Gunlake Quarry

Soil and Water Management Plan

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1. Introduction

1.1 Overview

This Soil and Water Management Plan (SWMP) has been prepared by Gunlake Quarries Pty Ltd (Gunlake) for Gunlake Quarry (the Quarry). The Quarry is located approximately 7 km northwest of Marulan, off the Brayton Road as shown on **Figure 1,** Appendix A.

Under Schedule 3, Condition 22 of the Gunlake Extension Project Development Consent (30th June 2017), Gunlake was required to prepare and implement a Soil and Water Management Plan to be submitted to the Secretary of the then Department of Planning and Infrastructure (DPI) for approval. This management review updates the previously approved plan dated April 2018 following the first Independent Environmental Audit of the SSD development consent. This SWMP continues to build on the original water management system and takes into account various improvements since 2009 as well as the future quarry extension.

The quarry has now been in operation since 2009 and its water management system is now well established and operating in accordance with previous approvals. The Gunlake Extension Project will continue to utilise the same basic principles including:

- ❐ effective clean water diversion around the disturbed area of the quarry. The diversion system is extended around future disturbed area as the quarry develops;
- ❐ capture and settlement of water runoff from disturbed areas including in-pit drainage, crushing and processing area, and external disturbed areas such as emplacement areas;
- ❐ re-use of water for dust suppression and process water.

This revised SWMP concentrates on the ongoing management for the existing operation and future development of the Gunlake Extension Project. This plan includes ongoing monitoring requirements in order to provide the data to assess the performance of the system and to verify the impact predictions made in the 2016 Gunlake Extension Project EIS.

The SWMP addresses a range of issues associated with water control and use at Gunlake Quarry. The SWMP identifies the existing surface and groundwater drainage patterns at the site. It also identifies quality characteristics and current users of surface water and groundwater. The SWMP identifies potential impacts of the quarrying operations on surface water and groundwater. The Plan incorporates information on:

- ❐ Site Water Balance.
- ❐ Erosion and Sediment Control Plan.
- ❐ Surface and Groundwater Management Plans.

The SWMP forms one component of the overall Project Environmental Management Strategy (EMS). The EMS includes a number of commitments and component management plans which together form the basis for the ongoing operation of Gunlake Quarry.

1.2 Aims and Objectives

The overall objectives for the SWMP are to:

- Implement the commitments made in the 2016 Gunlake Extension Project EIS including specific conditions of Development Consent and the revised Statement of Commitments.
- Ensure compliance with relevant environmental legislation.
- Manage environmental risks associated with the Gunlake Quarry.
- Provide for continuous improvement in environmental performance.
- Provide a mechanism to identify and correct areas of non-compliance.

1.3 Development Consent Requirements

The requirement to prepare this Soil and Water Management Plan along with environmental performance conditions and monitoring at Gunlake are covered by Conditions 21 and 22 of Schedule 3 of the Development Consent as detailed in Table 1.1 below.

Table 1.1 – Development Consent Conditions Relating to the Soil and Water Management Plan

Condition	Requirement	Where Addressed
Schedule 3:	**ENVIRONMENTAL PERFORMANCE CONDITIONS**	
22	**Water Management and Monitoring** The Applicant must prepare Soil and Water Management Plan for the development to the satisfaction of the Secretary. This plan must:	This Plan
	(a) be prepared by suitably qualified and experienced person/s approved by the Secretary	Noted
	(b) be prepared in consultation with EPA, Water NSW and DPI Water;	Noted, consultation is ongoing
	(c) be submitted to the Secretary for approval within six months of commencing development under this consent and prior to commencing quarrying operations under this consent;	Noted
	(d) include a: • Site Water Balance; • Erosion and Sediment Control Plan; • Surface Water Management Plan; and • Groundwater Management Plan	Chapters 4, 5, 6, 7 and 8
22 (d) (i)	**The Site Water Balance:**	
	Include details of: • sources and security of water supply; • water use and management on site; • any off-site water transfers; and • reporting procedures; and	Chapter 4 Section 4.1 Section 4.2 Section 4.3 Section 4.4 Chapter 9
	Measures that would be implemented to minimise clean water use on site.	Section 4.4
22 (d) (ii)	**Erosion and Sediment Control Plan:**	
	Is consistent with the requirements of the Landcom's *Managing Urban Stormwater: Soils and Construction* manual;	Noted, Section 7.1
	Identifies activities that could cause soil erosion and generate sediment	Section 7.2

Condition	Requirement	Where Addressed
Schedule 3:	**ENVIRONMENTAL PERFORMANCE CONDITIONS**	
	describes measures to minimise soil erosion and the potential for the transport of sediment to downstream waters, including for the haul road between the extraction area and the western emplacement area;	Section 4.2.2 - 4.2.9
	Describes the location, function, and capacity of erosion and sediment control structures, including for the haul road between the extraction area and the western emplacement area; and	Section 4.1
	Describes what measures would be implemented to maintain (and if necessary decommission) the structures over time.	Section 7.2.2 - 7.2.9
22 (d) (iii)	**The Surface Water Management Plan:**	
	Detailed baseline data on surface water flows and quality in water bodies that could potentially be affected by the development	Chapter 2 and Section 5.2
	Surface water impact assessment criteria	Section 5.3
	A protocol for managing any exceedances of the surface water impact assessment criteria;	
	A detailed description of the surface water management system on site including the: • Clean water diversion system; • Dirty water management system; • Water storages, including their capacity to contain dirty water during flood events; • Irrigation areas; and • Design of creek and stream crossings; and	Section 4.2 Section 4.2.10 Section 5.4.4 Section 5.4.5
	A program to monitor and report on: • The effectiveness of the water management system in ensuring that the development has a neutral or beneficial effect on downstream receiving waters; • Channel stability of the watercourses on the site; • Surface water flows and quality in watercourses on the site; • Surface water discharges from the site, including provisions for sampling of water quality during discharge events; • The impact of the irrigation areas on water quality	Section 5.4
	Details off the on-site waste water management system, including the effluent disposal area, that demonstrates there is adequate capacity for the wastewater loads generated by the development;	Section 5.6
22 (d) (iv)	**Groundwater Management Plan:**	
	detailed baseline data on groundwater levels, flows and quality in the region;	Chapter 2 and Section 6.2
	Groundwater impact assessment criteria for monitoring bores;	
	A program to monitor: • groundwater levels and quality on the site; • the impacts of the development on any groundwater dependent ecosystems; • the impacts of the development on any groundwater bores, springs, and seeps on privately-owned land; and	Chapter 6
	A protocol for the investigation of identified exceedances of the groundwater impact assessment criteria	Chapter 6

Gunlake will implement the SWMP as approved by the Secretary.

1.4 Consultation

Gunlake Quarry management have an ongoing close working relationship with Government stakeholders. The engagement process has included liaison during the initial Environmental Assessment, subsequent amendments and as part of the preparation of the various environmental management plans covering the existing operation.

The existing water management provisions on site have been discussed with various government agencies including Water NSW, DoI Water, the EPA and Council as part of ongoing liaison associated with the approval process. The implementation of the water pollution controls and erosion and sedimentation controls which formed part of the original project construction, including the Bypass Road were also discussed at length with government agencies and with the Community Consultative Committee. A draft of this SWMP was provided to Water NSW and DoI Water for comment. The response from Water NSW is contained in Appendix D.

1.5 Responsible Personnel

Key management personnel responsible for the implementation of this Plan are listed in the following table.

Table 1.4 – Roles and Responsibilities

Personnel	Responsibility
Vince Matthews	Overall management of the quarry operation including environmental management
Trevor Dennis	Implementation of environmental works
Kirsty Nielsen	Collection of environmental monitoring data and management

2. Existing Surface and Groundwater Characteristics

2.1 Existing Surface Water Drainage

Gunlake Quarry is located in the upper reaches of the Chapman's Creek catchment and is surrounded by undulating stony countryside primarily used for sheep and cattle grazing. Elevations range from approximately 690m AHD on the southern boundary to 620 m AHD on the eastern boundary at Brayton Road. Soils are shallow and generally of low fertility, consequently, pasture cover is generally low quality improved or native species. There is evidence of sheet and some gully erosion in the main watercourses around the quarry site.

The development site of the Gunlake Extension Project is wholly within the upper catchment of Chapman's Creek. Chapman's Creek flows generally from south to north through the Gunlake property, and then east to its confluence with Joarimin Creek approximately 1km downstream of the site. Joarimin Creek in turn flows north to join the Wollondilly River. Chapman's Creek and its tributaries are intermittent streams which flow only following significant rainfall events.

The catchment area and riparian zones have previously been extensively modified for agricultural production, predominantly grazing of sheep and cattle. A number of farm dams occur on the site on tributary streams some of which are spring fed, which provide for stock watering. Only the adjacent flats of Chapman's Creek are susceptible to temporary inundation after prolonged storms, however these areas provide the best pasture due to soil moisture, fertility and structure.

The above attributes form the basis of ongoing management principles governing the need to protect water systems, both surface and groundwater, during quarrying activities as well as managing the remaining land for agricultural and biodiversity uses.

2.2 Existing Groundwater Regime

The area is characterised by the Marulan Granite, being part of the Bindook Volcanic Complex. The Gunlake Quarry resource is a tuffaceous rhyodacite to a depth of well over 100 m below the surface. This igneous material is exceptionally hard with a low permeability and represents an aquitard, that is it has low hydraulic conductivity and contains very little groundwater. As a consequence, ground water resources in the area are very restricted. There are very few ground water supply bores in the area. Figure 2 of Appendix A shows the surface contours in the vicinity of the quarry. The direction of groundwater flow surrounding the quarry is generally to the north sub-parallel to the topography.

The 2016 Gunlake Extension Project EIS developed a revised groundwater model based on 10 years of both groundwater monitoring data coupled with operating experience. The lack of groundwater availability presents both operational benefits and constraints. The benefits relate to ease of extraction in dry conditions due to the lack of groundwater which in turn minimises the impact on regional groundwater resources, however the extreme lack of groundwater supply requires the operation to harvest and recycle water from its dirty water catchment areas.

2.3 Surface and Groundwater Quality

Gunlake undertakes water quality monitoring of both surface and groundwater systems. Full details of the results are included in the Surface Water and Groundwater Monitoring Program in Sections 5 and 6 respectively. Surface water samples have regularly been collected from three sites within Chapman's Creek to determine a basis for potential impact assessment as the quarry progresses. Baseline data on groundwater levels, quality and rock permeability has been obtained from a broad network of data recorder-equipped monitoring bores distributed around the proposed quarry.

Table 2.1 presents average analytical results for the background groundwater as sampled from a series of 9 groundwater monitoring bores determined from samples collected in June 2007 prior to quarrying activities commencing.

Table 2.1 - Summary of Background Groundwater Monitoring

Analyte	Range	Average
pH (pH units)	6.8-7.3	6.9
EC (uS/cm)	720-7210	3232
Sodium (mg/L)	110-575	293
Calcium (mg/L)	17-530	224
Potassium (mg/L)	2.5-18	9.7
Magnesium (mg/L)	17-435	177
Ammonia (mg/L)	<0.1-1.4	0.7
Chloride (mg/L)	110-2620	1093
Sulphate (mg/L)	3-44	17
Bicarbonate (mg/L)	210-760	490
Carbonate (mg/L)	<1	<1
Nitrate (mg/L)	<0.1-7.1	2.02
Nitrite (mg/L)	<0.1-0.33	0.14
Phosphate (mg/L)	<0.01-0.04	0.02
Total Phosphorous (mg/L)	0.33-4.0	1.16
Copper (mg/L)	0.001-0.003	0.002
Lead (mg/L)	<0.001	<0.001
Zinc (mg/L)	0.002-0.010	0.005
Cadmium (mg/L)	<0.0002	<0.0002
Chromium (mg/L)	<0.01	<0.01
Nickel (mg/L)	<0.01	<0.01
Total Iron (mg/L)	14-82	42
Dissolved Iron (mg/L)	<0.01-0.69	0.09
Arsenic (mg/L)	<0.01	<0.01
Mercury (mg/L)	<0.0001	<0.0001

Groundwater monitoring has been undertaken since February 2007 and there is now a significant baseline dataset. The data shows that there is generally an increasing trend in pH, salinity, sodium and chloride downstream within Chapman's Creek, while nitrogen, phosphorous, iron and manganese tend to decrease downstream. This data forms the basis for impact assessment as the quarry progresses and is shown in Table 2.2.

Table 2.2 Summary of Background Surface Water Quality

ANALYTE	SITE I		SITE D		SITE O	
	Range	Average	Range	Average	Range	Average
pH (pH units)	5.7-8.3	6.6	6.1-7.1	6.6	6.5-8.3	7.7
Electrical Conductivity (uS/cm)	61-3640	596*	62-230	111	240-4260	1212
TDS (mg/L)	91-2060	512**	77-190	118	193-2780	766
Salinity (g/kg)	0.04-1.53	0.19***	0.04-0.10	0.05	0.10-1.97	0.46
Sodium	7-379	61#	2-13	6	14-430	100
Chloride (mg/L)	6.2-846.0	134.0##	3.9-23.4	10.1	34.1-1220.0	311.2
Nitrate NO_3N (mg/L)	<0.010-0.592	0.086	<0.010-0.900	0.122	<0.010-1.50	0.186
Nitrite NO_2N (mg/L)	<0.010-0.046	0.018	<0.010-0.048	0.015	<0.010-0.087	0.015
NO_xN (mg/L)	<0.010-0.592	0.137	<0.010-0.948	0.132	<0.010-1.58	0.195
Total N (mg/L)	0.9-8.8	2.6	1.5-6.3	2.8	0.7-4.1	1.7
TKN (mg/L)	0.8-8.7	2.5	1.3-6.3	2.7	0.7-2.9	1.5
Phosphate as P (mg/L)	<0.010-0.249	0.043	<0.010-0.184	0.051	<0.010-0.079	0.011
Total Phosphorous (mg/L)	0.03-5.55	0.66	0.04-3.15	0.40	<0.01-0.37	0.10
Dissolved Iron (mg/L)	<0.05-28.6	6.96	1.49-7.82	2.45	<0.05-2.08	0.76
Manganese (mg/L)	0.012-1.700	0.358	0.066-0.972	0.292	0.004-0.164	0.058
Arsenic (mg/L)	<0.001-0.007	0.001	<0.001-0.004	0.001	<0.001-0.002	<0.001
TPH (C6-C9) (ug/L)	<20-<20	<20	<20-<20	<20	<20-<20	<20
TPH (C10-C14) (ug/L)	<50-70	<50	<50-<50	<50	<50-<50	<50
TPH (C15-C28) (ug/L)	<100-600	300	<100-300	165	<100-300	130
TPH (C29-C36) (ug/L)	<50-350	130	<50-370	120	<50-300	75
Benzene (ug/L)	<1-<1	<1	<1-<1	<1	<1-<1	<1
Toluene (ug/L)	<2-4	<2	<2-<2	<2	<2-<2	<2
Ethyl-benzene (ug/L)	<2-<2	<2	<2-<2	<2	<2-<2	<2
M and p xylene (ug/L)	<2-<2	<2	<2-<2	<2	<2-<2	<2
Oxylene (ug/L)	<2-<2	<2	<2-<2	<2	<2-<2	<2

* Reduces to 123 when two major events excluded
** Reduces to 263 when two major events excluded
*** Reduces to 0.07 when two major events excluded
# Reduces to 10 when two major events excluded
Reduces to 17.3 when two major events excluded

2.4 Surface and Groundwater Users

The area around the Gunlake Quarry is typically low in both surface and groundwater resources. Consequently, there are no significant users of these waters apart from general farm dam water supplies for stock water supply. There are very few ground water supply bores in the locality. The hard rock characteristics are predicted to limit predicted hydrological changes to a confined zone extending no more than 100 to 200 m from the quarry pit. There are five bores within a 5 km radius of the quarry boundary that are registered for private use (stock or stock and domestic), with the nearest bore being 1.2 km to the east southeast of the quarry boundary. Given the very hard nature of regional rock, it is not expected that these existing water supply bores will be affected by the quarry activities. Since the original quarry development Gunlake has purchased additional surrounding properties however these do not carry associated groundwater licences.

3. Site Water Balance

The 2016 Gunlake Extension Project EIS provided an updated water balance using recorded water supply and demand data since 2009. The expansion of the quarry pit and increased use of process water will require additional surface water controls to prevent or minimise potential impacts and to provide a reliable supply of water. Surface water within the quarry site has been differentiated into five categories (clean water, dirty water, process water, wastewater and potable water) base on water quality and intended use.

3.1 Sources and Security of Water Supply

A water balance model was developed for the extension project using a Visual Basics Program. A summary of the model outputs is provided in Appendix B. The model applied a continuous simulation methodology that simulates the performance of the surface water management plan for the operation, each stage of the extension project, and post closure under a range of climatic conditions. The key elements of the water balance included:

- Rainfall runoff
- Groundwater inflow
- Process water demand
- System losses (evaporation and seepage).

The 2019 Independent Environmental Audit recommended that the water balance be reviewed with respect to very low rainfall scenarios and determine if there are opportunities to store and conserve additional water on site. This review will be ongoing. The primary water source will be the following water management and pollution control structures:

- Process Water Dam
- Pit Sump (drop cut)
- Clean Water Dam 2
- Pit Dewatering Dam (to be constructed when required to dewater the pit)
- Sediment Dams 1, 2 and 3 (SD 1 and SD 3 capture dirty water runoff from the overburden emplacement areas and SD 2 will be constructed prior to development of southern extent of the western emplacement area).

Gunlake will continue to primarily source process water from water stored in the Process Water Dam (25 ML), pit sump (drop cut) (80 ML) and Cleanwater Dam 2 (15 ML). Collectively, these storages (when full) will provide 120 ML of storage. When accounting for evaporation losses, the storages will provide 8 to 9 months of process water supply. The water balance model was applied to assess the effectiveness of the surface water management system in providing a reliable supply of process water to the quarry operation.

Under the current water balance, as highlighted in Appendix B, the operation will experience water shortages in low rainfall years but may have an excess of water requiring disposal or utilisation in high rainfall years. Gunlake may be required to seek additional water supply sources as described in the 2016 EIS in low rainfall years. The existing operation has approval to dispose of excess water via irrigation.

As the quarry expands the in-pit storage for stormwater retention will increase. This in turn will increase the wet weather storage capacity.

The frequency and volume of predicted water imports (or shortages) over the 115 year water balance model timeframe. The results indicate that:

- ❒ During the initial year of the quarry plan, the operation was vulnerable to water shortages, requiring water imports with below average rainfall conditions occurring. This is due to the process water demand increasing in line with the production increase and the catchment area of the pit being limited to 29 ha (compared to 53 ha once fully developed). In addition, no groundwater inflows into the pit were predicted in Quarry Year 1.

- ❒ The risk of water shortages will decline significantly as the pit is developed to its ultimate footprint and groundwater inflows increase, as shown in Appendix B. Results indicating shortages are unlikely to occur post Quarry Year 10. The prevailing drought during recent times has to some extent prolonged the predicted water deficiencies however the model is still considered accurate in predicting greater future drought proofing due to higher stormwater retention capacity.

The water balance model results indicate that the quarry's process water requirements will be primarily met by extraction from the water management dams. As a contingency, if water shortfalls occur for a period of time, Gunlake will either:

- ❒ Reduce water usage through the use of chemical dust suppressants
- ❒ Seek an external water source and tanker water to the quarry; or
- ❒ Temporarily reduce the scale of the operation to ensure the dust management objectives are being achieved.

Potable water for domestic purposes is generated by rainwater tanks. Roof water is collected in tanks and used in bathrooms and kitchen facilities. Drinking water is also available on site via a bottled water dispenser.

Records will be kept of all external water imported to the site as well as any necessary controlled water discharges. This data will be reported in the Annual Review.

3.2 Water Uses

The primary water uses on site are for dust suppression and process water, while the primary water management system involves partial separation of clean and dirty water systems, the containment of dirty water and its subsequent recycling as outlined in the following sections. Given the potential shortfall in dry years and the potential need to dispose of water in high rainfall years, the water management system needs to remain flexible and adaptable to changing climatic conditions.

3.2.1 Plant Water Use

Water use in the process plant is primarily used for dust suppression. Flow meter data indicates that the net water use in the plant is 18.2 L per tonne processed. This is consistent with typical values for a hard rock quarry. The annual plant water use rate of

36.4 ML/year for the approved quarry extension operation (2 Mtpa) has been adopted for water balance modelling:

3.2.2 Haul Road Dust Suppression

Haul road dust suppression is required on non-rainy days to mitigate dust produced from the operation of trucks and other equipment on the haul roads. Required application rates on any given day are a function of the active haul road area and the prevailing climatic conditions.

Haul roads are currently watered at an average annualised application rate of 2.3L.m^2/day. The current operation requires dust control over approximately 5ha of haul roads which will increase to 8ha with the expanded quarry operation. Water usage varies depending on rainfall but on an average year dust suppression water usage will increase from 43ML/year to 69 ML/Year.

3.2.3 Domestic Water

Gunlake obtains its domestic water requirements from rainwater tanks that capture rainwater from various buildings on the site. Depending on weather conditions, this water may need to be supplemented with water imported to the site. Gunlake will monitor water usage as employee numbers increase to ensure that there is an adequate domestic water supply to the site at all times.

Domestic water use is limited given the nature of the operation and is largely catered for by bottled drinking water delivered to the site. Tank water is used for kitchen and ablutions. Shower facilities are provided however for the majority of the workforce the primary domestic water use is for toilet flushing within the office and workshop area. Average usage consists of 25L of bottled drinking water per day and a maximum of 2,000L of tank water per day at peak workforce numbers.

3.3 Off-site Water Transfers

The Quarry operation requires flexibility in managing its water given the fact that it is highly dependent on rainfall. This means that dirty surface water generated from the operation is collected and stored for re-use rather than discharged off site. Only clean surface water from undisturbed or rehabilitated areas is allowed to drain into Chapman’s Creek. However, excess water will be generated in above-average rainfall years. The balance between storing excess water to enable sufficient onsite storage for dry years will be an ongoing challenge to quarry management. Discharge and or transfer of water offsite for disposal will only occur in order to reduce the risk of either uncontrolled discharge or constraint to quarry operation due to excess water.

As the quarry area expands, the ability to store water increases. This in turn enables greater security against water shortfalls in dry years. Therefore, the potential for offsite discharge and transfers will reduce over time.

Gunlake will ensure that any water discharges or transfers that are required will be managed in the following way:

- Sediment will be controlled by sufficient residency time before discharge;
- Active settlement using flocculation will be used if required;
- pH adjustment will be undertaken if necessary;
- Uncontrolled discharge will be avoided by maintaining adequate stormwater capacity to contain the design storm event;
- Maintaining a release rate controlled by the pit dewatering
- Ensuring untreated wastewater from the site water treatment facility does not discharge to surface water;
- Ensuring water quality deterioration as a result of discharge or irrigation activities does not occur.

Discharge water quality will meet the criteria specified in Section 5.2.

3.4 Measures to Minimise Clean Water Use on Site

Irrespective of the projected water excess, it is appropriate that water conservation and recycling initiatives are undertaken. Although it is in Gunlake's interest to minimise water consumption, this would only be done in a manner that does not compromise dust suppression. Should runoff water not be available in times of low rainfall, water will be sourced from the surface dams existing on the property.

Measures to minimise clean water use from the quarry operation include:

- Preferential use of water contained in pollution control ponds on site.
- Record water usage which can be compared over time with environmental performance data;
- Determine the minimum water usage required for dust suppression to meet the dust mitigation objectives; and
- Maintain rainfall records.

This data will enable the operation to assess if sufficient water is being used for adequate dust suppression while at the same time maintaining adequate stored volume on site. This data will also enable the surface water runoff model to be updated if needed as the operation progresses through different rainfall years.

4. Erosion and Sediment Control Plan

The existing quarry operation has completed the erosion and sedimentation controls described in the 2016 Water Management Plan. Additional controls for the expanded quarry operation have been based on the current controls and management systems. These control systems will be progressively implemented as new water management structures are installed for the expanded quarry.

4.1 Introduction

The original Erosion and Sediment Control Plan for Gunlake was prepared by Morse McVey SEEC in 2009. This earlier plan was prepared in accordance with the requirements of *Managing Urban Stormwater: Soils and Construction, Volume 1, 4th Edition, 2004* Landcom (the "Blue Book"). The plan was updated in 2016 to include additional controls and management activities associated with developing quarry footprint.

This plan details the ongoing management of the remaining erosion and sedimentation controls on site as well permanent water management structures associated with the Gunlake Extension Project Development Consent (30th June 2017). The design criteria and operation of both temporary and permanent sediment controls still adhere to the original standards and requirements.

4.2 Erosion and Sedimentation Control Plan

Soil erosion occurs when the energy of moving water or air becomes sufficient to overcome the cohesive forces binding soil particles together. Sedimentation occurs when the water flow decreases in velocity to a point where soil particles can no longer remain in suspension and are deposited. At Gunlake, the principle mechanism of erosion is caused by water flowing over disturbed land and to a lesser extent historical erosion from past agricultural activities. Wind erosion occurs to a lesser extent and is generally confined to the exposed overburden emplacement prior to topdressing and revegetation.

Activities that have the highest potential to result in erosion and subsequent sedimentation impacts include:

- Topsoil stripping and stockpiling
- Overburden emplacement and shaping
- Batter slope construction and internal drainage systems.

4.2.1 General Principles

Gunlake operates under the following general erosion and sedimentation control principles:

- No soil is to be disturbed unless there are measures installed downstream to collect sediment during rainfall events and prevent sediment leaving the site. This may include the existing pollution control ponds, the quarry void or if outside these areas, temporary measures such as silt stop fencing or hay bales.

- Soil disturbance outside the existing pollution control system, such as pre-stripping for new extraction benches will be kept to a minimum at any one time.
- Exposed areas will be revegetated or stabilised as soon as practicable.
- Stabilisation will be done progressively as new areas are disturbed.
- Permanent rehabilitation will be done as soon as practicable following final shaping and topdressing.
- Clean water is to continue to be diverted around disturbed areas as far as practicable.
- Clean water channels are to be maintained in a stable condition with no evidence of erosion occurring. Velocity reduction devices such as check dams (sand bags), energy dissipaters or rock protection, to be installed if channel erosion is occurring.
- Channels which convey dirty water into pollution control ponds also need to be stable so as not to contribute to the sediment load entering the pollution control system.
- Dirty water channels and receiving ponds to be cleaned out when capacity is reduced by 30% or when the freeboard level do not allow for containment of the design storm event.

The performance of the existing controls on site will be visually inspected on a monthly basis or after heavy rain. Removal of any sediment build-up is to occur as required with the collected sediment disposed of with the normal quarry waste and overburden. Repairs of rills or gullies caused by heavy rainfall are to be repaired as soon as practicable.

Employees and contractors will ensure that all soil and water management works are undertaken as instructed in this Plan and constructed following the guidelines stated in the Blue Book. All subcontractors will be informed of their responsibilities in minimising the potential for soil erosion and pollution to downslope areas.

4.2.2 Erosion Control

In order to ensure effective erosion control and to encourage proactive planning the Quarry Manager will ensure the following activities are undertaken:

- Sedimentation controls are to be in place prior to disturbing any new areas.
- All sources of sediment are to be identified and controlled prior to disturbance.
- Drainage controls to be in place first prior to disturbing new areas, particularly the expanding overburden emplacement.
- Access to be restricted to disturbed areas to avoid further sediment movement or damage to revegetation and stabilisation work.
- Topsoil is to be stripped and stockpiled for later use in rehabilitation work.
- Stockpiles of topsoil will be at least 5 m from areas of likely concentrated or high velocity flows, especially earth banks and roads. If necessary, low flow earth banks or drains designed in accordance with the Blue Book will be constructed to divert localised run-on.
- During windy weather, large, unprotected areas will be kept moist (not wet) by sprinkling with water to reduce wind erosion.

- Where roads or large bare areas of soil are perpendicular to the contour, sheet-flow interceptors will be used every 80 m to break up the slope length (e.g. using low-flow earth banks). This will include the haul road between the extraction area and the western emplacement area.

4.2.3 Topsoil Management

Soils are shallow and generally of low fertility, consequently, pasture cover is generally low quality improved or native species. There is evidence of sheet and some gully erosion in the main watercourses around the quarry site predominantly as a result of past agricultural activities. Despite this, the topsoil remains a valuable resource and is recovered prior to extending the quarry extraction area or extending the waste emplacement. The recovered soil is then stockpiled for later use in rehabilitation work.

Soil and overburden is removed by an excavator loading into a 50t dump truck, and involves the removal of approximately 25 mm of topsoil and a further 1 m of clay subsoil where available followed by removal of the overburden above the target rock.

Wherever practicable, stripped topsoil and subsoil is directly replaced on completed sections of the final landform. When stockpiling is necessary, topsoil and subsoil is stockpiled separately in stockpiles not exceeding 2 m and 3 m in height respectively. Low stockpiles reduce the incidence of deterioration of the soil over time prior to reuse on prepared surfaces. The topsoil material is stockpiled at various locations and may be moved at the discretion of the site manager in response to specific site constraints.

Prior to topsoiling new areas, the underlying overburden will be deep ripped along the contour to aid in surface stability and to aid in moisture infiltration and root penetration. Topsoil will be left in a scarified or ploughed condition once replaced to help reduce soil erosion and compaction.

4.2.4 Site Stabilisation

Gunlake has adopted a progressive approach to the rehabilitation and stabilisation of disturbed areas within the project site to ensure that where practicable, areas where quarrying or overburden placement are completed are quickly shaped and vegetated to provide a stable landform. This will ensure that the direct transfer of subsoil and topsoil is maximised and the area of land remaining to be rehabilitated at the end of the quarry life is minimised. Future stabilisation activities will proceed after the following procedures:

- All newly formed batters or embankments are to be stabilised by topdressing and vegetating as soon as practicable once completed.
- Fertiliser and soil ameliorants are to be incorporated prior to initial sowing.
- Final surface is to be contour ripped to aid in soil stability and runoff control.
- Revegetation of these areas will follow the procedures outlined in the latest version of the Biodiversity and Rehabilitation Management Plan which may include a sterile cover crop to aid in initial soil stabilisation.
- All sown areas are to be inspected following heavy rain. Rilling or surface scour is to be corrected as soon as practicable.

4.2.5 Sediment Fences

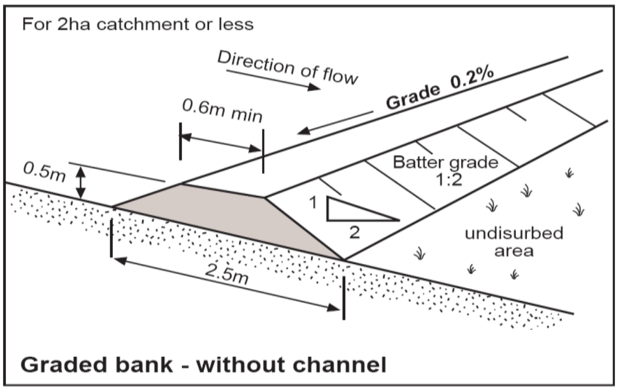
Sediment fencing consists of filter fabric erected down slope of all areas to be disturbed. There are several proprietary products available which generally have the same function and involve a buried toe with at least one metre of above ground filtration fabric supported between timber or metal pickets.

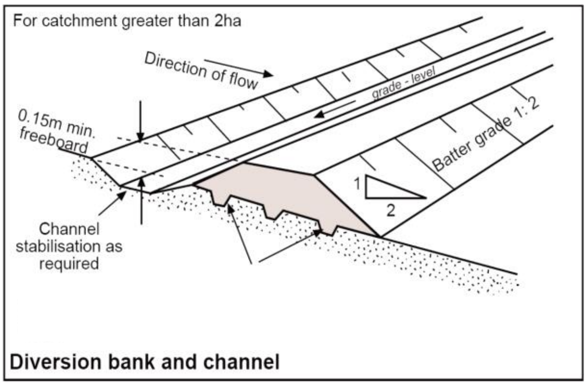
The purpose of the sediment fencing is to filter surface runoff from disturbed areas. There will be little further application for sediment fencing on site as most new disturbed areas lie within the overall pollution control system which prevents water from leaving the site.

4.2.6 Contour and Graded Banks

Contour banks are constructed in situ with no greater than a 1% fall to allow safe passage of water. Rock armour is provided where slopes are greater than 1% as has been the case for the toe drain around the base of the emplacement. These may be used in future as the overburden emplacement expands or on slopes where benching is not required. These channels are designed to convey water back to pollution control ponds and include roadside and hardstand drains.

There have been two types of drains used at Gunlake, one with an associated channel and one without. Constructing the banks with an associated channel allows for greater stability during high flows and therefore used on steeper slopes while a constructed embankment alone can be used on gentler slopes. These are shown diagrammatically below.





Typical arrangements on site at Gunlake are shown in Plate 1.

Plate 1 - Drainage Channels Around Existing Emplacement Area

Depending on the slope of the channel and estimated runoff velocity (greater than 2.5 m/s^2), protection is provided by rock lining or rock check dams located along the channel as shown on Plate 1. The check dams provide energy dissipation as well as stability. All other channels are grassed.

A clean water diversion system will be constructed to divert runoff from a clean water catchment that is located to the south of the pit. The system will be constructed along the southern and western edges of the final pit extent. Due to topographic constraints, the diversion system will need to be established on one of the upper benches within the quarry and will permanently divert clean water around the pit.

4.2.7 Absorption Banks and Level Spreaders

An absorption bank is the same as a contour bank but is constructed along the contour and then tapered up at each end. Runoff from the slope is therefore contained within the bank with no discharge at either end. These may be used in selected areas to retain as much water as possible within areas to be rehabilitated. They have yet to be used on site but may be considered in future.

Level spreaders at the end of grassed embankments have been used along the access road as these are flat and are generally not rock lined. These areas are now stable and represent clean runoff from the previous construction activities. These channels simply spread the water over the grass paddock.

4.2.8 Sediment Basins

Several small sediment basins were constructed during the construction of the quarry access road and infrastructure area. These basins have remained post construction to serve as ongoing pollution control structures. The location and design of the basins were contained in the original 2009 Soil and Water Management Plan. The structures are located below the areas disturbed by the original construction activities and sometimes exist within the dirty water system.

All sediment ponds were designed and constructed in accordance with “Blue Book” criteria and methods. Examples of the sediment basins constructed at Gunlake are provided in Plate 2 below.

Plate 2 - Sample of Gunlake Sediment Basins

Ongoing management of these structures include:

- Inspections of all drainage structures, channels and embankments on a monthly basis or following intense storm events.
- Evidence of severe erosion or instability to be corrected as soon as practicable.
- Structures that form part of the permanent water management system are to be cleaned out when capacity has been reduced by more than 30%.

4.2.9 Energy Dissipaters and Check Dams

Energy dissipaters, in the form of rock rubble have been placed where necessary within the current drainage system. These provide additional erosion protection during high flow conditions. Most commonly, channel protection has been provided at the delivery points into ponds, steep channels down batters and drop structures as shown in Plate 3. These have been installed along the main drains associated with the overburden emplacement, internal haul roads, and the bypass road (Ambrose Road). They will also be installed along the haul road between the extraction area and the western emplacement area.

Check dams have been also used extensively at Gunlake. These are usually constructed along drains longer than 100 m and where slope exceeds 2%. The dams are formed by rock walls across the channel at a height of up to 50 cm. The purpose of the check dams is to reduce flow velocity as well as channel grade. Sediment is collected behind the check dam which is then removed as required and inspected for scour, particularly immediately downstream. These have been installed along the main drains associated with the overburden emplacement.

4.2.10 Permanent Water Management Structures

The permanent water management structures covering the existing quarry operation, will be modified and expanded to accommodate the extension project area. The design and location of the new permanent water management structures were provided in the 2016 Gunlake Extension Project EIS. The upgraded water management system will include:

- 25ML Process Water Dam

- 15ML clean water dam (Clean Water Dam 2)
- Two sediment control dams covering the new emplacement area and one sediment control dam covering the noise bund emplacement area
- An in-pit sump (drop cut)
- 30ML Pit Dewatering Dam.
- A new clean water diversion system running along the extent of the final pit limit which will deliver water to Clean Water Dam 2.

The above structures are shown on Figure 4 Appendix A. These structures build on the existing water management system which include various small sediment ponds around the site and associated protected drainage channels.

Runoff from the hardstand including the office, carparking and workshop area will continue to drain into the Process Water Dam. Contained water is also recycled into the quarry process water circuit via the in-pit sump.

External drainage from the noise bund overburden emplacement and the extension project emplacement area is captured by a series of drains and embankments which discharge into small sediment dams. Only a minor quantity of water is derived from these areas. The access road drainage is controlled by a series of table drains which ultimately flow into one of two dams located either side of a tributary of Chapmans Creek which is crossed by the quarry access road. These dams prevent any runoff from the road entering the creek.

The primary water control system is the quarry pit. This will continue as the extraction area progresses. The developing quarry pit will continue to have a fully contained drainage system which will follow the lowest quarry bench back to a main in-pit sump (drop cut). In order to keep working areas drained as the quarry footprint increases, additional sumps may be constructed. These sumps will be linked as required and may also be utilised as point sources of water for dust suppression. From the sumps water can be pumped to the future Pit Dewatering Dam for later use in dust suppression or in the process water circuit. Water contained in the Pit Dewatering Dam will be used to supply the processing plant along with other water storages such as the Process Water Dam and pollution control structures. Water contained in the pollution control structures will be used preferentially to the water contained in Clean Water Dam 2.

4.2.11 Decommissioning of Erosion and Sediment Control Structures

Depending on the form of erosion controls installed, they will either be progressively removed or incorporated into the final landform. Examples of materials that may be removed when no longer required include silt control fencing, stakes and pickets associated with straw bales, and high value rock aggregate used in channel protection. The removal of rock aggregate will only occur if future instability has a low risk, for example rock protection on internal haul roads.

5. Surface Water Management Plan

This Chapter describes the way in which the existing water management system will be adapted and expanded to accommodate the expanded quarry development. It also outlines the baseline data and assessment criteria used in developing the final water management system. A Trigger Action Response Plan is also provided which outlines appropriate actions to be taken in order to maintain acceptable environmental outcomes for the operation.

5.1 Baseline Data

Gunlake Quarry undertakes regular monitoring of surface water quality within Chapman's Creek at two sites within the project boundary. Figures 2 and 3 of Appendix A shows the location of the surface water monitoring sites. The monitoring locations and nomenclature has developed over time with the current names shown. The sites generally include two sites downstream of the operation as well as two internal dams.

Chapman's Creek flows intermittently and for the majority of the time in the upper reaches of the Gunlake property it is dry. It is only in the lower sections of the creek within the project boundary that pools appear, which tend to dry rapidly in periods of dry weather. Chapman's Creek flows into Joaramin Creek approximately 1.4 km downstream from the Gunlake project boundary, and Joaramin Creek eventually flows into the Wollondilly River.

As shown in Table 2.2, the background water quality is highly variable which provides some difficulties in determining appropriate stream health criteria as discussed in the following section. The variability is a result of the highly intermittent flow regime. In order to determine overall trends in ambient water quality, the two new downstream sites will also be used to determine overall water quality during times when the quarry is not discharging.

5.2 Surface Water Impact Assessment Criteria

The results show a dramatic variation in background water quality prior to the quarry operation commencing. This is not unusual for an intermittent water course running through agricultural land. During dry conditions, naturally occurring salts and minerals concentrate in farm dams which then overflow during high intensity storm events which move these minerals through the streams.

Sediment movement can also be highly intermittent with long periods of little or no sediment movement followed by flushing events where large volumes of sediments move through the system. A similar pattern occurs with nutrients which concentrate in farm dams during low to average rainfall periods but then are flushed into surrounding waterways during storms.

Given the intermittent nature of the receiving waters, it is not possible to obtain the necessary 24 monthly background samples to enable Site Specific Trigger Values to be established under ANZECC guidelines. However, sufficient data has been obtained to determine general background water quality which can be used to determine potential impacts of the quarry on receiving water quality. Water quality parameters to be used as the basis for impact assessment are provided in Table 5.1. These are based on typical background water quality as well as reference to standard EPA discharge criteria.

Table 5.1 – Discharge Quality Parameters

Water Quality Parameter	Guideline or Trigger Value	Average Site Water Quality
pH (pH units)	6.5 to 8.5	7.1
Electrical Conductivity (µS/cm)	2,000	900
Total Suspended Solids (mg/L)	<50	-

5.3 Surface Water Management

The following management and monitoring provisions will operate for the permanent water management system. Responsibility for the implementation of these provisions rests with the Quarry Manager:

- ❒ All internal dirty water drains are to be inspected following intense rainfall events.
- ❒ All drains are to be maintained in a functioning condition without risk of blowout or short circuiting.
- ❒ All water quality control ponds are to be inspected following intense rainfall events. All inlet and outlet drains are to be maintained in a clean and stable condition.
- ❒ Field testing for pH and conductivity to be undertaken on sediment dams 1, 2 and 3 on a quarterly basis to determine general water quality is maintained.
- ❒ All pumps will be maintained to ensure they are operational.
- ❒ Dams to be cleaned out once capacity has been reduced by more than 30%.
- ❒ Prior to discharging water, the quality is to be tested and the parameters listed in Table 5.1 are to be met.
- ❒ Water quality within Chapmans Creek at the two downstream sites are to be monitored monthly during discharge.
- ❒ Records are to be kept of all water discharged from site or disposed by irrigation.

A summary of the surface water management strategy is provided in Table 5.2.

Table 5.2 – Surface Water Management Strategy

Management Objectives	Management Measures
Where practical, separate clean and quarry water circuits to minimise the volume of water that requires treatment.	Where possible, clean water diversion drains will be established up gradient from disturbance areas to reduce the volume of water that enters the quarry's water management system.
Provide appropriately sized sedimentation basins for all catchment areas that will be disturbed by the quarry operation.	Sedimentation basins will be established to capture and treat runoff from disturbed areas. The basins will be sized in accordance with the methods recommended in Managing Urban Stormwater: Soils and Construction,

Management Objectives	Management Measures
	Volume 2E – Mines and Quarries (DECC, 2008)
Establish suitable means to manage excess water that accumulates in the pit.	Water accumulated in the pit will be dewatered via pumping from in pit storages to the process water dam, that will store water for process water use. During periods of water surplus, water will be released from the dam when its water quality is suitable.
Minimise the volume and frequency of site discharge.	Water from disturbed areas will be captured in a series of water management dams. Water stored in dams will be used to meet process water demands and plant and haul road dust suppression. This water use will reduce dam levels and the associated discharge frequencies and volumes.
Establish site discharge locations and characteristics.	Site discharge locations have been identified for each stage of the quarry plan.
Establish the quarry's operational water demands and identify reliable water sources over the life of the quarry.	Water balance modelling has been undertaken to estimate the project's process water needs and the reliability of supply. The model was used to establish dam storage volumes that will reduce the risk of water shortages and associated need to import externally sourced water.
Establish an ongoing monitoring and review program that will enable the surface water management system to be progressively improved overtime.	The monitoring is summarised in Section 5.5.

Further details of the operation of the water management system are provided in the following sections.

5.4 Surface Water Management System

5.4.1 Clean Water Diversion System

A clean water diversion system will be constructed to divert runoff from a clean water catchment that is located to the south of the pit. The system will be constructed along the southern and western edges of the final pit extent. Due to topographic constraints, the channel will be established on one of the upper benches within the quarry and will permanently divert clean water around the pit.

The diversion system will be designed to minimise soil loss during high rainfall events and will be protected with rock as necessary as described in Section 4.2. The system will be inspected monthly or following heavy rain and any areas of scour will be repaired.

5.4.2 Dirty Water Management System

Runoff from dirty water catchments will be collected in either the Process Water Dam, the Pit Dewatering Dam once constructed, pit sump or the numerous sedimentation dams. All dams will be designed and constructed to provide adequate sedimentation treatment in accordance with the methods recommended in Managing Urban Stormwater: Soils and Construction, Volume 2E – Mines and Quarries (DECC, 2008).

The frequency and volume of overflows from the Process Water Dam and Pit Dewatering Dam will be reduced by the extraction of stored water to meet process water requirements, such as plant and haul road dust suppression.

5.4.3 Water Storages

The design volume of the main water storages on site are provided in Table 5.3.

Table 5.3 – Water Storages

Water Management Structure	Volume (ML)
Process Water Dam	25
Sediment Dam 1	2.4
Sediment Dam 2	1.2
Sediment Dam 3	1.4
Clean Water Dam 1A	2
Clean Water Dam 1B	7
Clean Water Dam 2	15
Pit Sump	80
Pit Dewatering Dam	30

The pit dewatering dam will be constructed to receive water that is dewatered from the pit when required.

5.4.4 Irrigation areas

The current operation has approval to use an irrigation area to dispose of excess treated water. The nominated area consists of rehabilitated areas of the existing emplacement area. This area benefits from additional watering available between periods of normal rainfall. The need to dispose of excess water generated from the quarry operation will reduce over time as the quarry expands. Management of irrigated water includes the following:

- Application of irrigation water will be such as to minimise erosive velocities across the emplacement surface
- Runoff is to be minimised but in any event would not be of sufficient quantity to overtop the existing sediment dams below the emplacement area.
- Water is to be tested prior to irrigation and irrigation will only occur if trigger values for the parameters listed in Table 5.1 are not exceeded.
- Daily inspections of the pumps, pipeline and sprinkler systems for operability including evidence of ponding or runoff indicating the rate of irrigation is too high
- The volume of irrigated water is to be monitored and recorded.

5.4.5 Creek Crossing Design

The 2016 Gunlake Extension Project EIS indicated that a new crossing of Chapmans Creek is required to transport overburden from the quarry to the emplacement area. The design of the crossing has yet to be completed but will likely include sufficient culvert capacity to convey peak flow from a one in 100 year critical duration storm event, that is, when the storm duration equals the time of concentration at the culvert location. The inlet and outlet of the culvert will be protected from peak flows through the culvert during intense storm events. If a new crossing is required a detailed design will be provided to DPIE two months prior to construction of the crossing commencing. Construction is likely to occur within the first five years of the Extension Project.

A crossing of Chapmans Creek exists at the toe of Clean Water Dam 2 which is currently used to transport overburden to the emplacement area. As this crossing occurs below the dam no further drainage works are required other than the safe passage from any overflows from the dam. This has been achieved using a protected surface over the crossing area.

5.5 Monitoring Program

The surface water monitoring program comprises monitoring at the following locations:

- ❒ Two receiving water sites that are located on Chapmans Creek, downstream of the quarry;
- ❒ The Process Water Dam; and
- ❒ In-pit sump (drop cut).

Details of the monitoring program is provided in the following sections.

5.5.1 Effectiveness of Water Management System

The effectiveness of the water management system will be verified by establishing ambient water quality data in order to compare this with any discharges or changes in water quality as a result of the operation. Gunlake quarry has a well established ambient water quality monitoring program inclusive of a substantive database on Chapmans Creek. The data shows that the upper reaches of Chapmans Creek are predominantly dry and only flow following heavy rain events, while the lower section towards Brayton Road at the Gunlake property boundary consists largely of unconnected stagnant pools which respond more quickly to rainfall events.

The dataset (refer Tables 2.1 and 2.2) shows that water quality in Chapmans Creek is largely influenced by groundwater baseflow. Salt levels are generally above 1,200 µS/cm with neutral pH. During high flow, the salt content would likely decrease.

5.5.2 Surface Water Discharges and Sampling

Uncontrolled discharges from the site will be avoided by managing in-pit dewatering rate and stored volumes. Offsite discharges may be required following heavy rainfall which would occur following primary settlement of water in the in-pit sumps followed by pumping to the process water dam. Discharges would occur from this dam at a rate equivalent to the volume of the water pumped from the pit. Water will be tested for the parameters as stated Table 5.1.

The ambient water quality monitoring program has been expanded to include two additional sampling points within the lower section of Chapmans Creek during heavy rainfall periods to better define background water quality during flow events. The resultant database will then be used to assess the potential impact of discharges from the quarry on the receiving waters.

5.5.3 Surface Water Quality and Flow

Surface water quality monitoring is currently undertaken at the sites described in Table 5.3 as per the 2016 EIS.

Table 5.3 - Location of Surface Water Monitoring Sites

Aspect	Objective	Monitoring Locations	Monitoring Description
Receiving Waters	To determine water quality trends and identify water quality impacts associated with the quarry operation	Receiving Water 1 (RW 1) Receiving Water 2 (RW 2)	Quarterly analysis. Refer to below for a description of the proposed analytes.
On-site Storages	To determine water quality trends in discharges from the on-site storages.	Process Water Dam (PWD) Pit Dewatering Dam (PDD)	Quarterly analysis of discharge from the on-site storages. Refer below for a description of analytes
Water Quantity Monitoring	To monitor the quarry's process water use.	Cumulative flow meters will be installed to monitor process water use	

Monitoring parameters are as follows:

- ❒ Electrical Conductivity (EC)
- ❒ Total Suspended Solids (TSS)
- ❒ Total Dissolved Solids (TDS)
- ❒ Dissolved Oxygen (DO)
- ❒ Turbidity
- ❒ pH
- ❒ Sodium
- ❒ Chloride
- ❒ Total Nitrogen (TN)
- ❒ Total Phosphorus (TP)
- ❒ Metals (Al, As, Co, Cu, Mn, Ni, Zn, Mg, Na, K, Ca, Cl, Fe)
- ❒ Total Oil and Grease (visual inspection only)

Assessment criteria exists for those analytes listed in Table 5.1. The remaining analytes are used to describe general water quality and do not have specific assessment or performance criteria.

The status of the flow within the creek is also recorded. As the surrounding creeklines are intermittent and only flow after prolonged rainfall, the flow status will be recorded as categories (low, moderate, high). Corresponding rainfall will be recorded in order to determine general runoff conditions. This information will be reported in the Annual Review and used to refine the general runoff model used in the EIS.

5.5.4 Channel Stability

As with most ephemeral streams, the infrequent flow events in Chapmans Creek give rise to infrequent but often high sediment movement. Ephemeral streams tend to remain apparently stable for long periods until major storm events when high flows cause channel scour and mass movement of sediment downstream. Although these are natural events, the loss of riparian vegetation through past agricultural activities can result in higher than normal instability of channels and banks.

The collection of quarterly water samples, which would need to correspond to flow events, will also be used to inspect channel stability and evidence of erosion or sedimentation. High flows are natural channel forming events and the movement of sediments downstream can also have beneficial effects on fluvial systems. The monitoring therefore needs to consider what is natural and what may have been exacerbated by past and current land uses. Any changes which may have occurred as a result of quarry activities will be noted separately and corrected as soon as practicable. All other data collected, including a photographic record, will be reported in the Annual Review.

5.5.5 Irrigation Areas and Water Quality

Gunlake has approval to irrigate water as a means of beneficial reuse of excess water. Irrigation has been used over a section of the overburden emplacement to facilitate rehabilitation. The irrigation water essentially represents rainwater runoff that is kept in on site storages until no longer needed or considered excess to the requirements of the quarry operation. Although the water quality found to date is highly suitable for irrigation, it will be important to undertake testing prior to irrigation to check that water quality has not deteriorated. The discharge parameters provided in Table 5.1 will also be used to determine suitability for irrigation.

The irrigation area will be inspected before, during and after each irrigation event. While irrigation is occurring, the pumps, pipelines and sprinkler system are to be inspected on a daily basis to check on operability. The inspections are to include evidence of ponding or runoff indicating that the rate of irrigation is too high.

The results of each inspection will be documented and recorded separately for reporting in the Annual Review. The information is also to be used to assess the irrigation methods and rates and adjustments are to be made as required.

The volume of water irrigated at any one time is to be monitored and recorded. The records are to include the period of irrigation, rate of application and total volume applied. The results are to be reported in the Annual Review.

5.5.6 Stream Health

Stream health will be checked quarterly when water quality sampling occurs. The following parameters will be checked:

- Evidence of stream bank erosion or instability;
- Vegetation cover and soil exposure;
- Evidence of sedimentation within the watercourse;
- Visual signs of poor water quality;
- Health of riparian vegetation including any indication of disease or dieback; and
- Weed infestation.

Data collected will be reported in the Annual Review and used to development any remedial measures required to improve stream health. This may include additional erosion and sedimentation controls, bank stability works and weed removal.

5.5.7 Reporting and Review of Results

The Annual Review will provide a summary of all environmental monitoring data and observations made during the reporting period and compare these with the stated objectives and targets. The Annual Review will also discuss the results of inspections of the surrounding water courses and objectively assess any potential impacts caused by the quarry activities.

5.6 On-site Waste Water Management

Gunlake operate a standard septic wastewater disposal system approved by Council. The system includes a primary collection tank, followed by a 1,000 m^2 x 600mm deep absorption trench system. The absorption trench consists of 20-40 mm aggregate which is topsoiled and grassed. The trench is fed via a distribution box which evenly conveys clarified effluent from the primary collection tank. The expected water quality within the final absorption trench is shown in Table 5.4.

Table 5.4 – Expected Quality of Wastewater after Treatment

Parameter	Typical Concentration	Upper Limit
Biochemical Oxygen Demand	<20 mg/L	50 mg/L
Suspended Solids	<30 mg/L	50mg/L
Total Nitrogen	25-50 mg/L	n/a
Total Phosphorus	10-15 mg/L	n/a
Faecal coliforms non-disinfected effluent	< 10^4 cfu/100 mL	n/a
Faecal coliforms disinfected effluent	<30 cfu/100 mL	100 cfu/100 mL
Dissolved Oxygen	>2mg/L	2 mg/L

These levels are within the capacity of normal nutrient uptake of pasture species within the wastewater irrigation area.

The septic system is maintained as required by an external contractor annually. The maintenance regime includes visual inspection of the septic absorption trench and sludge levels within the primary collection tank. Given the low levels of usage it is anticipated that the tank will need desludging once every five years. Gunlake has reviewed the operation of the septic system as a result of the 2019 Independent Environmental Audit and will ensure that the capacity of the system will continue to be adequate for increase in wastewater generation as a result of quarry staff increases in line with the quarry expansion.

5.7 Protocol for Managing Any Exceedances of Surface Water Impact Assessment Criteria

5.7.1 Trigger Action Response

The following triggers do not relate to any specific action required by the Quarry but rather are designed to enable the quarry to determine if there are any impacts caused as a result of the quarry development.

Table 5.2 - Trigger Action Response Plan

Trigger	Action Required	Any Follow Up Actions
Water Quality (when discharging)		
When the quarry is discharging, a 'significant' decrease in water quality in particular decreasing pH, increasing EC and increasing TDS in time in Chapmans Creek upstream of Brayton Road. A significant decrease is defined as: 1. a pH less than 6.0 2. A gradually increasing trend in EC & TDS values compared with any trends observed in the historic background monitoring site in Chapmans Creek (referred to as Site I).	Continue to monitor and assess surface water quality data during and after discharge events. Establish trends and correlate with quarrying activities and climatic data (rainfall) to determine any causal link with Gunlake quarrying operations. Apply statistical analysis to assess trends if required. Compare water quality data in downstream monitoring sites with water quality data from the background monitoring site (Site I).	If evolving geochemical anomalies are detected in downstream surface water samples in Chapmans Creek (compared with water quality at the background monitoring - Site I) and an impact from the proposed quarrying is suspected or demonstrated, carry out follow-up verification sampling at the two monitoring sites within 30 days of the receipt of the anomalous analytical results. Collate, interpret results and assess significance of any impacts. Develop mitigation measures the detail of which will depend on the type, distribution and degree of impact.
Stream flow (when extraction depth exceeds 20m)		
A 'significant' decrease in stream flow over time that may or may not be associated with quarrying activities	Continue to monitor and assess stream flow data, establish trends and correlate with quarrying activities, climatic data (rainfall) and water table fluctuations in monitoring bores. Apply statistical analysis to assess trends if required. Determine whether any decrease in stream flow may be due to impacts from the proposed quarrying	Continue to monitor and assess stream flow data and assess trends. In the unlikely event that some, or all the reduction of stream flow in Chapmans Creek is assessed by the hydrogeological and/or surface water consultant to be due to impacts from quarrying, determine at what stage the stream flow was impacted upon and the likely mechanism for the decrease in flow. Develop a contingency plan to restore any stream flows.

It is important to note that it is necessary for Gunlake Quarry to actively recycle process water to maintain operations during normal to dry rainfall years. Excess water will only occur during above average rainfall patterns which may necessitate offsite discharges or transfers to occur. As the quarry expands, the need for offsite discharge will diminish but the need to recycle water will remain.

6. Groundwater Management Plan

6.1 Scope

Gunlake quarry has been monitoring groundwater around the site since 2007. This work commenced in accordance with the original Groundwater Management Plan (GMP). The GMP has been progressively updated in line with subsequent approvals and the expanding quarry. This GMP covers the expanded quarry development and commitments made in the 2016 EIS and includes a summary of baseline groundwater data, assessment criteria and a protocol for the investigation of identified exceedances. This version also includes the recommendations found in the 2019 Independent Environmental Audit. Specifically, the scope of the Gunlake GMP is to:

- Develop a groundwater database which is sufficient to determine if the quarry operation is impacting on either groundwater resources or water quality within the local and surround area.
- Provide baseline data on groundwater levels, flows and quality including identified springs and seeps.
- Provide data on groundwater flows into the quarry pit.
- Verify the impact predictions made in the EIS.
- Gather sufficient data to refine the current groundwater model for future environmental assessments of the quarry development.

6.2 Background

The initial groundwater monitoring network was used to collect baseline water levels, water quality and rock permeability data from beneath, and surrounding the footprint of quarry. The current groundwater monitoring program now includes a set of monitoring targets, assessment criteria and trigger levels for investigating any potentially adverse impacts from quarrying operations on the groundwater system.

Four potential groundwater-related impacts are associated with the Gunlake Quarry were assessed as part of the approval process:

- Impact on any groundwater dependent ecosystems;
- Quality and quantity impacts on the local and district water table, any underlying hardrock aquifer systems and any groundwater users;
- Potential cumulative impacts with other quarries in the district; and
- Possible water quality issues associated with leachate from the quarry resource.

Although the EIS found that the potential impacts on groundwater were minor and manageable, the groundwater monitoring program was designed to provide the necessary data to verify this. The results of the monitoring program are reported every year in the Annual Review which provides an ongoing compliance protocol.

6.3 Potential Groundwater Impacts

Potential groundwater-related impacts that could arise from the operations at Gunlake Quarry include:

- Impact on local water features such as springs or groundwater dependent ecosystems;
- Reduction in local groundwater affecting local bores;
- Reduction in groundwater quality as a result of quarrying; and
- Potential cumulative impacts with other quarries in the district.

The approved expansion to the quarry footprint will result in the pit being closer to the nearest registered bore (GW05637), however the pit will still be more than 1,200 m from this bore. The hard rock characteristics of the surrounding strata are predicted to limit the hydrogeological changes to a confined zone extending no more than 100 to 200 m from the quarry pit depending on the geological conditions in the locality.

Under this management plan, groundwater monitoring bores have been established and will continue to be monitored for both standing water level and water quality. In light of the 2019 Independent Environmental Audit, the number of monitoring bores have been reviewed and at this stage the program is considered adequate. Opportunities to increase the number of monitoring sites on the western side of the quarry footprint will be pursued as the quarry footprint progressively expands. The results of this monitoring will be reported in the Annual Review.

6.3.1 Groundwater Quality, Quantity and Impacts on Water Users

Several groundwater studies have been undertaken as part of the approval process for the original quarry and various expansion projects. Each study concluded that due to the large separation distance between the quarry and the nearest groundwater bores, the potential for significant impact on any other water users surrounding the project site is considered to be very low.

The groundwater inflow into the quarry was predicted to be a maximum of 37ML/pa at extraction Year 20. The depth of extraction will progress to 598m AHD during this stage, approximately 45m below the pre-quarrying water level. Inflow rates are predicted to remain relatively constant as extraction progresses to a final depth of 572 m AHD and then gradually recede as the strata around the pit is dewatered.

Groundwater quality is unlikely to be impacted by the quarry development. Monitoring data since 2007 has not indicated any change in water quality and is generally in line with typical groundwater quality within the region.

Chapmans Creek loses baseflow to the underlying fractured rock water source. The rate of loss is governed by the hydraulic conductivity of the strata underlying the creek. The extension project will not impact on the hydraulic conductivity of the strata outside the pit therefore no impacts to baseflow is anticipated. The current hydrogeological model for the site indicates that depressurisation of the fractured rock water source will be minimal and the developing quarry void will have minimal impact on underlying strata and nearby alluvial deposits.

The groundwater monitoring program has been designed to identify any depressurisation as a result of the quarry extraction. The results will be reported in the Annual Review.

6.3.2 Groundwater Dependent Ecosystems

There are no ecosystems which are solely dependent on groundwater. The Box Gum Woodland is primarily reliant on rainfall but also to a lesser extent, shallow perched groundwater systems within the alluvial deposits. Drawdown in the fractured rock is not expected to impact vegetation health however groundwater levels within the fractured rock surrounding the quarry will continue to be monitored on a quarterly basis and any drawdown which could impact on vegetation communities will be reported in the Annual Review.

Monitoring of the Box Gum Woodlawn will continue on a quarterly basis within the riparian vegetation corridor of Chapmans Creek (as shown on Appendix 5 of the Development Consent). This program will include identification of the causes of deterioration which could relate to reduced groundwater baseflow within the alluvial.

6.3.3 Local Water Features

There are four groundwater springs on site, referred to as Springs 6, 7, 8 and 9 which may be impacted by drawdown from the quarry void. These springs will receive reduced groundwater contributions and the two closest to the quarry extension (Springs 6 and 7) may cease to flow. The springs do not support GDEs or hold any significant environmental value and predicted reductions in flow are not considered to require mitigation and specific management activities.

Each of the four groundwater springs will be monitored on a quarterly basis commencing in 2018. The monitoring will comprise a photographic and descriptive record. The timing of the inspections will correspond to the monitoring of the groundwater bores and riparian vegetation corridor. Based on groundwater modelling the first five years of monitoring will represent baseline data prior to potential impacts of the quarry occurring. The data will be presented in the Annual Review.

6.3.4 Groundwater Quality

The potential for the generation of poor quality leachate from the quarrying operations at Gunlake is considered to be low due mainly to the paucity of disseminated pyrite and/or other metal sulphides in the porphyry beneath the project site. Water monitoring to date suggests that the water quality generated by the extraction is contaminated with solids only which are removed by settling before being recycled for non-potable purposes around the site.

6.3.5 Cumulative Impacts from Neighbouring Operations

Based on geological and hydrogeological evidence and data, and given the separation distances and low rock permeability, there are no predicted cumulative impacts of Gunlake, Johnniefelds and Lynwood quarries operating concurrently.

6.4 Groundwater Monitoring

The groundwater monitoring program currently consist of two monitoring bores which are shown in **Figure 2** of Appendix A. Automated data loggers are installed in the groundwater monitoring bores. These loggers are programmed to take measurements of water level and temperature at a sample frequency of 6 hours. The location of the monitoring bores is provided in Table 6.1.

As the quarry progressively expands, earlier groundwater monitoring bores GM 24 and GM 36 have been incorporated into the extraction footprint. This has reduced the total number of current monitoring sites although the earlier ones still provide valuable data on groundwater, particularly prior to mining occurring. As recommended in the 2019 Independent Environmental Audit, additional monitoring sites to the west of the extraction area will be installed as the pit develops.

Table 6.1 - Location of Bore Monitoring Sites

Monitoring Bore	Co-ordinates MGA Grid		Depth of Bore	Elevation (m AHD)	Casing Sickup (m)	TOC Elevation of Bore Collar (m AHD)
	Easting (m)	Northing (m)				
GM6	771916	6159367	25.88	657.40	0.54	657.94
GM13	771916	6159042	22.36	665.20	0.50	665.70
GM24	771676	6158934	21.00	669.90	0.53	660.43
GM36	771920	6158843	17.12	666.60	0.60	667.20

Under the expanded quarry development, two of the bores will require replacing. The new locations will be included in this GMP when installed. These are likely to be on the western side of the quarry extraction area as recommended in the 2019 Independent Environmental Audit.

6.4.1 Groundwater Levels

In summary, water level measurements collected in the network of monitoring bores reveal varying degrees of fluctuation in the piezometric surface (often referred to as the 'water table') beneath and surrounding the quarry. It is noted that the since the commencement of automated water level logging, the water table remains higher than the initial measurements in all monitoring bores.

Groundwater levels will continue to be collected and reported in the Annual Review.

6.4.2 Groundwater Quality

As baseline groundwater quality has been established prior to quarrying activities occurring, ongoing groundwater monitoring will continue on a quarterly basis for water level and water quality indicators (pH, electrical conductivity and temperature). The following additional parameters will be monitored on a six-monthly basis:

- Sodium Adsorption Ratio;
- Total Hardness;
- Total Phosphorus (as P);
- Total Nitrogen;

- ❒ Major Cations (Calcium, Magnesium, Sodium and Potassium); and
- ❒ Metals (Arsenic, Cadmium, Chromium, Copper, Lead, Nickel, Zinc, Aluminium, Iron, Selenium and Mercury).

6.5 Groundwater Assessment Criteria and Trigger Values

The baseline monitoring results to date indicate that despite fluctuations in some water quality parameters, groundwater quality is good with moderate salinity, low metals and near neutral pH and generally meet the ANZECC (2000) default trigger ranges as shown in Table 6.2.

Although ANZECC guidelines are not suitable for assessing groundwater quality, the below table provides a good indication that the groundwater quality around the Gunlake Quarry is uncontaminated either naturally or through previous agricultural activities. The elevated salinity levels are still half the level of salt concentration considered acceptable for stock watering although there are no specific guidelines to compare with.

Table 6.2 - Water Quality Guidelines

Parameter	Average Groundwater Quality at Gunlake	ANZECC 95% Default / EPA Criteria	ANZECC Livestock Drinking Water Criteria*
PH	6.9	6.5 to 8.5	6.5-8.5
EC (uS/cm)	3232	350	3,350
TSS	-	50	50#
Ammonia (mg/L)	0.7	0.9	0.9#
Nitrate (mg/L)	2.02	400	400
Total Phosphorus (mg/L)	0.026	0.02	
Sulphate (mg/L)	17	1,000	1,000
Nickel (mg/L)	<0.01	0.011	1
Zinc (mg/L)	0.005	0.008	20
Arsenic (mg/L)	<0.01	0.024	0.5
Copper (mg/L)	0.002	0.0014	0.5
Mercury (mg/L)	<0.0001	0.0006	0.002
Cadmium (mg/L)	<0.0002	0.0002	0.01
Chromium (mg/L)	<0.01	0.001	1

*assumed groundwater assessment criteria

#ANZECC 95% Default / EPA criteria

6.6 Groundwater Trigger Action Response

Although it is highly unlikely that Gunlake Quarry will alter groundwater quality, there is the potential for groundwater levels immediately surrounding the quarry extraction area to fall slightly as the quarry deepens. As groundwater levels naturally fluctuate in response to climatic changes, determining the affect if any, of the quarry extraction is difficult. At present, groundwater levels around the quarry void are in fact rising, however the levels could fall in future. These trends would represent natural variability and are generally gradual in nature. Should an impact be caused by the quarry operation, there needs to be a relatively quick fall in standing groundwater level down dip of the quarry extraction area. This fall would also need to be correlated to an increase in groundwater ingress into the quarry void.

The following triggers in relation to groundwater will be refined in future years as more groundwater data is obtained.

Table 6.3 - Groundwater Trigger Action Response Plan

Trigger Value or level indicating potential impact	Action Required	Any follow up actions
Water Quality		
Concentration of metals and physical parameters increases above ANZECC guidelines stated in Table 6.2	Continue to monitor and assess bore water quality data, establish trends and correlate with quarrying activities and climatic data to determine a causal link (if any) with Gunlake quarrying operations.	If evolving geochemical anomalies are detected in groundwater sampled from the peripheral monitoring bores (compared with water quality in the background control bores) and an impact from the proposed quarrying on the 'hardrock' aquifer system is demonstrated, advise DPI (Water) and Department of Planning, Industry and Environment for further action.
Water Levels		
A 20% decrease in standing water level over 3 months in nominated bores.	Continue to monitor and assess water level data, establish trends and correlate with quarrying activities and climatic data (rainfall). Apply statistical analysis to assess trends if required. Determine whether any decrease in water level may be due to impacts from the quarry. Calculate and assess any distance drawdown effects with respect to any neighbouring water users (bores).	If some, or all of the water level declines in the monitoring bore network are assessed to be due to impacts from quarrying at Gunlake and distance drawdown calculations by the hydrogeological consultant (in consultation with the DPI Water) indicate a 'significant' impact on neighbouring water users (bores), access to the potentially affected bore/s should be requested in order to confirm and monitor any impact that may be solely or partly due to quarrying at Gunlake. If a 'significant' impact on a neighbouring water user is scientifically demonstrated, contingency plans may include developing a new groundwater source for the affected user, supplying a volume of water commensurate with the calculated loss and/or compensation.
Groundwater inflow into the pit		
Groundwater inflow greater than 37 ML/year. Net groundwater inflow calculated by ground survey and water balance calculations	If water balance calculations indicate that net groundwater inflow into the pit exceeds 37ML/year and the flow rate continues to exceed this annualised rate, commission a hydrogeological consultant to develop a groundwater computer model. The model simulates the porphyry-hosted water levels under pre-quarry, quarry and post quarry conditions, and predicts proximal and distal water level fluctuations (and impacts).	Gunlake to determine (in consultation with DPI Water) if the increased groundwater inflow has resulted, or is causing, loss of water availability to neighbouring water users. The results to be reported to the Department of Planning, Industry and Environment for further action.

Monitoring of surface water is also to be used to determine potential impacts on groundwater resources and vice versa. Any changes to groundwater quality should be detectable in the spring fed dams. The risk to groundwater is considered low due to:

- ❒ Low water availability within the hard rock resource being extracted.
- ❒ Separation from the alluvial/unconsolidated aquifers from the quarry extraction area.
- ❒ There are no natural chemical properties of the hard rock material which would be considered a contaminant in the local environment.

The previous environmental assessments did however note that linear geological defects imposed on the igneous rock mass during past regional deformation have resulted in localised springs. These springs are controlled by faults and subvertical discontinuities and therefore could be impacted if the flow of water along these fractures is intercepted. Based on geological mapping, the only spring which may be impacted by the quarry extraction is Spring 6, which feeds a farm dam on Chapmans Creek immediately to the west of the quarry extraction area. This spring, together with springs 7, 8 and 9, will continue to be monitored on a quarterly basis.

6.7 Data Management and Reporting

All data obtained as part of the groundwater monitoring program will be compiled and reported each year in the Annual Review. The data will be analysed against the established triggers and for any trends that may be occurring.

7. Communication and Reporting

Effective communication with government agencies, the workforce and the community are important features of the overall Environmental Management Strategy for Gunlake Quarry and therefore a key component of each Environmental Management Plan.

Project reporting requirements are defined in Schedule 5 of the Development Consent.

7.1 Community Consultation

Gunlake management is required keep the local community and relevant agencies informed about the construction, operation and environmental performance of the project. A Community Consultative Committee (CCC) has been formed and information relating to surface and groundwater is provided in CCC meetings on request.

7.2 Community Complaints

Gunlake maintains a community complaints register that identifies actions required to resolve community issues. The main phone line is listed in the white pages, the property sign at the main entrance, as well the company website. The complaints register records the following details:

- Complainant name and contact details
- Nature of the complaint (noise, dust, traffic etc)
- Time and date of the complaint
- Specifics of the complaint
- Actions taken to resolve the complaint
- Confirmation that the complaint has been resolved.

In the event that an issue is unresolved, the register will include details of the outstanding issues and any actions that are required. It is recognised that some issues may not have a simple resolution and have resulted in multiple complaints. These form part of the ongoing environmental improvement program for the operation.

7.3 Government Liaison

Gunlake will continue to liaise with relevant government agencies in relation to the ongoing quarry operation.

7.4 Public Access to Information

Gunlake provide updated environmental monitoring data on the company's web page as required by Condition 13 of Schedule 5 of the development consent. Information provided includes water monitoring data.

7.5 Reporting

Conditions 8, 9 and 10 of Schedule 5 detail the required reporting regime. These include incident reporting, regular reporting of environmental performance and annual reporting. Gunlake will continue to submit an Annual Review to the Department of Planning, Industry and Environment each year. The Annual Review is also submitted to the Community Consultative Committee and relevant agencies. The contents required for the Annual Review are detailed in Condition 10, Schedule 5 of the development consent.

8. Verification and Corrective Action

An essential component of the EMS is verification and implementation of corrective actions as required to achieve the requirements of the Development Consent and Environment Protection Licence.

8.1 Environmental Monitoring

The water management system at Gunlake requires ongoing monitoring as described in this Water Management Plan. This monitoring work falls within the overall monitoring program for the site which includes other environmental parameters such as noise and dust, traffic, vegetation and rehabilitation. The results of this monitoring is summarised in the Annual Review each year.

8.2 Non-Conformance, Corrective Action and Adaptive Management

Responsibility for identifying non-conformances will rest with a number of personnel on site to ensure that any non-conformances are identified as soon as possible. Primary responsibility rests with the Quarry Manager. All non-conformances are reported to the Quarry Manager in the first instance who then directs other key personnel as required.

Corrective actions are implemented as soon as practicable on identification of any non-conformances, and records of such are to be maintained. Corrective actions are to be in line with current best practice within the industry and ensure that appropriate guidelines are met.

Corrective action will be form part of the Adaptive Management process where any exceedance of the criteria and/or performance measures has occurred.

In such cases, Gunlake Quarry will at the earliest opportunity

- take all reasonable and feasible steps to ensure that the exceedance ceases and does not recur;
- consider all reasonable and feasible options for remediation (where relevant) and submit a report to the EPA and DPIE describing those options and any preferred remediation measures or other course of action; and
- implement remediation measures as directed by the EPA and/or DPIE.

8.3 Preventative Action Procedures

Preventative action will consist predominantly of regular inspections undertaken by the Quarry Manager, Environmental Officer or designated site personnel as well as external audits required under the Development Consent. Steps will be taken to ensure that any potential non-conformances do not occur. Any preventative actions will be commensurate with the environmental impact anticipated.

Any changes in procedures resulting from corrective and preventive action will be documented and the appropriate personnel notified, including Gunlake's management team.

8.4 Record Keeping

Records are kept of all environmental monitoring, audits and actions taken under the provisions of each Environmental Management Plan. Records must be legible, identifiable and traceable to the activity and stored and maintained so that they are readily retrievable and protected against damage, deterioration or loss. Not all records obtained as part of this Water Management Plan will be made public as they will largely consist of internal inspection records which are then used to undertake maintenance or repairs as necessary. The records however can be made available to regulatory authorities on request.

8.5 Management Review

In accordance with Condition 10, Schedule 5 of the Development Consent, this SWMP will be reviewed within three months of submitting an Annual Review, an Incident Report, an audit report, or approval of any modification to the Consent. Outcomes of these reviews may result in an update to this plan. The purpose of management review is to identify any weaknesses or out of date procedures. The aim is to maintain the SWMP in line with current industry and Australian standards and changes to environmental legislation and will take into account any further recommendations from Independent Environmental Audits.

8.6 Continuous Improvements

A key component of the environmental management of Gunlake Quarry is the commitment to continuous improvement. This will be measured by formal and informal criteria. Formal measures will include monitoring data, internal and external inspection and action plans. This information will be used to establish trends in non-compliance and environmental performance. The level of non-compliance with both statutory and company standards will then be summarised in the Annual Review.

Appendix A - Plans

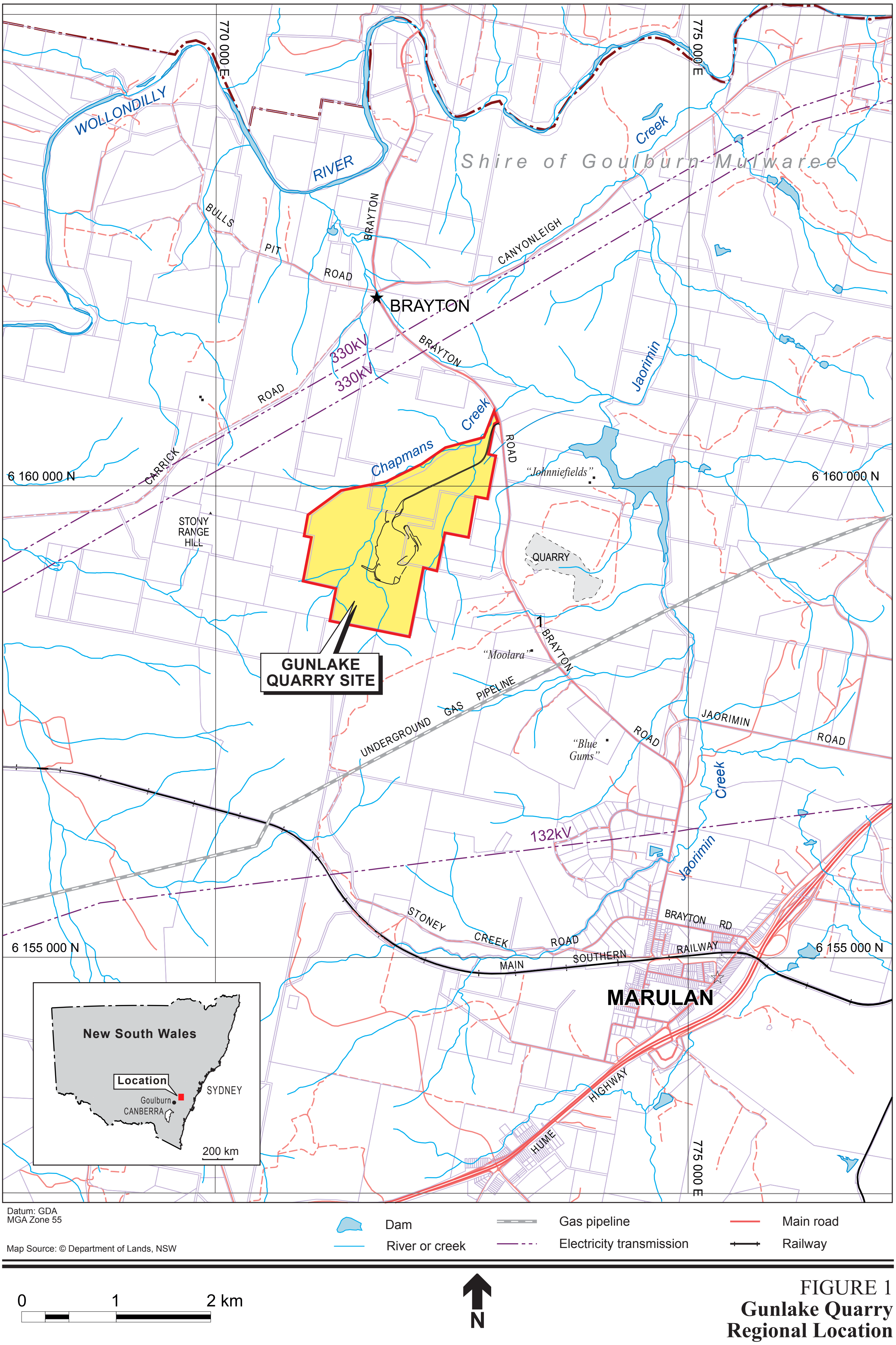


FIGURE 1
Gunlake Quarry
Regional Location

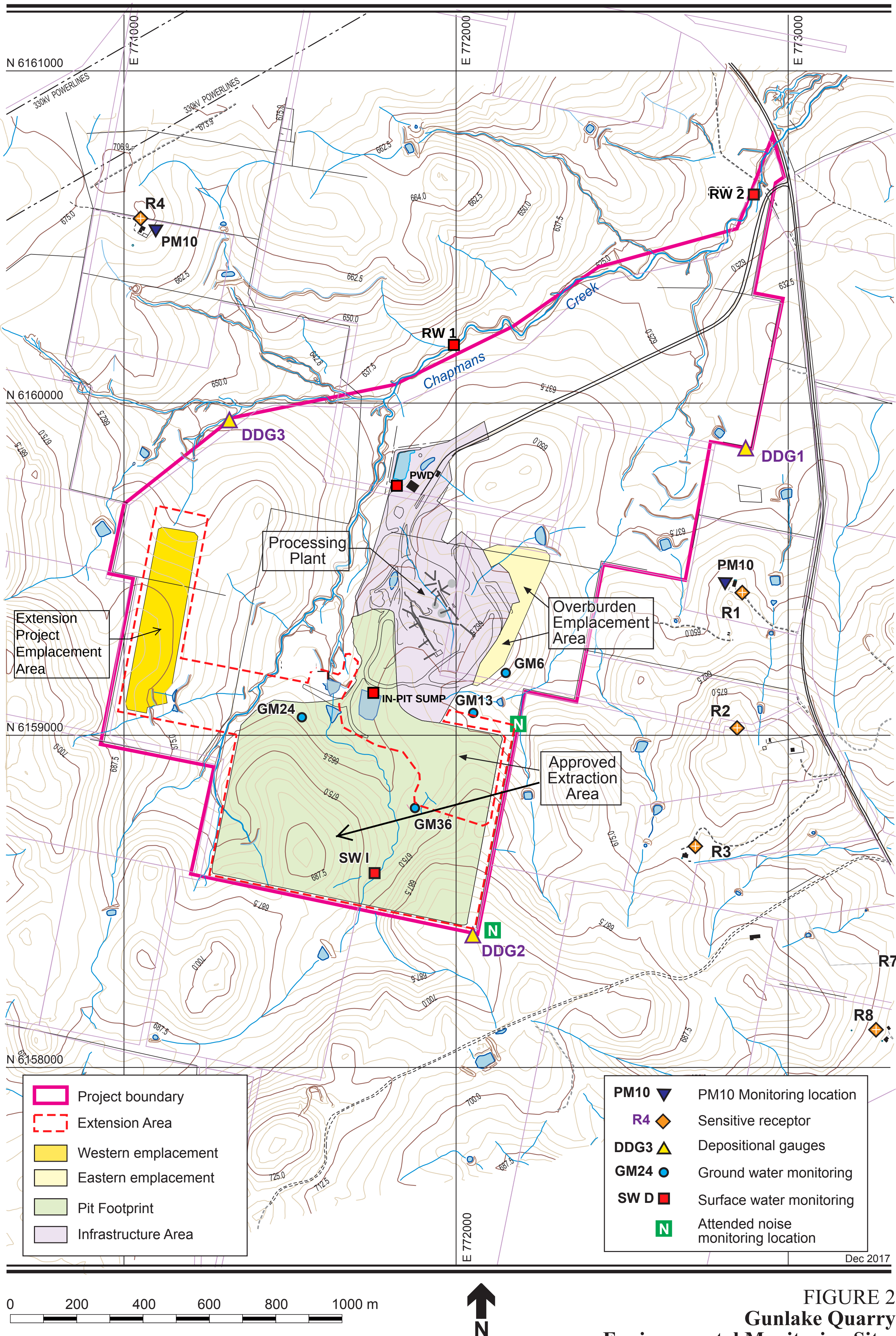


FIGURE 2
Gunlake Quarry
Environmental Monitoring Sites

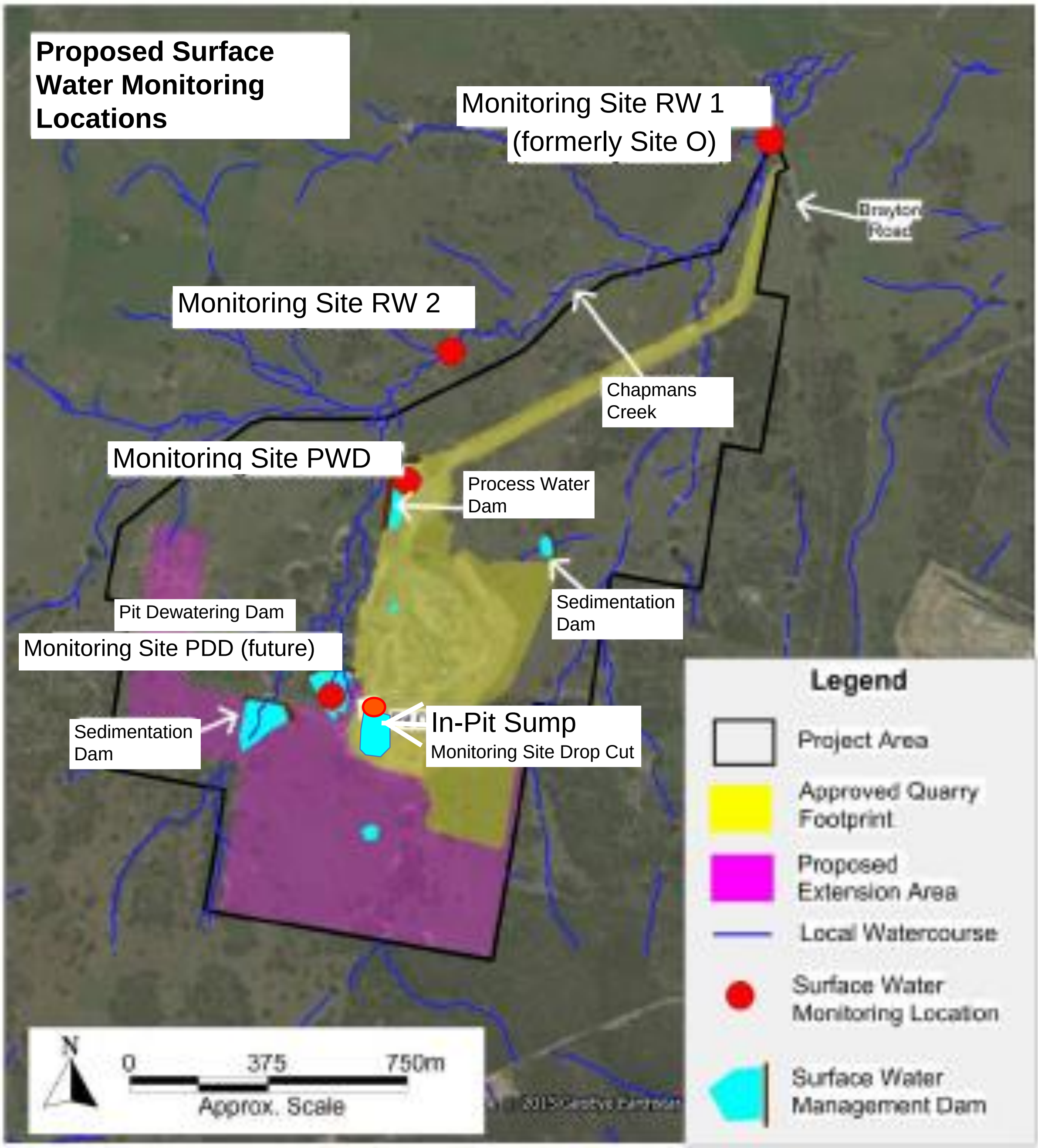


Figure 3: Surface Water Monitoring Locations

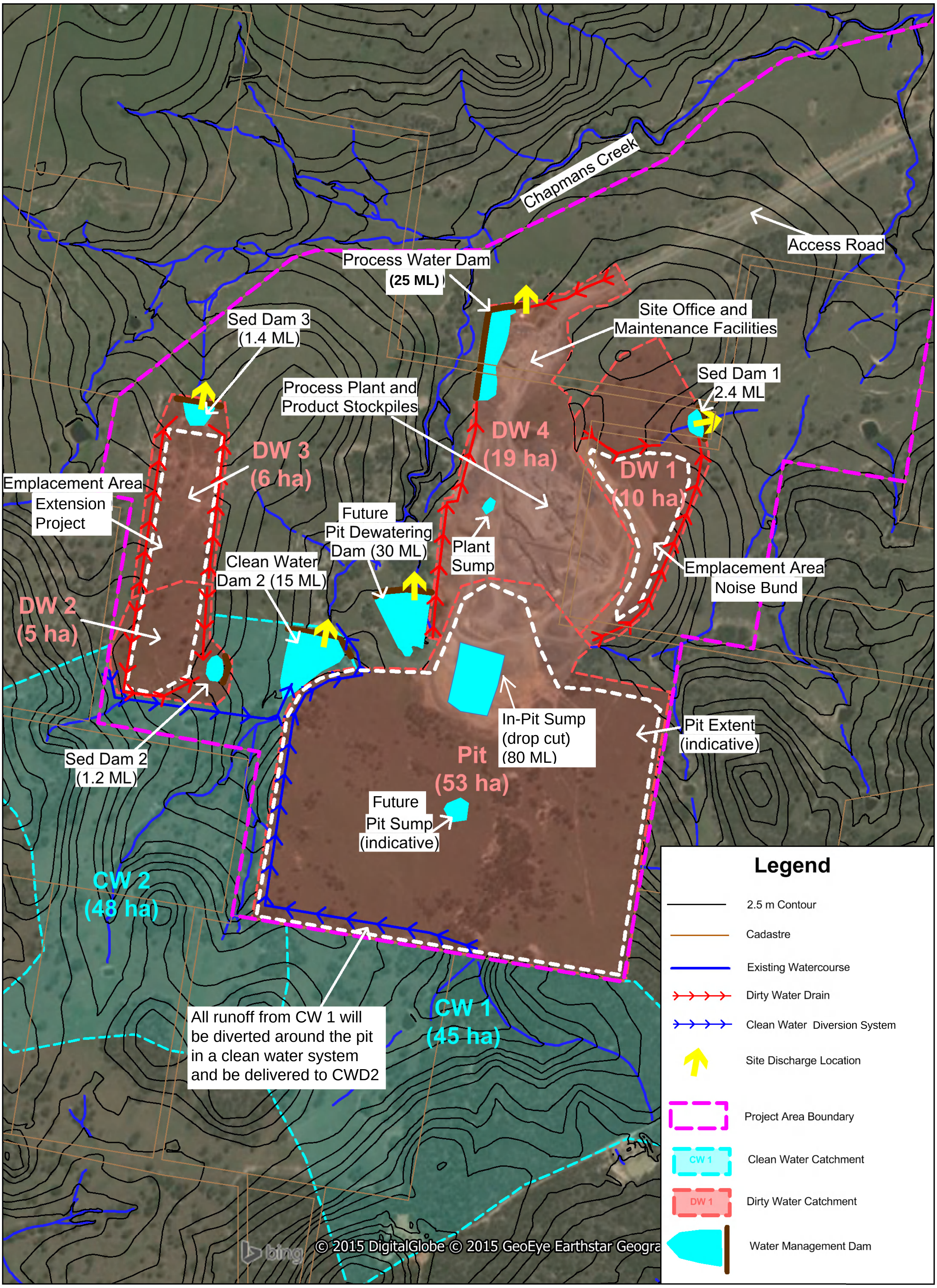


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Figure 4 Quarry Years 10 to 30: Surface Water Management Plan

NORTH

0 100 200m
Approx. Scale

SCALE 1:10,000 PAGE SIZE A4

Disclaimer: While all reasonable care has been taken to ensure the information contained on this map is up to date and accurate, this map contains information from a number of sources - no warranty is given that the information contained on this map is free from error or omission. Any reliance placed on such information shall be the sole risk of the user. Please verify the accuracy of all information prior to using it. This map is not a design document.

FILEPATH I:\Projects\PA1052 - Gunlake Quarry -EIS\E - Technical Data\E13 GIS

Appendix B – Site Water Balance

	Total Runoff (ML/year)	Groundwater Inflows (ML/year)	Water Imports (ML/year)	Total Inflows (ML/year)	Haul Road Dust Suppression (ML/year)	Plant Water Use (ML/year)	Evaporation (ML/year)	Overflows (ML/year)	Dam overflows (ML/year)	Controlled overflows (ML/year)	Total Outflows (ML/year)	Change in Storage over the Year (ML/year)
Approved Operation Typical Dry (10th Percentile) Rainfall Year Annual Rainfall *451 mm/year*	57	0.2	6	63	45	14	14	6	Na	Na	79	-16
Approved Operation Typical Median (50th Percentile) Rainfall Year Annual Rainfall *695 mm/year*	125	0.2	0	125	43	14	18	47	Na	Na	121	4
Approved Operation Typical Wet (90th Percentile) Rainfall Year Annual Rainfall *982 mm/year*	335	0.2	0	335	41	14	37	242	Na	Na	333	2
Quarry Year 1 Typical Dry (10th Percentile) Rainfall Year Annual Rainfall *451 mm/year*	82	0	30	113	73	36	29	Na	1	0	139	-27
Quarry Year 1 Typical Median (50th Percentile) Rainfall Year Annual Rainfall *695 mm/year*	164	0	3	167	69	36	34	Na	15	9	162	5
Quarry Year 1 Typical Wet (90th Percentile) Rainfall Year Annual Rainfall *982 mm/year*	368	0	0	368	66	36	39	Na	104	111	357	11
Quarry Year 5 Typical Dry (10th Percentile) Rainfall Year	95	23	2	120	73	36	32	Na	2	1	144	-24

	Total Runoff (ML/year)	Groundwater Inflows (ML/year)	Water Imports (ML/year)	Total Inflows (ML/year)	Haul Road Dust Suppression (ML/year)	Plant Water Use (ML/year)	Evaporation (ML/year)	Overflows (ML/year)	Dam overflows (ML/year)	Controlled overflows (ML/year)	Total Outflows (ML/year)	Change in Storage over the Year (ML/year)
Annual Rainfall *451 mm/year*												
Quarry Year 5 Typical Median (50th Percentile) Rainfall Year Annual Rainfall *695 mm/year*	183	23	0	206	69	36	38	Na	22	32	196	10
Quarry Year 5 Typical Wet (90th Percentile) Rainfall Year Annual Rainfall *982 mm/year*	393	23	0	415	66	36	42	Na	108	157	410	6
Quarry Years 10 to 30: Typical Dry (10th Percentile) Rainfall Year Annual Rainfall *451 mm/year*	107	34	0	142	73	36	36	Na	3	7	154	-12
Quarry Years 10 to 30: Typical Median (50th Percentile) Rainfall Year Annual Rainfall *695 mm/year*	204	34	0	239	69	36	41	Na	23	62	231	8
Quarry Years 10 to 30: Typical Wet (90th Percentile) Rainfall Year Annual Rainfall *982 mm/year*	426	34	0	461	66	36	45	Na	110	197	455	5

Appendix C – Stakeholder Consultation

From: Ravi Sundaram [mailto:ravi.sundaram@waternsw.com.au]
Sent: Thursday, 22 February 2018 2:12 PM
To: David Kelly <davidkelly@gunlake.com.au>
Cc: Peter Dupen <Peter.Dupen@waternsw.com.au>
Subject: RE: [Fwd: Request ID: #241904 : Gunlake Marulan Quarry - Extension Project MP07-0074, SSD7090, LEC 2017/00108663]

Hello David
Thank you for providing WaterNSW the opportunity to review and comment on the Gunlake Quarry Soil & Water Management Plan (SWMP) prepared to meet the Gunlake Quarry SSD approval conditions.

The quarry is within the Sydney drinking water catchment and located within Chapmans Creek which drains into Joaramin Creek about 1.4 km downstream of the quarry site which in turn drains into Wollondilly River.

WaterNSW in its response to the quarry's Response to Submissions on the Gunlake Quarry State Significant expansion project in 2017 requested that:
The quarry update the Water Management Plan (WMP) and ensure a neutral or beneficial effect on receiving water quality is achieved, and that the updated WMP to include:

- The site water balance
- Surface water management plans
- Soil and water management plans
- The surface and groundwater monitoring programs

WaterNSW also requested that the he existing on-site wastewater management system including effluent disposal to be upgraded to ensure there is adequate capacity for increased wastewater loads generated by the quarry extension

WaterNSW has reviewed the SWMP and considers that the above requirements as well as the requirements in the expansion project approval have been adequately addressed in the updated SWMP. WaterNSW notes that:

- The quarry has been in operation since 2009 and the water management system is now well established and operating in accordance with previous approvals. The updated SWMP therefore focuses on the ongoing management for the existing and future operation of the quarry.
- The quarry essentially operates as a zero water discharge site, has a lack of groundwater available at the site and is completely dependent on rainwater for its operational needs. The quarry water balance and water management therefore aims to maximize water harvesting including collection and treatment of dirty water for reuse in quarry operations. The current water balance projections indicate the quarry will experience water shortages in low rainfall years and will have an excess of water requiring disposal or utilization in high rainfall years.
- As the quarry expands, the ability to store water increases. This in turn enables greater security against water shortfalls in dry years. Therefore the potential for offsite discharge and transfers will reduce over time.
- The upgraded water management system will include a 30ML Pit Dewatering Dam, two sediment control dams covering the new emplacement area, an in-pit sump, a new clean water diversion channel running along the extent of the final pit limit which will deliver water to the existing clean water dam, expansion of the existing Process Water dam to increase capacity to 35ML, and a new creek crossing on Chapmans Creek to be designed as a culvert with the capacity to convey peak flow from a one in 100 year critical duration storm event.
- Runoff from dirty water catchments will be collected in either the Process Water Dam, the Pit-Dewatering Dam, pit sump or the various sedimentation dams.

- The current operation of the quarry has approval to use an irrigation area to dispose excess treated water in high rainfall years.
- The Quarry has modified the existing surface water monitoring program with addition of two additional receiving water sites on Chapmans Creek downstream of the quarry and monitoring at the proposed Process Water Dam and Pit Dewatering Dam.
- A Groundwater Management Plan with inclusion of a groundwater monitoring program which includes a set of monitoring targets, assessment criteria and trigger levels for investigating potential adverse impacts from quarrying operations on the groundwater system.
- A council approved septic wastewater disposal system including a primary collection tank and an absorption trench system which meets the needs of the quarry's current and future operations.

WaterNSW has also reviewed the Gunlake Quarry 2016-2017 Annual Review report and is satisfied that the quarry's current soil and water management structures operation and maintenance has not resulted in any water quality incident.

WaterNSW also notes that much of Chapmans Creek (an ephemeral creek) upper reaches within the quarry site are dry and water is seen to flow only after significant rainfall events. The quarry's operation as a zero discharge site and proposed implementation of water harvesting and reuse, new soil and water management structures and operational management detailed in the SWMP will result in a neutral or beneficial effect on the water quality of receiving waters. There is significant surface and groundwater monitoring baseline data and the quarry's operations since 2009 have not seen any significant adverse trends in water quality downstream of the quarry operations. The proposed surface and groundwater monitoring program to be implemented including the TARPS are considered adequate. The new water management structures will be implemented in a phased manner as the quarry operations expand and future annual review plans will report on the effectiveness of soil and water management measures proposed.

WaterNSW requests to be provided a copy of the updated and approved SWMP and future copies of the Annual reports for review.

Please contact me if you wish to discuss any matter raised above.
Regards.

Ravi
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From: WaterNSW Helpdesk [mailto:customer.helpdesk@statewater.com.au]
Sent: Friday, 2 February 2018 4:19 PM
To: water.wrg.hssc@dpi.nsw.gov.au; Salim Vhora; Alison Kniha

Subject: [Fwd: Request ID: #241904 : Gunlake Marulan Quarry - Extension Project MP07-0074, SSD7090, LEC 2017/00108663]

Good afternoon

For your actioning please.

Thanking you

Tracy

Tracy White
Customer Service Officer

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Status : Open Priority : Normal Mode: E-Mail

Category : Environmental Management - Sub Category: Customer Enquiry - Item: General

Account : Unknown

Contact Name : Kelly, David PH: MOB: 0437545732

Contact Email : davidkelly@gunlake.com.au

Description :

Dear Sir/Madam,

Please find attached our draft Soil & Water Management Plan for your comment, as required by our consent Ref MP07-0074, SSD7090, LEC 2017/00108663 (copy attached).

This is an update to the site's currently approved plan and takes into account the new conditions of consent for the quarry extension project.

Can you please provide your feedback within 2 weeks. If no feedback is received by then we will proceed on the basis that the updated plan has satisfied your requirements.

Thanks & regards,

David Kelly

Head of Development

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