STRATERRA™

NATURAL RESOURCES OF NEW ZEALAND

Submission

to the

Ministry of Economic Development

on

'Maximising our Mineral Potential: Stocktake of Schedule 4 of the Crown Minerals Act and Beyond'

May 2010

TABLE OF CONTENTS

Executive Summary

The government initiative to open up selected conservation lands for closer evaluation is an important step in better understanding their mineral potential. Straterra strongly supports all of the Government's proposals presented in the Discussion Paper.

New Zealand is well endowed with resources including oil, gas, coal, lignite, ironsands, methane hydrates, precious and base metals and other mineral resources such as aggregates, non-metallic minerals and high quality clays. This endowment is well summarised in the paper 'The Natural Resource Potential of New Zealand' by Richard Barker.[1]

New Zealand's resources, including those that are within Schedule 4, have the potential to make a major contribution to the national economy. Straterra believes that their development can be achieved without compromising environmental standards or creating a risk of undermining New Zealand's reputation for the management and maintenance of its environment.

The particular focus of the Schedule 4 Discussion Paper is on the potential for the extraction of precious and other metals in selected parts of Schedule 4. This is an important but relatively small and unexplored part of New Zealand's resource endowment.

This submission includes reports by NZIER and Lane Associates that consider the economic and environmental impact of mining respectively. These reports provide support for the Government's initiative, and provide some objective analysis that answers some of the questions that have been repeatedly posed in this debate. For example 'what is the economic benefit of a resource project, or a mining operation that might be developed in Schedule 4 land?', and, 'what are the likely environmental impacts of such a development?'

Recognising the strong reaction the Government's proposals have elicited, Straterra believes that before there can be informed debate on the merits of exploration and mining within Schedule 4 lands the focus needs to be on studying and understanding the resource potential and the economic and environmental values within the conservation estate. This will allow us to make informed and rational decisions about the areas within which it is appropriate that assessment of mineral potential and development of mines be allowed.

We live in a world where economically viable mineral deposits are becoming scarce, harder to find, and increasingly expensive to develop. Mineral activity in New Zealand, be it exploration, project consenting or mining operations, is covered by legislation that is robust, rigorous and world class. This legislative framework provides a very high level

[1] R Barker, March 2008, The Natural Resource Potential of New Zealand

of assurance that no project, or exploration activity, will be consented without sufficient consideration of the technical, economic, environmental and social issues that are relevant to it.

Straterra's recommendation is therefore that the allowed threshold of activity in Schedule 4 land be raised, so that sufficient prospecting activity can be conducted, including drilling, such that any economic ore deposits in Schedule 4 lands could first be identified. Straterra is recommending that the current maximum area permitted to be disturbed be increased from 4m x 4m (the current maximum) to 10m x 20m which is sufficient to establish a drill pad from which one, and sometimes more, holes can be drilled.

The key advantage of this approach is that any debate about removing an area of land from Schedule 4 would then be conducted with a higher, and more appropriate, level of understanding of the economic and environmental issues, and would be based on a small and very specific area of land. The area required for an opencast mine might typically be a few hundred hectares, and the area required for a typical underground mine would be measured in tens of hectares.

It will be important for explorers and investors that clear guidelines are developed for the consenting process in Schedule 4 lands. Mining companies need a clear understanding of the process and guidelines for getting consent for a project so they can make their own risk assessment. This does not mean a mining company needs certainty – that is not possible under New Zealand's legislation – but they do need confidence that if a 'suitable' balance of economic and environmental issues is achieved, a project is 'likely' to be consented. Guidelines for this 'balance' should be developed jointly by Crown Minerals and the Department of Conservation, with advice from industry and NGOs as appropriate.

The Government is currently proposing to transfer out 71 square kilometres (7058 hectares) from schedule 4 (whilst adding back 124 square kilometres or 12,400 hectares – mostly marine reserve). If the exploration work is done first, then this area could be reduced to a fraction of that size.

Straterra supports the proposal for joint decision making between the Minister of Conservation and Minister of Energy and Resources. The Minister of Energy and Resources holds the mineral estate in trust for all New Zealanders as does the Minister of Conservation hold in trust the Conservation estate. Joint decision making provides a balancing exercise on the part of the Crown as owner and custodian of both resources for grant of access.

Straterra also supports the proposed contestable conservation fund.

About Straterra

Straterra was formed in 2008 to establish a cohesive approach by industry stakeholders to maximise the long term contribution the resource sector can make to the New Zealand economy. It represents a number of organisations with interests in the Natural Resources sector including explorers, miners, scientists and constructors. Membership includes more than 95% of coal and gold production in New Zealand.

Introduction

Straterra welcomes the opportunity to comment on the Government's proposals as set out in 'Maximising our Mineral potential; Stocktake of Schedule 4 of the Crown Minerals Act and beyond', hereinafter referred to as 'The Discussion Paper'.

As the Discussion Paper notes, New Zealand is a resource rich country. The resource potential identified in the areas proposed to be removed from Schedule 4 is a small but important part of New Zealand's overall mineral endowment. We congratulate the Government on its proposal to open these areas of Schedule 4 to further exploration and development and look forward to working with the Government to build on this initiative and develop a broad and effective strategy that maximises the benefit for New Zealand from our resource endowment.

Our submission includes;

- a discussion of the economic impact of resource projects, based on the findings of a study conducted by the NZIER[2]
- a discussion on the environmental impact of mining, based on a report by Lane Associates Ltd[3]
- an overview of how mining companies typically approach exploration
- a proposal that sets out an alternative to the removal of land from Schedule 4, that may provide a path for the Government to follow and that responds to the public reaction seen to date, and
- responses to the questions posed in the Discussion Paper.

Straterra sees this discussion process as an important opportunity to provide some independent analysis and to comment on some of the 'myths' that have been promulgated by opponents in terms of the economic and environmental impact of mining.

We are also of the view that there are a number of options for New Zealand in terms of how best to maximise the value of our mineral resources, and we discuss exploration in that context.

[2] NZIER, April 2010, Diamond in the Rough
[3] Lane Associates Ltd, April 2010, Mining and the Environment ï an Overview.

Mining is a capital intensive and relatively high risk industry that can yield rich returns. Significant projects in the sector generally have lead times measured in years and investment prior to confirmation of a viable project is measured in tens of millions of dollars. To generate activity in the sector we must compete successfully for a share of international resource sector exploration and development funding.

A Stock take of the Industry

Data presented in the NZIER report provides an overview of a number of economic dimensions of the resource sector.

Direct Contribution to GDP for 2008

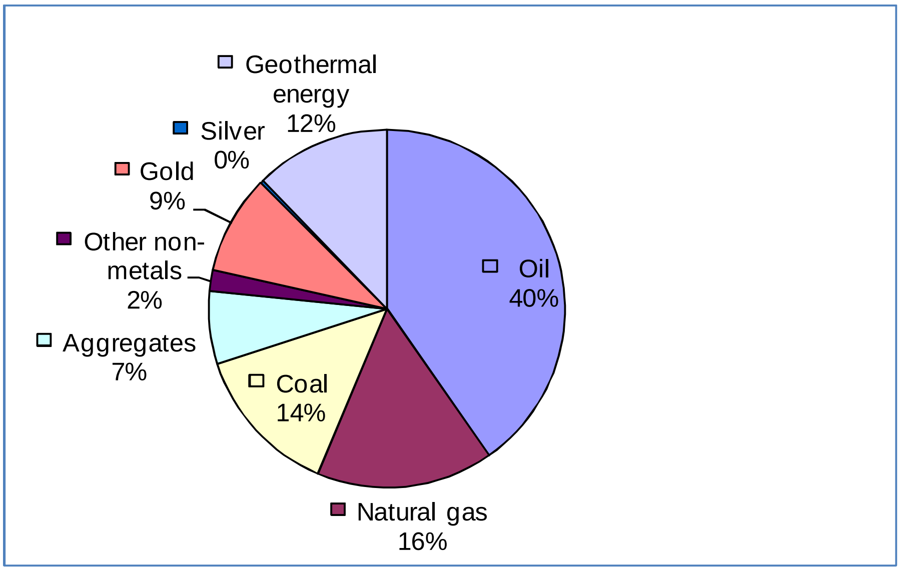
Mineral Resources Sector	$2.149 billion
Wine Industry	$0.454 billion
Tourism	$6.660 billion

Export Returns for 2009

From Coal, crude, mineral, gases, ore;	$3.6 billion (8.2% of total exports)
From Diary	$10.0 billion
From International Tourism	$9.3 billion

Analysis of Natural Resources Sector Output for 2008 (Est, NZIER)

Figure 1; Natural Resource Production by Value, 2008



Mineral Resources industry contribution; surplus; royalties, tax

2008 Surplus before income tax	$2 billion approx
2008 Estimated tax, royalties and levies	$181,000 per employee
2009 royalties and levies	$558 million

Production statistics for 2008;

Gold production	523,000 oz
Coal output	4.9 million tonnes
Non metal output	approx 42 million tonnes
Gas output	141 billion cubic feet
Oil output	21 million barrels

Jobs and multiplier

2009 Mineral Resources sector jobs	6800 directly
2009 supply of goods and services	8000

Employee income vs New Zealand average

2008 Median Mineral Resources income	$57,320 per annum
2008 Median NZ total	$33,530 per annum

Area of land mined

Table 1; Land Area Impact

	2007	
	Hectares	**%**
Grassland	8,086,160	55.00%
Native tussock etc for grazing	2,900,463	19.73%
Grain, seeds etc	367,404	2.50%
Wine	29,810	0.20%
Other horticulture	103,082	0.70%
Planted production forestry	1,708,282	11.62%
Mining	4,000	0.03%
Other	1,501,696	10.21%
Total	**14,700,897**	**100.00%**
Source:		
For agriculture and total, MAF;		
For mining, Barker		

Land productivity $ per Ha vs farming etc

Table 2; Land Productivity

	2008		
	Mining	Wine	Dairying
Land area (ha)	4,000	29,810	2,116,000
Export revenue ($m)	2,715	899	9,181
Contribution to GDP	2,149	454	7,185
Exports/ha ($/ha)	$678,750	$30,158	$4,339
GDP/ha ($/ha)	$537,250	$15,230	$3,395
Sources:			
Mining and Wine; Table 1 NZIER report			
Dairying; MAF for land, NZIER's QP for GDP			
and Stats NZ for exports			

Mineral Resources productivity measure 2009

Average value added per employee in mining sector	$223,971
Average value added per employee all NZ	$61,607

A further measure of the value of the resource sector to the New Zealand economy was provided by a recent study by Infometrics. This placed OceanaGold in the top 0.5% of companies in New Zealand in terms of its contribution to GDP. New Zealand has two other significant resource companies – Newmont Waihi Gold and Solid Energy whose revenue is in the top 0.8% of New Zealand companies and since the ratio of contribution to GDP to mining is high these firms are almost certainly all in the top 0.5% of firms in terms of contribution to GDP.

These are compelling economic and social measures, but equally there are environmental measures and outcomes (discussed below) that support the case for the positive contribution that mining can make in New Zealand.

Resource Estimates

There have been a number of estimates developed to describe New Zealand's resource endowment, including those in the Discussion Paper. There is a well developed, but fairly technical and complex set of protocols which the mining industry uses to describe and report various categories of mineral reserves and resources. These protocols are based on the level of knowledge, or certainty that can be ascribed to a particular resource.

For example, some of New Zealand's resource endowments such as the Southland and Otago lignites, are very well understood as there has been extensive drilling and project assessment already carried out. There is therefore a reasonably high level of confidence about the economic parameters associated with the development of these resources.

Other parts of New Zealand's resource endowment such as a number of the areas identified by Barker[4] and referenced in the Discussion Paper, are simply 'prospective'. This means the geological environment is 'encouraging' for the presence of metal or mineral occurrence or there could have been historical workings in the area.

Industry experience shows that typically hundreds, if not thousands, of prospective areas are subjected to preliminary, very low impact prospecting and assessment before a potential target for mining is identified.

This is important in the context of the public opposition to the Government's proposal, because much of the opposition chose to ignore the significantly different levels of field activity between the identification of a 'prospective area', and the development of a proposal for a mining project that would be put before the Environment Court. The next Section provides some discussion on this issue.

Mining Exploration and Development

The goal of any mineral prospecting program is to identify an economic resource, be it gold, base metals, coal etc. By way of example we present here a view of how mineral exploration proceeds, with the objective of providing a context for the Schedule 4 Discussion Paper.

Mineral prospecting through to mine development can be seen broadly as following a number of stages;

1. **Initial data gathering and analysis** can involve aeromagnetic surveys, regional mapping and assessment of the regional and local geology and examination of archives for records of prior activity. The essential features of this stage are that costs are relatively low and there is no impact on the land.

   Sophisticated modelling techniques would be used to analyse the data gathered to generate a number of 'targets', or 'prospective areas' for more detailed examination.

2. These targets are prioritised and more information is gathered through **field mapping, soil, rock chip, soil and stream samples** etc.

   The geology and samples are then further analysed and modelled and the targets further refined. Decisions could be made at this stage to do no further

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[4] Barker, (March 2008)

work on some, or all, of the targets, or some of the prospective areas could be selected for further work. These are the areas that, at this stage, are more likely to yield an economic ore deposit based on the work done to date.

3. **A drilling program** is then most likely to occur in the area(s) that meet the company's exploration criteria. There might be 1 or 2 prospective areas that justify the investment required for drilling, from hundreds or thousands of initial targets.

   Drilling would typically be done in 3 or 4 stages, each stage building on the understanding gained and seeking to define an economic ore deposit. Drilling would aim to understand/confirm the local geology, generate grade data, and provide samples for testing to develop the optimum physical and chemical process required to recover the values from the ore.

   At this point, when the costs of exploration are escalating and the target size is narrowing, an exploration company would require a greater degree of certainty that the lands it is exploring would be able to be removed from Schedule 4 protection.

4. **A pre-feasibility study** would then be initiated, including further drilling, process testing, development and analysis of production scenarios, economic modelling and risk assessment.

5. For the prospects that survive this rigour, a **Bankable Feasibility Study** would be carried out. The cost to this stage might be $30m for a medium sized gold project, and the time to this Stage, including permitting, access arrangements, and resource consents could be 3 to 5 years

It is likely that in the order of 1000 'prospective areas' are identified for every Bankable Feasibility Study. And of course, New Zealand's mineral permitting regime, landowner access requirements, RMA etc ensure that all stages are consented and managed to agreed and transparent environmental standards.

This is relevant to the Discussion Paper for a number of reasons.

- Most of the land proposed to be withdrawn from Schedule 4 in the Discussion Paper falls in Stages 1 or 2 in terms of our current knowledge ;

- Developing mineral projects is a costly and economically risky process. It is potentially very rewarding yet there is no guarantee of a successful outcome. The summary of the stages involved above makes it clear that allowing prospecting in areas as described in Stages 1 and 2 above, is a far cry from 'opening up for mining'

- Since there is going to be more mining in New Zealand, this is an opportunity for the industry to provide some explanation of how projects are developed and how the industry works.

- It provides the background for a discussion on options for progressing the Schedule 4 proposals.

The government's Schedule 4 proposals have polarised views across the country and, in a sense, invited opponents to argue that mining should be stopped. Of course very few people would argue that there should be no mining because every part of society relies on extractive industries in some way.

However it is easy to argue generically that mining should not occur in a specific place, like the Coromandel or Hauraki Gulf. On the other hand, it is harder to argue that mining should occur in any specific place without sufficient information to justify such a specific proposal or discussion.

Yet we do have sufficient information to say that many areas in Schedule 4, including those that have been proposed to be withdrawn from Schedule 4, are prospective for minerals – and that there is a reasonable chance that one or more economic mineral resources can be identified within these areas.

An Alternative Approach

Straterra was disappointed to observe how the national discussion so quickly became uninformed, emotive and polarised. We believe this discussion did not reflect the real views of most New Zealanders, and it certainly reduced the opportunity for a rational debate over the issues. Perhaps a more staged and careful approach can now be justified.

At present there is a low level of knowledge of the resource potential of most of the areas within Schedule 4. In some cases the estimates of value are simply based on an assessment of the geological environment – a reasonable approach but not sufficient in itself to facilitate a balanced assessment of the mining values in these areas.

Similarly, there is often a low level of knowledge about the ecological and conservation values of the areas in question.

The early stages of the assessment process (prospecting, as described in stages 1 and 2 above), involve non invasive mapping, rock chip, stream, sediment sampling. Subsequent stages of assessment are likely to include drilling, but only if there are very encouraging results from preliminary work. Drilling is expensive and is not undertaken without significant encouragement in terms of the geological and mineral potential.

Drilling can typically be done, in most areas, on a pad measuring 10m by 20m and where tracks do not exist, drill rigs are typically flown in by helicopter.

Straterra's view, and this is consistent with the views expressed by Newmont Waihi Gold, Pike River Coal and OceanaGold in their submissions, is that the threshold for allowed activity in Schedule 4 land should be raised, so that sufficient prospecting activity can be conducted, including drilling, such that an economic deposit could be identified. This change is relatively minor, in that the highest 'impact' activity that would typically be carried out in a mineral assessment program would generally be drilling. An area measuring 10m x 20m is sufficient to establish a drill pad from which one, and sometimes more, holes can be drilled. In many areas the drill rig and pads will be flown in by helicopter

The key advantage of this approach is that any debate about removing an area of land from Schedule 4 would only occur when a mining company had completed sufficient work to justify a project proposal, and the debate would then be fully informed by the economic and environmental assessments that had been carried out. Also, the land under consideration would be relatively small and very specific – the area required for an opencast mine might typically be a few hundred hectares[5], and the area required for a typical underground mine would be measured in tens of hectares. We note that the Department of Conservation, as custodians of all conservation land, has considerable experience and expertise in establishing and managing access agreements for mining companies to conduct prospecting programs. This is particularly true of the West Coast Conservancy and, while the process is rigorous, most mining companies understand it and are in agreement with the requirements and standards set by that process.

It will be important for explorers and investors that clear guidelines are developed for the consenting process on Schedule 4 lands. Mining companies need a clear understanding of the process and guidelines for getting consent for a project so they can make their own risk assessment. This does not mean a mining company needs certainty – that is not possible under New Zealand's legislation – but they do need confidence that if a 'suitable' balance of economic and environmental issues is achieved, a project is 'likely' to be consented.

Parameters and protocols for this 'balance' would need to be developed to give companies that confidence. This could be done jointly by Crown Minerals and the Department of Conservation, with advice from industry and NGOs as appropriate.

This approach would allow good decisions to be made for the benefit of New Zealand and avoid the pitfalls of arbitrary decisions being made over land for which we have insufficient information. Full consideration of the range of issues related to a specific area, including existing environmental values, impact of the proposal, the opportunity to

[5] 100 hectares equals 1 square kilometre

add value to the environment and the social and economic value the project creates, does not guarantee consent for a particular project. However it does allow the mining company to make an assessment of these issues, and therefore the risk of continued investment in the project.

Lastly, there has been public comment about the attractions of 'surgical mining' as a way to minimise surface impacts. The mining industry employs advanced technologies and has been a leader in the development of sophisticated technologies to minimise environmental impacts during mining. However, Mother Nature determines the physical characteristics of an economic ore deposit, and a mining company, as part of the assessment of the project, will determine the optimal technologies to apply to the project.

Some companies may adopt a policy to consider only underground projects because of their corporate assessment of the risks involved in getting development consent. As a country however, we have a legislative framework that guides the investment decisions companies make. Straterra believes there should be no regulation of one type of mining versus another until there is an understanding of the physical dimensions of any deposit discovered.

Economic Benefits of the Resource Sector

Much has been made of the economic issues surrounding the mining sector and the benefits that might arise from the Government's proposals. There have been many estimates of potential and indicated value across the resource sector and the Discussion Paper cites a number of these.

Straterra commissioned NZIER to prepare a report[6] that assesses the value of the resource sector in the New Zealand economy, and models the impact of two 'typical' resource projects as a way of illustrating the benefit of such development. The report is attached to this submission as Appendix A, and some key findings are included in this section.

Value of mining to the New Zealand economy

Between 2000 and 2006 the total volume of minerals produced from the mining and quarrying industries grew by 31% and the value by 66%. The sector contributed $1.5 billion or 1.1% of New Zealand's real GDP in the year to March 2009.

Oil is New Zealand's third largest export currently and in 2009 New Zealand earned $3.6 billion in revenue from exports of oil, coal, minerals, gases and ores representing 8.2%

[6] NZIER (2010)

of total exports. Royalty payments from the sector in 2008/09 were $519 million. In addition the sector paid the government $38 million in energy resource levies.

The sector directly employed 6800 people in 2009, a growth of 17% over the past five years compared to growth of 4% in total numbers employed in New Zealand. A further 8000 people are employed in supplying goods and services to the sector.

In employment terms this equated to New Zealand's wine industry and yet the quarrying, mining and oil and gas sector earns three times as much export revenue and contributes over 4 times as much to GDP.

All this comes from 4000ha of land compared to the 30,000ha used for the wine sector.

The current drive to improve our productivity plays well in the Mineral Resources sectors which has the highest GDP per employee at a level 3.6 times greater than the New Zealand average. On an exports per hectare basis the mining and quarrying sectors produce $175,000/ha, some 150 times as much as the average across all New Zealand.

Economic benefits of new resource discovery

NZIER estimate that the long run benefits to the economy of one new gold mine that produces 100,000oz[7] annually would increase GDP by 0.28% or $0.5 billion in total, over its productive life.

In the same way NZIER has estimated that a single oil field which produces 50 million barrels over its life, or about 4 million barrels per year, would increase GDP by 1.5% or $2.8 billion over it's productive life.

Taken together the two hypothetical developments would have the direct effect of increasing GDP by 1.8% or $3.3 billion.

There would also be flow on benefits for the rest of the economy and in this case they are clearly positive. Non building construction is the biggest winner through supplying the industry, but residential property and retail both benefit as well. The large royalty payments would benefit Government expenditure in areas such as health and education.

In terms of results at a national level these reasonably modest developments have the potential to make New Zealanders $3.3 billion dollars better off and lead to a 2%

[7] This is a medium sized gold mine that would produce annual revenues of $150m and employ around 85 people permanently . By comparison, OceanaGold operations in New Zealand produced in excess of 300,000oz of gold in the last Financial Year.

increase in wage growth across the economy. Private consumption, imports and exports would also enjoy strong growth.

One of the key assumptions in doing this analysis has been the price of gold and oil. As these are set by world prices NZIER have provided a sensitivity analysis to assess the impact of commodity price and exchange rate variations. At $50 and $110 per barrel and $800 and $1200 per ounce for oil and gold respectively the positive outcome for the economy ranges from a $1.6 billion to $5.1 billion increase in GDP.

Other factors

Beyond the pure economic analysis we need to look at some of the other areas affecting the level of investment in the minerals sector in New Zealand. The Fraser Institute in Canada publishes an international survey of mining companies assessing how policy settings affect investment in minerals exploration around the world. In the 09/10 survey New Zealand ranked 33rd out of 72 countries or territories surveyed. In general New Zealand ranked well in terms of factors which affect the general economic or political environment – labour skills, infrastructure and political stability. However in relation to mining specific policy settings New Zealand ranks below average. South Australia, the highest ranked Australian State, obtained its ranking based on the certainty and the quality of it's geological database. The interesting thing here is that the certainty element seemed to be more important than the actual policy setting. Resolving the question of access to Schedule 4 land will be seen by explorers as an important improvement in the quality of New Zealand's mineral legislation.

Another point to note is that the highly rated jurisdictions in the survey are not those with weak Government controls or uninformed populations. In many cases they are places with similar social and legal frameworks to New Zealand. This suggests that New Zealand could attract much more investment into this area with appropriate policies.

There is a misconception that because some mining companies have foreign ownership, the benefits of mining in New Zealand by those companies are sent off shore. Recent studies show that in excess of 90% of the turnover of both the Macraes mine in Otago, and the Newmont mine in Waihi have stayed in New Zealand in the form of wages, payments to suppliers and other production costs. This is where additional benefits for the country lie beyond the tax and royalty payments to the government. In addition, persons with New Zealand addresses figure prominently among the shareholders of OceanaGold, and Pike River Coal, the two significant mining companies listed in New Zealand.

There is also the issue of where the investment is going to come from to unlock our natural resources. The lack of depth in our capital markets and the fact that we are poor savers by international standards means that much of the money required is likely to come from international investors. This has certainly been the case so far and is common to most of the main industry sectors in New Zealand. It is crucial to the sector that foreign investment is available and encouraged.

The value of the money retained in New Zealand not only pays for the wages directly but indirectly sustains many jobs and businesses in the community. For example the Waihi community receives about $40 million per year from the Newmont Waihi Gold operation in the town. Pike River Coal spends more than $20 million per year in the Greymouth community.

Environmental Impact

Much of the debate has focussed on the environmental impacts of mining. Straterra commissioned Lane Associates to produce a report[8] that assessed how environmental management works in modern mining and broadly what environmental impacts could be expected from a 'typical' mining project.

Central to the discussion is the role of the Resource Management Act (RMA). This legislation controls all mining activity in New Zealand and imposes the highest standards of environmental protection on the industry, including any activity on Schedule 4 land.

The Lane report notes that the RMA can and does prevent inappropriate development. In Schedule 4 areas the higher environmental values will be assessed as part of the decision making process. The RMA is world class legislation and has been well studied around the world. For areas of special character or values this means only projects of extreme significance would ever be considered given the costs and timeframes required to consent such projects.

Lane's report looks in detail at the long term environmental issues affecting mining including Acid Rock Drainage (ARD). This was not well understood prior to the 1970s. However significant work has been done since then to better understand the process and to mitigate its effects. Many of the legacy issues involving old, closed mines involve ARD. In modern mines waste and tailings areas are engineered to prevent ARD impacts.

Permanent landform modification is also a factor in mining, particularly for open pit mines such as Macraes and Martha. This is accepted by the industry and would typically rule out protected areas with outstanding natural landscapes.

Open pits have the most significant permanent effect on the landform as it is usually uneconomic and unjustified to return the last pit to its original state. Successful rehabilitation is always a part of the planning for a mining operation, and leaving a lake can provided additional amenity values for the community in which the mining occurs.

[8] Lane, M. (2010), Mining and the Environment ï an Overview (The full report is included in the appendices)

Disposal of overburden[9] which can result in topographical change is another significant issue in any open pit mining operations. However these areas are typically available for use as operations progress and there can be significant improvement in productive capacity of the land, post mining. An example includes the Grey River gold dredge where mined areas are now productive dairy pasture.

Tailing storage facilities have come in for criticism over the years. Much has been made of the possibility of catastrophic failure or the slow leaching out of metals over the years. Technology has advanced rapidly in this area and the need and means to prevent long term leaching is well understood. Prevention of these problems is an integral part of the environment protection requirements under the RMA.

In underground mining the waste rock is typically disposed of underground by backfilling the voids left by mining so there is very little long term effect on the landforms. There may be some temporary requirement for stockpiling on the surface while waiting to backfill the voids and there may be some requirement for extra material to make up for that which is permanently removed.

Ground subsidence has been an issue in some historic mining areas around New Zealand. For all forms of mining now the geotechnical and technological issues are well understood and subsidence can be managed or prevented, as is appropriate.

The use of cyanide in the gold recovery process is commonly misunderstood and has led to much emotive debate even though its use is common in many industrial processes inside and outside the mining industry. Interestingly the technique was first used in New Zealand in 1889 with excellent results and the New Zealand Government bought the patent rights to make it more readily available to the mining industry. Cyanide is unstable and breaks down naturally with exposure to sunlight and air and it is not bio-accumulative. At Waihi water has been discharged directly into the local stream two years after being put in the tailings impoundment and natural processes have done their work. In any closure scenario any chemical residues in the tailing would be reduced to safe, permitted levels during the closure period.

Noise, vibration and dust all affect people and each of these issues is carefully managed and considered during the consent processes. Mining operations have a good record of compliance with these conditions and are proactive at working with the communities they affect to minimise any friction these issues can cause.

Bond requirements for mining companies under the RMA and DOC access agreements are an integral component of any consents in New Zealand. These bonds are calculated

[9] Overburden is waste rock that overlies the economic ore below.

for each individual operation to ensure complete restoration is insured and are regularly reviewed during the life of the operation.

Biodiversity Offsets

Since the signing of the Convention on Biological Diversity in Rio in 1992, which had the aim of reversing the loss of biodiversity around the World by 2010, the industrial sector has led society in progressively adopting practices to ensure that development is managed to minimise its impact on the natural world.

The mining sector is a leading participant in this initiative. In 2001 the International Council on Mining and Metals (ICMM), launched the Mining, Minerals and Sustainable Development (MMSD) project which resulted in the adoption of 10 Principles including a commitment to:

> *Seek continual improvement of our environmental performance and contribute to conservation of biodiversity and integrated approaches to land use planning*

This international trend has been mirrored in the mining sector in New Zealand, with the adoption of environmental policies typified by Solid Energy New Zealand's (SENZ) Environmental Policy which sets the goal of achieving a net positive effect on the environment as a cumulative result of all its activities. To achieve this, SENZ has undertaken, amongst other actions, to participate in non-mining activities to ensure a net positive outcome is secured.

Biodiversity offsets are defined as conservation actions designed to compensate for the unavoidable impact on biodiversity caused by development projects, to ensure "no net loss," and preferably a net gain, to the environment. Offsets are only appropriate when the developer has first used best practice to avoid and minimize harm to biodiversity. Offsets should endeavour to create an environmental credit of the same type and in the same vicinity as the loss and its occurrence.

To understand the impacts of its mining and associated activities, SENZ regularly measures and reports its environmental effects and the measures taken to offset the residual and unavoidable impacts of its business. To ensure these measures are appropriate in terms of type and size, SENZ has joined the international Business and Biodiversity Offset Programme to enable input from a wide cross section of international expertise in this area. As part of this programme, SENZ has established a pilot project to trial techniques in biodiversity quantification and offset.

Strongman Mine, located in the Grey District on the West Coast, was worked both as a surface and underground operation, ceasing finally in 2003. Since that time restoration of the site has been ongoing and is now substantially complete. Despite this restoration work, the mining activity has resulted in a loss of biodiversity values in the immediate and adjacent areas. As part of their commitment to achieving a net positive gain to the environment, SENZ have committed to measuring the biodiversity loss and undertaking appropriate work to offset this.

The work on this project started in 2007 and the offset design will be complete by late 2010 with field work then scheduled through 2012. In undertaking the offset design, the loss has first been quantified using an internationally developed metric which is used in turn to quantify the offset itself. This project is being undertaken in conjunction with the local community, the Department of Conservation and local runanga. The results of the work are reported internationally and are subject to expert review.

The Strongman project is an example of how the mining sector is acknowledging the impacts of its activities on the environment in which it works and how it is proactively seeking to address those impacts to ensure the maintenance of New Zealand's natural capital.

Discussion Paper Issues

Straterra strongly supports the conclusions set out on Pages 1 to 3 of the Discussion Paper. Specific comments are as follows:

Q1 On the areas proposed for removal from Schedule 4:

Straterra strongly supports in principle the removal of these areas from Schedule 4 but, in light of the public reaction and the considerations presented in the Section titled 'Mining Exploration and Development' on page 9, draws the reader's attention to the proposal headed 'An Alternative Approach' (page 11).

Straterra sees this initiative as one of many that can help build the New Zealand economy. This submission has presented the case for the contribution new mining projects can make to the New Zealand economy and the areas identified are clearly prospective.

We have not chosen to discuss each area individually because there is little value to be added by doing so. Companies wishing to explore will apply for permits in the areas made available, as they see fit, and carry out their prospecting programs. This is the appropriate response and this response will yield the economic and environmental knowledge that will justify, or not, further assessment.

Q2 On the areas proposed for addition to Schedule 4:

Clearly there needs to be suitable analysis and assessment of both the economic potential, and the environmental values, of any land prior to addition to Schedule 4. Providing this has occurred, Straterra has no objection to these areas being added.

Q3 On the assessment of areas:

Straterra supports the assessments of the areas as presented in the Discussion Paper, and draw the readers attention to the discussion in the Section titled 'An Alternative Approach' on page 11 of this submission. We also note that there are many other areas of Schedule 4 land which are at least as prospective as the areas identified. Under Straterra's proposal these areas could be assessed, for both economic and ecological values, prior to any decision to remove any of the areas from Schedule 4.

Q4 On the proposal to further investigate the mineral potential of some areas:

New Zealand is not high on the list of attractive destinations for mineral exploration globally[10]. Other regions have been active in carrying out baseline survey work such as that proposed in the Discussion Paper, and this has, in the case of South Australia for example, yielded spectacular results in terms of increased activity.

Straterra therefore strongly supports the further investigation of the areas suggested by Government. The priority should be areas of Schedule 4 because the additional information gained may assist in the assessment of what additional areas should be removed from Schedule 4 over time, or for which a higher threshold of prospecting activity should be allowed.

This initiative could be part of a broader strategy to do more baseline assessment in other prospective parts of New Zealand, and in the Exclusive Economic Zone.

The industry is willing to contribute resources to work with the Government on the work program on which this investment will be applied to ensure that New Zealand receives the best value for the investment made.

Q5 On a new contestable conservation fund:

Straterra is strongly supportive of the creation of the fund. The concept of the Government and industry 'giving back' is a good one.

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[10] Fraser Institute, (Feb 2009), Annual Survey of Mining Companies 2008/2009

We suggest that the fund should be governed by an independent panel as suggested, but run by the Department of Conservation. The priority would be to enhance the environment in a way that is additional to current activity. The principles under which the fund would be managed need to be clearly set out. The outcomes must be measurable and transparent.

Straterra supports the amounts proposed but suggests this be subject to review after an agreed period – say three years.

Q6 Approval of Access arrangements.

The overall objective in these proposals is to achieve a balance between environmental and economic considerations in relation to potential and actual projects. Virtually all activities we undertake in our society involve a balance of economic, social and environmental considerations, whether these activities are focussed on agriculture, tourism, town planning or other sectors.

For resource sector activities it is appropriate that the custodian of the mineral estate, the Minister Energy and Resources, has shared responsibility with the Minister of Conservation. Joint decision making allows a balance to be achieved by the Crown, as owner and custodian of the mineral and conservation estates, for the grant of access to conservation land.

Straterra supports the proposal for a joint decision to be made.

APPENDIX I

The Current and Potential Contribution of New Zealand's Mineral Resources Sector
NZIER

Diamond in the rough

The current and potential economic contribution of New Zealand's mineral resources sector

An NZIER report to Straterra

May 2010

About NZIER

NZIER is an independent specialist consulting firm that uses applied economic research and analysis to provide a wide range of strategic advice to clients in the public and private sectors, throughout New Zealand and Australia, and further afield.

NZIER is also known for its long-established Quarterly Survey of Business Opinion and Quarterly Predictions.

Our aim is to be the premier centre of applied economic research in New Zealand. We pride ourselves on our reputation for independence and delivering quality analysis in the right form, and at the right time, for our clients. We ensure quality through teamwork on individual projects, critical review at internal seminars, and by peer review at various stages through a project by a senior staff member otherwise not involved in the project.

NZIER was established in 1958.

Authorship

This report has been prepared at NZIER by Brent Layton, Johannah Branson, Claire Gall, Chris Schilling and James Zuccollo

Executive summary

Straterra is the industry group representing New Zealand's mineral resources sector. Amongst Straterra's aims is ensuring the availability of accurate information about the sector to enable government policy and public opinion to be based on full consideration of all the facts. To support this aim, Straterra has commissioned NZIER to provide an independent "exploration" of the current and potential contribution of the mineral resources sector to New Zealand's economic and social well-being.

Current contribution

For the purpose of this report, we define the mineral resources sector to comprise metals (e.g. gold, silver, ironsand), non-metallic/industrial minerals (used by almost every industry in a very wide range of products, including glass, steel, paper, paint, carpet, cosmetics and many other manufactured goods), aggregates (rock, gravel and sand), hydrocarbons (coal, gas and oil) and geothermal energy.

The mineral resources already makes a significant contribution to the New Zealand economy:

- In 2008, New Zealand's mining and quarrying industries extracted almost 49 million tonnes of metals, non-metals including aggregates and coal, from over 800 active mining and quarrying operations, with an estimated total output value of over $2 billion.
- Between 2000 and 2008, the total volume of this output grew 19%, but its total value more than doubled.
- In 2008, New Zealand extracted over 141 billion cubic feet of gas. This year also saw near record oil production of 21 million barrels, valued at $2.8 billion.
- Annual oil output has risen 53% since 1990, despite some fluctuation over the time period. Gas output has also fluctuated, but ended 2008 14% lower than in 1990.
- In 2008, the supply of geothermal energy reached 113 petajoules, worth $848 million.
- The annual output of geothermal energy has risen 22% since 1990.

In the year to June 2008, the mineral resources sector paid $181,000 in royalties and other taxes for each person employed, over seven times the average across all industries in New Zealand and over 25 times the average in the hospitality industry.

Current contribution continued

- Over the past 20 years, the mining, quarrying and oil and gas exploration and extraction sector has contributed on average 1.2% to New Zealand's annual total real GDP. Its relatively modest contribution to GDP belies the sector's importance as a supplier of essential inputs into other sectors.
- Oil is New Zealand's third largest earner of export revenue after dairy and tourism. In the year to March 2009, New Zealand earned $3.6 billion from exports of coal, crude, minerals, gases and ores, 8.2% of total export revenue.
- Over the same year, the mining, quarrying and oil and gas exploration and extraction sector employed on average 6,800 people, 0.31% of all people employed in New Zealand. In addition to workers employed directly within the sector, around a further 8,000 people are employed in supplying goods and services to this sector.

In the year to June 2009, the sector paid over $519 million in royalties to the Crown. Oil provided 98.5% of these royalties, with ironsand, coal and other minerals together providing the remaining 1.5%. In addition, gas provided $31 million and coal $7 million in energy resource levies.

In the year to June 2008, the mineral resources sector paid $181,000 in royalties and other taxes for each person employed, over seven times the average across all industries in New Zealand and over 25 times the average in the hospitality industry.

The mineral resources sector directly employs around the same number of workers as the wine industry, but earns three times as much export revenue and contributes over four times as much to New Zealand's GDP, using less than one seventh of the land area.

The mineral resources sector directly employs around the same number of workers as the wine industry, but earns three times as much export revenue and contributes over four times as much to New Zealand's GDP, using less than one seventh of the land area.

Combined, the two developments would increase GDP by 1.8%, or $3.3 billion, over and above what it would be without these developments.

Potential contribution

To explore the potential contribution to the New Zealand economy of further development of the mineral resources sector, we model the impacts of two modest but realistic hypothetical developments – a 1.5 million ounce goldmine development on the West Coast of the South Island and a 50 million barrel oilfield development offshore from Taranaki.

For this modelling, we use a computable general equilibrium model of the New Zealand economy, containing 131 industries, 210 goods and services and 14 regions. This model takes into account all the direct and indirect linkages between different industries, goods and services and regions over time in estimating the economic impacts – positive and negative – of these two developments.

The results of our modelling are:

- Both developments would make New Zealand wealthier, by unlocking currently unused or underutilised mineral resources. In both cases, New Zealand would undergo a positive resource or wealth shock. This is the primary driver of the results.

In the long run, the oilfield development would increase GDP by 1.5%, or $2.8 billion, in total over its productive life.

- In the long run, the oilfield development would increase GDP by 1.5%, or $2.8 billion, in total over its productive life.
- The goldmine development would increase GDP by 0.28%, or $0.5 billion, in total over its productive life.
- Combined, the two developments would increase GDP by 1.8%, or $3.3 billion, over and above what it would be without these developments.
- These GDP impacts are large relative to the those of expanding other sectors that use largely intermediate inputs to generate output that has much less added value than the outputs of the mineral resources sector.

Over the long run, changes in employment lead to positive wage growth throughout the economy. The developments would lead to a 2% increase in real wages, 1.5% due to the oilfield and 0.5% due to the goldmine.

- Over the long run, changes in employment lead to positive wage growth throughout the economy. The developments would lead to a 2% increase in real wages, 1.5% due to the oilfield and 0.5% due to the goldmine.
- The secondary driver of our results is the flow-on benefit of the wealth shocks on household expenditure, government expenditure and supplying industries. Higher employment and returns to capital boost national income and consumption. Under the model's assumptions, increased government revenue results in increased government expenditure distributed in the same manner as currently. As a result, royalty payments from the two developments raise government expenditure on public goods and services such as health and education. Higher personal incomes also result in more private consumption and imports.

Mineral resources sectors contribute 7.8% to total value added in Australia compared with 1.3% in New Zealand.

Growth prospects and challenges

The current policy interest in New Zealand's mineral resources sector has been partly stimulated by comparisons between the New Zealand and Australian economies and GDP per head. One obvious difference between the two economies is the relative importance of their mineral resources sectors, which contribute 7.8% to total value added in Australia compared with 1.3% in New Zealand.

The significance of this difference to attempts by New Zealand to close the gap between the two countries is underlined by the high value added per employee in the mineral resources sector. New Zealand's mineral resources sector provides the highest average value added per employee ($223,971), 3.6 times as much as the average across all New Zealand ($61,607).

Our endowment of mineral resources and access to skills and expertise, capital and markets are not materially inhibiting New Zealand from developing its mineral resources sector into a much larger contributor to the economy than it is currently. The main constraint is policy.

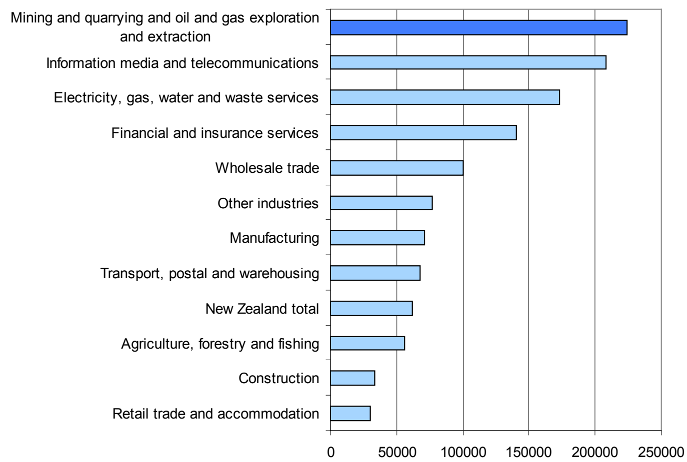
Endowment of mineral resources and access to skills and expertise, capital and markets are not materially inhibiting New Zealand from developing its mineral resources sector into a much larger contributor to the economy than it is currently. The main constraint is policy.

The two policy challenges New Zealand faces in further developing its mineral resources sector are, first, to determine whether it believes the economic and social benefits of this development outweigh its other consequences. Second, if the benefits are considered worth pursuing, the country needs to decide what policy settings it should adopt to encourage this development.

Internationally, New Zealand's current industry specific policy settings rate much less encouraging to mineral resources development than the policies adopted in many other jurisdictions. Several of the Australian states and Canadian provinces rate very highly in terms of the encouragement their policy settings provide to mineral resources development. These states have similar legal and social backgrounds to New Zealand and communities with similar attitudes to environmental protection. This augurs well for New Zealand's ability to develop policies that meet both the community's expectations in relation to development of the mineral resources sector and the requirements of investors and operators in the sector. The policy obstacles appear to be resolvable.

Real GDP per employee by industry 2009

Real (constant prices, 1995/96 dollars), production measure, $ per employee



Source: NZIER, Statistics New Zealand

Contents

Appendices

Figures

Tables

1. Purpose of this report

Straterra is the industry group representing New Zealand's mineral resources sector. New Zealand's mineral resources are primarily publicly owned, but, before Straterra, there was no single agency with a mandate to represent parties interested in the development of our mineral resource potential. Straterra was launched in 2008 to fulfil this role, encompassing and representing the interests of every part of the minerals sector, including metals, aggregates and hydrocarbons.

Exploration and extraction of new mineral resources inevitably raise concerns and sometimes conflicts. Amongst Straterra's aims is ensuring the availability of accurate information to counteract some of the misconceptions about the sector and to enable government policy and public opinion to be based on full consideration of all the facts.

To support this aim, Straterra has commissioned NZIER to provide an independent "exploration" of the current and potential future contribution of the mineral resources sector to New Zealand's economic and social well-being.

2. Current contribution

2.1 What are mineral resources?

For the purpose of this report, we define the mineral resources sector to comprise:

- metals – e.g. gold, silver, ironsand, aluminium, copper, lead, mercury and zinc
- non-metallic/industrial minerals – e.g. clay, pumice, silica sand, limestone, sulphur, phosphate and salt
- aggregates – rock, gravel and sand
- hydrocarbons – coal, natural gas, oil and coal seam gas and
- geothermal energy – although not strictly “mineral”, this is one of the “natural resources” extracted from beneath New Zealand and part of Straterra’s interests.

2.2 What are they used for?

The outputs of our mineral resources sector have a very wide range of uses throughout the economy. Some examples demonstrate their diversity and utility.

2.2.1 Metals

Most gold mined in New Zealand is exported, for use in jewellery and in fabrication and electronics in the telecommunications, aviation and other industries.

Most of our silver is also exported. Its main use is in photography, as well as in jewellery, silverware, electronics and medicine.

Ironsand is used to make steel, in New Zealand or exported to steel makers in other countries. Modern society was founded on the use of steel, especially in construction and transportation.

Tungsten, in the form of tungsten carbide, is a very durable material used to make machine tools subject to intense wear and abrasion and in other industrial uses including electronics and lighting.

2.2.2 Non-metals

Industrial minerals are used by almost every industry in a very wide range of products, including glass, steel, paper, paint, carpet, cosmetics and many other manufactured goods.

One of the most common non-metals is limestone for use in cement, roading, pottery and agriculture.

Others include clays for use in pottery and ceramics but also in the production of beer, wine, laundry detergent, paper, paint, pharmaceuticals and animal health products, dolomite used in agriculture, home gardening and glass making, sulphur used in fertilisers, pumice used in the production of wallboard, plaster and lightweight concrete, and silica sand used in glass making and in the building industry.

2.2.3 Aggregates

Aggregates are the most commonly used mineral products, primarily for roading, building, construction and fill.

2.2.4 Hydrocarbons

Around half of our coal is exported and half used domestically in steelmaking, electricity generation and industrial use by energy intensive industries such as forestry, dairy, meat and cement, as well as for commercial and home heating. Coal has a wide variety of industrial uses besides providing energy, including as activated carbon used in filters for water and air purifiers and kidney dialysis machines and carbon fibre used in construction, mountain bikes and tennis rackets.

The main use of our gas is in electricity generation, plus industrial uses including in methanol production, and for commercial and home heating.

Over 95% of our oil is exported, reflecting its high quality.

2.2.5 Geothermal energy

Geothermal energy also contributes to our national electricity generation and waste heat may be diverted to commercial heating in the vicinity of the plant.

2.3 How much do we produce?

2.3.1 Output

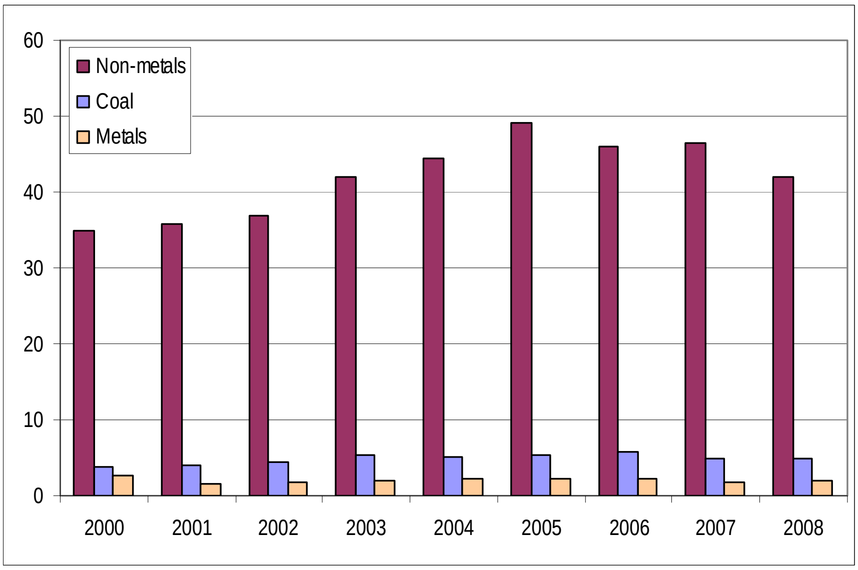
a) Mining and quarrying

In 2008, New Zealand's mining and quarrying industries extracted almost 49 million tonnes of metals, non-metals including aggregates and coal, from over 800 active mining and quarrying operations, with an estimated total output value of over $2 billion.[1] [2] Between 2000 and 2008, the total volume of this output grew 19%, but its total value more than doubled. This output is dominated by non-metals, as shown in Figure 1, although coal and metals have recently become higher earners, as shown in Figure 2.

[1] Estimated by Haworth and Barker (2009) – official data withheld by Crown Minerals for coal value in 2007 and 2008 for confidentiality (to avoid identifying performance of individual businesses).

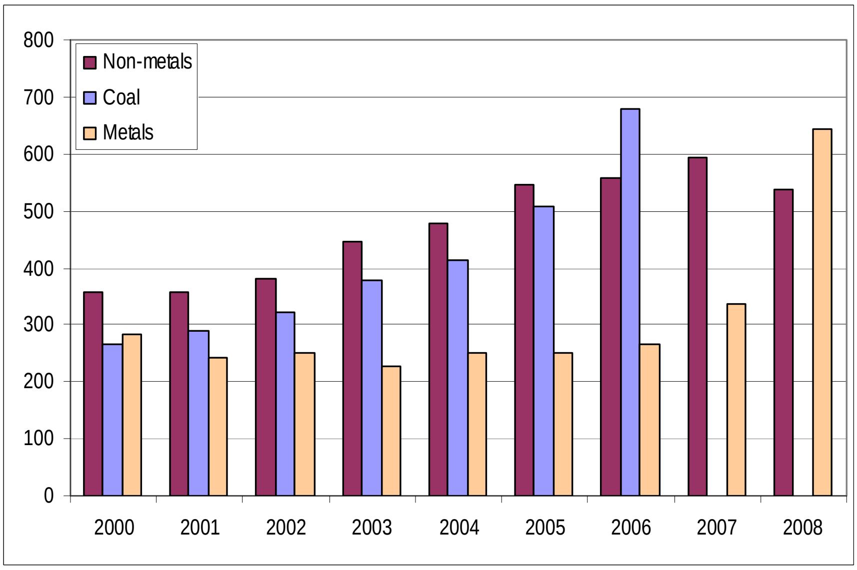
[2] All values throughout this report are expressed in New Zealand dollars, except where specified otherwise.

Figure 1 Mining and quarrying
Annual, calendar years, million tonnes



Source: NZIER, Crown Minerals (2009a)

Figure 2 Mining and quarrying output – value
Annual, calendar years, $ million, nominal (current prices)

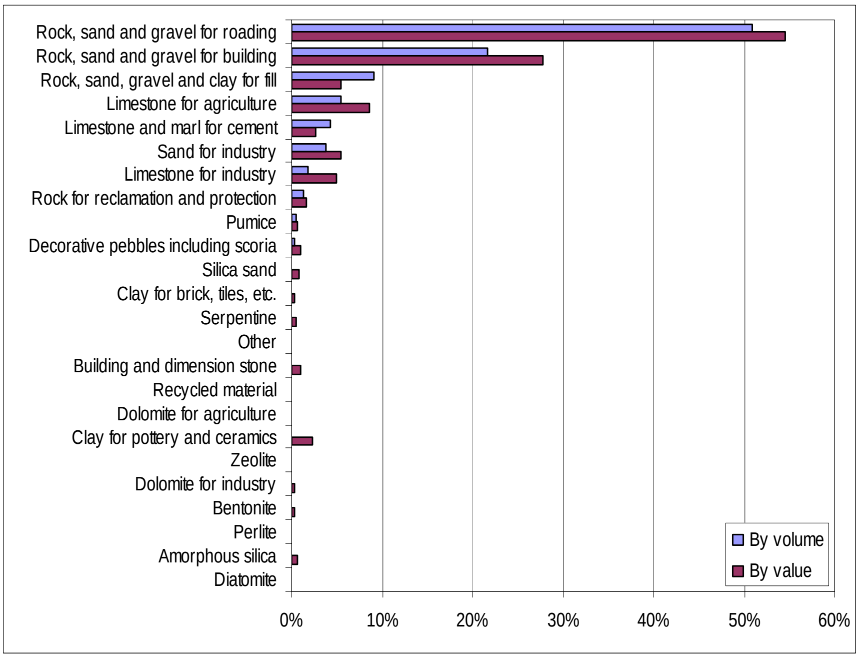


Notes: Data withheld by Crown Minerals for coal value 2007 and 2008.
Source: NZIER, Crown Minerals (2009a)

Rock, sand and gravel for roading, building and fill together typically account for over 80% of total non-metals output by volume and by value. Next most important is limestone for agriculture, cement and industry. The demand for aggregates and industrial minerals is driven by economic and population growth, with the downturn in non-metals in 2008 reflecting the recession in New Zealand and reduced export demand due to the global economic slowdown.

Figure 3 Output of non-metals

Percentage of total non-metals output, annual average 2000 to 2008



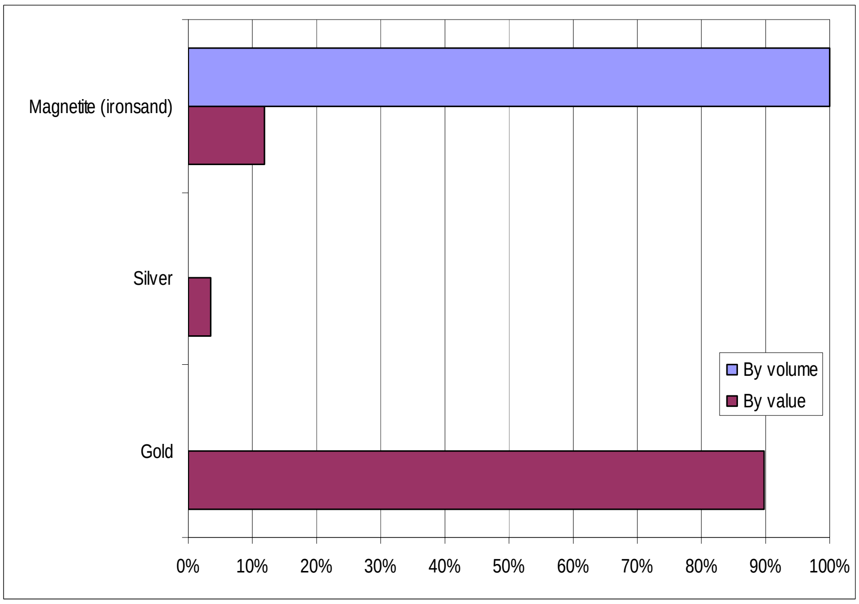
Notes: Data withheld by Crown Minerals for values 2000 to 2004 and 2008.

Source: NZIER, Crown Minerals (2009a)

Of total metals output, ironsand for export and steelmaking accounts for almost 100% by volume, in the average year, but 12% by value. In contrast, gold represents only 0.0005% of total volume, on average, but 90% of total value. In 2008, New Zealand's gold production exceeded 16 tonnes (523,000 ounces), its highest level since 1907 (Haworth and Barker, 2009), and also benefited from a high international price. Silver production this year was 31 tonnes and ironsand production over 2 million tonnes, but gold remained the highest earner, as shown in Figure 5.

Figure 4 Output of metals – annual averages

Percentage of total metals output, annual average 2000 to 2008

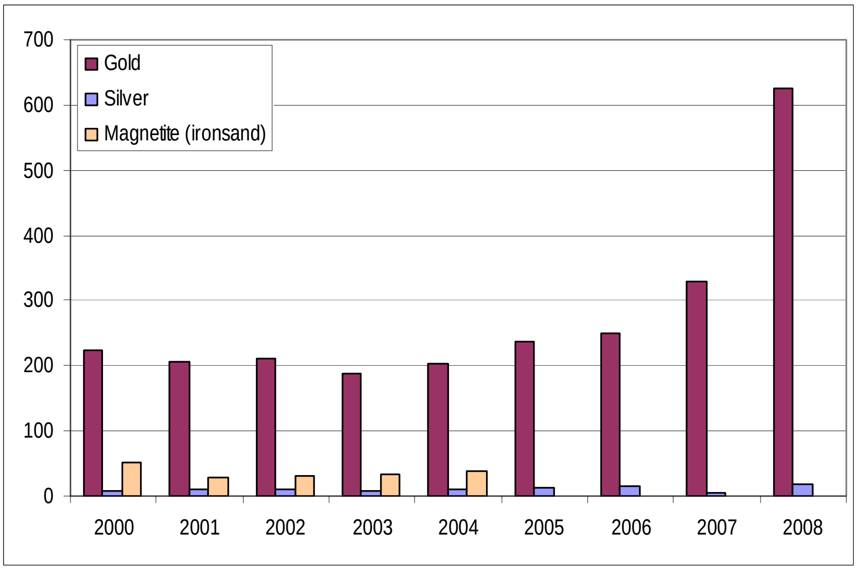


Notes: Average over years for which data available; data withheld by Crown Minerals for ironsand value 2005 to 2008.

Source: NZIER, Crown Minerals (2009a)

Figure 5 Output of metals – value

Annual, calendar years, $ million, nominal (current prices)



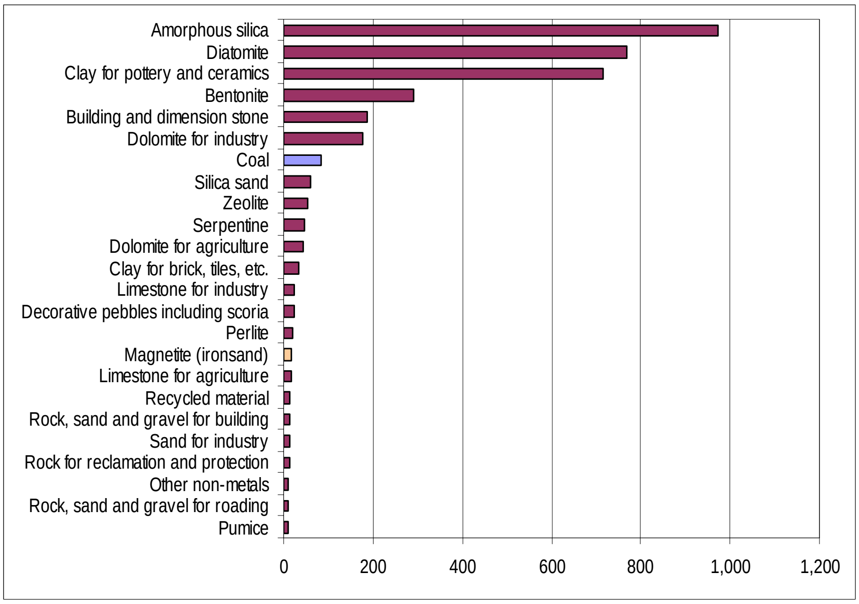
Notes: Data withheld by Crown Minerals for ironsand value 2005 to 2008.

Source: NZIER, Crown Minerals (2009a)

After gold and silver (with average unit values of $24.5 million/tonne and $0.4 million/tonne, respectively), amorphous silica (used in glass, optical fibres, ceramics and food), diatomite (used as a filtration aid, mild abrasive and absorbent), clay for pottery and ceramics and bentonite (used in cement, adhesives, ceramics and absorbents) have the highest average values per tonne, of all metals, non-metals and coal, over the years for which data are available, as shown in Figure 6.

Figure 6 Mining and quarrying output – unit value

Annual average, $/tonne, nominal (current prices)



Notes: Average over years for which data available; data withheld by Crown Minerals for ironsand 2005 to 2008, non-metals 2000 to 2004 and 2008, coal 2007 and 2008.

Source: NZIER, Crown Minerals (2009a)

New Zealand's coal has a relatively high unit value, averaging $83/tonne over 2000 to 2006. In 2008, output was 4.9 million tonnes, for export, steelmaking, electricity generation and industrial use, and contract prices rose in the second half of the year (Haworth and Barker, 2009).

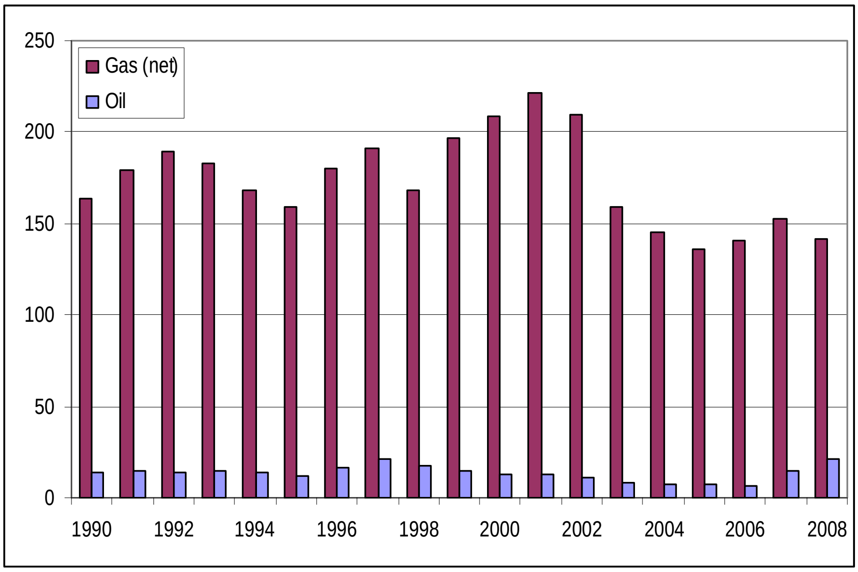
Mining and quarrying for non-metallic minerals occurs throughout New Zealand, but is greatest in the Auckland, Waikato, Northland and Canterbury regions (Barker *et al*., 2006). Mining for metals is concentrated in Otago and Waikato, plus a smaller amount in the West Coast. Coal mining is concentrated in the West Coast, Waikato and, to a lesser extent, Southland.

b) Oil and gas extraction

In 2008, New Zealand extracted over 141 billion cubic feet of gas (net of losses for gas flared, re-injected, extracted for LPG or extracted for own use). This year also saw near record oil production of 21 million barrels, valued at $2.8 billion (Crown Minerals, 2009b). Annual oil output has risen 53% since 1990, despite some fluctuation over the time period shown in Figure 7. Gas output has also fluctuated, but ended 2008 14% lower than in 1990.

Figure 7 Oil and gas output – volume

Annual, calendar years, billion cubic feet (gas) and million barrels (oil)



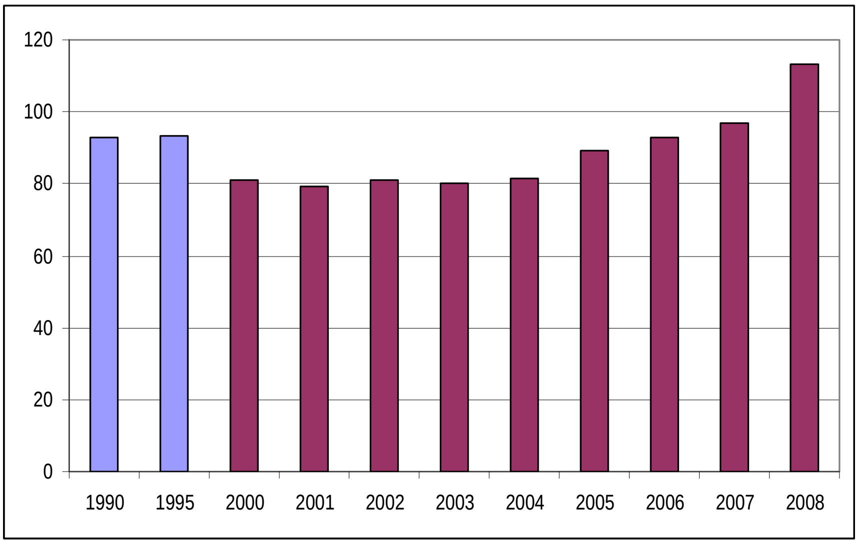
Source: NZIER, Ministry of Economic Development (2009)

c) Geothermal energy

In 2008, the supply of geothermal energy reached 113 petajoules. At an average value of $7.50/GJ, 2008's output was worth $848 million. The annual output of geothermal energy has risen 22% since 1990, as show in Figure 8.

Figure 8 Geothermal energy output – volume

Annual, calendar years, petajoules



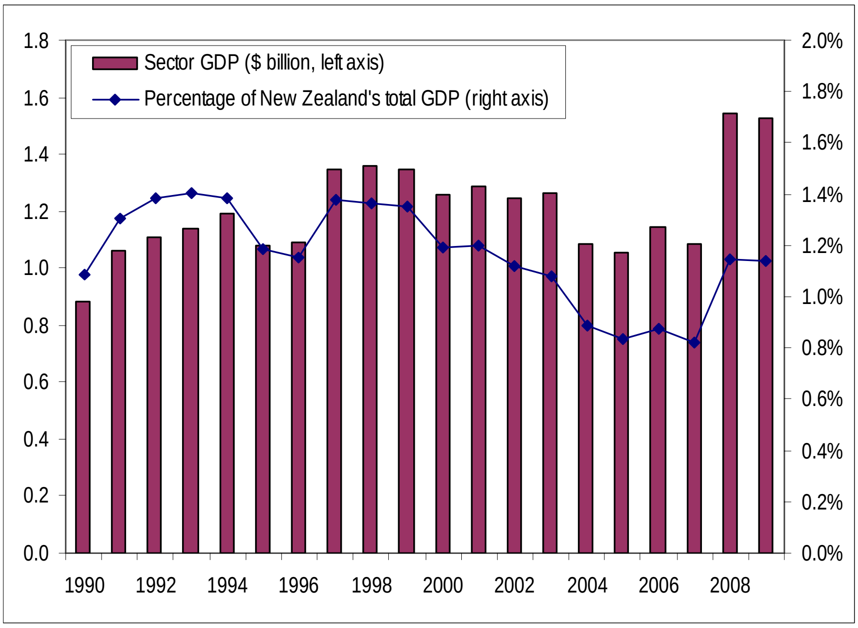
Source: NZIER, Ministry of Economic Development (2009)

2.3.2 Contribution to GDP

Over the past 20 years, the mining, quarrying and oil and gas exploration and extraction sector has contributed on average 1.2% to New Zealand's annual total real GDP. After a steady decline from 2000, this sector has shown a recent resurgence, as shown in Figure 9, due at least partly to investment in the Taranaki Basin (Department of Labour, 2010). By the year ending March 2009, this sector was contributing $1.5 billon, 1.1%, to New Zealand's total real GDP.

Figure 9 Contribution to New Zealand's real GDP

Annual, March years, real (constant prices, 1995/96 dollars), production measure



Source: NZIER, Statistics New Zealand

All this from less than 40 square kilometres of land throughout New Zealand, 0.01% of New Zealand's total land area (Barker, 2008).

The mineral resources sector is an integral part of the New Zealand economy. Its relatively modest contribution to GDP belies its importance as a supplier of essential inputs into other sectors. For example, New Zealand's high growth dairy and forestry sectors depend heavily on fertilisers and road transport, for which industrial minerals and aggregates are essential. Coal is an important source of energy for both industrial and domestic purposes. High value minerals, including some that are unique to New Zealand, bring in significant export revenue, even in small quantities.

2.3.3 Exports

Oil is New Zealand's third largest earner of export revenue after dairy and tourism. In the year to March 2009, New Zealand earned $3.6 billion in total from exports of coal, crude, minerals, gases and ores (compared with $10.0 billion from dairy and $9.3 billion from international tourism; Ministry of Tourism, 2009). This represents 8.2% of New Zealand's total export revenue. These exports have also shown a recent leap, as shown in Figure 10. Note that this excludes exports of products that use these materials as inputs or in the production process. In particular, our agricultural and forestry exports are heavy users of fertilisers and road transport, for which industrial minerals and aggregates are essential.

Figure 10 Share of New Zealand's exports

Annual, March years, nominal (current prices)

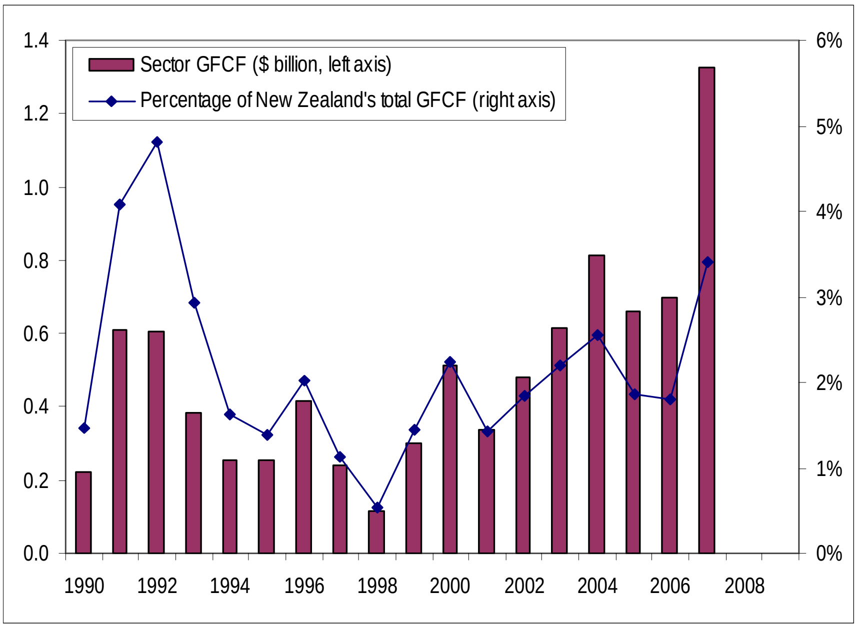
Source: NZIER, Statistics New Zealand (data available from June 2000 quarter only)

2.3.4 Investment

In the year to March 2007, $1.3 billion of total gross fixed capital formation (GFCF) was invested in the mining, quarrying and oil and gas exploration and extraction sector, 3.4% of total investment in New Zealand in this year. Since 1990, investment in this sector has averaged 2.2% of annual total GFCF in New Zealand. This has risen fairly steadily since 1998 and leapt in 2007, with investment in the Taranaki Basin (Department of Labour, 2010).

Figure 11 Share of New Zealand's investment

Annual, March years, nominal (current prices)



Source: NZIER, Statistics New Zealand (data available to 2007 only)

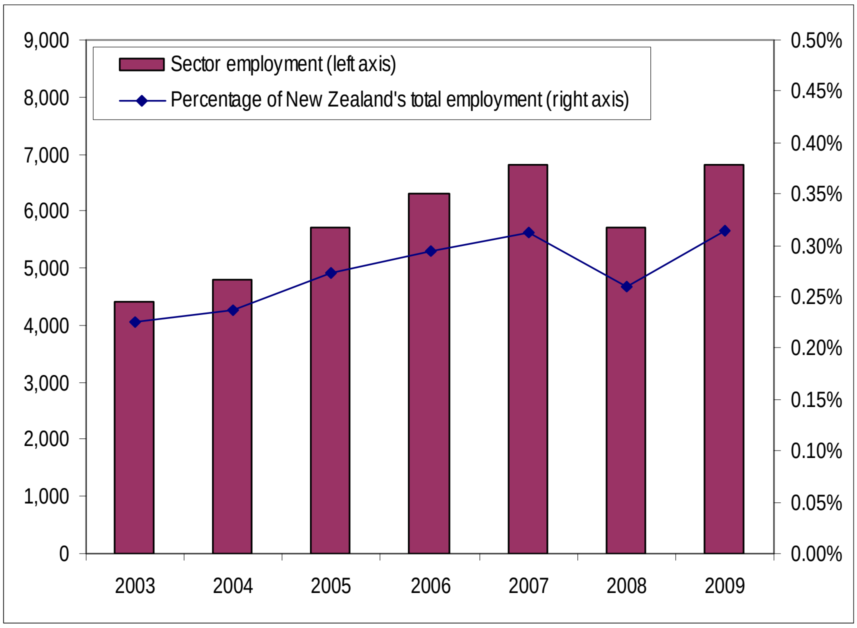
2.3.5 Employment

The mining, quarrying and oil and gas exploration and extraction sector is a relatively minor employer of New Zealand's total workforce, due in part to technological development which has made it now highly capital intensive (large amount of machinery per worker).

In 2009, the mining, quarrying and oil and gas exploration and extraction sector employed on average 6,800 people, 0.31% of all people employed in New Zealand. In addition to workers employed directly within the sector, around a further 8,000 people are employed in supplying goods and services to this sector (Department of Labour, 2010). It is still a very male dominated sector (almost nine out of 10 workers are male) and makes significant use of skilled workers from overseas (Department of Labour, 2010). More than four out of five jobs in the sector are outside the main centres of Auckland, Wellington and Christchurch (NZMIA, 2010).

Figure 12 Share of New Zealand's employment

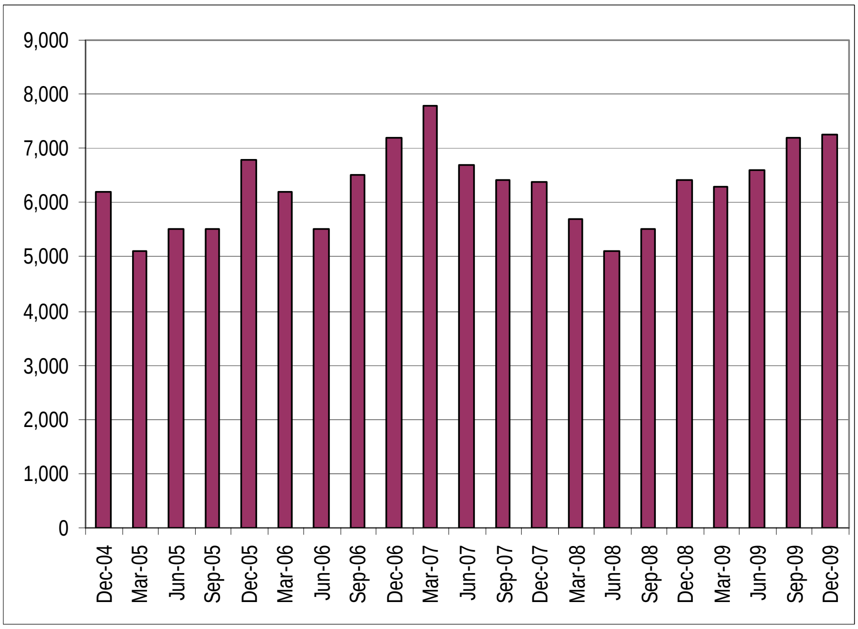
Numbers employed, annual, March years



Source: NZIER, Statistics New Zealand (data available from 2003 only)

Figure 13 Numbers employed

Quarter



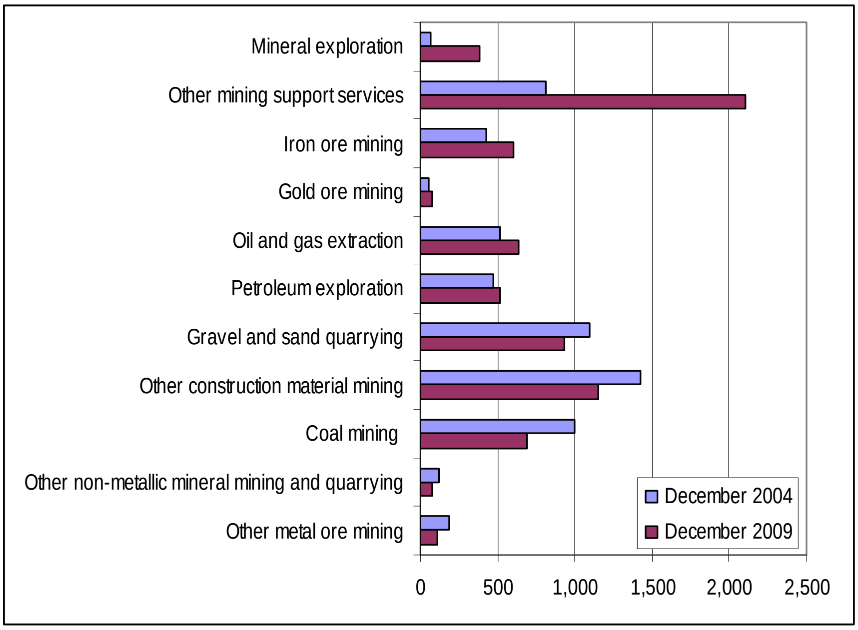
Source: NZIER, Department of Labour employment estimates

The number of workers employed in this sector has grown 17% over the past five years, compared with 4% growth in total numbers employed in New Zealand. As can be seen in Figure 13, employment in this sector peaked at 7,800 workers a year ahead of the New Zealand economy entering the 2008 recession, but also started to expand again a year ahead of the economy exiting recession.

Mineral exploration has shown the greatest percentage growth over this period, employing over five times as many workers at the end of 2009 and it did at the end of 2004. The greatest increase in number of workers employed was mining support services, employing an additional 1,290 people. Also showing strong employment growth have been iron ore mining, gold ore mining and oil and gas extraction. Employment has declined in other metal ore mining, other non-metallic mineral mining and quarrying, coal mining, other construction material mining and gravel and sand quarrying.

Figure 14 Numbers employed

Quarter



Source: NZIER, Department of Labour employment estimates

Furthermore, median earnings per worker in the mining, quarrying and oil and gas exploration and extraction sector have risen faster to 70% higher than the average across all New Zealand workers ($57,320 compared with $33,530, in 2008).

Figure 15 Median earnings per employee

Annual, March years, $ per employee

Source: NZIER, Statistics New Zealand

2.3.6 Royalty payments and other taxes

A further benefit to the rest of the economy is through the royalty payments collected by the Crown on mining, quarrying and oil and gas extraction and other taxes paid by the sector's businesses and employees.

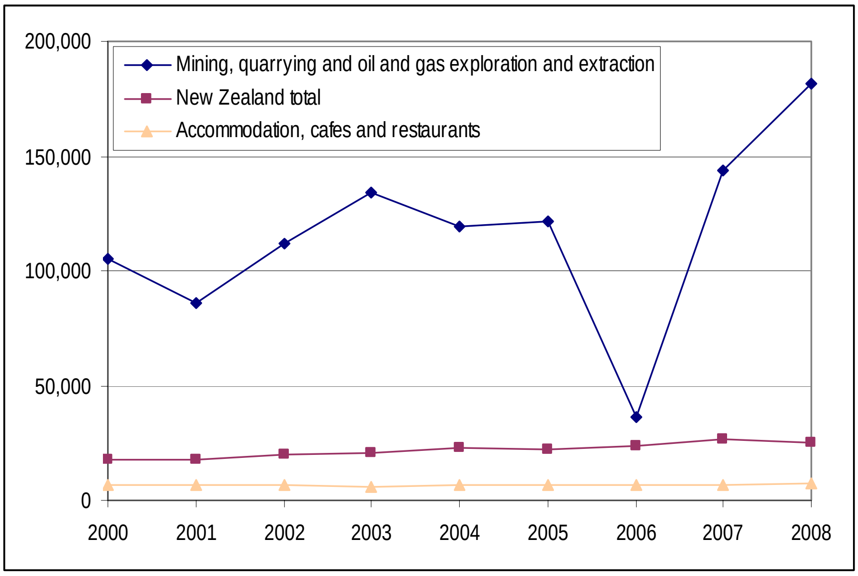
The Crown Minerals Act 1991 provides the right to charge a royalty on any mining permits issued by the Crown. The royalty for petroleum products is currently the greater of 5% ad valorem (net revenue obtained from sale of production) or 20% of accounting profits. For non-petroleum products the royalty regime comprises a specific royalty rate for low value to weight or volume minerals, such as clay, pumice and coal, and tiered ad valorem royalty for precious metals. For businesses that have annual net sales revenue of $1.5 million or less, the ad valorem rate is 1% and for those that have net sales over $1.5 million it is 2%. Very small businesses are exempt from royalties. These royalties, like general tax revenue, go straight into the government's consolidated revenue accounts to be spent on health, education and other public services.

In the year to June 2009, the sector's total royalty payments leapt 470% to over $519 million (Crown Minerals, 2009b). Oil provided 98.5% of these total royalties, with ironsand, coal and other minerals together providing the remaining 1.5%. In addition, gas provided $31 million and coal $7 million in energy resource levies (Treasury, 2009).

Together with corporate, income and indirect taxes, these royalty payments and energy resources levies make the mineral resources sector heavily taxed on a per employee basis, as shown in Figure 16. In the year to June 2008, the mineral resources sector paid $181,000 in taxes for each person employed, over seven times the average across all industries and over 25 times the average in the hospitality industry.

Figure 16 Average tax paid per employee

Income, corporate and indirect taxes, royalties and levies, annual, June years, $ per employee



Source: NZIER, Crown Minerals (2009b), Statistics New Zealand, Treasury (2009)

2.4 A jewel in our crown?

The above data suggest that, although smaller than the tourism industry, the mineral resources sector makes a larger contribution to the New Zealand economy than our prized wine industry. The mineral resources sector directly employs around the same number of workers as the wine industry, but earns three times as much export revenue and contributes over four times as much to New Zealand's GDP, using less than one seventh of the land area.

Table 1 Comparison with the wine and tourism industries 2008

March year

	Mineral resources sector	Wine industry	Tourism industry
Direct employment	5,700	5,940	94,200
Land area (ha)	4,000	29,810	n/a
Export revenue ($ billion)	2.715	0.899	9.400
Contribution to GDP ($ billion, nominal (current prices))	2.149	0.454	6.660

Notes: Direct contributions only – excludes input and processing/distribution industries.

Source: NZIER, Barker (2008), Ministry of Tourism (2009), NZIER (2009), Statistics New Zealand

3. Potential contribution

New Zealand is one of the most mineral rich countries in the world, with more than 600 known mineral deposits of 25 different mineral types within its total land area of 270,000 square kilometres (NZMIA, 2010).

We have so far exploited only a fraction of the available resources. Exploration to date has indicated substantial potential. The value of our in-ground metallic mineral resources has been estimated to exceed $140 billion, in 2008 prices (Barker, 2008, using Christie and Braithwaite, 1999). The value of our recoverable in-ground coal resources has been estimated to be around $240 billion, based on prices in 2004, which have since risen substantially (Barker *et al.,* 2006, using Barry *et al.*, 1994). New Zealand is currently in an exploration growth phase, which is likely to make further discoveries.

To illustrate the potential of the mineral resources sector to contribute further to the New Zealand economy, NZIER has modelled the impacts of two hypothetical but realistic individual developments on the New Zealand economy. We provide an initial investigation of the economy-wide costs and benefits of these developments. Both developments would make New Zealand wealthier by unlocking a previously unused or underutilised mineral resource. Unlocking this resource would cause New Zealand to experience a positive wealth shock. We explore how this wealth shock would reverberate throughout the rest of the New Zealand economy as our mineral exports rise.

3.1 Hypothetical developments

The two developments we have modelled are:

- discovery and development of another oilfield and
- development of another goldmine.

Both are hypothetical, but the cost and other data and timing of development we have used has been cross-checked against real developments that have occurred in New Zealand in the recent past. Both are relatively modest developments when compared with even the current scale of production of oil and gold. We have not assumed unrealistic or large developments to illustrate the potential for the economy.

3.1.1 Oilfield development

The hypothetical oilfield development is assumed to be offshore of Taranaki. We assume the exploratory drilling programme takes a year, consents a further year and development of the well another year. We assume bringing the well to production costs $400 million and takes five years from initial drilling.

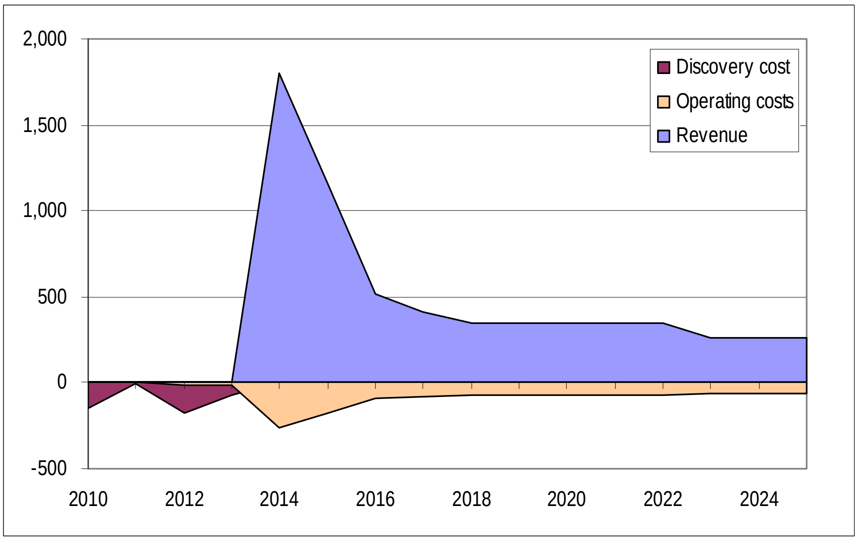
We assume that the well then produces a total of 50 million barrels of oil over a productive life of 12 years, or 4 million barrels per year on average. Current New Zealand annual oil production is just over 20 million barrels; the hypothetical development represents an expansion in oil production of approximately 20% on average. We assume a fixed world oil price of US$90/barrel throughout the production period. The production profile is heavily weighted towards earlier years, resulting in the spike in revenue shown in Figure 17.

We assume that extracted oil would be stored in a floating production storage and off-take (FPSO) vessel, before being transferred to a carrier for transportation to overseas markets. Use of a FPSO means that no pipeline to shore need be built, so we assume few shore facilities in our model. We assume that the FPSO would be dry leased for 14 years at a capital cost of $143 million and crewed by 35 people (two crews of 35, who rotate to shore).

Figure 17 shows the oilfield's main costs and revenues over time. The discovery costs include all costs of developing the field. Operating costs are primarily the marketing and shipping of the oil.

Figure 17 Costs and revenue of oilfield development

Annual, $ million



Source: NZIER

3.1.2 Goldmine development

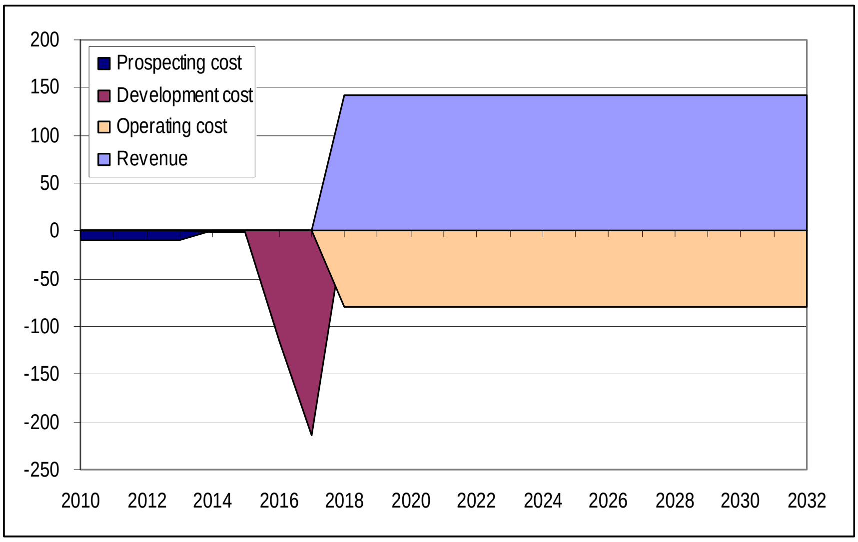
We assume that the hypothetical goldmine development is on the West Coast and takes four years to explore and prospect at a cost of $10 million per year. Prospecting employs 15 people for the four year period. The resource consent process takes another two years at a cost of $1 million per year and the mine's development a further two years at a cost of $30 million. We assume that development of the mine would employ around 50 people for the duration of construction.

We assume that the processing plant is built nearby over an 18 month period and costs $100 million to construct, employing 200 people. The mine then operates for 15 years and produces 100,000 ounces of gold per year (approximately 20% of the current annual production level), sold in export markets. Production and processing costs amount to $700 per ounce of gold and the gold is sold at an average world price of US$1,000 per ounce. We assume that the world price is not affected by the mine's production. The permanent staff of the mine and processing plant would be 85 people.

Figure 18 shows the goldmine's main costs and revenues over time. The large initial development cost takes until 2023 to recoup, if prospecting begins in 2010.

Figure 18 Costs and revenues of goldmine development

Annual, $ million



Source: NZIER, Straterra

3.2 Methodology

3.2.1 NZIER CGE model

We investigate the impacts of these two hypothetical developments using a static computational general equilibrium (CGE) model of the New Zealand economy. CGE modelling is a well-established and highly-respected technique, which has a rich history for assessing policy, regional and industry impacts. Our model was developed in close collaboration with Monash University, a global leader in building and applying CGE models.

The NZIER static CGE model contains information on 131 industries and 210 commodities in its basic form. It captures the various inter-linkages between these industries and commodities, as well as their links to households (via the labour market), the government sector, capital markets and the global economy (via imports and exports). For further information on the NZIER CGE model, see Appendix B .

The database underlying the NZIER CGE model was sourced from Statistics New Zealand's 1995/96 inter-industry tables, subsequently updated using Statistics New

Zealand's 2003 supply and use tables and finally scaled up to 2010 levels using the latest available Statistics New Zealand macroeconomic data.

3.2.2 Modelling approach

We are interested in estimating the potential contribution that these hypothetical developments could make to the New Zealand economy over the long run. We therefore do not model explicitly the time path of the developments (exploration and discovery, followed by investment and then production), but instead analyse a static, long-run scenario that estimates the overall contribution of the developments to the New Zealand economy. We use a long-run model "closure" that allows investment and capital to respond to growth, but fixes the labour supply at long-run trend levels.

We translate the two hypothetical developments outlined above into "shocks" or scenarios that the CGE model can analyse.

We assume that all production from these developments is exported, so the first shock that we model is the resulting increase in export volumes. The developments generate an estimated 50 million barrels of oil and 1.5 million ounces of gold for export over their productive lives. We assume a world price of US$90 a barrel for oil and US$1,000 per ounce for gold. The values of the export shocks are dependent on these world price assumptions, as shown in Table 2.

Table 2 Modelling scenarios

	Oilfield	Goldmine
World price (US$)	$90/barrel	$1,000/oz
Lifetime production	49.7 mmbbls	1,500,000 oz
Present value of production over productive life of development (NZ$ billion)	$3.469	$0.660

Source: NZIER

To model these export shocks, we fix the export price and require the necessary increases in export quantities in the model. We allow the productivity of the industry to be determined endogenously, increasing by the amount necessary to achieve these increases in production. The productivity gain is a proxy for the wealth generated by use of the mineral resources from these developments. Intuitively, the productivity gain approximates the growth in resources available to the industry and causes production and export volumes to rise.

An advantage of the CGE model is that it is based on an empirical "input-output" database that identifies the structure of the industries involved. Simulating the increases in exports that the developments generate in turn causes the oil and gold industries to expand within the model. This, in turn, leads to increased capital investment, employment, operational budgets and tax receipts for the government. We therefore do not need to shock the model further to generate demand for exploration and discovery services or to provide higher tax receipts. We do, however, tailor the shocks and database where appropriate to more realistically represent specific details of the two developments.

A second advantage of a CGE model is that it considers both the first round effects of the developments – increased production and increased returns to capital within the oil and gold industries – as well as the impact that this first round effect has on the rest of the New Zealand economy. For example, higher government tax receipts increase government spending.

On the other hand, the static approach used for this modelling has a number of limitations. Details are provided in Appendix C .

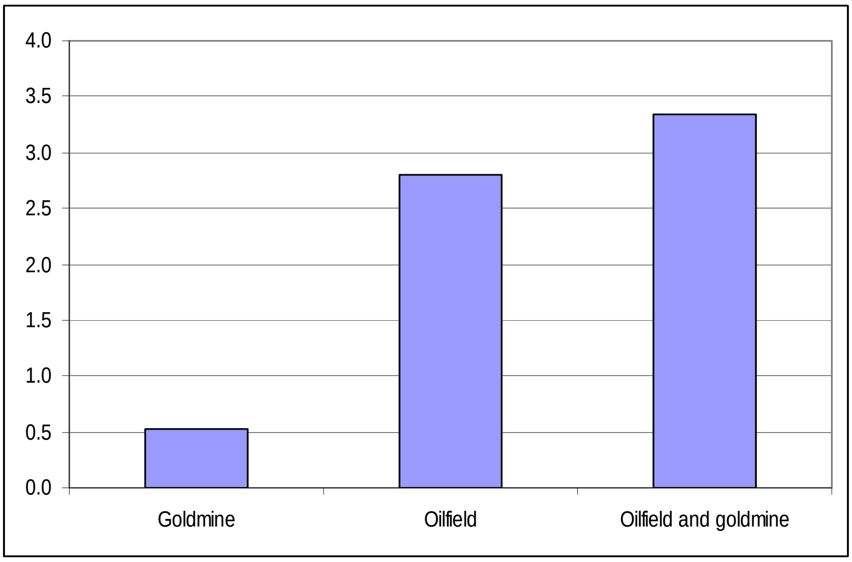
3.3 Results

3.3.1 Overview

Our analysis indicates that the two hypothetical developments both have significant, long-run, positive impacts on New Zealand:

- Both developments would make New Zealand wealthier, by unlocking currently unused or underutilised mineral resources. In both cases, New Zealand would undergo a positive resource or wealth shock. This is the primary driver of the results.

Figure 19 Impact of developments on GDP
Total present value over productive life, $ billion



Source: NZIER

- In the long run, the oilfield development would increase GDP by 1.5%, or $2.8 billion, in total over its productive life.
- The goldmine development would increase GDP by 0.28%, or $0.5 billion, in total over its productive life.

- Combined, the two developments would increase GDP by 1.8%, or $3.3 billion, over and above what it would be without these developments.
- Over the long run, changes in employment lead to positive wage growth throughout the economy (given the assumptions about the long-run labour supply). The developments would lead to a 2% increase in real wages, 1.5% due to the oilfield and 0.47% due to the goldmine.
- The secondary driver of our results is the flow-on benefit of the wealth shocks on household expenditure, government expenditure and supplying industries. Higher employment and returns to capital boost national income and consumption. Under the assumptions of the model increased government revenue results in increased government expenditure distributed in the same manner as at present. As a result the royalty payments mean more government expenditure on health and education. Higher personal incomes also result in more private consumption and more imports.
- The developments have high profitability. The increases in oil and gold production and revenue have a large impact on GDP. This GDP impact is high relative to the impact that would be experienced if the expansion occurred in other sectors that use largely intermediate inputs to generate output with little added value.

3.3.2 Detailed results

a) Interpretation

To analyse the detailed modelling results, we take a systematic approach to tracking the impacts as they flow through the economy, beginning with the direct impacts on the oil and gold industries. We then analyse the flow-on, or indirect and induced, impacts.

It can aid understanding to split the indirect impacts into the following categories:

- Household expenditure industries – industries that supply goods and services to households are likely to benefit from the increase in household incomes via the employment and wage impacts of the two developments, as well as increased returns to capital from growing oil and gold production. Such industries include housing, real estate and consumption goods.
- Supplying industries – mineral resources industries typically have a high degree of value-added, which simply means that, proportionately, they do not use large amounts of intermediate goods and services in production. Nonetheless, industries supplying goods and services to mining and quarrying and oil and gas exploration and extraction could be expected to benefit from the developments.
- Competing exporting industries – these are industries that suffer from growth in the mineral resources sector as they compete for resources that are now more expensive and face a stronger New Zealand dollar. Typically, these industries are the agricultural and manufacturing export industries, but in this case also include many downstream industries.[3]

[3] In a dynamic analysis, we would also consider the impacts on industries dependent on investment spending, such as commercial building and infrastructure construction. Due to the

- Government expenditure industries – the two developments result in increased royalty payments to the Crown. Under the standard assumption of the model, this increase in government revenue allows increased government spending, so we expect public sector goods and services, such as health and education, to benefit from the developments.[4]

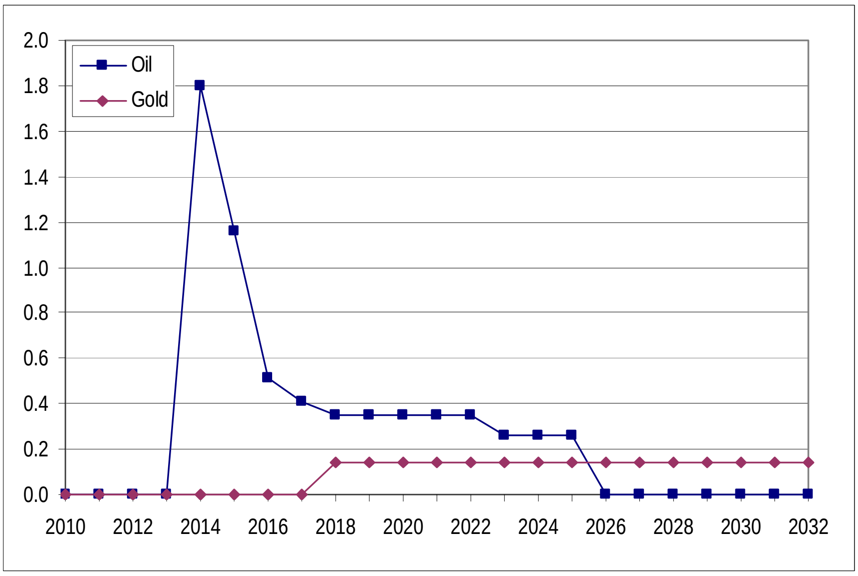
The specific details of each shock determine the size of each of the above indirect impacts.

The national results flow logically from the direct and indirect impacts. We focus on two key macroeconomic variables – real wages and gross domestic product (GDP).[5]

b) Direct impacts

The export volumes generated by the oilfield and goldmine developments, together with the world prices of oil and gold, are set exogenously. These result in increased revenue to the oil and gold industries as shown in Figure 20.

Figure 20 Additional oil and gold industry revenue
Annual, $ billion



Source: NZIER

These increases in revenue result in industry's value-added contribution to GDP rising by 245% and 71%, for the oilfield and goldmine developments respectively.

specifics of this analysis, in which we analyse the developments using a static model over the long run, we do not discuss the benefits to building and construction industries.

4 We would normally also consider the downstream industries that benefit, particularly from oil production. For this analysis, however, we assume no change to the price of oil faced by domestic downstream industries.

5 We also report the change in private consumption, which is a measure of economic welfare (how "well off" we are). Many economists see welfare as a better measure of economic benefit than GDP.

Capital and labour use grow, but by lesser amounts due to the developments using mineral resources (represented by increased productivity in the modelling).

c) Flow-on impacts

The flow-on impacts for household expenditure industries are clearly positive. Higher wages and returns to capital boost national income, leading to increased spending in industries such as retail and residential construction and property.

The non-building construction sector, a large supply industry for both the oil and gold mining sectors, sees strong gains from the developments as engineering services are used as intermediate inputs.

Competing exporting industries are negatively impacted by the increase in demand for the New Zealand dollar caused by increased oil and gold exports. The exchange rate appreciation results in them becoming less internationally competitive.

Finally, government expenditure industries such as health and education see positive gains from the developments. Large royalty payments increase government revenue, which in turn results in higher government spending, other things equal.

Table 3 Flow-on impacts on rest of economy

Percentage change in value added

	Oilfield and goldmine	Oilfield	Goldmine
Residential property (household expenditure industry)	2.4	2.1	0.4
Retail (household expenditure industry)	1.2	1.0	0.2
Non-building construction (supplying industry)	6.0	3.5	2.5
Horticulture (competing export industry)	-1.9	-1.6	-0.3
Textiles (competing export industry)	-3.7	-2.9	-0.7
Hospitals (government expenditure industry)	1.8	1.5	0.3
Schools (government expenditure industry)	1.7	1.4	0.2

Source: NZIER

d) National results

Table 4 summarises the results at the national level. It shows an increase in GDP, relative to business as usual without the two developments, of 1.8% or $3.3 billion, in total over the productive life of the developments. This is made up of 1.5% or $2.8 billion from the oilfield and 0.3% or $0.5 billion from the goldmine. Put simply, the oilfield and goldmine developments have the potential to make New Zealand $3.3 billion better off in terms of additional GDP over the long run.

The economy benefits from the wealth shocks of using previously unexploited resources to generate additional export revenues, resulting in increased wages and returns to capital for the mineral resources sector. This is the primary driver of the results.

The secondary driver of results is the flow-on benefits of the wealth shocks on household expenditure, government expenditure and supplying industries. Higher employment and returns to capital boost national income and consumption; higher royalty payments mean more government expenditure on health and education. Higher incomes result in more imports, in aggregate.

The developments also lead to strong positive wage growth, across the economy, of 2.0%, with 1.5% due to the oilfield and 0.5% due to the goldmine. Over the long run, we assume that labour supply follows population and immigration trends, thus growth in the economy puts upwards pressure on wages.

The potential contribution of the oilfield is higher than that of the goldmine because it produces more output. As identified in Table 2 above, we assume that the oilfield generates almost $3.5 billion in revenue over its productive life, in present value terms,[6] compared with the goldmine's $0.7 billion. Proportionately to the size of this production impact, the results for the oilfield and goldmine are similar.

Table 4 National results

Changes relative to business as usual

Development	Oilfield and goldmine	Oilfield	Goldmine
Real GDP (% change)	1.8	1.5	0.3
Real GDP ($ billion)	$3.334	$ 2.803	$0.531
Real wages (% change)	2.0	1.5	0.5
Private consumption (% change)	1.9	1.6	0.3
Real devaluation (% change)	-2.3	-1.9	-0.3
Imports (% change volume)	1.9	1.5	0.4
Exports (% change volume)	2.0	1.6	0.4

Source: NZIER

Finally, the modelling results are obviously sensitive to assumptions about the world prices of oil and gold. Higher prices would increase the estimated impacts proportionally.

3.3.3 Price sensitivity

Given that it is difficult to predict oil and gold prices over the long run and our results are sensitive to the average prices assumed, our estimates carry a degree of uncertainty. In this section, we therefore investigate the impact on our key results of higher and lower price assumptions.

The base assumption for the oilfield in the results presented above is an average price of US$90 per barrel. We now include a high price scenario where the average price is US$130 per barrel and a low price scenario where the price is US$50 per barrel. For the gold mine, the base price of US$1,000 per ounce is supplemented by

[6] Using a discount rate of 8%, as recommended by Treasury (2008) for use in cost-benefit analyses of public sector energy and water infrastructure investments.

a high price scenario of US$1,200 per ounce and low price scenario of US$800 per ounce. Table 5 shows the indirect effects of these higher and lower prices compared with the base prices assumed in the results presented above.

Table 5 Flow-on impacts on rest of economy – different price assumptions

Percentage change in value added, oilfield and goldmine

	Base price	High price	Low price
Residential property (household expenditure industry)	2.4	3.7	1.2
Retail (household expenditure industry)	1.2	1.9	0.6
Non building construction (supplying industry)	6.0	8.7	3.4
Horticulture (competing export industry)	-1.9	-3.0	-0.9
Textiles (competing export industry)	-3.7	-5.5	-1.8
Hospitals (government expenditure industry)	1.8	2.7	0.8
Schools (government expenditure industry)	1.7	2.6	0.8

Source: NZIER

The national results displayed in Table 6 show the same symmetry; higher prices increase GDP by a further 0.95%, while lower prices achieve a 0.95% smaller increase in GDP.[7]

Table 6 National results – different price assumptions

Changes relative to business as usual, oilfield and goldmine

	Base price	High price	Low price
Real GDP (% change)	1.8	2.8	0.9
Real GDP ($ billion)	$3.300	$1.600	$5.100
Real wages (% change)	2.0	3.0	1.0
Private consumption (% change)	1.9	2.9	0.9
Real devaluation (% change)	-2.3	-3.5	-1.1
Imports (% change volume)	1.9	2.9	0.9
Exports (% change volume)	2.0	3.0	1.0

Source: NZIER

Analysis of the magnitude of change in export value relative to change in GDP shows that a US$10 per barrel rise in the world price of oil, or US$10 per ounce rise in the world price of gold, increases GDP by about $10.4 million.

[7] Numbers cited may not sum precisely due to rounding.

4. Growth prospects and challenges

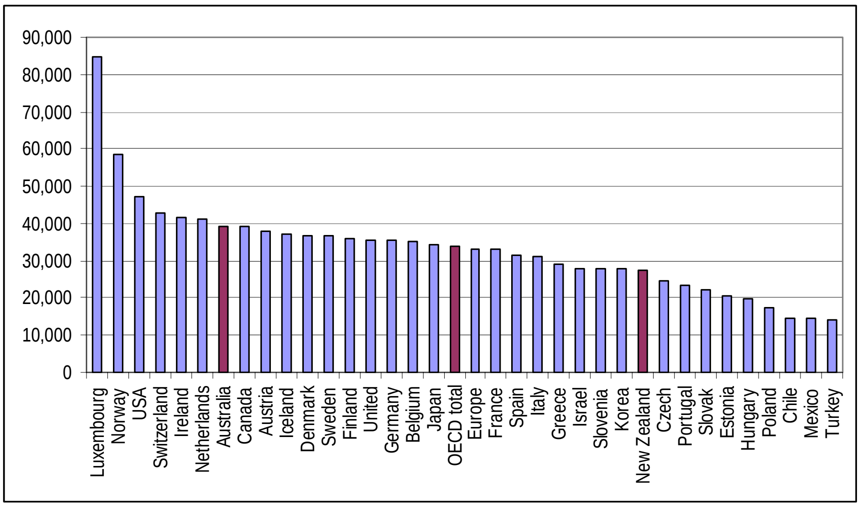
Several factors have lead to increased interest in the economic and social potential of the New Zealand mineral resources sector.

4.1 Comparison with Australia

The continued decline in the incomes of New Zealanders relative to Australians has increased interest in the differences between the two economies. Over the past 15 years, Australia has risen steadily up the OECD league table of income per head to seventh, whilst New Zealand has languished around the mid 20s.

Figure 21 GDP per capita 2008

US$, current prices, current purchasing power parities

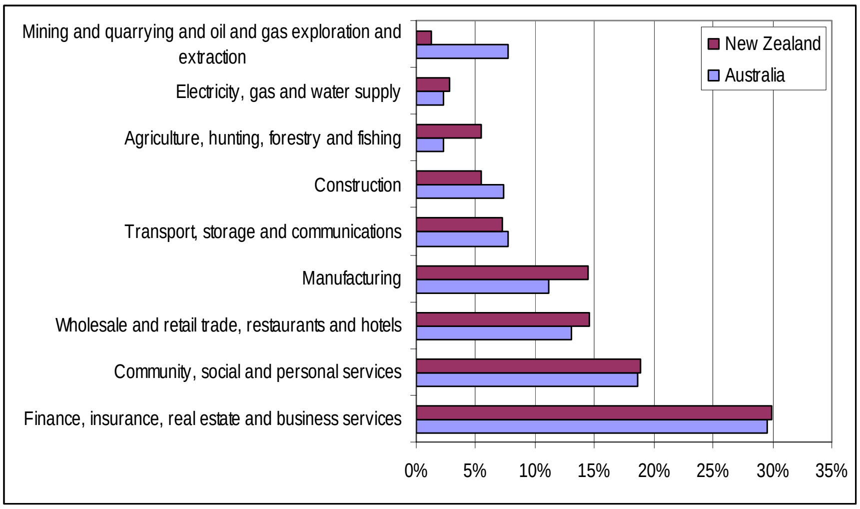


Source: NZIER, OECD (2010a)

One obvious difference between the New Zealand and Australian economies is the relative importance of their mineral resources sectors.

Figure 22 Contribution to value added by industry 2006

Percentage of total across all industries



Source: NZIER, OECD (2010b) (data available to 2006 only)

Although the consensus is that the exploitation of mineral resources does not explain all or even most of Australia's superior economic growth performance, it has provided a positive contribution. Naturally, this has increased focus on whether New Zealand is making the most of its own mineral resources.

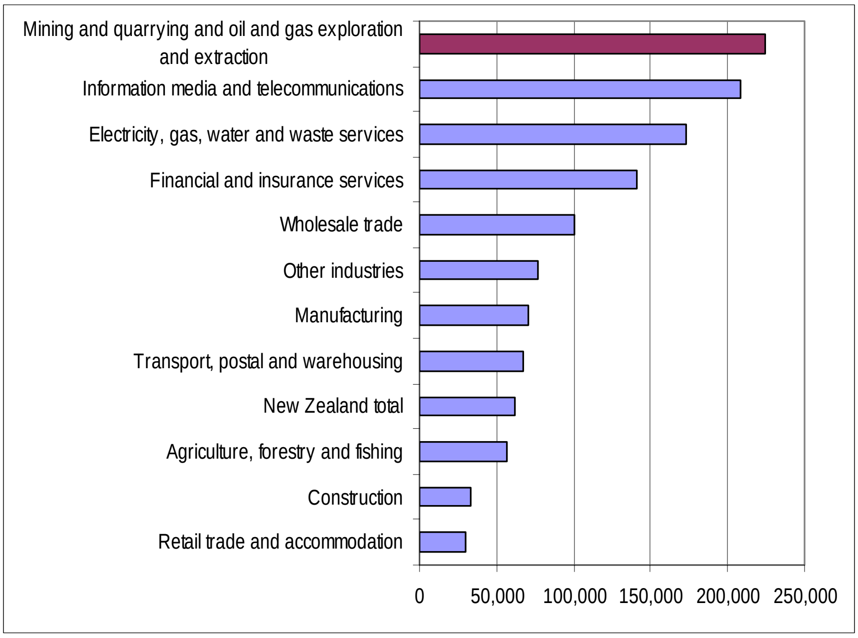
4.2 Productivity

Another aspect of comparing New Zealand and Australia's recent economic performances has played a role. The economic comparison of Australia with New Zealand has typically been couched in terms of GDP per head. Given that GDP is a measure of the total value added in an economy, the debate is essentially about value added per person – a very broad measure of "labour productivity". At a simplistic level, if New Zealand is to catch up with Australia, accelerated development of some high labour productivity sectors would seem a good way to contribute. The mineral resources sector is characterised by high labour productivity and its development is an obvious place to focus. That a considerable number of New Zealanders are engaged in the Australian mineral resources sectors at all levels and in all manner of roles adds to interest in the sector's potential here.

New Zealand's mineral resources sector provides the highest average value added per employee ($223,971), as shown in Figure 23, 3.6 times as much as the average across all New Zealand ($61,607).

Figure 23 Real GDP per employee by industry 2009

Real (constant prices, 1995/96 dollars), production measure, $ per employee

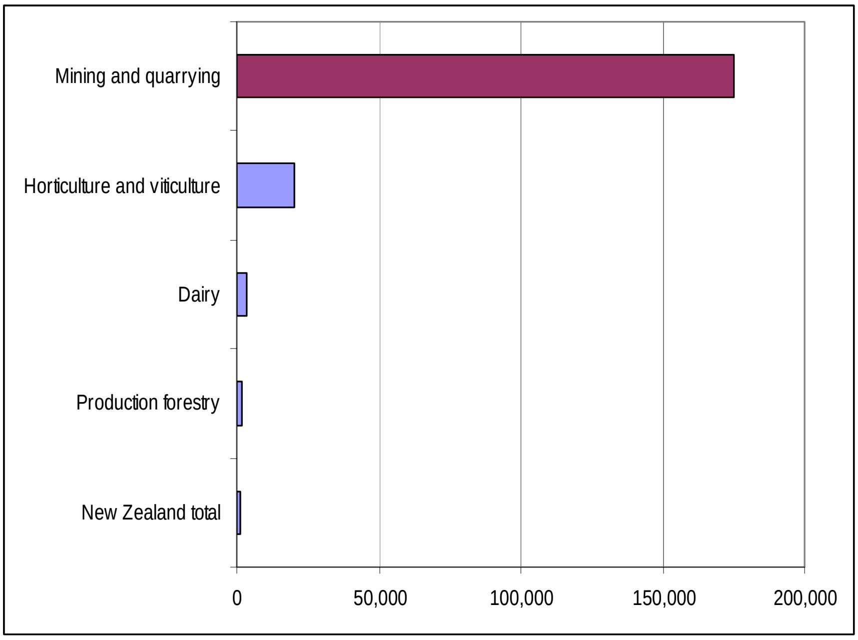


Source: NZIER, Statistics New Zealand

Given the high value of mining activities relative to the small land area they occupy, Barker (2008) estimates the annual export revenue per hectare of mining and quarrying (gold, ironsand, industrial minerals and coal) average $175,000/ha. This far exceeds the export revenue per hectare of New Zealand's other main primary sectors, as shown in Figure 24, and is almost 150 times as much as the average across all of New Zealand.

Figure 24 Export revenue per hectare by primary sector 2006

Nominal (current prices)



Source: NZIER, Barker (2008), Statistics New Zealand,

4.3 Export opportunities

Another factor which has played some part in raising interest in the potential of mineral resources has been the low levels of import tariffs to which the outputs of the sector are typically subject Agricultural products face sizeable tariff barriers or other trade restrictions in many high income countries. The Doha round of World Trade Organisation negotiations were intended to start the process of addressing this obstacle.

The Doha round has, however, stalled and New Zealand has responded to the failure of these key multilateral negotiations to make progress by entering bilateral and pluri-lateral agreements with a number of countries. Although agricultural protectionism is rife, especially among higher income economies, which offer the best prices for producers, high income countries have very low or zero tariffs on industrial raw materials, including those produced by the mineral resources sector. In short, the more readily available trade opportunities for mineral resources have brought increased focus on the potential of the sector in this country. If and when we develop increased exports from this sector, they will not face the restraints on volumes or tariffs that adversely affect increasing exports from New Zealand's agricultural sectors.

4.4 Skills and expertise

Although New Zealand's mineral resources sector is modest in size, many of the skills it uses are available and employed domestically in sectors such as building and construction, energy generation, transmission and distribution, telecommunications, information technology and professional services. This is not a sector in which there is an obvious skill shortage for New Zealand to overcome, provided it is able to offer pay rates comparable to Australia and other countries to attract internationally mobile expertise.

4.5 Legislation

Perhaps the greatest challenges the mineral resources sector does face in pursuing further growth lie in New Zealand's legislative and policy environment.

All naturally occurring gold, silver, uranium and petroleum in New Zealand is owned by the Crown. Almost all minerals under Crown land are owned by the Crown. On private land, minerals other than gold, silver, uranium and petroleum may be owned by the Crown, the landowner or another party or may be of unknown ownership. Prospecting, exploration and mining permits granted under the Crown Minerals Act 1991 are required to explore for or mine Crown-owned minerals. Exploration for and mining of privately owned minerals do not require a permit.

Where mineral resources are located under private land, this is most often pasture owned by farmers. The Crown Minerals Act requires the consent of land owners to be obtained before any work is carried out on pasture land beyond "minimum impact activities" such as hand sampling and geophysical surveys. Consent must be obtained for any work that has significant impact and for entry onto occupied and developed areas.

The Department of Conservation (Doc) administers about 30% of the land area of New Zealand. Any mining activities in these areas require an access arrangement granted by the Minister of Conservation.

In addition, mineral resources fall within the definition of "natural and physical resources", promoting the sustainable management of which is the purpose of the Resource Management Act 1991 (RMA). The RMA requires local authorities to manage minerals and other resources through regional policy statements and management plans, the purpose of which is to identify the resource management issues of the region and policies and methods to achieve integrated management of the region's natural and physical resources. Resource consents are required for activities that have an effect on the environment. For mining activities, these include water permits for taking or diverting water, discharge permits for discharges into water, air or onto land, land use consents for excavations and disturbance of land or the habitats of plants and animals and coastal permits for activities on or near the coast.

For minerals owned by the Crown, the following permits and consents are therefore required:

- a permit granted under the Crown Minerals Act
- an access arrangement negotiated with all landowners and occupiers
- if the land is administered by DoC, an access arrangement with the Department and
- resource consents to use land and water may be required from district and regional councils under the RMA.

Privately owned minerals do not require a permit under the Crown Minerals Act, but still require all the other above consents and the consent of the mineral owner.

Schedule 4 is a 1997 attachment to the Crown Minerals Act. This schedule restricts exploration and mining activities in a list of areas of DoC-managed land. These areas cover more than 30,000 square kilometres, around a third of the Conservation Estate and around 13% of the total land area of New Zealand. The Minister of Conservation may grant permits to mine in these areas, but carrying severe restrictions on disturbance of the ground surface.

Some of the land listed in Schedule 4 is thought to contain high value minerals, which could contribute significantly to New Zealand's economy. The government is currently reviewing whether some of the listed areas should be removed from Schedule 4. Some land is also being considered for addition to Schedule 4.

4.6 Policy settings

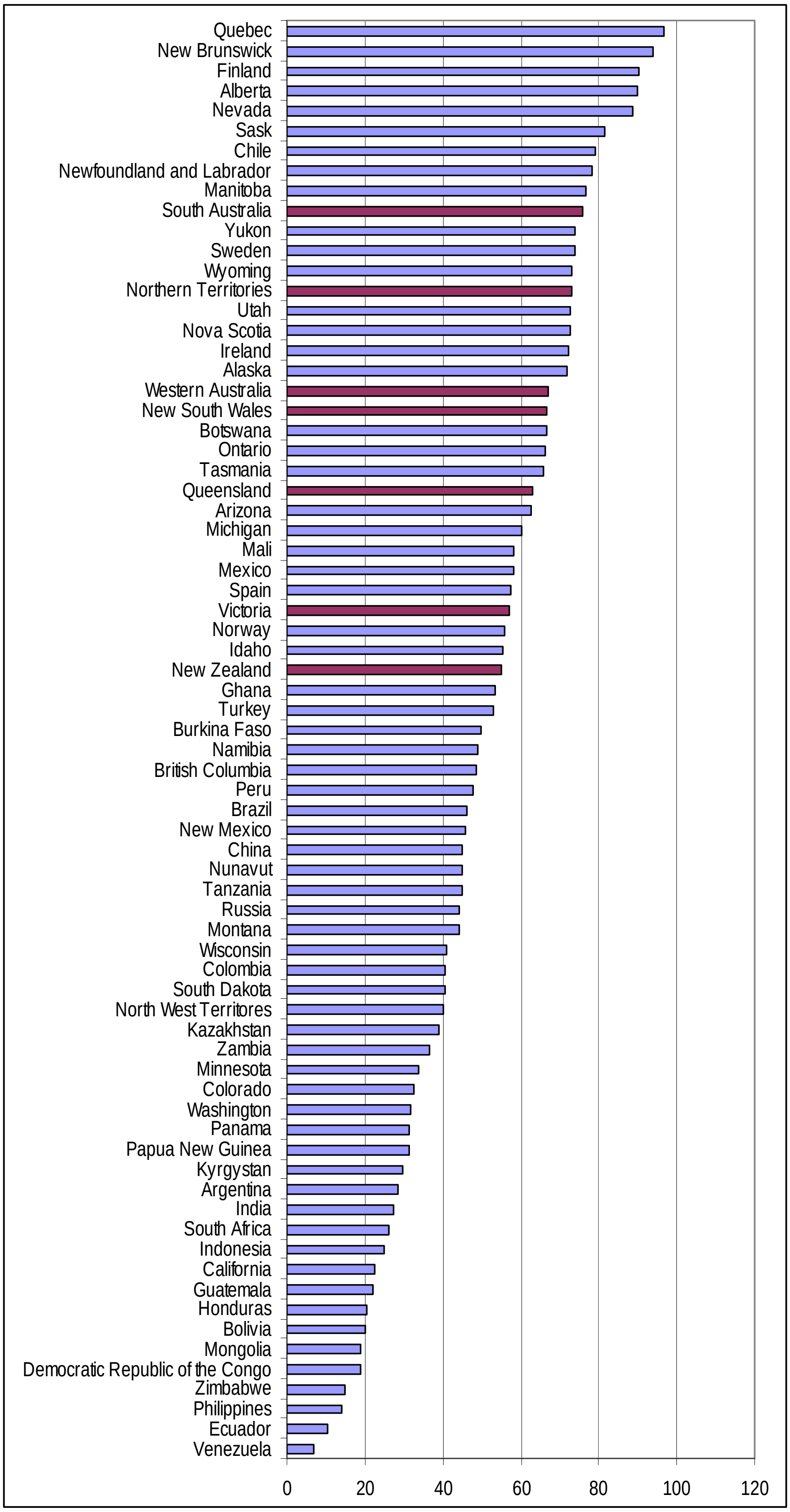
Every year since 1997 the Fraser Institute, a Canadian not-for-profit think tank, has published an international survey of mining companies (McMahon and Cervantes, 2010). The purpose of the survey is to assess how mineral endowments and public policy factors such as taxation and regulation affect investment in minerals exploration. Survey results represent the opinions of executives and exploration managers in mining and mineral consulting companies operating around the world. The latest survey, for 2009/10, covers 72 jurisdictions around the world, including New Zealand, and all the Australian states and territories except ACT.

The policy factors for each country are summarised into a "policy potential index" (PPI). This is a composite index that measures the effects on exploration of government policies including uncertainty concerning the administration, interpretation and enforcement of existing regulations; environmental regulations; regulatory duplication and inconsistencies; taxation; taxation concerning native land claims and protected areas; infrastructure, socioeconomic arrangements; political stability; labour issues; geological database; and security. The PPI is based on ranking and calculated so the maximum score is 100 and the minimum 0.

In the 2009/10 survey, New Zealand scored 55.1 on the PPI and ranked 33rd out of 72 countries.

Figure 25 Minerals exploration – policy potential index

Score (out of 100)



Source: NZIER, McMahon and Cervantes (2010)

All the Australian states and territories ranked higher than New Zealand. Highest of these was South Australia with a score of 75.9 and rank of 10th and the lowest was Victoria with a score of 57.0 and rank of 30th, just above New Zealand. Several Canadian provinces also rated very highly: Quebec (1st); New Brunswick (2nd); Alberta (4th); Saskatchewan (6th); Newfoundland & Labrador (8th); and Manitoba (9th) all ranked ahead of South Australia and well ahead of New Zealand.

The factors that lowered New Zealand's ranking were:

- uncertainty about which areas will be protected as wilderness areas or parks (67th; South Australia 22nd)
- uncertainty about environmental regulations (59th; South Australia 39th)
- uncertainty about native/aboriginal land claims (52nd: South Australia 59th)
- uncertainty about the administration, interpretation and enforcement of existing regulations (49th; South Australia 4th)
- geological databases (44th; South Australia 2nd)
- regulatory duplication and inconsistencies (41st; South Australia 19th)
- taxation regimes (39th; South Australia 17th) and
- labour regulations (39th; South Australia 22nd).

The factors that increased New Zealand's ranking were:

- security (21st; South Australia 20th) and
- socioeconomic agreements/community development conditions (26th; South Australia 28th).

The factors that had limited impact on New Zealand's ranking were:

- infrastructure (30th; South Australia 32nd)
- supply of labour/skills (31st; South Australia 20th) and
- political stability (35th; South Australia 8th).

In short, New Zealand ranks reasonably well or not too poorly in terms of factors shaped by the general economic and political environment – labour skills, infrastructure and political stability. In contrast, in relation to the mining specific policy settings and economic conditions, it ranks in most cases below its overall level on the PPI. New Zealand mining policies are not considered particularly mining friendly. On the other hand, South Australia, the highest ranked of the Australian jurisdictions, ranked 10th, obtains its high rating on the basis of the certainty surrounding its regime, the political stability (presumably in relation to mining policies) and the quality of its geological database.

4.7 Policy challenges

Two challenges New Zealand faces in relation to the development of mineral resources are, first, to determine whether it believes the economic and social benefits of development of its mineral resources outweigh the other consequences. We have used some hypothetical examples to demonstrate what the benefits might be, as information on this seems to be absent from much of the current public discussion. Second, if the benefits are considered worth pursuing, the country needs to decide the policy settings it should adopt to encourage development.

It is clear from McMahon and Cervantes (2010) that our current industry specific policy settings are not very encouraging to mineral resources development compared with the policies adopted in many other jurisdictions. The survey also shows, however, that there are jurisdictions with very similar legal and social backgrounds to New Zealand, in Canada and Australia, which have policies that are considered by international operators as amongst the best in any jurisdiction. The populations of these jurisdictions tend to have similar views to New Zealanders on environmental protection. It is not as if the highest ranked are places with no environmental awareness and weak government regimes that allow miners to do what they like. In view of the compatibility of cultural backgrounds, institutional arrangements and environmental attitudes, the ease with which we are able to learn from these jurisdictions and to adapt some of their policies should be high, if that is what we decide is needed.

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Appendix B CGE modelling framework[8]

B.1 ORANI-G

Our results were generated from a model of the New Zealand economy based on a tried and tested generic model (ORANI-G) that has been found effective for policy analysis in Australia and around the world. The model has been calibrated to local conditions and loaded with New Zealand data. The assumptions adopted are based on consultation with industry specialists and reflect best practice.

The model has been developed with considerable assistance from CGE modelling experts at the Centre of Policy Studies at Monash University in Melbourne. Australia.

B.2 Database structure

The model is based on a large database containing the value flows of the economy, as shown in Figure 26. The database defines the initial structure of the economy, which by definition is assumed to be in equilibrium in all markets. The structure of the database is broadly similar to traditional input-output tables. For example, commodities may be used as intermediate inputs for further production, used in investment, exported or consumed by households and the government. Industry costs include the costs of intermediates, margins, taxes and primary factor costs for labour, land and capital. As identified in input-output tables, the total value of producers' input costs (including margins, taxes, returns to factors and other costs) equates to the total value of output production (the "MAKE" matrix in the database).

The ORANI-NZ model consists of:

- 131 industries
- 210 commodities
- 14 regions
- 1 household and
- 24 occupations.

The database underlying the model has been sourced from Statistics New Zealand's 1995/96 inter-industry tables, subsequently updated using Statistics New Zealand's 2003 supply and use tables and finally scaled up to 2010 levels using the latest available Statistics New Zealand macroeconomic data.

The database has been sourced initially from Statistics New Zealand 1995/96 Inter-Industry tables, updated using the subsequently released 2003 Supply and Use tables, and finally 'up-scaled' to 2010 levels using latest Statistics New Zealand macroeconomic data.

[8] The detailed modelling description presented here is adapted from Horridge (2008).

Figure 26 ORANI-NZ database

		Absorption Matrix					
		1	2	3	4	5	6
		Producers	Investors	Household	Export	Government	Change in Inventories
	Size	← I →	← I →	← 1 →	← 1 →	← 1 →	← 1 →
Basic Flows	↑ C×S ↓	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Margins	↑ C×S×M ↓	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	n/a
Taxes	↑ C×S ↓	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	n/a
Labour	↑ O ↓	V1LAB					
Capital	↑ 1 ↓	V1CAP					
Land	↑ 1 ↓	V1LND					
Production Tax	↑ 1 ↓	V1PTX					
Other Costs	↑ 1 ↓	V1OCT					

C = 210 Commodities

I = 131 Industries

S = 2: Domestic, Imported

O = 24 Occupation Types

M = 5 Commodities used as Margins

	Joint Production Matrix
Size	← I →
↑ C ↓	MAKE

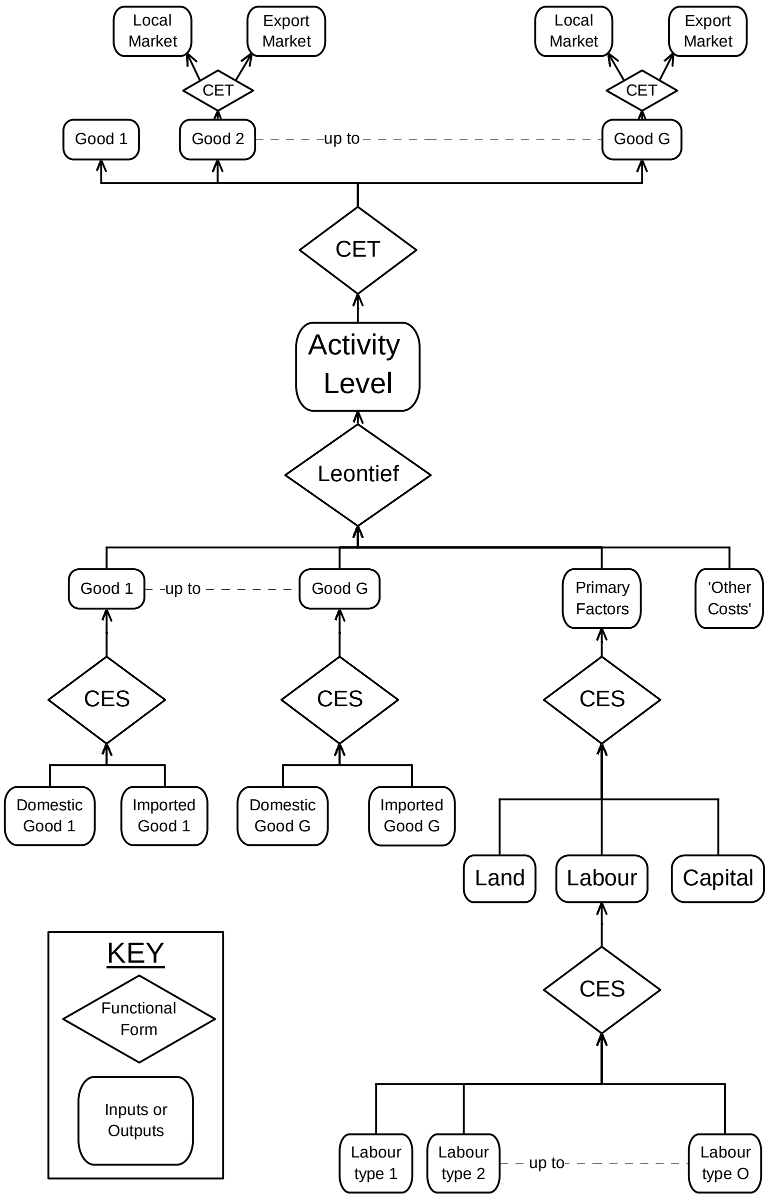
	Import Duty
Size	← 1 →
↑ C ↓	V0TAR

Source: Horridge (2008)

B.3 Production structure

The production structure of the model is presented in Figure 27. Each industry can produce a number of different commodities. Production inputs are intermediate commodities, both domestic and imported, and primary factors are labour, land and capital. Working from bottom to top, we see constant elasticity of substitution (CES) production nests for occupations, primary factors and the choice between imported and domestic commodities. In this case, an increase in price moves sourcing towards another input. For example, if the price of imports increases, more domestic commodities are demanded in the intermediate sourcing CES nest.

Figure 27 Production structure



Source: Horridge (2008)

At the activity level, intermediate goods, primary factors and other costs are combined using a Leontief production function. This means that the proportion of production inputs does not change. On the output side, there are two further constant elasticity of transformation (CET) nests. [9] The production mix of each industry is

[9] A CET function is identical to a CES function except that the transformation parameter has the opposite sign (i.e. increasing price increases output in a CET; in a CES, increasing price reduces demand).

dependent on the relative prices of each commodity. Similarly, the export nest determines local and export market shares depending on relative prices.

B.4 Regional extension

Policy impacts are often distributed unevenly across industries and regions. To capture these heterogeneous effects, the model is extended to include a regional component. A "top-down" approach is used to decompose national impacts to the regional level, using regional employment data as weighting. If a region has a high share of national output, its regional industry output will be proportionally affected. The exception is industries that produce commodities that are largely consumed within a region (mostly services). These are deemed to be local industries and it is assumed that their output moves in line with the local demand for the corresponding commodity, rather than with the national industry output. Note that an inherent assumption in the "top-down" approach is that industries use the same production technology across all regions.

Appendix C Modelling caveats

Like any economic modelling, the technique we have employed has its limitations. Caveats include:

- We have used a simple productivity shock to deliver the increased wealth that the two hypothetical developments will generate. This is a simplification of how the projects would operate.
- The analysis is static, looking at the impacts of the developments on the New Zealand economy at a point in time many years ahead. In reality, the benefits of the developments would be spread across the life of the projects, initially with investment in the facility increasing demand for construction and building; operational expenses including demand for intermediate inputs and labour and supply of fuel after the facility is running; and taxation revenue varying across the life of the development. We do not explicitly model the dynamics of the developments over time.
- On the basis of experience in other fields, the oilfield development would generate around 17,000 tonnes of carbon dioxide emissions as a result of flaring the gas co-produced with the oil. At a world price of $25/tonne, this is worth around $0.425 million. We have not included the cost of carbon explicitly within the preliminary modelling presented in this report. The precise timing of the oilfield development and its associated emissions would determine who wears the cost of these emissions. Initial industry assistance (i.e. free allocation of permits) may put the cost on the government, but over the long run we would expect the oil and gold industries and consumers to face the full cost of any emissions. Our preliminary static analysis does not consider this cost. A dynamic analysis that includes the appropriate phasing of the oilfield development (ramping up in production and emissions), as well as the phasing in the emissions trading scheme and its associated industry assistance, is required to investigate this cost more fully.
- Although the model database is highly disaggregated, it still invariably suffers from aggregation bias – we are modelling the entire oil and precious metals industries rather than one firm.
- The CGE model is based on Statistics New Zealand's input-output tables, with decisions based on principles of neoclassical economics. Structural changes to the economy as a consequence of the two hypothetical developments are therefore not captured in the modelling, nor are any non-competitive market structures. This means that the distributional elements of the results may differ in reality if firms with market power do not pass on benefits.

APPENDIX II

Mining and The Environment – An Overview
Lane Associates Ltd

FINAL REPORT

MINING AND THE ENVIRONMENT – AN OVERVIEW

Stock on Rehabilitation Areas of Waihi Gold's Waste Rock Embankment
Courtesy of Newmont Waihi Gold

Prepared for
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MINING AND THE ENVIRONMENT
TABLE OF CONTENTS

1 INTRODUCTION

1.1 PREAMBLE

Schedule 4 of the Crown Minerals Act 1991 lists areas of Crown land administered by the Department of Conservation over which Clause 61(1A) of the Act in effect imposes severe limitations on the use of that land for mining. Clause 61(1A) prevents the Minister of Conservation from entering into an access arrangement for the purposes of surface mining, and places restrictions on allowable areas of disturbance resulting from underground mining activities (the Act does not prohibit mining on Schedule 4 land *per se*).

The New Zealand Government's recently announced a review the land listed in Schedule 4 and is seeking public submissions on its proposal. In the run up to the lodging of submissions, there has been considerable discussion about the environmental effects of mining, much of it referring to the environmental practices and effects of historic mining that have little relevance to the environmental management practices of today's mining industry. Straterra commissioned Lane Associates to produce this brief report outlining the modern environmental practices used in mining as a supporting document to its Schedule 4 submission, the aim being to assist rational and informed debate around the issue.

1.2 QUALIFICATIONS AND LIMITATIONS

The task of covering the full range of environmental issues across all types of mining is too large a subject to be adequately covered within the scope of this brief paper. To make the scope manageable, consideration was given firstly to what type of mining should be the focus of the paper. In our experience, many New Zealanders consciously or unconsciously consider there to be a hierarchy for different types of mine and their potential to cause environmental damage. Topping the list is precious metal mining, particularly open pit, followed by coal mining[1], then quarrying, the environmental issues around which are largely ignored on a national or even regional scale. Because it is perceived as being the most environmentally damaging, the focus of this paper is primarily on environmental issues as they relate to precious metal mines, although many of the issues and practices described apply equally to other types of mines and to quarries.

Secondly, the scope of the environmental issues discussed in this paper is not exhaustive. The discussion has been limited to those matters that are typically covered in the media and which are the matters of most attention by those opposed to mining and those directly affected by the activities associated with mining. In the interests of brevity and to assist lay understanding, the issues have been dealt with in a general sense and draw on some New Zealand examples. However, behind each of the issues there is usually a considerable body of technical work, the detail from which cannot be included in this overview.

While the following discussion is limited to those environmental issues that are perceived as negatives, a brief mention needs to be made here to the potential for mining to generate a "net environmental benefit". There are a number of such initiatives within the New Zealand mining industry, Newmont Waihi Gold's Dotterel Watch Partnership and Kauri Bank programmes, and Solid Energy's contribution to the Department of Conservation's biodiversity offset project (BBOP), to name but a few.

[1] The issue of climate change has recently increased awareness around coal mining, but it probably still sits below precious metal mining in most people's minds in terms of potential environmental effect.

Finally, it is also important that consideration of the potential social and economic benefits from modern mining be included in the Schedule 4 debate, however these particular aspects are not discussed in this paper as they lie outside the report scope.

1.3 REPORT STRUCTURE

The potential environmental effects can be separated into two broad categories; long-term and short-term.

The long-term environmental effects are the permanent landform changes wrought by mining activity, and the potential environmental impairment that results from acid rock drainage if not properly managed during the mining operations. These effects last beyond the life of mine, in the case of changes to landform, or, in the case of acid rock drainage, have the potential to cause ongoing environmental impairment, and/or require active management, for decades or centuries.

The potential short-term environmental effects exist only during the establishment and operational phases of mining and do not exist beyond the end of mine closure. Such potential effects include dust, noise, traffic etc.

Section 2 discusses the potential long-term environmental issues while the operational effects are examined in Section 3.

A further major change to the environmental management practices applied to modern mines is the bonding strategies that are imposed by Regional and District Councils through the conditions of the resource consents under which all mines and quarries operate. A brief discussion of bonds is given in Section 4.

Section 5 contains a restatement of the key messages within this paper.

1.4 RESOURCE MANAGEMENT ACT

The picture portrayed in the media by many commentators is of fleets of trucks and bulldozers appearing over the horizon the instant an area of land is excised from Schedule 4. Even if mining resources could be discovered and proven in a short time frame, this picture ignores the role of the Resource Management Act 1991 (RMA). The RMA is the key legislative tool by which the environmental and social performance of a proposed mining proposal is assessed and, assuming the grant of consents, controlled. The important point to be remembered in relation to the RMA is that the removal of an area of land from Schedule 4 does not guarantee the establishment of a mine.

The following brief discussion of the role of the RMA is provided as a reminder that any mining project can only proceed after a thorough examination of all of the environmental and many of the social issues associated with a proposed project. If consents are granted, there is always a suite of environmental controls and checks imposed on a mining company to ensure that it meets its commitments to adequately protect the environment during its operations and into the future.

The RMA process provides the opportunity for extensive public involvement. The grant or refusal of the consents occurs only after a careful balance is made of the positive and negative aspects of the proposed project as raised by all contributors to the process. In the case of mining projects, that balancing exercise considers not only the effects that occur during mine operation but also provides for environmentally secure closure of a site at the end of mine life. It is our opinion that a large proportion (qualitatively, around half) of the effort that both the applicant and the councils put into consenting a new mine focuses on ensuring a robust closure scenario that provides confidence in the long-term environmental security of the closed site.

In our view, it is beyond question that the RMA process can and would prevent inappropriate development, including mining, in areas of high conservation, environmental, scenic, heritage or cultural value. When applied to areas of special value, the balancing exercise of the RMA process would inevitably find in favour of those special values. As a recent example, the original proposals for a couple of wind farms have been rejected and consents have not been granted These projects were proposed for areas of land without protection similar to that provided by Schedule 4. Another example is the declining of consent for the proposed Blue Mountain Lumber saw mill near Whangapoua on the Coromandel Peninsula (Ref.1).

Furthermore, the RMA can and does produce beneficial environmental and social outcomes that are equivalent to or better than that achieved in other countries. Newmont Waihi Gold's operation is held worldwide to be an excellent model of how modern mining should be conducted and has for years received a regular stream of overseas regulators, mining industry representatives and other interested visitors who come to Waihi to see and learn how Newmont operates in Waihi.

In our experience mining companies are not interested in projects in areas with special character and values. A recent example is the consent order signed by the Thames Coromandel District Council, the minerals industry, and Coromandel Watchdog in respect of an appeal by the industry on the Proposed Thames Coromandel District Plan. Under the agreement, the minerals industry agreed to retention in the District Plan of a prohibition on mining in areas in the northern part of the Peninsula, including Moehau, and elsewhere in the District where the coastal zone overlaps with areas of high landscape value, without any consideration required to be given to the mineral potential within those areas.

In most cases, this environmental consciousness stems from a recognition of and respect for the special nature of such places and a desire to see their values retained, i.e. the mining companies and their management and staff, who are predominantly New Zealanders, place a similar importance on these special areas as everyone else.

Even if that were not the case, the economic imperative that drives all commercial entities provides a significant disincentive to pursue mining projects in areas of special value and that therefore have a reduced chance of being successfully consented. Obtaining resource consents for a new mining project takes a minimum of two to three years (after an economic resource has been identified, which may be preceded by an additional two to three years of investigation) and several millions of dollars. No business is going to make an investment of this magnitude in both time and money on a project that has a comparatively low probability of success/return. So not only does the RMA provide protection for areas of special value against any form of inappropriate development, the low likelihood of successfully consenting inappropriate development discourages such projects being conceived in the first place.

As a final comment on the RMA, we have observed that there is usually some portion of a community that seems to expect the RMA consenting process to prevent any effects from an operation. This indicates a lack of understanding of the process. The RMA does not guarantee or even expect that there will be no effects from development, mining or otherwise. The requirement for resource consents imposed by the RMA explicitly recognises that there will be effects. The consents are used to place controls on those effects so that they will be acceptable to most people most of the time or prevent significant adverse environmental effects. The corollary is that resource consents are not required only in instances where activities have no effects, or where the effects are trivial.

The Act's expectation that there will be some effect from a consented activity is particularly relevant to the operational environmental effects of mining and needs to be kept in mine when reading section 3.

The role of the RMA is an underlying assumption to the mining-related environmental issues discussed in the remainder of this paper.

1.5 ACKNOWLEDGEMENTS

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- Mr Cam Wylie (RDCL)
- Mr Chris Baker (Saunders Unsworth Ltd)

2 LONG-TERM ENVIRONMENTAL ISSUES

2.1 ACID ROCK DRAINAGE

Mining involves the excavation and placement of a large quantity of soil and rock, a portion of which contains elevated concentrations of metals such as gold, silver, copper, zinc, iron and manganese. If liberated into the environment, many of these metals can potentially cause significant environmental damage. For example, if silver, copper and zinc enter a stream in dissolved form they can be toxic to aquatic plants and animals at very low concentrations, and at higher concentrations can render water unsafe to drink for stock or humans.

Acid rock drainage (ARD), which is the name given to the mechanism by which the metals are liberated, is typically the greatest potential environmental issue associated with precious metal and coal mining. It is therefore the matter that receives the most attention from both mining companies and the regional councils.

Ore is mineralised rock that contains elevated concentrations of metals that occur in chemical forms called sulphides. Sulphur compounds also occur in coal. Sulphides are practically immobile, however oxidation of sulphide minerals produces sulphates and releases the metals often to water-soluble forms. Subsequent contact with water (e.g. rainfall) leaches the oxidation products from the rock to form a sulphuric acid solution that contains soluble metals at potentially high concentrations.

ARD is a natural process that occurs wherever mineralised rock is exposed to air and water, e.g. can be seen as rust staining in road cuttings around the Coromandel Peninsula. But in nature the oxidation process tends to occur very slowly as erosion and other mechanisms expose fresh rock.

Excavation of rock during mining exposes it to atmospheric oxygen. In addition, the blasting and excavating breaks the rock, increasing the surface area exposed to the air and hence the opportunity for it to oxidise. For the metal-rich rock (ore), size reduction and increase in potential oxidising surface is further pronounced during the metal extraction process, which involves grinding the rock to a fine sand. The changes wrought by mining mean that oxidation of the minerals contained in the mined rock and tailings can potentially occur many times faster than occurs naturally. Notwithstanding this increased rate of oxidation, it is a process that would last for centuries before all of the mined rock oxidised.

While acid drainage from mining operations has a long history dating back thousands of years to Phoenician times when the Iberian Pyritic Belt in Spain was first exploited in the headwaters of the Rio Tinto (Red River), the science of ARD is relatively new. Environmental concerns in the late 1960s and early 1970s led to investigation of revegetation problems on acid waste heaps. At that time, the work was undertaken by agronomists searching for ways to establish plants on these materials. Since the mid-1970s, the focus has shifted to prevention methods (Dr Stuart Miller, EGi, pers. comm.).

In other words, the cause of ARD and the means by which it can be controlled were unknown to the mining industry until comparatively recently. The result of this previous lack of knowledge led to the environmental legacies that are often associated with historic mines. The most referred to example in New Zealand is the Tui Mine on the side of Mt Te Aroha. However, since the 1970s, the science of ARD has advanced significantly and there are now well-established and proven methods of geochemical testing and management of ARD. There are also sophisticated mathematical models and computer codes capable of predicting the rates and quantities of release of materials from sulphidic materials that enable good predictions to be made of environmental effects on water quality and the effectiveness of ARD controls.

Geochemical testing and modelling is now an essential part of the investigations that precede the establishment of modern mines, and appropriate ARD controls are an integral part of modern mining activities. The inclusion of the ARD controls virtually eliminates the risk of repeating the environmental legacies of the past.

By way of example, the ARD controls implemented at the Martha Mine throughout its life are considered “state of the art”. Potentially acidic rock is encapsulated in the engineered waste rock embankment between low permeability liners and covers constructed of soil and rock that cannot themselves form acid. The low permeability liners and covers are designed to exclude atmospheric oxygen and to minimise infiltration of rainwater, thereby minimising the rate and magnitude of sulphide oxidation that can occur over the long term. Before it is placed on the low permeability liner, the potentially acidic waste rock is dosed with limestone to delay the onset of acid drainage while awaiting the completion of the low permeability covers. The tailings are and will continue to be stored under water in the tailings impoundments where the water cover effectively excludes oxygen and prevents the formation of acidic conditions.

2.2 WATER QUALITY

The long-term water quality issue is directly linked with ARD. By preventing or minimising the oxidation of sulphides, acidic condition do not arise and soluble metals are not released, or are released at a low rate that does not compromise the life sustaining character of the receiving water.

Other water quality issues are short-term and are addressed in section 3.

2.3 LANDFORM

Almost without exception, mining renders permanent changes to landform, particularly open pit mining. For this reason, there will be a places and situations in New Zealand where mining is incompatible with the protection of areas with exceptional natural landscape or other values. The corollary is that there are many places and situations in New Zealand without such high values and that can therefore tolerate the changes wrought by mining.

Some of the landform changes caused by mining usually necessitate some change in land use once mining is completed. However, a change in land use need not necessarily be considered a negative effect of mining. The key is that the changes be recognised from the outset of a mining project and that suitable future land uses be provided for. A brief discussion follows of some of the main issues with examples of some of the solutions that have been applied or proposed.

2.3.1 Open Pits

Open pits cause significant change to existing landform. There are two related elements to open pit mining; the void created by mining; and the disposal of volumes of non-economic material, called overburden or waste rock.

Open Pits

The void created by mining usually cannot be economically returned to a state that allows for the reinstatement of the land use that preceded mining. An exception exists for some coal mines, for alluvial mining and for hard rock operations that comprise more than one pit. For these types of mining, much of the original area affected by the activities can be returned to its original land use. For example, the overburden from a subsequent pit can be used to backfill the preceding pit, rehabilitated and returned to the pre-existing farming or forestry activity. However, there is almost always an excess of overburden from the initial excavation that cannot be returned to the pits and a final void that remains unfilled.

Other uses for these areas are therefore necessary. Some examples of existing or proposed uses of remnant pits are sanitary landfills, (Greenmount in Manukau City, Redvale limestone quarry in Rodney District), the existing pit lake at Ross, West Coast, and the proposed recreational lake for the Martha Mine in Waihi, and tourism (Whangarei Quarry Gardens, Te Puna Quarry Park near Tauranga).

Overburden/Waste Rock Disposal

While overburden and waste rock disposal areas result in changes in topography, they can often be rehabilitated and returned to pre-existing land use, e.g. farming or forestry. In these situations, the changes of landform may not be significant and in many cases, the productivity of the rehabilitated land can be restored to that of the pre-mining landform. There may be cases where a lesser level of productivity occurs, e.g. on a new landform that is steeper than the pre-existing topography, or where certain land uses are inappropriate in the interests of long-term environmental security, e.g. trees can compromise the integrity of low permeability caps over sulphidic waste rock (refer s2.1 for discussion on acid rock drainage), These matters are all factors that need to be considered through the balancing exercise that is the RMA process prior to the grant of resource consents.

It is worth noting that the economic return from the temporary mining land use can be significant. For example, a decade of mining in an arid area such as that in which the Macraes Flat Gold Mine is located could produce an economic return in excess of farming that area in perpetuity. With much of the land area able to be returned to farming after the completion of mining, the loss of productive land is relatively small when balanced against the economic return from the temporary land use. For the Macraes Flat Gold Mine, the rehabilitation proposal also includes the Macraes Heritage and Art Park (Ref.2), which will provide a new tourist attraction to the area to complement the existing tourism attraction associated with the operating mine.

Evidence presented at the hearing for the Mining Licence that was granted for the Martha Mine in 1987 (Ref.3) showed the economic return in terms of Net Present Value from farm land on and adjacent to the then-proposed waste rock disposal area;

1. would be greater than that from continuing the then-current land use and levels of production;
2. would be greater than that from the expected changes to land use and levels of production; and
3. could be equal to or less than that achievable from optimising the future land use and levels of production.

The assessment was limited to the economic return from pastoral farming, agriculture/horticulture and forestry on the subject land and did not include the economic return from the mine.

In summary, the areas affected by a mine pits and waste rock disposal are not lost from future use, and while the type of use may need to change, that change need not be considered to produce a lesser outcome than existed before mining occurred. In some cases, it is possible to achieve a beneficial end result.

2.3.2 Tailings Storage Facilities

“Tailings” refers to the finely ground ore from which the precious metals have been extracted (and may refer to the reject material from washing coal). Tailings from precious metal mines need to be disposed of in a manner that prevents long term leaching of acid and dissolved metals, the most efficient methods being either permanent disposal under water or capping with a low permeability cap (refer s2.1 for discussion on acid rock drainage).

If the tailings are to be capped, then again farming would be suitable for the long-term land use of the area. Where the tailings are stored in an impoundment a change in land use is likely due to the creation of a pond where no pond previously existed. An example of the possible land use for tailings ponds is that currently proposed at Waihi for the Martha Mine where the impoundment will be rehabilitated to establish wetland and wildfowl habitat.

The impoundment into which the tailings are disposed may comprise a constructed embankment, as is the case in Waihi, mined out pits such as occurs at Macraes Flat, or may utilise a natural valley as in the case of the Reefton Gold Mine.

Where embankments are required to form the impoundment as in all of the above cases, they are constructed of waste rock and designed to be low-head water-retaining structures. The embankments are however more structurally robust than equivalent water storage embankments because tailings consolidate and develop strength equivalent to a weak soil on the upstream side of the embankment and there is additional buttressing of the downstream side of the embankments by the surplus of waste rock produced during mining.

Issues associated with the rehabilitation of the embankments are as described above for waste rock disposal areas.

2.3.3 Underground Mines

Modern mechanised hard rock underground mining requires the backfilling of the mined out voids (further discussed in s2.3.4). So typically, all the waste rock generated by an underground mine is ultimately disposed of underground (some quantity may be required to be stockpiled temporarily above ground until voids become available for backfilling).

Because the quantity of waste rock is only a portion of the total volume removed from underground (the total volume includes the ore as well as the waste rock), there can be a shortfall of backfill. This shortfall can be made up from mined or quarried material, or by using tailings. If tailings are not used for backfill, then a surface tailings storage facility as described above is required and the same issue on landform and long-term land use apply. Where tailings are disposed of underground, the landform and land use effects are associated only with the construction and operational phases of the project, i.e. the landform effects associated with underground mines can be minimal and temporary.

2.3.4 Ground Subsidence

In recent years, the post-closure issue of ground collapse has been raised in the public consciousness through the 2001 event that occurred in Waihi where a chimney cave associated with the historic underground Martha Mine opened up under a house that had been constructed many years after mining finished over an area of unfilled historic workings. Prior to this event, the best-known New Zealand example of ground subsidence associated with mining was probably the subsidence hazard associated with underground coal mining in the Kamo area, Whangarei. A brief examination is made of each type of failure.

Hard Rock Mines

In precious metal, hard rock mines like the historic Martha Mine, the ore typically occurs in veins that are essentially vertical and the mining method involves extracting the ore in “cells”, called stopes. The stopes are not continuous along the full length or through the full depth of the vein. Stopes were separated vertically by leaving a section of ore in-situ called a crown pillar. A crown pillar forms the floor of the stope above it and the roof of the stope below.

Some stopes of the historic Martha Mine were backfilled, which was a manual exercise that was not continued throughout the life of the mine. In particular, the deeper stopes that were mined later in the life of the historic Martha Mine were left largely unfilled. For example, unfilled historic mining voids on the Royal lode (above which the 2001 subsidence event occurred) were up to 14m wide and could be up to 21,000m^3 in volume (Ref.4).

There is also an expectation that many of the crown pillars were mined out near the end of the life of mine, reducing the depth of rock separating stopes if not removing it altogether. Over time, deterioration in the quality of the rock forming the crown pillars, and the backs (roofs) and walls of the stopes is expected to have led to collapse of material into the open voids. The falling material occupies more volume than in-situ rock due to the gaps that form between the fallen blocks of rock. If the expanding volume of falling material fills the void, it provides support for the roof and chokes off further collapse. However, if the void is large enough, the top of the void close enough to the surface, or the bulking of the falling material insufficient to choke off further collapse, the void can propagate to the surface. This is the chimney caving mechanism that created the 2001subsidence event in Waihi.

While there are a number of different mining methods used today, modern undergrounds are typically mined from the bottom up. Ore is initially mined out from the lower levels in the mine. The resulting voids are backfilled with previously mined waste rock to provide support to the void walls for stability and safety reasons. The backfill also forms the floor for mining the next section, which involves drilling and blasting the next block of ore above the backfill. The blasted ore falls onto the backfill from where it is loaded onto trucks and transported to surface for processing. The void created by the removal of this higher block of ore is then backfilled, further raising the mine's working floor. In this way, ore is progressively extracted from the bottom to the top of the orebody without the need for leaving crown pillars, which equate to lost revenue for the mining company.

While there will be unfilled voids that remain at the end of mining, progressive backfilling means that the size of these voids is small. If, as is might be expected, rock quality in the remnant voids deteriorates over time and some collapse of the roof or walls occurs, the small volume of the remnant voids means that the collapse is quickly choked off and does not reach the ground surface.

There are some hard rock mining methods that do cause subsidence, e.g. block caving, and their application may be dictated by the type of orebody being mined, e.g. porphyry deposits. The suitability of these types of mining in a given area will depend on the nature of the ground surface and its land use.

In summary, the subsidence risk posed by past hard rock mining practices can be virtually eliminated in many modern, mechanised underground mines. Where subsidence is the result mining, consideration would need to be given to the acceptability of that subsidence prior to granting consent.

Coal Mines

Unlike hard rock mines in which the orebody often occurs as vertical veins, coal deposits are often near-horizontal seams. Underground coal mining involves the removal of the horizontal stratum that is the coal seam.

The traditional mining methods used a procedure called bord and pillar (or room and pillar) mining in which pillars of coal were left in-situ to support the overlying strata. It was common practice to mine out at least some of these pillars towards the end of mine life. The removal of the supporting pillars resulted in collapse of the overlying strata and subsidence at the land surface. This is the cause of the subsidence in Kamo (Ref.5).

In modern underground coal mines, the potential for subsidence is considered and its control included in the mine design. With methods such as long-wall mining or retreat mining (bord and pillar technique with removal of the pillars as an area of the mine is depleted), removal of most of the coal resource results in the collapse of the overlying strata behind the working area and subsidence of the land surface is expected. However, in areas where subsidence needs to be controlled, the mine design can provide for pillars at intervals and in locations that minimise the effect.

In summary, subsidence effects can be controlled through appropriate practices, the level of control required being dependent on a number of factors such as geology, depth etc., but also importantly, the sensitivity of the overlying land. Whether or not any resulting subsidence is acceptable is a factor that needs to be considered and balanced in weighing the benefits and adverse effects during the consenting process.

3 OPERATIONAL ENVIRONMENTAL ISSUES

Control of operational environmental issues is required primarily to manage potential nuisance effects on people, except for those that relate to water quality.

Because it is the potential of effects on people that is the key concern, the majority of the discussion covered in this section draws on experience gained at Newmont's Waihi Gold operation. More than any other mine in New Zealand, the Waihi example provides coverage of the full range of operational environmental issues due to its location near the town centre, in the case of the Martha open pit, or its outskirts, in the case of the Favona underground mine.

3.1 CYANIDE

The use of cyanide in the precious metal industry is an emotive issue, although much of the concern is unwarranted. Interestingly, there seems to be little public reaction to other uses of cyanide, such as electro-plating, or as a poisonous bait for opossums. Like any chemical used in any industry, when managed properly cyanide does not pose a high risk to people or the environment and its benefits far outweigh the potential dis-benefits.

In a world first, the use of cyanide for the extraction of gold was trialed at the Karangahake Crown Mines near Waihi in 1889 (Ref.6). The trial included ore from the historic Martha Mine with excellent results that made high recoveries of low-grade ore possible at low cost. The New Zealand Government bought the patent rights to the cyanide process in 1897 to make it more readily available to the national mining industry (Ref.6).

Today, cyanide is used throughout the global precious metals industry to recover gold and silver. Without it, many modern precious metal mines would not be economic.

The cyanide process involves mixing the finely ground ore in a weak cyanide solution that dissolves the gold and silver from the rock. The soluble metals are then sorbed onto activated carbon, which is strained from the solution. The gold and silver are washed from the carbon using a hot cyanide solution and recovered in an electro-winning cell that uses a similar process to electro-plating. The cyanide solution from the leaching process is recycled to the process or pumped to the tailings impoundment with the tailings.

Cyanide is unstable, and on the tailings impoundment the action of sunlight and air break down the compound to its component elements, carbon and nitrogen, significantly reducing its concentration. For example, concentrations of the environmentally significant species of cyanide[1] on the tailings impoundments at Waihi are typically around 15 parts per million (ppm), which is well below the 50ppm concentration considered safe for migratory birds and wildfowl (Ref.7).

Where residual cyanide concentrations are high and could pose a threat to wildlife, cyanide destruction prior to deposition of tailings in the impoundment is an option. In New Zealand, OceanGold includes cyanide destruct in its process at Macraes Flat.

The tailings liquor is recycled from the impoundment back to the leach tanks, the residual cyanide concentration being "topped up" to the concentration required for the recovery process.

[1] Cyanide can occur in many forms, not all of which are toxic. The ecologically important form is the Weak Acid Dissociable cyanide (WAD cyanide).

Cyanide is not environmentally persistent or bio-accumulative, and once tailings deposition ceases at the end of mining, its concentration in the tailings impoundment drops over a year or so. At the Newmont Waihi Gold operation, the last tailings deposition to one of its two tailings storage facilities occurred in 2005. Water quality within that impoundment improved over a period of two years to a point where the concentration of cyanide (and trace metals) was less than receiving water standards. Water from that impoundment has been discharging directly to the Ohinemuri River without treatment since 2007. In summary, the cyanide in the tailings impoundments reduced to safe levels inside the time it would take to complete closure activities at the end of mining.

3.2 WATER QUALITY

Operational water quality issues include the;

1. control of sediment from earthmoving activities;
2. containment of hydrocarbons, e.g. spills of diesel and hydraulic oils;
3. containment of process chemicals;
4. control and management of ARD; and
5. treatment and discharge of surplus water including process water that may contain cyanide and soluble metals.

The control of sediment is provided by silt ponds using the same techniques applied to construction works or subdivision development. Similarly, containment of hydrocarbons involves bunding of storage areas and rapid response clean-up in the event of a spill. Mining uses chemicals that are common to other industries. These chemicals are subject to safe handling and storage protocols specific to their nature and the potential risk they pose to people and/or the environment. So for the first three above-listed issues, there is no difference between mining and other common developments and commercial and industrial enterprises.

ARD is not exclusively a mining issue although control of sulphide oxidation is an important environmental issue associated with many mines. The approach taken is to maximise source control, i.e. the exclusion of air and water as described above in s2.1. However, some management of water affected by ARD is inevitable during the operational phase of a mine before all source controls (liners, caps, covers, inundation etc.) are in place, which normally isn't possible until after mining has been completed.

The treatment of acidic water containing elevated metals concentrations is a well tried and tested process, and relies on technologies similar to those applied to domestic water supply treatment plants. It involves raising the pH of the water with hydrated lime, which allows metal hydroxide precipitates to form and be removed in conventional water treatment clarifiers. The process can be enhanced by the addition of coagulant and flocculating chemicals. The resulting clarified water has a pH and metals concentrations that allow for discharge to surface receiving waters without harm to aquatic organisms.

The Macraes Flat Gold Mine is a zero discharge site in terms of its process water. As with many sites in arid climates, the annual evapo-transpiration rate at Macraes Flat exceeds rainfall, the result of which is that process water is fully recycled and there is no surplus to discharge (the site does have consents to discharge stormwater under certain rainfall conditions). However, the rainfall at sites like Golden Cross and Martha (around three and two metres per annum respectively) generates an excess of process water that requires treatment prior to discharge.

Excess water from around these sites contains ARD products and requires treatment using the technology described immediately above. The only other water source is the tailings impoundment in which there are residual cyanide-metal complexes remaining from the gold recovery process. The treatment method applied to process water at both Golden Cross and Martha involves the oxidation of these cyanide-metal complexes using ozone. Once the cyanide complex is destroyed by the ozone, the soluble metals can be removed by the same treatment process as described for ARD products.

Treatment plants of the type described have worked for decades at both the Golden Cross and Martha Mines near Waihi and have been shown to be protective of the Waitekauri and Ohinemuri rivers into which they discharge (respectively).

If necessary, there are additional technologies capable of producing water of even better quality. In 2008, Newmont Waihi Gold installed a reverse osmosis treatment plant to polish the process water after the conventional treatment described above. Reverse osmosis is similar to the technology used in desalination plants that produce fresh water from salt water. It is easiest thought of a filtration process that occurs at a molecular scale. It has shown to be effective at removing metals from the treated process water down to very low levels.

3.3 GROUNDWATER

3.3.1 Groundwater Supply

Both surface and underground mining involve dewatering, often to several hundreds of metres below ground surface. The primary groundwater issue is whether or not dewatering adversely affects other users of the groundwater resource. The issues are similar for both coal and precious metal mines.

The effect of dewatering depends on the nature of the groundwater system in which mining occurs. For example, dewatering of some of the basaltic quarries in Auckland can result in widespread reductions in groundwater level. By comparison, the extensive dewatering required for the Martha and Favona mines has no measurable effect on groundwater users in the Waihi district.

The lack of effect at Waihi is because groundwater does not occur in an homogenous geological unit. Rather, there are typically a series of groundwater systems at any given site that have limited interconnection. The separate systems occur due to different geological layers, some of which are more permeable than others. The weathering of a layer in the geological sequence can create an hydraulic separation between the groundwater below and above that weathered layer. In the deep groundwater system affected by mining, the orebodies are often the primary aquifer with water stored in fractures and other structures. The rock outside the orebodies is tight, contains little water and doesn't dewater to any great extent. Nor do the upper groundwater systems dewater because of the separating, low permeability weathered layers in the sequence. Therefore, dewatering in this instance occurs with no affect on the groundwater systems from which others users draw water.

A similar outcome occurs with many coal mines. The coal contains more water in its fractures and fissures and is more permeable than the overlying or underlying strata, which are typically clays that exhibit low permeability and yield little groundwater.

Mine-associated groundwater is often unsuitable for use as domestic or farm supplies. Firstly, mines dewater strata that are deep and the economics of drilling into these systems can be prohibitive. There is little benefit in drilling very deep wells into the tight rock that produces poor groundwater yields, especially if there are shallower more productive aquifers available which are sustained by greater rates of recharge from rainfall. Secondly, the mineralisation that makes a rock an orebody can result in water of a quality unsuitable for consumption without treatment. Water from mineralised rock may contain elevated levels of iron, manganese, copper, zinc and other metals that render it unusable. Water from coal seams can contain elevated concentrations of iron and trace elements such as boron. Treating these groundwaters to potable standard would be uneconomic if alternative supplies are available, or in the case of elements such as boron, are not treatable using conventional systems.

Even in situations where mine dewatering does affect other groundwater users, the provision of an alternative supply to affected users can usually be accommodated within the operating costs of the mine.

Finally, dewatering is a temporary activity and the groundwater level will return to or near to its pre-mining level once dewatering ceases (unless some aspect of the mine permanently modifies some feature of the groundwater system). In Waihi for example, the historic underground Martha Mine was dewatered to a considerable depth before returning to near-pre-existing levels when pumping ceased. The modern open pit Martha Mine has again drawn down the water table in the deep groundwater system, albeit to only about half the depth of the historic underground mine.

3.3.2 Groundwater Quality

A second groundwater issue is the potential effect that a mining operation has on the quality of shallow groundwater. Appropriate bunding of fuel and chemical storage areas in line with practices used throughout industry provides an adequate level of protection. The key difference between mining and other industries is the potential effect on groundwater from ARD and/or seepage from tailings.

As described above in s2.1, best practice in managing potentially acid producing waste rock in New Zealand is to place it on low permeability liners which reduce the risk of seepage from this source from entering groundwater. These liners have leachate drains above them, preventing the build-up of acidic leachate that could drive seepage through the liner, and underdrains to intercept any seepage and limit the losses to groundwater. Ponds and drains that collect stormwater runoff from areas containing potentially acid forming rocks can be lined with HDPE to reduce seepage losses.

Within the tailings storage facilities, the weight of overlying tailings consolidates the bottom layers of tailings to a very low permeability equivalent or better than that achievable with plastic liners. For this reason, plastic liners have not been used in modern tailings storage facilities in New Zealand to date. In addition, the facilities have a system of underdrainage similar to that described above to intercept and limit seepage losses to groundwater.

The Martha Mine operation also has an extensive groundwater monitoring system of wells down-catchment of its waste rock and tailings storage areas, which provides for early warning in the event of excessive seepage, allowing the early implementation of mitigation measures such as groundwater cut-off drains if monitoring show mitigation to be necessary.

3.4 GROUND SETTLEMENT

The decrease in pore water pressure resulting from mine dewatering can cause settlement across broad areas as the reduction in pore pressure allows elastic compression and consolidation of compressible strata. The extent and magnitude of settlement depends on the degree of depressurisation, and the thickness and compressibility of the compressible layers but can range from a few millimetres to several hundred millimetres. By way of comparison, the natural wetting and drying of surface soils between seasons can produce changes in land surface level of tens of millimetres. For example, in Waihi where there is a very comprehensive network of surface settlement markers required by the conditions of consent of the

Martha and Favona mines, the ground level changes due to natural shrink-swell is up to 20-30mm.

Dewatering-related settlement seldom causes structural or cosmetic damage to buildings or other infrastructure as the land surface slowly settles as a unit and structures remain in the same or very similar positions relative to one another. The key potential area of concern is differential settlement over short distances, called tilt, because sudden changes in the magnitude of settlement across buildings or infrastructure can lead to damage. Tilt can be caused by sudden changes in the compressibility or discontinuities in the compressible strata. While not common, if such variability or discontinuities occur their effect would need to be accounted for when assessing the effects of dewatering.

When dewatering stops and groundwater levels recover, the land surface rebounds to some degree but may not return to the pre-existing level.

3.5 NOISE

Machinery and processing equipment used in mining does produce noise, the effects of which need to be assessed during the consenting process. The science around noise propagation is well established and codified in a New Zealand Standard. As demonstrated by Newmont Waihi Gold's Martha Mine in Waihi, it is possible to operate in a sensitive urban environment while meeting stringent noise controls.

Because of its proximity to the town, mining does not occur at the Martha Mine during night time, on Sundays, or on public holidays because the noise of the mining activities would exceed the more stringent noise limits that apply during those periods. However, to our knowledge, the operation has never exceeded its consent noise limits under the neutral meteorological conditions that are stipulated in the consent conditions and under which it is possible to obtain representative noise readings for the mine.

Processing of ore and the treatment of water do occur 24 hours a day and 365 days per year and these activities comply with the very stringent night time limit of 40dBA imposed by the Hauraki District Plan. To put this night time limit in perspective, it is worth noting that;

1. the ambient night time noise in Waihi, with or without the mill operating, does not always drop to 40dBA;
2. 40dBA is only ever achieved in the early hours of the morning, e.g. 2-4am; and
3. there are areas in Waihi that never meet the night time limit, e.g. within earshot of State Highway 2.

As already mentioned, the requirement of a consent condition anticipates that there will be some effect from an activity. In the case of noise, there are times when the noise of the operation is noticeable in certain areas within Waihi and complaints are received by both Newmont and the Hauraki District Council. Weather appears to be the primary cause, with light to moderate winds increasing the noise levels for those living downwind of the operation. These increases occur without any change to the mining activity, which has been repeatedly shown to comply with the consent's noise limits under the stipulated meteorological conditions.

The New Zealand Standard recognises the effects of meteorological conditions, and they are implicit in the noise limits imposed through District Plans. The philosophy is that short-term exposures to elevated noise levels are mitigated by periods of lesser noise, e.g. when the wind direction changes and reduces the level of noise received at a given location.

The other source of noise is blasting. Overpressure refers to the transient increase in pressure above atmospheric pressure generated by blasting. The dominant pulse from overpressure is largely inaudible and therefore has minimal direct effect on people (Ref.8). It is often misinterpreted as vibration as it can cause windows to rattle. Naturally-occurring events such as wind gusts routinely generate comparable or greater levels of overpressure than those generated by blasting.

3.6 VIBRATION

Humans are sensitive to vibration, and most international standards and legislation, including those set in District Plans, have been developed to ensure that blast-induced vibration levels are maintained at or below levels of human tolerance (Ref.9). For example, vibration generated by normal truck traffic at properties adjacent to a main road can be of a similar magnitude to the consent limits that apply to Newmont Waihi Gold's operations in Waihi. By being set to protect amenity value, these vibration limits can be one hundredth of the level at which property structural damage occurs and one tenth of that required to cause cosmetic damage.

Again, the setting of consent limits on vibration does not guarantee that people will not feel blasting vibration, but the levels set in District Plans are expected to avoid nuisance to most people most of the time. Because a the large number of variables affect the vibration generated by a blast (geology, groundwater, mining voids, blasting products, detonation timing, etc), each blast is typically designed so that the vibration levels it generates will be below the relevant consent limits in order to avoid a breach of those limits. For example, the vibration limit for the Martha Mine is 5mm/s (peak particle velocity) but almost 70% of the blasts between 1992 and 2002 generated vibrations of no more than 2mm/s. The experience at Waihi Gold is that the vibration from the typical blast is barely perceptible, or at least tolerated, by those living close to its operations, and that complaints occur only as the vibration approaches the consent limits.

In summary, the consent limits imposed on the Martha and Favona mines have been shown to be appropriate over a considerable period (more than 20 years for Martha).

3.7 DUST

Dust is generated from many activities, including traffic, road construction, sowing and harvesting, top dressing, lawn mowing and earthworks, which includes mining. Since the early 1980s an air quality monitoring network has operated in Waihi associated with the Martha Mine. It is one of the more, if not the most, comprehensive air monitoring programmes in New Zealand. Most of the following discussion has been derived from the results of that programme.

There are two components of interest for dust; suspended particulates that are primarily a health issue; and deposited particulates which are primarily a nuisance issue.

Newmont Waihi Gold routinely monitors inhalable particulates (particles less than 10 microns) and the silica content. The results of this programme and that of the suspended monitoring programme have confirmed a low occurrence of concentrations of human health significance to the local community (Ref.10).

The results are further supported by those from Newmont's routine lung function testing of its staff who, because of their daily proximity to the sources of inhalable particulates and silca, would be more susceptible to possible health issues from this source than others living in town. There have been no worker health issues identified through this programme.

A secondary health issue can be the impact of blasting fumes on some people who may be sensitive to the fumes. The potential for the generation of fumes depends on a number of factors including the type of explosive, the time between when the explosives are loaded into the blast holes and when the shot is fired, and weather conditions.

Well-managed blasts do not generate excessive fumes, and the separation between a blast site and a sensitive receiver would be expected to dilute the fumes to levels well below those that have the potential to cause health concerns. Newmont Waihi Gold has implemented a precautionary approach to its blasting in the Martha Mine that involves notifying people sensitive to potential blasting fumes before blasting occurs in certain areas of the pit under certain weather conditions.

In mining, the primary generator of deposited particulates is the transfer of excavated rock and soil from excavator to truck, truck to ground, and between conveyors especially during windy periods. Secondary sources include traffic on unsealed roads and material blown from stockpiles, again during windy conditions. The management of dust is simple and effective – completed areas of earthworks are rehabilitated and planted, temporarily inactive areas can be planted, and active areas can be watered using water carts or sprinklers.

3.8 TRAFFIC

Any commercial or industrial development generates traffic; construction traffic during establishment; and supply, export and staff related traffic during operations. New Zealand’s roading network is provided to cater for traffic, including the traffic generated by new activity. So the issue for a new mine is whether or not the existing network can accommodate the new travel patterns and increased traffic volumes safely and efficiently. The science used to evaluate the new traffic patterns and to assess the ability of an existing network to handle them is well proven.

Some examples of the solutions adopted to accommodate mining are;

1. the funding and upgrade to Campbell and Waitekauri roads to service the Golden Cross Mine near Waihi;
2. the use of a conveyor to transport ore and waste rock from the Martha Mine to reduce mine traffic through the Waihi urban zone;
3. the realignment of the Waikokowai Road around the Rotowaro coal mines;
4. the realighment of Macraes Road and the construction of an overbridge at the Macraes Flat Gold Mine.

In summary, roading and traffic issues are site-specific but workable solutions do exist if a need to overcome shortcomings with the current network is identified.

3.9 PROPERTY VALUES

Whether it is a child care centre or a mine, claims from neighbours that a new development will devalue their property are commonplace. To our knowledge, the only long-term study on property values is that conducted by Newmont Waihi Gold and its predecessors on residential property in Waihi.

The study covers property values from the early 1980s prior to the grant of the Mining Licence for the Martha Mine in 1987. It has been periodically updated over a period spanning more than 20 years. The property valuation study prepared in 2003 (Ref.11) confirmed the findings of previous similar studies that;

1. Prior to 1987 and the start of modern mining at Waihi, the average residential house price in Waihi was less than (about 80% of) that of the neighbouring and similar-sized towns of Paeroa and Te Aroha.

2. Since 1987, the average residential house price in Waihi has typically exceeded that in Paeroa and has been close to that in Te Aroha.
3. Since 1987, the rate of increase in property values in Waihi has been greater than that in either Paeroa or Te Aroha.
4. The impact of mining on Waihi property value has been a positive one.
5. There may be a few properties where the beneficial impact of the mining activity may not have been as great as for other properties in Waihi, however the market price for the negatively impacted properties would still be higher than would be the case if mining had not occurred.

It should be noted that these studies excluded properties bought or sold by the mining company to avoid any potential bias that these sales might have on the findings.

The rapid increase in property values in Waihi in 1987 when the Mining Licence was granted has been the subject of a separate statistical evaluation (Ref.12). The conclusion was that "*'Environmental valenhance'* [sic] *has occurred at Waihi as a result of gold mining activities as measured by a positive effect on residential property values*".

4 BONDS

With the enactment of the RMA and greater awareness by Regional and District Councils, the requirement for mining (and other) companies to post comprehensive bonds is one area of important advancement in the industry. Today there is little chance of the current mining operations leaving behind a non-rehabilitated legacy such as the Tui Mine on Mt Te Aroha.

Under the RMA, a bond may be imposed for the performance of conditions relating to long term effects. When applied to the closure and rehabilitation of a mine site, a bond indemnifies the people of New Zealand against the cost of rehabilitating the disturbed areas of a mine site in accordance with the consent conditions in the event that the mine owners are unwilling or unable to undertake those works. The quantum of such “rehabilitation bonds” is based on an assessment of the cost of major physical works for the area of the active mine including;

1. the removal of structures and infrastructure;
2. recontouring landforms;
3. covering recontoured and/or potentially acid-forming areas;
4. planting the disturbed areas;
5. ongoing water management/treatment; and
6. maintenance and monitoring.

In some instances, the adequacy of the bond quantum is periodically reviewed at regular intervals of between one and three years. Upon review, the quantum is recalculated based on the maximum area of exposure during the period prior to the subsequent review.

In the event that the mining company defaults on its closure obligations, the Regional and District Councils can call on the bond and use the funds made available to close the site.

For the Newmont Waihi Gold operations there is a second bond, called a “capitalisation bond”. Once all of its closure obligations have been met, Newmont proposes to pass ownership of the areas of mine disturbance (the Martha pit and the waste disposal area) to a Trust on which Newmont will settle an endowment fund sufficient to provide for the management of that land in perpetuity. The quantum of the endowment, the capitalisation sum, is calculated to provide annual interest payments sufficient to cover the ongoing costs of routine site maintenance, monitoring, insurance premiums, Trust management and a risk-based contingent liability fund to remediate any occurrences not covered by insurance that, if left unattended, would result in long-term environmental impairment. The capitalisation bond would provide that fund to the councils for settlement on the Trust in the event that Newmont could not or would not capitalise the Trust.

The calculation of a bond quantum makes no account of the likelihood of the bond being called upon. In reality, a mining or other company would need to go bankrupt before allowing the situation to deteriorate to the point where the councils need to call on a bond. It is therefore not unreasonable to assume that the likelihood of a mining company or other company defaulting on its closure obligations is low, and in some cases virtually inconceivable.

The posting of a bond not only provides indemnity for the host community, it also provides a significant incentive for any reputable mining company to meet its closure obligations. A company that defaulted on its obligations, resulting in the calling in of a bond, would effectively sound its own death knell as the damage done to its reputation were virtually eliminate its future chance of raising capital.

No better example of this is given by the experience at the Golden Cross Gold Mine near Waihi. Coeur Golden Cross made the decision to close the mine in 1997, shortly after discovering that its tailings storage facility was sited on an active landslide which may have contributed in part to that decision. At the time, the quantum of its water right bond totalled around $10 million.

The first important finding of note from this event is that due to the responsible and responsive actions of Coeur, the landslide did not lead to a catastrophic failure of the tailings storage facilities. Secondly, the landslide has since been stabilised. Thirdly, while its cheapest short-term option may have been to walk away from the site leaving the councils to call on the bond to fund stabilising the landslide and closing the site, Coeur chose to spend significantly more than $10 million to undertake the works, thus avoiding any call on the bond. And finally, more than a decade later Coeur still retains a presence on-site as it works towards meeting its final closure criterion.

5 CONCLUSIONS

This paper provides a brief overview of the environmental issues faced by the modern mining industry, gives examples of where these issues can occur and outlines some of the solutions adopted by the industry in New Zealand to address them. The key message in the paper is that the industry recognises and understands the environmental issues associated with its activities. It knows how to adequately manage them. And it has a robust recent track record that demonstrates that it manages its activities in a way that ensures good environmental outcomes.

For any balanced debate on Schedule 4 lands, not only is it important to consider the environmental issues, there needs to be a balance struck between them and the potential social and economic benefits, and indeed the potential net environmental benefit, that a responsible, modern mining industry can achieve.

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