United States Department of the Interior

BUREAU OF MINES
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WASHINGTON, D.C. 20241

January 24, 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: Annotated Outline--NRC Methodology Report--Task Order #003 of Interagency Agreement NRC-02-85-004

FIN #D1018

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

John L. Reuss

Enclosure

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ANNOTATED OUTLINE OF METHODOLOGIES UTILIZED IN ASSESSING NATURAL RESOURCES

(Interagency Agreement # NRC-02-85-004)

Prepared for the Nuclear Regulatory Commission, Washington D.C. 20555

ANNOTATED OUTLINE

NRC METHODOLOGY REPORT

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 NRC in their evaluation of DOE mineral assessments of proposed high-level nuclear waste repositories 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.

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. Particular emphasis is placed on the candidate sites in Hanford, WA; Yucca Mountain, NV; Deaf Smith County, TX; Richton Salt Dome, MS; and Davis Canyon, UT.

1. Purposes for Evaluating Mineral Resources in and Around a Candidate Site.

1.1. Determine quantity and quality of natural resources.

1.2. Develop and evaluate engineering aspects.

1.3. Estimate costs of extraction and subsequent recovery of a natural resource.

1.4. Identify past mining activities.

2. Resource Assessment Procedures.

2.1. Background data collection.

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 Literature and database searches of published and unpublished data relating to regional and local geologic, hydrologic, climatic, and historical data (will include examination of available drill cores, logs, production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

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

2.1.3. Prioritize areas for initial field investigations.

2.1.4. Environmental and legal requirements.

2.1.4.1. Base line studies.

2.1.4.2. Required bonding. Drilling, roads, reclamation, etc.

2.1.4.3. EIS preparation.

2.1.4.4. Permitting.

2.1.4.5. Investigation of legal status. Water and mineral rights, claims, pending litigation, etc.

2.2. Field data collection.

2.2.1. Surface and subsurface geologic mapping utilizing photogrammetry, topographic maps, geologic maps, mine maps, etc.

2.2.2. Surface and subsurface sampling. May include 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.

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

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

2.3. Initial compilation and interpretation of field data.

2.3.1. Map data (maps, charts, graphs, etc.).

2.3.2. Correlation of sample locations and accompanying data to the field area. Map overlays produced from analytical data to delineate anomalies.

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

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

2.4. Subsequent field investigations. Based on interpretation of data generated during initial field activities.

2.4.1. 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.

2.4.2. Down-hole geophysical exploration. May include induced polarization, resistivity, or other applicable techniques.

2.5. Total resource estimation.

2.5.1. Identified resources.

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

2.5.1.2. Quality estimates. Estimate of overall quality 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.

2.5.2. Undiscovered resources. Application of geostatistical resources estimation methods (prospector, ROCKVAL, Harris-subjective probability appraisal methods).

2.5.2.1. Hypothetical resources. Statistical methods supported by available quantitative data.

2.5.2.2. Speculative resources. Estimation of resources utilizing subjective probability methods.

2.6. Pre-development studies.

2.6.1. Geotechnics; including hydrology, geologic structure, rock properties, pre-mine stress, and other factors affecting resource extraction.

2.7. Capital and operating costs. Calculations based on application of BOM and industry costing systems.

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

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

2.7.3. Extraction system design. Methods employed in selection of a recovery system. Surface mine, underground mine; well design, etc.

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

2.7.4.1. Metallurgical or chemical testing. Design, analysis, and evaluation of anticipated recovery systems.

2.7.4.2. Pilot plant design and process refinement.

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

2.7.6. Transportation requirements. Assessment of existing or required highway, road, railroad, barge, pipeline, airline, or other transportation systems required to transport product to smelter, refinery, market, etc.

2.7.7. Reclamation requirements. Restoration, revegetation, water quality assurance, backfilling, grading, contouring, etc.

2.8. Economic analysis.

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. Comparison of industry and BOM mineral reserve-resource assessment approaches and goals.

3.1. Industry.

3.1.1. Industry evaluates deposits towards making an investment decision ("Reserves").

3.1.2. Industry collects published information and also generates its own data.

3.1.3. Industry generates feasibility studies at various levels of certainty (from plus or minus 25 pct up to within a few percent).

3.2. Bureau of Mines.

3.2.1. BOM evaluates deposits for input into national policy decisions.

3.2.2. BOM generally utilizes published and company provided data.

3.2.3. BOM calculates resources to a 50 pct (measured, indicated, and inferred) probability level.

3.2.4. BOM conducts feasibility studies to within a level of certainty of plus or minus 25 pct.

3.2.5. BOM evaluations limited by budget restraints.

4. References.

5. Glossary.