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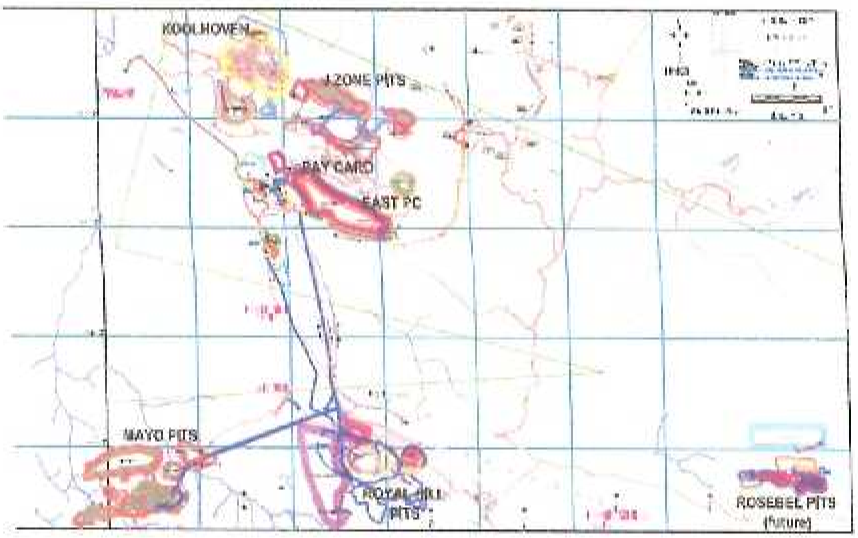
AN ECONOMIC ANALYSIS ON THE OUTSOURCING OF ORE AND WASTE HAULAGE AT THE ROSEBEL GOLDMINES



A thesis submitted for partial compliance of the requisition for the degree of

BACHELOR OF SCIENCE

IN

MINERAL RESOURCE MANAGEMENT

by

Winston Aboikoni

2012

Approval

To: Prof. Th. Wong

(Head Department of Geology and Mining)

The thesis, written by Aboikoni Winston, titled "AN ECONOMIC ANALYSIS ON THE OUTSOURCING OF ORE AND WASTE HAULAGE AT THE ROSEBEL GOLDMINES", is approved with regard to style and intellectual content, is referred to you for review.

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Date of presentation: 30 May 2012

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Table of Contents

List of Figures

List of Tables

List of appendices

Definitions and Abbreviations

Definitions: The following is a short list of definitions of the terms and units often used in this study.

Terms:

***Capital Costs*:** The opportunity cost of the funds employed as the result of an investment decision; the rate of return that a business could earn if it chose another investment with equivalent risk.

***Payload*:** Refers to the weight of material transported by a loaded truck.

***Stockpile*:** A storage place for ore for future use.

***Hauling*:** The activity of transporting material by truck.

***Depreciation*:** Decrease in value of an asset due to use.

Units:

***Mass unit*:** Masses and weights are expressed in metric tonnes or 1000 kilograms with a symbol of tonnes or mt.

***Financial unit*:** All dollar amounts are expressed in U.S. dollars.

Abbreviations:

Abbreviation	Explanation
EA	Economic analysis
KoolH	Koolhoven
KH Pit	Koolhoven pit
HGS	High Grade Stockpile
LGS	Low Grade Stockpile
PC Pit	Pay Caro pit
RH	Royal Hill
MCR	Main crusher
MA Dump	Mayo dump
Sm Crusher	Small crusher
PC cent Dump	Pay Caro central dump

Abstract

Hauling costs are one of the major cost components in any mine venture. Since there is a possibility for cost savings when using a contractor to haul material (ore or waste) at the Rosebel Gold Mines, an economic analysis was performed on the possible cost savings with such a contract and options for outsourcing were determined. This thesis examines the possibility of outsourcing hauling operations at the Rosebel Gold mines to a contractor and focuses especially on the hauling costs savings that can be made with a possible contract.

The actual data from January to May 2009 on 777 haulage costs and the contractor 40 tonne trucks haulage costs were analyzed. The haulage costs were evaluated and discussed in order to determine whether outsourcing would be beneficial.

The analysis showed that if the RGM had used the contractor to haul all of their Mayo ore to the feeder via the Mayo "High Grade Stockpile" (HGS) and had they re-allocated the 777s previously performing long Mayo ore hauls (from the pit and HGS to the feeder) to shorter hauls they could have reduced their mining cost by 1.8% $/t overall to produce a savings of $692,015. The total tonnes produced would have climbed by 14%. The study also shows that every tonne transported with contractor has saved them $0.32.

1. Introduction

Rosebel Gold Mines N.V. (R.G.M.) is a gold mining company operating in the district of Brokopondo in Central Suriname. At the time of this study the Rosebel property consisted of 6 mining pits: Mayo, Rosebel, Pay Caro, East Pay Caro, Royal Hill and Koolhoven. The property is located in an area of high rainfall and mining operations (especially haulage) are sensitive to rain. The mining activities were at Royal Hill, Pay Caro, Koolhoven and Mayo. Haulage is accomplished by 100-tonnes CAT777 haul trucks with 85-tonnes payload. A contractor was also hauling from the Mayo high grade stockpile to the feeder. Excavated soft ore goes straight to the apron feeder for further processing; hard ore must be crushed for further processing. Material rated as waste is taken to the waste rock storage areas near the pits.

Mining cost reduction and increasing productivity are important issues for every mining company, which is also one of the reasons why mining companies sometimes turn to the outsourcing of their operations. As hauling costs are one of the major cost components in the RGM mine venture, outsourcing components of this operation might be an option to reduce the mining cost.

Given that the contractor is already hauling material from one of the pits to the feeder and the possibility of outsourcing other routes in the future, the Problem of **"is it profitable for the R.G.M. to outsource haulage"** needs to be answered.

In accordance with the problem statement, the 2 main objectives of this project are:
To identify haulage cost savings in outsourcing the haulage of material (ore and waste) at the Rosebel Gold Mines.
To identify which hauling route is the best option for outsourcing.

During this project the hauling costs at the RGM are analyzed. As case study, an analysis of the calculated haulage costs for 777 trucks and for the contractor trucks under conditions at that time is performed.

The thesis consists of 5 chapters:

The introduction is in the first chapter. Chapter 2 gives the background information of the study area such as geology and general information about the subject of the project. Chapter 3 describes the methods used during the project to achieve the results, followed by the presentation of the results in chapter 4, discussion and conclusion in chapter 5, recommendations in chapter 6 and finally the references in chapter 7.

2. Literature Review

2.1 Location and Description of the Rosebel property

The Rosebel concession covers an area of 170 square kilometers in the north central Suriname at a latitude of 55° 25' North and a longitude of 55° 10' west. The property is located in the District of Brokopondo, between the Suriname River to the east and the Saramacca River to the west, approximately 80 kilometers south of the capital city of Paramaribo (figure 2.1). Rosebel is located in an area of small hills covered with tropical rain forest and separated by flat-lying savannah with a light cover of low trees, shrubs and grass. The climate is typically tropical, with high humidity and mean temperatures varying from 26°C to 28°C. There are two wet seasons each year: late April to mid-August and early December to early February, and the October dry season can result in near-drought conditions. Average rainfall at the project site is about 2,200 millimeters per year. Suriname is in a low seismic zone.

The Rosebel concession lies within the Guiana Shield, a Paleoproterozoic massif of rocks in the northwest corner of South America between the Orinoco and Amazon river basins, to the north and south respectively (figure 2.2).

A number of orogenic gold deposits occur within the Rosebel Concession along three major mineralized trends. The first occurs in the northern limb of the regional synformal structure, has a strike length of 12 kilometers and hosts the Pay Caro- East Pay Caro, Koolhoven and "J" Zone deposits as well as the Spin and Mamakreek anomalies. The second mineralized trend occurs in the southern limb, has a strike length of 15 kilometers and hosts the Mayo, Royal Hill and Roma deposits, as well as the Mossanto Hill, Eriaan Hill and Blauwe Tent exploration targets. (Paul Johnson et al., 2002)

Figure 2.1 Location of the Rosebel property*(IAMGOLD Annual Report 2008)*

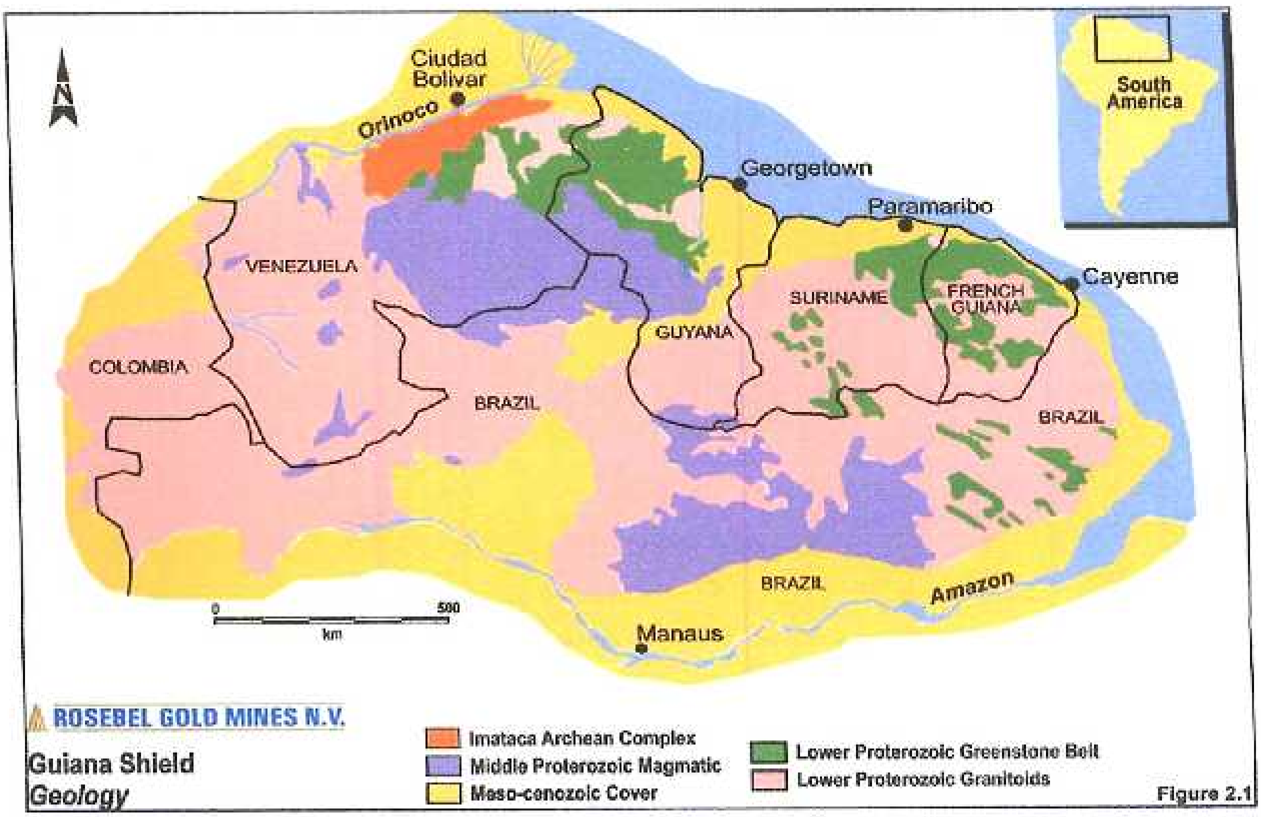

Figure 2.2 Geology of the Guiana Shield (Rosebel Goldmines Project Report 2002)

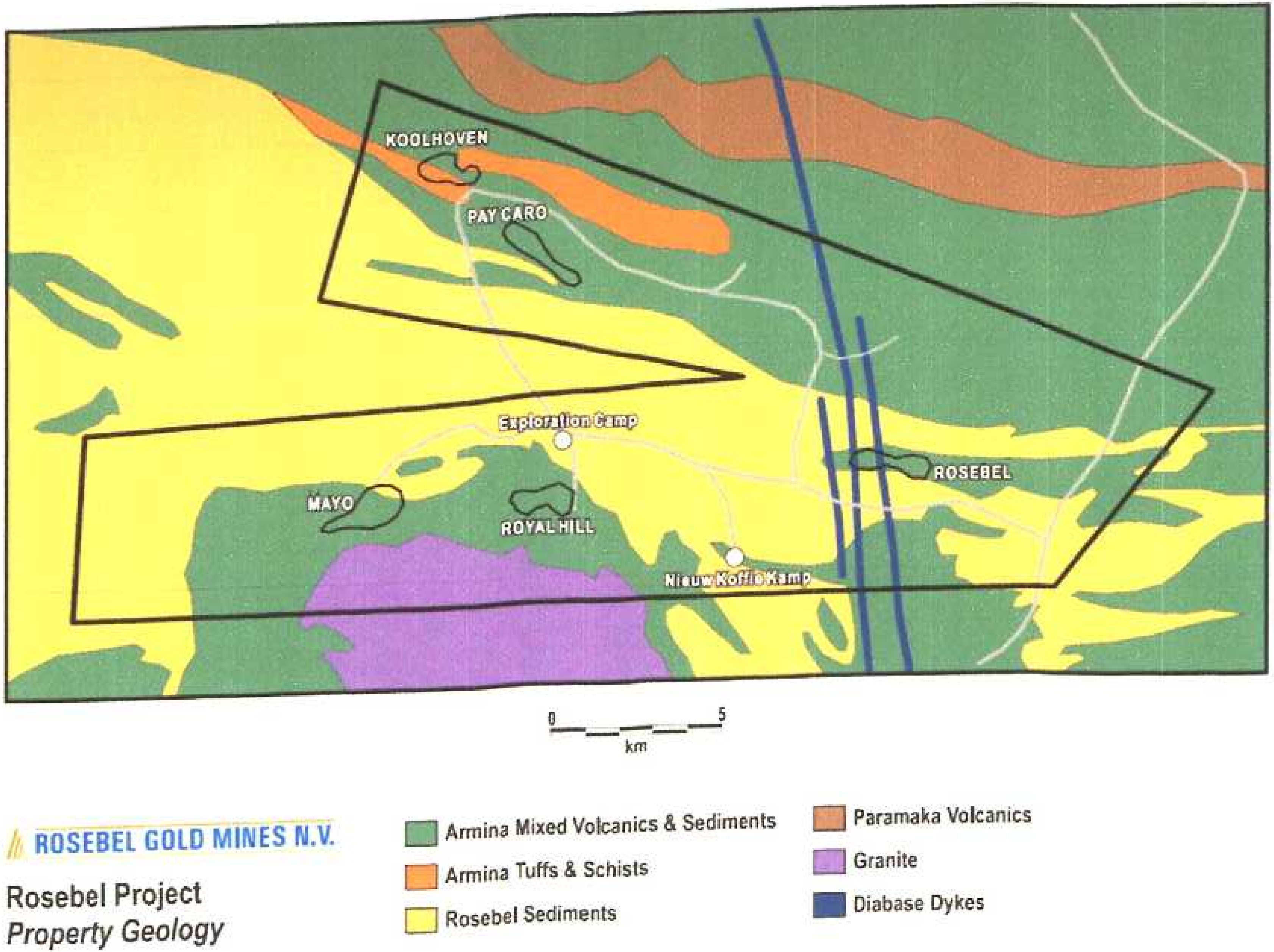

Figure 2.3 Geology of the Rosebel Project Property

(Rosebel Goldmines Project Report 2002)

2.2 Mining at Rosebel Gold Mines N.V.

Mining operations are based on the operating experiences of Omai Gold Mines Limited (OGML) in Guyana, which shares many similarities with the Rosebel Project. The current mining activities are taking place at five open-pits: Royal Hill, Pay Caro, East Pay Caro, Koolhoven and Mayo. Three additional pits will be mined in the future: Rosebel, Roma and J-Zone. The deposits in the pit areas generally have the following stratigraphy: a residual soil (saprolite) overlying highly weathered sedimentary or volcanic rock (transition) which in turn overlies fresh sedimentary or volcanic rock (hard rock).

Mining is by conventional open pit methods, using shovels and trucks. Mining is done on benches of five meters in height, although near-surface ore zones may be mined with a smaller bench. Mining benches are developed on a slope of 2 percent to facilitate drainage. All of the material mined requires drilling for sampling and grade control purposes. Material is designated as soft rock, transition, or hard rock with the latter two types requir[illegible]ing.

The mining sequence includes drilling, blasting and hauling for both ore and waste rock. Production drilling is accomplished by a fleet of drills drilling 150-millimeter diameter holes. The soft rock doesn't require blasting, but all material is drilled and sampled to delineate the ore zones. Soft rock is drilled using rotary bits, while transition and hard rock are drilled using down-to-hole hammer bits. Soft rock is excavated without blasting, while hard and transition rocks need to be blasted. The drilling pattern is approximately 4 meters by 4 meters, with a sub grade varying from 0.5 meter to 1 meter. If blasting is necessary the same boreholes drilled for sampling are used to place the explosives.

Excavation of material is done by $4 m^3$ backhoes, $10\ m^3$ hydraulic shovels and $10\ m^3$ front end loaders. Generally, hydraulic backhoes are used for the selective excavation of soft and transition ore. Hydraulic shovels are used for the excavation of ore and waste (figure 2.4). Front end loaders are used to handle stockpiled material, as well as blasted rock. Additional small backhoes are used for ditching and related tasks.

Excavated material rated as ore goes straight to the apron feeder (in case of soft rock) for further processing or first to the crusher if necessary (in case of hard rock) and then to the feeder. Excavated material rated as waste is taken to the waste dumps. Waste dumps are located adjacent to the individual pits.

Three stockpiles were developed nearby the mill site; for high grade transition rock, for high grade soft rock and for low grade soft rock. Waste rock is hauled to the waste dumps near the pits, while ore from the mining areas is hauled either to the feeders or to the different stockpiles near the pits.

2.3 Hauling at the RGM

Hauling units

Haulage is done with 85-tonnes payload haul trucks (CAT 777 mining trucks, figure 2.5 and 2.6). The haulage fleet at the time of the study consists of 32 haul trucks. The haulage fleet is now expanded to more trucks.

Figure 2.4: Hydraulic Shovel loading 777 haul truck at the mine site (RGM)

Figure 2.5: 777 truck (empty) at the aggregate plant site (RGM)

Figure 2.6: 777 truck (loaded) on a haul road at the RGM

Haul roads

The haul roads at the Rosebel project are built with mine waste rock and capped with a layer of crushed hard rock (figure 2.7). These haul roads are responsible for the connectivity of the individual pits with waste dumps, stockpiles and the feeders.

The general design criteria of haul roads are as follows:

Road width:	25 meters
Traveling surface:	20 meters
Maximum grade:	10 %

The resistance of the haul roads is strongly weather dependent, as the conditions of the roads change dramatically, for example with heavy rains. During rainy seasons the haul roads must be capped with crushed rock more often, whereas during the dry season continue watering of haul roads is required. This must be done in order to maintain a good road condition and good haulage productivity.

At Rosebel Gold Mines N.V. loading and hauling operations are controlled through a computerized truck dispatch system, the Wenco system. The system monitors the location of the production equipment, assigns trucks to loading units and provides production data.

Figure 2.7: Haul road, capped with crushed rock (RGM)

2.4 Outsourcing at the RGM

There are a couple of activities that were already being outsourced at the Rosebel Goldmines. These were for example several forms of transports and construction projects and ground moving activities, such as: (Haukes report Company profile, 2009).

- Transport of mine and personnel supplies
- Transport of dynamite and cyanide
- Transport of diesel
- Clearing & grubbing new mine area's
- Rental of various heavy equipment
- Labor contracting
- Material haulage (figure 2.8)

Figure 2.8: Contractor truck in a mining area

2.5 Outsourcing mining operations

Outsourcing refers to a company that contracts with another company to provide services that might otherwise be performed by in-house employees. The decision whether to outsource or to do in-house is often based upon achieving a lower production cost, making better use of available resources, focusing energy on the core competencies of a particular business, or just making more efficient use of labor, capital or land resources. (Hoogeveen D., 1994)

Other reasons for outsourcing are:

- Improve risk management
- Increase flexibility to meet changing business conditions
- Lack of internal expertise
- Faster setup of the function or service
- Less dependency upon internal resources
- Control of budget

While fundamental changes in unit-operations technologies are taking place, the way in which mining equipment and services are being acquired, operated, and maintained is also changing dramatically. Mine activities that are commonly outsourced include drilling and blasting operations, equipment-performance and regulatory compliance monitoring, warehousing, and maintenance and repair. An important advantage of outsourcing for mining companies is that these companies often can draw on the know-how accumulated by specialists from operations both within and outside mining (e.g., engine or lubricant manufacturers). Finally, by moving maintenance functions off-site, mining companies can ease their regulatory-compliance burdens. Some disadvantages and impediments to operations outsourcing are: managing the logistics of several maintenance contractors operating on-site, mistrust of contractors or the feeling that they are not members of the "mine team," and questions of union acceptance. Analyzing of cost components is therefore required before turning to outsourcing.

2.6 Economic analysis (EA)

An EA is a systematic method for studying problems of choice. Alternative ways to satisfy a goal (requirement) are studied by evaluating the quantifiable costs and benefits of each alternative. These costs are assessed objectively using economic and statistical techniques so that alternatives can be compared through a numerical ranking (Pedro Belli et al., 1997).

2.6.1 Goal of economic analysis

The goal of EA is to compare quantitative cost and benefit information for alternative solutions to a problem or requirement.

a. An EA promotes a clear understanding of the stated need, possible solutions, and cost implications. It allows the analyst to compare options on an equal basis (in time).

b. The EA approach results in an objective assessment of all costs, benefits, and uncertainties. Once identified, uncertainties can be evaluated through sensitivity analyses.

c. The ultimate goal is that tax dollars are spent most economically (Pedro Belli et al., 1997).

2.6.2 General guidelines for performing economic analysis

EA development consists of seven basic elements. An overview of these elements is given below. Chapter 3 contains a detailed discussion of each step.

a. Objective. State the purpose of the analysis clearly and concisely and, if possible, in quantitative terms. This is done so that a reviewer understands the project requirement to be met.

b. Develop a complete list of alternative solutions to the requirement.

This list will include feasible and non-feasible alternatives. If any alternative is left off of this list the validity of the EA may be questioned. Not including all alternatives biases the EA.

c. Document any assumptions. The impact of assumptions can be tested later in sensitivity analyses.

d. Collect cost and benefit data. Sources of data and the data calculations must be documented as they are very important in determining accuracy.

e. Perform the EA calculations accurately. Nothing can cause a reviewer to return an EA more quickly than to find mathematical errors. Most errors can be avoided by using one of the standard computer programs.

f. Perform sensitivity analysis. Test uncertainties in cost or benefit data—their values or the times they occur—to determine their impact on the results of the EA. Sensitivity analyses must be performed when large uncertainties exist.

g. Report the EA results and recommendations. This is essential to show management and decision makers that the best alternative has been selected and recommended for funding (Pedro Belli et al., 1997).

2.6.3 Principles of Economic Analysis

The economic analysis process

The seven steps in the EA process are shown in figure 2.7 and discussed in detail below.

Steps of an economic analysis:

Step 1: Establish the objective. The single most important step in an EA is to define the objective. Without a clear, concise statement of what the EA is to evaluate, the EA will not be successful. With this definition, the analyst sets the objectivity of the analysis.

b. Step 2: Identify alternatives. The next step is to list alternatives initially considered to meet the objective. Alternatives that are not feasible must be discussed in the documentation but need not be included in the cost comparison. An alternative is said to be feasible if it fully meets the stated objective.

c. Step 3: Formulate assumptions. In most EAs, the analysts must make some assumptions. Common assumptions include the estimated useful life of an asset, an estimated requirement, and the future cost of a required repair action.

d. Step 4: Estimate costs and benefits. This step is the most difficult and time–consuming part of an analysis. The analyst must consider costs and benefits associated with each alternative and how to collect or estimate them.

e. Step 5: Compare costs and benefits and rank alternatives. This step is the heart of the analysis. It is also the easiest, because once the first four steps have been completed, the comparisons and ranking can be done using computer programs. Comparisons give managers the information needed to make informed decisions. Once the costs and benefits for all options are found, one option can be compared with another.

f. Step 6: Perform sensitivity analysis. A sensitivity analysis is a "what–if" exercise. It tests whether the conclusion of an EA will change if some variable such as a cost, benefit, or assumed inflation rate changes.

(1) Sensitivity analyses should always be performed when:

(a) The results of the EA do not clearly favor any one alternative.

(b) There is a great deal of uncertainty about a cost, benefit, or assumption in the EA.

(2) If a change in a variable or assumption causes a change in the ranking of alternatives, the EA is said to be "sensitive" to that variable or assumption. By performing a sensitivity analysis and including its results in the report, the analyst ensures the decision maker that uncertainties in the EA have been tested and the results documented.

g. Step 7: Report results and recommendations. The EA report should be detailed and include data sources. It is important to state the recommendation because the cost comparison alone may not determine which alternative best meets the objective (Pedro Belli et al., 1997).

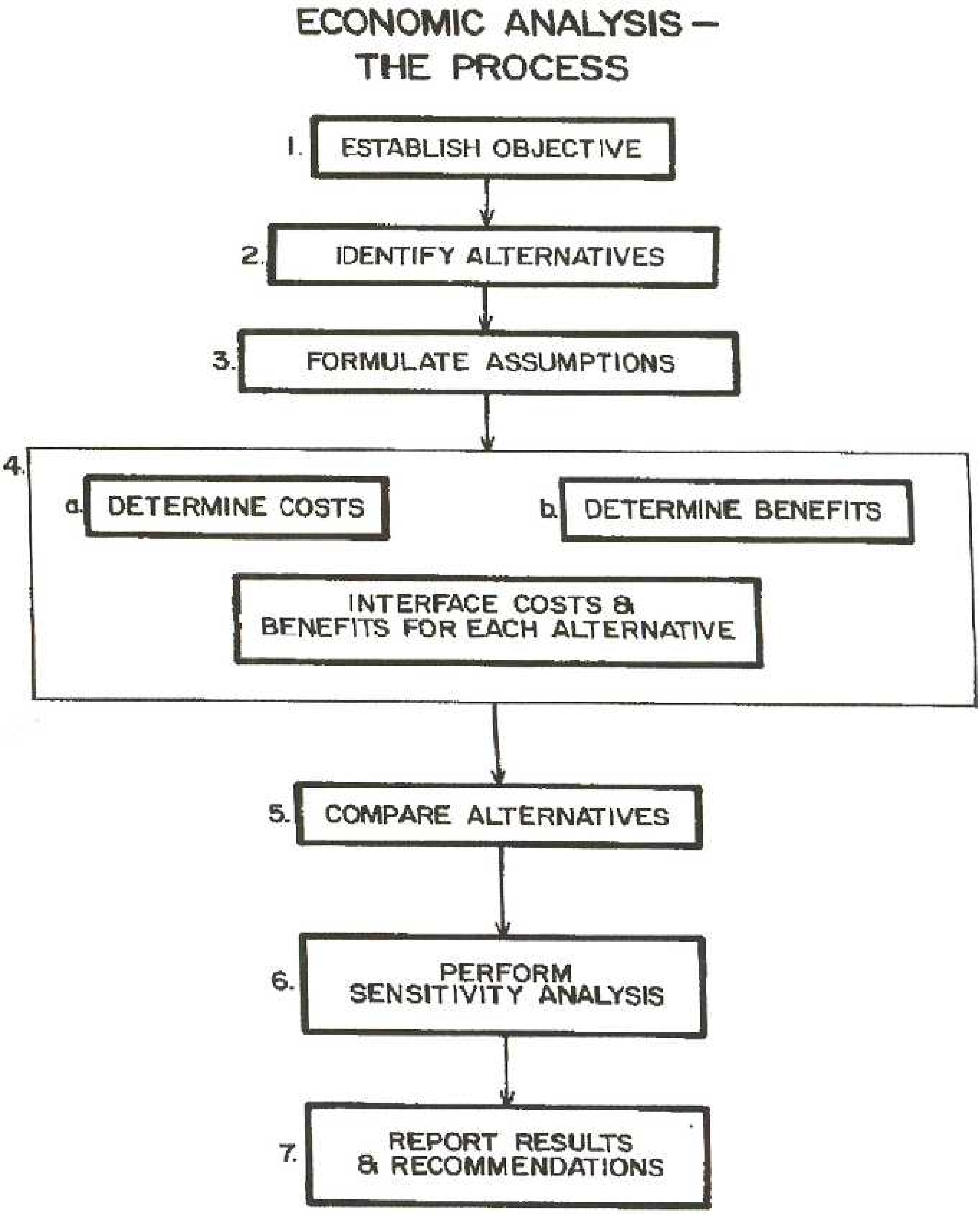

Figure 2.9: Steps of an economic analysis (Economic Analysis: Description and Methods, 1992)

2.6.4 Classes of economic analyses

There are two types of economic analyses— secondary and primary. A secondary analysis is for a situation in which a new requirement is to be met, or when the current method of meeting a requirement is no longer suitable to meet that requirement. A primary analysis is performed when a better, *less costly* way to meet an existing requirement is proposed; that is, although the requirement is being met by the current method, a better method is available.

a. Secondary analysis. In a secondary economic analysis, the most economical option is selected from a group of options, all of which will perform a function or satisfy a mission which is not justified on the basis of dollar savings. For example, an additional facility requirement may be justified due to the expanded mission of an installation. The economically preferred alternative does not result in an absolute savings; rather it represents the least–cost alternative relative to other possible alternatives.

b. Primary analysis. In this type of analysis, the purpose of comparing alternatives with a present method of operation for meeting a requirement is to minimize costs. Investments supported by primary EAs must predict absolute cost savings over the present method of meeting the requirement.

3. Methodology

As described in the introduction, analyzing the hauling costs of both the 777 and the Contractor 40t trucks is very critical for the selection of the hauling road to be outsourced to the contractor. To analyze the hauling costs of the hauling units at the Rosebel Goldmines, several evaluations were made. A literature study was carried out prior to starting the data collection and evaluation. For the data collection, software's of the RGM engineering department were used: Wenco DB and the RGM engineering Server. Figure 3.1 gives an overview of the evaluations and calculations done during the course of this study.

The evaluations made were as follows:

- Evaluation of the material movement during the first quarter of 2009
- Calculation of the Hauling unit cost from source to destination
- Calculation of the hauling unit productivity from source to destination
- Haulage cost savings comparisons

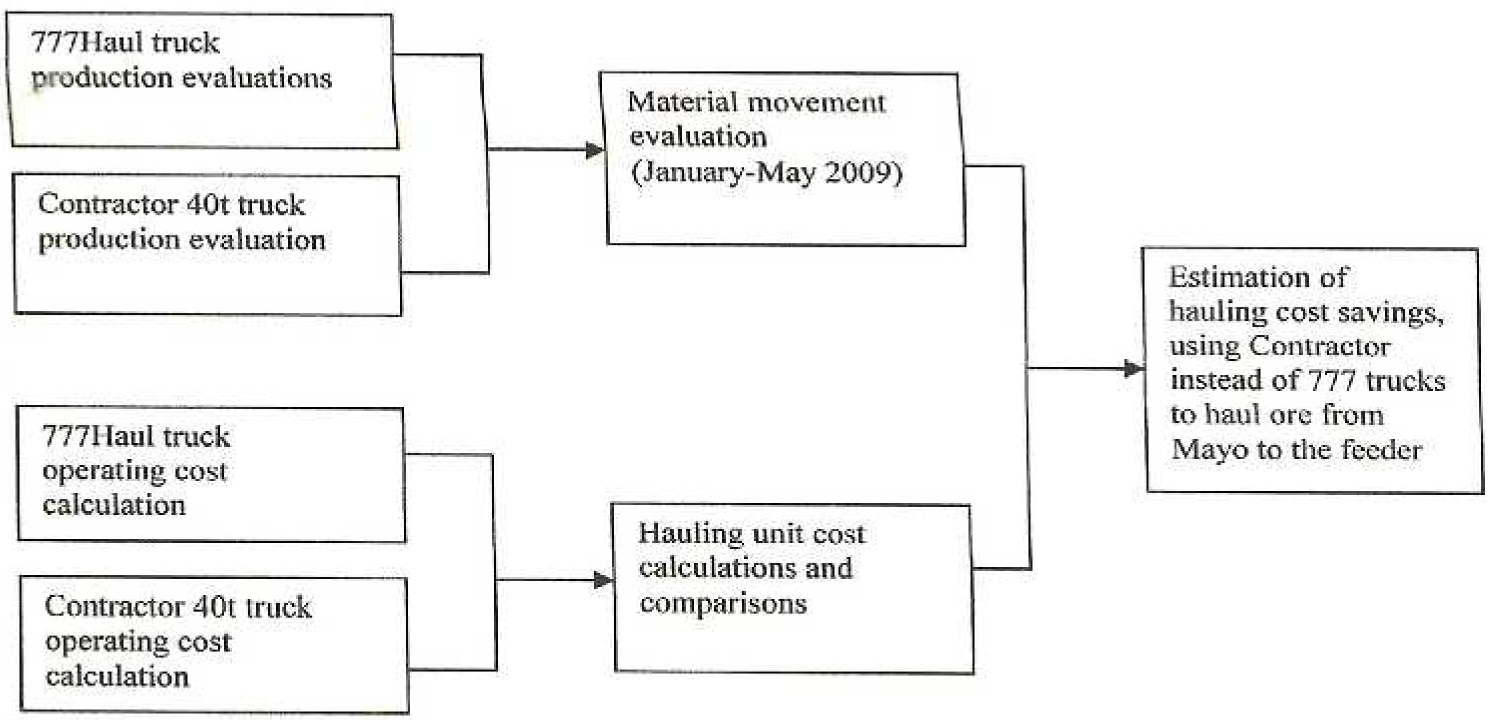

Figure 3: Overview of calculations and evaluations

3.1 Evaluation of the material movement from January to May, 2009

Material (ore and waste) movement at the Rosebel Goldmines from January to May 2009 was evaluated on quantity, source and destination (Table 1). The production from the different routes (from source to destination) was filtered down to 90% of the total production to limit the study to material transported from 8 sources to 18 destinations.

The data used for the calculation of the total production was gathered from the WencoDB Home computerized dispatching system reports for the period of 1 January 2009 until 31 May 2009.

The following equations were used to reduce the data to 90% of the total production:

Total production =∑daily tonnage from January to May (t)

Cumulative daily production/Total production = 0.9

As haulage productivity is inversely proportional to haul distance, the production per route was related to the distance to have a better understanding of the influence of each route hauling operation on the overall hauling operation.

Equation:

Production per distance = Tonnes*distance

Percentage of Fleet = production per distance/ Fleet

*Where Fleet is the sum of all individual Tonnes*distance*

Trucks required = percentage of fleet*(total trucks*0.9)

Total truck refers to the number of 777trucks used for the hauling operations.

The factor 0.9 is used to correct the number of trucks used due to the fact that only 90 percent of the actual production was included in the analysis.

Table 1: Example of the calculation worksheet used for the evaluation of the material movement from Januaryto May 2009

Month	Origin	Destination	Tonnes	Cumulative production(t)	Percentage
Month A	KH Pit	KOOLH DUMP	Input 1	Input 1	Input 1/Total production
Month B	KH Pit	KOOLH DUMP	Input 2	Input 1+ Input 2	(Input 1+ Input 2)/ Total prod.
Month C	KH Pit	KOOLH DUMP	Input 3	Input 1+ Input 2+ Input 3	(Input 1+ Input 2+ Input 3)/ Total prod.

3.2 Calculation of the Hauling unit cost

To calculate the current hauling unit cost for 777s, the following data was required:

- Total hauling cost/ 1st quarter 2009:

  This is the cost made for the overall hauling of material (ore and waste) from different locations to destinations during the months January to April 2009.

  The total hauling cost/ 1st quarter 2009 = total operation cost 1st quarter 2009+ total maintenance cost1st quarter 2009

- Tonnes moved/ 1st quarter 2009

This is the total amount of material (ore and waste) hauled from all sources to destinations in the 1st quarter of 2009.

The hauling costs and total tonnes moved were obtained from the quarterly production report on the RGM Engineering server.

After calculating and obtaining the data above, the total hauling cost from January to May was calculated by the use of the following Equation:

$$\underline{\text{Total hauling cost (Jan-May)}} = \text{Total hauling cost (Jan-April)} \times \frac{\text{tones moved (Jan}-\text{May)}}{\text{tones moved (Jan}-\text{April)}}$$

The haulage production from all pit areas to all destinations gives a great number of different route possibilities for haulage. To limit the analysis to routes that are associated with the direct haulage operations from pits and stockpiles to the feeder and crusher, the haulage production was reduced to 90% of the total haulage production from January to May. This gives a more easily workable number of route possibilities. The total hauling cost (Jan-May) was multiplied by 0.9 to get the correct number required. The number of possible routes for hauling is 32.

The total mining unit cost:

The total mining unit cost is the overall cost made on the mining of 1 tonne material (ore/waste). It includes all costs that contribute to the mining operation costs.

The Equation used for the calculation of the total mining unit cost is:

Total mining unit cost = ∑(explosive cost + labor cost+ tire cost+ maintenance cost + fuel and lubes cost)

The costs made on the use of explosives for blasting, cost of wages paid to workers, maintenance cost, lubrications and tire costs are all included in the total mining costs.

The total hauling unit cost = total mining unit cost- 777 hauling unit cost

RGM is paying the contractor according to the amount of material hauled. Since the contractor equipments are fueled by the RGM, the contractor cost per tonne is calculated as follows:

contractor cost per tonne = contractor unit cost + fuel cost

Where the contractor unit cost is $/tonne charge by contractor per tonne material hauled.

Fuel cost refers to: (fuel cost / day)/ tonne hauled per day

The fuel cost was calculated as follows:

$$\text{Fuel cost per tonne} = \frac{\text{liters/tonne}}{\text{cost per liter}}$$

Cost per liter refers to the price of diesel fuel.

Liters per tonne = average liters of fuel needed to move 1 tonne material (Appendix 3).

3.3 Analyzing the mining costs with and without using contractor to re-handle and haul material at Rosebel

For a better understanding of costs made for hauling at each one of the different routes (combinations), the total hauling cost per unit of ore using 777 was compared to the cost per unit using the contractor.

- Unit cost ($/mt of material) = specific unit cost + (total mining cost-haulage unit cost)
- contractor unit cost = contractor unit cost($/mt of material) + fuel cost

The hauling route that produced the best results for replacement with the contractor is the one where the mining unit cost when hauling with contractor is less than the mining cost when hauling with 777 haul trucks. This hauling route was selected for further analyzing of the costs savings.

The costs savings when outsourcing a certain route is then the difference between the mining unit cost when hauling with 777 haul trucks and the mining unit cost when hauling with the contractor. This cost saving can be calculated for the annual total production, which gives an annual cost savings in case of outsourcing.

During the course of the study, the contractor was hauling only on the Mayo pit-feeder route. The data used for the calculations of the hauling cost made by the contractor where therefore derived from the information of the contractor hauling operations in this route.

3.4 Haulage cost saving comparisons

The route, selected from the analysis above was used for the further cost savings analysis with different possibilities on outsourcing this hauling route. 5 cases were formulated, where in each one a different possibility was analyzed (Appendix2):

- In case 1 (base case) the (current) actual production was used, with the 777 trucks and contractor hauling from the HGS to the feeder.
- In case 2 only the current 777 production was used. Excluding the contractor production.
- In case 3 it was assumed that all 777 on long ore hauls from Mayo and the HGS were parked.
- In case 4 the 777s were re-allocated on long ore hauls from Mayo pit and the Mayo HGS to work on other shorter hauls.
- In case 5 0.9 of the re-allocated 777s were returned back to Mayo, but only to mine to the HGS. The contractor is then used to re-handle and haul all ore from Mayo via the Mayo-HGS to the feeder.

Parameters used in the cost saving comparisons are:

- 777 Base Level Production (tonnes)
- Contractor Production (HGS to Feeder) (tonnes)
- 777 Additional Production (tonnes)
- Total Production (tonnes)
- Total Haul Cost($)
- Haul Cost/tonne
- Total Mining Cost (Fully Burdened)
- Total Mining Cost / Tonne Moved

The following calculations and assumptions were made for the cost saving comparisons:

- 777 Base Level Production (tonnes) = total tonnes moved from January 2009 to May 2009.

- Contractor Production (HGS to Feeder) (tonnes) = total tonnes moved by the contractor from the Mayo HGS to the Feeder (61 days of working)

- 777 Additional Production (tonnes) = the extra production for if the 777s working at Mayo were put to haul from other pits.

- Total Production (tonnes) = 777 production + contractor production

- Total Haul Cost($)= 777 Haul cost + contractor haul cost

- Haul Cost/tonne = Total Haul Cost divided by the Total Production

- Total Mining Cost (Fully Burdened) = (total production –(amount of material re-handled from the Feeder and Crusher)) times total mining cost per tonne moved

- Total Mining Cost / Tonne Moved = overall mining cost for each tonne of material moved

4. Results

4.1 Results of the material movement evaluations

The results of the costs, production calculations and evaluations are described here. Also presented are the cost saving comparisons of using contractor instead of 777 to haul material from Mayo. Some results are shown in tables to give a better overview of the numbers presented.

All possible material transport routes for 777 trucks (Table 2) and contractor 40t trucks (Table 3) were selected based on information from the map in figure 4.1 and information's on material handling at the RGM. From the gathered monthly production report sheets, the total production from all sources to destinations was calculated and appeared to be 11,401,094t during the first quarter of 2009 and 20,145,282 t from January to May 2009 (Appendix 1). The production used for the further calculations in the analysis was 18,130,754t and represented 90 % of the total production.
From the gathered information on the material movement from 8 sources to 18 destinations, 32 different combinations were found for further calculations. 16 of these combinations were ore transports and the remaining 16 were waste transports (Table 4). It also came to the attention that from all the amount of material being moved in this period, 19.6% was moved along the Mayo route and 28% along the Koolhoven route.
Since the period used in this analysis was January- May, the quarterly numbers were converted to get the correct number of data needed for further calculations. For the first quarter of 2009 it appeared that 4,753,941 tonnes of ore were displaced and 13,376,813 tonnes of waste.

Table 2: Results of the selection of 777 trucks operating hauling route s .

	777 Truck					
Source	Destination					
	Feeder	MRC	Mayo LG Stk Pile	Mayo HG Stk Pile	Pay Caro Stk Pile	Waste Dump
Crusher	Not Selected route	Not Selected route	Not Selected route	Not Selected route	Not Selected route	Not Selected route
Feeder	Not Selected route	Not Selected route	Not Selected route	Not Selected route	Not Selected route	Selected route
Pay Caro	Selected route	Selected route	Not Selected route	Not Selected route	Selected route	Selected route
Koolhoven	Selected route	Selected route	Not Selected route	Not Selected route	Selected route	Selected route
Mayo	Selected route	Selected route	Selected route	Selected route	Not Selected route	Selected route
Royal Hill	Selected route	Selected route	Not Selected route	Not Selected route	Selected route	Selected route
Mayo LG Stk Pile	Selected route	Selected route	Not Selected route	Not Selected route	Not Selected route	Not Selected route
Mayo HG Stk Pile	Selected route	Selected route	Not Selected route	Not Selected route	Not Selected route	Not Selected route
HGR-S-PC1	Selected route	Selected route	Not Selected route	Not Selected route	Not Selected route	Not Selected route
LGS-S-PC1	Selected route	Selected route	Not Selected route	Not Selected route	Not Selected route	Not Selected route
HGS-S-MA	Not Selected route	Not Selected route	Not Selected route	Not Selected route	Not Selected route	Not Selected route
LG-S-Mayo	Not Selected route	Not Selected route	Not Selected route	Not Selected route	Not Selected route	Not Selected route

Selected route

Not Selected route

Table 3: Results of the selection of possible operating hauling route s for contractor.

Source	Destination			
Feeder	Mayo LG Stk Pile	Mayo HG Stk Pile	Pay Caro Stk Pile	Waste Dump
Pay Caro	Not Selected route	Not Selected route	Selected route	Selected route
Koolhoven	Not Selected route	Not Selected route	Selected route	Selected route
Mayo	Selected route	Selected route	Not Selected route	Selected route
Royal Hill	Not Selected route	Not Selected route	Selected route	Selected route
Mayo LG Stk Pile	Not Selected route	Not Selected route	Not Selected route	Not Selected route
Mayo HG Stk Pile	Not Selected route	Not Selected route	Not Selected route	Not Selected route
Pay Caro Stk Pile	Not Selected route	Not Selected route	Not Selected route	Not Selected route

Selected route

Not Selected route

Table 4: Results of the tonne *distance calculations, percentage of fleet and trucks required for each route ore/waste production.

Parameters

Source	Destination	Hauling Distance (one way in meters) Ore	Waste	Tonnes Ore	Waste	Tonnes x Distance TOTAL (T.km)	Percentage of Fleet	Trucks Required
HGR-S-MA	Feeder	7682		69029		530280778	1.3%	0.46
HGR-S-PCT	MCR	644		59323		38204012	0.1%	0.03
KH Pit	LGS-S-PC1	2530		53431		135180430	0.3%	0.12
KH Pit	Feeder	3312		1350000		4471200000	11.3%	3.88
LGS-S-PC1	Feeder	506		111488		56412928	0.1%	0.05
LGS-S-PC1	MCR	828		98793		81800604	0.2%	0.07
Mayo Pit	Feeder	8834		710,109		6273102906	15.9%	5.44
Mayo Pit	LG-S-Mayo	1288		83,377		107389576	0.3%	0.09
Mayo Pit	HGS-S-MA	1426		234,703		334686478	0.8%	0.29
PC Pit	Feeder	1932		355,876		687552432	1.7%	0.60
PC Pit	MCR	2944		385,104		1133746176	2.9%	0.98
PC Pit	LGS-S-PC1	2392		72,158		172601936	0.4%	0.15
RH North West Pit	Feeder	5842		166,969		975432898	2.5%	0.85
RH North West Pit	MCR	5566		367,427		2045098682	5.2%	1.77
RH North West Pit	HGR-S-PC1	6349		50,064		317856336	0.8%	0.28
RH South East Pit	Feeder	6763		586,090		3963726670	10.0%	3.44
KH Pit	KOOLH DUMP		1472		4,370,000	6432640000	16.3%	5.58
Mayo Pit	MA Dump		966		513,267	495815922	1.3%	0.43
PC Pit	PC Cent Dump		1794		373,888	670755072	1.7%	0.58
PC Pit	PC West Dump		2300		279,720	643356000	1.6%	0.56
PC Pit	PC-NORTH		920		2,946,575	2710849000	6.9%	2.35
RH North West Pit	Construct		3312		110,318	365373216	0.9%	0.32
RH North West Pit	Crusher		4923		94,331	464391513	1.2%	0.40
RH North West Pit	D-RH1-E		2668		100,849	269065132	0.7%	0.23
RH North West Pit	RH Dump Mid		1472		1,983,070	2919079040	7.4%	2.53
RH North West Pit	RH R-R DUMP		1426		89,700	127912200	0.3%	0.11
RH North West Pit	RH West		1334		119,851	159881234	0.4%	0.14
RH North West Pit	RH-SOUTH		2208		115,632	255315456	0.6%	0.22
RH North West Pit	Sm. Crusher		1840		120,343	221431120	0.6%	0.19
RH South East Pit	D-RH1-E		920		1,344,312	1236767040	3.1%	1.07
RH South East Pit	RH Dump Mid		2944		45,303	133372032	0.3%	0.12
RH South East Pit	RH R-R DUMP		1150		196,982	226529300	0.6%	0.20
RH South East Pit	RH-SOUTH		1380		572,672	790287360	2.0%	0.69
Totals		58838	33029	4,753,941	13376813	39447093479	100%	34.20

4.2 Hauling route selection

The costs per haul made for hauling at each route is made up of the hauling unit cost and the total mining cost.

To find out which route is more economically beneficial when hauling with the contractor, the costs made when hauling with 777 was compared to the cost made when hauling with the contractor. From these comparisons it turned out that the Mayo HGS –Feeder route was the one that could be outsourced to the contractor, with a different in costs of $0.32 per tonne. The outcome clearly shows that hauling with the contractor should have saved the company $53,311 if all the 164,460 tonnes hauled previously from Mayo was done by the contractor (Table 5).

Calculation of the hauling unit cost from source to destination

Calculations made for hauling unit cost from source to destination, gave the results presented in the table below:

Hauling unit cost

Haulage costs usually are presented as cost per tonne ($/t). Cost per tonne ($/t) is simply total truck cost divided by the total tonnes hauled by the truck.

Total hauling cost

The total hauling cost for the overall hauling of ore and waste from different locations to destinations during the months January to April 2009 was calculated by addition of the total operation cost 1st quarter 2009 to the total maintenance cost1st quarter 2009.

Table 5: results of hauling unit cost calculations from source to destination

Source	Destination	777 Hauling Unit Cost ($/mt)	Total Mining Cost Unit Cost ($/mt)	Unit Cost for Contractor	Total Unit Cost using Contractor	
HGR-S-MA	Feeder	$ 1.59	$ 2.58			
HGR-S-PCT	MCR	$ 0.13	$ 1.12			
KH Pit	LGS-S-PC1	$ 0.52	$ 1.51			
KH-Pit	Feeder	$ 0.69	$ 1.68			
LGS-S-PC1	Feeder	$ 0.10	$ 1.09			
LGS-S-PC1	MCR	$ 0.17	$ 1.16			
Mayo Pit	Feeder	$ 1.83	$ 2.82			* This haul can be replaced with contractor
Mayo Pit	LG-S-Mayo	$ 0.27	$ 1.28	$ 1.21	$ 2.50	Savings of $ 0.32 per tonne
Mayo Pit	HGS-S-MA	$ 0.30	$ 1.26			multiplied by 164,460 tonnes
PC Pit	Feeder	$ 0.40	$ 1.39			= a savings of $ 53,311
PC Pit	MCR	$ 0.61	$ 1.60			
PC Pit	LGS-S-PC1	$ 0.50	$ 1.48			
RH North West Pit	Feeder	$ 1.21	$ 2.20			
RH North West Pit	MCR	$ 1.15	$ 2.14			
RH North West Pit	HGR-S-PC1	$ 1.32	$ 2.31			
RH South East Pit	Feeder	$ 1.40	$ 2.39			
KH Pit	KOOLH DUMP	$ 0.31	$ 1.29			
Mayo Pit	MA Dump	$ 0.20	$ 1.19			
PC Pit	PC Cent Dump	$ 0.37	$ 1.36			
PC Pit	PC West Dump	$ 0.48	$ 1.47			
PC Pit	PC-NORTH	$ 0.19	$ 1.18			
RH North West Pit	Construct	$ 0.69	$ 1.68			
RH North West Pit	Crusher	$ 1.02	$ 2.01			
RH North West Pit	D-RH1-E	$ 0.55	$ 1.54			
RH North West Pit	RH Dump Mid	$ 0.31	$ 1.29			
RH North West Pit	RH R-R DUMP	$ 0.30	$ 1.28			
RH North West Pit	RH West	$ 0.28	$ 1.27			
RH North West Pit	RH-SOUTH	$ 0.46	$ 1.45			
RH North West Pit	Sm. Crusher	$ 0.38	$ 1.37			
RH South East Pit	D-RH1-E	$ 0.19	$ 1.18			
RH South East Pit	RH Dump Mid	$ 0.61	$ 1.60			
RH South East Pit	RH R-R DUMP	$ 0.24	$ 1.23			
RH South East Pit	RH-SOUTH	$ 0.29	$ 1.27			

4.3 Results of the haulage cost saving comparisons

As mentioned in the methods and techniques, 5 cases were formulated to analyze the possibilities for a contract_with the contractor (Appendix 2) .The results for these cases are given herewith:

In case 1: where the (current) actual production was used, the results show that 20,309,742 tonnes moved by 777s and the contractor generated a total mining cost of $29,371,263($1.446/t)

In case 2: The contractor was not included and it gives lower production and lower overall costs. The result is 20,145,282 tonnes and a total mining cost of $29,009,206 ($1.440/t)

In Case 3: where all 777s on long ore hauls from Mayo and the HGS were assumed to be parked, the result was that 19,366,144 tonnes was moved with a total mining cost of $ $26,670,497 ($1.377/t)

In case 4: the 777s were re-allocated on long ore hauls from Mayo pit and the Mayo HGS to work on other shorter hauls. The result was that 23,017,006 tonnes and a total mining cost of $31,863,076 ($1.384/t)

Case 5: of the analysis, where 0.9 of the re-allocated 777s were returned back to Mayo, to haul to the HGS and the contractor is used to re-handle and haul all ore from Mayo via the Mayo-HGS to the feeder, produced 23,181,466 tonnes and a total mining cost of $32,832,238 ($1.416/t)

If the diesel fuel price would go up, then the cost savings for IAMGOLD would go down as demonstrated in table 6.

Table 6: Sensitivity analysis of cost savings when using contractor versus fuel price

Diesel Price $ / L	Contractor Advantage ($ Savings / tonne Contracted)
0.40	0.36
0.50	0.35
0.60	0.34
0.70	0.33
0.80	0.32
0.90	0.31
1.00	0.30
1.10	0.29
1.20	0.28
1.30	0.27
1.40	0.26
1.50	0.25

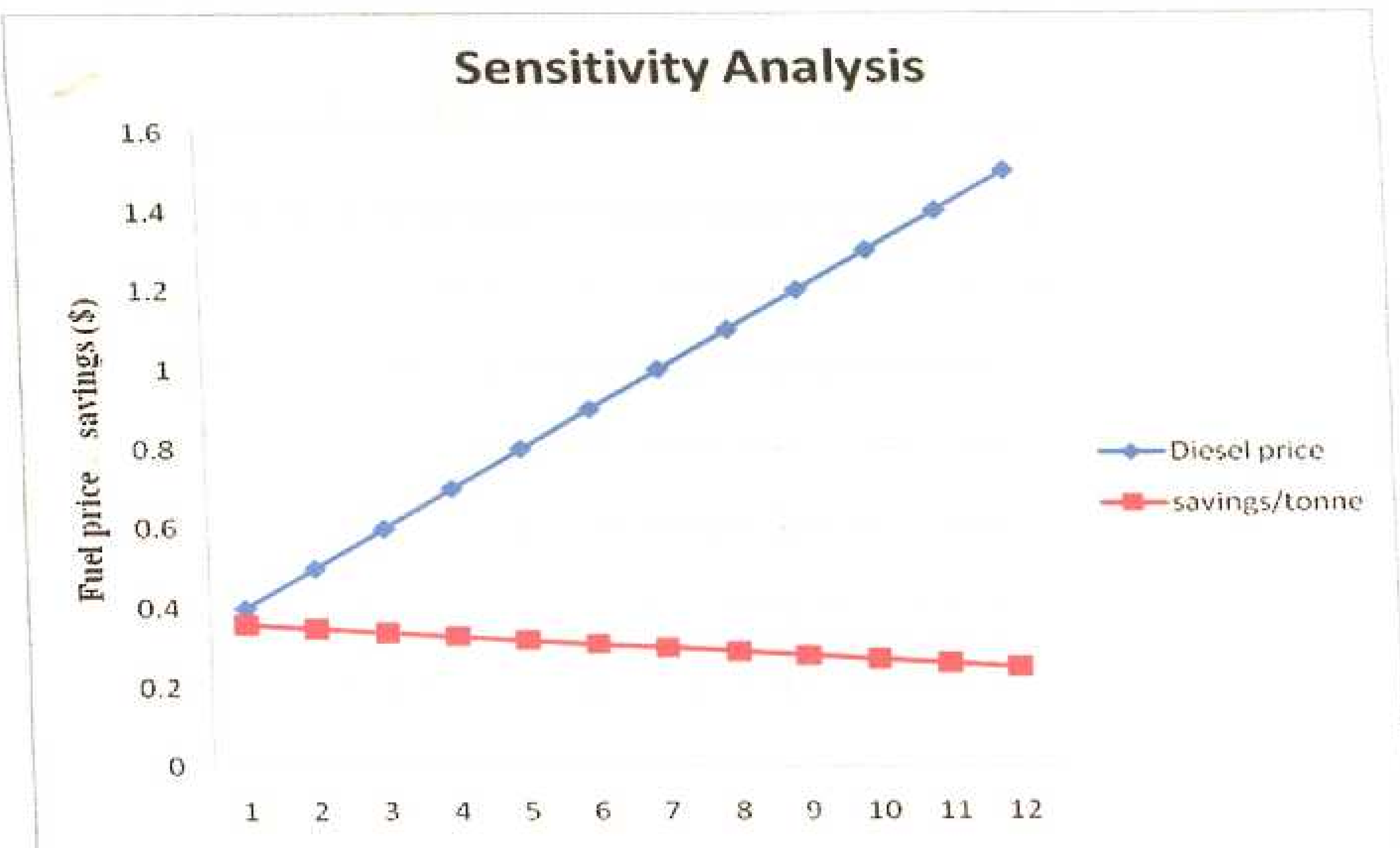

Figure 4: Sensitivity analyses of cost savings when using contractor versus fuel price

5. Discussion and Conclusion

5.1 Discussion

From the obtained results of the number of trucks required, the Mayo pit and the Koolhoven pit require approximately the same number of trucks. This can be explained by the fact that the Koolhoven pit has a greater production than the Mayo pit, whereas the Mayo pit has a greater haul distance than the Koolhoven pit, resulting in almost equal number of trucks required.

During the analysis a fixed cost is used for the contractor. Costs generated by hauling with 777 were compared with costs made for the hauling of the same amount of material with contractor. This was applied to all the possible routes for material haulage. The contractor costs for their hauling activities during the period Jan-May 2009 were used for these calculations. The contractor then was hauling from the Mayo H.G.S to the feeder. These costs were generalized as to be the contractor costs for all hauling routes in consideration.

The Royal Hill pit has steep sloped Haul roads and the flexibility of the contractor 40 ton trucks will decrease when hauling on these roads, especially during the rainy season. The Koolhoven pit on the other hand has shallower sloped haul roads just like the Mayo but for the current contractor hauling costs, hauling from the Koolhoven pit is in favor of the use of 777 trucks. This is why the Royal Hill pit and the Koolhoven pit are excluded in the further calculations.

5.2 Conclusion

1. Outsourcing of haulage is profitable for Rosebel Gold Mines from the Mayo pit. This with a cost savings of US$32 for each tonne contracted.

2. There are two options for the outsourcing of the Mayo-Feeder haulage.
Haulage can be done from the Mayo pit straight to the feeder and another option is from the Mayo pit to the Mayo high grade stockpile with 777 haul trucks and re-handled from the Mayo high grade stockpile to the feeder with contractor.

3. The most cost effective method for hauling from Mayo is by using the 777 haul trucks to haul from the Mayo pit to the stockpiles and the contractor haul trucks to haul from the stockpiles to the feeder.

4. If the Diesel price would go up, using contractor will give Rosebel Goldmines also less cost savings/tonne.

6. Recommendations

1. The Rosebel Gold Mines should use the contractor to perform the long distance haulage from the Mayo stockpiles to the feeder.

2. Adjusting the procedure to negotiate with the contractor to meet an economic beneficial deal for haulage from other pit areas.

3. Continue evaluation of incoming haulage cost data

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Appendices

Appendix 1: Operating unit cost per haul and material movement evaluations

Operating Unit Cost per Haul

2009 average

	1Q2009		100% of Hauls Jan 1 to May 31 2009		90% of Hauls Jan 1 to May 31 2009	
Total Hauling Cost :	5,146,863	$	9,094,303	$	8,184,873	$
Tonnes Moved	11,401,094	t	20,145,282	t	18,130,754	t
Unit Cost:	$ 0.451		$ 0.451		$ 0.451	

Fuel Unit Cost	
$ 0.40	per Liter

777 Haulage Unit Cost:	0.451	$/mt
Total Mining Unit Cost :	1.440	$/mt
Total - Haulage Unit Cost:	0.989	$/mt

Contractor Cost per Tonne					
Contractor Unit Cost	$	1.06	Truck Liters / Day		1015
Fuel	$	0.15	Backhoe Litres/Day		420
			$/Day	$	574
Total Unit Cost	$	1.21	$/tonne	$	0.15

Material movements

Tonnes Mined

	Tonnes Mined to Ore	Waste	SR
MA	1,028,189	513,267	0.50
RH	1,170,550	4,893,963	4.18
PC	813,138	3,600,183	4.43
KO	1,403,431	4,370,000	3.11
Stockpiles	338,633	0	0.00
TOTAL	4,753,941	13,376,813	2.81

Daily Production (tonnes per day) Ore	Waste	Combined
6,720	3,355	10,075
7,651	31,983	39,633
5,315	23,531	28,845
9,173	28,562	37,735
2,213		2,213
31,072	87,430	118,502

Appendix 2: Costs saving comparisons for hauling from Mayo

Economic analysis of mining costs at Rosebel with and without using Haukes to re-handle and haul ore from Mayo High Grade Stockpile to the Feeder: January to May 2009

January 2009 to May 2009	Case 1	Case2	Case3	Case4	Case5
	Actual Production with Contractor	Actual Production without Contractor	Actual Production without Contractor & without Mayo Long Ore Hauls	Prorated Production without Contractor & without Mayo Long Ore Hauls	Prorated Production with All Mayo Ore from Pit Hauled by 777 to HGS & then from HGS to Feeder using Contractor
# of 777s Working at Mayo (Ore & Waste)	6.7	6.7	0.8	0.8	1.7
# of 777s Working outside Mayo	31.3	31.3	31.3	37.2	36.3
# of 777s Parked	-		5.9	-	-
Total 777 Fleet	38.0	38.0	38.0	38.0	38.0
777 Base Level Production (tonne)	20,145,282	20,145,282	19,366,144	19,366,144	19,366,144
Contractor Production (HGS to Feeder) (toni	164,460				943,598
777 Additional Production (tonne)				3,650,861	2,871,723
Total Production (tonnes)	20,309,742	20,145,282	19,366,144	23,017,006	23,181,466
Cost: 777 Base Level Production	$ 9,094,303	$ 9,094,303	$ 7,525,822	$ 7,525,822	$ 7,525,822
Cost: Contractor Production	$ 199,478	$ -	$ -	$ -	$ 1,144,514
Cost: Additional 777 Production	$ -	$ -	$ -	$ 1,583,468	$ 1,245,537
Total Haul Cost($)	$ 9,293,781	$ 9,094,302.93	$ 7,525,822	$ 9,109,290	$ 9,915,873
Haul Cost / Tonne	$ 0.458	$ 0.451	$ 0.389	$ 0.396	$ 0.428
Total Mining Cost (Fully Burdened)	$ 29,371,263	$ 29,009,206	$ 26,670,497	$ 31,863,076	$ 32,832,238
Total Mining Cost / Tonne Moved	$ 1.446	$ 1.440	$ 1.377	$ 1.384	$ 1.416
Annual Cost Savings using Contractor for All Mayo Ore and Re-allocating 777s to other Hauls					$ 692,015

Appendix 3: Contractor fuel consumption of trucks transporting ore from Mayo HGS to the Feeder

Truck		Liters of Diesel May		Liters of Diesel June
9173		2679		3652
9174		3869		3513
9212		1083		4201
9215		2703		4769
9216		2550		5039
9217		2168		4501
9218		2673		4779
Month Total (Liters)		17725		30454
Liters Per Day		572		1015
Liters per Day per Truck		82		145
Tonnes		60128		112614
Tonnes/Day		1940		3754
Liters/Tonne		0.295		0.270
Cost/Liter	$	0.40	$	0.40
Total Cost	$	7,090	$	12,182
Cost / Tonne	**$**	**0.118**	**$**	**0.108**