be used, then consideration should also be given to the use of long term average exchange rates.

The following is an outline of several methods that a QP can use when selecting a commodity price:

- Current commodity price.

The use of current commodity prices presents a number of positives and negatives. In terms of positives, the estimate describes the company Mineral Resources and Mineral Reserves on the day of the report and it is a clear, concise and transparent method of determining the price. In terms of negatives, at the peak of the commodity cycle, use of current prices will tend to overstate the long term value of a company's Mineral Resources and Mineral Reserves and at the trough of the commodity cycle, it will tend to understate the long term value of a company's Mineral Resources and Mineral Reserves. Also, using current commodity prices could require significant annual adjustments to a company's Mineral Resource and Mineral Reserve base in periods of high price volatility.

- Three-year moving average – US Securities and Exchange Commission (SEC) guideline

The use of three year trailing average prices will remove some of the volatility when compared to using current prices; however, in a rising market this method understates Mineral Resources and Mineral Reserves, and in a falling market it overstates Mineral Resources and Mineral Reserves. In periods of rapid metal price changes, the differences may be significant.

- Long term historical averages (10 to 20 years)

Use of long term historical prices should remove the annual price volatility from a company's Mineral Resource and Mineral Reserve estimates and reporting but it can lead to material deviation in asset value when benchmarked against current price.

- Margin over Cash Cost of Production

Commodity prices have a relationship to cash costs and the world cash cost of production curve. In periods of higher commodity prices, companies may do more stripping or process more marginal ores or stockpiles because they can do it profitably. In periods of sustained higher prices, this can increase the average cash cost of production and in periods of sustained low prices, reduced stripping and the mining of higher grades can reduce the average cash cost of production. The QP may consider adding a margin to the current mid-point on the world cash cost of production curve as a way of determining the commodity price to be used in Mineral Resource and Mineral Reserve estimates. There are a number of services that provide cost data as well as forecast commodity prices (AME Mineral Economics, Brook Hunt & Associates Ltd. and the Commodities Research Unit, for example)

- Consensus Prices

The use of consensus prices obtained by collating the prices used by peers or as provided by industry observers, analysts for example, may be used in some cases. This methodology has the advantage of providing prices that are acceptable to a wide body of industry professionals.

- Contract Pricing

Long term contract prices may be used in some deposits, where appropriate contracts are in place. Again, these prices may be different than current market prices but would reflect the company's individual Mineral Resource and Mineral Reserve position over the term of the contracts.

**Issue 2. –** The CSA reports that many QPs are reporting estimates at multiple cut-off grades (including zero cut-off grades) but are not opining on which estimate should be disclosed in the company's Mineral Resource and Mineral Reserve statements.

QPs are reminded that the CIM Definition Standards and the CIM Best Practice Guidelines refer to one estimate of the Mineral Resources and Mineral Reserves of a deposit and industry practice is also to report one estimate of Mineral Resources or Mineral Reserves for the deposit. The reporting of a table of Mineral Resources or Mineral Reserves and omitting to select one estimate is not reporting a Mineral Resource or Mineral Reserve estimate for the property. In our discussions with the CSA, it has been indicated that they will consider a **technical report** that does not select a specific estimate to be non-compliant with NI 43-101. QPs are further reminded that one of the purposes of a NI 43-101 report is to report **an** estimate of Mineral Resources and Mineral Reserves.

CIM considers it reasonable to include variations of the cut-off grade to indicate the relative robustness of the estimate to changes in cut-off grade. However, CIM reminds QPs that:

- NI 43-101, CIM Definition Standards and CIM Estimation Best Practice Guidelines specifically prohibit the disclosure of tonnes and grade that are not classified.
- The QP who is disclosing any estimate must make it clear in the text of the report that the other estimates are included only to demonstrate the sensitivity of the Mineral Resources and Mineral Reserves estimate to changes in cut-off grade and are not the QPs estimate of the Mineral Resources and Mineral Reserves for the property.
- The QP is cautioned that an estimate below the selected economic cut-off grade for the estimate will not meet the test of "reasonable prospects for economic extraction" and therefore should not be reported.
- QPs are further cautioned that each estimate reported, in a table for example, must be individually checked to ensure compliance with the "reasonable prospects for economic extraction" definition.

Further discussion on the cut-off grades

CIM is aware that in special cases a cut-off grade is not applied to a deposit. In certain circumstances, the contacts between the rock types define the mining limit, rather than an economic cut-off grade. Examples of this are diamonds in a kimberlite pipe or certain industrial mineral deposits. The QP must describe these special situations in the **technical report.**

**Issue 3. –** What is the appropriate level of support required for the selection of a cut-off grade? Should the completion of a scoping study be the minimum standard for supporting the determination of a cut-off grade?

In general, the support for the determination of cut-off grade for an Inferred Mineral Resource would not be as rigorous as the support required for the cut-off grade for a Proven Mineral Reserve. The support for a cut-off grade for a Mineral Reserve estimate would include a great deal of engineering data and be supported by, at a minimum, a preliminary feasibility study. The data and analysis to support a Mineral Resource estimate would not be as detailed but determination of any cut-off grade should, at least, involve consideration of commodity price, operating costs and metallurgical recovery (if applicable). It is important, however, for the QP to explain the level of support used and the reasons for the selection of the cut-off grade.

For a Mineral Resource estimate, the parameters that are used to determine the cut-off grade have to be discussed. The QP is expected to use experience and comparisons to similar deposits to arrive at an appropriate cut-off grade in early stage testing of properties. Completion of a scoping study may be reasonable to support the cut-off grade for a Measured or Indicated Mineral Resource. For the determination of a cut-off grade for early stage (Inferred) Mineral Resources, completion of a scoping study may not be required.

As with all of the Mineral Reserve estimation process, the amount of data available and method for the determination must be discussed and disclosed in the **technical report**.

**Issue 4. –** The definition of a pre-feasibility study is general and lacks specific minimum requirements for each aspect or component of the study. Where can QPs go to get more information on the content of a preliminary feasibility study?

The CIM Standard Definitions include a definition of a preliminary feasibility study but a description of the components of a preliminary feasibility study are not provided. Many companies have internal guidelines for preparing various levels of economic studies of mining projects and define such terms as preliminary feasibility studies. Pincock Allen and Holt and Watts Griffis and McOuat Limited have published papers on this issue. These papers are attached to this document.

**Issue 5.** - Disclosing different Mineral Resource classification categories for different metals in the same Mineral Resource estimate.

A recent **technical report** disclosed different Mineral Resource categories for gold and silver grades that were being applied to the same tonnage in a gold deposit. The QP felt that the data were sufficient to support a classification of Indicated Mineral Resources for the gold values, but the data would only support a classification of Inferred Mineral Resources for the silver estimate. The Mineral Resource for silver was reported as a separate Inferred Resource. The CSA was concerned that this might be potentially misinterpreted by investors, as investors may double count the tonnage and treat the gold and silver as if they would be mined and recovered separately.

In general, the CIM Definition Standards and CIM Best Practices deal with the estimation of Mineral Resources and Mineral Reserves for a deposit and generally assume that an estimate for the deposit will be made and then classified with the same classification being applied to both the tonnage and grade of the estimate. Tonnes and grade are both fundamental components of the estimate of Mineral Resources and Mineral Reserves. Nothing in the widely held deliberations on the CIM Definition Standards ever arose concerning the potential to have multiple grade classifications for the same estimate of tonnage. The CIM Standard Definitions were revised effective Dec 13, 2005 and at that time there was no consideration of this issue. It is also clear from review of the international reporting standards there is no provision to allow multiple classification of grades with the same Mineral Resource tonnage. Again, classification of the estimate concerns both tonnage and grade.

In the case of the example described above, it would be very misleading to allow the gold grades to be classified as Indicated Mineral Resource and the silver grades to be classified as Inferred Mineral Resource for the same estimate in a report or public disclosure. In CIM's view, the QP must classify the estimate as an Indicated Mineral Resource and explain that silver is present in the deposit but insufficient information is available at this time to estimate a grade with the required confidence.

We posed this issue to a number of QPs in the industry to determine how they would classify the above estimate. Most QPs were not prepared to classify the estimate without more data about the project. The usual question was, "How important is the silver to the overall economics of the project?" Based on the information the QP provided, the Committees' sense is that if the project was economic on the basis of gold data alone, many QPs would classify the project as an Indicated Mineral Resource. If the silver assays were required to make the project economic, some QPs would refuse to classify the estimate until more sampling for silver was completed or they would classify the estimate as an Inferred Mineral Resource because of the lack of confidence in the silver data.

In all cases, the QPs were of the opinion that, in the report, the QP must make very clear the status of both sets of data so that there can be no confusion created in the mind of the reader. Most felt that the best way to do this was to explain that silver is present in the deposit, report the grade if material to the deposit but state that insufficient information is available to estimate a grade with the required confidence.

**Issue 6. –** Disclosing third-party estimates. The issue relates to situations where a company acquires a property with a previous Mineral Resource estimate disclosed by the previous owner after February 1, 2001. If the estimate is material information, the company must disclose it, and first time disclosure of a Mineral Resource on a material property triggers the filing of a **technical report**. The problem arises when the company does not have access to the original underlying data or the original QP to verify the estimate sufficiently to prepare the **technical report**. Further, the original QP or the company's independent QP may not be prepared to sign off on the estimates in a new **technical report**. The company cannot disclose the estimates as historical because they postdate February 1, 2001 and it would be misleading to disclose the estimates as exploration information.

The above issue deals with a legal interpretation of NI 43-101 and not the CIM Definition Standards in the Committees' opinion. However, the Committees suggest that the issuer may consider adding terms to a contract of sale of the property that has provisions to allow the QP to sign a consent to the disclosure of the successor company. If that cannot be done, then it is likely that an independent QP will have to be retained to prepare an independent NI 43-101 report to support the disclosure. The issuer may be able to apply for exemptive relief from the provision to provide a technical report if there is a current technical report on the property or may be able to apply for relief from the 45 day provision to provide a technical report. Again, CIM recognizes that these are legal and not technical issues.

PINCOCK Perspectives

ISSUE NO. 70 — September 2005

# Minimum Engineering Study Requirements

**PAH NEWS PIX**

- KAZAKHSTAN – LAND OF OPPORTUNITY
- U.S., AUSTRALIA MAY ALLOW MINING OF URANIUM
- NICKEL DEMAND REMAINS HEALTHY
- CHILE-CHINA FREE TRADE AGREEMENT

**CALENDAR**

- ***XXVI International Mining Congress (Expomines 2005)***
  *October 12–15, 2005*
  *World Trade Centre*
  *Boca del Rio, Veracruz, Mexico*
  *e-mail: coordinacion@expomines2005.com.mx*

- ***2005 Heavy Minerals Conference***
  *October 16–19, 2005*
  *Sawgrass Marriott Resort*
  *Ponte Vedra Beach, Jacksonville, Florida*
  *e-mail: meetings@smenet.org*

- ***Mines and Money London***
  *November 21–23, 2005*
  *Hilton London Metropole Hotel*
  *London, United Kingdom*
  *e-mail: tracey.fielder@mining-journal.com*

- ***Runge Professional Development Courses***
  *Mining for Non Miners - Nov. 30*
  *Dragline Mining System - Dec. 1-2*
  *Mining Economics - Dec. 5-6*
  *Truck and Loader Systems - Dec. 7-9*
  *Calgary, Alberta, Canada*
  *For more information or to register*
  *e-mail: frowe@runge.com.au*

*Pincock Perspectives Issue No. 34 (September 2002), Minimum Requirements for Feasibility Studies, remains one of our most requested newsletters. This month's issue is an update of that newsletter and accompanying table to reflect the changes in reporting requirements over the last three years.*

## INTRODUCTION

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. There are three levels of engineering studies during development that are commonly acknowledged by the mining industry, as follows:

- Conceptual
- Prefeasibility
- Feasibility

The enclosed table lists PAH's assessment of the minimum reporting requirements for the three levels of engineering studies.

In April 2005 The SEC Reserves Working Group/SME Resources and Reserve Committee submitted to the U.S. Securities and Exchange Commission their recommendations concerning estimation and reporting of mineral resources and mineral reserves. Included in these recommendations was a report specific for reserve reporting referred to as a "Mineral Reserves Declaration Report". For this newsletter PAH is addressing the standard types of reports that are used by companies to evaluate projects and seek financing, which are different requirements than reserve reporting, although reserves can be reported as part of the evaluation process. PAH will address the "Mineral Reserves Declaration Report" in a future newsletter when it is appropriate.

## CONCEPTUAL STUDY

The conceptual study, also commonly referred to as a scoping study, is the first 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 is low at ±50 percent. Although the level of drilling and sampling must be sufficient to define a resource, flow sheet development, cost estimation and production scheduling are often based on limited data, test work, and engineering design. The results of a conceptual study typically identify:

- 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 conceptual study is useful as a tool to determine if subsequent engineering studies are warranted. However, it is not valid for economic decision making nor is it sufficient for reserve reporting.

## ■ U.S., AUSTRALIA MAY ALLOW MINING OF URANIUM

*Uranium experts are claiming that the United State is moving towards becoming a nuclear society. Experts have predicted in a century from now 90% of our energy will come from nuclear power. Australia is close to allowing new uranium mines, and Sweden gets half its power from nuclear energy. The high prices of uranium could stimulate new mine production. Nuclear power is believed to be the cleanest and safest form of mass power generation, and cheapest source of power. It has been predicted that New Mexico, with its long history of government uranium mining, will allow the mining of uranium again. Virginia is the only state that has banned uranium mining. Permitting poses a problem for uranium miners – the process can take up to ten years, due to the politics involved.*

## ■ NICKEL DEMAND REMAINS HEALTHY

*China's demand for nickel rose 50% the first half of 2005. Nickel production, stainless steel scrap, and nickel inventories are unable to meet the demand. China is now the world's largest nickel consumer, surpassing the US. China accounts for 16% of the demand of nickel. The Asia-Pacific region consumes about 50% of the worlds nickel production and projections indicate that demands are to continue well into 2006. Four new mines are slated to come on line with in the next two years; however the demand for nickel will still not be met. Several nickel projects are delayed due to capital cost increases and other financing issues.*

## ■ CHILE-CHINA FREE TRADE AGREEMENT

*Chile and China could sign a free trade agreement as early as November, tying the world's biggest producer and consumer of copper. This would be the first full-fledged trade agreement for China. Twenty-five percent of Chile's trade is with Asia, where Chile already has a free trade agreement with South Korea, and studies are being done to determine if talks should begin with Japan. With a more than 6 percent growth in Chile's booming economy, its strongest exports include copper, wood pulp, and fertilizer. The influx of dollars from exports has helped boost the Chilean peso to its strongest in years against the dollar.*

## PREFEASIBILITY STUDY

The prefeasibility study represents an intermediate step in the engineering process to evaluate a mining project. The principal parameters for a prefeasibility study are based on some engineering basis. The level of accuracy is higher than the scoping study at ±25 percent. The engineering objectives of a prefeasibility study are to determine:

- Resources/reserves
- Mine and mill extraction methods
- Mine and mill production rates
- Environmental issues and permitting requirements
- Development period and mine life
- Product(s) recovery rates
- Product(s) marketability
- Capital cost estimates
- Operating cost estimates
- Economic analysis with sensitivity

At the prefeasibility study stage adequate geology and mine engineering work has been conducted to define a resource and a reserve (reserves at this stage depend on reporting jurisdiction). Sufficient test work has been completed to develop mining and processing parameters for equipment selection, flow sheet development, and production and development scheduling. Capital and operating cost estimates are derived from preliminary test work, assumed factors and some vendor quotes. The economic analysis of a prefeasibility study is of sufficient accuracy to assess various development options and the overall project viability. However, these cost estimates and engineering parameters are typically not considered of sufficient accuracy for final decision making or bank financing. Depending upon the government reporting jurisdiction, the study may or may not be sufficient for reserve reporting.

## FEASIBILITY STUDY

A feasibility study represents the last and 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. Accuracy is higher than the prefeasibility study and is typically ±15 percent. Feasibility study objectives are the same as those previously listed for the prefeasibility study, but the level of detail and accuracy for each objective are more stringent. The level of detail is typically dictated by whether the project is to be financed by the company or bank financed. Often the term "bankable" is used in describing a feasibility study. This term simply defines that the level of detail of the study is sufficient for financing provided the results are positive. In some cases, if the project is to be company financed the level of detail is higher than in a typical "bankable" feasibility study.

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 vendor quotes. A draft EIS/EA has been submitted to regulatory authorities or is close to being submitted. Economic analysis with sensitivities is based on annual cash flow calculations for the mine life. Provided the project is feasible, a proven and probable reserve statement can be made.

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.

### Geology and Resources

Every mineral deposit has its own unique geologic characteristics which must 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.

Resource estimation is based on the development of a three-dimensional model of the deposit with either manual or computer methods. 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 estimate is classified according to internationally recognized standards including the following (as well as others):

- Canadian National Instrument 43-101;
- Australasian Code for Reporting of Mineral Resources and Ore Reserves - prepared by the Joint Ore Reserve Committee (JORC);
- U.S. Securities & Exchange Commission Industry Guide 7; and
- The 2005 SME Guide for Reporting Exploration Results, Mineral Resources and Mineral Reserves.

**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 analysis is a tool that is being utilized more in the evaluation of projects especially surface mines. With this tool companies can determine what the impact of changes in prices, costs, and recoveries are on the project so that the areas in which the project is most sensitive to can be identified. Including inferred resources in an optimization analysis can help a company determine where to focus exploration drilling to increase measured and indicated resources. Preliminary production schedules can also be developed using this tool. Results from optimization analysis, however, do not constitute reserves because they are generally based on pit shells that do not include roads and ramps and contain unmineable shapes.

As the studies increase in complexity 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 one of the critical components 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 control. As the knowledge of the project is increased the more refined and detailed the mine design and production schedule can become.

**Process Engineering**

Process engineering for the mined ores is initiated in the engineering study after the production rate is established in the mining phase. Processing facilities are typically 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
- Selection of processing flow sheet and 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

■ ***KAZAKHSTAN – LAND OF OPPORTUNITY***

*Kazakhstan, one of the largest of former Soviet Union countries, has vast mineral potential. The country's growth rate is about 9% per annum. The government is keen to see the mining industry to develop. Mineral resources are abundant – there are large coal, iron ore, manganese, nickel, chromium, copper, cobalt, lead, zinc, bauxite, gold, and uranium deposits. It is believed that 15 – 20% of the world's lead, zinc, chromium, and gold could be hosted here. The government is interested in attracting more inward investment. The goal is to have extractive industries contribute to development and a reduction in poverty. The State Priority Act, which passed in December 2004, allows the government rights to buy any natural resource asset that is for sale in on its territory. This is supposed to ensure greater control over investment. The local government, in order to develop local industry, has requested companies operating in Kazakhstan be required to hire and train local people and use local supplies wherever possible.*

## *Minerals Corner—*

### *Betafite*

***$(Ca, Na, U)_2(Ti, Nb, Ta)_2O_6(OH, F)$***

*Betafite is a popular uranium bearing mineral, often found in Betafo, Malagasy Republic, Madagascar and Silver Crater Mine, Bancroft, Ontario, Canada. It can also be found in Russia, Spain, Peru, Pakistan, India, China, Norway, Brazil, California, Arizona, New Mexico and Colorado. Because of Betafite's rare chemical elements, it is one of several so-called Rare Earth Oxides. If Betafite has color, it would be black with a tint of yellow, brown, or green; however, typically it is lacking in color and its crystals are opaque. Betafite is a radio-active mineral.*

- Water supply
- Communications
- Port and marine
- Fuels
- Waste disposal systems
- Administration facilities
- Industrial facilities
- Transportation
- Townsite/Camp facilities

**Environmental**

Today, complex environmental issues faced by the global mining industry include:

- Environmental Impact Statements (EIS)
- Base line studies
- Environmental assessments
- Mine Permitting at the local, state, federal and international levels
- Mine-waste management design/ remediation
- Water management
- Wetlands mitigation/construction design
- Air quality and noise assessment
- Acid-rock drainage assessment and abatement
- Closure planning

**Surface Reclamation**

Environmental scientists and regulatory specialists help develop effective and economical environmental controls for mining operations, which comply with all applicable environmental regulations (international, federal, state, and local) affecting the mining industry.

**Economic Analysis**

Economic analysis is performed as the final step in the 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

Inputs to the cash flow derived from the various sections of the engineering study include:

- Ore production and grade schedules
- Commodity recovery (ies) and
- Commodity production schedule
- Capital costs (preproduction, sustaining and working)
- Operating costs

In addition to the inputs from the engineering study, other parameters to the pro-forma cash flow include:

- Royalties (private and governmental)
- Commodity price (s)
- Host country's tax regime (tax rates [federal, state, provincial], depreciation, depletion, etc.)

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

The results of the sensitivity analysis are plotted in a spider diagram to determine the project's sensitivity.

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 prefeasibility and feasibility study stages. Beyond the team's basic mine development experience is the consideration of the knowledge and experience of project financing and financial requirements that is required for bankable study preparation. Therefore, it is of critical importance to select the correct project team to ensure the timely and accurate completion of the study. Following this formula will reduce both project development and cost risks. Additionally, following the traditional progression of the studies from conceptual to prefeasiblity 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 be a delay in the project which is generally costly.

*This month's article was provided by PAH's Mining and Geology departments.*

pincock allen & holt

*Pincock, Allen & Holt is a consulting and engineering firm serving the international mineral resource industry. Your comments and suggestions are always welcome. Contact Pincock, Allen & Holt • 165 S. Union Blvd., Suite 950, Lakewood, Colorado 80228 • TEL 303.986.6950 • FAX 303.987.8907 • www.pincock.com. Pincock Perspectives is published as a free information service for friends and clients. Information for News Pix is paraphrased from various sources; references available upon request.*

*Consultants for Mining and Financial Solutions*

PINCOCK *Perspectives*

### *Minimum Report Contents for Engineering Studies*

| ***DESCRIPTION*** | ***Conceptual (Scoping) Study*** | ***Prefeasibility Study*** | ***Feasibility Study*** |
|---|---|---|---|
| ***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 | Deposit well-defined with three dimensional mapping, geologic maps, long sections, level plans |
| 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 mineralogic 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 |
| Condemnation Drilling | None | None | Areas under waste dumps, tailings and plant drilled |
| ***RESOURCES AND RESERVES (Internationally Recognized Standards [see note 1])*** | | | |
| ***Resources*** | Indicated and Inferred | Measured, Indicated, and Inferred | Indicated and Measured |
| 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 | Not performed | Preliminary analysis and determinations | Detailed analysis and determinations |
| Geostatistical Analysis | Not performed | Preliminary analysis and determinations | Detailed analysis and determinations |
| ***Reserves*** | Only resources estimated | Proven and Probable | Proven and Probable |
| Calculation Parameters | Usually no reserves are estimated | Known or estimated | Detailed analysis and determinations |
| Cutoff Grade (COG) Equations | Usually no reserves are estimated | Calculated from floating cone parameters | Optimized using mining/processing parameters |
| ***MINING*** | | | |
| Mining Method | Assumed between open pit and underground | Specific method identified | Method and mine plan finalized |
| Open Pit Mine Plan | | | |
| Pit Slopes | Assumed | Preliminary estimates by rock type and basic geotechnical data | Defined by geotechnical data from structural mapping and oriented core holes |
| Pit Design | Simple outline of final pit | Preliminary pit design from optimized analysis; preliminary haulroad incorporated | Detailed 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 | Dump sites identified from geotechnical data; final waste tonnages determined with incremental phases, yearly and final dump outlined |
| 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 |
| Production Schedule | Basic schedule based on assumed mine life | Yearly and mine life ore and waste tonnages and grade | Detailed annual schedules showing ore / product quality and waste tonnages and grades |
| 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*** | Minimal sampling; conduct lab bench scale process characterization tests on collected samples (if available) | Sampling of core; preliminary bench scale testing to determine preliminary recoveries, ore characterization and processing parameters for flow sheet development | Sampling of core for different ore body zones; confirm flow sheet; comprehensive beneficiation test program to determine recoveries, ore/product characterization and finalize processing parameters |
| ***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 optional | Complete design basis; basic engineering drawings essentially complete; trade-off studies performed |
| 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 |
| 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 togographic 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 |
| ***Dewatering*** | Dewatering parameters identified | Dewatering parameters estimated | Dewatering parameters confirmed and plan defined |

## Minimum Report Contents (continued)

| DESCRIPTION | Conceptual (Scoping) Study | Prefeasibility Study | Feasibility Study |
|---|---|---|---|
| **ENVIRONMENTAL** | | | |
| Setting | Preliminary evaluation of project setting for potentially significant environmental or permitting constraints for site data | Preliminary evaluation of the project's impact on the environment; schedule of environmental and/or other permitting requirements; evaluate project setting for potentially significant environmental and/or permitting constraints from site data | Characterization of all the project's potential impacts on the environment; finalize schedule of environmental and/or other permitting requirements; evaluate project setting for potentially significant environmental and/or permitting constraints |
| Data | Collect and review all available, existing data for environmental studie assessments or audits; regulatory inspections, waste handling practices, management plans, and all applicable environmental laws and regulations; no social, training or safety programs identified | Collect and review available environmental data from existing databases for environmental studies, assessments or audits; regulatory inspections, waste handling practices; management plans; and all applicable environmental laws and regulations; plans; initiate baseline data gatherin 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/or government reports; comprehensive gathering and evaluation of baseline environmental 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 managing any identified environmental issues | Preparation of environmental plans and monitoring programs; preliminary sediment and erosion control plan; conceptual reclamation 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; management plan finalized for solid and hazardous wastes; finalize impact mitigation plan; geotechnical stability analysis of all major facilities; finalize reclamation 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 environmental 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 determine development schedule set | Detailed development schedule; mine life known; development schedule finalized |
| 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<br>Civil Structural<br>Architectural<br>Piping/HVAC<br>Electrical<br>Instrumentation<br>Construction Labor<br>Construction Labor Productivity<br>Material Volumes/Amounts<br>Material/Equipment Pricing<br>Infrastructure | 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 |
| 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 |
| 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 |
| Commodity Price(s) | Estimated based on 3yr average minimum | Estimated based on 3yr average minimum | Estimated based on 3yr average minimum or detailed market studies |
| 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 | 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. Australiasian 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

Pincock, Allen & Holt is a consulting and engineering firm serving the international mineral resource industry. Your comments and suggestions are always welcome. Contact Pincock, Allen & Holt •
165 S. Union Blvd., Suite. 950, Lakewood, Colorado 80228 • TEL 303.986.6950 • FAX 303.987.8907 • www.pincock.com

**Jack F. McOuat - President**
**Watts, Griffis and McOuat Limited**

**Jack McOuat** graduated from the University of Toronto with a B.A. Sc. in geological engineering in 1956 and is one of the founding partners of the WGM Group. As President and Director of Watts, Griffis & McOuat Limited and Vice-President of WGM Inc., he acts as Executive Engineer for many of the company's projects.

Mr. McOuat is well experienced in all aspects of project evaluation, having planned and supervised field programs, engineering investigations, and feasibility studies on a world-wide basis. Assignment locations outside Canada have included Saudi Arabia, Morocco, Liberia, Ecuador, Argentina, Mexico and Australia, as well as Alaska and other parts of the United States.

In recognition of his achievements and his service to the industry, he was awarded the Order of Sons of Martha by the Association of Professional Engineers of Ontario (1989), and an Honourary Doctorate of Engineering Degree from the Technical University of Nova Scotia (1987).

## *Preliminary Feasibility Studies*

Following the initial valuation, the mining company turns to conducting preliminary feasibility studies. Although often under-utilized, such studies, when used properly, are a powerful guide in the design of exploration and evaluation programs. They can and should be used to justify increasing levels of project expenditures. Management can rely on preliminary feasibility studies to identify key areas where there is insufficient knowledge and more work is required. Every assumption used in a study represents such an area for investigation.

Preliminary feasibility studies frequently determine whether a project will continue to be explored, sold or terminated. It is therefore essential that such studies embrace the optimal skill sets available to management.

Preliminary feasibility studies must address all issues, not just projected capital and operating costs. In fact, the table of contents should be as complete as the final feasibility study, and items such as permitting, other environmental requirements, allowances for shutdown and reclamation costs should be considered.

# PRELIMINARY FEASIBILITY STUDIES

Prepared For

THE CANADIAN INSTITUTE OF MINING AND METALLURGY

6TH MINERAL ECONOMICS SYMPOSIUM

JANUARY 17, 1991

Prepared by:

Jack F. McOuat, P.Eng.
President
Watts, Griffis and McOuat Limited
Toronto, Canada

# PRELIMINARY FEASIBILITY STUDIES

## INTRODUCTION

Most mineral exploration projects which meet with some success are subject to one or more evaluations of their economic potential. The early studies, usually referred to as Preliminary Feasibility or Prefeasibility Studies (both improper adjectives in my opinion), should be an integral part of the ongoing investigation of any mineral deposit. This paper defines the various levels of studies, outlines why such studies are necessary, and discusses the inputs required, the benefits and the personnel needed.

The adjective "Preliminary" is not really appropriate. As a mining project is being explored and as various technical investigations are completed, it is, or should be, subjected from time to time to technical and economic evaluations. Each evaluation is a measure of the feasibility of the deposit and the document which presents the studies and findings is a "Feasibility Study". Each study incorporates all the data known at the time of preparation and is a stand alone evaluation.

"The Feasibility Study", "The Final Feasibility Study" or "The Bankable Feasibility Study" is simply the last (it is hoped) in a series of progressively more detailed and credible reports. This last study is distinguished only by its completeness in terms of knowledge of the orebody, detail of engineering and accuracy of cost estimating. I'm sure the next paper, entitled The Feasibility Study, will describe these in detail.

However in order to follow common practice, I will refer to the early feasibility studies which are the topic of this paper as "Preliminary Feasibility Studies" and the final study as "The Feasibility Study". While there is a body of literature about Feasibility studies, little seems to deal specifically with Preliminary Feasibility Studies.

In order to organize this presentation, a number of questions are posed:

What is a Preliminary Feasibility Study?
Why prepare a Preliminary Feasibility Study?
When should it be done?
Who should do it?
What should be in it?
What are the benefits?
What are the risks?

## WHAT IS A PRELIMINARY FEASIBILITY STUDY?

A Preliminary Feasibility Study is any assessment of the economic potential of a mineral property short of The Feasibility Study. These studies range in detail from back of the envelope calculations, carried out by an individual, to lengthy reports to which a quite large number of people contribute and which are almost indistinguishable from "The Feasibility Study" except for the engineering details, drawings and cost estimating.

Once one has moved away from the back of the envelope type study, four levels or types of Feasibility Study are recognized, the last of which is "The Feasibility Study". The four types are summarized on the following two pages and detailed in Appendix I. While four types of study are

## COMPARISON OF TYPES OF ECONOMIC FEASIBILITY STUDIES

| ITEM | TYPE 1 | TYPE 2 | TYPE 3 | TYPE 4 |
|---|---|---|---|---|
| **Ore body** | | | | |
| No. of drill holes | 0/10 | 10/20 | 20/40 | Sufficient |
| Reserve category | Potential/assumed | Indicated | Proven/probable | Proven |
| Bulk sampling | None | Possibly | Probably | Essential |
| **Mine** | | | | |
| Mining method | Assumed | General | Optimized | Finalized |
| Mine layout | None | Preliminary | General | Detailed |
| Equipment selection | Hypothetical | Preliminary | Optimized | Finalized |
| Rock mechanics | None | None | Preliminary | Essential |
| Visit by mining engineer | Possibly | Recommended | Essential | Essential |
| **Plant & Infrastructure Sites** | | | | |
| Plant capacity | Assumed | Preliminary | Optimized | Finalized |
| Plant and other sites | Assumed | General | Approximate | Specific |
| Maps and surveys | None | If available | Available | Detailed |
| Soil and foundations tests | None | None | Preliminary | Final |
| Site visits by project team | Possibly | Recommended | Essential | Essential |
| **Process** | | | | |
| Process flowsheets | Assumed | Preliminary | Normally optimized | Finalized |
| Bench scale tests | If available | Recommended | Essential | Essential |
| Pilot plant tests | Not needed | Possibly | Probably | Normally essential |
| Energy & material balances | Not essential | Preliminary | Optimized | Finalized |
| **Facilities Design** | | | | |
| Nature of facilities | Conceptual | Possible | Probable | Actual |
| Equipment selection | Hypothetical | Preliminary | Optimized | Finalized |
| General arrangements, mechanical | None | Minimum | Preliminary | Complete |
| General arrangements, structural | None | Outline | Outline | Preliminary |
| General arrangements, other | None | Minimum | Outline | Preliminary |
| Piping drawings | None | None | One-line | Some detail |
| Electrical drawings | None | None | One-line | Some detail |
| Specifications | None | Performance | General | Detailed |

| ITEM | TYPE 1 | TYPE 2 | TYPE 3 | TYPE 4 |
|---|---|---|---|---|
| **Basis for Capital Cost Estimating** | | | | |
| Estimates prepared by | Project Engineer | Snr. Estimators | Snr. Estimators | Estimating Dept. |
| Vendor quotations | Previous | Single source | Multiple | Competitive |
| Civil work | Rough sketch | Drawing estimate | Drawing estimate | Take-offs |
| Mechanical work | % of machinery | % of machinery | Man-hours/ton | Man-hours/ton |
| Structural work | Rough sketch | Preliminary drawings | Take-off/ton | Take-off/ton (1*) |
| Piping & instrumentation | % of machinery | % of machinery | Take-off | Take-off (1*) |
| Electrical work | $ per hp | $ per hp | Take-off | Take-off (1*) |
| Indirect costs | % of total | % of total | Calculated | Calculated |
| Contingency (2*) | 20-25% (2*) | 15-20% (2*) | 15% (2*) | 10% (2*) |
| **Operating Cost Determination** | | | | |
| Labour rates | Assumed | Investigate | Get contracts | Get contracts |
| Labour burden | Assumed | Calculated | Calculated | Calculated (3*) |
| Power costs | Assumed | Actual | Actual | Contract (3*) |
| Fuel costs | Assumed | Verbal quote | Letter quote | Contract (3*) |
| Expendable supplies | Assumed | Verbal quote | Letter quote | Contract (3*) |
| Reagents | Assumed | Verbal quote | Letter quote | Contract (3*) |
| Parts | Assumed | Verbal quote | Letter quote | Letter quote |
| **Economic Analysis** | | | | |
| D.C.F. | Manual | Detailed | Detailed | Detailed |
| Taxation data | Generalized | Detailed | Detailed | Detailed |
| Revenue base | Historical | Current | Letters of indication | Written proposals |
| **Use of Estimates** | Comparison/ rejection (4*) | General feasibility | Budget | Funding |
| **Relative Cost** | X | 3X | 5X | 10X |

NOTES:

(1*) Often subject to subcontract bids.
(2*) In this definition the percentage assigned to contingencies is a judgement factor and is not to be interpreted as meaning that estimates are necessarily accurate within this percentage range, nor is there an implied reference to any order of accuracy.
(3*) Contracts can be solicited if project is near term.
(4*) Also used to establish tonnage and grade targets for exploration programs.

defined, the distinction between them is somewhat like choosing a shade of grey from a paint chart.

Costs of preparing Preliminary Feasibility Studies obviously increase with their complexity, detail, and the amount of basic information available. Costs can range from about $50,000 for a Type 1 study on a relatively small accessible open pit project to over $1,000,000 for a Type 3 study on a large, remote or foreign open pit or underground project.

**WHY DO A PRELIMINARY FEASIBILITY STUDY?**

While Preliminary Feasibility Studies have several purposes, two stand out. The first and most obvious is to justify ongoing exploration and evaluation expenditures. If the exploration department, having met with some initial success on a prospect, wants management to approve a 100,000 foot drilling program at a cost of $3 million, to be followed by a $5 to $15 million underground exploration effort, it better have more than just some geological cross-sections to present to the Board of Directors. This will be particularly the case if these expenditures mean that exploration budget increases are necessary or other projects cut back.

In the case of smaller companies, which spend equity rather than earnings, the need for economic justification may be even greater as the Directors will likely have to approve a financing and financing normally means a dilution of equity. In addition, a Preliminary Feasibility Study will almost surely assist in the financing, assuming it is properly done and shows an acceptable rate of return.

In other words, Preliminary Feasibility studies help establish priorities and provide justification for increased expenditures.

The second key reason for doing a Preliminary Feasibility Study is to provide a powerful planning document which, if properly prepared, can identify those vital areas which require further information and study. While the instinct of the exploration department may be to continue drilling in order to add to, or detail, tonnage, it may be that other investigations are equally, if not more, essential. Such areas often include metallurgical testing, water supply, marketing, transportation, environmental permitting or taxation. Sometimes one or all of these are more crucial than adding to tonnage.

The study can identify clearly those aspects of the project which require further study, highlight potential show stoppers, and indicate areas which must be improved to meet threshold economics.

Another reason for a Preliminary Feasibility Study is to be able to illustrate to the exploration group the tonnage and grade necessary at a given location for a mine to be viable. This helps establish, sometimes as much as geology, the drilling pattern. There's not much point in drilling a deposit at 50 foot centres initially when the grade dictates that tens of millions of tons are required to make the project viable.

While this sounds self evident, inexperienced exploration people with little background in mineral economics find it difficult to realize that a deposit is of interest only when one converts the mineral values into recoverable dollars. The discovery of more recoverable dollars in the ground than it costs to dig them out is the often-forgotten only objective of exploration.

A Preliminary Feasibility Study is useful in describing potential environmental problems. As we all know, environmental legislation, regulations, and attitudes are having a great impact on mining and the costs of operations both during and after production are increasing as a result. A properly prepared Preliminary Feasibility Study will address the issues, costs and time to obtain permits and approvals. By the time a Type 2 or 3 Preliminary Feasibility Study is carried out, the permits needed, the field investigations needed to obtain these permits, and the cost and schedule for such investigations must be identified. Not uncommonly today, these investigations may cost millions of dollars and be the key element on the critical path. Woe betide the company or exploration department that leaves these until the last minute.

A well presented Preliminary Feasibility Study which discusses alternatives for sites, methods of tailings disposal, reclamation, and even social impacts can be a very supportive document when seeking permits, understanding and hopefully co-operation from environmental groups, government agencies, politicians and local residents.

Also, as a project matures, the company wants to announce it has an "ore deposit" or "ore reserves". In days gone by simply announcing tons and grade, which by comparison to others likely represented an economic deposit, would do. Today, securities commissions and stock exchanges are much more demanding. In the U.S., in our experience, for instance, one cannot claim to have "Reserves" unless supported by presentation of a Preliminary Feasibility Study.

Finally, the Preliminary Feasibility Study is a management tool. Budget justification was referred to earlier but the Preliminary Feasibility Study can do more. For example, if the project, at today's prices or market availability, is just on the verge of being economically attractive but will take many years to be fully evaluated and permitted, then a company may well wish to turn the project to stronger hands and preserve its own capital. Alternatively, the project's ultimate demand for capital may be greater than a company can raise or is willing to face in terms of dilution. Management needs to know this at an early stage to decide whether it should seek a buyer or joint venture partner.

The Preliminary Feasibility Study can bring all these elements into focus and can be used to establish values for sale, joint venture negotiations or to determine whether the project should be deferred.

**<u>WHEN SHOULD THEY BE DONE?</u>**

Other than the back of the envelope type study, a Preliminary Feasibility Study should be undertaken at least twice during the investigation of a mineral deposit. The first is at the stage where some indication of grade and possibly tonnage is available, unless the project is in an area where there are operating mines of the same nature. As stated earlier, a Preliminary Feasibility Study is the means by which a significantly increased budget can be justified.

The next time a formal study is justified is after a substantial amount of new data is available and major funding for final evaluation is being requested.

If a deposit delivers no surprises, either of a negative or positive nature, or if no new external factors arise such as the gold tax in Australia, a new set of environmental regulations, or a new and better discovery by a competitor which can impact on marketing or price of the commodity, then likely only two different levels of Preliminary Feasibility Studies prior to The Feasibility Study are likely needed. On occasion, projects go from a Type 2 to a Type 4.

If Preliminary Feasibility Studies are organized properly, they can be easily updated and expanded without re-inventing the wheel and this should be done automatically as significant new information becomes available.

It should not be forgotten that from the time of discovery to the time The Feasibility Study is delivered 10 years or more may go by. If Preliminary Feasibility Studies are undertaken at years three and six, for example, these are snapshots only. The assumptions, conclusions, and recommendations should be formally reviewed from time to time as new data becomes available from the many areas of investigation or outside factors change such as commodity prices or mineral demand.

**WHO SHOULD DO THEM?**

It takes an unusual, but usually quite small, group of people to carry out a good Preliminary Feasibility Study.

In a Type 1 study only three or four highly experienced people may be involved. The number increases to 10 to 20 for a Type 2 Study. In a Type 3, 30 to 100 and in a Type 4 sometimes over 100 people may be required. Study costs generally parallel the number of people involved. The average cost per man-hour should decline however as progressively more junior personnel become involved.

As the various Preliminary Feasibility Studies may well represent life or death for a project and as they should provide an accurate road map for further activities leading to project development, it should be obvious that the most experienced personnel available should be deployed.

In all types of Feasibility Studies, there must be three key players: the explorationist or project geologist, the mining engineer, and the metallurgist. The explorationist is vital for a number of reasons, including, of course, knowledge of the deposit. He will have responsibility for the geology, sampling, analyses, and initial tonnage and grade calculations. It is he who can provide the insight into the overall potential of the size of the deposit being assessed. Obviously this is extremely important in early stage studies when only limited proven or probable reserves are known.

A second reason to include the explorationist is that he is the most likely to "believe" in the deposit and to act as the project's Champion.

In addition it is he who will have, at the time any Preliminary Feasibility Study is prepared, the most knowledge about local conditions. Water supply, possible road routes, local construction materials, labour rates, local social attitudes and the like will be best known by those who have lived and worked in the area - the geologists. This is particularly important if the deposit being assessed is remote or in a foreign country or both.

Finally if the explorationist is involved in the preparation of a Preliminary Feasibility Study, he will be forced to become aware of factors, other than drill holes, assays, tons and grade, which have a major bearing on whether "his" deposit has the potential to become a mine. The list of such factors is long and it is very healthy for exploration people to be aware of the impact of such factors on whether or not "his" mineral resource is economically viable. It forces the explorationist to incorporate activities into field programs and to gather data about items which might not normally occur to them. Finally, it makes the explorationist think in terms of dollars and cents.

The mining engineer should have experience with various sizes of operations, mining methods, and capital and operating cost estimating so that he can approach the mining of the deposit with an open mind and a reservoir of experience to draw upon.

The metallurgist should be a person with extensive experience in a number of areas such as laboratory testing programs and their interpretation, flow sheet development, and plant operations. Ideally he should also have been involved in engineering studies, plant construction and startups at various sized plants.

Obviously these are not assignments for rookies nor are they assignments for out-of-date engineers or for individuals, regardless of age, whose experience has been only in operations, principally at one mine, and may therefore be inclined to do things only by the book or the way the book was interpreted by his long time employer.

The three key players must have imagination and balance amongst optimism, realism and pessimism.

If each of the three key players has had previous experience at operating mines and in the preparation of Preliminary Feasibility Studies, they may only need limited assistance for a Type 1 or Type 2 Study when historical costs and costs of new operations may be used as data bases for capital and operating costs. Usually this group is comfortable with operating cost calculations and it is not uncommon for the mining engineer to be competent to prepare the mine capital costs. Outside help may be needed for such areas as plant and infrastructure capital cost estimating.

If the proper people are involved initially, it is surprising how few changes there will be in those initial decisions regarding mining rates, methods, or facilities when undertaking a Type 3 or Type 4 Feasibility Study.

Even in the early Preliminary Feasibility Studies, financial projections have to be made - after all this is the whole point of the exercise. However, until the more advanced studies are done, when detailed tax and other financial matters become important these projections can usually be prepared by the technical people on a project basis rather than a corporate basis.

As the investigations of a deposit become more extensive and the detail incorporated in a study approaches that required for The Feasibility Study, more and more people become involved, ranging from environmental and other specialists to designers, to estimators, to marketing experts to accountants and so on. However, the key people stay the same: the explorationist, the mining engineer and the metallurgist.

Can Preliminary Feasibility Studies be done in-house? Certainly, Types 1 and 2 can be carried out if the personnel are on staff. However, except in quite large organizations, the people with the necessary background are rarely on staff.

Even companies with several mines do not have a continuous need for such a team or such individuals - other than the explorationist. Often these people have not had the opportunity to acquire the requisite project evaluation experience. In a penny wise and pound foolish manner, operating companies may try and do Types 1 and 2 or even a Type 3 Study by dragging in a team out of operations. Regrettably good operators - metallurgists,mining engineers or even construction superintendents cannot be assumed to be good feasibility study people - however, it is cheaper.

Obviously, if the Preliminary Feasibility Study is to be used to support external financing or to meet joint venture requirements, then independent advice and reports are needed.

On occasion when a Preliminary Feasibility Study is done in-house the worst dog fights can break out. The exploration people may feel they have been pushed aside by those head office or development group guys who are "so conservative they'd turn down Hemlo" or "all they do is look for reasons to turn a project down" and so on, whereas the development group may well think the explorationists "don't know anything" and would "spend fortunes drilling dogs" and haven't got the foggiest idea of what "real mining" is all about.

Sometimes there's more than a grain of truth in both attitudes but they can be very destructive in a company. Hence the advantage of an outside group. The team must be a small, experienced, imaginative, up-to-date, realistic, co-operative group of people.

## WHAT SHOULD BE IN THEM?

A Preliminary Feasibility Study should contain clear, complete and concise descriptions and tabulations of the facts available and assumptions made at the time the study is prepared.

In Preliminary Feasibility Studies, it is vital, more so than later, that all of the assumptions made by the authors be stated clearly. Equally, the thinking of the authors regarding all the key decisions whether based upon assumptions, or upon limited or extensive data, must be spelled out. For example in early stages, little is known about the rock mechanics. Nevertheless, for open pit or underground mines, pit slopes, dilution, backfill needs, etc. have to be assumed and the basis upon which these assumptions are made must be stated and their impact on costs, mineable grades and reserve recoveries made clear.

Unless the writer allows the reader to peer into his mind it is extremely difficult to appreciate the thought processes which lead to the assumptions or decisions. Subjective decisions are widespread in Preliminary Feasibility Studies and the reader needs to know what they are and how they were arrived at. In Preliminary Feasibility Studies, it is also important to make clear, not only what is known about each factor, but what is not known.

The table of contents of a Preliminary Feasibility Study should have identical main headings, and often the same sub-headings, as will "The Feasibility Study". Figure 2 is a summary of the table of contents blended from Type 2 Studies recently carried out. Appendix II provides a more detailed Table of Contents.

In Preliminary Feasibility Studies, the material under a heading is usually more narrative and briefer; but, each key topic must be addressed, becoming more detailed as one progresses up the scale of studies to The Feasibility Study.

While it may seem that the Table of Contents suggested is too detailed for a Type 1 or Type 2 Study, inclusion of each item

**PRELIMINARY FEASIBILITY STUDY
TYPICAL TABLE OF CONTENTS
(Main Headings Only)**



**Figure 2**

forces the team members to think about everything, provide costs for everything and identify all areas for further study.

A word of caution. The team members have to ensure that they do not try to make their estimates more detailed than knowledge of the deposit justifies. It is a natural instinct for engineers once they have, for example, a flowsheet, even when based upon preliminary test data, to want to go to detailed design.

This must be controlled for a number of reasons. It is an unnecessary and perhaps wasted expense to prepare a large number of detailed drawings and estimates for the plant, and other facilities. This can mislead the reader into the belief that such detail is based upon a sound foundation of detailed knowledge about all aspects of the project, particularly the deposit, which after all, forms the essence of the study.

The table of contents for any kind of feasibility study is getting longer not shorter. Only a few years ago, no one would have given a thought to reclamation or shut down costs during an exploration program. The fact that the rapidly expanding labyrinth of permits represent a very serious item on the critical path or that budgets for environmental studies and baseline data gathering can cost as much as the drilling programs is a new phenomenon. The Windy Craggy or Misty Fiords situations come to mind.

One of the important items which should be in Preliminary Feasibility Studies is a project schedule, initially as a bar chart, and in later studies, as critical path schedules.

In addition to indicating the economic viability of a deposit, its possible value, and whether or not it should be aggressively pursued, the Preliminary Feasibility Study should include, at a minimum, recommendations for further work and establish priorities for such work. The key recommendations will normally pertain to the deposit: drilling, underground verification, bulk sampling, metallurgical testing and so on. In addition, recommendations should be provided for other areas of investigation. Here, the list can, if desired by the owner and demanded by the project, be quite extensive, both for on-site activities such as investigation desired by the clients for water supply, building materials, environmental base line data, site conditioning, and road routes, and off-site activities such as marketing, sales contracts, smelter terms, permitting, and taxation studies.

A good Preliminary Feasibility Study is not only a test of the project's economic potential but a planning document and potentially a financing document.

**WHAT ARE THE BENEFITS?**

Assuming the study is well done there are a number of benefits to the owner from the Preliminary Feasibility Study. The Study may:

- provide a clear indication of the possible value of the project. This is the only test, other than the fundamentals of the geology and assays by which management can decide whether or not to pursue the project.

- identify crucial areas which need further investigation.

- inform management about the size and timing of future funding requirements.

- justify future expenditures.

- establish project priorities within a company.

- provide a management document for financing, planning and liaison with permitting authorities.

- provide the information to determine whether the project has the potential to meet corporate economic thresholds.

- indicate commodity prices and availability of markets necessary to warrant development.

- provide a planning and scheduling document for the exploration and development departments.

- force the exploration department to recognize the economic parameters the project must meet and to think in terms of dollars and cents.

- allow the owner to determine whether a mineral deposit represents "ore reserves" or "resources" and to have documented evidence to support the statement.

- keep management better informed than outside mining analysts about the potential value of the project. Rest assured as exploration results become available, mining analysts quickly start to calculate values by their own Preliminary Feasibility Studies - usually on the back of the envelope and not necessarily using the proper data.

WHAT ARE THE RISKS?

While the foregoing list of benefits is impressive, there are also risks. Some of the risks, which may hopefully be avoided by understanding the purpose, scope and quality of Preliminary Feasibility Studies, are as follows:

- project is abandoned or downgraded because too conservative an approach is taken for cut-off grades, capital costs, operating costs, revenues or even the potential size of the deposit.

- project "sizzle" or intangible exploration enthusiasm for a project is removed and all focus is on numbers.

- engineering department starts to drive a project and only the existing facts are considered. Geology and geological potential are pushed to the background. For example if Eskay Creek had been evaluated when only the southern, lower grade and refractory part of the deposit was known, the numbers likely would have suggested the resource was not economic and it might have been abandoned or shelved. An even better example is Hemlo prior to the "discovery hole".

- assumptions (favourable or unfavourable) become dogma and the project suffers. One of our clients benefitted greatly when existing dogma was challenged and found to be wrong. Ore reserves were more than doubled after a modest metallurgical test program at insignificant cost.

- management treats the document solely as an evaluation report and not as a planning document.

- a project gets pushed too hard, too fast because the assumptions used, based upon preliminary data, were too favourable. An operation plant designed and built before the orebody is properly and fully evaluated can result in an inappropriate mining method or rate or process flow sheet, potentially resulting in a corporate disaster.

- preliminary selections for location of facilities are reasonable at the time but not reviewed as more data becomes available. An easily understood example could be shaft location, properly located relative to the location of reserves at the time of preparation of a Preliminary Feasibility Study but which should be moved when 2 or 3 years later The Feasibility Study is done and the centre of gravity of reserves has moved several hundred of metres.

## CONCLUSIONS

In conclusion, Preliminary Feasibility Studies are extremely important documents. In many ways they are more important than "The Feasibility Study" as this latter document is normally a confirmation of results, is prepared at a time when all necessary basic data is available and few, if any, surprises can or should occur.

Preliminary Feasibility Studies have many uses and should not only be considered as evaluation reports but as documents for planning and effective project management.

They should be done by highly experienced people as they can represent the life or death of a project and be a blue print for all future activities.

## APPENDIX I

DEFINITION OF TYPES
OF
ECONOMIC FEASIBILITY STUDIES

## DEFINITION OF TYPES

## ECONOMIC FEASIBILITY STUDIES

The following definition of four types of economic feasibility studies is intended to clearly indicate the information required, the skills employed and the basis for each type of study. Further, the use for which each type of study is intended is outlined.

A definition of this nature must naturally use generalizations. Inevitably, there will be projects which do not easily fit this categorization. The intention is to provide an easily understood basis for discussing studies of any project.

## DEFINITION OF TYPE 1

## ECONOMIC FEASIBILITY STUDY

### Basis

A Type 1 study may be carried out before any drilling has been done, but is usually carried out after preliminary drilling of a mineral deposit has indicated the attitude and possible dimensions, as well as grade. It is based on assumed ore reserves, nominal plant capacity, assumed flowsheets, assumed process requirements, often without metallurgical test work, or seldom more than preliminary bench scale test work. Product specifications will be assumed. A visit to the actual site may or may not be made. No design drawings are prepared beyond "scratch pad" sketches made by the project engineer. Equipment lists are prepared based on the assumed flowsheet and priced on updated former quotations or telephone quotes from vendors' representatives. No equipment specifications are prepared, no vendors' proposals are solicited. Total facility costs are determined by roughly estimating building volume and foundation concrete and applying unit costs. Percentage factors are used for installation of machinery. Electrical costs other than motors and substations are estimated as unit costs per installed horsepower. Percentage factors are used for contractors' field overhead, construction plant, construction camp, design costs, procurement and contractors' profit. Revenue projections are based on assumed metallurgical recoveries and historical payment terms for the products.

### Information Required

It is necessary to know the milling capacity required by the client and for calculating operating costs, it is helpful to know the range of local labour rates, statutory and union required labour burden and the approximate cost of basic supplies such as fuel, power, explosives, grinding media, reagents, etc.

### Skills Employed

Of necessity, a Type 1 estimate must be made by a project engineer with experience in that sector of the mining industry covered by the feasibility study. Because of the lack of design drawings and specifications, professional estimators and purchasing people cannot be brought into the study. However, recent experience can be used for up-dating percentage factors and unit costs. Often the project engineer depends heavily upon his personal acquaintances among vendors and in operating companies.

## Use of Estimates

A Type 1 estimate contains heavy contingencies. These may range from 20% to 25% on structures and 10% to 15% on machinery. The percentage assigned to contingencies is a judgement factor, and is not to be interpreted as meaning that estimates are necessarily accurate within this percentage range, nor is there an implied reference to any order of accuracy. A Type 1 estimate may frequently be suitable to reject a project, but it is seldom adequate for positive acceptance of a project. It is often very useful in setting targets to guide the execution of an exploration program. A Type 1 estimate is also used for preliminary comparison of alternates and generally describes a hypothetical installation.

# DEFINITION OF TYPE 2

# ECONOMIC FEASIBILITY STUDY

## Basis

A Type 2 estimate is usually carried out after drilling has confirmed the shape and attitude of the mineralization. Some reserves might be calculated as drill-indicated and the potential reserves are probably becoming clear. There should be sufficient bench scale metallurgical test work to determine the probable process flowsheet and approximate material balance, and to size major items of process machinery. Product specifications will be determined following preliminary indications from buyers. One or more visits to the actual plant site are mandatory. Minimum general arrangement drawings are prepared, and equipment lists are based on recent letter quotations from vendors. Specifications are not prepared, and inquiries are usually limited to a single vendor. Facility costs are estimated by making approximate quantity take-offs from the general arrangement drawings and applying unit cost factors elsewhere. While foundation, concrete, and structural steel are not defined in detail, it is possible to make approximate estimates from the drawings. Machinery installation and electrical costs can be estimated more accurately than in Type 1. However, percentage factors are still employed for many installation costs. Percentage factors are used to determine indirect costs. Revenue is estimated on the basis of probable plant performance and current terms being currently offered by smelters or other buyers.

## Information Required

It is necessary to know the plant capacity required by the client and some written reports from competent metallurgical laboratories should be available concerning process requirements for calculating operating costs. Actual labour contracts from the area should be obtained, and letter quotations should be obtained from suppliers of basic materials such as fuel, explosives, grinding media, reagents, etc. Written schedules should be obtained from utility companies serving the area.

## Skills Employed

A Type 2 estimate is made under the supervision of a project engineer, knowledgeable in the sector of the mining industry covered by the feasibility study. However, since minimum general arrangement drawings are available, assistance may be sought from professional estimators, familiar with the sector covered by the study.

## Use of Estimates

Type 2 estimates still contain heavy contingencies, amounting to 15% to 20% for structures and at least 10% for machinery and installation. The percentage assigned to contingencies is a judgement factor, and is not to be interpreted as meaning that estimates are necessarily accurate within this percentage range, nor is there an implied reference to any order of accuracy. A Type 2 estimate may be suitable to indicate feasibility, but it may not be adequate for budgeting the project, depending on individual client policy. A Type 2 estimate usually describes a conceptual installation that might be built rather than the installation which will be built.

## DEFINITION OF TYPE 3

## ECONOMIC FEASIBILITY STUDY

### Basis

A Type 3 estimate may be undertaken once ore reserves are well defined within acceptable confidence limits for that type of ore body. Bench scale test work will be largely completed and will be supported with pilot plant investigations, if required. Product specifications will be based on market investigations. Several visits to the plant site may be required. Equipment lists and general arrangement drawings supported by one line piping and electrical drawings are prepared. No equipment specifications are prepared and formal vendors' bids are not solicited; however, letter quotations should be obtained from more than one vendor for each item. Machinery installation costs are determined by weight factors, from past experience, or percentage factors. Electrical and piping costs can be based on approximate electrical and piping runs. An estimate will be prepared for construction plant and camp, and estimates for design costs can be more highly refined. Revenue is estimated on the basis of estimated plant performance and payment indications from smelters or other buyers.

### Information Required

It is necessary to have accurate topographic maps available as well as preliminary soil data. Written reports should be available concerning bench scale and pilot plant work. Actual labour contracts from the area should be obtained and letter quotations should be obtained from suppliers of basic materials such as fuel, explosives, grinding media, reagents, etc. Written schedules should be obtained from utility companies serving the area. Use permits from government agencies should be investigated where required. Air and water pollution regulations should be investigated.

### Skills Employed

A Type 3 estimate is made under the supervision of a project engineer knowledgeable in the sector of the mining industry covered by the feasibility study. Because of the existence of general arrangement, piping, electrical, and instrument drawings, it is possible to use professional estimators skilled in electrical, piping and instrumentation estimating as well as estimators who are familiar with the industry covered by the study.

## Use of Estimates

A Type 3 estimate has reduced contingencies; however, the overall contingency is still of the order of 10% to 15%. The percentage assigned to contingencies is a judgement factor, and is not to be interpreted as meaning that estimates are necessarily accurate within this percentage range, nor is there an implied reference to any order of accuracy. A Type 3 estimate is generally suitable to determine feasibility and assist management in establishing a budget for the project. Financing is often arranged on the basis of a Type 3 estimate. A Type 3 estimate generally describes the installation that probably will be built rather than an installation which is conceptual only. The drawings prepared may become the basis for detailed engineering.

# DEFINITION OF TYPE 4

# ECONOMIC FEASIBILITY STUDY

## Basis

A Type 4 estimate is based upon proven ore reserves and contains all of the input of a Type 3 estimate with regard to process information. Product specifications will be finalized, based on thorough market investigations. It is based on general arrangement drawings, supported by piping and instrument drawings, and general arrangement drawings of structural steel and concrete. Drawings prepared may constitute approximately 25% or more of the drawings that will ultimately be required for the project. The total facility costs are estimated by making quantity take-offs and obtaining subcontract quotations for steel and concrete. Specifications are prepared and submitted to several machinery vendors who are requested to submit formal proposals. Machinery installation and electrical costs are determined by a professional estimating department. A detailed estimate can be prepared covering construction plant and construction camp and the contractors' field overhead. Sufficient drawings have been provided so that a detailed estimate can be made of the remaining engineering costs. Revenue projections are derived from calculated plant performance and payment terms determined from written proposals from smelters or other buyers.

## Information Required

In addition to all of the information input contained in Type 2 and Type 3 estimates, it will be necessary to have accurate topographic maps and actual surveys of the plant site, together with foundation data. A professional estimator should make several trips to the field with the project engineer to obtain information on all local codes and regulations pertaining to land use, and air and water pollution. Availability and cost of labour should be thoroughly investigated. All of the factors mentioned in Type 2 and Type 3 estimates which affect operating costs should be obtained in detail, preferably in written quotations from vendors and utility companies.

## Skills Employed

A Type 4 capital cost estimate is made entirely by professional estimators, supervised by the project engineer. Operating costs are estimated by the project engineer.

Use of Estimates

A Type 4 estimate contains minimum contingencies, but never less than 10%. The percentage assigned to contingencies is a judgement factor,and is not to be interpreted as meaning that estimates are necessarily accurate within this percentage range, nor is there an implied reference to any order of accuracy. A Type 4 estimate may be suitable for funding of the project; however, clients may differ as to the amount of detail which they require for funding. A Type 4 estimate should enable the client to authorize the engineers to proceed with a turn-key job of detailed design and construction. Additional detail design will be required, but the designs and estimates provided in the Type 4 estimate are for the plant that will be built and at this point further modifications would be minimal. A Type 4 estimate is seldom undertaken unless there is reasonable assurance as to the feasibility of the project. It may be follow-on work after a Type 1, Type 2 or Type 3 estimate. Financing is often arranged on the basis of a Type 3 estimate.

## APPENDIX II

## TYPICAL TABLE OF CONTENTS

## PRELIMINARY FEASIBILITY STUDY

## TYPICAL TABLE OF CONTENTS

*TABLE OF CONTENTS*
*(cont'd)*

# APPENDIX III

## REFERENCES

## REFERENCES


Berry, Charles W.
1988: Financial rules of thumb for mine evaluation.

Lattanzi, Christopher R.
1989: Significant factors in mine valuation. CIM Meeting, May 2, 1989.

Slavich, D.M.
1982: Project evaluation - a key step to implementation. CIM Bulletin, July, 1982.

Smith, L.D.
1988: Economic variables in project evaluation. Presented in Sao Paulo, Brazil, October, 1988.

Wood, John A.
1973: Preliminary feasibility studies and evaluation. SME Mining Engineering Handbook, 1973, pp. 5-84 - 5-92.