TWEED SHIRE COUNCIL

Acid Rock Drainage Management Plan

Kinnears Quarry

Version 2 July 2011

TWEED SHIRE COUNCIL | TOGETHER FORWARD

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Table of Contents

Table of Contents

1.0 Introduction

Tweed Shire Council (TSC) owns a quarry site (Kinnears Quarry) located on Harry's Road off Numinbah Road at North Arm, approximately 6km west of Murwillumbah. Development of the quarry has resulted in acid rock drainage (ARD) from water flowing from the site into an adjacent creek.

Council has commissioned two reports to assess the causes and extent of the ARD, and recommending remedial treatment options:

Report on Acid Rock Drainage (ARD) Investigations and Remedial Solutions – ECOROC Pty Ltd

Kinnears Quarry Acid Rock Drainage – Groundwater Assessment – Australasian Groundwater & Environmental Consultants Pty Ltd

In February 2011 the Department of Environment and Climate Change and Water (DECCW) issued a Prevention Notice to TSC requiring Council to develop an ARD Management Plan (ARDMP) for Kinnears Quarry. This document is presented in response to that Prevention Notice.

2.0 Background

Kinnears Quarry is one of three (3) adjacent hard rock quarries (the other two being Singh's and Sandercock's) established in the western flank of a steep, heavily wooded ridge, formed in deeply incised terrain of hard, resistant rocks of the Neranleigh Fernvale Beds. The quarries are located at Harrys Road, off the North-Arm Numinbah Road, approximately 6km west of Murwillumbah. See Figures 1 and 2 for location details.

Aerial photography shows that Kinners Quarry was operational pre- 1970. See Figure 3. Tweed Shire Council (TSC) purchased the land (now Lot 1 DP 1004207) that contains Kinnears Quarry in 1991 and continued extraction until 2006.

Kinnears quarry has been worked as a typical hillside quarry commencing from Harry's Road (~RL 24m AHD) and gradually working back (east) into the slope and upwards with a series of four (4) faces and benches. See Figure 4. Within benches (and faces) 2 and 3, a narrow 5-8m wide bed or lens of naturally occurring pyrite-rich, graphitic shale is exposed and is generating low pH surface and groundwater. For a cross section of the quarry refer to Figure 5. During and after rainfall events, the impacted acid rock drainage (ARD) from the site eventually flows into the adjacent unnamed creek located along the site's western boundary (hereafter referred to as Site Creek).

2.1 Acid Rock Drainage (ARD) Investigation

In March 2009 the Department of Environment and Climate Change (DECC) issued a Prevention Notice to TSC requiring investigation of the ARD (Appendix A).

In response to this Prevention Notice TSC engaged Ecoroc Pty Ltd (Ecoroc) to undertake an initial appraisal of the likely cause of the ARD condition and provide advice on what investigations and remedial treatment options are available to address the problem at the site. Their report was presented in July 2009 –

Report on Acid Rock Drainage (ARD) Investigations and Remedial Solutions – ECOROC Pty Ltd July 2009.

Appendix 1 of the Ecoroc report contains a Geological Assessment and Quarry Development Report prepared by Geobas Consulting Pty Ltd that provides a detailed description of the site geology.

2.2 Groundwater Investigation

In September 2009 the Department of Environment and Climate Change and Water (DECCW) issued a Prevention Notice to TSC requiring the construction of some of the ARD controls recommended in the Ecoroc report, and the investigation of groundwater at the site (Appendix B).

In response to this Prevention Notice TSC engaged Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) to undertake a hydrogeological investigation of the groundwater regime within the site including installation of a groundwater borehole network and monitoring of groundwater chemistry. AGE presented their report in October 2010 -

> *Kinnears Quarry Acid Rock Drainage – Groundwater Assessment – Australasian Groundwater & Environmental Consultants Pty Ltd – October 2010*

2.3 Acid Rock Drainage Management Plan

In February 2011 the Department of Environment, Climate Change and Water (DECCW) issued a Prevention Notice to TSC requiring Council to develop an Acid Rock Drainage (ARD) Management Plan for Kinnear's Quarry (Appendix C).

This document is presented in response to that Prevention Notice.

In summary, the ARD contaminated water produced at the site will be contained and collected in ponds. The collected ARD water will be neutralised by treatment with hydrated lime. After the treated water has stabilised chemically and the solids produced have settled, the treated water will be tested to ensure compliance with licence conditions before discharge into Site Creek or used for site irrigation for revegetation. The accumulated solids will be dried on site before transport to landfill disposal.

The areas of the site not occupied by water treatment and access facilities will be rehabilitated by revegetation.

FIGURE 1

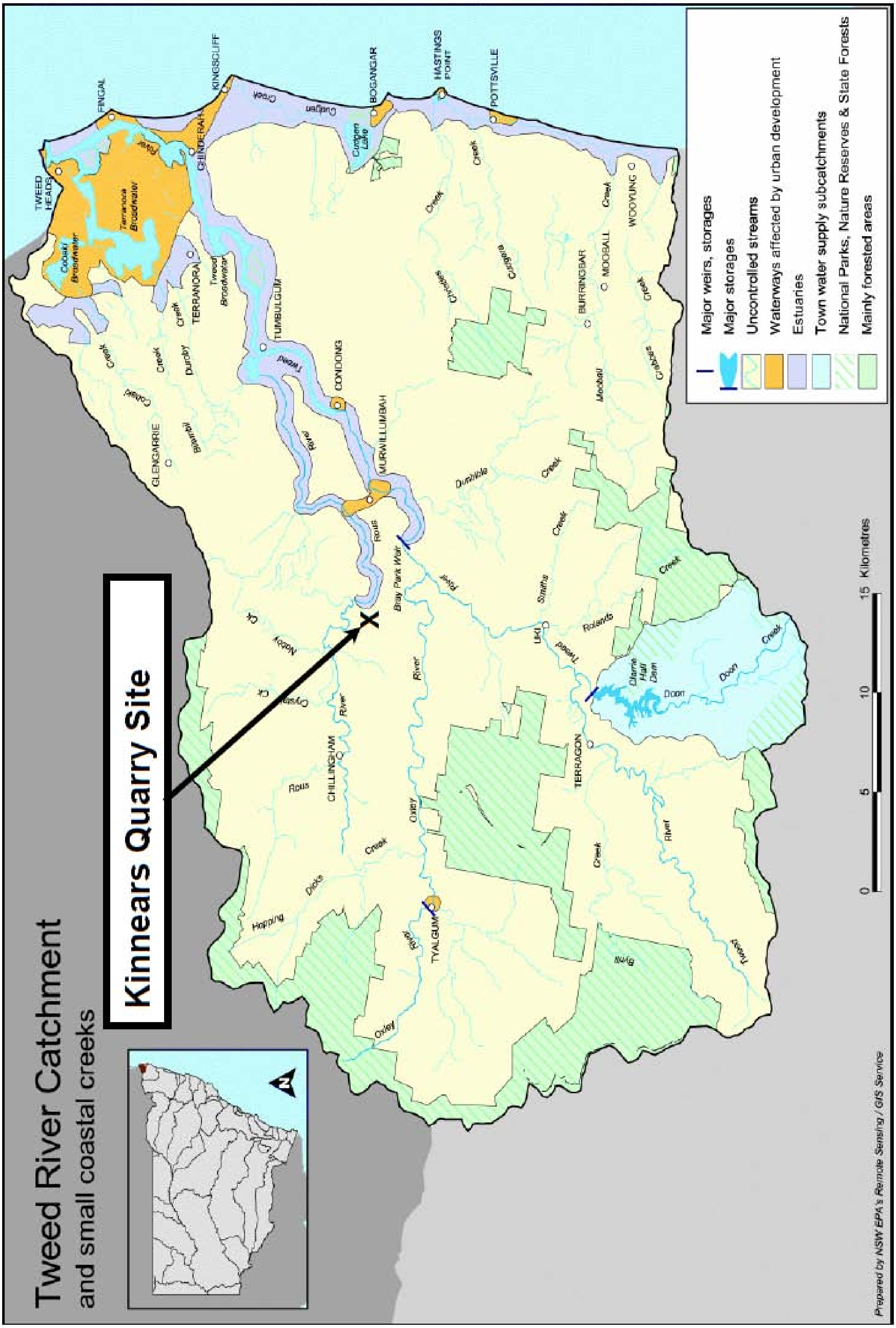

Tweed River Catchment
and small coastal creeks
Kinnears Quarry Site
Major weirs, storages
Major storages
Uncontrolled streams
Waterways affected by urban development
Estuaries
Town water supply subcatchments
National Parks, Nature Reserves & State Forests
Mainly forested areas
0 5 10 15 Kilometres
TWEED HEADS
FINGAL
KINGSCLIFF
CHINDERAH
BOGANGAR
HASTINGS POINT
POTTSVILLE
WOOYUNG
MOOBALL
BURRINGBAR
TERRANORA
TUMBULGUM
CONDONG
MURWILLUMBAH
GLENGARRIE
CHILLINGHAM
TYALGUM
TERRAGON
UKI
Clarrie Hall Dam
Bray Park Weir
Prepared by NSW EPA's Remote Sensing / GIS Service

FIGURE 2


- LEGEND -
Monitoring Bore
Abandoned Drillhole
Surface Water Sampling Site
Un-named Creek
Property Boundaries
Cross Section Line
AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
36 JEAYS STREET BOWEN HILLS QLD 4006 AUSTRALIA
TITLE: KINNEARS QUARRY
ACID ROCK DRAINAGE GROUNDWATER ASSESSMENT
SITE LAYOUT SHOWING MONITORING LOCATIONS
CLIENT: Tweed Shire Council
OFFICE: Brisbane
DRAWN BY: CJ
SCALE: 1:3,000 (A4)
PROJECT No: G1495
DRAWING No: 1
APPROVED BY:
DATE: October 2010
Singh Quarry
Kinnears Quarry
Sandercock Quarry
Harrys Road
MB1
MB2
MB3B
MB3A
MB4
KIN3
KIN4
A
B
N
E
S
W
0
50
100
meters

FIGURE 3


1970 Aerial Photo
\\tweed1\dfs\GIS_Imagery\Historic_Aerial_Photos\1970aerials\1970_run1_1645_5104-1.jpg - Windows Internet Explorer

FIGURE 4

FIGURE 5

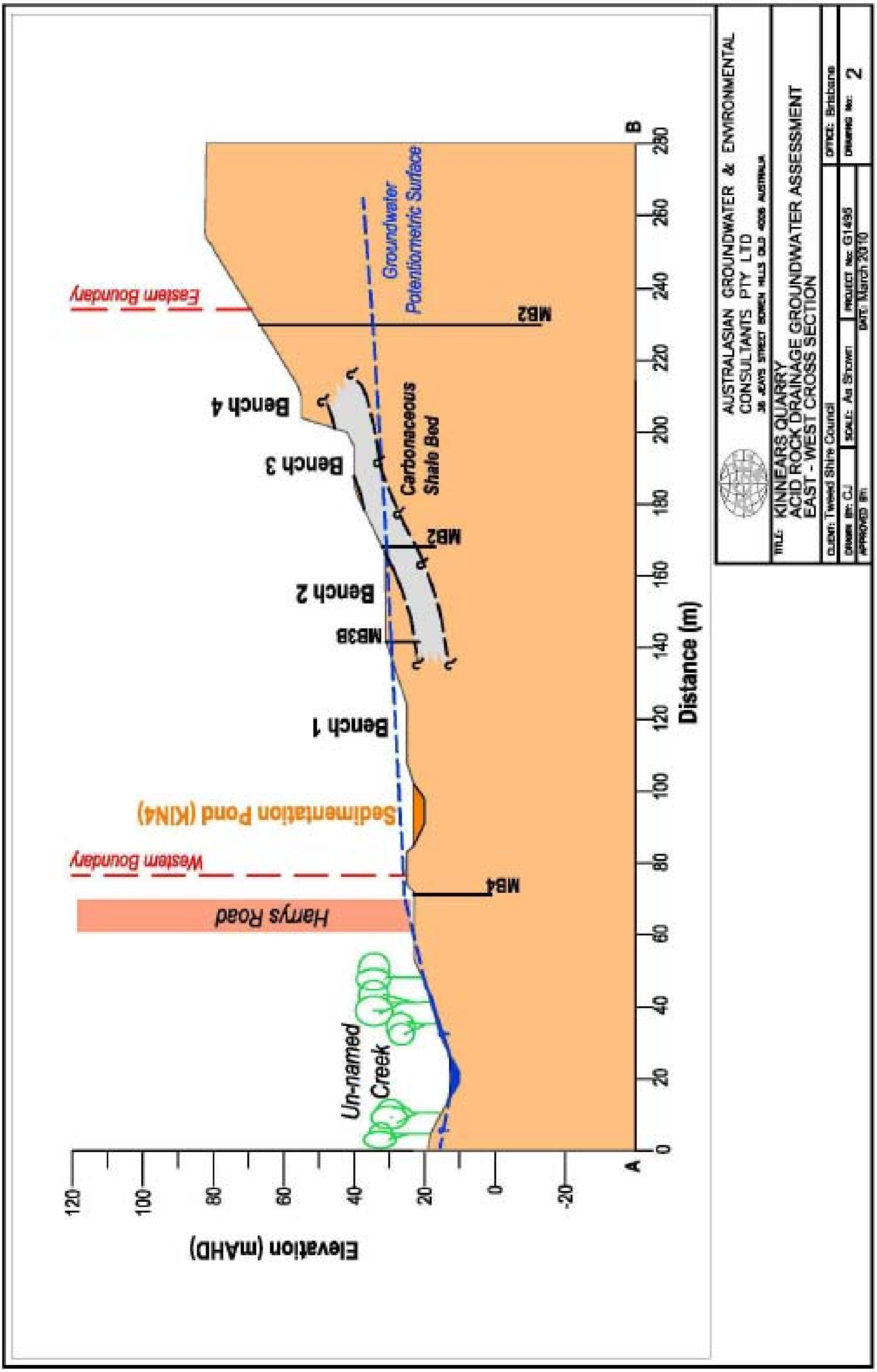
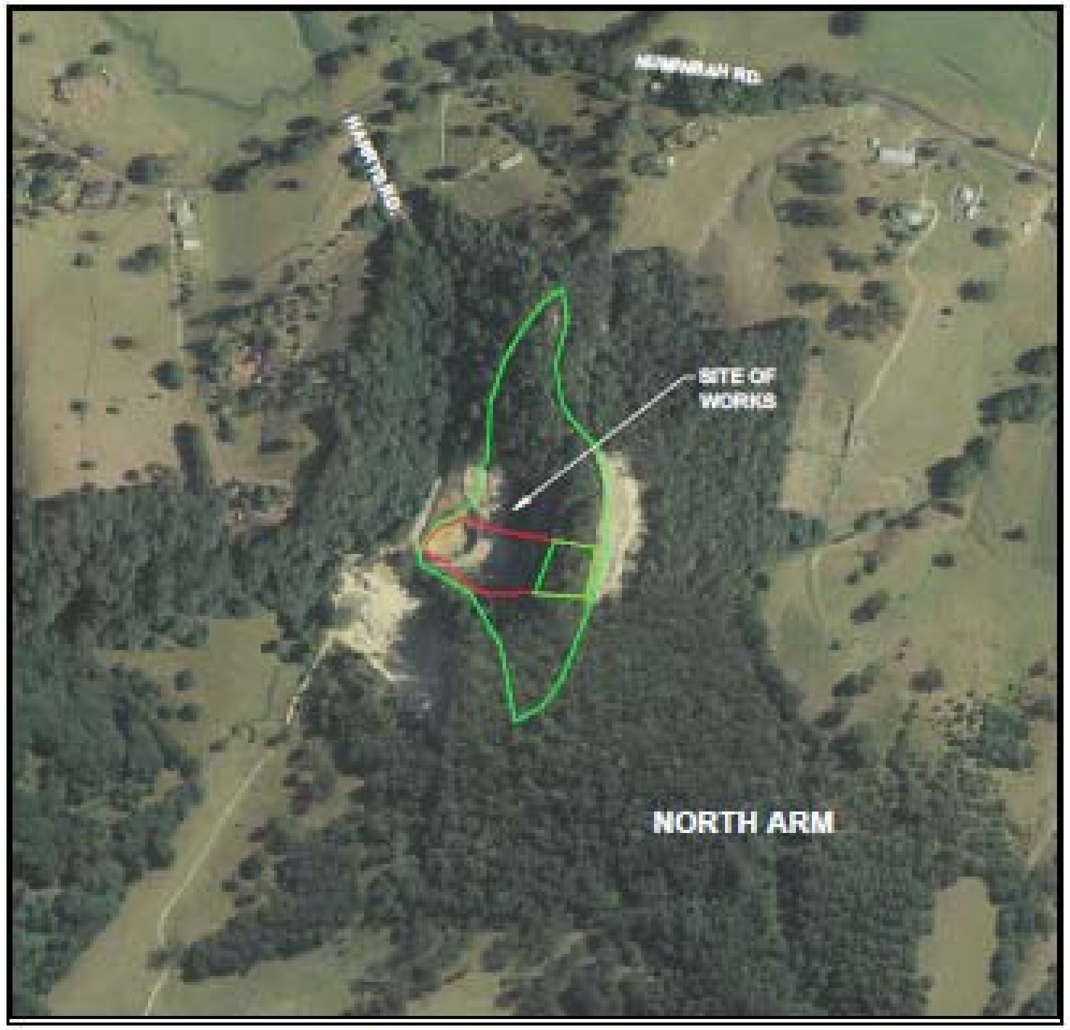

Elevation (mAHD)
Distance (m)
A
B
Un-named Creek
Harry's Road
Western Boundary
MB4
Sedimentation Pond (KIN4)
Bench 1
MB3B
Bench 2
MB2
Bench 3
Carbonaceous Shale Bed
Bench 4
Groundwater Potentiometric Surface
Eastern Boundary
AUSTRALASIAN GROUNDWATER & ENVIRONMENTAL CONSULTANTS PTY LTD
TITLE: KINNEARS QUARRY ACID ROCK DRAINAGE GROUNDWATER ASSESSMENT EAST - WEST CROSS SECTION
CLIENT: Tweed Shire Council
OFFICE: Brisbane
DRAWN BY: CJ
SCALE: As Shown
PROJECT No: G1495
DRAWING No: 2
DATE: March 2010

FiGURE 6 – DRAWING 1

KINNEARS QUARRY
ACID ROCK DRAINAGE REMEDIATION

TWEED SHIRE COUNCIL



APPROVALS
ON BEHALF OF COUNCIL

PROJECT MANAGER	PROJECT CLIENT	DESIGN MANAGER
DATE:	DATE:	DATE:

INDEX

DESCRIPTION	SHEET	ISSUE
INDEX & LOCALITY SKETCH	1	B
OVERALL SITE PLAN & EXISTING STORAGE POND VOLUMES	2	B
PROPOSED WORKS PLAN	3	B
PROPOSED WORKS TYPICAL SECTIONS	4	A

DESIGNED BY: W.Boyd / I.Kite
DRAWINGS BY: M.Cullen
SURVEY BY: T.S.C.
DATE: June 2011

SHEET 1 OF 4

WK09031/01

FIGURE 6 – DRAWING 2

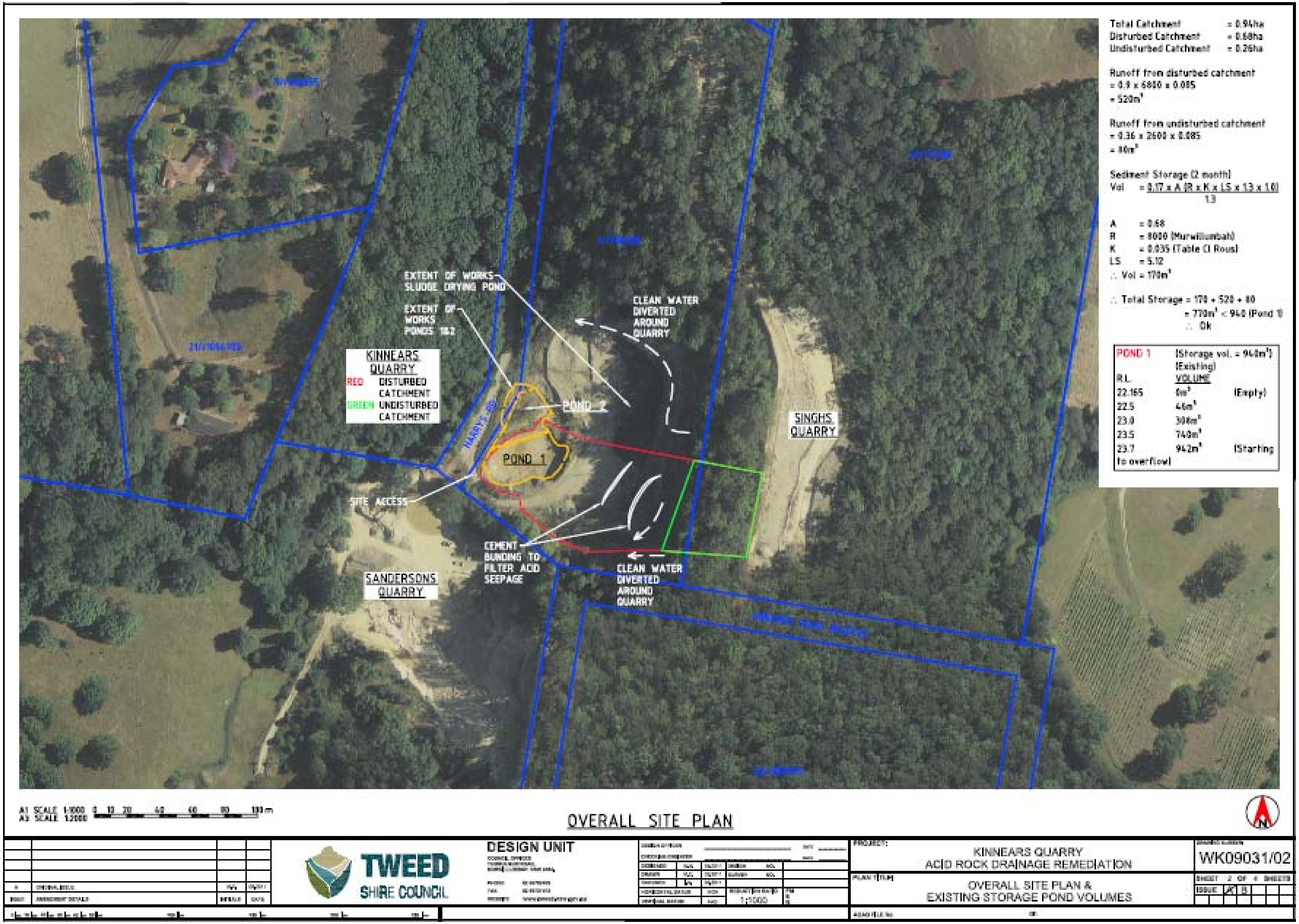


FIGURE 6 - DRAWING 3

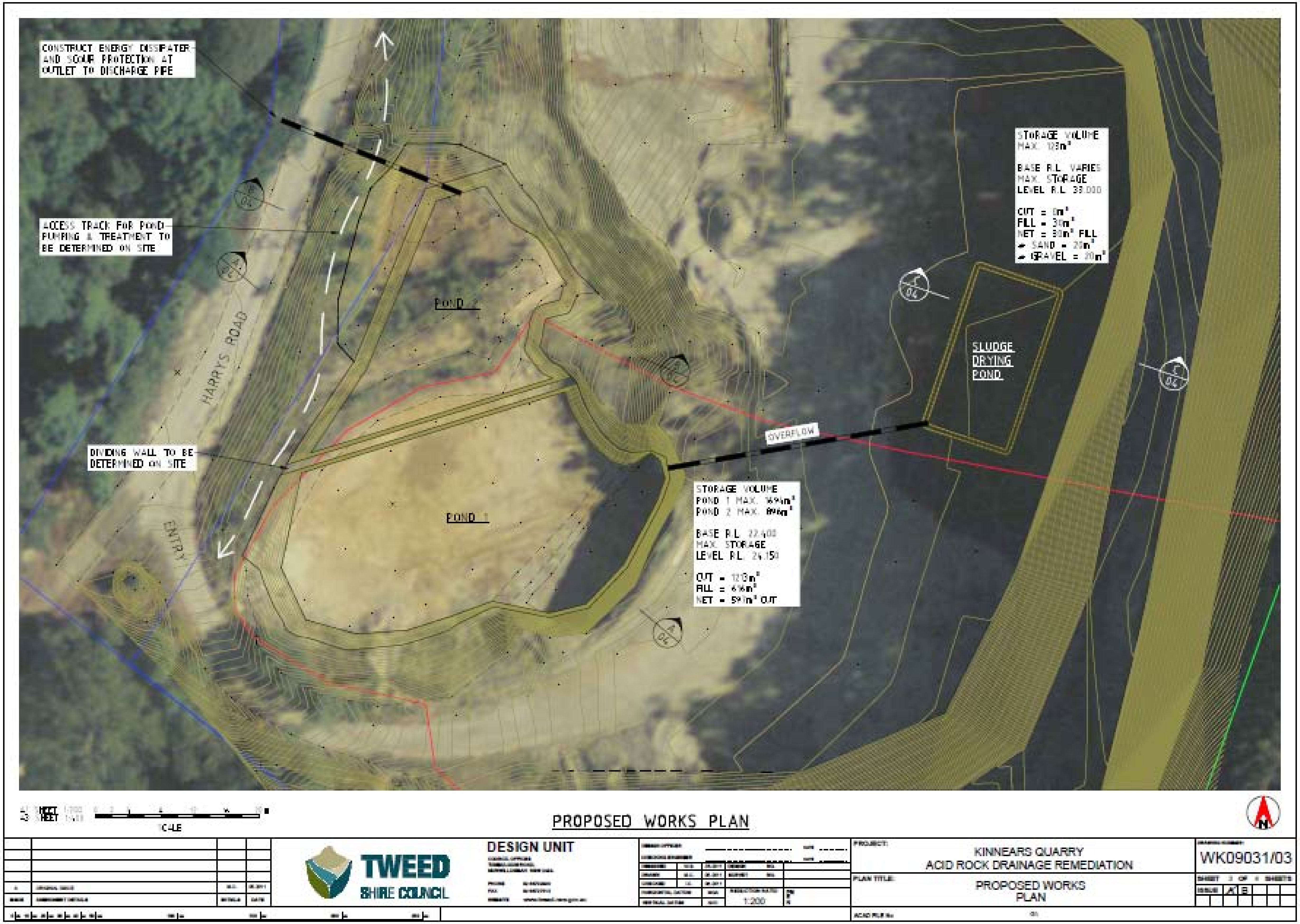
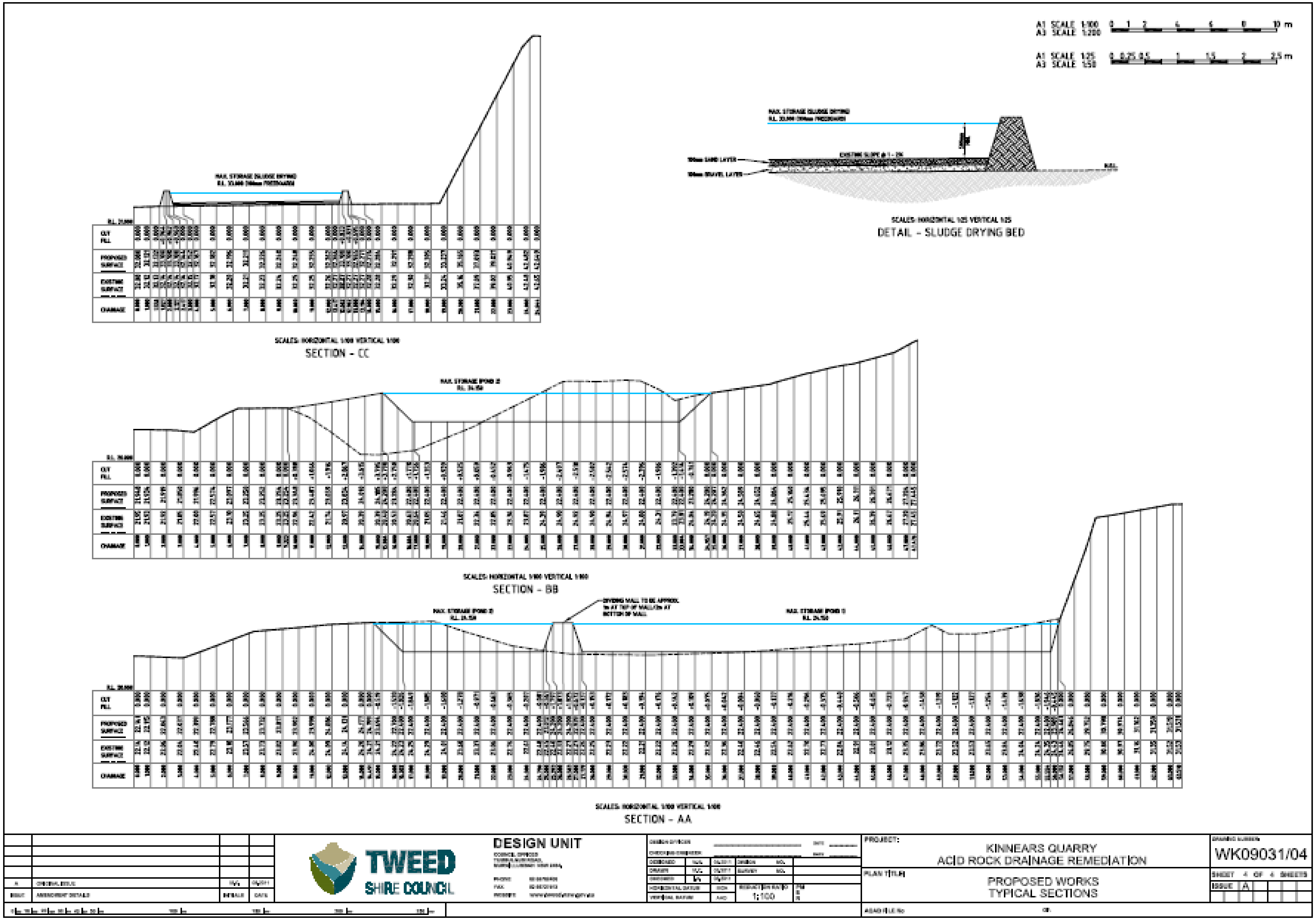


FIGURE 6 - DRAWING 4



3.0 Catchment Analysis

3.1 Diversion of uncontaminated runoff

The diversion of uncontaminated stormwater runoff around the existing sediment ponds was a condition of the Prevention Notice dated 29 September 2009. This work was completed by December 2009. Monitoring and observation during severe rainfall events has confirmed that these diversion works are functioning as intended. The catchment boundaries created by the diversions are shown on Figure 6 – Drawing 2 - No. WK09031/02.

The catchment and runoff calculations for the sizing of the contaminated water treatment/holding ponds for this ARD Management Plan have been based on this landform.

3.2 Diversion of Flows from Borehole BH4

As part of the groundwater study conducted by AGE, four boreholes were drilled to allow sampling of groundwater. (See Figure 2 for location)

It was found that the water table in borehole BH4 was above ground level, with the level dependent on recent rainfall history. As part of the ARD management for the site, borehole BH4 will be piped to discharge into the water treatment ponds.

3.3 Sizing of water treatment pond, (WTP)

As per the requirements of the Prevention Notice dated 24 February 2011 clause 1(a)i the water treatment/holding ponds have been designed to capture 85mm of rain with an allowance for seepage and inflow from monitoring bore MB4. The details of the catchment calculations are shown on Figure 6- Drawing 2 - No. WK09031/02.

Volume of collected water from 85mm rain event	520 m^3
Volume of Pond 1	1,694 m^3
Freeboard, seepage and sludge storage	1,174 m^3
Volume of Pond 2	896 m^3

When rain events in excess of the design intensity/duration (85mm over 5 days) occur the excess water will initially be stored in Pond 1 using the available freeboard capacity. When this freeboard capacity is exceeded the water will overtop the spillway into Pond 2. The available storage in Pond 2 will depend on the current treatment cycle (refer to 4.1 below for details). When the available capacity in Pond 2 is consumed by the inflowing stormwater it will overflow via the existing culvert under Harrys Road into Site Creek at the nominated discharge point. The process of successive overflows through Pond 1 and Pond 2 provides the greatest opportunity for initially storage of flows and then dilution of contaminated water before it is released into the Creek. Any water retained in both Pond 1 and Pond 2 after such an event will be tested and treated as per Section 4 below.

3.4 Lining of Water Treatment/Holding Ponds

The water treatment/holding Ponds 1 and 2 will be excavated to a hard base free of loose material and then lined with high durability reinforced shotcrete. The area of Pond 2 that is below the finished surface level (refer Figure 6 - Drawing 4 - No. WK09031/04) will be filled with compacted material prior to shotcrete surfacing.

4.0 Water Treatment

4.1 Treatment Regime

The collected contaminated water will be batch treated. After each rainfall event or when the water in Pond 1 has reached its design level (excluding freeboard allowance) the water will be chemically dosed in accordance with the dosage calculations for the water volume and pH (see 4.2 below). After allowing time for floc formation, sludge settlement and confirmation pH testing the water will be transferred to Pond 2 by pump, leaving Pond 1 ready to receive fresh inflow.

The treated water stored in Pond 2 will be regularly tested after transfer. When the water quality has stabilised and meets the release criteria it will be either used for irrigation of the revegetation plantings or pumped into Site Creek at the nominated discharge point.

4.2 Materials and Dosage Rate

Hydrated lime will be used as the neutralising agent.

The dosage rate to bring 100m^3 of contaminated water from the existing pH to pH7 is given in the following table.

Existing pH	Kg of Hydrated Lime per 100m^3 of Water
1.0	370
1.5	120
2.0	37
2.5	12
3.0	4
3.5	1.2
4.0	0.4
4.5	0.1
5.0	0.04
5.5	0.01
6.0	0.004
6.5	0.001

After the Ponds 1 and 2 have been constructed the water volume for various water depths will be calculated and a new table prepared giving the dosage for each pond for the various water levels. This will minimise the risk of miscalculation of dosage.

4.3 Equipment

The treatment of the contaminated water will be performed using a trailer mounted portable dosing plant. The plant consists of a 1,000 litre chemical mixing tank, chemical mixing/recirculating pump, and a pond water pump with a venturi orifice in the pressure outlet hose. The pumps are powered by integral petrol motors.

The dosing process involves filling the chemical mixing tank with water, starting the chemical mixing/recirculating pump, then gradually adding the calculated quantity of chemical to the tank. When the chemical is sufficiently dissolved the pond water pump is connected to the intake from the pond and started. The water is drawn from the pond and sprayed back onto the surface of the pond to provide aeration and increase the dissolved oxygen as an aid to flocculation. As the water is sprayed back into the pond the mixed chemical is gradually introduced via the venturi orifice. The process is continued until the mixed chemical is all dispersed into the pond water.

4.4 Storage of Materials

All materials (chemical, fuel) required for the treatment process are brought to the site on the day of treatment in a utility vehicle. There is no storage of materials on site.

4.5 Stabilisation and Release of Treated Water

Industry experience has indicated that it is possible for neutralised acid drainage water to have secondary chemical reactions after the initial neutralisation treatment. These secondary reactions can result in the treated water quality falling outside of discharge criteria after a short period. To allow for these secondary reactions and allow time to undertake any additional treatment that becomes necessary, the treated water from Pond 1 will be transferred and held in Pond 2 until the reactions have stabilised. When the discharge water quality criteria set down in the Prevention Notice have been met the treated water will be either used for irrigation of the revegetation plantings or discharged by pumping into Site Creek at the nominated discharge point.

4.6 Nominated Discharge Point

The Nominated Discharge Point from Pond 2 into Site Creek is the outlet from the existing culvert under Harry's Road. Its coordinates are:

- 532920 E (MGA)
- 6867080 N

At the outlet of the culvert an energy dissipater and scour protection will be constructed to prevent erosion of the creek bank.

4.7 Testing

4.7.1 During Dosing Process

Prior to dosing of the pond water its pH will be measured with a hand held multiprobe meter. The pH value obtained will be an input into the dosage calculation.

At regular intervals during the dosing process the pH will be measured to monitor the effectiveness of the treatment. The dosage will be adjusted during the final stages to achieve a pH towards the top of the desired pH range of the treated water (6.0 – 8.0).

4.7.2 After Dosing

The pH of the treated pond will be measured by hand held multiprobe meter daily after treatment. The water will also be tested for clarity to indicate the degree of flocculation and settlement. When the treated water has stabilised and settled it will be pumped from the upper surface of Pond 1 into Pond 2.

4.7.3 During Stabilisation

After discharge into Pond 2 the water will be tested daily by hand held multiprobe meter until its pH, dissolved oxygen, and clarity has stabilised. At that time a sample will be taken to the Tweed Laboratories for testing to confirm it meets the quality criteria set down in the Prevention Notice before discharge via irrigation of the revegetation plantings or pumping into Site Creek at the nominated discharge point.

4.8 Sludge Handling

The neutralisation of the contaminated water will cause the precipitation of metal hydroxides, which will form in the water as floc before settling out. These reactions are described by Skousen, Hilton and Faulkner [1]

> ***Metal Precipitation and pH***
>
> *Enough alkalinity must be added to raise water pH and supply hydroxides (OH^-) so dissolved metals in the water will form insoluble metal hydroxides and settle out of the water. The pH required to precipitate most metals from water ranges from pH 6 to 9 (except ferric iron which precipitates at about pH 3.5). The types and amounts of metals in the water therefore heavily influence the selection of an AMD treatment system. Ferrous iron converts to a solid bluish-green ferrous hydroxide at pH >8.5. In the presence of oxygen, ferrous iron oxidizes to ferric iron, and ferric hydroxide forms a yellowish-orange solid (commonly called yellow boy), which precipitates at pH >3.5. In oxygen-poor AMD where iron is primarily in the ferrous form, enough alkalinity must be added to raise the solution pH to 8.5 before ferrous hydroxide precipitates. A more efficient way of treating high ferrous AMD is to first aerate the water (also outgassing CO_2), causing the iron to convert from ferrous to ferric, and then adding a neutralizing chemical to raise the pH to 6 or 7 to form ferric hydroxide. Aeration after chemical addition is also beneficial. Aeration before and after treatment usually reduces the amount of neutralizing reagent necessary to precipitate iron from AMD. Aluminum (Al) hydroxide generally precipitates at pH > 5.0 but also enters solution again at a pH of 9.0. Manganese precipitation is variable due to its many oxidation states, but will generally precipitate at a pH of 9.0 to 9.5.*
>
> ***Oxidants***
>
> *Aeration is the process of introducing air into water. Oxidation occurs when oxygen in air combines with metals in the water. If the water is oxidized, metals generally will precipitate at lower pH values. For this reason, aeration of water can be a limiting factor in many water treatment systems. If aeration and oxidation were incorporated or improved in the treatment system, chemical treatment efficiency would increase and costs could be reduced.*

As noted in 4.3 above, the dosing treatment provides for the aeration of the water to aid the precipitation process. If weather conditions permit, the treated water will be held in Pond 1 long enough for the majority of the floc to settle (1 – 2 days) before being discharged to Pond 2. Additional floc settlement is expected to occur in Pond 2.

When the accumulation of settled floc in the ponds reaches the holding volume it will be pumped to the sludge drying bed. Drainage water from the drying bed is returned by gravity to either Pond 1 or Pond 2. When the sludge has dried sufficiently to allow handling as a solid it will be classified in accordance with the Waste Classification Guidelines (DECCW 2009) and if fit for landfill disposal it will be excavated and transported to Council's Stotts Island Landfill.

[1] Overview of Acid Mine Drainage Treatment with Chemicals

West Virginian University Extension Service

5.0 Water Quality Monitoring

5.1 Historical Records

Council has conducted water quality testing at the site for many years. This testing was conducted under various regimes

Groundwater Borehole Monitoring

The groundwater was sampled at four boreholes as shown on Figure 2 each month from February to August 2010. On the same days as the groundwater was sampled, surface water samples were taken at Kin 1 – 4. Refer to AGE report for details and results.

Surface Water Monitoring

The surface water has been sampled and tested at various locations for many years. Sampling was carried out monthly and after each significant rainfall event. The tabulated results of these tests from 2006 are shown in Tables 1-6.

5.2 Future Sampling and Testing

Clause 1(c) of the Prevention Notice requires the implementation of an ongoing water quality testing program for discharge water and Site Creek water upstream and downstream of Kinnears Quarry. This condition will be satisfied by continuing the existing testing program at locations KIN 1 – 5, with Pond 1 being KIN 4 and Pond 2 being KIN 5. This will provide continuity of test results and allow assessment of the effectiveness of the ARD treatment on improving stream water quality.

6.0 Quarry Rehabilitation

6.1 Existing Site Conditions

Kinnears Quarry has been worked as a typical hillside quarry commencing from Harrys Road and gradually working east into the hillside with a series of four faces and benches. Bench 1 and Harrys Road are at RL 24m AHD, bench 4 is at RL 58m AHD, with the top of face 4 at RL 68m AHD.

The quarry has been in its current landform since 2007. In December 2009 some minor work was carried out to divert uncontaminated runoff around the area of pyritic rock, and to create bund walls of cementitious waste in areas of ARD.

There exists a stockpile of topsoil in the centre rear of bench 2, a stockpile of mulch at the northern rear of bench 2, and a stockpile of coarse aggregate at the southern rear of bench 2. These three stockpiles comprise the majority of loose materials on the site. Apart from these loose materials the site is comprised predominantly of exposed bedrock with some covering of weathered gravel and/or soil. Examination of the test results for suspended solids for the existing sediment ponds and in Site Creek downstream of the quarry indicate that the quantity of sediment entering the Creek from the quarry is minimal.

There is a scattering of regrowth Eucalypt and other native species along bench 4. The undisturbed area beyond face 4 contains natural forest. At the southern end of the quarry adjacent to benches 1, 2 and 3 there is a vigorous growth of weed and grass.

Bench 2 of the quarry also acts as part of the access to the adjacent Singhs Quarry. This right of access is granted in the lease agreement between Council and the owner of Singhs Quarry and will be retained.

6.2 Landforming

This ARD Management Plan requires the existing small secondary sediment pond to be added to the area of the existing primary sediment pond by undertaking minor earthworks. The dam wall that forms the ponds will be realigned and raised to increase the pond capacity. A separating wall will be installed across the formed pond to create Pond 1 and Pond 2 required for the ARD treatment process.

An above-ground sludge drying bed will be constructed on bench 2. See Figure 6 – Drawing 3 - No. WK09031/03.

Any minor amounts of processed rock lying in the quarry will be collected and used in the landforming works. The existing stockpile of coarse aggregate will be used in the formation of the sludge drying bed and for filter beds within the site. The existing stockpiles of topsoil and mulch will be used for revegetation works on the site.

These are the only proposed changes to the existing landform.

6.3 Revegetation

Bench 1 will consist of Ponds 1 and 2, and access roads for conducting water treatment and handling processes.

The residual areas of bench 2 not occupied by access roads and water treatment features and bench 3 will be covered with topsoil and mulched to deter weed growth. The topsoil and mulch will come from on-site stockpiles and additional imported material. These areas will be planted with native species. Refer to tables 7 and 8 for the list of species. The proposed species include taller trees that will eventually provide visual screening for the quarry faces.

Bench 4 is not safely accessible. Given the existing native regrowth on this bench no further revegetation is proposed.

7.0 References

1 Skousen, J; Hilton, T; Faulkner, B; (circa 2000), ***Overview of Acid Mine Drainage Treatment with Chemicals***, West Virginia University Extension Service - Agriculture and Natural Resources - Land Reclamation www.wvu.edu/~agexten/landrec/land.htm

8.0 Appendices

Appendix A 1st Prevention Notice

DIRECTION TO TAKE PREVENTIVE ACTION

1. The Department of Environment & Climate Change (DECC) directs TWEED SHIRE COUNCIL to take the following action:

   Council is to engage an appropriately qualified consultant to assess the following:

   - Investigate the likely causes of acid generation and the total acid generating potential of the entire quarry site and immediate surrounding area; and
   - A review of immediate and long term options available for treatment of acidified stormwater and groundwater discharged from Kinnear's Quarry and the immediate surrounding area;
   - Long term options for the treatment and management of the source of acid generation in the quarry.

2. Council is to provide DECC with a consultants report addressing the above points by 31 July 2009.

Appendix B 2nd Prevention Notice

DIRECTION TO TAKE PREVENTIVE ACTION

Department of Environment, Climate Change and Water (DECCW) directs TWEED SHIRE COUNCIL to:

1. Undertake the following action as outlined in the 'Report on Acid Rock Drainage (ARD) Investigations and Remedial Solutions' (Ecoroc Pty Ltd July 2009):

    a) Re-profile diversion drains to minimise the flow of uncontaminated surface water into the existing sediment ponds. During re-profiling any obvious Potentially Acid Forming (PAF) rock scattered by the workings should be removed.
    In re-profiling diversion drains, Council must ensure that the diverted uncontaminated surface water runoff receives adequate treatment to minimise sediment runoff from the quarry.

    b) Application of cemetitous material or lime to the base around the PAF rock face exposures at faces 2 and 3. This material should also be placed to form a low bund wall around known ARD seepage points and sediment dams.

    Actions 1(a) and 1(b) are to be implemented by 30 November 2009.

    c) Conduct monthly surface water quality monitoring from the following locations:

    i) Kinnear Quarry sediment pond;

    ii) Creek upstream from Sandercock quarry (in paddock);

    iii) Creek at boundary of Sandercock Quarry and Kinnear Quarry;

    iv) Downstream in creek at culvert on Harry's Road.

    Water quality monitoring must involve the collection of in-situ data including pH, EC and Dissolved Oxygen. Samples must also be collected for the full suite of dissolved and total metals analysis.

    Action 1 (c) is to commence as of 5 October 2009.

2. Council must engage a groundwater specialist to conduct an investigation into the influence of groundwater on the generation of acid and metalliferous discharge from Kinnear's Quarry to the adjacent unnamed creek.

    A groundwater investigation proposal must be provided to DECCW by 6 November 2009. This proposal should include as a minimum:

    i) The utilisation of at least 3 groundwater wells to determine groundwater flow rate and flow direction.

    ii) Monthly monitoring of groundwater including pH, EG, Dissolved Oxygen, total and dissolved metals.

    iii) Reference to surface water quality monitoring data obtained from action 1(c) above.

    iv) Assessment of the relative contributions of ground and surface waters to acid and metalliferous drainage from the premises.

    Subject to DECCW approval, the groundwater investigation proposal must commence by 30 November 2009, and an interim report to be provided by 31 July 2010. Further monitoring requirements will be subject to the interim report findings.

Appendix C Final Prevention Notice

DIRECTION TO TAKE PREVENTIVE ACTION

To prevent the ongoing pollution of the creek, The Department of Environment, Climate Change and Water (DECCW) directs TWEED SHIRE COUNCIL to take the following action:

1. Develop an Acid Rock Drainage (ARD) Management Plan for Kinnear's Quarry that includes, but is not limited to:
   a. The upgrade of the quarry's sediment basins (primary and secondary). The basin/s must:
      i. Have the capacity to capture without discharge all ARD contaminated surface water (including groundwater seepage within the quarry) arising from rainfall of up to 85mm in total falling over a period of up to 5 consecutive days.
      ii. Include lining the basin/s floor and walls with a suitable impermeable barrier;
      iii. Have the capacity to accommodate temporary storage of sludge generated by the ARD treatment process/regime, in addition to the storage volume required under point (i) above;
      iv. A designated discharge point, including coordinates;
   b. A regime for the treatment of contaminated water that involves:
      i. Description of materials/chemicals to be used for treatment process;
      ii. The means by which treatment will take place (equipment/machinery required);
      iii. The proposed frequency of treatment of contaminated water to meet the following criteria prior to discharge:
         - pH: 6 - 8
         - Dissolved Oxygen: >5 mg/L
         - Total Suspended Solids (TSS): <20 mg/L
      iv. Ensuring that treated water meeting the discharge criteria outlined above is stable prior to discharge.
      v. The separation and diversion of all uncontaminated runoff generated on site.
   c. A surface water quality monitoring regime that includes:
      i. Monthly monitoring of treated discharges for the following parameters:

pH	**Iron(mg/L)**
Conductivity	**Magnesium (mg/L)**
Dissolved Oxygen (mg/L)	**Manganese (mg/L)**
TSS (mg/L)	**Sodium (mg/L)**
Aluminium (mg/L)	**Sulphur (mg/L)**
Calcium (mg/L)	

      ii. Monthly monitoring of The Creek upstream and downstream of Kinnear's Quarry for the parameters outlined in (i) above;

   d. The diversion of artesian groundwater flows from Monitoring Bore 4 (MB4) to the upgraded sediment basin for treatment prior to discharge.
   e. Detail how contaminated sludge generated from the ARD treatment process will be lawfully managed.
   f. The rehabilitation of all remaining exposed quarry floor surfaces outside the footprint of the upgraded sediment basin catchment.
   g. An outline how any fuel and/or chemicals to be used in the ARD treatment process will be stored and managed to eliminate any risk of pollution.

2. The ARD Management Plan for Kinnear's Quarry must be submitted to DECCW by 31 May 2011.
3. Subject to approval by the Department, the ARD Management Plan for Kinnear's Quarry must be implemented by 31 August 2011.
4. Council is to submit an application for an Environment Protection Licence to the Department prior to the commencement of any treatment and discharge regime.

9.0 List of Tables

Table 1 test results 2011

Table 2

Kinnears Quarry and Environs - Water Quality Test Results

Row	Site	Test	Units	No. of samples	Mean	d. Dev.	High	Low			Typical Values	18/05/2011	05/05/2011	05/05/2011	07/04/2011	04/04/2011	07/03/2011	01/03/2011	08/02/2011	11/01/2011
2												2011								
3								Date Sampled												
4								Rainfall Data	Previous day			0	0	0	2.5	0	2	5	0	40
5									Previous week			0	43	43	40	84.5	17	19	11	128
6									Weather			overcast	overcast	overcast	overcast	Fine & Hot	Fine	Fine/showers	fine & hot	rain
7											Report No.	11/1447-c	11/1304	11/1305						
8	KIN 1	Upstream Sandercocks quarry (Creek in Paddock)																		
9		Test	Units	No. of samples	Mean	d. Dev.	High	Low												
11		pH		23	6.0	0.8	8.8	5.2			6.1	5.4	5.8	5.8	6.6	5.4	6.1	5.9	6.3	6.2
12		Conductivity @ 25 C		23	118	25	155	44			125.0	118.0	91.0	91.0	129.0	113.0	122.0	125.0	104.0	112.0
13		Suspended Soilds		12	15	26	93	3				122.0	9.3			6.6		38.0		
14		Chloride		12	16	6	32	6			15.7	20.0	12.0			15.0		16.0		
15		Sulphur as Sulphate		23	7.3	4.4	23.0	4.3			7.7	5.7	3.6	3.6	4.3	4.5	5.1	5.1	4.1	4.5
16		Iron (Total)		23	0.3	0.2	0.9	0.0			0.3	3.5	0.4	0.4	0.3	0.4	0.2	1.1	0.4	0.6
17		Oil and Grease										2.0	6.0			2.0		2.0		
20	KIN 2	Upstream Kinnears at Outlet Pipe from Sandercocks (Creek in Sandercock Quarry)																		
21		Test	Units	No. of samples	Mean	d. Dev.	High	Low												
23		pH		19	4.5	1.3	7.9	3.1			4.3	5.0	5.6	5.6	5.9	5.2	5.6	5.3	5.8	5.6
24		Conductivity @ 25 C		19	271	124	548	87			255.1	154.0	160.0	91.0	175.0	145.0	163.0	160.0	122.0	144.0
25		Suspended Soilds		10	272	665	2,155	16				110.0	49.0			15.0		12.0		
26		Chloride		10	12.4	4.2	18.0	3.6			14.2	18.0	15.0			15.0		16.0		
27		Sulphur as Sulphate		19	73	38	152	15			82.1	26.0	23.0	24.0	23.0	22.0	21.0	25.0	13.0	20.0
28		Iron (Total)		19	9.1	6.3	22.0	0.4			8.5	11.0	4.9	5.5	3.0	3.0	2.4	2.3	2.1	1.5
29		Oil and Grease										2.0	2.0			2.0		2.0		
32	KIN 3	Upstream of Bridge over Harry's Rd near entrance (Large sedimentation Pond)																		
33		Test	Units	No. of samples	Mean	d. Dev.	High	Low												
35		pH		29	3.6	0.9	6.6	2.5			3.5	4.2	4.6	2.7	2.7	4.1	2.6	3.2	2.6	2.5
36		Conductivity @ 25 C		29	453	277	1,761	77			487.3	241.0	254.0	1,542.0	1,678.0	230.0	2,220.0	471.0	2,134.0	1,754.0
37		Suspended Soilds		12	27	71	253	1				14.0	8.0			9.1		3.6		
38		Chloride		18	13.9	3.7	21.0	5.6			13.1	19.0	16.0			15.0		15.0		
39		Sulphur as Sulphate		29	131	113	682	6			139.8	70.0	47.0	509.0	544.0	64.0	514.0	1.2	812.0	735.0
40		Iron (Total)		29	2.5	2.5	14.0	0.3			4.6	4.7	3.6	32.0	45.0	3.4	30.0	1.8	50.0	30.0
41		Oil and Grease										2.0	2.0			3.0		2.0		
44	KIN 4	Primary sediment pond (Creek at Harry's Road)																		
45		Test	Units	No. of samples	Mean	d. Dev.	High	Low												
47		pH		28	3.0	1.2	8.8	2.0			2.9	2.7	2.6	4.6	4.2	2.7	4.4	2.4	6.0	4.9
48		Conductivity @ 25 C		28	1,874	761	3,260	173			2,009.2	1.7	1,535.0	254.0	267.0	1,536.0	263.0	2,024.0	176.0	210.0
49		Suspended Soilds		12	12.2	19.2	59.0	1.8				2.1	3.2			3.8		2.9		
50		Chloride		17	8.5	5.3	25.0	1.9			7.5	11.0	8.0			8.0		9.0		
51		Sulphur as Sulphate		28	880	427	1,676	100			1,014.4	1,020.0	487.0	64.0	59.0	596.0	54.0	1,030.0	34.0	52.0
52		Iron (Total)		28	66	61	247	0			126.2	89.0	31.0	3.7	2.2	37.0	1.4	63.0	2.1	2.1
53		Oil and Grease										2.0	2.0			2.0		2.0		
56	KIN 5	Secondary sediment pond																		
57		Test	Units	No. of samples	Mean	d. Dev.	High	Low												
59		pH		12	2.8	0.5	3.8	2.2			3.0	2.8	3.1			3.2		4.6		
60		Conductivity @ 25 C		12	1,358	879	3,200	314			1,434.1	1,809.0	581.0			527.0		219.0		
61		Suspended Soilds		12	26.4	42.3	144.0	2.5				1.4	2.0			3.6		5.3		
62		Chloride		11	6.4	3.6	14.5	0.4			12.6	11.0	11.0			12.0		7.0		
63		Sulphur as Sulphate		12	510	503	1,888	27			587.7	897.0	166.0			17.3		129.0		
64		Iron (Total)		12	44	71	252	4			52.4	24.0	2.5			2.1		1.9		
65		Oil and Grease										2.0	2.0			2.0		2.0		

Table 2 test results 2010

Table 2

Kinnears Quarry and Environs - Water Quality Test Results

Site	Test	Units	No. of samples	Mean	Std. Dev.	High	Low	Typical Values	21/12/2010	10/12/2010	16/11/2010	04/11/2010	31/08/2010	24/08/2010	18/08/2010	21/07/2010	28/06/2010	21/06/2010	03/06/2010	18/05/2010	06/05/2010	22/04/2010	19/04/2010
	Date Sampled								2010														
	Rainfall Data: Previous day								2.5	6	0	0		6	0		3		2	0	0	30	
	Previous week								67	25.5	2.5	9.5		13.5	2		35		56	5.5	111.5	66	
	Weather								fine	showers	showers	overcast		overcast	fine		fine & cool		overcast/fine	fine & warm	fine & windy	isolated showers	
								Report No.															
KIN 1	**Upstream Sandercocks quarry (Creek in Paddock)**																						
	pH		23	6.0	0.8	8.8	5.2	6.1	5.7	5.8	5.8	6.5		6.3	5.5		5.2		6.0	5.5	5.7	5.5	
	Conductivity @ 25 C		23	118	25	155	44	125.0	108.0	115.0	118.0	84.0		136.0	130.0		126.0		100.0	119.0	97.0	145.0	
	Suspended Soilds		12	15	26	33	3		3.8		5.6				5.4					7.0		37.0	
	Chloride		12	16	6	32	6	15.7	13.0		17.0				15.0					17.0		32.0	
	Sulphur as Sulphate		23	7.3	4.4	23.0	4.3	7.7	4.4	6.3	5.4	5.7		6.3	5.7		8.0		6.2	5.7	5.7	6.8	
	Iron (Total)		23	0.3	0.2	0.9	0.0	0.3	0.2	0.5	0.3	0.1		0.2	0.2		0.2		0.4	0.4	0.1	0.8	
	Oil and Grease								2.0		2.0												
KIN 2	**Upstream Kinnears at Outlet Pipe from Sandercocks (Creek in Sandercock Quarry)**																						
	pH		19	4.5	1.3	7.9	3.1	4.3	4.9	4.7	4.3	4.5		5.1	5.0		3.8		4.6				
	Conductivity @ 25 C		19	271	124	548	87	255.1	126.0	216.0	186.0	135.0		222.0	231.0		226.0		228.0				
	Suspended Soilds		10	272	665	2,155	16		24.0		15.0				24.0								
	Chloride		10	12.4	4.2	18.0	3.6	14.2	13.0		16.0				14.0								
	Sulphur as Sulphate		19	73	38	152	15	82.1	25.0	54.0	42.0	42.0		48.0	52.0		61.0		62.0				
	Iron (Total)		19	9.1	6.3	22.0	0.4	8.5	2.9	11.0	6.5	3.8		5.9	7.1		10.0		8.7				
	Oil and Grease								2.0		2.0												
KIN 3	**Upstream of Bridge over Harry's Rd near entrance (Large sedimentation Pond)**																						
	pH		29	3.6	0.9	6.6	2.5	3.5	3.6	2.4	3.2	3.6	3.8	3.0	3.1	3.7	2.5	3.8	3.5	3.1	3.5	3.5	3.6
	Conductivity @ 25 C		29	453	277	1,761	77	487.3	252.0	3,430.0	363.0	183.0	368.0	467.0	468.0	343.0	441.0	360.0	444.0	416.0	351.0	361.0	418.0
	Suspended Soilds		12	27	71	253	1		21.0		3.5				1.6					1.2		3.2	
	Chloride		18	13.9	3.7	21.0	5.6	13.1	12.0		16.0		15.0		14.0	15.0		21.0		15.0		16.0	17.0
	Sulphur as Sulphate		29	131	113	682	6	199.8	60.0	1,340.0	97.0	96.0	132.0	123.0	137.0	114.0	145.0	113.0	5.9	112.0	101.0	80.0	131.0
	Iron (Total)		29	2.5	2.5	14.0	0.3	4.6	5.7	89.0	67.0	1.5	1.9	1.0	1.1	1.2	1.0	0.9	0.7	1.80	1.94	1.16	1.60
	Oil and Grease								2.0		2.0												
KIN 4	**Primary sediment pond (Creek at Harry's Road)**																						
	pH		28	3.0	1.2	8.8	2.0	2.9	2.8	3.7	2.2	2.6	3.5	3.0	3.2	8.8	2.7	2.7	2.6	2.3	3.9	2.6	2.6
	Conductivity @ 25 C		28	1,874	761	3,260	173	2,009.2	990.0	365.0	2,720.0	1,574.0	2,092.0	2,130.0	2,049.0	1,984.0	2,592.0	2,588.0	225.0	2,036.0	1,088.0	1,960.0	2,418.0
	Suspended Soilds		12	12.2	19.2	59.0	1.8		2.0		5.5				46.0					2.0		2.0	
	Chloride		17	8.5	5.3	25.0	1.9	7.5	6.0		9.0		11.0		9.0	10.0		13.0		7.0		25.0	10.0
	Sulphur as Sulphate		28	880	427	1,676	100	1,014.4	400.0	93.0	1,700.0	1,024.0	1,371.0	1,096.0	1,152.0	1,417.0	1,267.0	1,209.0	911.0	829.0	336.0	630.0	1,299.0
	Iron (Total)		28	66	61	247	0	126.2	5.2	1.6	0.9	32.0	4.8	6.6	18.0	0.4	95.0	100.0	73.0	78.0	11.0	4.4	125.0
	Oil and Grease								2.0		2.0												
KIN 5	**Secondary sediment pond**																						
	pH		12	2.8	0.5	3.8	2.2	3.0	5.4		2.2				3.1					2.2		2.8	
	Conductivity @ 25 C		12	1,358	879	3,200	314	1,434.1	493.0		2,703.0				967.0					2,113.0		1,000.0	
	Suspended Soilds		12	26.4	42.3	144.0	2.5		6.7		864.0				9.2					144.0		6.8	
	Chloride		11	6.4	3.6	14.5	0.4	12.6	7.0		9.0				6.0					7.0		5.0	
	Sulphur as Sulphate		12	510	503	1,888	27	587.7	181.0		1,600.0				392.0					732.0		252.0	
	Iron (Total)		12	44	71	252	4	52.4	1.4		66.0				7.3					76.0		3.8	
	Oil and Grease								2.0		6.0												

Table 3 test results 2009

1	Table 2																				
2	Kinnears Quarry and Environs - Water Quality Test Results																2009				
3							Date Sampled			Typical Value	03/12/2009	18/11/2009	05/11/2009	29/10/2009	08/10/2009	19/08/2009	25/06/2009	20/05/2009	31/03/2009	11/02/2009	29/01/2009
4							Rainfall Data		Previous day		0.0	8.0	0.0	21.0	0.0	0.0	0.0	2.0	50.0	0.0	5.0
5									Previous week		0.0	8.0	28.5	160.0	1.0	0.0	206.0	45.0	91.5	1.0	171.0
6									Weather		overcast, hot	overcast	fine, hot	hot, humid	fine, windy	fine, sunny	fine	rain	overcast, rain	hot/humid	showers/sunny
7										Report No.											
8	KIN 1	Upstream Sandercocks quarry (Creek in Paddock)																			
9		Test	Units	No. of samples	Mean	Std. Dev.	High	Low													
10																					
11		pH		23	6.0	0.8	8.8	5.2		6.1	5.7	5.8	6.3	5.2	7.1	6.4	8.8	6.2	5.3	6.0	6.0
12		Conductivity @ 25 C		23	118	25	155	44		125.0	124	145	155	139	131	125	107	44	110	121	96
13		Suspended Soilds		12	15	26	93	3				3.1		9		3.1	6	93	4.6	3.2	5.3
14		Chloride		12	16	6	32	6		15.7		16		18.5		14.1	16	5.6	16	15	12
15		Sulphur as Sulphate		23	7.3	4.4	23.0	4.3		7.7	6.5	6.1	7.1	6.9	19	4.3	5.2	23	6.1	4.9	5.6
16		Iron (Total)		23	0.3	0.2	0.9	0.0		0.3	0.17	0.26	0.33	0.28	0.25	0.94	0.03	0.38	0.26	0.23	0.22
17		Oil and Grease																			
18																					
19																		Was KIN 4 pre Nov 07			
20	KIN 2	Upstream Kinnears at Outlet Pipe from Sandercocks (Creek in Sandercock Quarry)																			
21		Test	Units	No. of samples	Mean	Std. Dev.	High	Low													
22																					
23		pH		19	4.5	1.3	7.9	3.1		4.3	3.8	3.3	3.8	3.7	6.5	6.2	7.9	4.7	5.6	3.5	3.6
24		Conductivity @ 25 C		19	271	124	548	87		255.1	260	456	344	305	152	151	153	87	356	400	211
25		Suspended Soilds		10	272	665	2,155	16				28		75		234	16	2155	69	37	60
26		Chloride		10	12.4	4.2	18.0	3.6		14.2		18		16.3		12	16	3.6	11	14	9
27		Sulphur as Sulphate		19	73	38	152	15		82.1	80	113	89	80	98	15.3	26	15	118	97	65
28		Iron (Total)		19	9.1	6.3	22.0	0.4		8.5	13	11	19	10	5.34	5.2	2.61	0.44	1.46	21	5.12
29		Oil and Grease																			
30																					
31																		Was KIN 6 pre Nov 07			
32	KIN 3	Upstream of Bridge over Harry's Rd near entrance (Large sedimentation Pond)																			
33		Test	Units	No. of samples	Mean	Std. Dev.	High	Low													
34																					
35		pH		29	3.6	0.9	6.6	2.5		3.5	2.6	3.0	3.4	3.1	3.5	6.0	5.3	6.6	3.3	3.2	2.8
36		Conductivity @ 25 C		29	453	277	1,761	77		487.3	537	645	613	355	348	326	257	77	360	664	407
37		Suspended Soilds		12	27	71	253	1				7.4		4.7		8.5	6.5	253	11	11	12
38		Chloride		18	13.9	3.7	21.0	5.6		13.1		14		12.2		13.6	17	5.6	18	14	9
39		Sulphur as Sulphate		29	131	113	682	6		139.8	178	165	169	95	98	56	73	39	109	169	119
40		Iron (Total)		29	2.5	2.5	14.0	0.3		4.6	3.62	2.61	3.83	1.93	3.6	1.3	2.27	0.25	4.45	2.69	1.3
41		Oil and Grease																			
42																					
43																					
44	KIN 4	Primary sediment pond (Creek at Harry's Road)																			
45		Test	Units	No. of samples	Mean	Std. Dev.	High	Low													
46																					
47		pH		28	3.0	1.2	8.8	2.0		2.9	2.5	2.2	2.6	2.2		3.5	3.3	3.9	2.4	2.5	2.0
48		Conductivity @ 25 C		28	1,874	761	3,260	173		2,009.2	3260	2431	2274	1215		3100	1294	173	1822	2555	1516
49		Suspended Soilds		12	12.2	19.2	59.0	1.8				5		4.9		4	3.7	59	2.6	1.8	4
50		Chloride		17	8.5	5.3	25.0	1.9		7.5		<3		3.4		5	9	1.9	11	7	5
51		Sulphur as Sulphate		28	880	427	1,676	100		1,014.4	1665	887	977	360		1676	467	100	642	1191	500
52		Iron (Total)		28	66	61	247	0		126.2	178	106	105	40		247	70	1.84	72	166	61
53		Oil and Grease																			
54																					
55																		Was KIN 1 pre Nov 07			
56	KIN 5	Secondary sediment pond																			
57		Test	Units	No. of samples	Mean	Std. Dev.	High	Low													
58																					
59		pH		12	2.8	0.5	3.8	2.2		3.0		2.3		2.3		3.0	3.2	3.8	2.9	2.6	2.3
60		Conductivity @ 25 C		12	1,358	879	3,200	314		1,434.1		2297		793		3200	966	314	590	2252	933
61		Suspended Soilds		12	26.4	42.3	144.0	2.5				78		3.1		19	13	2.5	19	8.7	7.7
62		Chloride		11	6.4	3.6	14.5	0.4		12.6		<3		0.4		14.5	8	3.1	8	7	7
63		Sulphur as Sulphate		12	510	503	1,888	27		587.7		605		212		1888	352	27	152	928	283
64		Iron (Total)		12	44	71	252	4		52.4		54		9.57		252	20	3.59	5.67	77	12
65		Oil and Grease																			

Table 4 test results 2008

1	Table 2																					
2	Kinnears Quarry and Environs - Water Quality Test Results										2008											
3								Date Sampled		Typical Value	26/11/2008	18/11/2008	05/11/2008	05/09/2008	18/08/2008	21/07/2008	23/06/2008	26/05/2008	28/04/2008	31/03/2008	03/03/2008	04/02/2008
4								Rainfall Data	Previous day		86.0	11.0						0.0		0.0		25.0
5									Previous week		206.5	56.5						32.0		44.0		81.5
6									Weather		showers	rain						fine		fine		showers
7										Report No.												
8	KIN 1	Upstream Sandercocks quarry (Creek in Paddock)																				
9		Test	Units	No. of samples	Mean	Std. Dev.	High	Low														
10																						
11		pH		23	6.0	0.8	8.8	5.2		6.1	5.7	6.0	6.3	5.8	6.2	6.7	6.3	6.9	6.0	6.6	5.4	5.7
12		Conductivity @ 25 C		23	118	25	155	44		125.0	110	132	130	103	72	96	90	108	111	940	512	60
13		Suspended Soilds		12	15	26	93	3			4.6	11	10	7	2	2.2	3	1.4	2.3	2.1	1.9	30
14		Chloride		12	16	6	32	6		15.7	15	14	18	13	24	15	18	16	15	19.5	16	25
15		Sulphur as Sulphate		23	7.3	4.4	23.0	4.3		7.7	6.4	7.2	7	7.5	6	6	6.7	6.7	5.9	5.6	7.4	4
16		Iron (Total)		23	0.3	0.2	0.9	0.0		0.3	0.37	0.59	0.6	0.19	0.02	0.23	0.18	0.03	0.02	0.02	0.13	0.53
17		Oil and Grease																				
18																						
19																						
20	KIN 2	Upstream Kinnears at Outlet Pipe from Sandercocks (Creek in Sandercock Quarry)																				
21		Test	Units	No. of samples	Mean	Std. Dev.	High	Low														
22																						
23		pH		19	4.5	1.3	7.9	3.1		4.3	3.7	4.1	5.8	4.6	5.5	5.9	4.3	7.0	4.8	5.3	4.1	3.7
24		Conductivity @ 25 C		19	271	124	548	87		255.1	305	278	170	212	124	180	330	161	260	268	688	282
25		Suspended Soilds		10	272	665	2,155	16			27	28	31	86	72	38	34	16	27	3	28	1230
26		Chloride		10	12.4	4.2	18.0	3.6		14.2	12	13	15	9	23	16	17	15	14	17.9	14	8
27		Sulphur as Sulphate		19	73	38	152	15		82.1	103	121	45	82	48	71	104	46	79	98	68	94
28		Iron (Total)		19	9.1	6.3	22.0	0.4		8.5	12	11	8.96	0.82	0.03	5.53	9.93	3.02	6.79	9.4	6.23	3.85
29		Oil and Grease																				
30																						
31																						
32	KIN 3	Upstream of Bridge over Harry's Rd near entrance (Large sedimentation Pond)																				
33		Test	Units	No. of samples	Mean	Std. Dev.	High	Low														
34																						
35		pH		29	3.6	0.9	6.6	2.5		3.5	3.5	3.0	2.2	3.0	2.8	3.4	3.2	3.5	3.2	2.9	3.4	3.9
36		Conductivity @ 25 C		29	453	277	1,761	77		487.3	469	377	2450	791	1624	470	590	530	681	462	1068	377
37		Suspended Soilds		12	27	71	253	1			5.8	5.3	3.4	14	4.8	3	7.4	6	51	5.6	3.3	22
38		Chloride		18	13.9	3.7	21.0	5.6		13.1	14	11	50	4.9	13	16	17	16	13	16.9	114	10
39		Sulphur as Sulphate		29	131	113	682	6		199.8	142	144	1348	263	1460	180	224	186	208	154	148	129
40		Iron (Total)		29	2.5	2.5	14.0	0.3		4.6	2.85	2.79	151	37	130	3.0	2.72	2.86	2.77	1.86	2.2	5.87
41		Oil and Grease																				
42																						
43																						
44	KIN 4	Primary sediment pond (Creek at Harry's Road)																				
45		Test	Units	No. of samples	Mean	Std. Dev.	High	Low														
46																						
47		pH		28	3.0	1.2	8.8	2.0		2.9	2.6	2.4	2.1	3.7	2.7	2.7	2.6	2.5	2.5	5.6	2.6	4.4
48		Conductivity @ 25 C		28	1,874	761	3,260	173		2,009.2	2039	944	1976	182	1553	1915	1980	3200	2360	2300	1810	640
49		Suspended Soilds		12	12.2	19.2	59.0	1.8			35	5	2	10	8.3	2	42	8.8	28	7.1	3.4	42
50		Chloride		17	8.5	5.3	25.0	1.9		7.5	27	4	25	13	14	8	7	9	6	8.9	9	10
51		Sulphur as Sulphate		28	880	427	1,676	100		1,014.4	950	442	1223	52	1320	1099	1144	1940	947	1131	1394	332
52		Iron (Total)		28	66	61	247	0		126.2	150	55	24	3.54	50	142	183	258	108	113	167	9.36
53		Oil and Grease																				
54																						
55																						
56	KIN 5	Secondary sediment pond																				
57		Test	Units	No. of samples	Mean	Std. Dev.	High	Low														
58																						
59		pH		12	2.8	0.5	3.8	2.2		3.0	2.8	2.7	3.0	3.9	3.5	2.7	2.7	2.7	2.7	3.7	2.8	4.0
60		Conductivity @ 25 C		12	1,358	879	3,200	314		1,434.1	1321	645	600	221	387	1890	1890	2630	1885	1216	6400	285
61		Suspended Soilds		12	26.4	42.3	144.0	2.5			20	3.3	21	15	2.1	145	26	36	43	4.8	6.4	30
62		Chloride		11	6.4	3.6	14.5	0.4		12.6	22	5	32	35	24	8	7	14	6	10.3	15	10
63		Sulphur as Sulphate		12	510	503	1,888	27		587.7	481	254	168	82	195	1186	1057	1900	773	523	1324	104
64		Iron (Total)		12	44	71	252	4		52.4	40	15	123	0.4	1.4	50	116	258	66	42	151	4.59
65		Oil and Grease																				

Table 5 test results 2007

1	Table 2																					
2	Kinnears Quarry and Environs - Water Quality Test Results															2007						
3							Date Sampled			Typical Value	10/12/2007	14/11/2007	20/08/2007	25/07/2007	28/05/2007	14/05/2007	02/04/2007	08/03/2007	05/03/2007	05/02/2007	08/01/2007	04/01/2007
4							Rainfall Data		Previous day				0.0		0.0	32.0	3	33.5			0	23
5									Previous week				55.0		2.0	35.0	7	55			41.5	39
6									Weather				raining		fine	fine	fine	fine	rain	fine	fine	rain
7										Report No.												
8	KIN 1	Upstream Sandercocks quarry (Creek in Paddock)																				
9		Test	Units	No. of samples	Mean	Std. Dev.	High	Low														
10																						
11		pH		23	6.0	0.8	8.8	5.2		6.1	7.3	6.4										
12		Conductivity @ 25 C		23	118	25	155	44		125.0	203	189										
13		Suspended Soilds		12	15	26	93	3			39	4.4										
14		Chloride		12	16	6	32	6		15.7	28	38										
15		Sulphur as Sulphate		23	7.3	4.4	23.0	4.3		7.7	9.1	9.2										
16		Iron (Total)		23	0.3	0.2	0.9	0.0		0.3	0.59	0.17										
17		Oil and Grease																				
18																						
19																						
20	KIN 2	Upstream Kinnears at Outlet Pipe from Sandercocks (Creek in Sandercock Quarry)																				
21		Test	Units	No. of samples	Mean	Std. Dev.	High	Low														
22																						
23		pH		19	4.5	1.3	7.9	3.1		4.3	3.1	3.0	4.6	3.6	3.8	3.2	3.5	2.2	inaccesible	3.0	2.6	3.2
24		Conductivity @ 25 C		19	271	124	548	87		255.1	930	853	778	494	280	528	600	2200		1123	1230	951
25		Suspended Soilds		10	272	665	2,155	16			11200	5750	344	394	258	114	77	8325		99	74	5300
26		Chloride		10	12.4	4.2	18.0	3.6		14.2	50	21	13	80	45	24	25	38		27	33	16
27		Sulphur as Sulphate		19	73	38	152	15		82.1	406	344	284	200	109	206	225	1120		647	734	501
28		Iron (Total)		19	9.1	6.3	22.0	0.4		8.5	11	14	5.07	11	4.38	6.66	24	88		117	190	31
29		Oil and Grease																				
30																						
31																						
32	KIN 3	Upstream of Bridge over Harry's Rd near entrance (Large sedimentation Pond)																				
33		Test	Units	No. of samples	Mean	Std. Dev.	High	Low														
34																						
35		pH		29	3.6	0.9	6.6	2.5		3.5	7.9	3.0	4.6	3.4	2.4	3.1	3.0	2.4	3.0	3.0	3.0	3.3
36		Conductivity @ 25 C		29	453	277	1,761	77		487.3	2700	955	914	1297	950	1060	1400	1160	1466	1052	825	806
37		Suspended Soilds		12	27	71	253	1			4.2	5.6	16	3.6	53	15	3.5	57	1.7	18	25	8.2
38		Chloride		18	13.9	3.7	21.0	5.6		13.1	18	19	18	40	38	23	35	15	15	21	40	16
39		Sulphur as Sulphate		29	131	113	682	6		199.8	5331	442	326	770	399	267	800	2180	853	475	433	410
40		Iron (Total)		29	2.5	2.5	14.0	0.3		4.6	12	12	8.24	13	8.96	15	28	14	28	18	6.96	5.29
41		Oil and Grease																				
42																						
43																						
44	KIN 4	Primary sediment pond (Creek at Harry's Road)																				
45		Test	Units	No. of samples	Mean	Std. Dev.	High	Low														
46																						
47		pH		28	3.0	1.2	8.8	2.0		2.9	3.1	2.8										
48		Conductivity @ 25 C		28	1,874	761	3,260	173		2,009.2	2180	1698										
49		Suspended Soilds		12	12.2	19.2	59.0	1.8			5.6	5.2										
50		Chloride		17	8.5	5.3	25.0	1.9		7.5	20	14										
51		Sulphur as Sulphate		28	880	427	1,676	100		1,014.4	1429	1066										
52		Iron (Total)		28	66	61	247	0		126.2	111	43										
53		Oil and Grease																				
54																						
55																						
56	KIN 5	Secondary sediment pond																				
57		Test	Units	No. of samples	Mean	Std. Dev.	High	Low														
58																						
59		pH		12	2.8	0.5	3.8	2.2		3.0	2.9	3.0	4.7	dry	dry	dry	dry	2.6	2.9	3.2	3.1	3.4
60		Conductivity @ 25 C		12	1,358	879	3,200	314		1,434.1	1648	1140	137					1580	1968	1643	1160	901
61		Suspended Soilds		12	26.4	42.3	144.0	2.5			15	1	36					16	3.5	31	36	44
62		Chloride		11	6.4	3.6	14.5	0.4		12.6	20	12	15					30	27	13	35	20
63		Sulphur as Sulphate		12	510	503	1,888	27		587.7	808	631	25					836	1380	1040	832	141
64		Iron (Total)		12	44	71	252	4		52.4	38	11	0.2					18	20	16	4.3	2.88
65		Oil and Grease																				
66																						

Table 6 test results 2006

Table 2															
Kinnears Quarry and Environs - Water Quality Test Results											2006				
							Date Sampled		Typical Value	12/12/2006	05/12/2006	13/11/2006	09/11/2006	16/10/2006	18/09/2006
							Rainfall Data	Previous day			56				
								Previous week			60				
								Weather		fine	fine				fine
									Report No.						
KIN 1	Upstream Sandercocks quarry (Creek in Paddock)														
	Test	Units	No. of samples	Mean	Std. Dev.	High	Low								
	pH		23	6.0	0.8	8.8	5.2		6.1						
	Conductivity @ 25 C		23	118	25	155	44		125.0						
	Suspended Soilds		12	15	26	93	3								
	Chloride		12	16	6	32	6		15.7						
	Sulphur as Sulphate		23	7.3	4.4	23.0	4.3		7.7						
	Iron (Total)		23	0.3	0.2	0.9	0.0		0.3						
	Oil and Grease														
KIN 2	Upstream Kinnears at Outlet Pipe from Sandercocks (Creek in Sandercock Quarry)														
	Test	Units	No. of samples	Mean	Std. Dev.	High	Low								
	pH		19	4.5	1.3	7.9	3.1		4.3		2.6	3.3	3.1	4.6	4.4
	Conductivity @ 25 C		19	271	124	548	87		255.1		1200	700	1160	260	348
	Suspended Soilds		10	272	665	2,155	16				384	57	490	49	38
	Chloride		10	12.4	4.2	18.0	3.6		14.2		39	24	21	25	15
	Sulphur as Sulphate		19	73	38	152	15		82.1		622	341	627	332	111
	Iron (Total)		19	9.1	6.3	22.0	0.4		8.5		89	37	134	4.43	3.68
	Oil and Grease														
KIN 3	Upstream of Bridge over Harry's Rd near entrance (Large sedimentation Pond)														
	Test	Units	No. of samples	Mean	Std. Dev.	High	Low								
	pH		29	3.6	0.9	6.6	2.5		3.5		2.7	2.9	3.4	2.9	3.4
	Conductivity @ 25 C		29	453	277	1,761	77		487.3		810	920	662	706	749
	Suspended Soilds		12	27	71	253	1				16	3.6	26	30	5
	Chloride		18	13.9	3.7	21.0	5.6		13.1		21	19	27	22	15
	Sulphur as Sulphate		29	131	113	682	6		199.8		425	399	258	327	300
	Iron (Total)		29	2.5	2.5	14.0	0.3		4.6		6.81	14	14	4.86	4.18
	Oil and Grease														
KIN 4	Primary sediment pond (Creek at Harry's Road)														
	Test	Units	No. of samples	Mean	Std. Dev.	High	Low								
	pH		28	3.0	1.2	8.8	2.0		2.9						
	Conductivity @ 25 C		28	1,874	761	3,260	173		2,009.2						
	Suspended Soilds		12	12.2	19.2	59.0	1.8								
	Chloride		17	8.5	5.3	25.0	1.9		7.5						
	Sulphur as Sulphate		28	880	427	1,676	100		1,014.4						
	Iron (Total)		28	66	61	247	0		126.2						
	Oil and Grease														
KIN 5	Secondary sediment pond														
	Test	Units	No. of samples	Mean	Std. Dev.	High	Low								
	pH		12	2.8	0.5	3.8	2.2		3.0		3.2	2.9	3.4	dry	3.0
	Conductivity @ 25 C		12	1,358	879	3,200	314		1,434.1		955	1770	955		2700
	Suspended Soilds		12	26.4	42.3	144.0	2.5				4.6	5	71		192
	Chloride		11	6.4	3.6	14.5	0.4		12.6		13	17	15		11
	Sulphur as Sulphate		12	510	503	1,888	27		587.7		539	1090	547		1860
	Iron (Total)		12	44	71	252	4		52.4		2.14	25	26		352
	Oil and Grease														

Table 7 Flora recorded at Kinnears Quarry during TSC field surveys

Family	Botanical name	Common Name	Status*	Suitable for rehabilitation#
Adiantaceae	*Adiantum hispidulum*	Rough maidenhair		N
Apocynaceae	*Tabernaemontana pandacaqui*	Banana bush		N
Araceae	*Gymnostachys anceps*	Settler's Flax		Y – S
Araliaceae	*Polyscias elegans*	Celerywood		Y – S
Araliaceae	*Polyscias murrayi*	Pencil Cedar		Y – S
Arecaceae	*Archontophoenix cunninghamiana*	Bangalow palm		Y – S
Arecaceae	*Calamus muelleri*	Lawyer vine		N
Argophyllaceae	*Argophyllum nullumense*	Silver leaf	ROTAP 3RCa[3]; Locally significant	N
Asparagaceae	*Asparagus aethiopicus*	Basket Asparagus Fern	Exotic	N
Asteraceae	*Ageratina riparia*	Mist flower	Exotic	N
Asteraceae	*Ageratum houstonianum*	Blue Billy Goat Weed	Exotic	N
Asteraceae	*Ambrosia artemisiifolia*	Annual Ragweed	Exotic; Declared Noxious	N
Asteraceae	*Baccharis halimifolia*	Groundsel Bush	Exotic; Declared Noxious	N
Asteraceae	*Bidens pilosa*	Cobblers Pegs	Exotic	N
Basellaceae	*Anredera cordifolia*	Madeira Vine	Exotic	N
Bignoniaceae	*Jacaranda mimosifolia*	Jacaranda	Exotic; naturalised	N
Blechnaceae	*Blechnum cartilagineum*	Gristle fern		N
Caesalpiniaceae	*Senna pendula var. glabrata*	Winter senna	Exotic	N
Casuarinaceae	*Allocasuarina torulosa*	Forest oak		Y – P
Cunoniaceae	*Davidsonia jerseyana*	Davidson's Plum	E1; E2; ROTAP: 2ECi	N
Cyatheaceae	*Cyathea cooperi*	Straw Treefern		N
Davalliaceae	*Nephrolepis cordifolia*	Fishbone Fern	Exotic	N
Dicksoniaceae	*Calochlaena dubia*	Common ground fern		N
Dioscoreaceae	*Dioscorea transversa*	Native yam		N
Elaeocarpaceae	*Elaeocarpus reticulatus*	Blueberry Ash		Y – S
Epacridaceae	*Trochocarpa laurina*	Tree heath		Y – S
Euphorbiaceae	*Breynia oblongifolia*	Coffee bush		Y – P
Euphorbiaceae	*Croton verreauxii*	Native Cascarilla		Y – S
Euphorbiaceae	*Mallotus philippensis*	Red Kamala		Y – P
Eupomatiaceae	*Eupomatia laurina*	Bolwarra		N

Family	Botanical name	Common Name	Status*	Suitable for rehabilitation#
Fabaceae	*Hovea acutifolia*	Brush Hovea		Y – P
Fabaceae - Caesalpinioideae	*Caesalpinia decapetala*	Thorny Poinciana	Exotic; Declared Noxious	N
Fabaceae - Faboideae	*Desmodium rhytidophyllum*	Hairy tick-trefoil		N
Fabaceae - Faboideae	*Desmodium uncinatum*	Silver-leaved Desmodium	Exotic	N
Fabaceae - Faboideae	*Macroptilium lathyroides*	Phasey Bean	Exotic	N
Fabaceae - Mimosoideae	*Acacia disparrima*	Hickory Wattle		Y – P
Fabaceae - Mimosoideae	*Acacia melanoxylon*	Blackwood		Y – P
Flagellariaceae	*Flagellaria indica*	Whip vine		N
Lauraceae	*Cinnamomum camphora*	Camphor laurel	Exotic	N
Lauraceae	*Cryptocarya glaucescens*	Jackwood		Y – S
Lauraceae	*Neolitsea dealbata*	White Bolly Gum		Y – P
Lomandraceae	*Lomandra longifolia*	Spiny-headed Mat Rush		Y – P
Luzuriagaceae	*Geitonoplesium cymosum*	Scrambling lily		N
Malvaceae	*Hibiscus heterophyllus subsp. heterophyllus*	Native Rosella		Y – P
Malvaceae	*Sida rhombifolia*	Paddy's Lucerne	Exotic	N
Meliaceae	*Melia azedarach*	White Cedar		Y – P
Meliaceae	*Synoum glandulosum*	Scentless Rosewood		Y – S
Menispermaceae	*Stephania japonica var. discolor*	Snake vine		N
Monimiaceae	*Wilkiea huegeliana*	Veiny Wilkiea		N
Moraceae	*Ficus fraseri*	Sandpaper Fig		N
Moraceae	*Ficus rubiginosa*	Rock Fig		N
Moraceae	*Ficus superba*	Deciduous Fig		N
Moraceae	*Maclura cochinchinensis*	Cockspur		N
Myrtaceae	*Archirhodomyrtus beckleri*	Rose Myrtle		Y – S
Myrtaceae	*Corymbia intermedia*	Pink Bloodwood		Y – P
Myrtaceae	*Eucalyptus acmenoides*	White Mahogany		Y – P
Myrtaceae	*Eucalyptus carnea*	Thick-leaved Mahogany		Y – P
Myrtaceae	*Eucalyptus grandis*	Flooded Gum		Y – P
Myrtaceae	*Eucalyptus microcorys*	Tallowwood		Y – P
Myrtaceae	*Eucalyptus saligna*	Sydney Blue Gum		Y – P
Myrtaceae	*Eucalyptus siderophloia*	Grey Ironbark		Y – P
Myrtaceae	*Lophostemon confertus*	Brushbox		Y – P
Myrtaceae	*Pilidiostigma glabrum*	Plum Myrtle		Y – S

Family	Botanical name	Common Name	Status*	Suitable for rehabilitation#
Myrtaceae	*Rhodamnia rubescens*	Scrub Turpentine		Y – S
Myrtaceae	*Syncarpia glomulifera*	Turpentine		Y – P
Myrtaceae	*Syzygium moorei*	Durobby	V1; ROTAP 2VCi; Locally significant	N
Ochnaceae	*Ochna serrulata*	Ochna	Exotic	N
Oleaceae	*Ligustrum lucidum*	Large Leaved Privet	Exotic	N
Passifloraceae	*Passiflora suberosa*	Corky Passion Flower	Exotic	N
Passifloraceae	*Passiflora subpeltata*	White Passionflower	Exotic	N
Pittosporaceae	*Pittosporum revolutum*	Hairy Pittosporum		Y – P
Poaceae	*Andropogon virginicus*	Whisky Grass	Exotic	N
Poaceae	*Chloris gayana*	Rhodes Grass	Exotic	N
Poaceae	*Eleusine indica*	Crowsfoot Grass	Exotic	N
Poaceae	*Imperata cylindrica*	Blady Grass		Y – P
Poaceae	*Melinis minutiflora*	Molasses grass	Exotic	N
Poaceae	*Melinis repens*	Red natal Grass	Exotic	N
Poaceae	*Oplismenus aemulus*	Basket grass		N
Poaceae	*Ottochloa gracillima*	Ottochloa		N
Poaceae	*Panicum maximum*	Guinea Grass		N
Poaceae	*Paspalum mandiocanum*	Broad-leaved Paspalum	Exotic	N
Poaceae	*Paspalum urvillei*	Vasey Grass	Exotic	N
Poaceae	*Setaria palmifolia*	Palm Grass	Exotic	N
Rhamnaceae	*Alphitonia petriei*	White Ash	Locally significant	Y – P
Rubiaceae	*Coffea arabica*	Coffee		N
Rubiaceae	*Morinda jasminoides*	Morinda		N
Rubiaceae	*Psychotria loniceroides*	Hairy psychotria		N
Rutaceae	*Flindersia schottiana*	Cudgerie		Y – S
Rutaceae	*Zieria smithii*	Sandfly zieria		N
Sapindaceae	*Cupaniopsis newmanii*	Long-leaved tuckeroo	ROTAP 2RC-[3]; Locally significant	N
Sapindaceae	*Diploglottis australis*	Native Tamarind		Y – S
Sapindaceae	*Guioa semiglauca*	Guioa		Y – P
Sapindaceae	*Jagera pseudorhus*	Foambark		Y – P
Smilacaceae	*Smilax australis*	Prickly smilax		N
Smilacaceae	*Smilax glyciphylla*	Sweet Sarsaparilla		N
Solanaceae	*Solanum mauritianum*	Wild tobacco bush	Exotic	N
Solanaceae	*Solanum nigrum*	Black-berry Nightshade	Exotic	N

Family	Botanical name	Common Name	Status*	Suitable for rehabilitation#
Tiliaceae	*Triumfetta rhomboidea*	Chinese Bur	Exotic; naturalised	N
Verbenacea	*Lantana camara*	Lantana	Exotic	N
Vitaceae	*Cissus hypoglauca*	Five-leaf water vine		N
Xanthorrhoea	*Xanthorrhoea johnsonii*			N
Zingiberaceae	*Alpinia caerulea*	Native ginger		N

* V = vulnerable, E = endangered; where:

1 *Threatened Species Conservation Act 1995*

2 *Environment Protection and Biodiversity Conservation Act 1999*

ROTAP – listed as rare or threatened in Briggs and Leigh (1995).

Locally significant – as defined in Tweed Vegetation Management Strategy (Kingston et al, 2004).

#: Y = Yes/N= No, species is suitable/not suitable for rehabilitation;

P = Pioneer species suitable for initial stage of rehabilitation;

S = Species suitable for supplementary planting, once pioneers have established.

Additional species suitable for rehabilitation but not previously recorded at site are listed in Table 8.

Table 8 Additional species suitable for rehabilitation

Family	Botanical name	Common Name	Status*	Suitable for rehabilitation
Elaeocarpaceae	*Elaeocarpus obovatus*	Hard Quandong		Y – P
Euphorbiaceae	*Homalanthus populifolius*	Bleeding Heart		Y – P
Euphorbiaceae	*Macaranga tanarius*	Macaranga		Y – P
Fabaceae – Mimosoideae	*Acacia aulacocarpa*	Brush Ironbark Wattle		Y – P
Fabaceae – Mimosoideae	*Acacia concurrens*	Curracabah		Y – P
Fabaceae – Mimosoideae	*Acacia fimbriata*	Fringed Wattle		Y – P
Fabaceae – Mimosoideae	*Acacia floribunda*	White Sally		Y – P
Fabaceae – Mimosoideae	*Acacia irrorata*	Green Wattle		Y – P
Fabaceae – Mimosoideae	*Acacia leiocalyx*	Black Wattle		Y – P
Fabaceae – Mimosoideae	*Acacia longissima*	Narrow-leaf Wattle		Y – P
Myrtaceae	*Syzygium crebrinerve*	Purple Cherry		Y – S
Phyllanthaceae	*Glochidion ferdinandii*	Cheese Tree		Y – P
Phyllanthaceae	*Glochidion sumatranum*	Umbrella Cheese Tree		Y – P
Poaceae	*Themeda triandra*	Kangaroo Grass		Y – P
Rhamnaceae	*Alphitonia excelsa*	Red Ash		Y – P
Sterculiaceae	*Commersonia bartramia*	Brown Kurrajong		Y – P
Urticaceae	*Pipturus argenteus*	Native Mulberry		Y – P

* V = vulnerable, E = endangered; where:

1 *Threatened Species Conservation Act 1995*

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#: Y = Yes/N= No, species is suitable/not suitable for rehabilitation;

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