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CHALLENGES IN QUALITY OF ENVIRONMENTAL MEASUREMENTS FOR COMPLIANCE

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INTRODUCTION

Quality systems development in environmental measurements for compliance with regulatory requirements for nuclear and other contaminants in the environment is one of the major challenges in current technolology disciplines. Efforts to fulfill the mission and objectives of funded projects will not be successful on a timely and cost-effective schedule without adequate plans and credible action for the protection of workers, facilities, and the public in environment, safety, and health aspects. This can be accomplished through quality assurance planning and implementation of an effective, controlled environmental measurements program.

It is estimated that presently there are 30,000 technical and professional scientists and engineers, who generate or verify some or all of the data generated in U. S. environmental projects. They consider accuracy, validity, and adequacy for certification of environmental sampling and measurements planned, scheduled, accomplished, reported, and evaluated for purposes of compliance with environmental regulatory requirements. This estimate identifies the "real" group of people who have impact on environmental regulatory compliance in any organization. Judging from the number of technical personnel occupied in this field, the importance placed on the quality of compliance data and processes is obvious. The prediction is made that even more technical personnel will become active participants in this area of legal requirements for generation of environmental compliance data and reports.

It rapidly is being recognized in industry that the quality of the processes of collection, analysis, and evaluation of environmental sampling and measurements, used in compliance with environmental regulations in support of project operations, is the Achilles Heel and determines the vulnerability of organization management systems. If project environmental activities are not accomplished by qualified personnel, contractors, and analytical laboratories, with specific objectives supported by standardized, documented, and approved procedures for sampling and determination of contaminants in groundwater, soil, etc., the data are in question. In addition, there are problems with the complexity of the laws; it is not clear which standard to use, and in many cases, there are no standards.

Also, there is need to match the quality of data with the objectives of a program. Some historical considerations in the development of quality measurements, and the impact of lack of experienced environmental advisory assistance early in current project planning will be discussed in following sections of this paper.

SELECTED HISTORICAL EVENTS IN DEVELOPMENT OF ENVIRONMENTAL QUALITY ASSURANCE GUIDANCE

In recent years, some remarkable accomplishments in environmental measurement discrimination and quality have been documented, detection instrumentation developed is highly sophisticated insofar as calibration is concerned, and technologies in unique operations have been proven. Examples of some of the historical factors which governed the evolution of quality assurance in environmental measurements will be discussed, with a perspective of that yet to be investigated and defined by research in field and laboratory operations.

Environmental contaminant measurement quality has been an objective of field and laboratory measurements personnel since the 1940's. Interest in refinement of measurement quality was generated primarily by the advent of the Atomic Age and many of the associated challenges to be met. The Atomic Energy Commission (AEC) national laboratories conducted environmental programs in support of the weapons related investigations and related facility activities for which they were responsible. Results from attempts by engineers and scientists to interpret and integrate answers available through sampling and measurement of radioactive fallout in those years were not the sophisticated quality achieved today, but were remarkably refined by many scientists.

Environmental studies of the migration of plutonium (Pu), other transuranics, and fission products, were begun in the early years of testing at the Defense Department Nevada Test Site (NTS). Computerized statistical modelling estimates were initiated and tested, based on data evaluations of an integrated environmental sampling and measurement program. (Complementary studies were sponsored by other AEC Divisions concerning effects in other than semi-arid environments and other aspects of environmental pathways to man.)

The objectives of the integrated Pu migration studies, involving approximately 24 - 26 contractor organizations and national laboratories, were the determination, verification, and understanding of 1) Pu transfer coefficients, or rates of movement in the environment, 2) environmental effects, 3) changes in chemical and physical state(s) of isotope residual existence, for Pu and the other contaminant isotopes resulting from weapons testing at the site, 4) distribution and inventory of contaminants, and 5) technology exchange and review, two to four times per year, conducted by the program officials and Headquarters sponsoring organization.

The Nevada scientific program was conducted in the varied environmental media of semi-arid lands, gentle sloping alluvial plains, mountains, and volcanic regions of the NTS. The Nevada Applied Ecology Group studies of environmental contaminants involved many subjects. Entries in Table 1 indicate some of the environmental compartments studied in the integrated program.

DEVELOPMENT OF INTEGRATED STANDARDIZED PROCEDURES IN ENVIRONMENTAL MEASUREMENTS FOR COMPLIANCE IN NUCLEAR ACTIVITIES

The urgency of the interdisciplinary studies program was almost overwhelming. The United States was involved in a Cold War with communist countries at the time, and could have been impacted at any time by the advent of a nuclear war. Development and testing of integrated procedures were conducted for standardization of sample collection, handling, analysis, documentation, data evaluation, instrumentation and calibration systems, toward a refinement of quality data for statistical evaluation and modelling. This process provided understanding for identification of impacting factors and measurement systems needed for radionuclide environmental migration and effects. In more recent years, the standardized procedures for environmental sampling and measurement have been applied as basis for compliance in several regulatory areas. EPA Safe Drinking Water regulations are an example of the application of historical methods of sampling and analysis to measurements for compliance.

BACKGROUND OF SELECTED STANDARDS AND CRITERIA DEVELOPMENT FOR COMPLIANCE

Insofar as environmental radioactive contaminants were concerned, the AEC with the USPHS (now EPA) established the compliance regulations and requirements for AEC employees and contractors to protect the safety and health of employees, contractors, visitors, the public, and facilities. Implementation procedures, guidelines, and orientation were provided by the AEC for all its environmental protection activities, together with USPHS regulations for the general public and worker protection. The USPHS and the AEC were concerned with environmental radioactive contamination impacting workers or somehow moving off-site, with possible impact on the environment and public. Alarm systems were placed at each regular site or facility exit or entry gate. Elaborate and extensive environmental measurement networks were established north of the NTS and broadly across the country in order to detect migration of radionuclides due to the weapons program. Employees and visitors to a contaminated site were required to observe official AEC regulations for the safety of workers, e.g., wear a film badge or a thermoluminescent dosimeter (TLD), and to participate in appropriate bioassay programs.

There were many other rules and regulations established for the safety and health of the workers and the potentially impacted public. As yet, there were no cleanup regulations for agency sites

other than guidelines for release of areas to the public. However, guidance and criteria limitations established by the AEC for transporting radioactive materials off-site, or for storage, research, disposal, handling of materials, etc., were reinforced. In the late 1960's, the AEC initiated draft sets of criteria for future cleanup on an individual basis at applicable contaminated sites.

ADVISORY INSTITUTIONS FOR RADIATION PROTECTION AND EFFECTS

In the 1950's, the National Council on Radiation Protection and Measurements (NCRP) and the International Commission for Radiological Protection (ICRP) were established. Committees made up of personnel from the National Academy of Science (NAS) and academic institutions provided the investigation, supportive evaluations, and examples of modelling necessary for the selection and documentation of reference criteria and standards for use in calculation of radiation exposure. Members of the Health Physics Society (HPS) formed in 1955, validated and tested ICRP and NCRP models, both in laboratory and in the field. Many studies relating to environmental impact of radionuclides were accomplished by use of chemical or physical analogs of the radionuclides released into the environment by weapons development and testing.

During the period that awareness was developing of the potential of unknown environmental impact from weapons testing, United States universities began training programs for radiobiologists and nuclear physicists. The University of Rochester in New York graduated several of the first Ph.D.s selected to establish AEC radiobiology research laboratories, to study under controlled conditions the uptake and deposition of radionuclides: Lovelace Fission Products Inhalation Laboratory (strontium, cesium, etc.), in Albuquerque, NM; Davis Laboratory (radium uptake), in Davis, CA; Battelle Pacific Northwest Laboratory, in Richland, WA.

EPA AND NRC: ENVIRONMENTAL REGULATORY AND ENFORCEMENT AGENCIES ESTABLISHED

In the 1970's, when part of the USPHS became the Environmental Protection Agency, the EPA formally assumed the responsibility for protection of the environment. This responsibility included, to a certain extent, the regulation of radioactive emissions, discharges, or releases from nuclear operations sites. EPA did not have authority within the boundaries of AEC facilities, but its authority did extend to the large boundary areas which surrounded AEC facilities and distanced the site activities from the public.

At first, the EPA was refused access to these large boundary areas. If fence-line measurements made by the EPA were above certain limits, the fence might be moved outward to assure that contaminant measurements would be at least below the EPA limits established as permissible from the fence-line outward. The AEC controlled these activities on their sites, in that it was their authorized defense work, their contamination, and their site property. The AEC both

conducted operations and controlled the enforcement of safety and health aspects of their operations.

Independently, the Nuclear Regulatory Commission (NRC) was established during this same period. The NRC was formed by moving a nucleus of regulatory and enforcement personnel from within the AEC to the new agency. The NRC was established to eliminate the conflict of AEC compliance with regulatory enforcement action that might be brought against the AEC itself.

Thus, at the end of this period, there existed two new regulatory agencies, NRC and EPA, with most of the enforcement responsibilities they carry today. Subsequent laws have added to those responsibilities.

PROGRAMS ESTABLISHED FOR WASTE DISPOSAL AND REMEDIAL ACTION

In 1980, the Low Level Radioactive Waste Policy Act was passed by Congress, requiring that each State either establish its own low level waste repository, or alternatively, join in a compact with other states to provide a repository for that State's medical and other radioactive wastes. The Office of Civilian Radioactive Waste Management was formed during this period, concerned with high level waste disposal (Yucca Mountain project). And, in 1982-83, the EPA prepared and published in the Federal Register the criteria and standards for the remediation of Uranium Mill Tailings processing sites (UMTRA Program), contaminated vicinity properties, and tailings (fuel-cycle by-products) which were the responsibility of the AEC under the Atomic Energy Act of 1946. These EPA criteria and standards included supplemental compliance standards for use where some by-product materials feasibly might not be completely removed for disposal. Use of supplemental standards or ALARA (As Low As Reasonably Achievable) requires special documented approval and justification in the certification and closure of remedial action performed by U. S. Department of Energy (DOE) contractors at facilities or on properties determined to be AEC/DOE responsibility.

Previously, Grand Junction--Mesa County, Colorado, had been determined by the Surgeon General to be a critical region for environmental clean-up (issuance of guidelines based on uranium miner exposure and lung cancer data). The Grand Junction Remedial Action Program (GJRAP) was the first major AEC remedial action program. The State of Colorado implemented the Grand Junction Program, with the AEC monitoring and providing funding. Later, the UMTRA Project and the GJRAP were combined for more cost-effective implementation of the programs under DOE's Albuquerque Operations Office.

In addition, the Atomic Energy Act of 1946 had authorized weapons development and uranium ore upgrading operations at certain Manhattan Engineer District (Corps of Engineers) facilities. Contaminated sites were located in New Jersey, Texas, Oregon, New York, Missouri, Illinois, Ohio, Maryland, and other states. The

Fernald Plant in Ohio and the University of Chicago stadium were among the approximately 35 original sites identified for a program of remediation. The authorized contaminated sites and contaminated vicinity properties became the Formerly Utilized Sites Remedial Action Program, or FUSRAP, managed by the DOE's Oak Ridge Operations Office.

A third major program was underway to clean up many contaminated surplus facilities in the United States and its territories, such as pilot reactors at the Hanford Reservation, Shippingport, Mayaguez in Puerto Rico, etc., and contaminated vicinity properties. This remedial program was called the Surplus Facilities Management Program, or SFMP, managed by DOE's Richland Operations Office. Later, the FUSRAP and SFMP were combined, for more cost-effective implementation of the programs, and placed as one program under DOE's Oak Ridge Operations Office.

Many additional locations of contaminated facilities, properties, and materials throughout the country were identified where multiple agency responsibility for cleanup existed. Some of these sites were slated for cleanup under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), better known as Superfund. CERCLA was enacted following several well-publicized incidents caused by the uncontrolled and dangerous disposal of toxic chemicals. Among other actions, the CERCLA legislation established a fund to cover the costs of the cleanup of abandoned hazardous chemical sites; hence, the name, "Superfund".

With a few exceptions, federal facilities conducting cleanup activities under the CERCLA program did not have access to the fund money; federal facilities are required to use their own funding to clean up contaminated sites for which they are responsible. Cleanup activities are conducted according to plans agreed upon by the agencies responsible for the facilities, EPA, and any appropriate state agencies.

VARIATION IN SITES AND CONTAMINANT MATERIALS

There was variation existing in contaminated sites and materials, in determination of responsible agency (or agencies), and in interpretations for implementation to comply with environmental certification requirements.

The contaminant materials varied in chemical, physical and environmental state from site to site. For example, at one facility, there were large quantities of pitchblende (the highest known concentration of natural uranium in the world) from the Belgian Congo; another, fuel materials development and processing by-products (including uranium mill tailings); chemical processing wastes; waste at contaminated facilities from separation of medical isotopes; contamination at military installations; chromates; sulfuric acid; radium waste from radium separation activities for Madam Curie's work at the Canonsburg, PA site, etc. Contaminated sanitary landfills were found which contained waste from previous

attempts to clean up during the 1960's, e.g., Middlesex, New Jersey, and Lewiston, New York.

Not only numerous federal environmental and transportation rules and regulations were being developed specifically for additional contaminants identified, but also many state, local, and Indian nation governing regulations were enacted. NRC guidance and enforcement documents were being published. There came into existence a multitude, literally hundreds, of environmental rules and regulations for permitting, etc. Some of these were much more stringent and binding on planning and conduct of remedial activities than federal regulations. All were concerned with public health, safety, environmental problems, and compliance issues.

ESTABLISHMENT OF DOE TECHNICAL MEASUREMENTS CENTER, GRAND JUNCTION, COLORADO

In 1982, the U. S. Department of Energy authorized the establishment of the Technical Measurements Center (TMC) at Grand Junction, Colorado, operated by former Bendix measurement personnel from the just-terminated national exploration program for uranium deposits. Dr. John R. Duray (formerly with Bendix) serves as the Manager of the TMC (RUST-Geotech Co., contractor) for DOE in Grand Junction.

The mission of the TMC at Grand Junction was to serve as a problem-solving and calibrations environmental measurements group for all DOE remedial activities in the United States, wherever located. This group today is acknowledged throughout the world as a center of excellence for advisory assistance in environmental field and laboratory measurement problems. The TMC operates cross-reference field and laboratory instrumentation calibration and technology development facilities. Responsible for developing calibration procedures and standardization of environmental procedures for the DOE, the TMC was instrumental in support of the UMTRA Project Technical Measurements and Quality Assurance program which was recognized by DOE as No. 1 in the United States.

The UMTRA Program (24 uranium mill processing sites and associated vicinity properties) was combined with the Grand Junction Program in 1983, surveying 32,000, and addressing remedial action at more than 10,000, contaminated vicinity properties, for construction engineering and pre- and post-remedial action certification of cleanup. In these programs, the TMC was the technical measurements problem-solving and calibrations support contractor, providing, testing, and establishing standardization of the many field and laboratory procedures essential to provide quality in program and project activities.

By 1986, the United States had the first quality assurance program identified in the environmental measurements disciplines, with standardized procedures for sampling, analysis, and field measurements. The DOE's Technical Measurements Center had

accomplished a major objective by providing the basis for an 80% confidence level program of quality assurance for people returning to their homes after certification of remediation by DOE contractors. The United States owes a great deal to the TMC team.

CURRENT ENVIRONMENTAL DATA QUALITY CONSIDERATIONS

The credibility of many federal, state, local, and industrial environmental reports is at risk. Based on the quality of measurement data generated, and evaluations accomplished for compliance with the existing volumes of current United States and world environmental regulations, the processes and procedures used in environmental measurement data quality assurance reflect some major issues. The question of credibility arises primarily because of the lack of understanding or knowledge by organization and engineering project managers of critical rationale required to be addressed, **prior to actual collection of environmental data.** The challenge is evident in the absence of certain procedures which should be included, required, and referenced for implementation by an organization in applicable quality assurance plans and/or programs.

A major factor which identifies this lack of awareness and orientation to environmental discipline technologies, is that many project managers without environmental advisory experience on their team, are reinventing the wheel. This is resulting in unnecessary duplication of technical effort. Continuous quality improvement, cost reduction in perceived quality support to operations, plus development of new technologies and systems for quality environmental measurements, must be given high priority if projects are to be completed in an effective and timely manner. These efforts also are critical for an organization to meet compliance requirements and to remain competitive.

INDICATIONS OF QUALITY IMPACT, AND RECOMMENDATIONS

The following are indicators of potential problems with regard to quality systems, and suggestions to improve data quality.

- Literature searches and related environmental advisory interface activities may not be identified as required to be conducted, evaluated, and documented in support of compliance requirements. This should be specifically addressed.

- Clear, understandable objectives may not be stated and established for environmental characterization activities. This should be done during the planning stages of a project.

- Specifications (including specific coordination approvals for change in environmental data generation procedures, or analytical services contractor) may not be included in contractual documentation for environmental data to be

generated for a project. Procedures to provide guidance should be developed.

- Many contractors may be authorized to conduct characterization of contaminated areas previously characterized, e. g. contracts may be awarded without specifications for conditions under which joint decisionmaking must be performed with the funding project manager and the funding organization's designated environmental advisor for site activities. Procedures should be developed to provide guidance in this respect.

- Contractors may be authorized to utilize analytical services laboratories which are not required to be previously evaluated by the funding organization's applicable environmental advisor for site activities. Procedures should be developed and established to provide guidance in this quality area.

- The responsibility for determining who, where, which, and how many samples should be collected may not be specifically defined in contractual documents. This item is critical for compliance certification. The qualifications of the responsible implementing person unquestionably must be specified and verified. If other persons on a team are identified as alternates, they too should be fully qualified, prior to selection of the contractor organization who will be responsible for the environmental sample collection, etc. for a project.

- The project samples for environmental compliance may not be planned, supervised, and evaluated by experienced, qualified personnel of the funding organization. The question of shared (split), or duplicate project sample collection for comparative (validation or verification) purposes normally comes under this person's responsibility for interface review and appropriate activity. Information as to compliance requirements and subsequent evaluations and/or additional sample activity should be referenced in specifications for the contractor.

- The environmental sampling and handling, storage, and shipping process may not be controlled in a critical aspect. Procedures must be documented carefully and be comprehensive for the activities covered.

- Assessment of the systems and activities may not be conducted in a routine manner, or quality checklists may not be adequate to cover assessments for interface operations. These should be prepared, coordinated, and reviewed with appropriate personnel.

- The calibration of instrumentation and instrumentation systems must be quality controlled. This is particularly important in the utilization of some of the new sophisticated systems available for detection of contaminants, analogs, interferences, and discriminations in the field and laboratory. Many times it is not clear that calibration of new systems has been accomplished, or that it is required. Here again, orientation and training in the field of environmental measurements may be more critical, quality related, and time-consuming than a project manager would want to accept.

- Establishment of positions and full use of such experienced environmental advisory staff perhaps may place a burden on present staff of an organization to effect full definition of such a function. To be cost-effective, a high priority must be given to: 1) selecting qualified personnel to perform the related environmental activities, and 2) development/implementation of procedures which can control the appropriate environmental, safety, health, and quality related aspects of operations.

- Other factors:

  * New regulations constantly appear, and regulations are constantly modified. For example, 10 CFR 820 Procedural Rules for DOE Nuclear Activities, effective September 16, 1993, has just been received, with additional interpretation of nuclear safety requirements. (Lack of funding will not be considered as a mitigation factor in enforcement actions where non-compliance is determined.) The implications and uncertainties of each new requirement will need to be addressed by the impacted organizations, and applicable quality defined.

  * There is increasing responsibility for, 1) awareness and understanding of environmental regulations and requirements; 2) control of compliance-type costs incurred; and 3) accountability for all quality-related aspects of operations and projects.

SUMMARY DISCUSSION

The historical review given is not intended to be inclusive of all events leading to present issues in establishing procedures for environmental measurements for compliance. It provides an understanding of some of the issues related to the formation of a common approach in organizing quality assurance planning documentation.

Sometimes, the results of audits and assessments may indicate that even when a technical environmental measurement quality advisory structure has been designated, reference to that capability is little used by managers. This is an important issue which needs to be addressed by quality managers. This situation may occur when project managers are not trained or oriented to environmental regulatory requirements for projects. Also, organization personnel may not be supervised by managers knowledgeable of procurement requirements, or documentation requirements. Thus, in addition to environmental advisory concerns, there may be training, orientation, or interface gaps in the control procedures for management of programs that need to be addressed.

This presentation was prepared to provide an alert to some of the quality challenges in measurements when striving for compliance with environmental regulatory requirements. Certain historical activities leading to the standardization of field and laboratory measurements have been reviewed. They are identified as a part of the basis from which advances in environmental measurement quality have been and will continue to be made.

Table 1. PLUTONIUM MIGRATION STUDIES OF THE NAEG:

SELECTED ENVIRONMENTAL COMPARTMENTS

Soil, TRU/Pu particles, groundwater, wells, run-off studies, crater studies	Size; type; chem. phys. state; location of transuranics on or in particles; concentration of radionuclides; moisture content; solubility; pH; elements
Soil contaminant distribution and inventory studies	
Vegetation studies	Solubility changes in nuclides
Ejecta mounds, burrowing animals, vegetation in mound	Soil; pelts, cells, chromosomes, blood, tissues; location, volume of contamination; type of particulate contamination, concentration of radionuclides
Microcosm, and microorganism studies	Solubility changes in radionuclides in environment
Desert range cattle * Dairy cattle, goats *	Milk, cheese, tissues uptake and transfer of radionuclides from environment and test site green chop
Migratory deer, coyotes, wild mustangs *	
Birds, chukkar quail *	
* USPHS/EPA, under MOU	
Snakes, spiders, insects	
Lizards, rabbits, kangaroo rats	
Chromosome studies	
Aerosol physics, dust devils, saltation	
Revegetation studies	
Pu movement in granite, tuff	

Table 1. (Continued)

Seismic studies
Technology development for standardization of field sample collection, handling, analysis, documentation, data base
Aerial survey studies with helicopter detector array
Ground vacuum studies
Integrated detection, identification of errors in relating aerial survey measurements to ground and air distribution measurements of radionuclides
Development of standard in situ measurement technology
Krigging
Randomized computer sample selection program for distribution and inventory
Integrated statistical modelling
Development of HL sample cutting facility
Development of HL waste processing and collection system
Remote sensing studies (boom detector)
Development of field sampling techniques and equipment
Development of laboratory analytical techniques for TRU and fission products
Burn area studies
Other

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