Hy-Tec Industries Pty Limited

ABN: 90 070 100 702

Austen Quarry
Stage 2 Extension Project

Surface Water Assessment

Prepared by

Groundwork Plus

September 2014

Specialist Consultant Studies Compendium
Volume 1, Part 2

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Surface Water Assessment

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EXECUTIVE SUMMARY

This Surface Water Management and Discharge Assessment (SWMDA) was prepared as Part 2 of a Specialist Consultant Studies Compendium to accompany an EIS for the Stage 2 Extension of the Austen Quarry ("the Stage 2 Extension"), located on Jenolan Caves Road, Hartley, NSW.

The principal objectives of the SWMDA are as follows.

- To segregate stormwater sub-catchments with similar uses, levels of disturbance and risk of pollution as clean, dirty and contaminated sub-catchments.
- To ensure adequate control measures are implemented to manage runoff from disturbed areas.
- To implement appropriate measures to eliminate or reduce pollutant and sediment loading in stormwater discharges from disturbed areas.
- To preserve downstream water quality.
- To reduce the potential for erosion on-site and subsequent sedimentation of natural waterways.
- To prevent the release of untreated stormwater from disturbed areas.
- To provide a framework for the surveillance, response and reporting of incidents which may impact on stormwater quality.
- To provide a basis for the training of quarry personnel for the management of stormwater and minimisation of the potential for stormwater contamination.

The Stage 2 Extension would result in an increase in the impact footprint of those catchments associated with the overburden emplacement (A1) and extraction area (L1 and L2) and consequntial decrease in the area of a small number of undisturbed catchments (A2, B and F). The remaining catchments of the Stage 2 Site (operational catchments J3 and K3 and undisturbed catchments C, D, G1, G2, H, I1, I2, J1, J2, K1, K2 and K4) would remain unchanged.

The Stage 2 Extension proposes no new infrastructure or changes to existing land elevations that would impact on local and regional flood regimes, or resultant impacts on infrastructure and public safety for flood events up to and including a 150 year ARI.

The Stage 2 Extension presents no greater opportunity for contaminants to enter the groundwater or adjacent water ways, with no uncontrolled releases predicted to occur from the extraction area catchments (L1 and L2). However, the extraction area is likely to require dewatering of groundwater and surface runoff collected within the extraction to ensure ongoing extraction operations. Dewatering of the extraction area would involve the transfer of water to storage dams SD1 and SD2 for appropriate treatment (i.e. flocculation) prior to being released into Coxs River. With no proposed changes in on-site water conveyancing structures or predicted change in geology within the extraction area, the water quality and maximum controlled discharge rate of treated waters are predicted to be similar to pre-Stage 2 Extension.

The proposed lateral extent of the extraction area is predicted to interfere with groundwater, however, no identifiable impact is predicted on groundwater recharge flows to adjacent waterways, users or on water quality (i.e. groundwater and surface).

Uncontrolled discharges of potentially sediment laden water are predicted to continue from existing ancillary operational catchments J3, K3 and A1 via sediment basins SB1, SB2b and SB3a/ SB3b respectively. The receiving environment is identified as a sensitive environment, which has a high conservation value and supports human uses (i.e. raw water supply) that are particularly sensitive to degraded water quality. In accordance with the *Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries, NSW DECC, 2008*, sediment basins on site are required to be designed to achieve required water quality for storms up to the nominated five-day duration for the 95th percentile event. An assessment of storage capacities of existing sediment basins (SB1, SB2b, SB3a, SD1, SD2 and SD6) was undertaken to determine whether these provide the required minimum design storage capacity, which found SB1, SB2b and SB3a to be undersized.

An MS-Excel based daily probabilistic Water Balance model was constructed to analyse potential discharges/annum from on-site storages, as well as dewatering rates from the extraction area. The Water Balance model was used to estimate the potential frequency and volume of discharges (controlled and uncontrolled) from on-site storages for prolonged (over a period of 35 years) dry (15th percentile) and wet (90th percentile) climatic scenarios. Climate data was sourced from the 66 years of data from the nearest available meteorological station (Lowther Park), including with and without mitigative water management measures. The outcome of the water balance assessments predicted that uncontrolled discharges would continue to be released from existing operational catchments J3, K3 and A1 via SB1, SB2b, SB3 (a/b) respectively for the duration of the Stage 2 Extension.

For overburden emplacement catchment (A1), modelling predicts that the installation of SB3b would eliminate uncontrolled discharges during a dry year and restrict to three (3) the number of discharge events during a wet year (with a predicted total estimated volume of 1.4ML). The frequency and volume of uncontrolled discharges would improve upon the pre-Stage 2 Extension water management.

By optimising the design holding capacity of SB2b, which accepts runoff from the Yorkeys Creek stockpile area, the frequency and volume of discharges would be an improvement upon the pre-Stage 2 Extension water management. Through adoption of the recommended water management protocols (i.e. in-situ treatment and control discharging), zero uncontrolled discharge events can be achieved during a dry year, and four (4) untreated/uncontrolled discharge event (covering a total of 8 days) during a wet year, with a predicted total estimated volume of 1.2 ML discharged.

For catchment K3 modelling demonstrates that there will be no change in the predicted frequency or volume of waters discharged via SB1, with 10 and 29 uncontrolled discharges totalling 41.1ML and 74ML per annum predicted during a dry and wet year respectively. Through the continuation of on-site water management involving the transfer of excess waters from SB1 to alternative sediment basins that have sufficient excess holding capacity above their own design requirements (SD6, SD1 and SD2) and redirecting overflow from the clean water catchment sediment basin SD5, the frequency and volume of uncontrolled discharges from SB1 can be significantly reduced, to less than if the design holding capacity of SB1 was optimised to meet regulatory requirements without the on-site water management system continuing.

A review of available on-site water monitoring results indicate that water released from operational areas pose a potential risk to the receiving aquatic ecosystem/s and downstream water suitability for identified environmental values (EVs) as follows.

- Protection of Aquatic Ecosystems (elevated Turbidity, Total Suspended Solids, Total Nitrogen, Dissolved Copper).

- Recreation Purpose (elevated Turbidity, Total Suspended Solids, Total Manganese and Ammonia concentrations).
- Long-term irrigation (elevated Total Nitrogen).
- Drinking water supply (elevated Turbidity, Biochemical Oxygen Demand, and Total Aluminium and Total Nitrogen concentrations).

Although uncontrolled discharges of water are mostly likely to occur during high and/or prolonged wet weather when natural stream flows are high, hence reducing the potential risk, there is the need for ongoing careful management and impact amelioration measures to limit any potential adverse impacts, particularly relating to possible indirect affects downstream off-site.

The proposed Stage 2 Extension can be operated in a manner to achieve a neutral to beneficial effect on water quality in the drinking water catchment by containing and/or reducing existing uncontrolled water releases from operational areas, where practicable, compared to pre-Stage 2 Extension. By doing so, the Proposal would meet the requirement of the State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 for new activities under Part 5 of the *Environmental Planning Assessment Act 1979* that are situated within the Sydney Drinking Water Catchment.

To achieve a neutral to beneficial effect on water quality, the implementation of the following recommended mitigation measures would need to be considered.

- Ensure that all sediment basins, except SB1, are constructed and their design holding capacity maintained to capture all rainfall runoff for a “designed” rainfall event (i.e. Type D basins capable of storing a 95^{th} percentile 5-day rainfall event).
- Installation of new sediment basin (SB3b), downstream of the overburden emplacement area footprint prior to the commencement of Stage 2 Extension, with a peak storage capacity of approximately 12.3ML to meet minimum regulatory requirements.
- Increase in the storage capacity of SB2b to achieve the required minimum design storage volume of 4ML.
- Installation of a diversion channel to divert overflows from the clean catchment dam SD5 around SD6 in order gain additional water storage capacity in SD6 to receive additional excess waters captured in SB1.
- Continuation of the management of the short fall in the total storage capacity of SB1 by pumping excess waters to other basins (e.g. SD1, SD2 and SD6) that have sufficient excess storage capacity.
- Discharge of in-situ treated water from SB1 in SD1 and SD2 to Coxs River on an as needs basis to regain design storage capacity.
- Discharge of in-situ treated water in SD6 to Yorkeys Creek, on an as needs basis, to regain/maximise additional water storage capacity to dewater excess waters from SB1.
- Installation of a diversion bund around SD1, SD2 and SD6 to divert clean overland flows from mixing with potentially contaminated waters from operational areas, which would also maximize the dams capacities to treat excess waters captured in SB1 and/or dewatered from the extraction area.
- Installation of SSEC management measures as shown on **Figure 6** to **18**.

On-going monitoring is also recommended of all implemented SSEC measures and on-site water releases (i.e. controlled and uncontrolled) to provide on-going assessment and improvement, if and where necessary to verify the carrying out of Stage 2 Extension has a neutral to beneficial effect on water quality of the receiving.

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1. INTRODUCTION

1.1 BACKGROUND

Groundwork Plus has been engaged by RW Corkery & Co Pty Ltd (RWC) on behalf of Hy-Tec Industries Pty Ltd (Hy-Tec) to prepare a Surface Water Management and Discharge Assessment (SWMDA) for the Stage 2 Extension of the Austen Quarry ("the Stage 2 Extension"), located on Jenolan Caves Road, Hartley.

The Stage 2 Extension represents a State Significant Development (SSD) in accordance with Schedule 1 (7) of the State Planning Policy (SEPP) (State and Regional Development 2011) and therefore requires an Environmental Impact Statement (EIS) to support the application pursuant to the requirements of the *Environmental Planning Assessment Act 1979* (EP&A Act). This report was prepared as Part 9 of a Specialist Consultant Studies as compendium which accompanies the EIS for the Stage 2 Extension.

1.2 SCOPE

The SWMDA provides strategies to control stormwater runoff from the proposed Stage 2 Extension and prevent or mitigate contamination of receiving aquatic environments and/or water bodies with pollutants such as silts and chemical residues (oils, greases and fuels).

This SWMDA sets out to:

- describe the site and identify potential impacts on the surrounding environment;
- identify legislation, impacts and issues associated with operations set practical and environmentally sound strategies and methods for the design, construction and management of stormwater runoff and erosion and sediment controls;
- describe audit and review processes;
- identify means of assessing whether non compliance events occur; and
- detail actions to be taken if objectives are not met.

This SWMDA also includes the following

- Catchment delineation and segregation of disturbed areas and undisturbed areas.
- Catchment hydrology and stormwater conveyance.
- Estimation of sediment transport from the disturbed areas of the quarry.
- Operational phase stormwater management and erosion and sediment control measures.
- Site Water Balance and estimation of frequency and volume of discharge from site water storages.
- Establishment of water quality objectives for the receiving waters.
- Assessment of discharge water quality against established water quality objectives for the receiving waters.
- Maintenance and Monitoring Program.

1.3 OBJECTIVES

The principal objectives of the SWMDA are as follows.

- To segregate stormwater sub-catchments with similar uses, levels of disturbance and risk of pollution as clean, dirty and contaminated sub-catchments.
- To ensure adequate control measures are implemented to manage runoff from disturbed areas.
- To implement appropriate measures to eliminate or reduce pollutant and sediment loading in stormwater discharges from disturbed areas.
- To preserve downstream water quality.
- To reduce the potential for erosion on-site and subsequent sedimentation of natural waterways.
- To prevent the release of untreated stormwater from disturbed areas.
- To provide a framework for the surveillance, response and reporting of incidents which may impact on stormwater quality.
- To provide a basis for the training of quarry personnel for the management of stormwater and minimisation of the potential for stormwater contamination.

These objectives would be achieved through the implementation of the following measures.

- Management strategies designed to minimise water pollution from the Stage 2 Extension Project.
- Specific operational phase controls to minimise sediment and nutrient export from the Stage 2 Extension Project.
- Optimising the volume of stormwater discharged from the Austen Quarry ("the Quarry") having regard to the mass and concentration of contaminants expected to reach the receiving waters.
- Segregating stormwater by quality or source.
- Reducing contaminant concentrations by the use of appropriate treatment methods.
- Designing a system able to accommodate staged development of the quarry.

1.4 PROJECT DESCRIPTION

1.4.1 Industry Type and Size

Hy-Tec has approval to operate the Austen Quarry on Lot 1 DP1005511, Jenolan Caves Road, Hartley, New South Wales ("the Site") owned by the Hartley Pastoral Corporation Pty Ltd (HPC); approximately 3.5km south-southwest of the village of Hartley and 10km south of Lithgow (see **Figure 1 – Site Location Plan**). The extent of the HPC owned land surrounding the Site provides a large buffer around the land leased by Hy-Tec.

The Quarry is currently operating under Development Consent No. 103/94 (DA 103/94), which based on the current quarry design and operations ("Stage 1"), is approved until March 2020. The current operation incorporates the following domain areas:

- The Stage 1 extraction area and associated overburden emplacement.
- A primary crushing station within the extraction area.
- A secondary processing area and associated product stockpiling areas.
- A product stockpile area referred to as "Yorkey's Creek Stockpile Area".
- Associated infrastructure including administration offices, amenities and weighbridges ("Administration Area").
- Structures associated with water supply, surface water and wastewater management and sediment and erosion control.

- Sealed quarry access road from Jenolan Caves Road to provide access to and from the Quarry for personnel and product transportation.

These site features of the existing quarry are shown on **Figure 2 – Quarry Layout Plan**.

The Stage 1 extraction area is approved to a depth of 730 m AHD and covers approximately 12.1 ha. Benches have been developed at between 10 m and 15 m vertical intervals with the extraction faces being 70° or steeper. Extraction of the resource is undertaken using conventional drilling and blasting methods. Surface vegetation is first cleared by bulldozer and stockpiled for placement over sections of the quarry to be rehabilitated. Any available soil resources are then stripped and stockpiled for spreading over rehabilitated slopes of the overburden emplacement, or other areas of the quarry to be rehabilitated. Any rippable rock below the soil and above the primary resource is ripped, loaded to haul trucks and placed within the rock emplacement. Non-rippable overburden and rhyolite is blasted (using ANFO) to fragment the material such that it can either be loaded and hauled to either the overburden emplacement or the primary crusher located on the 750m AHD level within the extraction area for crushing and delivery (by conveyor) to the remaining crushing and screening operations. Current blast sizes vary according to the location within the extraction area but generally vary from 10,000t through to 100,000t (with an average of approximately 60,000t).

The overburden emplacement has been developed immediately adjacent to the extraction area (to the south), partially in-filling the head of a gully between the 730 m AHD and 780 m AHD elevations. Covering an area of approximately 6.8 ha, the outer slopes of the overburden emplacement have been progressively rehabilitated through direct seeding and tube stock planting.

Hy-Tec proposes an extension of the extraction area and overburden emplacement covering approximately 25.7ha within Lot 1 and 2 on DP1005511 and Lot 31 on DP1009967 (“Stage 2 Extension”). All existing and proposed extraction, processing, stockpiling and transportation operations are located in an area leased by Hy-Tec from HPC. The Stage 2 Extension involves increasing the size and depth of the Stage 1 extraction area by 15.8 ha and overburden emplacement by 9.9 ha. The increase of the extraction area would be undertaken progressively via several stages. A list of these proposed stages of extraction area development and associated year of commencement has been presented in **Table 1 – Proposed Staging and Year of Commencement of Extraction Area Development**.

Table 1 – Proposed Staging and Year of Commencement of Extraction Area Development

Stage of Extraction Area Development	Predicted Year of Commencement
A	1
B	2
C	5
D	10
E	20
F	30
G	35

The footprints of the Stage 2 Extension are shown in **Figure A1** to **Figure A8** of **Appendix A Proposed Quarry Development Layout and Post Quarrying Catchment Delineation Plans for Stage 2 Extension of the Austen Quarry**.

The resource on-site consists of rhyolite, which is suitable as a source rock for aggregate, road pavements, drainage media, rip rap and a wide range of other hard rock quarry products. Quarrying of the rhyolite on the hilltop deposit would continue to entail open-face extraction by terracing using standard quarrying methodologies as follows.

- Clearing of areas to be quarried, and stripped of topsoil for reuse in rehabilitation.
- Stripping of overburden for relocation to an overburden emplacement or re-use as fill in on-site development/rehabilitation.
- Drilling and blasting of overburden and rhyolite.
- Loading of the blasted material into haul trucks for transport to onsite processing facilities (including belt conveyor transportation system, crushing and screening).
- Stockpiling of final products awaiting sale.

The existing development consent allows extraction to a depth of 730m AHD. The Stage 2 Extension proposes to increase the maximum depth of the extraction area to approximately 685m AHD. The extension will allow access to additional rhyolite (45 million tonnes), which would extend the life of the quarry by approximately 30 years.

Rhyolite extracted from the quarry would continue to be processed in the existing primary and secondary processing areas. Operation of the processing areas, stockpiling areas and administration areas of the quarry, which are approved under the existing development consent, are not expected to change as the quarry transitions into Stage 2.

The area encompassing the existing quarry and proposed extension is approximately 144 ha, which represents 0.21 per cent of the Coxs River Upstream Catchment from the head waters to Austen Quarry and approximately 0.08 per cent of the overall Coxs River Drainage basin. Although the Quarry covers only a small percentage of the overall catchment basin, based on its nature, area of disturbance and location within the Sydney Drinking Water Catchment (SDWC), the activity is considered to be high risk.

1.4.2 Existing Approvals

The Quarry is operated with the following development consent and licence.

- Development Consent DA 103/94 issued by the Council of the City of Greater Lithgow (now Lithgow City Council) on 22 March 1995, most recently modified by Lithgow City Council on 27 November 2012.
- Environment Protection Licence 12323 issued by the New South Wales (NSW) Environment Protection Authority (EPA). This licence is renewed annually with the renewal date being 1 July.

In addition, the following water licence has been issued to Hy-Tec under Section 87B of the *Water Management Act 2000* which provides access to water for harvesting and reuse on the Site.

- WAL 25616: allows for 20 units (1 unit = 2 ML) to be extracted from the Upper Nepean and Upstream Warragamba Water Source (Coxs River) of the Water Sharing Plan for the Greater Metropolitan Region Unregulated River Water Sources annually.

Hy-Tec has lodged an application with the NSW Office of Water (NOW) for a Controlled Activity Approval under the *Water Management Act 2000* for the ongoing activities within 40 m of the Coxs River. Hy-Tec has also lodged an application for a zero allocation Water Access Licence (WAL) for the Coxs River Fractured Rock Aquifer groundwater source.

1.4.3 Mobile Equipment

The Applicant currently operates the following mobile equipment within the extraction area and on the overburden emplacement.

- 1 x 85t excavator.
- 2 x 40t articulated haul trucks.
- 1x drill rig.
- 1 x bulldozer.

Two front-end loaders are also operated at the quarry with their use shared between the extraction area, processing area and various stockpiles. Depending on production rates, the above mobile equipment is supplemented by the hire of a second excavator and up to two additional haul trucks.

1.4.4 Hours of Operation

The current approved hours of operation is presented in **Table 2 – Hours of Operation** below.

Table 2 – Hours of Operation

Activity	Monday to Friday	Saturday	Sundays/Public Holidays
Extraction and Processing	6:00 AM to 6:00 PM	7:00 AM to 3:00 PM	No Activity
Blasting	9:00 AM to 5:00 PM	No Activity	No Activity
Product Loading and Transportation	5:00 AM to 10:00 PM	5:00 AM to 3:00 PM	No Activity

1.4.5 Existing Infrastructure and Services

Key infrastructure within the quarry includes the following:

- A hardstand area located to the immediate west of the processing operations (referred to as the Administration Area) on which the following has been constructed:
  - An administration centre incorporating demountable offices, amenities block and weighbridge.
  - An enclosed workshop constructed over a concrete floor.
  - An enclosed fuel storage building, constructed over a concrete bunded floor. Separate bunds are maintained within the structure for fuel, oils and lubricants.
  - Parking facilities for employees and visitors.
  - A meteorological station.
- A network of unsealed roads, tracks and erosion and sediment control structures.
- A sealed Quarry Access Road from the Jenolan Caves Road to Yorkeys Creek Crossing. This includes a centre-line the length of the road between the intersection with Jenolan Caves Road and a substantial culvert crossing of Yorkeys Creek to the immediate west of the weighbridge.
- Electrical power for all quarry operations is supplied by diesel powered generators. One large generator (1 000kVA) provides power to the primary crushing station, two large generators (1 000kVA) provide power to the secondary and tertiary crushing and screening operations and a fourth smaller generator provides power to the Administration Area.

1.4.6 Site Personnel

A total of 16 people are currently directly employed at the Austen Quarry. It is estimated that indirect employment, i.e. through transport operations, maintenance and other supply industries, of at least 40 people is also generated by the quarry.

1.4.7 Potential Contaminants of Concern

The most common sources of surface water contamination from on-site quarrying are summarised in **Table 3 – Potential Contaminants On-site**.

Table 3 – Potential Contaminants On-Site

Potential Source	Potential Contaminants
Sediment-laden runoff from overburden emplacements, waste-rock dumps, raw stockpiles, extraction area	Suspended Solids, pH, Salinity, Nitrate, Total Nitrogen, toxicants (metals/metalloids)
Sediment-laden runoff from erosion of exposed natural soils from land disturbance	Suspended Solids, Total Phosphorous, Nitrate, Total Nitrogen, pH, Salinity, toxicants (metals/metalloids)
Stormwater contamination from processing plant, workshops, fuel storage, vehicle wash-down areas, etc.	Salinity, Nitrate, Total Nitrogen, Pathogens (Faecal Coliforms), Heavy Metals, PAHs, Surfactants, hydrocarbons

2. SITE DESCRIPTION

2.1 CLIMATE

The climate of the Lithgow area is classified according to the Köppen climate classification as oceanic with warm summers, cool to cold winters and generally steady precipitation all year round.

2.1.1 Rainfall

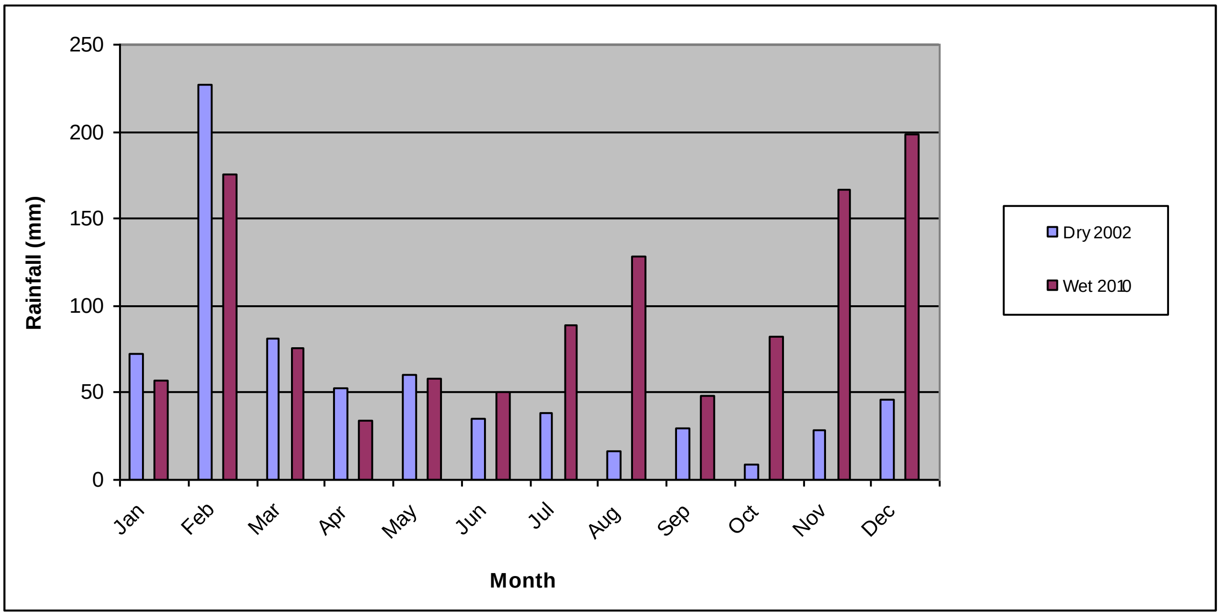
Daily rainfall observations were sourced from the Bureau of Meteorology (BoM) website for the synoptic open station Lowther Park (Station no. 063049), which is situated approximately 7 km southwest of the Site. From 66 years of data recorded at this open station, the rainfall statistics were derived to model the water balance for the dry (15th percentile) and wet (90th percentile) scenarios. See **Table 4 – 15th and 90th Percentile Rainfall Statistics** and **Graph 1 – 15th and 90th Percentile Monthly Rainfall** for the estimated rainfall statistics.

Table 4 – 15th and 90th Percentile Rainfall Statistics

15th Percentile Rainfall (mm/month)													
YEAR	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sept	Oct	Nov	Dec	ANNUAL
2002	72.2	226.6	81.2	52.2	60.4	35.0	38.0	16.2	29.4	9.2	28.2	45.6	694.2
90th Percentile Rainfall (mm/month)													
YEAR	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sept	Oct	Nov	Dec	ANNUAL
2010	57.4	175.6	75.8	34.2	57.6	50.8	88.6	128.6	48.4	82.6	167.2	198.8	1165.6

Source – Lowther Park (Station No. 063049) opened in 1945)

Graph 1 – 15th and 90th Percentile Monthly Rainfall



2.1.2 Evaporation

Evaporation data is not measured by the Bureau of Meteorology in Lithgow. Evaporation is measured at the Bathurst Agricultural Station. The quarry is located approximately 55km east of Bathurst. Bathurst is at a similar elevation and a similar geographical location to the Site and is therefore considered to provide the most indicative evaporation data for the Site. The evaporation data is mean data for the period 1966 to 2013.

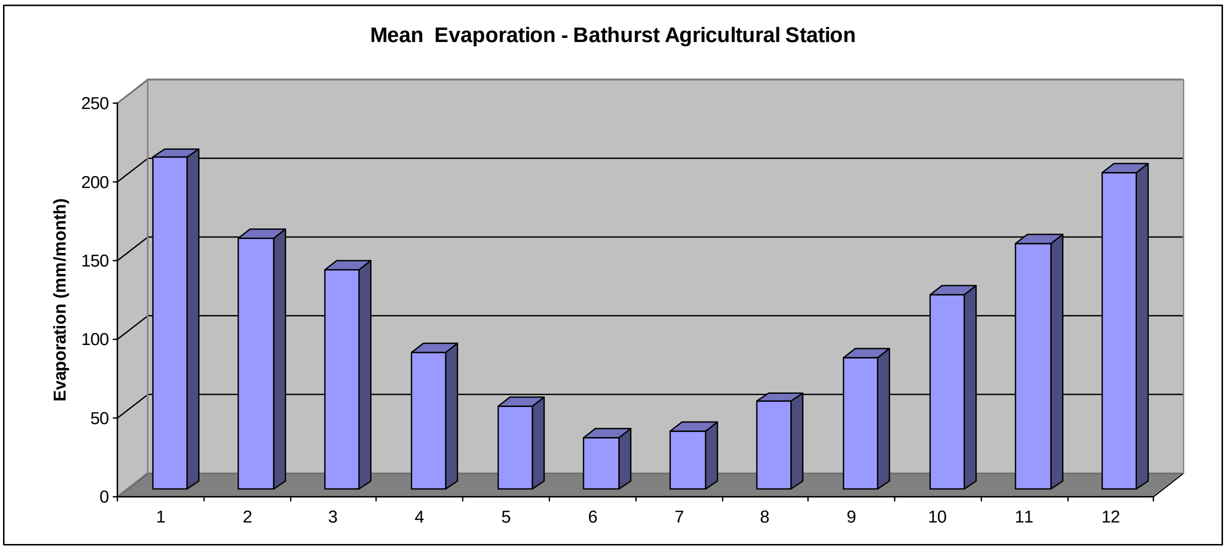
Mean daily evaporation rates sourced from the synoptic weather station Bathurst Agricultural Station (Station no. 063005) have been used to estimate mean monthly evaporation rates and these have been applied in the water balance assessment. The mean daily and mean monthly evaporation rates are summarised in **Table 5 – Mean Daily and Monthly Pan Evaporation Rates for Bathurst Agricultural Station** and graphically represented in **Graph 2 – Mean Monthly Pan Evaporation (Bathurst Agricultural Station)**.

Table 5 – Mean Daily and Monthly Pan Evaporation Rates for Bathurst Agricultural Station

Month	Mean Daily PE (mm)	Mean Monthly PE (mm)
Jan	6.8	210.8
Feb	5.7	159.6
Mar	4.5	140.0
Apr	2.9	87.0
May	1.7	52.7
June	1.1	33.0
July	1.2	37.2
Aug	1.8	55.8
Sept	2.8	84.0
Oct	4.0	124.0
Nov	5.2	156.0
Dec	6.5	201.5
Annual		1341.1

PE = pan evaporation

Graph 2 – Mean Monthly Pan Evaporation (Bathurst Agricultural Station)



Rainfall and evaporation data provided in **Section 2.1.1 Rainfall** and **Section 2.1.2 Evaporation** respectively, has been used to construct an MS-Excel based daily step probabilistic water balance model for various scenarios for the Stage 2 Extension. The Water Balance model was constructed to analyse potential discharges/annum, as well as dewatering rates from the quarry void and site water storages.

See **Section 4.0 Water Management** for details of the Water Balance Assessment for the Stage 2 Extension.

2.2 TOPOGRAPHY AND DRAINAGE

The Site is characterised by a series of ridges with general southwest to northeast orientation, typically reaching an elevation of approximately 800m AHD. The surrounding gullies typically flatten out at an elevation of approximately 700m AHD, but continue to drain into the Coxs River, which has an average elevation of approximately 660m AHD adjacent to the Site.

Elevated areas along the Jenolan Caves Road to the west of the Quarry Site reach elevations in excess of 900m AHD.

Slopes on and surrounding the Site typically range between 20 and 30 degrees.

The Coxs River is the primary surface water drainage adjacent to the Quarry Site. Yorkeys Creek is the only other substantial drainage close to the Quarry Site. Yorkeys Creek stretches over a distance of approximately 4km which is significant when compared to most gullies adjacent to the Quarry Site, which typically discharge surface water to the Coxs River within 1km of their headwaters. Yorkeys Creek runs in a south west to north east direction from Jenolan Caves Road to the Coxs River. Yorkeys Creek discharges into the Coxs River to the west of the Administration Area and secondary processing area. In the vicinity of the Quarry Site, Yorkeys Creek has an elevation less than 700m AHD. Yorkeys Creek drains the elevated ridges along Jenolan Caves Road (in excess of 900m). The Yorkeys Creek valley is a physical boundary which keeps surface water from the elevated western portion of the HPC property from the area immediately adjacent to the Site.

The elevated areas adjacent to the quarry typically drain into surrounding gullies which typically discharge into the Coxs River within 1km of the ridge tops

Gullies are typically too steep near the upper slopes to contain permanent water. Permanent water is present in the flatter gullies of the lower slopes adjacent to the Quarry, where colluvium is present.

Water falling within the existing extraction area is captured in a depression in the base of the extraction area. Water is stored here for later use at the Quarry. Excess water is pumped to several surface dams (i.e. Water Storage Dam (SD) 3 / SD4) to the north of the Quarry. Water is discharged occasionally into the Coxs River in accordance with Environment Protection Licence 12323.

Surface water and groundwater seepage which accumulates in the depression adjacent to the primary crusher is removed periodically to SD3/SD4 for settlement and treatment.

2.3 GEOLOGY

The Site is located within the Central Tablelands of NSW. Based on information published in the "Sydney, 1:250,000 Geological Series Sheet S1 56-5 (1966)" the Site is situated on volcanics of the Lower to Middle Devonian to Lower Carboniferous Period. These include "rhyolite and rhyo-dacites", "adamellite, granite and granodiorite", "gabbro and diorite" and "quartzite, sandstone, siltstone and claystone". The extraction area of the Quarry targets an extrusion of rhyolite. The rhyolite is typically surrounded by granite. To the east of the Site sedimentary sandstones, shales and coal measures overly the volcanics and express themselves as the sandstone cliffs and escarpments of the Blue Mountains.

The Site is characterised by steep terrain with outcropping rock and little or no topsoil, and is bordered by the Coxs River to the north and east. Given the upland environment the Coxs River features large cobble and boulders and has little or no floodplain. Lower gullies at the Site appeared to feature accumulations of colluvium from the upper slopes. The gullies were typically became wider and flatter further down slope.

2.4 GROUNDWATER

A groundwater assessment for the Stage 2 Extension has been undertaken by Ground Doctor Pty Ltd (Ground Doctor, 2014). The assessment investigated the potential for Stage 2 Extension to impact on the quality and/or quantity of groundwater available within a 5 km radius of the proposed extension area. The proposed Stage 2 Extension is classified as an aquifer interference activity, and is therefore subject to the provisions of the *NSW Department of Primary Industries (DPI) Aquifer Interference Policy* (2012).

An assessment of available data indicated that groundwater is present beneath the Site at a depth of approximately 730m AHD, the elevation of the current extraction area floor. The proposed extension would result in the lateral extension of the extraction area to the east and to a maximum depth of RL 685m AHD, some 45m below the water table but will remain well above the Coxs River and above the elevation of most surrounding natural drainage gullies. Groundwater would have to be removed from the extraction area as it extends below the water table, resulting in a lowering of the water table of the Site and the adjacent fractured rock. Approximately 45m of drawdown would occur; however, drawdown is not expected to propagate a significant distance due to the low permeability nature of the fractured rock and the presence of aquifer boundaries in all directions from the extraction area. Drawdown from the proposed Stage 2 Extension may result in a minor reduction in the availability of groundwater to the upper slopes of gullies which direct flow to the Coxs River. These impacts would be restricted to slopes surrounding the extraction area only. It is predicted that drawdown impacts would be negligible at a distance of approximately 225m from all sides of the extraction area (Groundwater Doctor, 2014).

No registered groundwater users have been identified within the maximum possible extent of the drawdown impacts around the quarry.

The preliminary groundwater assessment found that the proposed Stage 2 Extension presents little opportunity for contaminants to enter the groundwater. With the exception of fuel, hydraulic fluids, automotive chemicals and explosives, no chemicals would be used on the Site as part of the proposed Stage 2 Extension. Risks posed by the presence of these chemicals within the extraction area can be adequately addressed through implementation of appropriate environmental management procedures. Processing of extracted rhyolite is restricted to crushing and screening only.

Groundwater dependant ecosystems and culturally significant groundwater receptors have not been identified within the study area. Ground Doctor (2014) predicts that standing water levels between the extraction area and surrounding gullies, including Yorkeys Creek, would remain more elevated than the gullies; therefore a hydraulic gradient would be maintained toward the gullies allowing for groundwater to continue to discharge, or to maintain pre-development conditions.

Ground Doctor (2014) concludes that potential aquifer drawdown and water quality impacts associated with the Stage 2 Extension would be minimal, as defined by the *NSW Aquifer Interference Policy* (NSW DPI, 2012) and although Stage 2 Extension would intercept the water table, in accordance with section 89J of the EP&A Act, no water management or water supply work licence is required under the *Water Management Act 2000*.

2.5 SOILS AND EROSION HAZARD ASSESSMENT

2.5.1 Description of Site Soils

Soil mapping undertaken by the Department of Land and Water Conservation (DLWC) and the Sydney Catchment Authority (SCA) indicates that the existing processing area is located on the Marrangaroo Soil Landscape and both the existing and proposed extraction areas are located on the Mount Walker Soil Landscape.

The soil landscape mapping describes the Mount Walker Soil Landscape occurring on steep to very steep hills with narrow, rounded crests on the Lambie Group Metasediments. It comprises of yellow earths, lithosols, leached loams, red and yellow podzolic soils and soloths.

The soil landscape mapping describes the Marrangaroo Soil Landscape occurring on rolling hills and narrow flat to rounded convex crests on carboniferous granite. It comprises of yellow podzolic soils, earthy sands, siliceous sands, lithosols, minimal prairie soils, alluvial soils and yellow solodic soils.

An investigation of soils on the Site was undertaken by Strategic Environmental and Engineering Consulting (SEEC) Pty Ltd. Soils were investigated within the proposed extraction area extension by hand digging two test pits and using other exposures of batters formed by the excavations for drill rig platforms.

The investigation showed the soils conform to the expectation of the soil landscape mapping. Very gravelly, quartz rich, shallow, soils (lithosols) were encountered over the proposed extraction area. The top soil is thin (50 – 100 mm) and poorly formed. It consists of sandy loam with a small (10%) portion of coarse fragments derived from the parent rock. The subsoil consists of fine sandy loam to fine sandy clay loam with variable gravel content (10 to 60 percent) of the parent material (angular quartzite and schists).

Occasionally there are thicker pockets of finer soil but, equally, there are localised areas where bedrock is exposed. Bedrock depth is consistently less than 1.0 m.

2.5.2 Soil Erosion Potential

The soils investigation (SEEC Pty Ltd, December 2013) also assessed the susceptibility of site soils to erosion (sheet and wind erosion). The results of the soil erodibility (K-factor) analyses on the four soil samples (top soil and sub soil samples from two test pits) indicates that the K-factor ranges from 0.023 (moderate) to 0.048 (high). Therefore, despite the gravelly nature of the soils in the work area, they have been found to be moderately to highly erodible.

Laboratory analysis was also undertaken to test the soils' susceptibility to wind erosion. The results of the analyses indicate that the soils have a moderate to high susceptibility to wind erosion.

2.5.3 Soil Dispersibility Potential

Emerson Aggregate Test (EAT) testing was undertaken as part of the soil investigation (SEEC Pty Ltd, October 2013) to identify potential for dispersibility. The results of the testing indicated that the soils encountered in the test pits are not dispersible.

Further analysis undertaken in accordance with methods listed in *Managing Urban Stormwater: Soils and Construction, 2004 (NSW Government)* indicated that the soils identified in Test Pit 1 (TP1) was found to be Type D – Significantly Dispersible, while the soils in Test Pit 2 (TP2) were classified as Type C – Coarse.

The Exchangeable Sodium Percentage (ESP) was calculated to determine the sodicity of the soils. The results of the calculation indicated that all soils encountered within the test pits were non-sodic.

2.5.4 Analysis of Chemical Test Results

The soils encountered in TP1 and TP2 were analysed for Salinity, Cation Exchange Capacity (CEC), Base Saturation, pH and Organic Matter during the course of the soul investigation (SEEC Pty Ltd, October 2013). The results of these analyses are summarised below:

- Soils in the test pits have been found to be non-saline.
- The soils have been found to have very low CEC, ranging between 2.5 and 5.6.
- The results of the base saturation analysis indicated that despite their relative infertility, nutrient status is moderate in all samples and that some leaching of nutrients has occurred.
- The results of pH testing indicated that the soils encountered in TP1 and TP2 are moderately to very strongly acidic (ranging from 4.6 to 5.6).
- Topsoil across the Site is believed to have very high organic matter content.

2.6 FLOODING

The Secondary Processing Area has been constructed on 'waterfront land', as defined by the *Water Management Act 2000*, incorporating an elevated hardstand and bund within 40m of the Coxs River channel. While not defined, this is likely to affect flows within this stretch of the river when the water level is elevated. It is noted that these works have been constructed in accordance with the development consent and following the issue of a Permit (No. PAR9012617) issued under the now repealed *Rivers and Foreshores Improvement Act 1948*. Hy-Tec has made application to the NSW Office of Water for a Controlled Activity Approval for these works to replace PAR9012617.

It is also noted that Yorkeys Creek is also subject to flooding. However, following a flood event in February 2005, considered a 1 in 150 year ARI event (Parsons Brinkerhoff, 2005), it is confirmed that the Secondary Processing Area is not affected (and therefore not constrained) by local flooding. The existing Yorkeys Creek crossing has been designed and constructed to account for the flood recorded in February 2005.

The Stage 2 Extension Project proposes no new infrastructure or changes to existing land elevations that would impact on local and regional flood regimes, or resultant impacts on infrastructure and public safety for flood events up to and including a 150 year ARI; therefore, no detail flood assessment is considered warranted.

3. CATCHMENT DELINEATION AND HYDROLOGY

3.1 BACKGROUND INFORMATION AND CATCHMENT MAPPING

Mapping and analysis of the regional catchments of the Quarry have previously been undertaken as part of the Soil and Water Management Plan (July 2006) prepared by RW Corkery and Co Pty Ltd in conjunction with GSS Environmental (see **Appendix B Soil and Water Management Plan, RW Corkery**). These regional catchments are presented on Figure 1 – AUS10 Rhyolite Quarry Regional Catchments (RWC, July 2006) and summarised in **Table 6 – Regional Catchments, Austen Quarry**.

Table 6 – Regional Catchments, Austen Quarry

Catchment	Area (ha)	Description
1	103	Extraction area, processing area, Quarry site access road and quarry site facilities
2	115	Overburden emplacement
3	740	Site Access Road, Yorkeys Creek Crossing
4	195	Site Access Road

Source – Soil and Water Management Plan, RW Corkery and Co Pty Ltd, July 2006

3.2 PRE QUARRY EXTENSION

3.2.1 Catchment Delineation and Description of Existing Controls

Using available aerial imagery and topographical data for the site and its surroundings, a desktop analysis and mapping of the quarry catchments was undertaken by Groundwork Plus in November 2013. This was supported by a site assessment conducted by Groundwork Plus personnel on the 21st of November 2013.

A catchment delineation plan has been developed based on the findings of the desktop analysis and the site assessment; see **Figure 3 – Catchment Delineation Plan For Existing Operations** for details. The catchments have been segregated based on the level of disturbance, current use and existing stormwater management controls. These are listed in **Table 7 – Pre Quarry Catchment Delineation**.

Table 7 – Pre Quarry Catchment Delineation

Catchment	Area (ha)	Level of Disturbance	Description
A1	9.86	Partially Disturbed	Includes the existing overburden emplacement, access road and upstream densely vegetated area currently conveying runoff to existing Sediment Basin 3 (SB3). Overflows from SB3 are conveyed to Coxs River within an existing natural drainage line.
A2	104.86	Undisturbed	Includes densely vegetated and grassed areas currently conveying runoff to Coxs River within multiple existing natural drainage lines and as overland sheet flow.
B	17.79	Undisturbed	Includes densely vegetated areas currently conveying runoff to Coxs River within existing natural drainage lines.
C	12.91	Undisturbed	Includes densely vegetated areas currently conveying runoff to Coxs River within existing natural drainage lines.
D	6.96	Undisturbed	Includes densely vegetated areas currently conveying runoff to Coxs River within existing natural drainage lines.
E	24.75	Undisturbed	Includes densely vegetated areas currently conveying runoff to Coxs River within existing natural drainage lines.

Table 7 – Pre Quarry Catchment Delineation (Cont'd)

Catchment	Area (ha)	Level of Disturbance	Description
F	9.61	Undisturbed	Includes densely vegetated areas currently conveying runoff to Coxs River within existing natural drainage lines.
G1	3.85	Partially Disturbed	Includes vegetated areas, previously established access track and Storage Dams 1 and 2 (SD1 and WSD2). SD1 and SD2 were originally constructed as farm dams. SD1 currently receives water pumped via sub-surface drainage from the quarry sump in the primary processing area. Overflows from SD1 are conveyed overland to SD2. WSD1 and SD2 also receive overland flow runoff from the surrounding undisturbed catchment. Water within SD2 is pumped via sub-surface drainage to Sediment Basin 1 (SB1) located in the quarry's processing and stockpiling area. During extreme rainfall events excess water within SD2 is discharged to Coxs River using existing infrastructure (pump and sub-surface drainage) to reinstate freeboard.
G2	7.47	Partially Disturbed	Includes vegetated areas and previously established access track. Runoff from this catchment is discharged to Coxs River as overland sheet flow. During extreme rainfall events water from SD2 is discharged to this catchment and eventually to Coxs River.
H	3.85	Undisturbed	Includes densely vegetated and grassed areas currently conveying runoff to Coxs River.
I1	5.20	Partially Disturbed	Includes vegetated areas and previously established access track conveying runoff to Coxs River.
I2	0.85	Partially Disturbed	Includes vegetated areas and previously established access track conveying runoff to Coxs River.
J1	9.34	Undisturbed	Includes densely vegetated areas conveying runoff to Storage Dam 4 (SD4). Overflows from SD4 are conveyed to SB1 via a series of catch drains.
J2	8.59	Partially Disturbed	Includes the extraction area access road and densely vegetated areas conveying runoff to Storage Dam 3 (SD3). Overflows from SD3 are conveyed to SB1 via a series of catch drains.
J3	17.60	Heavily Disturbed	Includes part of the Quarry Access Road, secondary processing area, Administration Area and other amenities conveying runoff to SB1 via a series of catch drains, sub-surface drainage and overland sheet flow. Overflows from SB1 are conveyed to Coxs River (licensed by EPL 12323) via existing outlet pipes (900 mm diameter and 1050 mm diameter) and an existing spillway.
K1	42.61	Partially Disturbed	Includes part of the Quarry's Access Road, Storage Dam 5 (SD5), Storage Dam 6 (SD6) and relatively undisturbed areas upstream of SD6. SD6 receives runoff in the form of concentrated flows within an existing natural drainage line as well as overland sheet flow. Overflows from SD5 are discharged to SD6 over an existing embankment between the two dams. SD5 and SD6 also receive runoff from the Quarry Access Road via a series of contour drains that have been established along the road. Water from SD6 is pumped to SB1 to reinstate freeboard within SD6 during periods of low rainfall. Water is regularly recycled between SD6 and SD2. It is also anticipated that during periods of extreme rainfall SD6 overtop and discharge to Yorkeys Creek.
K2	686.42	Undisturbed	Includes Yorkeys Creek catchment to the Yorkeys Creek crossing culvert on the Quarry Access Road.
K3	6.01	Heavily Disturbed	Includes Yorkeys Creek stockpile area with flows conveyed to Sediment Basin 2a (SB2a) which primarily acts as a sediment forebay. Overflows from SB2a are conveyed via a catch drain to Sediment Basin 2b (SB2b). Low flows from SD4 are conveyed to Yorkeys Creek via an existing pipe outlet while high flows are discharged via an existing spillway.

Table 7 – Pre Quarry Catchment Delineation (Cont'd)

Catchment	Area (ha)	Level of Disturbance	Description
K4	3.42	Undisturbed	Includes grassed areas downstream of SB2b and Yorkeys Creek Crossing conveying runoff to Coxs River.
L	13.31	Heavily Disturbed	Includes the extraction area, haul roads and the primary crushing station. This catchment also includes a sump located adjacent to the primary crusher structure as well as the quarry drop cut. Water within the sump is pumped to SD1, as well as gravity fed to SB1 using sub-surface drainage.

3.2.2 Catchment Volumetric Runoff

An estimate of the peak runoff volumes generated by the various catchments of the existing quarry has been calculated using the following formula in accordance with Table 6.1 of *Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries, NSW Department of Environment and Climate Change (DECC), 2008.*

$$V = 10 \times C_V \times A \times R_{Y\%ile,\ x\text{-}day}\ (m^3)$$

Where:
10 = a unit conversion factor
C_V = the volumetric runoff coefficient defined as that portion of rainfall that runs off as stormwater over the x-day period
R = is the x-day total rainfall depth (mm) that is not exceeded in y percent of rainfall events.
A = total catchment area (ha)

Assumptions
The following assumptions have been made in the calculation of peak catchment runoff volumes from the various disturbed and undisturbed catchments of the quarry:

- A conservative C_V value of 0.74 has been assumed for all disturbed and undisturbed catchments of the quarry. The C_V values has been sourced from Table F2 of *Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries, DECC, 2008* and has been assumed based on the following assumptions:
  - Soils within the current operational area and Stage 2 Extension belong to Soil Hydrologic Group D; and
  - Rainfall depth of 56.4 (95^{th} percentile 5-day rainfall depth) for Lithgow in accordance with Table 6.3a of Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries, DECC, 2008.

The peak runoff volumes generated by the existing catchments of the quarry are listed in **Table 8 – Pre Quarry Extension Catchment Runoff Volumes**.

Table 8 – Pre Quarry Extension Catchment Runoff Volumes

Catchment ID	Catchment Area (ha)	Runoff Volume (m^3)
A1	9.860	4,115
A2	104.860	43,764
B	17.790	7,425
C	12.910	5,388
D	6.960	2,905
E	24.750	10,330
F	9.610	4,011
G1	3.850	1,607
G2	7.470	3,118
H	3.850	1,607
I1	5.200	2,170
I2	0.850	355
J1	9.340	3,898
J2	8.590	3,585
J3	17.600	7,346
K1	42.610	17,784
K2	686.420	286,484
K3	6.010	2,508
K4	3.420	1,427
L	13.310	5,555

3.3 CHARACTERISATION OF ON-SITE WATERS

The following sections present a characterisation of the on-site waters based on available on-site analytical data provided by RWC.

3.3.1 Extraction Area

Groundwater seepage and stormwater runoff within the extraction area is directed to one of two sumps; 1) Extraction Area Sump (Sump 1) and 2) load-out conveyor sump (Sump 2). Water quality within Sump 1 and Sump 2, based on samples collected on 12 August 2014, is presented in **Table 9 – Extraction Area Water Quality**.

Table 9 – Summary of Extraction Area Water Quality

Parameter	LOR	Sump 1	Sump 2
Sample Date		12/08/2014	12/08/2014
Physico-Chemical			
Electrical Conductivity (EC) (µS/cm)	1	1,150	1280
Total Dissolved Solids (TDS) (mg/L)	1	780	840
Metals/Metalloids (Dissolved) (µg/L)			
Arsenic (As)	1	2	3
Cadmium (Cd)	0.1	<0.1	<0.1
Chromium (Total) (Cr)	1	<1	<1
Copper (Cu)	1	2	2
Nickel (Ni)	1	<1	<1
Lead (Pb)	1	<1	<1
Zinc (Zn)	5	<5	20
Mercury (Hg)	0.1	<0.1	<0.1
Metals/Metalloids (Total) (µg/L)			
Arsenic (As)	1	2	4
Cadmium (Cd)	0.1	0.2	<0.1
Chromium (Cr) (total)	1	<1	<1
Copper (Cu)	1	2	2
Lead (Pb)	1	<1	<2
Mercury Hg)	0.1	<0.1	<0.1
Nickel Ni)	1	2	3
Zinc (Zn)	5	<5	18
Major Ions and Nutrients (mg/L)			
Ammonia (NH_4)	0.01	1.85	4.27
Total Nitrogen (TN)	0.01	11.8	16.4
NO_x as N	0.01	9.21	11.9
Nitrite as N(NO_2)	0.01	0.37	0.44
Nitrate as N (NO_3)	0.01	8.84	11.5
TKN	0.01	2.6	4.5
Total Phosphorus (TP)	0.01	<0.01	<0.01

Notes: na = no data available; LOR = Limits of Reporting

3.3.2 Sediment Basin 3a

Stormwater runoff from the existing overburden emplacement is currently directed to an existing sediment dam, Sediment Basin 3a (SB3a). A historical statistical summary of the water quality within SB3a for the period between February and November 2013 is presented in **Table 10 – Summary Statistics of SB3a Water Quality**.

Table 10 – Summary Statistics of SB3a Water Quality

Parameter	*n*	Minimum	Maximum	Median	Standard Deviation	95th Percentile
Physico-Chemical						
pH (pH units)	2	6.4	7.7	-	-	-
Electrical Conductivity (EC) (µS/cm)	2	180	680	-	-	-
Dissolved Oxygen (DO) (mg/L)	1	8.0	8.0	-	-	-
Biological Oxygen Demand (BOD) (mg/L)	1	1	1	-	-	-
Turbidity (NTU)	2	65	938	-	-	-
Total Suspended Solids (TSS) (mg/L)	2	22	354	-	-	-
Total Dissolved Solids (TDS) (mg/L)	2	121	456	-	-	-
Metals/Metalloids (Dissolved) (µg/L)						
Aluminium (Al) (pH > 5)	1	20	20	-	-	-
Iron (Fe)	1	<1	<1	-	-	-
Metals/Metalloids (Total) (µg/L)						
Aluminium (Al) (pH > 5)	1	1,210	1,210	-	-	-
Arsenic (As)	1	3	3	-	-	-
Cadmium (Cd)	1	<1	<1	-	-	-
Chromium (Cr) (total)	1	<1	<1	-	-	-
Chromium VI (Cr IV)	1	<1	<1	-	-	-
Copper (Cu)	1	4	4	-	-	-
Iron (Fe)	1	1,350	1,350	-	-	-
Lead (Pb)	1	2	2	-	-	-
Manganese (Mn)	1	672	672	-	-	-
Mercury (Hg)	1	<0.1	<0.1	-	-	-
Nickel (Ni)	1	<1	<1	-	-	-
Zinc (Zn)	1	9	9	-	-	-
Major Ions and Nutrients (mg/L)						
Ammonia (NH_4)	1	0.14	0.14	-	-	-
Total Nitrogen (TN)	1	3.2	3.2	-	-	-
NO_x-N	1	1.81	1.81	-	-	-
Total Phosphorus (TP)	1	0.08	0.08	-	-	-

Notes: na = no data available
- = n is insufficient to calculate statistic
LOR = Limits of Reporting

3.3.3 Sediment Basin 1

Sediment laden runoff from the secondary processing and Administration Areas (i.e. Catchment J3) is directed into Sediment Basin 1 (SB1) through a series of existing stormwater conveyance structures (culverts, sub-surface drainage and catch drains). SB1 also receives runoff from a small undisturbed catchment area upstream of the pug mill, see **Figure 3 – Catchment Delineation Plan for Existing Operations**. Additionally, overflows from clean catchment water storage dams SD3 and SD4 are also diverted to SB1 via a series of conveyance structures (culverts, sub-surface drainage and catch drains). A historical statistical summary of the water quality within SB1 for the period between February and November 2013 is presented in **Table 11 – Summary Statistics of SB1 Water Quality:**

Table 11 – Summary Statistics of SB1 Water Quality

Parameter	*n*	Minimum	Maximum	Median	Standard Deviation	95th Percentile
Physico-Chemical						
pH (pH units)①	10	6.6	7.9	7.5	0.4	7.9
EC (µS/cm)	10	200	780	330	157	605
DO (mg/L)	1	8.3	8.3	na	-	-
BOD_5 (mg/L)	8	1	3	1	0.9	3
Turbidity (NTU)	10	2	1,244	201	485	1,119
TSS (mg/L)	10	<5	520	108	231	516
TDS (mg/L)	10	58	368	206	90	355
Metals/Metalloids (Dissolved) (µg/L)						
Al (pH > 5)	1	20	20	-	-	-
Fe (total)	1	70	70	-	-	-
Metals/Metalloids (Total) (µg/L)						
Al (pH > 5)	1	7,630	7,630	-	-	-
As	1	3	3	-	-	-
Cd	1	1.1	1.1	-	-	-
Cr (total)	1	3	3	-	-	-
Cr VI	1	<1	<1	-	-	-
Cu	1	14	14	-	-	-
Fe (total)	1	7,700	7,700	-	-	-
Pb	1	31	31	-	-	-
Mn	1	325	325	-	-	-
Hg	1	<0.1	<0.1	-	-	-
Ni	1	2	2	-	-	-
Zn	1	92	92	-	-	-
Major Ions and Nutrients (mg/L)						
NH_4	1	0.02	0.02	-	-	-
TN	1	1	1	-	-	-
NO_x-N	1	0.35	0.35	-	-	-
TP	1	0.05	0.05	-	-	-

Notes: ① = 20th Percentile: 7.4; 80th Percentile: 7.8; - = n is insufficient to calculate statistic

3.3.4 Storage Dam 2

Storage Dam 2 (SD2) receives inflows from SD3, excess water dewatered from SB1 and the extraction area, and runoff from an upstream slightly disturbed catchment attributed to historical and current grazing practices. A historical statistical summary of the water quality within SD2 for the period between December 2007 and August 2014 is presented in **Table 12 – Summary Statistics of SD2 Water Quality**.

Table 12 – Summary Statistics of SD2 Water Quality

Parameter	*n*	Minimum	Maximum	Median	Standard Deviation	95th Percentile
Physico-Chemical						
pH (pH units)①	21	6.7	9.4	7.9	0.7	9.0
EC (µS/cm)	9	190	630	450	135	602
BOD_5 (mg/L)	19	1	10	3	3	10
Turbidity (NTU)	2	3	15	-	-	-
TSS (mg/L)	21	<5	495	9	118	277
TDS (mg/L)	22	96	836	280	173	741
Metals/Metalloids (Dissolved) (µg/L)						
Al (pH > 5)	1	10	10	-	-	-
As	1	<1	<1	-	-	-
Cd	1	<0.1	<0.1	-	-	-
Cr (total)	1	<1	<1	-	-	-
Cu	1	2	2	-	-	-
Ni	1	1	1	-	-	-
Pb	1	<1	<1	-	-	-
Zn	1	<5	<5	-	-	-
Fe (total)	1	<1	<1	-	-	-
Metals/Metalloids (Total) (µg/L)						
Al (pH > 5)	1	40	40	-	-	-
As	1	1	1	-	-	-
Cd	1	<0.1	<0.1	-	-	-
Cr (total)	1	<1	<1	-	-	-
Cr VI	1	<1	<1	-	-	-
Cu	1	2	2	-	-	-
Fe (total)	1	70	70	-	-	-
Pb	1	<1	<1	-	-	-
Mn	1	20	20	-	-	-
Hg	1	<1	<1	-	-	-
Ni	1	<1	<1	-	-	-
Zn	1	<5	<5	-	-	-
Major Ions and Nutrients (mg/L)						
NH_4	1	0.02	0.02	-	-	-
TN	1	0.3	0.3	-	-	-
NO_x-N	1	<0.1	<0.1	-	-	-
TP	1	<0.1	<0.1	-	-	-

Notes: ① = 20th Percentile: 7.4; 80th Percentile: 8.3; na = not applicable; - = n is insufficient to calculate statistic
Analysis data assumed to be representative of untreated water within SD4.

3.3.5 Storage Dam 6

Storage Dam 6 (SD6) is located near the Quarry Access Road, adjacent to Yorkeys Creek. Overflows from SD5 are discharged to SD6 over an existing embankment/grass spillway or siphoned via an existing pipe for supplementary water reuse on-site, inflows of excess water dewatered from SB1 is also received by SD5 and SD6 also receives overland flows from a small, partially disturbed catchment. A historical statistical summary of the water quality within SD6 for the period between December 2007 and August 2014 is presented in **Table 13 – Summary Statistics of SD6 Water Quality**.

Table 13 – Summary Statistics of SD6 Water Quality

Parameter	*n*	Minimum	Maximum	Median	Standard Deviation	95th Percentile
Physico-Chemical						
pH (pH units)①	24	6.5	9.7	8.0	0.5	8.7
EC (µS/cm)	8	200	830	453	241	812
BOD_5 (mg/L)	23	1	9	3	2	6
Turbidity (NTU)	2	74	133	-	-	-
TSS (mg/L)	24	<5	95	14	27	82
TDS (mg/L)	25	80	736	292	147	535
Metals/Metalloids (Dissolved) (µg/L)						
Al (pH > 5)	1	20	20	-	-	-
As	1	<1	<1			
Cd	1	<0.1	<0.1			
Cr (total)	1	<1	<1			
Cu	1	2	2			
Ni	1	<1	<1			
Pb	1	<1	<1			
Zn	1	<5	<5			
Fe (total)	1	<1	<1	-	-	-
Metals/Metalloids (Total) (µg/L)						
Al (pH > 5)	1	1,250	1,250	-	-	-
As	2	1	1	1	-	-
Cd	2	0.1	0.2	-	-	-
Cr (total)	2	<1	<1	-	-	-
Cr VI	1	<1	<1	-	-	-
Cu	2	2	6	-	-	-
Fe (total)	1	1,850	1,850	-	-	-
Pb	2	<1	5	-	-	-
Mn	1	241	241	-	-	-
Hg	2	<0.1	<0.1	-	-	-
Ni	2	<1	1	-	-	-
V	1	20	20	-	-	-
Zn	1	<5	<5			
Major Ions and Nutrients (mg/L)						
NH_4	2	0.03	0.6	-	-	-
TN	2	3.4	9.5	-	-	-
NO_x-N	2	2.32	8.29	-	-	-
TP	2	<0.01	0.05	-	-	-

Notes: ① = 20th Percentile: 7.7; 80th Percentile: 8.2; - = n is insufficient to calculate statistic

3.3.6 Sediment Basin 2b

Overflows from SB2b containing finer sediments from the Yorkeys Creek Stockpile Area are discharged to SB2b via an existing catch drain. SB2b also receives runoff carrying finer sediments produced by the existing steep batters of material stockpiles along the edge of the Yorkeys Creek Stockpile Area. A summary of the water quality within SB2b based on a sample collected in November 2013 is presented in **Table 14 – Summary Statistics of SB2 Water Quality**.

Table 14 – Summary Statistics of SB2b Water Quality

Parameter	*n*	Minimum	Maximum	Median	Standard Deviation	95^{th} Percentile
Physico-Chemical						
pH (pH units)①	1	8.2	8.2	-	-	-
EC (µS/cm)	1	860	860	-	-	-
DO (mg/L)	1	8.6	8.6	-	-	-
BOD_5 (mg/L)	1	127	127	-	-	-
Turbidity (NTU)	1	31	31	-	-	-
TSS (mg/L)	1	576	576	-	-	-
Metals/Metalloids (Dissolved) (µg/L)						
Al (pH > 5)	1	20	20	-	-	-
Fe (total)	1	<LOR	<LOR	-	-	-
Metals/Metalloids (Total) (µg/L)						
Al (pH > 5)	1	2,060	2,060	-	-	-
As	1	<LOR	<LOR	-	-	-
Cd	1	0.3	0.3	-	-	-
Cr (total)	1	<1	<1	-	-	-
Cr VI	1	<1	<1	-	-	-
Cu	1	8	8	-	-	-
Fe (total)	1	2,940	2,940	-	-	-
Pb	1	6	6	-	-	-
Mn	1	232	232	-	-	-
Hg	1	<0.1	<0.1	-	-	-
Ni	1	<1	<1	-	-	-
Al (pH > 5)	1	29	29	-	-	-
Major Ions and Nutrients (mg/L)						
NH_4	1	0.03	0.03	-	-	-
TN	1	3.3	3.3	-	-	-
NO_x-N	1	2.17	2.17	-	-	-
TP	1	0.08	0.08	-	-	-

Notes: - = n is insufficient to calculate statistic

3.4 POST QUARRY EXTENSION

3.4.1 Catchment Delineation

The post quarrying catchments for each stage of quarry development (Stage A through to Stage G) are listed in **Table 15 – Post Quarry Development Catchment Delineation** and shown on Figure A1 to Figure A8 of **Appendix A Proposed Quarry Development Layout and Post Quarrying Catchment Delineation Plans for Stage 2 Extension of the Austen Quarry**.

Table 15 – Post Quarry Development Catchment Delineation

<table>
<tr><th colspan="2" rowspan="2">Catchment ID</th><th colspan="8">Catchment Area (ha)</th></tr>
<tr><th>Existing</th><th>Stage A</th><th>Stage B</th><th>Stage C</th><th>Stage D</th><th>Stage E</th><th>Stage F</th><th>Stage G</th></tr>
<tr><td colspan="2">A1</td><td>8.47</td><td>8.38</td><td>18.970</td><td>19.500</td><td>18.810</td><td>17.250</td><td>16.490</td><td>16.490</td></tr>
<tr><td colspan="2">A2</td><td>12.65</td><td>11.01</td><td>89.880</td><td>88.860</td><td>88.860</td><td>88.190</td><td>87.100</td><td>87.100</td></tr>
<tr><td colspan="2">A3</td><td>90.54</td><td>90.39</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td colspan="2">B</td><td>17.67</td><td>17.420</td><td>16.990</td><td>16.370</td><td>15.390</td><td>15.260</td><td>15.260</td><td>15.260</td></tr>
<tr><td colspan="2">C</td><td>12.91</td><td>12.910</td><td>12.910</td><td>12.910</td><td>12.910</td><td>12.910</td><td>12.910</td><td>12.910</td></tr>
<tr><td colspan="2">D</td><td>6.96</td><td>6.960</td><td>6.960</td><td>6.960</td><td>6.960</td><td>6.960</td><td>6.960</td><td>6.960</td></tr>
<tr><td colspan="2">E</td><td>25.54</td><td>25.060</td><td>24.180</td><td>23.590</td><td>21.970</td><td>21.970</td><td>20.600</td><td>20.600</td></tr>
<tr><td colspan="2">F</td><td>9.24</td><td>9.170</td><td>9.170</td><td>9.170</td><td>9.170</td><td>9.170</td><td>9.170</td><td>9.170</td></tr>
<tr><td colspan="2">G1</td><td>3.85</td><td>3.850</td><td>3.850</td><td>3.850</td><td>3.850</td><td>3.850</td><td>3.850</td><td>3.850</td></tr>
<tr><td colspan="2">G2</td><td>7.47</td><td>7.470</td><td>7.470</td><td>7.470</td><td>7.470</td><td>7.470</td><td>7.470</td><td>7.470</td></tr>
<tr><td colspan="2">H</td><td>3.850</td><td>3.850</td><td>3.850</td><td>3.850</td><td>3.850</td><td>3.850</td><td>3.850</td><td>3.850</td></tr>
<tr><td colspan="2">I1</td><td>5.200</td><td>5.200</td><td>5.200</td><td>5.200</td><td>5.200</td><td>5.200</td><td>5.200</td><td>5.200</td></tr>
<tr><td colspan="2">I2</td><td>0.850</td><td>0.850</td><td>0.850</td><td>0.850</td><td>0.850</td><td>0.850</td><td>0.850</td><td>0.850</td></tr>
<tr><td colspan="2">J1</td><td>9.340</td><td>9.340</td><td>9.340</td><td>9.340</td><td>9.340</td><td>9.340</td><td>9.340</td><td>9.340</td></tr>
<tr><td colspan="2">J2</td><td>8.590</td><td>8.590</td><td>8.590</td><td>8.590</td><td>8.590</td><td>8.590</td><td>8.590</td><td>8.590</td></tr>
<tr><td colspan="2">J3</td><td>17.320</td><td>17.320</td><td>17.320</td><td>17.320</td><td>17.320</td><td>17.320</td><td>17.320</td><td>17.320</td></tr>
<tr><td colspan="2">K1</td><td>42.610</td><td>42.610</td><td>42.610</td><td>42.610</td><td>42.610</td><td>42.610</td><td>42.610</td><td>42.610</td></tr>
<tr><td colspan="2">K2</td><td>686.420</td><td>686.420</td><td>686.420</td><td>686.420</td><td>686.420</td><td>686.420</td><td>686.420</td><td>686.420</td></tr>
<tr><td colspan="2">K3</td><td>6.010</td><td>6.010</td><td>6.010</td><td>6.010</td><td>6.010</td><td>6.010</td><td>6.010</td><td>6.010</td></tr>
<tr><td colspan="2">K4</td><td>3.420</td><td>3.420</td><td>3.420</td><td>3.420</td><td>3.420</td><td>3.420</td><td>3.420</td><td>3.420</td></tr>
<tr><td rowspan="2">L</td><td>L1</td><td rowspan="2">16.35</td><td>16.180</td><td>16.520</td><td>16.290</td><td rowspan="2">26.27</td><td rowspan="2">28.62</td><td rowspan="2">31.83</td><td rowspan="2">31.83</td></tr>
<tr><td>L2</td><td>2.850</td><td>4.750</td><td>6.690</td></tr>
</table>

3.4.2 Catchment Volumetric Runoff

The peak runoff volumes generated by the post Stage 2 Extension catchments have been calculated using the formula and the assumptions listed in **Section 3.2.2 Catchment Volumetric Runoff** The peak runoff volumes for the post quarry development catchments are summarised in **Table 16 – Post Quarry Development Catchment Runoff Volumes**.

Table 16 – Post Quarry Development Catchment Runoff Volumes

<table>
<tr><th colspan="2" rowspan="2">Catchment ID</th><th rowspan="2">Current Operations</th><th rowspan="2">End of Stage 1</th><th colspan="7">Stage</th></tr>
<tr><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th><th>G</th></tr>
<tr><td colspan="2">A1</td><td>4,115</td><td>3,535</td><td>3497</td><td>7,917</td><td>8,139</td><td>7,851</td><td>7,199</td><td>6882</td><td>6882</td></tr>
<tr><td colspan="2">A2</td><td>43,764</td><td>43,067</td><td>42320</td><td>37,512</td><td>37,087</td><td>37,087</td><td>36,807</td><td>36352</td><td>36352</td></tr>
<tr><td colspan="2">B</td><td>7,425</td><td>7,375</td><td>7270</td><td>7,091</td><td>6,832</td><td>6,423</td><td>6,369</td><td>6,369</td><td>6,369</td></tr>
<tr><td colspan="2">C</td><td>5,388</td><td>5,388</td><td>5388</td><td>5,388</td><td>5,388</td><td>5,388</td><td>5,388</td><td>5,388</td><td>5,388</td></tr>
<tr><td colspan="2">D</td><td>2,905</td><td>2,905</td><td>2905</td><td>2,905</td><td>2,905</td><td>2,905</td><td>2,905</td><td>2,905</td><td>2,905</td></tr>
<tr><td colspan="2">E</td><td>10,330</td><td>10,659</td><td>10459</td><td>10,092</td><td>9,846</td><td>9,169</td><td>9,169</td><td>8,598</td><td>8,598</td></tr>
<tr><td colspan="2">F</td><td>4,011</td><td>3,856</td><td>3827</td><td>3,827</td><td>3,827</td><td>3,827</td><td>3,827</td><td>3,827</td><td>3,827</td></tr>
<tr><td colspan="2">G1</td><td>1,607</td><td>1,607</td><td>1607</td><td>1,607</td><td>1,607</td><td>1,607</td><td>1,607</td><td>1,607</td><td>1,607</td></tr>
<tr><td colspan="2">G2</td><td>3,118</td><td>3,118</td><td>3118</td><td>3,118</td><td>3,118</td><td>3,118</td><td>3,118</td><td>3,118</td><td>3,118</td></tr>
<tr><td colspan="2">H</td><td>1,607</td><td>1,607</td><td>1607</td><td>1,607</td><td>1,607</td><td>1,607</td><td>1,607</td><td>1,607</td><td>1,607</td></tr>
<tr><td colspan="2">I1</td><td>2,170</td><td>2,170</td><td>2170</td><td>2,170</td><td>2,170</td><td>2,170</td><td>2,170</td><td>2,170</td><td>2,170</td></tr>
<tr><td colspan="2">I2</td><td>3,55</td><td>355</td><td>355</td><td>355</td><td>355</td><td>355</td><td>355</td><td>355</td><td>355</td></tr>
<tr><td colspan="2">J1</td><td>3,898</td><td>3,898</td><td>3898</td><td>3,898</td><td>3,898</td><td>3,898</td><td>3,898</td><td>3,898</td><td>3,898</td></tr>
<tr><td colspan="2">J2</td><td>3,585</td><td>3,585</td><td>3585</td><td>3,585</td><td>3,585</td><td>3,585</td><td>3,585</td><td>3,585</td><td>3,585</td></tr>
<tr><td colspan="2">J3</td><td>7,346</td><td>7,229</td><td>7229</td><td>7,229</td><td>7,229</td><td>7,229</td><td>7,229</td><td>7,229</td><td>7,229</td></tr>
<tr><td colspan="2">K1</td><td>17,784</td><td>17,784</td><td>17784</td><td>17,784</td><td>17,784</td><td>17,784</td><td>17,784</td><td>17,784</td><td>17,784</td></tr>
<tr><td colspan="2">K2</td><td>286,484</td><td>286,484</td><td>286484</td><td>286,484</td><td>286,484</td><td>286,484</td><td>286,484</td><td>286,484</td><td>286,484</td></tr>
<tr><td colspan="2">K3</td><td>2,508</td><td>2,508</td><td>2508</td><td>2,508</td><td>2,508</td><td>2,508</td><td>2,508</td><td>2,508</td><td>2,508</td></tr>
<tr><td colspan="2">K4</td><td>1,427</td><td>1,427</td><td>1427</td><td>1,427</td><td>1,427</td><td>1,427</td><td>1,427</td><td>1,427</td><td>1,427</td></tr>
<tr><td rowspan="2">L</td><td>L1</td><td rowspan="2">5,555</td><td rowspan="2">6,824</td><td>6753</td><td>6,895</td><td>6,799</td><td rowspan="2">10,964</td><td rowspan="2">11,945</td><td rowspan="2">13,285</td><td rowspan="2">13,285</td></tr>
<tr><td>L2</td><td>1431</td><td>1,982</td><td>2,792</td></tr>
</table>

Catchment A2 is split into two additional sub-catchments in the End Stage 1, Stage A and Stage B scenarios of extraction area development. For these stages the runoff volumes generated by sub-catchments A2 and A3 have been combined.

3.4.3 Comparative Assessment of Pre and Post Extension Catchment Runoff Volumes

A comparative assessment of catchment runoff volumes for the pre and post extension scenarios was undertaken. The results of this analysis are summarised in **Table 17 – Comparison Pre - Quarry and Post - Quarry Extension Catchment Runoff Volumes**.

The Stage 2 Extension Project would have no effect on the footprints of existing operational catchments J3 and K3 as well as the undisturbed catchments C, D, G1, G2, H, I1, I2, J1, J2, K1, K2 and K4; however, would have an increase in the footprints *of operational catchments A1* and L (sub-catchments L1 and L2), and reduction of the footprints of undisturbed catchments *A2,* B and F.

Table 17 – Comparison of Pre and Post Extension Catchment Runoff Volumes

Catch-ment ID	Current Operations	–End Stage 1	Change (Current – to End of Stage 1)	Stage A	Change	Stage B	Change	Stage C	Change	Stage D	Change	Stage E	Change	Stage F	Change	Stage G	Change
A1	4115	3,535	-16.4%	3497	-1.1%	7,917	55.8%	8,139	2.7%	7,851	-3.7%	7,199	-9.0%	6882	-4.6%	6882	0.0%
A2	43764	43,067	-1.6%	42320	-1.8%	37,512	-12.8%	37,087	-	37,087	-	36,807	-	36352	-	36352	-
B	7425	7,375	-0.7%	7270	-1.4%	7,091	-2.5%	6,832	-3.8%	6,423	-6.4%	6,369	-0.9%	6,369	0.0%	6,369	0.0%
C	5388	5,388	0.0%	5388	0.0%	5,388	0.0%	5,388	0.0%	5,388	0.0%	5,388	0.0%	5,388	0.0%	5,388	0.0%
D	2905	2,905	0.0%	2905	0.0%	2,905	0.0%	2,905	0.0%	2,905	0.0%	2,905	0.0%	2,905	0.0%	2,905	0.0%
E	10330	10,659	3.1%	10459	-1.9%	10,092	-3.6%	9,846	-2.5%	9,169	-7.4%	9,169	0.0%	8,598	-6.7%	8,598	0.0%
F	4011	3,856	-4.0%	3827	-0.8%	3,827	0.0%	3,827	0.0%	3,827	0.0%	3,827	0.0%	3,827	0.0%	3,827	0.0%
G1	1607	1,607	0.0%	1607	0.0%	1,607	0.0%	1,607	0.0%	1,607	0.0%	1,607	0.0%	1,607	0.0%	1,607	0.0%
G2	3118	3,118	0.0%	3118	0.0%	3,118	0.0%	3,118	0.0%	3,118	0.0%	3,118	0.0%	3,118	0.0%	3,118	0.0%
H	1607	1,607	0.0%	1607	0.0%	1,607	0.0%	1,607	0.0%	1,607	0.0%	1,607	0.0%	1,607	0.0%	1,607	0.0%
I1	2170	2,170	0.0%	2170	0.0%	2,170	0.0%	2,170	0.0%	2,170	0.0%	2,170	0.0%	2,170	0.0%	2,170	0.0%
I2	355	355	0.0%	355	0.0%	355	0.0%	355	0.0%	355	0.0%	355	0.0%	355	0.0%	355	0.0%
J1	3898	3,898	0.0%	3898	0.0%	3,898	0.0%	3,898	0.0%	3,898	0.0%	3,898	0.0%	3,898	0.0%	3,898	0.0%
J2	3585	3,585	0.0%	3585	0.0%	3,585	0.0%	3,585	0.0%	3,585	0.0%	3,585	0.0%	3,585	0.0%	3,585	0.0%
J3	7346	7,229	-1.6%	7229	0.0%	7,229	0.0%	7,229	0.0%	7,229	0.0%	7,229	0.0%	7,229	0.0%	7,229	0.0%
K1	17784	17,784	0.0%	17784	0.0%	17,784	0.0%	17,784	0.0%	17,784	0.0%	17,784	0.0%	17,784	0.0%	17,784	0.0%
K2	286484	286,484	0.0%	286484	0.0%	286,484	0.0%	286,484	0.0%	286,484	0.0%	286,484	0.0%	286,484	0.0%	286,484	0.0%
K3	2508	2,508	0.0%	2508	0.0%	2,508	0.0%	2,508	0.0%	2,508	0.0%	2,508	0.0%	2,508	0.0%	2,508	0.0%
K4	1427	1,427	0.0%	1427	0.0%	1,427	0.0%	1,427	0.0%	1,427	0.0%	1,427	0.0%	1,427	0.0%	1,427	0.0%
L – L1	5,555	6,824	18.6%	6753	-1.1%	6,895	2.1%	6,799	-1.4%	10,964	13%	11,945	8.2%	13,285	10.1%	13,285	0.0%
L – L2				1431	100.0%	1,982	27.8%	2,792	29.0%								

Notes:
1. Sub-catchments L1 and L2 represent the two extraction areas that will be merged to form one larger pit post Year 5 extraction. .
2. (-) indicates a decrease in the catchment run off volume.
3. 0 indicates no change in the catchment runoff volume.
4. In order to determine the change in runoff volume for the extraction areas, the runoff volumes for Catchments L1 and L2 for Years 1, 2 and 5 have been clumped together.
5. Catchment A2 is split into two additional sub-catchments in the End of Stage 1, Stage A and Stage B scenarios of pit development. For these stages of development, the runoff volumes generated by sub-catchments A2 and A3 have been combined.

3.4.4 Location and Configuration of Water Releases

Uncontrolled releases are predicted to occur from SB1, SB3a and SD2 into Coxs River, at monitoring EPL Point 1, 9 and 10 respectively, and SB2b and SD6 into Yorkeys Creek, at monitoring EPL Point 8 and 11 respectively, during or immediately following storm events that exceed the established sediment basin or storage dam holding capacity. Uncontrolled releases at each of these locates are released via an existing grass or rock lined emergency spillway or pipe outlet structure (i.e. SB1).

Controlled releases of treated sediment basin waters occasionally occur from SB2b into Yorkeys Creek, at monitoring EPL Point 8, and from SB3a and SD2 into Cox River at monitoring EPL Point 9 and 10 respectively. Treated Waters from operational areas waters at each location are release via existing pipe outlet structure using a pump or gravity fed in the case of SD2.

The location of the controlled and uncontrolled site water releases have been shown on **Figure 4 – Discharge and Water Monitoring Location Plan**.

4. WATER MANAGEMENT

The Applicant has implemented a sustainable water management system, which aims for the current and future operations to be 100% self-sufficient in water, excluding drinking water supply. A sustainable water management system has been developed based upon capturing stormwater run-off for dust suppression and environmental controls.

The system is based upon capturing the water supply within the extraction area and pre-quarry farm dams; SD1, SD2, SD5 and SD6. These dams capture water prior to being re-used on site or released directly, or indirectly via Yorkeys Creek, into the Coxs River as environmental flows.

Runoff from undisturbed areas is, and would continue to be diverted around areas disturbed by quarry operations wherever practicable. This will reduce the potential for clean runoff to be polluted by quarry activities. Diversion of clean waters will be affected by contour and diversion drains, perimeter bunds and pipe culverts wherever practicable.

During extension and operation of the extraction and overburden emplacement areas, drainage will convey water from areas of disturbance to sediment basins located within the extraction area and/or around the Site (i.e. SB1, SB2a, SB2b, SD6, SD1, SD2 and SB3a/b) to prevent sediment laden or contaminated runoff leaving the Site. Sediment traps and sediment ponds form part of the Site water management system and improve water quality at various points along water drainage networks.

Excess waters are treated in-situ within SB2b, SB3a/b and SD2 using a coagulant (i.e. NALCO 8187.15H) to improve water quality prior to being pumped or drained directly or indirectly via Yorkeys Creek into the Coxs River. NALCO 8187 is a patterned coagulant, which is widely used within the water treatment industry.

Potable water supply is supplied by Lithgow City Council on an as needs basis, while sewage treatment for the offices and amenities are comprised of a self contained unit that rely upon rainwater captured of the on-site infrastructures roof-tops. No treated effluent is discharged on-site.

A schematic overview of the drainage and water management network is shown in **Figure 5 – Water Management System Schematic**.

5. STORMWATER SEDIMENT AND EROSION CONTROL MANAGEMENT

5.1 OVERVIEW OF EXISTING AND PROPOSED EROSION AND SEDIMENT CONTROL

The existing Stormwater, Erosion and Sediment Control (SSEC) measures for the disturbed and partially disturbed catchments of the quarry are shown on the following figures attached with this report:

- **Figure 6 – Stormwater, Sediment and Erosion Control Measures, Current Extraction Area**
- **Figure 7 – Stormwater, Sediment and Erosion Control Measures, Storage Dams and Coxs River Discharge**
- **Figure 8 – Stormwater, Sediment and Erosion Control Measures, Extraction Area Access Road**
- **Figure 9 – Stormwater, Sediment and Erosion Control Measures, Secondary Processing and Administration Area**
- **Figure 10 – Stormwater, Sediment and Erosion Control Measures, Yorkeys Creek Stockpile Area**
- **Figure 11 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (End of Stage 1)**
- **Figure 12 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage A)**
- **Figure 13 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage B)**
- **Figure 14 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage C)**
- **Figure 15 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage D)**
- **Figure 16 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage E)**
- **Figure 17 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage F)**
- **Figure 18 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage G)**

The following assumptions and disclaimers are made in the preparation of these conceptual stormwater management and ESC plans.

- The location and configuration of proposed stormwater management and ESC measures shown on these figures are conceptual and subject to change to suit potential future amendments to quarry staging and footprint.
- All stormwater conveyance, retardation and diversion structures (including drains and bunds) would be designed for the design minor storm event (Q_5 or Q_{10}).
- All diversion drains, drainage channels and catch drains would be rock and/or grass lined.
- Proposed sumps are non-engineered storage structures and have been provided to aid the quarry operator for the effective management of stormwater within the extraction area. The sumps shown on the above Figures have not been drawn to scale.
- All proposed sediment control devices must be de-silted and made fully operational as soon as practicable following a storm event, if the devices' sediment retention capacity falls below 70% of its design capacity.

Stormwater management and ESC measures in the form of flow conveyance and retardation structures (catch drain, bunds, etc.) and the provision of inlet and outlet scour protection for the retardation of flow velocity have been proposed for the existing operational areas of the quarry. These measures (included on **Figure 6** to **18**) are conceptual and broad ranging at this stage and have been proposed with a view to reducing erosion, scour and sedimentation.

The receiving environment has been identified as a sensitive environment, which has a high conservation value and supports human uses of water that are particularly sensitive to degraded water quality. In accordance with *Table 6.1 Recommended minimum design criteria for temporary erosion and sediment control measures at mines and quarries* of *Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries, NSW DECC, 2008*, sediment basins on site are required to be designed to achieve required water quality for storms up to the nominated five-day duration for the 95th percentile event.

The 95th percentile, five-day rainfall depth of 56.4 mm for Lithgow, listed in *Table 6.3a 75th, 80th, 85th, 90th and 95th-percentile 2 and 5-day rainfall depths for 59 sites in New South Wales* of *Managing Urban Stormwater, Soils and Construction – Volume 1, NSW DECC, 2008*, has been adopted as the design rainfall depth to calculate the required storage capacities of onsite sediment basins.

The formula listed below has been used to calculate the storage capacities of sediment basins.

$$\mathbf{V = 10 \times C_V \times A \times R_{Y\%ile,\ x\text{-}day}\ (m^3)}$$

Where:

10 = a unit conversion factor

C_V = the volumetric runoff coefficient defined as that portion of rainfall that runs off as stormwater over the x-day period. A volumetric runoff coefficient of 0.74 has been adopted for the quarry.

R = is the adopted 95th percentile, 5-day total rainfall depth (mm) of 56.4 mm for Lithgow.

A = total catchment area (ha)

An assessment of storage capacities of existing sediment basins (SB1, SB2b and SB3) has also been undertaken to determine if these provided the minimum storage capacity required in accordance with the selected design criteria.

Water Storage Dams SD1, SD2, SD3, SD4, SD5 and SD6 have been used in the recycling, management and/or treatment of sediment laden water from disturbed areas. Hence, they have been considered to be sediment treatment dams and included in the assessment, where applicable.

The locations of SB1, SB2(b), SB3a/b, SD1, SD2, SD3, SD4, SD5 and SD6 are shown on **Figure 7 – Stormwater, Sediment and Erosion Control Measures, Water Storage Dams and Coxs River Discharge**, **Figure 9 – Stormwater, Sediment and Erosion Control Measures, Secondary Processing and Administration Area** and **Figure 10 – Stormwater, Sediment and Erosion Control Measures, Yorkeys Creek Stockpiling Area**.

5.2 OVERBURDEN EMPLACEMENT AREA

5.2.1 Current Scenario

Stormwater runoff from the existing overburden emplacement is currently discharged to an existing sediment basin (SB3a). No information is available regarding the current storage capacity or depth of SB3a. SB3a currently captures and treats runoff from disturbed and undisturbed areas of Catchment A1 (see **Figure 3 – Catchment Delineation Plan, Existing Operations**). Based on site observations (21 November 2013), SB3a has been assumed to have a total depth of approximately 3 m and a surface area of 1,015 m² (sourced from aerial imagery), SD1 is estimated to have a current treatment and storage capacity of approximately 3 ML. This estimated volume does not take into account batter slopes.

The design storage capacity requirement of SB3a was calculated in accordance with Table 6.1 of *Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries, NSW DECC, 2008*, using the formula and assumptions listed in **Section 3.2.2 Catchment Volumetric Runoff**. On the basis of the conservative assumptions with respect to runoff, the analysis found that SB3a should have a total storage capacity of approximately 6.2 ML. This includes a conservative allowance of 50% of the settling zone capacity for sediment storage.

While the calculation of minimum sediment basin design capacity is likely to overestimate the minimum capacity requirement, the calculation indicates that SB3a does not have adequate storage and treatment capacity to treat sediment laden water from existing Catchment A1. The footprint of Catchment A1 is expected to increase with the proposed Stage 2 Extension (see Figure A1 to Figure A8 of **Appendix A Proposed Quarry Development Layout and Post Quarrying Catchment Delineation Plans for Stage 2 Extension of the Austen Quarry**) and therefore recalculation of an appropriately sized sediment basin, along with a review of stormwater management and ESC measures, will be necessary to ensure effective treatment of sediment laden water generated by these future proposed areas.

Stormwater, Sediment and Erosion Control (SSEC) management measures have been developed for the Stage 2 Extension in accordance with *Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries, NSW DECC, 2008* and *Best Practice Erosion and Sediment Control, International Erosion Control Association (IECA), 2008.* These SSEC management measures are explained in **Section 5.2.2 Stage 2 Extension and Development of Overburden Emplacement**.

5.2.2 Stage 2 Extension and Development of Overburden Emplacement

The development of the extraction area and the overburden emplacement would occur in 8 stages over a period of approximately 35 years. The development of the extraction area and overburden emplacement is shown on Figure A1 to Figure A8 of **Appendix A Proposed Quarry Development Layout and Post Quarrying Catchment Delineation Plans for Stage 2 Extension of the Austen Quarry**.

Specific SSEC management measures have been developed for the staged development of the extraction area and overburden emplacement. These measures are conceptual and broad ranging and designed for the effective management of stormwater runoff within the disturbed and undisturbed areas of the proposed staged development of the overburden emplacement and pit areas. These measures are shown on the following Figures:

- **Figure 11 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (End Stage1)**
- **Figure 12 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage A)**

- **Figure 13 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage B)**
- **Figure 14 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage C)**
- **Figure 15 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage D)**
- **Figure 16 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage E)**
- **Figure 17 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage F)**
- **Figure 18 – Conceptual Stormwater, Sediment and Erosion Control Measures, Pit Development (Stage G)**

Stormwater runoff from the overburden emplacement would be treated within a proposed new sediment basin (SB3b, see **Figure 11** to **Figure 18**) to be built downstream of the overburden emplacement area footprint. SB3b would need to be established prior to the commencement of Stage 2 Extension works (including the overburden emplacement) and has been designed in accordance with Table 6.1 of *Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries, NSW DECC, 2008*.

Stormwater runoff during the initial Stage 2 Extension establishment works (i.e. end of Stage 1) and Stage A would be treated within the existing sediment basin (SB3a) with overflows from SB3a discharged to the existing drainage gully and to SB3b. Therefore, SB3b would primarily function as a secondary treatment dam until Stage B of the Stage 2 Extension.

Using the same formula and conservative assumptions listed in **Section 3.2.2 Catchment Volumetric Runoff**, the minimum peak storage capacity of SB3b has been calculated as approximately 12.3 ML. The location and footprint of the proposed SB3b to provide this minimum capacity, along with associated SSEC management measures, are shown on **Figures 11** to **18**.

Flows generated within the proposed extraction area are to be managed using non-engineered sumps strategically located within the extraction area. The number and location of these sumps would vary between each stage of development of the extraction pit. The sumps have been provided to enable the quarry operator to effectively manage stormwater runoff, as well as dewater the extraction area as and when required.

See to **Figures 11** to **18** for location of the sumps and other SSEC management measures proposed for the staged extension of the extraction area.

5.3 SECONDARY PROCESSING AREA

Sediment laden runoff from the Secondary Processing Area is directed into SB1 through a series of existing stormwater conveyance structures (culverts, sub-surface drainage and catch drains) see Catchment J3 on **Figure 3 – Catchment Delineation Plan, Existing Operations**). Additionally, overflows from water storage dams SD3 and SD4 are also diverted to SB1 via a series of conveyance structures (culverts, sub-surface drainage and catch drains).

Water within SB1 is reused on-site for dust suppression of processing operations, hardstands and stockpiles. This involves the pumping of water on an as needs basis from SB1 via an existing pipeline to a 30kL above ground storage tank for the on-site water truck. As a result, the water level within SB1 is generally managed to maintain a minimum 2 m free board for stormwater control management, with excess water pumped via an existing piping system into SD1, SD2 and SD6 for temporary water storage and treatment prior to controlled discharge to Coxs River. When required, the water level within SB1 is supplemented for dust suppression by reversing the process (i.e. pumping water back from SD2 and SD6 into SB1).

Based on information received from RWC (Mr. Alex Irwin, 5 December 2013), SB1 has a total storage capacity of 6 ML. Calculated in accordance with Table 6.1 of *Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries, NSW DECC, 2008*, using the formula and assumptions listed in **Section 3.2.2 Catchment Volumetric Runoff**, the minimum design treatment and storage capacity of SB1 is 11 ML. Even considering the conservative method of calculating sediment storage requirement (50% of settling zone), this indicates that SB1 has insufficient treatment and storage capacity to treat flows generated by Catchment J3 (under 5-day 95th percentile rainfall conditions).

The additional storage volume (5 ML) could be provided by either expanding the footprint of the existing dam or by increasing the settling depth of SB1 either via excavation or building up the embankment of the dam. Internal review of this option by Hy-Tec has been completed, however, with these options considered unfeasible due to constraints imposed by available area and geotechnical (dam wall) stability requirements.

The short fall in the total storage capacity of SB1 (i.e. approximately 5 ML) is currently managed by pumping excess water to other dams (e.g. SD1, SD2 and SD6) that have excess storage capacity above their required design capacity (by approximately 12 ML). Provided it is demonstrated to be adequate and accepted by the Environmental Protection Authority (EPA), the Applicant would continue using this alternative water management strategy over enlarging SB1. The required free board within these basins would continue to be maintained by current management practice adopted of treating excess waters in-situ (i.e. by flocculation) prior to control release off-site into the adjacent waterways.

Additionally, it is recommended that the quarry operator consider the installation of a control valve on the existing pipe outlets of SB1 to enable the operator to minimise the potential for untreated and uncontrolled releases from SB1. Other SSEC management measures recommended for the processing, stockpiling and administration areas of the quarry are shown on **Figure 8 – Stormwater and ESC Measures, Administration, Processing and Stockpiling Area**.

5.4 STORAGE DAMS 1 AND 2

On-site personnel on 21 November 2013 advised that SD1 and SD2 were historically constructed by the land owner for use as farm dams (i.e. stock watering). Currently SD1 is used as a holding dam to recycle water between Sump 1 adjacent the primary crusher within the extraction area and SB1, while SD2 is used for water treatment of excess on-site waters from Sump 1 and SB1 prior to being released under controlled conditions. SD2 is generally empty unless in use tor water treatment.

SD1 also receives overland flow runoff from an upstream clean catchment area of approximately 2.3 ha. Overflows from SD1 are discharged over an existing embankment/grassed spillway to SD2. SD2 also receives runoff from an upstream clean catchment of 1.55 ha approximately.

Advice received from RWC (Mr. Alex Irwin, 5 December 2013), current storage volume of SD1 and SD2 is approximately 3.5 ML and 5 ML respectively. An assessment of required storage volumes in accordance with *Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries, NSW DECC, 2008* revealed that SD1 and SD2 require a minimum storage capacity of approximately 1.5 ML and 1 ML respectively. Based on the above preliminary assessment, SD1 and SD2 have sufficient storage capacity to treat flows from the upstream catchments and hence there is no additional works required to increase the storage capacity of these dams. Observations made on 20 November 2013 also confirmed that appropriate freeboard is being maintained within SD1 and SD2.

Other SSEC management measures recommended for SD1 and SD2 are shown on **Figure 6 – Stormwater, Sediment and Erosion Control Measures, Water Storage Dams and Coxs River Discharge**.

5.5 STORAGE DAMS 5 AND 6

SD5 and SD6 are located to the south of the quarry access road, on an ephemeral drainage gully discharging to Yorkeys Creek. SD5 receives runoff from a clean upstream catchment covering approximately 36 ha. Overflows from SD5 are discharged to SD6 over an existing embankment/grass spillway or siphoned via an existing pipe for supplementary water reuse on-site. In addition, SD6 also receives overland flows from a small, partially disturbed catchment, covering 3.1 ha which includes a small section of the quarry access road.

In addition, excess water from SB1 is pumped to SD6 for temporary storage. On an as needs basis, water is recycled between SD6 and SB1 in order to maintain an on-site water supply for dust suppression and as a means of reinstating freeboard within SB1 following rainfall events. Overflows from SD6 are discharged to Yorkeys Creek via an existing vegetated spillway and ultimately conveyed to Coxs River.

Advice received from RWC (Mr. Alex Irwin, 5 December 2013), current storage volume of SD5 and SD6 are approximately 4 ML and 8 ML respectively. An assessment of the minimum storage volumes in accordance with Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries (NSW DECC, 2008) revealed that SD5 and SD6 require a storage capacity of approximately 22.83 ML and 2 ML respectively. Based on the above preliminary assessment, SD6 has sufficient storage capacity to treat flows from the upstream catchments and hence there is no additional works required to increase the storage capacity of this dam. The capacity of SD5 would need to be increased by 18.83 ML, however, to comply.

As an alternative, as water collected in SD5 is from non-operational areas (i.e. clean catchment), any overflow from SD5 could be diverted around SD6 and discharged directly into Yorkeys Creek. This alternative solution is preferred and would be implemented by the Applicant.

SSEC management measures recommended for SD5 and SD6 are shown on **Figure 9 – Stormwater, Sediment and Erosion Control Measures, Yorkeys Creek Stockpiling Area.**

5.6 YORKEYS CREEK STOCKPILE AREA

The Yorkeys Creek Stockpile catchment mainly comprises an area approximately 6 ha in size. Stormwater runoff from a majority of the stockpile area is conveyed overland to a non-engineered sediment basin (SB2a) located in the north-eastern corner of the stockpile area. SB2a primarily functions as a sediment forebay and captures any coarse materials while overflows containing finer sediments are discharged to SB2b via an existing catch drain. SB2b also receives a lot of runoff carrying finer sediments produced by the existing steep batters of material stockpiles along the edge of the stockpile area. Low flows from SB2b are discharged via a 200 mm diameter outlet pipe while high flows are discharged over an existing spillway and embankment to Yorkeys Creek.

No information is available regarding the current storage capacity or depth of SB2b. Based on site observations and advice received from quarry personnel during the site visit undertaken by Groundwork Plus personnel (21 November 2013), SB2b was observed to have a total depth of approximately 2 to 3 m. Based on a surface area of 935 m² (sourced from aerial imagery) and assumed total depth of 3 m, SB2b is estimated to have a current treatment and storage capacity of approximately 2.8 ML. This estimated volume does not take into account batter slopes or freeboard.

The design storage capacity of SB2b was calculated in accordance with Table 6.1 of *Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries, NSW DECC, 2008* and using the formula and assumptions listed in **Section 3.2.2 Catchment Volumetric Runoff**. On the basis of the conservative assumptions with respect to runoff, the analysis found that SB2b should have a total storage capacity of approximately 4 ML. This includes a conservative allowance of 50% of the settling zone capacity for sediment storage.

While the calculation of minimum sediment basin design capacity is likely to overestimate the minimum capacity requirement, the calculation indicates that SB2b does not have adequate storage and treatment capacity to treat sediment laden water from existing Catchment K3. It is recommended that the storage capacity of SB2b be increased to achieve the required minimum design storage volume of 4 ML in accordance with *Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries, NSW DECC, 2008.* The additional storage volume can be provided by either increasing the footprint of SB2b or by raising the existing embankment and spillway.

Other SSEC management measures recommended for the Yorkeys Creek Stockpile Catchment including SB2b are shown on **Figure 10 – Stormwater and ESC Measures, Yorkeys Creek Stockpiling Area**.

6. WATER BALANCE ASSESSMENT

6.1 PURPOSE AND SCOPE OF WATER BALANCE ASSESSMENT

An MS-Excel based daily probabilistic Water Balance model was constructed to analyse potential discharges/annum from on-site storages, as well as dewatering rates from the proposed Stage 2 Extension of the extraction area. The Water Balance model was used to estimate the potential number and volume of discharges from onsite storages for the dry (15^{th} percentile) and wet (90^{th} percentile) rainfall scenarios. The climate data (rainfall and evaporation) used for the water balance assessment is summarised in **Section 3.1 Background Information and Catchment Mapping**.

6.2 HYDROGEOLOGICAL CONCEPTUAL MODEL

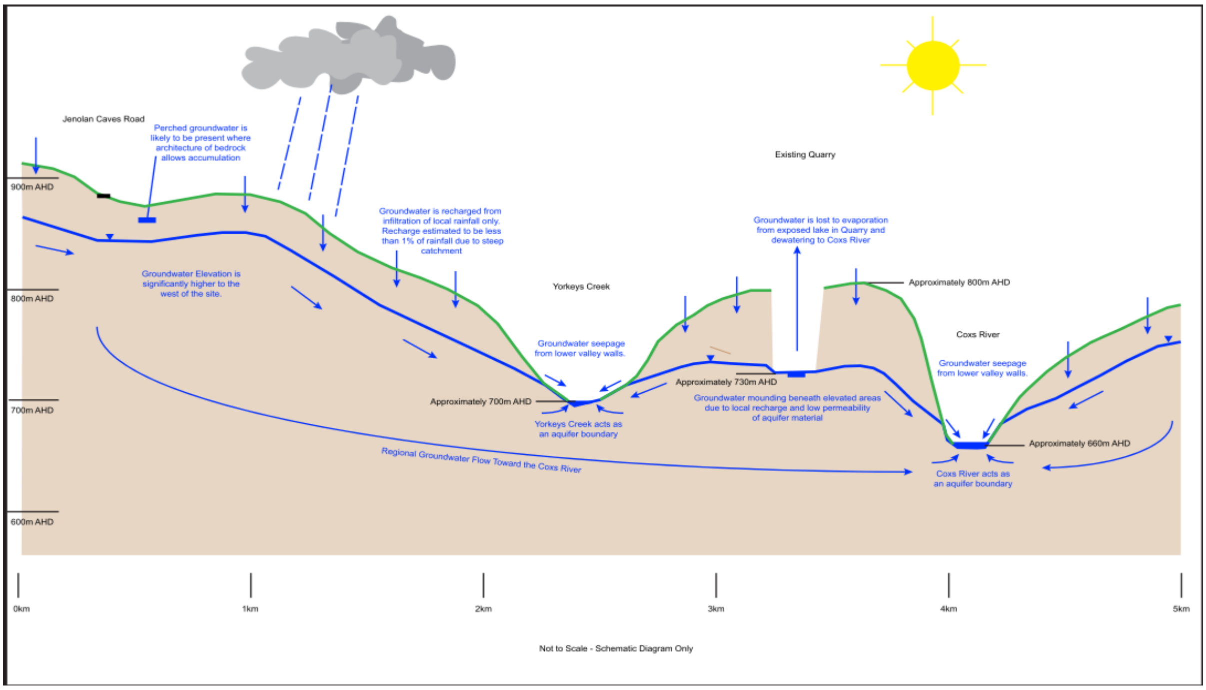
6.2.1 Existing Environment

The hydrogeological regime for the existing quarry is depicted in **Diagram 1 – Schematic of Conceptual Hydrogeological Model for the Existing Quarry** below. Groundwater beneath the Site is a mound as a result of recharge which occurs on the elevated areas of the Site and Surrounds. This water discharges into the surrounding valleys. This pattern is likely to occur across the local area beyond the Site, with local mounding of groundwater beneath elevated areas and discharge along drainage gullies and valleys. The Study Area is also likely to feature perched groundwater units where favourable architecture in bedrock allows local accumulations of rainwater infiltration above the regional water table. The valleys between elevated areas form boundaries which limit lateral movement of groundwater (Ground Doctor, 2014).

The Site is comprised of steep rocky slopes and rocky plateaus of limited area. It is expected that most rain falling within the Site would be lost to evaporation or would flow into surrounding gullies as surface runoff. Only a small portion of rainfall (less than 1%) would infiltrate the underlying fractured rock and become groundwater. The volume of rainfall infiltrating the subsurface would be offset by the volume of groundwater discharge occurring from the lower slopes or into the quarry. Groundwater discharge from the vicinity of the Site would drain into Coxs River (either directly or indirectly).

The findings of the Ground Water Assessment (Ground Doctor, 2014) have revealed that groundwater was encountered at a depth of 730 m AHD during the on-site investigation.

Diagram 1 – Schematic of Conceptual Hydrogeological Model for the Existing Quarry



Source: Draft Preliminary Groundwater Assessment –Austen Quarry Stage 2, Ground Doctor Pty Ltd, August 2013

6.2.2 Stage 2 Extension

The hydrogeological regime for Stage 2 Extension is depicted in **Diagram 2 – Schematic of Conceptual** Hydrogeological Model for Stage 2 Extension.

The main change to the groundwater regime at the Site would occur as a result of the need to lower the water table within the extraction area. The proposed Stage 2 Extension would result in extraction to a depth of approximately 685m AHD (some 45m below the current groundwater elevation). The average groundwater seepage rate over the life of the project has been predicted to be 4.3 ML/year (Groundwater Doctor 2014).

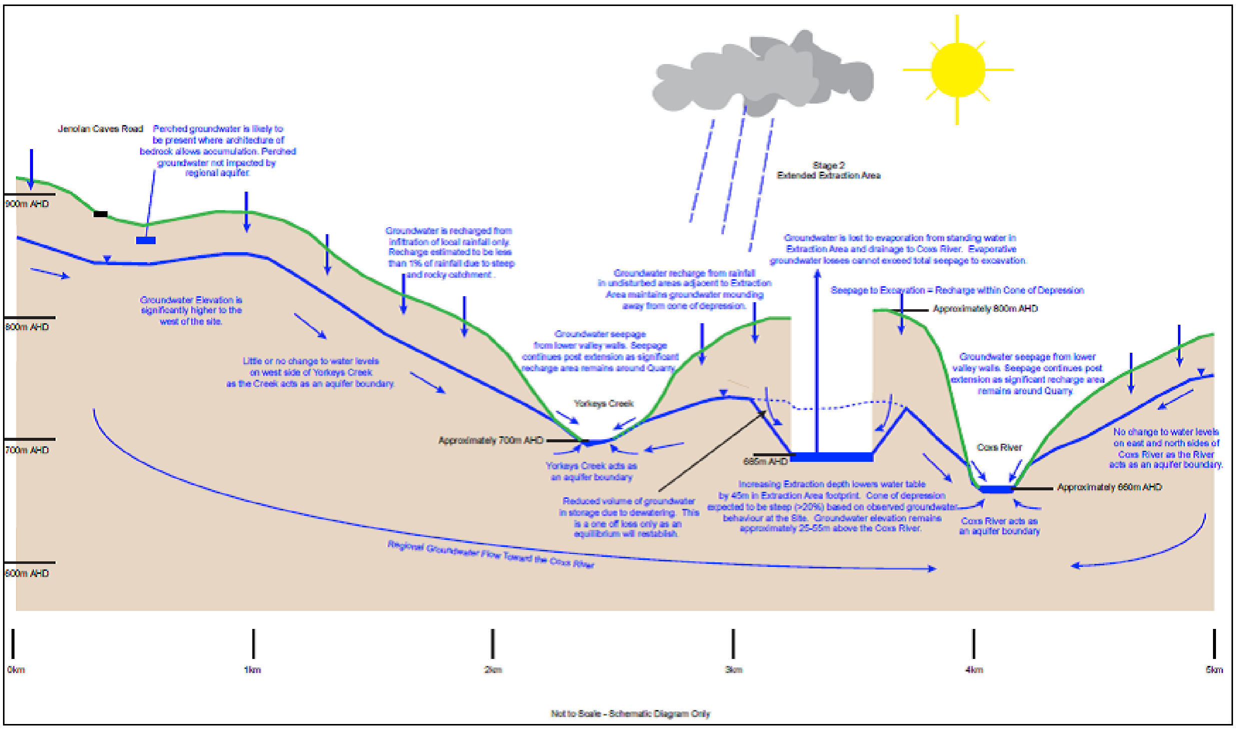
During and following extraction, a portion of the groundwater within the rhyolite hosted aquifer surrounding the extraction area would flow towards and seep into the extraction area. This is removed from the extraction area, along with accumulated surface water runoff by mechanical pumping of water from the extraction area or by gravity draining water from the extraction area to surrounding low lying areas. Some water would also be lost from the extraction area to evaporation. Ground Doctor (2014) describes this as a permanent drainage of groundwater from the aquifer within the surrounding zone of influence (cone of depression). The seepage of groundwater into the extraction area would result in the establishment of a new post-extraction SWL around the perimeter of the extraction area floor (at an elevation of approximately 685m AHD).

Once the drainage of groundwater from the cone of depression is complete, the water balance would return to pre-quarry conditions where the volume of rainfall infiltration is equal to the volume of groundwater discharge into the adjacent drains. A portion of this recharge which occurs over the cone of depression resultant from the extraction area would drain to the extraction area (and is referred to hereafter as the 'seepage' component of groundwater loss). As a result, during periods of higher infiltration, e.g. periods of heavy or sustained rainfall, groundwater seepage into the void of the final extraction area would be higher (as it would in other drains surrounding the extraction area) than during periods of low rainfall. Assuming groundwater inflow to the extraction area is redirected to the Coxs River there would be no significant long term change to the site water balance as a result of the proposed Stage 2 Extension. The only loss of water associated with the extension would be from the initial dewatering above and adjacent to the Quarry.

Elevated areas would remain around the periphery of the extraction area and groundwater recharge would still occur in these areas as it does at present. Groundwater mounding is expected to occur in the untouched areas adjacent to the extraction area and groundwater within the fractured rock adjacent to the Quarry would be expected to continue to discharge into the extraction area and into surrounding valleys.

Lowering of the water table within and surrounding the extraction area would result in a general lowering of the water table in the elevated area surrounding the Site. However, lowering of the water table beneath the extraction area is not expected to impact on areas to the west of Yorkeys Creek, to the north and east of the Coxs River and to the south of the unnamed drainage south of the Site, as these topographic features act as physical aquifer boundaries (Ground Doctor, 2014).

Diagram 2 – Schematic of Conceptual Hydrogeological Model for Stage 2 Extension of the Quarry



Source: Groundwater Assessment – Austen Quarry Stage 2, Ground Doctor Pty Ltd, August 2013

6.3 WATER BALANCE MODEL ASSUMPTIONS AND METHODOLOGY

For the purposes modelling, the following general assumptions have been made for the Site and have been applied to water balance assessments conducted for the extraction area and various other existing and proposed water storages on–site.

- Inflows can be segregated into 1) direct rainfall, 2) overland flow, 3) water moved/recycled between various on-site water storages and 4) groundwater seepage. Overland flow is assumed to be a set ratio of rainfall amounts (annual runoff coefficient) depending on land type (bare or vegetated).
- Dewatering rates adopted for the Water Balance model has been based on the existing physical capacity of the on-site water infrastructure, on-site water treatment methodology and the number of predicted suitable days for water treatment (i.e. periods of fine weather ≥ 3 days).
- Outflows are; 1) direct evaporation from the inundated extraction area/water storage (including sediment basins), 2) dewatering flows from the extraction area, 3) controlled and/or uncontrolled discharges from site water storages 4) water harvesting and reuse onsite and 5) water moved/recycled between water storages onsite to maintain freeboard. Evaporation from the land surface is not considered.
- Water from the extraction area and SB1 is reused on site for dust suppression only (in accordance with advice received from Quarry personnel, Groundwork Plus Site Assessment – 21 November 2013). In accordance with advice received from quarry personnel during the site assessment conducted by Groundwork Plus personnel on 21 November 2013, the daily dust suppression demand from SB1 has been assumed to be approximately 78 kL. This has been calculated based on the assumption that a water truck (with a storage capacity of 13 kL) is topped up with water at least 6 times during the course of an operational shift.
- Water reuse also includes topping up water from the extraction area sump to an existing 100 kL tank located adjacent to the primary crusher within the extraction area. For the purpose of modelling and in accordance with advice received from quarry personnel during the Groundwork Plus site assessment, the water use demand from the extraction area for the purpose of topping up the 100 kL tank has been assumed to be 200 kL/week for the current and all future stages of extension.
- It has been assumed that dust suppression is not undertaken on rain days with a precipitation depth of more than 10 mm of rainfall.
- The water balance does not take into account any additional storage that may be provided by sumps and drop cuts.
- The soil group has been assumed to be Group C Loamy Clay for areas within the extraction area that have not been subject to extraction including the other developed and undeveloped catchments of the Site. In accordance with Table B7 of the IECA Guidelines, single storm event runoff coefficients ranging between 0.09 and 0.75 have been used in the model to calculate daily runoff volumes from these areas.

Additionally, Groundwork Plus has undertaken an analysis of daily rainfall observations sourced from the Bureau of Meteorology (BoM) website for the synoptic station Lowther Park (Station no. 063049). The data from this station was used to estimate rainfall statistics to model the water balance for the dry (15th percentile) and wet (90th percentile) scenarios. See **Table 3 – 15th and 90th Percentile Rainfall Statistics** and **Graph 1 – 15th and 90th Percentile Monthly Rainfall** of **section 2.1.1 Rainfall** for the estimated rainfall statistics.

As part of the climate analysis, mean daily evaporation rates sourced from the synoptic weather station Bathurst Agricultural Station (Station no. 063005) have been used to estimate mean monthly evaporation rates and these have been applied in the water balance assessment. The mean daily and mean monthly evaporation rates are summarised in **Table 4 – Mean Daily and Monthly Pan Evaporation Rates for Bathurst Agricultural Station** and graphically represented in **Graph 2 – Mean Monthly Pan Evaporation (Bathurst Agricultural Station)** of **section 2.1.2 Evaporation**.

6.4 EXTRACTION AREA WATER BALANCE

6.4.1 Scenario 1 – No Dewatering of the Extraction Area

A water balance assessment was conducted to determine the predicted standing water levels of the extraction area for the current and future development of the extraction area and associated facilities. Modelling was undertaken for the dry (15th percentile) and the wet (90th percentile) rainfall years. For the purpose of modelling, the following assumptions have been made:

- Inflows are segregated into; 1) direct rainfall, 2) overland flow and 3) groundwater seepage at an average rate of 0.0057 ML/day. Overland flow is assumed to be a set ratio of rainfall amounts (annual runoff coefficient) depending on land type (bare or vegetated).
- Outflows are; 1) direct evaporation from the inundated extraction area/water storage, 2) supplementary water supply to SB1 and 3) water harvesting and reuse onsite at an average rate of 0.028 ML/day if volume is available. Evaporation from the land surface is not considered.
- Water from the extraction area is reused on-site for dust suppression which includes topping up water from the pit to an existing 100 kL tank located adjacent to the primary crusher within the extraction area. For the purpose of modelling and in accordance with advice received from quarry personnel during the Groundwork Plus site assessment, the water use demand from the extraction area for the purpose of topping up the 100 kL tank has been assumed to be 200 kL/week for the current and all future stages of the quarry extension.
- The residual/standing water level of the extraction area has been assumed to be zero (0) for the current year.
- The standing water level on the last day of the modelled dry and wet years have been assumed to the starting water depth/level for each succeeding year/stage of the Stage 2 Extension.
- The water balance does not take into account the additional storage that may be provided by sump/s or drop cuts.

Water balance assessments were undertaken assuming extreme climatic scenarios of 35 consecutive years of dry and wet climatic conditions (i.e. 15th and 90th percentile rainfall respectively). The summary findings of these assessments are shown in **Table 18 – Extraction Area Water Balance Assessment for Prolonged Dry Climatic Conditions with No Dewatering** and **Table 19 – Extraction Area Water Balance Assessment for Prolonged Wet Climatic Conditions with No Dewatering**.

Table 18 – Extraction Area Water Balance Assessment for Prolonged Dry Climate Conditions with No Dewatering

Water Storage	Stage of Quarry Development	Estimated Extraction Area Storage Capacity (ML)	Predicted Frequency and Volume of Uncontrolled Discharges		Supplementary flows discharged from Extraction Area to SB1 (ML)	Residual Volume (ML)
			Frequency (Number)	Volume (ML)		
Extraction Area	Current	1,175	0	0	11.0	3.3
	End of Stage 1	1,175	0	0	10.9	3.4
	A	1,342	0	0	11.8	5.0
	B	1,342	0	0	11.8	8.1
	C	1,424	0	0	11.8	16.4
	D	1,803	0	0	11.8	29.5
	E	3,325	0	0	11.8	22.5
	F	572	0	0	11.3	15.1
	G	3,231	0	0	11.8	22.7

Table 19 – Extraction Area Water Balance Assessment for Prolonged Wet Climate Conditions with No Dewatering

Water Storage	Stage of Quarry Development	Estimated Extraction Area Storage Capacity (ML)	Predicted Frequency and Volume of Uncontrolled Discharges		Supplementary flows discharged from Extraction Area to SB1 (ML)	Residual Volume (ML)
			Frequency (Number)	Volume (ML)		
Extraction Area	Current	1,175	0	0	17.0	34.0
	End of Stage 1	1,175	0	0	8.1	64.7
	A	1,342	0	0	8.1	99.8
	B	1,342	0	0	8.1	139.3
	C	1,424	0	0	8.1	257.6
	D	1,803	0	0	8.1	460.2
	E	3,325	0	0	8.1	834.5
	F	572	0	0	8.1	420.1
	G	3,231	0	0	8.1	187.6

The modelling predicted that the extraction area will have adequate storage capacity to contain flows within the extraction area for all Stages (estimated Year 35) under prolonged wet climatic conditions. Given the nature of the extraction area, flooding of the extraction area would eventually disrupt the day to day operations of the quarry, therefore hinder quarry production rates.

Existing dewatering infrastructure (i.e. extraction area sump (sump 1) and gravity fed low flow control pipes to SB1, and SD1 and SD2, provides the capability to dewater the extraction area and transfer water from sump 1 to SB1, and SD1 and SD2 respectively. The predicted maximum daily dewatering rate of 1,900 kL/day has been calculated for each existing gravity fed low flow control pipe (i.e. two gravity fed low flow control pipelines at 950 kL/day/each) based on the assumption that the pit can be dewatered using the existing infrastructure for a maximum of 8 hours during a normal operational day at an estimated gravitational flow rate of 0.033L/s.

6.4.2 Scenario 2 – Dewatering of Extraction Area to SD1 and SD2

A water balance assessment was conducted to determine predicted dewatering rates to dewater the extraction area with water discharged to SD1 and SD2. The assessment also predicted estimated standing water levels of the extraction area for the current and future development of the extraction area and associated facilities. Modelling was undertaken for the dry (15th percentile) and the wet (90th percentile) rainfall years. For the purpose of modelling, the following assumptions have been made:

- Inflows are segregated into; 1) direct rainfall, 2) overland flow, and 3) groundwater seepage. Overland flow is assumed to be a set ratio of rainfall amounts (annual runoff coefficient) depending on land type (bare or vegetated).
- Outflows are; 1) direct evaporation from the inundated extraction area 2) Supplementary water supply to SB1; 3) water harvesting and reuse onsite and 4) dewatering of pit inundated water to SD1 and SD2. Evaporation from the land surface is not considered.
- Water from the extraction area is reused on-site for dust suppression which includes topping up water from the extraction area to an existing 100 kL tank located adjacent to the primary crusher within the extraction area. For the purpose of modelling and in accordance with advice received from quarry personnel during the Groundwork Plus site assessment, the water use demand from the quarry pit for the purpose of topping up the 100 kL tank has been assumed to be 200 kL/week for the current and all future stages of the quarry extension.
- The residual/standing water level of the extraction area has been assumed to be zero (0) for the current year.
- The standing water level on the last day of the modelled dry and wet years have been assumed to the starting water depth/level for each succeeding year/stage of the Stage 2 Extension Project.
- The predicted maximum possible daily extraction area dewatering rate has been estimated to be 950 kL/pipe line. This rate has been calculated based on the assumption that Sump 1 in the pit can be dewatered for a maximum of 8 hrs/day at an estimated peak gravitational flow rate of 0.033L/s.
- The maximum required dewatering rate to completely dewater the extraction area is dependant the physical capacity of the existing water infrastructure, standing water levels of SD1 and SD2 and prevailing climatic conditions to undertake water treatment using existing on-site methodology.
- The water balance does not take into account the additional storage that may be provided by a quarry sump/s or drop cuts.

Water balance assessments were undertaken assuming extreme climatic scenarios of 35 consecutive years of dry and wet climatic conditions (i.e. 15th and 90th percentile rainfall respectively). The summary findings of these assessments are shown in **Table 20 – Extraction Area Water Balance Assessment for Prolonged Dry Climatic Conditions with Dewatering** and **Table 21 – Extraction Area Water Balance Assessment for Prolonged Wet Climatic Conditions with Dewatering**.

Table 20 – Extraction Area Water Balance Assessment for Prolonged Dry Climatic Conditions with Dewatering

Water Storage	Stage of Quarry Development	Estimated Storage Capacity (ML)	Predicted Frequency and Volume of Uncontrolled Discharges		Predicted Volume of Controlled Discharges to SD1/SD2 (ML)	Supplementary flows discharged from to SB1 (ML)	Required Average Daily Pumping rate to Dewater (ML/day)	Residual Volume (ML)
			Frequency (Number)	Volume (ML)				
Extraction Area	Current	1,175	0	0	3.3	11.0	0.011	0
	End of Stage 1	1,175	0	0	3.3	10.9	0.011	0
	A	1,342	0	0	5.0	11.8	0.017	0
	B	1,342	0	0	7.1	11.8	0.024	0
	C	1,424	0	0	7.1	11.8	0.024	0
	D	1,803	0	0	10.1	11.8	0.034	0
	E	3,325	0	0	0	11.8	0	0
	F	572	0	0	15.1	11.3	0.051	0
	G	3,231	0	0	0	11.8	0	0

Table 21 – Extraction Area Water Balance Assessment for Prolonged Wet Climatic Conditions with Dewatering

Water Storage	Stage of Quarry Development	Estimated Storage Capacity (ML)	Predicted Frequency and Volume of Uncontrolled Discharges		Predicted Volume of Controlled Discharges to SD1/SD2 (ML)	Supplementary flows discharged to SB1 (ML)	Required Average Daily Pumping rate to Dewater (ML/day)	Residual Volume (ML)
			Frequency (Number)	Volume (ML)				
Extraction Area	Current	1,175	0	0	34.1	16.9	0.123	0
	End of Stage 1	1,175	0	0	43.2	8.1	0.150	0
	A	1,342	0	0	46.9	8.1	0.163	0
	B	1,342	0	0	37.2	8.1	0.120	0
	C	1,424	0	0	55.3	8.1	0.192	0
	D	1,803	0	0	65.1	8.1	0.266	0
	E	3,325	0	0	33.4	8.1	0.139	0
	F	572	0	0	37.0	8.1	0.154	0
	G	3,231	0	0	37.9	8.1	0.154	0

The modelling indicated no uncontrolled discharges would occur with regular dewatering of the extraction area. Predicted daily average pumping rates required to dewater the extraction area for all years of pit development range between 0 to 1.13 ML/day, which is well below the existing water management drainage infrastructure's maximum capacity of 1.9 ML/day (i.e. 2 pipelines at 950 KL/day/each).

6.5 STORAGE DAMS 1 AND 2

6.5.1 Scenario 1 - Water Balance of SD1 and SD2

Water balance assessments were conducted to investigate the potential frequency and volume of controlled and uncontrolled discharges to Coxs River from the existing storage dams SD1 and SD2. The assessments were conducted assuming extreme climatic scenarios of 35 consecutive years of dry and wet climatic conditions (i.e. 15th and 90th percentile rainfall respectively).

The following additional assumptions were made in the water balance assessments:

- Extraction Area is not dewatered using the existing infrastructure.
- Inflows to SD1 and SD2 are segregated into 1) direct rainfall and 2) overland flow. Overland flow is assumed to be a set ratio of rainfall amounts (annual runoff coefficient) depending on land type (bare or vegetated).
- Outflows are; 1) direct evaporation from the inundated water storage and 2) uncontrolled discharges from SD1 and SD2. Evaporation from the land surface and stock watering is not considered.

The summary findings of these assessments are shown in **Table 22 – Water Balance Assessment for SD1 and SD2 for Prolonged Dry Climatic Conditions** and **Table 23 – Water Balance Assessment for SD1 and SD2 for Prolonged Wet Climatic Conditions**.

Modelling indicated that SD2 would receive approximately 2.42 ML/annum and 104.8 ML/annum of overflows respectively from SD1 for the prolonged continuous dry and wet climatic scenario respectively. Modelling also indicated that SD2 currently has sufficient capacity to receive overflows from SD1 and would not result in uncontrolled discharges to Coxs River for the prolonged dry climatic conditions scenario.

However, during a prolonged wet climatic conditions scenario, modelling has predicted that SD2 would generate approximately 104.3 ML of uncontrolled discharges to Coxs River.

It is understood that the current water management regime uses SD1 and SD2 to treat excess pit water and water captured in SB1 when capacity below the required freeboard is available within SD1 and SD2. A water balance assessment covering this scenario has therefore been undertaken to assess the predicted frequency and volume of controlled and uncontrolled discharges to Coxs River, see to **Section 6.5.2 Scenario 2 Water Balance of SD1 and SD2 receiving Dewatered Flows from Extraction Area**.

Table 22 – Water Balance Assessment for SD1 and SD2 for Prolonged Dry Climatic Conditions

Water Storage	Stage of Quarry Development	Predicted Uncontrolled Discharge Frequency	Predicted Uncontrolled Discharge Volume (ML)
SD1	Current	39	2.42
	End of Stage 1		
	A		
	B		
	C		
	D		
	E		
	F		
	G		
SD2	Current	0	0
	End of Stage 1		
	A		
	B		
	C		
	D		
	E		
	F		
	G		

Table 23 – Water Balance Assessment for SD1 and SD2 for Prolonged Wet Climatic Conditions

Water Storage	Stage of Quarry Development	Predicted Uncontrolled Discharge Frequency	Predicted Uncontrolled Discharge Volume (ML)
SD1	Current	84	10.5
	End of Stage 1		
	A		
	B		
	C		
	D		
	E		
	F		
	G		
SD2	Current	30	10.4
	End of Stage 1		
	A		
	B		
	C		
	D		
	E		
	F		
	G		

6.5.2 Scenario 2 - Water Balance of SD1 and SD2 receiving Dewatered Flows from Extraction Area

Water balance assessments were conducted to investigate the potential frequency and volume of controlled and uncontrolled discharges to Coxs River from the existing water storage dams SD1 and SD2, receiving dewatered flows form the extraction area. The assessments were conducted assuming extreme climatic scenarios of 35 consecutive years of dry and wet climatic conditions (i.e. 15^{th} and 90^{th} percentile rainfall respectively).

The following additional assumptions were made in the water balance assessments:

- For ease of modelling, the storage volumes of SD1 and SD2 have been combined.
- Inflows to SD1 and SD2 are segregated into 1) direct rainfall 2) overland flow 3) dewatered flows from the extraction area and 4) Flows pumped from SB1 to SD1 and SD2 as required to maintain freeboard within SB1. Overland flow is assumed to be a set ratio of rainfall amounts (annual runoff coefficient) depending on land type (bare or vegetated).
- Outflows are; 1) direct evaporation from the inundated water storage and 2) uncontrolled discharges from SD1 and SD2. Evaporation from the land surface and stock watering is not considered.

The summary findings of these assessments are shown in **Table 24 – Water Balance Assessment for SD1 and SD2 receiving Dewatered Flows from Extraction Area for Prolonged Dry Climatic Conditions** and **Table 25** – **Water Balance Assessment for SD1 and SD2 receiving Dewatered Flows from Extraction Area for Prolonged Wet Climatic Conditions**.

Table 24 – Water Balance Assessment for SD1 and SD2 receiving Dewatered Flows from Extraction Area for Prolonged Dry Climatic Conditions

Water Storage	Stage of Quarry Development	Predicted Uncontrolled Discharge Frequency	Predicted Uncontrolled Discharge Volume (ML)	Predicted Controlled Discharge Volume (ML)
SD1 and SD2	Current	0	0	10.2
	End of Stage 1	0	0	10.2
	A	0	0	11.8
	B	0	0	13.8
	C	0	0	13.8
	D	0	0	16.8
	E	0	0	7.5
	F	0	0	21.8
	G	0	0	7.5

Table 25 – Water Balance Assessment for SD1 and SD2 receiving Dewatered Flows from Extraction Area for Prolonged Wet Climatic Conditions

Water Storage	Stage of Quarry Development	Predicted Uncontrolled Discharge Frequency	Predicted Uncontrolled Discharge Volume (ML)	Predicted Controlled Discharge Volume (ML)
SD1 and SD2	Current	0	0	42.6
	End of Stage 1	0	0	51.6
	A	0	0	55.3
	B	0	0	37.2
	C	0	0	63.7
	D	0	0	73.5
	E	0	0	41.8
	F	0	0	45.4
	G	0	0	45.4

The modelling indicated no uncontrolled discharges would occur from SD1 and SD2 during the prolonged dry and wet climatic scenarios. Treated and controlled discharges from SD2 would be undertaken by quarry personnel as soon as practicable following a storm event. The annual volume of controlled discharges from SD2 for the prolonged dry and wet climatic scenarios is summarised in **Table 24 – Water Balance Assessment for SD1 and SD2 Receiving Dewatered Flows from Extraction Area for Prolonged Dry Climatic Conditions** and **Table 25** – **Water Balance Assessment for SD1 and SD2 Receiving Dewatered Flows from Extraction Area for Prolonged Wet Climatic Conditions**.

The volume of water in SD2 to be treated and discharged can be reduced by diverting clean overland runoff to SD1 and SD2 which will maximise the storage capacity and hence reduce volume of discharges, see **Section 6.5.3 Scenario 3 – Water Balance of SD1 and SD2 Receiving Dewatered Flows from Extraction Area with catchment runoff diverted around SD1 and SD2** for details.

6.5.3 Scenario 3 - Water Balance of SD1 and SD2 Receiving Dewatered Flows from Extraction Area with catchment runoff diverted around SD1 and SD2

The Water Balance Assessments for the prolonged dry and wet climatic scenarios constructed for Scenario 2 (see **Section 6.5.2 Scenario 2 – Water Balance of SD1 and SD2 Receiving Dewatered Flows from Extraction Area**) was rerun with the assumption that the clean catchment runoff is diverted around SD1 and SD2. The results of these assessments are summarised in **Table 26 – Water Balance Assessment of SD1 and SD2 for Prolonged Dry Climatic Conditions receiving Pit Flows with Clean Runoff Diverted to Coxs River** and **Table 27 – Water Balance Assessment of SD1 and SD2 for Prolonged Wet Climatic Conditions Receiving Extraction Area Flows with Clean Runoff Diverted to Coxs River**.

Table 26 – Water Balance Assessment for SD1 and SD2 for Prolonged Dry Climatic Conditions Receiving Extraction Area Flows with Clean Runoff Diverted to Coxs River

Water Storage	Stage of Quarry Development	Predicted Uncontrolled Discharge Frequency	Predicted Uncontrolled Discharge Volume (ML)	Predicted Controlled Discharge Volume (ML)
SD1 and SD2	Current	0	0	4.9
	End of Stage 1	0	0	4.9
	A	0	0	6.4
	B	0	0	8.3
	C	0	0	8.3
	D	0	0	11.3
	E	0	0	1.9
	F	0	0	16.3
	G	0	0	2.2

Table 27 – Water Balance Assessment for SD1 and SD2 for Prolonged Wet Climatic Conditions Receiving Extraction Area Flows with Clean Runoff Diverted to Coxs River

Water Storage	Stage of Quarry Development	Predicted Uncontrolled Discharge Frequency	Predicted Uncontrolled Discharge Volume (ML)	Predicted Controlled Discharge Volume (ML)
SD1 and SD2	Current	0	0	34.6
	End of Stage 1	0	0	43.6
	A	0	0	46.9
	B	0	0	29.2
	C	0	0	55.7
	D	0	0	65.5
	E	0	0	33.8
	F	0	0	37.4
	G	0	0	37.6

Modelling has predicted that the annual volume of controlled discharges from SD2 for the prolonged dry and wet climatic scenarios would be significantly reduced (i.e. a median reduction of approximately 46 percent during a dry year and approximately 17 percent during a wet year).

6.6 SEDIMENT BASIN 3B

A water balance assessment was conducted to investigate the potential frequency of uncontrolled release to Coxs River from the proposed sediment basin 3b (SB3b) designed to receive and treat stormwater runoff generated by the proposed overburden emplacement. The assessment was conducted for a dry (15^{th} percentile) and wet (90^{th} percentile) rainfall year, using rainfall and evaporation data summarised in **Section 2.1.2 Rainfall** and **Section 2.1.3 Evaporation** of this report.

The water balance model for SB3b has been built based on the following assumptions:

- The storage volume of SB3b has been designed to treat runoff generated by the Year 35 footprint of the proposed overburden emplacement (i.e. peak storage capacity of 12.3 ML).
- SB3b will be constructed prior to the start of quarry and overburden emplacement extension works.

- Inflows can be segregated into; 1) direct rainfall and 2) overland flow. Overland flow is assumed to be a set ratio of rainfall amounts (annual runoff coefficient) depending on land type (bare or vegetated).
- Outflows are; 1) direct evaporation from the inundated water storage, 2) controlled discharge of treated waters within 72 hours of a rainfall event, 3) uncontrolled discharges from site water. Evaporation from the land surface is not considered.

The findings of the water balance assessment for SB3b for a dry and wet rainfall year are summarised in **Table 28 - Findings of Water Balance Assessment – Proposed SB3b, Overburden Emplacement** below.

Table 28 – Findings of Water Balance Assessment – Proposed SB3b, Overburden Emplacement

Water Storage	Rainfall Scenario	Stage of Quarry Development	Predicted Frequency of Treated / Controlled Discharges (per annum)	Predicted Total Estimated Treated Volume Discharged (ML)	Predicted Frequency of Uncontrolled Discharges (days per annum)	Predicted Total Estimated Volume Discharged (ML)
SB3b	Dry Rainfall Year (15th Percentile)	Year 0 – Year 35	17	29.8	-	-
	Wet Rainfall Year (90th Percentile)		22	63	3	1.4

No uncontrolled discharges are predicted from SB3b during a modelled dry rainfall year, provided controlled discharges are regularly carried out following rainfall events. To prevent uncontrolled discharge events from occurring, it is estimated that 17 control discharge events, with a total of approximately 30 ML of treated water discharged to the existing drainage line and ultimately to Coxs River, will be required.

Even with regular controlled discharges (i.e. 22 controlled discharge events with a total of approximately 63 ML of treated water discharged), modelling predicts that uncontrolled discharges will occur at least once per annum at SB3b over a duration of 3 days, during a wet rainfall year, with approximately 1.4 ML of water discharged to the existing drainage line and ultimately to Coxs River. It is noted that this is as expected when considering the guidance provided by Table 6.1 of Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries (NSW DECC, 2008).

6.7 SEDIMENT BASIN 1

6.7.1 Scenario 1 – Water Balance of SB1 with no Water Management

Water balance assessments were conducted to investigate the potential frequency and volume of uncontrolled discharges from SB1 to Coxs River assuming 35 consecutive years of prolonged dry (15^{th} percentile rainfall) and wet (90^{th} percentile rainfall) climatic conditions based on its current total storage capacity of 6 ML.

Scenario 1 for SB1 has been built based on the following assumptions:

- Inflows can be segregated into 1) direct rainfall 2) overland flow and 3) uncontrolled discharges from the overtopping of SD3 and SD4. Overland flow is assumed to be a set ratio of rainfall amounts (annual runoff coefficient) depending on land type (bare or vegetated).
- Minimum freeboard of 2 m or 2.34 ML is to be maintained within SB1 at all times in order to receive overland flow from the administration, processing and stockpiling areas.
- Outflows are; 1) direct evaporation from the inundated water storage, 2) extraction of water for dust suppression, and 3) uncontrolled discharges.
- Evaporation from the land surface is not considered.
- In accordance with advice received from quarry personnel during the site assessment conducted by Groundwork Plus personnel on 21 November 2013, the daily dust suppression demand from SB1 has been assumed to be approximately 78 kL. This has been calculated based on the assumption that a water truck (with a storage capacity of 13 kL) is topped up with water at least 6 times during the course of an operational shift.
- It has been assumed that dust suppression is not undertaken on rain days with a precipitation depth of more than 10 mm of rainfall.

The summary findings of these assessments are shown in **Table 29 – Water Balance Assessment of SB1 for Prolonged Dry Climatic Conditions** and **Table 30 – Water Balance Assessment of SB1 for Prolonged Wet Climatic Conditions**.

Table 29 – Water Balance Assessment of SB1 for Prolonged Dry Climatic Conditions

Water Storage	Stage of Quarry Development	Predicted Frequency of Potential Uncontrolled Discharges (per annum)	Predicted Annual Estimated Volume Discharged to Coxs River (ML)
SB1	Current	10	38.0
	End of Stage 1	10	38.0
	A		
	B		
	C		
	D		
	E		
	F		
	G		

Table 30 –Water Balance Assessment of SB1 for Prolonged Wet Climatic Conditions

Water Storage	Stage of Quarry Development	Predicted Frequency of Potential Uncontrolled Discharges (per annum)	Predicted Annual Estimated Volume Discharged to Coxs River (ML)
SB1	Current	23	102.3
	End of Stage 1	23	102.3
	A		
	B		
	C		
	D		
	E		
	F		
	G		

Modelling predicts that SB1 will have approximately 10 and 23 uncontrolled discharges, totalling 38.0 ML and 102.3 ML for the current dry and wet climatic scenarios respectively. The annual volume of uncontrolled discharges from SD2 to Coxs River is predicted to remain unchanged with Stage 2 Extension as shown in **Table 29 – Water Balance Assessment of SB1 for Prolonged Dry Climatic Conditions** and **Table 30 – Water Balance Assessment of SB1 for Prolonged Wet Climatic Conditions**.

However, SB1 is currently part of the on-site water management system that allows excess water to be transferred to and from SD1 and SD2, and SD6 via existing stormwater drainage infrastructures in the form of hydraulic pumps and flow control pipes in order to reinstate or maintain freeboard within SB1, hence minimise the frequency of uncontrolled discharges.

6.7.2 Scenario 2 – Water Balance of SB1 with Water Management

Water balance assessments were conducted to investigate the potential frequency and volume of uncontrolled discharges from SB1 to Coxs River assuming 35 consecutive years of prolonged dry (15^{th} percentile rainfall) and wet (90^{th} percentile rainfall) climatic conditions under the current water management regime. Scenario 2 for SB1 has been built based on the following assumptions:

- SB1 current total storage capacity volume of 6 ML.
- Inflows can be segregated into 1) direct rainfall 2) overland flow 3) water recycled from SD2 4) flows dewatered from extraction area using existing water management infrastructure in; the form of sump and gravity fed control pipeline and 5) water moved from SD6 as required. Overland flow is assumed to be a set ratio of rainfall amounts (annual runoff coefficient) depending on land type (bare or vegetated).
- Minimum freeboard of 2m or 2.34 ML is to be maintained within SB1 at all times in order to receive overland flow from the administration, processing and stockpiling areas.
- Outflows are; 1) direct evaporation from the inundated water storage, 2) extraction of water for dust suppression, 3) water moved from SB1 to SD6 and/or SD1/SD2 as and when required to reinstate freeboard within SB1. Evaporation from the land surface is not considered.

- In accordance with advice received from quarry personnel during the site assessment conducted by Groundwork Plus personnel on 21 November 2013, the daily dust suppression demand from SB1 has been assumed to be approximately 78 kL. This has been calculated based on the assumption that a water truck (with a storage capacity of 13 kL) is topped up with water at least 6 times during the course of an operational shift.
- It has been assumed that dust suppression is not undertaken on rain days with a precipitation depth of more than 10 mm of rainfall.

The summary findings of these assessments are shown in **Table 31 – Water Balance Assessment of SB1 for Prolonged Dry Climatic Conditions with On-site Water Management** and **Table 32 – Water Balance Assessment of SB1 for Prolonged Wet Climatic Conditions with On-site Water Management**.

Table 31 – Water Balance Assessment of SB1 for Prolonged Dry Climatic Conditions with On-site Water Management

Water Storage	Stage of Quarry Development	Predicted Frequency of Potential Uncontrolled Discharges (per annum)	Predicted Annual Estimated Volume Discharged to Coxs River (ML)
SB1	Current	5	10.1
	End of Stage 1		
	A		
	B		
	C		
	D		
	E		
	F		
	G		

Table 32 – Water Balance Assessment of SB1 for Prolonged Wet Climatic Conditions with On-site Water Management

Water Storage	Stage of Quarry Development	Predicted Frequency of Potential Uncontrolled Discharges (per annum)	Predicted Annual Estimated Volume Discharged to Coxs River (ML)
SB1	Current	6	46.9
	End of Stage 1		
	A		
	B		
	C		
	D		
	E		
	F		
	G		

Modelling predicts that with on-site management of water within SB1, uncontrolled discharges from SB1 to Coxs River will be reduce by approximately 73 and 54 percent for the prolonged dry and wet climatic conditions scenarios respectively.

The volume of uncontrolled discharges to Coxs River can be further reduced by diverting overflows from SD5 around SD6 to Yorkeys Creek, hence maximising the available storage capacity within SD6 to receive excess waters from SB1.

The following additional management measures could also be considered/adopted to reduce (if not completely eliminate) the frequency and volume of uncontrolled discharges from SB1 into Coxs River by:

- Undertaking controlled discharges of treated waters from SD6 to Yorkeys Creek to maximise the available storage capacity within SD6 to receive additional excess waters from SB1
- Undertaking controlled discharges of in-situ treated waters within SD1/SD2 to Coxs River to reinstate freeboard
- Undertaking controlled discharges of in-situ treated waters within SB1 to Coxs River to reinstate freeboard.

6.7.3 Scenario 3 – Water Balance of SB1 meeting Regulatory Storage Capacity

Water balance assessments were conducted for comparison to the current water management regime of the potential frequency and volume of uncontrolled discharges from SB1 to Coxs River assuming 35 consecutive years of prolonged dry (15^{th} percentile rainfall) and wet (90^{th} percentile rainfall) climatic conditions, in the event that the storage capacity of SB1 was to be increased to 11 ML with a minimum freeboard capacity of 7.3 ML to meet regulatory requirements.

Scenario 3 for SB1 has been built based on the following assumptions:

- SB1 has an optimised total storage and treatment capacity of 11 ML.
- Inflows can be segregated into 1) direct rainfall 2) overland flow and 3) uncontrolled discharges from the overtopping of SD3 and SD4. Overland flow is assumed to be a set ratio of rainfall amounts (annual runoff coefficient) depending on land type (bare or vegetated).
- Minimum freeboard holding capacity of 7.3 ML is to be maintained within SB1 at all times in order to receive overland flow from the administration, processing and stockpiling areas.
- Outflows are; 1) direct evaporation from the inundated water storage, 2) extraction of water for dust suppression, and 3) uncontrolled discharges. Evaporation from the land surface is not considered.
- In accordance with advice received from quarry personnel during the site assessment conducted by Groundwork Plus personnel on 21 November 2013, the daily dust suppression demand from SB1 has been assumed to be approximately 78 kL. This has been calculated based on the assumption that a water truck (with a storage capacity of 13 kL) is topped up with water at least 6 times during the course of an operational shift.
- It has been assumed that dust suppression is not undertaken on rain days with a precipitation depth of more than 10 mm of rainfall.

The summary findings of these assessments are shown in **Table 33 – Water Balance Assessment for Optimised Storage Volume of SB1 for Prolonged Dry Climatic Conditions** and **Table 34 – Water Balance Assessment for Optimised Storage Volume of SB1 for Prolonged Wet Climatic Conditions**.

Table 33 – Water Balance Assessment for Optimised Storage Volume of SB1 Vs Current Water Management Regime for Prolonged Dry Climatic Conditions

Water Storage	Stage of Quarry Development	Regulatory Required SB1 Storage Capacity (11 ML) ①		Current Water Management Regime	
		Predicted Frequency of Potential Uncontrolled Discharges (per annum)	Predicted Annual Estimated Volume Discharged to Coxs River (ML)	Predicted Frequency of Potential Uncontrolled Discharges (per annum)	Predicted Annual Estimated Volume Discharged to Coxs River (ML)
SB1	Current	24	60.1	5	10.1
	End of Stage 1				
	A				
	B				
	C				
	D				
	E				
	F				
	G				

Note: ① without existing on-site water management regime

Table 34 – Water Balance Assessment for Optimised Storage Volume of SB1 Vs Current Water Management Regime for Prolonged Wet Climatic Conditions

Water Storage	Stage of Quarry Development	Regulatory Required SD2 Storage Capacity (11 ML)①		Current Water Management Regime	
		Predicted Frequency of Potential Uncontrolled Discharges (per annum)	Predicted Annual Estimated Volume Discharged to Coxs River (ML)	Predicted Frequency of Potential Uncontrolled Discharges (per annum)	Predicted Annual Estimated Volume Discharged to Coxs River (ML)
SB1	Current	22	97.3	6	46.9
	End of Stage 1				
	A				
	B				
	C				
	D				
	E				
	F				
	G				

Note: ①without existing on-site water management regime

Although there are obvious benefits of increasing the design storage capacity of SB1 to meet the regulatory requirements, hence reduce the frequency and number of uncontrolled discharges marginally, no benefit over the existing water management regime would be gained unless it to was continued. Given the direct (i.e. construction) and indirect (i.e. loss of processing/stockpile area) costs of increasing the size of SB1, the practicality due to the sediment basins location, and the on-going requirement to continue the existing water management regime, enlarging SB1 to meet regulatory requirements would not provide any significant net benefit over the current water management regime.

6.8 STORAGE DAMS 5 AND 6

6.8.1 Scenario 1 – Water Balance for SD5 and SD6 with no Water Management

Water balance assessments were conducted to investigate the potential frequency and volume of controlled and uncontrolled discharges to Yorkeys Creek from the existing water storage dams SD5 and SD6. The assessments were conducted assuming extreme climatic scenarios of 35 consecutive years of dry and wet climatic conditions (i.e. 15^{th} and 90^{th} percentile rainfall respectively). The water balance model for SD6 has been built based on the following assumptions:

- Inflows to SD5 and SD6 are segregated into 1) direct rainfall and 2) overland flow. Overland flow is assumed to be a set ratio of rainfall amounts (annual runoff coefficient) depending on land type (bare or vegetated).
- Additionally, SD6 receives uncontrolled discharges from SD5 over the existing embankment between SD5 and SD6, as well as low flows from SD5 via an existing low flow control pipe (i.e. lockable valves).
- Outflows are; 1) direct evaporation from the inundated water storage and 2) uncontrolled discharges from SD5 and SD6. Evaporation from the land surface and stock watering is not considered.
- SD6 has been modelled to maintain a freeboard volume of 2 ML to be available at all times to receive overland flows.

The summary findings of these assessments are shown in **Table 35 – Water Balance Assessment for SD5 and SD6 for Prolonged Dry Climatic Conditions** and **Table 36 – Water Balance Assessment for SD5 and SD6 for Prolonged Wet Climatic Conditions**.

Table 35 – Water Balance Assessment for SD5 and SD6 for Prolonged Dry Climatic Conditions

Water Storage	Stage of Quarry Development	Predicted Uncontrolled Discharge Frequency	Predicted Uncontrolled Discharge Volume (ML)
SD6	Current	24	53.9
	End of Stage 1	27	63.7
	A		
	B		
	C		
	D		
	E		
	F		
	G		
SD5	Current	35	58.9
	End of Stage 1	31	62.8
	A		
	B		
	C		
	D		
	E		
	F		
	G		

Table 36 – Water Balance Assessment for SD5 and SD6 for Prolonged Wet Climatic Conditions

Water Storage	Stage of Quarry Development	Predicted Uncontrolled Discharge Frequency	Predicted Uncontrolled Discharge Volume (ML)
SD6	Current	31	133.3
	End of Stage 1	25	142.7
	A		
	B		
	C		
	D		
	E		
	F		
	G		
SD5	Current	27	131.0
	End of Stage 1	33	134.9
	A		
	B		
	C		
	D		
	E		
	F		
	G		

Modelling predicts that SD6, in its natural state, will receive approximately 58.9 ML and 131 ML respectively of uncontrolled discharges from SD5 during a current dry and wet rainfall year. This volume of discharge is expected to increase to 62.8 ML and 134.9 ML respectively for each succeeding year of the modelled prolonged dry and wet climatic condition scenarios, on account of SD5 being inundated.

SD6 is predicted to discharge approximately 53.9 ML and 133.3 ML respectively to Yorkeys Creek during a current dry and wet rainfall year respectively. During the course of the modelled prolonged dry climatic conditions scenario (Stage A to Stage G) the volume of annual discharges to Yorkeys Creek from SD6 is estimated to increase to 63.7 ML/annum and 142.7 ML/annum during the modelled prolonged wet climatic conditions scenario.

However, SD6 is currently used to receive and store flows from SB1 to reinstate freeboard within SB1. A water balance scenario has been undertaken to determine uncontrolled discharges from SD6 to Yorkeys Creek based on the water management regime currently in use at the quarry. See **section 6.8.2 Water Balance for SD5 and SD6 with SD6 Receiving Flows from SB1** for details.

6.8.2 Scenario 2 - Water Balance for SD5 and SD6 with SD6 receiving Flows from SB1

Scenario 2 has been undertaken to predict the frequency of uncontrolled discharges from SD6 to Yorkeys Creek under the current water management regime at the quarry which includes SD6 receiving excess flows from SB1 in order to reinstate freeboard within SB1.

Scenario 1 was rerun for SD6 assuming extreme climatic scenarios of 35 consecutive years of dry and wet climatic conditions (i.e. 15^{th} and 90^{th} percentile rainfall respectively). Uncontrolled discharges from SD5 to SD6 were assumed to be the same as that predicted by the Scenario 1 water balance assessments and have been used in Scenario 2.

The summary findings of these assessments are shown in **Table 37 – Water Balance Assessment for SD6 Receiving Flows from SB1 for Prolonged Dry Climatic Conditions** and **Table 38 – Water Balance Assessment for SD6 Receiving Flows from SB1 for Prolonged Wet Climatic Conditions**.

Table 37 – Water Balance Assessment for SD6 Receiving Flows from SB1 for Prolonged Dry Climatic Conditions

Water Storage	Stage of Quarry Development	Predicted Uncontrolled Discharge Frequency	Predicted Uncontrolled Discharge Volume (ML)
SD6	Current	25	59.3
	End of Stage 1	28	69.1
	A		
	B		
	C		
	D		
	E		
	F		
	G		

Table 38 – Water Balance Assessment for SD6 receiving Flows from SB1 for Prolonged Wet Climatic Conditions

Water Storage	Stage of Quarry Development	Predicted Uncontrolled Discharge Frequency	Predicted Uncontrolled Discharge Volume (ML)
SD6	Current	29	137.7
	End of Stage 1		
	A		
	B		
	C		
	D		
	E		
	F		
	G		

Modelling indicated that the current water management regime in place at the Quarry will result in increased discharges from SD6 to Yorkeys Creek during the modelled scenarios of prolonged dry and wet climatic conditions.

The predicted uncontrolled discharges to Yorkeys Creek from SD6 can be reduced if discharges from SD5 to SD6 can be diverted to Yorkeys Creek. This option would provide greater storage capacity within SD6 to receive more flows if required from SB1, as well as reduce the frequency and volume of uncontrolled discharges from SD6 to Yorkeys Creek, see to **Section 6.8.3 Scenario 3 – Water Balance for SD6 Receiving Flows from SB1 with Overflows from SD5 Diverted to Yorkeys Creek** for details.

The diversion of overflows from SD5 around SD6 will also provide greater storage capacity within SD6 to receive additional excess flows from SB1 and hence reduce the frequency and volume of uncontrolled discharges from SB1 to Coxs River.

6.8.3 Scenario 3 – Water Balance for SD6 Receiving Flows from SB1 with Overflows from SD5 Diverted to Yorkeys Creek

Scenario 3 has been undertaken to predict the potential reduction in the frequency and volume of uncontrolled discharges from SD6 to Yorkeys Creek, with the diversion of overflows form SD5 diverted around SD6 to Yorkeys Creek.

Scenario 3 was undertaken assuming extreme climatic scenarios of 35 consecutive years of dry and wet climatic conditions (i.e. 15th and 90th percentile rainfall respectively).

The summary findings of these assessments are shown in **Table 39 – Revised Water Balance Assessment for SD6 Receiving Flows from SB1 for Prolonged Dry Climatic Conditions** and **Table 40 – Revised Water Balance Assessment for SD6 receiving Flows from SB1 for Prolonged Wet Climatic Conditions**.

Table 39 – Revised Water Balance Assessment for SD6 Receiving Flows from SB1 for Prolonged Dry Climatic Conditions

Water Storage	Stage of Quarry Development	Predicted Uncontrolled Discharge Frequency	Predicted Uncontrolled Discharge Volume (ML)
SD6	Current	26	2.83
	End of Stage 1	12	7.2
	A	26	8.73
	B		
	C		
	D		
	E		
	F		
	G		

Table 40 – Revised Water Balance Assessment for SD6 receiving Flows from SB1 for Prolonged Wet Climatic Conditions

Water Storage	Stage of Quarry Development	Predicted Uncontrolled Discharge Frequency	Predicted Uncontrolled Discharge Volume (ML)
SD6	Current	22	4.9
	End of Stage 1		
	A		
	B		
	C		
	D		
	E		
	F		
	G		

Modelling predicted that by diverting overflows from SD5 around SD6 to Yorkeys Creek, the frequency and volume of uncontrolled discharges from SD6 can be significantly reduced during both the prolonged dry and wet climatic scenarios.

Controlled discharges from SD6 to Yorkeys Creek would be essential in order to reinstate freeboard within SD6. Alternatively water from SD6 can be hydraulically moved to SD3 and/SD4 using existing infrastructure for treatment and discharge to Coxs River.

6.9 SEDIMENT BASIN 2B

A water balance assessment was conducted to investigate the potential frequency of uncontrolled release to Yorkeys Creek from the Sediment Basin 2b (SB2b) designed to receive and treat stormwater runoff generated by the Yorkeys Creek Stockpile area. The assessment was conducted for a dry (15th percentile) and wet (90th percentile) rainfall year, using rainfall and evaporation data summarised in **Section 2.1.1 Rainfall** and **Section 2.1.2 Evaporation** of this report.

The water balance model for SB2b has been built based on the following assumptions:

- The storage volume of SB2b has been redesigned to treat runoff generated by the existing Yorkeys Creek Stockpile area, which is not affected by the Stage 2 Extension (i.e. peak storage capacity of 4 ML)
- Inflows can be segregated into; 1) direct rainfall and 2) overland flow. Overland flow is assumed to be a set ratio of rainfall amounts (annual runoff coefficient) depending on land type (bare or vegetated).
- Outflows are; 1) direct evaporation from the inundated water storage, 2) controlled discharge of treated waters within 72 hours of a rainfall event, 3) uncontrolled discharges from site water. Evaporation from the land surface is not considered.

The findings of the water balance assessment for SB2b for a dry and wet rainfall year are summarised in **Table 41 – Water Balance Assessment for SB2b**.

Table 41 – Water Balance Assessment for SB2b

Scenario	Rainfall Scenario	Stage	Predicted Frequency of Treated / Controlled Discharges (per annum)	Predicted Total Estimated Treated Volume Discharged (ML)	Predicted Frequency of Uncontrolled Discharges (days per annum)	Predicted Total Estimated Volume Discharged (ML)
Current	Dry Rainfall Year (15th Percentile)	Pre- Stage 2 Extension	13	9.9	-	-
	Wet Rainfall Year (90th Percentile)		22	18.9	12	3.9
Stage 2 Extension	Dry Rainfall Year (15th Percentile)	Stage A to G	13	9.9	-	-
	Wet Rainfall Year (90th Percentile)		22	21.5	8	1.2

No uncontrolled discharges are predicted from SB2b during a modelled dry rainfall year, provided controlled discharges are regularly carried out following rainfall events. To prevent uncontrolled discharge events from occurring, it is estimated that 13 control discharge events, totally approximately 10 ML of treated water discharged to Yorkeys Creek and ultimately to Coxs River, would be required.

Even with regular controlled discharges (i.e. anticipated 22 controlled discharge events, totalling approximately 21.5 ML of treated water discharged), modelling has indicated that SB2b would overtop its spillway on 8 days (i.e. representing 4 discharge events) during a wet rainfall year, with approximately 1.2 ML of water discharged to Yorkeys Creek and ultimately to Coxs River. It is noted that this is as expected when considering the guidance provided by Table 6.1 of Managing Urban Stormwater, Soils and Construction – Volume 2E Mines and Quarries (NSW DECC, 2008).

7. MONITORING AND MAINTENANCE OF SSEC

A monitoring and maintenance program has been prepared for the existing and proposed operations at the Austen Quarry. This program involves regular inspection of the erosion, drainage and sediment controls. All quarry personnel would be responsible for the general surveillance of the stormwater control devices; however, a surveillance program would be implemented to monitor the effectiveness of the implemented devices. Stormwater management devices identified by quarry personnel as having failed or as being laden with sediments will be reported to the Quarry Manager. A summary schedule of the various inspections, performance criteria and responses that must be performed is shown in **Table 42 – Maintenance Plan for Stormwater Control Devices**.

8. RECEIVING ENVIRONMENT

The receiving environment from the licensed discharge points of the Austen Quarry SB1, SB3b, SD2 (EPL 12323 Points 9, 1 and 10 respectively) consist of a well vegetated, upland, freshwater segment of the lower Coxs River. The initial receiving environment from the licensed discharge points of the Austen Quarry SB2b and SD6 (EPL 12323 Points 8 and 11 respectively) is Yorkeys Creek. Yorkeys Creek is a tributary of the Coxs River that consists of a shallow, ephemeral, erosional, freshwater stream before entering the Coxs River. The upper catchment of Yorkeys Creek is relatively undisturbed with only a small portion historically cleared for grazing.

The Coxs River drains a catchment of approximately 2,630 km^2 on the western side of the Blue Mountains. It is bound to the west by the Great Dividing Range, to the north by the upper Colo River Catchment, and to the south by the Wollondilly River catchment.

The Coxs River is a directional, integrated, converging, tributary stream that rises in Gardiners Gap, within Ben Bullen State Forest, east of Cullen Bullen, and flows through the Megalong Valley and parts of the Greater Blue Mountains Area World Heritage Site including the Blue Mountains and Kanangra-Boyd national parks, heading generally south and then east, joined by fifteen tributaries including the Little, Jenolan, Kedumba, Kowmung and Wollondilly rivers, before reaching its confluence with the Warragamba River to form Lake Burragorang (behind Warragamba Dam), the largest of Sydney's water supply reservoirs.

Over most of its length the Coxs River valley-floor trough is underlain by granite. The upper reaches of its eastern tributaries drain sandstone and shales; the western tributaries primarily drain granite. The granite-derived soils are typically thin and highly erodible (CSIRO Land and Water May 2000).

Table 42– Maintenance Plan for Stormwater Control Devices

Inspection	Minimum Frequency	Performance Criteria	Response
Inspect water conveyance structures such as catch drains, contour drains and diversions.	Following significant rainfall events.	Erosion in areas adjacent to water conveying structures.	Eroded areas will be riprapped as soon as practicable.
		Overtopping of water conveying structures (identified by the scouring of the drain batters perpendicular to the direction of flow).	The drain will be cleaned of sediments and riprapping replaced to the original design specifications. Rehabilitation with suitable grasses in the catchment of the drain may be required to reduce sediment loading.
		Deposition of material in the water conveying structure greater than half the design depth.	Sediment/grit will be removed from the structure and used in rehabilitation works.
Inspect potential sediment storage capacity of sediment basins.	Following significant rainfall events.	30 per cent of the total sediment capacity remaining.	Sediment will be removed from the structure and used in rehabilitation works.
		Overtopping of the sediment dams.	To recycle dam water to ensure that adequate free storage is maintained for the collection and holding of runoff.
Inspect check dams, rock armouring and riprap.	Following significant rainfall events.	Check dam walls have collapsed or riprap has moved.	Larger sized rocks will be used in the construction of check dams and riprap or the drain will be concreted or redesigned.
Inspect culverts, pipe inlets and outlets.	Following significant rainfall events.	Check for erosion of inlets and outlets.	Riprap inflows and outflows of pipes where erosion has been observed.
		Debris build-up in pipe inlets or outlets or in culverts.	Remove debris.
		Overflow of pipes.	Check pipes for debris or blockages and remove the offending materials.

Note: Significant rainfall event is rainfall greater than 25 mm in one day.

The majority of the river reaches and mid-catchment are highly degraded as the land has been extensively cleared for industry, agriculture and grazing, and some creeks are highly modified by urban developments. Wide spread grazing, forestry and coal mining occurs in the upper catchment (CSIRO Land and Water May 2000).

The flow regime of the lower Coxs River is strongly influenced by land clearing in the upper and central parts of the catchment, regional climatic variations and the construction and operation of river impoundments (CSIRO Land and Water May 2000). The river is impounded at Lake Wallace, where it forms a cooling source for Wallerawang Power Station, Lake Lyell for a water supply for the city of Lithgow and water cooling for Wallerawang Power Station and downstream of the Site release points at Lake Burragorang, a major water supply source for greater metropolitan Sydney, referred to as the “Warragamba water supply network”.

The Warragamba catchment covers approximately 9,051 square kilometres, with Lake Burragorang itself covering 75 square kilometres. Land in the catchment is predominantly natural bushland and unfertilised grazing land with approximately 25 percent of the catchment declared Special Area, comprising mainly unspoilt bushland where public access is restricted to protect water quality.

The segment of the Coxs River between the Site and Lake Burragorang has high public access and utilised for recreational fishing, non-motor boating and significantly irrigation water supply.

The Environmental Values (EVs) identified for the receiving aquatic environment has been provided in **Table 43 – Environmental Values for Receiving Environment**.

Table 43 – Environmental Values for Receiving Environment

Type	Environmental Values
Aquatic Ecosystems	Ecosystem protection (aquatic plants, fish and other flora and fauna habitat) for a moderately disturbed level of protection
Human Uses	Agricultural uses (e.g. Long-term irrigation and Livestock water)
	Drinking water for Human Consumption
	Recreation

Limited water quality data has been provided from current quarry operations for the receiving environments. A summary of the background water quality of the Yorkeys Creek and Coxs River have been presented in **Table 44 – Summary Statistics of Yorkeys Creek Background Water Quality** and **Table 45 – Summary Statistics of Background Coxs River Water Quality** respectively.

In comparison with that of the background reference condition of Coxs River, Yorkeys Creek water quality is very similar with the exception of slightly greater variation in EC and turbidity recorded and higher nitrogen concentrations. Given the Coxs River is the main receiving water environment from the Site and that a stronger dataset of background water quality is available, background reference conditions for the Coxs River has been adopted to assess potential impact of site release waters on the receiving aquatic environment.

Table 44 – Summary Statistics of Background Yorkeys Creek Water Quality

Parameter	*n*	Minimum	Maximum	Median	Standard Deviation	75th Percentile	80th Percentile
Physico-Chemical							
pH (pH units)①	27	6.4	8.1	7.5	0.4	7.7	7.8
EC (µS/cm)	28	26	550	341	115	398	426
DO (mg/L)	1	8.3	8.3	-	-	-	-
BOD_5 (mg/L)	27	1	11	3	2.4	4.5	5
Turbidity (NTU)	27	0	122	4	24	13	14
TSS (mg/L)	27	<5	96	<5	18	5	7
TDS (mg/L)	28	70	382	239	75	259	274
Metals/Metalloids (Dissolved) (µg/L)							
As	1	2	2	-	-	-	-
Cd	1	<0.1	<0.1	-	-	-	-
Cr (Total)	1	<1	<1	-	-	-	-
Cu	1	<1	<1	-	-	-	-
Ni	1	<1	<1	-	-	-	-
Pb	1	<1	<1	-	-	-	-
Zn	1	<5	<5	-	-	-	-
Metals/Metalloids (Total) (µg/L)							
As	1	3	3	-	-	-	-
Cd	1	<0.1	<0.1	-	-	-	-
Cr (Total)	1	<1	<1	-	-	-	-
Cu	1	<1	<1	-	-	-	-
Ni	1	<1	<1	-	-	-	-
Pb	1	<1	<1	-	-	-	-
Zn	1	6	6	-	-	-	-
Major Ions and Nutrients (mg/L)							
NH_4	1	0.02	0.02	-	-	-	-
TN	1	3.1	3.1	-	-	-	-
NO_x-N	1	2.7	2.7	-	-	-	-
TP	1	<0.01	<0.01	-	-	-	-

Notes: Statistical summary of the water quality within Yorkeys Creek (upstream) for the period between March 2007 and August 2014; ① = 20th Percentile: 7.4; - = n is insufficient to calculate statistic.

Table 45 – Summary Statistics of Background Coxs River Water Quality

Parameter	*n*	Minimum	Maximum	Median	Standard Deviation	75th Percentile	80th Percentile
Physico-Chemical							
pH (pH units)①	80	6.6	9.2	7.5	0.4	7.7	7.7
EC (µS/cm)	80	140	740	273	117	322	338
DO (mg/L)	1	8.3	8.3	-	-	-	-
BOD_5 (mg/L)	74	<1	46	2	5.8	4	4
Turbidity (NTU)	76	1	1,300	5	152	8	10
TSS (mg/L)	80	<1	1,110	4	124	6.9	8.2
TDS (mg/L)	80	12	530	188	96	238	250
Metals/Metalloids (Dissolved) (µg/L)							
Al (pH > 5)	1	20	20	-	-	-	-
As	1	<1	<1	-	-	-	-
Cd	1	<0.1	<0.1	-	-	-	-
Cr (Total)	1	<1	<1	-	-	-	-
Cu	1	2	2	-	-	-	-
Ni	1	1	1	-	-	-	-
Pb	1	<1	<1	-	-	-	-
Zn	1	<5	<5	-	-	-	-
Fe (total)	1	340	340	-	-	-	-
Metals/Metalloids (Total) (µg/L)							
Al (pH > 5)	1	180	180	-	-	-	-
As	2	<1	1	-	-	-	-
Cd	2	<0.1	0.1	-	-	-	-
Cr (total)	2	<1	<1	-	-	-	-
Cu	2	1	2	-	-	-	-
Fe (total)	1	760	760	-	-	-	-
Pb	2	<1	<1	-	-	-	-
Mn	5	38	325	101	115	104	148
Hg	1	<0.1	<0.1	-	-	-	-
Ni	2	2	2	-	-	-	-
Zn	1	<5	<5	-	-	-	-
Major Ions and Nutrients (mg/L)							
NH_4	2	0.02	0.02	-	-	-	-
TN	2	0.3	0.4	-	-	-	-
NO_x-N	2	0.02	0.03	-	-	-	-
TP	2	<0.01	<0.01	-	-	-	-

Notes: Statistical summary of the water quality within Coxs River (upstream) for the period between August 2006 and August 2014; ① = 20th Percentile: 7.2; - = n is insufficient to calculate statistic.

9. ASSESSMENT CRITERIA

9.1 LOCALLY DERIVED WATER QUALITY OBJECTIVES

The assessment criteria for waters released from site have been derived from numerical guidelines published by the Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand Australian *Water Quality Guidelines for Fresh and Marine Waters* (ANZECC/ARMANZ, 2000) based on the identified EVs of the receiving environment and the applicable raw water quality established by the Sydney Catchment Authority (SCA).

Raw water quality within the Sydney Drinking Water Catchment is required to meet levels specified in the Australian Drinking Water Guidelines (NHMRC, 2011); however, for those water quality characteristics that may be expected to be improved through treatment processes, less stringent guidelines apply (Sydney Catchment Authority (SCA), *Annual Water Quality Monitoring Report 2011-12*). Applicable Numerical Guidelines for the assessment are presented in **Table 45 – Applicable Numerical Guidelines**.

On the basis of a comparison between the Numerical Guideline Assessment Criteria and established upstream background reference condition of the Coxs River at monitoring site EPL Point 2 (upstream of the Austen Quarry), it is clear that the local concentration for Turbidity exceeds that of the Numerical Guideline Assessment Criteria. The data also indicates that background reference conditions of the Coxs River for total Copper (Cu) and Ammonia (NH_4) may also exceed the Numerical Guideline Assessment Criteria; however, the number of samples to make the assessment are universally below the number recommend (n=18). The dataset is currently not statically valid, with n=2. The higher ammonia level is to be expected given the Sites surrounding environmental setting/land use (i.e. beef cattle grazing), while the higher Cu concentration is likely to be attributed to the natural geology of the area. Additional sampling of background water quality, with representative samples collected and analysed during low, medium and high river flows, would be required to establish Background Reference Conditions for those parameters.

Where derived Numerical Guideline Assessment Criteria in **Table 45 – Applicable Numerical Guidelines** are exceeded by upstream background reference conditions at EPL Point 2, the latter have been adopted. From the numerical guidelines and available Background Reference Conditions, criteria for assessment have been established and are presented in **Table 46 – Locally Derived Water Quality Objectives**.

Table 46 – Applicable Numerical Guidelines

SUBSTANCES	ANZECC/ARMANZ Guidelines *				NHMRC 2011	SCA①
	Protection of Slightly to Moderately Disturbed freshwaters	Recreational Purpose	Irrigation	Livestock Watering	Drinking Water	Site Specific Raw Water Quality②
Physico-Chemical						
pH (pH units)①	-	6-8.5	-	-	6-8.5	6-8.5
EC (µS/cm)	-	-	-	-	-	-
DO (mg/L)	-	-	-	-	-	-
BOD_5 (mg/L)	-	-	-	-	5	-
Turbidity (NTU)	-	-	-	-	-	40
TSS (mg/L)	-	10,000		2,500	-	-
Metals/Metalloids in µg/L						
Al (pH < 6.5)	ID		5,000	5,000	200	-
Al (pH >6.5)	55		5,000	5,000	200	2,600
As	24	50	100	500	10	-
Barium (Ba)			-	-	2,000	-
Beryllium (Be)	ID		100	-	60	-
Cd	0.2	5	10	10	2	-
Cr VI	1.0	50	100	100	50	-
Cobalt (Co)	1.4[a]		50	1,000		-
Cu	1.4	1,000	200	1,000	1,000	-
Pb	3.4	50	2,000	100	10	-
Mn	1,900	100	200	-	100	1,400
Hg	0.06	1	2	2	1	-
Ni	11	100	200	1,000	20	-
Vanadium (V)	ID			100		-
Zn	8	500	2,000	20,000	3,000	-
Major Ions and Nutrients in mg/L						
Nitrite–N (NO_2)	-	1		9.1	0.9	-
Nitrate–N (NO_3)	1.7[b]	10	90.3	11.3		-
NH_4	0.9	0.01	-	-	0.5	-
TN	-	-	-	-	1.4	-
TP	-	-	0.05	-	-	-
Sulphate (SO_4)	-	400			250	-

Notes:
[a] = Low reliability guideline value (ANZECC and ARMCANZ 2000)
[b] = Revised Nitrate-N toxicity guideline value (Hickey & Martin 2009)
① SCA Annual Water Quality Monitoring Report 2011-12
② Site specific raw water quality standard for supply to Prospect, Warragamba and Orchard Hills water filtration plants
ID = Insufficient data to derive a reliable trigger value
- = no applicable criteria set

Table 47 – Interim Locally Derived Water Quality Objectives

Type	Parameter	Numerical Guideline	Source	Background Reference Condition	Interim Locally Derived Water Quality Objective (LDWQO)
Physico-Chemical	pH (pH units)	6 – 8.5	SCA Site Specific Raw Water guideline	7.2 - 7.7	6 – 8.5
	EC (µS/cm)	-	-	322	322
	DO (% satn.)	-	-	-	-
	BOD_5 (mg/L)	5	Drinking Water guideline	4	5
	Turbidity (NTU)	40	SCA Site Specific Raw Water guideline	10	10
	TSS (mg/L)	-	-	8	8
	TDS (mg/L)	2,500	Livestock water guideline	250	2,500
Metals/ Metalloids in (µg/L)	Al (pH<6.5)	200	Drinking Water guideline	-	200
	Al (pH>6.5)	55	SMDS protection	-	55
	As	10	Drinking Water guideline	-	10
	Ba	2,000	Drinking Water guideline	-	2,000
	Be	60	Drinking Water guideline	-	60
	Cd	0.2	SMDS protection	-	0.2
	Cr VI	1	SMDS protection	-	1
	Co	1.4[a]	SMDS protection	-	1.4
	Cu	1.4	SMDS protection	-	1.4
	Pb	3.4	SMDS protection	-	3.4
	Mn	100	Recreation guideline	-	100
	Hg	0.06	SMDS protection	-	0.06
	Ni	11	SMDS protection	-	11
	V	100	Livestock water guideline	-	100
	Zn	8	SMDS protection	-	8
Major Ions and Nutrients in mg/L	NO_2	1	Recreation guideline	-	1
	NO_3	1.7[b]	SMDS protection	-	1.7
	NH_4	0.01	Recreation guideline	-	0.01
	TN	1.4	SCA Site Specific Raw Water guideline	-	1.4
	TP	0.05	Long-term Irrigation guideline	-	0.05
	SO_4	250	Drinking Water guideline	-	250

Note:
[t] = total; [d] = dissolved;
[a] = Low reliability guideline value (ANZECC and ARMCANZ 2000)
① Current EPL limit for TSS is 30 mg/L
[b] = Revised Nitrate-N toxicity guideline value (Hickey & Martin 2009)
Source: ANZECC & ARMCANZ (2000) guidelines (SMDS, Recreation, Long-term Irrigation and Livestock); NHMRC 2011 (Drinking Water guideline);

9.2 STATE ENVIRONMENTAL PLANNING POLICY (SYDNEY DRINKING WATER CATCHMENT) 2011

The Site is situated within the Sydney drinking water's sub-catchment of Mid Coxs River (NSW Planning, State Environmental Planning Policy (NSW Government, *Sydney Drinking Water Catchment) 2011 Sheet 2 of 19),* within the Warragamba Dam Catchment.

For new activities under Part 5 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), the *State Environmental Planning Policy (Sydney Drinking Water Catchment)* 2011 (the SEPP) states:

> "*A consent authority must not grant consent to the carrying out of development under Part 4 of the Act on land in the Sydney drinking water catchment unless it is satisfied that the carrying out of the proposed development would have a neutral or beneficial effect on water quality*."

Sydney Catchment Authority (2011) *Developments in Sydney's Drinking Water Catchment Water Quality Information Requirements* defines a neutral or beneficial effect on water quality as a development that:

- "*has no identifiable impact on water quality, or*
- *will be contain any water quality impact on the development site and stop it from reaching any watercourse, waterbody or drainage depression on site, or*
- *will transfer any water quality impact outside of the site where it is treated and disposed of to standards approved by the consent authority."*

10. IMPACT OF ON-SITE WATER RELEASES

10.1 RELEASE WATER QUALITY CHARACTERISTICS

No distinguishment between water quality of uncontrolled release waters and the water quality of water captured within on-site Sediment Basins or Storage Dams have been provided. It has therefore been assumed that on-site water quality data as presented in **Table 9** to **13** is also representative of uncontrolled release waters from the Site.

No characterisation data of treated release waters has been provided for assessment, however, it is assumed that water quality of any controlled discharges would comply with the Interim Locally Derived Water Quality Objectives (ILDWQO) or alternative release water quality conditions prescribed by the Site's Environmental Protection Licence.

10.2 DISCUSSION

10.2.1 Extraction Area

Water quality within the sumps (i.e. Sump 1 and Sump 2) of the extraction area represents a mixture of groundwater and surface water (see **Table 9 – Extraction Area Water Quality**). No detailed statistical analysis can be undertaken due to the small dataset available ($n \leq 2$); however, based on the limited water quality data available, the following water quality parameters equal or exceed the ILDWQO; EC, Dissolved metals (Cu and Zn) and Nutrients (NO_x-N, TN and NH_4).

Water EC concentration within the extraction area sumps poses a potential risk to the receiving freshwater ecosystem without sufficient dilution.

Based on the surrounding, location and current activity on-site, the elevated dissolved heavy metals (i.e. Cu and Zn) are considered to be reflective of the local geology and not related to unnatural sources. The measured Cu and Zn concentrations are considered to pose a potential risk, if not adequately diluted, on the receiving aquatic environment ecosystem. A one-fold dilution in the receiving environment would reduce the Cu and Zn concentrations below the respective ILDWQO.

Elevated nitrogen concentrations are likely to be attributed to explosives residual used for blasting within the extraction area and to a less extent organic matter (e.g. manures, top-soil erosion) associated with suspended particulates/sediment. The elevated nitrogen concentrations (TN, NO_x and NH_4) have the potential to cause oxygen depletion and nuisance algal problems, particularly if released during no or base flow conditions. The elevated TN concentration poses a potential risk, if not adequately diluted, on the receiving waters suitability for drinking water raw supply use. The elevated NH_4 concentration poses a potential risk, if not adequately diluted, on the receiving waters suitability for drinking water raw water supply and recreational use, while the elevated NO_x concentration also pose a potential low risk, if not adequately diluted, on the receiving waters suitability for long-term irrigation, livestock watering and recreational use.

Given no change in site geology is predicted to be encountered as part of the Stage 2 Expansion, no change in groundwater chemistry entering the extraction area is also predicted; however, water quality within the extraction area sumps are likely to be strongly influenced by seasonal conditions (i.e. rainfall, dry prolonged periods, etc.).

10.2.2 Sediment Basin 3a/b Water Quality

No detailed statistical analysis can be undertaken due to the small dataset available ($n \leq 2$); however, the following water quality parameters have equalled or exceed the ILDWQO; EC, Turbidity, TSS, Total metals (Al, Cu, Mn and Zn), TN, TP and NH_4 (see **Table 10 – Summary Statistics of SB3a Water Quality**).

Water EC has exceeded the ILDWQO of 322 μS/cm; however, the levels measured (i.e. maximum level 680 μS/cm) is considered to pose no genuine risk to the receiving waters EVs. Water turbidity and TSS concentrations of SB3a are considered to pose a potential risk to the receiving freshwater ecosystem and receiving waters suitability for other identified EVs (i.e. recreation use and drinking water supply) without sufficient dilution.

Although concentrations for some total metals (Al, Cu and Zn) exceeded the ILDWQO, it is not possible to assess the true risk to aquatic ecosystems on the basis of analysis of metals concentrations in unfiltered water samples. If a worst case scenario is assumed (dissolved metal concentrations equal total concentrations) the measured Al, Cu and Zn concentrations would pose a potential risk, if not adequately diluted on the receiving aquatic environment ecosystem. A one-fold dilution in the receiving environment would reduce the Zn concentrations below the respective locally derived release limit, while a two-fold dilution would be required for Cu concentrations, three-fold dilution for Mn and five-fold for Al. Given the location and current activity on-site, the elevated total heavy metals (i.e. Al, Mn, Cu and Zn) are considered to be reflective of the local geology, therefore, most likely associated with suspended particulates/sediment and not related to unnatural sources. In such case, dissolved metal concentrations are likely to be low than total concentrations as determined at other monitoring locations on-site where both have been analysed, so would the risk.

Of the elevated total metal concentrations, the Mn concentration poses a potential risk, if not adequately diluted, on the receiving waters suitability for recreational and long term irrigation use.

Given the surrounding land use (i.e. beef cattle grazing) and that no effluent from on-site operations is disposed of on-site, the elevated nutrient levels are considered to be associated with organic matter (e.g. manures, top-soil erosion) associated with suspended particulates/soils; however, on-site activities have the potential to promote their release.

The elevated TN and TP level has the potential to cause nuisance algal problems, particularly if released during no or base flow conditions. The elevated TN, TP and NH_4 concentrations also pose a potential low risk, if not adequately diluted, on the receiving waters suitability for drinking water, long-term irrigation and recreational use respectively.

If not adequately diluted, uncontrolled waters released from SB3a present a low risk to the receiving aquatic environments ecosystem protection and water suitability of identified EVs as follows:

- Protection of Aquatic Ecosystems (elevated Turbidity, TSS and potentially dissolved Al, Cu and Zn concentrations)
- Recreation Purpose (elevated turbidity, TSS, Mn and NH_4 concentrations)
- Long-term irrigation use (elevated TP concentration)
- Drinking water supply (elevated TN concentration).

Ongoing monitoring of background water quality within the Coxs River is required to establish local background reference conditions, therefore, it is recommended that background reference conditions at the time of release be undertaken (i.e. EPL Point 2) and downstream of the release point within Coxs River, pending accessibility, and on an event basis to assess compliance/risk to receiving waters EVs. Ongoing parameters to be monitored should include, but not be limited to Turbidity, TSS, total Mn and dissolved Cu, TP and NH_4. Dissolved Al and Zn have not been included as these parameters have not been detected above the ILDWQO were such analysis have been conducted on similar surface waters on-site.

10.2.3 Sediment Basin SB2b Water Quality

No detailed statistical analysis can be undertaken due to the small dataset provided (*n=1*); however, based on the available water quality data, the following water quality parameters have equalled or exceed the ILDWQO; EC, BOD_5, Turbidity, TSS, Total metals (Al, Cd, Cu, Pb, Mn and Zn), TN, TP and NH_4 (see Table 14 – Summary Statistics of SB2 Water Quality).

Water EC (860 μS/cm) exceeded the ILDWQO of 322 μS/cm; however, the level measured is considered to pose no genuine risk to the receiving waters EVs.

Water turbidity and TSS concentrations of SB2b are considered to pose a potential risk to the receiving freshwater ecosystem and receiving waters suitability for other identified EVs (i.e. recreation use and drinking water supply) without sufficient dilution.

Although concentrations for some total metals (Al, Cd, Cu, Pb, Mn and Zn) exceeded the ILDWQO, it is not possible to assess the true risk to aquatic ecosystems on the basis of analysis of metals concentrations in unfiltered water samples. If a worst case scenario is assumed (dissolved metal concentrations equal total concentrations) the measured Al, Cd, Cu, Pb, Mn and Zn concentrations would pose a potential risk, if not adequately diluted on the receiving aquatic environment ecosystem. A one-fold dilution in the receiving environment would reduce the Cd and Pb concentrations below the respective locally derived release limits, while a two-fold dilution would be required for Mn and Zn concentrations, three-fold dilution for Cu and six-fold for Al. Given the location and current activity on-site, the elevated total heavy metals are considered to be reflective of the local geology, therefore, most likely associated with suspended particulates/sediment and not related to unnatural sources. In such case, dissolved metal concentrations are likely to be lower than total concentrations measured, as determined at other monitoring locations on-site where both have been analysed, hence so would the potential risk.

Of the elevated total metal concentrations, the Mn concentration poses a potential risk, if not adequately diluted, on the receiving waters suitability for recreational and long term irrigation use.

Given the surrounding land use (i.e. beef cattle grazing) and that no effluent from on-site operations is disposed of on-site, the elevated BOD_5 and nutrient levels (i.e. TN, TP and NH_4) are considered to be associated with organic matter (e.g. manures, top-soil erosion) associated with suspended particulates/sediment. The elevated nutrient levels have the potential to cause toxicity or nuisance algal problems, particularly if released during no or base flow conditions. The elevated TN, TP and NH_4 also pose a potential low risk, if not adequately diluted, on the receiving waters suitability for raw water drinking supply, long-term irrigation and recreational use respectively.

If not adequately diluted, uncontrolled waters released from SB2b may present a risk to the receiving aquatic environments ecosystem protection and water suitability of identified EVs as follows:

- Protection of Aquatic Ecosystems (elevated Turbidity, TSS and potentially dissolved Al, Cd, Cu, Pb and Zn)
- Recreation Purpose (elevated turbidity, TSS, Mn and NH_4 concentrations)
- Long-term irrigation (elevated TP)
- Drinking water supply (elevated BOD_5, Turbidity, Al and TN concentrations).

Ongoing monitoring of background water quality within Coxs River is required to establish local background reference conditions; therefore, it is recommended that background reference conditions at the time of release be undertaken (i.e. EPL Point 2) and downstream of the release point (i.e. EPL Point 3) on an event basis to assess compliance/risk to receiving waters EVs. Ongoing parameters to be monitored should include but not be limited to Turbidity, TSS, BOD_5, total metals (Mn and Al), dissolved Cu, TN, TP and NH_4. Dissolved Al, Cd and Zn have not been included as these parameters have not been detected above the ILDWQO were such analysis have been conducted on similar surface waters on-site.

10.2.4 Storage Dam 2 Water Quality

Some detailed statistical analysis can be undertaken given the available dataset ($n \leq 22$ for Physico-chemical and n=1 for toxicity analysis); however, based on the available water quality data, the following water quality parameters have equalled or exceed the ILDWQO; pH, EC, Turbidity, TSS, Dissolved Cu and NH_4 (see **Table 12 – Summary Statistics of SD2 Water Quality**).

Water pH typically exceeds the locally derived release upper limit range of 8.5 pH units, with a 95^{th} percentile level of 9.0 based on dataset of *n*=22. The elevated pH is likely to be attributed to incorrect dosing of waters within SD2 with water treatment chemical/s and/or the presence of algal blooms.

Water EC (i.e. median concentration 450 μS/cm) typically exceeds the locally derived release limit of 320 μS/cm; however, the level measured is considered to pose no genuine risk to the receiving waters EVs.

Water turbidity and TSS concentrations of SD2 are considered to pose a potential risk to the receiving freshwater ecosystem and receiving waters suitability for other identified EVs (i.e. recreation use and drinking water supply) without sufficient dilution.

The measured dissolved Cu concentration exceeds the ILDWQO; therefore, indicates waters pose a potential risk if not adequately diluted on the receiving aquatic environment ecosystem; however, caution should be exercised as the data set is small (*n*=1). A less than one-fold dilution in the receiving environment would be required to reduce the dissolved Cu concentration below the respective locally derived release limit.

Given the surrounding land use (i.e. beef cattle grazing) and that no effluent from quarry operations is disposed of on-site, the elevated BOD_5 and NH_4 (equal to the ILDWQO) are likely to be associated with organic matter (e.g. manures) associated with suspended particulates/soils; however, on-site activities have the potential to promote their release.

Although the NH_4 concentration exceeded the respective locally derived release limit, it is equal to the NH4 concentration measured at the Coxs River background reference condition sample of 0.02 mg/L, therefore concentration is unlikely to pose any genuine risk to the downstream receiving waters suitability for recreational use.

If not adequately diluted, uncontrolled waters released from SD2 may present a risk to the receiving aquatic environments ecosystem protection and water suitability of identified EVs as follows:

- Protection of Aquatic Ecosystems (elevated pH, Turbidity, TSS and dissolved Cu)
- Recreation Purpose (elevated turbidity and TSS concentrations)
- Drinking Water Supply (elevated BOD_5).

Ongoing monitoring of background water quality within Coxs River is required to establish local background reference conditions, therefore, it is recommended that background reference conditions at the time of release be undertaken (i.e. EPL Point 2) and downstream of the release point (i.e. EPL Point 3) on an event basis to assess compliance/risk to receiving waters EVs. Ongoing parameters to be monitored should include but not be limited to Turbidity, TSS, BOD_5, dissolved Cu and NH_4.

10.2.5 Storage Dam 6 Water Quality

Some detail statistical analysis can be undertaken given the available dataset ($n \leq 24$ for Physico-chemical and *n*=1 for toxicity analysis); however, based on the available water quality data, the following water quality parameters have equalled or exceed the locally derived release limits; pH, EC, Turbidity, TSS, BOD_5, Total metals (Al and Mn), Dissolved Cu, TN, TP and NH_4 (see **Table 13 – Summary Statistics of SD6 Water Quality**).

Generally, the water quality of SD6 is similar to SB1. This is to be expected given excess water from SB1 is transferred to SD6 for storage as part of the on-site water management regime.

Water pH occasionally exceeds the ILDWQO upper range of 8.5 pH units, with a 95th percentile level of 8.7, based on dataset of *n*=24; however, the water pH is not considered to pose any genuine risk to the receiving waters EVs as the median pH level is below the ILDWQO at 8.0.

Water EC typically exceeds the ILDWQO of 322 μS/cm, with a median concentration of 453 μS/cm based on small dataset of *n*=8. Although median concentration is elevated compared to background conditions, the EC concentration of the SD6 waters is considered to pose only a low potential risk to the receiving waters EVs.

Water turbidity and TSS concentrations of SD5 are considered to pose a potential risk to the receiving freshwater ecosystem and receiving waters suitability for other identified EVs (i.e. recreation use and drinking water supply) without adequate dilution.

The measured dissolved Cu concentration exceeds the ILDWQO; therefore, indicates waters pose a potential risk if not adequately diluted on the receiving aquatic environment ecosystem; however, caution should be exercised as the data set is small (*n*=1). A less than one-fold dilution in the receiving environment would be required to reduce the dissolved Cu concentration below the respective locally derived release limit.

The elevated total metals (i.e. Al and Mn) are considered to be reflective of the local geology and not related to unnatural sources. A two-fold dilution in the receiving environment would reduce the Total Mn concentration below the ILDWQO, while a five-fold would be required for Total Al.

Given the surrounding land use (i.e. beef cattle grazing) and that no effluent from on-site operations is disposed of on-site, the elevated BOD_5 and nutrient levels (i.e. TP and NH_4) are considered to be associated with organic matter (e.g. manures, top-soil erosion) associated with suspended particulates/sediment. The elevated TN and TP level has the potential to cause nuisance algal problems, particularly if released during no or base flow conditions. The elevated BOD_5, TN, TP and NH_4 concentrations also pose a potential low risk if not adequately diluted on the receiving waters suitability for drinking water, long-term irrigation and recreational use respectively.

If not adequately diluted, uncontrolled waters released from SD6 may present a risk to the receiving aquatic environments ecosystem protection and water suitability of identified EVs as follows:

- Protection of Aquatic Ecosystems (elevated Turbidity, TSS, TN, TP, NH_4, dissolved Cu)
- Recreation Purpose (elevated turbidity, TSS and Mn and NH_4 concentrations)
- Long-term irrigation (elevated TP)
- Livestock watering (elevated Al)
- Drinking water supply (elevated Turbidity, BOD_5 and TN concentration).

Ongoing monitoring of background water quality within Coxs River is required to establish local background reference conditions, therefore, it is recommended that background reference conditions at the time of release be undertaken (i.e. EPL Point 2) and downstream of the release point (i.e. EPL Point 3) on an event basis to assess compliance/risk to receiving waters EVs. Ongoing parameters to be monitored should include but not be limited to Turbidity, TSS, BOD_5, Total Al and Mn, Dissolved Cu, NH_4 and TP.

11. ASSESSMENT AGAINST THE SEPP

11.1.1 Introduction

As stated in Section 9.2, the SEPP states:

> "*A consent authority must not grant consent to the carrying out of development under Part 4 of the Act on land in the Sydney drinking water catchment unless it is satisfied that the carrying out of the proposed development would have a neutral or beneficial effect on water quality*."

Sydney Catchment Authority (2011) *Developments in Sydney's Drinking Water Catchment Water Quality Information Requirements* defines a neutral or beneficial effect on water quality as a development that:

- "*has no identifiable impact on water quality, or*
- *will be contain any water quality impact on the development site and stop it from reaching any watercourse, waterbody or drainage depression on site, or*
- *will transfer any water quality impact outside of the site where it is treated and disposed of to standards approved by the consent authority."*

11.1.2 Stage 2 Extension Environmental Impacts

The Stage 2 Extension poses no new infrastructure or changes to existing land elevations that would impact on local and regional flood regimes, or resultant impacts on infrastructure and public safety for flood events up to and including a 150 year ARI.

No uncontrolled releases are predicted to occur for the Stage 2 Extension of the extraction area (sub-catchments L1 and L2). The water management regime employed on the Site involves the dewatering/treatment of waters collected within the extraction area prior to controlled release via SD1 and SD2 into the receiving environment.

With no proposed changes to on-site water conveyancing structures or predicted change in geology within the extraction area, the water quality and maximum controlled discharge rate of waters collected within the extraction area are proposed to be similar to pre-Stage 2 Extension conditions.

The proposed lateral extension of the extraction area to a maximum depth of RL 685m AHD, some 45m below the water table, would remain well above the Coxs River and the elevation of most surrounding natural drainage gullies. The impact on standing water levels between the extraction area and surrounding gullies, including Yorkeys Creek and Coxs River, would be restricted to a distance of approximately 225m (Ground Doctor, 2104). As such, a hydraulic gradient would be maintained toward the gullies allowing for groundwater to continue to discharge towards these, i.e. maintain pre-Stage 2 Extension conditions.

The proposed Stage 2 Extension also presents no greater opportunity for contaminants to enter the groundwater than the pre-Stage 2 Extension development. Risks posed by the ongoing presence of chemicals used on-site (i.e. diesel, hydraulic fluids, explosives) within the extraction area can be adequately addressed through implementation of appropriate environmental management procedures.

On the basis of the above discussion, the Stage 2 Extension has no identifiable impact on groundwater recharge flows to adjacent waterways or users, or water quality (surface and groundwater) provided adequate water treatment is undertaken prior to release. Therefore a neutral effect on receiving aquatic environment water quality is predicted for this sub-catchment.

11.1.3 Ancillary Sub-Catchment Environmental Impacts

It is predicted that potentially contaminated (i.e. sediment laden) waters would continue to be released from existing ancillary operational sub-catchments J3, K1, K3 and A1 via SB1, SB2b, SD6 and SB3a/b respectively. Uncontrolled waters released from site operational areas have been identified to pose a potential risk to the receiving aquatic ecosystem and water suitability for the following identified EVs:

- Protection of Aquatic Ecosystems
- Recreation Purpose
- Long-term irrigation
- Livestock watering
- Drinking water supply.

These releases are predicted to occur during times of event flows occurring within the natural waterways, hence any potential risk to receiving waters would be greatly reduced.

Carrying out of the Stage 2 Extension would result in no change in the catchment area, land use and runoff volumes between the pre and post extension (Stage A to Stage G) for catchments J3, K1 and K4, hence the potential risks identified are considered to be no greater than those present prior to the Stage 2 Extension.

Existing and/or new sediment basins would be re-sized, where necessary, to ensure their design capacity meets the minimum regulatory requirements (i.e. SB2b and SB3b). The resizing of the basins to meet the minimum regulatory requirement, would provide additional capacity compared to pre-extension; hence provide a beneficial effect on receiving water quality for those catchments by reducing the current discharge frequency and volume of untreated waters from catchment K4.

Proposed changes to the existing stormwater management on-site would separate overland flows from undisturbed catchment areas (i.e. clean waters) from potentially contaminated waters from disturbed operational areas by diverting clean overland flows or waters released from clean water storage dams around established treatment and/or sediment basins, where practicable as follows.

- Control discharging of treated excess waters in SB1 via SD1 and SD2 to Coxs River.
- A diversion bund to divert overland flows from the clean catchment above SD1 and SD2 to maximise capacity to receive water from SB1 for treatment prior to being discharged to Coxs River.
- A diversion channel to divert overflows from the clean catchment dam SD5 around SD6 in order gain additional water storage capacity in SD6 to receive access water from SB1.
- Control discharging of treated excess waters in SD6 to Yorkeys Creek to gain additional water storage capacity to dewater excess waters from SB1.

The implementation of the above stormwater management controls would further reduce the volume of potentially contaminated waters generated on-site and the frequency and volume of potentially contaminated waters released; hence provide a beneficial effect on receiving water quality from those catchments.

11.1.4 Conclusion

On the basis of the above discussions, it is evident that the proposed Stage 2 Extension can operate to achieve a neutral to beneficial effect on water quality in the drinking water catchment; however, there is the need for ongoing careful management and impact amelioration measures to limit any potential adverse impacts, particularly relating to possible indirect affects off-site. Improvements, as identified in other sections of this report, and on-going monitoring and maintenance of the on-site Stormwater, Sediment and Erosion Controls are required to prevent any potential adverse impacts on the water quality downstream of the Site.

12. RELEASE WATER MONITORING PROGRAM

To measure the performance on-site water management and potential on-going release water quality impacts on receiving waters, the following water monitoring program would be implemented.

12.1 PARAMETERS

The initial parameters that would be analysed are detailed below in **Table 47 – Water Quality Monitoring Parameters**; however, the list of parameters would be regularly review (i.e. annually) and revised as necessary based on water quality data collected.

Table 48 – Water Quality Monitoring Parameters

Parameter	Units	Sample Type
pH	pH units	Grab Sample or *In-situ*
Turbidity	NTU	Grab Sample or *In-situ*
Total Suspended Solid	mg/L	Grab Sample
BOD_5	mg/L	Grab Sample
Total Al and Mn	μg/L	Grab Sample
Dissolved Cu	μg/L	Grab Sample
Ammonia	mg/L	Grab Sample
Total Nitrogen	mg/L	Grab Sample
Total Phosphorus	mg/L	Grab Sample
Visual Oil & Grease/Litter	Present/Absent	Visual observation
	mg/L	Grab Sample

12.2 MONITORING LOCATIONS

Water quality sampling sites and monitoring frequency for discharge events are described in **Table 49 – Water Quality Monitoring Frequency and Points**, while locations of monitoring points are also shown on **Figure 4 – Discharge and Water Monitoring Location Plan**.

Table 49 – Water Quality Monitoring Frequency and Points

Monitoring Point	Location Description	Monitoring Frequency
EPL Point 9	Release point from SB3(a/b)	Prior to a controlled discharge and within 24 hours then weekly during uncontrolled discharge events;
EPL Point 1	Release point from SB1	
EPL Point 8	Release point from SB2b	
EPL Point 10	Release point from SD2	
EPL Point 11	Release point from SD6	
EPL Point 2	Upstream Coxs River	At commencement of then weekly during site discharge events
EPL Point 3	Downstream Coxs River	

12.3 CONTAMINANT RELEASE LIMITS

Based on the locally derived water quality objectives presented in **Table 47 – Locally Derived Water Quality Objectives** of this report, monitoring results at EPL Points 1, 8, 9, 10 and 11 would be compared against the following contaminated release limits presented in **Table 50 – Contaminant Release Limits** or alternative contaminated release limits imposed by the EPL. The release criteria would be updated as more data is collected and Background Reference Conditions for metals and nutrients can be determined.

Table 50 – Contaminant Release Limits

Parameter	Release Criteria	Type
Turbidity	Less than or equal to locally derived release limit (i.e. ≤11 NTU) or less than 10% above background (as measured at EPL Point 2), whichever is greater	Maximum
Total Suspended Solids	Less than or equal to locally derived release limit (i.e. ≤8 mg/L) or less than 10% above background (as measured at EPL Point 2), whichever is greater	Maximum
pH	6.0 – 8.5	Range
BOD_5	Less than or equal to locally derived release limit (i.e. ≤5 mg/L)	Maximum
Total Al	Less than or equal to locally derived release limit (i.e. ≤55 µg/L) or less than 10% above background (as measured at EPL Point 2), whichever is greater	Maximum
Total Mn	Less than or equal to locally derived release limit (i.e. ≤100 µg/L) or Less than 10% above background (as measured at EPL Point 2), whichever is greater	Maximum
Dissolved Cu	Less than or equal to locally derived release limit (i.e. 1.4 µg/L) or less than 10% above background (as measured at EPL Point 2), whichever is greater	Maximum

Table 50 – Contaminant Release Limits (Cont'd)

Parameter	Release Criteria	Type
TN	Less than or equal to locally derived release limit (i.e. ≤1.4 mg/L) or less than 10% above background (as measured at EPL Point 2), whichever is greater	Maximum
TP	Less than or equal to locally derived release limit (i.e. ≤0.05 mg/L) or less than 10% above background (as measured at EPL Point 2), whichever is greater	Maximum
NH_4	Less than or equal to locally derived release limit (i.e. ≤0.01 mg/L) or less than 10% above background (as measured at EPL Point 2), whichever is greater	Maximum
Visual Oil & Grease/Litter	Greater than 10 mg/L (current EPL release limit)	Maximum

12.4 CORRECTIVE ACTION

If contaminant release limits are exceeded at EPL Points 1, 8, 9, 10 and 11, corrective action would be implemented as presented in **Table 51 – Corrective Action to Exceedance of Contaminant Release Limits**.

Table 51 – Corrective Action to Exceedance of Contaminant Release Limits

Release Water Quality	Corrective Action(s)
Less than or equal to locally derived release limit or release limit prescribed by EPL or less than 10% above background (as measured at EPL Point 2), whichever is greater	Nil
Greater than locally derived release limit or greater than release limit prescribed by EPL or greater than 10% above background (as measured at EPL Point 2), whichever is greater	Cease discharge if practicable, advise EPA, investigate cause, implement immediate action to rectify (i.e. re-treat/retest to confirm compliance or implementation of additional SSEC) prior to recommencing control discharge.
Presence of visual oil and grease	Cease discharge if practicable, test for Oil and Grease and if >10mg/L advise EPA, investigate and implement immediate action to rectify and to prevent reoccurrence, arrange contractor to remove visual contamination and appropriately dispose/recycle contaminated water off-site at an appropriately licensed facility.

12.5 INTEGRITY OF WATERWAYS

While drainage pathways (man-made and natural) and banks of the drainage lines at the points of release are well vegetated, discharge can potentially increase stream erosion. To measure the water quality impacts of any quarry discharges on the integrity of receiving waterways, visual surveillance on at least a weekly basis during and then immediately following discharge events is proposed.

12.6 DRAINAGE STRUCTURES

Apart for the purpose built spillway, culverts and outlet pipes of the Sediment Basins and Storage Dams no other on-site drainage structures are likely to be affected by quarry discharges.

Corrective action, if required, will involve ceasing or scaling back the rate of discharge, where practicable, until remediation to drainage structures can be completed.

12.7 DRAINAGE DEPRESSION BED AND BANK INTEGRITY

Visual assessment of water clarity and drainage depression bed and bank integrity during water monitoring would be carried out to determine whether scouring is occurring. As per the proposed monitoring program described in the **section 12.8 Release Water Monitoring** below, the performance of drainage structures, corrective action, if required, would involve ceasing or scaling back the rate of discharge until remediation can be completed.

12.8 RELEASE WATER MONITORING

As part of the proposed monitoring program, an initial visual inspection of outlet structures and, bed and banks of the drainage depressions directly downstream of the discharge points will be conducted and documented (including photographs). Subsequent inspection would be conducted at commencement of discharge and then weekly until it is established that scouring is not occurring. Any bypassing of, or damage to, drainage structures and bed and banks of the drainage depressions/outlets would be repaired immediately. Discharge will be ceased or reduced until such repair is complete.

13. CONCLUSION AND RECOMMENDATIONS

The Stage 2 Extension is predicted to have no effect on the footprints of existing operational catchments, with the exception of increasing the footprints of operational sub-catchments A1 (overburden emplacement) and L (L1 and L2 of the extraction area).

No new infrastructure or changes to existing land elevations that would impact on local and regional flood regimes, or resultant impacts on infrastructure and public safety for flood events up to and including a 150 year ARI are proposed by the Stage 2 Extension.

The Stage 2 Extension is considered to present no greater opportunity for contaminants to enter the groundwater or adjacent water ways than pre-Stage 2 Extension development, with no uncontrolled releases predicted to occur for the Stage 2 Extension of the extraction area (sub-catchments L1 and L2). The existing water management regime employed at the quarry is proposed to continue, which involves dewatering and treatment of waters collected within the extraction area prior to controlled release via SD2 into the receiving environment. With no proposed changes in on-site water conveyancing structures or predicted change in geology within the extraction area, the water quality and maximum controlled discharge rate of waters collected within the extraction area are proposed to be similar to pre-Stage 2 Extension conditions.

The Stage 2 Extension would interfere with groundwater; however, no identifiable impact is predicted on groundwater recharge flows to adjacent waterways, users or on water quality (surface and groundwater) (Ground Doctor, 2014).

Uncontrolled discharges are predicted to continue to be released from existing ancillary operational catchments J3, K3 and A1 via SB1, SB2b and SB3a/b respectively. The frequency and volume of these discharges would be reduced by the proposed additional stormwater management recommended and limited to high or prolonged wet weather conditions when compared to pre-Stage 2 Extension conditions. Water contained within these releases is considered to pose a potential risk to the receiving aquatic ecosystem/s and downstream water suitability for identified EVs as follows.

- Protection of Aquatic Ecosystems (elevated Turbidity, TSS, TN, Dissolved Cu.
- Recreation Purpose (elevated turbidity, TSS, Mn and NH_4 concentrations).
- Long-term irrigation (elevated TP).
- Drinking water use (elevated BOD_5, Al and TN concentrations).

Although these uncontrolled discharges of untreated waters are mostly likely to occur during high and/or prolonged wet weather when natural stream flows are high, hence reducing the potential risk, there is the need for ongoing careful management and impact amelioration measures to limit any potential adverse impacts, particularly relating to possible indirect affects downstream off-site.

The proposed Stage 2 Extension can be operated in a manner to achieve a neutral to beneficial effect on water quality in the drinking water catchment by containing and/or reducing existing uncontrolled water releases from operational areas, where practicable, compared to pre-Stage 2 Extension. By doing so, the Stage 2 Extension would meet the requirement of the State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011 for new activities under Part 5 of the *Environmental Planning Assessment Act 1979* that are situated within the Sydney Drinking Water Catchment.

To achieve a neutral to beneficial effect on water quality, the implementation of the following \ mitigation measures is recommended.

- Ensuring sediment basins, except SB1, are constructed and their design holding capacity maintained to capture all rainfall runoff for a “designed” rainfall event (i.e. Type D basins capable of storing a 95^{th} percentile 5-day rainfall event).
- Installation of a new sediment basin (SB3b), with a peak storage capacity of approximately 12.3 ML to meet minimum regulatory requirements, downstream of the overburden emplacement area footprint prior to the commencement of Stage 2 Extension.
- Increase of the storage capacity of SB2b to achieve the required minimum design storage volume of 4 ML.
- Installation of a diversion channel to divert overflows from the clean catchment dam SD5 around SD6 in order gain additional water storage capacity in SD6 to receive additional excess waters captured in SB1.
- Continuation of the management of the short fall in the total storage capacity of SB1 by pumping excess waters to other basins (e.g. SD1, SD2 and SD6) that have sufficient excess storage capacity.
- Discharge of in-situ treated excess waters from SB1 in SD1 and SD2 to Coxs River on an as needs basis to regain design storage capacity.
- Discharge of treated in-situ waters in SD6 to Yorkeys Creek, on an as needs basis, to regain/maximise additional water storage capacity to dewater excess waters from SB1.
- Installation of a diversion bund around SD1, SD2 and SD6 to divert clean overland flows from mixing with potentially contaminated waters from operational areas, which would also maximize the dams capacities to treat excess waters captured in SB1 and/or dewatered from the extraction area.
- Installation of SSEC management measures as shown on **Figure 6** to **18**.

On-going monitoring is also recommended of all implemented SSEC measures and on-site water releases (i.e. controlled and uncontrolled) to provide on-going assessment and improvement, if and where necessary to verify the carrying out of Stage 2 Extension has a neutral to beneficial effect on water quality of the receiving.

14. REFERENCES

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