PROJECT

SOIL AND WATER MANAGEMENT PLAN BLAKEBROOK QUARRY BLAKEBROOK NEW SOUTH WALES

PREPARED FOR

LISMORE CITY COUNCIL

DATE

FEBRUARY 2019

GILBERT SUTHERLAND

DOCUMENT CONTROL

DOCUMENT 11737_SWMP_CMA3F.docx

TITLE Soil and Water Management Plan, Blakebrook Quarry, Blakebrook, New South Wales

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CLIENT REFERENCE –

SYNOPSIS This soil and water management plan (SWMP) establishes responsibilities and procedures for the management of Lismore City Council's hard rock quarry located on Lot 201 DP 1227138, Blakebrook, New South Wales.

REVISION HISTORY

REVISION #	DATE	EDITION BY	APPROVED BY
1	12/17	A. Fullagar	C. Anderson
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DISTRIBUTION

	REVISION NUMBER									
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SUMMARY

Lismore City Council (LCC) commissioned Gilbert & Sutherland Pty Ltd (G&S) to prepare a Soil and Water Management Plan (SWMP) to address the ‘Pollutant Studies and Reduction Programs’ requirements of the NSW Environmental Protection Authority’s (EPA) Licence Variation (issued 27 November 2017) for Blakebrook Quarry, located on premises described as Lot 201 on DP1227138.

Under the Licence Variation, an SWMP is required to detail the type, design, location and appropriate sizing of soil and water management measures for the site, as well as their operational management.

LCC has operated Blakebrook Quarry since 1979. In 2009, a Modification Application was approved to permit expansion of the operations within the Northern Pit. An SWMP was prepared by Environmental Resources Management (ERM) in support of that application, and subsequently approved.

A further Notice of Modification was issued by the former NSW Department of Planning (DoP) on 18 September 2017 in relation to expansion of operations to the Southern Pit. This current SWMP has been prepared in response to that Notice of Modification, and specifically to address Condition 19 of the approval. It both updates the previous SWMP to reflect current site operations and expands the scope to address works within the Southern Pit.

This SWMP incorporates a surface water assessment, a water balance assessment and sediment and erosion control techniques. These components form the basis of the SWMP tables.

The driving principles of this SWMP are to:

- divert clean water around the site operations (where possible)
- retain dirty water within the pits for reuse and/or treatment
- discharge waters from the pits as necessary, and only if they comply with water quality criteria
- update the SWMP (in particular water management drawings and plans) to align with site operations as they progress
- ensure a robust and straightforward approach to the management of soils and water on the site.

CONTENTS

1 Introduction

1.1 Background

Lismore City Council (LCC) commissioned Gilbert & Sutherland Pty Ltd (G&S) to prepare a Soil and Water Management Plan (SWMP) for Blakebrook Quarry to address the requirements of a *Notice of Variation of Licence No. 3384* (notice number 1558031, file number EF13/3226,) issued by NSW Environmental Protection Authority (EPA) on 17 November 2017.

The Environmental Protection Licence (No. 3384, version dated 17 November 2017) now includes the following requirement under *Section 8 Pollution Studies and Reduction Programs:*

> ***U1 Soil and Water Management Plan***
>
> *U1.1 A Soil and Water Management Plan (SWMP) must be prepared and submitted to the EPA by 18 December 2017 and implemented by 13 January 2018. The plan must describe the measures that will be employed to minimise soil erosion and the discharge of sediment and other pollutants from the premises. The SWMP must be prepared in accordance with the requirements of the Managing Urban Stormwater: Soils and Construction, Volume 1, 4th edition, March 2004 Landcom (the Blue Book) and Managing Urban Stormwater: Soils and Construction, Volume 2E Mines and Quarries, 2008, DECC.*

This SWMP has been prepared to address the above requirement in respect to the current operations of the quarry.

This report is divided into sections detailing the physical characteristics of the site and the findings of site assessments. The SWMP proposes management measures to prevent and/or minimise potential impacts during the operational phase of the works. It is these management sections that form the basis of the Soil and Water Management Plan for the site.

The report is based on site observations undertaken by G&S staff, a desktop assessment using available topographic and landscape information, on-site investigations and also utilises information from previous reports for Blakebrook Quarry, including:

- Blakebrook Quarry Expansion, Environmental Assessment Report, Final Report, prepared by ERM, dated January 2009.
- Blakebrook Quarry Expansion, Soil and Water Management Sub-Plan, prepared by ERM, dated April 2011.
- Blakebrook Quarry Water Balance Model 2016, prepared by NDC, dated February 2017.

1.2 Notice of Modification - Specific Environmental Conditions

Under the Notice of Modification, Schedule 3 Specific Environmental Conditions, under condition 19 the Proponent is required to prepare a SWMP for the project to the satisfaction of the Secretary.

To address this condition, this SWMP is prepared by G&S under the requirement of the Notice of Modification.

a) be prepared by suitably qualified and experienced person/s approved by the Secretary;
b) be prepared in consultation with the EPA and DPI Water;
c) be submitted to the Secretary for approval within 3 months of the determination of Modification 1, unless otherwise agreed by the Secretary; and
d) include a:
  - *a. Site Water Balance that includes:*
    - *i. details of:*
      - *1. sources and security of water supply;*
      - *2. water use and management on site;*
      - *3. any off-site water transfers; and*
      - *4. reporting procedures; and*
    - *ii. measures to be implemented to minimise clean water use on site;*
  - *b. Surface Water Management Plan, that includes:*

- i. *a program for obtaining detailed baseline data on surface water flows and quality in water bodies that could potentially be affected by the project;*
- ii. *a detailed description of the surface water management system on site including the:*
  1. *clean water diversion system;*
  2. *erosion and sediment controls;*
  3. *dirty water management system; and*
  4. *water storages; and*
- iii. *a program to monitor and report on:*
  1. *any surface water discharges;*
  2. *the effectiveness of the water management system,*
  3. *the quality of water discharged from the site to the environment;*
  4. *surface water flows and quality in local watercourses;*

c. *Groundwater Management Plan that includes:*

- i. *a provision that requires the Proponent to obtain appropriate water licence(s) to cover the volume of any unforeseen groundwater inflows into the quarry from the quarry face or floor; and*
- ii. *a monitoring program to manage potential impacts, if any, on any alluvium and associated surface water source near the proposed extraction area that includes:*
  1. *identification of a methodology for determining threshold water level criteria;*
  2. *contingency measures in the event of a breach of thresholds; and*
  3. *a program to regularly report on monitoring.*

1.3 Quarry operating conditions under EPA Licence 3384

The Environment Protection Licence for the quarry (EPA Licence 3384) permits land-based extractive activities on a production scale of 100,000 tonnes to 500,000 tonnes per annum for extraction, processing and storage. Ancillary activities permitted to be carried out at the premises include bitumen pre-mix or hot-mix industries.

The licence regulates water pollution resulting from the activities carried out at the site.

Currently, the licence permits site discharge from a single location, described as:

> *'Spillway of the settlement dam at the southern end of the site nearest the weighbridge as identified on site map entitled Blake Brook Quarry Water Management dated 21 July 2005.'*

Quarrying activities including loading and dispatch of trucks as well as the asphalt plant are permitted to operate during specified hours six days a week (Monday to Saturday) whilst blasting activities are limited to five days (Monday to Friday). No activities (with the exception of maintenance or government work) are permitted on Sundays or Public Holidays.

The operating conditions are detailed in Section 4 of the licence. The conditions specifically relating to water management are:

> ***O4 Processes and management***
>
> *O4.1 Sediment Basins shall be treated, if required, to reduce the Total Suspended Solids level to the licenced concentration limit before being discharged to the environment. Treatment can be with gypsum or any other material that has been approved by the EPA.*
>
> *O4.2 The licensee must maximise the diversion of run-on waters from lands upslope and around the site whilst land disturbance activities are being undertaken.*
>
> *O4.3 The licensee must maximise the diversion of stormwater runoff containing suspended solids to sediment basins installed on the premises.*
>
> *O4.4 Where sediment basins are necessary, all sediment basins and associated drainage must be installed and commissioned prior to the commencement of any clearing or grubbing works within the catchment area of the sediment basin that may cause sediment to leave the site.*

O4.5 The licensee must ensure the design storage capacity of the sediment basins installed on the premises is reinstated within 5 days of the cessation of a rainfall event that causes runoff to occur on or from the premises.

O4.6 The licensee must ensure that sampling point(s) for water discharged from the sediment basin(s) are provided and maintained in an appropriate condition to permit:

a) the clear identification of each sediment basin and discharge point;

b) the collection of representative samples of the water discharged from the sediment basin(s); and

c) access to the sampling point(s) at all times by an authorised officer of the EPA.

O4.7 The licensee must endeavour to maximise the reuse of captured stormwater on the premises.

O4.8 Each sedimentation basin must have a marker (the "sedimentation basin marker") that identifies the upper level of the sediment storage zone.

O4.9 Whenever the level of liquid and other material in any sedimentation basin exceeds the level indicated by the sedimentation basin marker, the licensee must take all practical measures as soon as possible to reduce the level of liquid and other material in the sedimentation basin.

O4.10 The sediment basins must meet the design and operational standards of Managing Urban Stormwater Soils and Construction: Volume 1 and Volume 2 E. Mines and quarries. The sediment basin sizes have been calculated to total 20.05 ML as outlined in the Blakebrook Quarry Expansion - Soil and Water Management Sub-Plan - April 2011, prepared by Environmental Resources Management Australia on behalf of Lismore City Council.

This report addresses the above operating conditions in respect to current and future operations at the quarry.

The drawings in Appendix 1 and the corresponding attachments have been designed to be updated over time to reflect the progress of works on site.

2 Site description and physical characteristics

2.1 Site description

LCC has owned and operated Blakebrook Quarry since 1979. The quarry is located on premises described as Lot 201 on DP 1227138 and is situated off Nimbin Road at Blakebrook, approximately seven kilometres northwest of Lismore, New South Wales (‘the site’).

The site occupies an area of approximately 126ha, with elevations (prior to commencement of quarrying operations) ranging from approximately 30 metres Australian Height Datum (mAHD) to 140 mAHD.

It is proposed that, once completed, the quarry pits will occupy a total area of 44.2 ha within the site, comprising the primary 40 ha northern pit to a maximum depth of 55 mAHD and a smaller 4.2 ha pit in the south of the site to a depth of 105 mAHD.

2.2 Catchment description

The site is situated on a ridge between Blakebrook Creek to its east and Terania Creek to its west. The main northern pit is located on the west-facing side of the ridge, within the natural terrain draining westwards via existing ephemeral gullies to Terania Creek.

The smaller southern pit is located on the eastern side of the ridge, with the natural terrain in this locale draining via existing ephemeral flow paths to the east towards Blakebrook Creek.

2.3 Vegetation

A large area, central to the site has previously been cleared and is occupied by the existing quarry pits, surrounding access roads and quarry and process plant infrastructure. The remainder of the site is occupied by vegetation of varying density, with some areas having been cleared for previous agricultural site uses and other areas occupied by dense tree cover.

2.4 Soils and landform

A review of the Morand (1994) 1:100,000 Soil Landscape Series 9540-9640 (Lismore-Ballina) indicates that the site geology is comprised of residual landscapes of the Frederick (fr) origin, surrounded by colluvial landscapes of the Georgica (ge and gea) type, as shown on Drawing No. 11737-003 (in Appendix 1).

The Frederick landscape type is characterised by low undulating rises on flat basalt plateau surfaces. Relief of 5-30 m, elevations of 130-180 m and slopes of 1-10%. Soils comprise shallow (<100 cm), poorly drained Prarie Soils (Gn3.42), localised moderately deep (100-150 cm), well drained Krasnozems (Uf5.2, Gn3.11, Gn4.11) on iron-rich material and deep (>150 cm), poorly drained Black Earths/Weisenboden (Ug5.15, Ug5.17) and Dense Clays (Uf6.61) within drainage depressions.

The surrounding Georgica landscapes are characterised by high rolling and steep waning hills on Lismore Basalts. Relief of 90-200 m and slopes of 15-30%. Sideslopes, ridgeslopes, and narrow, sharp ridges and crests are common. Widespread mass movement has created a hummocky microrelief and tarracettes are common. Soils comprise shallow (50-100 cm), moderately will drained Chocolate Soils (Db3.11) and Prarie Soils (Gn3.21, Um5.51) on crests and upper slopes. Shallow to moderately deep (50-150 cm), moderately well-drained Chocolate Soils (Db3.11, Db3.12) on upper slopes. Shallow to moderately deep (60-150 cm), well-drained Prarie Soils and Chocolate Soil/Prarie Soil intergrades (Gn3.21) on mid-slopes. Deep (>150 cm), poorly to moderately well-drained Black Earths (Ug5.17, Ug5.15) on lower slopes and footslopes.

2.5 Geology and Hydrogeology

The Quarry is located within Booerie Hill, an igneous outcrop composed of Tertiary-age basalts ascribed to the Lamington Group. The Quarry extracts these basalts that comprise a series of sub-horizontal, stacked and layered, massive and vesicular, ancient lavas of varying thickness and composition.

The bulk of the Quarry workings are hosted within a near-surface, local-scale, unconfined aquifer that is, in turn, hosted in the Krasnozem soils and an underlying regolith of weathered, fractured massive and vesicular basalt.[1] Below this aquifer, there is a deeper, intermediate-scale confined to semi-confined groundwater flow system within the interlayered and fractured horizons of the basalt.[2]

Deeper aquifers are effectively separated and confined by a relatively thick sequence of massive, poorly fractured basalt. The water bearing layers are; shallow (113 mAHD to 109 mAHD), the intermediate – upper (95 mAHD to 87.5 mAHD), intermediate – lower (72 mAHD to 65 mAHD) and deep (28.5 mAHD to 22.5 mAHD).[3]

The shallow aquifer responds to rainfall-recharge reflected in the formation of seeps. Groundwater flow in this shallow regolith-hosted aquifer is a function of topography whereby groundwater is recharged via the surrounding hills and ridge slopes. The deeper aquifers do not respond quickly to rainfall-recharge events.[4]

A characteristic of aquifers such as these is that the groundwater flow systems are likely isolated into groundwater flow 'cells', rather than homogenous aquifer systems.[5] This implies that the overall effect of quarrying on these aquifers is predicted to be only in the immediate vicinity of the Quarry, with minor and localised groundwater drawdown occurring.

The shallow aquifer is already intersected by the approved extraction in the northern pit to approximately 105 mAHD. The intermediate aquifers would be affected by extraction to the ultimate depth of 55 mAHD in the northern pit. Similarly, the shallow aquifer would be affected by excavation to the ultimate depth of 105 mAHD in the southern pit.

Once the northern pit intersects the intermediate aquifers (87.5 mAHD) the groundwater inflow to the pit is estimated to approximate 190kL/day (2.2 L/s).[6]

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[1] Environmental Resources Management (ERM) (2011). *Blakebrook Quarry Expansion, Groundwater Monitoring and Management Sub-Plan*. Prepared for Lismore City Council. ERM 0066641. April 2011.

[2] Ibid.

[3] Gilbert & Sutherland (2019). *Hydrogeological Review: Groundwater Monitoring & Management Blakebrook Quarry Nimbin Road, Lismore, New South Wales.* Prepared for Lismore City Council January 2019. Which can be downloaded at: https://www.dropbox.com/s/uqkp2l6yyh0ajr7/11737%20GWA%20RER7F.pdf?dl=0.

[4] Environmental Resources Management (ERM) (2011). *Blakebrook Quarry Expansion, Groundwater Monitoring and Management Sub-Plan*. Prepared for Lismore City Council. ERM 0066641. April 2011.

[5] Ibid.

[6] Gilbert & Sutherland (2019). *Hydrogeological Review: Groundwater Monitoring & Management Blakebrook Quarry Nimbin Road, Lismore, New South Wales.* Prepared for Lismore City Council January 2019. Which can be downloaded at: https://www.dropbox.com/s/uqkp2l6yyh0ajr7/11737%20GWA%20RER7F.pdf?dl=0.

3 Soil and Water Management Plan

3.1 Intent

This Soil and Water Management Plan (SWMP) has been prepared to address requirements of Environment Protection Licence No. 3384. The SWMP details the Proponent's commitments to mitigate the potential environmental impacts associated with the operation of the quarry and associated approved activities at Lot 201 on DP 1227138.

3.2 Aims and objectives

The control measures stated in this SWMP are designed to minimise any potential environmental impacts associated with the hard rock quarry operations and asphalt and processing plant activities at Blakebrook Quarry.

The SWMP aims to achieve the following:

- Provide evidence of practical and achievable plans for the management of site activities.
- Ensure that legislative and environmental requirements are complied with by producing an integrated planning framework for comprehensive monitoring and control of operational impacts. Specific commitments on strategies and design standards to be employed are also given.
- Provide a framework for regulatory authorities and the proponent to confirm compliance with policies and conditions.
- Provide evidence to the community that the operation is being managed in an environmentally responsible manner.

The objectives of the SWMP are to ensure the following:

- All reasonable and practical measures are taken to prevent and/or minimise the likelihood of environmental harm being caused.
- On-site activities occur without adverse environmental impact or causing nuisance to nearby sensitive receptors.
- Identify both existing and potential future environmental considerations relating to the project site and surrounding area.
- Provide mitigation measures to assist in the minimisation of any potential impacts.
- Good stewardship of natural resources, consistent with current good extractive industry practice.
- Potential impacts on adjoining land users are minimised.

3.3 Implementation

This SWMP requires the Proponent(s) to mitigate the potential environmental impacts associated with the hard rock quarrying operations and asphalt and processing plant activities at the site. The SWMP addresses each component of Condition 19 of the Notice of Modification. The summary table included as Attachment 5 identifies where each condition is addressed in this SWMP.

The Proponent is also responsible for all persons (including employees, plant operators, contractors, subcontractors, delivery drivers, etc) whose activities/actions breach the management measures specified in the SWMP. This responsibility also extends to adjacent properties in the event that operational activities encroach upon and cause potential environmental degradation.

3.4 SWMP structure

This SWMP acknowledges the potential environmental impacts associated with the operations at the Blakebrook Quarry site. Each SWMP control strategy is based upon proven environmental management methods and is presented as a commitment. The commitments made within this document will form the basis of future assessments which will be made available to LCC and other statutory authorities for review.

The SWMP is based on a series of tables, with the person responsible for the implementation of the measures clearly stated. The tables describe the issue, performance criteria, implementation strategy, monitoring, auditing and reporting requirements, failure/incident identification procedures and corrective actions. The format is presented below for reference purposes.

#.# Title

Person responsible	The person(s) who is responsible for implementing the SWMP provisions detailed in this table.
Issue	The issue with which the table deals.
Operational policy	The operational policy or management objective that applies to this issue.
Performance criteria	Performance criteria (outcomes) for this issue.
Implementation strategy	The strategies or tasks (to nominated operational design standards) that will be implemented to achieve the performance criteria.
Monitoring	The monitoring requirements which will document actual performance (i.e. specified limits to pre-selected indicators of change).
Auditing	The auditing requirements that will verify implementation of the strategies and compliance with agreed performance criteria.
Reporting	Content, timing and responsibility for reporting, including auditing of monitoring results.
Identification of incident or failure	The circumstances under which the agreed performance criteria are unlikely to be met and environmental harm is likely to result.
Corrective action	The action(s) to be implemented when a performance requirement is not reached and the company(s) responsible for action.

Commitment #

What the management has committed to on behalf of the proponent.

An objective of the tabular format is to allow for change and allow the SWMP to be a working document. If items need altering, changes will be made to the individual tables after appropriate consultation with the statutory authorities.

3.4.1 General commitments

Commitment 1

The Proponents undertake to comply with the environmental implementation strategy as contained within the approved SWMP.

Commitment 2

The Proponents undertake to fulfil all commitments made in this SWMP and to carry out their activities on the project site in accordance with relevant current statutory requirements and approved amendments.

Definitions

In this SWMP these terms have the following meanings;

- SWMP means the approved Soil and Water Management Plan and includes any amendments that are approved from time to time.
- Development means the development of the site for the purposes of the hard rock quarrying operations and asphalt and processing plant activities.
- Operational means the period when quarrying activities (including loading and dispatching of trucks and blasting) are occurring and/or the asphalt plant is operating.
- Proponent(s) means the person undertaking the development and/or operation of the site and includes the person(s) nominated as having responsibility for implementing the provisions of the SWMP.
- LCC means Lismore City Council.
- EPA means the NSW Environment Protection Authority
- DPE means the NSW Department of Planning and Environment

3.5 Management of potential impacts – operational phase

3.5.1 Extraction of quarry material

Person responsible:	Quarry manager
Issue	Extraction of Quarry Material
Operational policy	To control the progress of extraction in order to allow for effective environmental management.
Performance criteria	Environmental values shall be protected as defined in the Protection of the Environmental Operations Act 1997. Environmental impacts will be within the limits set by the approval conditions.
Implementation strategy	The limit of extraction will be clearly and permanently marked (by a licensed surveyor) with delineator posts on the ground. Extraction will not exceed the nominated depth. Extraction rates will not exceed a maximum quantity of 500,000 tonnes/year.
Monitoring	Monthly extraction rates will be calculated and recorded. Annual extraction rates will be calculated and recorded. Depth of extraction will be monitored annually using survey to ensure that extraction does not exceed the nominated depth. All records will be kept for at least 4 years after the monitoring or event to which they relate took place.
Auditing	Auditing will be undertaken by the Site Manager and/or the Proponent's nominated representative or independent consultant. The audit will include an inspection of site activities and a review of monitoring, complaints, corrective actions and reporting to assess compliance with this SWMP.
Reporting	Monthly records of accrued extraction rates will be maintained on-site and made available to DPE and/or EPA upon request. Annual return (including monitoring and complaints summary and statements of compliance) will be completed and supplied to the EPA via eConnect EPA or by registered post not later than 60 days after the end of each reporting period (based on the Licence Anniversary date of 17 January). A copy of each Annual Return supplied to the EPA will be kept by the licensee for a period of at least 4 years after the return was due to be supplied to the EPA.
Identification of incident or failure	Monitoring results of extraction rates and depth will indicate to management if extraction rate is too high, extraction depth too deep or limit of extraction is exceeded.

Corrective action	Extraction will be slowed or ceased if extraction operations are inappropriate, under instruction from Production Manager or General Manager.

Commitment 3

All extraction processes will be conducted in a manner that minimises adverse effects to the surrounding environment.

Commitment 4

An extraction plan will be implemented to ensure that extraction rates will be effectively monitored throughout the project's operational life.

3.5.2 Dust minimisation onsite

Person responsible:	Site nominated Environmental Manager/Quarry manager
Issue	Minimisation of movement of dust offsite
Operational policy	To minimise dust movement offsite.
Performance criteria	To control dust within the site so as to minimise movement offsite, to minimise complaints and, when complaints do arise, to respond in a manner that is timely, effective and consistent with this SWMP and relevant policies and legislation. Environmental values shall be protected as defined in the Protection of the Environment Operations (Clean Air) Regulation 2010 and Protection of the Environmental Operations Act 1997. Compliance with legislation regarding environmental nuisance.
Implementation strategy	• The transport and handling of materials will be minimised by placing adequately sized storage facilities close to processing areas. • Additional management measures that will be implemented as appropriate include: - Reducing drop heights of loading and unloading activities and protecting them from the wind; - Dampening of stored material; - Screening material to remove dusty fractions prior to external storage; - Restricting vehicle speeds; - Watering unsurfaced roads; - Wheel or body wash at appropriate distances from the site entrance; - Sheeting or covering of vehicles; and - Use of water sprays to moisten material. • All permanent bunds will be revegetated as quickly as possible. • Soil stockpiles will be covered or vegetated if they are to remain onsite for an extended period of time. The speed limit on all haulage roads onsite will be a maximum of 40km/hr. All loads will be secured prior to leaving the site in accordance with the Roads and Maritime guidelines. Haulage roads onsite will be maintained according to the following standards: • Temporary roads with a life of up to three (3) months will have no treatment. • Temporary roads with a life of three (3) to twelve (12) months will be gravel.

	• Permanent roads with a life of one (1) year and over will be gravel. • The haulage roads will be wetted down daily or as needed.
Monitoring	A site weather station will be used to measure and record wind speed and direction to assist in understanding weather conditions upon the receipt of a complaint. Monitoring will be undertaken in accordance with AS 3580.10.1 (2003) upon the receipt of complaints. The monitoring program will assess the success of the dust management programs implemented onsite. Monitoring records/results will be recorded, compiled and made available for inspection upon request by statutory authorities.
Auditing	Auditing will be undertaken by the Site Manager and/or the Proponent's nominated representative or an independent consultant. The audit will include an inspection of site activities and a review of monitoring, complaints, corrective actions and reporting to assess compliance with this SWMP.
Reporting	Any dust mitigation measures implemented (such as cessation of crushing, cessation of loading, application of water to stockpiles etc) shall be recorded in the Site Diary. Any incidents/complaints will be recorded in Council's customer complaints register and will be available for inspection by DPE and/or EPA upon request. Reporting to EPA required upon receipt of complaints will include the nature of the complaint, the weather conditions at the time and any necessary remedial actions undertaken or planned to be undertaken. The complaints will be recorded using Council's customer management system. If no complaints are received, a summary of dust management will be included within the Annual Return to be submitted to EPA. Annual return (including monitoring and complaints summary and statements of compliance) will be completed and supplied to the EPA via eConnect EPA or by registered post not later than 60 days after the end of each reporting period (based on the Licence Anniversary date of 17 January). A copy of each Annual Return supplied to the EPA will be kept by the licensee for a period of at least 4 years after the return was due to be supplied to the EPA.
Identification of incident or failure	Dust problems will be identified by complaints to Council by residents or monitoring.
Corrective action	Complaints by residents will be recorded by Council, using its customer management system, including any corrective actions undertaken and any outcomes achieved. Depending on the source of the dust the following measures will be implemented as appropriate:

	• Dampen exposed areas; • Dampen stockpiles; • Cease crushing; • Vegetate soil stockpiles; and • Dampen roads.

Commitment 5

Dust generating sources onsite will be managed to ensure that the local air quality complies with standards outlined by the EPA.

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3.5.3 Sediment and erosion control

Person responsible:	Site nominated Environmental Manager/Quarry manager
Issue	Sediment and erosion control
Operational policy	To control the displacement of sediment across and off site and responsibly manage water, notably rainfall runoff.
Performance criteria	No uncontrolled erosion or sediment accumulation results from on-site activities. 'Clean water', notably from undisturbed catchment areas around the pits, is appropriately diverted away from site operational areas. 'Dirty water' from operational areas is appropriately managed to promote sediment control, beneficial water reuse on-site, and discharge as necessary of suitable quality water to nominated off-site receiving waters.
Implementation strategy	Drainage, erosion and sediment controls will be installed, managed and/or implemented continuously as works progress. These controls will be installed in general accordance with drawing 11737-004 and 11737-005. It must be noted that LPD2 and LPD3 depicted on drawing 11737-005 '*Future Quarry Water Management',* will not come into effect until approved under EPL 3384. Temporary erosion measures (e.g. hay bales, straw fences) will be employed on-site where necessary. The following controls in accordance with *Managing Urban Stormwater: Soils and Construction, Volume 1, 4th edition, March 2004*, Landcom (the Blue Book) and *Managing Urban Stormwater: Soils and Construction, Volume 2E Mines and Quarries,* 2008, DECC, will be employed during the operation: 1. Clean water diversion bunds and associated drainage infrastructure will be installed upslope of the pits to divert runoff from undisturbed catchment areas around the pits. 2. Maintenance of the clean water diversion controls, including bunds, inlets and outlets, will be conducted as necessary to ensure the system functions as designed and supports this SWMP. 3. If any vegetation clearing or similar works occurs within the clean water catchment area, appropriate sediment and erosion controls will be identified and installed prior to the works commencing. 4. Stockpiled soil material will be stored in a manner to prevent sediment being washed off-site. 5. Water within the pits will be directed to the sediment basins located within each pit. 6. Runoff from operational areas outside the pits (processing areas etc.) will be directed to separate sediment basins located downslope of the respective catchment areas. 7. Where necessary, sediment basins will be dosed with flocculating agents as necessary to meet the water quality requirements specified in Table 3.5.4 below.

	8. Subject to meeting these specified water quality requirements, any water within sediment basins will be discharged within five days to ensure capacity for future rainfall events. 9. All discharges will be to points nominated on the attached drawings. Water from the sediment basin within the main (northern) pit will (where capacity exists) be pumped to the water storage dam for beneficial reuse on-site to support quarry operations. 10. Sediment will be cleaned out of sediment basins when accumulated sediment volume reaches 50% of the basin's design capacity. A marker will be installed to delineate this level. Removed materials will be placed upgradient of a sediment basin, so that water within in the sediment can drain back into the basin. The sediment is to be located such that it will not be re-entrained by stormwater flows discharging into the basin. The drained sediment will then be incorporated into products or mixed with topsoil (if necessary) and used onsite for rehabilitation.
Monitoring	Visual inspections monthly and following rainfall events (defined as >25mm in 24 hours) to ensure controls are sufficient, appropriately maintained and functional. A record of the inspections will be included in the Site Diary.
Auditing	Auditing will be undertaken by the Site Manager and/or the Proponent's nominated representative or an independent consultant. The audit will include an inspection of site activities, monitoring, complaints, corrective actions and reporting to assess compliance with this SWMP.
Reporting	Reporting (more frequently than the annual return) is only required if insufficient sediment and erosion control measures are identified. Annual return (including monitoring and complaints summary and statements of compliance) will be completed and supplied to the EPA via eConnect EPA or by registered post not later than 60 days after the end of each reporting period (based on the Licence Anniversary date of 17 January). A copy of each Annual Return supplied to the EPA will be kept by the licensee for a period of at least 4 years after the return was due to be supplied to the EPA.
Identification of incident or failure	• Signs of erosion on site. • Accumulation of debris within clean water diversion controls • Erosion adjacent to diversion controls that indicates failure • Excessive sediment within basins • Damaged or failed erosion controls
Corrective action	Improve, repair and/or redesign controls

Commitment 6
Appropriate sediment and erosion controls will be implemented on site in a timely manner to minimise sediment movements across and offsite during storm events.

Commitment 7

Clean water from the undisturbed upslope catchment will be diverted around the pits to a point of discharge.

Commitment 8
Dirty water will be appropriately managed to promote sediment control, beneficial water reuse on-site, and discharge as necessary of suitable quality water to nominated off-site receiving waters.

3.5.4 Surface water management and monitoring

Person responsible:	Site nominated Environmental Manager/Quarry manager
Issue	Management of surface water quality downstream of the quarry
Operational policy	To maintain surface water quality downstream of the quarry.
Performance criteria	Downstream surface water quality will not be adversely impacted by on-site operations. Surface water quality will be assessed against established background conditions. Where information regarding background quality is not available water quality will be assessed against the ANZECC (2000) guideline limits.
Implementation strategy	• Water quality monitoring will be undertaken on sediment basins prior to water from them being actively discharged from the site. The water will be tested for pH and total suspended solids (TSS). A visual inspection will also to be carried out for oil and grease. Discharge of the sedimentation basins will only occur if: ◦ pH is between 6.5 and 8.5; ◦ TSS < 50mg/L; and ◦ No visual oil or grease. • Over a minimum of 12 monitoring rounds turbidity will also be analysed. A statistical analysis will then be performed to establish a correlation between TSS and turbidity (the correlation will be undertaken on data of varying water quality i.e. near LOR to >50mg/L TSS). Once a correlation is successfully established (identified as an R^2 >0.7) the equivalent turbidity value to TSS 50mg/L will be used to provide rapid feedback on the suitability or otherwise for discharge of sediment basins. • Where necessary, settlement of the sediment basins will be assisted by dosing with a flocculant such as gypsum. • Reliable in situ monitoring equipment (pH and turbidity) will be available to quarry staff at all times and staff will be given appropriate training and supervision to ensure the accuracy and adequacy of monitoring. • Surface water conditions outside the excavation area will be monitored in accordance with the specifications in Attachment 6 to ensure that any significant variance from background conditions is identified in a timely manner and potential impacts from site operations can be assessed and, as appropriate, corrected.
Monitoring	• Monitoring of the waters contained within the sediment basin prior to its active discharge.

	• Daily monitoring of the waters contained within the sediment basin during active discharge from sedimentation basins. • Monitoring of offsite surface waters at the discharge points nominated in Attachment 6 prior to and during discharge operations.
Auditing	Auditing will be undertaken by the Site Manager and/or the Proponent's nominated representative or an independent consultant. The audit will include an inspection of site activities and a review of monitoring, complaints, corrective actions and reporting to assess compliance with the SWMP.
Reporting	• Results of the monitoring program will be compiled and records kept on-site for inspection by DPE and/or EPA upon request. • Results (including interpretation against the site specific targets contained in Attachment 6) will be compiled and forwarded to DPE and/or EPA upon request.
Identification of incident or failure	• Discharge of non-compliant waters from sedimentation basins • Deterioration in surface water quality downstream of the quarry.
Corrective action	If the test results for any parameter fail to meet the water quality targets and are likely to be attributable to site activities, further investigations will be conducted. The investigation will seek to ascertain if the incident/failure is an anomaly or if a sustained decline in surface water quality is present. If a trend exists for declining surface water quality, the likely cause(s) of contamination shall be identified and addressed. If the investigation indicates that site activities are triggering the incident/failure, the following will be implemented: • Locate the source of the contamination and take all possible actions to contain and control the contaminant. Investigate the cause of the contamination and take action to prevent a recurrence. • All extraction and processing activities taking place at the time of the incident/failure will be reviewed to verify compliance with the provisions of the SWMP and, if necessary, procedures shall be adjusted.

Commitment 9

Management will ensure downstream surface water quality is not degraded by site activities.

3.5.5 Groundwater management and monitoring

Person responsible:	Site nominated Environmental Manager/Quarry manager
Issue	Management of groundwater quality.
Operational policy	To prevent the degradation of groundwater quality and minimise potential impacts on the groundwater regime external to the site.
Performance criteria	Groundwater quality is not adversely impacted by on-site operations.
Implementation strategy	Monitoring of the groundwater bores at a frequency and for parameters as specified in specified in Attachment 7. Site specific groundwater quality targets for the monitoring locations are contained in Attachment 7, which provides information on the methodology used to derive the targets. Groundwater inflow monitoring will be undertaken in accordance with the below requirements. 1. Once the northern pit reaches an extraction depth of 87.5 mAHD the volumes of the groundwater inflows to the pit will be monitored . 2. Once the southern pit reaches an extraction depth of 113 mAHD the volumes of the groundwater inflows to the pit is to be monitored. 3. A water licence will be obtained, as required, to cover the volume of any unforeseen groundwater inflows into the quarry from the quarry face or floor.
Monitoring	• Monitoring of the groundwater bores at a frequency and for parameters as specified in specified in Attachment 7. • Download and review the water levels from the data loggers deployed in the bores on the frequency specified in Attachment 7. The loggers must record the water level on a minimum daily basis, this will allow for the quantification of quarry related activities on groundwater levels. • A water balance will be prepared for the site annually. The volume of groundwater inflows to the pit will be estimated based on a 'back calculation' from the rainfall runoff volume (from site specific rainfall data) and pumping/reuse records. This estimated actual groundwater inflow will be reviewed against the previous annual estimate and any drawdown observed in the groundwater bores. • Observed seepage areas and rates (if possible) will be recorded in the site diary. • On an annual basis the water level information, water quality information, water balance information and site logs will be reviewed by a suitability qualified person to confirm that site impacts are in accordance with those impacts anticipated by the GWA.[7]

[7] Gilbert & Sutherland (2019). *Hydrogeological Review: Groundwater Monitoring & Management Blakebrook Quarry Nimbin Road, Lismore, New South Wales.* Prepared for Lismore City Council January 2019. Which can be downloaded at: https://www.dropbox.com/s/uqkp2l6yyh0ajr7/11737%20GWA%20RER7F.pdf?dl=0.

Auditing	Auditing will be undertaken by the Site Manager and/or the Proponent's nominated representative or an independent consultant. The audit will include an inspection of site activities and a review of monitoring, complaints, corrective actions and reporting to assess compliance with the SWMP.
Reporting	Results of the monitoring program will be compiled and records kept on-site for inspection by DPE and/or EPA upon request. The assessment must adequately assess groundwater quality against the site specific triggers derived and contained in Attachment 7.
Identification of incident or failure	• Deterioration of groundwater quality due to on-site activities. • Continual non-compliance with the water quality targets. • Unanticipated drawdown within the groundwater bores (i.e. outside the expected drawdown) • Sudden or unexpected changes in groundwater levels recorded within the bores by the data loggers. • Reductions in flows within the landform downgradient of the site • Vegetation die-off in the downgradient landform
Corrective action	If the test results for any parameter fail to meet the water quality objectives or identification of a sudden and un-characteristic change in water levels are likely to be attributable to site activities, further investigations will be conducted. The investigation will seek to ascertain if the incident/failure is an anomaly or if a sustained decline in groundwater quality is present. If a trend exists for declining groundwater quality, the likely cause(s) of contamination will be identified and addressed. If the investigation indicate that site activities are triggering the incident/failure, the following will be implemented: • Locate the source of the contamination and take all possible actions to contain and control the contaminant. Investigate the cause of the contamination and take action to prevent a recurrence. • All extraction and processing activities taking place at the time of the incident/failure shall be reviewed to verify compliance with the provisions of the SWMP and, if necessary, procedures shall be adjusted. • If the issue is a change in level outside the expected drawdown then the GWA conceptual groundwater model will be revisited to determine if the changes identify potential offsite impacts and/or whether any corrective actions are recommended. • If a reduction in the seepage down-gradient of the site is identified, feasibility planning will be undertaken for active rehydration of the landform by pumping of suitable quality waters from within the sediment

	basins to downgradient recharge areas. These recharge areas will take the form of an existing gully, a strategically located flow spreading swale, of sub surface gravel recharge trenches. The form of any rehydration device is the subject of detailed design and, as appropriate, consultation. • Apply for the appropriate water licence(s) to cover the volume of any unforeseen groundwater inflows into the quarry from the quarry face or floor.

Commitment 10

Management will ensure that on-site activities do not appreciably impact the quality or quantity of groundwater resources and/or their use by GDE and surrounding landholders.

4 Administration of the SWMP

4.1 Amendment of the SWMP

If amendments to this SWMP are sought, the proponent will make application to EPA to amend the provisions of this SWMP. The application shall:

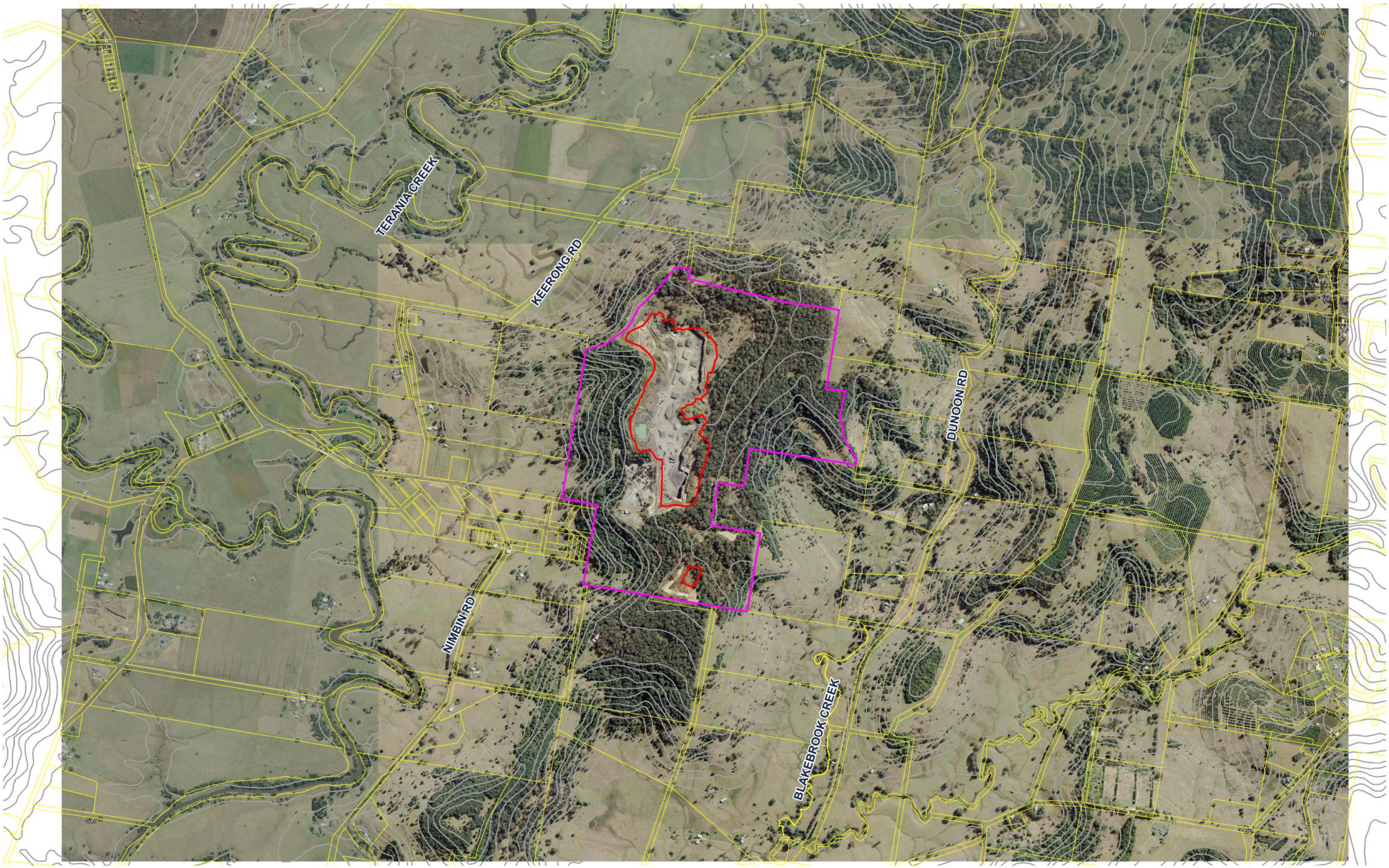
- be in writing;
- specify the provisions of the SWMP to which the application relates; and
- state how the proposed amendments achieve the objectives of the provisions to which the amendments relate.

EPA shall approve the amendment where it is satisfied acting reasonably that the proposed amendments achieve the objective of the provisions to which the amendment relates.

4.2 Incident management

The Proponent and any person appointed by the Proponent as having responsibility for a control strategy set out in this SWMP have clearly defined responsibilities under the *Protection of Environment Operations Act 1997* to report any incidents likely to cause material or serious environmental harm.

5 Attachment 1 – Drawings



ORIENTATION

SCALE

150 300 450 600 750 metres

ROBINA

PO Box 4115 Robina QLD4230 07 5578 9944
Email robina@access.gs www.access.gs

LEGEND

Quarry pit (existing)

Cadastral boundaries

Contours (10m interval)

Site boundary

SOURCES

Image source:	Google Earth - NSW Globe
Image dates:	4 September 2012

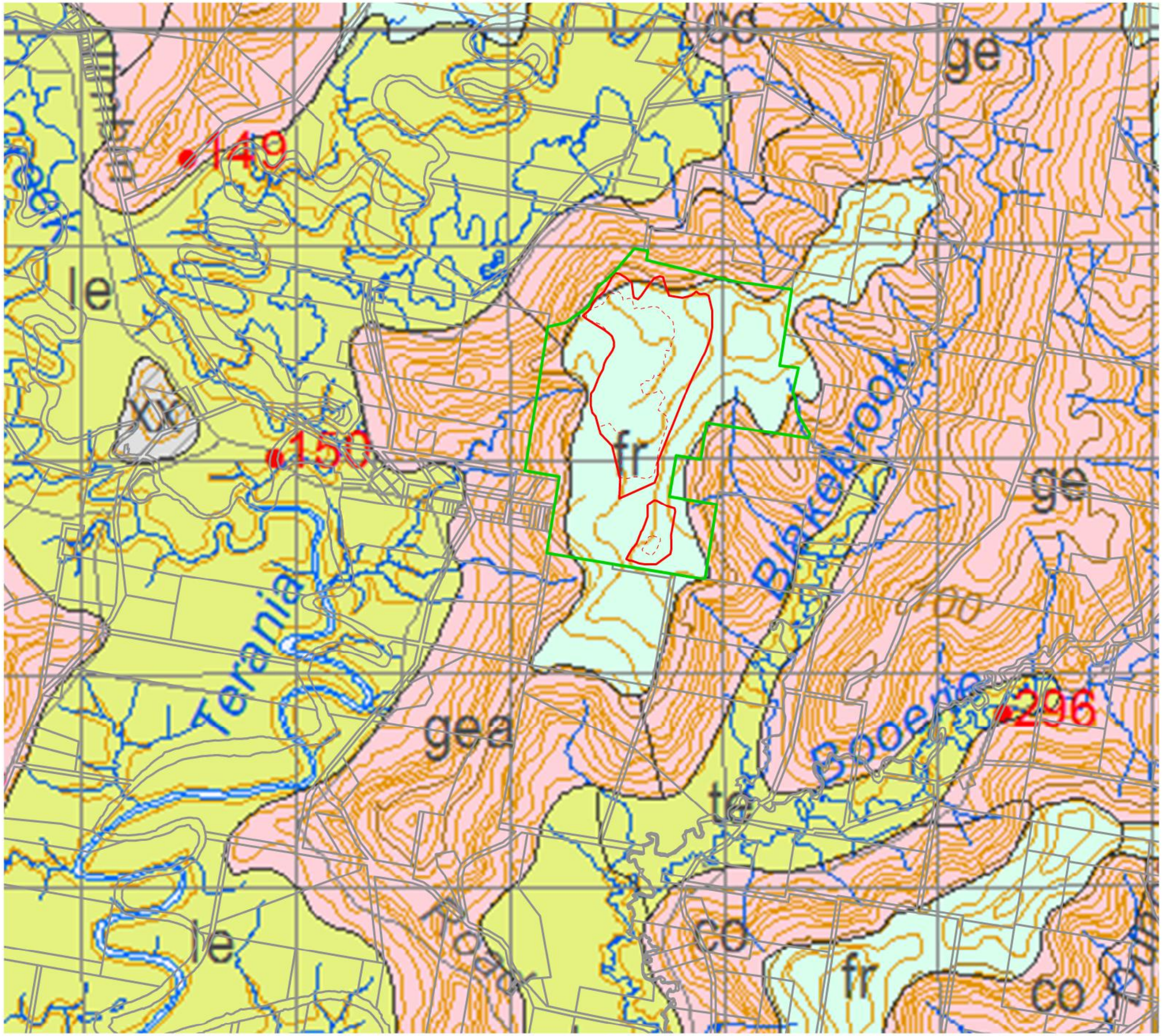
PROJECT
BLAKEBROOK QUARRY

CLIENT
LISMORE CITY COUNCIL

DRAWING
SITE LOCATION

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
1:16,000@A3	14/12/2018	AJF	CMA	11737	001	A

GILBERT SUTHERLAND



RESIDUAL LANDSCAPES

fr

FREDERICK (13.25km²)

Landscape - low undulating rsises on flat basalt plateau surfaces. Relief 5-30m, elevation 130-180m. Slopes 1-10%. Extensively cleared open-forest.

Soils - shallow (<100cm), poorly drained Prairie Soils (Gn3.42). Localised moderately deep (100-150cm), well-drained Krasnozems (Uf5.2, Gn3.11, Gn4.11) on iron-rich material. Deep (>150cm), poorly drained Black Earths/ Weisenbodens (Ug5.15, Ug5.17) and Dense Clays (Uf6.61) within drainage depressions.

Limitations - shallow, plastic soils with aluminium toxicity potential and sesaonal waterlogging. Localised rock outcrop.

COLLUVIAL LANDSCAPES

co

COOLAMON (65.0km²)

Landscape - very steep slopes on Lismore Basalts. Slopes 20-60%, relief 60-100m. Hummocky microrelief and boulder-strewn slopes. Extensively cleared closed-forest (rainforest).

Soils - shallow (<100cm), moderately well-drained stony Chocolate Soils (Um1.23) and shallow (<100cm), well-drained Krasnozems (Uf5.21,Gn3.11).

Limiations - steep slopes, mass movement hazard, shallow and stony soils, localised waterlogging.

ge

GEORGICA (254.25km²)

Landscape - high rolling and steep waning hills on Lismore Basalts. Relief 90-200m. Slopes 15-30%. Sideslopes, ridge slopes, and narrow, sharp ridges and crests are common. Widespread mass movement has created a hummocky microrelief and terracettes are common. Extensively cleared open-and closed-forest.

gea Landscape variant - gea (74.0km²) - areas of prominent benching, maximal slopes of 40->50%.

geb Landscape variant - geb (89.25km²) - areas of prominent fluted ridges.

gec Landscape variant - gec (62.75km²) - hills of lower relief occupying transitional zone from red to black basaltic soils.

Soils - shallow (50-100cm) moderately well-darined Chocolate Soils (Db3.11) and Prairie Soils (Gn3.21, Um5.51) on crests and upper slopes. Shallow to moderately deep (50-150cm), moderately well-drained Chocolate Soils (Db3.11, Db3.12) on upper slopes. Shallow to moderately deep (60-150cm), well-drained Prairie Soils and Chocolate Soil/Prairie Soil intergrades (Gn3.21) on midslopes. Deep (>150cm), poorly to moderately well-drained Black Earths (Ug5.17, Ug5.15) on lower slopes and footslopes.

Limitations - erodible soils with surface movement potential and localised low wet-bearing strength and water-logging. Steep slopes, widespread mass movement and localised rock outcrop with moderate erosion hazard.

ALLUVIAL LANDSCAPES

le

LEYCESTER (277.0km²)

Landscape - level to gently undulating broad to extensive (500->1500m) alluvial plains of extremely low relief, draining the Mackellar Hills. Extensively cleared closed-and open-forest.

Soils - deep (>200cm), poorly to moderately well-drained alluvial Black Earths (Ug5.15, Ug5.17) and Structured Clays (Uf6.42) occur throughout the floodplains. Wetter areas, such as ox-bow floors, have deep (>200cm), poorly drained Weisenbodens (Ug5.15, Ug5.17). Deep (>200cm), well-drained Earthy Sands (Uc5.21) line channels.

Limitations - moderately erodible, moderately plastic soils with low wet-bearing strength, moderate shrink-swell and localised waterlogging. Flooding, streambank erosion.

te

TERANIA (41.0km²)

Landscape - level to gently undulating alluvial plains of mid to upper reaches of main Richmond River tributaries draining basalt, rhyolite and sandstone areas. Relief <5m, slopes 0-3%. Ox-bows and inset terracing are common features. Extensively cleared closed and open-forest.

Soils - deep (>300cm), well-drained soils of No Suitable Group and dark Alluvial Clays (Uf6, Uf1, Gn2). Near sandstone areas deep (>300cm), well-drained soils of no suitable Group and brown Alluvial Clays (Db3, Db4). Deep (>200cm), poorly drained Weisenbodens and Black Earths (UG5.15, Ug5.17, Uf6) on more recent floodplains. Deep, rapidly drained Earthy Sands (Uc5.21) line channels.

Limitations - Highly erodible, seasonally waterlogged, stony soils of low fertility and low available water-holding capacity. High flood hazard and severe bank erosion.

ORIENTATION

SCALE

200 400 600 800 1000 metres

ROBINA
PO Box 4115 Robina QLD4230 07 5578 9944
Email robina@access.gs www.access.gs

LEGEND

- Cadastral boundary
- Site boundary
- Quarry footprint (future)
- Quarry footprint (existing)

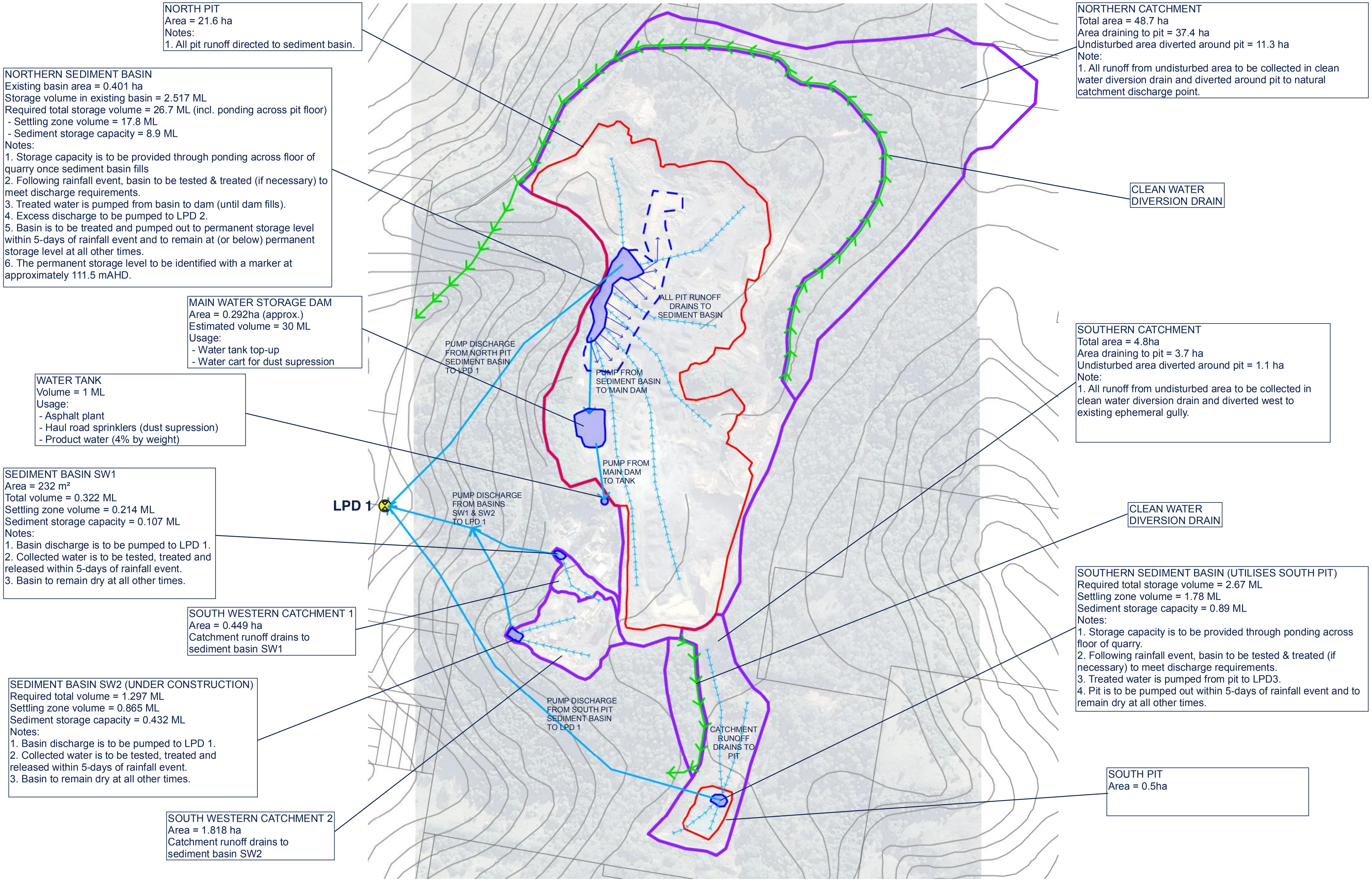
SOURCES

Map source: Morand (1994) 1:100,000 Soil Landscape Series 9540-9640 (Lismore-Ballina)

PROJECT	CLIENT	DRAWING
BLAKEBROOK QUARRY	LISMORE CITY COUNCIL	SOIL LANDSCAPES EXTRACT FROM LISMORE-BALLINA 1:100 000 SHEET

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
1:20 000@A3	14/12/2018	AJF	CMA	11737	003	A

GILBERT SUTHERLAND



ORIENTATION

SCALE

50 100 150 200 250 metres

ROBINA
PO Box 4115 Robina QLD4230 07 5578 9944
Email robina@access.gs **www.access.gs**

LEGEND

- Catchment boundary
- Quarry pit (existing)
- Discharge point
- Sediment basins / water storage
- Clean water diversion drain

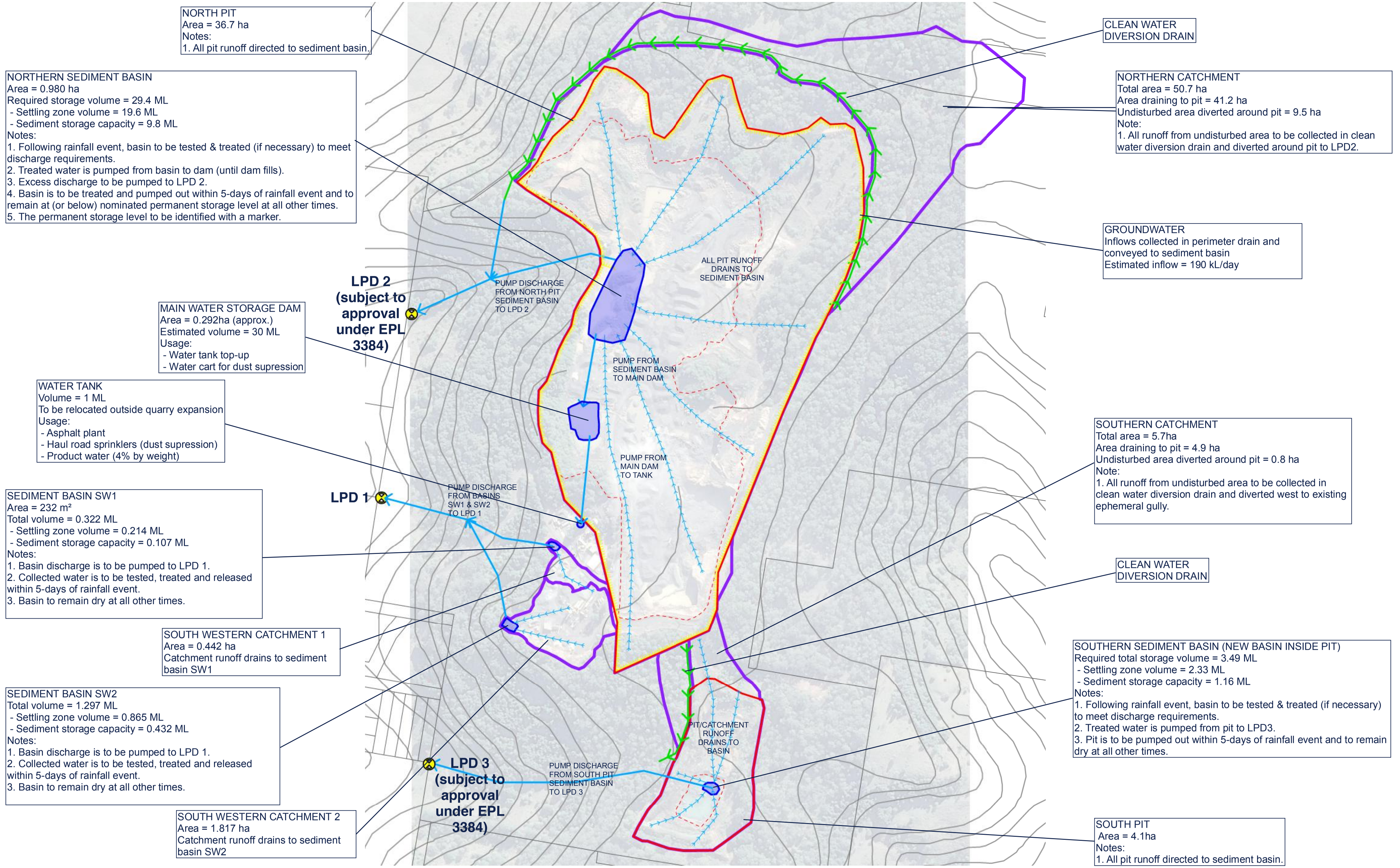
SOURCES

Image source: Google Earth Pro
Image dates: 6 June 2016

PROJECT	CLIENT	DRAWING
BLAKEBROOK QUARRY	LISMORE CITY COUNCIL	EXISTING QUARRY FOOTPRINT WATER MANAGEMENT

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
1:6,250@A3	14/12/2018	AJF	CMA	11737	004	A

GILBERT SUTHERLAND



ORIENTATION

SCALE

50 100 150 200 250 metres

ROBINA
PO Box 4115 Robina QLD4230 07 5578 9944
Email robina@access.gs www.access.gs

LEGEND

- Catchment boundary
- Quarry pit (future)
- Quarry pit (existing)
- Discharge point
- Clean water diversion drain
- Sediment basins / water storage
- Perimeter drain (groundwater inflows)

SOURCES

Image source: Google Earth Pro
Image dates: 6 June 2016

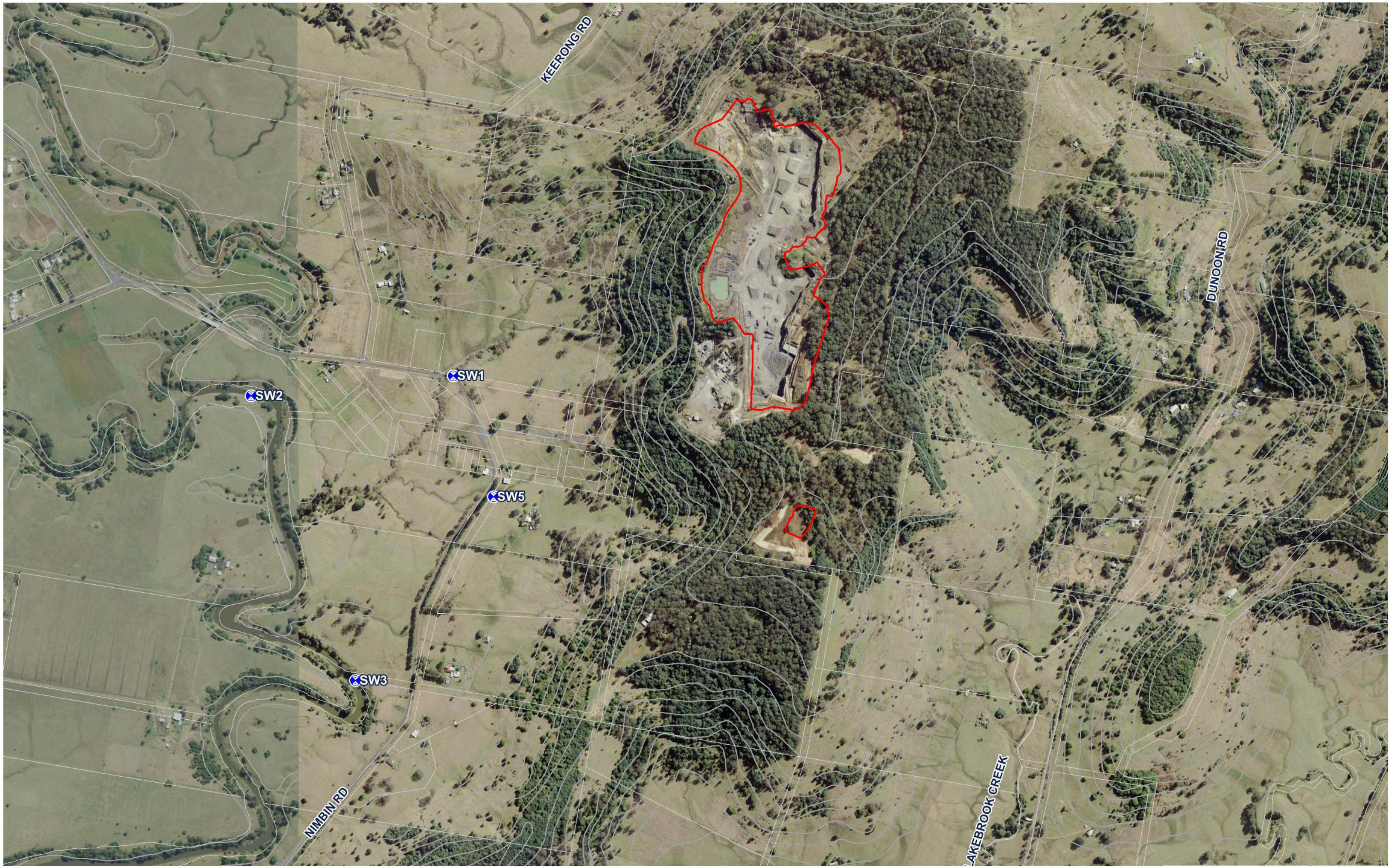
NOTES

1. LPD1 is currently the only licenced discharge point for the site.
2. An application has been lodged for approval of LPD2 and LPD3 as additional licensed discharge points under EPL 3384.
3. Until LPD2 and LPD3 are approved under EPL 3384, all site discharge is to be directed to LPD1.

PROJECT	CLIENT	DRAWING
BLAKEBROOK QUARRY	LISMORE CITY COUNCIL	FUTURE QUARRY FOOTPRINT WATER MANAGEMENT

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
1:6,250@A3	13/02/2019	AJF	CMA	11737	005	B

GILBERT + SUTHERLAND



ORIENTATION

SCALE

100 200 300 400 500 metres

ROBINA

PO Box 4115 Robina QLD4230 07 5578 9944
Email robina@access.gs www.access.gs

LEGEND

Quarry pit (existing)

Cadastral boundaries

Contours (10m interval)

Surface water monitoring locations

SOURCES

Image source: Google Earth - NSW Globe
Image date: 4 September 2012

PROJECT	CLIENT	DRAWING
BLAKEBROOK QUARRY	LISMORE CITY COUNCIL	SURFACE WATER MONITORING LOCATIONS

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
1:10,000@A3	14/12/2018	AJF	CMA	11737	008	-

GILBERT SUTHERLAND

6 Attachment 2 – Sediment basin sizing

Sediment retention basins are required to intercept runoff from all undisturbed site areas, and retain most sediment and other materials, thereby protecting downstream waterways from pollution.

In accordance with the requirements of the Licence, design of the sediment basins has been undertaken in accordance with *Managing Urban Stormwater: Soils and Construction, Volume 1, 4th edition, March 2004*, Landcom (the Blue Book) and *Managing Urban Stormwater: Soils and Construction, Volume 2E Mines and Quarries,* 2008, DECC.

6.1 Design objectives

6.1.1 Soil texture group

The soil materials on the site have been classified as Type F. Type F soils are fine grained soils with 33 percent or more of the particles being finer than 0.02mm. and less than 10 percent of the soil is dispersible.

These soils require long 'residence' times to settle in a sediment retention basin and the treatment process is described as slow settling in wet basins.

6.1.2 Design event

The design rainfall event for the site is the 90th percentile 5-day rainfall depth.

For Lismore, the applicable rainfall depth (from Table 6.3a of the Blue Book) is 60.2mm over any consecutive 5-day period.

6.2 Sediment basin capacity

Type F sediment basins are normally sized by:

$$V = V_{sz} + V_{ss}$$

where: V = Sediment basin volume (m³)

V_{sz} = Settling zone capacity (m³)

V_{ss} = Sediment storage zone capacity (m³)

6.2.1 Settling zone capacity

The settling zone capacity designed to capture Type F soils can be determined, based on the design rainfall depth, by:

$$V_{sz} = 10 C_v A R_{(y\ \%ile, 5-day)}$$

where: V_{sz} = Settling zone capacity (m³)

C_v = Volumetric runoff coefficient

A = Catchment area draining to basin (ha)

$R_{(y\ \%ile,\ 5\text{-}day)}$ = 5-day total rainfall depth that is not exceeded in y percent of rainfall events.

The design 5-day rainfall depth is 60.2mm.

The volumetric runoff coefficient is defined as the proportion of rainfall that runs off as stormwater. Values are defined in Table F2 of Appendix F of the Blue Book, and based on the soil type and the design rainfall depth, the applicable value for the runoff coefficient is 0.79.

6.2.2 Sediment storage capacity

The sediment storage zone capacity can be taken as 50 percent of the settling zone capacity.

6.3 Individual basin sizing

It is proposed to provide sediment basins within each of the two quarry pits for all runoff that can be captured within the pits. Additional sediment basins will be provided external to the pits for disturbed catchment areas that cannot be directed into the pits.

Sediment basin locations and contributing catchment areas for existing and anticipated future site conditions are shown on Drawings 11737-004 and 11737-005, respectively, included in Attachment 1. It must be noted that LPD2 and LPD3 depicted on drawing 11737-005 '*Future Quarry Water Management*', will not come into effect until approved under EPL 3384.

Basin sizing calculations are provided in Attachment 3.

It is intended that both the drawings and calculations will be updated and replaced over time to reflect the current operational status of the quarry.

6.4 Management of sediment basins

To ensure ongoing availability of the basins for their intended purpose, stormwater in the settling zone will be drained or pumped out within the time period adopted in the design of the basin (i.e. within 5 days following rainfall). This discharge is subject to being able to meet the nominated water quality targets.

Flocculation will be employed where extended settling is unlikely to achieve the objectives within the nominated time period. The basins will be kept dry, or maintained at or below the pre-defined standing water level, at all other times.

Only clear (<50 mg/L suspended solids) supernatant waters will be discharged from the settling zones within the basins. Where possible, floating pump inlets will be used to reduce the opportunity for entrainment of settled sediment during basin pump out.

For the basins not located within the pits, collected sediment will be periodically removed from the basins to maintain their capacity. This removed sediment is to be placed upgradient of a sediment basin, so that water within in the sediment can drain back into the basin.

The sediment is to be located such that it will not be re-entrained by stormwater flows discharging into the basin. Once the sediment is drained it can be incorporated into products or mixed with topsoil (if necessary) and used onsite for rehabilitation.

7 Attachment 3 – Sediment basin sizing calculations

7.1 Existing quarry footprint

Sediment basin sizing - Type F

Job No.	11737
Project:	Blakebrook Quarry
Client:	Lismore City Council
Date:	12/06/2018
Catchment:	North Pit - Existing

Settling Zone Capacity

$$V_{sz} = 10 \cdot C_v \cdot A \cdot R_{(y\ \%ile,\ 5\ day)}$$

Where:

V_{sz}	=	volume of settling zone (m³)
C_v	=	volumetric runoff coefficient (proportion of rainfall that runs off as stormwater
A	=	catchment area (ha)
$R_{(y\ \%ile,\ 5\ day)}$	=	5-day total rainfall depth (mm) that is not exceeded in y percent rainfall events

C_v =	0.79		(refer to Appendix F in Blue Book, Landcom 2004)
A =	37.402	ha	(assume 1.6m³/ha/year for developed catchments)
$R_{(y\ \%ilt,\ 5\ day)}$ =	60.2	mm	(95th %ile, refer to tables in Landcom Soils and Construction)
V_{sz} =	17788	m³	

Sediment storage capacity - 50% of Settling Zone

$$V_{ss} = 0.5 \cdot V_{sz}$$

Where:

V_{ss}	=	volume of sediment storage required (m³)
V_{sz}	=	volume of settling zone (m³)

V_{sz} =	17788	m³
V_{ss} =	8894	m³

Sediment basin volume

$$V = V_{sz} + V_{ss}$$

Where:

V_{sz}	=	total volume of sediment basin (m³)
V_{sz}	=	volume of settling zone (m³)
V_{ss}	=	volume of sediment storage required (m³)

V_{sz} =	17788	m³
V_{ss} =	8894	m³
V =	26681	m³

Sediment basin sizing - Type F

Job No.	11737
Project:	Blakebrook Quarry
Client:	Lismore City Council
Date:	12/06/2018
Catchment:	South Pit

Settling Zone Capacity

$$V_{sz} = 10 \cdot C_v \cdot A \cdot R_{(y\ \%ile,\ 5\ day)}$$

Where:

V_{sz}	=	volume of settling zone (m³)
C_v	=	volumetric runoff coefficient (proportion of rainfall that runs off as stormwater
A	=	catchment area (ha)
$R_{(y\ \%ile,\ 5\ day)}$	=	5-day total rainfall depth (mm) that is not exceeded in y percent rainfall events

C_v =	0.79		(refer to Appendix F in blue Book, Landcom 2004)
A =	3.746	ha	(assume 1.6m³/ha/year for developed catchments)
$R_{(y\ \%ilt,\ 5\ day)}$ =	60.2	mm	(95th %ile, refer to tables in Landcom Soils and Construction)
V_{sz} =	1782	m³	

Sediment storage capacity - 50% of Settling Zone

$$V_{ss} = 0.5 \cdot V_{sz}$$

Where:

V_{ss}	=	volume of sediment storage required (m³)
V_{sz}	=	volume of settling zone (m³)

V_{sz} =	1782	m³
V_{ss} =	891	m³

Sediment basin volume

$$V = V_{sz} + V_{ss}$$

Where:

V_{sz}	=	total volume of sediment basin (m³)
V_{sz}	=	volume of settling zone (m³)
V_{ss}	=	volume of sediment storage required (m³)

V_{sz} =	1782	m³
V_{ss} =	891	m³
V =	2672	m³

Sediment basin sizing - Type F

Job No.	11737
Project:	Blakebrook Quarry
Client:	Lismore City Council
Date:	12/06/2018
Catchment:	South-western Catchment 1

Settling Zone Capacity

$$V_{sz} = 10 \cdot C_v \cdot A \cdot R_{(y\ \%ile,\ 5\ day)}$$

Where:

V_{sz}	=	volume of settling zone (m³)
C_v	=	volumetric runoff coefficient (proportion of rainfall that runs off as stormwater
A	=	catchment area (ha)
$R_{(y\ \%ile,\ 5\ day)}$	=	5-day total rainfall depth (mm) that is not exceeded in y percent rainfall events

C_v =	0.79		(refer to Appendix F in blue Book, Landcom 2004)
A =	0.449	ha	
$R_{(y\ \%ilt,\ 5\ day)}$ =	60.2	mm	(95th %ile, refer to tables in Landcom Soils and Construction)
V_{sz} =	214	m³	

Sediment storage capacity - 50% of Settling Zone

$$V_{ss} = 0.5 \cdot V_{sz}$$

Where:

V_{ss}	=	volume of sediment storage required (m³)
V_{sz}	=	volume of settling zone (m³)

V_{sz} =	214	m³
V_{ss} =	107	m³

Sediment basin volume

$$V = V_{sz} + V_{ss}$$

Where:

V_{sz}	=	total volume of sediment basin (m³)
V_{sz}	=	volume of settling zone (m³)
V_{ss}	=	volume of sediment storage required (m³)

V_{sz} =	214	m³
V_{ss} =	107	m³
V =	320	m³

Sediment basin sizing - Type F

Job No.	11737
Project:	Blakebrook Quarry
Client:	Lismore City Council
Date:	12/06/2018
Catchment:	South-western Catchment 2

Settling Zone Capacity

$$V_{sz} = 10 \cdot C_v \cdot A \cdot R_{(y\ \%ile,\ 5\ day)}$$

Where:

V_{sz}	=	volume of settling zone (m³)
C_v	=	volumetric runoff coefficient (proportion of rainfall that runs off as stormwater
A	=	catchment area (ha)
$R_{(y\ \%ile,\ 5\ day)}$	=	5-day total rainfall depth (mm) that is not exceeded in y percent rainfall events

C_v =	0.79		(refer to Appendix F in blue Book, Landcom 2004)
A =	1.818	ha	
$R_{(y\ \%ilt,\ 5\ day)}$ =	60.2	mm	(95th %ile, refer to tables in Landcom Soils and Construction)
V_{sz} =	865	m³	

Sediment storage capacity - 50% of Settling Zone

$$V_{ss} = 0.5 \cdot V_{sz}$$

Where:

V_{ss}	=	volume of sediment storage required (m³)
V_{sz}	=	volume of settling zone (m³)

V_{sz} =	865	m³
V_{ss} =	432	m³

Sediment basin volume

$$V = V_{sz} + V_{ss}$$

Where:

V_{sz}	=	total volume of sediment basin (m³)
V_{sz}	=	volume of settling zone (m³)
V_{ss}	=	volume of sediment storage required (m³)

V_{sz} =	865	m³
V_{ss} =	432	m³
V =	1297	m³

7.2 Future quarry footprint

Sediment basin sizing - Type F

Job No.	11737
Project:	Blakebrook Quarry
Client:	Lismore City Council
Date:	12/06/2018
Catchment:	North Pit - Future

Settling Zone Capacity

$$V_{sz} = 10 \cdot C_v \cdot A \cdot R_{(y\ \%ile,\ 5\ day)}$$

Where:

V_{sz}	=	volume of settling zone (m³)
C_v	=	volumetric runoff coefficient (proportion of rainfall that runs off as stormwater
A	=	catchment area (ha)
$R_{(y\ \%ile,\ 5\ day)}$	=	5-day total rainfall depth (mm) that is not exceeded in y percent rainfall events

C_v =	0.79		(refer to Appendix F in Blue Book, Landcom 2004)
A =	41.218	ha	(assume 1.6m³/ha/year for developed catchments)
$R_{(y\ \%ilt,\ 5\ day)}$ =	60.2	mm	(95th %ile, refer to tables in Landcom Soils and Construction)
V_{sz} =	19602	m³	

Sediment storage capacity - 50% of Settling Zone

$$V_{ss} = 0.5 \cdot V_{sz}$$

Where:

V_{ss}	=	volume of sediment storage required (m³)
V_{sz}	=	volume of settling zone (m³)

V_{sz} =	19602	m³
V_{ss} =	9801	m³

Sediment basin volume

$$V = V_{sz} + V_{ss}$$

Where:

V_{sz}	=	total volume of sediment basin (m³)
V_{sz}	=	volume of settling zone (m³)
V_{ss}	=	volume of sediment storage required (m³)

V_{sz} =	19602	m³
V_{ss} =	9801	m³
V =	29404	m³

Sediment basin sizing - Type F

Job No.	11737
Project:	Blakebrook Quarry
Client:	Lismore City Council
Date:	12/06/2018
Catchment:	South Pit - Future

Settling Zone Capacity

$$V_{sz} = 10 \cdot C_v \cdot A \cdot R_{(y\ \%ile,\ 5\ day)}$$

Where:

V_{sz}	=	volume of settling zone (m³)
C_v	=	volumetric runoff coefficient (proportion of rainfall that runs off as stormwater
A	=	catchment area (ha)
$R_{(y\ \%ile,\ 5\ day)}$	=	5-day total rainfall depth (mm) that is not exceeded in y percent rainfall events

C_v =	0.79		(refer to Appendix F in blue Book, Landcom 2004)
A =	4.893	ha	(assume 1.6m³/ha/year for developed catchments)
$R_{(y\ \%ilt,\ 5\ day)}$ =	60.2	mm	(95th %ile, refer to tables in Landcom Soils and Construction)
V_{sz} =	2327	m³	

Sediment storage capacity - 50% of Settling Zone

$$V_{ss} = 0.5 \cdot V_{sz}$$

Where:

V_{ss}	=	volume of sediment storage required (m³)
V_{sz}	=	volume of settling zone (m³)

V_{sz} =	2327	m³
V_{ss} =	1164	m³

Sediment basin volume

$$V = V_{sz} + V_{ss}$$

Where:

V_{sz}	=	total volume of sediment basin (m³)
V_{sz}	=	volume of settling zone (m³)
V_{ss}	=	volume of sediment storage required (m³)

V_{sz} =	2327	m³
V_{ss} =	1164	m³
V =	3491	m³

Sediment basin sizing - Type F

Job No.	11737
Project:	Blakebrook Quarry
Client:	Lismore City Council
Date:	12/06/2018
Catchment:	South-western Catchment 1 - Future

Settling Zone Capacity

$$V_{sz} = 10 \cdot C_v \cdot A \cdot R_{(y\ \%ile,\ 5\ day)}$$

Where:

V_{sz}	=	volume of settling zone (m³)
C_v	=	volumetric runoff coefficient (proportion of rainfall that runs off as stormwater
A	=	catchment area (ha)
$R_{(y\ \%ile,\ 5\ day)}$	=	5-day total rainfall depth (mm) that is not exceeded in y percent rainfall events

C_v =	0.79		(refer to Appendix F in blue Book, Landcom 2004)
A =	0.442	ha	(assume 1.6m³/ha/year for developed catchments)
$R_{(y\ \%ilt,\ 5\ day)}$ =	60.2	mm	(95th %ile, refer to tables in Landcom Soils and Construction)
V_{sz} =	210	m³	

Sediment storage capacity - 50% of Settling Zone

$$V_{ss} = 0.5 \cdot V_{sz}$$

Where:

V_{ss}	=	volume of sediment storage required (m³)
V_{sz}	=	volume of settling zone (m³)

V_{sz} =	210	m³
V_{ss} =	105	m³

Sediment basin volume

$$V = V_{sz} + V_{ss}$$

Where:

V_{sz}	=	total volume of sediment basin (m³)
V_{sz}	=	volume of settling zone (m³)
V_{ss}	=	volume of sediment storage required (m³)

V_{sz} =	210	m³
V_{ss} =	105	m³
V =	315	m³

Sediment basin sizing - Type F

Job No.	11737
Project:	Blakebrook Quarry
Client:	Lismore City Council
Date:	18/12/2017
Catchment:	South-western Catchment 2 - Future

Settling Zone Capacity

$$V_{sz} = 10 \cdot C_v \cdot A \cdot R_{(y\ \%ile,\ 5\ day)}$$

Where:

V_{sz}	=	volume of settling zone (m³)
C_v	=	volumetric runoff coefficient (proportion of rainfall that runs off as stormwater
A	=	catchment area (ha)
$R_{(y\ \%ile,\ 5\ day)}$	=	5-day total rainfall depth (mm) that is not exceeded in y percent rainfall events

C_v =	0.79		(refer to Appendix F in blue Book, Landcom 2004)
A =	1.817	ha	(assume 1.6m³/ha/year for developed catchments)
$R_{(y\ \%ilt,\ 5\ day)}$ =	60.2	mm	(95th %ile, refer to tables in Landcom Soils and Construction)
V_{sz} =	864	m³	

Sediment storage capacity - 50% of Settling Zone

$$V_{ss} = 0.5 \cdot V_{sz}$$

Where:

V_{ss}	=	volume of sediment storage required (m³)
V_{sz}	=	volume of settling zone (m³)

V_{sz} =	864	m³
V_{ss} =	432	m³

Sediment basin volume

$$V = V_{sz} + V_{ss}$$

Where:

V_{sz}	=	total volume of sediment basin (m³)
V_{sz}	=	volume of settling zone (m³)
V_{ss}	=	volume of sediment storage required (m³)

V_{sz} =	864	m³
V_{ss} =	432	m³
V =	1296	m³

8 Attachment 4 – Site water balance

PROJECT

SITE WATER BALANCE BLAKEBROOK QUARRY BLAKEBROOK NEW SOUTH WALES

PREPARED FOR

LISMORE CITY COUNCIL

DATE

FEBRUARY 2019

GILBERT SUTHERLAND

DOCUMENT CONTROL

DOCUMENT 11737_WB_RAF4F.docx
TITLE Site Water Balance, Blakebrook Quarry, Blakebrook, New South Wales
PROJECT MANAGER C. Anderson
AUTHOR(S) A. Fullagar
CLIENT Lismore City Council
CLIENT CONTACT Eleisha Went
CLIENT REFERENCE –

SYNOPSIS This report details water balance modelling for the current and future quarry operations at Blakebrook Quarry, Blakebrook, New South Wales.

REVISION HISTORY

REVISION #	DATE	EDITION BY	APPROVED BY
1	01/18	A. Fullagar	C. Anderson / L. Varcoe
2	12/18	A. Fullagar	C. Anderson / L. Varcoe
3	12/02/19	A. Fullagar	C. Anderson / L. Varcoe
4	13/02/19	A. Fullagar	C. Anderson / L. Varcoe

DISTRIBUTION

	REVISION NUMBER									
Distribution	1	2	3	4	5	6	7	8	9	10
Lismore City Council	1	1	1	1						
G&S Library and File	1	1	1	1						

SUMMARY

Lismore City Council commissioned Gilbert & Sutherland to prepare a water balance assessment for Blakebrook Quarry under existing and proposed future site conditions for inclusion in the Soil and Water Management Plan (SWMP) for the site.

This water balance report uses estimates of quarry pit areas, catchment areas, water storage volumes and water usage that are applicable at the time of writing (February 2019). Models were developed to represent current and proposed future operational procedures at the site (to the degree that these practices could be quantified).

CONTENTS

1 Introduction

This water balance report uses estimates of quarry pit areas, catchment areas, water storage volumes and water usage that are applicable at the time of writing (February 2019). The model was developed to represent current operational procedures at the site (to the degree that these practices could be quantified). It is intended that this report be a 'living document' that is periodically updated to reflect changes to operational procedures over time (including improvements in quantifying water usage associated with current operations).

1.1 Version 3 and 4 – February 2019

There have been no further refinements to the modelling undertaken since the Version 2 report was issued in December 2018.

1.2 Version 2 – December 2018

Refinements to the modelling undertaken since the Version 1 report was issued in January 2018 include:

- Revision of the estimated product export volumes based on the 2017 annual return volumes (as reported in Gilbert & Sutherland's *'Annual Surface Water Balance 2017, Blakebrook Quarry, Blakebrook, New South Wales'* dated February 2018).
- Revision of the model for the 'current quarry footprint' to represent existing site conditions with a single licensed site discharge point, in place of the proposed three (3) discharge points that are currently under application. The model for the 'future quarry footprint' still includes three (3) discharge points in anticipation of approval of a license variation application to include the additional locations.
- Refinement of the southwestern catchment split between the pre-existing sediment basin SW1 and the under-construction sediment basin in SW2.
- Stage-area-storage relationships for the existing sediment basins in the North Pit and sub-catchment SW1 (based on detailed ground survey).
- Estimates of the post-construction stage-area-storage relationship for the sedimentation basin in SW2.
- Revised estimates of seepage out of water bodies based on the results of the groundwater assessment.
- An allowance for future groundwater interaction within the pits (based on the results of a groundwater assessment undertaken since the previous report was issued). This applies to the 'future quarry footprint' model only.

2 Model description and overview

2.1 Introduction

A spreadsheet-based water balance model was developed to examine the water flows in, within and out of the quarry development. The model defines the day-to-day site runoff, water storage volumes, water uses and stormwater discharges from the site. This day-to-day evaluation was then used to assess water supply and estimate annual discharges from the site.

The water balance model addresses discharge at one (1) identified site discharge point, LPD1, as shown on Drawing No. 11737-004 (in Attachment 1). LPD1 is currently the only licensed discharge point from the quarry and therefore the only discharge point addressed in the model for the ‘current quarry footprint’.

For the proposed ‘future quarry footprint’, a further two discharge points, LPD2 and LPD3, have also been addressed by the modelling. These are natural discharge points that are proposed to also be included as licensed discharge points for future quarry operations, as identified in G&S’ *‘Soil and Water Management Plan, Blakebrook Quarry, Blakebrook, New South Wales’* prepared for LCC and dated February 2019 (the SWMP). Lismore City Council (LCC) is currently in the process of applying for a licence variation to permit discharge at LPD2 and LPD3 in addition to LPD1, and as such they are shown on Drawing No. 11737-005 (in Attachment 1) which depicts proposed future quarry operations.

2.2 Model structure

The water balance was developed using a spreadsheet model, adopting a daily time-step for estimation of rainfall, runoff, collection, reuse and discharge of water from the site. The model primarily addresses surface water flows within the site and has been updated to include consideration of surface water to groundwater interactions based on the outcomes of G&S’s *‘Hydrogeological Review: Groundwater Monitoring & Management Blakebrook Quarry Nimbin Road, Lismore, New South Wales’* dated February 2019.

The model excludes all potable water usage and wastewater discharge from the site.

The model is comprised of four (4) separate ‘modules’ which, in general, operate independently with respect to water management within the site, however, at present, discharge out of each of the four site catchments is directed to a single licenced discharge point (LPD1). These four ‘modules’ are based on the four defined catchment areas and corresponding sedimentation basins shown on the drawings numbered 11737-004 and 11737-005 (in Attachment 1). These catchment areas are:

- North Pit
- South Pit
- South-western catchment 1 (SW1)
- South-western catchment 2 (SW2)

A summary of the management of surface water within each of the modelled modules is described herein.

2.2.1 North Pit

The North Pit has the largest catchment area, occupying the majority of the site. Surface water collected within the North Pit is relied upon for the majority of uses within the site. The North Pit contains a sedimentation basin (for treatment of runoff) and the main water storage dam. The main dam provides the primary water storage on the site and is used for filling of a water cart for dust-suppression within the site and also for topping up the water storage tank. The tank is a secondary water storage and is used to supply all other (non-potable) site uses.

Runoff from the undisturbed upslope areas within this catchment is intercepted by a clean water diversion drain and conveyed around the northern end of the pit to an existing ephemeral gully to which it would naturally drain, had the catchment not been disturbed for the quarry. This diverted clean water has been excluded from the water balance model.

Runoff from the pit and all remaining upslope areas draining into the pit is collected in a single sedimentation basin, currently located in the north-west of the pit. This sediment basin only has sufficient capacity internally to cater for nuisance events. In all larger events, runoff that exceeds the basin capacity will temporarily pond over the floor of the pit until it is treated and discharged. The sediment basin currently operates as a wet basin due to seepage into the basin from the surrounding rock. Level markers are to be installed within the basin to identify the permanent ponding level that must be restored after each rainfall event.

Following rainfall, water collected in the sediment basin is tested and treated (to meet the required water quality targets) before being discharged within 5 days. Discharge from the basin is pumped to the main dam for reuse within the site. When the dam reaches capacity, excess treated water is pumped out of the sediment basin and directed to LPD1. Subject to future approval of the additional site discharge points, it is intended that in the future excess treated water be pumped directly out to LPD2, a natural discharge point for the pre-quarry landform that is more suitable in proximity to the main dam within the North Pit than the currently licensed discharge point.

The main dam is isolated from directly receiving site runoff to ensure that a clean water supply is maintained on site whenever possible. The dam is topped up by treated water from the sediment basin. The water is used directly for filling of a water cart for dust suppression, and indirectly for all other non-potable site uses by topping up the water storage tank.

The water storage tank is used to supply the asphalt plant, sprinklers (for dust suppression on the haul road) and for maintaining product moisture during processing.

2.2.2 South Pit

The South Pit has a significantly smaller catchment area and, at present, runoff from this catchment is not required for water supply purposes. Accordingly, the management of surface water runoff in this catchment is focused on treatment and discharge to meet the site's water quality targets.

Runoff from a small undisturbed upslope area within this catchment is intercepted by a clean water diversion drain and conveyed around the north-western side of the pit to an adjacent ephemeral gully. This diverted clean water has been excluded from the water balance model.

Initial excavation works for the South Pit commenced in late 2014 under a temporary approval to service a specific state-government project. These initial works have been completed and further excavation works for the South Pit are currently on hold.

For the current extent of excavation, the South Pit is designed to operate as a sedimentation basin for treatment of runoff from the pit and contributing catchment area shown on Drawing No. 11737-004. Earthworks have been undertaken to direct all runoff from the disturbed upstream catchment (including the access road) to the pit.

The South Pit is intended to operate as a dry basin. Following rainfall, water collected in the South Pit will be tested and treated (to meet the required water quality targets) before being pumped out to LPD1 within five days of a rainfall event. Subject to future approval of the additional site discharge points, it is intended that in the future excess treated water be pumped directly out to LPD3, a natural discharge point for the pre-quarry landform that is more suitable in proximity to the South Pit than the currently licensed discharge point. The pit is to remain dry at all other times.

For future expansion of the South Pit excavation, a separate sediment basin will be constructed within the floor of the pit to treat surface runoff in a contained area during treatment, to minimise disturbance of quarry operations for the period following a rainfall event. The sediment basin will be operated in the same way as the pit is currently operated and any overflow from the basin (during events exceeding its design capacity) will be contained within the pit until the water is treated and discharged.

2.2.3 South-western catchments (SW1 and SW2)

The southwestern catchments (SW1 and SW2) are located outside of the quarry pit catchment areas and (similar to the South Pit) do not contribute to the site's water supply requirements. Both catchments discharge to LPD1. The management of surface water runoff in these catchments is focused on treatment and discharge to meet the site's water quality targets.

All catchment runoff is directed as surface flow to the respective basins. The sedimentation basins have been sized based on the design rainfall event for the site (60.2 mm in 5 days). Runoff up to the design event will be treated and pumped out of the basins within 5 days of a rainfall event. As these basins are not contained within the pits, catchment runoff during rainfall exceeding the design event will overflow from the basins and discharge directly to LPD1. Both sedimentation basins will remain dry at all other times.

2.2.4 Water balance flow chart

Figures 1 to 3 (in Attachment 2) provide a schematic of surface water flows within the site that have been included in the water balance model.

3 Model inputs and assumptions

3.1 Model inputs

The water balance model was run for the two scenarios – current and future quarry footprints – as depicted on the drawings numbered 11737-004 and 11737-005 in Attachment 1. The adopted assumptions for each of these scenarios are described herein.

3.1.1 Climate data

Daily time-step SILO Data Drill for the quarry site for the period from 1 January 1889 to 4 February 2018 was obtained from the Queensland Government Department of Science, Information Technology and Innovation (DSITI).

An analysis of the annual rainfall totals for 1889 to 2016 was undertaken to select a representative period to adopt for the water balance modelling. Based on this analysis, the 20-year period from 1 January 1981 to 31 December 2000 was adopted for the modelling. In selecting this period, consideration was also given to the availability of suitable daily time-step evaporation data, which was only available from 1970 onwards.

Table 3.1.1.1 provides a comparison of the annual rainfall statistics for the entire dataset and the adopted modelling period.

Table 3.1.1.1 Annual rainfall statistics

	Annual rainfall totals (mm)	
Statistic	Entire dataset (1889 to 2017)	Model period (1981 to 2000)
Mean	1,491	1,478
Minimum	585	869
Maximum	2,478	2,308
Percentile bands		
5th percentile	913	1,014
10th percentile	1,051	1,086
20th percentile	1,141	1,121
Median (50th percentile)	1,426	1,438
80th percentile	1,845	1,790
90th percentile	2,119	2,155
95th percentile	2,226	2,236

Based on the above analysis, the adopted modelling period has a similar average annual rainfall to the long-term dataset and includes annual totals ranging from below the 5th percentile to above the 95th percentile of the long- term dataset. The adopted period is therefore considered to be representative of long-term climatic conditions for the site.

Daily rainfall and pan evaporation drill data were adopted as inputs for the model. The average monthly rainfall and pan evaporation totals over the modeling period are provided in Table 3.1.1.2 (on the following page).

Table 3.1.1.2 Average monthly rainfall and pan evaporation

Month	Rainfall (mm)	Pan evaporation (mm)
January	147	165
February	192	134
March	184	128
April	183	97
May	151	70
June	98	63
July	80	72
August	49	95
September	41	126
October	74	150
November	111	154
December	170	171
Annual total	**1478**	**1425**

3.1.2 Catchment areas

Catchment areas included in the modelling for each of the four modules are described in Table 2.1.2.1.

Table 3.1.2.1 Contributing catchment areas

	Current footprint (December 2018)				Future quarry footprint			
Description	North Pit (ha)	South Pit (ha)	SW1	SW2	North Pit (ha)	South Pit (ha)	SW1	SW2
Areas included in model								
Catchment	37.107	3.746	0.449	1.818	40.924	4.893	0.442	1.817
Dam	0.292	-	-	-	0.292	-	-	-
Total	**37.399**	**3.746**	**0.449**	**1.818**	**41.216**	**4.893**	**0.442**	**1.817**
External catchment area (excluded from model)								
Undisturbed catchment	11.309	1.102	-	-	9.500	0.767	-	-

3.1.3 Storage volumes – existing quarry footprint

The capacity of the main dam and storage tank were provided by quarry management and are shown in Table 3.1.3.1 (following page).

Table 3.1.3.1 Storage volumes

Water storage	Volume (ML)
Main Dam	30
Tank	1.0

The sedimentation basins were modelled using stage-area-storage relationships to represent the settling zone capacity within each basin. For the sediment basins in the North Pit and South-western Catchment 1, these relationships were derived from ground survey data supplied by Newton Denny Chapmen (NDC). The following assumptions were made for modelling purposes:

- The North Pit sedimentation basin is permanently wet due to seepage into the basin from the surrounding rock.

- Based on a review available satellite imagery, it is estimated that, between rainfall events, the wet area of the basin is approximately 0.2 ha.
- A review of the basin survey returned a footprint of 0.202 ha at RL101.9 metres Australian Height Datum (mAHD) and this was adopted as the ‘bottom’ of the settling zone within the basin. The surveyed storage below this level is considered as sediment storage capacity and has been excluded from the model.
- As the basin is only sized to cater for nuisance events, the modelled stage-storage relationship was extended above the top of the surveyed basin area (0.4 ha at RL102.8 mAHD) to represent temporary ponding over the quarry floor by assuming the quarry floor grades towards the basin at an average of 1 percent.

The modelled storage characteristics for the north pit sedimentation basin are given in Table 3.1.3.2.

Table 3.1.3.2 North Pit sedimentation basin – modelled storage details (settling zone)

Elevation (mAHD)	Area (ha)	Volume (ML)
101.9	0.202	0.000
102.0	0.248	0.225
102.1	0.279	0.350
102.2	0.303	0.490
102.3	0.335	0.646
102.4	0.359	0.986
102.5	0.374	1.353
102.6	0.384	1.732
102.7	0.392	2.121
102.8	0.401	2.517
102.9	0.720	3.077
103.0	1.120	3.997
103.1	1.600	5.357
103.2	2.160	7.237
103.3	2.800	9.717
103.4	3.520	12.877
103.5	4.320	16.797
103.6	5.200	21.557
103.7	6.160	27.237
103.8	7.200	33.917
103.9	8.320	41.677
104.0	9.520	50.597
104.1	10.800	60.757
104.2	12.160	72.237
104.3	13.600	85.117
104.4	15.120	99.477

Under current site conditions, the south pit is utilised as a sediment basin for its contributing catchment. For modelling purposes, and based on the existing pit landform, it has been assumed to have vertical walls. The required sediment basin storage volume of 2.67 ML (settling zone capacity of 1.78ML plus sediment storage capacity of 0.89ML) is exceeded by the storage capacity of the pit and where necessary (in large rainfall events) the pit will fill above the required storage level, with discharge limited by the outlet pump capacity. The modelled conditions for the South Pit sedimentation basin are given in Table 3.1.3.3.

Table 3.1.3.3 South Pit as sedimentation basin – modelled storage details (settling zone)

Depth (m)	Area (ha)	Volume (ML)
0	0.490	0.00
0.365	0.490	1.78
1.000	0.490	4.90
2.000	0.490	9.80

The sediment basin in catchment SW1 is a dry basin. Based on the sedimentation basin design principles, where half of the of the settling zone capacity is included as additional sediment storage capacity, it was assumed that one third of the surveyed capacity was set aside as the sediment storage zone and the upper two-thirds of the surveyed capacity was the available settling zone for inclusion in the model.

The modelled settling zone storage characteristics for the sedimentation basin in sub-catchment SW1 are given in Table 3.1.3.4.

Table 3.1.3.4 SW1 sedimentation basin – modelled storage details (settling zone)

Elevation (mAHD)	Area (ha)	Volume (ML)
115.4	0.0000	0.000
115.5	0.0158	0.015
115.6	0.0166	0.032
115.7	0.0174	0.049
115.8	0.0182	0.066
115.9	0.0189	0.085
116.0	0.0196	0.104
116.1	0.0203	0.124
116.2	0.0210	0.145
116.3	0.0217	0.166
116.4	0.0225	0.188
116.5	0.0232	0.211

The sediment basin in catchment SW2 is currently under construction and once complete will operate as a dry basin. We have been advised that based on site conditions, the maximum basin depth that can be achieved in this location is 1.5 metres. Given that the required settling zone capacity is twice the sediment storage capacity, we have assumed the final basin form will have vertical walls and a settling zone depth of 1 metre. The modelled settling zone storage characteristics for the sedimentation basin in sub-catchment SW2 are given in Table 3.1.3.5.

Table 3.1.3.5 SW2 sedimentation basin – modelled storage details (settling zone)

Depth (m)	Area (ha)	Volume (ML)
0	0.0865	0.000
0.5	0.0865	0.433
1.0	0.0865	0.865

3.1.4 Storage volumes – future quarry footprint

Basins SW1 and SW2 (once constructed) will remain in place with no changes to the storage characteristics future quarry operations.

If the storage tank needs to be relocated in the future to allow for the planned quarry expansion, its volumetric capacity must remain the same at 1.0 ML.

As the quarry works progress, the main storage dam will require some works to maintain its capacity as the quarry floor is lowered. Detailed design for such changes to its configuration will be undertaken at such time in the future that these works are required. For modelling purposes, and until such time as re-design and modification works are undertaken, it has been assumed that the dam footprint and storage volume will remain in their current form.

As works progress and the floor is lowered in the North Pit, the sedimentation basin will require revision. Such works will include increasing the capacity of the sedimentation basin to cater for the design storm event without ponding across the quarry floor (noting that temporary ponding across the quarry floor is expected to occur in events exceeding the design event). The total required sedimentation basin capacity is 29.4 ML (settling zone capacity of 19.6 ML plus sediment storage capacity of 9.8 ML). Assuming a total basin depth of 3 metres and vertical walls, a basin area of 9,800 m² is required to be set aside for future works. For modelling purposes (to cater for events exceeding the design event), the basin stage-storage relationship has been extended above the top of the sediment basin to permit ponding across the quarry floor, assuming a 1 percent grade towards the basin. The modelled settling zone storage characteristics of the north pit sedimentation basin are shown in Table 3.1.4.1.

Table 3.1.4.1 North Pit sedimentation basin – modelled storage details (settling zone)

Depth (m)	Area (ha)	Volume (ML)
0	0.980	0.00
0.5	0.980	4.90
1.0	0.980	9.80
1.5	0.980	14.70
2.0	0.980	19.60
2.1	1.512	20.846
2.2	2.124	22.664
2.3	2.816	25.134
2.4	3.588	28.336
2.5	4.440	32.350
2.6	5.372	37.256
2.7	6.384	43.134
2.8	7.476	50.064
2.9	8.648	58.126
3.0	9.900	67.400
3.1	11.232	77.966
3.2	12.644	89.904
3.3	14.136	103.294
3.4	15.708	118.216

The south pit works are currently on hold and the entire pit floor is being used as a sedimentation basin for the South Pit catchment. When works to expand the south pit recommence, it is recommended that a separate sediment basin be installed in the floor of the South Pit, similar to the basin in the North Pit. The total required sedimentation basin capacity is 3.49 ML (settling zone capacity of 2.33 ML plus sediment storage capacity of 1.16 ML). Assuming a total basin depth of 3 metres and vertical walls, a basin area of 1,170 m² is required to be set aside for future works. For modelling purposes (to cater for events exceeding the design event), the basin stage-storage relationship has been extended above the top of the sediment basin to permit ponding across the quarry floor, assuming a 1 percent grade towards the basin. The modelled settling zone storage characteristics of the south pit sedimentation basin are shown in Table 3.1.4.2.

Table 3.1.4.2 South Pit sedimentation basin – modelled storage details (settling zone)

Depth (m)	Area (ha)	Volume (ML)
0	0.117	0.000
0.5	0.117	0.585
1.0	0.117	1.170
1.5	0.117	1.755
2.0	0.117	2.340
2.1	0.295	2.546
2.2	0.553	2.970
2.3	0.891	3.692
2.4	1.309	4.792
2.5	1.807	6.350
2.6	2.385	8.446
2.7	3.043	11.160

3.1.5 Water usage – main dam

Water truck

A water truck is used for dust suppression throughout the site. Water for the cart is sourced directly from the Main Dam. We have been advised by quarry management that:

- The water truck has as capacity of 17.5 kL.
- In warmer months, approximately 6-8 truck loads are currently used on site each day.
- In cooler months, approximately 2-4 truck loads are currently used on site each day.
- Following very light rainfall, a water truck use decision is made by visual observation of site conditions.
- During wet weather, the water truck is not used.

We anticipate that water usage for dust suppression will increase as the quarry footprint increases in the future (approximately doubling the current footprint). Based on the above estimates, the usage in Table 2.1.4.1 was adopted in the model. The highest water usage (in the warmer months) has been correlated with average monthly pan evaporation values.

Table 2.1.4.1 Water truck usage adopted in the model

Month	Current footprint (December 2017) (ML)	Future quarry footprint (ML)
January	8	16
February	6	12
March	6	12
April	4	8
May	3	6
June	2	4
July	3	6
August	4	8
September	6	12
October	7	14
November	7	14
December	8	16

For modelling purposes, it has been assumed that:

- the water truck will not operate on days where the rainfall exceeds pan evaporation; and
- the water truck will not operate on Sundays when the quarry is closed.

Quarry management recently introduced a daily log of water truck usage to better quantify actual site water usage. Those records will be reviewed periodically to inform updates to the water balance model estimates.

3.1.6 Water usage – storage tank

Quarry management has advised that the 1 ML storage tank is topped up from the dam once per week. On average, we have been advised that the tank empties to approximately 50 percent capacity within this time frame, however no measurements of water usage and top-up volumes have been undertaken to date to confirm this. Modelled water usage from the tank is described below.

It is noted that the *'Soil and Water Management Plan, Blakebrook Quarry, Blakebrook, New South Wales'* to which this water balance is attached provides recommendations regarding recording water usage data on site, so the following estimates can be improved for future reporting purposes.

Haul road sprinklers
Sprinklers are located along the haul road for dust suppression during truck movements. Water for the sprinklers is sourced from the storage tank. Based on the assumptions listed in ERM's April 2011 Soil and Water Management Sub-Plan, whilst operating, the sprinklers use approximately 20 kL per day. This daily demand has been applied to the model for 6 days per week, excluding Sundays when the quarry is closed.

Asphalt plant
An on-site asphalt plant is located across catchments SW1 and SW2 and sources its water from the storage tank. Estimated water usage for the plant was adopted from ERM's April 2011 Soil and Water Management Sub-Plan. When operating, the asphalt plant uses 0.2 kL/day. This demand is considered to be independent of climatic variables and has been applied to the model as a constant for the 6 days per week (excluding Sundays) when the plant is operating. The estimated annual plant water usage is 0.0616 ML.

Process/product water

Water is used to maintain moisture in the product during processing, at an average rate of four percent moisture (by weight) for all product exported from the site. This water is sourced from the storage tank.

For the current quarry footprint, daily product export data for 2017 was supplied and summed to return a total production for the year of 147,327.37 tonnes. To represent periodic changes in production rates (or product export rates), whilst recognising that the process/product water will not only be applied on the specific day that product is exported from the site, the product exported was totalled for each calendar month and then averaged across six-days per week (i.e. excluding Sundays) for that month (noting that no further adjustment was made for Public Holidays or holiday periods).

The total monthly product export and assumed daily product water demand for the current quarry footprint is given in Table 3.1.5.1. This demand has been applied to the model, six days per week (excluding Sundays) except where the rainfall exceeds pan evaporation, in which case no product moisture has been added in the model.

Table 3.1.5.1 Product water demand adopted in the model – current quarry footprint

Month	Monthly production (tonnes)	No. of days (excl. Sundays)	Average daily product (tonnes)	Daily water demand (kL)
January	13,499.8	26	519.2	20.8
February	8,799.2	24	366.6	14.7
March	5,528.6	27	204.8	8.2
April	1,939.25	25	77.6	3.1
May	9,345.35	27	346.1	13.8
June	11,432.35	26	439.7	17.6
July	12,757.7	26	490.7	19.6
August	20,679.55	27	765.9	30.6
September	26,844.87	26	1,032.5	41.3
October	15,464.95	26	594.8	23.8
November	20,524.35	26	789.4	31.6
December	511.4	26	19.7	0.8

The corresponding daily water demand is 19.15kL.

The licence permits the quarry to produce up to 500,000 tonnes annually, which has been adopted for the future quarry footprint model. This equates to an average daily product export of 1602.6 tonnes for the 6 days per week that the quarry is operational throughout the year. This increased production results in a daily water demand of 64.10kL. This has been applied to the model, 6 days per week (excluding Sundays) except where the rainfall exceeds pan evaporation, in which case no product moisture has been added in the model.

3.1.7 Controlled discharge from sedimentation basins

As noted above, it is a requirement of the license that rainfall runoff collected in the sedimentation basins (in the North Pit, South Pit and south-western catchments) be tested and treated (to meet the required water quality targets) before being discharged within five days.

For modelling purposes, the water balance assumes that satisfactory water quality can be achieved to commence discharge from the basins on the same day that any runoff is collected.

North Pit

For the North Pit, discharge from the basin will be primarily directed to the main dam. When the dam reaches capacity, excess treated water is to be pumped out of the sediment basin directly to LPD1. Subject to future approval of additional site discharge points, this will ultimately be pumped out to proposed LPD2.

For rainfall up to the design event, a base discharge rate has been applied to the model, based on emptying the required sedimentation basin capacity (including overflow to the pit floor) evenly across five days. For large rainfall events (exceeding the 60.2 mm design event) discharge is not required to meet the water quality targets and the basins will be emptied as soon as practicable.

For rainfall exceeding the design event, the maximum daily discharge from the North Pit sediment basin rate has been calculated based on pumping at a rate of 200 L/s for 12 hours per day.

South pit

All South Pit runoff will be collected within the pit. Discharge will be primarily directed to LPD1. Subject to future approval of additional site discharge points, this will ultimately be pumped out to proposed LPD3.

For rainfall up to the design event, a base discharge rate has been applied to the model, based on emptying the required sedimentation basin capacity evenly across five days. Discharge due to large rainfall events (> the 60.2 mm design event) is not required to meet the water quality targets and the basins will be emptied as soon as practicable.

For rainfall exceeding the design event, the maximum daily discharge rate from the South Pit sedimentation basin has been calculated based on pumping at a rate of 50 L/s for 12 hours per day.

Southwestern catchments

For the south-western catchments, SW1 and SW2, all surface runoff will be collected within the respective sedimentation basins located on the outlet of each catchment. These basins have been sized to capture and treat runoff during the five-day rainfall design event of 60.2 mm. It is a licence requirement that water collected during rainfall events (up to the five-day rainfall design event of 60.2 mm) be treated and discharged within five days of the event. Accordingly, for rainfall up to this design event, a base discharge rate (i.e. emptying each of the sedimentation basins evenly across five days) was modelled.

In rainfall events exceeding the design event, it is anticipated that catchment runoff (in excess of the basin capacity) will enter the basins and subsequently overflow to the receiving environment, leaving the site at LPD 1. The base pumping rate will still apply during these periods to empty the sedimentation basin capacity below the overflow level.

Summary of discharge rates

A summary of the pumping rates for emptying the sedimentation basins is provided in Table 3.1.7.1 (on the following page).

Table 3.1.7.1 Sedimentation basin discharge pumping rates

Water storage	Current footprint (December 2018)	Future quarry footprint
North Pit sedimentation basin		
Required settling zone volume (ML)	17.79	19.60
Base discharge rate (ML/day)	3.558	3.92
Maximum discharge rate (ML/day)	8.64	8.64
South Pit sedimentation basin		
Required settling zone volume (ML)	1.78	2.33
Base discharge rate (ML/day)	0.356	0.466
Maximum discharge rate (ML/day)	2.16	2.16
South-western catchment 1 sedimentation basin		
Settling zone volume (ML)	0.214	0.214
Discharge rate (ML/day)	0.0428	0.0428
South-western catchment 2 sedimentation basin		
Settling zone volume (ML)	0.865	0.865
Discharge rate (ML/day)	0.173	0.173

3.2 Water balance calculations

3.2.1 Runoff

The volumetric runoff coefficient is defined as the proportion of rainfall that runs off as stormwater. Catchment runoff was calculated adopting the volumetric runoff coefficients from Table F2 of Appendix F of the *Managing Urban Stormwater: Soils and Construction, Volume 1, 4th edition, March 2004*, Landcom (the Blue Book). Based on the soil type the applicable values for the runoff coefficient are shown in Table 3.2.1.1.

Table 3.2.1.1 Volumetric runoff coefficients (Soil Hydrologic Group D)

Rainfall depth (mm)	Runoff coefficient (C_v)
< 20	0.39
20 – 25	0.50
25 – 30	0.56
30 – 40	0.64
40 – 50	0.69
50 – 60	0.74
60 – 80	0.79
> 80	0.84

Rainfall runoff calculations were undertaken for all dry catchment areas contributing to the sedimentation basins. For wet catchment areas (i.e. the main storage dam and the calculated daily wet area for each sedimentation basin), rainfall was applied directly to the water body in the model with no volumetric reduction for conversion to runoff.

3.2.2 Evaporation

Losses due to evaporation were applied to all open water storages on a daily basis, based on the estimated wet area. The main dam area was assumed as a constant, adopting the area in Table 3.1.2.1. Wet areas for each of the sedimentation basins were based on the stage-storage relationships described in Sections 3.1.3 and 3.1.4. Evaporative losses from water bodies were calculated using a conversion factor of 0.7, applied to the pan evaporation data.

3.2.3 Seepage

Losses due to seepage were applied to all open water storages on a daily basis, based on the estimated wet area. The main dam area was assumed as a constant, adopting the area in Table 3.1.2.1. Wet areas for each of the sedimentation basins were based on the stage-storage relationships described in Sections 3.1.3 and 3.1.4.

For the current operating conditions, seepage losses from all water bodies have been calculated using a constant seepage rate of 10 mm/day.

For future operating conditions, the deeper excavation in the North Pit will result in the water bodies (Main Dam and north pit sediment basin) being located in geology with lower permeability. For these two water bodies, a constant seepage rate of 1 mm/day has been modelled. For the south pit and south-western catchment sediment basins, the rate of 10 mm/day has been applied (equivalent to current site conditions).

3.2.4 Groundwater inflows

As the excavation in the North Pit gets deeper, it will intersect existing aquifers, resulting in groundwater inflows into the pit. It is anticipated the groundwater will be collected in perimeter drains (to be constructed) and be conveyed to the sediment basin. Details of a groundwater assessment undertaken to quantify flows into the pit are given in G&S's 'Hydrogeological Review: Groundwater Monitoring & Management Blakebrook Quarry Nimbin Road, Lismore, New South Wales' dated December. Based on this assessment, it has been assumed that, under future operating conditions, 190 kL/day of groundwater will flow into the pit.

3.2.5 Initial conditions

For modelling purposes, the following assumptions have been made in respect of water storage volumes at the commencement of the 20-year model period:

- Main water storage dam – initial volume = 28.8 ML (average long-term storage volume under current conditions)
- Water storage tank – full (initial volume = 1 ML)
- North Pit sedimentation basin – empty
- South Pit (functioning as sedimentation basin) – empty
- South-western catchments (SW1 and SW2) sedimentation basins – empty

4 Results – Existing quarry conditions

4.1 Climate data summary

A summary of relevant climate data is provided in Table 4.1.1.1.

Table 4.1.1.1 Climate data analysis

Parameter	Average year	Minimum	Maximum
Total number of rainfall days per year	184.5	143	220
Total number of days per year exceeding 5-day design rainfall (60.2 mm) for previous 5 days	31.2	8	62
Number of events per year exceeding 5-day design rainfall (60.2 mm)	6.4	2	10
Duration of longest exceedance event [a]	7.8	5	16

[a] Duration of exceedance event is defined by number consecutive days that 5-day rainfall total exceeds 5-day design rainfall. Duration of exceedance will exclude (up to) the first to fourth days of rainfall event if 5-day design rainfall is not exceeded during those days.

4.2 Northern catchment

Based on the inputs and assumptions described above, the modelling results show that rainfall and runoff captured from the northern catchment alone provides sufficient inflow to the main dam to service all water demands within the quarry throughout the full range of modelled climatic conditions.

4.2.1 Northern catchment sedimentation basin

A summary of the annual water balance results for the Northern catchment sedimentation basin is presented in Table 4.2.1.1.

Table 4.2.1.1 Northern catchment sedimentation basin – annual volumes

Parameter	Average year	Minimum	Maximum
Rainfall volume – total North Pit catchment area (ML)	552.8	324.9	863.3
Runoff volume – total North Pit catchment area (ML) [a]	309.5	167.0	542.4
Total basin inflow (ML)	312.1	166.7	551.4
Evaporative losses (ML)	2.8	1.2	5.6
Seepage losses (ML)	10.9	4.6	23.4
Discharge – pumped to main dam	43.0	36.7	47.2
Discharge – pumped out to LPD1	255.5	113.7	490.7

[a] Total runoff expected to have been generated and discharged from equivalent catchment area if no obstructions (sediment basin, dam, quarry pit) were present. Estimate provided for comparison to estimated discharge diverted from this location to LPD1.

On average, it is estimated that total catchment discharge from the North Pit area reduces by approximately 17 percent as a result of the quarry operations. As current licence conditions require that all controlled site discharge be directed to the licenced discharge point at LPD1, runoff to the receiving environment downstream of the natural catchment discharge point west of the sedimentation basin will be reduced substantially (by 309.5 ML/year) with only runoff from the 11.3 hectare undisturbed upstream catchment that is diverted around quarry pit continuing to drain to this location (approximately 93.5 ML/year).

A summary of the estimated sedimentation basin performance is provided in Table 4.2.1.2.

Table 4.2.1.2 Northern catchment sedimentation basin performance

Parameter	Average year	Minimum	Maximum
Total number of discharge days (to Main Dam and/or LPD)	171	142	215
Total number of days discharging to Main Dam	135	117	158
Total number of days discharging to LPD	100	54	159
Total number of days per year when basin contains water [a]	29	11	54
Maximum number of consecutive days where basin contains water	9.1	3	24
Average number of days to empty basin	2.6	1.6	4.8

[a] Total number of days containing water has been calculated based on end-of-day volumes after all losses and discharges have been accounted for. More frequent wetting and drying during small events is expected and is accounted for by losses and/or immediate discharge.

The model inputs (basin volumes and pumping rates) dictate that the basin will be emptied within five days of the cessation of all rainfall events up to and including the five-day design rainfall event of 60.2 mm. Where rainfall exceeds the design capacity of the system or a rainfall event continues for more than the 5-day design event duration, the basin is expected to contain water for a longer period whilst active discharge is taking place, (as demonstrated by the results above).

4.2.2 Main Dam water balance

A summary of the water balance results for the Main Dam is presented in Table 4.2.2.1.

Table 4.2.2.1 Northern catchment Main Dam – annual volumes

Parameter	Average year	Minimum	Maximum
Dam inflow from direct rainfall (ML)	4.3	2.5	6.7
Dam inflow pumped from sediment basin (ML)	43.0	36.7	47.2
Total dam inflow (ML)	**47.3**	**43.0**	**51.0**
Evaporative losses (ML)	2.9	2.6	3.3
Seepage losses (ML)	10.7	10.6	10.7
Total losses (ML)	**13.6**	**13.2**	**13.9**
Usage – water truck for dust suppression (ML)	22.7	19.6	24.6
Usage – main tank top-up for other site usage (ML)	11.0	10.5	11.4
Total usage (ML)	**33.7**	**30.3**	**35.9**
Daily stored volume (ML) [a]	**28.8**	**16.7**	**30.9**

[a] Stored volumes reported using average, minimum and maximum daily levels for entire modelling period (not based on annual averages).

The modelling results show that under all modelled climatic conditions, the main dam has sufficient water to meet all quarry water demands. The minimum estimated storage volume is 16.7 ML (or 13.3 ML below full capacity) throughout the model period. It is recommended that detailed ground and bathymetric survey be undertaken to confirm the dam's storage volume and stage-area-volume estimates to improve the reliability of future supply estimates. Level loggers will also be installed to monitor variability in water levels to better quantify water losses from the storage (once reliable estimates of water usage are established). Figure 4 (attached) shows the estimated daily dam storage volumes for the entire model period.

Although controlled dam inflows (i.e. pumped discharge from the sediment basin) are restricted to occur only when the dam is below full storage level, direct rainfall onto the dam during large rainfall events results in the full-storage capacity being exceeded for a short time after such events. Freeboard of up to 1 ML will be provided within the bunded dam area to accommodate this rainfall without mixing with 'dirty' quarry pit runoff.

Water truck
Based on the inputs described in Section 3.1.4, the modelling estimates that water truck dust suppression uses an average annual volume of 22.7 ML (or 1,297 truck loads). Quarry management's recent introduction of a daily log of water truck movements will help to confirm and improve the accuracy of the water balance model.

4.2.3 Main Tank water balance

A summary of the water balance results for the Main Tank is presented in Table 4.2.3.1.

Table 4.2.3.1 Main tank – annual volumes

Parameter	Average year	Minimum	Maximum
Dam inflow pumped from main dam (ML)	11.0	10.5	11.4
Usage – haul road sprinklers (ML)	6.3	6.2	6.3
Usage – asphalt plant (ML)	0.1	0.1	0.1
Usage – process/product water (ML)	4.7	4.2	5.1
Average daily stored volume (ML) [a]	**0.89**	**0.62**	**1.0**

[a] Stored volumes reported using average, minimum and maximum daily levels for entire modelling period (not based on annual averages).

The attached Figure 5 shows the estimated daily storage volumes in the tank for the entire model period. Based on the stated water usage assumptions, the modelling suggests that throughout the modelling period the minimum water level in the rain tank prior to weekly top-up will be 0.62 ML.

On average, the modelling indicates 11.0 ML of water is used to top up the tank each year. Comparatively, this is significantly lower than the estimate from site staff of weekly top-up volume being equivalent to approximately 50 percent of capacity (which equates to 26 ML/year). It is recommended that a flow-meter be installed on the tank outlet to monitor and better quantify water usage from the tank.

4.3 Southern catchment

The southern catchment water balance was undertaken to estimate the impact of the south pit operations on site discharge volumes. Collection and storage of water within the catchment is intended to be temporary only to satisfy water quality treatment requirements.

4.3.1 Southern catchment – quarry pit

As noted, under existing site conditions the Southern Pit provides a sedimentation basin function for treating runoff from the entire southern catchment. A summary of the annual water balance results for the South Pit (sedimentation basin) is presented in Table 4.3.1.1 (following page).

Table 4.3.1.1 Southern catchment quarry pit (sedimentation basin) – annual volumes

Parameter	Average year	Minimum	Maximum
Rainfall volume – total South Pit catchment area (ML)	55.4	32.5	86.5
Runoff volume – total South Pit catchment area (ML) [a]	31.0	16.7	54.3
Total pit inflow (ML)	34.2	18.8	58.5
Evaporative losses (ML)	1.8	1.5	2.3
Seepage losses (ML)	5.3	3.7	7.4
Discharge – pumped out to LPD1	27.1	13.6	49.9

[a] Total runoff that expected to have been generated and discharged from equivalent catchment area if no obstructions (i.e. quarry pit) were present. Estimate provided for comparison to estimated discharge diverted from this location to LPD1.

On average, it is estimated that total catchment discharge from the South Pit catchment area reduces by approximately 13 percent as a result of the quarry operations. As current licence conditions require that all controlled site discharge be directed to the licenced discharge point at LPD1, runoff to the receiving environment downstream of the natural catchment discharge point west of the sedimentation basin will be reduced substantially with only runoff from the undisturbed catchment area downstream of the quarry pit continuing to drain to this location.

A summary of the estimated sedimentation basin performance is provided in Table 4.3.1.2.

Table 4.3.1.2 South Pit/sedimentation basin performance

Parameter	Average year	Minimum	Maximum
Total number of days discharging to LPD	85	61	121
Total number of days per year when pit contains water [a]	15	7	26
Maximum number of consecutive days where pit contains water	3.1	2	6
Average number of days to empty pit	1.5	1.1	1.9

[a] Total number of days containing water has been calculated based on end-of-day volumes after all losses and discharges have been accounted for. More frequent wetting and drying during small events is expected and is accounted for by losses and/or immediate discharge.

4.4 South-western catchments

The south-western catchment water balance has been undertaken to estimate catchment discharge volumes at LPD1. Collection and storage of water within these catchments is intended to be temporary only to satisfy water quality treatment requirements. As these basins are not confined within the quarry pits, in rainfall events exceeding their design capacity, the basins will overtop and discharge directly to the receiving environment, leaving the site at LPD1. The modelled storage volume for the existing sedimentation basin SW1 is based on detailed ground survey. Sizing for basin SW2 (under construction) was subsequently undertaken to treat the balance of the overall south-western catchment that exceeded the available capacity in basin in SW1. The modelled storage volume for basin SW2 is based on the required volume for the basin that is currently under construction (as described in Section 3.1.3).

4.4.1 South-western catchment 1 – sedimentation basin SW1

A summary of the annual water balance results for the catchment SW1 sedimentation basin is presented in Table 4.4.1.1 (following page).

Table 4.4.1.1 Sedimentation basin SW1 – annual volumes

Parameter	Average year	Minimum	Maximum
Rainfall volume – total SW1 catchment area (ML)	6.6	3.9	10.4
Runoff volume – total SW1 catchment area (ML) [a]	3.7	2.0	6.5
Total basin inflow (ML)	3.7	2.0	6.6
Evaporative losses (ML)	0.02	0.01	0.04
Seepage losses (ML)	0.08	0.03	0.15
Pumped discharge to LPD1 (ML)	3.0	1.9	4.9
Overflow to LPD1 (ML)	0.6	0	2.0
Total discharge to LPD1 (pumped and overflow) (ML)	3.7	2.0	6.5

[a] Total runoff that expected to have been generated and discharged from equivalent catchment area if no obstructions (i.e. sedimentation basin) were present. Estimate provided for comparison to estimated catchment discharge pumped to LPD1.

On average, it is estimated that total catchment discharge from the SW1 catchment area is comparable to the discharge for the same catchment area prior to the quarry operations.

A summary of the estimated sedimentation basin performance is provided in Table 4.4.1.2.

Table 4.4.1.2 Sedimentation basin SW1 performance

Parameter	Average year	Minimum	Maximum
Total number of days discharging to LPD	196	155	235
Total number of days of overflow	4	0	14
Total number of days per year when pit contains water [a]	44	19	79
Maximum number of consecutive days where pit contains water	9.6	5	18
Average number of days to empty pit	3.7	2.1	6.2

[a] Total number of days containing water has been calculated based on end-of-day volumes after all losses and discharges have been accounted for. More frequent wetting and drying during small events is expected and is accounted for by losses and/or immediate discharge.

The model inputs (basin volumes and pumping rates) dictate that the sedimentation basin will be emptied within five days of the cessation of all rainfall events up to and including the five-day design rainfall event of 60.2 mm.

Where rainfall exceeds the design capacity of the system, the basin will overflow at the same time as controlled discharge is taking place. Where a rainfall event continues for more than the five-day design event duration, the basin is expected to contain water for a longer period whilst active discharge is taking place, as indicated in the results above.

4.4.2 South-western catchment 2 – sedimentation basin SW2

A summary of the annual water balance results for the catchment SW2 sedimentation basin is presented in Table 4.4.2.1 (following page).

Table 4.4.2.1 Sedimentation basin SW2 – annual volumes

Parameter	Average year	Minimum	Maximum
Rainfall volume – total SW2 catchment area (ML)	26.9	15.8	42.0
Runoff volume – total SW2 catchment area (ML) [a]	15.0	8.1	26.4
Total basin inflow (ML)	15.2	8.2	26.7
Evaporative losses (ML)	0.10	0.05	0.18
Seepage losses (ML)	0.37	0.16	0.69
Pumped discharge to LPD1 (ML)	12.2	7.5	19.6
Overflow to LPD1 (ML)	2.6	0	7.9
Total discharge to LPD1 (pumped and overflow) (ML)	14.7	7.9	26.4

[a] Total runoff that expected to have been generated and discharged from equivalent catchment area if no obstructions (i.e. sedimentation basin) were present. Estimate provided for comparison to estimated catchment discharge pumped to LPD1.

On average, it is estimated that total catchment discharge from the SW2 catchment area to LPD 1 reduces by approximately 2 percent as a result of the quarry operations. This reduction is the result of evaporative and seepage losses during the temporary storage and controlled discharge of water for treatment in the sedimentation basin.

A summary of the estimated sedimentation basin performance is provided in Table 4.4.2.2.

Table 4.4.2.2 Sedimentation basin SW2 performance

Parameter	Average year	Minimum	Maximum
Total number of days discharging to LPD	195	155	234
Total number of days of overflow	4	0	14
Total number of days per year when pit contains water [a]	43	19	79
Maximum number of consecutive days where pit contains water	9.6	5	1
Average number of days to empty pit	3.7	2.1	6.2

[a] Total number of days containing water has been calculated based on end-of-day volumes after all losses and discharges have been accounted for. More frequent wetting and drying during small events is expected and is accounted for by losses and/or immediate discharge.

The model inputs (basin volumes and pumping rates) dictate that the sedimentation basin will be emptied within five days of the cessation of all rainfall events up to and including the five-day design rainfall event of 60.2 mm.

Where rainfall exceeds the design capacity of the system, the basin will overflow at the same time as controlled discharge is taking place. Where a rainfall event continues for more than the five-day design event duration, the basin is expected to contain water for a longer period whilst active discharge is taking place, as indicated in the results above.

4.5 Water supply and security

The Main Dam in the North Pit is used to provide all water supply requirements for the site and as such, no imported clean (mains) water is relied upon or needed for any operational uses on site. The Main Dam has a capacity of 30 ML. As detailed in Section 4.2.2, throughout the entire 20-year model period, the available volume of water stored in the dam does not fall below 16.7 ML (or 55.6 percent of capacity). With an average daily water usage across the site of 92.3 kL, this approximates to 181 days (or almost 6 months) of additional water supply available at all times throughout the modelling period.

Figure 4 (in Attachment 2) shows the estimated available storage levels throughout the model period, whilst Table 4.5.1 provides a summary of the frequency of availability of different supply levels (on a daily timestep basis) throughout the model period.

Table 4.5.1 Daily water supply availability – Main Dam

Main Dam storage volume (ML)	Percent of full storage (%)	Proportion of time storage level exceeded (%)
0	0	100.0%
3.0	10	100.0%
6.0	20	100.0%
9.0	30	100.0%
12.0	40	100.0%
15.0	50	100.0%
16.5	55	100.0%
18.0	60	99.9%
19.5	65	99.7%
21.0	70	99.1%
22.5	75	98.4%
24.0	80	97.0%
25.5	85	94.3%
27.0	90	88.2%
28.5	95	74.0%
30.0	100	11.0%
31.5	105	0.0%

5 Results – Future quarry conditions

5.1 Northern catchment

Based on the inputs and assumptions described above, the modelling results show that rainfall and runoff captured from the northern catchment alone, provides sufficient inflow to the main dam to service all water demands within the quarry throughout the full range of modelled climatic conditions.

5.1.1 Northern catchment sedimentation basin

Table 5.1.1.1 summarises the annual water balance results for the Northern catchment sedimentation basin.

Table 5.1.1.1 Northern catchment sedimentation basin – annual volumes

Parameter	Average year	Minimum	Maximum
Rainfall volume – total North Pit catchment area (ML)	609.2	358.0	951.4
Runoff volume – total North Pit catchment area (ML) [a]	341.1	184.1	597.7
Total basin inflow (ML)	411.4	252.4	674.6
Evaporative losses (ML)	1.9	0.4	5.3
Seepage losses (ML)	0.7	0.1	2.5
Discharge – pumped to main dam	66.7	56.1	73.8
Discharge – pumped out to LPD2	342.0	178.0	616.5

[a] Total runoff that expected to have been generated and discharged from equivalent catchment area if no obstructions (sediment basin, dam, quarry pit) were present. Estimate provided for comparison to estimated discharge pumped to (proposed) LPD2.

On average, it is expected that total catchment discharge from the North Pit area to (proposed) LPD 2 will be comparable to the discharge for the same undisturbed catchment area prior to quarrying works.
The comparative increase in catchment discharge (when compared to the substantial reduction in catchment discharge under existing conditions) is the combined result of:

- Interception of the groundwater table resulting in an additional inflow source to the quarry pit and significant contribution to the water usage demands within the site.
- Change in geotechnical characteristics of the landform with depth such that the permeability is significantly reduced and seepage from the sedimentation basin will also be reduced.
- Proposed (future) construction of a suitably sized sedimentation basin that does not rely on ponding over the quarry floor for all events up to the design event. The smaller wet basin footprint means evaporative losses from the basin are reduced.

A summary of the estimated sedimentation basin performance is provided in Table 5.1.1.2.

Table 5.1.1.2 Northern catchment sedimentation basin performance

Parameter	Average year	Minimum	Maximum
Total number of discharge days (to Main Dam and/or LPD) [a]	365	365	366
Total number of days discharging to Main Dam	289	250	317
Total number of days discharging to LPD	200	164	240
Total number of days per year when basin contains water [b]	35	12	70

Parameter	Average year	Minimum	Maximum
Max. number of consecutive days where basin contains water	12.4	3	36
Average number of days to empty basin	3.1	1.8	5.9

[a] Once the quarry pit intercepts groundwater, the basin will require continuous dewatering of the groundwater inflows to maintain capacity in preparation for rainfall events.

[b] Total number of days containing water has been calculated based on end-of-day volumes after all losses and discharges (including dewatering of groundwater inflows) have been accounted for. More frequent wetting and drying during small events is expected and is accounted for by losses and/or immediate discharge.

The model inputs (basin volumes and pumping rates) dictate that the sedimentation basin will be emptied within five days of the cessation of all rainfall events up to and including the 5-day design rainfall event of 60.2 mm. Where rainfall exceeds the design capacity of the system or a rainfall event continues for more than the 5-day design event duration, the basin is expected to contain water for a longer than five days, whilst active discharge is taking place, as demonstrated by the results above.

5.1.2 Main Dam water balance

A summary of the water balance results for the Main Dam is presented in Table 5.1.2.1.

Table 5.1.2.1 Northern catchment Main Dam – annual volumes

Parameter	Average year	Minimum	Maximum
Dam inflow from direct rainfall (ML)	4.3	2.5	6.7
Dam inflow pumped from sediment basin (ML)	66.7	56.1	73.8
Total dam inflow (ML)	**71.1**	**62.3**	**76.4**
Evaporative losses (ML)	2.9	2.6	3.3
Seepage losses (ML)	1.1	1.1	1.1
Total losses (ML)	**4.0**	**3.6**	**4.3**
Usage – water truck for dust suppression (ML)	45.3	39.2	49.2
Usage – main tank top-up for other site usage (ML)	21.7	20.0	23.1
Total usage (ML)	**67.0**	**59.2**	**72.3**
Daily stored volume (ML) [a]	**29.6**	**26.4**	**31.0**

[a] Stored volumes reported using average, minimum and maximum daily levels for entire modelling period (not based on annual averages).

The modelling results show that for predicted future conditions, the main dam will provide sufficient supply to service all water demands within the quarry throughout the full range of modelled climatic conditions, with a minimum estimated storage volume of 26.4 ML (or 3.6 ML below full capacity) throughout the model period. This indicates that a reduced dam capacity is feasible for future quarry operations without compromising reliability of supply. Further investigations will be required at such a time when quarry works progress to the point that the current dam required decommissioning and replacement to investigate the intermediate conditions (groundwater inflows, seepage etc.) as the modelling described above only reflects the ultimate stage of the quarry operations.

Section 5 of this report provides a series of recommendations to improve the accuracy of the above estimates. If implementation of those recommendations, and corresponding revisions of the water balance modelling, indicate that there is potential for the dam to empty during dry periods, the capacity of the dam will be increased in the future.

The attached Figure 6 shows the estimated future daily storage volumes in the dam for the entire model period (based on the existing dam capacity).

Although controlled dam inflows (i.e. pumped discharge from the sediment basin) have been restricted to only occurring when the dam is below full storage level, direct rainfall onto the dam during large rainfall events results in the dam exceeding full-storage capacity for a short time after such events. Sufficient freeboard (up to 1 ML) will be provided within the bunded dam area to accommodate this rainfall without mixing with dirty runoff from the quarry pit.

Water truck
Based on the inputs described in Section 3.1.4, the modelling estimates that an average annual volume of 45.3 ML is used by the water truck for dust suppression purposes. This equates 2,589 loads in the water truck. It is recommended that a daily log of all water truck movements be established on site to quantify actual site usage and improve the accuracy of future water balance modeling.

5.1.3 Main Tank water balance

A summary of the water balance results for the Main Tank is presented in Table 5.1.3.1 (following page).

Table 5.1.3.1 Northern catchment Main Dam – annual volumes

Parameter	Average year	Minimum	Maximum
Tank inflow pumped from main dam (ML)	21.7	20.0	23.1
Usage – haul road sprinklers (ML)	6.3	6.2	6.3
Usage – asphalt plant (ML)	0.1	0.1	0.1
Usage – process/product water (ML)	15.4	13.3	16.9
Average daily stored volume (ML)	**0.79**	**0.49**	**1.0**

The attached Figure 7 shows the estimated future daily storage volumes in the tank for the entire model period. Based on the water usage assumptions described above, the modelling suggests that, throughout the modelling period the minimum water level in the rain tank prior to weekly top-up will be 0.49 ML. Once the recommendations detailed in the water balance for the existing quarry operations are implemented, the estimates for future operations will be refined and modelling revised accordingly.

5.2 Southern catchment

The southern catchment water balance has been undertaken to estimate catchment discharge volumes at (proposed) LPD3. Collection and storage of water within the catchment is intended to be temporary only to satisfy water quality treatment requirements. If, following future expansion of the southern quarry pit, a more permanent water storage for re-use within the southern pit is required, this will be provided separately and in addition to the temporary sedimentation basin. In that case, the water balance modelling will be updated accordingly.

5.2.1 Southern catchment sedimentation basin

As noted above, under existing site conditions the southern pit provides a sedimentation basin function for treating runoff from the entire southern catchment. It is anticipated that when the southern pit expansion is undertaken as part of the future quarry operation, a sedimentation basin will be constructed within the southern pit, to limit the inundated area following rainfall events and allow quarry operations to return to normal as soon as possible after the event (whilst treatment and discharge of the collected water is taking place. A summary of the annual water balance results for the future South Pit sedimentation basin is presented in Table 5.2.1.1.

Table 5.2.1.1 Southern catchment sedimentation basin – annual volumes

Parameter	Average year	Minimum	Maximum
Rainfall volume – total South Pit catchment area (ML)	72.3	42.5	113.0
Runoff volume – total South Pit catchment area (ML) [a]	40.5	21.8	71.0
Total basin inflow (ML)	40.7	21.9	71.3
Evaporative losses (ML)	0.09	0.03	0.29
Seepage losses (ML)	0.36	0.09	1.08
Discharge – pumped out to LPD3	40.3	21.8	70.7

[a] Total runoff that expected to have been generated and discharged from equivalent catchment area if no obstructions (i.e. quarry pit) were present. Estimate provided for comparison to estimated discharge pumped to (proposed) LPD3.

On average, it is estimated that total catchment discharge from the South Pit catchment area will be comparable to the discharge for the same catchment area prior to the quarry operations.

A summary of the estimated sedimentation basin performance is provided in Table 5.2.1.2.

Table 5.2.1.2 Southern catchment sedimentation basin performance

Parameter	Average year	Minimum	Maximum
Total number of days discharging to LPD	188	149	223
Total number of days per year when basin contains water [a]	18	8	31
Maximum number of consecutive days where basin contains water	4.2	3	10
Average number of days to empty basin	1.7	1.4	2.1

[a] Total number of days containing water has been calculated based on end-of-day volumes after all losses and discharges have been accounted for. More frequent wetting and drying during small events is expected and is accounted for by losses and/or immediate discharge.

5.3 South-western catchments

The south-western catchment water balance has been undertaken to estimate catchment discharge volumes at LPD1. Collection and storage of water within these catchments is intended to be temporary only to satisfy water quality treatment requirements.

5.3.1 South-western catchment 1 – sedimentation basin SW1

A summary of the annual water balance results for the catchment SW1 sedimentation basin is presented in Table 5.3.1.1.

Table 5.3.1.1 Sedimentation basin SW1 – annual volumes

Parameter	Average year	Minimum	Maximum
Rainfall volume – total SW1 catchment area (ML)	6.6	3.9	10.4
Runoff volume – total SW1 catchment area (ML) [a]	3.7	2.0	6.5
Total basin inflow (ML)	3.7	2.0	6.6
Evaporative losses (ML)	0.02	0.01	0.04
Seepage losses (ML)	0.08	0.03	0.15
Discharge to LPD1 (pumped and overflow)	3.7	2.0	6.5

[a] Total runoff that expected to have been generated and discharged from equivalent catchment area if no obstructions (i.e. sedimentation basin) were present. Estimate provided for comparison to estimated catchment discharge pumped to LPD1.

On average, it is estimated that total catchment discharge from the SW1 catchment area is comparable to the discharge for the same catchment area prior to the quarry operations.

A summary of the estimated sedimentation basin performance is provided in Table 5.3.1.2.

Table 5.3.1.2 Sedimentation basin SW1 performance

Parameter	Average year	Minimum	Maximum
Total number of days discharging to LPD	196	155	235
Total number of days of overflow	4	0	14
Total number of days per year when pit contains water [a]	44	19	79
Maximum number of consecutive days where pit contains water	9.6	5	18
Average number of days to empty pit	3.7	2.1	6.2

[a] Total number of days containing water has been calculated based on end-of-day volumes after all losses and discharges have been accounted for. More frequent wetting and drying during small events is expected and is accounted for by losses and/or immediate discharge.

The model inputs (basin volumes and pumping rates) dictate that the sedimentation basin will be emptied within 5-days of the cessation of all rainfall events up to and including the 5-day design rainfall event of 60.2mm.

Where rainfall exceeds the design capacity of the system, the basin will overflow at the same time as controlled discharge is taking place. Where a rainfall event continues for more than the 5-day design event duration, the basin is expected to contain water for a longer period whilst active discharge is taking place, as demonstrated by the results above.

5.3.2 South-western catchment 2 – sedimentation basin SW2

A summary of the annual water balance results for the catchment SW1 sedimentation basin is presented in Table 5.3.2.1.

Table 5.3.2.1 Sedimentation basin SW2 – annual volumes

Parameter	Average year	Minimum	Maximum
Rainfall volume – total SW2 catchment area (ML)	26.9	15.8	42.0
Runoff volume – total SW2 catchment area (ML) [a]	15.0	8.1	26.4
Total basin inflow (ML)	15.2	8.2	26.7
Evaporative losses (ML)	0.10	0.05	0.18
Seepage losses (ML)	0.37	0.16	0.69
Discharge to LPD1 (pumped and overflow)	14.7	7.9	26.4

[a] Total runoff that expected to have been generated and discharged from equivalent catchment area if no obstructions (i.e. sedimentation basin) were present. Estimate provided for comparison to estimated catchment discharge pumped to LPD1.

On average, it is estimated that total catchment discharge from the SW2 catchment area to LPD 1 will be reduced by approximately 2 percent as a result of the future quarry operations (when compared to the same undeveloped catchment area). This reduction is the result of evaporative and seepage losses during the temporary storage and controlled discharge of water for treatment in the sedimentation basin.

A summary of the estimated sedimentation basin performance is provided in Table 5.3.2.2.

Table 5.3.2.2 Sedimentation basin SW2 performance

Parameter	Average year	Minimum	Maximum
Total number of days discharging to LPD	195	155	234
Total number of days of overflow	4	0	14
Total number of days per year when pit contains water [a]	43	19	79
Maximum number of consecutive days where pit contains water	9.6	5	18
Average number of days to empty pit	3.7	2.1	6.2

[a] Total number of days containing water has been calculated based on end-of-day volumes after all losses and discharges have been accounted for. More frequent wetting and drying during small events is expected and is accounted for by losses and/or immediate discharge.

The model inputs (basin volumes and pumping rates) dictate that the sedimentation basin will be emptied within 5 days of the cessation of all rainfall events up to and including the 5-day design rainfall event of 60.2 mm.

Where rainfall exceeds the design capacity of the system, the basin will overflow at the same time as controlled discharge is taking place. Where a rainfall event continues for more than the 5-day design event duration, the basin is expected to contain water for a longer period whilst active discharge is taking place, as demonstrated by the results above.

5.4 Water supply and security

Under the modelled ‘future quarry footprint’ scenario, the Main Dam in the North Pit is used to provide all water supply requirements for the site and as such, no imported clean (mains) water will be relied upon or needed for any future operational uses on site. Though the form of the dam will likely change as excavation within the pit deepens, for modelling purposes, it has been assumed that the Main Dam will maintain capacity of 30 ML at full storage. As detailed in Section 5.1.2, throughout the entire 20-year model period, the available volume of water stored in the dam is estimated not to fall below 26.4 ML (or 88 percent of capacity). With an average daily water usage across the site of 183.6 kL, this approximates to 144 days (greater than 4 months) of additional water supply available at all times throughout the modelling period.

Figure 6 (in Attachment 2) shows the estimated available storage levels throughout the model period, whilst Table 5.4.1 provides a summary of the frequency of availability of different supply levels (on a daily timestep basis) throughout the model period.

Table 5.4.1 Daily water supply availability – Main Dam

Main Dam storage volume (ML)	Percent of full storage (%)	Proportion of time storage level exceeded (%)
0	0	100.0%
3.0	10	100.0%
6.0	20	100.0%
9.0	30	100.0%
12.0	40	100.0%

Main Dam storage volume (ML)	Percent of full storage (%)	Proportion of time storage level exceeded (%)
15.0	50	100.0%
18.0	60	100.0%
21.0	70	100.0%
24.0	80	100.0%
25.5	85	100.0%
27.0	90	99.5%
28.5	95	95.8%
30.0	100	20.8%
31.5	105	0.0%

6 Recommendations

6.1 Existing quarry operations

It is recommended that the following actions be undertaken to better quantify water movements within the site and improve water balance estimates in the future:

- Install an automated weather station to record daily climate observations.
- Keep a daily log of all water truck activity.
- Install a flow meter on the outlet of the main tank to record/quantify water usage (data to be recorded on a daily basis).
- Monitor the installed level markers within each of the sedimentation basins to ensure they have suitable capacity for rain events.
- Keep a daily log (at the same time each day) of observed water levels within the main dam. Alternatively, an automated level logger can be installed.
- Install (or have readily available) pumps of sufficient capacity to discharge from each of the four sedimentation basins. Separate pumps will be available for each of the basins to ensure timely discharge of runoff.
- Pumps will be tested at minimum monthly intervals (during prolonged dry periods when not in use) to ensure they are maintained in working order for future rainfall events. All testing and maintenance activities will be recorded on site.
- Make all collected data available for inclusion in future model revisions.
- Revision of the water balance modelling in 12 months to improve estimates based on site recordings and observations.

6.2 Future quarry operations

It is recommended that the following actions be undertaken at a suitable time in the future to improve water balance estimates in the future:

- Continue with all recording and logging activities as described above.
- When the sedimentation basins within the northern or southern pit change due to progressing extraction, undertake detailed ground survey to establish a stage-area-storage relationship for the basin to ensure adequate treatment capacity. Install level markers within these sedimentation basin/s to mark the top of the sediment storage zone and incremental water levels above this point up to full settling zone capacity.
- Once the northern pit reaches an extraction depth of 87.5mAHD the volumes of the groundwater inflows to the pit is to be monitored, estimated and reported.
- Once the southern pit reaches an extraction depth of 113mAHD the volumes of the groundwater inflows to the pit is to be monitored, estimated and reported.
- Install (or have readily available) pumps of sufficient capacity to discharge from each of the four sedimentation basins. Separate pumps will be available for each of the basins to ensure timely discharge of runoff.
- Revision of the water balance modelling in conjunction with any significant changes to site operations (e.g. modified water storage structures, changes to the contributing catchment areas or drainage regime, excavation recommencing within the South Pit, excavation below 87.5mAHD in the northern pit and 113mAHD in the southern pit etc.).

7 Reporting requirements

7.1 Annual water balance reporting

An annual water balance report is to be prepared as part of the Annual Return for the quarry. The annual report is to include details of:

- Daily climate observations recorded at on-site weather station.
- Daily water truck activity (number of loads filled/used, truck capacity per load)
- Daily usage from water tank.
- Recorded water levels in all sedimentation basins based on installed level markers.
- Recorded water levels for the main dam (daily time step or logger data).
- Details of all water releases from all on-site sedimentation basins following rain events (time to which pumping commences based on water quality results, pump rates, duration of pumping, time until dry).
- Copies of records for testing and maintenance activities for all onsite water pumps.
- Records of material/product exports from the site.
- Once the northern pit reaches an extraction depth of 87.5 mAHD the volumes of the groundwater inflows to the pit is to be monitored, estimated and reported.
- Once the southern pit reaches an extraction depth of 113 mAHD the volumes of the groundwater inflows to the pit is to be monitored, estimated and reported.
- Annual water balance modelling to reflect actual practices during reporting year based on site recordings and observations.

7.2 Revised site water balance

This report, *'Site Water Balance, Blakebrook Quarry, Blakebrook, New South* Wales' is to be reviewed and revised periodically to reflect planned and actual changes to water management practices on the site, including, but not limited to:

- Upon completion of construction, and following as-constructed survey of, the sedimentation basin in catchment SW2 (if constructed basin form differs from the assumptions contained within this report).
- Upon approval of the proposed additional discharge points currently under application under EPL 3384.
- At any time where there are changes (proposed or actual) to the form of any water storage devices on site (e.g. north pit sedimentation basin changes to allow for increase excavation depth, south pit sediment basin construction when works in south pit recommence).
- In support of any application for changes to the current licence for the site (where the proposed licence changes involve any changes to the water management practices, water storages or any activity that influences on-site water use).
- If observed/recorded water usage (eg. water truck movements, volumes of water used from tank) on site within any annual return period differs by greater than 15 percent from the estimates contained within this report (after accounting for rainfall variability).
- If observed/recorded groundwater inflows (once intercepted) in either pit differ by greater than 15 percent from the estimates contained within this report.

8 Attachment 1 – Drawings

NORTH PIT
Area = 21.6 ha
Notes:
1. All pit runoff directed to sediment basin.

NORTHERN SEDIMENT BASIN
Existing basin area = 0.401 ha
Storage volume in existing basin = 2.517 ML
Required total storage volume = 26.7 ML (incl. ponding across pit floor)
- Settling zone volume = 17.8 ML
- Sediment storage capacity = 8.9 ML
Notes:
1. Storage capacity is to be provided through ponding across floor of quarry once sediment basin fills
2. Following rainfall event, basin to be tested & treated (if necessary) to meet discharge requirements.
3. Treated water is pumped from basin to dam (until dam fills).
4. Excess discharge to be pumped to LPD 2.
5. Basin is to be treated and pumped out to permanent storage level within 5-days of rainfall event and to remain at (or below) permanent storage level at all other times.
6. The permanent storage level to be identified with a marker at approximately 111.5 mAHD.

MAIN WATER STORAGE DAM
Area = 0.292ha (approx.)
Estimated volume = 30 ML
Usage:
- Water tank top-up
- Water cart for dust supression

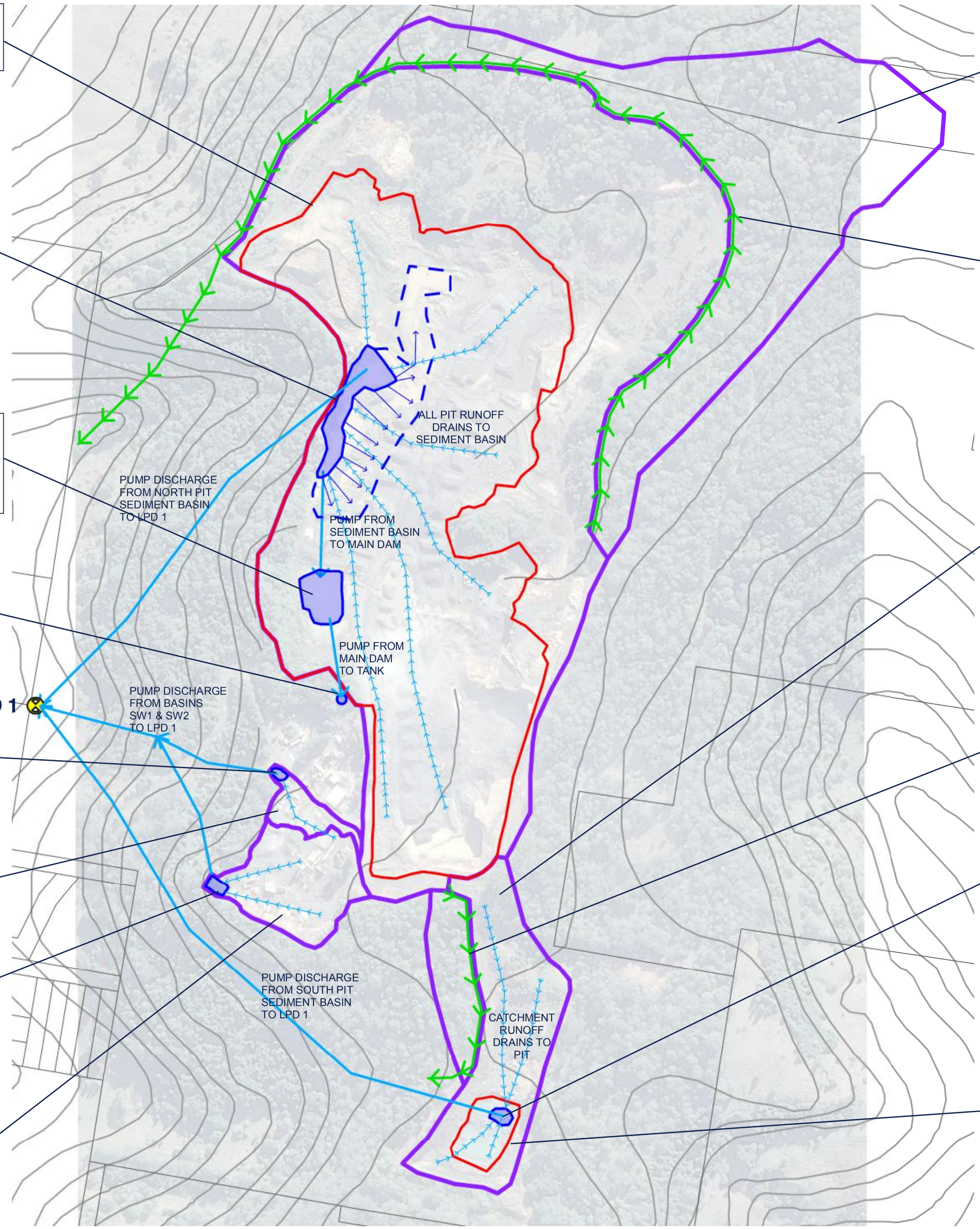
WATER TANK
Volume = 1 ML
Usage:
- Asphalt plant
- Haul road sprinklers (dust supression)
- Product water (4% by weight)

SEDIMENT BASIN SW1
Area = 232 m²
Total volume = 0.322 ML
Settling zone volume = 0.214 ML
Sediment storage capacity = 0.107 ML
Notes:
1. Basin discharge is to be pumped to LPD 1.
2. Collected water is to be tested, treated and released within 5-days of rainfall event.
3. Basin to remain dry at all other times.

SOUTH WESTERN CATCHMENT 1
Area = 0.449 ha
Catchment runoff drains to sediment basin SW1

SEDIMENT BASIN SW2 (UNDER CONSTRUCTION)
Required total volume = 1.297 ML
Settling zone volume = 0.865 ML
Sediment storage capacity = 0.432 ML
Notes:
1. Basin discharge is to be pumped to LPD 1.
2. Collected water is to be tested, treated and released within 5-days of rainfall event.
3. Basin to remain dry at all other times.

SOUTH WESTERN CATCHMENT 2
Area = 1.818 ha
Catchment runoff drains to sediment basin SW2



NORTHERN CATCHMENT
Total area = 48.7 ha
Area draining to pit = 37.4 ha
Undisturbed area diverted around pit = 11.3 ha
Note:
1. All runoff from undisturbed area to be collected in clean water diversion drain and diverted around pit to natural catchment discharge point.

CLEAN WATER DIVERSION DRAIN

SOUTHERN CATCHMENT
Total area = 4.8ha
Area draining to pit = 3.7 ha
Undisturbed area diverted around pit = 1.1 ha
Note:
1. All runoff from undisturbed area to be collected in clean water diversion drain and diverted west to existing ephemeral gully.

CLEAN WATER DIVERSION DRAIN

SOUTHERN SEDIMENT BASIN (UTILISES SOUTH PIT)
Required total storage volume = 2.67 ML
Settling zone volume = 1.78 ML
Sediment storage capacity = 0.89 ML
Notes:
1. Storage capacity is to be provided through ponding across floor of quarry.
2. Following rainfall event, basin to be tested & treated (if necessary) to meet discharge requirements.
3. Treated water is pumped from pit to LPD3.
4. Pit is to be pumped out within 5-days of rainfall event and to remain dry at all other times.

SOUTH PIT
Area = 0.5ha

ORIENTATION

SCALE
50 100 150 200 250
metres

ROBINA
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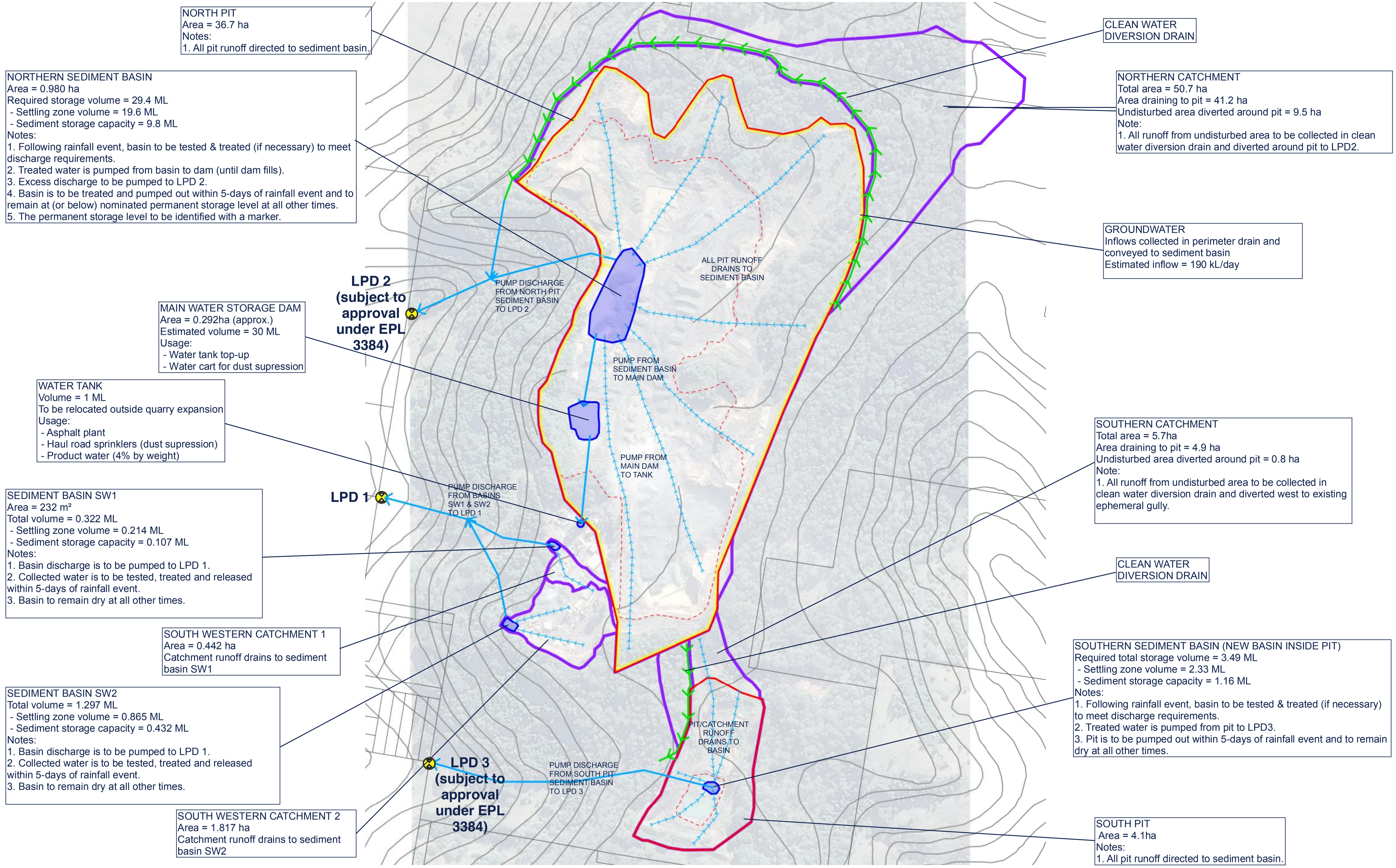
LEGEND
- Catchment boundary
- Quarry pit (existing)
- Discharge point
- Sediment basins / water storage
- Clean water diversion drain

SOURCES
Image source: Google Earth Pro
Image dates: 6 June 2016

PROJECT	CLIENT	DRAWING
BLAKEBROOK QUARRY SOIL AND WATER MANAGEMENT PLAN	LISMORE CITY COUNCIL	EXISTING QUARRY FOOTPRINT WATER MANAGEMENT

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
1:6,250@A3	12/12/2018	AJF	CMA	11737	004	A

GILBERT SUTHERLAND



ORIENTATION

SCALE

50 100 150 200 250 metres

ROBINA

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Email robina@access.gs **www.access.gs**

LEGEND

- Catchment boundary
- Quarry pit (future)
- Quarry pit (existing)
- Discharge point
- Clean water diversion drain
- Sediment basins / water storage
- Perimeter drain (groundwater inflows)

SOURCES

Image source: Google Earth Pro
Image dates: 6 June 2016

NOTES

1. LPD1 is currently the only licenced discharge point for the site.
2. An application has been lodged for approval of LPD2 and LPD3 as additional licensed discharge points under EPL 3384.
3. Until LPD2 and LPD3 are approved under EPL 3384, all site discharge is to be directed to LPD1.

PROJECT	CLIENT	DRAWING
BLAKEBROOK QUARRY	LISMORE CITY COUNCIL	FUTURE QUARRY FOOTPRINT WATER MANAGEMENT

SCALE	DATE	DRAWN	CHECKED	PROJECT	DRAWING	REVISION
1:6,250@A3	13/02/2019	AJF	CMA	11737	005	B

GILBERT + SUTHERLAND

9 Attachment 2 – Figures

Figure 1 – North Pit catchment water balance

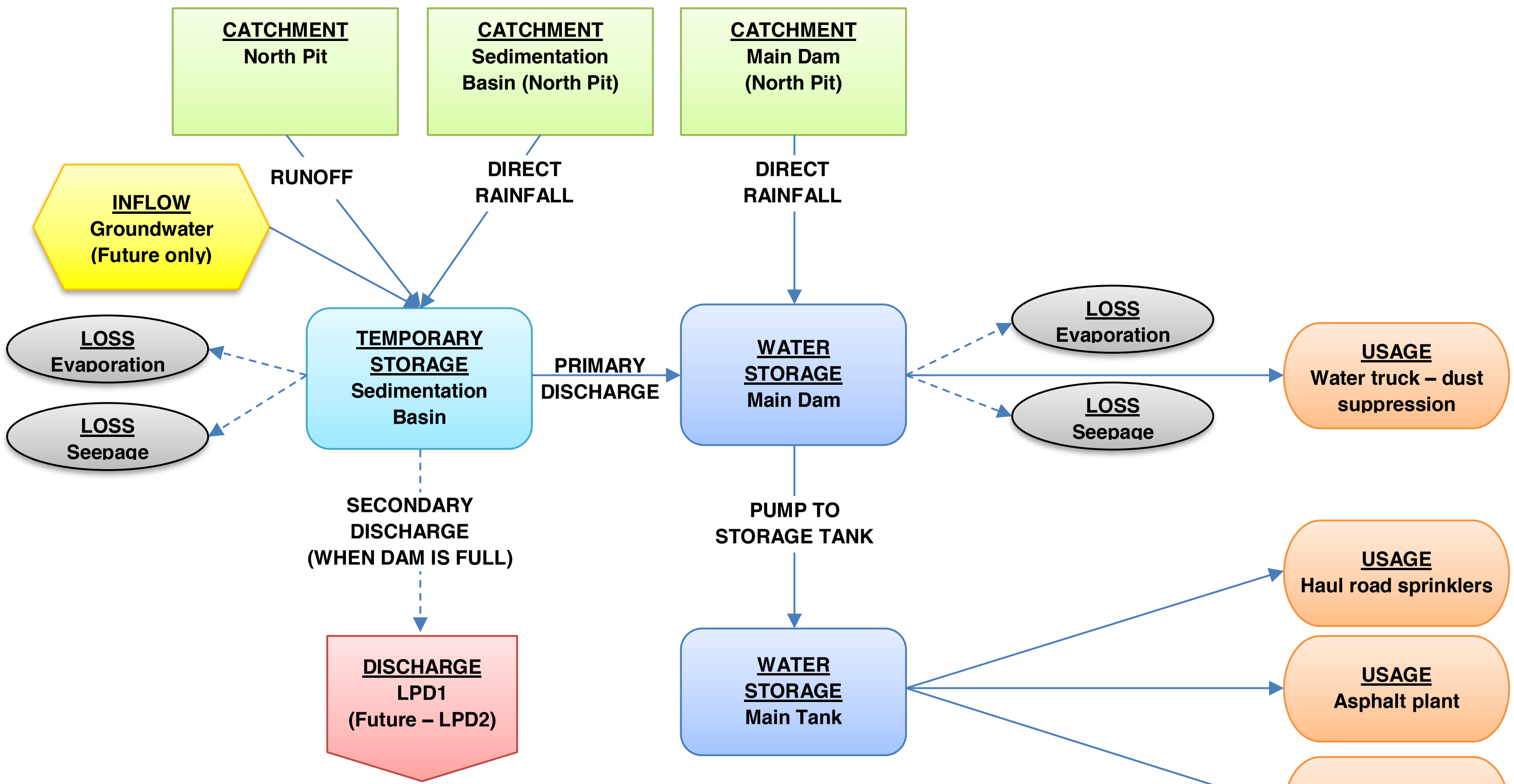


Figure 2 – South Pit catchment water balance

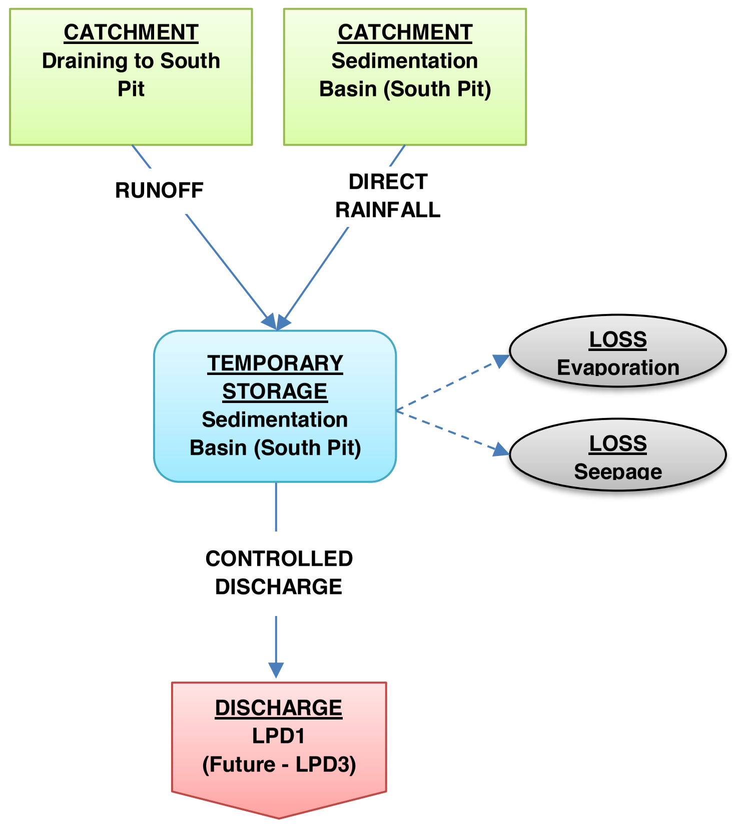


Figure 3 – South Western catchments water balance

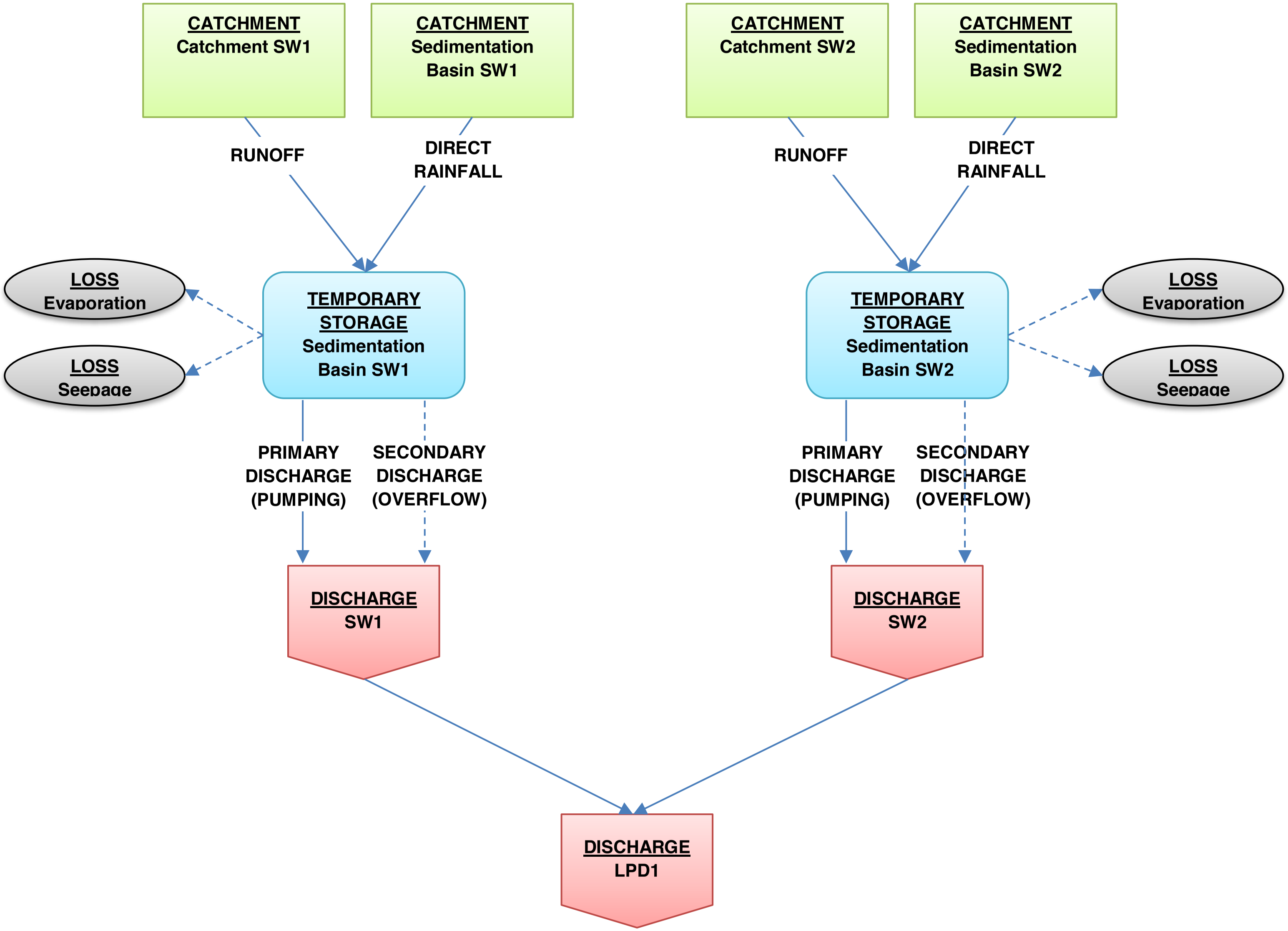


Figure 4 - Main Dam water balance for Existing Quarry Footprint

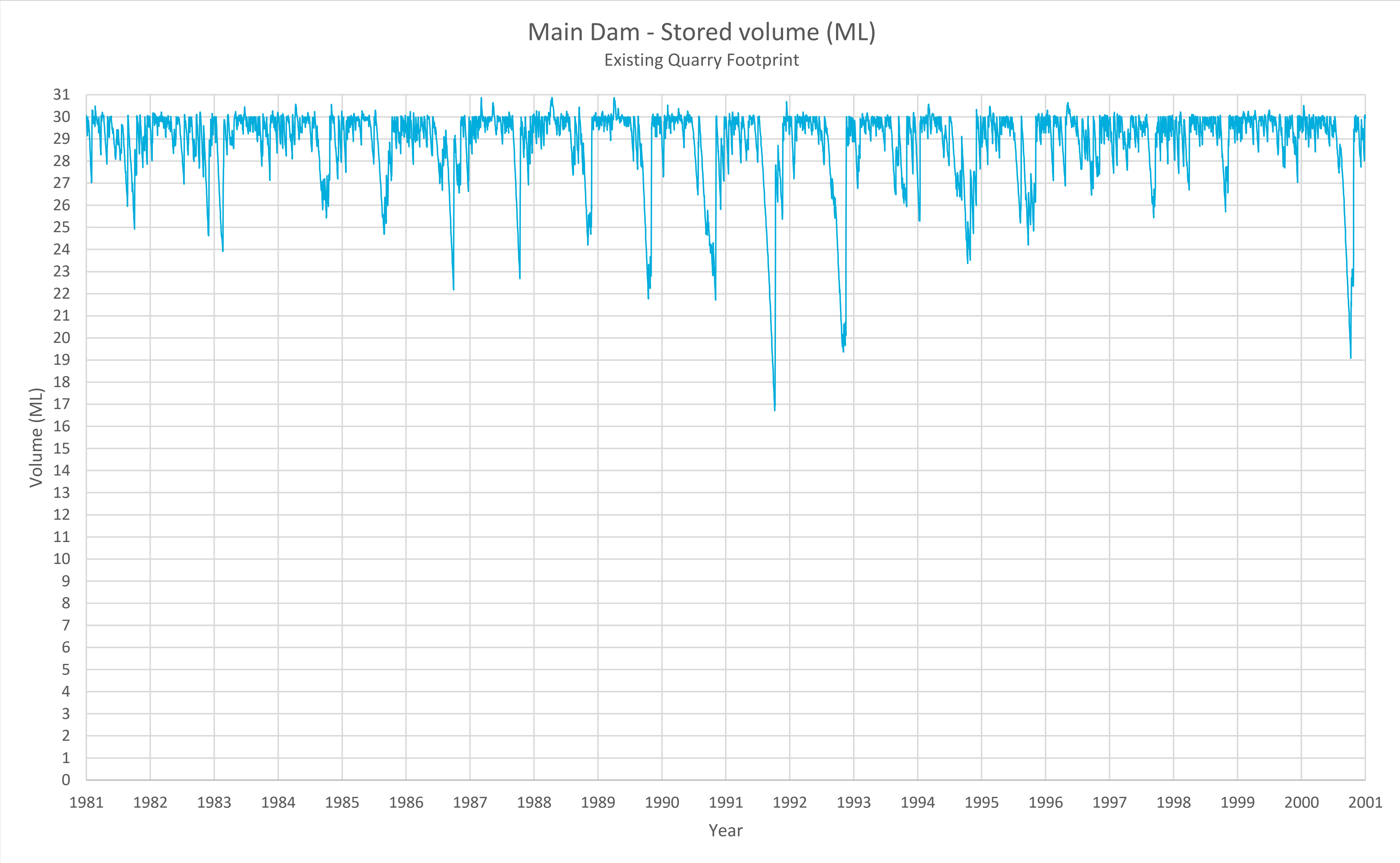


Figure 5 - Main Tank water balance for Existing Quarry Footprint

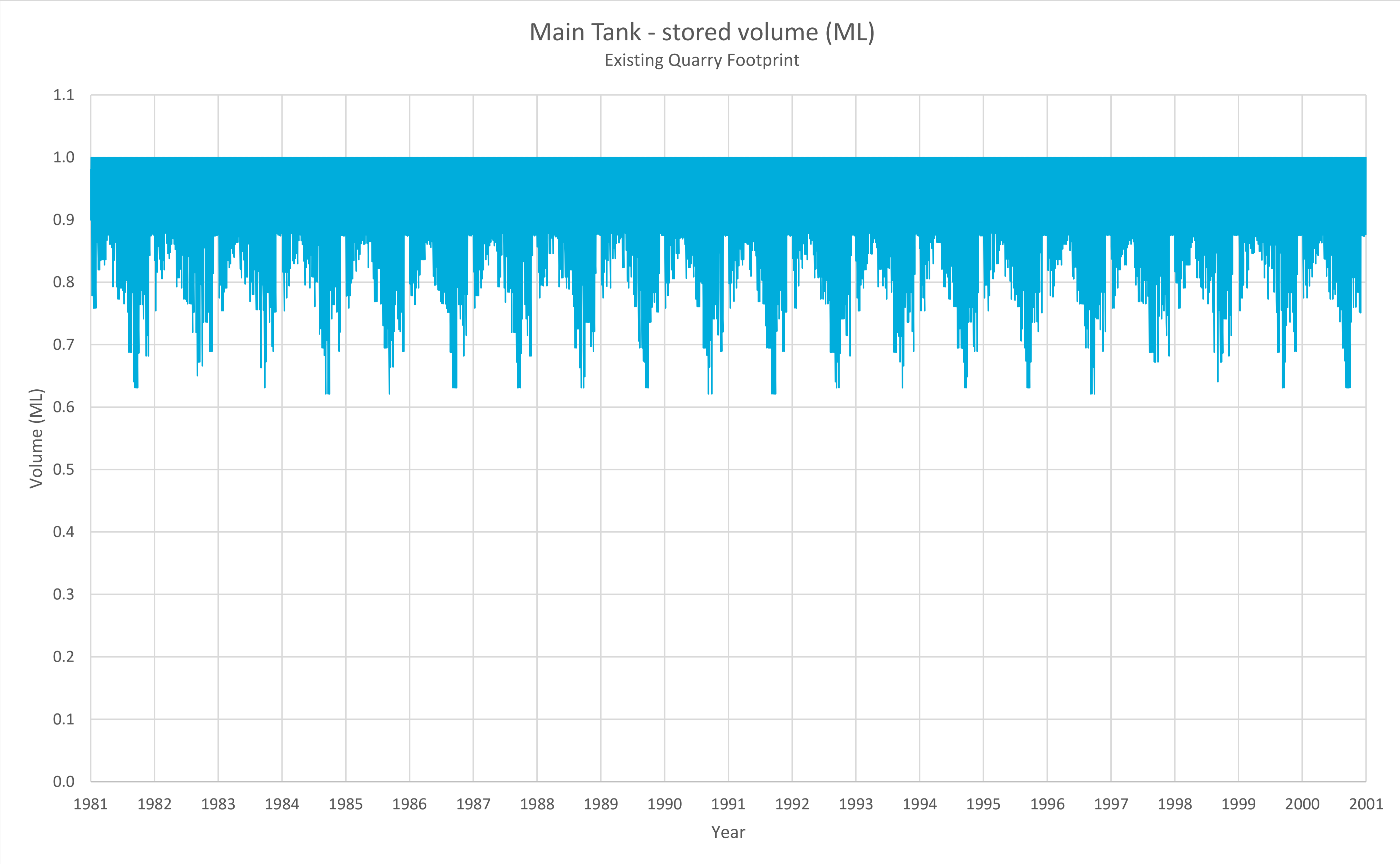


Figure 6 - Main Dam water balance for Future Quarry Footprint

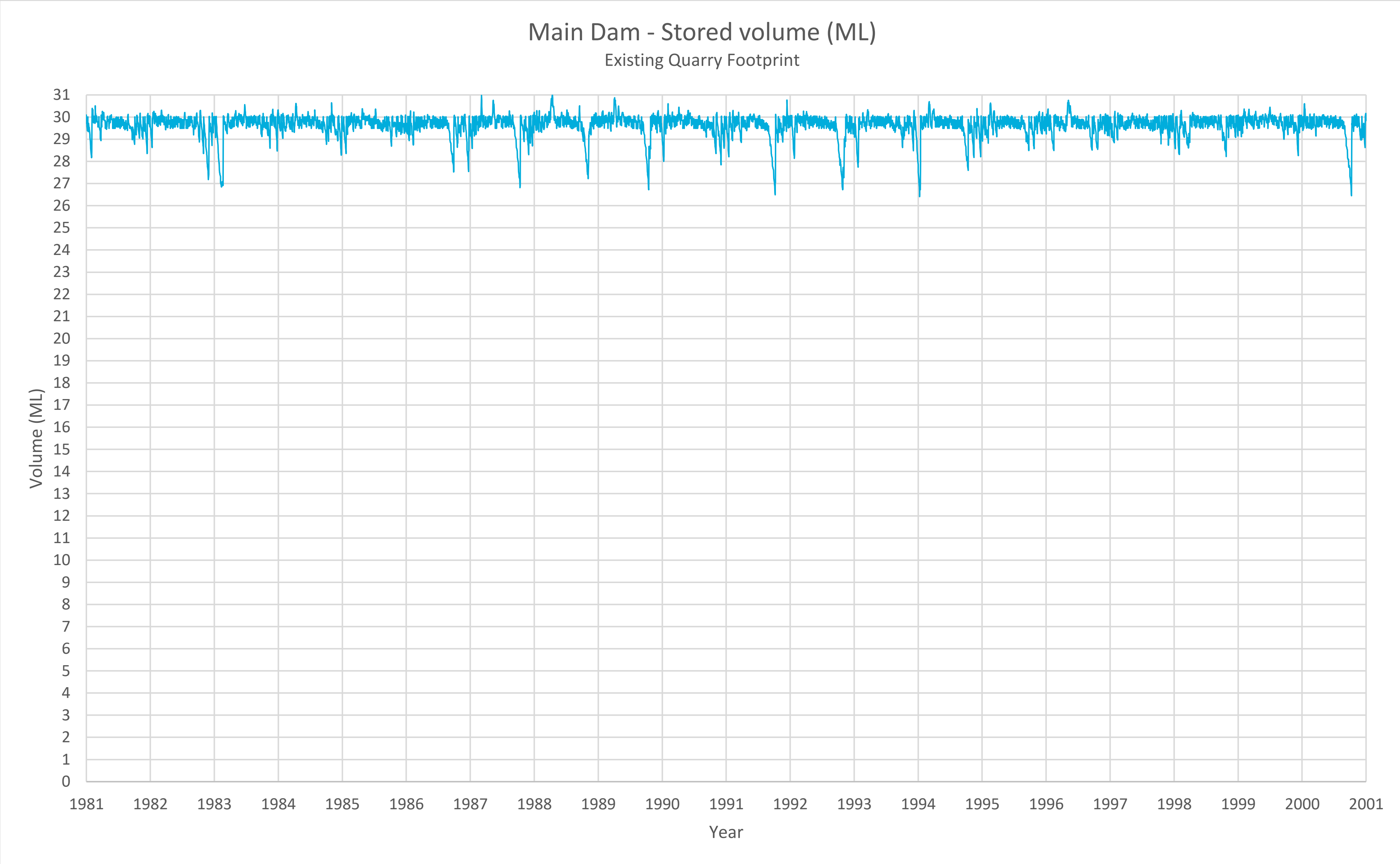
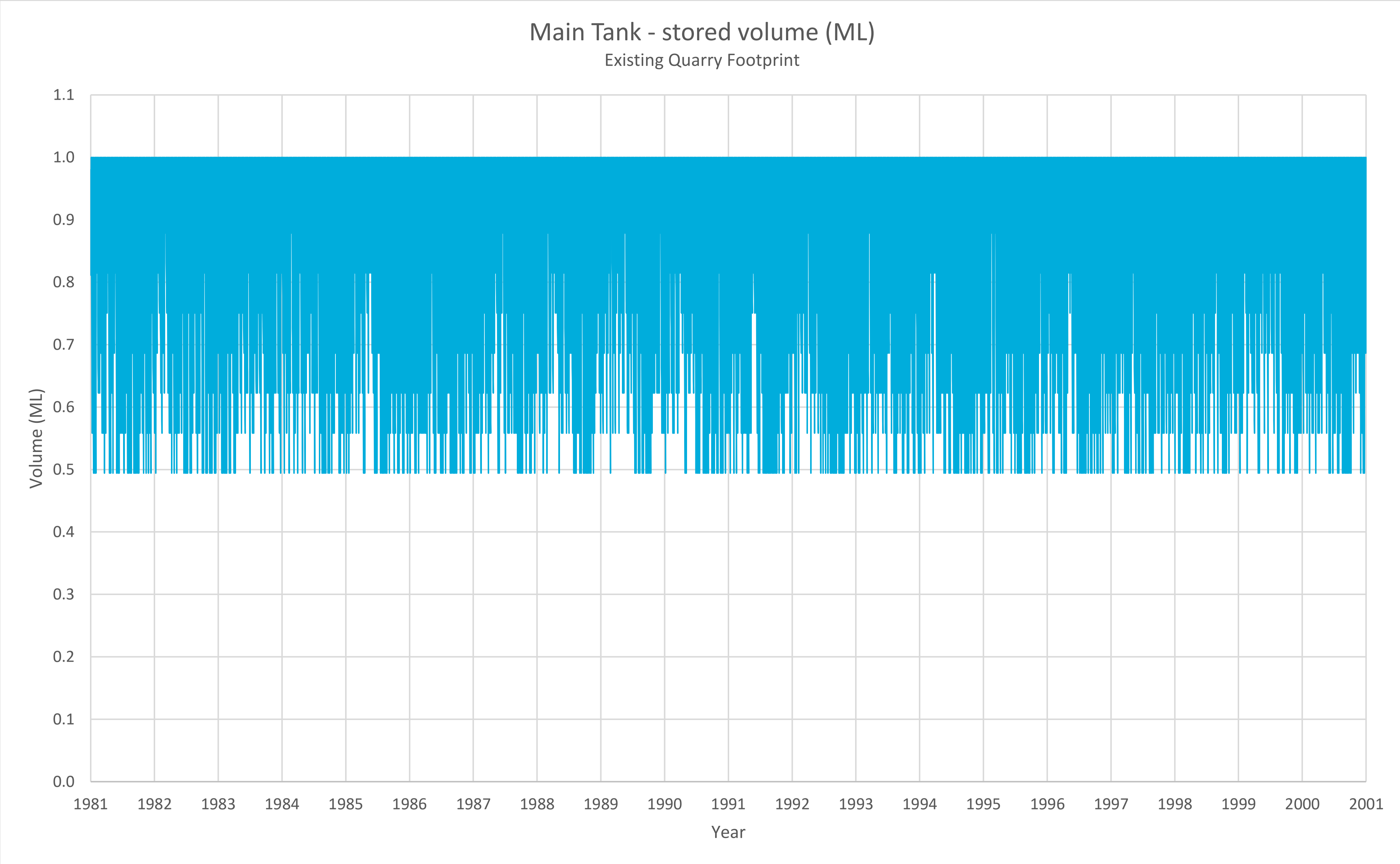


Figure 7 - Main Tank water balance for Future Quarry Footprint



9 Attachment 5 – Summary table, Condition 19 Schedule 3, Notice of Modification

<table>
<tr><th>Soil and Water Management Plan – Condition 19 of Schedule 3</th><th>Addressed in SWMP</th></tr>
<tr><td>e) be prepared by suitably qualified and experienced person/s approved by the Secretary;</td><td>Suitably qualified and experienced persons from Gilbert & Sutherland have prepared the SWMP. Endorsement is attached as Attachment 8.</td></tr>
<tr><td>f) be prepared in consultation with the EPA and DPI Water;</td><td>Draft versions of the reports are to be provided to the agencies for review and comment.</td></tr>
<tr><td>g) be submitted to the Secretary for approval within 3 months of the determination of Modification 1, unless otherwise agreed by the Secretary; and</td><td>Will be submitted to the Secretary for approval within 3 months of the determination of Modification 1.</td></tr>
<tr><td>h) include a:
a. Site Water Balance that includes:
i. details of:
1. sources and security of water supply;
2. water use and management on site;
3. any off-site water transfers; and
4. reporting procedures; and
ii. measures to be implemented to minimise clean water use on site;
b. Surface Water Management Plan, that includes:
i. a program for obtaining detailed baseline data on surface water flows and quality in water bodies that could potentially be affected by the project;
ii. a detailed description of the surface water management system on site including the:
1. clean water diversion system;
2. erosion and sediment controls;
3. dirty water management system; and
4. water storages; and
iii. a program to monitor and report on:
1. any surface water discharges;
2. the effectiveness of the water management system,
3. the quality of water discharged from the site to the environment;
4. surface water flows and quality in local watercourses;
c. Groundwater Management Plan that includes:
i. a provision that requires the Proponent to obtain appropriate water licence(s) to cover the volume of any unforeseen groundwater inflows into the quarry from the quarry face or floor; and</td><td>A Site Water Balance is included as Attachment 4.
A Surface Water Management Plan (SWMP) has been prepared and includes the following information:
<table>
<tr><th>Component of Condition 19</th><th>Location in SWMP</th></tr>
<tr><td>A program obtaining detailed baseline data on surface water flows and quality in water bodies that could potentially be affected by the project.</td><td>Section 3.5.4 Surface Water Management and Monitoring</td></tr>
<tr><td>A detailed description of the clean water diversion system</td><td>Section 3.5.3 Sediment and Erosion Control</td></tr>
<tr><td>A detailed description of erosion and sediment controls</td><td>Section 3.5.3 Sediment and Erosion Control</td></tr>
<tr><td>A detailed description of dirty water management system</td><td>Sections 3.5.3 Sediment and Erosion Control, 3.5.4 Surface Water Management and Monitoring and Attachment 4 – Site Surface Water Balance</td></tr>
<tr><td>A detailed description of water storages</td><td>Refer to Attachment 4 – Site Surface Water Balance</td></tr>
<tr><td>A program to monitor and report on any surface water discharge</td><td>Section 3.5.3 Sediment and Erosion Control – Implementation Strategy and Section 3.5.4 Surface Water Management and Monitoring</td></tr>
<tr><td>A program to monitor and report on the effectiveness of the water management system</td><td>Section 3.5.4 Surface Water Management and Monitoring</td></tr>
<tr><td>A program to monitor and report on the quality of water discharged from the site to the environment</td><td>Section 3.5.4 Surface Water Management and Monitoring</td></tr>
</table></td></tr>
</table>

ii. a monitoring program to manage potential impacts, if any, on any alluvium and associated surface water source near the proposed extraction area that includes: *1. identification of a methodology for determining threshold water level criteria;* *2. contingency measures in the event of a breach of thresholds; and* *3. a program to regularly report on monitoring.*	*A program to monitor and report on surface water flows and quality in local watercourses.* — Section 3.5.4 Surface Water Management and Monitoring A groundwater assessment has been prepared[8] and based on its findings and recommendations a suitable groundwater monitoring strategy developed. The requirements have been included in this SWMP.

Component of Condition 19	Location in SWMP
A provision that requires the Proponent to obtain appropriate water licences(s) to cover the volume of any unforeseen groundwater inflows into the quarry from the quarry face or floor.	Section 3.5.5 Groundwater Management and Monitoring – Implementation Strategy
A monitoring program to manage potential impacts, if any, on any alluvium and associated surface water source near the proposed excavation area that includes identification of a methodology for determining threshold water level criteria	Section 3.5.5 Groundwater Management and Monitoring – Performance Criteria
A monitoring program to manage potential impacts, if any, on any alluvium and associated surface water source near the proposed excavation area that includes contingency measures in the event of a breach of thresholds	Section 3.5.5 Groundwater Management and Monitoring – Identification of incident or failure & corrective action
A monitoring program to manage potential impacts, if any, on any alluvium and associated surface water source near the proposed excavation area that includes a program to regularly report on monitoring.	Section 3.5.5 Groundwater Management and Monitoring - Monitoring

[8] Gilbert & Sutherland (G&S) (2019*). Hydrogeological Review: Groundwater Monitoring & Management Blakebrook Quarry Nimbin Road, Lismore, New South Wales.* Prepared for Lismore City Council January 2018. Which can be downloaded at: https://www.dropbox.com/s/uqkp2l6yyh0ajr7/11737%20GWA%20RER7F.pdf?dl=0

10 Attachment 6 – Site specific surface water quality monitoring requirements and targets

- Water quality monitoring will be undertaken on sediment basins prior to the water from them being actively discharged from the site. The water is to be tested for pH and total suspended solids (TSS). A visual inspection is also to be carried out for oil and grease. Discharge of the sedimentation basins will only occur if:
  - pH is between 6.5 and 8.5;
  - TSS < 50mg/L; and there is
  - No visible oil or grease.
- Over a minimum of 12 monitoring rounds turbidity will also be analysed. A statistical analysis will then be performed to establish a correlation between TSS and turbidity (the correlation will be undertaken on data of varying water quality i.e. near LOR to >50mg/L TSS). Once a correlation is successfully established (identified as an R^2 >0.7) the equivalent turbidity value for a TSS of 50mg/L will be used (rather than measuring TSS) to provide rapid feedback on the suitability or otherwise for discharge of sediment basins.
- Background conditions for the receiving waters will be established by quarterly monitoring at SW1, SW2, SW3 and SW5 as shown on drawing 11737-008. This monitoring will ideally follow a rainfall event defined as (>25mm in 24 hours).[9] It must be ensured that at the time of sampling that no runoff is being derived from discharge from the active quarry area or sediment basins (whether that is active, i.e. pumping or passive, ie. overtopping).
- This background monitoring will include pH, EC, DO, temperature, turbidity, TSS, nutrients and a visual inspection for oil and grease. Once 8 rounds of data are available site specific targets will be established based on the 20th and 80th percentiles in accordance with ANZECC guidelines.
- These targets will then be used to assess whether surface water conditions outside of the excavation are being maintained, or otherwise, and this SWMP will be revised to incorporate this revised information. That revision will also recommend, on the basis of the background monitoring results, an appropriate regime for future surface water monitoring, whether in relation to discharge events and/or routine monitoring to assess the condition of receiving waters relative to measured background conditions.

Location	Easting	Northing	Description
SW1	523693	6818008	Flow under Nimbin Road, downstream of LPD1 and LPD2
SW2	523124	6817955	Upstream of site, discharges in Terania Creek
SW3	523422	6817156	Downstream of site, discharges in Terania Creek
SW5	523807	6817669	Flow under Nimbin Road, downstream of LPD3

[9] The receiving waters are largely ephemeral, with little or no surface flows present between events, precluding monitoring of dry-weather flows.

11 Attachment 7 – Site specific groundwater monitoring requirements and targets

Quarterly monitoring will be undertaken at each of the groundwater bores (BQN1s, BQN1i, BQN1d, BQN2s, BQN2i, BQN2d, BQS1s, BQS1i, BSN1d). In accordance with the Larry Cook 2016 report recommendations (and subsequent approval from DPI NSW), the groundwater will be analysed for:

- pH
- electrical conductivity
- TPH
- BTEX
- total iron,
- total lead

In addition to the above, it is recommended that the samples also be analysed for the following constituents to assist with characterisation of the groundwater:

- dissolved iron,
- dissolved lead
- total oils and grease (this is to be monitored as a surrogate for TPH and BTEX until sufficient data is available)
- major ions and cations

The interim site specific groundwater quality triggers are contained in the following table.

Interim Triggers data set 2016 to June 2018

Parameter	BQS1-S	BQS1-I	BQS1-D	BQN1-S	BQN1-I	BQN1-D	BQN2-S	BQN2-I	BQN2-D
pH	7.12	8.12	8.30	7.18	11.34	9.10	11.07	8.67	8.85
Electrical conductivity (dS/m)	0.512	1.624	1.829	1.171	2.082	1.440	1.138	1.200	1.014
Total oils and grease (mg/L)	10.8	21.0	14.2	4.1	9.0	4.4	3.6	6.9	4.0
Iron (mg/L)	1.829	4.977	6.580	2.162	1.972	97.645	0.579	0.301	3.904
Lead (mg/L)	0.001	0.005	0.009	**0.001** [1]	**0.018** [3]	**0.008** [4]	**0.004** [5]	**0.002** [5]	**0.005** [2]

Notes:
1 – Trigger based on maximum LOR.
2 – Non-parametric maximum – 74.1% coverage at 95% confidence level.
3 – Non-parametric maximum – 79.4% coverage at 95% confidence level.
4 – Non-parametric maximum – 71.7% coverage at 95% confidence level.
5 – Non-parametric maximum – 77.9% coverage at 95% confidence level.

The table is an excerpt from Appendix 13 of the G&S 2018 hydrogeological review of Blakebrook Quarry.[10] The triggers represent the 80th percentile values for each parameter based on the results available for each bore in the dataset, which spans the 2016 to 2018 time period and provides varying sample sizes/per

[10] Site specific groundwater targets were reported in Gilbert & Sutherland (2019). *Hydrogeological Review: Groundwater Monitoring & Management Blakebrook Quarry Nimbin Road, Lismore, New South Wales.* Prepared for Lismore City Council January 2019. Which can be downloaded at: https://www.dropbox.com/s/uqkp2l6yyh0ajr7/11737%20GWA%20RER7F.pdf?dl=0

parameter/per bore. The table footnotes indicate exceptions where an alternative to the 80th percentile is provided to address statistical issues related to the available sample size and/or other variables.

This SWMP notes that a target exceedance has a 20% probability per monitoring round (using this approach). As such, results from multiple monitoring events necessarily need to be reviewed as a group against the interim target to determine compliance or otherwise (i.e. one exceedance of the target is not necessarily an indication of non-compliance).

Once sufficient data is available (ideally 12 data points for each parameter for each bore) the interim targets contained in the above table will be updated. Data loggers will be deployed in each of the groundwater bores (BQN1s, BQN1i, BQN1d, BQN2s, BQN2i, BQN2d, BQS1s, BQS1i, BSN1d). The loggers must record the water level, at a minimum on a daily basis.

12 Attachment 8 – Secretary's endorsement for G&S to prepare SWMP