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EMERGENCY RADIOLOGICAL MONITORING AND ANALYSIS: FEDERAL RADIOLOGICAL MONITORING AND ASSESSMENT CENTER

Daryl J. Thomé
EG&G Energy Measurements, Inc.
P.O. Box 1912, RSL-24
Las Vegas, Nevada, 89125
(702) 295-8780

SUMMARY

The U.S. Federal Radiological Emergency Response Plan (FRERP)[1] provides the framework for integrating the various Federal agencies responding to a major radiological emergency. The FRERP authorizes the creation of the Federal Radiological Monitoring and Assessment Center (FRMAC),[2] which is established to coordinate all Federal agencies involved in the monitoring and assessment of the off-site radiological conditions in support of the impacted State(s) and the Lead Federal Agency (LFA). Within the FRMAC, the Monitoring and Analysis Division (M&A) is responsible for coordinating all FRMAC assets involved in conducting a comprehensive program of environmental monitoring, sampling, radioanalysis, and quality assurance.

To assure consistency, completeness, and the quality of the data produced, a methodology and procedures manual is being developed. This paper discusses the structure, assets, and operations of the FRMAC M&A and the content and preparation of the manual.

INTRODUCTION

For radiological emergencies occurring within the United States, the State or local governments have the primary responsibility for assuring the health and safety of the public and minimizing the impact on the environment. If the off-site response to an emergency exceeds State and/or local resources, assistance may be requested from the Federal government. The DOE may respond to a State's 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, a FRMAC can be established.

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

MONITORING AND ANALYSIS

Within the FRMAC, the M&A has the responsibility for coordinating all FRMAC assets involved in conducting a comprehensive program of environmental radiological monitoring, sampling, radioanalysis, and quality assurance. This program 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

The M&A must assure that all monitoring, sampling, and laboratory activities are accomplished in a manner which meets FRMAC requirements and that all monitoring measurements, sample collections, and derived analytical data are scientifically defensible, of acceptable known quality, and in consistent units.

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 put the data into the possession of the decision makers as quickly as possible. Monitoring instructions are transmitted via radio to the field monitoring teams by Net Control. The field monitoring teams transmit the radiological data to the Data Acquisition Officer, who transcribes the data on preestablished forms. The forms are then quickly

reviewed by the Field Data Specialist for completeness, reasonableness, and proper units. The data are hand plotted by M&A's Status Map Coordinator. The reviewed forms are photocopied, stamped as raw data, and distributed to Evaluation and Assessment (E&A), the Geographical Information System (GIS) team, 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's data base which will:

- Be comprehensive and traceable
- Contain all the radiological data
- Be applicable to immediate review and evaluation
- Meet 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 data and activities

Radioanalytical laboratory data are managed similarly 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 E&A and the FRMAC community.

Priorities for M&A are established and constantly reevaluated by the FRMAC's Senior Scientific Advisor, the E&A Manager, and the M&A Manager. These three individuals, in concert, continually evaluate the FRMAC requirements identified by the State(s) and the LFA against the M&A resources and adjust priorities accordingly. If a conflict arises, it is referred, via the FRMAC Director, to the State(s) and the LFA for resolution.

The M&A Manager is responsible for the overall management and direction of M&A. Representatives to M&A from the State(s) and LFA are extremely valuable. Because of their local and professional knowledge and their personal relationships, they provide great assistance in the efficient and optimal operation of M&A.

Aerial Measuring System

Both fixed-wing and helicopter aircraft can be used for radiological monitoring. Upon arriving at the location of a radiological emergency where deposition has occurred, the radiological monitoring aircraft fly a serpentine pattern traversing a circle with a radius of 16 km (10 mi) centered at the emergency site. This serpentine flight will also traverse the predominant plume footprint. 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 lower levels of detection of the aerial measuring systems are in the range of one microroentgen per hour above the background level. The mission for this initial flight is to determine:

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

Fixed-Wing Aircraft

To map radioactive deposition, fixed-wing aircraft are equipped with two 4x4x16-inch rectangular thallium-activated sodium iodide, NaI(Tl), gamma detectors. Each second a gamma spectrum, approximately 40 thousand electron volts (keV) to 3 million electron volts (MeV), is acquired and simultaneously the latitude, longitude, altitude, date and time of day, barometric pressure, and temperature are recorded. 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 4x4x16-inch rectangular NaI(Tl) gamma detectors plus one shielded 2x4x4-inch NaI(Tl) detector. The large detector array is exposed to the entire gamma radiation field and the shielded detector is upward-looking to provide a measure of the airborne and cosmic radiation. As the

spectra are 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 to overload the eight-detector array.[4]

Products that are available from aerial mapping include:

- Isodose and exposure contours calculated to one meter above the ground
- Surface deposition of specific radionuclides
- Total activity inventories of radionuclides of interest
- Gamma-ray energy spectra

The M&A provides these products to the E&A to be included in the assessment process, digitized, entered into the GIS, 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-ray spectroscopy systems provide a fast, accurate method of determining isotopic ratios and deposition concentrations. Many of the intrinsic germanium gamma-ray 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 dispersal emergencies involving nuclear weapons or spacecraft using plutonium-238 radiation thermal generators as a source for electrical power.

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 calibration capability is available to the State(s), the LFA, and any other group involved in radiological monitoring.

Environmental sampling equipment and supplies which will arrive along with the FRMAC main party 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 and sediment samples
- Equipment for sampling vegetation and produce
- Equipment for sampling water and milk

Chain-of-Custody procedures are followed during all sample collection and handling activities. The integrity and accountability of every sample is ensured by documenting that it is in the possession of a responsible person or it is secured in an acceptable manner.

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: 1) Each field monitoring team is equipped with a Global Positioning System (GPS) for the determination of the latitude and longitude; 2) the street orientation is noted by identifying the street address, street intersections, mile markers, or odometer readings from some well-defined landmark; and 3) the sector/distance is defined. Sector refers to the partitioning of the area about the emergency site into sixteen 22.5-degree sectors. The distance is calculated as 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. Also, this information is an error check for the latitude and longitude data.

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 with trained staff are provided by various federal agencies and federal agency contractors. 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. FRMAC can deploy with the capability to perform radioactive noble gas analysis. Analytical techniques available from most mobile laboratories include:

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

Environmental Dosimetry

For most radiation emergencies, thermoluminescence dosimeters (TLDs) provide a convenient, easily-deployable method for measuring and documenting integrated radiation exposure levels at various locations and radiation doses to residents and other personnel in the off-site areas.

Quality Assurance

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 quality assurance (QA) depend largely on the stage of the emergency. In the early stages of a radiological emergency, when there is minimal data available and the impact on the health and safety of the public is not well defined, the number of FRMAC resources devoted to QA will be the minimum that will assure the data is of acceptable quality. As the emergency stabilizes, the resources dedicated to QA will increase to approximately 20 percent.[5] QA considerations include:

Identification of the authenticity and/or traceability of all radioactive standards used for:

- Calibration
- Instrument quality control (QC)
- Quality Assurance samples

Identification and establishment of 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 which affects the quality of the data.

For the FRMAC 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 containing known amounts of radionuclides of interest. These samples are injected into the normal sample stream and unknown to the analyst.

Blank Samples

- Representative environmental samples containing no added radionuclides of interest (background samples)

Replicate sample analysis

- The same sample is independently analyzed more than once by the same laboratory.

Collocated samples

- When collecting samples 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 known amounts of radionuclides of interest, but unknown to the analyst, are submitted to the participating laboratories for analysis.

Cross-calibration of field instruments

- Identical calibration techniques, using the same radioactive standards, are applied to instruments being used to monitor the environment.

Instrument quality control check at the beginning and end of each shift

- Performance checks, using standard radioactive materials, are performed to assure instruments are functioning within prescribed limits.

Calibration and instrument quality control

- Radioactive standard solutions will be provided for laboratory instrumentation calibration and quality control checks.

As the emergency stabilizes, the approximate 20 percent of the resources dedicated to QA will consist of:[5]

- Blind samples submitted at the rate of one per 20 samples analyzed.

- Blank samples submitted at the rate of one per 20 samples analyzed.

- Replicate sample analysis - One sample randomly selected out of every 20 samples analyzed, will be independently analyzed twice.

- Collocated Samples - One out of every 20 samples collected will have a collocated sample also collected and analyzed.

MONITORING AND ANALYSIS MANUAL

To assure consistency, completeness, and the quality of the monitoring and analytical data produced by the FRMAC, a methodology and procedures manual is under development. The manual will address:

- Field monitoring procedures applicable to radiological emergencies
- Environmental sample collection procedures
- Environmental sample preparation and analysis procedures applicable for mobile laboratories
- Standard reporting units
- Quality Assurance
- Monitoring instrumentation calibration and maintenance

Initially, methods and procedures were obtained from many different sources. These sources included DOE, the U.S. Environmental Protection Agency, national laboratories, and various States. Although many methods are available and appropriate, the methods selected were based on the following criteria:

- Scientifically defensible
- Simple
- Applicable to a FRMAC deployment
- Most likely be adopted by others

It should be emphasized that the procedures are intended for use in responding to an emergency and processing relatively large numbers of samples in the shortest possible time. Therefore, in some cases, they represent a compromise between precise analytical determinations and determinations satisfactory for emergency response activities.

The first draft of the manual has been reviewed by the FRMAC M&A Working Group. The first working draft should be available for distribution and use by 1995. Our expectation is that once it is available to the emergency response community, many constructive modifications will be identified. For this reason, we are expecting to reissue this manual annually for the first few years, and later as dictated by improvements in technology and/or changes in policy.

CONCLUSION

The FRMAC team is a cadre of highly trained, 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 Analysis Division. This Division, using state-of-the-art technology and methodology, provides the radiological monitoring and analytically derived data that are the basis for protective actions for the public.

REFERENCE

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