The Use and Abuse of Feasibility Studies

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ABSTRACT

The development of a resource project inevitably requires the investigation of a vast range of issues across most engineering disciplines – mining, metallurgical, chemical, civil, electrical, mechanical and environmental – as well as the geosciences.

It is also a characteristic feature of the resource industry that no two orebodies – and hence no two development projects – are the same. So these technical issues have to be addressed to a greater or lesser extent in evaluating any resource project's development potential.

Not surprisingly then, technical issues tend to predominate when assessing the development potential of a project in the process typically referred to as 'doing a feasibility study'.

But the principal purpose of a 'feasibility study' is to determine whether a development opportunity makes good business sense, not just whether it is technically possible.

Resolution of technical issues is often seen as the primary focus of a feasibility study, whereas in reality, these technical issues are the basis upon which an asset delivery and business plan is built. This is not to say that technical issues are unimportant – they are a prerequisite to the demonstration of a project's viability.

The feasibility study process must therefore demonstrate that not only have the technical issues been satisfactorily addressed, but also that the broader commercial, economic and social issues have been considered in the development of a comprehensive business plan, which includes an assessment of the risk-reward profile of the proposed development.

This paper will present a framework for the conduct of 'feasibility studies' and provide guidance to minimum standards and best practice.

INTRODUCTION

It is generally accepted that the preparation of a feasibility study is an important element early in the life cycle of a resource development project (eg Laird, 2001; Amos, 2001). It is also widely accepted that the feasibility study process is multi-phased and iterative (eg West, 2006). Typically, initial assessments of the development potential of a resource project are aimed at assessing the project's key technical and economic characteristics, with subsequent assessments designed to confirm assumptions and reduce the uncertainty associated with the development to an acceptable level. References to feasibility studies are often prefaced with 'order of magnitude', 'preliminary', 'indicative', 'pre', 'final', 'bankable', 'definitive', 'detailed' or other terms to indicate the level of detail investigated in a study. Resolution of technical issues is often seen as the primary focus of a feasibility study, whereas in reality, these technical issues are the basis upon which a business plan is built. This is not to say that technical issues are unimportant – they are a prerequisite to the demonstration of a project's viability.

Both the JORC (2004) and the VALMIN (2005) Codes use the term 'feasibility study', though neither Code provides a definition of the term. Some definitions are provided in other Codes of Practice, including:

> *A Feasibility Study assesses in detail the technical soundness and economic viability of a mining project, and serves as the basis for the investment decision and as a bankable document for project financing. The study constitutes an audit of all geological, engineering, environmental, legal and economic information accumulated on the project. Generally, a separate environmental impact study is required* (United Nations, 2004).

> *... 'feasibility study' means a comprehensive study of a deposit in which all geological, engineering, operating, economic and other relevant factors are considered in sufficient detail that it could reasonably serve as the basis for a final decision by a financial institution to finance the development of the deposit for mineral production* (NI 43-101).

However, different people, different organisations and different situations inevitably give rise to different interpretations of what is to be investigated, what level of detail needs to be investigated, and even what is meant by technically feasible and economically viable in the context of a resource project development. Indeed, in the Mindev 97 Conference Proceedings (Barnes, 1997), an editor's note was included in the proceedings that highlighted the differing nomenclature used when referring to 'feasibility studies', cautioned against misunderstandings, and provided a table of 'equivalence of feasibility terminology'.

In ten years, it seems little has changed – it is commonplace in the industry for the term 'feasibility study' to be applied to a range of activities that include back of the envelope analyses, technology reviews, cash flow modelling and detailed project assessments complete with supporting development plans. The ubiquitous 'bankable' studies exhibit an extraordinary range in the extent and depth of the analysis of development issues – 'Bankable Feasibility Study' is perhaps one of the most abused and misleading phrases used in the industry.

This paper presents a framework for the conduct of 'feasibility studies' and provides guidance on minimum standards and best practice that allows consistency in evaluation approach across a wide range of projects. Rather than focus solely on technical issues, cost estimating or cash flow modelling, the framework treats technical feasibility and economic viability as platforms upon which a business plan is developed.

FEASIBILITY STUDY FUNDAMENTALS

All authors on the subject recognise the importance of feasibility studies in the project development cycle. Laird (2001), notes:

> *Ideally a final feasibility study is prepared when by virtue of preliminary evaluations, a project is known to be feasible and concepts are fairly well established.*

> *The feasibility study has one primary goal; to demonstrate that the project is economically viable if it is designed, constructed and operated in accordance with the concepts set forth in the study. Starting from a mineral resource database, the feasibility study will define the Ore Reserves, the mining methods, the mineral processing concepts and the scale of the project. The disciplined activity of developing a feasibility study leads the proponent to examine every aspect of the project, many of which might otherwise be ignored. All technical concepts will*

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be established and the corporate philosophy with respect to organisational structure, social and environmental responsibility, infrastructure contributions and financing will be determined. All the major decisions about how the project will be developed are made during the feasibility study. The success of the project will depend upon the assumptions and decisions in the feasibility study and the ability and empowerment of the development team.

The feasibility study process

The feasibility study process deals with uncertainty, and a phased and iterative study approach has evolved as a consequence. It is common practice for the feasibility study process to involve three phases, namely the conceptual or scoping phase, the preliminary or prefeasibility phase, and the final or definitive phase (eg West, 2006; Appleyard, 2001; Laird, 2001; White, 2001; Noort and Adams, 2006 and Shillabear, 2001), though additional study phases may be recognised during the project development cycle (Maslin, 2003).

Noort and Adams (2006) describe three phases of a study process as:

A scoping (concept) study should be used to define the potential of a project, eliminate those options that are unlikely to become optimal, and determine if there is sufficient opportunity to justify the investment required for further studies.

Prefeasibility studies should be used to select the preferred operating options from the shortlisted options defined by the scoping study and to provide a case for whether or not to commit to the large expenditure and effort involved in a subsequent definitive feasibility study.

Definitive (full) feasibility studies should be used to refine the optimal operating scenario defined by the prefeasibility study. They are often used to assist with outside financing requirements. The definitive feasibility study provides the basis for the decision on whether in fact further study is required, whether the project is worth pursuing or whether to advance the project to design and construction.

The entire study process can require considerable time, effort and funding. For example, BHP Billiton's Ravensthorpe Yabulu Integrated Nickel Project involved the expenditure of US$85 million in studies prior to the decision to proceed with project development, which at the time was estimated to cost US$1400 million. These studies spanned a six year period and included eight months of continuous pilot plant test work and 200 000 engineering man hours (Pointon, 2004). Rio's HISMELT technology was studied for 21 years prior to the commitment to build a commercial plant being taken in late 2002 (HISMELT, 2007).

Table 1 is extracted from a database collected by the authors of nine resource development projects costing in excess of A$200 million. It shows the project type, the estimated project cost (at the time of study completion and exclusive of costs incurred to that stage), the cost of studies undertaken to reach that decision point (exclusive of project acquisition, exploration and resource definition drilling) and the cost of studies as a percentage of the estimated project cost. Notwithstanding the limitations of the small sample size, these data show that for the sample analysed the average project feasibility study cost approximately 2.3 per cent of the total estimated project cost – slightly more for a greenfields project and slightly less for a brownfields project.

The role of feasibility studies in value creation

A key feature of the feasibility study process is that the ability of an owner to influence the outcome of a project is at its peak when the feasibility study process is defining what the project should and will be – yet adequate project definition can be achieved in the study process for only a small fraction of the total project expenditure.

During the study process, alternative project configurations can be studied and decisions made on whether or not to proceed with project development, and if so, what the optimum configuration is. However, once a decision to proceed is made, and design, procurement and construction efforts commence, there is little opportunity to influence the project outcome. This characteristic of the project development cycle as illustrated in Figure 1.

Regardless of where the study phases begin and end or how many phases are recognised, and even regardless of whether a study recommends proceeding to the next stage of the development cycle or not, each study phase creates value for the project owner. This value can arise either directly – by ensuring

TABLE 1

Sample feasibility study costs.

Type		Project estimated cost A$ M	Cost of feasibility study A$ M	Percentage of total cost
Brownfields	Smelter	$197	$4.2	2.1%
Brownfields	OP mine/refinery	$235	$8.7	3.7%
Brownfields	UG mine	$250	$3.0	1.2%
Brownfields	Mine/materials handling	$593	$10.5	1.8%
Brownfields	Smelter	$680	$14.0	2.1%
Greenfields	OP mine/concentrator	$750	$12.9	1.7%
Greenfields	OP mine/refinery/new technology	$750	$23.0	3.1%
Greenfields	OP mine/refinery/new technology	$901	$12.7	1.4%
Greenfields	OP mine/rail/port	$1950	$74.0	3.8%
			Min	1.2%
			Max	3.8%
			Average All Projects	2.3%
			Average Brownfields	2.2%
			Average Greenfields	2.5%

that viable opportunities are identified and developed, and by aiding in the identification of the optimal configuration if a project is developed, or indirectly – by halting or redirecting further effort on a project that is either technically infeasible or economically unviable in its proposed configuration.

It also follows that once a decision to proceed is made, and design, procurement and construction efforts commence, there is little opportunity to create value no matter how good the project execution is. Excellence in project execution is required just to maintain the value opportunity created from a good feasibility study, and excellence in project operation is required to deliver the value. A poorly defined project will not deliver the same outcome as a well defined project no matter how well executed and operated. Little scope exists to add or create value during project execution. This is illustrated in Figure 2.

There is a compelling case for the feasibility study process to be of the highest quality.

The importance of study phases

Having established that a feasibility study requires a multi-phased, iterative evaluation process, that the most influence on project outcome is exerted during the study process, and that the study process needs to be of the highest quality to deliver the maximum value, it is also important to remember that each study phase adds value. Laird (2001) notes:

> *It is critical that the purpose of the study be defined prior to its initiation, particularly when other partnerships or joint venture relationships are involved.*

This should be expanded – the purpose of each study phase must be clearly defined. Essentially, the purpose of each study phase is to answer the following questions:

- Scoping study:
  - What could it be?
  - Does it make sense to pursue this opportunity?
- Prefeasibility study:
  - What should it be?
  - Have I analysed enough alternatives?
  - Have I identified the optimum project configuration?
- Feasibility study:
  - What will it be?
  - What risks will this project involve?
  - What rewards will this project provide?
  - Have I presented an investment case that is unlikely to vary significantly?

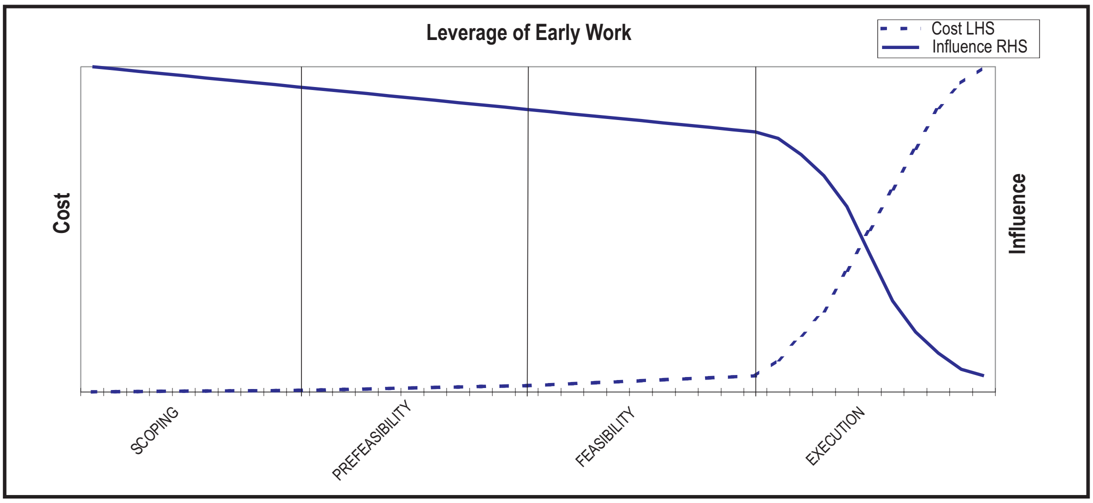

FIG 1 - The leverage of early work.

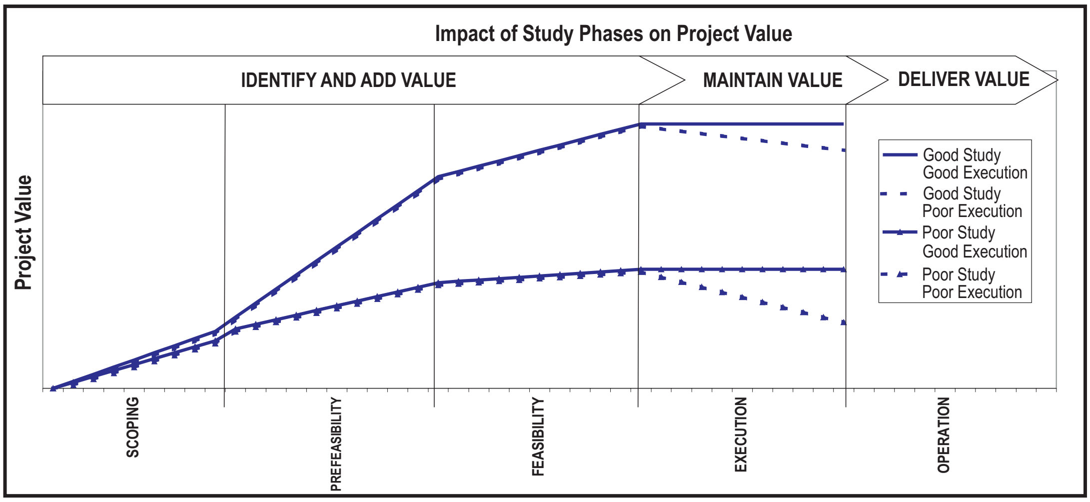

FIG 2 - The ability to create or add value.

In the event that a feasibility study culminates in a decision to proceed with project development, it is important that all of these questions – including those addressed in earlier study phases – be answered to ensure that value is maximised. Unless all study phases are completed, some of these questions will be left unanswered and value may be destroyed through wasted effort or lost opportunity.

INDUSTRY TRACK RECORD

The industry track record for delivering against feasibility study expectations is not good. Lawrance (1997) reports that:

> *There is strong evidence that, at least for major projects, there is an unwelcome record of failure* (Morris and Hough, 1986, p 5). *The World Bank (1978) lists 109 operations of which a quarter had cost overruns of 25 per cent or more, one-tenth had cost overruns of 50 per cent or more. Approximately half had time overruns of 25 per cent or more and approximately one-third had time and cost overruns of 50 per cent or more.*

Gypton (2002) reports that from a sample of 60 projects developed in North, Central and South America since 1980, the average cost overrun was 22 per cent, with only 40 per cent projects costing within ±15 per cent of the feasibility study estimate.

It would seem things have not got any better over time, although Gypton does note that:

> *Published comparisons of expectations (feasibility) versus actual performance … are almost non-existent. Feasibility study shortcomings are a sensitive subject at the very least, and in most cases, the operator is more interested in running a mine, not analysing what happened and why.*

But given that a feasibility study is about the delivery of a business plan, not just construction of a mine, process plant and infrastructure, project construction cost is but one measure of business success. Construction schedule, ramp-up time, product quality, product output, operating cost, safety and environmental outcomes are all key measures of business success for a resource development project, and published information on these measures of project success is also virtually non-existent.

Little information is available on the attainment of expected construction schedule, but the proliferation of public company reports that include the phrase 'on revised schedule' or the like indicates that project delays are not uncommon.

In relation to commissioning and ramp-up time, Nice (2002) contrasts the ramp-up of seven Australian projects with project ramp-up studies by other authors in 1979 and 1998 and concludes the most likely outcome for a process plant is that it will take 24 months to achieve name-plate capacity, and that this has been the case for the last 30 to 40 years. In the authors' experience, very few project owners allow such a ramp-up period in the financial modelling of their project, and generally argue that their project is different because times have changed, their project is simple, uses well known technology, has been done before, or some other excuse – they are usually disappointed

For other measures of project success, McCarthy (2004) provides a summary of overall project performance against expectations for 56 Australasian gold projects over a 15 year period from 1988-89. He concluded:

> *It is reasonable to conclude that about half of gold mining projects perform more or less as expected, and that stakeholder expectations will be met. About one quarter of projects will fail prematurely, usually under adverse financial circumstances, often involving extended litigation, administration or receivership. These projects have the potential to leave adverse environmental and community legacies and to reflect badly on the industry as a whole. A further quarter of projects will perform substantially better than the owner's expectations in terms of size or mine life. Different stakeholders will have different views on whether this is a good thing.*

Both the Gypton (2002) and McCarthy (2004) studies indicate that only about half of projects meet expectations – be that of cost and time to build the project or be that overall business outcome. With a rather fatalistic outlook, Gypton concludes:

> *… we need to acknowledge the fact that feasibility studies, and their estimates, are flawed documents by necessity. We should be prepared to test the economics of our projects at capital levels of say +20-25 per cent over the base estimate, including the contingency, and honestly ask ourselves if the project can withstand this risk.*

Whilst not disputing that a wider range of outcomes should be considered when testing the financial returns of a project, this approach will increase the number of false negative outcomes – it will kill off projects that may well be viable. This demands a better approach to study management and execution.

STUDY MANAGEMENT AND EXECUTION

In an analysis of the poor performance, both Gypton (2002) and Vancas (2002) list failure of owners' project management as a root cause. Gypton also notes:

> *Given the site-specific and intermittent nature of mine development, there is not a workable, detailed standard for the minimum level of definition required for a final feasibility study.*

The authors argue that improving the quality and definition of feasibility studies by the project owner is a key element – along with excellence in project execution and operation – in unlocking the value of a mineral resource

Since 1988, Enthalpy Pty Ltd (Enthalpy) has specialised in the provision of owners project management services, and from this experience, has developed a Capital Investment System (CIS) that has been used by major mining houses and government bodies both in Australia and offshore. The CIS consists of Policies, Process Manuals, Minimum Standards and Toolkits for the assessment and development of new business opportunities in the resource sector. Elements of the CIS have been licensed to Independent Engineers (Australia) Pty Ltd ('IEA'), which, since 2001, has been providing independent advice and opinions to project owners and financiers using the Enthalpy CIS as a benchmark.

A key outcome from the CIS is the development of a consistent approach to the scoping and conduct of feasibility studies. This is described below.

Project development and study framework

In scoping, managing, implementing and reviewing investment opportunities in a range of environments over the last 20 years, the authors have developed and refined the framework illustrated in Figure 3 for the project development lifecycle.

This framework incorporates three study phases together with the implementation and start-up, operation and closure and decommissioning phases of a project. Under this framework:

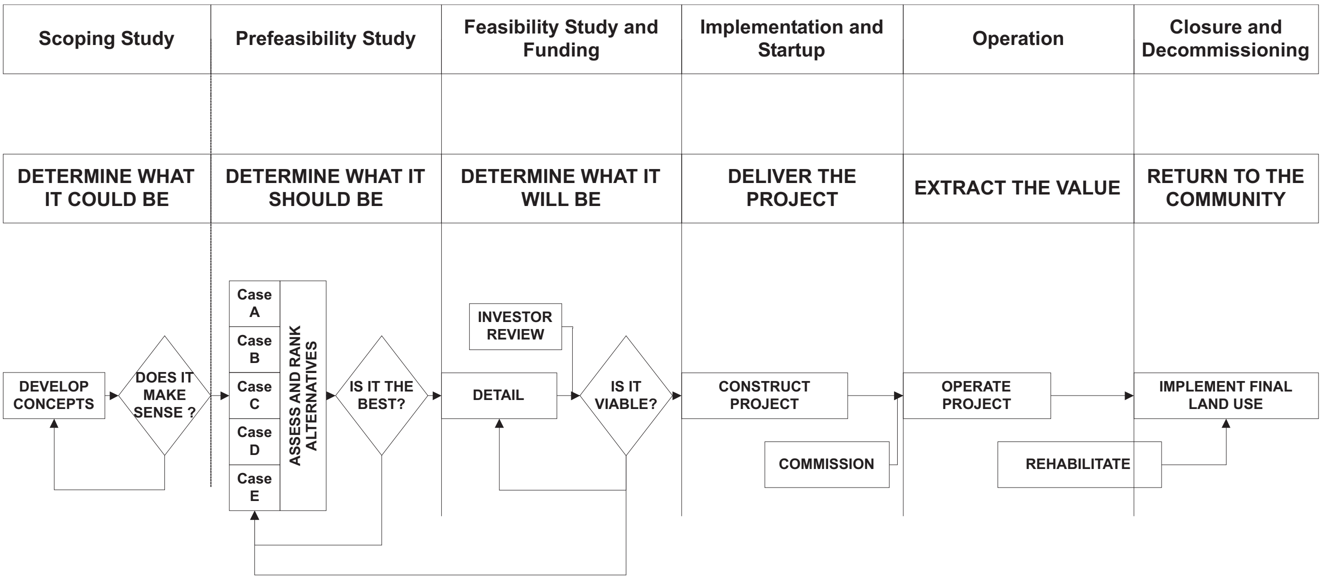

FIG 3 - The project development framework.

Scoping studies are typically undertaken during project generation or exploration and structured to:

- assess the potential of the new or expanded business opportunity;
- describe the general features of the opportunity including potential cases to be studied in the next phase;
- determine key business drivers for the opportunity and any potential fatal flaws;
- develop order of magnitude costs of the opportunity (both capital and operating);
- identify technical issues needing further investigation, such as geological drilling or test work required;
- determine the costs and time to undertake further development work to complete a prefeasibility study;
- identify the resources, personnel and services required to undertake further work on the opportunity; and
- provide a comprehensive report with supporting appendices that includes a recommendation to proceed or otherwise.

Prefeasibility studies are typically undertaken after the delineation of a mineral resource and structured to:

- assess the likely technical and economic viability of the opportunity;
- consider different mining, process, location and project configuration cases;
- consider different capacities for the project;
- determine and recommend the preferred optimum case to be examined during the feasibility study;
- outline the features of the recommended project;
- determine key business drivers for the opportunity and examine any potential fatal flaws;
- determine the risk profile of the opportunity;
- determine the nature and extent of the further geological, mining, metallurgical, environmental, marketing or other work needed to be undertaken during the feasibility study;
- determine the costs and time to undertake this work and prepare a feasibility study, including an estimate of the costs and time to develop the project following completion of the feasibility study;
- identify the resources, personnel and services required to undertake further work on the opportunity; and
- provide a comprehensive report with supporting appendices that includes a recommendation to proceed or otherwise.

Feasibility studies are typically undertaken after detailed data gathering of all material information relevant to the project development structured to:

- demonstrate the technical and economic viability of a business opportunity based on the proposed project;
- develop only one project configuration and investment case and define the scope, quality, cost and time of the proposed project;
- demonstrate that the project scope has been fully optimised to ensure the most efficient and productive use of the mineral resource, capital and human resources applied to the project;
- establish the risk profile and the uncertainties associated with this risk profile and develop mitigation strategies to reduce the likelihood of significant changes in the project assessment as set out in the feasibility study;
- plan the implementation phase of the proposed project to provide a baseline for management, control, monitoring and reporting of the project implementation and establish a management plan for the operations phase;
- facilitate the procurement of sufficient funds to develop the project in a timely manner; and
- provide a comprehensive report with supporting appendices that includes a clear recommendation to proceed with the investment or otherwise.

Minimum standards for the content and quality of each of the study phases have been established, which will be described later.

The framework recognises that the feasibility study process is iterative, and indeed any phase of a study may quite correctly recommend that the project be abandoned, shelved or reassessed. Whilst this may seem obvious, it is often difficult for a study team to reach such a conclusion after spending considerable time, effort and resources on the study. Accordingly, studies often do not progress smoothly through the study phases.

The framework provides clear decision points after the completion of each phase, though in practice, a decision to reassess a project or abandon a study can be made at any time.

However, under the framework, the rationale for this decision must be clearly reported and stored along with all project data, interpretations and reports. This will provide a valuable repository of project information in the event that circumstances change – projects that were previously assessed as not feasible can become feasible through, for example, ongoing exploration success, changes in technology, changes in markets, or the availability of infrastructure.

The framework also specifically incorporates the overlap of the following activities across project phases:

- the funding or financial closure activities commence before the completion of the feasibility study, but continue after the feasibility study is completed;
- the commissioning activities overlap with the construction and operation phases; and
- the rehabilitation activities overlap with the operation and the closure phases.

Of these, the commencement of financial closure activities well before the completion of the feasibility study is particularly important as financial closure can take a considerable time (particularly in the case of non-recourse project debt funding), and feasibility studies have a limited shelf life due to the need to refresh cost estimates and changes in economic or regulatory circumstances.

Bankability

The framework deliberately avoids the use of the term 'bankable feasibility study'. Guanera (1997) notes:

> *The definition of a bankable document is theoretically:*
>
> *A document which outlines the technical risks inherent in a mining project, delineates methods of eliminating those risks, and quantifies the potential economic returns that can be attained at various commodity prices.*
>
> *The bank itself will ultimately define what is required in a document that it will utilise to justify financing a mining project, so realistically, one could say that there is no such thing as a bankable document.*

Johnson and McCarthy (2001) continue this line and argue for the use of the term 'Bank-Approved' as opposed to 'Bankable':

> *The term 'bankable' feasibility study initially seems to have an added ring of veracity over the more mundane phrase 'feasibility study'. Adding 'bankability', after all, seems to imply that the study is like money a party can take to the bank. Unfortunately, the term is misleading … At the very least the knowledgeable lender, experienced in lending to mineral projects, will require that its own consultants and internal research departments review the study. The lender often then requires the parties to augment the study as support for the lending request. One can argue in good faith, then, that there really is no such thing as a 'bankable feasibility study' except after the selected financing lender prepares or approves one. In short, it would be far less misleading if the term were 'Bank-Approved' Feasibility Study.*

Guarnera (1997) notes:

> *Whether it is a financial institution that is considering financing a mining project or a mining company going to a financial institution for capital to finance their project, there are four general areas of risks involved in the analysis of a mining project:*
>
> - *bank risk,*
> - *country risk,*
> - *company risk, and*
> - *project risk.*

Given that the first three risk areas are difficult for a project owner to address, the focus of the minimum standards is on addressing project risk. Rather than attempt to define 'bankability', the authors have developed a set of criteria in Table 2 that a feasibility study should achieve to facilitate the procurement of bank debt. The minimum standards for the feasibility phase incorporate these characteristics.

Minimum study standards – content

Many authors provide some guidance as to the topics to be addressed during the study process (eg White, 2001; Noort and Adams, 2006; Amos, 2001; Kuestermeyer, 2002). Table 1 of the JORC Code also provides guidance on the criteria to be considered when assessing technical feasibility and economic viability, and the VALMIN Code lists issues to be considered when preparing an independent technical assessment or valuation.

Most authors note that the topics to be addressed in a feasibility study are project specific, but these can generally be categorised as either 'technical' or 'economic'. In the authors' experience, the early study phases tend to focus primarily on technical issues such as the resource, the metallurgical response,

TABLE 2

Study requirements for procurement of debt funding.

Characteristic	Required standard
Project configuration	The configuration of the project can be described and detailed in a unique manner and on a stand alone basis in regards to resource, process technology, scope, quality, cost and time parameters.
Project optimisation	To have reached a stage where all technical and commercial aspects have been optimised and defined.
Project variation	Parameters are unlikely to be varied materially following authorisation to proceed and commit funds to the project.
Study traceability	All aspects of the study report are capable of being tracked to a series of validated criteria and values, which are based on the appropriate level of representative test work, calculations and professional judgement which are acceptable to competent professional specialists.
Project control baseline	Budget and schedule are sufficiently detailed for use as a control base line for management of the project.
Study audits	Able to be audited and reviewed by lender's Independent Engineers and a full sign-off obtained.
Risk assessment	Sufficient to allow the project equity and debt providers to assess and allocate the risks of implementing and operating the project.
Financial model	Able to provide inputs to and be referenced in loan agreement documentation as required by debt providers.

the flow sheet, the mine design, the availability of water, waste dumps, tailings storage and environmental baselines. As studies progress, further site investigation and test work provides increasing confidence in the technical issues, allowing greater accuracy in costing and more sophisticated cash flow models to be prepared. Additional topics such as construction planning, infrastructure availability and permitting often appear in later study phases to support the required levels of accuracy. Less often, final phase feasibility studies include detailed execution and commissioning plans to provide even greater confidence in the working capital and cash flow requirements.

Although this approach to topic selection can result in reliable and valid recommendations being developed, it is our opinion that this approach is flawed for two reasons. Firstly, the failure to adopt a consistent table of contents for each study phase creates the potential for key issues to be either overlooked in early phases or forgotten in later phases. Secondly, it ignores or trivialises issues best categorised as 'business issues' such as competitor analysis, corporate capability (financial, managerial, technical and personnel), strategic fit and project rationale that are relevant to the deliberations on whether to proceed to the next phase or not.

Accordingly, a key feature of the CIS is the adoption of a comprehensive standard table of contents, to be applied across all study phases, which is presented in Table 3.

TABLE 3

Feasibility study table of contents.

Section No	Topic
1	Summary and recommendations
2	Development approach and rationale
3	Risk
4	Health and safety
5	Environment and community
6	Geology and mineral resource
7	Mining and ore reserve
8	Mineral processing
9	Product logistics
10	Waste management
11	Infrastructure
12	Human resources
13	Information technology
14	Project execution
15	Project operation
16	External relations
17	Capital costs
18	Operating costs
19	Product sales and revenue
20	Ownership and legal
21	Commercial
22	Financial analysis
23	Funding
24	Status of studies
25	Future work plan
26	Appendices

The inclusion in this table of contents of topics such as development approach and rationale, risk, human resources information technology, commercial and funding under the category of 'business issues' is an important addition to those in the usual technical and economic categories. This ensures that a study report, regardless of the study phase, includes analysis of all issues relevant to the proper consideration of a request for funding – be that funding for further studies or funding for actual project development. In addition, the adoption of a consistent table of contents for each study phase not only ensures a comprehensive assessment, but also assists with the capture and storage of project information, facilitates independent project reviews, minimises unnecessary duplication of work and eases the progression between study phases.

Minimum study standards – quality

Again, many authors provide guidance as to the level of accuracy for each study phase of a feasibility study (eg White, 2001; Cusworth, 1993). Indeed, most engineering firms have in-house standards (eg McCarthy, 2006; Kuestermeyer, 2002). However, Gypton (2002) notes:

> *The major EPCM firms have produced various guidelines, but these documents invariably are heavily influenced by the Chemical Process Industry, which has substantially different capital cost drivers.*

The CIS addresses this deficiency by expanding the standards applicable to each study phase to include standards for the 'business issues', not just the technical issues. It should also be emphasised that under the study framework, the progression from phase to phase of the study process does not involve a steady progression of each element of the study table of contents – the importance and effort applied to each study element changes from phase to phase. Technical issues should largely have been addressed during scoping and prefeasibility study phases to ensure that the optimum project configuration has been identified and is being defined in the feasibility phase. Conversely, there is little point in developing a detailed project execution or funding plan during the early study phases. This is shown in Figure 4.

Examples of the minimum standards illustrating these differences in progression of definition are:

- Table 4 Hydrogeology – essentially completed at the completion of the prefeasibility phase, and
- Table 5 Funding – only cursory review in scoping and prefeasibility phase, but detailed review in feasibility phase.

Minimum study standards – deliverables

The CIS provides minimum standards not only for content and quality of the study, but also for the deliverables from each study phase. Whilst it goes without saying that each element of the table of contents must be written up and consolidated into a report, which usually includes supporting appendices, the framework and minimum standards recognise that, in the event that a recommendation to proceed to the next phase of the project development cycle is made, then a key deliverable is a work plan for that subsequent phase. The standards to be achieved from the three study phases are provided in Table 6.

Minimum study standards – policy

The CIS includes policy governing the conduct of feasibility studies that mandates the adoption of the minimum standards for all study phases. These policies recognise the conflicts between the need for consistency in approach to feasibility studies, yet the flexibility to address the inevitable project specific issues by referring to the standards as minimum standards, and study managers are obligated to adopt a flexible approach such that any value improvement or risk reduction opportunities not specifically covered by the minimum standards are investigated.

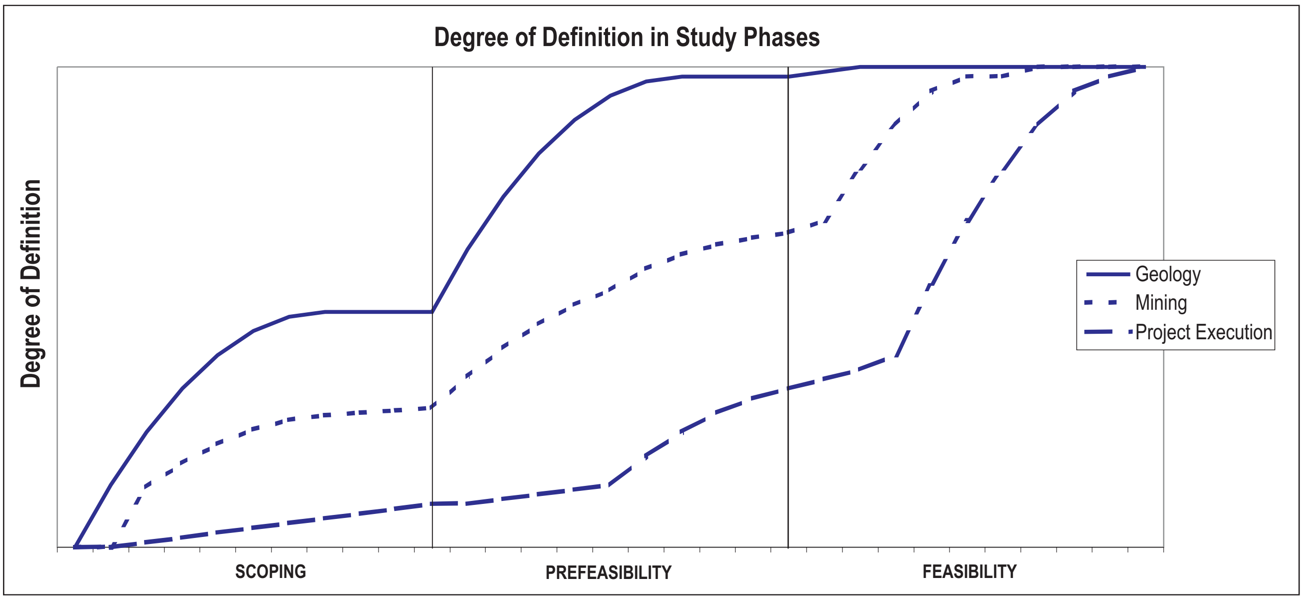

FIG 4 - The degree of definition in study phases.

TABLE 4

Study phase standards for hydrology.

Scoping study	Prefeasibility study	Feasibility study
Describe: The potential deposit groundwater regime(s) and any implications for mining. The likely project water demand (potable and process). The potential for suitable quantities and quality of groundwater (if necessary) to be available to support project development.	Describe: The groundwater regime existing within the deposit, including a description of aquifers and aquicludes, water levels, porosity and permeabilities and pore pressures, with specific mention of the likely impact on mining, with reference to: • test work; • groundwater modelling; • water quality; and • groundwater management program during construction and operation, including expected inflows, dewatering bore design (if required) and pumping rates. Provide a detailed assessment of the project groundwater requirements (potable and process) including an integrated site-wide water balance. If the project requires a water supply to be provided via a borefield, then describe: • the proposed means required and the test work that has been carried out to define the extent and rate at which the water can be supplied and its quality, • description of the proposed supply method (including capital and operating cost estimates conforming with the requirements of Sections 17 and 18); • numerical modelling of the water supply operation; and • ongoing monitoring requirements with costs associated.	Describe: The groundwater regime existing within the deposit, including a description of aquifers and aquicludes, water levels, porosity and permeabilities and pore pressures, with specific mention of the likely impact on mining, with reference to: • test work; • groundwater modelling; • water quality; and • groundwater management program during construction and operation, including expected inflows, dewatering bore design (if required) and pumping rates. Provide a detailed assessment of the project groundwater requirements (potable and process) including an integrated site-wide water balance. If the project requires a water supply to be provided via a borefield, then describe: • the proposed means required and the test work that has been carried out to define the extent and rate at which the water can be supplied and its quality, • description of the proposed supply method (including capital and operating cost estimates conforming with the requirements of Sections 17 and 18); • numerical modelling of the water supply operation; and • ongoing monitoring requirements with costs associated. Note: The availability of sufficient water to meet the project's needs must be confirmed together with confirmation that water abstraction permits will be available.

TABLE 5

Study phase standards for funding.

Scoping study	Prefeasibility study	Feasibility study
Funding: *Sources* An outline only of the potential source of funding for: • ongoing work, and • project development. *Structures* • Present the range of funding structures potentially available and discuss the cost and schedule ramifications.	Funding: *Sources* An outline only of the potential source of funding for: • ongoing work, and • project development. *Structures* • Report on the preliminary appraisal of the alternative funding structures undertaken. Make a recommendation as to the form and nature of sources and funding. • Identify the Independent Engineer qualified to advise lenders and acceptable to both parties and the status of any reviews.	Funding: Discuss: • the debt/equity mix, sources of finance, costs, choices of financiers, and the structure (recourse, non-recourse, etc); • the detailed terms of financing offers received and the status of any technical, legal or commercial due diligence by financiers; and • the risk management/allocation issues (including country assessment and mitigation measures). Evaluate risks and discuss risk allocation strategy. Report on the status of the Independent Engineer's latest project review. *Project funding support* • The type and size of completion support should be identified with reference to insurance support, contractual terms and the contracting strategy. • Any guarantees needed to ensure the financing structures can be used, should be noted. Any warranties to be obtained from technology supplies, engineers or equipment supplies should be outlined and the values quantified. • Describe guarantees and support required from the Company and external parties (eg parent company debt guarantee, off-take guarantee or price guarantee). Describe the issues that are or are likely to be conditions precedent to drawdown and the achievability and status of these CPs.

On the other hand, the policy mandates that a statement of compliance with the minimum standards be provided in each study phase report, and if any of the requirements of the minimum standards cannot be satisfied, or do not apply to the investment opportunity being studied, then the reasons for or justification of the non-conformance must be clearly and explicitly stated.

Minimum study standards – independent reviews

An essential element of the CIS is the declaration of review points in the project development cycle. During the study phase, these review points are set near the end of the prefeasibility and feasibility study phases such that the study phase work is complete and the study report in near final draft stage. These reviews are termed Independent Peer Reviews ('IPR') in recognition of the following principles:

- independent – implies previously uninvolved, impartial, unbiased and unaffected by the outcome of the review;
- peer – signifies a person who has the necessary experience and qualifications to be considered as an equal or better by the study team leaders and therefore qualified to opine on the study; and
- review – means providing a definitive, clear opinion on the study in relation to the standard achieved and must not involve rewriting the deliverables.

An IPR should focus on consistency between study areas and disciplines, key value drivers and key risks. The reviewer should be cognisant of the need to distinguish between matters of fact and matters of opinion. The reviewer and the study manager must agree on matters of fact, but may agree or disagree on matters of opinion. To illustrate this important distinction, an example from the authors' experience is as follows.

Statement of fact:

> *The Proponent initiated a schedule review in May 2006. The major outcome from this review was the recognition by the Proponent and the EPCM Contractor that schedule slippage was occurring and the target date for first gold pour of 5 October was not achievable. The project was rescheduled (Rev F) and the forecast date for completion of the project (defined as the completion of construction, commissioning and handover to operations of the last of the process plant facilities) was 15 March 2007.*

Statement of opinion:

> *The IPR Team is of the opinion that the revised schedule for completion of the project by mid-march 2007 is achievable, though it is an aggressive schedule with little if any float and multiple critical path items.*

TABLE 6

Study phase standards for future work programs.

Scoping study	Prefeasibility study	Feasibility study
Provide a future Work Plan (ie up to the point of commitment to a prefeasibility study) that includes a description of the following. *Scope and objectives* Define the scope and objectives for a project prefeasibility study (PFS), including: • declare the base and alternative cases to be considered, • declare technical issues requiring further investigation, and • identify test work to be undertaken. *Approach* Declare the execution strategy for the PFS, including: • minimum standards for the PFS Report, • resources required and organisation structure, • key personnel, and • key performance indicators for the PFS. *Cost and schedule* Provide an estimate of cost and schedule to undertake the PFS, including: • budget based on scope statement breakdown, • schedule (Level 2), and • key milestones.	Provide a future Work Plan (ie up to the point of commitment to a feasibility study) that includes a description of the following. *Scope and objectives* Define the scope and objectives for a project feasibility study, including: • declare preferred case to be considered in the feasibility study; • declare the scope of the preferred case for the project; • declare technical issues requiring further investigation; • identify test work to be undertaken; and • key technical or commercial issues, which must be overcome to prevent the feasibility study activities from being curtailed, suspended or terminated. *Approach* Declare the execution strategy for the feasibility study, including: • minimum standards for the feasibility study report, • procedures and systems to be employed, • reporting requirements, • contents of the study report, • the development of documentation or any data room, • resources required and organisation structure, • key personnel, and • key performance indicators for the feasibility study. The approach to the feasibility study will incorporate phases consisting of: • activities needing to be completed prior to commitment of the feasibility study; • feasibility study activities planned; and • any post feasibility study, but pre-project commitment activities. *Cost and schedule* Provide an estimate of cost and schedule to undertake the feasibility study, including: • budget based on scope statement breakdown, • schedule (Level 2), and • key milestones.	In addition to a detailed Project Execution Plan (see Section 14), provide an Early Works Plan for the period from completion of the feasibility study through to project approval that includes a description of the following. *Scope and objectives* Define the scope and objectives for the project: • declare the scope of the preferred case for the project; and • key technical or commercial issues, which must be overcome to prevent the project implementation activities from being curtailed, suspended or terminated. *Approach* The Early Works Plan will incorporate activities to be completed prior to commitment of the project (eg community liaison, contract negotiation, owners team set-up, land acquisition, early site works, long lead item procurement, preliminary engineering, training, etc). Declare the execution strategy for the project Early Works Program, including: • conditions precedent to board approval, • procedures and systems to be employed, • reporting requirements, • resources required and organisation structure, • key personnel, and • key performance indicators. Where third party funding is required for the project, the Early Works Plan will also cover financial closure activities necessary to procure third party funding for the project, including where necessary satisfaction of the conditions precedent to such third party funding. *Cost and schedule* Provide an estimate of cost and schedule to undertake the Early Works program, including: • budget based on scope statement breakdown, • schedule (Level 2), and • key milestones.

The reviewer and the study manager must agree on matters of fact, but may agree or disagree on matters of opinion.

A cautionary note and lessons learned

Gypton (2002) pragmatically notes:

> *Private industry simply cannot afford to study a project to a point of 'absolute certainty.' Good judgment will always be required for project evaluations, and sometimes, you have to make a decision based on data that is known to be incomplete, and live with it.*

Whilst adoption of the recommended approach to study management and execution can not and will not guarantee a project's success, the authors believe that the recommended approach will improve the chances of identifying the optimum project configuration that maximises the project value for a given risk profile, at the same time as reducing the chance of incorrectly classifying a project as unviable. Benefits arising from the recommended approach are that:

- studies are comprehensive,
- studies are fit for purpose,
- studies and terminology are consistent,
- studies address the needs of all stakeholders, and
- the study purpose and standards to be achieved can be clearly communicated to all study contributors at the outset.

There is a considerable body of literature relating to the pitfalls and perils of pertinent project development issues such as resource estimation, cost estimation and construction management. Shortcomings in these areas undoubtedly contribute to many project failures, but inevitably, the root cause of the failure of some projects is the failure of the study process itself. As Gypton notes, good judgement will always be necessary during project evaluations; however, from the authors' experience, factors that contribute to the failure of studies, and lessons learned include:

- failure to progress through the study phases – which can lead to suboptimal project development, proliferation of scope change during execution, wasted effort on a flawed business concept, or at worst failure to recognise fatal flaws until it's too late;
- failure to integrate study disciplines – having study contributors operating in isolation can lead to failure to identify fatal flaws or material issues, which in turn can lead to incorrect risk assessment;
- failure to challenge and validate the study outcomes with an outsider's eyes – which can lead to an unhealthy emotional attachment to a project and poor judgement;
- failure to plan for the next study phase – which can lead to inappropriate budget or schedule expectations;
- failure to recycle through study phases – which can arise when broad economic circumstances change or additional options are identified during the feasibility phase, which require a reassessment of the optimal project configuration;
- failure to fix study scope – which can lead to interminable analysis of alternative project configurations; and
- failure to involve all stakeholders – which can lead to project delays or late scope changes as their requirements are addressed.

Finally and probably the most important lesson to learn is the importance of maintaining perspective and exercising good judgement during the study process – it is always better to be approximately right than precisely wrong.

STUDY USES AND ABUSES

Thus far, this paper has presented some study fundamentals, the industry's poor track record for delivering against study expectations and a comprehensive study management system and approach aimed at improving on this track record. The rationale for undertaking studies and the benefits that a good study process can bring should be obvious, and whilst each study phase has a different purpose, if the final study phase is reached, a feasibility study should ultimately be used to:

- demonstrate the technical and economic viability of a business opportunity based on the proposed project,
- demonstrate that the project scope has been fully optimised,
- establish the risk profile of the project,
- facilitate the procurement of sufficient funds to develop the project in a timely manner, and
- support a recommendation to proceed with the investment or otherwise.

But how can a study be abused? Aside from deliberately fraudulent or misleading use of feasibility studies, the most common abuse of studies arises from a misunderstanding of the study phases and their respective purposes. This abuse of the study process may be a contributing factor in the relatively poor correlation between study expectations and project outcomes.

By way of illustration, one needs to look no further than the case of a public company that lodged a prospectus in late 2004 to raise $5.5 million, ostensibly for the exploration and development of a resource project in Western Australia. Included in the prospectus were the following statements:

- a full feasibility has been completed for Stage 1 based on a five year plan, with all the key processing features costed;
- the maximum capital requirements for this stage of the project has been budgeted at A$14.5 million; and
- production start-up before end of 2005.

So far, so good. But further in the prospectus, the following statement appears:

> *However, there are number of milestones for the company in achieving development of the … project:*
>
> *the resource needs to be upgraded to minable reserve status, a short infill drilling program (approximately 2000 m at an estimated cost of $650 000) needs to be undertaken to complete a mine plan to allow production to commence;*
>
> *secure mining license and environmental approval for an open cut operation (estimated to take between four to six months);*
>
> *undertake bulk testing to assist geological modelling of resource;*
>
> *develop open cut mine plan model; and*
>
> *undertake metallurgical test work program.*

A supplementary prospectus was subsequently issued to amend, supplement and clarify the disclosures made in the prospectus, but it is apparent that the company's understanding of the term 'full feasibility' differs markedly from a 'feasibility study' that complies with the minimum standards outlined above.

The project did eventually get into production in early 2007 at a reported cost of $41 million plus working capital, but it is clear that if not for the dramatic rise in commodity prices, the actual value of the project, whose scope is essentially unchanged but which came in 12 months late and at a cost 280 per cent over the prospectus forecast, would be substantially less than the project outlined in the prospectus.

The failure to understand the purpose of early phase feasibility studies, coupled with the failure to undertake studies that are fit for purpose represents an abuse of the study process. This can lead to the creation of unrealistic and unachievable expectations of project outcomes by all project stakeholders.

CONCLUSION

In the authors' experience, feasibility studies:

- are regularly portrayed as being much more comprehensive and accurate than they are,
- are often not fit for their intended purpose, and
- tend to focus on technical issues at the expense of critical business and project delivery issues.

The poor track record of the industry – which indicates only half of projects meet their feasibility study expectations – demands a better approach to the feasibility study process. This paper set out to present:

- a case for improvements in the study process;
- a framework for the conduct of feasibility studies; and
- guidance on minimum standards and best practice to provide consistent, fit for purpose project evaluations.

The authors hope that a compelling case for improvements in study standards, management and execution has been made.

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