3 SURFACE AND GROUNDWATER ENVIRONMENT

3.1 CATCHMENT DESCRIPTION

Peppertree Quarry is located within the Shoalhaven River Catchment in the Southern Tablelands of New South Wales. The Quarry is situated toward the edge of a plateau and adjacent to steep gullies that plunge into the ravine of the Barbers Creek system.

Barbers Creek is the primary receiving watercourse for any discharges or runoff from the site. Barbers Creek is a tributary of the Shoalhaven River (a drinking water supply) and is located immediately to the east of the quarry. The overall quarry resource area intersects three small catchments, two of which drain northwards to Tangarang Creek. Tangarang Creek is an ephemeral creek which has a catchment area of approximately 753 ha to the north-western corner of the quarry and flows into Barbers Creek that subsequently flows southward to meet the Shoalhaven River.

The land is mainly open grassland with a few scattered clumps of trees. Slopes range from less than 1% on the ridge line to about 20% near the drainage lines. The catchments are generally gently undulating and have been substantially cleared for agricultural uses, predominantly grazing.

3.2 CLIMATE

3.2.1 Rainfall

Collection of continuous weather records at the Quarry commenced in 2005/6. However, the Bureau of Meteorology (BoM) daily rainfall records provide a more comprehensive record of the long term climate of the area. Table 3.1 provides the rainfall statistics for daily rainfall records (1883 – 2014), sourced primarily from the BoM weather station at Marulan (George St) (BoM Stn No 70063), while Figure 3.1 provides the monthly statistics graphically.

Table 3.1: Rainfall Statistics for Combined Rainfall Record

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average	70	70	69	53	51	63	48	45	47	59	59	63	696
Minimum	0	0	0	0	0	0	0	0	0	1	0	0	288
5%ile	8	3	4	3	4	6	7	5	14	8	5	2	418
Median	62	55	49	41	31	41	32	33	39	48	51	53	669
95%ile	172	178	190	142	148	189	146	132	105	142	126	160	1,065
Maximum	262	298	330	233	406	406	319	224	197	263	248	204	1,469

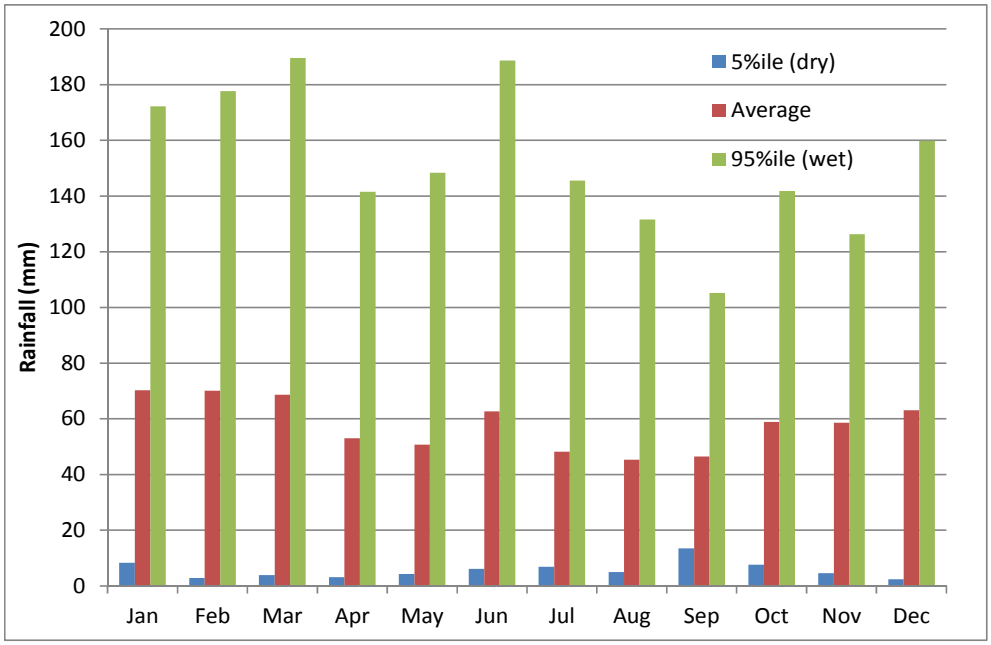


Figure 3.1: Monthly Rainfall Analysis (1883 - 2014)

The statistics show that average annual rainfall in the vicinity of the Quarry is approximately 696 mm. Peak precipitation occurs in the summer months, with lower rainfall in winter. On average, January and February are the wettest months of the year and August is the driest.

3.2.1.1 Rainfall Intensity

For purposes of assessing the required capacity of structures to convey peak flows, BoM 2013 rainfall frequency- duration-depth data has been used. Relevant aspects of this data applicable to the design of site water conveyance structures is summarised in Table 3.2.

Table 3.2: Rainfall Frequency / Duration / Depth (mm) Data for Marulan South

Duration	Annual Exceedance Probability (AEP)					
	0.5	0.2	0.1	0.1	0.02	0.01
5 min	6.3	8.5	10.1	11.7	13.8	15.5
10 min	9.9	13.6	16.3	19.0	22.7	25.6
15 min	12.2	16.9	20.2	23.6	28.2	31.9
30 min	16.4	22.4	26.7	31.0	36.9	41.5
1 hour	20.7	27.8	32.8	37.8	44.6	49.9
2 hour	25.9	34.2	40.0	45.8	53.6	59.8
3 hour	29.7	39.1	45.6	52.2	61.0	68.0

3.2.1.2 Five Day Rainfall

Sediment basins have been sized to comply with the requirements for capture of fine and dispersive sediments as set out in Table 6.1 of *Managing Urban Stormwater: Soils and Construction: Volume 2E Mines and Quarries* (DECC, 2008). The table specifies the adoption of the 95th percentile rainfall as the basis for sizing sediment basins that would overflow into 'sensitive' environments. Table 3.3 lists the 95th percentile rainfall depths for various durations for Mittagong and Goulburn (as set out in Table

6.3 of *Managing Urban Stormwater: Soils & Construction – Volume 1)*. The value for Marulan South has been derived on the basis of the relative proximity of the Quarry to Mittagong and Goulburn.

Table 3.3: 95th Percentile Rainfall Depths

Duration (days)	Mittagong (mm)	Goulburn (mm)	Marulan South (mm)
2	49.1	27.4	35.0
5	75.2	40.8	52.8
10	110.4	60.8	78.2
20	164.6	97.1	120.7

3.2.2 Evaporation

Mean daily evaporation data for the period 1971 to 2016 at BoM Station Goulburn TAFE (Stn No 070263) is provided in Table 3.4.

Table 3.4: Mean Daily Evaporation (mm) - Goulburn TAFE (Stn No 070263)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
6.3	5.2	4.0	2.5	1.6	1.1	1.2	1.9	2.8	3.9	5.0	6.1	3.5

3.3 GROUNDWATER

3.3.1 Hydrogeological Environment

Hydrogeological and hydrochemical assessments carried out for the Environmental Assessment (ERM, 2006) indicate that the granodiorite unit comprises a low-yielding fractured aquifer with groundwater occurring in localised, discrete and potentially discontinuous fracture zones. The most significant of these zones comprises the water table at the weathered horizon between the overburden and the more competent, underlying granodiorite approximately 15 to 30 m below ground.

No evidence was found for significant vertical or lateral connection between the various fracture zones. Recharge of groundwater was predicted to occur via direct infiltration where fractures and weathered bedrock is exposed or covered by only a thin layer of overburden. Annual average recharge rates were predicted to be 90 mm/y.

A groundwater gradient of 0.02 m/ m occurs across the majority of the site, dipping in a north-easterly direction to discharge in the gorges and creeks surrounding the resource area. The exception to this is the mound of groundwater with a steeper gradient (0.12 m/m) at the south of the resource area resulting from the permeability contrast between the granodiorite and limestone formations.

Groundwater migration rates across the site were calculated at 0.95 m/y with discharge rates of 0.013 m^3/day/m of exposed fracture zone, indicating a very low rate of groundwater migration.

3.3.2 Groundwater Use

A total of 30 registered wells are located within a 5 km radius of the Quarry, based on the DNR database of registered bores. Of these, 21 wells are located between 4 and 5 km from the Quarry and 11 wells are located on the opposite side of the Barbers Creek gorge which acts as a physical hydraulic barrier between the Quarry and the wells. Three wells are located within 2 km of the site, two of which are located on the opposite side of Barbers Creek gorge and therefore not in hydraulic connection with the quarry. One well has been identified approximately 1.5 km to the west of the site and may potentially be affected by quarry operations.

4 WATER QUALITY

4.1 BASELINE SURFACE WATER QUALITY

4.1.1 Location of Monitoring Sites

Boral has implemented a comprehensive surface water quality monitoring program in accordance with the requirements of CoA 29, with water quality monitoring at Tangarang Creek having been conducted since February 2012 and Barbers Creek since September 2014. The surface water sites relevant to this WMP are listed in Table 4.1 and the locations of the sites shown on Figure 4.1.

Table 4.1: Routine Creek Water Quality Monitoring Sites and Locations

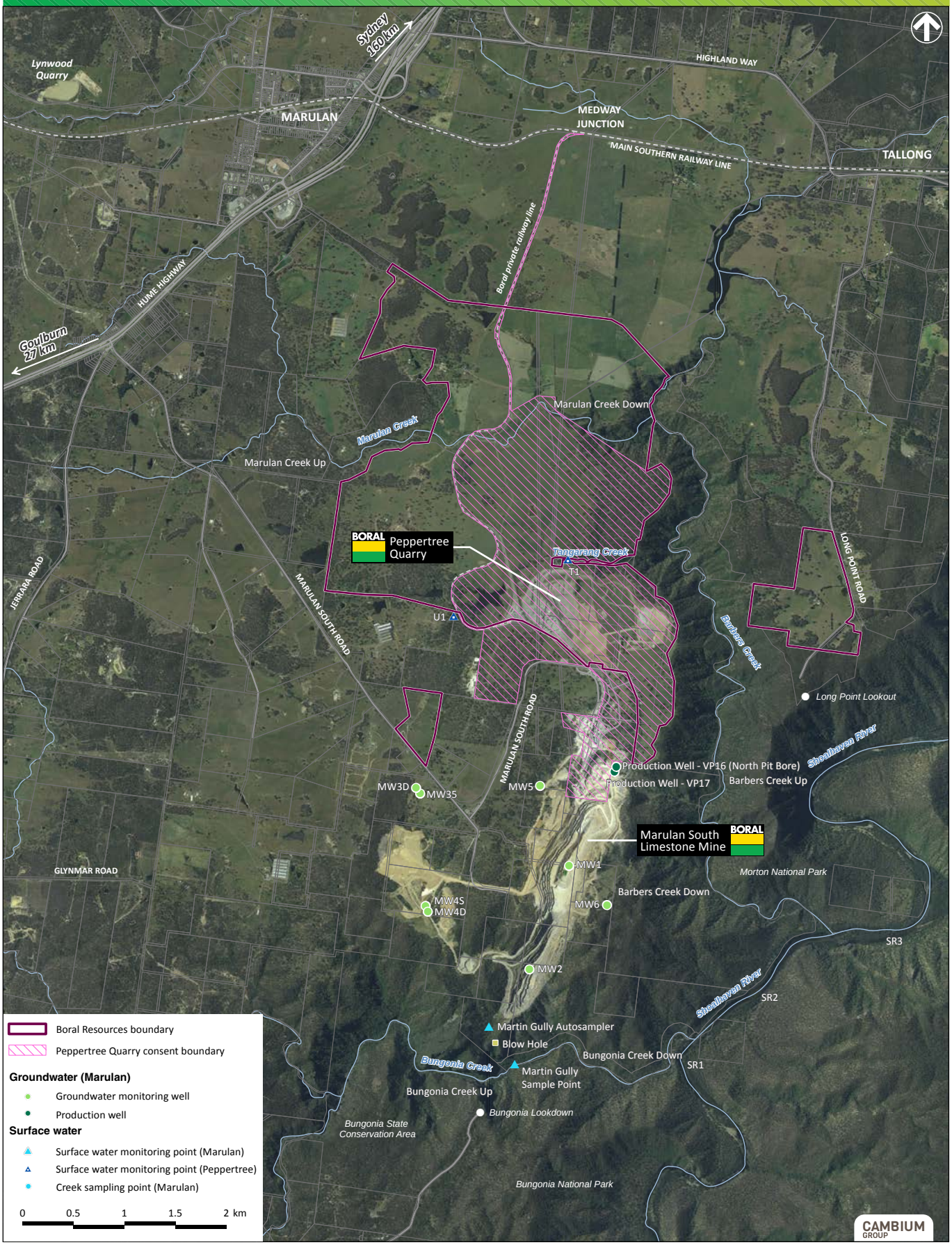
Site	Description	Easting	Northing	Commencement of monitoring	Monitoring Frequency
U1	Tangarang Creek upstream of Main Dam	226950	6149970	Feb 2012	quarterly
T1	Tangarang Creek downstream of Main Dam	228730	6150550	Feb 2012	quarterly
Marulan Up	Marulan Creek upstream of potential future dam	225825	6151504	Nov 2014	Monthly till 2017 now quarterly
Marulan Down	Marulan Creek downstream of potential future dam	228002	6151977	Nov 2014	Monthly till 2017 now quarterly
Barbers Up	Barbers Creek	229518	6148416	Sep 2014	Monthly till 2017 now quarterly
Barbers Down	Barbers Creek	229542	6147306	Sep 2014	Monthly till 2017 now quarterly

Table 4.1 includes two monitoring locations on Marulan Creek, which is a tributary of Barbers Creek located to the north of Tangarang Creek. Marulan Creek provides additional data to supplement that obtained for Barbers Creek and Tangarang Creek. It is appropriate for inclusion in the baseline water quality analysis as the catchment landform and landuse is similar to that of the Tangarang Creek catchment and it exhibits runoff quality typical of the open grazing land on the plateau to the west of Barbers Creek from which both Marulan Creek and Barbers Creek drain.

Boral Limited
Build something great™

BORAL®

Figure 4.1
Surface water and groundwater monitoring sites
Water Management Plan / Peppertree Quarry



DISCLAIMER
Cambium Group Pty Ltd disclaims all liability for all claims, expenses, losses, damages, and costs any person/company may incur as a result of their /its reliance on the accuracy or completeness of this document or its capability to achieve any purpose. © Cambium Group Pty Ltd 2017

031119_WMP_F4-1_170404_v03

4.1.2 Analytes Monitored

The suite of parameters analysed for each water quality sample is listed in Table 4.2.

Table 4.2: Water Quality Analytes

Field Analysis		
Dissolved oxygen (mg/L)	Electrical conductivity (µS/cm)	Oil and Grease
Turbidity (Water Quality Meter)	pH (field)	
Laboratory Analysis		
Total Dissolved Solids (mg/L)	Potassium (K+)	Bicarbonate (HCO_{3-})
Total Suspended Solids (mg/L)	Magnesium (Mg2+)	Nitrate (NO_{3-})
Turbidity – Laboratory (NTU)	Sodium (Na+)	Nitrite (NO_{2-})
TPH C10-C36	Ammonia (NH4+)	Total Nitrogen (TN)
Benzo[a]pyrene	Chloride (Cl-)	Total Phosphorous (TP)
Naphthalene	Sulphate (SO42-)	Faecal coliforms (cfu/100 mL)
Calcium (Ca2+)		

All data in measured in µg/L unless otherwise specified.

More details on the surface water quality monitoring regime are provided in Section 7.1.

4.1.3 Creek Water Quality

Table 4.3 contains key water quality statistics from the various monitoring locations in the vicinity of the Quarry for the period to December 2016. The relevant ANZECC default trigger values for ecosystem protection (upland rivers) are also provided in Table 4.3 for comparison purposes.

Refer Section 7.1 for further discussion on the surface water quality trigger values adopted for the WMP based on the statistics presented in Table 4.3.

Table 4.3: Summary of Creek Water Quality Statistics

Analyte	Unit	Statistic	Marulan Up	Marulan Dn	Tangarang Up (U1)	Tangarang Down (T1)	Barbers Up	Barbers Dn	SR 1	SR 2	SR 3	ANZECC* Default
pH	pH	Count	22	22	6	30	23	23	25	25	25	6.5 - 7.5
		20%ile	7.6	7.9	7.2	7.7	7.8	7.9	7.3	7.2	7.2	
		Median	7.8	8.0	7.4	7.9	8.0	8.1	7.4	7.4	7.4	
		80%ile	7.9	8.2	7.7	8.0	8.1	8.1	7.5	7.5	7.5	
Electrical** Conductivity @ 25°C	µS/cm	Count	22	22	6	30	23	23	25	24	25	30 – 350
		20%ile	480	650	214	356	414	446	84	89	94	
		Median	1015	888	249	654	509	550	102	103	108	
		80%ile	1,536	1,154	288	813	741	782	121	120	121	
Total Nitrogen as N	mg/L	Count	22	22	0	0	23	23	25	25	25	0.25
		20%ile	0.62	0.42			0.3	0.3	0.30	0.20	0.30	
		Median	0.85	0.65			0.40	0.50	0.50	0.40	0.50	
		80%ile	1.10	0.80			0.60	0.60	0.62	0.52	0.62	
Total Phosphorus as P	mg/L	Count	22	22	6	30	23	23	25	25	25	0.02
		20%ile	0.02	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	
		Median	0.04	0.02	0.12	<0.01	<0.01	<0.01	0.01	0.01	0.01	
		80%ile	0.09	0.05	0.34	0.07	0.03	0.04	0.03	0.02	0.02	

* ANZECC Default Trigger Value for ecosystem protection, South East Australia, slightly disturbed ecosystems in upland rivers,

** EC values for U1 and T1 have been calculated from TDS results using a conversion factor of 0.65.

4.2 SURFACE WATER FLOWS

CoA 29 of the Project Approval requires that "*the Surface Water Monitoring Program must include detailed baseline data on surface water flows and quality in Tangarang Creek and Barbers Creek.*"

Section 4.1 summarises the baseline surface water quality data collected for Tangarang Creek and Barbers Creek.

However, Surface water flow in Barbers Creek is not monitored, as the creek is located in steep inaccessible terrain unsuitable for the installation of flow gauging equipment. Therefore no baseline surface water data can be provided for Barbers Creek.

Baseline surface water flow data in Tangarang Creek was not collected prior to the commencement of operations at Peppertree Quarry, as there was no means of measuring flow until a V-Notch weir was constructed below the Main Dam as part of the development of the Quarry. Continuous surface water flows (environmental flows) downstream of the Quarry have been monitored at the weir on Tangarang Creek since January 2015. Analysis of the Tangarang Creek environmental flows for the period January 2015 to December 2016 is provided in Section 7.2.2.

4.3 BASELINE GROUNDWATER QUALITY

As part of the groundwater investigations undertaken for the EA (ERM, 2006) groundwater samples were collected from boreholes P12, P34, P39, DDH04, and from the existing domestic water supply well (W1) located on site. These sampling locations are shown on Figure 4.3.

Field parameters including temperature, DO, EC, pH and Oxidation-Reduction Potential (ORP) were recorded during the groundwater sampling. The results of the sampling are provided in Table 4.4.

Table 4.4: Field Groundwater Quality Parameters

Well ID	Sampling Date	Temperature ^{0}C	Dissolved Oxygen (mg/L)	EC (µS/cm)	pH	ORP (mV)
DDH04	11/11/05	15.8	3.70	548	7.08	+11
P34	11/11/05	15.5	4.94	3650	7.16	-236
P39	10/11/05	16.4	5.23	2,830	7.00	+193
P12	10/11/05	16.6	1.83	1,632	7.14	+58
W1	11/11/05	19.4	6.34	1,972	6.99	+46

Source: Marulan South Quarry Environmental Assessment Report (ERM, 2006)

Table 4.4 indicates that EC values ranged from fresh (550 µS/cm, DDH04) in the deeper sections of the aquifer to brackish (3,650 µS/cm, P34) in the pegmatite unit. Total Dissolved Solids (TDS) ranged from 370 mg/L (DDH04) in the deepest groundwater sample to 2,240 mg/L (P39). A plot of EC and TDS versus aquifer depth indicates that both generally decrease with depth, indicating that fresh groundwater is present at depth (Figure 4.2).

Groundwater pH was relatively neutral with samples ranging from 6.99 (W1) to 7.16 (P34), indicating natural groundwater influenced by water-rock interaction. ORP values ranged from oxidising (+193 mV, P39) to reducing (-234 mV, P34) in the pegmatite unit.

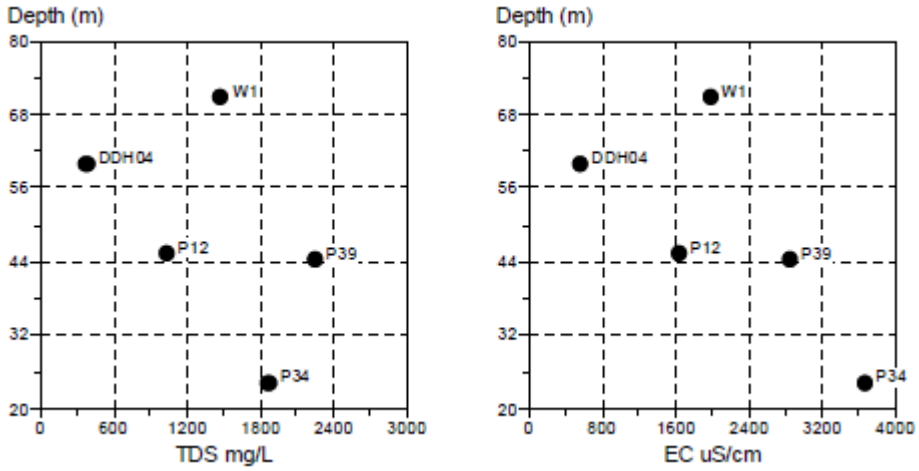


Figure 4.2: TDS and EC vs Depth

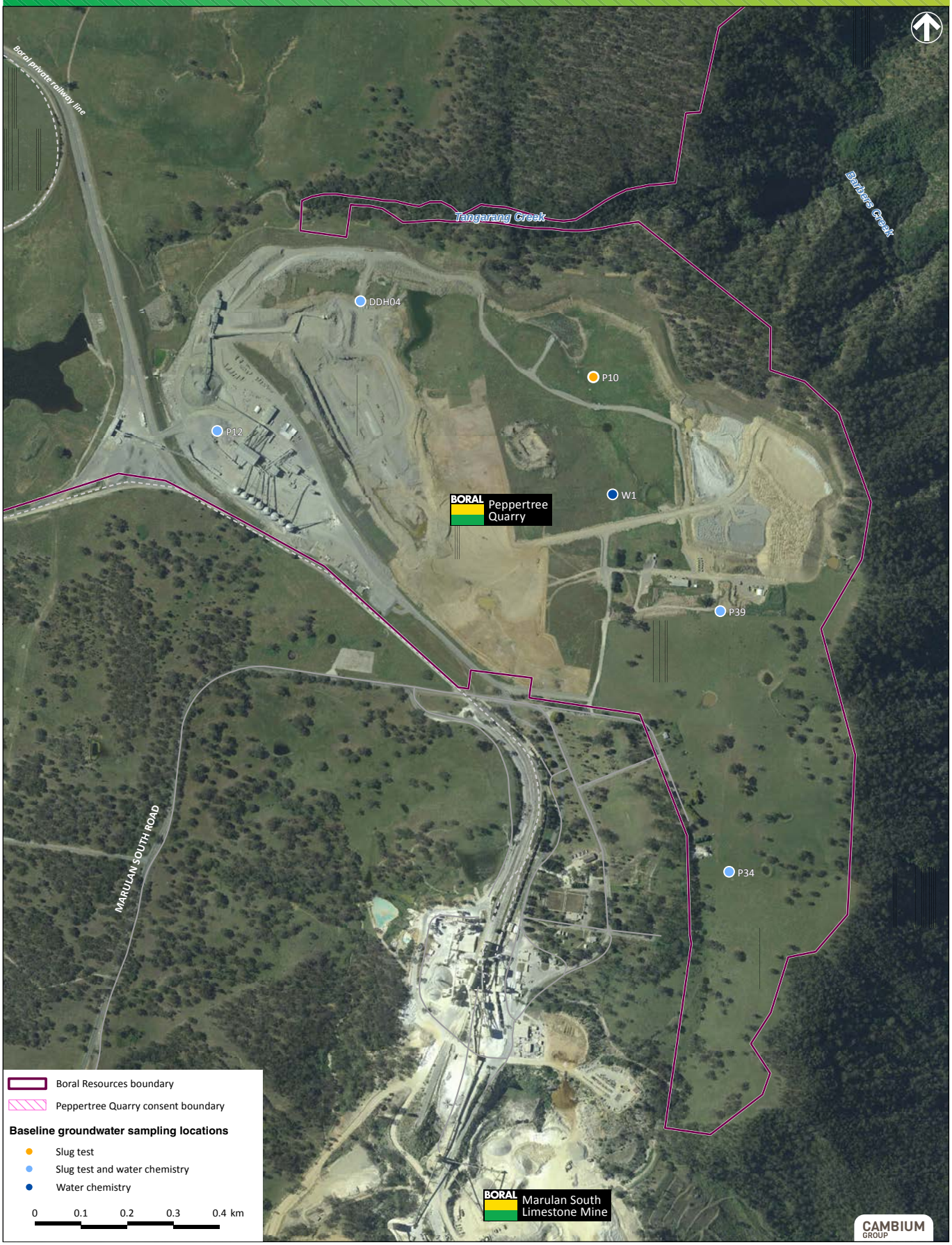
The groundwater samples were analysed for dissolved metals and the observed concentrations were assessed with reference to the ANZECC (2000) guideline values for 95% protection level for a fresh water ecosystem protection as shown in Table 4.5. The concentrations of most dissolved metals in the groundwater samples obtained from the granodiorite and the pegmatite indicated that these waters are slightly elevated with respect to the ANZECC (2000) guideline values.

Major cations and anions were analysed to delineate different hydrochemical water types. The concentrations of the major ions were found to be moderately elevated; suggesting water-rock interactions that are generally characteristic of local to intermediate groundwater systems (e.g. limited groundwater residence time relative to typical regional groundwater flow systems in similar lithologies).

Boral Limited
Build something great™

BORAL®

Figure 4.3
Baseline groundwater sampling locations
Water Management Plan / Peppertree Quarry



DISCLAIMER
Cambium Group Pty Ltd disclaims all liability for all claims, expenses, losses, damages, and costs any person/company may incur as a result of their /its reliance on the accuracy or completeness of this document or its capability to achieve any purpose. © Cambium Group Pty Ltd 2017

CAMBIUM GROUP

031119_WMP_F4-3_170410_v01

Table 4.5: Major Groundwater Ions and Metals

		TDS	Calcium	Magnesium	Sodium	Potassium	Sulphide	Chloride	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Zinc	Iron	Manganese
EQL		1	0.1	0.1	0.1	0.1	2	1	0.001	0.0001	0.001	0.001	0.001	0.0001	0.001	0.005	0.05	0.001
ANZECC 2000 95%									0.024	0.0002	0.001	0.0014	0.0034	0.0006	0.011	0.008		1.9
Sample ID	Date																	
P39	10-11-05	2240	212	220	190	9.9	60	1020	<0.001	0.0002	0.003	0.009	<0.001	<0.0001	0.011	0.056	0.12	0.086
P12	10-11-05	1030	119	67	130	3.4	27	340	0.001	0.0001	<0.001	0.004	<0.001	<0.0001	0.003	0.012	0.08	0.180
W1	10-11-05	1470	140	114	152	4.3	44	470	0.001	<0.0001	<0.001	0.001	<0.001	<0.0001	0.002	0.011	0.34	0.350
01011-1	10-11-05	1490	141	115	152	4.3	44	480	<0.001	<0.0001	<0.001	<0.001	<0.001	<0.0001	0.002	0.007	0.31	0.360
DDH04	11-11-05	370	48	29	48	4.1	4	38	0.001	0.0002	0.002	0.004	0.006	<0.0001	0.003	0.016	0.2	0.330
P34	11-11-05	1860	289	90	190	58	4	38	0.009	<0.0001	0.002	0.003	0.001	0.0003	0.008	0.025	0.51	1.820
Statistics																		
Average		1410	158.2	105.8	143.7	14	30.5	397.7	0.002	0.00017	0.001	0.004	0.002	0	0.005	0.021	0.26	0.521
Std Dev		652.3	82.84	64.57	52.48	21.69	23.03	363.7	0.003	5.8E-05	0.001	0.003	0.002	0	0.004	0.018	0.159	0.646
95% UCL		2483	294.4	212	230	49.67	68.38	995.9	0.008		0.003	0.009	0.005		0.011	0.051	0.522	1.583

Source: Marulan South Quarry Environmental Assessment Report (ERM, 2006)

Note: red font indicates Guideline criteria exceeded.

In 2015, a more comprehensive network of groundwater wells was installed.

The regional groundwater monitoring network comprises eight locations: eight deep piezometers and four shallow piezometers as outlined in Table 4.6 and shown in Figure 4.1. Quarterly monitoring of the groundwater network commenced in 2016 with four rounds completed prior to the commencement of below water table mining in late 2016. It is considered that these four rounds of data are representative of baseline conditions, as no impacts to groundwater flow have been observed as a result of mining activities during this period of monitoring.

Table 4.6: Groundwater Monitoring Network

Location	Easting	Northing	Depth (m)	Location	Comment
PQ01S	228788.200	6149364.768	25	South of quarry	Dry
PQ01D	228783.234	6149374.990	100	South of quarry	Monitors water flowing towards pit
PQ03	228287.593	6149608.358	100	South of quarry	Monitors water flowing towards pit
PQ04S	227607.030	6149950.634	15.7	West of quarry	Shallow groundwater
PQ04D	227625.617	6149946.868	103	West of quarry	Flow of groundwater towards pit
PQ05	227423.409	6149780.299	100	West of quarry	Sentinel bore
PQ06	227796.309	6150246.769	100	West of quarry	Located adjacent to pit entry ramp
PQ07	228654.336	6150385.320	101	North of quarry	Regional water flow
PQ08S	228941.804	6150143.768	30	North of quarry	Dry
PQ08D	228931.821	6150145.926	100	North of quarry	Downgradient monitoring
PQ09S	229132.282	6149729.457	66	East of quarry	Shallow groundwater
PQ09D	229120.479	6149710.338	100	East of quarry	Downgradient monitoring

All piezometers were installed into granitic bedrock that Boral quarries at Peppertree.

Figure 4.4: Groundwater FlowFigure 4.4 depicts the deep groundwater flow in May 2016 which indicates that groundwater is flowing towards the east. Shallow groundwater appears to be localised and perched with two of the four shallow piezometers being dry since initial installation.

Figure 4.4

Groundwater flow

Water Management Plan / Peppertree Quarry

RPS

Level 2, 27-31 Troode Street | West Perth | T +61 8 9211 1111 | F +61 8 9211 1122 | www.rpsgroup.com.au

Table 4.7 provides a statistical review of the water level data from the 2016 monitoring rounds for each piezometer (excluding PQ01S and PQ08S which were both dry during the 2016 monitoring period). The majority of the piezometers show relatively stable groundwater levels as evidenced by the low standard deviations.

Table 4.7: 2016 Groundwater Level Statistics

Location	Maximum SWL (m AHD)	Minimum SWL (m AHD)	Average SWL (m AHD)	Standard Deviation
PQ01D	574.05	576.19	574.66	1.38
PQ03D	570.92	576.90	573.18	2.29
PQ04S	590.22	590.69	590.48	0.17
PQ04D	584.05	585.94	585.02	0.66
PQ05D	591.83	592.15	591.95	0.13
PQ06D	568.01	580.69	577.03	5.22
PQ07D	572.66	574.51	573.99	0.34
PQ08D	575.27	575.86	575.54	0.24
PQ09S	574.98	575.22	575.09	0.10
PQ09D	575.96	576.27	576.06	0.13

Water quality samples were collected during each quarterly monitoring event in 2016. Field parameters were collected and samples sent to the laboratory for analysis of major cations and anions, nutrients and a suite of organic analytes (oil and grease, polycyclic aromatic hydrocarbons, total recoverable hydrocarbons and volatile aromatic hydrocarbons i.e. BTEX).

Table 4.8 provides the statistical analysis of the field chemistry data for the 2016 groundwater monitoring period. The results for pH, electrical conductivity (EC) and dissolved oxygen (DO) are presented.

Table 4.8: Field Chemistry Statistics

Location	Parameter	Maximum	Minimum	Average	Standard Deviation
PQ01D	pH	11.78	9.10	10.44	1.30
	EC	4,318	3,560	4,043	332
	DO	3.8	0.6	1.36	0.60
PQ03D	pH	12.87	12.55	12.67	0.15
	EC	5,770	4,208	4,679	731
	DO	2.73	0.85	1.66	0.78
PQ04S	pH	7.91	7.01	7.41	0.45
	EC	4,535	2,520	3,077	973
	DO	4.06	1.73	2.49	1.06
PQ04D	pH	8.49	6.24	7.46	1.14
	EC	1,187	1,040	1,094	81
	DO	6.01	2.78	4.64	1.67

Location	Parameter	Maximum	Minimum	Average	Standard Deviation
PQ05D	pH	8.04	7.11	7.68	0.41
	EC	1,917	1,655	1,761	121
	DO	1.78	0.25	0.84	0.66
PQ06D	pH	12.63	12.25	12.42	0.16
	EC	3,730	3,257	3,429	207
	DO	1.49	0.61	1.10	0.45
PQ07D	pH	12.48	11.9	12.16	0.30
	EC	4,070	1,777	2,579	1,017
	DO	2.82	0.77	1.85	0.90
PQ08D	pH	7.64	7.08	7.33	0.24
	EC	3,718	2,720	3,051	457
	DO	5.97	0.8	2.85	2.38
PQ09S	pH	7.97	7.03	7.37	0.41
	EC	3,596	1,902	2,719	6,93
	DO	4.76	1.71	3.21	1.29
PQ09D	pH	8.39	7.22	7.59	0.54
	EC	1,734	1,473	1,623	118
	DO	7.9	0.96	2.92	3.33

Notes: Units - EC is in µs/cm / DO is in mg/L

The following observations can be made:

- pH is slightly alkaline to highly alkaline across the site with pH over 10.00 common (PQ01D, PQ03D, PQ06D and PQ07D). The elevated pH is considered to be due to natural water-rock interactions associated with weathering granitic rock profiles.
- Electrical conductivity ranges from brackish to saline with concentrations generally between 1,000 µs/cm and 6,000 µs/cm.
- Average dissolved oxygen has typically ranged from around 1 to 5 mg/L. Dissolved oxygen levels have become more stable as the monitoring program has matured.

Table 4.9 provides a statistical assessment of key parameters from the laboratory analysis. This dataset was utilised to develop the trigger levels presented in Section 7.3. Figure 4.5 presents a piper diagram of laboratory results from May 2016. The key findings from the interpretation of the laboratory analysis from 2016 were:

- Due to poor yields, development of the bores was difficult. As a result, early monitoring rounds had multiple detections of organic analytes which were identified as likely being associated with drilling and piezometer installation activities. Concentrations reduced over the course of 2016 with the November 2016 monitoring round showing no detectable concentrations of petroleum hydrocarbons and other organic analytes tested.
- Nitrogen species (TKN, nitrate, nitrite, Total Nitrogen) were identified variably across the site up to approximately 5 mg/L and has been interpreted to be associated with the farming activities present currently and historically on site as well as to the west and south of the Quarry.

- Total Phosphorous is also slightly elevated across the site (up to 1 mg/L) for the same reasons as for the nitrogen species.
- The piper diagram (Figure 4.5*)* indicates that groundwater is dominated by chloride along with bicarbonate and carbonate (pH dependent with carbonate present as pH rises).
- The cations are less dominated by one ion with a trend towards sodium/potassium being dominant.
- The anions are also not dominated by one ion although there is a slight trend towards chloride.
- The presence of sodium and chloride indicate a likely rainwater source with potassium and alkalinity being impacted upon by water-rock interactions, particularly where active weathering is occurring.

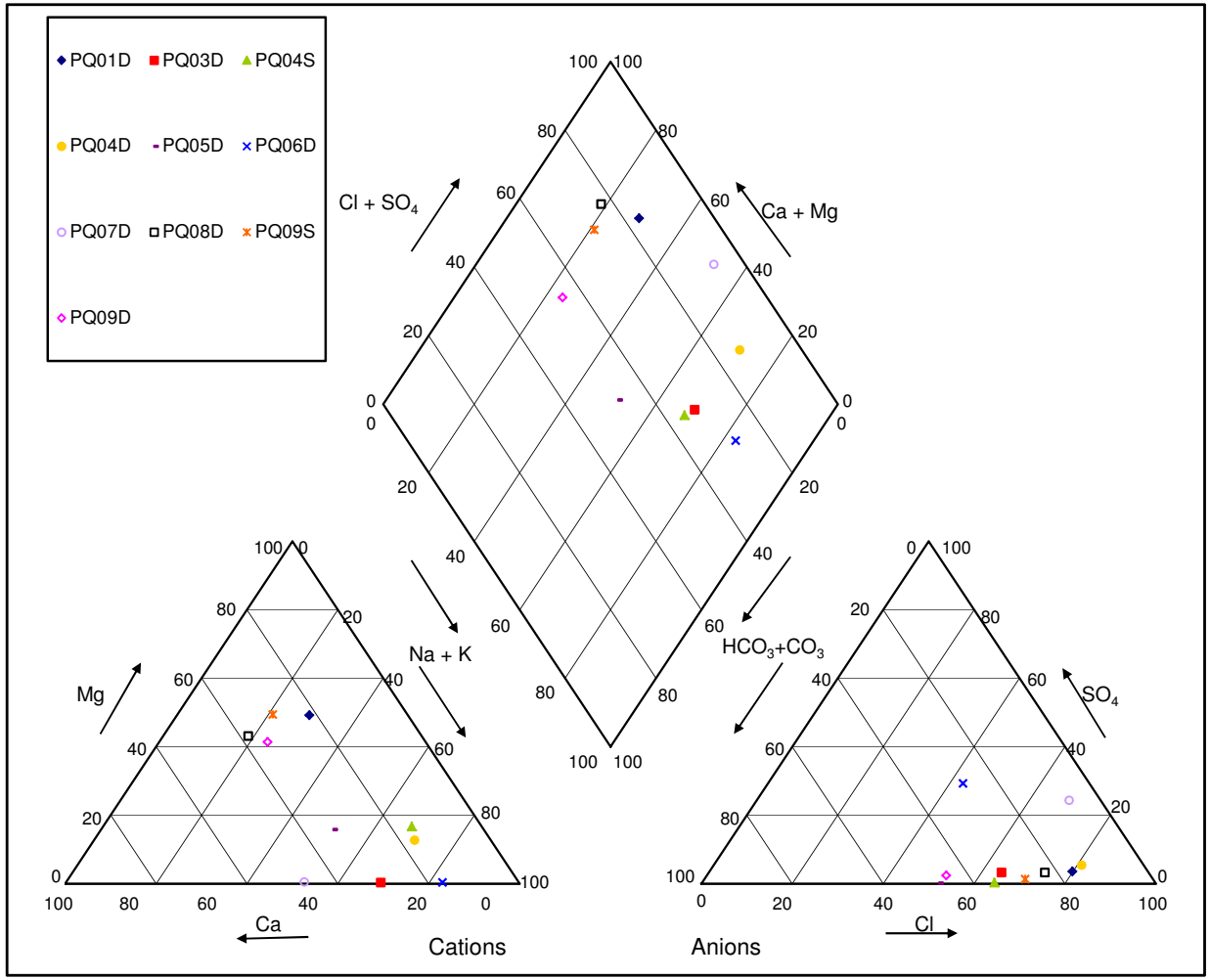
Table 4.9: Key Laboratory Analytes Statistical Assessment

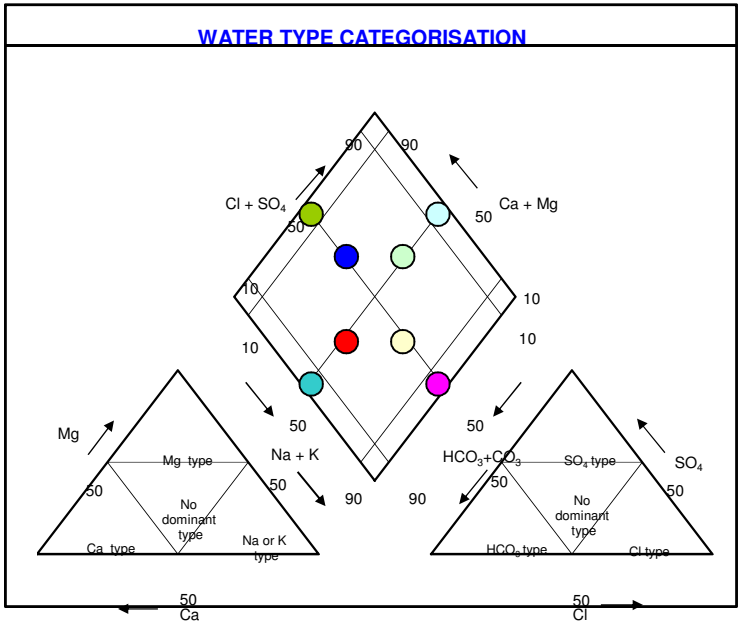
Bore		TDS	Alkalinity	Sulfate	Chloride	Calcium	Magnesium	Sodium	Potassium	Fluoride	Nitrite + Nitrate	TKN	Total N	Total P
PQ01D	Maximum	3180	459	83	1290	320	300	363	124	0.2	4.43	0.7	4.7	0.27
	Minimum	2040	104	70	1010	87	1	323	9	0.1	0.14	0.3	0.5	0.01
	Average	2615	314	78	1155	216	189	340	46	0.15	1.29	0.5	1.75	0.1
PQ03D	Maximum	1740	1230	15	214	216	1	201	404	0.4	0.05	1.5	1.5	0.22
	Minimum	1140	719	4	179	83	1	197	239	0.3	0.01	1	1	0.01
	Average	1383	929	12	198	149	1	199	318	0.38	0.023	1.33	1.35	0.07
PQ04S	Maximum	2320	568	66	968	90	92	640	5	1	1.64	0.8	2.4	0.6
	Minimum	1250	438	5	596	72	57	398	3	0.6	0.04	0.3	0.6	0.04
	Average	1688	505	36	691	84	69	480	4	0.8	0.81	0.55	1.4	0.29
PQ04D	Maximum	694	97	30	335	39	20	191	8	1.7	0.21	0.2	0.3	0.02
	Minimum	551	80	29	312	36	18	165	2	1.5	0.02	0.1	0.1	0.01
	Average	639	91	30	327	37	19	180	6	1.63	0.12	0.13	0.2	0.013
PQ05D	Maximum	1260	650	1	381	145	48	260	9	0.3	0.04	1.5	1.5	1
	Minimum	1080	518	1	348	133	42	237	7	0.2	0.01	0.3	0.3	0.03
	Average	1178	587	1	369	139	45	249	7.5	0.25	0.018	0.73	0.73	0.33
PQ06D	Maximum	1590	547	228	210	69	1	260	246	0.6	0.03	1.7	1.7	0.11
	Minimum	1030	480	182	190	28	1	253	224	0.5	0.01	1.1	1.1	0.02
	Average	1310	501	201	201	53	1	257	233	0.58	0.015	1.48	1.48	0.05
PQ07D	Maximum	1480	641	236	326	287	1	168	137	0.2	0.05	0.6	0.6	0.06
	Minimum	845	204	134	302	110	1	142	92	0.1	0.01	0.4	0.4	0.01
	Average	1120	346	175	315	178	1	156	108	0.18	0.03	0.55	0.55	0.035

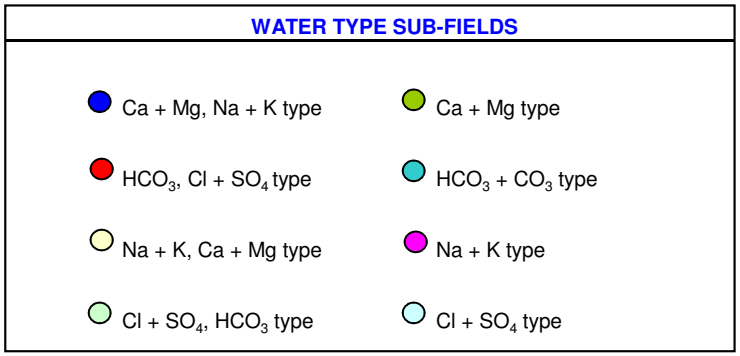
Bore		TDS	Alkalinity	Sulfate	Chloride	Calcium	Magnesium	Sodium	Potassium	Fluoride	Nitrite + Nitrate	TKN	Total N	Total P
PQ08D	Maximum	2160	428	60	798	258	177	145	6	0.2	0.06	0.1	0.1	0.15
	Minimum	2010	404	47	719	228	152	134	3	0.2	0.01	0.1	0.1	0.01
	Average	2083	416	55	770	242	165	141	4	0.2	0.03	0.1	0.1	0.08
PQ09S	Maximum	1950	509	21	727	194	196	155	7	0.3	4.3	0.8	4.5	0.96
	Minimum	1640	466	7	663	168	178	151	6	0.2	1.1	0.2	1.9	0.01
	Average	1845	493	16	700	180	185	153	6.5	0.23	2.3	0.53	2.85	0.32
PQ09D	Maximum	1190	514	21	334	133	110	104	4	0.3	2.09	1.6	2.4	2.23
	Minimum	944	489	9	309	113	96	97	3	0.2	0.01	0.1	0.1	0.03
	Average	1051	502	18	326	123	102	102	3.75	0.25	0.53	0.55	1.08	0.62

Notes: Units
EC is in µs/cm
All other analytes are in mg/L

Figure 4.5
Piper diagram of results
Water Management Plan / Peppertree Quarry







RPS

Piper Diagram

Figure 2

Date: 30/03/17

C:\Users\thompsonmb\Desktop\[HydroCHEM2.0.xls]Project Information

Project: Peppertree Quarry GW Monitorin Description: Groundwater Monitoring

Project No: WS00275D Client: Boral Pty Ltd

HydroCHEM 2.0