# Water-related Data Requirements for Improved Life Cycle Assessment of Mining, Mineral Processing and Tailings Management

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## INTRODUCTION

Life cycle assessment (LCA) provides an internationally standardised framework for estimating the environmental impacts associated with products or services (International Organisation for Standardisation, 2006). A particular strength of LCA is the ability to consider indirect impacts that occur at different stages of a product's life (eg raw material acquisition, manufacture, use, disposal or recycling) and through its supply chain (Figure 1). A wide variety of impact categories are able to be considered by LCA, such as the potential contribution to global warming, ozone depletion, marine eco-toxicity or freshwater eutrophication.

CSIRO has a long history of using LCA to compare the environmental impacts associated with alternative mining, mineral processing and metal production technologies (Haque and Norgate, 2014; Norgate and Haque, 2012, 2013). These 'mine-to-metal' assessments have primarily focused upon estimating embodied energy and greenhouse gas impacts associated with these production processes; however, more recently there has been a refocus to also consider consumptive water-use impacts in more detail (Northey *et al*, 2014).

The reliability of impact estimates developed using LCA are dependent upon two main factors:

1. the accuracy and representativeness of industrial input and output flows contained in life cycle inventory databases
2. the accuracy of characterisation factors used to quantify impacts based upon the inventory data.

The technical sophistication and regionalisation of characterisation factors for water-use impacts have improved substantially over the past several years, particularly as a result of increased interest in the 'water footprint' of products due to increasing concerns over global water security. However, the overall representativeness of water-use data contained in the major life cycle inventory databases is at times poor, particularly for industries such as mining that have very diverse interactions with water resources.

Water use at mining operations varies considerably due to a range of factors such as: the local climate, the particular ore processing technologies utilised, the approach taken to tailings management, varying water quality needs and risks and the ability of local environments to support water withdrawals and discharges. Analysis of data contained

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within the corporate sustainability reporting of mining companies has highlighted the scale of this variability (Mudd, 2008; Northey, Haque and Mudd, 2013).

Mining operations are increasingly collecting and reporting water-use data according to the Water Accounting Framework for the Minerals Industry (WAFMI) (MCA, 2014). However there are some differences in the data developed using the WAFMI and the data required by LCA methods, particularly as it relates to water quality. Some LCA methods, such as the ReCiPe impact assessment method (Goedkoop *et al*, 2009), simply require estimation of total pollutant loads to water – something that is routinely reported by mining operations to national and regional pollutant inventories. More recent LCA methods require classification of an operation's water inputs and outputs into eight distinct water quality categories, which have been defined using thresholds for 136 water quality parameters (Boulay *et al*, 2011). The WAFMI defines three water quality categories (MCA, 2014) that could potentially provide simplified data to these LCA methods. However, the influence of differing water quality thresholds used by the WAFMI and LCA water quality categories needs to be carefully assessed.

LCA studies typically only include detailed data for the operational phase of mining (see Figure 1), with post-closure impacts being accounted for very coarsely or in many cases ignored entirely. A range of impacts can occur post-closure following the rehabilitation or abandonment of a mine site. Hypersaline pit-lakes may form and become a permanent source of drawdown for surrounding groundwater systems. Post-closure impacts also occur due to generation of acid and/or metalliferous drainage (AMD) from waste rock, tailings material and the walls of mine voids. The impacts of AMD on local water quality may be transient due to 'first flush' effects, or in other cases may actively occur over decades or centuries – representing a perpetual impact to surrounding ecosystems and communities. There are several case studies of post-closure impacts included within the inventory databases used by LCA practitioners to assess the impacts of the industry.

Improvements to the quality and availability of life cycle inventory data for mine sites represents a significant opportunity to increase the reliability of results generated using LCA. Further research is required to provide guidance on accounting for life-of-mine

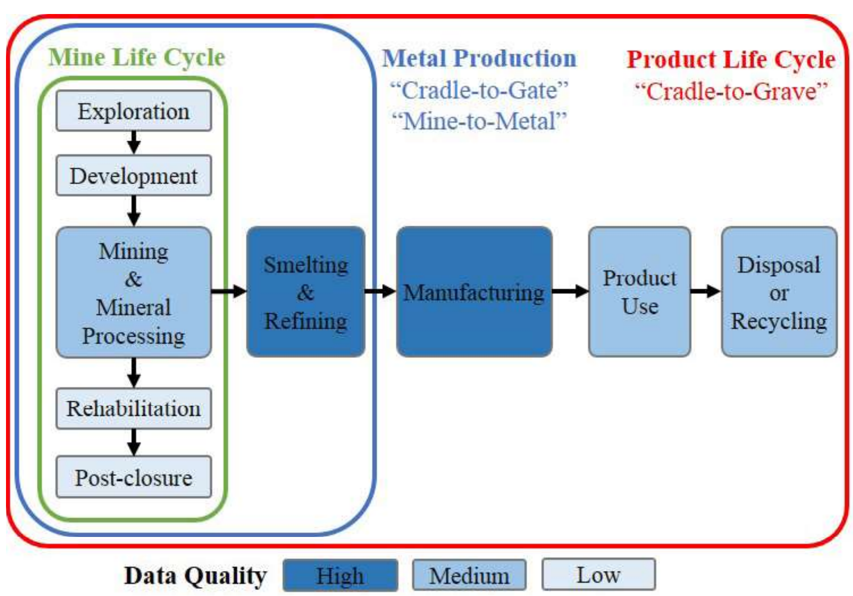


**FIG 1** – Processes associated with a mine, metal production and a product. The perceived quality of data currently available for life cycle assessment studies is shown.

water consumption and quality impacts consistently within life cycle inventory data sets, as well as the most appropriate temporal and geographic boundaries of assessments. Addressing these issues will enable more sophisticated inventory data sets for mining to be developed, while also improving estimates of the embodied impacts of mined products (eg carbon footprint, water footprint etc).

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## REFERENCES

**Boulay,** A-M, Bouchard, C, Deschênes, L and Margni, M, 2011. Categorising water for LCA inventory, *International Journal of Life Cycle Assessment*, 16:639–651.

**Goedkoop,** M J, Heijungs, R, Huijbregts, M, De Schryver, A, Strujis, J and van Zelm, R, 2009. *ReCiPe 2008: A Life Cycle Impact Assessment Method Which Comprises Harmonised Category Indicators at the Midpoint and the Endpoint Level, First Edition* (Ministry of Housing, Spatial Planning and the Environment: Netherlands).

**Haque,** N and Norgate, T, 2014. The greenhouse gas footprint of *in situ* leaching of uranium, gold and copper in Australia, *Journal of Cleaner Production*, 84:382–390.

**International Organisation for Standardisation (ISO),** 2006. ISO 14044:2006 – Environmental management – life cycle assessment – requirements and guidelines.

**Minerals Council of Australia (MCA),** 2014. Water accounting framework for the minerals industry, user guide, version 1.3 – January 2014.

**Mudd,** G M, 2008. Sustainability reporting and water resources: a preliminary assessment of embodied water and sustainable mining, *Mine Water and the Environment*, 27:136–144.

**Norgate,** T and Haque, N, 2012. Using life cycle assessment to evaluate some environmental impacts of gold production, *Journal of Cleaner Production*, 29–30:53–63.

**Norgate,** T and Haque, N, 2013. The greenhouse gas impact of IPCC and ore-sorting technologies, *Minerals Engineering*, 42:13–21.

**Northey,** S A, Haque, N, Lovel, R and Cooksey, M, 2014. Evaluating the application of water footprint methods to primary metal production systems, *Minerals Engineering*, 69:65–80.

**Northey,** S, Haque, N and Mudd, G, 2013. Using sustainability reporting to assess the environmental footprint of copper mining, *Journal of Cleaner Production*, 40:118–128.