

# Comparing coal mine rehabilitation practices in Queensland, Australia with Wyoming, United States of America

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## Abstract

*This paper compares open cut coal mine rehabilitation practices in Queensland, Australia, with Wyoming in the United States of America (USA). The industry in these jurisdictions have some similarities (and differences) that provide for qualitative comparison of the respective progressive rehabilitation performance. Rehabilitation of areas disturbed during open cut coal mining present a significant challenge in both jurisdictions. Open cut coal mining in both areas underwent significant expansion in the late 70s and early 80s. The regulation of mine rehabilitation (known as reclamation in the USA) has been approached differently in the USA and Australia. The USA introduced national federal laws governing reclamation early on during the expansion of the coal mining industry in 1977 with the option for individual states to be responsible for their implementation (primacy). In Australia, the responsibility for regulating mine rehabilitation rests with each of the states and territories. In Queensland, varying laws have been used to govern the rehabilitation process over time, however, laws governing environmental management of mining were consolidated in the mid-90s and again strengthened more recently in 2018.*

*This paper considers some of the key aspects of rehabilitation including financial assurance (bonding), final landforms including the requirement to backfill pits, groundwater management in alluvial zones and a comparison of the rates of mine rehabilitation reported in both jurisdictions. The information presented in this paper was compiled from site inspections of coal mines in Wyoming, meetings held between the Office of the Queensland Mine Rehabilitation Commissioner (QMRC), the Wyoming Department of Environmental Quality (WDEQ) and the Federal Office of Surface Mining Reclamation and Enforcement (OSMRE), in addition to a review of published guidance materials, government reports, and legislation from both jurisdictions.*

*Wyoming uses a system of full cost bonding, compared with a pooled fund/bonding hybrid model in Queensland. A desire to release bonds appears to motivate the completion of the rehabilitation and surrender process in Wyoming. Similarly, the hybrid system in Queensland provides a reduction in annual rehabilitation liability once rehabilitation is completed. Although the framework allows for this, there are few examples where parts of mining leases have been rehabilitated and surrendered in Queensland. A key difference between jurisdictions is that the USA, including Wyoming, requires mine voids to be backfilled to their 'approximate original contour' (AOC). Although some voids may be backfilled or partially backfilled after mining in Queensland, most are likely to remain and are unlikely to sustain a viable use in the long-term. Wyoming also has noteworthy protections for surface and groundwater hydrology including alluvial valley floors regarded as important for agriculture. A comparison of progressive rehabilitation rates found that the proportion of rehabilitated land compared with the area of disturbance was substantially higher (two-fold) in Wyoming compared with Queensland. This comparison carries some assumptions and is subject to change over time. Further analysis of the issues and examples are given with a view to identifying opportunities for improving rehabilitation rates.*

**Keywords:** coal mining, rehabilitation practices, progressive rehabilitation, Wyoming, Queensland

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# 1 Introduction

Coal production in Wyoming underwent expansion in the late 1970s after changes to the *Clean Air Act 1974* (United States of America [USA] 1974) and air quality reforms that drove a need for low sulphur coal (Wyoming Geological Survey 2021). Large-scale open cut mining began in 1961 in Queensland and expanded in the 1970's with the development of several open cut mines (Emmerton et al. 2018). The coal industry in Wyoming is similar in size and scale to that in Queensland. Coal mines in Wyoming currently produce approximately 40 percent of the thermal coal produced annually in the USA (Wyoming Geological Survey 2021). Similarly, Queensland produced approximately 50 percent of Australia's 2018–2019 coal production (Geosciences Australia 2021). Wyoming produced more than 220 million tonnes of thermal coal from open cut mines in 2023 (Office of Mine Inspector 2023). Coal produced in Wyoming does not require washing or processing. In Queensland the volume of saleable coal after processing was approximately 200 million tonnes in 2022 from open cut mines (Queensland Government 2023). Coal is produced in Wyoming from 16 open cut mines, with two large-scale open cut mines producing more than 60 million tonnes each in 2022 (Office of Mines Inspector 2022). These are some of the largest open cut coal mines in the world. In comparison, Queensland's coal was produced from 44 operational open cut mines in 2022 with the highest production rate of a single mine approximately 20 million tonnes in 2022 (Queensland Government 2023).

The type of coal deposits mined differ between Wyoming and Queensland. Wyoming produces thermal coal with low sulphur content that is primarily used for domestic power generation. The coal produced in Queensland is thermal and metallurgical coal with a substantial proportion of metallurgical coal exported overseas. Another point of difference is that strip ratios (i.e. the ratio of overburden to coal) for coal mining are substantially lower and the coal seams are generally thicker in Wyoming compared with the Bowen coal basin in Queensland. Often the Wyoming coal seams do not intercept substantial groundwater reserves. Most Wyoming coal is mined from shallow dipping coal seams that can be 30 m thick with minimal to no partings (Wyoming Mining Association 2013). Although coal seams can be up to 30 m thick at the extremes in the Bowen Basin, there are many examples where mines target multiple seams less than 10 m thick (Mutton 2003).

The *Surface Mining Control and Reclamation Act 1977* (SMCRA) (USA 1977) provides a high level of protection to certain stream valleys in the western United States from coal mining activities. These areas are referred to as alluvial valley floors (AVFs) and are generally defined as stream valleys underlain by unconsolidated streamlaid deposits which have sufficient water availability to be important for agriculture. With respect to AVFs, SMCRA:

1. prohibited mining on certain AVFs
2. set high reclamation standards for AVFs not prohibited from mining
3. required that mining operations will not materially damage the hydrologic functions of certain AVFs (USDO I OSMRE 1985).

While Queensland also has protections for groundwater under the *Environmental Protection Act 1994* (EP Act) (Government of Queensland 1994) and the *Water Act 2000* (Government of Queensland 2000), there are no similar requirements to restore or recreate the hydrological functions of alluvial aquifers after mining. Another distinguishing feature between jurisdictions is that Wyoming requires a joint post mine land use of domestic livestock grazing and wildlife. Wyoming land rehabilitation efforts therefore target species-specific habitat needs such as the planting of sagebrush to support the iconic sage grouse and many other sagebrush steppe obligate wildlife species (Mazza 2023). Greater sage grouse and other sagebrush-obligate wildlife species require sagebrush-dominated plant communities for their survival. Innovative and successful technological approaches have been developed and successfully implemented in Wyoming to re-establish sagebrush after mining (Mazza 2023; Wendtland et al. 1992). Rehabilitation of coal mines in Queensland commonly targets either establishing grazing pastures, native ecosystems, or a combination of both.

This paper compares mine rehabilitation practices in Queensland, Australia with Wyoming, USA. Wyoming was used as a reference point for this comparison with Queensland as both jurisdictions have large-scale and long-standing coal mining industries that share similar challenges for rehabilitation. Focus areas for this

comparison were financial assurance (bonding), re-establishing final landforms including backfill of open cut pits, groundwater management in alluvial zones and a comparison of the rates of mine rehabilitation reported in both jurisdictions. This paper addresses a gap in the literature and provides insights regarding international mining rehabilitation legislation and standards. It also provides new information on the rates of rehabilitation to disturbance being achieved between international jurisdictions and an analysis of the drivers for those respective differences.

## 2 Methodology

The information presented in this paper was compiled from site inspections of three coal mines in Wyoming, meetings held between the QMRC, WDEQ, the OSMRE, a review of guidance materials and government reports, legislation from both jurisdictions, and published literature.

This paper compares coal mine rehabilitation (known as reclamation in the USA) practices in both states and considers some key aspects of the regulatory framework used to govern rehabilitation in both states. Issues discussed include financial assurance (bonding), the definition of final landforms, groundwater management and mine rehabilitation rates.

The review considered the key pieces of legislation governing rehabilitation in both jurisdictions including the *Surface Mining Control and Reclamation Act 1977* (USA 1977) at the federal level in the USA and the *Wyoming Environmental Quality Act of 1973* (State of Wyoming 1973), *as amended* at the state level. The review also considered the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Commonwealth of Australia 1999) at the national level in Australia and the EP Act at the state level in Queensland. Related laws including the *Mineral and Energy Resources (Financial Provisioning) Act 2018* (MERFP Act) (Government of Queensland 2018), and the *Water Act 2000* (Government of Queensland 2000) from Queensland were also considered where these have a bearing on practices. Standards and guidance materials were also reviewed including Chapter 4: Environmental Protection Performance Standards from Wyoming (WDEQ 2022) and the Guideline for Progressive rehabilitation and closure plans from Queensland (DES 2023).

This paper compares the published rate of rehabilitation in hectares of disturbance due to mining, with the area in hectares that have been rehabilitated. This analysis represents a qualitative comparison of rehabilitation rates and is not intended to provide a statistical analysis of rehabilitation performance. The varying terminology used to describe rehabilitation in both jurisdictions is explained to support the interpretation of the figures presented.

## 3 Results

### 3.1 Rehabilitation laws in Wyoming and Queensland

In the USA, mine rehabilitation is governed at the federal level under the *Surface Mining Control and Reclamation Act 1977* (SMCRA) by OSMRE (USA 1977). State governments and tribal lands administrators are responsible for implementing laws to align with those set at the federal level where they gain 'primacy' for the implementation of SMCRA. This means that OSMRE is required to approve the procedures and practices established by the states that are equal to or more effective than the federal regulatory requirements.

A policy review of SMCRA by Yonk et al. (2019) suggests the regulatory rules and the reclamation efforts by mining companies have been successful in addressing the majority of environmental problems introduced by surface mining. Although Yonk et al. (2019) celebrate the success of SMCRA, they also recognise that it is not perfect and can present problems from 'static regulation' that can freeze outdated environmental policies in place. They also suggest that applying prescriptive rules can effectively limit innovation and improvement in practices. Nevertheless, clear and consistent rules provide a sound footing for industry and regulators to work with.

The WDEQ land quality division (LQD) regulates the permitting of coal production in Wyoming under the *Wyoming Environmental Quality Act of 1973* (State of Wyoming 1973), as amended (WEQA). The purpose of the WEQA is to 'prevent, reduce and eliminate pollution; to preserve, and enhance the air, water, and reclaim the land of Wyoming' (35-11-102) (State of Wyoming 1973). The WEQA requires a permit for coal mining. An application for a surface coal mining permit must describe a mine plan, including the estimated orderly progression of mining and reclamation on all proposed affected lands. An application must also include a reclamation plan that describes a time schedule for each major step in the reclamation process and ensures reclamation is undertaken at the earliest possible time. Wyoming Statute 35-11-406 of the WEQA describes Environmental Protection Performance Standards for surface coal mining operations (State of Wyoming 1973; WDEQ 2022). These regulatory standards describe the requirements for how rehabilitation is to occur, and the outcomes expected.

In comparison, Australia does not have federal laws and oversight of state agency practices. The regulation of mining and mine rehabilitation is primarily the remit of the states (Hamblin et al. 2022) and each state and territory in Australia independently hold the responsibility for regulating resource extraction and rehabilitation. At the Commonwealth level, the EPBC Act regulates impacts to Matters of National Environmental Significance (MNES) but does not refer directly to mine closure or rehabilitation under the objectives of the Act. However, mining projects may require assessment under the EPBC Act and require consideration of impacts to MNES including significant impacts to water resources. The absence of federal oversight of mining and mine rehabilitation laws in Australia has led to the development of different regulatory approaches for rehabilitation across the country. Queensland manages approvals for mining and rehabilitation under the EP Act. An environmental approval (called an Environmental Authority in Queensland) is required for large-scale mining under the EP Act. The EP Act requires mine sites to be progressively rehabilitated according to a progressive rehabilitation and closure (PRC) plan. A PRC plan includes a schedule that describes specific rehabilitation milestones and criteria to assess performance. Guidelines are also provided for the development of PRC plans (DES 2023).

### 3.2 Bonds and financial assurance

Queensland and Wyoming have mechanisms in place to manage financial risk to the state if an operator is unable to meet their obligations to rehabilitate the land should a mining company become bankrupt or go into liquidation and is unable to complete rehabilitation. Financial assurance (bonding) requirements provide a solid incentive to ensure coal companies conduct adequate reclamation (Yonk et al. 2019). In Queensland, mining permit holders are required to pay financial assurance, in the form of a contribution to a financial provisioning fund, or provide a surety to the Financial Provisioning Scheme established under the MERFP Act. This system is referred to here as a hybrid model because it uses both a pooled fund and operator-held sureties under different circumstances.

Under this system, the estimated rehabilitation cost (ERC) is the estimated cost incurred by the state to prevent harm and restore the environment (DES 2023). The amount of money that is required to be paid into the fund depends on the liability, or the ERC for the site and the assessed risk of the operator. Operators regarded as very low, low or moderate risk are required to pay a contribution to the scheme fund in an amount calculated by multiplying the ERC for the authority and the prescribed percentage for the risk category that range between 0.5% for the very low risk category, 1% for the low risk category and 2.75% for the moderate risk category (Queensland Treasury 2019). Operators regarded as high risk would be required to give surety equal to the full ERC amount (Queensland Treasury 2019).

As rehabilitation is undertaken progressively, the ERC is reduced and at the same time influences the risk rating used to calculate the contribution payable. Progressive rehabilitation is given a 15% weighting in the resource project characteristics assessment (RPCA) used to assess the risk category of an operator. The RPCA represents 25% of the overall financial soundness assessment that feeds into the risk category assessment. Rehabilitation that has been 'certified' (i.e. where an area has been rehabilitated to meet statutory requirements) is rated significantly higher in the RPCA than uncertified rehabilitation (Queensland Treasury

2019). The financial motivation to complete rehabilitation comes from reducing both the ERC and the overall risk rating of the operation that is used to determine the multiplier and define the contribution payable.

Contributions to the pooled fund from larger companies (including the total ERC for multiple operations across a corporate group) are limited to a threshold of 5% of the total liability exposure of the fund with the remainder of liability to be covered by a surety or financial guarantee. This is intended to prevent the fund from excessive exposure to any one entity (Queensland Treasury 2019). Once rehabilitation is complete, operators can request to surrender part of a resources tenure which would also reduce the ERC.

In the USA, SMCRA requires mining companies to hold a reclamation bond in the form of a corporate surety bond, a collateral bond, cash, a self-bond, or a combination of these (Yonk et al. 2019). Self-bonding has been common historically and there have been some concerns with some of the largest coal producers in the USA holding billions of dollars of self-bonds, and filing for bankruptcy under Chapter 11 (Yonk et al. 2019). The WDEQ LQD recently revised and updated its bonding rules in 2018 to address changes in financial assurance instruments, corporate structuring and financial markets that have occurred since the adoption of original bonding rules and regulations established in 1982.

Multiple changes have occurred since establishment of financial assurance rules and regulations, such as the Sarbanes Oxley Act and the Dodd-Frank Act that address increased complexity in corporate structures, and on- and off- balance sheet debt restructuring. Under the revised rules, a company cannot be 100% self-bonded and only companies with the highest third party independent credit rating are allowed to self-bond up to a maximum of 75% (Galloway 2019). Wyoming provides several financial assurance options including corporate surety, letters of credit, self-bonding, federally insured certificates of deposit, cash, government securities, property collateral, and a voluntary irrevocable assigned trust.

New and novel legislation promulgated in Wyoming in 2022 introduced the option to use an assigned trust account. The assigned trust is a cash funded trust account that is managed by the Wyoming State Treasurer to assure that the corpus assets of the trust account are protected and increase in value over time. The assigned trust accounts are established on an individual permit basis and are only available to WDEQ to cover the cost of reclamation in the event of forfeiture by the operator. This provides a way for an operator to pay into an assigned trust over time that is managed by the state government and gains value. Once the assigned trust becomes fully funded, the interest earned on the account above the required reclamation bond amount is returned to the operator. This turns the reclamation liability into an income producing asset over time.

In the USA, bond release for coal mines typically encompasses four phases including;

- area bond that covers the final placement and regrading of spoils
- phase I that covers the topsoiling and seeding of regraded lands
- phase II that includes vegetation establishment and soil stability
- phase III that includes final vegetation diversity and productivity requirements and is completed at a minimum 10 years following final Phase II seeding and vegetation establishment.

The final step in the process is to apply for 'Termination of Jurisdiction' once all rehabilitation phases have been completed. This process of releasing the bonds in phases motivates the completion of rehabilitation as it facilitates the direct return of bonds and release of all liability to the operator. Reduction of the reclamation bond only occurs after verification and approval by the state and federal regulators' specific bond release criteria and performance standards (Krzyszowska Waitkus 2022). Bonds in Wyoming are evaluated annually for adequacy.

It is reportedly becoming more difficult and costly to access sureties for mining operations (Queensland Treasury 2023). Yonk et al. (2019) state that the availability of company surety bonds has been an issue for decades given their cost is likely to increase over time and the probability that a surety company will provide a bond goes down. An annual payment into a pooled fund or trust or by self-bonding where possible is likely to provide an attractive option for operators compared with seeking surety. Although the system of financial

assurance differs between jurisdictions, both have sound mechanisms in place to manage risk exposure to the state where operators default on their environmental management obligations. The key difference between them is whether funds are paid upfront on an annual basis, or held in bonds that may be drawn upon if needed.

### 3.3 Final landform

Re-establishing a stable landform after mining is a complex and challenging task. The process involves backfilling pits, reshaping the landform through the regrading of spoils and reduction of highwalls, replacement of topsoil and revegetation. Ideally mining landforms are re-established to represent what was present prior to mining. This goal is not always achievable and can be influenced by technical constraints and legal requirements. In the USA, SMCRA section 515 (b,3) requires open cut coal operations to:

*'backfill, compact (where advisable to ensure stability or to prevent leaching of toxic materials), and grade in order to restore the approximate original contour' (AOC) (USA 1977).*

SMCRA section 701 (2) defines AOC as the:

*'surface configuration achieved by backfilling and grading of the mined areas so that the reclaimed area... closely resembles the general surface configuration of the land prior to mining and blends into and complements the drainage pattern of the surrounding terrain, with all highwalls and spoil piles eliminated' (USA 1977).*

This long-standing requirement has made backfilling of residual voids from open cut coal mines a standard practice that is routinely undertaken for surface coal mining in the USA. According to the requirements in the USA Code of Federal Regulations (2022), all highwalls, spoil piles and coal refuse piles are required to be eliminated and are not allowed to be left at the reclaimed mine.

In Queensland, residual mine voids have not historically been required to be backfilled and many highwalls and spoil piles have been allowed to remain post mining. While the number of residual voids that will remain in Queensland is not clear, one estimate from a 2021 report (published by the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development [IESC]) found there were 85 residual voids described in approvals for coal mines in the Fitzroy Basin (Coffey Services Australia Pty Ltd 2021). Most of these voids would not have a designated post mining land use (PMLU) and would not be legally required to be rehabilitated where they have been approved historically. Greater granularity around the number of voids will be seen as sites complete and receive approval for PRC plans. Most residual voids from open cut coal mines will partially fill with groundwater once mining is complete. Many would be expected to act as 'sinks' that are unlikely to release to surface or groundwater systems. Despite this, most will become increasingly saline over time and would not be expected to host any practical use in the long-term. A review by Clay et al. (2022) found that the quality of water held in coal mine voids may limit whether a PMLU can be sustained into the long-term. Water quality is a key limitation to achieving viable PMLUs in residual voids that are sustainable into the long-term. Such an outcome, whereby an area is left unrehabilitated and without a long-term post mining use, is unlikely to be regarded as a leading practice. At a minimum, safety concerns including the installation of safety bunding and fencing must be undertaken where a residual void is left.

In Queensland, a 'final landform design' is required to demonstrate that the land will be safe and structurally stable (DES 2023). Although there is guidance on the considerations that should be made in preparing a landform design, the goals or expectations are broadly left to the proponent to define. This can lead to wide variation in what may be proposed as final landforms. There are examples where highwalls are proposed to be left in place as 'steep rocky ecosystems'. This is said to be justified based on the premise that there are cliffs and rocky outcrops that can exist in the broader landscape and that they could provide, albeit unique, a niche ecological habitat. Having a clear requirement to re-establish the landform as it was prior to mining, would avoid the regulatory quandary of deciding whether such features are, or are not, acceptable.

### 3.4 Groundwater management in alluvial zones

Groundwater drawn from alluvial aquifers is a highly valued natural resource in the arid western states of the USA. Under SMCRA, alluvial valley floors in western states are given special protection (OTA 1981). SMCRA requires extensive baseline surveys of groundwater hydrology prior to mining, that provide a basis to define standards used to assess potential impacts to the functions of the aquifers and quality of water in them. Mine operators are required to ‘prevent long-term adverse changes in the hydrologic balance that could result from surface coal mining and reclamation operations, both on- and offsite’ of section § 715.17 of SMCRA (USA 1977).

Under the provisions of the SMCRA section § 822.12 (USA 1977), ‘surface coal mining and reclamation operations shall not: (1) interrupt, discontinue, or preclude farming on alluvial valley floors that are irrigated or naturally subirrigated; or (2) cause material damage to the quantity or quality of water in surface or underground water systems that supply alluvial valley floors’, provided that the AVF is not subject to the statutory exclusions of section § 35-11-406(n)(v) of the WEQA (State of Wyoming 1973). These statutory exclusions include:

1. AVFs on undeveloped rangelands, which are not significant to farming
2. AVFs where mining disturbance will be limited such that there will be negligible impact to a farm’s agricultural production
3. AVFs in areas at mines that produced coal in commercial quantities prior to the effective date of SMCRA (i.e. August 3 1977).

Significance to farming is determined by calculating the percent farm production loss as a result of mining the AVF. Any loss greater than 10 percent is considered to exceed the negligible impact criteria to both small and large Wyoming farming operations, and thus mining of the AVF is prohibited (WDEQ 2000). However, in each of these cases of statutory exclusion, the mine must restore the hydrological functions of the AVF after mining. Essential hydrologic functions are defined as ‘those conditions of surface and groundwater hydrology that support or enhance subirrigation or flood irrigation agricultural activities’ (WDEQ 2009). If the AVFs are located offsite and will not be mined, the essential hydrologic functions still must be preserved. This can be a challenging and lengthy process in the arid west but has been successfully undertaken in some locations. Hydrologic reclamation, including establishing groundwater recharge capacity and restoring groundwater quantity is linked to Phase III bond release requirements.

Queensland does not have comparable laws that directly preclude mining in areas that may impact aquifers used for farming or other agricultural uses, or require re-establishment of aquifers or recharge zones. However, Queensland laws require potential impacts to groundwater systems to be identified during the mining approvals process and mitigated against under the EP Act. Groundwater hydrology modelling is required to support mining approvals in Queensland.

Models are used to identify and assess potential impacts to groundwater systems and environmental values. This assessment process is also used to propose strategies to avoid or mitigate potential impacts (DES 2023). Mine operators in Queensland have a statutory right to take or interfere with ‘associated water’ during mining, under Chapter 12A of the *Mineral Resources Act 1989* (Government of Queensland 1989). This is referred to as underground water rights. Groundwater in coal seams in the Bowen Basin is often brackish or saline and where this is the case, the groundwater has less value as a useful water source by surrounding land users. Although less common, open cut coal mining may also impact groundwater systems with good quality water that is used for agricultural purposes, or may impact environmental values including basalt and shallow alluvial aquifers. The Environmental Protection Regulation 2019 (Government of Queensland 2019) requires the protection of environmental values of groundwater as an Environmental Objective in Schedule 8. Environmental Values in this regard include human uses such as for agriculture, and ecosystem values.

Where impacts to the environmental values of groundwater are anticipated to result from a mining activity, environmental approvals include thresholds for groundwater drawdown, monitoring, mitigation and management and may require a Groundwater Dependent Ecosystem Monitoring and Management Plan. Where impacts cannot be avoided, impacts to matters of state environmental significance may be required to be offset under the *Environmental Offsets Act 2014* (Government of Queensland 2014). Groundwater users affected by a mining activity may also be required to be compensated under 'make good' obligations under Chapter 3 of the *Water Act 2000* (Government of Queensland 2000). This is required where a groundwater bore's ability to provide a reasonable quantity or quality of water for the bore's authorised use or purpose is impaired. While there is no specific requirement to reinstate hydrologic functions after mining, mine closure plans will typically include requirements to meet groundwater quality and level thresholds as part of the PRCP prior to relinquishment.

### 3.5 Mine rehabilitation rates

A key aspect of ensuring rehabilitation is undertaken progressively throughout the life of a mine, is ensuring it is undertaken in a timely manner as mining is completed. Both Queensland and the USA require rehabilitation to be undertaken progressively as surface mining progresses. In Queensland, the EP Act requires a PRC plan and schedule of rehabilitation activities to be submitted to the administering authority. These allow rehabilitation performance to be planned and progress to be tracked. In the USA, 'contemporaneous reclamation' or rough backfill is required to occur after mining. USA state and federal laws also require reclamation to commence where mining is inactive (Galloway 2019). The concept of 'contemporaneous reclamation' used in the USA is also similar the requirement that land 'available for rehabilitation' must be rehabilitated as described in Queensland's laws. In Queensland, land is regarded as being 'available for rehabilitation' if the land is not being mined (section 126D [4]) EP Act (Government of Queensland 1994). However, there are some exceptions to this requirement. For example, land would not be required to be rehabilitated where the land has a probable or proven ore reserve that is to be mined within 10 years, or where permanent infrastructure like roads, dams or infrastructure are associated with a post mining land use. Exceptional circumstances are described further in section 187B of the Environmental Protection Regulation 2019 (Government of Queensland 2000). As stated earlier, Wyoming Coal Rules and Regulations describe four phases of rehabilitation to achieve bond release (OSMRE 2023). While Queensland's rehabilitation framework uses different terminology, these phases broadly align with the rehabilitation process described in Wyoming. For example, the term 'completed rehabilitation' is similar to having completed both phases I and II and 'progressive certification' is similar to Phase III.

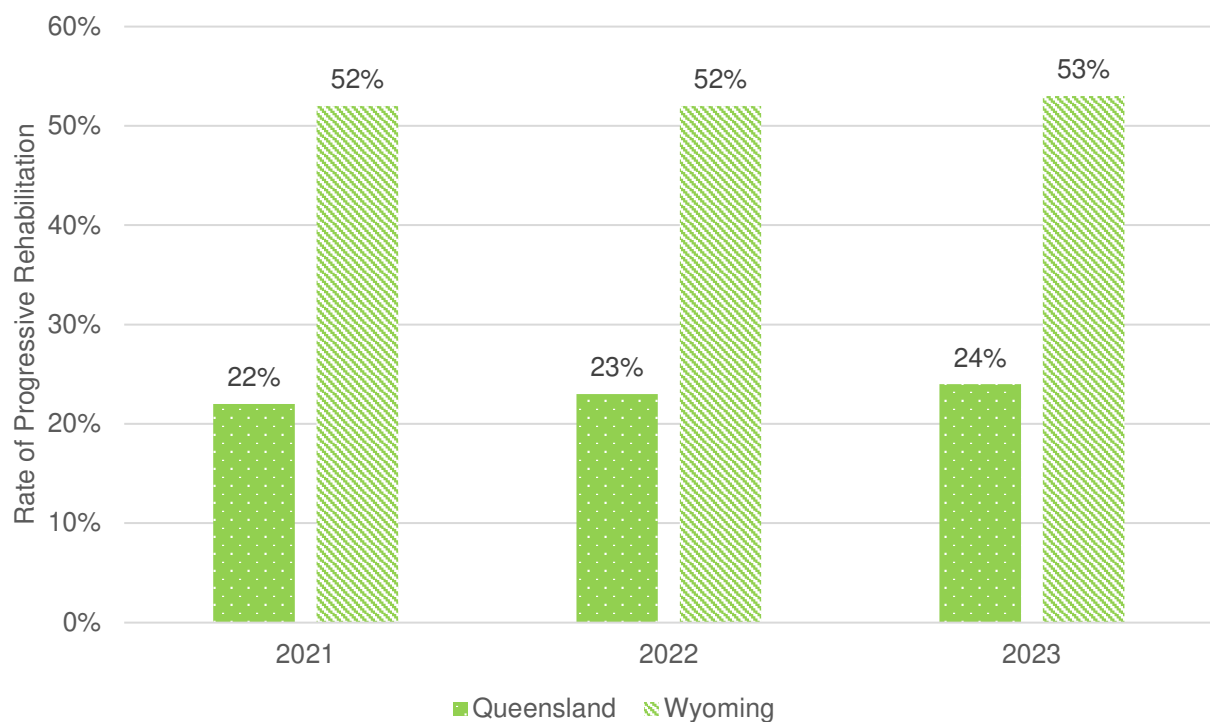
In Wyoming, coal mine operators must submit an annual report to the state regulatory agency under the WEQA W.S. §35-11-411 (State of Wyoming 1973). The Wyoming government submits an annual report of statewide rehabilitation success called an 'Oversight Report' to OSMRE that is based on those data from the individual mine annual report(s) (OSMRE 2023). Rehabilitation figures reported for the period July 1, 2022 to June 30, 2023 state the progressive rehabilitation rate for coal mines in Wyoming was 53% of land disturbed by coal mining has been backfilled, graded, topsoiled and seeded and has established vegetation (Figure 1). The rehabilitation rate reported here represents the cumulative ratio of reclaimed to disturbed land. This metric is comparable with the definition of 'completed rehabilitation' used in Queensland. The rehabilitation rates reported are higher if the area of land that is unable to be rehabilitated until after mining is complete was subtracted from the total area of rehabilitation. The area of land regarded as 'unable to be rehabilitated' accounts for areas such as buildings, ponds, haul roads, soil and overburden stockpiles and other long-term disturbances. This represents approximately 17% of the cumulative disturbed lands on Wyoming coal mines (OSMRE 2023). The Wyoming OSMRE Oversight Report does not include the mines that were completely rehabilitated and terminated. Historically, Wyoming has terminated 21 coal mines with a total of 126,000 permitted acres. If the terminated acres are included and the long-term facilities are excluded, then the rehabilitation rate is significantly higher than the reported 53%.

Like Wyoming, Queensland mine operators are required to submit an annual return to the regulator, that reports on compliance with permit conditions and describes rehabilitation progress. The information and



data are prepared by operators and is submitted to the regulator as an ‘annual return’. The Queensland Mine Rehabilitation Commissioner’s 2022-23 annual report summarises data up to 2022 (QMRC 2023). Based on data from annual returns data up to 31 December 2023, Queensland reportedly has a progressive rehabilitation rate for thermal and metallurgical coal mines of 24% (Figure 1). This represents areas reported by industry as the area that is ‘rehabilitation certified’ or ‘rehabilitation completed’. The cumulative rehabilitation rates reported for Wyoming and Queensland include areas unable to be rehabilitated until after mining is complete. This allows for a more balanced comparison than would be achievable if including those areas.

In Wyoming, the cumulative totals for Phase I bond release reported in 2023 was 47.7% of the total disturbance, Phase II was 37.8% of the total disturbance, and Phase III was 23.1% of total disturbance (OSMRE 2023). In Queensland, only a small proportion (approximately 2% of the total disturbance as of 31 December 2023) for all mines (i.e. coal and minerals) has been certified as complete. The process of certification is not mandatory and is industry-driven and may underestimate the actual area of land that could potentially meet this standard. Guidelines describing the certification process were released in 2023 which are intended to provide greater clarity around the requirements for certification. This may see an increase in the proportion of certified land in future.



**Figure 1 Rate of rehabilitation (percent of disturbed to completed rehabilitation) for coal mines in Queensland and Wyoming**

## 4 Conclusion

Both jurisdictions have strong laws in place to manage financial risk to the state for financial assurance and require bonds to cover rehabilitation should a mining company become bankrupt or go into liquidation and be unable to complete rehabilitation. Although the rules used in both jurisdictions differ, they effectively perform the same function, that is, they are intended to limit liability to the state. Both jurisdictions also have strong laws requiring progressive rehabilitation according to a planned schedule.

Cumulative rates of rehabilitation to disturbance reported in Queensland of 24% are substantially lower compared with the 53% of land rehabilitated reported in Wyoming. There are many factors that could influence this trend in both areas. One factor may be the lag time between introducing new laws in

Queensland and seeing outcomes on the ground. A driver for rehabilitation may be that Wyoming has clear rules for bond release criteria at each of the three stages of rehabilitation. Although undertaking progressive rehabilitation in Queensland will reduce the annual contribution an operator would make to the pooled fund, this differs from a direct release of bonds held.

The long-standing requirements in the USA to return mining areas to their 'approximate original contour' means that coal mine voids are routinely backfilled in Wyoming, apart from some technical exceptions and where wetlands or waterbodies present prior to mining are re-established. This is in stark contrast to Queensland where many residual voids from open cut coal mines will remain and these are likely to fill with groundwater once mining is complete. Although many would be expected to act as 'sinks' that are unlikely to release to surface or groundwater systems, they may not have an ongoing use. This is expected to remain largely unchanged given rehabilitation laws introduced in 2018, in Queensland, are not retrospective and many residual coal mine voids were authorised in historic approvals. New approvals would require a public interest evaluation where a final void is proposed, meaning that they would only be approved in those instances where such an outcome was regarded to be in the public interest.

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