaminated water.[8] That contention was decided in favor of Entergy after hearing and the decision was affirmed by the Commission.[9] The second Pilgrim Watch contention, designated Contention 3, which we admitted in limited form, challenged the SAMA analysis in Entergy's Environmental Report,[10] and read:

(. . .continued)

Plant Operating License and Petition for Backfit Order Requiring New Design Features to Protect Against Spent Fuel Pool Accidents (May 26, 2006). The Town of Plymouth also requested to participate in the proceedings and, in accordance with 10 C.F.R. § 2.315(c), the Board granted the Town's request. *See* Request of the Town of Plymouth to Participate as of Right Under 2.315(c) (Jun. 16, 2006); Order and Notice (Regarding Oral Argument and Limited Appearance Statement Sessions) (unpublished) (Jun. 21, 2006). The Town of Plymouth has not, however, chosen to participate substantively in the litigation over Contention 3.

[6] *See Entergy Nuclear Generation Co. and Entergy Nuclear Operations, Inc.* (Pilgrim Nuclear Power Station), LBP-06-23, 64 NRC 257, 288-300 (2007). The Massachusetts Attorney General's appeal of this decision was also rejected. *See Entergy Nuclear Vermont Yankee, LLC, and Entergy Nuclear Operations, Inc*. (Vermont Yankee Nuclear Power Station), *Entergy Nuclear Generation Co. and Entergy Nuclear Operations, Inc*. (Pilgrim Nuclear Power Station), CLI-07-03, 65 NRC 13 (2007).

[7] LBP-06-23, 64 NRC at 348-49

[8] *Id.*

[9] *Entergy Nuclear Generation Co. and Entergy Nuclear Operations, Inc.* (Pilgrim Nuclear Power Station), LBP-08-22, 68 NRC 590 (2008); *Entergy Nuclear Generation Company and Entergy Nuclear Operations, Inc*. (Pilgrim Nuclear Power Station), CLI-10-14, 71 NRC __ (June 17, 2010).

[10] LBP-06-23, 64 NRC at 341.

> 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.[11]

6. On May 17, 2007, Entergy moved for summary disposition of Contention 3.[12] The Staff filed a response supporting the SAMA Motion,[13] while Pilgrim Watch opposed it.[14] On July 9, 2007, PW filed a reply to the Staff's Response.[15] On October 30, 2007, a Board majority granted the motion for summary disposition of Contention 3, in LBP-07-13.[16]

7. On March 26, 2010, in response to PW's Petition for Review of, *inter alia*, the summary disposition of PW's Contention 3, the Commission issued a Memorandum and Order reversing in part, affirming in part, and remanding Contention 3, as limited by the Commission's Order, to the Board for further proceedings.[17] Specifically, the Commission remanded the meteorological patterns and atmospheric transport modeling issue.[18] In addition, the

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[11] *Id.*

[12] Entergy's Motion for Summary Disposition of Pilgrim Watch Contention 3) (May 17, 2007) ("SAMA Motion").

[13] NRC Staff Response To [SAMA Motion] (June 28, 2007).

[14] Pilgrim Watch Answer Opposing [SAMA Motion] (June 27, 2007).

[15] Pilgrim Watch's Answer to NRC Staff Response to [SAMA Motion] (July 9, 2007).

[16] *Pilgrim*, LBP-07-13, 66 NRC 131. Judge Young dissented from the Board's Order. *Id.* at 156.

[17] *Entergy Nuclear Generation Company and Entergy Nuclear Operations, Inc.* (Pilgrim Nuclear Power Station), CLI-10-11 ("Commission's Order"), 71 NRC ___ (March 26, 2010) (slip op. at 39).

[18] *Id.* at 26.

Commission remanded the economic costs and evacuation timing issues, but only to the extent that the Board's findings on the meteorology and atmospheric transport modeling would "materially call into question the relevant economic cost and evacuation timing conclusions in the Pilgrim SAMA analysis."[19] In remanding Contention 3, the Commission stated that "even assuming that the SAMA analysis does not entirely account for the sea breeze effect … if the sea breeze effect essentially is limited to lower population areas within 10 miles of the plant and occurs only on a limited number of days per year, its overall impact on the SAMA cost benefit conclusions may be insignificant."[20]

8. After briefings by the parties, we set out the scope of the remanded contention, including specific issues for each party to address, in a September 23, 2010 Order.[21] We stated that Remanded Contention 3's "primary and threshold issue [is] *whether the meteorological modeling in the Pilgrim SAMA analysis is adequate and reasonable to satisfy NEPA, and whether accounting for the meteorological patterns/issues of concern to Pilgrim Watch could, on its own, credibly alter the Pilgrim SAMA analysis conclusions on which SAMAs are cost-*

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[19] *Id.* at 27.

[20] *Id.* at 22.

[21] Order (Confirming Matters Addressed at September 15, 2010, Telephone Conference) September 23, 2010 ("Sept. 23, 2010 Order").

beneficial to implement."[22] The Board also asked the parties to address a series of related questions regarding the impact of the sea breeze effect[23] and hot spots[24] on the SAMA.[25]

9. On January 3, 2011, the parties filed initial written presentations and testimony, and on February 1, 2011, they filed rebuttal presentations and testimony.[26]

10. On January 13, 2011, Entergy filed a motion in limine, challenging the admissibility of Pilgrim Watch's prefiled testimony as well as several of Pilgrim Watch's prefiled

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[22] *Id.* at 1 (emphasis added).

[23] The sea breeze effect occurs because of differential heating between land and water surfaces, where air moving onshore from the ocean is heated by the landmass. Ramsdell Testimony at A7. This heated air rises due to its increased buoyancy and is eventually carried back out to the ocean by winds blowing in the opposite direction of the onshore breeze. Ramsdell Testimony at A7. As this heated air mass passes back out over the ocean, it cools and decreases in elevation until it rejoins the onshore breeze at a location normally south of the original breeze. Ramsdell Testimony at A7. This southward movement of the air mass during the sea breeze is a normal characteristic of this phenomena in the northern hemisphere. Ramsdell Testimony at A7.

[24] The term "hot spot" is normally associated with area with increased radiation levels due to elevated contamination. For purposes of PW's contention, the term "hot spot" refers to the process where a plume moves over water, remains tightly concentrated over the water, and comes back on-shore after a change in the wind direction with higher concentrations of radionuclides than would be expected based physical characteristics.

[25] Sept. 23, 2010 Order at Appendix A (internal citations omitted).

[26] Entergy Initial Statement of Position on Pilgrim Watch Contention 3 (January 3, 2011); Pilgrim Watch SAMA Remand Pre-Filed Testimony ("Pilgrim Watch's Initial Statement of Position") (Jan. 3, 2011); NRC Staff's Initial Statement of Position on Remanded Contention 3 (January 3, 2011).

exhibits.[27] The Staff supported the motion. Pilgrim Watch opposed the motion, but conceded that its pre-filed testimony was not testimony, but rather a statement of position.[28]

11. On February 16, 2011, the parties filed a joint motion to have the Board decide this matter without an oral evidentiary hearing, based on the parties' pre-filed testimony on the atmospheric transport modeling and related meteorological issues, including the January 30, 2011 declaration of Dr. Bruce Egan, submitted by Pilgrim Watch.[29]

12. On February 18, 2011, we held a telephone conference with all parties. The conference was memorialized in an order issued on February 22, 2011.[30] We granted the joint motion and requested that the parties file proposed findings of fact and conclusions of law by March 4, 2011.[31] We also granted in part and denied in part Entergy's Motion in Limine, admitting Pilgrim Watch's pre-filed exhibits.[32] We granted the motion in part and denied it in

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[27] *See* Entergy's Motion In Limine to Exclude from Evidence Pilgrim Watch's SAMA Remand Pre-Filed Testimony and Exhibits (Jan. 13, 2011); NRC Staff's Response in Support of Entergy's Motion In Limine (Jan. 24, 2011).

[28] Pilgrim Watch Reply to Entergy's Motion in Limine to Exclude from Evidence Pilgrim Watch's SAMA Remand Pre-filed Testimony and Exhibits ("Motion in Limine") (Jan. 23, 2011).

[29] Joint Motion Requesting Resolution of Contention 3 Meteorological Issues on Written Submissions (Feb. 16, 2011).

[30] Order (Addressing Joint Motion, Motion in Limine, Proposed Findings of Fact and Conclusions of Law/Concluding Statements of Position, and Argument to be Held March 9, 2011) (Feb. 22, 2011) ("Feb.22 Order").

[31] *Id*. at 2-3.

[32] *Id.* at 2.

part, admitting Pilgrim Watch's prefiled testimony as a statement of position only and admitting all of Pilgrim Watch's prefiled exhibits.[33]

13. On March 3, 2011, the Board issued a ruling with regard to whether the Mean Consequences Value issues were timely raised. A Board majority held that those issues were not timely raised.[34]

14. On March 9, 2011, the Board heard closing arguments on the threshold issue on the remanded Contention 3.

B. Witnesses

15. A total of five witnesses submitted written pre-filed testimony and rebuttal on behalf of Entergy and the Staff. A sixth witness submitted a statement on behalf of Pilgrim Watch.[35] Consistent with the parties' joint motion for a decision on the written submitted record, no oral testimony was received.

16. Entergy presented the testimony of two qualified witnesses: Dr. Kevin R. O'Kula, Advisory Engineer with URS Safety Management Solutions, LLC., and Dr. Steven R. Hanna, President of Hanna Consultants and an Adjunct Associate Professor at the Harvard School of

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[33] Order (Addressing Joint Motion, Motion in Limine, Proposed Findings of Fact and Conclusions of Law/Concluding Statements of Position, and Argument to be held March 9, 2011) (February 22, 2011).

[34] Memorandum And Order (Ruling on Timeliness of Mean Consequence Values Issue) (Mar. 3, 2011).

[35] The sixth witness had previously submitted declarations on behalf of Pilgrim Watch during this proceeding, which were attached as exhibits to Pilgrim Watch's Initial Statement of Position.

Public Health. The professional qualifications of each witness were discussed in their pre-filed testimony.[36]

17. Pilgrim Watch presented the declarations of one witness in meteorological modeling: Dr. Bruce A. Egan, President of Egan Environmental, Inc.[37] His professional qualifications were attached to his pre-filed declaration.[38]

18. The Staff presented written testimony and opinions of three highly qualified witnesses, namely: Dr. Nathan Bixler, Principal Member of the Technical Staff at Sandia National Laboratories, Dr. S. Tina Ghosh, Senior Program Manager for the Nuclear Regulatory Commission, and Mr. James Ramsdell, Senior Technical Researcher for Pacific Northwest

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[36] Testimony of Dr. Kevin R. O'Kula and Dr. Steven R. Hanna on Meteorological Matters Pertaining to Pilgrim Watch Contention 3 ("O'Kula/Hanna Testimony"), Entergy Exhibit ("Exh") ENT000001 at 1-5.

[37] Pilgrim Watch appended statements from Dr. Jan Beyea (PWA00002), Richard Rothstein (PWA00005), David I. Chanin (PWA0003 and PWA0004) and Dr. Edwin Lyman (PWA00012), Dr. Lyman's and Beyea's statements were not accompanied by statements of professional training and experience; thus, their expertise could not be determined. Dr. Lyman's report was unsworn. Additionally, their statements addressed issues that were out of scope for this hearing; had previously been excluded from this proceeding; and/or contained no support for their conclusions. Dr. Beyea's statements regarding the sea breeze effect, CALPUFF and hot spots are general, inconclusive and unsupported by any evidence. Dr. Beyea's statements regarding cancer risk factors are not part of SAMA analyses and are out of scope. Also, Dr. Beyea is unqualified to testify on issues related to atmospheric transport modeling at Pilgrim. Mr. Rothstein's statements pertain primarily to emergency response and evacuation issues and do not support application to SAMA analysis at Pilgrim. In addition, Mr. Rothstein's declaration cites an ADAMS document (ML070440358), which is not in evidence and will not be considered by this Board. Mr. Chanin's statements relate to economic consequences and do not relate to meteorological inputs and modeling and are, thus, out of scope.

[38] Declaration of Bruce A. Egan, Sc.D., CCM, in Support of Pilgrim Watch's Response Opposing Entergy's Motion for Summary Disposition of Pilgrim Watch Contention 3, Pilgrim Watch Exh. PWA00001 ("Exh. PWA00001"); Statement by Bruce A. Egan, Sc.D., CCM (January 30, 2011), Pilgrim Watch Exh. PWA00023 ("Exh. PWA00023").

Laboratories. The professional qualifications of the each witness were appended to their pre-filed testimony.[39]

19. All of the witnesses were found to be qualified to present testimony in the areas they addressed. The Board has accorded each witness's testimony the weight appropriate to their level of knowledge, training and experience related to the subject matter of this contention.

III. LEGAL AND REGULATORY REQUIREMENTS

20. The National Environmental Policy Act ("NEPA"), 42 U.S.C. § 4321 et seq., requires federal agencies, including the NRC, to take a hard look at the environmental impacts of their actions. NEPA does not mandate a specific outcome or a course of action including a decision to mitigate any potential impacts.[40] Nor does NEPA require consideration of worst-case scenarios.[41] The NRC fulfills its requirements under NEPA, for renewal of operating licenses, through the Final Supplemental Environmental Impact Statement ("FSEIS") and the Generic Environmental Impact Statement ("GEIS").[42]

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[39] NRC Staff Exhs. NRC 000011-13.

[40] *See, e.g.*, *Baltimore Gas and Elec. Co. v. Nat. Res. Def. Council*, 462 U.S. 87, 97 (1983) (*quoting Kleppe v. Sierra Club*, 427 U.S. 390, 410 n.21 (1976)) (stating that NEPA requires "only that the agency take a 'hard look' at the environmental consequences before taking a major action); Sierra Club v. Army Corps of Engineers, 446 F.3d 808, 815 (2006) (same); *Louisiana Energy Services, L.P.* (Claiborne Enrichment Center), CLI-98-3, 47 NRC 77, 87-88 (1998) (same); *Hydro Resources, Inc.* (P.O. Box 777, Crownpoint, New Mexico 87313), LBP-06-19, 64 NRC 53, 63-64 (2006) (same); *see also Winter v. Nat. Res. Def. Council*, 129 S.Ct. 365, 376 (2008) (stating that "NEPA imposes only procedural requirements" and does not mandate any particular results).

[41] *Robertson v. Methow Valley Citizens Counsel,* 490 U.S. 332, 333 (1989).

[42] 10 C.F.R. § 51.2.

21. The Commission has stated that "there is no NEPA requirement to use the best scientific methodology, and NEPA 'should be construed in light of reason if it is not to demand' virtually infinite study and resources."[43] The Commission has cautioned that "[o]ur boards do not sit to 'flyspeck' environmental documents or to add details or nuances. If the [EIS] on its face 'comes to grips with all important considerations' nothing more need be done."[44]

22. In this case, the Commission's Order remanding Contention 3 explained that the issue for adjudication is "not whether there are 'plainly better' atmospheric dispersion models or whether the SAMA analysis can be refined further" but, whether "it looks genuinely plausible that inclusion of an additional factor or use of other assumptions or models may change the cost-benefit conclusions for the SAMA candidates evaluated."[45] The Commission went on to explain that mathematical precision is not required for evaluating PW's Remanded Contention 3.[46] The Commission has also concluded that "[u]ltimately, NEPA requires the NRC to provide a 'reasonable' mitigation alternatives analysis, containing 'reasonable' estimates, including where appropriate, full disclosures of any known shortcomings in available methodology, disclosure of incomplete or unavailable information and significant uncertainties,

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[43] CLI-10-11, at 37.

[44] *Exelon Generation Co.*, LLC (Early Site Permit for Clinton ESP Site), CLI-05-29, 62 NRC 801, 811 (2005) (citing *Systems Energy Resources. Inc.* (Early Site Permit for Grand Gulf ESP Site), CLI-05-4, 61 NRC 10, 13 (2005) (footnote omitted)).

[45] CLI-10-11, at 39.

[46] *Id*.

and reasoned evaluation of whether and to what extent these or other considerations credibly could or would alter the Pilgrim SAMA analysis conclusions."[47]

IV. FINDINGS OF FACT

A. Statement of Issue

23. The issue before the Board in this case is "[w]hether the meteorological modeling in the Pilgrim SAMA analysis is adequate and reasonable to satisfy NEPA, and whether accounting for the meteorological patterns and issues of concern to Pilgrim Watch could, on its own, credibly alter the Pilgrim SAMA analysis conclusions on which SAMAs are cost-beneficial to implement."[48]

24. As discussed below, and after weighing all the written admitted evidence, we conclude that the concerns raised by Pilgrim Watch's contention, as remanded and limited by the Commission, lack merit because the use of additional meteorological data, alternative atmospheric and dispersion models, and accounting for the sea breeze effect and hot spots could not identify any new SAMAs as being potentially cost beneficial. Thus, the SAMA analysis for Pilgrim including its use of the ATMOS module and as discussed in the Staff's FSEIS is reasonable under NEPA.

25. Pilgrim Watch argues that the SAMA analysis submitted by Entergy and reflected in the Staff's FSEIS is unreasonable because other atmospheric transport models with higher

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[47] *Entergy Nuclear Generation Company and Entergy Nuclear Operations, Inc.* (Pilgrim Nuclear Power Station), CLI-10-22 ("Commission's Recusal Order"), 72 NRC ___ (Aug. 27, 2010) (slip op. at 9 – 10). *See also Baltimore Gas & Elec. Co. v. NRDC*, 462 U.S. 87, 88, 98-100, 101-02 (1983) (NRC complied with NEPA where it discussed major uncertainties.)

[48] September 23, 2010 Order at 1.

fidelity would provide more accurate transportation and deposition rates for the 50 mile radius surrounding Pilgrim.[49] Pilgrim Watch also asserts that by increasing the resolution of the atmospheric transport models, additional SAMAs would become cost beneficial.[50] As support for those assertions, Pilgrim Watch submitted two declarations by Dr. Bruce Egan, as well as other exhibits discussed below. However, in its "pre-filed testimony," which we have accepted as Pilgrim Watch's Initial Statement of Position,[51] Pilgrim Watch conceded that it could not demonstrate that "meteorology, *in and of itself,* would result in a significantly different SAMA analysis."[52] Pilgrim Watch also stated that "'…on its own' using a variable plume model would not alter Entergy's SAMA analysis," and "… neither Pilgrim Watch nor anyone else, regardless of how much time and money they might spend, can prove that 'meteorological patterns/issues … could, on its own, credibly alter the Pilgrim SAMA analysis/issues of concern.'"[53] Since Pilgrim Watch has conceded the sole remanded issue to be decided in this case, the Board need go no further. However, in order to develop a full record, we will dispose of all in-scope, relevant, and material matters raised by the parties in this proceeding.[54]

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[49] Exh. PWA00001 at ¶ 13 and Exh. PWA00023 at p. 5-6; Pilgrim Initial Statement of Position at 2.

[50] Exh. PWA00001 at ¶ 13.

[51] February 22, 2011 Order at 2.

[52] Pilgrim Watch Initial Statement of Position at 2 (January 3, 2011).

[53] *Id.* at 3,4.

[54] We will not consider the following Pilgrim Watch exhibits. PWA00011, PWA00013, PWA00014, PWA00020 contain discussions that are outside the scope of these proceedings. PWA00011 contains discussions related to epidemiological investigations of releases occurring during (continued. . .)

26. As the Staff explains, Pilgrim Watch's focus is too narrow because it is concerned only with how the atmospheric transport model projects the path of a single plume for a single set of weather data.[55] Pilgrim Watch and its expert, despite repeated unsupported assertions,[56] has not provided any evidence that using alternative meteorological data and transport models would alter the overall analysis sufficiently to identify a new cost-beneficial SAMA.

27. If the purpose of the SAMA analysis was to make emergency planning and response decisions based on path of the plume and its deposition rate under variable meteorological conditions, Pilgrim Watch's focus might be an important consideration. However, the actual purpose of a SAMA analysis is to identify particular mitigation measures that are potentially cost-beneficial given a particular accident, the likelihood of the accident, any characteristics of the accidental release, and the likely meteorological conditions that could occur at the time of the release.[57] Thus, the important comparison is not individual weather trials, as Pilgrim Watch seems to suggest, but to compare the values from all the weather trials

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(. . .continued)

normal plant operation at summary findings 2 and 3 at pages 1-2 section 8.5 on page 35 and section 10.1 at pages 37-38, which is out of scope. PWA00014 and PWA00020 relate to probabilistic modeling and, as Pilgrim Watch admits, are beyond the scope of this proceeding. See Pilgrim Watch Initial Statement of Position at 50, 55.

[55] NRC Staff Initial Statement of Position on Pilgrim Watch Contention 3 (hereinafter "Staff Initial Statement") at 9.

[56] See Egan Declaration Exhs. PWA00001 at ¶ 15 and PWA00023 at p. 8.

[57] Bixler/Ghosh Testimony, Exh. NRC00014 at A.7 – A.13, A.16, A.19 – A.20.

performed for a single accident utilizing the ATMOS module to results produced by higher resolution models as was done in NUREG-6853, "Comparison of Average Transport and Dispersion Among a Gaussian, a Two-Dimensional, and a Three-Dimensional Model," Exh. JNT000001.[58]

28. All of the witnesses for the Staff and Entergy agree that, as Dr. Bixler stated, it is highly unlikely that the issues raised by Pilgrim Watch in Contention 3 would result in Pilgrim's SAMA analysis failing to identify potentially cost-beneficial mitigation measures even if alternative atmospheric transport models were used.[59] Pilgrim Watch's failure to provide contrary credible evidence affirms the Staff and Entergy's opinion.

1. The SAMA Analysis

29. SAMA analyses are performed for license renewal pursuant to 10 C.F.R. § 51.53(c)(3)(ii)(L), which requires that if no SAMAs have been previously considered for the plant, then the environmental report must provide a consideration of SAMAs.[60]

30. According to Staff and Entergy testimony, the purpose of a SAMA analysis is to systematically search for potentially cost beneficial enhancements to further reduce nuclear power plant accident risk.[61] In particular, a SAMA analysis allows for the comparison of benefits

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[58] Bixler/Ghosh Testimony Exh. NRC00014 at A.34, A.36 – A.37, A.40.

[59] *Id.* at A6.

[60] *See also* 10 C.F.R. Part 51, Subpart A, Appendix B.

[61] Bixler/Ghosh Testimony, Exh. NRC000014 at A.7. *See also* O'Kula/Hanna Testimony Exh. ENT000001 at A.15.

derived from particular mitigation measures with their cost to implement.[62] The SAMA analysis for Pilgrim uses probabilistic risk assessment ("PRA") to consider improvements and evaluate the change in risk that would result from those improvements.[63]

31. The first step of a SAMA evaluation is to identify and characterize the leading contributors to core damage frequency ("CDF"), Large Early Release Fractions ("LERF"), and offsite risk based on a plant-specific risk study or applicable studies for other plants[64]

32. The next step in the SAMA analysis process is to identify candidate SAMAs to mitigate these risk contributors. Once candidate SAMAs have been identified, an initial screening is performed to determine which SAMAs cannot be cost-beneficial.[65] For example, if the cost of implementing a SAMA is higher than the elimination of all risk from operating the plant (called the "Maximum Achievable Benefit"), that SAMA is screened out since it cannot be cost effective. For each SAMA that survives this initial screening, a benefit assessment is performed to address how the change would affect relevant risk measures (i.e., the reduction gained in CDF, LERF, offsite population dose risk in person-rem/yr., and offsite economic cost

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[62] Bixler/ Ghosh Testimony, Exh. NRC000014 at A.7. *See also* O'Kula/Hanna Testimony Exh. ENT000001 at A.15, 16.

[63] Bixler/ Ghosh Testimony, Exh. NRC000014 at A.7. *See also* O'Kula/Hanna Testimony Exh. ENT000001 at A.16.

[64] Bixler/ Ghosh Testimony, Exh. NRC000014 at A.8; O'Kula/Hanna Testimony Exh. ENT000001 at A.15, 18(1).

[65] Bixler/ Ghosh Testimony, Exh. NRC000014 at A.8; O'Kula/Hanna Testimony Exh.ENT000001 at A.18.

risk in $/yr.). A cost assessment is also performed for each SAMA. To identify SAMAs that may be cost-beneficial, the net present value of each SAMA is estimated.[66]

33. Based on the dominant risk contributors, potential SAMAs are identified that could mitigate the associated risks of the particular plant, in this case Pilgrim. The contribution of external events is considered to the extent that it can be supported by available risk methods, because external events can affect whether or not a SAMA is cost-beneficial (greater reduction of risk). In some cases, a candidate SAMA may be identified to specifically mitigate risk from external events.[67] In other cases, a SAMA that may have been identified based on internal event considerations (e.g., use of portable generators to power equipment in a station blackout (“SBO”)) may also reduce the risk for external events (e.g., a seismically induced SBO). In addition to this search for SAMAs that mitigate plant-specific dominant risk contributors, the SAMA analyses for other plants are typically also consulted for ideas about potential candidate SAMAs and evaluated when applicable.[68]

34. Cost estimates for hardware modifications can be taken from past studies performed for a similar plant, or developed on a plant-specific basis. Procedure and training cost estimates are typically estimated based on plant experience. Cost estimates are generally conservative in that they neglect certain cost factors (e.g., surveillance/maintenance, the cost of

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[66] Bixler/ Ghosh Testimony, Exh. NRC000014 at A.8; O’Kula/Hanna Testimony Exh. ENT000001 at A.18.

[67] For example, the risk from an external event might be minimized by improving the characteristics of hardware only capable of being damaged during a seismic event.

[68] Bixler/ Ghosh Testimony, Exh. NRC00014 at A.9.

replacement power during implementation), and therefore tend to increase the number of potentially cost beneficial SAMAs. Typically, screening estimates are used for initial assessments and refined as appropriate if a SAMA is identified as being potentially cost-beneficial.[69]

35. A PRA assesses the risk from operating nuclear power plants by answering three basic questions: (1) what can go wrong, (2) how likely is it, and (3) what are the consequences. The baseline PRA for a plant evaluates the risk of operating the plant based on its current state, i.e., without implementing any of the proposed improvements. The PRA for a commercial power reactor has traditionally been divided into three levels: Level-1 is the evaluation of the combinations of plant failures that can lead to core damage; Level-2 is the evaluation of core damage progression and possible containment failure resulting in an environmental release for each core-damage sequence identified in Level-1; and Level-3 is the evaluation of the consequences that would result from the set of environmental releases identified in Level-2. All three levels of the PRA are required to perform a SAMA analysis. The MACCS2 code is used to perform the consequence analysis in the Level-3 portion of the PRA.[70]

36. Typically, the baseline PRA for a SAMA analysis starts with the existing most current version of the Level-1 and -2 PRA that is available for the plant at the time of the SAMA analysis. Since most plants do not have a Level-3 PRA, the Level-3 portion is normally

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[69] *Id.* at A.10.

[70] *Id.* at A.11.

developed using the MACCS2 code for the purpose of supporting the SAMA analysis. For the SAMA analysis, all potential consequences are converted into dollar amounts. Thus, the existing level-1 and -2 analysis with the new level-3 analysis form the baseline PRA that represents operating the plant in its current state and the corresponding economic risk. The baseline PRA also enables the calculation of the plant's "Maximum Achievable Benefit," which is the dollar amount that corresponds to all risk posed by the plant.[71]

37. The benefit from each SAMA is evaluated by modifying the PRA to account for the effect of the plant improvement being evaluated, and then comparing the risk results of the baseline and modified PRAs. A single plant improvement is evaluated at a time. The effect of the plant improvement might be to decrease the likelihood of an accident or group of accidents calculated in Level-1 of the PRA. Other plant improvements would have no effect on the frequency of accidents, but would diminish the outcome of some of the accidents, leading to smaller consequences. These would affect the magnitude of the source term predicted in Level-2 of the PRA and result in lower consequences in Level-3 of the PRA. Some plant improvements would reduce both accident frequencies and consequences. All consequences are translated to dollar amounts. The economic risk (in dollars) is reevaluated, assuming that one of the SAMAs was implemented. The benefit is the reduction in economic risk (in dollars) after implementing the SAMA compared with the baseline. This process is repeated to evaluate the benefit for each SAMA. The benefit calculated for an individual SAMA will be a fraction of

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[71] *Id.*

the “Maximum Achievable Benefit,” since an individual SAMA cannot eliminate all possible accident initiators nor mitigate all kinds of possible accidents.[72]

38. The cost effectiveness of the SAMA is evaluated by comparing the benefit with the cost to implement the SAMA. *Id.* at A.13; O’Kula/Hanna Testimony Exh. ENT000001 at A.18. The decrease in economic risk from implementing a SAMA, calculated by comparing the result of the baseline and modified PRAs, is evaluated in units of dollars per year of reactor operation. In Pilgrim’s case, the time period for the benefit is 20 years. The benefit over the 20-year period is evaluated by using a standard formula and discount rate to evaluate the present value of the benefit (according to guidance in NUREG/BR-0058 and NUREG/BR-0184). Elements of the benefit calculation include: averted public exposure costs, averted offsite property damage costs, averted occupational exposure costs, and averted onsite costs which include both averted cleanup and decontamination costs and averted replacement power costs. The present value of the benefit is compared with the cost of implementing the mitigation measure. The SAMA is considered cost effective if the benefit is greater than the cost; it is not cost effective if the benefit is less than the cost.[73]

39. Pilgrim Watch does not dispute that Entergy followed the foregoing steps in performing the SAMA analysis for Pilgrim. The dispute being raised in this case relates to the

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[72] *Id.* at A.12.

[73] *Id.* at A.13.

meteorological inputs to the SAMA analysis used in the MACCS2 code.[74] Thus, we find that this portion of the SAMA analysis was performed in accordance with accepted standards.

2. Source Term

40. The Board posed several questions to the parties relating to source terms.[75] In response to the Board's questions, the parties submitted additional information on source terms and their impact on the SAMA analysis. Based on that additional information, we find that the source term information was not material to the determination, in this proceeding, of whether alternative atmospheric transport models and meteorological issues would identify an additional cost-beneficial SAMA. Even assuming that source terms were material to the issue before us, we would have found that the source term was calculated and utilized in conformance with accepted procedures and standards.

41. "Source terms" are used in both SAMA analysis and in the MACCS2 Code. In a SAMA analysis, a source term describes the physical, chemical, and radiological composition of an atmospheric release. The information in the source term description includes the quantity of each important radionuclide released into the atmosphere, the initial time of the release relative to the start of the accident, the duration of the release, the elevation of the release, the buoyancy of the plume released, and the particle size of the released material.[76]

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[74] *See* September 23, 2010 Order at 2–3 ; Pilgrim Petition for Intervention at 34.

[75] September 23, 2010 Order at Appendix A, page 2.

[76] Bixler/ Ghosh Testimony, Exh. NRC00014 at A.

42. Pilgrim Watch has asserted that the source term used in the Pilgrim SAMA is non-conservative. Thus, the SAMA analysis is deficient.[77]

43. In its Initial Statement, Pilgrim Watch cited NUREG-1150 and NUREG-1465, submission, in its discussion of how the source term to be used for each computation of radioactivity dispersion and deposition is determined.[78] As explained by Dr. Ghosh and Entergy's experts, NUREG-1150 and NUREG-1465 are not applicable to SAMA analysis at Pilgrim.

44. NUREG-1150 is titled "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants" and addresses risks assessed from severe accidents in five nuclear power plants in terms of CDF, LERF, performance of containment structures, potential radionuclide releases and offsite consequences, and the overall risk. NUREG-1465 is titled "Accident Source Terms For Light-Water Nuclear Power Plants" and addresses source terms released into containment instead of released into the environment.[79]

45. Dr. Ghosh testified that it would not be appropriate to use NUREG-1465 source terms for Entergy's SAMA analysis. As is explained in Chapter 5 of NUREG-1465, there are numerous mechanisms that remove fission products from the containment atmosphere which result in a smaller source term being released from containment. Examples of removal mechanisms not modeled in the NUREG-1465 analysis include engineered safety features

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[77] Pilgrim Watch Initial Statement at 43-44; Appendix 4, page 2.

[78] *Id.* at 43-44.

[79] Ghosh Rebuttal Testimony, Exh. NRC000016 at A.1-2.

such as containment atmosphere sprays and suppression pools in boiling water reactors (such as Pilgrim) that trap and contain fission products in water, and natural processes such as aerosol deposition (where fission products become stuck on structural surfaces inside containment, for example). As explained in Chapter 5, NUREG-1465 does not provide numerical estimates of the containment source terms *after* the effect of these fission product removal mechanisms, but rather points readers to additional reference documents and approaches that could improve the calculation. Hence using the source terms provided in NUREG-1465 for a SAMA analysis would result in a gross over-estimate and is unreasonable where a plant-specific source term analysis is available. And, therefore, we find that source terms described in NUREG-1465 are inappropriate for comparison to site-specific source terms used in a SAMA analysis.

46. The Staff further testified that it would not be appropriate to use NUREG-1150 source terms for Entergy's SAMA analysis.[80] The NUREG-1150 study, completed 21 years ago, summarized an assessment of the risks from severe accidents at five commercial nuclear power plants in the United States. Pilgrim was not one of these five plants. Severe accident source terms depend on many plant design features and operational practices, and hence are plant-specific. In addition, the state of the art for source term analysis has evolved and improved in the intervening 21 years since NUREG-1150 was published. Thus, in the absence of all other information, NUREG-1150 might form a basis to begin an analysis of source terms for Pilgrim. In this case, Pilgrim used site-specific information and more recent versions of the codes

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[80] *Id.* at A. 2.

evaluated in NUREG-1150. Therefore, the source terms identified in NUREG-1150 would also be unreasonable in light of the site-specific calculations used in the submitted analysis.[81]

47. The source term is defined in the Level-2 portion and used in the Level-3 portion of the PRA analysis. It is used in the MACCS2 code to determine the off-site economic and human health consequences for that particular source term group. Risk analysis is the primary element of the level-3 PRA analysis. The risk analysis, which is performed by MACCS2, uses the source terms and frequencies generated by the Level-1 and -2 portions of the PRA analysis. MACCS2 utilizes the source terms to define the initial state of the plume released into the environment.[82]

48. The primary result of the Level-1 and -2 portions of the PRA is the estimation of a set of source terms, each corresponding to a specific accident sequence. The number of source terms is usually too large to perform an individual consequence analyses for each one. To reduce the computational effort for the consequence analysis, the source terms are sorted into a set of bins, often referred to as source term groups ("STGs"). These bins or STGs are generally based on the composition and timing of the release. Earlier releases normally result in greater consequences because there may not be adequate time to evacuate the public within the Emergency Planning Zone ("EPZ"), the area within about 10 miles of the plant, before the release begins. Larger releases lead to larger doses to members of the public and greater environmental contamination to deal with in the aftermath of the accident. Thus, the set of

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[81] *Id.* at A.2-3.

[82] Bixler/Ghosh Testimony, Exh. NRC000014 at A.19.

source terms in each bin or STG is expected to result in relatively similar consequences. In a SAMA analysis, a single source term is usually chosen to represent each STG. These representative source terms may be a best estimate or a bounding source term. In the Pilgrim SAMA analysis, a best estimate source term was chosen to represent each STG. STGs are referred to as Collapsed Accident Progression Bins ("CAPBs") in the Pilgrim Environment Report.[83] The frequency associated with each source term is the sum of the frequencies of all sequences that fall into each respective STG.[84]

49. Evaluation of source terms for a SAMA analysis requires a relatively detailed model that includes a multitude of physical process models accounting for timing of safety actions taken automatically by the installed systems and any human actions affecting accident progression and containment. Any radionuclide releases outside of containment are sequentially modeled from their release from the reactor core through any release or breach in containment. Source term calculations are usually based on the Methods for Estimation of Leakages and Consequences of Releases ("MELCOR") or Modular Accident Analysis Program ("MAAP") computer code. The Pilgrim SAMA analysis used the MAAP code as the basis for its source term analysis. Source terms generally depend on how rapidly an accident progresses, the path by which the radionuclides escape from the reactor into containment, the path through containment (or possibly bypassing containment altogether), and the effectiveness of both

[83] Pilgrim Nuclear Power Station Applicant's Environmental Report Operating License Renewal Stage, Attachment E, "Severe Accident Mitigation Alternatives Analysis," (2006) NRC Staff Exh. NRC000001, at E.1-44.

[84] Bixler/Ghosh Testimony, Exh. NRC000014 at A.14.

passive and active safety features, especially pools and sprays, that are intended to mitigate releases by, e.g., removing the radionuclides and/or reducing the internal pressure of the containment structure during the accident progression.[85]

50. A large number of source terms were calculated in the Pilgrim SAMA analysis, each corresponding to a specific accident sequence. Each source term was characterized as a set of release fractions corresponding to groups of radionuclides with potential for detrimental health effects. The Pilgrim SAMA used 19 STGs to characterize consequences based on the timing of release and the magnitude of release. A representative set of release fractions was assigned to each STG by calculating a frequency-weighted mean of the radionuclide release fraction for each accident within the STG. These representative STGs were used to perform the consequence analysis.[86]

51. A consequence analysis is performed for each STG identified in the Level-2 portion of the PRA. The consequences are evaluated assuming that the accident occurs. The likelihood of the accident occurring during one year of plant operation is the frequency associated with the STG. The risk is the expected value of the consequences. The risk per year of reactor operation for a STG is determined by multiplying the likelihood of that STG occurring during a year of reactor operation by the mean consequences of that STG. The total risk of operating the plant per year of operation is the sum of the risks for the entire set of STGs. The

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[85] *Id.* at A.22.

[86] *Id.*

time value of money is included in a SAMA analysis by using a standard formula to estimate the present value of the benefit of avoided accidents during future years.[87]

52. Five types of consequences are considered in a SAMA analysis. The first three of these are onsite costs and include (1) the monetary value of occupational doses to decontamination workers; (2) onsite decontamination costs; and (3) the cost to replace lost power. Estimation of these costs is independent of atmospheric transport and deposition modeling. The remaining two categories are offsite costs: (4) offsite economic costs associated with evacuation and relocation of the population, decontamination of property, loss of use of property, and condemnation of property and (5) a monetary value associated with doses to members of the public. These five types of costs are added together to get the total cost that would result if an accident occurred. For each type of cost, there is a standard method to evaluate that cost. MACCS2 is the standard tool used to evaluate off-site costs (4 and 5), as described in NUREG/BR-0158. Offsite economic cost (4) is a direct output from the MACCS2 code. The cost associated with doses to the public (5) is calculated by multiplying the mean population dose reported in the MACCS2 output by $2000/person-rem.[88]

53. Staff witness, Mr. Ramsdell, testified that the source terms used in SAMAs are derived from the isotopic inventory of the reactor core at the time of the postulated accident considering the path from the reactor core to the environment.[89] The release path may include

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[87] *Id.* at A.15.

[88] *Id.* at A.16.

[89] Ramsdell Testimony Exh. NRC000015 at A.20.

delays, filters and sprays. It may involve release through the containment or it may involve a bypass of the containment. Potential release paths are determined using probabilistic risk assessment considering severe accident initiating events and potential failures of equipment and humans. Accidents with similar release paths are grouped into release categories and assigned a source term. The Pilgrim severe accident consequence assessment includes evaluation of consequences for 19 release categories.[90] The overall consequence assessment is a probability weighted mean assessment with probabilities assigned on the basis of the Pilgrim Level 1 and Level 2 PRAs.[91]

54. Mr. Ramsdell concluded that the source terms used in MACCS2 for the Pilgrim SAMA evaluation were conservative. Safety analyses conducted following NRC regulatory guidance and standard review plan pursuant to NRC's responsibilities under the AEA have an intentional conservative bias. Typically they involve assumptions that overestimate adverse consequences. For example, atmospheric transport calculations used in evaluating accident consequences use dispersion parameters that are exceeded no more than 5% of the time.[92] In contrast, NRC guidance indicates that reasonable estimates of consequences should be used in environmental impact statements prepared under NEPA.[93]

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[90] *Id.*

[91] *Id.* at A.17.

[92] *See, e.g.*, Regulatory Guide 1.145, Rev. 1, "Atmospheric Dispersion Models For Potential Accident Consequence Assessments At Nuclear Power Plants," 1.145-5 (1983).

[93] Ramsdell Testimony Exh. NRC000015 at A.22.

55. Mr. Ramsdell testified that the use of conservative source terms in SAMAs and especially in the transport and deposition of contamination leads to conservative consequences. This is because the population dose and economic consequences calculated by MACCS2 are linearly related to the source term (isotopic release quantity). Doses and economic consequences are calculated from the concentration of radionuclides in the air and deposited on the surface. Therefore, conservative source terms translate directly to conservative consequences.[94]

56. The benefit associated with a SAMA is calculated by accounting for reductions in accident frequencies and reductions in accident consequences. The reduction in the economic cost risk assuming the SAMA was implemented compared with the baseline risk is the benefit of the SAMA.[95]

3. MACCS2 Code Analysis

57. Pilgrim Watch alleged in its Initial Statement of Position that the MACCS2 code is deficient because it does not model the sea breeze effect, hot spots, storms, geographical variations, terrain effects or distance.[96] In support of these statements, Pilgrim Watch submitted a document authored by Dr. Edwin Lyman regarding the SAMA analysis at the Indian Point Nuclear Power Plant.[97] This document was not sworn to, nor was there an attempt by Dr.

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[94] Bixler/Ghosh Testimony, NRC Exh. NRC000014 at A.19 – A.22.

[95] *Id.* at A.16.

[96] *See generally* Pilgrim Watch Initial Statement of Position.

[97] Pilgrim Watch Exh. PWA00012.

Lyman to apply his statements and conclusions to the Pilgrim SAMA analysis. In addition, Dr. Lyman's qualifications to present evidence on this matter were not offered into evidence. For those reasons, we will not afford Dr. Lyman's report equal weight with the sworn testimony of the qualified witnesses for the Staff and Entergy. Pilgrim Watch also offered a report by Dr. Jan Beyea.[98] While most of the report deals with issues that are beyond the scope of this matter, that portion of the report, approximately one page, that deals with meteorological issues contains only a few statements regarding what Dr. Beyea thinks should be considered in a SAMA, but with no technical justification nor sufficient basis to support his preferred code, CALPUFF.[99] Furthermore, Dr. Beyea concedes that "incorporating such meteorological understanding into a PSA or equivalent at Pilgrim would not be likely to make more than a factor of two difference in risk."[100]

58. This conclusion is in accord with the Staff's testimony. Mr. Ramsdell testified that the use of CALPUFF or AERMOD would not identify any mitigating measures as being cost beneficial solely because of the selection of an alternative atmospheric transport model.[101] Even if those codes had the full set of capabilities required for a SAMA analysis, the expected results would be very similar to those produced by MACCS2 and as demonstrated in NUREG-6853, "Comparison of Average Transport and Dispersion Among a Gaussian, a Two-

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[98] Pilgrim Watch Exh. PWA00002.

[99] *Id.*

[100] *Id.*

[101] Ramsdell Testimony Exh. NRC000015 at A.28.

Dimensional, and a Three-Dimensional Model," Ex. JNT000001. "Because the cost of the next most cost-beneficial SAMA is more than a factor of two greater than its benefit, there is a high degree of certainty that an alternative atmospheric transport model would not alter the transport and deposition of the radionuclides enough to make another SAMA potentially cost-beneficial."[102] Dr. Bixler agreed, based on his research with MACCS2 and other codes, and his experience modeling and reviewing codes.[103]

59. The NRC sponsored the development of MACCS and its successor code, MACCS2. MACCS2 was developed to evaluate the potential impacts of severe accidents at nuclear power plants on the public. The code has periodically been updated and subjected to peer review.[104]

60. MACCS2 consists of three modules that analyze given inputs to evaluate the consequences resulting from different potential accident scenarios. The three modules are known as ATMOS, EARLY, and CHRONC. Each module uses input data provided in multiple input text files in order to complete the calculations. The modules operate sequentially: (1) ATMOS, (2) EARLY, and (3) CHRONC.[105]

61. The ATMOS module uses an atmospheric transport model that uses the source terms and other input data, including a full year of hourly meteorological measurements (wind

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[102] *Id.* at A.48.

[103] Bixler/ Ghosh Testimony, Exh. NRC00014 at A.42.

[104] O'Kula/Hanna Testimony Exh. ENT000001 at A.20.

[105] Bixler/ Ghosh Testimony, Exh. NRC00014 at A.19. *See also* O'Kula/Hanna Testimony Exh. ENT000001 at A.22.

direction, wind velocity, precipitation rate, and stability class), surface roughness, and a spatial grid of the 50-mile region surrounding the plant.[106] The ATMOS module utilizes the input data to calculate consequences of the accident under statistically significant sample of the annual weather data. In Pilgrim's SAMA analysis, 146 weather trials were selected; that is 146 discrete times were selected as the accident initiation time. The wind in each of these 146 weather trials was forced to blow in all 16 compass directions based on the annual likelihood that wind would blow in each direction according to binned weather data with similar conditions.[107] For each accident scenario, 2336 meteorological conditions were modeled.[108] The ATMOS module determines the transport and deposition of contamination within the 50-mile area surrounding Pilgrim.[109] It calculates the location of the plume,concentration of each released isotope for each spatial grid cell, and further determines how much contamination falls out of the plume to be finally deposited into each spatial grid cell. Finally, these calculations are repeated for each accident scenario.[110] Pilgrim's SAMA analysis used 19 different representative accident scenarios (different source terms with distinct release characteristics) to represent the variety of

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[106] Bixler/ Ghosh Testimony, Exh. NRC00014 at A.19.

[107] Annual weather data is binned into separate files based on similar meteorological conditions including precipitation, stability, velocity and other characterizing properties. Bixler/ Ghosh Testimony, Exh. NRC000014 at A.19.

[108] The 2336 meteorological conditions modeled for each accident scenario is the result of modeling 146 weather trials and forcing the conditions through the 16 compass directions or 146*16. *Id*.

[109] Bixler/ Ghosh Testimony, Exh. NRC00014 at A.19.

[110] *Id.* at A.19.

accidents that could occur.[111] This information for each model run is passed from the ATMOS module to the EARLY and CHRONC modules for determination of the dose to the population and costs, like clean-up of the contamination, evacuation, and relocation, for each meteorological condition (i.e., 2336 meteorological conditions passed to EARLY and CHRONC for each accident scenario).[112]

62. EARLY and CHRONC use the information calculated by ATMOS along with additional input data to determine the doses and other consequences for separate portions of the response. EARLY models the doses and costs of the accident related to the initial response through the first seven (7) days. During this period of time, the plume passes through the grid and emergency response is implemented. CHRONC models the doses and costs of the accident related to its long-term responses and clean-up from seven days through 30 years.[113]

63. The EARLY module uses transport and deposition results from the ATMOS module and input data regarding human population in the area to model estimated doses during the plume passage and from deposition for the first seven (7) days of an accident. EARLY also uses input data describing dose conversion factors, land use, economic inputs (costs for

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[111] Modeling the 19 different accident scenarios results in 44,384 (19*2336) models for the transportation and deposition of contamination on the surrounding 50-mile area. Bixler/ Ghosh Testimony, Exh. NRC000014 at A.19.

[112] O'Kula/Hanna Testimony Exh. ENT000001 at A.36.

[113] Bixler/ Ghosh Testimony, Exh. NRC000014 at A.20.

emergency response, including evacuation), a spatial grid refinement factor, relocation information, re-suspension factors, cohort definitions, evacuation data, and shielding data.[114]

64. Using these input data, EARLY calculates the consequences of the accident for the first seven days. After seven days, the consequences are determined by the CHRONC module.[115]

65. The CHRONC module uses the transport and deposition calculations from the ATMOS module, some of the input data for the EARLY module, and additional input data regarding per diem costs for the displaced population, decontamination costs, long-term protective action values (habitability criteria), interdiction, weathering factors, a regional land value, and food-chain dose conversion factors.[116]

66. Based on these inputs, CHRONC calculates the costs or economic consequences of the accident. As part of the CHRONC module, the decision to decontaminate or condemn is made based on whether the habitability criterion could be met following decontamination. The effect of decontamination or condemnation is accounted for in the long-term consequences of the doses received by decontamination workers, doses received by members of the public, and in the economic costs for the accident.[117]

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[114] *Id*.

[115] *Id.*

[116] *Id*.

[117] *Id.*

67. Once CHRONC completes its calculations for one accident scenario, the MACCS2 code assembles an output file with a statistical description of the consequences, including the mean population dose and the mean offsite economic costs.[118]

68. Separately from the MACCS2 code, a spreadsheet or other similar application calculates the "mean consequence value"[119] by summing the on-site economic costs and the MACCS2 code outputs, including the mean of the offsite economic costs and value of the mean population dose.[120] Once the costs for each accident scenario and weather condition are calculated by MACCS2, the "mean consequence value" for each accident scenario is determined by calculating the statistical mean of the range of consequences calculated (summation of the consequences associated with the 2336 meteorological conditions weighted by the probability of each). Further, the likelihood of the accident occurring is accounted for by multiplying the probability that the accident would occur with the costs of the particular accident if it did occur. The net present value of the consequence is determined by using discount rates of, alternatively, 3% and 7%, to account for potential variations in the discount rate. Each of the other accident scenarios' "mean consequence value" is determined similarly. *Id.* In Pilgrim's case, 19 different accident scenarios and their representative source terms were used.[121]

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[118] *Id.*

[119] This Board denied Pilgrim Watch's motion to challenge the use of mean consequence values. *See* Order (Ruling on Timeliness of Mean Consequence Issue) (Nov. 23, 2010) at 2; Licensing Board Memorandum and Order (Ruling on Timeliness of Mean Consequence Value Issue) (Mar. 3, 2011) at 25.

[120] Bixler/ Ghosh Testimony, Exh. NRC000014 at A.21.

[121] *Id.* at A.21.

69. Dr. Bixler concluded that the projected transport and deposition of the radionuclides for the Pilgrim's SAMAs include a conservative bias.[122] That is because the Gaussian plume model utilized in the ATMOS module of the MACCS2 code is actually more conservative in estimating doses at larger distances from the point of release than the models suggested by PW.[123] The Gaussian model ensures that any radioactive contamination travels the shortest distance to each affected area and arrives at each affected area with a more concentrated plume. As a result, the model predicts larger doses and economic impacts, because the contamination has not had additional time to decay or to be diluted by dispersion.[124] In addition, the MACCS2 code has been compared to a LaGrangian particle tracking code, for estimating concentrations and deposition out to distances as great as 100 miles from the point of release, and produced results that agreed to within about a factor of two of those of the LaGrangian code within 50 miles.[125] [126]

70. Using conservative transport and deposition of radionuclides has an effect on the overall SAMAs.[127] Benefits predicted in a SAMA analysis increase with the concentration of radionuclides in the plume during transport and contamination of any area after deposition.

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[122] *Id.* at A.23.

[123] *Id.*

[124] *Id.* at A.24.

[125] NUREG-6853, "Comparison of Average Transport and Dispersion Among a Gaussian, a Two-Dimensional, and a Three-Dimensional Model," Ex. JNT000001 at 65-68.

[126] Bixler/ Ghosh Testimony, Exh. NRC000014 at A.24.

[127] *Id.* at A.25.

Thus, conservative transport and deposition directly influence the SAMA results. It is expected that the conservative transport and deposition in the ATMOS module will produce conservative results for the estimated benefits. This might cause some of the SAMAs to be determined cost beneficial when they are actually not cost beneficial.[128]

71. Statements by Mr. Egan seem to support Pilgrim's modeling. He argues that "[m]odeling simulations of radioactive decay and deposition processes act to deplete material from a plume as it travels downwind … if deposition rates are large in the areas near the source, depletion rates further away will be smaller and vice versa. ATMOS uses rates that do not vary with location. Similarly, the travel time of a plume will determine the fraction of radioactive decay that will occur in the near vs. far field of a release."[129] But, as Dr. Bixler testified, the ATMOS module uses a straight-line Gaussian plume model, which effectively minimizes the transport time, path, and maximizes the contamination reaching and being deposited in each spatial grid at longer distances. Thus, the ATMOS module actually addresses Dr. Egan's concerns as acknowledged in his declaration.[130]

72. Transport of contamination would be conservative because the Gaussian model conservatively estimates the shortest plume path. The shorter path of travel ensures that the maximum amount of contaminant reaches the downwind areas, which then receive more

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[128] *Id.* at A.25.

[129] Exh. PWA00023 at 6.

[130] Dr. Egan essentially acknowledges in his earlier declaration that the ATMOS module and Gaussian plume models could be conservative even if they were not precisely modeling variable plume paths. Exh. PWA00001 at 6, ¶ 13, Item 17,18, and 19.

accumulated radiological dose and greater economic consequences. Allowing the plume to travel along more circuitous paths increases the path length and the travel time to downwind areas, during which time the plume experiences increased dispersion, deposition, and decay, which all tend to minimize the impact on downwind areas located farther from the site. Thus, the Gaussian plume model tends to maximize the estimated consequences of any particular accident.[131]

73. It is important to accurately account for the half-life of each isotope. Depending on how the model accounts for the half-lives, an overestimate or underestimate of the exposure and necessary clean-up would result. For example, ignoring the radioactive decay of the isotopes would overestimate the dose and clean-up because dose rates from the contamination would remain constant indefinitely resulting in increased dose in excess of the dose that would actually occur. Alternatively, using a single half-life to model all the isotopes would most likely reduce the radionuclides too quickly resulting in doses below what would be expected to occur in an actual accident.[132]

74. Properly accounting for radioactive decay is important for the isotopes with short half-lives, i.e., half-lives that are less than or comparable to the length of the emergency phase, which is typically 1 week. Because they disappear relatively quickly, not accounting for the decay of those isotopes would lead to an overestimate of the consequences they would produce. However, not accounting for the radioactive daughters of these isotopes could lead to

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[131] *Id.* at A.26.

[132] *Id.* at A.27.

an under estimate of consequences. Neglecting radioactive decay would be reasonable only for long-lived isotopes.[133]

75. The majority of the isotopes that would be released during a nuclear reactor accident have half-lives that are less than one week. Thus, a simplified treatment of these half-lives would produce inaccurate results.[134]

76. Alternatively neglecting or simplistically treating radioactive decay could lead to an over- or under-estimate of consequences, depending on the radionuclides released and the simplifications used in the model. Any results based on ignoring radioactive decay or overly simplifying the decay process would be inaccurate unreliable, and unreasonable.[135]

77. A SAMA analysis would not be sufficiently reliable to make accurate predictions if the radioactive decay was not modeled.[136] Nor would a SAMA analysis be sufficiently reliable to make accurate predictions if all the isotopes were assumed to have a single half-life. The half-lives of the isotopes that are treated in a SAMA analysis range from about an hour to thousands of years. There is no way to accurately represent all of the half-lives by a single value.[137]

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[133] *Id.* at A.27.

[134] *Id.*

[135] *Id.*

[136] *Id.* at A. 28.

[137] *Id.* at A.29.

78. It would not be reasonable to use an atmospheric transport model that could not account for the radioactive decay of the released isotopes in a SAMA analysis.[138] It would not be reasonable because most of the isotopes treated in a SAMA analysis have a relatively short half-life. These produce a dose over a few hours or a few days. They either decay to a stable isotope that has no further consequence, or they decay to another radioisotope that also must be modeled. Properly treating the initial decay and any daughter ingrowth for the isotopes that would be released during a reactor accident is an essential part of the consequence analysis.[139]

79. Pilgrim Watch's expert, Dr. Bruce Egan, stated that other atmospheric dispersion models, such as AERMOD and CALPUFF would be more appropriate to use for the Pilgrim SAMA analysis.[140] We disagree for the reasons discussed above and in further detail below.

80. The Staff witnesses testified that AERMOD would not be more appropriate for use in SAMA analysis than the MACCS2 code because it fails to accurately model radioactive decay and daughter ingrowth, dose pathways, dose mitigation (evacuation, relocation, and decontamination), and economic consequences and relies on overly simplistic assumptions on key issues for estimating consequences.[141]

81. AERMOD was designed for short range (up to 50 km [31 mi.]) dispersion from stationary sources, and includes modeling the effect of surface terrain on the behavior of air

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[138] *Id.* at A.30.

[139] *Id.* at A.31.

[140] Exh. PWA00001 at ¶ 7.

[141] *See e.g.* Ramsdell Testimony Exh. NRC000015 at A. 27.

pollution plumes and of building downwash effects. Similar to the ATMOS module in the MACCS2 code, AERMOD models plume behavior using a Gaussian plume representation. However, AERMOD is limited to modeling a single half-life per-run and, thus, is unable to specifically model the multiple different half-lives applicable to the radionuclides likely to be released during a severe accident. Further, AERMOD does not model daughter ingrowth, dose pathways, dose mitigation (evacuation, relocation, or decontamination), and does not include an economic model. Introducing all of these missing models and adding the capability to handle the multiple half-lives and decay chains required for a SAMA analysis into AERMOD would be a very large task.[142] Even if you compared AERMOD to only the ATMOS portion of the MACCS2 code, it would fail to account for radioactive decay properly. It is limited to only being able to model a single half-life and would result in unrealistic results for the consequences of an accident.[143]

82. Entergy's witnesses added that both AERMOD and CALPUFF were developed for different purposes (i.e. for emergency planning) and perform worst case analyses, which are not required for SAMA analysis.[144]

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[142] Some might suggest that AERMOD's limit to a single half-life could be avoided by iteratively running the model for each isotope. However, this would likely result in increasing the number of model runs by at least an order of magnitude. For most source terms, the initial isotopes modeled range from 20 to potentially 60. This ignores modeling the daughters generated by the radioactive decay throughout the transport and deposition process.

[143] Bixler/ Ghosh Testimony, Exh. NRC000014 at A 33 – A.34.

[144] O'Kula/Hanna Testimony, Entergy Exh. ENT000001 at A.52 – A.53.

83. CALPUFF would not be more appropriate for use in the SAMA analysis because it is used by the EPA for applications involving long-range transport, which is typically defined as transport over distances beyond 50 km. CALPUFF uses a Gaussian puff model, where each puff follows the local wind direction. As of December 13, 2010, the most recently EPA-approved version of the CALPUFF System is Version 5.8 – Level 070623 of CALPUFF and includes changes through MCB-D. This version does not model radioactive decay for multiple isotopes, daughter ingrowth, dose pathways, dose mitigation (e.g., evacuation), or economic costs. As such, use of CALPUFF for SAMA analysis is inappropriate because it fails to model key aspects of potential radioactive release from a severe accident that are needed for a SAMA analysis. Finally, adding the additional missing models to CALPUFF that are required for a SAMA analysis would be a very large task. Even when CALPUFF is compared to just the ATMOS module, it lacks the ability to model the radioactive decay properly.[145]

84. The Gaussian plume model used in the MACCS2 has been compared to models like CALPUFF and AERMOD. It was compared with two Gaussian puff model codes from Pacific Northwest National Labs, RASCAL and RATCHET, and a state-of-the-art Lagrangian particle tracking code from the National Atmospheric Release Advisory Center (NARAC) at Lawrence Livermore National Laboratory called ADAPT/LODI.[146] The study was documented in NUREG-6853, “Comparison of Average Transport and Dispersion Among a Gaussian, a Two-Dimensional, and a Three-Dimensional Model,” Ex. JNT000001, which concluded that the mean

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[145] Bixler/Ghosh Testimony, Exh. NRC000014 at A35 – A.36.

[146] *Id.*

results computed by MACCS2 are within a factor of two (2) of those predicted by Gaussian puff models (similar to CALPUFF) and also to the results predicted by the Lagrangian particle tracking code, LODI.[147] In fact, the largest observed deviation between mean results produced by MACCS2 and LODI was 58%. For comparison, the largest observed deviation between one of the Gaussian puff model codes, RASCAL, and LODI was 61%. Generally, MACCS2 performed as well as or better than either of the Gaussian puff models when compared with the state-of-the-art code, ADAPT/LODI, for calculating mean consequence results. This conclusion undermines the assertion by Pilgrim Watch that CALPUFF is more suitable for a SAMA analysis than MACCS2. Furthermore, CALPUFF does not have all of the capabilities needed for a SAMA analysis.[148]

85. The Lawrence Livermore study is still valid in the context of a PRA-type analysis where the primary results are mean consequences or expected values. For PRA applications, special meteorological events, e.g., low-lying nocturnal jets and sea breezes, that only occur a few percent of the time do not have much effect on the overall, mean results. The Livermore study focused on mean results and showed that MACCS2, a Gaussian plume model, performed about as well as two Gaussian puff codes similar to CALPUFF.[149]

86. Gaussian puff models, like CALPUFF, are generally used to recreate or simulate specific meteorological instances. For example, RASCAL, which is NRC's code for emergency

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[147] *See Id.*; O'Kula/Hanna Testimony, Entergy Exh. ENT000001 at A.58.

[148] Bixler/ Ghosh Testimony, Exh. NRC000014 at A.37 – A.38.

[149] *Id.* at A.40.

response and employs a Gaussian puff model, would be used in the event of an actual radioactive release from a nuclear power plant. The emphasis for emergency response is on having an accurate picture of the plume trajectory so that officials can make informed decisions regarding sheltering and evacuation. This level of fidelity is not needed for PRA applications, which are concerned only with mean values over the entire modeled domain. The Livermore study shows that a Gaussian puff model does not produce better answers than a Gaussian plume model, like MACCS2, when consequences representing a mean over representative weather are the desired outcomes of the analysis.[150]

87. Based on the foregoing evidence, we find that the MACCS2 Code is more relevant and robust than the other types of atmospheric transport models, put forth by Pilgrim Watch, such as CALPUFF and AERMOD, for a SAMA analysis. The MACCS2 code was appropriate for use in preparing SAMA analysis at Pilgrim for NEPA use.

4. Sea Breeze Effect

88 Pilgrim Watch asserts that the "sea breeze" effect, if modeled, would significantly alter the SAMA analysis, such that more SAMAs would become cost effective.[151] To support that theory, Pilgrim Watch produced the statement of Dr. Richard Egan, who averred that "the sea breeze would draw contaminants across the land and inland subjecting the population to

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[150] *Id.*

[151] Exh. PWA00001 at ¶ 10.

potentially larger doses." Dr. Egan asserted that "the sea breeze flow is the common meteorological condition that must be closely monitored at [Pilgrim]."[152]

89. However, Staff witness, Mr. Ramsdell, explained that the sea breeze effect at Pilgrim has very little impact on the SAMA analysis. He testified that he would expect that the MACCS2 code and the ATMOS module would compare favorably to higher fidelity codes if used for a SAMA analysis at Pilgrim.[153] Entergy's witnesses testified that the Pilgrim SAMA adequately accounts for sea breezes. The on-site wind towers are close to the coastline and coastal breezes would be recorded and thus be included in the MACCS2 analysis.[154]

90. Pilgrim Watch contended that the straight-line atmospheric model in MACCS2 would result in a significant underestimate of offsite consequences of a severe accident because the code does not adequately model sea breeze circulations.[155] Mr. Ramsdell disagreed. He described the sea breeze phenomenon, explaining that the sea breeze circulation is a local wind pattern that can develop along a coast when there is there is no strong synoptic regime. A strong synoptic regime normally occurs when there are well-defined pressure systems in the area and these large-scale pressure patterns are responsible for the air flow. In the absence of a strong synoptic regime, a sea breeze pattern may result from differential heating of land and water surfaces. It is a diurnal pattern (i.e. daily pattern) that typically has

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[152] *Id.* at ¶13, Item 20.

[153] Ramsdell Testimony, Exh. NRC000015 at A. 14

[154] O'Kula/Hanna Testimony, Exh. ENT000001 at A.73. *See also* Ramsdell Testimony, Exh. NRC000015 at A.10.

[155] Pilgrim Watch Initial Statement at 4-6.

offshore flow in the early morning hours. As the land surface warms in response to heating, the flow rotates, becoming onshore by late morning or early afternoon. In the evening, the flow rotates becoming offshore once again. In the northern hemisphere, the flow generally rotates in a clockwise direction.[156] Entergy witness Hanna agreed with Mr. Ramsdell's analysis of sea breezes.[157]

91. Sea breeze events occur approximately 31 days per year, or 8.5% of the days. This conclusion was reached in a recent Master's degree thesis, authored by Jennifer E. Thorp, analyzing sea breeze events at General Edward Lawrence Logan International Airport ("Logan") in Boston, Massachusetts, over a recent ten (10) year period using criteria developed by Miller and Keim.[158] Thorp determined from the Logan data that meteorological conditions conducive to sea breeze events occurred at an average of about 88 days per year (24%), but actual sea breeze events only occurred at an average of about 31 days per year (8.5%).[159] However, Entergy's witnesses, using data from Pilgrim Watch's Exh. PWA000010 estimated that sea breezes occur about 45 days per year during the summer months.[160] The average time of onset

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[156] Ramsdell Testimony, Exh. NRC000015 at A.7.

[157] O'Kula/Hanna Testimony, Exh. ENT000001 at A.74.

[158] Jennifer E. Thorp, "The Eastern Massachusetts Sea Breeze Study," Ex. NRC000010 (May 2009) (unpublished) ; Miller, S.T.K., and B.D. Keim, Synoptic-Scale Controls on the Sea Breeze of the Central New England Coast 18 *Weather Forecasting*, 236–248 (2003).

[159] Ramsdell Testimony, Exh. NRC000015 at A.8.

[160] O'Kula/Hanna Testimony, Exh. ENT000001 at A.75; Ramsdell Testimony, Exh. NRC000015 at A.8.

of the sea breeze was about 10:00 am and the average duration was about 8 hours.[161] About 25% of the sea breeze events were marginal events that lasted less than 2 hours, were interrupted by periods of calm, or light and variable winds, or had no clear start or stop.[162] Typical inland penetration of the sea breeze varied from about 10 to 25 miles depending on the underlying synoptic situation.[163] Sea breeze flow patterns presented by Thorp suggest that the sea breeze circulation in the vicinity of Pilgrim is weaker than in the vicinity of Logan and has more limited inland penetration.[164]

92. The sea breeze in the vicinity of Pilgrim would be weaker than the sea breeze in the vicinity of Logan because the topographic setting for development of a classic sea breeze pattern is a straight or slightly curved coastline. The Pilgrim site does not fit this description. Cape Cod, Nantucket Sound and Buzzards Bay to the south of Pilgrim would tend to generate local flows under synoptic conditions conducive to sea breeze development that would not be aligned with onshore flow at Pilgrim.[165]

93. Although the MACCS2 code does not explicitly model sea breeze effects, it uses data for all meteorological conditions to determine the transport and dispersion of radionuclides, including the conditions prevalent during a sea breeze event. The meteorological conditions for

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[161] O'Kula/Hanna Testimony, Entergy Exh. ENT000001 at A.75; Ramsdell Testimony, Exh. NRC000015 at A.8.

[162] *Id.* at A.8. *Accord*, O'Kula/Hanna Testimony, Exh. ENT000001 at A. 75.

[163] *Id.* at A. 74-75; Ramsdell Testimony, Exh. NRC000015 at A.8.

[164] Ramsdell Testimony, Exh. NRC000015 at A.8.

[165] *Id.* at A.9.

all hours during the year are used to create a joint frequency distribution of transport direction, transport speed, atmospheric stability, and precipitation rate. Transport speed, atmospheric stability, and precipitation rate enter in to the MACCS2 atmospheric dispersion and deposition calculations directly. Data for all hours of a sea breeze event including both the offshore and onshore periods are treated equally in the joint frequency distribution.[166]

94. Pilgrim Watch emphasizes the absence of data that tracks hourly changes in wind direction to support the proposition that that the ATMOS module in the MACCS2 code is flawed .[167] However, Drs. Hanna and O'Kula convincingly demonstrated using CALMET that changes in wind direction lead to an insignificant change in the frequency that the plume would reach a specific location in the grid. Thus, using a multitower weather data is not a key concern, it is a minor concern. The Lawrence Livermore study showed that the ATMOS module over the 50-mile modeled domain outperformed models utilizing multitower weather data.[168]

95. Mr. Ramsdell testified that this is a reasonable treatment of sea breeze for the use to which the code output is being applied and the atmospheric model in MACCS2. This treatment, however, does not incorporate information about the temporal and spatial variation of the meteorological conditions during a sea breeze event that might be utilized in the model of a specific weather event rather than a more generic model of events under unknown conditions.

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[166] *Id.* at A.10.

[167] Exh. PWA00023 at 2.

[168] Bixler/Ghosh Testimony at Exh. NRC000014 at A.38; Ramsdell Testimony at Exh. NRC000015 at A.30.

In that sense, the MACCS2 treatment of meteorological conditions and the sea breeze effect is a simplified model.[169]

96. The sea breeze effect would not appreciably alter the offsite consequence outputs from MACCS2 and affect cost-benefit determination of the SAMA analysis. The straight-line model in MACCS2 does not account for changes in dispersion conditions (transport direction, speed, etc.) after the beginning of a release. MACCS2 will calculate consequences out to 50 miles in the initial transport direction even though the actual wind direction may change between the time of release and the time the release leaves the model domain. For example, in a typical sea breeze event at Pilgrim, radioactive isotopes released in the morning prior to the onset of the sea breeze will initially be transported into Cape Cod Bay. As the event progresses, the material will move to the south and then to the west or northwest, crossing the shoreline south of Pilgrim. Finally, when the flow reverts to a land breeze, the material will be carried offshore again. The consequences of the release will be south and west of Pilgrim. The plume is unlikely to get to the large population area 30 to 50 miles west of Pilgrim. MACCS2 will model the plume across Cape Cod, calculating consequences for the population on Cape Cod. Based on the meteorological data for Pilgrim and the typical rotation of winds for the location, isotopes in a release, beginning after the onset of the sea breeze, will generally move west or northwest for several hours and then turn to the east in the offshore flow in the evening. Inland penetration of the plume would be limited to the inland extent of the sea breeze—typically less than 30 miles based on the information presented by Thorp. MACCS2 would model the plume

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169 Ramsdell Testimony, Exh. NRC000015 at A.11.

as if it extended east to 50 miles, exposing the large population between 30 and 50 miles. The likelihood of the release beginning in the morning before the onset of the onshore flow is about 0.42 (10 hrs in 24 hrs).[170] Similarly, the likelihood of the release beginning during the onshore flow is about 0.33 (8 hrs in 24 hrs).[171] It can be assumed that MACCS2 underestimates consequences in the first case (release prior to onset of onshore flow), and it is likely that MACCS2 overestimates consequences in the second case (release during onshore flow). Recalling that sea breeze events occur about 8.5% of the days, it can then be estimated that the MACCS2 transport model would underestimate offsite consequences about 3.5% of the time (8.5% X 0.42) during the year because it didn't represent the sea breeze circulation explicitly.[172] It can also be estimated that MACCS2 would overestimate offsite consequences about 2.8% of the time (8.5% x 0.33).[173] The input to the SAMA analysis from the MACCS2 results consists of two numbers, an average population dose (person-rem) and an average offsite economic consequence (dollars), both cumulative values for the entire 50-mile radius model domain. Consequently, errors in offsite consequence assessments as a result from not modeling the sea breeze effect tend to be off-setting. The residual error in the input to the SAMA analysis will be small and is unlikely to affect the cost-benefit analysis especially in light of other conservatisms

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[170] Jennifer E. Thorp, "The Eastern Massachusetts Sea Breeze Study," Ex. NRC000010 (May 2009) (unpublished).

[171] *Id.*

[172] *See* Ramsdell Testimony, Exh. NRC00015 at A.8.

[173] *Id.*

in the SAMA analysis, like conservative source terms and assuming that the mitigation measures reduce the risk of an accident or release to zero.[174]

97. Pilgrim Watch's expert, Dr. Egan, makes several overstatements regarding terrain and the sea breeze effect studied by O'Kula and Hanna where a comparison of model predictions made in the relatively flat area of the Southern Great Plains (SGP) site in Oklahoma and Kansas cannot be used to state how model comparisons would fare at a coastal area like Plymouth, MA.[175] But neither site has complex terrain, so this is not a point of difference.[176] The presence of the ocean is a point of difference, but Staff's expert witness Mr, Ramsdell's testimony on the frequency of sea breezes as well as the CALMET calculation performed by O'Kula and Hanna establish this to have a very minor effect on the predicted consequences.[177]

98. Mr. Ramsdell and Dr. Bixler both concluded that the straight-line model in MACCS2 is appropriate for use at Pilgrim for identification of potentially cost beneficial SAMAs.[178] The SAMA analysis included in the Pilgrim FSEIS is a screening analysis to disclose potentially cost-beneficial alternatives SAMAs to decision makers. The model in MACCS2 is consistent with the models in other NRC codes used in licensing and evaluation of compliance with regulations. It would be inappropriate to use a more complex model requiring

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[174] *Id.* at A.14.

[175] PWA00023 at 7.

[176] O'Kula/Hanna Rebuttal Testimony, Exh. ENT000013 at A.7-8.

[177] Ramsdell Testimony, Exh. NRC000015 at A. 14; O'Kula/Hanna Testimony, Exh. ENT000013 at A. 14.

[178] Ramsdell Testimony, Exh. NRC000015 at A.15; Bixler/Ghosh Testimony at A.41 – A.44.

more data for a screening calculation involving a low probability event than is used for licensing calculation or calculations used to demonstrate compliance with regulations.[179]

99. Mr. Ramsdell further explained that, in order to evaluate why a particular model is appropriate for a selected use, it is important to understand the reason why a model is being employed. Here, the primary purpose of the model is to identify which mitigation measures are potentially cost beneficial for low probability events and screen out those measures that are clearly not cost-beneficial. The errors resulting from the atmospheric model include both overestimates and underestimates of offsite consequences. Because MACCS2 both overestimates and underestimates of the economic consequences during sea breeze events and the frequency of sea breeze events is small, the errors in the mean offsite consequence of severe accidents will be smaller than either the overestimates or underestimates. Given the screening nature of the SAMA analysis and the generally conservative assumptions made in other aspects of MACCS2 assessment of mean offsite consequences, the atmospheric model in MACCS2 is appropriate.[180] We agree.

5. Hot Spots

100. Pilgrim Watch stated that because hot spots were not modeled in the MACCS2 code, the code was deficient.[181] The Staff disagreed.

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[179] Ramsdell Testimony, Exh. NRC000015 at A.13; Bixler/Ghosh Testimony at A.41 – A.44.

[180] Ramsdell Testimony, Exh. NRC000015 at A.16.

[181] Pilgrim Watch Initial Statement at 6.

101. Mr. Ramsdell, explained that the term “hot spot” is not particularly well defined. In the MACCS2 lexicon, the term refers to an area in which the dose rate from surface contamination exceeds a user specified value. He generally defines it as an area in which the surface contamination is greater than the contamination in surrounding areas.[182] But in this case, the term is being used to describe the area where a plume comes onshore after an overwater transport.[183]

102. A “hot spot” could be formed in the vicinity of Pilgrim if a severe accident release were to occur with the right set of meteorological conditions. However, not all meteorological conditions would lead to a “hot spot”.[184]

103. Mr. Ramsdell stated that the most likely meteorological conditions that might lead to a “hot spot” in the vicinity of Pilgrim would be related to precipitation starting after the release was underway. Similarly, most of the large release pathways for severe accidents are ground-level releases, so “hot spot” mechanisms associated with elevated releases would not come into play.[185] He estimated that the conditions that might lead to a precipitation “hot spot” in the vicinity of Pilgrim might exist 10% to 20% of the time. If the “hot spot” definition is expanded to include areas where a plume comes on shore, the frequency would likely be somewhat higher,

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[182] Ramsdell Testimony, Exh. NRC000015 at A.38.

[183] *Id.* at A.39.

[184] *Id.* at A.40.

[185] *Id.* at A.41.

perhaps 20 to 30 percent.[186] This estimation was based on climatological records for the area that indicate that precipitation occurs on about 35% of the days. He started with the 35% and reduced the estimate assuming that precipitation in most cases precipitation is continuous for several hours at a time and that a "hot spot" is likely if a release occurs in the few hours before the onset of precipitation. He also looked at the meteorological data summary for 2001 in the Pilgrim MACCS2 run. It indicates that precipitation occurred on 2020 hours (23% of the year), and that precipitation started after the release about 14% of the time.[187]

104. MACCS2 models meteorological conditions that could lead to a precipitation caused "hot spot." It does not model "hot spots" that might be caused by the onshore arrival of an offshore plume during a sea breeze event.[188] MACCS2 calculated the deposition resulting from precipitation. The combination of wet deposition due to precipitation and the normal dry deposition results in areas that have greater surface contamination than areas only contaminated by dry deposition. MACCS2 models the onset of precipitation as a function of distance from the release point. Therefore, in Mr. Ramsdell's opinion, MACCS2 creates a hot spot whenever the onset of precipitation occurs at distances of more than 2 miles from Pilgrim.[189]

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[186] *Id.* at A.42

[187] *Id.* A.43.

[188] *Id.* at A.44.

[189] *Id.* at A.43.

105. This approach to dealing with "hot spots" is consistent with the general atmospheric modeling approach in MACCS2. The same general deposition mechanisms would be used in more complex models.[190]

106. However, in his opinion, the modeling of "hot spots" is not essential to the evaluation of SAMAs and is unlikely to affect the identification of potentially cost beneficial SAMAs.[191] This is because, in many respects, the rationale for concluding that the MACCS2 treatment of hot spots is reasonable is similar to the rationale for concluding that explicit treatment of sea breeze events is not essential for SAMA analyses. A "hot spot" is a relatively small area compared to the model domain and the magnitude of "hot spots" would be small. Consequently the affect of the hot spot on the two spatially and temporally integrated parameters (population dose and economic cost) used in the SAMA analysis is small when a hot spot exists. Further, considering the frequency of conditions that might lead to a hot spot, the affect of hot spots on the climatological mean parameter values is even smaller. Finally, in the case of Pilgrim, the population dose and economic cost parameter values would have to increase by more than a factor of 2 before the next least costly SAMA would be identified in the screening process as being potentially cost beneficial. Therefore, he concluded that even if MACCS2 included effects from hot spots related to onshore arrival of plumes it would not lead

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[190] *Id.* at A.45.

[191] *Id.* at A.47.

to identification of another cost beneficial SAMA at Pilgrim.[192] We agree that the hot spot phenomenon would have little effect on the Pilgrim SAMA analysis.

V. CONCLUSIONS OF LAW

107. The Board has considered all of the written evidence presented by the parties on the SAMA contention and the record, on the severe accident mitigation alternative analysis contention, as limited and remanded by the Commission's March 26, 2010, Memorandum and Order, the pre-filed testimony and rebuttal of the parties in this proceeding, the orders issued by this Board, the exhibits received in evidence and the oral argument of counsel. Based on a review of the admitted written record in this proceeding, consideration of the proposed findings of fact and conclusions of law submitted by the parties, and based upon the findings of fact set forth above, which are supported by reliable, probative and substantial evidence in the record, the Board has decided all matters in controversy concerning this remanded contention in favor of the Staff and reaches the following conclusions.

1. Pilgrim Watch has not demonstrated any significant meteorological modeling deficiency that calls into question the Pilgrim SAMA cost-benefit conclusions.

2. Pilgrim Watch has not shown that the Pilgrim SAMA analysis of meteorological patterns is inadequate.

3. Pilgrim Watch has not shown that the Pilgrim SAMA analysis' atmospheric dispersion model is inadequate.

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[192] *Id.* at A.48.

4. Pilgrim Watch has not demonstrated that use of alternative atmospheric transport models , like AERMOD and CALPUFF, will result in any significant change in an Applicant's SAMA cost-benefit conclusions.

5. Pilgrim Watch has not demonstrated that use of the atmospheric transport models, like AERMOD and CALPUFF, in the SAMA cost-benefit analysis will result in a determination that any additional SAMAs are potentially cost-effective to implement.

6. As Pilgrim Watch has not demonstrate that it's concerns regarding the atmospheric transport models, sea breeze effect, and hot spots could result in the identification of new potentially cost-beneficial SAMAs, no genuine dispute remains regarding the economic costs data the Applicant used in its SAMA analysis.

7. As Pilgrim Watch has not demonstrate that it's concerns regarding the atmospheric transport models, sea breeze effect, and hot spots could result in the identification of new potentially cost-beneficial SAMAs, no genuine dispute remains regarding the data on evacuation timing the Applicant used in its SAMA analysis.

8. Thus, Contention 3, as remanded, is resolved in favor of the Staff.

9. All issues, motions, arguments, or proposed findings presented by the parties regarding Pilgrim Watch Contention 3 but not addressed herein have been found to be without merit or unnecessary for this decision.

ORDER

For the foregoing reasons, it is hereby ordered that Pilgrim Watch's contention, as remanded, is resolved in favor of the Applicant, Entergy. This initial decision shall constitute the final decision of the Commission forty (40) days from the date of its issuance, unless, within fifteen (15) days of its service, a petition for review is filed in accordance with 10 C.F.R. § 2.341(b)(1).

It is so ORDERED.

Respectfully submitted,

/Signed (electronically) by/

Susan L. Uttal
Counsel for NRC Staff

Dated at Rockville, Maryland
this 4th day of March 2011

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
ENTERGY NUCLEAR OPERATIONS, INC.	)	Docket No. 50-293-LR
	)	
(Pilgrim Nuclear Power Station)	)	
	)	

CERTIFICATE OF SERVICE

I hereby certify that copies of the NRC Staff's Proposed Findings of Fact and Conclusions of Law, and Order in the Form of an Initial Decision have been served upon the following by the Electronic Information Exchange this 4th day of March, 2011:

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