

Repurposing Mines Post-Closure

AusIMM New Zealand – August 2025

Emeritus Professor David Williams, FAusIMM

D.Williams@uq.edu.au

School of Civil Engineering

The University of Queensland, Brisbane, Australia
and

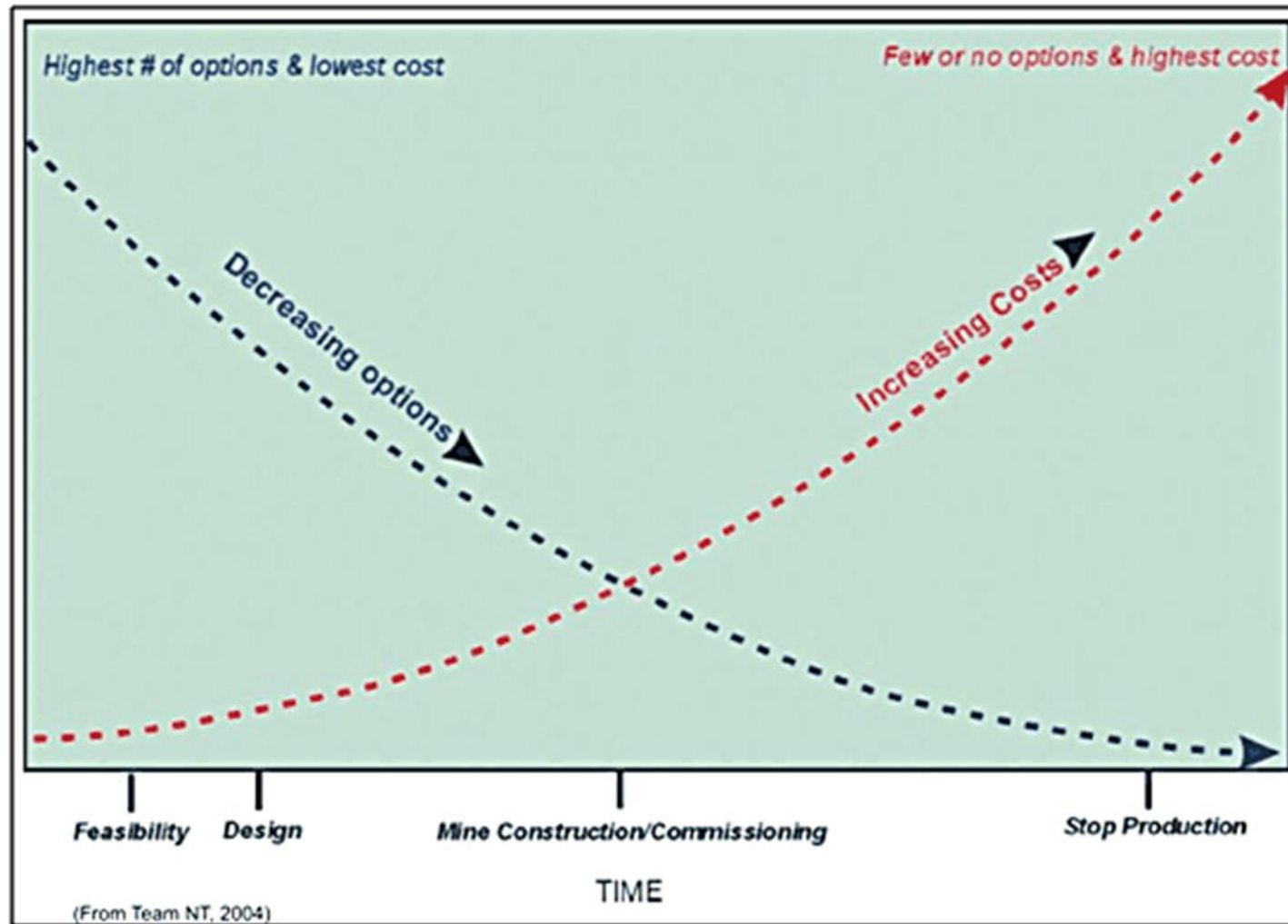
Independent Mine Tailings and Closure Consultant



Bias and Ego

- Everyone brings their own “**Bias**” to any discussion, including that on **Mine Closure and Repurposing**
- Some also bring “**Ego**”, particularly in the mining industry, which is far more damaging than Bias
- Both contribute to:
 - “*Doing what we have always done*” (expecting or hoping for a different outcome)
 - Being “**Complicit**” in maintaining the status quo
 - Loss of community **Confidence and Trust**, which is very difficult to restore
- **We should all strive to think critically and add value**
 - Reprocessing low grade ore and tailings does little to reduce waste volumes
 - Repurposing wastes (e.g., for construction sand) best reduces their volume
 - Repurposing mine sites has the potential to best add value post-closure

Options decrease and costs increase with time



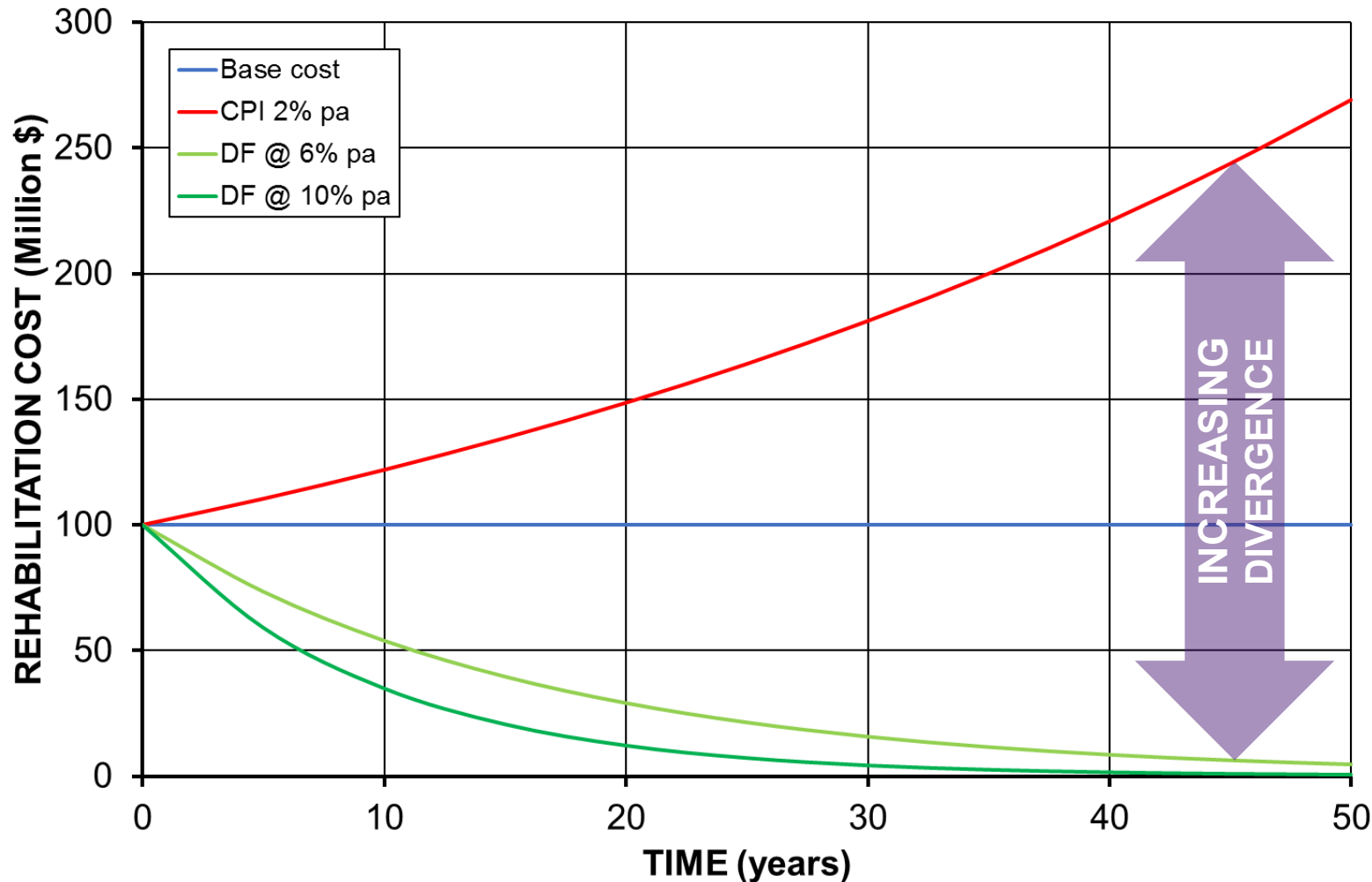
(GARD Guide)

This is somewhat counter to NPV accounting, favouring whole-of-life accounting!

Are Mine Operations and Closure mutually exclusive?

MINE OPERATIONS	MINE CLOSURE
Mine operators are not focussed on future closure	Future closure opportunities are ignored
The Processing Plant is located as close as possible to the pit to minimise ore haulage	Waste rock dumps and tailings facilities spread over expanding footprints
Open pits and (increasingly) block caves are cheaper to operate than underground mines	Open pits and block cave subsidence are difficult to rehabilitate , compared with underground mines
Waste rock , being more expensive to transport than a tailings slurry, is located as close as possible to the open pit, typically end-dumped at the angle of repose	This results in an inverted waste profile , with inert surficial waste materials being placed close to the pit and potentially contaminating wastes further out and on top
Geotechnically Operational pit, waste rock dump and tailings facility slopes are as steep as is stable	Closure slopes tend to be (excessively) flattened
Tailings are cheapest to transport as a slurry to a distant tailings dam, that may be constructed using waste rock	Slurry tailings occupy more volume and are difficult to rehabilitate and waste rock must be transported further
Little attention is paid to the quantity and quality of seepage and sediment , despite no release being allowed	Seepage and sediment may need management in perpetuity
Materials suitable for use in rehabilitation are not stockpiled	There is a greater need for and a greater shortage of rehabilitation materials

Divergent perceptions of rehabilitation cost over time (\$100 M base cost)



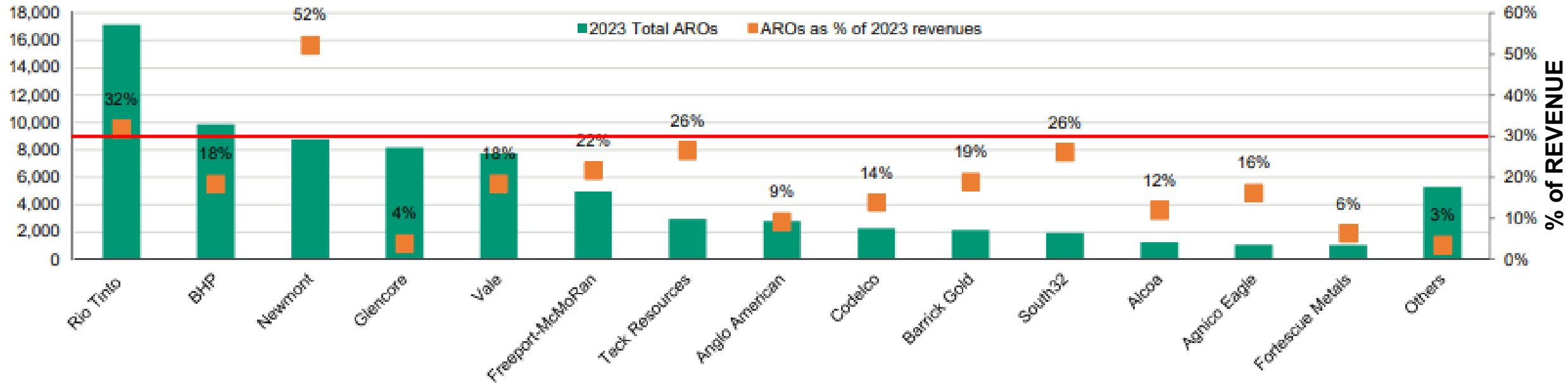
Which approach is more realistic of actual rehabilitation costs delayed over time?

We need a new narrative focussed on opportunities for adding value to site post-closure, which sets the budget, resulting in wins for the Company, Community and Government

Mine rehabilitation liabilities by Company

Most mining companies' asset retirement liabilities below 30% of revenue
 Total asset retirement liabilities by company and as a percentage of revenue (\$ millions)

REHABILITATION LIABILITY (M USD)



Note: Annualized H1 2024 revenue for Newmont
 Source: FactSet, Company data, Moody's Ratings

The commodity recovered is minimal, making mining and processing a mine waste business!

Value-added Mine Closure

CONVENTIONAL COST-BASED REHABILITATION	VALUE-ADDED REHABILITATION
Production rules	Post-closure “value” is identified upfront
Rehabilitation is seen by operator and regulator as a “cost”	Examples include:
Operator discounts cost over time, discouraging rehabilitation	<ul style="list-style-type: none"> • Renewable energy (NIMBY) – solar, wind and pumped storage, delivered to grid via mine transmission lines
Infrastructure such as power lines are stripped, for little return	<ul style="list-style-type: none"> • Agriculture and/or fishery dams
Rehabilitation is limited to “smoothing” and “greening”, even when this may be impossible	<ul style="list-style-type: none"> • Tourism and heritage (the older the better)
Post-closure land use and function are limited	“Value” sets the (available) rehabilitation budget
Operator loses social and financial licences to operate	Potential wins for operator, future land user and Government

The Eden Project, UK – A former China clay pit



(102 Things to do with a hole in the ground)

Bounce Below and Underground Golf, UK



(102 Things to do with a hole in the ground)

Shimao Wonderland 5-Star Intercontinental Hotel, China



*(102 Things to do
with a hole in the
ground)*

From Sand Mining to the Gold Coast, Queensland



MDS, SOUTHPORT - SEPT, 1952

(102 Things to do with a hole in the ground)



Kidston Gold Mines and waste storages



Poor quality seepage collection



From TSF



From NWRD

Revegetation of TSF and WRD tops



TSF solar farm



WRD

Revegetation of angle of repose WRD side slopes



End-dumping growth medium



Emerging vegetation after aerial seeding

Kidston Genex – Gold Mine to Renewable Energy Hub



The success of Kidston Genex

- Kidston Genex is arguably the best Australian example of mined landform stability enabling a mine site to transition to a sustainable future land use
- In addition to adding energy value, Kidston Genex will enable the ongoing management of this former mine site
- It is a model for other value-added re-purposing of mine sites elsewhere
- **It remains to add the legislation to enable a Mine Lease (with an attached rehabilitation bond) to transition to an Industrial Land Use**

Capping mine wastes

- **Mine waste storages often contain potential contaminants, requiring capping to limit oxidation and/or seepage**
- **The “apple skin” analogy:**
 - Apple skins are thin and easily pierced, exposing the flesh of the apple
 - Any capping over potentially contaminating mine wastes is likely to be thin and vulnerable to piercing – Will it last?
- **Any capping must be as robust as possible, handle rainfall without excessive seepage and resist erosion:**
 - Rainfall can be “*stored*” (in low rainfall regions) or “*shed*” (in high rainfall regions)
 - Erosion is best resisted by limiting catchments and applying a rocky surface texture
 - **Some choices:** No cover for benign wastes, wet soil, compacted clayey soil, “*store and release*” covers (suited to dry climates), more robust than “*shedding*” covers (suited to wet climates)

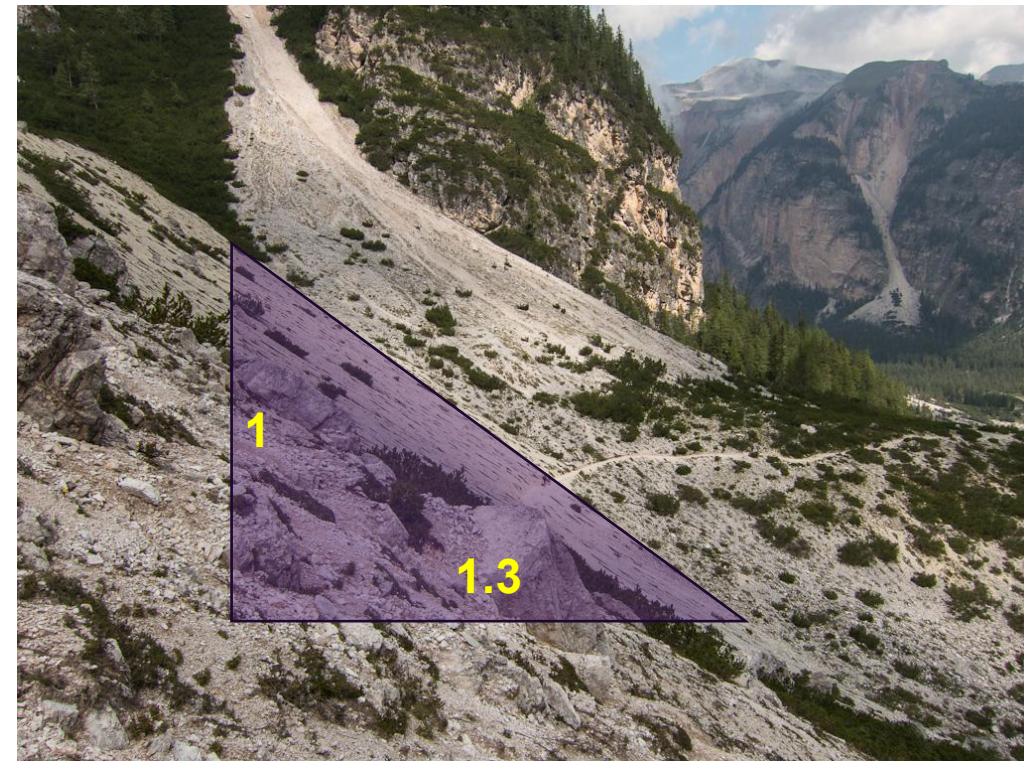
Mine waste slope treatments

- **Natural slopes persist** because they are rocky and resistant to erosion over geological time, and can be steep (up to angle of repose)
- **A balance is required between geotechnical, erosional (rilling, gullying and sediment loss) and geochemical (seepage) stability of slopes:**
 - There is a “*perception*” that steep mine slopes should be flattened, and “*greened*”
 - The flatter the slope, the greater the catchment and erosion for a given slope height
 - Hence, slopes should be flattened to the extent required for geotechnical stability, **BUT** not to the extent that erosional and/or geochemical stability are impaired
- **Shrubs and trees are found on slopes** due to deep drainage, while shallow-rooted grasses tend to predominate on flat areas
- **Ensure geochemical stability by burying contaminating wastes, ensure geotechnical stability, and minimise erosion by applying a rocky cover and revegetation**

Flawed drivers for mine slope flattening

- **Operationally, mine waste slopes are constructed as steep as is geotechnically stable:**
 - Angle of repose ($\sim 37^\circ$ or 77% or 1.3H:1V) for waste rock and spoil
 - 1.5H:1V to 3H:1V for tailings dams, for granular to clayey slopes
- **WHS Legislation** places liability on mine general managers and companies to ensure the safety of workers, **BUT** does not specify slope angles:
 - This liability drives slope flattening to flatter than 4H:1V (an arbitrary choice) to ensure worker safety, where footprint is available, otherwise safety bunds are required
- **Rehabilitation** typically requires slope flattening to an arbitrary $<4\text{H}:1\text{V}$ (14° or 25%) for native woodland or $<8\text{H}:1\text{V}$ (7° or 12.5%) for grazing (**which is still too steep!**)
- **There is a mismatch between mine, natural and dam slopes!**

Angle of repose of natural scree / talus slopes



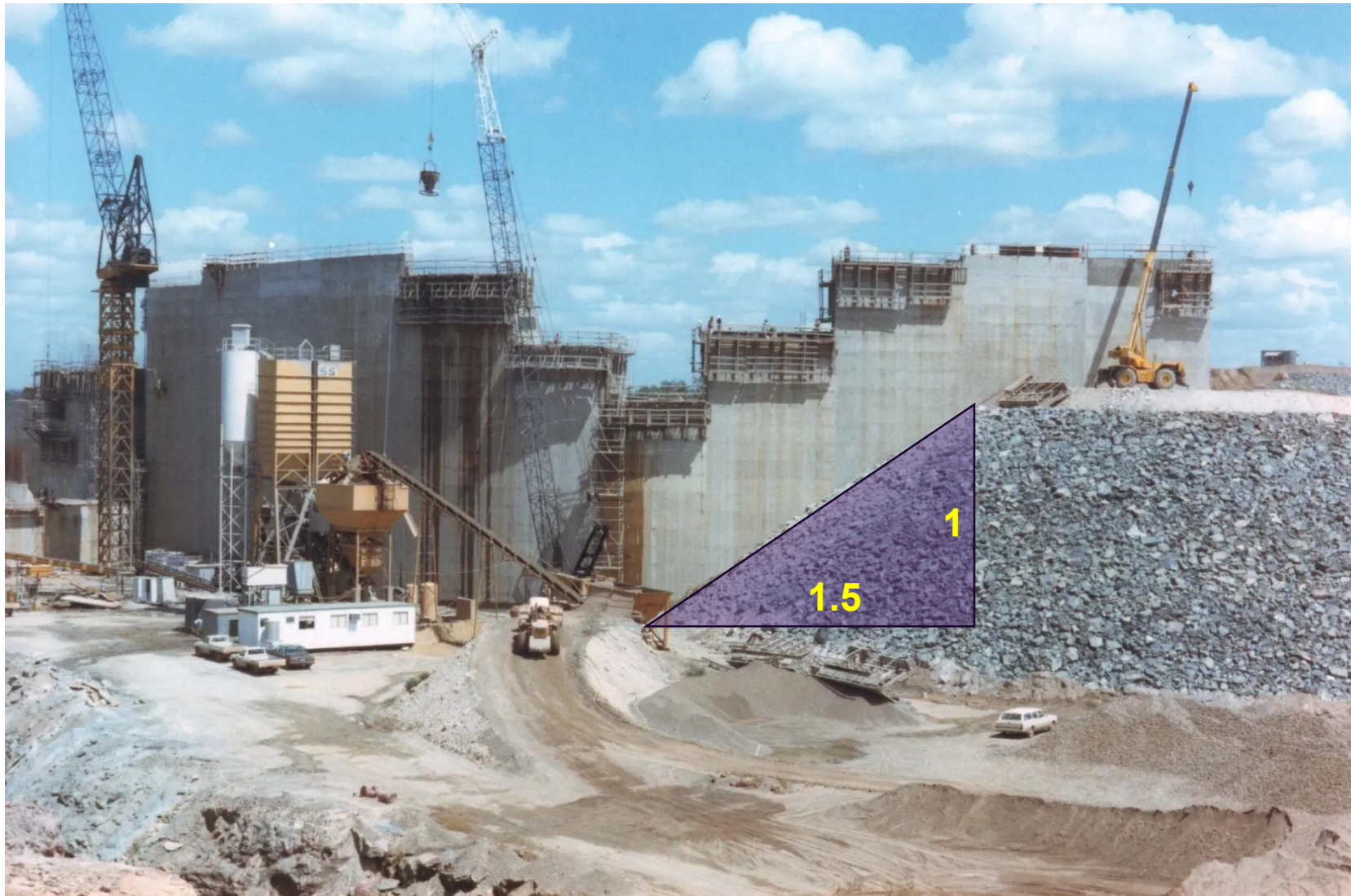
Wivenhoe Dam – Earth and rock fill



Note absence of toe fencing or bunding!



Wivenhoe Dam – Steep slope of rock fill slope



What is successful tailings facility closure? – You judge



Revegetated top



Top native habitat



Top pond and native habitat



Revegetated 1.5H:1V slope



Rock-armoured steep slope

Erosion of a flattened, contoured, drained, and topsoiled and grassed mine waste slope – Make any sense?



Life Ribermine, Iberian Peninsula – Geomorphic Landform



Rio Tinto Mine, Iberian Peninsula – Geomorphic Landform





Christopher Bareither



Rick Friedel



David Williams



David Brett

Colorado State Univ, Georgia Tech, Univ of California, Berkeley, Univ of Illinois



Mike Henderson



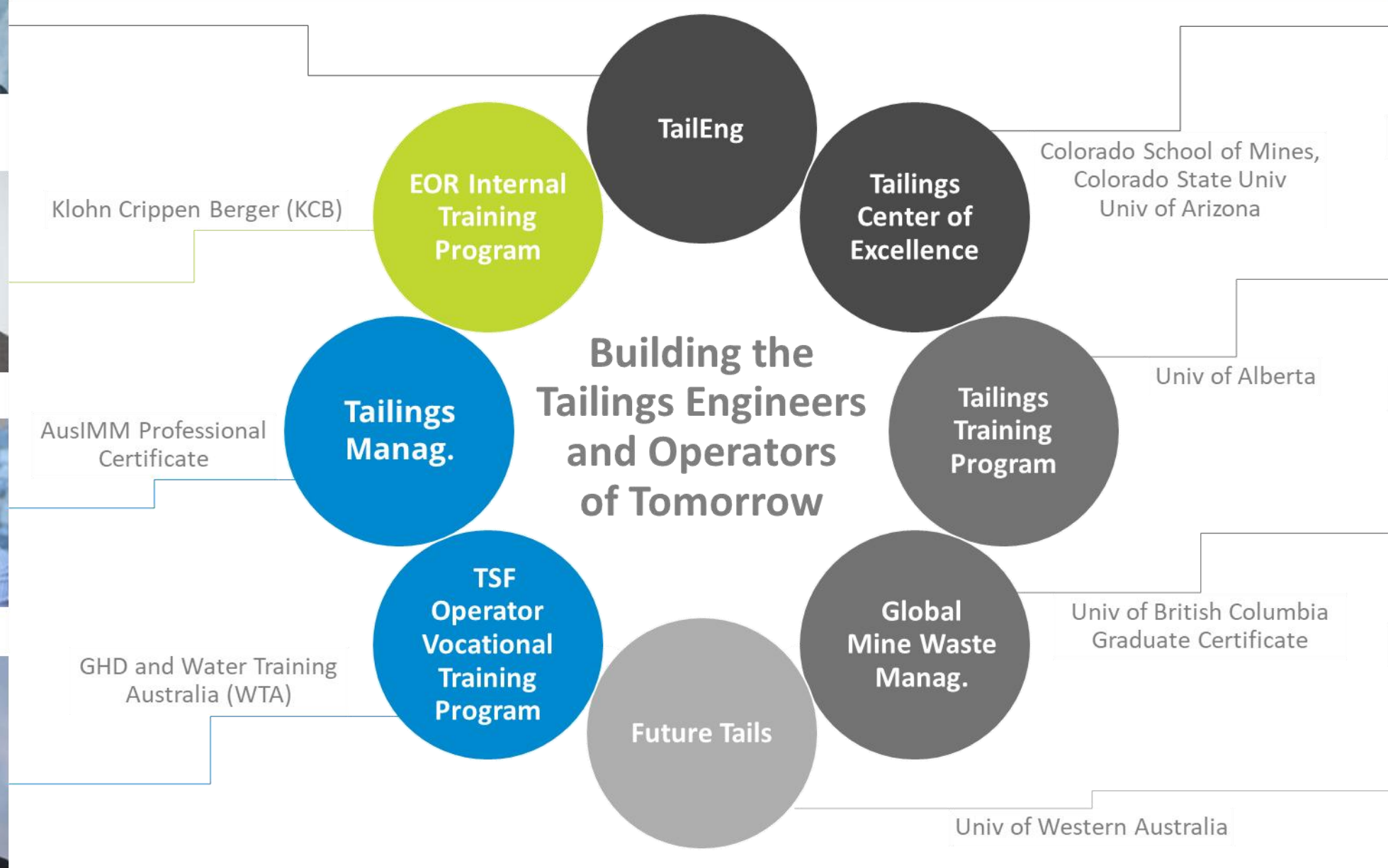
Ward Wilson



Dirk Van Zyl



Andy Fourie



AusIMM Professional Certificate in Tailings Management

Gain an awareness, competency and expand your knowledge on fundamental geotechnical, geochemical, governance, closure and socio-economic considerations of tailings management, including GISTM

- www.ausimm.com/courses/professional-certificates/tailings-management/
- Live and interactive, online in 6 x 90-minute Webinars plus 30-minute Q&A over 6 weeks, plus Comprehensive Assessment (~8 hours/week)
- Eleven offerings to date have attracted **over 1,300 participants**, mainly tailings practitioners (consultants and operators), ~60% from Australasia and ~40% international
- Next offering: **Starting 30 September**