

# Acid Rock Management Challenges

## Reedy Creek Quarry

### Gold Coast

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#### **Abstract:**

The purpose of this paper is to outline the geo-environmental challenges associated with the management of acid rock encountered at the Reedy Creek Quarry and key outcomes of a recently completed Acid Rock Management Plan. Rainfall runoff collected onsite is typically around pH 2.7-3.0 which is substantially below the quarry's licensed discharge limit, and has the potential to adversely impact on the downstream receiving environment. Acid drainage is due to rainfall interaction with acid rock containing pyrite, which is prevalent in localised sections of the quarry. Council commissioned consultants to undertake a geo-environmental investigation and to produce an Acid Rock Management Plan.

#### **INTRODUCTION**

The Reedy Creek Quarry is owned and operated by the Gold Coast City Council, and is located at Andrews, Gold Coast. It produces approximately 250,000 t/annum of high quality crushed rock and earth fill construction material products. It is an open cut quarry established to extract a hard and resistant band of quartzite and lower strength argillite (shale like) materials.

Quarry release water is discharged into Stoney Creek which is an ephemeral creek collecting runoff from the Pacific Highway and mostly developed upstream catchment. Other adjoining large privately operated quarries also drain into this creek system. Stoney Creek flows immediately downstream into the Burleigh Waters lake system, and the Mermaid Waters tidal canal, which ultimately discharges to the Nerang River.

The quarry location and Stony creek catchment are shown in figure 1.

Rocks encountered during extraction contain variable amounts of pyrite (iron sulfide) which oxidizes when exposed to the atmosphere to form deleterious and highly soluble acid salts.

A key environmental issue at the quarry is the management of acid rock drainage. Typical acid rock drainage collected on the site is around pH 2.7-3.0, requiring treatment prior to discharge to the downstream receiving environment. Council commissioned consultants to undertake a geo-environmental investigation and to produce an Acid Rock Management Plan (ARMP).

Operations at the Quarry are carried out under an Environmental Protection Agency (EPA) license. The license includes water quality performance criteria for waters released off-site, and other conditions to mitigate environmental harm. Release water is required to be within the pH range 6.5-9.0.

#### **QUARRY GEOLOGY OVERVIEW**

The pit floor of the Reedy Creek Quarry is presently excavated to RL 18m AHD. The floor consists of mainly weathered quartzite. A pit lake with sump level RL 9m AHD is located centrally in the pit floor. Up to 6 developed benches and sub-vertical faces are evident in the eastern high-wall which is at maximum RL 80m AHD.

Quarrying activities has resulted in the exposure of quartzites, argillites and carbonaceous shale in the eastern side wall (figure 2). The basic geological model of the eastern side wall generally consists of a thick band quartzite underlain by shale and metasilstone (figure 3).

As the next stage of quarrying involves extraction of the north eastern face, it was important the quarry ascertain the extent of potential acid forming rock in this location.



**Figure 1: Reedy Creek Quarry Locality / Catchment Map**

### **ACID FORMING ROCK**

Rocks encountered during quarrying operations at the Reedy Creek quarry have been shown to contain variable amounts of pyrite (iron sulfide) which oxidizes when exposed to the atmosphere to form deleterious and highly soluble acid salts.

Any excavated/blasted face that has a high enough concentration of pyrite and/or other sulfides has the potential to generate and release acid. The occurrence of pyrite is highly variable within the quartzite and associated low grade metamorphic interbeds that comprise the rocks exposed in the Reedy Creek Quarry, with highest occurrence noted in beds of carbonaceous shale and overlying quartzite material in the presently exposed north eastern face of the quarry (figure 2).

Products supplied by the quarry are generally sourced from rocks that are resistant to weathering such as quartzite (rather than carbonaceous shale).



Figure 2: Picture of N-E Face with exposed carbonaceous shale (Acid Hot Spot)

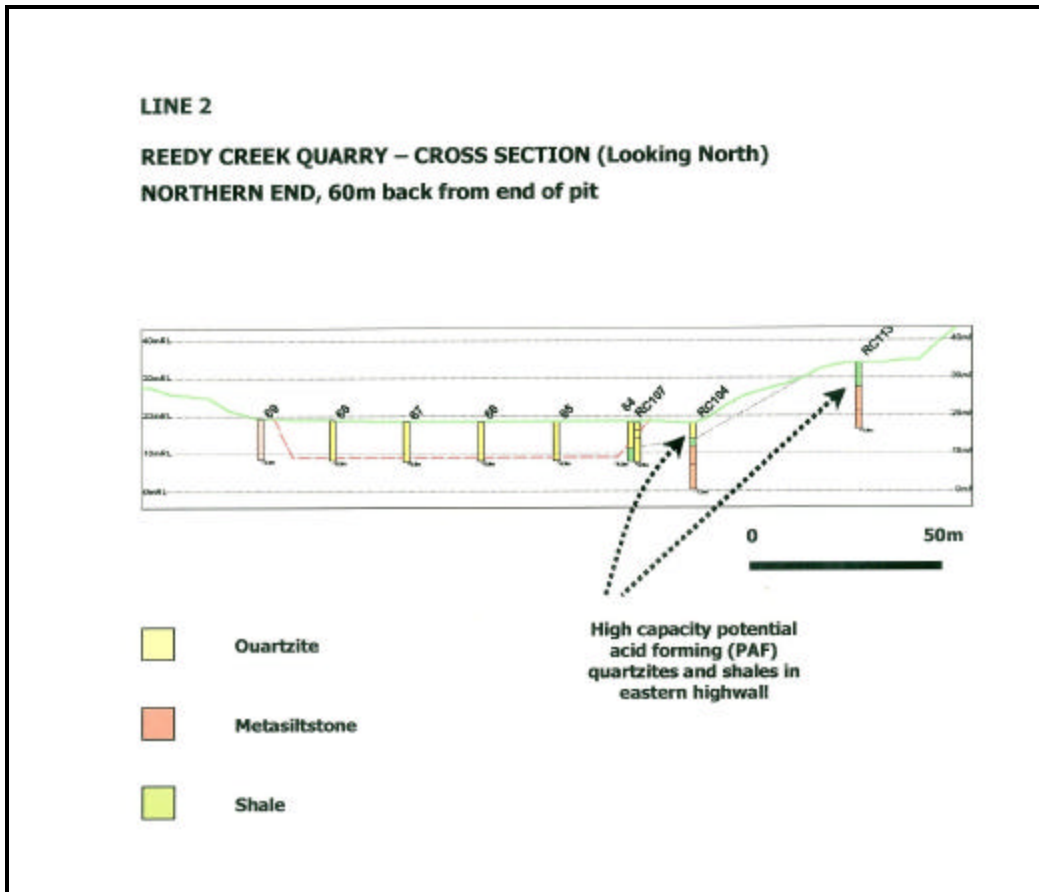


Figure 3: Typical Pit floor/ N-E Face Cross-section

The net acid producing potential of quartzite is generally lower than carbonaceous shale due to less pyrite content and the presence of minerals, which provide acid neutralization capacity (ANC).

The general acid production chemical reactions are similar to that for acid production in acid sulphate soils, where pyrite is typically encountered in low lying coastal areas.

### **ACID ROCK DRAINAGE**

During rainfall events, surface water flows across and percolates through exposed and fissile surfaces of potentially acid forming rocks. If the exposed rock is acid forming and has insufficient natural acid neutralizing capability, then acidic rock drainage is generated.

Key Reactions to the acid production process are:

1.  $\text{FeS}_2 + 3.5\text{O}_2 + \text{H}_2\text{O} = \text{Fe}^{2+} + 2 \text{SO}_4^{2-} + 2\text{H}^+$  (acid generating)
2.  $\text{Fe}^{2+} + 0.25 \text{O}_2 + \text{H}^+ = \text{Fe}^{3+} + 0.5 \text{H}_2\text{O}$  (acid consuming)
3.  $\text{Fe}^{3+} + 3 \text{H}_2\text{O} + \text{Fe}(\text{OH})_3 + 3 \text{H}^+$  (acid generating)

### **LATENT ACIDITY**

Complete oxidation of  $\text{Fe}^{2+}$  (ferrous iron) to  $\text{Fe}^{3+}$  (ferric iron) in equation 3 can be slow in which case acid production may only become apparent after quarry water has travelled several kilometres off site. It is important the quarry consider latent acidity to ensure that released waters did not generate acid in the downstream receiving environment.

To account for potential latent acidity, total acidity tests are completed where samples are titrated with a strong base to a set pH (typically pH 8.3). The total acidity is reported in units of 'mg  $\text{CaCO}_3$  /L'. A hydrated lime dosage amount is determined for the pit lake by converting the acidity measure into units of 'mg  $\text{Ca}(\text{OH})_2$  /L'.

### **KEY OUTCOMES OF THE ACID ROCK MANAGEMENT PLAN**

#### **1. Non - Acid Rainfall Runoff Diversion**

The quarry has implemented an on-site surface water diversion system to separate non-acid catchment runoff from contaminated acid runoff to minimise treatable acid rock drainage volumes. Having undertaken basic geological mapping the source of the acid rock drainage was determined and diversion drains installed.

#### **2. Increased On-site Storage for Acid Rock Drainage**

Pit lake capacity has been increased substantially to accommodate discharge for up to a Q20 average recurrence interval (ARI) storm event for runoff capture and treatment purposes. This exceeds EPA minimum requirements. This provides an extremely high level of lake overflow immunity. The large storage volume enables cumulative storage of acid rock drainage from many successive rainfall events. Pit lake treatment and pump-out is undertaken periodically to maintain a minimum residual storage capacity. Figure 4 shows the pit lake full to just below pit floor level.

#### **3. Passive Acid Rock Drainage Treatment System**

A passive acid rock drainage treatment system has been trialled. Highly alkaline cement waste has been profiled into pit floor perimeter berms to intercept and neutralise acid run-off, prior to it reaching the pit lake. Based on the long term observed buffering impact on sampled pit lake waters, the effectiveness of this passive approach appears limited. Upon exposure to the acid rock drainage the cement waste forms a surrounding precipitate. This limits further effective neutralisation.



**Figure 4: Picture of full pit lake**

#### **4. Active Acid Rock Drainage Treatment System**

Once collected in the pit lake, acid waters are laboratory tested for pH and other water quality parameters including turbidity, suspended solids and heavy metals. Based on the test results an optimum hydrated lime (calcium hydroxide) dosage is determined and applied to raise the pH to EPA licensed release standards. Additional laboratory testing is undertaken to ascertain the potential for latent acidity.

Based on successful trials, the quarry has determined that the application of hydrated lime in a diluted slurry form is the most cost effective active treatment option. Lime slurry is applied via a customised mixing tank / high pressure spray plant similar to a common hydro-mulching machine as shown in figure 5. Pit lake water is subjected to testing before and after treatment to monitor treatment effectiveness and to ensure water quality compliance with EPA license requirements, before release off site.

#### **5. Handling, Use and Disposal of Acid Forming Rock.**

A visual identification guide was prepared to assist plant operators identify potential acid forming rock. In conjunction with the guide, rock sample tests are completed to enable the quarry to confirm the locations of highly concentrated acid rock areas, which are referred to as 'hot spots'. Hot Spot material is separated and stockpiled into a bunded area where stockpile leachate is captured and directed to the pit lake for treatment.

The quarry is planning to trial blend the acid rock with various low cost neutralising agents eg calcium carbonate and cement waste products, to stabilise it for manufacture into inert earth fill construction products. Alternatively the acid rock can be safely disposed of long term submerged in the quarry pit lake or encapsulated with clay fill, where it is denied access to oxygen. Reliable identification and selective handling of acid rock was required to minimise the risk of contamination with other quarry products.

#### **6. Ground water monitoring**

Preliminary geological assessment has identified pit lake geology to comprise quartzite and argillite that is distinctly weathered with mostly intact/un-fractured rock, likely to provide good hydraulic isolation from the lower groundwater. The quarry plans to initiate a ground water monitoring program to ensure that there are no adverse environmental impacts associated with acid pit lake contamination of groundwater.



**Figure 5: Picture of hydrated lime applied to Pit Lake**

## **CONCLUSIONS**

Rocks encountered during quarrying operations at the Reedy Creek quarry have been shown to contain variable amounts of pyrite (iron sulfide) which oxidizes when exposed to the atmosphere to generate acid rock drainage.

Trial of a passive acid rock drainage treatment system using fine cement waste in catch berms to intercept and neutralize surface flows has proven to be of limited effectiveness.

An active treatment system involving the in-situ neutralisation of collected acid waters in the pit lake by application of a hydrated lime slurry, has proven to be the most effective treatment option of acid rock drainage to date.

Latent acidity impacts have been considered to ensure that released waters do not produce acid in the downstream receiving environment, following release off site..

Implementation of the key outcomes of the Acid Rock Management Plan has enabled Council to mitigate potential environmental harm and better plan and manage extraction operations in quarry resources containing acid rock.

## **REFERENCES**

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