# National University of Engineering

GEOLOGY, MINING AND METALLURGICAL ENGINEERING

Course: Mines Valuation

## Projects Evaluation Matrix

<table>
<thead>
<tr>
<th>Members</th>
</tr>
</thead>
<tbody>
<tr>
<td>Erika Raquel Gallardo Coz</td>
</tr>
<tr>
<td>Juan Guzmán Romaní</td>
</tr>
<tr>
<td>Nilton Anthony Rios Villalobos</td>
</tr>
</tbody>
</table>
ABSTRACT

According to the latest report of the ombudsman's office so far this year, 89 social and environmental conflicts have been registered, of which 62.9% belong to the mining sector.

In the Apurímac region, one of the longest mining conflicts in the sector has recently occurred that would have caused substantial economic losses to the company MMG Limited, operator of the Las Bambas mining project, because the company would not have complied with part of the agreement.

Initially Las Bambas within the EIA had planned the construction of a mining pipeline to transport its concentrates, however, when changing its owner, the EIA was modified indicating that the concentrate would be transported by trucks, the conflict started as a result of the where the trucks circulated did not have the license of the community members of the Yavi Yavi farm located in the district of Colquemarca (Apurímac), this, added to the dust and noise generated, unleashed a widespread malaise.

The objective of this paper is the selection of a transport method that does not cause considerable negative impacts to society, for which three alternatives of transport of concentrate identified in the literature, transport by pipeline, transport by trucks and transport have been evaluated. by rail using a decision matrix, in which, in addition to the economic criteria, with a majority weight of 35%, other factors including social, environmental, legal and engineering factors were considered.

As a result of the weighting of the decision matrix, a score of the concentrate transport system is obtained by mining pipeline of 3.59, for the transport by trucks 2.49, for the transport by rail 2.16.

From the results of the decision matrix, the transport method of concentrating by mineraduct was selected, this alternative is the most economical and also generates less social and environmental impacts.

Keywords. Decision matrix, mining pipeline, trade off, risk, impacts.
INDEX

INTRODUCTION 7

CHAPTER I: PROJECT DESCRIPTION 8
  1.1. General 8
  1.2. Problem Statement and Justification 9
    1.2.1. Problem Statement 9
    1.2.2. Justification 10
  1.3. General and Specific Objectives 10
    1.3.1. General Objective 10
    1.3.2. Specific Objectives 10

CHAPTER II: THEORETICAL FOUNDATIONS 11
  2.1. Logistics management in mining operations 11
  2.2. Type of copper concentrate transport 11
    2.2.1. Transportation of minerals by continuous means 11
    2.2.2. Transportation of minerals by discreet means 11
  2.3. Regulation on mineral transport 12
  2.4. Mining value chain 12
  2.5. Use of a mining-pipeline to transport ore concentrate 13
    2.5.1. Advantages 13
    2.5.2. Components of a mining-pipeline 13
    2.5.3. General characteristics of a mining-pipeline 14
    2.5.4. Economic Evaluation 14
  2.6. Use of trucks to transport ore concentrates 21
    2.6.1. Environmental Management 22
    2.6.2. Safety Management 23
    2.6.3. Social Management 23
    2.6.4. Legal Management 24
    2.6.5. Investment Management 25
    2.6.6. Operation Management 25
    2.6.7. Transportation Management 30
    2.6.8. Cost Analysis 34
  2.7. Use of railroad to transport ore concentrate 40
    2.7.1. Current Situation 40
    2.7.2. Case: Las Bambas 41
    2.7.3. Improvement proposal 42
    2.7.4. Advantages of railroad transport of concentrate 43
2.7.5. Disadvantages of railroad transport of concentrate 43
2.7.6. Construction of the section: Las Bambas - Cambapata Station (Cusco) 43
2.7.7. Calculation of the Capital Expenditure (CAPEX) 45
2.7.8. Calculation of the Operational Expenditures (OPEX) 45
2.7.9. Calculation of total transport cost 45

CHAPTER III: METHODOLOGY 46
CHAPTER IV: RESULTS 47
CHAPTER V: DISCUSSION OF RESULTS 49
CONCLUSIONS 50
RECOMMENDATIONS 51
BIBLIOGRAPHIC REFERENCES 52

TABLES INDEX

Table 1. Cost of construction. 15
Table 2. Cost of the piping element. 16
Table 3. Summary of the equipment and buildings useful lives. 18
Table 4. Calculation of the pipeline cost in USD/m. 20
Table 5. Calculation of total investment. 20
Table 6. Equivalent annual cost for transportation by pipeline. 20
Table 7. Routes from the mine to the Port of Matarani. 22
Table 8. Round Trip, Ring 1 Day 1. 27
Table 9. Round Trip, Ring 2 Day 2. 28
Table 10. Round Trip Ring 3 Day 3. 30
Table 11. Trucks Technical specifications. 32
Table 12. Round Trip Factors. 33
Table 13. Fleet Sizing. 33
Table 14. Truck transport detail. 33
Table 15. Production plan of Concentrate transport. 34
Table 16. Variable rate considerations. 35
Table 17. Components of the variable rate. 35
Table 18. Weighting of fixed rates. 36
Table 19. Weighting of variable rates. 36
Table 20. Summary of costs for transport by truck. 37
Table 21. Cost analysis for transport by truck. 37
Table 22. Monthly costs for transport by truck. 38
Table 23. Equivalent annual cost for transportation by truck. 39
Table 24. Details of train requirements. 42
Table 25. Equivalent annual cost for transportation by train. 45
Table 26. Summary of the economic evaluation of the three alternatives. 47
Table 27. Decision Matrix. 48
Table 28. Summary of the results of the decision matrix. 49

FIGURES INDEX

Figure 1. History of the Las Bambas Project. 9
Figure 2. Mining value chain. 12
Figure 3. Section view of a mining-pipeline section under construction. 14
Figure 4. Section view of a mining-pipeline section in operation. 14
Figure 5. Trace of the mining-pipeline route (Concentrating plant - Km 99 Chasquipampa). 19
Figure 6. Topographic profile of the mining-pipeline route. 19
Figure 7. Truck used for the transport of concentrates. 21
Figure 8. Route used to transport concentrate. Las Bambas - Puerto Matarani. 24
Figure 9. Round Trip, description of the "Mine to Port" transport. 26
Figure 10. Route A – B: Day 1, Ring 1. Las Bambas – Espinar. 26
Figure 11. Route B – C – B: Day 2, Ring 2. Espinar – Km 99(Chasquipampa) – Espinar. 28
Figure 12. Route B – A: Day 3, Ring 3. Espinar – Las Bambas 29
Figure 13. Container Truck. 31
Figure 14. ISO Container. 31
Figure 15. Dimensions of the container truck. 31
Figure 16. Map of the Central Railroad route. 40
Figure 17. Central Railroad. 40
Figure 18. South and South East Stations of the Railroad route. 41
Figure 19. Transfer station at Km 99 (Chasquipampa) 42
Figure 20. Section: Las Bambas –Cambapata Station 44
CONCLUSIONS

1. The total cost of transporting the concentrate through the mining-pipeline is $34,633 million, being the lowest of the three alternatives under evaluation, therefore, it is the best alternative from an economic point of view.

2. From the results obtained in the decision matrix for the evaluation of the three alternatives of concentrate transport through the weighting of certain criteria considered (economic, environmental, social, etc.), it is concluded that the mining-pipeline is the best alternative to select.

3. Through the review of the available literature regarding methods of transport of concentrate, three alternatives were identified: continuous transport by mining-pipeline, discrete transport through railways and trucks.

4. The transport of concentrate through the mining-pipeline complies with environmental laws regarding the transport of materials, also does not generate significant socio-environmental impacts, in relation to the remaining alternatives.