Paste 2008 — A.B. Fourie, R.J.Jewell, A. Paterson, P. Slatter (eds)
©2008 Australian Centre for Geomechanics, Perth, ISBN 978-0-9804185-4-5

State of Practice for Tailings Thickening in the State of Nevada, USA

B.F. Ulrich *Knight Piésold and Co., United States of America*

Abstract

The state of Nevada is considered to be the centre of gold mining activity in the USA, ranking as the third largest gold producer in the world behind South Africa and Australia (some reports now place Nevada in fourth place behind China). According to the Nevada Division of Minerals, Nevada led the United States in the production of gold in 2005 with about 213 metric tons (mt) of gold.

For the same year, South Africa's total gold production was 296 mt, followed by Australia at 263 mt. Total US gold production in 2005 was 262 mt. Consequently, the production of gold in Nevada accounts for a significant amount of gold produced globally.

The making of gold produces a significant amount of tailings, and it is thus obvious that a considerable amount of the world's gold tailings is produced in the state of Nevada. A survey of operating gold mines in Nevada has been completed to establish the state of practice in tailings thickening in this important gold producing region. A summary of the results of this survey are presented herein, indicating that there are currently no high density or paste tailings facilities in Nevada, partially due to the regulatory framework in Nevada.

1 Background

Nevada has been a significant producer of precious metals for almost 150 years. The discovery of the Comstock Lode in 1885 helped to spur on the state's long mining tradition. Today, Nevada produces approximately 85% of the gold produced in the USA. The location of the state of Nevada is shown in Figure 1.

An illustration of world gold production provided in Figure 2 depicts the approximate gold production from several major gold producing countries from 1970 through 2006.

If Nevada accounts for 85% of the USA's total gold production, and the average gold grade is conservatively estimated at 6 g/t, then Nevada would have mined approximately 1 billion t of gold ore from 1970 through 2006. Such mining creates very significant tailings production. No attempt has been made here to approximate the amount of this ore that is milled versus placed on heap leach pads – let it be simply said that a significant fraction of this product ends up in tailings facilities.

Gold producers from across the state of Nevada were polled as part of this paper; respondents of the survey reported a total daily tailings production of nearly 140 000 t (over 50 Mmt annually). There were only two noteworthy gold producers that failed to respond to the survey.

2 Survey

A survey was made of most of the largest precious metals producing mines in Nevada. Only two recipients did not respond to the survey. It should be mentioned that in Nevada, it is common for a single mine to have several orebodies, including one or more surface and underground workings, while the tailings all report to a single tailings facility. Table 1 provides some information regarding the general characteristics of the tailings facilities. The mine names are shown only as numbers to help keep their information somewhat confidential.

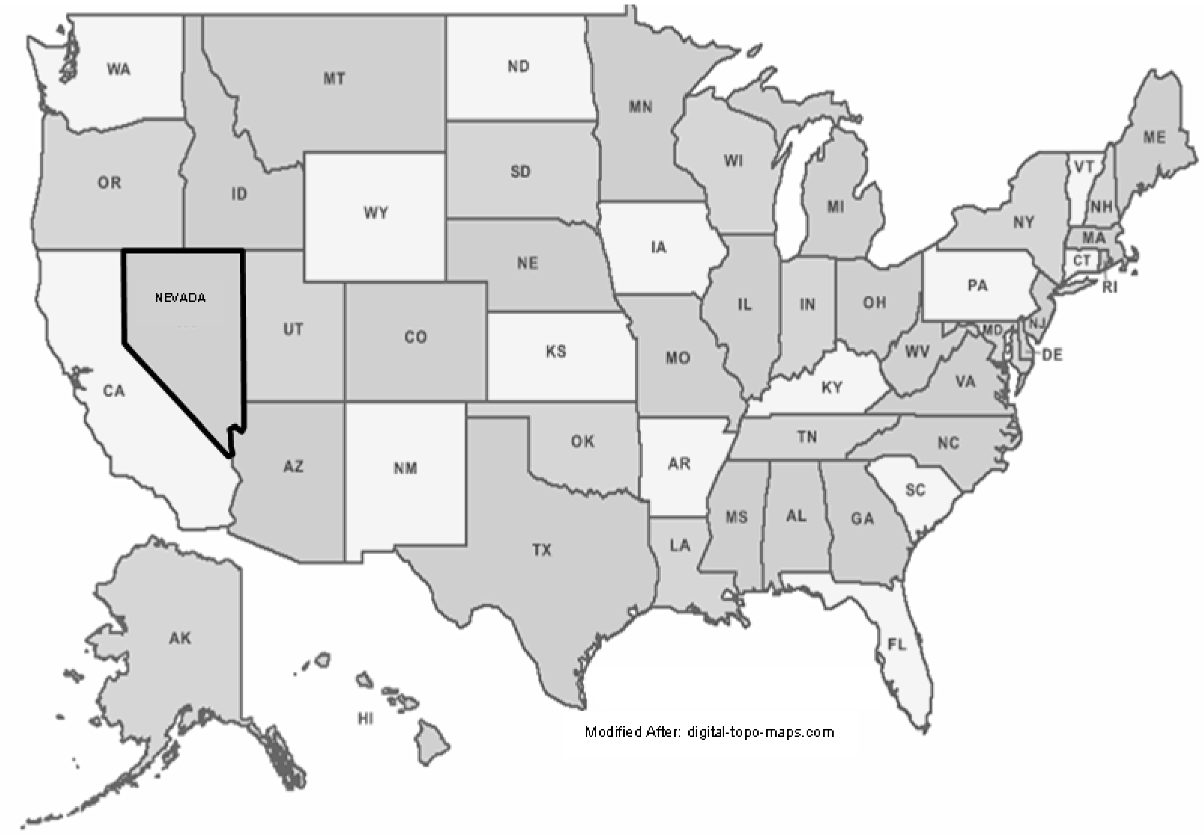

Figure 1 Map of USA showing Nevada

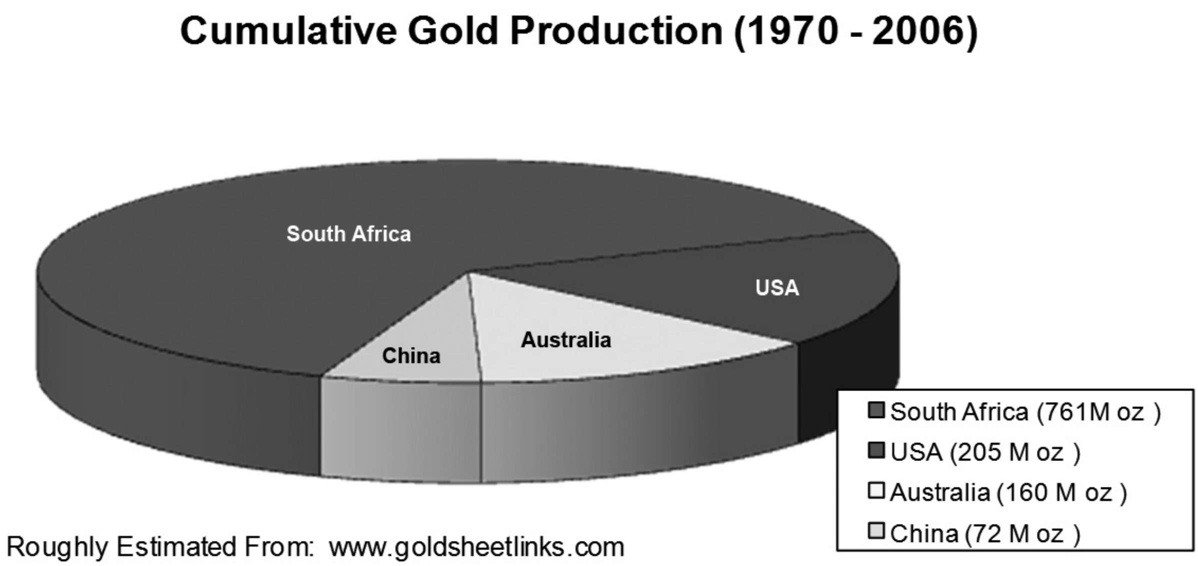

Figure 2 Summary of four significant gold producers (1970 – 2006)

Table 1 Summary of tailings facility characteristics

Mine Designation	Embankment Type	Maximum Height (m) Present	Maximum Height (m) Ultimate	Perimeter Length (km)
1	CL	45	60	10
2	D/S & CL	6	40	6
3	D/S & U/S	45	45	4
4	MCL, then U/S	45	60	5
5	D/S	125	140	5
6	CL	50	60	7

C/L: Centerline, D/S: Downstream, U/S: Upstream, MCL: Modified centerline

Table 2 provides some background information on the various operations that were surveyed for this paper.

Table 2 Summary of operational information

Mine Designation	Daily Tailings Production Rate (tpd)	Tailings Storage (Mm^3) Present	Tailings Storage (Mm^3) Ultimate	Deposition Method	Beach Slope (%)	In-place Dry Density (t/m^3)
1	36,000	58	175	Cyclones	0.25 to 0.05	1.4
2	29,000	8	107	Subaerial	0.23	1.4
3	3,000	38	42	Subaerial	n/a	1.2
4	11,000	13	43	Multiple points	0.125 to 2	1.4
5	27,000	85	124	Subaerial	0.3	1.3
6	10,000	38	92	Subaerial	0.4	1.0

3 Tailings thickening

The operators were also asked about their tailings thickening practices. The survey results are summarised below, retaining the mine designation numbers as shown above:

- Thickening is carried out using a conventional thickener to obtain a tailings underflow with a solids content ranging from 46 to 50%, by weight. Thickening beyond this point would be problematic for the cyclone operation.
- A conventional thickener is used to obtain a solids content of approximately 45%.
- A conventional bridge-type thickener is used to achieve a solids content ranging from 50 to 55%.
- A counter current decantation (CCD) thickener is used to recapture process chemicals. The thickened tailings slurry ranges in solids content from 45 to 50%.
- No thickener is used. Tailings are produced at a solids content of about 35%.
- A conventional thickener is used to achieve a solids content of about 35%.

These ranges of tailings solids contents are fairly traditional. Some operators are considering additional thickening to ease water handling or to increase initial tailings settled density, but still within traditional thickening limits.

Given some of the current trends in tailings thickening, it appears as if Nevada is lagging the industry. A further discussion is helpful in coming to a better understanding.

4 Nevada's regulatory framework

The State of Nevada has a semi-prescriptive set of codes pertaining to the construction of tailings facilities. To-date, these codes have driven much of the design selection process for tailings facilities. The codes for tailings facilities in Nevada include:

- The facility must achieve zero discharge for areas where annual evaporation exceeds precipitation (a typical characteristic throughout much of Nevada).
- Releases of contaminants into the underlying formation must be minimised.
- Liners must be constructed within the basin of the facility, such as 300 mm of soil liner with a permeability not greater than 1×10^{-6} cm/s (or equivalent).
- Additional requirements may be imposed based on project-specific information (size of pond, characteristics of impounded tailings, depth to ground water).
- The basin area beneath the supernatant pond must have a double liner with leak detection.

Thus, we are charged with building zero-discharge, lined tailings facilities in Nevada. The Nevada regulatory code for tailings facilities stipulates the use of liners to protect the environment. Because the facilities are lined, it is very common for them to be fully or partially drained by use of an underdrain system. This combination of drains and liners provides for further environmental protection by reducing the hydraulic head on the liner. Post operation tailings consolidation is also accelerated through the use of an engineered drainage system. A summary of tailings facility lining systems employed in the surveyed Nevada mines is provided in Table 3.

Table 3 Summary of lining systems at surveyed facilities

Mine Designation	Description of Basin Lining System
1	Bentonite ammended seal zone beneath barge channel, remainer unlined.*
2	Fully geomembrane lined w/underdrainage system, double lined w/leak detection in pond area.
3	Unlined, partial natural clay basin.*
4	Fully geomembrane lined w/underdrainage system, double lined w/leak detection in pond area.
5	Fully geomembrane lined w/underdrainage system, double lined w/leak detection in pond area.
6	Fully geomembrane lined w/underdrainage system, double lined w/leak detection in pond area.

* Denotes facilities constructed prior to current codes.

It may be observed from the information in Table 3 that the industry is in compliance with the State's regulations for lining with the exception of the facilities that are "grandfathered in". The two operators who did not respond to this survey are also known to have fully geomembrane-lined basins with underdrainage systems and double liner with leak detection in the pond area.

5 Paste practices

Elsewhere in the world, paste (and high density thickened tailings) have been employed for a myriad of reasons, including:

- Minimise potential for pollution of the environment.
- Increase stored dry density.
- Reduced water consumption.

- Improved closure opportunities.
- Improved economics.
- To better utilise the terrain.
- Operator preference.
- Regulatory preference.

The disparity between practices in Nevada and elsewhere is intriguing. Because mine waste regulations in Nevada preceded much of the paste and thickened tailings technologies, it would seem that it will be quite some time before such applications are used in Nevada; it does not seem as if a combination of full lining systems and high density or paste tailings could be economical.

6 Future of tailings thickening in Nevada

There is a gold producer in Nevada who is currently investigating the use of paste backfill in their underground operations. They also previously investigated this possibility, but terminated the work due to the stringency of the State's regulations. Their efforts are once again underway with a revitalised interest and enthusiasm.

The State's regulations are centred around the goal of protecting the State's water. Therefore, mine waste may not release into the environment any contaminants that may violate the State's regulations for safe drinking water standards. There is a second regulation that allows some mining operations to adhere to a "non-degradation" standard rather than a safe drinking water standard. The State's standards for drinking water include limits on cyanide levels. Free cyanide levels in drinking water may not exceed 0.2 parts per million (ppm).

The difficulty of consistently achieving this low level of weak acid dissociable (WAD) cyanide in paste tailings ended studies for the first attempt to place paste in the underground mine. Their current studies are aimed at investigating not only the chemical levels within the paste tailings, but also what chemicals may be released once the paste is in place. If successful, this may also help clear the way for surface disposal facilities with low cyanide level paste tailings with less strict lining system requirements, but significant studies regarding the possibilities of contaminating the ground water are still required.

The driving force behind the possibility of building a surface paste facility in Nevada would have to lead to rethinking the regulations while still fulfilling the concept of protecting the waters of the State. This would have to be based on the central concept that only a very minor amount of fluids would bleed from a true paste, but also very likely focus on tailings that have been detoxified.

Additional work will be necessary in order to build the first economically viable surface paste disposal facility in Nevada.

Acknowledgements

The author would like to thank the many respondents to this survey. Their assistance in the completion of this paper was vital.