Potential Environmental and Socio-Economic Impacts from Neglected Mining Occurrences in South Australia

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ABSTRACT: South Australia, alongside the rest of Australia has a recognised mining industry, which is still responsible for the establishment and growth of new communities. Mines provide a strong economy for the country and their surrounding communities. This economic benefit however comes at an environmental cost as soils, biodiversity and water bodies are all adversely effected by the pollutants emitted by mining activities. These impacts are more prevalent when responsible mine closure does not take place and can occur alongside economic and public health issues. This report compiles various government resources to generate a consistent mine database for South Australia. A spatial analysis was undertaken to identify the locations of mines in relation to potential sensitive receptors. Understanding the relationship between mining activities, both neglected and active, and their surroundings is important for the establishment of consistent and effective mining regulations. This report showed that the spatial analysis of mining activities can be useful in identifying areas that may have been, or will be, impacted by mines as well as which areas may need further investigation.

1 INTRODUCTION

Australia, alongside other nations in the world, is tasked with combating the growing threat of climate change, this means that taking care of the environment is more important than ever. Mining has had been a major contributor to the Australian economy since settlement and has provided many jobs and been of great economic benefit to the country, however there are many adverse environmental and socio-economic impacts that are associated with the construction, operation and closure of mines.

Mining occurrences have an impact on the environment, no matter how small or large the activity. The drastic changes to topography, soil and water that occur and are difficult to correct and can cause irreversible damages when not rehabilitated properly. Environmental deterioration is unavoidable during the lifecycle of a mine and each stage of the mining process has potentially harmful impacts to the environment, society and health and safety of the community, however inappropriate rehabilitation methods exacerbate this. The environmental impacts of mining occurrences include land degradation, water quality, pollution, harm to livestock and wildlife biodiversity. The socio-economic factors include economic burden to public and private entities, and numerous health impacts on the surrounding community. All of these impacts are more of an issue when a mine is neglected. Neglected mines are defined as ceased mining occurrences that have no owner and will be the focus of this study. Neglected mines can also be called ‘abandoned’ ‘derelict’ or orphaned.

Nowadays the damages done by the mining industry are well known, and progressive rehabilitation is often undertaken. This aims to make mines “safe, stable non-polluting and self-sustainable to an agreed post-mining land use” (Lechner, et al., 2016). South Australia is now making efforts to rehabilitate its mine, such as the Leigh Creek coal mine with closed in 2015, however, prior to 1971 South Australia did not have legislation to regulate how a mine should be dealt with after its closure. As a result, Australia is littered with neglected mine sites whose impacts are not monitored and unknown at this stage, and there is currently no system in place to deal with these neglected mining occurrences. As a first world country with a strong mining history Australia should set a precedent on how to deal with these mines. Tasmania, unlike South Australia, is one Australian state who has begun to do this and has done so by setting up a mine Rehabilitation Trust Fund (Mineral Resources Tasmania, n.d.). This is a programme dedicated to the rehabilitation of abandoned mines in Tasmania.

This report aims to compile a comprehensive database of all mining occurrences within South Australia and define their statuses consistently. The spatial analysis undertaken aims to identify a number of the sensitive receptors in proximity to the mining occurrences which may be more susceptible to the impacts of mine activity. Although there are numerous studies investigating all impacts of mines as well as neglected mines, none have related these impacts to mining sites within South Australia.

2 METHOD

2.1 *Mine Database*

A database of all mining occurrences within South Australia was created for the purpose of this study. It included information such as the mine location, status, name and which commodities are present. The database was generated primarily using a databased already established by the South Australian government called SARIG (SARIG, 2018). However, to ensure accuracy, this database was cross-referenced with other sources such as the Australian Mine Atlas (Geoscience Australia, 2015). The SARIG database was however the most extensive and detailed, and as such provided the majority of the data.

Mineral deposits which were categorised as 'occurrences' by SARIG were not included in this study. This is because an occurrence is classed any locality where a useful mineral or earth material is found, whereas a 'deposit' is an occurrence of significant size that may have economic value (Davies, 2018). Due to these definitions provided by the South Australian government, 'occurrences' were not deemed to be impactful enough, both now and in the future, to include in this study.

A limitation of using this database is that once activity ceases, it is possible that the mine has been reclassed as a prospect or occurrence (Davies, 2018) and as a result some mines may have been categorised incorrectly, despite cross-checking the database.

2.2 *Mine Status and Definition*

This study has adopted the definition for mine statuses as established by the Canadian National Orphaned/Abandoned Mines Initiative (NOAMI). The South Australian definitions were converted to the NAOMI classifications based on both organisations' definitions. This was done in an attempt to achieve consistency amongst databases which have been, or are currently being, created for other Australian states, as the NOAMI statuses are well established and have clear definitions. NOAMI defines a 'neglected' mine as an "orphaned or abandoned mine for which the owner cannot be found or for which the owner is financially unable or unwilling to carry out clean-up" (NOAMI, 2004).

South Australia's statuses are listed as: abandoned, active, care/maintenance, ceased, not worked, recreation, rehabilitation, seasonal and unknown (SARIG, 2018). Based on both the NOAMI and South Australian descriptions of the different status, mining activities were recategorized. Those mines under the South Australian statuses 'abandoned' and 'ceased' were classed as abandoned under the NOAMI status. Although the mines that South Australia has classed as rehabilitated may not be rehabilitated to the most recent requirements, the fact that the state classified them as rehabilitated was deemed suitable for the scope of this study, and as such these mines were categorised as 'terminated' under NOAMI definitions.

2.3 *Spatial Analysis*

A spatial analysis was undertaken in order to visualise the relationship between the mine sites as per the database, and sensitive receptors. Due to the small number of mines in South Australia compared to other states, the analysis was done for all mines, not just abandoned ones. This analysis was undertaken using GIS software.

The data used to undertake this analysis was sourced from the South Australian Government Data Directory (Government of South Australia, 2018). The joins and relates between data were conducted through the "join and relate" function in ArcMap, and the distances analysed using "buffer" and "intersect". Figure 1 shows the location of all 487 mine sites in South Australia, which have been classes as: abandoned (54), active (22), terminated (15), and mineral sites (396).

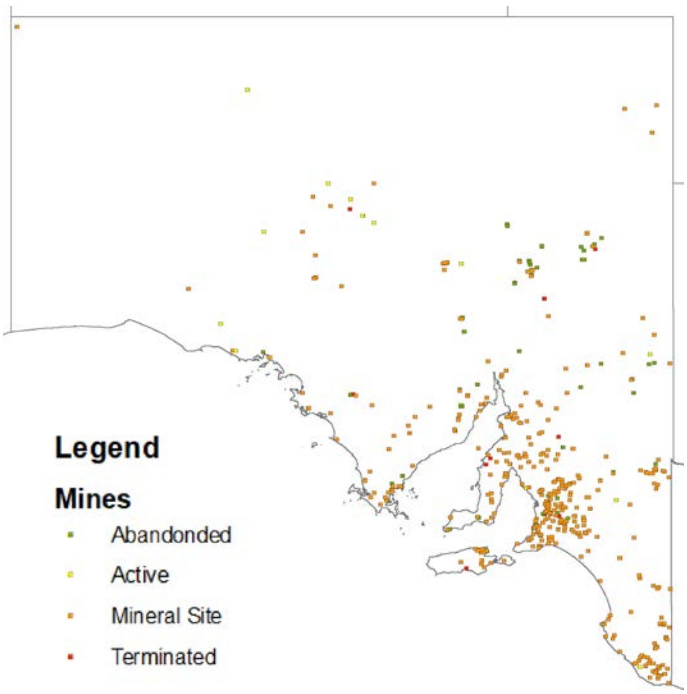

Figure 1: Location of Mines in South Australia

3 RESULTS AND DISCUSSION

3.1 *Environmental Factors*

Acid Sulphate Soils are naturally occurring soils and sediments which undergo an oxidation reaction when exposed to air, producing sulphuric acid (Department of Environment Regulation, 2015). The acidic water that is produced through this process is known as Acid Mine Drainage (AMD) and it has a number of significant environmental impacts. As any sulphate containing mineral is a potential source of AMD, it is a common issue associated with mining activities. This process may occur naturally, however mining activity greatly increases the rate of sulphuric acid production (Waters & Webster-Brown, 2013).

AMD has the ability to impact the chemistry, physiology, biology and ecology of the terrestrial and aquatic systems it comes into contact with. Gray (1997) categorised the pollutant effects of AMD as metal toxicity, acidity and salinization. These factors contaminate groundwater and waterways, as well as soil and vegetation (Department of Environment Regulation, 2015). Protocols must be established to achieve effectives strategies for the management of AMD discharges as its environmental impacts can be dramatic, and corrective measures must be undertaken for those mines which have not been rehabilitated correctly.

In addition to AMD, there are a number of other environmental factors which must be considered when analysing active and abandoned mine sites, this includes their impacts on conservation areas and vegetation.

3.1.1 *Soils and Biodiversity.*

Soil is impacted by mining activities in a number of ways, including subsidence and land clearing. It is also subjected to many pollutants entering it due to AMD. When these issues are left unaddressed during a mine's lifetime and closure, the effects on the surrounding soils can last decades.

For the spatial analysis of soil quality and chemistry, South Australia had limited data, restricted to the southern border of the state ranging from east to west. As such, this analysis will be limited to a smaller range than the rest of the report analysis. There were a total of 376 mines within this area, thus this area represents the majority of the mine sites in the state (77.21%). Figure 2 shows exactly which area (in red) of South Australia is being depicted in figures 3-5. This was done in order to identify the different soil information clearly as the different soils areas are small and difficult to see. These figures show the soil ratings and the mines present in the greater Adelaide area, depicted in figure 2.

ADM causes an increase in heavy metal pollution, one of these metals is aluminium. Although aluminium is the most common element in the Earth's crust and is safe when bounded in rocks, it can become dangerous when released. Figure 3 shows the aluminium

Figure 2: Location of Soil Analysis Area (in red)

toxicity levels of the soils within the greater Adelaide area, and which mines sit on this land. 36 (9.57%) mines were located on top of soil which was classed as having high toxicity.

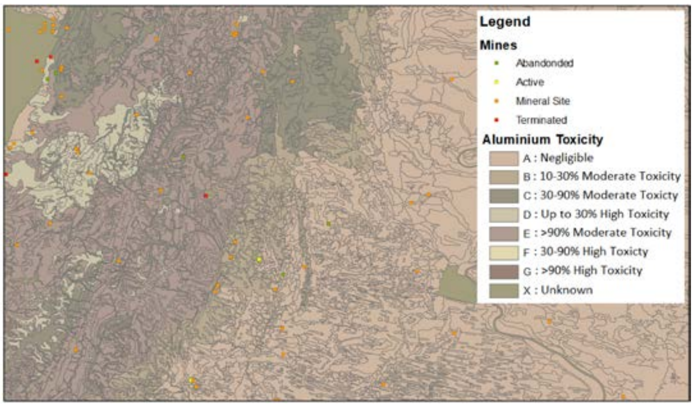

Figure 3: Aluminium Toxicity Levels of Soils and Mines in the Greater Adelaide Area

Increased aluminium levels in soil have the ability to severely alter an ecosystem. Aluminium is a growth limiting factor and as such, in soils it causes plant growth to decline by damaging their root systems. For a number of decades its presence has been partially to blame for the declining forests in Europe. Aluminium is also toxic to many fungi (Rosseland, et al., 1990), disrupting ecological symbiosis. It has the potential to accumulate in plants, allowing it to enter terrestrial food webs and cause further damage. It effects enzyme systems in vertebrates and leads to a reduction in species diversity. Aluminium toxicity can affect both natural ecosystems as well as crops, meaning it also has an impact on the economy. Aluminium toxicity is dependent on soil acidity and as such correction of pH levels will generally alleviate the symptoms of aluminium (Department of Envrionment and

Water, 2017), however these areas must first be identified.

Excessive salt levels are also associated with AMD and they have been found to be a significant problem in South Australia (Department of Agriculture and Water Resources, 2016) as salt can impact ecosystem health and reduce agricultural productivity. The varying salinity levels in soils in the greater Adelaide area are depicted in figure 4. 7 mines (1.86%) sit on soil which have a salinity level of moderately high or above.

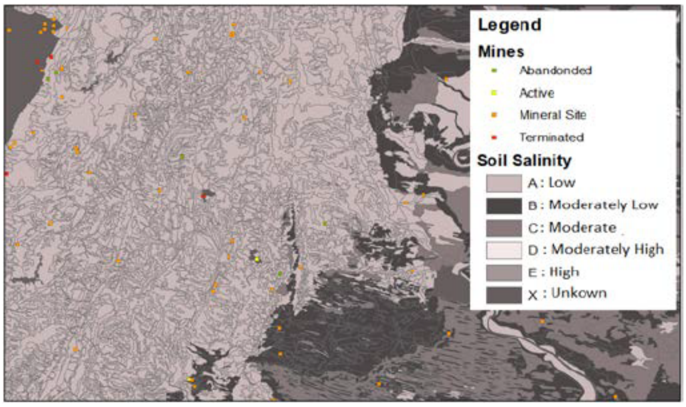

Figure 4: Salinity Levels in Soil, and Mines in the Greater Adelaide Area

Much like high levels of aluminium, high concentrations of salt can lead to a decline in biodiversity in the area. The impacts range from small, such as a reduction in plant vigour, to large, such as the development of bare patches earth known as 'salt scalds' (Office of Environment and Heritage, 2018). These areas make it easier for erosion to spread and for salt to enter fresh waterbodies. Excessive salt levels can also cause a reduction in native vegetation by allowing more salt resistance species to grow.

Due to the small number of mines in areas of high salinity, excessive salt levels do not appear to be of great concern to South Australia, however it is something to be aware of and may be an issue in other states as salinization levels are affected by soil type and climate. High salinity levels also have some economic impact, like high toxicity levels.

Another aspect of AMD is its effect on acidity levels in soils. These levels are dependent on land use and management practices as well as climate. Figure 5 shows the future potential acidification levels of soils in the greater Adelaide area, mapped alongside mine sites. 102 (27.13%) mining occurrences sit on soils which have an acidification potential of greater than 30%, 5 of these mines are abandoned.

Soil acidity is an environmental as well as an economic concern of the state, as it has already posed a major problem for large areas in New South Wales and Western Australia. The longer it is left untreated, the more difficult and expensive it becomes to repair. High acidity levels affect vegetation growth, leading to decrease plant growth (Gazey, 2018).

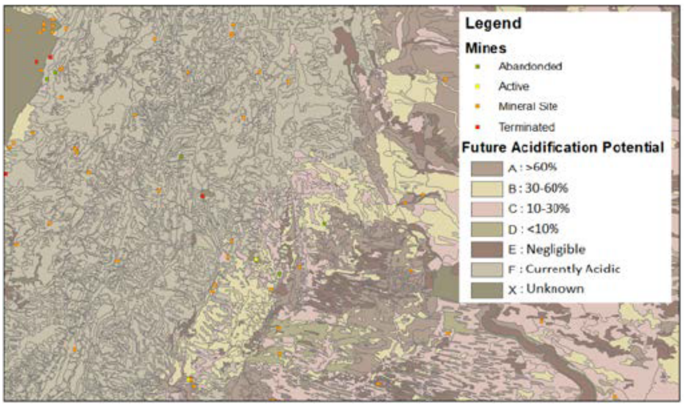

Figure 5: Future Acidification Potential of Soil, and Mines in the Greater Adelaide Area

3.1.2 *Water and Biodiversity*

Water is severely impacted by both active mining and ceased mining occurrences. Pollutants can seep through the soil and into the groundwater, affecting the water quality, and are also able to make their way into fresh waterbodies, compromising their value. These impacts can affect human health and infrastructure as well as water and wildlife. All South Australia's waterbodies which are within 5km of a mining occurrence are shown in figure 6. 94.36% (461) of mines lie within 5km of a waterbody, 49 of these are classed as abandoned.

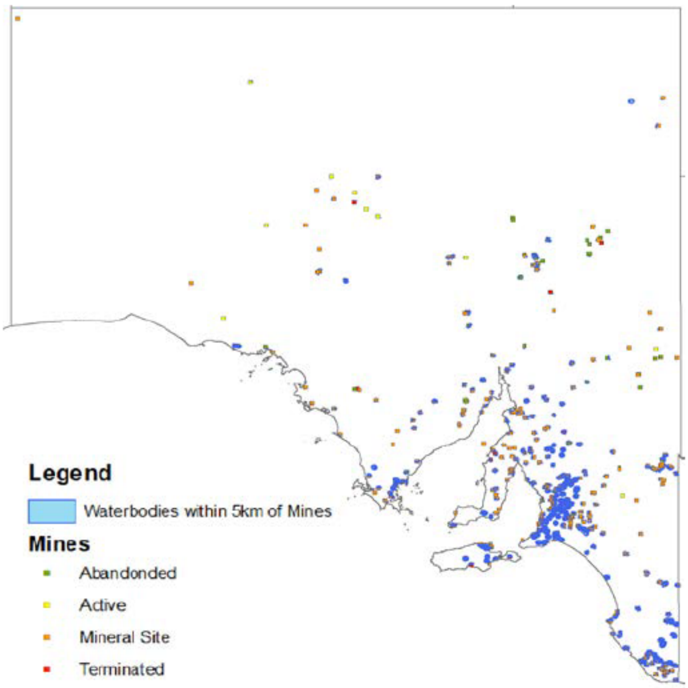

Figure 6: South Australian Mining Occurrences, and Waterbodies located within 5km of a Mine

AMD has the ability to introduce salinity and acidity, and dissolve metals into lakes, rivers and estuaries (Fraser Institute, 2012), much like it does for soils. It can have dramatic effects on the ecology of receiving waters. Vegetation clearance allows water to travel more freely, allowing it to enter groundwater and waterways more easily.

Excessive aluminium levels have vast impacts on aquatic environments and have been long been recognised as a toxic agent to freshwater organisms (Rosseland, et al., 1990). The metal affects both animals with gills, like fish, affecting their ability to absorb oxygen, as well as invertebrates, where aluminium can accumulate. This can have wider implications as it allows the toxin to move further up the food chain and impact larger animals such as mammals and birds. A study of the low volume streams of the Stockton Plateau in New Zealand found high aluminium levels had led to severely reduced taxa richness and abundance (Pope, et al., 2010) and that fish crayfish and eels were virtually absent.

Increased salinity levels in waterbodies are also attributed to AMD, resulting in contamination of these waterbodies. The effects of high salt levels are not well known, but Nielsen et al. (2003) found that some impacts may not be evident for a number of generations, and rising salt levels can often exceed the tolerance of sensitive biota such as algae and aquatic plants. Currently the rate of change of salinity levels is faster than these species can adapt to. Increased salinity also means that there are economic factors to consider in relation to mine closures.

The increased acidity levels in water caused by AMD have the potential to poison plants in and around the effected waterbodies. It can also kill fish and other aquatic creatures; it makes them weaker and more vulnerable to diseases, making it difficult for them to reach adulthood. This can lead to changes in the ecosystem over time as acid-tolerate species replace the more sensitive ones. Mosquitoes are an example of these more tolerant species, meaning acidified wetlands can become sources of mosquito plagues (The State of Queensland, 2018).

AMD affects different ecosystems in different ways and is difficult to quantify and predict due to its complexity, thus further analysis needs to be undertaken for each site. It also needs to be considered during rehabilitation as it can have adverse effects on water sources which people drink and eat from, thus their safety must be considered. Due to the high volume of waterbodies in proximity to abandoned mines, any potential changes in the environment should be closely monitored.

3.1.3 *Conservation Areas and Land Clearing*

Mining and abandoned mines can impact flora and fauna whose protection is particularly important in conservation areas. The land clearing associated with mining is a further environmental impact, particularly for open-cut mines and quarries, due to their large sizes. The removal of vegetation due to mining activities disrupts ecosystems and leads to an increase in dust pollution, impacting community health.

Removing vegetation from its natural habitat disrupts the ecosystem. Separating habitats can impede the transportation of plant spores and disrupt the breeding patterns of local wildlife. These damages are especially pertinent in Australia were the wildlife is so unique. The regeneration of flora and fauna at an abandoned mine site can take decades, and native flora grows less easily than introduced flora (Cristescu, et al., 2012), as such, it requires special attention. Additionally, vegetations important for human health as it minimises dust pollution.

Figure 7 shows the mines located inside, and within a 2km radius of South Australia's conservation areas, as noted by the state government. This includes both state, and federal areas of conservation and heritage. There are 100 mines (20.53%) which lie within 2km of state and federal protected areas. The conservation areas displayed in figure 7 include all national and state declared conservation areas. This includes parks and EPBC declared zones of protection like Ramsar Wetlands.

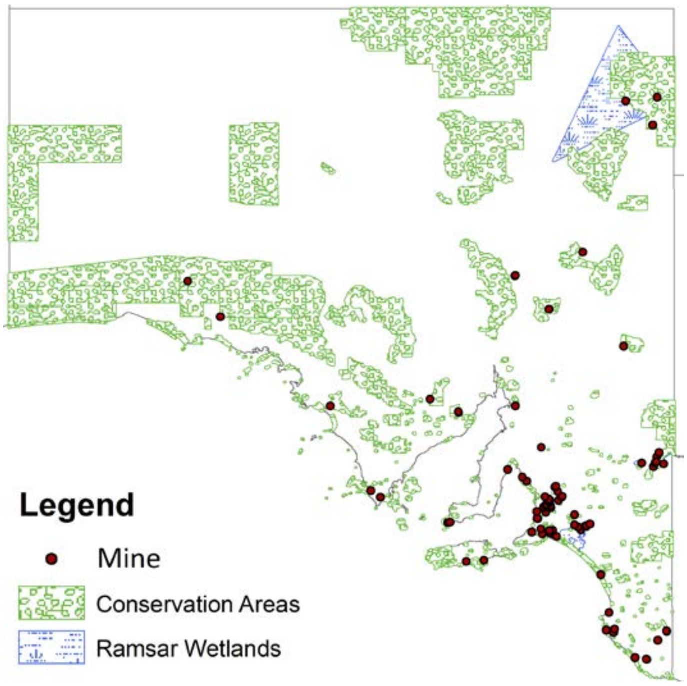

Figure 7: Location of Mines located in Conservation Areas and Ramsar Wetlands

These wetlands are part of the Ramsar Convention, an intergovernmental treaty with over 160 countries which provides a framework for the protection of wetlands and their resources. Wetlands are amongst the world's most productive ecosystems and must be protected. Noting which mines are in close proximity to these conservation areas is important for the conservation of Australia's wildlife and managing any adverse effects.

3.2 *Socio-Economic Factors*

3.2.1 *Acid Mine Drainage*

AMD has economic impacts as well as environmental ones, thus managing AMD discharge from mines and abandoned mines is financially beneficial in the long run. As higher aluminium concentrations effect plant growth, crop production can be adversely affected, impacting agricultural profitability.

Increased salinity levels similarly have wide economic impacts as they have the ability to impact infrastructure such as bridges and roads. Salinity increases the hardness of waters and if this enters a public water supply, it can damage hot water systems and other household appliances, meaning expensive treatment to the supply is required to ensure it is suitable for public use (Office of Environment and Heritage, 2018). Increased salt levels are also expensive for agricultural production. Sensitive crops are affected by saline water levels. Not only does the salt impact crop growth, it also affects the machinery and fences associated with this production.

High acidity levels have extensive impacts on infrastructure, it corrodes concrete and steel and slowly compromises the integrity of pipes, roads, bridges and building foundations. Repairing and replacing these comes at an immense cost to the state and entities who own them, as they may be required to be restored before the end of their planned lifespans (The State of Queensland, 2018). Acidity also greatly impacts agricultural productivity. Currently approximately 50% of Australia's agricultural land has a less than optimal acidity level for crop production (Gazey, 2018). This has led to significant production losses, and restrictions in crop varieties, reducing market opportunities and therefore the economy.

Impacts of AMD must be monitored to ensure abandoned mines and other mining activities do to not further impact the state's agricultural industry and compromise its infrastructure and water supply.

3.2.2 *Subsidence*

Mine subsidence is the movement of ground surface as a result of mine activity, due to movement of soil. These subsidence occurrences usually take the form of troughs or sinkholes and these can cause significant impact on different surface features, which impact both the environment and the economy.

Many factors influence the likelihood of subsidence, these include the mine type, size and ground geology. Mitigating the risk of subsidence is important for the rehabilitation of mines because it impacts the future regrowth of vegetation and biodiversity. Mine subsidence can also impact current infrastructure, and even shallow, neglected subsidence can have a significant impact on transport infrastructure (Helm, et al., 2013).

Figure 8 shows that many of the state's mines are in close proximity to a road and the study has assumed this increases the likelihood of subsidence. This poses an economic burden on the organisations who own the roads and figure 8 indicates how many roads may be at risk. Subsidence also has an impact on all underground infrastructure, including water and gas pipework and as such subsidence must be mitigated in order to avoid exorbitant costs.

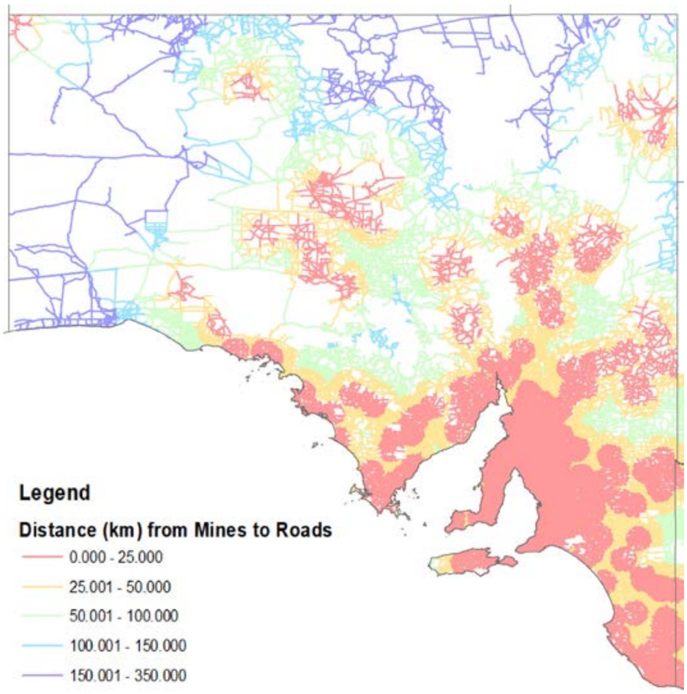

Figure 8: Distance in kilometres between Mines and the Closest Road

3.2.3 *Public Health*

Mining creates communities; townships are established and centred around mining as the predominant economic source. These communities are however at a greater risk of the health issues associated with mining due to their proximity. If mines are not rehabilitated properly the impacts on surrounding the communities can continue to be harmful after closure.

As no data was found for townships within the state, hospitals were used as an indicator for a large community presence, as such this analysis provides only a small insight to how many communities may be affected by mining occurrences. Spatial data for private and public hospitals was obtained from the

South Australia database, and a spatial analysis was done to identify close mines. Figure 9 shows the locations of all hospitals in the state, and the mines which lie within a 5km radius of these. A total of 81 mines were identified (16.63%) and 6 of these are abandoned.

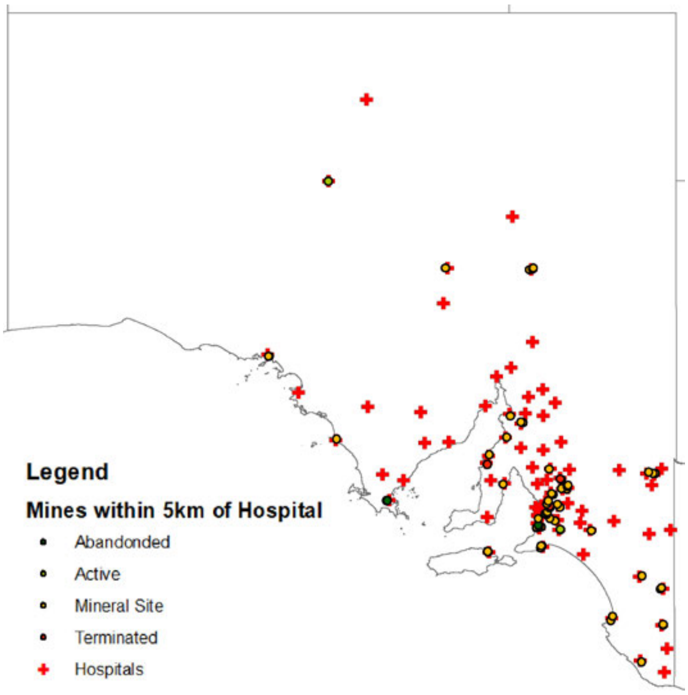

Figure 9: Location of Mines within 5km of a Hospital

Mines pose a risk to public health due to the pollution from both chemicals and particulates that occur. Explosives used to expose minerals create large amounts of dust, as does the lack of vegetation in the area. Additionally, wind can disperse the particles from waste piles and spread dust to local communities. This can cause eye irritation and the inhalation of these particles can affect the respiratory health of the people in surrounding communities; it can lead to respiratory diseases and cancers (Coelho, et al., 2007). Additionally, dust particles have the potential to contaminant food which may be consumed. Following the closure of a mine, these are health risks which may continue, especially if rehabilitation steps have not been undertaken.

AMD pollutes water, and this causes further physical health issues. Water supplies with high salinity levels can be harmful for human consumption. The town of Dubbo in New South Wales is surrounded by a number of mines, and sits on the Macquarie River, whose water currently exceeds World Health Organisation guidelines for acceptable drinking water 6% of the time which is expected to increase to over 80% of the time (Office of Environment and Heritage, 2018). AMD can also cause water to be acidic, such water is unacceptable for human consumption and can lead to stunted growth and mental impairment (The State of Queensland, 2018). Additionally, contact with acidic soils can cause skin irritation.

Ensuring the appropriate closure of mines is important for the physical health of the surrounding communities. Studies have found that preventative measures make a difference to the physical health of the community, however it does not eliminate the issue completely (Coelho, et al., 2007). As such, more investigations need to be done into neglected mines and their surrounding communities in the South Australian state.

3.2.4 *Population*

South Australia's strong mining history has led to the creation of numerous prosperous town, and with them, a growing population. The number of people employed by the mining industry has consistently increased since the 1980s and with this comes the establishment of new towns.

The rural mining town of Roxby Downs in South Australia had an average annual increase on 4.1% between 2006 and 2011. These towns are more prone to the negative effects associated with mining, as well as neglected mines due to their proximity to the mines. Areas with high densities of neglected mines to population were located using an intersect of the mine database and the population per local government area.

A map of all local government areas (LGA) is provided in figure 10. The figure indicates of how many mines are present in each LGA per 1000 people. Areas of with high densities of mine sites to population were identified.

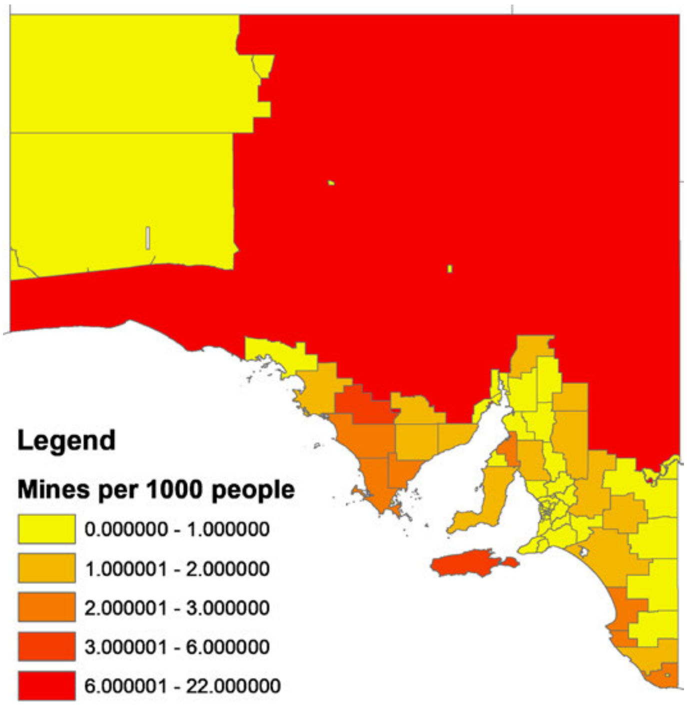

Figure 10: Number of Mines Located within each Local Government Area (per 1000 people)

The communities surrounding these dense mining occurrences are much more susceptible to all the negative impacts associated with mine activities.

4 CONCLUSION

This report successfully categorised the mining occurrences in South Australia and identified their locations in relation to sensitive receptors. The spatial analysis undertaken helped to identify which areas may be more susceptible to the impacts of active and neglected mining occurrences. Impacts from neglected mines can last decades after the closure of a mine, and affect not only the natural environment around it, but also the health of the community and the economy. This report focused on potential effects on soil chemistry, water and the physical and economic wellbeing of communities. These impacts highlight why responsible mine closure is so important. Understanding which kinds of areas are currently affected, or are likely to be affected, is important for establishing effective mine rehabilitation protocols for operating and abandoned mines. More investigation is required for the state of South Australia, and careful monitoring of these sensitive receptors would be beneficial in order to accurately identify any changes which occur.

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ABSTRACT: Despite the positive impacts of mining, the environment and social-economic impacts are detrimental and become increasingly difficult to remediate if appropriate rehabilitation action is not undertaken. This report collates Government resources to generate a mine database for the Northern Territory, and assign these occurrences into a hierarchy. Through the use of spatial GIS software, the correlation between neglected mines and sensitive receptors such as roads, public infrastructure, heritage areas and water streams is explored to highlight the various environmental and social-economic impacts. The results showed that spatial mapping of neglected mines within the Northern Territory is useful for identifying areas that should be prioritised for further research due to their potential environmental and social-economic impacts.

1 INTRODUCTION

Mining in Australia began well before the country was colonised; however, not for the production of fuel and precious goods as it is commonly used for today. Minerals were mined by the indigenous community to produce rock art of various colours, which can still be found around Australia today, around 50,000 years later (NSW Department of Primary Industries (2007).

Australia's mineral industry is the largest contributor to its export trade (Geoscience Australia, 2015) During the gold rush, colonies emigrated to Australia, thus growing the population and development of the country; however, this large increase in economic growth had extremely adverse effects to the environmental and social-economic state of the Northern Territory (NT). The lack of documentation through a mine's operation, and subsequently the framework for rehabilitation, means that there is no accurate source quantifying the impacts that the abandoned mines have in the Northern Territory.

The vital task of caring for the environment is becoming more substantial due to the threat of climate change. The Northern Territory is now aiming to reduce the impact of mining through the adoption of the Mining Management Act 2001 (Mining Management Act, 2001). In 2014 the Legacy Mines Program was established with the aim to identify, assess, investigate and manage any environmental impacts caused from these neglected mines (NTGR, 2019, Submission 53 – Senate Enquiry).

In February 2017 the senate referred an inquiry into the 'rehabilitation of mining and resources projects as it relates to commonwealth responsibilities' (Environment and Communications References Committee, 2019). From just under one hundred submissions to the inquiry, only three reported on the Northern Territory. One submission from the NT Government Resources site highlights the importance of creating a nationwide 'Abandoned Mines Rehabilitation Program,' and recognises programs around the world with effective policies and practises (NTGR, 2019, Submission 53 – Senate Enquiry), all which have been explored within this report. The final report published by the senate in March 2019 listed zero abandoned mines recorded for the NT due to incomplete datasets (Environment and Communications References Committee, 2019). Five reports were submitted to the senate from Monash University. The data collated from each of these reports, including this report, will provide a comprehensive national database on derelict, abandoned and operating mines in Australia (Miller, 2017).

This report intends to create a combined mine and quarry database for Northern Territory mineral occurrences. This database will identify abandoned mines that can then be used to complete a nationwide database. This report explores the risks of acid mine drainage, biodiversity and land clearing, as well as the impacts of mining on public infrastructure, conservation areas and ways to rectify the neglected mines issue. The undertaken spatial analysis will aid in identifying areas that may have potential environmental and social-economic impacts from neglected mines and quarries. This has been achieved through the use of Geographic Information System (GIS) software.

2 METHOD

2.1 *Northern Territory mining occurrence database*

2.1.1 *Mining occurrence database resources*

The Northern Territory mine and quarry database was created using publicly available datasets from Northern Territory Government Resources (NTGR) (Department of Primary Industry and Resources, 2019) and Geoscience Australia (Geoscience Australia, 2019). The NTGR data included more detailed and accurate information such as the mine location, status, name, commodities present and size, therefore this was the primary data source used.

Minerals classified as 'occurrences' were not included in this study as an occurrence may consist of 'historical shafts; earlier mine entrances; related prospects; different zones of mineralisation,' (Geoscience Australia, 2015). Mineral occurrences were therefore not deemed large enough to cause significant environmental and social-economic impacts. All mine and quarry sites were mapped as point sources and correlated to ensure no duplicates of sites had been created.

The dataset from Geoscience Australia is currently undergoing reclassification with the abandoned mine category being separated into 'Ceased,' 'Historical Workings' and 'Abandoned.' The mines currently listed under these categories were not included in the neglected mine database. This database should be updated in October 2019, which is when NTGR are to complete their reclassification of mining sites.

2.1.2 *Mining occurrence database anomaly*

It is important to note that the resources for mining datasets in the Northern Territory are significantly less than in other states throughout Australia. There is no database of the location, mine type, commodity, commodity size or mine footprint for legacy mine sites (Mining Legacies, 2019). There are also many mineral occurrences with undefined status and unknown commodities, which therefore could not be used in this analysis and have been classified as undefined. There was no data for the location of schools or hospitals in the Northern Territory, further emphasing the anomaly within the resourcing sites.

This lack of data poses possibly the greatest potential risk to environmental and social-economic factors in the NT. An abandoned mine left unidentified and unanalysed could potentially cause unfavourable impacts on the surrounding environment and communities. If not identified, these impacts may have a flow on effect for years to come if not rehabilitated appropriately.

It is therefore recommended that a thorough investigation and analysis is undertaken to locate all mines in the NT and create a comprehensive and accurate database.

2.1.3 *Mining occurrence database accuracy*

Due to poor record keeping, the exact number of mines and their status in the Northern Territory cannot be confirmed. Duplicate points in an area create increased density in mining areas, therefore most of the Geoscience Australia duplicates were eliminated as these had insufficient information. The NTGR data had very accurate information on the major and minor commodities of each site, therefore these were used to illustrate the main commodities found in neglected mines, as seen in Figure 1 (below). To ensure the accuracy of the database, the sites should be visited. By visiting the various sites, not only can the accuracy of the database be ensured, but the specific site risks can be evaluated. This could be performed by a mining rehabilitation program either through the NT or a nationwide program. Therefore, it is recommended that an abandoned mines rehabilitation program is established to investigate the risks and confirm the location and various data associated with the neglected mines.

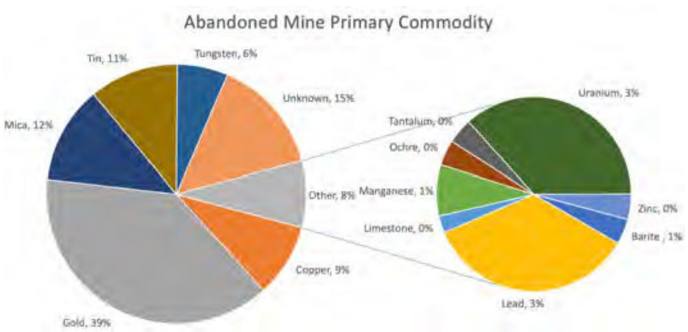

Figure 1. Abandoned Mine Major Commodities

Table 1. Datasets used to create spatial analysis

Dataset Name	Resource site	Data points or polygons used	Date last updated	Accuracy m
Mines and Mineral Occurrences	NTGR	1168	Currently updating	100-300
Roads and Water	Geoscience Australia	26579	1/3/19	Unknown
Schools*	-	199	1/4/19	0.1
Hospitals*	-	6	1/4/19	0.1
Acid Sulphate Soils	CSIRO	39066	25/6/11	Unknown
Sensitive Areas	Department of the Environment and Energy	551	16/1/18	Unknown

*Schools and Hospitals data created by the author for the purpose of this research project

2.2 *Mining occurrence status and definitions*

For consistency between submissions to the senate inquiry (Miller, 2017), the word 'neglected' in this report has been adapted from the Canadian National Orphaned/Abandoned Mines Initiative definitions (NAOMI, 2004), and defined as a "mine or quarry site that has not been terminated and has no obvious owner." The NAOMI hierarchy was adapted to include 'Care and Maintenance', 'Heritage', 'Ceased' and 'Undefined' sites. The undefined sites list all of the mining occurrences with insufficient data to classify their status. The Ceased and Heritage sites are those that are under reclassification from NTGR; however, it is known that they are inactive.

In total, 1705 mining occurrences were identified, with only 10 of those currently listed as active. 620 sites were unclassified and thus not included in this investigation. 1075 sites are currently listed as inactive, with majority of those identified as neglected mining sites. Legacy mines have been included in this hierarchy; however, there is currently no data for the NT. Table 2 describes the mine status definitions that were used to classify the mines into the NAOMI hierarchy, shown in Figure 2.

Table 2. Mining Status Definitions

Status	Definition
Active	A site on which mineral exploration, mining or processing is ongoing with the proper regulatory approvals in place.
Inactive	All mineral sites which are not considered active mineral sites
Heritage	Small old workings (pre-1950s) with insignificant production or with unknown production
Care and Maintenance	A closed mine site where there is potential to recommence operations at a later date
Neglected	An inactive site that has not been terminated and that has no obvious owner.
Terminated	A former active mineral site at which mineral exploration, mining or processing has concluded and all current appropriate regulatory obligations have been satisfied.
Ceased	Mining has ceased but regulatory obligations may or may not have been satisfied. Mainly used for post-1950s operations
Abandoned	A neglected mineral site that has not been terminated and that has no responsible owner.
Legacy	A neglected mineral site that has not been terminated and that has an owner.
Undefined	Mining occurrences with no status

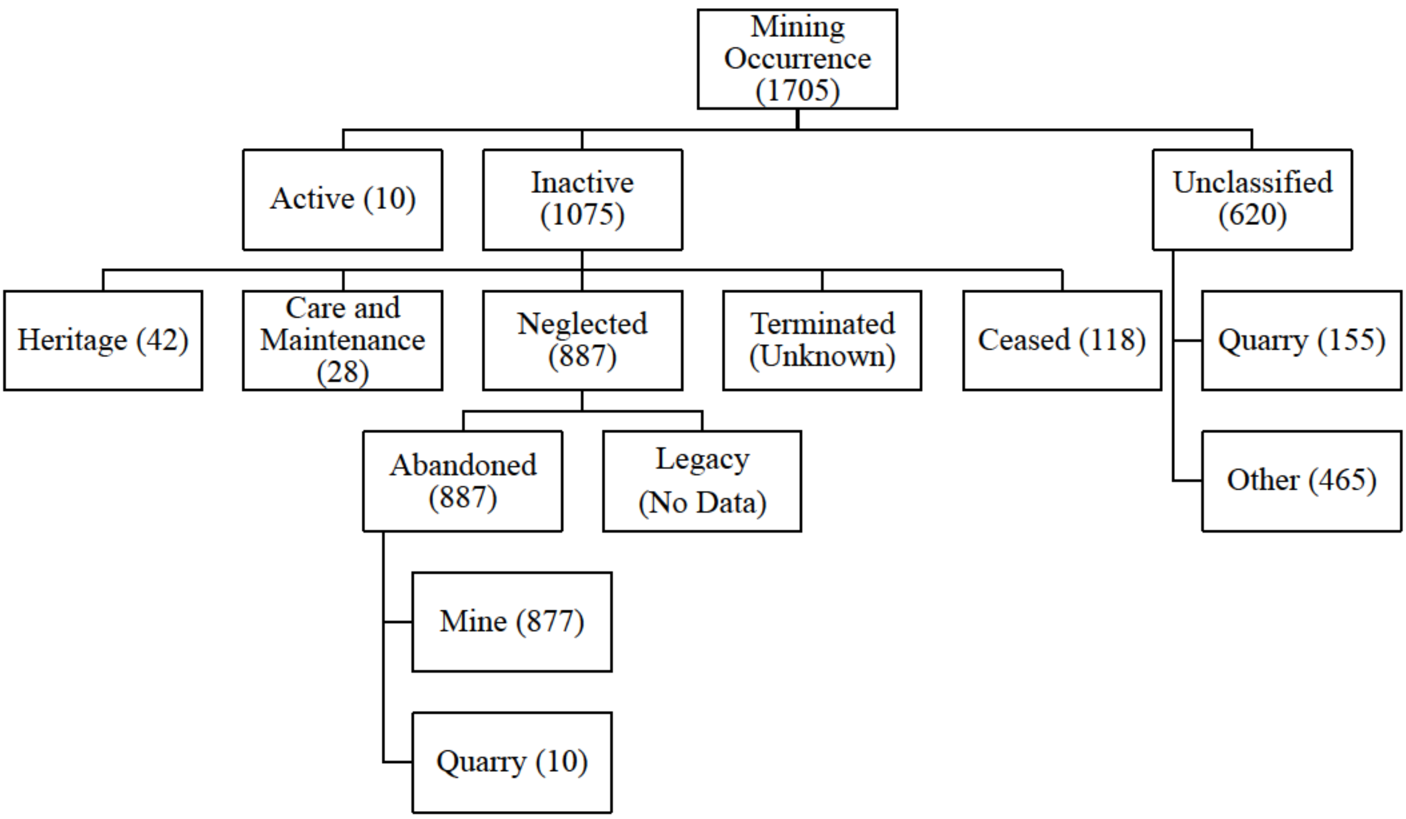

Figure 2. NOAMI Mining Hierarchy for Northern Territory

2.3 *Spatial Analysis*

Spatial analysis has been adopted to provide visualisation of relationships between sensitive receptors and neglected mine sites. This analysis was undertaken using ArcMap GIS software. This method of analysis was deemed optimal by others such as Boggs et al (2000) who used GIS techniques to assess catchment wide mining related impacts on the Swift Creek Catchment in NT (Boggs et al., 2000).

The location of mines and their classification can be seen in Figure 3 (right). Acid Sulphate Soils (ASS) map was sourced from CSIRO (Fitzpatrick, Powell, Marvanek, 2011). Maps for topographic data such as roads and major water courses were sourced from Geoscience Australia (Geoscience Australia, 2019). Other maps were created from lists of hospitals or schools and their locations were searched on Google Earth for latitude and longitude coordinates, which could then be input into ArcMap.

The distances were calculated using either the ‘Near’ or ‘Join and Relate’ functions in ArcMap. These distances were then classified from low to high proximity creating distance heat maps. For the Acid Mine Drainage (AMD) and sensitive areas high risk locations, a model was created in ArcMap using the functions ‘Euclidean Distance’, ‘Reclass’ and ‘Weighted Overlay.’ To determine the percentage of mines within a certain distance of sensitive receptors, the ‘buffer’ and ‘intersect’ tools were utilised.

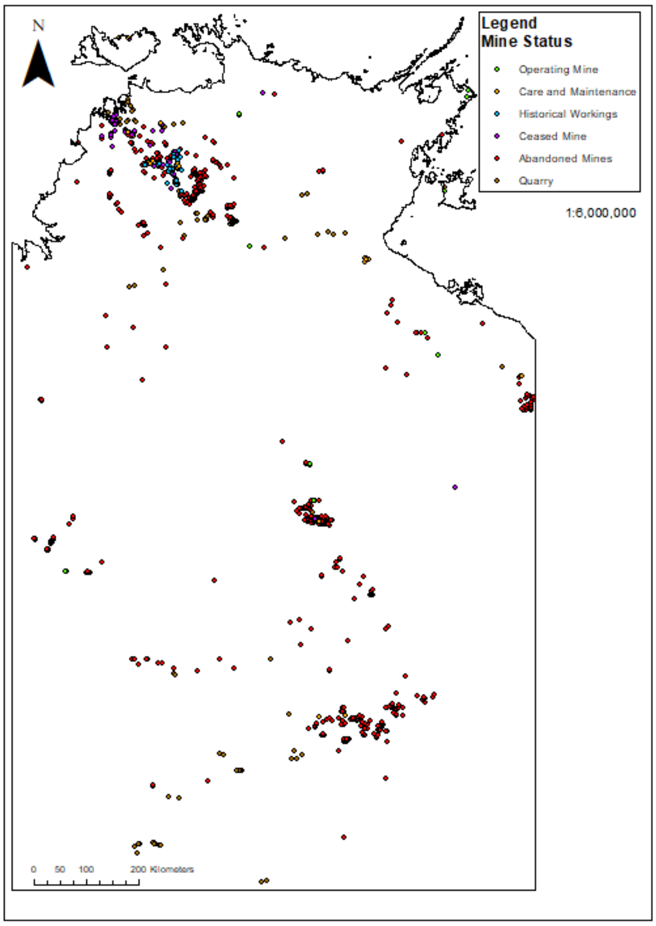

Figure 3. Location of Mines and their Classification

3 RESULTS & DISCUSSION

3.1 *Environment*

3.1.1 *Acid Sulphate Soils and Acid Mine Drainage*

From the NT Government (Hill, Edmeades, 2008), the Darwin region has some of the most potentially toxic Acid Sulphate Soils (ASS) in Australia. ASS are naturally occurring sediments and soils containing iron sulphides. These soils oxidise when exposed and create sulphuric acid (Department of Environment and Natural Resources, 2019). Although the oxidisation of sulphides in rock is a natural process, mining operations accelerate the process by providing flow paths that increase the rate of release of the pollutants (Harries, 1997). The water created as a biproduct of this process is called Acid Mine Drainage (AMD).

Acid sulphate soils are usually categorised in different probability classes. Figure 4 (right) depicts class A areas which have a probability greater than 70% of being ASS (CSIRO, 2011). The areas highlighted in red are closer than 50km to a neglected mine, with 174 or 19.84% of neglected mines within 2km of ASS soils. This data was combined with major water course areas to portray high risk areas of AMD, which is presented in Figure 5 (next page). The red areas on this figure occupy a significant portion

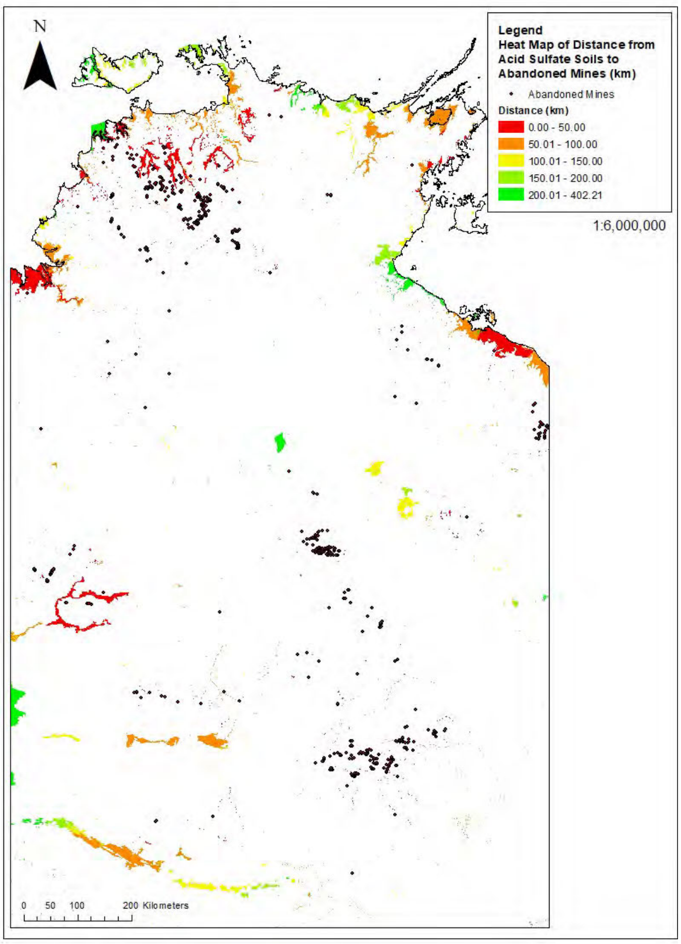

Figure 4.Class A Acid Sulphate Soils

of the Territory, thus emphasising the risk imposed from AMD in the NT. AMD has a detrimental environmental effect chemically, physically, biologically and ecologically. As there are adverse impacts on many factors, AMD has the potential to collapse a community almost immediately, unlike any other single pollutant (Gray, 1997). There is no management solution, but rather an indefinite management to decrease the risks of the contamination (Lechner, 2017).

ASS are commonly found along the coast and the leaching of sulphuric acid into waterways can cause the chemical impact to spread, rather than being a local issue. AMD is not just confined to areas where mines disturb ASS. It can also be caused from uplifting underlying rock that is rich in sulphides (harries, 1997). These contaminated stockpiles can also cause severe AMD impacts and if not recognised, can further spread the contaminants. AMD can cause long term and costly impacts on water quality and ecosytems where remediation is extremely problematic. Despite the natural drainage that occurs from ASS in some river systems where ecology has adapted to these conditions, mining activities accelerate the acid generation process which can thus cause varying impacts on the ecosystem. The human health is at risk as accumulation of these non-biodegradable, heavy metals in living organisms causes various diseases and disorders (Kumari, Udayabhanu and Prasad, 2010). Biologically, short term exposure can cause death, while long term exposure can lead to risks for future generations such as stunted growth, lower reproduction rates and deformities (Kumari, Udayabhanu and Prasad, 2010). AMD can also decrease the quality of soil which then has cascading ecological effects to food and water sources. As the acidity in the water increases, the oxygen levels decrease, thus causing a loss of life for the many water-based organisms. The heavy metals can also physically impact water streams through sedimentation. The sedimentation combined with the pollutants causes a decrease in light passing through water, as well as increasing stream velocity (Gray, 1997).

Figure 5 shows that Darwin; the capital of the NT, is a high-risk area for AMD due to the number of abandoned mines in the region, and its proximity to the ocean and major water courses. AMD pollution in NT would shut down the community of Darwin. This would be detrimental at a state and national level as NT is one of the leaders in international exports and heavily contributes to the Australia's economy.

In 1996, a policy to combat AMD was adopted via the Northern Territory Department of Mines and Energy (Harries, 1997). According to the published Government document 'Preventing Acid and Malliferous Drainage', AMD risks should be 'explored initially in the pre-feasibility stage, and operations should only proceed if AMD can be maintained and managed sufficiently' (Jones, 2016). For future mining practises, it is guaranteed that investigations into

Figure 5. High risk areas of AMD

the impacts of AMD will occur; however, there is nothing currently outlining that neglected mines dating back to the 1800s are undergoing any investigation into their environmental or social-economic impacts. This further highlights the importance of the senate inquiry as the research conducted can provide enough evidence to encourage Government Resources to explore the impacts of abandoned mines, not only in the NT, but throughout Australia.

The Rum Jungle mine in NT polluted the Finniss River due to acid rock drainage and underwent rehabilitation for three years at a cost of $18.6 million in the 1980s. This mine is still undergoing rehabilitation today with an additional cost of around $29 million being spent since 2009. The estimated cost to manage sulphidic mine wastes is $60 million per year for Australia (Harries, 1997). If AMD is not properly managed initially, it can lead to further increased costs in the future.

It is recommended that further analysis is undertaken to understand the direct impacts each abandoned site has. AMD is one of the most concerning environmental issues as it poses a risk to community health, biodiversity, agriculture, tourism and the economy. These effects will not only be felt immediately, but for decades and possibly centuries afterwards if mines are not properly rehabilitated.

3.1.2 *Conservation Areas and Land Clearing*

As of February 2019, the NT has developed Land Clearing Guidelines (Department of Environment and Natural Resources, 2019). This guideline states 'the clearing of native vegetation should not impact declared heritage places, archaeological sites or sacred sites; and these areas should be excluded from the proposed clearing footprint as applicable.' However, it is not prohibited completely. With 53% of the territory classified as conservation and natural environments (ABARES, 2019), the likelihood of land clearing within sensitive areas is relatively high.

Sensitive areas have been adopted as those that are Australian Aboriginal Freehold Lands as declared in the Aboriginal Land Rights Act 1976 (GlobalForestWatch, 2019), protected conservation areas and National Heritage Sites. 207 (23.60%) of neglected mines lie within 2km of sensitive areas. Figure 6 (right) highlights in red, high risk areas as they are within 2km of sensitive areas and abandoned mines.

Quarries and open pit mines have the greatest adverse impact on land clearing due to their size. The main impact of land clearing is that habitats are removed, therefore many native animals and plants are lost. Habitat loss can also lead to weed invasion and dust pollution which can be difficult to manage. Land clearing also increases erosion and sedimentation of waterways which results in decreased water quality. This disruption to the natural environment can also impact mating of animals; a great concern to native Australian animals. The rehabilitation program to grow flora and reintroduce fauna to the area can take many years; a costly maintenance procedure (Cristescu, Frère, Banks, (2012).

Ramsar wetlands are those that are representative, rare or unique wetlands, or are important for conserving biological diversity, and there are two in the NT; Cobourg Peninsula and Kakadu National Park (Department of the Environment and Energy, 2018). Kakadu National Park is World Heritage Listed, a Ramsar wetland, a National Heritage Site and Aboriginal Land, therefore protection of this site is essential.

There are 28 abandoned mines (3.19%) within 2km of this site. As seen in Figure 7 (right), the currently operational Ranger Mine lies within Kakadu National Park and is due to cease operations in 2021 (Australian Government Initiative, 2018), with rehabilitation to be completed be 2026 (Department of Industry, Innovation and Science, 2019). 79km^2 of the Mirrar indigenous people's land was cleared to establish this mine that was approved by the government. This mine has been operational since 1980 as is Australia's longest operational uranium mine (Department of Industry, Innovation and Science.
(2019). The heavy metals and radiation of this mine must be contained to avoid further adverse impacts on the surrounding environment, all of which is protected heritage land.

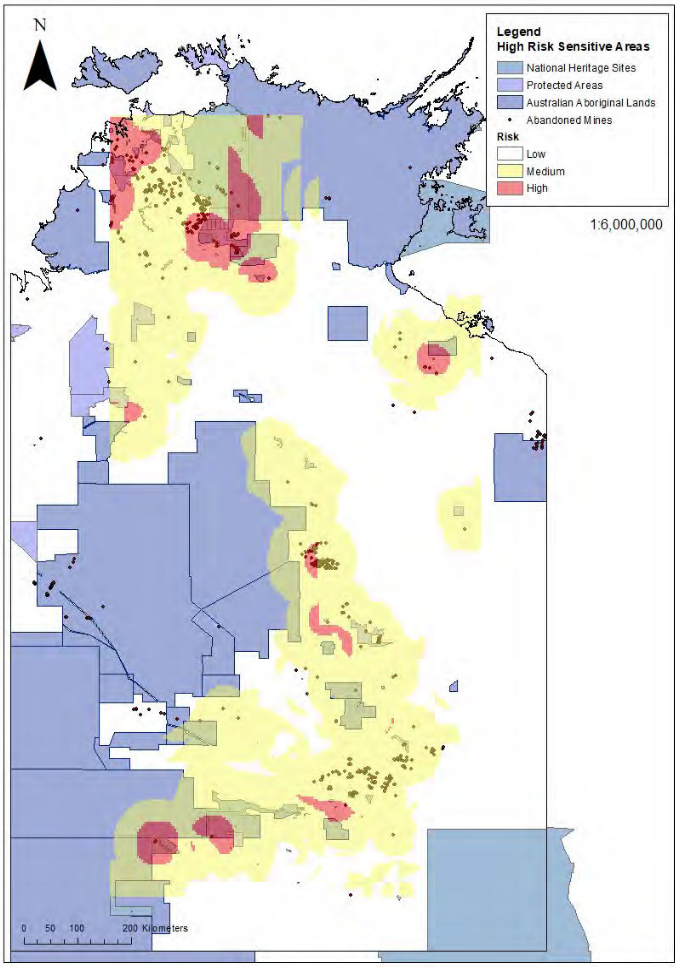

Figure 6.Sensitive areas at risk of land clearing impacts

Figure 7. Ranger Mine within Kakadu Nation Park (Environment Centre NT, 2019)

It is recommended that all the sites, but specifically the ones in close proximity to Ramsar wetlands undergo further investigation as wetlands contain the world's most productive ecosystems (Department of the Environment and Energy, 2012), and thus are vital to protect.

3.1.3 *Water and Biodiversity*

Mining activities both active and inactive can have adverse effects on local water ways. Water can become contaminated not only from acid mine drainage, but also from heavy metals and dust. If a water body becomes contaminated, this can lead to decreased health and safety conditions for flora, fauna, communities and public infrastructure.

Pollution of water systems can result in a decline of macroinvertebrate biodiversity and abundance (Sullivan et al, 2014). This is due to the contact with heavy metals in the water which prevents gills from operating correctly and thus causes fish to die due to decreased oxygen intake (Kumari, Udayabhanu and Prasad, 2010). The pollution of water also limits its usage for irrigation and agriculture which would be quite damaging in the NT, as 46% of the area is dedicated to agriculture (ABARES, 2019). The decrease in agricultural production would impact the economy, health of livestock and the livelihoods of farmers around Australia.

185 (21.09%) of neglected mines lie within 2km of a major water course in the NT. Figure 8 outlines the major water courses throughout NT with red areas being within 50km of abandoned mines. Further research should be undertaken at each site to investigate any further changes to the water quality.

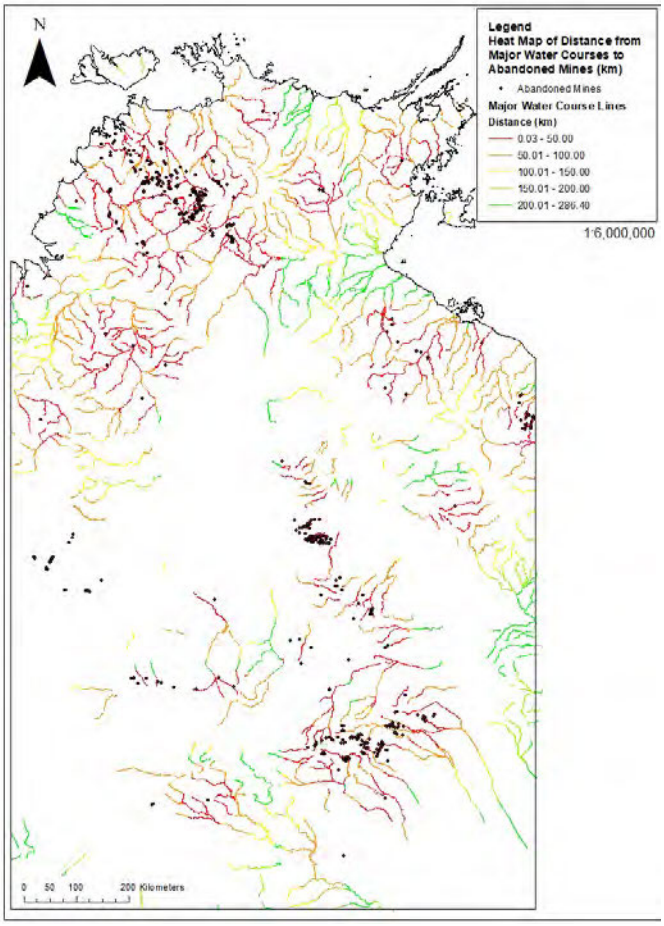

Figure 8. Heat map of major water courses

3.2 *Socio-economic*

3.2.1 *Subsidence*

Subsidence is the surface movement of the ground due to mining activities, which can have significant consequences (Galvin, 2016). The extent of mine subsidence depends on the mining method, local geology, depth of mining and amount of material extracted (NSW Minerals Council, 2013).

The creation of new fractures by subsidence exposes fresh rock to reaction with groundwater or infiltrating surface water, and releases salts, acid and iron oxides. (Department of the Environment, 2015). Subsidence can also expose acid sulphate soils (EPA Northern Territory, 2006). The ground movement can also cause vibrations and dislocations in sensitive infrastructure such as water, gas and power mains. This not only puts public safety at risk, but also is a major inconvenience as the repair to fix these services is extremely costly and time consuming if the damage is significant. The movement of soils also disrupts the growth of flora and biodiversity, which stunts the rehabilitation process.

Figure 9 presents principal and secondary roads in the NT and their relative distance to neglected mines. 84 (9.58%) of abandoned mines lie within 2km of these road types.

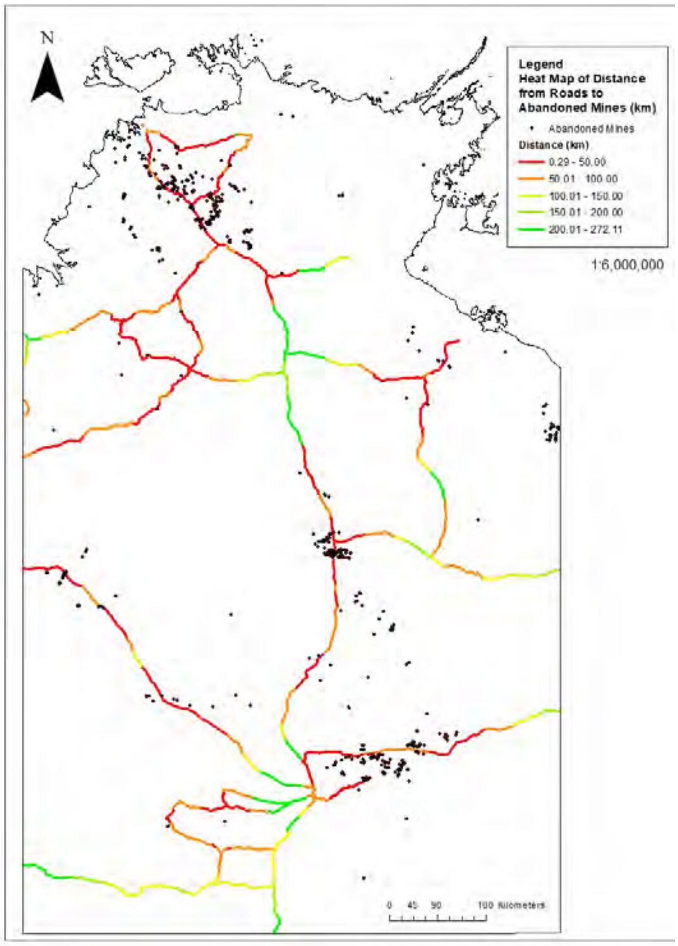

Figure 9. Heat map of principal and secondary roads

3.2.2 *Public Infrastructure*

Figure 10 portrays the locations of hospitals and schools in the NT, red triangles being schools within 50km of an abandoned mine. There are only six hospitals in the NT, one of which has an abandoned mine only 734m away. 11 (1.25%) abandoned mines are within 2km of a school.

803 points (42.89%) of primary and secondary roads in the NT lie with 50km of mines. This is because towns and thoroughfares are created to accommodate the influx of people for mining. However, as these towns are in close proximity to the mine sites, the people are at a higher risk of the adverse health effects. There are only six hospitals in the NT and therefore, these services are not as easily accessible as they are in other states. If mines are not rehabilitated appropriately, communities throughout NT do not have adequate access to health resources, therefore it is essential that the rehabilitation of mines for public safety occurs. The clearing of vegetation and use of explosives in mining activities leads to an increase in pollution from both dust and metals. If waste piles are also incorrectly maintained, dust from these can pollute local communities. Particle levels have been linked to increased hospital admissions and emergency room visits and even to death from heart or lung diseases (NSW Government Health, 2017); however, with the low number of hospitals in the NT, this is a huge risk to public health and safety. Other health risks are skin and eye irritation, poisoning and asthma.

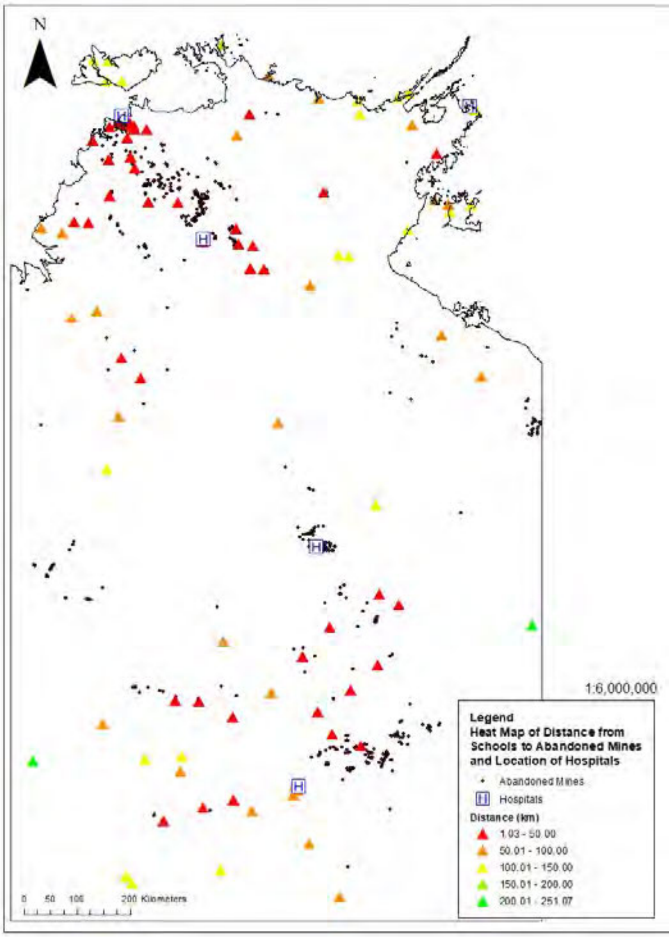

Figure 10. Heat map of schools and locations of hospitals

3.3 *Rectification*

The lack of a national database on abandoned mines makes it very difficult to quantify the potential risk of abandoned mines throughout Australia. The rehabilitation of these mines is also difficult to justify without knowing all of the threats an abandoned mine poses. Australia is significantly behind other countries in terms of their rehabilitation standards. Canada have the National Orphaned/Abandoned Mines Initiative, which has been referenced to clearly define the status of mining operations. The lack of clear mine status definitions are a key inhibitor to successful mine rehabilitation (Mhlongo, Amponsah-Dacosta, 2016).

Around the world, abandoned mines have been turned into various creations. One of the most famous would be the Eden Project; a clay pit that was transformed into a biome that now houses the largest rainforest in captivity (Eden Project, 2019). This site now welcomes millions through its doors every year and holds large scale events, while maintaining a strong sustainability policy and educating all who have visited on the importance of sustainability. In Germany, abandoned coal mines were filled with water to create recreational lakes. A site in Wales turned an abandoned site into a giant trampoline site (Welsh Government, 2019), thus depicting the wide range of uses for abandoned mines. What once was a wasted and costly space has now been turned into a tourist site, providing ongoing jobs for the local community and an economic boost to an otherwise obsolete site.

4 CONCLUSION

This report classifies mining occurrences in the Northern Territory and identifies their locality in relation to sensitive receptors which may potentially cause negative environmental and social-economic impacts. Areas were identified through spatial analysis that may be more vulnerable to these impacts and therefore should be investigated further. This report focuses on the impact of environmental receptors such as acid mine drainage, and topographical features such as roads and major water ways, as well as public infrastructure. Neglected mining can have adverse effects on the environment and the local community, thus highlighting the importance of responsible mine rehabilitation and closure. In addition to this, the report identifies the need for a more detailed and accurate database within the Northern Territory. The difference in data between states further emphasises that there is no clear idea of how significant the impacts of the mining industry are in the Northern Territory, thus further research is encouraged.

5 RECOMMENDATIONS

- Update the mine and quarry database for NT after it has been reclassified
- Reclassify this database into mine status definitions
- Investigate abandoned mine sites in the NT, specifically the sites near wetlands
- Create a nationwide database, similar to Canada
- Create a nationally coordinated abandoned mines program
- Define a nationwide mine status definition standard
- Mine rehabilitation framework should be outlined nation wide
- Standards for mine rehabilitation should be confirmed

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Local government influence on quarry restoration

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ABSTRACT: The environmental and economic considerations of site rehabilitation and restoration are frequently studied to suggest and examine methods for reducing the legacy impacts of end-of-life extractive industry sites. Although the lifetime of a quarry extends beyond the completion of extractive works, studies on the social impacts of the quarrying industry typically focus on the approval and operation phases. This article reports on the opportunity to improve the social considerations of quarry restoration within the existing regulatory framework in Victoria by increasing the influence of local government within the rehabilitation planning process. Drawing on strategic planning documentation from local governments and the experiences of 20 council officers in relation to quarries within their municipalities, it is contended that Victorian local governments are well-positioned to provide strategic guidance to quarry proponents in determining restoration end-uses of value to the local community. However, to derive the most value from these interactions, changes to the regulatory framework need to address the considerable timeframe of quarry operation and the limited capacity of local governments in terms of technical and human resourcing.

1 INTRODUCTION

Victoria's quarrying industry is seeing sustained growth as a result of public investment in infrastructure and urban sprawl due to population growth. The state government approved 11 new quarries over 2018/19 to help meet growing demand for stone, rock and sand, with total demand expected to double from 2015 to 2050 (DEWLP, 2020, ERR, 2019).

1.1 *Literature review*

Whilst the rehabilitation of end-of-life sites is mandatory under State legislation, a previous study by Werner et al. (2020) identified 18,171 abandoned mines and quarries in Victoria. 'Abandoned' mine sites are defined by the Canadian National Orphaned/Abandoned Mines Initiative as "*mines for which the owner cannot be found, or for which the owner is financially unable or unwilling to carry out clean-up*" (NOAMI, 2015). Victoria's regulatory framework governing mine rehabilitation was audited in 2020 by the Victorian Auditor-General's Office (VAGO), with the report revealing 231 sites classed as 'inactive' (VAGO, 2020). While neither dataset disaggregates unrehabilitated sites in Victoria into mines and quarries, active sites in Victoria were distributed by one works authority (quarry) for every 2.76 mining licences in 2020 (Werner et al., 2020). This presents a clear challenge for the extractive resources industry, exacerbated by the growing demand for quarry resources and the accompanying pressure on government agencies regarding the allocation of funding for the management of past, current, and future sites.

The terms 'remediation', 'rehabilitation', 'restoration', and 'reclamation' are used interchangeably throughout the literature to describe post-extraction processes on mine and quarry sites. Guided by the two-stage process adopted in the Victorian regulatory framework, the term 'rehabilitation' is favoured throughout this study to describe the process of establishing a landform which meets legislated standards often defined by safety and environmental parameters, while the term 'restoration' is used to refer to additional works carried out to uplift this landform to an 'end use'.

Numerous studies have highlighted the financial challenges associated with rehabilitating and restoring end-of-life mine sites (Costanza et al., 2014, Gorey et al., 2014), with Werner et al. (2020, p. 746) suggesting the use of "rehabilitation-based" business opportunities as a method of "deriving value" from end-of-life sites to incentivise restoration. Although such economic considerations may be the predominant driver for private quarrying proponents, Stacey et al. (2010, p. 379) emphasise that "closure does not take place in a social, economic or environmental vacuum". Suggestions of the growing role of social responsibility in extractive industries highlight the evolution of the 'social licence to operate' (SLO), which Moffat and Zhang (2014, p. 61) define as the "ongoing acceptance and approval of a mining development by local community members and other stakeholders that can affect its profitability". Numerous studies explore the SLO for the operation phase of mine sites (Bridge, 2004, Joyce and Thomson, 2000, Moffat et al., 2016), with Prno and Slocombe (2012, p. 347) recognising local communities as the "key arbiter" in the determination of a social licence due to their engagement with projects. Furthermore, Harvey and Brereton (2005) emphasise the development of relationships between proponents, local governments and communities as a growing obligation for mining corporations. While it is apparent that community influence has increased over time (Moffat et al., 2016), existing research highlights that improvement in this area has focused heavily on the approval and operation of quarries, with less consideration given to the community's needs in its rehabilitation and restoration phases. Therefore, in addition to creating a value-added restoration opportunity for the proponent, the social impact of a quarry's end-use must be a key consideration for restoration to be successful in the context of the local community.

1.2 *Regulation of the extractive resources industry*

Earth Resources Regulation (ERR) is the leading authority on extractive industries in Victoria, enforcing the *Mineral Resources (Sustainable Development) Act 1990* (the MR Act), the parent legislation to the *Mineral Resources (Sustainable Development) (Extractive Industries) Regulations 2019* (the EI Regulations), which detail specific aspects of the MR Act in the context of the quarrying industry. Part 7 of the MR Act refers to the rehabilitation requirements for mining and quarrying, establishing a precedent for the level of restoration which must be legally undertaken following the completion of activities. Quarry operators are required to prepare a 'rehabilitation plan' as part of their broader work plan, which is submitted to ERR as an application for a work authority (Fig. 1). The EI Regulations stipulate that both the post-quarrying landform and land use must "consider community views expressed during consultation" and be "safe, stable and sustainable"

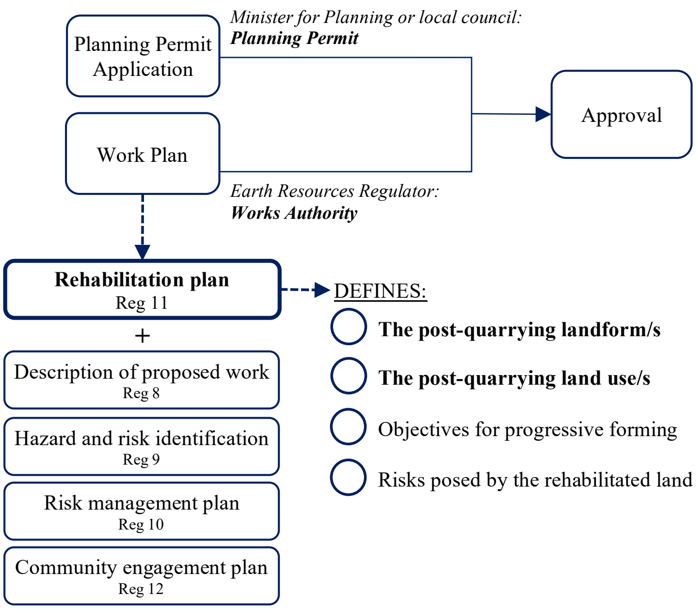

Figure 1 - Extractive resource industry works approval and rehabilitation plan requirements.

(Reg 11). In the same document, 'sustainable' is defined as rehabilitation which aligns with the principles of sustainable development. While not further detailed, the principles of sustainable development are commonly interpreted as the economic, environmental, and social aspects of sustainability (Stacey et al., 2010).

In addition to a rehabilitation plan, a proponent must enter a rehabilitation bond under Section 80 of the MR Act. While the Minister for Resources has full authority over the determination of the bond amount, if the quarry is on private land, they must consult with the local government (LG) whose municipality the land is located within prior to determining the bond amount. Additionally, the relevant LG/s must be consulted before a bond is returned. It is noteworthy that this is an amended regulation in response to an ERR self-initiated review to "assess and improve" rehabilitation (ERR, 2021b). As such, the aforementioned guidelines only apply in full to new work plans and variations submitted from 1 July 2021 (ERR, 2021a). Additionally, there is a separate *Code of Practice for Small Quarries* relating to quarries less than five hectares in area and five metres in depth. While the findings of this research may relate to quarries within this classification, the specific rehabilitation requirements outlined in the Code are beyond the scope of this study.

1.3 *Local government in Victoria*

Australia's multilevel governance structure positions local government (LG) as the closest tier of government to the community. In Victoria, a 2020 review of the *Local Government Act* (the LG Act) was centred on the transition to what the state government describes as "principles-based" regulation of the sector, centred on assigning LGs greater agency to apply broad legislated principles in consideration of their local community, municipal context, and individual capacity (DJPR, 2020). Savini and Grant (2020, p. 515) describe the shift as one to "deliberative engagement", defined as a participatory form of governance allowing for greater community involvement in decision making.

Considering such governance structures, this research asks if LGs are well-positioned to improve the social impact of end-of-life quarry sites. To qualify the potential influence of LG involvement in the rehabilitation planning process and the likelihood of successful outcomes, the following sub-questions are addressed: (1) To what extent do LGs deal with matters relating to extractive industries? (2) Are LGs well positioned to address matters relating to restoration end-uses? And (3) What are the apparent challenges of extending the legislation to involve LGs in rehabilitation planning?

This article aims to contribute to the improvement of the rehabilitation and restoration outcomes of quarries to value-added end uses which are considerate of, and beneficial to, the social needs of the local community.

2 METHODS

The research adopts a multi-method, multi-case study approach to address each sub-component of the major research question (Valentine, 2005). A combination of textual analysis and semi-structured interviews aims to understand the ways in which LGs apply state legislation within their municipal context, as well as revealing variations in their processes and experiences.

The broad research group is comprised of 61 individual cases, each defined by an LG whose municipality contains one or more extractive industry interest area (EIIA) based on open-source data from DataVic (2014). There are 903 sites across 61 municipalities, with one additional site located in French Island. As French Island has no LG, this point was excluded from the research.

Additional demographic data was incorporated to explore patterns between the case studies, and to determine the plausibility of extrapolating the interview findings to the full research group. Case studies were assigned a location classification of 'urban' or 'regional' based on the Urban Growth Boundary (UGB), with a regional classification for municipalities outside the UGB, and urban for those which intersect or are wholly within the UGB (Fig. 2). The 2020 population density (persons/km^2) of each municipality was obtained from the Australian Bureau of Statistics (ABS) (2021) and grouped into four ranges used to classify population density around Australia (ABS, 2012) (Appendix A).

2.1 *Document Analysis*

The primary document analysis undertaken for this research was of the most recently published 'council plan' available on each LG's website to gain insight into strategic planning at the LG level. Council plans were revitalised in the 2020 reform to the *LG Act* to allow for greater community involvement in strategic planning, the extent of which is highlighted by Savini and Grant's (2020) spotlight of a media release from the Minister for LG titled 'Council Plan Changes Puts Residents First'.

The council plan analysis focused on the inclusion of strategic objectives and strategies for achieving these objectives (referred to collectively as 'strategic priorities' from this point forward) required under Reg. 90(2)(a) and (b), resulting in a consistently structured, comprehensive data source specific to each case study. The strategic priorities of each council plan were manually binary coded using NVivo to understand commonalities in LGs' priorities in relation to their demographic attributes. An inductive coding process was followed for the thematic analysis of the council plans by first identifying broad trends related to land use, before specifying narrower codes related to recurring themes (Cope and Kurtz, 2016, Heydarian, 2016).

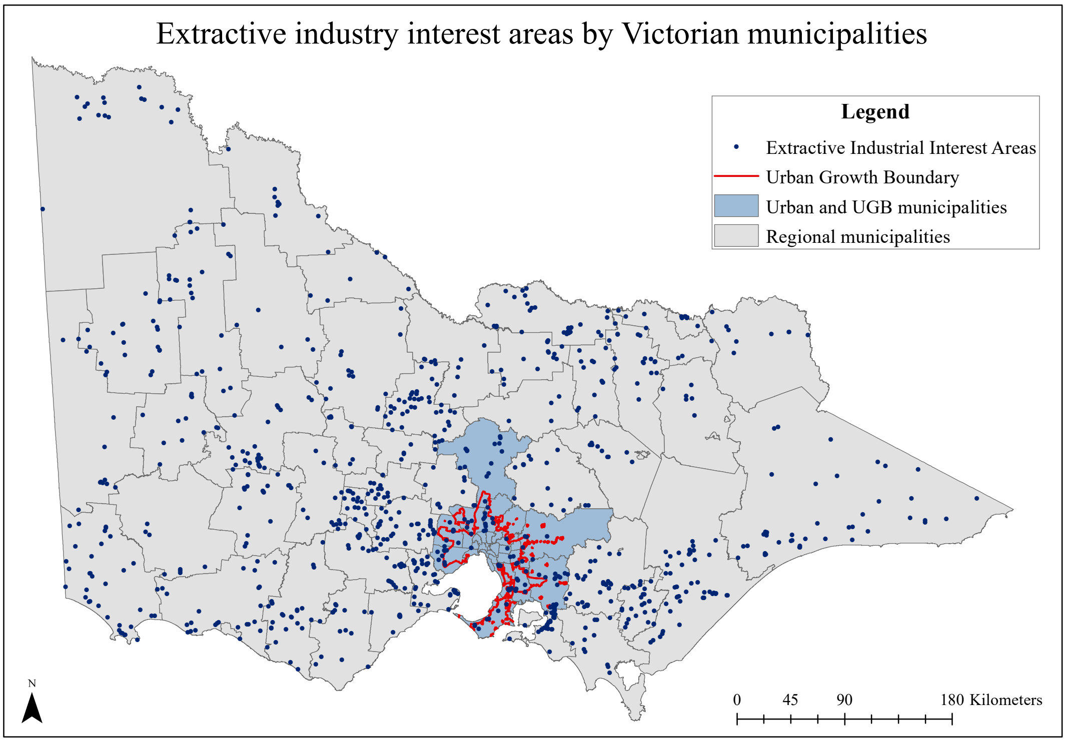

Figure 2 - The distribution of extractive industry interest areas across Victorian municipalities

Textual analysis was further supported by state government policy and planning documentation to provide broader context to the role of LGs.

2.2 *Semi-Structured Interviews*

Semi-structured interviews provide the opportunity to guide qualitative data collection along the key lines of the focus within the research question, while allowing for flexibility in participant responses (Dunn, 2005). As such, they are often used in multi-method research alongside textual analysis to triangulate the data set by revealing different perspectives and individual experiences (Valentine, 2005, Carruthers, 1990).

The snowball sampling method was employed to reach participants, with the initial research requests sent to each of the 61 LGs' administrative emails. No specific roles were requested for participation, with the snowball selection methodology reliant on referral to reach suitable informants (Noy, 2008, Naderifar et al., 2017). Where replies noted a lack of a suitable participant engaged in matters related to quarries, requests were guided to broader themes of planning and the environment. As a result, participants were distributed across a variety of teams within their respective LG (Fig. 3). While each interview related to one case study, there was no limit to the number of participants, with a total of 20 participants interviewed across 13 LGs. Interviews were conducted virtually between July and October 2021 and had durations of 20-60 minutes depending on the number of participants. All participants have been de-identified and will be referred to by identifying codes relating to their role as per Figure 3.

Interview questions were prepared within three overarching categories correlating to the sub-research questions. Follow up questions aimed to specify answers and extract greater information in relation to the specific experiences of the participants. Following transcription, a two-phase inductive coding process was followed in accordance with the interview questions. Descriptive coding focused on answers to the broad interview questions, which were then narrowed down through analytical coding in relation to the sub-research questions and links with the regulatory framework, council plan analysis and secondary literature (Cope and Kurtz, 2016).

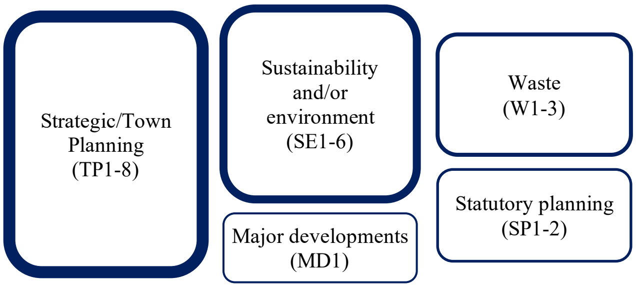

Figure 3 - Interview participants, their relevant team and identifying codes.

3 RESULTS AND DISCUSSION

3.1 *Rehabilitation policy in practice*

Interview data highlights inconsistency in the interactions between quarry proponents and LGs. From the 20 council officers interviewed, LG interactions with the quarrying industry were largely driven by three key factors: community complaints during operation, permit applications for establishment or changes to operations, and interaction with relevant state policy. Participants had experience with planning and extractive industry components of state policy relating to quarries through Environmental Effects Statements (EES) for new proposals, the Strategic Extractive Resource Area (SERA) pilot project, and regional land use planning for areas containing quarry sites and interest areas, including Precinct Structure Plans and Green Wedge Management Plans.

Of the interviewed cases, two LGs had direct partnership with a quarry proponent for the establishment of council-owned landfill, while another managed legacy landfill sites which had been constructed in old quarry sites. SE5's LG had restored an old quarry to a recreational end use (a process which preceded their employment at the relevant LG), while SE4 postulated that their LG owned "probably a dozen properties with old quarries on them", at least two of which were private quarries transferred to council ownership. The participants' experience in quarry rehabilitation planning was limited, with just two of the participants having been involved in rehabilitation planning for a quarry on privately owned land. TP1 described rehabilitation planning as "almost a bit of an afterthought", a comment supported by almost unanimous agreement that LG's interaction with the industry is heavily focused on the approval and operational phases of quarrying.

Limitations of the sample size must be considered in making generalisations regarding LGs' interactions with rehabilitation plans, however the use of the snowball selection process to access relevant informants supports the presumption that a reasonable proportion of the participants had amongst the greatest quarry experience within their respective LG (Waters, 2015, Noy, 2008). For example, SE4 had been involved in the EES process for the approval of a new quarry, which required commenting on biodiversity loss due to the quarry establishment. Although the quarry proponent's EES submission requires similar information to what is required in a standard work plan, SE4 stated that rehabilitation plans were "not part of what [they'd] seen". Of similar nature, TP7 stated that rehabilitation was excluded from the scope of their LG's input in the SERA Project, describing rehabilitation plans as "behind the scenes sort of stuff".

While these findings do not conclusively indicate that LGs aren't being consulted in relation to rehabilitation requirements and subsequent bond determination as per the regulatory framework, they do highlight that LGs are interacting with the quarrying industry in a variety of meaningful ways throughout their establishment and operation. In addition, these interactions are occurring through multiple channels within LG organisations relating to permitting, community advocacy and consultation, site specific operation negotiations and environmental management. This raises questions regarding the apparent exclusion of LGs from rehabilitation planning within the work approval process, with quarry proponents seemingly assigned the agency to engage LGs (or vice versa) as they wish in the absence of specific planning permit conditions. Accordingly, the following sections will explore the benefits and challenges associated with regulating LG participation in rehabilitation planning.

3.2 *Strategic planning in the local context*

The multilevel governance structure within land use and strategic planning assigns the state government almost full authority to implement binding policy. The subsidiary role of LGs is to apply such policy within a narrower spatial context bound most-broadly by their municipality (Searle and Bunker, 2010). Figures 4 and 5 highlight the incidence of themes addressed by the strategic priorities within each case's council plan, disaggregated by the LG's location and population density as markers of the geographic and demographic variability between LGA's across Victoria.

Trends in the geographic and demographic distributions of strategic objectives of LGs highlight significant variation in the way in which state policy is broken down and contextualised at a local scale. Although they sit at the lowest tier of governance, the narrow spatial context of LGs provides greater opportunity to address the variability of social conditions within the municipality. This is reinforced by Thompson and Maginn's (2012, p. 206) exploration of 'spatial planning', and its

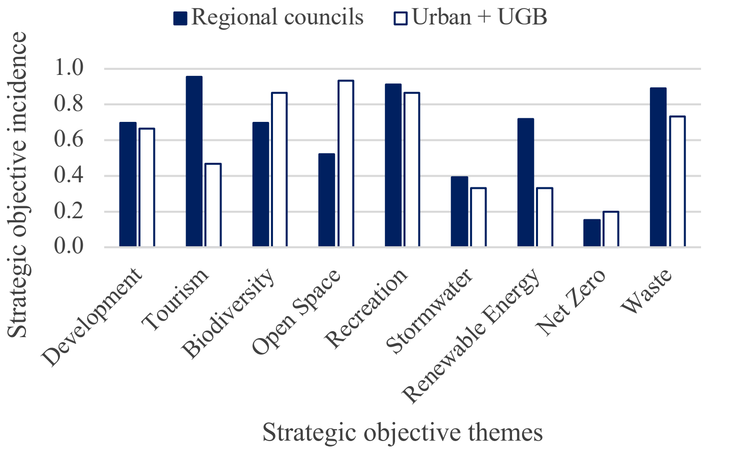

Figure 4 – Incidence of relevant LG strategic priorities by location

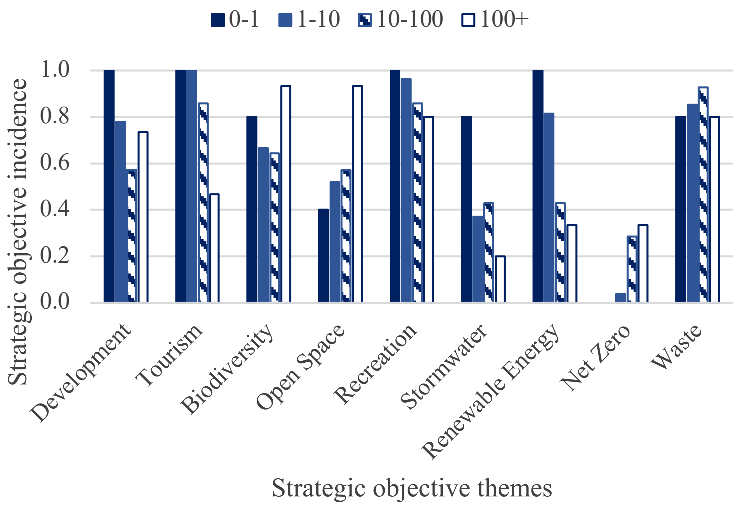

Figure 5 – Incidence of relevant LG strategic priorities by municipal population density

attempts to integrate planning across areas bound by common "environmental, social and economic matters" as opposed to ubiquitous regulation of individual land uses. Trends in policy data lend themselves to this notion, with tourism unanimously prioritised by LGs whose municipal population density is below 10 people/m^2, while the incidence of priorities relating to open space increases by 63% between the highest density brackets. TP1 provided empirical support of the importance of spatial planning in relation to a work authority approved by ERR for a quarry within their municipality, where the proponent's solution to the "visual impact" of overburden was to "plant vegetation on top of it". While a seemingly unproblematic solution, TP1 highlighted that in spatial context of the quarry, planting of that nature "increase[s] bushfire risk to the surrounding properties". This example supports a common benefit attributed to the municipal and sub-municipal scope of LG planning throughout the interviews more broadly, with SE4 describing LG as being "much more connected to the community than state government" through better knowledge regarding the "makeup of [their] local, localised areas".

While such findings emphasise that LGs are well positioned to provide strategic guidance on the use of land to best suit the needs of the surrounding community, it is necessary to understand the potential for this knowledge to be applied to the specific land uses recognised as end uses for restored quarry sites. Table 1 contextualises these themes in relation to six potential end use restoration categories for end-of-life quarries.

Table 1 – Suggested restoration end-uses and LG strategic planning priorities

Potential end use restoration categories	**Development**	**Tourism**	**Biodiversity**	**Open space**	**Recreation**	**Stormwater**	**Renewable energy**	**Net zero**	**Waste**
Mixed use – urban, recreational, open space (Damigos and Kaliampakos, 2003, Drake, 2011)	X			X	X				
Tourism (Cole, 2004, Caamaño-Franco and Suárez, 2020)		X							
Renewable energy generation (Werner et al., 2020)							X	X	
Restored ecosystem (Kerbiriou et al., 2018, Vosloo, 2018)			X	X					
Waste management (El-Fadel et al., 2001)									X
Water storage (Harper et al., 2018)						X			

It is therefore highlighted that broadly speaking, LGs' strategic objectives are highly interlinked with potential end uses for quarry restoration, with each restoration category linking to at least one recurring strategic theme. While this data suggests that LGs may be of benefit to quarry proponents to guide them to a broad classification of end use, it is recognised that the proponents must nominate potential specific restoration end uses in the rehabilitation plan. This specification is necessary in the rehabilitation planning phase, as the final use/s for the site ultimately defines the condition and form of the final rehabilitated landform of the quarry site.

Employing 'tourism' as an example end use category, Figure 6 illustrates a breakdown of strategic priorities relating to tourism across the case studies, noting that some council plans had more than one priority within this theme. The varied distribution of specific priorities relating to tourism highlights both the means of LGs to recognise functions missing or lacking in their municipality, and the importance of engaging with the local context at a narrower level.

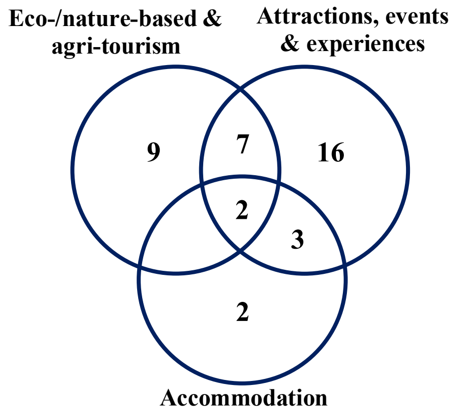

Figure 6 – Specific strategic priorities relating to tourism

It is therefore evidenced that undertaking closer analysis of LGs' strategic priorities pertaining to a relevant theme further emphasises the relevance of LG strategic planning to determining appropriate end uses for a site. Demographic and geographic trends emphasise that distinctions in the social conditions significantly influence strategic planning, highlighting the relevance of LGs in being able to view quarry sites within their regional context. As such, LGs are in a position of considerable value in being able to suggest restoration to specific end uses which meet the needs of the community, addressing the social sustainability element of the regulatory framework.

3.3 *Restoration to public land – local government and site acquisition*

Land acquisition is relevant to the restoration of end-of-life quarries where proposed end uses pertain to public assets, including recreation and open space. In these occurrences, value for quarry proponents lies largely in the sale of rehabilitated land to public agencies, including LGs, as the end uses have little to no revenue base. Where topics raised in the interviews lent themselves to questions regarding LGs' appetite for acquiring quarry sites, 'risk' and 'liability' were common terms raised in participants' responses. SE1 described their LG as generally being "risk averse", while SP1 speculated more specifically on concerns relating to the potential "ongoing liability maintenance concerns" associated with movements and differential settlement in the final landform of the site. This apprehension was corroborated by numerous participants who referenced the technical specifications of quarrying as potential barriers to increased LG involvement in rehabilitation planning, particularly regarding the acquisition of rehabilitated sites.

References to site suitability were highly focused on the technical aspects of quarry rehabilitation, revealing a distinction in the capacity of LGs to independently engage with quarry proponents.

When asked about their LG's understandings of the technical aspects of quarry operation and rehabilitation, multiple participants questioned the specificity of the terminology used by proponents to describe quarried landforms, suggesting a general mistrust of the information they are provided. For instance, SE1 stated "we are relying on what the mining company is telling us", continuing on to say "they're gonna emphasise the good stuff, right?". In general, participants focused on the vagueness of "stable" and "safe" (MD1 & SP1; TP2) as terms used to define the landform, as well as further stressing the need for standardised definitions to outline what end uses are considered "appropriate" based on the standard of rehabilitation (TP1 & SP1). SE1 was not unique in stating the extent to which their LG relies on private proponents for the provision of information, with five participants noting that most of the information they receive regarding quarries within their respective municipality comes directly from the proponents. This highlighted a common shortcoming not only relating to accessing accurate, trustworthy information, but also interpreting the information provided. TP4 described it as:

"We don't always understand exactly what they're doing. We're not experts in the field, we rely on their, you know, their explanations, and it just makes it very challenging."

Three LGs stated that they bring in consultants to deal with the technical aspects of either operation or rehabilitation, while one noted that they "rely a lot" on the ERR (TP1). Notably, all three LGs who mentioned engaging external consultants are in the highest population density category (100+ people/km^2 band), while the LG engaging ERR falls within the 10-100 people/km^2 band. While it is difficult to label this a pattern on its own, it does lend itself to common trend separating urban/peri-urban and rural LGs across Victoria, where an LG's capacity to outsource expertise through the engagement of consultants is highly related to their population density as a consequence of funding through municipal rates (Savini and Grant, 2020, Dollery and Crase, 2004). This is further substantiated by SP2's statement that the largest challenge associated with LG involvement would relate to the issue of resourcing, stating that "as you go further and further out [from metropolitan Melbourne], it's going to become a resourcing issue. Resources are slim".

Such findings are likely representative of why the regulatory framework is centred on ERR as a state government body dealing with matters directly related to extractive industries, as this makeup allows the centralisation of relevant technical knowledge and resources. However, it must be questioned if the current vertical power structure subordinating LGs' involvement in quarry restoration is creating a dual barrier to socially sustainable restoration, where LGs are hesitant to acquire sites regardless of their potential benefit to the community, and more broadly, technical barriers are excluding LGs from rehabilitation planning.

3.4 *Statutory planning and the matter of time*

Land use planning plays a significant role in all aspects of quarrying, including ensuring access to quarry resources, implementing buffer zones for the separation of incompatible land uses during operation, and transitioning end-of-life quarries to suitable end uses (DELWP, 2020). While a work authority from ERR is required to allow quarrying on a specific site, a planning permit must be obtained for approval to alter the land use of a site within the constraints of the relevant planning scheme. In lieu of an EES or VCAT hearing, LGs as the local planning authority typically manage the provision of permits under the *Planning and Environment Act 1987* (P&E Act).

Interview participants generally alluded to permit provisions as secondary to work authority regulation, resulting in LGs positioned as what TP7 described as a "secondary or third party […] off to the side". SP1 described the relationship between the legislation as a "challenging nexus", categorising quarry permits as "pretty light on in terms of their conditions". Rather, they generally include "a broad statement that, you know, the site must operate in accordance with that work plan". While no participants mentioned direct conflict between the legislation, interview participants highlighted that the permit process itself is not well-suited to the typically long and unspecified timeframes of quarrying. SP2 stated that "generally when permits are issued, we don't necessarily issue expiry dates on them", while MD1 added "they [quarry proponents] are reluctant to kind of open up or be too transparent about what their plans are too far in advance because it depends on the market". This highlights a shortcoming in the regulatory framework, as proponents are providing rehabilitation plans relating to an end use for the site at a point in the process when they are unable to accurately determine an end date. In support of this, TP2 added:

"When you've got a quarry and it's got a permit life for 100 years, the world and things change and evolve. […] So even when a lot of our quarries actually commenced operations, there was no urban growth boundary, there was no green wedge".

As part of the permit process, SP2 highlighted that their LG "do receive [rehabilitation] plans, we do assess them and endorse them". When asked about the flexibility of such endorsements, they stated:

"Once we stamp those plans and endorse them, that's that legal document, right? We can't go back and take that stamp off and say we want changes; we don't have the authority to do so."

Some participants were able to give tangible evidence emphasising this lack of review as a flaw in the regulatory framework. TP2 described a quarry within their municipality who was issued a permit "back in the 60s" and was now looking at rehabilitation, and they had a "condition that council [could] take it over as a landfill", yet their LG "do[esn't] do landfill anymore". MD1's LG had the same experience, telling the proponent, "the State's not allowing any more landfills".

While both the MR Act and P&E Act allow for updates to a quarry's work authority and permit to accommodate modifications in the quarry operation, these updates are reliant upon initiation by the proponent. Vivoda et al. (2019, p. 407) class elements in mine regulation as either 'restrictive' or 'enabling', finding that a lack of restrictive regulation relating to mine rehabilitation typically results in a "heightened risk of continuing liability for local communities and the state". Applying these classifications to the review process reveals a significant lean towards 'enabling' regulation, where proponents are assigned the agency to drive reviews to their site. In the case of changes to operations, participants highlighted profitability as a common driver for updates to operation within quarry sites, highlighting the "market driven" (MD1) nature of the industry. While it is therefore logical for proponents to initiate reviews in these circumstances, in contrast, there is no obvious incentive for proponents to review their rehabilitation plan in the context of changes to the surrounding area and local community, suggesting that rehabilitation plan reviews would be best enforced by a governing authority.

Every interview highlighted the advocacy role of LG as a major driver for long term decision making, suggesting that LGs are well-positioned to govern the review and update of rehabilitation plans. Anecdotally, W2 described it in terms of their LG's long term emission reduction targets:

"We can go and purchase a piece of equipment that has a higher value to purchase, but then offers greener emissions in the long run, whereas a contractor would say let's buy the cheapest thing and make the most of our money."

Therefore, it is highlighted that LGs are invested into matters impacting the community long term, justifying their lack of ability to mandate rehabilitation plan reviews as a shortfall within the regulatory framework.

3.5 *The challenges of council involvement*

When asked to speculate on what they could foresee as the biggest challenge to their LG having greater influence regarding quarry restoration, participants' answers fell into four themes, depicted in Figure 7. This section will explore these challenges to determine the extent to which they need to be considered in recommendations pertaining to altering the role of LGs in an official capacity.

Five LGs agreed on resourcing as the biggest constraint to greater involvement. Exploring this challenge more narrowly, three LGs highlighted a lack of technical knowledge as their largest challenge, while two focused more closely on human resources. Both of these LGs sit within the 10-100 population density bracket, with MD1 clarifying their LG's challenge:

"Before my role was created, there was no designated person to put the time and resources into quarries […] so it kind of just floated around the planning department and only really got dealt with when the planning application came in."

A lack of community push was identified as a challenge by two LGs, notably the two interviewed cases with the lowest population densities. In both instances, the isolated nature of quarries within the municipality resulted in reduced community pressure on the LGs to interact with the quarries, with SE1 describing their situation as an "out of sight, out of mind sort of context". Other participants inadvertently supported this point from the oppositive perspective, describing "community angst that feeds into […] our councillors, and it just causes a lot of work" (TP4), "quite contentious" permit applications (SP1), and quarries as a "significant stressor" (TP6). Pini et al. (2007, p. 168) argue that a lack of community involvement in matters relating to natural resource management in

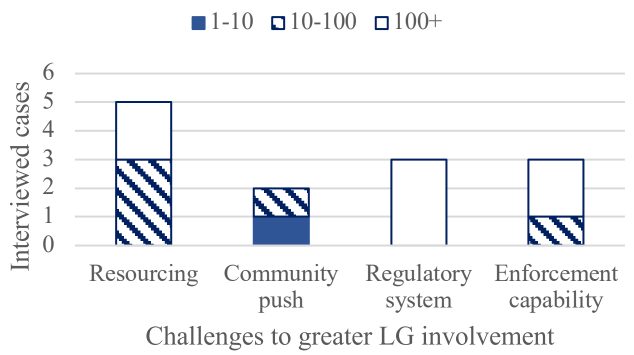

Figure 7 – Challenges to LG influence identified in interviews by municipal population density (persons/m^2)

rural municipalities is a human resourcing issue, evident of a broader reliance on community engagement to push less "pressing commitments". On this basis, the barrier for these LGs may best be managed alongside the resourcing challenges previously identified, with specific technical and human resources needed to prioritise rehabilitation planning and improve the capacity of LGs to interact more meaningfully with the quarrying industry.

While differing in the specific challenge identified, cases whose responses were coded as 'regulatory system' and 'enforcement capability' were inherently linked in describing their challenge in relation to the position of LG within the regulatory hierarchy. Challenges relating to the regulatory system were classed as those where LGs assigned responsibility directly to the state government. For example, TP2 and TP5 outlined constraints to their influence pertaining to quarries within the green wedges within their respective municipalities, summarising "we advocate […], we will make submissions and put our views forward" and "we might want to do these sorts of things, but at the end of the day, we can't do anything because the Minister has to approve it and it has to go through two houses of Parliament for approval" (TP5; TP2).

In contrast, the remaining three cases identified enforcement capability in relation to the horizontal distribution of power, and the ability of their LG to "influence" private quarry proponents (SE4). While heavily related to the distribution of power by the state government, it may also be questioned whether the lack of LGs' agency and enforcement over quarry proponents ultimately occurs as a result of constraints to their technological knowledge and human resourcing capabilities. Unsurprisingly, the "degree of expertise" of LGs is listed as one of five key factors for determining the law enforcement role by Concerton and LeRoy (1990, p. 950), suggesting that perhaps a concerted effort from the state government to improve the capacity of LGs would allow them to play a greater role in the restoration of end-of-life quarry sites.

4 CONCLUSIONS AND RECOMMENDATIONS

Victoria's extractive industry sector is governed through a regulatory framework which appears to be prioritised foremost on the Earth Resources Regulator. While the centralisation of authority may best enforce quarrying operation, consideration of rehabilitation planning from the application process to beyond a quarry's lifetime may not be best suited to the current framework. The examination of LGs' strategic planning documentation and semi-structured interviews revealed LGs are interacting with the quarrying industry in a range of meaningful ways, however, these interactions are often constrained by shortages in resourcing, particularly in relation to the technical nature of site rehabilitation. While LGs are well positioned to guide restoration to end uses which are considerate of the local community through their mandated strategic planning within the *Local Government Act 2020*, their involvement in rehabilitation planning is currently sporadic at best. To capitalise off the value of LGs' contextual knowledge of conditions within their municipality and thus, improve the social suitability of restoration end uses, provisions for capacity building and regulated reviews to rehabilitation plans are recommended to better facilitate LG involvement. It is suggested that further research into the extent of LG influence should focus on the quarrying industry, studying the rehabilitation planning process in practice across the lifetime of quarries to examine appropriate timeframes and methods for communication and review to achieve socially sustainable restoration.

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APPENDIX A

Researched set of Victorian LGs and the number of extractive areas within, and population density of, each municipality. LGs in bold participated in semi-structured interviews

Regional (46)						**Urban (15)**		
	Num. EIIA sites	Pop. density		Num. EIIA sites	Pop. density		Num. EIIA sites	Pop. density
Alpine Shire	6	1-10	Loddon Shire	14	1-10	Brimbank City	1	100+
Ararat Rural City	19	1-10	Macedon Ranges Shire	10	10-100	**Cardinia Shire**	18	10-100
Ballarat City	16	100+	Mansfield Shire	9	1-10	Casey City	7	100+
Bass Coast Shire	22	10-100	Mildura Rural City	19	1-10	**Frankston City**	7	100+
Baw Baw Shire	30	10-100	Moira Shire	33	1-10	**Hume City**	6	100+
Benalla Rural City	13	1-10	**Moorabool Shire**	34	10-100	**Kingston City**	4	100+
Buloke Shire	6	0-1	Mount Alexander Shire	6	10-100	Knox City	4	100+
Campaspe Shire	9	1-10	Moyne Shire	24	1-10	Manningham City	1	100+
Central Goldfields Shire	8	1-10	Murrindindi Shire	16	1-10	**Melton City**	6	100+
Colac-Otway Shire	14	1-10	Northern Grampians Shire	24	1-10	**Mitchell Shire**	14	10-100
Corangamite Shire	26	1-10	Pyrenees Shire	13	1-10	**Mornington Peninsula Shire**	7	100+
East Gippsland Shire	42	1-10	South Gippsland Shire	17	1-10	Whitehorse City	1	100+
Gannawarra Shire	6	1-10	Southern Grampians Shire	9	1-10	**Whittlesea City**	10	100+
Glenelg Shire	35	1-10	Strathbogie Shire	4	1-10	**Wyndham City**	9	100+
Golden Plains Shire	23	1-10	Surf Coast Shire	9	10-100	Yarra Ranges Shire	6	10-100
Greater Bendigo City	39	10-100	Swan Hill Rural City	9	1-10			
Greater Geelong City	30	100+	Towong Shire	9	0-1			
Greater Shepparton City	15	10-100	Wangaratta Rural City	19	1-10			
Hepburn Shire	13	10-100	Warrnambool City	1	100+			
Hindmarsh Shire	18	0-1	Wellington Shire	45	1-10			
Horsham Rural City	12	1-10	West Wimmera Shire	13	0-1			
Indigo Shire	6	1-10	**Wodonga City**	7	10-100			
Latrobe City	26	10-100	Yarriambiack Shire	24	0-1			