United States Department of the Interior

BUREAU OF MINES

WESTERN FIELD OPERATIONS CENTER
EAST 360 3RD AVENUE
SPOKANE, WASHINGTON 99202

April 10, 1986

Memorandum

To: John Reuss, Project Manager, NRC Program

From: Project Leader, NRC

Subject: Draft Outline--Natural Resource Assessment Methodologies for
          Proposed High-Level Waste Repositories

Pursuant to our conference call on Tuesday, April 8, I am sending a draft
outline to you and Don Bleiwas. The outline should adequately explain the
modifications that were discussed on Tuesday. Don should let me know by
Friday a.m. if he understands the direction we are taking so I can call
Richard Lee and inform him of our status as he requested.

Nicholas Wetzel

NATURAL RESOURCE ASSESSMENT METHODOLOGIES
FOR PROPOSED HIGH-LEVEL WASTE REPOSITORIES

Prepared for the Nuclear Regulatory Commission
Under Interagency Agreement NRC-02-84-004

INTRODUCTION

The Bureau of Mines (BOM), pursuant to Task Order #003, Interagency Agreement NRC-02-85-004, is directed to provide a document designed to assist the Nuclear Regulatory Commission (NRC) in providing guidance to the Department of Energy (DOE) to ensure sufficient application of natural resources evaluation methodologies during site characterization and of DOE's compliance with 10 CFR Part 60, Subpart B, Section 21.

The objective of the report is to detail the generally accepted methods for assessing resources. It describes standard industry and BOM assessment methodologies. It also examines the rationale for selecting a particular methodology or hybrid methodology, including a description of uncertainties associated with those methodologies.

DOE, during site characterization, will acquire data for the purpose of evaluating the potential of a candidate site as a repository for high-level nuclear waste disposal; data will not be acquired for the specific purpose of locating natural resources. This document will thus identify opportunities to acquire data relating to natural resources during the course of site characterization programs conducted by the DOE.

The document is generally applicable to any geologic province in the United States and applies to all mineral commodities (including metals, nonmetals, fossil fuels, and geothermal resources) currently recoverable or that may become recoverable in the future as the result of advances in extraction/processing technology.

1.0 Regulatory basis for identification and evaluation (assessment) of natural resources in and around a proposed high-level nuclear waste repository.

   1.1 Regulations mandating natural resource assessment.
   1.1.5 10 CFR 60.21 (c) (13). Regulation quoted and discussed.
   1.1.1 10 CFR 60.122 (c) (17). Regulation quoted and discussed.
   1.1.2 10 CFR 60.122 (c) (18). Regulation quoted and discussed.
   1.1.3 10 CFR 60.122 (c) (19). Regulation quoted and discussed.
   1.1.4 10 CFR 60.122 (c) (20). Regulation quoted and discussed.

   1.2 Regulatory limitations on activities related to natural resource assessment.
   1.2.1 10 CFR 60.10 (d) (1). Regulation quoted and discussed.
   1.2.1 10 CFR 60.10 (d) (2). Regulation quoted and discussed.
   1.2.1 10 CFR 60.10 (d) (3). Regulation quoted and discussed.
   1.2.1 10 CFR 60.10 (d) (4). Regulation quoted and discussed.

   1.3 Regulatory compliance. Primary intent of document is two-fold:
   1) To provide DOE and its contractors with guidelines relating to accepted methods of documenting compliance with regulations governing natural resource identification and evaluation, and,
   2) to assist NRC in determining DOE's compliance with said regulations.

   1.4 Opportunities for resource assessment during preparation of site characterization plans.
   Natural resource data may be generated during course of site characterization. Such data may be utilized to augment and/or update literature, databases, current geological models. Resources discovered during site characterization may form basis for deposit models the use of which may indicate other undiscovered resources in the geological setting.

2.0 Resource assessment procedures.

2.1 Introduction. Methodologies presented in the following sections
    describe standard industry and BOM techniques employed in the
    assessment of natural resources. During the course of site
    characterization, these methodologies may be utilized to meet the
    requirements of natural resource assessment as set forth in 10 CFR
    Part 60 presented in section 1.0 of this document. Method
    applications and limitations are also discussed.

2.2 Background data collection.

2.2.1 Literature and database searches of published and unpublished
      data relating to regional and local geologic, hydrologic,
      climatic, and historical data (will include courthouse records
      searches and examination of available drill cores, logs,
      production data, etc.)

2.2.2 Personal contacts with knowledgeable individuals. Includes
      Federal, State, and local agencies, universities, and
      industry representatives.

2.3 Identification of natural resources of the geologic setting. This
    section addresses those requirements set forth in 10 CFR Part 60.21
    (c) (13) relating to identification of known and/or undiscovered
    natural resources in the geologic setting, methods employed in such
    identification, and the possible effects of exploitation of these
    resources on the ability of a proposed HLW repository's ability to
    isolate radionuclides from the accessible environment. Evaluation of
    such resources [as required by 10 CFR Part 60.21 (c) (13)] are
    discussed in later sections of this document.

2.3.1 Identification of those areas similar in size to a candidate area
      that are representative of and occur within the geologic setting.

2.3.1.1 Identification of those areas in the geologic setting that in the
        past have been targets of resource exploration (mapping, sampling,
        drilling, test pits, trenches, or adits, etc.), or have been exploited
        (development, underground workings, open pits, tailings dams and
        ponds, dumps, diversion dams, ditches, etc). This process will
        utilize information developed during the background data collection
        phase.

2.3.1.2 Identification of those areas, using data obtained during the data collection phase and the following methods, that may host undiscovered natural resources.

2.3.1.2.1 Methods for comparing natural resource potential of a hypothetical site (proposed HLW repository or areas proximal to such sites) to other areas within the geologic setting include, but are not limited to: 1) Analogy (similarities in lithology, mineralogy, structure, ground preparation); 2) geologic inference (trends of mineralized zones, fault offsets, bedding), and 3) various statistical methods.

2.3.2 Possible effects upon a HLW repository's ability to isolate radionuclides from the accessible environment as the result of exploiting proximal natural resources. Discussion will include possible effects of drilling, blasting, underground workings, open pits, surface subsidence, modifications to surface and ground water movement patterns, human and vehicle traffic, etc.

2.4 Field data collection, compilation, and interpretation.

2.4.1 Map data. Surface and subsurface geologic mapping utilizing photogrammetry, topographic maps, geologic maps, mine maps, etc.

2.4.2 Surface and subsurface sampling. Including but not limited to chip, channel, grab, select, stream, well, sediment, soil, water, pan and bulk samples; drill core, auger, and slotted tube samples; samples taken in test trenches, pits, adits, etc. These samples may be subjected to: Fire assay, chemical analysis, scanning electron microscope, microprobe, x-ray diffraction, x-ray fluorescence, atomic absorption, x-ray crystallography, whole-rock analysis, thin and polished section analysis, etc.

2.4.3 Geochemical surveys. Including but not limited to one or more of the following: Soil analysis, stream and well water sampling, stream sediment sampling.

2.4.4 Geophysical surveys. Including but not limited to induced polarization, electromagnetic methods, reflection, multi-channel seismic refraction, detection of anomalous radioactivity, very low frequency and self-potential methods, surface and airborne magnetic surveys, gravity surveys and resistivity.

2.4.5 Map data compilation. Including but not limited to generation and interpretation of maps, charts, and graphs.

2.4.6 Correlation of sample locations and accompanying data. Including map overlays produced from analytical data to delineate anomalies.

2.4.7 Interpretation of sample analyses, geochemical, and geophysical data.

2.4.8 Deposit modeling. Comparison of deposit data and parameters to established deposit models (massive sulfides, layered intrusives, Mississippi Valley type Pb/Zn, etc.).

2.4.9 Diamond core or percussion drilling. Program to determine areal extent, depth, and attitude of a potential resource and to provide additional subsurface data pertaining to mineral, hydrocarbon, or geothermal resources provided such activities do not compromise provisions of 10 CFR Part 60.10 (d) (1-4).

2.4.10 Down-hole geophysical exploration. Including but not limited to induced polarization and resistivity.

2.5 Total resource estimation.

2.5.1 Identified resources. Including a tabulation of those resources which are measured, indicated, and inferred.

2.5.1.1 Quantity estimates of resource in terms of in situ tonnage, cu. ft. barrels, flasks contained, etc.

2.5.1.2 Quality estimates of resource in terms of weight percent, parts per million, or other applicable units.

2.5.1.3 Detailed resource geometry. Determination of vein habits, hydrocarbon traps, subsurface structure, and other features that affect engineering, extraction, and recovery of a resource (see geotechnics section 2.6.1).

2.5.2 Undiscovered resources. Application of statistical resource estimation methods (PROSPECTOR, ROCKVAL, Harris-subjective probability appraisal methods).

2.5.2.1 Hypothetical resources. Those resources generatated utilizing statistical methods supported by available quantitative data.

2.5.2.2 Speculative resources. Those resources generated utilizing subjective probability methods.

2.6 Pre-development studies. A discussion of the studies required to provide sufficient data to determine gross and net value of natural resources.

2.6.1 Environmental and legal requirements. A discussion of the necessary environmental and legal requirements which may be encountered during development of a natural resource.

2.6.1.1 Base line studies, EIS preparation, and permitting.

2.6.1.2 Reclamation requirements including but not limited to restoration, revegetation, water quality assurance, backfilling, grading, and contouring.

2.6.1.3 Investigation of legal status including water and mineral rights, claims and pending litigations.

2.6.2 Geotechnics. Including but not limited to hydrology, geologic structure, rock properties, pre-mine stress, and other factors affecting resource extraction.

2.6.3 Extraction system design. Methods employed in selection of a recovery system (surface mine, underground mine, well design).

2.6.4 Processing system design. Methods employed in determining processing requirements.

2.6.4.1 Metallurgical or chemical testing, design analysis, and evaluation of anticipated recovery systems.

2.6.4.2 Pilot plant design and process refinement.

2.6.5 Ancillary systems design. Anticipated infrastructure requirements (water, power, support facilities).

2.6.6 Transportation requirements. Assessment of existing or required highway, road, railroad, barge, pipeline, airline, or other transporation system required to transport product to smelter, refinery, market, etc.

2.7 Capital and operating costs. Calculations based on application of BOM and industry costing systems utilizing data generated during pre-development studies.

2.7.1 Capital requirements. Estimated capital expenditures required to bring a resource into production (acquisition, exploration, mine plant and equipment, mill plant and equipment, infrastructure).

2.7.2 Operating costs. Estimated costs required to sustain production (labor, supplies, equipment maintenance, administration).

2.7.3. Costing systems. A discussion of various methods (BOM cost estimating system) for generating capital and operating cost estimates.

2.8 Economic analysis. Utilization of cost estimations to determine gross and net value of natural resources.

2.8.1 Price determinations. An economic determination of the price required for competitive production.

2.8.2 Financial evaluations. An economic determination of the discounted cash flow rate of return (DCFROR) on the initial capital investment or net present value (NPV).

2.8.3 Market analyses. A determination of the marketability of the products evaluated.

3.0 Summary.

3.1 Relationship to Site Characterization Plans.

3.2 Relationship to 10 CFR Part 60, Subpart B, Section 21.

3.3 Relationship to Regulatory Guide 4.17.

4.0 Glossary.

5.0 References.