PILGRIM WATCH

August 1, 2013

PILGRIM WATCH COMMENT REGARDING SECY-12-0110, CONSIDERATION OF ECONOMIC CONSEQUENCES WITHIN THE NRC'S REGULATORY FRAMEWORK

Pilgrim Watch (hereinafter "PW") provides expanded comments to those made during the Public Meeting July 29, 2013 and revisions to its comments provided to the Commissioners and ACRS in 2012 prior to the vote on SECY-12-0110.

I. OVERVIEW

Change the Regulatory Framework to Incorporate the Real-World Lessons Learned (and should be Learned) From Fukushima.

There is a very long list of lessons that the NRC and the nuclear industry should have learned from Fukushima. The following are among the most important. The NRC's current methodology for estimating the consequences of a severe accident either ignores or drastically underestimates all of them.

1. The probability of a core damage event is ten times what the NRC has assumed; and the chance of a GE Mark I boiling water reactor self-destructing with massive offsite contamination is 1 about in 8 (3/33), factoring in the age of U.S. reactors compared to Fukushima Daiichi's.

2. The NRC's "economic consequence" analyses cannot continue simply to ignore the enormous (far more than a core melt-down) damage that a spent fuel pool accident will cause. Luckily, to date the Fukushima "accident" has "only" resulted in three core melt-downs. But the NRC cannot continue to ignore that only "luck" has insured that

Fukushima's spent fuel pools have not failed also (especially Unit 4's), and that they may well fail in the not-distant future.

3. In the event of a severe accident, there will be enormous aqueous radioactive releases and damage. The NRC's approved consequence analyses cannot continue to ignore aqueous releases.

4. There is no rational basis for the NRC/industry assumption that an accident will last only a day (usual industry practice) and in any event not more than 4 days (MACCS2 code's maximum limit)

5. There is no rational basis to limit analyses to 50 miles.

6. There is no rational basis for the NRC/industry assumption that the only radioactive release that needs to be considered is an atmospheric (forget about aqueous) release from the core (forget about the spent fuel pool), and even then only noble gasses and a small fraction of the Cs-137 in a core need be taken into consideration.

7. Similarly, there is no rational basis for the NRC/industry assumption that a radioactive release will only affect a very limited geographic area defined by an outdated straight-line Gaussian plume.

8. Clean-up and Decontamination is an enormously expensive job, extending over decades. Hosing down buildings and plowing under fields does not clean-up or decontaminate. The NRC cannot continue to ignore: that there is no cleanup-standard; that clean-up cannot possibly take just one year; that it has given no consideration to what can and must be done to the tons of contaminated wastes; that clean-up after a nuclear explosion is not comparable to clean-up after a nuclear reactor accident; and that forests, wetlands and water simply cannot be cleaned and will re-contaminate areas.

9. The MACCS2 code used by industry (with the NRC's approval) to model economic consequences of a severe accident is, at best severely limited in what it can do and what it cannot. Even in those areas where the MACCS2 code has some capability, the NRC cannot continue to allow industry to manipulate the way in which it uses the code to intentionally minimize potential consequences; ignore real health costs; create essentially

useless evacuation time estimates; choose the input parameters into the model; and choose to average the code's inputs by a mean and not the 95^{th} percentile.

II. ANALYSES

A. Probability and Probabilistic Modeling

Fukushima raised baseline > 10 times - from 1 event per 31,000 RY to 1 event per 2,900 RY

The probability of severe core damage and accompanying radioactive release can be estimated in two ways. One is by direct experience and the other by Probabilistic Risk Assessment (PRA). Fukushima has expanded our knowledge by direct experience, and the lessons that should be learned provide a reality check on PRAs.

The MACCS2 that NRC and industry use to conduct PRAs have little or no basis in direct experience**.** For example, the MACCS2 code restricts the times for cleanup and decommissioning after a severe accident to one year. After Chernobyl, the Russians quit after four years and the Japanese estimate that it will take decades to clean-up after Fukushima.

If that code has been used to perform a cost-benefit analysis at Fukushima Daiichi in January 2011, the predicted offsite consequence costs would not have justified the cost of taking any mitigation steps to reduce the risk of a severe accident. This tells us that PRA, by itself and as currently run, is inadequate. The risks, and problems, inherent in probabilistic modeling, particularly as it is now practiced by the NRC and nuclear industry, are legion. For example:

1. By using probabilistic modeling and incorrect parameters in a SAMA analysis, a licensee can arrive at a result that downplays the likely consequences of a severe accident, and thus saves the licensee money by incorrectly discounting possible mitigation alternatives. This could have enormous implications for public health and safety. A potentially cost effective mitigation alternative that could prevent or reduce the impacts of that accident would likely not even be considered.
2. Consequence analysis multiplies the probability of an accident by the consequences. By multiplying large consequence values by very low probability, the consequence values appear unrealistically very low – far lower than the real-world lessons from Fukushima show.

Probabilistic modeling that uses a low probability number can, and likely will, underestimate the deaths, injuries, and economic impact likely from a severe accident. No matter how high the potential consequence values may be, if they are multiplied by a low probability number, the consequence figures on which decisions are based become far less startling. For example, if an analysis shows that the consequences of a severe accident radioactive would include 100,000 cancer fatalities, PRA would reduce the "risk" on which any SAMA was based to only 1 cancer fatality per year by assuming (and there is no basis for anything other than an assumption) that associated probability of the release was 1/100,000 per year.

3. PW is not arguing that probability is not taken into consideration, but it must be taken with caution and tested against real-world experience, particularly as it relates to SAMA analyses. Kamiar Jamali's (DOE Project Manager for Code Manual for MACCS2) *Use of Risk Measures in Design and Licensing Future Reactors,*[1] explains that "PRA" uncertainties are so large and so unknowable that it is a huge mistake to use a single number coming from them for any decision regarding adequate protection. "Examples of these uncertainties include probabilistic quantification of single and common-cause hardware or software failures, occurrence of certain physical phenomena, human errors of omission and commission, magnitudes of source terms, radionuclide release and transport, atmospheric dispersion, biological effects of radiation, dose calculations, and many others." (Jamali, Pg., 935) (Emphasis added)

4. Probability analysis has other pitfalls. PRAs do not consider human error. More important, PRAs project into the future and assume (based on very little real experience) that there is a likelihood that an accident scenario will occur in hundreds, if not thousands, of years is vanishingly small. But no reactors have operated more than 45 years, and there have been at least six severe accidents.[2] The uncertainty inherent in predicting the future must be respected by making certain that appropriate and up-to-date assumptions are used in the analysis.

Fukushima showed Probabilistic Risk Assessments (PRA) uncertainties are extremely large and that it is a huge mistake to use a single number coming from them as the basis for any decision regarding adequate protection. Examples of these uncertainties include, for example:

[1] Kamiar Jamali, *Use of Risk Measures in Design and Licensing Future Reactors,* Reliability Engineering and System Safety 95 (2010) 935-943

[2] Including the 1961 fatal accident at SL-1.

probabilistic quantification of single and common-cause hardware or software failures, occurrence of certain physical phenomena, human errors of omission and commission, magnitudes of source terms, radionuclide release and transport, atmospheric dispersion, biological effects of radiation, dose calculations, and many others.

The probability analysis that lies at the heart of the regulatory framework needs to be changed to incorporate the real-world lessons learned, and should be learned, from Fukushima.

B. The Probability of a Core Damage Event

The NRC's current baseline estimates that there may be *one Core Damage Event per 31,000 RY* (years of reactor operation). Fukushima raised the number of *actual* core damage events at Generation II commercial reactors in the last 34 years to five[3] - TMI, Chernobyl and Units 1 though 3 at Fukushima. Based on this actual experience, the likelihood of a significant accident core melt in any given year is about 1 in 7 years.

The NRC prefers to speak in terms of events per year (or years) of reactor operation. The five Generation II commercial reactor core melts occurred in a world-wide fleet of 440, with a total of 14,484 reactor years of operation (RYs) as of May 16, 2011. In NRC-speak, this translates to a core damage frequency of 3.4E-04 per RY (or **1 event per 2, 900 RY**). No matter how stated, the probability of *one core-melt for every 2,900 RY* (years of reactor operation) is more than ten times the current baseline estimate of only **1 event per 31,000 RYs**. Put another way, based upon observed experience with more than 400 reactors operating worldwide, a significant nuclear accident has occurred approximately every seven years (2900/400=7.25). [4]

Whether thought of in terms of one accident every seven years or one event every 2,900 reactor years (the year could be tomorrow or many years later), it could hardly be clearer that future SAMA analyses should be done using a baseline CDF that is at least an order of magnitude higher than that currently used.

[3] This does not include the fatal accident at SL-1 in 1961.

[4] These two quite different ways of stating probability of a Core Damage Event (once every seven years or once in every 2,900 reactor years) is perhaps one of the clearest examples of the ability of a PRA to confuse and mislead the public.

Further from direct experience at Fukushima SAMA options to implement (based on updated cost-benefit analyses based on Fukushima's direct experience, not analyses based on pre-Fukushima assumptions/inputs) are measures to mitigate: structural damage; multi-day station black-out; loss service water and or loss fresh water supply; containment venting and hydrogen control systems upgraded using passive mechanisms; measures to prevent spent fuel pool fires, low-density, open-frame racks; filtered venting that uses passive mechanisms.[5]

C. Spent Fuel Pools

Today, there are about 1,230 irradiated spent fuel rods, containing roughly 37 million curies (~1.4E+18 Becquerel) of long-lived radioactivity in Fukushima's pool No. 4.[6] The No. 4 pool is about 100 feet above ground, is structurally damaged and is exposed to the open elements. If an earthquake or other event were to cause Unit 4's pool to drain this could result in a catastrophic radiological fire involving nearly 10 times the amount of Cs-137 released by the Chernobyl accident. It would also cause a shutdown of all six reactors, and would affect the common spent fuel pool containing 6,375 fuel rods, located some 50 meters from reactor 4. None of these radioactive fuel rods are protected by a containment vessel; all are open to the air.

The danger presented by spent fuel is the reason that the NRC recommended that all Americans within 50 miles of Fukushima be evacuated. Yet the NRC's economic consequence analyses (inexplicably for any reason other than the potential cost to the industry of dealing with the issue) continue to ignore the consequences of a spent fuel accident. No rational analysis could do so. Accidents are severe, and cause economic consequences, because they release radioactivity - whether from the reactor core or a spent fuel pool, the consequences are the same

[5] Massachusetts Office of the Attorney General Request for Hearing Pilgrim License Renewal (Dr. Gordon Thompson Report, New and Significant Information From Fukushima Daiichi Accident in the Context of Future Operation of the Pilgrim Nuclear Power Plant, June 1, 2011, Section VI.I, beginning pg., 14, NRC Electronic Library, EHD)

[6] Currently available information is that the about the total of number of spent fuel assemblies are being stored at the Dai-Ichi site is between 10,833 and 11,138. In either event, they contain about 330 million curies (~1.2 E+19 Bq) of long-lived radioactivity. About 130 million of the 330 million curies is Cesium-137 — **roughly 85 times the amount of Cs-137 released at the Chernobyl accident** as estimated by the U.S. National Council on Radiation Protection (NCRP). The total spent reactor fuel inventory at the Fukushima-Daichi site contains nearly half of the total amount of Cs-137 estimated by the NCRP to have been released by all atmospheric nuclear weapons testing, Chernobyl, and world-wide reprocessing plants (~270 million curies or ~9.9 E+18 Becquerel).

- except that the amount of radioactivity caused by a spent fuel accident would dwarf that caused by a core melt-down.

The importance of a spent fuel accident, and of requiring SAMAs to model spent fuel pool releases, is illustrated by pointing to Pilgrim, where a spent fuel pool fire could release more than 44,010,000 curies of Cs-137, an amount 8 times more than a core release. Further, a spent fuel pool fire would result in releases going higher into the air and significantly impacting locations at greater distance with denser populations.

Dr. Beyea estimated the cost of a 10% release from a spent pool fire to be $105-175 billion dollars; and that a 100% release of C-137 would cost somewhere between $ 342 - $ 488 billion. (Beyea, 10) Entergy's LRA SAMA, based on currently approved NRC models, considered only the release of a relatively small amount of C-137 from the reactor core[7].

And a severe accident from the spent fuel pool at Pilgrim, for example, resulting from human error, mechanical failure, natural disasters, or an act of malice, is reasonably foreseeable. The offsite cost risk of a pool fire is substantially higher than the offsite cost of a release from a core-damage accident.

There are significant potential interactions between the pool and the reactor in the context of severe accidents, especially at Mark I's and Mark II's. In both, as at Fukushima, the spent-fuel pool is located in the attic of the main reactor building, outside primary containment. It shares essential support systems with the reactor. There could be at least three types of interactions between the pool and reactor.[8]

First, a pool fire and a core-damage accident could occur together, with a common cause. For example, a severe earthquake could cause leakage of water from the pool, while also damaging the reactor and its supporting systems to such an extent that a core-damage accident occurs.

[7] The 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 Plants Operating License and Petition for Backfit Order Requiring New Design features to Protect Against Spent Fuel Pool Accidents, Docket No. 50-293, May 26, 2006 includes a Report to The Massachusetts Attorney General On The Potential Consequences Of A Spent Fuel Pool Fire At The Pilgrim Or Vermont Yankee Nuclear Plant, Jan Beyea, PhD., May 25, 2006.

[8] Dr. Gordon Thompson, Risks of Pool Storage of Spent Fuel at Pilgrim Nuclear Power Station and Vermont Yankee, A Report for the Massachusetts Attorney General by IRSS, May 2006, Pgs., 12, 16. NRC Electronic Library, Adams Accession Number ML061630088"

Second, the high radiation field produced by a pool fire could initiate or exacerbate an accident at the reactor by precluding the presence and functioning of operating personnel.

Third, the high radiation field produced by a core-damage accident could initiate or exacerbate a pool fire, again by precluding the presence and functioning of operating personnel.

Many core-damage sequences would involve the interruption of cooling to the pool, which would call for the presence of personnel to provide makeup water or spray cooling of exposed fuel. The third type of interaction was considered in a license-amendment proceeding in regard to expansion of spent-fuel-pool capacity at the Harris nuclear power plant. Such accidents are conceivable and would result in a very high magnitude of release.

Although, SAMAs designed to avoid or mitigate conventional accidents may be different than SAMAs designed to avoid or mitigate spent fuel accidents. The radiological consequences of a spent-fuel-pool fire are significantly different from the consequences of a core-damage accident.

Additionally, spent fuel pool fires result in a large plume rise that will carry releases further afield, pertinent to economic consequences and to the specific question of whether analyses should expand beyond 50 miles. For example, the National Academy of Sciences report, *Safety and Security of Commercial Spent Nuclear Fuel Storage Public Report* (April 2005) said that if a terrorist attack on the spent fuel pool leads to a zirconium cladding fire; it could result in large amounts of radioactive material spreading hundreds of miles.

> "Finding 3B … a terrorist attack that partially or completely drained a spent fuel pool could lead to a propagating zirconium cladding fire and the release of large quantities of radioactive materials to the environment. Details are provided in the committee's classified report." NAS, 6
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> "Such (zirconium cladding) fires would create thermal plumes that could potentially transport radioactive aerosols hundreds of miles downwind under appropriate atmospheric conditions." NAS, 50

D. Aqueous Discharges[9]

[9] Pilgrim Watch Request For Hearing On A New Contention Regarding Inadequacy Of Environmental Report, Post Fukushima, November 18, 2011; Pilgrim Watch's Petition For Review Of LBP- 12-01,January 11, 2012, NRC's EHD, Pilgrim LRA.

Millions of gallons of water were pumped into the Fukushima reactors, and those millions of gallons flowed into the sea. Current NRC economic consequences take no account of aqueous discharges, to say nothing of their affect on either the local or long-distance marine economies.

Post Fukushima Daiichi, it plainly is necessary to update SAMA analyses to take into account new and significant information learned from Fukushima regarding the probability of containment failure in the event of an accident and the concomitant probability of a significantly larger volume of off-site consequences due to the need for flooding the reactor (vessel, containment, pool) with huge amounts of water in a severe accident, as at Fukushima.

This was recognized by the Commission.[10] But the Commission also should do something about it-require implementation. Direct contamination from water pumped into a reactor would add to that resulting from aqueous transport and dispersion of radioactive materials through subsurface water, sediments, soils and groundwater, plus atmospheric fallout on the waters - resulting in <u>three sources of contamination in the waters</u>. A rational economic analysis must recognize all three.

E. How Long an Accident

The Fukushima disaster was not over a day after it started. Units 1-3 continue to release radioactive materials today - years after the accident began.

The MACCS2 code limits the total duration of a radioactive release to no more than four (4) days, if the Applicant chooses to use four plumes occurring sequentially over a four day period (IPLUME 3)[11]. Licensees have chosen not to take that option and limited analyses to a single plume having a total duration of one day.[12] In any case either a day or a four-day plume is plainly of insufficient duration in light of lessons learned from Fukushima. The Fukushima crisis stretches over many months. A release that goes on for the better part of two years will cause offsite consequences that far exceed one that lasts only a day.

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[10] SECY-11-0089, Enclosure 1, pg., 29; http://www.nrc.gov/reading-rm/doc-collections/commission/secys/2011/2011-0089scy.pdf; and Commission Voting Record, Decision Item SECY-11-0089, September 21, 2011, http://www.nrc.gov/reading-rm/doc-collections/commission/cvr/2011/2011-0089vtr.pdf

[11] NUREG/CR-6613 Code Manual for MACCS2: Volume 1, User's Guide, 2-2

[12] The MACCS2 uses a Gaussian plume model with Pasquill-Gifford dispersion parameters (Users code 5-1). Its equation is limited to plumes of 10 hour duration.

G. Distance > 50 miles

Chernobyl and Fukushima showed that impact of a severe accident does not necessarily stop at 50 miles; and SAMAs and other probability analyses should not continue to be restricted to 50 miles. For example:

1. Spent Fuel Pool Fires: National Academy of Sciences, *Safety and Security of Commercial Spent Nuclear Fuel Storage Public Report*, April 2005, said

> "Such (zirconium cladding) fires would create thermal plumes that could potentially transport radioactive aerosols hundreds of miles downwind under appropriate atmospheric conditions." NAS, 50

2. Terrorism is an on-going threat; reactors are vulnerable, with no onsite or structural defense from an air attack. In the event of aircraft related attack resulting in radiological release, fire and smoke from burning jet fuel can carry radioactivity to higher altitudes and subsequently disperse radioactivity beyond 50 miles.

3. Advanced Meteorological Understanding: Advanced variable plume models concerning the flow of air in coastal areas, river valleys, lake regions, and hilly terrain show that winds are variable in these locations and spread concentrated releases of radiation at a far greater distance than the current simplistic straight- line plume models. Straight line models incorrectly assume plumes travel like a beam from a flashlight and impact a pie-wedged shape.

a. Sea Breeze: (applies to any large body of water – ocean/lake): There is a misconception that the sea breeze is generally a highly beneficial phenomenon that disperses and dilutes the plume concentration and thereby lowers the projected doses downwind from the release point. However, if the same meteorological conditions (strong solar insolation, low synoptic-scale winds) that are conducive to the formation of sea breezes at a coastal site occurred at a non coastal location, the resulting vertical thermals developing over a pollution source would carry contaminants aloft. In contrast, at a coastal site, the sea breeze draws contaminants downward across the land and inland subjecting the population to larger doses.

b. Behavior Plumes over Water: Planning should, but does not, reflect understanding of the flow of air over and around large bodies of water. As an example at Pilgrim, located on New England's Coastline, winds initially headed out to sea will remain tightly concentrated due to

reduced turbulence over water until the winds blow the puffs back over land.[13] This can lead to hot spots of radioactivity in unexpected places – beyond 50

c. Diffusion at Valley Sites – Gravity Drainage:[14] With no solar heating at night, the earth cools. Higher elevations cool faster; cool air flows towards warmer air in the valley. This flow is known as gravity drainage. In the absence of other influences, the drainage, compacted plume, will head downriver greater distances than now modeled.

d. Improved understanding of the health effects of radiation: the National Academies latest report on the Biological Effects of Ionizing Radiation (BEIR VII) showed that radiation is far more harmful at lower doses than previously thought, especially for women, children and fetuses. Therefore those beyond 50 miles may well be at greater risk because they are more sensitive to radiation exposure than previously thought.

6. Indirect or Secondary Consequences: Indirect or secondary economic consequences cover effects that are produced outside areas directly impacted by the contamination within the present 50 mile radius; for example, the impact on non-contaminated food marketing, on tourism, or the nation's nuclear programs.

H. All Radioactive Releases Must be Considered

The only releases considered under current NRC practice are noble gases from the core and a small fraction of the core inventory of Cs-137. One fundamental lesson that should be learned from Fukushima is current practice necessarily, even if perhaps not intentionally,

[13] Zager M, Tjernstrom M, Angevine W. 2004, New England coastal boundary layer modeling. In: AMS 16th Symposium on boundary Layers and Turbulence, August 2004, Portland, Maine. Angevine WM. Tjernstrom M, Senff CJ, White AB. 2004. Coastal Boundary layer Transport of urban pollution in New England In: 16th Symposium of boundary layers and turbulence Portland, Maine, 13th Symposium on Turbulence and diffusion, August 2004, Portland, Maine. Angevine WM. Tjernstrom M, Zager M. 2006. Modeling of the Coastal Boundary Layer and Pollutant Transport in New England, J. of Appl. Meteorol. & Climatol. 45: 137-154. Scire JS, Strimaitis DG, Yamatino RJ. 2000 A User's Guide for the CALPUFF Dispersion Model (Version 5). Concord MA: Earth Tech, Inc.

[14] The State Of New York's Motion For Summary Disposition On Use Of Straight Line Gaussian Air Dispersion Model For The Environmental Impact Analysis Of Significant Radiological Accidents At Indian Point And NYS Contention 16/16A, (DPR-26, DPR-64) August 28, 2009, Declaration of Bruce A. Egan, Sc.D., explains that concentrated radiation can spread at distances far greater than 10-miles along river valleys.

drastically underestimates many releases that cause significant damage and economic consequences.

Even if we were to put aqueous discharges and radioactive releases from spent fuel pools to one side, there is no justification for not modeling the total potential amount of Cs-137 from the core. For example the Cs-137 inventory in Pilgrim Station's core has the potential of releasing more than twice the amount of Cs-137 than was released at Chernobyl. The amount of Cs-137 released during Chernobyl in 1986 was 2,403,000 curies; the amount of Cs-137 in Pilgrim's Core during license extension will be 190,000 TBq or 190,000 X 27 Ci = 5,130,000 curies.

However, and consistent with permitted NRC and industry practice, Entergy's LRA MACCS2 model apparently estimated costs based on a release only (i) of noble gases in the core inventory and (ii) a small fraction of the core inventory of CsI. [PNPS Radionuclide Release Category Summary, Figure E.1.1].

The regulatory framework changes should require: (1) modeling the actual amount of Cs-137 from the core and not basing release as current practice on noble gasses and a small fraction of the core inventory of Cs-137; (2) including release from the spent fuel pool; (3) not allowing use of codes that have not been validated by the NRC such as the MAAP code; (4) requiring modeling aqueous discharges, not simply atmospheric; and (5) using complex air dispersion models instead of the straight-line Gaussian plume embedded in the MACCS2; and modeling releases over an extended duration, as occurred in Fukushima, that considers multiple changes in wind direction and plumes contaminating wider areas.

I. Radioactive Release Concentration- Meteorology[15]

Current NRC practice ignores aqueous releases, and thus takes absolutely no account of where radioactive liquids discharged into a body of water are likely to flow. Radioactive liquid from Fukushima has been detected at the West Coast of the United States.

Current NRC practice with respect to determining the geographic concentration of atmospheric radionuclides released in a severe accident is also inadequate - and once again

[15] See: Pilgrim Watch Comment Regarding Secy-12-0110, Consideration Of Economic Consequences Within The NRC's Regulatory Framework, July31, 2013 submitted to the staff committee following the July 29, 2013 Public Meeting on SECY 12-0110

designed to minimize predicted economic consequences and potential industry mitigation costs. The atmospheric dispersion model embedded in the MACCS2 code is a steady-state, straight-line Gaussian plume model that assumes meteorological conditions that are steady in time and uniform spatially across the study region. The plume model is not appropriate for sites located near large bodies of water, river valleys and varied topography. It underestimates the area likely to be affected in a severe accident and the dose likely to be received in those areas. Variable plume models such as AERMOD or CALPUFF are appropriate, and readily available.

The NRC knows this. For example NRC made a presentation to the National Radiological Emergency Planning Conference[16] concluded that the straight-line Gaussian plume models cannot accurately predict dispersion in a complex terrain and are therefore scientifically defective for that purpose [ADAMS - ML091050226, ML091050257, and ML091050269 (page references used here refer to the portion attached, Part 2, ML091050257).] Most reactors, if not all, are located in complex terrains. In the presentation, NRC said that the "most limiting aspect" of the basic Gaussian Model, is its "inability to evaluate spatial and temporal differences in model inputs" [Slide 28]. Spatial refers to the ability to represent impacts on the plume after releases from the site e.g., plume bending to follow a river valley or sea breeze circulation. Temporal refers to the ability of the model to reflect data changes over time, e.g., change in release rate and meteorology [Slide 4]. Because the basic Gaussian model is non-spatial, it cannot account for the effect of terrain on the trajectory of the plume – that is, the plume is assumed to travel in a straight line regardless of the surrounding terrain. Therefore, it cannot, for example, "'curve' a plume around mountains or follow a river valley." NRC 2009 Presentation, Slide 33. Further NRC says that it cannot account for transport and diffusion in coastal sites subject to the sea breeze. The NRC says that the sea breeze causes the plume to change direction caused by differences in temperature of the air above the water versus that above the land after sunrise. If the regional wind flow is light, a circulation will be established between the two air masses. At night, the land cools faster, and a reverse circulation (weak) may occur [Slide 43]. Turbulence causes the plume to be drawn to ground level [Slide 44]. The presentation goes on to

[16] What's in the Black Box, Dispersion, Prepared for 2009 National Radiological Emergency Planning Conference, Stephen F. LaVie, Sr. Emergency Preparedness Specialist, Nuclear Security and Incident Response, Division of Preparedness and Response, Adams Accession No. ML091050257

say that, “Additional meteorological towers may be necessary to adequately model sea breeze sites” [Slide 40].

Significantly, the NRC 2009 Presentation then discussed the methods of more advanced models that *can* address terrain impact on plume transport, including models in which emissions from a source are released as a series of puffs, each of which can be carried separately by the wind, (NRC 2009 Presentation Slides 35, 36). This modeling method is similar to CALPUFF. Licensees are not required, however, to use these models in order to more accurately predict where the plume will travel to base protective action recommendations.

Likewise, EPA has recognized the need for complex models. For example EPA's November 2005 Modeling Guideline (Appendix A to Appendix W) lists EPA's "preferred models” and the use of straight line Gaussian plume model, called ATMOS, is not listed. Sections 6.1 and 6.2.3 discuss that the Gaussian model is not capable of modeling beyond 50 km (32 miles) and the basis for EPA to recommend CALPUFF, a non - straight line model.[17] DOE, too, recognizes the limitations of the straight-line Gaussian plume model. They say for example that Gaussian models are inherently flat-earth models, and perform best over regions of transport where there is minimal variation in terrain. Because of this, there is inherent conservatism (and simplicity) if the environs have a significant nearby buildings, tall vegetation, or grade variations not taken into account in the dispersion parameterization.[18]

Fukushima made clear the importance of accurate meteorological modeling. The radioactive liquid releases from Fukushima have travelled thousands of miles through the Pacific Ocean. The radioactive atmospheric releases have not travelled simply in a straight line.

J. Cleanup/Decontamination[19]

Actual cleanup costs are the “Elephant in the Room” that NRC and industry have tried to avoid. After the real-world experiences in Japan proper modeling of these costs can no longer be

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[17] http://www.epa.gov/scram001/guidance/guide/appw_05.pdf

[18] The MACCS2 Guidance Report June 2004 Final Report, page 3-8:3.2 Phenomenological Regimes of Applicability

[19] See for example: Decl. Francois Le May ML 1204813411 (5/18/12) Exh. NYS 0000241 (Dec 21, 2011) & NYS000242 (Dec 21,2011) New contention 12-C: NYAGO’s expert ran a SAMA with higher damage costs and longer time decontaminate Cleanup from 1 year (Entergy) to 200 years→ NY costs from $1/person to $100,000/person (Entergy) to $2,000,000

avoided. Cleanup costs realistically assessed will result in major offsite costs requiring the addition of a large number of mitigations. The cost formula used in the MACCS2 underestimates costs likely to be incurred.

Lessons learned from Fukushima are highlighted in the following March 2012 Associated Press article, *Japan decontaminates towns near tsunami-hit nuclear plant, unsure costly effort will succeed*. [20]

> FUKUSHIMA, Japan — Workers in rubber boots chip at the frozen ground, scraping until they've removed the top 2 inches (5 centimeters) of radioactive soil from the yard of a single home. Total amount of waste gathered: roughly 60 tons.
>
> One down, tens of thousands to go. And since wind and rain spread radiation easily, even this yard may need to be dug up again.
>
> * * *
>
> Experts leading the government-funded project cannot guarantee success. They say there's no prior model for what they're trying to do. Even if they succeed, they're creating another problem they don't yet know how to solve: where to dump all the radioactive soil and debris they haul away.
>
> The government has budgeted $14 billion (1.15 trillion yen) through March 2014 for the cleanup, which could take decades.
>
> * * *
>
> Radiation accumulates in soil, plants and exterior building walls. Workers start cleaning a property by washing or chopping off tree branches and raking up fallen leaves. Then they clean out building gutters and hose down the roof with high-pressure water. Next come the walls and windows. Finally, they replace the topsoil with fresh earth.
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> * * *

[20] Japan decontaminates towns near tsunami-hit nuclear plant, unsure costly effort will succeed, Mari Yamaguchi, Associated Press, March 5, 2012, http://www.washingtonpost.com/world/asia_pacific/japan-decontaminates-towns-near-tsunami-hit-nuclear-plant-unsure-costly-effort-will-succeed/2012/03/05/gIQAQ0VHsR_print.html

> Experts say it may be possible to clean up less-contaminated areas, but nothing is promising in the most contaminated places, where any improvement is quickly wiped out by radiation falling from trees, mountains and other untreated areas.
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> * * *
>
> "It's largely trial and error," said Kazuaki Iijima, a radiation expert at the Japan Atomic Energy Agency, which is supervising the pilot projects. "Decontamination means we are only moving contaminant from one place to another. We can at least keep it away from the people and their living space, but we can never get rid of it completely."
>
> Then there's the question of finding places willing to accept an ever-growing pile of radioactive waste.
>
> The Environment Ministry expects the cleanup to generate at least 100 million cubic meters (130 million cubic yards) of soil, enough to fill 80 domed baseball stadiums.
>
> * * *
>
> The waste would remain in the longer-term storage for 30 years, until half the radioactive cesium breaks down. Then it would still have to be treated and compacted — using technology that hasn't been fully developed yet — before being buried deep underground in enclosed containers.

Nothing in current NRC approved economic consequence analyses even tries to address the real-world lessons of Fukushima. The disaster in Fukushima has laid bare one truth: A disaster here would result in losses requiring the government to make payouts of epic proportions. That's because Fukushima is budgeted to cost 14 billion dollars *simply* through March 2014, according to Japanese experts. If there is a severe nuclear reactor accident in the US, the Price-Anderson Fund can't handle those kinds of losses. The money cap in Price Anderson is based on a MACCS analysis, also.

The current NRC approved consequences models:

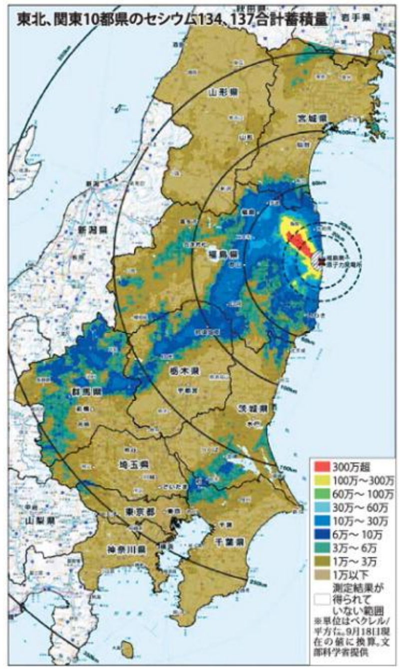
- Underestimate both the size of the area likely to be contaminated, and the extent of contamination.
- Underestimate the volume of waste.
- Underestimate how long cleanup and decontamination will take.

- Ignore that forests, wetlands, and bodies of water essentially cannot be cleaned up or decontaminated.
- Ignore that the technologies needed for cleanup have not even been developed.
- Ignore there is not even a cleanup standard.
- Are based on estimates of what is required for nuclear weapon cleanup, rather than the very different problems presented by nuclear reactor accident.
- Minimize consequences by assuming a straight-line Gaussian plume model, ignoring aqueous discharges, and ignoring that an accident can persist over many weeks and months.
- The huge volume of waste is underestimated; and that there are no available safe disposal options is ignored. In fact waste disposal is not modeled.
- The time that decontamination will take is underestimated. Technologies to cleanup have not been developed; current cleanup methods used in Japan and assumed in US models do not work- hosing down buildings and plowing under fields. They are based on nuclear weapons cleanup that is a different from cleanup after a nuclear reactor accident. Many radionuclides, like Cs-137, have long half-lives.
- Contamination in certain media simply cannot be decontaminated-forests, wetlands, water - from groundwater to oceans; and in turn runoff will re-contaminate cleaned areas.
- No Cleanup Standard

The Contaminated Area

The cost of cleanup fundamentally reflects the size of the area contaminated, and the level of contamination. A year ago, the Japanese press reported that the Fukushima accident contaminated 13,000 square kilometers (an area nearly equivalent to the size of Connecticut (land area and water). The contaminated area extended in all directions and at considerable distance from the site.[21] The Japanese Ministry of Education, Culture, Sports, Science and Technology (MEXT) map showed the spread of radiation from Fukushima across 10 prefectures, including Tokyo and Kanagawa.[22].

[21] *Estimated 13,000 square km eligible for decontamination* Asahi.com (Asahi Shimbun), Oct 12, 2011
[22] Mainichi News, http://mdn.mainichi.jp/mdnnews/news/20111007p2a00m0na009000c.html; Gov't radiation info in English http://radioactivity.mext.go.jp/en/



So far as PW knows, no one has even attempted to calculate how much of the Pacific Ocean and connecting waters have been contaminated by aqueous discharges.

Beyond "how large an area," is the question of "how contaminated?" The level of contamination in the affected areas depends on both the size of the release at any point in time, and also on its duration. The Fukushima release has continued for months.

The basic lesson to be learned from these simple facts is that any remotely adequate economic consequence analysis must take into account the very real likelihood of a large level release that continues for a long period of time and contaminates many thousands of square miles. Current NRC economic analyses unrealistically limit the duration of the radioactive release, the size of the affected area, and the radiation source.

- Duration: The Fukushima disaster persisted over many months. But the NRC approved consequence code, MACCS2, limits the total duration of a radioactive releases to no more than four (4) days, if the user chooses to use four plumes occurring sequentially over a four day period.[23] Licensees choose not to take that option and limit economic cost analyses to a single plume having a total duration of less than a day. However a longer

[23] NUREG/CR-6613 Code Manual for MACCS2: Volume 1, User's Guide, 2-2

release such as that at Fukushima will cause offsite consequences that will increase contamination, and result in required re-decontamination, and significantly increase cleanup costs and the overall cost-benefit analyses.

- Size of Affected Area. How large an area will be contaminated, and where that area is likely to be, depends on assumptions made about the radioactive plume. Fukushima showed that the plume did not travel simply in a straight-line.[24] However the NRC approved computer code, MACCS2 assumes a straight-line Gaussian plume model that limits the spread of contaminants to a pie-shaped wedge.[25] This ignores that winds are complex and variable near large water bodies, along rivers, and hilly terrain so that a much larger geographic area, in multiple directions, is impacted. Fukushima taught that no plume can safely be assumed to travel in a straight line, and it is obvious that plumes from releases extending over many months will be variable.
- Non-Atmospheric Releases. The economic consequence analyses approved by NRC only model atmospheric releases and plumes. Fukushima also showed that contamination is also spread by aqueous discharges. In Japan enormous quantities of contaminated water flowed into the Pacific Ocean as result of "feed and bleed" and from runoff into groundwater, streams and other water bodies from contaminants deposited by atmospheric releases on land.

- What Can't Be Cleaned-up? Lessons learned from Fukushima show that forests, water and shorelines, for example, cannot realistically be cleaned up and decontaminated. For example the Japan Times reported in September 2011[26] that

> In August, the government acknowledged difficulties in removing soil and ground cover from the forests, due mostly to the volume of radioactive waste that would be generated by the effort.
>
> "Huge volumes of soil and other (contaminated) items would be involved because the forests occupy a huge area."
>
> The government effectively shelved any approach to decontaminating forests when it said that removing both the contaminated soil and compost

[24] Gov't radiation info in English http://radioactivity.mext.go.jp/en/
[25] NUREG/CR-6613/SAND97-0594, Vol. 1,Code Manual for MACCS2:Volume 1, User's Guide, May 1998 D. Chanin, M.L. Young
[26] Institute probing radioactive contamination of Fukushima forests, Japan Times,, Sep. 17, 2011

> materials would strip the forests of important ecological functions, including water retention.

Real world experience also shows that bodies of water, such as the Pacific, cannot be cleaned up either. Further, ocean currents may re-circulate the contamination for years contaminating and re-contaminating beaches and marine life increasing costs from a continuous need to cleanup and pay for damaged to the environment[27].

Losing a forest or marine life is a serious economic consequence. The NRC's economic consequence analyses cannot properly ignore.

Waste Volume and Disposal

Lessons learned from Fukushima show that the Japanese Environment Ministry expects the cleanup to generate at least 100 million cubic meters (130 million cubic yards) of soil, enough to fill 80 domed baseball stadiums.[28]. The Yomiuri Press reported that disposal sites refuse to accept 140,000 tons of tainted waste.[29] Because there is no available storage for the high volume of waste and no community willing to host the disposal site,[30] waste is piling up and run-off from it contaminates and re-contaminates groundwater and property.[31] The problem cannot be solved soon because the technology is not there and cesium-137 takes 30 years to decay one half-life.[32]

The Japanese Government's clean-up budget for the next two years is $14 billion; the NRC's estimate is nowhere near that.

The present U.S. cost model (MACCS2) does not account for the disposal and storage of waste and assumes that cleanup can be quickly accomplished.

Decontamination time is a major variable in determining cleanup costs. To determine the time required for cleanup, licensees improperly use the MACCS2's Sample Problem A, designed

[27] Fukushima's radioactive sea contamination lingers, Andy Coghlan, New Scientist, Sept 30, 2011; Radioactive cesium may be brought back by Ocean in 20-30 years , Tokyo Times, 09.16.11
[28] Ibid
[29] *Daily Yomiuri* - Disposal sites refuse to accept 140,000 tons of tainted waste March 4, 2012
[30] Mainiichi Press, *Residents near Fukushima mountains face nuclear recontamination every rainfall, October 11. 2011*
[31] Ibid
[32] Ibid

for testing only.[33] Sample Problem A assumes to achieve a decontamination factor (DF) of 3 reducing contamination 67% will take 60 days; and to achieve a DF of 15 to reduce contamination to 93.3%, 130 days. There is no basis for these assumptions. Chernobyl spent 4 years and quit; Japan estimates decades. The MACCS2 code restricts the time for cleanup to simply one year. It is unreasonable and not justified.

There is no excuse for ignoring waste storage, and Fukushima proved (and continues to prove) that latter is a pipe-dream. The NRC economic consequences model also does not account for costs incurred for safeguarding the wastes and preventing their being re-suspended. Even optimistically assuming an available radioactive waste repository, it seems unlikely that there would be a sufficient quantity of transport containers, and many communities will quite certainly object to the millions of tons of hazardous materials being transported through them.

Technologies for Cleanup Not Developed - Current Methods Ineffective

Cleanup methods used in Japan, and assumed in NRC approved US models, do not work. Hosing down buildings and plowing under fields does not remove contamination. It simply moves it to another place, such as the groundwater, to reappear at a later date and require more monies to either start again or bare the cost. NRC knows this. For example the *MACCS2 Code Manual* notes that the MACCS2 computer model does not assume that plowing will move the radiation to below the root zone for crops or reduce root uptake and food doses to the consumer of such crops. Thus, it cannot be said that the decontamination strategies identified remove the radiation from the environment. Also the fact that cesium is soluble, which means that precipitation events or fire-hosing can actually facilitate cesiums binding to structural surfaces or spread it into a community's infrastructure (*e.g.*, sidewalks, gutters, drains, sewer pipes) and ecosystem (*e.g.*, groundwater, streams, lakes, reservoirs).[34] The ability of cesium and other fission products to bind to surfaces is especially pronounced for porous or rough surfaces.[35]

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[33] NYS000241, December 21, 2011, Pre-filed written testimony of Dr. Francois J. Lemay, NYS Contention 12-C

[34] Chanin, D.; Murfin, W. (1996). *Site Restoration: Estimation of Attributable Costs from Plutonium-Dispersal Accidents*, SAND96-0957, DE9601166, Sandia National Laboratories. Original 300-dpi OSTI version available at: http://chaninconsulting.com/downloads/sand96-0957.pdf (10.4 MB), OCR-readable courtesy S. Aftergood, FAS, E-12.

[35] Ibid, 5-8, E-1, E-3, E-4, E-8, E-11

A reasonable question is why the MACCS2 code, NRC and Japanese authorities assume hosing and plowing under fields was cleanup. The likely, and unacceptable, answer is that the needed technologies for cleanup have not been developed - their development is predicted to be decades down the road - and the that cost of actually removing all of the contamination too big to even think about - far more than the $14 billion budgeted through 2014 by the Japanese government. However, the fact that the cost of any real clean-up is unimaginable is no excuse for the NRC pretending it isn't real and not requiring modeling it in NRC approved economic analysis.

The Faulty Premise of the NRC's Clean-Up Model[36]

The MACCS2 economic consequence analysis is based on WASH-1400; and WASH-1400, in turn, was based on clean up after a nuclear explosion Cleanup after a nuclear bomb explosion is not comparable to clean up after a nuclear reactor accident and assuming so will underestimate even the limited costs that the NRC economic analysis takes into consideration.

Particle Size: Nuclear weapon explosions result in larger-sized radionuclide particles; reactor accidents release small sized particles. Decontamination is far less effective, or even possible, for small particle sizes. Nuclear reactor releases range in size from a fraction of a micron to a couple of microns; whereas nuclear bomb explosions fallout is much larger- particles that are ten to hundreds of microns. These small nuclear reactor releases get wedged into small cracks and crevices of buildings making clean up extremely difficult or impossible. Further reactors release Cs-137 that are no only small particles but soluble. Cesium particles are capable of ion exchange with sodium and potassium in materials such as concrete and migrate over time into the interior and cannot be washed off. Plutonium on the other hand is insoluble.

Mass Loading: Nuclear weapon explosions result in fallout involving large mass loading where there is a small amount of radioactive material in a large mass of dirt and demolished material. Only the bottom layer is in contact with the soil and the massive amount of debris could be shoveled, swept up with brooms or vacuums resulting in a relatively effective, quick and

[36] Chanin, D.; Murfin, W. (1996). *Site Restoration: Estimation of Attributable Costs from Plutonium-Dispersal Accidents*, SAND96-0957, DE9601166, Sandia National Laboratories. Original 300-dpi OSTI version; NYS000241, December 21, 2011, Pre-filed written testimony of Dr. Francois J. Lemay, NYS Contention 12-C,

cheap cleanup that would not be the case with a nuclear reactors fine particulate. The Japanese are learning this the hard way, as those in Chernobyl before had discovered.

Type Radiation Released: In addition, a weapon explosion results in non-penetrating radiation so that workers only require basic respiration and skin protection. This allows for cleaning up soon after the event. In contrast a reactor release involves gamma radiation and there is no gear to protect workers from gamma radiation. Therefore cleanup cannot be expedited, unless workers health shamefully and unethically is ignored. Decontamination is less effective with the passage of time.

Clean-up Standard

How clean is clean (the cleanup standard) will determine the cost of cleanup and public acceptance. Currently the NRC and EPA have not agreed on a cleanup standard.[37] The potential standard ranges from 15 mrem/yr to 5 rem/yr. The General Accounting Office (GAO) agrees that the difference in current EPA and NRC cleanup standards have implications for both the pace and ultimate cost of cleanup.[38] It is not possible to talk about economic consequence analyses absent pre-set cleanup standards.

Likewise, firm standards were not pre-set in Japan prior to the accident. Real world experience there shows that the public will not tolerate a relaxed standard. The public expects cleanup to reach pre-accident levels.[39] The same will be true here.

The economic consequences of a radiological event are highly dependent on cleanup standards and cleanup costs generally increase dramatically for standards more stringent than 500 mrem/yr. This was shown true by two studies commissioned by the US Department of Homeland Security for the economic consequences of a Rad/Nuc attack. Although considerably

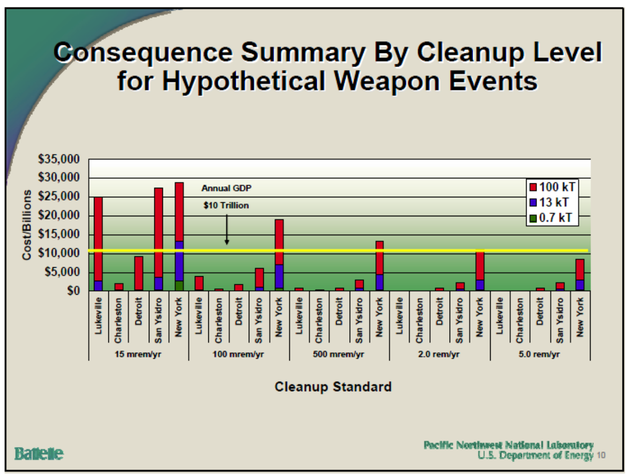
[37] See Pilgrim Watch's Request For Hearing On New Contention; the information upon which this contention is available from a trade publication INSIDE EPA; please see report and supporting documents at http://environmentalnewsstand.com/Environmental-NewsStand-General/Public-Content/agencies-struggle-to-craft-offsite-cleanup-plan-for-nuclear-power-accidents/menu-id-608.html

[38] GAO, "Radiation Standards Scientific Basis Inconclusive, and EPA and NRC Disagreement Continues," June 2004

[39] *In One Japanese City, Hot Spots to Avoid*, Wall Street Journal, Phred Dvorak, Sept 3, 2011

more deposition would occur in reactor accident, magnifying consequences and costs, there are important lessons to be learned from these studies.

Barbara Reichmuth's study, Economic Consequences of a Rad/Nuc attack: Cleanup Standards Significantly Affect Cost, 2005,[40] Table 1 Summary Unit Costs for D &D (Decontamination and Decommissioning) Building Replacement and Evacuation Costs provides estimates for different types of areas from farm or range land to high density urban areas. Reichmuth's study also points out that the economic consequences of a Rad/Nuc event are highly dependent on cleanup standards: "Cleanup costs generally increase dramatically for standards more stringent than 500 mrem/yr."



A similar study was done by Robert Luna, *Survey of Costs Arising from Potential Radionuclide Scattering Events*,[41] concluded that,

> …the expenditures needed to recover from a successful attack using an RDD type device …are likely to be significant from the standpoint of resources available to local or state governments Even a device that contaminates an area of a few hundred acres (a square kilometer) to a level that requires modest remediation is likely to produce costs ranging from $10M to $300M or more depending on the intensity of

[40] Economic Consequences of a Rad/Nuc attack: Cleanup Standards Significantly Affect Cost Barbara Reichmuth, Steve Short, Tom Wood, Fred Rutz, Debbie Swartz, Pacific Northwest National laboratory, 2005

[41] Survey of Costs Arising From Potential Radionuclide Scattering Events, Robert Luna, Sandia National laboratories, WM2008 Conference, February 24-28, 2008, Phoenix AZ

commercialization, population density, and details of land use in the area." (Luna, Pg., 6)

EPA's Draft PAG[42]

How clean is clean has a huge impact on economic consequences. Standards should, but are not based on the National Academy of Sciences BEIR VII report and neither do they incorporate other recent studies showing more, not less, health consequences from lower levels of exposure.

EPA issued (April 15, 2013) its new Protective Action Guides (PAGs) for dealing with radioactive releases. The PAGs eliminate requirements to evacuate people when thyroid or skin radiation doses exceed certain levels, lift a lifetime limit on radiation from such an event that would have triggered relocation, recommend dumping radioactive waste in municipal garbage dumps not designed for such waste, and propose five options for drinking water, all of which would dramatically increase the permitted concentrations of radioactivity in drinking water, by as much as 27,000 times.

Overall the PAGS base cleanup on economics not as they should on health effects. Clean is as clean as we are willing to pay for or can achieve. Highlights of what is wrong with the PAGS and how EPA is abdicating its responsibility to protect public health include, for example:

1. EPA eliminates the existing requirements from the 1992 PAGs triggering evacuation when thyroid or skin doses exceed specified limits.
2. EPA eliminates the existing relocation limit of 5 rem cumulative dose over 50 years, saying it might conflict with their long-term cleanup approach, which in the new associated guidance from NCRP would allow cumulative 50-year doses of 100 rem, twenty-fold higher. <u>Even thirty years exposure at the 2 rem/year figure would, by EPA's own official risk estimates, result in an excess cancer in every eighth person exposed</u>; orders of magnitude higher risk than EPA has ever considered acceptable.
3. EPA incorrectly argues that relaxed long-term standard is somehow justified because the public's exposure will not be for 70 years. But this is a disingenuous argument. The core

[42] See, for example, Pilgrim Watch Comments (07.15.13); Committee to Bridge the Gap Comments

of the long-term cleanup part of the PAGs is setting a very high permissible annual dose that one would be allowed to get for a whole lifetime (indeed, the standard 70 year lifetime assumption) without the government having to cleanup at all. The one-year exposure is for the intermediate phase; the long-term phase is forever, and that is what is so troubling about relaxing long-term cleanup standards.

4. EPA says that the Safe Drinking Water Act Maximum Contaminant Limits (MCLs) may not be appropriate and propose five alternatives far more lax, and does so in footnotes. Those proposed weaker limits would allow concentrations of radionuclides in drinking water orders of magnitude higher than considered safe by EPA under the Safe Drinking Water Act. I have attached two tables Dr. Hirsch put together comparing these levels for four key radionuclides. Their proposals are frequently as bad as the Bush water PAG proposal and in some cases worse. Generally, they are proposing allowing hundreds to tens of thousands of times higher concentrations of radioactivity in drinking water than EPA has historically allowed as safe under the Safe Drinking Water Act.

Obama Drinking Water PAG proposals vs. Existing EPA Safe Drinking Water Levels and Bush Administration PAG Proposal
units = Bq/L

Radionuclide	EPA Safe Drinking Water Act Maximum Contaminant Limit (MCL)	Bush Proposed Drinking Water PAG	Obama Proposed Drinking Water Page Alternative I (EPA 2013 fn 26)	Obama Proposed Drinking Water PAG Alternative II (EPA 2013 PAG fn 25)	Obama Proposed Drinking Water PAG Alternative III (EPA 2013 PAG fn 27)	Obama Proposed Drinking Water Alternative IV (EPA 2013 PAG fn 24a)	Obama Proposed Drinking Water Alternative V (EPA 2013 PAG fn 24b)
Iodine-131	0.111	314	314	3000	170	10	300
Strontium-90	0.296	246	246	200	160	10	
Cesium-137	7.4	503	503	2000	1200	10	
Plutonium-239	0.555	27	27	50	2	1	

Factors by Which Obama Drinking Water PAG Proposals Would Exceed Existing EPA Safe Drinking Water Levels

Radionuclide	Bush Proposed Drinking Water PAG	Obama Proposed Drinking Water Page Alternative I (EPA 2013 fn 26)	Obama Proposed Drinking Water PAG Alternative II (EPA 2013 PAG fn 25)	Obama Proposed Drinking Water PAG Alternative III (EPA 2013 PAG fn 27)	Obama Proposed Drinking Water Alternative IV (EPA 2013 PAG fn 24a)	Obama Proposed Drinking Water Alternative V (EPA 2013 PAG fn 24b)
Iodine-131	2829	2829	27027	1532	90	2703
Strontium-90	828	828	676	541	34	
Cesium-137	68	68	270	162	1.35	
Plutonium-239	49	49	90	3.6	1.8	

Note: Second vertical column, "Obama proposed Drinking Water Page" should read PAGs not Page

5. EPA incorporates 1998 guidance allowing extremely high contamination of food, despite internal EPA criticism of doing so which said it would produce a cancer in every fiftieth person so exposed.
6. EPA incorporates the DHS PAGs for dealing with long-term cleanup from a nuclear weapons explosion and applies it to any kind of release. The DHS PAG is based on "optimization" and contemplated permitting long-term doses as high as several rem per year. The new PAG is tied to the NCRP new guidance which would allows doses up to 2 rem per year over a lifetime (the equivalent of about 1000 extra chest X-rays every year, or 3 X-rays every day of your life from birth to death). EPA's estimate of a 70-year lifetime exposure at that level would be one in every six people exposed would get a cancer (the risk coefficient they use is different for exposure over a lifetime than for earlier years because of the elevated risk at younger ages
7. The associated NCRP guidance on implementing the PAGs for long term cleanup recommends radionuclide concentration levels so high that they would allow concentrations for strontium-90, for example, hundreds of thousands of times higher than the EPA's official Preliminary Remediation Goals for the same exposure scenarios. They would produce cancer risks using EPA's risk figures in the several cancers per ten people exposed, orders of magnitude outside the long-held acceptable risk range.
8. In essence, the PAGs and the documents associated with them are saying nuclear power accidents could be so widespread and produce such immense radiation levels that the government would simply abandon most cleanup obligations and force people to live with exposures so high that extremely large fractions of the exposed population would get cancer from the exposure.
9. Troubling in a different fashion, EPA buries the “bad stuff” in footnote references to a whole series of other documents so it is hard for a lay reader to see the troubling things EPA has done. EPA thereby has made the PAG manual itself essentially useless in a real accident. It was supposed to be a stand-alone, clear document that a first-responder could take off the shelf, look up a table in it, see if a radiation level exceeded a PAG and if so undertake the protective action described therein. But all of that is now removed from the PAG document. Instead, there are footnotes to URLs for numerous referenced

documents, most of which are contradictory, so that the PAG does not achieve its intention that is to be useful in providing some guidance.

Furthermore, EPA is statutorily mandated to produce the PAGs and other radiation guidance for the rest of the federal family and historically has viewed DOE and NRC as not sufficiently protective in radiation matters. The PAG now abdicates EPA's responsibility to come up with guidance and instead references almost exclusively documents from DOE that EPA has historically opposed. For example, it now directs the use of DOE's Operational Guidance document which uses cleanup concentrations hundreds of thousands of times higher than EPA's official concentrations. Rather than use its own conversions from concentration to risk, EPA now defaults to DOE's models, documents, and values with which it has long disagreed as technically not defensible and not sufficiently protective. But at the end of the day, no emergency responder will have a Protective Action Guide that is useable. If it were used, however, it would allow doses to the public so far outside the range ever considered acceptable as to be deeply disturbing.

Although public comments are supposedly being solicited, EPA has made the PAGs immediately effective, making the comment opportunity pretty meaningless.

K. MACCS2 CODE

The MELCOR Accident Consequence Code System (MACCS2) computer program is used by industry with NRC's approval. The MACCS2 code, and its predecessor the MACCS code, were developed for research purposes not licensing purposes –for that reason they were not held to the QA requirements of NQA-a (American Society of Mechanical Engineering, QA Program Requirements for Nuclear Facilities, 1994). Rather they were developed using following the less rigorous QA guidelines of ANSI/ANS 10.4. [American Nuclear Standards Institute and American Nuclear Society, *Guidelines for the Verification and Validation of Scientific and Engineering Codes for the Nuclear Industry*, ANSI/ANS 10.4, La Grange Park, IL (1987). The code is not Quality Assured.[43]

[43] Chanin, D.I. (2005), "The Development of MACCS2: Lessons Learned," [written for:] *EFCOG Safety Analysis Annual Workshop Proceedings*, Santa Fe, NM, April 29–May 5, 2005. Full text: the development of maccs2.pdf (154 KB), revised 12/17/2009. http://chaninconsulting.com/index.php?resume.

David Chanin, who wrote the FORTRAN for the MACCS2, is clear that the code does not provide useful economic cost information:[44]

> If you want to discuss economic costs … the 'cost model' of MACCS2 is not worth anyone's time. My sincere advice is to not waste anyone's time (and money) in trying to make any sense of it." (and) "I have spent many many hours pondering how MACCS2 could be used to calculate economic costs and concluded it was impossible."

Prior to Fukushima, parties in license renewal adjudications showed that the MACCS2 severely minimized costs and required updating - for example, the license renewal adjudication proceedings at Pilgrim (Pilgrim Watch) Indian Point (New York State) and Seabrook (NECNP).

Real-world experiences from Japan confirm that the cost formula and assumptions contained in the MACCS2 underestimate the costs likely to be incurred as a result of a severe accident. Many are discussed in the foregoing discussion - incorrect assumptions regarding the probability of a core damage events, spent fuel pool events and amount of Cs-137 released from the core; assuming that only atmospheric releases (and not aqueous releases) are consequential and that the plume moves in a straight line; assuming that accidents are over in a day or less; and assuming that cleanup and decontamination can be readily accomplished and waste disposal ignored.

There are other fundamental deficiencies in the code, including incorrect assumptions regarding health costs and evacuation time estimates, and what economic variables are necessary to include. And equally important is the fact that the NRC has allowed to use licensees to manipulate their use in the code for no reason other than to reduce that the licensees will be required to do to avoid another Fukushima.

Health Costs & Evacuation Time Estimates

The health costs resulting from a severe accident directly depend on who was exposed and for how long, and the latter in turn depends on whether evacuation was timely and successful.

[44] Pilgrim watch Answer Entergy's Summary Disposition, Contention 3- Exhibit, David Chanin Affidavit, NRC Electronic library, Adams Accession Number ML071980073 (June 9, 2007)

Evacuation Time Estimates (ETEs): With no apparent complaint from the NRC, licensees consistently use faulty, in some cases almost ludicrous, assumptions about who should evacuate and how long it will take them (to say nothing of the far greater number of individuals who will, and in many cases probably should, try) to evacuate. If realistic evacuation times and assumptions regarding evacuation are not used; if they were, analyses would show far fewer will evacuate in a timely manner, and the inevitable result will be increased health-related costs.

The standard KLD time estimates used are based on NUREG/CR-7002 and telephone surveys; neither Sandia's nor industry's telephone surveys inform the respondent that the questions pertain to a nuclear reactor accident. These documents contain multiple incorrect assumptions. Examples include: the population will follow a staged evacuation ignoring the public's almost instant ability to communicate; a straight-line Gaussian plume defines the evacuation "key-hole" where the public knows winds are variable and will act accordingly; and there will only be a 20% shadow evacuation out to 15 miles from reactor and the rest of the population will not attempt to evacuate disproved by real-world experience such as TMI and Graniteville. The telephone surveys regarding evacuation used to justify these assumptions were carefully designed not to tell the responders why evacuation might be ordered. Responders were not told the survey was for a nuclear reactor accident. The public responds differently in a nuclear disaster than a storm.

Further the KLD's do not take into consideration the many variables that would slow evacuation: shadow evacuation; evacuation time estimates during inclement weather coinciding with high traffic periods such as commuter traffic, traffic during peak commute times, holidays, summer beach/holiday traffic; notification delay delays because notification is largely based on sirens that cannot be heard indoors above normal ambient noise with windows closed or air conditioning systems operating.

Health Effects Radiation: Having artificially reduced the potential number of potentially effected (not only through inaccurate evacuation times but also by assuming that only those in a small geographic areas will potentially be effected and only for a short time), the NRC economic consequences analysis goes on intentionally to further underestimate the cost, not only in dollars but also in human suffering.

The effects of radiation exposure on public health after an accident rarely are immediately evident. The latency period for cancers, diseases and reproductive disorders extends over many years. Lessons learned from previous accidents and the most recent report by the National Academies of Sciences (**BEIR VII), and studies by Cardis and the Techna River Cohort**, all show that the assumptions in the MACCS2 concerning health impact are outdated and underestimate health effects.

1. Value of Life: NRC value assigned to life is far lower than other federal agencies. Other agencies value life at $ 5-9 million. For example EPA values a life lost at $6.1 million (U.S.E.P.A., 1997, The Benefits and Costs of the Clean Air Act, 1970 to 1990, Report to US Congress (October), pages 44-45). The GAO reported that it is hard to justify below $5 million whereas NRC remains at $3 million. If NRC raised its valuation then more retrofits would be justified.

2. $2000/person-rem conversion rate: The population dose conversion factor of $2000/person-rem used by licensees in the code, and allowed by NRC, to estimate the cost of the health effects generated by radiation exposure is based on a deeply flawed analysis and seriously underestimates the cost of the health consequences of severe accidents.

This conversion factor is inappropriate. It does not take into account the significant loss of life associated with early fatalities from acute radiation exposure that could result from some severe accident scenarios. Neither does it properly estimate the generation of stochastic health effects by failing to take into account the fact that some members of the public exposed to radiation after a severe accident will receive doses above the threshold level for application of a dose- and dose-rate reduction effectiveness factor (DDREF).

The NRC approved $2000/person-rem conversion factor is apparently intended to represent the cost associated with the harm caused by radiation exposure with respect to the causation of "stochastic health effects," that is cancers and not deterministic effects, commonly known as radiation sickness[45] The value was derived by NRC staff by dividing the Staff's estimate for the value of a statistical life, $3 million (presumably in 1995 dollars, the year the analysis was published) by a risk coefficient for stochastic health effects from low-level radiation of $7x10^{-}$

[45] U.S. Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, "Reassessment of NRC's Dollar Per Person-Rem Conversion Factor Policy," NUREG-1530, 1995, p. 12.

^{4}/person-rem, as recommended in Publication No. 60 of the International Commission on Radiological Protection (ICRP). (This risk coefficient includes nonfatal stochastic health effects in addition to fatal cancers.) But the use of this conversion factor in SAMA analyses is inappropriate in two key respects and as a result underestimates the health-related costs associated with severe accidents.

First, the $2000/person-rem conversion factor is specifically intended to represent only stochastic health effects (e.g. cancer), and not deterministic health effects "including early fatalities which could result from very high doses to particular individuals."[46] However, for some of the severe accident scenarios evaluated, large numbers of early fatalities could occur representing a significant fraction of the total number of projected fatalities, both early and latent. This is consistent with the findings of the Generic Environmental Impact Statement for License Renewal of Nuclear Plants (NUREG-1437).[47] Therefore, it is inappropriate to use a conversion factor that does not include deterministic effects. According to NRC's guidance, "the NRC believes that regulatory issues involving deterministic effects and/or early fatalities would be very rare, and can be addressed on a case-specific basis, as the need arises."[48] How for example can this be justified in a spent fuel pool fire accident?

Second, the $2000/person-rem factor, as derived by NRC, also underestimates the total cost of the latent cancer fatalities that would result from a given population dose because it assumes that all exposed persons receive dose commitments below the threshold at which the dose and dose-rate reduction factor (DDREF) (typically a factor of 2) should be applied. However, for certain severe accident scenarios considerable numbers of people would receive doses high enough so that the DDREF should not be applied.[49] This means, essentially, that for those individuals, a one-rem dose would be worth "more" because it would be more effective at cancer induction than for individuals receiving doses below the threshold. To illustrate, if a group of 1000 people receive doses of 30 rem each over a short period of time (population dose 30,000 person-rem), 30 latent cancer fatalities would be expected, associated with a cost of $90 million, using NRC's estimate of $3 million per statistical life and a cancer risk coefficient of $1x10^-$

[46] U.S. NRC (1995), op cit., p. 1.
[47] U.S. NRC, Generic Environmental Impact Statement for License Renewal of Nuclear Plants, NUREG-1437, Vol. 1, May 1996, Table 5.5.
[48] U.S. NRC, "Reassessment of NRC's Dollar Per Person-Rem Conversion Factor Policy (1995), op cit., p. 13.
[49] The default value of the DDREF threshold is 20 rem in the MACCS2 code input

[3]/person-rem. If a group of 100,000 people received doses of 0.3 rem each (also a population dose of 30,000 person- rem) a DDREF of 2 would be applied, and only 15 latent cancer fatalities would be expected, at a cost of $45 million. Thus a single cost conversion factor, based on a DDREF of 2, is not appropriate when some members of an exposed population receive doses for which a DDREF would not be applied.

A better way to estimate the cost equivalent of the health consequences resulting from a severe accident would be simply to sum the total number of early fatalities and latent cancer fatalities, as computed by the MACCS2 code, and multiply by not a $3 million figure but a higher life valuation, in line with other federal agencies. It is not reasonable to distinguish between the loss of a "statistical" life and the loss of a "deterministic" life when calculating the cost of health effects. The NRC does so. Why? The only apparent reason is to save the industry money.

3. Health Impacts Ignored: Wrongly, the NRC analysis does not even consider cancer incidence. Neither does it consider many other potential health effects from exposure in a severe radiological event (National Academy of Sciences, BEIR VII Report, 2005).

4. Recent Studies Ignored: The NRC's SAMA analyses need to be based on current research. Recent studies published on radiation workers (Cardis et al. 2005[50]) and by the Techa River cohort (Krestina et al (2005[51]) show a marked increase in the value of cancer mortality risk per unit of radiation at low doses (2-3 rem average). Both studies give similar values for low dose, protracted exposure, namely (1) cancer death per Sievert (100 rem). Using the results of the study by Cardis et al. and use of the risk numbers derived from the Techa River cohort a number of additional SAMAs would become cost effective.

5. Indirect health costs ignored: They include, for example, medical expenditures for treatment, losses in time and economic productivity, liability resulting from radiation health related illness and death, and caregivers evacuating and leaving patients unattended, as at Fukushima. All of these are economic consequences.

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[50] Elizabeth Cardis, "Risk of cancer risk after low doses of ionising radiation: retrospective cohort study in 15 countries." *British Medical Journal* (2005) 331:77. Referenced Beyea

[51] Krestinina LY, Preston DL, Ostroumova EV, Degteva MO, Ron E, Vyushkova OV, et al. 2005.Protracted radiation exposure and cancer mortality in the Techa River cohort. Radiation Research 164(5):602-611.

Other Economic Consequences

Lessons learned from Fukushima demonstrate that the MACCS2's assumptions of what economic variables to model are too limited and serve to underestimate offsite economic consequences**.** In addition to those already discussed, any realistic analysis of economic consequences would have to consider the following.

1. Indirect economic effects or the "multiplier effects ignored:" Depending on the business done inside the building contaminated, the regional and national economy could be negatively impacted. A resulting decrease in the area's real estate prices, tourism, and commercial transactions could have long-term negative effects on the region's economy.

2. Economic infrastructure ignored: The MACCS2 considers the costs of farm and non-farm decontamination and the value of farm and nonfarm wealth; however, nowhere in the economic consequences analysis is there any discussion of the loss of, and costs to remediate the economic infrastructure that make business, tourism and other economic activity possible. Economic infrastructure is the basic physical and organizational structures needed for the operation of a society or enterprise, or the services and facilities necessary for an economy to function. The term typically, and as used by PW, refers to the technical structures that support a society, such as roads, water supply, sewers, power grids telecommunications, and so forth. Viewed functionally, infrastructure *facilitates* the production of goods and services; for example, roads enable the transport of raw materials to a factory, and also for the distribution of finished products to markets. Also, the term may also include basic social services such as schools and hospitals

3. Other economic costs ignored: The economic consequences should, but does not, include the business value of property and the incurred costs such as costs required from job retraining, unemployment payments, and inevitable litigation. Further, one of the cited general criticisms of the MACCS2 Code is that "the economic model included in the code models only the economic cost of mitigative actions.[52]"

4. Discount Rate: Discount rates make sense for marketable goods-not all consequences will occur soon after the event; however for non-marketable goods, such as health effects or

[52] 1997 MACCS2 User Guide

environmental damage a much reduced rate makes more sense for medium term and an even lower or no discount rate at all for effects appearing far into the future[53].

Manipulating the Code

In order to ensure realistic cost-benefit analyses, the NRC cannot continue to allow as a matter of policy licensees to choose how they will use the MACCS2 code. Section 6.10 of the 1997 User Guide, Generation of Consequence Distributions, explains. It says, "Under the control of parameters supplied by the user on the EARLY and CHRONC input files, the EARLY and CHRONC modules can calculate a variety of different consequence measures to portray the impact of a facility accident on the surrounding region. *The user has total control over the results that will be produced.*"[54] (Emphasis added)

Because the licensee is a business, its focus is on both the bottom line and dispelling public fear of nuclear power; therefore, the licensee will use its "control over the results that will be produced" to minimize offsite consequences/costs. It is NRC's responsibility to fulfill its legal obligation to protect public health, safety and property to take control.

Examples User Control of Inputs Minimizing Consequences

- **Clean-up Economic Costs:** New York States Contention 12-C expert, Dr. Francois Lemay reviewed applicants SAMAs in license renewal and found that all used values derived from Sample Problem A. Those values do not account for site specific circumstances and underestimate costs.[55] The underestimation of costs is primarily due to Sample Problem A's input values for the CHRONC Module. The underestimation is mostly due to costs and times for decontamination that were unrealistic given what is currently known about decontamination data and the complexities of an urban and hyper-urban area such as that

[53] Crick, M.J., Hofer, E.., Hayward, S.M., (1988), Uncertainty analysis of the foodchain and atmospheric dispersion modules of MARC, NRPB-R184
[54] User Guide for MACCS2, the Code Manual for MACCS2: Volume 1, User's Guide, SAND97-0594, which was written in 1997. Chanin, D.I., and M.L. Young, Code Manual for MACCS2:Volume 1, User's Guide, SAND97-0594 Sandia National Laboratories, Albuquerque, NM, (1997)
[55] NYS000241, December 21, 2011, Pre-filed written testimony of Dr. Francois J. Lemay, NYS Contention 12-C, pg., 63-70

surrounding Indian Point and many other reactors that are now located near densely populated areas. To illustrate from Lemay's Testimony:

Table 13: Summary of ISR proposed inputs and calculated OECRs (costs in 2005 USD)

Parameter	Description	Entergy's value	ISR's proposed input value		ISR's calculated OECR ($/yr) and ratio*	
			Minimum	Maximum	Minimum	Maximum
CDNFRM (DF=3)	Per capita cost of nonfarm light decontamination	$5,184	$19,000	$272,000	4.21E+05 (1.99)	1.25E+06 (5.88)
CDNFRM (DF=15)	Per capita cost of nonfarm heavy decontamination	$13,824	$90,000	$898,000		
TIMDEC (DF=3)	Time required for light decontamination	60 d	2 y	15 y	6.44E+05 (3.04)	1.20E+06 (5.66)
TIMDEC (DF=15)	Time required for heavy decontamination	120 d	4 y	30 y		
VALWNF	Per capita value of nonfarm wealth (2004 USD)	$208,838	$284,189		2.51E+05 (1.18)	
DPRATE	Depreciation rate	20%	20%		2.12E+05 (1.00)	
DSRATE	Societal discount rate for property	12%	5%	7%	1.87E+05 (0.88)	1.95E+05 (0.92)
POPCST	Per capita cost of long-term relocation	$8,640	$10,640	$49,857	2.23E+05 (1.05)	4.41E+05 (2.08)
FRNFIM	Nonfarm wealth improvements fraction	80%	90%		2.19E+05 (1.03)	
Using all of ISR's proposed input values					**9.07E+05 (4.28)**	**1.47E+06 (6.96)**

Notes: * The ratio shown in brackets is the ratio of the ISR-calculated OECR to the Entergy-calculated OECR ($2.12E+05/yr).

Q: If all of the ISR proposed inputs are used, what is the effect on the OECR?

A: The OECR is determined to be between 4 and 7 times the currently calculated Entergy value of $212,000/year.

Q. Does this conclude your testimony?

A. Yes.

Pre-filed Written Testimony of François J. Lemay Consolidated Contention NYS-12-C

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- **Meteorological Inputs**: PW discussed in the foregoing a fundamental defect in the MACCS2 code is that its meteorological inputs to the code are all based on the straight-line Gaussian plume model. This model does not allow consideration of the fact that the winds for a given time period may be spatially varying. The 1997 User Guide for MACCS2, SAND 97-0594[56] makes a related point: "The atmospheric model included in the code does not model the impact of terrain effects on atmospheric dispersion." Indeed, the MACCS2 Guidance Report, June 2004,[57] is even clearer that inputs to the code do <u>not</u> account for

[56] Chanin, D.I., and M.L. Young, Code Manual for MACCS2:Volume 1, User's Guide, SAND97-0594 Sandia National Laboratories, Albuquerque, NM, (1997)
[57] MACCS2 Guidance Report June 2004 Final Report page 3-8:3.2 Phenomenological Regimes of Applicability

variations resulting from *site-specific* conditions. (1)The "code does not model dispersion close to the source (less than 100 meters from the source);" thereby ignoring resuspension of contamination blowing offsite. (2) The code "should be applied with caution at distances greater than ten to fifteen miles, especially if meteorological conditions are likely to be different from those at the source of release." There are large potentially affected population concentrations more than 10-15 miles from reactor sites. (3) "Gaussian models are inherently flat-earth models, and perform best over regions where there is minimal variation in terrain." What sites if any are located in flat-earth sites?

Matters are made worse by leaving the choice of input parameters to the user. Users may choose to leave input meteorological data for only a single year and using precipitation data was collected from a *single, on-site* weather station. [Example Pilgrim Application ER, E.1.5.2.6] One year of data is insufficient; seasonal wind distributions can vary greatly from one year to the next and "*The NRC staff considers 5 years of hourly observations to be representative of long-term trends at most sites*[58]. Further, the simple fact is that measurements from a single onsite anemometer will not provide sufficient information to project how an accidental release of a hazardous material would travel.

- **Averaging:** The licensee conducts SAMA analyses. The NRC does not, and as far as can be told it does not even have the ability to insure than a licensee's analysis is correct. The outcome of a SAMA analysis, controlled by the licensee, is functionally dependent on the statistical input parameters chosen by the licensee.[59]

  The MACSS2 consequence code has 3 modules. The ATMOS module computes the dispersal pattern of radionuclides as a function of downwind distance using a Gaussian plume model. The EARLY module utilizes the radionuclide dispersal data generated by ATMOS, together with additional user-specified data, to calculate individual and collective radiation doses and associated health impacts to the affected population resulting from "early" exposures; e.g. those occurring within a user-specified period after the radionuclide release, usually a week. The CHRONC module utilizes the same inputs from the ATMOS

[58] NRC Regulatory Guide 1.194, 2003
[59] See Declaration of Edwin S. Lyman, PhD. Regarding the Mechanics of Computing Mean Consequences in SAMA Analyses, November 22, 2010.

module as EARLY, but calculates doses and other consequences resulting from exposures subsequent to the emergency-phase period evaluated by EARLY. The CHRONC considers doses resulting from groundshine, resuspension, and consumption of contaminated food and water.

CHRONIC also contains features designed to assess the economic consequences of radiological releases, and models intermediate and long-term protective actions (decontamination, interdiction, condemnation) that can affect both chronic radiation doses and economic costs. The Output file "averages" consequences from EARLY and CHRONC and **permits the user to "average" using any one of several percentiles**, including "mean," 90^{th} percentile, and 95^{th} percentile. It is then necessary for the SAMA analysis to determine which statistical parameter should be used as input into the SAMA analysis: e.g., the mean, the median or the 95^{th} percentile. Once this input parameter is chosen, then the population dose-risks and off-site economic dose risks can be calculated, summed and compared to the costs of mitigative measures. The choice of statistical input parameter determines the level of protection which mitigative measures would be expected to provide.

Dr Lyman in an affidavit for Pilgrim Watch explained that, "A choice of 95^{th} percentile, for example, means that mitigative measures would be considered cost-beneficial if they were no more expensive than the value of the averted risk to the public from a severe accident for 95 percent of the meteorological conditions expected to occur over the course of a year. In contrast, use of the mean consequences would imply that measures would be cost-beneficial if they were no more expensive than the (significantly lower) value of the averted risk to the public for an accident occurring under average meteorological conditions. This is analogous to the situation of a homeowner who is considering whether to spend the money to install windows to protect against a 20-year storm or just an average storm.

III. CONCLUSION

The foregoing shows that the regulatory framework needs to be changed. Without change, the NRC's and industry's analysis of the economic consequences of a severe accident will

continue to significantly minimize the consequences from a severe accident so that the retrofits needed are not cost justified, and the likelihood of an accident will remain far higher than it should be.

The lessons that should be learned from Fukushima make obvious not only the need for change, but also the magnitude by which the current model's minimization of costs unacceptably fails to require many SAMAs that would be cost effective if the described defects in the analyses were addressed. In *Duke Energy Corp.*, at 13, the board said that "[w]hile NEPA does not require agencies to select particular options, it is intended to 'foster both informed decision-making and informed public participation, and thus to ensure the agency does not act upon incomplete information, only to regret its decision after it is too late to correct' (*citing Louisiana Energy Services* (Claiborne Enrichment Center), CLI-98-3, 47 NRC 77, 88 (1998))." It then said "if 'further analysis' is called for, that in itself is a valid and meaningful remedy under NEPA."

The fundamental deficiencies in the NRC approved economic consequence analysis require that the regulatory framework itself must be changed. Unless they are changed, none of the recommendations from the Lessons Learned Task Force will ever be implemented. Because the guidelines for how the NRC and industry will conduct backfitting cost-benefit analyses are rooted in *pre-Fukushima* assumptions, there is little or no chance that any analysis based on the current economic consequences assumptions and methodologies will show that any possible offsite consequences are greater than the cost of the backfit.

Dr. Edwin Lyman, Senior Scientist at the Union of Concerned Scientists summarized it well:[60]

> One might think, therefore, that the NRC should modify its cost-benefit analysis guidelines to incorporate lessons learned from Fukushima *before* using such an analysis to assess the costs and benefits of the other recommended upgrades to safety requirements. Indeed, the Near Term Task Force considered development of a new post-Fukushima regulatory framework to be its top recommendation.
>
> However, the Commission ordered the staff to put such an effort on the back burner, effectively leaving it to be resolved only *after* all the other recommendations had

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[60] Going in Circles, Dr. Edwin Lyman, Union Concerned Scientists, December 22, 2011. http://allthingsnuclear.org/nrcs-post-fukushima-response-going-in-circles/#

been addressed. This has created a pattern of circular reasoning that could endanger the implementation of all the other proposed actions, and could leave the NRC chasing its tail for years to come.

Respectfully Submitted,

(Electronically signed)

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