



FINAL v3

Socio-Economic Baseline Report

Hillside Project

September 2012

Rex Minerals Limited

Hillside Project Feasibility Study
Rex Minerals

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Version:	Details:	Approved:	Date:
v1	Initial draft to client	Danielle Martin	
v2	Second draft to client	Danielle Martin	04/09/2012
v3	Final report	Danielle Martin	23/01/2013

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INTRODUCTION

Background

Rex Minerals Limited (Rex) proposes to develop the Hillside copper-gold project, 12km south of the town of Ardrossan on the Yorke Peninsula, South Australia.

This Report

Rex commissioned the compilation of a socio-economic baseline characterisation in preparation for possible future environmental and social impact assessment of the Hillside project. It is Rex's intention to apply to the South Australian Government for a Mining Lease for the Project.

Rex commissioned DMC to prepare the socio-economic baseline characterisation to describe the current socio-economic environment in the Project area and the region more broadly. It is against this baseline that a future assessment of socio-economic impacts will be conducted.

The objective of this Socio-economic Baseline Report is to demonstrate that Rex understands the socio-economic context in which its Project will occur in order that it can identify, monitor and measure the changes (impacts) that occur as a direct and indirect result of the Project.

Study Area

For the purposes of this socio-economic baseline characterisation a two-tiered study area was defined recognising that while the majority of potential impacts (positive and negative) would be felt locally, the Project would also have an effect on the region more broadly.

Primary Study Area

The primary study area is defined by the boundaries of the ABS Census Postal Area of 5571, which includes the townships of Ardrossan, Black Point, James Well, Pine Point, Port Julia, Rogues Point, Sheaoak Flat and Tiddy Widdy Beach.

The township of Ardrossan, the largest town in the primary study area, is located approximately 165km by road from Adelaide on the mid-eastern coast of the Yorke Peninsula, approximately 12km north of the Hillside Project site (see Figure F01 for location). Due to its close proximity to the Project site, Ardrossan is the nearest sizable residential community from which a local workforce is most likely to be sourced (to the extent possible) and accommodated, and from which available goods and services will be procured. It will likely experience the greatest level of activity associated with the Project and thus is the town most likely to experience the greatest impact (both positive and negative) associated with the Project. It is noted, however that the coastal settlements of James Well, Rogues Point and Pine Point are located between Ardrossan and the Project and that Pine Point is the closest residential community to the Project. Their proximity to the Project means those communities will also be impacted by aspects such as Project traffic and potentially noise and dust from the Project, in some cases possibly even to a greater extent than Ardrossan. But because those communities are residential only and rely on Ardrossan as the regional hub for retail, physical and social services, the breadth of impact at Ardrossan is likely to be greater, and is the point of source for broader impacts across the primary study area.

Regional Study Area

The regional study area is defined by the Goyder state electoral division (SED) boundaries, as illustrated in Figure F01. Goyder SED is made up of the district councils of Yorke Peninsula, Copper Coast, Barunga West (part), Wakefield Regional Council (part) and Mallala (part).

This study area has been chosen as the second-level study area because it reflects the residential settlements within a reasonable daily driving distance of the Project (an actual kilometre radius has not been defined, because it is considered that a range of factors will

influence residents' choices about how far they are prepared to drive to work at the Project and Rex is yet to define its roster, transportation and health and safety requirements that will facilitate or constrain residents' daily driving options). At the southern end of the Goyder SED is the town of Yorketown, located approximately 80km from Ardrossan (less than 70km from the Project site), at the north western boundary of the SED is Wallaroo, located approximately 68km from Ardrossan (80km from the Project site), and at the south eastern boundary of the SED is Dublin, located approximately 90km from Ardrossan (102km from the Project site).

Given the Goyder SED boundary is considered to represent the reasonable daily driving distance for workers associated with the Project (directly or indirectly), it is considered the reasonable area in which the primary spread of impact and benefit from the Project will manifest. Further, using a SED aligns with ABS Census data, allowing for the analysis of a large range of social indicator data and comparison over time.

Within the Goyder SED, the District Council of Yorke Peninsula (DCYP) is the local council area most relevant to the Project; it is the local council area in which the Project is located. Where data is included in this report that can only be obtained at a local council level (ie, not through ABS Census data), such as been included as it pertains to DCYP.

South Australia

Data representing the entire state of South Australia is included for comparison of local data against State averages and to indicate the potential effect of the Project at the State level.

Australia

Data representing the nation of Australia has also been included for comparison of local and State data against national averages and to indicate the potential effect of the Project at a national level.

Data Limitations

At the time of writing, only part of the 2011 ABS Census data had been released. The full range of data was not expected to be available until December 2013. As a result, this report contains a combination of data from ABS Census' 2006 and 2011. Where information from other sources was more current than ABS 2006 data, it has also been used in order to give the reader a more accurate indication of baseline conditions.

Study Scope

The objective of the Socio-economic Baseline Report was to provide information on specific aspects of the existing socio-economic conditions in the project area, including:

- demography and population
- land use
- social services
- physical and social infrastructure
- the economic base of the region.

Preparation of this report involved the following tasks:

- Review of existing literature to describe the social and economic profile of the study area and region.
- Summary of demographic profiles of relevant communities within the study area.
- Identification and description of relevant historical and current influences on the study area and region.
- Characterisation of existing land uses.
- Assessment of the compatibility of the project with the provisions of the existing local planning schemes.
- Interviews with key informants.
- Community survey of perceptions about the project.

1. COUNTRY AND REGIONAL SETTING

The following chapter outlines geographic boundaries and setting for the Project's key study areas and potentially affected communities. Furthermore, the chapter also provides a summary of key governance, economic and industry profiles for each study area. The intention of this chapter is to provide an understanding of the key geographical, political and economic characteristics of the Project's key study areas.

1.1 Geographical Setting

1.1.1 Primary Study Area

Ardrossan is a small coastal community of 1,136 people (ABS, 2011) that is characterised by a high percentage of older persons, below State average incomes, higher than State average unemployment and higher than State average home ownership (see Chapter 3 Social Environment, Chapter 4 Work Force and Accommodation and Chapter 6 Economic Environment for further information). The township is well serviced with respect to health services and educational facilities for a township of its size (see Chapter 3 Social Environment).

The primary study area also includes the townships of Black Point, James Well, Pine Point, Port Julia, Rogues Point, Sheaoak Flat and Tiddy Widdy Beach; coastal communities comprising a mix of holiday and permanent residences.

In the 2006 Census (ABS, 2006), the most common industries of employment for persons aged 15 years and over usually resident in postcode area 5571 were Sheep, Beef Cattle and Grain Farming (20.9%), Other Food Product Manufacturing (7.8%), Hospitals (6.9%), School Education (6.4%) and Supermarket and Grocery Stores (3.4%). Industry of Employment data from the 2011 Census was not available at the time of writing. Global grain handling company, Viterra, operates a bulk loading facility at Ardrossan.

1.1.2 Regional Study Area

The regional study area is defined by the Goyder state electoral division (SED) boundaries, as illustrated in Figure F01. Goyder SED is made up of the district councils of Yorke Peninsula, Copper Coast, Barunga West (part), Wakefield Regional Council (part) and Mallala (part).

The Goyder SED contains the following main towns; Wallaroo (population 3,674), Maitland (population 1,046), Balaklava (population 1,827), Ardrossan (population 1,136), Moonta (population 681), Minlaton (population 1,261) and Port Wakefield (population 556).

1.1.3 South Australia

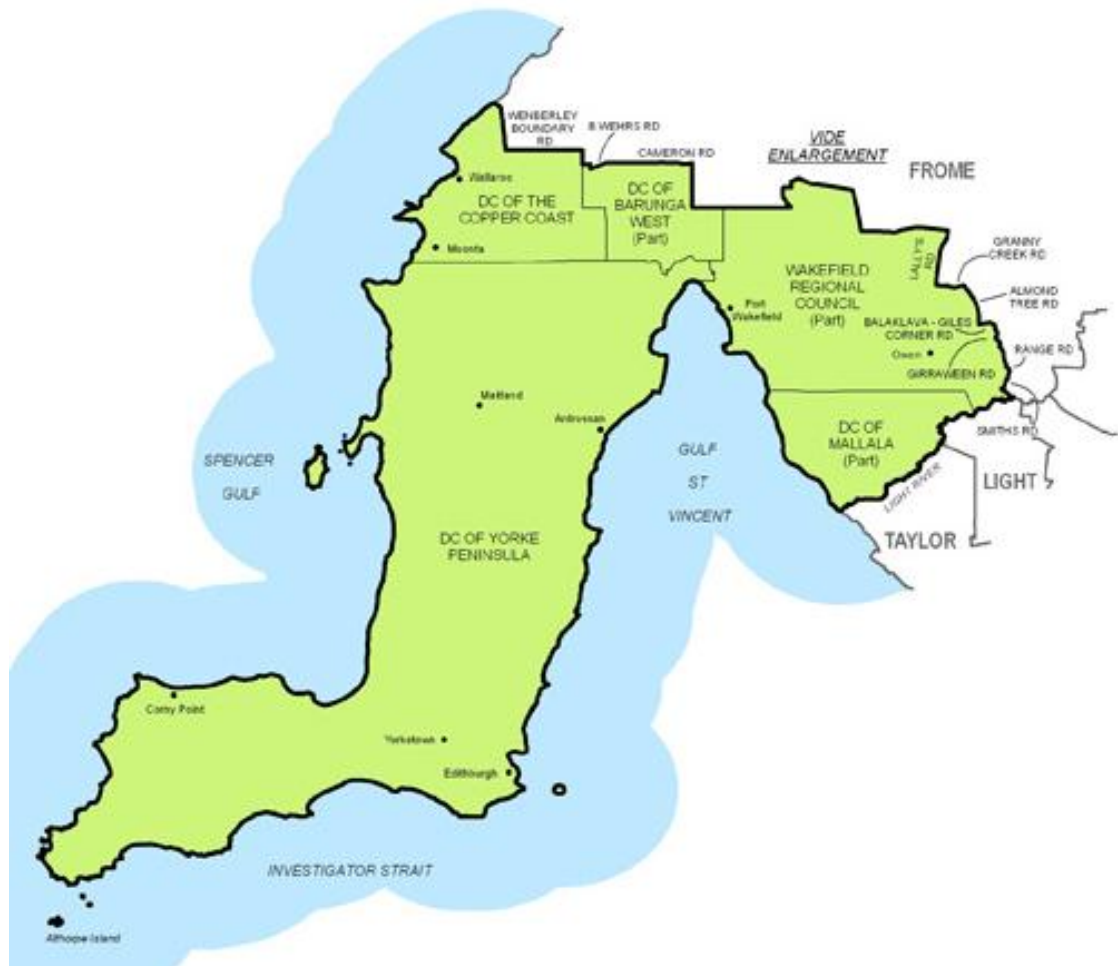
South Australia is characterised by its natural features (Murray River, Flinders Rangers, Kangaroo Island, 3,800 km coastline) and its 'outback' environment. It has a long mining history, dating back to the 1840s, and a thriving current mining industry comprising iron oxide, copper, gold, silver and uranium deposits, including BHP Billiton's mammoth Olympic Dam copper, uranium mine.

1.1.4 Australia

Australia is the world's 13th largest economy and has the fifth-highest per capita income (CIA, 2011). It has the second-highest human development index globally, and ranks highly in many international comparisons of national performance, such as quality of life, health, education, economic freedom, and the protection of civil liberties and political rights (UN, 2010).

Mining in Australia is a significant primary industry and contributor to the Australian economy. Historically, mining booms have also encouraged immigration to Australia. A range of different ores and minerals are mined throughout the country.

Figure F01: Boundaries of the Goyder State Electoral Division (Regional Study Area)



Source: Electoral Division South Australia, 2010

1.2 Potentially Affected Communities

As described in *Section 1.1.1 Primary Study Area*, the local communities most likely to be directly affected by the Project are included in post code area 5571. They are, in likely order of impact:

- Ardrossan
- Pine Point
- James Well
- Rouges Point
- Tiddy Widdy Beach
- Black Point
- Port Julia
- Sheaoak Flat

In addition to the direct and indirect impacts likely to be experienced by these communities, some communities in the regional study area are also likely to experience at least some direct and indirect impacts of the Project, particularly communities located along key transport routes for consumables, product or workers to and from the Project site and regional centres such as Port Wakefield, Maitland, Kadina and Wallaroo from which additional services, goods and accommodation are likely to be required (directly and indirectly a result of the Project). Economic stimulus is likely to be felt to differing degrees across the regional study area.

1.3 Governance Profile

The primary study area is located primarily in the Federal electorate of Grey and the State electorate of Goyder.

The regional study area crosses both Grey and Wakefield Federal electorates (ECSA Website, April 2012). There is one federal member for Grey (Rowan Ramsey); one federal member for Wakefield (Nick Champion); and one state member for Goyder (Steve Griffiths) (AEC Website, April 2012).

The DCYP is the local government body responsible for managing the municipality in which the primary study area and much of the regional study area is located. Other local government bodies in the regional study area include:

- District Council of the Copper Coast
- District Council of Barunga West (part)
- Wakefield Regional Council (part)
- District Council of Mallala (part).

The DCYP was formed in 1997 as a result of the voluntary amalgamation of the District Councils of Central Yorke Peninsula, Minlaton, Yorketown and Warooka (DC of Yorke Peninsula Website, April 2012).

There are three electoral wards in the DCYP (Kalkabury, Gum Flat and Innes Pentonvale) from which one mayor; one deputy mayor and ten additional councilors are elected. The council is served by a Chief Executive Officer who is responsible for managing council staff and day-to-day activities, as well as implementing council decisions. At the time of writing there were two female and ten male elected officials on the DCYP. Council meetings are open to the public and are held on the second Wednesday of every month in Minlaton (DC of Yorke Peninsula Website, April 2012).

1.4 Economic and Industry Profile

Table T01 below provides a comparison of key economic indicators across both study areas, South Australia and Australia. It draws on a combination of data from different timescales, as referenced in the table note, but nonetheless illustrates that the primary and regional study areas are characterised by lower workforce participation, higher unemployment and significantly below-average incomes when compared to the State of South Australia and the nation as a whole. At the time of writing, 2011 National Census data for employment and labour force participation had not been released, so 2006 Census data is relied on.

The regional study area's economy is based mainly on agricultural activities based predominantly on cereal grains and livestock (more than 690,000ha across the regional study area were in use for agricultural purposes in 2006 (ABS, 2006) and more than half a million livestock (sheep, cattle and pigs) were reared. The total gross value of agricultural production in the regional study area in 2006 was \$96.7m (ABS, 2006). Information from the 2011 National Census was not available at the time of writing.

The primary industries are augmented in the regional study area by extractive industries including dolomite, sand mining, salt production and gypsum, and tourism.

Tourism contributed approximately \$166 million to the regional economy in 2009-10. The total number of visitors to the region in that period was 883,000 made up of 436,000 domestic day trippers, 443,000 domestic overnight visitors who stayed over 1.4 million nights and 4,000 international visitors (Yorke Peninsula Tourism, 2011).

The region's aquaculture industry is increasing.

The South Australian economy grew at a rate of 2.4% in 2010-11, compared with 2.1% for the nation as a whole.

With respect to mining royalties, the South Australian Government collected \$152.4 million in mining royalties and fees for exploration permits in the financial year 2008-09 (CGC, 2012). This equated to 2.4% of total state revenue.

While National Census data for employment in the study area was yet to be released at the time of writing, the number of unemployed persons in the region was in the order of 350 in March 2003 and by June 2011 had decreased to 140, a reduction of approximately 60 per cent over the period. The number of unemployed persons in South Australia decreased by approximately 11 per cent in the same period (DEEWR, 2011).

The unemployment rate in the primary and secondary study areas was 7.8% and 5.4% respectively in the 2006 Census. This is set against more recent unemployment figures for the region of 2.8% at the June quarter 2011 (DEEWR, 2011). It is expected that Census data from 2011, when released, is likely to indicate lower unemployment rates in the primary and regional study areas than in 2006.

Sheep, beef cattle and grain farming were the major industries of employment in both the primary and regional study areas, employing just over 27% and 21% of working-age residents respectively (ABS, 2006).

For the primary study area, the major industry of employment was 'Food Product Manufacturing' (ABS, 2006), which is the category representing the large grain processing facility run by Viterra in Ardrossan. Employment in school education and hospitals figures prominently across all study areas, which is consistent with State and National data (ABS, 2006).

Many people within the Yorke and Mid North region (which includes all three key study areas) experience underemployment as a result of the high levels of seasonal and casual employment in the region (RDAYMN, 2010). The predominance of employment in agriculture, viticulture, retail and hospitality industries indicates that this will continue to be a characteristic of employment in the region (RDAYMN, 2010).

A detailed analysis of key economic indicators is provided in Chapter 6 Economic Environment, while a more detailed analysis of labour force characteristics is available in Chapter 4 Workforce and Accommodation.

Table T01: Comparison of Key Economic Indicators Across Study Areas

	Primary Study Area	Regional Study Area	South Australia	Australia
Labour Force Participation (% of Labour Force Population aged 15 and over) ABS 2006	384 people (43.0% participate rate) 52.3% full time 33.6% part time	18,598 people (54.7% participation rate) 56.8% full time 31.1% part time	728,070 people (62.2% participation rate) 58.5% full time 30.0% part time	9,607,987 people (64.6% participation rate) 60.7% full time 27.9% part time
Unemployment Rate (% of Labour Force Population aged 15 and over) ABS 2006	7.8%	5.4%	5.2%	5.2%
Median Weekly Individual Income ABS 2011	\$387	\$409	\$534	\$577
Household Income less than \$600 gross	44.1%	38.7%	27.7%	23.7%

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	Primary Study Area	Regional Study Area	South Australia	Australia
weekly income ABS 2011				
Household Income more than \$3,000 gross weekly income ABS 2011	2.0%	2.9%	7.3%	11.2%
Building Approvals ABS 2010	N/a ¹	481 dwellings \$166.1m total value	12,560 dwellings \$5 451.3m total value	171,429 dwellings \$86 833.1m total value
Gross Domestic/State Product (GDP or GSP) ABS 2010-11	N/a	N/a	2.4%	2.1%

Sources: ABS Census 2006; ABS Regional Profiles 2010; ABS 2009/10 Household Expenditure Survey, Australia: Summary results; ABS National Accounts, State Accounts 2010-11

1. A breakdown of building approvals for postcode 5571 was not available, but for context, the DCYP received 167 applications in 2010/11 at a combined total value of \$29.9m.

A further detailed analysis of the major industries of employment across key study areas is provided in Chapter 6 Economic Environment, Section 6.1 Major Industries.

2. LAND OWNERSHIP AND USE

The following chapter provides a description of the existing land ownership and land use within the study areas; discusses land ownership and use policies; profiles key environmental and cultural assets; and outlines the closure and rehabilitation plans for the Project.

2.1 Existing Land Ownership

2.1.1 Land Ownership

Project Area

More than 98% of the land within Rex's Exploration licences (EL 3874, 3875 and 4514) is freehold land. Land use is dominated by broad acre cropping of cereals and pulses and grazing. There are a number of small conservation reserves and some council-owned and -managed land including areas for service provision, roads and other infrastructure. Air Services Australia also owns a small parcel of land.

The freehold agricultural land is classified as 'exempt' from mining under the *SA Mining Act 1971*. (Refer to further information in Section 2.1.2 Exempt Land).

The majority of the land defining the main Hillside resource within EL 3874 is currently being purchased by Rex and negotiations are being held to purchase additional land in this area.

There are no Native Title Claims over the leases however an Indigenous Land Use Agreement is in place between Narungga Local Government and District Council of Barunga West, Copper Coast District Council, Wakefield Regional District Council and Yorke Peninsula District Council (NNT SI2003/004). Land is subject to the *SA Aboriginal Heritage Act 1988*, which protects all Aboriginal sites, objects and remains. This legislation provides Traditional Owners with rights over the land to protect their cultural heritage.

Primary Study Area

The vast majority of land in the primary study area is freehold land. Like the Project area, the land use in Primary study areas is dominated by broad acre cropping of cereals and pulses and grazing. The Indigenous Land Use Agreement between Narungga Local Government and Yorke Peninsula District Council applies to all of the primary study area.

Regional Study Area

The vast majority of land in the regional study area is freehold land, and once again the land use in this study area is dominated by agricultural activities, however, according to the RDAYMN Regional Roadmap (2010), the traditional industry base of the region has changed in the past decade from being reliant on broad acre farming to a much broader base, including intensive farming and animal husbandry (RDAYMN, 2010).

2.1.2 Exempt Land

The Hillside project area does not include national parks or native title land or land under claim. It does include small areas of land designated for conservation, capital works and communications. The vast majority of the land falls under Section 9 of the Mining Act, which exempts certain types of land from mining operations, unless the landowner has 'waived' their rights.

Exempt land includes:

- Land within 400 m of a house.
- Land within 150 m of a shed, dam or well.
- Cultivated land.
- Public infrastructure such as water works, recreation reserves, airfields, railways, public buildings (schools, hospitals etc).

According to the Act, to obtain a 'waiver' from the landowner, the leaseholder or applicant (Rex Minerals in this case) is required to negotiate appropriate compensation and access conditions with the affected landowners. If the negotiations fail, the matter may be taken to the Warden's Court (or Environment Resources and Development Court) by the landowner or leaseholder operator to determine if exemption should be waived and the amount of compensation payable.

Rex Minerals currently has access to three key landholdings at Hillside with additional land holdings either under negotiation or targeted for purchase.

2.1.3 Heritage Management

Access to land is contingent on complying with the *Aboriginal Heritage Act 1988* and, according to the Hillside Scoping Study (2011), the Project site has numerous heritage items. Access to this land will require the agreed salvage of these items from the site by the Narungga people. Current negotiations are underway with representatives of the Narungga heritage committee as to the best way to achieve this through Aboriginal Affairs and Reconciliation Division (AARD) in compliance with the Act.

Current heritage management involves exclusion from working in areas where heritage items have been found. An Aboriginal Collaborative Heritage Agreement between Narungga Nations Aboriginal Corporation and Rex Minerals has been finalised for exploration and an agreed management plan for heritage surveys and salvage of items in designated areas is in place.

2.2. Existing Land Use

The landscapes of the region around the regional study area include plains, hills and rugged ranges, undisturbed bush-land and native grasslands, coastal vistas and cliffs, and mangrove forests and wetlands (RDAYMN, 2010).

The region supports a diverse array of species, ecological communities and ecosystems. However, some argue that broad-scale clearance for agricultural production has resulted in a direct loss of fragmentation of extensive areas of habitat and resultant loss or decline of many species, and disruption to ecological processes (RDAYMN, 2010).

The extensive clearing of native vegetation since European settlement has left only 161,000 hectares or 26% remaining in the Yorke and Mid North region within which the regional study area is located. Important remnants also occur along roadsides, rail reserves, cemeteries and the coastal strip. These often small and narrow remnants often provide the only representative examples of the original vegetation (RDAYMN, 2010).

2.2.1 Indigenous Land Use and Connections

Before the coming of the European pastoralists, the Yorke Peninsula was the home of the Narungga people, who occupied the land from near Port Wakefield in the east, over to Port Broughton in the west, and all the way down to the southern tip of the Yorke Peninsula. The Narungga consisted of four clans, Kurnara (north), Windera (east), Wari, (west) and Dilpa (south) (RDAYMN, 2011).

The population of the Narungga people at the time of first contact was estimated at 500. This number had halved by 1856 and by 1880 there were less than 100 Aboriginal people of full Narungga descent on Yorke Peninsula. Once the Point Pearce Mission was opened in 1868, residents were discouraged from speaking their language and practicing their beliefs. Some Narungga people resisted the move to the mission and continued to live independently, off the land, or by gaining work outside of the mission. These groups continued to speak their own language and practice their culture - but were reluctant to pass these on to mission residents (RDAYMN, 2011).

The cultural identity of the Narungga was also challenged when Aboriginal people from other language groups were moved to Point Pearce - most significantly after the closure of Poonindie Mission in 1894. But the residents of the Point Pearce Mission maintained their community

identity and fought for their rights to land in the Yorke Peninsula. This entitlement was acknowledged in 1972, when ownership of 5,777 hectares was transferred to the Point Pearce Community Council under the *Aboriginal Lands Trust Act 1966* (RDAYMN, 2011).

Today both the Narungga Aboriginal Progress Association, based in Maitland, and the Narungga Heritage Committee, based in Point Pearce, are working to continue and revive Narungga culture and language through education, tourism and cultural awareness training (RDAYMN, 2011).

As noted in *Section 2.1*, the Project area is subject to an Indigenous Land Use Agreement between Narungga Local Government and the Yorke Peninsula District Council (NNT SI2003/004) as well as the *SA Aboriginal Heritage Act 1988*, which protects all Aboriginal sites, objects and remains.

2.2.2 Agricultural Land Use and Farming

Regional Study Area

The Yorke Peninsula produces around a quarter of South Australia's grain harvest, contributing an average \$300 million per annum to the State economy. Wheat and barley account for two thirds of the total value of production, with peas, canola, beans and lentils the other major crops. Livestock production (primarily sheep, pork and poultry) contributes more than \$110 million to the economy (SA Planning, 2007).

As previously identified, the vast majority of land in the regional study area is used for agricultural purposes, including farming. Table T02 outlines the agricultural commodities (in 2006) for the regional study area by total hectares and total number of livestock.

Table T02: Agricultural Commodities in the Regional Study Area

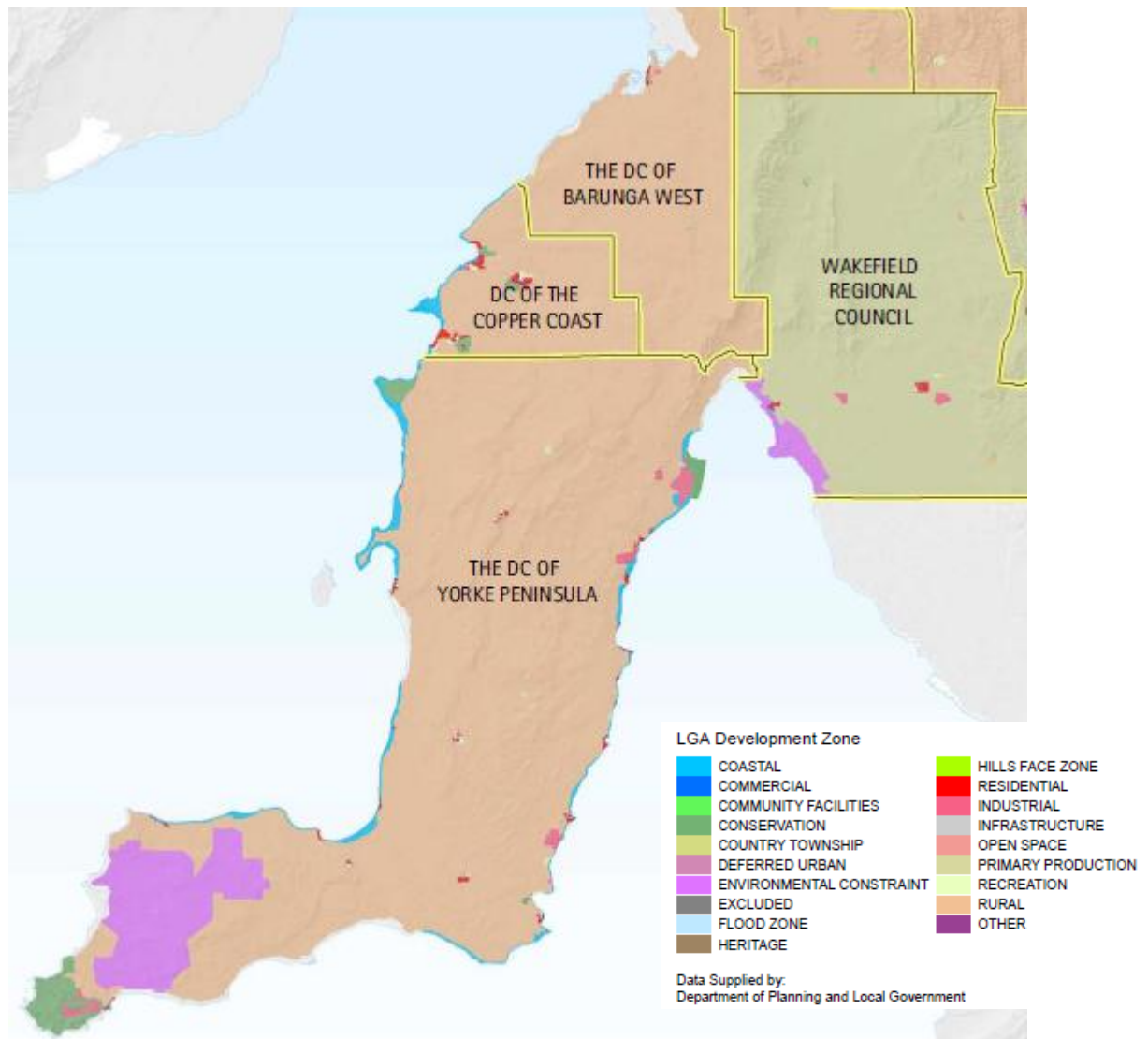
Agricultural Commodities by Total Number of Hectares	
Area of holding	2,021,672.3
Cereals for grain	742,571.4
Vegetables for Human Consumption	301.1
Orchard trees (including nuts)	252.9
All fruit (excluding grapes)	258.4
Non-cereal broadacre crops	197,929.6
Agricultural Commodities by Total Number of Livestock	
Sheep and lambs	1,362,390
Milk cattle (excluding house cows)	4,085
Meat cattle	44,134
Pigs	62,458

2.2.3 Zoning

As shown in Figure F02, below, the primary study area's zoning is mainly industrial, with pockets of coastal and residential zones. The residential zoning is concentrated around Ardrossan and Pine Point/Sheaoak Flat. The remainder of the primary study area is zoned coastal.

The zoning in the regional study area is mainly rural, with pockets of coastal and conservation zoning along the coastline. In the lower boot of the Yorke Peninsula, there is a large pocket of land zoned 'environmental constraint' indicating Warrenben Conservation Park and Innes National Park.

Figure F02 Zoning in the Regional Study Area



Source: Regional Development Australia Yorke and Mid North

Interviews with Roger Brooks, Director Development Services and Trevor Graham, Director Assets and Infrastructure Services from DCYP in July 2012 indicated that land availability in the primary study area was not constrained for future development (pers comm. July 1202).

They reported there was land to the north and to a lesser extent to the south of the town that was available for residential development, indicating that in total, there were more than 200 residential lots available at the time. This was in addition to at least 12 industrial lots. The Directors also reported other subdivisions in various stages of planning and approval in Port Vincent and James Well, as well as rezoning occurring around Maitland, Middleton and Moorooka that aimed to expand the existing town boundaries.

The Directors also felt that Ardrossan we well equipped to accommodate residential development with adequate sewerage, water and power systems in place.

The Directors indicated that the only likely constraint to rapid development in the primary study area would be the DCYP's capacity to cope with significant additional planning and approval workload.

2.2.4 Environmental and Cultural Assets

Figure F03, below, provides a visual representation of the key environment and cultural assets in the primary and regional study areas. It also indicates that there are a number of noteworthy geological monuments in the primary study area and in the area between the primary study area and the Project site.

Within the regional study area there are more than 12 State Heritage Places, five lands on the National Estate Register and several patches of natural vegetation that have been designated for protection (SA Planning, 2007). The Clinton Conservation Area is also located within the regional study area, approximately 34km north of Ardrossan. There are 12 Conservation Parks and two National Parks in the regional study area, totaling 45,145 ha, with an additional 17,036 ha protected under Heritage Agreements.

2.2.5 Land Use Planning and Initiatives

In 2007 the Yorke Peninsula Regional Land Use Framework was published by Planning SA and included an integrated spatial vision for the growth and development of the regional study area (see Figure F02 above for further details).

The integrated vision was designed to balance the needs of people today with the needs of future generations (Planning SA, 2007). According to the framework, the vision allows for communities to develop and grow, and supports initiatives that help retain the special qualities of the regional study area, while fostering vibrant and distinctive towns that support a range of lifestyles (Planning SA, 2007). Economic activities are also supported that benefit the local and regional economy, providing local employment and attracting people to the region (Planning SA, 2007).

The integrated vision also seeks to recognise the variation in geographic features, economic strengths and community aspirations across the regional study area, and make the most of the different opportunities these present (Planning SA, 2007).

The vision focuses on the following key elements:

- Population and industry growth – with a focus on the Copper Coast and Wakefield Plains.
- Sustainable coastal growth.
- Strengthened inland towns.
- Conservation and nature-based tourism – in particular in western and southern Yorke Peninsula.

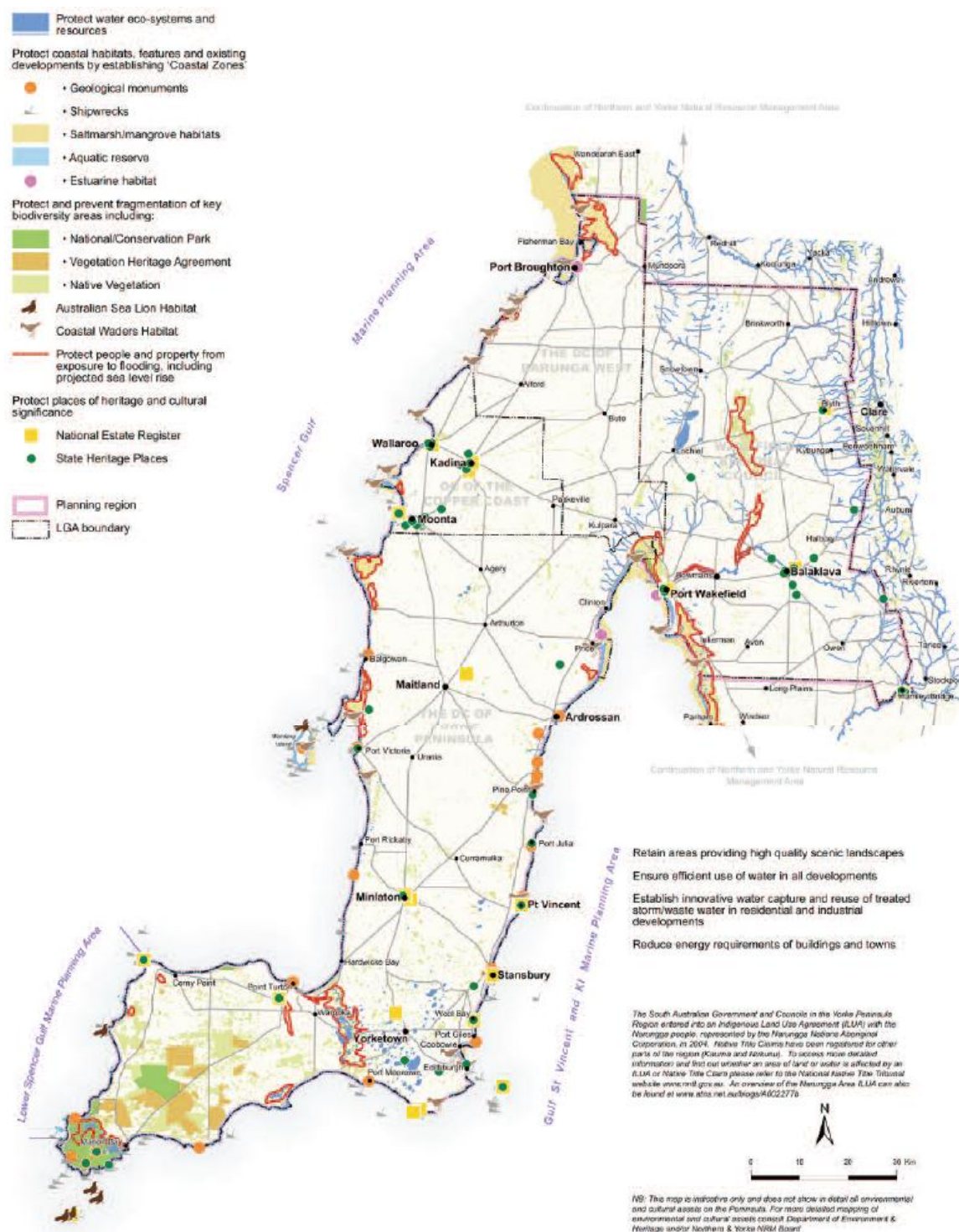
With respect to the primary study area, the key features of the integrated vision include strengthening the heritage township character of Ardrossan and reinforcing the town's supporting commercial/services role (SA planning, 2007).

The same key features are applicable in the other key towns of Maitland and Minlaton within the regional study area. Other initiatives of note within this study area include the expansion of the wind farm industry in Sheaoak Flat and Port Vincent (SA Planning), 2007.

Key Economic Development Zones in the Regional Study Area

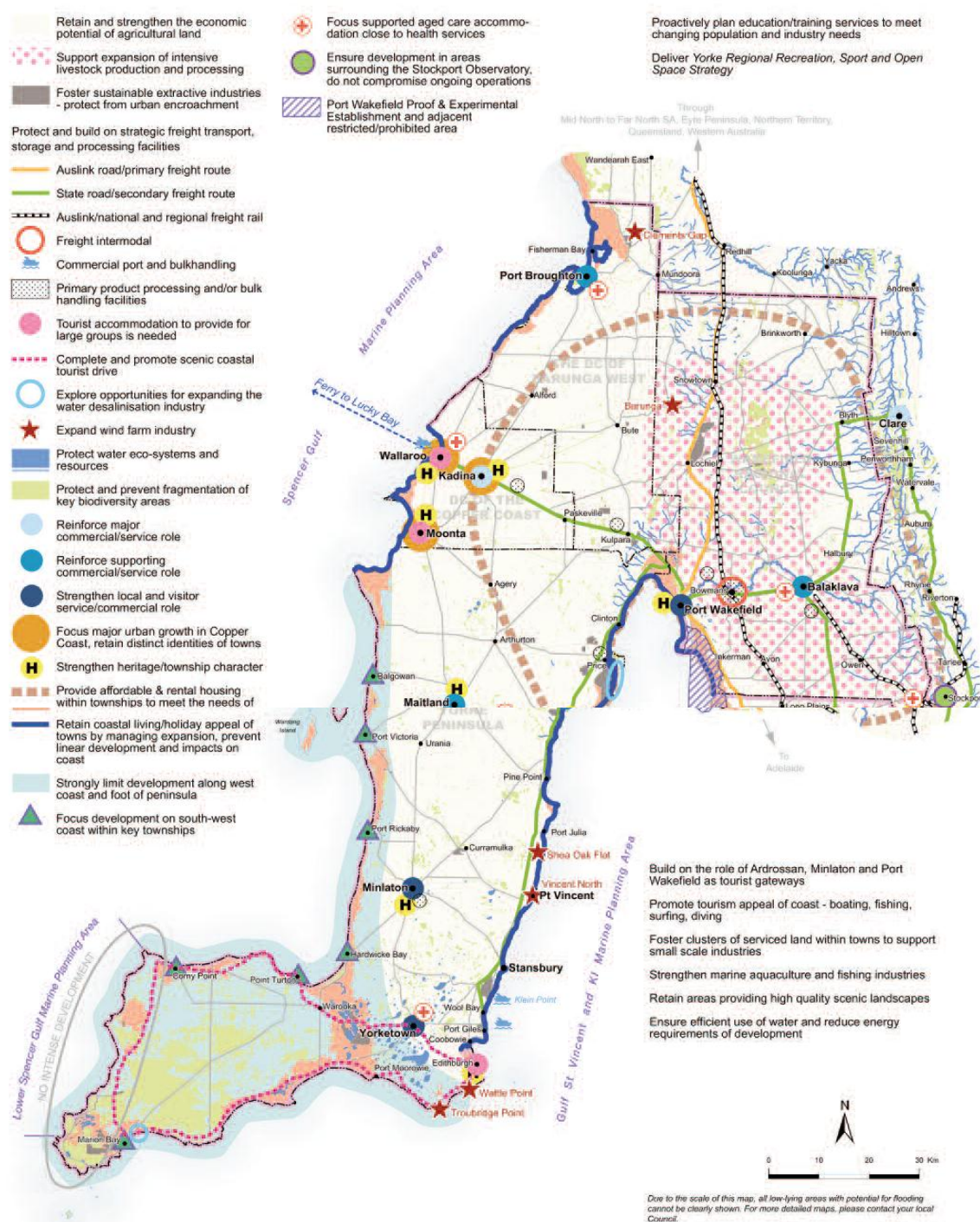
Figure F03, below, provides a visual representation of the key economic development zones in the primary and regional study areas. With respect to the primary study area, the key features include a focus on commercial activities within the township of Ardrossan by ensuring they are well suited to and designed for commercial activities (SA Planning, 2007). The same key features are applicable in the other key towns of Maitland and Minlaton within the regional study area.

Figure F03: Environmental and Cultural Assets in the Primary and Regional Study Areas



Source: Planning SA Yorke Regional Land Use Framework, 2007

Figure F04: Integrated Vision for the Regional Study Area



Source: Planning SA Yorke Regional Land use Framework 2007

Figure F05: Economic Development Zones in the Primary and Regional Study Areas



Source: Planning SA Yorke Regional Land Use Framework, 2007

2.3 Rehabilitation, Closure and Post-Mine Land Use

The Rex Minerals Hillside Project Scoping Study (2011) acknowledges that developing a rehabilitation and closure plan for the Project is the final phase in the approvals process. At the time of writing, additional studies and planning activities were required in order for Rex to meet these planning requirements.

2.3.1 Closure Planning

The closure and rehabilitation plan will demonstrate that the site will be progressively rehabilitated (where practical) to a stable condition and use, consistent with the land use at the time mining operations commenced, or to a post-mining land use as agreed with stakeholders (including the landowner). It is the intention of Rex that the plan not only complies with legal obligations, but also reflects community expectations and delivers a sustainable outcome for the project site. The underlying methodology will be a 'risk-based closure planning process'.

The specific standards set for each mining activity will be met before relinquishment. These standards will include:

- General economic standards.
- The community and future generations are left with no residual liability for site rehabilitation or maintenance.
- Adverse economic effects are minimised.
- Provision is made for reasonable access for future mining (or reprocessing) of any remaining resource.
- General social standards.
- Demonstration of effective ongoing community engagement.
- Closure is planned to minimise the disruption/impact on the community.
- Development of programs, driven by the needs of the community, that contribute to the sustainability of the community.
- Future public health and safety are not compromised.
- General environmental and rehabilitation standards.
- Physical, geochemical and ecological stability.
- The protection of the quality of the surrounding water resources.
- Risk of adverse effects to people, livestock, other fauna and the environment in general has been reduced as far as practicable to a level acceptable to all stakeholders.
- Clearly defined realistic beneficial and sustainable post-mining land use.
- Monitoring and reporting criteria for successful final and progressive rehabilitation.
- Signoff criteria and post surrender action and funding.

3. SOCIAL ENVIRONMENT

The following chapter provides an overview of the social environment within the key study areas. Specifically, the chapter provides a description of the key population and demography indicators for the Project's study areas; discusses amenity and profiles key social services, facilities and crime in the local areas surrounding the Project.

3.1 Population and Demography

Table T04 Comparison of Key Demographic Indicators, below, provides a detailed analysis of the key indicators across all of the study areas. Statistical data was sourced from the National Census 2011 or 2006 as indicated, unless otherwise indicated.

3.1.1 Primary Study Area

Population

At the last census, the primary study area had a total population of 1,580 persons, a decrease from 1,945 persons (or 19%) in 2006.

There were only slightly more males (50.8% or 802 persons) than females (49.2% or 778 persons); the gender balance was marginally more favorable of males in 2006. Both the primary and regional study areas defy State and national trends for greater female representation in the population, albeit only slightly higher.

A total of 25 persons identified themselves as Indigenous in 2011, compared with 17 in 2006.

Age

The vast majority (59.9%) of the population were aged 55 years or older, compared with 48% in 2006, and the median age was 60 years old, compared with 53 in 2006.

Almost one quarter (24.8%) were between the ages of 25 and 54 years (compared with 31% in 2006), and significantly, more than a third (39%) were aged over 65 years (compared with 29% in 2006). Only 15% were between the ages of 0 and 24, compared with 21% in 2006. Only 9.7% were children aged between 0-14 years, compared with 14.5% in 2006.

These age comparisons between 2011 and 2006 show the primary study area's population is aging and each age bracket is not being filled at the same rate as previously with younger people. The percentage of over-65s suggests the area is increasingly popular as a retirement destination.

Ethnicity and Language

More than 83% of residents were born in Australia (consistent with 81% in 2006), with the majority of overseas-born residents originating from England (6.6%), Germany (1%) and Scotland (0.7%). English was the only language spoken at home by 95.6% of the population, slightly higher than reported in 2006 when 91% of respondents spoke English at home.

Other languages included German (0.2%), Dutch (0.2%) and Urdu (0.2%).

Comparisons between 2011 and 2006 suggest the primary study area has become marginally less culturally diverse in the period but not to a level of statistical significance.

Religion

The majority of residents identified as belonging to the Uniting Church (28.7%), with 22.5% recording no religious affiliation, 17.8% Anglican and 12.5% Catholic. These results are comparable to 2006 data.

Marital Status

In 2011, 59.2% of the population was married, 13.2% were separated or divorced, 11.9% were widowed and 15.6% had never married. The proportion of residents never married in the primary study area is about half that of the State or National average.

The median age of married persons was 64, compared with those who had never married at 30 years. Slightly more of the population in 2006 was married (63.5%), less people were separated or divorced (11%) and about the same proportion of people (16.1%) had never married in 2006.

Table T04: Comparison of Key Demographic Indicators Across Study Areas

	Primary Study Area	Regional Study Area	South Australia	Australia
Total Population	1,580	30,800	1,596,572	21,507,717
Sex Ratio	50.8% male 49.2% female	50.3% male 49.7% female	49.3% male 50.7% female	49.4% male 50.6% female
Indigenous origin	25 (1.6%)	734 (2.4%)	30,431 (1.9%)	548,369 (2.5%)
Median Age	60 years	48 years	39 years	37 years
Born outside Australia	254 (16.2%)	4,266 (15.9%)	425,784 (26.7%)	6,489,870 (30.2%)
Speaks English Only	1,513 (95.6%)	29,274 (95.0%)	1,303,065 (81.6%)	16,509,291 (76.8%)
Religious Affiliation	Uniting 28.7% None 22.5% Anglican 17.8% Catholic 12.5% Lutheran 4.9%	None 27.0% Uniting 23.1% Anglican 13.9% Catholic 12.4% Lutheran 5.0%	None 28.1% Catholic 19.9% Anglican 12.6% Uniting 8.9% Lutheran 4.5%	Catholic 25.3% None 22.3% Anglican 17.1% Uniting 5.0% Lutheran 1.2%
Registered Marital Status People 15 years and over	Married 59.2% Separated 3.0% Divorced 10.2% Widowed 11.9% Never 15.6%	Married 54.0% Separated 3.0% Divorced 9.8% Widowed 8.4% Never 24.7%	Married 48.4% Separated 3.0% Divorced 9.1% Widowed 6.3% Never 33.3%	Married 48.7% Separated 3.0% Divorced 8.4% Widowed 5.5% Never 34.3%

Source: ABS 2011

3.1.2 Regional Study area

Population

At the last census, the regional study area had a total population of 30,800 persons. There were only slightly more males (50.3%) in the study area than females (49.7%). This was consistent with the 2006 population and sex ratio.

A total of 734 people (2.4%) identified themselves as Indigenous in 2011, compared with 602 (2%) in 2006.

Age

Almost half (47.9%) of the population was aged over 55 years old and the median age was 48 years old. Like the primary study area, this contrasts sharply with only about a third of the population aged over 55 in 2006 and the median age then of 46.

One third (33%) were aged between 25-54 years, while just over a quarter (26.5%) were between the ages of 0 and 24 (both consistent with 2006).

Seventeen percent of the population of the regional study area were children aged between 0-14 years, also consistent with 2006.

Similar to the primary study area, the population in the regional study area is aging, but unlike the primary study area, all but the older age brackets are steady.

Ethnicity and Language

Just over 86% of residents in the regional study area were born in Australia, with overseas-born residents originating from England (5.3%), New Zealand (0.5%) and Scotland (0.5%). English is the only language spoken at home by 95.0% of the population, followed by Italian (0.2%), German (0.2%) and Greek (0.2%). The 2011 results show little variation from 2006.

Religion

The majority of residents in the regional study area recorded no religious affiliation (27%), while 23.1% identified as belonging to the Uniting Church, followed by 13.9% Anglican and 12.4% Catholic and 5% Lutheran. From 2006 to 2011, a greater proportion of the population are reporting to be of no religion (22.4% in 2006), and each of the religious groups had decreased (none particularly more than another).

Marital Status

In 2011, 54% of the population was married, 12.8% were separated or divorced, 8.4% were widowed and 24.7% had never married.

The median age of married persons was 58, compared with those who had never married at 26 years. Slightly more of the population in 2006 was married (56.4%), less people were separated or divorced (11.9%) and slightly less people (22.9%) had never married in 2006.

3.1.3 Income

A detailed analysis of average weekly incomes across the key study areas is provided in Chapter 6 Economic Environment, Section 6.2.2 Income.

3.2 Amenity

3.2.1 Primary Study Area

Sense of Place and Social Values

The town of Ardrossan, the largest town in the primary study area, is characterised as a small coastal town consisting of one main street with plenty of historical charm. The town is situated atop picturesque red cliffs providing great views of the local beaches and coastline.

The town is reasonably well serviced with physical, social and retail services. It's population, and that of the other town in the primary study area, increase significantly during the summer, particularly over the holiday period when both harvesting and tourism activity increases.

Residents of Ardrossan are said to value its relaxed coastal lifestyle and the close, friendly relationships between locals that is often found in rural environments (SA Tourism Board, 2012). The same can be said of the other smaller townships within this study area. All located on the coast, the other towns in the primary study have consisted predominately of holiday houses in the past. Today, they generally comprise a mix of holiday and permanent residences.

Air Quality

The South Australian Environmental Protection Authority monitors air quality in the Upper Spencer Gulf at Port Pirie and Whyalla. It notes the potential, at times of prevailing winds, for emissions from the steel works at Whyalla, lead smelter at Port Pirie and the State's major brown coal power station at Port Augusta to travel down the gulf, potentially affecting the quality of air in some places. Port Pirie is about 160km from Ardrossan (EPA, 2008).

In the primary study area, fire smoke, seasonal burning off, and air emissions from bulk transport, grain harvesting and agricultural activity affect air quality to some extent at times.

Noise

Agricultural industry is predominant in the study area, which also supports an industrial port facility, extensive bulk transport, an operating extractive industry and recreational marine activities (particularly boating). Typical noise associated with these types of industries and activities exist in the study area.

In August 2011, Suzlon Energy Australia announced plans to build “one of the world’s largest wind farms” 20km southwest of Ardrossan (ABC, 2011) promoting significant local concern about the impacts of noise associated with wind turbines.

3.2.2 Regional Study Area

Sense of Place and Social Values

Consistent with the information above, communities within the regional study area have a strong sense of local identity that can partly be attributed to the early pattern of European settlement and the relatively high number of small townships and communities that have persisted through until today. The geographical and biophysical variation across the region has also played a significant role in influencing the natural communities of interest, that tend to more naturally align towards sub-regions around the Yorke Peninsula and Mid North regions (RDAMYN, 2011).

The region is steeped in pioneering history as a result of the 19th century copper mining boom and the explosion of agricultural trade in the region (SA Tourism Board, 2012). This means residents of the regional study area see intrinsic value in both the agricultural and industrial sectors to the region.

The region is home to a number of notable geological monuments and conservation areas (see Chapter 2 Section 2.2.5 Environmental and Cultural Assets for further information).

The coastline of the region is a near-continuous corridor of over 800 km and provides the basis for many of the region’s industries, including fishing and tourism.

3.6 Health and Wellbeing

Table T05 below outlines the key health indicators across the regional study area. These indicators are not available at the micro level of the primary study area.

Table T05: Key Health Indicators Across Key Study Areas

	Regional Study Area (Represented by Yorke and Lower North SD or Goyder SED as noted)	South Australia	Australia
Median Age¹	48	39	37
Life Expectancy²	78	80	79
Self-Assessed Health Status²	16% poor or fair 62.7% very good or excellent	15.5% poor or fair 66.2% very good or excellent	14.7% poor or fair 68.3% very good or excellent
Self Assessed Psychological Stress²	12% high or very high	12.1% high or very high	11.7% high or very high
Levels of Chronic Disease²	3.6% Type 2 Diabetes 7.2% high cholesterol	3.5% Type 2 Diabetes 7.4% high cholesterol	3.4% Type 2 Diabetes 5.6% high cholesterol
At least 1 of 4 Health Risk Factors (Smoking, Excessive Alcohol, Inactivity or Obesity)²	64.8%	57.6%	55.9%
Low Birth-Weight	6.7%	6.8%	6.5%

	Regional Study Area (Represented by Yorke and Lower North SD or Goyder SED as noted)	South Australia	Australia
Babies²			
Smoking During Pregnancy²	21.1%	16.8%	15%
Child Mortality (deaths per 100,000 children under 5 years old)²	124.2	97.6	112.4
Fully Immunised (children aged 12- 15months)²	89.3%	91.8%	91.3%

1. ABS 2011, Goyder SED. 2. PHIDU, 2012, Social Health Atlas, Yorke Peninsula DC.

Health Status

Based on self-assessments, residents in the regional study area consider themselves to be comparatively healthy (both mentally and physically) compared to their South Australian and Australian counterparts. The area has similar levels of self-assessed physical health (63% very good to excellent) and psychological distress (12% high or very high) to the State and National averages. These statistics represent residents in the Yorke and Lower North Statistical Division (these statistics are not available for Goyder SED).

Chronic Disease

Residents in the regional study area have a slightly higher level of Type 2 diabetes (3.6%) than the State and National averages, and more people with high cholesterol (7.2%) than the national average (5.6%). There are also a larger percentage of people (64.8%) with at least one of four key health risk factors (smoking, excessive alcohol, inactivity and/or obesity) compared with 57.6% of South Australians and 55.9% of the Nation as a whole.

Infant and Child Health

With respect to infant wellbeing, the study area has a comparable percentage of low birth weight babies (6.7%) compared with 6.8% for South Australia and 6.5% for Australia. The percentage of mothers smoking during pregnancy (21.1%) is notably higher than State and National averages (16.8% and 15% respectively).

Regarding immunisation status, just under 90% of children aged 12-15months in the study area are fully immunised, which is comparable with 91.8% in South Australia and 91.3% throughout the Nation.

Information on available health care services and infrastructure is provided at *Section 3.9 Social Services and Facilities*.

3.7 Education

Table T06 below outlines education status across the study areas.

Table T06: Education Status Across Study Areas

	Primary Study Area	Regional Study Area	South Australia	Australia
Pre-school	9 3.8%	338 4.8%	20,581 4.5%	332,844 5.1%
Primary (Government, Catholic and Other non-Government)	77 32.1%	2,597 37.1%	136,539 29.7%	1,755,208 27%

	Primary Study Area	Regional Study Area	South Australia	Australia
Secondary (Government, Catholic and Other non-Government)	47 19.6%	1,656 23.7%	90,951 19.8%	1,336,044 20.5%
Technical or further education	12 5.0%	437 6.2%	34,842 7.6%	473,606 7.3%
University or tertiary	3 1.2%	215 3.1%	65,957 14.4%	932,524 14.3%
Other	9 3.8%	114 1.6%	11,101 2.4%	161,660 2.5%

Source: ABS 2011, Goyder SED and 5571.

Pre-School and Primary Education

In the primary study area, a smaller proportion of the population attended pre-school than in the regional study area, State or nationally. Regional attendance was consistent with the State and national averages. This may be the result of limited preschool places available in the primary study area (refer Section 3.8.2 Education Facilities indicates few vacancies in the area). In 2011 in the primary study area, 17.3% of the population responded that they cared for children in the two weeks prior to the National Census. This compared with 24.6% of the population across the regional study area.

Primary school attendance across both study areas was higher than the State and national averages. Overwhelmingly services are government-provided.

Secondary Education

Attendance at secondary education in the primary study area was consistent with the State average. A higher proportion attended secondary school across the regional area.

No residents in the primary study area in 2011 reported attending catholic or other non-government secondary schools.

Technical or Further Education

Attendance at technical or further education was lower in the primary study area (only 12 residents, or 5%) compared with the State (14.4%) or nationally (14.3%). This is likely because of lack of facilities in the immediate vicinity and the composition of local industries where further qualifications are often not required in order to obtain meaningful employment.

University or Tertiary Education

Attendance at university or education was low in the primary study area (1.2%) and the regional study area (3.1%) than across the broader regional area, State or nationally. Again, this is likely because of lack of facilities in the region and the composition of local industries where further qualifications are often not required in order to obtain meaningful employment.

Information on available education services and infrastructure is provided at *Section 3.9 Social Services and Facilities*.

3.8 Social Services and Facilities

Information in the following section is based predominately on data from Yorke and Mid North Region (which includes the primary study area and the majority of the regional study area, but does not allow for a more detailed breakdown to these levels) and is sourced primarily from the Regional Development Australia Yorke and Mid North Regional Roadmap, August 2010 (and supplemented with additional local information where available).

3.8.1 Health and Medical Services

There are at least 10 health services centres (run by SA Health) in the regional study area,

located at Ardrossan, Balaklava, Maitland, Minlaton, Moonta, Wallaroo, Port Wakefield, Hamley Bridge and Yorketown.

These sites provide a range of accident and emergency, acute inpatient, elective surgery, maternal and birthing, community health, aged care and various associated and clinical support services to their communities. The significant numbers of early retired and aged persons in the region is a major issue for the provision of health services. There are some access difficulties to local and metropolitan health facilities due to limited public and community transport.

Of these 10 centres, one is located within the primary study area. The following health services are available at the Ardrossan Community Health Centre (Ardrossan Hospital Website, May 2012):

- Physiotherapy
- Dental Care
- Audiology
- Asthma
- Immunizations
- Podiatry
- Child and Youth Health Services
- Child and Family Psychology
- Mental Health Nurse
- General Surgeon
- Optometry
- Cardiology
- Psychology

Doctors/General Practitioners

There are General Practitioners in medical practices in the following towns within the regional study area - Ardrossan, Balaklava, Hamley Bridge, Kadina, Laura, Maitland, Minlaton, Moonta, Wallaroo (2 practices), Port Wakefield, and Yorketown. Residents in towns that do not have resident GPs have a 20-30 minutes' drive to the nearest GP (SA Health, 2010).

The Ardrossan Medical Centre has four general practitioners that see patients at the centre and provide house visits for exceptional circumstances only (Pers-Comms, Ardrossan Medical Centre, 7 May 2012).

Hospitals

SA Health Public Hospitals are located in Balaklava, Maitland, Wallaroo and Yorketown (SA Health, 2010) within the regional study area.

Private hospitals are located in Ardrossan (Ardrossan Community Hospital), Moonta (Moonta Health and Aged Care Services) and Wallaroo (Northern Yorke Private Hospital).

Ardrossan Community Hospital is located 15km from the Project by road. It has 16 hospital beds (vacancies fluctuant) and 25 aged care beds (with no vacancies at the time of writing). It provides 24 accident and emergency, helipad and links to Mediflight retrieval teams, acute medical care, palliative care, convalescence, respite, aged care and physiotherapy. Hospitals at Maitland and Yorketown contain 18 and 26 hospital beds respectively, and Maitland also has 14 aged care beds (with one vacancy at the time of writing).

There were no obstetrics services located in the primary study area; the closest public obstetrics services were located at the Wallaroo Hospital, while the closest private facilities were in Adelaide.

The closest medical imaging and X-ray services were located at Wallaroo, approximately 80kms from the Project site (SA Health, 2010).

Disability Services

Disability SA offered case management and brokerage services in partnership with other non-government organisations for the provision of a wide range of services to support people with disabilities across the region (SA Health, 2010). Support offices were located in Kadina. There was also the Commonwealth Respite Centre in Wallaroo (SA Health, 2010).

Home and Community Care (HACC)

HACC provided co-State- and Commonwealth-funded services to support mainly the frail aged, and to a lesser extent people with a disability or special needs (SA Health, 2010). Services included community nursing, domiciliary care, leisure options for aged and disabled, and the assessment and provision of high and low level care packages to support people to live independently in their homes (SA Health, 2010). Community health services were located in Maitland, Minlaton and Wallaroo (SA Health, 2010).

Mental Health Services

Public mental health services were operated by SA Health at Minlaton and Wallaroo.

Aboriginal Health Services

Aboriginal health services were located in Maitland, Point Pearce, and Moonta.

Dental Services

Public dental care was provided by the SA Dental Service in community dental clinics in Kadina, and Maitland. There were school dental service clinics, which provided dental care to full-time students in schools or tertiary education up to the age 18 years, in Kadina and Maitland (SA Health, 2010).

The Ardrossan Dental Service operates from the Ardrossan Community Health Centre and there were additional private dental clinics in Maitland and Yorketown (Yellow Pages, April 2010).

Drug and Alcohol Services

Public drug and alcohol support services were provided by SA Health from support centres in Minlaton and Wallaroo (SA Health, 2010).

Access to Medical Services

Compared with other more isolated communities in rural South Australia, there was a range (albeit limited) of local and intrastate transport options available, including some community and patient transport schemes, to allow residents of the regional study area to access various health care facilities.

Transport from Yorketown to Adelaide was available three times per week, and from Wallaroo to Adelaide, seven days a week. A health bus (Yorke Peninsula Community Transport and Services Inc.) traveled from Yorketown to Adelaide, via Minlaton and the Copper Coast, Monday-Friday for people to attend medical appointments (SA Health, 2010).

SA Health's 10 Year Health Care Plan for the Yorke Peninsula

In 2010, SA Health announced that health care planning had recently been carried out by each regional cluster as part of consultations for the South Australian Government's 'Country Health Care Plan'. As a result of this planning, SA Health published the Yorke Peninsula and Lower North 10-Year Local Health Service Plan (SA Health, 2010).

According to this plan, service priorities for the region (particularly where gaps/issues with existing services have been identified by the community in consultation regarding the 10-year Health Care Plans) include:

- Waiting times for services – predominantly waiting for an appointment to see a GP or specialist.
- Access to GPs, and to a lesser extent medical specialists.

- Communication and information – access to information about services and being able to understand health information.
- Patient journey – transport and the associated costs and upheaval, discharge planning.

Health priorities identified by the Yorke and Lower North community include:

- Drugs and alcohol services – not enough services, lack of prevention and early intervention.
- Chronic disease and conditions – predominantly diabetes, cancer and obesity, treatment/management and healthy lifestyle options.
- Health needs of an ageing population – in-home and residential, available locally.
- Community based care – community health and out of hospital services (including outpatient services).
- Oral health – access, cost, availability of private and public dental services.

These service and health priorities provide an indication of sensitive health areas that the Project will be required to consider in its impact management.

3.8.2 Educational Facilities

Preschool, Primary and Secondary Education Infrastructure

The following information is based on a telephone interview with the finance manager from the Ardrossan Area School on the 10th May 2012.

The Ardrossan Area School provided education for 196 students from the ages of Reception to Year 12. At the time of writing there were 16 teachers employed at the school. Table T07 provides details on the number of classes, students and current vacancies for each year level.

Table T07: Ardrossan Area School Class and Student Numbers

Year Level	Number of Classes	Number of Students	Number of Current Vacancies (with Current Staff Numbers)
Reception	1 x Combined Reception - Year 1	9	There is room for 9 additional students with the levels of Reception to Year 3 based on class sizes of 20 children across three composite classes.
Year 1	1 x Combined Reception and Year 1 and 1 x Combined Year 1-2	17	
Year 2	1 x Combined Year 1-2 and 1 x Combined Year 2-3	12	
Year 3	1 x Combined Year 2-3	13	
Year 4	1 x Combined 4-5	16	9 vacancies
Year 5	1 x Combined 4-5	15	10 vacancies
Year 6	1 x Combined 5-6	12	13 vacancies
Year 7	1 class	22	3 vacancies
Year 8	1 class	14	11 vacancies
Year 9	1 class	12	13 vacancies
Year 10	1 class	10	15 vacancies
Year 11	1 class	9	16 vacancies
Year 12	1 class	15	10 vacancies

The facilities at the school could accommodate up to 350 students in classes of a maximum of 25 students per class. Additional teachers would be required to accommodate increased class numbers at the school beyond the vacancies outlined above.

The South Australian Department of Education & Children's Services (DECS) administered 13 primary schools in the regional study area at Balaklava, Curramulka, Edithburgh, Hamley Bridge, Kadina, Owen, Port Vincent, Port Wakefield, Stansbury, Wallaroo Mines, Wallaroo, Warooka and Watervale.

In addition to these schools there were also:

- 5 R-12 schools or Area Schools at Ardrossan (profiled above), Maitland, Minlaton, Moonta and Yorketown (four of which, Ardrossan, Maitland, Minlaton and Yorketown are located in the secondary study area).
- 2 secondary schools at Balaklava and Kadina,
- 1 Aboriginal school at Point Pearce.
- 1 Special Education Unit - The Disability Unit at Kadina High School.
- 2 support units for home schooling.

For pre-school age children there existed:

- 13 Pre-schools at Ardrossan, Balaklava, Edithburgh, Hamley Bridge, Kadina, Maitland, Minlaton, Moonta, Owen, Port Wakefield, Stansbury, Wallaroo and Yorketown.
- Family day care units supporting home-based providers from Maitland.
- 1 Children's Centre at Balaklava.

At the time of writing the Ardrossan Community Kindergarten had capacity for 30 preschool children with vacancies for five children in one session and one child in another session (Jane Klæbe, Ardrossan Community Kindergarten Director, pers-comm, 9 May 2012).

In addition to the publically funded schools there were private primary schools located in Maitland, Wallaroo and Yorketown, and two private secondary colleges at Balaklava and Kadina.

The Yorke Mid North Regional Directorate was located at Port Pirie, and in total there were 9,320 students enrolled in state schools in this region (including 153 indigenous students).

Trade Training Centres (TTC)

There were three TTC consortiums established or in the process of establishment across the broader study area – Lower North (Balaklava, Clare, Burra, Riverton), Southern Yorke (Minlaton, Yorketown, Ardrossan, Maitland) and Northern Yorke and Pt Pirie (Moonta, Kadina, Pt Broughton, John Pirie).

Universities

There were no university campuses in the region. The closest university campus was The University of Adelaide's Roseworthy Campus (located 150kms or 2 hours drive from the primary study area).

Registered Training Organisations (RTOs)

There was a small number of RTOs in the region including TAFE SA Regional, which had four campuses in the regional study area at Clare, Kadina, Yorketown, Narungga (Point Pearce/Maitland). In addition to these services, the following programs were available across the broader study area:

- Regional Skills Training provides flexible learning across the state in Agriculture and Viticulture.
- MADEC Australia Inc is a Job Service Australia (JSA) provider in Kadina and is expanding its delivery into Community Services, Retail and Hospitality.
- BITE Australia Moonta delivers Hair and Beauty in Yorke.
- Taoundi College provides Hospitality training.
- Employment Directions in Kadina is a JSA provider that runs introductory courses including basic computing, interview techniques, OH&S and motivational strategies.

A number of other private RTOs visited the region on demand, including Civil Train, Flexible Construction Training & Assessment, Adelaide Training and Employment Centre, and some services and licensing training and assessment are provided by Courtesy Training, Access Training Solutions and Career Systems Inc.

3.8.3 Sport and Recreation Facilities

Sport, recreation and the provision of open space is an important aspect of overall community health and wellbeing.

A wide range of sporting clubs are available within the regional study area and provide a varied range of recreational pursuits in addition to the opportunities available from the coastline surrounding the peninsula.

Some of the sports catered for include football, tennis, basketball, netball, polo-crosse, cricket, bowls, 8-ball, snooker and darts. There was a yacht club at Port Vincent, which caters for sailing on most levels and wind surfing. Other recreational pursuits available included pony club, fishing, boating and many art and craft groups (DC of Yorke Peninsula Website, 2012).

At Ardrossan there was a football oval, golf course, tennis courts, lawn bowling green and three basketball/netball courts utilised by the following sports clubs (Ardrossan Community Services Website, May 2012):

- East Coast Basketball Club
- Ardrossan Bowling Club
- Ardrossan Cricket Club
- Ardrossan Football Club
- Ardrossan Golf Club
- Ardrossan Hockey Club
- Ardrossan Netball Club
- Ardrossan Tennis Club

There were also two playgrounds located on the foreshore in Ardrossan.

3.8.4 Arts and Culture

The broader regional study area is considered to be attractive to visual artists and many live in the region (latest statistics collected by the Australia Council for the Arts show that nearly 50% of Australia's artists live in regional Australia). Artists can assist in creating strong regional identity, be an asset to the tourism and hospitality sectors, and work in the health and environment sectors to assist with education and public awareness activities. Increased access to arts activities can attract people to live in a region, and keep young people living in the region (RDAYMN, 2010).

Thriving artist communities exist throughout the entire region. Many local artist groups hold regular exhibitions, and participate in festivals such as SALA (South Australian Living Artists) Festival each August, and Flinders Ranges: a brush with art Festival annually in September/October. The significant annual Rotary Art Shows in the Clare Valley and on the Yorke Peninsula attract significant local and other interest. The region is home to many galleries - regional art galleries, community galleries, and commercial galleries. The regional and community galleries rely heavily on volunteers. There is the potential for more collaboration between artists and private enterprise, Government and non-government organisations (especially environment and health) to provide employment opportunities for artists (RDAYMN, 2010).

There were seven arts- and craft-related business in located in Ardrossan, including the Blue Crab Studio Art Gallery. There was also an Ardrossan and District Historical Museum that provided cultural information on historical features and practices of the local community (SA Tourism Board, 2012).

3.8.5 Volunteering

The 2011 ABS Census reported that a total of 23.2% of residents aged 15 and over in the regional study area were engaged in volunteering, with women comprising 55% of the volunteering effort.

According to the Ardrossan Community Services (2012), volunteering activities were conducted by the following groups:

- ACE- Ardrossan Community Entertainment
- Anglican Church of St. James Ardrossan
- Ardrossan Historical Museum
- Ardrossan & Districts Community Club
- Ardrossan Angels
- Ardrossan Antics Newsletter
- Ardrossan Bingo Club
- Ardrossan Community Hospital Foundation inc
- Ardrossan Community Hospital Ladies Auxiliary
- Ardrossan Freemasons Lodge
- Ardrossan Garden Club
- Ardrossan Lions Club
- Ardrossan Progress Association
- Ardrossan Uniting Church Adult Fellowship Group
- Ardrossan Uniting Church Parish
- Black Point Progress Association
- Care and Share
- Catering and Halls
- Catholic Church of St Christopher, Ardrossan
- Choir- YP Community Singers
- Community Car and Transport
- Craft and Drop In Group
- CWA Ardrossan
- Friends of Women's and Children's Hospital
- Friends of Women's and Children's Hospital Auxiliary
- Hall Bookings and Catering
- James Well and Rogues Point Progress Association
- Loose Cannonz Theatre Group
- Lutheran Church, Maitland
- Maitland Auto Preservation Society
- Maitland Progress Association
- Meals On Wheels
- Men's Shed CYP Group
- Mis Fits Exercise Group
- National Servicemen's Association, YP Sub Branch
- Pine Point Progress Association
- Probus
- RSL Sub Branch
- Rural Financial Counselling Service SA Inc
- Share and Care
- Tiddy Widdy Progress Association
- Tidy Towns Group
- Yorke Peninsula Branch of the Embroiderers' Guild of South Australia
- YP Carers Link
- YP Leisure Options.

3.8.6 Police and Emergency Services

The regional study area sat within the Mid North and Yorke Police Local Service Area, which contained 29 police stations and was headquartered outside of the study area in Port Pirie.

Operationally, there was a move towards clusters of police stations, in order to improve efficiency of resources and ensure a consistent level of police presence is available for each cluster (RDAYMN, 2010).

There was a police station at Ardrossan manned by two police officers who worked a roster that covered the town seven days a week. When officers were not present in the Ardrossan Station inquiries were redirected to the Kadina Police Station, located approximately 60kms away by road (Pers-Comms, Kadina Police Station, May 2012).

Port Pirie had the only professional ambulance service in the region, which meant that the regional study area was covered by volunteers (RDAYMN, 2010). There was a SA Ambulance brigade based at Ardrossan.

The regional study area fell within the Country Fire Services Region 2, which covered about 17,000 square kilometres and included the Mount Lofty Ranges north of the Torrens River, Mid North, Clare Valley and Yorke Peninsula areas of South Australia (Country Fire Service, 2102).

Region 2 had 11 groups, 84 brigades and 2,835 volunteers. The Southern Yorke and Yorke Valley groups contained 16 brigades and covered the Yorke Peninsula area surrounding the Project. Of these brigades, ten were based within the secondary study area (Ardrossan, Balgowan, Brentwood, Corny Point, Cunliffe, Curramulka, Edithburgh, Maitland, Marion Bay and Minlaton).

3.8.7 Crime and Safety

According to the South Australian Attorney Generals Department Office of Crime Statistics and Research (OSCAR)(2012), the crime rate in the DCYP was markedly lower than the crime rate for the Yorke and Mid North region.

Table T07, below, provides a comparison of the relevant data.

The vast majority of crimes in the DC of Yorke Peninsula were crimes against property, followed by driving offences and crimes against good order (drug offences) (OSCAR, 2012).

Table T07: Crime Rate in the Study Area (per 1,000 people)

Year	DCYP	Yorke and Mid North Region
2002	105	128
2003	98	119
2004	102	126
2005	95	121
2006	92	113
2007	98	N/A
2008	82	N/A
2009	80	N/A

Source: South Australian Attorney Generals Department Office of Crime Statistics and Research (OSCAR) Website, 2012

Stephen Moulds, Brevet Sergeant from the Ardrossan Police in an interview in July 2012, said that crime rates were low in the primary study area and seasonal. He reported that winter was a quiet time in respect to law and order issues and that summer was generally busier because of the greater population/visitation numbers in the area (pers comm. July 1202).

According to Brevet Sergeant Moulds, local criminal issues in the primary study area consisted mainly of:

- Traffic and drink driving offences.
- Occasional house break ins.
- Physical assaults.
- Drugs and drug cooking
- Occasional theft.

Table T08 below outlines some of the more recent law and order issues reported in the Neighbourhood Watch bulletin for the Ardrossan area.

According to Brevet Sergeant Moulds, constraints to policing the area were largely created from insufficient staff numbers, with only two officers in the area, who swapped on-call duties each week. The nearest back-up police resources were located in Maitland, 25km away, resulting in a 20 minute response time at least.

Officer Moulds believed crime rates had dropped in recent years due to local police having a good and close relationship with the community and with the addition of the Neighbourhood Watch programme, which provided a newsletter to the community every two months.

Table T08: Excerpt of Police Report from Neighbourhood Watch Bulletin

Date	Type	Location
15/11/12	Offenders broke into and stole a computer.	Ardrossan Area School
23/11/12	A man was reported for driving whilst disqualified.	Ardrossan
02/12/12	A large quantity of property was stolen from sheds.	Sandilands
11/01/12	A house was broken into and a quad bike stolen.	Tiddy Widdy Beach
22/02/12	A female was assaulted.	Port Clinton
23/03/12	Reports of theft of underwear stolen from clothes lines.	Ardrossan
29/03/12	House broken into and property stolen.	Ardrossan
16/05/12	Offenders stole electrical items from verandah of house.	Pine Point
19/06/12	Two males and one female were arrested for possession of prescribed equipment for manufacturing drugs.	Pine Point

4. WORKFORCE AND ACCOMMODATION

The following chapter describes the existing workforce and accommodation status and preferences of people living in the study areas. Considering these aspects is important in determining potential socio-economic impacts because (in this case) it enables the prediction of:

- changes to the workforce, including labour availability for such a project.
- potential effects on the population of increased labour demands in the region.
- regional capacity to accommodate the workforce and associated additional increase in population (multiplier effect).
- changes in accommodation standards that may indicate changes (for the better or worse) in residents' quality of life.

This chapter describes the existing:

- employment and labour profile.
- workforce outlook.
- accommodation and housing.

References to the regional study area in this chapter refer to information either from the Goyder SED or, where not available, from the combined Local Government Areas of Barunga West, Copper Coast, Wakefield and Yorke Peninsula (which, in conjunction with the DC of Mallala make up the regional study area). As this collated information is not readily available for the entire regional study area, this aggregated information has been included as a representation of the regional study area.

At the time of writing, 2011 National Census data for employment and labour were yet to be released (due 31 October, 2011). As such, data used herein relies on that from the 2006 National Census, except where otherwise stated.

4.1 Hillside Workforce and Accommodation Requirements

Current estimates of number of employees by mine section and accommodation type required for the Hillside project are presented in Table T09 below.

Table T09 Estimated Hillside Project Workforce Breakdown

	Years 1 to 5 (avg.)				Years 6+ (avg.)			
	Resident	Local	Camp	Total	Resident	Local	Camp	Total
G&A	15	10	36	61	15	10	36	61
Mine	7	61	297	364	7	67	321	394
Mill + Port	15	40	141	196	15	40	141	196
Total	37	111	474	621	37	117	498	651

Source: Hillside Scoping Study, Rex Minerals, 2011

Due to its location, it is expected that the Hillside mine will run a variety of rosters including:

- 4 panel 12 hours shifts for majority of supervisors, artisans and operators employed within the mining and processing departments;
- 2 panel day shift only roster for personnel in technical support roles;
- Standard day shift for personnel in managerial and administrative support roles.

In line with the roster variations, it is assumed that there would be various accommodation requirements including:

- Existing residences for locally sourced employees;

- Single persons camp accommodation for personnel sourced out of the immediate area and working on a shift or panel roster;
- Company owned accommodation for residential senior personnel;
- Company assisted rental accommodation for other residential personnel.

The proximity of the proposed operation to the town of Ardrossan and the major regional centre of Adelaide provide the Project with a potentially unique opportunity to accommodate staff. Additional options to house senior staff in Ardrossan will create a sought after family coastal lifestyle while separate quarters for staff requiring temporary accommodation can also be constructed close to town.

The project scoping study assumed that up to 20 house and land packages would be purchased by Rex Minerals in Ardrossan to house the senior staff. Single accommodation for approximately 310 staff would be provided at a suitable location (to be identified in subsequent studies) between the mine site and Ardrossan.

4.2 Skills Survey 2012

The 2006 Census data for employment can be set against the results of a skills survey conducted by RDAYMN in May 2012. The survey involved 301 participants in the majority of the regional study area and aimed to explore:

- The employment situation among respondents.
- The likelihood of respondents to change industries or relocate for employment.
- The education, training and skills of respondents.

It found that:

- Most respondents were working full time (63%); one-quarter (23%) were working part time and 6% were working on contract. The remainder (8%) were not working.
- Respondents were working in a wide variety of industries; mainly mining (15%) and manufacturing (12%).
- Most respondents indicated that their job was located at Port Pirie (25%), Kadina (15%) and Ardrossan (10%).
- The majority of respondents (63%) worked less than 20km from home; 23% worked between 20 and 100km from home; 15% worked more than 100km from home.
- The majority of respondents (69%) were not required to stay away from home for employment.
- Respondents had been in their current job for less than four years (47%); or four or more years (53%).
- The factors that respondents indicated would make them consider relocating for work were an improved salary (67%), job satisfaction (59%) and lifestyle/recreation (46%). 14% of employed respondents would not consider relocating for work.
- 7% of respondents were planning on retiring in the next three years, but most would consider part time work while in retirement.
- 66% would either probably (36%) or definitely (30%) consider working in a different industry than the one they were employed in.
- 85% had worked in a different industry/job than the one they were currently in.
- Interest in working in the mining sector was highest (71% somewhat or very interested); agriculture sector was lowest (47% somewhat or very interested).

- 71% had a qualification of some kind (certification, degree, trade). Respondents most commonly held a ticket/licence for forklift (36%) and OH&S training (35%).
- The factor most important to respondents when considering job options was maintaining a work/life balance (91% rated a 4 or 5 out of 5).
- The scenario that respondents most commonly indicated as being the most likely to make them consider applying for a mining job on the Yorke Peninsula was a mining related job that required different skills than they had and would provide training in those skills.

4.3 Existing Employment Labour Profile

Throughout the following sections, the 'labour force participation rate' refers to the percentage of working-age persons actively involved in employment activities. The 'unemployment rate' refers to percentage of working-age persons looking for work by currently not employed.

4.3.1 Employment and Unemployment

During the week prior to the 2006 census, primary study area had a potential labour force of 685 people (45.5% of total persons) aged 15 years and over. Of these, 57.2% were employed full-time, 29.2% were employed part-time, 3.8% were employed but away from work, 3.2% were employed but did not state their hours worked and 6.6% were unemployed. There were 819 residents aged 15 years and over not in the labour force (54.5%). These people may include stay-at-home parents/carers, the early retirees and individuals with health issues or disabilities that prevent them from working.

By comparison, just over 58% of the South Australian workforce was engaged in full time work, 30% in part time work and 5.2% unemployed. For Australia, the figures are 60.7% full time, 27.9% part time and 5.2% unemployed. These comparisons indicate that primary study area has a lower percentage of full time employees (57.2%) and a higher percentage of unemployed people (6.6%) than the State and National averages.

Similarly, the percentage of people not in the labour force for South Australia and Australia was 37.7% and 35.4% respectively. When compared with the figure mentioned above (54.5%) this indicates a high percentage of potential employees in primary study area who are not actively engaged in the labour force.

Table T10 below provides a comparison of this employment data across study areas.

Table T10: Comparison of Key Employment Indicators Across Study Areas

	Primary Study Area	Regional Study Area	South Australia	Australia
Total Potential Workforce (Number of Persons aged 15 and over)	685	12,264	728,070	14,879,103
Employment type (%)	57.2% full time 29.2% part time	55.2% full time 31.7% part time	58.5% full time 30.0% part time	60.7% full time 27.9% part time
Unemployment Rate (% of Labour Force Population aged 15 and over)	6.6%	6.5%	5.2%	5.2%
Number of	819 (54.5% of	11,483 (48.4% of	441,820 (37.8%	5,271,116 (35.4%

	Primary Study Area	Regional Study Area	South Australia	Australia
Persons aged 15 and over and not in the Labour Force	potential labour force)	potential labour force)	of potential labour force)	of potential labour force)

Source: ABS 2006

Regional study area

The regional study area had a slighter lower percentage of full time employees (55.2%) and a slightly higher percentage of unemployed people (6.5%) to the State and National averages.

As with the previous study areas, there was a high percentage of residents in the broader study area who were not actively engaged in the labour force.

Casual and Seasonal Employment

Many people within the region experience underemployment as a result of the high levels of seasonal and casual employment. The predominance of employment in agriculture, viticulture, retail and hospitality industries indicates that that this will continue to be an issue in the region (RDAYMN, 2010). Given that some of these same industries are prevalent in primary study area, the same assumptions regarding causal and seasonal work can also be made for these areas.

4.3.2 Skills and Qualifications

Post-School Qualifications

Table T11 below outlines the highest levels of post-school qualifications across the study areas.

In the primary study area the most common post-school qualification was a certificate (41%), followed by advanced diploma (8.6%) and bachelor degree (8.4%).

For the regional study area, the most common post-school qualification was a certificate (43.9%), followed by advanced diploma (10.9%) and bachelor degree (10.8%).

There are proportionally significantly less residents in the primary and regional study areas with bachelor degrees, but a greater number proportionally with certificate-level qualifications.

Table T11: Highest Post-School Qualification (persons aged 15-85 years old)

	Primary study area	Regional Study area	South Australia	Australia
Postgraduate Degree	8 (1.2%)	96 (1%)	22,896 (3.8%)	413,094 (4.9%)
Graduate Diploma and Graduate Certificate	11 (1.6%)	155 (1.6%)	16,100 (2.7%)	228,553 (2.7%)
Bachelor Degree	58 (8.4%)	1,047 (10.8%)	120,979 (20.3%)	1,840,661 (22.0%)
Advanced Diploma	60 (8.6%)	1,052 (10.9%)	79,698 (13.4%)	1,130,661 (13.5%)
Certificate	284 (40.9%)	4,255 (43.9%)	212,581 (35.7%)	2,662,777 (31.8%)
Inadequately Described	18 (2.6%)	279 (2.9%)	15,942 (2.7%)	234,972 (2.8%)
Not Stated	255 (36.7%)	2,805 (29%)	127,187 (21.4%)	1,851,290 (22.1%)
Total	694	9,689	595,380	8,362,008

Source: ABS 2006

Table T12 below outlines the fields of post-school qualifications across the study areas.

In primary study area the most common field of post-school qualification was engineering and related technologies (19.7%), followed by health (8.0%) and education (7.3%).

Similarly, for the broader study area the most common field of post-school qualification was engineering and related technologies (19.2%), followed by health (10.6%) and then management and commerce (9.5%).

These findings are similar to the most common field of post-school qualifications for South Australia and Australia as a whole, with engineering and related technologies the most common qualification in South Australia and Australia (along with management and commerce as equal first across all of Australia).

Table T12: Field of Qualification (persons aged 15-85 year old)

	Primary study area	Regional Study area	South Australia	Australia
Natural & Physical Sciences	1.7%	0.9%	2.8%	2.7%
Information Technology	0%	0.5%	2.0%	2.6%
Engineering & Related Technologies	19.7%	19.2%	17.9%	16.2%
Architecture & Building	5.6%	5.6%	4.8%	5.5%
Agriculture, Environmental & Related Studies	5.5%	4.9%	2.3%	2.0%
Health	8.0%	10.6%	10.1%	8.4%
Education	7.3%	8.1%	7.5%	7.4%
Management & Commerce	6.3%	9.5%	14.4%	16.2%
Society & Culture	4.4%	6.5%	9.3%	8.9%
Creative Arts	0%	1.1%	2.6%	3.0%
Food, Hospitality & Personal Services	5.0%	5.7%	5.2%	4.7%
Mixed Field Programmes	0%	0.1%	0.2%	0.1%
Inadequately Described	1.0%	0.7%	1.1%	1.2%
Not Stated	35.4%	26.6%	20.0%	21.0%
Total persons	697 (100%)	9,686 (100%)	595,380 (100%)	8,361,882 (100%)

Source: ABS 2006

4.3.3 Occupations

Table T13 below provides a comparison of key occupations across all study areas. Table T14 provides definitions of key occupations for further information.

According to the 2006 census, the majority of employees in the primary study area were managers (27.8%), followed by labourers (14.8%) and technicians and trade workers (12.5%). Similarly, the majority of employees in the regional study area were managers (24.3%) followed by labourers (16.0%) and technicians and trade workers (13.5%).

In comparison, the majority of employees in South Australia were professionals (18.4%) followed by clerical and administrative workers (14.5%) and technicians and trade workers (14.2%). For Australia, the majority of employees were also professionals (19.8%) followed by clerical and administrative workers (15.0%) and technicians and trade workers (14.4%).

According to RESA, the high percentage of managers in the region is mainly made up of farmers and farm managers (RESA, 2011).

Table F13: Comparison of Key Occupations Across Study Areas

	Primary study area	Regional study area	South Australia	Australia
Managers	27.8%	24.3%	13.4%	13.2%
Labourers	14.8%	16.0%	12.4%	10.5%
Technicians and Trades Workers	12.5%	13.5%	14.2%	14.4%
Clerical and Administrative Workers	11.1%	9.9%	14.5%	15.0%
Professionals	9.1%	10.2%	18.4%	19.8%
Community and Personal Service Workers	7.7%	9.4%	9.4%	8.8%
Sales Workers	7.3%	7.9%	9.6%	9.8%
Machinery Operators And Drivers	6.7%	7.0%	6.4%	6.6%

Table T14: Definitions of Key Occupations

Occupation	Definition
Managers	Chief Executives, General Managers and Legislators; Farmers and Farm Managers; Specialist Managers; Hospitality, Retail and Service Managers
Labourers	Cleaners and Laundry Workers; Construction and Mining Labourers; Factory Process Workers; Farm, Forestry and Garden Workers; Food Preparation Assistants; Other Labourers
Technicians and Trade Workers	Engineering, ICT and Science Technicians; Automotive and Engineering Trades Workers; Construction Trades Workers; Electrotechnology and Telecommunications Trade Workers; Food Trades Workers; Skilled Animal and Horticultural Workers; other Technicians and Trades Workers
Professionals	Arts and Media Professionals, Business, Human Resources and Marketing Professionals; Design, Engineering, Science and Transport Professionals; Education Professional; Health Professionals; Information and Communication Technology (ICT) Professionals; Legal, Social and Welfare Professionals
Community and Personal Service Workers	Health and Welfare Support Workers; Carers and Aides; Hospitality Workers; Protective Services Workers; Sports and Personal Services Workers
Clerical and	Office Managers and Program Administrators; Office and Practice Managers; Personal

Administrative Workers	Assistants and Secretaries; General Clerical Workers; Inquiry Clerks and Receptionists; Numerical Clerks; Clerical and Office Support Workers; Other Clerical and Administrative Workers; Logistics Clerks; Miscellaneous Clerical and Administrative Workers
Sales Workers	Sales Representatives and Agents; Sales Assistants and Salespersons; Sales Support Workers
Machinery Operators and Drivers	Machine and Stationary Plant Operators; Mobile Plant Operators; Road and Rail Drivers; Storepersons

Source: ABS 2006

4.3.4 Current Vacancies

A search of the Australian Job Search website in August 2012 revealed the following job vacancies in the study area. The data indicates that the majority of available employment is casual and requires little to no formal qualifications.

Table T15 Current Job Listings (Primary Study Area) (Australian Job Search Website, August 2012)

Occupation	Number	Type	Location
Grain harvest labourers	15	Casual	Ardrossan
School cleaner	1	Part-time (relief)	Ardrossan
Total	16		

The following vacancies were also available in the regional study area. Given the limited number of vacancies in the primary study area, it is anticipated that residents from this region would be prepared to drive to these towns for employment.

Table T16 Current Job Listings (Regional Study Area) (Australian Job Search Website, August 2012)

Occupation	Number
Clerical and administrative workers	38
Community and personal services workers	5
Labourers	225
Machinery operators and drivers	7
Managers	4
Professionals	2
Sales workers	10
Technical and trades workers	14
Total	305

4.4 Workforce Outlook

4.4.1 Regional Workforce Studies

A recent study conducted by RESA (2011) regarding workforce projections in the Eyre Peninsula Resource Sector provided a projected workforce outlook of between 700 (with project probability weightings) and 2,200 (without probability weightings) direct new jobs in the resources sector over the coming decade.¹ Essentially, what this means is that it is anticipated that as a result of new

¹ The probability weightings in the RESA study are based on the maturity and likelihood of completion of the seven projects including in the study. For each of the seven projects, a probability weighing of between 5% and 100% was

mining projects in the area, at least 700 and up to 2,200 new jobs will be created between 2011-2021 on the Eyre Peninsula. Specifically, the study found that:

If all seven mines included in this study proceed to the operating phase, it is estimated that more than 2,200 ongoing direct jobs will be created in mining and processing operations over the next decade, with many positions continuing for decades to come. Conservative estimates of new jobs associated with construction of mines and infrastructure indicate there will be a requirement for at least a further 4500 jobs over the next five years, peaking at 1,700 positions in 2014, (RESA, 2011).

Given the proximity to and similarity of the Eyre Peninsula with the Yorke Peninsula (both in social context and project development pipeline) the results of this study can also be extrapolated to provide an indication of workforce projections on the Yorke Peninsula.

Predicted Workforce Availability

Given the currently low levels of unemployment in the study areas, it is anticipated that employees for the Project will be sourced from existing positions (potentially to the detriment of previous employers) or the currently high percentage of working-age people currently not engaged in the workforce, but who may wish to be for the right incentives. It is also possible that employees will be sourced from outside of the region (See Section 4.1.1 Employment and Unemployment for further details.)

Predicted Workforce Opportunities

From the workforce forecasts provided, the RESA Study (2011) found that the following occupations (in no particular order) were most likely to experience the greatest job openings:

- Accountant
- Surveyor
- Electrical Engineer
- Mechanical Engineer
- Production or Plant Engineer
- Mining Engineer
- Environmental Scientist
- Geologist
- Metallurgist
- Occupational Health and Safety Professional
- Laboratory Technician
- Electrical Technician
- Mechanical Technician
- Metallurgical Technician
- Motor Mechanic - Diesel
- Welder
- Metal Fabricator/Boilermaker
- Fitter
- Electrician
- Driller
- Miner
- Stationary Plant Operator
- Mobile Plant Operator

given based on the current development phase of the project. The lower the probability weighting, to lower the potential for completion of the project, and therefore the study adjusted employment forecasts accordingly in the project probability weighted figures. Please refer to the RESA Workforce Study page 13 for full details.

- Truck Driver
- Mining Support Worker

Whilst a specific breakdown of exact occupations was not available, the data provided in this chapter suggests that the majority of employees in the regional study area were labourers and technicians and trades workers. Consequently, it is expected that individuals with experience in the above-mentioned occupations should be available to be locally sourced (but would be drawn from existing employment).

Furthermore, the study also found that qualifications for which there would be the greatest demand include:

- Bachelor of Engineering (Mechanical)
- Bachelor of Engineering (Mining)
- Bachelor of Science (Mineral Geoscience)
- Certificate III in Engineering (Fabrication Trade)
- Certificate III in Engineering (Mechanical Trade)
- Certificate III in Electrotechnology Electrician
- Certificate III in Mining Exploration
- Certificate II to IV in Resource Processing
- Certificate II to IV in Surface Extraction Operations
- Dual Certificate II Program in Resources IWP and Surface Extraction

Given the high proportion of individuals with post-secondary qualifications in the field of engineering and related technologies within the regional study area it is expected that individuals with the above-mentioned qualifications should be available to be locally sourced (but would likely be drawn from existing employment).

While estimates of the proportion of positions available to people without experience were varied and indications ranged from nil (for technical roles in new mines) to 100% for plant operators, the RESA study concluded that a pragmatic estimate would be 10% to 20% of positions being available to people without experience for most positions require formal qualifications (RESA, 2011).

4.5 Housing and Accommodation

4.5.1 Total Housing and Accommodation Stocks

Table T17 outlines the number of dwellings by type across the study areas (ABS, 2011).

This data indicates that the vast majority of households within the study areas occupy separate houses (88.4% for the primary study area and 93.9% for the regional study area). These figures are much higher than the State and National averages of 79.9% and 75.6% respectively and are consistent with the types of dwellings most commonly found in rural areas.

The number of unoccupied dwellings in the primary study area is almost five times the average for both the State and Nation, and is likely indicative of the holiday nature of some of the communities within postcode 5571. A large number of unoccupied dwellings also exist across the regional study area.

Table T17: Comparison of Number of Dwellings Across Study Areas

	Primary Study Area	Regional Study Area	South Australia	Australia
Total	1,653	20,062	702,814	8,694,793
Unoccupied (number and % of total)	938 (56.7%)	7,482 (37.3%)	83,777 (11.9%)	934,471 (10.7%)

Occupied (number and % of total)	715 (43.3%)	12,580 (62.7%)	619,037 (88.1%)	7,760,322 (89.3%)
Separate house (number and % of occupied)	630 (88.4%)	11,812 (93.9%)	494,471 (79.9%)	5,864,573 (75.6%)
Semi-detached, row or terrace house, townhouse etc (number and % of occupied)	33 (4.6%)	391 (3.1%)	66,465 (10.7%)	765,978 (9.9%)
Flat, unit or apartment (number and % of occupied)	3 (0.4%)	176 (1.4%)	54,968 (8.9%)	1,056,236 (13.6%)
Other dwellings (number and % of occupied)	47 (6.6%)	190 (1.5%)	2,812 (0.5%)	66,666 (0.9%)

4.5.2 Housing Affordability

Home Ownership

Regarding home ownership, Table T18 provides a comparison of dwellings by tenure type across the study areas.

In 2011 in the primary study area, 57.8% of occupied private dwellings were fully owned, significantly more than at State or national level.

Consistent with these findings, the percentage of rented dwellings across the study areas was slightly lower than the State and National averages.

These high levels of home ownership may be due to the relative affordability of houses in the area, or the prevalence of older people who have lived in the area for a long time, allowing them to pay off their homes entirely.

Table T18: Comparison of Dwelling Tenure Type Across Study Areas

	Primary Study Area	Regional Study Area	South Australia	Australia
Owned outright	413 (57.8%)	5,809 (46.2%)	203,281 (32.8%)	2,488,149 (32.1%)
Rented	141 (19.7%)	2879 (22.9%)	172,727 (27.9%)	2,297,458 (29.6%)
Owned with a mortgage	127 (17.8%)	3416 (27.2%)	218,402 (35.3%)	2,709,433 (34.9%)
Other tenure type	9 (1.3%)	157 (1.2%)	8,937 (1.4%)	70,070 (0.9%)
Not stated	24 (3.4%)	319 (2.5%)	15,694 (2.5%)	195,213 (2.5%)

Property Prices

According to realestate.com.au in August 2012, the most recent median house price for Ardrossan (the largest town in the primary study area) was \$240,000. Table T19 below indicates the trends in median house prices in Ardrossan over the past five years.

Table T19: Ardrossan Median House and Unit Prices

Year	Median House Price	House Price % Change (YoY)	Median Unit Price	Unit Price % Change (YoY)
-------------	---------------------------	-----------------------------------	--------------------------	----------------------------------

2007	\$225,000	10.3%	\$294,500	-
2008	\$233,500	3.8%	\$292,000	-0.8%
2009	\$275,000	17.8%	295,000	1.0%
2010	\$274,500	-0.2%	\$293,750	-0.4%
2011	\$285,000	3.8%	\$300,000	2.1%

Source: www.realestate.com.au, 2011; Yorke Peninsula Housing Affordability Report, 2010, www.livingin-australia.com.au, 2011

The Department for Manufacturing, Innovation, Trade, Resources and Energy (DMITRE) EasyData Website (2012) indicated that 19.2% of dwelling sales in the DC of Yorke Peninsula between July 2001 and June 2010 were considered affordable to low income households, compared with 13.6% across the State of South Australia.

The median house price in the Yorke and Mid North region (which includes the regional study area) is an affordable \$288,000 compared to \$353,000 in Adelaide (RDAYMN, 2011).

Rent and Housing Loan Repayments

Table T20 below provides a comparison of median rent or housing loan repayments across study areas. Rental prices in the primary and regional study areas were significantly cheaper than both the State and National averages.

With respect to rental properties, DMIRTE noted that 94.6% of private rentals in the regional study area between July 2000 and June 2010 were considered affordable to low income households, compared with 57.6% across the State (DMITRE, 2012).

Table T20 also provides data on average monthly housing loan repayments, which indicates that, like rental prices, housing loan repayments in the primary and regional study area were significantly cheaper than both the State and National averages.

When viewed together, the monthly loan repayments and weekly rent data indicated that, at least historically, access to affordable housing within the study area was significantly better than across the State and Nation.

Nevertheless, according to RDAYMN (2011), the Yorke and Mid North region (which includes the regional study area) had experienced a significant increase in the number of households spending more than 30% of their income on mortgage repayments or rent between 2001 and 2006.

Table T20: Comparison of Median Rent or Housing Loan Repayments Across Study Areas

	Primary Study Area	Regional Study Area	South Australia	Australia
Median rent (\$/weekly)	\$150	\$160	\$220	\$285
Median housing loan repayment (\$/monthly)	\$1,107	\$1083	\$1,500	\$1,800

4.5.3 Public Housing

According to the SA Department for Families and Communities (2012), in 2007 there were 49,469 social housing stocks (dwellings) in South Australia; 145 were located on the Yorke Peninsula (part of the regional study area), with 22 belonging to the Aboriginal Housing Association, 26 to the South Australian Community Housing Authority and 97 to the South Australian Housing Trust (Dept of Families and Communities, 2012).

4.5.4 Temporary Accommodation

Given the region's prominence as a tourist destination, there was a reasonable number of temporary accommodation venues available in the study area (shown the table below, based on latest available data). Nevertheless, given the high volume of tourist traffic, particularly in the peak season, it is anticipated that these venues would have limited vacancies and affordability for low-income families/individuals.

An Internet search for available accommodation indicated that the cost of temporary accommodation (excluding caravan parks) on the Yorke Peninsula ranged from \$90-\$200 per night (lastminute.com.au, August 2012).

The average cost of a motel room in the primary study area was between \$90-110 per night (Ardrossan Hotel-Motel, 2012). The average cost of a cabin in the primary study area was between \$85-140 per night. The average cost of a caravan site was between \$22-35 a night (Ardrossan Caravan Park, 2012).

Table T21: Tourist Accommodation Venues Yorke Peninsula DC (LGA)

	DCYP
Hotels, Motels, Serviced Apartments - 5 to 14 rooms	8
Hotels, Motels, Serviced Apartments - 15 or more rooms	1
Caravan Parks	15
Holiday Flats & Units	0
Visitor Hostels	1

Source: ABS 2009

5. INFRASTRUCTURE

The following chapter provides an overview of key infrastructure within the Project's study areas. Specifically, the chapter outlines key energy, water and sewerage and waste infrastructure, as well as road networks; transportation, port and rail information, and communications infrastructure.

When reading this chapter, please note that infrastructure data and information provided by the SA Government and regional development boards is collated and provided at the Yorke and Mid North Region level. Similar data collated and provided by the district councils is presented at a local government area (LGA) level.

Consequently, general infrastructure data from the Yorke and Mid North Region has been used to represent the regional study area (Goyder SED), however any references to areas or facilities specifically outside of the study area boundaries has been removed or its location noted.

5.1 Regional Infrastructure Overview

The major infrastructure networks servicing the region are shown in Figure F06. This map shows that Ardrossan is close to the main electricity and road network. The main water supply is some distance to the west. The Hillside project is located approximately 15km to the south of Ardrossan.

5.2 Energy Infrastructure

5.2.1 Electricity

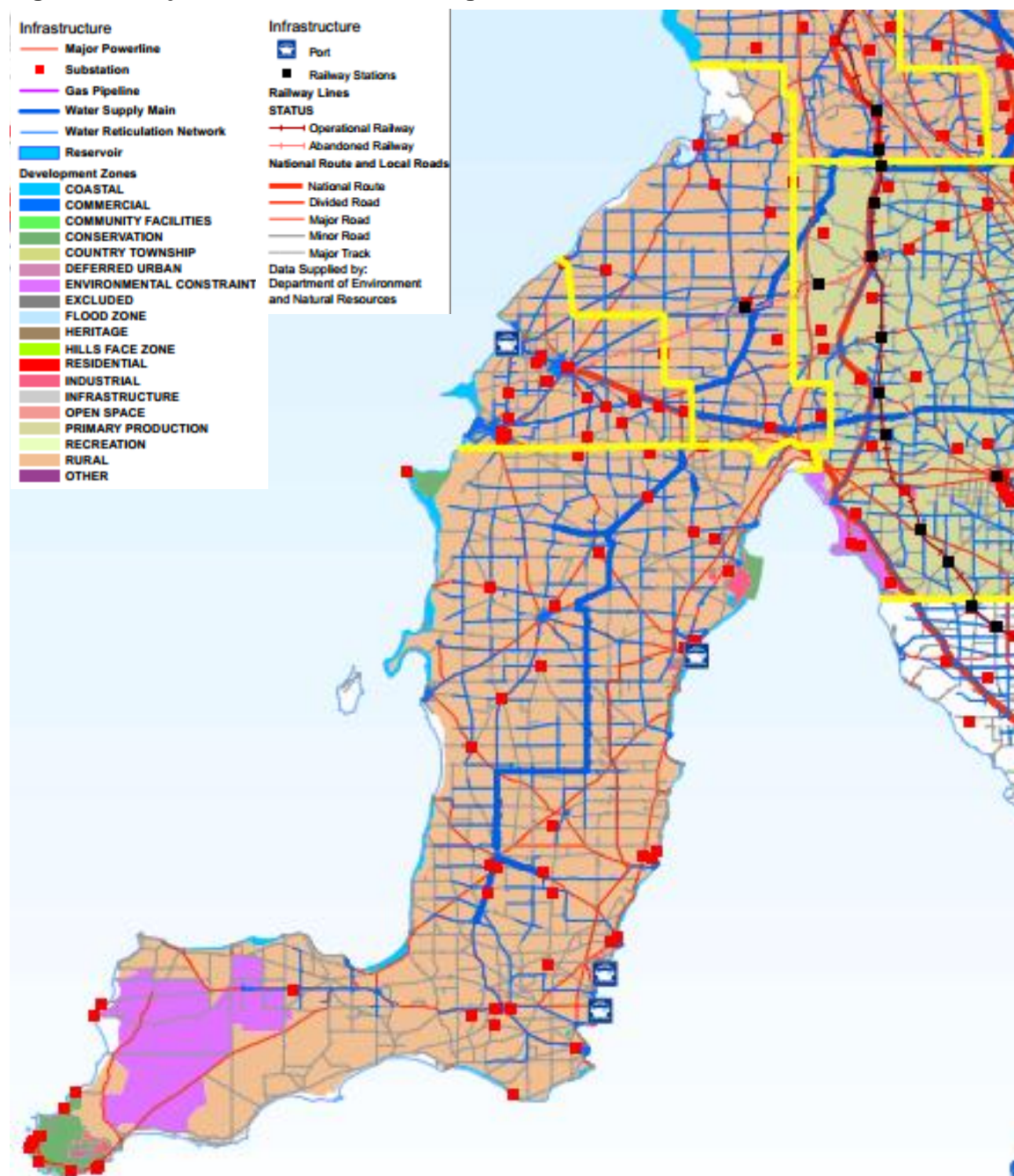
Power transmission to the Yorke Peninsula is currently supplied by ElectraNet via the Hummocks substation northwest of Port Wakefield, approximately 60km from Ardrossan. A 132kV transmission line runs to the Ardrossan west substation, providing the major power source to most areas of the Yorke Peninsula.

This power supply is supplemented by the Wattle Point Wind Farm (Edithburgh), which has the capacity to generate 91MW. A significant portion of this power however is untapped due to a lack of transmission capacity, which is preventing the expansion of wind power generation on the peninsula. Wattle Point wind farm generates approximately 30GWhr/year. Power is fed back into the National grid. The site is currently owned and operated by Australian Gas Light Company (AGL) subsidiary, AGL Energy.

The Ardrossan West Substation is currently being upgraded to increase transmission network reliability to meet the increasing electricity demands of the area by increasing the capacity of both existing 132/33kV transformers. ElectraNet's website indicates work should be complete by October 2012.

Wind farm expansion/approvals are in place from Wattle Point to Barunga and when on line will have an estimated total capacity of 560MW. It is recognised that for the Yorke Peninsula to realise its potential as an important renewable energy provider for the state it needs to have a significant upgrade to the electricity network capacity.

Figure F06 Major Infrastructure of the Region



Source: Regional Development Australia, Yorke and Mid North

The broader region is home to two gas turbine power stations that use gas or diesel combustion to generate all of the electricity they produce. One is located near Hallett (just outside of the regional study area) with a capacity of 180MW and the other near Mintaro (also just outside of the regional study area) with a capacity of 90 MW (RDAMYN, 2011).

5.2.2 Gas

The Epic Natural Gas Supply Line is geographically close to urban centres in the Adelaide Plains but there is currently no supply infrastructure. There are also no gas distribution systems on Yorke Peninsula (Yorke Regional Development Board, 2006). The closest natural gas supply is delivered via the lateral line, servicing Port Pirie and Whyalla, which branches off from near Whyte Yarcowie on the main Moomba – Adelaide gas pipeline (RDAMYN, 2010).

5.3 Water

5.3.1 Water Supply

Water supply on the Yorke Peninsula is predominantly sourced from two resources: the River Murray and the Para Wurlie groundwater basin (SA Water, 2010). The current SA Water potable water supply to the Yorke Peninsula region consists of three water supply systems:

- The Upper Paskeville system provides River Murray water to the majority of the region south from Paskeville;
- The Warooka system supplies water from the Para Wurlie groundwater basin to the townships of Warooka and Point Turton and surrounding farmlands;
- The Lower Paskeville system supplies River Murray water to the copper coast area including the townships of Kadina, Moonta and Wallaroo.

The Upper Paskeville system services the primary study area and a large majority of the regional study area (see Figure F07 for further details).

The Upper Paskeville system is configured with a central trunk main extending through the centre of the peninsula to as far south as Yorketown and Edithburgh, with several auxiliary branches extending east and west to service farmlands and coastal areas along the way (see Figure F07 below for further details). Meeting the increasing demand for water in coastal areas on Yorke Peninsula is partly constrained by the historical configuration of the central trunk main (SA Water, 2010).

The District Council of Yorke Peninsula has augmented this water supply with a desalination plant at Marion Bay. In addition, they operate community wastewater management schemes incorporating reuse of treated effluent mainly for irrigating sporting fields. The council also own and operate a number of small water supply schemes including Black Point. The Point Pearce water supply scheme is administered by the Point Pearce Aboriginal Corporation. SA Water provides some emergency operational assistance for this scheme as required (SA Water, 2010).

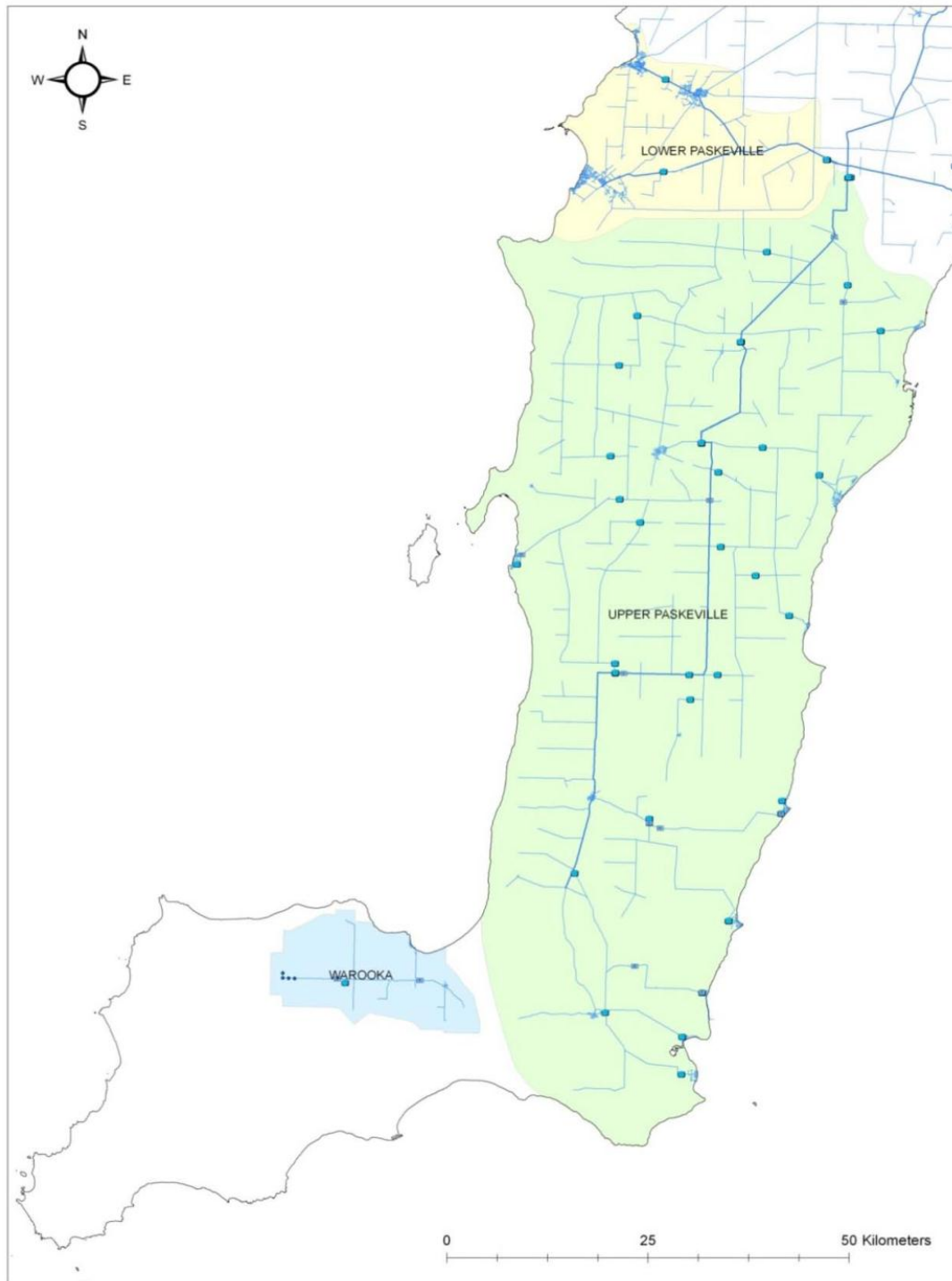
5.3.2 Planned Improvements to Water Availability

Northern Yorke Peninsula is dependent on water from the River Murray, while the area west of Warooka relies on aquifer and rainwater supplies. Most pipes were laid prior to the 1960s and are ageing and nearing capacity. Ongoing growth in tourism and residential development will continue test the system's peak capacity. Additional reticulated water is required to support planned residential and industrial expansion. Many of the regions district councils recycle waste and stormwater for use on parklands, ovals and golf courses (Planning SA, 2007).

According to SA Water, there is a general consensus that a lack of water to strategic sites is inhibiting development throughout the region, especially tourism projects (SA Water, 2007). Studies have been initiated to identify and evaluate new and alternative water sources for the region including, for example:

- Desalination including small scale solar desalination
- Treated stormwater and effluent
- Fresh groundwater
- Haulage of water
- Local wells and bores
- Upgrade of existing systems
- Provision of new systems
- Aquifer storage and recovery (eg: from roof water collection)

Figure F07 Main water supply network on the Yorke Peninsula



Source: SA Water, 2010

SA Water's Yorke Peninsula Long Term Water Plan (2010) shows that water supply in the Upper Parkerville system is currently under stress, particularly during summer, and is already inadequate to meet projected demand for a number of communities. Current demand for this system is 2,750ML/a – projected in 30 years to increase to between 3,250 to 3,600ML/a. The increase demand is based on projected population growth and tourism with little allowance for other industry growth such as mining (SA Water, 2010).

The plan has taken into consideration CSIRO's recent assessments of possible future temperature, rainfall and evaporation projections under different CO₂ emission scenarios. This analysis indicated that climate variability could potentially increase the overall Yorke Peninsula demand for water by approximately 13% by 2030 and 30% by 2070 (SA Water, 2010).

The plan modelled a number of water supply options designed to improve water supply to the Upper Paskerville system:

- Augmentation of the existing WSS central trunk and auxiliary branches with continued supply from the River Murray;
- Construction of an east coast trunk main to more directly supply coastal areas with water sourced from the River Murray;
- Augmentation of the existing system, but supplemented with supply from small desalination plants;
- Augmentation of the existing system, but with isolation of the lower Yorke Peninsula which would be supplied with water sourced from a desalination plant.

The long term plan concluded that:

- Supply to the area will continue to be from the Murray River via pipe;
- Demand will increase particularly as there are limits on any ground water extraction used to supply other parts of the peninsula;
- Desalination was not seen as a good option in the short term (till at least 2030) and only in very restricted areas (Port Vincent and Port Rickaby);
- To accommodate any immediate supply / demand shortfall, SA Water may recommend to Government the implementation of further demand management initiatives;
- Any augmentation to / extension of SA Water's existing water scheme systems to accommodate future projected growth and development would be undertaken on a commercial basis.

The plan concludes that mining companies will source their own water for mining extraction and operations. The plan did however make allowance for associated demands, for example growth in residential demand as a result of mining ventures (SA Water, 2010).

5.3.3 Hillside Project Water Requirements

Table T22 below defines the preliminary water requirements for the Hillside project.

Table T22 Hillside Water Consumption Estimates

Water Usage	Consumption (m ³ /hr)	Annual Consumption (Gl/a)
Raw Process Water (make-up)	491	4.3
Potable Water	198	2

Source: Hillside Scoping Study 2011.

The Hillside Project would utilise water from the Upper Paskeville system. The current SA extraction limits from the Murray River system are 50Gl/a which is further limited in periods of extended drought to ~31Gl/a.

The projects proximity to the coast and given the constraints of readily available fresh water supplies in the region the study has assumed that the bulk of the process water utilised will be seawater.

In addition to the supply options discussed above, the Hillside Project Scoping Study (2011) also included a preliminary investigation into the construction of a dedicated seawater desalination

plant using conventional reverse osmosis technology (SWRO). While scheme water is the preferred option due to the lower permitting requirements, the option to construct and operate a SWRO plant was considered.

5.4 Sewerage and Waste Management

5.4.1 Sewerage

Most towns in the study areas are serviced by common effluent systems or septic tank effluent disposal systems (STEDS). Common effluent systems are currently provided at Ardrossan, Maitland, Yorketown and Black Point (all of which are in the regional study area). The District Council of Yorke Peninsula was investigating establishing similar systems at larger coastal settlements such as Port Vincent and Stansbury. Other towns rely on site septic tank disposal of effluent (Yorke Regional Development Board, 2006).

5.4.2 Waste Management

Waste management facilities in the District Council of Yorke Peninsula currently has three landfill sites located at Arthurton, Port Vincent and Warooka. The study areas have 15 landfills waste transfer facilities at Port Wakefield and Inkerman, and a recycling/waste transfer facility at Moonta (two of which, Port Wakefield and Moonta, are in the regional study area).

Weekly rubbish collection and bi-weekly recycling collection occurs in Ardrossan on a Monday (DC of Yorke Peninsula Website, May 2012). Weekly kerbside waste collection services are provided in major towns. District Council of Copper Coast also provides a fortnightly recycling collection service in Kadina, Wallaroo and Moonta, (all of which are in the regional study area), while Wakefield Regional Council provides an annual hard waste service (Planning SA, 2007).

5.5 Roads and Transportation

5.5.1 Road Network

Primary Study Area

Ardrossan is accessible via the following three main roads:

- Arthurton Rd to the Northwest
- Maitland-Ardrossan Rd to the West
- Main Coast Rd (St Vincent Hwy) to the North and South

Regional Study Area

The region and project area are well supported via sealed national and regional highway systems, which connect the Project site to the capital city of Adelaide and other key port and rail infrastructure. The Port Wakefield highway forms part of the national highway system (A1) and connects with the Yorke Peninsula via Port Lakefield, the Copper Coast Highway and the Yorke Valley Highway into Ardrossan. Simplified overview of the regional highway network is shown in Figure F08.

5.5.2 Traffic Volumes

Primary industries (both agriculture and mining) generate most heavy vehicle movements on the Yorke Peninsula. The increased use of roads by farm produce and bulk grain vehicles is placing significant demands on the existing road network. In addition, the large influx of tourists during summer and weekends significantly increases pressure on roads and causes concern for safety.

Road traffic volumes have increased in recent years with the majority of grain exports from the Yorke Peninsula area being transported in road trains along national roads. Salt and bauxite are also road-hauled in the area. An additional source of road traffic expected around the mine, plant and port site will be associated with the tourist industry.

Estimates provided in November 2011 (RDAYMN, 2011) indicate daily traffic movements in the vicinity of the project were in the order of:

- 1,700 vehicles travelling on Coast Rd, between Ardrossan and Curramulka Rd turn off
- 850 vehicles travelling on Coast Rd, after Curramulka Rd turn off, to Pine Point
- Approximately 500 vehicles travelling on Curramulka Rd.

Freight movement is a major part of the regional study area regional economy. It provides the capacity to export product domestically, nationally and internationally. Bowmans intermodal facility (between Port Wakefield and Balaklava) is identified as a significant strategic asset for the region and State, providing effective transfer between road and rail networks (Yorke and Mid North Regional Freight Forum, June 2011).

Figure F09 shows annual average daily traffic estimates in the study area.

5.5.3 Ports

There are a number of port facilities currently in operation and within close proximity to the Project including Ardrossan, Adelaide, Port Pirie and Klein Point.

Table T23 outlines a summary of the relevant port details for the Ardrossan Port, which is the only port that sits within the study area and has the closest proximity to the Project site.

The Ardrossan port, owned and operated by Viterra, is approximately 12km from the Project site and is used to export grain, as well as dolomite from an adjacent mine. Currently the port handles around 600,000 tonne of product per annum indicating sufficient capacity for expansion.

Figure 09 Annual Average Daily Traffic Estimates in the Study Area



Source: Department Transport, Energy and Infrastructure, October 2011.

Table T23 Ardrossan Port Facilities

Port	Ardrossan
Distance from Project Site (km)	12
Port Authority	Viterra
Description	Bulk loading plant with a capacity of 2000 t/h for grain. Currently also loads dolomite, however capable of handling other dry bulk commodities
Port Type	Pier, jetty, wharf
Port Size	Very small
Maximum Draft (m)	8.23
Maximum Vessel Size	Over 150
Container Terminal	No
Bulk Cargo (Grain)	Tent conveyor system, two fixed booms, one operating at a time. Currently capable of loading approximately 2000 t/h for dolomite loading. Capable of handling other dry bulk commodities

Source: Rex Minerals Hillside Scoping Study, 2011

5.3.4 Rail

There were no freight or passenger rail services on the Yorke Peninsula.

Wakefield Regional Council is traversed by the national Sydney - Perth line and the State rail network that connects the grain silos at Balaklava, Bowmans, Owen, Nantawarra and Long Plains to Adelaide.

The national railway link connecting Adelaide to Perth crosses approximately 85km from the Project close to the entrance to the Yorke Peninsula. The Bowmans industrial site is located approximately 80km from site, which includes the Patrick's rail PortLink intermodal facility. This facility is currently predominantly utilised for rail transport of grain into Adelaide, which is located approximately 90km away.

5.5.5 Public Transport

The Southern Yorke Peninsula Bus Service annually transports more than 2,000 people around Yorke Peninsula. Bus services between Ardrossan and Adelaide operate five times a week and between Pine Point and Adelaide three times a week (www.ypcoaches.com.au, April 2012). These services also stop at other major towns throughout the regional study area. Public transport is a critical issue for many residents in the region. The Community Passenger Network annually transports nearly 9,000 people by private car for a fee. Private bus services provide public transport access to and from Adelaide, with pensioners and seniors accounting for half of total patronage.

Cycling and walking offer access within townships for those residents without a car, and some district councils have developed 'cycling plans' and maintain footpaths to support these modes of transport.

Table T24 below outlines the destinations and frequency of bus services in the primary study area.

Table T24 Bus Services to/from the Primary Study Area

Company	Destination	Frequency
Southern Yorke Peninsula Bus Service	Ardrossan - To and From Adelaide	5 times a week (Mon, Tues, Thurs, Fri, Sun)
Southern Yorke Peninsula Bus Service	Pine Point - To and From Adelaide	2 times a week (Mon and Fri)

5.6 Communications

5.6.1 Communications Infrastructure and Coverage

Telstra, Optus and Vodafone all provide mobile services within the primary and regional study areas (www.telstra.com.au, www.optus.com.au, www.vodafone.com.au, July 2012). Information and Communications Technology (ICT) infrastructure access varies throughout the region. Broadband services have been upgraded through the Broadbanding Yorke Peninsula Project (Broadband SA, 2005). In the Mid North, ADSL broadband is only available in a few of the larger towns. Mobile phone coverage is good near most of the larger towns; however there are significant gaps, particularly in the north of the region.

Table T25 below provides details of coverage within the primary study area.

Table T25: Mobile Phone Coverage in the Primary Study area

Town	Telstra	Optus	Vodafone
Ardrossan	Full Coverage	Full Coverage	Full Coverage
Black Point	Full Coverage	Full Coverage	Patchy Coverage
James Well	Full Coverage	Full Coverage	Full Coverage
Pine Point	Full Coverage	Full Coverage	Patchy Coverage
Port Julia	Full Coverage	Full Coverage	Patchy Coverage
Rogues Point	Full Coverage	Full Coverage	Full Coverage
Sheaoak Flat	Full Coverage	Full Coverage	Patchy Coverage
Tiddy Widdy Beach	Full Coverage	Full Coverage	Full Coverage

5.6.2 Internet Connection

According to the 2011 national census, 54% of dwellings in the primary study area had some form of internet access, compared with 64.4% of dwellings for the regional study area, 73.2% of dwellings in South Australia and 76.8% of dwellings nationally. Throughout the key study areas approximately 87% of dwellings with Internet used a broadband connection, which is almost exactly on par with the 89.4% of South Australians and 91% of Australians using a broadband connection.

The Internet service provider Internode is able to provide ADSL broadband through the following telephone exchanges in the secondary study area (Internode, 2012):

- Ardrossan
- Brentwood
- Coobowie
- Curramulka
- Maitland
- Minlaton
- Port Victoria
- Port Vincent

Fixed-Wireless Broadband is also available throughout the major towns and regions in the regional study area, however service may be impacted by trees and vegetation. In 2008, several caravan parks on the Yorke Peninsula were granted free wifi access as a result of a partnership between Internode and the DC of Yorke Peninsula (Internode, 2012). Public Internet access is available through the libraries at Ardrossan, Maitland and Minlaton (DC of Yorke Peninsula Website, May 2012).

Public online broadband access is available throughout the regional study area through libraries at Ardrossan, Balaklava, Kadina, Maitland, Minlaton, Moonta, Wallaroo and Yorketown (Planning SA, 2007; DC of Yorke Peninsula Website, 2012).

6. ECONOMIC ENVIRONMENT

The following chapter provides a description of the economic environment in the study areas; outlines key economic characteristics, discusses notable indicators of rising or declining economic aspects within the study area as they relate to the Project; and identifies areas where the construction and operation of the Project would potentially affect aspects of the existing economic environment.

6.1 Major Industries

Table T26 below compares the top three industries of employment across each of the four study areas.

The top three industries in the primary and regional study areas are sheep, beef/cattle and grain farming employing approximately 21% and 16% of working-age residents respectively. Food product manufacturing, school education and hospitals figure prominently across all study areas, which is consistent with State and national data.

Tourism within the Yorke Peninsula region is a growing industry that contributed approximately \$166 million to the regional economy in 2009-10, made up of \$33 million from domestic day trippers and \$132 million from domestic overnight visitors. In 2009/2010, the total number of visitors to the Yorke Peninsula region was 883,000 made up of 436,000 domestic day trippers, 443,000 domestic overnight visitors who stayed over 1.4 million nights and 4,000 international visitors (Yorke Peninsula Tourism, 2011).

The \$166 million of visitor expenditure in the Yorke Peninsula region in 2009/2010 generated approximately \$77 million in Gross Regional Product (GRP) and approximately 1,100 full and part time jobs (Yorke Peninsula Tourism, 2011).

Figures provided by the National Parks and Wildlife Service estimate that 180,000 people visit the Innes National Park annually (DC of Yorke Peninsula Website, April 2012).

Table T26: Key Industries of Employment Across Study Areas

	Primary study Area	Regional Study Area	South Australia	Australia
Top Major Employment Industries (Labour Force Population aged 15 years and over)	Sheep, Beef Cattle and Grain Farming (20.9%) Food Product Manufacturing (7.8%) Hospitals (6.9%) School Education (6.4%) Supermarkets and Grocery (3.4%)	Sheep, Beef Cattle and Grain Farming (16.4%) School Education (5.2%) Supermarket and Grocery (3.5%) Hospitals (3.3%) Residential care (2.7%)	School Education (4.5%) Hospitals (3.7%) Restaurants and Takeaway Food Services (3.2%) Supermarket and Grocery (2.6%); Residential (2.3%)	School Education (4.5%) Cafes, Restaurants and Takeaway Food Services (3.6%) Hospitals (3.3%) Supermarket and Grocery (2.4%) Legal and Accounting (2.0%)

Source: ABS 2011

6.2 Key Economic Indicators

Table T27 below compares the key economic indicators across the study areas.

6.2.1 Employment

Section 4.2.1 Employment and Unemployment indicates that of the total potential labour force in the primary and regional study areas 45.5% and 51.6% of persons aged 15 years and over

respectively were working. The unemployment rate was 6.6% and 6.5% respectively in the primary and regional study areas.

6.2.3 Income

Primary Study Area

In 2011, the median weekly income for residents in the primary study area was \$387, which was significantly lower than the \$543 and \$577 average weekly incomes for South Australia and Australia respectively. This may be due to the large number of older people and others not actively participating in the workforce (see Chapter 4 Workforce and Accommodation).

Regional Study Area

Median weekly income for regional study area residents was \$409, which was significantly lower than the \$543 and \$577 average weekly incomes for South Australia and Australia respectively. As with the primary study area, this may be due to the large number of older people and others not actively participating in the workforce (see Chapter 4 Workforce and Accommodation).

This median income is only slightly higher than the averages for the primary study area and is low compared with State and national averages.

Table T27: Comparison of Key Economic Indicators Across Study Areas

	Primary Study Area	Regional Study Area	South Australia	Australia
Median Weekly Individual Income (Gross)	\$387	\$409	\$534	\$577
Top 3 Major Household Expenses (% of total household expenditure) (2010)	N/a	N/a	Housing costs (17.4%); Food and non-alcoholic beverages (17.2%); Transportation Costs (14.8%)	Housing costs (18%); Food and non-alcoholic beverages (16.5%); Transportation Costs (15.6%)
Building Approvals (2010)	N/a	387 dwellings \$123.7m total value	12 560 dwellings \$5 451.3m total value	171 429 dwellings \$86 833.1m total value
Gross Domestic/State Product (GDP or GSP) (Dec 10-11)	NR	NR	2.4%	2.1%

Sources: ABS Census 2006; ABS Regional Profiles 2010; ABS 2009/10 Household Expenditure Survey, Australia: Summary results; ABS National Accounts, State Accounts 2010-11

6.2.4 Cost of Living

Due to the absence of data specific to the primary and regional study areas, State expenditure data has been used to characterise the cost of living and household expenditure for the study areas.

Housing costs in South Australia take up the largest percentage expenditure of gross income (17.4%), which is slightly lower than the national average (18%). Expenditure on food and non-alcoholic beverages is the next largest expense, with South Australians spending 17.2% of total expenditure in this area, compared with 16.5% for the whole of the nation. Transport and recreation are also significant areas of expenditure in the state; although with percentages slighter lower than the national average.

Table T28 shows the comparisons of household expenditure of South Australia and Nationally.

Table T28 Comparison of Household Expenditure

	South Australia	Australia
Current housing costs (selected dwelling)	17.4%	18.0%
Domestic fuel and power	3.3%	2.6%
Food and non-alcoholic beverages	17.2%	16.5%
Alcoholic beverages	2.5%	2.6%
Tobacco products	1.4%	1.0%
Clothing and footwear	3.5%	3.6%
Household furnishings and equipment	4.8%	4.7%
Household services and operation	5.5%	5.5%
Medical care and health expenses	5.7%	5.3%
Transport	14.8%	15.6%
Recreation	13.0%	13.1%
Personal care	2.1%	1.9%
Miscellaneous goods and services	8.8%	9.4%

Source: ABS 2009/10 Household Expenditure Survey, Australia: Summary results

6.2.5 Building Construction

In 2010 the, total number of building approvals for new dwellings in the regional study area was 387, with a total value of \$123.7 million.

Throughout the state of South Australia there 12,560 building approvals for new dwellings in the same year, with a total value of \$5,541.3 million, while in Australia there were 171,429 building approvals in 2010, with a total value of \$86,833.1 million.

6.2.6 Gross Domestic Product (GDP)

In the year from December 2010 to December 2011 the economy of South Australia grew at a rate of 2.4%, compared with a national growth rate of 2.1%. When compared with other States, South Australia was the nation's fourth fastest growing economy and one of five economies that grew faster than the national average. Interestingly, South Australia appears to sit right in the middle of the growth rates for the top three mining states within Australia (Western Australia, South Australia and Queensland). Table T29 below provides a comparison of GDP across all States in Australia.

Table T29: Comparison of GSP across States

State	Gross State Product or Gross Domestic Product (Annual Growth)
Western Australia	3.5%
Australian Capital Territory (ACT)	2.8%
Victoria	2.5%
South Australia	2.4%
New South Wales	2.2%
Northern Territory	1.6%
Tasmania	0.8%
Queensland	0.2%
Australia	2.1%

Source: ABS National Accounts, State Accounts 2010-11

6.2.7 Local Business Capacity

Table T30 outlines the type and number of businesses in Ardrossan, the largest town within the primary study area. As shown in the table, the majority of businesses in Ardrossan are in the building, maintenance, trade and home and garden services category, followed by retail stores.

T30: Types of Businesses in (or servicing) Ardrossan

Type of Business	Number of Businesses
Automotive Fuels, Service, Marine and Caravans	6
Food and Beverages	9
Hair and Beauty, Massage and Personal Fitness	8
Professional and Trade Services	5
Animal Care	5
Art and Craft	7
Banking and Finance	6
Building, Maintenance, Trade, Home and Garden Services	21
Newspaper	1
Retail	16
Primary Industry	6

Source: Ardrossan Community Services Website, May 2012

6.3 Key Economic Inputs

6.3.1 Mining Royalties

Natural resource royalties paid by mining businesses are collected by State and Territory governments for mining onshore and up to three nautical miles offshore, and by the Australian Government outside that area. The basis of the mineral royalties varies between states. Some royalties are based on the value of production at mine site, others on sales value, gross proceeds or profit. The rates imposed also vary between commodities (ABS, 2010).

For South Australia, a royalty rate of 3.5 per cent applies to refined metallic products, including refined copper, gold and silver. It also applies to categories of industrial minerals and construction materials, including limestone and gypsum (DMITRE Website, 2012).

A royalty rate of 5.0 per cent applies to other mineral products, generally concentrates or minimally processed products, including copper concentrate, uranium oxide concentrate and iron ore. New mines are eligible for a concessional rate of 2.0 per cent for the first five years (DMITRE Website, 2012).

National Mining Royalty Payments

Natural resource royalty expenses include payments under mineral lease arrangements, and resource rent taxes and royalties. According to the ABS Year Book Australia 2009-10, mining royalties expenses totaled \$6,573m in 2006-07. The greatest proportion of royalties was paid by the oil and gas extraction industry (\$2,990m or 46%). Metal ore mining businesses (comprising copper, gold, mineral sands, silver-lead-zinc, bauxite, nickel and other metal ore mining) paid \$947m or 14% of total mining royalties in 2006-07. The coal mining industry paid \$1,696m (26%) and iron ore mining businesses \$849m (13%). The remaining royalties were paid by non-metallic mineral mining and quarrying, exploration and other mining support services and businesses (ABS, 2010).

South Australian Mining Royalty Payments

According to the Commonwealth Grants Commission (CGC, 2012), the South Australian Government collected more than \$155 million in mining royalties and fees for exploration permits in the financial year 2010-11. This equated to 2.5% of total state revenue.

6.3.2 Taxes

Total Taxation Revenue

In the fiscal year 2010-2011, the South Australian government had a total taxation revenue of \$3,831 million, compared with a national revenue of \$288,075 million. With respect to local government taxation revenue, local governments within South Australia had a total taxation revenue of \$1,086 million. When compared with other states, South Australia was the nation's fifth largest taxation collector for both State and local government taxes.

Table T31 below provides a comparison of taxation revenue across all States in Australia.

Table T31: Total Taxation Revenue by Level of Government (2010-11)

	State Government	Local Government
New South Wales	\$20,417m	\$3,317m
Victoria	\$14,857m	\$3,410m
Queensland	\$9,975m	\$2,792m
Western Australia	\$6,540m	\$1,420m
South Australia	\$3,831m	\$1,086m
Australian Capital Territory (ACT)	\$1,244m	N/A
Tasmania	\$860m	\$298m
Northern Territory	\$397m	\$86m
Commonwealth Government	\$288,075m	N/A

Source: ABS Taxation Revenue, Australia, 2010-11, 2012

Assessed Fiscal Capacity

According to Commonwealth Grants Commission (CGC), South Australia has the third lowest assessed fiscal capacity of all Australian states, largely due to its below average revenue raising capacity across all State taxes, especially conveyance duty, payroll tax and mining revenue (CGC, 2012).

Those effects are reinforced by its above average assessed expenses, which reflect its above-average shares of older people, people of low socio-economic status and residents of small communities in poor water areas, as well as high rural road use and large numbers of lengthy rural roads (CGC, 2012).

Conversely, South Australia's below average population growth means it has below average investment and net lending requirements. It also receives above average revenue from Commonwealth payments (CGC, 2012).

References

ABC, 2011. \$1.3 Billion Wind Farm Proposal for Ardrossan. 31 August 2011. Accessed at <http://www.abc.net.au/local/stories/2011/08/31/3306383.htm>.

ABS Population Census Data 2006, accessed via <http://www.abs.gov.au/websitedbs/censushome.nsf/home/data?opendocument#from-banner=LN> in March-April 2012

ABS Population Census Data 2011, accessed via <http://www.abs.gov.au/websitedbs/censushome.nsf/home/data?opendocument#from-banner=LN> in July 2012

ABS National Accounts, State Accounts 2010-11, accessed via <http://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/5220.0Main%20Features22010-11?opendocument&tabname=Summary&prodno=5220.0&issue=2010-11&num=&view=> on 23 April 2012

ABS Taxation Revenue, Australia, 2010-11, accessed via <http://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/5506.0Main%20Features22010-11?opendocument&tabname=Summary&prodno=5506.0&issue=2010-11&num=&view=> on 23 April 2012

ABS Year Book Australia, 2009-10, accessed via <http://www.abs.gov.au/AUSSTATS/abs@.nsf/0/0F2FAE2AE39180F0CA25773700169CC3?opendocument> on 23 April 2012

Adelaide UniCare Website, Maitland and Minlaton Medical Centres Pages, accessed via http://www.adelaideunicare.com.au/index.php?option=com_content&view=article&id=19&Itemid=4 on 7 May 2012)

Ardrossan Caravan Park Website, access via <http://www.ardrossancaravanpark.com.au/accommodation.htm> on 8 May 2012

Ardrossan Community Services Website, Business Listings Page, accessed via <http://ardrossan.sa.au/business> on 7 May 2012

Ardrossan Community Services Website, Community Clubs Page, accessed via <http://ardrossan.sa.au/community-services/community-groups> on 7 May 2012

Ardrossan Community Services Website, Sports Club Page, accessed via <http://ardrossan.sa.au/community-services/sports-clubs/sports-and-rec-group> on 7 May 2012

Ardrossan Hotel-Motel Website, access via <http://www.ardrossanhotelmotel.com.au/> on 8 May 2012

Australian Electoral Commission (AEC), Information on State and Federal Electorates, accessed via <http://www.aec.gov.au/Electorates/index.htm> on 23 April 2012

Aged Care Australia, Aged Care Facilities in Ardrossan, accessed via http://www.agedcareaustralia.gov.au/internet/AgedCare/Publishing.nsf/content/aged+care+home+record?OpenDocument&id=4128&from=matching%2Bhomes%3FOpenDocument%26type%3D1%26name%3DINCE%26care_level%3Dany%26special_needs%3Dnone%26btnSubmit%3Dgo on 18 April 2012

Ardrossan Community Hospital, List of Health Services at Ardrossan Community Health Centre, accessed via <http://www.ardrossanhospital.com.au/index.php/health-centre> on 7 May 2012

Ardrossan Medical Centre, Pers-Comms with Nicole from Reception, via telephone on 7 May 2012

Australian Job Search, Job Vacancies in the Kadina/Clare Region, accessed via <http://jobsearch.gov.au/findajob/selectoccupation.aspx?LocationCode=59124KAC>, on 3 April 2012

Broadband SA, Broadbanding Yorke Case Study, accessed via www.broadband.sa.gov.au on 25 March 2012

CIA World Factbook, 2011, GDP (Official Exchange Rate), accessed via <https://www.cia.gov/library/publications/the-world-factbook/fields/2195.html>.

Commonwealth Grants Commission, South Australia Assessed Fiscal Capacity, accessed via http://www.cgc.gov.au/_data/assets/pdf_file/0003/23358/South_Australia.pdf on 18 April 2012

Department of Further Education, Employment, Science and Technology (DFEEST), Workforce Planning and Policy Regional Profile Yorke, 2010 accessed via <http://www.yorkeandmidnorth.com.au/uploads/files/Workforce%20Region%20Profile%20-%20Yorke%20and%20Mid%20North%202010.pdf> on February 14 2012

Department of Manufacturing, Innovation, Trade, Resources and Energy (DMITRE) Website, Mineral Royalties Page, accessed via http://www.minerals.pir.sa.gov.au/licensing_and_regulation/fees_rents_and_royalties/mineral_royalties on 15 April 2012

District Council (DC) of Yorke Peninsula, General Website, accessed via <http://www.yorke.sa.gov.au/> on 3 April 2012

Electoral Commission of South Australia, Electoral Districts, accessed via <http://www.ecsa.sa.gov.au/apps/news/?sectionID=6> on 18 April 2012

EPA 2008. Environmental Protection Authority, South Australia. South Australia's Air Quality 2008. Accessed at: http://www.epa.sa.gov.au/xstd_files/Air/Report/air_quality_2008.pdf

Farmbuy.com.au, Rural Properties for Sale in Yorke Peninsula, accessed via <http://www.farmbuy.com/stateSearch.aspx?state=SA> on 3 April 2012

Kadina Police Station, Pers-Comms with Duty Sergeant, via telephone on 8 May 2012 (Ardrossan Police Station was unattended at time of call).

lastminute.com.au, Yorke Peninsula Accommodation, accessed via www.lastminute.com.au on 3 April 2012

Optus, Mobile Phone Coverage in Yorke Peninsula, accessed via www.optus.com.au on 18 April 2012

Planning SA, Yorke Peninsula Regional Land Use Framework, December 2007, accessed via http://www.sa.gov.au/upload/franchise/Housing,%20property%20and%20land/PLG/Region_plan_Yorke.pdf on 14 February 2012

Public Health Information Development Unit (PHIDU), Social Health Atlas of Australia, South Australia (by Statistical Local Area), 2011, accessed via http://www.publichealth.gov.au/data/a-social-health-atlas-of-australia_-2011.html on 25 March 2012

Realestate.com.au, Properties for Sale in Ardrossan, accessed via <http://www.realestate.com.au/buy/in-ardrossan,+sa+5571/list-1> on 3 April 2012

Regional Development Australia Yorke and Mid North (RDAYMN), Yorke and Mid North Regional Roadmap, April 2011, accessed via <http://www.yorkeandmidnorth.com.au/uploads/files/Resources/RDA%20Yorke%20and%20Mid%20North%20Regional%20Roadmap%20April%202011%20-%20for%20web4.pdf> on 14 February 2012

Regional Development Australia Yorke and Mid North (RDAYMN), November 2011, pers comms.

Resources and Engineering Skills Alliance (RESA), Workforce Study for the Resources Sector in the Eyre Peninsula, 2011, accessed via <http://www.tasc.sa.gov.au/LinkClick.aspx?fileticket=hVhutkp5ws0%3d&tabid=142&mid=581> on 25 March 2012

Rex Minerals, Hillside Project Scoping Study, July 2011

SA Health, Yorke Peninsula 10 Year Local Health Service Plan 2010-2019, 2010, accessed via <http://www.countryhealthsa.sa.gov.au/LinkClick.aspx?fileticket=cGEHta66heQ%3D&tabid=584> on 25 March 2012

SA Health, SA Health Services Directory – Aboriginal Health Team Page, access via <http://www.hsfinder.sa.gov.au/Pages/ServicesSites/ServicesSitesView.aspx?ServicesSitesID=1040607188> on 7 May 2012

SA Water, Long Term Plan for Yorke Peninsula, October 2010, accessed via http://www.sawater.com.au/NR/rdonlyres/D8BA8481-802F-467F-A859-6DB026B9B911/0/YPLTP_FinalLongTermPlan.pdf on 14 February 2012

South Australia Tourism Board, Yorke Peninsula Visitors Guide, 2012 accessed via <http://yorkepeninsulavisitorguide.realviewdigital.com/#folio=CV1> on 18 April 2012

South Australian Country Fire Service, Region 2, accessed via http://www.cfs.sa.gov.au/site/about_us/cfs_regions/region_2.jsp on 30 March 2012

South Australian Department of Families and Communities Website, Housing Data Page, accessed via <http://info.id.com.au/ahiu/> on 18 April 2012

South Australian Office of Crime Statistics and Research (OSCAR), Crime Rate Statistics, accessed via [http://www.ocsar.sa.gov.au/region_files/LGA%20Yorke%20Peninsula%20\(DC\).html](http://www.ocsar.sa.gov.au/region_files/LGA%20Yorke%20Peninsula%20(DC).html) on 3 April 2012

Telstra, Mobile Phone Coverage in Yorke Peninsula, accessed via www.telstra.com.au on 18 April 2012

Vodafone, Mobile Phone Coverage in Yorke Peninsula, accessed via www.vodafone.com.au on 18 April 2012

United Nations Human Development Index 2011, accessed via <http://hdr.undp.org/en/reports/global/hdr2011/>.

Whereis.com.au, Playground Finder, accessed via <http://www.whereis.com/sa/ardrossan/category-playgrounds#session=NTQ=> on 7 May 2012

Yellow Pages, Dentists in Ardrossan, accessed via <http://www.yellowpages.com.au/search/listings?clue=dentist&locationClue=ardrossan&selectedViewMode=LIST&emsLocationId> on 18 April 2012

Yellow Pages, Temporary Accommodation in Ardrossan, accessed via <http://www.yellowpages.com.au/search/listings?clue=dentist&locationClue=ardrossan&selectedViewMode=LIST&emsLocationId> on 8 May 2012

Yorke and Mid North Regional Freight Forum, Meeting Report, June 2011, accessed via http://www.yorkeandmidnorth.com.au/uploads/files/Resources/Publications%20-%20Regional%20Freight%20Forum/1_RDA%20YMN.pdf on 25 March 2012

Yorke Peninsula Coaches, Bus Timetable for Yorke Peninsula, accessed via www.YPCoaches.com.au on 18 April 2012

Yorke Regional Development Board, Yorke Region – South Australia, Socio-Economic and Infrastructure Profile, 2006, accessed via http://www.yorkeregion.com.au/pdf/Yorke_Region_Infrastruct.pdf on 14 February 2012

Traffic and Transport Impact Assessment

TRAFFIC ASSESSMENT
FOR
REX MINERALS HILLSIDE COPPER MINE
YORKE PENINSULA

20/03/2013

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Executive Summary

Rex Mineral's proposed Hillside copper/gold mining operation will be located between the townships of Ardrossan and Pine Point on the Yorke Peninsula in South Australia.

Over the project's 15+ year operational life mining site will contain both open pit and underground mining and a crushing / processing plant, with concentrate transported via pipeline to a filtration, storage and loading facility at the Ardrossan Port. It is anticipated that a construction workforce of up to 1000 people will be required during the 2 year construction phase, and that an ongoing operational workforce of about 530 will be employed for the life of the project.

The project will have impacts on local traffic during the construction phase through modifications to: Yorke Highway, St Vincent Highway, Sandy Church Rd and Pint Point Rd; through increased heavy and oversized vehicle traffic; and through increased local traffic as a result of the increased population.

The proposed road modifications have been reviewed by the local Council and community, and will be subject to DPTI and DCYP approval prior to construction. A traffic impact study prepared by AECOM has found that the modifications will not have significant negative impacts on the surrounding community.

Assessment of traffic and noise impacts created during mining operation has shown that road transport of ore concentrate is not a viable option, and has resulted in the decision to split the operation into 'mine' and 'port' operations connected by an underground pipeline. A decision has also been made to minimise the number of light vehicle trips required for staff transport by providing a bus service from local population centres. Increased heavy and oversized vehicle traffic will be managed through specific Traffic Management Plans to minimise the impact on the local community.

With the proposed controls and programs in place, negative impacts on the local community will be confined to localised, short-term disruptions; and an overall benefit to traffic flow and road safety is expected to result upon completion of the proposed road modifications.

Introduction

Hillside Project Overview

Subject to obtaining the required approvals, Rex Minerals intends to develop a copper/gold mining operation at their Hillside site on the Yorke Peninsula in South Australia. The proposed mine will be located approximately 12km south of Ardrossan and will consist of open cut and underground mining, crushing, processing and the production of copper/gold concentrate and iron ore concentrate. In addition to the mine site, a filtration, storage and loading facility will be constructed at the Ardrossan Port to load concentrate onto ships for distribution to customers.



Figure 1: Location of the proposed Hillside mining operation

Development of the proposed mine will have an impact on local traffic during the construction and operational phases through an increase in traffic volumes, predominantly along the Yorke Highway between the site and Ardrossan and further north to Port Wakefield and Adelaide.

Study Methodology

For the purpose of undertaking this traffic impact assessment background traffic assessment data has been sourced from the Department of Planning Transport and Infrastructure (DPTI) South Australia for major roads and a traffic monitoring program involving traffic counts and traffic monitoring equipment has been carried out by Rex Minerals on roads surrounding and affected by the mine site.

Rex Minerals traffic counts were conducted at the junction of Yorke Highway/St Vincent Highway between 6 December 2011 and 12 December 2011 to represent peak harvesting traffic and again between 25 January 2012 and 31 January to represent peak holiday traffic. Electronic counts were

undertaken on the smaller roads using a Metro Count 5600 traffic meter between May and October 2012.



Figure 2: Proposed Hillside Project location and surrounding roads

Road Network

Yorke Highway

The Yorke Highway is controlled by Department of Planning Transport and Infrastructure (DPTI) and functions as the primary linking road down the Yorke Peninsula from Adelaide to Marion Bay. Traffic data for this assessment has been sourced from published DPTI annual average traffic estimates and Rex Minerals traffic counts.

St Vincent Highway

The DPTI controlled St Vincent Highway extends south along the coast from the Yorke Highway, 4.4 kilometres north of Pine Point, to the township of Coobowie. It functions as a major linking road down the peninsula and is the primary connection between a number of townships and grain export facilities. Traffic data for this assessment has been sourced from published DPTI annual average traffic estimates and Rex Minerals traffic counts.

Sandy Church Road

Sandy Church road is an unsealed, District Council Yorke Peninsula (DCYP) controlled road which extends approximately 36 kilometres from the Yorke Highway north of Pine Point to Port Victoria. It is an east-west connecting road used primarily for residents and farmers to access their property and during harvest for transporting grain to the Ardrossan Port. Traffic data was collected using an electronic traffic counter placed on Sandy Church Rd between 18 July and 18 August 2012.

Pine Point Road

Pine Point road is an unsealed DCYP controlled road which extends approximately 28.6 km NW from the small township of Pine Point to the town of Maitland. It is used primarily for residents and farmers to access their property and during harvest for transporting grain to the Ardrossan Port and Port Giles to the south. Traffic data was collected using an electronic traffic counter placed on Pine Point Rd between 30 April 2012 and 30 May 2012.

Redding Road

Redding road is an unsealed DCYP controlled local access road which is used predominantly for residential access and access to land for primary production. Traffic data was collected using an electronic traffic counter placed on Redding Rd between 10 October and 10 November 2012.

Scheduled Road Improvement Projects

A study which has been prepared for the Regional Development Australia Yorke & Mid North, titled the Regional Development Australia Yorke and Mid North: Infrastructure Audit 2012 has identified projects which are underway and in the planning stages to improve the road and freight system of the Yorke and Mid North Region.

This document identifies four major scheduled projects and studies for the Ardrossan area either under way or in the planning stages that will impact upon the works required for the proposed Hillside development:

The route from Ardrossan to Pt. Wakefield needs to be gazetted for road train access to improve efficiency of the extensive commodity movement from and to the Peninsula. Currently road train access is gazetted from Ardrossan to Pt. Giles, but not the Ardrossan to Pt. Wakefield leg of the route so access to Pt. Giles can occur. Requirements to make this road gazetted include construction of slip lanes and additional signage along the route¹.

Ardrossan & Port Giles. Key freight route networks need to be mapped and consolidated, with the identification of investment required to address current freight capacity issues and increases associated with the agricultural and extraction industries. Additionally, anticipated increases with expansion of the mining industry in the region need to be incorporated. Ideally, the study needs to be completed prior to June 2012 to feed into the state and national freight strategies¹.

Five-year program of works to improve efficiency on the state's important freight routes including road widening and shoulder sealing, intersection improvements, level crossing upgrades and overtaking lanes¹.

Road trains and other heavy vehicles have limited access to the York and Mid North regions. Strategies to be put in place that align with State and Federal freight movement strategies and strategic plans. From a local Council observation it is a real necessity that State &

¹ Regional Development Australia Yorke and Mid North: Infrastructure Audit 2012.

Federal Government fund country Councils to upgrade and maintain unsealed commodity roads to a high standard so farmers and transport companies are able to get down the last mile. The burden on local country Councils is unsustainable and it is driving small country Councils to an untenable and unrealistic state of affairs².

These road improvement projects will likely be increased in priority by the Rex Minerals Hillside project and will be of benefit to the project through improved heavy vehicle access up and down the length of the peninsula.

Alternative Transport Options

Rail

No passenger or commercial rail services currently operate on the Yorke Peninsula. The closest rail service, Bowmans intermodal facility, is located approximately 75km from the site. The Bowmans facility links into the national rail network, providing the option of transferring the concentrate to major ports or industrial centres across Australia.

Port

Yorke Peninsula has 2 major deep sea ports, located at Wallaroo on the north west coast (81km from site) and Pt Giles on the south east coast (57km from site). These ports are primarily used for the export of grain and agricultural commodities. The shallow water Ardrossan port is approximately 12km from site and is currently used predominantly for the transport of dolomite from the Arrium operated mine at Ardrossan and to a lesser extent industrial salt from the Price salt works.

Background Traffic

Economic activity on the Yorke Peninsula is dominated by primary production (predominantly agriculture, with some existing mining activity) and tourism. The region likely to be most affected by the proposed mine development is along the Yorke and St Vincent Highways between Ardrossan to the north and the township of Pine Point to the south. This stretch of highways sees significant seasonal variation in traffic loads, with light vehicle traffic increasing substantially throughout the summer months and on holiday weekends as tourist numbers increase; and heavy vehicle traffic peaking between October and March) as grain is transported from properties across the peninsula to receival and storage facilities at Ardrossan, and down to Port Giles for distribution.

Comparison of the traffic volumes from the DPTI estimates and the peak traffic period surveys which Rex has conducted in Tables 1-3 show that the survey carried out during Peak Harvest time correlates well with annual average figures for the Yorke Hwy and Yorke Hwy/Minlaton Rd segments. However, the annual average figures appear to be underestimating normal traffic volumes on the St Vincent Hwy by as much as 50%, and on all three main roads by up to 100% during peak holiday periods.

² Regional Development Australia Yorke and Mid North: Infrastructure Audit 2012.

DPTI Data		
Traffic Type	7 day average	Proportion %
Yorke Highway		
General	10570	89%
Commercial	1330	11%
Total Weekly traffic	11900	
Daily vehicle average	1700	
Yorke Highway/Minlaton Rd		
General	2933	91%
Commercial	287	9%
Total Weekly traffic	3220	
Daily vehicle average	460	
St Vincent Highway		
General	4550	76%
Commercial	1400	24%
Total Weekly traffic	5950	
Daily vehicle average	850	

Table 1: DPTI Annual Average Traffic Estimates

Peak Harvest Period		
Traffic Type	7 Day Average	Proportion %
Yorke Highway		
General	10710	90%
Commercial	1255	10%
Total Weekly traffic	11965	
Daily vehicle average	1709	
Yorke Highway/Minlaton Rd		
General	3380	91%
Commercial	346	9%
Total Weekly traffic	3726	
Daily vehicle average	532	
St Vincent Highway		
General	7330	89%
Commercial	909	11%
Total Weekly traffic	8239	
Daily vehicle average	1177	

Table 2: Rex Minerals December 2011 traffic count, representing peak harvesting traffic

Peak Holiday Period		
Traffic Type	7 Day Average	Proportion %
Yorke Highway		
General	15923	97%
Commercial	411	3%
Total Weekly traffic	16334	
Daily vehicle average	2722	
Yorke Highway/Minlaton Rd		
General	5160	97%
Commercial	171	3%
Total Weekly traffic	5331	
Daily vehicle average	889	
St Vincent Highway		
General	10763	98%
Commercial	240	2%
Total Weekly traffic	11003	
Daily vehicle average	1834	

Table 3: Rex Minerals January 2012 traffic count, representing peak holiday traffic

If the data is broken down further to split the commercial category down into medium and heavy vehicles as in Tables 6 – 8, it can be seen that traffic on the three main roads is typically made up of approximately 90% light vehicles (Class 1&2 vehicles as per the AustRoads classification system), 3% Medium Vehicles (Class 3,4&5) and 7% heavy vehicles (Class 6-12), however during peak holiday periods the number of light vehicles increases significantly with the result that commercial vehicles make up only 2-3% of the traffic load.

Peak Holiday Traffic		
Traffic Type	7 Day Average	Proportion %
Yorke Highway		
Light	15923	97.5%
Medium	301	1.8%
Heavy	110	0.7%
Total	16334	
Daily Average total	2722	
Yorke Highway/Minlaton Rd		
Light	5160	96.8%
Medium	112	2.1%
Heavy	59	1.1%
Total	5331	
Daily Average total	889	
St Vincent Highway		
Light	10763	97.8%
Medium	189	1.7%
Heavy	51	0.5%
Total	11003	
Daily Average total	1834	

Table 4: Rex Minerals January 2012 survey results broken down into Light, Medium & Heavy categories

Peak Harvest traffic		
Traffic Type	7 Day Average	Proportion %
Yorke Highway		
Light	10710	89.5%
Medium	406	3.4%
Heavy	849	7.1%
Total	11965	
Daily Average total	1709	
Yorke Highway/Minlaton Rd		
Light	3380	90.7%
Medium	114	3.1%
Heavy	232	6.2%
Total	3726	
Daily Average total	532	
St Vincent Highway		
Light	7330	89.0%
Medium	292	3.5%
Heavy	617	7.5%
Total	8239	
Daily Average total	1177	

Table 5: Rex Minerals December 2011 survey results broken down into Light, Medium & Heavy categories

Electronic Traffic Counts (7 Day average)		
Traffic Type	7 Day Average	Proportion %
Pine Point Road		
Light	167	68.3%
Medium	68	27.7%
Heavy	10	4.1%
Total	244	
Daily Average total	35	
Redding Road		
Light	105	72.5%
Medium	33	23.0%
Heavy	7	4.5%
Total	145	
Daily Average total	21	
Sandy Church Road		
Light	204	75.4%
Medium	44	16.3%
Heavy	22	8.3%
Total	270	
Daily Average total	39	

Table 6: Rex Minerals electronic traffic counts on unsealed secondary roads around the proposed site

Traffic monitoring on the unsealed secondary roads around the site was conducted between May and October 2012 and shows that in addition to traffic numbers being significantly lower than on the major roads, the traffic mix is also markedly different with typically only 70-75% of traffic made up of light vehicles. On Pine Point Rd and Redding Rd the majority of the remainder was made up of medium vehicles (predominantly attributable to the local school bus) with less than 5% or approximately 1 trip per day being heavy vehicles. Sandy Church Rd receives a higher proportion of heavy vehicles (over 8%).

School Bus Routes

In addition to normal through traffic, the school bus that services the Ardrossan area school runs on a route that is likely to be affected by the proposed development. This route can be seen in Figure 9, and travels along the Yorke and St Vincent highways to Pine Point, along Pine Point Rd, Redding Rd, and Sandy Church Rd.



Figure 3: Ardrossan School Bus route

The bus route is likely to be affected from the early stages of the project by the increased heavy vehicle traffic expected along the Yorke Highway, Pine Point Road and Sandy Church Road; and in later stages by trucks transporting waste rock material across Redding Road to the waste rock dump which will be located to the west of Redding Road. Consultation with the DCYP will be required in the preparation of traffic management plans to minimise potential impacts on pick-up and drop-off points along this route, particularly in the later stages of the project.

Anticipated Traffic Increase during Construction

The construction phase of the project is expected to take approximately 2 years, and will require between 500 and 1,000 staff depending on construction stage. It is anticipated that the majority of these staff will be accommodated in temporary accommodation located at the Hillside site and in existing housing within the region, and that a mix of buses and light vehicles will be utilized transport construction workers not staying in the camp facilities to and from their accommodation.

Construction planning was underway at the time of writing and it was not possible to obtain detailed estimates of likely vehicle numbers throughout the construction phase. It is expected however that at peak construction activity there will be a significant increase in light and heavy vehicle traffic in the vicinity of the site. This increased traffic will be managed through the use of busses to transport staff to and from the site, comprehensive traffic management plans to minimise the impact of heavy vehicle traffic on local communities and detailed construction and logistics planning to ensure that local roads are capable of handling any oversized cargo that needs to be transported to site.

Anticipated Traffic Increase during Operation

To minimise the increase in vehicular traffic in the region as a result of the mine development Rex Minerals has assessed a number of process designs, concentrate dispatch methods and locations, and options to transport staff to and from the mine site.

Based on the current 15MT/annum process plant design parameters, approximately 6,150 tonnes of concentrate will be produced each day. Utilizing B-double trucks with a net transport capacity of 44 tonnes this will result in an average of approximately 140 round trips per day from the processing plant to the dispatch point, which is equivalent to a 230% increase in peak harvest period heavy vehicle traffic along the Yorke Highway and a 17-fold increase over peak holiday periods.

The impact of an increase in heavy vehicle traffic of this magnitude upon local amenity, road safety and road surface deterioration is beyond what is considered acceptable, making road transport of the concentrate to Ardrossan, Bowmans, Port Giles or Wallaroo unviable.

As a result, the processing plant has been designed to produce a concentrate slurry that will be pumped via a pipeline to a filtration, storage and ship loading facility to be located at the Ardrossan port thus negating the need for trucking concentrates on public roads.

Heavy vehicles delivering materials and equipment will primarily travel to and from the mine and port sites along the Yorke Highway, entering the mine site from Sandy Church Road. During operations, it is estimated that an average of 10 heavy vehicles per day will access the mine site; that is, a total of approximately 20 vehicle movements to and from the mine site daily. To the port site, it is estimated that an average of three heavy vehicles per day will access the port site; that is, a total of approximately six vehicle movements to and from the port site daily.

The mine and port operations are anticipated to employ an average of approximately 532 people over the operational life of mine. Allowing for limited carpooling and assuming a low number of trips in addition to the work/home commute this translates to approximately an extra 1000 light vehicle trips per day to and from the site. This represents an increase in the level of light vehicle traffic of over 30% above peak holiday numbers on the Yorke Highway, and more than 50% on the other major roads in the vicinity of the site and over under normal conditions. An increase of this magnitude is not considered to be acceptable to the community and as a result, it is anticipated that buses will be used to transport staff to and from mine and port sites to minimise the amount of light vehicle traffic generated by the project. Buses used to transport employees to the site will travel primarily along the Yorke Highway and St Vincent Highway, entering the site at the same location as heavy vehicles. It is expected however, that a small number of workers will travel to and from the port and mine site in light vehicles. Light vehicles, depending on their origin, will likely travel primarily along the Yorke Highway and St Vincent Highway. Table 8 outlines the estimated total vehicle movements expected to and from the port and mine site each day.

Site	Vehicle movements		
	Light vehicles	Buses	Heavy vehicles
Port site	20	4	6
Mine site	160	20	20

Table 7: Estimated additional vehicle movements during the operational phase of the mine

As the Yorke and St Vincent Highways are major linking roads along the peninsula, and are a primary connection between a number of townships and grain storage and export facilities both roads currently support significant volumes of traffic, particularly during harvest and peak tourist times.

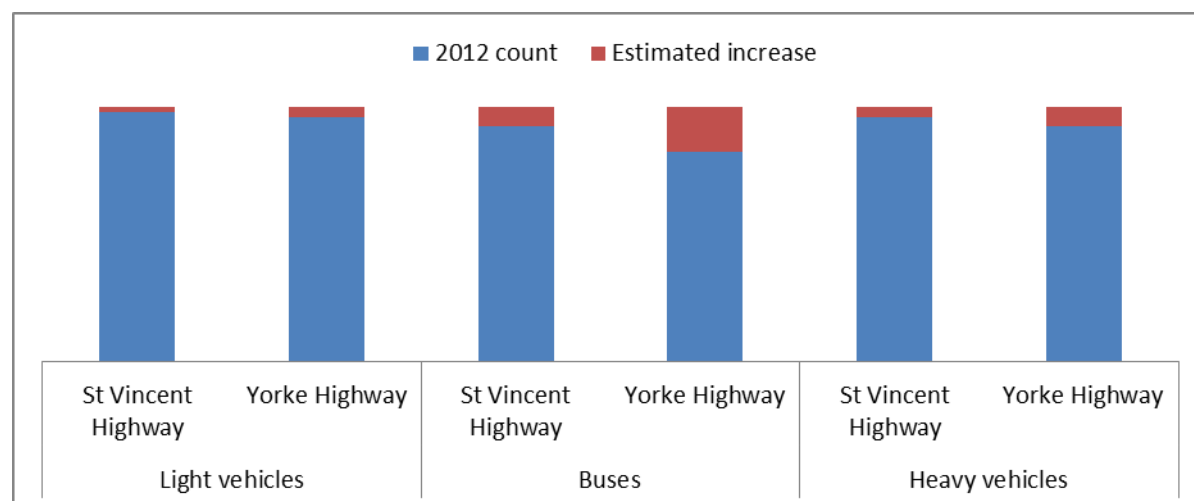


Figure 4: Impact of estimated traffic increases on the Yorke and St Vincent Highways resulting from mining activities

Figure 10 shows the highest (worst case) traffic counts on the St Vincent Highway and Yorke Highway during peak tourism or harvest times. The figure shows that light vehicle increases are estimated at less than 5% on both the St Vincent and Yorke highways; medium vehicle traffic will increase by about 8% and 21% on the St Vincent and Yorke highways respectively; and that heavy vehicle traffic will increase by about 4% and 11% respectively.

These indicative estimated project increases in traffic on the St Vincent and Yorke highways show that traffic increases directly associated with the Project are not significant, except for the effect of buses on the Yorke Highway. For the purposes of this exercise, all project buses have been assumed to travel along the Yorke Highway, albeit that some will only travel on the St Vincent Highway before joining the Yorke Highway to access the mine entrance. Despite the low significance of most traffic increases, it is considered likely that there will be localised impacts on residents of the coastal communities of Rogues Point, James Well and Pine Point who use the highways to access their properties, particularly around shift change periods.

Proposed modifications to road network

The size and location of the proposed mine development (Figure 10) will require a number of modifications to roads in the vicinity of the site which can be summarised as:

- Realignment of the coastal section of Yorke/St Vincent Highway to be outside the 400m blast exclusion zone surrounding the pit
- Closure and relocation of the inland section of the Yorke Highway
- Upgrading sections of Sandy Church and Pine Point Roads



Figure 5: Conceptual plant design and location

The Tonkin engineering consultancy group were engaged to prepare options for road modifications to meet the project design requirements, the detail of which can be found in Appendix 3. Following presentation of these options to both the Community Consultative Group and the local Council it was agreed that it would be preferable to re-route the inland section of the Yorke Hwy along an upgraded Pine Point Rd rather than along Sandy Church Rd or further south along Black Bobs Road.



Figure 6: Road works proposed for the Hillside Project

Following on from this decision, a coastal alignment of the Yorke/St Vincent Highway diversion (as shown in Figure 11) was selected as it minimises impact on coastal properties, provides maximum separation from the buffer zone, avoids significant road works required to extend Pine Point Rd and cross a deep gully just north of Pine Point, and provides excellent coastal views which are anticipated to be beneficial for tourism.

The Pine Point Road is currently an unsealed minor road that joins the St Vincent Hwy at a simple T-intersection. Grading of the road to maintain a passable surface throughout its life to date has resulted in the road surface now being below the surrounding landscape. To bring Pine Point Road up to the standard that will be required for it to adequately replace the inland section of the Yorke Highway the section between the St Vincent highway and Yorke Highway will be raised so that it sits 0.3m-0.5m above the surrounding land, the surface will be sealed, and the intersection with the St Vincent Hwy realigned, regraded and upgraded to a Channelised Right Turn (CHR) to meet design criteria for a 110km/h roadway. Safe connection with the Yorke Highway will require construction of a new section of road at the western end of Pine Point Road. To avoid impacts on sensitive vegetation communities and adjacent properties a curvilinear road design has been selected, with sealed apron T-junctions providing connections with Redding Rd.

The re-routing of traffic from the existing inland section of the Yorke Highway along an upgraded Pine Point Road will result in a significant increase of traffic along this section of road which will have an impact on the residents of this section of road. At peak traffic periods (during holidays for light and medium vehicles and harvest for heavy vehicles) light vehicle traffic is expected to increase 30-fold over current levels, medium vehicle traffic 2-fold, heavy traffic 23-fold, with total average traffic flow increasing 25-fold over current levels along Pine Point Road. While this increase in vehicle numbers will be noticed by residents on Pine Point Rd, noise modelling conducted by AECOM into the impact of this increase has shown that it will remain at least 5dB(A) below guideline levels and that noise attenuation will not be required.

The Sandy Church Rd is proposed to serve as the main access road to the mine site and will need to be upgraded to adequately serve this purpose. The current T-junction with the Yorke Highway has sight-line limitations to both the north and south created by localised crests which will need to be re-profiled to increase the sight distance to above the 300m required for a design speed of 110km/h. The intersection will also be upgraded to a Channelised Right Turn (CHR), and the section of the road between the plant entrance and the junction with the Yorke Highway will be sealed to improve its durability under the increased traffic load that will result from mine operations.

Conclusion

Planning by Rex Minerals to minimise the number of light vehicle trips through the use of busses to transport staff to and from the site, and to transport concentrate via a pipeline rather than by road will result in relatively small and manageable increases in traffic in the areas around the proposed operation.

Following ongoing consultation with the local Council and community and agreement with both groups regarding the preferred options for road modifications this report has identified that while there will be some short term, localised disruption caused by road works and the transport of major plant items to the site; no significant, long term negative impacts will occur as a result of the changes as proposed. In some instances, such as the Sandy Church and Pine Point road intersections with the Yorke Hwy, traffic flow and road safety will be improved as a result of the proposed modifications.

Appendix 1

DPTI Annual average daily traffic estimates



Appendix 2

DPTI Commercial vehicle traffic estimates



Appendix 3

Tonkin Preliminary Design Report

Appendix 5.5-A
Visual Amenity Assessment



VISUAL AMENITY ASSESSMENT (VAA)

Rex Minerals Ltd

HILLSIDE PROJECT


Cooe
Care Of Our Environment

Previously trading as Natural Resource Services Pty Ltd

REX MINERALS HILLSIDE PROJECT VISUAL AMENITY ASSESSMENT (VAA), 2013

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DOCUMENT CONTROL

Document code: REXVIS01_20130314_RexVisualAmenityPlan_FinalDraft

Date	Version	Author(s)	Editor(s)	Client Rep.
20 Feb 2013	Draft01	Agnès Cantin Sean Steed	Angela Mayo	Pam McRae-Williams
14 Mar 2013	Final Draft	Agnès Cantin	Sean Steed	Pam McRae-Williams
12 Apr 2013	Final	Pam McRae-Williams	Sean Steed	Pam McRae-Williams; John Burgess

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1. Introduction

Rex Minerals (SA) Pty Ltd (Rex), an Australian minerals exploration and development company, made a significant copper discovery in 2008 at its Hillside Copper Project (Hillside Project) which the company is proposing to develop. The Hillside Project is located on the mid-eastern coast of the Yorke Peninsula, which is to the west of Adelaide and skirted by the Spencer and St Vincent Gulf (**Figure 1**). Rex is proposing to mine copper-gold & iron ore deposits on the Hillside Project site, approximately 3 km north of Pine Point and approximately 10 km south of the Port of Ardrossan. Ore processing will occur on the Hillside Project site to produce a copper/gold and magnetite concentrates. The concentrate will be transported via an underground pipeline system to an existing loading facility at the Port of Ardrossan and shipped in bulk form to domestic and offshore smelters.

Context

COOE Pty Ltd (COOE) has been working closely with Rex to assist with the environmental approvals for the proposed Hillside Project. Rex has commissioned COOE to prepare a Visual Amenity Assessment (VAA) supported by a 3D visualisation for the Hillside Project for the Mining Lease Proposal document. The 3D animation will provide stakeholders a better understanding of what the mine would look like in real life from various vantage points around the proposed Hillside Project.

Objectives

The objective of the VAA is to model the visual effects of the mining and progressive rehabilitation operations which will occur during mining operations and five years post mining. The VAA will illustrate the visual amenity impact from the Hillside Project specifically in relation to landform change so that it can be adequately assessed throughout the life of mine. This output of the VAA will be used by Rex as a consultation tool for the stakeholders to gain a realistic perspective of what the site will look like from a series of vantage points.

The VAA addresses techniques to minimise the impact of landforms constructed as a result of mining operations to the surrounding areas. This report:

- Examines the existing landscape character through a photographic survey of selected key sites around the proposed Hillside Project site.
- Provides a detailed Viewshed and line-of-sight analysis of the area.
- Models existing features and the Hillside Project in five year stages and a rehabilitated final form.
- Identifies techniques to address the visual impact of mining operations.
- Outlines rehabilitation measures for the landforms around the Hillside Project site.

2. Site Selection

Sites were selected by Rex and COOE based on a Viewshed analysis and in consultation with the Community Consultative Group (CCG). The selected sites were confirmed with a site inspection on the 5th of September 2012. The GPS reference point was taken to assist in future locating and comparison (Table 1). A photographic survey of each site was undertaken to determine the landscape character of the area and the visual impact of mining operations on the adjacent landscape. The selected sites considered the location of the surrounding residential receptors, visible locations along main transport routes for the general public and potential viewpoints for the wider community. The resulting locations

selected are along major, secondary and minor roads within the area surrounding the proposed mining lease area.

Details of each site's selection are outlined in the following sections.

Table 1 Visual amenity site locations

(Datum: GDA94; UTM Zone 53k)

Site No	Reference name	Latitude	Longitude
1	Black Point	34.6132	137.8963
2	Pine Point Rd (removed, see below)	-	-
3	Sandy Church Rd	34.4869	137.8882
4	Yorke Hwy	34.5128	137.8090
5	Corner (Yorke Hwy – Sandy Church Rd)	34.5578	137.8559
6	Pine Point	34.5695	137.8806
7	Yorke Hwy (south of the Hillside project site)	34.5599	137.8368

Site 2 on Pine Point Rd adjacent the SA Water tank was initially included in the selection process and viewshed analysis as it is representational of the outlook close to residential dwellings. Under the proposed road diversion it will also be vantage point for traffic headed inland along the proposed rerouting of the Yorke Hwy in the direction of Minlaton. Permission was sought and obtained from the closest resident to this site, however during the field work the landowner was unwilling for the photos to be taken across his property. To compensate sites 6 & 7 were added, the southern side of the Hillside Project (looking north) can be clearly observed from sites 1, 6 and 7.

3. Visualisation Methodology

Each image was constructed with a 170° field of view, to simulate the field-of-view of the human eye. Photographs were taken from the surrounding area at fixed angular intervals using a mechatronic photography head, before being compiled, lens-corrected and stitched together to create the final image. This methodology is considerably more robust than taking an individual photograph as it simulates the full field-of-view, rather than a limited range.

3.1 Limitations

Care should be taken when viewing the full field-of-view images in a flattened form, as it can be viewed out of context. Viewpoint 4, for example, is taken alongside a straight road; however the flattened image shows a bending of the road off into the distance. If the image is viewed in its optimal state, it would be printed out and wrapped around in a circular fashion (so that the image covers a 170° arc. The viewer will then stand at the centre of the circular arc and look at the dead centre of the image.

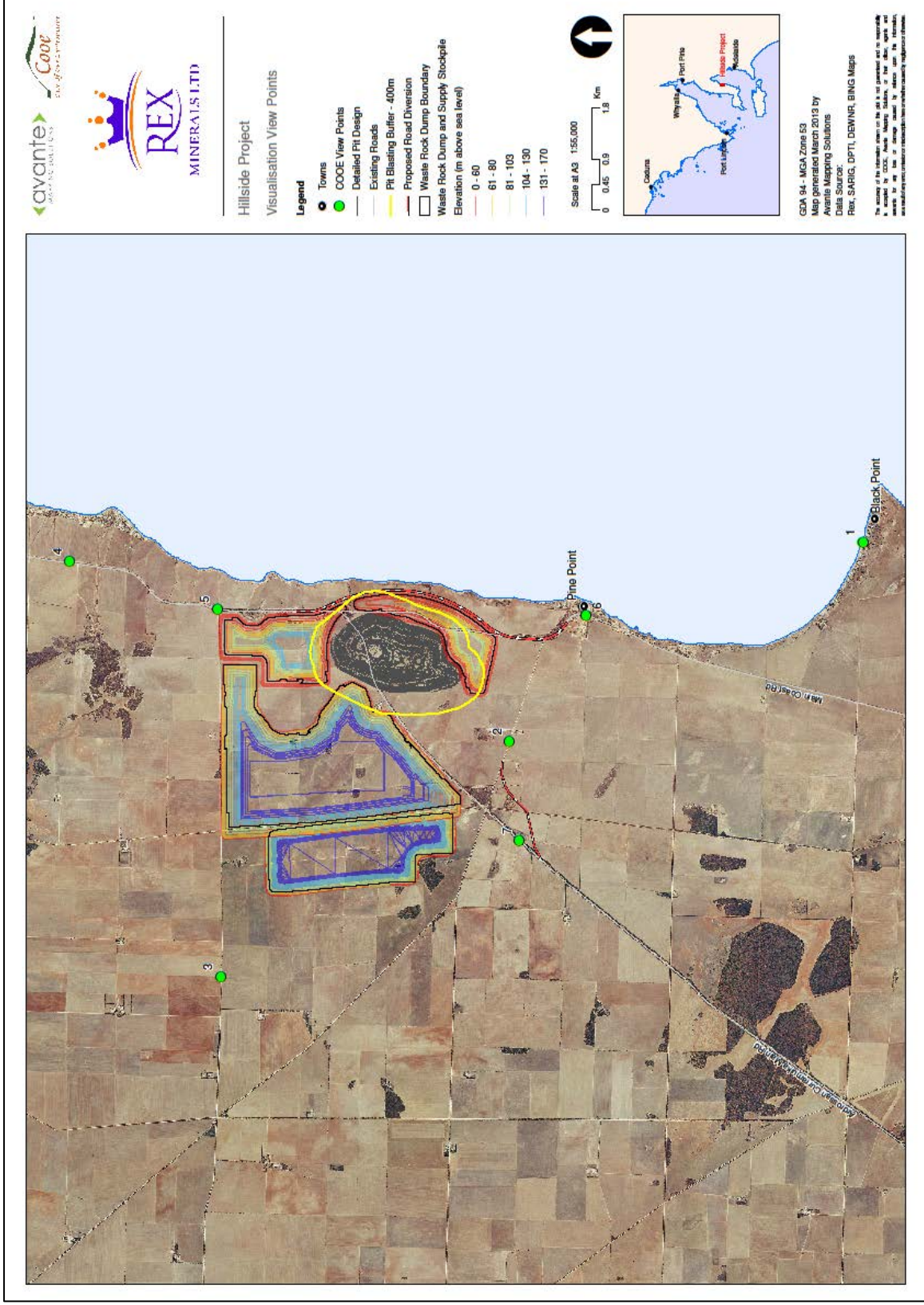


Figure 1 Viewpoint locations

4. Landscape Character and Viewshed analysis

The visual environment of the Hillside Project site is characterised by undulating topography with small ridges and shallow drainage lines running from north-west to the sea in the south-east. The surrounding area is predominantly agricultural cropping and livestock farming land, flanked by coastal landscapes to the east and mild-undulating hills to the west. Broad-scale clearance has removed a large proportion of native vegetation within the region. Isolated areas of remnant vegetation are predominantly surrounded by agricultural land (NYNRM Board 2009).

Using customised GIS tools available through ESRI's ArcGIS, a Viewshed analysis was prepared of the area for Rex's proposed Hillside Project. Using elevation contour data a Digital Elevation Model (DEM) of the study area was developed.

The DEM analysed in relation to the heights of the proposed mine site waste rock dumps (WRD) and topsoil and ore stockpiles across 5, 10 and 15- year periods and the final rehabilitated landform. The GIS models compared the heights of constructed landform to the original and assigned values according to the visual impact (i.e. assign a score on how visible an area compared to the surrounding area).

The analysis was performed in two steps:

- Index the Viewshed for each stage of the mine site development, describing the degree of visibility from the surrounding areas to establish the most appropriate viewpoints.
- A Binary (or Absolute) Viewshed for each stage of the mine life was developed to illustrate the change in landform at each of the sensitive viewpoints. The study included a Line of Site (LOS) analysis to clearly describe the view from each of the viewpoint selected.

Figure 2 identifies the location of each Waste Rock Dump (WRD) and their highest elevations on the proposed mining lease. Results of the viewshed analysis identifies that the top of western WRD will be the highest landform created (Figure 3), yet its visibility will be low to medium on the sides facing out of the mining lease (Figure 4). The north and south WRD will have a lower elevation in comparison to the western WRDs. The visibility of the eastern side of the north WRD will be high but as discussed further Rex will implement measures to minimise the visual amenity of the WRDs along the Yorke Highway. As would be expected the sides of all of the WRDs will be visible from at least one view point (Figure 5). Table 2 provides an indication of the height of the WRD above the existing land surface and is used as a more meaningful description of visual height changes.

Table 2 Visual amenity site locations

WRD	Final RL	Height above existing land surface (m)
Western	170	89-112
North eastern	90	20-45
South eastern	100	50-83
Far western	160	70-97

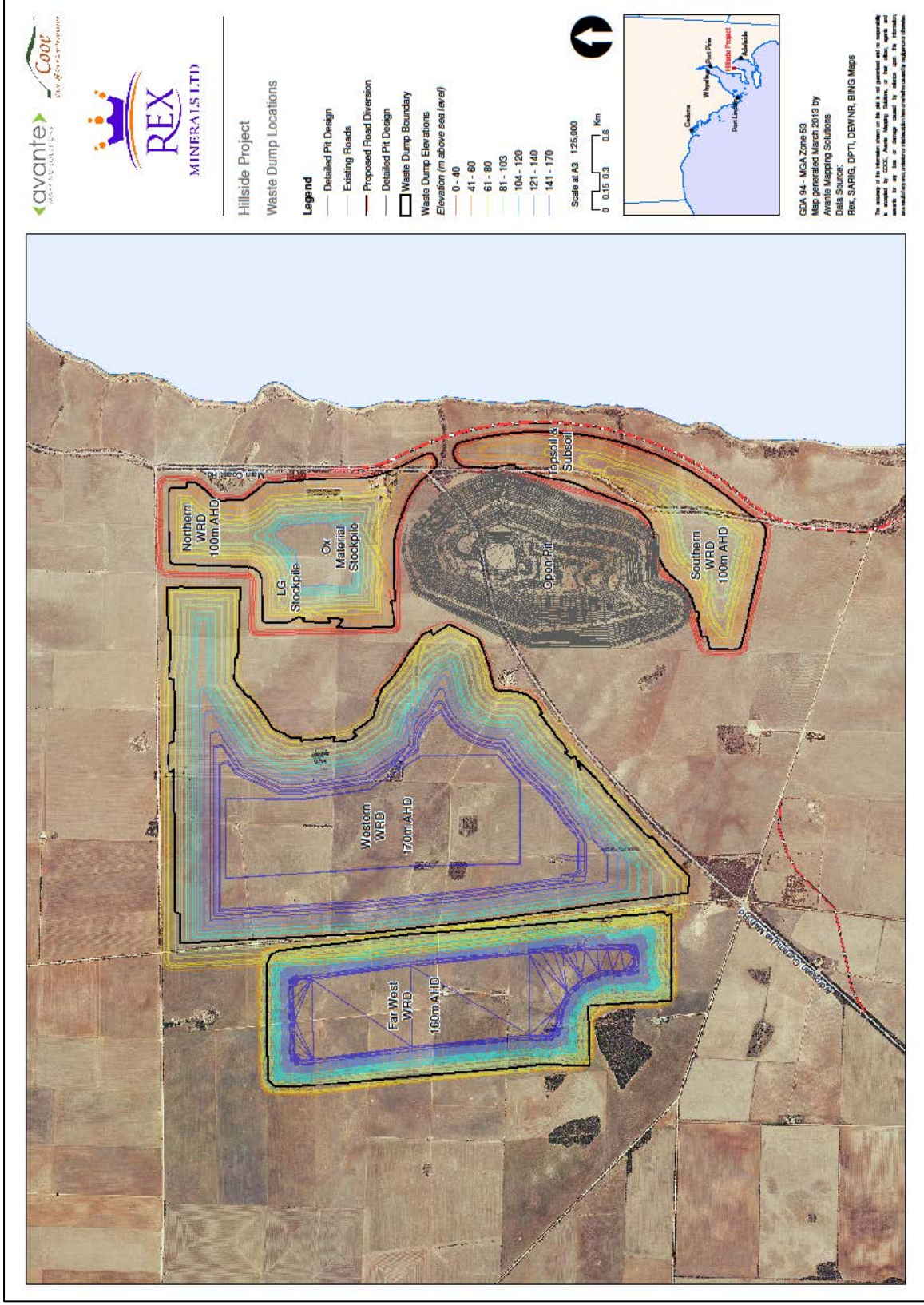


Figure 2 Waste rock dump locations

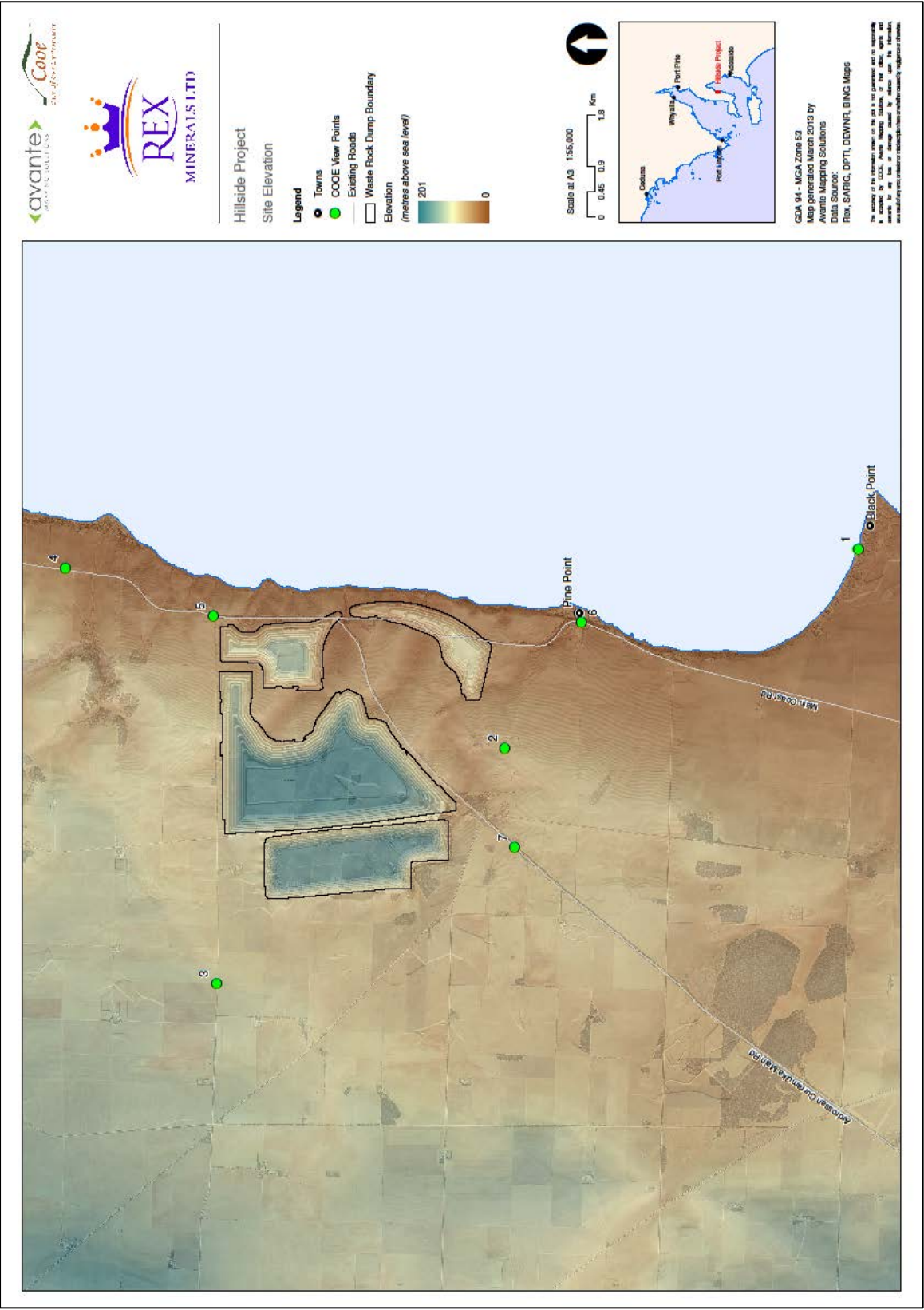


Figure 3 Viewshed analysis, Elevation

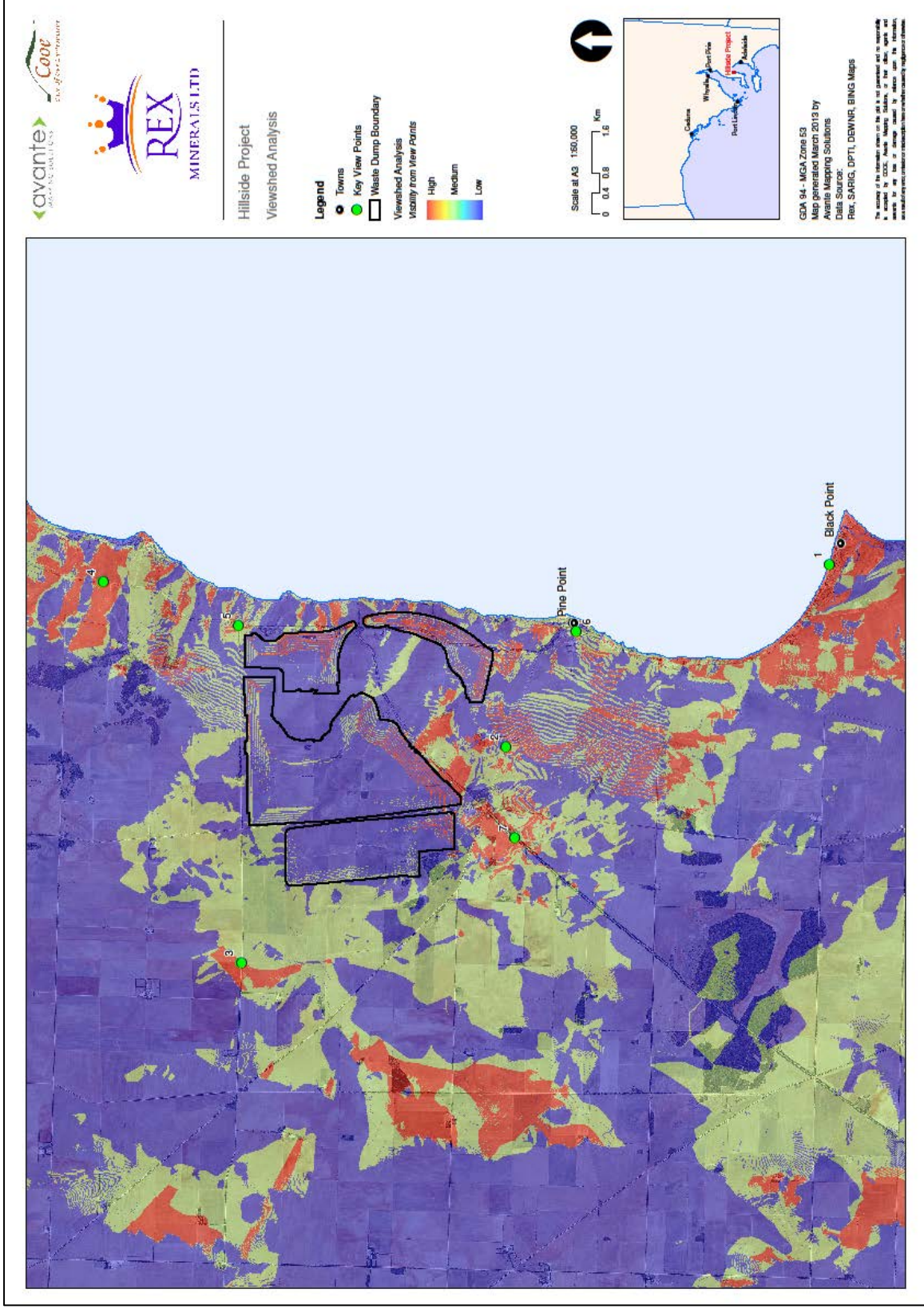


Figure 4 Viewshed analysis, Visibility index

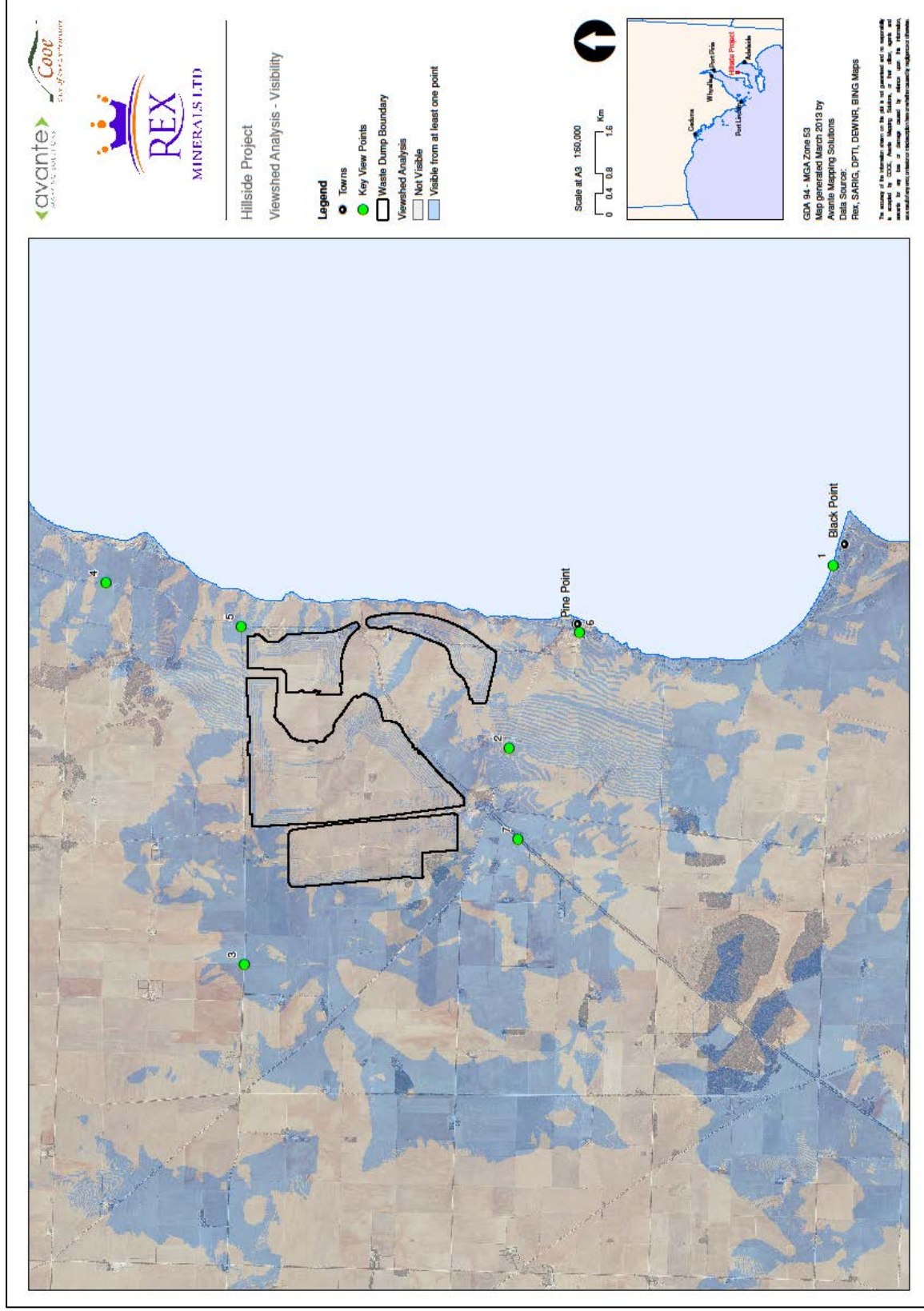


Figure 5 Viewshed analysis, Visibility

5. Visual Amenity Impact Assessment

The visual impact of the Hillside mine is dependent on the particular location, extent of visibility, degree of obstruction of existing features and views and the line of site of a particular feature. Visibility is influenced by the undulating topography and the existing vegetation cover.

The mining methods will involve both open-cut and underground operations. The main visible features resulting from these operations will be the WRDs. Mining infrastructure (processing facility) will be located within the WRDs and have limited visibility from surrounding roads. The following factors will affect the extent to which elements of the mine operations impact visually on the landscape:

- Location and elevation of surrounding residential dwellings;
- Location and elevation of major and minor roads;
- Landform and proportion;
- Colour within the landscape;
- Vegetation type and density; and
- Mine Infrastructure.

1. Location and elevation of surrounding residential dwellings

Dwellings directly surrounding the proposed Mining Lease comprise primarily of farm houses and their associated infrastructure. Several small townships, located along the coastline, are located within 3 to 8 km of the mining lease. These include James Well, Rogues Point and Pine Point. The region that extends from Pine Point and south to Sheaoak Flat shares 194 residents (ABS 2011). James Well and Rogues Point share 63 permanent residents (ABS 2011). Holiday homes make up the majority of the residential dwellings many of which are occupied intermittently, particularly on weekends during holiday periods.

There are numerous residential dwellings within a 2 km radius of the proposed mining project. Several of these dwellings are unoccupied or intermittently occupied. For the purpose of this visual amenity assessment it is estimated that 10 residences have views (most at a distance of approximately 2 km) across the proposed Hillside Project site based on the visibility analysis (Figure 5) and 4 occupied dwellings within 1km of the project. This excludes residences at Black Point and Rogues Point/James Well settlements, as they are more than 2 km from the site and excludes those residences at Pine Point that are behind the coastal cliffs or face east.

2. Location and elevation of major and minor roads

The proposed Hillside Project is bordered by major and minor roads. Major roads are located to the east and south of the mining lease with the Yorke Highway and St Vincent Highway, respectively. Rex is proposing to realign a part of the Yorke Highway. The new road alignment shown in **Figure 1** will be located below the line of site of the WRDs along the eastern edge of the proposed mining lease.

Minor roads include Sandy Church Road to the north and Redding Road to the west of the lease. There are no requirements to alter the alignment of these roads for mining operations. From these minor roads the visual impact will be increased due to the level

elevation with the mining lease. The height and size of the western and far western WRDs from these locations will appear greater.

3. Landform and proportion

Topography within the project area varies subtly, with a flat to gently undulating landscape. From a distance, the WRDs will appear to form a part of the broader landscape. Closer viewpoints on the western sides of the lease will reveal a greater visual impact (refer Site 3) including the western and far western WRDs which will not be consistent with the existing landscape. Community views favour the WRD to be higher to reduce the area of agricultural land they impact. This has resulted in the WRD being higher than other nearby landforms.

At mine closure the four WRDs will rise between approximately 20 and 112 m above the natural topography forming hill landforms. The north eastern WRD will merge with the south eastern WRD around the three quarters of the pit. The western WRD will be separated by the access road from the north eastern WRD. The far western WRD will be a separate structure separated from the western end of the western WRD by a public road (Figure 2). The western WRD contains the integrated Tailings Dam Facility (TSF).

4. Colour within the landscape

The natural colours within the landscape have a significant impact on visibility. The area is and mostly surrounded by annual agricultural crops which vary from green during the growing season to brown during summer and autumn. The visual impact of the Hillside Project will vary depending on the existing vegetation surrounding the disturbed areas within the mine site and the colour of the waste rock and topsoil in the mounded material. The projected colour of the WRDs is grey/brown and will gradually be covered with agricultural grasses or vegetation.

The use of a dust control agent is being considered by Rex to use on the WRDs may assist in reducing glare and blend the mounds into the surroundings. It is also anticipated that annual grass cover could be used to reduce dust and result in a more agreeable visual landscape.

5. Vegetation type and density

The presence or absence of tree cover influences the character and perceived visual quality of the landscape. The vegetation surrounding the Hillside Project site is sparse and mostly located along road verges or small areas or remnant vegetation within some areas. Road side and buffer zone plantings of native vegetation and grasses will assist in ameliorating or screening views of the project site. The greatest visual impact will be along the minor roads where road side vegetation is minimal especially along Sandy Church Road and Redding Road as well as the rerouted Yorke Highway along Pine Point Road. With some road side clearing potentially required for the relocation of the Yorke Highway along eastern side of the proposed mining lease, during construction and early mine development visibility will be increased for a period whilst vegetation is re-established. However the existing topography will reduce the visual impact of from those sections of the road that are relocated closer to the coast.

6. Built infrastructure

Built structures currently surrounding the proposed mining lease are limited, comprising townships and farms. A number of sheds and mine plant structures will be established

during the construction phase. The nature of the impact will largely be determined by the size of the infrastructure and type of surrounding landscape. The design of the Hillside Project will screen the visual impact of the process area as it will be obscured by the north eastern WRD on the eastern side and the western WRD blocking the northern, southern and western aspects. Other mine infrastructure will be positioned and be screened by natural topography and vegetation.

Assessment Summary:

The following aspects will be visually dominant due to their proximity from viewpoints along primary roads and as well as their relative size to the surrounding topography:

- The north and west aspects of the western WRD
- The east aspects of the northern WRD on the eastern side of the proposed mining lease.

Rex acknowledges that the proposed mine will introduce a significant visible change in the landscape over the life of the Hillside Project and at various locations will permanently change the landform. Ongoing rehabilitation and appropriate management plans will be introduced to mitigate where practical the visual impact of these landscape changes.

6. Visual Amenity Control Measures

Rex will implement a number of visual amenity and landscape control initiatives around the operation to mitigate potential impacts on the surrounding area. The purpose of the control measures is to ensure the effective implementation of visual amenity and landscaping programs.

The following plan for each factor outlines the appropriate actions that can be implemented to lessen the visual impact of mining operations.

1. Location and elevation of surrounding residential dwellings

There are at the time of writing four occupied residential dwellings within 1 km from the proposed mining operations and two dwellings where occupants are relocating. Rex proposes the use of ongoing rehabilitation including planting vegetation screens to minimise the visual amenity to surrounding dwellings. The locations of the WRDs have been designed such that they will screen activities on-site.

There are a number of other dwellings at a minimum 2 km away from the proposed Hillside Project area.

2. Location and elevation of major and minor roads

The engineering of the Yorke highway re-alignment has taken into account the visual impact of the proposed mine to passing traffic. The new sections of the highway will be constructed below the line of sight of the mine. Establishment of vegetation corridor on the western side of the highway will further reducing views to the project site. Ocean views from the Yorke Highway will be enhanced in the design of the re-alignment.

Views to the mine operations from the southern side will be minimised through the establishment of vegetation along road reserves where adequate space exists.

3. Landform

The desired outcome at relinquishment is to hand over a physically stable landform with native vegetation trending towards self-sustainability and rehabilitated pastures /cropping land.

The location and form of the WRDs have been design to reduce, as much as possible, the visual impact to surrounding areas. At mine closure the four WRDs will rise 20 and 112 m above the natural topography forming tiered hill landforms. The TSF is encapsulated within an integrated waste facility located within the western WRD. The north eastern WRD will merge with the south eastern WRD around the three quarters of the pit void. The western WRD will be separated by the access road from the north eastern WRD. The far western WRD will be a separate structure and separated from the western WRD by a public road. The WRDs will be sculptured in such a way so as to soften the visual impact.

Reduced visual impact of WRD's can be achieved by progressive rehabilitation and planting of grasses including annual crops and native vegetation that will blend in with the surrounding largely agricultural landscape. The WRDs will be rehabilitated progressively; the south-eastern and north-eastern waste rock dumps will reach their maximum height in years 3 to 5 and will be rehabilitated at year 5. The lower 10° slope is suitable for grasses and reestablishment of a cropped landscape. These slopes grade to 15° with the upper section reaching a 20° slope. These upper slopes would be suitable for re-establishment of native vegetation and reflect similar landscapes elsewhere on the Yorke Peninsula. The open pit void will have very limited visibility to the public from the southern eastern aspect and limited visible from specific vantage points within the proposed ML boundary.

4. Colour within the landscape

The colours of the region are dominated by agriculture crops which are lush green during the growing season and light yellow /brown once grasses dry of and are harvested. The rock material in the WRD will be brown/grey.

Revegetation including the broadcasting of annual grasses on the faces of the WRD's as soon as practicable will reduce the visual impacts of these landforms with the resultant colour more reflective of the surrounding landscape.

5. Vegetation

Ongoing progressive rehabilitation of the disturbed land within the Hillside Project will assist in reducing the impact on visual amenity of the proposed mine. Rehabilitation will comprise agricultural pursuits and planting of native vegetation, both of which require different rehabilitation techniques. At relinquishment, the landforms can be vegetated by a mix of native vegetation and agricultural crops and pasture dependent on the resultant slope and land form and final land use objectives and community expectations.

There are many techniques that can be implemented to reduce the impact on visual amenity which can be used to increase vegetation within and around the mine area and to screen mine infrastructure. Some of these techniques have multiple roles such as dust suppression and increase habitat creation, weed control and improved productivity.

Direct seeding & tube stock revegetation

Depending on the location both direct seeding and tube stock planting around the mine lease progressively to create screens and stabilise areas disturbed during construction and following the finalisation of landforms. Direct seeding can be used in areas where revegetation areas are larger and accessible. The use of native species endemic to the area will be maximised and will be integrated into vegetation management plans. Advice on species selection from relevant experts will ensure positive biodiversity and habitat outcomes.

Feature Planting

At specific locations around the mine site, feature planting will be required for natural screening and to encourage biodiversity within the mine site.

Species selection will reflect those native species that achieve the best screening effect for screening specific infrastructure or viewpoints where vegetated earthen bunds or large plantings are impractical. Species will be selected for growth rate, density and robustness. In areas requiring a more immediate visual effect, advanced vegetation will be used.

Roadside planting will also screen views of mining operations and provide wildlife corridors. Any works to be undertaken within public areas will be developed in consultation with the District Council of Yorke Peninsula and the Department of Planning, Transport and Infrastructure (DPTI).

Use of agricultural crops provides a quick and effective vegetation that is fast growing and can be used to readily assimilate areas on suitable slopes (lower slopes of the WRD) and land surfaces (areas disturbed during construction) with the surrounding landscapes.

Topsoil stockpiles will be used for revegetation. Short term stockpiles (stored for 3-5 years) will be stabilised grasses. Longer term stockpiles will be stabilised with both grasses and shrubs to blend in with the surrounding landscape.

Surface Spray (hydro mulching)

Hydro mulching can be used to assist in dust suppression and in establishing vegetation cover. Seed impregnated mulch can be sprayed on slopes if required. The benefits of using a surface spray include: suppression of windblown dust, reduced soil erosion, containing stockpiles, and accelerated germination/re-vegetation.

Maintenance Program

Visual amenity controls are required to be monitored and maintained to ensure effectiveness in reducing visual amenity impacts. Re-vegetation areas including annual plantings, tube and direct seeded native vegetation, and trees screens will be maintained through regular inspections and re-plantings as part of a vegetation management plan.

6. Built infrastructure

Any office or accommodation infrastructure required in the vicinity of the Hillside Project site will be designed to meet planning requirements. Prominent built structures will be screened with earthen bunds, fencing and with advanced trees where possible. Structures and buildings will use non-reflective, natural coloured materials to reduce their visual impact. Structures will also be screened from public roads by the WRDs. The process plant and

infrastructure will be located between the western and northern eastern WRDs and as such will be obstructed from view.

New power lines required for the project should be located so as not to obscure ocean views from coastal roads where possible.

The proposed mine operations will also include built infrastructure within the precinct of the existing Port of Ardrossan and the upgrade and use of the existing ship loading facilities. This area is currently zoned industrial and already impacts on the visual amenity of the area. Building will comply with council visual amenity building requirements. A pipeline running from the mine to the port facilities will be underground and will not impact on coastal views from the Yorke Highway.

7. Visual Outcomes

The following section outlines the progressive visual outcomes at the seven viewpoints surrounding the mine operations. At each site an impression of the visual outcome is presented prior to mining (existing view) and after 5, 10 and 15 years of mining operations. Each period illustrated show the changes from the previous stage. An impression is also provided for the final rehabilitated form which would be achieved post mine life. For each period during mining operations two photographs are provided. The first displays the progression under normal conditions and the second highlights any change in the landscape in pink to clearly demonstrate landform changes over time.

All photographs were taken on 5th December 2012. Weather conditions at the time were slightly overcast with light southerly winds.

Black Point (Site 1)

Black Point was selected as it will have direct line of sight view of the Hillside site. The site is located around 5 kilometres south from the proposed mine, near the beach. The selected view-point is on the corner of narrow public track by the sign "91", the view is back across bay directly looking over Pine Point to the Hillside Project area.

Existing View

The existing view shows the natural undulations of the region. Ocean weather conditions at the time included calm sea conditions with a low tide of 0.40 m.

After 5 years

After 5 years the south eastern WRD mound (raised elevation 50-83 m) will be visible in the distance (approximately 8 km). This WRD will be stabilised with native vegetation and grasses/crop on lower slopes by the end of this period and blend to the natural contours of the landscape.

After 10 years

At 10 years the western WRD mound becomes more visible in the distance increasing in height and extent. These changes will be visible from Black Point, but overlap with the surrounding landscape reduces the impact on visual amenity for this viewpoint.

After 15 years

After 15 years there will be further increases in the western WRD's height and far the western WRD becomes visible. Established revegetating of the face of the southern WRD and progressive sculpturing and revegetation of the western WRD, mostly at the southern end reduce its visual impact from this view point.

Rehabilitated landform

The rehabilitated landscape shows that the WRDs will be largely integrated with the undulating surrounding landscape from this viewpoint. As the vegetation in front of the WRD is minimal in comparison to other sections of the coastline, the increased vegetation will be noticeable.

Sandy Church Road (Site 3)

The Sandy Church Road site was selected as it has an elevated viewpoint that will expose a wide view of the Hillside site from the west. Sandy Church Road is used by local residents on the Yorke Peninsula. The Site 3 location is just over the crest of the hill approximately 1.5 km west of Hillside Project near a large water tank.

Existing view

The existing view shows that the landscape is relatively flat and the visual amenity is dominated by agricultural crops and associated infrastructure.

After 5 years

After five years of operation the western WRD will be partially constructed and visible and results in a noticeable change in the landscape. The toe of the WRD will consist of stabilised topsoil stockpiles and be planted with vegetation. Progressive rehabilitation of the lower slopes on the northern face will be underway softening this view.

After 10 years

After 10 years the western WRDs will have increased in height to near its maximum of 89m above the natural surface of the land on the western face. The southern face maximum elevation is 112m but will not be visible from this view point. Progressive rehabilitation of the slopes on the northern face and western face will be underway softening this view. The southern section of the far western WRD will become visible from this viewpoint.

After 15 years

At 15 years the western WRDs will have increased slightly in height and vegetation will be established on lower slopes and much of the upper slopes. The most notable landscape change is the far western WRD which now extends its full design length and is between 70-97 m in height above the natural land surface forming a mesa shaped landform. While the western WRD is still visible for the most part the far western WRD now obscures most of the western WRD. Revegetation of the toe of the slopes and faces will be well advanced with native and agricultural species and upper slopes will be progressively revegetated.

Rehabilitated landform

The rehabilitated western and far western WRD's show that the upper section of the new landform will be revegetated with native vegetation and the lower sections vegetated with grasses/crop species. The new landforms will be noticeable from this viewpoint but with the ongoing rehabilitation the WRDs will begin to blend into the surrounding landscape and resemble similar landforms on the Yorke Peninsula.

Yorke Highway (Site 4)

Site 4 is located on the Yorke Highway near the James Well turnoff on top of the crest looking south/south-west to the Hillside Project. This site will be one of the first viewpoints of the Hillside Project for motorists heading south.

Existing view

The existing view depicts the undulating landscape of the region and the sparse vegetation cover. In the far distance low rising hills with native vegetation on the top can be seen.

After 5 years

Within the first 5 years of mine operations, the north eastern WRD will be established and create a screen to the remainder of the project area. This WRD will be between 20 to 45 m above the existing land surface. A change in the landscape will be noticeable. The toe of the WRD will consist of stabilised topsoil stockpiles and screen trees. The sides of the WRD will already be revegetated with a range of native species. From this view point the vegetated WRD blends with the surrounded vegetated hill visible to the north west.

After 10 years

After 10 years there will be slight increase in the height of the WRD at its eastern end. The length of the WRD mound will increase towards the east as the northern face of western WRD increases in height. Vegetation on the north eastern WRD is now clearly visible softening the visual impact.

After 15 years

Over the 15 year period of mining operations slight changes to this viewpoint will be observed mainly in the height of the structures to the west. The modelling shows that the addition of the WRDs will not notably detract from the existing landscape. The colour of the WRDs will blend into the surrounding landscape and similar landscape feature in the area.

Rehabilitated landform

The rehabilitated impression clearly shows that there will be an increase in the vegetation. The WRD's will be revegetated with agricultural crops and native species. The re-vegetation will blend with the current landscape from this viewpoint.

Corner (Yorke Highway – Sandy Church Road) (Site 5)

Site 5 is located on the corner of Yorke Highway and Sandy Church Road (east side of the road) looking south west onto the Hillside Project site. The entrance to process plant will be located approximately 1.5 km along Sandy Church Road. This site will provide a close view of the proposed mine site and an example of how visual screening aids will be utilised to mitigate the close up appearance of the Hillside Project.

Existing view

The existing view shows the vegetation corridors along the Yorke Highway and the limited vegetation along Sandy Church Road. The overall topography from this viewpoint is relatively flat across the top of a slight rise.

After 5 years

The most prominent change at this viewpoint will occur during the initial five years of operations. The changes observed will be similar to that from Site 4. The north eastern WRD mound will be located close to the boundary of the proposed mine site. The northern face of this mound will be approximate 20 to 45 m above the nature land surface and will be largely rehabilitated by year five. Early planting of screening vegetation and vegetated topsoil stockpiles reduce the visual impact from this close proximity view point. The process plant and associated infrastructure will not be visible from the Yorke Highway as they will be located behind the north eastern WRD and the northern face of the western WRD. There will be limited visibility at the entrance to the site along Sandy Church Road.

After 10 and 15 years

During the subsequent periods of operation there will be little change in the extent of the WRD from this viewpoint however the western WRD will increase in height. The planting of screen vegetation softens the impact. The most noticeable change throughout the period will be the increase in native tree and grass screens. Vegetation planted along the boundary further minimises the visual impact from this viewpoint when final mine rehabilitated stages are underway and remaining topsoils stockpiles have been redeployed.

Rehabilitated landform

The rehabilitated impression demonstrates the increase in native vegetation compared to existing views. The vegetation will soften the visual impact of the WRD and will increase the available land returned to native vegetation. The landform changes from this viewpoint are notable and will largely impact passing road users along the Yorke Highway and those local residents using Sandy Church Road. There are no residences that are directly impacted from this view point.

Pine Point (Site 6)

Site 6 is located along the St Vincent Highway as it passes through the northern fringe of the Pine Point township. The photograph was taken from on the gravel parking area near the local attractions sign. The viewpoint looks NW onto the Hillside Project site. This site will provide a view from the Pine Point township and for traffic travelling north along the St Vincent Highway. No houses directly face this direction but rather face toward the ocean view to the east.

Existing view

The overall topography from this viewpoint is slightly undulating. It can be observed how the landscape lowers towards the ocean.

After 5 years

The most prominent change will occur during the initial five years of operations. The southern eastern WRD will be located close to the southern boundary of the proposed mine lease. Within the first five years of the mine operations to this WRD will be completed and rehabilitated. Infill planting along the road corridor will soften this view. This WRD is positioned to screen the project from the Pine Point and other southern viewpoints. The WRD will be vegetated with a range of native and agricultural species. The landform change and increase in native vegetation are the most notable impacts on visual amenity from this viewpoint.

After 10 and 15 years

During the subsequent periods of operation there will be little change in the size of this WRD. The visual change will be associated with growth of revegetated areas. The WRD will minimise views to the site's infrastructure. Native tree screens planted along the boundary to further minimise the visual impact and enhance visual amenity from this viewpoint.

Rehabilitated landform

The rehabilitated impression demonstrates the increase in native vegetation compared to existing views. As the vegetation establishes it will soften the visual impact of the WRD and will integrate it with the surrounding landscape to resemble other vegetated hills on the Peninsula.

Yorke Highway (Site 7)

Site 7 was selected to show the southern aspect of the Hillside Project as an alternative the initially selected site 2. At this point on the Yorke Highway, northbound motorists on the Yorke Highway will have one of the first views of the Hillside Project site.

Existing view

The existing view shows the dense vegetation along the road corridor and the flat landscape of the cropping fields.

After 5 years

No changes will be visible within the first five years of operation as the construction of the WRD's is being screened by existing roadside vegetation

After 10 years

After 10 years the northern section of the western WRD will become visible in the distance but will be largely screened by existing vegetation.

After 15 years

After 15 years there will be an increase in the height of the western WRD and the far western waste rock dump will become visible from this view point. This view is visible from passing traffic through a break in the vegetation. The majority of the WRD will remain screened by the roadside vegetation. Revegetation of the WRD with native and agricultural species will soften the visual impact.

Rehabilitated landform

The rehabilitated impression shows that the WRD will be obvious in comparison to the flat landscape surrounding it. However, the revegetation of the WRD and the glimpse of the landform by passing traffic is unlikely to impact on the overall visual amenity from this viewpoint over time.

8. Conclusion

The VAA illustrates the landscape character of the area and the visual impact of the proposed Rex Mine operations. Each viewpoint was chosen to provide, as much as possible, an overview of how the proposed mine will impact on the surrounding landscape.

The proposed Hillside Project will result in large landscape changes however Rex proposes to manage their operations in such a way as to minimise the negative impact on the visual amenity of the area. Through various management plans Rex will be implementing several control measures to reduce the impact on visual amenity of the proposed mine including increased road-side vegetation, on-going rehabilitation, temporary physical barriers and engineering design. With ongoing rehabilitation of all areas the visual amenity of the landscape changes will be softened and integrate with the surrounding landscape as much as practical to meet with community acceptance.

Photo monitoring for the 7 viewpoints will continue throughout the stages of the project to assess and monitor changes in visual amenity. Ongoing community consultation will ensure community expectations are met and visual amenity changes are acceptable to the wider community.

9. References

Australian Bureau of Statistics (2011). Data & Analysis.

URL: <http://www.abs.gov.au/websitedbs/censushome.nsf/home/data?opendocument#from-banner=LN>. Viewed: 25 January 2013.

Hillside Mine

Pre-construction noise monitoring



Hillside Mine

Pre-construction noise monitoring

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9 November 2012

60279729

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Quality Information

Document Hillside Mine

Ref 60279729

Date 9 November 2012

Prepared by Adam Cook

Reviewed by Simon Moore

Revision History


Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
0	9-Nov-2012	Initial issue	Simon Moore Principal Engineer - Acoustics	

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Glossary

A-Weighting	The “A” weighting scale is designed to adjust the absolute sound pressure levels to correspond to the subjective response of the human ear.
dB(A)	A-Weighted sound pressure level measured in decibels.
L_{Aeq}	Equivalent (energy averaged) noise level measured over a time period. This noise descriptor is commonly used in environmental noise policies and assessments. The time period the measurement is averaged over may be included in the subscript, i.e. $L_{Aeq,10min}$
L_{Amax}	The maximum A-Weighted noise level recorded over a measurement period
L_{Amin}	The minimum A-Weighted noise level recorded over a measurement period
L_{A90}	Noise level exceeded 90% of the measurement period. This descriptor is used to represent the background noise level.
ABL	Assessment Background Level. The 10 th percentile of the L_{A90} noise levels recorded over the measurement period.

1.0 Introduction

This report details the results of pre-construction noise monitoring undertaken by AECOM for the proposed Hillside Mine, located approximately 12 km south of Ardrossan, South Australia. The development also includes a port facility to be located in Ardrossan, adjacent to the existing Arrium port facility.

Noise measurements were undertaken at locations around the proposed mine site, over the period 14-28 August 2012.

The proposed site for the Hillside Mine is shown in Figure 1. Figure 2 shows the approximate location of the proposed port facility.

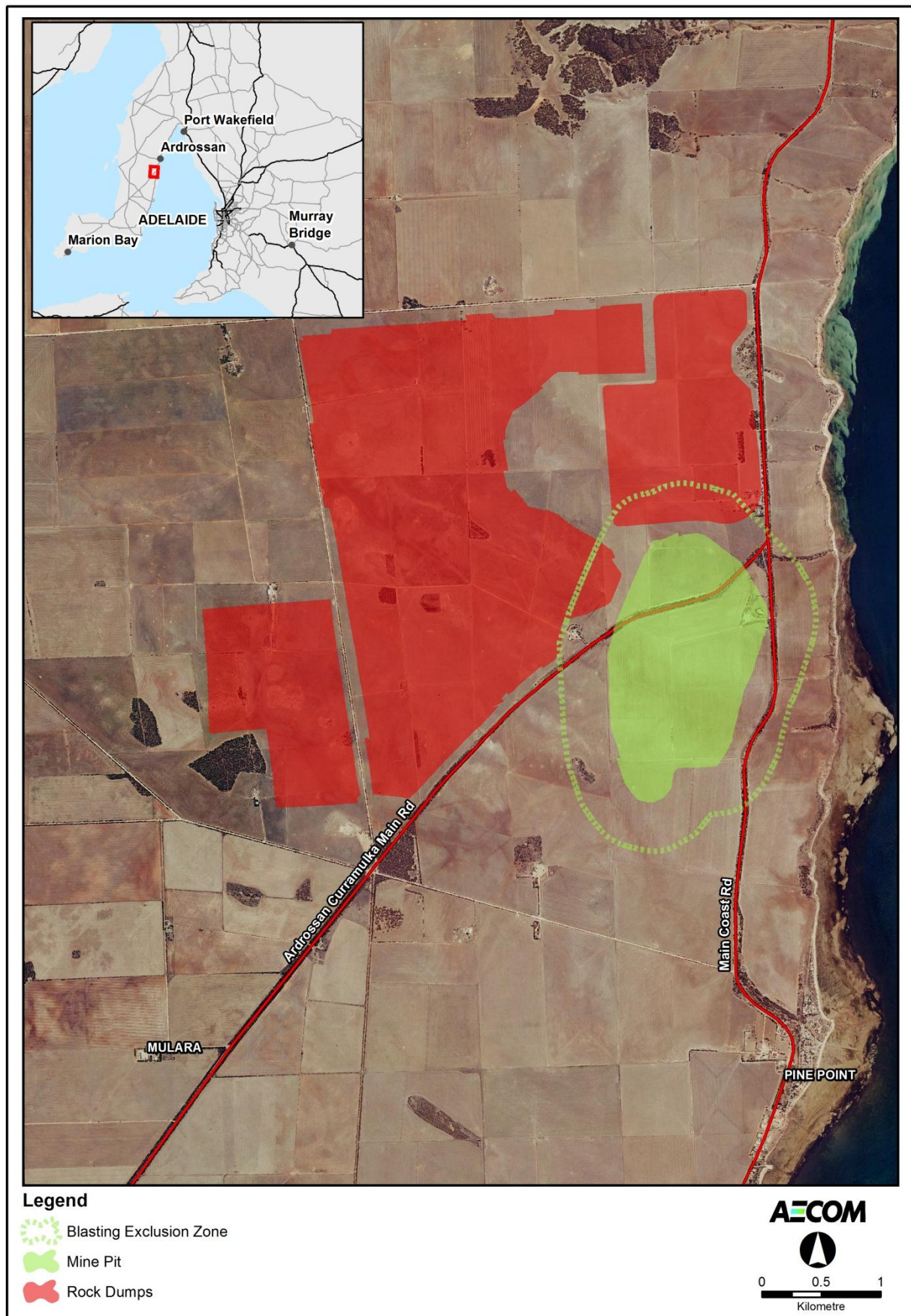


Figure 1 Proposed site for the Hillside Mine development



Figure 2 Approximate location for port facility

2.0 Attended noise monitoring

Attended noise measurements were undertaken at locations in Ardrossan on 14 and 28 August 2012 for the purpose of determining noise levels from operations at the existing Arrium port facility. The attended monitoring locations used on both occasions are shown in Figure 3.



Figure 3 Attended noise monitoring locations

The sound level meter used for attended monitoring was a Brüel and Kjaer 2250, which is a Type 1 instrument suitable for field and laboratory use. Calibration of the meter was field checked before and after the measurements with a Brüel and Kjaer 4231 portable sound level calibrator, and was found not to have drifted. A summary of equipment used is included in Table 1. Copies of NATA calibration certificates for the noise monitoring equipment are included in Appendix B.

Table 1 Field equipment for attended noise monitoring

Make/model	Serial #	Last calibration date	Calibration due date
Brüel and Kjaer 2250	2600405	9 December 2010	9 December 2012
Brüel and Kjaer 4231	2242325	18 May 2012	18 May 2013

Results from attended noise monitoring undertaken on 14 August are provided in Table 2. Weather data from the time of the attended measurements indicated winds were westerly to north-westerly at 2-4 m/s.

Table 2 Attended noise monitoring results from 14 August 2012

Location	Start time	L _{eq}	L _{max}	L ₁₀	L ₉₀	Site observations
1	21:35	38	60	42	26	Noise from truck movements occurring frequently inside Arrium facility. Occasional car passing on Yorke Highway.
2	22:02	48	53	49	44	Constant stonefall noise from inside Arrium facility while ship loading underway.
3	22:26	31	51	33	27	Distant stonefall noise from Arrium facility, wind in trees. Occasional car passing on Fifth Street and Yorke Highway.
4	22:49	27	43	32	20	Mainly noise from wind in trees.
5	23:18	21	31	23	19	Wind noise from nearby bushes and trees.
6	23:33	22	37	24	20	Occasional noise from livestock in paddock nearby. One or two vehicles passing on Yorke Highway.
7	23:47	21	39	22	20	Occasional vehicle passing on Yorke Highway

Results from attended noise monitoring undertaken on 28 August are provided in Table 3. Weather data from the time of the attended measurements indicated winds were westerly at 4-5 m/s.

Table 3 Attended noise monitoring results from 28 August 2012

Location	Start time	L _{eq}	L _{max}	L ₁₀	L ₉₀	Site observations
1	21:42	42	53	44	39	Noise level controlled by a large front end loader on Arrium site. Occasional car passby on Yorke Highway. Some wind noise in nearby trees during lulls in other noise levels.
2	22:08	53	59	56	50	Constant stonefall noise from inside Arrium facility while ship loading underway. Occasional noise from front end loader movements.
3	22:30	37	50	40	33	Distant stonefall noise from Arrium facility up until 22:45. Wind in trees. Occasional car passing on Fifth Street and Yorke Highway.
4	22:54	31	44	33	26	Faint noise from loader in Arrium facility. Dogs barking occasionally nearby.
5	23:15	28	42	31	24	Wind noise from nearby bushes and trees.
6	23:34	36	49	40	27	Noise of wind in trees and long grass. Occasional noise from livestock in paddock nearby.
7	23:47	35	46	38	29	Noise of wind in trees and long grass. Occasional vehicle passing on Yorke Highway

3.0 Unattended noise monitoring

Unattended noise measurements were undertaken at six locations surrounding the proposed mine and port sites over the period 14-28 August 2012. Monitoring locations were selected to be representative of the closest noise-sensitive receivers surrounding the proposed mine and port sites and are shown in Figure 4.

Noise data was logged in 15-minute intervals at all locations. Graphs of the noise data collected at each location over the unattended noise monitoring period are provided in Appendix A. Results have also been tabulated for each location, including:

- maximum measured $L_{Aeq,15min}$, daytime and night time
- minimum measured $L_{Aeq,15min}$, daytime and night time
- median $L_{Aeq,15min}$, daytime and night time
- daytime and night-time ABL
- highest night time L_{Amax}
- $L_{Aeq,15hr}$
- $L_{Aeq,9hr}$

Daytime hours are considered to be 7 am to 10 pm. Night-time hours are from 10pm to 7am, and descriptors are reported for the date the measurement started.

The calibration of the noise logging equipment was field checked before and after deployment with a Brüel and Kjaer 4231 portable sound level calibrator, and was found not to have drifted. Copies of the NATA Calibration certificates for the noise loggers are included in Appendix B.

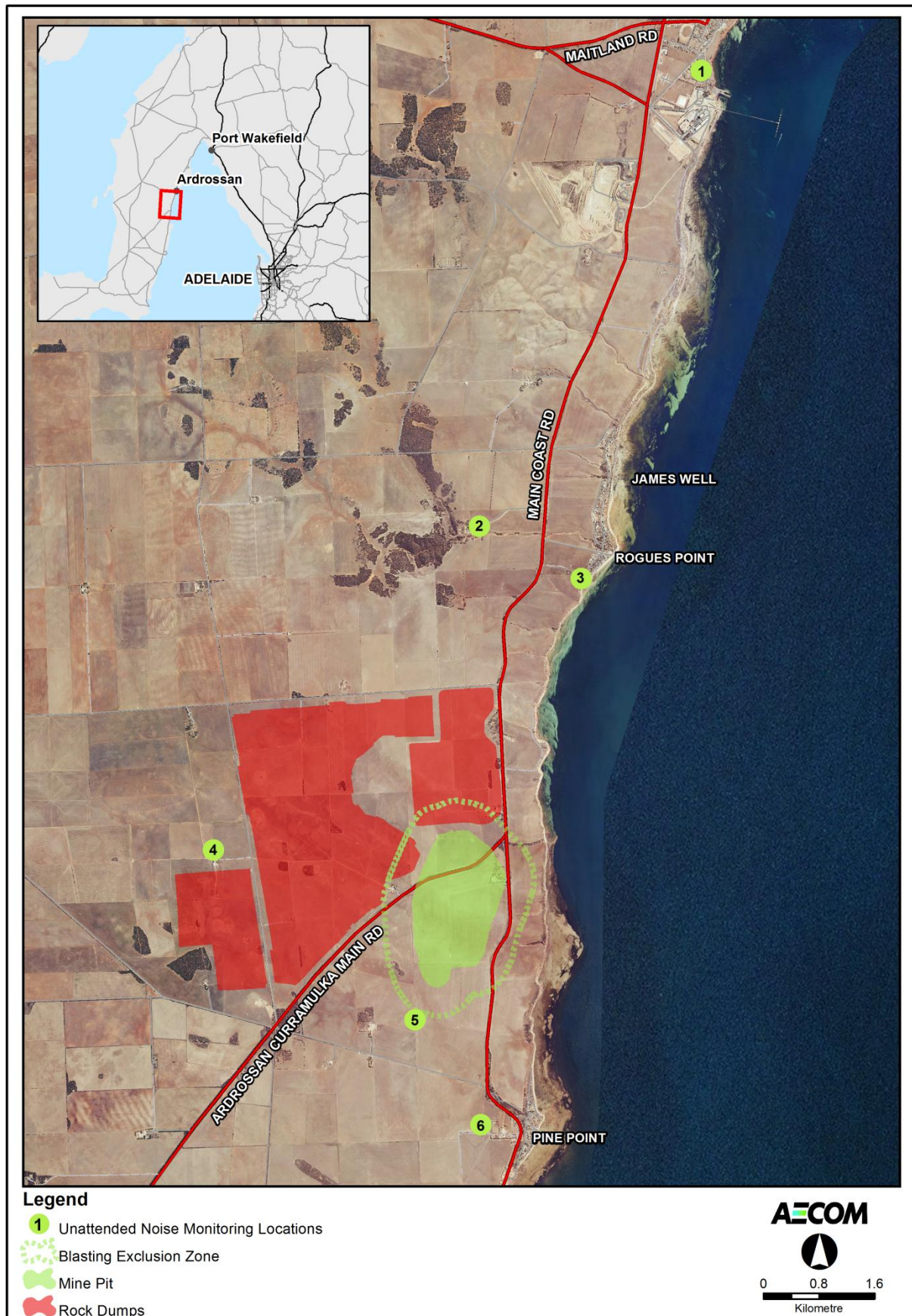


Figure 4 Unattended noise monitoring locations

3.1 Location 1

Location 1 was in the backyard of a residential location on Hogarth Street in Ardrossan, approximately 1.2 km north east of the proposed port facility site and 1 km south of the Ardrossan town centre. Figure 5 shows the location of noise monitoring equipment.



Figure 5 Unattended noise monitoring location 1

Details of the noise logging equipment used at this location are included in Table 4 and Figure 6 shows the equipment setup on site.

Table 4 Equipment installed at unattended noise monitoring location 1

Make/Model	Serial #	Last calibration date	Calibration due date
Svan 957	27539	11 April 2012	11 April 2014

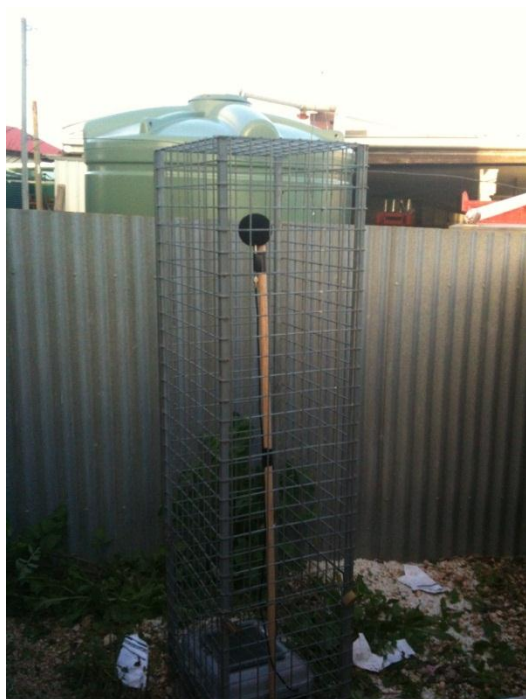


Figure 6 Noise logger installed at Location 1

Sources of noise observed in the area surrounding Location 1 included the Arrium facility to the south, occupants of the surrounding residences, and vehicles on Fifth Street and Yorke Highway. Table 5 and Table 6 provide a summary of the noise levels measured during the logging period.

Table 5 Location 1 noise monitoring results: daytime (7am – 10pm) descriptors

Date	$L_{Aeq,15hr}$	Maximum $L_{Aeq,15min}$	Minimum $L_{Aeq,15min}$	Median $L_{Aeq,15min}$
15/08/2012	47	51	41	46
16/08/2012	56	70	42	49
17/08/2012	51	57	47	51
18/08/2012	48	57	39	47
19/08/2012	53	66	40	47
20/08/2012	49	59	38	47

Table 6 Location 1 noise monitoring results: night time (10pm – 7am) descriptors

Date	$L_{Aeq,9hr}$	Maximum $L_{Aeq,15min}$	Minimum $L_{Aeq,15min}$	Median $L_{Aeq,15min}$	Max Night time L_{Amax}
14/08/2012	42	51	29	35	78
15/08/2012	42	49	25	37	75

Date	L _{Aeq,9hr}	Maximum L _{Aeq,15min}	Minimum L _{Aeq,15min}	Median L _{Aeq,15min}	Max Night time L _{Amax}
16/08/2012	52	61	39	49	78
17/08/2012	41	49	31	34	79
18/08/2012	41	53	26	31	78
19/08/2012	42	51	26	32	77
20/08/2012	42	50	31	39	70

Noise levels after 20 August were not recorded due to an equipment failure. ABL has not been reported as statistical noise data was not recorded at this location.

3.2 Location 2

Location 2 was 40 m south of a house located approximately 8 km southwest of Ardrossan, off the Yorke Highway. The logging location was 2.4 km north of the Hillside Mine site. Figure 7 shows the location of noise monitoring equipment.



Figure 7 Unattended noise monitoring location 2

Details of the noise logging equipment used at Location 2 are included in Table 7 and Figure 8 shows the equipment installed on site.

Table 7 Equipment installed at unattended noise monitoring location 2

Make/Model	Serial #	Last calibration date	Calibration due date
Svan 957	27551	11 April 2012	11 April 2014

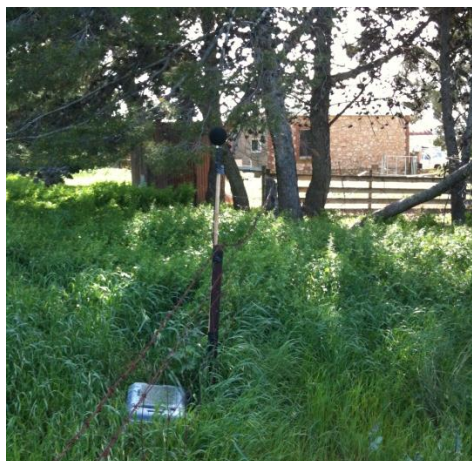


Figure 8 Noise logger installed at Location 2

Sources of noise observed in the area include traffic on Yorke Highway, and also residents and farming equipment near the receiver location. Table 8 and Table 9 provide a summary of the noise levels measured during the logging period.

Table 8 Location 2 noise monitoring results: daytime (7am – 10pm) descriptors

Date	L _{Aeq,15hr}	Maximum L _{Aeq,15min}	Minimum L _{Aeq,15min}	Median L _{Aeq,15min}
15/08/2012	41	53	23	44
16/08/2012	50	65	43	52
17/08/2012	48	59	37	51
18/08/2012	48	51	31	39
19/08/2012	51	52	28	39
20/08/2012	46	58	39	47
21/08/2012	52	56	31	43
22/08/2012	53	55	22	45
23/08/2012	52	65	34	54
24/08/2012	46	55	21	47
25/08/2012	45	51	29	44
26/08/2012	47	51	30	38
27/08/2012	47	51	30	43
28/08/2012	45	58	27	50

Table 9 Location 2 noise monitoring results: night time (10pm – 7am) descriptors

Date	L _{Aeq,9hr}	Maximum L _{Aeq,15min}	Minimum L _{Aeq,15min}	Median L _{Aeq,15min}	Max Night time L _{Amax}
14/08/2012	39	52	19	22	72
15/08/2012	35	46	19	25	70
16/08/2012	50	58	31	47	71
17/08/2012	38	46	30	37	66
18/08/2012	39	50	21	29	70
19/08/2012	36	47	21	28	74
20/08/2012	48	53	33	47	76
21/08/2012	40	55	20	29	74
22/08/2012	45	55	29	41	73
23/08/2012	49	52	22	46	77
24/08/2012	39	52	20	25	73
25/08/2012	36	46	20	29	70
26/08/2012	41	53	25	30	70
27/08/2012	41	48	24	37	72
28/08/2012	37	46	21	31	65

ABL has not been reported as statistical noise data was not recorded at this location.

3.3 Location 3

Location 3 was at the western boundary of houses at Rogues Point, approximately 8.5 km south of Ardrossan town centre and 2 km northeast of the Hillside mine site. Figure 9 shows the location of noise monitoring equipment.



Figure 9 Unattended noise monitoring location 3

Details of the noise logging equipment used at Location 3 are included in Table 10.

Table 10 Equipment installed at unattended noise monitoring location 3

Make/Model	Serial #	Last calibration date	Calibration due date
Rion NL-21	409174	23 July 2011	23 July 2013

Sources of noise observed in the area surrounding Location 3 included traffic from Yorke Highway and residents at Rogues Point. Table 11 and Table 12 provide a summary of the noise levels measured during the logging period.

Table 11 Location 3 noise monitoring results: daytime (7am – 10pm) descriptors

Date	L _{Aeq,15hr}	Maximum L _{Aeq,15min}	Minimum L _{Aeq,15min}	Median L _{Aeq,15min}	Daytime ABL
15/08/2012	50	57	39	47	25
16/08/2012	61	71	45	57	41
17/08/2012	54	60	39	52	36
18/08/2012	45	55	33	43	29
19/08/2012	45	54	24	43	23
20/08/2012	54	61	39	52	35
21/08/2012	46	56	31	45	22
22/08/2012	50	58	34	46	24
23/08/2012	62	72	40	59	36
24/08/2012	52	59	34	51	30
25/08/2012	47	53	33	46	30
26/08/2012	44	53	22	41	19
27/08/2012	49	60	25	44	22
28/08/2012	59	65	38	56	35

Table 12 Location 3 noise monitoring results: night time (10pm – 7am) descriptors

Date	L _{Aeq,9hr}	Highest L _{Aeq,15min}	Lowest L _{Aeq,15min}	Median L _{Aeq,15min}	L _{Amax}	Night time ABL
14/08/2012	39	49	20	33	72	19
15/08/2012	42	54	21	34	74	20
16/08/2012	56	65	35	50	82	34
17/08/2012	41	51	35	39	77	35
18/08/2012	36	47	28	31	67	25
19/08/2012	40	49	21	32	76	19
20/08/2012	54	60	32	53	81	26
21/08/2012	37	48	20	27	69	19
22/08/2012	49	62	29	41	78	26
23/08/2012	49	55	25	44	74	23
24/08/2012	41	53	21	34	73	20

Date	L _{Aeq,9hr}	Highest L _{Aeq,15min}	Lowest L _{Aeq,15min}	Median L _{Aeq,15min}	L _{Amax}	Night time ABL
25/08/2012	37	46	23	32	70	22
26/08/2012	39	50	22	30	71	21
27/08/2012	43	52	23	39	73	20
28/08/2012	41	51	23	35	74	20

3.4 Location 4

Location 4 was on farming land 140 m north of a residence off Reddings Road. The monitoring location is approximately 6 km northwest of Pine Point and 500 m west of the Hillside mine site. Figure 10 shows the location of noise monitoring equipment.

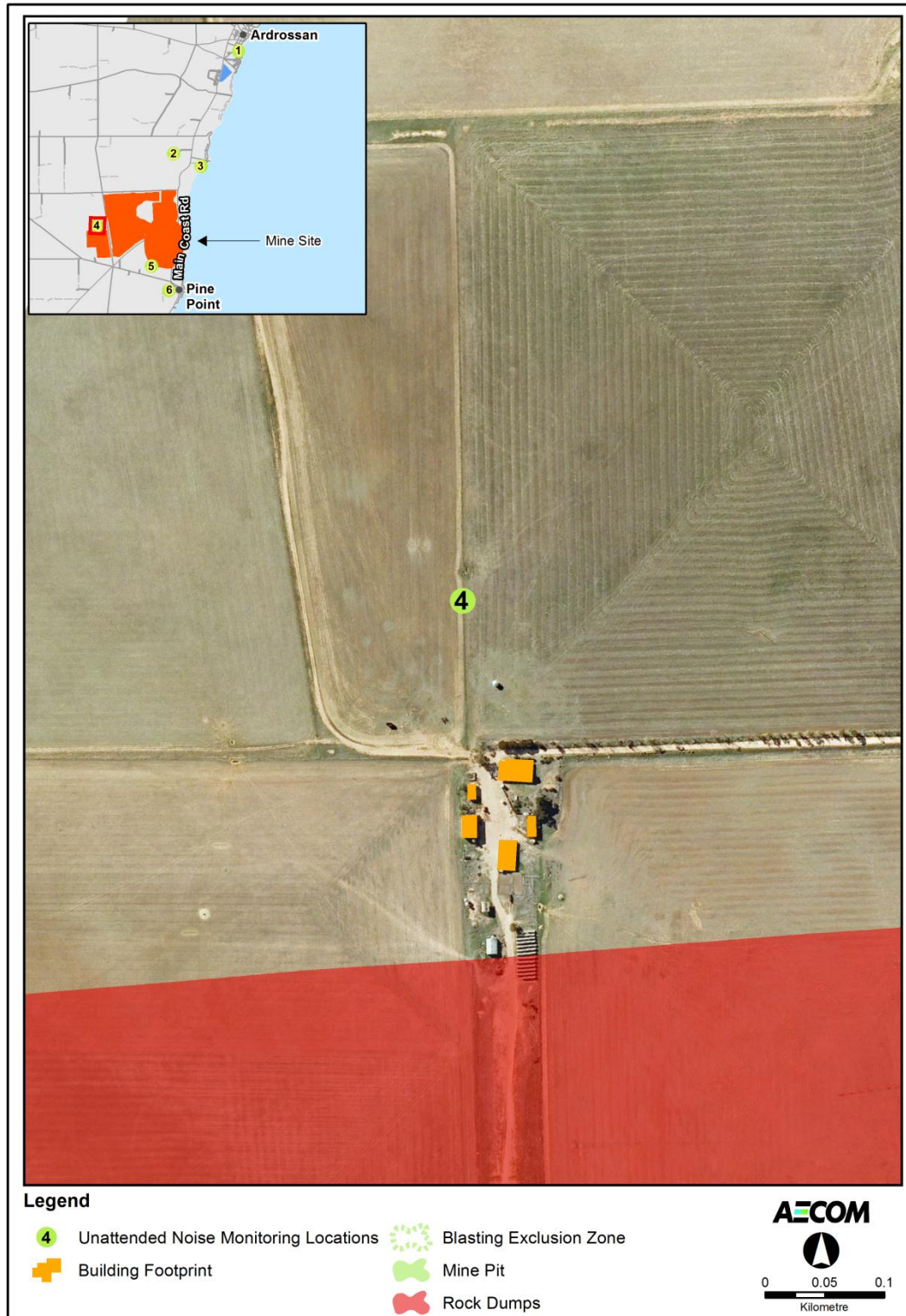


Figure 10 Unattended noise monitoring location 4

Details of the noise logging equipment used at Location 4 are included in Table 13 and Figure 11 shows the equipment setup on site.

Table 13 Equipment installed at unattended noise monitoring location 4

Make/Model	Serial #	Last calibration date	Calibration due date
Rion NL-21	765699	31 July 2012	31 July 2014



Figure 11 Noise logger installed at Location 4

Sources of noise observed in the surrounding area include traffic on Yorke Highway, farming equipment, and residents in the area. Table 14 and Table 15 provide a summary of the noise levels measured during the logging period.

Table 14 Location 4 noise monitoring results: daytime (7am – 10pm) descriptors

Date	L _{Aeq,15hr}	Maximum L _{Aeq,15min}	Minimum L _{Aeq,15min}	Median L _{Aeq,15min}	Daytime ABL
15/08/2012	38	51	24	41	26
16/08/2012	35	66	35	56	38
17/08/2012	47	55	30	50	28
18/08/2012	34	45	24	34	21
19/08/2012	31	41	19	30	18
20/08/2012	40	54	37	44	35
21/08/2012	34	52	20	36	19
22/08/2012	32	59	30	40	29
23/08/2012	49	67	38	55	35
24/08/2012	42	55	24	48	23
25/08/2012	30	53	25	38	24
26/08/2012	31	42	18	28	18
27/08/2012	38	49	29	38	27
28/08/2012	52	60	29	48	29

Table 15 Location 4 noise monitoring results: night time (10pm – 7am) descriptors

Date	L _{Aeq,9hr}	Maximum L _{Aeq,15min}	Minimum L _{Aeq,15min}	Median L _{Aeq,15min}	Max Night time L _{Amax}	Night time ABL
14/08/2012	31	37	22	27	54	19
15/08/2012	35	48	20	24	63	19
16/08/2012	54	62	40	51	77	35
17/08/2012	33	37	29	32	53	28
18/08/2012	29	36	22	27	55	20
19/08/2012	34	41	22	28	52	21
20/08/2012	51	56	30	45	75	30
21/08/2012	35	48	20	28	53	18
22/08/2012	46	58	32	43	73	31
23/08/2012	46	53	22	40	68	22
24/08/2012	29	37	18	27	59	17
25/08/2012	30	37	20	29	55	21
26/08/2012	41	48	20	38	55	19
27/08/2012	39	43	27	39	60	27
28/08/2012	40	47	23	36	57	23

3.5 Location 5

Location 5 was on Rex Minerals owned land, approximately 2.2 km northwest of Pine Point and 2.4 km southwest of the Hillside Mine site office. Figure 12 shows the location of noise monitoring equipment.



Figure 12 Unattended noise monitoring location 5

Details of the noise logging equipment used at Location 5 are included in Table 16 and Figure 13 shows the equipment setup on site.

Table 16 Equipment installed at unattended noise monitoring location 5

Make/Model	Serial #	Last calibration date	Calibration due date
Brüel and Kjaer 2250	2717736	14 September 2010	14 September 2012



Figure 13 Noise logger installed at Location 5

Sources of noise observed in the area surrounding Location 5 included equipment on the proposed mine site, and farming equipment, livestock and residents living in the adjoining property. Table 17 and Table 18 provide a summary of the noise levels measured during the logging period.

Table 17 Location 5 noise monitoring results: daytime (7am – 10pm) descriptors

Date	$L_{Aeq,15hr}$	Maximum $L_{Aeq,15min}$	Minimum $L_{Aeq,15min}$	Median $L_{Aeq,15min}$	Daytime ABL
15/08/2012	41	63	27	45	25
16/08/2012	46	76	45	64	36
17/08/2012	53	66	35	53	31
18/08/2012	38	55	27	38	24
19/08/2012	39	57	29	35	25
20/08/2012	45	63	37	52	34
21/08/2012	34	63	25	41	24
22/08/2012	42	65	27	42	29
23/08/2012	57	73	38	64	35
24/08/2012	39	61	28	48	25
25/08/2012	42	58	28	47	26
26/08/2012	45	65	28	38	25
27/08/2012	49	63	34	43	32
28/08/2012	57	71	33	61	32

Table 18 Location 5 noise monitoring results: night time (10pm – 7am) descriptors

Date	L _{Aeq,9hr}	Maximum L _{Aeq,15min}	Minimum L _{Aeq,15min}	Median L _{Aeq,15min}	Max Night time L _{Amax}	Night time ABL
14/08/2012	35	39	26	35	66	23
15/08/2012	41	53	23	34	69	24
16/08/2012	58	66	42	53	84	34
17/08/2012	38	49	27	36	76	27
18/08/2012	33	38	27	32	62	23
19/08/2012	37	46	28	34	58	26
20/08/2012	61	66	32	55	83	29
21/08/2012	31	38	22	28	55	21
22/08/2012	52	63	34	48	79	32
23/08/2012	55	62	24	43	79	23
24/08/2012	32	44	23	28	76	23
25/08/2012	31	36	23	28	58	23
26/08/2012	36	44	31	35	60	28
27/08/2012	46	55	34	39	69	31
28/08/2012	35	42	21	30	60	21

3.6 Location 6

Location 6 was on farming land 300 m west of a homestead located off St Vincent Highway. The location was approximately 500 m west of Pine Point, and 1.5 km south of the Hillside mine site. Figure 14 shows the location of noise monitoring equipment.



Figure 14 Unattended noise monitoring location 6

Details of the noise logging equipment used at Location 6 are included in Table 19 and Figure 15 shows the equipment setup on site.

Table 19 Equipment installed at unattended noise monitoring location 6

Make/Model	Serial #	Last calibration date	Calibration due date
Rion NL-21	265112	3 February 2012	3 February 2014

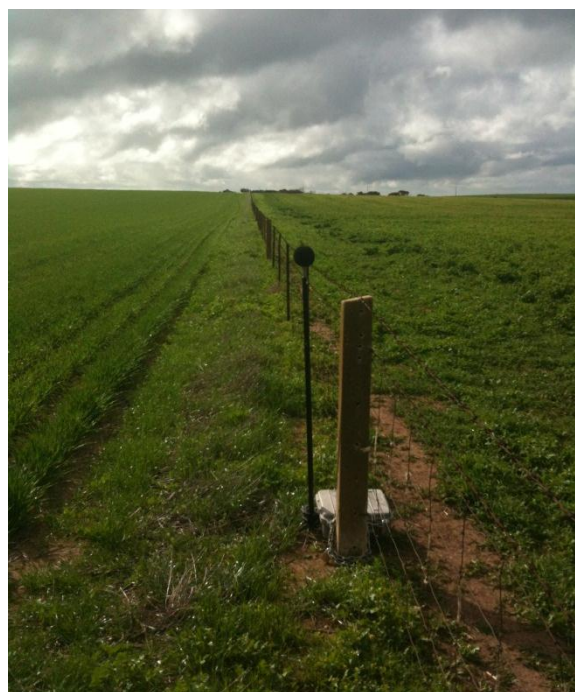


Figure 15 Noise logger installed at Location 6

Sources of noise observed in the area surrounding Location 6 included traffic on St. Vincent Highway, farming equipment and residents living at the homestead. Table 20 and Table 21 provide a summary of the noise levels measured during the logging period.

Table 20 Location 6 noise monitoring results: daytime (7am – 10pm) descriptors

Date	$L_{Aeq,15hr}$	Maximum $L_{Aeq,15min}$	Minimum $L_{Aeq,15min}$	Median $L_{Aeq,15min}$	Daytime ABL
15/08/2012	41	55	35	42	22
16/08/2012	37	65	37	52	34
17/08/2012	44	56	29	45	27
18/08/2012	36	47	23	35	22
19/08/2012	35	42	27	35	21
20/08/2012	41	54	34	46	31
21/08/2012	40	49	31	38	20
22/08/2012	44	54	26	43	23
23/08/2012	49	66	33	51	29
24/08/2012	36	51	28	39	22
25/08/2012	42	55	26	40	21
26/08/2012	34	50	22	35	21

Date	L _{Aeq,15hr}	Maximum L _{Aeq,15min}	Minimum L _{Aeq,15min}	Median L _{Aeq,15min}	Daytime ABL
27/08/2012	43	49	30	39	23
28/08/2012	53	62	30	48	25

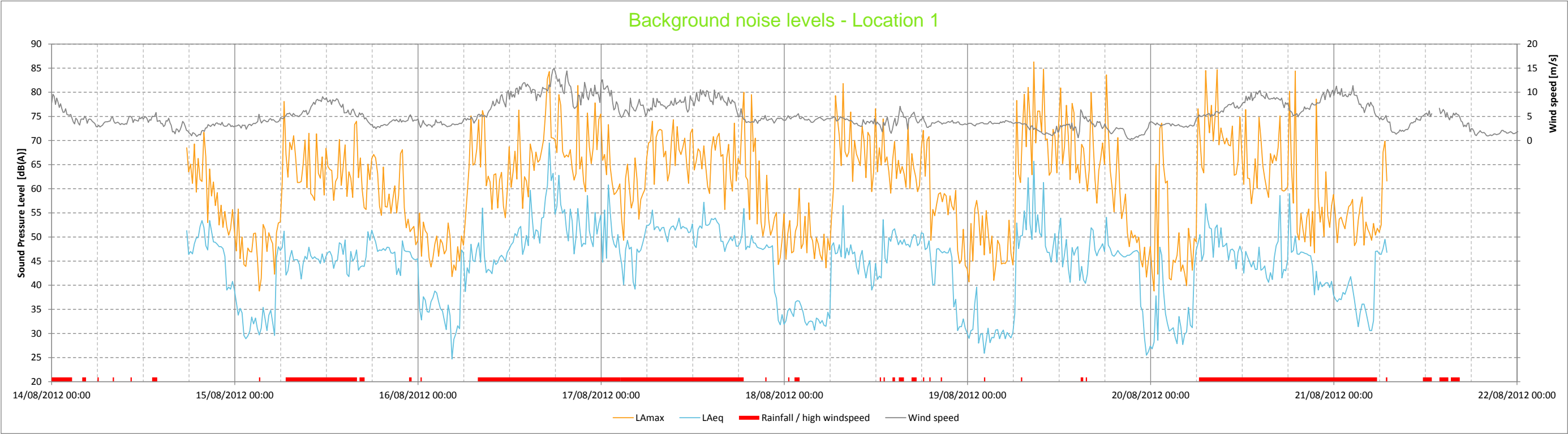
Table 21 Location 6 noise monitoring results: night time (10pm – 7am) descriptors

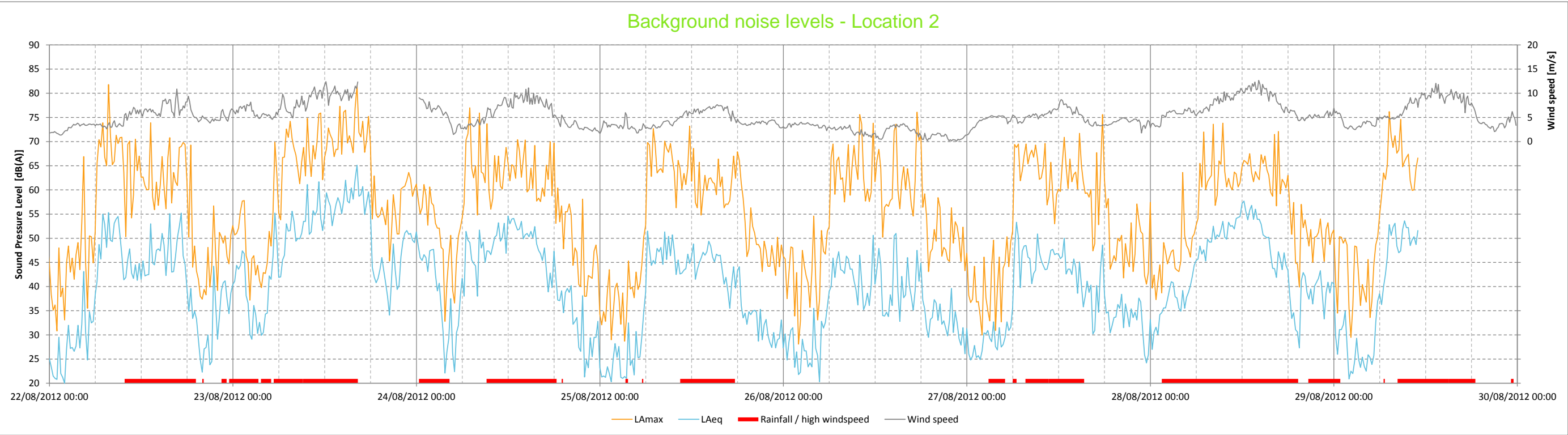
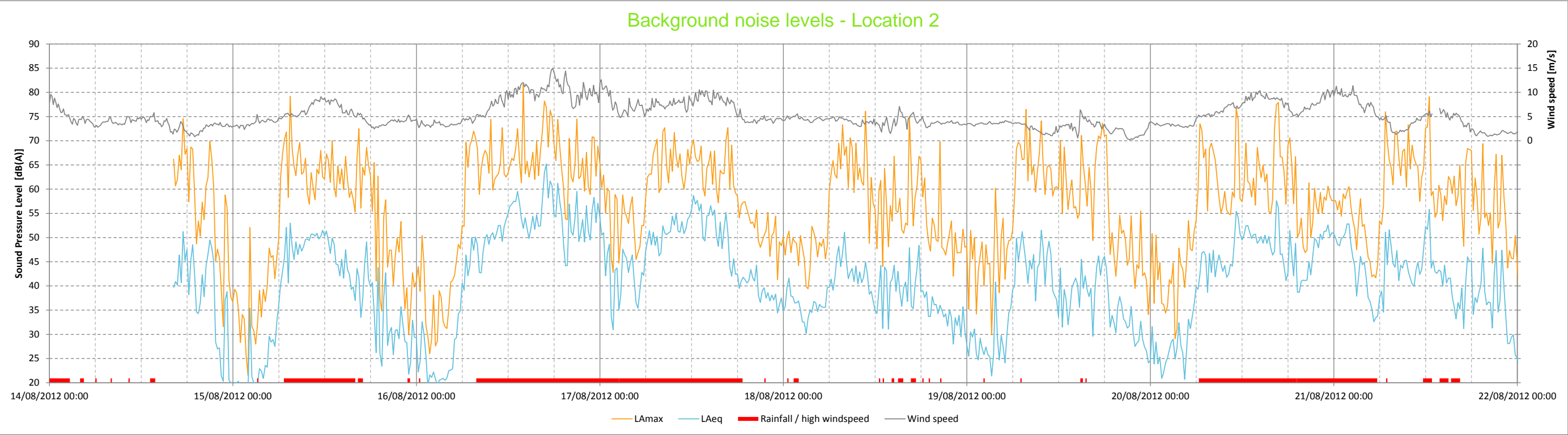
Date	L _{Aeq,9hr}	Maximum L _{Aeq,15min}	Minimum L _{Aeq,15min}	Median L _{Aeq,15min}	Max Night time L _{Amax}	Night time ABL
14/08/2012	32	40	20	29	62	20
15/08/2012	32	39	22	29	57	21
16/08/2012	50	61	32	45	80	28
17/08/2012	31	37	27	30	59	26
18/08/2012	29	36	21	27	56	21
19/08/2012	34	41	21	31	58	20
20/08/2012	50	57	27	41	71	23
21/08/2012	34	42	19	28	62	19
22/08/2012	46	60	28	36	75	24
23/08/2012	42	49	20	33	68	20
24/08/2012	31	39	20	28	56	20
25/08/2012	29	35	20	24	55	20
26/08/2012	34	42	21	31	59	20
27/08/2012	35	46	26	33	64	24
28/08/2012	33	41	20	29	61	20

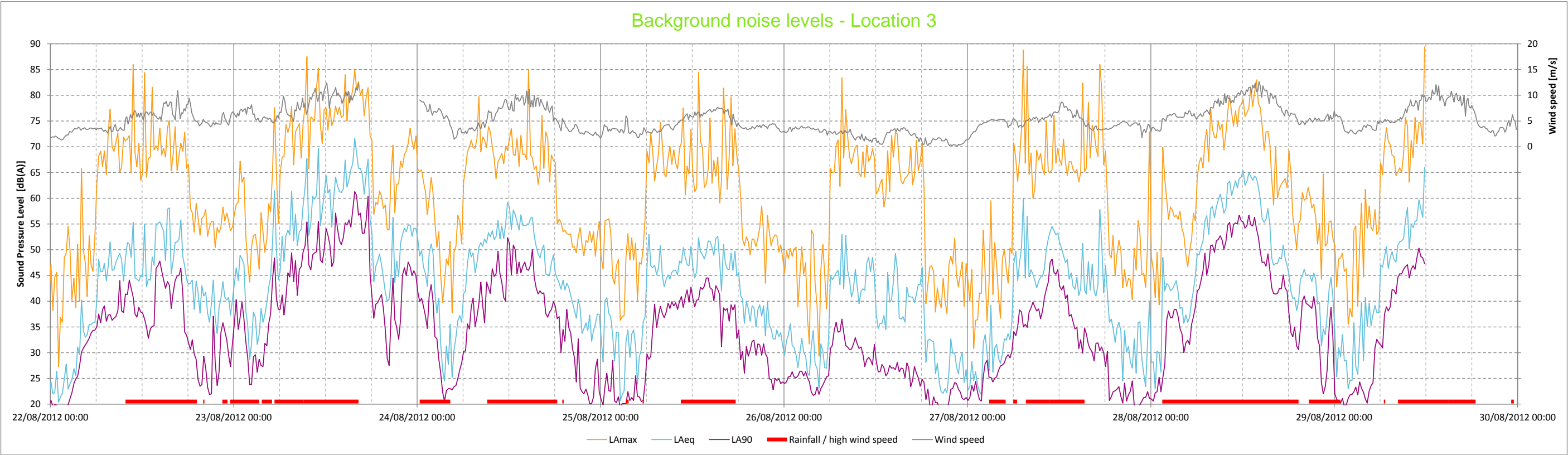
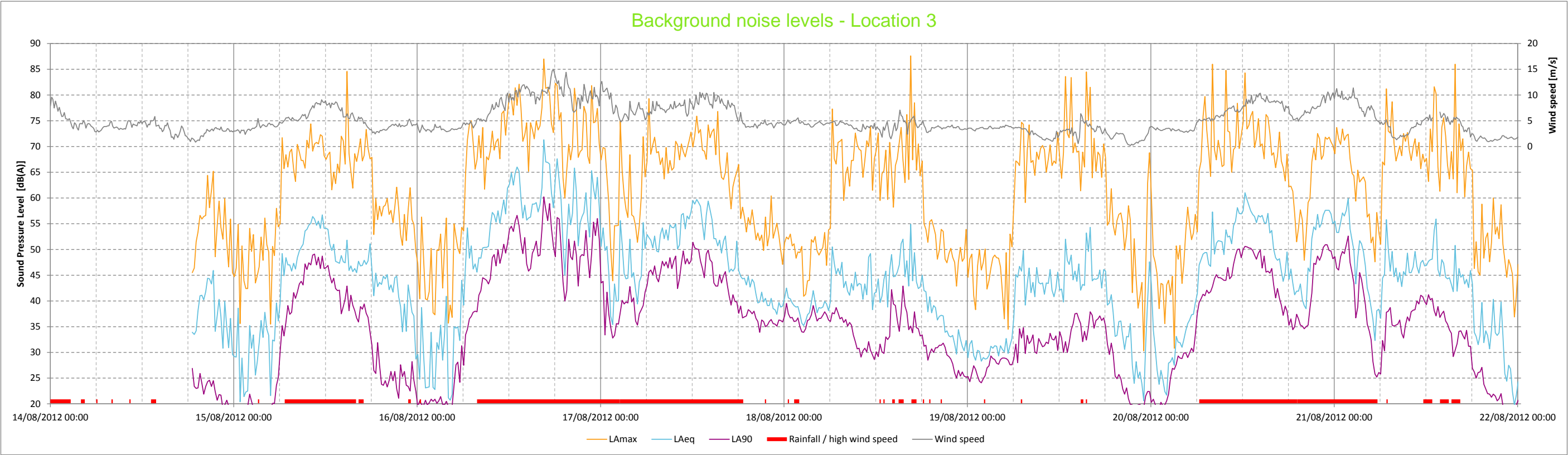
Appendix A

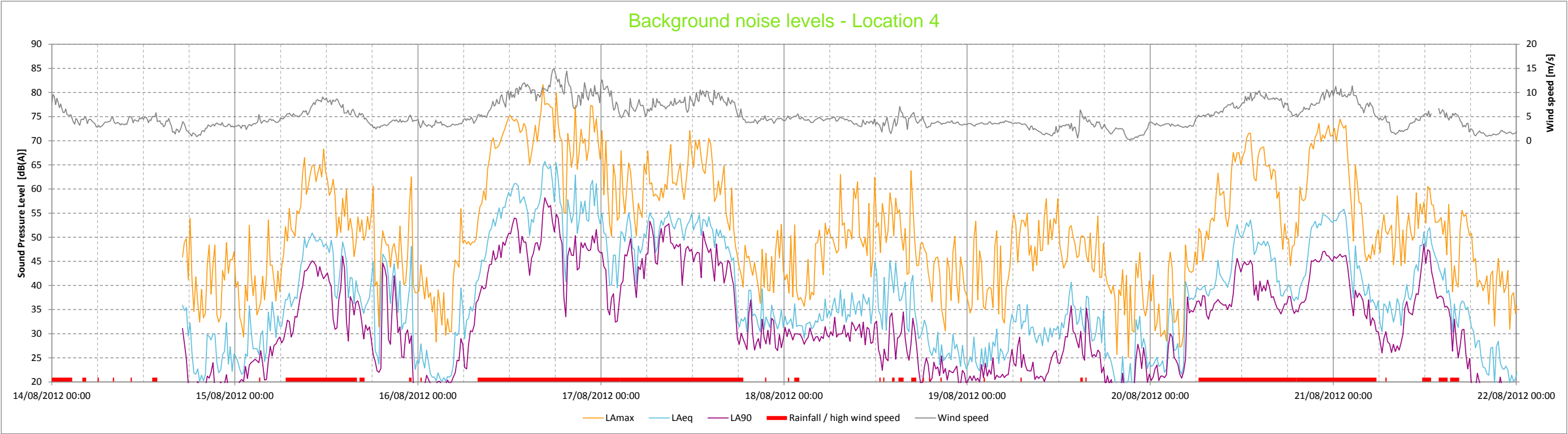
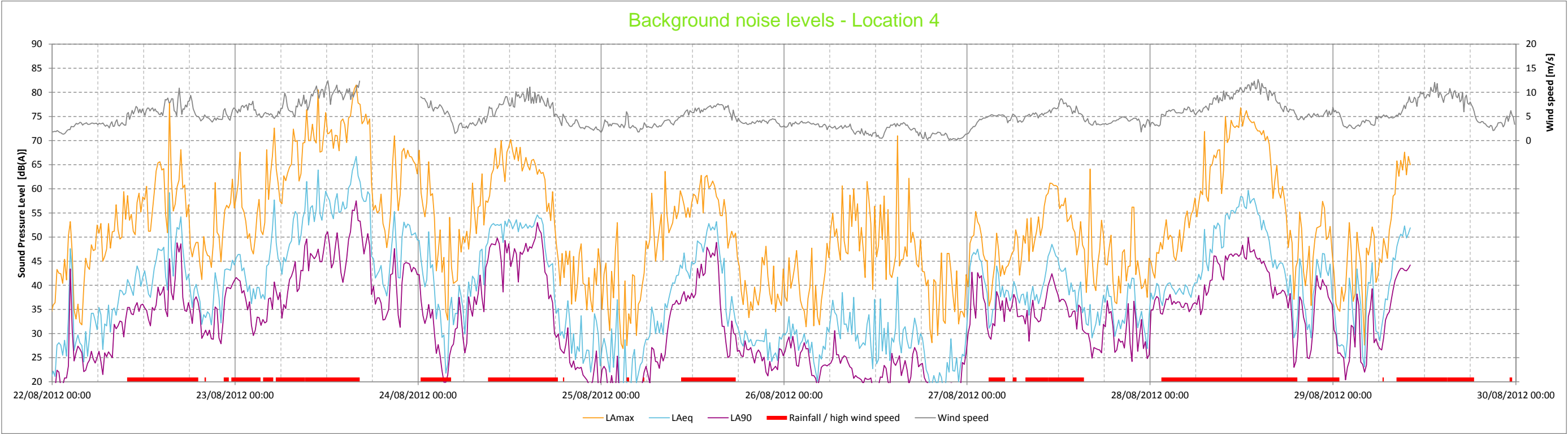
Unattended noise monitoring results

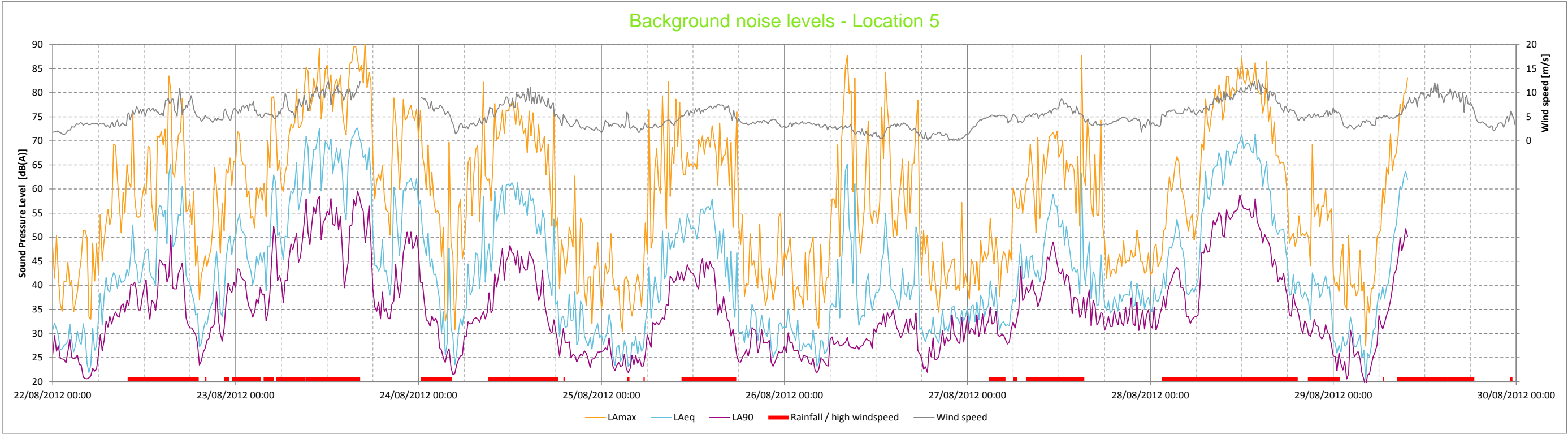
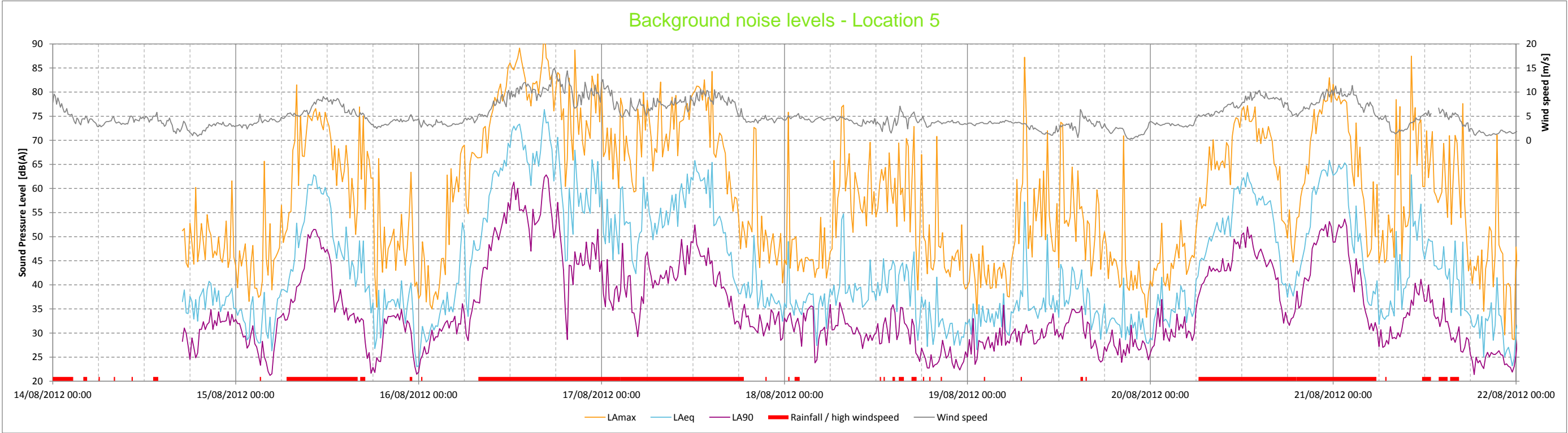
Appendix A Unattended noise monitoring results

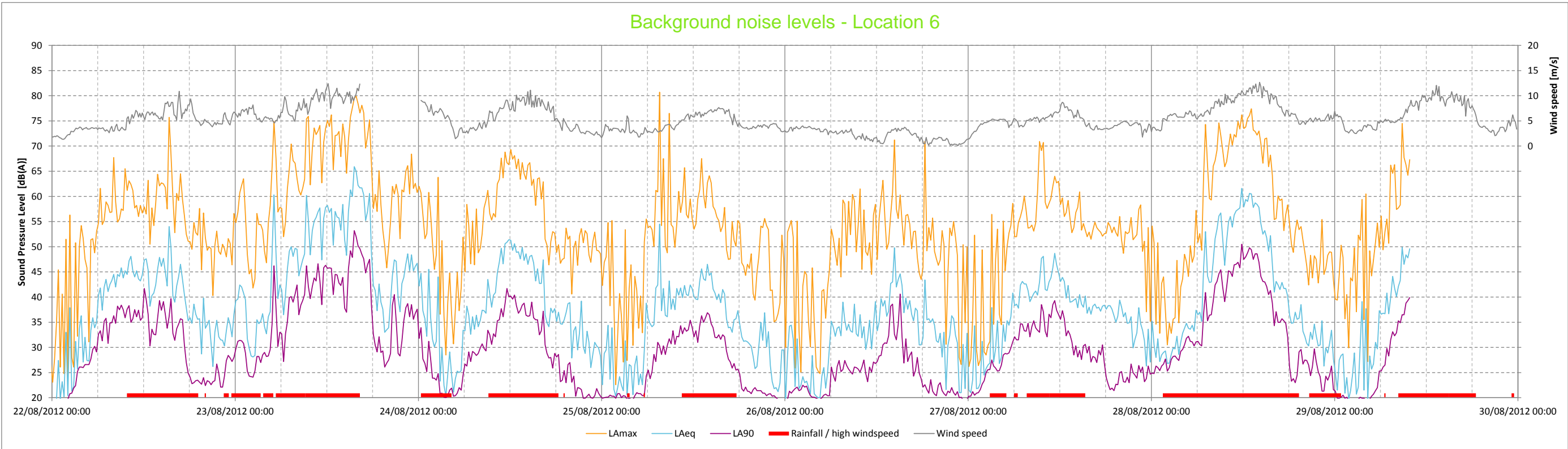
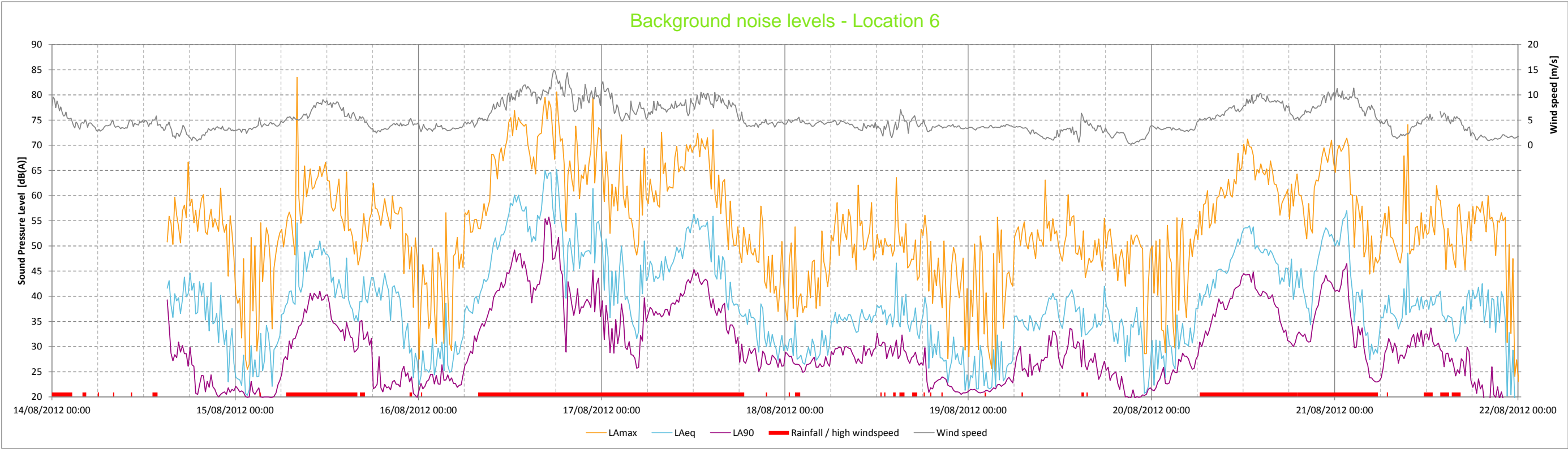














Appendix B

Calibration certificates

Appendix B Calibration certificates

CERTIFICATE OF CALIBRATION			
CERTIFICATE NO.: SLM 37909 & FILT 2312			
Equipment Description: Sound Level Meter			
Manufacturer:	B & K		
Model No:	2250	Serial No:	2600405
Microphone Type:	4189	Serial No:	2603667
Filter Type:	1/3 Octave	Serial No:	2600405
Comments:	All tests passed for type 1.		
Owner:	AECOM Level 28, 91 King William Street Adelaide SA 5000		
Ambient Pressure:	955 hPa ± 1.5 hPa		
Temperature:	23 °C $\pm 2^\circ$ C Relative Humidity: 61 %RH $\pm 5\%$ RH		
Date of Calibration:	09/12/2010	Issue Date:	09/12/2010
Acu-Vib Test Procedure:	AVP05 (SLM) & AVP06 (Filters) if applicable		
CHECKED BY:	AA	AUTHORISED SIGNATORY:	Jack Kidd
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 Accredited Lab. No. 9262 Acoustic and Vibration Measurements		 HEAD OFFICE Unit 14, 22 Hudson Ave. Castle Hill NSW 2154 Tel: (02) 96808133 Fax: (02) 96808233 Mobile: 0413 806806 web site: www.acu-vib.com.au	

CERTIFICATE OF CALIBRATION

CERTIFICATE No: 13355

EQUIPMENT TESTED: Sound Level Calibrator

Manufacturer: B & K
Type No: 4231 Serial No: 2242325
Owner: AECOM
Level 28, 91 King William Street
Adelaide SA 5000

Tests Performed: Measured output sound pressure level was found to be:
Before adjustment: 94.21 & 114.24 dB re 20 uPa at 999.9 Hz THD< 1%.
After adjustment: 94.21 & 114.24 dB re 20 uPa at 999.9 Hz THD< 1%.

Uncertainty Output ± 0.1 dB
(at 95% c.l.) k=2: Freq. ± 0.05 Hz

CONDITION OF TEST:Ambient Pressure: 1008 hPa ± 1.5 hPa Relative Humidity: 52 % RH $\pm 5\%$ RHTemperature: 23 °C $\pm 2^\circ$ C

Date of Calibration: 18/05/2012 Issue Date: 18/05/2012

Acu-Vib Test Procedure: AVP02 (Calibrators)

Test Method: AS IEC 60942 - 2004

CHECKED BY: *[Signature]* AUTHORISED SIGNATORY: *[Signature]*

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CERTIFICATE OF CALIBRATION

CERTIFICATE No.: SLM 38899 & FILT 2718

Equipment Description: Sound Level Meter

Manufacturer: Svantek

Model No: Svan-957 Serial No: 27539

Microphone Type: 7052E Serial No: 50502

Filter Type: 1/3 Octave Serial No: 27539

Comments: All tests passed for type 1.

Owner: AECOM
540 Wickham Street
Fortitude Valley QLD 4006

Ambient Pressure: 1017 hPa ± 1.5 hPa

Temperature: 23 °C $\pm 2^\circ$ C Relative Humidity: 54 %RH $\pm 5\%$ RH

Date of Calibration: 11/04/2012 Issue Date: 12/04/2012

Acu-Vib Test Procedure: AVP05 (SLM) & AVP06 (Filters) if applicable

CHECKED BY: *[Signature]* AUTHORISED SIGNATORY: *[Signature]*

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CERTIFICATE OF CALIBRATION

CERTIFICATE No.: SLM 38897 & FILT 2717

Equipment Description: Sound Level Meter

Manufacturer: Svantek

Model No: Svan-957 **Serial No:** 27551

Microphone Type: 7052E **Serial No:** 50540

Filter Type: 1/3 Octave **Serial No:** 27551

Comments: All tests passed for type 1.

Owner: AECOM
540 Wickham Street
Fortitude Valley QLD 4006

Ambient Pressure: 1017 hPa ± 1.5 hPa

Temperature: 23 °C $\pm 2^\circ$ C **Relative Humidity:** 54 %RH $\pm 5\%$ RH

Date of Calibration: 11/04/2012 **Issue Date:** 12/04/2012

Acu-Vib Test Procedure: AVP05 (SLM) & AVP06 (Filters) if applicable

CHECKED BY: *AV* **AUTHORISED SIGNATORY:** *Jack Kieft*



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CERTIFICATE OF CALIBRATION			
CERTIFICATE No.: SLM 38307			
Equipment Description: Sound Level Meter			
Manufacturer:	Rion		
Model No:	NL-21	Serial No:	00409174
Microphone Type:	UC-52	Serial No:	128714
Filter Type:	-	Serial No:	-
Comments:	All tests passed for type 2.		
Owner:	AECOM Level 1, 21 Stokes Street Townsville QLD 4810		
Ambient Pressure:	1003 hPa ± 1.5 hPa		
Temperature:	23 °C $\pm 2^\circ$ C Relative Humidity: 63 %RH $\pm 5\%$ RH		
Date of Calibration:	23/07/2011	Issue Date:	25/07/2011
Acu-Vib Test Procedure:	AVP05 (SLM) & AVP06 (Filters) if applicable		
CHECKED BY:	<i>ASH</i>	AUTHORISED SIGNATORY:	<i>Jack Kiehl</i>
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CERTIFICATE OF CALIBRATION

CERTIFICATE No.: **SLM 39166**

Equipment Description: Sound Level Meter

Manufacturer: Rion

Model No: NL-21 **Serial No:** 00765699

Microphone Type: UC-52 **Serial No:** 106853

Filter Type: - **Serial No:** -

Comments: All tests passed for type 2.

Owner: AECOM
Level 28, 91 King William Street
Adelaide SA 5000

Ambient Pressure: 1007 hPa ± 1.5 hPa

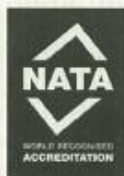
Temperature: 23 °C $\pm 2^\circ$ C **Relative Humidity:** 35 %RH $\pm 5\%$ RH

Date of Calibration: 31/07/2012 **Issue Date:** 01/08/2012

Acu-Vib Test Procedure: AVP05 (SLM) & AVP06 (Filters) if applicable

CHECKED BY: *[Signature]* **AUTHORISED SIGNATORY:** *[Signature]*
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CERTIFICATE OF CALIBRATION

CERTIFICATE No.: **SLM 37754 & FILT 2243**

Equipment Description: Sound Level Meter

Manufacturer: B & K

Model No: 2250 **Serial No:** 2717736

Microphone Type: 4189 **Serial No:** 2710571

Filter Type: 1/3 Octave **Serial No:** 2717736

Comments: All tests passed for type 1.

Owner: AECOM
Level 28, 91 King William Street
Adelaide SA 5000

Ambient Pressure: 994 hPa ± 1.5 hPa

Temperature: 23 °C $\pm 2^\circ$ C **Relative Humidity:** 63 %RH $\pm 5\%$ RH

Date of Calibration: 14/09/2010 **Issue Date:** 15/09/2010

Acu-Vib Test Procedure: AVP05 (SLM) & AVP06 (Filters) if applicable

CHECKED BY: *AM* **AUTHORISED SIGNATORY:** *Jack Kirt*


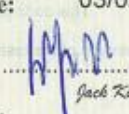


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web site: www.acu-vib.com.au

CERTIFICATE OF CALIBRATION			
CERTIFICATE NO.: SLM 38748			
Equipment Description: Sound Level Meter			
Manufacturer:	Rion		
Model No:	NL-21	Serial No:	00265112
Microphone Type:	UC-52	Serial No:	109044
Filter Type:	-	Serial No:	-
Comments:	All tests passed for type 2.		
Owner:	AECOM Level 28, 91 King William Street Adelaide SA 5000		
Ambient Pressure:	992 hPa ± 1.5 hPa		
Temperature:	23 °C $\pm 2^\circ$ C Relative Humidity: 82 %RH $\pm 5\%$ RH		
Date of Calibration:	03/02/2012	Issue Date:	03/02/2012
Acu-Vib Test Procedure:	AVP05 (SLM)		
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Hillside Mine

Road diversion - Road traffic noise assessment



Hillside Mine

Road diversion - Road traffic noise assessment

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21 December 2012

60279729 - A12L02RP

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Quality Information

Document Hillside Mine

Ref 60279729 - A12L02RP

Date 21 December 2012

Prepared by Adam Cook

Reviewed by Simon Moore

Revision History


Revision	Revision Date	Details	Authorised	
			Name/Position	Signature
0	21-Dec-2012	Initial issue	Simon Moore Principal Engineer - Acoustics	

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Glossary

'A' Weighted	Frequency filter applied to measured noise levels to represent how humans hear sounds.
dB(A)	'A' Weighted overall sound pressure level.
$L_{Aeq,T}$	Equivalent (energy averaged) noise level measured over a time period T. This descriptor is used within the <i>Environment Protection (Noise) Policy</i> and the Department for Planning Transport, and Infrastructure <i>Road Traffic Noise Guidelines</i> .
$L_{Aeq,15h}$	Equivalent (energy averaged) noise level measured over the 15 hour daytime period (7am to 10pm).
$L_{Aeq,9h}$	Equivalent (energy averaged) noise level measured over the 9 hour night time period (10pm to 7am).

1.0 Introduction

AECOM has been engaged to provide an assessment of road traffic noise arising from road upgrade works associated with the Hillside Mine project, near Ardrossan, South Australia.

The proposed upgrade works involve:

- intersection upgrade at corner of Yorke Highway and Sandy Church Road
- re-alignment of the St Vincent Highway around the proposed Blasting Exclusion Zone for the mine site
- diversion of Pine Point road near Yorke Highway intersection
- sealing of Pine Point road between the diversion works and St Vincent Highway
- closure of Yorke Highway between St Vincent Highway and Pine Point Road
- intersection upgrade at the corner of Pine Point Road and St Vincent Highway

The location of the proposed road upgrade works, and that of the nearest noise-sensitive receivers is illustrated in Figure 1.



Figure 1 Proposed road works

2.0 Noise criteria

Noise criteria for major road projects are derived from the Department of Planning Transport and Infrastructure (DPTI) Road Traffic Noise Guidelines (RTNG) which outline DPTI's obligations for managing road traffic noise impacts under the *Environment Protection Act 1993* (EP Act).

The RTNG define noise sensitive land uses that are eligible for noise mitigation treatments, as including:

- existing dwellings in a zone where dwellings are contemplated as defined by the relevant Development Plan
- existing nursing homes
- caravan parks that accommodate existing long term residential use.

Noise sensitive land uses that were identified within the road realignment project area are shown in Figure 1. Two houses, labelled R1 and R2, have been identified as requiring a road traffic noise assessment for the proposed works. They are located to the North and South of Pine Point Road respectively.

Compliance with noise criteria under the RTNG is required at both project opening and 10 years after opening. This assessment is therefore based upon the 2023 traffic volumes, which are greater than existing volumes.

The noise criteria are derived as follows:

- for areas presently exposed to road traffic noise of less than day time 53 dB(A) $L_{Aeq,15h}$ and night time 48 dB(A) $L_{Aeq,9h}$ the external target criteria for 2023 will be:
 - day time 55 dB(A) $L_{Aeq,15h}$ and night time 50 dB(A) $L_{Aeq,9h}$
- for areas presently exposed to road traffic noise greater than day time 53 dB(A) $L_{Aeq,15h}$ and night time 48 dB(A) $L_{Aeq,9h}$, the external target criteria for 2023 will be the lower of:
 - the existing noise level plus 2 dB(A)
 - A day time 65 dB(A) $L_{Aeq,15h}$ and night time 60 dB(A) $L_{Aeq,9h}$.

Assessment times are:

- day time — the 15 hour period between 7 am and 10 pm
- night time — the 9 hour period between 10 pm and 7 am

Noise levels are predicted or measured at a location one metre from the most exposed window at a height of 1.5 m above floor level. Noise levels at this location are affected by reflections from the building façade, in which case all predictions are to include a façade reflection factor of +2.5 dB. If noise levels for individual properties are measured at locations not subject to reflections from the building façade, they are also subject to an adjustment factor of +2.5 dB to ensure that the comparison of noise levels against the noise level criteria are consistent.

Where predicted future road traffic noise levels exceed the external target criteria, all reasonable and practicable noise mitigation measures will be considered. The noise mitigation treatments should include a combination of the following that is deemed to be reasonable and practicable:

- road design measures
- roadside noise barriers and/or property fences
- property treatment packages to individual residences.

Noise-sensitive receivers in the vicinity of the road works are currently exposed to less than 53 dB(A) $L_{Aeq,15h}$ and 48 dB(A) $L_{Aeq,9h}$. As such, the applicable road traffic noise criteria are 55 dB(A) $L_{Aeq,15h}$ (day time) and 50 dB(A) $L_{Aeq,9h}$ (night time)

3.0 Pre-construction noise monitoring

Pre-construction noise monitoring was undertaken at several sites around the proposed Hillside mine during the period 14 – 28 August 2012. Results were reported in AECOM report 60279709-A12K01RP (Pre-Construction Noise Monitoring Report).

Results from the pre-construction noise monitoring at the location shown in Figure 2 have been used to calibrate the road traffic noise model. This location represents the closest noise-sensitive receiver to the road construction works for which background noise monitoring was undertaken.

A summary of the noise monitoring results relevant to the road traffic modelling are included in Table 1.

Table 1 Pre-construction noise monitoring results

Date	L _{Aeq,15hr}	L _{Aeq,9hr}
14/08/2012	-	32
15/08/2012	41	32
16/08/2012	37	50
17/08/2012	44	31
18/08/2012	36	29
19/08/2012	35	34
20/08/2012	41	50
21/08/2012	40	34
22/08/2012	44	46
23/08/2012	49	42
24/08/2012	36	31
25/08/2012	42	29
26/08/2012	34	34
27/08/2012	43	35
28/08/2012	53	33
Median	41	34

Noise monitoring results show the difference between the daytime and night time noise levels is greater than 5 dB(A). Considering that the difference between the daytime and night time noise criteria is 5 dB(A), this suggests that the daytime criteria will be the controlling criterion.



Figure 2 Pre-construction noise monitoring location

4.0 Road traffic noise assessment

4.1 Modelling inputs and methodology

Road traffic noise predictions are carried out in accordance with the United Kingdom, Department of Environment (1988), *Calculation of Road Traffic Noise* manual (CoRTN). The predictions are carried out using the CoRTN calculation algorithm, as implemented by SoundPlan version 7.0 environmental noise modelling software.

The noise model utilises existing terrain contours for the Yorke Peninsula region, as well as the future road alignments provided by Rex Minerals. Traffic volumes (including Commercial Vehicle (CV) percentages) have been based on traffic counts provided by DPTI for Yorke Highway and St Vincent Highway. Traffic counts are provided in Appendix B.

Future traffic volumes conservatively assume a 3% compound annual growth in general traffic from 2013 until 2023 (10 years after opening). It is also assumed that the closure of the section of Yorke Highway will result in the traffic from this road being diverted entirely onto the new alignment of the St Vincent Highway and Pine Point Road.

Table 2 shows the road traffic volumes adapted for the noise modelling for existing and future (2023) models respectively. The road traffic model assumes that 90% of the AADT flow is during the day time hours, 7 am to 10 pm.

Table 2 Existing road traffic volumes

Road	AADT	Day flow	Night flow	CV%
Ardrossan-Minlaton Road	460	414	46	9
Pine Point Road	30 ⁽¹⁾	-	-	-
Yorke Highway (North of existing Yorke Highway turnoff)	1900	1710	190	9
St Vincent Highway (South of existing Yorke Highway turnoff)	1200	1080	120	15

Table 3 2023 road traffic volumes

Road	AADT	Day flow	Night flow	CV%
Pine Point Road	659	593	66	9
St Vincent Highway	1613	1452	161	9
Yorke Highway	2553	2298	255	15

Notes:

- (1) Traffic data for pine point road has been provided by Rex Minerals, based upon traffic data collected over the period 29 April – 5 June 2012. Given the low volumes on Pine Point Road, existing road traffic noise emissions from this road have been assumed to be negligible.

The road surface types input into the road traffic noise model have been based upon existing pavements with the road surface corrections used summarised in Table 4.

Table 4 Road surfaces assumed for noise modelling

Road	Pavement type	Noise level correction relative to dense graded asphalt (DGA), dB(A)
Yorke Highway	7 mm single seal	+ 2
St Vincent Highway		
Pine Point Road (re-pavement and diversion)		

Vehicle speeds have been modelled based upon existing posted speed limits. These are all 110 km/h, except for the section of St Vincent Highway 300m from the Pine Point town centre, which is signposted as 60 km/h.

4.2 Calibration of model

The road traffic noise model was calibrated based upon the pre-construction measured noise data provided in Section 3.0. The existing road was modelled with existing traffic flows and used to predict noise levels at the logger location, which were then compared to measured levels. Table 5 summarises predicted (PNL) and measured (MNL) free field noise levels for the measurement location.

Low night time traffic volumes at the calibration location resulted in the night time noise level being influenced by noise sources other than road traffic noise. As such, only the daytime $L_{eq,15hr}$ noise levels have been used to calibrate the model.

Table 5 Calibration summary

Day time $L_{eq,15hr}$, dB(A)		
MNL	PNL	MNL-PNL
41	40	-1

As the predicted noise levels were 1 dB(A) $L_{eq,15h}$ less than the measured noise level, a further calibration factor of +1 dB(A) was applied to the model.

4.3 Predicted noise levels

The calibrated existing road network model was used to predict current noise levels at all sensitive receivers near the proposed works and to derive noise criteria in accordance with the procedure outlined in Section 2.0. The model of the future road network (inclusive of proposed works) was used to predict road traffic noise levels at residences in 2023, with the predicted levels compared to the criteria.

Table 6 summarises the predicted existing day time and night time results respectively for the noise-sensitive residences. Table 7 presents predicted results for the same receivers in 2023. Noise contour plots for daytime and night-time in 2023 are included in Appendix A.

Table 6 Predicted current day time road traffic noise levels

Receiver	Criteria, dB(A)		Predicted existing noise levels, dB(A)		Exceedance dB(A)
	Day $L_{eq,15hr}$	Night $L_{eq,9hr}$	Day $L_{eq,15hr}$	Night $L_{eq,9hr}$	
R1	55	50	41	-(1)	-
R2	55	50	40	-(1)	-

Notes:

- (1) Due to the low measured night-time road traffic volumes on Pine Point Road, night time road traffic noise levels at locations R1 and R2 are predicted to be negligible.

Table 7 Predicted future day time road traffic noise levels

Receiver	Criteria, dB(A)		Predicted 2023 noise levels, dB(A)		Exceedance dB(A)
	Day $L_{eq,15hr}$	Night $L_{eq,9hr}$	Day $L_{eq,15hr}$	Night $L_{eq,9hr}$	
R1	55	50	47	39	-
R2	55	50	50	43	-

It should be noted that the above predictions have assumed that the future spray seal road surfaces will be worn to a similar degree to the existing St Vincent Highway surface on the site. The road traffic noise levels on opening may be up to 2 dB(A) higher than those presented in Table 7. This is because the new spray seal surface is likely

to produce higher noise levels than the current surface. However, as the surface wears over time, it is expected that the relative noise level produced by the surface would decrease and result in the noise levels shown in Table 7 (with the predicted 2023 traffic volumes). It is noted that even at opening, the predicted noise levels are expected to be well below the RTNG noise criteria.

The predictions indicate that road traffic noise levels at the two noise-sensitive receivers are expected to comply with the applicable road traffic noise criteria. Daytime noise levels at R1 and R2 are predicted to increase by 5 and 10 dB(A) respectively, as shown in Figure 3. However, both the daytime and night-time noise levels are predicted to remain at least 5 dB(A) below the RTNG criteria.

4.4 Noise mitigation

As the RTNG noise criteria are not expected to be exceeded at the identified noise-sensitive receivers, no noise mitigation is necessary for noise from road traffic.

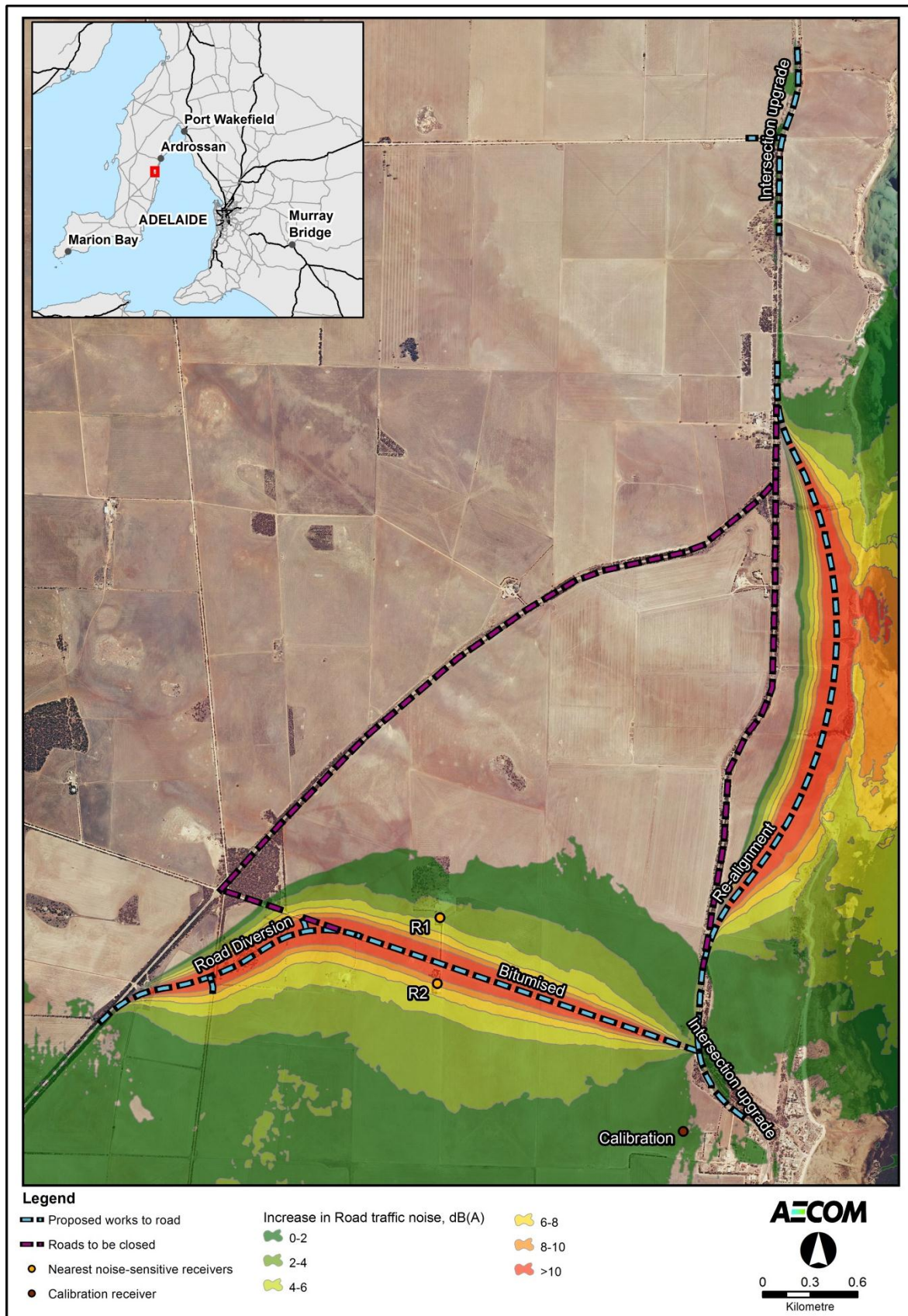


Figure 3 Map of increase in road traffic noise levels

5.0 Conclusion

AECOM has undertaken an assessment of road traffic noise from road upgrade works associated with the Hillside Mine project.

External noise levels from road traffic were found to satisfy the RTNG noise criteria, and as such, noise mitigation treatments for road traffic noise will not be required.

Appendix A

Road traffic noise contour plots - 2023

Appendix A Road traffic noise contour plots - 2023



Figure 4 2023 daytime road traffic noise contour



Figure 5 2023 night-time road traffic noise contour

Appendix B

DPTI Traffic Data

Appendix B DPTI Traffic Data



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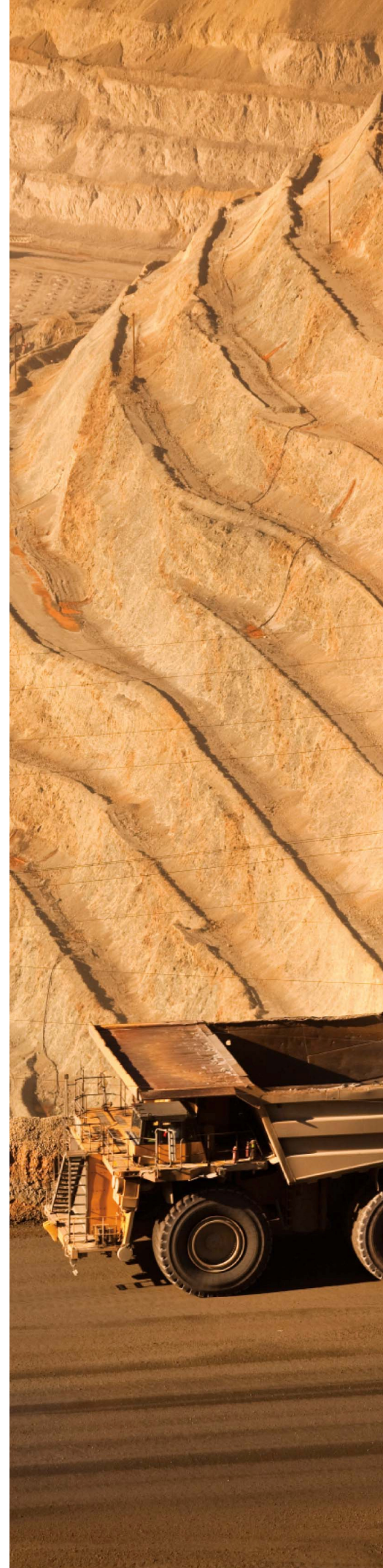
REPORT

HILLSIDE PROJECT DUST AND ODOUR IMPACT ASSESSMENT

Rex Minerals

Job No: 5970D

31 July 2013



PROJECT TITLE: Hillside Project Dust and Odour Impact Assessment

JOB NUMBER: 5970D

PREPARED FOR: Rex Minerals

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VERSION	DATE	PREPARED BY	REVIEWED BY
01	04.02.2013	R Chalmer/J Meline	R Ormerod
02	19.02.2013	R Chalmer/J Meline	R Ormerod
03	31.07.2013	R Chalmer/J Meline	R Ormerod

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1 INTRODUCTION

The Rex Minerals Hillside Project is a proposed open cut copper-gold mine approximately 10 kilometres (km) south of Ardrossan on the Yorke Peninsula in South Australia. The proposed mine pit location is to the immediate west of the St Vincent Highway and within 1 km of the coastline.

Production at the mine is expected to be 15 mega tonnes per annum (MTA) of ore and handling of 900 MT of waste rock over the life time of the mine. The ore concentrate will be pipelined to Port Ardrossan where it will be dewatered, stored and loaded onto ships. The ship loading facilities at Port Ardrossan will be also upgraded to allow for shipment of ore.

As part of a Program for Environment Protection and Rehabilitation (PEPR), Rex Minerals engaged Pacific Environment (formerly 'PAEHolmes') to conduct a dust and odour impact assessment for the project.

This report contains the following:

- A description of the project, focussing on aspects relevant to dust and odour impacts (Section 3)
- The methodology used for the assessment (Section 4).
- The dust and odour criteria used in the study (Section 5).
- An analysis of meteorology in the region (Section 6).
- A characterisation of emissions used in the study (Section 7).
- A summary of background monitoring data used in the assessment (Section 8).
- The results of the assessment (Section 9).
- Conclusions of the study (Section 10).

2 OBJECTIVE

The purpose of the study was to assess the air quality impacts from the Hillside Project mine. The assessment identified requirements for dust control levels and monitoring.

3 PROJECT DESCRIPTION

3.1 Production Details

The mine is proposed as a combination open cut and underground design with waste rock and tailings storage facilities to the west of the pit location. Waste rock will also be stored to the north and east of the pit (see Figure 3.1). The mine processing plant is proposed to be located to the northwest of the pit.

The mine is proposed to produce 15 MTA of ore and handle 900 MT of waste rock over the life time of the mine. The life time of the mine is expected to be more than 15 years. The processing plant is expected to handle 225 MT of ore during its lifetime (Rex Minerals, 2013).

Dust emissions from the mine and associated activities are directly linked to materials handling and vehicle movements as well as other activities and wind erosion of waste rock storage and stockpiles.

3.2 Description of Odorous Processes

Odours are associated with the reagents used in the flotation circuit to separate metals from the crushed ore. While the reagents are present in the highest concentrations in the flotation circuit, odour emissions from the processing plant are minor due to the relatively small total surface areas of the flotation circuit vessels and mixing tanks. In contrast, the larger surface area of the tailings storage facility (TSF) leads to a greater total emission rate, despite the relatively low concentrations of the reagents in the tailings (see Section 7.1).

The floatation reagents include:

- potassium amyl xanthate (collector)
- methyl iso-butyl carbinol (frother)
- sodium bisulphite (antiscalant)
- Magnafloc 800HP (flocculant)
- Orica DSP052 (collector)
- quicklime (pH modifier).

3.3 The Site

The proposed layout for the mine in full production is presented in Figure 3.1



Figure 3.1: Proposed mine layout

The proposed mine layout is presented in Figure 3.1 (note that north is to the left). The mine processing plant with ROM pad, crusher and the main stockpile is located to the northwest of the pit surrounded by the eastern and western waste rock dump areas. The eastern waste rock dump area stretches around the pit on the northern, eastern and southern sides. The TSF will be located in the western waste rock dump (rock dump 14A).

The mine as assessed as presented in Figure 3.1 represents a conservative version of the mine development at year five of operations with a conservative assumption on un-remediated waste rock dump surface areas. The western waste rock dump 14 B will not be started on until post year five but was included in the modelling (together with the western waste rock dump 14 A and the eastern waste rock dump). At completion of year five the remediation of the eastern waste rock dump (to the north and stretching around the eastern side of the pit) will be completed closing this area for further rock dumping.



Figure 3.2: Proposed Port Operations Layout

The port operations layout is presented in Figure 3.2 (note that north is to the left of the image). Ore concentrate is pumped to the concentrate storage at the southern end of the existing port site just south of Ardrossan where it is dewatered and stored in an enclosed building under negative pressure. Exhaust air is treated with a baghouse filter. The materials transfer for the ship loading will occur via a covered and extracted conveyer line from the concentrate storage facility to the pier conveyer line transfer point. The covered ship loading conveyer line will be covered and will contain a belt wash on the return line.

The ship loader will operate with a telescopic chute and dust suppression skirt. The ship loading frequency will be five shipments per month.

3.4 Sensitive Receptors

The nearest sensitive receptors to the mine operations are presented in Figure 3.3.

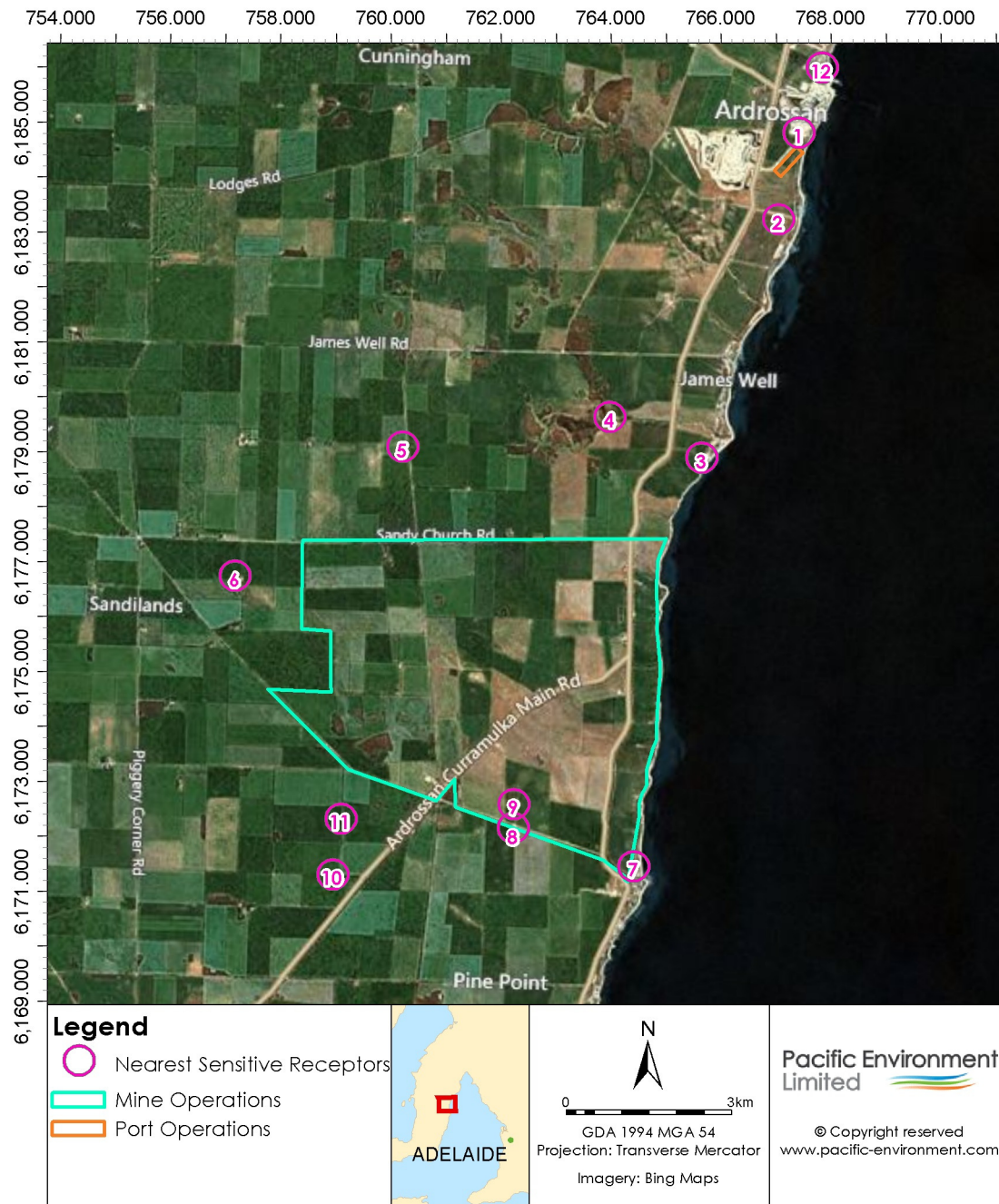


Figure 3.3: Sensitive receptors

4 STUDY APPROACH AND METHODOLOGY

An overview of the assessment and dispersion modelling methodology is presented in Figure 4.1

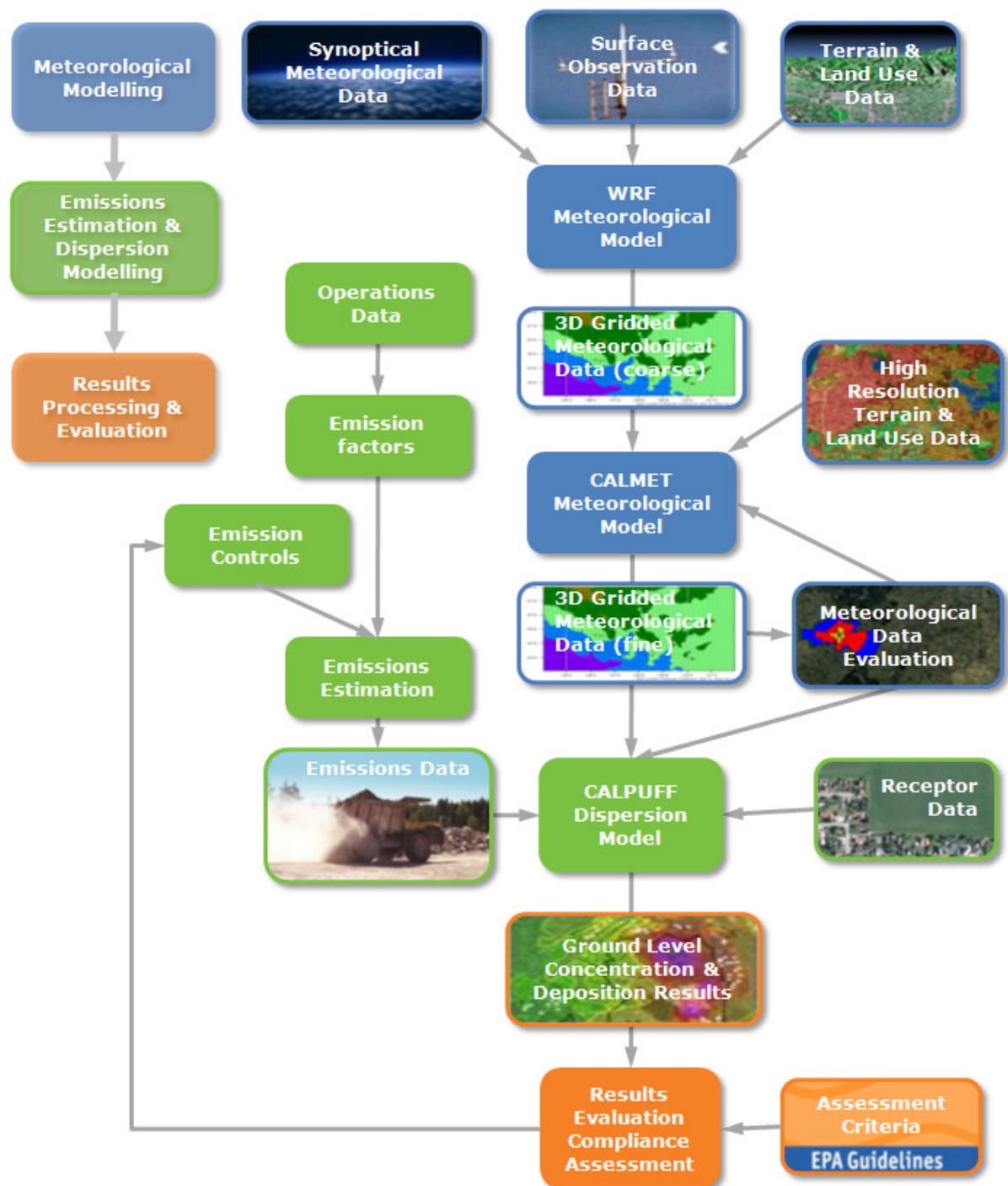


Figure 4.1: Assessment and dispersion modelling methodology

The dust and odour dispersion modelling is based on an advanced modelling system using the models WRF, CALMET and CALPUFF. This system substantially overcomes the basic limitations of the steady-state Gaussian plume models such as AUSPLUME. These limitations are most severe in light winds, in coastal environments and where terrain affects atmospheric flow.

The modelling system works as follows:

- WRF is a prognostic meteorological model that generates gridded three dimensional meteorological data for each hour of the model run period.
- CALMET, the diagnostic meteorological pre-processor for the dispersion model CALPUFF, calculates three dimensional meteorological data based on observed ground and upper level meteorological data, as well as modelled upper air data, generated for example by WRF.
- CALPUFF then calculates the dispersion of plumes within the three dimensional meteorological field processed with CALMET.

4.1 Processing of Meteorological Data

4.2 Meteorological Data Processing

The meteorological data for the dispersion modelling was processed in a two-step process. Synoptic scale meteorological data were first processed in the Weather Research and Forecasting Model (WRF) and then further processed in CALMET to produce fine scale meteorological data for the dispersion modelling with CALPUFF.

4.2.1 WRF

WRF is the 'next-generation' mesoscale numerical weather prediction system and is a replacement for the widely used MM5 system. The model was primarily designed to serve both operational forecasting and atmospheric research needs. WRF features multiple dynamical cores, a 3-dimensional variational data assimilation system and a software architecture allowing for computational parallelism and system extensibility (WRF, 2012).

The model allows simulations reflecting either real data or idealised configurations and is a computationally efficient operational forecasting tool developed to include recent advances in physics, numerics and data assimilation contributed by the research community. WRF is suitable for a broad spectrum of applications across scales ranging from metres to thousands of kilometres. Using WRF for processing of meteorological data for dispersion modelling is a recent development and is currently becoming best practice for many applications (WRF, 2012).

WRF was developed (and continues to be developed) in the United States by a collaborative partnership including the National Center for Atmospheric Research (NCAR), the National Oceanic and Atmospheric Administration (the National Centers for Environmental Prediction (NCEP), the Forecast Systems Laboratory (FSL), the Air Force Weather Agency (AFWA), the Naval Research Laboratory, the University of Oklahoma, the Federal Aviation Administration (FAA) and others (WRF, 2012)

WRF was configured with a domain at 8 km resolution and was assimilated by surface data for the BoM stations at Edinburgh RAAF, Clare, Snowtown, Adelaide Airport, Roseworthy, Noarlunga, Port Augusta and Whyalla. Meteorological data processed by WRF was input to CALMET for further processing down to the fine scale used in the dispersion modelling.

4.2.2 CALMET

CALMET is a meteorological pre-processor that includes a wind field generator containing objective analysis and parameterised treatments of slope flows, terrain effects, and terrain blocking effects. The pre-processor uses the meteorological inputs in combination with land use and geophysical information for the modelling domain to predict a gridded three-dimensional meteorological field (containing data

on wind components, air temperature, relative humidity, mixing height, and other micro meteorological variables) across the domain used in the CALPUFF dispersion model.

The WRF input data to CALMET were processed in a two-step process for an outer and an inner CALMET domain. The domains are presented in Figure 4.2 below.

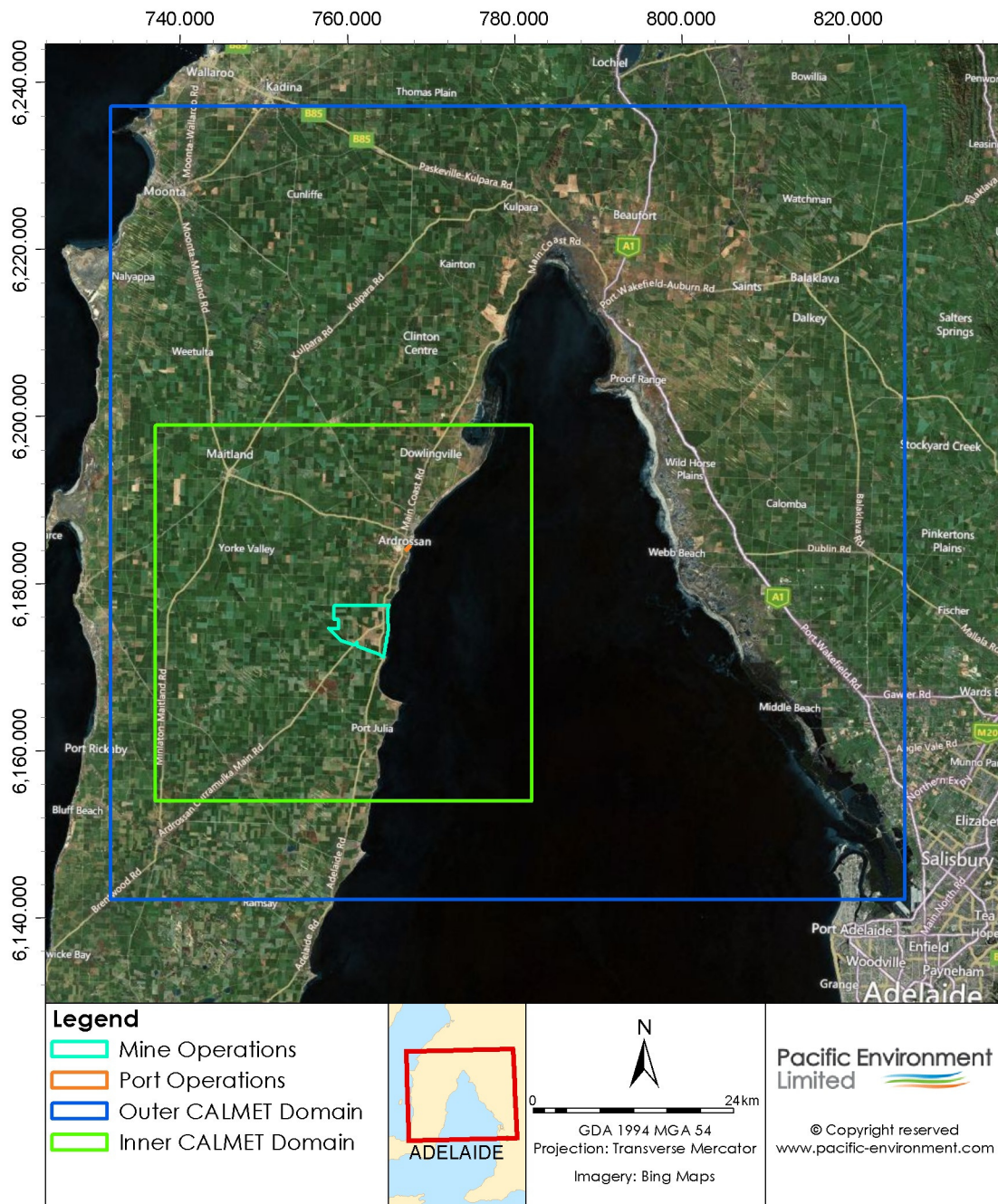


Figure 4.2: Inner and Outer CALMET Domains

For the first step, the WRF data for a larger domain of 95 km by 95 km was processed with a receptor resolution of 1 km.

For the second step the coarse CALMET wind field was further processed for a smaller 45 km by 45 km domain at a finer 300 m grid point resolution. This second step ensures development of the wind field to fine scale topography, land use and other factors near the site, such as land-sea interactions. This step produces the meteorological data for the dispersion modelling with CALPUFF.

High resolution land use data were used in the processing of the meteorological data for both the outer and inner CALMET domains. The land use data used is presented in Figure 4.3.

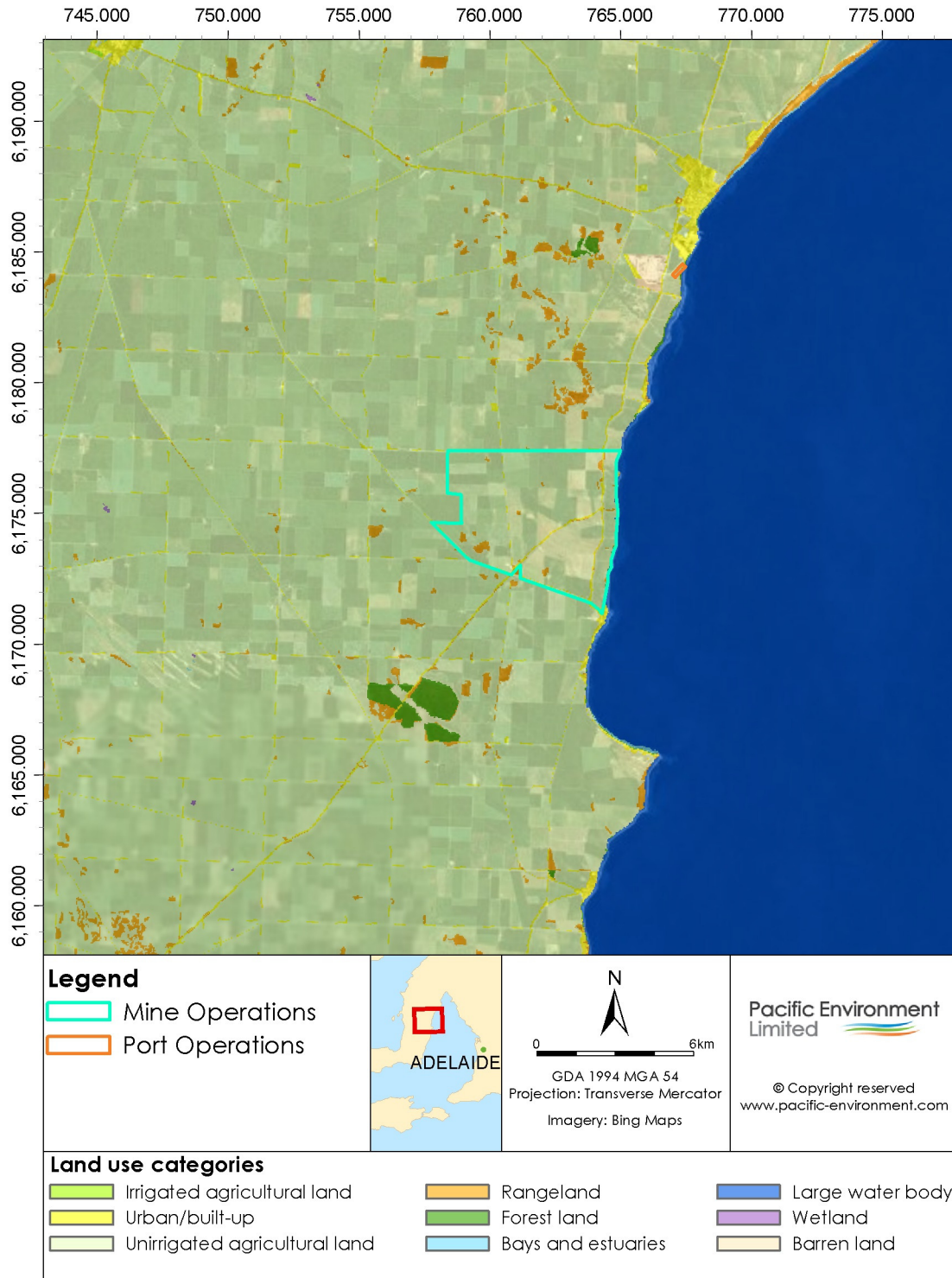


Figure 4.3: Land Use for Inner CALMET Domain

The processed meteorological data is evaluated Section 6.

4.3 Dispersion Modelling

4.3.1 CALPUFF

CALPUFF is a multi layer, multi species, non-steady state puff dispersion model that can simulate the effects of time- and space-varying meteorological conditions on pollutant transport, transformation and removal. The model contains algorithms for near-source effects such as building downwash, partial plume penetration, sub-grid scale interactions as well as longer range effects such as pollutant removal, chemical transformation, vertical wind shear and coastal interaction. The model employs dispersion equations based on a Gaussian distribution of pollutants across released puffs and takes into account the complex arrangement of emissions from point, area, volume and line sources.

As with any dispersion model, CALPUFF requires input in three major areas:

- emission rates
- meteorology
- terrain and surface details as well as receptor locations.

CALPUFF is a US EPA regulatory model for long range transport and for situations affected by complex meteorology, such as very light winds and seabreezes. A detailed description of CALPUFF is provided in the user manual (TRC, 2006).

4.4 Estimation of Emission Rates

Emission rates for the dispersion modelling were estimated based on the proposed mining activities and the proposed mine layout plan.

4.4.1 Dust Emission Rates

Dust emissions were estimated and assessed for the two particle size fractions PM_{10}^a and TSP^b . This allowed for evaluation of impacts of PM_{10} against the NEPM air quality standard to assess the potential for health impacts and TSP for assessment of potential for nuisance dust impacts.

Dust emissions were estimated for all relevant site activities associated with the mine and port operations based on industry best practice emission factors. Dust emissions from mobile and stationary plant equipment and activities, blasting and site wind erosion were included. The assessment scenario assumed advanced mine development and full mine production to account for emissions from site when the mine emissions potential is the largest.

A detailed description of the methods used for emissions estimation is provided in Appendix A.

4.4.2 Odour Emission Rates

Odour emissions were estimated for the TSF. Odour from the processing plant was not included since emissions estimation for other facilities has shown that odour emission rates from the processing plant area are negligible (<<1%) compared to estimated odour emission rates from the TSF. While the concentration of flotation reagents is much higher in the processing plant floatation and mixing vessels, the surface areas for these sources result in much lower emission rates compared to the larger surface area of the TSF.

^a PM_{10} – Particulate matter with equivalent aerodynamical particle diameter of 10 μm or less.

^b TSP – Total suspended particulate matter (for practical purposes, meaning all particles with equivalent aerodynamical particle diameter of about 30 μm or less).

The odour emission rate for the TSF was estimated using data collected from another copper mine in Australia with similar flotation reagents. The surface area of the TSF was assumed to be the maximum possible with the proposed design.

4.5 Background Concentrations

Background concentration data is added to predicted PM₁₀ ground level concentrations in the assessment of impacts against the NEPM air quality standard. Different methodologies to account for background PM₁₀ concentrations can be applied. For this assessment, the method specified in the Victorian SEPP (Victorian Government Gazette, 2001), which uses the 70th percentile of 24 hour average concentrations as a constant background value, was used. This is a common practice. Additional analysis considering a statistical background concentration evaluation method is provided in Appendix B.

Due to its limited availability, the site baseline PM₁₀ data set was not considered sufficient for use as background data. The PM₁₀ baseline monitoring data collected at site is further discussed in Section 8. Instead, Whyalla Schultz Reserve PM₁₀ data was used^c (see Table 4.1) as best available representative data set and the 70th percentile was calculated for the years 2009 to 2012. This 70th percentile PM₁₀ concentration of 18.1 µg/m³ compares to the 79th percentile of the available baseline data.

Table 4.1: PM₁₀ Background Concentration Data

Substance	Monitoring Year	Background Concentration (70 th percentile)	Averaging Period	Monitoring station	Data Availability ^a
PM ₁₀	2009	23.0 µg/m ³	1 day	Whyalla, Schultz Reserve	92.9%
PM ₁₀	2010	16.2 µg/m ³	1 day	Whyalla, Schultz Reserve	98.1%
PM ₁₀	2011	16.6 µg/m ³	1 day	Whyalla, Schultz Reserve	95.3%
PM ₁₀	2012	18.6 µg/m ³	1 day	Whyalla, Schultz Reserve	92.1%
PM ₁₀	2009 – 2012	18.1 µg/m ³	1 day	Whyalla, Schultz Reserve	94.6%

a. Data availability based on validated data. Daily averages were considered invalid with less than 75% of hourly data.

Source: (SA EPA, 2013)

^c Considering differences between urban and more rural conditions in PM₁₀ data it was considered that the Whyalla Schultz Reserve location is likely more representative for background data on Yorke Peninsula than any of the Adelaide metropolitan monitoring locations.

5 ASSESSMENT CRITERIA

The study assesses dust impacts by comparing PM₁₀ and TSP concentrations and dust deposition rates to the assessment criteria proposed in the baseline monitoring program. Odour impacts are assessed against the SA EPA Odour Guidelines.

5.1 Dust Impact Assessment Criteria

Predicted PM₁₀ concentrations are assessed against the National Environment Protection Measure for Ambient Air Quality (NEPM) criterion of 50 µg/m³ for 24hr average.

There are no South Australian assessment criteria for TSP concentration and dust deposition rates. Hence, the NSW impact assessment criteria for TSP annual average of 90 µg/m³ and dust deposition rate of 2 g/m²/month are applied (DEC (NSW), 2005).

5.2 Odour Impact Assessment Criteria

Odour impacts are assessed against the SA EPA guideline *Odour Assessment using Odour Source Modelling, April 2007* (SA EPA, 2007b).

The odour assessment criteria defined by the SA EPA are presented in Table 5.1. These criteria apply to 99.9th percentile dispersion modelling results calculated as 3-minute averages. The guidelines are intended to be used for a defined population cluster and multiple criteria may be applied to account for the varying population densities in different directions or locations from the odour source being assessed.

Table 5.1: Odour assessment criteria

Number of people	Odour units (ou) (3-minute average, 99.9%)
2,000 or more	2
350 or more	4
60 or more	6
12 or more	8
Single residence (less than 12)	10

Source: (SA EPA, 2007b)

The relevant assessment criteria determined based on population data were 4 ou for Ardrossan, 6 ou for James Well and Pine Point and 10 ou for single residences.

Odour impact criteria are typically represented by three variables:

- concentration
- averaging time
- percentile.

Concentration refers to odour strength. Odour concentration for odour samples is determined by dynamic olfactometry. However, it is worthwhile noting that the odour concentrations of dispersion modelling results cannot normally be measured. The measurement of odour concentration is therefore more relevant to the emissions measurement component of the modelling process.

Averaging time for odour criteria are typically 1 hour or 3 minutes. Dispersion models used for predicting odour concentrations use a basic time interval of one hour for individual calculations. To obtain results for shorter averaging periods than 1 hour, the 1 hour concentration is typically converted using a statistical relationship.

The **percentile** value refers to the percentage of time during which the modelled odour concentration is no greater than the stated concentration. An odour criterion specified for the 99.9th percentile allows

exceedances of the criteria for 0.1% of the modelling period. For an assessment period of 12 months of hourly data (~8760 hours) this means that the 8 hours of highest concentrations are disregarded. For a lower percentile like the 99.5th percentile the 44 hours of highest concentrations are disregarded. By decreasing the percentile, the reliance of the dataset on maximum type values reduces, meaning that more frequent meteorological patterns become more evident, and a more typical pattern of odour contours can be seen. Odour criteria associated with lower percentile values (like the 99.5th percentile) tend to be set lower than odour criteria for higher percentile values (like the 99.9th percentile) to maintain predicted separation distances in the results.

6 METEOROLOGICAL DATA USED IN THE ASSESSMENT

The primary meteorological parameters involved in modelling plume dispersion are wind direction, wind speed, temperature, turbulence (atmospheric stability) and mixing height (depth of turbulent layer).

6.1 Wind

Wind conditions affect the rate of plume dilution and the direction in which a plume travels. Wind speed may also affect emission rates: for example, wind-blown dust.

The wind roses in this section show the frequency of occurrence of winds by direction and strength. The bars correspond to the 16 compass points (north, north-north-east, north-east etc). The bar at the top of each wind rose diagram represents winds blowing from the north (i.e. northerly winds), and so on. The length of the bar represents the frequency of occurrence of winds from that direction, and the colour of the bar sections correspond to wind speed categories, as per the legend. Thus it is possible to visualise how often winds of a certain direction and strength occur over any period of time.

Wind roses plotted from data extracted from CALMET for the mine site are presented in Figure 6.1 to Figure 6.3. These can be compared against the site observation data plotted in Figure 6.4. The prevailing wind direction at the site is southerly, often as an afternoon sea breeze. The generated data have a slightly lower average wind speed and a slightly higher frequency of northerly winds.

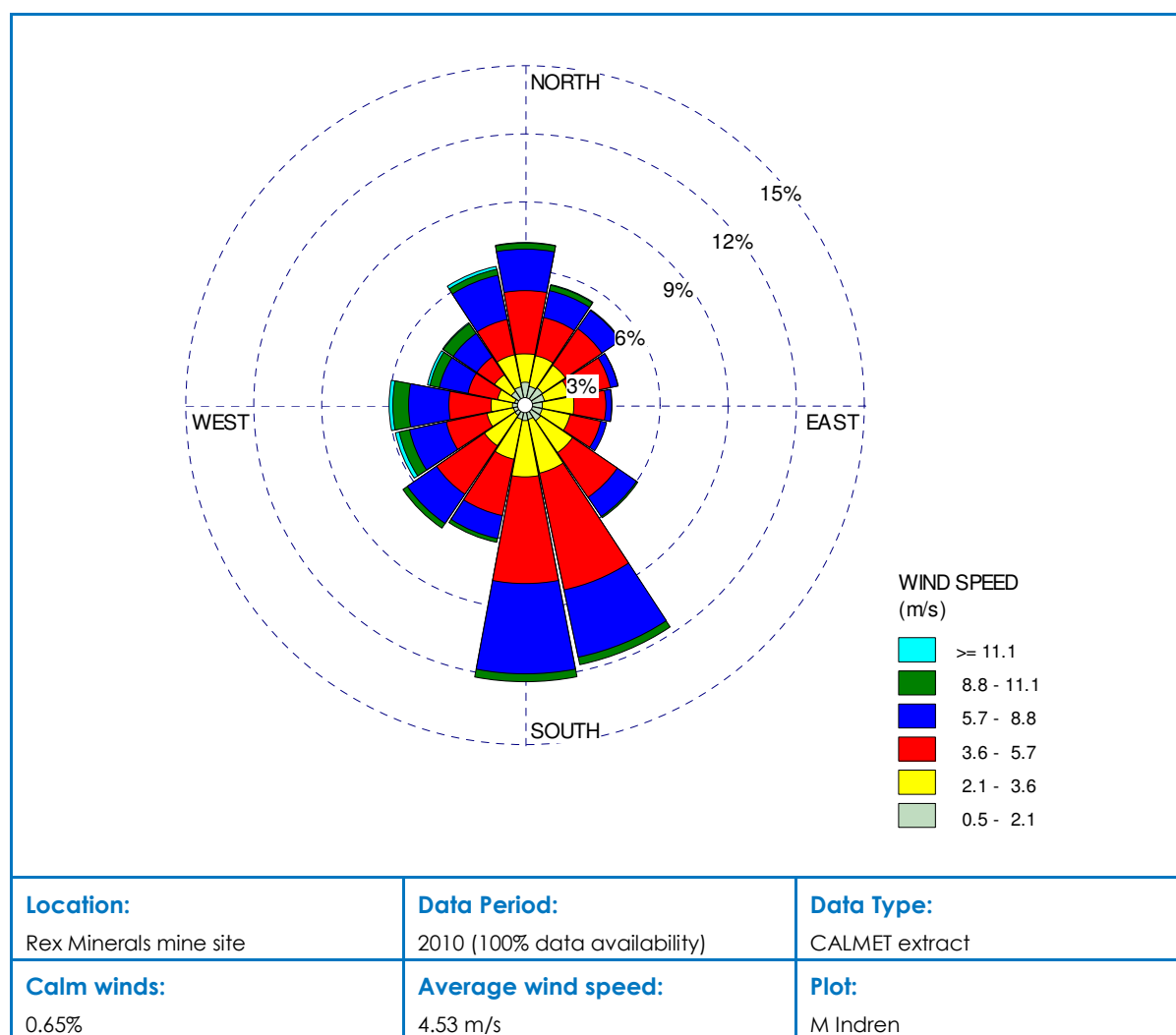


Figure 6.1: Wind rose for the Rex Minerals mine site

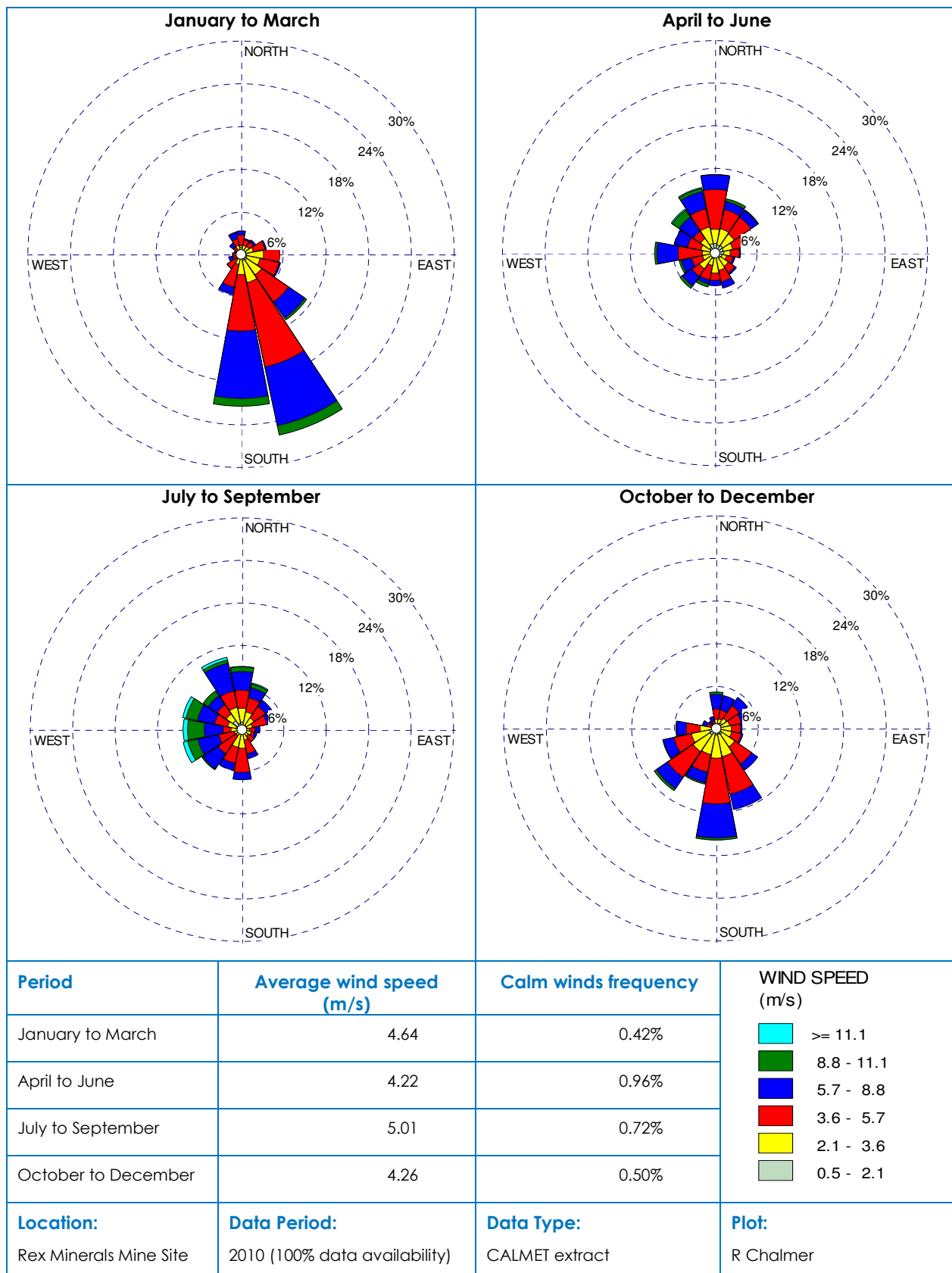


Figure 6.2: Wind roses for the Rex Minerals mine site (time of year)

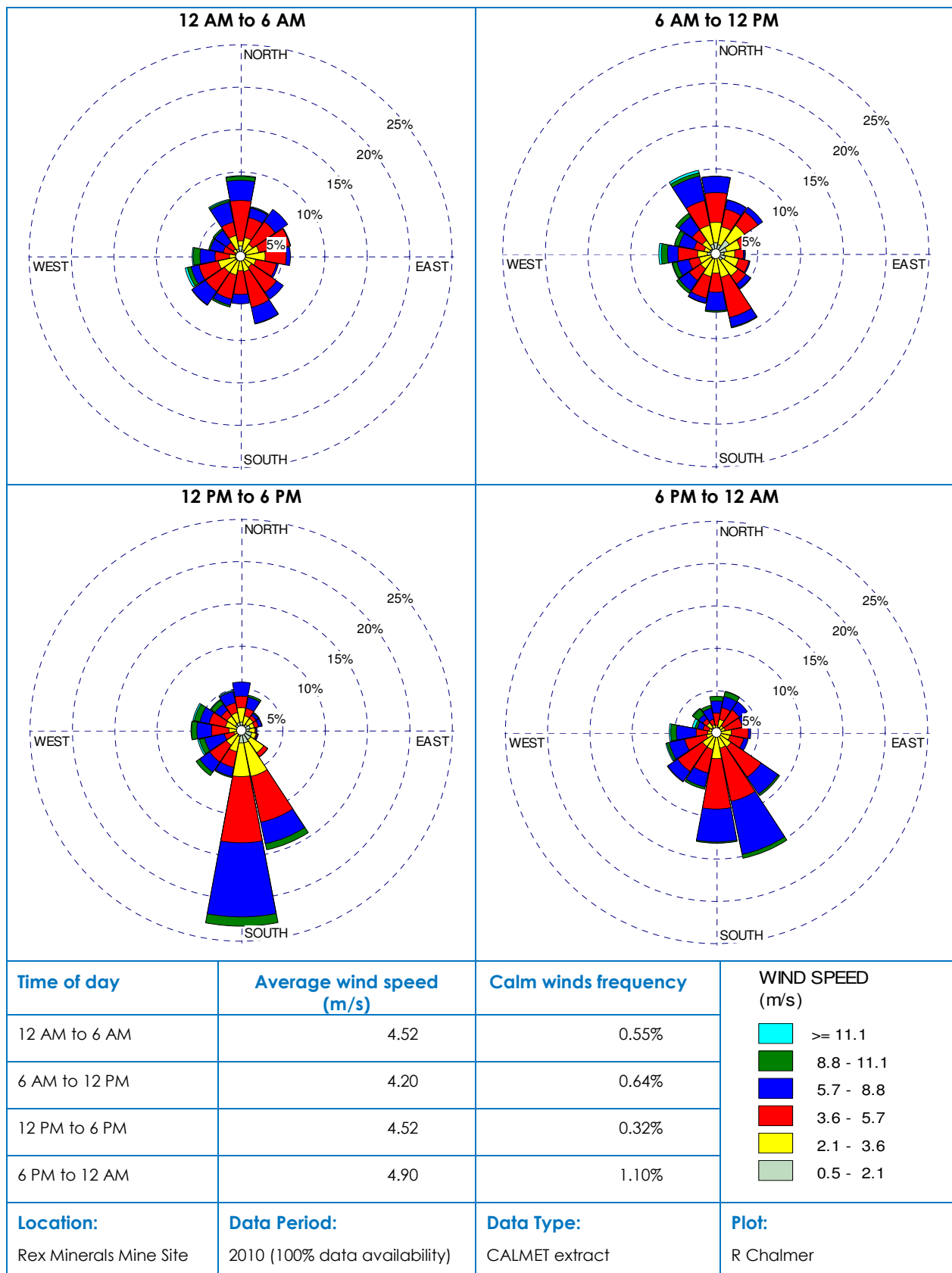


Figure 6.3: Wind rose for the Rex Minerals mine site (time of day)

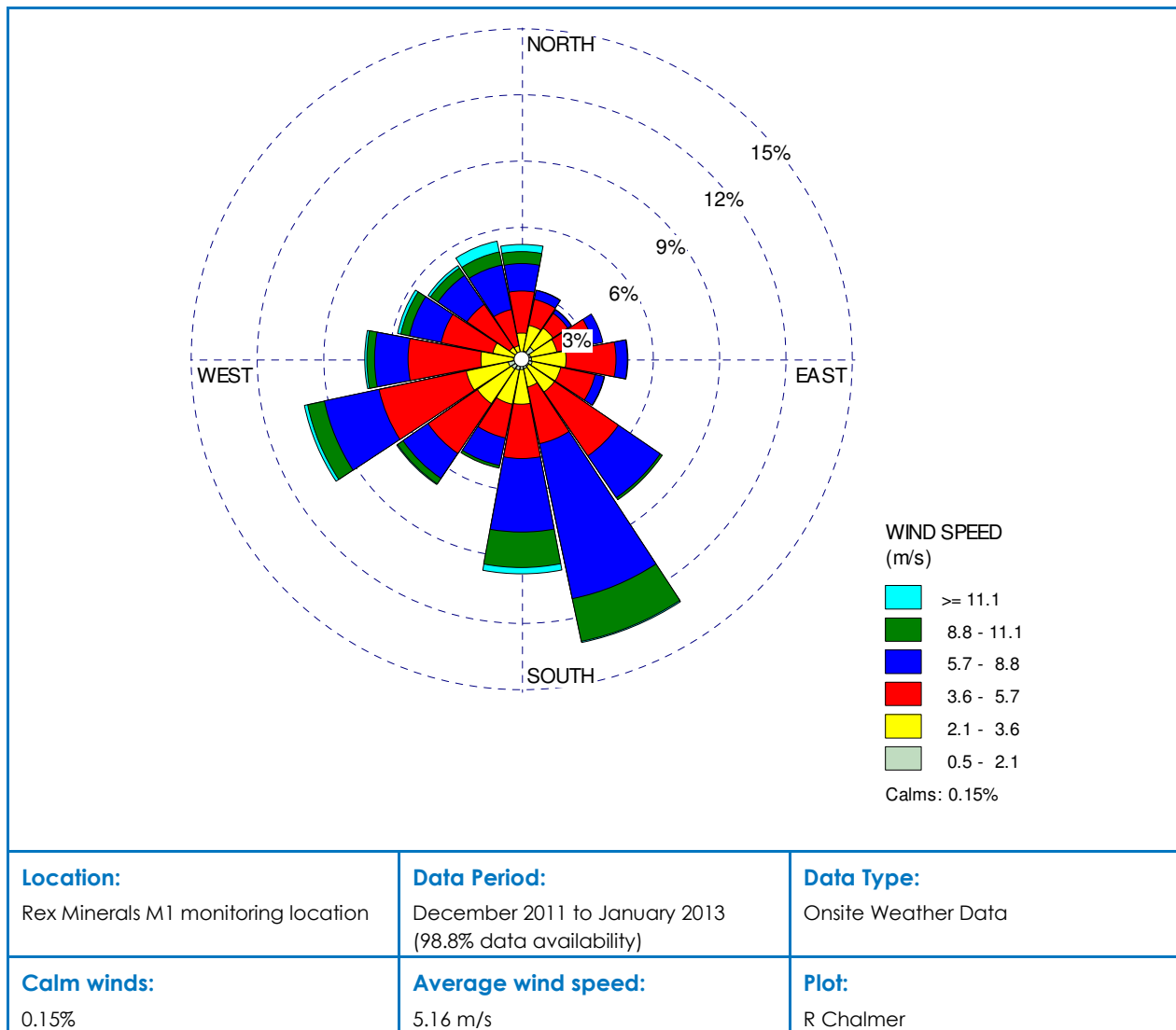


Figure 6.4: Wind rose for the Rex Minerals mine site (observations)

6.2 Stability

Atmospheric turbulence is an important factor in plume dispersion. Turbulence acts to increase the cross-sectional area of the plume due to random motions, thus diluting or diffusing a plume. As turbulence increases, the rate of plume dilution or diffusion increases. Weak turbulence limits plume diffusion and is a critical factor in causing high plume concentrations downwind of a source, particularly when combined with very low wind speeds.

Turbulence is related to the vertical temperature gradient, the condition of which determines what is known as stability, or thermal stability. For traditional dispersion modelling using Gaussian plume models, categories of atmospheric stability are used in conjunction with other meteorological data to describe atmospheric conditions and thus dispersion.

The most well-known stability classification is the Pasquill-Gifford scheme^d, which denotes stability classes from A to F. Class A is described as highly unstable and occurs in association with strong surface heating and light winds, leading to intense convective turbulence and much enhanced plume dilution. At the other extreme, class F denotes very stable conditions associated with strong temperature inversions and light winds, which commonly occur under clear skies at night and in early mornings. Under these conditions plumes can remain relatively undiluted for considerable distances downwind.

Intermediate stability classes grade from moderately unstable (B), through neutral (D) to slightly stable (E). Whilst classes A and F are strongly associated with clear skies, class D is linked to windy and/or cloudy weather, and short periods around sunset and sunrise when surface heating or cooling is small. As a general rule, unstable (or convective) conditions dominate during the daytime and stable flows are dominant at night. This diurnal pattern is most pronounced when there is relatively little cloud cover and light to moderate winds.

The frequency distributions of stability classes in the CALMET meteorological file are presented in Figure 6.5. The data shows a high frequency of occurrence of D class stability which is typical for coastal and windy locations.

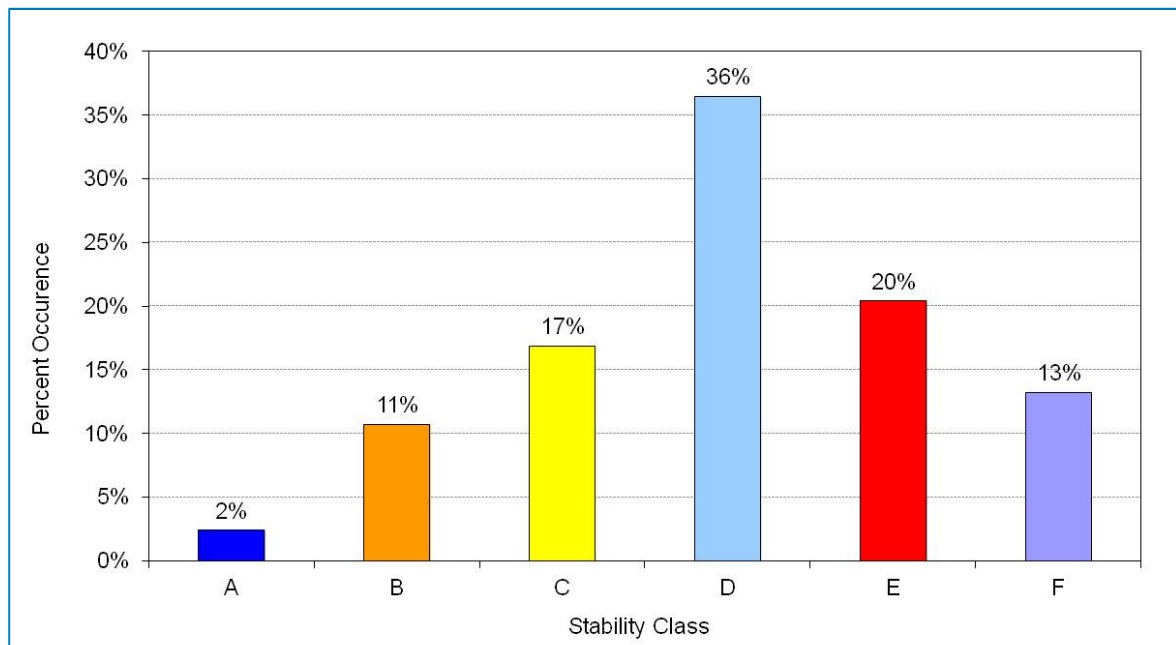


Figure 6.5: Frequency distribution of the estimated stability classes at the Rex Minerals mine site

^d A more accurate turbulence scheme within CALPUFF, based on micrometeorological parameters was used for the modelling.

6.3 Mixing Height

Mixing height is the depth of the atmospheric mixing layer beneath an elevated temperature inversion. It is an important parameter in air pollution meteorology as vertical diffusion or mixing of a plume is generally considered to be limited by the mixing height. This is because the air above this layer tends to be stable, with restricted vertical motions.

The estimated diurnal variation of mixing height at the site is presented in Figure 6.6. The diurnal cycle is clear in this figure. At night, mixing height is normally relatively low. After sunrise, it increases in response to convective mixing due to solar heating of the earth's surface. The CALMET estimated mixing height behaviour is consistent with expectations for near coastal locations.

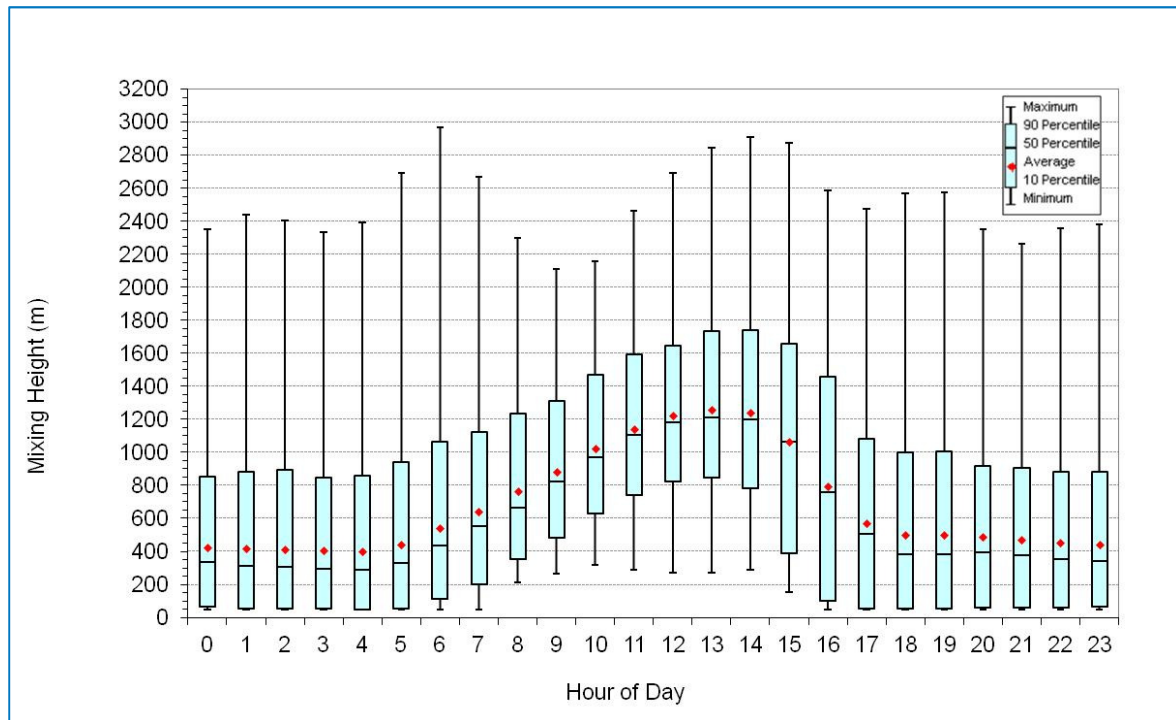


Figure 6.6: Estimated mixing heights at the Rex Minerals mine site

7 EMISSION ESTIMATION

7.1 Odour Emissions

The TSF odour emissions data was sourced from another copper mine in Australia with similar flotation reagents. The odour data was collected with the isolation flux hood method and based on an average of four samples (two samples taken on the dry TSF beach and two samples taken on the wet TSF beach).

The surface area for the TSF used was the maximum TSF surface area of the wet and dry beaches as estimated from site plans.

Odour emissions from the mine processing plant area were excluded from the assessment since the total contribution of odour emissions from this area is less than 1% of emissions from the TSF.

Table 7.1: Summary of Odour Emissions

Source	Total odour emission rate (ou s ⁻¹)	Odour emission rate (ou m ⁻² s ⁻¹)	Surface area (m ²)	Modelling source type
TSF	596,600	0.38	1,570,000	Area source

7.2 Dust Emissions

Dust emission rates for TSP and PM₁₀ are summarised in Table 7.2 and Table 7.3, also including percentages of estimated emissions per source and the applied emission control options. The applied dust controls for mining and port operations are summarised in Table 7.4 and Table 7.5. Full details on the dust emission estimation are provided in Appendix A. The contributions to total emissions of TSP and PM₁₀ from site activities are presented in Figure 7.1.

Table 7.2: Summary of TSP and PM₁₀ Emissions

	Annual TSP Emissions (kg/year)	Annual PM ₁₀ Emissions (kg/year)
Pit Activities (including haul roads within the pit)	589,378	356,984
Loading and Unloading Activities	68,957	29,026
Wind Erosion from Exposed areas	19,249	9,625
Haul Roads outside of pit	675,032	192,415
Crushing Activities	22,500	9,000
Port Operations	6,111	2,444
TOTAL EMISSIONS	1,381,227	599,494

Table 7.3: Dust Sources with Emissions Percentages and Applied Emission Controls

Proposed Facility Source	Emission Substance	% of Total Emissions	Emission Control Options
Wheel Generated Dust	Nuisance Dust (TSP)	85%	Road way salt spray
	PM ₁₀	77%	Road way silt content
Dust emissions from blasting activities	Nuisance Dust (TSP)	4.2%	
	PM ₁₀	9.6%	
Materials handling dust emissions from activities within the pit	Nuisance Dust (TSP)	2.5%	Ore moisture content No controls other than pit retention
	PM ₁₀	5.0%	
Materials handling dust emissions from activities outside the pit	Nuisance Dust (TSP)	5.0%	Ore moisture content Water sprays Enclosures Wind breaks
	PM ₁₀	4.8%	
Dust emissions from crushing activities	Nuisance Dust (TSP)	1.6%	Ore moisture content Enclosure Water sprays
	PM ₁₀	1.5%	
Wind erosion dust emissions from waste rock stockpile	Nuisance Dust (TSP)	0.9%	Lower disturbance rate Rehabilitation
	PM ₁₀	1.0%	
Wind erosion dust emissions from exposed areas	Nuisance Dust (TSP)	0.5%	Water sprays Wind breaks
	PM ₁₀	0.6%	
Dust emissions from port operations	Nuisance Dust (TSP)	0.4%	Enclosed concentrate handling shed under negative pressure Baghouse High moisture content Telescopic chute with dust suppression skirt Water sprays
	PM ₁₀	0.4%	
Dust emissions from drilling activities	Nuisance Dust (TSP)	0.01%	Fabric filters during drilling
	PM ₁₀	0.02%	

Table 7.4: Dust Sources from Mine Operations with Dust Controls and Control Efficiencies

Description of Activity	Description of Dust Control	Control Efficiency	
		CE _{TSP}	CE _{PM10}
Ore loaded into crusher	Water Sprays Enclosure	85%	85%
Unloading of ore at ROM pad	Water sprays on unloading trucks	70%	70%
Unloading of waste rock at waste rock dumps	Water sprays on unloading trucks	70%	70%
Wheel generated dust from transport of copper ore in pit	Salt sprays on road Pit Retention	97%	93%
Wheel generated dust from transport of waste rock in pit	Salt sprays on road Pit Retention	97%	93%
Wheel generated dust from transport of copper ore outside pit	Salt sprays on road	93%	93%
Wheel generated dust from transport of waste rock in pit	Salt sprays on road	93%	93%
Drilling Operations	Pit Retention Fabric Filter for Drilling	99.5%	99.1%
Blasting Operations	Pit Retention	50%	5%
Wind erosion from ROM pad stockpile	Water Sprays Wind Breaks	65%	65%
Wind erosion from copper ore main stockpile	Water Sprays Wind Breaks	65%	65%
Wind erosion from waste rock dumps	No controls (disturbed monthly)	0%	0%
Primary crushing of copper ore	Water Sprays Enclosure	85%	85%
Conveying from Primary crusher to main stockpile	Water Sprays Wind Breaks	65%	65%
Conveying from main stockpile to SAG mill	Water Sprays Enclosure	85%	85%
Use of excavators/shovels/front end loaders within the pit	Pit Retention	50%	5%
Use of excavators/shovels/front end loaders at the ROM pad	Water Sprays	50%	50%
Open pit maintenance (bulldozers)	Pit Retention	50%	5%
ROM pad stockpile maintenance (bulldozers)	Water Sprays	50%	50%
Main stockpile maintenance (bulldozers)	Water Sprays	50%	50%

Table 7.5: Dust Sources from Port Operations with Dust Controls and Control Efficiencies

Description of Activity	Description of Dust Control Factor	Control Efficiency	
		CE _{TSP}	CE _{PM10}
Concentrate handling within Shed – Fugitive Emissions	Total Enclosure Water Sprays	99.5%	99.5%
Concentrate handling within Shed – Baghouse Stack Emissions	Fabric Filter Water Sprays	99.5%	99.5%
Conveying from Concentrate handling shed to ship loader	Enclosure	70%	70%
Ship Loading	Telescopic chute with water sprays Wind Guards	88%	88%

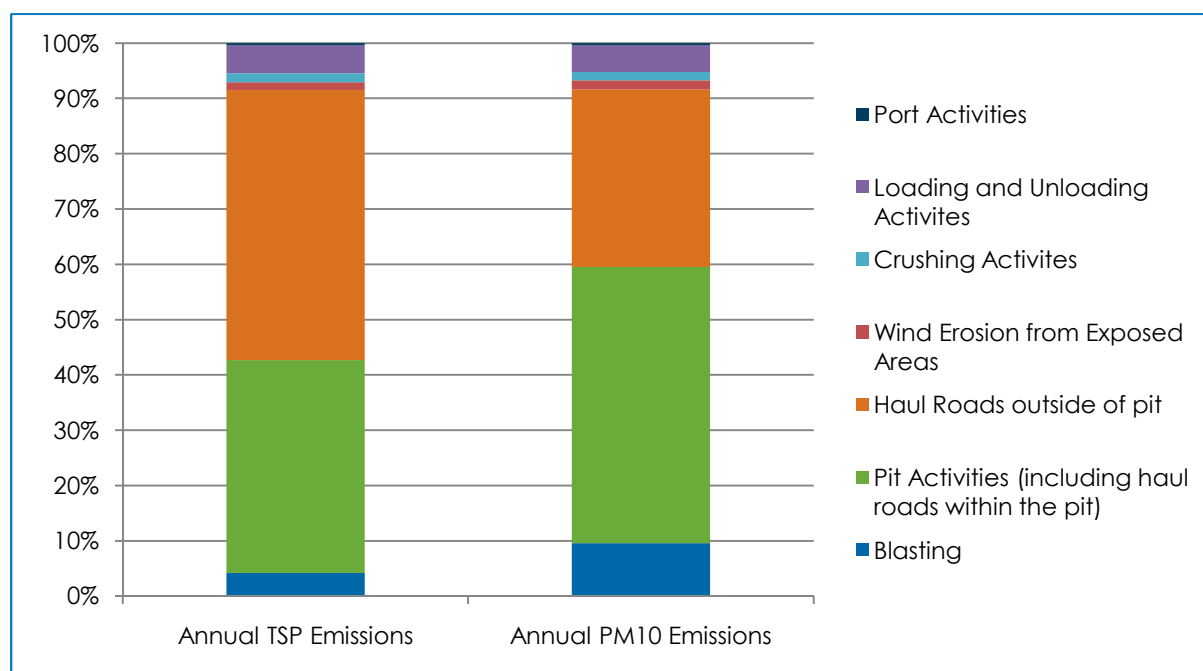


Figure 7.1: Source Contribution of TSP and PM₁₀ Emissions from Site

8.2 Ambient PM₁₀ Concentrations

Ambient PM₁₀ monitoring was conducted from the 10th of January 2012 to the 2nd of November 2012. The data availability for this entire period was 67%. The PM₁₀ data is summarised in Table 8.1.

A polar plot of the hourly average PM₁₀ concentration is shown in Figure 8.2.

Table 8.1: Ambient Daily Average PM₁₀ Concentration Data Statistics

Month	Number of Exceedances ^a	Monthly Average (µg/m ³)	Maximum (µg/m ³)	2nd Highest (µg/m ³)	6th Highest (µg/m ³)	90th Percentile	Data Recovery ^b
January ^c	1	15.6	55.4	39.9	17.3	24.1	95%
February ^d	0	-	-	-	-	-	0%
March ^d	0	-	-	-	-	-	0%
April ^e	0	11.6	39.3	36.3	13.6	20.3	80%
May	2	14.6	100.7	75.2	14.0	16.6	100%
June ^f	0	10.1	20.3	17.3	11.8	17.1	53%
July ^g	0	8.4	15.3	14.2	9.9	13.4	61%
August	0	12.1	41.1	22.0	14.3	18.8	100%
September ^h	3	21.1	198.3	65.8	16.8	34.5	97%
October	0	12.9	34.7	24.3	19.3	21.0	100%
November ⁱ	0	9.0	10.6	7.3	-	10.3	-
Overall	6	12.8	198.3	100.7	55.4	20.7	67%

- Exceedances above the daily average NEPM guideline of 50 µg/m³
- Data recovery based on validated data. Daily averages were considered invalid with less than 75% of hourly data.
- Data recorded from 10th January to the 30th of January, data missing from the 31st of January due to complications in the data transfer/download
- Data missing for the February and March due to complications in the data transfer/download
- Data missing from the 1st to the 7th of April due to complications in the data transfer/download
- Data missing from the 11th to the 25th of June due to complications in the data transfer/download
- Data missing from the 18th to the 30th of July due to broken tape
- Data missing from the 25th to the 26th of September due to complications in the data transfer/download
- Data missing from the 3rd of November onwards due to flow failures and hardware issues

The baseline data showed that the NEPM air quality standard was exceeded on one occasion in January, two occasions in May and three occasions in September. These events occurred on days with high northerly wind speeds and with regional observations ^e also demonstrating elevated PM₁₀ concentrations.

^e Ambient air quality monitoring data for the Adelaide region provided by the South Australian EPA.

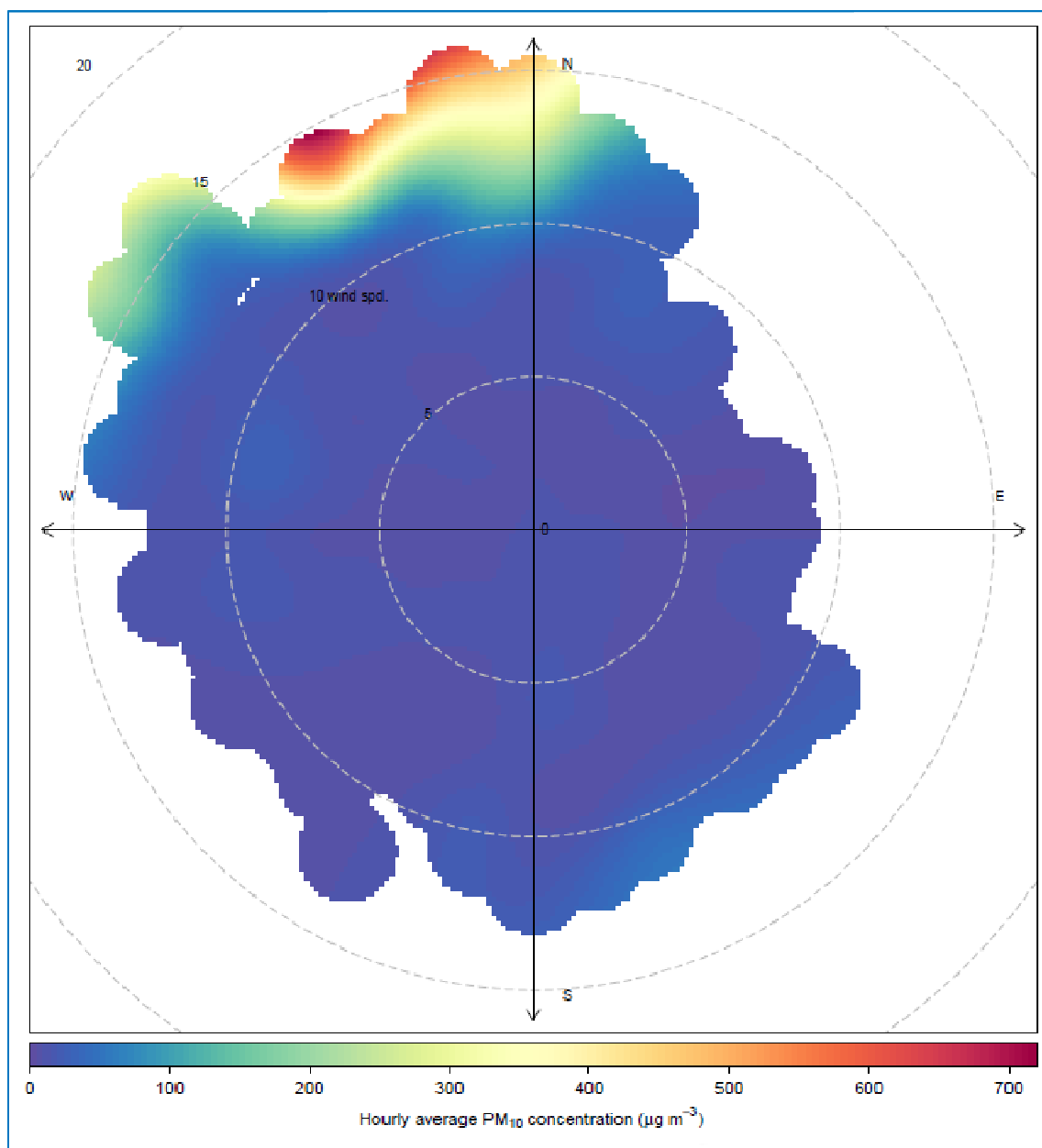


Figure 8.2: Polar Plot of Hourly Average PM₁₀ Concentrations (coloured) against wind speed in metres per second (distance from centre)

The plot presented in Figure 8.2 shows that the highest PM₁₀ concentrations occur with strong north north-westerly winds.

8.3 Ambient TSP Concentrations

Ambient TSP concentrations were sampled at M1 using a HiVol. The sampling program was for sampling every 6th day as per the Australian Standard. The available ambient TSP data are presented in Table 8.2 and Figure 8.3. The last recorded monitoring result was significantly higher than previous results. No specific contributing factor has been possible to identify in regard to this at this stage.

Table 8.2: Ambient TSP Concentration Data Statistics

Year	Average (µg/m ³)	Maximum (µg/m ³)	2nd Highest (µg/m ³)	6th Highest (µg/m ³)	90th Percentile (µg/m ³)	Number of Samples
21 February to 21 November 2012 ^a	26.0	178	63.4	26.5	41.9	33

a. Data missing for the month of July

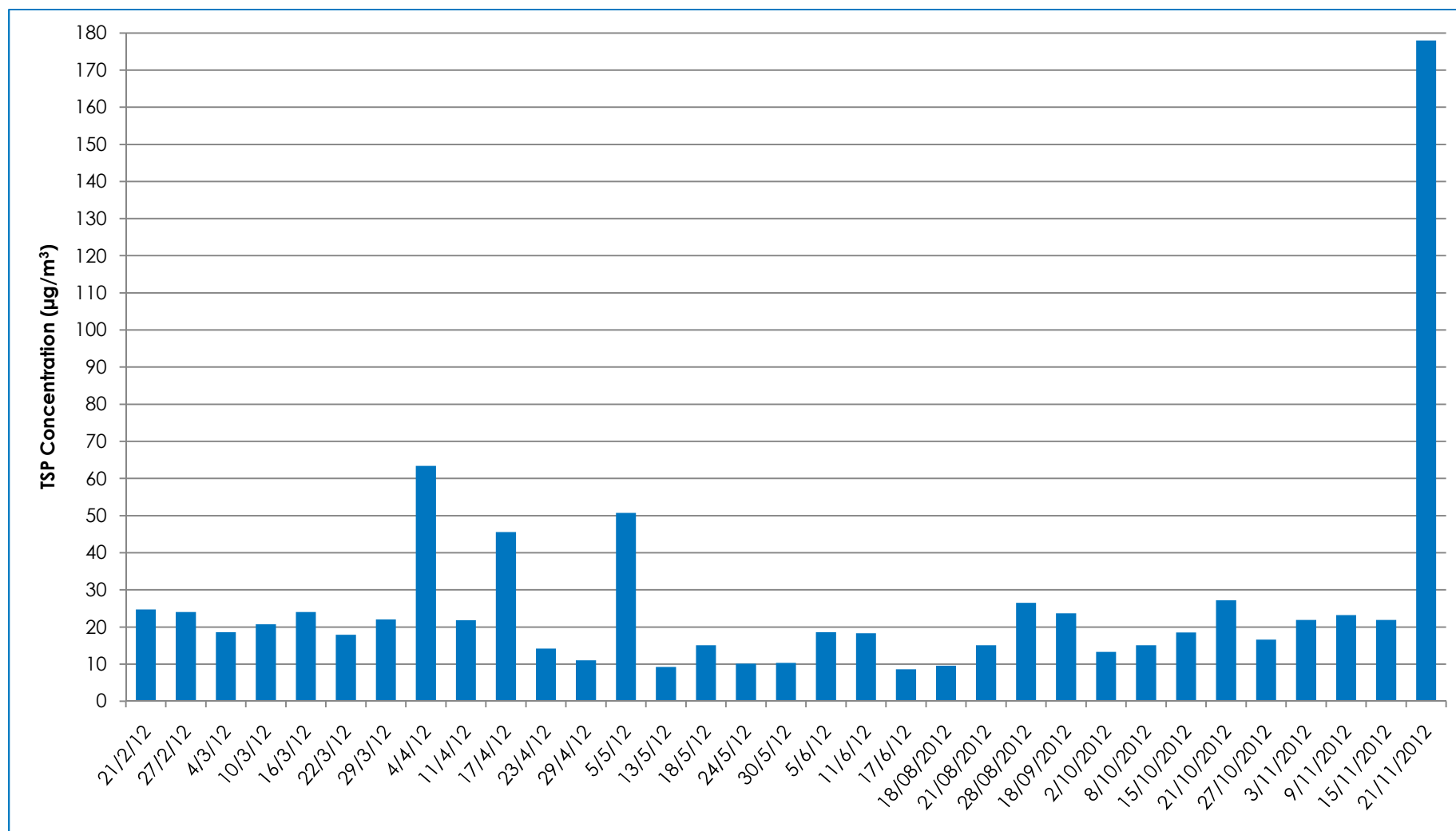


Figure 8.3: Measured On-site TSP Concentration Data

8.4 Dust Deposition

The dust deposition monitoring provides dust deposition rates (reported as total insoluble matter) at each location. Results were available for all monitoring locations from December 2011 to November 2012. Location M18 was installed in September 2012. Duplicate data was available for M6, M9 and M13 for the months of August and September 2012.

All available dust deposition data are presented in Table 8.3 and the averages for each location are presented in Table 8.4.

Table 8.3: Total insoluble matter (dust) deposition monitoring results

Monitoring Location	Total Insoluble Matter Deposition Rate (g/(m ² month))													
	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12	May-12	Jun-12	Jul-12	Aug-12	Duplicate Aug-12 ^a	Sep-12	Duplicate Sep-12 ^a	Oct-12	Nov-12 ^b
M1	5.6	0.7	7.8	3.4	2.7	<0.1	2.1	<0.1	8.7	-	50.2	-	5.1	4
M2	0.4	0.4	0.3	0.2	0.8	<0.1	1	0.6	1.5	-	0.4	-	0.8	3
M3	0.1	0.2	2.9	<0.1	0.4	<0.1	1.1	0.6	1.5	-	0.2	-	0.7	0.6
M4	0.3	0.3	0.3	0.2	0.7	0.5	0.2	0.2	0.4	-	0.1	-	0.6	0.8
M5	<0.1	0.5	0.3	0.2	0.3	1.2	4	0.3	2.1	-	5.9	-	6.5	2.3
M6	0.2	0.8	2.3	5.2	6.2	14.2	4.6	4.3	2.5	1.6	0.5	0.1	2.1	1.1
M7	0.4	0.6	0.3	0.4	0.1	1.1	9	0.5	3.2	-	0.9	-	1.0	1
M8	0.3	0.2	0.2	0.1	<0.1	0.1	1.3	0.2	9.3	-	0.4	-	1.2	1.1
M9	0.5	1.5	0.5	0.3	1.5	<0.1	30.5	0.5	1.4	45.7	9.8	2	2.5	5.8
M10	2.8	0.5	0.6	0.2	0.4	1.7	3	0.5	4.4	-	1.3	-	2.4	6.6
M11	0.8	13.1	0.7	2.6	0.6	0.2	0.2	<0.1	2.0	-	1.2	-	0.9	0.6
M12	1	53.9	2.3	0.6	0.4	<0.1	0.4	0.2	2.4	-	1.6	-	6.9	12.4
M13	1.7	0.9	0.4	0.5	0.6	0.2	0.4	0.3	0.8	10	0.1	0.1	0.8	0.8
M14	0.7	0.3	0.2	0.3	0.6	0.2	0.4	0.2	3.5	-	17.2	-	1.3	3.4
M18	-	-	-	-	-	-	-	-	-	-	0.2	-	1.0	0.7

a. Duplicate analysis results conducted by SIMTARS

b. Analysis conducted by SIMTARS for all monitoring locations

Table 8.4: Average Total Dust Deposition for each location

Monitoring Location	Average Total Dust Deposition (g/(m ² .month)) ^a
M1	3.66
M2	0.79
M3	0.71
M4	0.38
M5	1.98
M6	3.26
M7	1.54
M8	1.21
M9	2.20
M10	2.03
M11	1.92
M12	2.57
M13	1.26
M14	1.01
M18	0.63

- a. Average for all available data including duplicate results. Data greater than or equal to 2 standard deviations (15.5 g/(m².month)) were considered invalid and removed. Values of <0.1 were taken as 0.1 g/(m².month)

9 DISPERSION MODELLING RESULTS

9.1 Odour

The predicted odour impacts are presented in Figure 9.1 and demonstrate compliance for all receptors.

It is our experience that odour emissions from mining activities from processing plants and TSFs are very limited. In most situations there is no detectable odour over TSFs or only the very lowest level of detectable odour present.

The shorthand notation in the figure captions incorporate percentile and averaging time in the form of $C_{p,t}$ where C is the concentration and the subscripts p and t refer to the percentile value and the averaging time, respectively. Hence, $C_{99.9, 3\text{-min}}$ refers to the 99.9th percentile 3-minute average concentration.

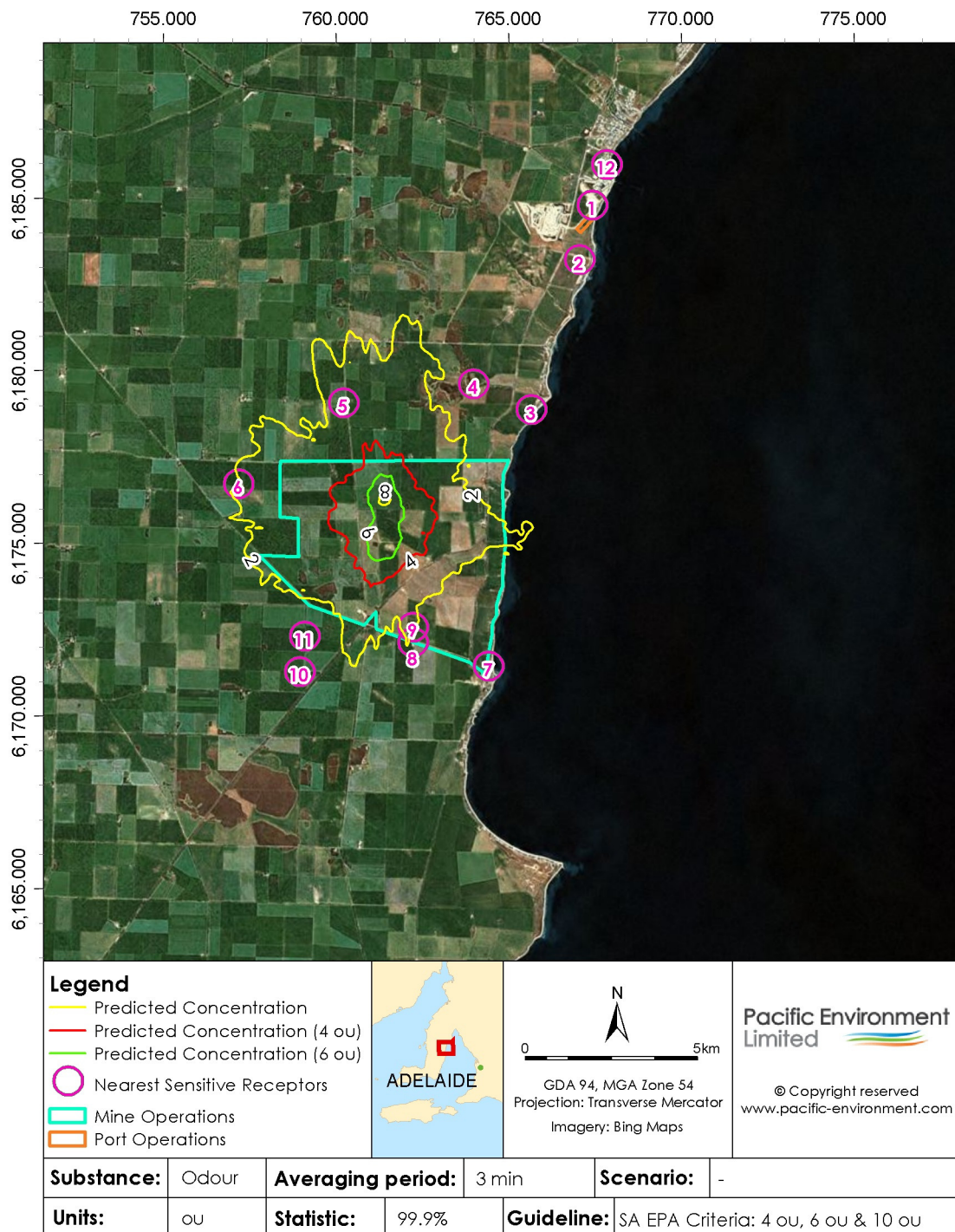


Figure 9.1: C_{99.9}, 3-min Predicted Odour Concentration Contours

As presented in Figure 9.1 compliance is predicted at all receptors with a significant margin. The assessment criteria were determined as:

- 4 ou for Ardrossan – receptor 1 and 12
- 6 ou for James Well and Pine Point – receptors 3 and 7
- 10 ou for single receptors – receptors 2, 4, 5, 6, 8, 9, 10, 11

9.2 Dust

9.2.1 PM Concentration

Table 9.1 shows results expressed as the maximum daily average PM₁₀ concentrations for full production on all days. These results include background concentration and assume that dust controls (as listed in Table 7.3) are applied. The results presented in Table 9.1 are also plotted in Figure 9.4. A contour plot of the maximum predicted daily PM₁₀ concentrations for mining operations is presented in Figure 9.2. A contour plot of the maximum predicted daily PM₁₀ concentrations for port operations excluding background concentration is presented in Figure 9.3.

In addition to the maximum predicted daily concentrations in Table 9.1, the predicted peak concentrations excluding the top 1, 2, 3, 4, 5 and 10 days are also included. This demonstrates that compliance for all receptors can be achieved if operations are actively managed by avoiding or restricting relevant operations in the worst dispersion and sensitive receptor exposure conditions. This is an increasingly common practice and can be done by incorporating real-time dust and wind monitoring information into operational decisions.

The predicted exceedances for the full all-days mine production are at receptors 8 and 9, which are the closest receptors to the south of the mine. Typical conditions contributing to the peak concentrations were identified as stable light wind conditions from the northerly direction, generally occurring overnight and in the early morning. The full distributions of predicted daily concentrations are presented in Figure 9.5 and Figure 9.6.

The proposed dust control systems for the port operations are expected to significantly reduce emissions from the materials handling associated with the ore storage and ship loading. The predicted impacts from port operations, assuming controls in place, are minimal.

The source contributions to the maximum predicted daily average PM₁₀ concentration at each sensitive receptor are presented in Figure 9.7. This identifies haul road activities as the most significant source contributing to peak impacts.

Table 9.1: Maximum Predicted Daily Average PM₁₀ Concentration at Nearest Sensitive Receptors

Receptor	Maximum Predicted Daily Average PM ₁₀ Concentration (µg/m ³) ^a						
	Maximum	1 day excluded	2 days excluded	3 days excluded	4 days excluded	5 days excluded	10 days excluded
1	22.8	22.6	21.9	21.5	21.3	21.3	20.4
2	25.2	23.8	23.0	22.0	21.8	21.8	21.0
3	35.3	33.7	30.3	30.1	28.0	26.5	24.7
4	40.7	32.9	32.7	32.5	31.3	29.8	26.8
5	27.6	26.8	26.5	26.2	25.6	24.2	22.7
6	27.8	27.0	25.7	25.4	22.8	22.6	21.8
7	39.7	35.0	34.7	34.1	33.4	33.3	28.0
8	60.3	46.0	41.5	41.2	37.7	37.5	30.3
9	57.5	52.9	52.7	49.6	40.5	39.3	33.8
10	39.4	34.4	30.4	28.9	25.5	25.0	23.3
11	44.3	32.5	30.8	30.6	29.2	27.4	24.7
12	22.2	21.9	21.7	21.6	21.3	20.8	20.4

a. Including background concentration of 18.1 µg/m³

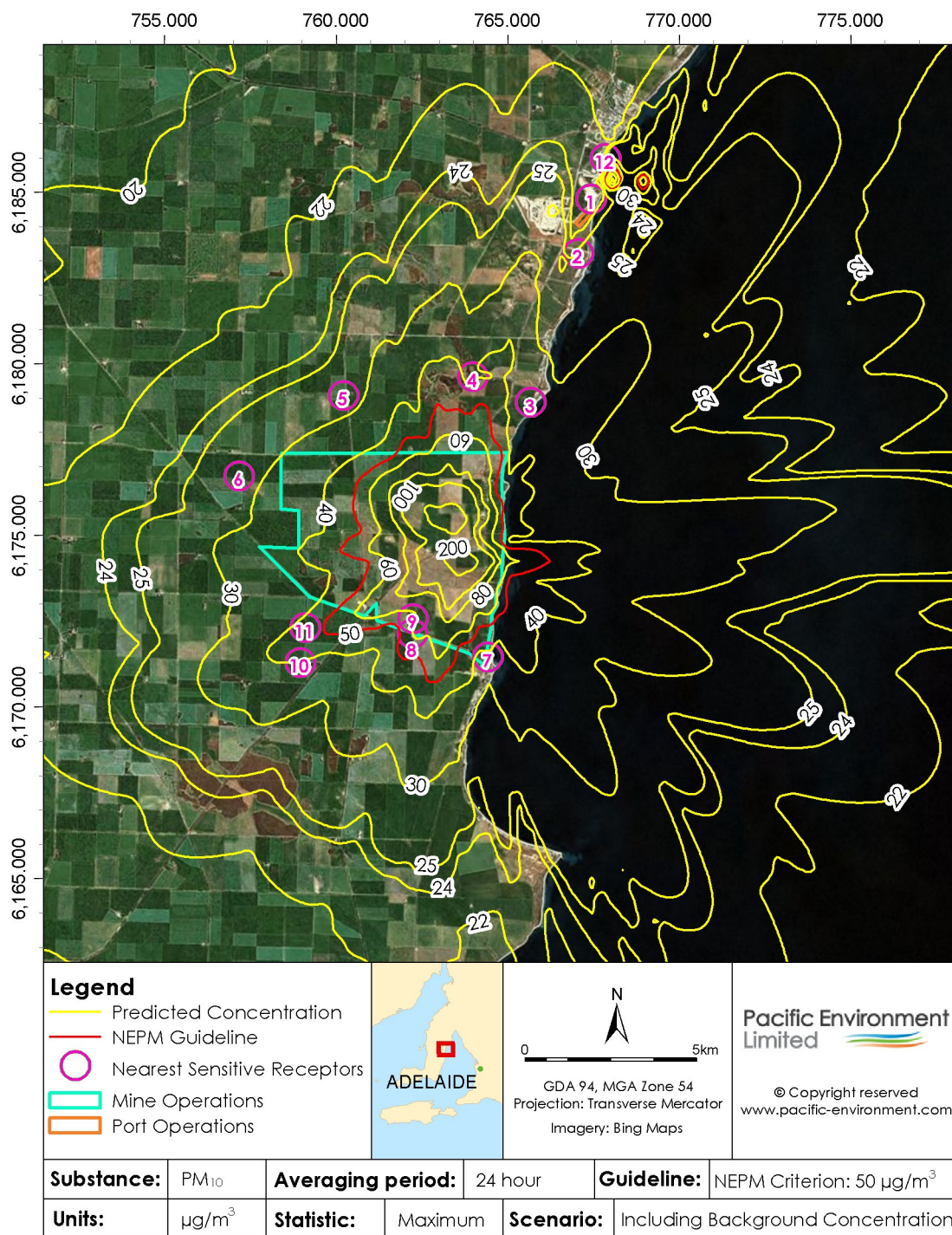


Figure 9.2: Predicted maximum 24-hour PM₁₀ Concentration (Mine Operations) – including background concentration

The results plotted in Figure 9.2 and Figure 9.3 are based on full production for all days with no limitations on operations. Compliance with the NEPM criterion of 50 µg/m³ is predicted at receptors 1 to 7, 10 to 12. Receptor 8 displays compliance 364 days of the year and receptor 9 displays compliance for 362 days of the year. In regard to sensitivity of the applied background PM₁₀ concentration an increase to 20 µg/m³ would result in 361 days of compliance for receptor 9. This can be seen in Table 9.1 and the distributions of predicted daily concentrations at receptors 8 and 9 are also presented in Figure 9.5 and Figure 9.6.

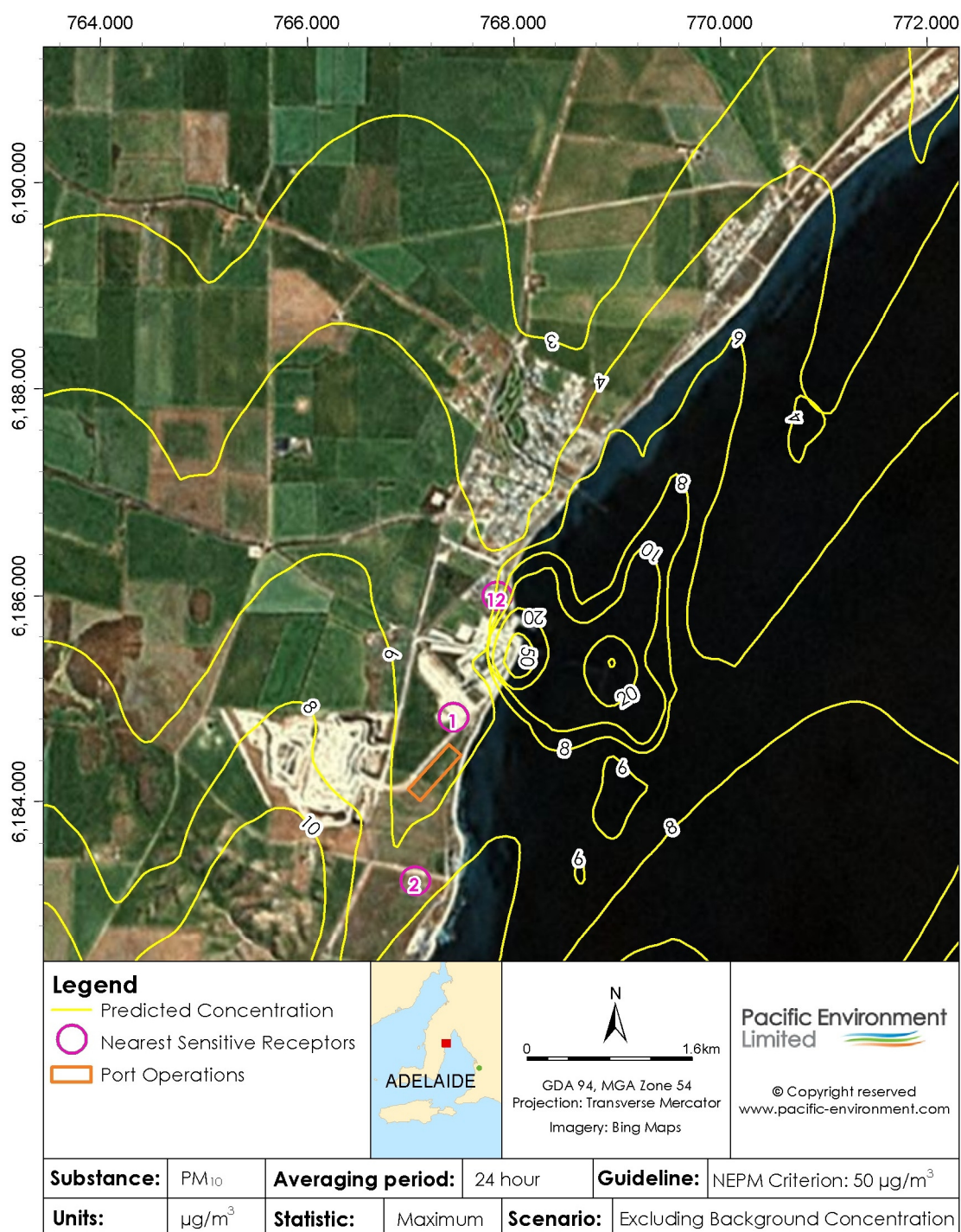


Figure 9.3: Predicted maximum 24-hour PM₁₀ Concentration (Port Operations) – excluding background concentration

The results for the predicted maximum PM₁₀ impacts from the port operations (also including the impacts from the mine) are presented in Figure 9.3. These results are presented without addition of background concentration data. Specific baseline PM₁₀ data has not been obtained for the port however the results demonstrate that impacts are concentrated around the conveyer transfer point and the ship loading locations with fairly rapid drop-offs in impacts from these sources.

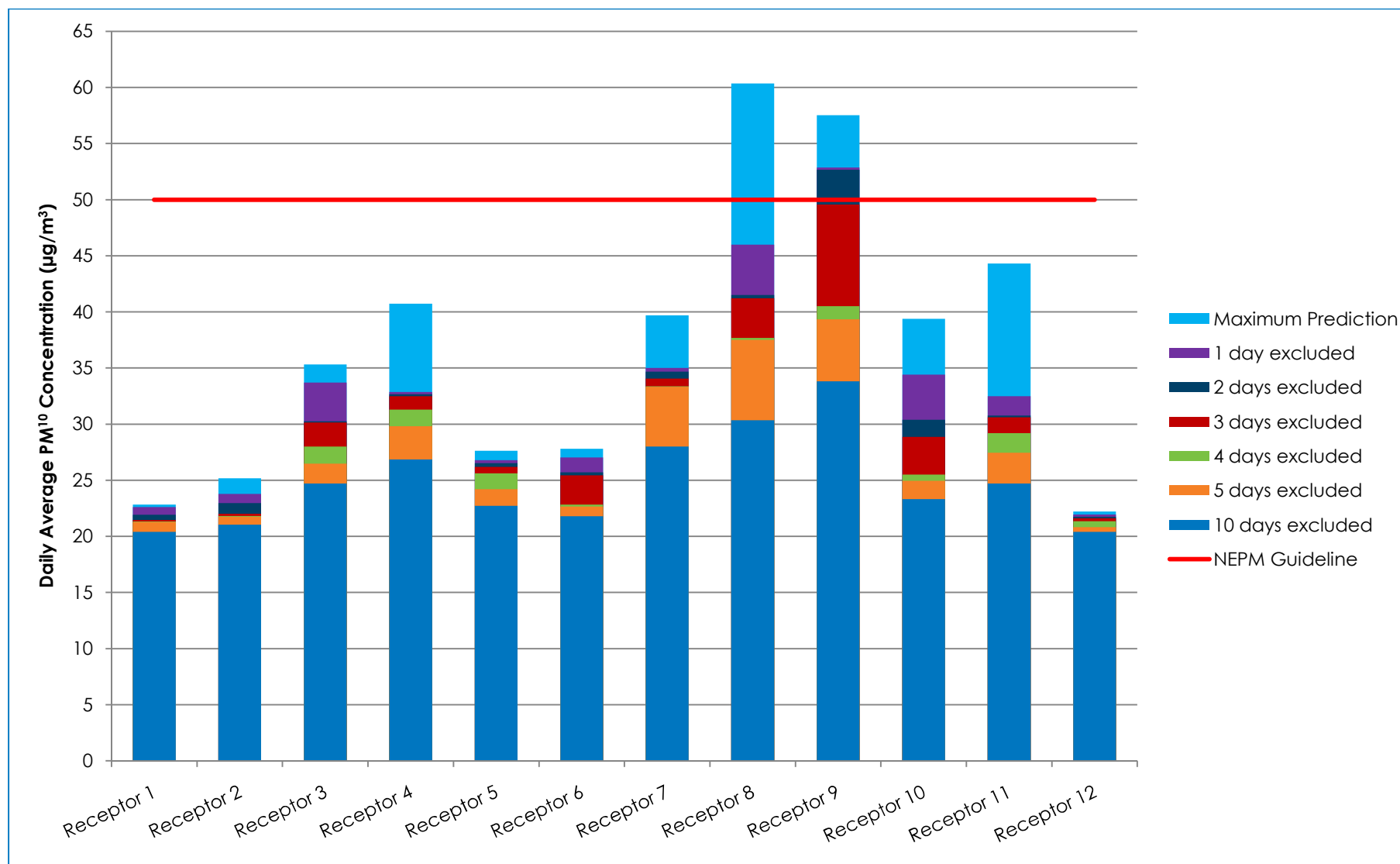


Figure 9.4: Maximum Predicted Daily Average PM₁₀ Concentration for Nearest Sensitive Receptors (including background concentration)

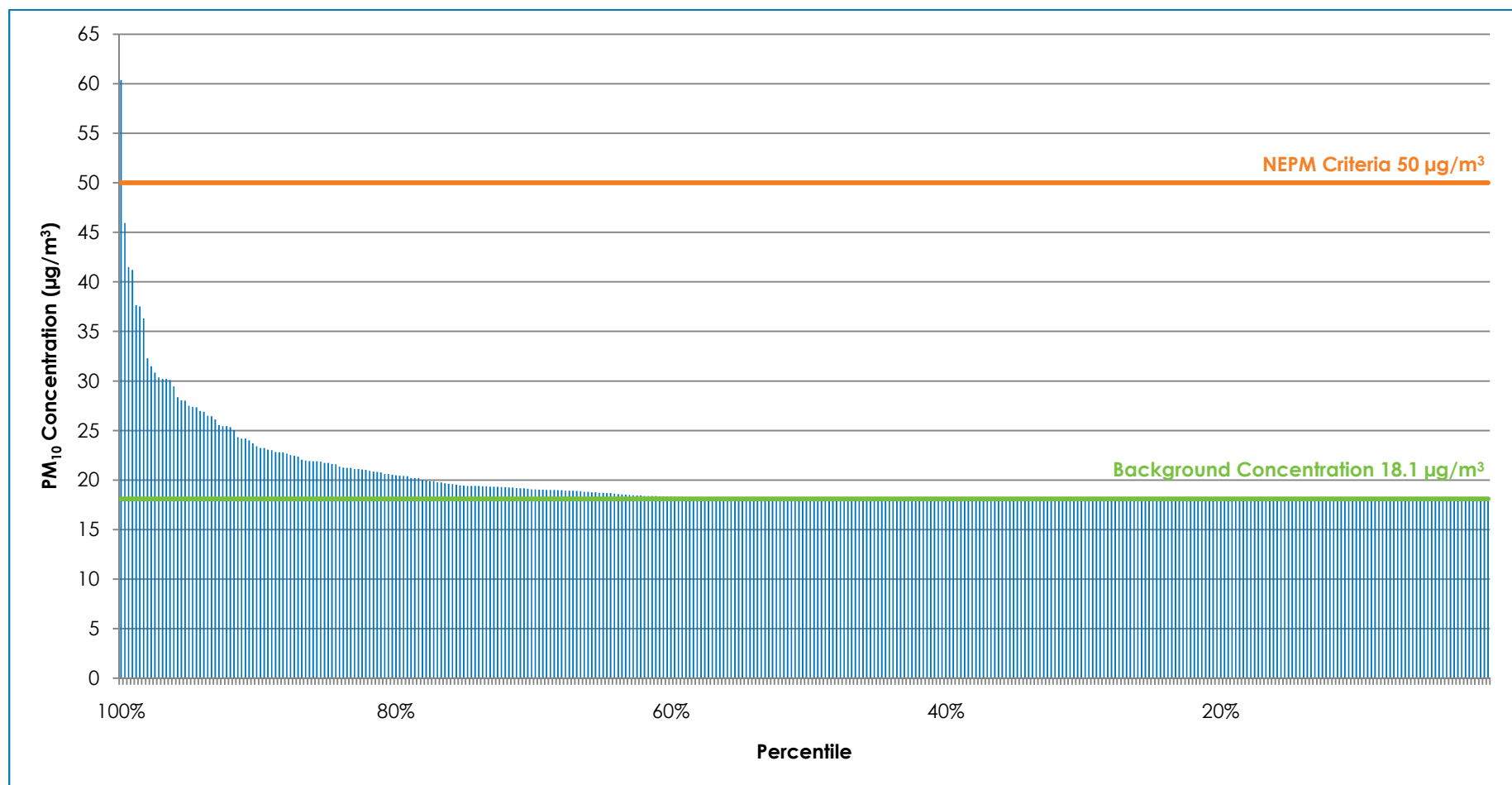


Figure 9.5: Daily Average PM₁₀ Concentrations against Percentile for Receptor 8

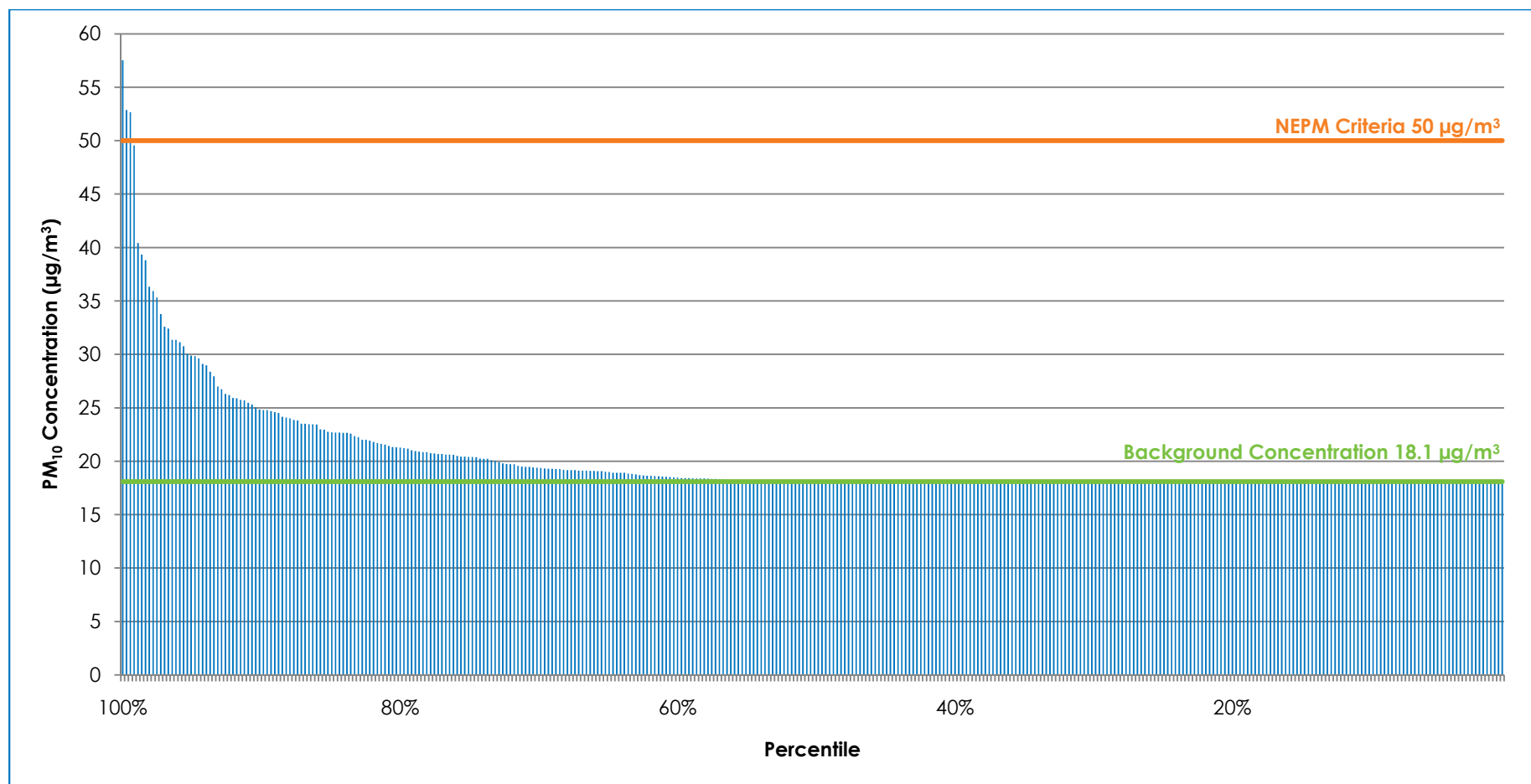


Figure 9.6: Daily Average PM₁₀ Concentrations against Percentile for Receptor 9

Figure 9.7 shows that the largest contributing source of PM₁₀ at the peak impacts is hauls roads. Since haul road emissions are directly related to activity, management of the haul road activities is predicted to offer the most effective way of controlling operations to avoid exceedances.

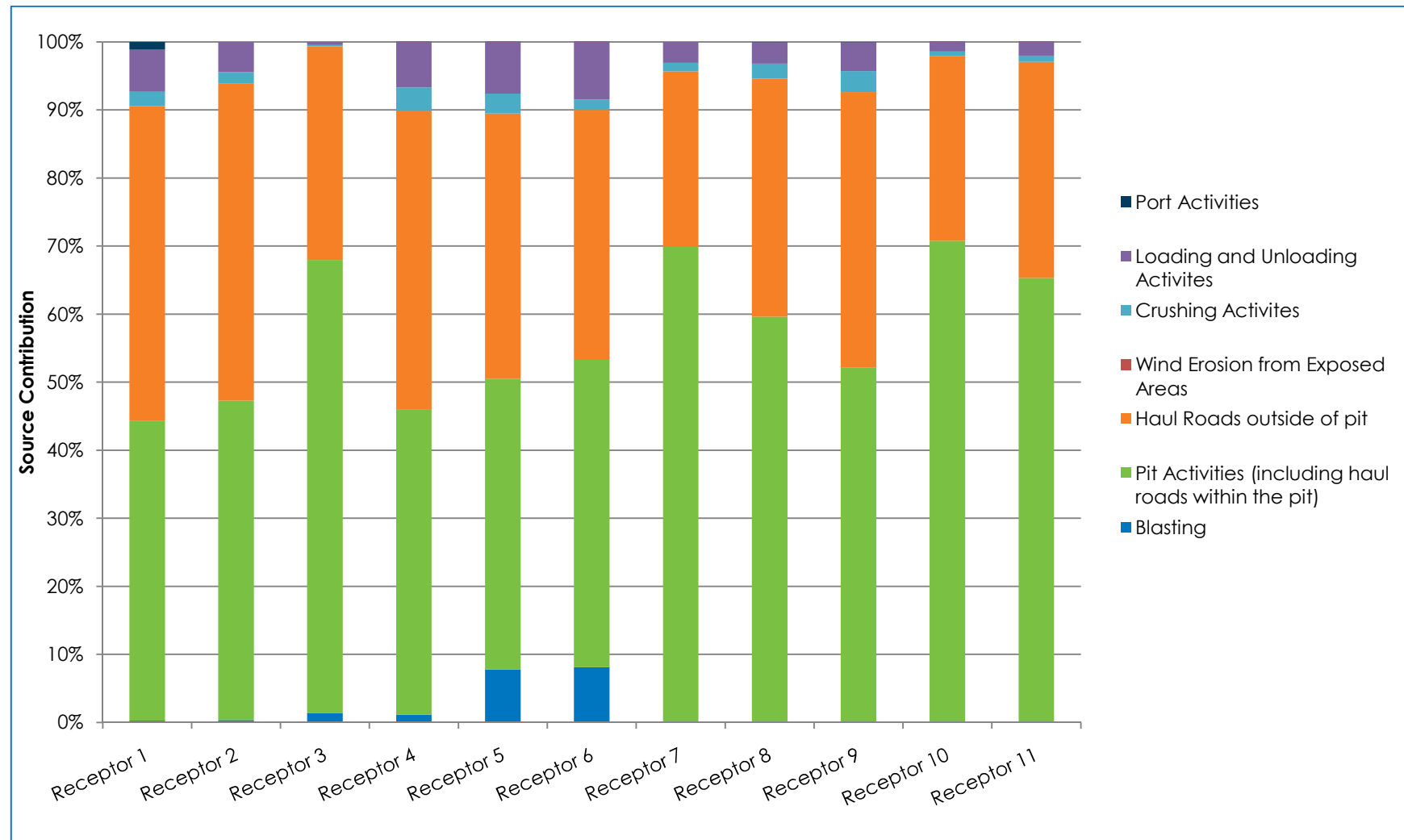


Figure 9.7: Source Contribution for Maximum Predicted Daily Average PM₁₀ Concentration at Nearest Receptor (excluding background concentration)

Predicted annual average TSP concentrations are presented in Table 9.2 (excluding background concentration) and Table 9.3 (including background concentration). Contour plots are presented for the mine operations in Figure 9.8 and port operations in Figure 9.9.

Table 9.2: Annual Average TSP Concentration (excluding background)

Receptor	Annual Average TSP Concentration ^a (µg/m ³)
1	0.44
2	0.54
3	1.64
4	1.86
5	1.21
6	0.74
7	1.94
8	2.80
9	3.60
10	1.02
11	1.31
12	0.52

a. Not including background TSP concentration

Table 9.3: Annual Average TSP Concentration (including background)

Receptor	Annual Average TSP Concentration ^a (µg/m ³)
1	26.4
2	26.5
3	27.6
4	27.9
5	27.2
6	26.7
7	27.9
8	28.8
9	29.6
10	27.0
11	27.3
12	26.5

a. Including background annual average TSP concentration (26 µg/m³)

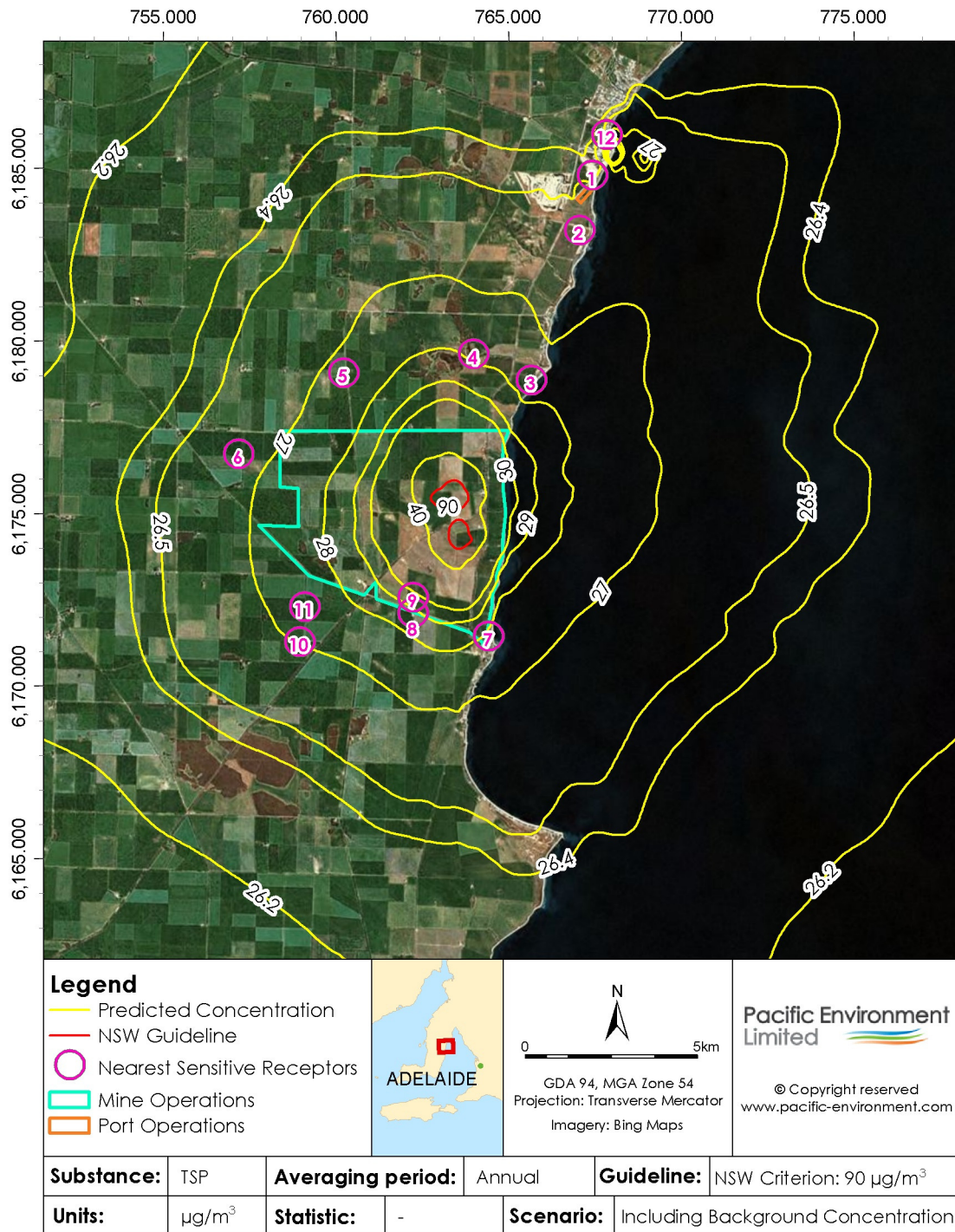


Figure 9.8: Predicted Annual Average TSP Concentration (Mine Operations) – including background concentration

Evaluation against the NSW criterion for the annual average concentration of 90 µg/m³ shows compliance at all receptors. From Figure 9.8 it is shown that 90 µg/m³ contour line is contained within the site boundary.

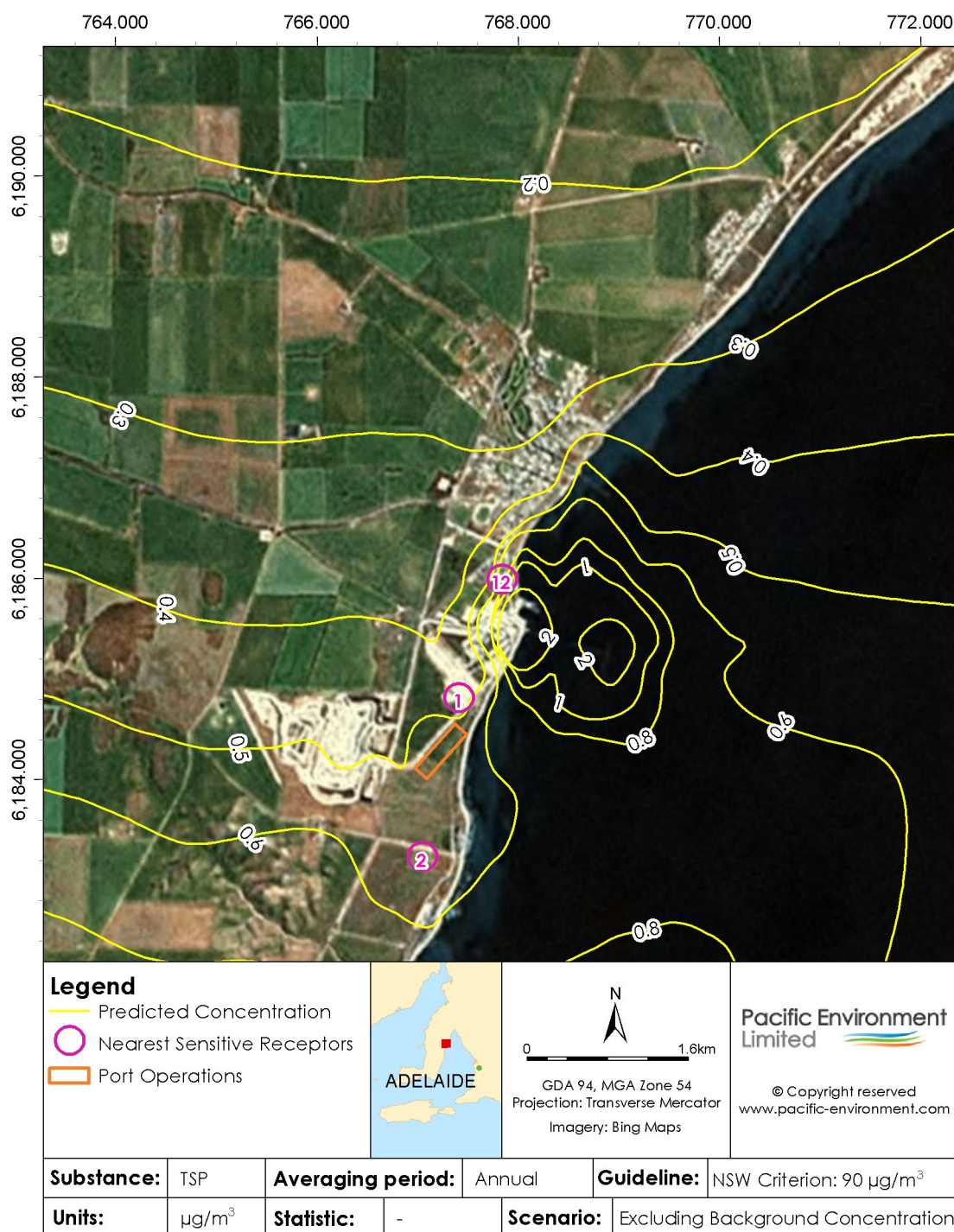


Figure 9.9: Predicted Annual Average TSP Concentration (Port Operations) – excluding background concentration

As for the maximum predicted PM₁₀ concentrations for the port operations the predicted annual averages of TSP are concentrated to the conveyer transfer point and the ship loading locations. Overall the contribution from the operations is small.

9.2.2 Deposition Results

Predicted annual average dust deposition rates are presented as additional impacts (background deposition rates not included) in Table 9.4, Figure 9.10 and Figure 9.11.

Table 9.4: Annual Average Dust Deposition

Receptor	Annual Average Dust Deposition ^a (g/m ² .month)
1	0.030
2	0.027
3	0.11
4	0.15
5	0.12
6	0.041
7	0.17
8	0.21
9	0.27
10	0.063
11	0.082
12	0.048

a. Not including background dust deposition

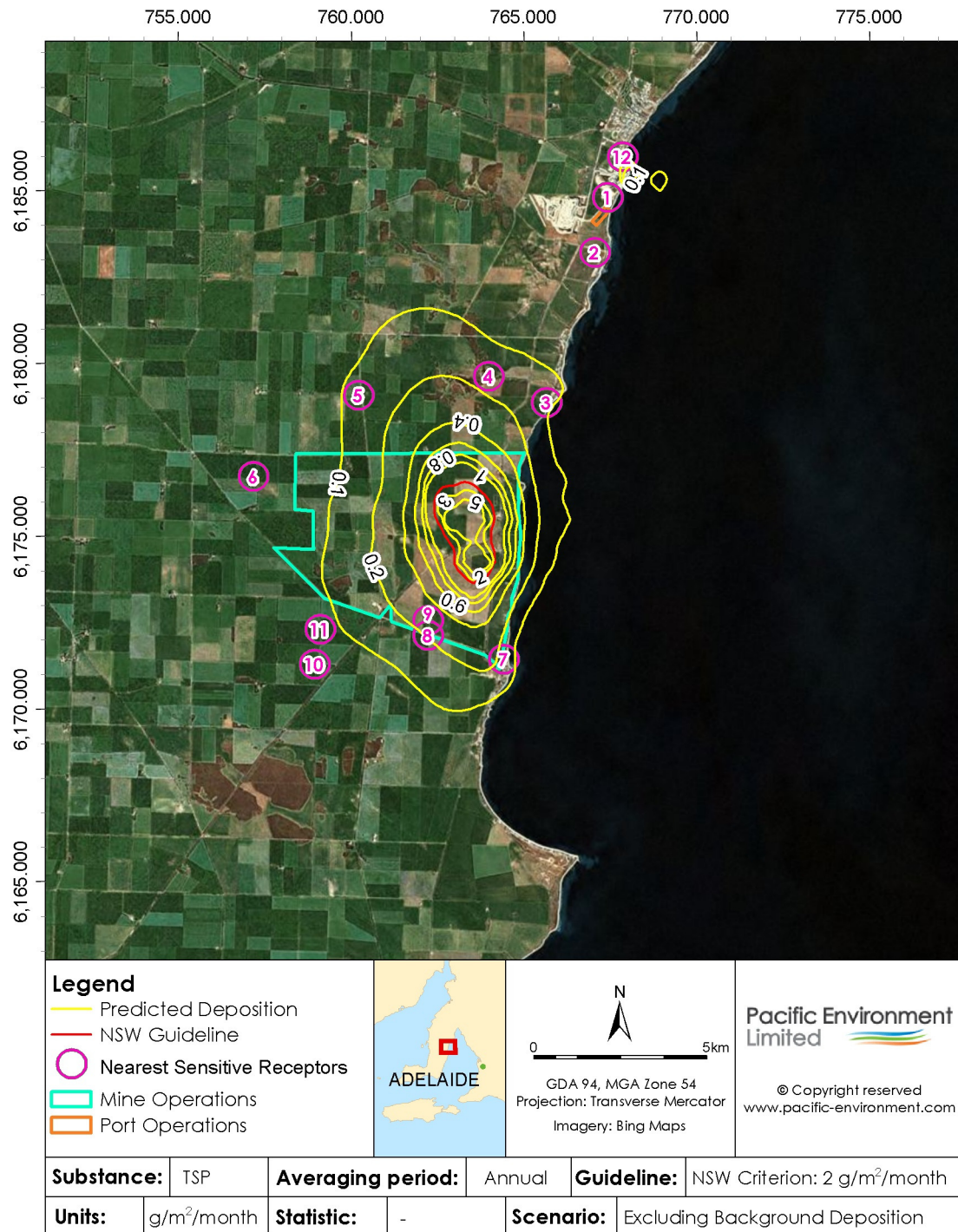


Figure 9.10: Predicted Annual Average Dust Deposition (Mine Operations) – excluding background deposition

Overall very limited impacts are predicted for dust deposition at the nearest receptors. The results show compliance with the NSW criterion of a maximum increase of 2 g/m²/month at the nearest sensitive receptors. The 2 g/m²/month deposition rate contour is contained within the site boundary. With a predicted dust deposition rate of 0.27 g/m²/month at the nearest receptor (receptor 9) and with a significant margin to the NSW criterion it is not expected that nuisance dust deposition impacts would be significant. This is further discussed below.



Figure 9.11: Predicted Annual Average Dust Deposition (Port Operations) – excluding background deposition

The dust deposition impacts from the port operations are very limited and predicted to be concentrated around the conveyer transfer point and the ship loading as predicted for the PM₁₀ and TSP concentrations.

9.2.3 Discussion on Deposition Related Potential Impacts

Potential impacts related to dust deposition include:

- rainwater tank contamination
- grain contamination (at the port)
- marine impacts
- crop impacts.

Summary discussions are provided on these items below.

RAINWATER TANK CONTAMINATION

To address concerns around potential for contamination of rainwater tanks it is suggested that first flush systems are discussed with concern residents and that tanks are sampled for baseline results before mine operations commence, and through operations as required, to assess impact. Based on the relatively low predicted impacts of dust deposition at the nearest receptors the risks associated with contamination of rainwater tanks are considered to be low. Monitoring of dust deposition will continue from the baseline monitoring.

GRAIN CONTAMINATION

The risk of contamination of grain stored at the port is low and effectively managed by the high level dust control systems for the concentrate handling and storage shed and proposed monitoring. The dust controls for the concentrate storage shed include negative pressure on the storage shed and extraction over the conveyer line to the pier. The exhaust ventilation will be treated by a baghouse before discharge. In addition to the dust controls, dust suppression is also managed by the ore and concentrate material moisture contents. Dust deposition monitoring that targets the grain storage facilities will be undertaken.

MARINE IMPACTS

The potential for marine impacts due to deposition of dust has been addressed separately and is considered of low risk.

CROP IMPACTS

Impacts on crops related to deposition of dust from the mining activities are considered to be of low risk considering the baseline dust deposition rates in relation to the predicted additional impacts. Ongoing monitoring is, however, proposed to be undertaken by Rex to address any community concerns.

In general, monitoring of dust deposition rates will be continued from the baseline monitoring and any ongoing monitoring requirement related to dust issues should be summarised in the dust management and monitoring plan.

Any air quality issues of concern to the community should be brought up and addressed through the community consultation which will be essential in communication with the community.

10 CONCLUSIONS

The predicted odour concentrations are below the assessment criteria by significant margins and it is not anticipated that odour impacts will be an issue of any significance, provided that the management of emissions is consistent with the basis of this assessment.

Dust deposition rates are predicted to be low at the nearest receptors, especially compared to the NSW assessment criteria applied in the assessment.

Predicted PM₁₀ concentrations comply at all sensitive receptors, except those closest to the south of the mine (receptors 8 and 9) for all but a few days per year. This indicates that there is some risk of exceedances at these receptors. Continuous real-time monitoring will be required to ensure that the mining operations are modified as required under adverse conditions to maintain compliance.

The peak impact conditions at the receptors to the south of the mine are identified to occur on days dominated by stable, light northerly winds occurring typically overnight and in the early morning. The source apportionment results identify haul truck wheel-generated dust as the main contributor to dust concentrations at peak impact conditions.

PM₁₀ monitoring would be most informative if placed both north and south of the mine site. This would provide data on PM₁₀ concentrations both upwind and downwind of the mine in prevailing wind conditions. It would also gather data for the worst predicted exposure conditions.

Dust monitoring and dust management details for the operations will be provided in a Dust Management and Monitoring Plan.

Risks associated with dust deposition impacts - including contamination of rainwater tanks, contamination of grain storages at the port, marine and crop impacts - are all considered to be low but have been addressed by ongoing monitoring to address community concerns and to verify performance.

Generally, the community consultation process will be essential in managing communication on air quality related issues with the community. Maintaining appropriate levels and types of communication is important in facilitating unimpeded information between operators and the community, which ensures that any issues are quickly identified and addressed.

11 REFERENCES

- Air & Waste Management Association. (2000). *Air Pollution Engineering Manual - Second Edition*. New York: John Wiley & Sons, Inc.
- BoM. (2012). Daily Rainfall - Pine Point. Bureau of Meteorology.
- CARB. (2012). Particulate Matter (PM) Speciation Profiles. California Air Resources Board.
- DEC (NSW). (2005). *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*.
- Gillette, D., Adams, J., Endo, A., Smith, D., & Kihl, R. (1980). Threshold Velocities for Input of Soil Particles into the Air by Desert Soils. *Journal of Geophysical Research* , 5621-5630.
- Hillgrove Copper. (2011). *Kanmantoo Copper Project Mining and Rehabilitation Program Main Report February 2011*. Adelaide: Department for Manufacturing, Innovation, Trade, Resources and Energy.
- Hurley P. (2008b). *TAPM V4 Part 1: Technical Description - CSIRO Marine and Atmospheric Research Paper No. 25 Aspendale, Victoria: CSIRO Marine and Atmospheric REsearch*.
- Hurley P. (2008c). *TAPM V4 Part 2: Summary of Some Verification Studies - CSIRO Marine and Atmospheric Research Paper No. 26 Aspendale, Victoria: CSIRO Marine and Atmospheric Research*.
- Hurley P. (2008a). *TAPM V4 User Manual - CSIRO Marine and Atmospheric Research Internal Report No.5 Aspendale, Victoria: CSIRO Marine and Atmospheric Research*.
- Peng, S., & Zhang, J. (2007). *Engineering Geology for Underground Rocks*. New York: Springer.
- Queensland EPA. (2008). *Environment Protection (Air) Policy*. Queensland.
- Rex Minerals. (2012a). List of Equipment for Dust Modelling Spreadsheet. *List of Equipment for Dust Modelling Spreadsheet.xls* . Rex Minerals.
- Rex Minerals. (2012b). Meeting held 1 November 2012.
- Rex Minerals. (2012e). Meeting held 17 December 2012.
- Rex Minerals. (2012c). Open pit mobile equipment. *Open pit mobile equipment.xlsx* . Rex Minerals.
- Rex Minerals. (2013). *PFS Summary*. Retrieved 2012, from Rex Minerals LTD:
<http://www.rexminerals.com.au/pfs-summary/>
- Rex Minerals. (2012d). Site and Port Layout. *31 oct update on site and port layout.pdf* . Rex Minerals.
- Rushing, J. F., & Tingle, J. S. (2007). Evaluation of Products and Application Procedures for Mitigating Dust in Temperate Climates. *Transportation Research Record, No 1989, Vol 1* , 305-311.
- SA EPA. (2007a). *Guidelines for Separation Distances. December 2007*.
- SA EPA. (2007). *Odour Assessment using Odour Source Modelling. April 2007*.
- SA EPA. (2007b). *Odour Assessment using Odour Source Modelling. April 2007*. Adelaide: South Australia Environment Protection Authority.

- SA EPA. (2007b). *Odour Assessment using Odour Source Modelling*. April 2007.
- SA EPA. (2010). *South Australia Air Quality 2008*.
- SA EPA. (2013). *South Australia Air Quality Data*. SA EPA.
- SEWPaC. (2012b). *NPI Emission Estimation Technique Manual for Fugitive Emissions V2.0*. Department of Sustainability, Environment, Water, Population and Communities.
- SEWPaC. (2012). *NPI Emission Estimation Technique Manual for Mining V3.1*. Department of Sustainability, Environment, Water, Population and Communities.
- SEWPaC. (2012a). *NPI Emission Estimation Technique Manual for Mining V3.1*. Department of Sustainability, Environment, Water, Population and Communities.
- TRC. (2006). *CALPUFF Version 6 User's Instructions*. May 2006.
- TRC. (2010). *Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusions into the 'Approved Methods for the Modelling and Assessments of Air Pollutants in NSW Australia'*. June 2010.
- US EPA. (1982). AP-42 Fifth Edition Volume 1. *Chapter 11.14: Metallic Minerals Processing - Final Section* . US EPA.
- US EPA. (2003). AP-42 Fifth Edition Volume 1. *Chapter 11.19.2 Background Information for Revised AP-42 Section 11.19.2, Crushed Stone Processing* . US EPA.
- US EPA. (2006a). AP-42 Fifth Edition Volume 1. *Chapter 13.2.4 Aggregate Handling and Storage Piles* . US EPA.
- US EPA. (2006c). AP-42 Fifth Edition Volume 1. *Chapter 13.2.5: Industrial Wind Erosion - Final Section* . US EPA.
- US EPA. (2006b). AP-42 Fifth Edition Volume I. *Chapter 13.2.2 Unpaved Roads* . US EPA.
- Victorian Government Gazette. (2001). *State Environment Protection Policy (Air Quality Management)*. No. S 240 21 December 2001 . Victorian Government Printer.
- WRF. (2012). *WRF The Weather Research & Forecasting Model*. Retrieved April 19, 2012, from <http://wrf-model.org/index.php>

Appendix A **ESTIMATION OF EMISSIONS**

A.1 ESTIMATION OF DUST EMISSIONS

A.1.1 Loading and Unloading Operations

A.1.1.1 Loading Operations

Emissions estimation techniques for copper ore loading were sourced from AP-42 Chapter 11.24 Metallic Minerals Processing (US EPA, 1982). The moisture content of the copper ore within the mine operations was assumed to be greater than 4%, classing the ore as high-moisture (Rex Minerals, 2012e). The default emission factors used to estimate emissions of TSP and PM₁₀ for materials handling and transfers are shown in Table 11.1. The emissions were calculated using the equation shown below. The materials handled and control efficiencies associated with the loading and unloading are shown in Table 11.2, Table 11.1 and Table 11.3 respectively.

Table 11.1: Emission Factors for Loading Operations

Material	Activity Area	Emission Factor	Value (kg/t)
Copper Ore (low moisture)	Crushing Operations	EF_{TSP}	0.005
		$EF_{PM_{10}}$	0.002

Source: (US EPA, 1982)

$$E_i = M \times EF_i \times (1 - CE_i)$$

where:

E_i	=	Emission rate for substance i	(kg/annum)
M	=	Total amount of material loaded or unloaded	(tonnes/annum)
EF_i	=	Uncontrolled emission factor for substance i	(kg/tonne)
CE_i	=	Overall control efficiency for substance i	(%)

Table 11.2: Activity Data for Loading Operations

Activity Area	Data Input	Value (tonnes)
Crushing	Total amount of copper ore loaded into Crusher	15,000,000

Source: (Rex Minerals, 2012b)

Table 11.3: Control Efficiencies for Loading Operations

Activity Area	Data Input	Control	Control Efficiency	Value (%)
Crushing	Total amount of copper ore loaded into Crusher	Water Sprays	CE_{TSP}	85
		Enclosure	$CE_{PM_{10}}$	85

Source: (SEWPac, 2012a)

A.1.1.2 Unloading Operations

Emission estimation techniques for copper ore and waste rock unloading were sourced from AP-42 Chapter 13.2.4 Aggregate Handling and Storage Piles (US EPA, 2006a). The equation used to calculate the emission factor is given below. The values for k_i vary with the particle size ranges shown in Table 11.4. The emission factor equation inputs for the loading and unloading of copper ore and waste rock are shown in Table 11.5. The calculated emission factors for the loading and unloading of waste rock is summarised in Table 11.6.

$$EF_i = k_i \times 0.0016 \times \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

where:

EF_i	=	Emission factor for loading and unloading of trucks for substance i	(kg/tonne)
k_i	=	Particle size multiplier	(-)
M	=	Moisture content of material being loaded or unloaded	(%)
U	=	Mean wind speed	(m/s)

Table 11.4: Particle Size Multipliers

Particle Size	Particle Size Multiplier (k_i)
<30 μm	0.74
<10 μm	0.35

Source: (US EPA, 2006a)

Table 11.5: Emission Factor Equation Inputs for Unloading Operations

Activity Area	Variable	Value	Units
ROM pad	Mean Wind Speed (U) ^a	4.54	m/s
Waste Rock Dump	Waste Rock Moisture Content (M)	4.8 ^b	%

a. Source: CALMET extract

b. Source: (US EPA, 2006a), Upper limit of moisture content range

Table 11.6: Emission Factors for Unloading Operations

Activity Area	Emission Factor	Value (kg/t)
ROM pad	EF_{TSP}	8.90×10^{-4}
	EF_{PM10}	4.21×10^{-4}
Waste Rock Dump	EF_{TSP}	8.90×10^{-4}
	EF_{PM10}	4.21×10^{-4}

Total TSP and PM_{10} emissions for the loading and unloading were estimated using the equation below. The activity data and control efficiencies are presented in Table 11.7 and Table 11.8 respectively.

$$E_i = M \times EF_i \times \left(\frac{100 - CE_i}{100}\right)$$

where:

E_i	=	Emission rate for substance i	(kg/annum)
M	=	Total amount of material loaded or unloaded	(tonnes/annum)
EF_i	=	Uncontrolled emission factor for substance i	(kg/tonne)
CE_i	=	Overall control efficiency for substance i	(%)

Table 11.7: Activity Data for Unloading Operations

Activity Area	Data Input	Value (tonnes)
ROM Pad	Total amount of copper ore unloaded	15,000,000
Waste Rock Dump	Total amount of waste rock unloaded	60,000,000

Source: (Rex Minerals, 2012b)

Table 11.8: Control Efficiencies for Unloading Operations

Activity Area	Description	Control Efficiency	Value (%)
ROM Pad	Water sprays on unloading trucks	CE _{TSP}	70
		CE _{PM10}	70
Waste Rock Dump	Water sprays on unloading trucks	CE _{TSP}	70
		CE _{PM10}	70

Source: (SEWPaC, 2012a)

A.1.2 Wheel-Generated Dust (Unpaved Roads)

Emissions from wheel-generated dust from unpaved roads were estimated using the method outlined in AP-42 Chapter 13.2.2 Unpaved Roads (US EPA, 2006b). The general equation for the emission factor for is shown below. The constants k, a and b are dependent of the particle size range and are summarised in Table 11.9. The emission factor equation inputs are summarised in Table 11.10.

$$EF_{TSP} = 0.2819 \times k \times \left(\frac{s}{12}\right)^a \times \left(\frac{1.102311 \times W}{3}\right)^b$$

Table 11.9: Constants for Wheel-Generated Dust from Industrial Roads

Constant	PM ₁₀	TSP ^a
k (lb/VKT)	1.5	4.9
a	0.9	0.7
b	0.45	0.45

a. Value for PM₃₀ assumed to be equivalent to TSP

Source: (US EPA, 2006b)

Table 11.10: Emission Factor Equation Inputs for Wheel-Generated Dust (Unpaved Roads)

Activity Area	Material	Data Input	Value	Units
Open Pit ROM Pad Waste Rock Dump	Copper Ore	Silt Content ^a	8.4	%
	Waste Rock	Vehicle Average Weight ^b	260	tonnes

a. Source: (US EPA, 2006b). Mean silt content for haul roads in western surface coal mining

b. Source: (US EPA, 2006b). Upper limit of mean vehicle weight range.

Table 11.11: Emission Factors for Wheel-Generated Dust (Unpaved Roads)

Activity Area	Material	Emission Factor	Value (kg/km)
Open Pit ROM Pad Waste Rock Dump	Copper Ore	EF _{TSP}	8.37
	Waste Rock	EF _{PM10}	2.39

Total emissions of TSP and PM₁₀ from wheel-generated dust were estimated using the equation below. The total distance travelled was estimated using the haul road length, the truck capacity and the total amount of material loaded. This method is outlined below. The activity data and control efficiencies for wheel-generated dust (unpaved road) are summarised in Table 11.12 and Table 11.13 respectively.

$$E_i = EF_i \times TD \times \left(\frac{100 - CE_i}{100} \right)$$

where:

E_i	=	Emission rate of substance i	(kg/annum)
EF_i	=	Uncontrolled emission factor for substance i	(kg/km)
TD	=	Total distance travelled on unpaved roads by the vehicle	(km/annum)
CE_i	=	Overall control efficiency for pollutant i	(%)

$$TD = L \times \frac{M}{C_T}$$

where:

TD	=	Total distance travelled on unpaved roads by the vehicle	(km/annum)
L	=	Haul road length	(km)
M	=	Total amount of material loaded	(tonnes/annum)
C_T	=	Truck capacity	(tonnes)

Table 11.12: Activity Data for Wheel Generated Dust (Unpaved Roads)

Activity Area	Description	Data Input	Value	Units
Open Pit	In Pit Copper Ore	Type of Truck ^a	Cat 789C	-
		Haul Road Length (L) ^b	2.0	km
		Total Amount of Ore Trucked ^c	15,000,000	tonnes
		Truck Capacity (C _T) ^d	177	tonnes
	In Pit Waste Rock	Type of Truck ^a	Cat 789C	-
		Haul Road Length (L) ^b	2.0	km
		Total Amount of Ore Trucked ^a	60,000,000	tonnes
		Truck Capacity (C _T) ^d	177	tonnes
ROM Pad	Copper Ore Outside of Pit	Type of Truck ^a	Cat 789C	-
		Haul Road Length (L) ^c	2.3	km
		Total Amount of Ore Trucked ^a	15,000,000	tonnes
		Truck Capacity (C _T) ^d	177	tonnes
Waste Rock Dump	Waste Rock to Waste Rock Dump	Type of Truck ^a	Cat 789C	-
		Haul Road Length (L) ^a	2.3	km
		Total Amount of Ore Trucked ^a	60,000,000	tonnes
		Truck Capacity (C _T) ^d	177	tonnes

- Source: (Rex Minerals, 2012c)
- Pacific Environment assumption based on 0.1km depth of pit and 5% grade
- Source: (Rex Minerals, 2012b)
- Truck capacity based off caterpillar specifications

Table 11.13: Control Efficiencies for Wheel-Generated Dust (Unpaved Roads)

Activity Area	Material	Description	Control Efficiency	Value (%)
Open Pit	In Pit Copper Ore	Salt sprays on road	CE _{TSP}	97
	In Pit Waste Rock	Pit Retention	CE _{PM10}	93
ROM Pad	Copper Ore Outside of Pit	Salt sprays on road	CE _{TSP}	93
			CE _{PM10}	93
Waste Rock Dump	Overburden to Waste Rock Dump	Salt sprays on road	CE _{TSP}	93
			CE _{PM10}	93

Source: (Rushing & Tingle, 2007)

A.1.3 Drilling

Emissions due to drilling were estimated using the NPI EET Manual for Mining V3.1 (SEWPaC, 2012a). The default emission factors were used to estimate emissions from drilling and are displayed in Table 11.14. The activity data and control efficiencies for drilling are summarised in Table 11.15 and Table 11.16 respectively.

Table 11.14: Default Emission Factors for Drilling

Activity Area	Material	Emission Factor	Value (kg/hole)
Open Pit	Copper Ore and Waste Rock	EF _{TSP}	0.59
		EF _{PM10}	0.31

Source: (SEWPaC, 2012a)

$$E_i = EF_i \times HD \times \left(\frac{100 - CE_i}{100} \right)$$

where:

E_i	=	Emission rate for pollutant i	(kg/annum)
EF_i	=	Uncontrolled emission factor of pollutant i	(kg/hole)
HD	=	Holes drilled in material i	(holes/annum)
CE_i	=	Overall control efficiency for pollutant i	(%)

The number of holes drilled per annum was estimated based on a blast size of 500,000 tonnes (Rex Minerals, 2012b). A density of 2,600 kg/m³ (Peng & Zhang, 2007) and a hold depth of 15 m were assumed to calculate the area of the blast. Based on the assumption of 0.11 holes per m², the number of holes per blast was calculated. For a conservative estimate it was assumed that there would be one blast per day for the year.

Table 11.15: Activity Data for Drilling

Activity Area	Material	Data Input	Values (holes)
Open Pit	Ore and Waste Rock	Number of Holes Drilled	49,947

Source: (Rex Minerals, 2012b) and (Peng & Zhang, 2007)

Table 11.16: Control Efficiencies for Drilling

Activity Area	Material	Description	Control Efficiency	Value (%)
Open Pit	Ore and Waste Rock	Pit Retention	CE _{TSP}	99.5
		Fabric Filter for Drilling	CE _{PM10}	99.1

Source: (SEWPaC, 2012a)

A.1.4 Blasting

Blasting emission estimation techniques were sourced from the NPI EET Manual for Mining (SEWPaC, 2012a). The equations used to calculate the emission factors for TSP and PM₁₀ are given below. The emission factor equation inputs are provided in Table 11.17.

$$EF_{TSP} = 0.00022 \times A^{1.5}$$

$$EF_{PM_{10}} = 0.52 \times 0.00022 \times A^{1.5}$$

where:

EF_{TSP}	=	Emission factor for TSP due to blasting	(kg/blast)
$EF_{PM_{10}}$	=	Emissions factor for PM ₁₀ due to blasting	(kg/blast)
A_i	=	The horizontal area blasted of material i (with depth ≤ 21m)	(m ²)
M_i	=	The moisture content of the blasted material i	(%)
D_i	=	The depth of the blast holes in material i	(m)

Table 11.17: Emission Factor Equation Inputs for Blasting

Activity Area	Material	Data Input	Description	Value	Units
Open Pit	Copper Ore and Waste Rock	Area Blasted	Blasting	12,821 ^a	m ²

a. Calculated using the same method outline in Section A.1.3: Drilling

Source: (Rex Minerals, 2012b) and (Peng & Zhang, 2007)

Total emissions of TSP and PM₁₀ associated with blasting were estimated using the equation below. The data inputs and control efficiencies associated with blasting operations are listed in Table 11.18 and Table 11.19 respectively.

$$E_i = EF_i \times NB \times \left(\frac{100 - CE_i}{100} \right)$$

where:

E_i	=	Emission rate for pollutant i	(kg/a)
EF_i	=	Uncontrolled emission factor for pollutant i	(kg/blast)
NB	=	Number of blasts per year on material m	(blasts/a)
CE_i	=	Overall control efficiency for pollutant i	(%)

Table 11.18: Activity Data for Blasting

Activity area	Material	Data Input	Value (blasts per year)
Open Pit	Copper Ore and Waste Rock	Number of Blasts	365 ^a

a. Assumed one blast per day (Rex Minerals, 2012a)

Table 11.19: Control Efficiencies for Blasting

Activity area	Material	Description	Control Efficiency	Value (%)
Open Pit	Copper Ore and Waste Rock	Pit Retention	CE _{TSP}	50
			CE _{PM10}	5

Source: (SEWPaC, 2012a)

A.1.5 Wind Erosion

TSP and PM₁₀ emissions associated with wind erosion for all areas were estimated using the equation below. The area of the wind erosion sources were calculated based on the total areas when the waste rock dumps have been established. This allows for a conservative assessment. The data inputs to estimate the emissions associated with wind erosion are listed in Table 11.20. The control efficiencies for wind erosion are summarised in Table 11.21.

$$E_i = EF_i \times A \times \left(\frac{100 - CE_i}{100} \right)$$

where:

E_i	=	Emission rate for substance i	(kg/a)
A	=	Total exposed areas	(ha)
EF_i	=	Uncontrolled emission factor for substance i	(kg/ha/a)
CE_i	=	Overall control efficiency for substance i	(%)

Table 11.20: Activity Data for Wind Erosion

Material	Activity area	Data Input	Value (ha)
Copper Ore	Crushing Circuit	Total area of ROM pad stockpile	5.5
		Total area of Copper Ore Main Stockpile	1.9
Waste Rock	Waste Rock Dump	Total area of Eastern Waste Rock Dump	297
		Total area of Western Waste Rock Dump 14A ^a	524
		Total area of Western Waste Rock Dump 14B	160

a. TSF area omitted from Western WRD 14A

Source: (Rex Minerals, 2012d)

Table 11.21: Control Efficiencies for Wind Erosion

Material	Data Input	Description	Control Efficiency	Value (%)
Copper Ore	ROM pad stockpile	Water Sprays Wind Breaks	CE_{TSP}	65
	Copper Ore Main Stockpile		CE_{PM10}	65
Waste Rock	Eastern Waste Rock Dump	No Controls	CE_{TSP}	0
	Western Waste Rock Dump 14A		CE_{TSP}	0
	Western Waste Rock Dump 14B			

Source: (SEWPaC, 2012a)

Wind erosion emission factors were calculated using two methods. The emissions associated with wind erosion from ROM pad and main stockpile were estimated using a technique outline in the NPI EET Manual for Mining V3.1 (SEWPaC, 2012a). The emissions associated with the open pit and waste rock dumps were estimated using a technique from AP-42 Chapter 13.2.5 Industrial Wind Erosion (US EPA, 2006c). Both methods are outlined below.

A.1.5.1 Wind Erosion – ROM Pad and Main Stockpile

The emissions from wind erosion of the ROM pad and main stockpile were estimated using a technique outlined in the NPI EET Manual for Mining (SEWPaC, 2012a). The equation used to calculate the emission factor for TSP is shown below. The emission factor equation inputs for wind erosion are summarised in Table 11.22.

$$EF_{TSP} = 1.9 \times \left(\frac{S_{(\%)}}{1.5} \right) \times 365 \times \left(\frac{365 - p}{235} \right) \times \left(\frac{f_{(\%)}}{15} \right)$$

where:

EF_{TSP}	=	Emission factor for TSP due to material handling	(kg/ha/annum)
$S_{(\%)}$	=	Silt Content	(%)
p	=	Number of days per year when rainfall is greater than 0.254mm	(days)
$f_{(\%)}$	=	Percentage of time that wind speed is greater than 5.4m/s at the mean height of the stockpile	(%)

A proportionality factor was included in the wind blown dust based on the strength of the wind speed, as shown below. This allowed for a more accurate representation of the windblown dust, as at higher wind speeds there is a greater emission from stockpiles. It is assumed that the rate of wind erosion is linearly proportional to wind power (energy per unit time). Wind power has a cubic relationship to wind speed:

$$\text{Wind Erosion} \propto \text{Wind Speed}^3$$

Table 11.22: Emission Factor Equation Inputs for Wind Erosion

Material	Activity area	Data Input	Value	Units
Copper Ore	Main Stockpile	Silt Content (s) ^a	2.5	%
		Percentage of Time Wind Speed > 5.4 m/s (f) ^b	31.8	%
		Days With Rainfall > 0.25 mm (p) ^b	115	days
	ROM pad	Silt Content (s) ^a	2.5	%
		Percentage of Time Wind Speed > 5.4 m/s (f) ^b	31.8	%
		Days With Rainfall > 0.25 mm (p) ^b	115	days

a. Source: (US EPA, 2003), average of silt content

b. Source: CALMET Meteorological extract

c. Source: Pine Point Rainfall Data (BoM, 2012)

Table 11.23: Emission Factors for Wind Erosion

Material	Activity area	Emission Factor	Value (kg/ha/annum)
Copper Ore	Main Stockpile	EF _{TSP}	15,644
	ROM Pad	EF _{PM10}	7,822

A.1.5.2 Wind Erosion – Waste Rock Dumps

Emissions associated with wind erosion from the waste rock dumps were estimated using a technique from the AP-42 Chapter 13.2.5 Industrial Wind Erosion (US EPA, 2006c). It was assumed that the refresh rate of the waste rock dumps were monthly i.e. 12 times a year.

Using the soil properties from a study undertaken by Gillette (1980) it was assumed that the threshold velocity of the soil type would be similar to soil type III-11 as it has the highest observed moisture content of 9.2%. However for a conservative assessment the threshold velocity for soil type III-15 was used. This soil type has a lower moisture content than will be observed. For this reason 0.83 m/s was used for the threshold friction velocity (u_t^*) to estimate wind erosion emissions from the Waste Rock Dumps.

Hourly wind speed data was extracted at the mine site from CALMET. The NPI EET for Fugitive Emissions states that the fastest mile wind speed has been found to be approximately 1.27 times the hourly wind speed (SEWPaC, 2012b). This gust relationship was used to calculate the fastest mile wind speed for the hourly data extracted from CALMET.

The equations used to calculate the emission factors for TSP and PM₁₀ are given below. For the waste rock dump wind erosion emissions, it was assumed to be monthly disturbances. Emission factor equation inputs are provided in Table 11.24 and the resulting emission factors are listed in Table 11.25.

$$EF_{TSP} = 1 \sum_{i=1}^N P_i$$

$$EF_{PM10} = 0.5 \sum_{i=1}^N P_i$$

Where

EF_i	=	Emission factor for substance i	(g/m ² /annum)
N	=	Number of disturbances per year	(-)
P_i	=	Erosion potential corresponding to the observed (or probable) fastest mile of wind for the i th period between disturbances	(g/m ²)

$$P = 58(u^* - u_t^*)^2 + 25(u^* - u_t^*)$$

$$u^* = 0.053u_{10}^+$$

Where

u^*	=	Friction velocity	(m/s)
u_t	=	Threshold friction velocity	(m/s)
u_{10}^+	=	Fastest mile of reference anemometer for period between disturbances	(m/s)

Table 11.24: Emission Factor Equation Inputs for Wind Erosion – Waste Rock Dump

Material	Activity area	Description	Substance	Value (m/s)
Waste Rock	Waste Rock Dump	Threshold friction velocity (u_t^*) ^a	TSP	0.83
			PM ₁₀	0.83
		Fastest mile of reference anemometer for period between disturbances (u_{10}^+) ^b	TSP	Multiple data values based off hourly wind speed data
			PM ₁₀	

a. Source: (Gillette, Adams, Endo, Smith, & Kihl, 1980)

b. Derived from CALMET meteorological data, Year 2010

Table 11.25: Emission Factors for Wind Erosion – Waste Rock Dump

Material	Activity area	Description	Emission Factor	Value (kg/ha/a)
Overburden	Waste Rock Dump	Refreshed monthly	EF _{TSP}	12.8
			EF _{PM10}	6.4

A.1.6 Crushing

Emissions from the crushing of copper ore were estimated using the method outlined in AP-42 Chapter 11.24 Metallic Minerals Processing (US EPA, 1982). The default emission factors for primary crushing were used to estimate the emissions for TSP and PM₁₀ and are summarised in Table 11.26. Primary crushing was only included in the modelling as grinding within the SAG and ball mills was operated with water sprays which produce negligible dust emissions (US EPA, 1982).

Table 11.26: Default Emission Factors for Crushing

Material	Description	Emission Factor	Value (kg/tonne)
Copper Ore	Primary Crushing	EF _{TSP}	0.20
		EF _{PM10}	0.02

Source: (US EPA, 1982)

The emissions for crushing of copper ore were calculated using the equation shown below. The activity data for crushing is summarised Table 11.27. The control efficiencies applied to the crushing of copper ore is shown in Table 11.28.

$$E_i = EF_i \times MC_i \times \left(\frac{100 - CE_i}{100} \right)$$

where:

E_i	=	Emission rate for pollutant i	(kg/annum)
EF_i	=	Uncontrolled emission factor for substance i	(kg/tonne)
MC_i	=	The amount of material i crushed	(tonnes/annum)
CE_i	=	Overall control efficiency for substance i	(%)

Table 11.27: Activity Data for Crushing

Material	Data Input	Value (tonnes)
Copper Ore	Total Ore Crushed	15,000,000

Source: (Rex Minerals, 2012b)

Table 11.28: Control Efficiencies for Crushing

Material	Activity area	Description	Control Efficiency	Value (%)
Copper Ore	Primary Crusher	Water Sprays Enclosure	CE _{TSP}	85
			CE _{PM10}	85

Source: (SEWPaC, 2012a)

A.1.7 Miscellaneous Transfer Points Associated with Conveying

Emissions associated with miscellaneous transfer points (conveying) were estimated using a technique from AP-42 Chapter 11.24 Metallic Minerals Processing (US EPA, 1982). The default emission factors for high moisture content ores were used to estimate emissions of TSP and PM₁₀ from miscellaneous transfer points (conveying) and are provided in Table 11.29. Total emissions of TSP and PM₁₀ associated with miscellaneous transfer points (conveying) were estimated using the equation below.

The data inputs and control efficiencies associated with miscellaneous transfer points (conveying) are listed in Table 11.30 and Table 11.31.

$$E_i = N_{MTP} \times M \times EF_i \times \left(\frac{100 - CE_i}{100} \right)$$

where:

E_i	=	Emission rate for substance i	(kg/a)
N_{MTP}	=	Number of miscellaneous transfer points along the conveying path	(-)
M	=	Total amount of material conveyed	(tonnes/a)
EF_i	=	Uncontrolled emission factor for substance i	(kg/tonne)
CE_i	=	Overall control efficiency for substance i	(%)

Table 11.29: Default Emission Factors for Miscellaneous Transfer Points (Conveying)

Material	Description	Emission Factor	Value (kg/t)
Copper Ore	Conveying from Primary Crusher to Main Stockpile	EF _{TSP}	0.005
	Conveying from Main Stockpile to SAG mill	EF _{PM10}	0.002

Source: (US EPA, 1982)

Table 11.30: Activity Data for Miscellaneous Transfer Points (Conveying)

Material	Description	Data Input	Value	Units
Copper Ore	Conveying from Primary Crusher to Main Stockpile	Total Material Conveyed	15,000,000	tonnes
		Number of Miscellaneous Transfer Points	1	-
	Conveying from Main Stockpile to SAG Mill	Total Material Conveyed	15,000,000	tonnes
		Number of Miscellaneous Transfer Points	1	-

Source: (Rex Minerals, 2012b)

Table 11.31: Control Efficiencies for Miscellaneous Transfer Points (Conveying)

Material	Activity area	Description	Control Efficiency	Value (%)
Copper Ore	Conveying from Primary Crusher to Main Stockpile	Water Sprays Wind Breaks	CE _{TSP}	65
			CE _{PM10}	65
	Conveying from Main Stockpile to SAG Mill	Water Sprays Enclosure	CE _{TSP}	85
			CE _{PM10}	85

Source: (SEWPaC, 2012)

A.1.8 Miscellaneous Transfer Points Associated with Stockpiles

Emissions associated with miscellaneous transfer points (stockpiles) were estimated using a technique from AP-42 Chapter 13.2.4 Aggregate Handling and Storage Piles (US EPA, 2006a). Operations include the use of excavators, shovels and front end loaders. The equations used to calculate the emission factor is shown below. The constant, k_i , is dependent on the particle size range, this is summarised in Table 11.4. Emission factor equation inputs are provided in Table 11.32 and the resulting emission factors are listed in Table 11.33.

$$EF_i = k_i \times 0.0016 \times \frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

where:

EF_i	=	Emission factor for loading and unloading of trucks for substance i	(kg/tonne)
k_i	=	Particle size multiplier	(-)
M	=	Moisture content of material being loaded or unloaded	(%)
U	=	Mean wind speed	(m/s)

Table 11.32: Emission Factor Equation Inputs for Miscellaneous Transfer Points (Stockpiles)

Activity area	Description	Variable	Value	Unit
Open Pit	Copper Ore and Waste Rock	Mean Wind Speed (U) ^a	4.54	m/s
		Waste Rock Moisture Content (M)	4.8 ^b	%
ROM Pad	ROM pad to primary crushing	Mean Wind Speed (U) ^a	4.54	m/s
		Waste Rock Moisture Content (M)	4.8 ^b	%

a. Source: CALMET meteorological extract for 2010

b. Source: (US EPA, 2006a), Upper limit of moisture content range

Table 11.33: Emission Factors for Miscellaneous Transfer Points (Stockpiles)

Material	Activity area	Emission Factor	Value (kg/t)
Copper Ore and Waste Rock	Open Pit	EF _{TSP}	8.90 x 10 ⁻⁴
		EF _{PM10}	4.21 x 10 ⁻⁴
Copper Ore	ROM Pad	EF _{TSP}	8.90 x 10 ⁻⁴
		EF _{PM10}	4.21 x 10 ⁻⁴

Total emissions associated with miscellaneous transfer points (stockpiles) were estimated using the equation below. The data inputs and control efficiencies are listed in Table 11.34 and Table 11.35.

$$E_i = M \times EF_i \times \left(\frac{100 - CE_i}{100} \right)$$

where:

E_i	=	Emission rate for pollutant i	(kg/a)
M	=	Total amount of material transferred	(tonnes/a)
EF_i	=	Uncontrolled emission factor for pollutant i	(kg/tonne)
CE_i	=	Overall control efficiency for substance i	(%)

Table 11.34: Activity Data for Miscellaneous Transfer Points

Activity area	Material	Data Input	Value (tonnes)
Open Pit	Copper Ore	Total amount of ore transferred out of the pit	15,000,000
	Waste Rock	Total amount of waste rock transferred out of the pit	60,000,000
ROM Pad	Copper Ore	Total amount of ore handled by front end loaders at ROM pad to primary crushing	150,000 ^a

a. Assumption of 1% of materials handled by front end loader at ROM pad

Source: (Rex Minerals, 2012b)

Table 11.35: Control Efficiencies for Miscellaneous Transfer Points (Stockpiles)

Material	Activity area	Description	Control Efficiency	Value (%)
Copper Ore	Open Pit	Pit Retention	CE _{TSP}	50
			CE _{PM10}	5
Waste Rock	Open Pit	Pit Retention	CE _{TSP}	50
			CE _{PM10}	5
Copper Ore	ROM Pad	Water Sprays	CE _{TSP}	50
			CE _{PM10}	50

A.1.9 Bulldozing

Bulldozing emission estimation techniques were sourced from NPI EET Manual for Mining V3.1 (SEWPaC, 2012). The equations used to calculate the emission factors for TSP and PM₁₀ are given below. The silt

and moisture contents used are provided in Table 11.36 and the resulting emission factors are provided in Table 11.37.

$$EF_{TSP} = \frac{2.6 \times s^{1.2}}{M^{1.3}}$$

$$EF_{PM_{10}} = \frac{0.34 \times s^{1.5}}{M^{1.4}}$$

where:

EF_{TSP}	=	Emission factor for TSP due to bulldozer operations	(kg/h)
$EF_{PM_{10}}$	=	Emission factor for PM ₁₀ due to bulldozer operations	(kg/h)
s	=	Silt content of material bulldozed	(%)
M	=	Moisture content of material bulldozed	(%)

Table 11.36: Emission Factor Equation Inputs for Bulldozing

Material	Activity area	Description	Data Input	Value (%)
Copper Ore Waste Rock	Open Pit	Open pit maintenance	Silt Content ^a	2.5
			Moisture Content ^b	10
Copper Ore	ROM Pad	ROM pad stockpile maintenance	Silt Content ^a	2.5
			Moisture Content ^b	10
Copper Ore	Crushing Circuit	Main Stockpile maintenance	Silt Content ^a	2.5
			Moisture Content ^b	10

a. Source: (US EPA, 2003), mean of silt content

b. Source: (Rex Minerals, 2012e)

Table 11.37: Emission Factors for Bulldozing

Material	Description	Emission Factor	Value (kg/h)
Copper Ore	Open pit maintenance	EF _{TSP}	0.39
		EF _{PM10}	0.05
	ROM pad stockpile maintenance	EF _{TSP}	0.39
		EF _{PM10}	0.05
	Main Stockpile maintenance	EF _{TSP}	0.39
		EF _{PM10}	0.05
Waste Rock	Open pit maintenance	EF _{TSP}	0.39
		EF _{PM10}	0.05

Total emissions associated with bulldozing for TSP and PM₁₀ were estimated using the equation below. The data inputs and control efficiencies associated with bulldozing are listed in Table 11.38 and Table 11.39 respectively.

$$E_i = OH_{total} \times EF_i \times \left(\frac{100 - CE_i}{100} \right)$$

where:

E_i	=	Emission rate for pollutant i	(kg/a)
OH_{total}	=	Total operating hours of bulldozers	(hrs/a)
EF_i	=	Uncontrolled emission factor for pollutant i	(kg/h)
CE_i	=	Overall control efficiency for pollutant i	(%)

Table 11.38: Activity Data for Bulldozing

Material	Description	Data Input	OH _{total} (hours/annum)
Copper Ore Waste Rock	Open pit maintenance	Total Operating Hours	4,073 ^a
Copper Ore	ROM pad stockpile maintenance Main Stockpile maintenance	Total Operating Hours	339 ^b

Source: PEL assumption

- a. 12 hours of operation per day with 93% operation per year
- b. 1 hour of operation a day with 93% operation per year

Table 11.39: Control Efficiencies for Bulldozing

Material	Description	Description	Emission Factor	Value (kg/h)
Copper Ore Waste Rock	Open pit maintenance	Pit Retention	CE _{TSP}	50
			CE _{PM10}	5
Copper Ore	ROM pad stockpile maintenance	Water Sprays	CE _{TSP}	50
			CE _{PM10}	50
	Main Stockpile maintenance	Water Sprays	CE _{TSP}	50
			CE _{PM10}	50

A.1.10 Port Operations

Port operation emissions were estimated using a technique from AP-42 Chapter 11.24 Metallic Minerals Processing (US EPA, 1982). The default emission factors for high moisture content ores were used to estimate emissions of TSP and PM₁₀ from miscellaneous transfer points within the port operations and are provided in Table 11.40. Total emissions of TSP and PM₁₀ associated with miscellaneous transfer points (conveying) were estimated using the equation below.

The data inputs and control efficiencies associated with miscellaneous transfer points (conveying) are listed in Table 11.30 and Table 11.31.

$$E_i = N_{MTP} \times M \times EF_i \times \left(\frac{100 - CE_i}{100} \right)$$

where:

E_i	=	Emission rate for substance i	(kg/a)
N_{MTP}	=	Number of miscellaneous transfer points along the conveying path	(-)
M	=	Total amount of material conveyed	(tonnes/a)
EF_i	=	Uncontrolled emission factor for substance i	(kg/tonne)
CE_i	=	Overall control efficiency for substance i	(%)

Table 11.40: Default Emission Factors for Miscellaneous Transfer Points (Conveying)

Material	Description	Emission Factor	Value (kg/t)
Copper Ore	Conveying from Primary Crusher to Main Stockpile	EF _{TSP}	0.005
	Conveying from Main Stockpile to SAG mill	EF _{PM10}	0.002

Source: (US EPA, 1982)

Table 11.41: Activity Data for Miscellaneous Transfer Points (Conveying)

Material	Description	Data Input	Value	Units
Copper Ore	Concentrate handling within Shed	Total Material Conveyed	1,520,000 ^a	tonnes
		Number of Miscellaneous Transfer Points	3	-
	Conveying from Concentrate handling shed to ship loader	Total Material Conveyed	1,520,000 ^a	tonnes
		Number of Miscellaneous Transfer Points	1	-
	Ship Loading	Total Material Conveyed	2,000 ^b	kg/h
		Number of Miscellaneous Transfer Points	1	-

a. Source: (Rex Minerals, 2012e)

b. Source: (Rex Minerals, 2012b) – maximum ship loading capacity

Table 11.42: Control Efficiencies for Miscellaneous Transfer Points (Conveying)

Material	Activity area	Description	Control Efficiency	Value (%)
Copper Ore	Concentrate handling within Shed – Fugitive Emissions	Total Enclosure Water Sprays	CE _{TSP}	99.5
			CE _{PM10}	99.5
	Concentrate handling within Shed – Baghouse Stack Emissions	Fabric Filter Water Sprays	CE _{TSP}	99.8
			CE _{PM10}	99.8
	Conveying from Concentrate handling shed to ship loader	Enclosure	CE _{TSP}	70
			CE _{PM10}	70
	Ship Loading	Telescopic Chute with Water Sprays Wind Guards	CE _{TSP}	88
			CE _{PM10}	88

Source: (SEWPaC, 2012) and (Air & Waste Management Association, 2000)

A.1.11 Summary of Emissions

Table A.1: Summary of TSP and PM₁₀ Emissions

	Annual TSP Emissions (kg/year)	Annual PM ₁₀ Emissions (kg/year)
Pit Activities (including haul roads within the pit)	589,378	356,984
Loading and Unloading Activities	68,957	29,026
Wind Erosion from Exposed areas	19,249	9,625
Haul Roads	675,032	192,415
Crushing Activities	22,500	9,000
Port Operations	6,111	2,444
TOTAL EMISSIONS	1,381,227	599,494

Appendix B **SENSITIVITY ANALYSIS**

B.1 INTRODUCTION

This appendix was prepared to provide additional information to the dust study completed in February 2013 (the main body of the report). It includes an evaluation of predicted dust impacts that considers haul road dust controls based on water sprays instead of salt spray, dust suppressant chemicals such as calcium and magnesium chlorides, and the implications for compliance with assessment criteria. The assessment and evaluation was based on a revised estimation of the haul road dust emissions and a dispersion modelling sensitivity analysis of the overall mine dust impacts.

B.2 REVISION OF HAUL ROAD DUST CONTROL METHOD AND CONTROL EFFICIENCY

B.2.1 Previous Wheel Generated Haul Road Dust Emissions Estimation

Chapter 1 For the dust study completed in February 2013 the uncontrolled wheel-generated haul road dust emission rates were estimated very conservatively based on the assumption of a relatively high haul road surface silt content of 8.4%. For dust control, sprays of hygroscopic salts such as calcium and magnesium chlorides were applied with a control efficiency of 93% (Rushing & Tingle, 2007). For the haul road sections within the pit, a pit retention factor of 50% was applied to the coarser particle size fraction of TSP (PM₁₁₋₃₀). The combined control factor was calculated using the equation below (NPI, 2012) and gave an emission reduction of 97% for the pit haul road TSP PM₁₁₋₃₀ dust component.

$$1 - ((1 - .93) \times (1 - 0.5)) \approx 0.97$$

Considering the water balance at hand for the Hillside Project reliance on high level water sprays rather than specific chemical dust suppressants such as calcium and/or magnesium chlorides for haul road dust control is more appropriate. In this light, the sensitivity of impacts to the haul road dust control efficiency was examined and the results are presented below.

B.2.2 Updated Wheel Generated Haul Road Dust Emissions Estimation

The emissions estimation for wheel-generated haul road dust emissions was updated as follows for the additional assessment scenario presented in this appendix:

- Water spray control factor instead of chemical salt spray for haul road dust suppression.
- Revised assumption on haul road surface silt content.
- Updated vehicle movements based on an equipment change to a haul truck with higher payload capacity.

B.2.2.1 Water Spray Dust Control Factor

The wheel-generated haul road dust control factor was revised with the change from chemical salt spray dust suppression to water sprays. The control factor was estimated based on the same methodology as applied in the Olympic Dam Expansion dust study (BHP, 2009) for the equation below (Cowherd, Muleski, & Kinsey, 1988).

$$C = 100 - \frac{0.8 p d t}{i}$$

The parameters are detailed in Table B.2.1. They are based on an annual average daily evaporation rate and the worst case pit haul road traffic rates including both ore and waste rock haulage. A control efficiency factor of 83.5% can be achieved, as applied in the Olympic Dam Expansion dust study (BHP, 2009).

For summer conditions it is estimated that roughly double the application frequency would be required for the same control efficiency.

Table B.2.1: Haul Road Water Spray Control Efficiency Calculation Parameters

Parameter	Value	Commentary
p = potential average hourly daytime evaporation rate	0.39 mm/hr	Based on annual average evaporation rate.
d = average hourly daytime traffic rate	39.3 hr ⁻¹	Based on pit traffic rates of ore & waste rock haul trucks.
i = application intensity	2.2 L/m ²	
t = time between applications	3 hr	
C = average control efficiency	83.5%	Based on above values.

Considering the water balance from the mine dewatering, there will be no limitations on availability of water for water sprays. This assures that a well maintained water spraying program can be operated. The salinity of the available water will also in all likelihood produce better dust suppression performance than an equal amount of fresh water.

B.2.2.2 Haul Road Surface Silt Content

In reconsidering the haul road dust control the haul road surface silt content was also revised. The haul road surface silt content applied in the main body of the report was very conservative at 8.4% (US EPA, 2006b). For this revision the surface silt content was amended to a lower available reference of 4.3% (US EPA, 1998) to reduce the level of conservatism applied. However, these surface silt contents should be viewed in consideration of recent haul road surface silt samples taken in New South Wales providing an average silt content of 2.7% across three mines (PAEHolmes, 2013). The relevance of the surface silt data for better accuracy in emissions estimation is becoming more recognised and the previous reliance on literature data for this parameter is starting to become replaced with actual data. There is, however, limited data for Australian conditions.

Emission rates estimated based on the different silt contents are presented in Table B.2.2, where they are compared to the haul road emission rates applied in the Olympic Dam Expansion dust study. As can be seen, the applied haul road uncontrolled dust emission rates for PM₁₀ and TSP are higher, and hence more conservative, than the Olympic Dam Expansion dust study haul road emission rates.

Table B.2.2: Haul Road Surface Silt Contents Corresponding Uncontrolled Dust Emission Rates

Parameter	PM ₁₀	TSP	Commentary
Haul road dust emission rate based on 8.4% silt content	2.39 kg/VKT	8.37 kg/VKT	For comparison the Olympic Dam Expansion dust study uncontrolled haul road emission rates were estimated to (BHP, 2009): PM ₁₀ : 1.0 kg/VKT TSP: 4.0 kg/VKT
Haul road dust emission rate based on 4.3% silt content	1.31 kg/VKT	5.24 kg/VKT	

B.2.2.3 Haul Road Vehicle Movements

The haul road truck payload capacity changed with an update of the proposed haul truck fleet from CAT 789C with a payload capacity of 177 tonnes to CAT 793D with a payload capacity of 218 tonnes. The increased capacity reduced the number of truck movements and this was also taken account of in the updated scenario.

B.3 UPDATED EMISSIONS ESTIMATION

B.3.1 Summary Total Emissions

The updated total emissions following the update of the haul road wheel generated dust emissions are presented in Table B.3.1.

Table B.3.1: Summary of TSP and PM₁₀ Emissions

	Annual TSP Emissions (kg/year)	Annual PM ₁₀ Emissions (kg/year)
Pit Activities (including haul roads within the pit)	687,570	369,775
Loading and Unloading Activities	68,957	29,026
Wind Erosion from Exposed areas	19,249	9,625
Haul Roads outside of pit	808,462	201,564
Crushing Activities	22,500	9,000
Port Operations	6,111	2,444
TOTAL EMISSIONS	1,612,849	621,434

B.3.2 Wheel-Generated Dust (Unpaved Roads)

Emissions from wheel-generated dust from unpaved roads were estimated using the method outlined in AP-42 Chapter 13.2.2 Unpaved Roads (US EPA, 2006b). The general equation for the emission factor is shown below. The constants k, a and b are dependent on the particle size range and are summarised in Table 11.9. The emission factor equation inputs are summarised in Table 11.10 and the calculated uncontrolled emission rates are summarised in Table 11.11.

$$EF_{TSP} = 0.2819 \times k \times \left(\frac{s}{12}\right)^a \times \left(\frac{1.102311 \times W}{3}\right)^b$$

Table B.3.2: Constants for Wheel-Generated Dust from Industrial Roads

Constant	PM ₁₀	TSP ^a
k (lb/VKT)	1.5	4.9
a	0.9	0.7
b	0.45	0.45

b. Value for PM₃₀ assumed to be equivalent to TSP

Source: (US EPA, 2006b)

Table B.3.3: Emission Factor Equation Inputs for Wheel-Generated Dust (Unpaved Roads)

Activity Area	Material	Data Input	Value	Units
Open Pit ROM Pad Waste Rock Dump	Copper Ore	Silt Content ^a	4.3	%
	Waste Rock	Vehicle Average Weight ^b	260	tonnes

c. Source: (US EPA, 1998). Mean silt content for haul trucks

d. Source: (US EPA, 2006b). Upper limit of mean vehicle weight range.

Table B.3.4: Emission Factors for Wheel-Generated Dust (Unpaved Roads)

Activity Area	Material	Emission Factor	Value (kg/km)
Open Pit ROM Pad Waste Rock Dump	Copper Ore	EF _{TSP}	5.24
	Waste Rock	EF _{PM10}	1.31

Total emissions of TSP and PM₁₀ from wheel-generated dust were estimated using the equation below. The total distance travelled was estimated using the haul road length, the truck capacity and the total amount of material loaded. This method is outlined below. The activity data and control efficiencies for wheel-generated dust (unpaved road) are summarised in Table 11.12 and Table 11.13 respectively.

$$E_i = EF_i \times TD \times \left(\frac{100 - CE_i}{100} \right)$$

where:

E_i	=	Emission rate of substance i	(kg/annum)
EF_i	=	Uncontrolled emission factor for substance i	(kg/km)
TD	=	Total distance travelled on unpaved roads by the vehicle	(km/annum)
CE_i	=	Overall control efficiency for pollutant i	(%)

$$TD = L \times \frac{M}{C_T}$$

where:

TD	=	Total distance travelled on unpaved roads by the vehicle	(km/annum)
L	=	Haul road length	(km)
M	=	Total amount of material loaded	(tonnes/annum)
C_T	=	Truck capacity	(tonnes)

Table B.3.5: Activity Data for Wheel Generated Dust (Unpaved Roads)

Activity Area	Description	Data Input	Value	Units
Open Pit	In Pit Copper Ore	Type of Truck ^a	Cat 793D	-
		Haul Road Length (L) ^b	2.0	km
		Total Amount of Ore Trucked ^c	15,000,000	tonnes
		Truck Capacity (C _T) ^d	218	tonnes
	In Pit Waste Rock	Type of Truck ^a	Cat 793D	-
		Haul Road Length (L) ^b	2.0	km
		Total Amount of Ore Trucked ^a	60,000,000	tonnes
		Truck Capacity (C _T) ^d	218	tonnes
ROM Pad	Copper Ore Outside of Pit	Type of Truck ^a	Cat 793D	-
		Haul Road Length (L) ^c	2.3	km
		Total Amount of Ore Trucked ^a	15,000,000	tonnes
		Truck Capacity (C _T) ^d	218	tonnes

Waste Rock Dump	Waste Rock to Waste Rock Dump	Type of Truck ^a	Cat 793D	-
		Haul Road Length (L) ^a	2.3	km
		Total Amount of Ore Trucked ^a	60,000,000	tonnes
		Truck Capacity (C _T) ^d	218	tonnes

e. Source: (Rex Minerals, 2013b)

f. Pacific Environment estimate based on assumed 0.1 km depth of pit and 5% grade

g. Source: (Rex Minerals, 2012b)

h. Truck capacity based off caterpillar specifications.

Table B.3.6: Control Efficiencies for Wheel-Generated Dust (Unpaved Roads)

Activity Area	Material	Description	Control Efficiency	Value ^c (%)
Open Pit	In Pit Copper Ore	Water Sprays ^a	CE _{TSP}	92
	In Pit Waste Rock	Pit Retention ^b	CE _{PM10}	84
ROM Pad	Copper Ore Outside of Pit	Water Sprays ^a	CE _{TSP}	84
			CE _{PM10}	84
Waste Rock Dump	Overburden to Waste Rock Dump	Water Sprays ^a	CE _{TSP}	84
			CE _{PM10}	84

a. Source: (Cowherd, Muleski, & Kinsey, 1988) calculated as described in Section B.2.2.1

b. Source: (SEWPaC, 2012) 50% and combined factor calculated as described in Section B.2.1

c. Values rounded to nearest whole number

B.4 PM₁₀ BACKGROUND CONCENTRATION DATA

Table 4.1 shows the distribution of the number of days with ambient concentrations above the NEPM air quality standard of 50 µg/m³. The data are for 4 years of data from the Schultz Reserve monitoring site in Whyalla. While 2009 had a total of 9 exceedance days, there was a total of 4 exceedance days across the other 3 years. In comparison, the Rex Minerals baseline data showed 6 exceedances for the monitoring during 2012 with no data collected during the drier months (67% data recovery).

Table B.4.1: PM₁₀ Background Concentration Data

Substance	Monitoring Year	Number of Exceedance Days (above 50 µg/m ³)	Monitoring station	Data Availability ^a
PM ₁₀	2009	9	Whyalla, Schultz Reserve	92.9%
PM ₁₀	2010	3	Whyalla, Schultz Reserve	98.1%
PM ₁₀	2011	1	Whyalla, Schultz Reserve	95.3%
PM ₁₀	2012	0	Whyalla, Schultz Reserve	92.1%
PM ₁₀	2009 – 2012	13	Whyalla, Schultz Reserve	94.6%

b. Data availability based on validated data. Daily averages were considered invalid with less than 75% of hourly data.

Source: (SA EPA, 2013)

Figure B.4.1 compares the frequency distributions of the Whyalla PM₁₀ concentrations and the Hillside baseline data. While there are limitations to this comparison based on the difference in data availability between the two sites (4 years compared to approximately 8 months), it appears that the Hillside

location has a higher frequency of elevated PM₁₀ concentrations than Whyalla^f but may have a lower annual average concentration than Whyalla. Almost all of the higher concentrations recorded at Hillside occur on days with high wind speed events.

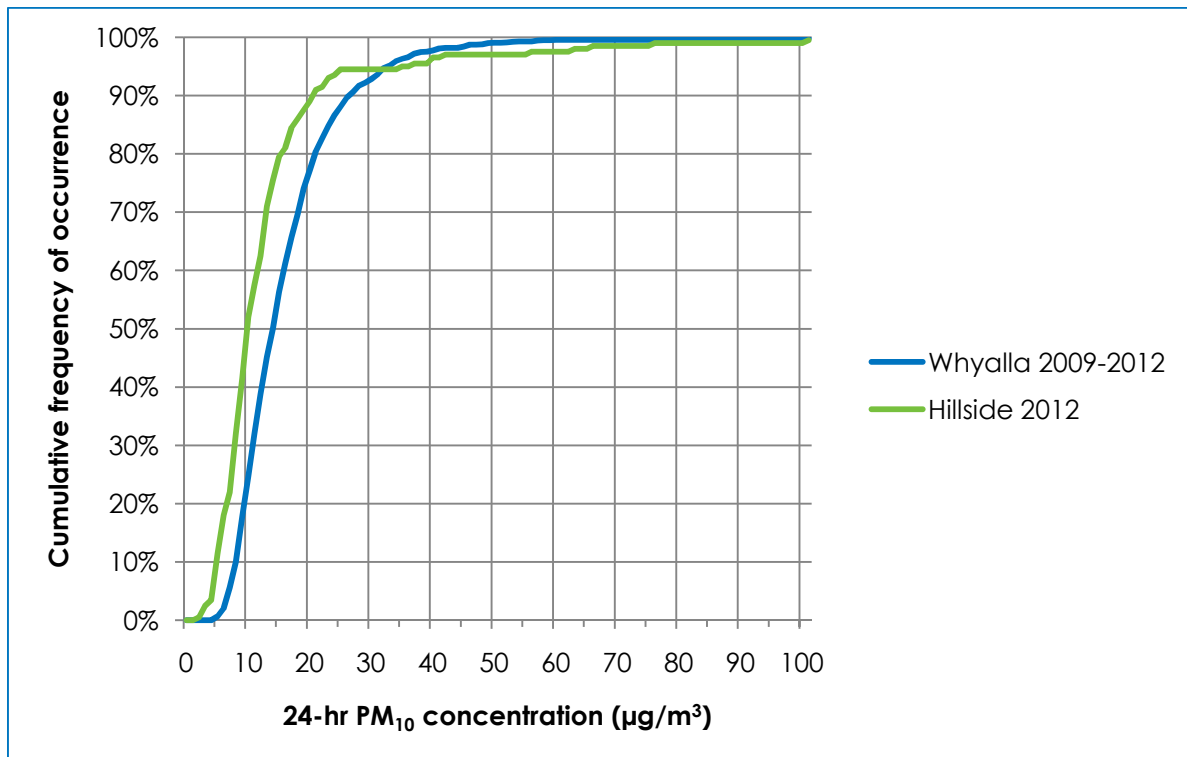


Figure B.4.1: Cumulative Frequency Distributions of Ambient Background PM₁₀ Concentrations, Showing Percentage of Hours when Concentration is Less than or Equal to the Value on the x-axis

B.5 DISPERSION MODELLING RESULTS (REVISED MODELLING)

In this section the dispersion modelling results with cumulative background concentrations are evaluated based on two methodologies.

In Section B.5.1 the results are evaluated using a 70th percentile background concentration, as in the main body of the report.

In Section 0 the results are evaluated using a statistical representation of background concentration values.

B.5.1 Cumulative Assessment of Predicted PM₁₀ Concentrations and 70th Percentile Background Concentration

Table B.5.1 shows the results from the updated dispersion modelling scenario (values in bold) and the main report results (second value within brackets). The overall increase in predicted concentrations is small, at most a few percent for the peak predicted impacts. Based on the 70th percentile background

^f Six exceedances of 50 µg/m³ were also recorded at Hillside in 2012 while there were none at Schultz Reserve in Whyalla during the same period.

concentration, one additional day per year would exceed the NEPM air quality standard⁹. The results in Table B.5.1 are also plotted in Figure B.5.1 and time series data showing all predicted concentrations as percentiles for Receptors 8 and 9 are presented in Figure B.5.2 and Figure B.5.3.

Contour plots are presented in Figure B.5.4 and Figure B.5.5.

Table B.5.1: Maximum Predicted Daily Average PM₁₀ Concentration at Nearest Sensitive Receptors

Receptor	Maximum Predicted Daily Average PM ₁₀ Concentration (µg/m ³) ^a						
	Maximum	1 day excluded	2 days excluded	3 days excluded	4 days excluded	5 days excluded	10 days excluded
1	23.1 (22.8)	22.8 (22.6)	22.1 (21.9)	21.6 (21.5)	21.5 (21.3)	21.5 (21.3)	20.6 (20.4)
2	25.5 (25.2)	24.0 (23.8)	23.2 (23.0)	22.2 (22.0)	22.0 (21.8)	21.9 (21.8)	21.2 (21.0)
3	36.1 (35.3)	34.4 (33.7)	30.8 (30.3)	30.7 (30.1)	28.4 (28.0)	26.8 (26.5)	25.0 (24.7)
4	41.6 (40.7)	33.5 (32.9)	33.2 (32.7)	33.1 (32.5)	31.8 (31.3)	30.3 (29.8)	27.2 (26.8)
5	28.0 (27.6)	27.1 (26.8)	26.9 (26.5)	26.5 (26.2)	25.9 (25.6)	24.4 (24.2)	22.9 (22.7)
6	28.2 (27.8)	27.4 (27.0)	26.0 (25.7)	25.7 (25.4)	23.0 (22.8)	22.8 (22.6)	21.9 (21.8)
7	40.6 (39.7)	35.6 (35.0)	35.4 (34.7)	34.7 (34.1)	34.0 (33.4)	34.0 (33.3)	28.4 (28.0)
8	62.2 (60.3)	47.1 (46.0)	42.5 (41.5)	42.1 (41.2)	38.4 (37.7)	38.4 (37.5)	30.9 (30.3)
9	59.2 (57.5)	54.4 (52.9)	54.1 (52.7)	50.8 (49.6)	41.3 (40.5)	40.3 (39.3)	34.4 (33.8)
10	40.3 (39.4)	35.1 (34.4)	30.9 (30.4)	29.3 (28.9)	25.8 (25.5)	25.2 (25.0)	23.5 (23.3)
11	45.4 (44.3)	33.1 (32.5)	31.3 (30.8)	31.1 (30.6)	29.7 (29.2)	27.8 (27.4)	24.9 (24.7)
12	22.3 (22.2)	22.2 (21.9)	21.8 (21.7)	21.7 (21.6)	21.2 (21.3)	20.9 (20.8)	20.4 (20.4)

b. Including background concentration of 18.1 µg/m³

⁹ The NEPM goal is a maximum of 5 days per year exceeding the standard, including the effects of natural events.

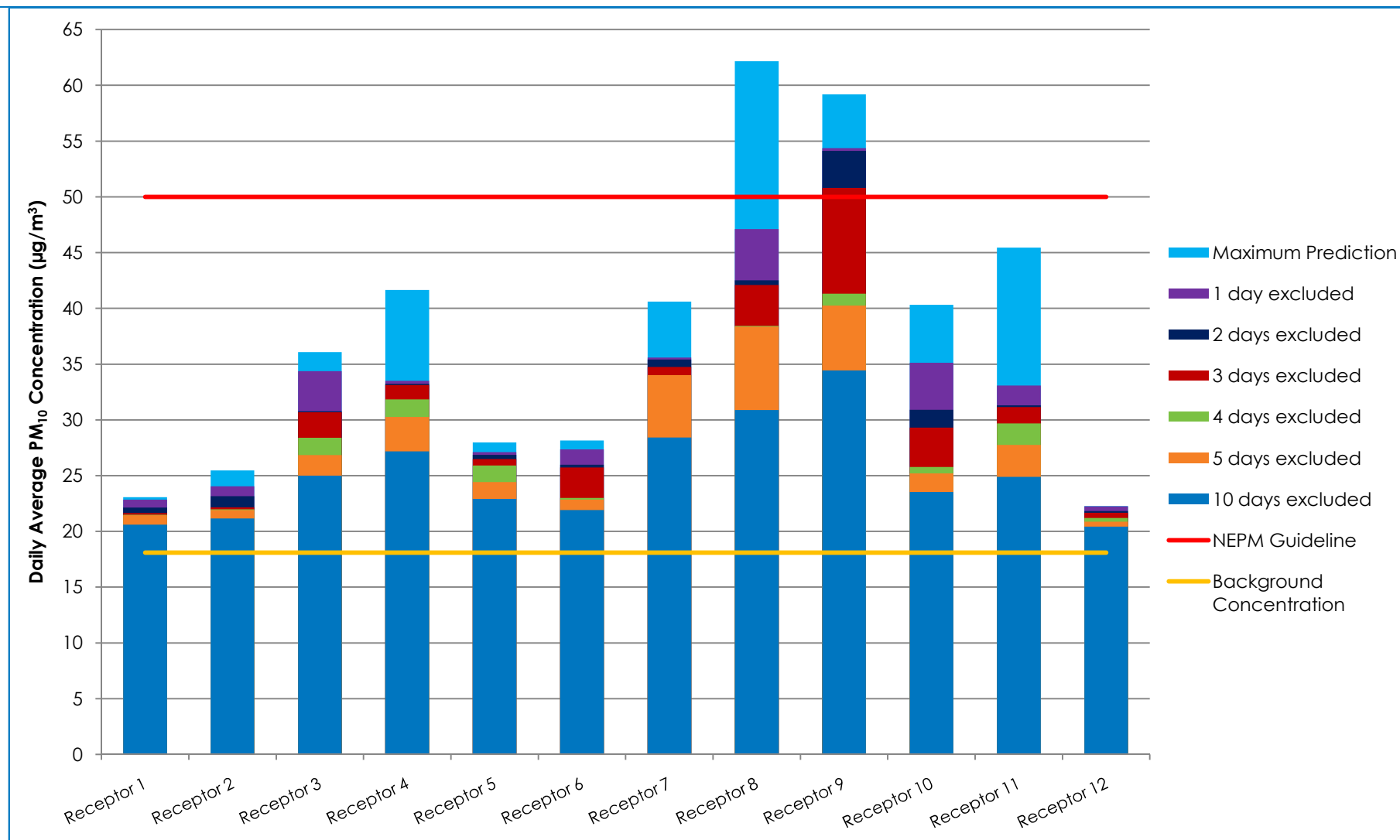


Figure B.5.1: Maximum Predicted Daily Average PM₁₀ Concentration for Nearest Sensitive Receptors (including background concentration)

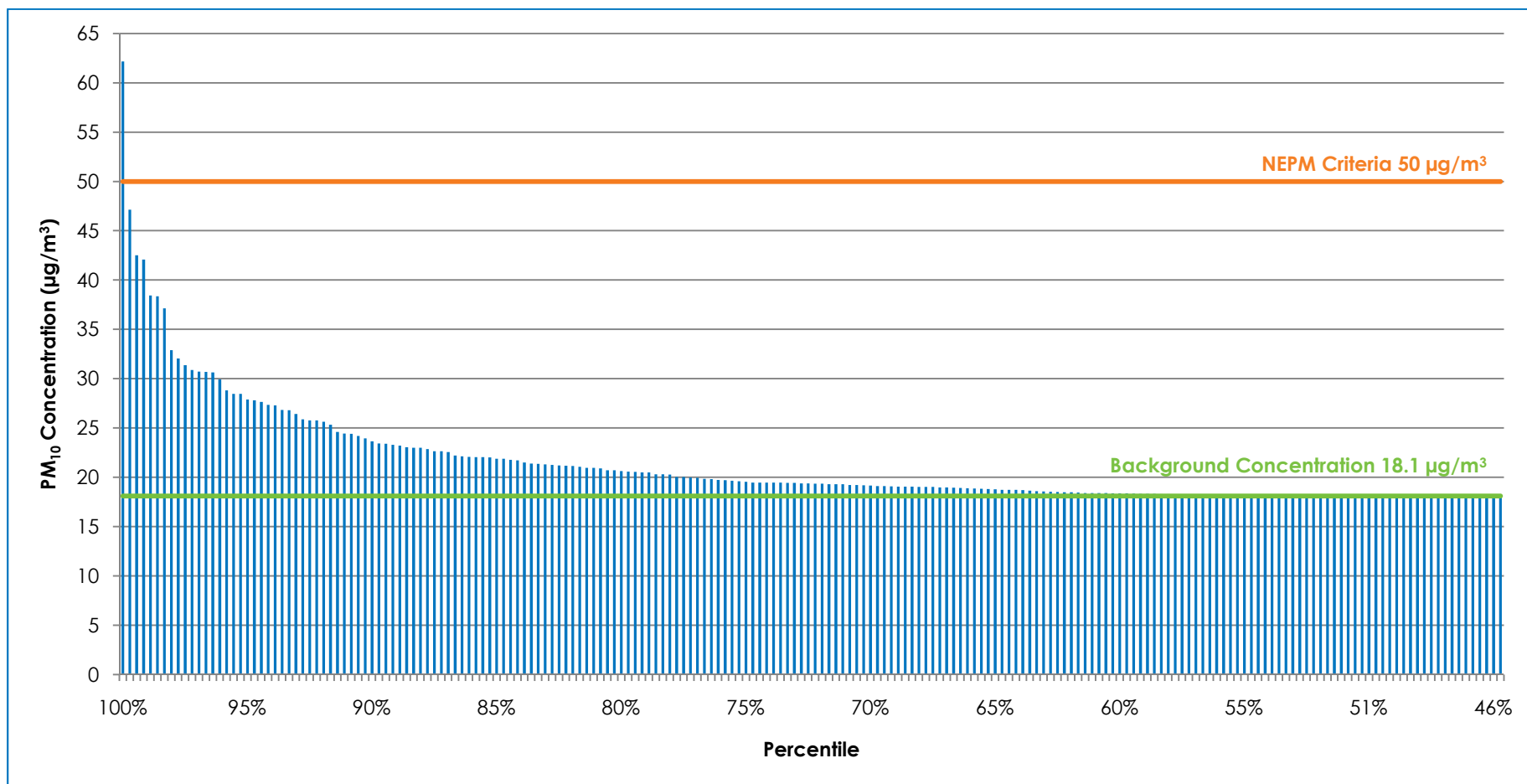


Figure B.5.2: 24-hour Average PM₁₀ Concentrations against Percentile for Receptor 8

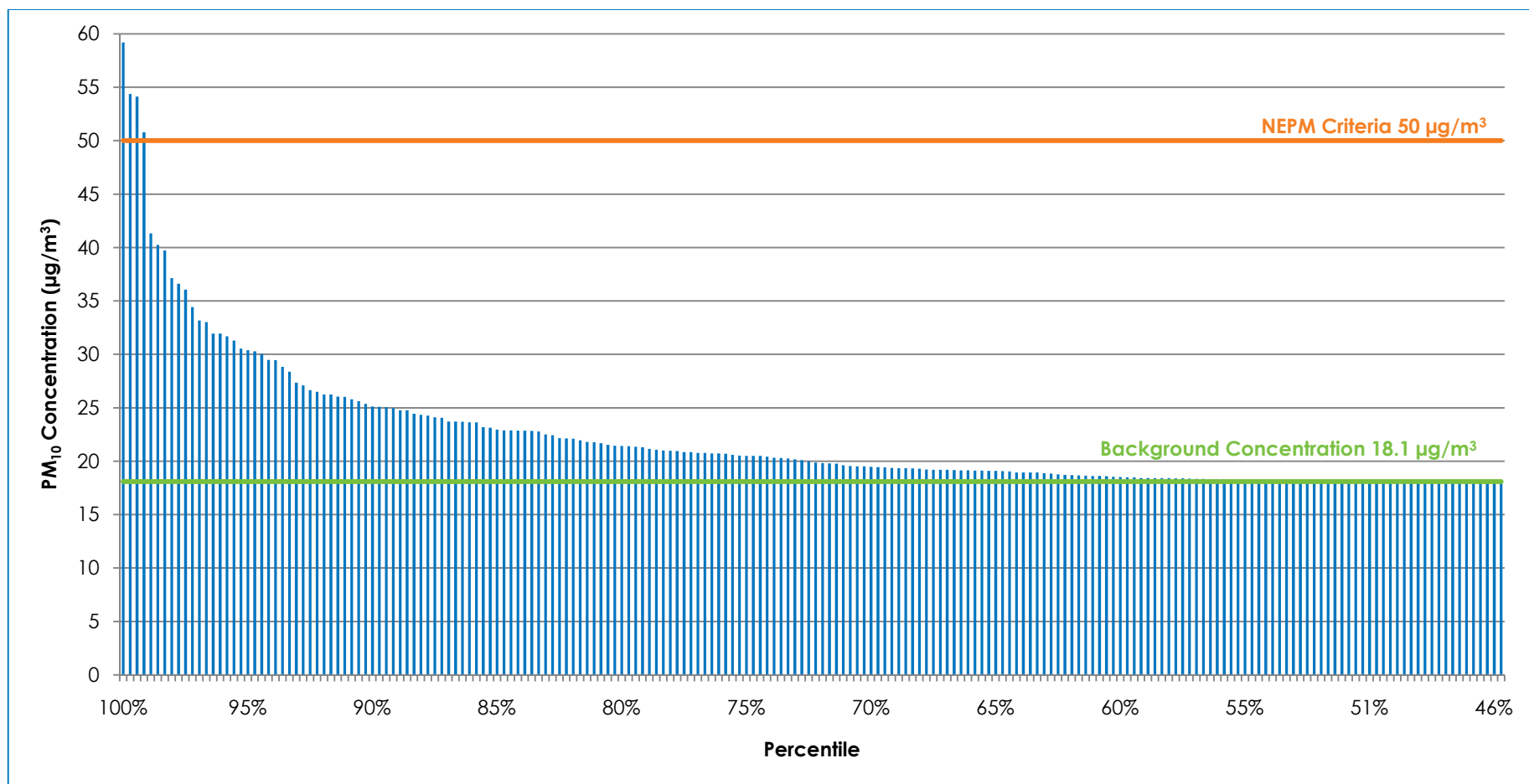


Figure B.5.3: 24-hour Average PM₁₀ Concentrations against Percentile for Receptor 9

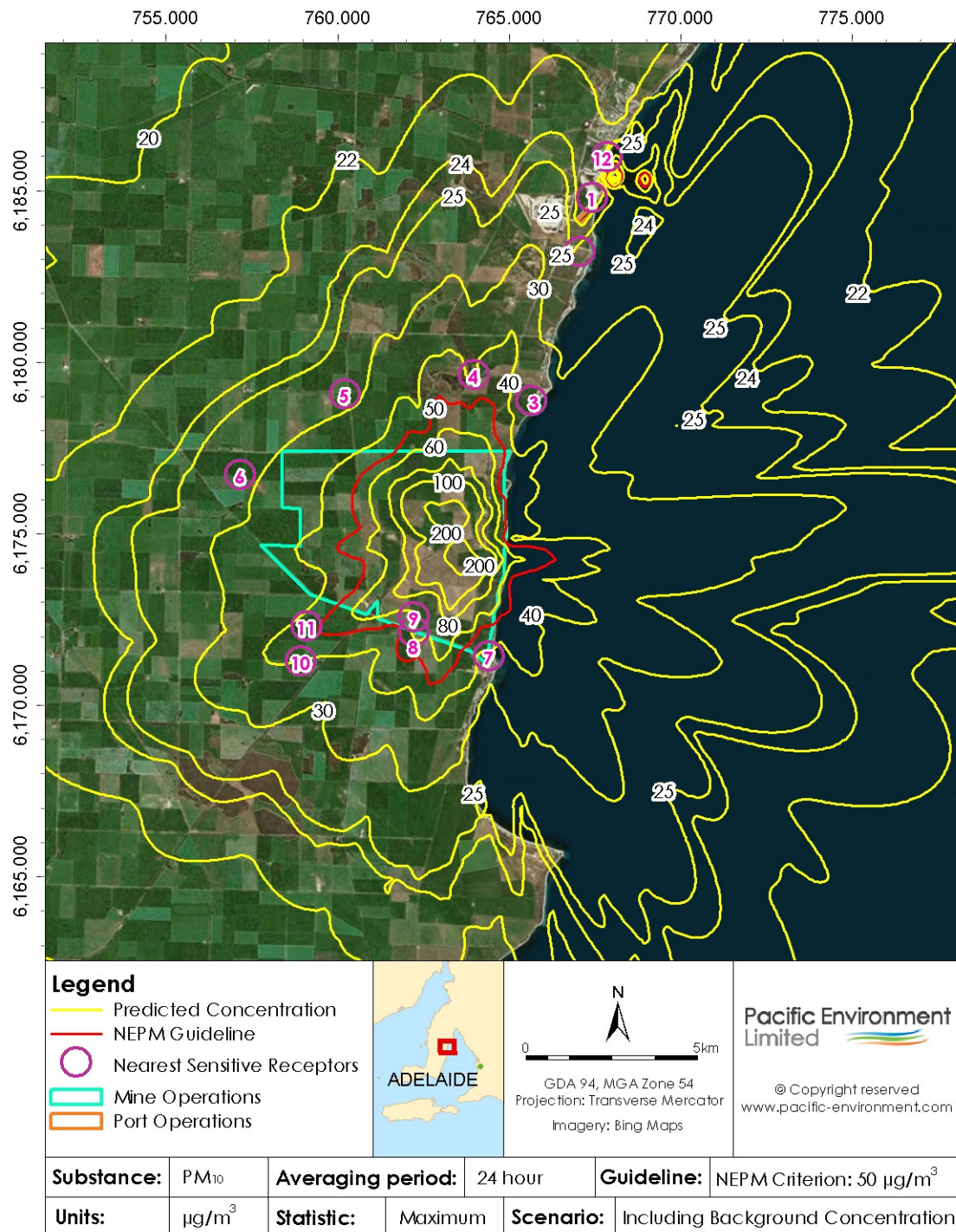


Figure B.5.4: Predicted maximum 24-hour PM₁₀ Concentration (Mine Operations) – including background concentration

Figure B.5.4 shows the predicted PM₁₀ impacts from the revised haul road dust emissions scenario. The increased footprint of the 50 µg/m³ contour is very limited.

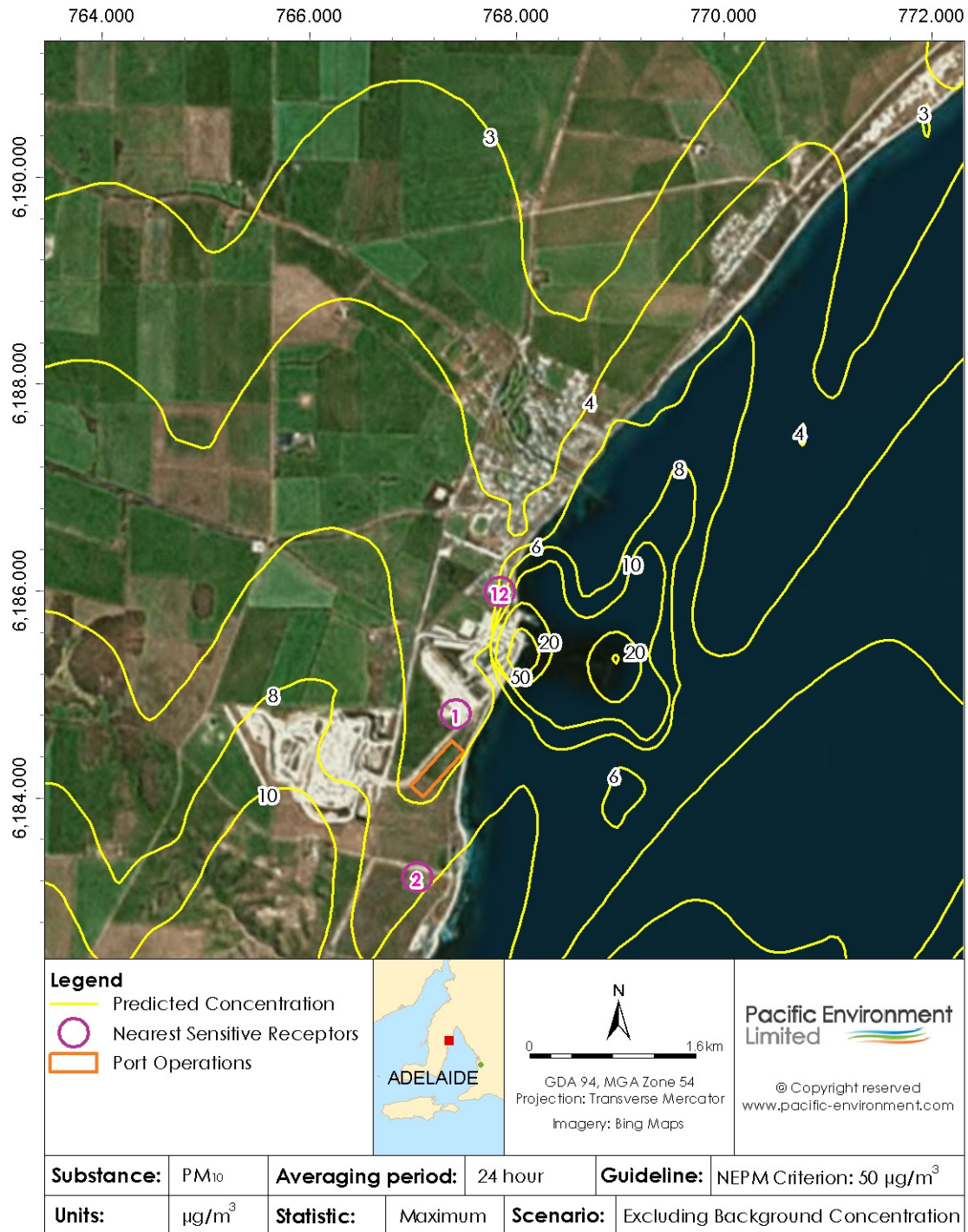


Figure B.5.5: Predicted maximum 24-hour PM₁₀ Concentration (Port Operations) – excluding background concentration

Considering the distance from the mine operations the impacts from the revised haul road dust emissions scenario around Ardrossan, presented in Figure B.5.5, show very little increase (as presented in Table B.5.1) in the predicted PM₁₀ concentrations.

B.5.2 Cumulative Assessment of Predicted PM₁₀ Concentrations and Statistically Generated Background Concentrations

A statistical approach, using a Monte Carlo or probability-based simulation, was used for an additional investigation of cumulative^h 24-hour PM₁₀ concentrations. The approach takes all of the background monitoring data (Whyalla Schultz Reserve 2009-2012) and determines key statistical properties of the data. Then those statistical properties are combined with a series of random numbers to produce a randomised simulation of 24-hour average PM₁₀ concentrations for any period of time, in this case a year. The simulated concentrations when aggregated have the same statistical properties as the monitoring data. However, because the simulation uses a randomised process, each simulation produces a different specific series of daily values. In this way, the method produces different time series of daily background concentrations that are statistically consistent with the monitoring data, yet different in detail. A simulated series of years of background concentrations then allows us to see how potential variations in background concentrations affect the cumulative predictions in future years. We run the Monte Carlo simulation using the Oracle Crystal Ball software (version 11.1.1.2).

For this assessment, 250,000 random background concentrations were generated and added to the predicted 24-hour PM₁₀ concentrations at Receptors 8 and 9. This then enabled a probability distribution of cumulative 24-hour PM₁₀ concentrations to be produced.

The process assumes that a randomly selected background value from the dataset would have a chance equal to that of any other background value from the dataset of occurring on the given future day when the mine is in operation. With sufficient repetition, this yields a good statistical estimate of the combined and independent effects of varying background and the proposed mine contributions to total 24-hour PM₁₀ concentrations.

The results of the simulations for Receptor 8 and 9 are presented in Figure B.5.6. They show the predicted number of days that cumulative 24-hour PM₁₀ concentration would exceed each 24-hour PM₁₀ concentration. The results, also presented in Table B.5.2, show that based on the Whyalla 2009 to 2012 background data typically the background concentration would exceed the NEPM standard 3 times per year. Receptor 8 and 9 would see 5 and 6 exceedances (including background) per year if full production mining operations were to take place on all days without reactive or practice management, i.e., with no shutdown or adjustment of operations to reduce emissions at critical times.

Table B.5.2: Number of Estimated NEPM Exceedances

Receptor/ Background	Number of predicted exceedances per year	Commentary
Background	3	Background alone
Receptor 8	5	Including background
Receptor 9	6	Including background

^h Predicted plus background

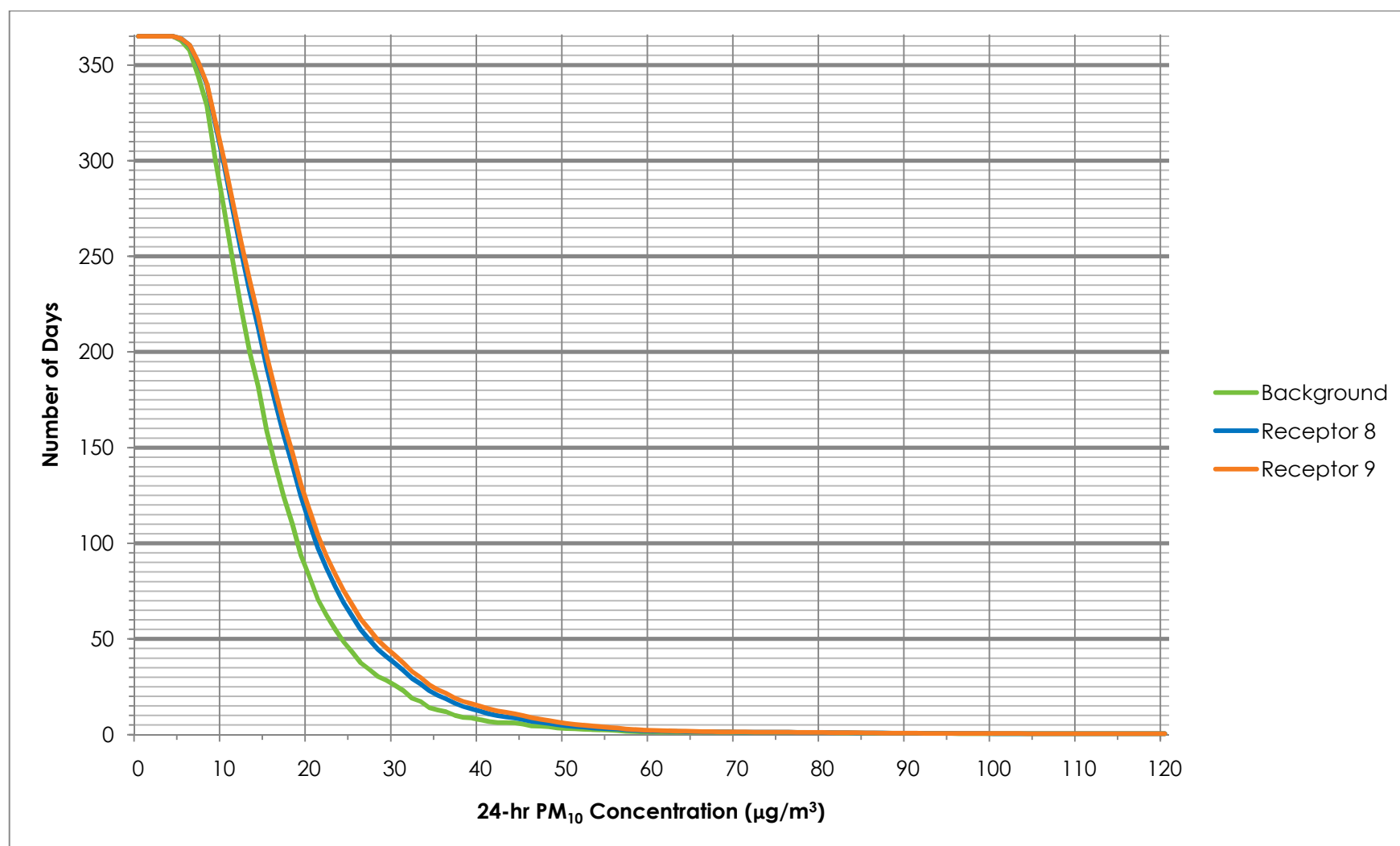


Figure B.5.6: Cumulative PM₁₀ Concentration Results

B.5.3 Annual Average TSP and Dust Deposition Results

The predicted TSP annual average concentration and dust deposition rate increases due to the revised emissions estimation are presented in Table 9.3 and Table 9.4. Contour plots are presented in Figure B.5.7 to Figure B.5.10. The results, all based around longer averaging periods than the PM₁₀ results, show small increases.

Table B.5.3: Annual Average TSP Concentration (including background)

Receptor	Annual Average TSP Concentration ^a (µg/m ³)
1	26.5 (26.4)
2	26.6 (26.5)
3	27.9 (27.6)
4	28.1 (27.9)
5	27.4 (27.2)
6	26.8 (26.7)
7	28.2 (27.9)
8	29.2 (28.8)
9	30.1 (29.6)
10	27.1 (27.0)
11	27.5 (27.3)
12	26.6 (26.5)

b. Including background annual average TSP concentration (26 µg/m³)

Table B.5.4: Annual Average Dust Deposition

Receptor	Annual Average Dust Deposition ^a (g/m ² .month)
1	0.034 (0.030)
2	0.033 (0.027)
3	0.13 (0.11)
4	0.18 (0.15)
5	0.15 (0.12)
6	0.049 (0.041)
7	0.20 (0.17)
8	0.25 (0.21)
9	0.32 (0.27)
10	0.076 (0.063)
11	0.098 (0.082)
12	0.051 (0.048)

b. Not including background dust deposition

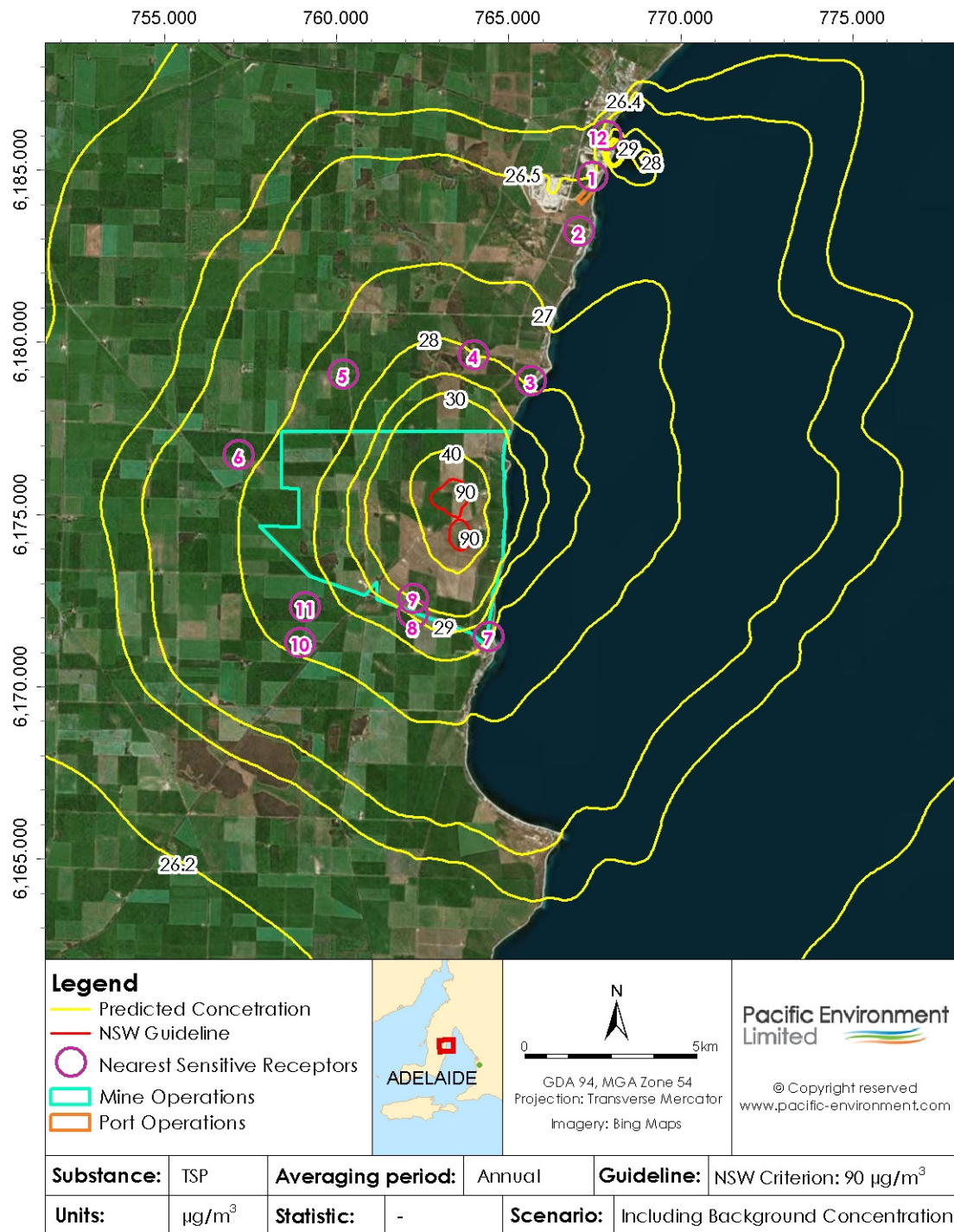


Figure B.5.7: Predicted Annual Average TSP Concentration (Mine Operations) – including background concentration

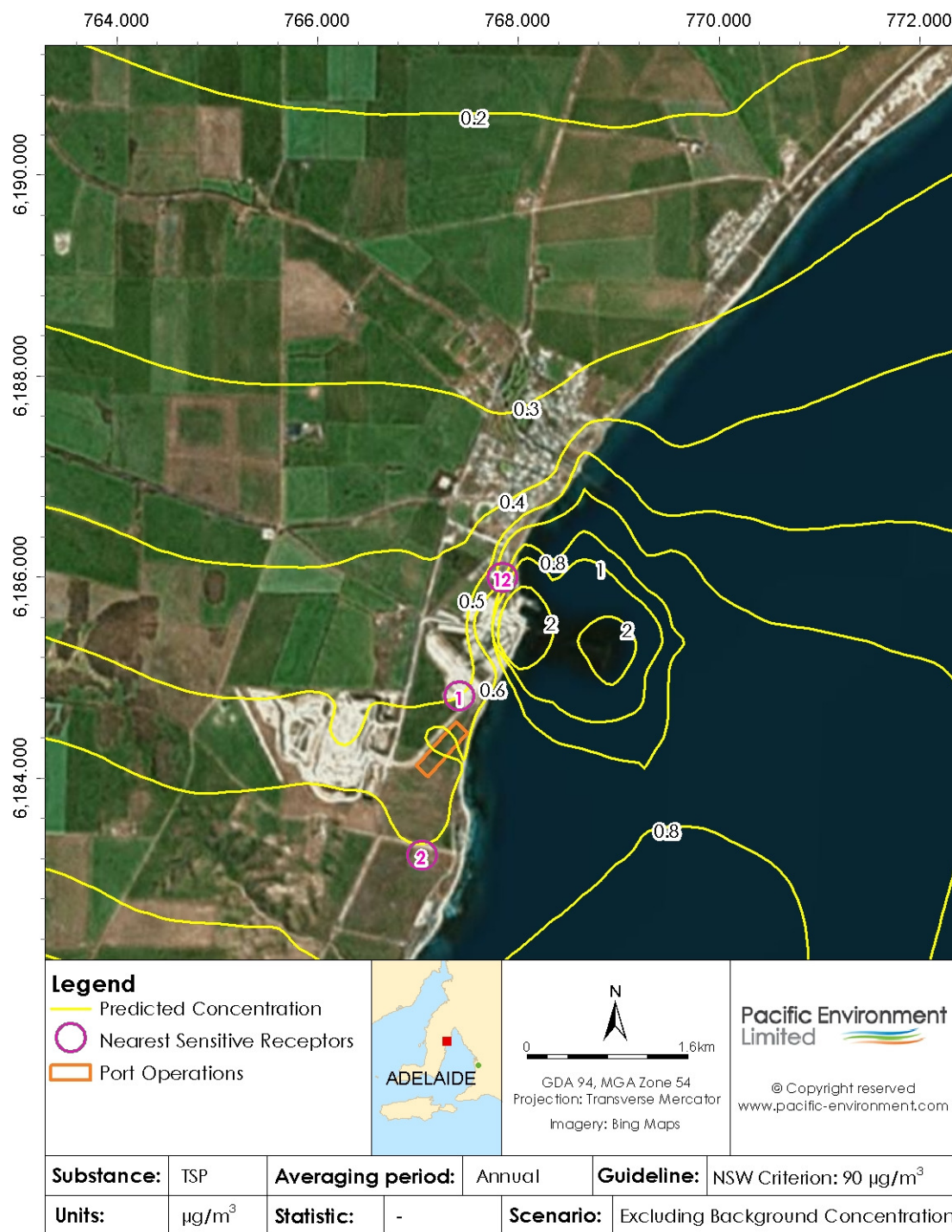


Figure B.5.8: Predicted Annual Average TSP Concentration (Port Operations) – excluding background concentration

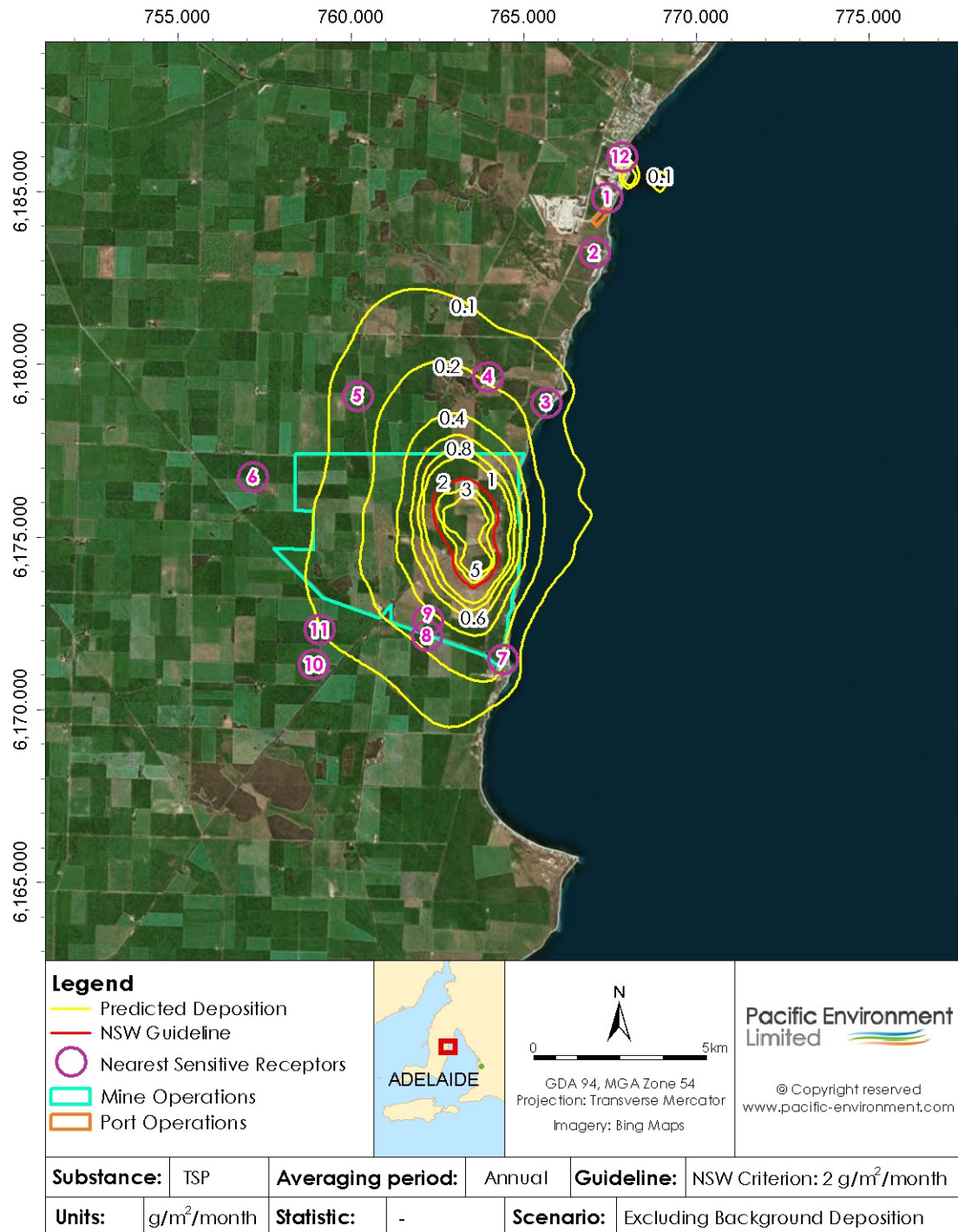


Figure B.5.9: Predicted Annual Average Dust Deposition (Mine Operations) – excluding background deposition

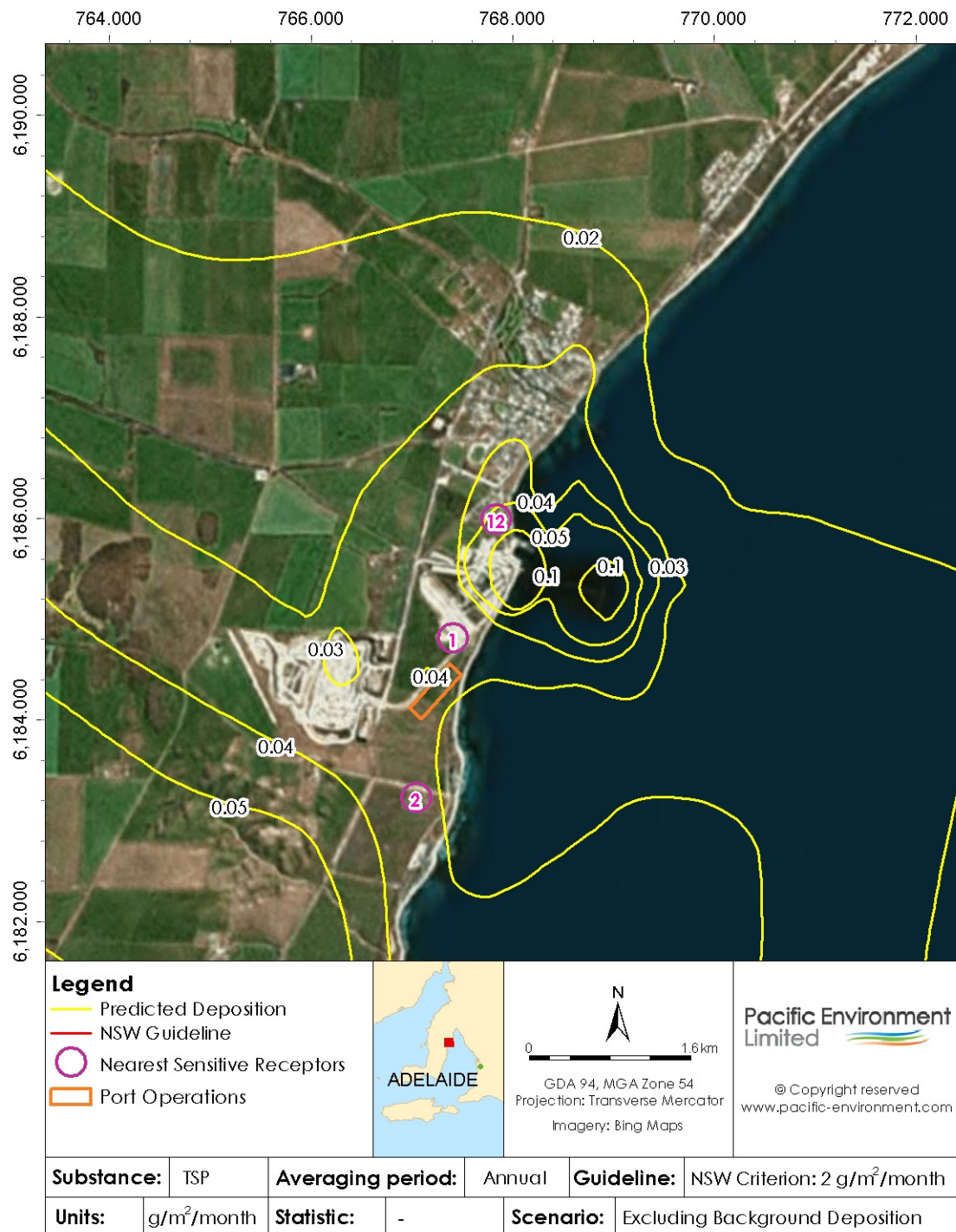


Figure B.5.10: Predicted Annual Average Dust Deposition (Port Operations) – excluding background deposition

B.6 SUMMARY DISCUSSION

The assessment shows that haul road dust control based on a high level water spray program achieves a similar outcome, in terms of dust impacts, to that predicted in the main assessment report. Only marginally higher predicted impacts are expected compared to the scenario of magnesium/calcium chloride salt sprays for haul road dust control. A main contributing factor to this outcome, with the application of a lower dust emission control factor, is the revision of the haul road surface silt content, which was assumed very conservatively in the main body report and reduced in this revision to be consistent with more relevant data sources. While the surface silt content was reduced, the resulting haul road dust emission rate can still be considered conservative.

The cumulative analysis of predicted PM₁₀ concentrations and simulated background concentrations for Receptors 8 and 9 showed 5 and 6 exceedance days, including 3 days of ambient background exceedances. The statistical approach estimates 2 and 3 exceedance days on top of ambient exceedance days. In comparison, assessment based on the 70th background concentration yielded 4 exceedance days per year.

Ambient dust levels do vary from year to year and there is suggestion that the PM₁₀ concentration distributions differ between Whyalla Schultz Reserve and the Hillside location. However, while the number of natural exceedance days varies from year to year it is not expected that the year to year dust trend would significantly impact on the number of predicted exceedance days. This is because adjustment or shutdown of operations under critical conditions is feasible, and would be based on real-time dust monitoring.

As discussed in the main body of the report a real-time monitoring system is proposed for monitoring and active management of PM₁₀ levels to ensure that operations can occur without PM₁₀ NEPM exceedances at nearby receptors. The purpose of the real-time monitoring system is to inform the operations when additional dust suppression, adjustment or shutdown of the operations is required to avoid a NEPM exceedance.

B.7 REFERENCES

- BHP. (2009). *Olympic Dam Expansion Draft Environmental Impact Statement 2009. Appendix L*.
- Cowherd, C., Muleski, G. E., & Kinsey, J. S. (1988). *Control of Open Fugitive Dust Sources*. North Carolina: US EPA - Office of Air Quality Planning and Standards.
- NPI. (2012). *National Pollutant Inventory Emissions Estimation Technique Manual for Mining version 3.1. January 2012*.
- PAEHolmes. (2013). *Generation, Measurement, and Control of Dust Emissions from Unsealed Haul Roads. ACARP Project C20023. March 2013*.
- Rex Minerals. (2012b). Meeting held 1 November 2012.
- Rex Minerals. (2013b). Rex Equipment Jan13. *Rex Equipment Jan13.xlsx*.
- Rushing, J. F., & Tingle, J. S. (2007). Evaluation of Products and Application Procedures for Mitigating Dust in Temperate Climates. *Transportation Research Record, No 1989, Vol 1*, 305-311.
- SA EPA. (2013). South Australia Air Quality Data. SA EPA.

SEWPaC. (2012). *NPI Emission Estimation Technique Manual for Mining V3.1*. Department for Sustainability, Environment, Water, Population and Communities.

US EPA. (2006b). *AP-42 Fifth Edition Volume I. Chapter 13.2.2 Unpaved Roads*. US EPA.

US EPA. (1998). *AP-42 Fifth Volume 1. Chapter 11.9 Western Surface Coal Mining - Final Section*. US EPA.




HILLSIDE PRE-FEASIBILITY STUDY

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MINING PLUS

Document Control Information

	K Ugh'FcW'Gla d]b[REVISION	
			NO.	DATE
	MCREXH22-MEPR-3.09 K Ugh'FcW'Gla d]b[03	21/12/2012

Revision Tracking

Revision:	Prepared By:	Reviewed By:	Issued For:	Approved By:	Date:	Signature:
01	Ben Brown, Michael Check, Jamie Gough, Andrew Bales, Michael Shi	Craig Burr	RC	Craig Burr	12/12/2012	
02	Ben Brown, Michael Check, Jamie Gough, Andrew Bales, Michael Shi	Darren Head, Stewart Robinson	FV	Andrew Gasmier	20/12/2012	
03		Craig Burr	FV	Andrew Gasmier	20/12/2012	

Issued for: Review and Comment (RC), Information Only (IO), Implementation (IM), Final Version (FV).

% WASTE ROCK G5A D@B ;

%I Introduction

The Geochemical characterisation of waste rock has been completed or the partial fulfilment of Pre-Feasibility Study (PFS). The scope of this study does not allow any quantitative assessment of the various waste rock types present at the Hillside project at this stage.

The results of the waste rock sampling and analysis indicate a general benign waste rock character in the Hillside project area.

For a project of this size, an accurate and detailed understanding of all mine wastes is crucial to mitigate the site's potential environmental impact as part of planned mining activities. Based on the results of the first round of analysis, MP recommended a second round of sampling and analysis which was completed with the primary objectives and considerations for this sampling and analysis program outlined below:

1. Further assessment of any waste rock types deemed to have “uncertain” acid producing characteristics from the first round of testing. This includes material whose samples exhibited borderline NAPP values under-sampled and areas which are expected to be significantly under-represented in the total waste rock inventory;
2. More detailed understanding of the variation in the concentration of uranium present throughout the deposit, in order to facilitate appropriate management during the operational phase; and
3. Testing of some existing samples for the presence and characterisation of potential fibrous minerals.

Where further sampling and analysis is recommended, the samples were geographically and geologically representative of the proposed pit, planned for the PFS of the Hillside project.

%2 Lithological domains and cross sections

The lithological domains of waste rock were established by sampling rocks and studying their mineralogy.

The following general guiding principles are assumed:

- The data from the waste characterisation and mining models would be used to design the waste dump, to mitigate environmental impacts with particular attention paid to acid mine drainage (AMD) and mobilisation of metals and metalloids, including uranium;
- Waste rock generated from within the final pit perimeter is included in the assessment.
- All major waste rock lithologies and minor waste rock lithologies of consequence have been included in the assessment;
- Low grade and sub-grade ore are also included in the assessment; and
- The volumes of individual waste rock types have been excluded in the present study, pending updates to the pit design. The intention is for volumes to be assigned to waste rock types as part of future work.

There are fourteen waste rock lithological types (domains) as defined in the block model (rex_may_2012) as shown in Table %I below:

Table %1: Waste rock lithological types for the Hillside project

Waste rock lithology	Domain ID
Granite	1
Gabbro	2
Impure Carbonate	3
Unmineralised Metasediment	4
Skarn (red rock altered)	5
Skarn (pyritic)	6
Skarn (sulphide absent)	7
Pegmatite	8
Breccia (sulphide absent)	9
Breccia (pyritic)	10
Skarn (mineralised)	11
Metasediment (mineralised)	12
Other (mineralised)	13
Gritstone	14

%3 Waste rock domain and sampling

The sampling was done ensuring a geological continuity and representativeness of each lithological domain. In the granite rock type, twenty four (24) samples were collected from seven (7) different drill holes.

In the gabbro lithology, seven (7) samples were taken from six (6) drill holes. Samples from HDD-095 and HDD-107 are in continuity with other samples HDD-16, HDD-098, and HDD-215 across the length of the pit.

Four samples were taken of the Impure carbonate from four (4) drill holes.

Five (5) samples from five (5) drill holes were taken from the unmineralised metasediment lithology. HDD-33 and HDD-272 are continuous with a sedimentary package to the east of the pit including the mineralised sample at HDD-74 and a further 15 samples were obtained from the September sample round. A sedimentary package in proximity to the pine point fault including the chloritic metasediment sample HDD-26 was also analysed.

In the Red rock altered metasediment, nine (9) samples were taken from nine (9) drill holes. All samples are in continuity, with HDD-26 and HDD-256 associated with alteration along the pine point fault.

The skarn and mineralised skarn rock types, thirty five (35) samples were taken from nineteen (19) drill holes. Samples from HDD-252, HDD-256, HDD-260, HDD-262 and the pyritic skarn sample at HDD-272 are all part of a skarn that cross cuts the pine point fault (Figure %1, %2, %3). A total of thirteen (13) samples were taken for the Pegmatite unit from twelve (12) drill holes. HDD-26 and HDD-74 are continuous in a pegmatite near the eastern pit edge, with HDD-58 samples located in separate pegmatite, in proximity to the pine point fault to the west.

For the Breccia unit, a total of ten (10) samples were taken over ten (10) holes, HDD-33 and HDD-224 are continuous, with the other samples and continuous along the pine point and associated fault structures.

A total of fifteen (15) samples were taken from the “other mineralised” rock category and sampled from fourteen (14) drill holes.

The lithological unit of Gritstone sits predominantly to the north west of the pit and fifteen (15) samples were taken from the oxide, transitional and fresh oxidation zones. A total of 5 drillholes were used and samples were taken from corresponding oxidation zones within these holes.

The cover sequence across the site was also sampled. A total of 26 samples were analysed from eleven (11) drill holes.

The geological continuity of few of the waste rock domains are shown in Figure %1 to Figure %3 below.

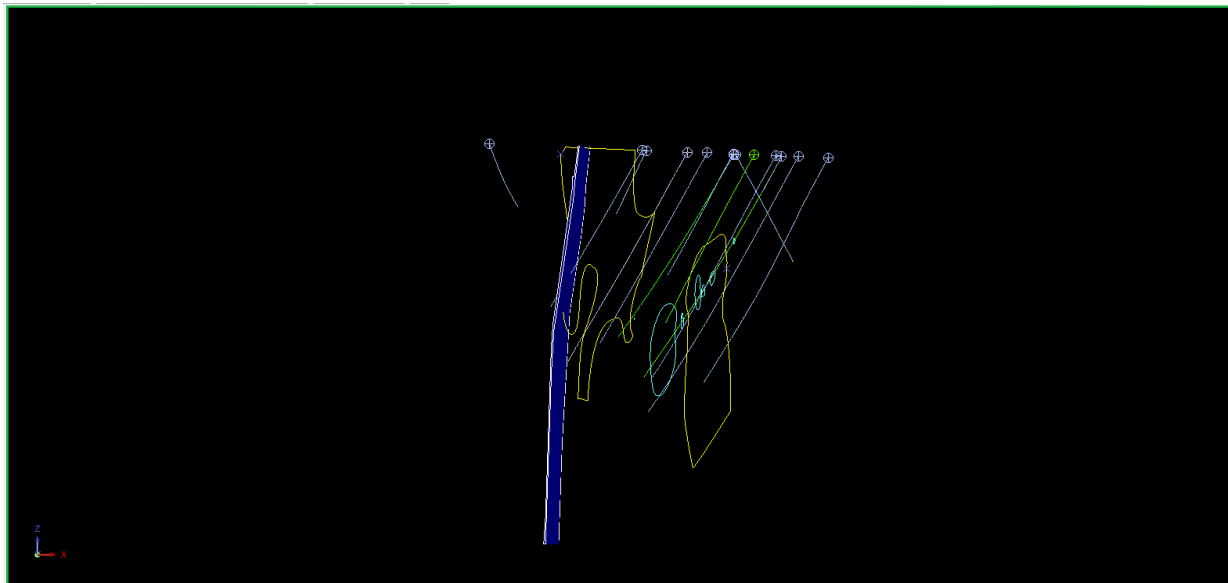


Figure %1: Skarn, sampled area in yellow, cross section 6175100mN

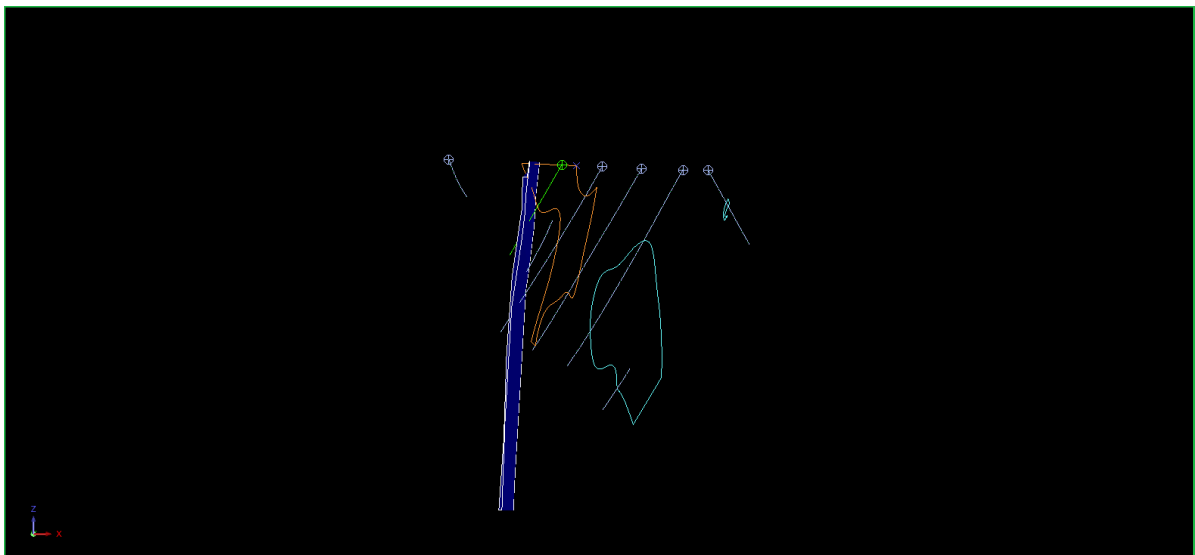


Figure %2: Skarn, sampled area in orange, cross section 6175200mN

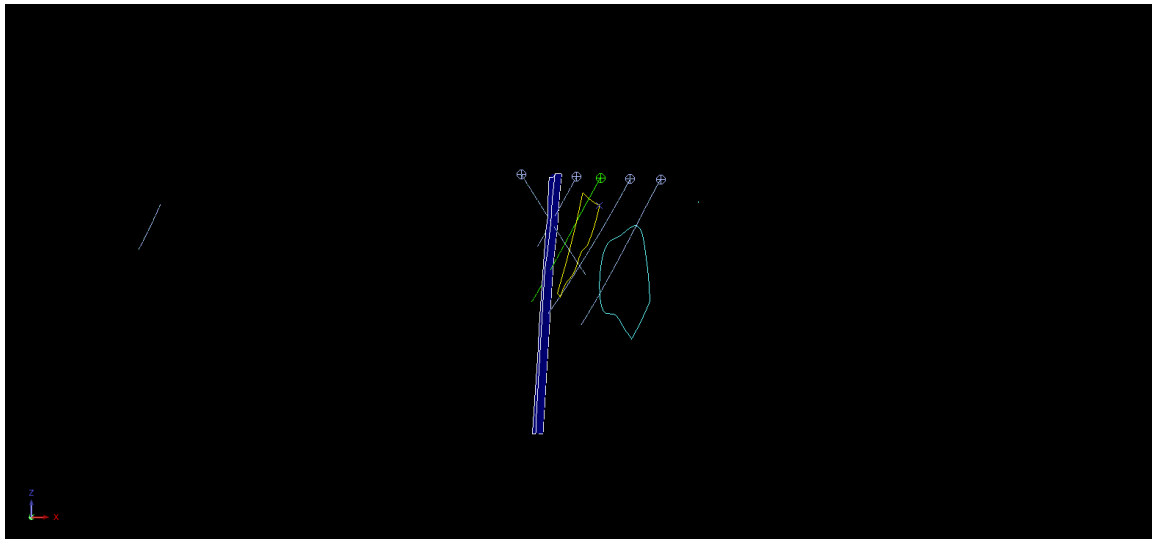


Figure %3: Skarn, sampled area in yellow, cross section 6175300mN

%4 Sampling Approach

%4.1 Sample locations

Based on drilling offsets during the pre-feasibility study, samples were collected to best represent lithological domains and to obtain a sampling spread within the proposed pit to most effectively target lithologies to best represent geology and structural conditions. The Figure %4 , Figure %5 and Figure %6 show snapshots of drill hole locations across the pit, both from a plan and cross sectional view. The locations of samples are shown in red at various depths within various drill holes Figure %6. The sample locations show a reasonable spatial distribution in Figure %4, located to the north, north central and eastern regions.

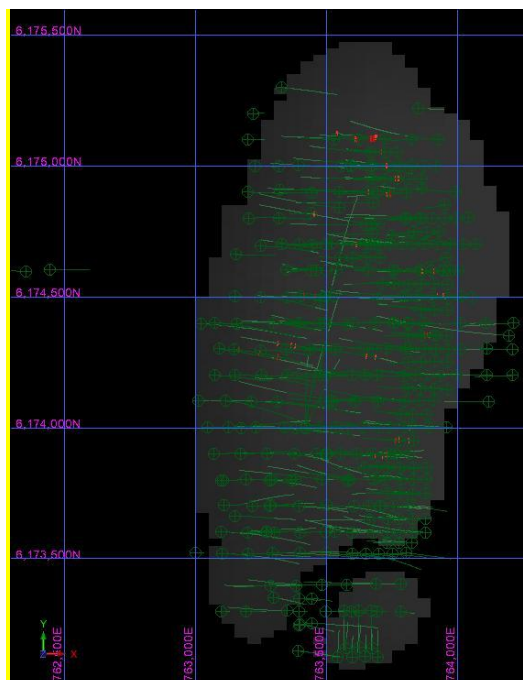


Figure %4: Plan view of pit shell showing drill holes and locations of samples taken shown in red

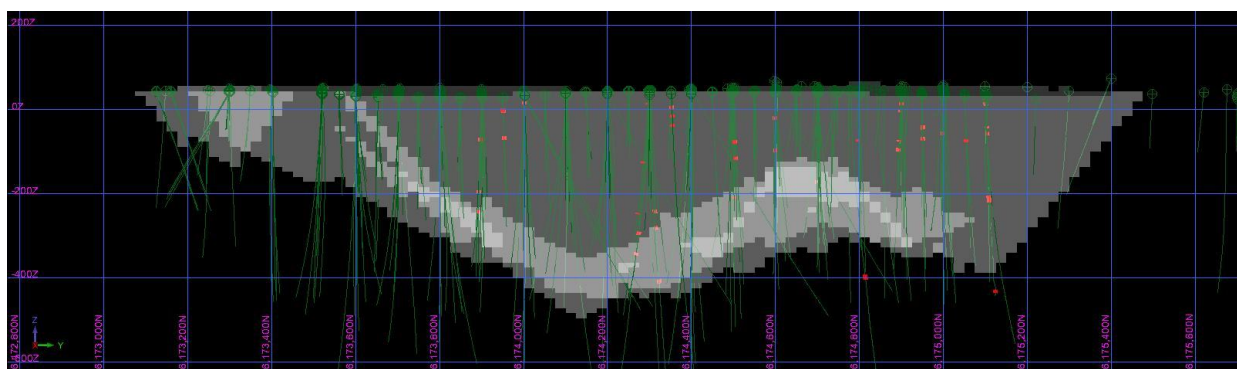


Figure %5: Cross section of pit shell looking west, showing drill holes and locations of samples taken at depth

The samples were taken across from the original ground surface through to 550m vertical depth below the surface. These samples are considered representative of oxidised, transitional and fresh rock zones to be exposed in the proposed pits. A total of seventy nine (79) of these samples were from the oxide zone, fifty three (53) were from the transitional zone, and twenty (20) were taken from the fresh zone.

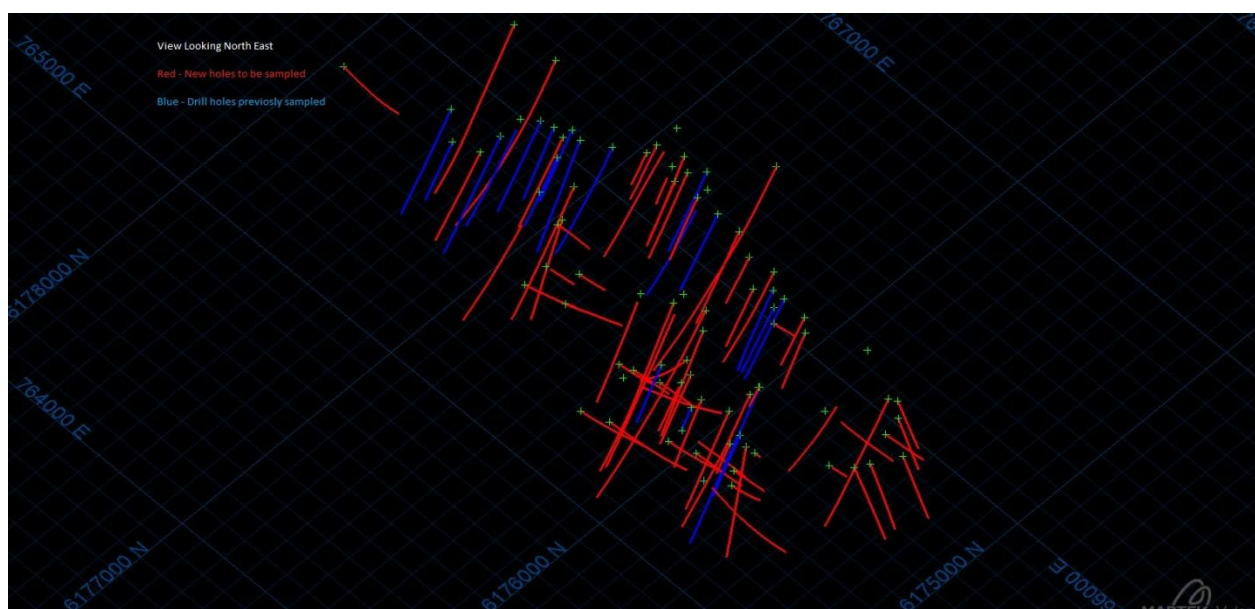


Figure %6: View looking north east, showing drill holes from the two phases of sampling, one in March 2012 and the second in September 2012

%5 Discussion on sample test results

%5.1 Discussion of acid forming potential

Based upon the NAPP calculation, none of the samples could be classified as PAF. The two samples classified as uncertain (HDD-103 105-100, a transitional granite; and HDD-224 130-140, an oxidised Breccia) are unlikely to be acid producing in practice, as they have very low total sulphur contents (less than 0.01%, and 0.04%, respectively). All of the remaining samples are classified as ACM or NAF using the NAPP calculation. These results are consistent with the rule of thumb that materials containing less than 0.3% total sulphur are unlikely to generate significant quantities of acid.

Of the two samples classified as PAF based on the ratio method, only one sample was classified as NAF.

The impure carbonate sample is unlikely to be an acid producing material, as its total sulphur content is relatively low at 0.09% and the majority of this sulphur is likely to be present as metal sulphates. This sample was classified as NAF using the NAPP calculation.

The pyritic skarn, while having relatively high sulphur content, may also exhibit a significant proportion of sulphur in the form of metal sulphates. This sample was classified as NAF using the NAPP calculation.

When interpreting the data, it is important to note that the ratio method provides a very conservative determination of whether a material is likely to produce acid, as it is based on the assumption that all of the sulphur contained within a sample is able to form acid. This assumption may not be true for many samples. In addition, it requires that NAF material have an Acid Neutralising Capacity twice its Maximum Potential Acidity in order to be classified as NAF. The NAPP method used in this analysis is more accurate and less conservative than the ratio method, as it results in any material with an Acid Neutralising Capacity greater than its Maximum Potential Acidity being classified as NAF or ACM. The NAPP calculation still provides a degree of conservatism, as it is also based on the assumption that 100% of the sample's sulphur content is able to be converted to acid.

5.2 Classification of acid forming potential of waste rock

The rock types and hole locations have been classified as PAF, NAF, ANC or "Uncertain," as shown in Table 5.2. For rock types that included a sample with a NAPP value between -5 and 0 kg H₂SO₄/t, comments regarding the need for additional testing are included.

Tables 5.2 and Appendix 2 of the main Geochemical Characterisation of Waste Rock report groups waste rock lithologies according to their potential to generate acid based on NAPP test results of the samples.

Table 5.2: Classification of March 2012 sampled waste rock types

Lithology	Oxidation state	No. samples	NAPP classification and comments	Maximum NAPP (kg H ₂ SO ₄ /t)
Granite	Fresh	2	NAF	-32.4
	Oxide	2	Uncertain. Borderline NAPP in some samples. S content low, but need clarity based on large amount of material.	-3.5
	Transitional	5	Uncertain. Samples exhibit variation in ANC. S content is low, need clarity based on large amount of material.	-4.4
Gabbro	Fresh	2	NAF	-36.1
	Oxide	3	NAF. Other samples exhibit lower NAPP, low S content.	-3.5
	Transitional	2	NAF	-13.4
Impure	Fresh	1	ACM	< -583.69

Lithology	Oxidation state	No. samples	NAPP classification and comments	Maximum NAPP (kg H ₂ SO ₄ /t.)
Carbonate	Oxide	2	NAF. The borderline NAPP value of one sample is likely to be an error. The other oxidised sample is highly ACM as expected.	-2.2
	Transitional	1	ACM	< -364.69
Unmineralised Metasediment	Fresh	3	NAF	-18.4
	Oxide	1	NAF. Low S content.	-4.4
	Transitional	1	NAF.	-8.1
Unmineralised Metasediment (chloritic)	Fresh	1	NAF	-43.0
Skarn (red rock altered)	Fresh	4	NAF. Some samples ACM	-6.9
	Oxide	4	NAF. Other samples more strongly NAF. Low S content.	-4.4
	Transitional	1	ACM	-130.7
Skarn (pyritic)	Fresh	1	Uncertain. Classified PAF using the ratio method. Likely to be treated as Low Grade Ore. If not treated, easily encapsulated given low amount	-15.2
Skarn (sulphide absent)	Fresh	1	NAF	-46.7
	Oxide	5	NAF. Other samples more strongly NAF or ACM	-4.1
	Transitional	4	NAF. Some samples ACM	-18.1
Pegmatite	Fresh	2	NAF	-22.4
Breccia (sulphide absent)	Fresh	3	NAF	-82.7
	Oxide	2	NAF. All other Breccia samples are either strongly NAF or ACM. The ANC test that resulted in NAPP>0 for one sample is likely to be an error. Also, this rock type has a very low S content.	1.2
	Transitional	2	NAF	-37.1
Breccia (pyritic)		0	ACM	-110.2
Skarn (mineralised)		0	Uncertain – not sampled	

Lithology	Oxidation state	No. samples	NAPP classification and comments	Maximum NAPP (kg H ₂ SO ₄ /t.)
Metasediment (mineralised)		0	Uncertain – not sampled	
Other (mineralised)		0	Uncertain – not sampled	
Pegmatite - Supergene (native copper)	Transitional	1	NAF. Very low sulphur	-4.7
Gritstone		0	Uncertain – not sampled	

5.3 Discussion of leachate results

The results of the leachate test work indicate that leachate from the samples is relatively benign. Comment is provided on a number of analytes of interest:

Aluminium – up to 96.5 mg/L was detected in samples, with most samples having some detectable Aluminium present. The ANZECC target value for aluminium in fresh waters is 13mg/L, and in recreational waters 200mg/L.

Barium – barium was detected in only ten (10) samples, with concentrations of up to 1mg/L. The ANZECC target value for barium in fresh waters is 0.2mg/L and in recreational waters is 1,000mg/L.

Vanadium – was detected in a minority of samples, however there are currently no ANZECC guideline values for vanadium in fresh or recreational waters.

Phosphorous – most samples exhibited phosphorous at a concentration suitable for irrigation under ANZECC guidelines.

Manganese – detected in most samples at concentrations of up to 2.1mg/L. The ANZECC target value for manganese in fresh waters is 0.06mg/L and in recreational waters is 100mg/L.

Magnesium – detected in the majority of samples at levels up to 32.5mg/L, however no ANZECC target values currently exist.

Potassium – detected in the majority of samples at levels up to 14.5mg/L, however no ANZECC target values currently exist.

Iron - detected in the majority of samples at levels up to 118mg/L. This concentration is above the ANZECC guideline value for short term irrigation waters (10mg/L), but is well under the guideline for recreational waters (300mg/L).

Other Analytes were rarely if at all detected. TDS was under 1000mg/L for all but 2 samples.

While some analytes resulted in sample being over guideline values for fresh, irrigation water and stock water, dilution with uncontaminated waters would reduce these values to guideline values. Based on

these results, waste rock leachate is unlikely to present a significant risk to the environment. A number of leachate management options are viable for further consideration, including:

- Containment and evaporation; and
- Dilution and release (with all required approvals and permits in place, and adequate monitoring).

It should be noted that, given the acid consuming nature of the majority of the waste rock associated with the Hillside project, the long term waste rock dumps may begin to exhibit alkaline conditions. Most metals are less mobile under alkaline conditions, with the exception of metals that form oxyanions such as molybdenum, hexavalent chromium and arsenic. A long term monitoring program should be taken into consideration.

%5.4 Discussion on uranium concentration in waste rock samples of Hillside project

Inductively coupled plasma mass spectroscopy (ICPMS) was used to identify the abundance of certain elements within each waste rock sample taken for the Hillside project. Using this technique, Uranium was identified at varying concentrations in all samples.

Appendix 6 of the main Geochemical Characterisation of Waste Rock report shows the concentration of Uranium detected in each sample. Samples that show elevated Uranium content but not exceeding the threshold concentration of 80 ppm are highlighted in Appendix 6 of the main Waste Rock Characterisation report and reproduced below:

- HDD-206 88-95, a transitional granite (55 ppmU);
- HDD-272 188-198, a fresh red rock (55 ppmU);
- HDD-213 138-148, an oxidised red rock (60 ppmU);
- HDD-272 175-185, a fresh pyritic skarn (75 ppmU);
- HDD214 101-111, an oxidised skarn (47 ppmU); and
- HDD-224 130-140, an oxidised breccia (55 ppmU).

In general, there is little correlation between waste rock lithology and elevated Uranium values, the lithologies that display high Uranium values also display instances of much lower Uranium content. For example, one sample of granite returned value of 55 ppm U, however other granite samples returned values of between 11 and 27 ppm U. Other lithologies display similar results. This suggests that Uranium content is not dependent on lithology. Uranium content may be dependent on geographical location within the deposit; however this would need to be confirmed through further investigation.

%% Concluding remarks and recommendations

Results of the first round of waste rock sampling and analysis indicate a relatively benign waste rock character associated with the Hillside project.

Fibrous Material

Skarns containing amphiboles, serpentine and talc minerals should be further investigated for minor fibrous minerals (mineral phase) such as Asbestiform Actinolite, Chrysolite, Crocidolite etc. Apparently, the present campaign for mineralogical analyses shows insignificant presence of asbestos or asbestiform minerals. Assuming the analyses of existing Skarn samples are limited for gaining an understanding of the fibrous characteristics of the waste rock, MP recommends further investigation during the feasibility stage.

Acid Rock Drainage

In general, the waste rock from the Hillside project exhibits very limited potential to generate acid. However, given the large volume of waste rock associated with the project, further sampling may be required. If further sampling is required MP recommends the following rock types be subjected to further investigation:

- Oxidised and transitional granite;
- Pyritic skarn; and
- Mineralised rock types and gritstones.

The justifications for recommending potential further investigation are detailed in the main report.

The above recommended additional sampling can also be carried out during later phase of project development taking note of the fact that present study reflects in general a limited overall acid generating potential.

Leachate

The results of the leachate test work indicate that leachate from the samples is relatively benign. Based on these results, waste rock leachate is unlikely to present a significant risk to the environment. A number of leachate management options are viable for further consideration, including:

- Containment and evaporation; and
- Dilution and release (with required approvals and permits, and adequate monitoring).

It should be noted that, given the acid consuming nature of the majority of the waste rock associated with the Hillside project, in the long term waste rock dumps may exhibit alkaline conditions. Most metals are less mobile under alkaline conditions, with the exception of metals that form oxyanions such as molybdenum, hexavalent chromium and arsenic. A long term monitoring program should be taken into consideration.

Uranium

Using the *National Directory for Radiation Protection* (Australian Radiation Protection and Nuclear Safety Agency, 2011), it was determined that material containing over 80 ppm U would be classified as radioactive and would need to be managed under the RPC Act.

Uranium was identified at varying concentrations in all samples of waste rock characterisation of Hillside project, with little correlation between waste rock type and uranium content. However, a better perspective about correlation can be derived about the geographical distribution of Uranium through further investigation.

Six (6) samples show higher but not exceeding the calculated Uranium threshold of 80 ppm. It may be possible to blend material that exceeds the threshold Uranium concentration with lower-concentration material in order to construct a waste rock dump that would be classified as non-radioactive under Schedule 4 of the *National Directory for Radiation Protection*. In order to design and schedule such a waste rock facility, there is a need to define the schedule for waste rock extraction in terms of its Uranium concentration.

In order to achieve this, the following would be required:

- An accurate understanding of the distribution of Uranium throughout the waste zones of the deposit; and
- A schedule for waste rock extraction.

MP's opinions and recommendations are as under:

Waste dump design

- I. MP is of the opinion that it may be possible to blend material that has elevated Uranium and exceeds the threshold Uranium concentration with lower-concentration material in order to construct a waste rock dump that would be classified as non-radioactive under Schedule 4 of the *National Directory for Radiation Protection*. In order to design and schedule such a waste rock facility, there is a need to define the schedule for waste rock extraction in terms of its Uranium concentration;

2. In order to achieve this, the following would be required:
 - a. An accurate understanding of the distribution of Uranium throughout the waste zones and
 - b. A schedule for waste rock extraction.

Further investigation

3. During the feasibility stage of the project, Rex Minerals should undertake an additional waste rock sampling and analysis program, designed to enable mapping and assessment of the Uranium concentration throughout the waste zones of the project. This is required to gain more confidence in the assessment and evaluation Uranium in the deposit. This can be evaluated in tandem with the Uranium distribution of ore domain.


A key component of the *National Directory for Radiation Protection* for classification of material as being exempt from control through legislation is the definition of activity concentration. For the purposes of the document, activity concentration of a radionuclide is defined as the “activity per unit mass of the material in which the radionuclide is *essentially uniformly distributed*” (Australian Radiation Protection and Nuclear Safety Agency, 2011, emphasis added). Therefore, MP thinks that it is of critical importance that waste rock containing Uranium is scheduled and blended so as to satisfy this requirement.



REX MINERALS
HILLSIDE PROJECT
WASTE ROCK CHARACTERISATION
REPORT



Document Control Information

	Rex Minerals Hillside Project Pre-feasibility Study - Waste Rock Characterisation Report		REVISION	
			No.	DATE
	MCREXH22-GSWR-001		1.3	20/06/2012

Revision Tracking

Revision:	Prepared By:	Reviewed By:	Issued For:	Approved By:	Date:	Signature:
1.0	S Keeling		IO	S Keeling	02/05/2012	
1.1	C B Boothey K Longmore	D Head	RC	D Head	13/06/2012	
1.2	C B Boothey K Longmore	D Head	RC	D Head	15/06/2012	
1.3	K Longmore	C McVie	FV	C McVie	20/06/2012	

Issued for: Review and Comment (RC), Information Only (IO), Implementation (IM), Final Version (FV).

EXECUTIVE SUMMARY

Mining Plus (MP) has been engaged by Rex Minerals (Rex) to complete a mining pre-feasibility study for Rex's Hillside project, located near Ardrossan in South Australia. The scope of work for this PFS is to complete a mine study with the primary deliverable being a cost model to an accuracy of +25% / -15%.

As part of this PFS scope of work a waste rock characterisation study is included. The objectives of this waste rock characterisation study are to:

- Carry out preliminary investigations into waste rock characterisation, identifying any potentially reactive material to assist with waste dump design considerations and design parameters for encapsulation, and environmental management and approvals.
- Comment on the potential presence of fibrous material within the waste rock samples provided.
- Comment on the presence of uranium within the waste rock samples provided.
- Comment on the potential for waste rock to produce potentially harmful leachate.
- Provide recommendations for further waste rock investigations required in order to adequately understand the waste rock character of the Hillside project, and to meet all regulatory, including approvals and permitting, requirements.

The scope of this study does not allow for consideration of the quantities of the various waste rock types present at the Hillside project. The quantities of the waste rock for each waste rock clarification will be provided a later date upon the completion of open pit mine design and scheduling as part of the PFS work being completed over the coming months.

Rex Minerals provided 485.6m of diamond core covering the waste rock types within the oxide, transition, and fresh zones of the proposed Hillside mining project. Of this 485.6m, 57 individual samples were taken and these were deemed to be representative of the 14 dominant waste lithologies as defined by Rex personnel (see later). Samples were analysed for their acid production potential and elemental and mineralogical compositions. In addition, leachate testwork was performed in accordance with Australian Standard AS4439.3.

Results of the waste rock sampling and analysis indicate a relatively benign waste rock character associated with the Hillside project. For a project of this size, an accurate and detailed understanding of all mine wastes is crucial to minimising the site's potential environmental impact as part of planned mining activities. Based on the results from this study, a second round of sampling and analysis is recommended, with the primary objectives and considerations for this sampling and analysis program outlined below: to:

1. Further assessment of any waste rock types deemed to have "uncertain" acid producing characteristics from the first round of testing. This includes material whose samples exhibited borderline NAPP values, were under-sampled or which are expected to be significantly represented in the total waste rock inventory.
2. More detailed understanding of the variation in the concentration of uranium present throughout the deposit, in order to facilitate appropriate management during the operational phase.
3. Testing of some existing samples for presence and character of fibrous materials.

Where further sampling and analysis is recommended, samples should be geographically and geologically representative of the proposed pit, that will be produced from planned mining engineering work as part of the PFS for the Hillside project.

Fibrous Material

Skarns containing amphiboles, serpentine and talc minerals should be further investigated for minor fibrous minerals such as Actinolite. It is anticipated that analysis of existing Skarn samples would be sufficient for gaining an understanding of the fibrous characteristics of the waste rock.

Acid Rock Drainage

In general, the waste rock from the Hillside project exhibits very limited potential to generate acid. However, given the large volume of waste rock associated with the project, it is imperative that a degree of certainty be attained. To this end, it is recommended that several rock types be subject to further investigation, via additional targeted sampling and analysis. These rock types are:

- Oxidised and transitional granite
- Pyritic skarn
- Mineralised rock types and gritstones

The justifications for recommending further investigation are detailed in Section 6.5 of this report.

Leachate

The results of the leachate testwork indicate that leachate from the samples is relatively benign. Based on these results, waste rock leachate is unlikely to present a significant risk to the environment. A number of leachate management options are viable for further consideration, including:

- Containment and evaporation
- Dilution and release (with required approvals and permits, and adequate monitoring)

It should be noted that, given the acid consuming nature of the majority of the waste rock associated with the Hillside project, in the long term waste rock dumps may exhibit alkaline conditions. Most metals are less mobile under alkaline conditions, with the exception of metals that form oxyanions such as molybdenum, hexavalent chromium and arsenic. A long term monitoring program should take this into consideration.

Uranium

Using the *National Directory for Radiation Protection* (Australian Radiation Protection and Nuclear Safety Agency, 2011), it was determined that material containing over 40 ppmU would be classified as radioactive, and would need to be managed under the RPC Act.

Uranium was identified at varying concentrations in all samples, with little correlation between waste rock type and uranium content. Uranium content may be related to geographic location within the deposit, however this would need to be confirmed through further investigation.

Six (6) samples exceeded the calculated Uranium threshold of 40 ppm. It may be possible to blend material that exceeds the threshold Uranium concentration with lower-concentration material in order to construct a waste rock dump that would be classified as non-radioactive under Schedule 4 of the *National Directory for Radiation Protection*. In order to design and schedule such a waste rock facility, there is a need to define the schedule for waste rock extraction in terms of its Uranium concentration.

In order to achieve this, the following would be required:

- An accurate understanding of the distribution of Uranium throughout the deposit
- A schedule for waste rock extraction

Therefore, it is recommended that during the feasibility stage of the project, Rex Minerals undertake an additional waste rock sampling and analysis program, designed to enable mapping of the Uranium concentration throughout the deposit. The current waste rock sampling and analysis program is insufficient for the level of accuracy that would be required.

A key component of the *National Directory for Radiation Protection* for classification of material as being exempt from control through legislation is the definition of activity concentration. For the purposes of the document, activity concentration of a radionuclide is defined as the “activity per unit mass of the material in which the radionuclide is *essentially uniformly distributed*” (Australian Radiation Protection and Nuclear Safety Agency, 2011, emphasis added). Therefore, it is of critical importance that waste rock containing Uranium is scheduled and blended so as to satisfy this requirement.

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I INTRODUCTION

Mining Plus (MP) has been engaged by Rex Minerals Ltd (Rex) to complete a mining pre-feasibility study for Rex's Hillside project, located near Ardrossan in South Australia, approximately 150km north-west of Adelaide on the Yorke Peninsula. The scope of work for this PFS is to complete a mine study with the primary deliverable being a cost model to an accuracy of +25% / -15%.

As part of this PFS scope of work a waste rock characterisation assessment study for the proposed open pit mine is included. .

The objectives of this waste rock characterisation study are to:

- Carry out preliminary investigations into waste rock characterisation, identifying any potentially reactive material to assist with waste dump design considerations and design parameters for encapsulation, and environmental management and approvals.
- Comment on the potential presence of fibrous material within the waste rock samples provided.
- Comment on the presence of uranium within the waste rock samples provided.
- Comment on the potential for waste rock to produce potentially harmful leachate.
- Provide recommendations for further waste rock investigations required in order to adequately understand the waste rock character of the Hillside project, and to meet all regulatory, including approvals and permitting, requirements.

The scope of this study does not allow for consideration of the quantities of the various waste rock types present at the Hillside project. The quantities of the waste rock for each waste rock clarification will be provided at a later date upon the completion of open pit mine design and scheduling as part of the PFS work being completed over the coming months.

The Hillside deposit is a high tonnage, low grade iron oxide copper-gold (IOCG) deposit. It is located within the geological region known as the Pine Point Copper Belt. The ore body consists of multiple lenses along a strike length of approximately 2.5km.

From the previous completed scoping study Rex Minerals propose to develop a two stage open pit mine with a stage one production rate of 7.5Mtpa for a period of approximately six years, followed by the second stage which would supply ore at a rate of 15Mtpa for another six years. In addition to copper and gold production it is proposed to produce some 12.5Mt of iron ore concentrate. Commensurate with ore production the initial Scoping Study for the project delineated waste production of approximately 870Mt over the life of the mine.

The Inferred Mineral Resource is stated by Rex to contain 217Mt of ore at an average grade of 0.7% copper, 0.2 g/t gold, and 12.4% iron for a total contained metal inventory of 151,900 tonnes of copper, 1.4 million ounces of gold, and 26.9Mt of iron (*Rex Minerals Hillside Project Scoping Study, July 2011*). The iron production will be in the form of magnetite fines.

The mineralisation was initially identified from a magnetic anomaly approximately 2km long and 0.5km wide. Exploration to date indicates that copper mineralisation extends from approximately 10m below ground level to over 500m. The mineralisation is also associated with three major north-south trending faults, the Songvaar, the Zaroni, and Parsee fault zones (*Rex Minerals Ltd Corporate Booklet, February 2011*).

2 SITE DESCRIPTION

The Hillside iron-oxide copper gold (IOCG) deposit was discovered by Rex in early 2008. The discovery was made as a result of exploration drilling of discrete magnetic and gravity features observed to be spatially associated with the regional NNE trending Pine Point (Ardrossan) Fault Zone and coincident with the historical Hillside Cu - Au mine, located approximately 15km south of Ardrossan.



Figure 2.1 Location of the Hillside Project

The project is located on the Yorke Peninsula which is to the west of Adelaide and skirted by Spencer Gulf and St Vincent Gulf. The project is located on the mid-eastern coast of the peninsula as shown in Figure 2.1. Adelaide is approximately 180km by road

2.1 Geology

The Hillside iron-oxide copper gold (IOCG) deposit is located within the Moonta Subdomain of the Olympic Cu-Au Province of the eastern Gawler Craton of South Australia, which is host to the Olympic Dam, Prominent Hill, Carrapateena, and Moonta-Wallaroo deposits, and occurs within the Pine Point

Structural Corridor and is bounded on the west by the Pine Point fault zone (Figure 2.2). The historic Moonta-Wallaroo Cu-Au mining field is within the Moonta Subdomain and is hosted by the ~1750Ma Wallaroo Group that preserves some evidence of evaporitic sedimentation, similar to other major iron oxide-Cu-Au (IOCG) provinces in Australia and North America (*Rex Minerals Hillside Project Scoping Study, July 2011*).

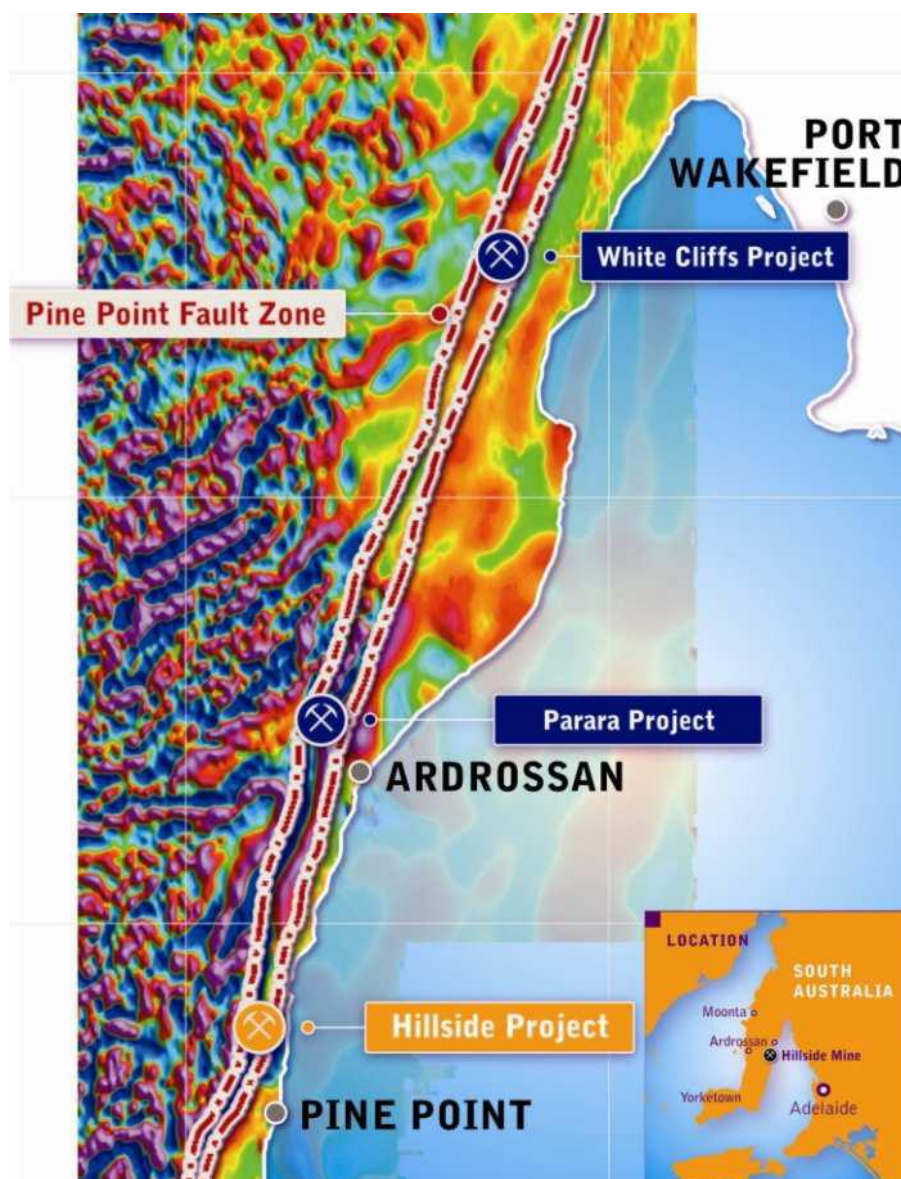


Figure 2.2 Magnetic Survey Image of the Pine Point Structural Corridor

(Rex Minerals, The Hillside Cu – Au Project Yorke Peninsula November 2009)

The Moonta-Wallaroo, Olympic Dam, Prominent Hill, and Carrapateena Cu-Au (U) deposits are hosted within Paleo-Mesoproterozoic rocks of the Olympic Domain that extends along the eastern edge of the currently preserved Gawler Craton. Underlying and to the west is Mesoarchean to Paleoproterozoic basement partly overlain by the thick Mesoproterozoic Gawler Range Volcanics. Unconformably overlying the deposits are the Neoproterozoic sediments of the Stuart Shelf marking the western flank of the Adelaide Geosyncline intracontinental rift-complex. The Olympic Domain may reappear to the east as the deeply buried western part of the Curnamona Province, this contention being supported by the presence of large magnetic and gravity anomalies, early Mesoproterozoic granites and volcanics, and deformation and alteration styles similar to those of the Gawler Craton. One such magnetic-gravity

anomaly in the Gawler Craton forms a laterally extensive, deeply buried feature paralleling the eastern coast of Yorke Peninsula immediately east of the Pine Point Fault, and is proximal to the Hillside deposit.

The Hillside deposit is hosted by a folded sequence of intensely altered metasediments and skarns belonging to the Wallaroo Group (Moonta Subdomain), which are intruded by MesoProterozoic granitoids within the main mineralised area. The intrusions comprise variable-width dykes of micro-granite to micro-diorite (plus occasional coarser phases). A more significant stock/pluton of granite lies in the eastern sector of the prospect. The sequence also includes micro-gabbro which may be either a late-stage intrusive associated with the Curramulka Gabbro (and possible heat/fluid source), or may represent early sills (*Rex Minerals Hillside Project Scoping Study, July 2011*).

The deposit is masked by a sequence of calcareous Tertiary cover sediments ranging from less than a metre to 30m in vertical thickness.

The Cu-Au mineralisation is hosted by a number of steeply west-dipping tension gash “breccia” structures which are magnetite-dominant and strike north-south (Figure 2.3). At least three structures with individual Cu-mineralised strike lengths of 1.5km and a combined Cu-mineralised strike length of +4km have been defined to date. Copper mineralisation within all structures remains open along strike and at depth, and has been observed from as shallow as 5m below surface to 700m below surface.

The mineralising system displays several characteristics which are similar to both the Moonta – Wallaroo Cu deposits, and the deeper Cloncurry-style IOCG deposits (e.g., Ernest Henry and Starra). Primary copper mineralisation is dominated by chalcopyrite with subordinate bornite and chalcocite. Secondary copper mineralisation is dominated by malachite and chalcocite with subordinate azurite, cuprite, atacamite, chrysocolla, and native copper. Preliminary interpretation of the distribution of mineralisation zoning indicates a zoning from eastern shallow supergene copper on the “Songvaar” and “Parsee” structures to deep primary copper lenses on the western “Zanoni” structure. Primary copper zones comprise parallel steeply-dipping lenses of massive chalcopyrite with true widths estimated to be in the order of 1.0m to 30m, surrounded by network vein and cm-scale blebby chalcopyrite, within a larger envelope of disseminated millimetre to centimetre scale chalcopyrite (*Rex Minerals Hillside Project Scoping Study, July 2011*).

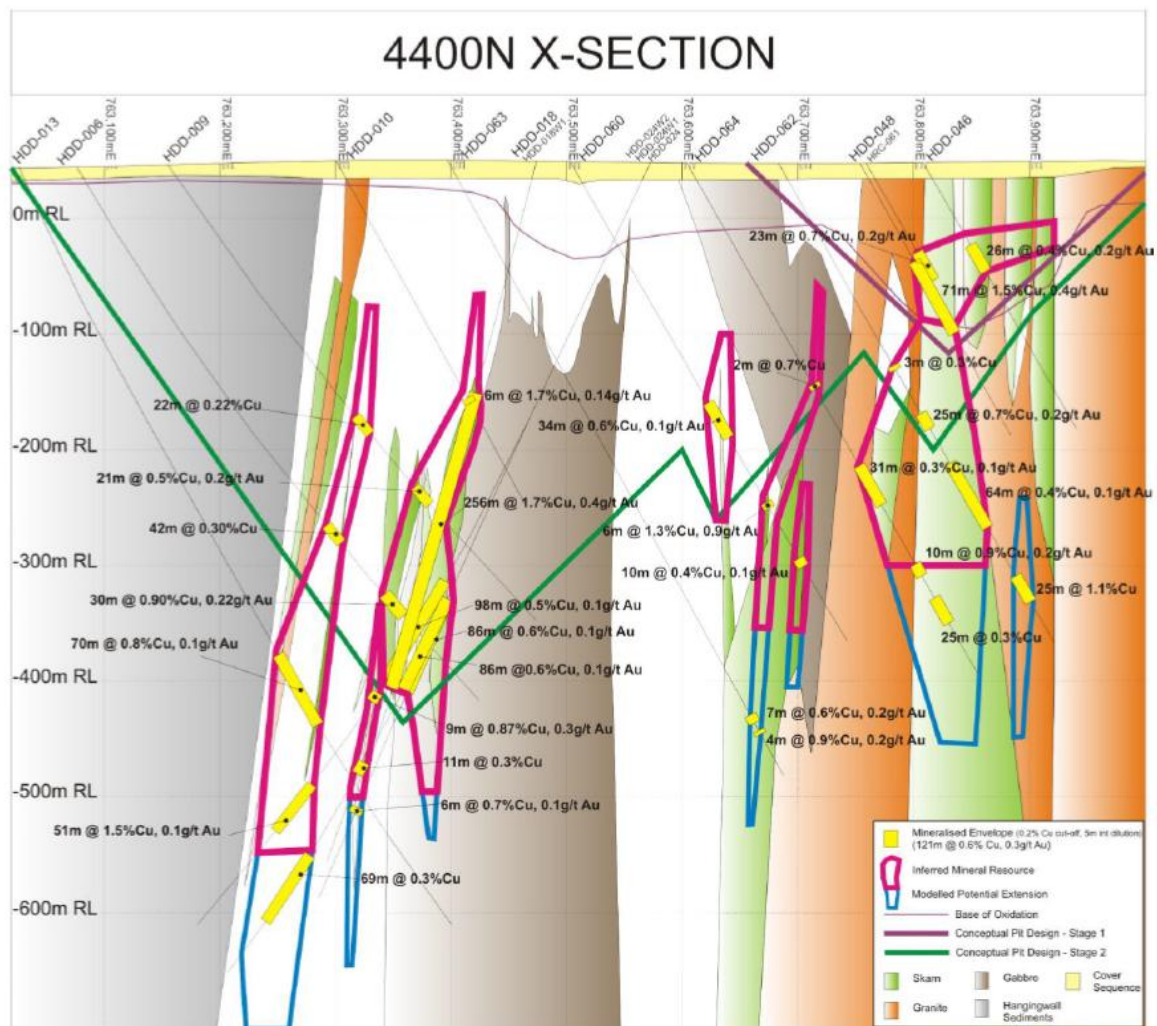


Figure 2.3 Cross-Section of Local Geology at 6174400mN

(Rex Minerals Hillside Project Scoping Study, July 2011)

3 METHODOLOGY

3.1 Waste Rock Types

A review of the waste rock types within the Hillside Deposit was undertaken by Rex. The aim of the review was to define the waste rock types in order to enable the selection of representative samples for analysis to determine their acid generating potential. The following general guiding principles are assumed:

- The data from the waste characterisation and mining models will be used to design the waste dump to minimise environmental impacts with particular attention paid to acid mine drainage (AMD), and mobilisation of metals and metalloids, including uranium.
- Waste rock generated from within the Stage Three pit perimeter is included in the assessment.
- All major waste rock lithologies and minor waste rock lithologies of consequence have been included in the assessment.
- Low grade and sub-grade ore are also included in the assessment
- The volumes of individual waste rock types have been excluded from this analysis, pending updates to the pit design. The intention is for volumes to be assigned to waste rock types as part of future work.

There are fourteen waste rock lithological types as defined in the block model (rex_may_2012) as shown in Table 3-1 below:

Table 3-1 Waste rock Lithological Types for the Hillside Project.

Waste Rock Lithology	Code
Granite	1
Gabbro	2
Impure Carbonate	3
Unmineralised Metasediment	4
Skarn (red rock altered)	5
Skarn (pyritic)	6
Skarn (sulphide absent)	7
Pegmatite	8
Breccia (sulphide absent)	9
Breccia (pyritic)	10
Skarn (mineralised)	11
Metasediment (mineralised)	12
Other (mineralised)	13
Gritstone	14

The final waste rocks investigated (and concordant codes) are:

- Oxidised, transitional, and fresh granite rock (1)
- Oxidised, transitional, and fresh gabbro rock (2)
- Oxidised, transitional, and fresh impure carbonate rock (3)
- Oxidised, transitional, and fresh banded non mineralised meta-sediment rock (4)
- Fresh strongly chloritic meta-sediment rock (4)
- Oxidised, transitional, and fresh skarn (red rock altered) (5)
- Fresh pyritic skarn rock (6)

- Oxidised, transitional, and fresh skarn rock (7)
- Fresh pegmatite rock (8)
- Oxidised, transitional, and fresh breccia rock (9)
- Mineralised metasediment (12)
- Transitional pegmatite rock containing native copper (13)

The number of waste rock samples and the waste rock lithology type from where they were taken are shown in Rex Minerals collected fifty seven (57) waste rock samples for analysis from the Hillside Project (Appendix 1). These samples totalled 485.6m of diamond drill core. Of the 695 drill holes at the Hillside Project, thirty three (33) holes were sampled for waste rock characterisation (4.8 % of total drill holes). Of the 211 287.7m drilled at Hillside, 485.6m (0.2% of total meters drilled) were sampled for waste rock characterisation. The majority of drill hole samples are contained within the conceptual study pit design (excluding HDD-280 and HDD-299).

The samples were taken across a range from the natural surface through to 550m vertical depth below the surface. These samples are considered representative of oxidised, transitional and fresh rock zones to be exposed in the proposed pits. Nineteen (19) of these samples were from the oxide zone, eighteen (18) were from the transitional zone, and twenty (20) were from the fresh zone.

below.

Table 3-2 Waste rock sample types for the Hillside Project

Waste Rock Lithology Type	Waste Rock Oxidation	No. Samples Taken
Granite	Fresh	2
	Oxide	2
	Transitional	5
Gabbro	Fresh	2
	Oxide	3
	Transitional	2
Impure Carbonate	Fresh	1
	Oxide	2
	Transitional	1
Unmineralised Metasediment	Fresh	3
	Oxide	1
	Transitional	1
Unmineralised Metasediment (chloritic)	Fresh	1
Skarn (red rock altered)	Fresh	4
	Oxide	4
	Transitional	1
Skarn (pyritic)	Fresh	1
Skarn (sulphide absent)	Fresh	1
	Oxide	5
	Transitional	4
Pegmatite	Fresh	2
Breccia (sulphide absent)	Fresh	3
	Oxide	2

Waste Rock Lithology Type	Waste Rock Oxidation	No. Samples Taken
	Transitional	2
Breccia (pyritic)		0
Skarn (mineralised)		0
Metasediment (mineralised)	Transitional	1
Other (mineralised)		0
Pegmatite - Supergene (native copper)	Transitional	1
Gritstone		0
TOTAL		57

3.1.1 Waste Rock Continuity

Each waste rock lithology type was assessed for geological continuity.

The granite rock type consisted of nine (9) samples from seven (7) different holes. Samples were taken from geologically continuous zones.

From the gabbro lithology, seven (7) samples were taken within six (6) holes. Samples from HDD-095 and HDD-107 are geologically continuous with other samples HDD-16, HDD-098, and HDD-215 across the length of the pit.

Impure carbonate – four (4) samples within four (4) holes, appear to be geologically continuous.

Five (5) samples within five (5) holes were taken from the unmineralised metasediment lithology. HDD-33 and HDD-272 are continuous with a sedimentary package to the east of the pit including the mineralised sample at HDD-74, and the other samples are continuous with a sedimentary package in proximity to the pine point fault including the chloritic metasediment sample HDD-26.

Red rock altered metasediment – nine (9) samples, from nine (9) holes. All samples are geologically continuous, with HDD-26 and HDD-256 associated with alteration along the pine point fault.

The skarn rock types consisted of ten (10) samples, nine (9) holes. Samples from HDD-252, HDD-256, HDD-260, HDD-262 and the pyritic skarn sample at HDD-272 are all part of a skarn that cross cuts the pine point fault. All other samples are geologically continuous across the middle and east of the pit.

Pegmatite – three (3) samples were taken from three (3) holes sampled. HDD-26 and HDD-74 are geologically continuous in a pegmatite near the eastern pit edge, with HDD-58 samples located in separate pegmatite, in proximity to the pine point fault to the west.

Breccia six (6) samples were taken over six (6) holes, HDD-33 and HDD-224 are geologically continuous, with the other samples continuous along the pine point fault and associated fault structures.

Examples of waste rock geological continuity are shown in Figure 3.1 to Figure 3.3 below.

Figure 3.1 Skarn, sampled area in yellow, cross section 6175100mN

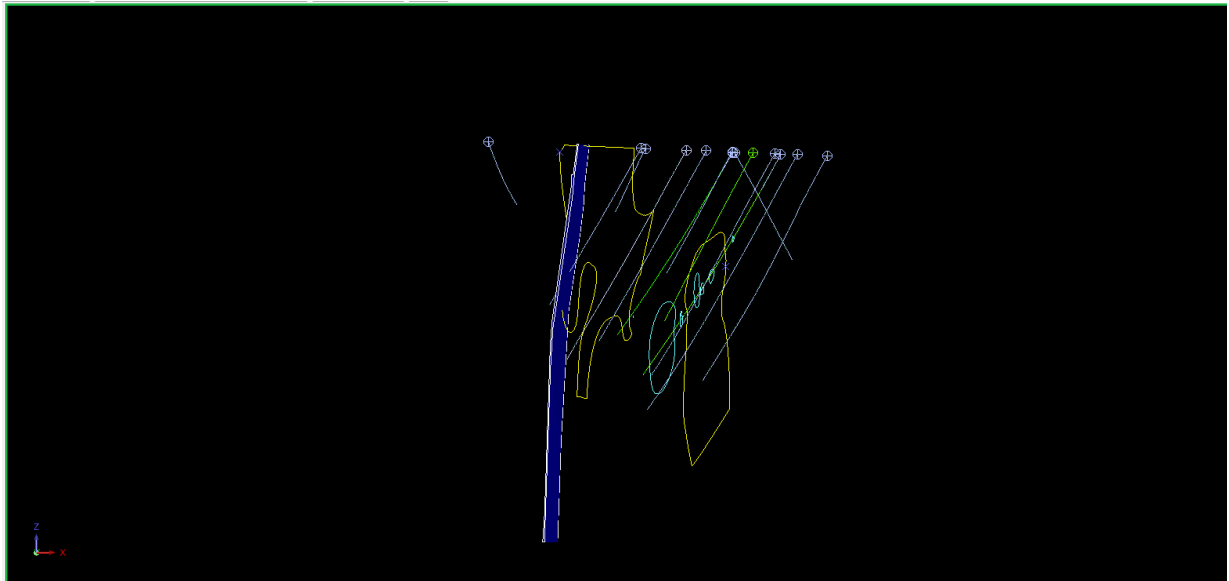


Figure 3.2 Skarn, sampled area in orange, cross section 6175200mN

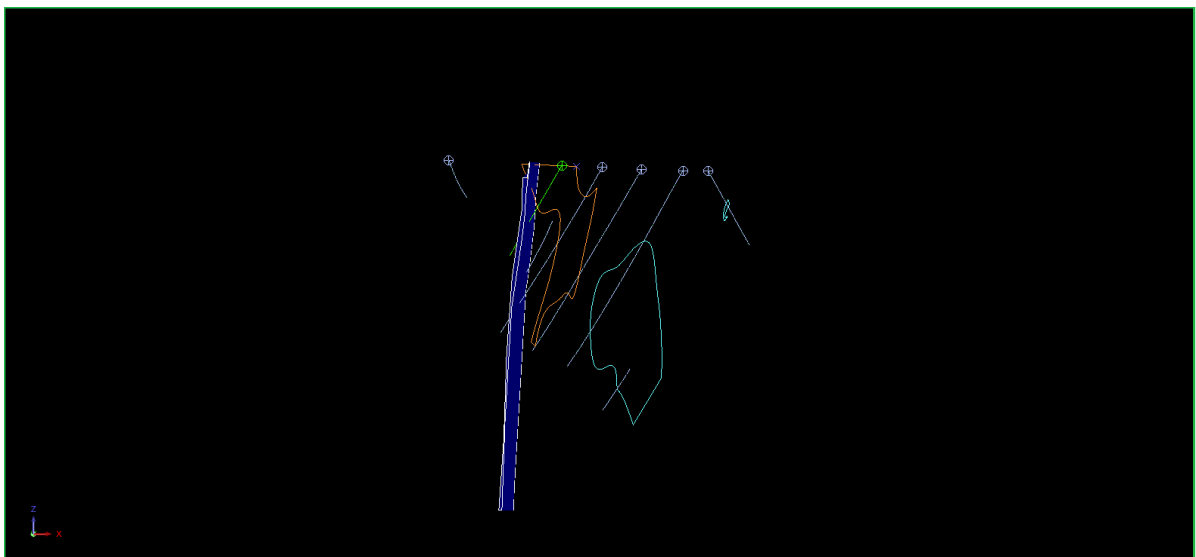
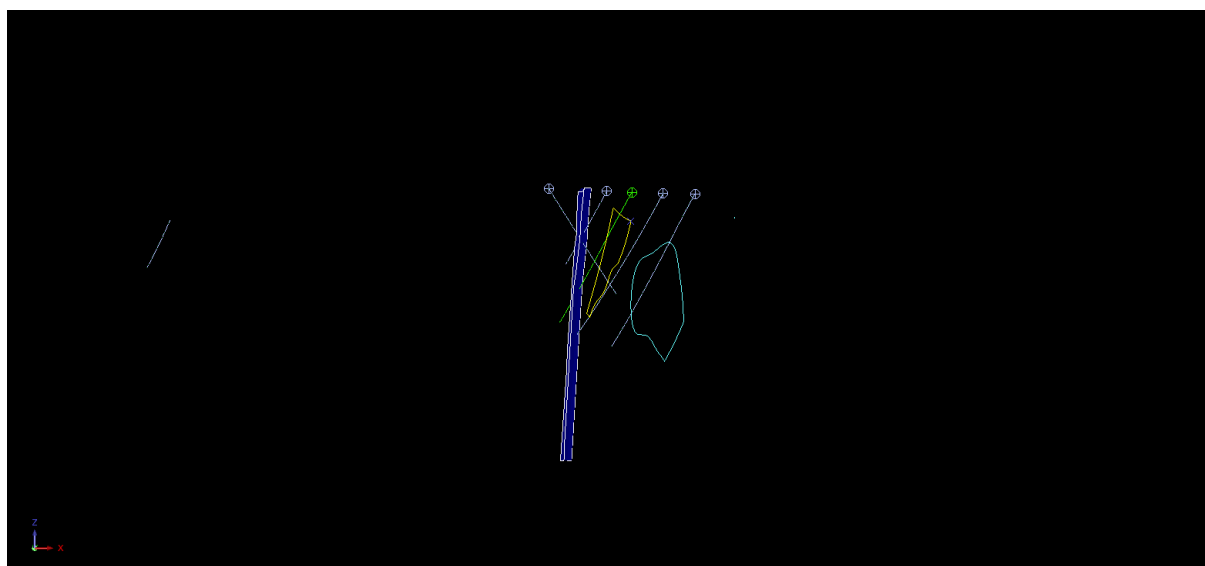


Figure 3.3 Skarn, sampled area in yellow, cross section 6175300mN

3.2 Sampling Programme

Rex Minerals collected fifty seven (57) waste rock samples for analysis from the Hillside Project (Appendix 1). These samples totalled 485.6m of diamond drill core. Of the 695 drill holes at the Hillside Project, thirty three (33) holes were sampled for waste rock characterisation (4.8 % of total drill holes). Of the 211287.7m drilled at Hillside, 485.6m (0.2% of total meters drilled) were sampled for waste rock characterisation. The majority of drill hole samples are contained within the conceptual study pit design (excluding HDD-280 and HDD-299).

The samples were taken across a range from the natural surface through to 550m vertical depth below the surface. These samples are considered representative of oxidised, transitional and fresh rock zones to be exposed in the proposed pits. Nineteen (19) of these samples were from the oxide zone, eighteen (18) were from the transitional zone, and twenty (20) were from the fresh zone.

All rock samples were prepared and analysed by Amdel-Bureau Veritas Australia Laboratory Services using published environmental procedures. A copy of the analytical report is included as Appendix 2.

3.3 Test Work Program

The following geochemical testing program was conducted on all of the samples:

- Multi-element whole rock digests
- Total Sulphur determination
- Sulphate/Sulphide analysis
- Total Carbon determination
- Acid Neutralising Capacity (ANC) analysis
- Net Acid Production Potential (NAPP) analysis
- Net Acid Generation (NAG) analysis
- Electrical conductivity (EC) analysis
- Australian Standard Leaching Procedure (ASLP) 4439.3 (including multi-element and total dissolved solids determination)
- Quantitative x-ray diffraction mineralogical analysis

4 ACID FORMING WASTE CLASSIFICATION METHODOLOGY

There is no simple method of defining whether waste rock containing small quantities of sulphur will produce sulphuric acid. Sulphide minerals containing ferrous iron such as pyrite (FeS_2), marcasite (FeS_2) and pyrrhotite ($\sim\text{FeS}$) normally, but do not always oxidise to produce sulphuric acid and ferric oxy-hydroxide. Whilst sulphur in pyrite will always form sulphuric acid, a portion of the sulphur in marcasite and pyrrhotite forms highly soluble sulphite, bi-sulphite and more complex sulphur compounds and elemental sulphur, some or all of which may never form acid.

Sulphur in chalcopyrite and arsenopyrite rarely forms sulphuric acid due to simultaneous oxidation of copper and/or arsenic resulting in formation of non-acid forming copper sulphides, oxides and soluble neutral sulphates. Sulphur in galena, sphalerite, molybdenite, stibnite and other iron-free sulphides is non-acid producing. Sulphur present as sulphate in minerals such as barite, anhydrite, gypsum, epsomite, alkali sulphates and the alum group of minerals is also non-acid producing.

Potential for acid production relies on determination of total sulphur content (Tot_S), non-sulphide sulphur content (commonly described as sulphate-sulphur (SO_4_S)) and where necessary, determination of sulphur in the acid insoluble minerals barite (barium sulphate) and celestite (strontium sulphate), commonly described as barite sulphur, may be undertaken.

Acid Neutralisation Capacity (ANC), a measure of the natural ability of the sample to neutralise acid is normally determined and Net Acid Generation (NAG), a measure of the sulphur released by reaction with strong hydrogen peroxide, only determined where there is any doubt about the classification. NAG can be unreliable, giving excessively high results in the presence of organic carbon compounds and certain reduced sulphur radicals which contain non-acid generating sulphur compounds.

Calculations are undertaken to estimate Maximum Potential Acidity (MPA) and Net Acid Production Potential (NAPP). MPA is based on the assumption that 100% of all sulphur is acid producing (sourced from pyrite FeS_2) which as previously described is incorrect. NAPP is a calculation based on the MPA, SO_4_S (sulphate sulphur) and ANC so that value also uses the same incorrect assumption. However, with care and geological understanding, NAPP is suitable for conservative prediction of potential acid generation. NAPP over-estimates potential acidity as it does not allow for sulphur in non-acid producing sulphide minerals or in barite

Due to the lack of reliability of the MPA calculation, the analysis concept and the ratio concept are commonly used to classify the acid formation potential of waste rock:

1. **The Analysis Concept.** Where Tot_S is less than 0.30%S, ARD is unlikely to occur. This sulphur value corresponds to a maximum of 9.2 kilograms H_2SO_4 per tonne. With weathered rocks in arid areas where there may be a substantial percentage of SO_4_S and some carbonate minerals present, this 'rule of thumb' is often reasonably reliable. It is commonly inaccurate in humid climates and is unsuitable for acid sulphate soil investigations.
2. **The Ratio Concept.** This compares the direct calculation of MPA from Tot_S and the ANC analytical measurement, then classifies samples as Non Acid Forming (NAF) where the ratio of ANC/MPA is ≥ 2 and Potentially Acid Forming (PAF) where the same ratio is ≤ 2 . This methodology has been recommended by a Western Australian governmental authority.
 - a. This methodology does not allow for SO_4_S , or sulphur associated with barium sulphate or organic materials. For oxide to fresh rock, transitional and (supergene enriched) sulphide samples, many iron ores, most manganese ores and most zinc-copper stratiform

sulphide horizons in felsic volcanic rocks, this methodology fails, often classifying incorrectly due to $\text{SO}_4\text{-S}$ and barium sulphate content.

- b. The ratio concept is unsatisfactory for use in acid sulphate soils and in conditions of very high salinity. It will give incorrect results if applied to waste rock in stockpiles that have not been rehabilitated and where the dominant residual sulphides in the wastes are base metal sulphides. This includes the iron-bearing sulphides chalcopyrite and arsenopyrite which each have high sulphur content, but generate very little or no acid.

In this report, the ratio method is used to give a first pass indication of the likely classification for each sample. Final classification of wastes undertaken in this report is based on the NAPP of each sample and uses the following methodology:

- Analysis for Total Sulphur (Tot_S)
- Analysis for Acid Neutralising Capacity (ANC)
- Calculation of Net Acid Producing Potential (NAPP)

Table 4-1 shows the NAPP Classification of Acid Rock Drainage. The classes are substantially more conservative than either the Analysis concept or the Ratio concept methodologies described above. The PAF-LC and "Uncertain" Classes will commonly be classified as NAF using either of the Analysis or the Ratio concepts.

Table 4-1 NAPP Classification of Acid Rock Drainage

Primary Geochemical Waste Type Class	NAPP Value $\text{kgH}_2\text{SO}_4/\text{tonne}^*$
Potentially Acid Forming (PAF)	≥ 10
Potentially Acid Forming - Low Capacity (PAF-LC)	5 - 10
Uncertain, probably NAF	0 - 5
Non Acid Forming (NAF)	- 100 to 0
Acid Consuming Materials (ACM)	< - 100

"Uncertain samples" if important, can be re-classified by undertaking a NAG determination but this has not been required at this stage of the project. Values at this level can often be PAF-LC where acid sulphate soil areas are being investigated, or where there is a total absence of acid neutralising capacity in the host rocks.

5 QAQC

The laboratory that undertook the sample analysis is accredited by the National Association of Testing Authorities, Australia (NATA). Descriptions of their internal QAQC procedures are described below.

5.1 Laboratory Internal QAQC

5.1.1 Sample Preparation

Sample pulverisers are cleaned mechanically and/or with a vacuum. Quartz or blue metal washes are utilised to ensure no carry over contamination between individual jobs. Samples of wash materials are retained for analysis if required.

5.1.2 Analysis

A nominal one in twenty (5%) of all samples are analysed in duplicate. This indicates any variance at the analytical stage. In addition, re-splits if required are also analysed to determine the precision of the sample preparation and analytical procedures.

Blanks and reference materials are randomly inserted into every rack of samples. These provide a measure of accuracy. Internal quality control data (standards, replicates etc) can be reported as a separate “quality report” on a basis approved by the client.

The reference materials used may be national, international reference standards, in-house or client supplied. Specific materials will be selected based on the elements of interest and expected ranges of concentration. Values are determined independently through various means including laboratory round robin. These materials are prepared in bulk and are used extensively across a number of Amdel’s laboratories.

Samples returning anomalous results will be re-assayed by techniques considered appropriate for the level of analyte encountered.

5.1.3 Quality Assurance

Amdel has adopted the ISO 9001 Quality Management Systems. All Amdel laboratories work to documented procedures in accordance with this standard.

NATA (ISO17025) certified reports are available on request through our Adelaide laboratory for all common geochemical, ore and concentrate analysis.

5.1.4 Detection Limit and Accuracy

Detection limits quoted in this services guide are set for standard sample types analysed for each method. In some cases better detection limits may be achievable. Please contact the laboratory to discuss your specific requirements so that we can determine the analysis method, and detection limit that best suits your needs.

Results are reported in increments equivalent to the limit of detection, or a set number of significant figures, whichever is the largest. As a rule of thumb, however, accuracy equivalent to

+/- 2 times detection limit is achievable, up to a concentration of 10 times the detection limit, and then +/- 5% of the value thereafter. Results reported in increments equivalent to the DL or a set number of significant figures whichever is the largest.

Detection limits may vary slightly between each of our laboratories due to differences in the laboratory's configuration, instrumentation, and quality of consumables procured locally.

5.2 Laboratory Data QAQC

Upon receiving the laboratory results the following QAQC procedures were used to validate the analytical results.

5.2.1 Geochemical Data QAQC

The sample ID's from the original Sample Submission Sheet were compared to the sample ID's in the received laboratory data and no error were found.

5.2.2 Mineralogical Data QAQC

The sample ID's from the original Sample Submission Sheet were compared to the sample ID's in the received laboratory data and one sample ID was found to be in error. Communications received from the laboratory confirmed that this was a transposition error that occurred when the sample ID's were entered into the laboratory's system. The laboratory re-issued the analytical report with the error removed.

6 GEOCHEMICAL TEST RESULTS

This section provides summaries of the results for chemical analysis of the fifty seven (57) waste rock samples provided by Rex.

6.1 General Comment on Material Volume

Material volumes have not been assessed as part of this analysis. Pit optimisation is ongoing, and once a greater degree of certainty has been achieved, an assessment of the volumes of the various waste rock types will need to be included in the next iteration of the waste rock characterisation study.

6.2 Mineralogy of the Waste Types

6.2.1 Granite

The fresh granite sample consists of a majority of quartz, and feldspar, with some chlorite and calcite alteration. With an increase in weathering, decreases in quartz, chlorite and calcite and typical increase in clay minerals.

Notably with an average of 76% plagioclase feldspar in comparison to alkali feldspar, these two fresh rock samples taken at HDD-101 and HDD-280 should be classified as a granodiorite.

6.2.2 Gabbro

The fresh gabbro sample is made up of plagioclase and amphibole, with some quartz. With an increase in weathering, decreases in quartz, feldspar and calcite and typical increase in clay minerals.

With low silica at an average of 10%, substantially less than 45% typically contained within a gabbro this rock type is ultramafic and should be classified as a peridotite. Additionally one sample shows high amphibole content, and could be classified as an amphibolite with other evidence of metamorphism.

6.2.3 Impure Carbonate Rock

Impure carbonate rock is predominantly calcite as expected. As weathering intensifies, increases in quartz, chlorite and clay minerals occur.

6.2.4 Metasediment

The unmineralised and mineralised metasediment samples are quartz, plagioclase, and chlorite dominant. With weathering quartz and plagioclase and chlorite decrease, being replaced by clay minerals.

The chloritic metasediment sample contains 25% chlorite, and is otherwise similar in composition to the non chloritic metasediment samples.

6.2.5 Red Rock Altered Skarn

The red rock altered skarn is predominantly quartz, hematite and plagioclase. With an increase in weathering decreases occur in quartz, chlorite, hematite and alkali.

6.2.6 Skarn

Predominantly quartz, plagioclase and chlorite make up the skarn samples. With oxidation clay and alkali feldspar increase, and decreases occur in plagioclase and chlorite.

The pyritic skarn sample contains higher levels of magnetite and talc, with lower percentages of plagioclase feldspar, otherwise similar in composition to the other skarn samples.

Skarn samples contain garnet and rutile, evidence of high pressure and high temperature metamorphism.

6.2.7 Pegmatite

Pegmatite samples are predominantly plagioclase and quartz. With an increase in weathering quartz decreases, and mica increases.

The pegmatite with native copper shows a higher level of amorphous minerals (possibly chalcopyrite) with higher levels of magnetite and hematite.

6.2.8 Breccia

The fresh breccia samples consist of amorphous minerals and plagioclase, with some chlorite and dolomite. With weathering samples increased in amorphous minerals, alkali and hematite and a decrease in quartz and rutile.

The presence of garnet and rutile indicate metamorphism/ metamorphic rocks contained within the brecciated material.

6.3 Whole Rock Digest

Appendix 3 contains the results of the whole rock mineralogical digest undertaken for the waste rock samples.

It is considered that the Amphiboles, Serpentine and Talc minerals present in the Skarn may be potential indicators for minor fibrous minerals such as Actinolite. This should be investigated further at the feasibility stage.

6.4 Acid Rock Drainage Characterisation

This section discusses the classification of:

1. The waste rock samples submitted for the first round of analysis, according to their acid production characteristics.
2. The waste rock types present in the Hillside project, as NAF, PAF, ACM or “uncertain and requiring further investigation.”

6.4.1 Classification of Samples

The classification of each waste rock sample using the NAPP classification is shown at Appendix 4. Refer to Table 4-1 for cut-off NAPP values for each classification. NAPP has been calculated using the formula:

$$NAPP = MPA - ANC$$

where

$$MPA = TOT_S \times 30.625$$

and TOT_S is expressed as a percentage.

The ratio ANC/MPA is also included in the table for reference. The ratio method classifies waste material as either PAF ($ANC/MPA \leq 2$) or NAF ($ANC/MPA > 2$). Samples which would be classified PAF under the ratio method are highlighted in orange in Appendix 4.

Discussion of Sample Classification

Using the NAPP calculation, none of the samples could be classified as PAF. The two samples classified as uncertain (HDD-103 105-100, a transitional granite; and HDD-224 130-140, an oxidised Breccia) are unlikely to be acid producing in practice, as they have very low total sulphur contents (less than 0.01%, and 0.04%, respectively). All of the remaining samples are classified as ACM or NAF using the NAPP calculation. These results are consistent with the rule of thumb that materials containing less than 0.3% total sulphur are unlikely to generate significant quantities of acid.

Of the two samples classified as PAF based on the ratio method (highlighted orange in Appendix 4):

- The impure carbonate sample is unlikely to be an acid producing material, as its total sulphur content is relatively low at 0.09% and the majority of this sulphur is likely to be present as metal sulphates. This sample was classified as NAF using the NAPP calculation.
- The pyritic skarn, while having relatively high sulphur content, may also exhibit a significant proportion of sulphur in the form of metal sulphates. This sample was classified as NAF using the NAPP calculation.

When interpreting the data in Appendix 4, it is important to note that the ratio method provides a very conservative determination of whether a material is likely to produce acid, as it is based on the assumption that all of the sulphur contained within a sample is able to form acid. This assumption is untrue for most samples, as discussed in Section 4. In addition, it requires that NAF material have an Acid Neutralising Capacity twice its Maximum Potential Acidity in order to be classified as NAF. The NAPP method used in this analysis is more accurate and less conservative than the ratio method, as it results in any material with an Acid Neutralising Capacity greater than its Maximum Potential Acidity being classified as NAF or ACM. The NAPP calculation still provides a degree of redundancy, as it is also based on the assumption that 100% of the sample's sulphur content is able to be converted to acid.

6.4.2 Classification of Rock Types

Section 6.3 above classified the samples according to their acid generating characteristics based on the NAPP calculation. Some judgement is required in order to classify the different rock types based on this classification. The rock types have been classified as PAF, NAF, ANC or "Uncertain," as shown in below. For rock types that included a sample with a NAPP value between -5 and 0 kgH₂SO₄/t, comments regarding the need for additional testing are included.

below groups the waste rock lithologies according to their potential to generate acid based on NAPP test results of the samples.

Table 6-1 Classification of Waste Rock Types

Lithology	Oxidation State	No. Samples	NAPP Classification and Comments	Maximum NAPP (kgH ₂ SO ₄ /t _s)
Granite	Fresh	2	NAF	-32.4
	Oxide	2	Uncertain. Borderline NAPP in some samples. S content low, but need clarity based on large amount of material.	-3.5
	Transitional	5	Uncertain. Samples exhibit variation in ANC. S content is low, need clarity based on large amount of material.	-4.4
Gabbro	Fresh	2	NAF	-36.1
	Oxide	3	NAF. Other samples exhibit lower NAPP, low S content.	-3.5
	Transitional	2	NAF	-13.4
Impure Carbonate	Fresh	1	ACM	< -583.69
	Oxide	2	NAF. The borderline NAPP value of one sample is likely to be an error. The other oxidised sample is highly ACM as expected.	-2.2
	Transitional	1	ACM	< -364.69
Unmineralised Metasediment	Fresh	3	NAF	-18.4
	Oxide	1	NAF. Low S content.	-4.4
	Transitional	1	NAF.	-8.1
Unmineralised Metasediment (chloritic)	Fresh	1	NAF	-43.0
Skarn (red rock altered)	Fresh	4	NAF. Some samples ACM	-6.9
	Oxide	4	NAF. Other samples more strongly NAF. Low S content.	-4.4
	Transitional	1	ACM	-130.7
Skarn (pyritic)	Fresh	1	Uncertain. Classified PAF using the ratio method. Likely to be treated as Low Grade Ore. If not treated, easily encapsulated given low amount	-15.2
Skarn (sulphide absent)	Fresh	1	NAF	-46.7
	Oxide	5	NAF. Other samples more strongly NAF or ACM	-4.1
	Transitional	4	NAF. Some samples ACM	-18.1
Pegmatite	Fresh	2	NAF	-22.4
Breccia (sulphide absent)	Fresh	3	NAF	-82.7
	Oxide	2	NAF. All other Breccia samples are either strongly NAF or ACM. The ANC test that resulted in NAPP>0 for one sample is likely to be an error. Also, this rock type has a very low S content.	1.2
	Transitional	2	NAF	-37.1
Breccia		0	ACM	-110.2

Lithology	Oxidation State	No. Samples	NAPP Classification and Comments	Maximum NAPP (kgH ₂ SO ₄ /t.)
(pyritic)				
Skarn (mineralised)		0	Uncertain – not sampled	
Metasediment (mineralised)		0	Uncertain – not sampled	
Other (mineralised)		0	Uncertain – not sampled	
Pegmatite - Supergene (native copper)	Transitional	1	NAF. Very low sulphur	-4.7
Gritstone		0	Uncertain – not sampled	

Table 6-2 Lithologies by NAPP Classification

NAPP Classification	Lithologies
PAF	Nil
NAF	Granite (fresh), Gabbro (all oxidation states), Impure Carbonate (oxide), Unmineralised Metasediments (all oxidation states), Skarn (fresh and oxide), Sulphide-absent Skarn (all oxidation states), Pegmatite (fresh), Sulphide-absent Breccia (all oxidation states), Supergene Pegmatite (transitional)
ACM	Impure Carbonate (transitional and fresh), Skarn (transitional), Pyritic Breccia
Uncertain	Granite (transitional and oxide), Mineralised Skarn, Pyritic Skarn (fresh), Mineralised Metasediment, Gritstone, other mineralised lithologies,

6.5 Discussion and Recommendations Arising from the Classification of Rock Types

In general, the waste rock from the Hillside project exhibits very limited potential to generate acid. However, given the large volume of waste rock associated with the project, it is imperative that a degree of certainty be attained. To this end, it is recommended that several rock types be subject to further investigation, via additional targeted sampling and analysis. These rock types, and the justification for recommending further investigation, are:

- Oxidised and transitional granite. While all oxidised and transitional granite samples were classified as NAF using the NAPP calculation, further sampling and analysis is recommended as granite is expected to account for nearly one-third of the project's waste material and only two and five samples of the respective oxidation states were taken in this preliminary round of sampling. The total sulphur content of this material is relatively low, and therefore the material is unlikely to be acid generating, however given that the calculated NAPP values of several samples were close to zero, and the significant representation of this material in the project's waste inventory, further investigation is recommended to achieve a robust understanding of this material.

- Pyritic skarn. While classified NAF using the NAPP calculation, the ratio method results in a PAF classification for this material. This material has a high enough sulphur content to potentially produce acid under certain conditions. This material may be treated as low grade ore.
- Mineralised rock types and gritstones were not sampled as part of this preliminary waste rock investigation, and should be included in the next stage. These rock types each consist of only a small proportion of the total volume of waste material expected from the project; these proportions should be reflected in the next round of sampling.

6.6 Leach Test Work

The samples were subjected to a toxicity characteristic leaching procedure (TCLP) test. The TCLP test is an analytical method used to simulate leaching that may occur from the material in the field. The method is used to determine if a waste is characteristically hazardous based on the mobility of toxic substances associated with the waste.

The TCLP test was used to determine the concentration of the following analytes in the leachate obtained from each sample: Al, As, Ba, Be, Cd, Co, Cr, Cr(3), Cr(6), Fe, K, Mg, Mn, Ni, P, Pb, Sn, Sr, Te, Th, Ti, U, V, Y Zn, Zr, and TDS. The results of the TCLP test work are shown in Appendix 5.

6.6.1 Discussion of Leachate Results

As seen in Appendix 5, the results of the leachate testwork indicate that leachate from the samples is relatively benign. Comment is provided on a number of analytes of interest:

- Aluminium – up to 96.5 mg/L was detected in samples, with most samples having some detectable Aluminium present. The ANZECC target value for aluminium in fresh waters is 13mg/L, and in recreational waters 200mg/L.
- Barium – barium was detected in only ten (10) samples, with concentrations of up to 1mg/L. The ANZECC target value for barium in fresh waters is 0.2mg/L and in recreational waters is 1,000mg/L.
- Vanadium – was detected in a minority of samples, however there are currently no ANZECC guideline values for vanadium in fresh or recreational waters.
- Phosphorous – most samples exhibited phosphorous at a concentration suitable for irrigation under ANZECC guidelines.
- Manganese – detected in most samples at concentrations of up to 2.1mg/L. The ANZECC target value for manganese in fresh waters is 0.06mg/L and in recreational waters in 100mg/L.
- Magnesium – detected in the majority of samples at levels up to 32.5mg/L, however no ANZECC target values currently exist.
- Potassium – detected in the majority of samples at levels up to 14.5mg/L, however no ANZECC target values currently exist.
- Iron - detected in the majority of samples at levels up to 118mg/L. This concentration is above the ANZECC guideline value for short term irrigation waters (10mg/L), but is well under the guideline for recreational waters (300mg/L)>

Other analytes were rarely if at all detected. TDS was well under 1000mg/L for all but 2 samples.

While some analytes push the sample over guideline values for fresh, irrigation water and stock water, dilution with uncontaminated waters would easily reduce these values to guideline values. Based on these results, waste rock leachate is unlikely to present a significant risk to the environment. A number of leachate management options are viable for further consideration, including:

- Containment and evaporation
- Dilution and release (with all required approvals and permits in place, and adequate monitoring)

It should be noted that, given the acid consuming nature of the majority of the waste rock associated with the Hillside project, in the long term waste rock dumps may begin to exhibit alkaline conditions. Most metals are less mobile under alkaline conditions, with the exception of metals that form oxyanions such as molybdenum, hexavalent chromium and arsenic. A long term monitoring program should take this into consideration.

6.7 Uranium Analysis

6.7.1 Regulatory Framework

Naturally Occurring Radioactive Material (NORM) is known to occur in the Hillside deposit. In South Australia, NORM must be managed according to the *Radiation Protection and Control Act 1982* (RPC Act), where concentrations of NORM exceed the activity concentration or total activity level thresholds prescribed in Schedule 4 of the *National Directory for Radiation Protection* (Australian Radiation Protection and Nuclear Safety Agency, 2011).

The activity of a radionuclide is defined as the quantity of instances of radioactive decay per second. The activity concentration of a radionuclide is defined as the activity level per unit mass of the material in which the radionuclide is essentially uniformly distributed.

Table 6.3 below shows the prescribed total activity and activity concentration thresholds for naturally occurring Uranium, (Australian Radiation Protection and Nuclear Safety Agency, 2011), above which the RPC Act would apply.

Table 6-3 Activity Concentration and Total Activity Thresholds

Radionuclide	Activity Concentration Threshold (Bq/g)	Total Activity (Bq)
Uranium (naturally occurring)	1.0	1,000

Naturally occurring Uranium consists of three (3) isotopes that appear in constant proportions: Uranium-234 (U-234), Uranium-235 (U-235) and Uranium-238 (U-238). The characteristics of each of these isotopes are shown in Table 6-4 below.

Table 6-4 Characteristics of Isotopes found in Naturally Occurring Uranium

	U-234	U-235	U-238
Atomic mass (g/mol)	234.041	235.044	238.051
Molar proportion in naturally occurring sample (%)	0.0054	0.72	99.275
Mass proportion in naturally occurring sample (%)	0.0053	0.711	99.284
Half life (years)	244,500	703.8×10^6	4.468×10^9

The Universal Law of Radioactive Decay can be used to define the specific activity (A_s) for each of the three naturally occurring Uranium isotopes, measured as Becquerels per gram of isotope, Bq/g.

$$A_s = \frac{N_A}{m_a} * \frac{\ln 2}{t_h} \quad (1)$$

Where:

- A_S = Specific activity (Bq/g)
- N_A = Avogadro's constant (mol^{-1})
- m_a = Isotope atomic mass (g/mol)
- t_h = Isotope half life

Table 6-5 below shows the calculated specific activity of each isotope and the contribution of each isotope to the specific activity of naturally occurring Uranium, based on each isotope's proportion by mass in a naturally occurring Uranium sample.

Table 6-5 Specific Activity of Isotopes found in Naturally Occurring Uranium

	U-234	U-235	U-238
Specific Activity (Bq/g)	231.1×10^6	79,958	12,436
Contribution to S_A of naturally occurring Uranium (Bq/g)	12,248	568	12,346

Summing each isotope's contribution gives a specific activity of naturally occurring Uranium of 25,162 Bq/g.

For determining whether a waste rock material is classified as a radioactive material under Schedule 4 of the *National Directory for Radiation Protection*, the applicable threshold is the activity concentration, rather than total activity.

Relating the calculated specific activity of naturally occurring Uranium to the threshold value given in **Error! Reference source not found.** it is possible to determine the concentration of Uranium in a naturally occurring rock sample that would cause the threshold activity concentration value to be exceeded:

$$C_{T(U)} = \frac{A_T}{A_{S(U)}} * 10^6 \quad (2)$$

Where:

- $C_{T(U)}$ = Threshold value for concentration of Uranium in a naturally occurring sample under Schedule 4 of the *National Directory for Radiation Protection*, in mg(U)/kg or ppm(U).
- A_T = Threshold activity concentration level for naturally occurring Uranium under Schedule 4 of the *National Directory for Radiation Protection*, in Bq/g
- $A_{S(U)}$ = Specific activity of naturally occurring Uranium in Bq/g

Using the threshold activity concentration of 1.0 Bq/g and the calculated specific activity of naturally occurring Uranium of 25,162 Bq/g, the threshold for Uranium concentration is calculated as 40 ppm.

6.7.2 Uranium Concentration in Waste Rock Samples

Inductively coupled plasma mass spectroscopy (ICPMS) was used to identify the abundance of certain elements within each waste rock sample taken for the Hillside project. Using this technique, Uranium was identified at varying concentrations in all samples.

Appendix 6 shows the concentration of Uranium detected in each sample. Samples that exceed the threshold concentration of 40 ppm are highlighted in Appendix 6 and reproduced below:

- HDD-206 88-95, a transitional granite (55 ppmU)
- HDD-272 188-198, a fresh red rock (55 ppmU)
- HDD-213 138-148, an oxidised red rock (60 ppmU)
- HDD-272 175-185, a fresh pyritic skarn (75 ppmU)
- HDD214 101-111, an oxidised skarn (47 ppmU)
- HDD-224 130-140, an oxidised breccia (55 ppmU)

In general, there is little correlation between waste rock lithology and exceedence of Uranium threshold, the lithologies that display an instance of threshold exceedence also display instances of much lower Uranium content. For example, one sample of granite returned value of 55 ppmU, however other granite samples returned values of between 11 and 27 ppmU. Other lithologies display similar results. This suggests that Uranium content is not dependent on lithology. Uranium content may be dependent on geographical location within the deposit, however this would need to be confirmed through further investigation.

6.7.3 Recommendations

It may be possible to blend material that exceeds the threshold Uranium concentration with lower-concentration material in order to construct a waste rock dump that would be classified as non-radioactive under Schedule 4 of the *National Directory for Radiation Protection*. In order to design and schedule such a waste rock facility, there is a need to define the schedule for waste rock extraction in terms of its Uranium concentration.

In order to achieve this, the following would be required:

- An accurate understanding of the distribution of Uranium throughout the deposit
- A schedule for waste rock extraction

Therefore, it is recommended that during the feasibility stage of the project, Rex Minerals undertake an additional waste rock sampling and analysis program, designed to enable mapping of the Uranium concentration throughout the deposit. The current waste rock sampling and analysis program is insufficient for the level of accuracy that would be required.

A key component of the *National Directory for Radiation Protection* for classification of material as being exempt from control through legislation is the definition of activity concentration. For the purposes of the document, activity concentration of a radionuclide is defined as the “activity per unit mass of the material in which the radionuclide is *essentially uniformly distributed*” (Australian Radiation Protection and Nuclear Safety Agency, 2011, emphasis added). Therefore, it is of critical importance that waste rock containing Uranium is scheduled and blended so as to satisfy this requirement.

7 CONCLUSION

7.1 General

Results of the first round of waste rock sampling and analysis indicate a relatively benign waste rock character associated with the Hillside project. For a project of this size, an accurate and detailed understanding of all mine wastes is crucial to minimising the site's environmental impact. To this end, a second round of sampling and analysis is recommended, targeted to:

1. Further assessment of any waste rock types deemed to have “uncertain” acid producing characteristics from the first round of testing. This includes material whose samples exhibited borderline NAPP values, were under-sampled or which are expected to be significantly represented in the total waste rock inventory.
1. More detailed understanding of the variation in the concentration of uranium present throughout the deposit, in order to facilitate appropriate management during the operational phase.
2. Testing of some existing samples for presence and character of fibrous materials.

Where further sampling and analysis is recommended, samples should be geographically and geologically representative of the proposed pit.

7.2 Fibrous Material

Skarns containing amphiboles, serpentine and talc minerals should be further investigated for minor fibrous minerals such as Actinolite. It is anticipated that analysis of existing Skarn samples would be sufficient for gaining an understanding of the fibrous characteristics of the waste rock.

7.3 Acid Rock Drainage

In general, the waste rock from the Hillside project exhibits very limited potential to generate acid. However, given the large volume of waste rock associated with the project, it is imperative that a degree of certainty be attained. To this end, it is recommended that several rock types be subject to further investigation, via additional targeted sampling and analysis. These rock types are:

- Oxidised and transitional granite
- Pyritic skarn
- Mineralised rock types and gritstones

The justifications for recommending further investigation are detailed in Section 6.5 of this report.

7.4 Leachate

The results of the leachate testwork indicate that leachate from the samples is relatively benign. Based on these results, waste rock leachate is unlikely to present a significant risk to the environment. A number of leachate management options are viable for further consideration, including:

- Containment and evaporation
- Dilution and release (with required approvals and permits, and adequate monitoring)

It should be noted that, given the acid consuming nature of the majority of the waste rock associated with the Hillside project, in the long term waste rock dumps may exhibit alkaline conditions. Most metals are less mobile under alkaline conditions, with the exception of metals that form oxyanions such as molybdenum, hexavalent chromium and arsenic. A long term monitoring program should take this into consideration.

7.5 Uranium

Using the *National Directory for Radiation Protection* (Australian Radiation Protection and Nuclear Safety Agency, 2011), it was determined that material containing over 40 ppmU would be classified as radioactive, and would need to be managed under the RPC Act.

Uranium was identified at varying concentrations in all samples, with little correlation between waste rock type and uranium content. Uranium content may be related to geographic location within the deposit, however this would need to be confirmed through further investigation.

Six (6) samples exceeded the calculated Uranium threshold of 40 ppm. It may be possible to blend material that exceeds the threshold Uranium concentration with lower-concentration material in order to construct a waste rock dump that would be classified as non-radioactive under Schedule 4 of the *National Directory for Radiation Protection*. In order to design and schedule such a waste rock facility, there is a need to define the schedule for waste rock extraction in terms of its Uranium concentration.

In order to achieve this, the following would be required:

- An accurate understanding of the distribution of Uranium throughout the deposit
- A schedule for waste rock extraction

Therefore, it is recommended that during the feasibility stage of the project, Rex Minerals undertake an additional waste rock sampling and analysis program, designed to enable mapping of the Uranium concentration throughout the deposit. The current waste rock sampling and analysis program is insufficient for the level of accuracy that would be required.

A key component of the *National Directory for Radiation Protection* for classification of material as being exempt from control through legislation is the definition of activity concentration. For the purposes of the document, activity concentration of a radionuclide is defined as the “activity per unit mass of the material in which the radionuclide is *essentially uniformly distributed*” (Australian Radiation Protection and Nuclear Safety Agency, 2011, emphasis added). Therefore, it is of critical importance that waste rock containing Uranium is scheduled and blended so as to satisfy this requirement.

APPENDIX I WASTE ROCK SAMPLES

The table below details the samples used in this analysis.

Hole ID	Sample Interval (m)	Sample Length (m)	Waste Lithology	Waste Type
HDD-033 269-275	269-275	6	Breccia	Fresh
HDD-069 313-323	313-323	10	Breccia	Fresh
HDD-352 200.9-204.4	200.9-204.4	3.5	Breccia	Fresh
HDD-224 130-140	130-140	10	Breccia	Oxide
HDD-225 14.8-17.7	14.8-17.7	2.9	Breccia	Oxide
HDD-270 32-42	32-42	10	Breccia	Transitional
HDD-023 191-196	191-196	5	Breccia	Transitional
HDD-016 458-467	458-467	9	Gabbro	Fresh
HDD-107 502-517	502-517	15	Gabbro	Fresh
HDD-095 128-132	128-132	4	Gabbro	Oxide
HDD-098 31-40	31-40	9	Gabbro	Oxide
HDD-098 55.2-62	55.2-62	6.8	Gabbro	Oxide
HDD-095 150-160	150-160	10	Gabbro	Transitional
HDD-215 34-44	34-44	10	Gabbro	Transitional
HDD-101 540-550	540-550	10	Granite	Fresh
HDD-280 213-226	213-226	13	Granite	Fresh
HDD-078 14-24	14-24	10	Granite	Oxide
HDD-207 114-124	114-124	10	Granite	Oxide
HDD-103 100-105	100-105	5	Granite	Transitional
HDD-103 105-110	105-110	5	Granite	Transitional
HDD-206 64.5-70	64.5-70	5.5	Granite	Transitional
HDD-206 88-95	88-95	7	Granite	Transitional
HDD-215 107-117	107-117	10	Granite	Transitional
HDD-101 270-290	270-290	10	Impure Carbonate	Fresh
HDD-103 85-90	85-90	5	Impure Carbonate	Oxide
HDD-207 83-95	83-95	12	Impure Carbonate	Oxide
HDD-023 31-35	31-35	4	Impure Carbonate	Transitional
HDD-023 333-337	333-337	4	Meta-Sediment (Banded/Non-Mineralised)	Fresh
HDD-033 124-134	124-134	10	Meta-Sediment (Banded/Non-Mineralised)	Fresh
HDD-272 102-112	102-112	10	Meta-Sediment (Banded/Non-Mineralised)	Fresh
HDD-299 80-91	80-91	9	Meta-Sediment (Banded/Non-Mineralised)	Oxide
HDD-074 65-75	65-75	10	Meta-Sediment (Banded/Non-Mineralised)	Transitional
HDD-264 40-47	40-47	7	Meta-Sediment (Banded/Non-Mineralised)	Transitional
HDD-026 485-495	485-495	10	Pegmatite	Fresh
HDD-058 100-110	100-110	10	Pegmatite	Fresh
HDD-074 154-164	154-164	10	Pegmatite (Supergene)	Transitional
HDD-026 306-316	306-316	10	Red Rock (Altered)	Fresh
HDD-043 245-255	245-255	10	Red Rock (Altered)	Fresh
HDD-069 258-268	258-268	10	Red Rock (Altered)	Fresh
HDD-272 188-198	188-198	10	Red Rock (Altered)	Fresh
HDD-205 134-141	134-141	7	Red Rock (Altered)	Oxide
HDD-206 38-48	38-48	10	Red Rock (Altered)	Oxide
HDD-213 138-148	138-148	10	Red Rock (Altered)	Oxide

Hole ID	Sample Interval (m)	Sample Length (m)	Waste Lithology	Waste Type
HDD-220 32-41	32-41	9	Red Rock (Altered)	Oxide
HDD-256 65-75	65-75	10	Red Rock (Altered)	Transitional
HDD-016 397-407	397-407	10	Skarn	Fresh
HDD-214 101-111	101-111	10	Skarn	Oxide
HDD-217 119-127	119-127	8	Skarn	Oxide
HDD-225 24-33	24-33	9	Skarn	Oxide
HDD-260 28-35	28-35	7	Skarn	Oxide
HDD-262 68-78	68-78	10	Skarn	Oxide
HDD-206 61.6-64.5	.6-64.5	2.9	Skarn	Transitional
HDD-224 176-186	176-186	10	Skarn	Transitional
HDD-256 56-65	56-65	9	Skarn	Transitional
HDD-260 38-44	38-44	6	Skarn	Transitional
HDD-272 175-185	175-185	10	Skarn (Pyritic)	Fresh
HDD-026 348-358	348-358	10	Meta-Sediment (Strongly chloritic)	Fresh

APPENDIX 2 ANALYTICAL REPORTS



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A M D E L

Mr Scott Keeling
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FINAL ANALYSIS REPORT

Your Order No:	TBA	Our Job Number:	2AD1115
Sample rec'd:	06/03/12	Results reported:	02/05/12
No. of samples:	57	Type of Sample:	ROCK AND SOIL

Results apply to sample(s) submitted by the client.

Report comprises a letter and report pages: 1 to 22

This report supersedes any preliminary results previously reported.

This document should not be reproduced except in full.

Approved:

Darryl Hartley
Business Unit Manager
Adelaide Geoanalytical

Robert Silvani
Senior Chemist

Neville Walkom
Senior Chemist

Report Codes:

N.A. - Not Available
L.N.R. - Listed But Not Received

I.S. - Insufficient Sample
R.N.L. - Received But Not Listed

Please Note

- 1) The results for elements 'Al, Ba, Cr, Ti, W, Zr, Sn' by code IC3E digest are acid soluble only, and results may be semi-quantative. 'K' values > 1% by code IC3E may bias low due to the insolubility of potassium perchlorate.
- 2) For scheme IC4, Total 'Fe' is analysed but is calculated and reported as 'Fe2O3'

Job: 2AD1115
O/N: TBA



Final

ANALYTICAL REPORT

A M D E L

SAMPLE	Al	Ca	Cr	K	Mg	Mn	Na
HDD-101 540-550	8.11	1.93	< 20	4.25	0.295	0.035	3.75
HDD-280 213-226	5.82	2.46	30	1.68	2.450	0.065	1.58
HDD-103 105-110	8.21	0.20	< 20	4.59	0.225	0.015	3.54
HDD-206 88-95	7.10	0.33	< 20	3.56	1.035	0.035	2.67
HDD-215 107-117	8.68	0.21	< 20	5.51	0.370	0.040	3.48
HDD-206 64.5-70	9.53	1.17	< 20	4.87	1.355	0.065	3.69
HDD-103 100-105	7.94	0.26	< 20	5.64	0.485	0.025	2.76
HDD-078 14-24	11.9	0.02	< 20	3.88	0.100	0.015	0.23
HDD-207 114-124	11.8	0.06	< 20	5.47	0.070	0.175	0.18
HDD-016 458-467	8.23	3.09	190	1.99	4.875	0.140	2.49
HDD-107 502-517	6.44	1.33	75	2.24	4.140	0.100	1.45
HDD-215 34-44	8.52	0.27	35	3.89	4.960	0.120	0.73
HDD-095 150-160	7.14	0.26	140	1.96	5.07	0.120	1.77
HDD-095 128-132	7.12	0.31	205	1.87	4.820	0.115	1.52
HDD-098 31-40	7.88	0.04	140	3.45	0.725	0.025	1.05
HDD-098 55.2-62	7.29	0.77	135	1.80	3.115	0.095	2.74
HDD-101 270-290	2.345	26.3	25	1.84	1.265	0.195	0.12
HDD-023 31-35	4.670	13.2	40	2.19	2.890	0.390	0.69
HDD-207 83-95	13.1	0.12	< 20	0.10	0.130	0.435	0.25
HDD-103 85-90	4.460	4.00	25	3.02	2.040	1.770	0.29
HDD-272 102-112	9.15	0.66	85	3.28	2.010	0.040	2.91
HDD-026 348-358	5.94	1.19	85	1.23	6.70	0.130	0.49
HDD-033 124-134	6.34	0.61	35	2.09	5.56	0.075	1.01
HDD-023 333-337	5.59	0.92	75	2.71	0.865	0.030	2.04
HDD-074 65-75	5.16	0.26	30	2.55	0.620	0.030	1.01
HDD-299 80-91	9.17	0.16	80	5.54	2.670	0.035	0.96
HDD-264 40-47	6.73	0.24	55	5.16	3.385	0.100	0.25
HDD-069 258-268	4.320	10.2	25	3.64	1.370	0.090	0.53
HDD-272 188-198	2.485	6.09	< 20	0.47	2.120	0.115	0.04
HDD-026 306-316	6.94	0.17	< 20	5.81	0.605	0.020	1.68
HDD-043 245-255	7.17	2.69	80	4.63	1.675	0.060	2.09
HDD-205 134-141	6.16	1.01	50	1.63	2.620	0.105	1.87
HDD-256 65-75	4.380	5.54	< 20	2.39	5.56	0.135	0.68
HDD-220 32-41	6.63	0.09	< 20	4.22	0.290	0.045	0.26
HDD-213 138-148	5.17	0.42	60	2.54	0.655	0.120	0.23
HDD-206 38-48	8.94	0.39	30	4.67	1.060	0.120	2.18
HDD-272 175-185	1.620	2.74	< 20	0.08	3.425	0.075	0.67
HDD-016 397-407	5.51	6.23	25	0.29	2.140	0.100	2.39
HDD-256 56-65	2.365	4.77	35	0.48	8.96	0.150	0.17
HDD-260 38-44	4.265	12.9	25	0.29	5.80	0.310	0.20
HDD-224 176-186	5.80	0.71	40	4.62	1.740	0.070	0.14
HDD-206 61.6-64.5	7.27	2.94	60	3.48	2.940	0.140	0.13
HDD-225 24-33	3.780	9.29	25	1.06	3.930	0.310	0.57
HDD-260 28-35	5.45	6.37	25	3.33	5.05	0.190	0.34
HDD-262 68-78	6.43	0.31	50	1.32	3.420	0.110	1.78
HDD-217 119-127	7.93	2.40	30	7.29	0.510	0.465	0.25
HDD-214 101-111	8.37	1.38	20	6.46	0.585	0.740	0.36
HDD-058 100-110	6.50	2.17	< 20	1.06	0.185	0.030	4.52
HDD-026 485-495	6.01	0.70	< 20	3.34	0.865	0.015	2.58
HDD-074 154-164	2.970	0.07	< 20	1.91	0.830	0.050	0.35
UNITS	%	%	ppm	%	%	%	%
DET.LIM	0.005	0.01	20	0.01	0.005	0.005	0.01
SCHEME	IC4	IC4	IC4	IC4	IC4	IC4	IC4

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SAMPLE	Al	Ca	Cr	K	Mg	Mn	Na
HDD-069 313-323	2.075	5.78	< 20	0.98	2.740	0.080	0.19
HDD-033 269-275	6.38	7.69	40	2.66	2.820	0.165	1.34
HDD-352 200.9-204.4	3.475	7.97	< 20	0.22	6.21	0.180	0.05
HDD-270 32-42	5.76	0.29	130	2.60	4.200	0.070	0.22
HDD-224 130-140	5.68	0.06	35	0.42	0.390	0.115	0.10
HDD-225 14.8-17.7	9.38	0.13	115	6.21	3.105	0.110	0.95
HDD-023 191-196	4.550	5.08	65	1.26	5.69	0.165	0.03

UNITS	%	%	ppm	%	%	%	%
DET.LIM	0.005	0.01	20	0.01	0.005	0.005	0.01
SCHEME	IC4	IC4	IC4	IC4	IC4	IC4	IC4

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SAMPLE	Ba	Be	Bi	Ce	Co	Ga	La
HDD-101 540-550	205	4.0	< 3	175	< 15	17	100
HDD-280 213-226	110	15.0	< 3	75	65	22	40
HDD-103 105-110	475	2.5	< 3	170	< 15	16	90
HDD-206 88-95	490	6.0	< 3	310	35	16	195
HDD-215 107-117	465	2.5	< 3	150	< 15	17	80
HDD-206 64.5-70	605	3.5	< 3	160	25	19	65
HDD-103 100-105	475	3.5	< 3	220	< 15	15	115
HDD-078 14-24	730	3.5	< 3	180	< 15	22	115
HDD-207 114-124	640	6.0	< 3	355	< 15	24	180
HDD-016 458-467	355	2.5	< 3	29	45	18	13
HDD-107 502-517	595	3.5	< 3	70	40	17	38
HDD-215 34-44	1020	5.5	< 3	85	60	28	33
HDD-095 150-160	410	3.5	< 3	37	45	20	18
HDD-095 128-132	830	4.5	< 3	42	65	19	18
HDD-098 31-40	545	2.5	< 3	43	45	20	28
HDD-098 55.2-62	350	3.0	< 3	50	40	17	21
HDD-101 270-290	740	2.0	< 3	49	< 15	6	27
HDD-023 31-35	1300	1.5	< 3	42	20	11	20
HDD-207 83-95	555	6.0	< 3	155	30	27	70
HDD-103 85-90	1670	7.5	< 3	60	35	13	26
HDD-272 102-112	770	5.0	< 3	80	15	22	40
HDD-026 348-358	310	3.0	< 3	21	85	28	9
HDD-033 124-134	265	2.5	< 3	24	65	17	11
HDD-023 333-337	680	2.5	< 3	29	35	14	13
HDD-074 65-75	1045	8.5	< 3	65	55	12	1350
HDD-299 80-91	1130	5.0	< 3	60	25	21	33
HDD-264 40-47	1070	5.0	< 3	45	185	19	37
HDD-069 258-268	1065	5.0	< 3	31	20	10	16
HDD-272 188-198	65	17.0	< 3	580	55	18	395
HDD-026 306-316	480	14.0	< 3	23	< 15	16	10
HDD-043 245-255	635	5.5	< 3	95	15	14	46
HDD-205 134-141	440	6.5	< 3	120	40	12	44
HDD-256 65-75	505	2.5	< 3	27	35	9	10
HDD-220 32-41	880	4.5	< 3	90	< 15	12	42
HDD-213 138-148	650	5.0	< 3	140	75	16	55
HDD-206 38-48	925	4.5	< 3	70	50	16	27
HDD-272 175-185	140	32.5	< 3	115	160	15	65
HDD-016 397-407	130	4.5	< 3	330	35	11	245
HDD-256 56-65	380	2.5	< 3	24	60	7	13
HDD-260 38-44	120	2.5	< 3	80	15	9	27
HDD-224 176-186	1435	5.5	< 3	160	60	15	75
HDD-206 61.6-64.5	710	4.5	< 3	130	40	19	43
HDD-225 24-33	615	4.5	< 3	90	35	10	45
HDD-260 28-35	745	3.0	< 3	150	15	10	70
HDD-262 68-78	240	16.5	< 3	140	70	26	90
HDD-217 119-127	3010	5.0	< 3	130	15	16	65
HDD-214 101-111	9130	5.5	< 3	130	35	21	70
HDD-058 100-110	360	4.0	< 3	29	< 15	17	15
HDD-026 485-495	205	7.0	< 3	22	< 15	13	11
HDD-074 154-164	620	5.0	< 3	16	55	12	7
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DET.LIM	10	0.5	3	1	15	1	1
SCHEME	IC4M	IC4M	IC4M	IC4M	IC4M	IC4M	IC4M

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SAMPLE	Ba	Be	Bi	Ce	Co	Ga	La
HDD-069 313-323	205	4.0	< 3	21	20	6	9
HDD-033 269-275	345	3.0	< 3	70	55	16	41
HDD-352 200.9-204.4	35	8.0	< 3	105	55	13	65
HDD-270 32-42	425	2.5	< 3	19	155	25	9
HDD-224 130-140	335	4.0	< 3	120	40	19	20
HDD-225 14.8-17.7	1530	6.0	< 3	110	45	21	55
HDD-023 191-196	880	2.5	< 3	60	20	11	26

UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DET.LIM	10	0.5	3	1	15	1	1
SCHEME	IC4M	IC4M	IC4M	IC4M	IC4M	IC4M	IC4M

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SAMPLE	Mo	Nb	Rb	Re	Sb	Se	Sn
HDD-101 540-550	2	25	165	< 0.1	< 1	< 10	< 10
HDD-280 213-226	< 2	25	200	< 0.1	< 1	< 10	15
HDD-103 105-110	< 2	25	175	< 0.1	< 1	< 10	< 10
HDD-206 88-95	< 2	20	150	< 0.1	< 1	< 10	< 10
HDD-215 107-117	< 2	20	180	< 0.1	< 1	< 10	< 10
HDD-206 64.5-70	< 2	30	185	< 0.1	< 1	< 10	< 10
HDD-103 100-105	< 2	20	220	< 0.1	< 1	< 10	< 10
HDD-078 14-24	< 2	35	165	< 0.1	< 1	< 10	10
HDD-207 114-124	< 2	45	215	< 0.1	< 1	< 10	< 10
HDD-016 458-467	< 2	< 10	145	< 0.1	< 1	< 10	< 10
HDD-107 502-517	3	10	155	< 0.1	< 1	< 10	< 10
HDD-215 34-44	< 2	30	240	< 0.1	< 1	< 10	20
HDD-095 150-160	< 2	15	140	< 0.1	< 1	< 10	< 10
HDD-095 128-132	< 2	15	155	< 0.1	< 1	< 10	< 10
HDD-098 31-40	< 2	20	320	< 0.1	< 1	< 10	< 10
HDD-098 55.2-62	< 2	10	125	< 0.1	< 1	< 10	< 10
HDD-101 270-290	< 2	< 10	80	< 0.1	< 1	< 10	< 10
HDD-023 31-35	< 2	< 10	100	< 0.1	< 1	< 10	< 10
HDD-207 83-95	4	25	6.0	< 0.1	1	< 10	< 10
HDD-103 85-90	< 2	10	145	< 0.1	1	< 10	< 10
HDD-272 102-112	< 2	15	225	< 0.1	< 1	< 10	< 10
HDD-026 348-358	3	10	75	< 0.1	< 1	< 10	15
HDD-033 124-134	2	15	165	< 0.1	< 1	< 10	< 10
HDD-023 333-337	< 2	10	100	< 0.1	< 1	< 10	< 10
HDD-074 65-75	< 2	30	200	< 0.1	< 1	< 10	< 10
HDD-299 80-91	< 2	15	410	< 0.1	< 1	< 10	< 10
HDD-264 40-47	< 2	15	290	< 0.1	< 1	< 10	< 10
HDD-069 258-268	< 2	10	165	< 0.1	< 1	< 10	< 10
HDD-272 188-198	< 2	10	27.5	< 0.1	< 1	< 10	85
HDD-026 306-316	32	40	510	< 0.1	< 1	< 10	< 10
HDD-043 245-255	< 2	< 10	175	< 0.1	< 1	< 10	15
HDD-205 134-141	< 2	60	80	< 0.1	< 1	< 10	15
HDD-256 65-75	< 2	< 10	195	< 0.1	< 1	< 10	10
HDD-220 32-41	2	15	150	< 0.1	< 1	< 10	< 10
HDD-213 138-148	< 2	10	325	< 0.1	< 1	< 10	< 10
HDD-206 38-48	< 2	20	190	< 0.1	< 1	< 10	< 10
HDD-272 175-185	< 2	< 10	17.5	< 0.1	< 1	< 10	25
HDD-016 397-407	< 2	10	13.5	< 0.1	< 1	< 10	< 10
HDD-256 56-65	< 2	< 10	43.0	< 0.1	< 1	< 10	< 10
HDD-260 38-44	< 2	< 10	23.5	< 0.1	< 1	< 10	< 10
HDD-224 176-186	< 2	15	215	< 0.1	< 1	< 10	< 10
HDD-206 61.6-64.5	< 2	45	155	< 0.1	< 1	< 10	15
HDD-225 24-33	< 2	< 10	55	< 0.1	< 1	< 10	15
HDD-260 28-35	< 2	15	155	< 0.1	< 1	< 10	< 10
HDD-262 68-78	< 2	25	155	< 0.1	< 1	< 10	15
HDD-217 119-127	< 2	15	350	< 0.1	< 1	< 10	< 10
HDD-214 101-111	< 2	15	290	< 0.1	< 1	< 10	< 10
HDD-058 100-110	< 2	< 10	48.5	< 0.1	< 1	< 10	< 10
HDD-026 485-495	< 2	< 10	355	< 0.1	< 1	< 10	< 10
HDD-074 154-164	< 2	< 10	115	< 0.1	< 1	< 10	< 10
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DET.LIM	2	10	0.5	0.1	1	10	10
SCHEME	IC4M	IC4M	IC4M	IC4M	IC4M	IC4M	IC4M

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SAMPLE	Mo	Nb	Rb	Re	Sb	Se	Sn
HDD-069 313-323	< 2	< 10	42.0	< 0.1	< 1	< 10	< 10
HDD-033 269-275	< 2	20	140	< 0.1	< 1	< 10	40
HDD-352 200.9-204.4	< 2	< 10	14.5	< 0.1	< 1	< 10	10
HDD-270 32-42	< 2	< 10	90	< 0.1	< 1	< 10	< 10
HDD-224 130-140	< 2	25	27.0	< 0.1	< 1	< 10	< 10
HDD-225 14.8-17.7	< 2	20	355	< 0.1	< 1	< 10	< 10
HDD-023 191-196	< 2	< 10	90	< 0.1	1	< 10	< 10

UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DET.LIM	2	10	0.5	0.1	1	10	10
SCHEME	IC4M	IC4M	IC4M	IC4M	IC4M	IC4M	IC4M

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SAMPLE	As	Cd	Cu	Li	Ni	Pb	Zn
HDD-101 540-550	4	< 2	31	4	< 2	< 5	8
HDD-280 213-226	4	< 2	2120	30	30	5	26
HDD-103 105-110	8	< 2	70	4	2	< 5	14
HDD-206 88-95	16	< 2	120	13	8	< 5	32
HDD-215 107-117	10	< 2	165	4	3	< 5	11
HDD-206 64.5-70	8	< 2	36	16	5	< 5	32
HDD-103 100-105	10	< 2	60	8	3	< 5	29
HDD-078 14-24	14	< 2	940	12	4	< 5	10
HDD-207 114-124	16	< 2	180	30	4	< 5	36
HDD-016 458-467	10	< 2	130	35	85	< 5	60
HDD-107 502-517	8	< 2	255	47	44	< 5	55
HDD-215 34-44	18	< 2	200	65	65	10	100
HDD-095 150-160	18	< 2	50	60	60	< 5	42
HDD-095 128-132	16	< 2	190	70	70	< 5	50
HDD-098 31-40	12	< 2	230	11	50	10	60
HDD-098 55.2-62	14	< 2	105	49	49	10	85
HDD-101 270-290	10	< 2	100	15	8	30	22
HDD-023 31-35	12	< 2	185	32	27	< 5	13
HDD-207 83-95	14	< 2	1550	105	65	20	90
HDD-103 85-90	< 3	< 2	90	40	12	10	130
HDD-272 102-112	4	< 2	5	21	43	< 5	18
HDD-026 348-358	8	< 2	540	65	65	< 5	80
HDD-033 124-134	< 3	< 2	60	55	28	< 5	60
HDD-023 333-337	4	< 2	37	9	21	< 5	14
HDD-074 65-75	75	< 2	9575	17	29	20	200
HDD-299 80-91	8	< 2	17	36	39	< 5	27
HDD-264 40-47	10	< 2	965	60	41	< 5	120
HDD-069 258-268	4	< 2	105	29	9	10	34
HDD-272 188-198	20	< 2	85	40	5	10	46
HDD-026 306-316	< 3	< 2	405	7	2	5	13
HDD-043 245-255	6	< 2	275	20	19	30	49
HDD-205 134-141	4	< 2	280	33	13	15	75
HDD-256 65-75	4	< 2	55	49	10	10	80
HDD-220 32-41	6	< 2	530	9	3	10	43
HDD-213 138-148	10	< 2	255	27	28	15	75
HDD-206 38-48	4	< 2	570	29	22	5	60
HDD-272 175-185	< 3	< 2	2100	42	17	25	44
HDD-016 397-407	10	< 2	190	20	15	10	24
HDD-256 56-65	< 3	< 2	35	49	7	< 5	100
HDD-260 38-44	4	< 2	7	120	4	10	55
HDD-224 176-186	10	< 2	1560	28	24	10	70
HDD-206 61.6-64.5	6	< 2	130	55	20	10	100
HDD-225 24-33	6	< 2	1095	90	11	10	125
HDD-260 28-35	< 3	< 2	34	75	8	10	85
HDD-262 68-78	10	< 2	820	50	18	10	110
HDD-217 119-127	12	< 2	280	18	21	10	205
HDD-214 101-111	< 3	< 2	360	20	47	10	445
HDD-058 100-110	< 3	< 2	75	2	< 2	< 5	7
HDD-026 485-495	< 3	< 2	10	14	< 2	< 5	5
HDD-074 154-164	< 3	< 2	2400	12	14	20	31
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DET.LIM	3	2	2	2	2	5	2
SCHEME	IC3E	IC3E	IC3E	IC3E	IC3E	IC3E	IC3E

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SAMPLE	As	Cd	Cu	Li	Ni	Pb	Zn
HDD-069 313-323	< 3	< 2	415	22	7	10	55
HDD-033 269-275	6	< 2	520	34	26	5	70
HDD-352 200.9-204.4	4	< 2	330	75	11	< 5	90
HDD-270 32-42	6	< 2	385	50	55	< 5	50
HDD-224 130-140	8	< 2	765	35	17	15	15
HDD-225 14.8-17.7	10	< 2	605	75	46	< 5	100
HDD-023 191-196	6	< 2	145	70	43	< 5	16

UNITS	ppm	ppm	ppm	ppm	ppm	ppm	ppm
DET.LIM	3	2	2	2	2	5	2
SCHEME	IC3E	IC3E	IC3E	IC3E	IC3E	IC3E	IC3E

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SAMPLE	Al	Cr	Fe	K	Mg	Mn	P
HDD-101 540-550	< 0.5	< 0.1	< 0.5	7.0	0.4	< 0.1	< 0.2
HDD-280 213-226	< 0.5	< 0.1	1.0	4.5	2.6	< 0.1	< 0.2
HDD-103 105-110	2.5	< 0.1	1.5	6.5	0.8	< 0.1	0.4
HDD-206 88-95	2.0	< 0.1	3.0	6.5	1.2	< 0.1	< 0.2
HDD-215 107-117	2.5	< 0.1	1.5	8.0	1.0	0.1	0.6
HDD-206 64.5-70	< 0.5	< 0.1	0.5	5.5	0.6	< 0.1	0.4
HDD-103 100-105	2.5	< 0.1	1.5	7.0	1.6	< 0.1	0.4
HDD-078 14-24	< 0.5	< 0.1	< 0.5	6.0	6.0	0.2	0.4
HDD-207 114-124	< 0.5	< 0.1	< 0.5	4.5	2.4	0.4	0.2
HDD-016 458-467	1.0	< 0.1	2.0	5.5	2.2	< 0.1	0.4
HDD-107 502-517	< 0.5	< 0.1	1.0	3.5	1.4	< 0.1	0.4
HDD-215 34-44	10.0	< 0.1	8.5	2.5	6.0	< 0.1	0.4
HDD-095 150-160	5.5	< 0.1	7.5	1.5	7.0	0.1	< 0.2
HDD-095 128-132	24.5	< 0.1	20.5	6.0	27.5	0.6	0.4
HDD-098 31-40	< 0.5	< 0.1	< 0.5	3.5	< 0.2	< 0.1	0.2
HDD-098 55.2-62	96.5	0.2	118	10.0	140	2.1	0.2
HDD-101 270-290	< 0.5	< 0.1	< 0.5	2.0	0.2	< 0.1	< 0.2
HDD-023 31-35	< 0.5	< 0.1	< 0.5	8.5	1.8	< 0.1	< 0.2
HDD-207 83-95	< 0.5	< 0.1	< 0.5	4.5	4.8	< 0.1	< 0.2
HDD-103 85-90	8.5	< 0.1	15.0	4.0	16.0	2.3	0.4
HDD-272 102-112	1.5	< 0.1	1.5	9.0	1.2	< 0.1	0.6
HDD-026 348-358	3.0	< 0.1	5.0	2.5	6.0	< 0.1	0.2
HDD-033 124-134	1.0	< 0.1	1.5	12.0	2.8	< 0.1	0.4
HDD-023 333-337	0.5	< 0.1	< 0.5	3.0	0.8	< 0.1	0.2
HDD-074 65-75	6.0	< 0.1	6.5	1.5	3.2	< 0.1	0.6
HDD-299 80-91	3.5	< 0.1	2.0	4.5	1.6	< 0.1	< 0.2
HDD-264 40-47	12.0	< 0.1	20.0	1.0	15.5	0.3	0.4
HDD-069 258-268	< 0.5	< 0.1	< 0.5	4.5	1.0	< 0.1	0.4
HDD-272 188-198	< 0.5	< 0.1	< 0.5	3.0	3.2	< 0.1	< 0.2
HDD-026 306-316	0.5	< 0.1	< 0.5	11.0	1.0	< 0.1	< 0.2
HDD-043 245-255	< 0.5	< 0.1	< 0.5	9.0	1.2	< 0.1	0.4
HDD-205 134-141	11.0	< 0.1	14.0	2.5	12.5	0.2	0.4
HDD-256 65-75	11.0	< 0.1	14.0	4.0	28.5	0.4	0.2
HDD-220 32-41	4.0	< 0.1	2.5	2.0	1.8	0.2	0.2
HDD-213 138-148	6.0	< 0.1	6.0	2.5	3.0	0.2	1.0
HDD-206 38-48	11.5	< 0.1	8.0	3.5	8.5	0.9	0.2
HDD-272 175-185	1.0	< 0.1	1.5	0.5	6.0	< 0.1	0.4
HDD-016 397-407	< 0.5	< 0.1	< 0.5	0.5	1.4	< 0.1	0.4
HDD-256 56-65	11.0	< 0.1	16.5	< 0.5	32.5	0.4	0.4
HDD-260 38-44	10.5	< 0.1	8.0	1.0	26.0	0.3	0.4
HDD-224 176-186	6.0	< 0.1	5.0	2.0	5.5	0.1	0.4
HDD-206 61.6-64.5	4.5	< 0.1	4.5	1.5	4.0	0.1	0.4
HDD-225 24-33	16.5	< 0.1	18.0	1.5	37.0	1.0	0.2
HDD-260 28-35	5.0	< 0.1	4.0	2.5	10.0	0.1	< 0.2
HDD-262 68-78	13.0	< 0.1	17.0	4.0	13.5	0.2	0.4
HDD-217 119-127	7.5	< 0.1	4.5	4.5	6.0	0.9	0.6
HDD-214 101-111	7.0	< 0.1	5.5	1.5	4.2	1.3	< 0.2
HDD-058 100-110	< 0.5	< 0.1	< 0.5	1.0	0.2	< 0.1	0.6
HDD-026 485-495	1.0	< 0.1	< 0.5	6.5	2.0	< 0.1	0.6
HDD-074 154-164	4.0	< 0.1	6.0	7.0	3.6	0.1	0.4
UNITS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
DET.LIM	0.5	0.1	0.5	0.5	0.2	0.1	0.2
SCHEME	IND7E	IND7E	IND7E	IND7E	IND7E	IND7E	IND7E

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SAMPLE	Al	Cr	Fe	K	Mg	Mn	P
HDD-069 313-323	< 0.5	< 0.1	< 0.5	3.5	1.4	< 0.1	< 0.2
HDD-033 269-275	1.0	< 0.1	1.0	5.5	3.2	< 0.1	0.2
HDD-352 200.9-204.4	1.0	< 0.1	1.5	1.0	3.0	< 0.1	0.4
HDD-270 32-42	7.0	< 0.1	10.5	< 0.5	6.5	< 0.1	0.2
HDD-224 130-140	< 0.5	< 0.1	< 0.5	1.5	2.8	0.1	0.6
HDD-225 14.8-17.7	13.5	< 0.1	13.5	2.0	14.0	0.3	0.4
HDD-023 191-196	< 0.5	< 0.1	< 0.5	14.5	3.6	< 0.1	0.6

UNITS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
DET.LIM	0.5	0.1	0.5	0.5	0.2	0.1	0.2
SCHEME	IND7E	IND7E	IND7E	IND7E	IND7E	IND7E	IND7E

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A M D E L

SAMPLE	As	Ba	Be	Cd	Co	Ni	Pb
HDD-101 540-550	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-280 213-226	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-103 105-110	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-206 88-95	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-215 107-117	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-206 64.5-70	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-103 100-105	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-078 14-24	< 0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-207 114-124	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-016 458-467	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-107 502-517	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-215 34-44	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-095 150-160	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-095 128-132	< 0.1	0.4	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-098 31-40	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-098 55.2-62	< 0.1	0.6	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-101 270-290	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-023 31-35	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-207 83-95	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-103 85-90	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-272 102-112	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-026 348-358	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-033 124-134	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-023 333-337	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-074 65-75	< 0.1	0.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-299 80-91	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-264 40-47	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-069 258-268	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-272 188-198	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-026 306-316	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-043 245-255	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-205 134-141	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-256 65-75	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-220 32-41	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-213 138-148	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-206 38-48	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-272 175-185	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-016 397-407	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-256 56-65	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-260 38-44	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-224 176-186	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-206 61.6-64.5	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-225 24-33	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-260 28-35	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-262 68-78	< 0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-217 119-127	< 0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-214 101-111	< 0.1	1.0	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-058 100-110	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-026 485-495	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-074 154-164	< 0.1	0.2	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
UNITS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
DET.LIM	0.1	0.1	0.1	0.1	0.1	0.1	0.1
SCHEME	IND7M	IND7M	IND7M	IND7M	IND7M	IND7M	IND7M

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SAMPLE	As	Ba	Be	Cd	Co	Ni	Pb
HDD-069 313-323	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-033 269-275	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-352 200.9-204.4	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-270 32-42	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-224 130-140	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-225 14.8-17.7	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1
HDD-023 191-196	< 0.1	0.3	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1

UNITS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
DET.LIM	0.1	0.1	0.1	0.1	0.1	0.1	0.1
SCHEME	IND7M	IND7M	IND7M	IND7M	IND7M	IND7M	IND7M

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SAMPLE	Sn	Sr	Te	Th	Y	U	Zn
HDD-101 540-550	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-280 213-226	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-103 105-110	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-206 88-95	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-215 107-117	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-206 64.5-70	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-103 100-105	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-078 14-24	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-207 114-124	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-016 458-467	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-107 502-517	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-215 34-44	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-095 150-160	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-095 128-132	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-098 31-40	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-098 55.2-62	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	0.3
HDD-101 270-290	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-023 31-35	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-207 83-95	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-103 85-90	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-272 102-112	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-026 348-358	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-033 124-134	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-023 333-337	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-074 65-75	< 0.1	< 0.1	< 0.1	< 0.1	0.10	< 0.1	0.1
HDD-299 80-91	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-264 40-47	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-069 258-268	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-272 188-198	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-026 306-316	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-043 245-255	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-205 134-141	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-256 65-75	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-220 32-41	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-213 138-148	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-206 38-48	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-272 175-185	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-016 397-407	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-256 56-65	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-260 38-44	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-224 176-186	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-206 61.6-64.5	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-225 24-33	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	0.1
HDD-260 28-35	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-262 68-78	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-217 119-127	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	0.2
HDD-214 101-111	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	0.2
HDD-058 100-110	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-026 485-495	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-074 154-164	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
UNITS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
DET.LIM	0.1	0.1	0.1	0.1	0.05	0.1	0.1
SCHEME	IND7M	IND7M	IND7M	IND7M	IND7M	IND7M	IND7M

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SAMPLE	Sn	Sr	Te	Th	Y	U	Zn
HDD-069 313-323	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-033 269-275	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-352 200.9-204.4	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-270 32-42	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-224 130-140	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-225 14.8-17.7	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1
HDD-023 191-196	< 0.1	< 0.1	< 0.1	< 0.1	< 0.05	< 0.1	< 0.1

UNITS	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
DET.LIM	0.1	0.1	0.1	0.1	0.05	0.1	0.1
SCHEME	IND7M	IND7M	IND7M	IND7M	IND7M	IND7M	IND7M

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SAMPLE	P	Si	V	Hg	ANC	NAPP	NAG			
HDD-101 540-550	0.045	31.7	< 20	< 0.05	33	-33	< 1			
HDD-280 213-226	0.075	28.2	60	< 0.05	61	-60	< 1			
HDD-103 105-110	0.055	32.9	< 20	< 0.05	< 1	< 1	3			
HDD-206 88-95	0.115	31.0	30	< 0.05	9	-8	1			
HDD-215 107-117	0.060	31.1	25	< 0.05	5	-4	< 1			
HDD-206 64.5-70	0.085	27.5	25	< 0.05	28	-27	< 1			
HDD-103 100-105	0.040	32.7	< 20	< 0.05	5	-4	4			
HDD-078 14-24	0.030	24.4	30	< 0.05	5	-4	6			
HDD-207 114-124	0.020	27.2	30	< 0.05	5	-3	< 1			
HDD-016 458-467	0.045	23.4	340	< 0.05	37	-37	< 1			
HDD-107 502-517	0.060	26.4	255	< 0.05	42	-42	< 1			
HDD-215 34-44	0.115	20.9	345	< 0.05	14	-13	2			
HDD-095 150-160	0.065	23.3	355	< 0.05	33	-31	< 1			
HDD-095 128-132	0.080	23.5	290	< 0.05	23	-22	< 1			
HDD-098 31-40	0.010	26.3	275	< 0.05	5	-5	3			
HDD-098 55.2-62	0.065	24.7	345	< 0.05	33	-33	< 1			
HDD-101 270-290	0.065	10.9	25	< 0.05	584	-584	< 1			
HDD-023 31-35	0.055	18.5	60	< 0.05	365	-364	< 1			
HDD-207 83-95	0.030	26.9	30	< 0.05	5	-4	< 1			
HDD-103 85-90	0.075	22.5	40	< 0.05	108	-104	< 1			
HDD-272 102-112	0.040	29.1	110	< 0.05	19	-13	< 1			
HDD-026 348-358	0.070	24.3	210	< 0.05	47	-43	< 1			
HDD-033 124-134	0.075	28.2	80	< 0.05	47	-46	< 1			
HDD-023 333-337	0.065	26.8	95	< 0.05	14	-13	< 1			
HDD-074 65-75	0.115	24.4	45	< 0.05	9	-9	< 1			
HDD-299 80-91	0.065	28.1	105	< 0.05	5	-5	< 1			
HDD-264 40-47	0.100	22.3	145	< 0.05	37	-37	< 1			
HDD-069 258-268	0.045	25.2	< 20	< 0.05	103	-101	< 1			
HDD-272 188-198	0.115	16.3	60	< 0.05	164	-160	< 1			
HDD-026 306-316	< 0.005	34.6	< 20	< 0.05	9	-7	< 1			
HDD-043 245-255	0.080	30.4	60	< 0.05	61	-61	< 1			
HDD-205 134-141	0.105	26.1	30	< 0.05	9	-9	< 1			
HDD-256 65-75	0.065	23.7	30	< 0.05	131	-131	< 1			
HDD-220 32-41	0.020	33.5	< 20	< 0.05	9	-9	< 1			
HDD-213 138-148	0.190	26.1	180	< 0.05	37	13	< 1			
HDD-206 38-48	0.045	26.8	50	< 0.05	5	< 1	< 1			
HDD-272 175-185	0.130	15.7	45	< 0.05	66	-65	< 1			
HDD-016 397-407	0.090	24.3	45	< 0.05	51	-51	< 1			
HDD-256 56-65	< 0.005	21.8	< 20	< 0.05	155	-154	< 1			
HDD-260 38-44	0.095	17.0	50	< 0.05	117	-116	< 1			
HDD-224 176-186	0.100	28.2	85	< 0.05	19	-18	< 1			
HDD-206 61.6-64.5	0.105	23.8	75	< 0.05	19	-19	< 1			
HDD-225 24-33	0.140	18.8	45	< 0.05	164	-164	< 1			
HDD-260 28-35	0.105	22.6	30	< 0.05	154	-153	< 1			
HDD-262 68-78	0.070	23.6	95	< 0.05	38	-37	< 1			
HDD-217 119-127	0.265	27.7	50	< 0.05	14	-14	< 1			
HDD-214 101-111	0.005	28.2	40	< 0.05	5	-4	< 1			
HDD-058 100-110	0.005	34.4	< 20	< 0.05	37	-37	< 1			
HDD-026 485-495	< 0.005	35.5	< 20	< 0.05	23	-22	< 1			
HDD-074 154-164	0.025	16.3	65	< 0.05	5	-5	< 1			
UNITS	%	%	ppm	ppm	Kg	H2S	Kg	H2S	Kg	H2S
DET.LIM	0.005	0.005	20	0.05	1	1A	1	1	1	1
SCHEME	IC4	IC4	IC4	AA6	SIE5	SIE5	SIE5	1		

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SAMPLE	P	Si	V	Hg	ANC	NAPP	NAG
HDD-069 313-323	0.030	32.8	20	< 0.05	112	-112	< 1
HDD-033 269-275	0.065	22.7	80	< 0.05	94	-93	< 1
HDD-352 200.9-204.4	0.055	23.1	30	< 0.05	201	-200	< 1
HDD-270 32-42	0.100	23.6	160	< 0.05	38	-37	< 1
HDD-224 130-140	0.040	21.4	115	< 0.05	< 1	< 1	< 1
HDD-225 14.8-17.7	0.045	25.2	150	< 0.05	19	-19	3
HDD-023 191-196	0.075	24.8	140	< 0.05	215	-215	< 1

UNITS	%	%	ppm	ppm	Kg	H2S	Kg	H2S	Kg	H2S
DET.LIM	0.005	0.005	20	0.05	1	1A	1	1	1	1
SCHEME	IC4	IC4	IC4	AA6	SIE5	SIE5	SIE5_1			

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SAMPLE	Sr	Ta	Ti	U	Y	Zr	EC
HDD-101 540-550	15	2	< 3	12.5	38	0.07%	310
HDD-280 213-226	45	7	< 3	26.5	60	275	249
HDD-103 105-110	20	< 2	< 3	11.0	55	0.07%	306
HDD-206 88-95	20	< 2	< 3	55	47	0.07%	426
HDD-215 107-117	20	< 2	< 3	18.5	38	0.09%	324
HDD-206 64.5-70	25	< 2	< 3	20.5	60	0.10%	321
HDD-103 100-105	20	< 2	< 3	19.0	70	0.06%	310
HDD-078 14-24	25	2	< 3	26.5	105	0.11%	2050
HDD-207 114-124	20	3	< 3	22.5	65	0.11%	1239
HDD-016 458-467	55	< 2	< 3	4.0	28	100	304
HDD-107 502-517	40	< 2	< 3	11.5	33	95	229
HDD-215 34-44	15	2	< 3	22.0	65	195	153
HDD-095 150-160	30	< 2	< 3	8.0	28	235	263
HDD-095 128-132	30	< 2	< 3	10.0	30	140	308
HDD-098 31-40	25	< 2	< 3	14.0	65	205	1551
HDD-098 55.2-62	50	< 2	< 3	9.5	34	130	327
HDD-101 270-290	50	< 2	< 3	2.5	16	45	211
HDD-023 31-35	85	< 2	< 3	4.0	17	65	218
HDD-207 83-95	15	< 2	< 3	31.0	48	250	2470
HDD-103 85-90	15	< 2	< 3	13.0	26	135	538
HDD-272 102-112	40	< 2	< 3	7.0	26	160	236
HDD-026 348-358	15	< 2	< 3	4.5	22	90	239
HDD-033 124-134	30	< 2	< 3	11.5	17	125	205
HDD-023 333-337	15	< 2	< 3	6.0	15	140	123
HDD-074 65-75	50	< 2	< 3	38.0	210	120	296
HDD-299 80-91	30	< 2	< 3	3.0	28	165	131
HDD-264 40-47	20	< 2	< 3	7.0	22	145	364
HDD-069 258-268	35	< 2	< 3	19.0	28	65	160
HDD-272 188-198	40	< 2	< 3	55	135	90	227
HDD-026 306-316	20	13	< 3	22.0	47	65	229
HDD-043 245-255	25	< 2	< 3	34.5	33	105	266
HDD-205 134-141	30	6	< 3	36.0	55	185	297
HDD-256 65-75	20	< 2	< 3	9.0	22	175	492
HDD-220 32-41	15	< 2	< 3	20.5	35	470	1041
HDD-213 138-148	25	< 2	< 3	60	55	95	656
HDD-206 38-48	20	< 2	< 3	29.0	40	0.06%	678
HDD-272 175-185	15	< 2	< 3	75	45	65	370
HDD-016 397-407	120	< 2	< 3	25.5	27	135	288
HDD-256 56-65	15	< 2	< 3	5.0	11	145	534
HDD-260 38-44	15	< 2	< 3	11.5	30	90	585
HDD-224 176-186	45	< 2	< 3	16.0	29	170	340
HDD-206 61.6-64.5	55	< 2	< 3	25.5	60	145	192
HDD-225 24-33	25	< 2	< 3	20.0	39	130	913
HDD-260 28-35	40	< 2	< 3	7.5	31	80	579
HDD-262 68-78	15	9	< 3	18.5	49	100	267
HDD-217 119-127	40	< 2	< 3	30.0	39	155	737
HDD-214 101-111	65	< 2	< 3	47.0	30	250	1152
HDD-058 100-110	20	9	< 3	12.0	18	55	210
HDD-026 485-495	10	10	< 3	7.0	17	20	231
HDD-074 154-164	5	< 2	< 3	17.0	9	30	188
UNITS	ppm	ppm	ppm	ppm	ppm	ppm	us/cm
DET.LIM	5	2	3	0.5	1	15	1
SCHEME	IC4M	IC4M	IC4M	IC4M	IC4M	IC4M	SIE4

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SAMPLE	Sr	Ta	Tl	U	Y	Zr	EC
HDD-069 313-323	20	< 2	< 3	10.0	14	60	314
HDD-033 269-275	85	< 2	< 3	7.5	31	150	226
HDD-352 200.9-204.4	20	< 2	< 3	13.0	55	105	254
HDD-270 32-42	10	< 2	< 3	7.0	23	130	354
HDD-224 130-140	20	< 2	< 3	55	21	95	946
HDD-225 14.8-17.7	50	< 2	< 3	9.0	36	155	258
HDD-023 191-196	15	< 2	< 3	5.5	30	110	270

UNITS	ppm	ppm	ppm	ppm	ppm	ppm	us/cm
DET.LIM	5	2	3	0.5	1	15	1
SCHEME	IC4M	IC4M	IC4M	IC4M	IC4M	IC4M	SIE4

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SAMPLE	S	C	SO4	S=	TDS	Ti	V
HDD-101 540-550	0.02	0.56	N.A.	N.A.	150	< 0.2	< 0.2
HDD-280 213-226	0.45	0.41	0.20	0.40	125	< 0.2	< 0.2
HDD-103 105-110	< 0.01	< 0.02	N.A.	N.A.	155	< 0.2	< 0.2
HDD-206 88-95	0.02	0.02	N.A.	N.A.	215	< 0.2	< 0.2
HDD-215 107-117	0.02	< 0.02	N.A.	N.A.	160	< 0.2	< 0.2
HDD-206 64.5-70	0.06	0.30	N.A.	N.A.	160	< 0.2	< 0.2
HDD-103 100-105	0.02	0.04	N.A.	N.A.	155	< 0.2	< 0.2
HDD-078 14-24	0.05	0.02	N.A.	N.A.	1030	< 0.2	< 0.2
HDD-207 114-124	0.03	0.06	N.A.	N.A.	620	< 0.2	< 0.2
HDD-016 458-467	0.03	0.27	N.A.	N.A.	150	< 0.2	< 0.2
HDD-107 502-517	0.07	0.30	N.A.	N.A.	115	< 0.2	< 0.2
HDD-215 34-44	0.02	< 0.02	N.A.	N.A.	75	< 0.2	< 0.2
HDD-095 150-160	0.02	< 0.02	N.A.	N.A.	130	< 0.2	< 0.2
HDD-095 128-132	0.02	< 0.02	N.A.	N.A.	155	0.4	0.2
HDD-098 31-40	0.05	0.02	N.A.	N.A.	775	< 0.2	< 0.2
HDD-098 55.2-62	0.04	0.03	N.A.	N.A.	165	0.6	0.4
HDD-101 270-290	< 0.01	7.4	N.A.	N.A.	105	< 0.2	< 0.2
HDD-023 31-35	< 0.01	4.7	N.A.	N.A.	110	< 0.2	< 0.2
HDD-207 83-95	0.09	0.05	0.25	< 0.05	1240	< 0.2	< 0.2
HDD-103 85-90	0.03	2.0	N.A.	N.A.	270	< 0.2	0.2
HDD-272 102-112	0.02	0.16	N.A.	N.A.	115	< 0.2	< 0.2
HDD-026 348-358	0.13	0.22	0.15	0.05	120	< 0.2	< 0.2
HDD-033 124-134	0.18	0.12	0.35	0.05	105	< 0.2	< 0.2
HDD-023 333-337	0.12	0.17	0.35	< 0.05	60	< 0.2	< 0.2
HDD-074 65-75	0.03	0.04	N.A.	N.A.	150	< 0.2	< 0.2
HDD-299 80-91	0.02	< 0.02	N.A.	N.A.	65	< 0.2	0.4
HDD-264 40-47	0.02	< 0.02	N.A.	N.A.	185	< 0.2	0.2
HDD-069 258-268	< 0.01	3.2	N.A.	N.A.	80	< 0.2	< 0.2
HDD-272 188-198	0.01	1.6	N.A.	N.A.	115	< 0.2	0.4
HDD-026 306-316	0.07	0.04	N.A.	N.A.	115	< 0.2	0.4
HDD-043 245-255	0.12	0.70	0.20	0.05	135	< 0.2	0.2
HDD-205 134-141	0.06	< 0.02	N.A.	N.A.	150	< 0.2	0.4
HDD-256 65-75	< 0.01	1.2	N.A.	N.A.	245	< 0.2	0.4
HDD-220 32-41	0.03	< 0.02	N.A.	N.A.	525	< 0.2	0.2
HDD-213 138-148	0.04	0.04	N.A.	N.A.	330	< 0.2	0.6
HDD-206 38-48	0.02	0.02	N.A.	N.A.	340	< 0.2	0.4
HDD-272 175-185	1.66	0.59	0.35	1.55	185	< 0.2	0.4
HDD-016 397-407	0.14	0.38	0.40	< 0.05	145	< 0.2	0.4
HDD-256 56-65	0.01	1.3	N.A.	N.A.	270	< 0.2	0.4
HDD-260 38-44	< 0.01	0.99	N.A.	N.A.	295	< 0.2	0.4
HDD-224 176-186	0.03	< 0.02	N.A.	N.A.	170	< 0.2	0.4
HDD-206 61.6-64.5	0.02	< 0.02	N.A.	N.A.	95	< 0.2	0.4
HDD-225 24-33	< 0.01	1.2	N.A.	N.A.	460	< 0.2	0.4
HDD-260 28-35	< 0.01	1.5	N.A.	N.A.	290	< 0.2	0.4
HDD-262 68-78	< 0.01	0.04	N.A.	N.A.	265	< 0.2	0.4
HDD-217 119-127	0.03	0.15	N.A.	N.A.	370	< 0.2	0.4
HDD-214 101-111	0.03	< 0.02	N.A.	N.A.	580	< 0.2	0.4
HDD-058 100-110	< 0.01	0.63	N.A.	N.A.	105	< 0.2	0.4
HDD-026 485-495	0.02	0.22	N.A.	N.A.	115	< 0.2	0.4
HDD-074 154-164	< 0.01	< 0.02	N.A.	N.A.	95	< 0.2	0.4
UNITS	%	%	%	%	ppm	mg/L	mg/L
DET.LIM	0.01	0.02	0.05	0.05	1	0.2	0.2
SCHEME	MET6A	MET6A	GRAV2	GRAV2	SIE6	IND7E	IND7E

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SAMPLE	S	C	SO4	S=	TDS	Ti	V
HDD-069 313-323	0.06	1.2	N.A.	N.A.	160	< 0.2	0.2
HDD-033 269-275	0.37	1.1	0.20	0.30	115	< 0.2	0.4
HDD-352 200.9-204.4	< 0.01	2.3	N.A.	N.A.	130	< 0.2	0.2
HDD-270 32-42	0.03	0.02	N.A.	N.A.	180	< 0.2	0.2
HDD-224 130-140	0.04	0.03	N.A.	N.A.	475	< 0.2	0.2
HDD-225 14.8-17.7	0.01	< 0.02	N.A.	N.A.	130	< 0.2	0.2
HDD-023 191-196	0.01	2.7	N.A.	N.A.	135	< 0.2	0.2

UNITS	%	%	%	%	ppm	mg/L	mg/L
DET.LIM	0.01	0.02	0.05	0.05	1	0.2	0.2
SCHEME	MET6A	MET6A	GRAV2	GRAV2	SIE6	IND7E	IND7E

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SAMPLE	Cr	Cr3	Cr6	Zr
HDD-101 540-550	< 0.1	< 0.1	< 0.1	< 0.1
HDD-280 213-226	< 0.1	< 0.1	< 0.1	< 0.1
HDD-103 105-110	< 0.1	< 0.1	< 0.1	< 0.1
HDD-206 88-95	< 0.1	< 0.1	< 0.1	< 0.1
HDD-215 107-117	< 0.1	< 0.1	< 0.1	< 0.1
HDD-206 64.5-70	< 0.1	< 0.1	< 0.1	< 0.1
HDD-103 100-105	< 0.1	< 0.1	< 0.1	< 0.1
HDD-078 14-24	< 0.1	< 0.1	< 0.1	< 0.1
HDD-207 114-124	< 0.1	< 0.1	< 0.1	< 0.1
HDD-016 458-467	< 0.1	< 0.1	< 0.1	< 0.1
HDD-107 502-517	< 0.1	< 0.1	< 0.1	< 0.1
HDD-215 34-44	< 0.1	< 0.1	< 0.1	< 0.1
HDD-095 150-160	< 0.1	< 0.1	< 0.1	< 0.1
HDD-095 128-132	0.1	< 0.1	0.1	< 0.1
HDD-098 31-40	< 0.1	< 0.1	< 0.1	< 0.1
HDD-098 55.2-62	0.2	< 0.1	0.2	< 0.1
HDD-101 270-290	< 0.1	< 0.1	< 0.1	< 0.1
HDD-023 31-35	< 0.1	< 0.1	< 0.1	< 0.1
HDD-207 83-95	< 0.1	< 0.1	< 0.1	< 0.1
HDD-103 85-90	< 0.1	< 0.1	< 0.1	< 0.1
HDD-272 102-112	< 0.1	< 0.1	< 0.1	< 0.1
HDD-026 348-358	< 0.1	< 0.1	< 0.1	< 0.1
HDD-033 124-134	< 0.1	< 0.1	< 0.1	< 0.1
HDD-023 333-337	< 0.1	< 0.1	< 0.1	< 0.1
HDD-074 65-75	< 0.1	< 0.1	< 0.1	< 0.1
HDD-299 80-91	< 0.1	< 0.1	< 0.1	< 0.1
HDD-264 40-47	< 0.1	< 0.1	< 0.1	< 0.1
HDD-069 258-268	< 0.1	< 0.1	< 0.1	< 0.1
HDD-272 188-198	< 0.1	< 0.1	< 0.1	< 0.1
HDD-026 306-316	< 0.1	< 0.1	< 0.1	< 0.1
HDD-043 245-255	< 0.1	< 0.1	< 0.1	< 0.1
HDD-205 134-141	< 0.1	< 0.1	< 0.1	< 0.1
HDD-256 65-75	< 0.1	< 0.1	< 0.1	< 0.1
HDD-220 32-41	< 0.1	< 0.1	< 0.1	< 0.1
HDD-213 138-148	0.1	< 0.1	0.1	< 0.1
HDD-206 38-48	< 0.1	< 0.1	< 0.1	< 0.1
HDD-272 175-185	< 0.1	< 0.1	< 0.1	< 0.1
HDD-016 397-407	< 0.1	< 0.1	< 0.1	< 0.1
HDD-256 56-65	< 0.1	< 0.1	< 0.1	< 0.1
HDD-260 38-44	< 0.1	< 0.1	< 0.1	< 0.1
HDD-224 176-186	< 0.1	< 0.1	< 0.1	< 0.1
HDD-206 61.6-64.5	< 0.1	< 0.1	< 0.1	< 0.1
HDD-225 24-33	< 0.1	< 0.1	< 0.1	< 0.1
HDD-260 28-35	< 0.1	< 0.1	< 0.1	< 0.1
HDD-262 68-78	< 0.1	< 0.1	< 0.1	< 0.1
HDD-217 119-127	< 0.1	< 0.1	< 0.1	< 0.1
HDD-214 101-111	< 0.1	< 0.1	< 0.1	< 0.1
HDD-058 100-110	< 0.1	< 0.1	< 0.1	< 0.1
HDD-026 485-495	< 0.1	< 0.1	< 0.1	< 0.1
HDD-074 154-164	< 0.1	< 0.1	< 0.1	< 0.1
UNITS	mg/L	mg/L	mg/L	mg/L
DET.LIM	0.1	0.1	0.1	0.1
SCHEME	IND7A	IND7A	IND7A	IND7M

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SAMPLE	Cr	Cr3	Cr6	Zr
HDD-069 313-323	< 0.1	< 0.1	< 0.1	< 0.1
HDD-033 269-275	< 0.1	< 0.1	< 0.1	< 0.1
HDD-352 200.9-204.4	< 0.1	< 0.1	< 0.1	< 0.1
HDD-270 32-42	< 0.1	< 0.1	< 0.1	< 0.1
HDD-224 130-140	< 0.1	< 0.1	< 0.1	< 0.1
HDD-225 14.8-17.7	0.1	< 0.1	0.1	< 0.1
HDD-023 191-196	< 0.1	< 0.1	< 0.1	< 0.1

UNITS	mg/L	mg/L	mg/L	mg/L
DET.LIM	0.1	0.1	0.1	0.1
SCHEME	IND7A	IND7A	IND7A	IND7M

APPENDIX 3 WHOLE ROCK MINERALOGICAL DIGEST RESULTS

The table below details the results of the whole rock mineralogical digest results.

|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|

[illegible]

Transitional Skarn	46	41	38	48	35	49	37	55	23	20	26	15	23	16	41	50	41	50	41	53	46	44	36	44	41	48	44	50
Transitional Skarn	14	24	3	9	14	6	15	19	13	17	2	9	5	3	13	8	12	20	26	18	12	19	13	7	23	29	16	14
Transitional Skarn	6	9	3	4	6	2	23	11	12	0	3	3	3	3	1	3	3	20	14	18	1	3	5	3	3		6	14
Transitional Skarn				3	5																							
Transitional Red Rock (Altered)					4		4	4										5										
Transitional Pegmatite (Supergene)																												
Transitional Meta-Sediment (Banded/Non-Mineralised)																												
Transitional Meta-Sediment (Banded/Non-Mineralised)																												
Transitional Impure Carbonate																												
Transitional Granite																												
Transitional Granite																												
Transitional Granite																												
Transitional Granite																												
Transitional Granite																												
Transitional Gabbro																												
Transitional Gabbro																												
Transitional Breccia																												
Transitional Breccia																												
Oxide Skarn																												
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Oxide Skarn																												
Oxide Skarn																												
Oxide Skarn																												
Oxide Red Rock (Altered)																												
Oxide Red Rock (Altered)																												
Oxide Red Rock (Altered)																												
Oxide Red Rock (Altered)																												
Oxide Meta-Sediment (Banded/Non-Mineralised)																												
Amorphous	50	44	48	41	44	36	50	55	27	46	53	41	50	41	16	23	15	26	20	23	55	37	49	35	48	38	41	46
Quartz	14	16	29	23	7	9	11	13	19	12	18	26	8	12	13	22	9	2	17	13	19	10	15	14	9	3	24	14
Chlorite	14	6			3	3	4	5	3	1	18	14	20	20	3	5	3	3	0	12	11	23	2	6	4	3	9	6
Amphibole																								5	3			
Plagioclase	5	23			29			13					5	21	48	35	48	46	38	8	4	0	4	4				
Alkali Feldspar	1	4	15	8	13	2	9		45	27	8		12	2	17	11	18	16	22	5	0	25	7	5			16	16
Magnetite																							5					
Mica	15	0			2		0					3	3	1		1	2	2		3	1		1	2		0	2	
Hematite	1	6		9	3	6	2	4	3	0	4	1	2	3	2	2	2	3	1	0	10	5	17	3	4	2	7	3
Serpentine																												
Anatase											0																	
Pyrite																												
Kaolinite			6	18	0																							
Goethite				1																								

Calcite		1					9					0			1	0	2	2	2	27	0	0		11	9	8		
Talc																							6	22	*			
Dolomite					10						15									8								
Ankerite						1									1	2						1		0	1			
Titanite																												
Smectite			2																									
Smectite 2					6	14	10	1	14														8		9			
Siderite																												
Rutile											1														1	1		
Garnet					28			2	1																36			
Epidote																											15	

APPENDIX 4 NAPP CLASSIFICATION OF SAMPLES

The table below shows the classification of each sample based on the NAPP analysis. The ratio NAC/MPA is also shown, and samples which would be classified as PAF using the ratio method are highlighted in orange.

Sample ID	Lithology and Oxidation State	ANC (kg H ₂ SO ₄ /t) ¹	MPA (kg H ₂ SO ₄ /t) ²	Ratio	NAPP (kg H ₂ SO ₄ /t)	Classification
HDD-101 540-550	Granite (Fresh)	33	0.6	53.9	-32.4	NAF
HDD-280 213-226	Granite (Fresh)	61	13.8	4.4	-47.2	NAF
HDD-103 105-110	Granite (transitional)	< 1	< 0.31	Uncertain	Uncertain	Uncertain, probably NAF based on very low sulphur content
HDD-206 88-95	Granite (transitional)	9	0.6	14.7	-8.4	NAF
HDD-215 107-117	Granite (transitional)	5	0.6	8.2	-4.4	NAF
HDD-206 64.5-70	Granite (transitional)	28	1.8	15.2	-26.2	NAF
HDD-103 100-105	Granite (transitional)	5	0.6	8.2	-4.4	NAF
HDD-078 14-24	Granite (Oxide)	5	1.5	3.3	-3.5	NAF
HDD-207 114-124	Granite (Oxide)	5	0.9	5.4	-4.1	NAF
HDD-016 458-467	Gabbro (Fresh)	37	0.9	40.3	-36.1	NAF
HDD-107 502-517	Gabbro (Fresh)	42	2.1	19.6	-39.9	NAF
HDD-215 34-44	Gabbro (Transitional-oxide)	14	0.6	22.9	-13.4	NAF
HDD-095 150-160	Gabbro (Transitional)	33	0.6	53.9	-32.4	NAF

¹ Detection limit 1.0 kg.H₂SO₄

² Detection limit 0.31 kg.H₂SO₄

HDD-095 128-132	Gabbro (Oxide)	23	0.6	37.6	-22.4	NAF
HDD-098 31-40	Gabbro (Oxide)	5	1.5	3.3	-3.5	NAF
HDD-098 55.2-62	Gabbro (Oxide)	33	1.2	26.9	-31.8	NAF
HDD-101 270-290	Impure Carbonate (Fresh)	584	< 0.31	> 1883.9	< -583.69	ACM
HDD-023 31-35	Impure Carbonate (Transitional)	365	< 0.31	> 1177.4	< -364.69	ACM
HDD-207 83-95	Impure Carbonate (Oxide)	5	2.8	1.8	-2.2	NAF
HDD-103 85-90	Impure Carbonate (Oxide)	108	0.9	117.6	-107.1	ACM
HDD-272 102-112	Meta-sediment banded/non mineralised (Fresh)	19	0.6	31.0	-18.4	NAF
HDD-026 348-358	Strongly chloritic meta-sediment	47	4.0	11.8	-43.0	NAF
HDD-033 124-134	Meta-sediment banded/non mineralised (Fresh)	47	5.5	8.5	-41.5	NAF
HDD-023 333-337	Banded meta-sed fresh	14	3.7	3.8	-10.3	NAF
HDD-074 65-75	Meta-sediment banded/non mineralised (Transitional)	9	0.9	9.8	-8.1	NAF
HDD-299 80-91	Meta-sediment banded/non mineralised (Oxide)	5	0.6	8.2	-4.4	NAF
HDD-264 40-47	Meta-sediment banded/non mineralised (Transitional)	37	0.6	60.4	-36.4	NAF
HDD-069 258-268	Red Rock (RR) Altered (Fresh)	103	< 0.31	> 332.3	< -102.69	ACM
HDD-272 188-198	Red Rock (RR) Altered (Fresh)	164	0.3	535.5	-163.7	ACM

HDD-026 306-316	Red Rock (RR) Altered (Fresh)	9	2.1	4.2	-6.9	NAF
HDD-043 245-255	Red Rock (RR) Altered (Fresh)	61	3.7	16.6	-57.3	NAF
HDD-205 134-141	Red Rock (RR) Altered (Oxide)	9	1.8	4.9	-7.2	NAF
HDD-256 65-75	Red Rock (RR) Altered (Transitional)	131	<0.31	> 422.6	< -130.69	ACM
HDD-220 32-41	Red Rock (RR) Altered (Oxide)	9	0.9	9.8	-8.1	NAF
HDD-213 138-148	Red Rock (RR) Altered (Oxide)	37	1.2	30.2	-35.8	NAF
HDD-206 38-48	Red Rock (RR) Altered (Oxide)	5	0.6	8.2	-4.4	NAF
HDD-272 175-185	Skarn pyritic (Fresh) Low Grade Ore	66	50.8	1.3	-15.2	NAF
HDD-016 397-407	Skarn (Fresh)	51	4.3	11.9	-46.7	NAF
HDD-256 56-65	Skarn (Transitional)	155	0.3	506.1	-154.7	ACM
HDD-260 38-44	Skarn (Transitional)	117	<0.31	> 377.4	< -116.69	ACM
HDD-224 176-186	Skarn (Transitional)	19	0.9	20.7	-18.1	NAF
HDD-206 61.6-64.5	Skarn (Transitional)	19	0.6	31.0	-18.4	NAF
HDD-225 24-33	Skarn (Oxide)	164	<0.31	> 529.0	< -163.69	ACM
HDD-260 28-35	Skarn (Oxide)	154	<0.31	> 496.8	< -153.69	ACM
HDD-262 68-78	Skarn (Oxide)	38	<0.31	> 122.9	< -37.69	NAF
HDD-217 119-127	Skarn (Oxide)	14	0.9	15.2	-13.1	NAF
HDD-214 101-111	Skarn (Oxide)	5	0.9	5.4	-4.1	NAF
HDD-058	Pegmatite (fresh)	37	<0.31	> 119.4	< -36.69	NAF

100-110						
HDD-026 485-495	Pegmatite (fresh)	23	0.6	37.6	-22.4	NAF
HDD-074 154-164	Pegmatite (Transitional) Native Copper supergene	5	<0.31	> 16.1	< -4.69	NAF
HDD-069 313-323	Breccia - Pyritic (fresh)	112	1.8	61.0	-110.2	ACM
HDD-033 269-275	Breccia - mineralised (fresh)	94	11.3	8.3	-82.7	NAF
HDD-352 200.9- 204.4	Breccia - Sulphide absent	201	<0.31	> 648.4	< -200.69	ACM
HDD-270 32-42	Breccia (Transitional)	38	0.9	41.4	-37.1	NAF
HDD-224 130-140	Breccia (Oxidised)	<1	1.2	Uncertain	0.2 - 1.2	Uncertain, probably NAF based on very low sulphur content
HDD-225 14.8-17.7	Breccia (Oxidised)	19	0.3	62.0	-18.7	NAF
HDD-023 191-196	Breccia Transitional to fresh	215	0.3	702.0	-214.7	ACM

APPENDIX 5 LEACHATE TEST RESULTS

The table below details the results of the leachate testwork.

Sample ID	Analyte Concentration (mg/L)																										
	TDS	Al	As	Ba	Be	Cd	Co	Cr	Cr3	Cr6	Fe	K	Mg	Mn	Ni	P	Pb	Sn	Sr	Te	Th	Ti	U	V	Y	Zn	Zr
HDD-101 540-550	150	<0.5	0.1	0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1	<0.5	7	0.4	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.05	<0.1	<0.1
HDD-280 213-226	125	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1	4.5	2.6	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.05	<0.1	<0.1
HDD-103 105-110	155	2.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.5	6.5	0.8	<0.1	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.05	<0.1	<0.1
HDD-206 88-95	215	2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	3	6.5	1.2	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.05	<0.1	<0.1
HDD-215 107-117	160	2.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.5	8	1	0.1	<0.1	0.6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.05	<0.1	<0.1
HDD-206 64.5-70	160	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.5	5.5	0.6	<0.1	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.05	<0.1	<0.1
HDD-103 100-105	155	2.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.5	7	1.6	<0.1	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.05	<0.1	<0.1
HDD-078 14-	1030	<0.5	<0.1									6	6	0.2		0.4											

24				<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5				<0.1		<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.05	<0.1	<0.1
HDD-207 114-124	620	<0.5	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	4.5	2.4	0.4	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.05	<0.1	<0.1
HDD-016 458-467	150	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2	5.5	2.2	<0.1	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.05	<0.1	<0.1
HDD-107 502-517	115	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1	3.5	1.4	<0.1	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.05	<0.1	<0.1
HDD-215 34-44	75	10	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	8.5	2.5	6	<0.1	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.05	<0.1	<0.1
HDD-095 150-160	130	5.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	7.5	1.5	7	0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.05	<0.1	<0.1
HDD-095 128-132	155	24.5	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	0.1	20.5	6	27.5	0.6	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	0.4	<0.1	0.2	<0.05	<0.1	<0.1
HDD-098 31-40	775	<0.5	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	3.5	<0.2	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.05	<0.1	<0.1
HDD-098 55.2-62	165	96.5	<0.1	<0.1	<0.1	<0.1	<0.1	0.2	<0.1	0.2	118	10	140	2.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	0.6	<0.1	0.4	<0.05	0.3	<0.1
HDD-101 270-290	105	<0.5	<0.1	0.6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	2	0.2	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.05	<0.1	<0.1
HDD-	110		<0.1									8.5	1.8														

023 31-35		<0.5		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5			<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.05	<0.1	<0.1
HDD-207 83-95	1240	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	4.5	4.8	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.05	<0.1	<0.1
HDD-103 85-90	270	8.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	15	4	16	2.3	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.2	<0.05	<0.1	<0.1
HDD-272 102-112	115	1.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.5	9	1.2	<0.1	<0.1	0.6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.05	<0.1	<0.1
HDD-026 348-358	120	3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	5	2.5	6	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.05	<0.1	<0.1
HDD-033 124-134	105	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.5	12	2.8	<0.1	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.05	<0.1	<0.1
HDD-023 333-337	60	0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	3	0.8	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.05	<0.1	<0.1
HDD-074 65-75	150	6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	6.5	1.5	3.2	<0.1	<0.1	0.6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	0.1	0.1	<0.1
HDD-299 80-91	65	3.5	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2	4.5	1.6	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.4	<0.05	<0.1	<0.1
HDD-264 40-47	185	12	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	20	1	15.5	0.3	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.2	<0.05	<0.1	<0.1

HDD-069 258-268	80	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	4.5	1	<0.1	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.05	<0.1	<0.1
HDD-272 188-198	115	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	3	3.2	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.4	<0.05	<0.1	<0.1
HDD-026 306-316	115	0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	11	1	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.4	<0.05	<0.1	<0.1
HDD-043 245-255	135	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	9	1.2	<0.1	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.2	<0.05	<0.1	<0.1
HDD-205 134-141	150	11	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	14	2.5	12.5	0.2	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.4	<0.05	<0.1	<0.1
HDD-256 65-75	245	11	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	14	4	28.5	0.4	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.4	<0.05	<0.1	<0.1
HDD-220 32-41	525	4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	2.5	2	1.8	0.2	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.2	<0.05	<0.1	<0.1
HDD-213 138-148	330	6	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	0.1	6	2.5	3	0.2	<0.1	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.6	<0.05	<0.1	<0.1
HDD-069 258-268	340	11.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	8	3.5	8.5	0.9	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.4	<0.05	<0.1	<0.1
HDD-272 188-	185	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.5	0.5	6	<0.1	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.4	<0.05	<0.1	<0.1

198																											
HDD-206 38-48	145	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	0.5	1.4	<0.1	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.4	<0.05	<0.1	<0.1
HDD-272 175-185	270	11	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	16.5	<0.5	32.5	0.4	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.4	<0.05	<0.1	<0.1
HDD-016 397-407	295	10.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	8	1	26	0.3	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.4	<0.05	<0.1	<0.1
HDD-256 56-65	170	6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	5	2	5.5	0.1	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.4	<0.05	<0.1	<0.1
HDD-260 38-44	95	4.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	4.5	1.5	4	0.1	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.4	<0.05	<0.1	<0.1
HDD-224 176-186	460	16.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	18	1.5	37	1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.4	<0.05	0.1	<0.1
HDD-206 61.6-64.5	290	5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	4	2.5	10	0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.4	<0.05	<0.1	<0.1
HDD-225 24-33	265	13	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	17	4	13.5	0.2	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.4	<0.05	<0.1	<0.1
HDD-260 28-35	370	7.5	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	4.5	4.5	6	0.9	<0.1	0.6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.4	<0.05	0.2	<0.1

HDD-262 68-78	580	7	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	5.5	1.5	4.2	1.3	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.4	<0.05	0.2	<0.1
HDD-217 119-127	105	<0.5	<0.1	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	1	0.2	<0.1	<0.1	0.6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.4	<0.05	<0.1	<0.1
HDD-214 101-111	115	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	6.5	2	<0.1	<0.1	0.6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.4	<0.05	<0.1	<0.1
HDD-058 100-110	95	4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	6	7	3.6	0.1	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.4	<0.05	<0.1	<0.1
HDD-026 485-495	160	<0.5	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	3.5	1.4	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.2	<0.05	<0.1	<0.1
HDD-074 154-164	115	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1	5.5	3.2	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.4	<0.05	<0.1	<0.1
HDD-069 313-323	130	1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.5	1	3	<0.1	<0.1	0.4	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.2	<0.05	<0.1	<0.1
HDD-033 269-275	180	7	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	10.5	<0.5	6.5	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.2	<0.05	<0.1	<0.1
HDD-352 200.9-204.4	475	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	1.5	2.8	0.1	<0.1	0.6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.2	<0.05	<0.1	<0.1
HDD-270 32-	130	13.5	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	<0.1	0.1	13.5	2	14	0.3		0.4									0.2			

42															<0.1		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1		<0.05	<0.1	<0.1
HDD-224 130-140	135	<0.5	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	14.5	3.6	<0.1	<0.1	0.6	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	0.2	<0.05	<0.1	<0.1
HDD-225 14.8-17.7	150	<0.5	<0.1	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.5	7	0.4	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.05	<0.1	<0.1
HDD-023 191-196	125	<0.5	0.1	0.1	0.1	0.1	0.1	<0.1	<0.1	<0.1	1	4.5	2.6	<0.1	<0.1	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.2	<0.1	<0.2	<0.05	<0.1	<0.1

APPENDIX 6 URANIUM CONCENTRATIONS IN WASTE ROCK SAMPLES

The table below shows the proportion of Uranium detected in the ICPMS test for each waste rock sample. Samples which exceeded the threshold limit (Section 6.7) are highlighted.

Sample ID	Lithology and Oxidation State	Uranium Concentration (ppm)
HDD-101 540-550	Granite (Fresh)	12.5
HDD-280 213-226	Granite (Fresh)	26.5
HDD-103 105-110	Granite (transitional)	11
HDD-206 88-95	Granite (transitional)	55
HDD-215 107-117	Granite (transitional)	18.5
HDD-206 64.5-70	Granite (transitional)	20.5
HDD-103 100-105	Granite (transitional)	19
HDD-078 14-24	Granite (Oxide)	26.5
HDD-207 114-124	Granite (Oxide)	22.5
HDD-016 458-467	Gabbro (Fresh)	4
HDD-107 502-517	Gabbro (Fresh)	11.5
HDD-215 34-44	Gabbro (Transitional-oxide)	22
HDD-095 150-160	Gabbro (Transitional)	8
HDD-095 128-132	Gabbro (Oxide)	10
HDD-098 31-40	Gabbro (Oxide)	14
HDD-098 55.2-62	Gabbro (Oxide)	9.5
HDD-101 270-290	Impure Carbonate (Fresh)	2.5
HDD-023 31-35	Impure Carbonate	4

	(Transitional)	
HDD-207 83-95	Impure Carbonate (Oxide)	31
HDD-103 85-90	Impure Carbonate (Oxide)	13
HDD-272 102-112	Meta-sediment banded/non mineralised (Fresh)	7
HDD-026 348-358	Strongly chloritic meta-sediment	4.5
HDD-033 124-134	Meta-sediment banded/non mineralised (Fresh)	11.5
HDD-023 333-337	Banded meta-sed fresh	6
HDD-074 65-75	Meta-sediment banded/non mineralised (Transitional)	38
HDD-299 80-91	Meta-sediment banded/non mineralised (Oxide)	3
HDD-264 40-47	Meta-sediment banded/non mineralised (Transitional)	7
HDD-069 258-268	Red Rock (RR) Altered (Fresh)	19
HDD-272 188-198	Red Rock (RR) Altered (Fresh)	55
HDD-026 306-316	Red Rock (RR) Altered (Fresh)	22
HDD-043 245-255	Red Rock (RR) Altered (Fresh)	34.5
HDD-205 134-141	Red Rock (RR) Altered (Oxide)	36
HDD-256 65-75	Red Rock (RR) Altered (Transitional)	9

HDD-220 32-41	Red Rock (RR) Altered (Oxide)	20.5
HDD-213 138-148	Red Rock (RR) Altered (Oxide)	60
HDD-206 38-48	Red Rock (RR) Altered (Oxide)	29
HDD-272 175-185	Skarn pyritic (Fresh) Low Grade Ore	75
HDD-016 397-407	Skarn (Fresh)	25.5
HDD-256 56-65	Skarn (Transitional)	5
HDD-260 38-44	Skarn (Transitional)	11.5
HDD-224 176-186	Skarn (Transitional)	16
HDD-206 61.6-64.5	Skarn (Transitional)	25.5
HDD-225 24-33	Skarn (Oxide)	20
HDD-260 28-35	Skarn (Oxide)	7.5
HDD-262 68-78	Skarn (Oxide)	18.5
HDD-217 119-127	Skarn (Oxide)	30
HDD-214 101-111	Skarn (Oxide)	47
HDD-058 100-110	Pegmatite (fresh)	12
HDD-026 485-495	Pegmatite (fresh)	7
HDD-074 154-164	Pegmatite (Transitional) Native Copper supergene	17
HDD-069 313-323	Breccia - Pyritic (fresh)	10
HDD-033 269-275	Breccia - mineralised (fresh)	7.5
HDD-352 200.9-204.4	Breccia - Sulphide absent	13

HDD-270 32-42	Breccia (Transitional)	7
HDD-224 130-140	Breccia (Oxidised)	55
HDD-225 14.8-17.7	Breccia (Oxidised)	9
HDD-023 191-196	Breccia Transitional to fresh	5.5

APPENDIX 7 REFERENCES


1. Gregory, Courtney *Curtin University* and Reid, A
Targeted, in situ U–Pb geochronology of accessory minerals associated with IOCG deposits: Hillside Project, Yorke Peninsula. Abstract of talk presented 4 August 2010
2. Lowe, Geoff, Rex Minerals Ltd, The Hillside Cu – Au Project Yorke Peninsula, November 2009,
3. Miller, S., Fines, P., Tran, AB., Williams, DJ. and Wilson, GW.,
Geochemical and Mineralogical Characterisation of Two Contrasting Waste Rock Dumps — The INAP Waste Rock Dump Characterisation Project.
4. Global Acid Rock Drainage (GARD) Guide, www.gardguide.com
5. Rex Minerals Ltd Corporate Booklet, February 2011.
6. Rex Minerals Hillside Project Scoping Study, July 2011



PRE-FEASIBILITY HYDROLOGY REPORT



Document Control Information

	PRE-FEASIBILITY HYDROLOGY REPORT	REVISION	
		No.	DATE
		0	14 06 2013

Revision Tracking

Revision:	Prepared By:	Reviewed By:	Issued For:	Approved By:	Date:	Signature:
A	K.Longmore	S.Robinson	RC		08.04.13	
B	K.Longmore	S.Robinson	RC		30.04.13	
C	K.Longmore	S.Robinson	RC		08.05.13	
D	K.Longmore	S.Robinson	RC		27.05.13	
0	K.Longmore		FV		14.06.13	

Issued for: Review and Comment (RC), Information Only (IO), Implementation (IM), Final Version (FV).

EXECUTIVE SUMMARY

This report is a high level hydrological study investigating potential impacts of flooding on proposed operations at the Hillside project. Its intent is to provide runoff and flood extent estimations and initial advice regarding the need for drainage control infrastructure.

The scope of this high level hydrological study is to:

- Describe the catchments that contribute runoff to the proposed Hillside mining area, and comment on the likelihood of flooding.
- Estimate the peak flow rate at key locations in the catchments likely to result from the design 100 year average recurrence interval (ARI) storm
- Map the estimated extents of the floodplain resulting from the design 100 year ARI storm within the project area for the undeveloped site.
- Comment on the likely interactions of extreme storm events within the project area, and provide initial advice on the need for drainage control infrastructure.

In a year of average rainfall, impacts arising from the interaction of surface water and mine infrastructure are expected to be minimal. However, modelling and analysis indicate that the Hillside project will alter the natural drainage regime, and the impacts arising from these changes may be significant under extreme storm conditions.

A number of mitigation measures are proposed to ameliorate the impacts associated with surface water during and after operations at the Hillside site. Mitigation measures include:

- Engineered drainage controls such as diversions, drains, bunds and retention ponds.
- Appropriate design of significant features (such as waste rock dumps) to manage runoff and erosion.
- Appropriate management practices during operations, such as progressive rehabilitation of disturbed areas and implementation of hydrocarbon, chemical and waste rock management plans.
- Implementation of a surface water monitoring plan that provides timely feedback on the quality and quantity of discharges

In addition to the mitigation measures described in this report, it is recommended that a risk assessment be undertaken in order to determine an appropriate ARI storm event to use as the basis of design for engineered controls. The risk assessment should consider the consequences of adverse impacts, and balance this with safety, operational, economic, social and environmental objectives. It is likely that the design ARI would vary by domain.

Design flow rates (for drains) and volumes (for retention basins) would need to be determined. The models used in this study can be configured for the selected design storms and are suitable to use for design purposes.

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I INTRODUCTION

I.1 Background

Mining Plus was commissioned by Rex Minerals (Rex) to undertake a Pre-Feasibility Mining Study (PFS) for the Hillside Project, including an assessment of the site's runoff response to extreme storm events. To this end, Mining Plus engaged Open Earth Consulting Pty Ltd (OEC) to undertake high-level hydrological investigations.

The Hillside project is located on the mid-eastern coast of the Yorke Peninsula in South Australia, approximately 10 km south of Ardrossan and 75km north-west of Adelaide across the Gulf of St Vincent. Adelaide is approximately 180km by road. The project location is shown in Figure I-1.



Figure I-1 Project location

The Hillside resource is an iron-oxide/copper/gold (IOCG) deposit associated with the regional north-north-east trending Pine Point (Ardrossan) Fault Zone, and coincident with the historical Hillside copper/gold mine.

I.2 Scope

The scope of this high level hydrological study is to:

- Describe the catchments that contribute runoff to the proposed Hillside mining area, and comment on the likelihood of flooding.

- Estimate the peak flow rate at key locations in the catchments likely to result from the design 100 year average recurrence interval (ARI) storm
- Map the estimated extents of the floodplain resulting from the design 100 year ARI storm within the project area under natural conditions.
- Comment on the likely interactions of extreme storm events within the project area, and provide initial advice on the need for drainage control infrastructure and other mitigation measures.

1.3 Report structure

This report is structured as follows:

- Section 1 provides an introduction to the project and discusses the scope of the study.
- Section 2 describes the methods, assumptions and limitations of the study.
- Section 3 provides a description of the catchments contributing runoff to the project area, as well as local climate information.
- Section 4 presents the results of hydrological modelling.
- Section 5 presents the results of the flood extent estimation.
- Section 6 describes potential surface water impacts and recommended conceptual-level mitigation measures.
- Section 7 summarises the study's conclusions and recommendations.

2 METHOD, ASSUMPTIONS AND LIMITATIONS

2.1 Introduction

This section discusses the methods and assumptions used in this study. It also discusses the limitations of the study, and provides a justification for the methods chosen.

2.2 Methods

2.2.1 Introduction

The study consisted of three (3) main stages, each supplying the inputs required for the subsequent stage:

1. Topographical and catchment analysis
2. Hydrological analysis
3. Hydraulic analysis

2.2.2 Topographical and catchment analysis

Mining Plus supplied data for catchments for the undeveloped site, and these were modified in accordance with the mine layout to produce catchments for the developed site. Catchment areas were calculated using GIS tools.

2.2.3 Hydrological analysis

Hydrological analysis of a catchment is undertaken in order to estimate the catchment's response to rainfall. The runoff and streamflow routing software RORB was used to perform the hydrological analysis of the Hillside site's catchments for each scenario.

RORB calculates rainfall losses and produces streamflow hydrographs from which the peak flow rate and total flow volumes can be derived for points of interest within a catchment.

By applying a loss model to individual rainfall events, RORB simulates a rainfall excess, which is routed through the stream network. A catchment storage model representing the effects of overland flow storage and channel storage is then applied to the rainfall excess to define the runoff hydrograph (Laurenson, Mein, & Nathan, 2010). RORB is widely used by Australian engineers and hydrologists, and is recommended for use in the industry-standard publication *Australian Rainfall and Runoff* (The Institute of Engineers Australia, 1997).

Individual storm event data for input to the model was taken from the Bureau of Meteorology's (BOM) storm intensity-frequency-duration data portal. Design storms for the 100 year ARI events were selected by determining the storm duration resulting in the peak flow.

Table 2-1 below shows the intensity-frequency-duration (IFD) chart for the project area (Bureau of Meteorology, 2012) from which design storms were derived.

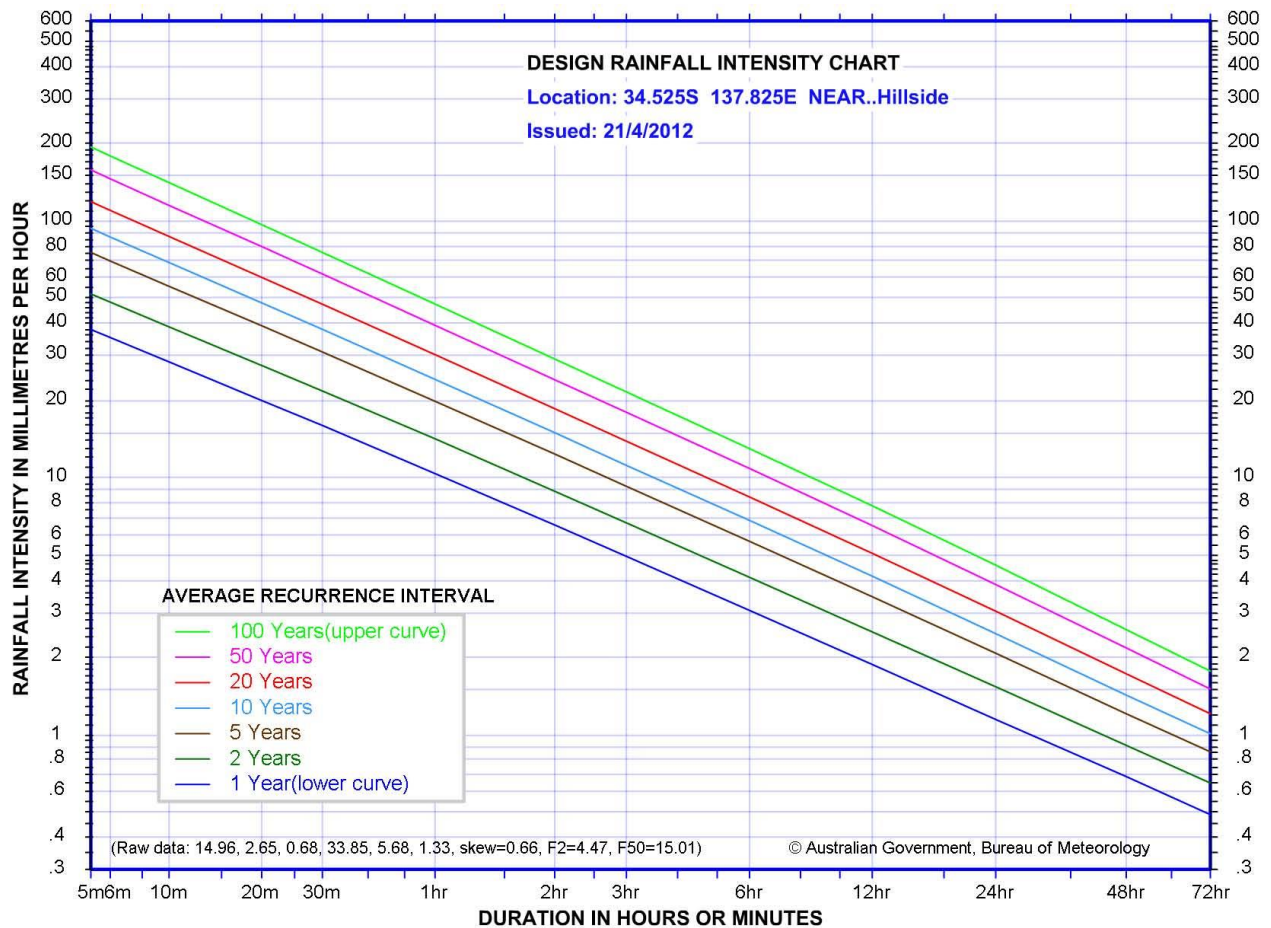


Figure 2-1 – Intensity-frequency-duration data (Source: BOM, 2012)

Due to the size of the catchments being analysed, spatial and temporal variations within individual storm events need to be considered. An areal reduction factor was applied to each rainfall event to account for spatial variation. The temporal rainfall pattern for coastal South Australia from Pilgrim & Cordery (1975) was applied to account for temporal variation.

A summary of the 100 year ARI storm events adopted for use in the model is shown in Table 2-1 below.

An impervious fraction of 0.05 was applied to the catchments consisting of undeveloped land, and 0.15 to catchments consisting of waste rock dumps.

The initial-loss/continuing-loss infiltration model was applied to the catchments. The initial loss was set to 25mm and the continuing loss was set at 4.5mm/hr. These values were derived from values for similar soil types in Cordery & Pilgrim (1975) and Hill, Mein, & Siriwardena (1998). Values for the RORB parameters k_c and m were determined using equation 3.24 in Book 5 of *Australian Rainfall and Runoff* (1987).

Table 2-1 – Design rainfall for standard storm durations, Hillside

Duration	Average Intensity (mm/hr)	Total Rainfall Depth (mm)	Areal Reduction Factor	Modified Total Rainfall Depth (mm)
30 min	75.4	37.7	0.58	21.9
1 hour	47.5	47.5	0.65	30.9
2 hour	29.0	58	0.72	41.8
6 hour	13.0	78	0.85	66.3
12 hour	7.8	93.6	0.88	82.4
24 hour	4.6	110.4	0.91	100.5

2.2.4 Flood plain analysis

The 100 year ARI flood extents were estimated using the peak flow rates obtained in the hydrological analysis. A steady flow analysis performed by the one-dimensional hydraulic modelling software HECRAS was used in the analysis. This software performs one-dimensional steady and unsteady flow calculations for a network of natural and constructed channels. The effects of various obstructions such as bridges, culverts, weirs, and structures in the flood plain may be considered in the computations. The steady flow system is designed for application in flood plain management and flood studies to evaluate floodway encroachments. Also, capabilities are available for assessing the change in water surface profiles due to channel improvements, floodplain obstructions and levees.

A Manning's roughness value of 0.03 was applied to the main channel and a value of 0.035 to the overbanks (Chow, 1959). Where channels discharged to the ocean, a downstream water surface of 0.3m was assumed. This simulates a flood during moderate tide conditions.

In certain instances where a natural channel is blocked by the placement of mining infrastructure, for example a waste rock dump, one-dimensional steady state analyses break down and would be inappropriate for modelling purposes. In these cases, the following modelling approach was used:

- Topographical analysis of the depression and obstruction created by the natural drainage and the mining infrastructure was undertaken.
- A flood hydrograph was created for the design storm, and the entire volume of the design flood routed to the location of the depression-obstruction interface.
- GIS tools were used to determine the water level, and thus the local extent of the design flood, resulting from the routing of the flood to the depression-obstruction interface.

2.3 Assumptions and Limitations

The reader should be aware of the following assumptions and limitations associated with this study:

- The following GIS data supplied by Mining Plus was used in the study:

- Contours
 - Sub-catchments for the undeveloped site
 - Drainages for the undeveloped site
 - Waste rock dumps
 - Pit
 - Plant
 - Roads
- All work for this study is based on the 100 year ARI storm event.
- Calibration data (that is, streamflow data) is not available for the Hillside site. Typically in modelling the hydrology of a site, it is important to verify and calibrate runoff parameters. As no calibration data exists for the Hillside site, the adopted parameters contain uncertainty and should be calibrated once site specific data becomes available. It is not uncommon for calibration to result in alteration of the RORB-modelled peak flow rates by a factor of two (2).
- The focus of the study is the waste rock dumps, particularly containment of runoff and erosion from these surfaces. The plant area has not been included in this study, however drainage in this area has been analysed by others and management measures proposed.
- The steady flow assumption in hydraulic modelling is that at any section in the flow system, the discharge is constant in time. A constant flow enters the drainage system for a long period of time until the system stabilises, and is suitable for analysis of a long lasting flood event. If the flood being analysed reaches its peak in less time than it takes to reach the stable condition, modelled flood peaks are likely to be conservative.
- The study does not include an assessment of flooding of the tails storage facility.
- The three main drainages in the natural site were considered.
- A one-dimensional hydraulic model assesses flows in the direction of main channel flow only. Such a model is not able to accurately assess characteristics of the flow that occurs in other directions, such as perpendicular to the main flow direction. One-dimensional models are extremely useful for analysing stream and channel flow, however break down when flow in other directions becomes significant.
- Culverts at road crossing locations were not considered.

3 TOPOGRAPHY AND CATCHMENT ANALYSIS

This section discusses the major aspects of the project area's hydrology, namely:

- Topography and flow regime of the undeveloped site
- Land Use
- Soils
- Climate
- Hydrological character of the developed site.

3.1 Topography and Flow Regime of the Undeveloped Site

Figure 3-1 below shows the hydrological character of the site, including the topography represented by contours at an interval of 1.0m.

The project area is relatively flat. Slopes in the western section of the project area are generally less than 1.5%, and increase to approximately 3% in the vicinity of natural, channelised drainage paths.

Sheet flow is the dominant drainage regime, particularly in the upper reaches of the catchments affecting the project area, however small; ephemeral drainage channels are also evident. Runoff ultimately drains to St Vincent Gulf.

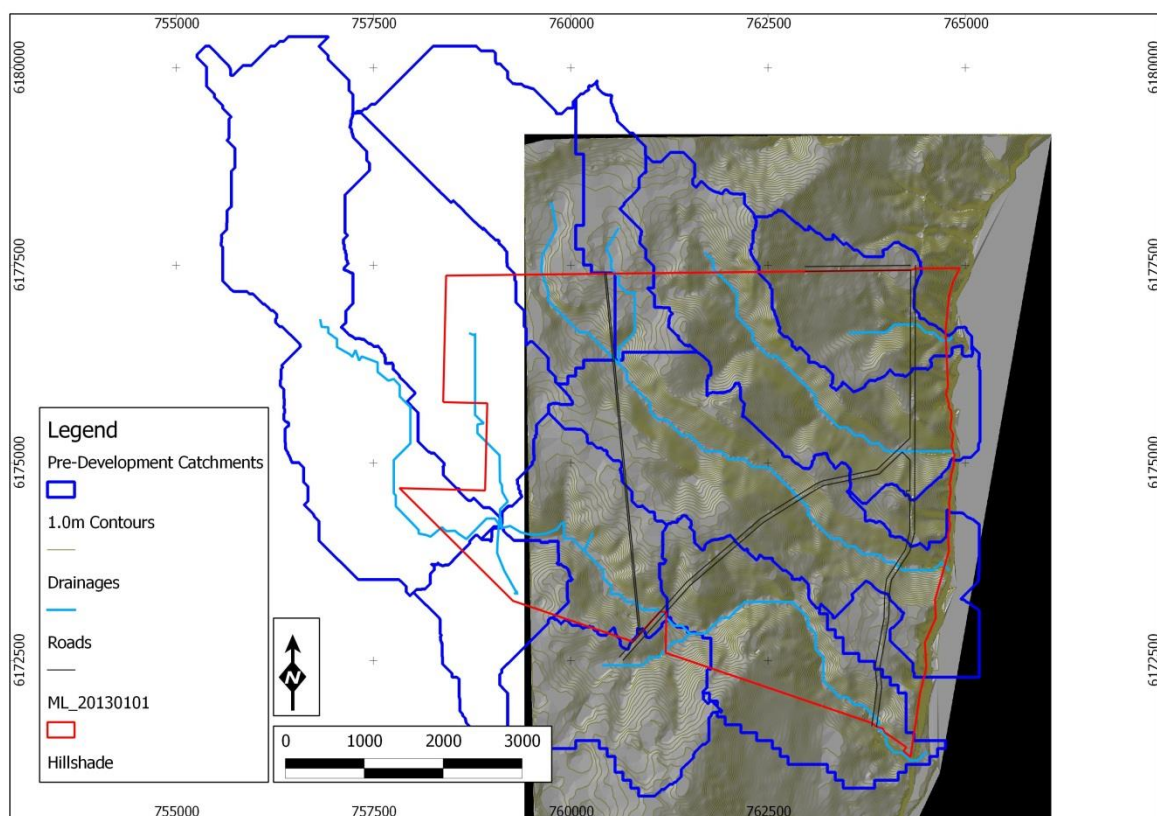


Figure 3-1 – Hydrological character of the undeveloped site

3.2 Land Use

The predominant land use in the project area is rural agricultural, with much of the land being used for dry cropping. Figure 3-2 and 3-3 below show the land use typical of the area.



Figure 3-2 – Typical project area land use (Source: Mining Plus)



Figure 3-3- Typical project area land use (Source: Mining Plus)

3.3 Soils

The CSIRO maintains the Australian Soil Resource Information System (ASRIS), which provides online access to soil information. The level of detail depends on the survey coverage in each region. In the Hillside area, soils have been mapped to the system level at a resolution of 300m. This level of detail is appropriate for catchment management and hydrological modelling (ASRIS, 2012).

ASRIS data indicates that surface soil (A1 Horizon) texture in the project area varies from sandy clay loam (20-30% clay content) and sandy loam (10-20% clay content) in the west to sand (<10% clay content) in the east. Lower surface soil (A12-A2 Horizons) exhibits a slightly higher clay content in the western part of the project area, while in the east the lower surface soil is classified as sandy (<10% clay content). Both surface and sub-surface soils are predominantly sandy loams and sands.

3.4 Climate

The nearest weather stations are located at (record length shown in brackets):

- Ardrossan (131 years), 17km north of the site
- Port Vincent (114 years), 26km south of the site
- Maitland (132 years), 29km north west of the site
- Price (67 years), 35km north of the site

The regional climate is temperate, with long, hot, dry summers and cool winters. Most of the annual rainfall occurs in the winter months, with June and July recording the highest monthly precipitation. January and February are typically the driest months.

Maximum daily summer temperatures at Price are often in excess of 30°C. Winter minimums are often below 15°C. The highest recorded temperature at Price is 46.1°C (14 January 2001) and the lowest is 10.2°C (2 July 1984).

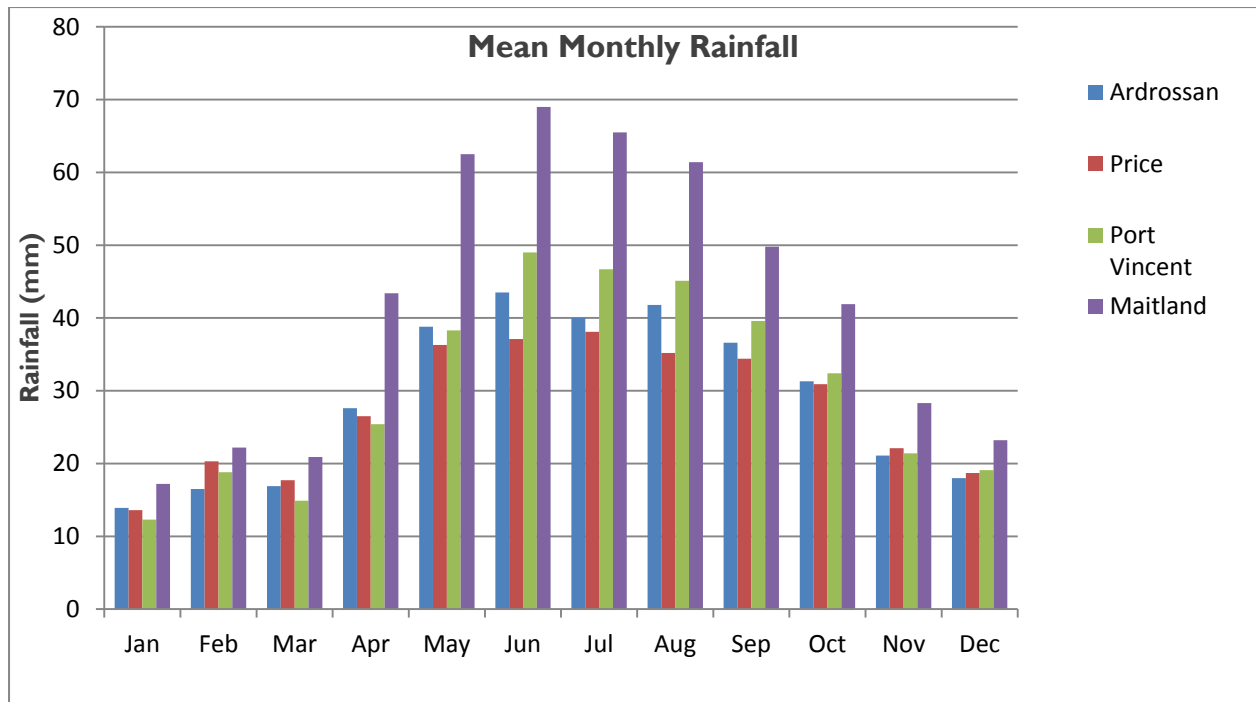
Maximum daily summer temperatures at Maitland vary between 29°C - 33°C, and mean minimum winter temperatures between 12°C - 13°C. The highest recorded temperature at Maitland is 45.0°C (28 January 2009) and the lowest is 7.8°C (11 August 1960).

Table 3-1 – Mean monthly temperature maxima and minima, °C (Source: BOM, 2012)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Monthly Maximum (Price)	33.4	33.9	30.3	28.1	21.8	18.9	19	21.3	24	28.6	29.6	34.8
Mean Monthly Minimum (Price)	24.8	22.9	22.8	19.1	16.8	14.2	14.3	14.9	15.6	19.6	21.6	21.8
Mean Monthly Maximum (Maitland)	33.5	32.3	30	26	20.5	19.6	15.9	17.8	20.7	23.8	30	29.1
Mean Monthly Minimum (Maitland)	25.8	24.9	23.5	19.1	14.9	13.3	12.6	13.5	15.1	18.3	21.2	22.1

Mean annual rainfall from the four stations varies between 331mm (Price) and 504mm (Maitland). Monthly average rainfall from the four stations is shown in Figure 3-4 below.

Figure 3-4 – Mean monthly rainfall (Source: BOM, 2012)



Evaporation data was unavailable at the time of writing, but will not affect the models used in this study.

3.5 Hydrological Character of the Developed Site

The footprint of the Hillside site is projected to be fully developed by the fifth year of operations. After this time waste rock dumps would increase in height only. OEC analysed the hydrological character of the developed site, including approximate delineation of subcatchments and drainage paths. Runoff originating from the waste rock dumps was assumed to flow in the general direction of the natural site's drainage (that is, from north-west to south-east), with the exception of runoff originating from dump slopes.

The following data were used in the delineation of catchments:

- 1.0m contour data extending from the St Vincent Gulf coast in the vicinity of the project area to approximately 6km west.
- Topographical data representing the major landforms associated with mining activities (waste rock dumps and the pit).
- Vector data showing the location (but not elevation) of existing and planned infrastructure (roads, processing facilities and offices).

Figure 3-5 below shows the site's hydrological character beyond its fifth year of operation.

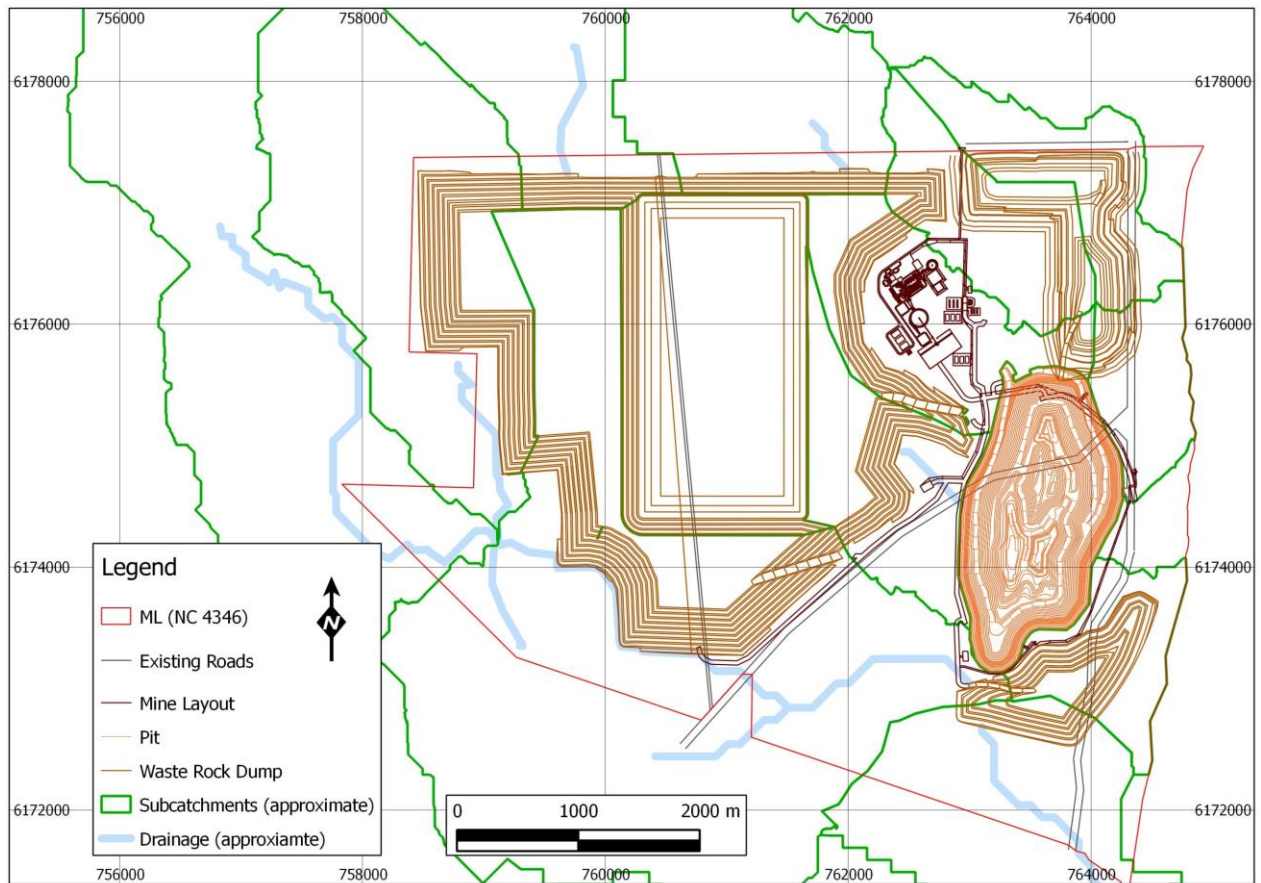


Figure 3-5 – Hydrological character of the developed site

Figure 3-5 shows that runoff may pond where mine infrastructure obstructs the natural drainage system. These areas in particular are likely to require drainage management infrastructure, which should be designed based on a suitable ARI and with runoff conveyance and quality requirements in mind.

4 PEAK FLOW ESTIMATION

4.1 Introduction

This section presents the results of the hydrological analyses of the design 100 year ARI storm for the undeveloped and developed sites.

4.2 Undeveloped Site

Of the standard storm durations analysed, the six-hour storm resulted in the highest peak flows at the catchment outlets. Modelled peak flows at points of interest within the project area are shown below in Figure 4-1.

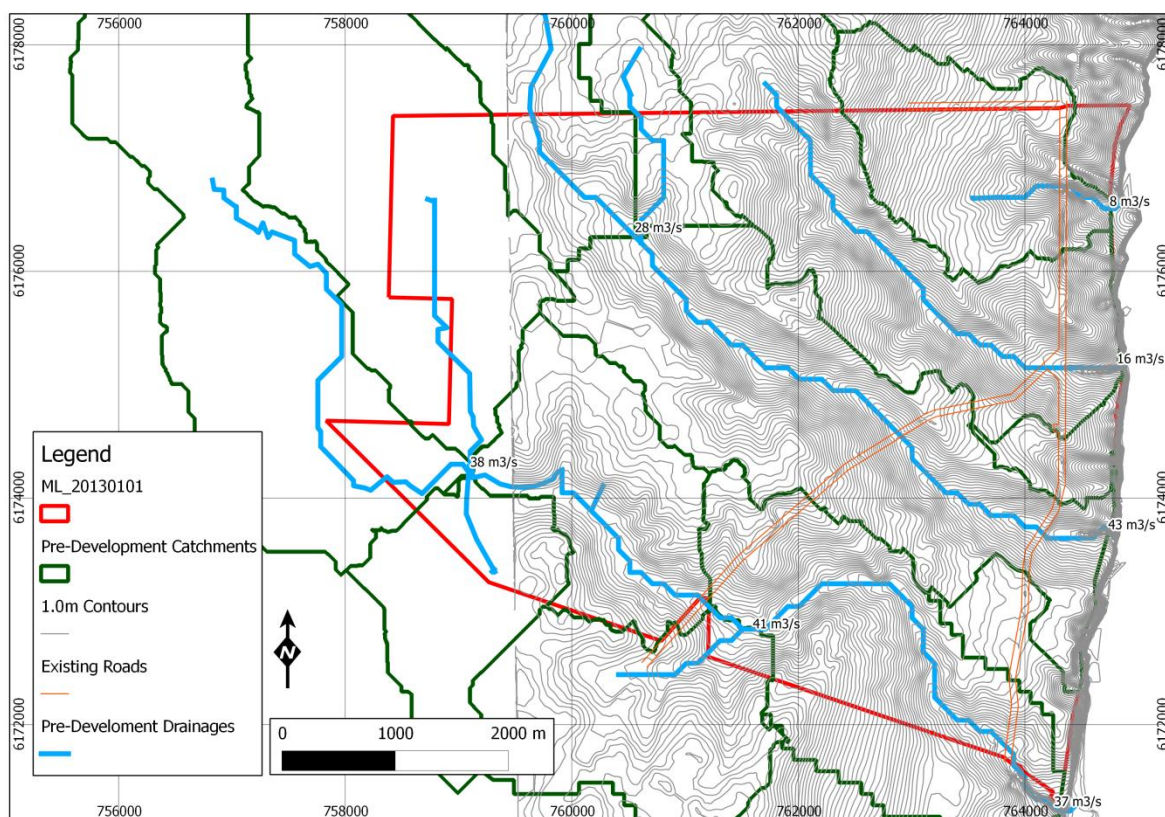


Figure 4-1 – Modelled 100 year ARI peak flow rates (undeveloped site)

4.3 Developed Site

For the majority of catchments in the developed site, the six-hour storm resulted in the highest peak flows. For some of the smaller catchments formed by the waste rock dumps and the pit, the two-hour storm was determined to be the critical storm.

The peak flows at points of interest within the developed site are shown in Figure 4-2 below. Where runoff from a catchment is obstructed by mining infrastructure and is unable to flow to the natural

outlet, the volume of runoff (rather than the peak runoff flow rate) arising from the design storm is shown. Section 2.2.4 contains further information pertaining to this.

The south-east waste rock dump dams the natural drainage channel to approximately 49.6m AHD. The storage associated with this dam has the effect of attenuating the flood wave and reducing the peak flow downstream of the dump. Topographical analysis of this area indicates that a volume of approximately 205ML would be stored before the dam height is exceeded.

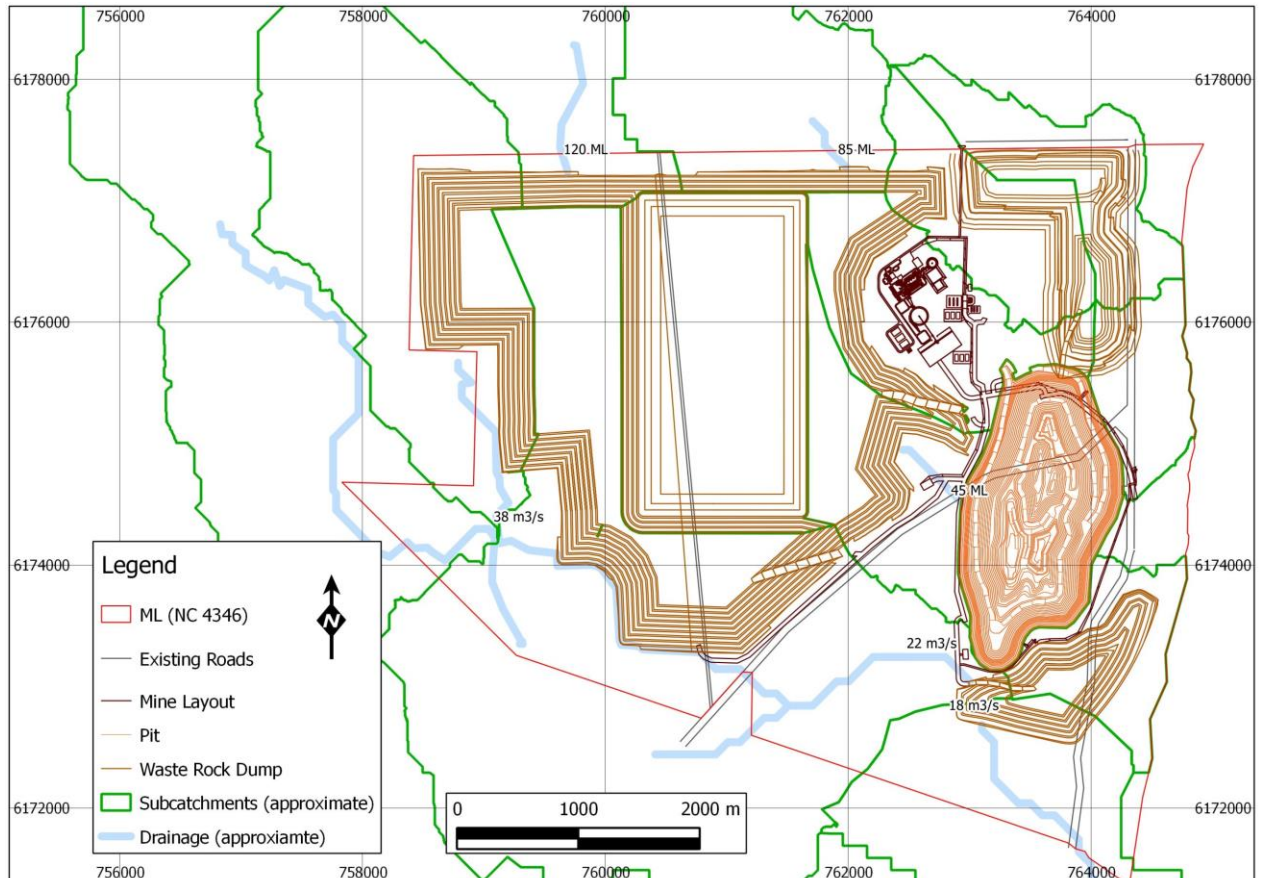


Figure 4-2 - Estimated 100 year ARI peak flow rates/volume (developed site)

5 FLOOD EXTENT ESTIMATION

5.1 Introduction

This section presents the results of the estimate of the extents of the design 100 year ARI storm for the undeveloped site.

5.2 Undeveloped Site

Figure 5-1 below shows the estimated extents of the 100 year ARI flood for the undeveloped site.

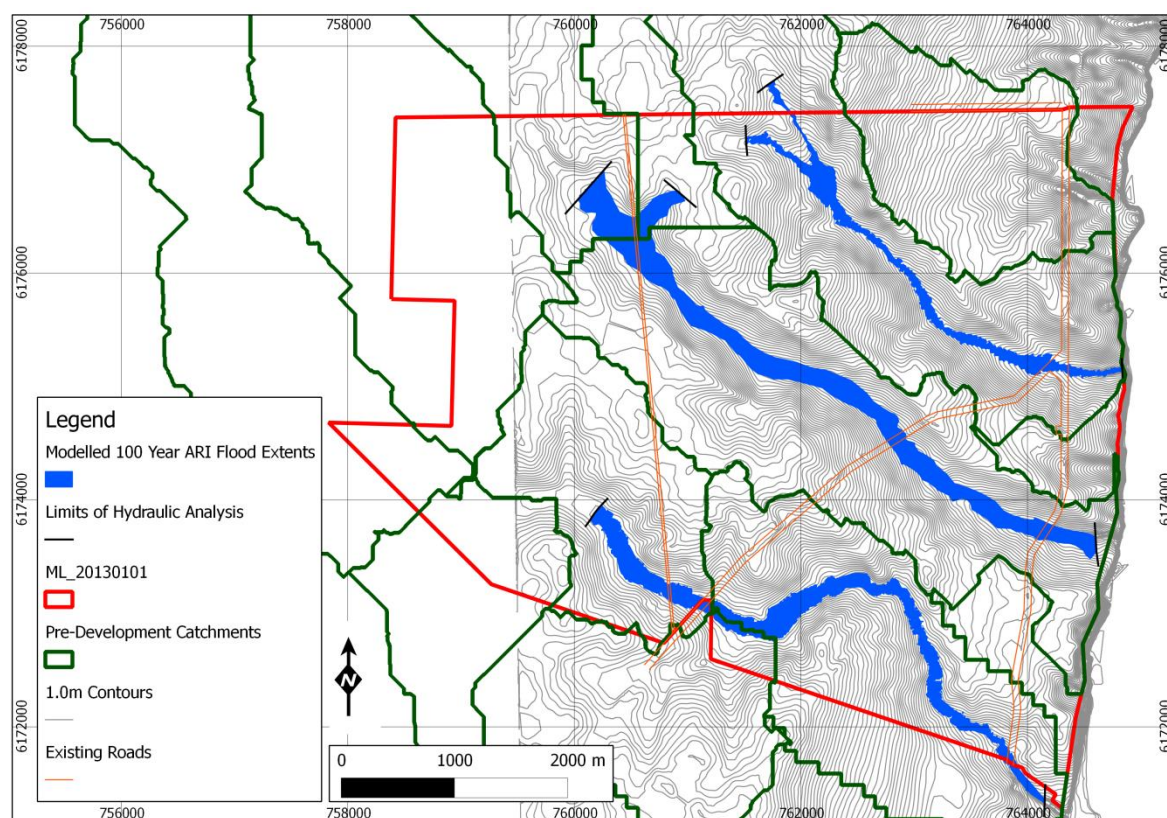


Figure 5-1 – Estimated 100 year ARI flood extents (undeveloped site)

5.3 Developed Site

Figure 5-2 below shows the estimated 100 year ARI flood extents for the developed site.

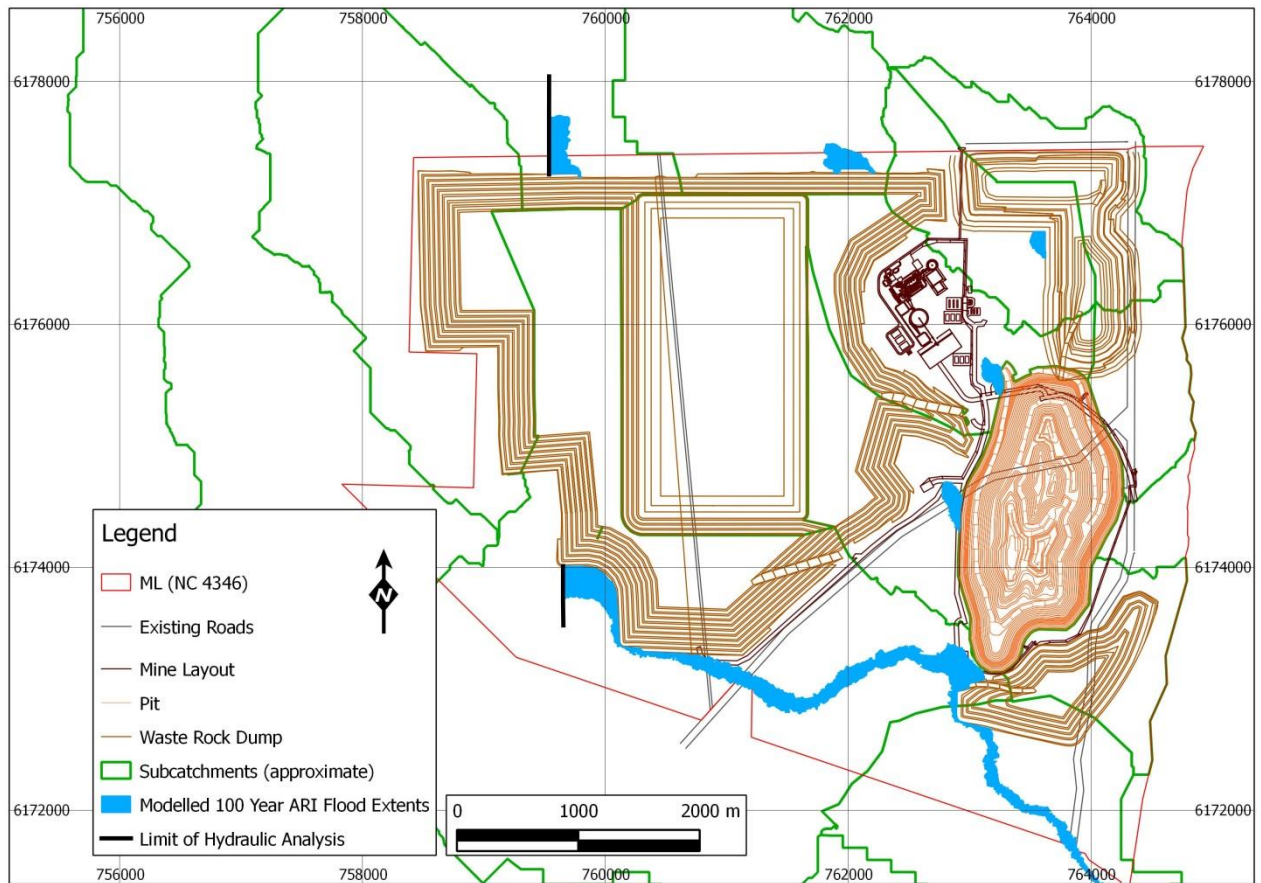


Figure 5-2 Estimated 100 year ARI flood extents (developed site)

5.4 Discussion of Results

5.4.1 General

The results show that:

- Without mitigation measures, the 100 year ARI storm is likely to produce runoff that interacts with waste rock dumps, the pit and other mine infrastructure.
- Development of waste rock dumps and the pit will obstruct the existent natural drainage lines of the site. This is likely to cause ponding of runoff arising from the 100 year ARI storm.
- Without mitigation measures, runoff from areas such as the waste rock dumps would enter the natural drainage system.

Risks associated with flooding, ponding and contamination of runoff arising from the 100 year ARI storm could be managed effectively using engineered drainage control structures and earthworks, as well as appropriate management practices during operations. These mitigation measures are described in 6.

6 POTENTIAL SURFACE WATER IMPACTS AND MITIGATION MEASURES

6.1 Introduction

This section discusses surface water management at the Hillside site. Firstly, surface water management objectives are defined. Potential impacts arising from the interaction of mine infrastructure, particularly waste rock dumps, and surface water are identified. Mitigation measures are proposed, with detailed design of such measures to be undertaken during the project feasibility stage. Finally, mitigation measures for closure are proposed, again subject to detailed design.

6.2 Surface Water Management Objectives

The following objectives were defined in order to set the framework for surface water management for the Hillside project:

1. Reduce risks to personnel and infrastructure arising from surface water flows as far as reasonably practical.
2. Minimise negative environmental impacts associated with changes to the natural surface water regime as far as reasonably practical.
3. Manage water resources as efficiently as possible.

6.3 Potential Surface Water Impacts

Although there are no permanent rivers or creeks flowing within the project limits, there are several ephemeral drainage lines that cross the site in a generally south-easterly direction. These drainage lines discharge to St. Vincent Gulf.

In an average year, impacts arising from the interaction of surface water and mine infrastructure are expected to be minimal. However, modelling and analysis indicate that the Hillside project will alter the natural drainage regime, and the impacts arising from these changes may be significant under extreme storm conditions.

This section identifies the impacts potentially arising from modifications to the existing hydrology so that suitable mitigation and management measures may be identified and implemented.

The following potential impacts were identified, in increasing order of assessed significance:

- Disruption of downstream surface water flows
- Increased sediment loads in downstream surface water flows
- Contamination of runoff with mine wastes such as hydrocarbons
- Flooding of mine infrastructure, including ingress of runoff to the pit

6.4 Mitigation Measures

This section proposes mitigation measures for each of the potential impacts identified above. All mitigation measures are subject to detailed design during the project's feasibility stage.

6.4.1 Disruption of downstream surface water flows

A reduction in downstream flows due to placement of mine infrastructure is unlikely to result in significant negative impacts, as all flows crossing the site are ephemeral; irregular and inconsistent downstream flows are part of the natural hydrological regime. Diversion of major drainage lines around mine infrastructure where possible and release of clean water from sedimentation ponds would mitigate this impact.

6.4.2 Dam formation

Runoff from extreme storm events has the potential to collect behind the south-east waste rock dump, which essentially dams the natural drainage system to approximately 49.6m AHD. This has safety, economic and environmental implications for downstream users and environs in the event of dam failure. Failure of a damming structure has the potential to result in a destructive, high energy flood wave propagating rapidly downstream. Such a flood wave has the potential to damage or destroy infrastructure, such as roads and buildings, and could endanger human health and safety.

The most effective mitigation measure for this impact is the diversion of the natural channel around the toe of the south-east waste rock dump, preventing the formation of a dam on the channel. Detailed design of a diversion channel should occur during feasibility studies, and would require topographical and geotechnical inputs to determine the most cost-effective, stable and efficient layout. It is important to note that diverting the natural channel around the waste rock dump would eliminate the flood-wave attenuating effect of the dam as modelled in this investigation, and thus increase the peak flow at the catchment outlet.

6.4.3 Increased sediment loads

There is potential for the project to cause an increase in erosion of areas disturbed by mining activities, resulting in increased sediment loads in surface runoff. The following mitigation measures are proposed for this impact:

- A system of catch drains and sediment ponds to contain runoff from waste rock dumps for treatment (sedimentation) prior to discharge. Drains and ponds would be sized to contain runoff arising from the design storm, and would be suitably lined or armoured as appropriate. In certain locations, such as the northern dump areas, design of ponds would take into account runoff originating further upstream, but which is unsuitable for diversion.
- Construction of a system of internal drains that captures runoff from other areas disturbed by mining activities and directs it to one or more sedimentation ponds prior to discharge. Drains and ponds would be sized to contain runoff arising from the design storm and would be lined or armoured as appropriate.
- Implementation of a monitoring plan which includes analysis for suspended solids in discharge from sedimentation ponds.

- Diversion of the southern drainage line around the south-western and south-eastern waste rock dump areas. The diversion would be sized to contain the design storm, and suitably lined or armoured.
- Appropriate design of waste rock dumps to minimise erosion potential. This would include selection of a suitable batter angle for stability.
- Progressive rehabilitation of waste rock dumps (and other disturbed areas) as permitted by the mine plan in order to stabilise waste dump slopes and reduce erosion potential.

6.4.4 Contamination of runoff with mine wastes

Without appropriate management measures, there is potential for mining operations to result in contamination of runoff. The major contaminants of significance are:

- Hydrocarbons (from workshops, fuel farms and maintenance areas);
- Other chemicals (from processing operations); and
- Acidic drainage (resulting from oxidation of acid forming rock material) which may also mobilise certain metals.

The following mitigation measures are proposed:

- Implementation of a hydrocarbon and chemical management plan, including appropriate bunding and storage, provision of spill kits, the use of hardstand areas where hydrocarbons are transferred, and appropriate disposal procedures.
- Provision of drains, sumps and oily water separators in workshops and maintenance facilities for the containment of hydrocarbon waste.
- Characterisation of waste rock material and implementation of a waste rock management plan to prevent the oxidation of potentially acid forming material.
- Implementation of a monitoring plan which includes analysis for hydrocarbons, relevant chemicals, pH and metals.

6.4.5 Flooding of mine infrastructure

Without appropriate mitigation measures, there is potential for flood waters to encroach on mine infrastructure, including ingress of runoff to the pit. The following mitigation measures are proposed:

- A safety bund around the pit, particularly on the northern and western sides, designed to prevent the ingress of upstream runoff arising from the design storm.
- Diversion of the southern drainage line around the south-eastern waste rock dump area, including the southern portion of the pit. The diversion would be sized to contain the design storm, and suitably lined or armoured.
- Design of haul roads to prevent disruption of operations due to flooding arising from the design storm. This would include appropriately sized and placed culverts, embankments and drains as necessary.
- Appropriate design and siting of plant and other infrastructure, including a system of internal drains to manage runoff arising from the design storm.

6.4.6 Conceptual Drain, Pond and Diversion Layout

Figure 6-I below shows a conceptual layout for drains, ponds and channel diversions for the management of runoff. The figure is conceptual only, and its purpose is to illustrate the extent and type of drainage management works that would be appropriate for Hillside. No sizing, design or alignment selection was included. A safety bund around the pit is not shown in the figure, but should be considered during feasibility studies.

Detailed design and layout of water management infrastructure should take place during feasibility studies. A basis of design should be developed as a result of a robust risk assessment, which considers health, safety, operational, environmental and economic consequences of surface water impacts.

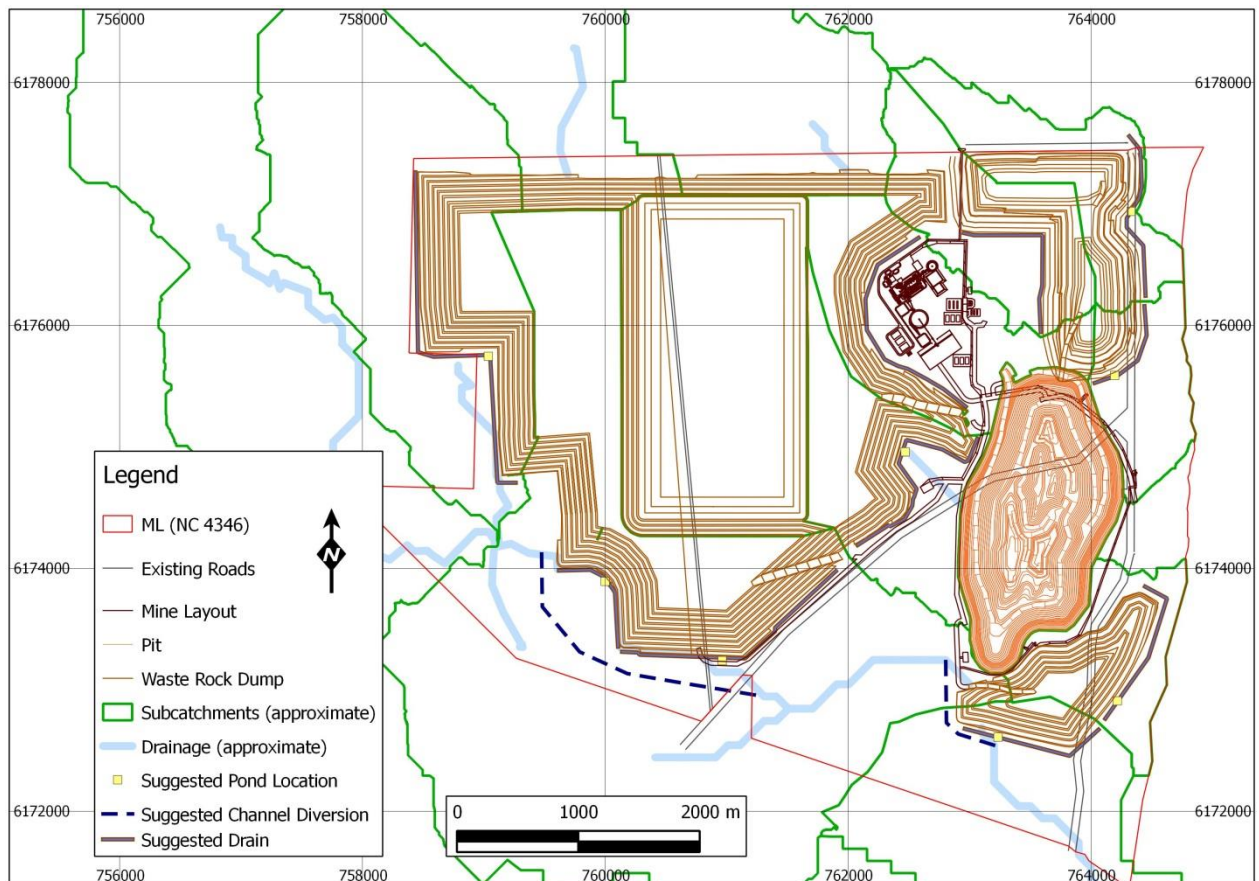


Figure 6-I Conceptual surface water management

6.5 Post-closure Surface Water Management

The overarching goal of post-closure surface water management is the stabilisation of surface water flows from the site so that they approximate natural conditions. In order to achieve this, the following measures are recommended:

- Design of final landforms to reduce erosion potential. This may include selection of an appropriate batter angle and placement of benches. The final design would be based on the characteristics of the landform cover material, and the results of testing and monitoring of this material during the project's operational phase.
- Runoff from final waste rock dumps would be directed to a series of self-draining catch dams and/or silt traps to contain sediment. These would be sized so that for storms up to and

including the design storm, the quality of discharged water is similar to that of the natural drainage.

- Other water management infrastructure used during operations would be decommissioned and removed if it was not required to sustain the post-closure hydrological regime.
- Monitoring of surface water quality from the site (and remediation, if required) until such time as it can be shown that the quality of water released from the site has stabilised to a level not worse than the receiving environment. It is expected that as rehabilitation progresses, sediment loads would stabilise and reach an equilibrium with natural conditions.
- Internal runoff should be directed to either the pit or the southern drainage diversion.

7 CONCLUSIONS AND RECOMMENDATIONS

This study examined the surface hydrology of the Hillside site (Section 3) and estimated peak runoff flow rates and, where appropriate, runoff volumes arising from the 100 year ARI storm (Section 4). This data was used to map the estimated extents of the flood arising from this storm (Section 5). The results of this exercise were then used to describe the likely impacts associated with surface water at the Hillside operation and to suggest conceptual mitigation measures (Section 6).

While extreme storm events are likely to produce flooding at Hillside, in a year with average rainfall it can be reasonably expected that impacts from flooding would be insignificant. The soil types mapped in the project area are generally permeable and average rainfall is relatively low. Existent drainages in the area are ephemeral by nature. No anecdotal evidence of frequent flooding was encountered.

In addition to the mitigation measures described in Section 6, it is recommended that a risk assessment be undertaken in order to determine an appropriate ARI storm event to use as the basis of design for engineered controls. The risk assessment should consider the consequences of adverse impacts, and balance this with safety, operational, economic, social and environmental objectives. It is likely that the design ARI would vary by domain.

Design flow rates (for drains) and volumes (for retention basins) would need to be determined. The models used in this study can be configured for the selected design storms and are suitable to use for design purposes.

REFERENCES

ASRIS. (2012). Australian Soil Resource Information System.

Chow, V. T. (1959). *Open Channel Hydraulics*. McGraw Hill.

Cordery, I., & Pilgrim, D. H. (n.d.). On the Lack of Dependence of Losses from Flood Runoff on Soil and Cover Characteristics. *Hydrological Effects of Agriculture and Forestry Practice*. Hamburg.

Hill, P., Mein, R., & Siriwardena, L. (1998). *How Much Rainfall Becomes Runoff? Loss Modelling for Flood Estimation*. Melbourne: Cooperative Research Centre for Catchment Hydrology.

Laurenson, E. M., Mein, R. G., & Nathan, R. J. (2010). *RORB Version 6 Runoff Routing Program Users Manual*. Melbourne: Sinclair Knight Mertz.

The Institute of Engineers Australia. (1997). *Australian Rainfall and Runoff*.




HILLSIDE PRE-FEASIBILITY STUDY

Hydrogeology



Document Control Information

	HILLSIDE PRE-FEASIBILITY STUDY HYDROGEOLOGY		REVISION	
			NO.	DATE
	MCREXH22-MEPR- 3.12		03	19/12/2012

Revision:	Prepared By:	Reviewed By:	Issued For:	Approved By:	Date:	Signature:
01	R. Aldam	P. Murphy	RC	P. Murphy	03/09/2012	
02	P. Murphy	L. Stubbs	RC	P. Murphy	18/12/2012	
03	P. Murphy	H. Doodie	RC	P. Murphy	19/12/2012	

EXECUTIVE SUMMARY

This report documents:

- The results of a field testing program to define the conceptual hydrogeology and the hydrogeological parameters of the Hillside site.
- The creation of a numerical groundwater model and the subsequent analysis of the PFS mine design.
- The creation of a water balance model to quantify the pit dewatering requirements and the excess water available for use in the production process.

A total of 22 groundwater investigation wells were installed in the period 4 January 2012 to 7 March 2012. Some of these investigation wells were the allocated monitoring bores and were used as either wells or monitoring bores dependant on the yields encountered.

The potentiometric surface contours indicate that groundwater flows from west to east toward Gulf St Vincent under a hydraulic gradient of approximately 0.02.

Air lift yields were highly variable, ranging from effectively zero to in excess of 10 l/s.

Observations during drilling indicated that much of the flow constituting the air lift yields occurred in the saprock interval (the zone below the base of saprolite and above fresh rock).

Test pumping was carried out by Aldam Geoscience with the assistance of REX plant and personnel. This included a submersible pump, power supply, lay flat riser, well headworks (flange, elbow, fittings), gate valve, flow meter and discharge line.

Wells that produced water at approximately 1 l/s or more were test pumped at a constant rate for durations of up to 1470 minutes. Nearby wells and available diamond drill holes/geotechnical investigation drill holes were also monitored during testing and changes in water level recorded as observation well responses.

Transmissivity (T) values from the hanging wall, the southern and northern fault extensions, and Leprena are very low (<1), those from the Pine Point and Dart Faults are also low (<2), from the footwall granites are low to moderate (1 – 33), from the pit are low to moderate and from the coastal granites are low to very high (12 – 253).

Groundwater samples were collected from each well during test pumping. The results indicate that groundwater on site is saline to hyper saline, its pH is neutral to slightly acidic, and contains high concentrations of sodium, chloride and magnesium, but generally low metals concentrations.

The drilling and test pumping program produced results that did not match predicted outcomes, particularly with respect to yields from major structures on site. It was concluded that the majority of rock mass on site, whilst being highly fractured, jointed and faulted, was of low transmissivity, resulting from the effects of weathering and kaolinisation. It was also considered that fracture porosity did not increase with depth, and that the greatest fracture porosity occurs within the saprock interval.

The zoning of aquifer properties differs from the conceptual model as the northern fault extensions, southern fault extensions, Leprena and hanging wall domains were assigned the same values. This was based on test pumping results, which did not provide data to support the hydrogeological differentiation of the hanging wall metasediments from the northern and southern fault extensions. Likewise, the

Leprena ore body has been found thus far to be of very low hydraulic conductivity, it was therefore assigned properties identical to the southern fault extensions.

A digital groundwater model was constructed for the Hillside Deposit site and surrounding areas to enable dewatering rates to be estimated and the potential effects of dewatering to be evaluated. It was developed using 'MODFLOW' groundwater modelling software (Harborogh and Mac Donald 1966), supported by the pre and post-processing platform PMWIN (Simcore Software 2010).

The low hydraulic conductivity (K) values obtained from test pumping within and outside the pit footprint suggest that dewatering using vertical pumped wells located on the pit crest will not be effective. This is because in tight units such as those encountered at Hillside, the cone of depression and radius of influence of pumping is small, and the wells would be set back too far from the pit floor to maintain dry working conditions.

It was considered more realistic to use drain cells located on the pit floor as the model drainage simulation mechanism.

The proposed open pit mine life is 13 years. Pit outlines (crest, floor and walls) and elevation data for 13 successive years of mining have been used to create pit shells for each of the years. These were incorporated into the model and the model was then run under transient conditions to provide estimates of dewatering rates for each year modelled.

The underground mining operation begins in Year 3 and continues until the end of Year 17 but the drain cells remain open in Year 18. Drains remain in place in each completed mining area to simulate voids created by the stoping as well as development headings.

The numerical model has shown that:

- Relatively small flows originate from the upper 2 layers (seasonal perched Quaternary aquifers and saprolitic confining layer);
- The greatest flows occur as the pit passes through the saprock of Layer 3 reaching a maximum of about 170 l/sec in the third year from the current model;
- Hydraulic gradients towards the pit are very steep and the phreatic surface is expected to be very close to the pit walls, especially in the lower levels; and
- The low K environment surrounding the pit acts to restrict the expansion of the area of influence of the pit dewatering.

The scope of the water balance model for the mining area is to access whether:

- The mine dewatering will produce enough water to support the dust suppression for the pit;
- There is excess water, how much water will the pit dewatering be able to contribute to the plant production water requirement?

The mining area is defined as the area bounded by the crest of the open pit.

There are two primary sources of incoming water:

- Rainfall; and
- Inflows of groundwater.

There are three primary sources of outgoing water:

- Evaporation;
- Dust suppression; and
- Water lost to blasting/stockpiles.

The input that has the most influence over the pit water balance is the groundwater inflows to the open pit and the UG operation.

The effects of the rainfall, evaporation and dust suppression, although minimal individually, are amplified as they all contribute to less water in the summer and more in the winter.

For that reason there is a significant variation in the volume of water in excess between the summer and winter months.

For the majority of the mine life there will be an excess of water in the range of 55 to 105 l/s. There are two periods (Years 2 and 3 and Years 7 to 9) where the inflows increase, and thus the water in excess increases. In the winter of Years 2 and 3 there could be up to 170 l/s water in excess, and in Year 7 there could be up to 160 l/s in excess. The summer volumes are significantly less at around 100 l/s.

It is proposed that the excess water from pit dewatering will be delivered to a holding pond positioned at the top of the main ramp in close proximity to the plant. This water can be utilised as plant production water.

The plant is able to utilise up to 170 l/s of excess water at this stage from mine dewatering to use for plant production.

At this stage of the study the plant is able to utilise all the water produced from pit dewatering, but it is close to the upper limit of the capacity in the peak periods (i.e. the winter of Year 3 when the excess water is predicted to be around 170 l/s).

As contingency, excess water disposal options have been considered and will be implemented if required. They include:

- Utilisation of in pit bores to allow the pit dewatering volumes to be more consistent year to year;
- Temporary storage in the pit during times of peak flow;
- Temporary storage in the 100 ML tails dam seepage storage pond area;
- Evaporation using mechanical means such as evaporators;
- Utilisation of in pit bores that can be used in the summer months to advance dewatering and thus reduce the flows short term in the winter months;
- Utilisation of pit perimeter bores to form a cut off bore field between the Gulf St Vincent and the pit with discharge to Gulf St Vincent;
- Discharge of excess pit water to the Gulf St Vincent;
- Disposal of excess water via an injection bore field; and
- Grouting the aquifer to reduce inflows.

These contingencies should be investigated further in the next stage of the study if required.

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I SUPERVISION OF WATER WELL (AND MONITORING BORE) DRILLING AND EQUIPPING

A total of 22 groundwater investigation wells were installed in the period 4 January 2012 to 7 March 2012. These investigation wells were used as either wells or monitoring bores dependant on the yields encountered.

All wells were drilled and completed by Diverse Drilling Pty Ltd, using blade/air and down hole hammer/air methods.

Well construction permits were obtained from the Department for Water (DoW) and drilling was carried out by a licensed water well driller.

Drilling depths were planned to be 200 metres. Some wells were completed shallower due to not having the capacity to dispose of the water produced, and two were drilled to 204 metres. All wells were drilled to target zones of structural complexity or areas in which significant intersections of water had been encountered during reverse circulation (RC) drilling.

Wells were installed in all hydrogeological domains shown in Figure I-1. One well was installed in each of the southern fault extensions, two wells were drilled into the hanging wall, five wells were installed into the eastern granite (with one as an observation well to WBTH 011), two into Leprena and the remaining 12 were installed into the main pit area. All wells were drilled vertically and cased with 200 mm or 177 mm PVC casing to below the base of weathering. Steel casing was installed on two wells due to problematic ground conditions; steel casing was able to be driven through zones of instability whereas PVC casing has the potential to shatter.

The well completion summary is shown in Table I-1.

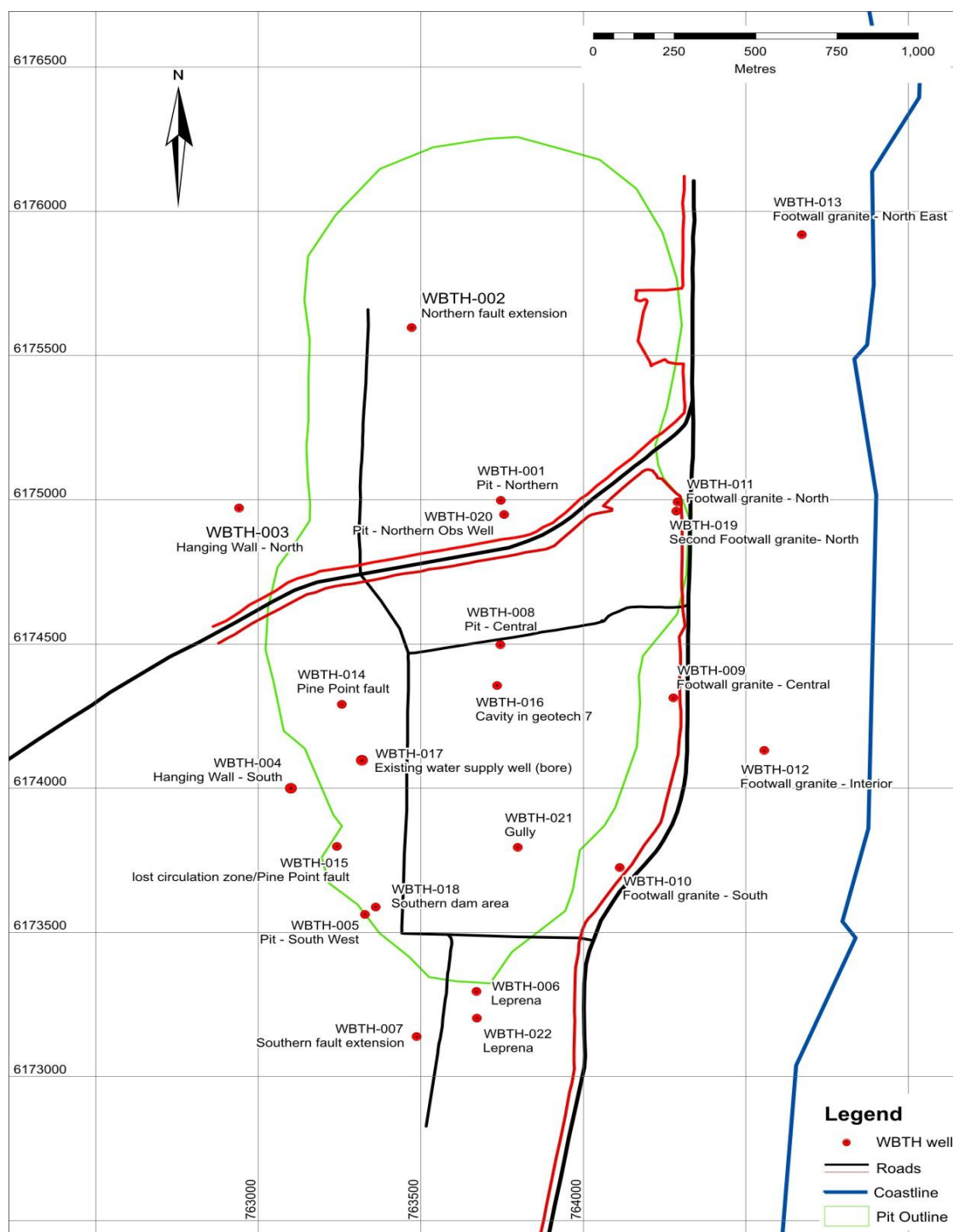


Figure I-1 Well locations

Table I-1: Well completion summary

Well identifier	Permit no	Location	Start date	Completion date	Final depth (m)	Casing depth (m)	Casing diam (mm)	Slotted interval (m)	Gravel pack	Completed in	Depth first water (m)	Final air lift yield (l/s)	SWL (from TOC)	SWL date	Standpipe height (m)
WBTH 001	208390	pit northern	1/02/2012	3/02/2012	166	84	200	-	-	metasediments	85	8	29.7	7/03/2012	0.87
WBTH 002	208389	northern fault extensions	30/01/2012	31/01/2012	200	18	200	-	-	metasediments	145	1.2	33.87	7/03/2012	0.73
WBTH 003	208388	hanging wall north	3/02/2012	6/02/2012	200	42	200	-	-	metasediments	42	seep	31.88	7/03/2012	0.62
WBTH 004 (a)	208395	hanging wall south	23/01/2012		-	-									
WBTH 004(b)	208395	hanging wall south	12/02/2012	15/02/2012	200	72	200	18-72	y	metasediments	not stated	0.5	12.63	7/03/2012	0.26
WBTH 005	208392	pit south west	5/01/2012	9/01/2012	150	un cased	-	-	-	gabbro / metasediments	60	-	21.96	7/03/2012	0.86
WBTH 005(2)	208392	pit south west	12/01/2012	15/01/2012	198	90	200	60 – 84	y	granite / metasediments	42	8.3	29.57	24/01/2012	0.33
WBTH 006	208393	Leprena	15/01/2012	19/01/2012	204	60	200	-	-	skarn / granite	78	<0.1	27.32	24/01/2012	0.82
WBTH007	208394	southern fault extensions	23/01/2012	26/01/2012	200	60	200	48 – 60	y	red rock skarn	55	<1	21.52	7/03/2012	0.62
WBTH 008	208397	pit central	10/01/2012	12/01/2012	204	106	200	-	-	granite / gabbro	72	0.8	35.49	24/01/2012	0.71
WBTH 009	208399	footwall granite central	21/01/2012	22/01/2012	200	36	200	-	-	granite	59	<1	35.49	24/01/2012	0.47
WBTH 010	208400	footwall granite south	19/01/2012	21/01/2012	200	12	200	-	-	granite	44	1.2	19	24/01/2012	0.61
WBTH 011	208398	footwall granite north	26/01/2012	30/01/2012	200	72	200	-	-	granite	97	1.8	21.4	7/03/2012	0.46

Well identifier	Permit no	Location	Start date	Completion date	Final depth (m)	Casing depth (m)	Casing diam (mm)	Slotted interval (m)	Gravel pack	Completed in	Depth first water (m)	Final air lift yield (l/s)	SWL (from TOC)	SWL date	Standpipe height (m)
WBTH 012	208411	footwall granite interior	6/02/2012	8/02/2012	200	36	200	-	-	granite	60	1.2	25.23	7/03/2012	0.81
WBTH 013	208410	footwall granite NE	8/02/2012	9/02/2012	107	30	200	-	-	granite	66	>10	23.5	7/03/2012	0.79
WBTH 014	208396	Pine Point Fault	10/02/2012	11/02/2012	200	18	200	-	-	metasediments	-	nil	dry	7/03/2012	
WBTH 015	208402	pit SW nr HDD 359	20/02/2012	21/02/2012	200	12	177	-	-	metasediments	50	0.5	12.96	7/03/2012	0.64
WBTH 016	208401	pit central nr geotech hole 7	15/02/2012	16/02/2012	200	60	177	-	-	granite/metased/gabbro??	80	2.1	36.55	7/03/2012	0.55
WBTH 017	208403	adj water bore in gully	22/02/2012	23/02/2012	200	30	177	-	-	metasediments	51	1	9.91	7/03/2012	0.57
WBTH 018	208381	pit sw obs	23/02/2012	26/02/2012	200	60	177	-	-	metasediments	92	2	21.23	7/03/2012	0.97
WBTH 019	208382	northern footwall granite obs	26/02/2012	28/02/2012	200	72	177	-	-	granite	58	<1	21.43	7/03/2012	0.48
WBTH 020	208383	pit north obs	28/02/2012	1/03/2012	126	120	124	-	-	metasediments	60	2	31.96	7/03/2012	1.23
WBTH 021	208384	pit south east	1/03/2012	3/03/2012	200	90	177	-	-	metasediments	80	0.25	17.8	7/03/2012	0.96
WBTH 022	208385	Leprena	5/03/2012	6/03/2012	200	60	177	-	-	metasediments	96	seep	dry	7/03/2012	-

As shown in Table I-1, air lift yields were highly variable, ranging from effectively zero to in excess of 10 l/s. Many wells that were sited to target known structures failed to produce water at significant rates, with only WBTH 001, WBTH 5 and WBTH 013 yielding at rates in excess of 5 l/s. Even wells that were sited by REX geologists on known structures, such as the Pine Point Fault failed to produce water at significant rates (WBTH 001, 005 and 013). Deep weathering was encountered at many locations, with joints and fractures within the rocks being in-filled with clay minerals. This was evident in metasediments, skarn and granites. However, relatively unweathered rock was also found on drilling to be low yielding.

Observations during drilling indicated that much of the flow constituting the air lift yields occurred in the saprock interval (the zone below the base of saprolite and above fresh rock).

I.1 Depth to water monitoring

Well locations and casing elevations were survey levelled by REX staff in February 2012. Depth to water (SWL) in these wells was measured on 7 March 2012. SWL and water elevations derived from these surveys are presented in Table I-2. A potentiometric surface map derived from these water elevations is presented as Figure I-2.

Table I-2: SWL and water elevations - 7 March 2012

Hole number	Easting	Northing	Ground elev (mAHD)	Casing height (mAGL)	Elevation TOC	SWL (mTOC)	Water elevation (mAHD)
WBTH-001	763748.66	6175000.5	36.91	0.94	37.85	29.7	8.15
WBTH-002	763475.32	6175600.1	44	0.7	44.7	33.87	10.83
WBTH-003	762943.89	6174973.2	59.4	0.82	60.22	31.88	28.34
WBTH-004	763099.41	6173999	43.1	0.45	43.55	12.63	30.92
WBTH-005	763330.75	6173564.7	45.5	0.35	45.85	21.96	23.89
WBTH-006	763674.08	6173297.4	42.02	1.13	43.15	26.44	16.71
WBTH-007	763490.27	6173141	44.1	0.63	44.73	21.52	23.21
WBTH-008	763747.94	6174499.7	44.19	0.84	45.03	35.96	9.07
WBTH-009	764279.74	6174314.7	31.2	0.78	31.98	28.73	3.25
WBTH-010	764115.32	6173726.5	22.4	0.75	23.15	18.82	4.33
WBTH-011	764292.77	6174995.4	23.1	0.58	23.68	21.4	2.28
WBTH-012	764559.31	6174133.8	27.08	0.81	27.89	25.23	2.66
WBTH-013	764675.35	6175921.1	23.59	0.81	24.4	23.5	0.9
WBTH-014	763260.07	6174292.5	44	0.66	44.66	dry	
WBTH-015	763244.39	6173800.3	43.4	0.8	44.2	12.96	31.24
WBTH-016	763737.86	6174358.8	45.6	0.7	46.3	36.55	9.75
WBTH-017	763319.04	6174095.7	35	0.65	35.65	9.91	25.74
WBTH-018	763364.28	6173589.3	44.69	0.95	45.64	21.23	24.41
WBTH-019	764288.83	6174963.5	23.87	1.2	25.07	21.43	3.64
WBTH-020	763759.25	6174951.9	39.18	1.23	40.41	31.96	8.45
WBTH-021	763675.01	6173204.4	42.8	0.96	43.76	17.8	25.96

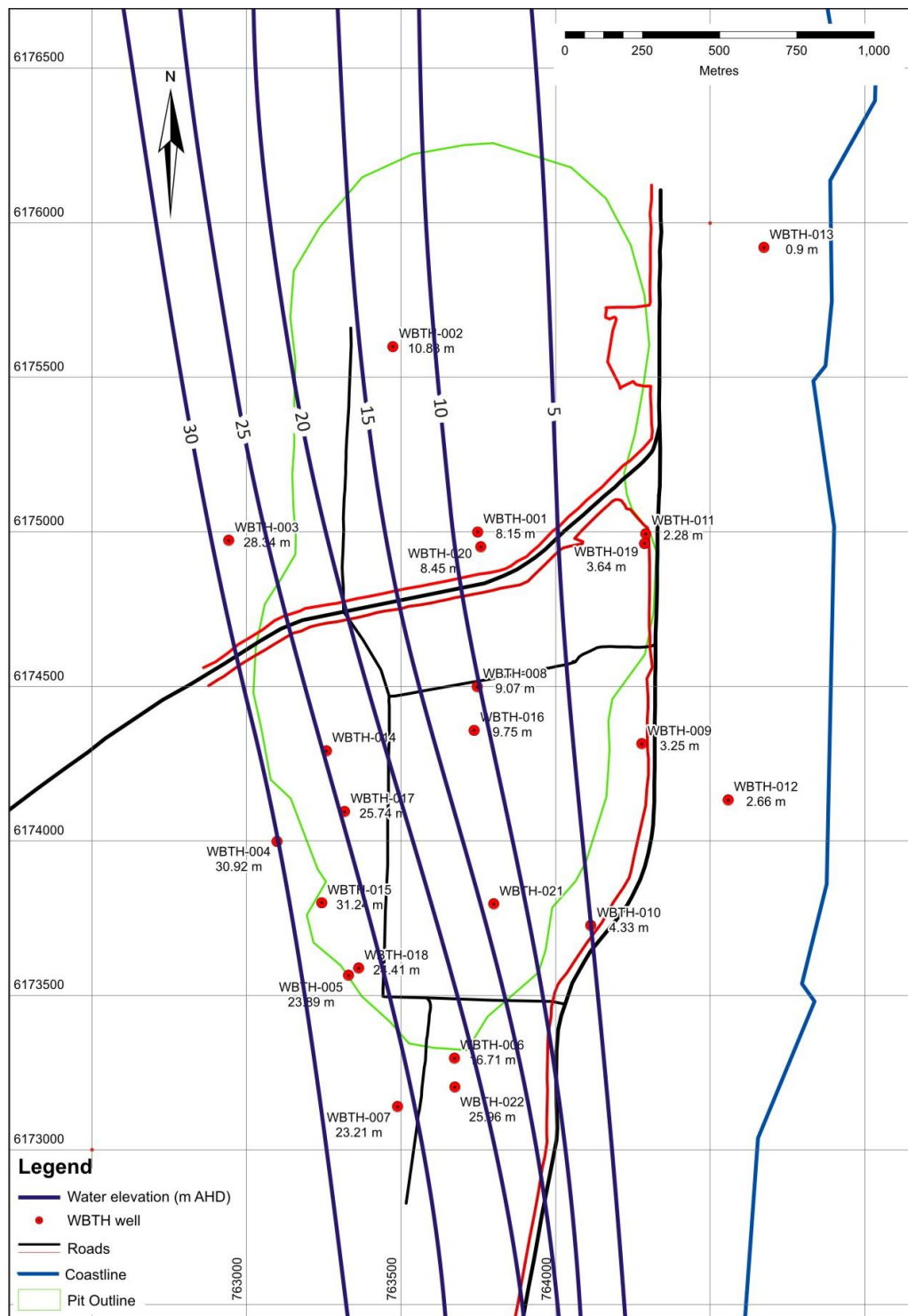


Figure I-2: Potentiometric surface map - basement aquifer - March 2012

As shown in Figure I-2, the potentiometric surface contours indicate that groundwater flows from west to east toward Gulf St Vincent under a hydraulic gradient of approximately 0.02.

2 SUPERVISION OF TEST PUMPING AND RECOVERY TESTING

Test pumping was carried out by Aldam Geoscience with the assistance of REX equipment and personnel. This included a submersible pump, power supply, lay flat riser, well head works (flange, elbow, fittings), gate valve, flow meter and discharge line. The submersible pump was attached to a 'lay flat' riser with integral power cord and lowered into each well by suspending the riser/pump from a tractor and lowering it to the well to a depth of 90 metres below top of casing. This provided an available drawdown of test pumping generally in the range 50 to 60 metres.

A water level dipmeter conduit was also installed to just above the pump to enable depth to water measurements to be taken without snagging the dipmeter tape on the pump riser. The lay flat discharge riser was attached to an elbow which was attached to a gate valve and flow meter to enable discharge to be set, measured and maintained at a constant rate during testing. The discharge line was then connected to poly piping to enable water to be discharged, which was to dams where available and to holding tanks where not. Water discharged to holding tanks was then pumped to water tankers and transported to the main water holding dams on the Hillside property.

When the pump was installed, the pump was turned on and the discharge rate set for the test. This was achieved by measuring the rate of change of water level for various pumping rates using a calibrated dip meter and selecting a rate that would enable the test to occur for a time period sufficient for the collection of meaningful data. When the rate had been established, the pump was turned off and water levels allowed to recover overnight prior to test commencement.

On the morning of testing, depth to water was measured in the well being tested and selected observation wells. These were generally the nearest investigation wells and on occasion geotechnical investigation holes. The test was then commenced with depth to water measured regularly on a logarithmic frequency (every minute from 1 to 10 min, 2 mins from 10 to 30 min, and 5 mins from 30 to 60 min), with the period of measurement increasing until depth to water measurements were taken hourly. The discharge rate was also monitored and maintained at a constant rate. These data were manually recorded and transferred to spreadsheet for analysis.

Water samples were also collected during the test and sent to a NATA accredited laboratory for analysis. The pump used when pump testing was sited 90 metres below the top of the casing.

Wells that produced water at approximately 1 l/s or more were test pumped. Testing occurred in the period 23 February to the 11 March 2012 and involved installing a submersible pump down each test well and pumping that well at a constant rate for durations of up to 1470 minutes. The change in water level was monitored with time and the results recorded for interpretation. A summary of test pumping activities is presented in Table 2-1.

Nearby wells and available diamond drill holes/geotechnical investigation drill holes were also monitored during testing and changes in water level recorded as observation well responses.

A summary of wells pumped and duration of testing is presented in Table 2-1. Wells WBTH 003, 006, 007, 014, 016, 021 and 022 were not tested as they were dry or very low yielding (less than 1 l/s). Wells WBTH 018, 019, 020 were installed as observation wells for the test pumping of wells WBTH 005, 011, and 001 respectively.

Table 2-1: Wells Pumped and Duration of Testing

Well pumped	Location	Date tested	Test duration (min)	Pumping rate (l/s)	Maximum drawdown (m)
WBTH 001	Pit central/northern	11/03/2012	1805	1.02	3.8
WBTH 002 (test 2)	Northern fault extensions	22/03/2012	142	0.26	11.7
WBTH 004	Hanging wall south	23/03/2012	420	0.22	3.32
WBTH 005	Pit south west	16/03/2012	1815	1.25	8.21
WBTH 008	Pit central	23/02/2012	398	0.5	8.13
WBTH 8 test 2	Pit central	5/03/2012	1470	0.5	8.77
WBTH 009 (test 1)	Footwall granite central	18/03/2012	155	0.4	5.85
WBTH 009 (test 2)	Footwall granite central	19/03/2012	480	0.5	8.42
WBTH 010	Footwall granite	26/02/2012	300	1.1	2.86
WBTH 011	Footwall granite	7/03/2012	1320	0.98	1.62
WBTH 012	Coastal granite	20/03/2012	950	0.58	5.48
WBTH 013	Granite coastal north	11/04/2012	720	6.67	3.92
WBTH 015	Pine Point Fault	28/03/2012	595	0.26	11.09
WBTH 017	Dart Fault adj supply well	29/02/2012	480	0.58	12.16

Recovery testing was completed on selected holes but was not used in any of the data analysis as sufficiently good data was obtained from the pump testing.

3 DATA ANALYSIS

The analysis of test pumping data was carried out by Aldam Geoscience using Clarke (1988) test pumping analysis software. A summary of test pumping analysis is presented as Table 3-1. Wells WBTH 03, 6, 7, 14, 16, 18, 19, 20, 21 and 22 were not test pumped due to very low yields obtained during air lift development.

Table 3-1: Test Pumping Analysis Summary

Pumped well	Well analysed	Analytical method (using Clarke 1998)	Transmissivity (m ² /d)	Storage coefficient (unitless)
WBTH 001	WBTH 001 (pumped well)	Confined, singly bounded	21.94	0.03514
	WBTH 001 (pumped well)	Confined partially bounded strip	22.24	0.03337
WBTH 002	WBTH 020	Confined aquifer with recharge boundary	12.35	0.00019
	WBTH 020	Leaky artesian strip	12.35	0.00017
	WBTH 002 (pumped well)	Leaky artesian, semi bounded	0.45553	0.05845
WBTH 004	WBTH 004 (pumped well)	Leaky artesian, infinite	1.00284	0.75535
WBTH 005	WBTH 018	Confined, infinite	11.6451	0.00028
	WBTH 005 (pumped well)	Confined, semi bounded	20.14	0.16367
WBTH 008	WBTH 016	Confined, semi bounded	1.68179	0.02052
	Metallurgy well	Confined, semi bounded	5.97163	0.08129
	WBTH 008 (pumped well)	Confined, semi bounded	2.27305	0.32929
WBTH 009	WBTH 009 (pumped well)	Confined, semi bounded	1.8954	0.16189
WBTH 010	WBTH 010 (pumped well)	Leaky artesian, partially bounded strip	33.29	0.06850
WBTH 011	WBTH 011 (pumped well)	Confined, semi bounded	2.098	0.34100
	WBTH 019 (obs well)	Confined, semi bounded	13.79	0.00030
WBTH 012	WBTH 012 (pumped well)	Leaky artesian, semi bounded	12.56	0.05854
WBTH 013	WBTH 013 (pumped well)	Confined, infinite	253.159	0.00000
	WBTH 013 (pumped well)	Leaky artesian, infinite	160.359	0.00234
WBTH 015	WBTH 015 (pumped well)	Confined, semi bounded	1.30187	0.44736
WBTH 017	WBTH 017 (pumped well)	Confined, semi bounded	2.01904	0.12030

As shown in Table 3-1, transmissivities varied from less than 1 m²/d to over 250 m²/d. It is concluded that wells with low transmissivities did not encounter significant and transmissive fractures or that

fractures present had been in-filled ('healed') by fluids associated with mineralisation or clay minerals resulting from deep weathering.

Storage coefficient values ranged from 0.1 to 0.000004. High storage coefficient values are generally indicative of unconfined aquifer conditions; whereas, low values are typically obtained in confined aquifers.

Transmissivities from test pumping analysis are presented grouped according to domain below.

T values from the hanging wall, the southern and northern fault extensions, and Leprena are very low (<1), values from the Pine Point and Dart faults are low (<2), from the footwall granites are low to moderate (1 – 33), from the pit are low to moderate and from the coastal granites range from low to very high (12 – 253).

These ranges have been used in the construction of the groundwater model for the site and surrounds.

The highest values were obtained in wells WBTH 005, 10, 12 and are thought to be due to the wells having intersected discrete fractures. The wells with low T are thought not to have been completed in major fractures and faults, or in such features that have been healed with fluids associated with mineralisation or deep weathering (e.g. Pine Point Fault).

Table 3-2: Well Transmissivity Values

Location	Well	Transmissivity (m ² /d)
Pit	WBTH 001	12 to 22
Pit	WBTH 005	11 to 20
Pit	WBTH 008	1 to 6
Pit	WBTH 021	<1
Northern fault extensions	WBTH 002	<1
Hanging wall	WBTH 003	<1
Hanging wall	WBTH 004	1.00
Southern fault extensions	WBTH 007	<1
Leprena	WBTH 006	<1
Leprena	WBTH 022	<1
Footwall granite	WBTH 009	1.89
Footwall granite	WBTH 010	33.00
Footwall granite	WBTH 011	2.00
Coastal granite	WBTH 012	12.56
Coastal granite	WBTH 013	253.00
Pine Point fault	WBTH 014	<1
Pine Point fault	WBTH 015	1.30
Dart fault	WBTH 017	2.00

Please see Appendix A for the complete data analyses.

3.1 Groundwater sampling and analysis

Groundwater samples were collected from each well during test pumping and dispatched to MGT Environmental Consulting Pty Ltd (MGT) for laboratory analysis for anions, cations, pH, electrical conductivity (EC), metals and nutrients. Analytical results are presented in Table 3-3. Analyses from a sample of sea water collected on 12 April 2012 are also included.

The results indicate that groundwater on site is saline to hyper saline, is neutral to slightly acidic pH, and contains high concentrations of sodium, chloride and magnesium, but generally low metals concentrations. Nutrient concentrations are also low. Water from well WBTH 013 is very similar to sea water.

Metals concentrations are generally low but have not been measured against any specific criteria. Such criteria have not been included in this report as it is understood that groundwater at Hillside is not used for human consumption, irrigation, stock purposes, nor does it support groundwater dependent ecosystems. Marine discharge criteria have not been included as this groundwater moves from west to east (refer Figure 5-5) and discharges to the sea via natural processes (refer Figure 1-2).

Table 3-3: Hillside water chemistry

WELL	WBTH 001	WBTH 002	WBTH 004	WBTH 005	WBTH 009	WBTH 012	WBTH 8	WBTH 10	WBTH 11	WBTH 17	WBTH 013	SEAWATER
Date sampled	11-Mar	22-Mar	23-Mar	16-Mar	19-Mar	21-Mar	5-Mar	27-Feb	7-Mar	29-Feb	11-Apr	12-Apr
Chloride	12000	16000	10000	13000	15000	15000	11000	13000	24000	11000	21000	22000
Conductivity	39000	47000	32000	40000	46000	47000	35000	38000	72000	36000	63000	66000
Nitrate (as N)	< 0.02	3.7	< 0.02	< 0.02	< 0.02	< 0.02	0.05	0.51	0.03	0.53	< 0.02	< 0.02
Nitrite (as N)	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
pH	7.1	7.1	7.2	7.2	6.8	6.2	7.3	7	6.8	7.3	6.9	8.3
Total Dissolved Solids	24000	29000	20000	24000	29000	29000	21000	25000	46000	22000	39000	40000
Calcium	400	550	360	410	450	390	370	400	1300	410	940	600
Magnesium	1000	1300	700	850	1100	1000	810	980	1900	820	1500	1800
Potassium	110	120	110	130	140	170	110	130	200	120	190	560
Sodium	6700	8500	5900	7200	8200	8200	6100	7200	11000	6200	10000	11000
Bicarbonate Alkalinity-mg CaCO ₃ /L	620	840	590	630	240	83	490	310	310	660	320	120
Carbonate Alkalinity-mg CaCO ₃ /L	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	18
Sulphate (S)	850	990	680	800	930	980	730	810	770	690	1000	1100
Nitrate and Nitrite (N)	< 0.05	3.7	< 0.05	< 0.05	< 0.05	< 0.05	0.06	0.51	< 0.05	0.54	< 0.05	< 0.05
Total Kjeldahl Nitrogen (N)	< 0.2	< 0.2	< 0.2	0.2	0.6	1.5	0.4	0.3	< 0.2	< 0.2	< 0.2	< 0.2
Total Nitrogen (N)	< 0.2	3.7	< 0.2	0.2	0.6	1.5	0.5	0.8	< 0.2	0.5	< 0.2	< 0.2
Ammonia(N)	< 0.01	< 0.01	< 0.01	0.15	0.55	1.4	0.37	0.23	0.12	0.06	0.03	0.05
Arsenic (filtered)	0.007	0.014	0.007	0.008	0.004	0.003	0.015	0.014	0.006	< 0.001	0.017	0.021
Barium (filtered)	0.03	0.03	0.02	0.04	< 0.02	< 0.02	0.02	0.02	0.04	0.03	< 0.1	< 0.1
Beryllium (filtered)	< 0.001	< 0.001	< 0.001	< 0.001	0.003	0.013	0.001	0.001	< 0.001	< 0.001	< 0.005	< 0.005
Boron (filtered)	1.7	5.5	5.3	2	4.6	5	4	3.7	3.7	4.4	2.8	2.9
Cadmium (filtered)	< 0.0002	0.0003	< 0.0002	< 0.0002	0.0003	0.001	0.0002	0.0002	< .0002	< .0002	< 0.001	< 0.001
Chromium (filtered)	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	0.005	0.005	0.008	0.006	< 0.005	< 0.005
Cobalt (filtered)	0.004	0.003	< 0.001	0.013	0.012	0.031	0.019	0.015	0.005	0.016	0.005	< 0.005
Copper (filtered)	0.15	0.024	0.39	0.033	0.003	0.005	2.8	0.012	0.014	0.18	0.012	< 0.005
Iron (filtered)	1.8	1.6	1	2	2.4	10	2.5	2.6	8.8	3	4	1.4

WELL	WBTH 001	WBTH 002	WBTH 004	WBTH 005	WBTH 009	WBTH 012	WBTH 8	WBTH 10	WBTH 11	WBTH 17	WBTH 013	SEAWATER
Lead (filtered)	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.006	< 0.001	< 0.001	< 0.001	< 0.001	< 0.005	< 0.005
Manganese (filtered)	0.4	0.04	0.1	1.3	3	8	2.3	2.6	3.9	0.19	2	< 0.025
Mercury (filtered)	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< .0001	< .0001	< .0001	< 0.0001	< 0.0001
Molybdenum (filtered)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.015
Nickel (filtered)	0.002	0.01	0.003	0.003	0.011	0.019	0.005	0.012	0.021	0.014	0.005	< 0.005
Selenium (filtered)	0.049	0.072	0.05	0.051	0.03	0.021	0.14	0.17	0.35	0.17	0.082	0.092
Silver (filtered)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Tin (filtered)	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.025	< 0.025
Zinc (filtered)	0.015	0.02	0.014	0.017	0.009	0.01	0.011	0.004	0.004	0.008	0.025	0.018
Antimony (filtered)	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	< 0.025	< 0.025
Thallium (filtered)	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	0.001	< 0.001
Uranium (filtered)	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	0.078	< 0.025
Sulphide (S)	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	< 0.05	< 0.05
Suspended Solids	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	39	19
Phosphate total (P)	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	0.06	< 0.05
Phosphorus (filtered)	NM	NM	NM	NM	NM	NM	NM	NM	NM	NM	< 5	< 5

4 REVISED CONCEPTUAL MODEL

The drilling and test pumping program produced results that did not match predicted outcomes, particularly with respect to yields from major structures on site. Only two sites on the Hillside and Germein blocks produced water at high air lift rates and produced high transmissivities on test pumping (WBTH 001 and WBTH 008). In addition, only one well that was completed in granites (WBTH 013) was found to be high yielding and of high transmissivity, even though drill core indicated the presence of significant fracture sets. Likewise, areas shown by diamond drilling to be highly fractured did not produce high yields when drilled for water, even when high yields were recorded during RC drilling.

Drilling has indicated that Tertiary / Quaternary age aquifers do not occur on site (except as local 'perched' or seasonal aquifers) and that the fractured basement rocks form a single confined aquifer. This aquifer is confined by saprolitic materials derived from the weathering of the basement rocks. Test pumping indicates that well yields and aquifer hydraulic conductivities / transmissivities at sites drilled are in general, low, with high yields and transmissivities occurring at isolated locations only. This indicates that structures present at Hillside do not appear to be as transmissive as originally thought from the desktop study, due mainly to their infilling with clayey materials derived from deep weathering. However, wells were drilled vertical (90°), and it is possible that more transmissive fracture sets could be intersected by wells drilled at lesser angles. Drilling indicates that, other than where significant open fractures have been encountered, the saprock interval that occurs between the saprolite and the underlying fresh rocks are the highest yielding unit.

It was concluded that the majority of rock mass on site, whilst being highly fractured, jointed and faulted, was of low transmissivity, resulting from the effects of weathering and kaolinisation. It was also considered that fracture porosity did not increase with depth, and that the greatest fracture porosity occurs within the saprock interval. High yielding fractures are thought to be open and transmissive due to more recent fracture development that postdates the episode of deep weathering. Some open and transmissive fracture sets could persist at depths to or below the proposed pit floor level.

The Pine Point Fault was found to be almost dry, due principally to the weathering of metasediments. Other fault systems were either not encountered or were weathered and filled. Exceptions were fractures at WBTH 005 and WBTH 001, both wells producing high air lift yields during drilling. However, test pumping indicates that the aquifer at these locations is of low to moderate transmissivity, with it likely that individual fractures or discrete fracture sets being the source of the high yields.

Wells were also drilled into fresh rock that did not yield significant quantities of water. This was concluded to indicate that fractures, if present in the domain (eg Leprena), were either not intersected by drilling or were in a state of compression and therefore not able to store and transmit significant volumes of water.

Well WBTH 013, located to the north east of the Hillside Deposit in the coastal granites intersected an aquifer that produced an air lift yield in excess of 10 l/s. Test pumping also indicated that the aquifer at that location is of moderate to high transmissivity.

The zoning of aquifer properties differs from the conceptual model as the northern fault extensions, southern fault extensions, Leprena and hanging wall domains were assigned the same values. This was based on test pumping results, which did not provide data to support the hydrogeological differentiation of the hanging wall metasediments from the northern and southern fault extensions. Likewise, the Leprena ore body has been found thus far to be of very low hydraulic conductivity, so it was assigned properties identical to the southern fault extensions.

5 DEVELOP NUMERICAL GROUNDWATER MODEL

A digital groundwater model was constructed for the Hillside project area to enable dewatering rates to be estimated and the potential effects of dewatering to be evaluated. It was developed using 'MODFLOW' groundwater modelling software (Harborogh and Mac Donald 1966), supported by the pre and post-processing platform PMWIN (Simcore Software 2010).

5.1 Model set-up

A model domain extending from 761000E to 765800E and 6172000N to 6178000N (see Figure 5-1) was established based on the conceptual pit design.



Figure 5-1: Groundwater model – model domain

The model consists of 4 layers, each of which has 472 rows and 260 columns ranging in size from 100 x 100 m to 5 x 5 m in the area of the pit (Figure 5-2).

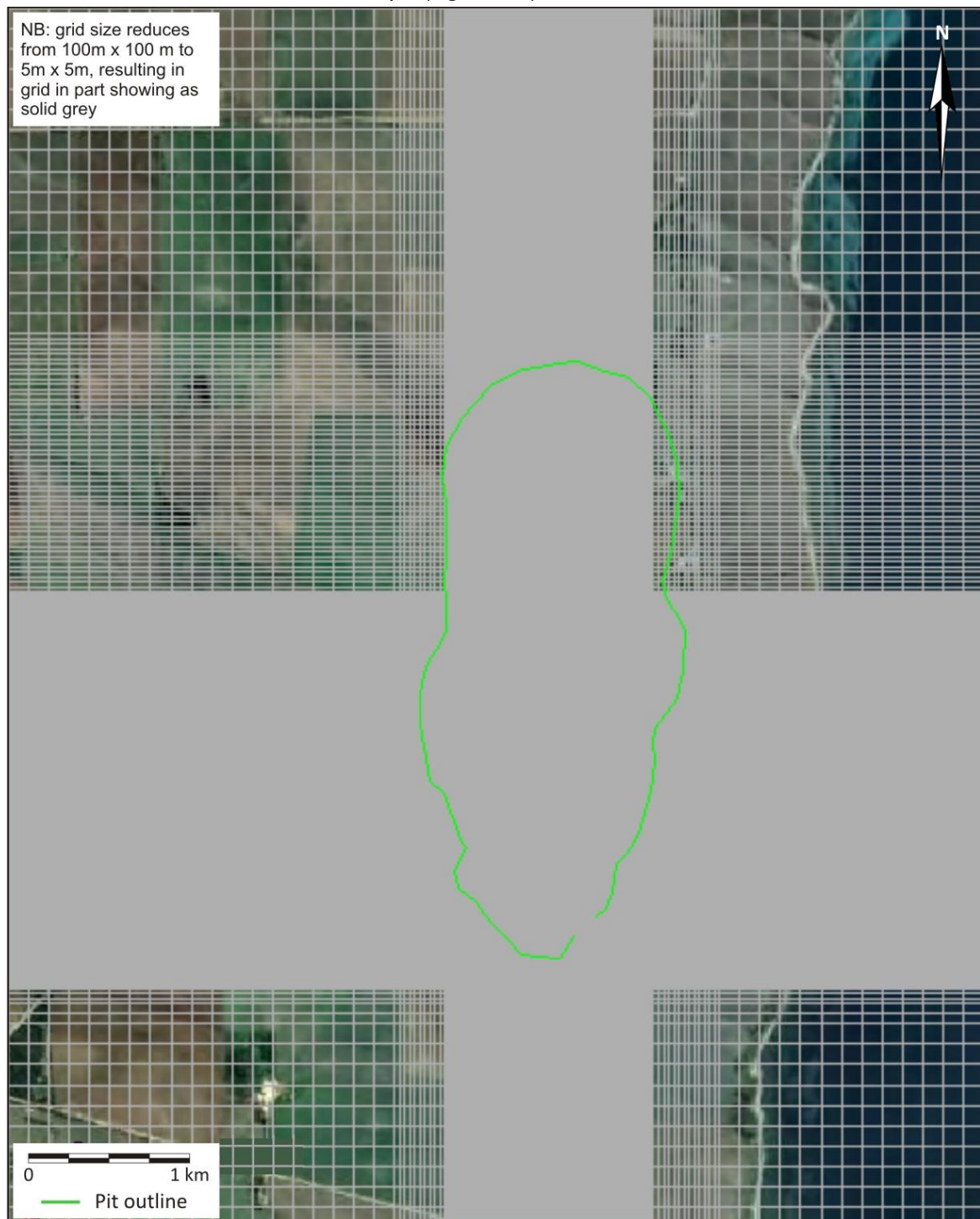


Figure 5-2: Groundwater model – model grid

Vertical discretisation was into four layers as follows:-

- LAYER 1 Superficial Quaternary deposits – largely dry
- LAYER 2 Saprolitic zone
- LAYER 3 Part-weathered fractured bedrock (saprock) intersected by water drilling program
- LAYER 4 Less permeable fractured bedrock

The geometry of the layer bases was derived with the aid of diamond, RC and groundwater (hammer/air) drilling data provided by REX with some modifications to permit contouring without overlaps between surfaces in complex sloping areas.

The model bottom surfaces are shown in Figure 5-3 (Layer 1), Figure 5-4 (Layer 2) and Figure 5-5 (Layer 3). The lowest layer (Layer 4) was set to extend down to -900 m AHD, i.e. a depth at which the base of the layer would not impact the modelling outcomes.

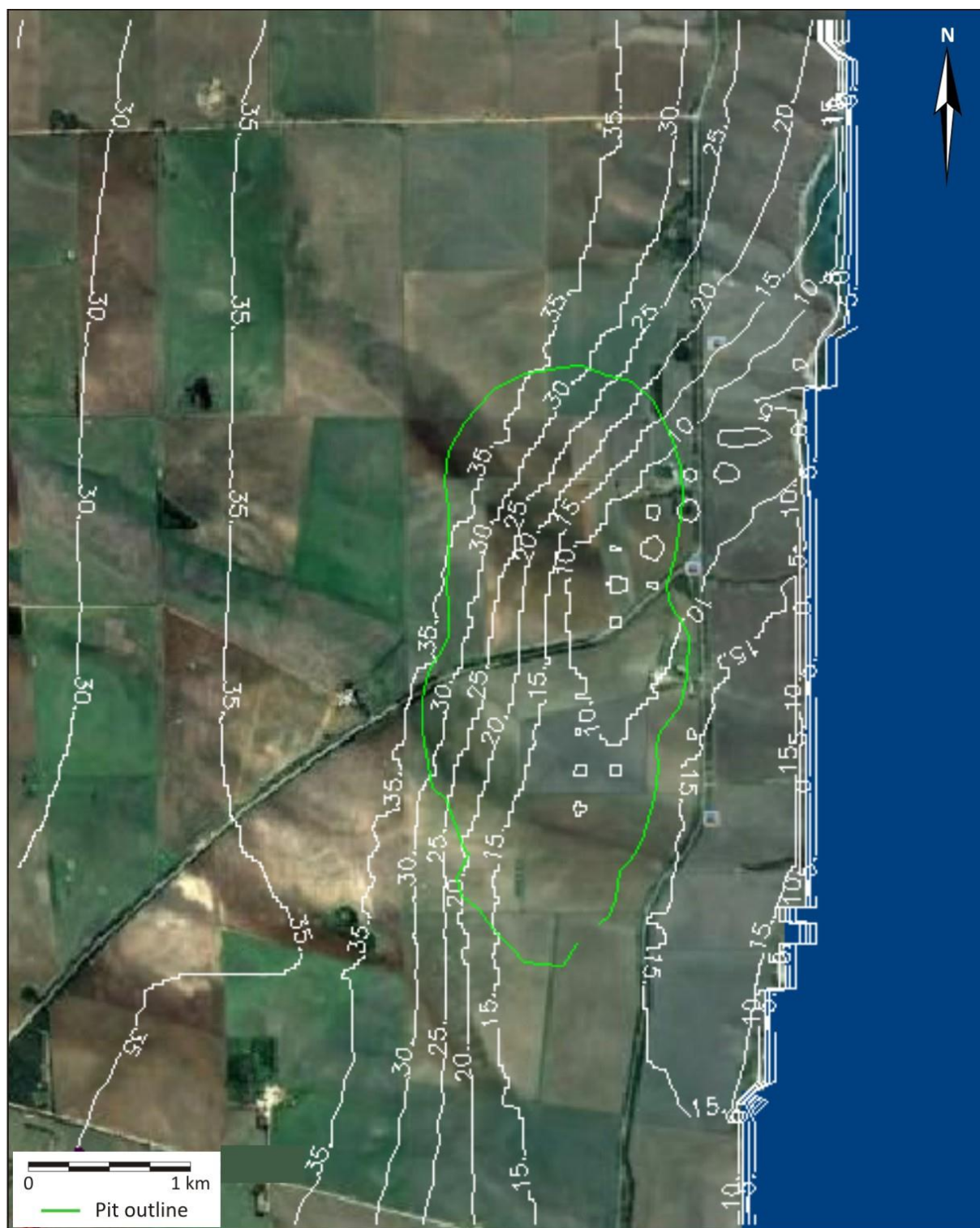


Figure 5-3: Groundwater model – base of Layer 1 elevation contours (m AHD)



Figure 5-4: Groundwater model – base of Layer 2 elevation contours (m AHD)



Figure 5-5: Groundwater model – base of Layer 3 elevation contours (m AHD)

Figure 5-6 shows a cross section of the model through the pit area with the deepest 400 m omitted so that the structure of the upper layers can be more clearly seen including a marked valley-like depression in the surfaces to the east of the pit position.

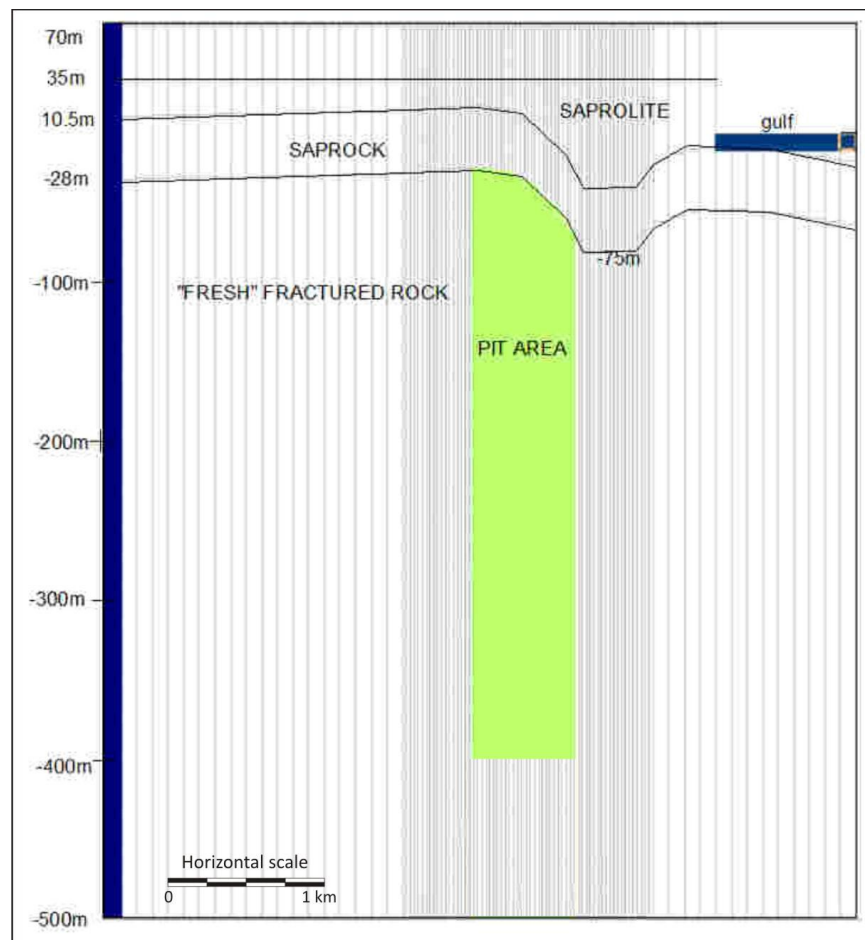


Figure 5-6: Groundwater model – west-east cross section

5.2 Aquifer properties

5.2.1 Hydraulic conductivity

Horizontal hydraulic conductivities (K_h) were assigned to model cells based on test pumping results and are summarized below:

- Layer 1 (largely above the water table) $K_h = 0.2$ m/day. Layer 1 consists of Quaternary and Tertiary age sediments, mainly sand and clay. Todd (1980) includes a table (Table 3.1) that displays the likely range of permeability values for rocks including sediments. Silt is shown as having an hydraulic conductivity of 0.08 m/d, so a value of 0.2 is considered to be representative of a material that is a little more sandy than silt;
- Layer 2 (mostly clayey saprolite) $K_h = 0.0001$ m/day. Table 3.1 of Todd (1980) states clay K to be 0.0002 m/d and a slightly higher value has been used. The St Vincent Basin Sediments to the east has a K_h of 0.5 m/day, based on a mid value between the Todd (1980) Table 3.1 values of 2.5 m/d for fine sand and 0.08 m/d for silt;
- Layer 3 – as shown in Figure 5-7. The majority of pumping tests were carried out in materials which have been grouped as layer 3 in the model. Three (3) domains were included in the model (with northern fault extensions, hanging wall, Leprena and southern fault extensions of the conceptual model being consolidated into a single domain) and K_h values allocated based on a

review of test results. The highest Kh domain was analysed as described in Section 3 and the value of 0.016m/day was believed to be representative of the rockmass without significant water bearing fractures structural features (e.g. faults and fractures); and

- Layer 4 – Layer 3 values * 0.1 m/day because it is assumed that Kh is likely to reduce with increasing depth as described in the pumping test section.

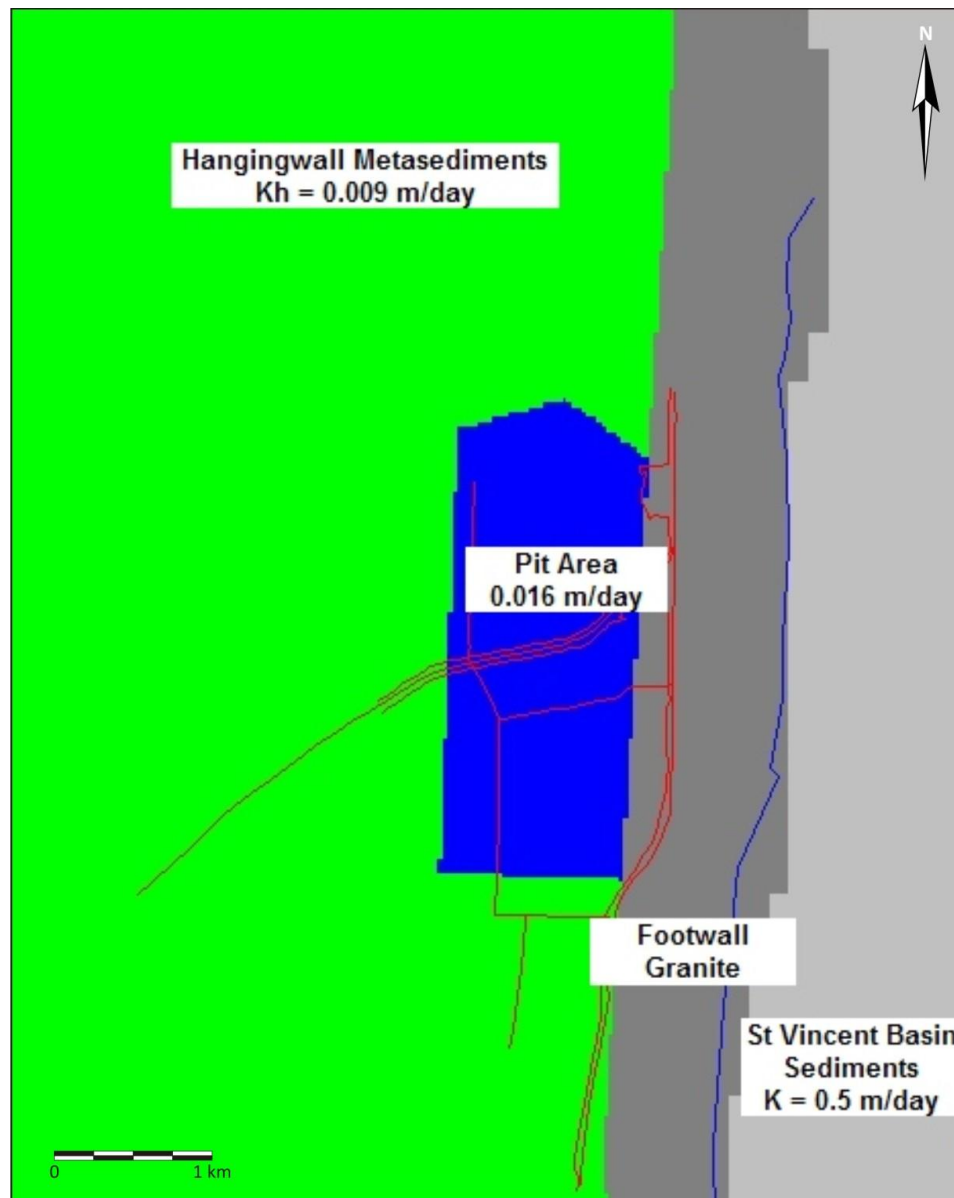


Figure 5-7: Groundwater model - kh values in Layer 3

Vertical Hydraulic Conductivities (Kv) were set as follows;

- Layer 1 Kv - 0.03 m/day, because in layered sediments the Kv value is generally accepted as falling in the range Kh/10 to Kh/3 due to anisotropy;
- Layer 2 Kv - 0.0001 m/day is similar but a little less than Kh for this layer, assuming that the saprolitic materials are relatively homogenous;
- Layer 3 Kv = Kh as it is assumed that the permeability of this layer is due to regularly spaced but minor fractures and the layer is thus homogenous; and

- Layer 4 $K_v = K_h/3$ as it is assumed that fractures become less open with depth, except for St Vincent Basin Sediments to the east where $K_v = K_h$ as the selected value is considered to be an average, non directional value.

5.2.2 Specific yield

Specific Yield (S_y) was set to a uniform value of 0.001% throughout the model domain to reflect the anticipated small proportion of voids associated with tight fractures in these basement rocks. This is consistent with the results produced from analysis of the pumping tests, which are believed to be more representative of the immediate vicinity of the tested wells than of the overall rock mass.

Specific Storage (S_s) was set to 0.005 in Layer 1 and 0.001 elsewhere. S_s is obtained by dividing storage coefficient by aquifer thickness (i.e. $S_s = S/b$). An aquifer thickness of 60m has been used in this calculation as the majority of water intersections occurred in the interval 90m to 150m. The average storage coefficient from pumping tests (omitting the anomalously high values which are believed to be unreasonable) is 0.06, leading to an S_s value of $0.06/60 = 0.001$. The Layer 1 value was increased 5-fold in recognition of the geologically much younger, less consolidated nature of the materials.

5.2.3 Initial heads

Initial heads (water elevations) for all layers were set as shown in Figure 5-8, but the geometry of the base of Layers 1 and 2 results in areas where both units are dry. The heads were controlled by general head boundary (GHB) cells whose head values were varied until a reasonable approximation of the observed heads and west to east hydraulic gradient across the pit was obtained.

Some very low observed heads within the pit area were omitted from the process until the detailed hydrogeology of the pit area is better understood, with specific reference to the suspected influence of structural zones which did not emerge clearly from the vertical drilling program conducted during the study.

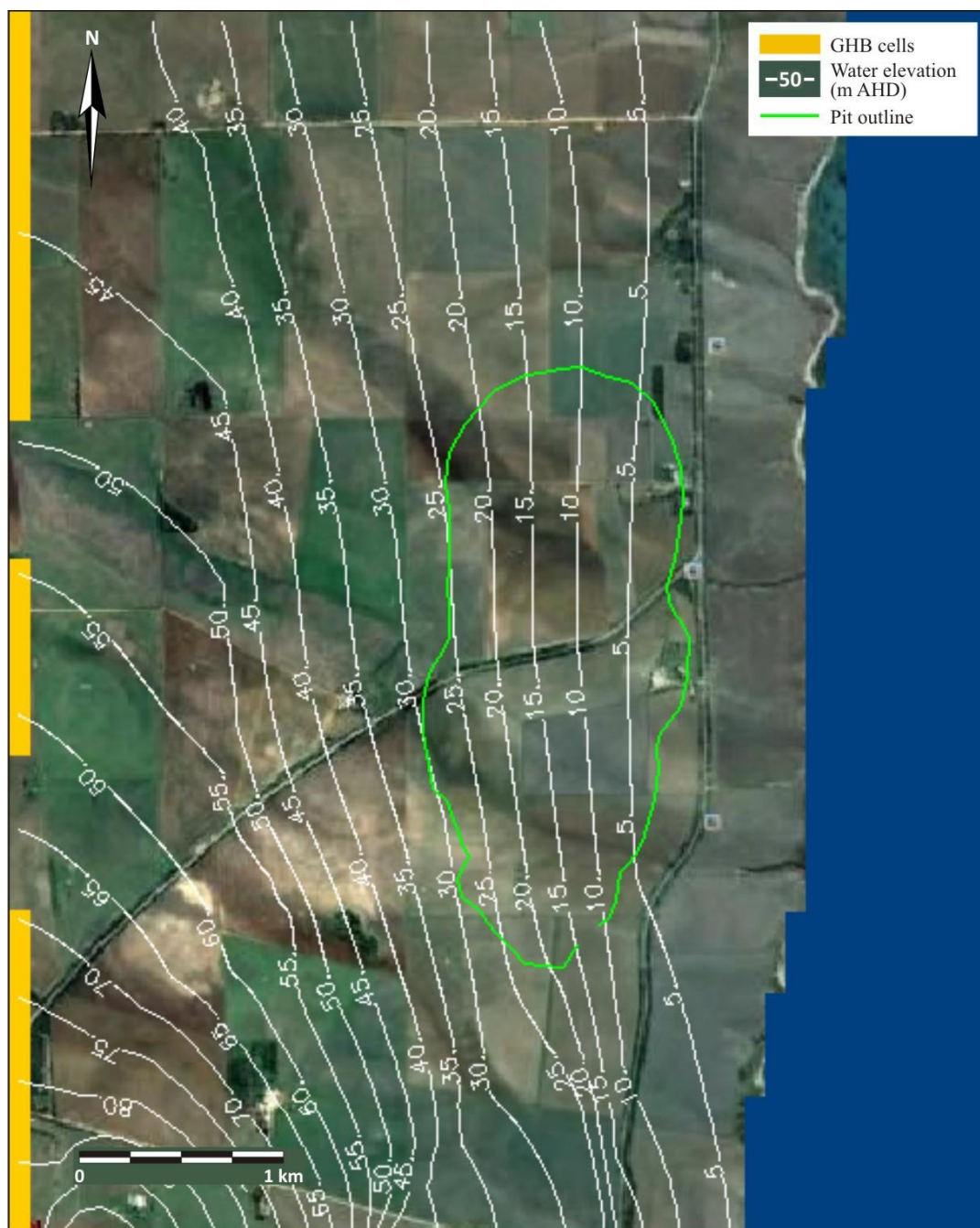


Figure 5-8: Groundwater model – initial heads, all layers

The blue area to the east of Figure 5-8 is the model representation of the gulf at sea level which is modelled using the “reservoir” package (dark blue in Figure 5-33). It is effectively a constant head source but with limited vertical connectivity with the underlying layer, for the purposes of water balance recording. The model reservoir is present only in layer 1. In other layers the shoreline is represented by a line of GHB cells set at zero m AHD.

5.2.4 Boundary conditions

General head boundary (GHB) cells were included in all layers at the locations shown in yellow in Figure 5-8. On the western boundary of the model domain heads were set at 87m AHD. In the southwest and northwest corner model domain heads were set at 42.5m AHD. A line of similar cells at 0 m AHD

defining the position of the model coastline where the gulf waters are represented by the reservoir package with the head set to 0m AHD.

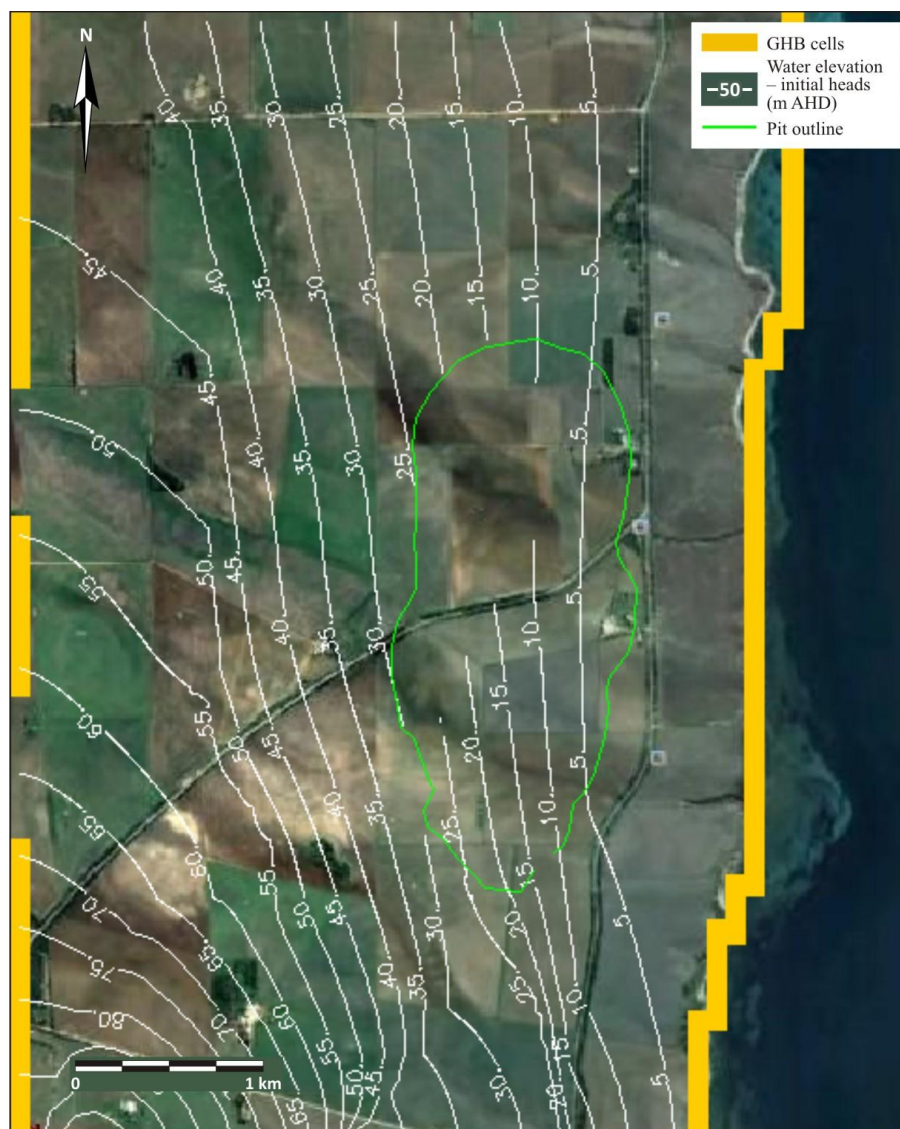


Figure 5-9: Groundwater model – general head boundary cells, all layers

The line of GHB cells representing the model shoreline also defines the western extent of the St Vincent Basin sediments which is believed also to coincide with the position of the Ardrossan Fault (Drexel and Preiss, 1995).

5.2.5 Recharge

In the absence of any useful pre-development groundwater monitoring data it was not possible to calibrate the model, therefore recharge (the principal parameter together with K used in calibration of water table levels) was omitted from this preliminary model.

Recharge to the basement rock aquifer below the saprolite has not been included in this model. However, recharge may occur at low rates through the saprolite, and could be included in subsequent versions if recharge data become available.

5.2.6 Dewatering philosophy

The low hydraulic conductivity (K) values obtained from test pumping within and outside the pit footprint suggest that dewatering using vertical pumped wells located on the pit crest will not be effective. This is because in tight units such as encountered at Hillside, the cone of depression and radius of influence of pumping is small, and the wells would be set back too far from the pit floor to maintain dry working conditions.

It was considered more realistic to use drain cells located on the pit floor as the model drainage simulation mechanism.

5.3 Final PFS design model runs

5.3.1 Open pit inflows

The proposed open pit mine life is 13 years. Pit outlines (crest, floor and walls) and elevation data for 13 successive years of mining has been modelled. These were incorporated into the model and the model was then run under transient conditions to provide estimates of dewatering rates for each year modelled. Pit crest and floor outlines are presented in Figures 1 to 13.

The model was run in 13 stress periods of one year duration with six time steps in each stress period.

The pit bottom at the end of each year (and stress period) was represented by an area of drain cells set to the elevations as shown in Figure 5-10 through to Figure 5-22 for the relevant year end (stress period).

The drain cells representing the higher (earlier) pit bottom edges were retained to ensure that the seepage profile did not deviate from the pit profile i.e. to ensure that upper levels remained drained as the pit became deeper.

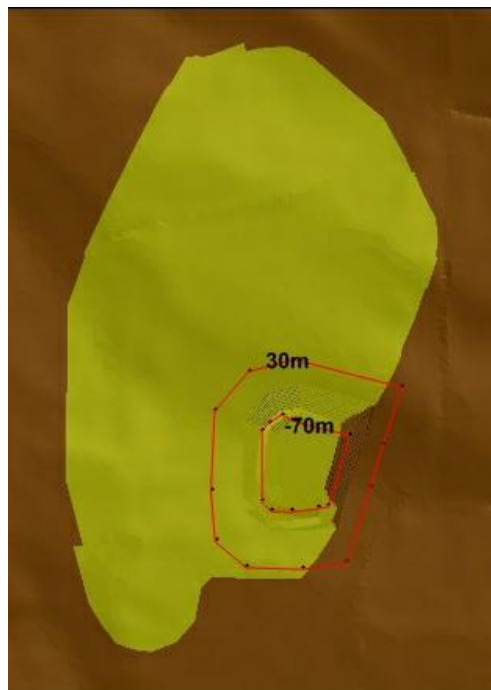


Figure 5-10: Year 1

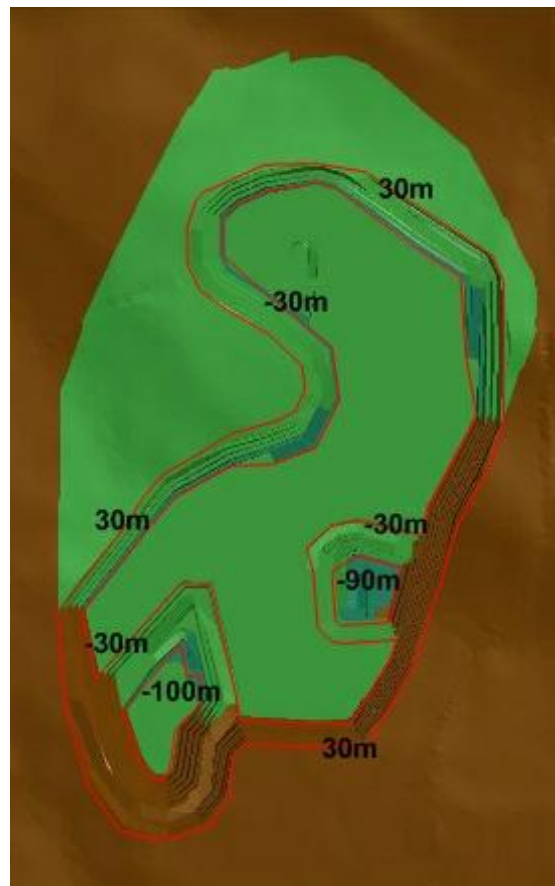


Figure 5-11: Year 2

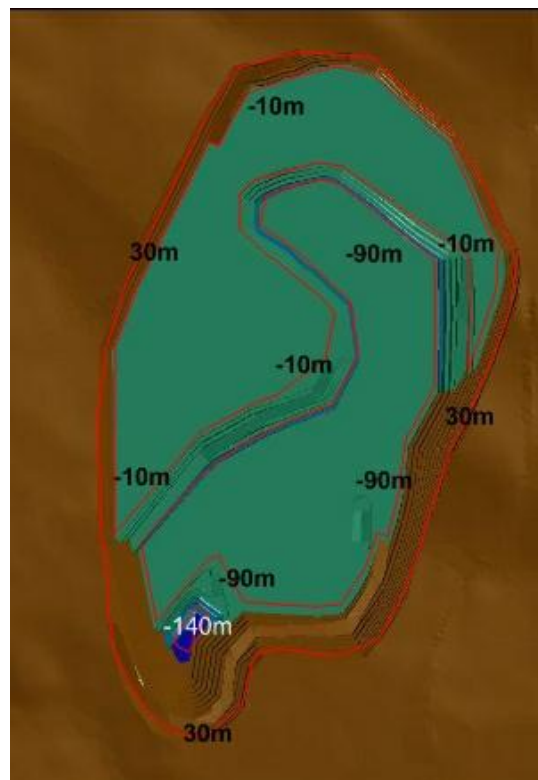


Figure 5-12: Year 3

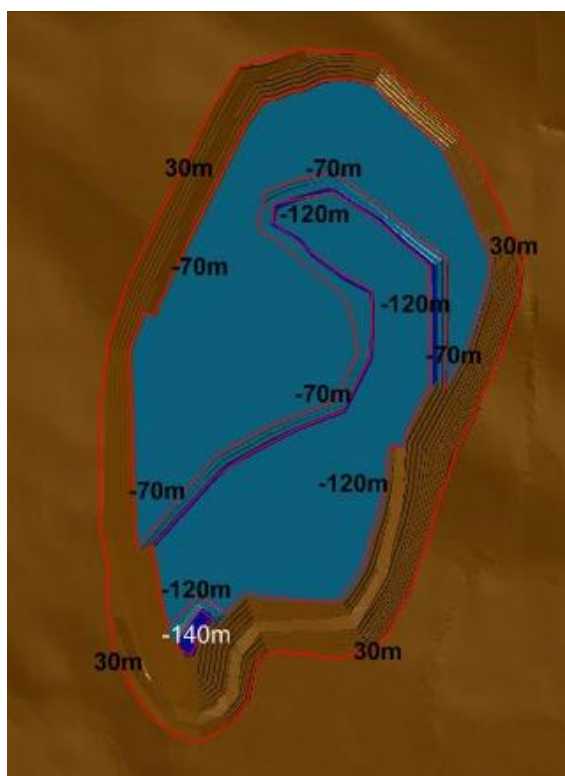


Figure 5-13: Year 4

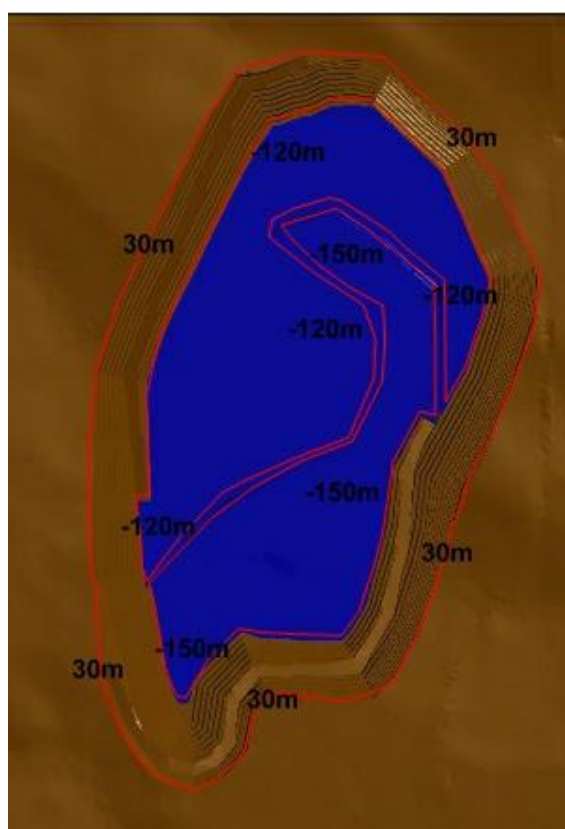


Figure 5-14: Year 5

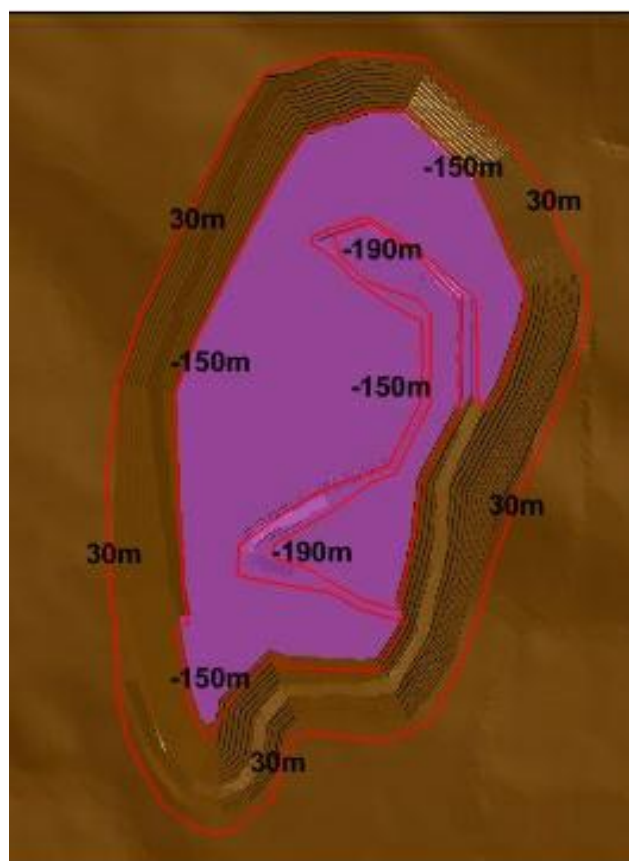


Figure 5-15: Year 6



Figure 5-16: Year 7

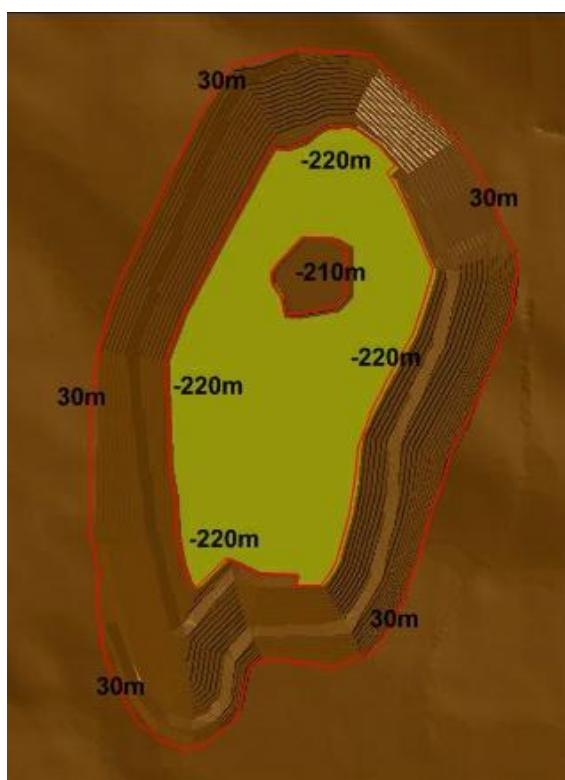


Figure 5-17: Year 8



Figure 5-18: Year 9



Figure 5-19: Year 10



Figure 5-20: Year 11



Figure 5-21: Year 12



Figure 5-22: Year 13

Water elevation contours

Model water elevations (hydraulic heads) resulting from the simulated pit excavation are shown for end of Years 3, 6, 9 and 13 in Figure 5-23 through to Figure 5-26, respectively.

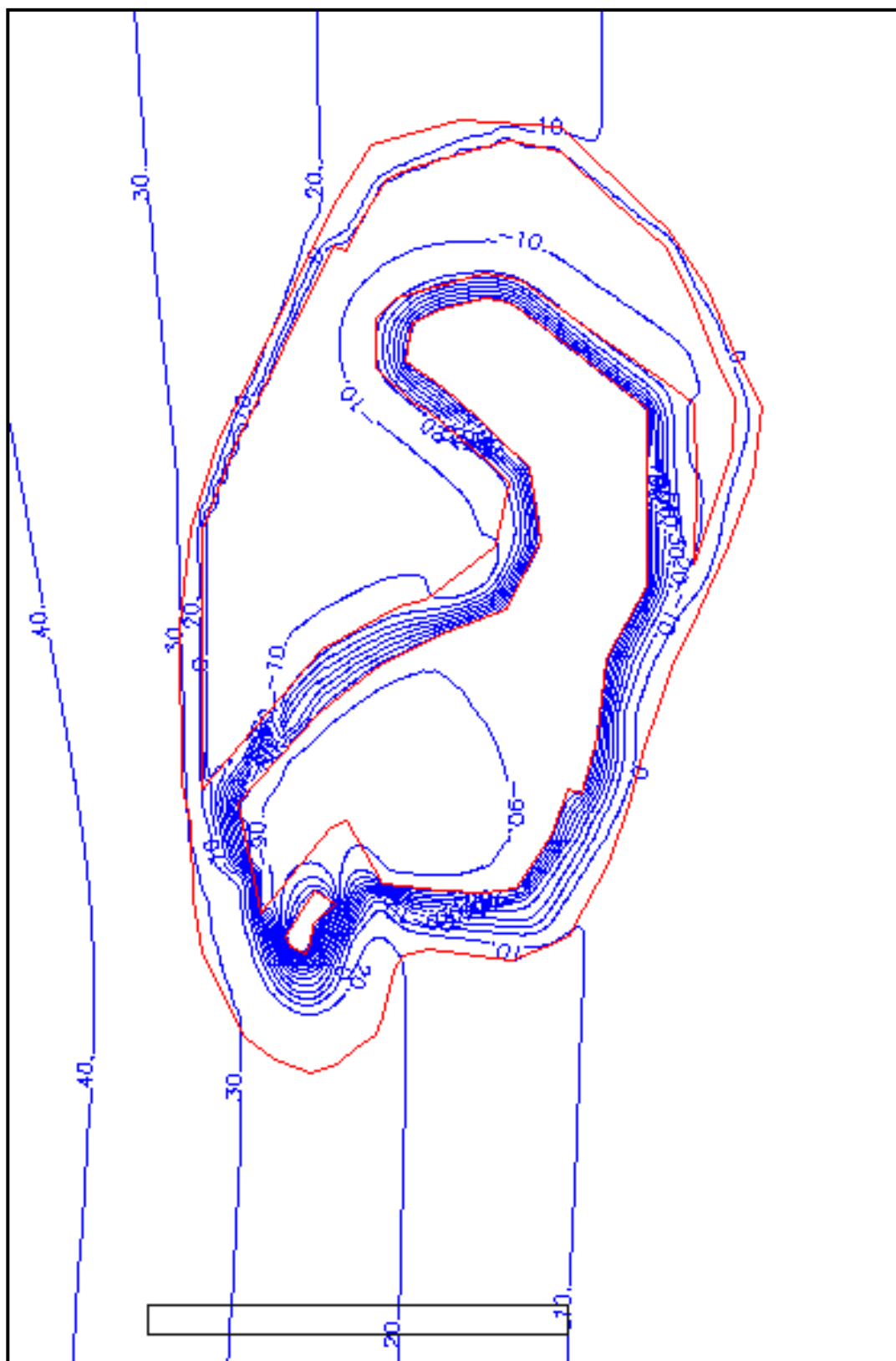


Figure 5-23: Model heads at end of Year 3

The closeness/proximity of the contours between the upper area at -10m AHD and the lower area at -90m AHD in Figure 1 indicates that the groundwater surface will be close to the pit walls, a common feature of a low permeability rockmass.

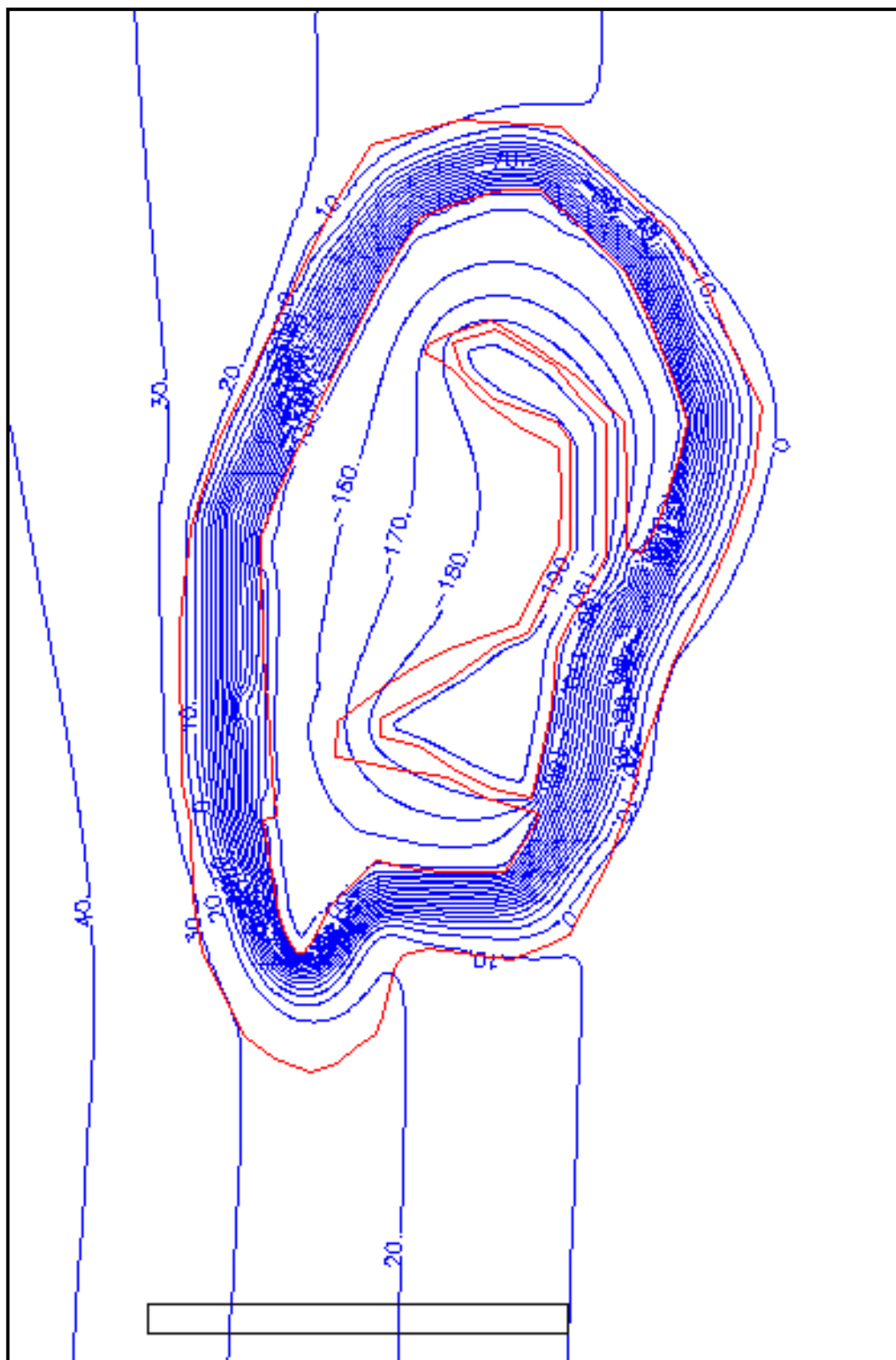


Figure 5-24: Model heads at end of Year 6.

The same feature is seen in Figure 5-24, the large upper floor area at -150m AHD

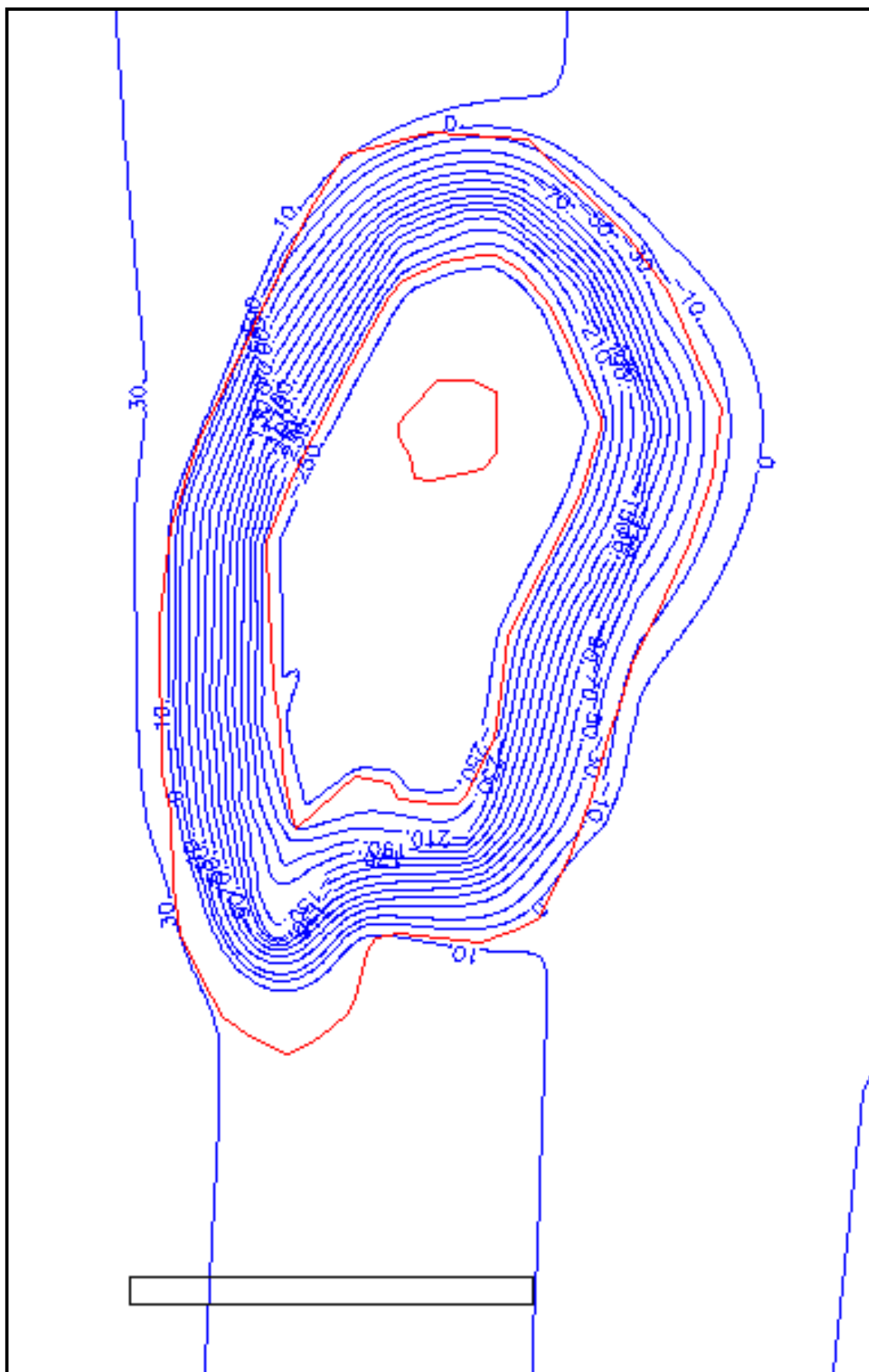


Figure 5-25: Model heads at end of Year 9

In Figure 5-25, the pit bottom is at -250 m AHD and the steep hydraulic gradient is clear even though the contour interval has been increased from 10 to 20 m.

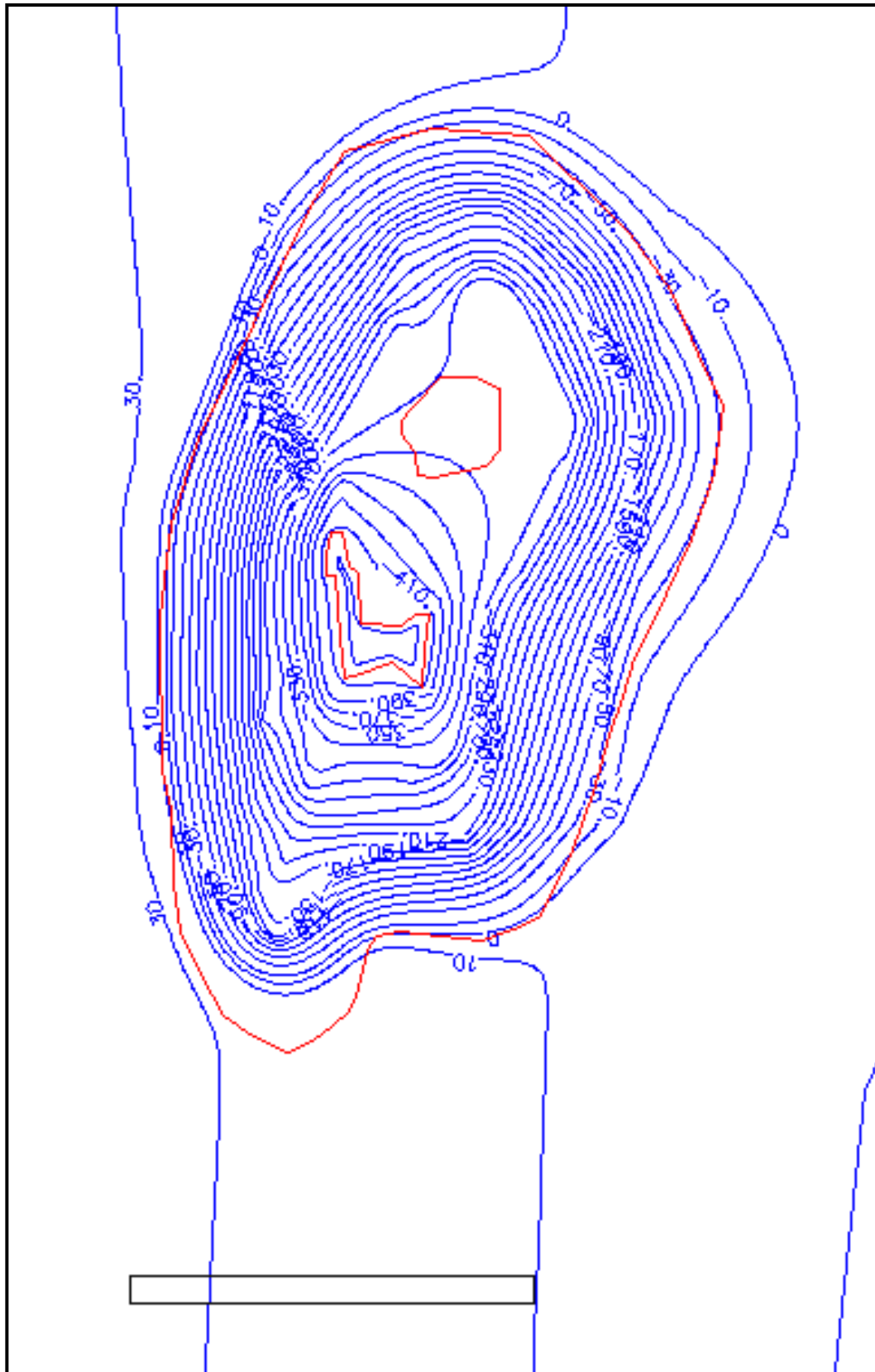


Figure 5-26: Model heads after 13 years

After 13 years, the zero AHD contour has moved to a position only 200 metres east of the pit crest at the north-eastern margin of the pit.

Model drain flows

The total flow at the end of each year from all model drains was extracted from the Water Balance record and the resulting drain flow versus time plot is shown in Figure 5-27.

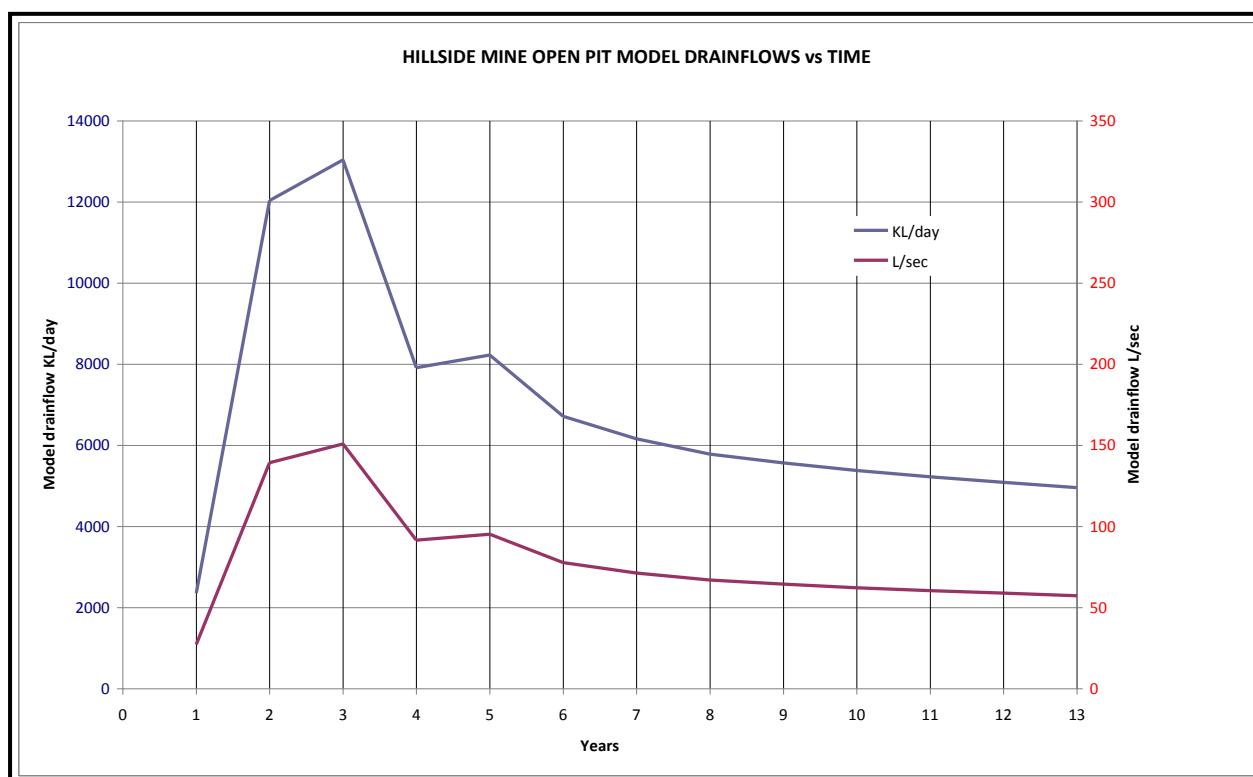


Figure 5-27: Hillside open Pit Model Drain Flows vs Time

Model drain flows peak at 150 l/sec at the end of Year 3 and reduce to 92 l/sec at end Year 4. After an increase to 95 l/sec at Year 5, the rates decline gradually to 57 l/s after 13 years.

5.3.2 Open pit and Underground Inflows

The revised (PFS) design includes the underground mining of 6 ore bodies in addition to the development of the open pit. The Figure 5-28 shows a south to north section with the six ore bodies identified as numbers 1 to 6. The same information in plan view is shown in Figure 5-29.

It should be noted that Figure 5-29 is viewed from below.

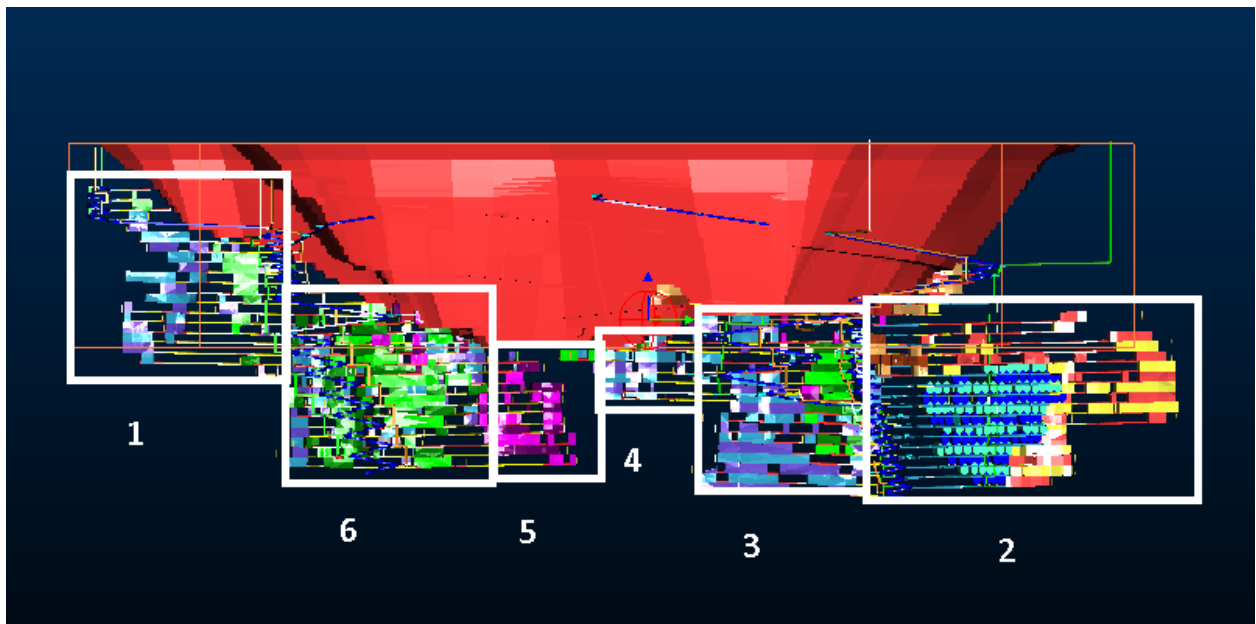


Figure 5-28: South North section showing ore bodies 1 to 6

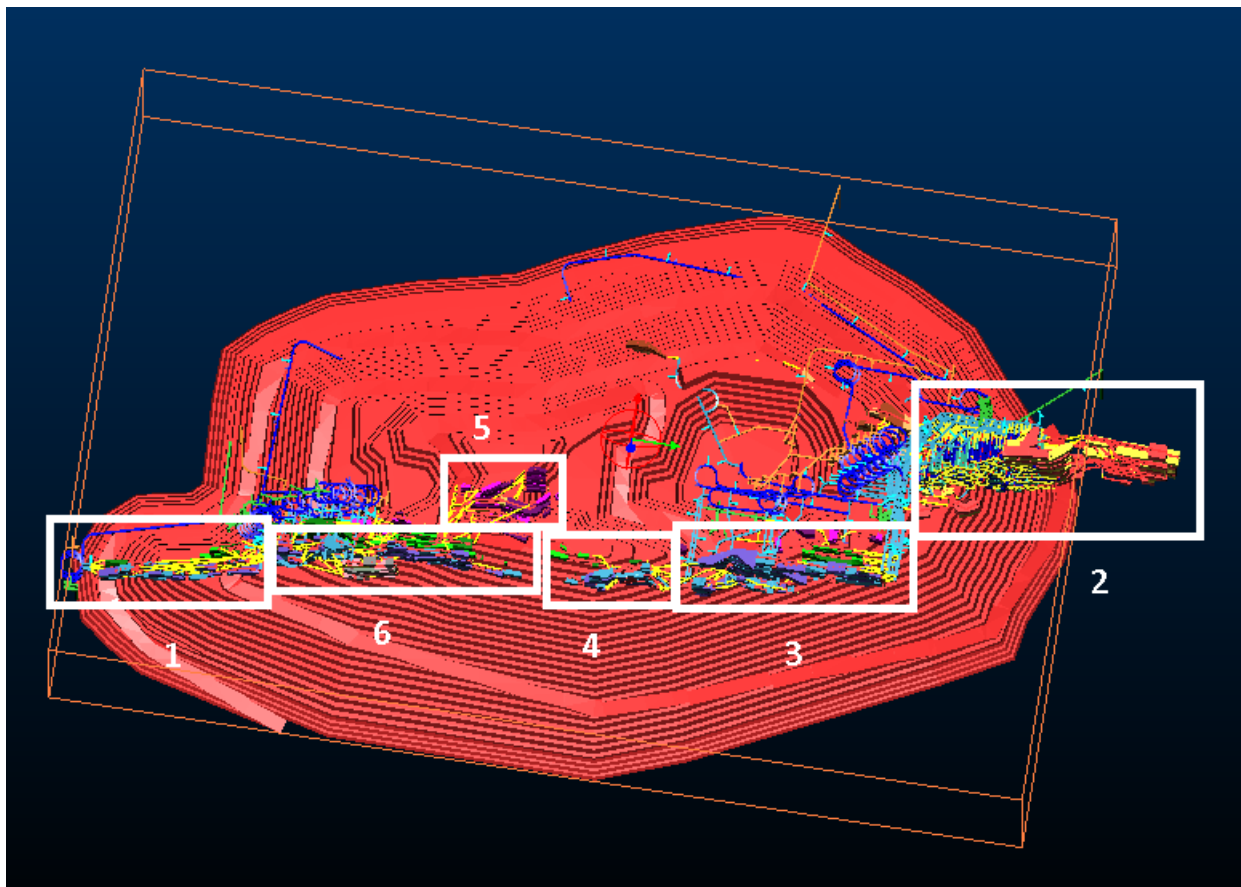


Figure 5-29: Plan view of underground ore bodies 1 to 6

The underground ore bodies were entered into the model initially in the form of drain cells with outlines as shown in Figure 5-30 (also viewed from below) The ore bodies are modelled as having different widths (in plan view) and at different times as shown in the Table 5-2.

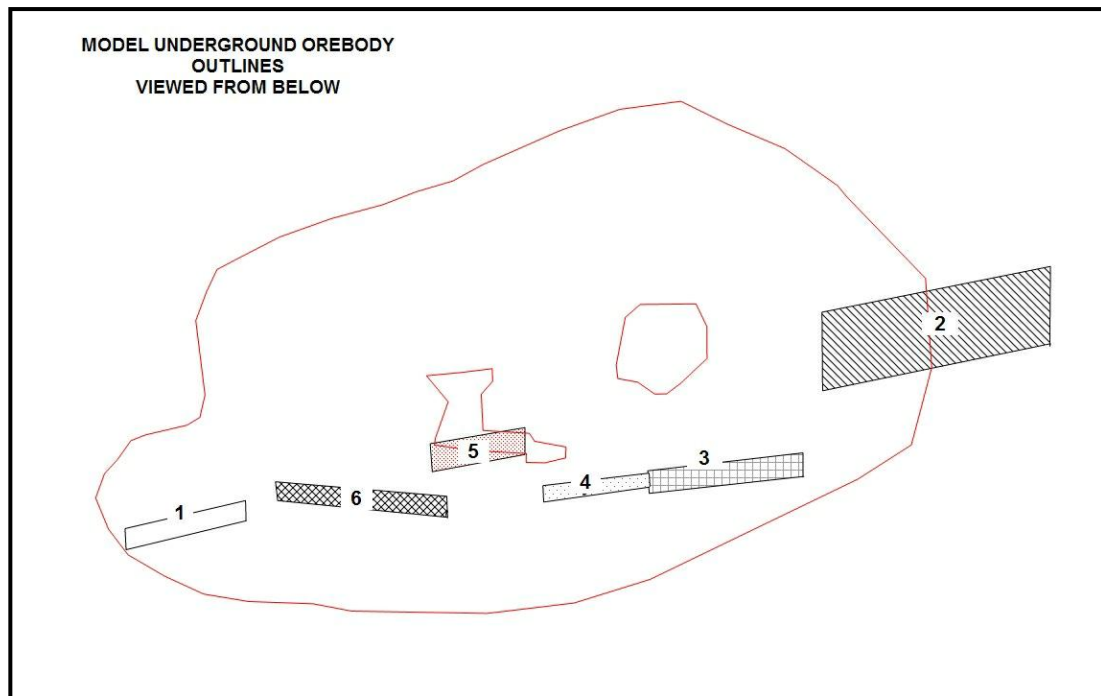


Figure 5-30: Plan view of Underground Stopping Areas – ore bodies 1 to 6. (Viewed from below)

In Year 3, the underground mining operation begins in ore body 1 and continues until the end of Year 7, after which time the drain cells remain in place to simulate the voids created by stoping. Mining of underground ore body 2 begins in Year 7 and continues until the end of Year 17 but the drain cells remain open in Year 18.

Underground mining begins in ore bodies 3, 4, 5, and 6 in Year 12, with mining finishing in Year 16 at ore body 4, Year 17 at ore body 5, and Year 18 at ore bodies 3 and 6.

Again, drains remain in place in each completed mining area to simulate voids created by the stoping as well as development headings.

The systematic deepening of workings in each area follows the pattern described in Table 5-3. With the total depth interval mined divided by the number of years each area is active to produce the annual increment in depth per area (expressed as “Bottom Elevation” in the schedule). **Table 5-1 below shows the cross over between open pit and underground mining.**

Table 5-1: Crossover of open pit and underground mining modelled

End Of Year	1	2	3	4	5	6	7	8	9
Open pit	x	x	x	x	x	x	x	x	x
Underground			x	x	x	x	x	x	x

Table 5-2: Underground mining schedule as modelled

Ore body:	Date to:	Date From:	Depth From:	Depth to:
Ore body 1	1/04/2017	1/03/2021	-120	-470
Ore body 2	1/07/2020	1/08/2030	-340	-770
Ore body 3	1/04/2026	1/01/2032	-340	-790
Ore body 4	1/04/2026	1/04/2029	-390	-560
Ore body 5	1/04/2026	1/01/2032	-510	-710
Ore body 6	1/04/2026	1/01/2032	-320	-720

To facilitate the extraction of individual ore body drain flows from the overall water balance, the underground workings were simulated using the MODFLOW “RIVER” package. This functions in a similar way to the DRAIN package in removing water when the adjacent heads are higher than the designated “river” level (behaving as a gaining or effluent stream). Drain flows and River flows appear as separate items in the water balance. The two elements can be summed to yield the total model drain flow.

The discharge in the form of model drain flows for the pit, plus river cell flows from underground mining is shown in Figure 5-31 in units of l/sec.

Later years show an increase from the 55 to 95 l/sec range between Years 5 and 13 for the pit alone, to 110 to 150 l/sec over the same time interval when underground mining is added. At the end of 18 years the drain flows are estimated to be 105 l/sec.

Up to Year 6 the underground workings only contribute approximately 20 l/sec to the total, largely because the area of underground workings is close to the already partially drained southern area of the pit. In Year 7 the underground component of model flow peaks at 100 l/sec, falling to 70 l/sec in Year 12 before escalating to 95 l/sec in Year 13 reducing slightly to 92.5 l/sec at the end of Year 18.

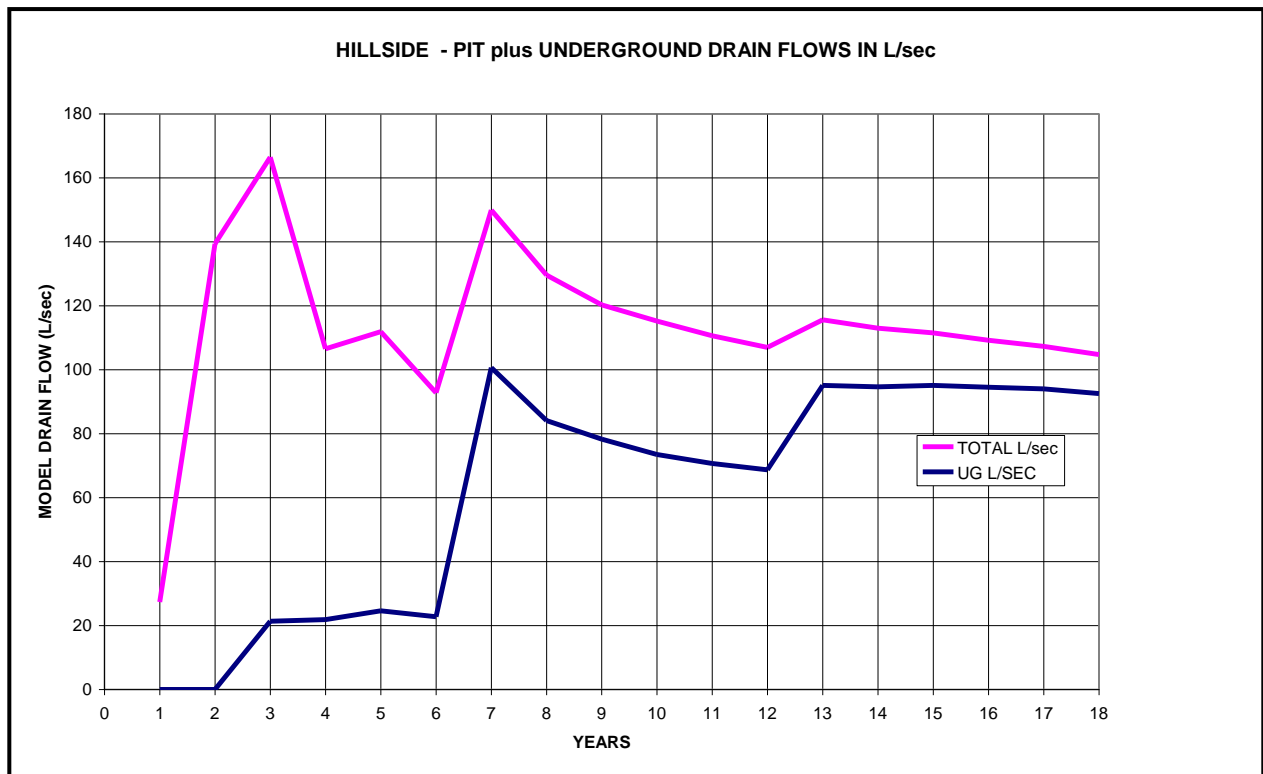


Figure 5-31: Total and underground model flows in l/sec

It is clear from Figure 5-31 that the flow to the underground workings result in drawdown this reduces the flow from the drain cells representing the pit as the generally deeper underground operation becomes the focus of the flow pattern.

Model flows from individual ore body areas

By designating each ore body area, as shown in Figure 21, as a specific subregion when extracting the water balance information, it was possible to provide an estimate of flow vs. time for each individual ore body area as a guide to possible pumping requirements.

Figure 5-32 shows the individual ore body area flow vs. time and table 1 lists the flow rates at each year end.

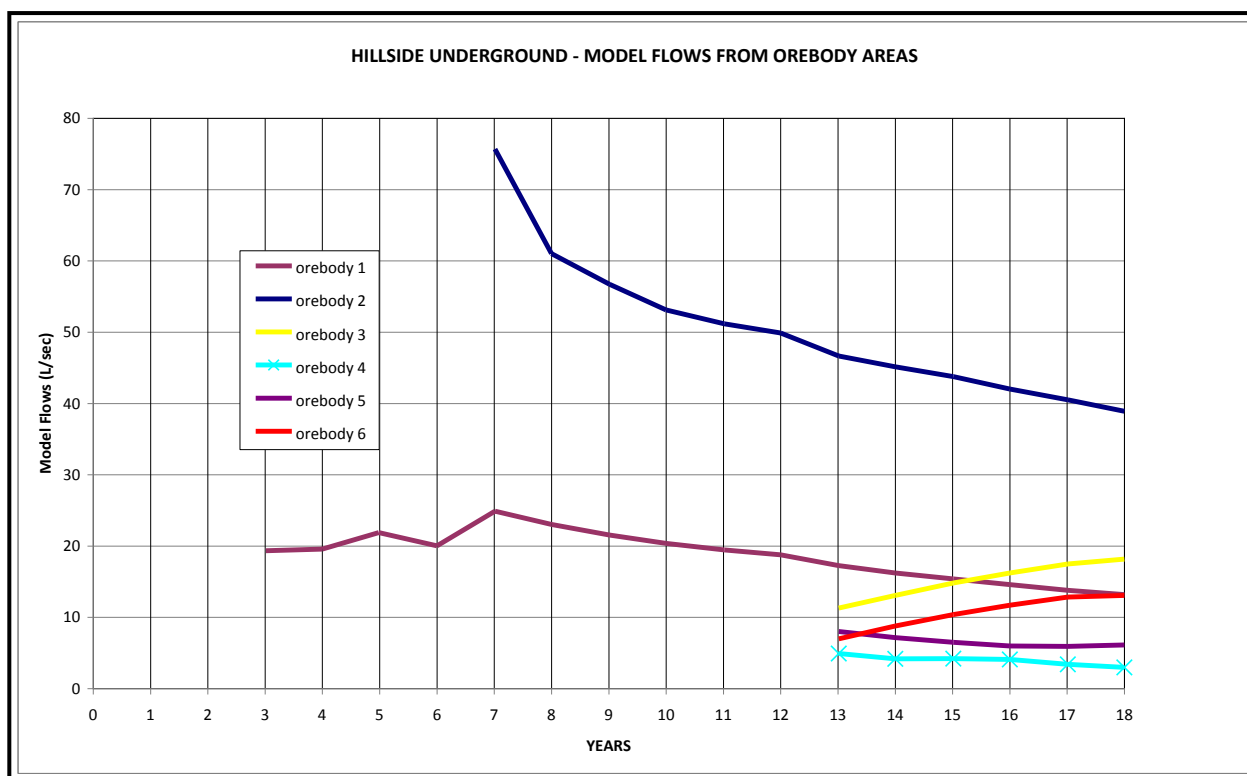


Figure 5-32: Model Flows from Individual Underground Ore body Areas

The bulk of the drainage flow from underground workings occurs in ore body areas 1 and 2 with areas 3, 4, 5 and 6 falling within that area already partially drained by the pit and earlier underground workings.

Table 5-3: Model drain flows from individual ore body areas.

Years	Underground area flows in l/sec					
	Ore body 1	Ore body 2	Ore body 3	Ore body 4	Ore body 5	Ore body 6
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	19.3	0	0	0	0	0
4	19.6	0	0	0	0	0
5	21.9	0	0	0	0	0
6	20	0	0	0	0	0
7	24.9	75.7	0	0	0	0
8	23	61	0	0	0	0
9	21.5	56.7	0	0	0	0
10	20.4	53.1	0	0	0	0
11	19.4	51.2	0	0	0	0
12	18.8	49.9	0	0	0	0
13	17.2	46.6	11.3	4.9	8	7
14	16.2	45.1	13.1	4.2	7.2	8.8
15	15.4	43.8	14.8	4.2	6.5	10.4
16	14.6	42	16.2	4.1	6	11.7
17	13.8	40.5	17.5	3.4	5.9	12.8
18	13.2	38.9	18.2	3	6.1	13.1

Water elevation contours

Model water elevations at the ends of Years 3, 6, 9, 12, 13, 15 and 18 are presented in Figure 5-33 to Figure 5-39, respectively. In these figures, the open pit drain cells are coloured purple and the river cells representing the underground workings are coloured light blue.

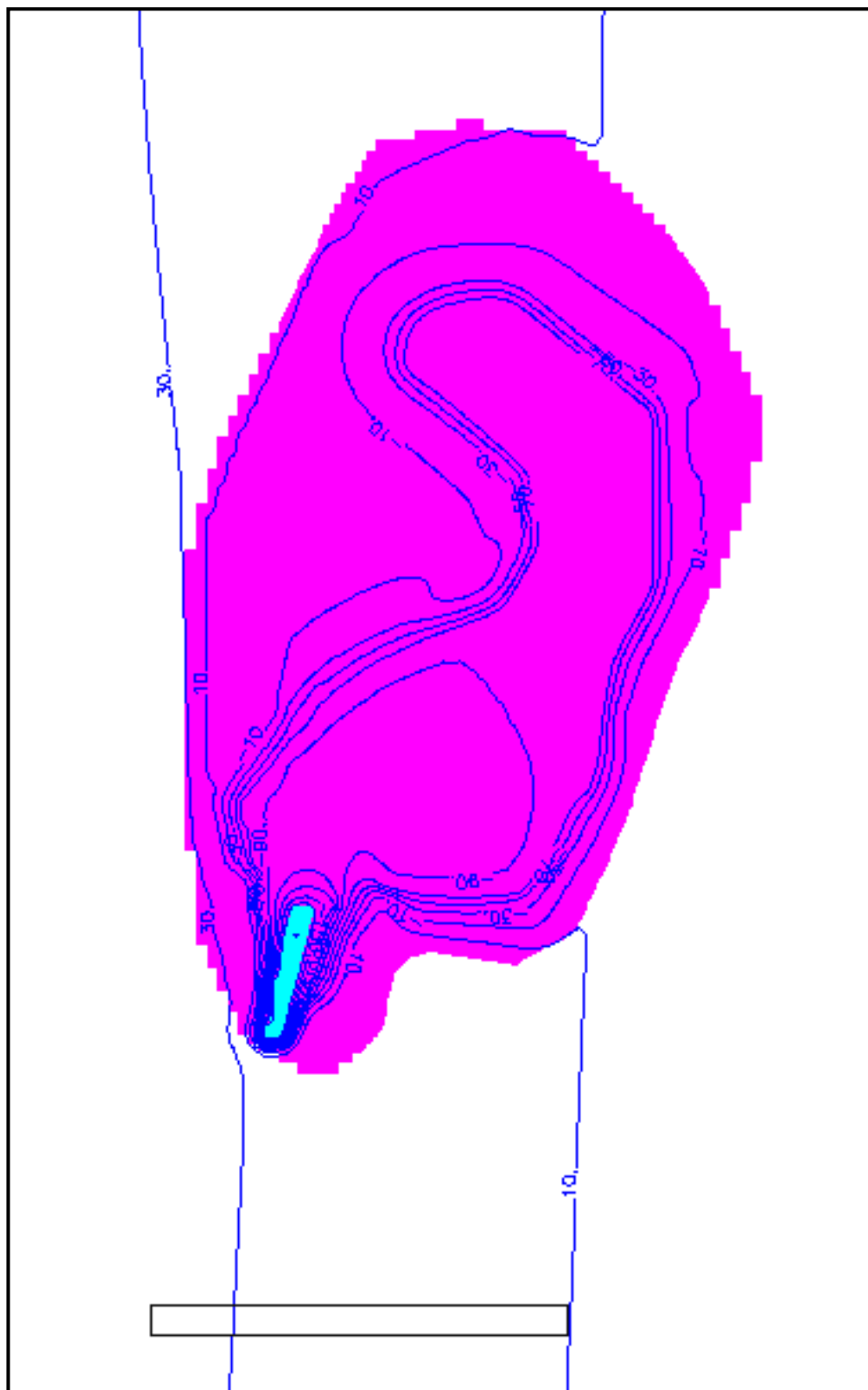


Figure 5-33: Model Heads at end Year 3



Figure 5-34: Model Heads at end Year 6

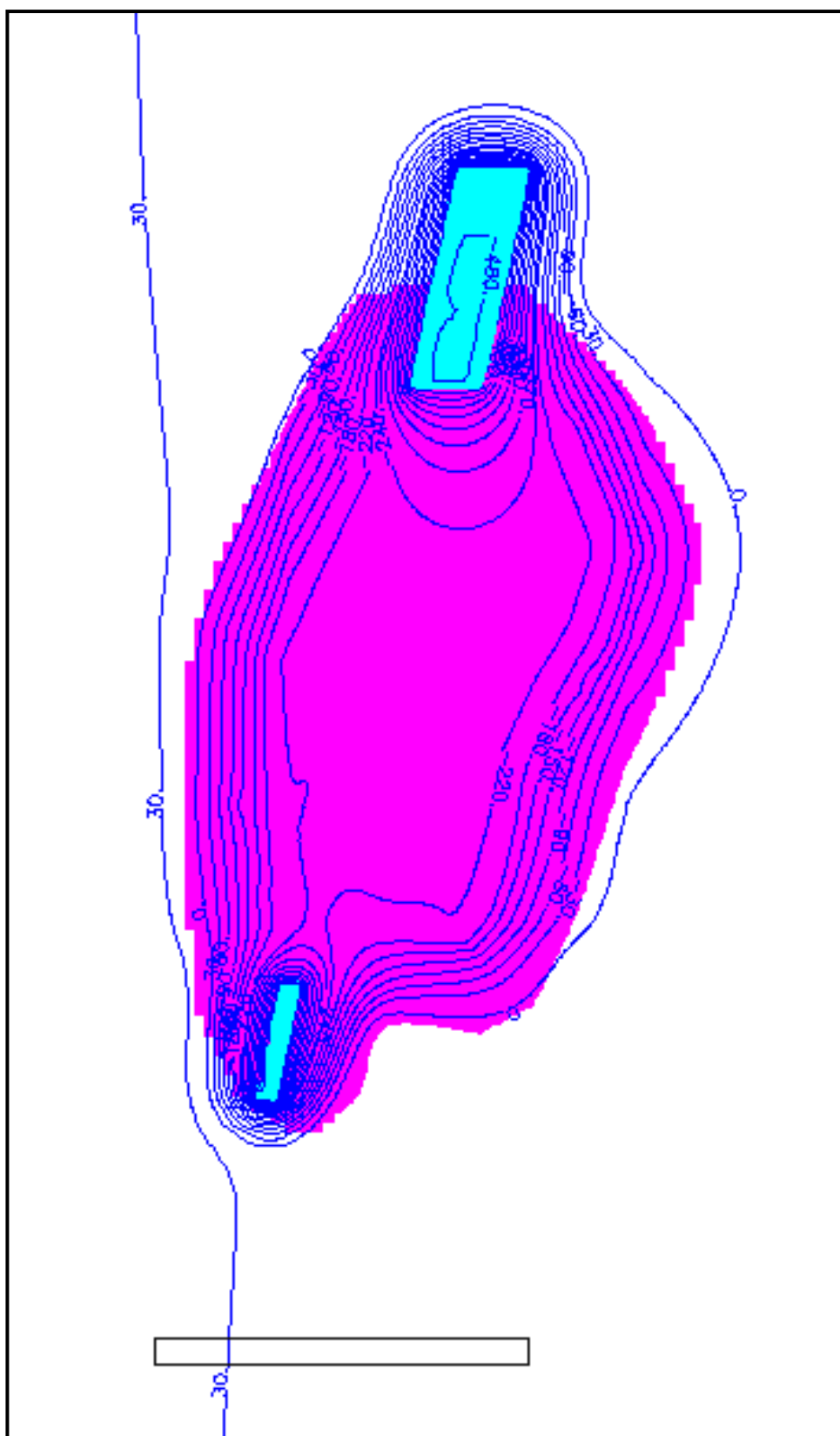


Figure 5-35: Model Heads at end Year 9

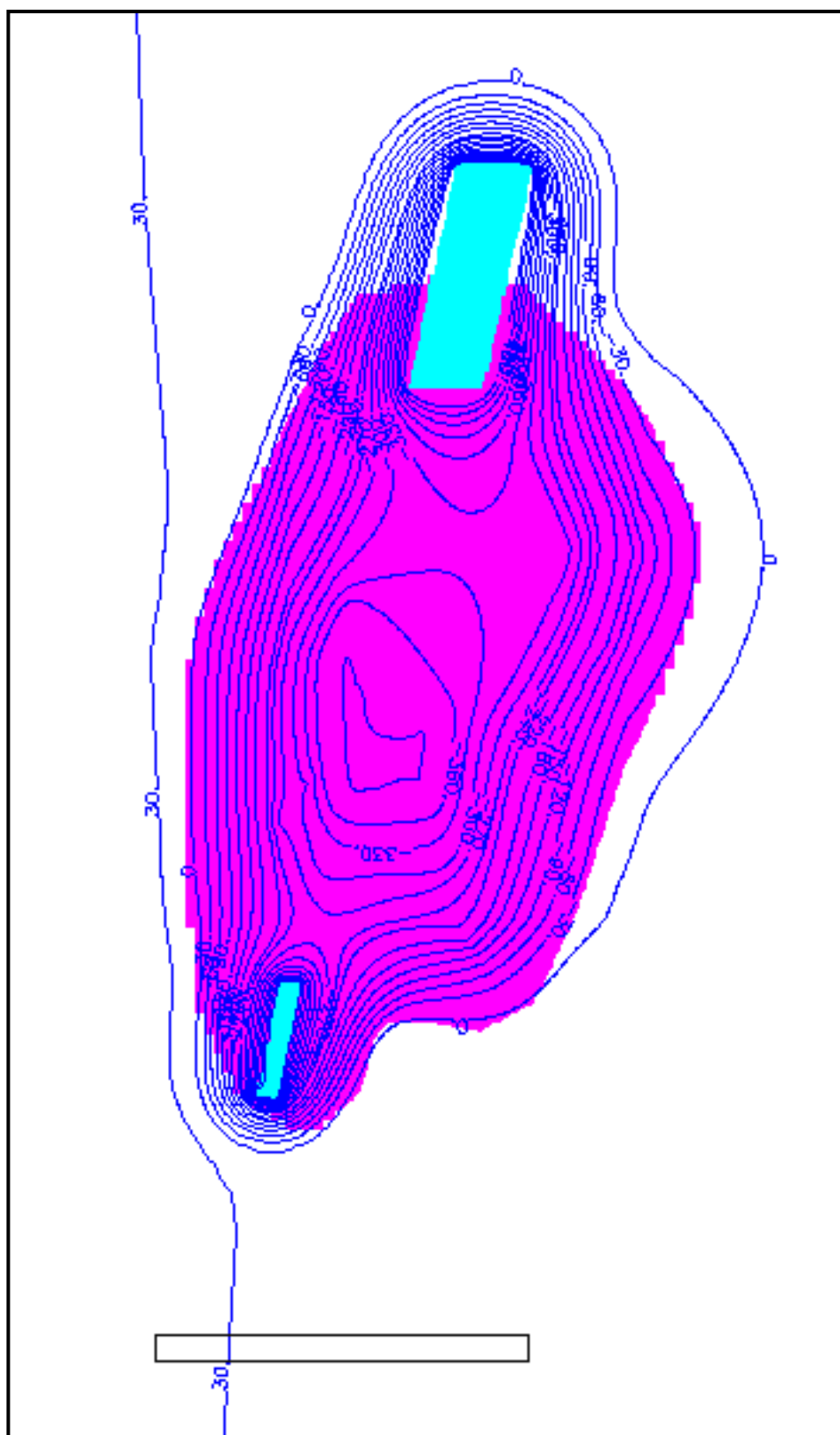


Figure 5-36: Model Heads at end Year 12

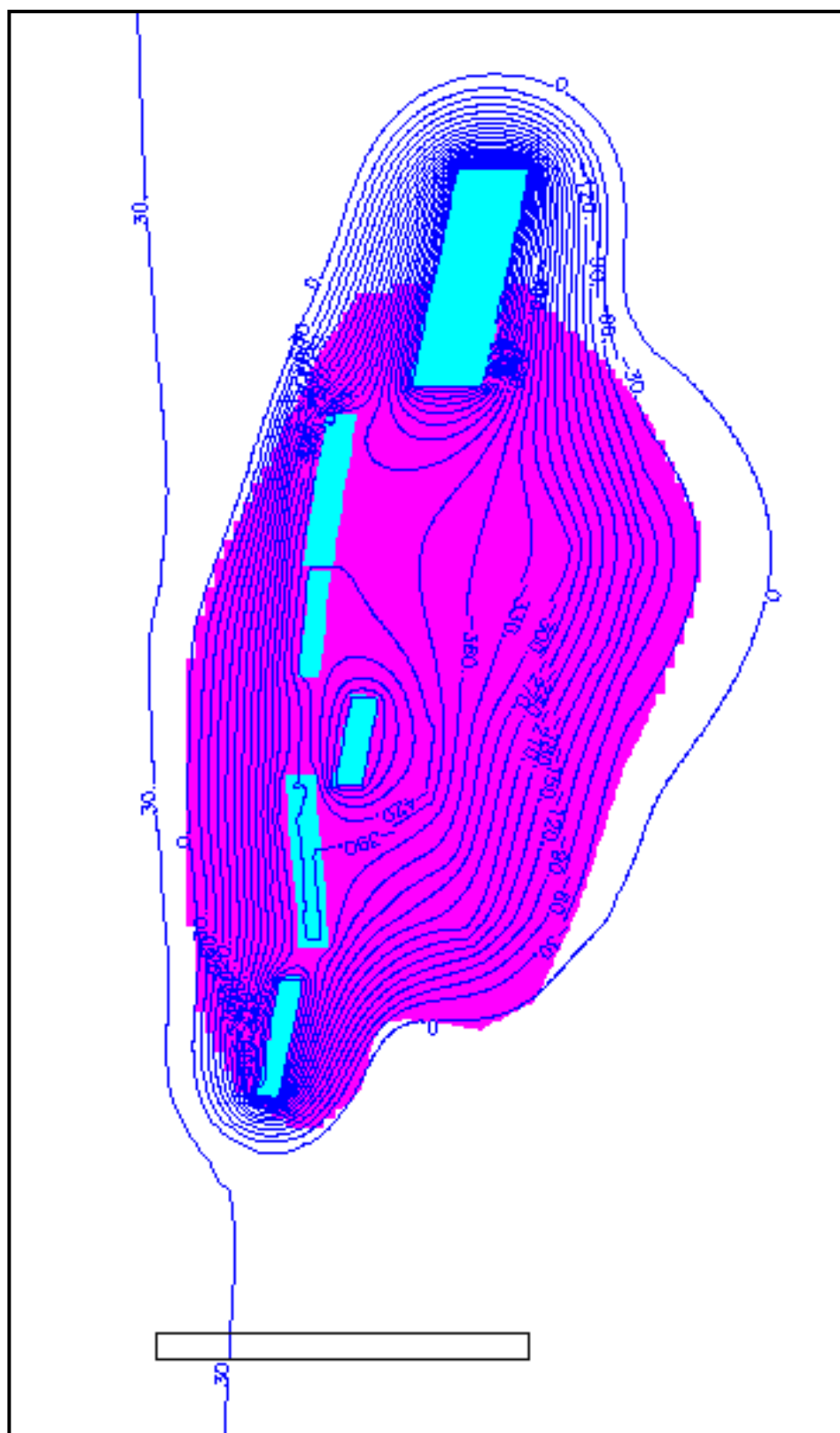


Figure 29: Model Heads at end Year 13

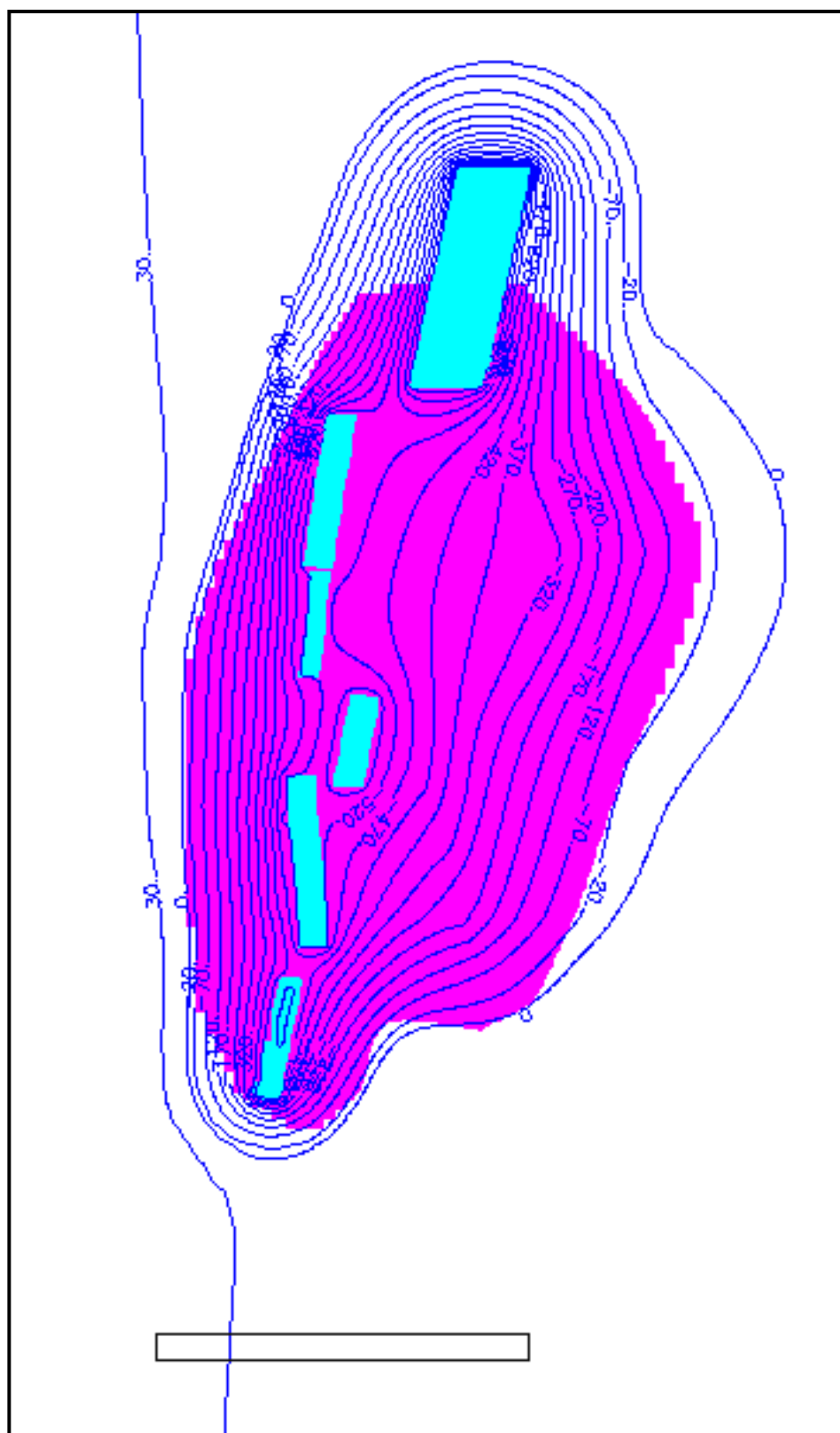


Figure 5-37: Model Heads at end Year 15

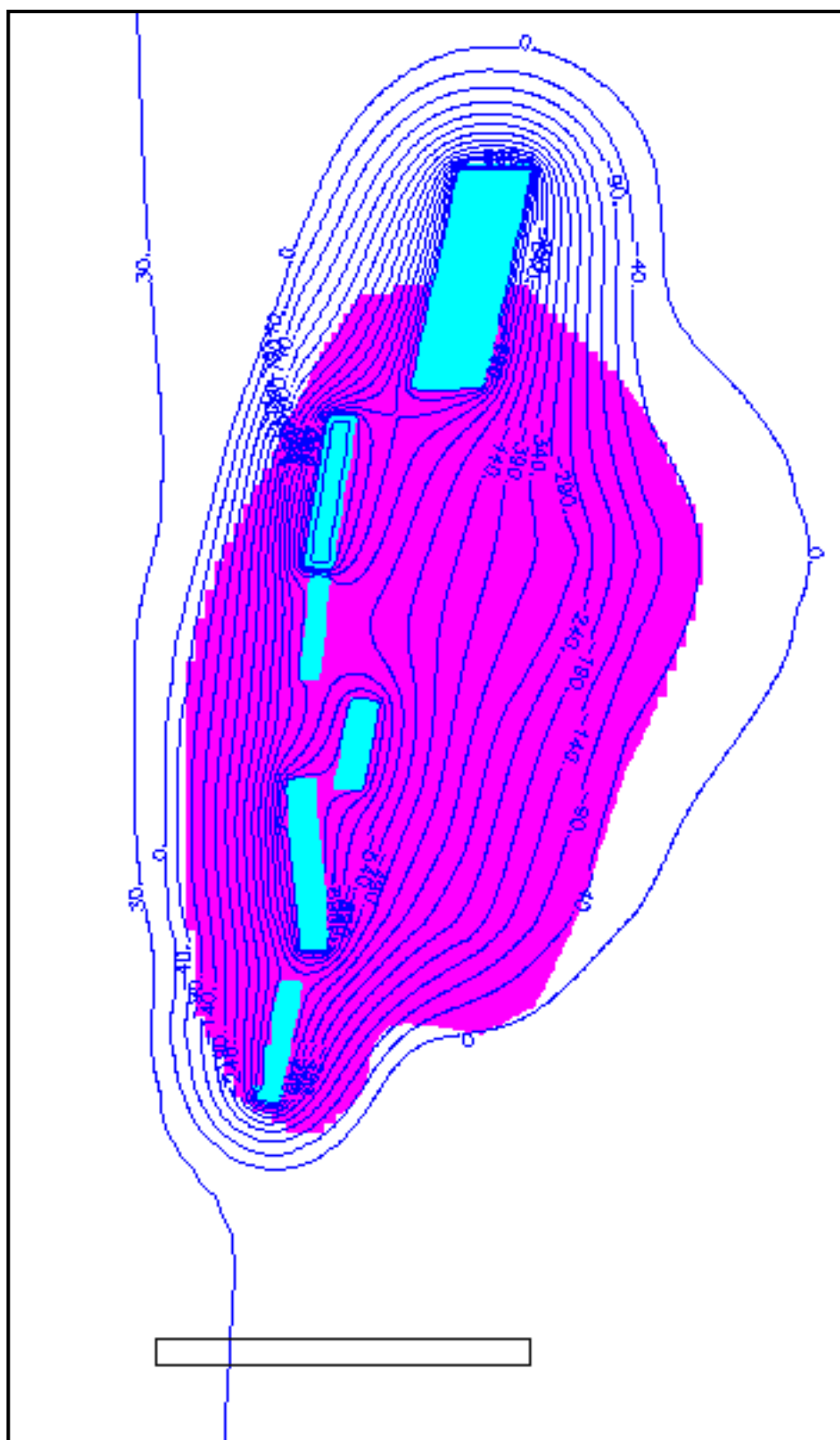


Figure 5-38: Model Heads at end Year 18

The effect of focusing the flow around the sinks represented by the underground workings (in light blue) can be seen in these figures. As described above, this effect shifts a large proportion of the open pit drainage flows to the underground as shown in Figure 5-21 and Figure 5-22.

The areal extent of the cone of depression after 18 years of mining is shown by the drawdown contours in Figure 5-38. The limited extent of drawdown is due to the low K of the rockmass. The zero drawdown contour is less than 1,000 metres from the eastern pit wall and approximately 600 metres from the western wall.

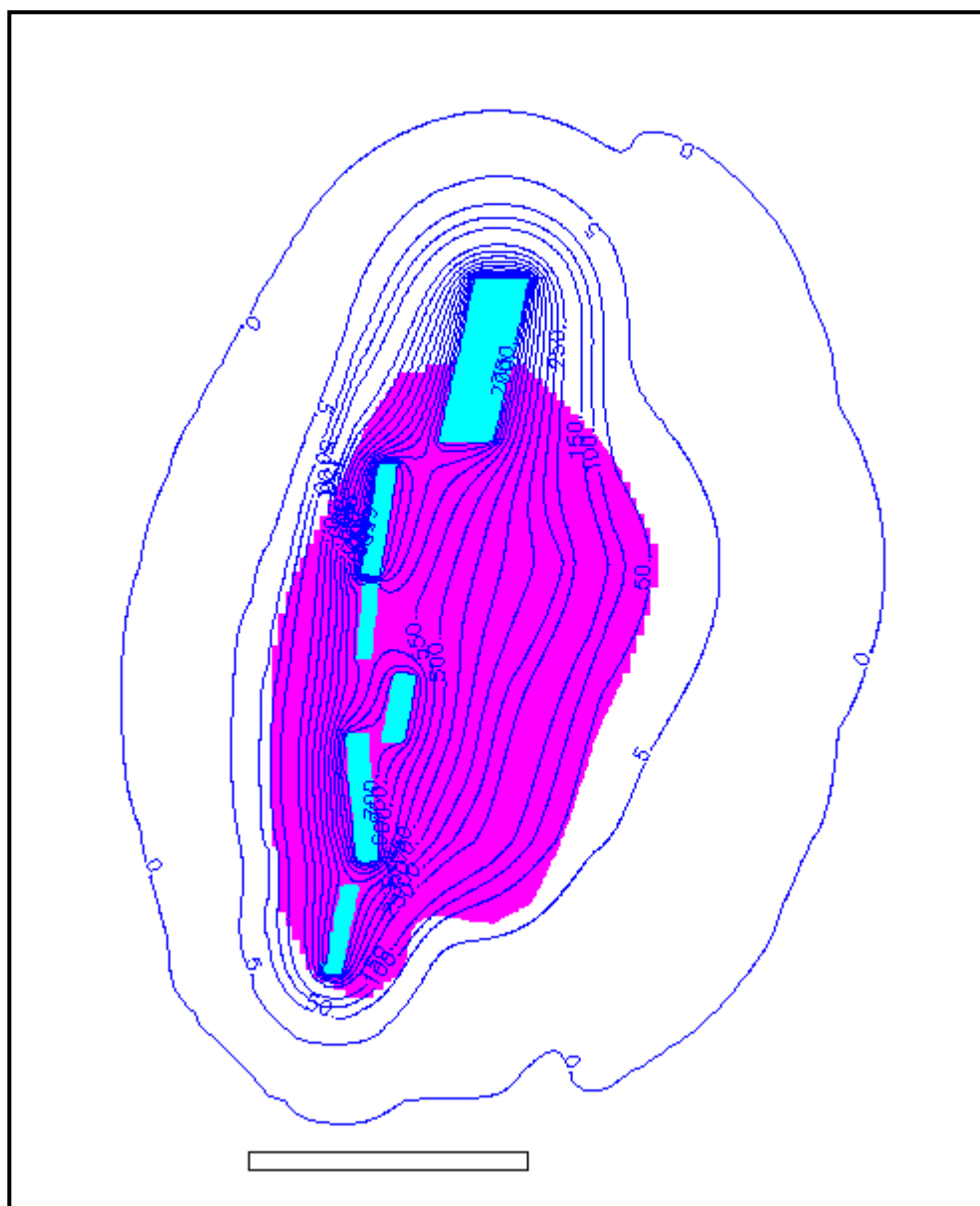


Figure 5-39: Model Drawdown at end Year 18

5.3.3 Conclusions from the model run

The low hydraulic conductivity (K) values obtained from test pumping within and outside the pit footprint suggest that dewatering using vertical pumped wells located on the pit crest will not be effective. This is because in tight units such as encountered at Hillside, the cone of depression and radius of influence of pumping is small, the wells would be set back too far from the pit floor to maintain dry working conditions.

The drain cell approach used in the model simulates gravity drainage using toe and pit floor drains, with collection by sumps.

The numerical model has shown that:

- Relatively small flows originate from the upper two layers (seasonal perched Quaternary aquifers and saprolitic confining layer).
- The greatest flows occur as the pit passes through the saprock of Layer 3 reaching a maximum of about 170 l/sec in the third year from the current model.
- Hydraulic gradients towards the pit are very steep and the phreatic surface is expected to be very close to the pit walls, especially in the lower levels.
- The low K environment surrounding the pit acts to restrict the expansion of the area of influence of the pit dewatering.

It should be noted that the model was developed at an early stage in the evaluation process and is a simple representation of the aquifer system using the information available at the time. Subsequent assessments may provide information that may lead to the model needing to be revised. Pit design and scheduling also effects the model so if there are any significant changes to either of those the model will need to be re run.

The fractured rock aquifer (Layer 4) and to some extent the saprock (Layer 3) are likely to contain structural elements which may be more transmissive than the bulk of the rock mass. Apart from two isolated sites (WBTH001 and WBTH005), such features were not delineated in the drilling to date and the materials have therefore been treated as equivalent porous media. Future drilling may reveal structurally controlled high K zones which will have to be incorporated into any updates of the model properties.

Recent drilling in the area to the north east of the pit has revealed an area of granite, known as the “Coastal granite”, which appears to be characterised by higher permeabilities than encountered generally within the pit area. This feature appears also to be related to an electro-magnetic anomaly which passes through the middle of the pit. This suggests that the structural features which were not located using vertical drilling methods may be present and, if proven by subsequent drilling and pumping tests will need to be incorporated into any future version of the model. The coastal granite assessment is reported under separate cover and will be further investigated in the next stage of the study.

6 WATER BALANCE - DATA GATHER

The scope of the water balance model for the mining area is to assess whether:

- The mine dewatering will produce enough water to support the dust suppression for the pit; and
- There is excess water, how much water will the pit dewatering be able to contribute to the plant production water requirement?

The mining area is defined as the area bounded by the crest of the open pit.

6.1 Inputs

There are two primary sources of incoming water:

- Rainfall falling on the area of the pit; and
- Inflows of groundwater.

There are three primary sources of outgoing water:

- Evaporation;
- Dust suppression; and
- Water lost to blasting/stockpiles.

The incoming water minus the outgoing water determines if there is likely to be either an excess or a deficit of water from the mining environment.

6.1.1 Incoming Water

Rainfall

The rainfall contribution to the water balance was calculated using rainfall data from the Bureau of Meteorology (BOM).

Mean annual rainfall from the four stations varies between 331 mm (Price) and 504 mm (Maitland). Monthly average rainfall from the four stations is shown in Figure 6-1 .

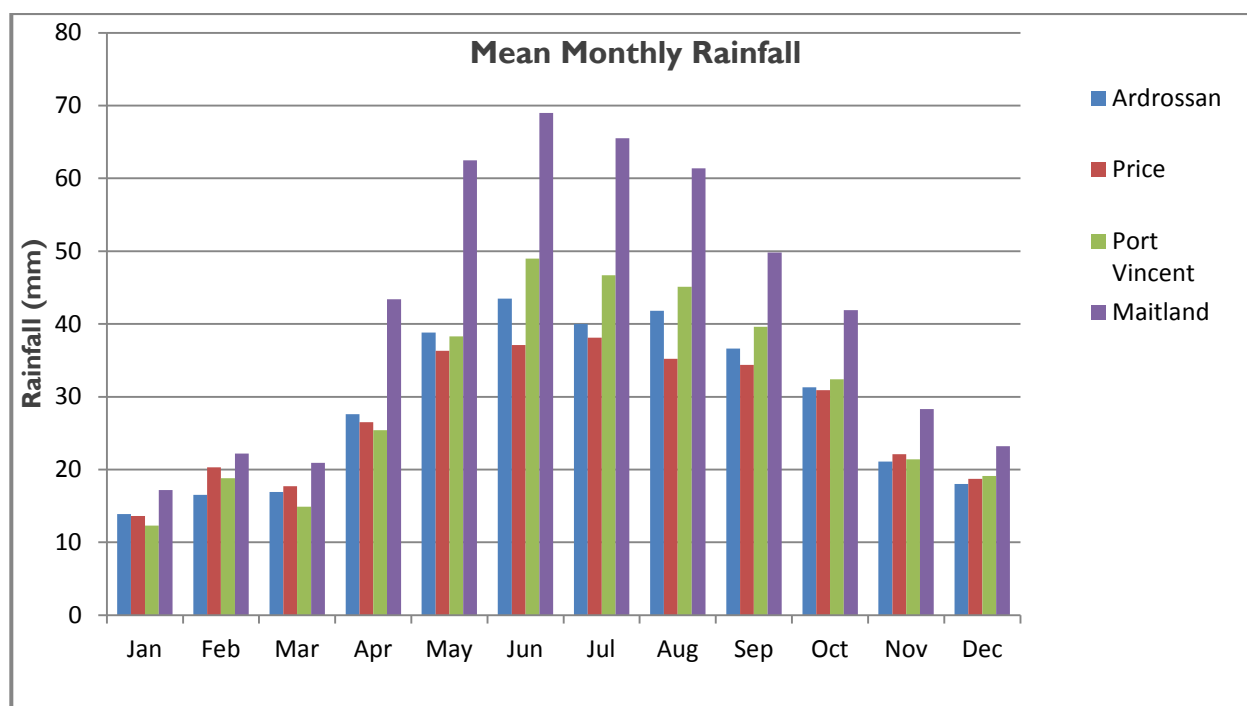


Figure 6-1: Mean Monthly Rainfall (source: BOM, 2012)

The rainfall figures for Ardrossan were used in the model. In order to calculate a likely volume of rainfall per month that will contribute to the water balance these figures were then multiplied by the horizontal area of the pit outline to give a volume.

This volume was then multiplied by a “runoff” coefficient to account for the fact that not all the water that falls as rain will be seen in the pit dewatering. Some will evaporate before it flows to the base of the pit. A “runoff” coefficient of 0.75 was used to account for the fact that some areas of the pit are very steep (the batters) and some areas are flat (the berms) so an average needs to be used.

Inflows

Inflows to the pit were taken directly from the numerical modelling discussed in Section 7 - Develop Water Balance Model.

6.1.2 Outgoing water

Evaporation

Groundwater will flow into the pit through the pit walls and into the underground workings as the mine is developed.

This water flowing into the open pit component of the mine will seep through the walls, most obviously in the bottom 50m of the pit.

As that water is seeping through the walls they may appear “wet”. These “wet” walls will be subject to evaporation.

The model assumes that the bottom 50 metres of the open pit will be subject to evaporation off the walls and the surface area has been calculated based on these assumptions. (Length of wall times height being 50 metres.)

The evaporation figures were taken from the BOM website and are shown in Table 6-1.

Table 6-1: Price Monthly Evaporation Oct 2010 – Sep 2011

Month	Evaporation (mm)
Oct 2010	161.3
Nov 2010	222.5
Dec 2010	262.6
Jan 2011	292.4
Feb 2011	200.2
Mar 2011	160.6
Apr 2011	103
May 2011	76.1
Jun 2011	78.6
Jul 2011	49.7
Aug 2011	80.4
Sep 2011	172.6

An “evaporation factor” was applied to these figures to account for the fact that in the pit, the evaporation rate is likely to be less than the pan evaporation rates quoted above. This is due to there being:

- Less wind exposure;
- Less sun exposure; and
- A humid environment in the base of the pit.

An evaporation factor of 0.6 has been used.

The main assumption regarding the evaporation is that walls are “wet” rather than water flowing through a number of defined structures.

Dust suppression

Dust suppression has been calculated based on the utilisation of 2 x 175KL water trucks being utilised to support the mine for dust suppression.

Assumptions:

- The duty cycle of each truck is 1 load per 3 hours;
- There will be 90% utilisation on day shift required; and
- There will be 50% utilisation on night shift required.

These are annual average numbers to give an approximated overall water usage for the year.

Table 6-2 shows the dust suppression assumptions. Table 6-3 shows the likely water usage based on the assumptions in Table 6-2.

Table 6-2: Dust suppression assumptions

Truck capacity (789 Cat - 195T = 175 kl)	175	kl
No. of trucks	2	
No. of loads per hour	0.33	
Day shift utilisation	90%	
Night shift utilisation	50%	
Use per 24 hour period	17	Hours

Table 6-3: Water usage for dust suppression

Volume of water consumed	L ('000)
Daily	1,960
Weekly	13,719
Monthly	59,611
Yearly	715,328

The dust suppression annual number was then divided over the 12 months to account for the different dust suppression requirements dependant on the season.

The percentages used per month shown in Table 6-4 were based on the evaporation rates shown in Table 6-1 and smoothed to give a more realistic distribution of water usage based on the truck availability (ie. two trucks at 95% availability in the summer is the maximum realistic usage for dust suppression which is 12% of 715 ML, so 12% should be the highest monthly usage).

Table 6-4: Percentage of water used per month of annual total

January	12%
February	11%
March	9%
April	7%
May	6%
June	5%
July	5%
August	6%
September	7%
October	9%
November	11%
December	12%

Water lost to blasting/stockpiles

Some water will be lost to evaporation during wet blasting, and some water will also be lost as moisture when the ore and waste is hauled from the pit.

The figure used was 0.3% of the total movement which gave realistic numbers in the vicinity of 125 m³ per day lost to blasting and stockpiles.

6.1.3 Pit Parameters

The pit parameters are used for the following calculations and are shown in Table 6-5.

- Pit dimensions and wet areas: used to calculate the surface area available for evaporation; and
- Final surface area of the pit: used to calculate the rainfall contribution falling on the pit.

Table 6-5: Pit parameters

Pit dimensions (North)	2300	m
Pit dimensions (South)	1300	m
Final Surface area of pit (m²)	2179800	m ²
Wet Area at base of pit	50	m

Table 6-6 represents the size of the pit over time.

The pit crest size is used to calculate the rainfall contribution. It can be seen that it reaches 100% of the final size in Year 3.

The pit base size is used to calculate the area available for evaporation. In Years 1, 2 and 3, the pit is growing and the base is also growing. After Year 3 when the pit crest is at full size and the pit starts to become deeper, the pit base slowly reduces in size over time until the open pit stage is finished in Year 13. Beyond that the pit base stays the same size.

Table 6-6: Pit crest and base size as a percentage of the final pit

	Pit Size (% of final)	Pit base size (% of final)
Year 1	20%	20%
Year 2	70%	70%
Year 3	100%	100%
Year 4	100%	94%
Year 5	100%	88%
Year 6	100%	82%
Year 7	100%	76%
Year 8	100%	70%
Year 9	100%	64%
Year 10	100%	58%
Year 11	100%	52%
Year 12	100%	46%
Year 13	100%	40%
Year 14	100%	40%
Year 15	100%	40%
Year 16	100%	40%
Year 17	100%	40%
Year 18	100%	40%

7 DEVELOP WATER BALANCE MODEL

Based on the data gather, a spreadsheet was developed specifically to model the water excess or deficit over time.

7.1 Analysis

The results from the model are demonstrated in Figure 7-1.

- Rainfall is high in the winter and low in the summer and does not increase or decrease over time as the pit crest reaches full size and stays there from Year 3 onwards;
- The evaporation peaks in Year 3 and then reduces over time as the base of the pit becomes smaller. It is much higher in summer than in winter;
- The dust suppression increases slowly over the life of the mine representing a gradual increase in haulage distances as the pit deepens and the waste dumps become larger;
- The inflows do not vary with season but vary year to year with the pit and UG dimensions. This is taken direct from the numerical model; and
- The surplus/deficit is the rainfall and inflows minus the evaporation, blasting/stockpile loss and the dust suppression. It can be seen that it is highly variable dependant on the season, however, the model predicts a permanent water surplus (albeit a reduced surplus in summer compared to the surplus volumes in winter).

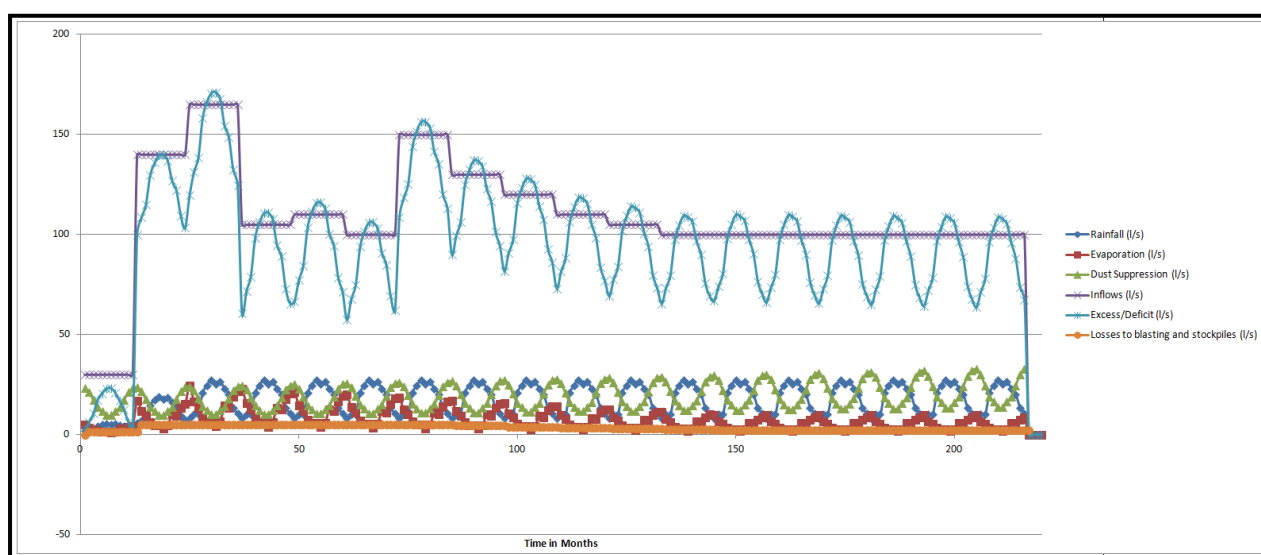


Figure 7-1: Water balance model outputs

7.2 Discussion

The input that has the most influence over the pit water balance is the groundwater inflows to the open pit and the underground operation. In comparison to the inflows, the rainfall, evaporation and the dust suppression are minimal, and although they change slightly over the life of the mine their overall contribution is consistent.

The effects of the rainfall, evaporation and dust suppression, although minimal individually, are amplified as they all contribute to less water in the summer and more in the winter. For that reason there is a significant variation in the volume of water in excess between the summer and winter months. For the majority of the mine life there will be an excess of water in the range of 55 to 105 l/s as can be seen in Figure 7-1. There are two periods (Years 2 and 3 and Years 7 to 9) where the inflows increase, and thus the water surplus increase over those periods.

It can be seen that in the winter of Years 2 and 3 there could be up to 170 l/s water in surplus and in Year 7 there could be up to 160 l/s in surplus. The summer volumes are significantly less at around 100 l/s.

7.3 Water Chemistry

The water chemistry has been calculated using a mass balance of the bores drilled to date, their location, and their likely contribution to the overall water seeping into the pit.

The contribution of rainfall has not been considered as it is minor, and the addition of fresh water would be balanced by the increase in salinity from the evaporation, leading to no significant overall change in the water chemistry.

Based on the conceptual model and the transmissivity of the ground it has been assumed that the eastern wall will contribute most of the water, 60%, the western wall will contribute 20% and the pit area will also contribute 20%.

The bores that were drilled and sampled in each respective area are detailed in Table 7-1.

Table 7-1: Water wells drilled in the pit - east and west wall

Pit	East Wall	West Wall
WBTH 001	WBTH 009	WBTH 002
WBTH 008	WBTH 012	WBTH 004
	WBTH 010	WBTH 005
	WBTH 011	WBTH 017
	WBTH 013	

The results of the mass balance are shown in Table 7-2 with the total column outlining the likely water chemistry of the excess water.

Table 7-2: Mass balance for the likely chemistry of the pit water

	Pit Total	East Total	West Total	Total
	20%	60%	20%	100%
Chloride	11,500	17,600	12,500	15,360
Conductivity	37,000	53,200	38,750	47,070
pH	7.2	6.7	7.2	6.9
Total Dissolved Solids	22,500	33,600	23,750	29,410
Calcium	385	696	432.5	581
Magnesium	905	1,296	918	1,142
Potassium	110	166	120	146
Sodium	6,400	8,920	6950	8022
Bicarbonate Alkalinity-mg CaCO ₃ /l	555	253	680	399
Sulphate (S)	790	898	790	812
Ammonia(N)	0.185	0.466	0.0525	0.1617
Arsenic (filtered)	0.011	0.0088	0.00725	0.00831
Boron (filtered)	2.85	3.96	4.30	3.94
Iron (filtered)	2.15	5.56	1.90	2.68
Selenium (filtered)	0.0945	0.1306	0.08575	0.09647
Zinc (filtered)	0.013	0.0104	0.01475	0.01353
Suspended Solids	0	7.8	0	1.56

7.4 Water management

It is proposed that the excess water from pit dewatering will be delivered to a holding pond positioned at the top of the main ramp in close proximity to the plant. This water can be utilised as plant production water.

The plant is able to take up to 170 l/s of surplus water at this stage from mine dewatering to use for plant production.

7.4.1 Water management contingencies

At this stage of the study the plant is able to utilise all the water produced from pit dewatering, but it is close to the upper limit of the capacity in the peak periods (ie. the winter of Year 3 when the excess water is predicted to be around 170 l/s).

As contingency, surplus water disposal options have been considered and will be implemented if required, including:

- Utilisation of in pit bores to allow the pit dewatering volumes to be more consistent year to year;
- Temporary storage in the pit during times of peak flow;
- Temporary storage in the 100 ML tails dam seepage storage pond area;
- Evaporation using mechanical means such as evaporators;
- Utilisation of in pit bores that can be used in the summer months to advance dewatering and thus reduce the flows short term in the winter months;

- Utilisation of pit perimeter bores to form a cut off bore field between the Gulf St Vincent and the pit with discharge to Gulf St Vincent;
- Discharge of excess pit water to the Gulf St Vincent;
- Disposal of excess water via an injection bore field; and
- Grouting the aquifer to reduce inflows.

These contingencies should be investigated further in the next stage of the study if required.

8 FURTHER WORK RECOMMENDATIONS

The main contribution to the water balance is pit inflows. Any future work to better define the pit inflows will have the most significant effect on the water balance.

It is recommended that wells are constructed at an angle of 60° in locations where significant structures are known to exist but where groundwater assessment to date has not encountered high yielding rock units. This could include areas where weathering has been found in resource drilling to be shallow, where the rocks are siliceous (i.e. unlikely to be significantly weathered) or at locations where structures have been identified that post date major weathering events.

Water investigation wells have been installed to depths of approximately 200 metres. This is significantly shallower than the anticipated pit floor level of approximately 400 metres. Hydrogeological parameters have been assumed at depths greater than 200 metres. It is recommended that wells be constructed to pit floor depths to enable hydraulic properties to be evaluated from 200 metres to the base of pit. These wells should be inclined at an angle, e.g. 60°.

All wells should be test pumped in the manner described above. Additional long term tests may be carried out in wells that have intersected significant high yielding fracture sets.

Water samples should be collected from all wells installed and analysed as described.

Results of the coastal granites groundwater assessment should be incorporated in the model as appropriate.

The significance of the electromagnetic (EM) anomaly should be investigated further to determine if there is any correlation between the electromagnetic response and groundwater yields.

9 REFERENCES

Clarke, D.K 1998. - Groundwater Discharge Tests: Simulation and Analysis. ELSEVIER, Amsterdam (1998)

Drexel, J.F and Preiss, W.V. (eds), 1995. 'The geology of South Australia, Vol 2, The Phanerozoic.' South Australia Geological Survey, Bulletin 54.

Freeze, R.A. and Cherry, J.A 1979. 'Groundwater', Prentice – Hall inc.

Harbaugh A.W and M.G McDonald (1996), User's documentation for MODFLOW-96, an update to the U.S. Geological Survey modular finite-difference ground-water flow model, USGS Open-File Report 96-485

Simcore Software (2010), Processing Modflow - An Integrated Modelling Environment for the Simulation of Groundwater Flow, Transport and Reactive Processes

Primary Industries Resources South Australia (2003), The MAITLAND Special 1:250,000 geological map sheet (PIRSA 2003)

Todd, David Keith, 1923- Groundwater Hydrology, 1980. John Wiley and Sons, Inc

10 APPENDIX A – PUMP TESTING RESULTS

10.1 WBTH001

This well was intended to be drilled to 200m depth but was terminated at 166m due to problems disposing of the 8l/sec yield.

WBTH001 was tested for 1 day at an average rate of 93.5m³/day. Drawdown data were analysed with the Clarke software. Output is shown in the following figures.

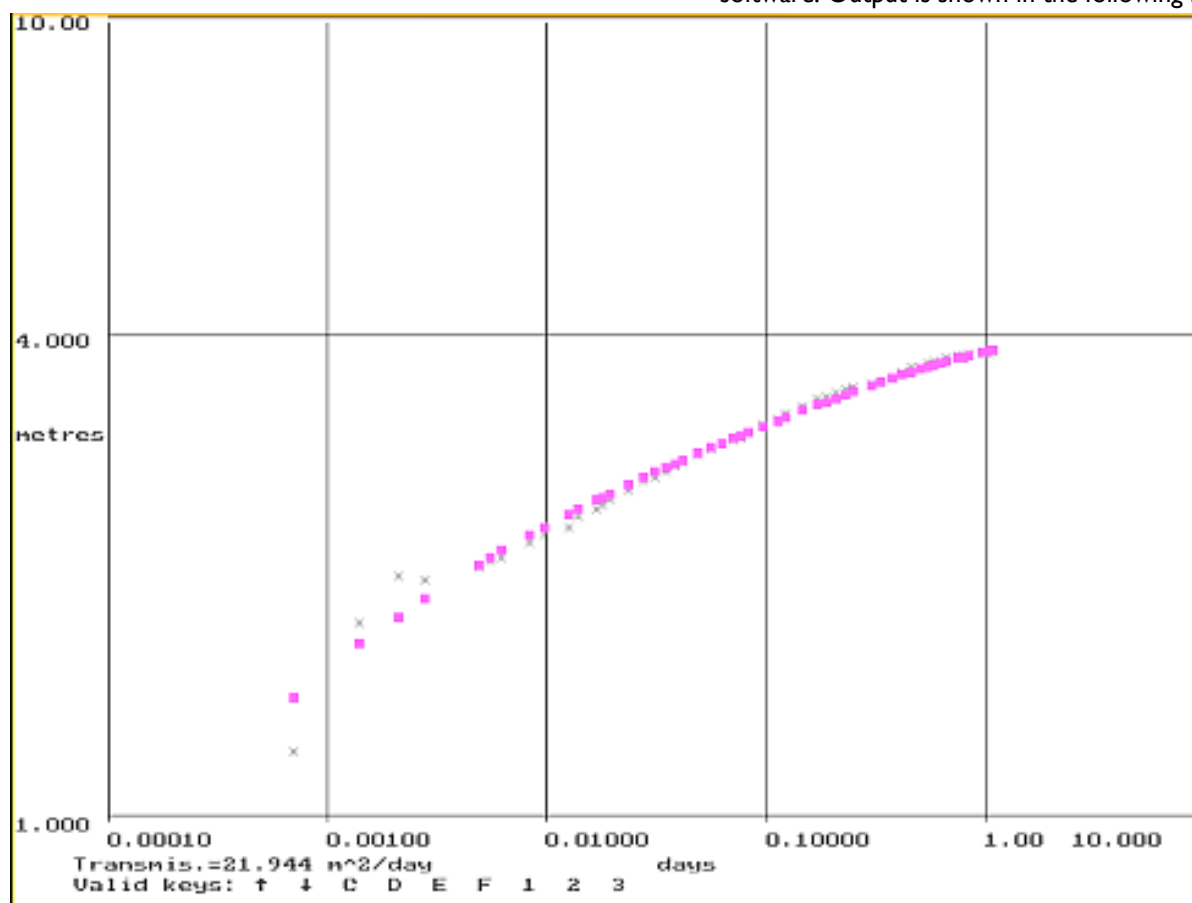


Figure 10-1: WBTH 001 pumped well

Confined aquifer with recharge boundary interpretation

Summary analysis data:

Aquifer type: confined, singly bounded (recharge boundary).

Transmissivity = 21.9439 m²/day, storage coefficient = 0.03513693

Image well distance = 54.2309 metres

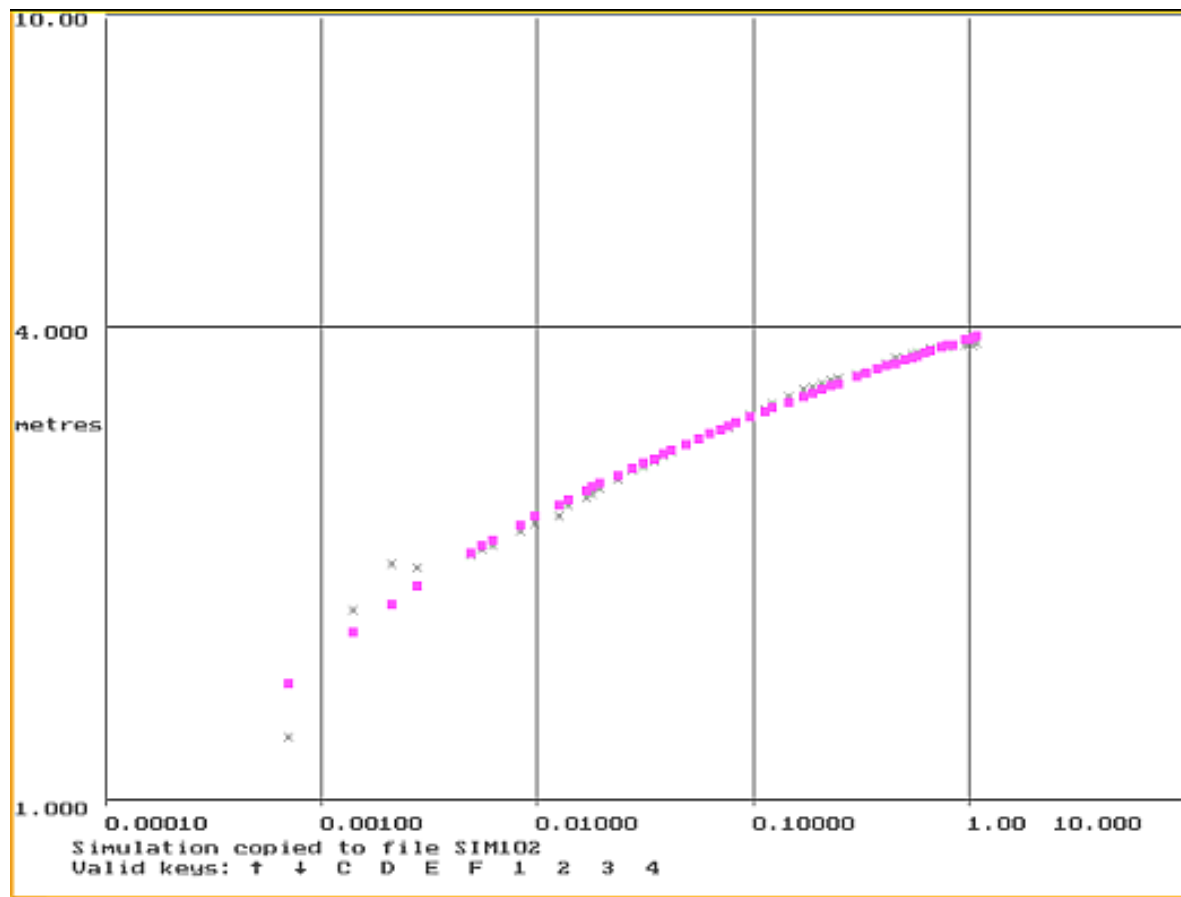


Figure 10-2: WBTH 001 pumped response

Confined partially bounded strip aquifer interpretation

Summary analysis data:

Aquifer type: confined, partially bounded strip.

Transmissivity = 22.2421 m²/day, storage coefficient = 0.03337018

Strip width = 5.53312 metres

Transmissivity beyond boundary = 21.8491 m²/day

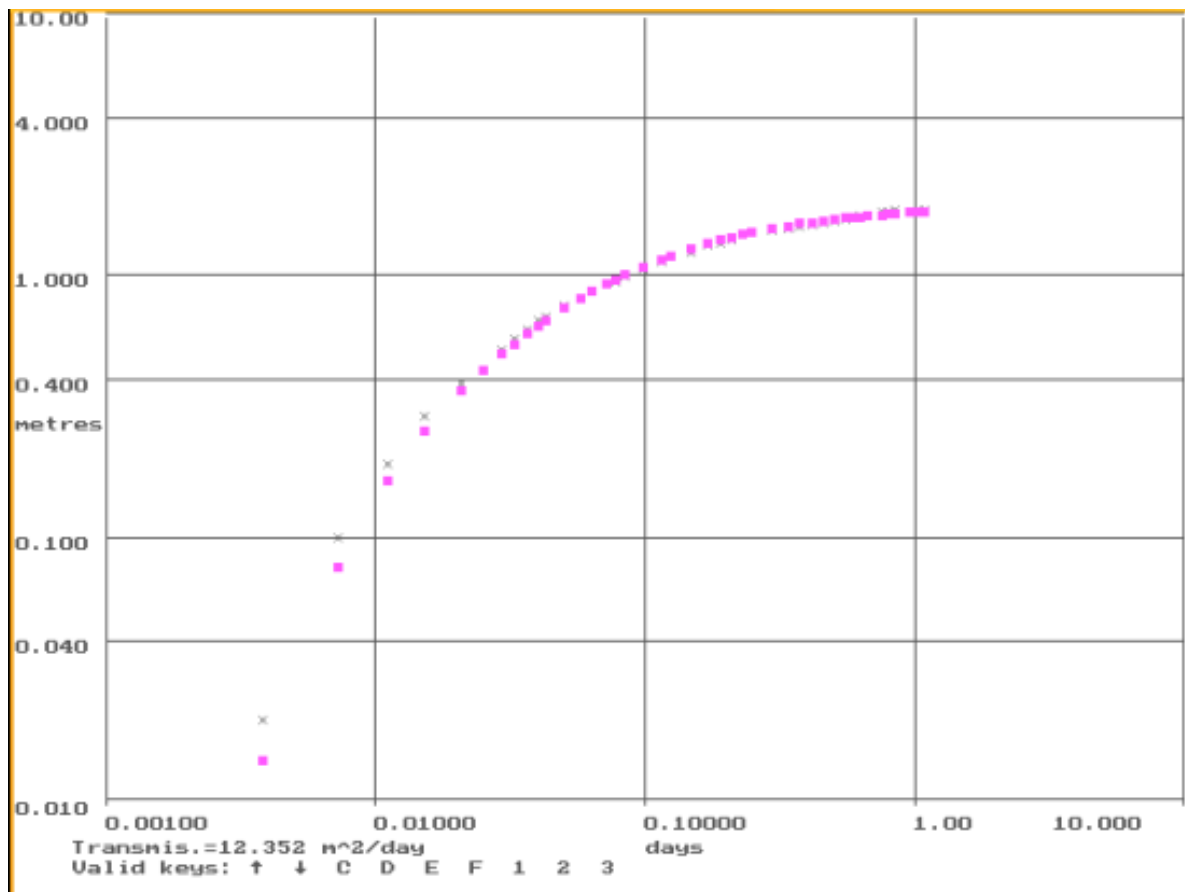


Figure 10-3: WBTH 001 test: observation well WBTH 020 response

Confined aquifer with recharge boundary interpretation

Summary analysis data:

- Aquifer type: confined, singly bounded (recharge boundary).
- Transmissivity = 12.3516 m²/day, storage coefficient = 0.00019265
- Distance from pumped well to piezometer = 50.0000 metres
- Image well distance = 231.747 metres

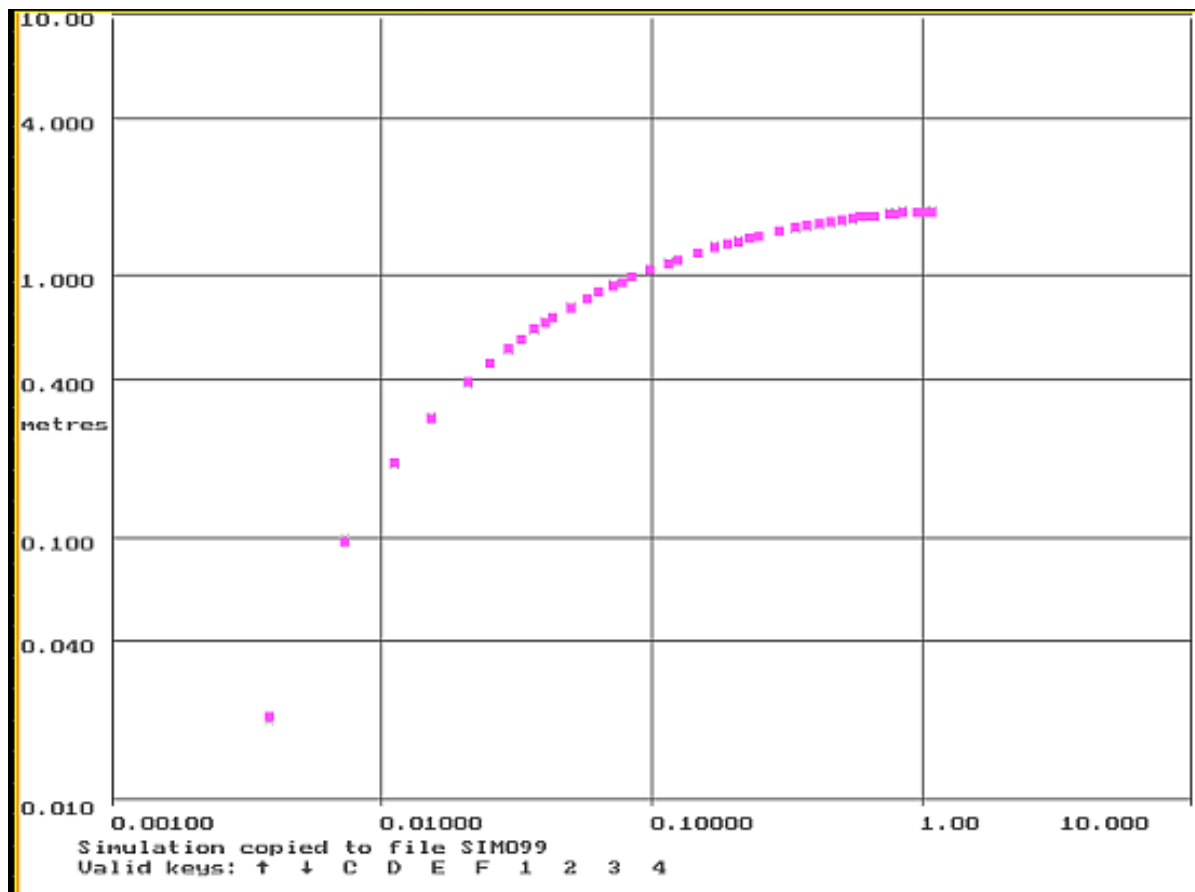


Figure 10-4: WBTH 001 test, observation well WBTH 020

Leaky artesian strip aquifer interpretation

Summary analysis data:

- Aquifer type: leaky artesian, strip (two parallel discharge boundaries).
- Transmissivity = $12.3516 \text{ m}^2/\text{day}$, storage coefficient = 0.00017009
- Leakage coefficient = 151.964 metres
- Distance from pumped well to piezometer = 50.0000 metres
- Strip width = 341.948 metres

For the observation well WBTH 020 ($r = 231.747\text{m}$), a reasonable fit for the data was obtained using the Clark (1988) method for a confined aquifer with a single recharge but the early time data fit is improved when matched with the leaky artesian strip model.

Analysis of the drawdown in the pumping well produced a reasonable fit with a confined aquifer with recharge boundary, or a partially bounded strip. Both analyses indicating a higher Transmissivity ($\sim 23\text{m}^2/\text{d}$) than the observation well data ($\sim 12\text{m}^2/\text{day}$).

A storage coefficient in the elastic range ($1.7\text{e-}04$) was indicated from the observation well and a much larger value ($3.5\text{e-}02$) was obtained from the pumped well.

10.2 WBTH002

WBTH002 intersected largely pelitic metasediments and intersected only minor water intersections below 150m with an airlift yield of 1.2l/sec.

The well was only pumped for 48 minutes due to the well not being able to supply sufficient water at 22.15m³/day. A leaky artesian semi bounded aquifer interpretation was used, as shown in Figure 12.

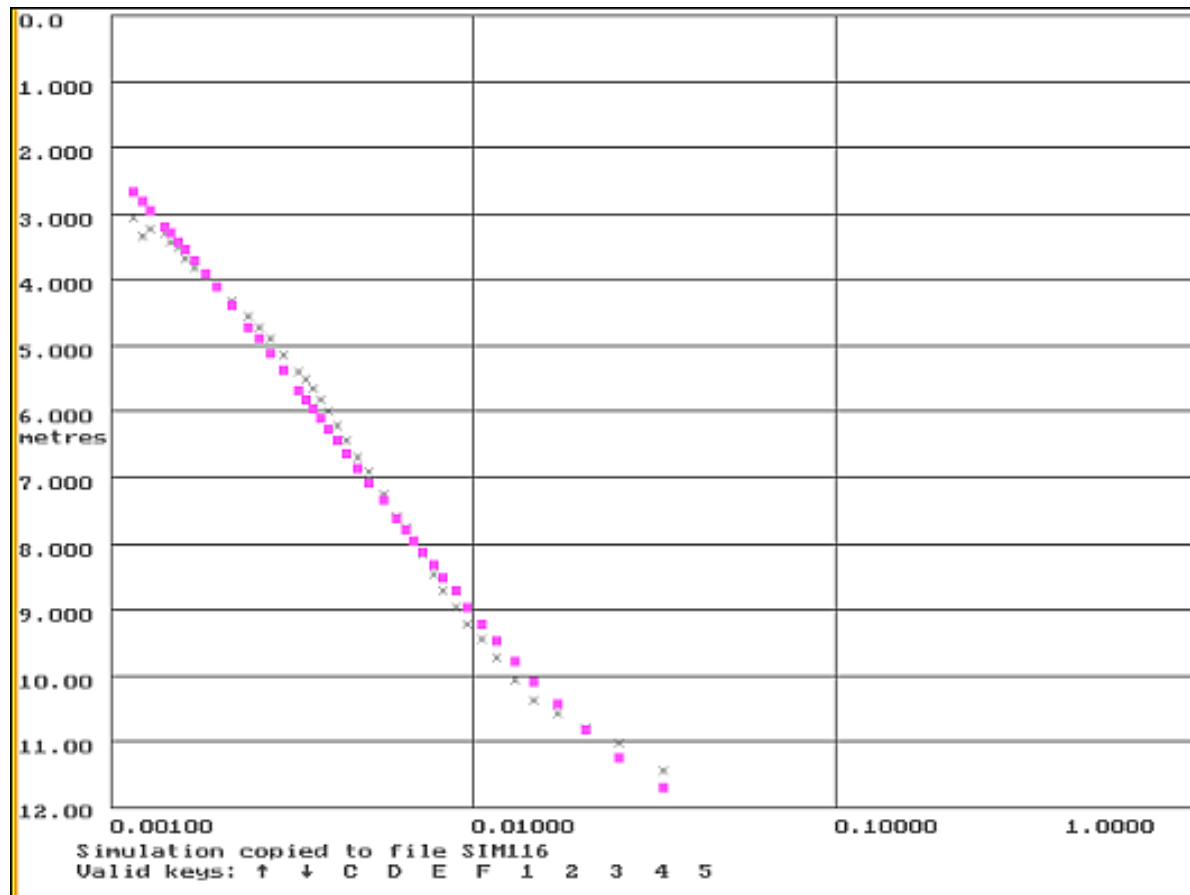


Figure 10-5: WBTH 002 test

Leaky artesian semi bounded aquifer interpretation

Summary analysis data:

- Aquifer type: leaky artesian, semi bounded (partial boundary).
- Transmissivity = 0.45553 m²/day, storage coefficient = 0.05844528
- Leakage coefficient = 0.54848 metres
- Image well distance = 1.02273 metres
- Transmissivity beyond boundary = 0.96386 m²/day

With an open-hole interval of 164m, a transmissivity of 0.455m²/day indicates an average K value of 3.4e-03m/day which cannot be considered to be an aquifer in the normal (water supply) sense of the term.

10.3 WBTH004

A very low yielding well, located in the hanging wall, WBTH004 encountered difficulties during drilling. It was tested for 330 minutes at an average rate of 19.5m³/day. It was interpreted as being a leaky artesian aquifer with output from the Clarke software shown in Figure 10-6 .

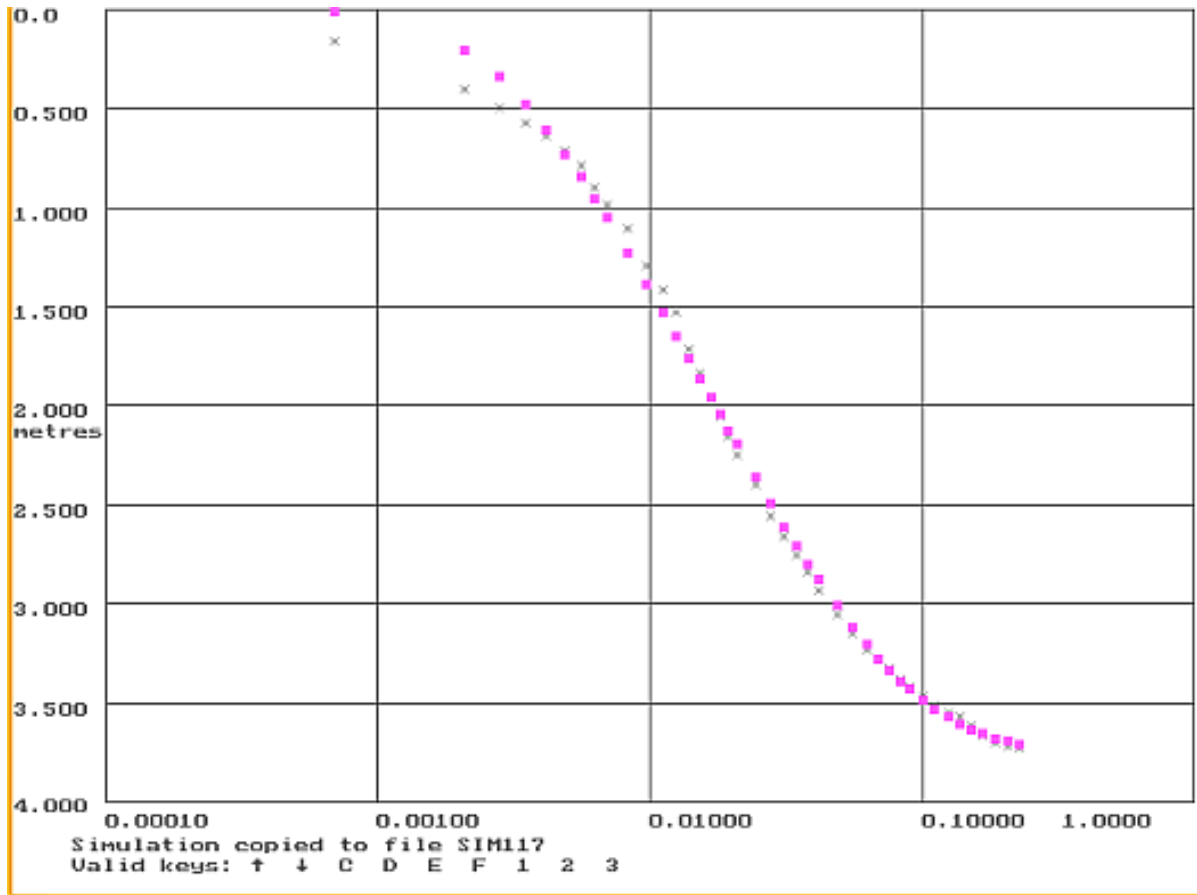


Figure 10-6: WBTH 004 test
Leaky artesian aquifer interpretation

Summary analysis data:

- Aquifer type: leaky artesian, infinite.
- Transmissivity = 1.00284 m²/day, storage coefficient = 0.75535262
- Leakage coefficient = 0.33932 metres

The curve-match is very good with only minor departures at early times when the stored water in the casing can have a serious impact at very low pumping rates.

With a slotted interval of 54 metres and a transmissivity of 1m²/day, this well test indicates very low permeability rocks in the hangingwall.

10.4 WBTH005

One of the higher yielding wells (8.3l/sec air lift), WBTH005 was pumped at 108m³/day for 1.25 days with an observation well, WBTH18 (r = 41.6 metres).

The pumped aquifer drawdown analysis is shown in Figure 10-7.

Despite a relatively high air lift yield, the modest pumping rate of 108m³/day was necessary because of the necessity to restrict discharge rates because of disposal challenges (water tanker trucking).

The transmissivity (T) calculated from the analysis of the pumping well is 20 m²/d whilst the T value from observation well WBTH 018 is 11 m²/d (refer Figure 10-8).

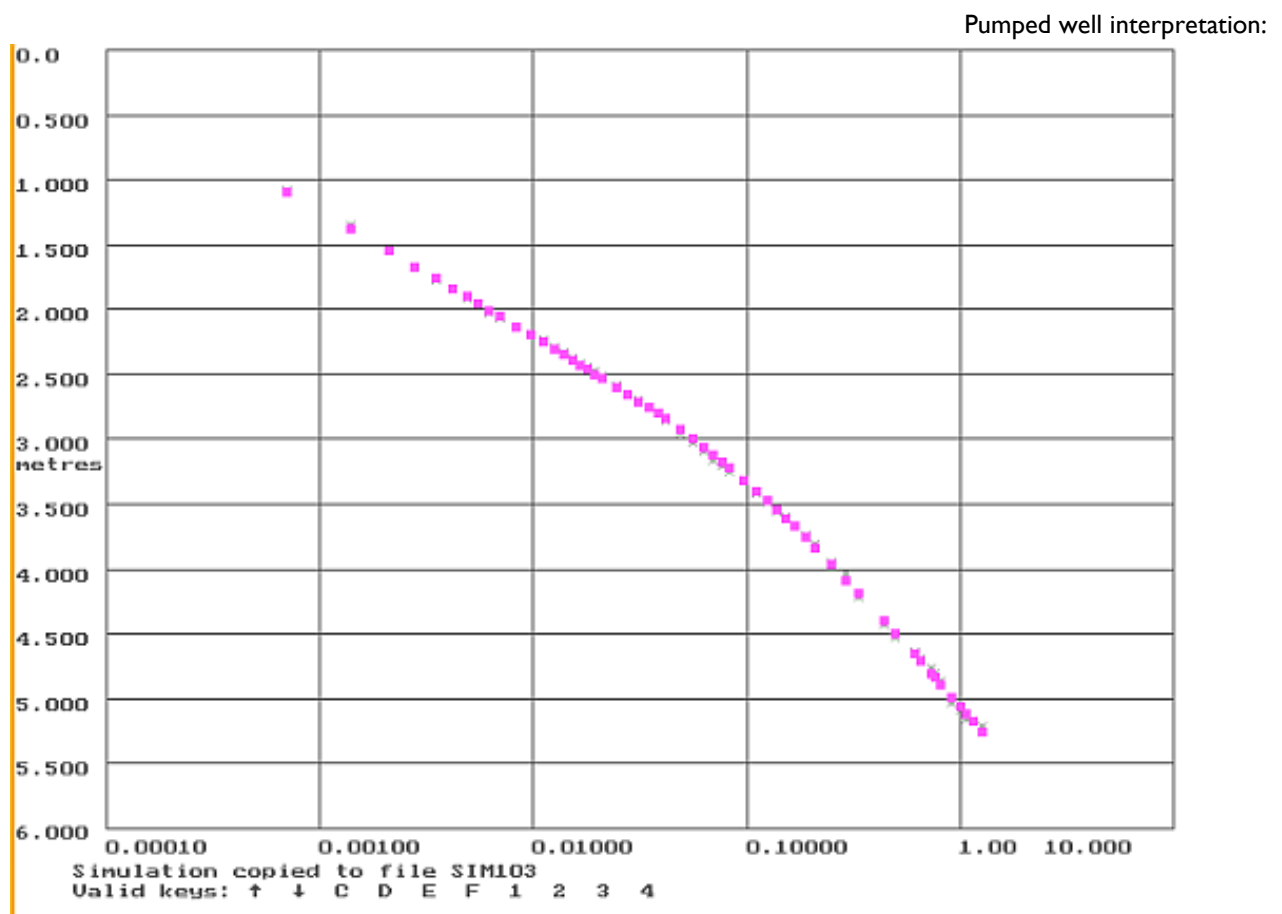


Figure 10-7: WBTH 005 test

Confined semi bounded aquifer interpretation

Summary analysis data:

- Aquifer type: confined, semi bounded (partial boundary).
- Transmissivity = 20.1421 m²/day, storage coefficient = 0.1636639
- Image well distance = 6.11425 metres
- Transmissivity beyond boundary = 0.00000 m²/day

Obs well interpretation:

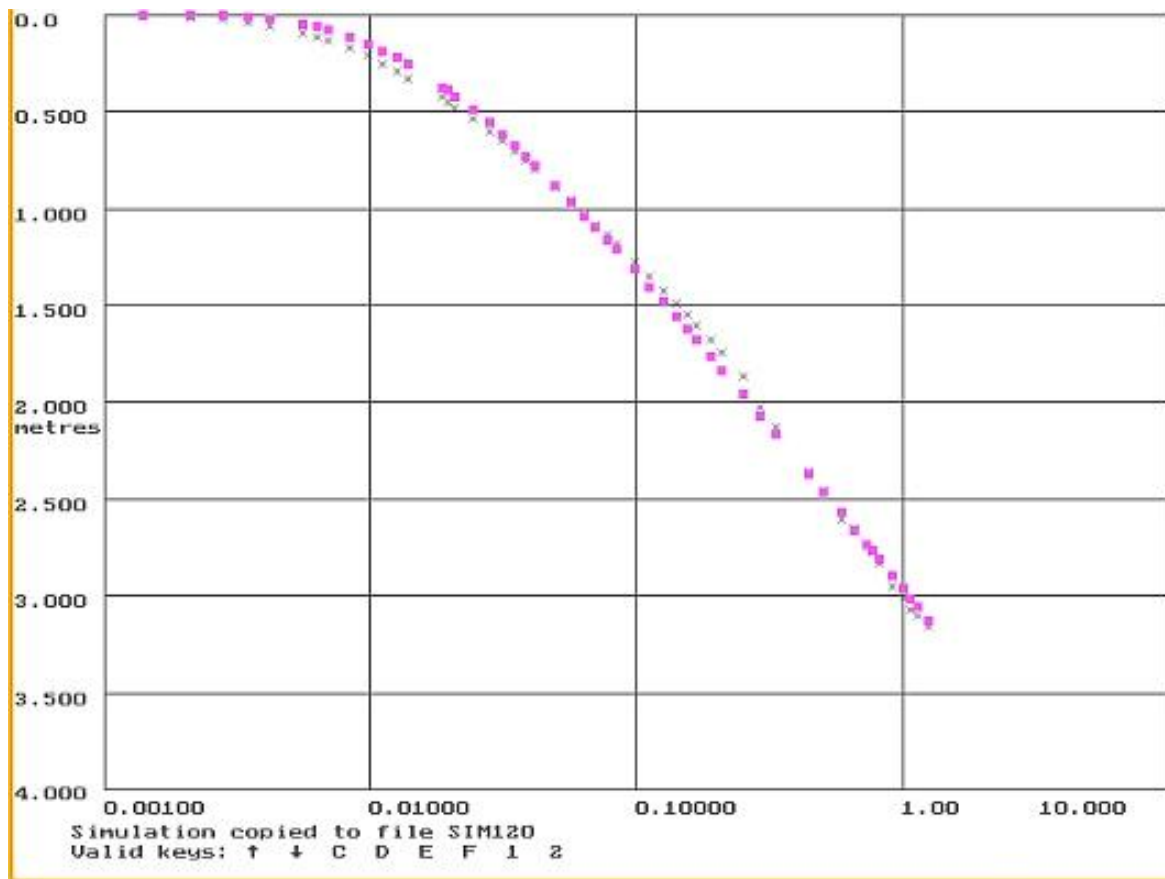


Figure 10-8: WBTH 005 test: observation well WBTH 018 response
Confined aquifer interpretation

Summary analysis data:

- Aquifer type: confined, infinite.
- Transmissivity = 11.6451 m²/day, storage coefficient = 0.00027709
- Distance from pumped well to piezometer = 41.6000 metres

As with the WBTH001 testing, the pumped well yielded a transmissivity (20 m²/day) of almost twice that of the observation well (11.6m²/day) and storage coefficient of 0.16 compared with the “elastic” range value of 2.77e-04 from the observation well.

10.5 WBTH008

WBTH008 test is the only test of the series to be supported by 2 observation wells, WBTH 016, 144m to the south and “Metallurgy” Well 122m to the east.

The pumping well response is shown in Figure 10-9. Responses from observation wells WBTH 016 and ‘Metallurgy’ well are shown in Figure 10-10 and Figure 10-11.

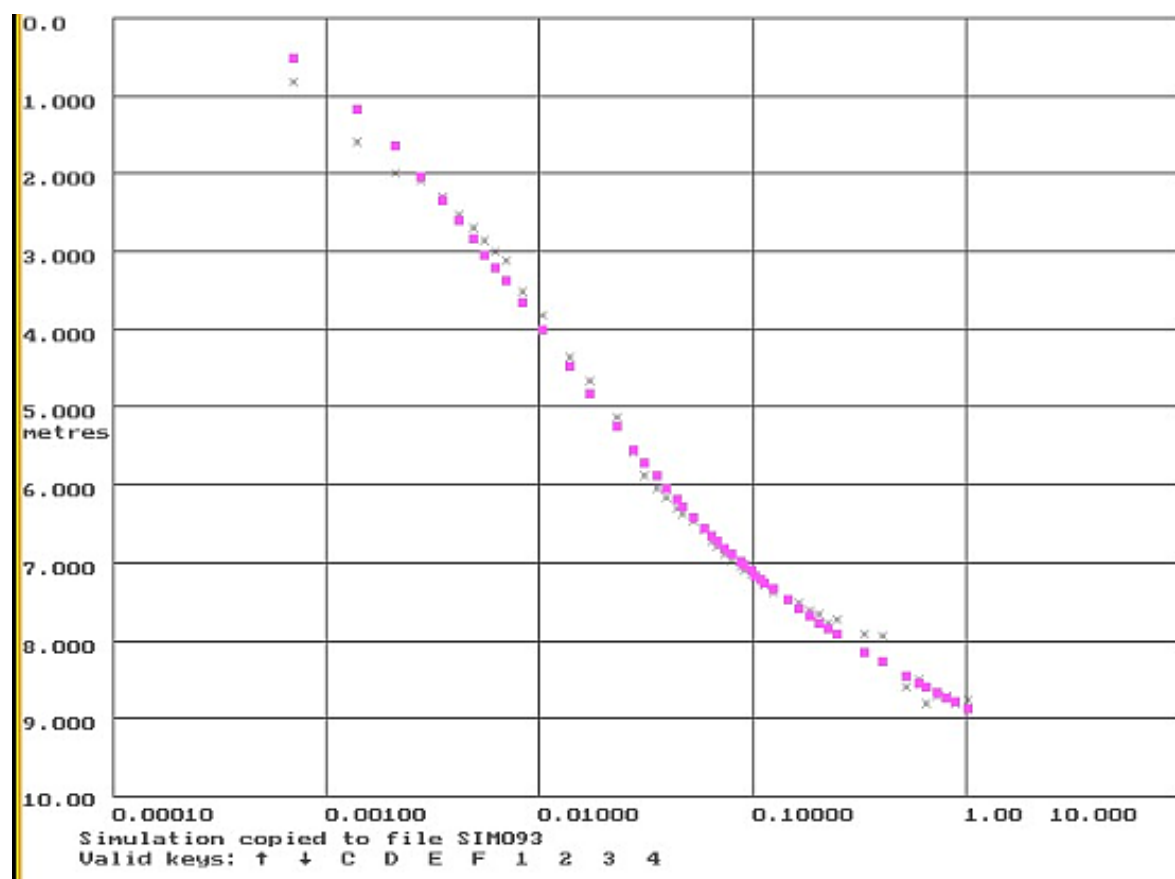


Figure 10-9: WBTH 008 test
Confined, semi bounded, aquifer interpretation

Summary analysis data:

- Aquifer type: confined, semi bounded (partial boundary).
- Transmissivity = 2.27305 m²/day, storage coefficient = 0.32929038
- Image well distance = 1.18961 metres

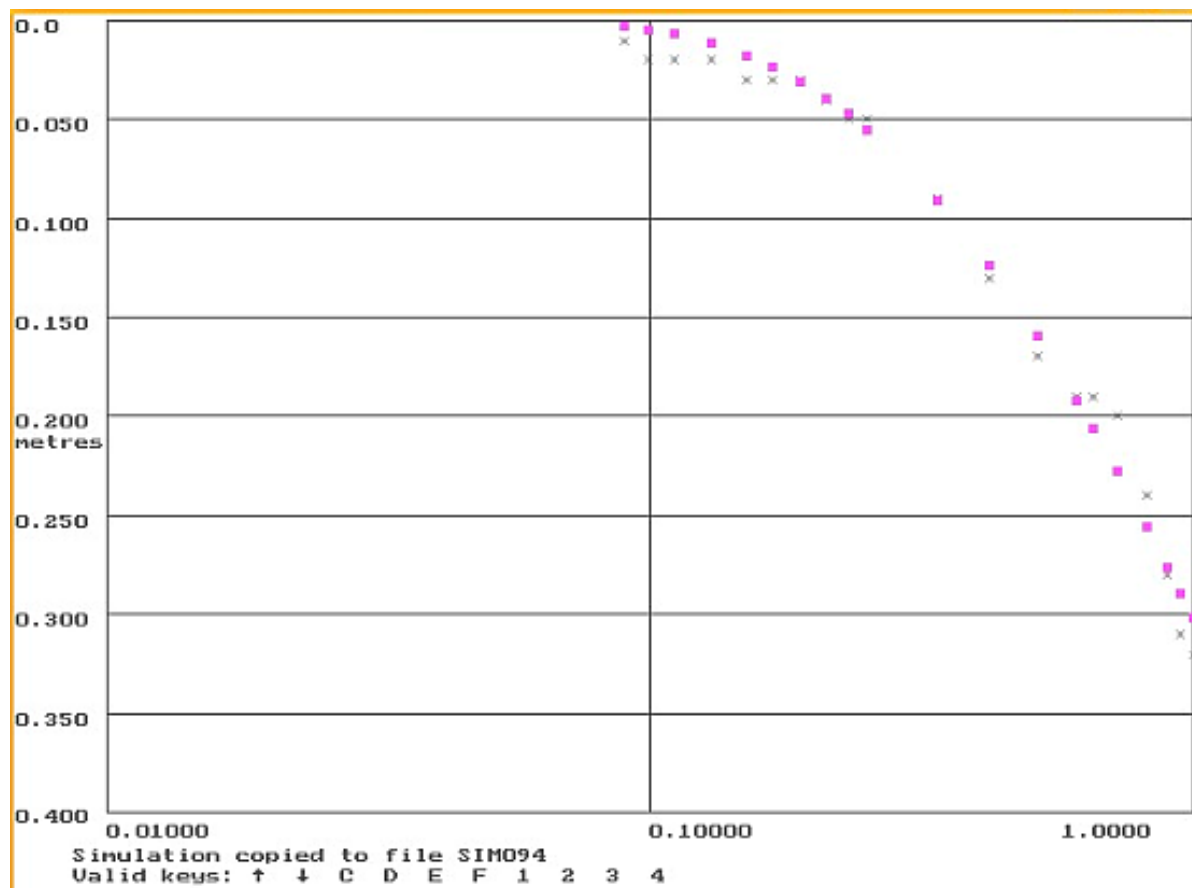


Figure 10-10: WBTH 008 test: observation well WBTH 016 response
Confined, semi bounded, aquifer interpretation

Summary analysis data:

- Aquifer type: confined, semi bounded (partial boundary).
- Transmissivity = 1.68179 m²/day, storage coefficient = 0.02051632
- Distance from pumped well to piezometer = 144.000 metres
- Image well distance = 9.74834 metres
- Transmissivity beyond boundary = 1.26134 m²/day

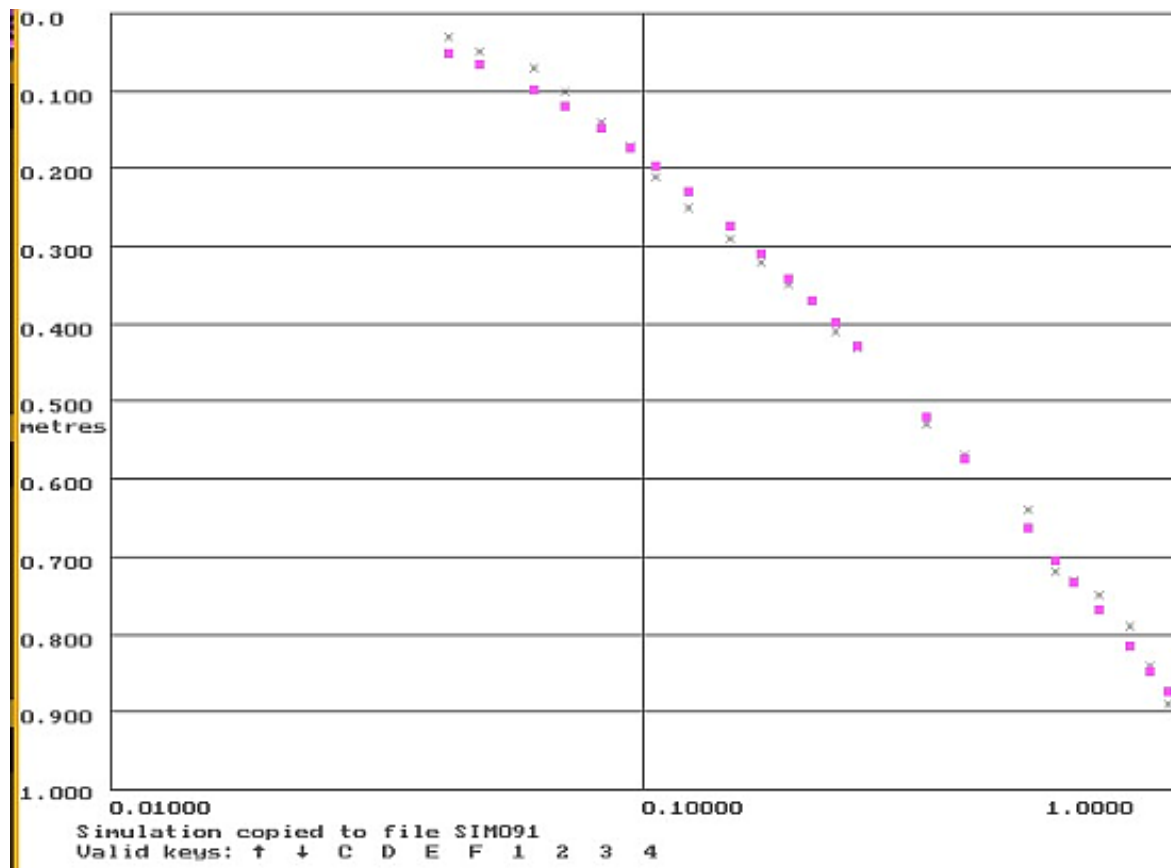


Figure 10-11: WBTH 008 test: observation well 'Metallurgy hole'
Confined, semi bounded, aquifer interpretation

Summary analysis data:

- Aquifer type: confined, semibounded (partial boundary);
- Transmissivity = 5.97163 m²/day, storage coefficient = 0.08129124;
- Distance from pumped well to piezometer = 122.000 metres;
- Image well distance = 4.05452 metres; and
- Transmissivity beyond boundary = 1.55900 m²/day.

10.6 WBTH009

WBTH009 was tested for 8 hours at an average of 44.62m³/day resulting in the drawdown illustrated in Figure 10-12.

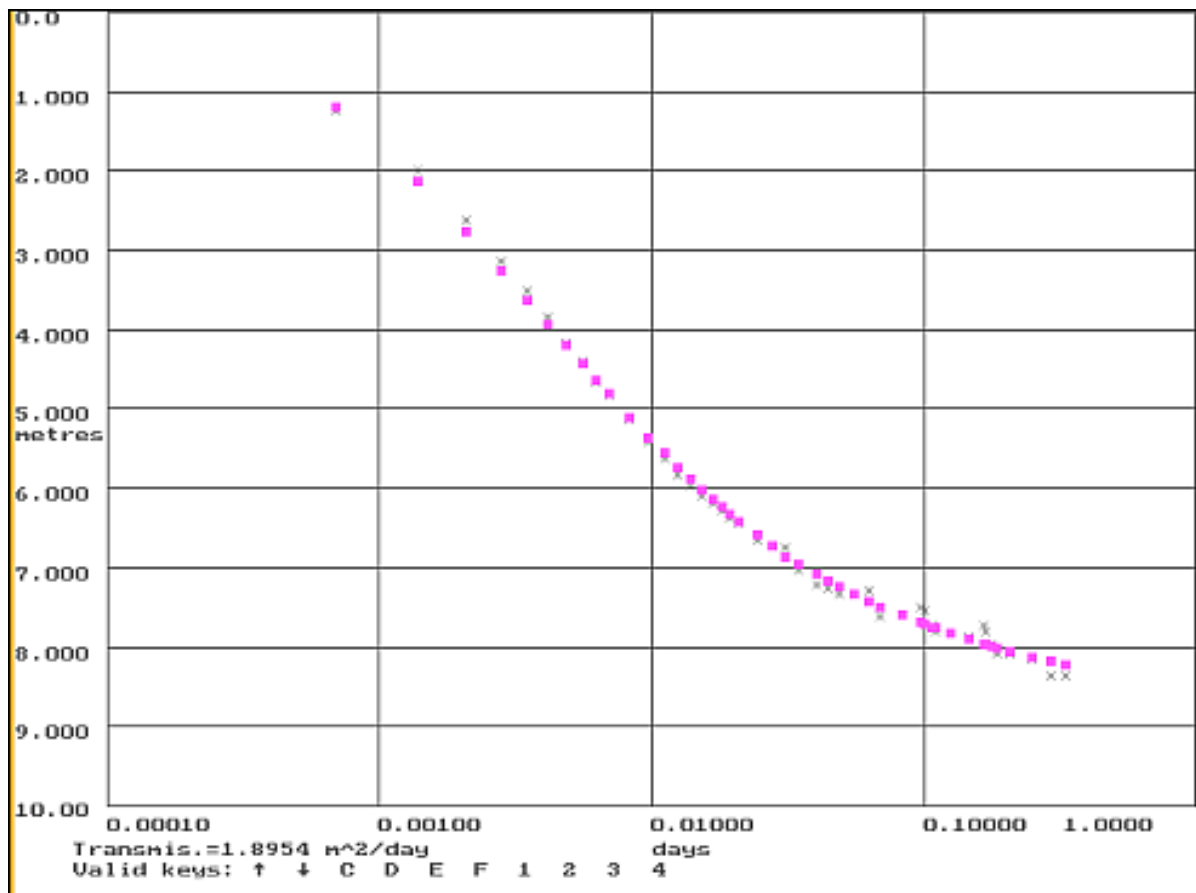


Figure 10-12: WBTH 009 test

Confined, semi bounded, aquifer interpretation

Summary analysis data:

- Aquifer type: confined, semi bounded (partial boundary);
- Transmissivity = 1.89540 m²/day, storage coefficient = 0.16189290;
- Image well distance = 0.92521 metres; and
- Transmissivity beyond boundary = 23.0262 m²/day.

The well is located within the footwall granites and the aquifer-type indicated (confined semi-bounded) suggests the presence of structural elements which could result in zones of enhanced permeability within a very low permeability unit.

10.7 WBTH10

Also located within the footwall granites, WBTH10 yielded only 1.2 l/sec on air lifting. The drawdown at a pumping rate of 86.4m³/day is shown in Figure 10-13. The Clarke (1988) analysis suggests that the aquifer can be characterised as a partially bounded leaky strip aquifer (a lenticular zone of higher hydraulic conductivity material occurs between 2 zones of lower hydraulic conductivity materials. 'Leaky'

indicates that water can move from one to the other but that the properties of the units are sufficiently different for them to be differentiated).

The strip width of approximately 6m suggests a shear zone with a T value of approximately 33m²/day within the shear and <1.0m²/day outside.

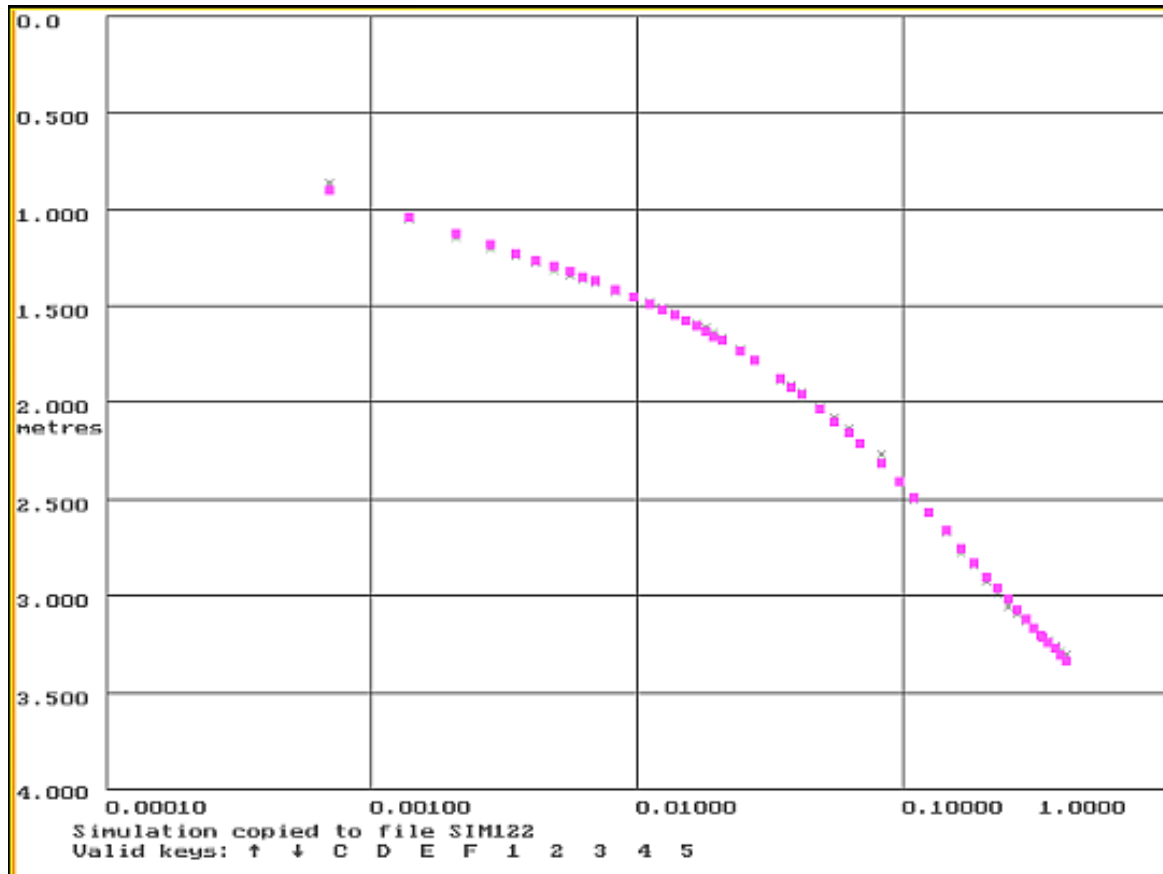


Figure 10-13: WBTH 010 test

Confined leaky partially bounded strip aquifer interpretation

Summary analysis data:

- Aquifer type: leaky artesian, partially bounded strip;
- Transmissivity = 33.2982 m²/day, storage coefficient = 0.06853125;
- Leakage coefficient = 14.4509 metres;
- Strip width = 6.22449 metres; and
- Transmissivity beyond boundary = 0.91042 m²/day.

10.8 WBTH11

WBTH11 is also located in the footwall granite. It was tested at a rate of 83.2m³/day for 1320 mins and observations were also made in WBTH19 at a distance of 30m from the pumping well.

The analysis of drawdown due to pumping in WBTH 011 is shown in Figure 10-14. The observation well (WBTH19) drawdown is presented in Figure 10-15.

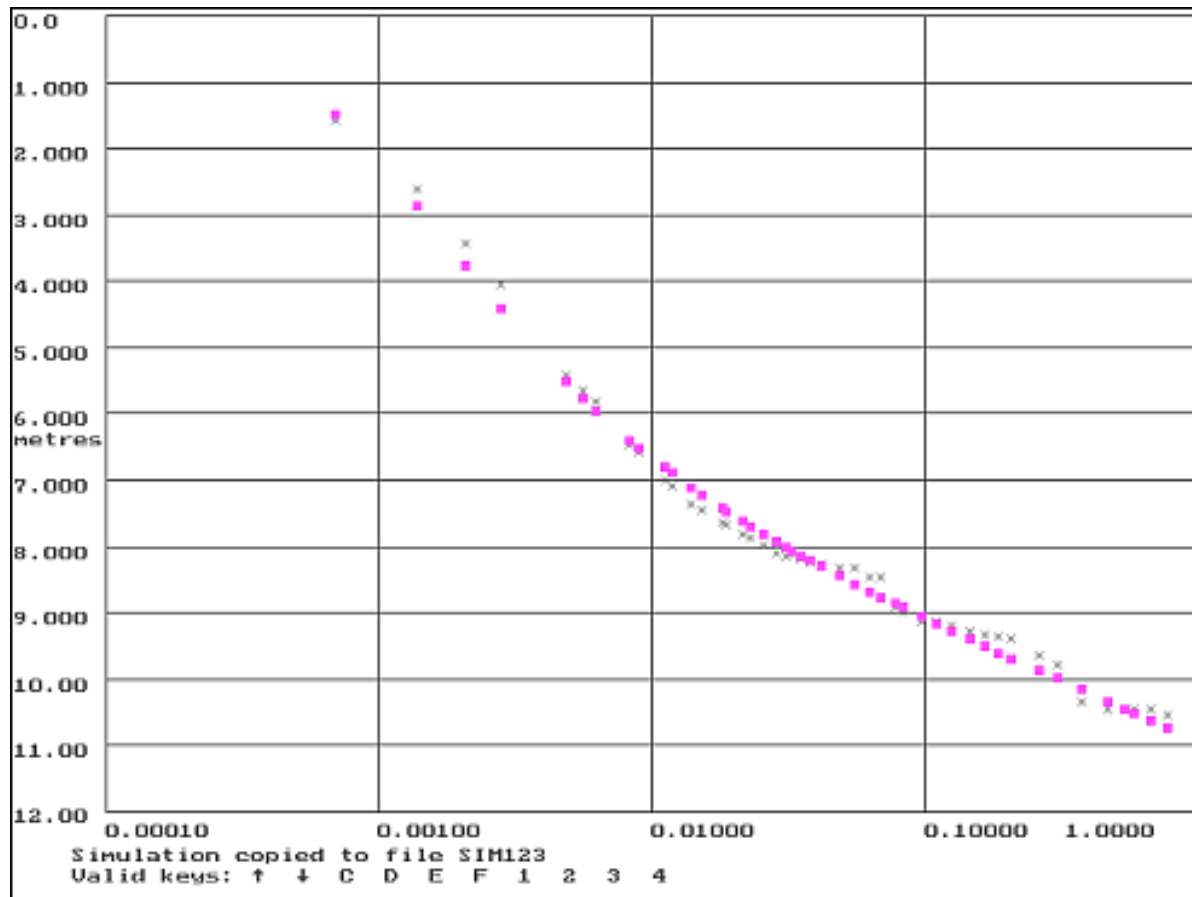


Figure 10-14: WBTH 011 test, pumped response

Confined semi bounded aquifer interpretation

Summary analysis data:

- Aquifer type: confined, semi-bounded (partial boundary);
- Transmissivity = 2.09847 m²/day, storage coefficient = 0.34100086;
- Image well distance = 0.30734 metres; and
- Transmissivity beyond boundary = 15.0712 m²/day.

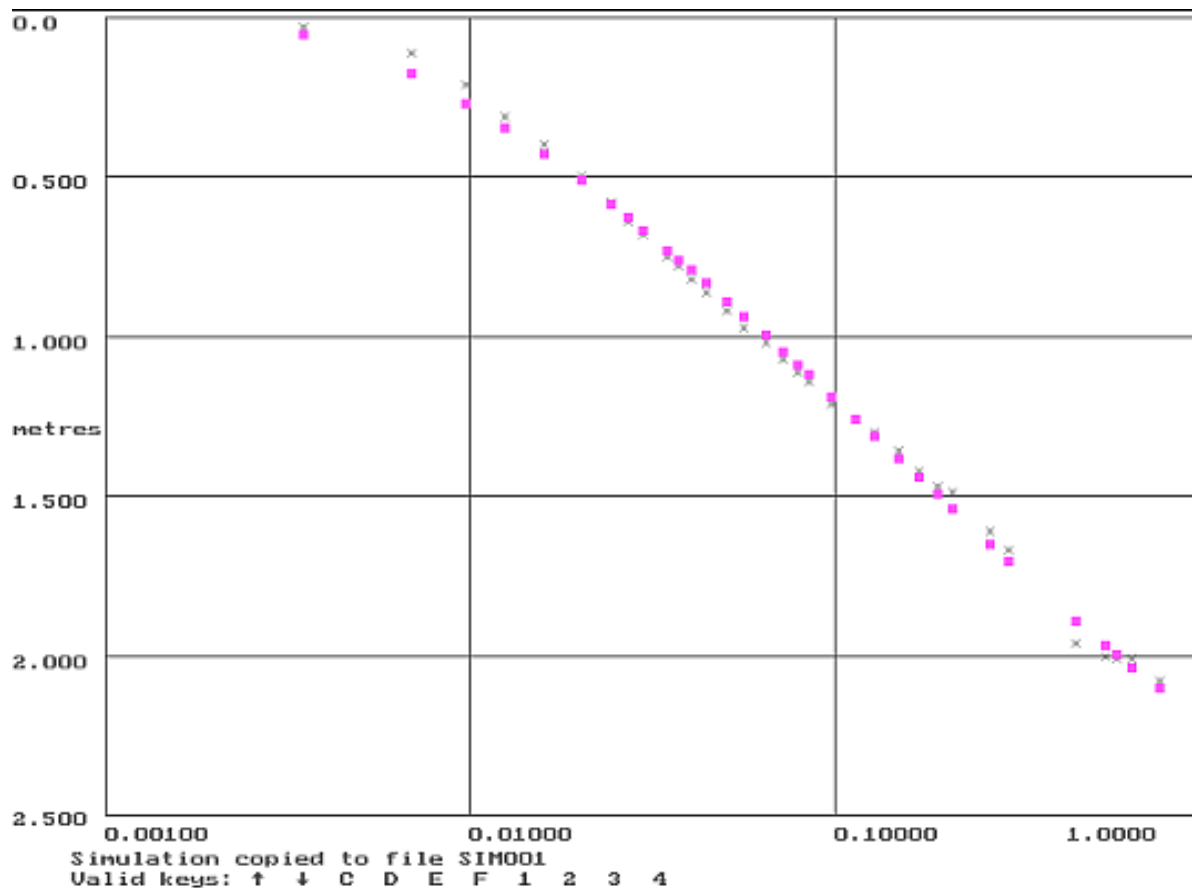


Figure 10-15: WBTH 011 test, observation well WBTH 019 response

Confined semi bounded aquifer interpretation

Summary analysis data:

- Aquifer type: confined, semi bounded (partial boundary);
- Transmissivity = 13.7972 m²/day, storage coefficient = 0.00029941;
- Distance from pumped well to piezometer = 30.0000 metres;
- Image well distance = 396.161 metres; and
- Transmissivity beyond boundary = 62.4593 m²/day.

The image well distance and transmissivity beyond the boundary are difficult to reconcile with the result of the analysis of the pumped well data. However, the T value of 13.78 m²/day and storage coefficient of approximately 3.0E-04 are considered to be valid.

Also, both the pumped and observation wells are interpreted as being affected by boundaries with the material on the distant side of the boundary having a greater T than at the well.

10.9 WBTH12

Located in the footwall granites, WBTH12 was air lifted at 1.2l/sec and pumped at 50.19m³/day for 90 mins then 60m³/day to a total of 950 mins.

The drawdown in the pumped well is shown in Figure 10-16.

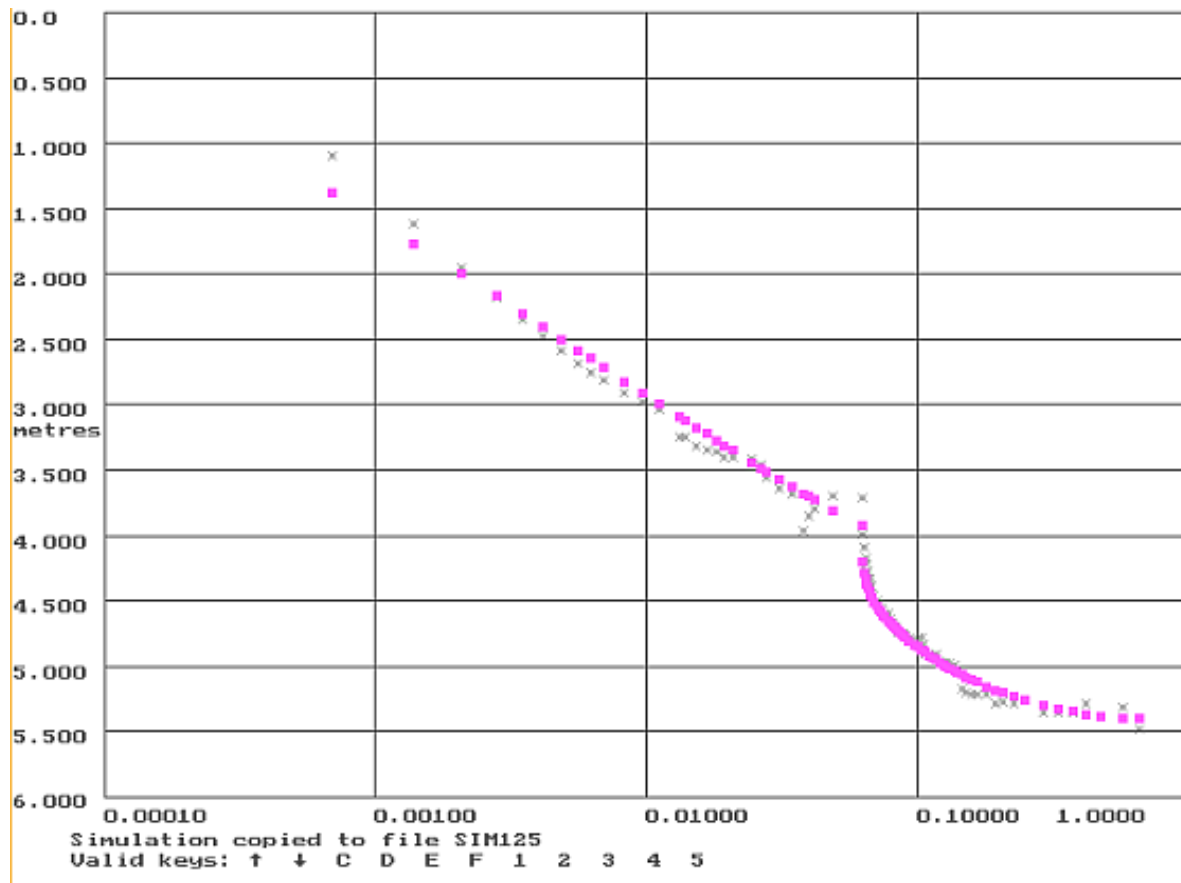


Figure 10-16: WBTH 012 test

Leaky artesian semi bounded aquifer interpretation

Summary analysis data:

- Aquifer type: leaky artesian, semi bounded (partial boundary);
- Transmissivity = 12.5608 m²/day, storage coefficient = 0.05854938;
- Leakage coefficient = 6.95461 metres;
- Image well distance = 0.43593 metres; and
- Transmissivity beyond boundary = 0.29370 m²/day.

In a manner similar to the other footwall granite wells, WBTH12 shows signs of the in-homogeneity of the granite body with narrow zones of higher T representing structural control. This is probably a result of the shear zones. However the maximum values of T encountered are still small when it is recalled that there is generally more than 150 metres of granite exposed in each well.

10.10WBTH13

WBTH13, in the footwall granite, was the highest yielding hole on air lift with a yield of >10l/sec.

The well was pumped at approximately 578 m³/d for 12 hours, resulting in the drawdown versus time plot shown in Figure 10-17.

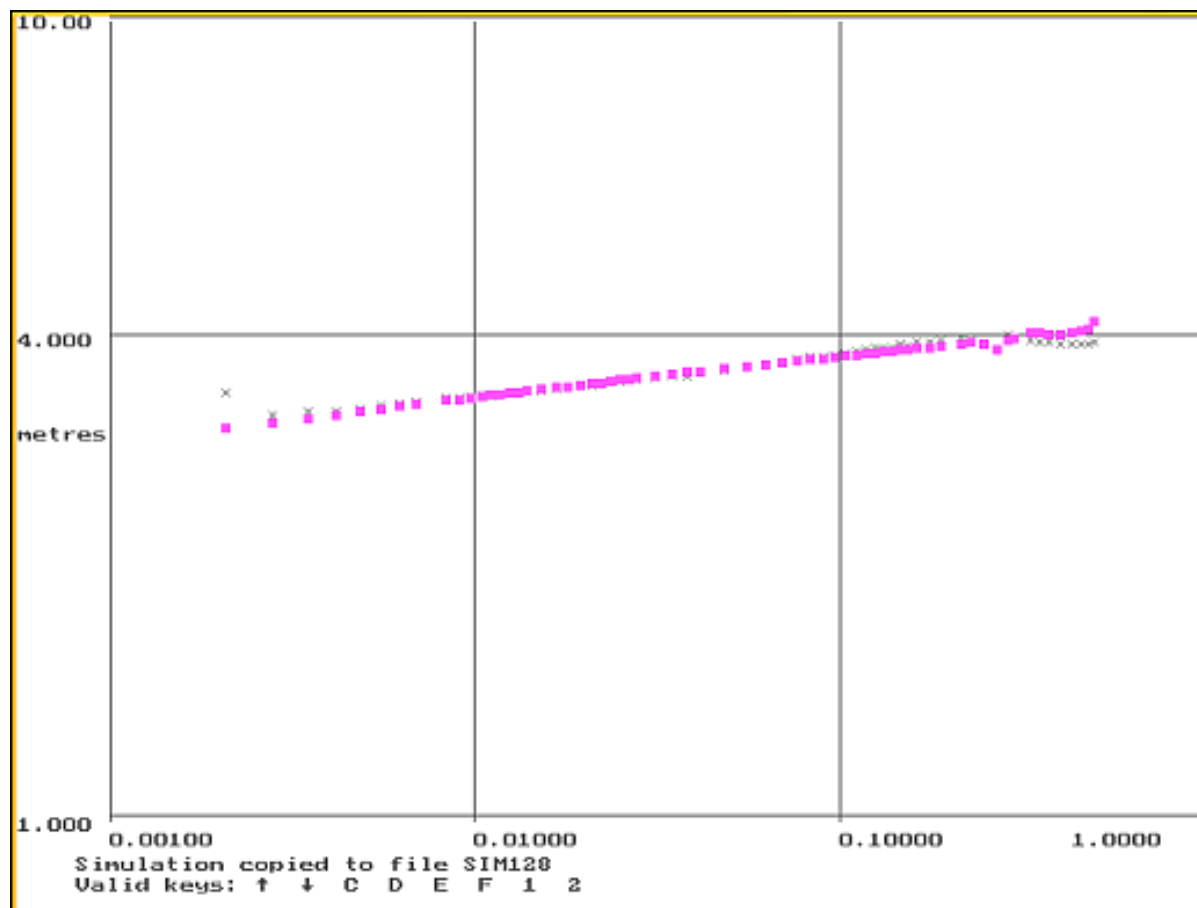


Figure 10-17: WBTH 013 test
Confined aquifer interpretation

Summary analysis data:

- • Aquifer type: confined, infinite; and
- • Transmissivity = 253.159 m²/day, storage coefficient = 0.00000496.

The minor deviations towards the end of the testing period are due to variations in discharge rate due to kinking of the discharge line.

This well is considered to be anomalous within the footwall granite since it shows both a relatively high transmissivity and absence of obvious boundary effects.

An alternative interpretation is shown in which the aquifer is treated as a leaky artesian aquifer.

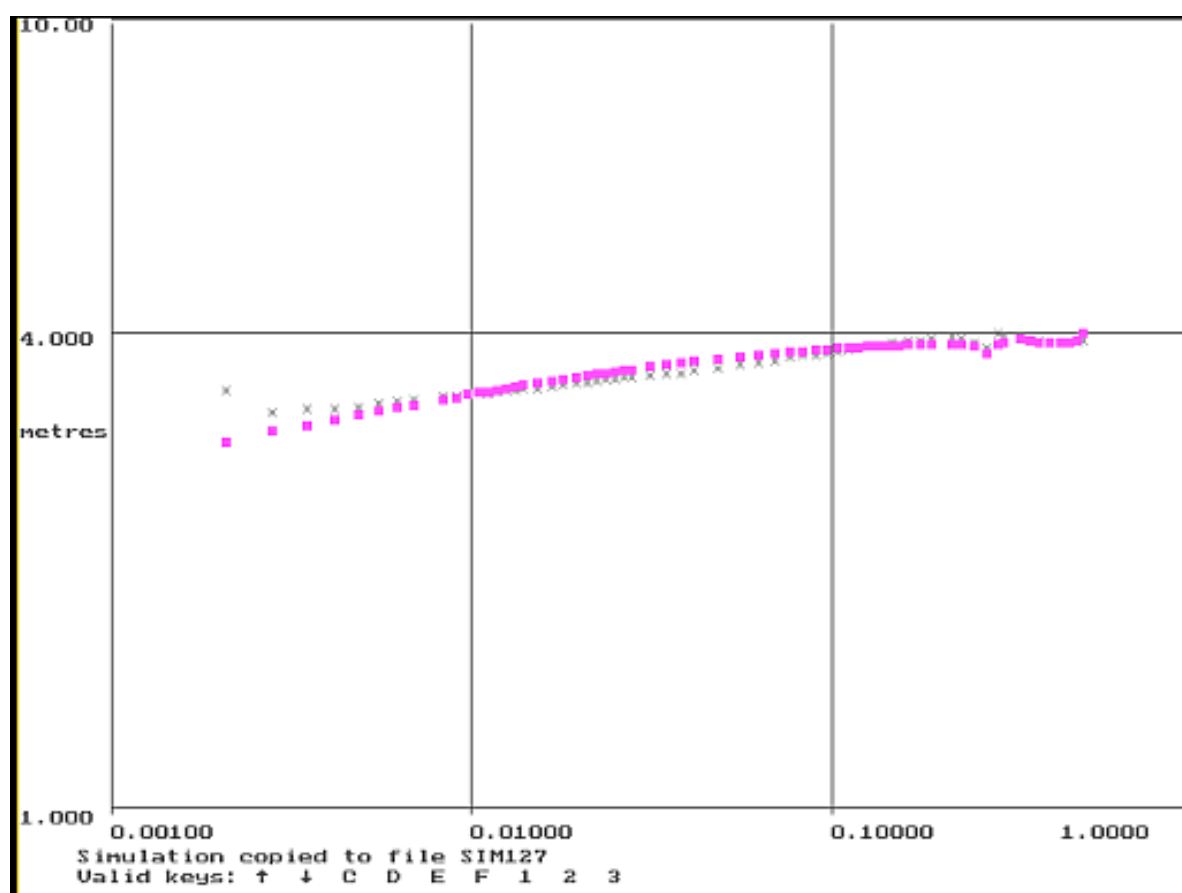


Figure 10-18: WBTH 013 test
Leaky artesian aquifer interpretation

Summary analysis data:

- Aquifer type: leaky artesian, infinite;
- Transmissivity = 160.359 m²/day, storage coefficient = 0.00234014; and
- Leakage coefficient = 86.3068 metres.

The fit of observed data is closer towards the beginning of the testing period.

10.11 WBTH15

With an estimated air lift yield of approximately 0.5 l/sec, WBTH15 could only be pumped for 595 mins at 22.62 m³/day resulting in the drawdown plot shown in Figure 10-19.

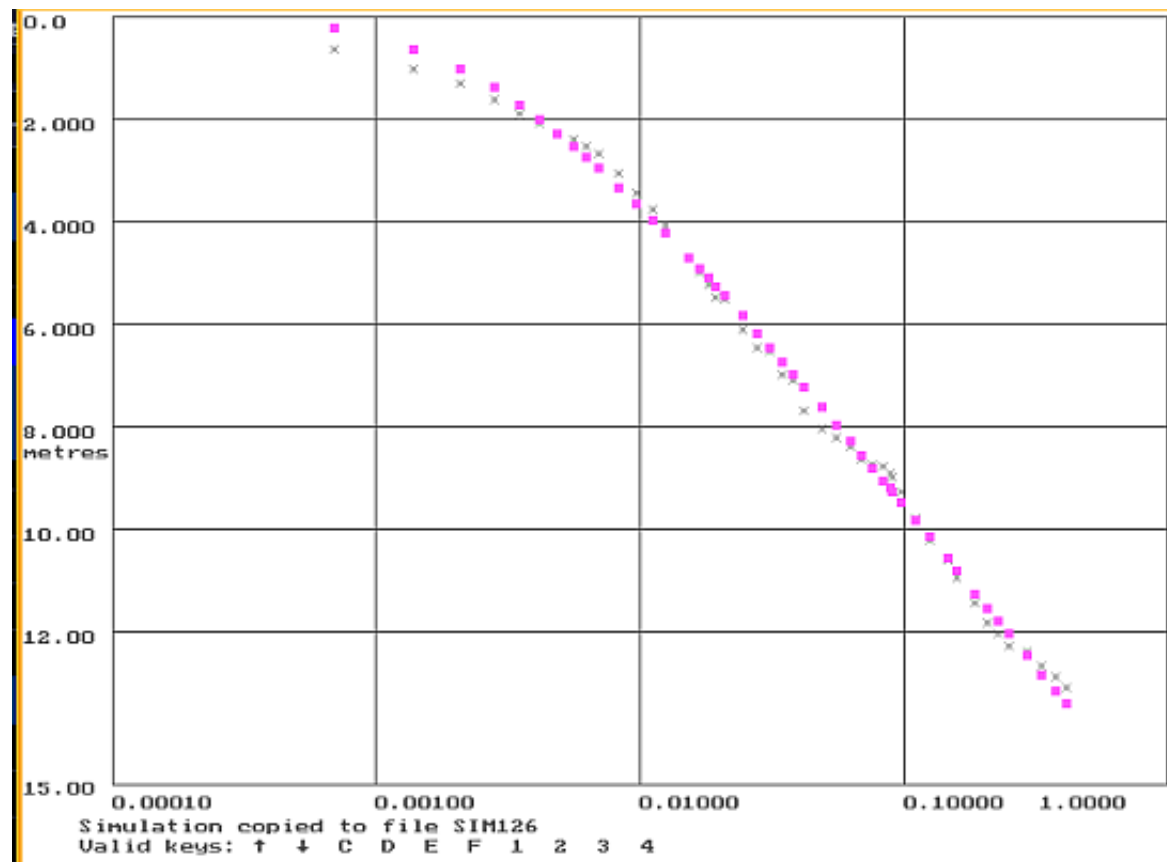


Figure 10-19: WBTH 015 test

Confined semi bounded aquifer interpretation

Summary analysis data:

- Aquifer type: confined, semi bounded (partial boundary);
- Transmissivity = 1.30187 m²/day, storage coefficient = 0.44735629;
- Image well distance = 0.21121 metres; and
- Transmissivity beyond boundary = 0.00000 m²/day.

The analysis indicates that the yield is probably coming from a single fracture, or very weakly developed fracture zone set in a rock mass of almost zero permeability.

10.12WBTH17

With an air lift yield of 1l/sec, WBTH17 was pumped at between 46 and 54 m³/day for 480 mins. The drawdown plot is presented in Figure 10-20.

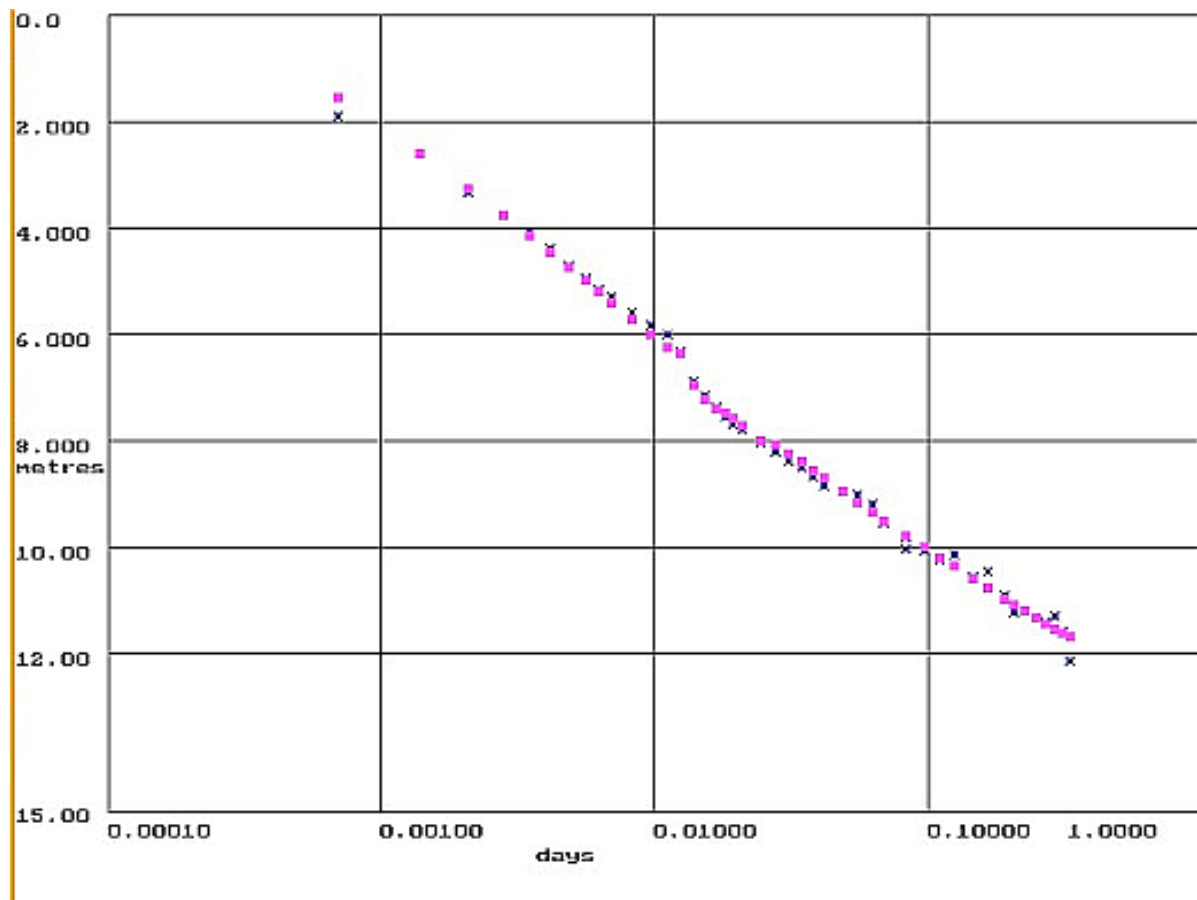


Figure 10-20: WBTH 017 test

Confined semi bounded aquifer interpretation

Summary analysis data:

- Aquifer type: confined, semi bounded (partial boundary);
- Transmissivity = 2.01904 m²/day, storage coefficient = 0.12034856;
- Image well distance = 1.94394 metres; and
- Transmissivity beyond boundary = 4.35180 m²/day.

The kink in the curve is the result of an increase in pumping rate. The two T values on either side of the idealised boundary are small and characteristic of the hanging wall metasediments where influenced by a relatively major structural feature. Without faulting/shearing, the hanging wall metasediments appear to be almost impermeable.

11 APPENDIX B: PRELIMINARY TESTING AND OUTPUTS OF THE MODEL

Preliminary model outputs were required to proceed with other areas of the study prior to the modelling on the final PFS pit.

Preliminary pit floor levels have been defined on a year by year basis by taking the information contained in the conceptual study and converting it into a useable format for hydrogeological modelling. The results are presented in Table 11-1. Footprints for each of the (13) yearly pit floor levels, are presented in Figure 11-1 and Figure 11-2. In the model, each cell inside the pit floor footprint was set as a drainage cell for each year (stress period) with the elevation of the drain cell set as the maximum depths presented in Table 11-1. In each subsequent year, the configuration and elevations of drainage cells changed according to the shape of the pit floor for the corresponding mining advance.

The development of the pit has been simulated as a two-stage process, in accordance with a modified version of the pit design information. As shown in Table 11-1, stages 1 and 2 occur simultaneously in Years 7 – 8, and whilst the maximum depth remains constant from Year 8 to Year 10, the footprints shown in Figure 11-1 and Figure 11-2 change considerably as the Stage 2 pit enlarges at the deeper levels.

The geometry of the proposed two-stage pit design was too complex to be used in modelling, as MODFLOW groundwater models have difficulty functioning with highly variable layer geometries and configurations. A simplified geometry was therefore adopted which is still considered suitable for estimating changes in water levels and the possible range in discharge during the life of the operation.

The model was run with 13 yearly stress periods, each including six time steps. Potentiometric contours for the end of time step 6 in each stress period are presented as Figure 11-3 to Figure 11-9.

Table 11-1: Annual pit floor levels (from Mining One conceptual study)

Year	Stage 1 Pit floor level (m AHD)	Stage 2 Pit floor level (m AHD)	Maximum Depth (m AHD)	Vertical Advance (m)
0	Ground level			
1	10		10	<60
2	-20		-20	30
3	-60		-60	40
4	-90		-90	30
5	-120		-120	30
6	-170		-170	50
7	-190	-100	-190	20
8	-220	-140	-220	30
9		-180	-220	0
10		-210	-220	0
11		-250	-250	30
12		-290	-290	40
13		-390	-390	100

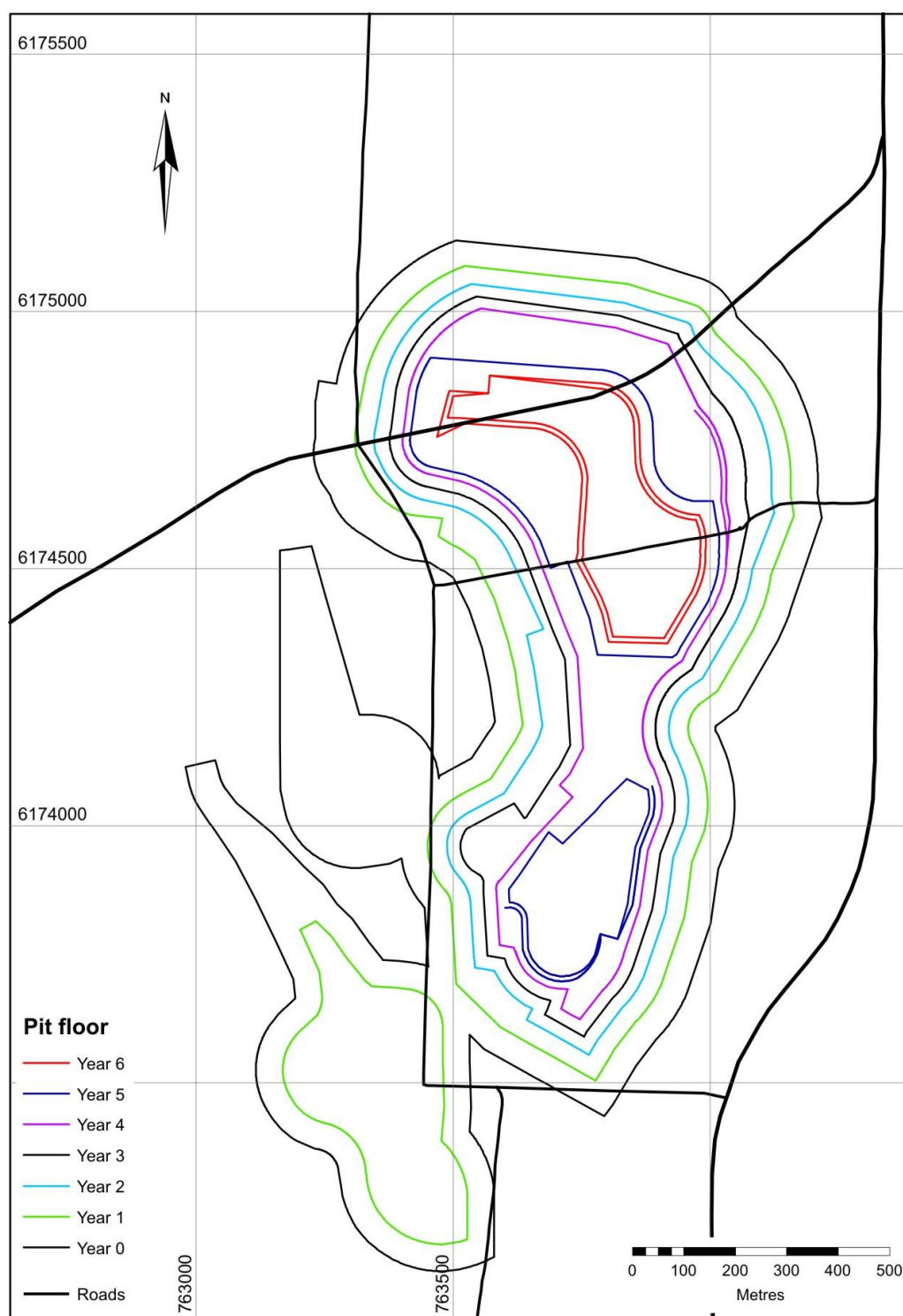


Figure 11-1: Model pit floor outlines Years 0-6

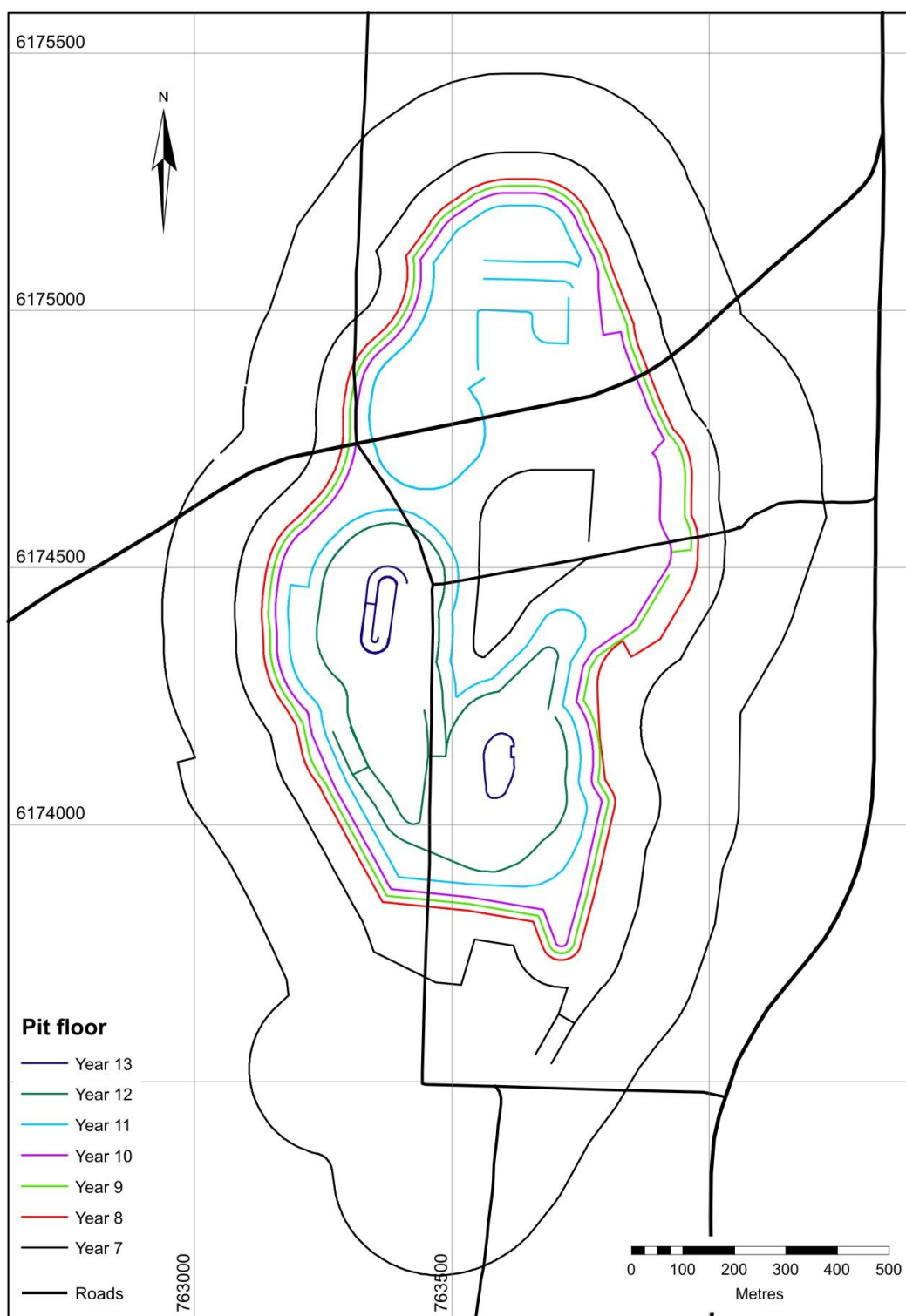


Figure 11-2: Model pit floor outlines Years 7-13

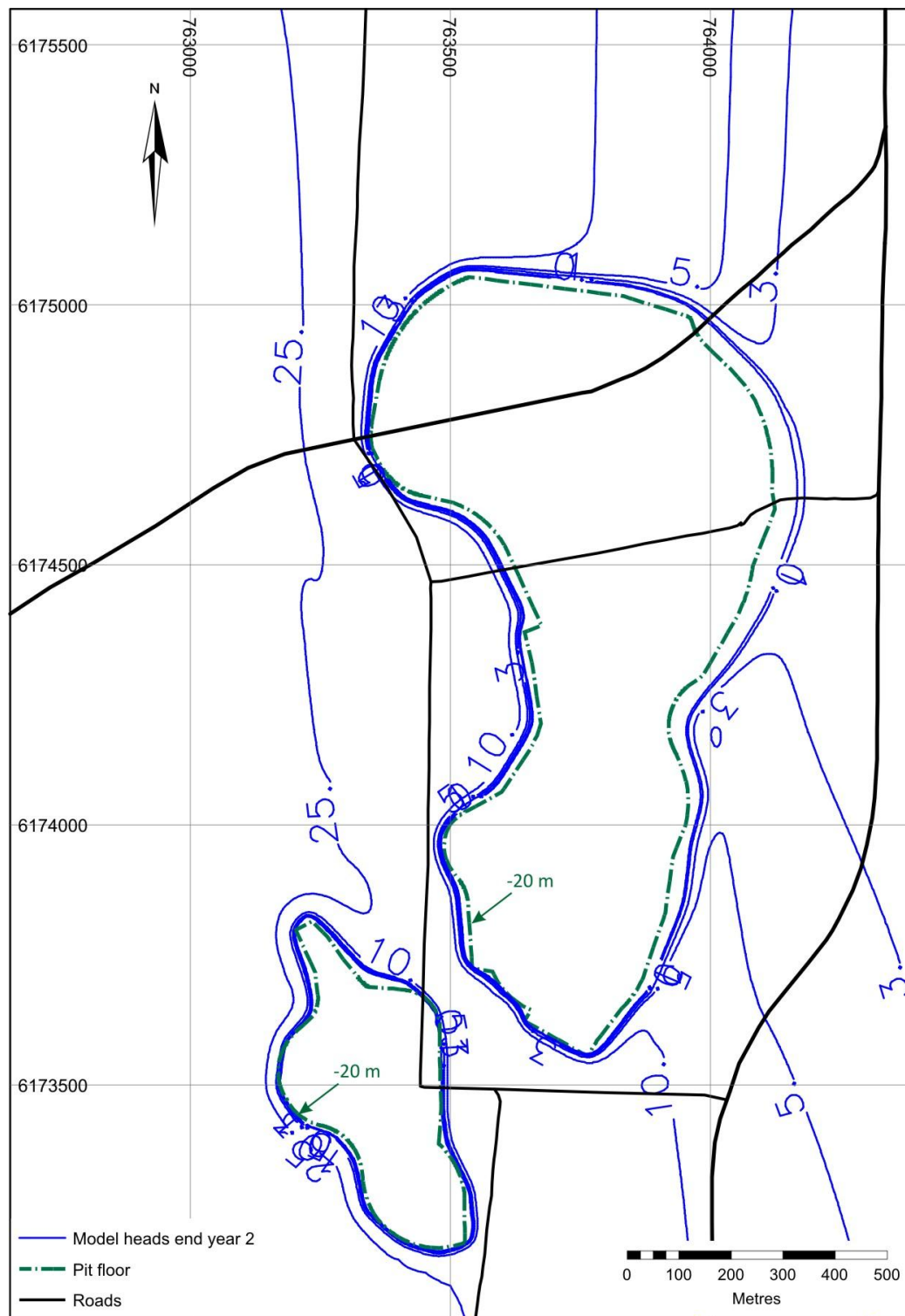


Figure 11-3: Model heads end Year 2

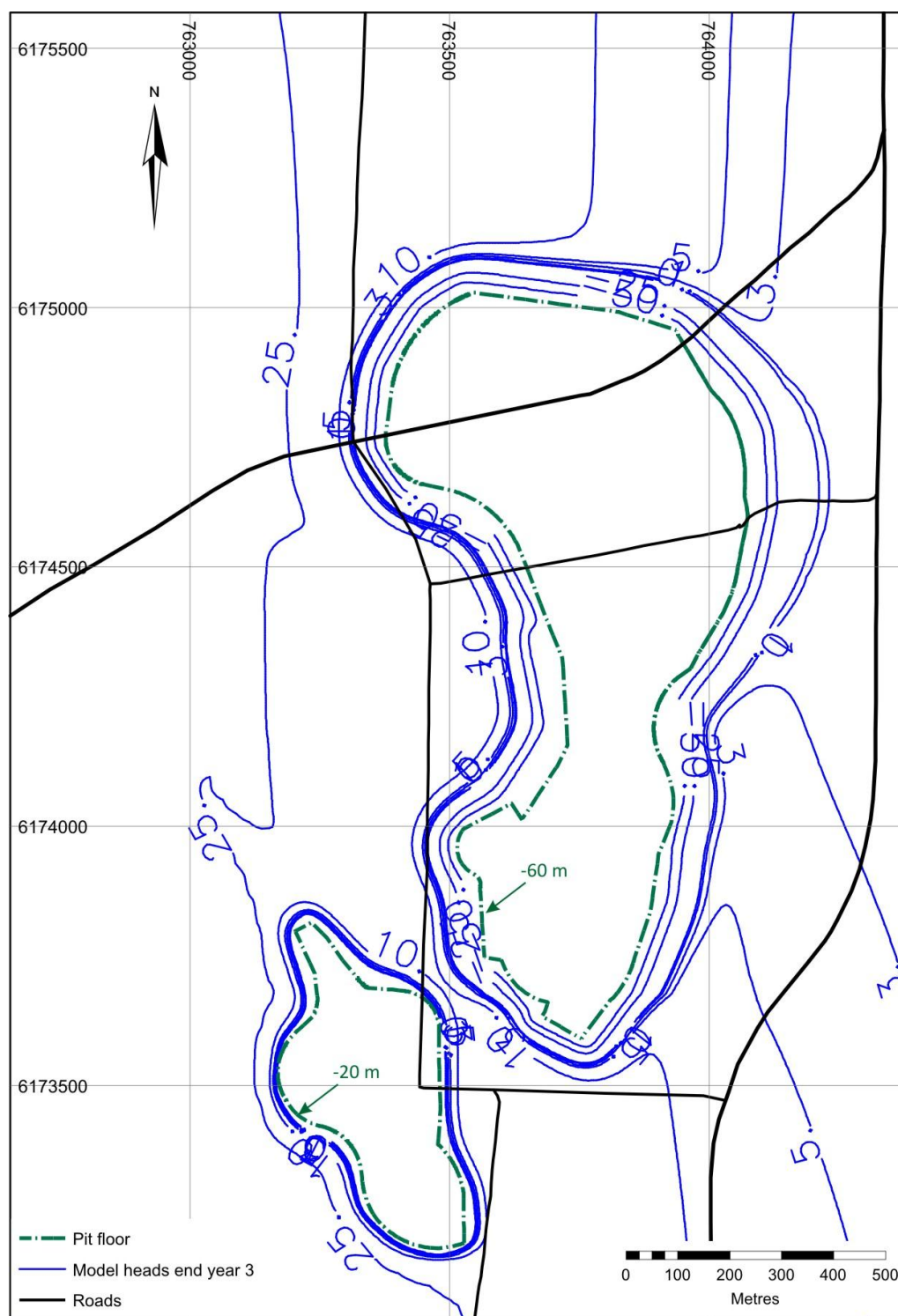


Figure 11-4: Model heads end Year 3

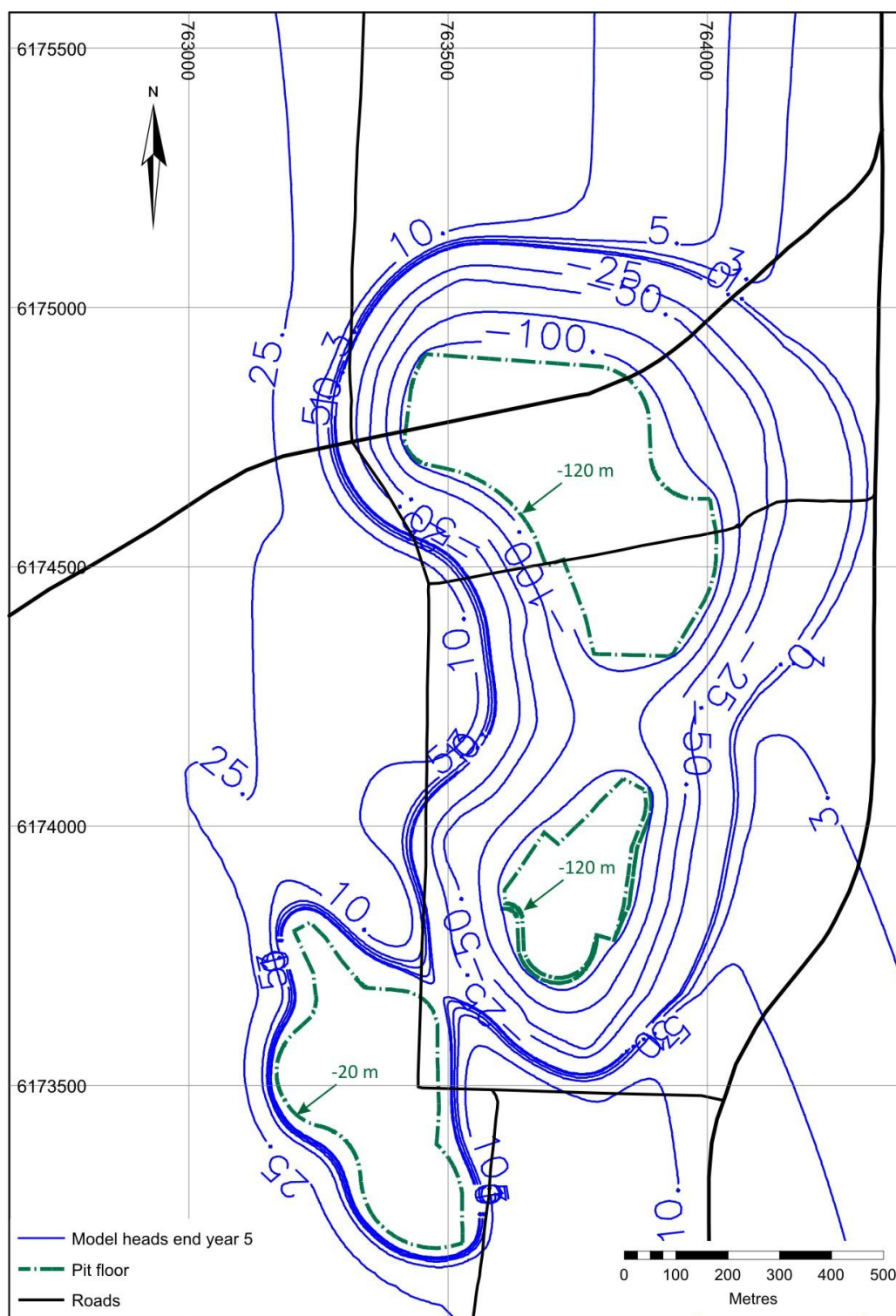


Figure 11-5: Model heads end Year 5

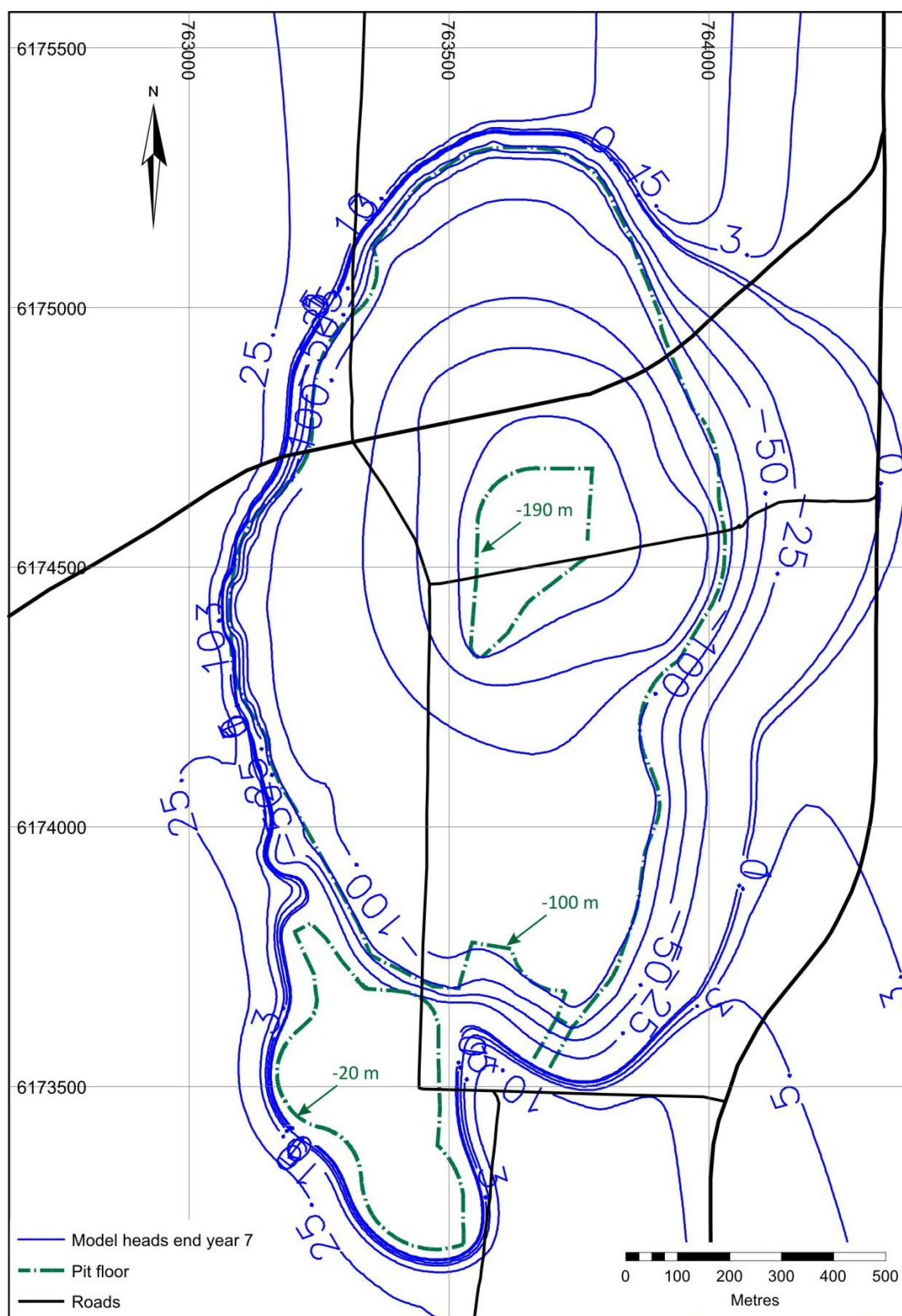


Figure 11-6: Model heads end Year 7

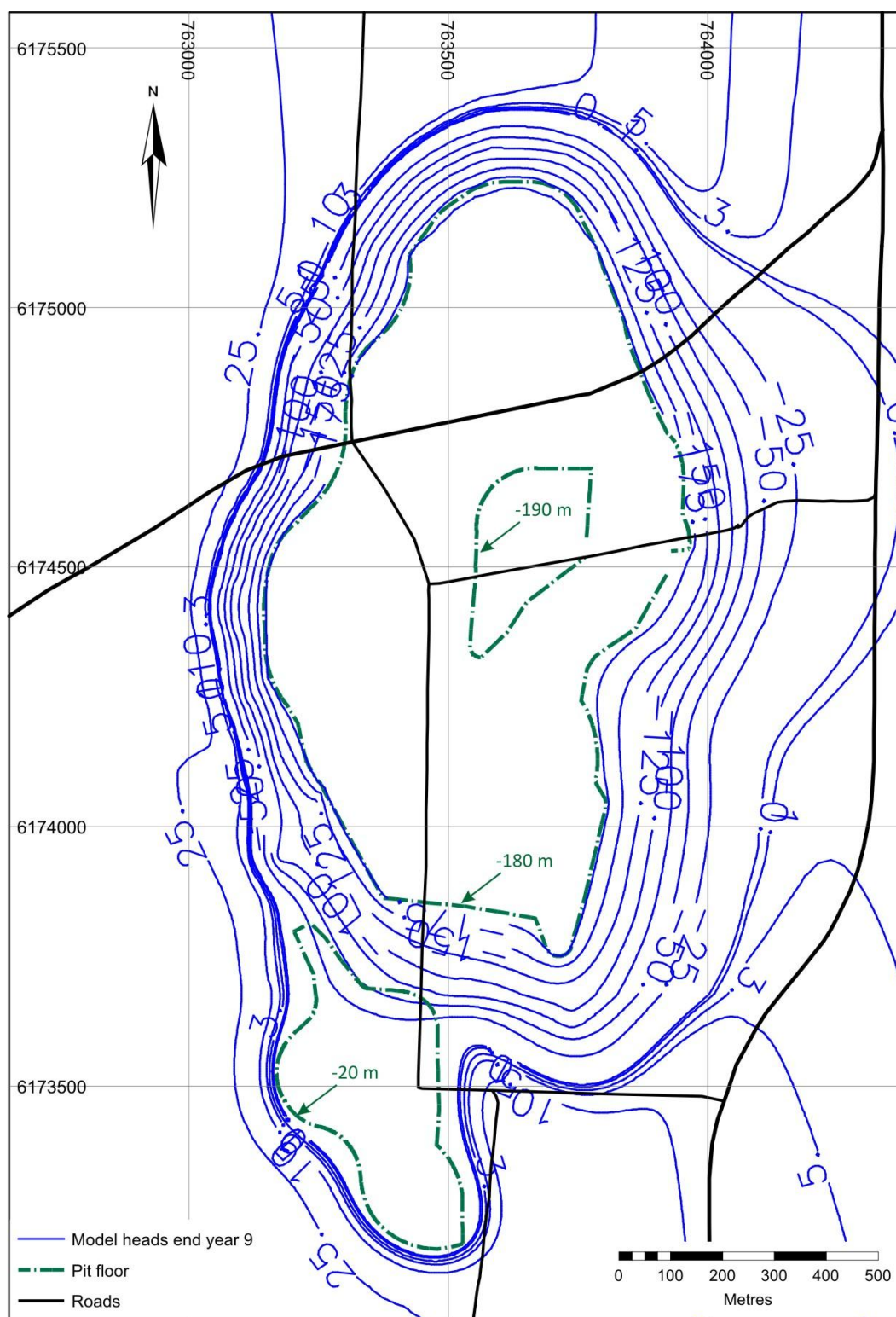


Figure 11-7: Model heads end Year 9

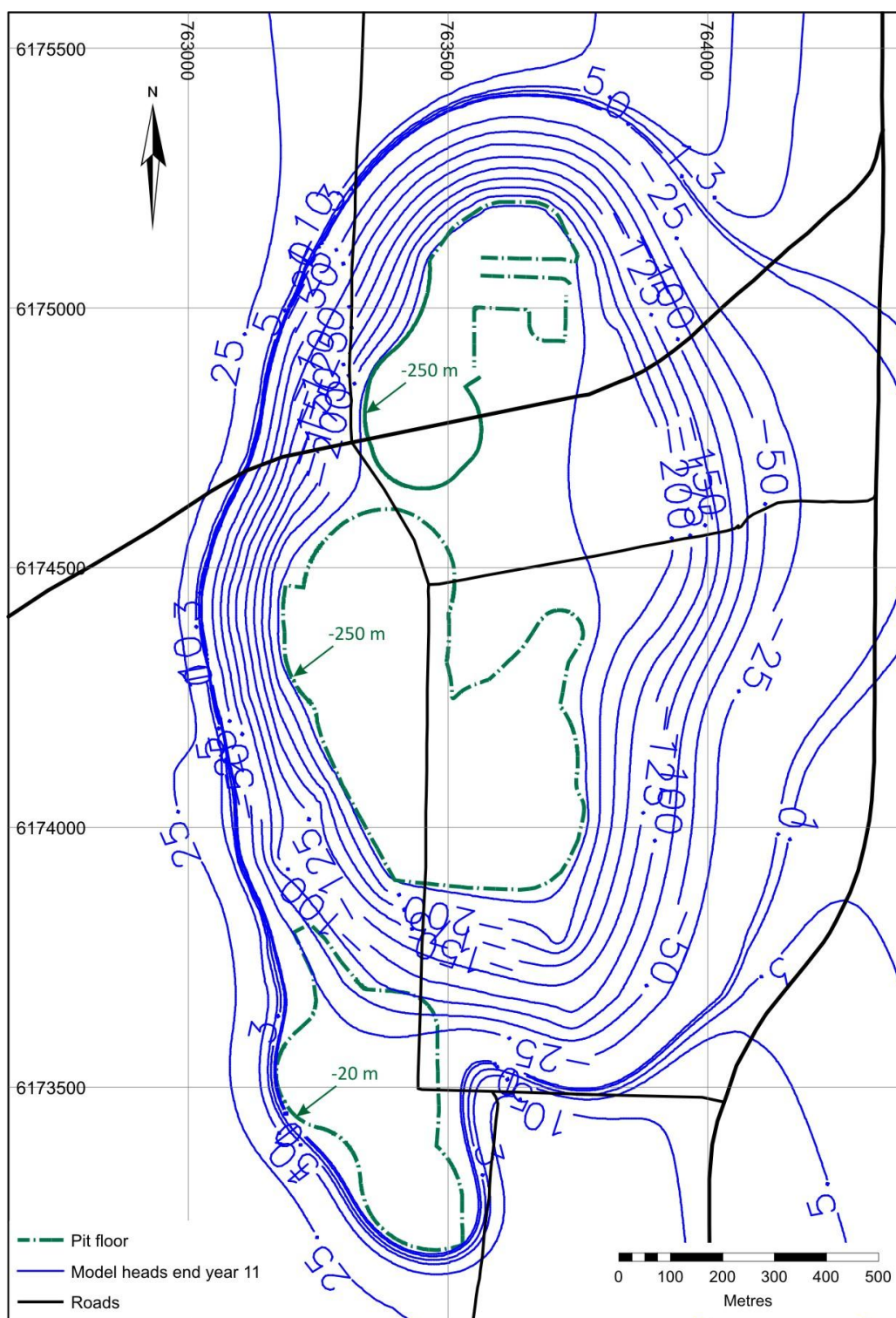


Figure 11-8: Model heads end Year 11

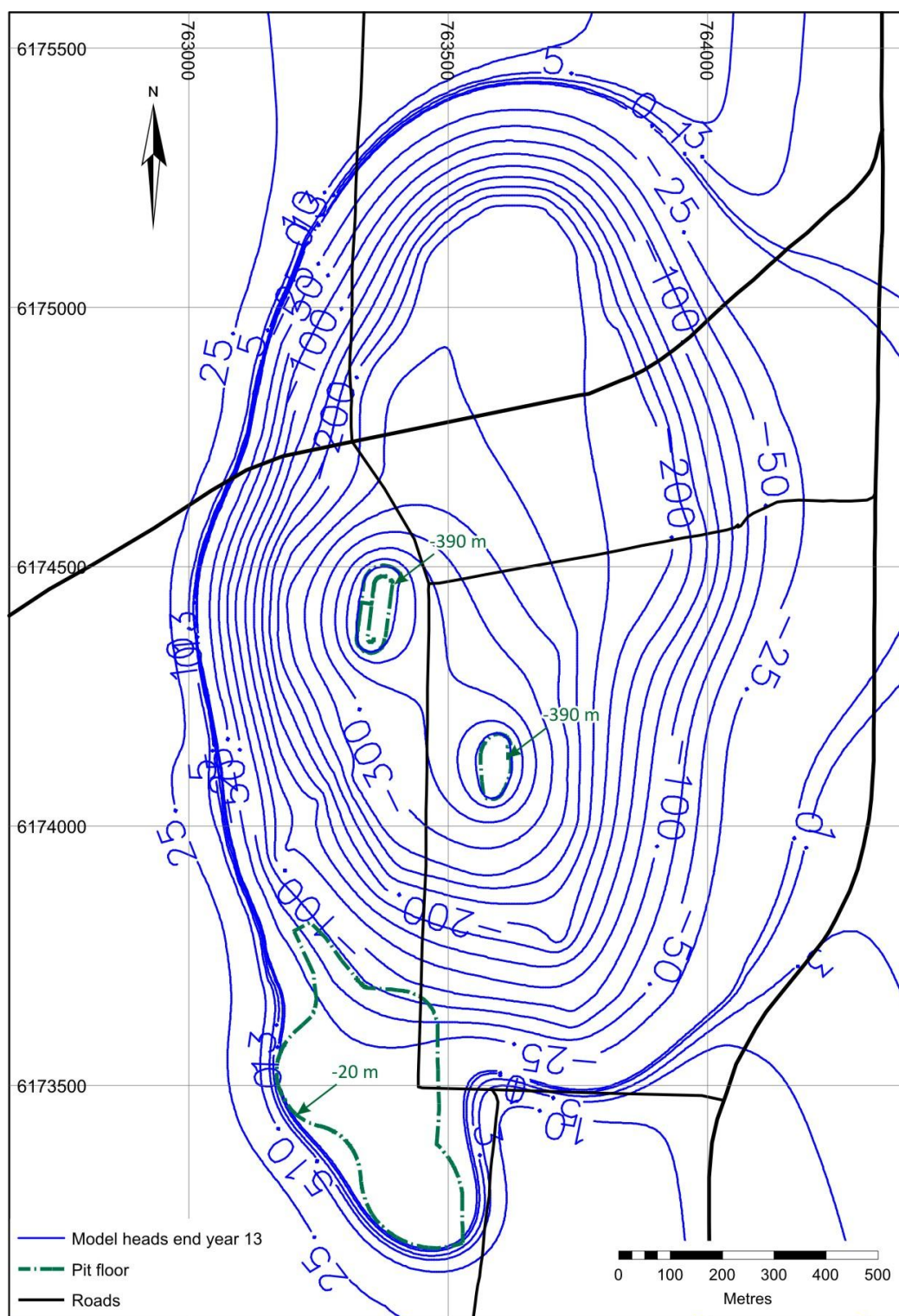


Figure 11-9: Model heads end Year 13

11.1.1 Model Discharge Estimates

The model was run with 13 stress periods, each corresponding to one year of operations. These stress periods were divided into 6 time steps to better facilitate computation. Multiple time steps enable the model to process the data over smaller time increments, thereby increasing the reliability of the model outputs.

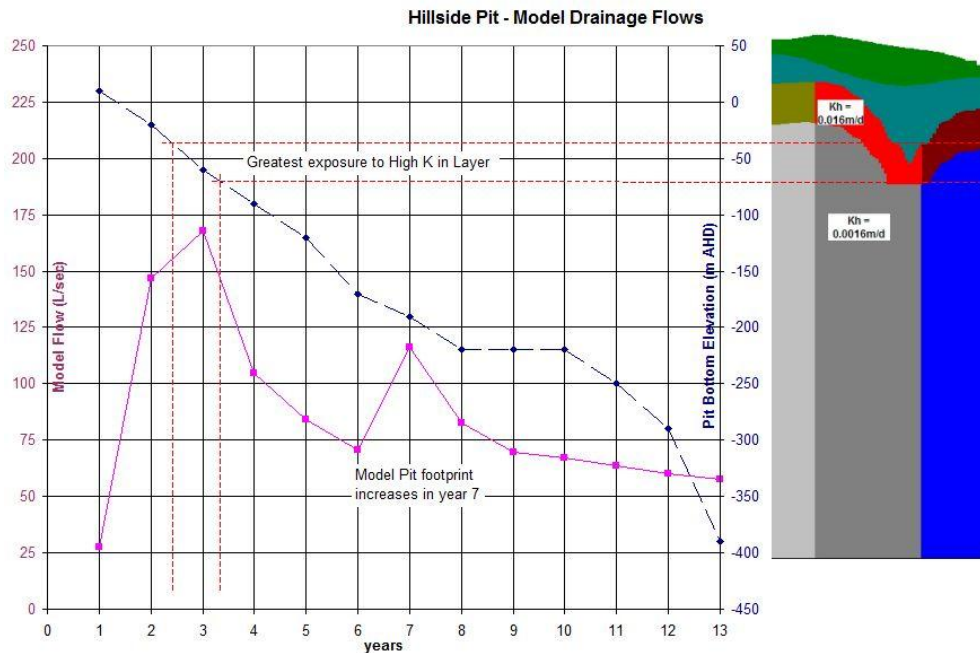


Figure 11-10: Model discharge estimates

Drain flows are predicted by the model to occur at rates of between 50 and 100 l/s for the majority of the mining period. With low flows in the first year (pre strip and possible dry mining), followed by an increase in discharge in Year 2 as the pit deepens through cover and saprolite, and partially intersects the saprock of layer 3. In Year 3, a maximum in discharge of over 160l/sec is predicted as the excavation intersects the full sap rock interval. This interval has been shown by drilling and test pumping to be the most transmissive interval of the profile (other than locations where discrete open fractures have been encountered). Discharge is shown to reduce in Years 4, 5 and 6 as the pit shape is consolidated but then increases in Year 7 as the footprint expands in the upper levels of the pit. Years 8 – 13 are shown by the model to be periods in which discharge decreases slowly from about 78 l/s to 56 l/s.

11.1.2 Possible Discharge from Underground Workings

Discharge from an underground development beneath the pit floor was modelled. This was treated as an extension to the drain model scenario. Spatial details for the four (4) underground openings associated with this scenario are presented in Table 11-2.

Table 11-2: Underground openings dimensions

	To		From		Width	From	Max Depth
	X	Y	X	Y			
Ore body 1 (OB1)	763403	6175364	763088	6173200	50	Base of pit	-750
Ore body 2 (OB2)	763661	6175397	763547	6175090	50	Base of pit	-650
Ore body 3 (OB3)	763579	6174259	763468	6173350	50	Base of pit	-650
Ore body 4 (OB4)	763900	6174600	763605	6173450	50	Base of pit	-550

The locations of the 4 “underground” ore bodies are shown as lines in Figure 11-11. Each ore body was modelled as a 50 metre wide strip of drain cells, representing conceptual stopes, over the length of the line for the elevations and times shown in Table 11-3.

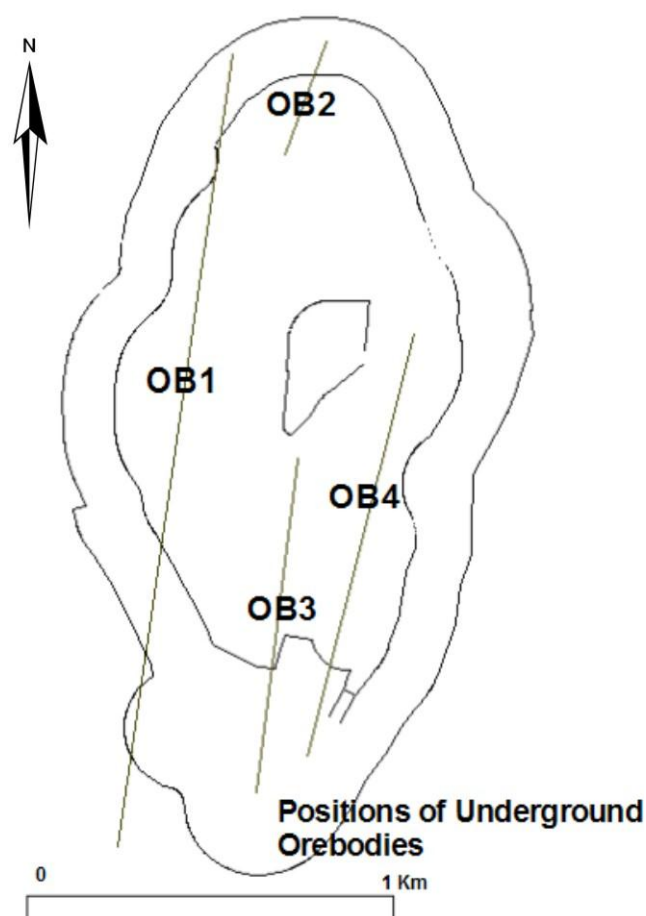


Figure 11-11: Plan view of modelled underground ore body locations

Table 11-3: Modelled underground ore body (OB) elevations (m AHD)

Stress Period	Duration	Model Years end of year	Drain Elevation (m AHD)			
			OB1	OB2	OB3	OB4
14	2.5yrs	13 to 15.5	-480	-455	-455	-440
15	2.5yrs	15.5 to 18	-570	-520	-520	-490
16	2.5yrs	18 to 20.5	-660	-585	-585	-650
17	2.5yrs	20.5 to 23	-750	-650	-650	-650
'OB' = orebody						

The model was run as a 10 year underground operation contiguous with the open pit mining program using the scheduling information presented in Table 11-3. It was also modelled as a 20 year post open pit

operation in which each of the 4 stress periods was increased to 5 years duration. Ore body 4 was mined out after 15 years and the remaining three zones were active for the full 20 years

Modelled discharge rates for the open pit plus the 10 year underground operation (Years 14 – 23) is shown in Figure 11-12. For the pit plus the 20 year operation (Years 14 -33) see Figure 11-13.

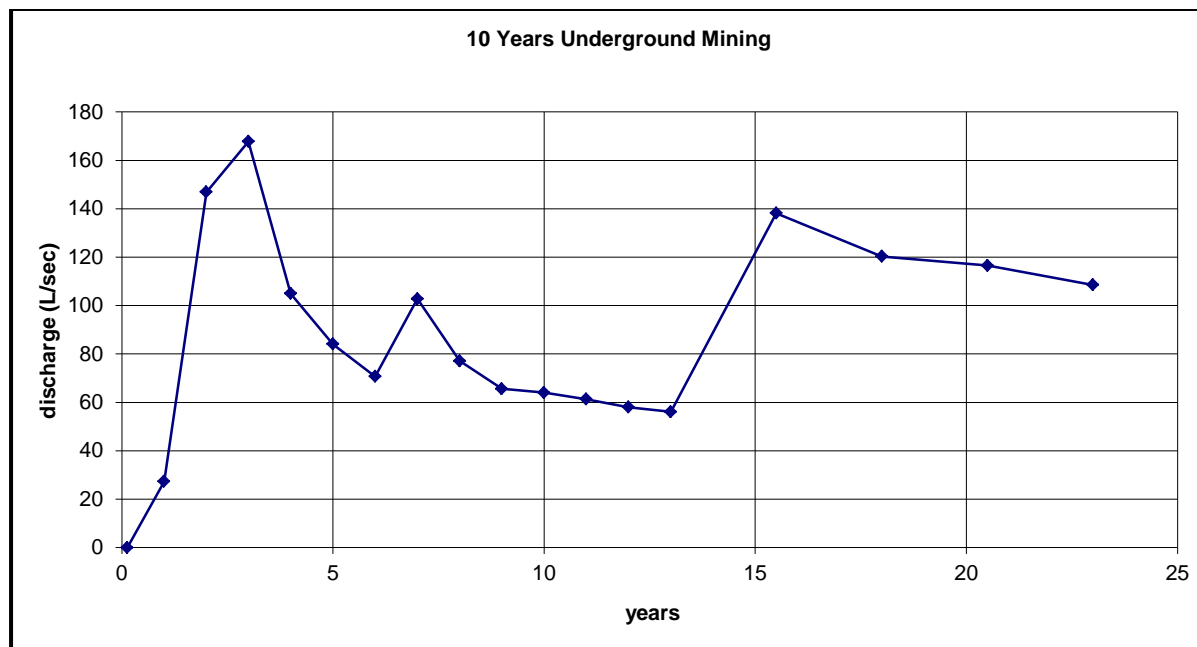


Figure 11-12: Model discharge estimates for a 10 year underground operation

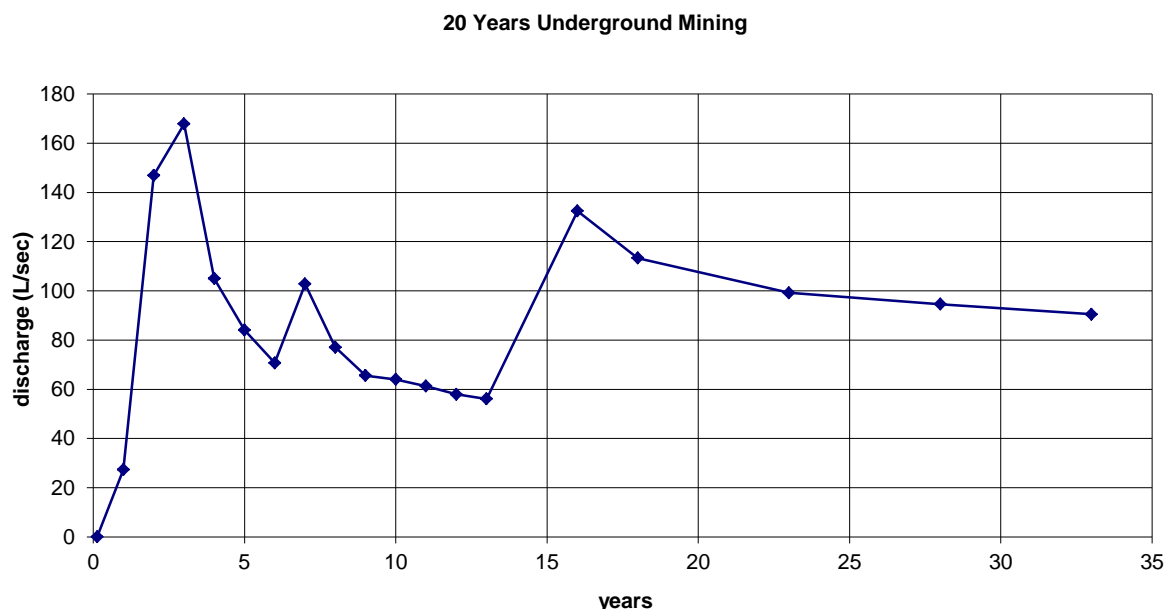


Figure 11-13: Model discharge estimates for a 20 year underground operation

Modelled heads (water elevations in m AHD) at the end of the 10 year underground operation (23 years total operation) are shown in Figure 11-14 and after 20 years (33 years total operation) in Figure 11-15.

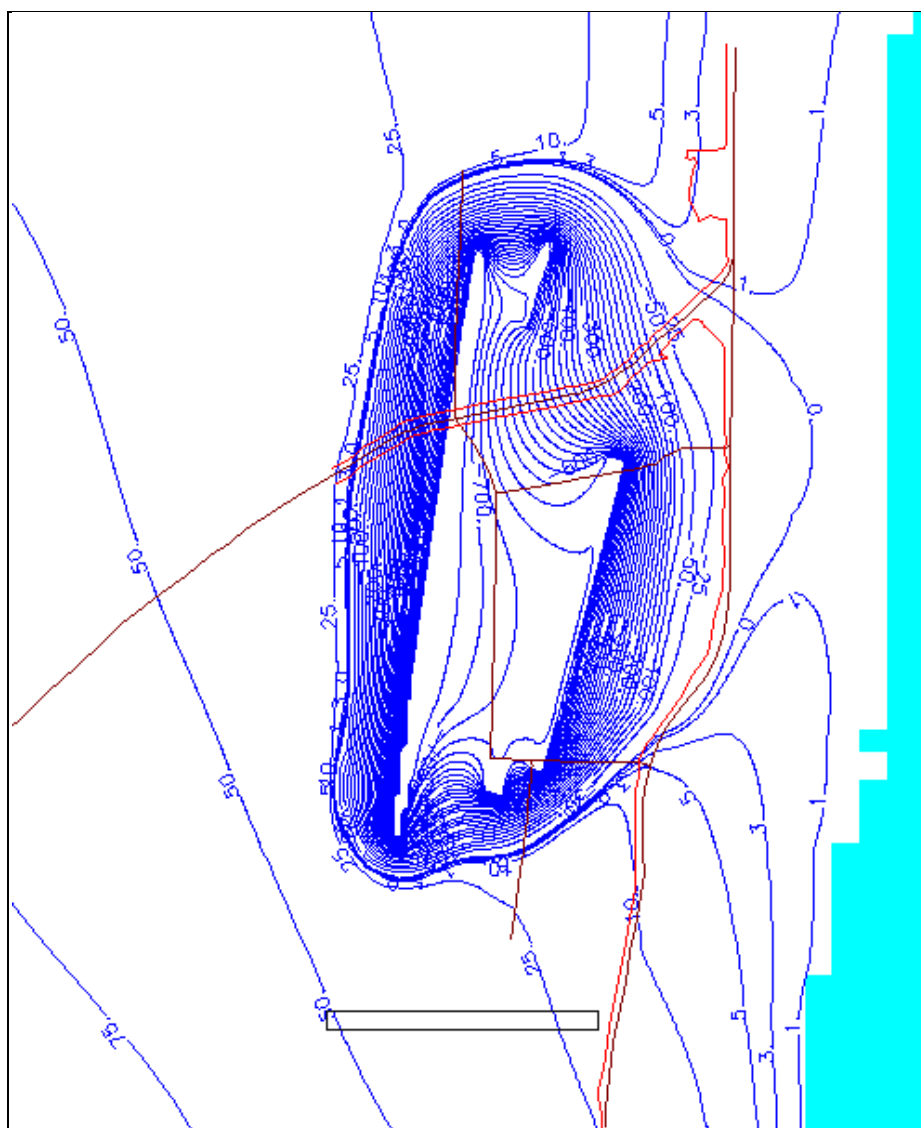


Figure 11-14: Model heads after 10 years of underground operations

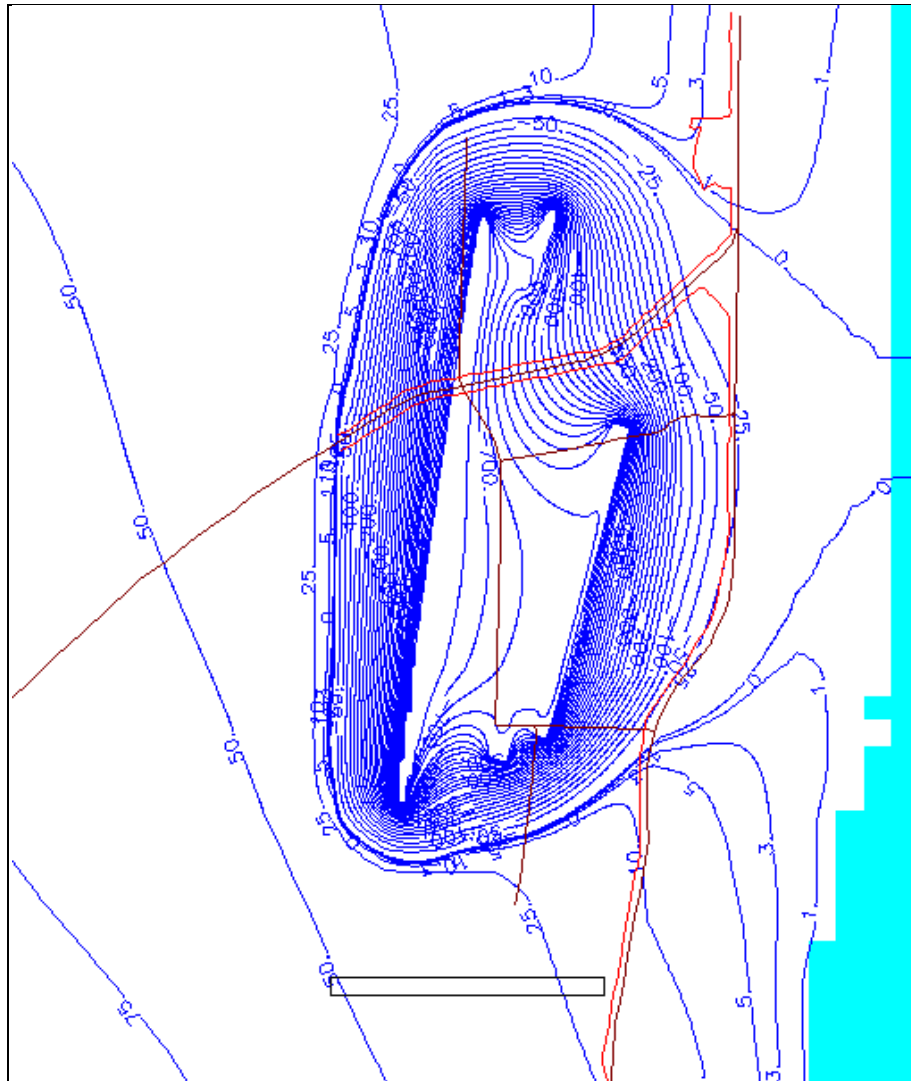


Figure 11-15: Modelled heads after 20 years of underground operations

The detailed configuration of the proposed underground workings was not available at this stage. Therefore the representation of the underground stopes as 50 metre wide drains is somewhat simplified, however, serves to provide an indication of the expected discharge over the 10 or 20 year period of operation.

As shown in the figures above, the model discharge rises from around 50 l/sec at the end of the open pit phase to a maximum of 139 l/sec at Year 16 for the 10 year underground scenario, and 132 l/sec at Year 16 for the 20 year scenario. The discharge rates fall gradually to 107 l/sec at 23 years in the 10 year underground scenario and 90 l/sec at 33 years in the 20 year underground case. The difference in rates is due to the different rates of deepening where a given depth increment takes 2.5 years in the 10 year run and 5 years in the 20 year run.

The model shows that groundwater is being drawn toward the pit from the coastal granites, with the 20 year underground scenario showing drawdown occurring at the coast.