- - - Working Review Draft Report #2 - - -
April 6, 2006

EPA-SAB-RAC-06-xxx

The Honorable Stephen L. Johnson
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, DC 20460

Subject: Review of Agency Draft entitled *"Expansion and Upgrade of the RadNet Air Monitoring Network, Vol. 1 &2, Concept and Plan,"* 2005

Dear Administrator Johnson:

The Radiation Advisory Committee's (RAC) RadNet Review Panel of the Science Advisory Board has completed its review of the Agency's draft entitled *"Expansion and Upgrade of the RadNet Air Monitoring Network, Vol. 1 &2, Concept and Plan,"* dated 2005.

The Panel commends the Agency ….. (continue) ……

The Panel recommends …… (continue) ……

The Panel finds that there is a need to …….(continue) ……

Text to be provided at a later date.

In summary, the SAB finds that the draft entitled *"Expansion and Upgrade of the RadNet Air Monitoring Network, Vol. 1 &2, Concept and Plan,"* dated 2005 is an important document that ….. (continue)…..

The Panel appreciates the opportunity to review this draft document. We hope that the recommendations contained herein will enable EPA to enhance the RadNet Air Monitoring Network and ensure its essential service to the public. We look forward to your response to the recommendations contained in this Advisory, and in particular to the items raised in this letter to you.

Sincerely,

Dr. M. Granger Morgan Dr. Jill Lipoti

Chair	Chair, RAC RadNet Review Panel
Science Advisory Board	Science Advisory Board

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2. INTRODUCTION

2.1 Background

RadNet is the United States' only comprehensive network for monitoring radioactivity and ionizing radiation in the environment with more than 200 sampling stations nationwide. Since its inception in 1973, RadNet (formerly known as the Environmental Radiation Ambient Monitoring System (ERAMS) has continuously monitored multiple media, including air precipitation, surface water, drinking water, and milk. EPA is proposing a plan for upgrading and expanding the air monitoring component of RadNet. The plan is designed to go beyond the original mission of providing information on nuclear or radiological accidents. The mission now includes homeland security concerns and the special problems posed by possible intentional releases of radiation to the nation's environment.

EPA's plan proposes additional and updated air monitoring equipment with more monitoring stations, both of which will provide greater flexibility in responses to radiological and nuclear emergencies, significantly reduced response time, and improved processing and communication of data. The ultimate goal of RadNet air monitoring is to provide timely, scientifically sound data and information to decision makers and the public.

Formal planning for RadNet began in the mid 1990's when the Office of Radiation and Indoor Air (ORIA) initiated a comprehensive assessment of RadNet to determine if the system was meeting its objectives and if the objectives were still pertinent to EPA's mission. The first Radiation Advisory Committee (RAC) advisory, in 1995, concentrated on an ORIA proposed preliminary design for a RadNet reconfiguration plan. The second RAC advisory, in 1997, examined the reconfiguration plan for RadNet that was developed, in large part, based in the guidance from the previous advisory.

In 1999 and 2000, three events placed the RadNet national air monitoring component on emergency status and confirmed some lessons on limitations in the existing system. The three events were the Tokaimura, Japan criticality incident and the fires near the Department of Energy's (DOE)'s facilities at Los Alamos National Laboratory, and the Hanford Reservation. The Tokaimura incident highlighted the fact that the existing air monitoring system was not designed to detect noble gases. The two fires underscored the limitations of having low sampling density and the relatively slow system response time. Air filters had to be shipped to NAREL for analyses, and it took several days for definitive data to reach decision makers and the public.

In early 2001, ORIA began working on a new vision for a nation-wide radiation monitoring system. In August of 2001, the design team announced their goals, and was well along in their planning. The terrorist attacks on the United States on September 11, 2001 expedited and strongly influenced the subsequent planning for updating and expanding RadNet. The design team decided to concentrate on the air monitoring portion of RadNet, and elected to have a series of deployable monitors that could be positioned in an emergency to augment the fixed monitors positioned in predetermined locations and to add real-time monitoring capability to the system.

Since use of deployable monitors had already been planned prior to September 11, 2001 and as they could be procured more quickly, the first available homeland security funding (late in 2001) was committed to the acquisition. ORIA then turned its attention to the system of fixed monitors with testing of a prototype in 2002. By 2003, EPA had decided that the prototype had demonstrated the technical feasibility of adding real time gamma and beta monitoring capability to the fixed air monitoring stations. A proposal was submitted to the capital budget for upgrading and expanding the fixed air monitoring station component of RadNet, and, after evaluation by the Office of Management and Budget, was funded in the FY 04 budget. An actual purchase was made in 2005.

The RadNet upgrade and expansion project is currently in the early implementation phase. The first prototype fixed monitor has been received, tested, and is installed at ORIA's laboratory in Montgomery. A set of 40 deployable monitors has been acquired, 20 of which have been delivered to each of ORIA's labs in Montgomery and Las Vegas. The information technology infrastructure is in place for handling real-time data.

The next steps include the national siting plan (where to put the fixed monitors), how to distribute and operate the deployables under emergency conditions, and the best protocols for dissemination of verified RadNet data during emergencies. EPA plans to acquire and deploy the fixed monitors at the rate of five (5) per month. EPA requested that the Radiation Advisory Committee (RAC) provide input for these next steps.

2.2 Charge to the RAC RadNet Review Panel

The Agency's Office of Radiation and Indoor Air requested that the EPA Science Advisory Board review and provide advice on a draft document entitled *"Expansion and Upgrade of the RadNet Air Monitoring Network, (Volume 1&2) Concept and Plan,"* dated October 2005. EPA requested response to the following specific charge questions:

Charge Question 1: *Are the proposed upgrades and expansion of the RADNET air monitoring network reasonable in meeting the air network's objectives?*

Charge Question 2: *Is the overall approach for siting monitors appropriate and reasonable given the upgraded and expanded system's objectives?*

2a) *Is the methodology for determining the locations of the fixed monitors appropriate given the intended uses of the data and the system's objectives?*

2b) *Are the criteria for the local siting of the fixed monitors reasonable given the need to address both technical and practical issue*s?

2c) *Does the plan provide sufficient flexibility for placing the deployable monitors to accommodate different types of events?*
2d) *Does the plan provide for a practical interplay between the fixed and deployable monitors to accommodate the different types of events that would utilize them?*

Charge Question 3: *Given that the system will be producing near real-time data, are the overall proposals for data management appropriate to the system's objectives?*

3a) *Is the approach and frequency of data collection for the near real-time data reasonable for routine and emergency conditions?*

3b) *Do the modes of data transmission from the field to the central database include effective and necessary options?*

3c) *Are the review and evaluation of data efficient and effective considering the decision making and public information needs during an emergency?*

3d) *Given the selected measurements systems are the quality assurance and control procedures appropriate for near real-time data?*

2.3 Acknowledgement and Overview

The RAC RadNet Review Panel (the Review Panel) met on December 19-21, 2005 in Montgomery, AL at the National Air and Radiation Environmental Laboratory (NAREL) to consider these charge questions. The meeting location was important to facilitate discussion of the system since members could see (and touch) the prototype fixed and deployable monitors. Review Panel members were able to maximize the interaction with staff involved in the project at NAREL since they were all available at the meeting. This face-to-face interaction was integral to the Review Panel's understanding of the thought processes during design of the system. The hands-on aspect of being able to directly experience the fixed and deployable monitors was also essential. Review Panel members even commented on the noise associated with the monitors in operation as a consideration in establishing the siting criteria. The Review Panel wishes to express their sincere thanks to the NAREL staff in accommodating their needs during the meeting and for making it as productive as possible.

The Review Panel wishes to commend ORIA on the planning that went into this meeting. The document *"Expansion and Upgrade of the RadNet Air Monitoring Network* (*Volume 1&2) Concept and Plan,"* 2005 was well-written and provided much needed background to the RAC's RadNet Review Panelists. During the meeting, the staff worked hard to augment this excellent document with additional pieces of information that the committee members felt were necessary to assist with the review. The staff took extreme care to honor all the Review Panel's requests and demonstrated their patience as Panel members struggled to understand all that went into the decisions on equipment, siting and deployment strategies, and anticipated data uses.

3. RESPONSE TO CHARGE QUESTION #1

<u>Charge Question 1:</u> ***Are the proposed upgrades and expansion of the RadNet air monitoring network reasonable in meeting the air network's objectives?***

In its briefing document, EPA stated the mission and objectives of the expanded and upgraded RadNet monitoring network as (in paraphrased form):

- Provide data on baseline levels of radiation in the environment;
- To the extent practicable, maintain readiness to respond to emergencies by collecting information on ambient levels capable of revealing trends;
- During events, provide credible information to public officials (and the public) that evaluates the immediate threat and the potential for long-term effects; and
- Ensure that data generated are timely and are compatible with other sources.

The Review Panel believes, in general, that the proposed expansions and upgrades significantly enhance the ability of the RadNet monitoring network to meet this mission and objectives. However, in making this statement, the Review Panel is concerned about a number of specific issues that are detailed below.

3.1 Issues with respective roles of fixed and deployable monitors

Current plans for the upgraded RadNet system of air monitoring instruments call for a system comprising 180 fixed samplers and 40 deployable samplers. The 40 deployable units have been purchased and are available for deployment from the National Air and Radiation Environmental Laboratory (NAREL) in Montgomery and the Radiation and Indoor Environments National Laboratory (RIENL) in Las Vegas. Procurement of the fixed monitors is in progress, but procurement of the full complement of 180 samplers is not projected to be completed for a number of years. Both types of units will be needed in response to a major airborne release of radionuclides. It is planned that the deployable units will be used to expand the sampling network of interest around the site of a known airborne release. As discussed below, deployable units could also be used routinely in the near future to expand the fixed station network until more fixed sampling units can be obtained.

The objectives above identify two basic operational scenarios: "routine" and "emergency" (i.e., a radiological 'incident,' whether accidental or intentional). In practice, the necessary monitoring data to characterize the radioactivity/radiation 'environment' in these two scenarios exist at multiple levels of scale or "resolution." For the sake of simplicity, the Review Panel identifies three levels: large (multi-state; 100s to 1000s of miles), regional (10s to 100s of miles), and local (miles).

Routine (also called baseline) monitoring is predominately a large-scale activity. The purpose of this monitoring is to characterize, on an on-going basis, the ambient radiation environment in space and time. For this purpose, air monitoring needs to be supplemented with other existing RadNet-based media sampling, including water and milk sampling.

Emergency monitoring requires data inputs at all three levels of scale. Large- and regional-scale data are used to track major releases, typically from nuclear power plant accidents or detonation of an improvised nuclear device (rather than from a Radiological Dispersion Device, RDD). Local data are most relevant for RDD events, and help determine evacuation vs. shelter-in-place decisions. For such decision-making, real-time data are critical.

Of major importance, while the Panel's view of the expanded and upgraded RadNet network's capabilities to meet EPA objectives is essentially consistent with EPA, its view of the respective roles of the fixed and deployable monitors is significantly different than that of EPA and is a major factor in the responses and recommendations in this report.

Routine monitoring relies almost exclusively on the fixed monitor network. Expanded coverage is most important for meeting the mission of the routine monitoring. In this regard, the major benefit of the expansion and upgrade plan is the addition of up to 180 monitoring sites. Here, the fixed monitors provide large-scale data; the deployable monitors can (if deployed) provide regional trends and (to a complementary extent) local level data. (Local scale data are also provided by portable monitors representing local and state assets.)

3.2 Issues with the monitors themselves

Because of timing and resource issues, there are some differences in the design and operation of the fixed and deployable types of monitors selected by ORIA. The design of the deployable units was in response to the fires at Hanford and Low Alamos. Procurement of these units began before the conceptual design of the fixed monitors was complete. Additionally, practical considerations dictated that the deployable units be sturdy enough to withstand damage from repeated shipping and handling.

Both types of monitors are capable of sampling air at high volumetric rates (35-75 m^3/hr) through a 4"-dia. filter. The fixed stations use a polyester filter, while the deployable units use a glass fiber filter. The deployable unit also has a second sampling head operated at a lower sampling rate (0.8-7 m^3/hr) suitable for sampling radioactive gases. The sampling heads are located in different places in the two types of monitors. The two sampling heads on the deployable units are located on extensions several feet above the system's equipment enclosure, whereas the sampling head in the fixed unit is located in the top portion of the system's enclosure along with two radiation detectors that provide periodic in-place measurements of the accumulation of radionuclides on the filter medium. These detectors are a 2"x2" NaI detector to measure gamma emissions and a 600 mm^2 ion-implanted silicon detector to measure alpha and beta emissions from radionuclides on the filter sample periodically during the sampling cycle. These radiation measurements can be transmitted via satellite to NAREL for analysis and storage.

The deployable unit has no built-in capability for monitoring either the high volume or low-volume filters in place, so the filters must be counted and analyzed at NAREL or in a mobile laboratory brought near the area of interest. Another difference between the deployable and fixed units is the ability of the deployable units to provide measurements of the external gamma radiation field at the sampling site. Measurements from two compensated GM detectors also can be transmitted to NAREL via satellite. The fixed sampling unit has no comparable capability for quantifying external photon radiation fields.

Because both the fixed and deployable sampling units will be used to provide important information to decision makers, it is imperative that both the similarities and differences between these two monitoring systems be understood and quantified so that the resulting data will be of high quality and consistency.

3.3 Potential sampling biases in the fixed air monitor

The configuration of the detector and filter in the fixed air sampler may result in bias in collection of larger particles due to impaction on the detector or associated support surfaces. The EPA report should include a figure that shows, with dimensions, the locations of the two detectors relative to the filter and indicates the expected air flow path. *The impact of this geometrical arrangement on the deposition of airborne particles should be evaluated by an experienced professional using laboratory or field tests that address, among other questions:*

- Is particle deposition on the filter uniform across the filter?

- Does a significant fraction of particles deposit on the surfaces of the two detectors to contaminate them?

- Are there sampling biases related to different particle-size regions?

While large particles (greater than 10 µm AMAD) are not of biological significance with regard to inhalation by humans, they may be of concern in evaluating the potential for soil and surface water impacts. Also, depending on the type of incident that results in generation of air particulates, NAREL should consider whether "hot particles" might be in the larger size range and thus would not be collected on the filter in proportion to their presence in the airborne material.

The currently-designed instruments have not been tested for the collection efficiency of airborne particulates as a function of the wind speed and direction at which they arrive at the sampler. The sampling efficiency versus particle size might also be impacted and should be tested. A wind tunnel would be a good place to conduct such tests. It is better to know these characteristics now, than to learn that there might be a problem later. This seems to be particularly critical for the new fixed samplers where local siting criteria allow the sampler to be located no closer than 2 meters from walls, 5 meters from building ventilation exhausts and intakes, 20 meters from a tree drip line, 50 meters from streets and highways, etc. All of these factors can impact the representativeness of the measurements to ambient air.

One of the arguments for large particles not being of major concern for RadNet is the expectation that an event that results in airborne dust generation will occur at a considerable distance from the sampler. Thus, the large particles would fall out before the plume reached the detector. This would be true for most of the fixed samplers for a single event, but not for the fixed samplers that are located in the population centers where the probability of a terrorist incident involving release of radioactive material is the greatest. A sampler in the vicinity of the incident is of primary importance in such a case and should be capable of representative sampling of airborne dust.

3.4 Measurement of external photon radiation fields

The deployable sampling units use GM detectors to provide near real-time data on gamma exposure rates, but no similar measurements can currently be made with the fixed monitors. If it is assumed that the near real-time collection of these gamma exposure measurements is an important function of the deployable units, then *consideration should be given to making similar gamma exposure measurements on the fixed sampling units as well.* It seems inconsistent to have this capability only on the deployable units.

Certain quality assurance efforts are needed for the radiation exposure data collected by the GM detectors with the portable monitors. These data may contribute significantly to the evaluation of a radiological incident and needs to be trustworthy. The following aspects should be considered:

1. Results are reported (on p.60) to be accurate within 15% at the low end of the scale at 2 µR/h, and 10% at the high end of 1 R/h. Is this information certified by the manufacturer? In any case, EPA should test reliability initially and at intervals for selected monitors by comparison to a direct exposure-rate detector such as a pressurized ionization chamber.

2. The instruments are reported to have been calibrated with Cs-137 and to have an energy response within 20% between 60 keV and 1,000 keV. Does the

manufacturer certify this information? EPA should test instruments for energy dependence by exposing selected detectors to point or extended sources. For example, radionuclides may be selected that emit single gamma rays of approximately 30, 60, 120, 300, 600, and 1,200 keV, of which one should be Cs-137 at 661 keV. Such sets also can be used for intercomparison with monitors by cooperating organizations, such as state agencies.

3. QC considerations for exposure-rate measurements, discussed on p.90, should include specific actions such as the ones suggested above.

4. The international unit equivalent to 1 R is 2.58 x 10^{-4} C/kg, not 10 mSv, as shown on p.60. The decision to convert R to mSv should be left to the organization responsible for assigning radiation dose.

While Cs-137 may be an important gamma-emitting radionuclide in the event of a nuclear incident, Co-60 – with gamma photons twice the energy of the Cs-137 photons – may be of equal or greater importance for a "dirty bomb" event. It is also important to note that the GM detector response to scattered Cs-137 gamma radiation may be different from the response to the unattenuated Cs-137 radiation. While it might be impractical to cross-calibrate each deployable system against a pressurized ion chamber (PIC), *NAREL should consider cross-calibrating the prototype using a series of different energy gamma emitters*, including naturally occurring thorium with its relatively high energy gamma Th-208 decay product and uranium with its lower average energy decay products.

Cross-calibration would afford a degree of assurance that the GM detectors are accurately measuring exposure when a variety of different gamma energies are present. Said another way, the EPA report should address the following aspects of detector response:

- the pattern of the energy response in the form of a curve or tabulated values from the low-energy cutoff to about 3,000 keV;
- the standard deviation of measured exposure rates for the full claimed range of 2 *R/h to 1 R/h ; and
- the response to beta-particles and associated Bremsstrahlung.

The use of the radiation measurement units Sv and rem for the output of the GM detectors is somewhat misleading since a GM detector measures counts per unit time. With appropriate cross-calibration against a Pressurized Ion Chamber (PIC), the output could be converted to roentgens. However, if the units Sv and rem are being used in the sense that they represent effective dose, the one-to-one ratio of roentgen to rem may not be appropriate. The conversion from exposure in roentgen to effective dose in Sv or rem depends on both the receptor (e.g., adult or child) and the energy of the gamma radiation.

3.5 Measurements of alpha emitters at fixed stations

The description of major components of the fixed air monitoring stations on p.25 of the EPA report includes "Instruments for measuring gamma and beta radiation emanating from particles collected on the air filter media." Measurements of alpha emissions are not mentioned on p. 25, but the detailed specification sheet provided mentions the capability to measure both low and high energy alpha particles. During the December 19-21,2005 meeting, NAREL staff told the Review Panel that a complicated algorithm is needed to distinguish alpha emissions measured in the fixed monitor from the measurements of alpha emissions of naturally-occurring radon (Rn) progeny. *It is important that this capability be perfected because other alpha emitters besides Am-241 may become important in assessing potential terrorist activities.*

3.6 Need for numerical clarity and transparency

3.6.1 Value of the Protective Action Guide (PAG)

In the EPA report the PAG is stated to be the committed effective dose equivalent (CEDE) of 1 rem that results from inhaling a specified radionuclide continuously during a 4- day period (p.24, para. 5). The measurement requirements, including the minimum detectable activity (MDA) for selected radionuclides specified in the EPA report, are related to this value.

While the instruments provide the output in Roentgens, it is expected that EPA will do the necessary conversion to provide the information in rem to the decision-makers so that they can compare it to the PAG. The Review Panel was not asked to comment on the appropriateness of the PAG, however, it is necessary to point out that the assumptions for conversion from R to rem should be explicit in the documentation so that the conversion can be replicated at a later time.

3.6.2 Relation of the EPA-specified MDA value to the PAG for fixed-location monitor

The MDA values (at the 95% confidence level) are given in terms of nanocuries (nCi) for each of 7 radionuclides on a filter to be counted for no more than 1 h with the specified NaI(Tl) detector and spectrometer (p. 27, para. 1). Of the 7 radionuclides, Am-241, Cs-137, Co-60, and Ir-192 were considered to be important because of their availability in large quantity (p.24, para. 3). An MDA value also is given for Sr-90 counted with the silicon detector and spectrometer (p.27, para.2).

The EPA report should include the nCi value on the filter that corresponds to the selected limit on intake related to the PAG (see part A) for each of the 8 radionuclides. The purpose is to confirm that the MDA is (1) suitably lower than specified by the PAG to permit reliable measurement results, and (2) not unreasonably low compared to the

PAG, e.g. not so sensitive that very high readings will be produced by very low exposure levels.

This information can be extracted from the two tables that were distributed by EPA staff in response to a request at the meeting. One table is a list of radionuclide concentrations (in pCi/m^3) that correspond to the PAG for 1 rem by inhalation during 4 d (and fractions of this PAG) for 5 of the 8 radionuclides. The other table is a list of nCi for a 30 m^3 sample related to estimated risk per nCi inhaled given in Federal Radiation Guide #13, for all 8 radionuclides (and 2 others). The EPA staff should decide which data set is appropriate, apply the selected factors for m^3 collected on the filter for counting and m^3 inhaled in the 4-d period, and discuss the appropriateness of the specified MDA values.

3.6.3 Calculation of the MDA values for the fixed-location monitor

Calculation of the MDA for radionuclides detected by the NaI(Tl) detector is addressed in a separate document, "MDA for the EPA's fixed Radnet monitors", WSRC-TR-2005-00527 (12/16/05) that was distributed at the meeting. The value of the MDA is related to the standard deviation, ∗, by MDA = (2.8 + 4.65∗)/constant.

The constant relates counts accumulated for this study in 10 minutes to nCi. Values of ∗ were obtained by measuring the counts recorded with the detector in the regions of interest for various radionuclide standards and obtaining the counting efficiency for these measurements. The Westinghouse Savanna River Company (WSRC) report notes that the calculation of ∗ is more complex than shown if background peaks intrude on the regions of interest for a radionuclide, as is the case of radon progeny intruding on Am-241 and Cs-137. The radon-progeny background on filters is stated in the EPA report to fluctuate from 0.3 to 30 nCi (p.26, para.6). The calculated MDA values based on measurements that do not include radon-progeny fluctuation range from 12.3 to 1.1 nCi for the 7 radionuclides. The MDA value for Am-241 is above the specified MDA for the 10-min count but equals it for the expected 60-min count; the MDA for each of the other radionuclides is 1 – 3 orders of magnitude below the EPA-specified MDA value.

The calculated MDA values reported in the WSRC report should be inserted into the EPA report with an explanation of the reasons for the much larger EPA-specified MDA values (p.27, para. 1), except for Am-241. If one reason is the indicated radon-progeny fluctuation, the extent of increase in MDA values over those calculated in the WSRC report should be tested in a field study. Relative to the EPA-specified MDA values, however, the fluctuation appears to be significant only for Am-241.

Before inserting the WSRC data in the EPA report, some improvements in the WSRC report are recommended. Calculation of ∗ should be explicitly shown, with counts and background counts tabulated for each region of interest. Apparent errors made in the sample calculation for Cs-137 should be corrected in calculations of MDA(cps), MDA(dps), and MDA(nCi).

The MDA calculation for Sr-90 measured by the silicon detector should be shown for the direct beta-particle count and counter background, and for the influence of radon-progeny fluctuation. Any difference between these values and the EPA-specified MDA should be explained.

The implications of the change in the thickness (from thick to thin) of the silicon-detector window reported by EPA staff at the meeting should be discussed in the EPA report. If the alpha-particle spectra that now can be measured are useful to compensate for radon-progeny fluctuations, the appropriate calculations and test results should be presented. Conversely, any detrimental effects of cross talk on Sr-90 counting sensitivity should be reported.

3.7 Other Issues

The Review Panel found that the compilation of other radiation monitoring systems in the United States presented in Appendix C was incomplete. However, it is an indication of the importance that is placed on radiation monitoring that all of these systems were developed, largely independently of the RadNet or formerly, ERAMS systems. Given the degree of interest in monitoring and the extensive development work that ORIA put into RadNet, the Panel members surmised that other entities would consider purchasing fixed monitoring systems and request that they be tied in to RadNet. In anticipation of these requests, the Panel suggests that ORIA consider under what basis they would accept such additions to the RadNet and what inherent constraints they have in increasing the number of stations. Additionally, ORIA should give some thought to the issues of cross-calibration, costs for analysis of particulate filters, and other operational concerns that may arise in contemplating expansion on an ad hoc basis.

4. OVERALL APPROACH FOR SITING MONITORS

Charge Question #2: *Is the overall approach for siting monitors appropriate and reasonable given the upgraded and expanded system's objectives?*

2a. *Is the methodology for determining the locations of the fixed monitors appropriate given the intended uses of the data and the system's objectives?*

2b. *Are the criteria for the local siting of the fixed monitors reasonable given the need to address both technical and practical issues?*

2c. *Does the plan provide sufficient flexibility for placing the deployable monitors to accommodate different types of events?*

2d. *Does the plan provide for a practical interplay between the fixed and deployable monitors to accommodate different types of events that would utilize them?*

4.1 Response to Charge Question # 2

Is the overall approach for siting monitors appropriate and reasonable given the upgraded and expanded system's objectives?

The Review Panel believes, in general, that the proposed EPA approach for siting fixed and deployable monitors significantly enhances the ability of the RadNet monitoring network to meet mission objectives. Nevertheless, the Review Panel is concerned about a number of specific issues that are detailed below.

Given the limited resources the difficulties in designing the siting plan stems from two seemingly contradictory drivers: population- vs. geography-based. The siting plan proposed is therefore the result of a compromise between monitoring people and spanning the nation, or between socio-political considerations and mission requirements. There is an apparent discrepancy between the stated RadNet objectives in the context of EPA responsibilities, and the interplay and use of deployable vs. fixed monitors. This is reflected in a lack of clarity in the usage of deployable monitors: What are the decision-making processes and prioritizations used to accommodate different types of events from long term monitoring deficiencies to the response to catastrophic incidents? Are the objectives for the usage of deployable monitors strictly identical to those for the fixed monitors? Given that any incident response plan or EPA decision based on RADNET will depend on analyses from models that integrate data from a wide range of sources, it is essential that the RADNET network be optimized in terms of these models. These process-oriented environmental models are typically underdetermined as they contain more uncertain parameters than the state variables available to them for calibration. Therefore we strongly advocate the use of sensitivity analyses in the siting of future monitor stations (fixed and deployable). This represents a necessary step to optimize the value of collected monitoring data to the decision makers.

4.1.1 Population-based vs. geographic-based siting

Even though the siting plan is not intended to monitor a city-based incident, it has been designed to accommodate one monitor per major city. For populated Western and Eastern coastline areas this results in an anomalously high density of fixed monitors at the exponse of other regions, notably the US-Canadian boarder, Central Northern United States, Central and Eastern Nevada and Eastern Oregon. We feel that there should be a better balance between between physical deployment schemes and modeling requirements for effective environmental assessment, data interpretation and decision making.

From these considerations and the limited resources available, the Review Panel suggests at a minimum that a more aggressive declustering of fixed monitors be considered initially, particularly in the vicinity of the Los Angeles and New York metropolitan areas, and that local and regional meteorological models be used along with other considerations, to pare down and redistribute fixed monitors. We also suggest that model sensitivity analyses be performed on siting configurations and distribution densities so as to optimize the placement of fixed monitoring stations in terms of the limited resources available to meet EPA goals (see comments above). This will result in better geographic coverage consistent with the primary decisions for siting a 'receptor-based system' with a focus on national impact. This approach is also more flexible in terms of adapting to limited resources and the deployment of a lesser amount of fixed monitors than the eventual 180 planned for. A related concern includes: How did the mileage radii for de-clustering and gap-filling arise, and how is "proximity" defined?

4.1.2 Fixed vs. deployable monitor networks

It is unclear whether the proposed deployment of mobile monitors in predicated solely on the RadNet objectives outlined for the deployment of fixed monitors: the collection of environmental data within the context of a National scope, and for the sole purpose of monitoring, assessment and baseline data collection. Given the limited resources and possible limitations on the number of fixed monitors deployed in the near-term, it appears that at least some of the mobile units could be used to fill coverage gaps identified through modeling. To the degree to which mobile units are actually a response to EPA's new monitoring responsibilities as outlined in the post 9/11 *Nuclear/Radiological Incident Annex* document, *National Response Plan (NRP)*, then this should be specifically included in the siting discussion and reviewed in that context. Specifically the mission of the RadNet Air Network includes providing "data for radiological emergency response assessments in support of homeland security and radiological accidents." This objective is vague and brings into question responsibility and chain of command. Under most circumstances, EPA is not the lead but a supporting organization to the Coordinating Agency (CA). This may also preclude the pre-deployment of mobile monitoring stations by the EPA and requires the integration of what then becomes two separate systems each associated with both deployable and fixed monitoring Networks.

To avoid future implementation failures and the loss of key data, this apparent discrepancy needs to be specifically addressed in the report, integrated and planned for by EPA, the Federal Radiological Monitoring and Assessment Center (FRMAC) and the end user IMAAC that generates the plume projections.

4.2 Response to Charge Question # 2a

Is the methodology for determining the locations of the fixed monitors appropriate given the intended uses of the data and the system's objectives?

The Review Panel strongly suggests that the declustering of high density population areas be more aggressive and involve the use of model constraints and meteorological forecast predictions. To this end the Review Panel supports the use of sensitivity analyses and confirmatory transport modeling proposed by EPA, in conjunction with Savannah River National Laboratory, the US Weather Bureau, IMAAC and/or other partners.

Overall, the Review Panel considers that the methodology for determining the locations of the fixed monitors is appropriate with some reservations: There appear to be a few gaps in the proposed siting methodology for fixed monitors, resulting from (1) the apparent lack of recognition of local and regional meteorological constraints; (2) possibly significant gaps in geographic coverage; (3) deficiencies in siting scenarios in the context of uncertainty in the near term number of operational fixed monitors, and (4) RadNet mission priorities; and (5) integration with current EPA monitoring responsibilities.

4.2.1 Meteorological constraints

The proposed EPA scheme for adapting fixed monitor locations to both population density and land coverage achieved about 50% population coverage and about 82 % land coverage. With the constraint of 180 independent stations this appears satisfactory as an initial siting basis. However, meteorological and natural background radiation conditions (e.g., radon) may demand adjustments of this distribution as experience is gained with actual operation of the system as it is deployed over a number of years and results from preliminary models are considered. The data from the RadNet Air Monitoring Network should eventually be combined with a standard US Weather Bureau computer code for projecting variations in the local geological and meteorological conditions in the area of the monitor and regional atmospheric conditions and trends. Meteorological monitoring associated with the fixed monitor Network is desirable in some cases, and should be decided on a site-specific basis, based on 2 considerations: (a) no "canyon effect" exists, and (b) no alternative "close" meteorological monitoring exists (where "close" still needs to be defined). In this way, elevated radiation conditions and their atmospheric transport could then be predicted and their significance assessed with respect to natural and/or man-made anomalies.

4.2.2 Gaps in coverage [duplicates 5.2.1]

The fixed monitor siting plan proposed is the result of a compromise between monitoring people and spanning the nation. As a consequence, even though the siting plan is not intended to monitor a city-based incident it allows for one monitor per city. For populated Eastern and Western coastline areas (e.g., Los Angeles basin and the New York metropolitan area) this results in an anomalously high density of fixed monitors compared to other regions, notably the US-Canadian boarder, Central Northern United States, Central and Eastern Nevada and Eastern Oregon. Some of this concern may be addressed through joint US-Canadian operations. At a minimum, NAREL should note the locations of Canadian monitoring facilities to indicate if the coverage is better than it appears from the US maps alone. In addition, the Review Panel suggests that initially a more aggressive declustering of fixed monitors be considered in the vicinity of the largest population centers (i.e., Los Angeles and New York metropolitan areas) and that local and regional meteorological models be used along with other considerations, to pare down and redistribute fixed monitors on a physical geography basis. This will result in improved geographic coverage consistent with the primary decisions for siting receptor-based system with a focus on <u>national</u> impact.

4.2.3 Uncertainty in number of near-term fixed monitors

Given the limited resources and possible limitations on the number of fixed monitors deployed in the near-term, it appears that scenarios with less than 180 fixed monitors be examined in terms of immediate impact of system response. In addition at least some of the mobile units could be used to fill coverage gaps identified through modeling. This approach has the advantage of being more flexible and responding to changing environmental conditions. It requires a thorough study in terms of costs and added complexity in the event that deployable systems are required in response to an unanticipated radiological incident.

4.2.4 Mission priority

In keeping with EPA responsibilities and the continuity of the RadNet mission, the most important function of the fixed monitors is the continued and improved routine evaluation of the ambient radiation environment. In the context of the new RadNet network, this involves continued coordination of the air monitoring Network with the other current EPA networks involving water and milk monitoring, even in the context of a later evaluation and update of those systems. This again emphasizes that population density is not necessarily the main driver but that isolated areas that involve many rural communities also support the monitoring infrastructure of the Nation. In view of the resource limitations to the new RadNet system, NAREL should not lose sight of the EPA function that involves tracking the transfer of ambient air-borne radiological conditions to Nation's food supply.

4.2.5 Integration with existing networks

Even though RadNet is a receptor-based system, it should strive to leverage any and all additional monitoring stations by working with other existing systems, such as those in individual States and around Nuclear Power Plants and other source areas. Moreover, there should be a mechanism established for entities such as States or cities who may use their own funds to purchase stations that are comply with the standards for becoming full-fledged 'members' of the network. There also appears to be a lack of coordination with Canadian monitoring networks. Specifically, the US southern border seems to be well covered by the proposed siting plan, whereas monitors along the northern Canadian border appear scarce. Health Canada maintains monitoring stations in Edmonton, Calgary, Saskatoon, and Regina and perhaps elsewhere but the EPA does not appear to have engaged Health Canada and there is no mention of the monitoring capabilities or planned joint coordination efforts between the US and Canada.

4.2.6 Other questions

A further question regarding siting is how EPA will respond to socio-political factors that could derail the siting scenario.

Do the plans for storing, deploying and siting the deployable monitors include sufficient flexibility to effectively respond to simultaneous potential or real radiological events) in a timely manner and /or in the absence of viable infrastructure (e.g. key and appropriately and adequately trained support personnel, communications, electrical power, transportation routes and modes. Plans addressing these issues were mentioned by EPA staff during the meeting with the Review Panel but there is little evidence in the report that such contingencies have been more than summarily thought through or provided for.

4.3 Response to Charge Question #2b

Are the criteria for the local siting of the fixed monitors reasonable given the need to address both technical and practical issues?

Ideally, the siting plan would evolve from modeling considerations, rather than be determined beforehand.. Given the current approach to siting, at a minimum, sensitivity analyses and a post-hoc confirmatory modeling (i.e., siting plan validation) should be used. The sensitivity analyses will help focus limited resources on those siting configurations that are most optimal to RADNET objectives, and help identify to which state variables the models are most sensitive and less certain in terms of their formulation and/or parameterization for a given siting geometry. The analysis will also help reduce uncertainty by identifying any potential interactions or variables that exert the greatest influence on the variability of model outcomes and interpretation.

Additionally, siting criteria based on a combination of "population" and "cluster density" – as EPA is proposing – may or may not make sense depending on the answers to the 2 additional considerations (a) and (b) below.

There are complex and non-intuitive issues involved in siting monitors, and the plan cannot be evaluated in a vacuum. At least two important additional considerations are highly relevant to the discussion:

(a) Whether or not other fixed and portable monitoring networks complementary to RadNet (e.g., RERT) will also be providing similar and/or compatible data; and

(b) What are the sampling requirements for the mathematical models used to estimate environmental distributions in space and time? For example, the models may require or be optimally served by, more uniform geographic sampling, or conversely, a non-uniform sampling scheme that is driven by geographic/geologic and meteorological factors (in 3 dimensions) rather than population or sampling density per se.

In planning the distribution of fixed monitors, EPA used the following assumptions. In order to validate model predictions modelers and planners require a well-spaced network that include 'non-zero' readings in contaminated areas and 'zero' readings in non-contaminated areas. Decision-makers require monitors where large population centers are located, as well as other (e.g., food production sites). The public also demands that monitors exist where they are located although other relevant concerns include agriculture (monitoring of areas that are otherwise unpopulated or geographically "uninteresting"), business and tourism areas, and border areas that anticipate plumes from other countries.

In order to address these needs, EPA took an approach that is both population-based and geographically-based:

- Start with the largest cities (population-based);
- Remove the "over" clustering of monitors in certain areas; and
- Fill in the gaps (geographically-based).

In addition to the points covered in the report, the Review Panel strongly encourages that several additional points be either added or reconsidered:

(1) **Siting needs based on model requirement**. Given that the models will be used for rapid decision making and analysis, it follows that criteria satisfying required model inputs be prioritized so that the results are quantitative and the model predictions are robust;

(2) **Practical considerations** involving siting protocols based on monitoring station security and operation must be specified and prioritized;

(3) **Vertical siting considerations need attention** in view of the role of possible monitoring obstructions, different sampling environments (e.g., monitors at different elevations sampling different plume horizons), etc…; and,
(4) **The effective use of other existing resources** that could benefit rapid detection and analysis of a radioactive plume.

4.3.1 Model requirements

Models may best be served by input data that require more uniform geographic sampling, or a non-uniform sampling scheme that is driven by geographic/geologic and meteorological factors in three dimensions, rather than by a population or sampling density scheme. For quantitative analysis and understanding of the Network data, optimal siting is therefore the product of simulation requirements, anticipated scenarios, and variations within each. In practice, the sampling requirements are also model specific and as different models come into play, optimizing the siting plan involves integration of several results that together stochastically predict the space and time distribution of radioactive plume in three dimensions.

The following approach is offered by way of example:

Step1: Model 3-5 different, plausible scenarios, using one or more mathematical models, including any used by IMAAC. The initial tests should involve a dense monitoring coverage or over-sampling (e.g., simulating the availability of input from thousands of monitors), thereby establishing the 'ground truth' space and time distribution;

Step 2: Use a preferred model to simulate a case with 180 monitoring stations as proposed in the RadNet siting plan and vary the siting density distribution using proposed EPA siting plan(s);

Step 3: Perform a sensitivity analysis in which a number of monitors are "removed" from a "preferred RadNet siting configuration" to reduce the total number of stations from 180 to [180 – 20] or [180- 40];

Step 4: Using a realistic number of monitoring stations, change the geometry of their distribution so as to capture model sensitivity to site geometry and distribution.

Step 5: Compare all model run results. This sensitivity analysis could render (i) the optimum deployment for 180 fixed monitors; (ii) provide a comparison of the preferred monitor distribution to an optimal siting scenario involving a greater or ideal number of monitors (>>180); (iii) optimize the use of a resource-limited monitor sampling scheme (<180 stations); and (iv) help in the design of portable station deployment either as temporary stations to offset perceived coverage gaps or for use in rapid deployment scenarios and effective integration with other networks, including fixed RadNet monitors.

4.3.2 Practical issues

The approaches discussed above focus on the selection of 180 "optimum" cities (or geographic sites throughout the country) without regard to either technical or practical issues, but based only on sampling considerations, either from a population- and clustering-basis, or in the context of modeling. *The actual selection of sites, however, must also be driven by technical and practical issues.* These include:

(i) The availability of the appropriate electrical power;

(ii) An accessible and secure place to site the system; and

(iii) The availability of appropriate volunteers to maintain and "operate" the system.

4.3.3 Vertical siting

A key issue that needs further specification and refinement is the vertical location of the fixed monitors. A rooftop location may be the preferred (and potentially standardizable) location, to avoid the "canyon effect" that might otherwise be present, especially in large cities. This in turn introduces the 3 dimensionality of the siting problem which will need to be taken into consideration when comparing different sites. The Review Panel suggests that the "2-meter rule" be amended or redefined in the context of tall buildings or large vertical structures.

4.3.4 Effective use of resources

A complete inventory of all existing, functional radiation equipment should be performed by EPA to determine available non-EPA resources, which may include the environmental radiation equipment at nuclear power plants, resources at universities, federal, state, and industrial laboratories, or medical facilities. In the event of a major incident within a given region the EPA could rapidly assess national needs and enlist these resources for extended coverage.

4.4 Response to Charge Question #2c

Does the plan provide sufficient flexibility for placing the deployable monitors to accommodate different types of events?

A key question is whether or not the systems could be systematically deployed for "routine" monitoring to supplement the fixed monitors, thereby increasing their utility, and still be as readily deployable in an emergency.

This question requires resolution of the apparent discrepancy noted earlier between the stated RadNet objectives and the interplay and use of deployable vs. fixed monitors. Both the RadNet document and the EPA RadNet presentations bring uncertainty as to the ultimate objectives for the usage of deployable monitors. EPA's plan to date does not include routinely using the deployable monitors (i.e., in the absence of an emergency). To the degree to which mobile units are actually a response to EPA's new monitoring responsibilities as outlined in the post 9/11 *Nuclear/Radiological Incident Annex* document *(NRP)*, then the flexibility of the deployment depends on the mobile Network ability to adapt to rapid response times and deployment requirements. This can only be accomplished if the siting is 'pre-planned' by incident type, regardless of location. This in turn requires that the deployment scenarios be tied to 'realistic' model renditions of different scenarios and that both model and siting plan be responsive to the input of new incident boundary conditions in a timely and effective way. At present, this is not the case and the Review Panel urges the EPA to take measures in this direction and lead the way to the use of the RadNet database.

Other considerations are the practical effective deployment requirements within the framework of limited resources. These issues include (1) Storage; (2) Pre-Deployment, (3) Personnel Training, (4) Flexible Response to Incident Scenarios, and (5) Other Concerns.

4.4.1 Mobile unit storage

The EPA proposes to house the deployable systems in its two main detector R&D lab sites (Las Vegas and Montgomery). EPA believes that it is important to do so, in order to be able to provide continuing maintenance, and to deploy the monitors with trained staff. As an alternative, however, it may make more sense to store the systems at a more diverse set of regional locations, where they could be potentially deployed more rapidly in the event of an emergency.

4.4.2 Pre-Deployment

Under certain circumstances and in response to a DHS request, if a pre-deployment option for the mobile stations were envisaged, it would drastically change the nature of the RadNet mission and can make it much more of an event detection and early warning response system. In view of the possibility the EPA would be requested to pre-deploy its portable air monitors, the criteria for pre-deployment should be clearly addressed and carefully established. There are a large number of gatherings of large numbers of people where there may well be pressure to pre-deploy the monitors. Fairly routine pre-deployments have positive and negative aspects. On the positive side it enables operators to become familiar with shipping and setting up the systems. It also increases the probability that they will be in place when needed. On the negative side, apart from the cost, routine pre-deployments increases the probability that they will be in some other location when they are needed to be used post-event or need to be re-deployed due to environmental changes. There needs to be further discussion of how such situations will be handled and how operator safety would be addressed.

4.4.3 Personnel training

The large number of deployable monitors ideally permits rapid deployment and operation of field monitors where and when required to meet specific situations. Since the tactics and location of a radiological based terrorist attack may not be know, the deployable monitors must permit rapid response to a given situation in 'real time.' Because of the variety of potential radiological terrorist attacks that are not significantly transported by the atmosphere, a small inventory of specialized monitors (e.g., noble gas, alpha spectrometers, C-14 detectors) should be available for rapid deployment. However, in relation to the use of deployable monitors the EPA states that the "information concerning the exact location of each monitor relative to buildings, terrain level changed, other obstacles, along with a description of the surface terrain (for surface roughness determination), will need to be relayed to meteorologists so they can determine the value of the data prior to use."

EPA relies on volunteers to deploy their portable monitors and bring flexibility to the deployment scenario. Without training or experience it is difficult to imagine the success of this enterprise in the light of a National emergency, where potential risks to personnel safety are to be envisioned. EPA needs to clarify how these untrained individuals will know how to adequately provide the required terrain descriptions in a timely and accurate manner before starting the sampling activities; and assure themselves of the robustness of their deployment plan in view of recent incidents during hurricane Katrina where major defections of police and emergency personnel occurred.

Are there sufficient cross-trained key personnel and appropriately- trained volunteers to effect a response in the event that the core groups are not available for whatever reasons??

How are 'volunteers' credentialed?

4.4.4 Flexible response to incident scenarios

The overall plan for the deployment of the RadNet portable monitors seems to rely on the occurrence of a single radiation incident and does not consider multiple near-simultaneous incidents. Based on the history of the 9-11 attack, where three to four locations were targeted simultaneously, the single incident assumption is inadequate.

Simultaneous, coordinated dirty bomb or nuclear device attacks on several cities (e.g., Boston, New York, Miami, Chicago, and Los Angeles) are as plausible as a single event scenario. ORIA should therefore revisit its deployable siting plan and determine the effectiveness of the proposed methodology if only five to ten mobile stations are available for deployment at each of several locations instead of the 20 to 40 monitoring stations per site they depict in the Report.

As discussed in the Charge Question 2b answer, the deployment and siting of mobile air monitoring stations would be greatly improved by a modeling exercise where the siting is closely tied to model scenarios involving different types of incidents (e.g., dirty bombs vs. nuclear devices), as well as different areas (e.g., large cities vs. industrial or military centers).

4.4.5 Other concerns

There are also some practical operational issues that need resolving. (i) How (and by whom) will the (acute) siting of the deployable monitors be determined? (ii) In practice, how long will it take to deploy the monitors relative to the start of an event, and how does this lag time influence the desirability of pre-deployment? (iii) Finally are the deployable monitors considered fixed stations once positioned or will they be remobilized to track possible contaminant plume movements?

The RadNet siting plan provides flexibility for placing deployable monitors for different types of events; however, the role of the deployables is not totally clear. Are the deployables for monitoring the edge of a plume or are they to provide assurance to populated areas not covered by fixed monitors, that they have not been affected? The deployables are a flexible, well designed system, but the locations where they will be placed relative to where the contaminated plume is located needs better definition.

The air concentration and external gamma radiation data from the RERT teams and the deployables should be integrated. This should be the easiest data to integrate since it is collected by the same organization and provide an extra safeguard to the operators.

In the early phase, the deployable monitors are to provide gamma radiation and airborne radioactive particulate data to modelers to assist in validation of model output or adjustment of input parameters (page 16). But the deployment scheme is to place the monitors outside of the contaminated area. To assist the modelers, the monitors may have to be placed inside the plume to measure gamma or airborne above background.

The scheme for siting deployable monitors is to put them where they will measure background or pick up resuspension. Decision-makers will be looking for more data on the impacted areas, particularly from monitoring stations that can send data remotely without exposing personnel, except for short timeframes to change filters. Has the correct mission for the deployables been identified? Is there a short term strategy to use the deployables in the location of a fixed monitor on a temporary basis as part of the testing program? The Review Panel suggests that EPA explore this strategy.

Finally, the RADNET report should also reference and when possible follow the guidance provided by the *Environmental Engineering Committee's Modeling Resolution* (U.S. EPA SAB, 1989) and the *Guidance on the Development, Evaluation, and Application of Regulatory Environmental Models and Models Knowledge Base* (U.S. EPA SAB, *Quality Review Draft*: 02.24.2006). Even though these reports do not specifically address the use model sensitivity analysis in the optimization of the design for siting monitoring instruments, many fundamental model requirements are presented in the context of data integration and interpretation in the context of a regulatory decision making environment and information dissemination.

4.5 Response to Charge Question #2d

Does the plan provide for a practical interplay between the fixed and deployable monitors to accommodate different types of events that would utilize them?

While the Review Panel's view of the expanded and upgraded RadNet Air Network's capabilities to meet EPA objectives is essentially consistent with EPA objectives, the Review Panel's view of the respective roles of the fixed and deployable monitors is significantly different than that of EPA, and is a major factor in determining what constitutes an effective interplay between fixed and deployable monitors.

Concerning the interplay between fixed and deployable monitors, EPA proposes in essence, to treat the data from the two types of monitors in a similar fashion. Yet, the fixed stations do not include exposure rate measurements, and the deployable monitors do not include gamma spectrometry. In addition, the collection filters (for air sampling) are different on the two systems. These differences lead to a number of issues. How will the fixed and deployable data be integrated (e.g., in the context of modeling), especially given the different gamma-ray detectors? How will cross-calibration of the systems, considering the use of different air sampling filters, be accomplished?

These questions lead to more fundamental questions. Why is exposure rate measurable on the deployable, but not on the fixed, monitors? In this regard, what is the purpose of the exposure rate monitoring on the deployable monitors? Finally the EPA needs to address foreseen shortcomings in the RadNet program in the near term: (1) Shortage of fixed monitoring stations and (2) Scenario dependence of the interplay between fixed and deployable stations.

4.5.1 Near-term network shortage

Current plans for the upgraded RadNet system of air monitoring instruments call for a system comprising 180 fixed samplers and 80 deployable samplers. The 80 deployable units have been purchased and are available for deployment from NAREL in Montgomery and RIENL in Las Vegas. Procurement of the fixed monitors is in progress, but the full complement of 180 samplers is not projected to be completed for a number of years. However the projections made by EPA in the RadNet report are based on full deployment of 180 fixed monitors and the availability of 80 deployable monitors. Both types of units will be needed in response to a major airborne release of radionuclides.

It is planned that the deployable units will be used to expand the sampling network of interest around the site of a known airborne release. In light of the near-term limitations to the Network discussed above, it is important that the interplay between both types of monitors include a scenario where deployable units be used routinely in the near future to expand the fixed station network until more fixed sampling units can be obtained.

4.5.2 Scenario dependence

The objectives associated with the interplay of fixed and deployable monitors will be specific to the two basic operational scenarios: (a) "routine" and (b) "emergency" (i.e., a radiological 'incident,' whether accidental or intentional). In practice, the necessary monitoring data to characterize the radioactivity/radiation 'environment' in these two basic scenarios exists at multiple scales of detection or "resolution." For the sake of simplicity, three scales can be identified: National- or Interstate-scale (multi-state; 10^2 to 10^3 mile radius), Regional-scale (10^1 to 10^2 mile radius), and Local-scale (1 to 10 mile radius).

a) 'Routine' or 'baseline' monitoring is predominately an Interstate-scale activity. Routine monitoring relies virtually exclusively on the fixed monitor network: in this case, real-time monitoring is not as important as expanded coverage. The major benefit of the expansion and upgrade plan is the addition of up to 180 new monitoring sites. Fixed monitors provide Interstate-scale data, the deployable monitors provide Regional- and (to a complementary extent) Local-scale data. Local-scale data are also supplemented by portable monitors representing local- and state-assets. The purpose of this monitoring is to characterize, on an on-going basis, the ambient radiation environment in space and time. For this purpose, air monitoring needs to be supplemented with other existing monitoring Networks, including water and milk monitoring/sampling. The interplay with deployable monitors will depend on the ability of the fixed network to fulfill coverage requirements on the National scale. Deployables could be used to supplement that coverage; and

b) 'Emergency' monitoring requires data inputs at all 3 scales. Interstate- and Regional-scale data are used to track transport of major releases, typically from nuclear power plant accidents, the detonation(s) of improvised nuclear device(s) (rather than from an RDD). Local-scale data are most relevant for smaller RDD events, and help determine evacuation vs. shelter-in-place decisions. However, in addition, EPA should also address the pros and cons of 'routinely' pre-deploying the monitors to places where "intel" suggests that they may be needed (e.g., Times Square NYC during New Year's eve, Super Bowl game, World Series, Olympics, Mardi Gras, etc.) For such decision-making, real-time data are critical and deployables must be well integrated with fixed Networks in terms of data integration and immediate availability to the key decision making agencies FRMAC and the end user IMAAC that generates the plume projections. For small events the best interplay between monitor types would factor in all of the monitors in the Nation in spite of data quality variability, for state, local, utility, DOE and others.

5. OVERALL PROPOSALS FOR DATA MANAGEMENT

Charge Question 3: *Given that the system will be producing near real-time data, are the overall proposals for data management appropriate to the system's objectives?*

3a) Is the approach and frequency of data collection for the near real-time data reasonable for routine and emergency conditions?
3b) Do the modes of data transmission from the field to the central database include effective and necessary options?
3c) Are the review and evaluation of data efficient and effective considering the decision making and public information needs during an emergency?
3d) Given the selected measurements systems are the quality assurance and control procedures appropriate for near real-time data?

5.1 Issues with data analysis and management

A fundamental issue raised by the briefing document is the need for and use of "zero" readings. A closely related issue is the portrayal of 'not distinguishable from background' values, and their dissemination to incident commanders, policy makers, and the public. *The Review Panel recommends the use of PAGs, not simply MDAs, for definition of trigger levels.*

EPA staff explained that hourly data for the 7 regions of interest of the gamma-ray spectrometer, and Sr-90 by the alpha/beta particle spectrometer, at 180 fixed sampling stations will be transmitted by telemetry to a central group for collection and analysis. The resulting radionuclide concentration data will be stored, promptly distributed to appropriate government agencies, and made available to the public.

Two important aspects of evaluating these approximately 35,000 data points per day related just to radionuclide levels are:

1) rapid identification of elevated levels to identify locations of concern; and
2) avoidance of false positives that misdirect concern.

The EPA report should consider limiting the information distributed by the central analysis group to measurements that exceed a critical value selected for each radionuclide. The critical value should be selected to be significantly greater than the 2∗ MDA, but well below the limit on intake by inhalation. By selecting a 2∗ limit, 2.3% of null values – about 800 data points per day – would randomly exceed the limit and become the focus of concern. *This leads to the suggestion that, because even at a 3.1∗ limit, 0.1% of null values or about 3 per day, still will be above the limit, a data-pattern recognition program should be instituted and controlled by an experienced radiological professional at the central location.*

5.2 Response to charge question #3a

Is the approach and frequency of data collection for the near real-time data reasonable for routine and emergency conditions?

The answer to this question depends to some extent on how the data will be interpreted in relation to the multiple objectives outlined for RadNet. The approach and frequency of collection of near real time data appears to be reasonable for deciding during an emergency that an area is not likely to be effected by a particular event or events. The data in this case would be used by a decision maker in determining whether a PAG might be exceeded with a recommendation for evacuation. The decision would revolve around a relatively high exposure rate compared to the normal exposure rate so the outlined approach and frequency appear to be reasonable. As emphasized in the ORIA presentations, the primary objective is to identify areas that do not need to be evacuated during an emergency based upon a PAG. The frequency of collection appears to be a reasonable length for what is needed after an emergency.

Routine collection of information needs to have the same approach and frequency to (1) be continuously monitored so that the system is continuously ready for an emergency and (2) provide comparable background or baseline information for comparison. For these purposes the approach and frequency of near real time data collection appear to be reasonable. However, if routine collection will also be used to detect events then a better analysis of how this will occur is needed. Because a large volume of data will be collected in routine operation careful thought needs to be given to the types of decision rules used to test whether a particular set of data represents an increase above background. During routine operation of the fixed monitors consideration of how frequently false positives can be tolerated that would trigger an immediate data review. Immediate data review requires a commitment of valuable human resources that can come at any hour of the week, night or day. Hypothetically, if there were 10 ROI's for 168 hours each week in 180 monitors it would require performing about 300,000 statistical tests per week with perhaps 300 significant at the p=0.001, or 1 in a thousand, level each week, a number that is probably much greater than could be reviewed. Careful development of decision rules will require much thought and collaboration among all members of the RadNet team and their partner agencies. In developing these rules it is also necessary to balance the desire to actually being able to determine when a plume may be first seen by a monitor. It would be tragic to set decision rules for triggering a review at too high a level and to miss the early evidence of an event. The optimization of decision rules should also take into account the number of monitors and their physical locations. This means that the rules would have to change over time as the RadNet system is expanded. There does not appear to be a process in place for deriving optimal decision rules for RadNet.

When an actual event occurs, a different type of decision criteria is needed because it now becomes important to detect a different type of event, that is "when the monitor detects the plume" rather than the question of "dose a plume exist". At this stage the concern is not about false positives but about false negatives. At the same time, filters will be counted more frequently and more detailed data on spectra become available which will alter how you make decisions. At later stages of the emergency, decision rules will be needed designed specifically for areas along the boundaries of the plume. There are a number of additional uses outlined for RadNet such as identification of resuspension events that will require different decision rules.

One issue that should be considered when designing decision rules is the type of terrorism events that might occur. Most of the events considered seem to center around single large releases or explosions. Some actual terrorism events in this country involving nonradioactive materials have used contamination over a longer period of time at lower concentrations (chlordane in Wisconsin). Although it is hard to imagine an event of this type involving an airborne release that would be dispersed over a wide enough area that RadNet could detect, it probably deserves consideration when decision rules are being built. For example could an actual event be missed because an adjustment was made for an apparent “trend” in background?

5.3 Response to Charge Question #3b

Do the modes of data transmission from the field to the central data base include effective and necessary options?

Generally, the modes appear to be satisfactory. There are a variety of backup systems for communicating data including modem backup to the satellite telemetry. The panel liked the idea of using the PDA for getting information from the data-logger. All of the systems appear to be based on existing technology and the panel felt that the EPA should keep abreast of future improvements as the systems are deployed and employ them as needed. Some panelists felt that it was premature to conclude that the data systems were appropriate because it seems that the system had only been tested for a few days. Modifications to the system and its options will probably become clear once there has been much more testing of multiple data streams over longer periods.

Even though a communication technology may not change in terms of its technical specifications, other factors may have a detrimental or beneficial effect on the existing technology. An example would be when a form of communication becomes more popular can the existing infrastructure deal with the volume of use during an emergency? Also there should be an ongoing evaluation of the degree of independence of the alternative communications methods—are infrastructure changes causing two previously independent communication methods become dependent on the same resources.

The present plan provides multiple modes of transmission as the solution to the problem of potential failure of one or more communications links. There is the need to consider how decisions should be made with incomplete transmission of the data because of partial failure of all of the communication methods. If only partial information was received from the field stations, how would available data be prioritized? Should decision rules be changed when data are incomplete or information has larger variability than anticipated?

The charge question dealt with the transmission of data from the field to the central data base at NAREL. The evaluation and interpretation of RADNET data also involves other communication links that are critical to the process of providing high-quality information to decision makers and other stakeholders. The vulnerability of these communication links should also be considered in any evaluation of the RADNET system. Effective interpretation of RADNET data requires modeling at a center remote from NAREL—what alternative communication methods are available to link to this center? Similar concerns arise over communication of results to decision makers since for many scenarios the decision makers are likely to be located at the site of the emergency where communication methods may not be working. FRMAC and coordinating agencies also need to have alternative communication methods. Also if the field stations, NAREL, modeling center, FRMAC, agencies, and decision makers are identified as a communications system to provide information to the public in an emergency then there is a need to consider not only the communication links between the parts of the system but also the need for alternative sites such as the modeling center to preserve the communication system to the public.

The panel expressed some concern with regard to the operators being a weak link in some aspects of the transmission of data. While understanding the plan to use non-radiological personnel for such tasks, it is believed that there are sufficient trained radiation safety personnel available to be able to use some of them for this role. For example, there could be many volunteers from the Health Physics Society who are unlikely to have a formal role in an emergency that would be willing to help. In addition, radiation safety staff from other, unaffected States may be called upon through mutual aid agreements. This becomes important if the role of the deployable monitors is revised in line with other panel recommendations. If the deployables are used in areas where there are measurable radiation or contamination levels non-radiological personnel may not respond appropriately.

The panel believes that the revised mission of deployable monitors has a number of other impacts. It makes it important to have a direct read-out of radiation levels on the monitor itself. It is felt that being able to download a local dose rate to a PDA and then read it would not be satisfactory. Similarly, there is likely to be more need for electrical generators than has been planned for up to this point as well as a greater need for security of the deployables once positioned.

The panel felt that only having one person from each lab responsible for 20 systems was too few. A span of control of about 5 teams to one lab expert would be much better.

Support is needed for deployable exercises so that there can be an evaluation of the SOPs for: set-up; criteria for siting; evaluation of data transmission; data QA; data presentation; use of data by incident management; as well as message evaluation on data interpretation.

5.4 Response to Charge Question #3c

Are the review and evaluation of data efficient and effective considering the decision-making and public information needs during an emergency?

5.4.1 Review and evaluation of data

The presentations on methods to provide Quality Assurance/Quality Control (QA/QC) of the data showed that the plans for ensuring the quality of the data were adequate. In addition, the automatic and computerized methods currently in place to determine if the equipment is working properly and that data are accurate were well thought out. Given that any incident response plan or EPA decision based on RADNET will depend on analyses from models that integrate data from a wide range of sources, it is essential that the RADNET network be optimized in terms of these models. These process-oriented environmental models are typically underdetermined as they contain more uncertain parameters than the state variables available to them for calibration. Therefore we strongly advocate the use of sensitivity analyses in the siting of future monitor stations (fixed and deployable). This represents a necessary step to optimize the value of collected monitoring data to the decision makers.

The Review Panel notes that standard operating procedures (SOP) should be in place and accompany all the QA/QC plans to insure that the data are handled reproducibly prior to any release and that information from the system is accurate and reliable. The QA/QC system should be tested over an extended period of time with "dry runs" to determine if the methods can insure that the equipment is operating properly at both the fixed and deployable stations.

In the rare case when one of the fixed stations has a reading that is outside the predetermined range of acceptability, everything possible must be done to expedite the QA/QC process to validate the readings. Even in an emergency, it is essential that the proper QA and QC be done on the data before release; the time table for releasing the data should not be compressed in any way that may jeopardize data quality.

The air monitoring and data management/transmission system have only recently been delivered to NAREL and have not been completely tested. The discussion of data in the Concept and Plan document is brief and provides only a conceptual plan for data management. The Review Panel did not see complete raw data sets or data in the form that will be provided to users, including the public. The NAREL proposal for data management appears to be adequate, but it cannot be conclusively stated that it is appropriate to the system's objectives until the data management procedures are developed and tested.

5.4.2 Communication to decision makers and the public

The presentation of data in a manner that accurately conveys technical information must vary for different events and for users with varying needs and levels of technical expertise. The method of presenting the data to decision-makers does not need to be the same as the methods used to present the data to the public. Data collected routinely from the fixed monitors can be supplied in raw form to either of these groups. They need to be made available in an easy-to-access form as soon as they have been appropriately evaluated for quality assurance and control (QA/QC), as has been done in the past. The handling and release of the data in emergencies has different requirements which need to be carefully considered

5.4.3 Communication with decision makers

In an emergency, the EPA's responsibility is to provide accurate and reliable data to National Atmospheric Release Advisory Center (NARAC) Interagency Modeling and Atmospheric Assessment Center (IMAAC) at Lawrence Livermore National Laboratory as soon as possible so that models can be adequately developed to help understand the dose, distribution and direction of the plume. As soon as the data have been conveyed to IMAAC and properly evaluated, IMAAC needs to convey the models along with all other information on the event to Federal Radiological Monitoring and Assessment Center (FRMAC).

Immediately following the recognition of a radiation incident, local Incident Command center will be established to direct local responders in their rescue and treatment of people who are directly affected and to protect the public who are not affected. Incident Command will make decisions on the basis of the information at hand. These decisions must be informed by data that describe the nature and significance of any potential radiation exposure. Very early qualitative data will be collected locally and provide information for early decisions but historical and quantitative data collected by EPA, including RadNet data, should be forwarded through channels as soon as possible. Because data need to be reviewed to assure quality, there will be some delay. Everything possible should be done during emergencies to minimize the time necessary to review the data and forward it to inform local Incident Command as soon as possible.

5.4.4 Communication with the public

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In the event of an emergency, FRMAC, rather than EPA, has the initial responsibility for releasing information to the public. It is important that the flow of data from the event to the public be restricted to this line of communication (EPA to IMAAC to FRMAC), so that the messages the public receives are consistent, accurate and useful as possible. For example it is important that there is not one message reporting activity in dpm and another suggesting some type of radiation dose. After communication from FRMAC has occurred, EPA should then make every effort to rapidly supply the validated raw data in a form that is easy for the public to understand.

5.4.5 Units for communication

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The Review Panel was concerned that in the preparation of documentation, such as the *"Expansion and Upgrade of the RadNet Air Monitoring Network,"(Volume 1 and 2) Concept and Plan,"* the appropriate international units to express activity, radiation exposure, dose and risk were not used. This may be related to the fact that international units were adopted and came into wide spread use after much of the monitoring data were derived by the systems that have been replaced by RadNet. The Review Panel considered a strong recommendation that all data should be re-evaluated using the appropriate S.I. units with the corresponding older units in parenthesis, i.e. Bq (pCi) or rem (Sv) etc. However, convincing arguments were presented that instrumentation commonly used by first responders do not use appropriate S.I units, nor is their training presented in these units. The Review Panel was convinced that clarity of communication and comprehension was more important than international conformity at this time, so the recommendation has been softened to suggest that S.I. units may be presented in parenthesis in preparation for a transition in the future.

5.4.6 Communicating risk

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Great care needs to be taken in converting raw data from counts per minute, to exposure, dose and risk. Raw counting data are very site, detector, nuclide, isotope, particle size, chemical form and population specific. Thus, without much additional information and analysis, the raw data (counts per minute) cannot be used to make even the crudest estimates of risk. In conveying the raw data to the public, it is important that the message does not convey an improper perception of the risk from any event. For example, Figure B.1 page B-2 in the report records the level of activity as Monthly Maximum Gross Beta Concentration (pCi/m^3) over a 13 year time period. It shows that the activity during this time varies by more than 100,000 times. Conveying such raw data to the public would suggest that the risk had changed by a very large amount. Historical data suggest that these large changes in activity in the air have resulted in non detectable changes in the frequency of cancer among the U.S.population This is finding related to the high frequency of spontaneously or naturally-occurring cancer (all types) in the population (approximately 4 in 10 persons will develop some form of cancer during their lifetime) and the relatively low additional risk of cancer associated with exposure to ionizing radiation.

5.4.7 Other factors that complicate accurate communication

The difficulty in communicating raw data from RadNet is further complicated by the wide range of background radiation and radioactive materials in the environment. *Information on background radiation and its variability also needs to be communicated to the public relative to the changes measured by RadNet.* It would be important for information on the range of background radiation to be quantified and made available with any report to the public.

The difference between "calculated risk" based on estimates of radiation doses to populations or individuals and "measured increases in cancer frequency" based on observations of the number of cancer cases in epidemiological studies following low dose radiation exposures of large populations needs to be further established and discussed in a framework that the public can understand. The magnitude of the risk of radiation-induced cancer compared to the risk of developing cancer in the absence of prior radiation exposure (i.e. spontaneously) needs to be *correctly and clearly* communicated using appropriate language in any releases to the public. *Care should be taken to avoid the estimation of the number of excess cancers in large populations exposed to very low doses of radiation. This is a calculation that should not be done by EPA or from data derived from RadNet.*

5.4.8 Preparing for communication in an emergency

The Review Panel recommends that ORIA develop standard messages for use in press releases and emergency broadcast messages. These statements should be part of any exercise with RadNet participation.Statements should be devised from mock These statements need to be related to exposure, activity, dose and risk utilizing a range which would encompass those typically found from mock "data". *Such statements must be carefully reviewed by social scientists and communications experts to be sure that the messages are understandable and accurate.*

The messages derived for use in exercises also need to be discussed with decision makers associated with the area where the exercise is conducted. These decision makers should include individuals like the Governors, City Managers, Mayor, Media managers, Chief of Police and Fire Chief. The decision makers should be asked to respond to the information provided and let EPA, IMAAC, and FRMAC know what information that they need to make decisions and how the data and messages supplied would influence the decisions that they must make in the time of a real event or emergency. Studies of this type will help to develop useful, understandable and accurate messages that can be used to convey the data derived from RadNet following an event involving radiation dispersal devices or improvised nuclear weapons.

It will be especially important to have these messages developed well ahead of time and defined for rapid use in the case of a real event. Such messages will need to be modified to be specific for each real event. They must provide a foundation that will help the public understand if they were exposed, the levels of the exposure, the radiation doses associated with the exposure and the level of damage or risk associated with the exposure. This will provide a rational basis for any action or sacrifice that the public are asked to make by the decision makers.

5.5 Response to Charge Question #3d

Given the selected measurements systems, are the quality assurance and control procedures appropriate for near real-time data?

It is EPA policy that all EPA environmental programs observe 48 CFR 46 and comply fully with the American National Standard ANSI/ASQC E4-1994 for the agency-wide Quality System. 48 CFR 46 and ANSI/ASQC E4-1994 provide the regulatory and operational basis for QA/QC procedures and appear appropriate and adequate for the RadNet Air Monitoring Network. However, given the extensive array of requirements and activities provided in these regulations and standards, important issues regarding the RadNet Air Monitoring Network include the following:

- The specific EPA QA System established to assure that environmental data from the RadNet Air Monitoring Network used to support federal, state, and local decisions are of adequate quality and usability for their intended purposes;
- Are all organizations and individuals under direct contract to EPA for RadNet Air Monitoring related activities providing their services, products, deliverable items, personnel training, and work in full conformance with 48 CFR 46 and ANSI/ASQC E4-1994?;
- Has EPA audited and documented that the required quality and performance of these services, products, deliverable items, personnel training, personnel training, and work is adequate and demonstrated for other interested parties?;
- Annual assessments (as documents available to appropriate agencies) of the effectiveness of each quality system component associated with the RadNet Air Monitoring Network are required to demonstrate conformance to the minimum specifications of ANSI/ASQC E4-1994; and
- Because the integrity and accuracy of the data measured, gathered, processed and disseminated is essential to the successful mission of the RadNet Air Monitoring Network, a controlled testing and periodic assessment of the overall performance of the system is essential for national security and confidence in the network.

REFERENCES

[NOTE: To be provided by RAC's RadNet Review Panel. DFO has provided references to ERAMS I, ERAMS II, etc. below, and will provide others, including relevant ***FR*** notices if needed. - - - KJK]

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U.S. EPA CREM. 2003. *Draft Guidance on the Development, Evaluation, and Application of regulatory Environmental Models*, Prepared by the Council for Regulatory Environmental Modeling (CREM), November 2003, 60 pages [see also the hotlink for this document at http://www.epa.gov/ord/crem/library/CREM%20Guidance%20Draft%2012_03.pdf]

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U.S. EPA SAB. 1998. "*An SAB Advisory: Environmental Radiation Ambient Monitoring System (ERAMS) II, An Advisory by the Radiation Advisory Committee (RAC)*," EPA-SAB-RAC-ADV-98-001, August 28, 1998

U.S. EPA SAB. 1996. "*Radiation Advisory Committee (RAC) Advisory on Environmental Radiation Ambient Monitoring System (ERAMS)*," EPA-SAB-RAC-ADV-96-003, April 5, 1996

APPENDIX A – Description of the SAB Process

[NOTE: Will be further edited as appropriate and provided here or in introduction. - - - KJK]

A-1 Request for EPA Science Advisory Board (SAB) Review

The EPA Office of Radiation and Indoor Air (ORIA) requested the SAB to provide advice on the National Monitoring System (NMS) upgrade, formerly known as the Environmental Radiation Ambient Monitoring System (ERAMS). The Radiation Advisory Committee (RAC) held a public conference call meeting on February 28, 2005 to receive briefings from ORIA about this request, to receive public comments and to discuss its plan for the coming year (see ***FR***, Vol. 70, No. 19, January 31, 2005, pp. 4847-4848).

A-2 Panel Formation

The Panel (Radiation Advisory Committee's (RAC) RadNet Review Panel) was formed in accordance with the principles set out in the 2002 commentary of the SAB, *Panel Formation Process: Immediate Steps to Improve Policies and Procedures: An SAB Commentary* (U.S. EPA SAB. 2002). A notice offering the public the opportunity to nominate qualified individuals for service on the Panel was published, where the SAB Staff Office requested nominations of experts to augment expertise to the SAB's Radiation Advisory Committee (RAC) for SAB review of RadNet's air radiation network, a nationwide system to track environmental radiation (see ***FR***, Vol. 70, No. 56, March 24, 2005, pp. 15083-15084). The SAB Staff Office sought individuals who have radiation expertise and knowledge of ERAMS in the following areas:

1) Instrumentation (especially air monitors and detection equipment involving fixed and deployable monitors, sodium iodide crystals, and gamma exposure instruments);
2) Statistics (especially involving data interpretation, identification of abnormalities during normal operations, monitor siting plans, baseline data and data trends analysis, data coverage issues, and data interpretation);
3) Modeling (especially involving validating and refining source terms, dispersion modeling, meteorological assumptions and estimates);
4) Risk assessment (with particular experience and expertise in population dose reconstruction, health data interpretation, and health effects); and
5) Risk communication.

The SAB Staff Office Director, in consultation with SAB Staff, including the Designated Federal Officer (DFO), the SAB Ethics Advisor, and the Chair of the SAB's Chartered Board, selected the final Panel. Selection criteria included: excellent qualifications in terms of scientific and technical expertise; the need to maintain a balance with respect to qualifying expertise, background and perspectives, willingness to serve and availability to meet during the proposed time periods, and the candidate's prior involvement with the topic under consideration. The final Panel includes persons with expertise advertised in the ***Federal Register*** as outlined above. The Panel members, in addition to having new persons to serve, also include individuals who are experienced SAB consultants familiar with the Agency. The final panel determination memo was signed on November 22, 2005 and posted prior to the December 1, 2005 conference call meeting of the Panel.

A-3 Panel Review Process and Review Documents

The RAC's RadNet Review Panel first met via conference call on December 1, 2005 to be briefed by the Agency staff on the draft document to be reviewed, to clarify the charge to the Panel, and to assign specific charge questions to the individual Panelists in preparation for the face-to-face meeting. The actual face-to-face meeting of the RAC's RadNet Review Panel to conduct a peer review of the Agency's draft document entitled *"Expansion and Upgrade of the RadNet Air Monitoring Network, Vols. 1 &2 Concept and Plan,"* dated October, 2005 was held on December 19 and 20, 2005 in the Agency's NAREL in Montgomery, AL where many of the Agency ORIA Staff implementing and managing RadNet are housed (see ***FR***, Vol. 70, No. 220, November 16, 2005, pp. 69550-69551).

The RAC's RadNet Review Panel scheduled three (3) additional public conference calls to reach closure on their draft report in critique of the Agency's RadNet draft document dated October, 2005. The meetings that are scheduled include March 20, 2006, April 10, 2006, and June 12, 2006. (see ***FR***, Vol. 71, No. 40, March 1, 2006, pp. 10501-10502).

(KJK will briefly summarize the public conference call meetings as they occur, as well as a briefly summarize the Chartered Board's Quality Review process when that is complete. - - - KJK).

APPENDIX B- BIOSKETCHES

U.S. ENVIRONMENTAL PROTECTION AGENCY
SCIENCE ADVISORY BOARD
RADIATION ADVISORY COMMITTEE (RAC) RadNet REVIEW PANEL

Biosketches of the RAC RadNet Review Panel

Dr. Bruce B. Boecker:

Dr. Bruce B. Boecker: is a Scientist Emeritus of the Lovelace Respiratory Research Institute, Albuquerque, New Mexico. He is a Diplomate of the American Board of health Physics, a Certified Health Physicist, and a Fellow of the Health Physics Society (HPS). He has served on numerous committees especially for the National Council Council on Radiation Protection and Measurements, NCRP, International Commission on Radiological Protection, ICRP, and the National Academy of Science/National Research Council, NAS/NRC, dealing with the intake, internal doses, bioassays, epidemiology, radiobiology and risk of radionuclides. He has been elevated to honorary member of the NCRP. He was a consultant to develop a Federal strategy for research into the biological effects of ionizing radiation. He currently serves as a Technical Staff Consultant with the NCRP dealing with various Homeland Security topics. Dr. Boecker's research interests have been manily in tow broad areas, namely (1) inhalation toxicology and (2) dose-response relationships for long-term biological effects produced by internally deposited radionuclides. He has been particularly involved in the conduct of animal experimentation to develop information to support predictions of consequences of accidental exposure of man or to establish standards to ensure the safe and orderly conduct of activities that might result in release of toxic agents to man's environment. His personal research efforts have been associated primarily with the radiobiology and toxicology of airborne material associated with different activities in the nuclear fuel cycle. This research has spanned broadly from studies of aerosol characteristics as they may influence patterns of deposition, retention, and dosimetry on through to risk assessments for different nuclear energy systems. Dr. Boecker holds a Ph.D. and M.S. in Radiation Biology from the University of Rochester and a B.A. in Physics from Grinnell College.

Dr. Antone L. Brooks

Dr. Antone L. Brooks is a radiation biologist, Senior Scientist and Professor of Radiation Toxicology in the Environmental Science Department at Washington State University. Dr. Brooks received an associate's degree in Chemistry from Dixie Junior College in St. George, Utah, a B.S. in Experimental Biology and an M.S. in Radiation Biology from the University of Utah in Salt lake City. He received his Ph.D. in Physical Biology and Genetics from Cornell University in Ithaca, New York. Dr. Brooks has conducted extensive research on health effects of radiation exposure from both external radiation sources and internally deposited radioactive materials. He has used both molecular, cell and whole animal research to help define these effects. His current research is focused at developing a scientific basis for radiation risk estimates following low-dose radiation exposure. He has done extensive work to define energy barriers for radiation-induced cellular effects, has characterized cell and molecular responses that result in bystander effects, adaptive responses and genomic instability. His current focus is to understand how these new observations result in paradigm shifts that may impact the shape of radiation dose-response relationships in the low dose region. A major current focus is developing better tools to communicate the results of radiation science including a web site, http://lowdose.tricity.wsu.edu. Dr. Brooks has served as a member of the NAS BEIR VI Committee on Health Effects of Exposure to Radon. He is a member of the National Council on Radiation Protection and measurements (NCRP) and is on the Board of Directors of the NCRP. He is currently serving on the EPA Science Advisory Board (SAB) as a member of the Radiation Advisory Committee (RAC). He is a member of the Editorial Board of the International Journal of Radiation Biology and the International Journal of Low Radiation.

Dr. Gilles Y. Bussod:

Dr. Gilles Y. Bussod is Chief Scientist with New England Research, Inc. in White River Junction, VT, and an Adjunct Professor in Earth Sciences at The University of Vermont in Burlington, VT. He also holds an appointment as Professor Candidat aux Universités de France, a Doctorate in Geophysics from the Université de Paris VII, France, and a PhD in Geology from the University of California, Los Angeles. He has recently served on the Faculty of Science at the International Research Center of the Catholic University of Leuven, Campus Kortrijk in Belgium and was employed as President of Science Network International, Inc., in Santa Fe, NM. Previously he was a staff Hydrogeologist and Geochemist at Los Alamos National Laboratory, Los Alamos, NM, and a Science Fellow at both the Bayerisches Geoinstitut in Bayreuth, Germany, and the Lunar and Planetary Institute, Houston, TX. He also served as a National Laboratory Representative to the Middle East, and a Delegation Member to the U.S. Secretary of State Madeleine Albright, at the Economic Summit Conference in Doha, Qatar. As the Los Alamos National Laboratory Project Leader and technical manager for the Yucca Mountain Project, he received several Achievement Awards and Patents. Dr. Bussod's research is centered on Environmental Restoration of contaminated DoD and DOE sites, specializing in the design and implementation of integrated laboratory and field studies on radionuclide transport, the remobilization of "legacy waste" in the environment, and the effect of subsurface heterogeneities on modeling transport phenomena and upscaling. He was PI for the Underground Unsaturated Zone Transport Test, Busted Butte, NV, and The Cerro Grande Subsurface Remediation Project, Los Alamos, NM. He holds authorship or co-authorship in over 60 publications involving geochemical flow and transport and related phenomena, as well and over 30 invited oral presentations dealing with unsaturated zone modeling, high pressure and high temperature research in experimental rock physics and petrology, novel drilling methods, rock melting drilling systems, deformation mechanisms, energy extraction techniques, high pressure experimental seismic velocity measurements and related topics.

Dr. Brian Dodd:

Dr. Brian Dodd is originally from the U.K. where he worked at Imperial College and the Royal Naval College in Greenwich. He and his family moved to the USA in 1978, taking up citizenship in 1993. Until February 2004, Dr. Dodd was Head of the International Atomic Energy Agency's Radiation Source Safety and Security Unit, managing the IAEA's efforts in dealing with orphan sources and the potential use of radioactive sources for radiological terrorism. He is currently 'retired' form the managerial burdens of work, but is still pursuing the technical aspects as BDConsulting in Las Vegas. Prior to joining the IAEA he was at Oregon State University for 20 years, most recently as the Director of its Radiation Center a well as a Professor of Health Physics and Nuclear Engineering. Dr. Dodd has been involved with the Health Physics Society for many years, including terms of office on the Board of Directors and as treasurer. He is currently (2005-6) the President-Elect of the HPS as well as Treasurer of the International Radiation Protection Association. His fields of expertise include safety and security of radioactive sources, transportation of radioactive material, emergency response, training and research reactors. Brian Dodd has authored or co-authored a number of IAEA/UN publications on security of radioactive sources, safe transport of radioactive materials, management of radiation protection, quality aspects of research reactor operations and related topics. He has authored or co-authored over 100 publications in technical journals, conference proceedings, reports and others dealing broadly with the above topics. Dr. Dodd has a B.S. in Nuclear Engineering and Ph.D. in Reactor Physics from Queen Mary College, London University.

Dr. Shirley A. Fry:

Dr. Shirley A. Fry is a self-employed consultant in radiation health effects. She holds a medical degree from the University of Dublin, Trinity College, Ireland, and a master's degree in epidemiology in the School of Public Health, University of North Carolina, Chapel Hill. She was on the staff of the Medical Sciences Division (MSD) of Oak Ridge Associated Universities (ORAU) from 1978 until her retirement in 1995. At ORAU she was member of MSD's Radiation Emergency Assistance Center/Training Site's (REAC/TS) clinical staff, teaching faculty and response team (1978-1995); director of its Center for Epidemiologic Research (1984-1991) and its assistant director (1991-1995). Subsequently she was a member of the Scientific Advisory Council and later the scientific director of the International Consortium for Radiation Health Effects Research, a Washington, DC.-based consortium of research groups at academic institutions in the US, Belarus, Russian Federation and Ukraine established to conduct collaborative epidemiological studies among groups potentially exposed to radiation as the result of the 1986 Chernobyl reactor accident. She continued a part-time association with ORAU until November 2005. Her areas of scientific interest are in the acute and chronic health effects of radiation, specifically in the long term follow-up of individuals and populations previously accidentally exposed or at risk of occupational exposure to radiation, including workers employed by US Department of Energy, its predecessor agencies and their contractors, and in the US radium dial painting industry. Dr. Fry is the author or co-author of a number of publications on topics relating to these groups. She has served on national and international committees concerned with radiation health effects, including the Institute of Medicine' Medical Follow-up Agency (IOM/MFUA's) Committee on Battlefield Exposure Criteria and the National Academies of Sciences/ National Research Council 's Board of Radiation Effects Research (NAS/NRC's BEAR) Committee on the Assessment of the Scientific Information for the Radiation Exposure,Screening and Education Program, the Health Studies Group of the US/USSR Joint Commission on Chernobyl Nuclear Reactor Safety and the International Agency for Research on Cancer's International Study Group on Cancer Risk Among Nuclear Workers.

Dr. William C. Griffith:

Dr. William C. Griffith was trained as a biostatistician and has collaborated for over three decades in studies of the dosimetry and health effects of radiation and other toxicants. His work has included design, data collection and analysis of laboratory and field based studies. In particular he has extensive experience in estimation of doses from internally deposited radionuclides and estimation of dose response in terms of age specific incidence rates and prevalence. He has also been active in translating his experience into models that are useful for health protection through is participation in committees of the National Council for Radiation Protection. More recently he has analyzed how these models are applied in environmental cleanup of the Department of Energy's Hanford site, and he has worked extensively with committees of the Hanford Advisory Board. Most recently he has been funded as part of the Department of Energy's Low Dose Radiation Program to translate laboratory results into mathematical models that will be useful for future regulation of radiation. Dr. Griffith also has experience in the study of non-radioactive toxicants. He was part of the team at the Lovelace Inhalation Toxicology Research Institute that was the first to prove that diesel exhausts are pulmonary carcinogens in laboratory animals. For the last five years at the University of Washington he has been Director of the Risk Characterization Core for the Child Health Center funded by the Environmental Protection Agency and the National Institute of Environmental Health Science. As director he has designed and developed statistical methods for analysis of a community based randomized intervention to test the effectiveness of educating farm workers about how they can decrease the accidental exposures of their children from pesticides they bring home on their clothes. Dr. Griffith has also collaborated with EPA Region 10 by lecturing frequently on how to apply statistical methods to superfund cleanup decisions. This year he organized 8 workshops on the application of new genomic and proteonomic methods in collaboration with EPA-ORD for EPA regions, state and tribal environmental offices.

Dr. Helen Ann Grogan:

Dr. Helen Ann Grogan is a member of the SAB's Radiation Advisory Committee. She is employed as an independent consultant who has her own consulting firm, Cascade Scientific, which has been subcontracted by Risk Assessments Corporation (RAC) to work on a variety of projects, including an independent assessment of the risks to the public from the 2002 Cerro Grande Fire for the New Mexico Environment Department, development of a risk-based screening for historical radionuclide releases to the Columbia River from the Hanford Nuclear Facility in Washington under contract to the Centers for Disease Control and Prevention (CDC), and two dose reconstruction projects (Rocky Flats near Denver, CO and Savannah River in So. Carolina). Her work for the Rochy Flats site emphasized quantifying cancer risk and its uncertainty following exposure to plutonium from inhalation and ingestion. Dr. Grogan is currently working with other RAC contractors on the RACER project to develop a process and tool that can be used to guide the efforts to reduce public health risk and ecological impact from radionuclides and chemicals originating at the Los Alamos National Laboratory. DR. Grogan has assisted in the development of an International Features Events and Processes (FEP) database for the Nuclear Energy Agency (NEA) Organization for Economic Cooperation and Development(OECD) in France to be used in the performance assessment of radioactive waste disposal systems. In addition, she was also involved with the Swiss National Cooperative for the Disposal of Radioactive Waste (Nagra), specifically in modeling the biosphere for repository performance assessment, and in development of scenario analyses for the Nagra Kristallin I and Wellenberg projects and development of supporting data bases that identify important phenomena (FEPs -features, events and processes) that need to be accounted for in repository performance assessment. She was actively involved in the Biospheric Model Valuation Study - Phase I and II BIOMOVS study (Biospheric Model Validation Study), which is an international cooperative effort to test models designed to quantify the transfer and accumulation of radionuclides and other trace substances in the environment. Dr. Grogan's doctoral thesis title is "Pathways of radionuclides from soils into crops under British field conditions." She has authored or co-authored several dozen publications, and technical reports dealing with the role of microbiology modeling the geological containment of radioactive wastes, plant uptake of radionuclides, laboratory modeling studies of microbial activity, models for prediction of doses from the ingestion of terrestrial foods (with a focus on radionuclides), long-term radioactive waste disposal assessment, modeling of radionuclides in the biosphere, quantitative modeling of the effects of microorganisms on radionuclide transport from a High Level Waste respository and related topics. She received her Bachelor of Science Degree in Botany with honors from the Imperial College of Science and Technology at the University of London, and her Ph.D. from that same university.

Dr. Richard W. Hornung :

Dr. Richard W. Hornung is a member of the Radiation Advisory Committee (RAC) since FY 2001. He recently (2005) became Director of Biostatistics and Data Management of Cincinnati Children's Hospital Medical Center, Division of General and Community

Pediatrics. He headed the Statistical Working Group of the RAC's Multi-Agency Radiological Laboratory Analytical Protocols (MARLAP) Review Panel. He served as a consultant to the RAC (March, 1999), and participated in the SAB's advisory on Radon Risk. He was Senior Research Associate and Director of the Division of Biostatistical Research and Support in the Institute for Health Policy and Health Services Research at the University of Cincinnati Medical Center in Cincinnati, Ohio. He has served since 1996 as a member of the White House Committee on Revisions to the Radiation Exposure Compensation Act. Since 1990, he has served as an advisor on the National Research Council. He received numerous awards, including the U.S. Public Health Service award for "Sustained High Level Performance in the Field of Biostsatistics." He was a consultant to the National Academy of Science Committee on the Biological Effects of Ionizing Radiation (BEIR IV). He is a reviewer for a dozen scientific journals. His peer-reviewed publications deal with exposure assessment methods, lung cancer risk in Uranium miners, dose assessments, dose reconstruction, development of models for use in estimating exposures to a number of pollutants, including diesel exhaust, benzene, ethylene oxide, lung cancer in shipyard workers and other related topics. In the area of radiation research, he is currently funded under contract to the University of Kentucky to serve as the scientific director of an occupational epi study of workers at the Paducah Gaseous Diffusion Plant. He is also funded by NIOSH as the biostatistician on a study of radiation related cancers among residents living near the Fernald plant in Southwestern Ohio. Dr. Horning has a B.S. in Mathematics from the University of Dayton, an M.S. in Statistics from the University of Kentucky, and a Ph.D. in Biostatistics from the University of North Carolina.

Mr. Richard Jaquish:

Mr. Richard Jaquish has over 40 years experience in environmental radiation surveillance. He was the Director of the Technical Support Laboratory of the EPA National Environmental Research Center in Las Vegas which provided laboratory services for the analysis of samples from underground nuclear testing and plowshare programs. Analytical procedures were developed for unique radionuclides and media resulting from nuclear tests. In 1980 he became a senior research engineer with Battelle Memorial Institute in Richland, WA where he was manager of the environmental radiation program for the Hanford site. He was later the manager of the Office of Hanford Environmental that managed the programs in environmental surveillance, groundwater monitoring, meteorology, and wildlife resources. In 1995 he took a position with the Washington Department of Health as an advisor in environmental radiation and Hanford cleanup activities.

Hands on monitoring experience in unique environments included six months of monitoring radioactivity in Antarctica, monitoring fallout in Eskimos in Alaska, and regularly serving on a flight crew for aerial monitoring of radioactive plumes on and around the Nevada Test Site. He was a regular member of emergency response teams at Battelle and the State of Washington and responded to several unusual occurrences including the 2000 Hanford fire.

Mr. Jaquish served two terms on the American Public Health Committee on Laboratory Standards and Practices. He was a member of the National Council on Radiation Protection and Measurements (NCRP) Committee 64 (1994-2000) on Environmental Radiation and Waste Issues and is currently a member of NCRP Committee 64-22 that is preparing a guide on "Design of Effective Effluent Monitoring and Environmental Surveillance Programs." Mr. Jaquish has a B.S. degree in Civil Engineering from Washington State University and an M.S. in Engineering and Applied Physics from Harvard University. He has over 20 publications in environmental radioactivity.

Dr. Janet A. Johnson:

Dr. Janet A. Johnson is currently employed by MFG, Inc. in Fort Collins, CO as a Senior Radiation Scientist with expertise in health physics, radiation risk assessment, and environmental health. MFG, Inc., a Tetratech Company, provides environmental engineering consulting services to industry including the mining sector. She holds a BS in Chemistry from the University of Massachusetts, an MS in Radiological Physics from the University of Rochester School of Medicine and Dentistry, and a PhD degree in Microbiology (Environmental health) from Colorado State University. Dr. Johnson was formally employed by Colorado State University as Interim Director of Environmental Health Services in Fort Collins, Colorado. She is a certified industrial hygienist (CIH, radiological aspects) and is also certified in the comprehensive practice of health physics by the American Board of Health Physics. She is an active member of a number of radiation and health-oriented professional organizations, and is a Fellow of the Health Physics Society (HPS), as well as a former member of the Board of Directors of the HPS. She has served on the Colorado Radiation Advisory Committee since 1988 and was a member of the Colorado Hazardous Waste Commission (1992-1997). Dr. Johnson's primary consulting work focuses on the mining industry with emphasis on uranium recovery facilities. She is also involved in developing technical basis documents for the National Institutes of Occupational Safety and Health (NIOSH) dose reconstruction project under the Energy Employees Occupational Illness Compensation Program Act (EEOICPA). Dr. Johnson is a former chair of the Radiation Advisory Committee. In addition, she chaired the ERAMS II advisory (EPA-SAB-RAC-ADV-98-001, August 28, 1998).

Dr. Bernd Kahn:

Dr. Bernd Kahn is Head of the Environmental Radiation Branch since 1974 (formerly the Environmental Resources Center) and now Professor Emeritus of the Nuclear and Radiological Engineering and Health Physics Programs at Georgia Institute of Technology (GIT). He received his B.S. in Chemical Engineering from Newark College of Engineering (Now New Jersey Institute of Technology), M.S. in Physics from Vanderbilt University and Ph.D. in Chemistry from the Massachusetts Institute of Technology. He was Adjunct Professor of Nuclear Engineering at the University of

Cincinnati (1970-1974), Chief of the Radiological & Nuclear Engineering Facility at the U.S. EPA's National Environmental Research Center (1970-1974), undertaking research in environmental, medical, and biological radiological programs, including studies of radioactive fallout in food, radionuclide metabolism in laboratory animals, and SR-90 balances in human infants; an Engineer/Radiochemist with the U.S. Public Health Service (1954-1970), evaluating the treatment of low-and intermediate-level radioactive wastes; and a Health Physicist and Radiochemist with Union Carbide Corporation (1951-1954).

Dr. Kahn has served on a number of distinguished committees, panels and commissions, including the National Research Council committees on decontamination and decommissioning of uranium enrichment facilities, buried transuranium waste, single shell tank wastes, Panel on Sources and Control Technologies, Committee on Nuclear Science, and Subcommittee on the Use of Radioactivity Standards. Dr. Kahn serves on the U.S. EPA SAB's Radiation Advisory Committee, having been on the RAC reviews of both ERAMS I and ERAMS II, the predecessor systems to RadNet, as well as the MARLAP review on laboratory radiation measurement protocols. He has served on the National Council on Radiation Protection and Measurements (NCRP) Scientific Committees as Chair of the Scientific Committee 64-22 for Effluent and Environmental Monitoring, Chair of the Task Group 5 on Public Exposure from Nuclear Power, member of the Scientific Committee 84 on Radionuclide Contamination, member of the Scientific Committee 64 on Environmental Issues, member of the Scientific Committee 63-1 on Public Knowledge About Radiation Accidents, member of the Scientific Committee38 on Accident-Generated Waste Water, member of the Scientific Committee 18A on Radioactivity Measurement Procedures, and member of the Scientific Committee 35 on Environmental Radiation Measurements.

Dr. Kahn is widely published with over 160 publications on the topics of radiation measurements, monitoring and protocols, fate of radionuclide discharges, critical pathways for radiation and population exposure, radiochemical analyses for environmental studies, airborne radiation in buildings , emergency response to accidents involving radioactive materials, airborne fallout, sources, fate and occurrences and health effects of radionuclides in the environment, surveillance of radionuclides in the food chain, integrated environmental measurement, germanium detectors and other devices, decommissioning procedures and radiation-related topics.

Dr. Jonathan M. Links:

Dr. Jonathan M. Links is Professor of Environmental Health Sciences at the Johns Hopkins Bloomberg School of Public Health, with joint appointments in Radiology and Emergency Medicine at the Johns Hopkins School of Medicine. He is a medical physicist, with a B.A. in Medical Physics from the University of California, Berkeley, and a Ph.D. in Environmental Health Sciences (with a concentration in Radiation Health Sciences) from Johns Hopkins University. Dr. Links' expertise is in radiation physics and dosimetry, medical imaging instrumentation, radiation-based biomarkers, and terrorism preparedness and response. Dr. Links is a member of the Delta Omega National Public Health Honor Society, and is a past president of the Society of Nuclear Medicine, a 16,000 member professional medical society. Dr. Links is currently Director of the Johns Hopkins Center for Public Health Preparedness, and is Baltimore City's radiation terror expert, working with the Health, Fire, and Police Departments. He is a current member of the EPA SAB's Radiation Advisory Committee.

Dr. Jill A. Lipoti:

Dr. Jill A. Lipoti was recently reappointed by the Administrator to serve a second two-year term as Chair of the SAB's Radiation Advisory Committee (RAC). She was recently appointed (2005) as Director, Division of Environmental Safety & Health for the New Jersey Department of Environmental Protection (NJ DEP) in Trenton, NJ. From 1989 until late 2005, she held the position of Assistant Director of Radiation Protection Programs of the NJ DEP. This program administers licensing and inspection of radiation sources, certification of technologists, radon public awareness, certification of radon testing and mitigation firms, low level radioactive waste siting issues, nuclear emergency response, oversight of nuclear power plant activities for environmental releases, and non-ionizing radiation. She has also held positions of Chief of the NJ DEP Bureau of Hazardous Substances Information (6/88 to 4/89), as well as Supervisor of Communication/ Outreach in the NJ DEP Bureau of Hazardous Substances Information (7/87 to 6/88). Dr. Lipoti served as a Hazardous Materials Specialist with the NY/NJ Port Authority (9/84 to 6/87), as an Assistant Instructor in the Department of Environmental Science at Rutgers University in New Brunswick, NJ (6/79 to 9/84), and as an Adjunct Professor of Chemistry at Middlesex County College in Edison, NJ (9/79 to 6/80, and 9/83 to 6/84). Dr. Lipoti's funding comes from the NJ DEP as a State employee. A modest portion of the funding as a state employee is charged to her time spent on and EPA Grant for the NJ Radon Program, as well as for NJ DEP activities related to the four Nuclear Power Plants in the State of New Jersey.

She has publications and proceedings in a broad range of topical areas, such as diagnostic radiology quality assurance, certification of radiation risks from high-dose fluoroscopy, nuclear power plant and X-Ray program redesign, reduced emissions from mammography, public confidence in nuclear regulatory effectiveness, the linear non-threshold regulation, similarities and differences in radiation risk management, partnerships between state regulators and various other organizations, electromagnetic fields from transformers located within buildings, community Right-to-Know, identifying individuals susceptible to noise-induced hearing loss, community noise control, safety for supervisors - an updated manual for training of supervisors at the Port Authority, and a variety of other topics.

Dr. Lipoti holds numerous appointments to boards and councils. For instance, she currently serves as Chair of the Committee on Public Information on Radiation Protection and as Liaison to the American College of Radiology, as well as Liaison to the American Association of Physicists in Medicine. She has served as Chairman of the Conference of

Radiation Control Program Directors (1997-98), the Board of Directors and Chair of of the Environmental Nuclear Council (1992-95), Chair of the Transportation Committee (1991-93) and is a member of the National Council on Radiation Protection and Measurement (NCRP). She is a member of the Health Physics Society, the American College of Radiology, the Science Advisory Board's Radiation Advisory Committee and other organizations. She is the State of New Jersey Representative to the U.S. Nuclear Regulatory Commission (NRC), the Interagency Steering Committee on Radiation Standards (ISCORS), and served as a member of the Technical Electronic Products Radiation Safety Standards Committee for the U.S. Food and Drug Administration (FDA).

Dr. Lipoti has provided expert testimony on a variety of radiation-related topics. She has provided comments on the revised oversight program for nuclear power plants, and orphan source recovery, and licensee's accountability programs before the U.S. NRC. She has also provided comments to various Congressional committees and subcommittees, such as comments on the Radon Disclosure and Awareness Act in a joint hearing before the United States House of Representatives Subcommittee on Transportation and Hazardous Materials and the Subcommittee on Health and the Environment, and comments on the Indoor Radon Abatement Reauthorization Act of 1993 in a hearing before the U.S. Senate Committee in Environment and Public Works, Subcommittee on Clean Air Nuclear Regulations.

Dr. Lipoti holds a Ph.D and M.S. in Environmental Science from Rutgers University, and a B.S. in Environmental Science from Cook College in New Brunswick, NJ.

Dr. Gary M. Sandquist:

Dr. Gary M. Sandquist is currently a Professor of Mechanical Engineering and former Director of the Graduate Nuclear Engineering Program at the University of Utah. Previously he was a Distinguished Visiting Professor in Physics and Civil and Mechanical Engineering Departments at the U.S. Military Academy at West Point, where he supported and trained Army personnel in Functional Area 52 activities (Nuclear operations). He has a B.S. in Mechanical Engineering, M.S. in Engineering Science, Ph.D. in Mechanical and Nuclear Engineering, MBA, was a Post Doctoral Fellow at MIT, and served a Sabbatical at ben Gurion University in Beer Sheva, Israel. He is a Registered Professional Engineer in Utah and New York (Mechanical) and California (Nuclear), a Board Certified ealth Physicist, a Diplomate in Environmental Engineering, a Certified Quality Auditor, and a retired U.S. Naval Reserve Commander with an Intelligence Designator. The Reactor Supervisor and U.S. Nuclear Regulatory Commission (NRC) Licensed Senior Reactor Operator for a TRIGA research reactor, he served as a short mission expert in nuclear science and safeguards for the International Atomic Energy Agency (IAEA) and as Technical Training Director for the joint DOE, EPA, DRI Community Radiation Monitoring Program at the Nevada Test Site. Dr. Sandquist's principal scientific interests include risk assessment; radiation transport, analytical detection and measurement; assessment and decontamination of chemical and radioactive hazards; design and execution of characterization and final status surveys using Multi-Agency Site Survey and Investigation Manual (MARSSIM); and design and operation of heating, ventilation and air-conditioning (HVAC) systems. He is a Fellow of the American Society of Mechanical Engineering (ASME) and American Nuclear Society (QUANS). He has authored or co-authored 500 publications including 5 books and book chapters, 180 refereed papers, 325 technical reports, developed 17 major technical computer codes and participated in over 200 technical meetings, conferences, workshops and government hearings.

Dr. Richard J. Vetter

Dr. Richard J. Vetter is Radiation Safety Officer for Mayo Clinic and Professor of Biophysics in the Mayo College of Medicine in Rochester, Minnesota, and Director of Safety for Mayo Foundation. His major areas of interest include biological effects and dosimetry of ionizing and nonionizing radiation and public policy of radiation applications. Dr. Vetter is certified by the American Board of Health Physics and the American Board of Medical Physics. He is former Health Physics Society President and has served as Editor-in-Chief of the Health Physics Journal, as well as the Board of Directors of the Minnesota Safety Council. He currently serves as a member of the National Council on Radiation Protection and Measurements Board of Directors and a member of the Nuclear Regulatory Commission Advisory Committee on Medical Use of Isotopes. He is a member of the American Association of Physicists in Medicine, the Radiological Society of North America, the Society of Nuclear Medicine, the American Academy of Health Physics, and the International Radiation Protection Association. He has served in numerous capacities on the Mayo Clinic Activities, such as the Radiation Safety Committee, the Mayo Foundation Radiation Safety Committee, the Safety Council, and the Foundation Environmental Health and Safety Committee. He has participated in a number of professional activities at the state level, such as the Governor's Task Force on Low Level Radioactive Waste. He is or has been a reviewer for the American Council on Science and Health, the Health Physics Journal, Radiation Research and numerous other publications. He is author or co-author of more than 200 publications in health physics and related areas. He received his B.S. and M.S. in Biology from South Dakota State University in Brookings, SD and his Ph.D. in Health Physics from Purdue University in West Lafayete, IN.

Ms. Susan Wiltshire:

Susan Wiltshire is a former Vice President of the consulting firm JK Research Associates, Inc. Her areas of expertise include radioactive waste management, public involvement in policy and technical decisions, and risk communication. She has planned and facilitated citizen involvement, moderated multi-party discussions and assisted with the peer review of technical projects and written and spoken extensively about the public's role in the formulation of public policy. Ms. Wiltshire's wrote the 1993 version of the League of Women Voters' *"A Nuclear Waste Primer,"* the 1985 revision of which she coauthored.

Ms. Wiltshire has served on a number of committees of the National Academies National Research Council including the Board on Radioactive Waste Management, the Committee on Technical Bases for Yucca Mountain Standards, and the Committee on Risk Perception and Communication. She chaired both the Committee to Review New York State's Siting and Methodology Selection for Low Level Radioactive Waste Disposal and the Committee on Optimizing the Characterization and Transportation of Transuranic Waste Destined for the Waste Isolation Pilot Plant. Ms. Wiltshire is a Vice President and member of the Board of the National Council on Radiation Protection and Measurements (NCRP) and serves as Chairman of that organization's Committee on Public Policy and Risk Communication. She is a former member of the U.S. Environmental Protection Agency Advisory Committee on Radiation Site Cleanup Regulation and its committee on the Waste Isolation Pilot Plant (WIPP), which she has chaired.

Ms. Wiltshire served two terms as member and Chairman of the elected Board of Selectmen, the chief executive body of the Town of Hamilton, Massachusetts, and of the Town's appointed Finance Committee. She is former Chairman of the Board of Northeast Health System, Beverly, Massachusetts and of Beverly Hospital. Ms. Wiltshire was formerly President of the League of Women Voters of Massachusetts. She graduated Phi Beta Kappa with High Honors from the University of Florida, receiving a BS in Mathematics.

APPENDIX C –ACRONYMS

AL	Alabama
Am	Americium (Am-141 isotope)
AMAD	Activity Median Aerodynamic Diameter (Reference to particle size)
AMADF	Activity Median Aerodynamic Diameter Factor (Reference to particle size)
ANSI	American National Standards Institute
ASQC	American Society for Quality Control (also American Society for Control of Quality (ANSI/ASQC)
Be	Becquerel
C-14	Carbon 14
CA	Coordinating Agency
CEDE	Committed Effective Dose Equivalent
CFR	Code of Federal Regulations
Ci	Curie
Co	Cobalt
cps	Counts Per Second
Cs	Cesium (Cs-137 isotope)
DFO	Designated Federal Officer
DHS	Department of Homeland Security (U.S. DHS)
DOD	Department of Defense (U.S. DOD)
DOE	Department of Energy (U.S. DOE)
dpm	Disintegrations Per Minute
dps	Disintegrations Per Second

EPA	Environmental Protection Agency (U.S.EPA)
FERMAC	Federal Emergency Radiological Monitoring and Assessment Center
FRMAC	Federal Radiological Monitoring and Assessment Center
GM	Geiger Mueller (Detector)
hr	Hour
IMAAC	Inter-Agency Modeling and Atmospheric Assessment Center
IMMAAC	
Ir	Iridium (Ir-192 isotope)
keV	kiloelectron volts
MDA	Minimum Detectable Activity
MGBC	Maximum Gross Beta Concentration
MMGBC	Monthly Maximum Gross Beta Concentration
mm^2	Square Millimeter
m^3	Cubic Meter
µm	micrometer
NaI	Sodium Iodide
NaI (TI)	Sodium Iodide Thallium (Crystal/Detector)
NARAC	National Atmospheric Release Advisory Center
NAREL	National Air and Radiation Environmental Laboratory (U.S. EPA/ORIA/NAREL, Montgomery, AL)
NIST	National Institute of Standards and Technology
NRP	National Response Plan
nCi	nanocuries

NYC	New York City
ORIA	Office of Radiation and Indoor Air (U.S. EPA/ORIA)
PAG	Protective Action Guide
pCi	picocuries
PIC	Pressurized Ion Chamber
QA	Quality Assurance
QC	Quality Control
QA/QC	Quality Assurance/Quality Control
R	Roentgen
RAC	Radiation Advisory Committee (U.S. EPA/SAB/RAC)
RadNet	Radiation Network, a Nationwide System to Track Environmental Radiation
RDD	Radiological Dispersion Device
R & D	Research and Development
Rem	Rad (Roentgen) Equivalent Man (1 rem = 0.01 Sv)
RERT	Radiological Emergency Response Team
RIENL	Radiation and Indoor Environments National Laboratory (U.S. EPA/ORIA/RIENL, Las Vegas)
R/h	Roentgen/hour
Rn	Radon
SAB	Science Advisory Board (U.S. EPA/SAB)
SI	International System of Units (from NIST ,as defined by the General Conference of Weights & Measures in 1960)
SOP	Standard Operating Procedures
Sr	Strontium (Sr-90)

Sv	Sievert (1 rem = 0.01 Sv)
Tl	Thallium (Tl-208 isotope)
TR	Toxicological Review
US	United States
WSRC	Westinghouse Savanna River Company (contractors for Savanna River)

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