Application of life cycle assessment to mine tailings management

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Environnement et gestion des rejets miniers

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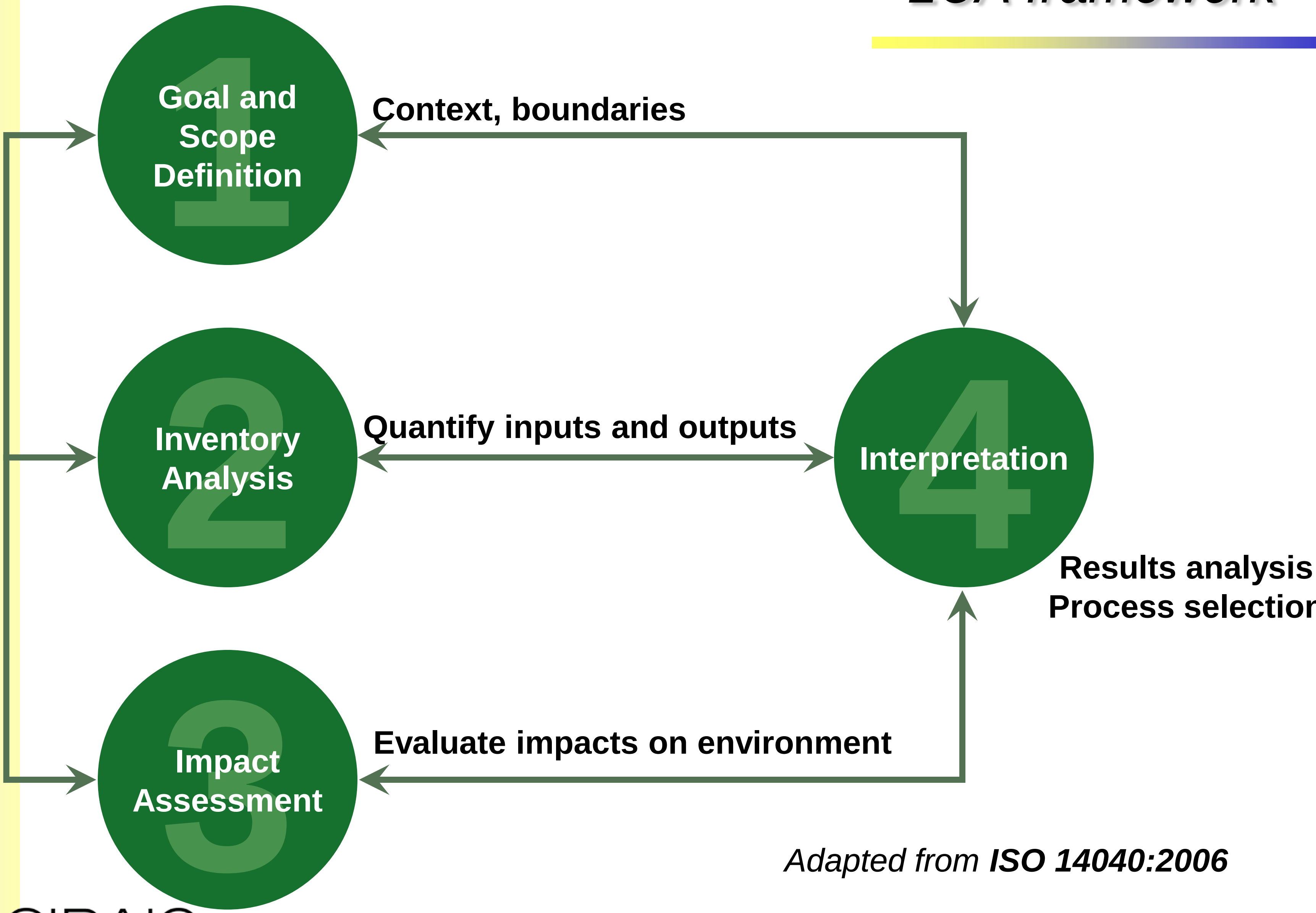
Le génie sans frontières

Life cycle assessment (LCA)

- LCA is a tool that considers the **environmental impacts** of a product/process for its entire life cycle (cradle-to-grave).
- LCA evaluates all the stages of the product/process as a chain to estimate potential environmental impacts **from each stage in the life cycle**.
- Use of LCA in mining and metal industry:
  - *Comparison and selection of technologies*
  - *Evaluation and improvement of processes and new technologies*
  - *Optimisation of materials and energy consumption in processes*

LCA framework



Adapted from ***ISO 14040:2006***

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Relevance of LCA in mine tailings management

- **Tailings management methods usually selected using technical and economical criteria.**
- Need for a tool to **evaluate and compare the environmental impacts of the various management methods** : LCA.

Until now, in LCA research:

- **Little emphasis** put on mine tailings management (lack of specific data) (Durucan *et al*. 2006).
- In the majority of the studies, the **tailings are regarded as solid waste** and not as a process which can be the source of emissions (Stewart *et al*. 2004).
- To our knowledge, **no LCAs are available** in the public literature concerning the **comparison of tailings management methods**.

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Objectives of the projet

1. Present LCA as a tool for environmental impact evaluation in tailings management context;

2. Draw the inventory of a specific case (Mine Louvicourt) and of different tailings management scenarios;

3. Assess and compare the environmental impacts of management scenarios.

Louvicourt mine

- Underground Cu/Zn mine located in Abitibi-Témiscamingue
- Opened 1994, closed 2005
  - 15.5M tonnes of ore extracted,
  - 13.3M tonnes tailings, 2.2M tonnes of concentrate
  - 25M m^3 of final effluent
  - Tailings disposal site surface = 97 ha
- Tailings sent to the tailings disposal site (6.3M tonnes), to backfill plant (7M tonnes)
- Water covered tailing disposal site

Goal and scenarios

Methodology

Comparison of tailings management scenarios for an underground mine

Scenario	Tailings management methods		
	Mine operation	Mine closure options	
1	Tailings disposal site	a	Water cover
		b	Cover of desulphurized tailings, elevated water table, rehabilitation with granular material
		c	Multi-layered cover, elevated water table, revegetation
2*	Tailings disposal site + backfill	a*	Water cover
		b	Cover of desulphurized tailings, elevated water table, rehabilitation with granular material
		c	Multi-layered cover, elevated water table, revegetation

*** Real situation**

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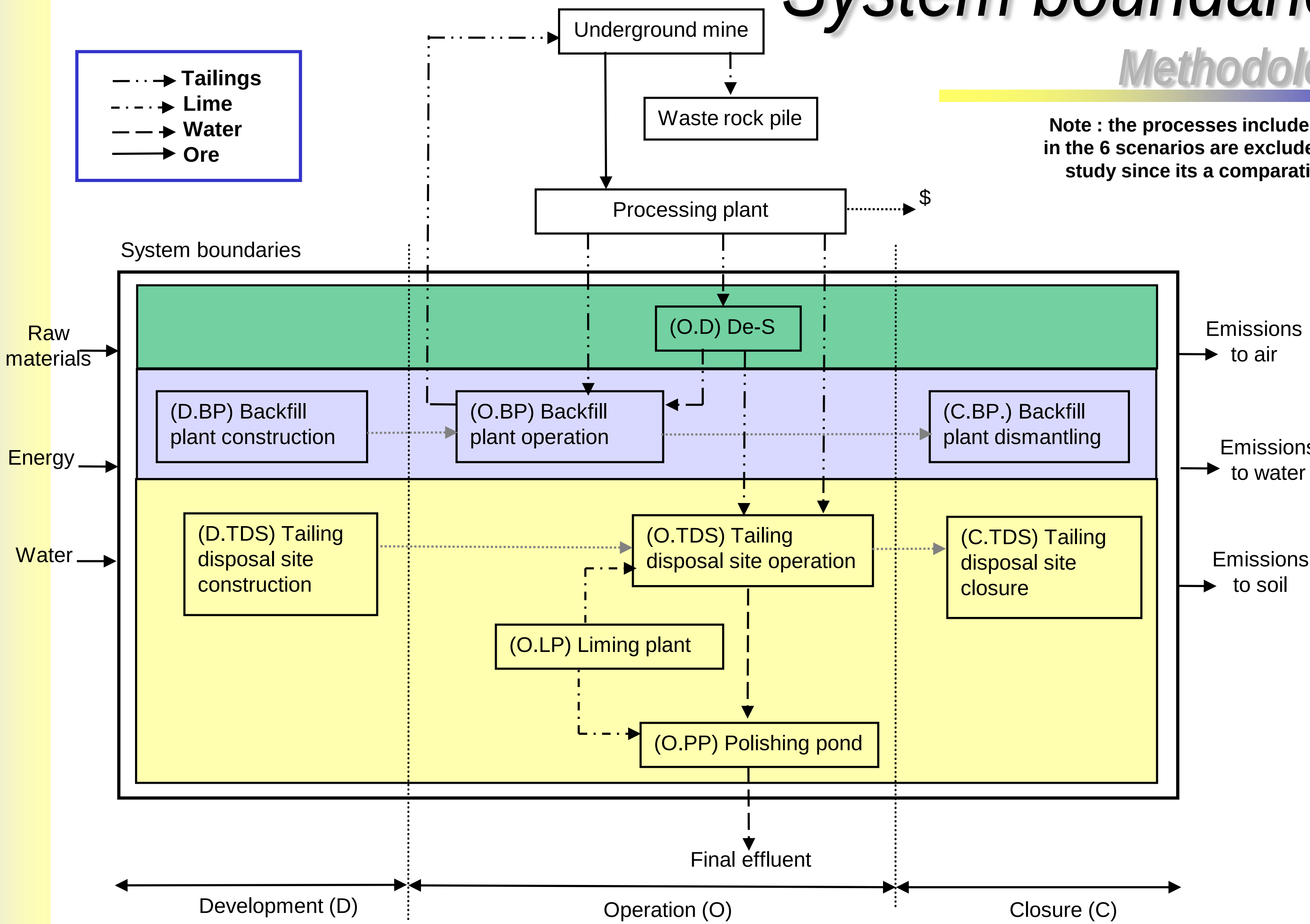
System boundaries

Methodology

Note : the processes included similarly in the 6 scenarios are excluded from the study since its a comparative study



= life cycle stages for the 6 scenarios, = life cycle stages in 2A, 2B and 2C, = life cycle stages in 1B and 2B.

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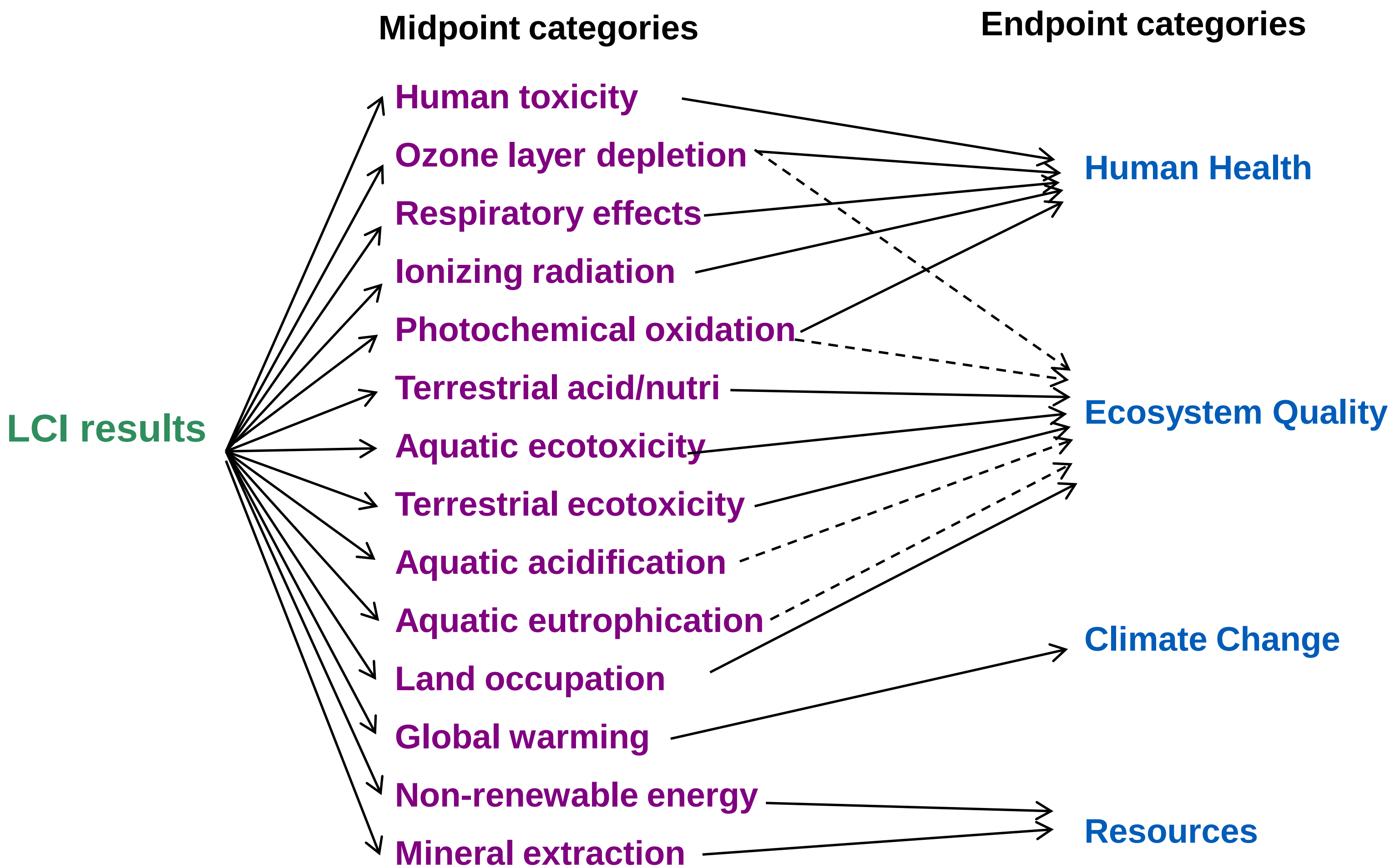
Life cycle inventory and impact assessment

- **Life cycle inventory**
  - Specific data collected on site (via questionnaires, site visits, interviews with technicians, engineers and geologists, consultant's reports)
  - Generic data (databases, literature, experts, etc.)

- **Life cycle impact assessment**
  - **IMPACT 2002+** (midpoint and damage results)

IMPACT 2002+



Adapted from Jolliet *et al.* 2003

Life cycle inventory (example)

Results

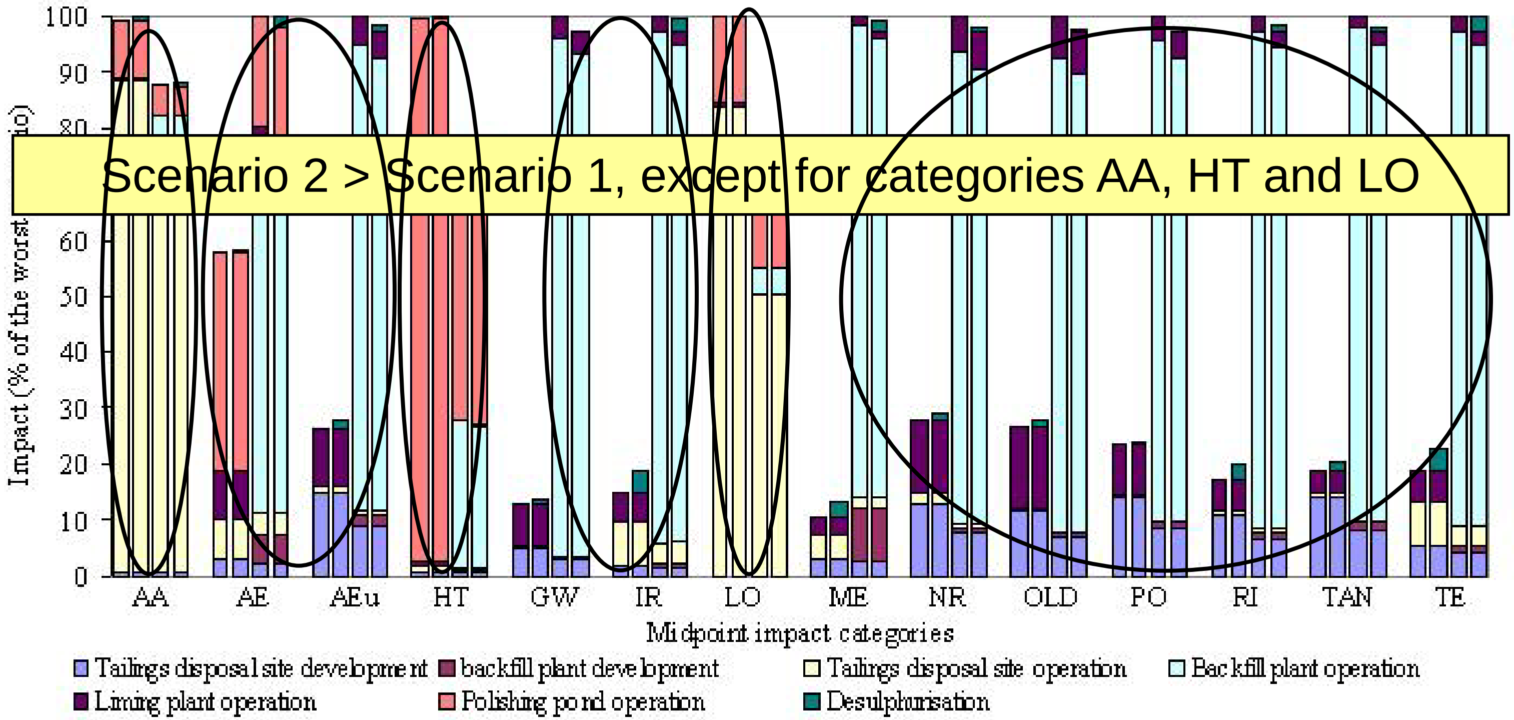
Inputs and outputs (>1%) of scenario 2A for the operation phase

Inputs		Outputs (>1%)		
Quicklime	5,44 x10^6 kg	Air	CO_2 (bio. and fossil)	1,55x10^8 kg
Polyester	1,46x10^3 kg	Water	Ammonia	7,44x10^4 kg
Nylon	5,14x10^3 kg		BOD_5	1,28x10^5 kg
Hydraulic oil	4,22x10^3 kg		Calcium, ion	5,32x10^4 kg
Slag	1,94x10^8 kg		Chloride	6,12x10^5 kg
Cement	5,07x10^7 kg		COD	1,83x10^5 kg
			DOC	5,00x10^4 kg
Diesel (plant)	4,29x10^5 kg		Silicon	7,79x10^4 kg
Diesel (transport)	4,59x10^6 kg		Sodium, ion	2,44x10^5 kg
Electricity	5,31x10^7 kWh		Sulphate	5,08x10^4 kg
			Sulphuric acid	3,12x10^6 kg
Land occupation *(forest, clear-cutting)*	1,74x10^7 m^2yr		Suspended solids	1,71x10^5 kg
Clean water	1,97x10^6 m^3		Total organic matter	5,01x10^4 kg
Process water	1,04x10^7 m^3	Soil	Calcium	1,07x10^3 kg
			Carbon	7,89x10^2 kg
			Chloride	3,14x10^4 kg
			Iron	2,79x10^3 kg
			Oil, non specified	2,82x10^4 kg

Impacts related to site development and operation

Results

Contribution of the stages of development and operation to the various scenarios



1st bar **1A : Tailings disposal site + Water cover**
1C : Tailings disposal site + Multi-layered cover

2nd bar **1B : Tailings disposal site + Cover of desulphurized tailings**

3rd bar **2A : Tailings disposal site and backfill plant + Water cover**
2C : Tailings disposal site and backfill plant + Multi-layered cover

4th bar **2B : Tailings disposal site and backfill plant + Cover of desulphurized tailings**

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Conclusions

- Successful application of LCA to tailings management: environmental impacts of several tailings disposal scenarios

- <u>Development and operation</u>

  Tailings disposal site + backfill (sc. 2) > Tailings disposal site (sc. 1) for 11 impact categories (out of 14)

- Longer time scale (up to 100 years): scenario 2 with backfill has less impacts (lower land occupation) (Reid 2006)

Conclusions

- Among first LCA studies on the comparison of tailings management with site specific data
- Successful example of co-operation between industries, consultants and universities

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