

REHAB2003_09

Mount Bischoff Acid Mine Drainage Remediation

Addendum to Pitt and Sherry Report



Arthur River Showing Iron –Manganese Precipitates Smothering River Bottom

January 2003

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1 Introduction

Mineral Resources Tasmania (MRT) have received funding from the Riverworks Program to undertake remediation works at Mount Bischoff.

A joint venture consisting of Pitt & Sherry and John Miedecke & Partners (JMP) has been commissioned by MRT to undertake site investigations and develop a prioritised program of works to address the acid mine drainage issue at Mount Bischoff. Mount Bischoff is located directly north of the township of Waratah and was the site of the first major mineral resource to be developed in western Tasmania.

This report is intended as an adjunct to the Pitt and Sherry main report, as insufficient time was available to incorporate the two reports into one.

As requested by the Steering Committee and Pitt and Sherry detailed remediation options were reviewed and costed. These are included as Section 6.

2 Results

2.1 Surface Workings

The surface workings of Mount Bischoff can be conveniently divided into two primary areas (Morrison 2002):

- An upper level where the workings are predominately of high heritage value and low acid producing geology.
- A lower level predominately of low heritage value and high acid producing geology.

Both these areas have undergone extensive mining activity and are significantly degraded. The landforms that remain are steep, potentially dangerous, open to the weather and have negligible vegetation.

2.1.1 Surface Water and Catchments

In general, it is evident that minimal water ponding or pooling occurs on the mine site during rainfall events. Incident rainfall ingress is basically directed into the mine through open workings and fractured ground, active subsidence being observed in several areas. Rainfall falling on the exposed face of Mount Bischoff has been observed to flow to underground workings via shaft, stopes and fractures.

There is significant potential for the capture and diversion of clean drainage away from underground workings and infiltration routes.

The upper level area – such as the Desert Face, drain to the Brown Face open pit and then underground. This probably exits via the Stanhope Adit and/or reports to deeper workings and exits via the Bischoff Extended workings.

The Slaughter Yard Face has high infiltration rates due to fractured ground and stopes.

There is also runoff from the Upper level workings which drains over the face and into stopes near the Greisen face and then underground. Some drainage continues over the Pig Flat and then to Happy Valley. There are many surface expressions which drain to underground after rain events.

The White Face and Happy Valley have many exposed pyrites which are significant acid generating sources.

North Valley Workings were heavily overgrown, however there are open stopes and collapsed adits which do intercept surface waters. A similar situation exist for the Bischoff Extended workings.

2.1.2 Waste Rock

No significant waste rock dumps were identified in the surface workings area.

There was no significant visible AD from waste dumps observed.

2.1.3 Tailings

There are no significant tailings deposits on site. Most of the tailings have been released to the Waratah River and Tinstone creek. From existing water sampling these do not constitute a significant AD source.

2.1.4 Concentrate

Two small dumps were identified. One is located directly below the old Kenworthy Mill and the other on the floor under the White Face workings.

Both dumps appear to contain significant amounts of disseminated pyrite and therefore have the potential to produce acid drainage.

2.1.5 Surface Area of Workings

The calculation of surface area and rainfall ingress support the observations that Adit 9 is the major drainage from the Bischoff Extended and Mt Bischoff workings themselves. Although there are no plans showing a connection.

2.1.6 Mineralogy and Geochemistry

The site investigation of the exposed workings confirm that the upper area contains little acid forming material. However, the exposed faces of the lower workings contain significant amounts of acid producing minerals.

Dolomite (unaltered) has some acid neutralising material but is limited and may be uneconomic to utilise.

Some clay or low permeability material suitable for encapsulation of acidic material is present on the mine site and can be used. However an external source is required. A suitable source is located near the Allen's Workings and the Don Hill Workings. Significant quantities of basalt soil, clay and weathered rock occur on privately owned land on the outskirts of Waratah.

No detailed geochemical mapping of AD sources has been done and no details of alkalinity requirements.

2.1.7 North Valley Waste Dumps

North Valley "waste" dumps are most likely totally of alluvial origin, with very minor component on tailings and transported sediment from workings on Mt Bischoff itself. As such the acid producing is expected to be insignificant. All mining has been with gravity/alluvial. Any sulphides could be expected to be recovered for retreatment during the mining process or buried deep beneath the water table as part of the alluvial dredging and earthmoving operations.

Water sampling in the Waratah River has nor revealed any major source.

The Silver Cliff and Persic mines are located in the Arthur River catchment.

2.2 Underground Workings

Mount Bischoff Mine Area

The main drainage sources and contributing to acid drainage from the site were inspected and recorded.

It appears as if the main drainage from the Brown face workings and the upper levels of the Mt Bischoff workings, which are extensive, drain via the Stanhope Adit to the north of the mountain and Websters Creek. This adit, from mine plans, was put in as a drainage adit and workings above the adit – such as the Queen workings and the brown face open pit may drain to this adit. However, flow rates were low at the time of sampling. Some drainage may also report to lower levels in the mine and ultimately to Bischoff Extended.

Websters Creek is clearly a major contamination source and has evidence of consistent flow. It has been identified as the main source of AD to the Waratah River. The main drainage was from the Stanhope Adit. There are also a number of other adits which access the Queen Workings at a higher level. This adit has difficult access and from mine plans there are a number of potential

leakage paths if it were plugged. Therefore, plugging the adit is not seen as feasible, or cost effective as it would flood only limited workings before another exit point would act as a drain.

North Valley

The North Valley workings are quite extensive and were worked until the 1940's. There are numerous adits, open stopes and drives. The drainage from the workings appears to be concentrated in only one adit which drains to the Waratah River via a pond. This dries up in summer and may not constitute a major contamination source.

It is not feasible to plug these adits.

Mount Bischoff Extended

The Bischoff Extended workings, from mine plans, were worked until 1921 approximately. The working extended from 1 to six level. The 6 level adit was a major working level with ore trammed down to the mill. It appears in good condition and may access the underground workings. The 9 level adit was constructed quite early, probably as a drainage adit and/or as an ore pass as the adit entrance was quite close to the mill site. It appears that the ore body petered out at depth as there are only limited workings on the 7 and 8 level.

Adit 9 drainage constitutes the major drainage from the entire underground workings and because of the relatively high and consistent flows is believed to drain both the Bischoff Extended and Mt Bischoff mine workings. While mine plans do not show a connection, it is thought likely that the western cross cut from the Mt Bischoff mine was driven to connect to the Extended workings some time after the Extended mine was closed in the early 1920's (it was a separate company). Tributaries may also have connected the workings later in the 1940's.

The 9 level adit was driven some 300 m before connecting with winzes from both the 5 and 6 levels connecting with the 9 level adit. The adit was driven through bedrock and geologically structurally competent materials and therefore there is potential to block the adit via a plug.

However, this will only serve to flood the adit and winzes before flowing out the 6 level adit. Mine plans indicate that there are two winzes which connect 6 and 5 levels to 9 level. These would therefore constitute the flow paths and there may be potential to block these adits if they can be accessed underground. MRT have discussed the possibility of accessing the adits and underground workings with Renison mine rescue team and a visit is scheduled for early January. If this is not feasible the only way to flood underground workings will be to plug 9 level and 6 level adits. Both are feasible as they geologically competent.

The levels above (4 and 5 adits) were located, but had collapsed. 5 Level will require investigation. Mine plans show that there were quite extensive workings near the adit entrances and that any flooding above level 5 would eventually find its way to the surface. Therefore flooding will not be feasible above the 4 level. However, this will flood significant underground workings.

It can be expected that eventually that the mine waters will eventually express themselves at the surface probably near the 5 Adit or 4 adit area. This drainage can be directed by an open channel to the Waratah River catchment via the Silver Cliff Road. Due to the limited flooding of underground workings and also as it is thought that the Mt Bischoff working drain to the Bischoff extended, only limited effects on water quality are expected.

2.3 Receiving Waters

The Silver Cliff and Persic mine drain to the Arthur River and not the Waratah(aerial photographs).

2.4 Catchment Details

The use of a simple catchment model with historic water quality would have assisted with a more accurate determination of appropriate remediation options and their effectiveness. The catchment map prepared by Pitt and Sherry provides the basis for this analysis.

2.5 Analytical Results

The laboratory did not complete pH buffering curves.

A plot of pH vs dissolved metal concentration should be developed so that the pH/ solubility can be determined.

Figure 1 shows a plot of all data from the sampling compared with the pH (laboratory).

3 Discussion

3.1 Analytical Results

Figure 1 shows the plot of pH vs metal concentration. It clearly shows that the raise in pH to approx 5 will result in significant reduction in dissolved metal concentrations. This is occurring naturally in the receiving waters and accounts for the floc deposition in the Arthur River. Buffering curves with selected water samples will determine pH adjustments and effects on dissolved metal concentrations.

3.2 Mineralogy

Geochemical mapping of acid producing zones could be done with alkalinity addition rates determined to buffer acidity.

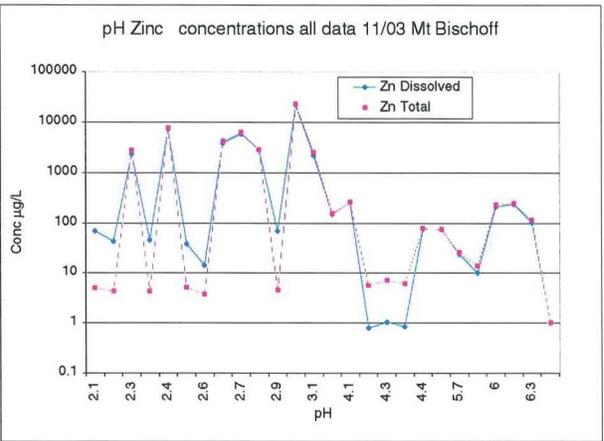
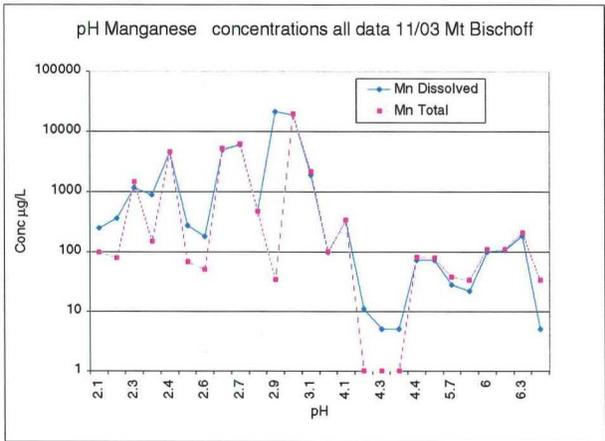
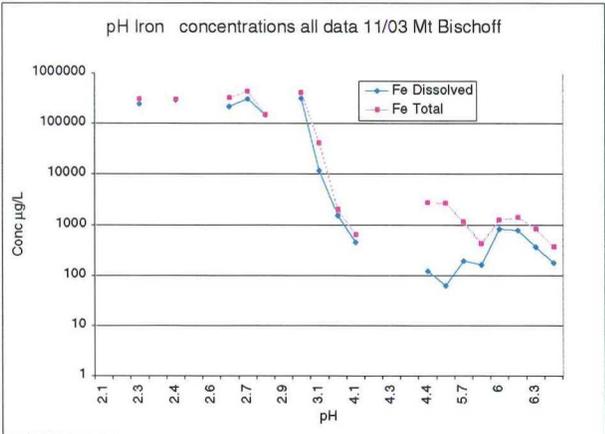
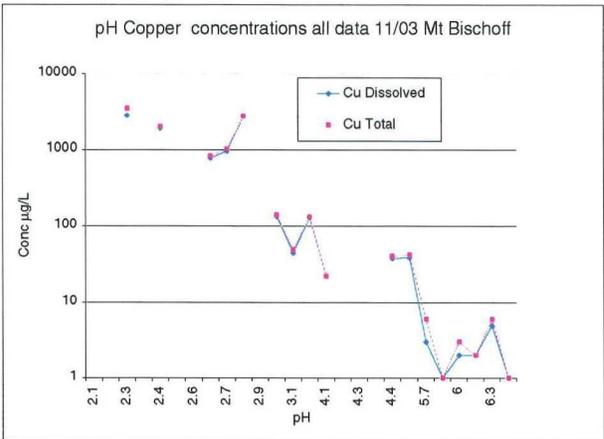
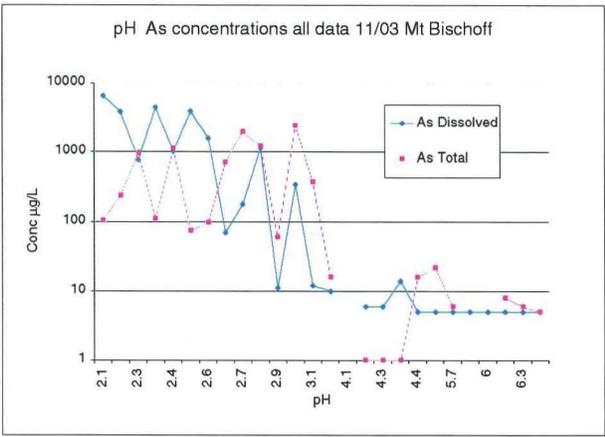
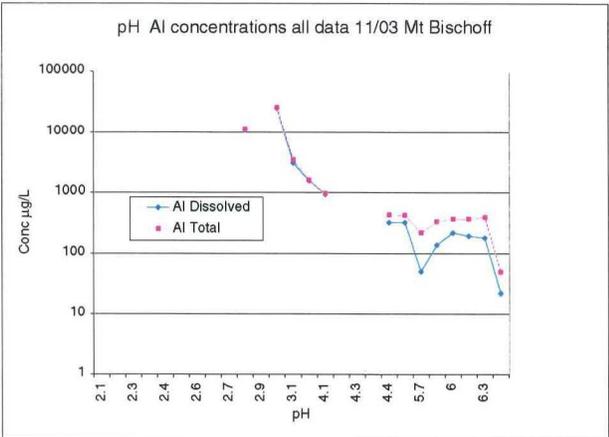
3.3 Emission Evaluation

The flow measurements and water sample analysis results were used to calculate flux emissions from various emissions as well as the mass loading into the receiving waters. The historical data reported in Miedecke 2002, could have been used in a simple catchment model to confirm/add to missing data, in particular low flows.

Acidity could have been calculated from metal concentrations.

John Miedecke Environmental and Engineering Consultants

Figure 1 pH vs Metal Concentrations 11/03

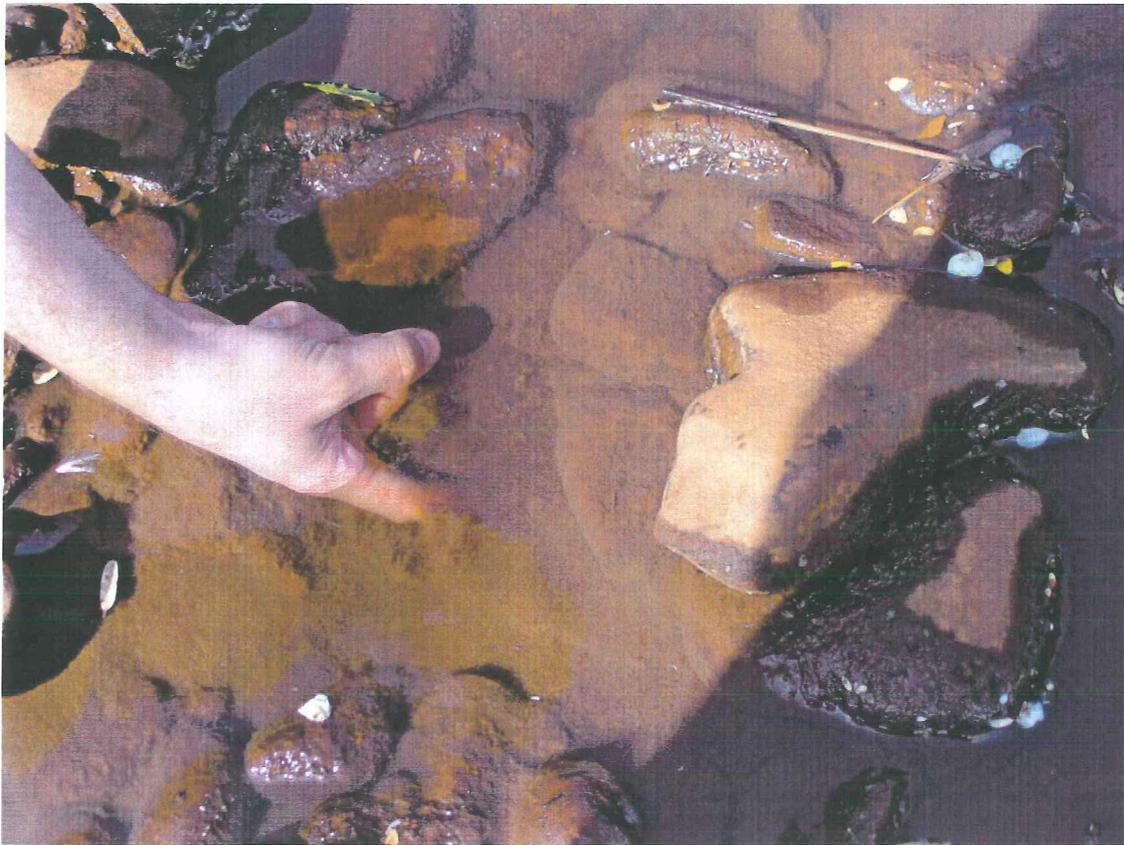


The load calculations for the major pollutants indicate that by far the major loads are Fe, Al, Mn and zinc. As, Cu etc are low. Acid flux varies with flows.

3.4 Water Analysis Comparison to PEV's

The Arthur River appears to have little dissolved organic carbon, alkalinity or water hardness to moderate toxicity.

The observation that an order of magnitude of reduction of the zinc, aluminium and copper in the Arthur River below Mount Bischoff appears necessary to achieve some biodiversity ignores the biological impacts of the high loads of iron, manganese and Al floc which are generated as the acidity is buffered and metals precipitate from solution in the river. This has been mentioned by IFS and can be readily observed (see photograph). It is probable that this is the major biological impact and is also a significant aesthetic problem (see photo on cover).



Aluminium. Iron and Manganese Precipitates in the Arthur River below Tinstone Creek.

For practical purposes using limestone and “natural” buffering, Zn will be hard to remove.

A significant amount of the zinc in the Arthur River below Mount Bischoff is originating from the Magnet mine which is located to the west of Mount Bischoff on Magnet Creek. Historic data in Miedecke 2002 demonstrates this.

The downstream impact on the Arthur River's water quality of overburden, clay and tailings (including tin) is not known however water quality data in the Arthur River (see Miedecke 2002) indicates that this is not a significant issue.

4 Potential Remediation Options

A number of feasible options are discussed below. These were discussed on site and at the project meeting and were outlined in the Inception Report.

Drainage Diversions for surface waters from ingress to U/G Workings

The Mount Bischoff workings, in particular, has areas which currently drain to the underground workings – Brown Face Greissen Face etc. A program of works to divert waters from draining to the Brown Face Pit is recommended. This will consist of a surface diversion drain diverting overland flow from the Desert face and other nearby areas to the lower workings (it is not possible to divert elsewhere due to topography). Figure 2 shows a drainage design. The Slaughter Yard Face has many areas of open fractured rock with high infiltration rates. This area can be contoured and compacted with drainage diverted to the drain over the face. A similar program is recommended for the Pig Flat, White Face, Gossan face, Allans Workings and Happy Valley in conjunction with adit, costean and depression filling.

Similar areas can be located in the North Valley workings and diversions established around open stopes and adits.

A preliminary estimate of these works is \$25,000.

Sealing / plugging of shafts

There are a number of accessible shafts located on the slopes of Mount Bischoff. They include the Stanhope Shaft and a number of others including a hexagonal ventilation shaft (which is rare). A number of these shafts are open at depth and access underground workings and stopes. Many are intercepting surface drainage and routing this underground. The Stanhope Shaft has been observed to exhaust warm air laden with sulphides in winter time.

These shafts are both dangerous and also are a route for surface infiltration and should be filled and covered. This can readily be done by filling with overburden materials won from the surrounding areas and also capped with approx 5m of clay to eliminate air and water ingress. The hexagonal timber lined shaft should be preserved.

These shafts are identified on the Ortho photo map (Plan 1 remediation geology). There are also a number of old costeans and pits which also should be filled.

The filling will be cost effective and depending on depth should cost approximately \$1000 per shaft. The Stanhope shaft could require substantial fill and may cost up to \$5000.

Sealing / plugging of adits

Adits 6 and possibly 5 should be accessed by the Renison mine rescue team and the condition assessed.

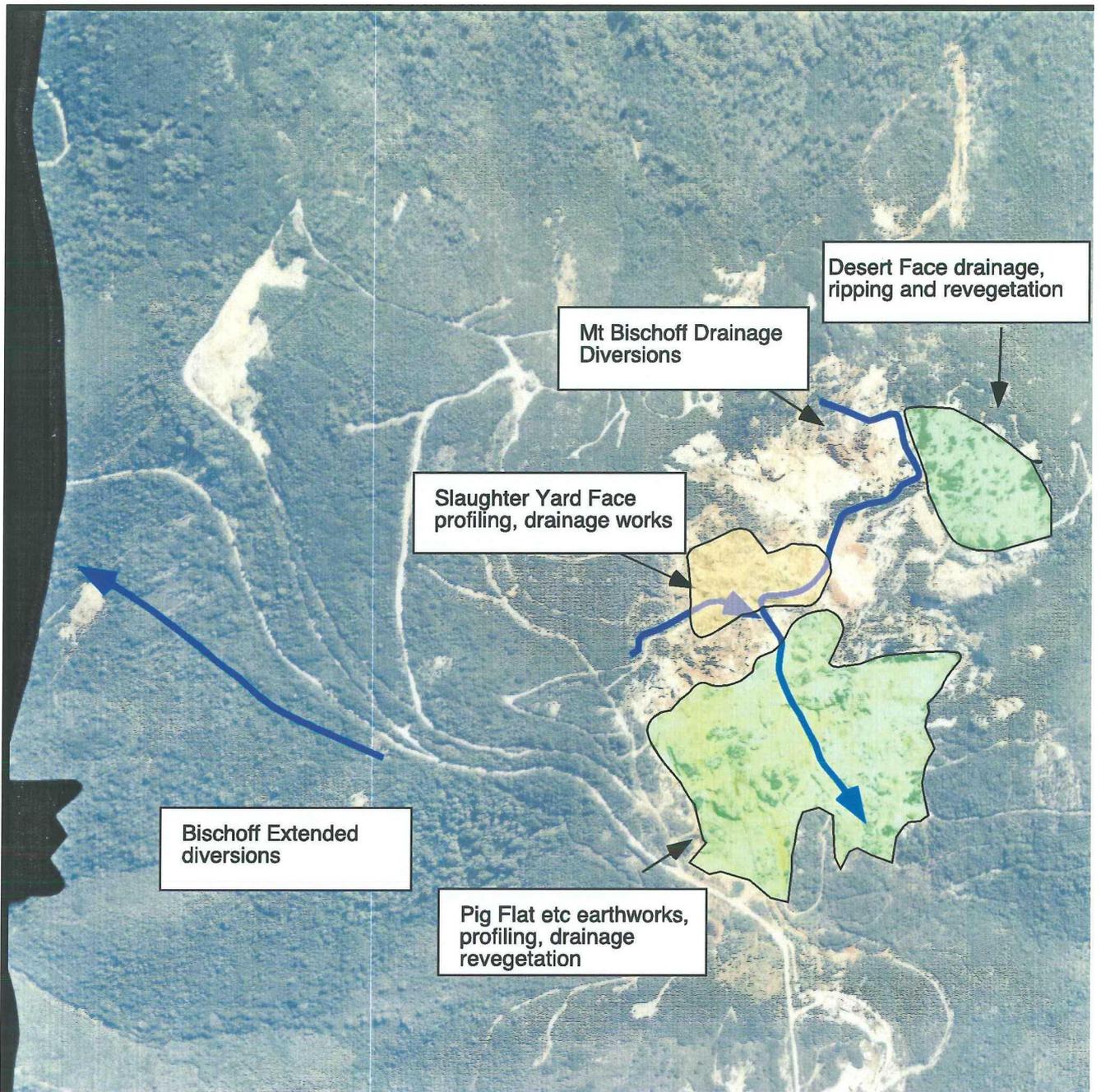


Figure 2

**Mount Bischoff Remediation
REMIEDIATION WORKS**

JMP Jan 2003

If this is not feasible the 9 level adit should be accessed via the continuation of a road from Adit 6 and the entrance cleaned out. This will require the diversion of the outflow via settling ponds further down Tinstone Creek. The adit will require cleaning out and access constructed to allow examination and plug location and design. This will probably require the drilling of a large diameter drill hole into the Adit from above to allow concrete to be placed under pressure. Similar with Adit 6.

The NE lode adits should be investigated for potential plugging although loads are not high.

No other Adit plugging is feasible or recommended

These works – including access roads, site investigations etc have not been costed in detail but may cost up to \$50,000. A plus may cost approx \$10-\$25,000 depending on location.

Passive alkalinity addition/ water treatment

The natural waters are devoid of natural alkalinity or organics and have little buffering capacity, but are slightly acidic.

The addition of alkalinity via crushed limestone addition and/or alkaline drains such as ALDS has been demonstrated to be an effective way of raising alkalinity and therefore buffering acid generation sources insitu or in receiving waters. These are recommend along all diversion lines and also in natural waters, such as Waratah River , Tinstone Creek, North Valley creeks etc.

Crushed limestone may be backloaded from Lynchford quarry at an economical rate.

No detailed costing has been made. Limestone would cost approx \$30/tonne on site.

Waste rock/ore/ concentrate encapsulation

There is no evidence that North valley Alluvial workings are contributing contaminant to Waratah River. Concentrate stockpiles and identified acid producing materials at lower levels – including exposed pyrites should be buried/covered with limestone addition. This can be done in conjunction with rehabilitation works.

Diversion of discharges to treatment

There are existing wetlands located adjacent to the Waratah River. These can be used to treat AD with the assistance of alkalinity addition. While Zn concentrations will most likely remain elevated with modest alkalinity addition the majority of the Fe and Mn will precipitate and with them the Al, Cu and As.

The diversion of the Adit 9 drainage (via Adit 6 or 5) via an open drain and the access road (with limestone addition) will remove the major pollutant source from the Arthur River to the Waratah catchment where it is more accessible and is available for passive treatment. The alternative is to divert to natural areas and treat further down Tinstone creek.

The North Valley road is ideally located to collect and divert economically the Stanhope and North Face workings. A drain can be excavated on the upper side of the road and lined with

crushed limestone. The AD can be diverted to the storage pond. Alkalinity addition can also be provided the construction of an ALD, and/ or application of limestone sands to drainage lines.

The North Valley workings and Gun Club Creek drainage can be diverted via an open drain – limestone lined, to a settlement pond constructed nearby. This will drain via the alluvial workings and sub-surface drainage to the Waratah River. Drainage lines can be limestone lined to add alkalinity.

Figure 3 shows a plan of possible diversions.

No detailed costing has been made.

Rehabilitation

The lower workings at Mt Bischoff are ideally suited to a comprehensive clean up and rehabilitation. These consist of Gossan Face, Pig Flat, White Face, Happy Valley Face and Allans Workings.

This would consist of :

- Profiling and drainage;
- Filling of shafts and depressions;
- Development of a car park;
- Fencing of Greiseen Face stopes;
- Limestone addition;
- Importation of clean clay/topsoil;
- Burial of acid producing material and rubbish; and
- Revegetation.

No detailed costing has been made.

Archaeology/ Tourism

The numerous items and sites of archaeological interest have been identified and mapped by MRT. Potential work plans should be reviewed and Areas which require protection should be identified and appropriate boundaries delineated before any site works.

Areas and items of geological, historic and general interest have been identified and the potential for tourism should be investigated.

Site works can provide access and areas for interpretation and these require implementation.

5 Recommendations

It is recommended that the above works be considered for design and evaluation.

Archaeology and tourism aspects require consideration.

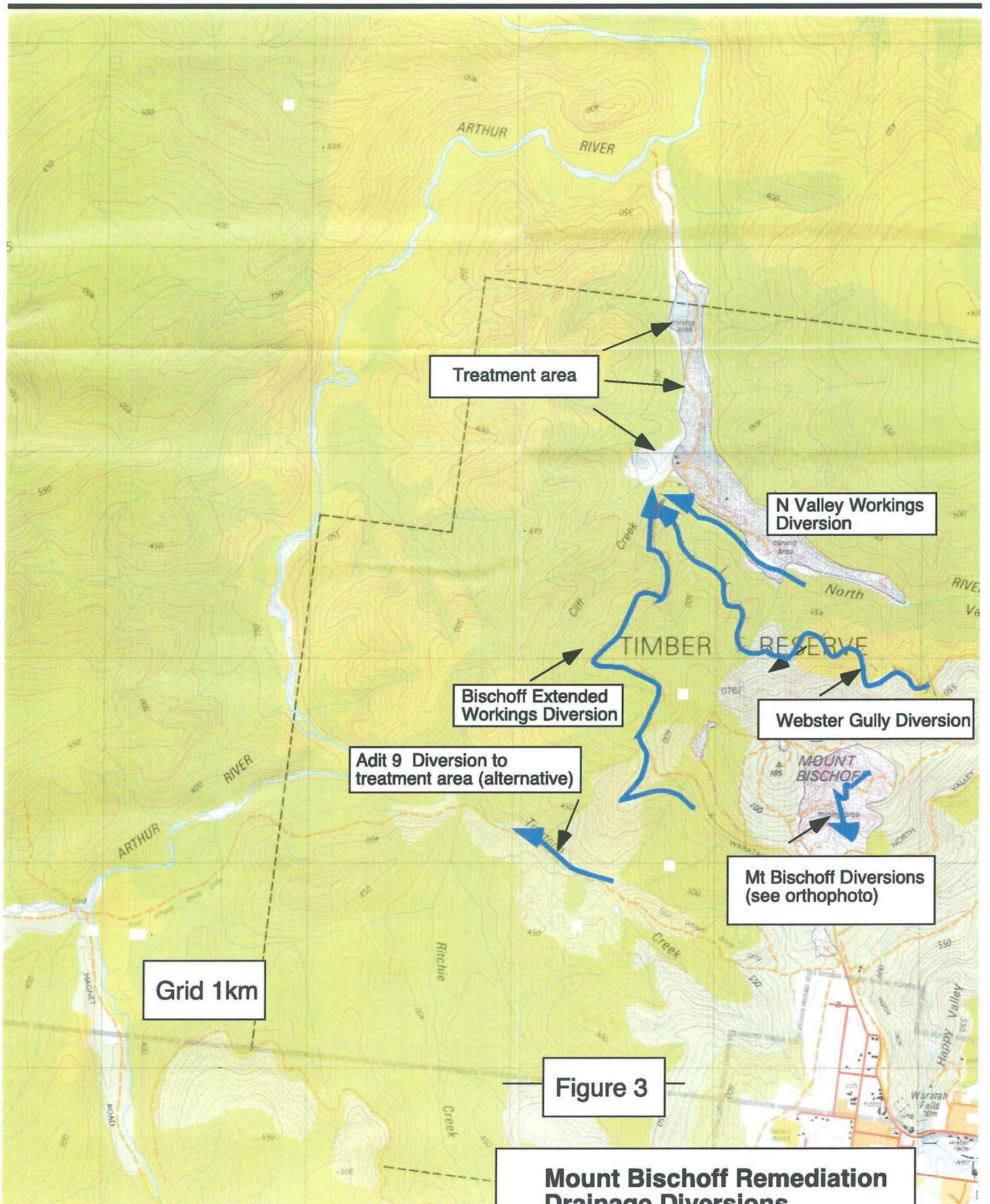


Figure 3

**Mount Bischoff Remediation
Drainage Diversions**
JMP Jan 2003

6 Costing and Review of Remediation Options

As a result of Steering Committed meeting, the following options were reviewed and costed in more detail.

Webster Creek Diversion Drain (2km)

Webster Creek is the main pollutant source to the Waratah River.

The intention is to divert drainage from Webster Creek (which includes the Stanhope , Queen and North workings) via an open drain along the existing North Valley road to the aerobic wetlands.

The drain will consist of an excavated limestone rock lined channel on the upper side of the existing road with piped culvert diversions of creeks intercepted (and currently passing under the road). Costs \$50,000

Advantages

This will remove the major Waratah River pollutant source and improve the Waratah River conditions and allow the treatment of the acid drainage.

Cost effective few technical difficulties.

Water quality improvements are expected with the acid drainage buffered by the limestone in the rock drain. It is will result in the accumulation of iron rich sludge and the effectiveness will reduce over time until periodically disturbed and cleaned out Without buffering and metal solubility curves it is not possible to quantify the improvements but a reduction in loads by approx 25-50% is expected at the drain outflow.

By transferring the AD to the Cliff Creek catchment and the wetlands will allow further treatment via additional alkalinity and collection of precipitates.

Disadvantages

To maintain drain effectiveness will require maintenance.

Will require additional alkalinity at wetlands

North Valley Adit Drainage Diversion (1km)

Open drain from the adit outflow to the west.to the Cliff Creek drainage and wetlands

Similar to Webster Creek diversion.

Cost \$30,000

Diversion of Bischoff Extended Drainage via Underground Diversions on 5 and 6 Level.

Adit 9 is the major pollutant source at Mt Bischoff.

RIVER

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Treatment area

N Valley Workings Diversion

Webster Gully Diversion

TIMBER RESERVE

Table 5.2.6

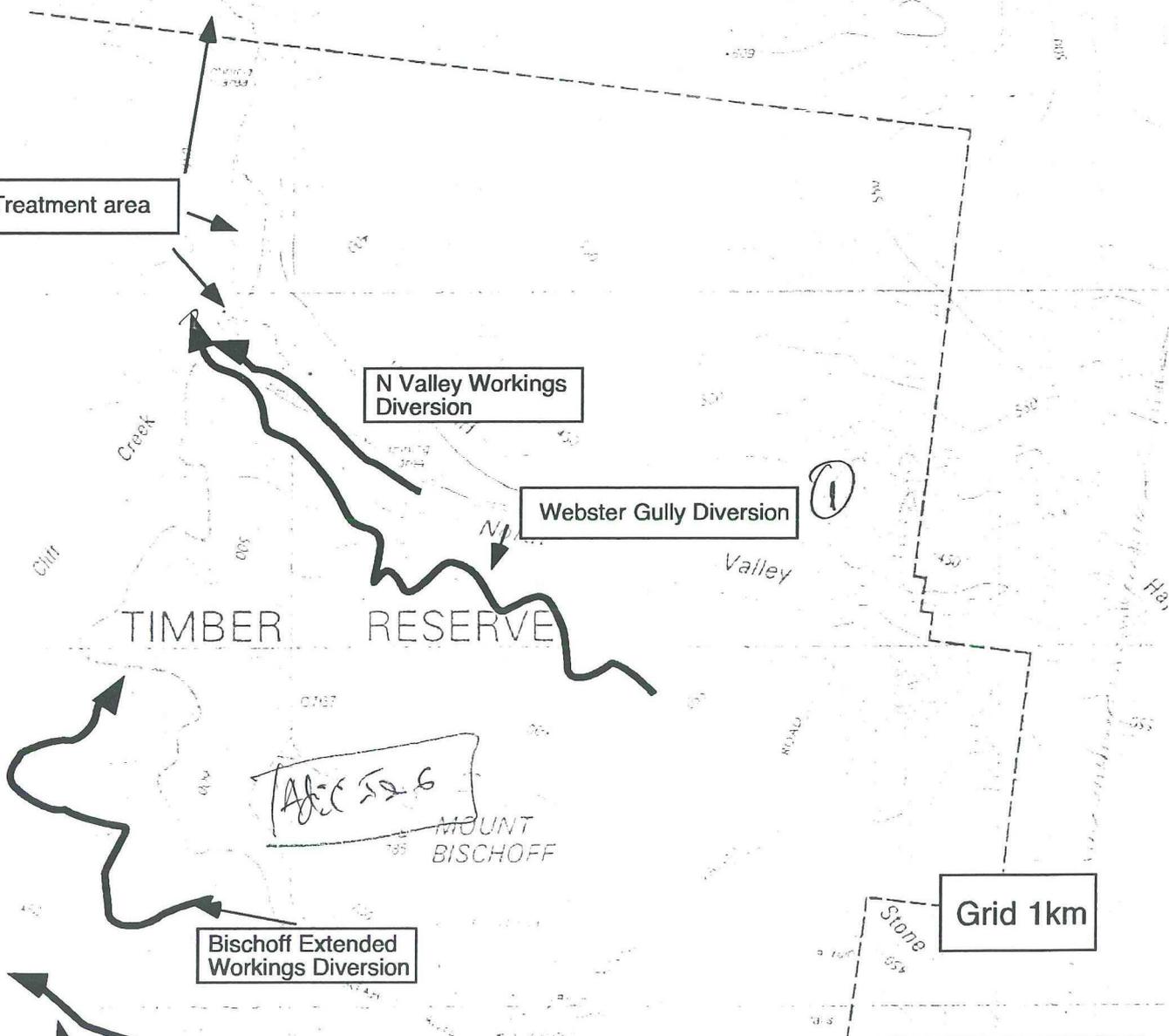
MOUNT BISCHOFF

Bischoff Extended Workings Diversion

Grid 1km

Adit 9 Diversion to treatment area (alternative)

Mount Bischoff Remediation Drainage Diversions
JMP Jan 2003



The intention is to divert drainage from the upper levels reaching 9 Level and reduce the loads to Tinstone Creek.

This would involve the accessing of 5 and 6 level (via 6 Level Adit initially). Assuming access is available the works would consist of the concrete bunding of the winzes (or only one if accessible) which drain to 9 Level Adit at both 5 and 6 level adits.

Cost estimates (assuming good access) is approx \$9000

Advantages

It would then redirect the Adit 9 drainage out of Adit 6 portal and be available for collection/treatment (via drainage to Cliff Creek and wetlands).

Would result in the same effect as plugging Adit 9 at much less cost and disturbance and remove the major source from Tinstone creek. and improvements to Arthur River water quality above Waratah River.

Disadvantage

It will not result in any net water quality improvements (unless Adit 6 plugged)

Feasibility uncertain until workings accessed.

Adits 516 Drainage Diversion to Cliff Creek (1km) Open drain from the adit outflow to the west to the Cliff Creek drainage and wetlands to transfer the Adit 9 drainage to Cliff Creek Catchment.

Similar to Webster Creek diversion.

Cost \$34,000

Alkalinity Addition To Cliff Creek

Cliff Creek is uncontaminated and the addition of limestone will only raise alkalinity to saturation therefore low concentrations expected. If it received Adit 5/6 drainage will provide treatment for this source.

Additional of alkalinity via limestone sands placed in the creek is expected to generate approx 10mg/1 alkalinity (based on Storys Creek experience) in the creek flows. This will provide a long term alkalinity source. This could include the roadway May be possible to construct ALD to generate higher concentrations. The construction of an ALD could add up to 100mg/1 in the outflow.

Costs

The addition of approx 1000 tonnes of limestone sands would cost approx \$35,000.

ALD trial \$ 10,000

1000 Tonne ALD \$70,000

Advantages

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Cheap and cost effective

Will add alkalinity to natural waters and inflows to wetlands and provide buffering of acid inputs from Websters etc. Long term effectiveness with gradual dissolution.

ALD performance would require trials.

Disadvantages

Alkalinity Addition To Tinstone Creek

Additional of alkalinity via limestone sands placed in the creek is expected to be effective in raising the pH and precipitating AD from Adit 9. It would consist of the placement of 1000 tonnes of sands to Tinstone Creek directly above and below the confluence with Adit 9 inflow and also at Adit 6 creek.

Water quality improvements are expected with the acid drainage buffered by the limestone. This will result in the accumulation of iron rich sludge but the active reworking in high flow periods would retain effectiveness

Without buffering and metal solubility curves it is not possible to quantify the improvements but a reduction in loads by approx 25-50% is expected at the outflow to Arthur River.

With redirection to an old alluvial mining area, it will be possible to collect most of the precipitates.

Based on 112 t day of limestone consumption will provide 5-6 years supply.

Costs

The addition of approx 1000 tonnes of limestone sands would cost approx \$50,0000.

Includes creek redirection.

Advantages

Cheap and cost effective. Could be short term solution while Adit 9 is investigated.

Will add alkalinity to contaminated waters and provide buffering of acid inputs from Adit 9. Medium term effectiveness with gradual dissolution.. Will require periodic addition. Will improve Arthur R water quality.

Disadvantages

Difficult summer only access. Requires rehandle and transport of sands. Will require periodic addition. Some precipitates and poor water quality likely to still flow to Arthur River unless collected in wetlands.