Objectives of Feasibility Studies

By P L McCarthy [1]

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The life cycle of a mining project includes:

- Exploration
- Discovery
- Assessment
- Development
- Production
- Closure

Feasibility studies are required in the pre-production stages to justify the continued investment of money. Usually a scoping study is followed by one or more prefeasibility studies which reflect the increasing level of technical and economic knowledge gained at the various earlier stages. These culminate in a final feasibility study which demonstrates the economic feasibility of the project with sufficient certainty to allow a decision to mine. The level of engineering which has been attained in the feasibility study is usually well short of that required for construction, so a further period of detailed engineering follows. This usually continues during construction and only tapers off when production is imminent.

The first evaluations of the property occur well before the scoping study, and form the basis of a decision to commence exploration. These may involve considering likely costs and revenues for conceptual targets, or sometimes look at the economics of discovering a similar orebody to one which was mined on or near the property in the past. Many times such analyses are not done prior to exploration. This procedure sets minimum targets for grade and tonnages against which the progress of exploration can be reviewed or considered.

If the initial drill intercepts give some indication of potential economic size and grade, the scoping study is carried out to justify further exploration. Exploration including preliminary metallurgical assessment, geotechnical investigations and so on will continue until sufficient data has been gathered to permit a prefeasibility study to be carried out.

The prefeasibility study usually considers a range of mining and processing alternatives and varying production rates. Usually the options are narrowed down to one or two in each area. At this stage it is usually possible to detail the additional work including further definition drilling, metallurgical test work and site investigation which will be needed to support a feasibility study. The results of the prefeasibility study are used to justify expenditure on gathering this additional information and the considerable expenditure needed to carry out the final feasibility study on a substantial project. The final feasibility study provides a basis for a commitment to proceed with project development, detailed design and construction.

While it is convenient to refer to scoping studies, prefeasibility studies, and final feasibility studies, in reality the study process is iterative and several increasingly detailed prefeasibility studies may be undertaken before committing to the final feasibility study. Regardless of the level of study the areas addressed will include:

- geology and resources,
- mining and ore reserves,
- processing and transportation,
- market and price expectations,
- infrastructure,
- the various "soft" implications of location - political risks, skills, recruitment, logistics and environment,
- economic evaluation including consideration of capital and operating costs, revenues, taxes and royalties,
- an assessment of whether the project is sufficiently attractive to proceed to the next stage.

Types of Feasibility Studies

Scoping Studies

A scoping study may be carried out very early in the project life. For example it may be used as a basis for acquiring exploration areas or making a commitment for exploration funding. At this stage the investment risk may be relatively small but it is obviously undesirable to expend further funds on something that has no chance of being economic.

The major risk is that a viable mining project is relinquished due to an inadequate assessment. When it is considered that there is a very low probability of an exploration project proceeding to a mine it is evident that this risk is quite a serious one at the scoping study stage. For this reason it is essential that experienced people are involved in the scoping study. Due to organisational structures, there is a risk that this may be left to exploration departments and geologists who may have only limited expertise in the areas of mining and mineral processing. It should be noted that exploration companies usually employ only geologists.

It is acceptable for scoping studies to be based on very limited information or speculative assumptions in the absence of hard

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data. The study is directed at the potential of the property rather than a conservative view based on limited information.

Prefeasibility Studies

There are three common reasons for carrying out prefeasibility studies as follows:

1) As a basis for committing to a major exploration program following a successful preliminary program. It is possible for commitments of $10 to 20M for ongoing exploration and development to be made on the basis of a prefeasibility study. For example, where reserves cannot be proven by surface drilling a decline may be developed for exploration at an early stage of the project. This happened at Stawell in Victoria, and is planned for Ballarat.

2) To attract a buyer to the project or to attract a joint venture partner or as a basis for a major underwriting to raise the required risk capital. A prefeasibility study may also be prepared in full or in part by potential purchasers as part of the due diligence process.

3) To provide a justification for proceeding to a final feasibility study.

The results of a prefeasibility study may be the first hard project information which is seen by corporate decision makers. There is a risk that the findings are committed to memory so that it becomes difficult to dislodge them with subsequent information. In such cases, the prefeasibility study is the real decision point, with the subsequent feasibility study being seen by management as a necessary step along the path which has already been irrevocably committed.

For these reasons the prefeasibility study must be prepared with great care by experienced people, and its conclusions heavily qualified wherever necessary. Assumptions should be realistic rather than optimistic because it is very difficult to bring management and markets back to reality in the event that the final feasibility study is significantly less favourable.

The main features of the prefeasibility study are;

Mine design based on a resource model.
Best alternative selected from a range of alternatives.

Preliminary studies completed on geotechnical, environmental, and infrastructure requirements.

Bench scale metallurgical tests and preliminary process design completed.

Cost estimates based on factored or comparative prices.

Study accuracy 15% to 25%.

Ready to proceed to final feasibility study.

Final Feasibility Studies

The final feasibility study is usually based on the most attractive alternative for the project as previously determined. The aim of the study is to remove all significant uncertainties and to present the relevant information with back up material in a concise and accessible way. The final feasibility study has three objectives;

1) To demonstrate within a reasonable confidence that the project can be constructed and operated in a technically sound and economically viable manner.

2) To provide a basis for detailed design and construction.

3) To enable the raising of finance for the project from banks or other sources.

Terminology

A range of sometimes conflicting titles are used for studies, including the following;

Scoping study
Class 1 Study
Preliminary Evaluation
"Order-of-Magnitude Estimate"
"Capacity Factor Estimate"
Screening study
Prefeasibility Study

Class 2 Study
Intermediate Economic Study
Preliminary Feasibility Study
"Equipment Factor Estimate"

Final Feasibility Study
Class 3 Study
Bankable Feasibility Study
"Forced Detailed Estimate"

Detailed Engineering Study
Class 4 Study
Project Control Estimate
Definitive Cost Estimate
"Fall-out Detailed Estimate"

Thompson (1993) reports that "he discovered that if 10 people were discussing preliminary engineering or that old standby definitive estimate, there were 10 different opinions" (as to the meaning of these terms). Some of the above terms are not widely used in Australia.

The terminology used in these notes is that usually used by the authors, and we believe it to be widely used in the Australian mining industry.

Accuracy of Feasibility Studies

The probable accuracy achieved by each phase of the study/design process is illustrated in Figure 1. The engineering requirements for each type of study are listed in Table 1 The overall study accuracy cannot readily be calculated, and is usually a matter for judgement based on experience.

Contingency Allowance

The contingency allowance is intended to make provision for:

Items which have not been covered because of oversight.

Unpredictable external changes, such as changes in legislation, taxation and royalties, or provision or discontinuation of external infrastructure services.

Changes arising from a greater knowledge with time, from poor initial appreciation, or simply the limited depth of engineering analysis during the feasibility stage. Examples include more rock in foundations, alternative equipment, bid rates different to assumptions, need for wet explosives, refinement of metallurgical process, design errors, accidents.

The key to the assessment is the manner in which the contingency level is derived. There should be different levels for different considered circumstances for various components of the project. These can then be summed to show the overall contingency allowance.

The discipline of a measured consideration is important. For example, with a firm quote for standard equipment e.g. a truck, little contingency allowance is required. On the other hand there may have been no foundation drilling in which case excavation costs may be more and more concrete will be required. There may also be the effect of subsequent construction being delayed.

There has been a trend recently to estimate the probability of not exceeding the estimate, including the contingency. This can be difficult to justify if the contingency is intended to allow for the unpredictable. The main thing is to convey to the owner a feel for the levels of uncertainties upon which the estimates are based. It might also be possible to account for some of these "contingencies" using risk analysis.

The project manager, in assessing contingencies, needs to guard against the human nature self- interest/self- justification of the engineers undertaking the design and compiling the contingency estimate.

The "Bankable" Study

The meaning of the term bankable will vary depending on when it is used. To the engineers preparing a feasibility study, the term bankable only refers to the technical completeness and the level of detail contained in the report which they are preparing. Their scope of work is usually not broad enough to fully satisfy a bank's requirements. The engineers' feasibility study often stops short of analysing overall project viability or profitability. This analysis and sometimes the marketing component of the study may be carried out by the project sponsor. In this case the technical reports would be considered bankable by the engineers but perhaps not by the bank or the sponsor.

A bank may be satisfied with the technical work and economics sufficient to lend 60% of future development cost where the sponsors are seeking 80%. Despite the accuracy of the engineering, in this case the sponsors have not got what they require of a bankable study. Daley (1990) argues that the term "Bankable" should be avoided by engineers and project sponsors.

From a lender's view point the following information is required:

An Engineering Feasibility Study by an independent engineer of high reputation. Alternatively, where an established resource company has carried out the feasibility study in-house, a review by an independent engineer.

Independently prepared or reviewed ore reserve and resource reports. A bank will usually be prepared to provide a loan facility which can be fully repaid within the period of depletion of the proved ore reserve defined at the time of final feasibility. A mine life (proved and probable reserves) at least twice the projected loan life is usually required.

Final Feasibility Study engineering with capital and operating cost estimates to an accuracy of 10 to 15% including realistic contingency allowances.

A monthly project development plan containing a full description of the project with a detail schedule of planned activities and expenditures in monthly periods until project commissioning. This may be prepared subsequent to the final feasibility study during the loan negotiation.

Identification of risks in the operational phase with sensitivity analyses of likely or possible downsides.

Figure 1 – ***Probable accuracy of each study/design phase***

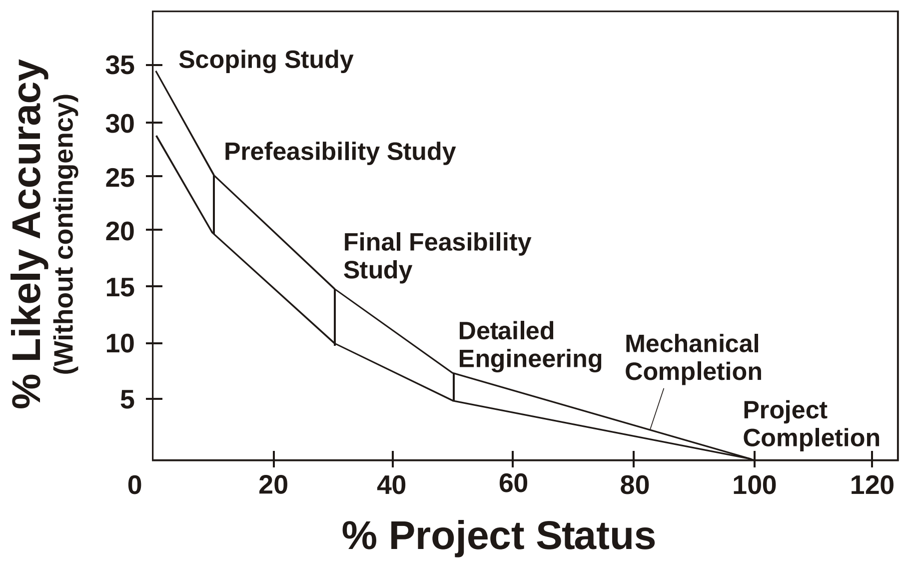

Table 1 – ***Engineering requirements by type of study***
After Thompson 1993

Item	Scoping Study	Preliminary Feasibility Study	Final Feasibility Study	Detailed Design
Site				
Geographical location	Assumed	General	Approximate	Specific
Maps and surveys	None	If Available	Available	Detailed
Soil and Foundations Test	None	None	Preliminary	Final
Site visits by project team	Possibly	Recommended	Essential	Essential
Mining				
Basis for Schedule	Indicated/Inferred Resources	Measured/Indicated Resources	Proven/Probable Reserve	Proven/Probable Reserve
Mining Method	Assumed	Preliminary	Optimised	Finalised
Mining Rate	By Analogy	Preliminary	Optimised by Detailed Scheduling	Finalised
Geotechnical	Assumed	Preliminary	Detailed	Finalised
Equipment Selection	Not Essential	Preliminary	Type and Capacity	Make and Model
Treatment Process				
Process Flowsheets	Assumed	Preliminary	Optimised	Finalised
Bench-scale Tests	If Available	Recommended	Essential	Essential
Pilot Plant Tests	Not Needed	Recommended	Recommended	Essential
Energy and Material Balances	Not Essential	Preliminary	Optimised	Finalised
Facilities Design				
Nature of Facilities	Conceptual	Possible	Probable	Actual
Equipment Selection	Hypothetical	Preliminary	Optimised	Finalised
General Arrangements, Mechanical	Sometimes	Minimum	Preliminary	Complete
General Arrangements, Structural	None	Outline	Outline	Preliminary
General Arrangements, Other	None	None	Single-line	Some Detail
Piping Drawings	None	None	Single-line	Some Detail
Electrical Drawings	None	None	Single-line	Some Detail
Specifications	None	Performance	General/Major Equipment	Detailed
Basis for Capital Cost Estimating				
Estimates Prepared by	Project Staff	Specialist Engineer	Specialist Engineer	Estimators
Quotations From Suppliers	Existing Files	Single Source	Multiple	Competitive
Civil Work	Rough Sketch	Drawing Estimate	Drawing Estimate	Take-offs
Mechanical Work	% of Machinery	% of Machinery	Manhours/Tonne	Manhours/Tonne
Structural Work	Rough Sketch	Preliminary Drawings	Take-off/Tonne	Take-off/Tonne
Piping and Instrumentation	% of Machinery	% of Machinery	Take-off	Take-off
Electrical Work	$ per Kw	$ per Kw	Take-off	Take-off
Indirect Costs	% of Total	% of Total	Calculated	Calculated
Accuracy (Based on Experience)	20-25%	15-20%	15%	10%
Operating Cost Determination				
Labour Costs	Assumed	Investigative	Investigative	Negotiate
On-costs	Assumed	Calculated	Calculated	Calculated
Power Costs	Assumed	Actual	Actual	Contract
Fuel Costs	Assumed	Verbal Quote	Letter Quote	Contract
Consumable Supplies	Assumed	Verbal Quote	Letter Quote	Contract
Reagents	Assumed	Verbal Quote	Letter Quote	Contract
Maintenance Supplies	Assumed	Verbal Quote	Letter Quote	Contract
Economic Analysis	If Meaningful	If Required	Required	If Requested
Use of Estimates	Comparison/ Rejection Preliminary Evaluation	Commitment to Final Feasibility Study	Commitment to Project	Project Control

Working capital requirements.

Production schedules, cost and revenue estimates, quarterly for the first two years, half yearly to the end of year five and annually thereafter.

A market assessment including the depth of market for the product and the commodity price.

A detailed description of the sponsors including;

- previous experience in this type of project,
- experience in the geographical area,
- present operations and their financial performance,
- current management strengths,
- specific form of association of sponsors (joint venture, partnership, etc.).

Environmental considerations, usually involving a full environmental impact study by experienced consultants.

Political considerations, depending on the country concerned.

Analysis of management and employee skills.

A preliminary financing plan showing the major sources of finance including;

- equity contribution from each partner,
- disbursement schedules,
- loans from governmental agencies, international or commercial banks,
- overrun financing,
- completion guarantees and completion test proposal.

Risk categories for a mining project are;

Under Company Control
Operating:
Technical Costs
Resource/reserve assessment
Participant, i.e., joint venture partners
Completion

Outside Company Control
Reserve realisation
Market
Political
Force majeure type risks including strikes, natural disasters and wars
Foreign exchange

Under Bank Control
Syndication
Funding
Ideally a bank or financing/lending institution would like to see a clear and concise review of the project risks associated with any proposed mining project.

When preparing the Feasibility Study it is very useful to have a clear statement from the proposed financiers of what they require. For example, the International Finance Corporation has a 10-page document setting out its requirements.

A brief checklist includes;

industry structure and competition

historical and projected supply- demand curves

consumption outlook

technological changes or potential substitutions,

project competitiveness in relation to operating mines and other proposed developments,

specific marketing advantages or disadvantages including product differentiation.