P I T T & S H E R R Y

Royal George Tin Mine Tailings Rehabilitation Review Report

Prepared for

Mineral Resources Tasmania

May 2006

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Table of Contents

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1. Introduction

Pitt & Sherry (P&S) was engaged by Mineral Resources Tasmania (MRT) in January 2006 to undertake a review of the tailings rehabilitation options for the former Royal George tin mine in the northeast of Tasmania.

The former mine workings and tailings areas are located over an area immediately to the south of the Royal George township.

The regional and local settings for the mine tailings are shown in Figure 1 and Figure 2 below.

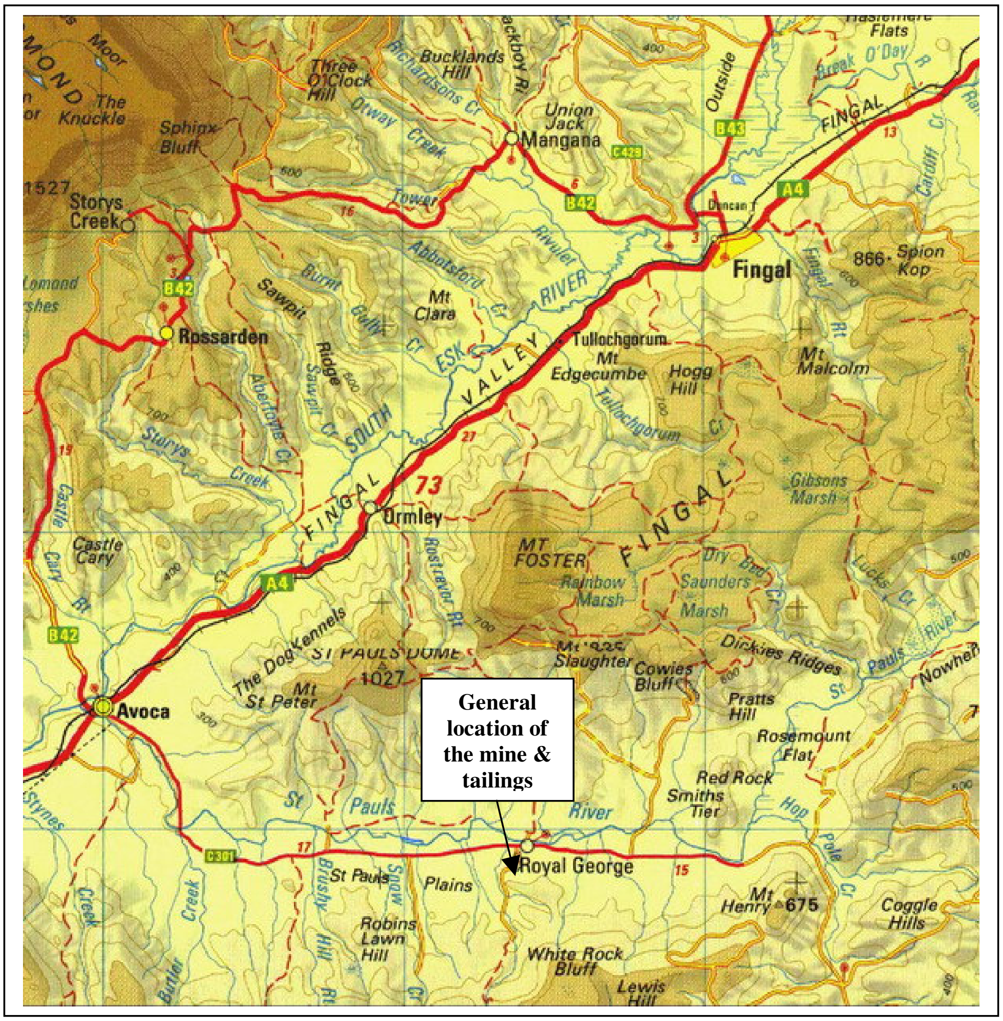


Figure 1. Regional setting.

Both the township and the adjacent mine are located in an east west orientated valley between St Pauls Dome and Snow Hill.

The valley forms part of the St Pauls River catchment, which supplies irrigation and homestead water to surrounding farms and potable water for several Royal George residences. The St Pauls River joins the South Esk River at Avoca.

It is apparent from the local topography that the surface water and groundwater drainage from the mine workings and tailings area trend towards the St Pauls River via School Creek for the mine area and an unnamed natural drainage gully for the tailings.

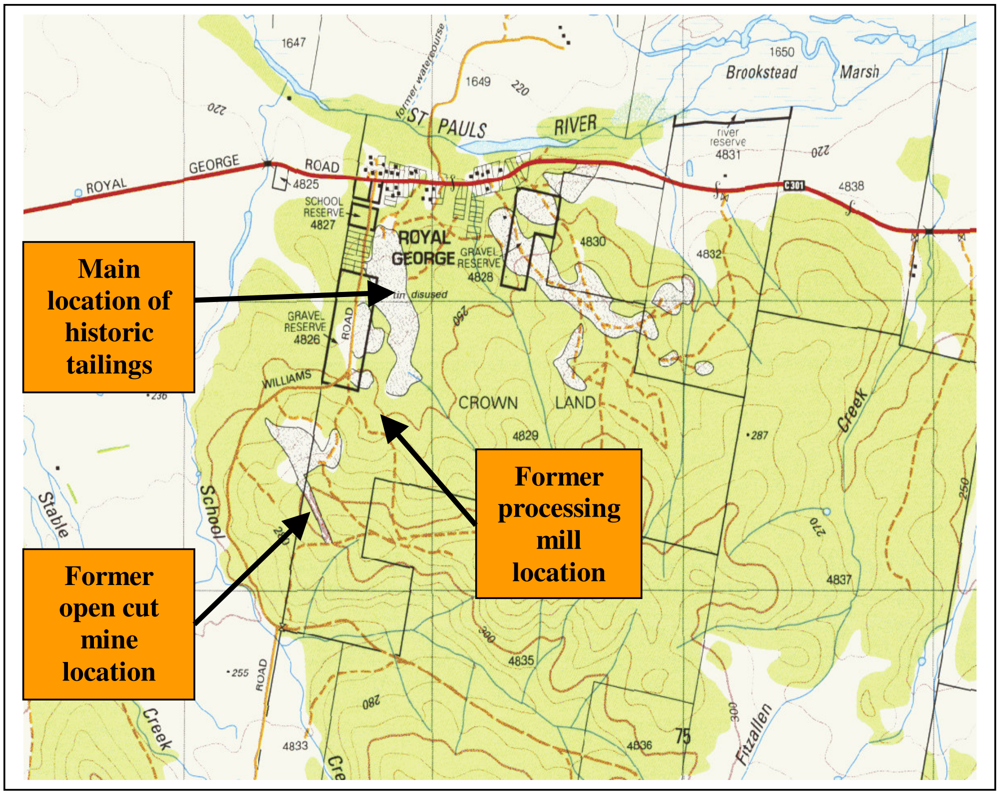


Figure 2. Local setting.

1.1 Background

The tin lodes of the Royal George mine were discovered in the 1880s and mining of the ore was conducted on a limited scale until 1911. The peak mining and processing activities occurred from 1911 to 1922.

Following closure in 1922, the mine appears to have reverted again to intermittent production until 1928. The mine produced approximately 900 tonnes of tin concentrate.

The main rock type at the mine site is coarse-grained granite with dykes of graphic granite, pegmatites, greisen and porphyry rock.

Veins of quartz of varying thickness up to 3 metres traverse all of the dykes. The mineralisation occurs in these veins. It is likely that waste rock from the mine was primarily coarse-grained granite surrounding the mineralised dykes along with some dyke granite, pegmatites, greisen and porphyry rock.

The concentrating mill tailings are likely to consist primarily of the quartz vein material including some granite, pegmatites, greisen, porphyry rock and unrecovered minerals.

The former mine workings appears to consist of an open cut approximately 300 m long, 25 metres wide narrowing to approximately 3 metres at each end and up to 15 m deep. In the mine area there is also an adit, a shaft and a drive approximately 25 m below the open cut, a number of trenches and costeans and dumps.

The historic tailings cover an area of approximately 600 m by 50 m wide. The tailings are largely unvegetated and easily accessible by foot and vehicles.

The tailings have the potential to affect a person's visual appreciation of the area as well as causing an environment nuisance in the form of:

- Dust emissions over town residences
- Discolouration and siltation of the St Pauls River
- Chemical contamination of the St Pauls River.

The tailings area appears to be used occasionally as a recreational vehicle facility as well as a random rubbish disposal area including for abandoned car bodies.

A water diversion 'cut off' drain has been constructed with the objective to prevent natural drainage passing through the tailings. The effectiveness of this 'cut off' drain is not known.

MRT has conducted internal analysis on the tailings and submitted tailings and water samples to Analytical Services Tasmania for analysis.

The water samples consisted of grab samples of specific seeps and drainage associated with the tailings but these results have not been fully interpreted.

No analyses have been undertaken of the ambient water quality of the St Pauls River upstream and downstream of water discharges from the tailings area.

Since closure of the mine and in more recent times, exploration activities have been conducted in the area. The uranium content of the mineralised zones has been of particular interest.

1.2 Scope of Works

The scope of this work requires the following:

- An independent review of the available tailings water and soil analytical data
- Collection and analysis of background catchment samples for comparison
- Nutrient analysis of the tailings
- Formulation of a rehabilitation plan for the site
- Submission of a report in hard copy and digitally.

Matters to be addressed include:

- Whether or not the drainage through the tailings needs to be controlled or treated
- What nutrients need to be added to the tailings to facilitate revegetation of the site
- The most cost-effective way to remediate the site.

2. Methodology

The following methodology was adopted to deliver the work within the budget.

- Preliminary tailings site inspection
- Site investigation, including:
    - Water sampling and analysis of the St Pauls River upstream and downstream of any potential aqueous emissions
    - Water sampling and analysis of tailings seeps and drainage
    - Selected soil sampling as required
    - Determination of tailings groundwater levels
    - GPS recordings
    - Photography as required
- Review of the MRT - Royal George file #68199
- Nutrient analysis of selected tailings samples
- Radioactivity checks of the 2005 MRT tailings samples by the Health Physics section of the Department of Health and Human Services

- Draft a review report for MRT with interpretation of existing and current data and including remediation recommendations
- Submit a draft review report to MRT for comment and finalise the report.

3. Site Observations

Jim Lockley from Pitt & Sherry conducted preliminary site observations on the 22 February 2006.

Jim Lockley and Michael Pollington from Pitt & Sherry, and Wojciech Grun and Shane Heawood from MRT, conducted the full site investigation on the 1 March 2006.

The site observations are outlined below.

3.1 Drainage

The tailings from the former mill processing plant are deposited in a natural drainage line, which drains down gradient through the Royal George township to the St Pauls River.

The tailings appear to be comprised mainly of decomposed granite, sands (including quartz sands) and clays.

Surface waters appear to flow as sheet drainage in the upper tailings area with localised erosion gorges through the middle tailings area and dam walling.

Below the gorges the surface water flows down dedicated drainage paths past the local waste transfer station area to the main road culvert and on to the St Pauls River.

There is evidence that significant amounts of the tailings have historically been washed down the drainage lines to the St Pauls River.

It is likely that a significant proportion of the upstream catchment's surface water and incident rainfall infiltrate the tailings and report as tailings seepage and groundwater.

At the time of the site inspection surface water flows were negligible and restricted to specific locations. Two seep areas were identified but the flows were very low.

The approximate location of the surface water drainage is shown in Figure 3 below. Photographs 1 to 6 in Appendix A show the drainage types above, through and below the tailings site. The approximate locations of the photographs are also shown in Figure 3.

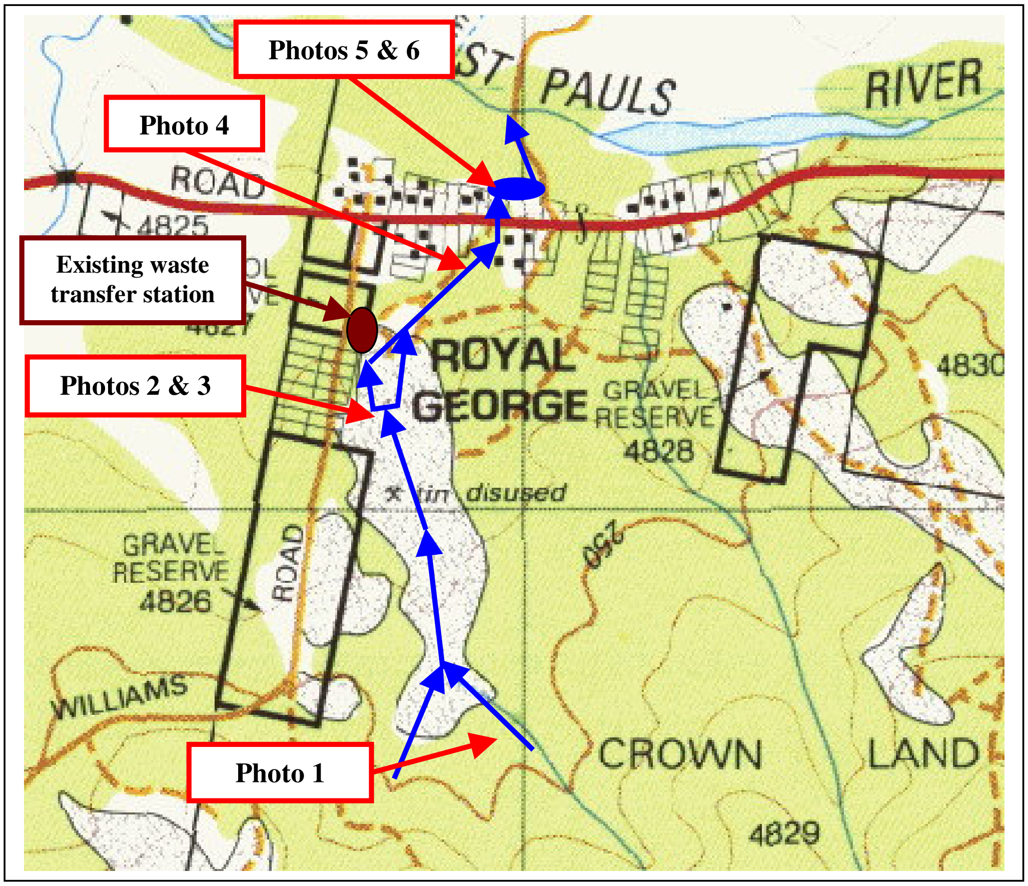


Figure 3. Drainage line (blue) from above, through and below the tailings area. Location of photographs in Appendix A (red) and waste transfer station (dark red).

3.2 Past Remediation Works

There appears to have been some surface water diversion works undertaken around the tailings in the distant past. It is not known who undertook this work and why.

The diversion works involved the installation of a surface water 'cut off' drain from above the tailings area at the southern end near the former mill site, which extends down the eastern side for the full extent of the tailings area.

The approximate location of the 'cut off' drain is highlighted in blue in Figure 4 below. Photographs 7 to 10 in Appendix A are representative and indicative of the current condition of the 'cut off' drainage works around the tailings site.

The drain may have been effective to some degree in the past but current evidence suggests that the drain has weathered and is now not very effective at preventing water ingress into the tailings area.

Initial site indications are that the drain:

- Has shallowed due to weathering in sandy country
- Is relative permeable
- Has little evidence that high surface water flows have been collected and diverted.

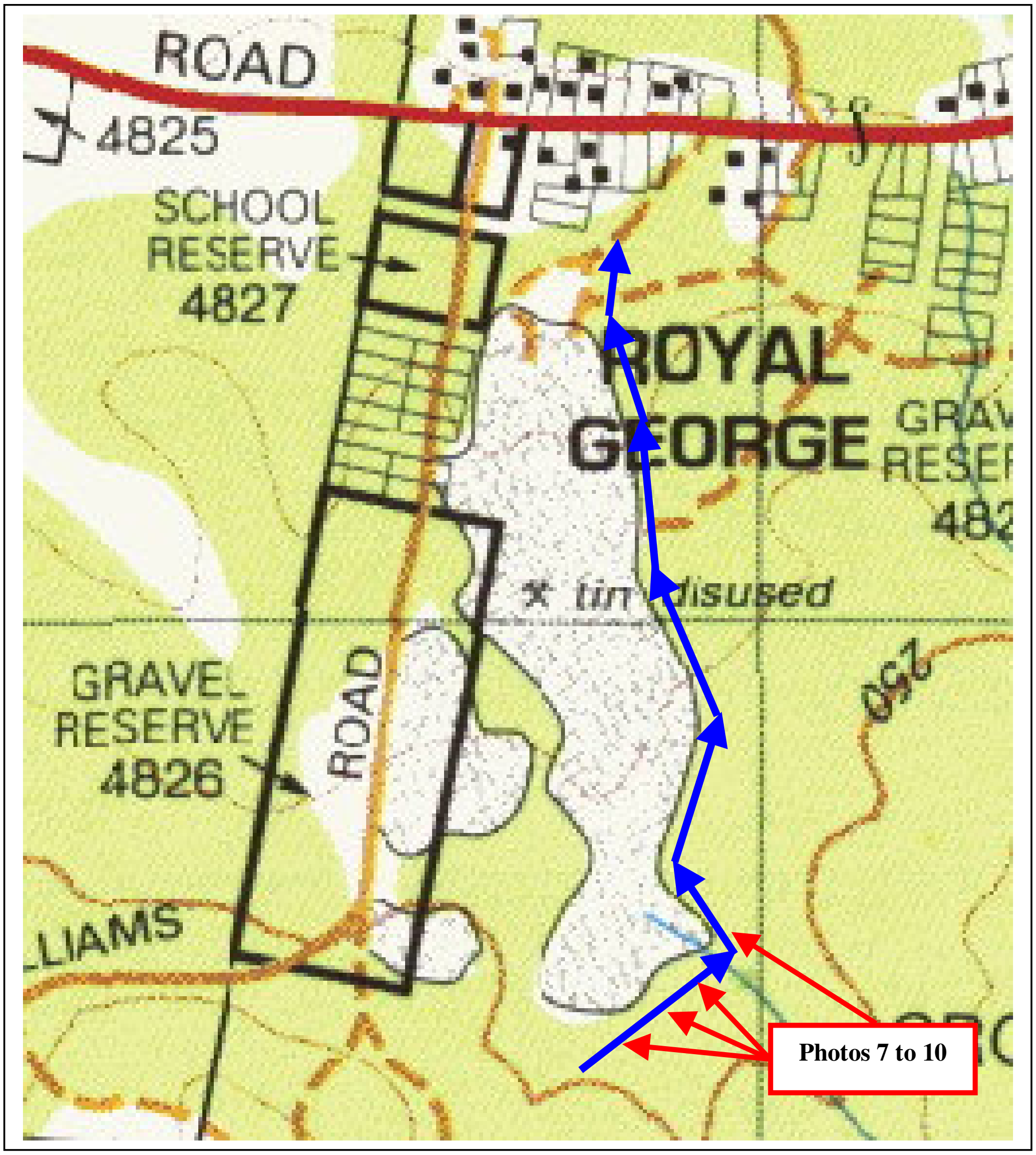


Figure 4. Approximate location (blue) of existing 'cut off' drain. Location of photographs in Appendix A (red).

3.3 Tailings

The tailings extend over a significant area as indicated in Figure 2 and Figure 3 above.

The tailings are mainly located in a natural drainage line below the former mill site. They extend approximately 600 m in length down to the township with an average width of approximately 50 m.

The surface of the tailings varies in composition from fine clays to fine sands.

The overall tailings area consists of several former tailings dams and ponds. For the purposes of the report, the tailings area is divided into the top tailings dams, the middle dams and the lower tailings dams.

Photographs 11 to 18 in Appendix A are representative and indicative of the current condition of the tailings site.

Photographs 11 to 14 were taken of the top tailings area, photographs 15 and 16 were taken of the middle tailings area and photographs 17 and 18 were taken of the lower tailings area.

Most of the tailings are devoid of vegetation. Rubbish and abandoned cars were observed on the tailings areas. Some off road vehicle recreational use was also evident on some areas.

3.4 Water Users

Stormwater from the tailings catchment area reports to the St Pauls River via a storm water culvert drain under the Royal George main road and then previously dispersed into the St Pauls River over flood flats.

These flood flats extent for approximately 100 m south of the river proper.

There appears to have been some improvements works undertaken to the stormwater drainage below the main road to improve water drainage around the flood flats area to the St Pauls River.

This work was probably required due to the deposition and build up of catchment sediments and the local tailings in the area below the main road causing local ponding or flooding in that area.

The stormwater drainage improvements, which also collects drainage from the tailings area, now directs stormwater further upstream than may have previously occurred over the flood flats.

A local resident advised that at least 'half a dozen' residents have historically source potable and homestead water from the St Pauls River. The improved storm water drain now discharges approximately 20 m upstream of the homestead water intakes.

The water usage by local residences and the improved storm water drainage at the water intakes need to be considered when developing a tailings remediation strategy.

The location of the previous and new stormwater drainage and the water intakes are shown in Figure 5 below.

The likely former diffuse stormwater discharge over flood flats to the St Pauls River is shown in olive green. The discharge location following stormwater drainage improvement works is shown in red. The 'half a dozen' homestead water intakes are grouped together at one location shown in blue.

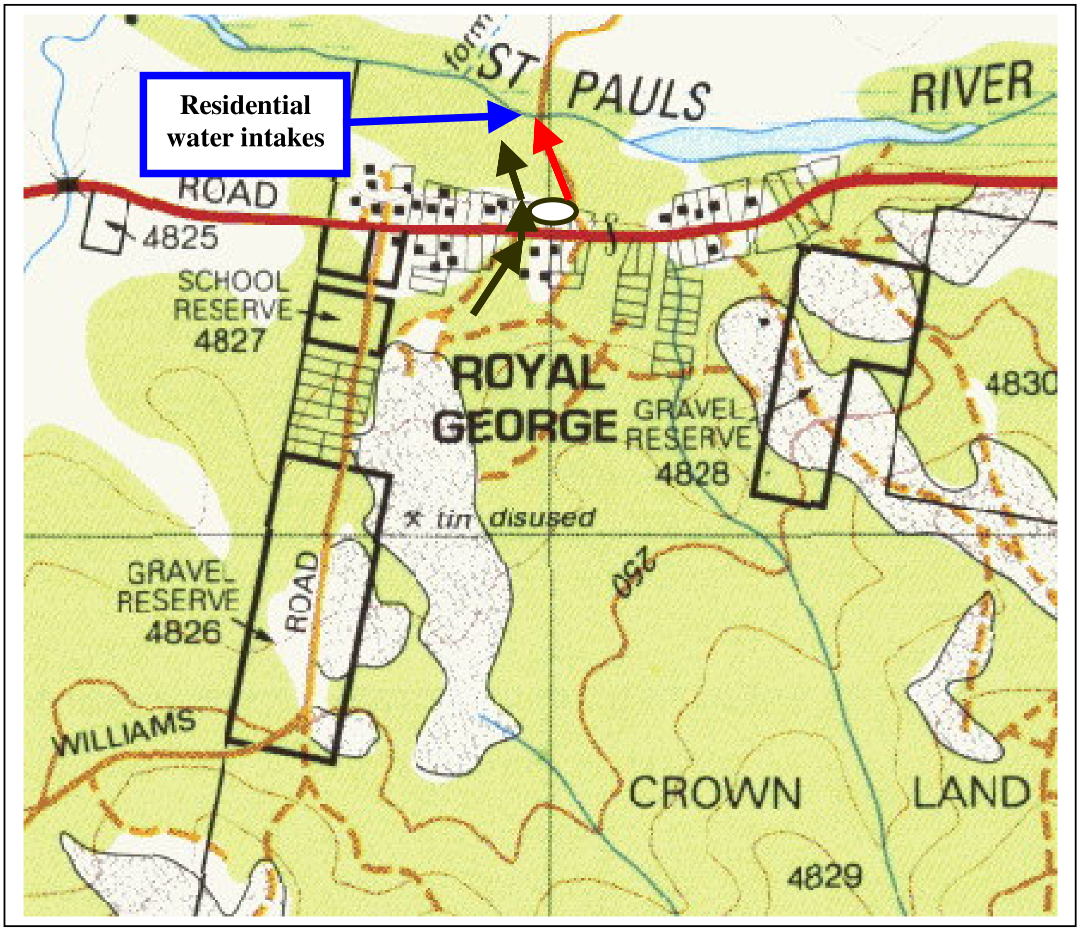


Figure 5. Location of the former (olive green) and current (red) stormwater drainage and the residential and homestead water intakes (blue).

3.5 Former Mine and Mill Sites

The opportunity was taken during the site inspection to quickly inspect the former mine and mill areas south of the tailings.

This was undertaken out of interest and to ensure that these areas were not connected directly to the tailings impacts.

Although the inspection of these areas was not part of the project brief, the observations are summarised as follows.

- The open cut mine and associated adit and shaft are easily accessible on foot
- The open cut mine area is accessible by four wheel drive vehicles
- The open cut has been used for the disposal of rubbish
- The open cut has sheer rock faces up to approximately 15 m which represent a real risks to unwary visitors
- The open cut presents a risk to wildlife
- Revegetation of the open cut is occurring naturally, including stands of gum tress
- Aqueous emissions from the mine area are likely to report to School Creek and not to the tailings area
- The mill area and surrounds drain towards the top tailings area and to the top cut off drain
- There were no obvious pollutant sources of meaningful amounts that have the potential to impact on the tailings
- The heritage in the mill site did not appear to have any extraordinary values.

Photographs 19 to 22 in Appendix A were taken in the former mine and mill locations.

4. Review of Current Information

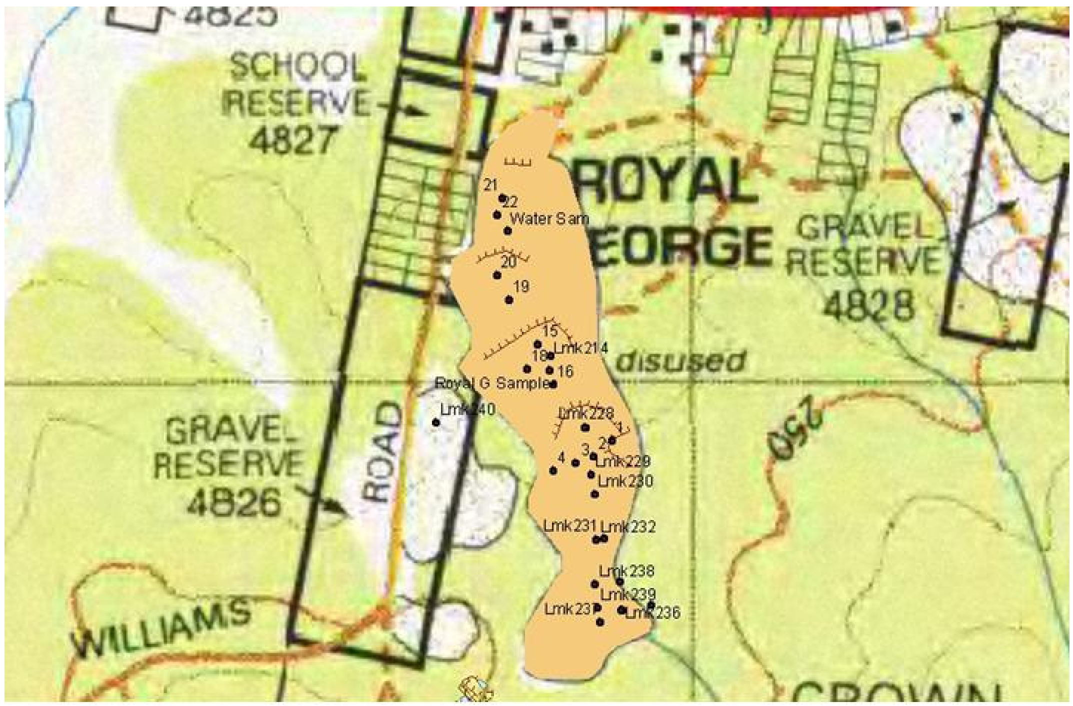
The project brief identified relevant MRT information for review. This information was submitted to Pitt &Sherry as well as the contents of MRT file #68199.

The information for review is summarised as follows:

- A report entitled *Royal George Tailings, Scoping Study Into Rehabilitation Options, Nigel Bedford, Civil Engineering Consultant, April 2005.*
- Tailings area pit logs associated with the above mentioned scoping study.
- Analytical Reports #24271 and #24686 dated 4 February 2005 and 8 April 2005 respectively from Analytical Services Tasmania for water samples taken by MRT at the tailings area in January 2005 and March 2005 respectively.

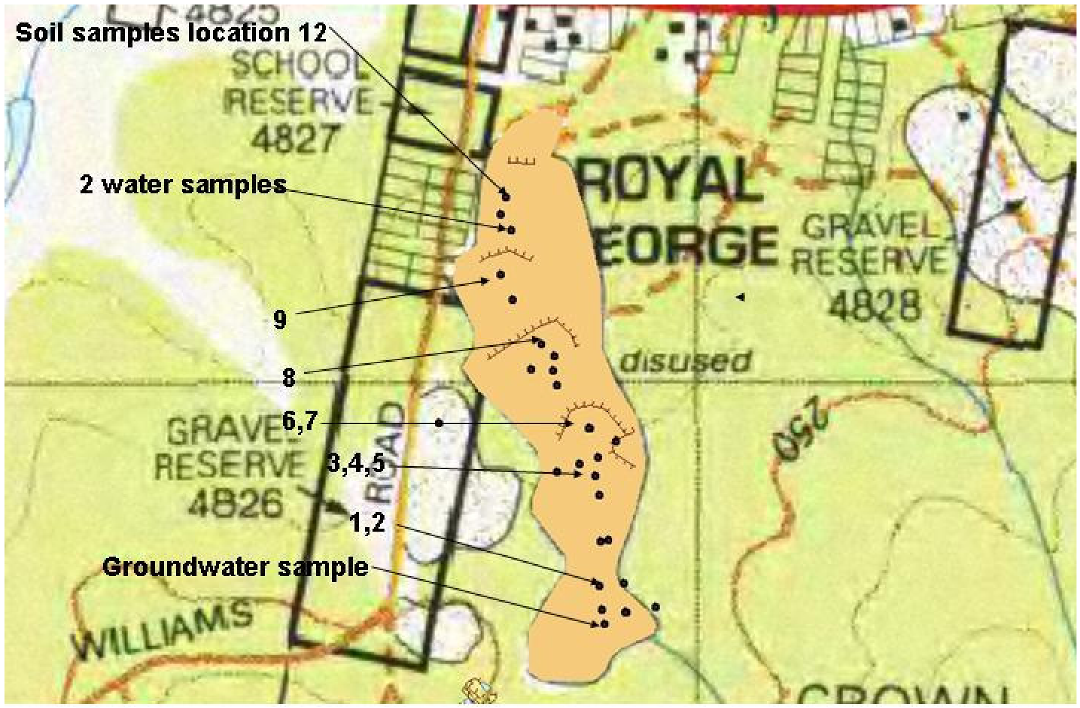
- Analytical Report #24709 dated 12 April 2005 from Analytical Services Tasmania for soil samples taken by MRT during the commission of the above mentioned scoping study.
- Analytical results from the MRT - Tasmanian Geological Survey laboratory dated 8 June 2005 for the same soil samples that were submitted to Analytical Services Tasmania mentioned above.

The MRT information regarding the location of the 'Bedford - Scoping Survey' test pit hole sites and the location of the MRT soil and water samples sites are shown in Figure 6 and Figure 7 below.



Test pit sites to evaluate volume and material type

Figure 6. Tailings area test pit locations.



Locations of samples with chemical analyses

Figure 7. MRT soil and water sample site locations.

4.1 Scoping Study Report April 2005

The civil engineering report supplied by MRT was entitled *Royal George Tailings, Scoping Study Into Rehabilitation Options, Nigel Bedford, Civil Engineering Consultant, April 2005.*

The findings and recommendations of the scoping study can be summarised as follows:

- The bulk of the tailings are contained in the remnants of a series of six identified dams over an area of approximately 28,000 m^2 with a bulk volume of approximately 36,000 m^3
- The tailings area is approximately 600 m long by approximately 50 m wide by an average of approximately 1.3 m in depth
- The study identified 4 options for encapsulation of the relocated tailings to best practice

    - Geosynthetic liner and cap ($797,590 budget estimate)
    - Geosynthetic cap only ($596,754 budget estimate)
    - HDPE cap only ($526,462)
    - Clay liner only ($491,315)

- A detailed survey of the tailings area should be undertaken prior to committing to any of the proposed civil engineering remediation works
- A search for clay resources south of the ‘old tip site’ should be undertaken prior to any of the proposed civil engineering remediation works
- A geological fault may exist in the tailings area
- The study identified an area adjacent to the current tailings location, removed from the existing drainage line, suitable for relocation and encapsulation of the tailings to best practice
- The study identified the likely relocation footprint scenarios including minimisation of the required wall volumes
- The study identified an alternative *in situ* remediation option. This option was to construct an embankment wall across the tailings ‘gully’ provided that the tailings slope stability and topography are suitable
- The budget cost estimate for tailings relocation and encapsulation to best practice is of the order of $567,000, including contract administration and project management costs.

4.1.1 P&S interpretation

The details of the scope of works for the scoping survey are not known. The following review is subject to this limitation.

- The scoping survey report appears to address MRT requirements to an acceptable standard.
- The relocation and encapsulation options in the study reflected industry best practice.
- Should a tailings relocation remediation option be considered further, the environmental risks need to be identified, assessed, mitigated and managed.
- The main risks will be associated with materials disturbance, storage and handling (both tailings and possibly clay). The cost of this Environmental Management Plan may need to be included in the budget estimate.

- ➢ The potential tailings area fault line mentioned in the survey may affect the fate of groundwater flow in the tailings area and hence the design and construction costs of the possible alternative *in situ* embankment wall remediation option.

Other potential *in situ* remediation options have been identified by P&S and are listed below. They include:

1. Installation of a new improved catchment 'cut off drain' closer to the tailings to ensure catchment water ingress into the tailings is minimised. This drain needs to be much deeper and wider than currently exists
2. Installation of a culvert drain through the entire length of the tailings along the natural drainage line to transport catchment water through the tailings area while minimising ingress
3. Recontouring and selective armouring of the tailings surface to reduce rain water ingress, utilising as much site clay as possible
4. Installation of armoured 'chevron' or 'fishbone' type surface drains on the tailings to more efficiently remove rainfall and reduce rainwater ingress
5. Revegetation of the surface of the tailings to reduce rain water ingress and utilise plant evapotranspiration to reduce seepage from the dump.
6. Addition of agricultural limestone by spreader to raise the pH of the tailings for revegetation
7. Addition of regional forest waste and deactivated sewage sludge to the surface of the tailings to promote revegetation, provided the potential for downstream impacts are minimised
8. It may be necessary to install a proper all weather access road on the tailings to facilitate on going remediation works
9. Installation of a large open armoured drain down the centre of the entire length of the tailings area, constructed to appropriate design, along the natural drainage line to transport catchment water across the tailings area while minimising ingress
10. Installation of passive open limestone drains in specific seep locations for targeted treatment and mitigation of pollutant toxicity
11. Installation of downstream storm water gabions or settling ponds to remove solids from entering receiving waters
12. A combination of two or more of the above

4.2 Tailings Test Pit Logs 2005

The 2005 tailings test pit logs are contained in Appendix B.

There were 22 test pits installed down the length of the tailings area as indicated in Figure 6.

The average tailings depth was 1.3 m with a standard deviation of ± 1.0 m. The median was 1.1 m, with a maximum of 3.7 m and minimum of 0.0 m. The average topsoil depth was 0.17 m with a standard deviation of ± 0.19 m. The median was 0.2 m, with a maximum of 0.7 m and minimum of 0.0 m.

The sub-grade material below the tailings and underlying topsoil varied from clay type material (mainly black clay), clayey gravel and granitic gravel (some of which was quite porous).

Of the test pit logs reported in the scoping survey, the number with clay, clayey gravel and granitic gravel types were relatively evenly split. There was one test pit with grey silt at the lower end of the tailings area.

One test pit made water at 2.0 m at the top end of the tailings and this water was sampled and sent for analysis.

Two test pits were reported as 'wet' below 3 m in depth but were too deep to sample safely. One of these was in the lower section of the tailings area; the other was towards the middle reaches of the tailings

There appeared to be little stratification or classification of the tailings.

4.2.1 P&S interpretation

The average tailings depth of 1.3 m is relatively shallow when compared with modern tailings storage facilities.

The underlying sub-grade material appears to be of greatly varying types and hence hydraulic permeability/conductivity.

The direction and fate of groundwater below the tailings will depend on the amount, locality and permeability of the sub-grade material below the tailings.

Most of the test pit logs reported that sub-grade material was encountered before the groundwater. According to the (#2) test pit log (in the upper tailings area) groundwater was encountered at 2 m. This is approximately 0.9 m below the tailings in the sub-grade material. None of the other test pit logs reported groundwater less than 2.7 m in depth. Only two test pits (#15 and #20) reported 'wet' conditions. These two pits were 3.7 m and 3.1 m deep respectively. No water samples could be taken at the time.

It appears from the log data that the groundwater level was approximately 3 metres below the tailings surface and located under the tailings for most of the tailings dump at the time the test pits were excavated.

The tailings groundwater levels recorded in February/March 2005 study may be higher in winter after heavy rainfall events.

The 22 test pit logs indicate that 75% of the tailings are shallower than 2.0 m. 95% of the tailings are less than 2.7 m in depth.

Given the relatively shallow average depth of the tailings and the lack of groundwater observed in the tailings to this time, the tailings are likely to have been continually wetted and drained over the past 77 years.

This 'weathering' would have introduced oxygen into the tailings over 77 years and oxidised the sulphides in the tailings. It is likely that the pollutant mass emissions rates have therefore peaked and are falling along with the sulphide content.

The shallow nature would also suggest that water retention time in the dump is probably in the order of weeks to months and not years as is the case in much larger waste rock and tailings dumps.

Any alternative in situ remediation option such as constructing an embankment wall in the tailings area to flood the tailings would require a detailed survey of the underlying material and groundwater pathways.

This cost would need to be included in any budget estimations.

4.3 Analytical Reports for 2005 Water Samples

Analytical Services Tasmania (AST) analytical reports #24271 and #24686 are contained in Appendix C.

The analytical results are tabulated and compared to receiving water quality criteria in Table 1 below. The table also includes calculated dilution factors to achieve accepted water quality criteria.

The results in Table 1 are expressed as µg/L unless otherwise stated.

Analytes	RG1	RG2	RG3	Anzecc Guideline 95% Eco. Protection	Max. Dilution Factor for Environment.	Drinking Water Guideline	Max. Dilution Factor for drinking water
pH	4.6	3.0	2.7	**6.5 – 7.5**	App.7	**6.5 –8.5**	App.7
EC µS/cm	314	748	1100	**30 - 350**	4	**500000 µg/L TDS**	
T/Alk.mg/L	<2	<2	<1				
Acidity mg/L	41	172	315				
Sulphate mg/L	98	170				**250000**	

Analytes	RG1	RG2	RG3	Anzecc Guideline 95% Eco. Protection	Max. Dilution Factor for Environment.	Drinking Water Guideline	Max. Dilution Factor for drinking water
mg/L							
Hardness mg/L	49.7	13.2	20.7			**200000**	
T/Al	10700	12400	26800	**55 pH>6.5**	NA-clay	**200**	NA-clay
T/As	671	79	338	**13**	52	**7**	96
T/Cd	143	164	320	**0.2**	1600	**2**	160
T/Co	11	12	25				
T/Cr	7	<1	2	**1.0**	7	**50**	
T/Cu	12200	12200	14000	**1.4**	10000	**2000**	7
T/Fe	14500	8100	21200			**300**	71
T/Mn	136	106	206	**1900**	NA	**100**	2
T/Ni	9	8	15			**20**	
T/Pb	191	<5	9	**3.4**	56	**10**	19
T/Zn	2600	4140	8850	**8.0**	1100	**3000**	3
Diss. Ca mg/L	17.0	1.45	2.0				
T/Ca mg/L			2.19				
T/K mg/L			6.83				
Diss. Mg mg/L	1.73	2.32	3.82				
T/Mg mg/L			3.87				
T/Na mg/L			15.7			**180000**	

Table 1. AST tailings seepage analytical results including water quality guidelines and dilution factors. Grey shading shows exceedance of drinking water guidelines and dilution factor for compliance. Green shading shows exceedance of Anzecc guideline trigger values and dilution factor to achieve compliance.

4.3.1 P&S interpretation

The results exceeding the guidelines values are shaded in Table 1.

The dilution factors calculated in Table 1 are based on the highest results. Due to the very limited database the average concentrations have not been calculated.

These dilution factors are only indicative. The analytical results are targeted on specific seeps and may not relate to actual downstream discharges and mass emission rates.

Dilution to acceptable levels may well be achieved in the combined tailings area discharge and future monitoring should target the downstream surface water (and if applicable the groundwater) discharges.

The elevated levels of heavy metals in the tailings dump seeps, particularly cadmium and arsenic, are the main human health risk. The risk exists for pollutants to enter the residential and homestead water supply for several town residences.

The cadmium and arsenic pollutants in the seepage samples require the greatest dilution to achieve NHMRC drinking water criteria.

Environmentally, the elevated results for copper, cadmium and zinc concentrations in the tailings seepages and groundwater have the potential to cause environmental harm.

A maximum dilution factor of the order of 10,000:1 may be required to achieve the copper trigger values of the ANZECC guidelines for the protection of 95% of aquatic species in the St Pauls River.

The results reported are for total metals. The dissolved and more ecologically toxic metal concentrations may be significantly lower than the ‘totals’ reported.

The mass emission rates for copper, cadmium and zinc from the tailings are unknown at this stage. Although the local seepage concentrations are elevated, the mass emission rates from the tailings may be relatively low.

Very little buffering capacity is evident in the tailings seeps and groundwater. The low total alkalinity levels support this, as do the low calcium and magnesium concentrations.

Addition of limestone or magnesite to the tailings would increase the groundwater pH and reduce acidity. The addition of limestone alkalinity for sulphuric acid neutralisation also increases the water hardness, which typically reduces toxicity, and facilitates revegetation.

From visual observations it is apparent that the dissolved organic content of the drainage water is very low and therefore little heavy metal complexation to reduce toxicity can be expected.

The final draft paper for the ‘Environmental Management Goals for Tasmanian Surface Waters, Macquarie River & South Esk River Catchments’ was completed and endorsed by The Board of Environmental Management and Pollution Control, local government (Northern Midlands, Break O’Day, Dorset and Central Highland Councils) and the Tasmanian Parks and Wildlife Services, in December 2005.

The St Pauls River runs for approximately 28 km through a large area of private land before passing the Royal George township.

In accordance with the ratified environmental management goals, the protected environmental values (PEVs) for the St Pauls River are interpreted to be:

- Protection of modified (not pristine) ecosystems from which edible fish are harvested
- Primary contact water quality; Secondary contact water quality; Aesthetic water quality
- Agricultural Water Uses: - Irrigation; Stock watering

Community Water Values are also outlined in the PEVs, but no residential or homestead water uses for the St Pauls River at Royal George are included. Potable water values and uses are only included in PEVs for public water supply facilities.

Regardless of this formality, localised water usage by several residences for homestead and possibly potable water supply does exist. The Director of Public Health advises that such users should disinfect or boil the water. This may be applicable for disinfection of biological pathogens but will not reduce heavy metal toxicity.

The local water usage in the vicinity of the confluence of tailings drainage and the St Pauls River needs to be considered when assessing and developing remediation options for the tailings area.

Ambient water monitoring of the St Pauls River should be undertaken on a routine basis until such time as the potential risks can be evaluated further.

Consultation with water users and the local council can then be undertaken from a more informed position, than currently exists.

4.4 Analytical Report for 2005 Soil Samples

The field sheet associated with for the MRT soil samples from the tailings test pits is contained in Appendix D.

Analytical Services Tasmania (AST) analytical report #24709 is contained in Appendix E.

The analytical results are tabulated in Table 2 below and compared to:

- The National Environment Protection Measure, Guideline on Investigation Levels for Soil and Groundwater, Schedule B(1)
- The DPIWE, Bulletin No. 105, Classification of Contaminated Soil for Disposal, April 2006.

The results in Table 2 are expressed as mg/kg dry mass basis unless otherwise stated.

Analyte	RG1	RG2	RG3	RG4	RG6	RG7	RG8	RG9	RG12	Average	NEPM HIL	NEPM EIL	Dilution factor to EIL	DPIWE
As	1020	15	1000	84	450	83	863	1550	2600	852	**500**	**20**	130	**750**
Cd	14	<1	15	11	6	1	13	22	46	14.3	**100**	**3**	15	**400**
Co	<1	5	<1	2	<1	6	<1	<1	3	2.3	**500**			**1000**
Cr	1	22	1	6	<1	27	<1	<1	1	6.8	**500**	**1**	27	**2000**
Cu	65	5	329	239	39	7	99	275	4020	564	**5000**	**100**	40	**7500**
Mn	18	49	23	18	12	58	16	21	29	30	**7500**	**500**		**25000**
Ni	<1	9	<1	3	<1	9	<1	<1	2	3.1	**3000**	**60**		**3000**
Pb	249	56	315	31	117	179	163	495	670	253	**1500**	**600**	1.1	**3000**
Zn	43	63	72	72	54	87	96	228	888	178	**35000**	**200**	4.4	**50000**
S												**600**		

Table 2. AST soil analytical results and NEPM investigation levels (HIL = Health Investigation Levels for Commercial/Industrial sites, EIL = Ecological Investigation Level) and DPIWE Level 4 criteria - contaminated soil remediation required prior to disposal. Grey shading shows exceedance of health investigation levels. Green shading shows exceedance of ecological investigation levels and dilution factor to achieve compliance.

4.4.1 P&S interpretation

The results exceeding the investigation levels are shaded in Table 2. The EIL dilution factors are calculated for the highest result.

The main health based risk is the arsenic concentration in the tailings. The arsenic concentrations generally exceed the DPIWE contamination level requiring remediation for disposal to landfill.

Site RG12 had arsenic levels up to five times the NEPM health investigation level. The arsenic concentration of over half the sample sites as well as the average also exceeded the NEPM – HIL.

The NEPM – HIL investigation level is based on commercial/industrial land uses including shops, offices, factories and industrial premises.

It should be noted that the number and degree of exposure pathways at the Royal George tailings dump would be lower than if commercial or industrial activities were undertaken on the site.

The residential health risk pathways are likely to be by fugitive dust respiration and/or ingestion of water containing tailings pollutants.

The arsenic concentration of over half the sample sites as well as the average also exceeded the DPIWE contaminated soil requiring remediation prior to disposal.

Although the DPIWE guidelines are used to classify the degree of contamination of materials for disposal to landfill facilities, these criteria are included to assist risk identification with reasonable quantification.

Environmentally, the elevated results for arsenic, copper and cadmium in the soils represent the main risk to the receiving waters as shown in the Table 2 comparison with the NEPM - EIL.

It is interesting to note that generally higher heavy metal concentrations are recorded in the down gradient zones of the tailings dump, nearest to the township and the waste transfer station.

4.5 MRT Laboratory Report on 2005 Soil Samples

The field sheet for the MRT soil samples from the tailings test pits is contained in Appendix D.

The MRT laboratory analytical results for arsenic, cobalt, copper, nickel, lead and zinc in the soil samples agree remarkably well with the Analytical Services Tasmania results for the same samples and will not be considered further, as they have been reviewed in section 4.4.

The MRT laboratory analysis report for the soil samples is contained in Appendix F.

The analytical results are tabulated in Table 3 below and compared to:

- The National Environment Protection Measure, Guideline on Investigation Levels for Soil and Groundwater, Schedule B(1). Note there are no HIL guideline values in the NEPM for the uncommon elements in the table, so that column has been removed from the Table 3.
- The DPIWE, Bulletin No. 105, Classification of Contaminated Soil for Disposal, April 2006.

The results in Table 3 are expressed as mg/kg dry mass basis unless otherwise stated. bdl = below detection levels.

Analyte	RG1	RG2	RG3	RG4	RG6	RG7	RG8	RG9	RG12	RG13	Average	NEPM - EIL	DPIWE
Bi	27	bdl	26	bdl	6	9	11	61	80	bdl	22		
Ga	21	30	27	16	13	45	18	30	29	16	25		
W	29	20	28	13	16	36	21	36	50	16	27		
Sn	2200	34	2250	105	1000	68	1200	2950	2700	1700	1421		**900**
%S	0.2	0	0.3	0.1	0.1	0	0.2	1.2	2.4	0.3	0.5	**0.06**	
Th	23	18	26	bdl	bdl	62	13	44	51	13	25		
Sr	72	21	110	16	24	23	44	115	110	25	56		
U	37	18	53	11	18	50	38	39	78	bdl	34		
Rb	420	480	560	360	240	550	360	620	570	390	455		
Y	37	46	40	34	21	81	30	53	61	32	44		
Zr	76	180	78	140	47	190	59	105	115	72	106		
Nb	19	18	18	14	8	29	14	17	12	12	16		
Mo	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	bdl	40	4		**4000**
pH										4.9			
HCl sol. %S										0.15			
ANC										0			
NAPP										4.7			

Table 3. MRT soil analyses and NEPM - EIL (Ecological Investigation Level) and DPIWE Level 4 criteria - contaminated soil remediation required prior to disposal. ANC = Acid neutralising Capacity (mg/kg). NAPP = Net Acid Producing Potential (mg/kg). Green shading shows exceedance of NEPM ecological investigation levels or DPIWE contaminated soil criteria. Brown shading shows radioactive elements.

4.5.1 P&S interpretation

The results exceeding the investigation levels are highlighted in Table 3. The results for radioactive elements are also highlighted.

The elevated tin levels in the tailings are typical of tailings for a processing mill of this era (early 1900s). All but two of the tin results as well as the average are above the DPIWE criteria, as highlighted in Table 3.

The technology available at that time would most likely only have a tin recover efficiency of approximately 75%.

The speciation of the tin concentrations is likely to be as cassiterite or tin oxide.

Cassiterite is a naturally occurring and stable mineral, which is prevalent in the local and regional area. Future tailings water analysis should include the dissolved tin concentration, which is more environmentally relevant.

A comparison of the dissolved tin concentrations with the trigger values of the ANZECC guidelines for fresh and marine waters would give a better appreciation of the actual environmental risks and potential impacts.

Many of the sulphur results and the average are above the 600 mg/kg or 0.06% NEPM – EIL investigation level. The % sulphur is indicative of the potential for the tailings to produce sulphuric acid, particularly if a significant proportion of the sulphur is present as sulphide.

It is generally accepted that material with <0.1% S and <5 mg/kg acid neutralising capacity (ANC) is deemed to be 'baron rock'.

Although not excessive, the tailings have the potential to produce sulphuric acid and the dissolution of heavy metals.

Using the average 0.5% sulphur and assuming that most of the sulphur is sulphide and noting that the tailings now have minimal acid neutralising capacity, then the maximum potential acidity (MPA) of the tailings is 0.5 x 30.6 = kg H_2SO_4 /t of tailings = 15.3 kg acid/t tailings.

Given that there is approximately 50,000 tonnes of tailings, the maximum potential sulphuric acid production of the tailings is 50,000 x 15.3 = 765 tonnes.

The oxidisable sulphides in the tailings are likely to be significantly less than 0.5%. It is likely to be approximately half the total sulphur given the age, profile and nature of the tailings.

The order of magnitude of the neutralisation requirement for the tailings is approximately 300 tonnes of limestone.

Uranium deposits were discovered for the first time in Tasmania at the Royal George ore body in 1955, in the form of the torbernite mineral.

The uranium levels in the tailings are slightly elevated with an average concentration of 34 mg/kg as outlined in Table 3 above. Uranium is widely spread in nature and is present in the earth's crust at approximately 4 mg/kg. Uranium is used in the steel industry, ceramics and glass.

Thorium is also a relatively plentiful element in the earths crust at approximately 12 mg/kg (comparable to lead). Thorium is used in strengthening nickel and in the electronics industry. It has an average concentration of 25 mg/kg in the tailings.

Rubidium is an alkali metal, which occurs in traces in salt deposits and also in the lithium mineral lepidolite. It is the 16^{th} most abundant element in the earths crust and averages about 100 mg/kg compared to the average tailings content of 455 mg/kg.

The human body tends to treat Rb^{+} ions as if they were potassium ions, and therefore concentrates rubidium in the body's electrolytic fluid.

The ions are not particularly toxic, and are relatively quickly removed in the sweat and urine. However, taken in excess it can be dangerous.

Regardless of the perceived low health risks, it is recommended that the Health Physics Section of the Department of Health and Human Services is consulted for a preliminary assessment of the radiation levels in the tailings.

5. Site Investigations

The site investigation was developed following the review of MRT data and in consultation with MRT.

The on site investigation was focussed on the following key elements. The investigation was limited to one day and was undertaken on 1 March 2006.

- Recheck groundwater levels by test drilling in specific areas
- Undertake selective soil sampling and analysis
- Undertake soil nutrient analysis on samples previously collected by MRT
- Undertake sampling and analysis of site seepage and drainage including receiving water analysis

The Health Physics Section of the Department of Health and Human Services undertook an offsite radiation assessment on the MRT 2005 tailings samples.

Although this was not part of the scope of work or part of the site investigation it is included for completeness of the site risk assessment.

5.1 Desktop Data

The readily available desktop data, which may have relevance to decision-making and the design for current and future remediation options for the Royal George Mine, are included below.

5.1.1 Weather data

No reliable weather data has been identified for the Royal George. The following weather data for Avoca and Fingal is deemed indicative of the rainfall and evaporation rates for Royal George and adequate for the purposes of this report.

This is based on the fact that Avoca is only 14 km to the west northwest of Royal George and Fingal only 22 km to the north northeast.

Avoca:

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Mean rainfall mm/month	38	33	38	46	48	52	48	53	50	55	46	50	557

Courtesy: DPIF, South Esk Basin, State of Rivers Report, 1996.

Fingal:

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Mean rainfall mm/month	44.8	39.9	44.0	52.9	51.1	65.7	56.7	58.9	49.2	55.4	44.3	50.0	613
Mean evaporation. mm/month*	164	160	112	75	56	57	40	43	90	112	126	186	1221
Mean rainfall - evaporation difference. mm/month	-119	-120	-68	-22	-5	9	17	16	-41	-57	-82	-136	-608
Mean daily max. temp.°C	23.0	22.9	21.4	18.4	15.2	12.8	12.2	13.2	15.2	17.3	19.3	21.4	**Max. daily 38.0**
Mean daily min. temp.°C	10.2	9.9	7.8	5.4	2.9	1.1	0.4	1.0	3.3	4.9	6.9	8.6	**Min. daily –9.0**

Courtesy: Bureau of Meteorology. *Limited to 1.3 years of data. The grey shading highlights the months where the rainfall exceeds evaporation and the difference.

The Avoca rainfall figures from the State of the River Report are slightly lower than the data for Fingal. The Fingal database is much larger and includes some limited evaporation data, which will be useful for the purposes of this report.

Annual evaporation exceeds annual rainfall by approximately 600 mm. The mean monthly rainfall only exceeds mean monthly evaporation in June, July and August by 9 mm, 17 mm and 16 mm respectively. Total 42 mm.

If water inputs to the tailings can be limited to the average incident rainfall less the average evaporation, then the maximum surplus incident rainfall that could for infiltrate into the tailings is estimated to be 1,260 kL (30,000 m^2 x 42/1000 m), assuming 3 ha of tailings (2.8 plus a peripheral allowance of 0.2) and 42 mm/year surplus rainfall less evaporation.

Depending on the tailings permeability and run off coefficients, the actual infiltration may be significantly lower.

The volume of the tailings was determined in the scoping study to be approximately 36,000 m^3. Refer to section 4.1. The pore water volume of sand is usually 20 to 50% and the pore water volume of clay is usually 50 to 75%.

Depending on the permeability or hydraulic conductance of the tailings, the tailings have the potential to contain pore water volumes between 7,200 kL (20% of 36,000 m^3) to 27,000 kL (75% of 36,000 m^3).

This capacity greatly exceeds the potential surplus annual average incident rainfall infiltration of 1,260 kL.

Based on the climate conditions in the area, a potential remediation option is to limit water infiltration to incident rainfall by installing cut off drains.

The secondary surface mineralisation (crystallisation) observed 1 March 2006 on specific surface areas of the tailings dams indicates that during summer surface evaporation is drawing underlying pore water to the surface by osmosis and capillary mechanisms.

Both the test drill holes and secondary mineralisation are discussed later in this report.

5.1.2 Catchment characteristics assessment

Spreadsheets for the tailings area catchment characteristics assessment are contained in Appendix G.

The catchment area is delineated in Figure 8 below.

The catchment characteristics are summarised as follows:

- Area 72 ha
- Travel distance 1,615 m
- Average slope 8%
- Runoff coefficient 0.4
- Time of flow concentration 41 minutes
- Discharge flow:

- 2.34 cumecs (1 in 5 year storm event)
- 2.63 cumecs (1 in 10 year storm event)
- 3.04 cumecs (1 in 20 year storm event)
- 3.58 cumecs (1 in 50 year storm event)
- 4.01 cumecs (1 in 100 year storm event)

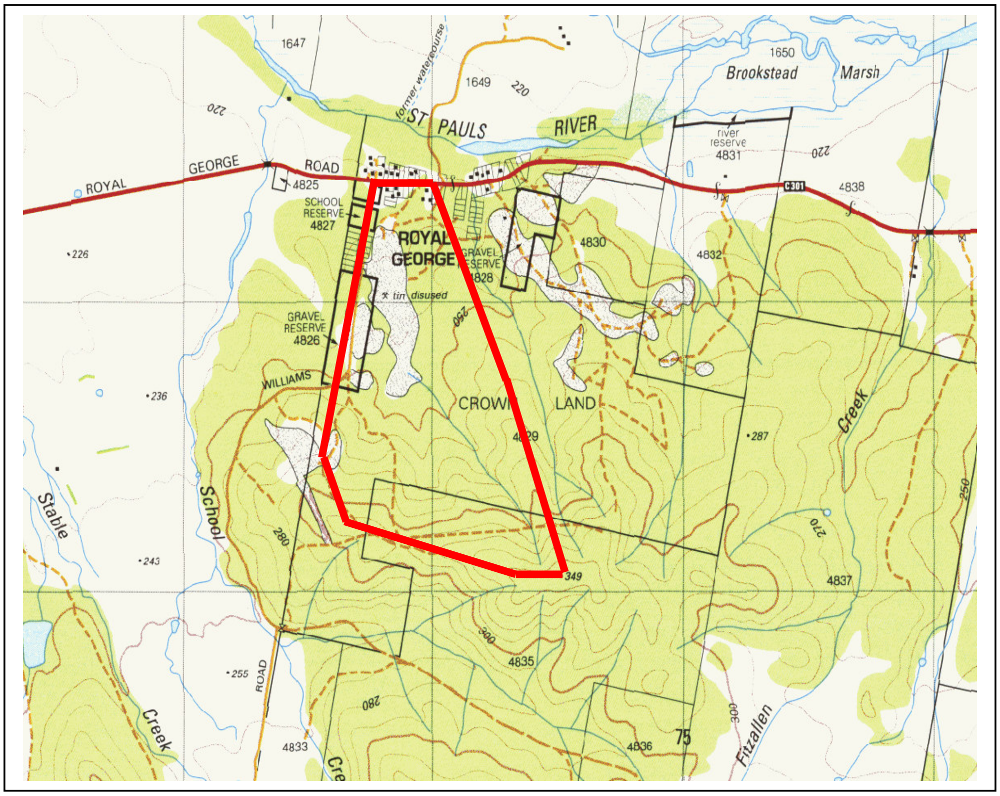


Figure 8. Tailings area catchment.

The St Pauls River has a catchment area to Avoca of 495 km^2. The catchment area to Royal George is approximately 336 km^2 or 33,600 ha.

This equates to a dilution ratio for discharges from the tailings catchment of approximately 33,600 ha / 72 ha = approximately 470:1 based on catchment areas.

This is an indicative dilution. Because the tailings and receiving catchments will have different time of flow concentrations and the tailings pollutant flux concentration may not match the flow concentration, the actual dilution will be different. The 470:1 dilution is indicative of the order of magnitude, however.

The first flush from the tailings area during the onset of a significant rainfall event following a long dry period is a possible time of the highest pollutant mass emissions at the lowest dilution ratios, before the flow in the St Pauls River increases to match.

The estimated time of flow concentration for the St Pauls River at Royal George is approximately 7 hours. The difference between the St Pauls River catchment and the tailings catchment times of flow concentration (approximately 7 hours – 41 minutes = 6.3 hours) is a possible period of high risk of causing local environmental nuisance or harm and to human health (especially after a long dry period).

The infiltration rate of rainwater and stormwater and the elution rate of pollutants from the tailings are not known at this time. This timeframe may well match the 6-hour difference in time of flow concentrations in which case the risk of impact would be reduced.

If the tailings pollutant elution timeframe is longer than St Pauls River time of concentration then the main emissions from the tailings may occur after the peak river flows have subsided.

5.1.3 Mine Geology

The tin ore deposit at the Royal George Mine consists mainly of disseminated cassiterite (tin oxide) accompanied by torbernite (a uranium ore - hydrated copper uranyl phosphate) in greisenised porphyritic Devonian granite.

The ore body is of a fracture filling type and the major mineral is cassiterite, with possibly some wolframite (tungsten ore) and sphalerite (zinc sulphide) together with a host of minor base metal sulphides.

The minor sulphides are likely to contain stannite (copper, iron, tin sulphide) and arsenopyrite. This would explain the presents of zinc, copper and arsenic in aqueous emissions from the tailings dump.

5.1.4 State of Rivers Report

The South Esk Basin, State of Rivers Report 1996, is a reference for water quality in the St Pauls River downstream of the Royal George tailings dam. The data was collected from 1992 to 1995.

The water quality recorded in the report shows that the water quality of the St Pauls River downstream of the Royal George mine is quite high but no water samples were taken in the vicinity of the tailings discharge.

No heavy metal analyses relevant to those in the Royal George tailings discharge especially those that have the potential to cause environmental nuisance or harm were undertaken.

The State of Rivers report refers to a 1984 river ecology study of the South Esk River, which reported that they found ‘ healthy fauna’ in the St Pauls River downstream of Royal George.

The summary of the database for the St Pauls River taken from the above-mentioned report is contained in Table 4 below.

St Pauls River u/s South Esk

	Units	Count	Maximum	Minimum	Mean	Median
Flow Range	Cumecs	37	30.2	0.028	2.16	0.362
Temperature	Celsius	36	22.5	4.9	13.4	12.3
Conductivity @ 25 °C (field)	µS/cm	32	208	71	133	128
Dissolved Oxyegen	mg/L	10	11.3	7.6	9.74	9.95
Field pH		33	7.7	5.3	6.5	6.5
Turbidity	N.T.U.	14	26.2	0.59	4.02	2.22
Suspended Solids	mg/L	37	6	< 1	1.08	< 1
Conductivity @ 25 °C (Lab)	µS/cm	34	230	77	132	125
pH - Lab		36	8.9	5.8	7.2	7.3
Ammonia -N	mg/L	37	0.03	< 0.005	< 0.005	< 0.005
Nitrite - N	mg/L	37	0.011	< 0.005	< 0.005	< 0.005
Nitrate - N	mg/L	37	0.23	< 0.005	0.017	< 0.005
Total Kjeldahl - N	mg/L	12	0.32	< 0.05	0.188	0.185
Total P	mg/L	37	0.032	0.002	0.009	0.009
Dissolved Reactive P	mg/L	37	0.018	< 0.001	0.003	0.002
#TN by Calc.	mg/L	13	0.453	0.034	0.223	0.214
Colour	Hazen Units	4	30	20	25	25
TDS	mg/L	4	100	63	88.50	95.5
Hardness	mg/L	4	56	38	46.75	46.5
Total Alkalinity	mg/L	4	18	13	15.25	15
Chloride	mg/L	4	30	15	21.50	20.5
Flouride	mg/L	4	< 0.1	< 0.1	< 0.10	< 0.1
Suplhate	mg/L	4	1.6	0.9	1.30	1.35
Iron - Total	mg/L	4	0.72	0.18	0.39	0.335
Manganese - Total	mg/L	4	< 0.01	< 0.01	< 0.01	< 0.01
Calcium	mg/L	4	9.6	6.7	8.30	8.45
Magnesium	mg/L	4	7.8	5.1	6.33	6.2
Potassium	mg/L	4	0.57	0.42	0.47	0.45
Sodium	mg/L	4	15	11	12.25	11.5
Silica (Molybdate Reactive)	mg/L	4	14.3	9.5	11.10	10.3

Table 4. Summary table from the State of Rivers report.

The above analytical results in the State of Rivers report agree well with the receiving waters analyses both upstream and downstream of the tailings discharge for 1 March 2006.

The 1 March 2006 analyses are discussed later in this report.

The State of Rivers report also includes flow measurements for the St Pauls River. The results are subject to a very limited database but indicate the very variable flows in the river.

The St Pauls River flow is very variable during summer – particularly in December and January, reflecting the random occurrence of subtropical low-pressure systems, which can feed easterly storm activity at these times.

The lowest flows are usually indicated in March and April, although May and October November are often periods of low flow also.

The indicative monthly river flows have been copied from the State of Rivers report and shown in Figure 9 below.

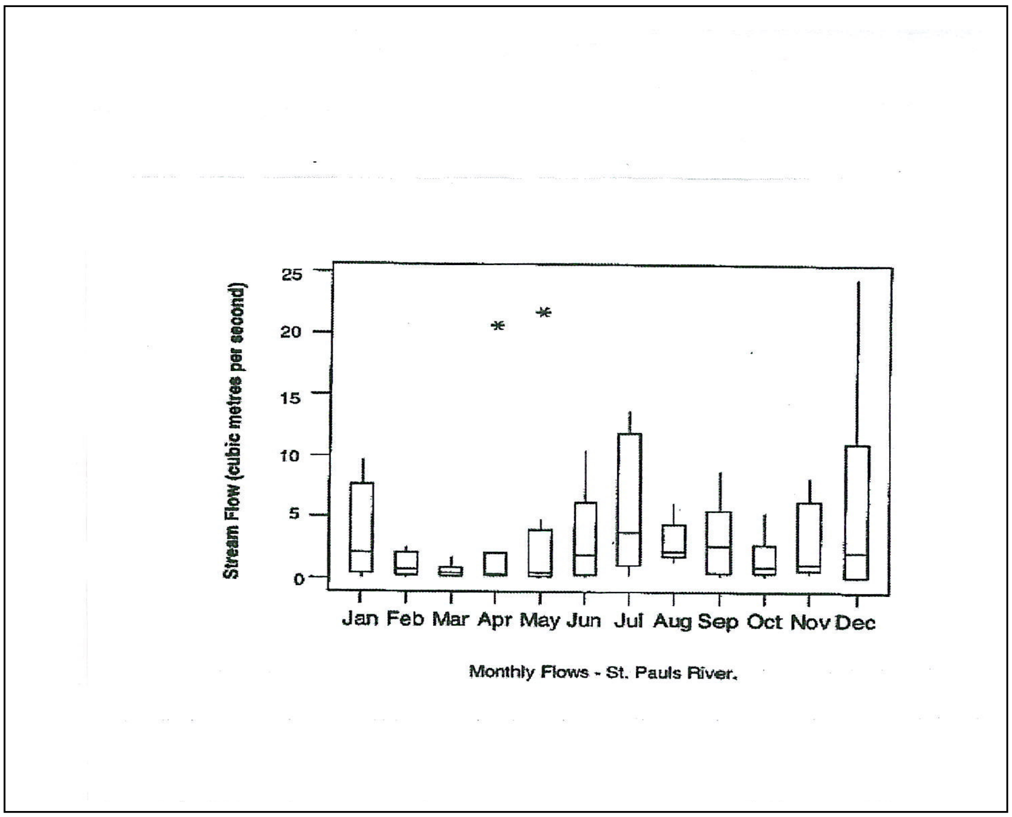


Figure 9. Indicative monthly flows in the St Pauls River.

The State of Rivers report records that pollutant loads generally increase significantly during flood events.

The St Pauls River has been recorded as having a peak suspended solids concentration of 350 mg/L and a flow that was equivalent to a suspended solids load of 6.3 t/minute or 9100 t/day.

The new Department of Primary Industries and Water, Water Information System Tasmania (WIST) – St Pauls River monitoring station #18311 is also a useful reference regarding flows.

This reference gives flow records for up to 5 years. The reference supports the State of Rivers average daily flow of approximately 2.2 cumecs.

The maximum flows for 2003, 2004 and 2005 were, however, 408 cumecs, 453 cumecs and 226 cumecs respectively, much greater than the maximum 30 cumecs reported in the State of Rivers report. The minimums were all zero.

The St Pauls River flows at Royal George can be estimated as approximately 0.75 of the St Pauls River flow at Avoca. These figures agree with a catchment characteristic assessment in Appendix G.

The Rivers and Water Supply Commission has a web site which includes flow data and limited water quality data. The annual reports contain summarises.

5.2 Groundwater Test Drill Holes

Following the review of existing MRT information and the preliminary site inspection, it was decided to undertake some drill hole testing.

The aim was to determine if groundwater existed in the lower tailings area and to monitor the groundwater if encountered.

Four test drill holes were installed in the lower tailings area using the MRT trailer mounted 'Treifus' auger rig.

No meaningful groundwater was encountered before the auger refused on underlying rock or reached a depth of 3.0 to 3.5 m whichever came first.

A summary table of the field observations is contained in Table 5 below. Photographs 23 and 24 in Appendix A show the auger material for each test hole.

The locations of the test drill holes DH1, DH2, DH3 and DH4 are shown in Figure 10 below.

	Drill Hole 1	**Drill Hole 2**	**Drill Hole 3**	**Drill Hole 4**
Drill Hole Depth (m)	3.0	3.5	2.5	0.5
Groundwater Depth (m)	Nil encountered	Nil encountered	Nil encountered soil moist	Nil encountered
Tailings Profile (m)	**0.0 to 1.5** Sandy gravel	**0.0 to 1.5** Sandy gravel	**0.0 to 1.5** Sandy clay, moist	**0.0 to 0.5** Sand, some clay
	1.5 to 3.0 Clay, low plasticity, sandy	**1.5 to 3.5** Clayey sand	**1.5 to 2.0** Sandy clay, increasing sand	**0.5** Granite
			2.0 to 2.5 Sand, clayey	

Table 5 Test Drill Hole Logs

5.2.1 Interpretation

The tailings were relatively dry with no groundwater encountered. Drill hole 3 was moist but did not make water. No groundwater sampling was possible.

The depths of the drill holes appear to reflect the natural topography of the original landform and the results from the previous scoping survey, especially for area 4.

It may be of interest to test drill during winter but access may be limited. Hand augering may be an alternative to be pursued if deemed necessary at a later date.

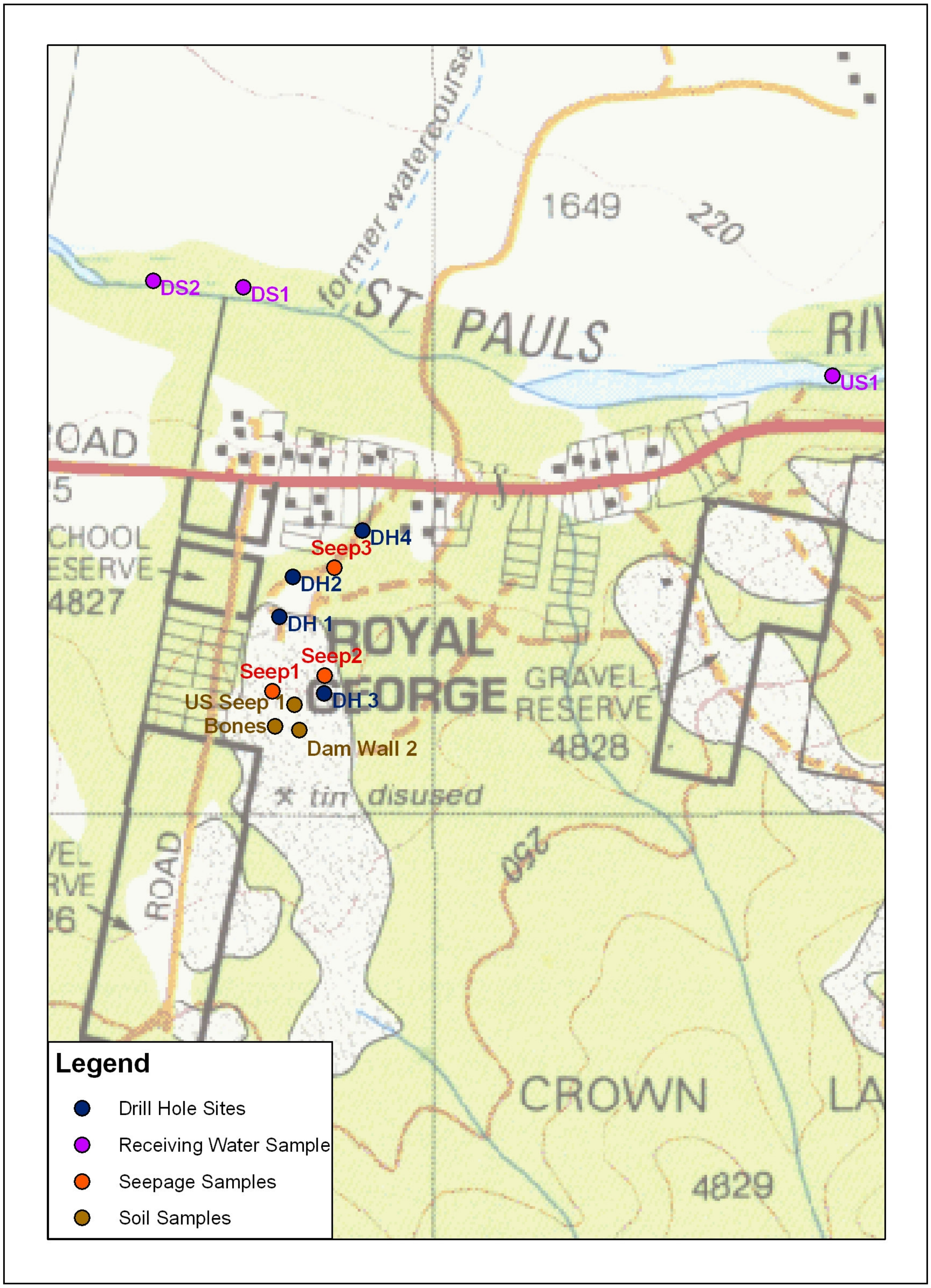

1649
220
former watercourse
ST PAULS
RIV
DS2
DS1
US1
ROAD
CHOOL
ESERVE
4827
DH4
Seep3
DH2
DH 1
ROYAL
GEORGE
Seep2
Seep1
US Seep 1
DH 3
Bones
Dam Wall 2
GRAVEL
RESERVE
4828
tin disused
250
ROAD
CROWN
LA
4829
Legend
Drill Hole Sites
Receiving Water Sample
Seepage Samples
Soil Samples

Figure 10. Location of 2006 test drill holes (blue). Location of 2006 selective soil sample sites (brown). Location of 2006 seepage water sample sites (red). Location of 2006 St Pauls River water sample sites (mauve).

5.3 Selective Soil Analysis

The existing MRT tailings samples collected in 2005 were considered representative of the tailings and the 2005 analytical results have been discussed in sections 4.4 and 4.5.

Three unusual secondary surface mineralisation locations on the tailings were identified and targeted for selective sampling and analysis. The samples were named US Seep 1, RG Bones and 2 Dam Wall.

The WGS 84 coordinates for the collective soil samples sites area are Easting 573902 and Northing 5369288.

The AST analytical report #27920 for these three selective tailings surface sample is contained in Appendix H.

Photographs of the 'blue' secondary mineralisation are shown in photographs 25 and 26 in Appendix A. The locations of the three selective sample sites are show in Figure 10 above.

The 2006 analytical results for the three selective tailings surface sample are summarised and compared to the average tailings results from 2005 and appropriate guidelines in Table 6 below.

Results expressed as mg/kg dry mass basis unless otherwise stated.

Analyte	2005 Average	US Seep1	RG Bones	2 Dam Wall	NEPM HIL	NEPM EIL	Dilution factor to EIL	DPIWE
SO_4^{2-}		260000	62800	138		**2000**	130	
Al		23800	8010	2250				
As	852	527	688	937	**500**	**20**	47	**750**
Cd	14.3	204	55.2	11.7	**100**	**3**	68	**400**
Co	2.3	15.1	3.8	2.1	**500**			**1000**
Cr	6.8	4.6	2.5	1.4	**500**	**1**	5	**2000**
Cu	564	20900	3030	701	**5000**	**100**	209	**7500**
Fe		9420	13000	78200				
Mn	30	151	63.6	14.8	**7500**	**500**		**25000**

Analyte	2005 Average	US Seep1	RG Bones	2 Dam Wall	NEPM HIL	NEPM EIL	Dilution factor to EIL	DPIWE
Ni	3.1	10.5	5.5	1.7	**3000**	**60**		**3000**
Pb	253	121	199	349	**1500**	**600**		**3000**
Rb		51.8	48.2	36.8				
Sn		147	230	676				**900**
Th		4.6	8.5	12.3				
U		623	233	14.9				
Zn	178	5060	1670	359	**35000**	**200**	25	**50000**

Table 6. Selective tailings analyses and NEPM investigation levels (HIL = Health Investigation Levels for Commercial/Industrial sites, EIL = Ecological Investigation Level) and DPIWE Level 4 criteria - contaminated soil remediation required prior to disposal. Grey shading shows exceedance of health investigation levels. Green shading shows exceedance of ecological investigation levels and dilution factor to achieve compliance.

5.3.1 Intepretation

The results exceeding the investigation levels are highlighted in Table 6. The EIL dilution factors are calculated for the highest result.

From a health risk perspective the arsenic, cadmium and copper concentrations are the main risk.

The US Seep 1 'blue surface crystals' and RG Bones samples contained significantly elevated levels of the following parameters, compared to the 2005 tailings analytical results as discussed in section 4.4 and 4.5.

Parameter	US Seep 1	RG Bones
Sulphate	26% w/w	6.3% w/w
Aluminium	2.4% w/w	0.8% w/w
Cadmium	204 mg/kg	55 mg/kg
Copper	2.1% w/w	0.3% w/w
Uranium	623 mg/kg	233 mg/kg
Zinc	0.5%	0.2%

It is likely that the water-soluble copper, zinc, aluminium and cadmium sulphates have concentrated as crystals at the surface of the tailings due to evaporation and osmosis/capillary actions.

The sulphates result from the oxidation of sulphides in the tailings.

These highly water-soluble sulphate compounds are readily transportable into the St Pauls River.

All other elements were similar to or below the 2005 results.

5.4 Tailings Nutrients

The existing MRT tailings samples collected in 2005 were considered representative of the tailings.

Eight of these samples were submitted for nutrient analysis. The samples were analysed for paste pH, total nitrogen and total phosphorus.

The AST analytical report # 28210 is contained in Appendix I.

Table 7 below summarises the results and compares them to acceptable soil pH and nutrient levels for re-vegetation.

Results are expressed as mg/kg dry mass basis.

MRT Sample	pH	Total nitrogen	Total phosphorus	pH rating against target 6.5	Nitrogen rating against target 1000 mg/kg	Phosphorus rating against target 100 mg/kg
2	5.3	255	20	Low	Low	Low
3	4.0	120	470	Very low	Very low	Very high
4	4.5	64	42	Very low	Very low	Low
6	4.4	26	220	Very low	Very low	Very high
7	5.4	1500	53	Low	High	Medium
8	3.6	50	390	Very low	Very low	Very high
9	2.9	82	690	Very low	Very low	Very high

12	3.0	100	940	Very low	Very low	Very high

Table 7. Nutrient results and re-vegetation criteria.

The rating criteria for pH are: <5.0 very low, <6.0 low, 6.0 to 7.0 medium, >7.0 high, >8.0 very high.

The rating criteria for Total Nitrogen are: <200 very low, <500 low, 500 to 1000 medium, >1000 high, >5000 very high.

The rating criteria for Total Phosphorus area: <10 very low, <50 low, 50 to 100 medium, >100 high, >200m very high.

5.4.1 Interpretation

The tailings have a very low to low pH. If re-vegetation is a primary objective then treatment with agricultural limestone is the most likely option to raise this pH to acceptable levels over a sustained period of time.

Application rates of 10 tonne per hectare per year appear applicable. This equates to approximately 30 t/year or 300 t over ten years.

The total nitrogen and total phosphorus content of the tailings are very low. The available or soluble nutrients are likely to be significantly lower than the totals.

Application of a general purpose NPK fertiliser such as 8-4-10 may be applicable.

It is recommended that the tailings catchment drainage and access issues are resolved beforehand.

It may also be advantageous to increase the organic material in and on the tailings by applying forest harvesting waste and local council deactivated sewage sludge in conjunction with chemical treatment.

Natural revegetation has the potential to improve the tailings stability, aqueous mass emissions and air emissions provided favourable conditions are provided at the site.

At the moment such conditions are not evident.

5.5 Water Quality

The preliminary site inspection identified tailings seeps and receiving water sample sites that were considered appropriate for further investigation.

The site water quality investigation for the tailings and receiving waters and results are contained below.

5.5.1 Site Seepage

Three tailings seepage locations were identified and targeted for the 2006 tailings seepage sampling and analysis.

The AST analytical report #27920 relevant for the three selective tailings seepage samples are contained in Appendix H. The samples are named Seep 1, Seep 2 and Seep 3.

Photographs of the seepage sample sites are shown in photographs 4, 27 and 28 in Appendix A. The locations of the three selective seepage sites are show in Figure 10 above. The WGS 84 coordinates for the seepage sample sites are:

Seep1 - Easting 573898, Northing 5369332

Seep2 - Easting 573964, Northing 5369351

Seep3 - Easting 573976, Northing 5369486.

The analytical results are tabulated in Table 8 below and compared to the 2005 results and receiving water quality criteria. The table also includes calculated dilution factors to achieve accepted water quality criteria.

The results are expressed as µg/L unless otherwise stated.

Analytes	**2005 RG1**	**2005 RG2**	**2005 RG3**	**2006 Seep1**	**2006 Seep2**	**2006 Seep3**	**Anzecc Guideline 95% Eco. Protection**	**Max. Dilution Factor for Environment.**
pH	4.6	3.0	2.7	**3.0**	**3.5**	**3.4**	**6.5 – 7.5**	App.7
EC µS/cm	314	748	1100	**672**	**553**	**745**	**30 - 350**	2
T/Alk. mg/L	<2	<2	<1	**<2**	**<2**	**<2**		
Acidity mg/L	41	172	315	**136**	**115**	**254**		
Sulphate mg/L	98	170		**147**	**175**	**331**		
Hardness mg/L	49.7	13.2	20.7	**13.3**	**35.8**	**55.2**		
T/Al	10700	12400	26800	**7950**	**11800**	**29600**	**55 pH>6.5**	NA – clay present
T/As	671	79	338	**432**	**116**	**39.7**	**13**	33

Analytes	2005 RG1	2005 RG2	2005 RG3	2006 Seep1	2006 Seep2	2006 Seep3	Anzecc Guideline 95% Eco. Protection	Max. Dilution Factor for Environment.
T/Cd	143	164	320	**126**	**349**	**468**	**0.2**	2340
T/Co	11	12	25	**10.0**	**28.8**	**32.8**		
T/Cr	7	<1	2	**2**	**2**	**3**	**1.0**	3
T/Cu	12200	12200	14000	**8780**	**8270**	**19700**	**1.4**	14071
T/Fe	14500	8100	21200	**26000**	**9180**	**64460**		
T/Mn	136	106	206	**89.8**	**169**	**827**	**1900**	
T/Ni	9	8	15	**7.2**	**15.1**	**44.4**		
T/Pb	191	<5	9	**2.4**	**25.1**	**2.0**	**3.4**	7
T/Rb				**92.2**	**107**	**103**		
T/Sn				**<1.0**	**<1.0**	**<1.0**		
T/Th				**<0.5**	**<0.5**	**0.7**		
T/U				**173**	**185**	**602**		
T/Zn	2600	4140	8850	**3550**	**4840**	**6760**	**8.0**	845
Diss. Ca mg/L	17.0	1.45	2.0	**1.29**	**2.08**	**9.57**		
T/Ca mg/L			2.19	**1.14**	**1.85**	**9.08**		
T/K mg/L			6.83	**5.19**	**7.26**	**11.8**		
Diss. Mg mg/L	1.73	2.32	3.82	**2.44**	**7.44**	**7.59**		
T/Mg mg/L			3.87	**2.39**	**7.34**	**7.52**		
T/Na mg/L			15.7	**18.3**	**33.1**	**17.1**		

Table 8. Tailings seepage samples - analytical results and receiving water quality guidelines. Green shading shows exceedance of the 2006 results with ecological investigation levels and the dilution factor to achieve compliance.

The 2006 seepage results exceeding the guidelines values are highlighted for ease of identification in Table 8.

The dilution factors calculated in Table 8 are based on the highest results for 2006.

The 2006 seepage results agree well with the 2005 results for similar seeps.

The dilution factors included in the table are only indicative. The analytical results are targeted on specific seeps and may not relate to actual downstream discharges and mass emission rates.

It should be noted that dilution to acceptable levels might well be achieved in the tailings area.

Future monitoring to attain a better appreciation of the impacts of these seeps should target the downstream surface water (and if applicable the groundwater) discharges as well as the receiving waters, particularly during the first flush and following a storm event.

5.5.2 St Pauls River

Three St Pauls River sites were identified and targeted for sampling and analysis.

The AST analytical report #27920 containing the results for these three St Pauls River samples is contained in Appendix H.

The samples are named US1, DS1 and DS2. The US1 is upstream of the confluence of the tailings drainage with the St Pauls River.

DS1 and DS2 sites are downstream and separated to give delineation of any mixing zone.

The upstream and downstream sites are shown in photographs 29 and 31 in Appendix A.

The locations of the three St Pauls River sample sites are show in Figure 10 above. The WGS 84 coordinates for the sample sites are:

US1 - Easting 573898, Northing 5369332

DS1 - Easting 573964, Northing 5369351

DS2 - Easting 573976, Northing 5369486.

The analytical results are tabulated in Table 8 below and compared to the trigger values of the ANZECC water quality guidelines for the protection of 95% of ecosystems and drinking water guidelines as well as the average the State of Rivers report 1996.

The table also includes any calculated dilution factors to achieve accepted water quality criteria, if applicable.

The results are expressed as µg/L unless otherwise stated.

Analytes	US1	DS1	DS2	Average State of Rivers 1996	Anzecc Guideline to protect 95% Eco.	Max. Dilution Factor for Environ.	Drinking Water Guideline	Max. Dilution Factor for drinking
pH	7.2	7.2	7.4	7.2	**6.5 – 7.5**		**6.5 –8.5**	
EC µS/cm	185	185	186	132	**30 - 350**		**500000 µg/L TDS**	
T/Alk. mg/L	48	47	47	15				
Acidity mg/L	3	3	3					
Sulphate mg/L	2	2.1	2.3	1.3			**250000**	
Hardness mg/L	55.3	56.6	57.8	46.75			**200000**	
T/Al	19.9	30.8	27.8		**55 pH>6.5**		**200**	
T/As	<0.5	1.0	1.0		**13**		**7**	
T/Cd	<0.1	<0.1	<0.1		**0.2**		**2**	
T/Co	0.3	0.2	0.2					
T/Cr	<1	<1	<1		**1.0**		**50**	
T/Cu	<1	11.5	14.3		**1.4**	10	**2000**	
T/Fe	692	640	665	390			**300**	
T/Mn	14.5	7.7	9.2	10	**1900**		**100**	
T/Ni	0.6	0.6	0.8				**20**	
T/Pb	<0.5	<0.5	<0.5		**3.4**		**10**	
T/Rb	1.8	1.9	1.9					
T/Sn	<1.0	<1.0	<1.0					
T/Th	<0.5	<0.5	<0.5					
T/U	<0.1	1.1	1.1				**20**	
T/Zn	<1.0	1.1	17.1		**8.0**	2	**3000**	
Diss. Ca mg/L	11.4	11.7	12.2					
T/Ca mg/L	11.8	11.8	12.0	8.3				
T/K mg/L	0.77	0.83	0.75	0.47				

Analytes	US1	DS1	DS2	Average State of Rivers 1996	Anzecc Guideline to protect 95% Eco.	Max. Dilution Factor for Environ.	Drinking Water Guideline	Max. Dilution Factor for drinking
Diss. Mg mg/L	6.51	6.67	6.66					
T/Mg mg/L	6.81	6.91	6.91	6.33				
T/Na mg/L	13.1	13.7	13.4	12.25			**180000**	

Table 8. St Pauls River water sample analytical results. Including receiving water and drinking quality guidelines and dilution factors to achieve guidelines. **Grey shading shows exceedance of drinking water guidelines and dilution factor for compliance. Green shading shows exceedance of Anzecc guideline trigger values and dilution factor to achieve compliance.**

5.5.3 Interpretation

The results exceeding the guidelines values are highlighted in Table 8.

The 2006 St Pauls River water quality analytical results agree well with the 1996 State of Rivers data for the parameters measured in that study.

There were generally very similar results in the parameters from upstream to downstream indicating minimal mass discharge from the tailings area to St Pauls River at the time of monitoring.

The two downstream results generally had similar water quality, which indicates no delineation of the potential impact at the time of monitoring. The elevated zinc result for DS2 is unexplainable but may be due to sample contamination.

It appears that following dry weather conditions the tailings emissions have little impact on the river water quality. However, this may not be indicative of the impact of the tailings area discharges during rainfall events or following rainfall events.

The dilution factors calculated in Table 8 are based on the highest results. Copper and zinc levels exceeded the guideline trigger values.

Using copper as a key indicator, it appears that the dilution ratio may be in the order of 1000:1 at the time of monitoring.

The water quality parameters were selected to measure the potential impacts of pollutants from the tailings area. They should not be used to demonstrate that the water is suitable for human consumption.

For example, no pathogenic organisms have been analysed in relation to drinking water quality and pollutant levels may be significantly different at other monitoring times.

The Director of Public Health advises anyone taking water for drinking from sources other than from a public water supply utility should ensure that the water is disinfected by appropriate means.

5.6 Radiation

The MRT tailings samples were taken to Dr Barbra Shields and Dr Stephen Newbery at the Health Physics section of the Department of Health and Human Services.

A bench top preliminary radiation investigation was undertaken using an 'Exploranium GR 130 Minispec Gamma Ray Spectrometer' and the dose rate was checked with a 'Multi/Channel Analyser Gamma Ray Spectrometer'.

According to the Health Physics section the bench top testing indicated minimal radiation activity and dose rates from the tailings samples.

Their advice is that the estimated activity concentrations of the soil mean that the material would be exempt from:

- Any licensing requirements
- Any requirement for the site to be registered
- The provision of abandonment
- Does not need a certificate of compliance for the source
- Does not need notification for change of circumstance.

In relation to the water quality samples the Australian Drinking Water Guidelines' Fact Sheet Uranium – states that 'based on health effects the concentration of uranium in drinking water should not exceed 0.02 mg/L (20 µg/L)'. The guidelines also state, that apart from the 20 µg/L chemical toxicity, the radiological requirement is 30 µg/L.

The uranium analytical results for the St Pauls River on 1 March 2006 of 0.1, 1.1 and 1.1 µg/L comply with the both the chemical and radiological criteria guideline. However further water quality testing is required to expand the database to validate this initial finding.

The seepage results of 173, 185 and 602 µg/L uranium require a dilution of approximately 30:1 to achieve the drinking water quality guidelines.

6. Discussion

The catchment in which the tailings are located is relatively wide and flat at the top southern end of the tailings dump and then slopes downwards to the north and narrows to the original drainage line.

The existing cut off drains appear too flat and ineffective. To install a cut off drain around this area of the dump successfully will require a design with constant and adequate slope. Some preliminary survey investigation and design work may be required to ensure effectiveness.

Moving large quantities of tailings raises risks of chemical and physical releases. It is not recommended to install any dam walls across the gully, as the nature of the underlying ground is not known.

The strength of the small remnant dam walls for each tailings area and the underlying ground is not known so rebuilding of these walls is not considered advisable unless information on their ability to contain hydraulic head pressure is known (i.e. were the dam walls built on old tailings as upstream constructions or were they downstream constructions?).

The installation of a large culvert drain down through the middle of the dump(s) is not recommended given costs of approximately $180,000 plus installation and the need to access and disturb tailings.

It is considered that to transport surface water across the tailings is a high-risk activity that could increase emissions to those currently occurring. It is also considered a very high risk to re-profile the dump or install swale surface drains for the same reasons. None of these options will be considered further.

The tailings have naturally profiled and settled over nearly 80 years and this landform should be left in place. If water ingress and run off can be limited to incident rainfall, then erosion and infiltration should be minimised to manageable levels.

Some infiltration and elution at manageable levels may actually be beneficial to prevent the accumulation and hence the risk of increasing soluble contaminants in the dump.

An alternative to directing the stormwater through or over the dump is to install a new improved cut off drain across the top end angled with an appropriate fall to connect with a new improved drain down the eastern side of the dump. The new drains would replace the existing drains, which appear to have weathered and become ineffective.

An appropriately designed, deeper, wider and armoured drain, capable of taking up to approximately 3 to 4 cumecs of flow can be constructed down the eastern side.

This drain would be positioned closer to or just on the edge of the tailings. The existing roadside drain on the western side of the dump (Williams Road) should also be upgraded to a better standard.

A conceptual plan is shown in Figure 11 below. The drain is highlighted in blue.

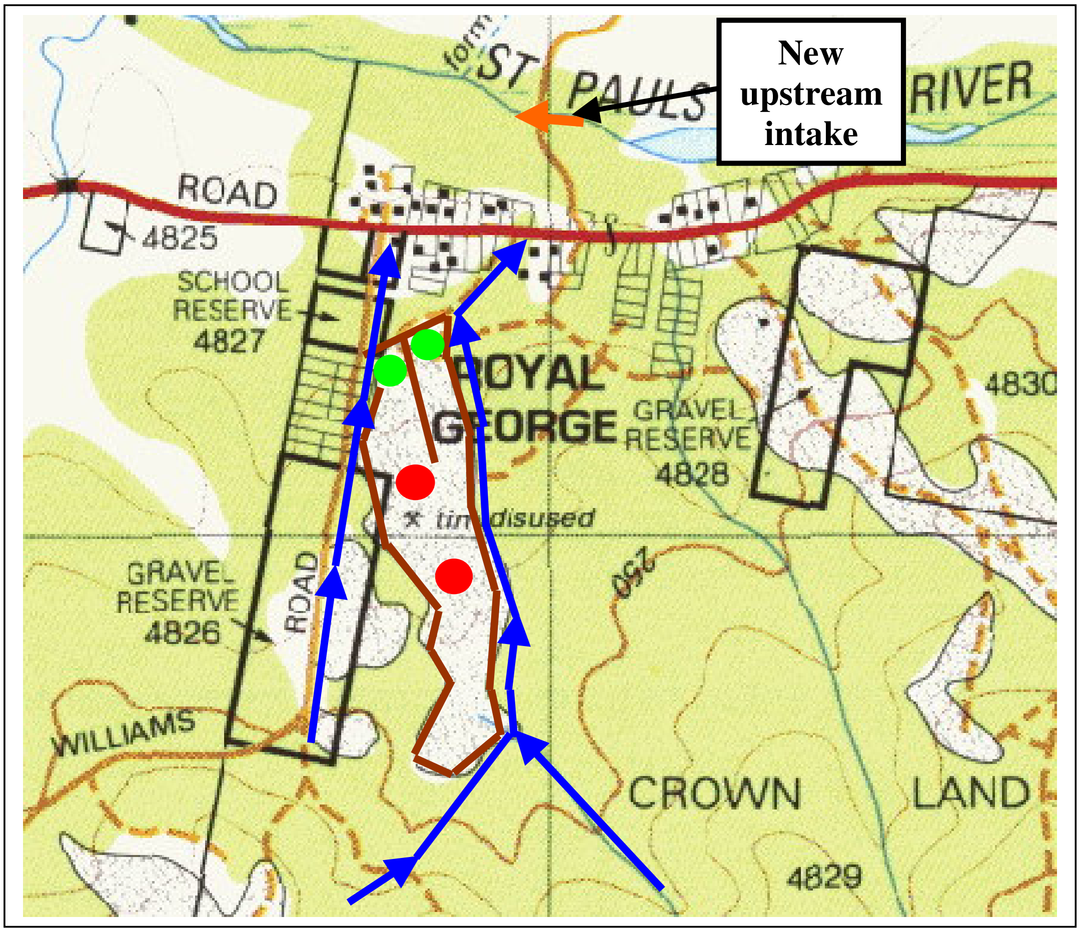


Figure 11. Conceptual plan of the proposed remediation options. Proposed drainage works are highlighted in blue. Proposed road works are highlighted in brown. Proposed erosion mitigation works are highlighted in red. Proposed homestead water intake is highlighted in orange. Potential passive open limestone seepage treatments are highlighted in green.

Areas on the tailings where remnant dam walls have eroded can be excavated out and significantly widened and armoured with boulders to dissipate surface water flow energy and reduce further erosion.

The rocks or boulders could be sourced from nearby mines. A long armed excavator would be the preferred equipment used for this remediation. The dam wall areas requiring excavation and flattening to reduce local erosion are highlighted in red on Figure 11.

A proper access road should be installed around the tailings to facilitate any revegetation initiatives such as limestone neutralisation of tailings, application of general purpose NPK fertiliser (E.g. 8 4 10) and the application of organic material. Proper culverts should be installed where access roads cross the cut off drains.

The organic material such as forest waste and deactivated sewage sludge could be sourced from nearby forestry activity and council wastewater treatment plants.

It is envisaged that if the tailings properties and nature can be improved, natural revegetation will occur over time. Ongoing natural revegetation should stabilise the tailings over time also.

Road materials could be sourced from nearby quarries. Refer to Figure 11 for the conceptual road plan. The road is highlighted in brown.

The water quality analyses indicate that risks of chemical contamination of the St Pauls River exist but the mass emissions may be low. Also a significant dilution in the St Pauls River is expected but may vary with time during storm events.

It is not possible to demonstrate that drinking water quality for chemical parameters relevant to the tailings is always achieved but initial indications are that it is quite possible.

Relocation of the homestead water intakes further upstream appears a logical option regardless. This would also reduce the risk of impact on the homestead water quality should revegetation options such as fertiliser applications and the use of forest waste and deactivated sewage sludge to assist revegetation initiatives be implemented. The conceptual extension of the homestead water supply is shown in orange in Figure 11.

The relocation of the water intakes should in no way be construed as encouraging the inappropriate use of this water. It is purely a perceived risk mitigation measure.

Treatment of seeps is considered an option of last resort. Implementation of water diversion upgrades and revegetation may negate their need. Potential passive open limestone drainage treatment areas are highlighted in green in Figure 11.

It is recommended that the installation of a settling pond(s) to remove solids from the tailings run off water including seepage treatment precipitates (if treatment is implemented) be delayed until the any potential benefits of water diversion upgrades and revegetation have been realised.

The lack of downstream space and favourable topography will limit the size of the settling ponds to an extent that they may not effective at removing particulate matter, especially clay material.

Prior to finalising the remediation plan, consultation should be undertaken with stakeholders and other interested parties. At the same time a dedicated water sampling regime should be implemented over a specific timeframe to address the identified information gaps and to verify the scale of the identified risks and mitigation measures recommended.

Access to the general area should be controlled by the strategic location of large boulders. These could be sourced from nearby mines.

7. Recommendations

It is recommended that a staged approach to the rehabilitation program be adopted.

Stage 1.

- This conceptual remediation plan is developed in consultation with key stakeholders, council and interested parties.
- A small, dedicated monitoring program and land survey is implemented over a nominal timeframe to address the identified information gaps and to validate the recommended remediation actions.
- The plan is finalised and costed. The action plans outlined in the following stages are subject to acceptance and approval in Stage 1.

Stage 2.

- The existing water intakes are extended upstream.
- Permanent all weather access roads are constructed around the tailings for on going remediation work.
- Access to the site is limited by the strategic placement of large boulders and/or gates.
- Depending on the findings of the monitoring in stage 1, newly designed surface water cut off drains may be installed to replace the existing drains. The new drains should be deeper and closer to the tailings to improve the fall and flows and designed to a longer life expectancy.

Stage 3.

- Contract a land rehabilitation company to develop details, then implement and manage a re-vegetation program.
- The program is likely to include the following:
    - Add alkalinity (ag-lime) to the surface of the tailings over a specified timeframe.

- Add inorganic fertilisers as deemed necessary.
- Add organic material to the surface of the tailings such as forest waste and deactivated sewage sludge.
- Review revegetation progress annually, including monitoring the tailing's seeps and the tailing's surface soils chemistry.

Stage 4.

- As a last resort, install downstream solids collection ponds if identified by the monitoring program as being required to achieve water quality objectives.
- As a last resort, install on site, passive, open limestone drainage treatment if identified by the monitoring program to be necessary to achieve water quality objectives.

APPENDIX A

PHOTOGRAPHS

APPENDIX B

TAILINGS TEST PIT LOGS 2005

Area	Test Pit No.	Depth tailings in meters	Depth T/Soil in meters	Depth Subgrade in meters	Type Subgrade	Comments	Length	Breadth	Volume
Area 1	#1	0.9	0.3	1.0	Clay				
	#2	1.1	0.3	1.0	Clayey gravel	Water at 2.0m deep			
	#3	2.4	0.0	0.4	Black Clay				
	#4	0.0	N/A	N/A	Granitic gravel	No sign clay material			
	#5	1.6	0.3	0.6	Porous granitic gravel	No sign clay material			
	#6	1.3	0.0	1.0	Black clay				
	#7	1.1	0.4	1.0	Black clay				
	#8a	0.8	0.1		Granitic gravel				
	#8b	1.1	0.2	1.0	Granitic gravel				
	Averages	1.3	0.2				50	87	5,573
Area 2	#9	0.5	0.7	0.5	Black Clay	0.7m gravel layer with thin skin topsoil			
	#10	0.8	0.4	0.8	Clayey gravel				
	#11	0.4	0.0		Granitic gravel				
	#12	0.1	0.0		Granitic gravel				
	#13	0.7	0.0	0.7	Clayey gravel				
	#14	0.4	0.0	0.3	Granitic gravel				
	Averages	0.5	0.2				50	160	3,800
Area 3	Averages	0.8				Gully between wetlands and first pond	56	50	2,193
Area 4	#15	3.7	0.0		Porous granitic gravel	Wet. Pit too deep to sample			
	#16	2.1	0.4	0.8	Clayey gravel				
	#17	0.6	0.0	0.8	Clayey gravel				
	#18	2.6	0.0	0.8	Clayey gravel				
	Averages	2.2	0.1				45	90	9,062
Area 5	#19	2.1	0.2		Black Clay				
	#20	2.9	0.2			Wet. Pit too deep to sample			
	Averages	2.5	0.2				60	60	9,000
Area 6	#21	1.9	0.3	0.5	Grey Silt				
	#22	1.1	0.2	0.5	Black Clay				
	Averages	1.5	0.3				56	22	1,806

Averages	1.46

31,435

Accuracy + or - 15%

APPENDIX C

ANALYTICAL REPORTS FOR 2005 WATER SAMPLES

ANALYTICAL SERVICES TASMANIA
Sandy Bay Laboratory
c/- Chemistry Department University of Tasmania
Sandy Bay Tasmania 7005
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Laboratory Report

Report No: 24271 **Issue No:** 1 **Report Date** 04-Feb-2005 16:44

Status: Full Report

Site Description: Royal George

Received: 21-Jan-05

Submitted By: Mineral Resources Tasmania

Client Order No:

Report To: W. Grun

Client: Mineral Resources Tasmania

Address: Gordons Hill Rd Rosny TAS 7018

ANALYTICAL SERVICES TASMANIA

Report No: 24271 **Issue No:** 1 **Report Date:** 04-Feb-2005 16:44

Method	Analyte	Units / Sampled On :	Lab.No.: 68221 Sample Id.: RG D3 SEEPAGE 19/01/05
1001-Water	pH		2.7
1002-Water	Conductivity	µS/cm	1100
1101-Water	Alkalinity Total	mg CaCO3/L	<1
1102-Water	Acidity	mg CaCO3/L	315
1109-Water	Hardness	mg CaCO3/L	20.7
1301-Water	Al Total	µg/L	26800
	As Total	µg/L	338
	Cd Total	µg/L	320
	Co Total	µg/L	25
	Cr Total	µg/L	2
	Cu Total	µg/L	14000
	Fe Total	µg/L	21200
	Mn Total	µg/L	206
	Ni Total	µg/L	15
	Pb Total	µg/L	9
	Zn Total	µg/L	8850
1302-Water	Ca Dissolved	mg/L	2.00
	Ca Total	mg/L	2.19
	K Total	mg/L	6.83
	Mg Dissolved	mg/L	3.82
	Mg Total	mg/L	3.87
	Na Total	mg/L	15.7

ANALYTICAL SERVICES TASMANIA

Report No: 24271 **Issue No:** 1 **Report Date:** 04-Feb-2005 16:44

Test Method(s) :

Test Date

Inorganic Testing

1001-Water:	pH in Water by APHA Method 4500-H	31-Jan-2005
1002-Water:	Conductivity by APHA Method 2510	31-Jan-2005
1101-Water:	Alkalinity by APHA Method 2320/4500-CO2	02-Feb-2005
1102-Water:	Acidity by APHA Method 2310	02-Feb-2005
1109-Water:	Hardness by APHA Method 2340	02-Feb-2005
1301-Water:	Metals in Water by APHA Method 3030/3120	28-Jan-2005
1302-Water:	Major Cations in Water by APHA Method 3030/3120	28-Jan-2005

Authorised By:

NATA

Samples analysed as received.

Accreditation No. 5589

05/01581 [illegible] ROYAL GEORGE 1H

Tasmania

ANALYTICAL SERVICES TASMANIA
Sandy Bay Laboratory
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Sandy Bay Tasmania 7005
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Laboratory Report

Report No: 24686 **Issue No:** 1 **Report Date** 08-Apr-2005 18:16

Status: Full Report

Site Description:

Received: 11-Mar-05

Submitted to: Sandy Bay Laboratory

Submitted By: W. Grun

Client Order No:

Report To: W. Grun

Client: Mineral Resources Tasmania

Address: Gordons Hill Rd Rosny TAS 7018

ANALYTICAL SERVICES TASMANIA

Report No: 24686 **Issue No:** 1 **Report Date:** 08-Apr-2005 18:16

Method	Analyte	Units / Sampled On :	71417	71418
		Lab.No.:	**71417**	**71418**
		Sample Id.:	Royal George 2	Royal George ~~11~~ 1
			09/03/05	09/03/05
1001-Water	pH		3.0	4.6
1002-Water	Conductivity	µS/cm	748	314
1101-Water	Alkalinity Total	mg CaCO3/L	<2	<2
1102-Water	Acidity	mg CaCO3/L	172	41
1103-Water	Sulphate	mg/L	170	98
1109-Water	Hardness	mg CaCO3/L	13.2	49.7
1301-Water	Al Total	µg/L	12400	10700
	As Total	µg/L	79	671
	Cd Total	µg/L	164	143
	Co Total	µg/L	12	11
	Cr Total	µg/L	<1	7
	Cu Total	µg/L	12200	12200
	Fe Total	µg/L	8100	14500
	Mn Total	µg/L	106	136
	Ni Total	µg/L	8	9
	Pb Total	µg/L	<5	191
	Zn Total	µg/L	4140	2600
1302-Water	Ca Dissolved	mg/L	1.45	17.0
	Mg Dissolved	mg/L	2.32	1.73
			LOWER AREA SEEPAGE	TOP GROUNDWATER

ANALYTICAL SERVICES TASMANIA

Report No: 24686 **Issue No:** 1 **Report Date:** 08-Apr-2005 18:16

Test Method(s) :		Test Date

Inorganic Testing

1001-Water:	pH in Water by APHA Method 4500-H	22-Mar-2005
1002-Water:	Conductivity by APHA Method 2510	22-Mar-2005
1101-Water:	Alkalinity by APHA Method 2320/4500-CO2	04-Apr-2005
1102-Water:	Acidity by APHA Method 2310	07-Apr-2005
1109-Water:	Hardness by APHA Method 2340	06-Apr-2005
1301-Water:	Metals in Water by APHA Method 3030/3120	01-Apr-2005
1302-Water:	Major Cations in Water by APHA Method 3030/3120	01-Apr-2005

Authorised By:

1103-Water:	Anions by Ion Chromatography APHA Method 4110B	30-Mar-2005

Authorised By:

NATA

This document shall not be reproduced, except in full.
Samples analysed as received.

Accredition No. 5589

APPENDIX D

SOIL SAMPLING FIELD SHEET 2005

Royal George

Date	Sample Id	Test Pit Id	Material Type	Full Horizon	Test Type	Comments
9-Mar-05	#1	TP#9	Tailings	yes	WG	
9-Mar-05	#2	TP#9	S/soil	yes	WG	clayey gravel
9-Mar-05	#3	TP#5	Tailings	yes	WG	
9-Mar-05	#4	TP#5	S/soil	yes	WG	
9-Mar-05	#5	TP#5	S/soil	yes	BFP Permeability	
9-Mar-05	#6	TP#6	Tailings	yes	WG	
9-Mar-05	#7	TP#6	S/soil	yes	WG	Black Clay/silt
9-Mar-05	#8	TP#15	Tailings	yes	WG	
9-Mar-05	#9	TP#20	Tailings	yes	WG	
9-Mar-05	#10	Adjacent Gravel Pit Clay	Prospective Clay seal		BFP Permeability	Adjacent Gravel Pit Clay
9-Mar-05	#11	TP#2	Water Infiltration		WG	

APPENDIX E

ANALYTICAL REPORT FOR 2005 SOIL SAMPLES

ANALYTICAL SERVICES TASMANIA

c/- Chemistry Department University of Tasmania
Sandy Bay Laboratory

Telephone: (03) 6226 7175 Fax: (03) 6226 7825 Email: ast.sandybay@dpiwe.tas.gov.au

Tasmania

NATA Accredition No. 5589

Date:	12-Apr-05	
Pages:	4	(including this one)

To:	W. Grun Mineral Resources Tasmania	**From:**	Amanda Freeman
Address	Gordons Hill Rd Rosny TAS 7018		
Fax No:	62338338	**Fax No**	(03) 6226 7825
Phone:	62338320	**Phone:**	(03) 6226 7175
Mobile:	0418338279		

Order No

Please find enclosed report number 24709 : issue number 1.

The invoice for this report will follow.

REG No. 05\01581

RECORDS
FILE No 68109

1H

ANALYTICAL SERVICES TASMANIA

Sandy Bay Laboratory

c/- Chemistry Department University of Tasmania
Sandy Bay Tasmania 7005
Telephone: (03) 6226 7175 Fax: (03) 6226 7825
Email: ast.sandybay@dpiwe.tas.gov.au

Tasmania

Laboratory Report

Report No: 24709 **Issue No: 1** **Report Date 12-Apr-2005 12:07**

Status: Full Report

Site Description: Royal George

Received: 16-Mar-05

Submitted to: Sandy Bay Laboratory

Submitted By: W. Grun

Client Order No:

Report To: W. Grun

Client: Mineral Resources Tasmania

Address: Gordons Hill Rd Rosny TAS 7018

The tests, calibrations or measurements covered by this document have been performed in accordance with NATA requirements which include the requirements of ISO/IEC 17025 and are traceable to national standards of measurement.

Samples analysed as received.

NATA
ACCREDITED FOR
TECHNICAL COMPETENCE

ANALYTICAL SERVICES TASMANIA

Report No: 24709 **Issue No:** 1 **Report Date:** 12-Apr-2005 12:07

Method	Analyte	Lab.No.:	71577	71578	71579	71580	71581	71582	71583	71584	71585
		Sample Id.:	Royal George 1	Royal George 2	Royal George 3	Royal George 4	Royal George 6	Royal George 7	Royal George 8	Royal George 9	Royal George 12
		Units / Sampled On :									
2301-Soil	As	mg/kgDMB	1020	15	1000	84	450	83	863	1550	2600
	Cd	mg/kgDMB	14	<1	15	11	6	1	13	22	46
	Co	mg/kgDMB	<1	5	<1	2	<1	6	<1	<1	3
	Cr	mg/kgDMB	1	22	1	6	<1	27	<1	<1	1
	Cu	mg/kgDMB	65	5	329	239	39	7	99	275	4020
	Mn	mg/kgDMB	18	49	23	18	12	58	16	21	29
	Ni	mg/kgDMB	<1	9	<1	3	<1	9	<1	<1	2
	Pb	mg/kgDMB	249	56	315	31	117	179	163	495	670
	Zn	mg/kgDMB	43	63	72	72	54	87	96	228	888

ANALYTICAL SERVICES TASMANIA

Report No: 24709 **Issue No:** 1 **Report Date:** 12-Apr-2005 12:07

Test Method(s) :		**Test Date**
Inorganic Testing		
2301-Soil:	Metals in Soil, Sediment & Dust by ICPAES	07-Apr-2005

Authorised By: [signature]

NATA

This document shall not be reproduced, except in full.
Samples analysed as received.

Accreditation No. 5589

APPENDIX F

MRT LABORATORY REPORT FOR 2005 SOIL SAMPLES

11 5

MINERAL RESOURCES TASMANIA

Tasmania

RECORDS
File No: 68199

MEMORANDUM

TO: WOJCIECH GRUN

FROM: LES HAY

SUBJECT: ANALYSIS RESULTS

DATE: 26 APRIL 2005

Results of Royal George 'waste fines' samples for pH, ANC, S & NAPP.

				(mgCaCO3/1000mg sample)	
Reg. N^{o}	**I.D.**	**pH**	**HCL sol %S**	**ANC**	**NAPP**
20050113	Waste fines	4.9	0.15_2	Nil	4.7

L.M.Hay. L.M. Hay.
SENIOR CHEMIST

Analyses by: JM.

Copy on 69184

L, lr on Royal George tailings

Tasmania

MINERAL RESOURCES TASMANIA

MEMORANDUM

TO: WOJCIECH GRUN

FROM: LES HAY

SUBJECT: ANALYSIS RESULTS

DATE: 08 JUNE 2005

Results of Royal George samples for Traces MP2 & MP4.

20050104---20050112 inclusive: (results given in May.)
& 20050113

L.M.Hay.

L.M.Hay.
SENIOR CHEMIST

Sheet1

Tasmanian Geological Survey
XRF Analysis
Requested by: W. Grun

analysis date	8/06/2006
analysis type	Wrtrace
treatment	pdisk
method	xrft
standard	STNDA
medium	ACT
analysis originator	RNW
sample originator	WG

Lab Anal No	Sample id	Co	As	Bi	Ga	Zn	W	Cu	Ni	Sn	Pb	% S
Detection Limit		8	20	5	5	5	10	5	5	9	10	%
20050104	Sample#1	bdl	970	27	21	74	29	71	5	2200	280	0.2
20050105	Sample#2	bdl	bdl	bdl	30	96	20	10	16	34	75	0.0
20050106	Sample#3	bdl	920	26	27	120	28	340	bdl	2250	350	0.3
20050107	Sample#4	bdl	62	bdl	16	83	13	300	6	105	31	0.1
20050108	Sample#6	bdl	350	6	13	64	16	38	bdl	1000	120	0.1
20050109	Sample#7	14	84	9	45	165	36	10	17	68	260	0.0
20050110	Sample#8	bdl	710	11	18	130	21	120	bdl	1200	175	0.2
20050111	Sample#9	bdl	1750	61	30	480	36	350	6	2950	620	1.2
20050112	Site 21	bdl	1900	80	29	1050	50	4100	5	2700	740	2.4
20050113	13 waste 'fines'	bdl	510	bdl	16	150	16	27	62	1700	120	0.3

Note: Sn values for most samples are well outside range of current calibration

L.M.Hay. [signature] **Analyses by:** RNW
SENIOR CHEMIST.

Page 1

Give in MA

Sheet1

			Tasmanian Geological Survey						
analysis date	8/06/2005		**XRF Analysis**						
analysis type	Wrtrace		**Requested by:**		W. Grun				
treatment	pdisk								
method	xrft								
standard	STNDA								
medium	ACT								
analysis originator	RNW								
sample originator	WG								
Lab Anal No	Sample id	Th	Sr	U	Rb	Y	Zr	Nb	Mo
Detection Limit		10	5	10	5	5	5	3	5
20050104	Sample#1	23	72	37	420	37	76	19	bdl
20050105	Sample#2	18	21	18	480	46	180	18	bdl
20050106	Sample#3	26	110	53	560	40	78	18	bdl
20050107	Sample#4	bdl	16	11	360	34	140	14	bdl
20050108	Sample#6	bdl	24	18	240	21	47	8	bdl
20050109	Sample#7	62	23	50	550	81	190	29	bdl
20050110	Sample#8	13	44	38	360	30	59	14	bdl
20050111	Sample#9	44	115	39	620	53	105	17	bdl
20050112	Site 21	51	110	78	570	61	115	12	bdl
20050113	13 waste 'fines'	13	25	bdl	390	32	72	12	40
		L.M.Hay.	LMH.		**Analyses by:**	RNW			
		SENIOR CHEMIST.							

Given in MAY

Page 1

APPENDIX G

CATCHMENT CHARACTERISTICS ASSESSMENT

APPENDIX H

2006 ANALYTICAL REPORT #27920 WATER AND SOIL

ANALYTICAL SERVICES TASMANIA

c/- Chemistry Department University of Tasmania
Sandy Bay Laboratory

Telephone: (03) 6226 7175 Fax: (03) 6226 7825 Email: ast.sandybay@dpiwc.tas.gov.au

Accredition No. 5589

Date:	11-Apr-06
Pages:	5 (including this one)

To:	J. Lockley Pitt & Sherry	**From:**	Amanda Freeman
Address	PO Box 94 Hobart TAS 7001		
Fax No:	62231299	**Fax No**	(03) 6226 7825
Phone:	62101466	**Phone:**	(03) 6226 7175
Mobile:	0407681618		

Order No

Please find enclosed report number 27920 : issue number 1.

The invoice for this report will follow.

ANALYTICAL SERVICES TASMANIA
Sandy Bay Laboratory
c/- Chemistry Department University of Tasmania
Sandy Bay Tasmania 7005
Telephone: (03) 6226 7175 Fax: (03) 6226 7825
Email: ast.sandybay@dpiwe.tas.gov.au

Laboratory Report

Report No: 27920 **Issue No:** 1 **Report Date** 11-Apr-2006 14:19
Status: Full Report

Site Description: Royal George
Received: 02-Mar-06

Submitted to: Sandy Bay Laboratory
Submitted By: J. Lockley (Pitt & Sherry)

Client Order No:
Report To: J. Lockley
Client: Pitt & Sherry
Address: PO Box 94 Hobart TAS 7001

ANALYTICAL SERVICES TASMANIA

Report No: 27920 **Issue No:** 1 **Report Date:** 11-Apr-2006 14:19

Method	Analyte	Lab.No.: / Sample Id.: / Units / Sampled On :	87418 US SEEP 1 01/03/06 13:00	87419 RG BONES 01/03/06 13:00	87420 2 DAM WALL 01/03/06 13:00	87437 SEEP 1 01/03/06 13:00	87438 SEEP 2 01/03/06 13:00	87439 SEEP 3 01/03/06 13:00	87440 DS 1 01/03/06 13:00	87441 DS 2 01/03/06 13:00	87442 US 1 01/03/06 13:00
1001-Water	pH					3.0	3.5	3.4	7.2	7.4	7.2
1002-Water	Conductivity	µS/cm				672	553	745	185	186	185
1101-Water	Alkalinity Total	mg CaCO3/L				<2	<2	<2	47	47	48
1102-Water	Acidity	mg CaCO3/L				136	115	254	3	3	3
1103-Water	Sulphate	mg/L				147	175	331	2.1	2.3	2.0
1109a-Water	Hardness	mg CaCO3/L				13.3	35.8	55.2	56.6	57.8	55.3
1311-Water	Al Total	µg/L				7950	11800	29600	30.8	27.8	19.9
	As Total	µg/L				432	116	39.7	1.0	1.0	<0.5
	Ca Dissolved	mg/L				1.29	2.08	9.57	11.7	12.2	11.4
	Ca Total	mg/L				1.14	1.85	9.08	11.8	12.0	11.8
	Cd Total	µg/L				126	349	468	<0.1	0.1	<0.1
	Co Total	µg/L				10.0	28.8	32.8	0.2	0.2	0.3
	Cr Total	µg/L				2	2	3	<1	<1	<1
	Cu Total	µg/L				8780	8270	19700	11.5	14.3	<1.0
	Fe Total	µg/L				26000	9180	6460	640	665	692
	K Total	mg/L				5.19	7.26	11.8	0.83	0.75	0.77
	Mg Dissolved	mg/L				2.44	7.44	7.59	6.67	6.66	6.51
	Mg Total	mg/L				2.39	7.34	7.52	6.91	6.91	6.81
	Mn Total	µg/L				89.8	169	827	7.7	9.2	14.5
	Na Total	mg/L				18.3	33.1	17.1	13.7	13.4	13.1
	Ni Total	µg/L				7.2	15.1	44.4	0.6	0.8	0.6
	Pb Total	µg/L				2.4	25.1	2.0	<0.5	<0.5	<0.5
	Rb Total*	µg/L				92.2	107	103	1.9	1.9	1.8
	Sn Total*	µg/L				<1.0	<1.0	<1.0	<1.0	<1.0	<1.0

* NATA accreditation does not cover this analyte.

ANALYTICAL SERVICES TASMANIA

Report No: 27920 **Issue No:** 1 **Report Date:** 11-Apr-2006 14:19

Method	Analyte	Units / Sampled On :	87418 US SEEP 1 01/03/06 13:00	87419 RG BONES 01/03/06 13:00	87420 2 DAM WALL 01/03/06 13:00	87437 SEEP 1 01/03/06 13:00	87438 SEEP 2 01/03/06 13:00	87439 SEEP 3 01/03/06 13:00	87440 DS 1 01/03/06 13:00	87441 DS 2 01/03/06 13:00	87442 US 1 01/03/06 13:00
1311-Water	Th Total	µg/L				<0.5	<0.5	0.7	<0.5	<0.5	<0.5
	U Total	µg/L				173	185	602	1.1	1.1	<0.1
	Zn Total	µg/L				3550	4840	6760	1.1	17.1	<1.0
2209-Soil	Sulphate	mg/kgDMB	260000	62800	138						
2331-Soil	Al	mg/kgDMB	23800	8010	2250						
	As	mg/kgDMB	527	688	937						
	Cd	mg/kgDMB	204	55.2	11.7						
	Co	mg/kgDMB	15.1	3.8	2.1						
	Cr	mg/kgDMB	4.6	2.5	1.4						
	Cu	mg/kgDMB	20900	3030	701						
	Fe	mg/kgDMB	9420	13000	78200						
	Mn	mg/kgDMB	151	63.6	14.8						
	Ni	mg/kgDMB	10.5	5.5	1.7						
	Pb	mg/kgDMB	121	199	349						
	Rb	mg/kgDMB	51.8	48.2	36.8						
	Sn	mg/kgDMB	147	230	676						
	Th	mg/kgDMB	4.6	8.5	12.3						
	U	mg/kgDMB	623	233	14.9						
	Zn	mg/kgDMB	5060	1670	359						

* NATA accreditation does not cover this analyte.

ANALYTICAL SERVICES TASMANIA

Report No: 27920 **Issue No:** 1 **Report Date:** 11-Apr-2006 14:19

Test Method(s) :

Test Date

Inorganic Testing

1001-Water:	pH in Water by APHA Method 4500-H Work Conducted at: Sandy Bay	15-Mar-2006
1002-Water:	Conductivity by APHA Method 2510 Work Conducted at: Sandy Bay	15-Mar-2006
1101-Water:	Alkalinity by APHA Method 2320/4500-CO2 Work Conducted at: Sandy Bay	16-Mar-2006
1102-Water:	Acidity by APHA Method 2310 Work Conducted at: Sandy Bay	22-Mar-2006
1103-Water:	Anions by Ion Chromatography APHA Method 4110C Work Conducted at: Sandy Bay	17-Mar-2006
1109a-Water:	Hardness by APHA Method 2340 Work Conducted at: Sandy Bay	11-Apr-2006
1311-Water:	Metals in Water by ICPMS by USEPA Method 200.8 Work Conducted at: Sandy Bay	30-Mar-2006
2209-Soil:	Water Extractable Anions by ASLS 3A1 and APHA 4110C * Work Conducted at: Sandy Bay	16-Mar-2006
2331-Soil:	Metals in Soil, Sediment & Dust by ICP-MS * Work Conducted at: Sandy Bay	05-Apr-2006

Authorised By: M.G. J...

Mike Johnson
Manager

NATA

Accreditation No. 5589

APPENDIX I

2006 ANALYTICAL REPORT #28210 SOIL NUTRIENTS

ANALYTICAL SERVICES TASMANIA

c/- Chemistry Department University of Tasmania
Sandy Bay Laboratory

Telephone: (03) 6226 7175 Fax: (03) 6226 7825 Email: ast.sandybay@dpiwe.tas.gov.au

Accredition No. 5589

Date:	27-Apr-06
Pages:	4 (including this one)

To:	J. Lockley Pitt & Sherry	**From:**	Amanda Freeman
Address	PO Box 94 Hobart TAS 7001		
Fax No:	62231299	**Fax No**	(03) 6226 7825
Phone:	62101466	**Phone:**	(03) 6226 7175
Mobile:	0407681618		

Order No

Please find enclosed report number 28210 : issue number 1.

A copy of this report has been sent to:

AST - New Town Reports, AST - New Town, 20 St Johns Avenue, New Town 7008.

The invoice for this report will follow.

ANALYTICAL SERVICES TASMANIA
Sandy Bay Laboratory
c/- Chemistry Department University of Tasmania
Sandy Bay Tasmania 7005
Telephone: (03) 6226 7175 Fax: (03) 6226 7825
Email: ast.sandybay@dpiwe.tas.gov.au

Laboratory Report

Report No: 28210 **Issue No:** 1 **Report Date** 27-Apr-2006 11:19

Status: Full Report

Site Description: MRT Royal George

Received: 28-Mar-06

Submitted to: Sandy Bay Laboratory

Submitted By: J. Lockley (Pitt & Sherry)

Client Order No:

Report To: J. Lockley

Client: Pitt & Sherry

Address: PO Box 94 Hobart TAS 7001

The tests, calibrations or measurements covered by this document have been performed in accordance with NATA requirements which include the requirements of ISO/IEC 17025 and are traceable to national standards of measurement.

Samples analysed as received.

NATA ACCREDITED FOR TECHNICAL COMPETENCE

ANALYTICAL SERVICES TASMANIA

Report No: 28210 **Issue No:** 1 **Report Date:** 27-Apr-2006 11:19

		Method:	2003-Soil	2202-Soil	2202-Soil
		Analyte:	pH	Nitrogen, Total *	Phosphorus, Total *
Lab.No.	Sample Id.	Sampled On		mg/kgDMB	mg-P/kgDMB
88713	Sample 2	01/04/2005	5.3	255	20
88714	Sample 3	01/04/2005	4.0	120	470
88715	Sample 4	01/04/2005	4.5	64	42
88716	Sample 6	01/04/2005	4.4	26	220
88717	Sample 7	01/04/2005	5.4	1500	53
88718	Sample 8	01/04/2005	3.6	50	390
88719	Sample 9	01/04/2005	2.9	82	690
88720	Sample 12	01/04/2005	3.0	100	940

* NATA accreditation does not cover this analyte.

ANALYTICAL SERVICES TASMANIA

Report No: 28210 **Issue No:** 1 **Report Date:** 27-Apr-2006 11:19

Test Method(s) :		**Test Date**

Inorganic Testing

2003-Soil:	pH in Soil 1:5 Soil:Water Suspension ASLS 4A1 Work Conducted at: Sandy Bay	06-Apr-2006

Authorised By:

Damien Norman
Section Head - Inorganic

Organic and Nutrient Testing

2202-Soil:	Total N & P in Soil, Sediment & Other Solids * Work Conducted at: New Town	19-Apr-2006

Authorised By:

Mike Johnson
Manager

*** NATA accreditation does not cover the performance of this service.**

Accreditation No. 5589