

Multiple account analysis of tailings technologies to define the next TSF stages

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ABSTRACT

Multiple Account Analysis (MAA) is a decision-support methodology that enables the objective comparison of alternatives by integrating multidisciplinary criteria within a structured evaluation framework. In tailings management projects, this approach is especially valuable because the technically preferred option is not always the most suitable once environmental, social, operational, and economic factors are incorporated.

This paper presents the MAA methodology, with particular emphasis on tailings management technologies, and its application to project operations. The methodology provides an effective decision-making framework that goes beyond purely technical aspects to incorporate site-specific considerations which can have a significant impact, sometimes leading to the exclusion of options that appear robust on technical grounds alone. The process also enables thorough documentation of the decision-making pathway, covering the full range of criteria adopted.

The study demonstrates that MAA provides a robust and transparent framework for tailings decision-making and is an effective tool for documenting the rationale behind complex project choices.

INTRODUCTION

Knight Piésold conducted a Multiple Account Analysis (MAA) study for a mine in Santa Cruz, Argentina, to define the future facilities required to store tailings resulting from operations during the upcoming phases of its Tailings Storage Facility (TSF). The study evaluated various locations for new TSFs and Filtered Storage Facilities (FSFs), along with different tailing types (conventional, thickened and paste) and equipment technologies.

Initially, 13 potential locations and 12 tailings management technologies were identified. Through a pre-screening process, these options were narrowed to a smaller subset of viable site-technology combinations. After workshops and technical review, seven alternatives were selected for final evaluation within the MAA framework. From these, two alternatives were subsequently advanced to prefeasibility-level engineering.

The study required the participation of a multidisciplinary team involving environmental, social, operational, maintenance, and economic specialists from both the Client and Knight Piésold. A structured decision-making process was therefore needed to support a transparent and defensible recommendation.

This paper summarizes the MAA methodology applied in the study and discusses the main outcomes that supported the selection of the preferred tailings alternative.

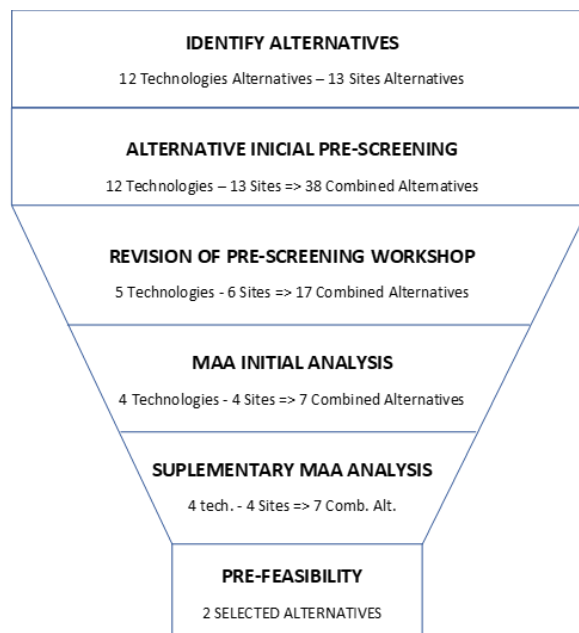


Figure 1 MAA sequence.

METHODOLOGY

Overview of the MAA approach

Multiple Account Analysis is a structured decision-making methodology widely used in engineering projects where alternatives must be evaluated against a combination of quantitative and qualitative criteria. The method provides a framework for comparing options from different perspectives and for balancing potentially conflicting priorities among stakeholders.

In this study, MAA was used to assess combined alternatives defined by the pairing of storage sites and tailings technologies. The methodology included the following steps, as shown in the image below.

The development of this study was undertaken with due consideration of the documents listed in the References section.

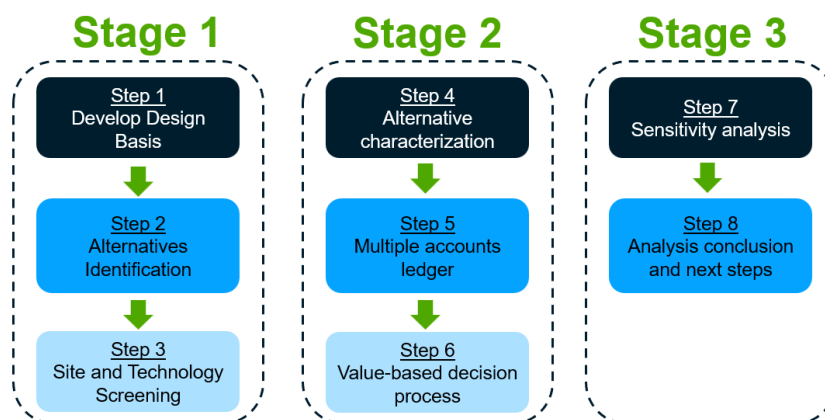


Figure 2 MAA stages and steps.

Identification, screening and refinement of alternatives

At the outset, the study considered 12 technology alternatives and 13 site alternatives, producing 38 possible combined alternatives. These included both conventional and filtered storage concepts.

Following technical screening and multidisciplinary workshops, 17 combined alternatives were selected for further consideration. A second refinement stage reduced this group to the final seven alternatives carried into the MAA scoring exercise. These seven alternatives comprised four technology options and four site options, including alternatives for both conventional and filtered tailings storage.

During the course of the work, the Client updated the production business plan, which required the selected alternatives to be revised in order to ensure consistent scoring and comparison under the new project basis.

Technology Options	Concentration (Cw%) / Moisture Content (%wt)	Yield Strength (Pa)	Tailings Transport	Maximum Technology Throughput (tpd)
A- Slurry (Un-thickened / Conventional)	less than 50% Cw	0	Centrifugal Pump	> 100,000
B - High Density (High Rate / Density Thickener)	50% Cw to 65% Cw	40 - 200	Centrifugal Pump / PD	> 100,000
C – Paste (Deep Cone)	65% Cw to 75% Cw	>200	Positive Displacement	< 50,000
D – Filtered (Filter Press)	10% wt to 25% wt	N/A	Conveyor / Stacker	30,000 (tpd / per unit)
E – Filtered (Belt Press)	25% wt to 35% wt	N/A	Conveyor / Stacker	1,500 (tpd / per unit)
F – Filtered (Centrifuge)	25% wt to 35% wt	N/A	Conveyor / Stacker	1,500 (tpd / per unit)
G – Filtered (Vacuum Filter)	25% wt to 35% wt	N/A	Conveyor / Stacker	7,200 (per unit)
H – Backfill (Paste / Filter)	65% Cw to 75% Cw	> 200 / N/A	PD Pump / Conveyor	30,000 to 50,000
I – Cyclone (Cyclone)	25% to 35% Cw	0	Centrifugal Pump	> 80,000
J - Eco-Tailings (Filter / Crushing)	10% wt to 25% wt	N/A	Conveyor / Stacker	30,000 (tpd / per unit)
K - Co-Mingled (Paste / Waste Rock)	65% Cw to 75% Cw	>200	Positive Displacement	< 50,000
L - Co-Mingled (Filter / Waste Rock)	10% wt to 25% wt	N/A	Conveyor / Stacker	30,000 (tpd / per unit)

Table 1 Technologies alternatives

Accounts, sub-accounts and indicators

The evaluation was organized into four main accounts: **Environmental, Technical, Social and Economic**

Each account was subdivided into sub-accounts and indicators designed to capture the main drivers affecting the suitability of each alternative. Examples included footprint, closure implications, constructability, operational complexity, water management, maintainability, permitting constraints, community and heritage considerations, capital cost, and operating cost.

Weighting and Scoring

Weighting factors were assigned at three levels: account, sub-account, and indicator. These weightings were defined through stakeholder workshops and reflected the relative importance of each criterion for the project. This structure allowed the evaluation to incorporate both measurable project parameters and qualitative considerations that are often critical in tailings decision-making.

Each alternative was scored against the selected indicators by the multidisciplinary team, based on available engineering information, operational considerations, and site constraints. The scoring exercise was carried out jointly by representatives of the Client and Knight Piésold in order to promote alignment and reduce subjectivity.

ACCOUNT	SUB-ACCOUNT	WEIGHTING	INDICATOR	WEIGHTING
Environmental	Hydrology / Hydrogeology	1	Watersheds affected	1
	Terrestrial Resources - General	2	Tailings management facilities / General climate change / Reduction of Emissions / Carbon footprint (affected area)	2
	Effects to population	2	Potential dust emission - Camp Site	2
	Reduction of water use	3	Does design meet Newmont objectives to reduce water use	3
	Permitting	3	Ease of obtaining environmental permits and social license	3
Technical	Design Considerations	3	Tailings storage capacity to total embankment fill volume ratio	3
			Tailings storage capacity to Liner area ratio	3
			Ease of construction	3
			Upstream catchment area	1
	Construction Materials	2	Availability of fill material	2
	Closure	2	Ease to implement closure	1
			Closure cover soil volume	2
	Other Design Considerations	1	Flexibility for potential future expansion	1
	Water	1	Reclaim water pumping mechanical system complexity	1
	Schedule Related	3	Can be permitted, designed and constructed before additional storage is required.	3
Social	Additional storage required	3	Short term storage required to implement ultimate solution.	3
	Tailings	2	Complexity to transport tailings (TSF and FSF)	2
	Ecological / Cultural Values	2	Community perception / Land Acquisition / Interference with existing roads	2
Economics	Union Conflicts	3	Possible schedule delays and over cost due to conflicts with the main unions at the site. Cost increment associated.	3
	Operational Impacts and Perception	1	Opportunities for sustainable jobs during construction / operations	1
Economics	Capital Costs	3	Civil Works	3
			Tailings transport-handling system (slurry system, conveyor truck, filtering, thickening, cycloning) and reclaim water systems	3
	Operating Costs	2	Pumping and equipment costs and its maintenance costs	2
	Closure Costs	2	Closure cost	2
	Opportunity Costs	3	Risk arising from schedule delays	3

Table 2 Account, sub-account indicator and weights

ACCOU NT	SUB-ACCOUNT	INDICATOR	TSF											
			0.a TSF1 EXPANSION (787masl)		0.b TSF1 EXPANSION (792 masl)				1-TSF2					
			A- Slurry (Thickened) - BASE CASE		A- Slurry (Thickened) - BASE CASE		B - High Density (High Rate / Density Thickener)		A- Slurry (Thickened) - BASE CASE		B - High Density (High Rate / Density Thickener)		I - Cyclone (Cyclone)	
			Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score
Environmental	Hydrology / Hydrogeology	Watersheds affected	6	6	6	6	6	6	6	6	6	6	6	6
	Terrestrial Resources - General	Tailings management facilities / General climate change / Reduction of Emissions / Carbon footprint (affected area)	5	10	5	10	5	10	1	2	1	2	1	2
	Effects to population	Potential dust emission - Camp Site	3	6	3	6	3	6	6	12	6	12	6	12
	Reduction of water use	Does design meet Newmont objectives to reduce water use	1	3	1	3	2	6	1	3	2	6	3	9
	Permitting	Ease of obtaining environmental permits and social license	5	15	5	15	5	15	4	12	4	12	4	12
ENVIRONMENTAL ACCOUNT TOTAL				40 3,6	40 3,6		43 3,9		35 3,2		38 3,5		41 3,7	
STATISTICS			3 1 1		3 1 1		3 1 1		2 1 2		2 1 2		2 2 1	
			2,00	4,64	2,00	4,64	1,64	3,97	2,51	4,80	2,28	4,34	2,12	4,27

Figure 3 Scoring example

Sensitivity analysis

To test the robustness of the results, several sensitivity scenarios were developed by applying different weighting emphases to the environmental, technical, social, and economic accounts. This step was particularly important to identify whether the preferred alternatives remained consistent under different decision perspectives.

ACCOUNT	SCENARIOS			
	1 - Env. Canada	2- Objective	3- Excluding Economics	4- Only Economics
Environmental	6	1	1	0
Technical	3	1	1	0
Social	2	1	1	0
Economics	3	1	0	1
Total	14	4	3	1

Table 2 Sensitivity scenarios

RESULTS AND DISCUSSION

Based on the analyses carried out, the relative account weighting factors and the resulting MAA rankings for the final seven alternatives considered showed that, across all evaluated scenarios, the alternatives that best adapted to the imposed requirements were:

- Alternative 0.b (existing TSF1 – 792 masl) with thickened tailings (A – Base Case) for conventional sites; and
- Alternative 5 (Filtered Site above existing TSF1 – 784 masl) with filter press tailings (D – Filtered) for filtered sites.

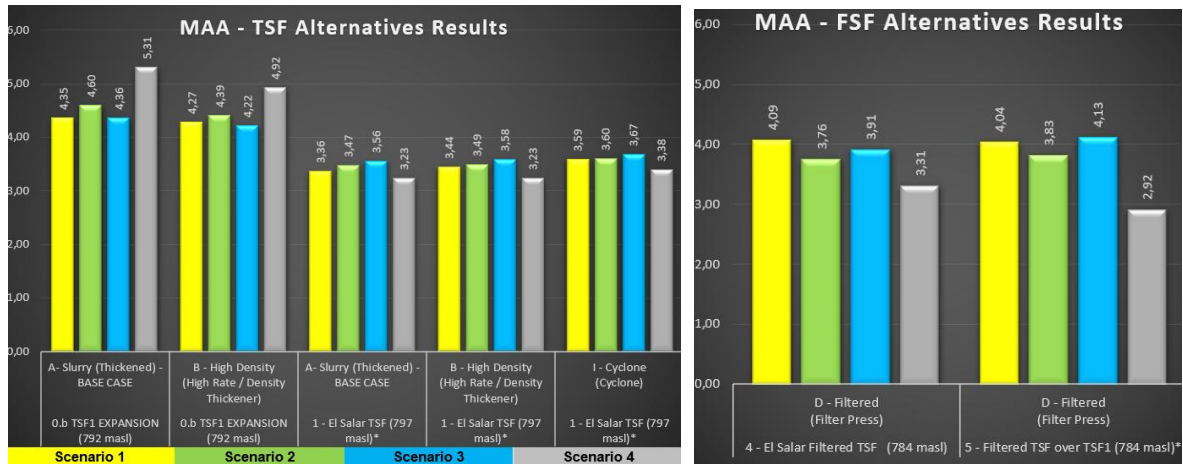


Figure 5 Results

Among the conventional alternatives, Alternative 0.b obtained the highest ranking. Its main advantages were associated with the use of an existing disturbed area, which reduced the environmental footprint and avoided many of the impacts associated with a new site. These benefits included lower closure requirements, a reduced need for new permits, and fewer land disturbance implications.

The filtered tailings option above TSF1 was the strongest of the filtered alternatives. However, despite its favorable performance in some technical and environmental aspects, it was generally less attractive than the conventional thickened tailings option when overall project economics were considered.

A key outcome of the MAA was that the cost of filtered tailings infrastructure, particularly filtration equipment, additional handling systems, and pipelines—significantly affected the ranking of filtered alternatives. This disadvantage became more pronounced when evaluated on a cost-per-ton basis, given the lower projected storage capacity of the filtered sites.

The analysis therefore indicated that, for the specific project conditions, the conventional thickened tailings option at the existing TSF1 site offered the best balance among environmental, technical, social, and economic criteria. The MAA also highlighted that some alternatives that initially appeared technically robust became less attractive once site-specific constraints and lifecycle implications were fully considered.

These findings reinforce the importance of adopting an integrated decision-making framework for tailings planning. In complex projects, the technically feasible option is not necessarily the most suitable once broader project drivers are included in the assessment.

CONCLUSION

This paper presented the application of Multiple Account Analysis to the selection of tailings storage alternatives for a mine in Santa Cruz, Argentina. The methodology proved effective in structuring the evaluation of multiple site and technology combinations and in supporting a transparent, multidisciplinary decision-making process.

The main conclusions are as follows:

1. **MAA is a robust tool for tailings decision-making**, particularly when alternatives must be evaluated beyond purely technical performance.
2. **Site-specific qualitative criteria can strongly influence the result**, especially in environmental, social, permitting, and closure-related matters.
3. **The definition of accounts, sub-accounts, and indicators is critical** to ensure a meaningful and defensible evaluation.
4. **Sensitivity analyses are essential** to test the stability of rankings under different decision priorities.
5. For the case study presented, **the preferred alternative was the use of the existing TSF1 with thickened tailings**, as it provided the best overall balance of impacts, operability, and cost.

REFERENCES

- Mining and Processing Division Environment Canada (2013) - Guidelines for the Assessment of Alternatives for Mine Waste Disposal
- Canadian Dam Association (2014). – Application of Dam Safety Guidelines to Mining Dams
- Global Industry Standard on Tailings management (GISTM).
- International Congress on Large Dams (ICOLD) – Guidelines for Tailings Dams.
- Mining Association Canada (MAC) – Tailings Management Guidelines.