DOE/NV/11718-036
UC-700

FEDERAL RADIOLOGICAL RESPONSE IN THE UNITED STATES

by
Daryl J. Thomé
Bechtel Nevada
Remote Sensing Laboratory
P.O. Box 98521
Las Vegas, Nevada, USA
89193-8521

Bruce W. Hurley, Ph.D.
U.S. Department of Energy
Nevada Operations Office
P.O. Box 98518
Las Vegas, Nevada, USA
89193

ABSTRACT

The Federal Radiological Monitoring and Assessment Center (FRMAC) is authorized by the Federal Radiological Emergency Response Plan (FRERP) to coordinate all off-site radiological response assistance to state and local governments in the event of a major radiological emergency in the United States. The FRMAC is established by the U.S. Department of Energy to coordinate all federal assets involved in conducting a comprehensive program of environmental monitoring, sampling, radioanalysis, quality assurance, and dose assessment. This program includes

- Aerial Radiological Monitoring - Fixed-Wing and Helicopter
- Field Monitoring and Sampling
- Radioanalysis - Mobile and Institutional Laboratories
- Radiation Detection Instrumentation - Calibration and Maintenance
- Environmental Dosimetry
- Integrated Program of Quality Assurance

This paper discusses the structure, assets, and operations of the FRMAC program.

INTRODUCTION

The accident at the Three Mile Island Nuclear Power Generating Station on March 29, 1979, revealed the need for a formal plan to coordinate and integrate the federal response to any major radiological emergency occurring in the United States. This was the genesis of the Federal Radiological Emergency Response Plan (FRERP). The FRERP

1. Provides the federal government's concept of operations based on specific authorities for responding to radiological emergencies.
2. Outlines federal policies and planning considerations on which the concept of operations of the Plan and federal agency-specific response plans are based.
3. Specifies authorities and responsibilities of each federal agency that may have a significant role in such emergencies.

The FRERP also creates the Federal Radiological Monitoring and Assessment Center (FRMAC). When a FRMAC is activated, it is responsible for all federal off-site radiological monitoring and assessment activities. These activities will be conducted in support of the state(s), in response to the assessment needs of the Lead Federal Agency (LFA), and to meet the statutory responsibilities of participating federal agencies.[1]

Within the United States, the state or local governments have the primary responsibility for ensuring the health and safety of the public and to minimize the impact on the environment. For emergencies involving an area under federal control, the on-site area is the responsibility of the LFA. The on-site area is defined as that area within

1. The boundary established by the owner or operator of a fixed nuclear facility.
2. The area established by the Department of Defense (DoD) or Department of Energy (DOE) as a National Defense Area or a National Security Area, respectively.
3. The area established around a downed/ditched U.S. spacecraft.[1]

"The LFA is the Federal agency that owns, authorizes, regulates, or is otherwise deemed responsible for the facility or radiological activity causing the emergency and that has authority to take action on-site."[(2)] The LFA will coordinate all federal actions and assist the state and local governments in developing protective action recommendations.

If the off-site response to the emergency exceeds state and/or local resources, assistance may be requested from the federal government. The DOE has the responsibility for providing the initial off-site radiological monitoring and assessment assistance. The DOE may respond to a state or LFA request for assistance by deploying a Radiological Assistance Program (RAP) team from the appropriate DOE region. If the emergency requires more assets than RAP can provide, the state or LFA can request that a FRMAC be established.

FEDERAL RADIOLOGICAL MONITORING AND ASSESSMENT CENTER (FRMAC)

The FRMAC can be a large organization comprised of a professional staff of 300 or more individuals from many different agencies. The focus of the FRMAC is to provide to the state(s) and the LFA radiological monitoring and assessment support, data interpretations, dose projections, and a common set of quality-assured environmental data.

Initially, a FRMAC Advance Party of approximately ten individuals is deployed to the emergency site to establish communications with the state(s) and the LFA, determine their requirements, define the appropriate level and composition of a FRMAC response, locate a suitable site for the operational FRMAC, and initiate logistical arrangements for the full FRMAC deployment. Also, the Advance Party meeting with the state(s) and the LFA will define the initial FRMAC Monitoring and Sampling Plan. This plan will reflect the state(s) and LFA requirements and emphasize public safety by monitoring where people are located, providing monitoring data to estimate the validity of the dispersion and deposition models in use, and characterizing the off-site area.

An operational FRMAC organization has a management structure plus five divisions:

1. Liaison
2. Support
3. Monitoring
4. Assessment
5. Health and Safety

The Liaison Division coordinates all FRMAC liaisons assigned to the various state, local, facility, and LFA emergency operations centers. This division also coordinates all of the representatives to the FRMAC from these same organizations. The Support Division provides all the necessary support to sustain a fully operational FRMAC including photo, video, electrical, transportation, communications, logistics, security, and secretarial. The Monitoring Division is responsible for coordinating all FRMAC assets involved in conducting a comprehensive program of environmental radiological monitoring, sampling, radioanalysis, and quality assurance. A detailed discussion of the Monitoring Division follows in the next section. The Assessment Division assesses the radiological data obtained by the Monitoring Division, calculates dose projections, develops radiation exposure and isodose contours, prepares results as a basis for protective actions and recovery operations, provides an overview of the radiological situation, and maintains a comprehensive and traceable environmental radiological database. All finished data products are transmitted by the Assessment Division to the FRMAC Director for release to the state(s) and

the LFA. The Health and Safety Division is responsible for the health and safety of the FRMAC personnel. This division provides guidance in areas such as health physics, industrial hygiene, general safety, and medical care. Radiation-related medical advice to state and local health care providers is also available through this division.

Collocated with the FRMAC is the Advisory Team for Environment, Food, and Health. This team is comprised of representatives from the Environmental Protection Agency, Department of Health and Human Services, and the U.S. Department of Agriculture. They are supported by other federal agencies as required by the emergency. Their primary responsibility is to provide the LFA with advice concerning the following:

- Federal protective action recommendations
- Disposition of contaminated livestock
- Minimizing losses of agricultural resources
- Availability of food, animal feed, and water-supply inspection programs to assure wholesomeness
- Relocation, reentry, and other radiation protection measures prior to recovery
- Health and safety advice for the public

MONITORING

The Monitoring Division includes

- Aerial Radiological Monitoring - Fixed-Wing and Helicopter
- Field Monitoring and Sampling
- Radioanalysis - Mobile and Fixed Laboratories
- Radiation Detection Instrumentation - Calibration and Maintenance
- Environmental Dosimetry
- Integrated Program of Quality Assurance

Early in an emergency, monitoring data will be scarce but urgently needed as a basis for protective actions. The flow of data is expedited to get the data into the possession of the decision makers as quickly as possible. Monitoring instructions are transmitted by radio to the field monitoring teams by Net Control. The field monitoring teams transmit the radiological data to the Data Acquisition Officer who transcribes this data on preestablished forms. These forms are then quickly reviewed by the Field Data Specialist for completeness, reasonableness, and proper units. The data are hand plotted by the Status Map Coordinator. The reviewed forms are photocopied, stamped as raw data, and distributed to the Assessment Division and all other interested parties including federal, state, local, and LFA representatives located at the FRMAC. The original copy of all data forms is documented and archived in the FRMAC database.

The FRMAC database will

- Be comprehensive and traceable
- Contain all of the radiological data evaluation
- Be applicable to immediate review and evaluation
- Meet the U.S. Environmental Protection Agency's legal and long-term retention requirements
- Contain complete descriptive information to allow reconstruction of the radiological situation at some future time
- Be traceable from final results back through all intermediate steps to their origin by
  - Identifying individual field monitoring team members and organizations
  - Identifying laboratory which performed the analysis
  - Identifying instrumentation by serial numbers
  - Documenting calibration, monitoring, and analytical procedures
  - Documenting applicable Quality Assurance/Quality Control (QA/QC) data and activities

Radioanalytical laboratory data are managed similar to the field monitoring data. Environmental samples are received and managed by Sample Control. Analytical data are reviewed for completeness, reasonableness, and proper units by the Analysis Specialist prior to distribution to the Assessment Division and the FRMAC community.

Priorities for the Monitoring Division are established and constantly reevaluated by the FRMAC Senior Scientific Advisor, the Assessment Division Manager, and the Monitoring Division Manager. These three individuals, in concert, continually evaluate the FRMAC requirements identified by the state(s) and the LFA against the monitoring resources and adjust priorities accordingly. If conflicts arise, the conflict is referred back, by the FRMAC Director, to the state(s) and the LFA for resolution.

Representatives to the Monitoring Division from the state(s), counties, and LFA are extremely valuable. Because of their local and professional knowledge and their personal relationships with the off-site residents, they provide great assistance in the efficient and optimal operation of this division. Also, at their discretion, the state(s) and local emergency response organizations may join the FRMAC.

Aerial Measuring System

Both fixed-wing and helicopter aircraft can be used for radiological monitoring. The concept of operations is that upon arriving at the location of a radiological emergency, where deposition has occurred, the radiological monitoring aircraft will fly a serpentine pattern traversing the predominant plume footprint and a circle with a radius of 16 kilometers (10 miles) centered on the emergency site. During flight, cursory radiological data such as the spectral summation count rate relative to the background and the dominant isotopes can be identified and radioed to ground control. Upon landing, the data tapes are transferred to an on-scene mobile computer laboratory for processing.

The data processing requires approximately two hours to complete. The mission for this initial flight is to determine

- Direction and approximate exposure rates along the deposition center line
- Outline of contamination footprint
- Major isotopes

Fixed-Wing Aircraft

To map radioactive deposition, fixed-wing aircraft are equipped with two 4- x 4- x 16-inch rectangular thallium-activated sodium iodide, NaI(Tl), gamma detectors. The gamma spectral data are acquired by a Radiation and Environmental Data Acquisition and Recorder, Version IV (REDAR IV), developed by EG&G Energy Measurements, Inc. The REDAR IV is a portable ruggedized multimicroprocessor-based data acquisition and real-time analysis system. The REDAR IV acquires a gamma spectrum (approximately 40 thousand electron volts [kev] to 3 million electron volts [mev]) each second and simultaneously records the latitude, longitude, altitude, date and time of day, barometric pressure, and temperature. The data are partially analyzed on board and stored on magnetic tape cartridges for detailed analysis upon landing.[3]

Helicopters

For detailed radioactive deposition mapping, helicopters are equipped with two instrument pods mounted to the skid struts. Each pod contains four 2- x 4- x 16-inch rectangular NaI(Tl) gamma detectors plus one shielded 2- x 4- x 4-inch NaI(Tl) detector. The large detector array is exposed to the entire gamma radiation field and the shielded detector is upward-looking which provides a measure of the airborne and cosmic radiation. As the REDAR IV acquires the spectra multiplexed from all eight detectors, one of the eight detectors is also routed to a separate analog-to-digital converter. This independent spectral acquisition provides the ability to acquire spectra in radiation fields that are sufficiently intense as to overload the eight-detector array.[4]

Normally, to radiologically map an area, the helicopter will fly at an approximate altitude of 46 meters (150 feet) and a speed of 36 meters per second (70 knots). Parallel flight lines are separated by approximately 76 meters (250 feet). Flying at an altitude of 46 meters (150 feet) provides a monitoring window on the ground of approximately 92 meters (300 feet) in width. In this manner, the helicopter can map the ground deposition at a rate of about 10.5 square kilometers per hour (4 square miles per hour).

Products that are available from aerial mapping include

- Isodose and exposure contours calculated to 1 meter above the ground
- Soil concentrations of specific radionuclides
- Total activity inventories of radionuclides of interest
- Gamma-ray energy spectra

The Monitoring Division provides these products to the Assessment Division to be included in the assessment process, digitized, and entered into the geographical information system and distributed to all users of the data.

Field Monitoring and Sampling

FRMAC monitoring personnel will arrive on-scene with the appropriate instrumentation for monitoring the type of radiological emergency at hand. For a mixed fission product release or an unknown gamma-emitting radionuclide contaminant, the intrinsic germanium *in situ* gamma spectroscopy systems provide a fast, accurate method of determining isotopic ratios and deposition concentrations. The intrinsic germanium gamma detectors are equipped with beryllium windows to allow the acquisition of photons with energies as low as 10 kev. This makes possible the detection of transuranics such as plutonium-238, plutonium-239, and americium-241. Specialized instruments such as Field Instruments for the Detection of Low Energy Radiation (FIDLER) are available for emergencies involving nuclear weapons or spacecraft using plutonium-238 radiation thermal generators.

Instrument repair equipment plus an irradiator and various traceable radioactive sources are deployed for calibration and maintenance of the field radiation detection instrumentation. To maximize the comparability of the radiological data acquired by the various organizations, this capability is available to the state(s), the LFA, and any other group involved in radiological monitoring.

The environmental sampling supplies and equipment which will arrive with the FRMAC Main Party will include

- Low- and high-volume air samplers for particulates and reactive gases
- Whole air samplers for noble gas analysis
- Specialized sampling tools for reproducible, well-defined soil samples
- Equipment for sampling vegetation and produce
- Equipment for sampling water and milk

Accurately knowing the physical locations of field measurements and sample collections is critical to a meaningful characterization of the emergency situation. All such locations are identified in three ways: the latitude and longitude is determined, the street orientation is noted, and the sector/distance is defined. To determine the latitude and longitude, the field monitoring teams are equipped with Global Positioning System (GPS) units. The street orientation is defined by the street address, street intersections, mile markers, or odometer readings from some well-defined landmark. Sector refers to the partitioning of the area about the emergency site into sixteen 22.5-degree sectors. The distance is the distance from the emergency site to the monitoring location. The sector/distance information allows the Status Map Coordinator to rapidly locate and identify a monitoring or sampling site on the status map.

Radioanalysis - Mobile and Fixed Laboratories

FRMAC has access to both mobile and institutional (fixed) radioanalytical laboratories for the analysis of environmental samples. The mobile laboratories associated with a FRMAC provide a rapid initial qualitative and quantitative estimate of the radionuclides of interest. For a more detailed analysis

and/or for analyses beyond the capability of the mobile laboratories, samples are shipped to fixed laboratories. Analytical techniques available from most mobile laboratories include

- Gamma spectroscopy
- Gross alpha and beta
- Liquid scintillation counting

Quality Assurance (QA)

Having an estimate of the quality of the data that are being used as a basis for protective actions is of paramount importance. The resources devoted to QA depend largely on the stage of the emergency. In the early stages of a radiological emergency when the impact on the health and safety of the public is not well-defined, the amount of FRMAC resources devoted to QA will be the minimum that will ensure acceptable quality of the data for the use it is intended. As the emergency stabilizes, the resources dedicated to QA will increase to approximately 20 percent. QA considerations include the following:

- Identifying the authenticity and/or traceability of all radioactive standards used for
  - Calibration
  - Instrument quality control
  - Quality assurance samples
- Identifying and establishing the authenticity and validity of all data collected in support of the FRMAC by providing for the accountability and integrity of all environmental samples and monitoring data
  - From collection
  - Through analysis
  - To archiving
- Accountability of all related documentation such as
  - Method of collection
  - Field monitoring and sample collection forms
  - Sample control forms
  - Standard operating procedures
  - All QA/QC records
  - Identification by serial number of all instrumentation and equipment used that affects the quality of the data

To identify the quality of the data, the following QA/QC activities are employed:

- Matrix Spiked Samples
  - The analyst will analyze representative environmental samples containing known amounts of radionuclides of interest.
- Blind Samples
  - Representative environmental samples, which contain known amounts of radionuclides of interest, are injected into the normal sample stream. These QA samples are unknown to the analyst.
- Blank Samples
  - Representative environmental samples prepared with no added radionuclides of interest.

- Replicate sample analysis
  - The same sample is analyzed more than once by the same laboratory.
- Collocated samples
  - When samples are collected in the field, more than one sample is collected at the same location and under identical conditions.
- Round Robins
  - The same representative environmental samples containing know amounts of radionuclides of interest, but unknown to the analysts, are submitted to the participating laboratories.
- Cross-calibration of field instruments
  - Identical calibration techniques, using the same radioactive standards, are applied to all instruments being used to monitor the environment.
- Instrument quality control check at the beginning and end of each shift
  - Calibration checks, using standard radioactive materials, are made to ensure instruments are functioning within prescribed limits.
- Calibration and Instrument Quality Control
  - Radioactive standard solutions will be provided for laboratory instrumentation, calibration, and daily instrument response checks.

SUMMARY

The FRMAC team is a cadre of highly trained and experienced scientists, technicians, and support personnel from many different agencies, all working together during a major radiological emergency to support the state(s) and the LFA. The foundation of the FRMAC is the Monitoring and Assessment Divisions. Using state-of-the-art technology and methodology, they provide the radiological monitoring, derived analytical data, and dose projections that are the basis for protective actions for the public.

REFERENCES

1. "Federal Radiological Emergency Response Plan (FRERP), Operational Plan, Notice." *Federal Register* 61:90 (8 May 1996).

2. *Federal Radiological Monitoring and Assessment Center Operations Plan, Emergency Phase*. Doc. No. DOE/NV-XXX, FRMAC-101-95, 1995; Department of Energy, Nevada Operations Office, Las Vegas, NV.

3. Hendricks, T.J. "Radiation and Environmental Data Analysis Computer (REDAC) Hardware, Software, and Analysis Procedures," *Remote Sensing Technology, Proceedings of a Symposium on Remote Sensing Technology in Support of the United States Department of Energy*. Report No. EGG-10282-1057, 1985; EG&G Energy Measurements, Las Vegas, NV.

4. Riedhauser, S. R. *An Aerial Radiological Survey of the Sandia National Laboratory and Surrounding Area*. Report No. EGG-11265-1030, 1994; EG&G Energy Measurements, Las Vegas, NV.

This work was supported by the U.S. Department of Energy, Nevada Operations Office, under Contract No. DE-AC08-96NV11718.