RPMGLOBAL

PERSPECTIVES

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MINIMUM ENGINEERING STUDY REQUIREMENT

UPDATE

The evaluation of a mining project from exploration through development and production is a lengthy and complicated process.

Mine development commitment activities for a potential project are initiated when a mineral resource is identified and continue through to the start of construction. The technical feasibility and the economic viability of each project are determined during the phases of mine development with more detailed engineering data required at each stage.

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There are at least four levels of engineering studies during development that are commonly acknowledged by the mining industry:

1. Conceptual Study
2. Preliminary Economic Assessment (PEA), or Scoping study
3. Pre-feasibility (PFS)
4. Feasibility (FS)

Some other commonly used study names include:

- Definitive Feasibility Study (DFS)
- Bankable Feasibility Study (BFS)
- Front End Engineering Design (FEED)
- Stage Gates Studies
- Front End Loading (FEL) Studies
- Basic Engineering
- Detailed Engineering

For this paper RPMGlobal is addressing only the PEA, PFS and FS types of reports that are used by companies to evaluate projects, meet regulatory requirements and seek financing. These are key studies to the industry since reporting jurisdictions use them to define the point at which "ore reserves" can be publically reported. Some of the other types of reports and stages have different meanings for different companies, and a lot of the definitions are based on a company's incorporation (public vs. non-public), its size (major vs. junior) where the mining project is based and what it's historical reporting requirements entailed (for example in the former Soviet Union vs. China vs. in South America), etc.

This paper and the enclosed table lists RPMGlobal's guidelines for the minimum suggested requirements for the three key levels of engineering studies, regardless of jurisdiction, incorporation or geographic location. We highlight the word "minimum" and recognize many studies exceed our suggested guidelines. We also recognize different companies and different engineering firms suggest different minimums than does RPMGlobal. Standards or codes have been developed in many jurisdictions around the world to ensure factual and consistent reporting of mineral data is practiced. Most or all these codes have adopted similar definitions for data collection, resource and reserve reporting, and the other aspects of evaluating mineral deposits in advancing stages of evaluation. Two common codes used in the industry are the CIM reporting code and associated Canadian NI-43101 and the Australian "JORC" code. Neither of these two codes should be confused with an engineering study as they have been developed to ensure that misleading, erroneous or fraudulent information relating to mineral properties is not reported to investors on the stock exchanges they oversee.

Included in most standards are references to definitions of Preliminary Economic Assessment/Scoping studies, pre-feasibility studies, and feasibility level studies, and the following descriptions are consistent with those definitions. As the level of engineering detail increases through each study stage, as measured by accuracy, the overall degree of uncertainties decreases.

Preliminary Economic Assessment (PEA) / Scoping Study

The PEA, also commonly referred to as a scoping study is an early level study and the preliminary evaluation of the mining project. The principal parameters for a conceptual study are mostly assumed and/or factored. Accordingly, the level of accuracy of capital costs is as low as ±50%. Although the level of drilling and sampling with the required QA/QC, must be sufficient to define as a minimum an inferred resource. Flow sheet development, cost estimation and production scheduling are often based on limited data, test work, and engineering design. Metallurgical test work is based on ore types and examines mineralogical, comminution and separation characteristics in order to establish the likely flowsheet and product recoveries. The results of a PEA typically identify:

- Probable mining and processing schemes
- Technical parameters requiring additional examination or test work
- General features and parameters of the proposed project
- Magnitude of capital and operating cost estimates
- Level of effort for project development

A PEA is useful as a tool to determine if subsequent exploration activities and engineering studies are warranted. However, it is not valid for economic decision making nor is it sufficient for reserve reporting.

Pre-feasibility Study

The pre-feasibility study (PFS) is an intermediate step in the engineering process to evaluate the technical and economic viability of a mining project. The pre-feasibility study is a critical step for project development as it represents the minimum prerequisite for conversion of a geologic resource into a reportable reserve. Total engineering at the pre-feasibility level is still limited, often representing less than 10% of the total engineering effort, but should increase the level of accuracy in the cost estimate to ± 25%. The engineering objectives of a pre-feasibility study are to study a range of development options to reasonably assess:

- Mining method and production rates
- Dilution and extraction estimates
- Processing method, processing rates and recovery estimate
- Tailing and waste containment
- Hydrology studies
- Marketing requirements
- Environmental and permitting requirements

- Social License
- Governmental requirements
- Legal concerns
- Detailed financial analysis and project economics with sensitivities
- Capital cost estimates
- Operating cost estimates

At the pre-feasibility study stage adequate geology, drilling, sampling and QA/QC (to verify the accuracy and precision of the assay test work) and mine engineering work has been conducted to define a resource that may be convertible to a mineral reserve pending positive economic outcome of the pre-feasibility study. Significant metallurgical test work, typically involving Locked Cycle Testing (LCT) and may include pilot testing, has been performed on representative ore blends of all significant rock and mineralisation types based on selected composites, representative of key years in the life of mine schedule. In addition, the feed grade-recovery relationship for major ore types and thus blends is established. Mining and processing parameters must be sufficient for flow sheet development, production and development scheduling and major equipment selection. Typically flowsheet modelling is conducted, particularly for the comminution circuit. With regard to Infrastructure and planned operations, potential issues with important environmental and social considerations must be assessed to determine the potential show stoppers such as the existence of critical habitat and the level of involuntary resettlement required for the Project. Capital and operating cost estimates utilize significant vendor quotes on major equipment, but other construction costs are often factored. The economic analysis of a pre-feasibility study is of sufficient accuracy to assess various development options and overall project viability; however, cost estimates and engineering parameters are not typically considered of sufficient accuracy for project execution decisions or debt financing commitments.

The Canadian Institute of Mining, Metallurgy, and Petroleum (CIM) defines a Pre-feasibility Study as "a comprehensive study of a range of options for the technical and economic viability of a mineral project that has advanced to a stage where a preferred mining method, in the case of underground mining, or processing is determined. It includes a financial analysis based on reasonable assumptions on the Modifying Factors and the evaluation of any other relevant factors which are sufficient for a Qualified Person, acting reasonably, to determine if all or part of the Mineral Resource may be converted to a Mineral Reserve at the time of reporting. A Pre-feasibility Study is at a lower confidence level than a Feasibility Study."1

It is intended that through trade-off studies in the Pre -feasibility Study stage, the favoured development options are selected prior to commencing the Feasibility Study.

Feasibility Study

A feasibility study, (FS), represents the next and thus far most detailed step in the engineering process for evaluating a mining project for a "go/no-go" decision and financing purposes. Principal parameters for a feasibility study are based on sound and complete engineering and test work. Cost estimate accuracy is higher than the pre-feasibility study and is typically ±15%. Feasibility study objectives are the same as those previously listed for the pre-feasibility study, but the level of detail and accuracy for each objective are more stringent. In the past, the term "bankable" was used in describing a feasibility study. This term simply implied that the level of detail of the study is sufficient for potential project financing.

Detailed geologic and mine engineering work has been conducted to define a resource and reserve. Detailed test work has been completed to develop all mining and processing parameters for pit slope design, hydrology, geotechnical, flow sheet development, equipment selection and sizing, consumables and power consumption, material balance, general arrangement drawings, production and development schedules, capital and operating cost estimates. Capital and operating cost estimates are derived from take-offs and full vendor quotes. A draft Environmental Social Impact Assessment (EISA) has been submitted to regulatory authorities or is close to being submitted. The right to mine has been granted (required by SEC to declare reserves) or can be reasonably expected to be granted (allowed by NI 43-101 and JORC to declare reserves). Economic analysis with sensitivities is based on annual cash flow calculations for the mine life.

The Canadian Institute of Mining, Metallurgy, and Petroleum (CIM) defines a Feasibility Study as "a comprehensive technical and economic study of the selected development option for a mineral project that includes appropriately detailed assessments of applicable Modifying Factors together with any other relevant operational factors and detailed financial analysis that are necessary to demonstrate, at the time of reporting, that extraction is reasonably justified (economically mineable). The results of the study may reasonably serve as the basis for a final decision by a proponent or financial institution to proceed with, or finance, the development of the project. The confidence level of the study will be higher than that of a Pre-Feasibility Study."2

Key Engineering Study Tasks

The following sections contain a brief description of the major areas that are incorporated into engineering studies. As the level of the study increases in complexity, the level of detail required increases as shown in the attached table. For a summary comparison of capital cost estimates by study level, see Figure 1.

Processing

Graphite deposits typically range from 2% to 8% Cg, with 15% to 20% Cg considered high grade. With the exception of vein deposits, which can be selectively mined (often by hand), all other graphitic ores require processing. The flowsheet is determined by both the mineralogy and the target market and

Geology, Resources and Reserves

Every mineral deposit has its own unique geologic characteristics which must be considered in the preparation of engineering studies. The amount of required geologic information for the determination of resources varies significantly as a function of the engineering study level and the complexity of the deposit and mineralogy. Geologic features control economic mineralization, and with the appropriate geologic modeling, a reliable grade estimate will be determined using a combination of geologic controls and geostatistics.

As part of the geological study which generally includes drilling, sampling, and assaying, a rigorous and well documented Quality Control / Quality Assurance (QA/QC) program must be conducted to allow verification of the accuracy and precision of the basic sampling and assay data. Industry standards generally require a series of blanks, standard reference material, coarse and pulp duplicates, and samples sent to a second laboratory for assaying.

Resource estimation is based on the development of a three-dimensional model of the deposit geology, mineralisation characteristics and continuity. The completed resource allows for rapid tabulation of mineral inventory and provides a basis for all subsequent determinations of reserves, mine design and planning. The objective is to provide the most reliable and accurate resource estimate with available data. The resource and reserve estimate is classified according to internationally recognized standards. The current listing rules for mining projects, minimum project stage, resource/reserve reporting code and level of engineering study required by various jurisdictions to declare "reserves" is summarized in Figure 2.

Mining

Upon completion of the deposit's geologic interpretation and resource estimate, the mining method, either surface and/or underground, is selected. This selection is based on the geometry of the deposit and depth of the deposit. As the studies progress, the detail incorporated into the actual design of the mine increases.

Optimization software is then used to determine open pit economic limits or define stope shapes for underground mining projects. The selection of economic mining limits is often supported by a strategic analysis that includes assessing the impact of changes in prices, costs, and recoveries. At this stage, including inferred resources in the pit limit optimization analysis can also help a company determine where to focus exploration drilling to increase measured and indicated resources. Although the strategic analysis task involves preparing preliminary production schedules, the basis lacks key design features (such as haulage ramps, in the case of open pits), and therefore the results cannot be equated to declarable mineral reserves.

As the level of engineering study is advanced, the detail incorporated into the mine design, production scheduling, and capital and operating cost estimation increases. For the mine design, the detail and quantity of geotechnical data is critical as it dictates the pit slopes in surface mines and the design of underground openings and specific underground mining methods. Mine design and scheduling can also be impacted by the need to meet processing requirements such as maintaining mill feed grades or rock type blends, and by environmental requirements such as surface and groundwater management. As the knowledge of the project is increased, the more refined and detailed the mine design and production schedule can become. With increasing engineering detail, resources may possibly then be converted to reserves.

Process Engineering

Process development requirements at the feasibility level should include test work on representative samples sufficient to develop a flow sheet, pilot testing of this flow sheet on representative blends of all significant ore types, and variability testing of all significant ore types and mining blends sufficient to identify probable plant throughput and recovery variation. Processing facilities are designed to produce marketable products for shipment directly to the consumers (e.g. copper cathodes from SX-EW) or to subsequent processing facilities (e.g. concentrates to smelters-refineries).

Key components for process engineering in engineering studies include:

- Metallurgical test work
- Mineralogical studies
- Consideration of project site conditions
- Identification of best tailing containment location and form
- Selection of processing flow sheet and design basis
- Determination of processing design criteria and description
- Plant processing facilities layout
- Equipment sizes and specifications
- Plant services

Infrastructure

The infrastructure requirements for mining projects are site specific. The capital cost for infrastructure can vary substantially from site to site as a percentage of the total capital cost, and are often more of a function of the location rather than the mining or processing methods. Thus, the capital cost estimate in engineering studies must be based on a proper identification and assessment of the infrastructure requirements. Infrastructure covers a wide range of facilities and services as listed below:

- Access and service roads
- Utilities
- Water supply
- Communications
- Port and marine
- Fuels

- Waste disposal systems
- Administration facilities
- Industrial facilities
- Transportation
- Townsite/Camp

Marketing Study

Marketing studies are critical to define the nature of the market. This includes the preferred production rate, the potential for substitution, potential competitors (new mines coming on stream), product specifications, future product prices, likely buyers and terms of sales. Depending upon the commodity type, product samples are supplied to potential buyers for evaluation as a part of the negotiation process. This may entail additional pilot plant test work in order to produce sufficient samples. Marketing studies are critical to define the nature of the market. This includes the preferred production rate, the potential for substitution, potential competitors (new mines coming on stream), product specifications, future product prices, likely buyers and terms of sales. Depending upon the commodity type, product samples are supplied to potential buyers for evaluation as a part of the negotiation process. This may entail additional pilot plant test work in order to produce sufficient samples.

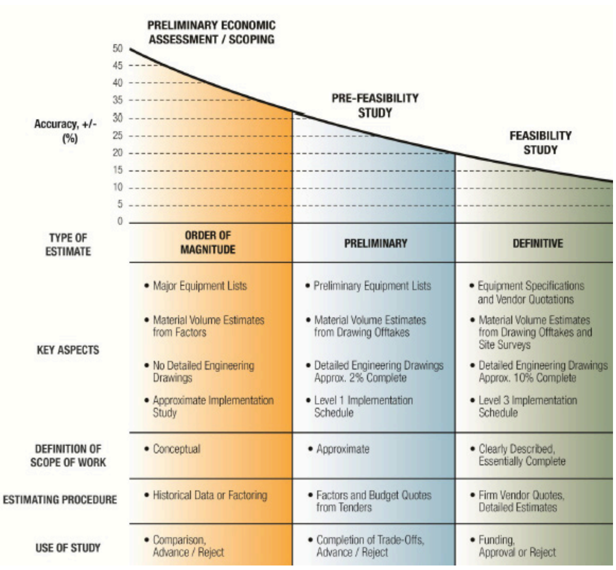

Figure 1

Environmental & Social Management

Environmental scientists and regulatory specialists help develop effective and economical environmental controls for mining operations, which comply with applicable environmental regulations (international, federal, state, and local) affecting the mining industry. Environmental and social considerations faced by the global mining industry in the development of mining prospects include the following general categories.

Environmental Management

Design and implementation of baseline studies for the environmental aspects of the Project Development of Environmental Social Impact Assessments (ESIA) that address all potential impacts and proposes corresponding mitigations:

- Mine permitting at the local, state, federal and international levels
- Air quality and noise assessment
- Mine-waste management design and associated mitigation measures required to protect the environment
- Water management (surface and groundwater)
- Biodiversity Management
- Habitat assessment including critical and natural habitats
- Wetlands mitigation/construction design where applicable
- Acid-rock drainage and leachable elements assessment and associated mitigation measures
- Closure planning for the environmental aspects

Social Management

- Design and Implementation of baseline studies for the social aspects of the project
- Development of Environmental Social Impact Assessments (ESIA) that address all potential impacts and proposes corresponding mitigations.
- Stakeholder engagement actions
- Grievance mechanism Activities
- Acquisition of a "social license"
- Closure planning

Economic Analysis

Economic analysis is performed as the final step in each engineering study to provide a measure of the project's economic viability. Economic analysis is performed using conventional pro forma cash flow analysis for the mining industry incorporating the following:

- Constant or current dollars
- Leveraged or unleveraged financing
- Project basis (stand alone or combined)
- Pre- or after-tax basis
- Discounting period of project's annual cash flows (i.e. mid- or end-of-year)

Economic measures determined in the analysis typically include:

- Net present values at selected discount rates
- Discounted cash flow return of investment
- Internal rate of return
- Payback period

Sensitivity analyses to the base case are performed to key project variables which typically include:

- Commodity price(s)
- Commodity recovery(ies)
- Capital costs
- Operating costs
- Currency exchange rates

As can be seen above, the development of any level of study requires professionals with extensive mining experience in many different disciplines. Enhancing the capabilities of the study team will reduce the risk faced during the development of the property. For example, during the conceptual study, the study team may identify a fatal flaw that places the project at such risk that the project should not proceed at that particular point in time.

On the other hand, an experienced team can provide the knowledge base to optimize the project as much as possible or apply the best-available proven technology during the pre-feasibility and feasibility study stages. Beyond the team's basic mine development experience is the consideration of the knowledge and experience of project financing team and financial requirements that is required for bankable study preparation.

Therefore, it is of critical importance to select the correct project team to ensure an optimal outcome and timely completion of the study. Following this approach will reduce both project development and cost risks. Additionally, following the traditional progression of the studies from conceptual to pre-feasibility to feasibility generally saves time and money in the long run as critical issues can be identified and addressed early on rather than at a later stage where the impact can result in a costly project delay.

Listing Entity	Listing Rules which apply to Mining Projects	Minimum Project Status for Listing	Mineral Resource/Reserve Reporting Code	Study Level for Reserve Declaration
ASX	Chapter 5	Exploration	JORC	PFS
HKEx 香港交易所	Chapter 18	Pre-Development	JORC or CIM or SAMREC	PFS
SGX (Main Board)	Main Board Listing Rules 624, 749, 750, 1014(2) and 1207(21) Practice Note 6.3 Appendix 7.5	Exploration	JORC	PFS
SGX (Catalist)	Catalist listing Rules 440, 441, 704(35), 705(7), 1014(2) and 1204(23) Practice Note 4C Appendix 4C	Exploration	JORC	PFS
上海證券交易所	None	None	Classification for resources/ reserves of solid mineral commodities (GB/T 17766 1999)	Chinese Standards
TSX	NI 43-101/ Appendix 3F	Exploration	CIM	PFS
NYSE		Advanced Development	SEC Industry Guide 7	FS
AIM	AIM Rules Guidance Note 2009	Exploration	JORC or CIM or SAMREC	PFS
London Stock Exchange	Financial Conduct Authority Handbook (includes Main Board and AIM Listing, Prospectus and Disclosure Rules, ESMA Prospectus Directive 2011; ESMA Note on Prospectus Directive	Pre-Development	JORC or CIM or SAMREC	PFS

Figure 2

Minimum Report Contents for Engineering Studies

DESCRIPTION	*Preliminary Economic Assessment (PEA, Scoping Study)*	*Prefeasibility Study (PFS)*	*Feasibility Study (FS)*
INTRODUCTION			
Location, Topography and Climate			
Site Location Map	Basic map	Preliminary map showing claims and boundaries	Detailed map showing all claims and boundaries
Topography Map	Basic map showing site topography	Preliminary map showing site topographic features	Detailed topographic map; aerial surveys verified with ground controls and surveys
Property Ownership	Review of property lease	Review of property lease; claims list provided; mineral rights known	Property lease and rights secured and controlled; claims list and map provided; mineral rights secured
Current Status and History			
Historical Chronology	Basic presentation	Full presentation	Detailed presentation
Past Production (if any)	Basic presentation	Full presentation	Detailed presentation
EXPLORATION AND GEOLOGY			
Geologic Description			
Review	Preliminary review	Preliminary site-specific analysis	Detailed site-specific analysis
Data Posting	Review of available existing maps	Detailed geologic mapping with cross-sections, lithology and mineralogy, and domains	Deposit well-defined with three dimensional mapping, geologic maps, long sections, level plans, lithology and mineralogy, and domains
Geologic Assessment	Preliminary	Basic assessment and review	Detailed assessment of structures/rock contacts, alteration, mineralization, deposit trends
Mineralogical Sampling & Analysis	Limited sampling; preliminary assessment	Preliminary mineralogical sampling and analysis; preliminary mineralogical study	Detailed mineralogical sampling and mapping; detailed mineralogical study
Drilling, Sampling and Assaying			
Drill Hole Parameters	Wide spaced drilling as appropriate	Initial in-fills of wide spaced drilling; preliminary grid patterns	Close spaced drilling on a detailed grid pattern to support calculated reserve categories
Underground Drilling	Review of existing data	Drilling if accessible	Detailed drilling if accessible
Samples	Preliminary; some outcrop samples	Geophysical and geotechnical sampling; test pits	All sampling programs complete
Drilling/Assay Data	Preliminary check of existing drill hole data	Check of drill holes (coordinates, elevations, angles, etc.), check assays, angled hole vs. vertical hole comparison; assay flow diagram, dependable database	Check of drill holes (coordinates, elevations, angles, etc.), check assays, angled hole vs. vertical hole etc.), check assays, angled hole vs. vertical hole comparison, twin hole drilling; assay flow diagram; validated database

Appendix A

Minimum Report Contents for Engineering Studies (continued)			
DESCRIPTION	***Preliminary Economic Assessment (PEA, Scoping Study)***	***Prefeasibility Study (PFS)***	***Feasibility Study (FS)***
QA/QC protocol and data	Defined QA/QC protocol that verify sample and assay results. This protocol should include blanks, standard reference material, coarse and pulp duplicates, field duplicates and third party check assays. The verification samples should constitute a minimum of 10% of the sample stream.	Defined QA/QC protocol that verify sample and assay results. This protocol should include blanks, standard reference material, coarse and pulp duplicates, field duplicates and third party check assays. The verification samples should constitute a minimum of 10% of the sample stream.	Defined QA/QC protocol that verify sample and assay results. This protocol should include blanks, standard reference material, coarse and pulp duplicates, field duplicates and third party check assays. The verification samples should constitute a minimum of 10% of the sample stream.
Condemnation Drilling	None	None	Areas under waste dumps, tailings and plant drilled
RESOURCES AND RESERVES (Internationally Recognized Standards [see note 1])			
Resources	Measured, Indicated, and Inferred	Measured, Indicated, and Inferred	Measured, Indicated, and Inferred
Geologic Controls	Assumed	Established from geologic data and/or variograms	Well established from geologic data
Tonnage Factors	Preliminary assessment if available	Preliminary analysis and determinations	Detailed analysis and determinations
Statistical Analysis	Preliminary analysis and determinations	Preliminary analysis and determinations	Detailed analysis and determinations
Geostatistical Analysis	Preliminary analysis and determinations	Preliminary analysis and determinations	Detailed analysis and determinations
Pit Optimization	Pit limit optimization software	Pit limit optimization software	Pit limit optimization software
Reserves	Only resources estimated	Proven and Probable	Proven and Probable
Calculation Parameters	Usually no reserves are estimated	Known or estimated	Detailed analysis and determinations including dilution and losses
Pit Optimization	Pit limit optimization software	Pit limit optimization software	Pit limit optimization software
Cutoff Grade (COG) Equations	Manually calculate to estimate minable inventory, or strategic mine planning software	Manually calculate to estimate minable inventory (underground project), strategic mine planning software (underground and open pit)	Manually calculate to estimate minable inventory (underground project), strategic mine planning software (underground and open pit)
MINING			
Mining Method	Assumed between open pit and underground	Specific method identified, generic equipment	Method and mine plan finalized, including optimization of SMU and equipment types
Open Pit Mine Plan			
Pit Slopes	Assumed	Preliminary 3D model based on preliminary estimates by rock type and basic geotechnical data	3D model defined by geotechnical data from structural mapping and oriented core holes

Appendix A

Minimum Report Contents for Engineering Studies (continued)			
DESCRIPTION	***Preliminary Economic Assessment (PEA, Scoping Study)***	***Prefeasibility Study (PFS)***	***Feasibility Study (FS)***
Pit Design	Simple LG cone outline of final pit	Preliminary pit design from optimized analysis; preliminary haulroad incorporated, trade-off studies completed	Detailed, optimized pit designs with phases and access for equipment operation
Waste Dumps	Simple outline of final dumps	Preliminary design for total waste tonnage; incremental and final outline of dumps, trade-off studies completed.	Dump sites identified from geotechnical data; final waste tonnages determined with incremental phases, yearly and final dump outlined
Underground Mine Plan			
Underground Mine Plan	Assumed mining system; general outline of mine plan and development	Preliminary mining system identified from geologic and geotechnical data; preliminary outline of mine plan and development including mine access	Specific mining system identified from geologic and geotechnical data; detailed outline of mine plan and development including mine access
All Mining Operations			
Production Schedule	Basic schedule based on assumed mine life	Annual schedule for life of mine of ore and waste tonnages and grade, plant grade, recovery and production. Some sequence optimization, e.g., optimize grade or quality profile.	Detailed schedules with monthly time increments from ramp-up to steady state, then annual thereafter, for life of mine. Should match budget time-line schedule. Mulitple iterations to optimize mining sequence. Report ore / product quality and waste tonnages and grades plus plant recovery and production.
Capital Cost Estimate	Order-of-magnitude, factored or from similar operations	Preliminary equipment list; budget or historical price quotes; some factoring	Detailed equipment list; firm price quotes for all major equipment items; all capital items identified
Operating Cost Estimate	Order-of-magnitude; factored or from similar operations	Quantified estimates for labor, power and consumables; budget or historical price quotes for unit prices; some factoring	Detailed engineering estimate by project area based on quotes and studies
PROCESSING			
Ore Sampling and Test Work	Lab bench scale data and ore characterization data used in combination with plant benchmarking to develop preliminary recovery and throughput	Range of flowsheets with recovery and throughput developed from bench scale testing and often verified with pilot scale work, especially for new processes	Sampling of core for variability testing to identify ranges of throughput and recovery backed up with locked-cycle and/or pilot testing
Process Engineering and Design			
Production Rate and Product(s)	First estimate of production rate and product(s)	Preliminary mining and processing rates and plant product(s)	Fixed mining and processing rates and plant product(s)
Design Basis	Preliminary using factored estimates	General design basis; preliminary engineering drawings; trade-off studies completed	Complete design basis; basic engineering drawings essentially complete

Appendix A

Minimum Report Contents for Engineering Studies (continued)			
DESCRIPTION	**Preliminary Economic Assessment (PEA, Scoping Study)**	**Prefeasibility Study (PFS)**	**Feasibility Study (FS)**
Design Concept	Outline of design criteria and specifications incorporating area/regional climatic conditions	Design criteria established for construction site incorporating known site climatic conditions	Design specifications defined incorporating known site climatic conditions
Tailings Containment	Identify possible sites and capacities	Identify several options and determine the best site or sites	Finalize sites, location; develop geotechnical data for site and for tailings; generate general arrangement drawings and preliminary specifications
Process Description	General	Narrative; 1 to 2% of detail engineering complete	Detailed; 5 to 15% of detail engineering complete
Layout	Approximate geographic locations and site map; no general arrangement drawings	Optimization of facility locations on site map showing topography; simple general arrangement drawings of major equipment items	Exact geographic locations on site map with topography; detailed general arrangement drawings; detailed layout of all facilities
Flow Sheets	Assumed flow sheet from known processes; simple block diagram	Establishment of probable flow sheet from preliminary test work data; major process flow diagrams; initial determinations of material and heat balances.	Detailed flow sheet based on comprehensive beneficiation test program, detailed equipment list; diagrams for all process flows; material and heat balances finalized
Civil Work	Rough topographic maps; no soil conditions considered or quantities estimated	Rough topographic maps; soil conditions report for foundation determinations; basic preliminary quantities	Detailed topographic maps with soil conditions identified for foundation design, loadings and quantities
Equipment Specifications	Major equipment items listed	Preliminary listing of major equipment items with initial sizings and specifications	Complete listing of major equipment items with detailed sizings and specifications
Architectural	None	Sketches	Exterior elevations only
Piping/HVAC	None	Preliminary P&ID	Major P&ID
Electrical Distribution	None	Basic one-line diagram	All design one-line diagram
Motors	None	General description	Detailed list of major items with horsepower
Instrumentation	None	General description	Detailed list of components
INFRASTRUCTURE			
Facilities	General overview with types of support facilities described	All required support facilities identified, sizes and quantities estimated	All necessary support facilities identified, sized and costed
Communications	Communications requirements identified	Communications systems study	Communications licensing and standards known
Power	Overview of power availability and regional unit power costs	Power sources and requirements identified; unit costs obtained from power source	Power requirements and unit costs derived from detailed engineering study; unit costs from quotes
HYDROLOGY			
Water Sources	Estimated using regional data	Preliminary hydrology study	Specific water source identified
Water Usage	Factored plant volume and unit costs	Required plant water volumes and unit costs estimated	Requisite plant volumes and unit costs derived from detailed engineering/geotechnical studies

Appendix A

Minimum Report Contents for Engineering Studies (continued)			
DESCRIPTION	***Preliminary Economic Assessment (PEA, Scoping Study)***	***Prefeasibility Study (PFS)***	***Feasibility Study (FS)***
Dewatering	Dewatering parameters identified	Dewatering parameters estimated	Dewatering parameters confirmed and plan defined
Setting	Preliminary evaluation of project setting for potentially significant environmental and social constraints for site data	Preliminary evaluation of the project's impact on the environment; schedule of environmental and social other permitting requirements; evaluate project setting for potentially significant environmental and social permitting constraints from site data	Characterization of all the project's potential impacts; finalize schedule of environmental and/or other permitting requirements; evaluate project setting for potentially significant environmental and social permitting constraints
Data	Collect and review all available, existing data for environmental and social studies, assessments or audits; regulatory inspections, waste handling practices, management plans, and all applicable laws and regulations; social, training or safety programs identified	Collect and review available data from existing databases for environmental studies, assessments or audits; regulatory inspections, waste handling practices; management plans; and all applicable laws and regulations; plans; initiate baseline data gathering; social, training, and health /safety programs identified	All requisite environmental data for project are identified; site sampling and analyses are complete; detailed review of the type, scope and schedule for producing environmental and social government reports; comprehensive gathering and evaluation of baseline environmental and social conditions; social, training, and health/safety programs confirmed
EIS/EA	None	Draft EIS/EA initiated	Draft EIS/EA submitted to regulatory authorities
Reporting and Plans	Conceptual plans for mitigating any identified environmental issues	Preparation of environmental and social plans and monitoring programs; preliminary sediment and erosion control plan; conceptual closure plan; evaluation of acid rock drainage; geotechnical stability review of waste dumps and tailings dam; preliminary impact mitigation plan; preliminary spill and emergency response plan	Environmental characteristics used in project design; environmental plans and monitoring programs are finalized; sediment and erosion control plan; finalize management plans for tailings and wasterock; management plan finalized for solid and hazardous wastes; finalize impact mitigation plan; geotechnical stability analysis of all major facilities; finalize closure plan; final analysis of acid rock drainage; finalize spill and emergency response plan
Monitoring	Not considered	Outline of a site environmental monitoring plan	Complete environmental monitoring plan
Permit Requirements	General overview	Comprehensive overview and listing of required permits	Detailed evaluation of all pertinent authorizations and permitting requirements and schedule for obtaining operating license
PROJECT DEVELOPMENT SCHEDULE			
Development Plan	Development period and mine life estimated	Development period and overall schedule estimated; mine life determined; development schedule set	Detailed development schedule; mine life known; development schedule finalized

Appendix A

Minimum Report Contents for Engineering Studies (continued)			
DESCRIPTION	***Preliminary Economic Assessment (PEA, Scoping Study)***	***Prefeasibility Study (PFS)***	***Feasibility Study (FS)***
Project Master Schedule	Estimated showing start and end of construction; Gantt bar chart of major work elements	Gantt bar chart with overall time frames; schedule outline for detailed engineering; QA/QC program outlined; preliminary construction schedule; preliminary project execution plan	Gantt bar chart with overall time frames and project flow planning; detailed project level schedule showing project deliverables and detailed engineering; CP schedule; major milestones identified; project control system outlined; QA/QC and safety program finalized; preliminary project procedures manual; project design basis finalized
CAPITAL COST ESTIMATE			
Basis	Order-of-magnitude based historic data or factoring	Estimates from historical factors, percentages and vendor quotes based on materials volumes	Detailed from estimates; engineering 15 to 25% complete; multiple vendor quotes
Civil Structural			
Architectural			
Piping/HVAC			
Electrical			
Instrumentation			
Construction Labor			
Construction Labor Productivity			
Material Volumes/Amounts			
Material/Equipment Pricing			
Infrastructure			
Contractors	Included in unit cost or as a percentage of total cost	Percentage of direct cost by cost area for contractor; historic for subcontractors	Written quotes from contractor and subcontractors
EPCM	Percentage of estimated construction cost	Percentage of detailed construction cost	Calculated estimate from EPC(M) firm
Pricing	FOB mine site including all taxes and duties	FOB mine site including all taxes and duties	FOB mine site including all taxes and duties
Owner's	Historic estimate	Estimate from experience factored for similar project	Estimate prepared from detail zero based budget
Environmental Compliance	Factored from historic experience	Estimate from experience factored for similar project	Estimate prepared from detail zero based budget for design engineering and specific permit requirements
Escalation	Typically not considered	Based on company's current budget percentage	Based by cost area with risk
Working Capital	Factored from historic experience	Estimate from experience factored for similar project	Estimate prepared from detail zero based budget
Accuracy	+/- 50%	+/- 25%	+/- 15%
Contingency	25%	15%	10%
OPERATING COST ESTIMATE			
Basis	Order-of-Magnitude estimate	Estimates for unit rates and quantified estimates with some factoring	Detailed from zero-based budget; minimal factoring

Appendix A

Minimum Report Contents for Engineering Studies (continued)			
DESCRIPTION	***Preliminary Economic Assessment (PEA, Scoping Study)***	***Prefeasibility Study (PFS)***	***Feasibility Study (FS)***
Operating Quantities	General	Quantified by estimates with some factoring	Detailed estimates
Unit Costs	Historic unit costs and factoring	Estimates for labor, power and consumables; some factoring	Letter quotes from vendors; minimal factoring
Accuracy	+/- 35%	+/- 25%	+/- 15%
ECONOMIC EVALUATION			
Financial Analysis	Preliminary assessment of principal economic parameters	Assessment of the principal economic parameters	Full assessment of all principal economic parameters
Marketing and Commodity Price(s)	Industry knowledge and Consensus Pricing	Preliminary market analysis to confirm product placement, quality targets and production constraints. Consensus pricing	Detailed marketing study and consensus pricing or price forecasts
Royalties and Taxes	Preliminary assessment	Preliminary analysis	Detailed analysis with tax authority opinion
Smelting, Refining and Freight	Historic data	Budgetary quotes	Firm quotes
Cash Flow Analysis	Simple cash flow	Preliminary cash flow	Formal, detailed cash flow
Economic Criteria	Simple IRR and NPV (pre- and after-tax)	Preliminary IRR and NPV (pre- and after-tax)	Fully defined IRR, NPV, ROI, and payback period (pre- and after-tax)
Sensitivity Analysis	Basic analysis to minimal amount of project variables	Preliminary to selected key project variables	Numerous analysis to all key project variables
RISK EVALUATION			
Risk Assessment	General overview	Fatal flaw analysis	Risk Workshop. Formal Monte Carlo analysis and fatal flaw analysis
Project	Preliminary overview of geology, engineering, and environmental	Preliminary environmental, country, permitting, technology, and business; detailed geology and engineering	Detailed geology, engineering, environmental, legal, permitting, country, technology, business, and financial

Note 1: Internationally Recognized Standards include:

1. Canadian National Instrument 43-101 and 43-101 CP.
2. Australasian Code for Reporting of Mineral Resources and Ore Reserves - prepared by the Joint Ore Reserve Committed (JORC)
3. U.S. Securities & Exchange Commission Industry Guide 7
4. SME Guide for Reporting Exploration Information, Mineral Resources and Mineral Reserves
5. Environmental aspects should consider applicable local, national and international guidelines including IFC and Equator Principle standards.

RPMGlobal is a consulting and engineering firm serving the international mineral resource industry. Your comments and suggestions are always welcome. Contact RungePincockMinarco •
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Appendix A

