Centre for Social Responsibility in Mining
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Mining as a temporary land use scoping project: transitions and repurposing

Authors

Dr Sarah Holcombe, Senior Research Fellow, CSRM
Julia Keenan, Research Fellow, CSRM

Centre for Social Responsibility in Mining (CSRM)
Sustainable Minerals Institute (SMI)
The University of Queensland, Australia

Acknowledgements

This project report is part of a broader initiative, the Social Aspects of Mine Closure Research Consortium. Established in 2019, the consortium is a multi-party, industry-university research collaboration challenging accepted industry norms and practices around mine closure and demanding new approaches placing people at the centre of closure. Industry partners in the consortium include: Anglo American, BHP, MMG, Newcrest, Newmont, Oceana Gold and Rio Tinto. The initiative falls under the SMI's Transforming Mine Lifecycles cross-cutting program.

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Cover image

The SunMine solar farm, built on reclaimed land at Teck Resources Limited's former Sullivan Mine site, British Columbia, Canada. Photo used with permission from Teck Resources.

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The Sustainable Minerals Institute (SMI) is a world-leading research institute[2] committed to developing knowledge-based solutions to the sustainability challenges of the global resource industry, and to training the next generation of industry and community leaders. The Institute is transdisciplinary, and our work is impartial and rigorous. Our research integrates the expertise of production, environmental and social science specialists to deliver responsible resource development.

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The Centre for Social Responsibility in Mining (CSRM) focuses on the social, cultural, economic and political challenges that occur when change is brought about by mineral resource extraction. The Centre contributes to industry change through independent research, teaching and by convening and participating in multi-stakeholder dialogue processes. Our team consists of geographers, anthropologists, sociologists, political scientists, economists, development and natural resource specialists.

[1] QS World University Rankings and Performance Ranking of Scientific Papers for World Universities, 2018.

[2] The University of Queensland ranks first in the world for mining and mineral engineering, 2018 Shanghai Rankings by subject.

Executive summary

Introduction

Post-mining land use and associated economies have become a priority issue in mine lifecycle planning. This scoping project starts from the position that reconceptualising mine 'closure' may enhance the industry's contribution to sustainable development.

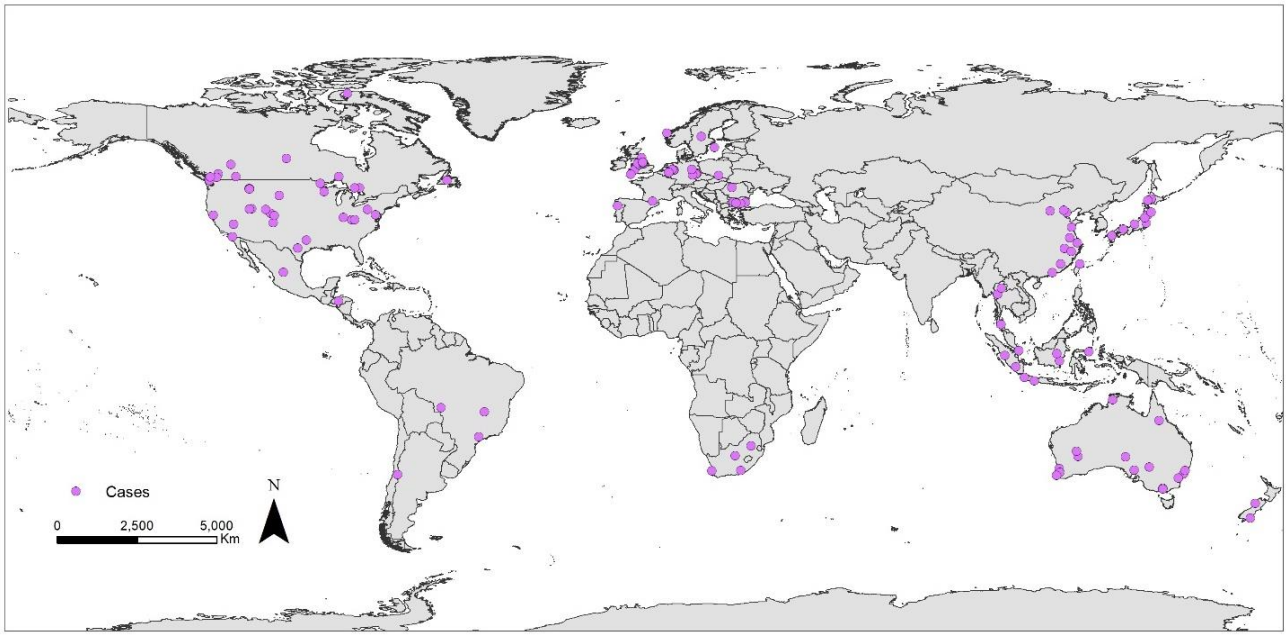
This project reframes mining as a temporary land use, which positions post-mining land use as intrinsic to the mine lifecycle, including the planning and operational phases. Rehabilitation and restoration during operations tend to have a narrower remit, and focus on returning sites to their pre-mining state, which in many cases of large-scale, open-cut mines is unrealistic.

The primary focus is on identifying examples of post-mining repurposing of land and related economic transitions that are being led and/or funded by industry. Transitions led by state or other actors (e.g. civil society groups) provide additional inspiration for industry-led opportunities. Our findings provide an initial repository of cases that different parties can to refer to in making decisions about post-mining futures.

The aim of the project is to provide an overview of the 'state of play' and identify future research and policy directions that encompass a breadth of options for repurposed mining landscapes, infrastructure and economic linkages.

Methodology and project parameters

We developed a global database of repurposing cases building on the S&P Global Market Intelligence database (the 'S&P database'), relevant literature and other publicly available information. We were able to document 141 cases in total in our repurposing database (see figure below).



Global map of repurposing database cases

As this is a scoping project, we were constrained by timing and resourcing in the number of cases we could identify. We aimed for a sampling coverage from the major regions of the world, attempting to find around 20 cases per region. For some regions, we struggled to find any cases, while in others we limited ourselves to 20 to ensure we had time to cover other regions.

In developing the repurposing database we realised that repurposing often occurs after or alongside other activities in the closure process. We established four 'transition categories' as the first order of activity. The first three categories refer to post-closure repurposing activity, and the fourth refers to repurposing initiated during the operations phase.

The transition categories are:

1. Rehabilitation and remediation
2. Regeneration and reclamation
3. Repurposing

} post closure

4. Co-purposing } during operation

When a mine site is repurposed, there is often more than one land use. To ensure that our database could capture this detail and diversity, we developed a typology of land-use categories and sub-categories ('activities'). We found 11 land-use categories of activity and, within these categories, a further 38 sub-categories of land-use activities.

Key finding:

Mine sites are typically re-used for more than one purpose, indicating that though the previous mining land-use may have been singular, post-mining transitions are not.

Allowing for more than one categorisation led to one of our key findings: that mine sites are typically re-used for more than one purpose, indicating that though the previous mining land-use may have been singular, post-mining transitions are not.

We identified 313 different activities at the 141 repurposing sites in our database, an average of 2.22 uses per case. We found that the post-mining land uses address a singular purpose in only 25% of our sample (n=36).

While a lot of mining occurs in remote/regional areas, of the 141 repurposing cases we found that 94 cases were less than 50km from a community or township. Within this range, 33 of the repurposing cases are within 10km or less of a town with 50,000 or fewer residents and 65 cases are within 20km of a township.

Findings

Our findings include:

- our general observations on the research process
- an analysis of the most common repurposing land uses
- factors influencing repurposing, including factors internal and external to the company
- initial observations about industry approaches to repurposing.

General observations on the research process

Overall, we observed that there were very few examples of repurposing relative to the number of closed mines. We know that there are thousands of closed mines globally — beyond the 1804 captured by the S&P database. 'Closed' in this context refers to a post-operational stage of mine life, which the S&P database predominantly categorises as 'inactive'. Comparatively, abandoned and historical mines seem to have greater research, historical and interest group documentation. Government websites occasionally had information about closed and abandoned mines, but rarely included detailed information.

The little information available about repurposing from company websites may reflect a focus on rehabilitation over repurposing, but also that barriers to repurposing exist (either imaginative or practical). Where we did find examples of repurposing, we nonetheless found it difficult to access detailed information about the social, regulatory, financial processes that enabled repurposing.

Analysis of the most common repurposing land uses

The most common category of repurposing was 'community and culture'. This category includes: cultural/historical precincts, reclamation art, museums or exhibitions of mining/industrial history, and community event spaces. This form of repurposing emerged 76 times in our sample. An important element of this form of repurposing is reconfiguring mining infrastructure as cultural heritage. However, this form of repurposing was not usually led by industry and tends to relate to abandoned mines and/or historical sites. Though we found exceptions to this.

Land-use categories	Number of cases
Community & culture	76
Conservation & eco-system services	63
Non-intensive recreation	51
Education & research	32
Construction	20
Intensive recreation	19
Lake or pool	16
Agriculture	14
Light industrial	12
Alternative health	6
Forestry	4
Grand total	**313**

The next most predominant repurposing practice we found was 'conservation and eco-system services' at 63 occurrences. This category encompasses wildlife habitat, native woodlands, carbon offset and sequestration, and wetlands. Sites that were rehabilitated back to their prior state, but not transformed into recognised biodiversity areas or transferred to 'public use' were not included.

Non-intensive recreation is the third most predominant category of land use with 51 occurrences. This category encompasses park and open green space, public/botanical gardens, paths for walking, hiking, running, cycling and horse-riding and eco-tourism.

Of note, is that the categories of 'conservation and eco-system services' and 'non-intensive recreation', together make-up more than one third of the total in terms of primary re-purposing categories. And, as repurposing activities, they are co-located at least 37 sites.

Influencing factors

Because our main interest is in influencing future industry-led and/or funded repurposing, the factors that enable or inhibit repurposing are relevant to the analysis.

External factors

Location of the operation	• proximity to communities and towns, which may have changed over the life of mine • attachment of residents to towns (though 'closed') may hold residents who champion repurposing and economic transitions • connectivity to existing infrastructure (roads, railways, energy networks) • the ecological value of the mine location (in regional context) and its potential to add to eco-system services, habitat and associated community values • land zoning and tenure.
Economic viability	• local supply and demand issues, if the aim is a commercial venture • a constellation of inter-related repurposing projects that synergise with each other are more likely to be economically effective • the possibilities of extractive industry companies diversifying into alternative energy resource projects, or commercial & residential real estate.

Internal factors

Stakeholder & community engagement practices	• whether the company has a 'beyond the gate' approach to local/regional stakeholder engagement • community engagement & inclusive practices are essential through life of mine, including during concurrent or progressive reclamation, as such an approach will more likely lead to positive post-mining land-use transitions • innovative approaches include establishing foundations and trusts for local communities to develop their own local ventures and development initiatives.
Company policies and standards	• though we have not analysed the policies and standards of every company that has successfully engaged in repurposing or co-purposing, we note that where such guidance and leadership exists, the internal structures in place may assist in establishing a business case for repurposing • such standards, as noted among the major companies that are engaging in repurposing (also at legacy sites), include Closure Standards that specifically address beneficial post-mining land uses and consideration of subsequent economic activities, conservation or community use.
Continuity of the company and the operation	• many of the examples we found of industry led repurposing were of mining companies with long life mines and established attachments with the local region • small locally based operations and family businesses (notably quarries) with local commitment and community attachment invested in beneficial land-use transitions.

Industry approaches

While our research is exploratory, we are able to make some initial observations about existing approaches to repurposing from industry. These include, that there are few examples of industry-led and/or funded repurposing relative to the number of mines in post-production. They are limited to 12 countries in our dataset (and that we could locate information about in the time available). They include the US, Australia, Indonesia, Canada, South Africa, Thailand, Brazil, New Zealand, China, Honduras, Japan and France, totalling 47 cases.

Themes to have emerged from industry approaches to repurposing include:

- **Economic diversification beyond a singular industry (and commodity) has become an interest of industry, communities and governments.** Transitioning away from the production of carbon energy resources to renewable and sustainable alternatives is linked in many cases to energy transitions, as a global issue.
- **Association between long life mines and industry investment in post-mining land use and economic transitions.** There appears to be a link between a mining company 'putting down roots' as part of its investment in a long life mine and also taking an interest in and responsibility for post-mining land use and economic transitions on closure. Of the 47 cases where we could find firm evidence of industry led repurposing, approximately 23 cases were from long life mines.
- **Approaches that recognise the cumulative impacts of mine regions/mine clusters.** The majority of regional scale repurposing is led by the state and there is now a considerable repository of research on the drivers behind these initiatives and the mechanisms behind the best practice examples. It seems that without state intervention in terms of policy development and financial support, establishing socio-economic transitions in post-mining regions is very challenging.
- **Out-reach for input and innovation.** There is an example of a company reaching out to communities and educational groups for input into potential repurposing options. Freeport-McMoRan's Henderson Mine has collaborated with the Colorado School of Mines to hold a student challenge to: 'Develop a concept for sustainable repurposing of the Henderson Mine surface facilities and land holdings that provides a socioeconomic benefit to the surrounding communities, is economically sustainable, socially acceptable and provides a positive and lasting legacy in the state of Colorado.'
- **Community partnerships and concurrent rehabilitation.** Some companies have established community partnerships to develop shared goals in education and conservation in reclamation projects. Community partnership panels are one avenue for integrating post-mining land use with rehabilitation outcomes. Creating land uses that coincide with community sustainability objectives and the potential uses for reclaimed land.

Lessons from non-industry-led repurposing

More than half of the cases we found were not industry led and/or industry funded. Nonetheless, these cases provide useful and relevant lessons for the industry on the key ingredients for successful post-mining land-use regeneration and economic rehabilitation. Our findings are congruent with Pearman's (2009), key ingredients, and include:

- leadership, vision and commitment
- local solutions to fit local circumstances (hence the essential need to consult locally)
- creative partnerships for funding, development and implementation (coalitions of NGOs and community groups)
- collaboration with diverse interests and expertise
- community involvement and consultation at all stages, developing shared responsibility and ownership.

1.1.1 Regional approaches to environmental and socio-economic transitions

The repurposing database includes examples of regional environmental and, consequently economic, rehabilitation. Regional approaches can address historic or legacy issues, particularly for regions where mines closed prior to closure regulations. There are many regional examples, including: the coal districts of the Ruhr valley, Germany; the China Clay pits of Cornwall, UK; the Limburg region, the Netherlands; and Appalachian coal country (AMD&Art project), US.

One example of an innovative practice that is regional in scale is the concept of 'community greenways', which appears to have emerged in British Columbia, Canada. This approach recognizes the 'interconnected corridors linking human development and natural systems'. A key component of the concept is the 'integration of mine sites and working landscapes that acknowledge the importance of resource extraction activities and incorporate these requirements within a comprehensive plan for sustained environmental and recreational networks'.

1.1.2 Abandoned mines and mining regions: lessons from state-led repurposing

Though we actively sought examples of repurposing by industry post mine closure, approximately 15 of the examples in our database relate to abandoned mines and we have included them in the study as they offer lessons for industry. Many developed states have established abandoned mines programs. In mining regions, with a predominant mineral and operational type, a regional approach to transformation and economic rehabilitation has been the standard.

In Australia, several states have abandoned mines policies, including Western Australia (WA) and Queensland (Qld). Two northern Canadian abandoned mines programs, the CLEANS (Clean-up of Abandoned Northern Sites in Northern Saskatchewan) and another program, led by Arn Keeling and John Sandlos, (funded by the Canadian Social Science and Humanities Research Council) both marry environmental science with community volunteerism and also environmental science with Indigenous Ecological Knowledge.

1.1.3 Remediation and restoration: coupling the science with the social

Some leading edge cases of repurposing by the state and public/private coalitions couple the science with the social, such that effective post-mining transitions and repurposing also take into account the politics and social dimensions of landscape repair. In these cases ecological restoration is understood in terms of how communities can create or recover economic, cultural and social value through the processes of healing environmental damage. Examples of this approach include the state led remediation followed by public/private partnerships of the Britannia mine abandoned mine and associated infrastructure of in British Columbia, Canada. Restoration has the potential to foster a new sense of place, as we found in all of the 14 examples of legacy and abandoned mines that we identified, and that have been remediated and repurposed near townships.

Regional comparisons of repurposing

A brief discussion of regional comparisons highlights the global diversity of approaches to repurposing. We provide an overview of the key patterns and themes to emerge from the cases that we located from the jurisdictions.

Latin America	According to the S&P database there are 153 'closed', 'inactive' and 'rehabilitation' mines in this region. Of the 15 mines from this region we followed up from the S&P database, the Pearman (2009) text and on-line searches we could only find three cases that have been industry-led repurposing.
USA	The S&P database has 590 properties listed in the closed and inactive categories in the USA, while six of these are listed as in rehabilitation, and several are in care and maintenance. Of the 20 possible cases we investigated 14 were industry led, while of these we included three cases of concurrent reclamation.
Canada	For this jurisdiction the S&P database has 112 properties listed as closed, with the vast majority listed as 'inactive', only four are listed as 'rehabilitation'. These four were followed up, with one of them being a case of repurposing. We found 12 cases of repurposing and co-purposing in this jurisdiction, half of which were by industry. All of the cases we found were from long life mines, from over 100 years old to the 1970s.
Australia and New Zealand	As the jurisdictions with the most readily accessible information, we anticipated finding a greater number of examples for this jurisdiction, than for others. This was not the case. We located a total of 17 sites, two of these being in New Zealand.
Europe	There are large numbers of closed mines in Europe. Several countries — particularly former coal producing countries — have undertaken regional or national programs of rehabilitation and repurposing, particularly in relation to preserving industrial heritage.
China	Although the S&P database contains 198 'closed' properties in China, we found it difficult to access information about repurposing beyond one national initiative and one commercial case. Most of the cases included in the database came from the National Mine Park program which transformed former mines into tourism destinations.
Japan	Only eight properties are listed in the S&P database. There are a variety of uses for the repurposed sites, including: conservation, with eco-tourism and educational facilities; amusement parks and sports venues; and high tech scientific research laboratories, primarily for physics research.
Indonesia	In the case of Indonesia, where we were able to identify eight cases, there is a clear process for companies to follow in order to achieve lease relinquishment, generally including transfer back to the local government. Food production appears to be a priority.
The rest of Asia, the Pacific, Africa, Russia and the Middle East	For the rest of the world, we were not as successful at identifying repurposing cases. We found three cases in South Africa, three in Thailand and one in Taiwan. We attribute this result to a combination of limiting factors including: language, public documentation, research time, and familiarity with the regions. Further, mining in many of these regions has only recently opened up to major international or publicly listed mining companies, or are in jurisdictions with limited regulatory capacity.

Practices that may impact sustainable transitions/ repurposing

We also identified practices that may adversely impact on sustainable transitions and repurposing. They include:

Progressive (or concurrent) rehabilitation

Concurrent or progressive rehabilitation has become a standard practice during the life of mines in many OECD states. Though there are benefits for the company in spreading out the cost of the rehabilitation over the life of mine, as well as benefits to the environment, we also consider the implications of this practice in context of post-mining transitions.

In our database, we have included four examples of concurrent rehabilitation that also demonstrate engagement with possible post-mining land uses, and subsequently they could be regarded as examples of co-purposing. These good practice examples illustrate how inactive areas of long life mines can be rehabilitated at the same time as consideration is given to land-use transitions. The three examples from the US offer multiple transition pathways through community partnerships and outreach.

Industry factors: on-selling, minerals sector volatility

Our findings suggest that the practice of major companies on-selling no longer productive mines to smaller companies that don't have either the financial resources or the social performance capabilities to effectively take on closure — reclamation and repurposing — may be one of the reasons for the lack of industry funded examples. For instance, the industry-led repurposing cases we found evidence of in Australia were all by major companies. If junior companies are repurposing, then they are rarely publicising it on-line and we acknowledge that this may be a limitation.

Conversely, we found several examples from several major companies who, in the process of asset acquisition, have acquired legacy sites which they are developing plans to repurpose or have repurposed. So in these cases on-selling to major companies can be a positive outcome for post-mining land-use-transitions.

Future research

As a desktop scoping exercise, this research was limited by the extent of the publically available data we could access. The repurposing database is thus a snapshot of examples, however it contains many gaps and inconclusive data. Future research could actively address this limitation by being extended to:

- include different languages. A further avenue of research could involve drawing on the breadth of geographical and linguistic knowledge in the SMI to improve our research in non-English speaking countries
- draw on CSRM's expertise in mapping and demographics by extending the database to include a statistically significant number of cases.

A key piece of future research would be to undertake 'on the ground' case studies of repurposed sites. We have identified fourteen potential case study sites that would be suitable for this kind of research (Appendix B). Case studies would ideally:

- include interviews and site visits, as often sites and local organisations are the only holders of documentation of these processes, and can be supplemented by personal/institutional memory.

- specifically focus on the enablers (regulatory, economic, local stakeholder, etc.) at particular sites, such as alternative energy sites or recreational mine pit lakes, for instance.
- investigate different perspectives — such as from a state regulators' perspective, Indigenous groups' perspective, communities and the mining and post-mining operators.

Outcomes of this type of research would be:

- to capture corporate lessons on successful repurposing. There is not a lot of publically available information on experience. There are good practice examples and some companies do share the closure and repurposing news — but this is rare.
- so that companies can begin to tell the closure stories — to close the sustainability loop
- so that shareholders, community and civil society have access to successful examples
- to gain a multi-stakeholder or regional perspective; as a retrospective on challenges encountered in the repurposing journey and how these were overcome.

We could learn and understand more about the examples of the range of abandoned mines programs, in Australia, the UK, the USA and Canada. The purpose of doing so would be to explore further the types of approaches and practices they have developed to finalise post-mining land uses and what the enablers have been for specific repurposing cases.

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1. Introduction

Post-mining land use and associated economies have become a priority issue in mine lifecycle planning. This project starts from the position that reconceptualising mine 'closure' may enhance the industry's contribution to sustainable development.

This scoping exercise reframes mining as a temporary land use, which positions post-mining land use as intrinsic to the mine lifecycle, including the planning and operational phases. Rehabilitation and restoration during operations tend to have a narrower remit, and focus on returning sites to their pre-mining state, which in many cases of large-scale open-cut mines is unrealistic.[3] Our approach applies a particular lens, which enables us to expand beyond rehabilitation.

Managing society-environmental relationships in the lead-up to and following mine closure is a noted gap in research, policy and practice.[4] As a result, opportunities for asset regeneration, repurposing and transfer are being missed. This project is primarily concerned with identifying examples of post-mining repurposing of land and related economic transitions that are being led by industry. Transitions led by state or other actors (e.g. civil society groups) provide additional inspiration for industry-led opportunities. Our findings provide an initial repository of cases that different parties can to refer to in making decisions about post-mining futures. In particular, we focus on:

- the range of repurposing land re-use types (via a typology of land-use categories and sub-categories)
- jurisdictional and geographical patterns
- current good practice and innovations
- opportunities for future research.

The aim of the project is to provide an overview of the 'state of play' and identify future research and policy directions that encompass a breadth of options for repurposed mining landscapes, infrastructure and economic linkages.

2. Background

Ensuring the post-mining landscape is returned to a safe and stable condition is usually the first order priority in mine closure, though achieving this can be a challenge. The drive for industry to do more than rehabilitation is growing. One of the many drivers for this expectation is the scale of mines, with the deepest mines extending kilometres below surface level. In many of these cases, it is not possible or feasible to return the landscape to the prior condition, so creative repurposing of mine features and elements of mine infrastructure is an important consideration. At the same time, these large-scale mines employ hundreds, sometimes thousands of people and consideration of economic transitions for mining workforces, notably local dependant populations, is increasingly

[3] Doley, D., Audet, P and D. Mulligan. 2012. 'Examining the Australian Context for Post mine land rehabilitation: Reconciling the development of natural and novel ecosystems among post-disturbance landscapes'. In *Agriculture, Ecosystems and Environment* 163: 85-93

[4] Bainton, N. and Holcombe, S. 2018. 'The social aspects of mine closure: a global literature review'. Centre for Social Responsibility in Mining, Sustainable Minerals Institute, UQ.

expected of industry post closure, as employment is often positioned at the 'heart' of development.[5]

Likewise, there has been a convergence between the establishment of mine closure regulations from the 1970s to the 1990s in many jurisdictions globally and the development of major industrial scale mines that will subsequently need to follow these closure requirements.[6] Impacts upon sustainable livelihoods, and demographic change will be complex to manage. Applying innovative approaches to such large-scale closures offers opportunity for industry to leave positive legacies.

The topicality of this issue is evident with several recent initiatives. These include the ICMM's recent revision of the *Integrated Mine Closure: Good Practice Guide*, which now incorporates a 'screening tool' for repurposing activities.[7] Likewise, the 2019 mine closure conference (in Perth, Western Australia), had for the first time, a specific workshop session on Repurposing, entitled 'Reimagine. Repurpose. Relinquish.' with over 35 workshop participants from across the world. Also in Western Australia, a *Framework for Developing Mine Site Completion Criteria* has been developed.[8] Though its focus is the environmental aspects of closure there is one mention of repurposing, which suggests its nascence in Australia.[9]

The negative environmental and socio-economic legacies of centuries of abandoned mines are now also widely recognised, notably in developed nations where there are active programs of reclamation by states and civil society groups.[10] We briefly discuss a range of these programs and the lessons they provide for industry-led creative repurposing and socio-economic transitions. Likewise, there are positive examples by some mining companies of linkages with these programs to scale-up their own efforts at post-closure reclamation and repurposing.

3. Methodology and project parameters

This section describes our approach to this research project. As a scoping project, we provide detail about how we developed our databases and the analytical categories that we established. We also describe limitations we encountered, and our approach to the data gathering.

3.1 The S&P database as the starting point

We have developed a global database of repurposing and co-purposing cases building on the S&P Global Market Intelligence database (the 'S&P database'). Though for our task there are limitations to this index, it is nevertheless one of the most complete databases on the global extent of private sector extractive operations. The database provides a range of useful data including the headings

[5] Betcherman, G and Rama, M. 2017. Jobs for Development: Challenges and Solutions in Different Country Settings. Oxford University Press. UK.

[6] For instance, well-known operations approaching closure currently include Yannacocha and Pierena (Peru), Phu Bia and Sepon (Lao PDR), Hidden Valley and Ok Tedi (PNG), Waihi and Macraes (NZ), Vatakoula gold mine (Fiji), Mintails and Richards Bay (South Africa), to name but a few. While in Australia, they include Argyle, Ranger, Gove, East Weipa and Telfer. All of these mines are situated in complex social and economic landscapes, and social legacies such as economic dependency,

[7] ICMM 2019. *Integrated Mine Closure: Good Practice Guide 2nd Edition.* See Tool 4 Screening Alternatives for Repurposing. Pages 86-87. Available at http://www.icmm.com/website/publications/pdfs/closure/190107_good_practice_guide_web.pdf

[8] Young, RE., Manero, A., Miller, P.B., Kragt, M.E., Standish, R.J, Jasper, D.A and Boggs, G.S. 2019. *A Framework for developing Mine site completion criteria in Western Australia*. The Western Australian Biodiversity Institute., Perth, WA.

[9] As the Framework indicates: 'While the most common PMLU [post-mining land-use] for Western Australian mines is to revert to pre-mining land use, such selection should be based on a thorough examination of all possible options. Alternative post-mining land uses should not be ruled out, as it may achieve a beneficial outcome for the key stakeholders in some circumstances. Where the opportunity presents, mining companies may also consider repurposing the use of the land for other beneficial uses if the legislation allows and relevant stakeholders and regulators agree' (2019: 16).

[10] Unger, C. 2017. 'Legacy Issues and Abandoned Mines'. In [eds] O'Callaghan, T and Graetz, G, *Mining in the Asia Pacific: Risks, Challenges and Opportunities.* Springer International Publishing, Cham, pp 333-369.

we apply in Table 1. These categories allowed us to sort and filter our case records according to commodity, region, operator, etc.

Table 1: S&P data categories

S&P data categories	
Property name	Operator HQ
Property ID	Operator country
Primary commodity	List of owners
Also known as	Activity status
State/Province	Development stage
Country Name	General comments
Latitude (degrees)	Full work history
Longitude (degrees)	Environmental comments
Operator name	Actual closure year
Operator common name	Actual start-up year

Our initial selection of cases gives a quantitative indication of the scale of this task. We selected all cases in the S&P database with a 'development stage' of 'closed'. This returned around 1800 records. Within this set, a further category — 'activity status' — indicated the last activity recorded at each operation. These activities are displayed in Table 2.

Table 2: Activity status of S&P 'closed operations'

Activity status	Number of cases
Abandoned	1
Active	1
Care and maintenance	21
Inactive	1719
No info	2
Rehabilitation	49
Relinquished	1
Temporarily on hold	2
Under litigation	2
(Not specified)	6
Total	**1804**

Most operations are listed as 'inactive'. 'Rehabilitation' is not a commonly reported activity, with only 49 of 1804 (2.71%) of the S&P sample listed as such. Of the approximately 590 operations listed as 'closed' in the USA, only six of these are listed as being in 'rehabilitation'. The rest are listed as 'inactive' or 'care and maintenance'.

Of note, regions such as the Middle East, Africa and parts of Europe have very little coverage in the S&P database. Approximately 73% of the S&P sample are from ten countries (see Table 3). *As*

a result, this limitation skews the dataset toward particular regions. Likewise, only 10% (n=68) of the cases are of mines closed in 1995 or earlier, as such this is a limited historic record.

Table 3: Top 10 countries in S&P sample

Row labels	Count of country name
USA	591
China	198
Australia	164
Canada	114
South Africa	80
Russia	60
Ukraine	38
Kazakhstan	26
Brazil	25
Indonesia	24
Total	**1320 (73.17%)**

Low numbers in these other regions does not necessarily equate to fewer operations, however. The S&P database is not complete. Its records of sites in the closure phase is limited to publicly traded companies, and so the many state owned, or majority state owned, companies in Latin American states, Russia, China and India for instance are not included. Figure 1Figure 1 shows the spread of S&P cases by closure year (see Appendix A for further discussion on the limitations of the S&P database for this project).

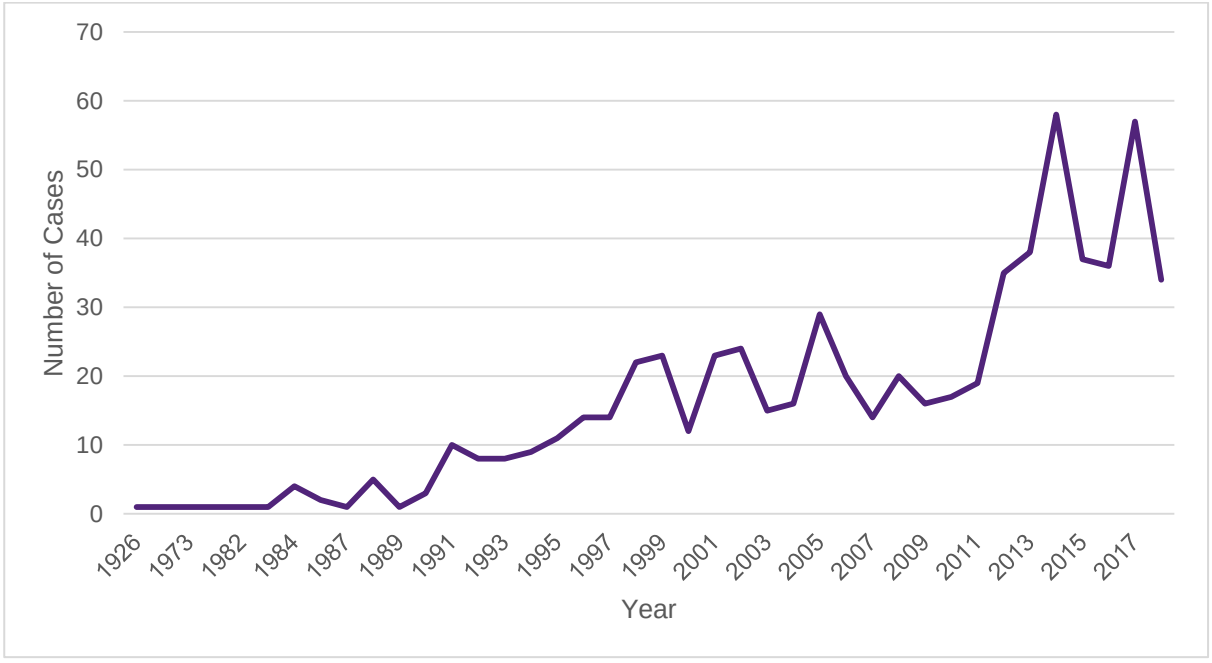

Figure 1: S&P cases by closure year

3.2 Initial investigation of S&P cases

We used the S&P database as a launching pad to begin to locate potential examples and case studies of closed operations that had undergone forms of repurposing and, potentially, associated economic transitioning. We initially investigated the cases that were operated by major and mid-tier companies. We assumed that major and mid-tier companies would be more likely to have a website and publically reported information about the status of the site. In many cases information was unavailable or the site closure did not move beyond rehabilitation. This later situation includes Teck Resources Duckpond mine, SSR's Duthie mine (both Canada) and Goldcorp's Reefton mine (NZ). We also found that most companies, no matter their size, tend to focus their reporting on economically active, rather than closed, sites. Nevertheless, as the rehabilitation category in the S&P database was relatively small (n = 49 sites), we searched for information about many of these sites. We rarely found cases of repurposing (n = approx. 4).

When we did find information about a closed operation either within the S&P database or in our wider search, we focused on sites with evidence of repurposing. To reiterate, by repurposing we refer to a site where the post-mining activity progressed beyond rehabilitation and/or the return to the pre-mine state (e.g. private grazing land). Definitions are provided in Section 4. We further prioritised examples of repurposing that have been led by industry.[11] However, as these cases are not common, we also included cases where the repurposing was led by the state or civil society groups. We included these non-industry led examples, as they nonetheless provide lessons for industry, as we discuss in Section 5.5.

3.3 Developing our dataset: Two tiers of detail

The first tier of detail, and the largest database in this scoping exercise is extracted from the S&P database. As described above, the 'closed' cases from the S&P database gave us an initial quantitative indication of the scale of the project task, to locate repurposing examples.

This was followed by the development of a database of repurposing cases. We refer to this second tier of detail as the 'repurposing database' and it contains 141 cases of repurposing and is based on the style of the S&P database. This database is available for public use through contacting the authors at CSRM. It includes the same data categories that we selected from S&P (see Table 1) supplemented by our own categories related to repurposing (see Section 4). This approach focusses on maximising the number of cases that could potentially be further explored, as well as establishing a large enough sample of cases of repurposing so that we can identify general patterns. Unfortunately, however the level of detail we could locate about each case from publicly available sources was quite low.

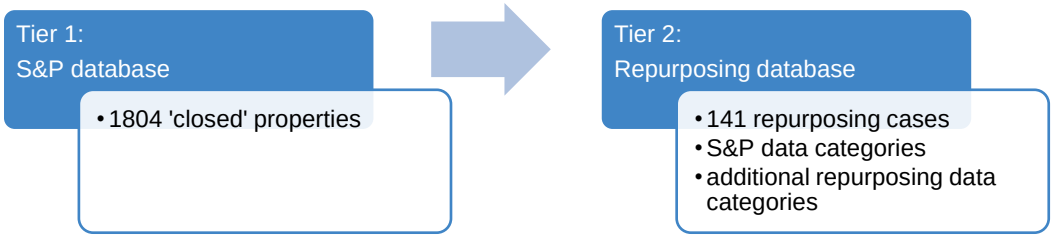

Figure 2: Tiers of data detail

[11] As these were not common, we initially included 20 of the sites in our database where there was no repurposing (though it may have initially looked promising). These 'dead-ends', i.e. where there was no repurposing but only rehabilitation for instance, or where the operation was on-sold, have become a separate data-set. We captured these separately as they potentially provide lessons for the future.

We included 12 cases of quarries in our repurposing database, as these were captured in our broader search beyond the S&P database and some states refer to them as mines.

As this is a scoping project, we were constrained by timing and resourcing in the number of cases we could identify, so we appreciate that there will be cases that we have not included. We aimed for a sampling coverage from the major regions of the world, attempting to find around 20 cases per region. For some regions, we struggled to find any cases, while in others we limited ourselves to 20 to ensure we had time to cover other regions.

A potential extension to this project would be to add a third tier of detail in the form of case studies to detail the qualitative aspects of repurposing.

In Appendix B we provide a list of identified case study options for future research.

3.4 Further data

In addition to researching the S&P cases, we also drew on existing grey and academic literature to locate further examples to build the repurposing database. Below lists our source, and describes what we drew from it:

Table 4: Data sources

Pearman (2009) *101 Things to do with a Hole in the Ground*	• As we attempted to pursue the examples, it became clear that the significant majority of the cases reported are in relation to abandoned mines and state led repurposing. Very few were examples of industry led transitioning or repurposing.
Annual International Mine Closure Conference papers	• Though this conference focuses on the environmental or physical aspects of rehabilitation, there are a small proportion of papers by industry and consultants of case studies of closed operations that have transitioned via forms of repurposing.
Research programs (supported by government)	• The CLEANS program (Clean up of Abandoned Northern Sites), established by the Saskatchewan research Council, entails remediation and rehabilitation of up 37 legacy mine sites in Northern Saskatchewan.[12] • Another Canadian program in Newfoundland and Labrador, led by Arn Keeling and John Sandlos, is a multi-site and multi-year project examining abandoned mines in Northern Canada, which produced a significant number of case studies.[13]
Government initiatives (see also Section 5.5.1 Regional approaches)	• National Coalfields Program in the UK • Internationale Bauausstellung Emscher Park (IBA Emscher Park) or International Architecture Exhibition Emscher Park (1988-1999) in the Ruhr region of Germany • The National Mining Parks of China (recognised by the Department of Land and Resources). • Abandoned mines programs in Australia, including Qld and most recently WA (2016).

Ultimately, we were able to find information on 30 cases of repurposing from the S&P database. We located 111 additional cases (103 repurposing cases, eight co-purposing cases) from literature

[12] Available at https://www.src.sk.ca/project-cleans and see https://www.src.sk.ca/sites/default/files/resources/project%2520cleans%2520fact%2520sheet.pdf
[13] Available at https://www.mun.ca/geog/people/faculty/akeeling.php

and internet searches. Figure 3 is a global map of these cases. Figure 4 and Figure 5 present the distribution of the total 141 cases by commodity and country respectively. Missing data for some cases is shown as 'not specified'. This is something we hope to improve in future iterations of the repurposing database.

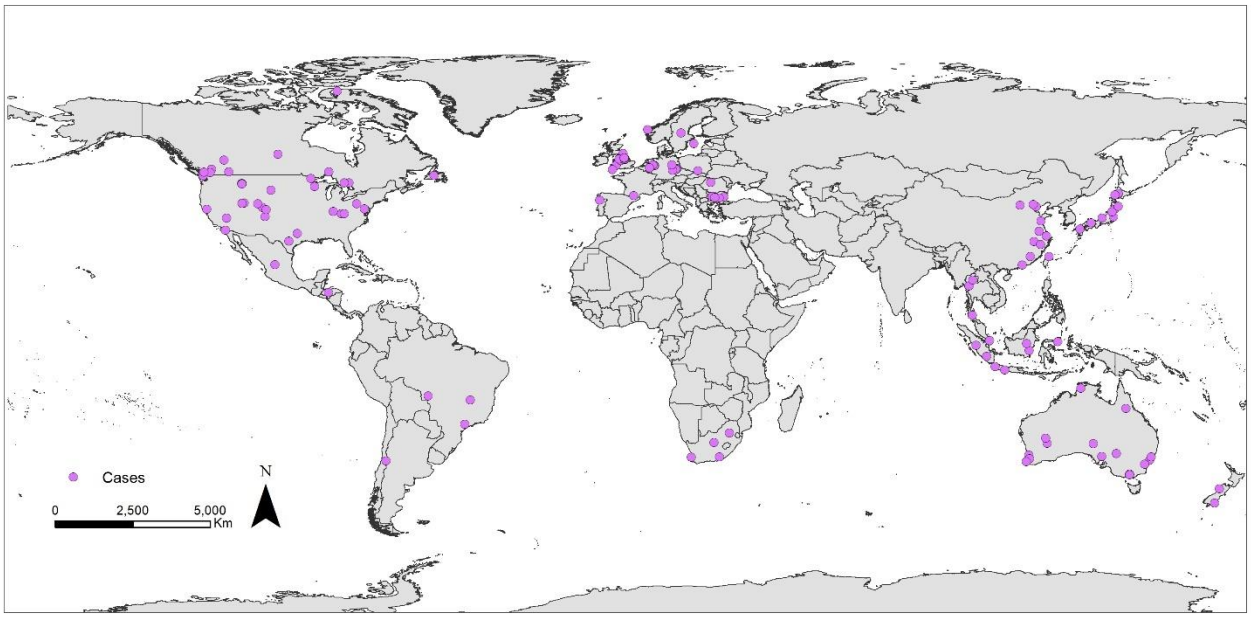

Figure 3: Global map of repurposing database cases[14]

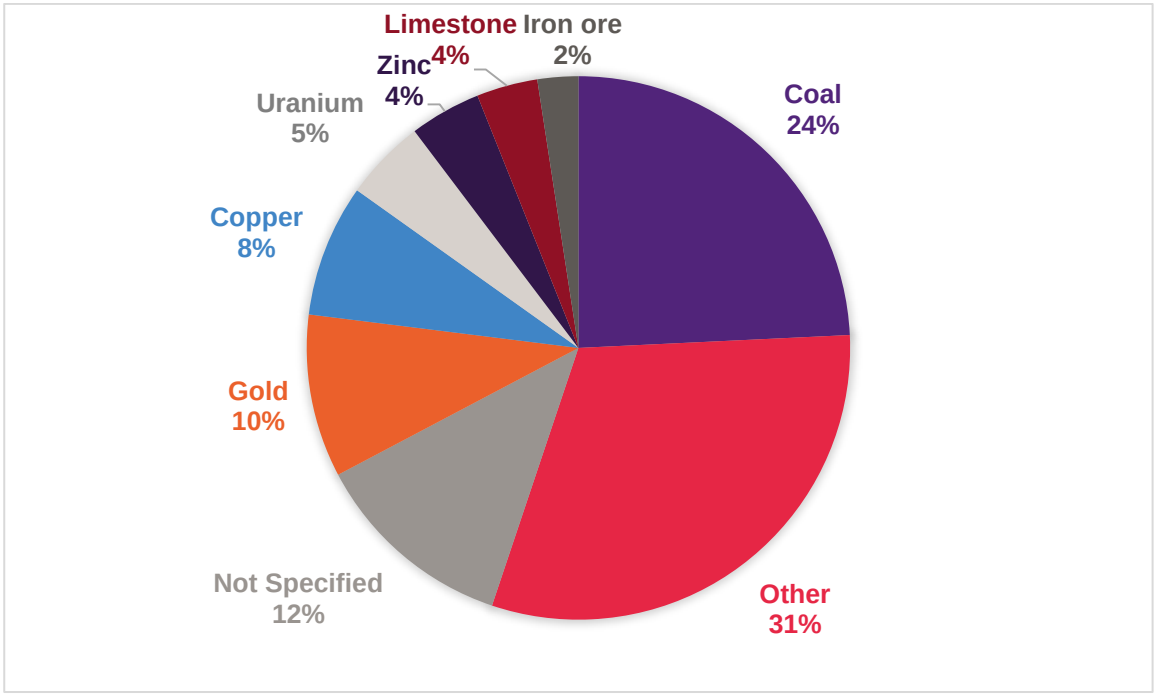

Figure 4: Percentage of cases by commodity (n=141)[15]

[14] Thanks to Dr Kamila Svobodova (CSRM) for producing these maps, and for assisting with additional data sets.

[15] 'Other' includes: sand (3 cases), silver (3), clay (2), bauxite (2), ilmenite (2), salt (2), molybdenum (2), granite (1), olivine (1), borate (1), opal (1), diamond (1), phosphate (1), nickel (1), pyrite (1), kaolin (1), lead (1), lignite (1).

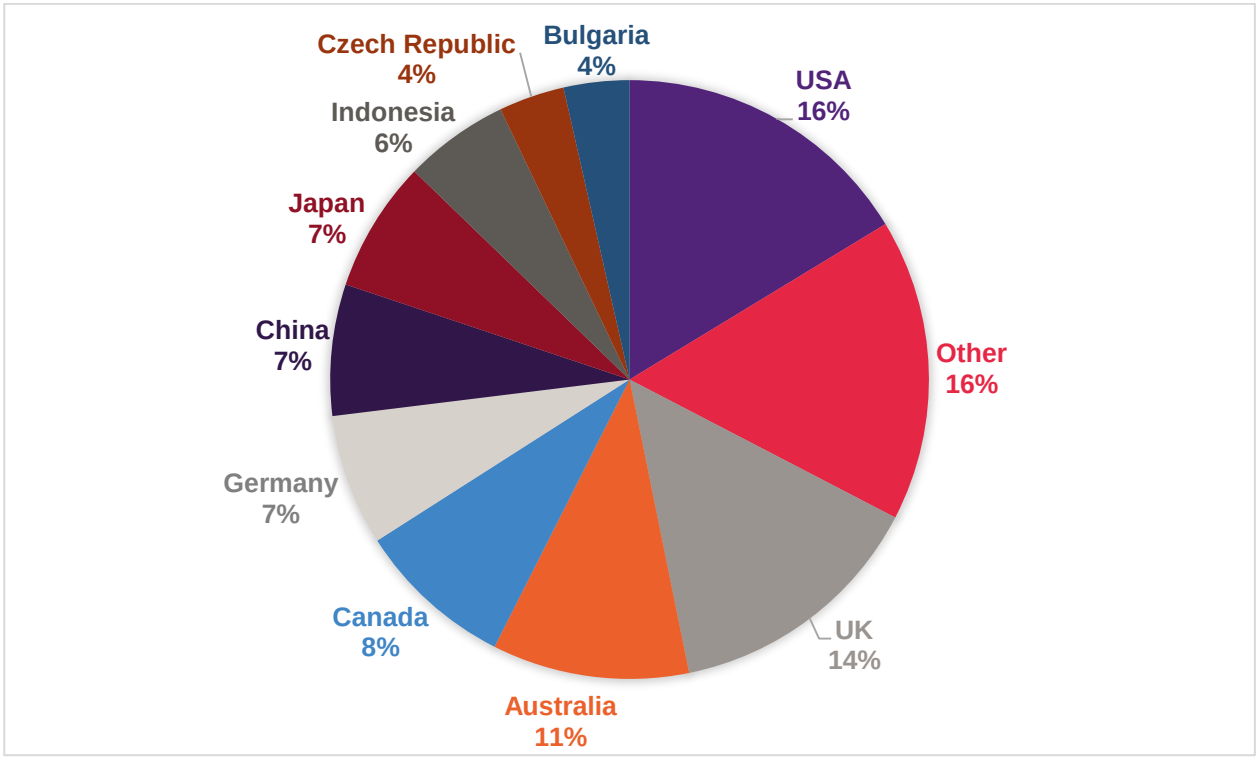

Figure 5: Percentage of cases by country (n=141)[16]

4. The repurposing database

In addition to this report, the 'repurposing database' is a key output from this project. As mentioned above, the database draws from the S&P Global Market Intelligence database. We used Microsoft Excel to develop the database and conduct analysis. The database will be held by CSRM and available for future research by the Social Aspects of Mine Closure Consortium. There is potential for this database to connect to other available databases (e.g. by co-ordinate location, S&P property ID), although this was not a focus of this project.

This section of the report traces our approach to developing the repurposing database to record information about post-mining repurposing in terms of:

- what transitions took place
- the new uses for land
- further themes emerging from the data.

We describe these data categories and provide an analysis of the patterns and themes that emerged from the database.

[16] Other includes: Brazil (3 cases), South Africa (3), Thailand (3), Sweden (2), New Zealand (2), Romania (1), Taiwan (1), Chile (1), Norway (1), Portugal (1), Honduras (1), France (1), Poland (1), Mexico (1), Netherlands (1).

4.1 Transition categories

In developing our database, we realised that repurposing often occurs after or alongside other activities in the closure process. We established four 'transition categories' as the first order of activity.[17] The first three categories refer to post closure repurposing activity, and the fourth refers to repurposing initiated during the operations phase.

The transition categories are:

5. Rehabilitation and remediation
6. Regeneration and reclamation } post closure
7. Repurposing
8. Co-purposing } during operation

We acknowledge that, to some extent, our allocation of each operation within these particular categories is subjective. Nevertheless, given the available information about each operation, we have attempted to be consistent in the application of these categories to particular operations. In this section, we define each category, and discuss their use in our database.

4.1.1 Rehabilitation and remediation

This category is used for the technical environmental aspects of closure (i.e. dealing with acid mine drainage, soil contamination) to ensure a stable, non-polluting environment. This environmental clean-up is usually necessary before safe human and flora/fauna activity can be reinstated and as a result may be the most immediate and obligatory activity.

Rehabilitation: The return of disturbed land to a stable, productive and self-sustaining condition, after taking into account beneficial uses of the site and surrounding land. Reinstatement of degrees of ecosystem structure and function where restoration is not the aspiration.[18]

Remediation: often referring to abandoned mine sites, remediation aims to return sites to a physically and chemically stable state. This includes undertaking corrective actions to reduce environmental contamination to acceptable regulation-based standards.

4.1.2 Regeneration and reclamation

This category mostly refers to processes of restoration of ecosystems that have been degraded, without the need for active decontamination of the environment. Such sites include strip mining and quarries.

Regeneration: Re-establishment of ecosystem structure and function to an image of its prior near-natural state or replication to a desired reference ecosystem.[19]

Reclamation: Reclamation focusses on returning land and/or infrastructure to a state where economic, environmental or human uses are possible.

[17] We also initially included a category named 'not repurposing' (for about 20 cases). This label was used for cases that we wanted to include in the database to build a more complete picture of the transitions landscape. Some of these 'not repurposing' cases included: open mines undertaking progressive rehabilitation, with plans for future repurposing; reopened mines, and mines where rehabilitation was the only activity. However, as indicated earlier — these cases are now a separate database.

[18] DITR 2016. Mine Rehabilitation, Leading Practice Sustainable Development Program for the Mining Industry. https://www.industry.gov.au/sites/default/files/2019-04/lpsdp-mine-rehabilitation-handbook-english.pdf

[19] DITR 2016. Mine Rehabilitation, Leading Practice Sustainable Development Program for the Mining Industry. https://www.industry.gov.au/sites/default/files/2019-04/lpsdp-mine-rehabilitation-handbook-english.pdf

4.1.3 Repurposing

Repurposing: Repurposing utilises elements of the existing mining infrastructure (i.e. roads, mine housing, operational buildings) and the reconfigured aspects of the landscape (i.e. mine voids and mine features) for a different activity post closure. This activity purposefully assists in transitioning the local economy and mitigates the loss of the mine by building on and/or establishing new forms of attachment to the site and region. One of the first two categories above are usually necessary to achieve before repurposing, but not always.

In our database, we found 85 cases of repurposing following on from another transition type, and 48 cases of direct repurposing. (We note the limitations of the secondary data we accessed and thus some of these cases of direct repurposing may have required forms of mitigation before re-use).

4.1.4 Co-purposing

Co-purposing: Co-purposing consists of developing a beneficial activity on a site where operations or management relating to the primary business is on-going. In this report, we have included examples of concurrent or progressive reclamation of a closed area of an on-going operation that also demonstrate additional beneficial transitions beyond rehabilitation. Such practices look beyond closure to engage with possible post-mining land uses.

We found eight co-purposing cases.

4.1.5 Trends

Our figures indicate that, in our repurposing database, it is as common to repurpose a site that requires regeneration and reclamation, as is does the more intensive rehabilitation and remediation. However, we note that, as a scoping exercise, we have not closely investigated this prior aspect to repurposing and likewise the timeframes in doing so.

Table 5: Transition types (all cases)

Transition type	1st Transition	2nd Transition	3rd Transition
Co-purposing	8		
Regeneration & reclamation	42	3	
Rehabilitation & remediation	43		
Repurposing	48	82	3

Likewise, in the cases that were more amenable to repurposing and did not require either rehabilitation and remediation or restoration and regeneration (48 of these) — these sites were predominantly quarries, surface operations and coal mines and we anticipate that on closer investigation, it is probable that these also required forms of remediation prior to repurposing, as many of these are historical mines.

4.2 Land-use categories and sub-categories

As we found more examples (from the range of sources discussed earlier), it became obvious that when a mine site is repurposed, there is often more than one land use. To ensure that our database could capture this detail and diversity, we developed a typology of land-use categories and sub-categories (‘activities’).

In developing our typology we have taken inspiration from two sources in particular. These are the recent Framework for Developing mine-site completion criteria in WA (Young et al 2019)[20] and an academic article on 'Mined Land Suitability Analysis and Post-Mining Land Uses' (Soltanmohammadi 2009). These two sources both provide an overarching framework for assessing the possibilities that each site presents for different kinds of post-mining land uses.

As our search for repurposed sites progressed and we entered new items into our database, we expanded and refined the categories and activities. Our final classification categories are presented in Table 6.

Table 6: Land-use classification categories and land-use activities

Land-use category	Land-use activities
Agriculture	Arable farmland
	Pasture or hay-land
	Nursery
	Food production
	Aquaculture
Forestry	Lumber production
Lake or pool	Sailing, swimming &/ fishing pond
	Town water supply
	Flood protection
Intensive recreation	Sports field
	Ski field
	Amusement park
	Racetrack
Non-intensive recreation	Park & open green space
	Public/botanical garden
	Paths for walking, hiking, running, cycling &/ horse-riding
	Eco-tourism
Community & culture	Cultural/historical precinct
	Reclamation art
	Museum or exhibition of mining/industrial history
	Community events space
Construction	Commercial real estate (i.e. shopping centre, business park, hotel, data centre, casino)
	Housing estate
	Airport
Light industrial	Factory
	Military/defence
	Recycling & repurposing of decommissioned materials
	Alternative energy
Education & research	Rehabilitation research and education
	Research facility

[20] Available from https://www.dmp.wa.gov.au/Documents/Environment/Framework_developing_mine-site_completion_criteria_WA.pdf

	Education facility
	School outreach
Alternative health	Therapy
	Medicinal
Conservation & eco-system services	Wildlife habitat
	Native woodlands
	Carbon offset & sequestration
	Wetlands

We realised that it was possible for mine sites to be re-used for more than one purpose, so we allowed for up to three levels of classification in the database. We named these primary, secondary and tertiary land-use categories and activities, although it was not always clear if there was a difference in scale or importance from the data available. In cases where this was not obvious, we reflected the order of mention in our sources.

Treating all levels of classification equally, the most common activities are shown in Figure 6.

Table 7: Most common repurposing activities (all levels)

Activities	Occurrences
Wildlife habitat	33
Museum or exhibition of mining/industrial history	28
Cultural/historical precinct	27
Park & open green space	25
Native woodlands	23
Community events space	14
Commercial real estate (e.g. shopping centre, business park, hotel, data centre, casino)	13
Education facility	13
Research facility	12
Paths for walking, hiking, running, cycling &/ horse-riding	10
Sailing, swimming &/ fishing pond	10
Eco-tourism	9
Alternative energy	8
Sports field	8
Public/botanical garden	7
Reclamation art	7
Rehabilitation research and education	7
Amusement park	6
Therapy	6
Town water supply	6
Wetlands	6
Housing estate	5
Aquaculture	4
Food production	4

Lumber production	4
Nursery	4
Recycling & repurposing of decommissioned materials	3
Ski field	3
Airport/port	2
Pasture or hay-land	2
Racetrack	2
Carbon offset & sequestration	1
Military/defence	1

Allowing for more than one categorisation led to one of our key findings: that mine sites were very often re-used for more than one purpose, indicating that though the previous mining land-use may have been singular, post-mining transitions are not.

As can be seen in the table, we identified 313 different activities at the 141 repurposing sites in our database, an average of 2.22 uses per case. Perhaps the most important feature to note about the repurposing land-use categories in these three tables is that the post-mining land uses address a singular purpose in only 25% of our sample (n=36). See Appendix D for the frequency count across the three categories.

Table 8: Concurrent activities

One land use only	Two land uses	Three+ land uses
36	38	67

Table 9: Frequency of primary land-use categories

Land-use categories	Number of cases
Community & culture	30
Non-intensive recreation	23
Conservation & eco-system services	23
Construction	12
Intensive recreation	12
Lake or pool	9
Education & research	9
Light industrial	8
Agriculture	6
Alternative health	6
Forestry	3
Grand total	**141**

Table 10: Frequency of secondary land-use categories

Land-use categories	Number of cases
Conservation & eco-system services	29
Community & culture	27
Non-intensive recreation	13
Education & research	11

Intensive recreation	8
Construction	6
Lake or pool	5
Agriculture	3
Light industrial	2
Forestry	1
Grand total	**105**

Table 11: Frequency of tertiary land-use categories

Land-use categories	Number of cases
Community & culture	20
Conservation & eco-system services	13
Intensive recreation	11
Education & research	10
Lake or pool	4
Non-intensive recreation	3
Light industrial	3
Agriculture	2
Construction	1
Grand total	**67**

4.3 Further categories

We also added additional categories to the repurposing database in an attempt to further contextualise the operations. We had to be selective about these categories to balance research utility (i.e. providing detailed information) and practicality (i.e. levels of data accessibility and timeframes). The additional categories are shown in Table 12.

Table 12: Repurposing database categories

Repurposing database categories	
Post-mining name	Post-mining owner
Community/township Y/N	Re-used component
Indigenous interests Y/N	Transition funder(s)
Abandoned Y/N	Funder category
Transition start	Area
Transition end	Free text
Post-mining operator	References

Unfortunately, we found it difficult to populate these categories either with any data or with any certainty. These categories may be important in determining the opportunities for, and approach to, repurposing at each site, so we fleshed them out as much as possible.

For example, while a lot of mining occurs in remote/regional areas, we found that 94 cases of the 141 repurposing examples were within 50km to a community or township (see Table 13), with our own coding from qualitative data. This usually meant that an interested community was mentioned in qualitative data about the repurposed project.

We cross-referenced this with Natural Earth's Populated Places dataset.[21] Using this data, we found that 33 of the repurposing cases are within 10km or less of a town with 50,000 or fewer residents and sixty-five cases are within 20km.[22] Further research could investigate the difference between repurposing examples in small or large communities, and in communities in different proximities to population centres.

Table 13: Repurposing cases with proximate communities

Proximate community from qualitative data:	
Yes (settlement of any size)	94/111
Proximate town of >50,000 people from global dataset:	
<10km from town	33
<20km from town	65
<50km from town	94

If the data was available, we also recorded whether a case involved Indigenous interests. Given the location of many remote operations, involving Indigenous interests would be a key component of any transition process. However, we were only able to find 11 cases where industry engagement with, and thus reporting of, Indigenous rights and interests were indicated (i.e. in relation to community programs or employment). We think that this is a major underestimation of Indigenous interests due to underreporting, and in some cases lack of state-based recognition of Indigenous peoples leading to a lack of formal industry recognition and engagement.

We also cross-referenced this with an Indigenous Peoples' Land dataset.[23] Of the 141 cases in the database, 32 of them are within 20km or less of formally recognised Indigenous territory. Table 14 shows the breakdown by country.

Table 14: Repurposing cases with reported Indigenous interests

Indigenous interests from qualitative data:	
Yes	11/111
Number of sites <20km from Indigenous Peoples' Land:	
Australia	8
Canada	8
Indonesia	4
USA	4
Thailand	3
Taiwan	1
New Zealand	1
South Africa	1

We included a category to indicate whether or not a mine had been abandoned. This has implications for identifying the appropriate body to lead and/or fund repurposing. For the 85 cases where we could find this information, we identified 15 cases of repurposing of abandoned mines, and 68 of non-abandoned mines. None of these abandoned mines were in the S&P database and they tend to be historical mines and those that ceased production prior to regulations.

[21] Natural Earth (2020) Populated Places dataset, accessed 10 Jan 2020, from https://www.naturalearthdata.com/downloads/10m-cultural-vectors/10m-populated-places/
[22] Note that a 50,000 population is the smallest town identified in the Populated Places dataset.
[23] Garnett, ST, Burgess, ND, Fa, JE, Fernández-Llamazares, Á, Molnár, Z, Robinson, CJ ... & Collier, NF 2018, 'A spatial overview of the global importance of Indigenous lands for conservation', Nature Sustainability, vol. 1, no. 7, pp. 369.

Table 15: Abandoned mines

Abandoned?	Number of cases
No	68
Yes	15
Not known	56
Grand total	**141**

Another category of interest is who funded the repurposing project. In reality, we found that there were often multiple contributors to a transition. We recorded the names of all groups in the database but also included a coded variable 'funder category'. This applied only to the lead funder and allows us to examine the similarities and differences between state- or company-led projects. However, given the limitations of the data available it was not always possible to be certain about the funders, so there will be a small margin of error in some cases. We also found seven examples of repurposing transformations that were funded by public-private partnerships. We also note that 'funded' does not necessarily translate to 'led'. Community groups could have led the transition in terms of wanting the repurposing, identifying post-mining land uses, etc while the company funds the transition.

Table 16: Repurposing funder category

Funder	Number of cases
Company	49
Private	6
Public-private partnership	7
State	35
Not known	44
Grand total	**141**

4.4 Parameters for post-mining land use and transitions

We anticipate that states that are members of the OECD will have a land-use management classification system that may need to be directly referenced in any post-mining land-use, as a regulatory element in closure. In Australia, it is the Australian Land Use and Management (ALUM) classification system developed by ABARES (2016), see Appendix C.

Likewise, at a federal level in Australia, the multiple land-use framework (MLUF) is also a useful tool. Though the MLUF does not specifically address mine closure, it is an important tool for supporting more effective management of the social aspects of closure. This is achieved in part through an emphasis on inclusive and tailored engagement with diverse stakeholder groups (including landholders), and the recommendation that resources are best utilised when planning processes consider the social, economic, environmental and heritage values of land use for current and future generations.[24]

[24] COAG, Standing Council for Energy and Resources. 2013. The *Multiple Land Use Framework* (MLUF).

Drawing on Young et al (2019) and Soltanmohammmadi (2009), the possibilities for post-mining land use will be framed by the following requirements:

- relevant to the tenure
- relevant to the environment where the mine operates, ie. natural conditions, terrain configuration, vegetation and water bodies
- considerate of historical commitments at the site and at a regional scale
- achievable in the context of land capability and safeguarded against physical, chemical and biological hazards
- acceptable to key stakeholders, including regulators, local authorities and Indigenous groups
- ecologically sustainable and, where appropriate economically productive; and
- within in any other legislative constraints.

The major question that we are addressing is: what factors have actually led to, or acted as a precursor for, repurposing? We are interested in *practice* and to the extent that this framework of conditions, above, may act or will act as parameters for industry action — then they are useful. And likewise, this framework caters for all forms of post-mining land use, including the return to the previous land use. A number of these conditions will lead to rehabilitation as the end point; as the most appropriate post-mining land use.

5. Our findings

In this section, we report the findings of this research scoping project. We cover:

- our general observations on the research process
- the most common repurposing land uses
- factors influencing repurposing, both external to the company and internal
- initial observations about industry approaches to repurposing

5.1 General observations on the research process

Overall, we observed that there were very few examples of repurposing relative to the number of closed mines. We know that there are thousands of closed mines globally — beyond the 1804 captured by the S&P database — yet we were only able to find information approximately 141 operations that had progressed to a form of repurposing (including co-purposing). Our time was limited, yet we found it difficult to even find this many examples.

We found very little to no information available about (recently) closed mines generally. Most mining company websites we visited contained little to no information about mines that had closed. Most information about rehabilitation related to on-going or concurrent activities. There were a handful of mentions of successful relinquishment.[25]

Comparatively, abandoned and historical mines seem to have greater research, historical and interest group documentation. Government websites occasionally had information about closed and abandoned mines, but rarely included detailed information.

[25] These include Glencore's new Wallsend coal mine in NSW, two operations in WA: BHPs Beenup titanium mine and the Rio Tinto subsidiary Norgold Bottle Creek gold mine, multiple cases in the Czech Republic (coal and lignite), the Petangis mine in Indonesia and the Momino mine in Bulgaria.

The little information available about repurposing from company websites may reflect a focus on rehabilitation over repurposing, but also that barriers to repurposing exist (either imaginative or practical). Where we did find examples of repurposing, we nonetheless found it difficult to access detailed information about the social, regulatory, financial etc. processes that enabled repurposing.

Nevertheless, we recognise that there are industry initiatives, such as the North American Mine Closure Working Group (NAMCWC) established in 2014 to 'share learnings and best practices in closure, reclamation or remediation of our mines, smelters and refineries…and [to] promote thought leadership/innovation in closure and repurposing/co-purposing of mining properties'.[26] This group made-up of 13 major companies, is to be applauded for developing this initiative and we suggest that it could gain greater leverage if the positive examples and lessons could be shared publically via company websites and open forums.

Historically there has been an ad-hoc approach to mine closure and repurposing. There are a variety of innovative and successful examples, but these appear to be relatively isolated examples. With the exception of government initiatives in Germany, the UK, the Czech Republic and China (often on a regional scale), we found that repurposing of mine sites is uncommon. Thus, many of the examples of environmental and, consequently economic, rehabilitation are in mining regions and many of these address historic or legacy issues when mines closed prior to regulations. Nevertheless, there are important lessons to be learnt from these regional scale approaches that also deal with cumulative impacts and economic transitions.

Though we inserted an Indigenous peoples' category in the repurposing database this category was rarely able to be populated. There are a handful of operations, predominantly from Canada and Australia, where we found data indicating that closure processes actively engaged Indigenous interests. These include the Wesfarmers Collieburn coal mines in Western Australia. This company engaged with the local Ngalang Boodja Aboriginal Council to establish an enterprise using the mine-pit lakes.

Meaningful engagement with Indigenous Peoples around repurposing is clearly a gap in available data, and likely also in the majority of practice. Given the importance of long-term connections to land for Indigenous Peoples and associated livelihoods, they should be centred in any engagement about mine transitions.

5.2 Repurposing land uses

In this section, we explore some of the most common repurposed land uses. We also discuss the land uses that make significant contributions to sustainable development. By broad category, the most common repurposed land uses in our database are shown in Table 17.

Table 17: Repurposed land use by category

Land-use categories	Number of cases
Community & culture	76
Conservation & eco-system services	63
Non-intensive recreation	51
Education & research	32
Construction	20
Intensive recreation	19

[26] Thanks to Carl Grant (Anglo American) for sharing the NAMCWG Repurposing/Co-purposing Guidance — Consolidated Draft, 11 March 2019.

Lake or pool	16
Agriculture	14
Light industrial	12
Alternative health	6
Forestry	4
Grand total	**313**

5.2.1 Land-use observations

Community and culture

Community & culture	Museum or exhibition of mining/industrial history	28
	Cultural/historical precinct	27
	Community events space	14
	Reclamation art	7
	Total	**76**

An important element of this form of repurposing is reconfiguring mining infrastructure as cultural heritage. Though this is not usually led by industry and it tends to relate to abandoned mines and/or historical sites. However, the case of the Morro Velho mine in Brazil, repurposed by AngloGold Ashanti, is an exception to this.

There is a small, but growing body of literature on the ways in which long life mines can also develop cultural values, where sentimental attachments form and historical values accrue to a site over several generations.[27]

For instance, throughout many regions of Europe the history of the industrial revolution has left a very deep mining legacy. As a result, many European states seem to be more advanced, than other regions globally, with memorialising both ancient and modern mining landscapes.

In the UK, the work of the post-mining alliance and the Clayfutures Project (of which the Eden Project is a part) has regenerated mining land in the region of a depressed economy. In such contexts, the social aspects of closure also encompasses industrial heritage and the preservation of historical artefacts from the operational history of the project for both economic and research opportunities.

In the US Appalachian coal mining region, which is characterised by abandoned mines, coalitions of community groups, various levels of state and federal government agencies and the university sector developed the 'AMD&ART' program as a purposeful effort to link acid mine drainage (AMD) remediation with the arts. This included the development of the 'Ghost Town Rail Trail'.[28] In South

[27] Rose, J.E., Morgan, H.L., 2010. 'Tea and Cake: talking with communities about life after mining'. In: Fourie, A., Tibbett, M. and Wiertz, J. (Eds), Proceedings of the 5th International Conference on Mine Closure. Australian Centre for Geomechanics, Perth. pp. 159–166.
Jones, C.E., MacLean, M.L.A., 2013. 'Reclaimed landscapes — incorporating cultural values'. In: Tibbett, M., Fourie, A. and Digby, C. (Eds.), Proceedings of the Eighth International Conference on Mine Closure. Australian Centre for Geomechanics, Perth, pp. 441–446.

[28] Comp, T.A., 2013. From environmental liability to community asset: mined land reclamation. In: Fourie, A., Tibbett, M., Digby, C. (Eds.), Proceedings of the 8th International Conference on Mine Closure. Australian Centre for Geomechanics, Perth. pp. 415–422.

Dakota, a case study of the 120-year Homestake lead mine in the USA discusses the tourist economy that has developed which includes interpretive pathways and historical mine tours.[29]

Examples of mine site cultural heritage from Australia include the Mt Kembla mine rehabilitation and memorial pathway, and Broken Hill as an active mining town and a heritage listed city renowned for its mining history.[30]

Art reclamation is also a creative avenue for re-imagining post-mining landscapes and we found several examples of this where, for instance, mine waste dumps were re-sculpted as new landscape features (see also regional approaches below). One example of industry led reclamation of tailings, in Ontario Canada, became known as the McLeod tailings project. In this case a re-known landscape architect worked with Barrick Gold to rehabilitate and reshape 14 million tonnes of tailings into a new landform and cultural artefact at the entry into the town, 'serving to spur economic redevelopment by reshaping access to the town'.[31]

Conservation and eco-system services

Conservation & eco-system services	Wildlife habitat	33
	Native woodlands	23
	Wetlands	6
	Carbon offset & sequestration	1
	Total	**63**

As the second most frequently found form of repurposing by industry, this form of reclamation for eco-system services is also typically multi-purpose.

While environmental restoration is often viewed primarily as wildlife habitat, and indeed this is the single most common form of repurposing (via sub-category), it also often includes other purposes, such as for K-12 educational purposes, outdoor science labs and non-intensive recreational purposes such as hiking or wildlife/bird watching.

This linking of eco-system services with people focused activity (see further below) also indicates that many of the repurposing sites are within ready reach of townships. As such, restoring these places also restores potential for economic rehabilitation, as amenity that also boosts real estate value as well as restoring the pride of local and regional residents in their home hinterland.

Linkages with specific environmental groups scale up the conservation task, such as Freeport McMoRan's (which we will refer to as Freeport) engagement with Bat Conservation International for their closed North American mines[32] and also with the Trout Unlimited NGO, for river restoration, as undertaken by Freeport and Newmont.

Ready opportunities for conservation and eco-system services are often available in areas of mining leases that are not impacted by the mine, as they are closed off from public access or use.

[29] Duex, T.A., 2010. Sustainable development activities during closure of the Homestake gold mine. In: A. Fourie, Tibbett, M. and Wiertz, J. (Eds.), Proceedings of the 4th International Conference on Mine Closure. Australian Centre for Geomechanics, Perth, pp. 193–198.

[30] Larance, A.J., 2012. 'Mt Kembla Mine rehabilitation and memorial pathway: a case study of effective stakeholder engagement to ensure successful final land use planning and environmentally and socially sensitive project outcomes'. In: Fourie, A. and Tibbett, M. (Eds.), Proceedings of the 7th International Conference on Mine Closure. Australian Centre for Geomechanics, Perth, pp. 731–746.

[31] Hine, A., Kirsch, P., and Amislev, I. 2014. 'Red Mud: Art and the post-mining landscape'. In *Artlink Magazine*. December. Available from https://www.artlink.com.au/articles/4247/red-mud-art-and-the-post-mining-landscape/

[32] See http://www.batcon.org/our-work/regions/usa-canada/address-serious-threats/subterranean-work/abandoned-mine-initiative

This link of environmental restoration with eco-system services is also a recognition that economic sustainability is coupled with environmental sustainability. Thus, in many cases, non-intensive recreation and conservation land uses are co-located.

Non-intensive recreation

Non-intensive recreation	Park & open green space	25
	Paths for walking, hiking, running, cycling &/ horse-riding	10
	Eco-tourism	9
	Public/botanical garden	7
	Total	**51**

Though we have separately categorised Conservation and Eco-system Services from this category of Non-intensive Recreation, there are significant overlaps in the theme of environmental regeneration in order to reclaim degraded landscapes as green spaces. These two inter-related categories make up the substantive forms of repurposing; at approximately one-third of the total. Likewise, both categories are often coupled as primary and secondary activities.

Increasing urbanisation in the location of some mine sites will change the post-mining land-use possibilities, as those living close to these sites seek outdoor amenity.

For abandoned mine sites, improving amenity and community use (e.g. as a park with play equipment, or paths and trails) can also have positive impacts on the surrounding areas. The National Coalfields Programme in the UK reported reductions in anti-social behaviour, increases in neighbouring land value, and improved community/social capital following the transformation of collieries into Land Trust parks and woodlands.

Parks and gardens can provide a relatively low cost repurposing option, albeit one that is unlikely to generate an income. Maintenance costs are likely to be relatively low, so a combination of perpetual trust and volunteer management may be possible.

However, there are some examples where eco-tourism — as an eco-precinct - can develop as significant forms of economic rehabilitation for an ex-mining region. For instance, the multipurpose case of the Eden Project, in a reclaimed china clay quarry in Cornwall (UK), combines environmental education and outreach with research, tourism and an entertainment venue. The entry fee is significant, and there are speciality shops and restaurants on site.

Education and research

Education and research	Education facility	13
	Research facility	12
	Rehabilitation research and education	7
	Total	**32**

As the fourth most common form of repurposing, education and research venues draw on the unique aspects of the mine site features that often lend themselves to frontier scientific research. This can include innovative forms of rehabilitation of tailings, such as Freeport's Climax mine (Colorado) concurrent reclamation using bio-solids (recycling sewerage) and the Homestake mining company's agreement with the University of California to establish a reserve for research and teaching in relation to a habitat program. While the concurrent rehabilitation at Newmont's Cripple Creek mine (Colorado) includes environmental field trips for aquatic biology and wildlife

habitat investigations and restoration forest management at various levels from university to school. Such links with external scientific experts scale up the rehabilitation efforts by improving practise, engaging in public outreach and including closure considerations.

Features of some abandoned mines have also lent themselves to unusual partnerships with science and research, such as underground mine shafts being repurposed for biosecure underground growth chambers (FlinFlon mine in Manitoba). While the underground mine component of the historic Soudan iron ore mine in Minnesota has become host to the MINOS neutrino oscillation experiment and the Cryogenic dark matter experiment (University of Minnesota).

Lake, pool or wetland

Lake, pool, wetland	Sailing, swimming &/ fishing pond	10
	Town water supply	6
	Total	**16**

Though we did not find numerous examples of repurposing pit voids and tailings dams into permanent water features, there is significant scope for this form of repurposing. The last half century has seen development of technologies allowing large-scale open-cut mining in areas which would previously have been worked underground, if mined at all. This has left a legacy of many thousands of mine pit lakes worldwide.[33] As these technologies continue to develop, the result is likely to be ever larger and deeper pits.[34]

We also recognise that because water is essential to life and not always readily available in many regions where mining occurs — there are likely to be many stakeholders with perspectives about any repurposing that involves an additional and permanent water supply.

Examples we found included a tailings pond (from the Highland Valley copper mine) that had been remediated into a fishing pond in British Colombia, Canada by Teck, that has now become a place for recreational fishers, as well as a research site for tailings pond reclamation techniques.

Elsewhere, in the Philippines mine pit lakes have also been repurposed as large-scale water reservoirs.[35] And in the case of the Kidston Gen-ex project in Qld, the mine pit voids have filled with water and been repurposed as pumped-hydro dams.

McCullough and Lund (2006) state that 'the potential for pit lakes to provide benefit to companies, communities, and the environment is frequently unrecognised and yet may be a vital contribution to the sustainability of the open-cut mining industry. Sustainable pit lake management aims to minimise short and long term pit lake liabilities and maximise short and long term pit lake opportunities. Improved remediation technologies are offering more avenues for pit lakes resource exploitation than ever before, at the same time mining companies, local communities, and regulatory authorities are becoming more aware of the benefit these resources can offer.'[36]

However, as the example of the closed Misima mine in Papua New Guinea demonstrates, although the mining company repurposed the pit to generate hydro-electricity for local villages, the pit is now a highly acidic lake, and the electricity supply is unsustainable with-out fuel and

[33] Klapper, H. and Geller, W. 2002. Water quality management of mining lakes—a new field of applied hydrobiology. Acta Hydrochim. Hydrobiol., 29: 363–374.
[34] McCullough, C.D. 2008. 'Approaches to remediation of acid mine drainage in mine pit lakes'. In International Journal of Mining, Reclamation and Environment Vol 22, Issue 2.
[35] Chaloping-March, M. 2008. 'Business Expediency, Contingency and Socio-political realities — a case of unplanned mine closure'. In [eds] A. Fourie, M. Tibbett, I Weiersbye and P. Dye. *Mine Closure 2008 Proceedings of the Third International Conference on Mine Closure*. Johannesburg, South Africa. UWA, University of Witwatersrand. Pp 863-872.
[36] McCullough, C.D and Lund, M. 2006. 'Opportunities for Sustainable Mining Pit Lakes in Australia'. In Mine Water and the Environment (2006) 25: 220–226

maintenance, neither of which is available in the post-mining era. This demonstrates how such well-intentioned ideas can flounder in the absence of accessible markets.[37]

Construction

Construction	Commercial real estate (i.e. Shopping centre, business park, hotel, data centre, casino, night club)	13
	Housing estate	5
	Airport/port	2
	Total	**20**

The majority of these repurposed sites are historical and utilise the unique aspects of the mines features as a business advantage. There are a vast array of different forms of development on sites, from the world's first 'ground-scraper' hotel, plunging 88 metres into an old quarry on the fringes of Shanghai,[38] to night clubs in historic underground mines in Mexico and a naval base in the remote Nunuvut Arctic, utilising the mining infrastructure of the airport, roads and dock.

In Europe, and other densely populated areas, former mining sites are in demand for housing and commercial real estate. In response to the depressed economic circumstances of the UK's coalfields, the Homes and Community Agency's (HCA) National Coalfields Programme sought to drive economic development by transforming abandoned mine sites into 'land in use'.[39] The program developed two million square metres of employment floor space, and over 13,100 homes built. The program also invested in repurposing projects that improved public amenity, including parks and gardens, which helped to make investment more attractive.

Light industrial

Light industrial	Alternative energy	8
	Recycling & repurposing of decommissioned materials	3
	Military/defence	1
	Total	**12**

This was the 8th most common form of repurposing. Thus, while this was not a significant trend in the repurposing examples, we suggest that this is a potential growth area. This is for the obvious reasons that there is a global shift in the move toward renewable energy leading to new business opportunities and an increasing societal expectation that this shift will occur, leading to the ready adoption of sustainable energy forms, at least in developed states.

Examples, such as the Kidston Gen-ex project in Qld and the Woodlawn eco-precinct in NSW are multipurpose. Though not examples of repurposing led or funded by industry, in these cases, the constellation of existing infrastructure, mine site features, an accessible electricity market and state support, has led to a viable alternative energy repurposing project. Likewise, the proximity to source product and the subsequent market are key features.

[37] Macintyre, M., 2018. 'Afterword. Places, Migration and Sustainability: Anthropological Reflections on Mining and Movement'. In the Journal of Sustainable Development Vol 26: 501-506.
[38] See the 2018 ABC report: 'The 18-storey Intercontinental Shanghai Wonderland includes two entire floors of underwater suites looking into a large aquarium, while guests on the other levels get panoramic views of an artificial waterfall on the opposite side of the quarry.' Available from https://www.abc.net.au/news/2018-11-20/worlds-first-groundscraper-opens-in-shanghai/10510522
[39] Homes and Community Agency National Coalfield Programme (2010) A Review of Coalfields Regeneration, accessed Nov 2019, from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/6295/1728082.pdf

Renewable energy projects led by industry include the solar farm projects developed by Chevron for their Questa mine in New Mexico and Teck's solar farm on the reclaimed Sullivan mine site in BC, Canada.

In the Chevron example, they established Chevron Technology Ventures (CTV) to support the transition, as a sister company of Chevron Mining Inc. (CMI). They developed the facility as a concentrated photovoltaic system (CPV) technology demonstration project. The USA EPA prepared a case study of this CMI solar facility. They indicated that CTV sells the electricity generated to the Kit Carson Electric Cooperative; on sunny days, it provides enough energy to power the nearby Questa community. According to the EPA case study, the facility also illustrates how private parties can work with them and other state agencies to incorporate renewable energy development at mining and Superfund sites and creatively reuse former mine waste disposal areas.[40] The case study by the EPA (see footnote) also outlines the raft of incentives provided by that state to build renewable energy projects.[41]

5.3 Influencing factors

Because our main interest is in influencing future industry-led repurposing, the factors that enable or inhibit repurposing are relevant to our analysis. Here, we present our initial observations about these influencing factors — both external to the operation, and internal (see also Appendix E ICMM's 2019 table of 'Enabling and Constraining Factors', which we will not repeat here)

5.3.1 External factors

Location

- Proximity to communities and towns (this may have changed over the life of mine)
- Attachment of residents to towns (though 'closed') may hold residents who champion repurposing and economic transitions
- Connectivity to existing infrastructure (roads, railways, energy networks)
- The ecological value of the mine location (in regional context) and its potential to add to eco-system services, habitat and associated community values
- Land zoning / tenure

Economic viability

- A constellation of inter-related repurposing projects that synergise with each other are more likely to be economically effective

[40] USA Environmental Protection Agency. Abandoned Mines Land Team. 2011. 'New Energies: Utility-scale solar on a tailings disposal facility Chevron Questa Superfund site in Questa, New Mexico'. Available from https://semspub.epa.gov/work/HQ/190025.pdf

[41] As the EPA case study indicates: The mine's location in New Mexico was one of the main reasons why CTV chose to develop the solar facility there. The state's abundant renewable energy resources provide economic and environmental benefits. In addition, the State of New Mexico has a variety of renewable energy development policies and programs.
In 2004, New Mexico's governor declared the state a 'Clean Energy State' and adopted Executive Orders to promote and implement policies regarding renewable energy development, energy efficiency, conservation and greenhouse gases. The state's Climate Change Executive Order followed in 2005. Then, in 2007, the state set goals for reducing energy use per capita. These goals included reducing energy use by 10 per cent below 2005 levels by 2012 and 20 per cent below 2005 levels by 2020. The goals also directed state agencies to reduce their energy use by 20 per cent by 2015.
Also in 2007, New Mexico established a renewable portfolio standard, or RPS. All investor-owned utilities must include renewable energy in their energy portfolio — 15 per cent of total retail sales to New Mexico customers by 2015 and 20 per cent by 2020. Investor-owned utilities must also fully diversify their renewable energy portfolio to include wind, solar, other technologies and distributed generation. The RPS also applies to rural electric cooperatives… (USA EPA case study 2011)

- Economic viability (local supply and demand issues) is essential for any industry led repurposing if the aim is a commercial venture
- The possibilities of extractive industry companies diversifying into alternative energy resource projects / commercial & residential real estate

5.3.2 Internal factors

Stakeholder and community engagement practices

- Whether the company has, or had at the time of the time of the repurposing, a 'beyond the gate' approach is a fundamental element in addressing beyond the life of mine and thus pursuing possible repurposing avenues
- Community engagement & inclusive practices are essential through life of mine, including during concurrent or progressive reclamation, as this will lead to positive post-mining land-use transitions
- Innovative approaches include establishing foundations and trusts for local communities to develop their own local ventures and development initiatives
- As the USA based publication *Aggregates Manager: Your Guide to Profitable Production*'s 'reclamation photo contest' (2015) stated: 'that's the message I hope operators throughout the United States and Canada take away from this contest. Build trust with your local communities. Take their needs into account when considering future use of your property. Foster an environment where each entity helps the other. That is a future plan worth creating'.[42]

Company policies and standards

- Though we have not analysed the policies and standards of every company that has successfully engaged in repurposing or co-purposing, we note that where such guidance and leadership exists, the internal structures in place may assist in establishing a business case for repurposing
- Such standards, as noted among the major companies that are engaging in repurposing (also at legacy sites), include closure standards that specifically address beneficial post-mining land uses and consideration of subsequent economic activities, conservation or community use
- Likewise, staff with specific social performance roles and responsibilities for legacies and mine closure are important in terms of implementing these policies and standards.

Continuity of the company and the operation

- Many of the examples we found of industry led repurposing were of mining companies with long life mines and established attachments with the local region
- Likewise, we also found that small locally based operations and family businesses, notably quarries) with local commitment and community attachment invested in beneficial land-use transitions.

[42] See Aggregates Manager: https://www.aggman.com/photos-reclamation-photo-contest-entries-showcase-post-mining-opportunities/

5.4 Industry approaches

While our research is exploratory, we are able to make some initial observations about existing approaches to repurposing from industry.

There are few examples of industry-led repurposing relative to the number of mines in post-production. They are limited to 13 countries in our dataset (and that we could locate information about in the time available).

Table 18: Company-led and/or funded repurposing cases by country

Country	Number of cases
USA	11
Indonesia	8
Australia	8
Canada	6
South Africa	3
Brazil	3
Thailand	3
New Zealand	2
Czech Republic	1
China	1
Japan	1
France	1
Honduras	1
Grand total	**49**

5.4.1 Economic diversification beyond a singular industry (and commodity) has become an interest of industry, communities and governments

Transitioning away from the production of carbon energy resources to renewable and sustainable alternatives is linked in many cases to energy transitions, as a global issue. For instance, in November 2018, a joint Chinese and US conference led by Shanxi (China) and Wyoming (USA) gathered global experts in Wyoming to attend the Jackson Hole Centre for Global Affairs Forum. Forum attendees had the common goal of identifying the challenges and opportunities for coal communities worldwide as they transition their economies away from coal and in funding just transitions for coal workers.

Those attending the conference were seeking to optimize renewable energy generation while successfully diversifying. For instance, Shanxi Province, praised in the media as a coal community transition success story, closed 36 mines in 2018.[43] That same year, the province increased total installed wind and solar power capacities by 30 per cent, increasing wind and solar generation by 40 per cent and ensuring employment transitions. These changes were the results of strong local and national political efforts, according to reports.[44]

[43] We note that these mines would have been state owned, thus facilitating a centralised approach to economic transitions.
[44] See https://www.newsecuritybeat.org/2019/03/coal-communities-struggle-diversify/ 'The Chinese central government is reining in coal production in Shanxi and other coal producing provinces in a three-year action plan targeting air pollution amidst a national Blue Sky Protection War. Also driving Shanxi's green transition are other environmental concerns, such as severe soil and aquifer pollution, that have made old mining areas unfit for farming and construction. The Shanxi provincial government supports training and re-employment, such as mine reclamation jobs or subsidies for individuals to start their own businesses. Even ride-share companies like DiDi have partnered with coal companies to hire laid off coal miners as drivers, says Duan. While this kind of safety net does not

The multi-purpose renewable energy projects, of the Kidston gold mine (Qld) and the Woodlawn copper, lead and zinc mine (NSW) in Australia are also examples where political support at local and state level was crucial for the projects. These two repurposing projects have led to forms of local and regional economic transitions. Kidston's transformation into Kidston Gen-ex 'renewable energy hub' comprises pumped hydro, solar and wind with the construction stages of each hub component employing numbers that may be equivalent to the previous industry. While the transition of the Woodlawn open-pit into a bio-reactor (putrescible waste to energy) is also part of a larger eco-precinct comprising a sustainable working farm producing wool and meat, aquaculture and hydroponic horticulture, as well as solar and wind farms.

In the Appalachian coal region of the USA, though there are estimated to be 1.2 million acres, including 500 mountains flattened by mountain top removal, we could find very few cases of repurposing.[45] A case we did find was of a privately owned thermal coal mining company planning to diversify beyond carbon energy into renewable alternatives, though their 'foundation was built on coal'.[46] They are investing in solar energy renewables on the post-mining removed mountain-top. As this company (Ross Harris Group) stated on their website:

> *A new effort has been made in Eastern Kentucky to diversify the state's energy resources, creating new types of jobs for those out of work due to the decline in the coal mining industry… begin constructing a multi-million solar-energy farm over reclaimed mine areas just outside Pikeville. The facility will be the largest in the state... It will include immense quantities of solar panels expected to produce between 50 to 100 megawatts of electricity. The project will also offer an estimated 100 jobs, most of which will be offered to unemployed coal miners.*[47]

5.4.2 Association between long life mines and industry investment in post-mining land use and economic transitions

There appears to be a link between a mining company 'putting down roots' as part of its investment in a long life mine and also taking an interest in and responsibility for post-mining land use and economic transitions on closure.[48]

Of the 47 cases where we could find firm evidence of industry led repurposing, approximately 23 cases were from long life mines.[49] For example, of the 14 cases in the USA of industry led repurposing (including concurrent reclamation and co-purposing) 10 are in relation to long life mines operated by the same company, or company subsidiary, from inception. For instance, Rio Tinto's Bingham Canyon mine (aka Kennecott copper mine), near Salt Lake City, which has operated since approximately 1906, is a case of co-purposing a mining land buffer zone into a residential and commercial estate using sustainable principles. And similarly to most other co-

help all unemployed coal workers, according to Han Wenke, "the case of Shanxi proves that policy and institutional factors can address the challenges and opportunities facing energy transition"'.

[45] See the NRDC The Myth of Mountaintop Removal Reclamation. https://www.nrdc.org/media/2010/100517

[46] See https://www.rossharrisgroup.com/projects/met-coal/

[47] See https://www.rossharrisgroup.com/projects/solar-project/

[48] Conversely, the instance of the San Manuel copper mine in Arizona appears to be a case that supports this contention. In this case an industry take-over of a long-life mine led shortly after to closure, with the new company appearing to have little interest in developing socio-economic transition strategies for the town and region. This seems to be an unfortunate example of a long life mine and associated mining town where opportunities for socio-economic transitions were missed. Though the mine operated from the early 1950s to the late 1990s and was the major employer for the region, it was acquired by BHP in the late 1990's and the local perceptions, according to media, were that the company did not have any investment in the town or its staff who largely comprised the town. Consideration about the socio-economic impacts of this closure on the local town was not apparent as a priority in public reporting. A negative and bitter anti-company campaign in the San Manuel mining town is evident (see media reports: https://www.insidetucsonbusiness.com/news/top_stories/with-mines-gone-san-manuel-holds-out-hope-for-future/article_45d1e7b4-d4ea-11e0-aeb1-001cc4c002e0.html.

[49] We are classifying a 'long-life mine' as 20 or more years. Many mines in our data-base are far older than this.

purposing sites a raft of other activities are also included. In this case they include mine tours, progressive reclamation for wildlife habitat and an in-land seashore bird reserve.

While in Latin America of the three cases of industry led repurposing that we found evidence of, two of them were of long life mines operated by the same company for decades. These include the Morro Velho AngloGold Ashanti mine in Brazil and the Felicissimo limestone mine, operated by Holcim (note this was categorised as a mine, rather than quarry by Sanchez et al 2014, see below).[50]

The link between long life mines, reputational considerations and changes in state environmental regulations appear to be one of the drivers for industry investment in re/co-purposing and economic transitions in particular jurisdictions, such as North America. Though we have not investigated this in detail and this is to some extent speculative, we suggest that in such contexts the local, long term and ongoing exposure of long-life mines places pressure on and expectation for active CSR locally, as also compelled by regulatory changes over the life of mine. Local industry newsletters and annual sustainability reporting also shed some light on community outreach activities. For instance, Vale's four 2018/2019 community reports on their Canadian website are all for long-life mines (three in Canada, one in Wales), of these the Creighton mine in Sudbury is a potential case study.[51]

5.4.3 Approaches that recognize the cumulative impacts of mine regions / mine clusters

The majority of regional scale repurposing is led by the state and there is a growing body of research on the drivers behind these initiatives and the mechanisms behind the best practice examples. It seems that without state intervention in terms of policy development and financial support, establishing socio-economic transitions in post-mining regions is very challenging. See for instance, the report *The Ruhr or Appalachia? Deciding the Future of Australia's Coal Power Workers and Communities* (2018), which clearly identifies the need for structural adjustment policies that will lead to just transitions for workers and communities.[52]

Though at this stage, the research and industry focus has been on coal mines, other mining regions — such as the Pilbara iron ore region — can also learn from these regional approaches to transition.

A notable example of a company that incorporates regional scale remediation, rehabilitation and economic diversification led by industry is the nickel and copper region of Sudbury in Canada through Vale (as above). This site addresses both long-term legacies and, as the company is still operating, provides an example of a good neighbour approach to communities and environmental reclamation, also driven by changing regulatory standards. This site addresses both long-term legacies and provides an example of concurrent reclamation and co-purposing, as they grow 100,000 trees a year in the closed sections of the extensive underground Creighton mine to revegetate vast areas, as well as undertaking other activities.

Such approaches nevertheless recognize the cumulative impacts of mine regions or mine clusters and attempt to develop strategies to not only mitigate impacts, but also address post-mining transitions.

[50] These two examples are both profiled in Sánchez, L.E.; Silva-Sánchez, S.S.; Neri, A.C. 2014. *Guide for Mine Closure Planning. Brasília*.

[51] See the Vale Canadian site: http://www.vale.com/canada/EN/aboutvale/communities/sudbury/Pages/default.aspx

[52] See Sheldon, P. Raja, J and De Rosa Pontello, A. 2018. The Ruhr or Appalachia? Deciding the Future of Australia's Coal Power Workers and Communities. IRRC Report for the CFMMEU Mining and Energy. UNSW, Sydney

5.4.4 Out-reach for input and innovation

There is an example of a company reaching out to communities and educational groups for input into potential repurposing options.

According to the Colorado Mining Association, Freeport-McMoRan's Henderson Mine has collaborated with the Colorado School of Mines (CSM) to hold a student challenge to 'Develop a concept for sustainable repurposing of the Henderson Mine surface facilities and land holdings that provides a socioeconomic benefit to the surrounding communities, is economically sustainable, socially acceptable and provides a positive and lasting legacy in the state of Colorado.' [53]

The objective of the competition was to develop a concept for sustainable repurposing of the Henderson Mine surface facilities and land holdings that provides a socioeconomic benefit to the surrounding communities, is economically sustainable, socially acceptable and provides a positive and lasting legacy in the state of Colorado. The concepts that progressed to the final round were:

- a pumped hydroelectric storage facility
- a data centre and technology campus
- a comprehensive automotive testing facility
- an anaerobic digestion bio-gas plant, composting facility, and mushroom farm
- a community college with an emphasis on environmental science and water treatment.

Though we cannot comment on how these ideas were received by the company or the status of the potential repurposing, this active engagement of stakeholders suggests an outward looking approach that potentially embraces innovative repurposing transitions.

5.4.5 Community partnerships and concurrent rehabilitation

Some companies have established community partnerships to develop shared goals in education and conservation in reclamation projects. Such partnerships establish land uses that coincide with community sustainability objectives and the potential uses for reclaimed land. Community partnership panels are one avenue for integrating post-mining land use with rehabilitation outcomes. We have included Freeport's Climax mine and Newmont's Cripple Creek and Victor mines (both in Colorado) as examples of co-purposing and concurrent reclamation in the repurposing database and these cases are discussed in the Regional Comparisons Section.

This approach includes Freeport McMoRan's partnership with the Colorado Inactive Mine reclamation Program (CIMRP). Since 2012, in their North America operations they have developed a program over five years to assist the CIMRP in leveraging other funds from multiple government agencies and non-profit environmental organisations that work in abandoned mine lands. They also established a multi-year partnership with Trout Unlimited (an environmental NGO) to further address river quality issues on abandoned lands in Colorado.[54] While Newmont also has a partnership with Trout Unlimited in the US (2017), though we couldn't find detail on-line about the projects sponsored.[55]

We suggest that the reason these cooperative activities with NGOs in relation to neighbouring sites are relevant in the context of a repurposing discussion is because they are not stand-alone ventures, but one element in a broader approach that engages coalitions of experts to assist in scaling up closure and co/repurposing activity. They are active instances in a 'beyond the gate' approach to closure and rehabilitation.

[53] Colorado mining association https://www.coloradomining.org/page/CMAEnvironmentalSustainabilityPartners.
[54] See Freeport McMoRan 2014. Reclamation in North America: Supporting a Sustainable Future.
[55] Note that we are yet to speak with Newmont as a Consortium partner about this initiative.

5.5 Lessons from outside the mining industry

As discussed, more than half of the cases we found were not industry led and/or industry funded. Nonetheless, these cases provide useful and relevant lessons for the industry.

Lessons for industry, government and NGOs on the key ingredients for successful post-mining land-use regeneration and economic rehabilitation can be found in Pearman (2009, *101 Things to Do with a Hole in the Ground*). Our findings are congruent with these. They include:

- leadership, vision and commitment
- local solutions to fit local circumstances (hence the essential need to consult locally)
- creative partnerships for funding, development and implementation (coalitions of NGOs and community groups)
- collaboration with diverse interests, developing shared interests
- community involvement and consultation at all stages, developing shared responsibility and ownership.

5.5.1 Regional approaches to environmental and socio-economic transitions

The repurposing database includes examples of regional environmental and, consequently economic, rehabilitation. Regional approaches can address historic or legacy issues, particularly for regions where mines closed prior to closure regulations. Examples include:

- the coal districts of the Ruhr valley, Germany
- the China Clay pits of Cornwall, UK
- Limburg region, the Netherlands
- Appalachian coal country (AMD&Art project), US.

No particular company takes responsibility for regional legacies. So while these are not examples from particular companies, industry can learn from the processes that were developed to engage stakeholders and the innovative practices and policies that evolved.

One example of an innovative practice is the concept of ‘community greenways’, which appears to have emerged in B.C Canada. It is useful for developing an approach that recognizes the ‘interconnected corridors linking human development and natural systems’.[56] A key component of the concept is the ‘integration of mine sites and working landscapes that acknowledge the importance of resource extraction activities and incorporate these requirements within a comprehensive plan for sustained environmental and recreational networks’. This concept was applied to the repurposing of at least five abandoned coal mines. Engaging this approach can assist with long term site management, as Backhouse states:

> *Perhaps counter intuitively the development of a post use plan that incorporates recreational access and environmental protections can assist over the medium and longer term by encouraging casual surveillance by recreational users. Recreational amenities developed as part of a greenway plan are frequently undertaken with the support and contribution of recreational user groups and environmental organisations. The contribution is significant for the obvious initial benefit of lowering implementation*

[56] Backhouse, D.C. 2012. ‘Community Greenways — Ecological and Recreational re-use of industrial landscapes’. In A.B Fourie and M. Tibbett [eds] Mine Closure Conference 2012. Australian Centre Geomechanics, Perth.

costs…building…public support for the greenway experience which in turn leads to a high level of reporting of incidental damage or vandalism (Backhouse 2012: 766).

5.5.2 Abandoned mines and mining regions: lessons from state-led repurposing

When we refer to abandoned mines, we are referring to:

- mines that ceased production pre-regulation and remained un-remediated and contaminating
- mines where the company has gone bankrupt, leaving the state to remediate, or
- in the case of the UK, coal mines that the state had closed and subsequently decades after have developed programs to regenerate and restore the affected regions.

Though we actively sought examples of industry-led repurposing, approximately 15 of the examples in our database relate to abandoned mines. Many developed states have established abandoned mines programs.

In mining regions, with a predominant mineral and operational type, a regional approach to transformation and economic rehabilitation has been the standard. The Ruhr Valley - Germany and the Limburg region in the Netherlands are good practice examples).[57]

In regions where long life mines have closed and several generations of family members have worked for the mine, attachment to towns (though 'closed') will hold residents, as family identities are inter-woven with the town's history. In these cases, community-driven repurposing with a coalition of interests is the standard approach to transitioning these sites.

A range of abandoned mines programs

In Australia, several states have abandoned mines policies, including Western Australia 'Abandoned mines policy' (2016)[58] and in Queensland. According to the Queensland government website, 'most abandoned mines date from before 2000, before Queensland laws were amended to provide stronger environmental management and rehabilitation requirements for mining activities'.[59]

We did not have the scope to investigate whether any of these involved repurposing. However, we note that the fourth aim of the Queensland approach (after making the sites 'safe, secure and durable') is also to potentially make them 'productive - by investigating opportunities to commercialise abandoned mines or repurpose the land for a future appropriate use'.

The two Canadian abandoned mines programs, that we are aware of, marry environmental science with community volunteerism and environmental science with Indigenous Ecological Knowledge. The first program known as CLEANS (Clean-up of Abandoned Northern Sites), entails rehabilitation and remediation of up 37 legacy mine sites in Northern Saskatchewan, predominantly uranium mines. An important element in this program is the opportunity to engage meaningfully

[57] Conversely, poor practice examples come from Coal regions of the USA, where the lack of repurposing and economic rehabilitation is standard, according to the Natural Resources Defence Council, the NDRC). The NRDC examined 500 mountaintop removal sites in Kentucky, West Virginia, Virginia and Tennessee. Of these locations, 90 were excluded from the study due to active, ongoing mining activity. Of the 410 remaining sites surveyed:
366 (89.3 per cent) had no form of verifiable post-mining economic reclamation excluding forestry and pasture
26 (6.3 per cent of total) yield some form of verifiable post-mining economic development.
Overall, the NDRC found that economic activity occurred on just 6 to 11 per cent of all reclaimed mountaintop removal sites surveyed as part of this analysis (NRDC 2010). Note that this is partly explained by many thermal coal mining companies filing for bankruptcy.

[58] See http://www.dmp.wa.gov.au/Environment/Completed-projects-25704.aspx which outline two successful pilot programs: The black diamond ex-coal mining site where 'the discontinuation of mining resulted in the pit filling with water creating a pit lake of around 700 metres in length. Black Diamond was the first pilot project under the Abandoned Mines Program and was selected in response to community concerns regarding safety at the site which had become a popular, unmanaged recreation area.'

[59] In Qld, 'since 2013, the program has made safe more than 450 mine features at 138 sites'. See https://www.qld.gov.au/environment/land/management/abandoned-mines/management

with local indigenous and northern populations to solicit their local and traditional knowledge regarding the individual sites and to apply the clean-up funds in such a way as to build jobs and economic capacity locally.

Another northern Canadian program, led by Arn Keeling and John Sandlos, was a multi-site, multi-year Social Sciences and Humanities Research Council (SSHRC) project examining the inter-relationships between environmental legacies of abandoned mines and socio-economic impacts on the mining region. The project produced a significant number of case studies.[60]

Remediation and restoration: coupling the science with the social[61]

Some leading edge cases of repurposing by the state and public/private coalitions couple the science with the social, such that effective post-mining transitions and repurposing also take into account the politics and social dimensions of landscape repair.

In these cases ecological restoration is understood in terms of how communities can create or recover economic, cultural and social value through the processes of healing environmental damage. Examples of this approach include the state led remediation followed by public/private partnerships of the Britannia mine abandoned mine and associated infrastructure of in British Columbia, Canada.[62]

Though remediation processes, of waste rock, tailings and mine voids, are often complex technical matters for environmental experts and geo-chemists, and state regulations about decontamination and self-sustaining eco-systems have to be adhered to, understanding that remediation and the associated restoration entail more than 'the technical' is an essential step in any potential transition and repurposing. Cases, such as the AMD&Art trail in Appalachia recognise this link.[63]

The increasing attention to the technical, environmental and engineering challenges to remediation is a positive outcome of managing mine closure. However, less attention has been given by industry to public participation and community values associated with cleaning up mine sites. Addressing this would not only include public education and outreach opportunities by industry, but to incorporating new approaches linking rehabilitation and restoration with specific post-mining land-uses.

As such, restoration has the potential to foster a new sense of place, as we found in all of the 14 examples of legacy and abandoned mines that we identified, and that have been remediated and repurposed near townships.

New approaches consider an expanded definition of mine remediation that encompass concepts of social justice, repair, mediation, reconciliation and care (to borrow from Beckett and Keeling 2019). This may especially be the case for mines on the lands of Indigenous peoples where the rehabilitation of cultural landscapes is coupled with ecological restoration.[64]

[60] See for instance, Sandlos, J. and Keeling, A., 2016. 'Aboriginal communities, traditional knowledge, and the Environmental legacies of extractive development in Canada'. In *Extractive Industries and Society* 3, 278–287. And Keeling, A., Sandlos, J. (Eds.), 2015. *Mining and Communities in Northern Canada: History Politics, and Memory*. University of Calgary Press, Calgary, Alberta.

[61] This section takes inspiration from Beckett and Keeling. 2019. 'Rethinking remediation: mine reclamation, environmental Justice, and relations of care'. In *Local Environment Vol* 24, No 3: 216-230.

[62] O'Hara, G., Bordian, J. Clausen, K., Wernick, B.G., 2010. 'Environmental remediation works stimulate renewed interest in mine heritage and tourism at Britannia Beach'. In: Fourie, A., Tibbett, M. and Wiertz, J. (Eds.), Proceedings of the 5th International Conference on Mine Closure. Australian Centre for Geomechanics, Perth, pp. 205–215.

[63] Comp, T.A., 2013. From environmental liability to community asset: mined land reclamation. In: Fourie, A., Tibbett, M., Digby, C. (Eds.), Proceedings of the 8th International Conference on Mine Closure. Australian Centre for Geomechanics, Perth. pp. 415–422.

[64] Jones, C.E., MacLean, M.L.A., 2013. 'Reclaimed landscapes — incorporating cultural values'. In: Tibbett, M., Fourie, A. and Digby, C. (Eds.), Proceedings of the Eighth International Conference on Mine Closure. Australian Centre for Geomechanics, Perth, pp. 441–446.

5.6 Regional comparisons

5.6.1 Latin America

According to the S&P database there are 153 ‘closed’, ‘inactive’ and ‘rehabilitation’ mines in this region. Of the 18 Latin American states, those with the most significant number with mines in this category are Brazil: 25 mines, Peru: 23 mines, Mexico: 21 mines, Bolivia: 19 mines and Chile with 22 mines.

Figure 6: Map of Latin American repurposing cases by commodity

Of the 15 mines from this region we followed up from the S&P database, the Pearman (2009) text and on-line searches we could only find three cases that have been industry-led repurposing. These include the Morro Vehlo AngloGold Ashanti mine in Brazil and the San Martin Goldcorp Inc mine in Honduras and the Holcim Felicissmo limestone mine in Brazil. If there are current examples of repurposing (and even rehabilitation being undertaken by industry) — it is not widely publicised by them (though we acknowledge the limitation of our English searches). The other repursuing sites in this region we found relate to historical mines.

Likewise, at the 2019 Enviromine /SRmining mining conference in Chile — though they had a session on ‘land rehabilitation, revegetation and closure activities — there were no papers with concrete closure examples from Latin America. However, the Guide for Mine Closure Planning: Brasilia (Sanchez et al, 2014) provides some useful examples for that state which we draw on.

The predominant repurposing pattern to emerge in this jurisdiction is of historic sites being recognised and repurposed as mine site tourism and early industrial history, with the funding for doing so, met by the state and local governments. For instance, six of the seven Latin American

repurposed sites from the Pearman text (2009) are historic sites. We attempted to locate the site that did appear to be industry led - The San Jose Reservoir Yanacocha Peru. However, the information available is in relation to the active Minera Yanacocha Newmont mine. Much of the content available on line about this operation is in relation to water contamination, environmental devastation and human rights abuses. In many states in Latin America, the themes of contestation and conflict over the mines impact and environmental and social devastation (Samarco in 2015 Vale and BHP, and Brumadhino in 2019 — Vale, both iron ore mines in Brazil)[65] overshadowed potential positive post-mining stories.

5.6.2 USA

The S&P database has 590 mines listed in the closed and inactive categories in the USA, while six of these are listed as in rehabilitation, and several are in care and maintenance. Of the 20 possible cases we investigated 14 were industry led, while of these we included three cases of concurrent reclamation (Freeport McMoRan's Climax mine, Newmont's Cripple Creek and Victor mines and Trapper mine led by a consortium), all in Colorado. These three operations are good practice examples of combining concurrent reclamation with community outreach, education, science and ecosystem services which would improve final reclamation and rehabilitation outcomes. Thus, they are examples of co-purposing. Many of the examples we found of industry-led repurposing were of long-life mines.

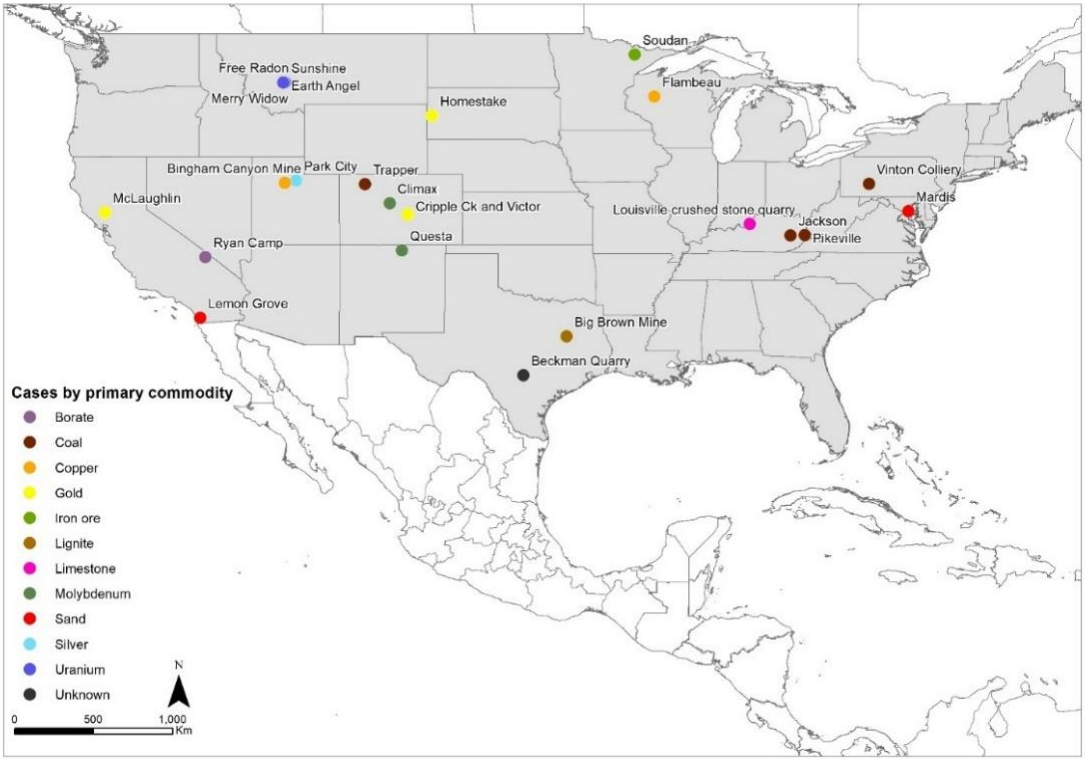

Figure 7: Map of USA repurposing cases by commodity

The abandoned mine legacy in the USA is also an important part of any consideration of repurposing in this jurisdiction. In the western USA alone there are over 500,000 abandoned mines, while 40% of western headwaters are polluted with mine wastes. There are now a diverse

[65] The Brumadinho dam disaster occurred in January 2019 when a tailings dam at the Córrego do Feijão iron ore mine, Minas Gerais, Brazil, suffered a catastrophic failure. The dam is owned by Vale, the same company that was involved in the 2015 Mariana dam disaster from the Samarco mine (also with BHP). At least 248 people died as a result of the 2019 collapse, while 19 people were killed in the 2015 disaster. A massive lawsuit from the 2015 catastrophe is still ongoing.

range of federal and state funded projects and NGO coalitions of experts and community groups beginning to reclaim the most polluting of these sites. In this region of the US, such groups include Trout Unlimited and the Reclaiming Appalachia Coalition. There is a significant opportunity for industry to also engage with such groups that have experience and interests on both on current reclamation activity and incorporating neighbouring abandoned mines in current reclamation. Several companies are doing so (including Newmont and Freeport McMoRan).

According to the on-line site Reclamation Colorado, the most common land uses include wildlife habitat, cropland, pastureland, water storage, and occasionally industrial or recreational uses. Lands that are reclaimed for wildlife habitat are often improved by establishment of a more diverse plant community and weed control. As such, reclaimed lands provide valuable wildlife habitat throughout the state of Colorado, according to the Reclamation Colorado group.[66]

A useful website is 'reclamation stories' from the Minerals Education Coalition.[67] In the U.S., the passing of the Surface Mining Control and Reclamation Act of 1977 (SMCRA) has resulted in more than two million acres of reclaimed land.

5.6.3 Canada

For this jurisdiction the S&P database has 112 mines listed as closed, with the vast majority listed as 'inactive', only four are listed as 'rehabilitation'. These four were followed up, with one of them being a case of repurposing. This was the Elliot Lake Uranium mines in Ontario (Denison Mines Corp and BHP Billiton) where the mining town has become repurposed as a retirement village and associated historical mine tourism. However, the extent of industry engagement in this post-mining land use is not clear.

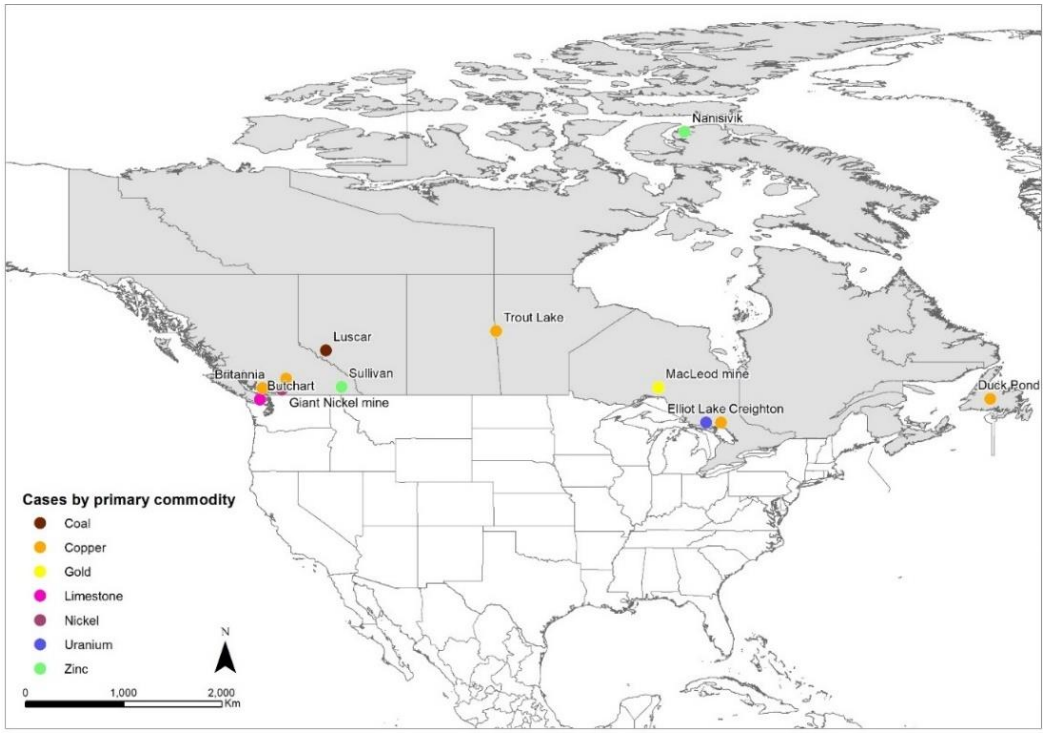

Figure 8: Map of Canadian repurposing cases by commodity

[66] See https://www.reclamationcolorado.com/mine-life/reclamation/

[67] This is an industry advocacy site. They have reclamation examples of 4 aggregates, 3 coal and energy, 3 industrial minerals and 3 metals, approximately half of which are industry led. https://mineralseducationcoalition.org/mining-minerals-information/reclamation-stories/

Several Canadian based companies, including Teck, Vale Inco and Freeport McMoRan, have produced a range of publically available case-study materials on their reclamation activities for their North American sites. As a result, we acknowledge that we have profiled the activities of these companies in these jurisdictions (USA and Canada) due to the availability of the data, (though recognising the lack of independence of this material), it has nevertheless been very useful. Indeed, such public outreach is to be commended.

We found 12 cases of repurposing and co-purposing in this jurisdiction, half of which were by industry (Figure 8). All of the cases we found were from long life mines, from over 100 years old to the 1970s.

5.6.4 Australia and New Zealand

As the jurisdictions with the most readily accessible information, we anticipated finding a greater number of examples for this jurisdiction, than for others. This was not the case, as we located a total of 17 sites, two of these being in New Zealand (Figure 9).

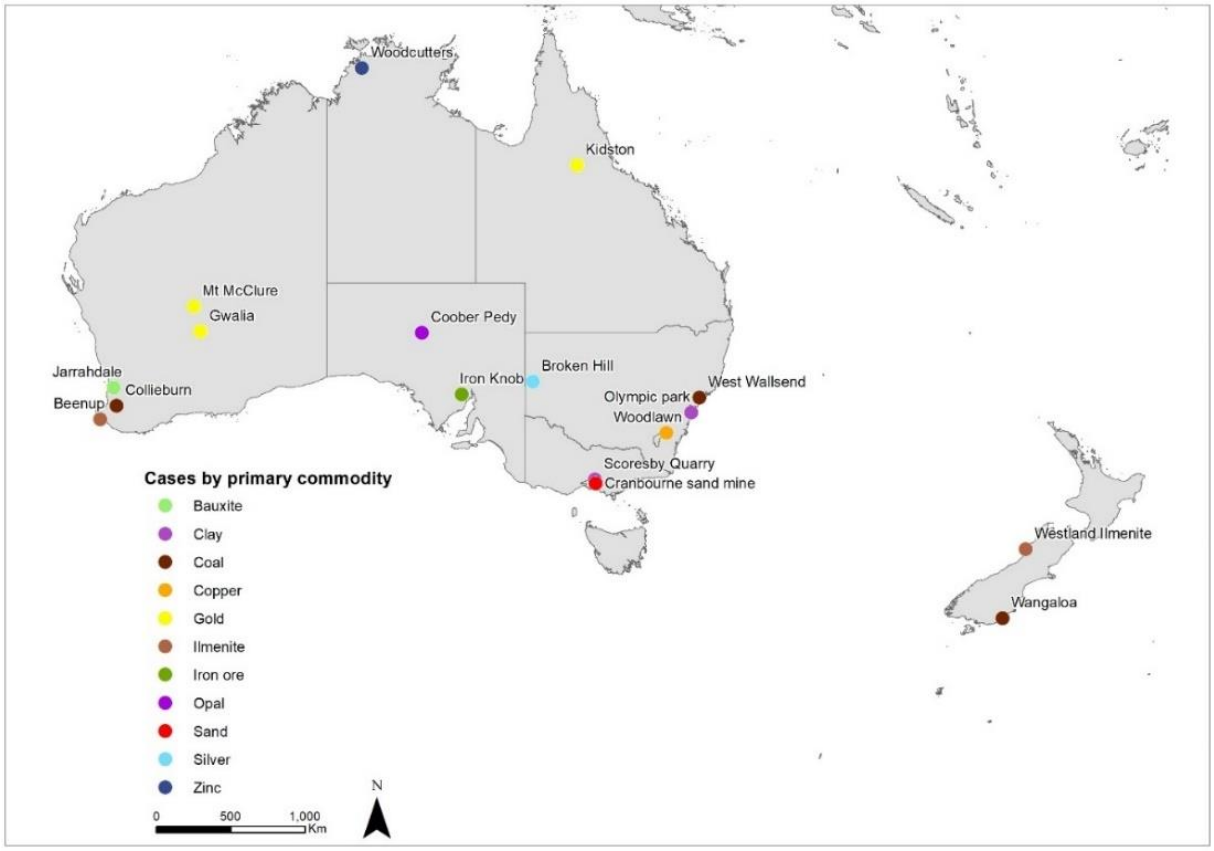

Figure 9: Map of Australian and New Zealand repurposing cases by commodity

The S&P index has 18 Australian sites categorised as 'rehabilitation'. However, there was very little publicly available information about the majority of these. Two of those we did find information for and that have undertaken, or are undertaking, forms of repurposing are the Newmont Woodcutters mine in the NT and Glencore's Westside coal mine in NSW.[68] Both of these sites and another three are cases of industry led repurposing or as consortium of industry and others (as far as we could

[68] Note that Glencore has several mines in the Newcastle region — the Westside coal and New West Wallsend (among others) — are both at or near relinquishment.

ascertain). The Woodcutters and Westside mines have both incorporated permanent lakes into their closure designs, with Glencore using the mine void and Newmont constructing a lake on the request of Traditional Owners. Both areas are being/have been revegetated.

A stand-out example of regional multi-use industry led repurposing is the Wesfarmers coal region of Collie in WA. Many of the mine features were repurposed — such as the mine voids into recreational lakes and an aquaculture industry, while much of the mine infrastructure, such as the roads, office and workshops were also repurposed. The transition was actively supported by the state government coal futures group and the Royalties for regions program.

Of note, the case studies provided in the MCA 'Mine Rehabilitation in the Australian Minerals Industry' (2015) and the Decipher Report 'Your Guide to Mine Rehabilitation in Australia' (2016) do not provide any cases of industry led repurposing and economic transitions. With the exception of the Woodcutters mine, they are cases of return to prior land-use.

We have not included the potential proposal to repurpose the Yallourn power station and associated brown coal open cut mine at Anglesea in Victoria. This has been receiving considerable media attention. As the ABC site states, 'representatives from UK-based charity Eden Project are in Australia to share their $150 million vision for the site with local residents, in the hope they can secure community support for a large eco-tourism development. The concept plan includes a 100-hectare lake to replace the open cut coal mine and an educational centre, including physical exhibitions and virtual reality, to teach visitors about the natural world'.[69]

Though very few closed operations in Australia have been relinquished, of interest and potential follow-up, is that in South Australia where 18 mines that have been rehabilitated and relinquished, according to the Decipher report.[70]

5.6.5 Europe

There are thousands of closed mines in Europe. Several countries — particularly former coal producing countries — have undertaken regional or national programs of rehabilitation and repurposing, particularly in relation to preserving industrial heritage. As we wanted to provide an overview of mine repurposing worldwide, we limited our investigation of Europe to two major initiatives, in Germany (10 cases) and the UK (13). The remainder of our cases were found through a snowballing search strategy. We found seven additional UK cases, in addition to a small number of mines in Czech Republic (5), Bulgaria (5), Sweden (2), Netherlands (1), Poland (1), Portugal (1), France (1), Romania (1) and Norway (1) (Figure 10). There are undoubtedly further cases that we have not included.[71]

In Germany and the UK, coal mines underwent a process of nationalisation as the industry wound down. This has been followed with regional/national programmes for rehabilitating mines with funding from the state, and in partnership. For example, in the Emscher Zone a government funded administrative body oversaw applications and tenders for a range of activities along the Ruhr River basin.[72] Some of these projects were privately funded, while others were funded by regional, local or federal government bodies.

[69] Available at https://www.abc.net.au/news/2019-05-26/eden-project-vision-to-transform-disused-anglesea-coal-mine/11150808
[70] See Decipher (2016: 9) Your Guide to Mine Rehabilitation in Australia: Samples, case studies, regulation, progressive rehabilitation and new legislative changes. Available at https://www.decipher.com.au/mine-rehabilitation-guide/
[71] In comparison, the S&P database relatively fewer cases in Europe than other regions, with only 159 cases. This is largely due to the limits of the S&P database. Its records of closure are relatively sparse before the 1990s.
[72] Open-IBA n.d. 1989 – 1999 IBA Emscher Park: A future for an industrial region, accessed Nov 2019, from http://www.open-iba.de/en/geschichte/1989-1999-iba-emscher-park/

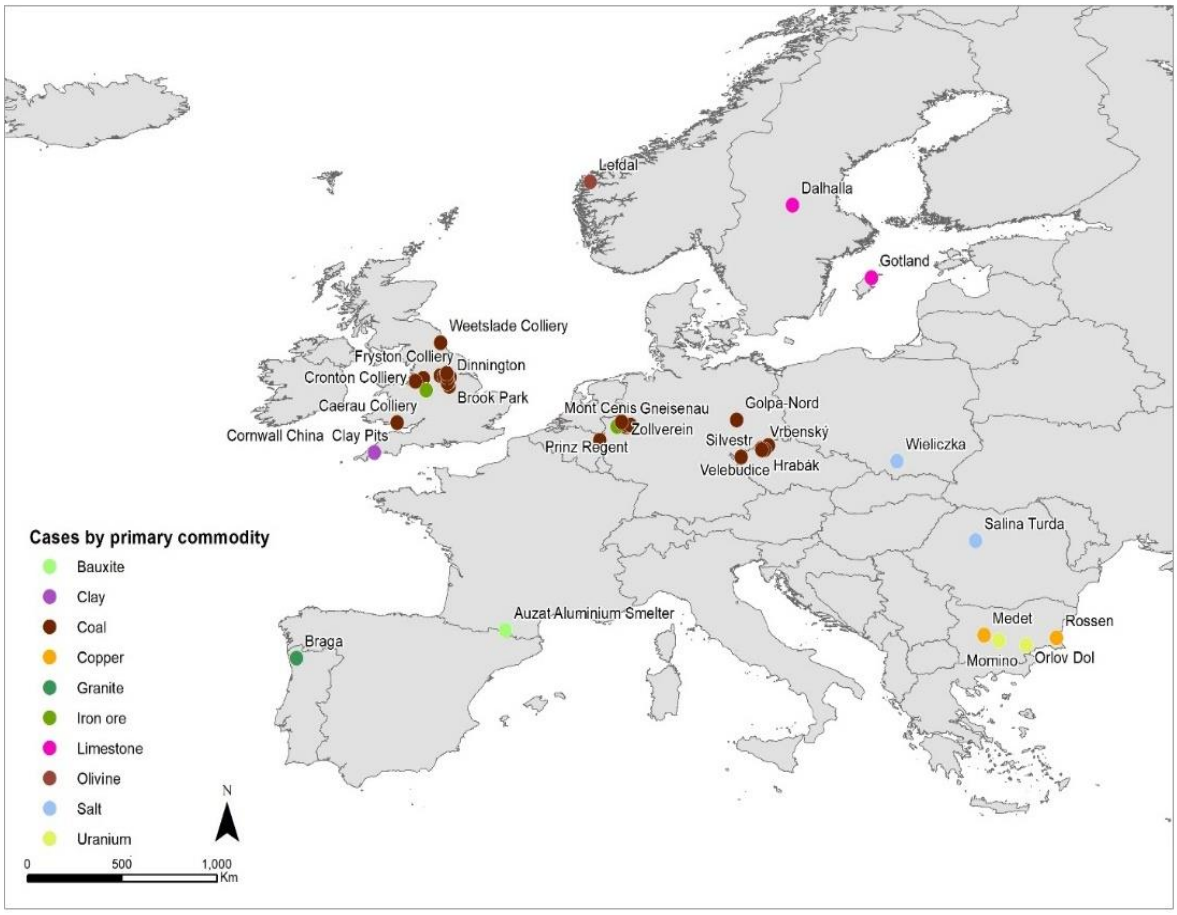

Figure 10: Map of European repurposing cases by commodity

The Homes and Community Agency's (HCA) National Coalfields Programme in the UK has transformed over 93 sites (of 107 identified sites).[73] The program plans include: over 4,000 hectares of land brought back into use; over two million square metres of employment floor space; more than 42,500 jobs created; and over 13,100 homes built.

The National Coalfields Programme provides valuable lessons about the complexity and coordination challenges of repurposing.

The program includes abandoned mines transformed into industrial heritage destinations, and modern era coal mines transformed into public parks, trails and nature preserves. These projects are often in residential or peri-urban areas and contribute to local amenity, encouraging economic development. Often these mines were state owned.

There are some novel examples of mine repurposing for commercial use by private companies. They include, the Olivine mine in Norway converted into a secure data storage centre by a private company.[74] The underground workings of the mine are used to store data hardware, while the existing electricity connections provides power. The site of the data centre, in Norway's fjords, also provides access to cold water for cooling.

[73] Homes and Community Agency National Coalfield Programme (2010) A Review of Coalfields Regeneration, accessed Nov 2019, from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/6295/1728082.pdf
[74] Lefdal Mine Datacenter, https://www.lefdalmine.com/

While Auzat, France (Rio Tinto) has been repurposed into a sports centre, with indoor and outdoor fields as well as walking, running and hiking trails.[75]

5.6.6 Asia

We were able to identify 32 cases in Asia (Figure 11). Japan and China are represented by ten cases each, and Indonesia by nine cases. Though we know there are many other cases in Asia, we only had enough time to add three in Thailand, and one in Taiwan. Further research throughout Asia would provide a clearer picture.

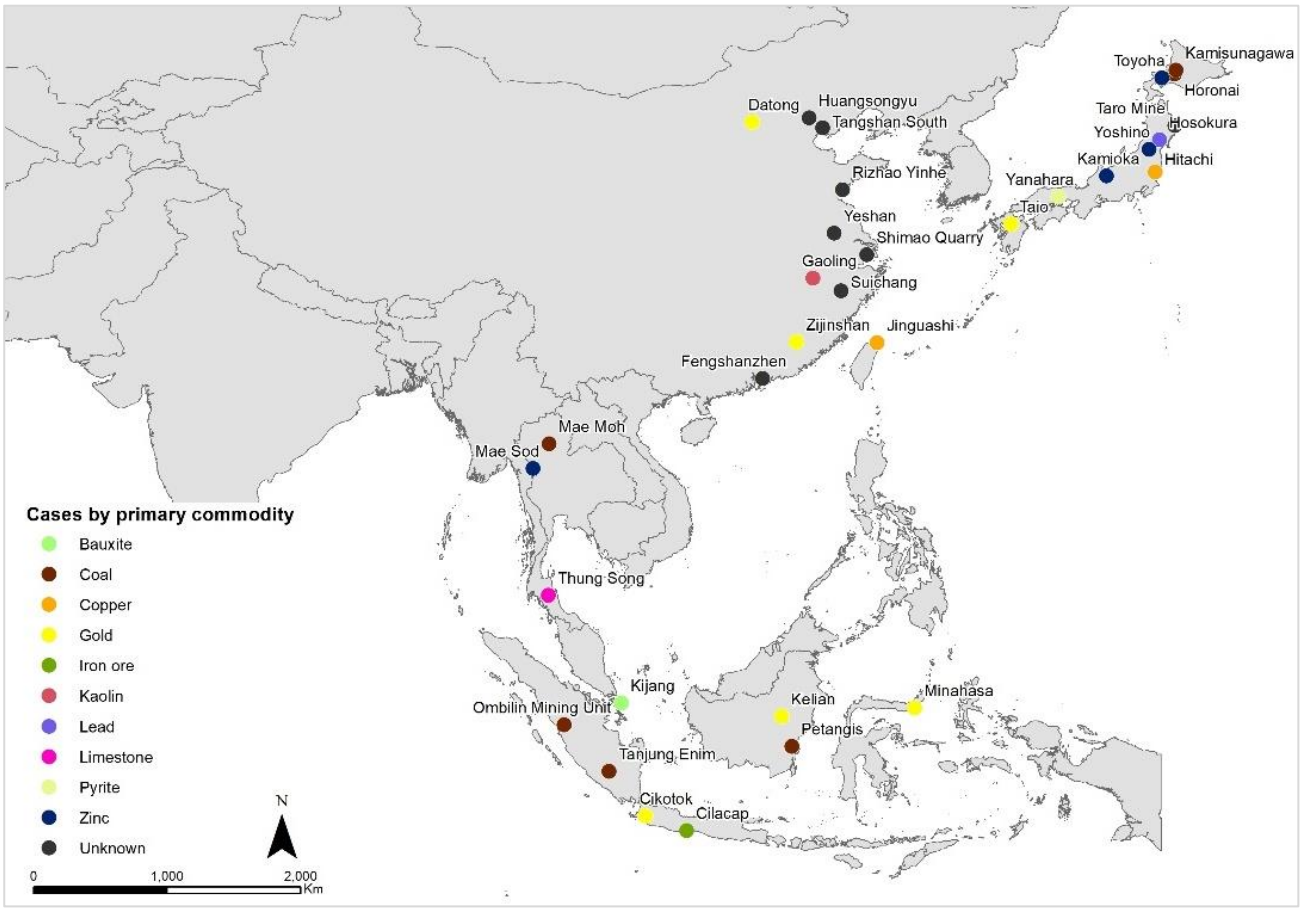

Figure 11: Map of Asian repurposing cases by commodity

Japan

A basic level of information about Japanese mining (e.g. names, dates, location, commodity, company) is available online in English, although only eight sites are recorded in the S&P database. Two of these, plus eight additional sites were included in our repurposing database. The sites not in the S&P database would have closed before S&P records begin.

There are a variety of uses for the repurposed sites, including: community and culture, with eco-tourism and museum or exhibition of mining/industrial history; amusement parks and sports venues; and high-tech scientific research laboratories, primarily for physics research.

Further research on the variety of repurposed uses in Japan may be of use, however, unique conditions in Japan may not provide a lot of generalizable data on process or outcome.

[75] Rio Tinto (2019) Auzat Case Study. https://www.riotinto.com/documents/RT_Prf5%20Auzat%20case%20study.pdf

China

Although the S&P database contains 198 'closed' properties in China, we found it difficult to access information about repurposing beyond one national initiative and one commercial case study.

Most of the cases (9) included in the database came from the National Mine Park program has transforms former mines into tourism destinations. The goals of the programs include: legacy mine heritage protection; education; mining Tourism and research.[76]

To 2018, there have been 88 mine parks announced and granted funding for construction. Thirty-three of these have opened.[77]

Indonesia

The S&P database contains 24 records of closed mines. Of these we were able to categories five as repurposing. We found three additional cases which were not included in the S&P database.

In Indonesia, there is a clear process for companies to follow in order to achieve lease relinquishment, generally including transfer back to the local government. Basic information on this process is usually indicated on company websites. Community consultation is a common feature, as is diversification of the local economy post-mining. Food production appears to be a priority. It is hard to determine how effective these transition and relinquishment programs have been. On the ground research would be useful in these cases.

5.6.7 The rest of Asia, the Pacific region, Africa, Russia and the Middle East

For the rest of the world, we were not as successful at identifying repurposing cases. We found three cases in South Africa, three in Thailand and one in Taiwan.

We attribute this result to a combination of limiting factors including: language, public documentation, research time, and familiarity with the regions. Further, mining in many of these regions has only recently opened up to major international or publicly listed mining companies, or is in jurisdictions with limited regulatory capacity. We believe there are further cases of repurposing in these locations, but that they are difficult to surface via searching the internet.

A further avenue of research could involve drawing on the breadth of geographical and linguistic knowledge in the SMI to improve our research in non-English speaking countries.

Examples of repurposing are not readily available in the Pacific, though we are aware that there are a number of inactive mines and mines in rehabilitation, including the BHP Ok Tedi mine. In developing states, such as PNG, it is often the infrastructure that the industry establishes, the roads, houses, schools and health services that people are keen to have maintained post-mining. However, without effective on-going governance arrangements the best laid post-mining land use plans can falter, as discussed below.

An example that gets drawn on as a good practice case-study is the Misima gold mine,[78] on Misima Island PNG (Placer Dome), which operated from 1987 until 2004.[79] This site has been through closure and rehabilitation. As the case study prepared for the Leading Practice Mine Closure and Completion Guide (2006) stated (paraphrased): there is a significant interaction between the various biophysical and socioeconomic mine closure aspects. The landform use is suitable for agricultural purposes, and social opportunities have been created with local landholder groups. The government is managing the hydroelectric power and water system on behalf of the

[76] Dr. Yubiao Li. (2016).Derelict Mine Managements in China: the. Opportunities and Challenges. The Cooperative Research Centre for Contamination Assessment and Remediation of the Environment (CRC CARE).
[77] Ministry of Natural Resources, PRC. (2018) China Mineral Resources.
[78] Note, however, that this site is not in the repurposing database. We could include it in another iteration.
[79] See Australian Government 2006. *Leading Practice Mine Closure and Completion Guide.* Available at https://nt.gov.au/__data/assets/pdf_file/0015/203415/mine-closure-and-completion.pdf

community. And local and provincial governments are now responsible for the health and medical centres and other infrastructure installed as part of the community development plan.

However, as indicated in section 5.2, although the mining company repurposed the pit to generate hydro-electricity for local villages, the pit is now a highly acidic lake, and the electricity supply is unsustainable, as fuel and maintenance are no longer available in the post-mining era.[80] The challenge for industry in this case, as in others in less developed states, is ensuring that skills transfer and succession planning occur combined with trust fund arrangements with independent oversight to manage ongoing projects.

5.7 Practices that may adversely impact on sustainable transitions and repurposing

The following reflections have surfaced during the research for this project, as practices that may either hinder or assist in repurposing options.

5.7.1 Progressive (or concurrent) rehabilitation

Concurrent or progressive rehabilitation has become a standard practice during the life of mine in many developed states.[81] Though there are benefits for the company in spreading out the cost of the rehabilitation over the life of mine, as well as benefits to the environment, in this context of post-mining transitions, the implications of this practice need to be considered. Questions to consider include:

- Does this on-going activity preclude community and stakeholder engagement in post-mine planning?
- Or is the progressive rehabilitation part of the closure plan agreed to with the community and other stakeholders?
- Does progressive rehabilitation potentially impact on, or limit, creative final land use options?

On the other hand, concurrent reclamation *can* contribute to post-mining land-use planning. In our database we have included four examples of concurrent rehabilitation (three from the US and one from Australia) that also demonstrate engagement with possible post-mining land uses, and subsequently they could be regarded as examples of co-purposing. These good practice examples illustrate how inactive areas of long-life mines can be rehabilitated at the same time as consideration is given to land-use transitions. The three examples from the US offer multiple transition pathways through community partnerships and outreach.

5.7.2 Industry factors: on-selling, minerals sector volatility

Our findings suggest that the practice of major company's on-selling no longer productive mines to smaller companies that do not have either the financial resources or the social performance capabilities to effectively take on closure — reclamation and repurposing — may be one of the reasons for the lack of industry funded examples. For instance, in relation to the industry-led repurposing cases we found evidence of in Australia, they were all by major companies. If junior

[80] Macintyre, M., 2018. 'Afterword. Places, Migration and Sustainability: Anthropological Reflections on Mining and Movement'. In the Journal of *Sustainable Development* Vol 26: 501-506.

[81] For instance, the Australian Government *Mine Closure: Leading Practice Sustainable Development Program for the Mining Industry* (2016: 21) states: 'Undertaking progressive rehabilitation before closure can help to reduce liability while providing increased certainty that a sustainable rehabilitation prescription exists. The business case for progressive rehabilitation is multifaceted, with tangible and intangible aspects. Tangible benefits include decreased financial assurance, compliance with regulatory requirements and more accurate costing for sustainable rehabilitation in closure provisioning. Intangible benefits include those related to timelines and project approvals, when sustainable rehabilitation can be demonstrated and an ongoing social licence to operate demonstrates to external stakeholders that mining can be a valued, responsible and transient land use'.

companies are repurposing, then they are rarely publicising it online and we acknowledge that this may be a limitation.

Conversely, we found several examples from majors (Newmont and Rio Tinto) who, in the process of asset acquisition, have acquired legacy sites which they are developing plans to repurpose or have repurposed (respectively Woodcutters in the NT and Auzat in France). So in these cases on-selling to major companies can be a positive outcome for post-mining land-use transitions. So that there are suggestions that it may be more beneficial for closure if a major company picks it up who has social performance standards that incorporate sustainability standards (which might include Closure and Reclamation standard and a Community Investment and Development standard).

In contrast, there are several examples of nationalisation of the mining industry. These have occurred in regions where mining has wound down due to government policy, exhaustion of reserves or economic issues. State control of multiple mining properties has underpinned regional-level programs such as the Emscher IBA in Germany and the National Coalfields Programme in the UK.

5.7.3 Economic rehabilitation

In the context of post-mining land use and repurposing, the concept of 'economic rehabilitation' is a useful and evocative one. However, we note that it has two possible definitions. Perhaps the most dominant definition in the applied mining context associates 'economic rehabilitation' with re-mining previously uneconomic tailings, often due to the advent of new technologies or changes in commodity price.[82] As a form of transition to a smaller scale local mining economy, economic rehabilitation associated with re-mining may use existing employees or skills. It may be pursued by the original company in on-selling the assets to a smaller company, as this also reduces liabilities for the on-selling company. Though there may be obvious short term benefits for both the on-selling company, the employee base and the local area, in the context of considering post-mining land-use transitions there are also risks with this form of transition.

One risk is that this form of economic rehabilitation is short term or finite (as the previous mining was). This asset on-selling also potentially increases the post-mining risks for the local community and the region as the, usually, smaller company will likely have less CSR investment in the region. And, as local community benefit agreements and mine closure plans were negotiated and implemented with the original company, there may be less corporate commitment to, and investment in, ensuring these commitments are fulfilled. The re-mining will also likely have a significantly shorter lifespan than the previous mine.

While we recognise that re-mining is a form of transition, we have not included examples of this activity in the scoping review. Instead, we focus on other forms of economic rehabilitation. Some examples entail economic diversification of, not only the local community or region, but also of the mining company as they innovate and pursue new forms of investment away from non-renewable extractives and into developing alternative energy sources, notably the case with thermal coal.

[82] For instance, the Qld based company Raging Bull established Century Bull (taking over the Century mine) to reprocess tailings from remnant mineralisation (zinc bearing tailings), using existing infrastructure while progressively rehabilitating sites to generate ongoing economic contribution. Available at https://www.i-q.net.au/main/century-bull-reveals-strategy-to-revive-zinc-operation

6. Future research

As a desktop scoping exercise, this research was limited by the extent of the publically available data we could access. The repurposing database is thus a snapshot of examples, however it contains many gaps and inconclusive data. Future research could actively address this limitation by being extended to:

- include different languages. A further avenue of research could involve drawing on the breadth of geographical and linguistic knowledge in the SMI to improve our research in non-English speaking countries
- draw on CSRMs expertise in mapping and demographics by extending the database to include a statistically significant number of cases.

We could undertake case studies:

- of specific repurposed sites — which would include interviews and site visits
- such case studies could specifically focus on the enablers (regulatory, economic, local stakeholder, etc.) at particular sites, such as alternative energy sites or recreational mine pit lakes, for instance.
- with a focus on different perspectives — such as from a state regulators perspective or an Indigenous groups perspective
- to capture corporate lessons on successful repurposing. There is not a lot of publically available information on experience. There are good practice examples and some companies do share the closure and repurposing news — but this is rare.
- So that companies can begin to tell the closure stories — to close the sustainability loop - so that shareholders, community and civil society have access to successful examples
- to gain a multi-stakeholder or regional perspective; as a retrospective on challenges encountered in the repurposing journey and how these were overcome.
- a suggested list of cases for further study is included in Appendix B.

We could learn and understand more about the examples of the range of abandoned mines programs, in Australia, the UK, the USA and Canada. This line of inquiry would seek to explore further the types of approaches and practices they have developed to finalise post-mining land uses and what the enablers have been for specific repurposing cases.

We did not have the opportunity in this brief project to explore the literature on just (economic) transitions and its relevance to post-mining transitions and repurposing.

As a rapidly growing field of research, notably in the area of managing the rights of workers during the closure of thermal coal mines and the associated power stations, one would anticipate transferable lessons to the repurposing field. Another stage of this research would provide an opportunity to connect this topic to broader debates and agendas.

Finally, it is also of note that in our early development of the repurposing database we initially retained the cases of rehabilitation that did not progress to repurposing. We did this because they may provide examples of ‘missed opportunities’ or conversely the barriers to potential repurposing. These approximately 20 examples are now in their own database. Some of these are sites where the return to the previous land use was the most appropriate option, as the case in remote Australian rangelands where the prior land-use was pastoralism. Hence, including these sites in the dataset enables a broader perspective across the range of options.

Further resources

Beckett, C and Keeling A. 2019. ‘Rethinking remediation: mine reclamation, environmental Justice, and relations of care’. In *Local Environment Vol 24,* No 3: 216-230.

Chaloping-March, M. 2017. *Social Terrains of Mine Closure in the Philippines*. Routledge Focus. New York.

Soltanmohammadi, H,. Osanloo M, and Bazzazi, A.A. 2009. ‘Deriving Preference Order of post-mining land uses through the MSLA framework: application for an outranking technique’. In *Environmental Geology* 58: 877-888.

Young, RE., Manero, A., Miller, P.B., Kragt, M.E., Standish, R.J, Jasper, D.A and Boggs, G.S. 2019. *A Framework for developing Mine site completion criteria in Western Australia*. The Western Australian Biodiversity Institute., Perth, WA.

Appendices

Appendix A: Limitations of the S&P database[83]

The S&P database is a compilation of press releases and other information disclosed by mining companies for the stock market. So their definition of 'closed' is basically a self (company) reported index: 'operator/owner said it is closed'.

As a result, there are lot of uncertainties that we need to be aware of when using this data. This includes that some closed mines may not have been reported at all at any stage of their life cycle and simply don't have a record. Some mines may be closed but may be considered for reopening. Or some mines are listed as 'care and maintenance' or 'limited production' while in reality they are closed but their owners haven't disclosed this yet.

Note that the S&P doesn't keep good track of closures that occurred before 2000s.

'Closed' does not necessarily mean relinquished … the caveats for the S&P site (EL): 'The S&P database is a compilation of press releases and other information disclosed by mining companies for the stock market. So their definition of "closed" basically is: "operator/owner said it is closed"'.

So we can work with it while acknowledging the limitations. It will probably not be possible to use the S&P to identify rehabilitated mines, relinquished mines or abandoned mines. The S&P doesn't make the distinction unfortunately.

[83] Thanks to Dr Eleonore Lebre for assisting with this discussion qualifying the limitations of this database.

Appendix B: Potential case studies

We found very few detailed case studies that analyse the social, political and/or regulatory processes by which an operation was transformed and repurposed. We suggest that this empirical research is a future stage of the project. The following table provides a selection of the cases we suggest pursuing further.

Property name	Primary commodity	Operator name	Country name	Activity
Big Brown Mine	Lignite	Luminant	USA	Multiple (inc aquaculture)
Bingham Canyon Mine	Copper	Rio Tinto	USA	Multiple (inc housing estate)
Collieburn Region	Coal	Wesfarmers	Australia	Multiple (inc aquaculture)
Creighton	Copper	Vale	Canada	Multiple (inc community events space)
Emscher Zone	Coal	Multiple	Germany	Multiple (inc museum or exhibition of mining/industrial history)
Kamioka	Zinc	Mitsui	Japan	Research facility
Kidston	Gold	Placer Dome	Australia	Alternative energy
Mae Moh	Coal	Electricity Generating Authority of Thailand	Thailand	Multiple (inc museum or exhibition of mining/industrial history)
Minahasa	Gold	Newmont	Indonesia	Multiple (inc public/botanical garden)
Morro Velho	Gold	AngloGold Ashanti	Brazil	Multiple (inc museum or exhibition of mining/industrial history)
National Coalfields Programme	Coal	Multiple	UK	Multiple (inc park & open green space)
Questa	Molybdenum	Chevron	USA	Alternative energy
San Martin	Gold	Goldcorp	Honduras	Multiple (inc food production)
Woodlawn	Copper	Denehurst Ltd	Australia	Multiple (inc alternative energy)

Appendix C: Summary of Australian Land Use and Management classification

Primary class	Definition	Secondary classes
1. Conservation and Natural Environments	Conservation purposes based on maintaining the essentially natural ecosystems present.	Nature conservation; Managed resource protection; Other minimal use
2. Production from Relatively Natural Environments	Primary production with limited change to the native vegetation.	Grazing native vegetation; Production native forests
3. Production from Dryland Agriculture and Plantations	Primary production based on dryland farming systems.	Plantation forests; Grazing modified pastures; Cropping; Perennial horticulture; Seasonal horticulture; Land in transition
4. Production from Irrigated Agriculture and Plantations	Primary production based on irrigated farming.	Irrigated plantation forests; Grazing irrigated modified pastures; Irrigated cropping; Irrigated perennial horticulture; Irrigated seasonal horticulture; Irrigated land in transition
5. Intensive Uses	Land subject to extensive modification, generally in association with closer residential settlement, commercial or industrial uses.	Intensive horticulture; Intensive animal production; Manufacturing and industrial; Residential and farm infrastructure; Services; Utilities; Transport and communication; Mining; Waste treatment and disposal
6. Water	Water features.	Lake; Reservoir; River; Channel/aqueduct; Marsh/wetland; Estuary/coastal waters

Source: ABARES 2016

Appendix D: Frequency counts of land-use activities, by category

Frequency count of primary land-use activities, grouped by category

Land-use categories Land-use activities	Occurrences: primary use
Agriculture	**8**
Aquaculture	2
Food production	3
Nursery	2
Pasture or hay-land	1
Alternative health	**6**
Therapy	6
Community & culture	**31**
Community events space	2
Cultural/historical precinct	9
Museum or exhibition of mining/industrial history	18
Reclamation art	2
Conservation & eco-system services	**23**
Native woodlands	6
Wetlands	2
Wildlife habitat	15
Construction	**13**
Airport/Port	2
Commercial real estate (i.e. shopping centre, business park, hotel, data centre, casino)	7
Housing estate	4
Education & research	**9**
Education facility	1
Rehabilitation research and education	1
Research facility	7
Forestry	**3**
Lumber production	3
Intensive recreation	**10**
Amusement park	2
Racetrack	1
Ski field	2
Sports field	5
Lake or pool	**7**
Sailing, swimming & fishing pond	4
Town water supply	3
Light industrial	**7**
Alternative energy	6
Recycling & repurposing of decommissioned materials	1
Non-intensive recreation	**24**
Eco-tourism	1
Park & open green space	19
Paths for walking, hiking, running, cycling & horse-riding	2

Public/botanical garden	2
Grand total	**141**

Frequency count of secondary land-use activities (grouped by category)

Land-use categories Land-use activities	Occurrences: secondary use
Agriculture	**4**
Aquaculture	1
Food production	1
Nursery	2
Community & culture	**28**
Community events space	3
Cultural/historical precinct	14
Museum or exhibition of mining/industrial history	9
Reclamation art	2
Conservation & eco-system services	**29**
Carbon offset & sequestration	1
Native woodlands	14
Wetlands	3
Wildlife habitat	11
Construction	**6**
Commercial real estate (i.e. Shopping centre, business park, hotel, data centre, casino)	5
Housing estate	1
Education & research	**11**
Education facility	4
Rehabilitation research and education	3
Research facility	4
Forestry	**1**
Lumber production	1
Intensive recreation	**4**
Amusement park	1
Racetrack	1
Sports field	2
Lake or pool	**4**
Sailing, swimming &/ fishing pond	1
Town water supply	3
Light industrial	**2**
Alternative energy	1
Military/defence	1
Non-intensive recreation	**16**
Eco-tourism	2
Park & open green space	5
Paths for walking, hiking, running, cycling &/ horse-riding	7
Public/botanical garden	2
Grand total	**105**

Frequency count of tertiary land-use activities (grouped by category)

Land-use categories Land-use activities	Occurrences: tertiary use
Agriculture	2
Aquaculture	1
Pasture or hay-land	1
Community & culture	**17**
Community events space	9
Cultural/historical precinct	4
Museum or exhibition of mining/industrial history	1
Reclamation art	3
Conservation & eco-system services	**11**
Native woodlands	3
Wetlands	1
Wildlife habitat	7
Construction	**1**
Commercial real estate (i.e. shopping centre, business park, hotel, data centre, casino)	1
Education & research	**12**
Education facility	8
Rehabilitation research and education	3
Research facility	1
Intensive recreation	**5**
Amusement park	3
Ski field	1
Sports field	1
Lake or pool	**5**
Sailing, swimming &/ fishing pond	5
Light industrial	**3**
Alternative energy	1
Recycling & repurposing of decommissioned materials	2
Non-intensive recreation	**11**
Eco-tourism	6
Park & open green space	1
Paths for walking, hiking, running, cycling &/ horse-riding	1
Public/botanical garden	3
Grand total	**67**

Appendix E: Excerpt from ICMM's Integrated Mine Closure Toolkit 2nd Edition, 2019

Step 2. Constraining and facilitating characteristics
External infrastructure aspects to consider as part of the screening process could include: • industrial context • access to airports • rail access to site • tourism potential • availability of high-pressure natural gas • renewable energy potential • access to electric transmission lines • deep-water port/dock facilities • available power options, including alternative/ • proximity to other 'compatible' industries renewable energy supplies • proximity to communities • availability of city/town sewer and water • land zoning/tenure. • access to major roadways
Internal infrastructure, permit and utility considerations could include: • location and availability of reclaimed land and domains • existing water abstraction and discharge permits • existing water storage (storm, industrial, effluent) • available buildings for reuse, sale, lease; condition of • existing air quality permits • buildings and maintenance needs • existing waste treatment or waste disposal permits • site utilities (power, water wells) • land contamination and feasible remediation levels (eg • site transport (roads, rail) — extent, coverage, condition industrial, agricultural or residential levels). • remaining mineral resources for industrial purposes (eg rock, stone, sand, gravel)

Appendix F: Further data tables

Table 19: All cases by commodity

Primary commodity	Number of cases	Primary commodity	Number of cases
Coal	40	**Molybdenum**	2
Gold	16	**Granite**	1
Copper	13	**Olivine**	1
Uranium	8	**Borate**	1
Zinc	7	**Opal**	1
Limestone	6	**Diamond**	1
Iron ore	4	**Phosphate**	1
Sand	3	**Nickel**	1
Silver	3	**Pyrite**	1
Clay	2	**Kaolin**	1
Bauxite	2	**Lead**	1
Ilmenite	2	**Lignite**	1
Salt	2	**Not specified**	21
		Grand total	**141**

Table 20: All cases by country

Country	Number of cases	Country	Number of cases
USA	23	**Sweden**	2
UK	20	**New Zealand**	2
Australia	15	**Romania**	1
Canada	12	**Taiwan**	1
China	10	**Chile**	1
Germany	10	**Norway**	1
Japan	10	**Portugal**	1
Indonesia	8	**Honduras**	1
Czech Republic	5	**France**	1
Bulgaria	5	**Poland**	1
Brazil	3	**Mexico**	1
South Africa	3	**Netherlands**	1
		Grand total	**141**

THE UNIVERSITY OF QUEENSLAND
AUSTRALIA

CREATE CHANGE

Contact details

Dr Sarah Holcombe
T +61 7 3364 4152
M +61 0400 731 607
E s.holcombe@uq.edu.au
W smi.uq.edu.au

CRICOS Provider Number 00025B