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April 30, 1986

Memorandum

To: John L. Reuss, Program Manager, NRC Project
From: John R. Norberg, Supervisor, Special Projects Section
Subject: Final Annotated Outline--NRC Methodology Report
as Required Under Task Order No. 003

Enclosed is the final annotated outline for the NRC Methodology Report
and a transmittal memorandum for your signature.

John R. Norberg
John R. Norberg

Enclosures

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United States Department of the Interior

BUREAU OF MINES
2401 E STREET, NW.
WASHINGTON, D.C. 20241

April 30, 1986

Memorandum

To: Richard Lee, Project Officer, Geotechnical Branch, Division of Waste Management, U.S. Nuclear Regulatory Commission

From: John L. Reuss, NRC Program Manager

Subject: Final Annotated Outline--NRC Methodology Report--Task Order #003 of Interagency Agreement NRC-02-85-004

FIN #D1018

Enclosed is the final Methodology Report annotated outline as required under Task Order #003 of Interagency Agreement NRC-02-85-004.

John L. Reuss

Enclosure

ANNOTATED OUTLINE

**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) regarding accepted methodologies for evaluating natural resources to meet the requirements of 10 CFR Part 60.

The objective of the report is to detail the generally accepted methods for locating and evaluating mineral 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. This report will identify methods available to DOE for evaluating mineral resource potential during site characterization activities.

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 likely 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 compliance. Primary intent of report is: 1) To provide guidance to DOE regarding accepted methods for demonstrating compliance with regulations governing natural resource identification and evaluation, and, 2) to assist NRC in making a finding of DOE's compliance with the requirements of 10 CFR Part 60.

1.3 Available methods for natural resource assessment during site characterization. Natural resource data may be obtained during site characterization. Such data may be utilized to augment and/or revise models developed through literature and database searches. Information obtained about natural resources during site characterization may form the basis for deposit models, or augment models, the use of which may indicate other undiscovered resources within the geologic 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, maps, etc.).

2.2.2 Contacts with knowledgeable individuals. Including, but not limited to, Federal, State, and local agencies, universities, and the private sector.

2.3 Methods for identifying and evaluating natural resources using information obtained from Section 2.2 above. This section addresses those requirements of 10 CFR Part 60 relating to identification of known and/or undiscovered natural resources within the geologic setting and methods for evaluating such resources.

2.3.1 Methods for identifying areas to be used for probabilistic comparison with the proposed site.

2.3.1.1 Identification of those areas within 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 background data collection (see Section 2.2). From these sources preliminary models will be developed for purposes of conducting probabilistic comparison.

2.3.2 Methods for conducting probabilistic comparison of those areas identified in Section 2.3.1.

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, cross sections, 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 Refine previous models. Comparison of deposit data and parameters to established generic 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, cubic feet, 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 probabilistic resource estimation methods (PROSPECTOR, ROCKVAL, Harris-subjective probability appraisal methods).
 - 2.5.2.1 Hypothetical resources. Those resources estimated utilizing probabilistic methods supported by available quantitative data.
 - 2.5.2.2 Speculative resources. Those resources estimated 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 transportation 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 (Bureau of Mines 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.