Discussion Paper for the 2014 Gilbert W. Beebe Symposium on the Science and Response to a Nuclear Reactor Accident

To be held at The Keck Center of the National Academy of Sciences

May 13, 2014

DRAFT BACKGROUND INFORMATION ON U.S. EMERGENCY RESPONSE TO A NUCLEAR REACTOR ACCIDENT

Prepared by
Ourania Kosti
Senior Program Officer
Nuclear and Radiation Studies Board
National Academy of Sciences
Email: okosti@nas.edu

History of the Gilbert W. Beebe Symposium

The Gilbert W. Beebe Symposium was established by the Board on Radiation Effects Research (now the Nuclear and Radiation Studies Board) in 2002 to honor the scientific achievements of the late Dr. Gilbert Beebe (National Cancer Institute), who was one of the designers and key implementers of the epidemiology studies of Japanese atomic bombing survivors and co-founder of the Medical Follow-up Agency.

The ten symposia that have been held to date have addressed a wide range of topics related to radiation and health:

- Scientific Highlights of RERF Studies and Chernobyl Studies (2002)
- Psychological Consequences of Exposure to Ionizing Radiation (2003)
- Recent Developments in Radiation Risk Assessment (2004)
- Beyond BEIR VII (2005)
- Pre-and Post-Conception Radiation Exposure: Sensitivity of Gametes, Fetuses, and Children (2006)
- Sixty Years of ABCC/RERF: Major Contributions and Future Studies (2007)
- Radiation as a Cause of Cardiovascular Disease (2008)
- Radiation Exposures from Imaging and Image Guided Interventions (2009)
- Scientific Advances in Radiobiology and Radiation Epidemiology, Implications for Radiation Exposure Regulations (2010)
- Tracking Radiation Exposure from Medical Diagnostic Procedures (2011)

2014 Gilbert W. Beebe Symposium

The 2014 Beebe Symposium topic was prompted by the March 2011 accident at the Fukushima Daiichi nuclear power plant that was initiated by the 9.0-magnitude earthquake and tsunami off the east coast of Japan. This was the fourth severe nuclear accident that has occurred since the beginning of the nuclear age some 60 years ago; the Windscale accident in the United Kingdom in 1957, the Three Mile Island accident in the United States in 1979, and the Chernobyl accident in the Ukraine in 1986 are the other three severe accidents.

The rarity of nuclear accidents and the limited amount of existing experiences that have been assembled over the decades heightens the importance of learning from the past. These lessons can be used to improve future responses to accidents, if they occur, and help to mitigate their consequences.

This year's symposium will promote discussions among federal, state, academic, research institute, industry, and the media on current scientific knowledge and response plans for nuclear reactor accidents. Specifically, the symposium will address:

- Off-site emergency response (e.g., shelter, prophylactic medicine, evacuation) and long-term management of the accident consequences (e.g., cleanup of contaminated areas, resettlement).
- Estimating radiation exposures of affected populations.
- Health effects (e.g., mental distress, cancer, other diseases) and population monitoring.
- Other radiological consequences (e.g., land and water contamination, disruption of food distribution, disruption of the economy).
- Communication among plant officials, government officials, and the public and the role of the media.

The symposium will not address the causes of nuclear accidents or examine lessons learned regarding nuclear power plant design, operations, or regulations.

This discussion paper is intended to provide background information for the symposium. It describes federal and state responsibilities and introduces some of the nomenclature related to protective action guidance at the different phases of a nuclear reactor accident.

Nuclear Reactor Accident Response in the United States

There are 100 nuclear reactors in the United States operating at 62 sites in 31 states. These plants are regulated by the Nuclear Regulatory Commission (NRC). After the 1979 Three Mile Island accident, the NRC made it mandatory that each site have on-site and off-site emergency response plans to protect the plant workers and members of the public from radiation exposure in the event of a nuclear reactor accident. Possible means of exposure to radiation are direct external exposure from the plume and deposited material and internal exposure resulting from the inhalation or ingestion of radioactive material. Off-site planning, the focus of this symposium, includes preparations for evacuation, sheltering-in-place, use of potassium iodide (KI), food interdictions, or other protective actions.

The NRC has defined two Emergency Planning Zones (EPZs) around nuclear power plants to facilitate planning for response to a nuclear power plant emergency.[1] Although the name may imply a circular area, the actual size and shape of the EPZs vary from plant to plant and depend on the site layout, geographical features of the surrounding area, political subdivisions, and characteristics of the surrounding community such as land use. However, typically:

- The plume exposure pathway EPZ has a radius of about 10 miles (~16 km) and protective action plans such as evacuation, sheltering-in-place, use of KI are in place to protect populations from potential exposures to radiation.
- The ingestion exposure pathway EPZ has a radius of about 50 miles (~80 km) and protective action plans such as restrictions on land use and consumption of contaminated food and water are in place to prevent or reduce dose from potential ingestion of radioactive materials.

Plant personnel are at all times responsible for on-site accident response and for limiting the consequences of the accident by preventing radioactive releases off-site.

The off-site response to a nuclear reactor accident starts with the plant personnel, among other response actions, notifying state and local authorities and the NRC about the occurrence of the accident. If the accident has reached the level of a general emergency,[2] plant personnel make protective action recommendations to the state and local authorities.[3]

[1] NRC and EPA, Planning Basis for the Development of State and Local Government Radiological Emergency Response Plans in Support of Light Water Nuclear Power Plants, NUREG-0396/EPA 520/1-78-016 (Washington, D.C.: December 1978).
[2] A general emergency is declared when doses to the general public from the accident are expected to exceed Environmental Protection Agency (EPA) Protective Actions Guidelines (PAGs). EPA defines a PAG as the projected radiation dose from an unplanned radioactive release at which a protective action to minimize or avoid that dose and therefore risk from that dose is recommended.
[3] http://www.fema.gov/pdf/emergency/nrf/nrf_nuclearradiologicalincidentannex.pdf

State Responsibilities

State and counties where nuclear reactors are located are responsible for the preparation of radiological emergency response plans. The purpose of these plans is to organize and coordinate actions taken by the plant owner, federal and state agencies, local governments, and support groups into a comprehensive and effective response and to allocate and deploy resources and personnel in response to an emergency.

State and local authorities are responsible for making decisions and issuing orders for protective actions. These decisions are based on the status of the plant, prognosis for the accident, and meteorological conditions. Other responsibilities of state and local authorities include independent plume modeling and dose projection, off-site tracking of radioactive releases, sampling of the environment and the food supply for contamination, the establishment and operation of reception centers that provide radiation monitoring and decontamination of the general public, and providing recommendations to the agricultural community.

Federal Responsibilities

Several federal agencies provide guidance to the state and local governments. These agencies and the state and local authorities coordinate the response through an individual or joint Emergency Operations Center. Dissemination of information related to the accident to the media and members of the public will be coordinated by the Joint Information Center.

The President and White House are kept informed about all aspects of the emergency and have the authority to accelerate federal emergency response in the absence of a specific request from state officials.[4]

The roles and responsibilities of the different federal agencies are described in federal planning documents such as the National Response Framework (NRF) [5,6] and radiation-specific documents such as the NRF's Nuclear/Radiological Incident Annex. These documents also define the process and structure for coordinated delivery of federal assistance. Pursuant to the Homeland Security Act of 2002,[7] the Department of Homeland Security (DHS) has the overall responsibility for coordinating the response to a domestic nuclear reactor accident.

Federal agencies, with DHS as the coordinator are also prepared to provide whatever assistance and resources are required in responding to a nuclear accident should federal assistance is requested by the state and local governments.

---

[4] Robert T. Stafford Disaster Relief and Emergency Assistance Act, Public Law 93-288, as amended, 42 U.S.C. 5121 et seq.

[5] http://www.fema.gov/media-library-data/20130726-1914-250451246/final_national_response_framework_20130501.pdf

[6] The NRF contains 15 Emergency Support Function (ESF) Annexes that include protocols for communications (ESF #2), Public health and Medical Services (ESF # 6), Long-Term Community Recovery (ESF # 14), and External Affairs (ESF #15).

[7] https://www.dhs.gov/homeland-security-act-2002

Nuclear Regulatory Commission (NRC)

The NRC is responsible for monitoring and providing assistance to plant personnel to mitigate the consequences of a nuclear reactor accident. This includes assessing the status of the plant, accident progression, and on-site activities to prevent or mitigate the accident. NRC offers technical expertise regarding the on-site incident conditions and plant personnel activities. It may also provide technical assistance to state and local governments with source term estimation, plume dispersion, and dose assessment calculations to supplement those of the plant and off-site response organizations. The NRC is a member of the Interagency Modeling and Atmospheric Assessment Center (IMAAC) which provides interagency coordination for producing and disseminating predictions of the effects from radiological releases.[8,9]

Federal Emergency Management Agency (FEMA)

FEMA is responsible for overseeing off-site preparedness of state and local authorities through its Radiological Emergency Preparedness program.[10] FEMA is responsible for coordinating the provision of federal assistance to state and local government agencies during a nuclear reactor accident.

Environmental Protection Agency (EPA)

One of EPA's roles in a radiological emergency is to provide guidance on implementing PAGs to assist emergency responders with recommendations on protective actions.[11] EPA also participates in the Advisory Team for Environment Food and Health.[12] This team develops coordinated recommendations on environmental, food and health matters, and assists in the development and implementation of a long-term plan for monitoring radioactivity in the environment. It also assists in the development and implementation of a long-term recovery plan.

Department of Health and Human Services (HHS)/ Centers for Disease Control and Prevention (CDC)

The Department of Health and Human Services (HHS)/Centers for Disease Control and Prevention (CDC) is responsible for providing guidance to state and local authorities on health effects from exposure to radiation following a nuclear reactor accident and how to minimize physical and psychological adverse health effects from exposure to radiation. HHS/CDC also

[8] https://narac.llnl.gov/uploads/DHS_IMAAC_Fact_Sheet_4-05_vcuny.pdf
[9] Other IMAAC federal partners are the Department of Homeland Security, Department of Defense, Department of Energy, Environmental Protection Agency, National Oceanic and Atmospheric Administration (Department of Commerce), and National Aeronautics and Space Administration.
[10] NUREG-0654 FEMA REP-1, Criteria for Preparation and Evaluation of Radiological Emergency Response Plans and Preparedness in Support of Nuclear Power Plants
[11] http://www.epa.gov/rpdweb00/docs/er/pag-manual-interim-public-comment-4-2-2013.pdf
[12] The Department of Agriculture (USDA), the Food and Drug Administration (FDA), and the Centers for Disease Control and Prevention (CDC) are also part of the Advisory Team for Environment Food and Health.

provides medical guidance to individuals exposed to radiation and may assist with laboratory bioassays to assess human exposures. Additionally, it provides guidance on conducting surveillance of exposed populations for potential long-term health effects.

Within HHS, the Office of the Assistant Secretary for Preparedness and Response (ASPR) is responsible for preparing for and responding to the public health and medical effects of natural and man-made disasters.[13]

Department of Energy (DOE)

The Department of Energy's/National Nuclear Security Administration's (DOE/NNSA) coordinates federal environmental radiological monitoring and produces predictive plume models and dose assessments. This information would be provided to decision makers at the federal, state, and local levels to assist with making protective action decisions and communicating them to the public.

NNSA makes use of a variety of emergency response assets to map the probable or actual spread of radioactivity in the environment. They include the National Atmospheric Release Advisory Center (NARAC) for plume and deposition modeling, the Aerial Measuring System (AMS) for measurements of actual ground deposition with aircraft-mounted detectors, and the Radiation Emergency Assistance Center/Training Site (REAC/TS) to provide specialized assistance, training, and dose assessment related to the medical management of radiation injuries. NNSA can create a Federal Radiological Monitoring and Assessment Center (FRMAC)[14] to help integrate consequence management resources and coordinate the development of a common operating framework.

Food and Drug Administration (FDA)

As noted previously, FDA participates in the Advisory Team for Environment Food and Health. FDA provides laboratory capabilities and Derived Intervention Levels (DILS) for possible embargo of inputs into the food supply.

Department of Agriculture (USDA)

During a nuclear emergency, the USDA may assist with the collection and assessment of agricultural samples within the Ingestion Exposure Pathway EPZ to determine the effect of a nuclear reactor accident on agriculture. Also, in conjunction with HHS, USDA monitors the production and distribution of food through wholesale channels to ensure that the levels of contamination in the product are below the DILs.

[13] http://www.hsdl.org/?view&did=33528
[14] EPA takes over management of the FRMAC when the response phase of the incident is over and the recovery phase has begun.

Department of Defense (DOD)

Subject to the approval of the Secretary of Defense, DOD provides Defense Support of Civil Authorities in response to requests for assistance during domestic incidents. DOD also provides immediate assistance under Immediate Response Authority for any civil emergency that may require immediate action to save lives, prevent human suffering, or mitigate great property damage.

Nuclear Accident Event Progression and Response

The effectiveness of decisions regarding the appropriate response actions to a nuclear reactor accident will be determined by the ability to promptly and effectively reduce or avoid potential exposure from radiation. These decisions are complex and involve balancing the risk avoided by the protective action with the risk involved in taking the action.

Protective action decisions may differ depending on the *phase* of the accident as available information and urgency to make decisions also differ. Federal agencies define three phases in structuring the response to a radiological emergency in the United States: early (or emergency), intermediate, and late (or recovery) phase. These phases are represented by the activities performed rather than by precise time periods; some overlap between phases may exist.

The emergency phase lasts from several hours to days from initiation of the nuclear reactor accident. During this phase, the ability to assess radiological conditions are often limited but immediate decisions for protective actions may be required to protect populations from exposure to direct radiation and inhalation from an airborne plume. Such actions are generally based on plant conditions and projected doses and include evacuation and sheltering-in-place (possibly supplemented by KI) and are addressed by assignment of a PAG. Restrictions on the consumption and use of contaminated food and water may be initiated during this phase.

The intermediate phase lasts from weeks to months. During this phase the nuclear reactor has been brought under control and there are no further radioactive releases in excess of the PAGs. At this point environmental measurements are made available for use as a basis for decisions on additional protective actions. Doses may accrue in this phase from deposited, resuspended, and ingested radioactive material. The protective actions issued during this phase are relocation[15] and decontamination to reduce radiation levels in the environment. Similar to the emergency phase, protective actions are addressed by assignment of a PAG.

The recovery phase can last from months to years. It begins when actions have started to remediate contaminated areas and allow relocated populations to reoccupy or resettle.[16] Recovery ends when all actions have been completed. In contrast to the other phases, there is limited guidance on the complicated issues of long-term recovery.

[15] Relocation is a protective action often issued in the intermediate and recovery phases. It involves the removal or continued exclusion of people from areas deemed contaminated to avoid low-level, long-term chronic radiation exposure.

[16] The term reoccupancy refers to moving back to the area where one lived at the time of the nuclear emergency. The term resettlement refers to living in a new area after being permanently relocated.