Applying the "Seven Questions" to Heap Leaching[1]

By Mark E. Smith[2]

In 1999 the International Institute for Environment and Development was commissioned by the World Business Council for Sustainable Development to under take the Mining, Minerals and Sustainable Development (MMSD) project. MMSD North America was then formed as a partnership of the International Institute for Sustainable Development and the Mining Life-Cycle Center at Mackay School of Mines, which produced *The Seven Questions to Sustainability: How to Access the Contribution of Mining and Minerals Activities.* The Seven Questions create a framework for evaluating mineral development in terms of the goal of sustainable development. Each of the Seven Questions follows (Table 1) along with a discussion of how to apply this in a rural South American heap leaching context – that is, how does heap leaching advance the goals of SD in comparison to the alternative process options?

Table 1: Seven Questions to Sustainability (from MMSD North America)

Engagement	Are engagement processes in place and working effectively?
People	Will people's well-being be maintained or improved?
Environment	Is the integrity of the environment assured over the long term?
Economy	Is the economic viability of the project or operation assured, and will the economy of the community and beyond be better off as a result?
Traditional and Non-market Activities	Are traditional and non-market activities in the community and surrounding area accounted for in a way that is acceptable to the local people?
Institutional Arrangements and Governance	Are rules, incentives, programs and capacities in place to address project or operational consequences?
Synthesis and Continuous Learning	Does a full synthesis show that the net result will be positive or negative in the long term, and will there be periodic reassessments?

1 - Engagement. At first glance heap leaching offers no better inroads to this aspect of sustainable development than any other mining activity. However, deeper consideration brings forth some interesting points. Since a heap leach project is not as capital driven as a conventional milling operation, there is more room for consideration of alternatives. And since the construction technologies are more accessible to local contractors, there are more opportunities for partnering between the owner and contractors, and less reliance on imported technologies and equipment. Thus, a heap leach operation is more accessible to the local community, improving opportunities for engagement.

[1] First published in The Mining Record, Denver, CO, USA, June, 2004.
[2] Mark E. Smith is vice president for South American operations for Vector Engineering, Inc. and is based in Lima, Peru. smith@vectoreng.com

2 - People. Heap leaching is an inherently more hands-on process then milling. It is the "low technology" solution for low grade ores, and as such requires more people doing things that are more transferable to other industries. Transferable skills learned by heap leach personnel include pipe laying, irrigation systems, operating and maintenance of pumps and controls, surveying, earthworks, liner construction and maintenance, slope and erosion control, reclamation and revegetation, and various other aspects of civil construction. All of these have broad applications outside the mineral industry, making a heap leach work force highly employable.

3 - Environment. Arguably the two biggest mining environmental legacies are acid drainage and failures of dams and waste dumps (either structural failure or loss of containment). Heap leach facilities in general have had far fewer serious ARD problems then conventional milling operations, in part because by leaching lower grade ore they can reduce the size (and for a copper project, the sulfide content) of the waste dumps. This is not to trivialize the problem of residual acid from copper leaching operations, something that has not yet been fully addressed by the industry. On the other hand, spent heap leach ore (ripios) from gold operations is usually strongly alkaline; mixing waste types can help compensate for acidic waste rock.[3]

In terms of catastrophic failures, tailings dams and waste dumps are the principal cause of fatalities (not related to direct mine workplace accidents) with an average of 10 fatalities per year caused by tailings and waste dump failures.[4] People only remotely related to mining know about the Omai and Los Frailes tailings dam failures. The history of heap and dump leaching is, by comparison, very good. There have been no significant leach heap or dump slope failures and no failure-related fatalities. Spent heaps are also more stable and easier to reclaim than old tailings deposits, if for no other reason than their self-draining characteristics. In the study entitled *Mineral recovery, recycling, waste prevention and confinement for sustainable development in Asia and the Pacific Rim* the United Nations Economic and Social Commission for Asia and the Pacific listed heap leaching as one of the "clean technologies for mineral waste minimization, recovery and recycling" (1995) because of its efficiency, cost effectiveness and environmentally acceptability.

Thus, simply reducing reliance on conventional tailings disposal is of itself a move towards more sustainable development.[5]

4 - Economy. The obvious points here are that heap leach technology allows more ore to be processed since a lower cut off grade results, allowing a longer life or a larger operation, or both. It is also less capital intensive and thus less sensitive to commodity price fluctuations and generally a lower risk investment.

---

[3] *Breaking New Ground*, chapter 10, MMSD, Earthcan Publishing, London, 2002.
[4] Smith, M. E., "*Copper Dump Leaching*" in Mining magazine, July 2002.
[5] Leduc, M., M. Bachens and M. E. Smith, "*Tailings Co-disposal™ in Sustainable Development,*" proceedings of the annual meeting of the Society for Mining, Metals and Exploration, SME, Denver, February, 2004 and "*Safer, Cleaner, and Potentially Cost-Effectiv*e," Mining Environmental Management magazine, March, 2004.

Beyond these obvious answers lie some other important considerations. One of the common criticism of our industry (both within and outside the anti-globalization movement) is that, while mining investment is very large, it over-relies on capital and thus overstates the benefits to the local community. Mining investment therefore can not be directly compared with other types of economic development in terms of capital investment and the resulting effects on regional economies. By way of comparison consider the Antamina copper-zinc mining and milling complex in Peru, with a total capital cost of about US $1.8 billion (before acquisition, working capital and financing charges). A similar investment in public infrastructure would touch nearly every person in Peru, something that a single mine cannot hope to achieve. Heap leach technology shifts the balance of investments, de-emphasizing capital in favor of operating expenses. Payments for operations are something that the communities can generally share in to a greater extent than initial capitalization. This de-emphasis on capital is logical, as mills are supposed to be more capital intensive, in favor of higher and faster recovery of metals; mills include much more automation to keep the expensive equipment running at maximum efficiency. Heap leaching also increases employment beyond the process circuit. Lower cut off grades means bigger mines; many heaps are truck stacked or have a considerable haulage component and in the contrary there are significant conveyor/stacker systems with the related operating workforce.

Tables 2 and 3 show the striking contrast. The employment figures are total direct permanent employment during operations. Capitalization is estimated in constant year 2000 US dollars and generally excludes land acquisition, financing charges, working capital. Both employment and capital are in very round figures and are from a mix of official and unofficial sources.

Table 2: Capital and Employment: Milling

	Pascua-Lama[1] **(Au, Chile-Arg)**	**Confidential**[1] **(Cu, Peru)**	**Antamina**[2] **(Cu-Zn, Peru)**	**Total**
Capital, US $	$1,100m	$400m	$1,760m	$3,260m
Employment (1st Qt. 2004)				
Total	900	700	1,400	3,000
Per $1m capitalization	0.8	1.7	0.8	0.9

Notes: 1= in development; 2= in operation

Table 3: Capital and Employment: Heap Leaching

	Pierina[2] **(Au, Peru)**	**Veladero**[1] **(Au, Arg)**	**Andacollo**[3] **(Au, Chile)**	**A. Chicama**[1] **(Au, Peru)**	**Total**
Capital, US $	$290m	$280m	$110m	$280m	$960m
Employment (1st Qt. 2004)					
Total	500	400	300	600	1,800
Per $1m capitalization	1.7	1.4	2.7	2.1	1.9

Notes: 1= in development; 2= in operation, 3= in closure

5 - Traditional and non-market activities. By expanding employment in areas with transferable skills, a more sustainable workforce results. In an Andean setting, for example, many of these skills are directly applicable to traditional activities, such as irrigation, erosion control, stone masonry, slope stabilization, and so forth. Admittedly the tools and techniques used at a modern mine are not directly applicable to traditional Andean *campesino* life, but certainly they have more in common then mill operations and maintenance.

6 - Institutional arrangements and governance. The key here is having systems in place to address project consequences, especially unforeseen ones (since the foreseen consequences should already have been provided for). As discussed elsewhere, the potential for catastrophic failure or chronic long-term problems such as ARD may be less in a heap leach environment, thus the need for responsive systems is likewise less. Further, the types of problems inherent to a heap leach project tend to be more manageable at a local level. A milling operation poses the key threats of a tailings dam failure and containment leakage, with related surface and groundwater contamination. Groundwater contamination could continue indefinitely, given the difficulty in properly dewatering and securing a conventional tailings deposit. The typical threat from a leach heap is excessive leakage from the leach pad during its operating life. At closure heaps are usually self-draining and thus the potential for post-closure leakage is significantly reduced.

7 - Synthesis and continuous learning. *Does the project, when considered holistically, have a net positive or negative affect, and will this be reassessed periodically?* Heap leaching has the potential for reducing all types of impacts, improving economic benefits in the local community and reducing economic risk. It also leaves a more secure site after operations and thus reduces long-term environmental liability. At the same time, it uses technologies that are both more locally available and have more applications outside mining. Since the projects are less capital intensive and typically subject to expansions or revisions in the leach pad and stacking operations annually or bi-annually, project re-evaluation is a deeply engrained part of the heap leach culture. Expanding this to include the local community should be an easy step.