PRESTON BEACH ROAD NORTH – HYDROGEOLOGICAL ASSESSMENT (REVISED)

Report for Doyle's Lime Services

11 August 2021

ManagedRecharge

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Final – Amended and updated V1	Karen Johnston – Principal Natalie Pethick – Project Hydrogeologist	Carlo Doyle – Director Kirsten Muir-Thompson – Accendo Australia	9/08/2019
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DBCA Amendments (Revised)	Karen Johnston – Principal Hydrogeologist	Carlo Doyle – Director Kirsten Muir-Thompson – Accendo Australia	11/08/2021

Preston Beach Road North – Hydrogeological Assessment (Revised)

Report for Doyle's Lime Services

1. Introduction

Managed Recharge was engaged by Doyle's Lime Services to provide a hydrogeological assessment for Lot 1002, Preston Beach Road North, in particular with regard to any potential groundwater interaction with the environmentally significant Yalgorup lakes located east of the proposed site. Doyle's Lime Service is proposing to develop a limestone quarry at the site, extracting limestone from a pit covering an area of approximately 13 ha and excavated to 4 m above the groundwater table. The site location is shown in Figure 1.

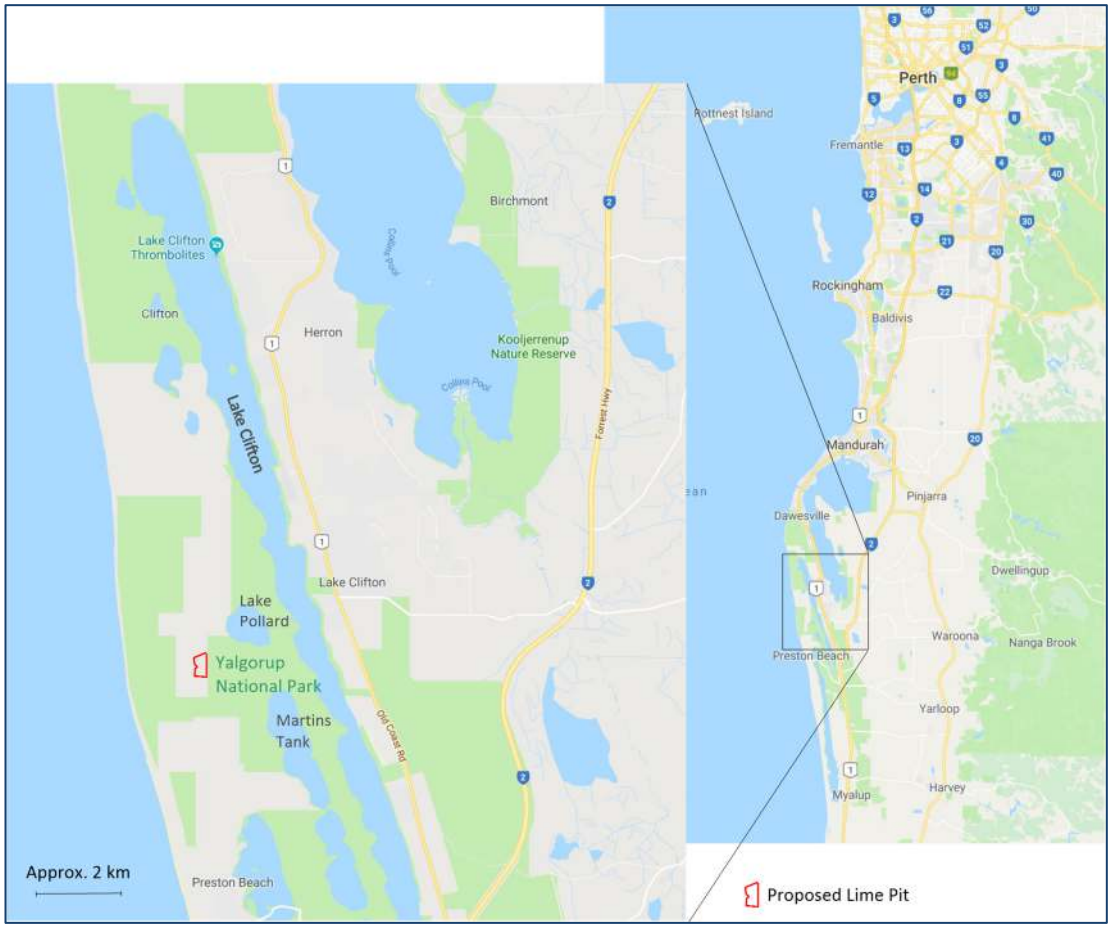


Figure 1: Site Location

The Department of Water and Environmental Regulation (DWER) have expressed concern relating to potential environmental impacts on Lake Pollard and/or Lake Clifton that might arise from the extraction process, and in conjunction with the Environmental Protection Agency (EPA) the Department developed a scope of work to assess possible impacts on hydrological processes and environmental water quality for the proposal (Appendix A). In particular, the EPA's objective is to maintain groundwater and surface water flow regimes and water quality so that the environmental values of the internationally-significant coastal-lakes system are protected.

This hydrogeological investigation, therefore, aimed to provide site specific data to determine current groundwater conditions at the site and to assess potential impacts. The work included:

1. Measuring depth to groundwater and defining the hydraulic gradient of the water table to ascertain groundwater flow directions;
2. Assessment of groundwater salinity and determining the depth of the saline-water interface at the proposed development site;
3. Providing stratigraphic data for the surficial sediments to the top of groundwater, and a deep stratigraphic profile for the superficial aquifer at the proposed development site;
4. Collecting and assessing background monitoring data to adequately define pre-development hydrogeological conditions; and,
5. High-level groundwater flow and geochemical modelling to inform an impact risk assessment and provide scientifically defensible characterisation of the system.

In addressing the preliminary key environmental factors and work required, as outlined in Table 4 of Environmental Scoping Document (ESD) (Appendix A), the following table refers the reader to the sections within this report which address, from a hydrogeological perspective, the required work for Inland Waters.

This revised version of the report incorporates amendments requested by the Department of Biodiversity, Conservation and Attractions (DBCA) as documented in Appendix A-A.

1.1 Background

The current proposal for development of a limestone pit on Lot 1002, Preston Beach Road North, represents an amendment to an earlier proposal for a limestone pit on a neighboring property, Lot 1001, located immediately to the north (Landform Research, 2016). The earlier proposal was amended in response to regulator feedback expressing concerns about the potential impact on Lake Pollard, located 200 m east of the original site. The proposed limestone extraction area has subsequently been moved south, thereby providing a greater buffer between the proposed pit and Lake Pollard and minimising the potential for groundwater-related environmental impact. The revised location also addresses a number of other issues raised by the Minister for Environment and EPA, including maintaining a limestone ridge intact between the proposed project and the lakes.

Table 1 – Sections of Report Addressing the Required Work for Inland Waters (as per Table 4, ESD)

INLAND WATERS	
Required Work # 1.	Refer to Sections: ▪ 1 – Introduction ▪ 1.1 – Background ▪ 5.1 – Environmental Values
Required Work # 2.	Refer to Sections: ▪ 2.3.5 – Conceptual Hydrogeological Model (Regional) ▪ 3.3 – Conceptual Hydrogeological Model (Site) ▪ 5.2.3 – Interflow / Winter Storage ▪ 7. – Response to ESD Work Required
Required Work # 3.	Refer to Sections: ▪ 2.0 – Regional Hydrogeology ▪ 3.0 – Site Hydrogeology ▪ 5.2 – Proposed Development Impact Assessment ▪ 5.3 – Potential Post-Development Impact Assessment ▪ 7. – Response to ESD Work Required
Required Work # 4.	Refer to Section: ▪ 5.2.2 – Groundwater Recharge Estimations and Contribution to Lake Water Budget ▪ 5.2.5 – Environmental Risk Assessment ▪ 5.2.6 – Hydrological Processes and Inland Waters Environmental Quality ▪ 5.2.7 – Geochemical Modelling – PHREEQC Analysis ▪ 5.3 – Potential Post-Development Impact Assessment ▪ 7. – Response to ESD Work Required
Required Work # 5.	Refer to Section: ▪ 7. – Response to ESD Work Required
Required Work # 6.	Refer to Section: ▪ 5.2.6 – Hydrological Processes and Inland Waters Environmental Quality ▪ 7. – Response to ESD Work Required
Required Work # 7.	Refer to Section: ▪ 5.2.6 – Hydrological Processes and Inland Waters Environmental Quality ▪ 7. – Response to EDS Work Required
Required Work # 8:	Refer to Section: ▪ 5.2 – Proposed Development Impact Assessment ▪ 7 – Response to ESD Work Required
Required Work # 9:	Refer to Section: ▪ 7. – Response to ESD Work Required

The newly proposed pit covers an area of about 13 ha, approximately 800 m south-west of Lake Pollard, 2 km west of Lake Clifton and 1.5 km north-west of Martin's Tank Lake; it lies immediately west of Yalgorup National Park (Fig. 1). The National Park is an internationally recognised, Class A Conservation Reserve and the lakes form part of the Peel-Yalgorup Ramsar-listed wetlands. The wetlands provide an important habitat for water birds and Lake Clifton contains rare, living thrombolites that are found predominantly on the north-east side of the lake in a stretch that extends approximately 15 km (EPA, 2010). The EPA considers the area to be extremely important for conservation and has indicated significant environmental constraints exist on the land lying between the Yalgorup lakes and the coast and that development is subsequently highly constrained in this area (EPA, 2010). It is noted however, that this position is based on a regional-scale assessment and may be reviewed with a detailed, local-scale investigation (EPA, 2010).

Historically the land has been cleared and used for grazing, and an old homestead remains on site.

Excavation of the proposed pit will be maintained well above the water table and no dewatering is required. Any water required for dust suppression and general operations will be trucked into site.[1]

1.2 Topography and Drainage

Lot 1002 covers an area of generally low-lying land (about 5 to 10 m AHD) that rises to a limestone ridge to the east (up to 35 m AHD in the National Park) and sand dunes to the west (up to 25 m AHD) (Fig. 2).

While there are no surface drainage features on the site, and most rainfall is likely to be infiltrated directly to the ground, in high rainfall events water may flow over-ground into the north-south trending swale on the western side of the site before infiltrating to the aquifer. It is possible that the swale acts as a local groundwater recharge area.

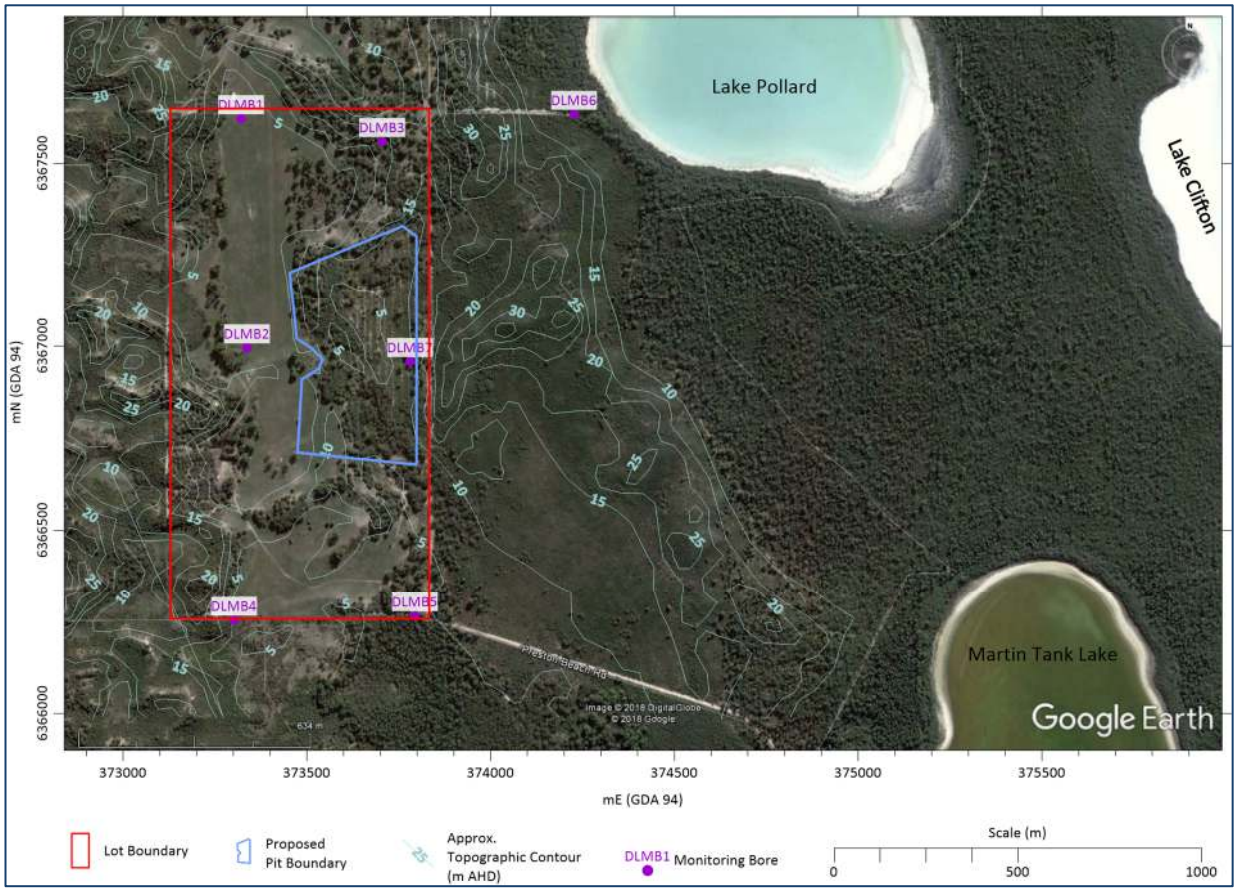


Figure 2: Site Topography and Monitoring Bore Locations

1.3 Climate and Rainfall

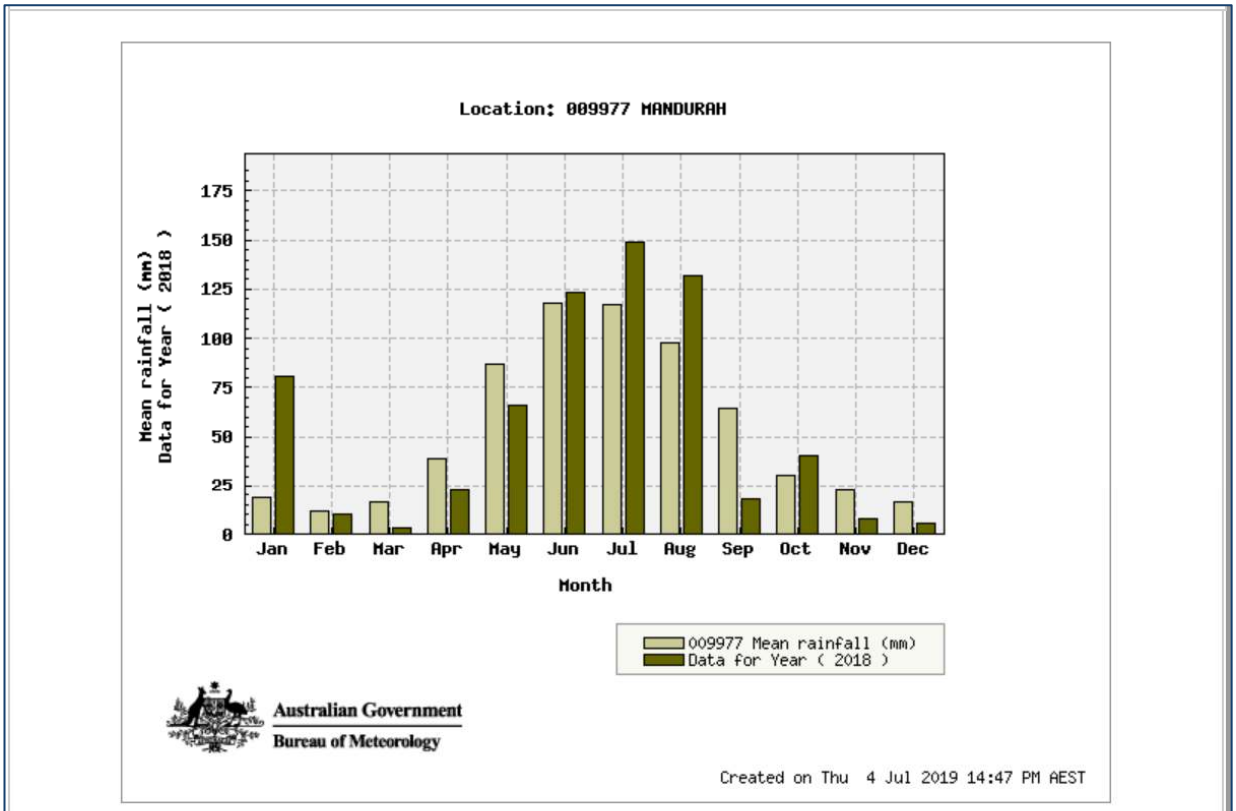
The site has a Mediterranean-type climate, with hot dry summers and cool wet winters. In Mandurah, located approximately 30 km to the north, the average annual rainfall is 623 mm, with most of the rainfall

[1] Previously it was anticipated that a small groundwater allocation of up to 5000 kL/annum would be required. However, concerns relating to possible upconing of saline water, and the likely rigorous regulatory requirements associated obtaining a groundwater allocation at this site has made that option cost prohibitive.

occurring between May and September as cold fronts move across the south-west of the State. In summer, isolated storms associated with cyclonic activity in the far-north can produce very heavy rainfall events. The long-term rainfall data for Mandurah (BoM site 009977) is presented in Figure 3 along with data for 2018.

Figure 3 shows that rainfall was well above average in January 2018, with an extreme rainfall event delivering 80.6 mm over several days, above average in July, August and October, close to average in February and June, and below average in March, April, May, September, November and December 2018. The total annual rainfall was 5% above the mean rainfall for years between 2001 and 2019.

Annual evaporation for the area is about 1500 mm, with evaporation greatly exceeding rainfall from September to April each year.



Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual	Years
Mean rainfall (mm) for years 2001 to 2019	18.4	12.1	16.5	39.1	86.6	118.2	117.2	97.7	64.2	30.7	22.7	16.7	625.9	17
Statistics	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**	**Years**
Rainfall (mm) for year 2018	*80.6*	*10.0*	*3.6*	*22.6*	*66.0*	*123.0*	*149.0*	*131.8*	*18.2*	*40.8*	*8.0*	*5.4*	*659.0*	1

12.3 = Not quality controlled

Figure 3: Rainfall Data for Mandurah (Bureau of Meteorology, Site 009977)

2. Regional Hydrogeology

Of interest in the current study is the hydrogeology of the superficial formations of the western Swan Coastal Plain. The geology and groundwater resources for the superficial aquifer in the Lake Clifton area have been described by Commander (1988) and Deeney (1989); details are provided below along with updated information as referenced.

2.1 Geology

The site under investigation lies on the western margin of the Swan Coastal Plain, which comprises sedimentary formations of the Perth Basin, extending to depths of up to 8000 m and bound to the east by the Darling Fault and to the west by the coast.

The superficial formations comprise Cainozoic sediments, between 12 and 90 m thick, unconformably overlying Mesozoic sediments of the Osborne, Leederville or Cattamarra Coal Measures (formerly Cockleshell Gully Formation) formations. The erosional surface dips gently and unevenly to the west, ranging in elevation from about 50 m AHD near the Darling Scarp to -28 m AHD near the coast. Figure 4 provides a schematic stratigraphic section for the geology north of Preston Beach (Kelsey, 2011).

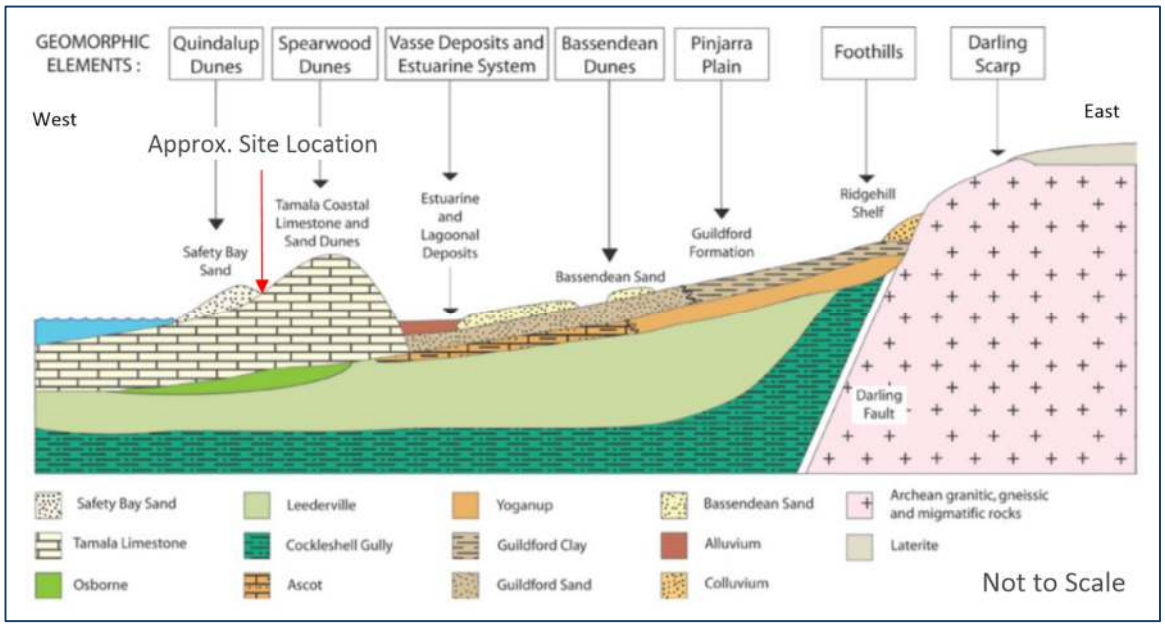


Figure 4: East-West Stratigraphic Succession for the Swan Coastal Plain near Mandurah (after Kelsey et al, 2011)

The proposed limestone pit is situated at the contact between the Quindalup Dunes (Safety Bay Sand) and Spearwood Dunes (Tamala Coastal Limestone and Sand). The lakes of concern (Lake Pollard, Lake Clifton and Martin Tank Lake) are represented by the Estuarine and Lagoonal deposits east of the Tamala Limestone ridge, which overlie Tamala Limestone/Sand to the west and Bassendean and/or Guildford Sand to the east. The Tertiary-aged Ascot Formation Limestone may be present at depth. These Quaternary and Tertiary sediments unconformably overlie the Cretaceous Osborne and/or Leederville Formations. The stratigraphy for the study area is summarised in Table 2 and described in order of increasing age below (after Kelsey et al, 2011).

The alluvium, estuarine, lagoonal and swamp deposits are of Holocene age. Estuarine and lagoonal deposits comprise black, brown and grey, humic sandy-clay, silt, marl, clayey sand and calcarenite unconformably overlying the Tamala Limestone and Guildford Formation. They occur on the floor and at the margins of the coastal lakes. Swamp deposits, consisting of dark grey to black, fine-grained sand, silt and clay, and containing peat and diatomite, occupy the floors and margins of the wetlands.

The Safety Bay Sand is of Holocene age and comprises unlithified, calcareous-sand unconformably overlying the Tamala Limestone. It forms a narrow strip of stable and mobile dunes along the coastline.

Table 2: Study Area Stratigraphy

	Age		Formation	Max. Thickness (m)	Lithology
Quaternary	Holocene	superficial formations	Alluvium, esturine, lagoonal and swamp deposits	15	Sand, silt, clay and peat
			Safety Bay Sand	50	Medium- to course-grained quartz sand and shells
	Pleistocene		Bassendean Sand	15?	Fine- to medium-grained leached quartz sand
			Tamala Limestone	90	Limestone, sand, calcarenite, minor clay, minor fossils
			Guildford Formation Sand	30	Sand, minor clay, calcareous sand and fossils
Late Tertiary			Ascot Formation	25	Sand, silt, minor limestone, fossiliferous
Early-Late Cretaceous		Osborne Formation			Siltstone and clay
Early Cretaceous		Leederville Formation			Sand, siltstone, clay, shale
Early-Middle Jurassic		Cattamarra Coal Measures			Sand, siltstone, clay, shale

The Tamala Limestone comprises limestone, calcarenite and sand with minor clay and shell beds. It unconformably overlies Cretaceous sediments in the west and the Ascot Formation along its eastern margin. It has a maximum thickness of about 90 m and extends to about -28 m AHD along the coast.

Bassendean and Guildford Formation sands occur to the east of the Tamala Limestone. Bassendean sand is white to pale-grey, moderately sorted, fine- to medium-grained quartz containing traces of heavy minerals. It unconformably overlies the Guildford Formation, and forms a thin cover over much of the coastal plain's central region. The Guildford Sand consists of grey, poorly sorted, fine- to very-coarse-grained quartz sand with minor clay beds and traces of heavy minerals. It unconformably overlies the Ascot Formation.

2.2 Coastal Lakes

Lake Pollard, Martins Tank and Lake Clifton are part of the Yalgorup coastal lake system, which forms three parallel lines of lakes within 5 km of the coast. Martins Tank Lake lies east of Lake Preston separated by a limestone ridge, and Lake Clifton is separated from Martins Tank and Lake Pollard by a shallow sand ridge (Commander, 1988).

The lakes receive virtually no runoff and are maintained by direct rainfall accession and groundwater inflow. They act as groundwater sinks, with no outflow other than by evaporation. They are underlain by hypersaline groundwater, which, because it is denser than seawater, allows the lake levels to periodically fall below sea level (Commander, 1988). Monitoring conducted to the north of the site in 2008 showed water levels in Lake Pollard ranged from about -0.5 m AHD in February/March to about 0.45 m AHD in August/September, and in Lake Clifton they ranged from about -0.65 m AHD in February/March to about 0.35 m AHD in August/September (ENV Australia, 2009). These water level data indicate a very shallow gradient towards Lake Clifton; however Commander (1988) indicates a low groundwater mound lies beneath the low sand ridge separating the lakes, which would act as a barrier to groundwater flow between the lakes.

2.3 Hydrogeology

The superficial formations, which consist predominantly of clay and sand in the east of the Swan Coastal Plain, and of sand and limestone in the west, form an unconfined aquifer extending westwards from the Darling Scarp to the coast (Deeney, 1989).

At the proposed development site, the superficial aquifer is shallow and unconfined and occurs within the Safety Bay Sand and Tamala Limestone. The aquifer is confined at the base by low permeability sediments within the Osborne and/or Leederville Formations. East of the site, groundwater is present within the Tamala Limestone, Bassendean Sand, Guildford Sand and Ascot Formation, with hydraulic connection between the shallow sediments and the lagoonal and swamp deposits of the coastal lakes and wetlands.

2.3.1 Groundwater Recharge and Discharge

Groundwater recharge in the area is via direct rainfall infiltration, with infiltrated rainfall likely to reach the water table within days due to high vertical hydraulic conductivities (CyMod, 2009). Discharge from the superficial aquifer in this region is predominantly from the coastal lake system via evaporation. Groundwater west of the groundwater divide, beneath the Quindalup Dunes, will flow to the ocean. Minimal abstraction occurs in the area.

2.3.2 Regional Groundwater Levels and Flow

The water table elevation in the superficial aquifer generally falls from east to west, following the gentle topographic gradient except within the Spearwood Dunes [limestone ridge] (Deeney, 1989). The presence of watercourses, lakes and inlets has resulted in the formation of complex groundwater-flow regimes in the region, which include a number of groundwater divides (Deeney, 1989), or flow boundaries whose positions may be inferred from the water table configuration (Commander, 1988).

Commander (1988) identified six groundwater flow systems between Harvey and Leschenault Inlets, one of which is “Martins Tank” an internal flow system covering a relatively small area of about 20 km^2 with groundwater discharging to Martins Tank and other coastal lakes including Lake Pollard. The site under investigation lies within this flow system. It is noted that the eastern divide of the Martins Tank flow system is inferred to lie between Lake Pollard/Martins Tank and Lake Clifton (Fig. 5), and so groundwater from the proposed site will not reach Lake Clifton if/when this divide is present.

2.3.3 Local Groundwater Levels and Flow

Figure 6 shows long-term water level monitoring for DWER monitoring bore B2, located approximately 200 m west of Martins Tank Lake, which was drilled and constructed as part of the Lake Clifton Project (Commander, 1988). The data indicate a period of gradually declining groundwater levels between about 1979 and 1999, which appears to have stabilised over the last 20 years. Groundwater levels in B2 generally range from about -0.2 to 0.4 m AHD, with variations reflecting summer evaporation from the lake and recharge via winter rainfall received in the area. It is noted that groundwater levels fall below sea level for two to three months each year in response to evaporation losses from the coastal lakes.

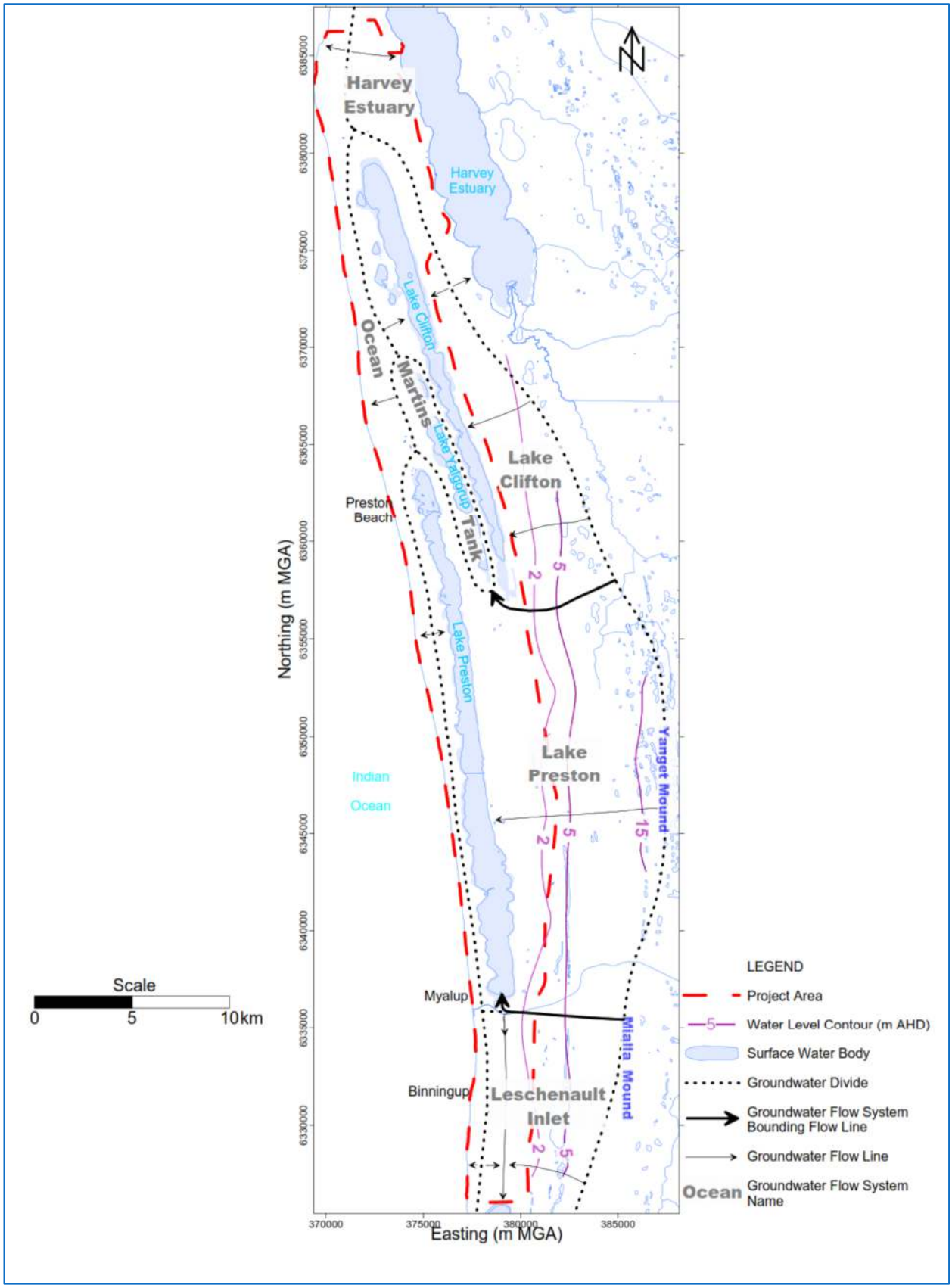


Figure 5: Groundwater Flow Systems (Rockwater, 2009)

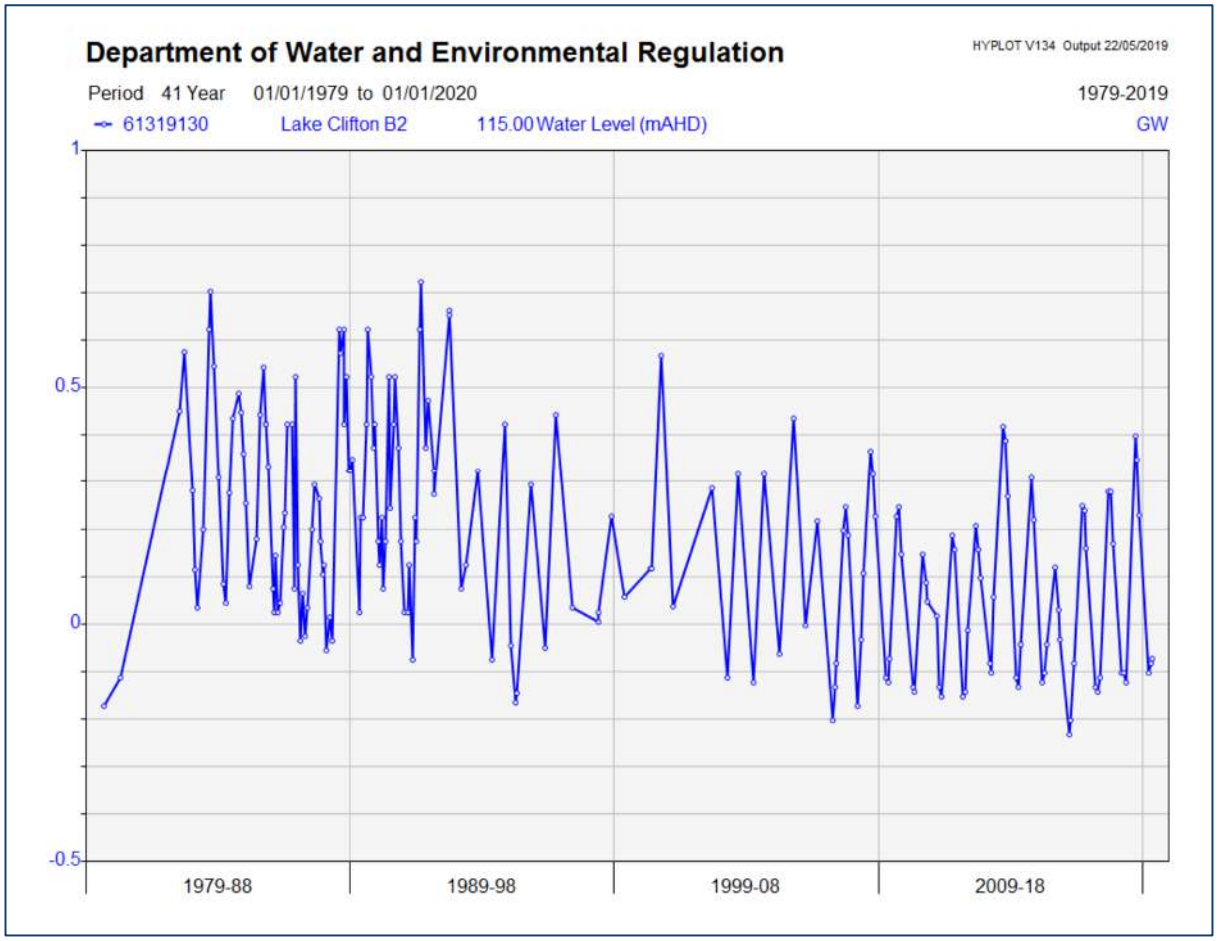


Figure 6: Groundwater Levels for DWER Monitoring Bore, Lake Clifton B2 (WIR Database)

In 2009, an investigation was undertaken just north of the current study area for Cape Bouvard Investments (ENV Australia, 2009), which included installation of a series of monitoring bores and a 12-month monitoring program. The study included a line of monitoring bores (MW Series - MW1 to MW6) giving an east-west transect to the north-west of Lake Pollard (Fig. 7). Bore completion and groundwater level data for these monitoring bores are provided in Table 3 and Appendices B and C.

Table 3: Bore Completion and Groundwater Data for MW Series Bores (ENV, 2009)

Monitoring Bore	Coordinates & RL		Bore Depth	Slotted Interval (m bgl)		SWL 2007 to 2008 (m AHD)		Salinity	Slotted in
	mE	mN	m bgl	from	to	Minimum	Max	µS/cm	
MW1	374323	6368286	13	3	12	-0.04	0.49	4220	Tamala Limestone
MW2	373768	6368205	31	25	31	0.07	0.52	13650	Tamala Limestone
MW3	373782	6368206	25	19	25	0.10	0.55	1090	Tamala Limestone
MW4	373782	6368211	21	14	21	0.00	0.49	860	Tamala Limestone
MW5	373371	6368176	18	6	18	0.12	0.53	10780	Tamala Limestone
MW6	373377	6368181	25	16	25			>20000	Tamala Limestone

Note: MW2 to MW4 and MW5&6 are nested bores (ie, installed at same location). Water table bores highlighted in blue.

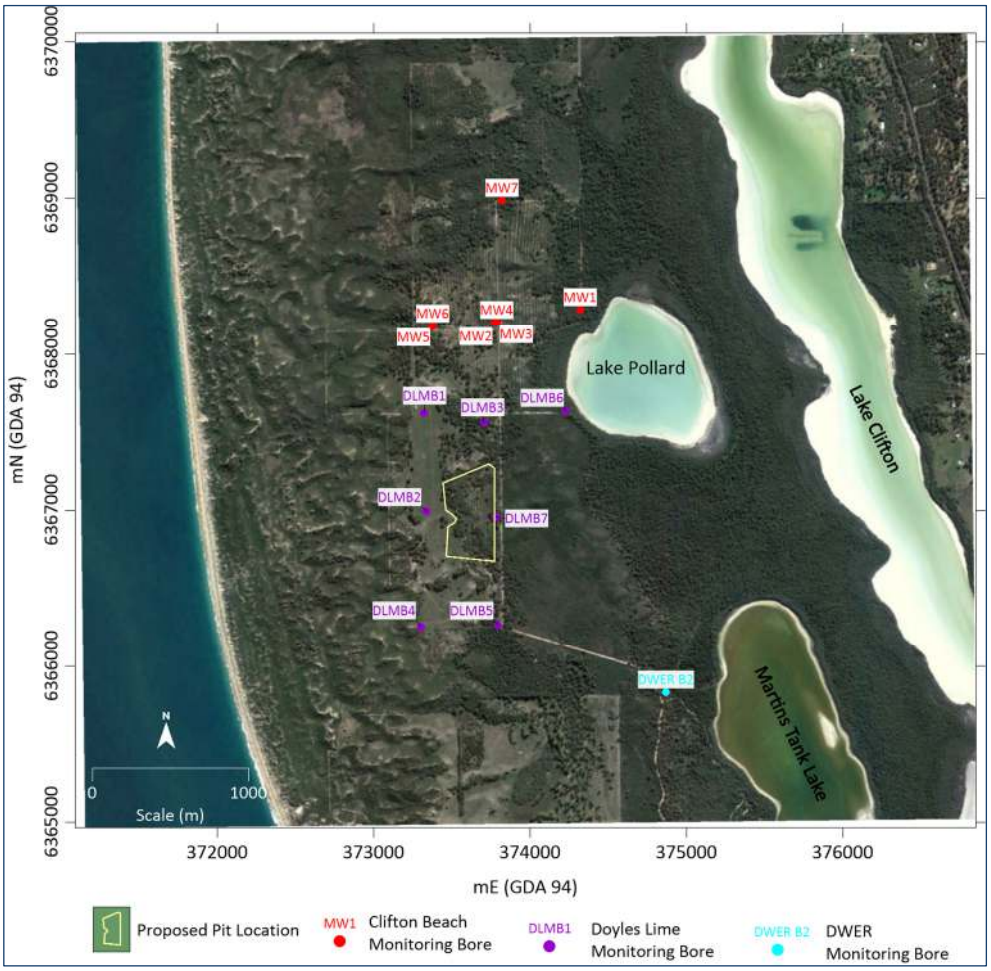


Figure 7: Monitoring Bore Locations

Monitoring results for the MW Series bores show minimum groundwater levels in the shallow bores, ranging from -0.04 m AHD in MW1 to 0.12 m AHD in MW5, indicating a hydraulic gradient of 0.00016 toward the lake in summer. In winter, the maximum groundwater levels in the shallow bores range from about 0.49 m AHD in MW1 and MW4 to 0.53 m AHD in MW5, indicating a maximum hydraulic gradient of 0.00004. The results are consistent with earlier studies and show the water table is close to sea level with a very low hydraulic gradient falling to the east toward the lake, particularly in summer when evaporation from the lakes creates a deeper cone of depression. Groundwater levels fluctuate seasonally by about 0.5 m in direct response to infiltration of winter rainfall and changes in evaporation rates from the lakes.

2.3.4 Groundwater Salinity

In the Martins Tank flow system, rainfall maintains a lens of fresh or brackish groundwater surrounding the coastal lakes (Commander, 1988). Hydraulic boundaries occur between groundwater bodies with strongly contrasting salinities, with less-dense fresh water generally forced upward over more saline groundwater.

When drilled, the brackish lens in DWER monitoring bore B2 extended to a depth of about 14 m, overlying hypersaline groundwater with a well-defined interface and thin mixed zone (Fig. 8). In 1988, the salinity

of the brackish zone in B2 ranged from 1000 to 4000 mg/L total dissolved solids (TDS), increasing with depth, and the salinity of the underlying hypersaline water was in the order of 44000 mg/L TDS.

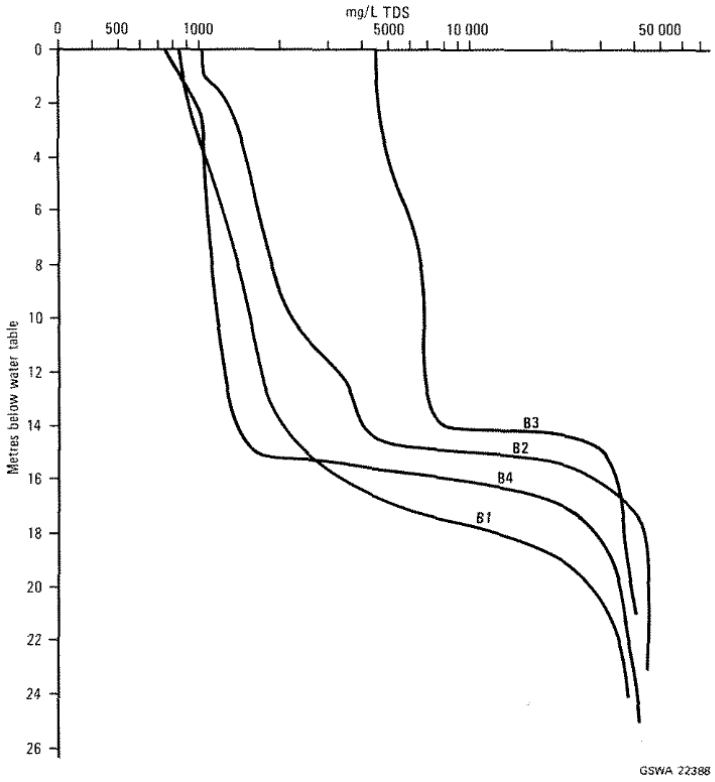


Figure 8: Salinity-Depth Profile for DWER B2 (Commander, 1988)

To the north of the study site, the freshwater lens in 2008 was apparently thinner, extending about seven metres below the water table (Figs 9 and 10) (ENV Australia, 2009). In the westernmost bores, MW5 and MW6, the freshwater lens overlies groundwater with salinity between about 18000 and 30000 mg/L TDS (Fig. 9), suggesting the bores are completed within the coastal saltwater wedge. At MW1, near Lake Pollard, brackish water overlies more saline (up to ~10000 mg/L TDS) water at depth (Fig. 10). MW1 does not appear to have been completed deep enough to measure salinity past the saline water interface. The depth of the saline-water interface varied by up to ~1 m throughout the year, being deeper following winter rainfall.

2.3.5 Conceptual Hydrogeological Model - Regional

The site under investigation lies to the west of a series of coastal lakes that are in direct hydraulic connection with the superficial aquifer and act as groundwater discharge zones in the region. Through evaporative processes the lakes and underlying groundwater have become hypersaline, allowing water levels to fall below sea-level in summer months, creating cones of depression and an internal groundwater flow system (i.e. groundwater flows inland rather than to the coast).

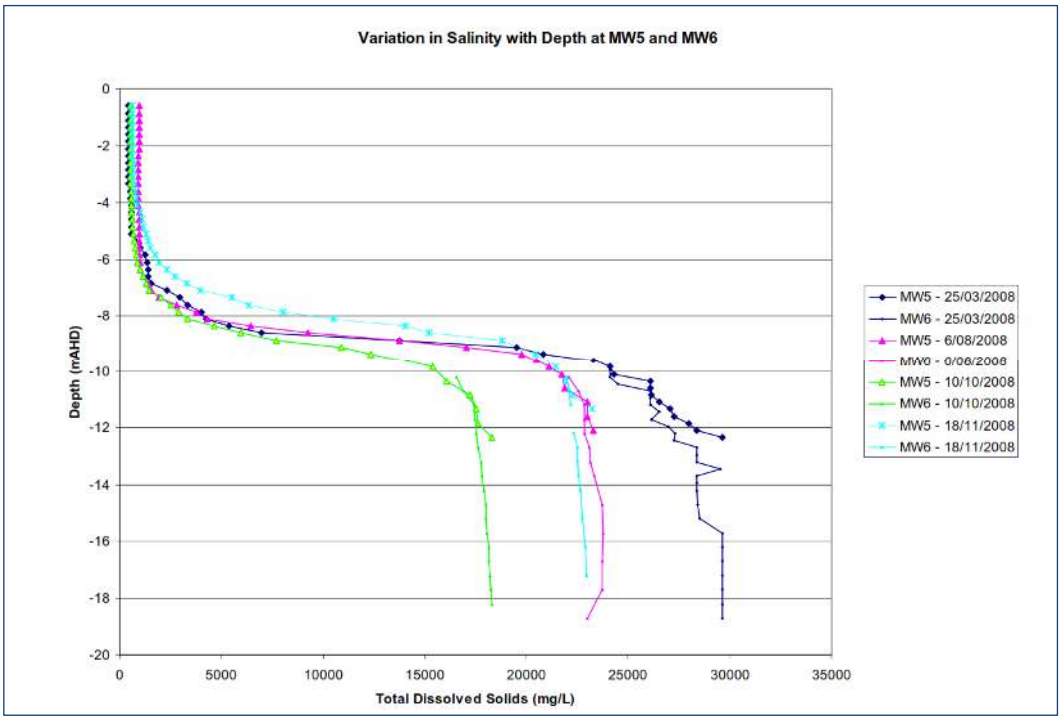


Figure 9: Salinity-Depth Profile for Monitoring Bores MW5 and MW6 (ENV, 2009)

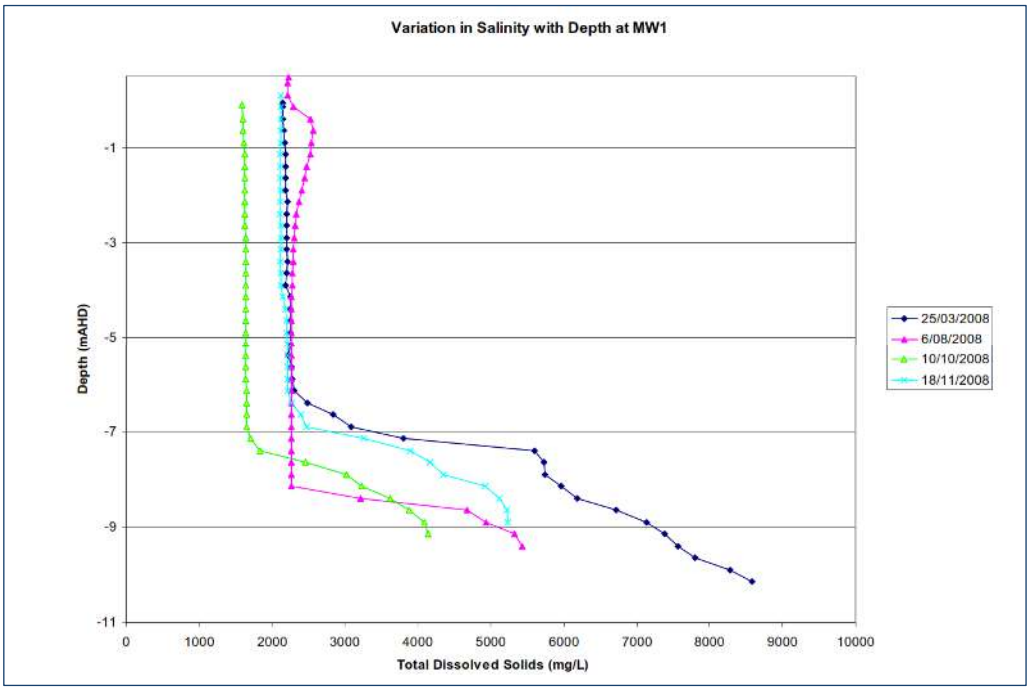


Figure 10: Salinity-Depth Profile for Monitoring Bore MW1 (ENV, 2009)

Groundwater recharge occurs predominantly in winter months through direct rainfall infiltration, creating a very low-lying groundwater mound and freshwater lens within the Safety Bay Sand and Tamala Limestone, beneath the thin strip of coastal dunes that separate the lakes from the coast. Further to the west, within several hundred metres of the coast, groundwater flow is toward the coast. The groundwater divide shifts to the east in spring and to the west in autumn as the cone of depression created by the lakes shallows and deepens, respectively.

Groundwater flow at Lot 1002 is toward mainly toward Lake Pollard, with some possible incidental flow towards Lake Clifton and Martins Tank under a very low hydraulic gradient. A groundwater-divide may lie to the east of Lake Pollard and Martins Tank Lake, beneath the low-lying sand dunes that separate them from Lake Clifton, this divide, when present, will prevent groundwater from the site reaching Lake Clifton.

A conceptual hydrogeological section for the coastal groundwater subarea is provided in Figure 11 (DoW, 2015).

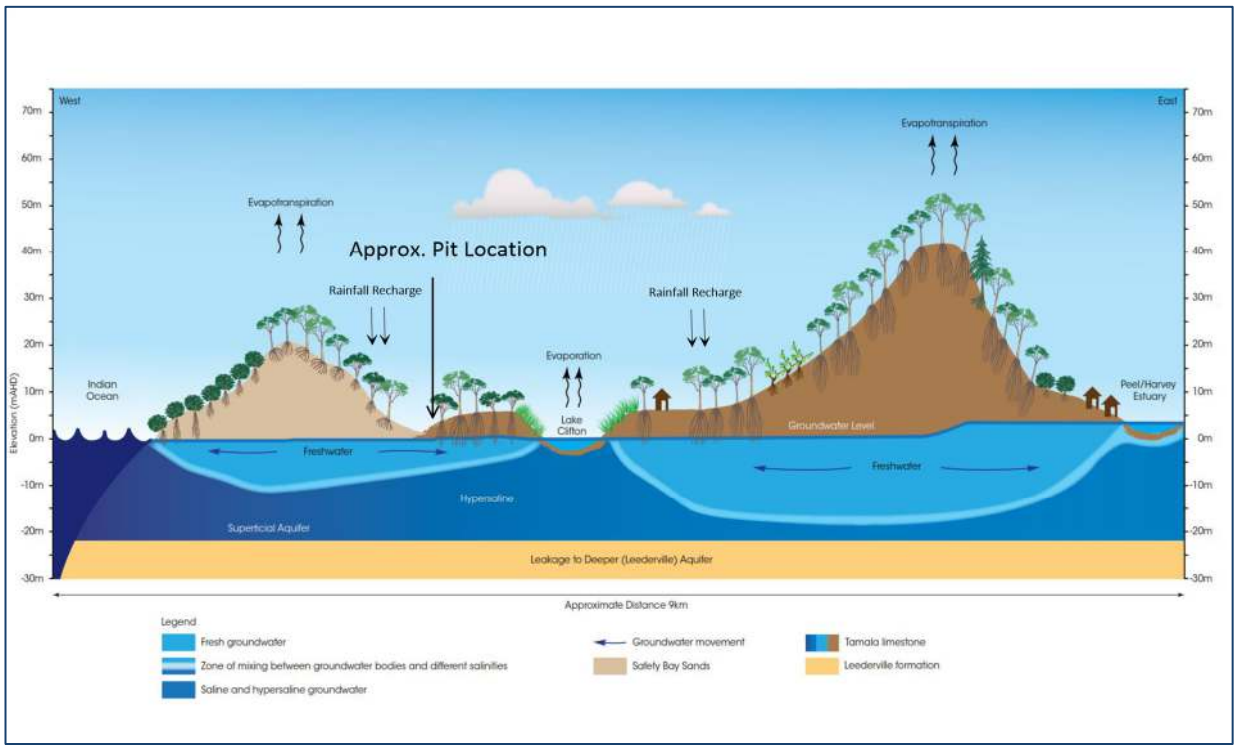


Figure 11: Conceptual Hydrogeology for Coastal Sub-Area (after DoW, 2015)

3. Site Investigation

A drilling program was undertaken in March and May 2018, primarily to define the water table contours at the site and determine groundwater flow characteristics in relation to potential flow towards the coastal lakes, in particular Lake Pollard, Martins Tank Lake and Lake Clifton. A deeper monitoring bore was also drilled and constructed to determine the depth of the freshwater lens and the nature and position of the saline water interface at this location.

The monitoring bores have subsequently been used to collect background groundwater data for the site to better understand existing seasonal trends and aquifer characteristics.

The results are presented below.

3.1 Drilling Program

Seven monitoring bores, DLMB1 to DLMB7, were drilled and constructed between 12 March and 24 May, 2018, by StrataProbe using a tractor mounted auger and a small Geoprobe, 7822DT, track-mounted

drilling rig. The drilling contractor was engaged directly by the client, with minimal input from Managed Recharge.

Six of the monitoring bores (DLMB1 to DLMB6) were drilled to about 2 m below the water table using a 100 mm-diameter auger, and completed with 50 mm ND, Class 9 uPVC threaded-casing, slotted over the lower 3 m. Graded gravel pack (0.8 to 2 mm) was installed in the annulus to above the slots, with bentonite granules placed on top of the gravel. Drill cuttings were then used to backfill the annulus to surface and steel surface casing was installed and cemented into place. Bore completion logs are provided in Appendix D and monitoring bore details are summarised in Table 4.

Table 4: Summary of Monitoring Bore Details

Monitoring Bore	Easting mE (GDA 94)	Northing mN (GDA 94)	Ground Elevation m AHD	Top of Casing m AHD	Blank Casing m bgl	Slots m bgl	Groundwater Level m bgl	Groundwater Level m AHD	Salinity µS/cm
DLMB1	373317	6367623	2.87	3.49	-0.62 - 2.5	2.5 - 5.5	3.35	0.14	680
DLMB2	373336	6366976	2.79	3.44	-0.65 - 2.5	2.5 - 5.5	3.27	0.17	600
DLMB3	373702	6367568	10.17	10.49	-0.32 - 8.5	8.5 - 11.5	10.47	0.02	730
DLMB4	373299	6366256	3.30	3.9	-0.60 - 2.0	2.0 - 5.0	3.71	0.19	590
DLMB5	373788	6366263	2.89	3.49	-0.60 - 2.0	2.0 - 5.0	3.44	0.05	1570
DLMB6	374234	6367635	3.39	3.82	-0.43 - 2.5	2.5 - 5.5	3.91	-0.09	1930
DLMB7	373779	6366915	7.91	8.49	-0.58 - 0.5	0.5 - 18.0	8.41	0.08	12980

One monitoring bore, DLMB7, was drilled at 100 mm-diameter to 21 m depth using mud-rotary drilling techniques. Lost circulation occurred at the top of the hole and no cuttings were returned from 6 m depth onwards. It was noted that the drilling mud had a very low viscosity, and this may have contributed to poor drilling returns. Drilling progressed quickly, and the limestone appears to be cavernous. Class 9, threaded uPVC-casing was installed to 18 m depth, slotted almost to surface (the intended completion depth was 21 m with 18 m slotted, however the casing could not be advanced past 18 m, probably due to fall-back of drill cuttings). Gravel pack was installed to surface and steel surface casing installed and cemented into place. A bore completion log is provided in Appendix D and details are summarised in Table 4.

Monitoring bores DLMB1 to DLMB6 were pumped for 10 minutes at about 12 L/min following construction until the water ran fairly clear. Monitoring bore DLMB7 was air-lifted for several hours in an attempt to remove drilling fluids and develop the bore, however loss of air to the highly permeable formation prevented an effective air-lift and minimal water was produced from the bore. The bore was subsequently pumped at about 1.5 L/min for three hours with the pump set near the base of the bore. While the water cleared, drilling-fluids remained in the bore.

3.2 Site Hydrogeology

The hydrogeology of the proposed site, as determined from the drilling program and in the context of the regional hydrogeology described in Section 2, is summarized below.

3.2.1 Geology

Shallow monitoring bores located in the swale to the west of the site (DLMB1, DLMB2 and DLMB4) are completed in Safety Bay Sand: Grey-brown to buff, very fine- to coarse-grained with a minor very-coarse fraction, sub-rounded to well-rounded with some spherical grains, generally moderately to poorly sorted, occasionally well sorted, calcareous quartz-sand (quartz is clear, frosted and orange) with some small shells, minor heavy minerals and possible traces of garnet and glauconite.

Monitoring bores located along the eastern boundary of the site (DLMB3, DLMB5, DLMB6 and DLMB7) have between 0.5 m (DLMB7) and 5.5 m (DLMB3) of sand overlying Tamala Limestone/Sand: buff-cream to cream, very-fine- to course-grained sand (as above) in a carbonate matrix, layered with calcarenite and some silt and clay. The sand has a high shell-fragment content. There is evidence of secondary porosity, including secondary mineralisation on weathered faces and significant loss of circulation at DLMB7.

3.2.2 Groundwater Levels and Flow

Groundwater levels were measured between 3.27 m btc (below top of PVC casing) (DLMB2) and 10.47 m btc (DLMB3) on 24 May 2018 (Table 4), with the deeper groundwater levels occurring at sites with higher topographical elevation. The water table occurs at an elevation of between -0.09 m AHD (DLMB6) and 0.19 m AHD (DLMB4).

Figure 12 shows groundwater level contours across the site in May 2018. The plot shows that groundwater flow beneath the proposed pit is to the east-north-east and east toward the coastal lakes, and that a low groundwater ridge is located to the west of the proposed pit-site. It is noted that the groundwater elevation is in no way related to the topography in this area, and no groundwater mounding evident beneath the limestone ridge (DLMB3 and DLMB7).

Seasonal groundwater levels were measured at the site and in DWER monitoring bore B2 between May 2018 and June 2019, the results are tabulated in Table 5 and plotted with salinity and rainfall in Figure 13. The results show seasonal fluctuations in the groundwater table elevation of between 0.18 and 0.32 m, with the largest changes observed in the bores closest to the lakes (B2 and DLMB6). The average seasonal variation is 0.24 m, which is relatively low and consistent with regional groundwater level changes commonly observed in the high-permeability Tamala Limestone. Bores reported as dry in April 2019 had tree roots ingressing at the water table; they were cleared during the June 2019 monitoring event.

Table 5 – Groundwater Level and Salinity Monitoring Results

Monitoring Bore	GWL	GWL	Salinity	GWL	GWL	Salinity	GWL	GWL	Salinity	GWL	GWL	Salinity
	m btc	m AHD	µS/cm	m btc	m AHD	µS/cm	m btc	m AHD	µS/cm	m btc	m AHD	µS/cm
	24 May 2018			19 November 2018			30 April 2019			21 June 2019		
DLMB1	3.35	0.14	680	3.17	0.32	693	dry @ 3.23	NA	NA	3.28	0.21	764
DLMB2	3.27	0.17	600	3.08	0.36	600	3.28	0.16	646	3.12	0.32	642
DLMB3	10.47	0.02	730	10.26	0.23	585	10.47	0.02	602	10.37	0.12	598
DLMB4	3.71	0.19	590	3.45	0.45	582	3.71	0.19	658	3.65	0.25	630
DLMB5	3.44	0.05	1570	3.2	0.29	1714	dry @ 3.38	NA	NA	3.36	0.13	1468
DLMB6	3.91	-0.09	1930	3.62	0.2	2911	dry @ 3.74	NA	NA	3.78	0.04	2433
DLMB7	8.41	0.08	12980*	8.17	0.32	960	8.4	0.09	1016	8.3	0.19	1032
Lake Clifton B2	4.72	-0.08	NA	4.4	0.24	5230	4.71	-0.07	5018	4.6	0.04	4847

* Air-lifted sample, full interval and with drilling fluid

Measured value of 4.51 m btc apparently in error - measurment corrected using data from WIR Database collected around the same time (Fig. 6).

When groundwater levels are at a minimum (May 2018), there is a very low groundwater gradient of 0.00024 toward Lake Pollard from the northern half of the proposed pit, and 0.00019 toward Lake Clifton from the southern half of the proposed pit. Groundwater flows from the south of the pit area are likely to be deflected to the north toward Lake Pollard in response to evaporative lows in the water table, and the presence of a groundwater divide located to the immediate west of Lake Clifton (Fig. 12). There is apparently no significant groundwater flow from the proposed pit area towards Martins Tank Lake. The values represent near-maximum flow gradients as groundwater gradients towards the lakes are greatest in autumn, when groundwater levels near the lake are at a minimum (Fig. 13).

Figure 12: Groundwater Level Contours – 24 May 2018

Figure 13: Groundwater Levels, Salinity and Rainfall (Monitoring Bores DLMB1-7)

The hydraulic gradient can be used with regional estimates of aquifer hydraulic conductivity to determine potential rates of groundwater flow from the proposed pit area towards the lakes.

Darcy's velocity equation is as follows:

$$groundwater\ velocity = \frac{\text{hydraulic conductivity x hydraulic gradient}}{\text{aquifer porosity}}$$

The hydraulic conductivity (K) of Tamala Limestone/Sand in this region is reported to range from about 20 to 200 m/d:

- 60 m/d (Commander, 1988)
- 150 to 200 m/d (Shams, 1999)
- 20 to 60 m/d (CyMod, 2009)

The specific yield for the Tamala Limestone (approximate aquifer porosity) is about 0.2 (Davidson and Yu, 2008).

Using Darcy's velocity equation, with K = 20 to 200 m/d, the groundwater flow rate towards Lake Pollard is estimated to be between about 9 and 90 m/year, and between about 7 and 70 m/year toward Lake

Clifton, giving travel times of between 9 and 90 years to Lake Pollard and from 30 to 300 years to Lake Clifton. If it is assumed a K value of 60 m/d best represents regional conditions, the groundwater flow rate is likely to be in the order of 26 m/year towards Lake Pollard and 21 m/year toward Lake Clifton, giving representative travel times of about 30 years to Lake Pollard and 95 years to Lake Clifton. It is noted that these estimated flow rates do not allow for the inferred groundwater divide between the site and Lake Clifton (Fig's 5 & 12), which is likely to prevent or obstruct water travelling the full distance to that lake.

3.2.3 Groundwater Salinity

Groundwater salinity readings have been measured in-situ, using a Herron Conductivity Plus electrical conductivity (EC) probe, to sample 1 m below the water table from monitoring bores DLMB1 to DLMB7 and DWER monitoring bore B2. A total of 4 monitoring rounds have been completed to-date with the results tabulated in Table 5 and plotted with groundwater levels and rainfall in Figure 13.

The results show that groundwater is freshest to the west of the site, with salinity increasing to the east and south-east. The low salinity groundwater beneath the swale (DLMB1, DLMB2 and DLMB4), where the water table elevation is highest, indicates that this area is a local groundwater recharge zone. Similarly, the low salinity measured in DLMB3 to the north indicates groundwater recharge likely occurs on the flanks of the limestone ridge in the areas where rainfall runoff might be channeled (the bore is located in shallow valley – Fig. 2). It is possible that the salinity results from monitoring bore DLMB7 are influenced by more saline groundwater from below as the bore is slotted over a much deeper interval than the other DLMB series bores; this may also be true for results from B2.

Groundwater salinity profiles were measured in monitoring bores DLMB7 and DWER bore B2 at 1 m intervals to the bottom of casing. Salinity profile data were collected in November 2018, April 2019 and June 2019, the data are tabulated in Tables 6 and 7 and plotted in Figures 14 and 15. A salinity profile was also measured in DLMB7 in May 2018, at the time the bore was constructed, however the results are clearly influenced by the presence of drilling fluids (Fig. 14) and are therefore not representative of aquifer conditions.

Table 6 - Salinity Profile Data Collected from Monitoring Bore DLMB7

DLMB7								
Nov-18			**Apr-18**			**Jun-18**		
Depth (m btc)	**Salinity** (µS/cm)	**Elevation** (m AHD)	**Depth** (m btc)	**Salinity** (µS/cm)	**Elevation** (m AHD)	**Depth** (m btc)	**Salinity** (µS/cm)	**Elevation** (m AHD)
8.5	964	-0.01	9.4	1016	-0.91	9	1032	-0.51
9	960	-0.51	10.4	1023	-1.91	10	1014	-1.51
10	969	-1.51	11.4	1659	-2.91	11	1533	-2.51
11	976	-2.51	12.4	2434	-3.91	12	2154	-3.51
12	1975	-3.51	13.4	4400	-4.91	13	3624	-4.51
13	2775	-4.51	14.4	6898	-5.91	14	5832	-5.51
14	5080	-5.51	15.4	12198	-6.91	15	9234	-6.51
15	8545	-6.51	16.4	17783	-7.91	16	14110	-7.51
16	13491	-7.51	17.4	24950	-8.91	17	22460	-8.51
17	21060	-8.51	18.4	29405	-9.91	18	28154	-9.51
18	27389	-9.51				18.4	29594	-9.91

Table 7 - Salinity Profile Data Collected from DWER Monitoring Bore B2

DWER Bore B2										
Nov-18				**Apr-19**				**Jun-19**			
Depth (m btc)	**Salinity** (µS/cm)	**Elevation** (m AHD)	(m bwt)	**Depth** (m btc)	**Salinity** (µS/cm)	**Elevation** (m AHD)	(m bwt)	**Depth** (m btc)	**Salinity** (µS/cm)	**Elevation** (m AHD)	(m bwt)
5.4	5230	-0.76	1	5.51	5018	-0.87	1	5.6	4847	-0.96	1
6.4	5319	-1.76	2	6.51	5074	-1.87	2	6.6	4864	-1.96	2
7.4	5327	-2.76	3	7.51	5074	-2.87	3	7.6	4892	-2.96	3
8.4	5352	-3.76	4	8.51	5098	-3.87	4	8.6	5014	-3.96	4
9.4	5364	-4.76	5	9.51	5145	-4.87	5	9.6	5092	-4.96	5
10.4	5373	-5.76	6	10.51	5150	-5.87	6	10.6	5083	-5.96	6
11.4	5388	-6.76	7	11.51	5155	-6.87	7	11.6	5090	-6.96	7
12.4	5401	-7.76	8	12.51	5165	-7.87	8	12.6	5101	-7.96	8
13.4	5830	-8.76	9	13.51	10569	-8.87	9	13.6	10119	-8.96	9
14.4	6550	-9.76	10	14.51	14973	-9.87	10	14.6	14556	-9.96	10
15.4	14515	-10.76	11	15.51	15508	-10.87	11	15.6	15234	-10.96	11
16.4	15150	-11.76	12	16.51	16031	-11.87	12	16.6	15485	-11.96	12
17.4	15169	-12.76	13	17.51	16524	-12.87	13	17.6	16434	-12.96	13
18.4	15195	-13.76	14	18.51	16534	-13.87	14	18.6	16738	-13.96	14
19.4	24669	-14.76	15	19.51	30996	-14.87	15	19.6	29673	-14.96	15
20.4	40780	-15.76	16	20.51	48480	-15.87	16	20.6	45646	-15.96	16
21.4	51115	-16.76	17	21.51	55583	-16.87	17	21.6	54941	-16.96	17
22.4	53950	-17.76	18	22.51	55972	-17.87	18	22.6	55078	-17.96	18
23.4	54642	-18.76	19					23.6	55512	-18.96	19
24.4	55115	-19.76	20					24.6	56421	-19.96	20
25.4	55937	-20.76	21					25.6	57486	-20.96	21
								26.6	58265	-21.96	22
								27.6	58795	-22.96	23

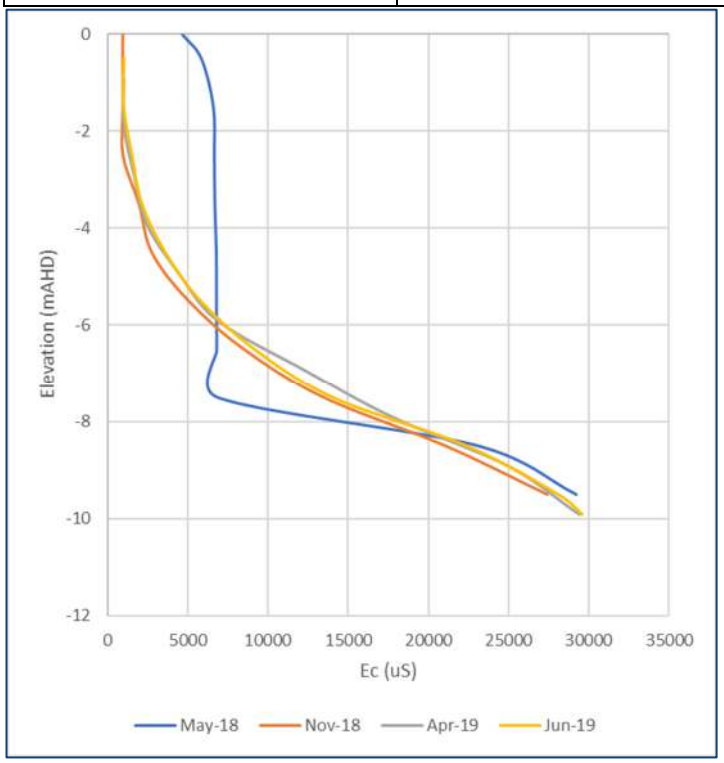


Figure 14 - Groundwater Salinity Profile from DLMB7

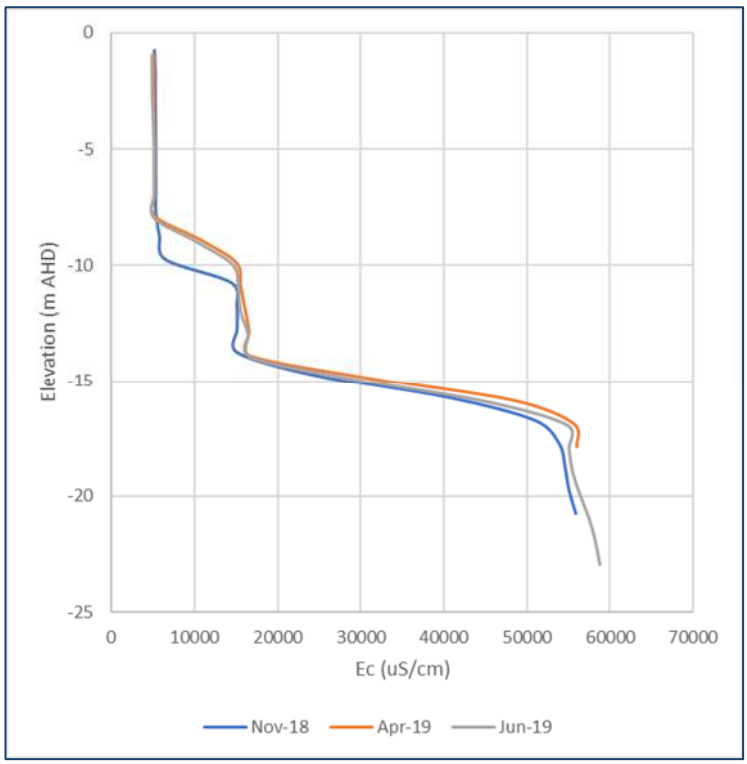


Figure 15 - Groundwater Salinity Profile from DWER Bore B2

The salinity profile for monitoring bore DLMB7 (Fig. 14) shows fresh water (<1670 µS/cm[2]) extends from the water table at about 0.1 to 0.3 m AHD to between about -2.5 (May and June 2019) and -2.9 (November 2018) m AHD, giving a freshwater lens of between 2.6 and 3.2 m thickness for the end of autumn and spring, respectively. The results suggest seasonal thinning of the freshwater lens by approximately 0.6 m at this location. There is a gradual increase in salinity below the fresh water, with slightly brackish groundwater (>1670 and <3340 µS/cm) to about -4.0 to -4.5 m AHD, brackish groundwater (> 3340 and <16670 µS/cm) to about -7.5 m AHD, and saline groundwater (>16670 and <58330 µS/cm) to about -9.5 to -10 m AHD. These results vary from historical records for nearby monitoring bores, where a thicker freshwater lens (5 to 6 m thickness) has typically overlain a sharp and well-defined saline water interface (e.g. Fig. 9). It is unclear whether the difference relates to changes in the aquifer over the last decade or the location of the bores; an attempt was made to run salinity profiles in the northern bores (MW1, MW5 and MW6) in November 2018, however they were found to be inaccessible due to bore deterioration.

Comparison of the salinity profile for DWER monitoring bore B2, using data collected between November 2018 and June 2019 (Fig. 15), and historical data (Fig. 8), suggests salinity in the superficial aquifer has increased in this region since the late 1980's, with brackish water of about 5000 µS/cm (approx. 3000 mg/L TDS) (cf. 1000 to 3000 mg/L in 1988) overlying a stepped saline interface that lies between about -8 and -9.5 m AHD. The saline interface also appears to have risen by several meters with salinities in excess of 5000 mg/L (>8330 µS/cm) occurring at 9 to 11 m below the water table in 2018/2019, compared with about 15 m below the water table in 1988 (Fig. 8). Salinity monitoring results for B2 show

[2] Salinity classification modified from DWER online document *Understanding Salinity*, and using the approximation: TDS = 0.6*EC to convert electrical conductivity measurements to mg/L.

an approximate rise of 2 m in the saline water interface between the end of spring (November 2018) and end of autumn (May 2018).

3.2.4 Groundwater Chemistry

In November 2018, six groundwater samples and one surface water sample were collected for laboratory analysis, and tested for a suite of major ions, metals, nutrients and physical parameters. The six groundwater samples were collected, using a GeoSub 12 V submersible pump, from monitoring bores DLMB1 to DLMB6; the surface water sample was collected by hand from the western edge of Lake Pollard. Monitoring bore DLMB7 was not sampled as the bore is completed with slotted casing from the top of the aquifer through the saline water interface, which would yield non-representative results. Sample collection, storage and transport methods were as per Australian Standard water quality sampling guidelines (AS/NZS 5667: 1998) and field parameters were measured using a calibrated YSI ProPlus multi-parameter meter.

The major ions tested comprised calcium (Ca), sodium (Na), chloride (Cl), magnesium (Mg) and potassium (K), the metals comprised aluminium (Al), iron (Fe) and manganese (Mn), and nutrients comprised ammonium (NH_3), nitrite (NO_2), nitrate (NO_3) and phosphorus (P). The results returned no anomalous values nor any elevated metals or nutrients values. The results are tabulated in Table 8.

Table 8 - Groundwater and Surface Water Chemistry Results

Parameter	Units	DLMB 1	DLMB 2	DLMB 3	DLMB 4	DLMB 5	DLMB 6	LAKE POLLARD
Major Ions								
Calcium (Ca)	mg/L	92.2	86.5	81.7	81.2	90.5	126	645
Magnesium (Mg)	mg/L	10.5	7.4	18.9	9.9	41.2	57	2100
Sodium (Na)	mg/L	37.2	31.7	20.9	29.6	158	325	16100
Potassium (K)	mg/L	1.7	2.5	0.9	2.4	4.3	2.1	423
Chloride (Cl)	mg/L	75	51	34	57	324	666	27600
Bicarbonate (HCO_3)	mg/L	293	288	301	261	392	427	189
Sulphate (SO_4)	mg/L	32	28	19	17	69	66	2800
Silicate (SiO_2)	mg/L	6	6.5	10	8.3	10	12	14
Nutrients								
Amonium (N_NH_3)	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.62
Nitrite (N_NO_2)	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Nitrate (N_NO_3)	mg/L	0.15	0.02	2.6	3.1	0.02	0.64	0.01
N_NOx	mg/L	0.15	0.024	2.6	3.1	0.027	0.65	0.017
Phosphorous (P_SR)	mg/L	0.005	0.006	0.006	0.015	0.006	0.008	<0.005
Metals								
Aluminium (Al) (total)	mg/L	<0.005	0.043	<0.005	<0.005	<0.005	0.011	<0.050
Iron (Fe) (total)	mg/L	0.022	0.02	<0.005	0.007	0.021	0.008	<0.050
Manganese (Mn) (total)	mg/L	0.0075	0.0061	0.0004	0.0023	0.031	0.001	0.013
Physical Parameters								
Total Dissolved Solids (TDS_grav)	mg/L	410	360	340	370	950	1400	60000
pH		8.0	8.0	8.0	8.0	7.8	7.9	7.9
Electrical Conductivity (EC)	µS/cm	693	600	585	582	1714	2911	76000
Hardness	mg/L	270	250	280	240	400	550	10000
Alkalinity	mg/L	241	236	247	214	321	351	155
Carbonate (CO_3)	mg/L	<1	<1	<1	<1	<1	<1	<1
Field Parameters								
Standing Water Level (SWL)	m btc	3.17	3.08	10.26	3.45	3.2	3.62	NA
pH		7.36	7.39	7.42	7.51	7.31	7.25	7.82
Electrical Conductivity (EC)*	µS/cm	760	670	630	650	1790	2830	79200
Temperature	°C	18.7	19.6	20.2	19.4	19.5	19.6	22.8

* Measured with down-hole EC probe 1 m below water table in monitoring bores

The groundwater sampled is fresh (<1000 mg/L TDS) to brackish (1000 – 2000 mg/L TDS), with field pH ranging from near neutral (7.3) to slightly alkaline (7.8).

The results for major ions are plotted on a Piper diagram in Figure 16. The plot shows groundwater samples from the western and northern bores, DLMB1, DLMB2, DLMB3 and DLMB4 are a Ca-HCO_3 type, typical of fresh water recharged through a carbonate soil profile, the water from Lake Pollard has a strong Na-Cl signature, typical of seawater, and the samples from DLMB5 and DLMB6 fall on a mixing line between these two end-members indicating the groundwater is a mixture of the two types (Appelo, 1994). The results support the conceptual hydrogeological model, confirming groundwater recharge via rainfall infiltration occurs to the west and north of the site, and indicating mixing of fresh water with saline water in bores DLMB5 and DLMB6. The latter is expected for DLMB6, which is located close to Lake Pollard but is unexpected for DLMB5, which is located on the dunes away from the lakes. It is possible, however, that the Ca-HCO_3-Na-Cl signature in DLMB5 is the result of recharge from a sumpland located just to the south of this bore (Fig. 20 in Section 5.1).

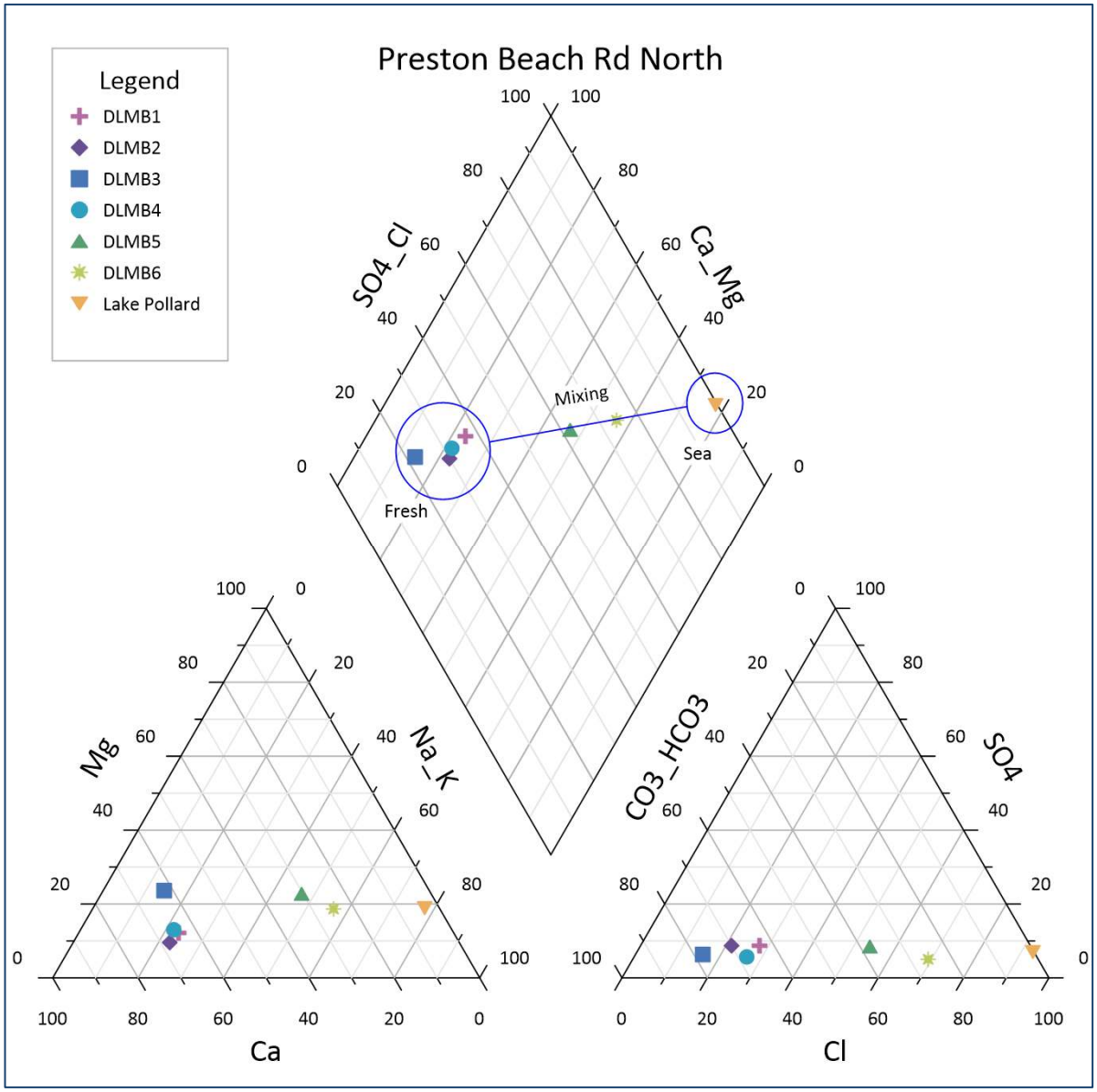


Figure 16: Piper Diagram for Samples Collected in November 2018

The general hydro-chemical trend across the site is illustrated with Stiff diagrams in Figure 17; note the scale differs for groundwater composition and lake water composition. The plot clearly shows the following spatial distribution characteristics:

- Ca-HCO_3 type waters beneath most of the site (DLMB1-4);
- Strong Na-Cl signature for water in Lake Pollard with depleted levels of Ca-HCO_3 indicative of likely calcite precipitation, and relatively enriched in Mg^{2+} and to a lesser extent SO_4^-.
- Groundwater next to the lake (DLMB6) has a strong Na-Cl signature showing lake water moves into the aquifer to the west of Lake Pollard, probably following heavy rainfall events and winter recharge. The groundwater is also relatively enriched with Ca-HCO_3, consistent with continued dissolution of calcite as the groundwater moves through the limestone aquifer towards the lake. Mg^{2+} and, to a lesser extent, SO_4^-, are also relatively enriched compared to most of the groundwater beneath the site.
- The groundwater composition to the south-east of the property (DLMB5) is clearly impacted by a source of saline water, with a higher proportion of Na-Cl than across most of the site. The groundwater is also relatively enriched with HCO_3^{2-}, Mg^{2+} and SO_4^-. Originally it was believed that this could be indicative of mixing of groundwater from Martins Tank Lake (Letter report, 2018), however further investigation shows a small sumpland exists <150 m south-east of the monitoring bore, and this is a more likely source of mixing at this location.

Figure 17 - Stiff Diagrams for 2018 Sampling Results Showing Spatial Trends for Groundwater Composition

The results are consistent with rainfall infiltration through carbonate bearing sediments across most of the site, with mixing evident with saline water in monitoring bores DLMB5 and DLMB6. Once the groundwater discharges to the lake, carbonates are apparently precipitated from the solution.

The groundwater and lake samples have also been analysed using the USGS geochemical modelling software, PHREEQC, to test the saturation indices and thus to assess the potential for precipitation and/or dissolution of carbonate minerals within the aquifer and at Lake Pollard. The results are reported in Section 5.2.7 of this report.

3.3 Conceptual Hydrogeological Model - Site

The EPA Environmental Scoping Document (ESD) requires a conceptual model of the hydrogeological system to be developed, including recharge and discharge mechanisms, aquifer connectivity, surface water/groundwater interactions and groundwater chemistry. The EPA is particularly concerned with potential environmental impacts associated with "winter rainfall storage" within the limestone ridge, and groundwater movement toward Lake Pollard. A hydrogeological model has been developed for the site (Fig. 18) using the results from the drilling and monitoring program and informed by the regional hydrogeological models available for the area.

The results of the current study validate earlier groundwater investigations in the area and the previously proposed conceptual hydrogeological model (Fig. 11). That is, the superficial aquifer beneath the site occurs along a narrow coastal strip within the highly permeable Safety Bay Sands and/or Tamala Limestone. The aquifer is recharged by direct rainfall infiltration, which creates a freshwater lens overlying the coastal saltwater interface to the west, and hypersaline groundwater derived from the coastal lakes and wetlands to the east. A low-lying groundwater divide lies to the west of the site and groundwater flows under a very low hydraulic gradient towards the coastal lakes, which act as regional groundwater sinks and create a complex series of internal groundwater-flow systems (Commander, 1988).

Groundwater levels at the site range from approximately 3.5 m below ground level (bgl) in low-lying areas, to more than 10 m bgl beneath the limestone ridge of the Spearwood dunes. Groundwater elevations show the water table is essentially flat-lying with a very slight rise to the west and south-west of the proposed pit area, beneath the north-south trending, interdunal swale. The groundwater in this area has a low salinity (<500 mg/L TDS), indicating an area of groundwater recharge. Groundwater flows under a very low gradient to the east and north-east toward the coastal lakes at an estimated rate of about 25 m/year. Most of the groundwater flow from the proposed pit location is toward Lake Pollard, and while a small proportion of groundwater flow from the southern end of the proposed pit appears to be toward Lake Clifton, 2km to the east, groundwater from the site is unlikely to reach this lake due to a low-lying groundwater divide inferred to lie beneath the low-lying dunes to the west of Lake Clifton, and the diversion of groundwater flow to the north towards Lake Pollard. There is no apparent groundwater flow from the proposed pit area toward the closer Martin's Tank Lake.

Seasonal fluctuations in the water table are in the order of 0.24 to 0.5 m, consistent with variations seen elsewhere in the high-permeability Tamala limestone formation (Deeney, 1989), with the largest variations occurring near the lakes, apparently in response to summer evaporation.

There is no evidence of groundwater levels being influenced by local topography, nor any significant groundwater mounding beneath the limestone ridge that could meaningfully be described as "winter rainfall storage".

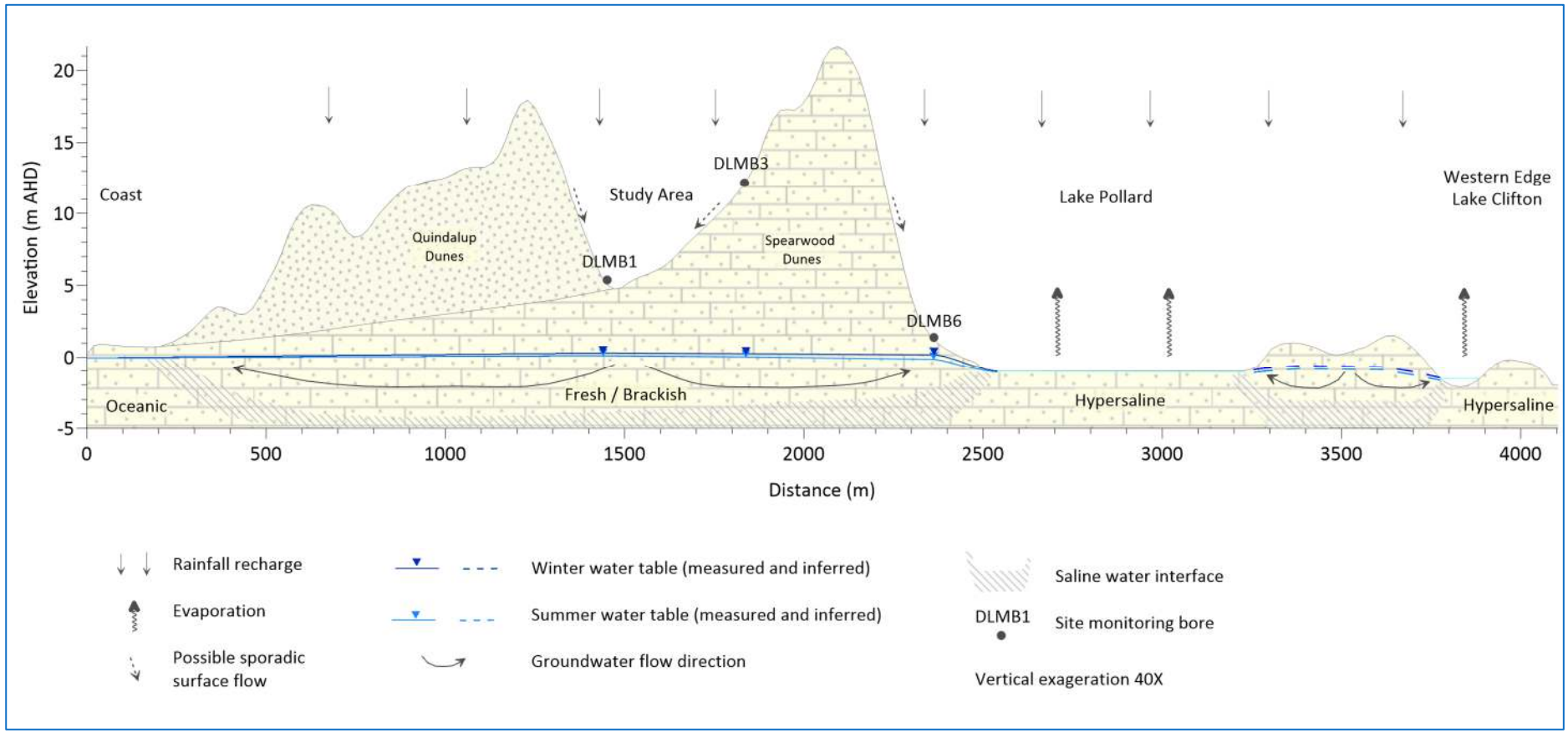


Figure 18: Conceptual Hydrogeological Model – Preston Beach North (after Commander, 1988)

Salinity profile monitoring suggests the fresh-water lens has contracted in the region, likely as a result of reduced rainfall recharge, and groundwater salinity in general appears to be increasing. The geochemical sampling results support the groundwater recharge/discharge model proposed, that is groundwater recharge occurs across the site via direct rainfall infiltration, particularly beneath the interdunal swale and in areas of potentially increased surface water flow, as evidenced by the fresh groundwater with a strong calcium-bicarbonate signature. Groundwater salinity increases toward the east, particularly in the vicinity of Lake Pollard and also near a local multi-use sumpland (UFI 3103) located just south-east of the property boundary. The elevated salinity probably represents local recharge from these surface water features, as evidenced from the increased proportion of sodium-chloride in the groundwater sampled from bores in these locations (Fig. 17). The groundwater across the site generally has elevated levels of calcium-bicarbonate relating to dissolution of calcite in the aquifer and overlying sediments.

Water sampled from Lake Pollard is hypersaline and has a strong sodium-chloride signature. It is depleted with regard to calcium-bicarbonate indicating calcite precipitation has occurred in the lake.

There are no surface water drainage features present on Lot 1002, with the possible exception of the ill-defined valley to the north-east of the site (Fig. 2) and surface flows are likely restricted to episodic, high-rainfall events. The property is internally draining, and any rainfall runoff from the limestone ridge is directed westwards towards the interdunal swale (Fig. 18), where it infiltrates to the groundwater system. There is no surface water flow toward the coastal lakes or Yalgorup National Park from the proposed pit area.

It is noted that the concept of “winter rainfall storage” has not been defined by the EPA in the scoping document and is not referenced in any of the publicly documented studies relating to this region. It is assumed that the term originates from the appeal document submitted by Whitehead and Vogwill (2015), where reference is made to the “significant rainwater storage capacity” and “inflow from” the “western limestone ridge”. The hydrogeological investigations and assessment herein have found no evidence supporting the occurrence of significant winter storage within the limestone ridge, with monitoring results verifying previous conceptual models that propose rapid infiltration of rainfall to the water table, nor any reason to suppose that there is significantly more “fresh groundwater entering from the highly elevated limestone ridge to the west” than from elsewhere within the system, as all groundwater flow within the Tamala Limestone and Spearwood dunes occurs under a very low gradient that bears not relationship to the local topography.

4 Groundwater Use

The proposed limestone excavation is located in the Southwest Coastal, Coastal Groundwater Area. The sub-area extends north to south from the northern edge of Lake Clifton to the southern edge of Lake Preston, and from the eastern edge of these lakes to the coast (Fig. 19). The DWER Water Register indicates only one licence has been allocated for the superficial aquifer in this area: 20000 kL/annum to Cape Bouvard Developments. As the development has not progressed it is unlikely the groundwater is being used at this time.

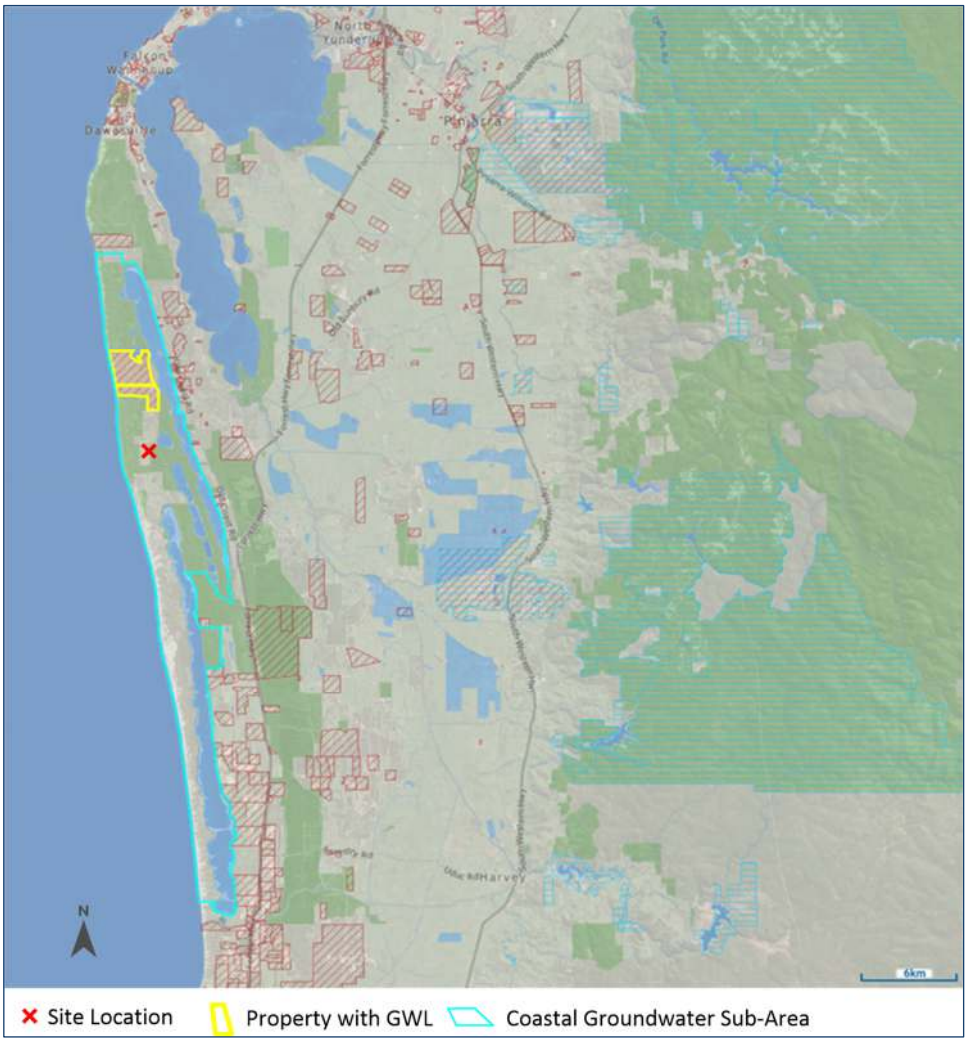


Figure 19 - Groundwater Allocation Area (DWER Water Register – June 2018)

Total allocation volumes are not currently available online; however it is indicated that groundwater is available for allocation (DWER Water Register).

Given concerns expressed by regulatory authorities with regard to the potential for saline upconing at the site, however, and the rigorous hydrogeological assessment process likely to be required to access groundwater, the proponent will not be seeking a groundwater allocation. It is proposed that the 5000 kL/annum of water required primarily for dust suppression will be trucked into site.

Should a groundwater licence be sought in the future, a 26D groundwater licence would be required to drill and construct a water-supply bore and a 5C groundwater licence with a groundwater management operating strategy would likely be required to abstract groundwater at this location.

5 Assessment of Potential Impacts

5.1 Environmental Values

The proposed limestone extraction site is located to the west of the Yalgorup coastal lake and Peel-Yalgorup Ramsar wetland systems, in an area identified by the EPA as having important international, national and regional environmental values. In particular, the EPA specifically considers any development

of the land between the Yalgorup lakes and the coast to be highly constrained due to the special environmental values of the Ramsar listed wetland system, not least of which relate to the Lake Clifton thrombolites (EPA, 2010). The location of geomorphic wetlands in relation to the proposed pit are provided in Figure 20.

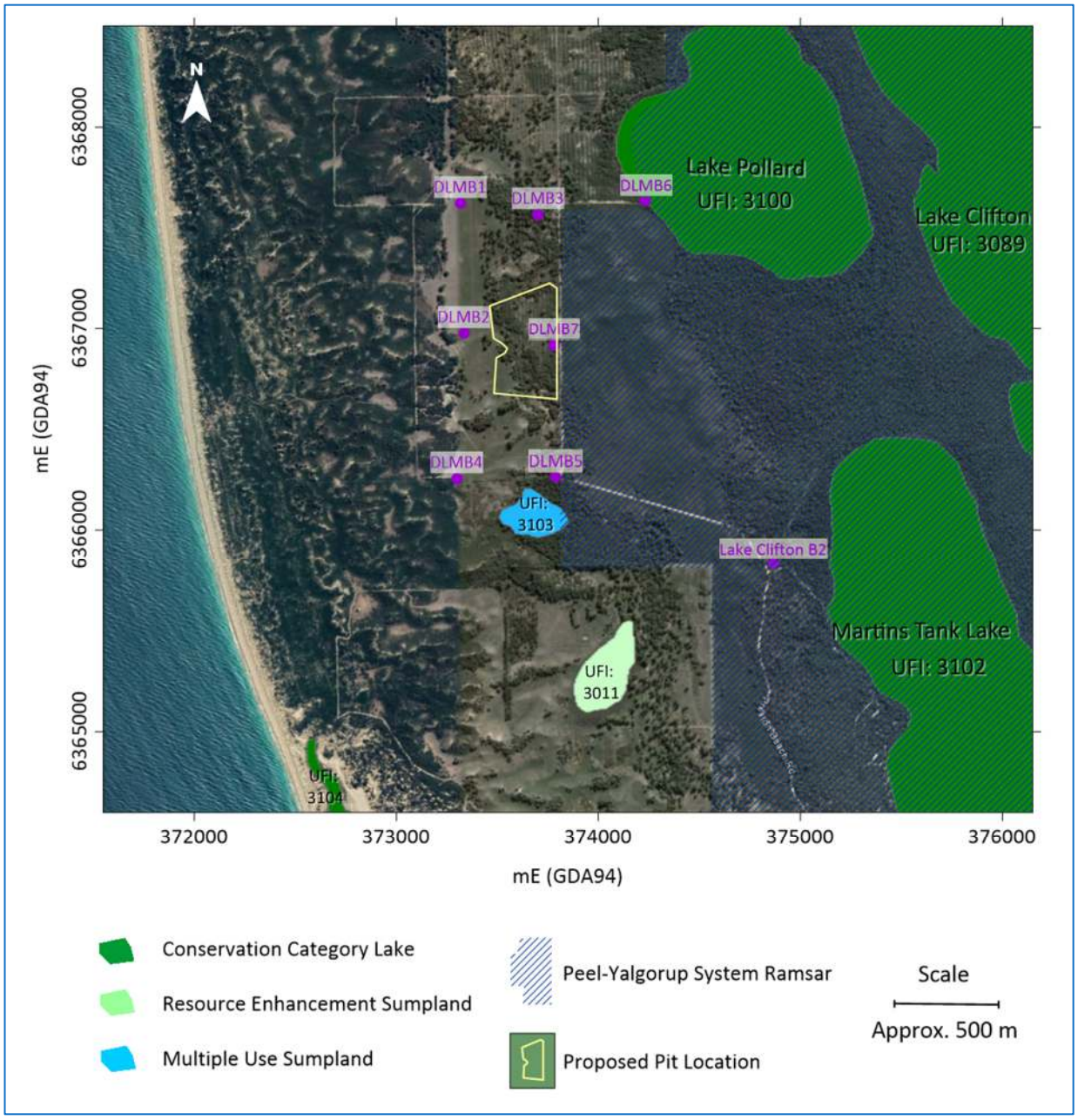


Figure 20: Geomorphic Wetlands

Of particular concern are developments that change existing land use and management systems and may adversely impact the lake ecosystems through changes to groundwater quality and quantity. This includes excavation for mining operations where groundwater extraction might decrease the amount of freshwater flowing to the lakes (EPA, 2010).

It has been noted that the Lake Clifton living microbialites (thrombolites) are in serious decline, likely due to a decrease in fresh groundwater reaching the lake as a result of existing land development and groundwater use to the east of Lake Clifton (EPA, 2010), and it is believed that development west of the

lakes may amplify the adverse impacts by altering the quality and/or quantity of groundwater flow from the west. The existence and formation of these rare geo-heritage features, which extend approximately 15 km along the north-eastern edge of Lake Clifton, is directly related to the hydrogeology of the region, with upwelling of fresh, carbonate-rich groundwater within the lake and seepage along the eastern shores sustaining their growth (EPA, 2010).

The DBCA have also indicated that the wetlands located approximately 470 m to the south of the proposal (UFI 3103) (Fig. 20) are likely to contain values commensurate with Conservation Category wetlands (App. A-A) (although the wetland is listed as "multiple use", which by definition indicates a level of degradation rendering it not a priority for conservation), as well as unsurveyed interdunal wetlands in the coastal dunes to the west of the proposal which may potentially contained threatened ecological community (TEC) *Sedge lands in Holocene dune swales of the southern Swan Coastal Plain* (Floristic Community Type SCP19).

The EPA has advised the Minister that the environmental values of the area are intrinsically linked, and that the region's hydrogeology underpins the ecology and international significance of the Yalgorup Lakes, hence, protection and maintenance of the natural groundwater regime is considered to be of utmost importance (EPA, 2010). It is the EPA's view that development adjacent to the lakes poses a significant risk and unacceptable threat to the ecological character of the lakes, and so any proposal for development is required to show, in a scientifically rigorous manner, that there will be no adverse impact on the hydrological regime. This requirement naturally extends to the wetlands to the south and west of the proposal.

5.2 Proposed Development Impact Assessment

It is noted that the current investigation shows that hydrogeological characteristics in the region are changing under existing conditions, and that some of the issues noted to be occurring to the east of the Yalgorup Lakes (Section 5.1) are already in play to the west of the lakes as well. This is consistent with DWER's assessment for the Peel Coastal groundwater area, which nominates climate change as a key factor in changing groundwater conditions (DoW, 2015). This assessment therefore considers the potential for the proposed development to exacerbate changes that are already occurring as a result of lower rainfall and climate change.

5.2.1 Groundwater Abstraction

The proposal is for excavation to occur above the water table, negating any need for dewatering, and the modest water supply requirements (up to 5000 kL/annum) will be met by trucking water to site.

Previously it was assumed a small allocation with abstractions rates of up to 30 kL/d (0.4 L/s) would be sought for dust suppression, and earlier versions of this report provide analytical modelling of likely drawdown response (Managed Recharge, 2019). The modelling, using Neuman's Solution for a range of hydraulic conductivities, indicated a maximum drawdown of <0.1 m 10 m from the production bore for a conservative hydraulic conductivity of 20 m/d.

It was noted that any groundwater abstraction should be via a low-flow production bore, designed to reduce the potential of the saline water up-coning towards the well and that a groundwater management

operating strategy, incorporating a groundwater monitoring program, might be necessary as part of the groundwater licensing requirements.

5.2.2 Groundwater Recharge Estimations and Contribution to Lake Water Budget

The coastal lakes act as a groundwater sink, and water budget analysis is required by the EPA to assess the potential risk of impact to the coastal lakes (Lake Pollard, Lake Clifton and Martins Tank) and nearby wetlands from the proposed limestone pit development (Appendix A). Of particular concern is the stated risk relating to the removal of "winter rain storage capacity" in the limestone ridge and subsequent impacts to hydrogeological processes and water quality on the nearby conservation significant wetlands.

It is noted for clarity that there is no evidence to support the presence of "winter rainfall storage" capacity within the aquifer at this location (Section 3.3), and so the risk noted above is arguably not applicable to groundwater conditions at this site. Similarly, the current investigation shows there is no groundwater flow from the proposed pit area to Martins Tank Lake, and that any flow from the proposed pit towards Lake Clifton is negligible and likely to be diverted northwards towards Lake Pollard (Section 3.2.2); the analytical modelling therefore focuses on potential impact to Lake Pollard.

The potential impact of limestone and sand extraction on local groundwater recharge and its relation to the water budget for Lake Pollard has been assessed using several analytical methods, although it is noted that there are insufficient data available to develop a rigorous water budget for the aquifer and Lake Pollard, and any estimates should be considered indicative of the level of potential risk only.

Pit-area Contribution to Groundwater Discharge along the Western and Southern Sides of Lake Pollard

The area of recharge corresponding to the proposed pit area has been compared with the total estimated recharge area corresponding to a nominal "western discharge envelope" (Fig. 21). The "discharge envelope" marks out an area to the east of the inferred groundwater divide beneath the Quindalup Dunes, which can reasonably be assumed to contribute groundwater discharge to the western and southern sides of Lake Pollard, providing a measure for calculating an approximate proportion of groundwater discharge contributed from the proposed pit area.

The total estimated area for the "western discharge envelope" is around 2,316,300 m^2, and the total area for the proposed pit is about 203,400 m^2, i.e. slightly less than 10% of the "discharge envelope". Therefore, any change to rainfall recharge volume or groundwater quality resulting from the proposed development will impact an area <10% of the total area contributing groundwater discharge to Lake Pollard from the western dunes, and subsequently the risk of a significant adverse impact on the lake is considered to be low.

Figure 21: Approximate Area Providing Groundwater Discharge to Lake Pollard

Rainfall Recharge Volumes

Rainfall recharge via direct infiltration to the aquifer is the primary method of groundwater recharge in the region and maintains the freshwater lens that feeds into the coastal lakes, supporting their unique ecological systems. Two methods were used to estimate the volume of rainfall recharge occurring over the proposed pit area and the total "western discharge envelope" and the results compared.

The first method calculates recharge as a percentage of rainfall, whilst the second method calculates recharge based on water table fluctuations (WTF). The equations for each method are as follows:

Percentage of rainfall method:

$$Est.Rchg\ Volume = \ Average\ annual\ rainfall\ (m)\ x\ \%\ of\ annual\ rainfall\ that\ enters\ the\ aquifer\ x\ Area\ (m^2)$$

Water table fluctuation (WTF) method:

$$Est.Recharge = \ Sy\ x\ \triangle h\ (m)\ x\ Area\ (m^2)$$

Where Sy is specific yield, and $\triangle h$ is change in water table level over a 12-month period.

These methods are considered to be valid since groundwater recharge in the area is known to be dominated by direct rainfall infiltration, previous estimates for percentage of rainfall contributing to recharge are available (e.g. Commander, 1988, Shams, 1999 and DoW, 2009), and the water table fluctuation method relies on measurements of minimum and maximum water table levels, which are

available for the site over a 12-month period. Table 10 tabulates the recharge estimates based on these two methods for a couple of viable options.

Table 9 - Recharge Estimations for the Proposed Pit Area and the Western Discharge Envelope

		Recharge Estimation Methods							
		% of Rainfall				Water Table Fluctuation (WTF)			
	Area (m^2)	Average Rainfall (mm)	% of Rainfall	Rch as a % of Rainfall (m/yr)	Est. Recharge (m^3/yr)	Specific Yield	Change in h (m)	Est. Recharge (m)	Est. Recharge (m^3/yr)
Pit Area	203,400	623	8	0.04984	10,137	0.2	0.24	0.048	9,763
Western Discharge Envelope	2,316,300	623	8	0.04984	115,444	0.2	0.24	0.048	111,182
Pit Area	203,400	623	13	0.08099	16,473	0.2	0.4	0.08	16,272
Western Discharge Envelope	2,316,300	623	13	0.08099	187,597	0.2	0.4	0.08	185,304

Source of information: Average rainfall data from Bureau of Meteorology; Percentage of rainfall estimate after DoW, 2009.

The recharge estimates shown in Table 10 show that the two methods return similar results. Within the prosed pit area, recharge as a percentage of rainfall returned estimated volumes of between 10137 and 16473 m^3/yr, for 8 and 13 % net rainfall recharge respectively, and the WTF method returned estimated volumes of between 9763 and 16272 m^3/yr, for seasonal water table variations of 0.24 and 0.4 m, respectively. Within the "western discharge envelope", recharge as a percentage of rainfall returned estimated volumes of 115444 and 187597 m^3/yr, for 8 and 13 % net rainfall recharge respectively, and the WTF method returned estimated volumes of between 111,182 and 185304 m^3/yr.

The results can be applied in further analytical analysis by assessing the estimated recharge volume from the proposed pit area as a percentage of total groundwater discharge via evaporation from Lake Pollard. When the water levels in the lake are rising or remain in equilibrium, it can be assumed that the lake is being recharged at a rate equal to or higher than evapotranspiration. As the primary recharge mechanisms for the coastal lakes are direct rainfall accession and groundwater inflow, the calculated "net evaporation" (i.e. total evaporation minus rainfall) from the lake may provide an approximation of the total groundwater recharge to the lake.

With a published pan evapotranspiration (PET) rate of 1500 mm/yr (BoM, 2019) we can calculate a net evaporation rate of 877 mm/yr (1500 mm ET – 623 mm RF). Given a surface area for Lake Pollard of about 650600 m^2, the volume of discharge via evapotranspiration (ET) from Lake Pollard can be estimated to be around 570600 m^3/year (area * net PET). Assuming all recharge from the proposed pit area flows into Lake Pollard, which is conservative, the proportion of total groundwater recharge contributed to Lake Pollard from the proposed excavation site makes up approximately 2 to 3 % of the total groundwater discharged via ET. Therefore, any impact on the volume or quality of recharge water discharging to the lake from the proposed pit area can be considered to pose minimal risk of impact on the lake's hydrogeological regime as a whole.

This assessment can also be used to quantify potential impact on the lake from abstraction. Should abstraction be required in the future, it will be in the order of 5000 kL/yr, equating to a loss of < 1% per year of groundwater recharge to Lake Pollard.

5.2.3 *Surface Water Flow*

The potential for the proposed development to impact on surface flow to Lake Pollard has been assessed and is summarised in the following paragraphs.

The proposed pit is located on land at 5 m to 10 m (AHD) topographic elevation, on the western side of a northwest-southeast trending limestone ridge that has a maximum elevation of 20 m to 30m (AHD) (Fig. 22). The lake systems relevant to this study are located on the eastern side of the ridge.

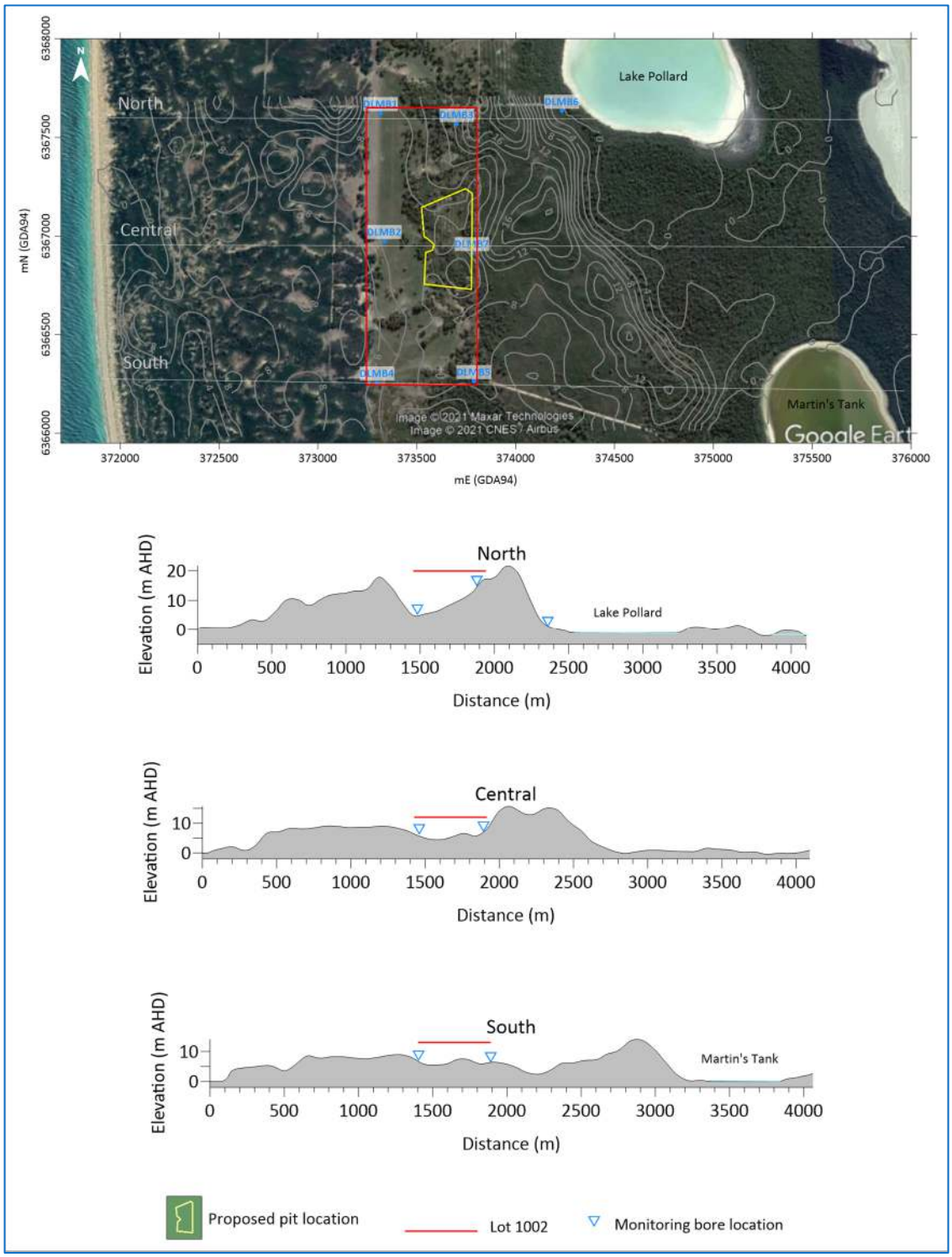


Figure 22: Site topography and cross-section profiles

Most rainfall occurring on site is likely to infiltrate directly to the underlying dunes, however following extreme rainfall events, or after periods of intense rainfall, there may be some transient surface water flow. Figure 22 shows the topography and cross-sectional views of the study area. The proposed excavation-site is located on the western flank of the limestone ridge (as marked by the site monitoring bores). The topographic contours and cross-sections show that any surface flow that occur at Lot 1002 is predominantly directed to the low-lying swale to the west of the proposed pit, and is essentially internal. Any surface flow that occurs on the eastern side of the ridge will flow east toward to lake systems i.e. following topography. It is noted that no excavation is planned to the south of the site, where some minor surface flow to the south and east might occur.

Any ground disturbance activities undertaken at the proposed pit location will have no impact on existing surface flow conditions with respect to any flow towards Lake Pollard, Lake Clifton, Martins Tank Lake or the Yalgorup National Park. Similarly, there is an adequate buffer between the proposed pit area and the western dune system, namely the north-south trending swale where any interdunal surface flow would naturally be directed before recharging to the aquifer; as disused pastural land, there are no notable environmental values that will be impacted by any modifications to surface flow resulting from pit excavation, and any impact will be contained within the property boundary.

5.2.4 Extractive Industry

The DoW's Water Quality Protection Note 15, indicates that extractive industries should be an accepted land use near most sensitive water resources provided the operator adheres to regulatory conditions designed to meet local planning, environmental and water source protection objectives (DoW, 2013). The extractive industry should not affect the water balance or ecology of natural lakes, swamps or wetlands with recognised conservation values or their fringing vegetation unless approved by the Minister for the Environment (DoW, 2013). An environmental risk assessment was previously undertaken for the proposal (Landform, 2016) and those elements relating to hydrological processes are discussed below under the heading *Environmental Risk Assessment*.

In the 2015 Peel Coastal Groundwater Allocation Plan, the Department of Water (DoW) indicated domestic bores in the region posed a low risk to the groundwater system due to low abstraction volumes that are spread out over a wide area (DoW, 2015). In addition, it determined that increased groundwater salinity in the region was due primarily to decreased rainfall and subsequent reduction in groundwater recharge, possibly compounded by increased evaporation rates, a conclusion supported in the current investigation. While it was considered that the Groundwater Area was not suitable for new bores due to declining water quality in some areas and potential impact on other users, at the time of publication groundwater in the Coastal sub-area was fully allocated; this is no longer the case and the current site investigation has shown that suitable groundwater is available at the site with no nearby users. Given concerns relating to the relatively thin nature of the freshwater lens and the potential for upconing and salinization, however, no application for a groundwater allocation is likely to be made and no abstraction is planned for the site.

5.2.5 Environmental Risk Assessment

The most relevant EPA objective to the current investigation, as addressed by Landform's 2016 environmental risk assessment, is the requirement to maintain the hydrological regime of groundwater

and surface water without significant change, so that existing and potential uses are protected along with any ecosystem that may be reliant on those regimes.

Surface Water Flow

In the Landform (2016) investigation, risks relating to impacts on surface water flow paths, streams, and associated ecological functions are considered to be low due to the absence of any of these features on-site. However, while it is noted that there are no permanent surface drainage features or water courses present, it is likely that overland flow occurs from the flanks of the dunes to the swale in heavy rainfall events. Excavation of the pit will level out the land on the western flank of the northwest-southeast trending limestone ridge that runs between the proposed site and the coastal lakes, and it is conceivable that this will result in increased infiltration and groundwater recharge in the area excavated following heavy rainfall events. However, as any run-off from the area would naturally infiltrate in the swale immediately west of the proposed pit, no net increase in groundwater recharge is anticipated in the long term. Less surface water to the swale, if it occurs, is unlikely to impact on environmental values within the swale as the land comprises degraded pasture with no notable reliance on surface water flow.

It is noted that the proposed site is essentially an internal catchment (i.e. there is minimal, if any surface flow away from the site) (Section 5.2.3), and there will be no change to surface flow characteristics in the neighboring Yalgorup National Park, where the coastal lakes and associated Ramsar-listed wetlands are located.

Groundwater Recharge and Discharge

Landform (2016) considers the risk to changes in groundwater flow volumes to the lakes as a result of the proposed development to be low, and this is also supported by the current investigation. Recharge to the aquifer via rainfall infiltration is unlikely to be significantly impacted at the site, which has been shown to be a local groundwater recharge area with rainfall infiltration occurring predominantly via the swale and/or dunes to the west of the proposed excavation site, and the limestone ridge to the north. Any additional recharge that might occur over the excavated area as a result of clearing and leveling the land is unlikely to represent a net increase in recharge in the long-term, as discussed in Section 5.3. There may be a temporary increase in groundwater recharge in the pit area as vegetation is cleared, however this should be mitigated once the land is rehabilitated and revegetated.

If rainfall recharge was doubled over half the pit area (allowing for staged extraction and revegetation) then additional recharge to the aquifer could be in the order of 5070 to 8240 m^3/yr (using recharge estimates in Section 5.2.2), which is < 5% of total estimated rainfall recharge potentially discharging to Lake Pollard from the western dunes.

Groundwater mounding in response to this potential additional recharge has been modelled using the analytical modelling program MOUNDSOLV (HydroSOLVE, 2021). The results are presented in detail in Appendix E and are summarised in Table 10. The modelling indicates that the groundwater levels at the perimeter of the pit might rise between 0.008 and 0.014 m, assuming an additional 8 to 13% annual rainfall recharge delivered over six months. For a worst-case scenario, with hydraulic conductivity in the Tamala Limestone as low as 20 m/d, the maximum groundwater level rise at the perimeter of the excavation area is 0.031 m (Fig. 23). These levels (< 3 cm in magnitude) represent changes that will be

indistinguishable from natural seasonal variations, and no significant impact on groundwater flow is anticipated.

Table 10 – Summary of groundwater mound modelling (MOUNDSOLV)

	Additional Recharge		Maximum Groundwater Mounding at Pit Perimeter	
	m^3/d	% Annual Rainfall	m	cm
North and South				
K_h = 60 m/d	28.16	8	0.008	0.8
	45.76	13	0.014	1.4
K_h = 20 m/d	28.16	8	0.019	1.9
	45.76	13	0.031	3.1

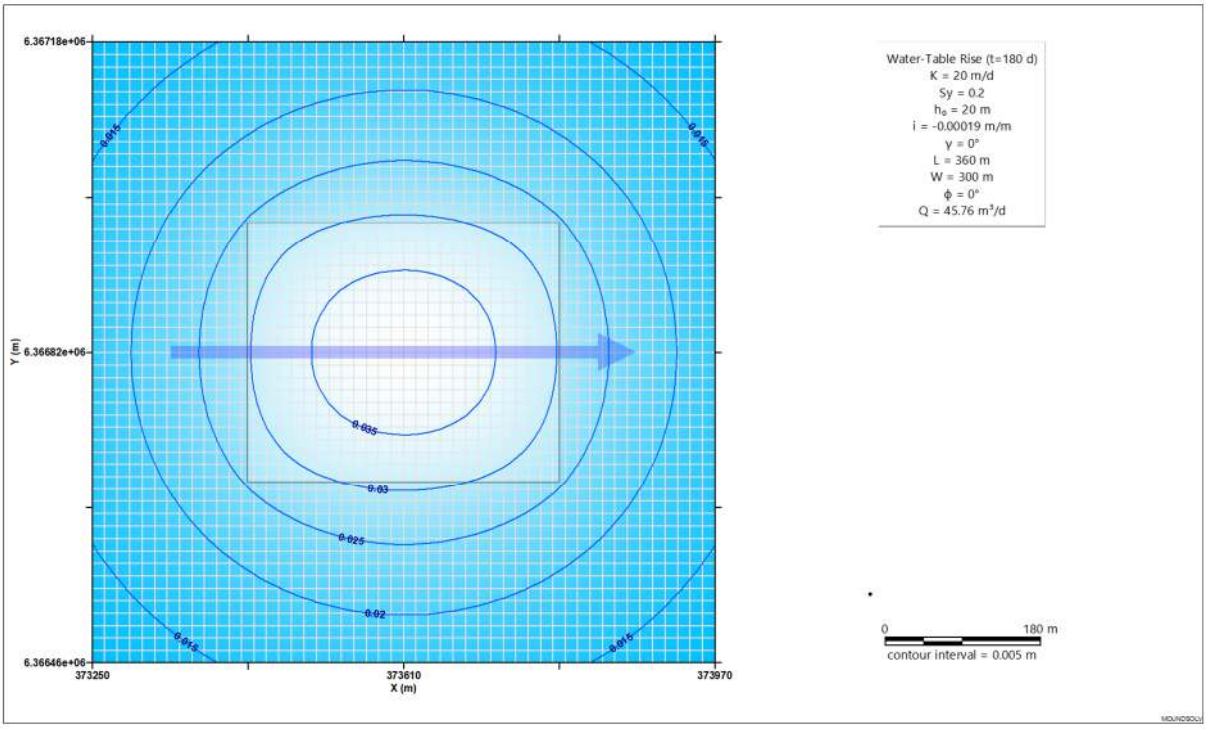


Figure 23: Maximum modelled groundwater level rise (m) for worst-case scenario (additional 13% annual rainfall recharge over half pit area delivered over 180 days, for aquifer hydraulic conductivity values of 20 m/d)

The proposed depth of undisturbed profile is >3 m, which should prevent any significant increase in evaporative discharge from the pit area. This is supported by the low salinity values measured in the groundwater beneath the swale (<500 mg/L TDS) indicating minimal evaporation of groundwater from the water table approximately 3.5 m below ground surface. Conversely, there is an apparent salinity plume near monitoring bore DLMB5 and possibly extending beneath DLMB7, which is inferred to originate at the multiuse sumpland (UFI 3103) just south of the site, where the land elevation dips to about 1.4 m AHD. These results show that while shallow depth to water does impact on groundwater salinity in the region, depth to water >3 m is apparently sufficient to mitigate against this risk.

Groundwater Abstraction

While the relatively modest water requirement for the proposal (5000 kL/annum) is likely to be sustainable from this site, concerns relating to upconing and salinisation of the groundwater system

mean that licensing conditions are likely to be stringent and costly. The decision has therefore been made to truck water into site, and therefore no groundwater abstraction is proposed.

Groundwater Salinity

With minimal changes to groundwater recharge and/or evapotranspiration, there is unlikely to be any adverse impact to groundwater salinity at the site. If there is a shift in the location of rainfall infiltration slightly to the east with the leveling of land on the western flank of the limestone ridge, this may decrease the groundwater salinity in that area and potentially thicken the freshwater lens closer to the lakes, but this is unlikely to have a detrimental impact on the hydrogeological system overall, and may even be beneficial.

Groundwater Dependent Ecosystems

The risk that the environmental values of the Ramsar-listed wetlands to the east of the site might be adversely impacted by changes in the hydrological regime is considered to be low, because any impact is likely to be minimal and well contained within the property boundaries. This conclusion naturally extends to any wetlands located to the west and/or south of the site.

Groundwater Contamination

The other notable risk to the groundwater system relating to extractive industry is contamination from hydrocarbons (fuel, oil, grease etc.) and waste disposal. It is understood that no major servicing of machinery will be undertaken on-site, and that any fuel will be stored according to standard industry requirements (Landform, 2016). Portable toilets will be provided, and all waste will be removed from site for disposal at an approved facility (Landform, 2016). The current investigation has shown the minimum depth to groundwater across the site is > 3 m bgl, which is the minimum requirement for water quality protection from extractive industry operations in a Priority 1 drinking water area. The risk for groundwater contamination is therefore considered to be low.

5.2.6 Hydrological Processes and Inland Waters Environmental Quality

In the EPA's Environmental Scoping Document (Appendix A), the potential risk of impact to hydrological processes and water quality in the nearby Yalgorup National Park and significant wetlands is raised, in particular with regard to the potential for removal of winter-rain storage capacity.

As required in the ESD, a conceptual model of the hydrogeological system has been developed including recharge and discharge mechanisms at the site and in relation to the environmentally sensitive conservation wetlands in the National Park (Fig. 18). It has been shown that Lot 1002 is essentially an internal surface water catchment that may act as a groundwater recharge zone. Fresh, shallow-groundwater flows under a very low hydraulic gradient towards the Yalgorup National Park and coastal lakes, which act as a regional groundwater discharge zone. Groundwater from the northern half of the proposed excavation area flows toward the south-western shore of Lake Pollard at an estimated rate of about 26 m/year (Section 3.2.2). Groundwater from the southern half of the proposed excavation area flows towards Lake Clifton at an estimated rate of about 21 m/year, however it is likely that the flow is diverted northward further to the east in response to the evaporative drawdown depression created by

the Lake Pollard and the groundwater divide inferred to lie between Lake Clifton and the western lakes, which probably prevents the groundwater reaching Lake Clifton itself.

Measurement of groundwater levels relative to the land surface has shown that there is no direct relationship between ground elevation and groundwater elevation, and there is no evidence to support the assertion that topography plays an important role in development of a groundwater mound at this location. Indeed, the water table has been shown to be essentially flat-lying across the site, with a very slight rise occurring beneath the low-lying land along the eastern contact with the Quindalup Dunes.

Further, the proposal is to excavate limestone and/or sand to no less than three metres above the water table, and the results from on-site drilling show that the superficial aquifer occurs within the saturated sediments of the Safety Bay Sand and/or Tamala Limestone, both of which have relatively high vertical hydraulic conductivities and allow rapid infiltration of rainfall to the water table. Groundwater levels measured on site over 12 months (Fig. 13) and to the south-east in monitoring bore B2 (Fig. 6) indicate groundwater level rise in response to winter rainfall is generally ≤ 0.5 m, which is well within the proposed undisturbed-ground buffer between the pit-floor and water table. There is no evidence of perched water at the site, and measured aquifer response to rainfall confirms infiltration to the aquifer occurs without notable delay (Fig. 23). It is also noted that groundwater level changes appear to be affected more by evaporative discharge from the lakes than rainfall recharge (as evidenced by larger seasonal fluctuations and lower minima in monitoring bores DLMB6 and B2, located near the lakes). This is consistent with the recharge/discharge calculations in Section 5.2.2, which show the volume of groundwater discharged from the lakes far exceeds groundwater recharge.

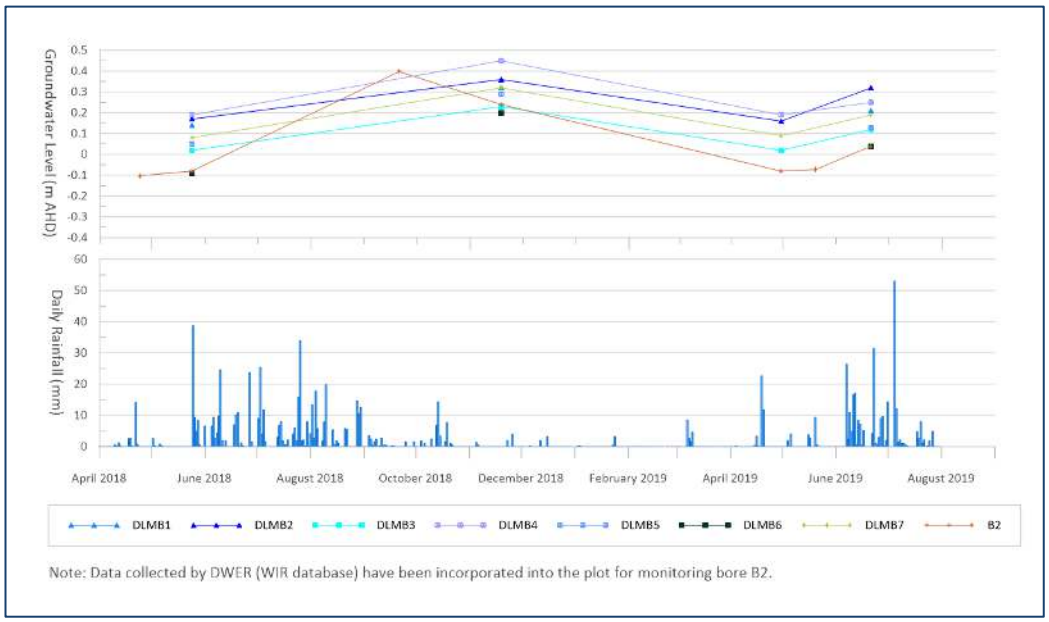


Figure 24: Groundwater Levels and Daily Rainfall

The results from the current investigation have found no evidence of significant winter rainfall storage associated with the limestone ridge, with the water table being essentially flat lying and well below the proposed pit floor elevation at all times of year. The risk of potential impact due to the removal of winter rainfall storage is therefore deemed to be low.

Any change to the site water balance is likely to be minimal since the proposed operations are unlikely to significantly affect net recharge or discharge. Geochemical and groundwater level modelling have shown the proposed operations are unlikely to have a significant effect on groundwater quality or groundwater levels at the site and therefor the risk of adversely impacting hydraulically connected ecosystems beyond the site boundary is also considered to be low. This is developed further in relation to potential post-development impacts below.

5.2.7 Geochemical Modelling – PHREEQC Analysis

Geochemical modelling was performed to assess current groundwater chemistry and saturation indices with respect to carbonate minerals (calcite, aragonite and siderite) and to determine the potential for increased discharge of calcium-bicarbonate to Lake Pollard due to increased limestone dissolution in the proposed pit area, resulting from the exposure of fresh and crushed limestone to the atmosphere and rainfall.

The values for major ion concentrations as detailed in Section 3.2.4, were input and analysed using the USGS geochemical modelling software, PHREEQC, and the results were reviewed to determine the potential for dissolution and/or precipitation of carbonate minerals in the groundwater system and Lake Pollard under existing conditions.

Values for saturation indices (SI) returned from the PHREEQC modelling program provide an indication of the degree of saturation with respect to specified minerals, which can then be used to assess whether those minerals will be likely to dissolve or precipitate in a given solution: for SI = 0 there is equilibrium between the mineral and solution; SI <0 reflects sub-saturation and the potential for dissolution; and, SI >0 reflects supersaturation and the potential for precipitation (Appelo, 1994); the greater the magnitude of the SI from zero the greater the potential for dissolution or precipitation. It is noted that SI values are based on thermodynamic estimations and that kinetic factors, the rate at which a chemical reaction will occur, will also affect the likelihood of a mineral dissolving or precipitating from solution, for example microbiological reactions can increase the potential for precipitation and formation of oxides on mineral faces can reduce the potential for dissolution.

The SI values calculated for carbonate minerals, aragonite, calcite and siderite, from the PHREEQC simulation are summarised in Table 11.

Table 11 – Summary of PHREEQC Results for Saturation Indices

Mineral	Formula	Saturation Index (SI)						
		DLMB1	DLMB2	DLMB3	DLMB4	DLMB5	DLMB6	Lake Pollard
Aragonite	$CaCO_3$	0.06	0.08	0.11	0.13	0.06	0.13	0.49
Calcite	$CaCO_3$	0.21	0.23	0.26	0.28	0.21	0.28	0.64
Siderite	$FeCO_3$	-1.49	-1.56	NA	-2.12	-1.47	-1.9	NA

Percentage errors <5%

The results show that under current conditions calcite and aragonite are near equilibrium or slightly supersaturated (SI between 0.06 and 0.28) in the groundwater system and that these minerals, particularly calcite, are likely to precipitate from solution under favourable conditions; the results are consistent with groundwater present in a limestone matrix. In general, groundwater present beneath the swale, in the Safety Bay Sand is less saturated with regard to $CaCO_3$ than the groundwater present in the Tamala Limestone, but the trend does not hold perfectly, with groundwater from monitoring bores

DLMB4 and DLMB5 showing contrary results. It is noted that there is no significant increase in saturation index between the monitoring bores on-site and monitoring bore DLMB6, located next to Lake Pollard indicating the groundwater is in equilibrium with the limestone matrix and minimal, if any, additional carbonate dissolution occurs along the groundwater flow path.

At Lake Pollard, the water is more highly supersaturated with regard to calcite and aragonite (SI = 0.64 and 0.49, respectively) probably as a result of mixing and evaporation, and these minerals will have a greater tendency to precipitate in the lake system, which is consistent with the assessment of geochemical characteristics in Section 3.2.4.

All samples are sub-saturated with regard to Siderite, indicating this mineral is likely to be dissolved in the groundwater and lake system.

It is possible that the rate of limestone dissolution will increase upon excavation, when fresh and crushed rock is directly exposed to the atmosphere and rainfall. Geochemical modelling, however, shows the native groundwater at this location is already in equilibrium or slightly supersaturated with respect to calcium carbonate minerals, and so the geochemical reaction is unlikely to proceed further (that is the reaction reaches a point where the rate of dissolution and precipitation equilibrate, equation below), and relative concentrations of Ca^{2+} and HCO_3^- should not increase significantly over and above existing conditions.

$$CaCO_3 + CO_2 + H_2O \leftrightarrows Ca^{2+} + 2HCO_3^-$$

Hence, the risk of impact to Lake Pollard, or other wetland features, due to changed geochemical conditions in the discharging groundwater as a result of excavation activities is considered low. In addition, it is anticipated that the rate of limestone dissolution will decrease over time as weathered surfaces develop on the exposed limestone. Any fines reaching the aquifer via solution channels in the limestone should settle long before the groundwater reaches the lake, given the estimated transport time of 30 years.

5.3 Potential Post-Development Impact Assessment

A conceptual assessment was completed on the potential impacts to recharge and surface flow regimes after excavation has ceased. The excavation activities are proposed to remain >3 m above the groundwater table and cover an area of approximately 0.23 km^2 on the western side of the northwest-southeast trending limestone ridge (Section 5.2.3).

Upon the completion of excavations, it is possible that the leveled land and any resulting shallow pits may act as a capture and recharge zone for rainfall and surface run-off, with the water either flowing laterally to the west as surface flow, or infiltrating directly to the groundwater table. In this case, slight temporal groundwater mounding may occur beneath any shallow pits after large precipitation events however, due to the high permeability of the aquifer matrix and the unsaturated zone, groundwater water will be dispersed relatively rapidly through the aquifer, and notable on-going mounding is unlikely. It is noted that any increased recharge beneath the excavation site will simply represent recharge that would otherwise have occurred in the swale immediately to the west of the pit area and does not represent a significant change to the hydrogeological regime.

When, or if, any shallow pits temporarily fill with water from rainfall and runoff, it is expected that the water will infiltrate rapidly, as it does elsewhere, with no increase in evaporation from surface water pooling. Similarly, no significant increase in evapotranspiration is anticipated as a result of lowering of the land surface since the proposed base of the excavation will remain >3 m above the groundwater table, which is greater than the extinction depth (0 to 3 m bgl) over which most evapotranspiration is generally expected to occur. In the case of larger, potentially groundwater-dependent species, such as Tuarts (*Eucalyptus gomphocephala*), DWER have provisionally classified them as being groundwater dependent when the depth to groundwater is <10 m (DoW, 2015), and so excavation and revegetation will not significantly alter the existing conditions for these trees at this location as the land to be excavated is generally at an elevation ≤10 m AHD. It is also possible that once vegetation is re-established, potential temporal surface pooling within the shallow pits could contribute to plant transpiration which in-turn may relieve the uptake of groundwater by the vegetation.

As discussed in detail in Section 5.2.3, there will be no change to surface water flow to Lake Pollard, Yalgorup National Park or other wetland features as a result of the proposed development.

Given the relatively small area of the proposed pit site, and that excavation is to remain more than 3 m above the groundwater table, the risk of long-term impact associated with possible changes in flow regimes will be minimal, with little, if any, impact on Lake Pollard, the Ramsar wetlands, or vegetation to the west.

6. Response to ESD – Work Required

The Environmental Scoping Document (ESD) (Appendix A) sets out specific work requirements to address the EPAs objective to "maintain the hydrogeological regimes and quality of groundwater and surface water so that environmental values are protected." The work conducted herein addresses this objective and informs the level of risk to hydrogeological processes and water quality of the nearby conservation-significant wetlands and the Yalgorup National Park. Table 12 provides a summary response to the relevant EPA requirements tabled in the scoping document.

Table 12: Summary Response to EPA Work Requirements

Inland Waters		
	EPA Requirement	**Response informed by Hydrogeological Assessment**
EPA objective	To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.	
Relevant activities	Excavation of sand and the limestone ridge to within 4 m above the water table, and groundwater abstraction for proposal activities including dust suppression.	Note, groundwater abstraction is no longer proposed.
Potential impacts and risks	Removal of the limestone ridge potentially removes winter rain storage capacity, and may have subsequent impacts to hydrological processes and water quality of the nearby conservation significant wetlands and the Yalgorup National Park.	The current investigation has found no evidence to support the presence of winter rain storage capacity within the limestone ridge. The risk of subsequent impacts to hydrological processes and water quality of nearby conservation significant wetlands and the Yalgorup National Park through removal of this storage capacity is therefore deemed to be low.
Required work	1. Provide a detailed description of the design and location of the proposal with the potential to impact surface water or groundwater.	**Section 1:** Introduction and documentation by Accendo Australia

	2. Develop a conceptual model of the hydrogeological system including recharge and discharge mechanisms, aquifer connectivity, surface water/groundwater interaction and water chemistry; in particular, the potential for winter rainfall storage at the limestone ridges and groundwater movement to Lake Pollard.	Sections 2.3.5, 3.3 & 5.2.3: Recharge to the aquifer is primarily by direct rainfall infiltration. Discharge occurs via evapotranspiration and evaporation, particularly from the coastal lakes: the resultant increase in water salinity creates a density-driven cone of depression, forming complex internal groundwater-flow systems toward the lakes. Groundwater from Lot 1002 flows easterly, under a very low hydraulic gradient, from a shallow ridge that lies beneath the Quindalup dunes west of the site, toward the coastal lakes at an estimated rate of around 26 m/yr. The lakes and wetlands in the area are in direct hydraulic connection with the superficial aquifer system and, in general, the lakes act as a groundwater sink. Seasonal variations in groundwater level are generally <0.5 m, typical of the Tamala Limestone aquifer, and are in response to rainfall infiltration and summer evaporation. The groundwater at the water table is in natural equilibrium with the carbonate bearing aquifer matrix and is mainly fresh with a calcium-bicarbonate signature; this water moves through the aquifer over a saline wedge and discharges to the coastal lakes. Groundwater in the immediate vicinity of wetlands and the lakes is brackish and a mixture of calcium-bicarbonate and sodium-chloride type waters. The water from Lake Pollard is hypersaline with a strong sodium-chloride signature and is super-saturated with regard to carbonate minerals, apparently leading to calcite precipitation in the lakes. Comparison of salinity profiles with historical data for the area indicates the hydrogeological system is apparently in a state of change, with a thinning of the fresh-water interface and an increase in groundwater salinity at the water table; these changes are considered to be in response to lower rainfall in the region and are related to climate change rather than groundwater abstraction, which is minimal in the area under investigation. The limestone ridge is highly permeable, as evidenced by the essentially flat-lying water table and low seasonal groundwater-level variations; there is no evidence of groundwater mounding associated with elevated topography or groundwater perching that might indicate potential winter rainfall storage. The site is located on the western flank of the limestone ridge (Spearwood Dunes) and any surface water flow is predominantly westerly, toward the north-south trending swale that transverses the property. Any surface flow to the swale will infiltrate and recharge the aquifer. There is no significant surface water run-off from the property.

	3. Conduct hydrogeological investigations, fit for purpose modelling and analysis to detail baseline hydrology and predictions of change (quality, level and flows) and impact as a result of (stage 1) removal of vegetation and (stage 2) long term loss of deep soil profile and increased evapotranspiration of re-vegetation on shallow groundwater in relation to water dependent ecosystems (most specifically Lake Clifton, Lake Pollard and Martins Tank) and the Yalgorup National Park, and include any potential impacts on westerly groundwater flows and wetland values to the west of the quarry. Provide a sensitivity analysis of the predictions from the modelling undertaken.	Hydrogeological investigations have been undertaken, including a review of existing literature for the region and a site drilling- and monitoring-program. The results, which incorporate baseline hydrology, hydrogeology and geochemistry, are provided in Sections 2 & 3. Fit-for-purpose modelling and analysis has been undertaken to assess the potential impact of excavation on groundwater recharge, evaporative discharge and groundwater quality, with the results showing the likelihood having a significant impact on the existing hydrological system is minimal and the risk to groundwater dependent ecosystems is low. The results are detailed, along with sensitivity analysis, in Sections 5.2 and 5.3.

	4. Map the extent, magnitude and rate of changes in hydrology (addressing groundwater levels, flows, quality and surface water inputs) as a result of (stage 1) removal of vegetation and (stage 2) long term loss of deep soil profile and increased evapotranspiration of re- vegetation on shallow groundwater in relation to water dependent ecosystems and most specifically Lake Clifton, Lake Pollard and Martins Tank, and include potential impacts to the westerly groundwater flow and wetland values to the west of the quarry. Fit for purpose geochemical modelling (e.g. PHREEQC) should be utilised where appropriate to support any risk assessment process.	The magnitude of predicted change in hydrology, including groundwater levels, groundwater flow, quality and surface water inputs as a result of removal of vegetation during extraction activities and possible increased evapotranspiration following revegetation are too small (<0.1 m) to generate meaningful maps of the extent of potential impact. The results of the hydrogeological investigations indicate any potential changes to the existing hydrological regime are likely to be confined within the boundary of Lot 1002. The baseline hydrogeology shows there is negligible potential for significant groundwater flow from beneath the proposed pit to Lake Clifton, and that there is no groundwater flow from the pit area to Martins Tank Lake; therefore the risk of potential impact to these water bodies is low. More in-depth analysis of potential changes to the hydrology of Lake Pollard was undertaken, which indicated no measurable impact is likely at this location either, with the area beneath the proposed pit area contributing <10% inflow from the western side of the lake. Analytical modelling using MOUNDSOLV indicates additional recharge potentially generated through land clearing could result in groundwater mounding <0.04 m in a worst-case scenario, which will have no measurable impact on groundwater flow rate or direction and will be indistinguishable from natural groundwater level variations. As the base of excavation will be >3 m above the water table (i.e. above extinction depth for most evapotranspiration processes), and the existing depth to water in the proposed pit area is generally 10 m or less (i.e. within the depth-range for large groundwater dependent vegetation such as the Tuarts), increased evapotranspiration following revegetation is unlikely, and therefore no measurable change to groundwater levels or water quality is anticipated. Geochemical modelling using PHREEQC shows the groundwater is in chemical equilibrium or slightly saturated with regard to calcium carbonate minerals, and therefore any potential for increased dissolution of fresh or crushed limestone is unlikely to result in a significant increase in Ca-HCO_3 in the groundwater, since dissolution and precipitation reactions are occurring at the same rate in the system, maintaining a chemical balance. Hence groundwater quality is unlikely to change significantly with regard to calcium carbonate minerals and the risk to the lakes is low. The results are detailed in **Sections 5.2.2, 5.2.5, 5.2.6, 5.2.7 and 5.3**.

	5. Map habitats, flora and fauna vulnerable to changes in hydrology (drawdown or groundwater level increase and water quality changes) in relation to predicted hydrogeological change, including interdunal swale habitats to the west of the proposed works.	Work conducted by Accendo Australia.
	6. Use the results of the modelling and other steps to identify if there are risks of changes in both increased and reduced discharge on lake levels and lake water quality, including the risk of acid sulphate soils. Also identify the risks of changes on the interdunal habitats to the west of the proposed works.	The hydrogeological investigation and numerical assessment indicate there will be minimal change to groundwater levels, groundwater flow or water quality resulting from the proposed extraction activities, and that any potential impact is likely to be indistinguishable from the current hydrogeological conditions. Hence there is little to no risk of increased or reduced groundwater discharge to the lakes impacting lake levels or lake water quality (Section 5.2.6). This assessment similarly applies to acid sulphate soils, where the risk generally relates to lowering of groundwater levels to the point of causing oxidation of organic and pyrite bearing sediments, and the interdunal habitats to the west of the proposed works.
	7. Provide a volumetric pre and post development conceptual water balance.	As an internal draining surface catchment, with the undisturbed profile remaining >3m above the groundwater table and revegetation of a previously revegetated area planned, no net volumetric change to the water balance is anticipated.
	8. Analyse, discuss and assess surface water and groundwater impacts.	
	The discussion should include:	
	• changes in groundwater levels and changes to surface water flows associated with the proposal	• Changes to groundwater levels from any additional recharge beneath the operational pit are estimated to be <0.04 m, being indistinguishable from current groundwater level variations. Surface water flow, where it may occur after intense rainfall events, is mainly westward toward the interdunal swale that transverses the property from the north to south; the site is essentially internally draining (i.e. there is no significant surface flow towards the National Park or lakes), and this will not change with excavation.
	• changes to water quality	• No significant changes to water quality are anticipated (Sections 5.2.5 & 5.2.7)

	• the nature, extent and duration of impacts	• The nature and extent of potential impacts to the hydrological cycle are minimal, with detailed assessment concluding no long-term changes to groundwater levels, groundwater flow or water quality are likely. A high-level water-budget indicates any changes relating to the excavated pit area will have no significant impact on the hydrology of the lakes, with the groundwater contribution from the pit area representing <10 % of the total input from the western inflow zone for Lake Pollard. Geochemical modelling shows the system is naturally in equilibrium with regard to carbonate minerals, and this is unlikely to change as a result of extraction activities. (Section 5.2)
	• impacts on environmental values of significant receptors, including but not limited to conservation significant wetlands (Lake Pollard and Martins Tank Lake) and the Yalgorup National Park.	• No measurable impact is anticipated on the environmental values of significant receptors, including and not limited to the conservation of significant wetlands (Lake Pollard and Martins Tank Lake) and the Yalgorup National Park, including wetlands to the west and south of the proposal site. (Section 5.2)
	9. Discuss the proposed management, monitoring and mitigation to prevent groundwater and surface water impacts, at local and catchment scale, as a result of implementing the proposal.	The overall management plan has been prepared by Accendo Australia. A groundwater monitoring program developed in consultation with DWER was used to provide background assessment of existing hydrogeological conditions for the site. The current study has shown that any potential impacts to groundwater and surface water are readily mitigated by maintaining an undisturbed profile >3 m above the water table and the judicious siting of the proposed extraction area on the western flank of the limestone ridge. Any hydrological impacts are likely to be confined within the property boundaries, with no measurable impact anticipated on a catchment scale. Any future groundwater monitoring requirements should be developed in consultation with DWER and EPA.
	10. Demonstrate in the ERD how the EPA's objective for this factor will be met	See documentation by Accendo Australia.
	11. Determine and quantify any significant residual impacts by applying the Residual Impact Significance Model (page 11) and WA Offset Template (Appendix 1) in the WA Environmental Offsets Guidelines (2014).	See documentation by Accendo Australia.

	12. Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the WA Environmental Offsets Policy and Guidelines. Spatial data defining the area of significant residual impacts should also be provided (e.g. vegetation type, vegetation condition, specific fauna species habitat).	See documentation by Accendo Australia.

7. Conclusions

A hydrogeological investigation has been conducted at Preston Beach Road North to determine the hydrological characteristics of the site and to assess potential impacts of a proposed limestone-extraction development on the nearby Ramsar-listed wetlands and environmentally sensitive coastal lakes, Lake Pollard, Lake Clifton and Martins Tank Lake. The proposed pit will cover an area of 13 ha and be excavated to a depth ending approximately 3 to 4 m above the water table.

The investigation has shown that the site has no permanent surface drainage features, and that most overland flow that might occur following heavy rainfall events will drain internally to the swale located immediately west of the proposed excavation site. Any change to the local landforms will not impact surface flow in the adjacent Yalgorup National Park, or to the coastal lakes.

A conceptual hydrogeological model has been developed for the site incorporating lithological and groundwater data obtained during drilling, construction and monitoring of six shallow and one deep monitoring bores. The conceptual model is consistent with previous investigations and indicates local groundwater-recharge via rainfall infiltration has developed a fresh-water lens beneath the Quindalup and Spearwood dunes, with groundwater flow under a very low hydraulic gradient towards Lake Pollard, Lake Clifton and Martins Tank Lake, which act as regional groundwater sinks. Groundwater from the site is unlike to reach Lake Clifton however due to the cones of depression created by Lakes Pollard and Martin Tank and the low-lying groundwater divide inferred to lie between the lakes. There is no evidence of groundwater mounding beneath the limestone ridge in winter, which would be indicative of increased storage capacity, and groundwater levels beneath the ridge are independent of topographic elevation.

While groundwater flow is toward the Yalgorup National Park and Ramsar listed wetlands, it is not anticipated that the regional water balance and environmental values will be significantly impacted, as any change to hydrogeological conditions relating to the proposal are likely to be minimal and well contained within the property boundaries. High-level water budget analyses suggest groundwater derived from beneath the proposed excavation site contributes <3% of total groundwater discharged to Lake Pollard via evaporation. Any change to groundwater levels associated with the proposed pit is likely be <0.1 m in magnitude and indistinguishable from natural variations in the hydrogeological system. Given the minimal change to groundwater levels, the potential for changes to groundwater flow direction and/or groundwater flow rate is negligible, and therefore the risk to interconnected ecosystems, either to the east, west or south, is deemed to be low. No groundwater abstraction is proposed.

Similarly, any additional recharge relating to land clearing will be transitional in nature, being mitigated by a staged and continuous rehabilitation and revegetation program. No additional evapotranspiration is anticipated during or following development as the planned pit-floor is well above the inferred extinction depth (0 – 3 m), and the land will be revegetated with plants that have similar evapotranspiration characteristics to those currently present. Groundwater geochemical modelling shows the native groundwater is in equilibrium with respect to carbonate minerals, and therefore it is unlikely that increased limestone dissolution rates, that may result from rainfall exposure to fresh or crushed rock, will have a significant impact on groundwater quality with regard to these minerals (as dissolution and precipitation reactions are balanced in the system). Assuming the proponent implements regulatory-compliant fueling, servicing and waste disposal management plans, the risk of groundwater

contamination is low, with an undisturbed soil profile of 3 m being considered adequate for protection of Priority 1 drinking water areas under DoW's extractive industry guidelines.

A groundwater monitoring program was developed to obtain background water quality and groundwater level and salinity data against which any future impacts can be assessed, if necessary. Any future groundwater monitoring program should be developed in consultation with DWER and EPA as part of the environmental and licensing process.

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Appendix A & A-A
EPA Environmental Scoping Document and Correspondence from DBCA

ENVIRONMENTAL SCOPING DOCUMENT

Proposal name:	**Limestone and Sand Quarry**
Proponent:	**Moresreel Pty Ltd (Trading as Doyles Lime Service)**
Assessment number:	**2095**
Location:	**Lot 1002 Preston Beach Road North, Preston Beach**
Local Government Area:	**Shire of Waroona**
Public review period:	**Environmental Review Document – 4 weeks**

1. Introduction

The Environmental Protection Authority (EPA) has determined that the above proposal is to be assessed under Part IV of the *Environmental Protection Act 1986* (EP Act).

The purpose of the Environmental Scoping Document (ESD) is to define the form, content, timing and procedure of the environmental review, required by s. 40(3) of the EP Act. This ESD has been prepared by the EPA in consultation with the proponent, decision-making authorities and interested agencies consistent with the EPA's *Procedures Manual*.

Form

The EPA requires that the form of the report on the environmental review required under s. 40 (Environmental Review Document, ERD) is according to the Environmental Review Document template.

Content

The EPA requires that the environmental review includes the content outlined in sections 2 to 6 of this ESD.

Timing

Table 1 sets out the timeline for the assessment of the proposal agreed between the EPA and the proponent.

Table 1 Assessment timeline

Key assessment milestones	Completion Date
EPA approves Environmental Scoping Document	17 May 2019
Proponent submits first draft Environmental Review Document	2 September 2019
EPA provides comment on first draft Environmental Review Document *(6 weeks from receipt of ERD)*	14 October 2019
Proponent submits revised draft Environmental Review Document	11 November 2019
EPA authorises release of Environmental Review Document for public review *(2 weeks from EPA approval of ERD)*	25 November 2019
Proponent releases Environmental Review Document for public review for 4 weeks	2 December 2019
Close of public review period (Plus 2 weeks for Christmas/New Year period)	13 January 2020
EPA provides Summary of Submissions *(3 weeks from close of public review period)*	3 February 2020
Proponent provides Response to Submissions	2 March 2020
EPA reviews the Response to Submissions *(4 weeks from receipt of Response to Submissions)*	30 March 2020
EPA prepares draft assessment report and completes assessment *(6 weeks from EPA accepting Response to Submissions)*	11 May 2020
EPA finalises assessment report (including two weeks consultation on draft conditions) and gives report to Minister *(6 weeks from completion of assessment)*	22 June 2020

Procedure

The EPA requires the proponent to undertake the environmental review according to the procedures in the *Administrative Procedures* and the *Procedures Manual*, including requirements for public review.

This ESD has not been released for public review. The ESD will be available on the EPA website (www.epa.wa.gov.au) upon endorsement and must be appended to the ERD.

2. The proposal

The subject of this ESD is the construction and operation of a limestone and sand quarry (13.9 hectares) at Lot 1002 Preston Beach North Road, Preston Beach in the Shire of Waroona. The proposal would involve screening and crushing of the limestone, and grading and maintenance of Preston Beach North Road for access. The regional location of the proposal is and the development envelope encompassing the physical elements of the proposal is delineated in Figure 1.

The key characteristics of the proposal are set out in Tables 2 and 3. The key proposal characteristics may change as a result of the findings of studies and investigations conducted and the application of the mitigation hierarchy by the proponent.

Doyles Lime Service previously referred a proposal for the construction and operation of a limestone and sand quarry at Lots 1001 and 1002 Preston Beach Road North, Preston Beach to the EPA. The limestone development at Lot 1001 was proposed to be approximately 200 metres (m) from Lake Pollard, which is a Conservation Category and Ramsar wetland. The EPA decided not to assess the proposal and provided public advice on 16 March 2016. That proposal was remitted back to the EPA for assessment due to uncertainties about the hydrological predictions. On 15 February 2016 Doyles Lime Service requested to formally withdraw the proposal on Lots 1001 and 1002 Preston Beach Road North, Preston Beach. On 10 May 2015, the EPA formally terminated the environmental impact assessment of that proposal. A modified proposal was referred to the EPA on 5 August 2016.

Table 2 Summary of the proposal

Proposal title	Limestone and Sand Quarry, Lot 1002 Preston Beach Road
Proponent name	Moresreel Pty Ltd (trading as Doyles Lime Service)
Short description	The proposal would involve construction and operation of a limestone and sand quarry at Lot 1002 Preston Beach Road North, Preston Beach in the Shire of Waroona. Extracted limestone would be screen and crushed using a mobile crusher. Grading and maintenance of Preston Beach North Road is also required for access.

Table 3 Location and proposed extent of physical and operational elements

Element	Location	Proposed extent
Physical elements		
Limestone and sand quarry	Figure 1	Clearing up to 13.9 ha of native vegetation within a 29.3 ha development envelope.

Transport route/quarry access	Figure 1	Lot 1002 Road Access Clearing up to 0.6 ha of native vegetation within a 29.3 ha development envelope. Preston Beach Road North Clearing up to 0.7 ha of native vegetation within a 29.3 ha development envelope.
Operational elements		
Water abstraction		Up to 5000 kilolitres per annum

3. Preliminary key environmental factors and required work

The preliminary key environmental factors for the environmental review are:

1. Inland Waters (formerly Hydrological Processes and Inland Waters Environmental Quality)
2. Flora and Vegetation
3. Terrestrial Fauna
4. Social Surroundings

Table 3 outlines the work required for each preliminary key environmental factor and contains the following elements for each factor:

- **EPA factor** and **EPA objective** for that factor.
- **Relevant activities** – the proposal activities that may have a significant impact on that factor.
- **Potential impacts and risks** to that factor.
- **Required work** for that factor.
- **Relevant policy and guidance** – EPA (and other) guidance and policy relevant to the assessment.

Table 4 Preliminary key environmental factors and required work

Inland Waters	
EPA objective	To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.
Relevant activities	Excavation of sand and the limestone ridge to within 4 m above the water table, and groundwater abstraction for proposal activities including dust suppression.

Potential impacts and risks	Removal of the limestone ridge potentially removes winter rain storage capacity, and may have subsequent impacts to hydrological processes and water quality of the nearby conservation significant wetlands and the Yalgorup National Park.
Required work	1. Provide a detailed description of the design and location of the proposal with the potential to impact surface water or groundwater. 2. Develop a conceptual model of the hydrogeological system including recharge and discharge mechanisms, aquifer connectivity, surface water/groundwater interaction and water chemistry; in particular, the potential for winter rainfall storage at the limestone ridges and groundwater movement to Lake Pollard. 3. Conduct hydrogeological investigations, fit for purpose modelling and analysis to detail baseline hydrology and predictions of change (quality, level and flows) and impact as a result of (stage 1) removal of vegetation and (stage 2) long term loss of deep soil profile and increased evapotranspiration of re-vegetation on shallow groundwater in relation to water dependent ecosystems (most specifically Lake Clifton, Lake Pollard and Martins Tank) and the Yalgorup National Park, and include any potential impacts on westerly groundwater flows and wetland values to the west of the quarry. Provide a sensitivity analysis of the predictions from the modelling undertaken. 4. Map the extent, magnitude and rate of changes in hydrology (addressing groundwater levels, flows, quality and surface water inputs) as a result of (stage 1) removal of vegetation and (stage 2) long term loss of deep soil profile and increased evapotranspiration of re-vegetation on shallow groundwater in relation to water dependent ecosystems and most specifically Lake Clifton, Lake Pollard and Martins Tank, and include potential impacts to the westerly groundwater flow and wetland values to the west of the quarry. Fit for purpose geochemical modelling (e.g. PHREEQC) should be utilised where appropriate to support any risk assessment process. 5. Map habitats, flora and fauna vulnerable to changes in hydrology (drawdown or groundwater level increase and water quality changes) in relation to predicted hydrogeological change, including interdunal swale habitats to the west of the proposed works. 6. Use the results of the modelling and other steps to identify if there are risks of changes in both increased and reduced discharge on lake levels and lake water quality, including the risk of acid sulphate soils. Also identify the risks of changes on the interdunal habitats to the west of the proposed works. 7. Provide a volumetric pre and post development conceptual water balance.

	8. Analyse, discuss and assess surface water and groundwater impacts. The discussion should include: • changes in groundwater levels and changes to surface water flows associated with the proposal • changes to water quality • the nature, extent and duration of impacts • impacts on environmental values of significant receptors, including but not limited to conservation significant wetlands (Lake Pollard and Martins Tank Lake) and the Yalgorup National Park. 9. Discuss the proposed management, monitoring and mitigation to prevent groundwater and surface water impacts, at local and catchment scale, as a result of implementing the proposal. 10. Demonstrate in the ERD how the EPA's objective for this factor will be met. 11. Determine and quantify any significant residual impacts by applying the Residual Impact Significance Model (page 11) and WA Offset Template (Appendix 1) in the WA Environmental Offsets Guidelines (2014). 12. Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the WA Environmental Offsets Policy and Guidelines. Spatial data defining the area of significant residual impacts should also be provided (e.g. vegetation type, vegetation condition, specific fauna species habitat).
Relevant policy and guidance	***EPA Policies and Guidance*** Environmental Factor Guideline – Inland waters (EPA 2018) Environmental Factor Guideline – Flora and vegetation (EPA 2016) Environmental Factor Guideline – Terrestrial fauna (EPA 2016) EPA Report 1359 – *Strategic Environmental Advice on the Dawesville to Binningup Area* (EPA 2010) ***Other Policies and Guidance*** Peel coastal groundwater allocation plan: Groundwater-dependent ecosystems Environmental Water Report Series Report No. 27 (Department of Water 2015) Peel coastal groundwater allocation plan: Water resource allocation and planning report series, Report No. 66 (Department of Water 2015) Water Quality Protection Note 15: Extractive Industries near sensitive water resources (Department of Water 2013) WA Environmental Offsets Policy (Government of Western Australia 2011)

	WA Environmental Offsets Guidelines (Government of Western Australia 2014).

Flora and Vegetation	
EPA objective	To protect flora and vegetation so that biological diversity and ecological integrity are maintained.
Relevant activities	Clearing of 15.2 ha of degraded to good condition vegetation for construction of the quarry, and access road upgrade.
Potential impacts and risks	Removal of vegetation for construction of the quarry and access road upgrade, and potential indirect impacts to flora and vegetation in the Yalgorup National Park.
Required work	13. Identify and characterise flora and vegetation in accordance with the requirements of EPA Guidance. The survey should take into account areas that are likely to be indirectly impacted as a result of the proposal (including by any reduction in groundwater), including the proposed access road upgrade and Yalgorup National Park and in buffer vegetation between the proposal area and Lake Pollard. Particular consideration should be given to the potential occurrences of the Priority 3 ecological community 'Tuart (*Eucalyptus gomphocephala*) woodlands of the Swan Coastal Plain'. If multiple surveys have been undertaken to support the assessment, a consolidated report should be provided including the integrated results of the surveys. Where surveys were undertaken prior to scoping, justification should be provided to demonstrate that they are relevant and consistent with EPA Guidance. Ensure species database searches and taxonomic identifications are up-to-date. 14. Undertake baseline mapping of weed affected areas in any area likely to be directly or indirectly impacted by the proposal. 15. Provide an analysis of the vegetation and significant flora species present and likely to be present within the development envelope and indirect impact areas outside of the development envelope. 16. Provide figures of the proposed clearing and predicted indirect impact to vegetation (specifically any groundwater dependent ecosystems) and significant flora species including threatened/priority ecological communities, threatened/priority flora, and significant flora and significant vegetation as defined by EPA guidance. 17. Discuss, and determine significance of, potential direct and indirect impacts to significant flora and vegetation as a result of the proposal at a local and regional level.

	18. Discuss the implications of upgrading Preston Beach North Road in context of existing EPA policies, in particular Strategic Environmental Advice on the Dawesville to Binningup Area (Report 1359). 19. Demonstrate that all practicable measures have been taken to reduce both the area of the proposed disturbance footprint and the development envelope based on proposal design and understanding of the environmental impacts. 20. Discuss proposed management, monitoring and mitigation methods to be implemented demonstrating that the proposal has addressed the mitigation hierarchy in relation to impacts on flora and vegetation. Both groundwater monitoring and vegetation health monitoring should be implemented in the area of predicted drawdown to ensure that ecological functions of plant communities are maintained. 21. Discuss management measures and outcome/objectives sought to ensure residual impacts (direct and indirect) are not greater than predicted. 22. Discuss the residual impacts, if any, including as appropriate, monitoring programmes to measure residual impacts, and management programmes to further mitigate these residual impacts and to deal with circumstances where outcomes fall short of intended objectives. 23. Provide an assessment on the physical and chemical characteristics of soil and soil profiles to be disturbed by the proposal, with particular focus on the ability to use such soil materials in post-mining rehabilitation works. 24. Prepare a Rehabilitation and Closure Plan consistent with the DMP and EPA (2015) *Guidelines for Preparing Mine Closure Plans*. The Plan should include but not be limited to: • Closure objectives and completion criteria addressing post mining landforms and soil profile design, native vegetation and habitat for conservation significant flora and fauna and base the conclusions on the availability of suitable substrates • Establish and measure vegetation and fauna reference and analogue sites to inform completion criteria. 25. Demonstrate that the proposal has been designed to avoid and minimise impacts including the placement of any access roads and infrastructure within vegetated areas and that placement has had regard to utilising existing areas of disturbance. 26. Describe the proposed rehabilitation methodology, including but not limited to: • Topsoil management • Retention or reuse of vegetative material

	• Return of species and communities (where feasible) consistent with the pre-existing composition of the affected area • Timeframes for rehabilitation, including sequencing of excavation and progressive rehabilitation. 27. Identify completion criteria, including criteria for reconstructed soils and soil profiles (identification and profile reconstruction), landform stability, drainage/erosion control and species and communities. 28. Demonstrate in the ERD how the EPA's objective for this factor will be met. 29. Determine and quantify any significant residual impacts by applying the Residual Impact Significance Model (page 11) and WA Offset Template (Appendix 1) in the WA Environmental Offsets Guidelines (2014). 30. Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the WA Environmental Offsets Policy and Guidelines. Spatial data defining the area of significant residual impacts should also be provided (e.g. vegetation type, vegetation condition, specific fauna species habitat).
Relevant policy and guidance	***EPA Policies and Guidance*** Environmental Factor Guideline – Flora and vegetation (EPA 2016) Environmental Factor Guideline – Terrestrial fauna (EPA 2016) Technical Guide – *Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA and Department of Parks and Wildlife 2015) EPA Report 1359 – *Strategic Environmental Advice on the Dawesville to Binningup Area* (EPA 2010) Environmental Protection Bulletin No. 12 – *Swan Bioplan - Peel Regionally Significant Natural Areas* (EPA 2013) *Guidelines for Preparing Mine Closure Plans* (DMP & EPA 2015) Guidance Statement No. 6 – *Rehabilitation of Terrestrial Ecosystems* (EPA 2006) ***Other Policies and Guidance*** WA Environmental Offsets Policy (Government of Western Australia 2011) WA Environmental Offsets Guidelines (Government of Western Australia 2014) Western Australian Planning Commission – *South Metropolitan Peel – Sub-Regional Planning Framework.*

Terrestrial Fauna	
EPA objective	To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.
Relevant activities	Clearing of 15.2 ha of degraded to good condition vegetation, crushing and screening of excavated materials, transport of excavated products, and access road upgrade.
Potential impacts and risks	Potential impacts to conservation significant fauna and removal of fauna habitat for construction of the quarry and access road upgrade, and potential indirect impacts to fauna in the Yalgorup National Park.
Required work	31. In accordance with EPA Guidance: • Carry out a desktop study of previous surveys and regional studies to predict the expected fauna assemblage of the proposal area and determine the level of survey required. • Conduct a Level 1 fauna survey including local and regional mapping of habitats (including rare or unusual habitat types) inside and outside of the development envelope. Where existing local information is inadequate or incomplete, comprehensive Level 2 fauna surveys are required. • Where conservation significant fauna have been identified in the desktop study or surveys, Level 2 targeted surveys are required. Identify potential impacts to conservation significant fauna species within the development envelope and immediate surrounds. Include mapping of the locations of any conservation significant fauna in relation to the proposal and fauna habitat. • Assess the likelihood of the habitats to support short-range endemic (SRE) invertebrate species. If the area is prospective for these species, undertake SRE invertebrate fauna sampling as per EPA Guidance. Include mapping of the locations of any known and potential SRE invertebrate species in relation to the proposal and fauna habitat. • Prepare a comprehensive listing of fauna species likely to occur in habitats to be directly or indirectly impacted. 32. Where the results from previous surveys are relied on for context, justification should be provided to demonstrate that they are relevant, representative of the development envelope, and were carried out using methods consistent with EPA Guidance. 33. Consider habitat types that provide important ecological function within and adjacent to the proposal area e.g. riparian vegetation, wetlands, areas of conservation significance or geological features

	which may support unique ecosystems. Particular consideration should be given the following: • Discuss the predicted level and significance of impacts to the Conservation Category and RAMSAR wetland Lake Pollard including hydrology, aquatic fauna and migratory waterbirds. Where significant impacts to Lake Pollard are identified, surveys for aquatic fauna and migratory waterbirds may be required. 34. Assess direct and indirect impacts on fauna, conservation significant fauna and fauna habitats, including percentages of habitat types to be impacted within the proposal area and on a regional scale. Provide figures showing the likely extent of loss of habitat types and the extent of habitat areas expected to recover from both direct and indirect impacts. Particular consideration should be given to the following: • impacts on the threatened western ringtail possum, including potential direct impacts from traffic on roads and operations • impacts to herpetofauna, which may include targeted surveys to priority reptile species *Ctenotus ora* and *Lerista lineata*. 35. Predict the residual impacts from the proposal on terrestrial fauna, including SRE fauna, for direct and indirect impacts after considering and applying avoidance and minimisation measures. 36. Discuss proposed management, monitoring and mitigation measures to be implemented for the proposal to ensure residual impacts are not greater than predicted. 37. Demonstrate in the ERD how the EPA's objective for this factor will be met. 38. Determine and quantify any significant residual impacts by applying the Residual Impact Significance Model (page 11) and WA Offset Template (Appendix 1) in the WA Environmental Offsets Guidelines (2014). 39. Where significant residual impacts remain, propose an appropriate offsets package that is consistent with the WA Environmental Offsets Policy and Guidelines. Spatial data defining the area of significant residual impacts should also be provided (e.g. vegetation type, vegetation condition, specific fauna species habitat).
Relevant policy and guidance	***EPA Policies and Guidance*** Environmental Factor Guideline – Terrestrial fauna (EPA 2016) Environmental Factor Guideline – Flora and vegetation (EPA 2016) Guidance Statement No. 56 – *Terrestrial Fauna Surveys for Environmental Impact Assessment in WA* (EPA 2004) Technical Guide – *Flora and Vegetation Surveys for Environmental Impact Assessment* (EPA and Department of Parks and Wildlife 2015)

	Guidance Statement No. 20 – *Sampling of Short Range Endemic Invertebrate Fauna for Environmental Impact Assessment in Western Australia* (EPA 2009) Technical Guide – *Terrestrial Vertebrate Fauna Surveys for Environmental Impact Assessment* (EPA 2010) EPA Report 1359 – *Strategic Environmental Advice on the Dawesville to Binningup Area* (EPA 2010) ***Other Policies and Guidance*** WA Environmental Offsets Policy (Government of Western Australia 2011) WA Environmental Offsets Guidelines (Government of Western Australia 2014) Western Australian Planning Commission – *South Metropolitan Peel – Sub-Regional Planning Framework.*

Social Surroundings	
EPA objective	To protect social surroundings from significant harm.
Relevant activities	Excavation of sand and limestone, crushing and screening of excavated materials, and transport of excavated products from site.
Potential impacts and risks	Operational activities could cause noise, dust and visual impacts at the nearby wetlands, and the Yalgorup National Park, thus impacting visitors to the area.
Required work	40. Characterise the land use and amenity values of the Yalgorup National Park and Lots 1000, 3045, 2657, 2275 and 2240 immediately north of the proposal (recently acquired for inclusion in the national park), particularly noting the sensitive receptors and important areas for human use that could be affected by noise and dust emissions, visual amenity issues and alterations to the landforms from excavation of the limestone ridge. Include relevant maps to show the locations of the sensitive receptors likely to be affected by the proposal. 41. Characterise noise impacts on sensitive receptors via a noise assessment in accordance with EPA Guidance. Demonstrate that noise can be managed such that it complies the *Environmental Protection (Noise) Regulations 1997* at sensitive receptor locations. 42. Characterise the environment by providing baseline data of dust emissions and assess the potential for dust impacts at sensitive receptor locations. 43. Characterise the environment by providing a description of the visual landscape character and scenic quality values and provide maps of the visual landscape units that may potentially be visually affected. This

	should include, but not limited to: landforms; vegetation; waterways (including wetlands) and can be undertaken by way of 3-dimensional modelling and/or photographs. 44. Identify and discuss the potential sources and impacts of noise, dust and alteration to landforms from the proposal. In particular, address potential impacts to the Yalgorup National Park, the properties proposed for future inclusion to the national park, and the impacts on the Lake Pollard walk trail. 45. Identify and discuss any impacts on the future use of the access way by the Department of Biodiversity Conservation and Attractions (DBCA) staff and visitors to the national park. 46. Identify the types and sizes of trucks, and the road upgrades required to accommodate operations and ensure the safety of other road users and campers using the Martin Tank campsite. Demonstrate how the road will be maintained to provide for the ongoing safety of road users and campers using the Martin Tank campsite. 47. Design and undertake a visual impact assessment (VIA) for before, during and after the proposed excavation activities, to assess the impacts of the proposal on visual amenity in accordance with the Western Australian Planning Commission (2007) *Visual Landscape Planning in Western Australia: a manual for evaluation, assessment, siting and design*, and in consultation with the DBCA. 48. The VIA will identify and describe the aspects of the proposal which may potentially affect the visual landscape character and scenic quality values both temporarily and permanently, using agreed (by the EPA, in consultation with the DBCA) reference and vantage points of surrounding areas including travel routes and use area's viewer positions and perceptions. 49. Predict the residual amenity impacts from the proposal on the landscape sensitive receptors and important areas for human use after considering and applying avoidance and minimisation measures. Impact predictions are to include, but not be limited to: • The likely extent, severity and duration of the impacts from noise, dust, light-spill, and alterations to the landscape, landform and to amenity • Simulations/modelling of the predicted residual impacts from the proposal, including changes to the landscape from the agreed reference and vantage points. 50. Identify management and mitigation measures for the proposal including closure and rehabilitation outcomes to ensure residual impacts are not greater than predicted. The ERD is to include: • A description of the management and mitigation measures

	• Management zones and strategies for managing visual landscape character relative to each stage of the proposed operation • Environmental management plans outlining the environmental outcomes/objectives, other key regulatory requirements; management actions, monitoring (including methodology, frequency, location and rational), trigger criteria, contingency actions, review, reporting, and consultation. 51. Demonstrate in the ERD how the EPA's objective for this factor will be met.
Relevant policy and guidance	***EPA Policies and Guidance*** Environmental Factor Guideline – Social surroundings (EPA 2016) Guidance Statement No. 3 – *Separation Distance Between Industrial and Sensitive Land Uses* (EPA 2005). ***Other Policies and Guidance*** Western Australian Planning Commission – *Visual Landscape Planning in Western Australia: a manual for evaluation, assessment, siting and design*.

4. Other environmental factors or matters

The EPA has identified the following other environmental factors or matters relevant to the proposal that must be addressed during the environmental review and discussed in the Environmental Review Document:

1. Subterranean fauna – including outcomes of consultation with the DBCA and consideration of potential for karst.
2. Landforms – including outcomes of consultation with interested parties and assessment of potential impacts.
3. Air Quality – the ERD will include the following works for greenhouse gas emissions:
    a. Characterise the greenhouse gas emission key sources from the proposal and estimate the expected annual Scope 1 (direct) greenhouse gas emissions.
    b. Provide details of any mitigation measures designed to avoid or minimise greenhouse gas emissions during the implementation of the proposal.
4. Other matters – demonstrate how the proposal is consistent with other relevant government environmental policy and guidance for the area, including the Western Australian Planning Commission's South Metropolitan Peel – Sub Regional Planning Framework (2018).

It is also important that the proponent be aware that other factors or matters may be identified during the course of the environmental review that were not apparent at the time that this ESD was prepared. If this situation arises, the proponent must consult with the EPA to determine whether these factors and/or matters are to be addressed in the ERD, and if so, to what extent.

5. Stakeholder consultation

The proponent must consult with stakeholders who are affected by, or are interested in the proposal. This includes the decision-making authorities (see section 6), other relevant state government agencies and local government authorities, in particular the DBCA, the local community and environmental non-government organisations.

The proponent must document the following in the ERD:

- identified stakeholders
- the stakeholder consultation undertaken and the outcomes, including decision-making authorities' specific regulatory approvals and any adjustments to the proposal as a result of consultation
- any future plans for consultation.

6. Decision-making authorities

At this stage, the EPA has identified the authorities listed in Table 4 as decision-making authorities (DMAs) for the proposal. Additional DMAs may be identified during the course of the assessment.

Table 5 Decision-making authorities

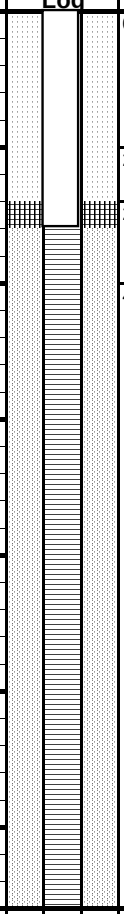
Decision-making authority	Relevant legislation
1. Minister for Environment	*Wildlife Conservation Act 1986*
2. Minister for Water	*Rights in Water and Irrigation Act 1914*
3. Chief Executive Officer, Department of Water and Environmental Regulation	Part V of the *Environmental Protection Act 1986*
4. Chief Executive Officer, Shire of Waroona	*Local Government Act 1995*
5. Chairman, Western Australia Planning Commission	*Planning and Development Act 2005* *Peel Region Scheme*

Figure 1 – Regional location and development envelope

Appendix B
MW Series Monitoring Bore Completion Logs
(ENV Australia, 2009)

Client: Cape Bouvard Investments
Logged By: JH
Drilled By: Waterwise
Soil Bore No: MW1
GPS: 0374323 E
6368286 N

Project: Clifton Beach GW Monitoring
Job No: 07.360
Date Logged: 7/11/2007
Installation Method: RAB- Mud Rotary

Depth BGL (m)	Sample Taken	Monitor Well Log	Profile	Lithology	Field Rank	Observations (PID in ppm$_v$ VOC)
			0.0 - 2.0	'Swamp deposits', grey/brown siltysand, poorly to moderately sorted		
2.0			2.0 - 2.75	Limestone		
			2.75 - 4.0	Spearwood sand		
4.0			4.0 - 13.0	Limestone- shell fragments, large intact shells, highly porous, a lot of gravel used		
6.0						
8.0						
						Next day gauge
						WT- 2.36 mbTOC
						Total depth - 14.4
						EC- 4.22 mS
10.0						Riser- 0.64
12.0						Screen from 3.0m
13.0						
				EOH @ 13 m		

NOTE:
- Monitor Well Screen
- Gravel Pack
- Bentonite Layer
- Sand Fill
- Cement Grout
- Initial water table at time drilling
- Water table during gauging (??Oct 04)

ENV. Australia
Level 7
182 St Georges Terrace
Perth, WA, 6000.

Client: Cape Bouvard Investments
Logged By: JH
Drilled By: Waterwise
Soil Bore No: MW2
GPS: 0373768 E
6368205 N

Project: Clifton Beach GW Monitoring
Job No: 07.360
Date Logged: 7/11/07
Installation Method: RAB- Mud Rotary

Depth BGL (m)	Sample Taken	Monitor Well Log	Profile	Lithology	Field Rank	Observations (PID in ppm_v VOC)
			0.0 - 2.0	SAND- brown/grey, medium grained, poorly sorted, limestone fragments		
			2.0 - 31.0	Limestone - less consolidated at the surface, becoming slightly more consolidated or harder with depth. At 30m became more porous (highly) at similar depth to MW1 - couldn't lift mud rotary, kept collapsing (very porous).		
3.0						
				Slightly harder limestone immediately above very porous layer		
6.0						
9.0						
						Riser 0.66m
						Total 31.135m
						Depth to water 16.460 mbTOC
						Sal/EC 13.65 mS
12.0						
15.0						
18.0						
21.0						
24.0						
						2 x 3 m screen
27.0						screen at 25m bGL
30.0						
				EOH @ 31 m		

NOTE:
- Monitor Well Screen
- Gravel Pack
- Bentonite Layer
- Sand Fill
- Cement Grout
- Initial water table at time drilling
- Water table during gauging (??Oct 04)

ENV. Australia
Level 7
182 St Georges Terrace
Perth, WA, 6000.

Client: Cape Bouvard Investments
Logged By: JH
Drilled By: Waterwise
Soil Bore No: MW3
GPS: 373782 E
6368206 N

Project: Clifton Beach GW Monitoring
Job No: 07.360
Date Logged: 7/11/07
Installation Method: RAB

Depth BGL (m)	Sample Taken	Monitor Well Log	Profile	Lithology	Field Rank	Observations (PID in ppm_v VOC)
			0.0 - 1.0	SAND- grey/brown, root debris, medium grained, poorly sorted		
			1.0 - 25.0	Limestone, more consolidated with depth, porous		
3.0						
						EC 1.09 mS
						Water table @ 16.545 bTOC
						Total 22.565m
						Riser 0.65m
6.0						
9.0						
12.0						
15.0						
18.0						
21.0						
						2 x 3 m screen
24.0						screen at 19m bGL
				EOH @ 25 m		

NOTE:

- Monitor Well Screen
- Gravel Pack
- Bentonite Layer
- Sand Fill
- Cement Grout
- Initial water table at time drilling
- Water table during gauging (??Oct 04)

ENV. Australia
Level 7
182 St Georges Terrace
Perth, WA, 6000.

Client: Cape Bouvard Investments
Logged By: JH
Drilled By: Waterwise
Soil Bore No: MW4
GPS: 0373782 E
6368211 N

Project: Clifton Beach GW Monitoring
Job No: 07.360
Date Logged: 7/11/07
Installation Method: RAB

Depth BGL (m)	Sample Taken	Monitor Well Log	Profile	Lithology	Field Rank	Observations (PID in ppm_v VOC)
			0.0 - 1.0	SAND- grey/brown, medium grained, root debris		
			1.0 -20.0	Limestone- becoming more consolidated with depth, porous		
2.0						
						SWL 16.765 mbTOC
						Total 21.040m
						Riser 0.680m
						EC 0.86 mS/cm
4.0						Temp 19.8 C
6.0						
8.0						
10.0						
12.0						
14.0						
16.0						
						2 x 3 m screen
18.0						screen at 14m bGL
20.0						
				EOH @ 20 m		

NOTE:
- Monitor Well Screen
- Gravel Pack
- Bentonite Layer
- Sand Fill
- Cement Grout
- Initial water table at time drilling
- Water table during gauging (??Oct 04)

ENV. Australia
Level 7
182 St Georges Terrace
Perth, WA, 6000.

Client: Cape Bouvard Investments
Logged By: JH
Drilled By: Waterwise
Soil Bore No: MW5
GPS:

Project: Clifton Beach GW Monitoring
Job No: 07.360
Date Logged: 8/11/07
Installation Method: RAB

Depth BGL (m)	Sample Taken	Monitor Well Log	Profile	Lithology	Field Rank	Observations (PID in ppm$_v$ VOC)
			0.0 - 2.0	Spearwood sand- yellow/brown, fine to medium grained		
2.0						fresh @ surface
			2.0 - 18.0	Limestone- less consolidated at the surface, more consolidated at depth, porous		SWL 6.132 mbTOC
						Total 18.192m
						Riser 0.69m
						EC 10.78 mS/cm
4.0						
6.0						
						screen at 6m bGL
8.0						
10.0						
12.0						
14.0						
16.0						
						4 x 3 m screen
18.0						
				EOH @ 18 m		

NOTE:

- Monitor Well Screen
- Gravel Pack
- Bentonite Layer
- Sand Fill
- Cement Grout
- Initial water table at time drilling
- Water table during gauging (??Oct 04)

ENV. Australia
Level 7
182 St Georges Terrace
Perth, WA, 6000.

Client: Cape Bouvard Investments
Logged By: JH
Drilled By: Waterwise
Soil Bore No: MW6
GPS:

Project: Clifton Beach GW Monitoring
Job No: 07.360
Date Logged: 8/11/07
Installation Method: RAB - Mud Rotary

Depth BGL (m)	Sample Taken	Monitor Well Log	Profile	Lithology	Field Rank	Observations (PID in ppm_v VOC)
			0.0 - 2.0	SAND- yellow/brown, medium grained size, poorly sorted		
			2.0 - 25.0	Limestone - porous softer/less consolidated at the surface, harder/more consolidated with depth, blending of highly porous to less porous - shells intact		SWL 6.420 mbTOC
3.0						Total 25.61m
						Riser 0.67m
						EC > 20 mS/cm
						EC @ 11.0 m - fresh 1.0 mS
6.0						EC @ 13.0 m - fresh 2.5 mS
						EC @ 16.0 m - fresh 11.0 mS
						EC @ 18.0 m - seawater
9.0						
12.0						
15.0						
						screen at 16m bGL
18.0						
21.0						
						3 x 3 m screens
24.0						
				EOH @ 25 m		

NOTE:

- Monitor Well Screen
- Gravel Pack
- Bentonite Layer
- Sand Fill
- Cement Grout
- Initial water table at time drilling
- Water table during gauging (??Oct 04)

ENV. Australia
Level 7
182 St Georges Terrace
Perth, WA, 6000.

Client: Cape Bouvard Investments
Logged By: JH
Drilled By: Waterwise
Soil Bore No: MW7
GPS:

Project: Clifton Beach GW Monitoring
Job No: 07.360
Date Logged: 8/11/07
Installation Method: RAB - Mud Rotary

Depth BGL (m)	Sample Taken	Monitor Well Log	Profile	Lithology	Field Rank	Observations (PID in ppm$_v$ VOC)
			0.0 - 4.0	SAND- yellow/brown, medium grained, poorly sorted, spearwood sand		
2.0						
4.0			4.0 - 17.0	Limestone - porous sand within cavities, collapsing the hole, more even/level at the surface, harder with depth		
6.0						
8.0						Final depth 17m, drilled 27m
10.0						
12.0						
14.0						Water table @ 7.0 m
16.0						5 x 3 m slots/screen
				EOH @ 17 m		

NOTE:

- Monitor Well Screen
- Gravel Pack
- Bentonite Layer
- Sand Fill
- Cement Grout
- Initial water table at time drilling
- Water table during gauging (??Oct 04)

ENV. Australia
Level 7
182 St Georges Terrace
Perth, WA, 6000.

Client: Cape Bouvard Investments
Logged By: JH
Drilled By: Waterwise
Soil Bore No: MW8
GPS: 374256 E
6369863 N

Project: Clifton Beach GW Monitoring
Job No: 07.360
Date Logged: 9/11/07
Installation Method: RAB

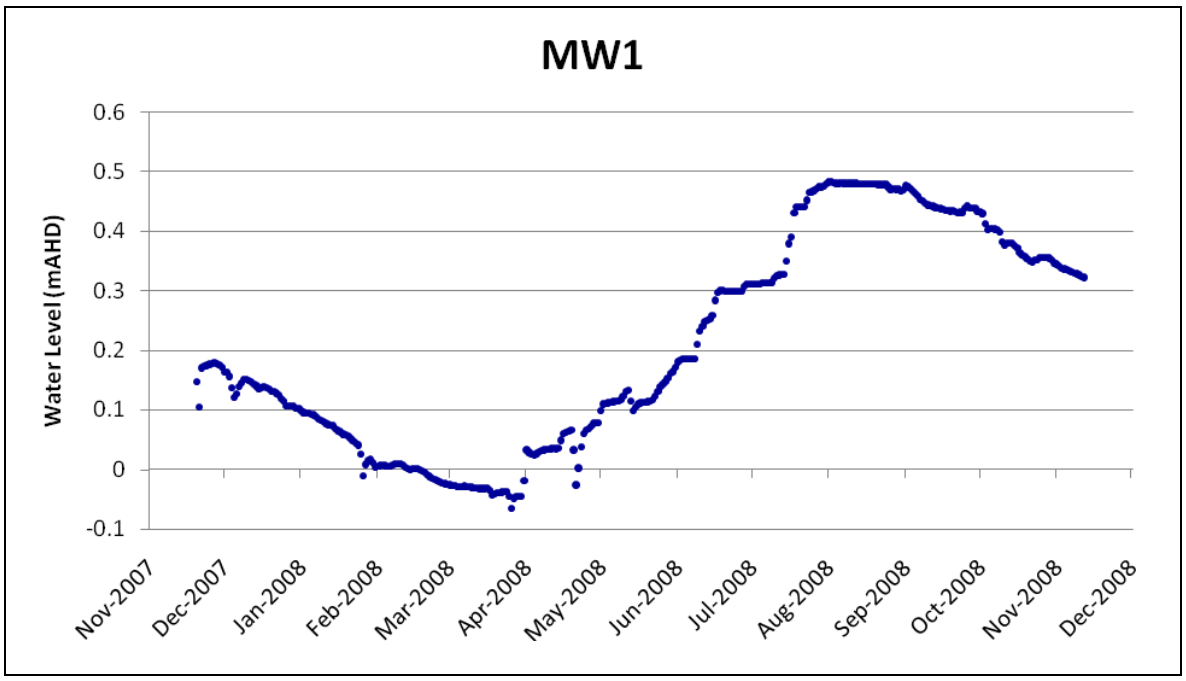
Depth BGL (m)	Sample Taken	Monitor Well Log	Profile	Lithology	Field Rank	Observations (PID in ppm_v VOC)
			0.0 - 1.5	SAND- yellow/brown, medium grained and finely sorted		
1.0						
			1.5 - 10.0	Limestone- porous loads of soft consolidated limestone with porous caverns, shell fragments, loss circulation		
						Drilled to 16m (late in last day),
2.0						kept at 10 m
3.0						
4.0						
5.0						
						Water table @ 5.3 m
6.0						
7.0						
8.0						
						3 x 3 m screen
9.0						
10.0						
				EOH @ 10 m		

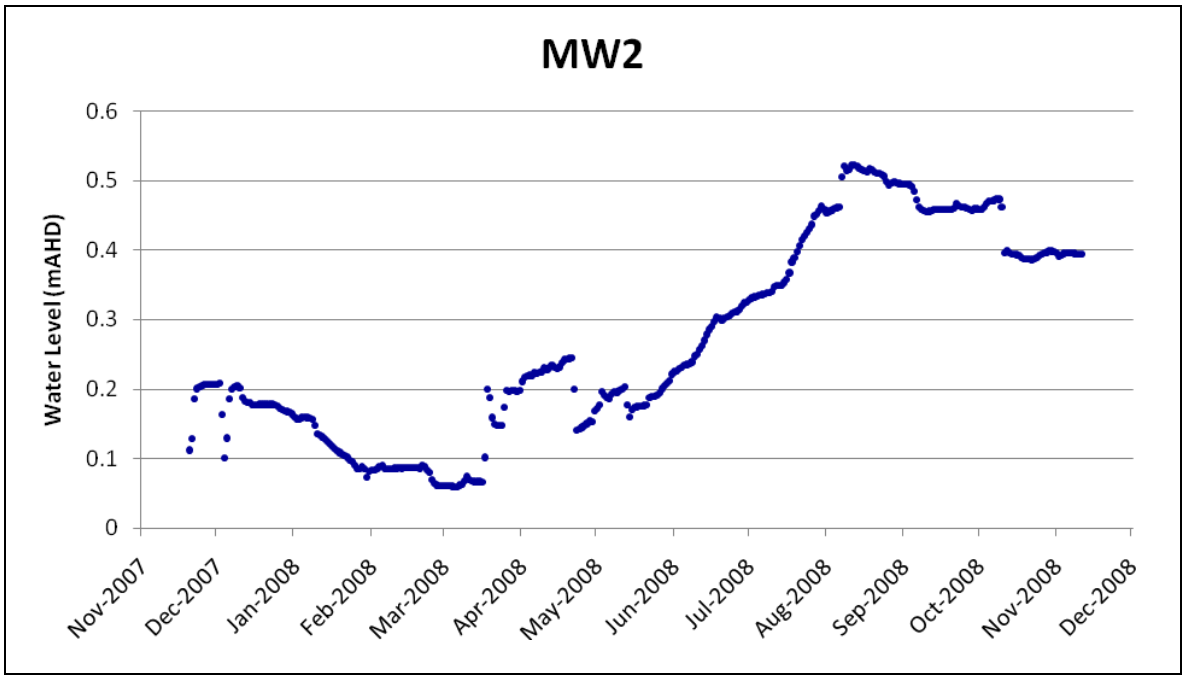
NOTE:

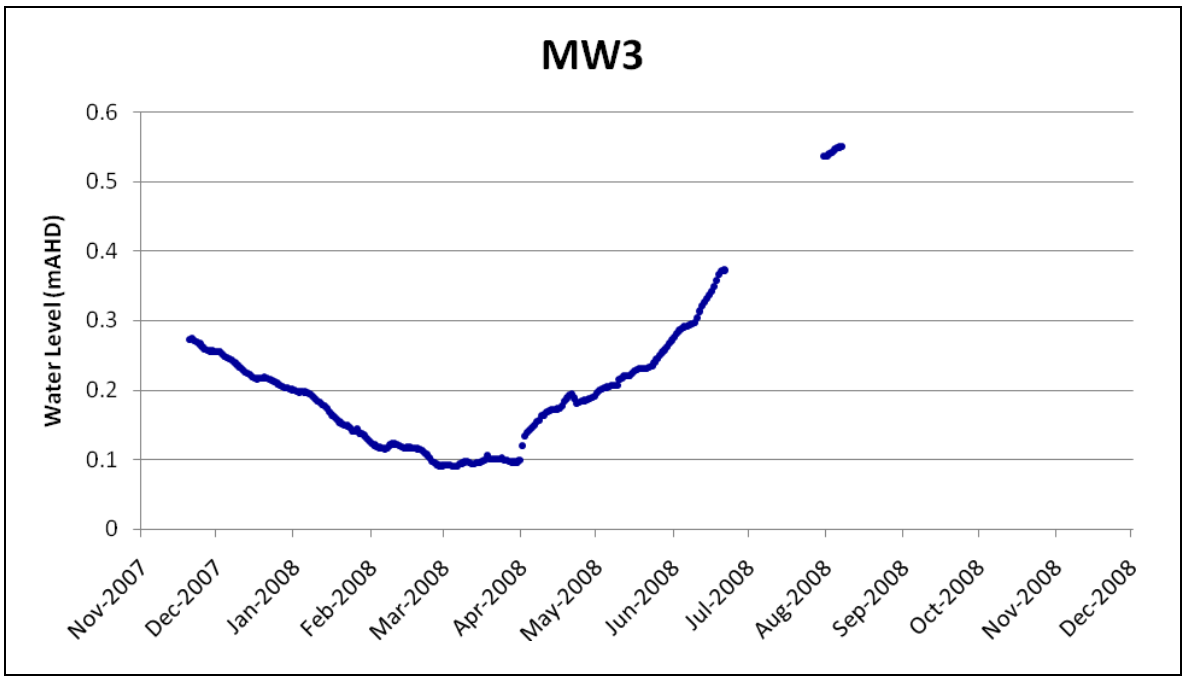
- Monitor Well Screen
- Gravel Pack
- Bentonite Layer
- Sand Fill
- Cement Grout
- Initial water table at time drilling
- Water table during gauging (??Oct 04)

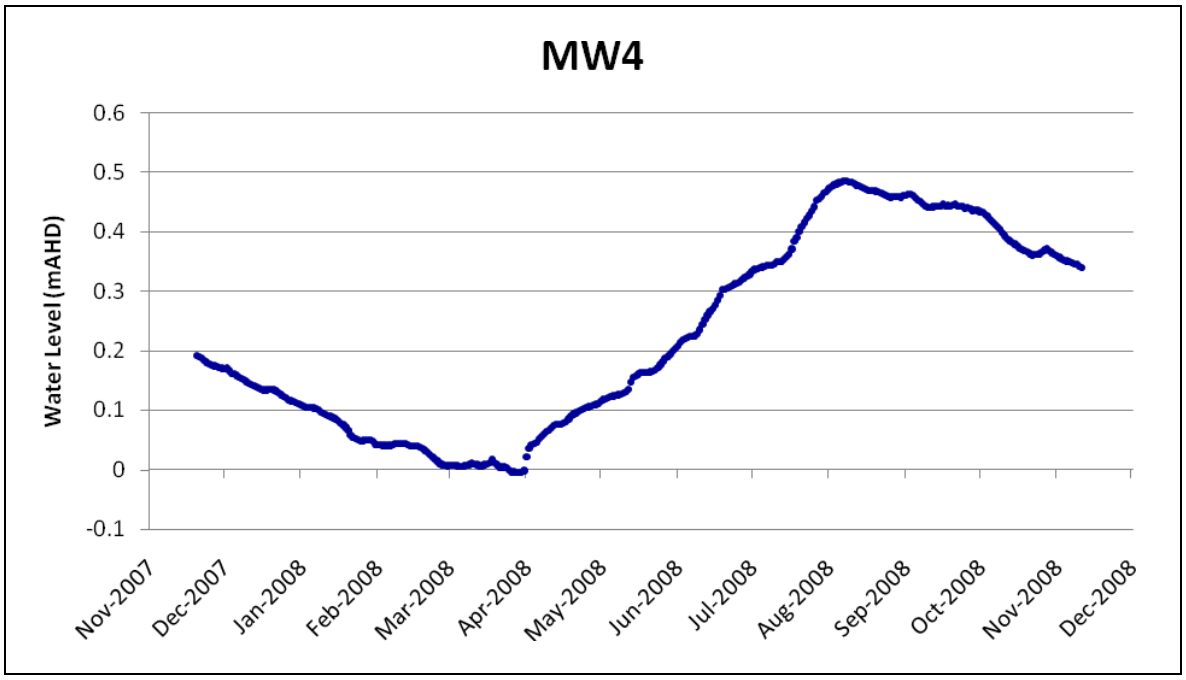
ENV. Australia
Level 7
182 St Georges Terrace
Perth, WA, 6000.

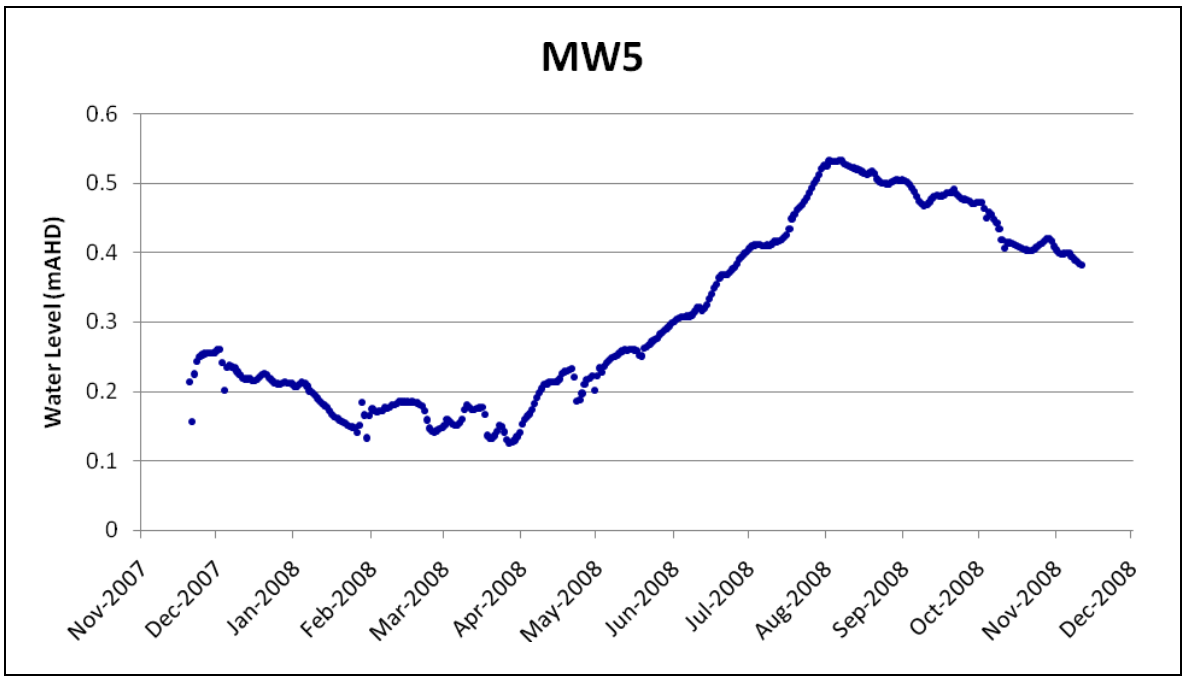
Appendix C
MW Series Monitoring Bore Groundwater Levels
(ENV Australia, 2009)

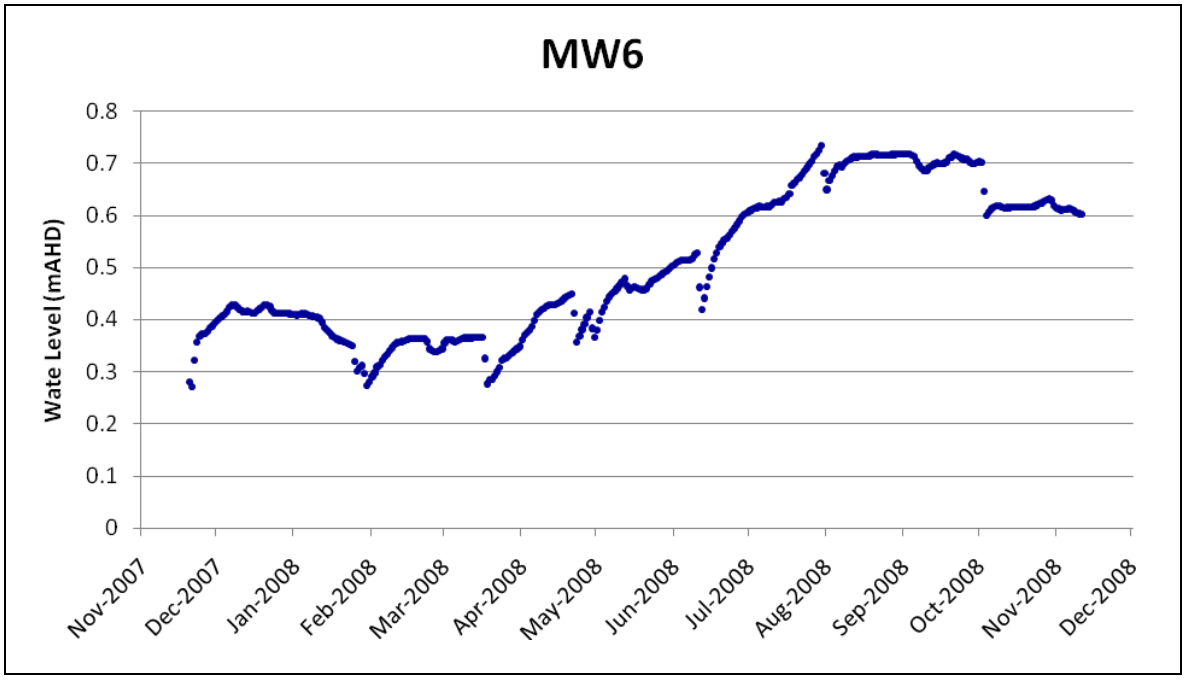

MW1
Water Level (mAHD)
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
Nov-2007
Dec-2007
Jan-2008
Feb-2008
Mar-2008
Apr-2008
May-2008
Jun-2008
Jul-2008
Aug-2008
Sep-2008
Oct-2008
Nov-2008
Dec-2008


MW2
Water Level (mAHD)
0.6
0.5
0.4
0.3
0.2
0.1
0
Nov-2007
Dec-2007
Jan-2008
Feb-2008
Mar-2008
Apr-2008
May-2008
Jun-2008
Jul-2008
Aug-2008
Sep-2008
Oct-2008
Nov-2008
Dec-2008


MW3
Water Level (mAHD)
0.6
0.5
0.4
0.3
0.2
0.1
0
Nov-2007
Dec-2007
Jan-2008
Feb-2008
Mar-2008
Apr-2008
May-2008
Jun-2008
Jul-2008
Aug-2008
Sep-2008
Oct-2008
Nov-2008
Dec-2008


MW4
Water Level (mAHD)
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
Nov-2007
Dec-2007
Jan-2008
Feb-2008
Mar-2008
Apr-2008
May-2008
Jun-2008
Jul-2008
Aug-2008
Sep-2008
Oct-2008
Nov-2008
Dec-2008

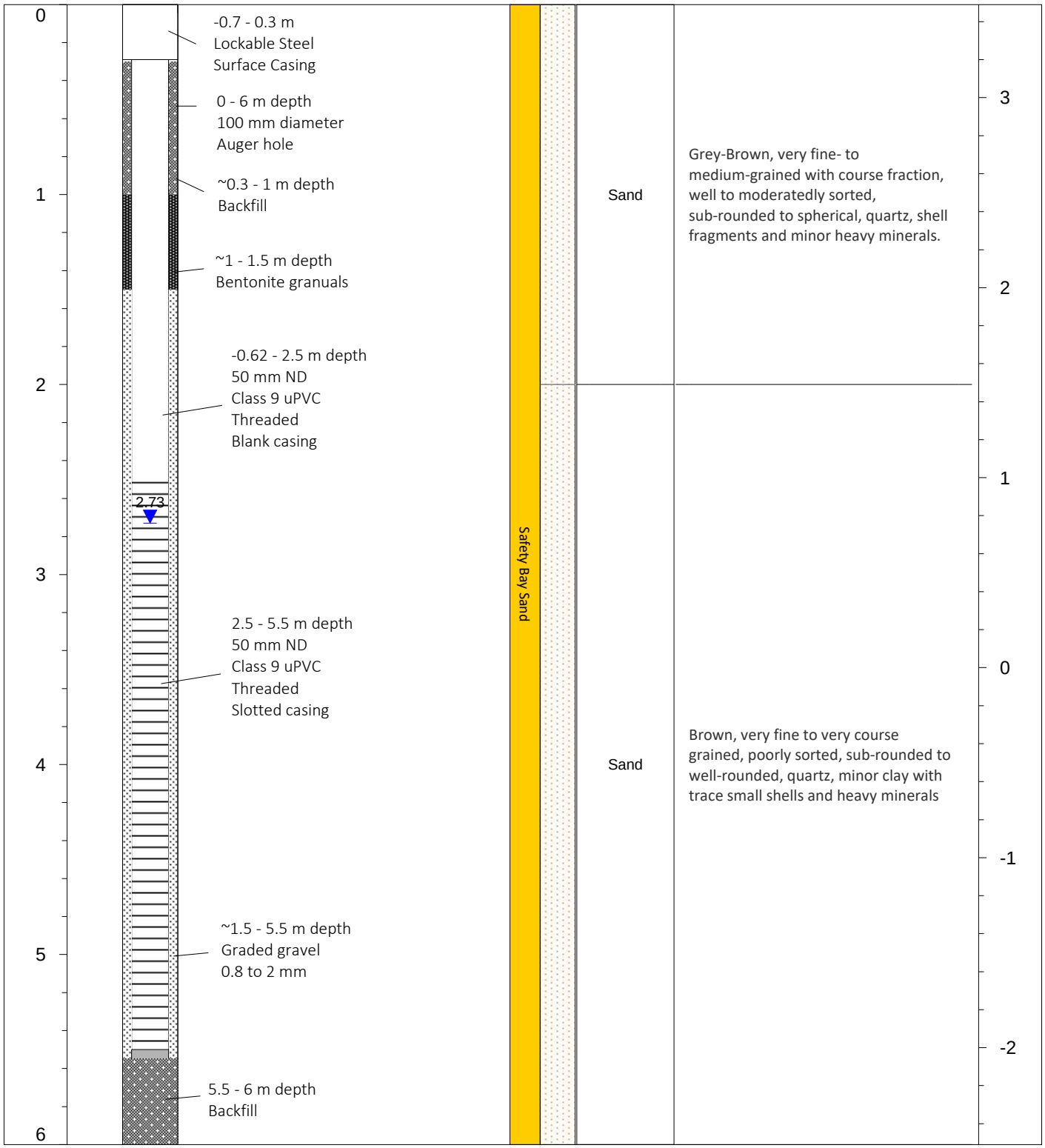

MW5
Water Level (mAHD)
0.6
0.5
0.4
0.3
0.2
0.1
0
Nov-2007
Dec-2007
Jan-2008
Feb-2008
Mar-2008
Apr-2008
May-2008
Jun-2008
Jul-2008
Aug-2008
Sep-2008
Oct-2008
Nov-2008
Dec-2008


MW6
Wate Level (mAHD)
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Nov-2007
Dec-2007
Jan-2008
Feb-2008
Mar-2008
Apr-2008
May-2008
Jun-2008
Jul-2008
Aug-2008
Sep-2008
Oct-2008
Nov-2008
Dec-2008

Appendix D
DL Series Monitoring Bore Completion Logs

Project: Doyle's Lime
Client: Doyle's Lime Service
Job No:3-0/17-009
Date: June 2018

Appendix D-1



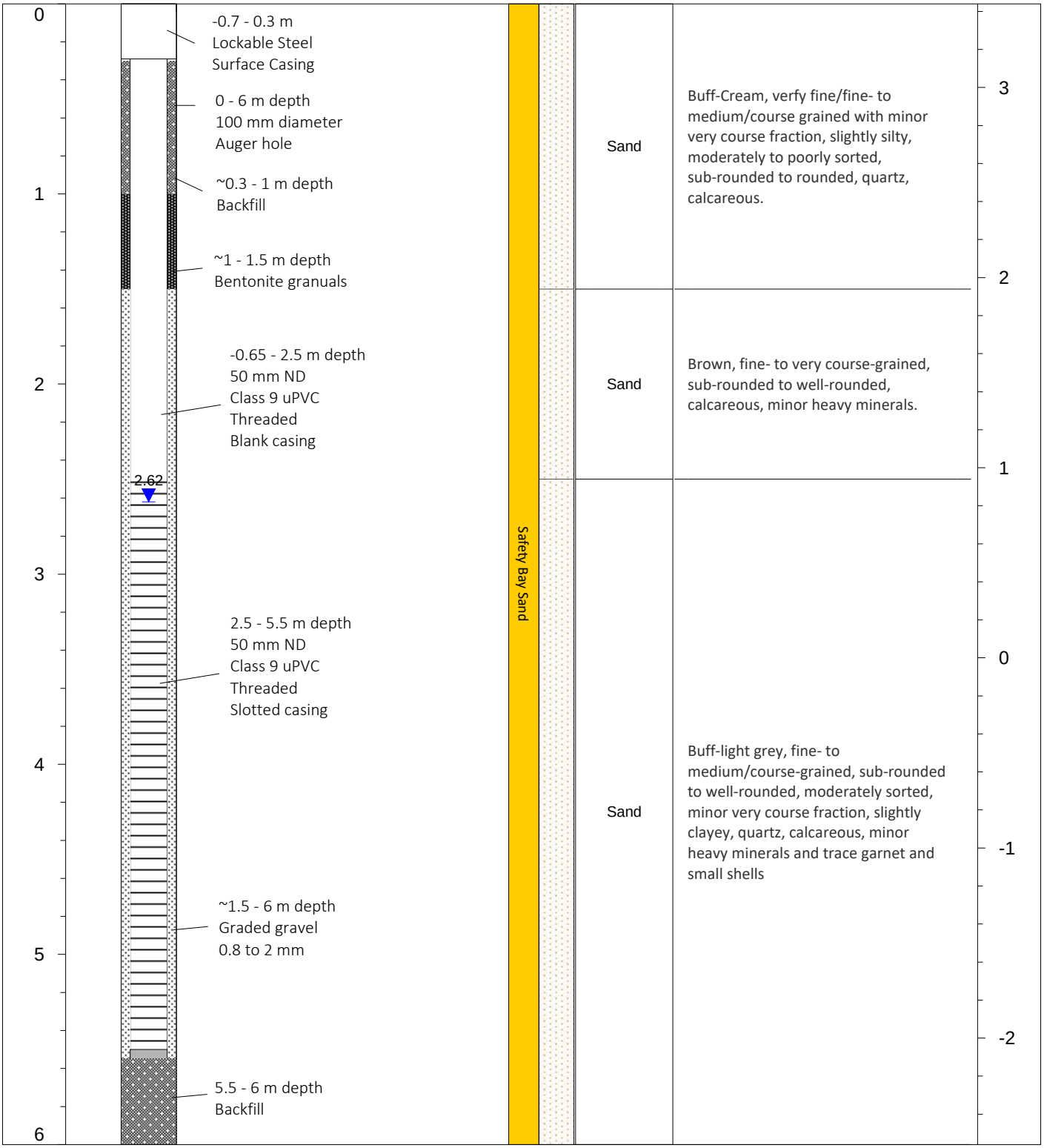
Bore Location: 373317 mE, 6367623 mN
Elev. 3.49 m AHD
Date Drilled: 12/03/2018
SWL: 2.73 m bgl (24/05/2018)
EC: 680 uS/cm

BORE COMPLETION DIAGRAM
MONITORING BORE DLMB1

ManagedRecharge

Project: Doyle's Lime
Client: Doyle's Lime Service
Job No:3-0/17-009
Date: June 2018

Appendix D-2



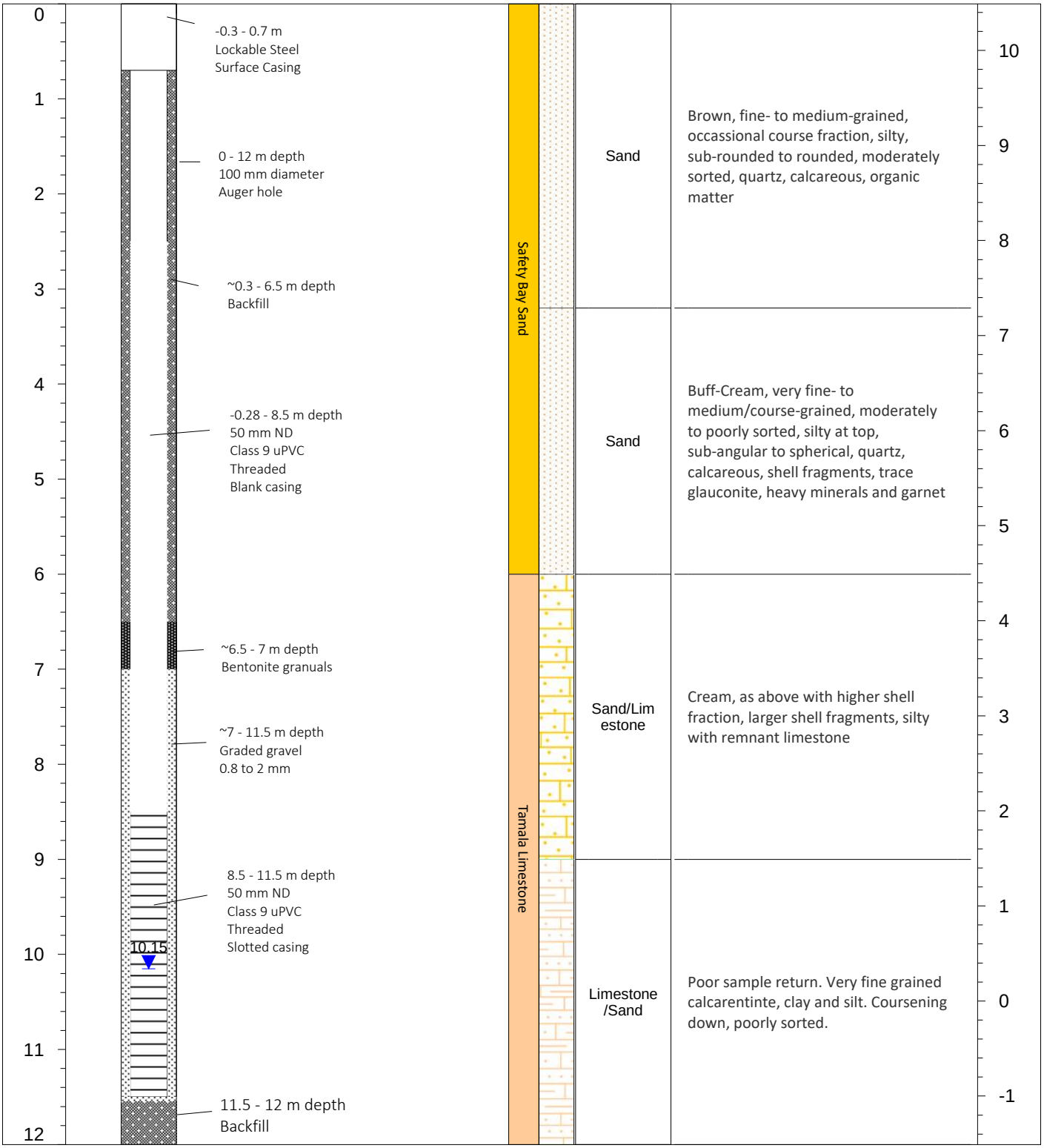
Bore Location: 373336 mE, 6366976 mN
Elev. 3.44 m AHD
Date Drilled: 12/03/2018
SWL: 2.62 m bgl (24/05/2018)
EC: 600 uS/cm

BORE COMPLETION DIAGRAM
MONITORING BORE DLMB2

ManagedRecharge

Project: Doyle's Lime
Client: Doyle's Lime Service
Job No:3-0/17-009
Date: June 2018

Appendix D-3



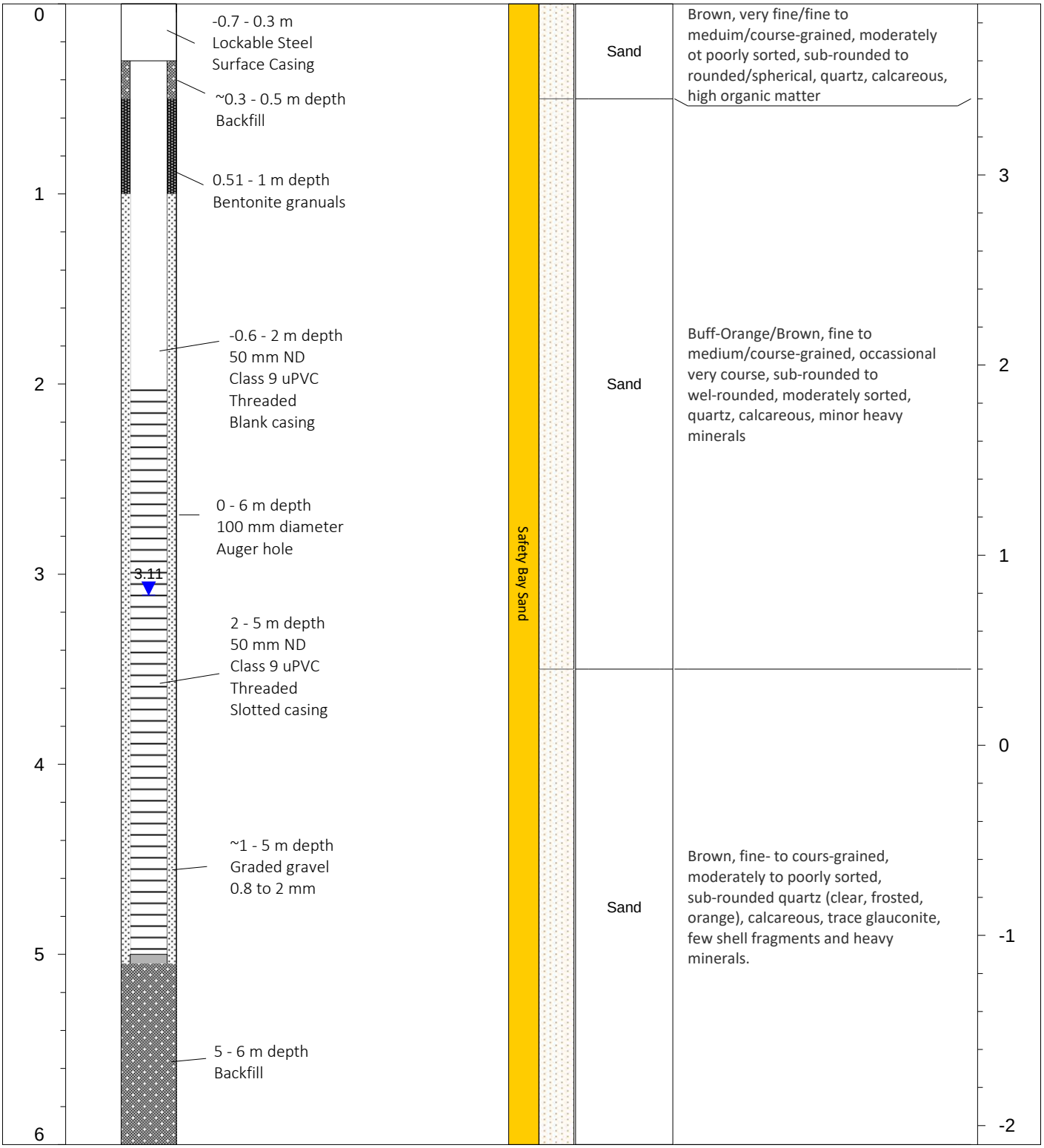
Bore Location: 373702 mE, 6367568 mN
Elev. 10.49 m AHD
Date Drilled: 12/03/2018
SWL: 10.15 m bgl (24/05/2018)
EC: 730 uS/cm

BORE COMPLETION DIAGRAM
MONITORING BORE DLMB3

ManagedRecharge

Project: Doyle's Lime
Client: Doyle's Lime Service
Job No:3-0/17-009
Date: June 2018

Appendix D-4



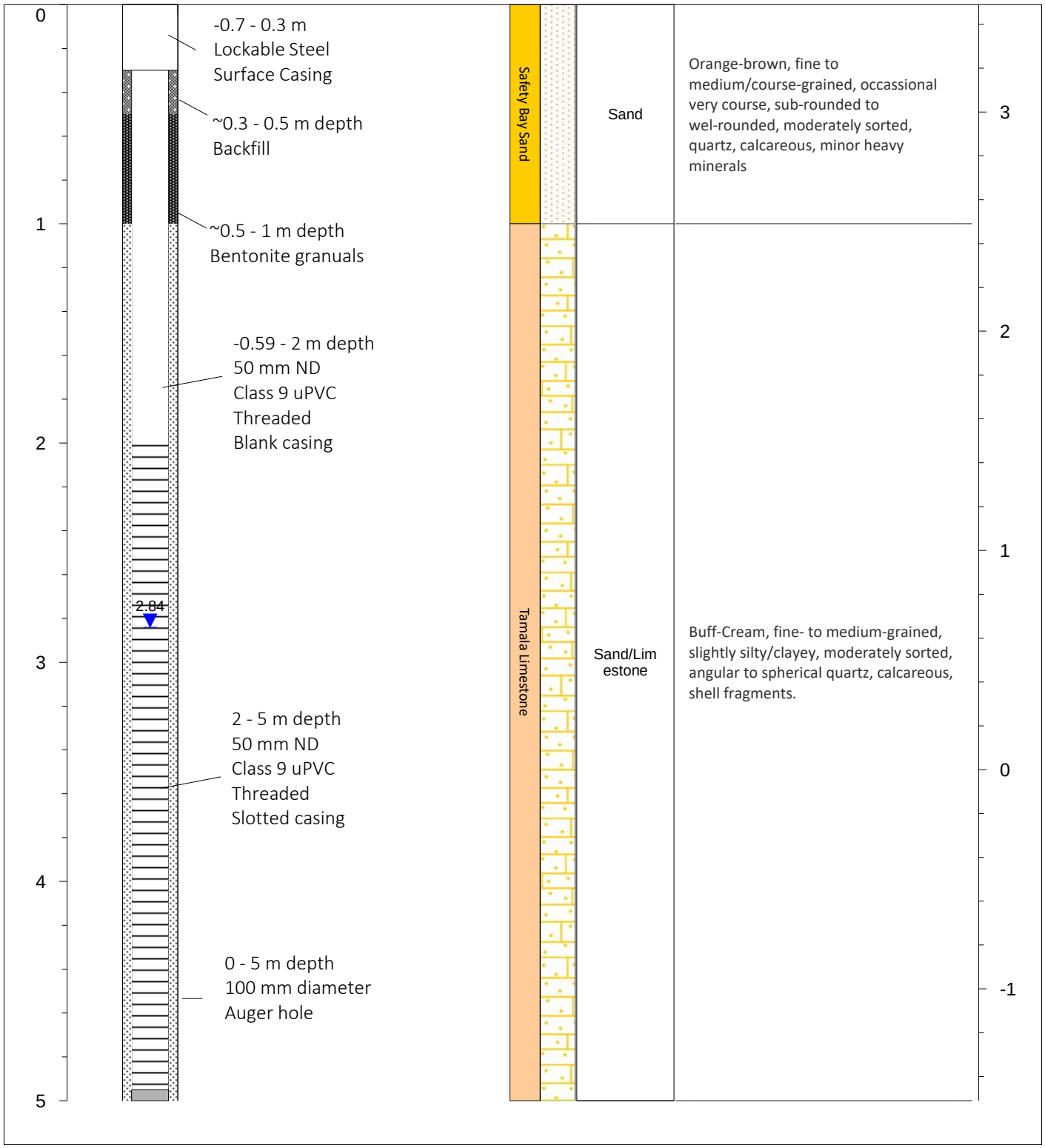
Bore Location: 373299 mE, 6366256 mN
Elev. 3.9 m AHD
Date Drilled: 12/03/2018
SWL: 3.11 m bgl (24/05/2018)
EC: 590 uS/cm

BORE COMPLETION DIAGRAM
MONITORING BORE DLMB4

ManagedRecharge

Project: Doyle's Lime
Client: Doyle's Lime Service
Job No:3-0/17-009
Date: June 2018

Appendix D-5



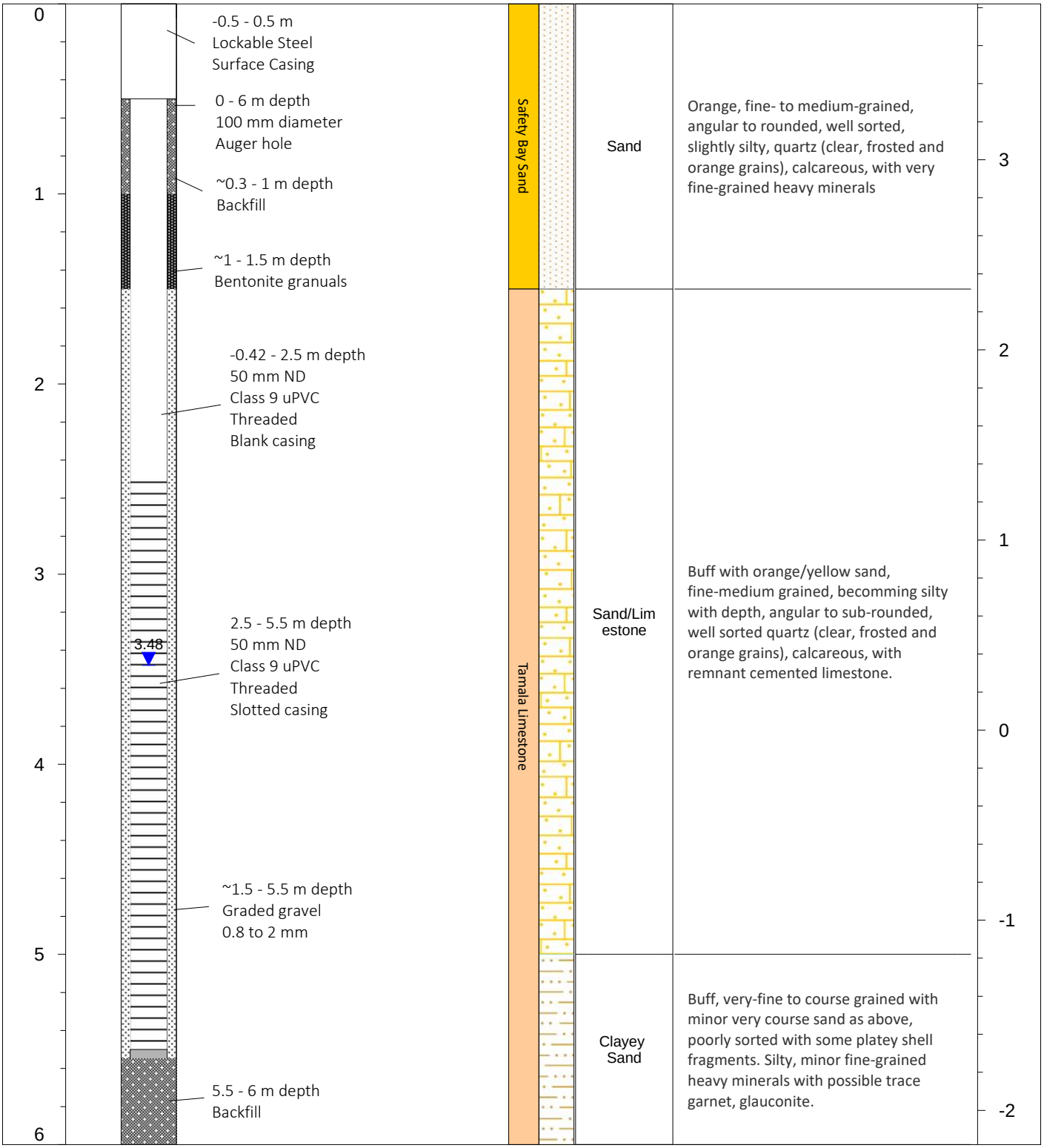
Bore Location: 373788 mE, 6366263 mN
Elev. 3.49 m AHD
Date Drilled: 12/03/2018
SWL: 2.84 m bgl (24/05/2018)
EC: 1570 uS/cm

BORE COMPLETION DIAGRAM
MONITORING BORE DLMB5

ManagedRecharge

Project: Doyle's Lime
Client: Doyle's Lime Service
Job No:3-0/17-009
Date: June 2018

Appendix D-6



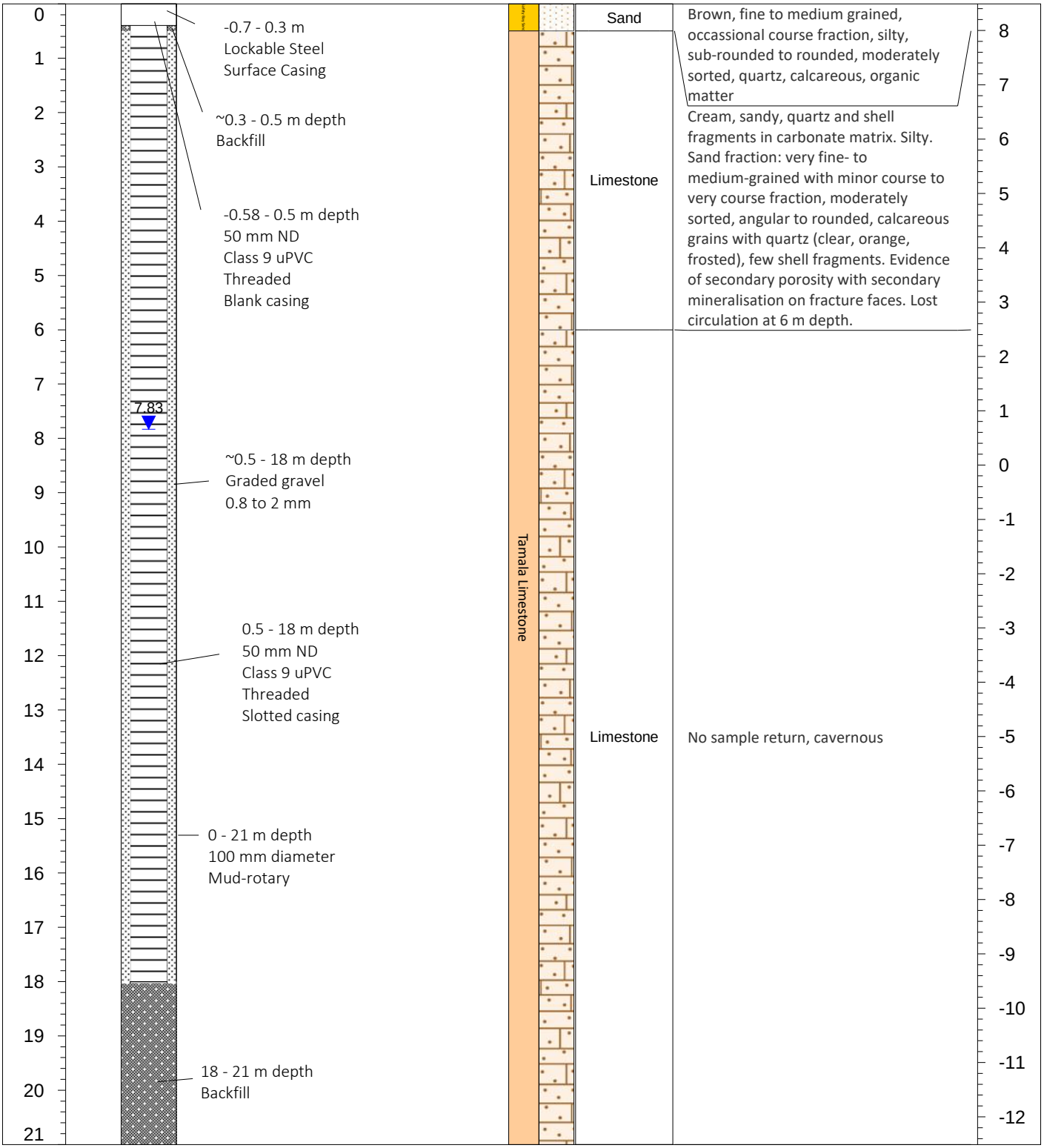
Bore Location: 374234 mE, 6367635 mN
Elev. 3.82 m AHD
Date Drilled: 23/05/2018
SWL: 3.48 m bgl (24/05/2018)
EC: 1930 uS/cm

BORE COMPLETION DIAGRAM
MONITORING BORE DLMB6

ManagedRecharge

Project: Doyle's Lime
Client: Doyle's Lime Service
Job No:3-0/17-009
Date: June 2018

Appendix D-7



Bore Location: 373779 mE, 6366915 mN
Elev. 8.49 m AHD
Date Drilled: 23/05/2018
SWL: 7.83 m bgl (24/05/2018)
EC: 12980 uS/cm

BORE COMPLETION DIAGRAM
MONITORING BORE DLMB7

ManagedRecharge

Appendix E
Modelled Groundwater Mounding (MOUNDSOLV)

Groundwater Mounding via Additional Recharge

Groundwater mounding beneath the pit has been modelled assuming a two-fold increase in rainfall recharge over half the proposed pit area during active excavation. Two areas have been modelled, the northern half of the proposed pit, and the southern half of the proposed pit This allows for active mining over half the pit area and either undisturbed ground or revegetated ground over the remaining area. Two scenarios have been modelled:

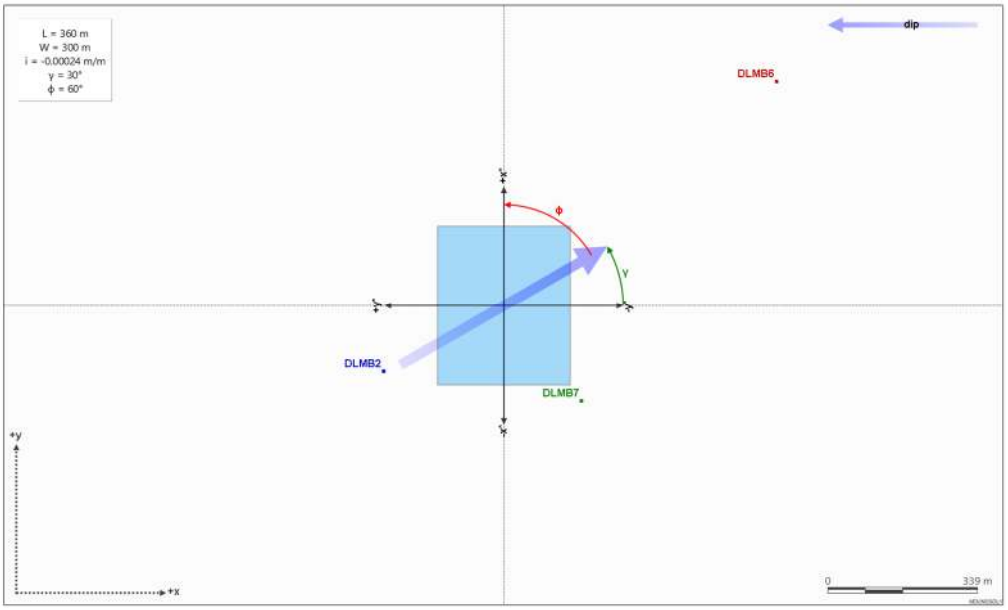
- 8 % annual rainfall recharge over 180 days (i.e. an additional 8% rainfall recharge applied over winter), and
- 13 % annual rainfall recharge over 180 days (i.e. an additional 13% rainfall recharge applied over winter).

The modelling has been conducted using HydroSOLVE Inc's MOUNDSOLV, a groundwater mounding analysis package. MOUNDSOLV can be used to simulate groundwater mounding under transient conditions and employs an analytical solution by Zlotnik, et al (2017), which is considered to predict a conservatively higher mound height compared to alternative methods and MODFLOW modelling results (HydroSOLVE, 2021). The results are presented below.

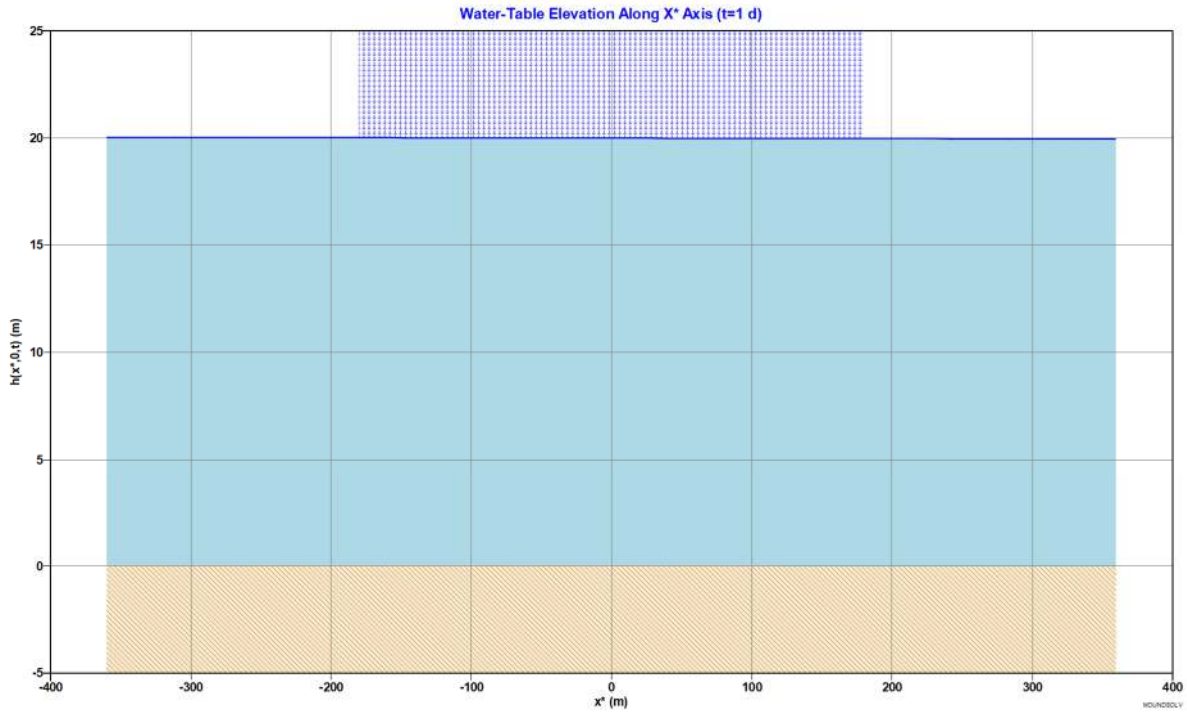
A. Northern Pit Area

a) Model Set-Up and Extent

The model set-up and extent for the Northern Pit area are shown in Appendix Figure 1, and a cross-section through the area is shown in Appendix Figure 2. The recharge area is nominally 360 m long by 300 m wide, giving a total area of 108000 m^2. The aquifer is assumed to be 20 m thick and a low groundwater gradient of 0.00024 has been applied, dipping towards Lake Pollard to the north-east. Monitoring points corresponding to monitoring bores DLMB2, DLMB6 and DLMB7 were input for reference.



Appendix Figure 1: Northern Pit modelled recharge area, with groundwater flow toward Lake Pollard under a hydraulic gradient of 0.00024



Appendix Figure 2: Schematic W-E cross section showing modelled aquifer thickness (blue), area of applied recharge (downward arrows) and starting groundwater levels (20 m above base of aquifer)

b) Input Parameters

The system was modelled with the following input parameters:

- Hydraulic conductivity – 60 m/d and 20 m/d
- Specific yield – 0.2
- Aquifer thickness – 20 m
- Recharge rate – 28.16 m^3/d and 45.76 m^3/d for 180 days.

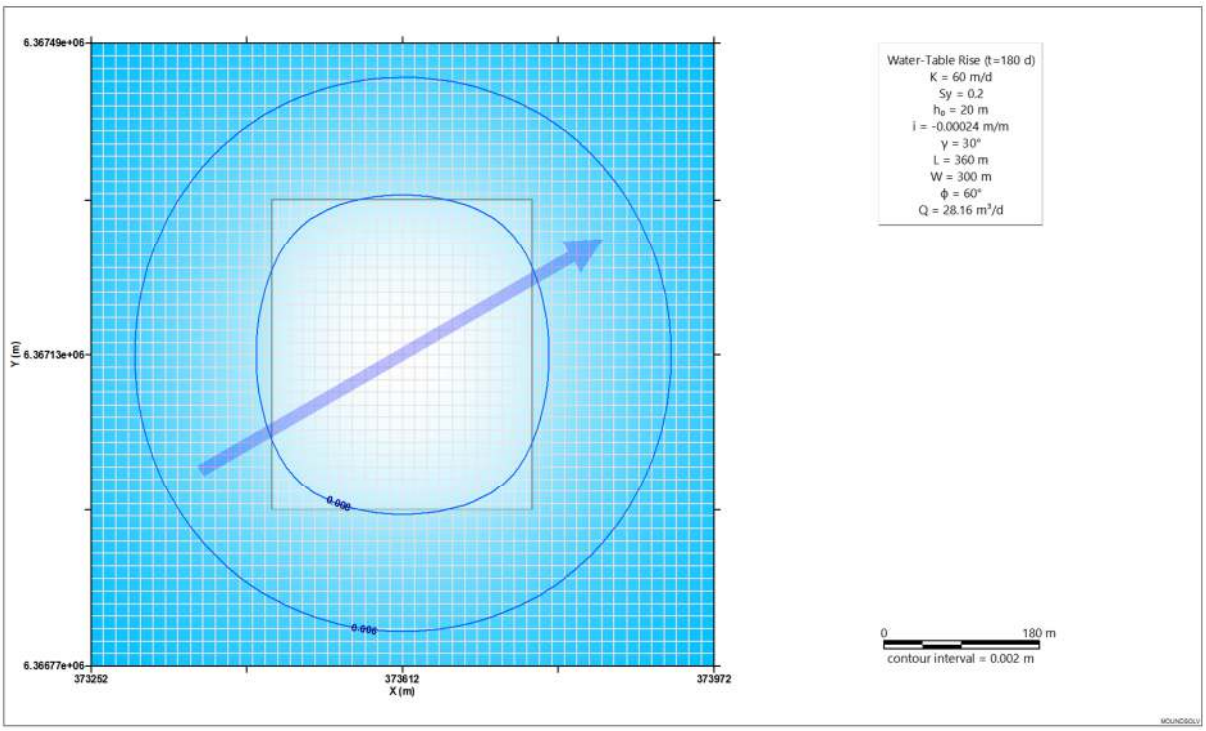
c) Modelling Results

The simulation results for each modelling scenario are presented below.

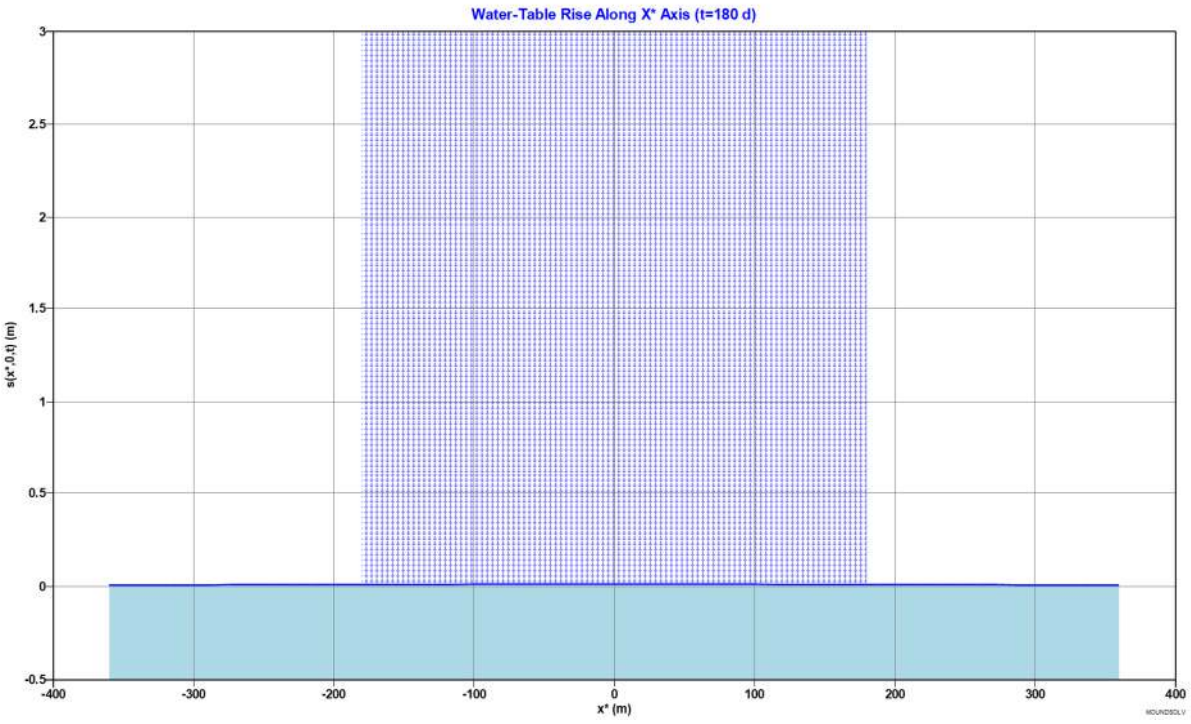
K_h = 60 m/d, additional 8% rainfall recharge:

Changes to groundwater levels after 180 days with a recharge rate of 28.16 m/d is provided in Appendix Figure 3, the results show that at the pit perimeter groundwater level rise is <0.01 m. This represents a negligible rise in the water table (Appendix Figure 4).

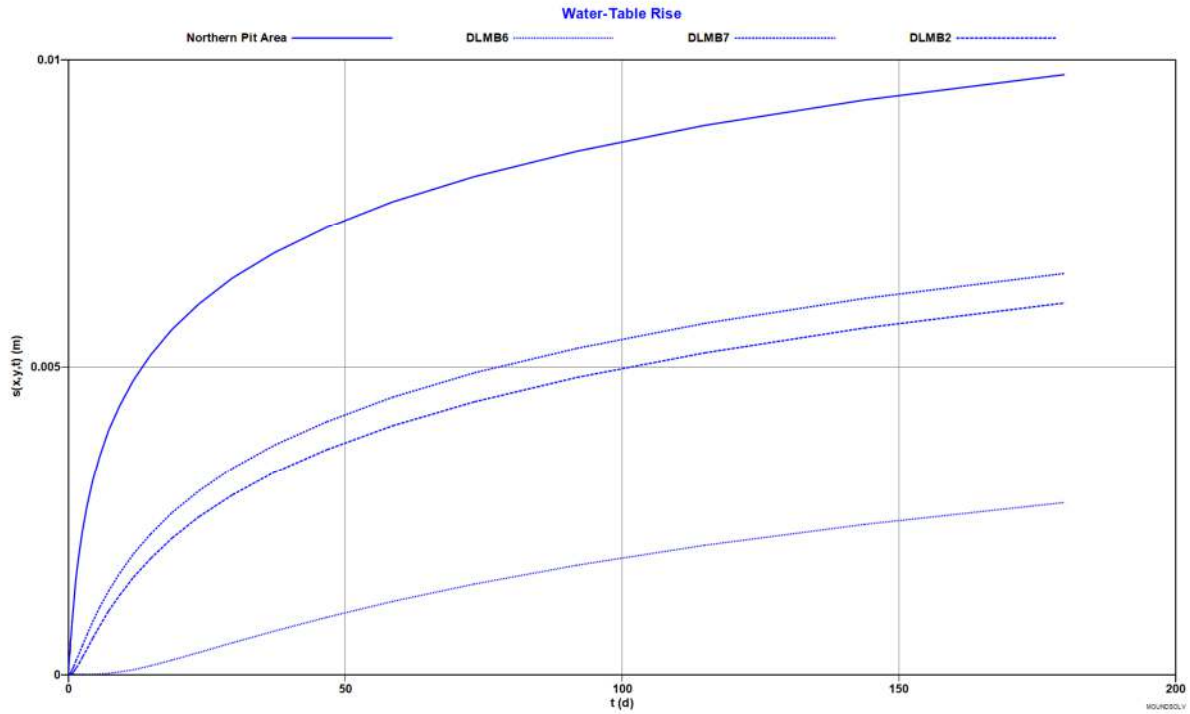
Appendix Figure 5 shows the groundwater level rise with time beneath the northern pit area and at each of the monitoring points. The results indicate a maximum groundwater level rise of 0.010 m beneath the excavated pit, 0.007 m at DLMB7, 0.006 m at DLMB2 and 0.003 m at DLMB6. This level of mounding (≤ 1 cm) will be indistinguishable from the natural seasonable variations at this site, and represents no measurable impact to the groundwater flow direction or velocity.



Appendix Figure 3: Groundwater level rise after 180 days with recharge of 28.16 m³/d (an additional 8% total rainfall over approximately half the proposed pit area)



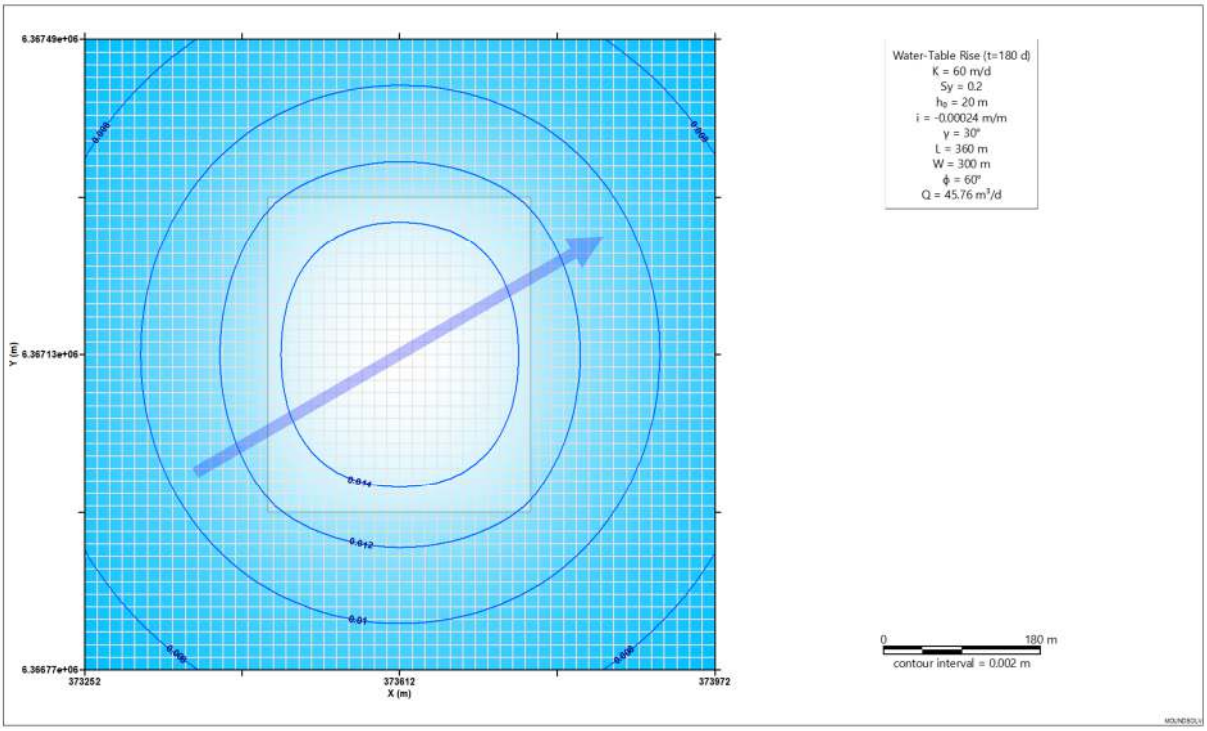
Appendix Figure 4: Cross section showing degree of groundwater mounding beneath the excavated pit after 180 days with recharge rate of 28.16 m³/d



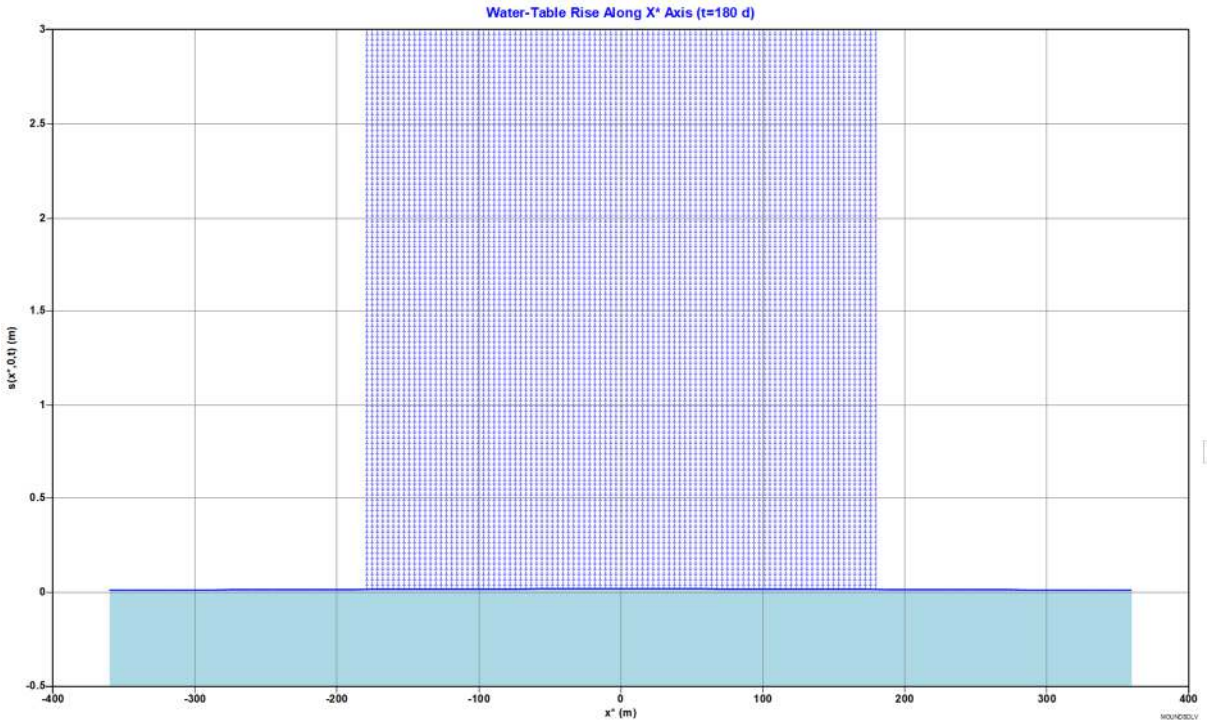
Appendix Figure 5: Groundwater level rise over 180 days with recharge rates of 28.16 m³/d

K_h = 60 m/d, additional 13% rainfall recharge:

Changes to groundwater levels after 180 days with a recharge rate of 45.76 m/d is provided in Appendix Figure 6, the results show that at the pit perimeter groundwater level rise is <0.014 m. This represents a negligible rise in the water table (Appendix Figure 7).

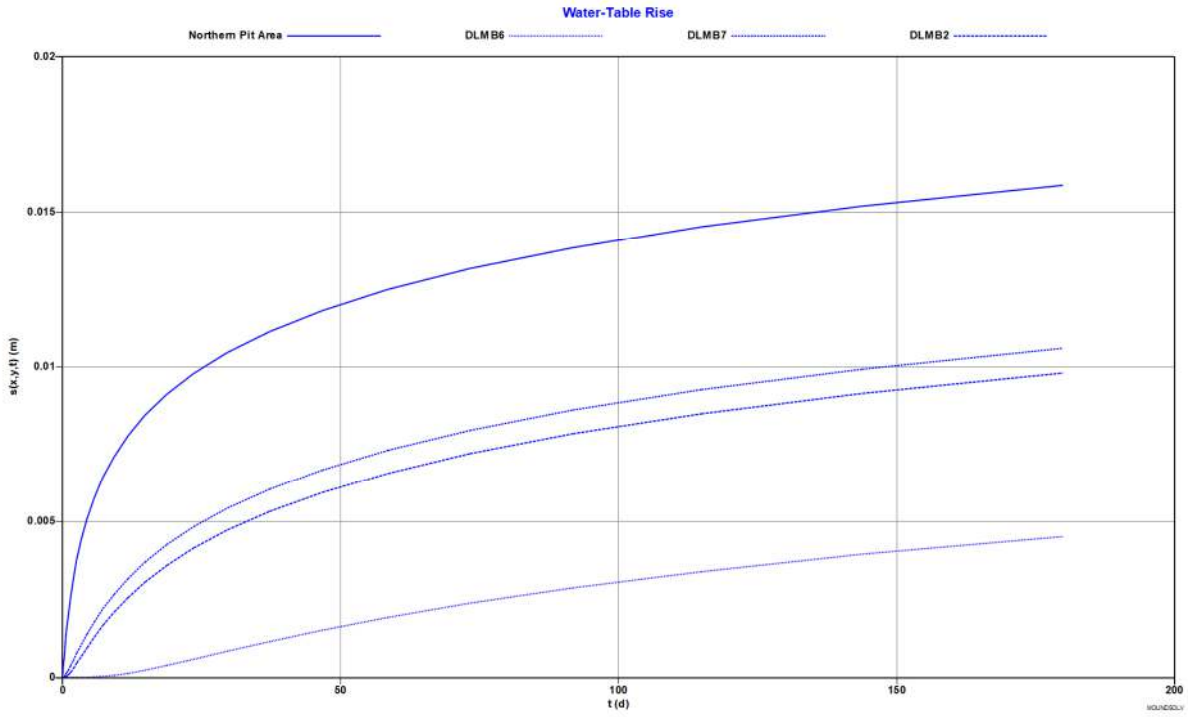


Appendix Figure 6: Groundwater level rise after 180 days with recharge of 45.76 m³/d (an additional 13% total rainfall over approximately half the proposed pit area)



Appendix Figure 7: Cross section showing degree of groundwater mounding beneath the excavated pit after 180 days with recharge rate of 45.76 m³/d

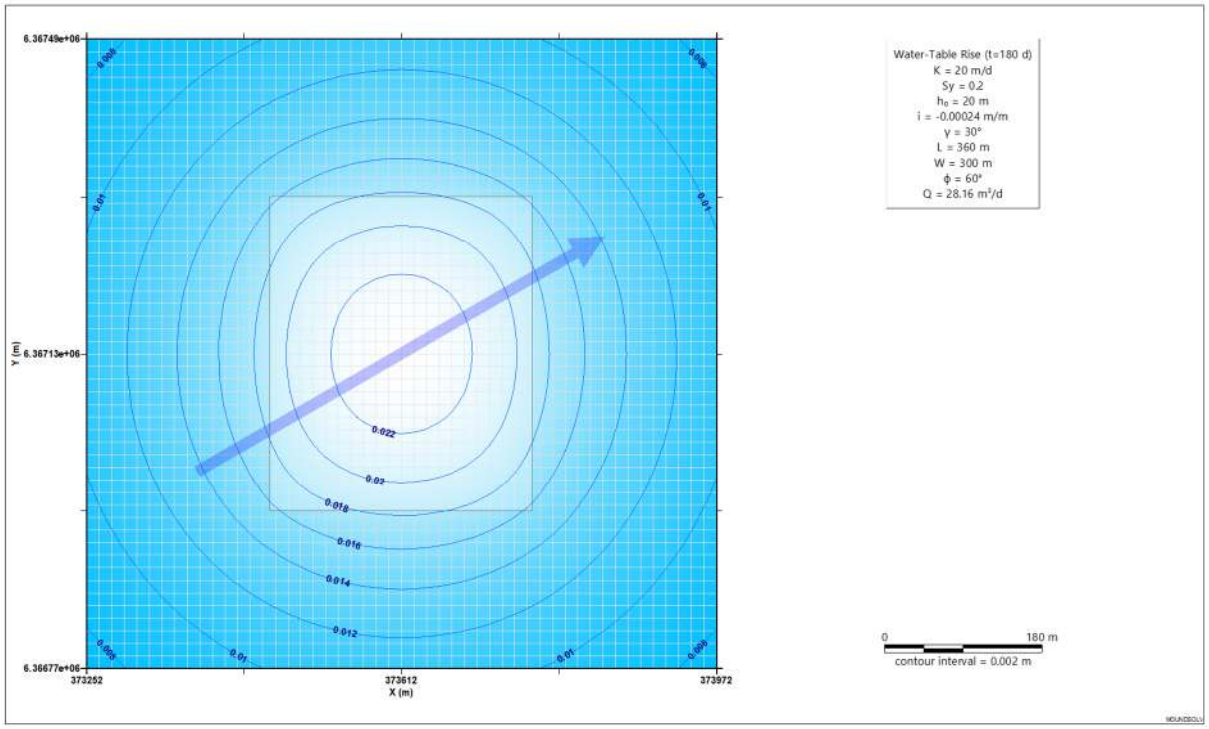
Appendix Figure 8 shows the groundwater level rise with time beneath the northern pit area and at each of the monitoring points. The results indicate a maximum groundwater level rise of 0.016 m beneath the excavated pit, 0.011 m at DLMB7, 0.010 m at DLMB2 and 0.005 m at DLMB6. This level of mounding (< 2 cm) will be indistinguishable from the natural seasonable variations at this site, and represents no measurable impact to the groundwater flow direction or velocity.



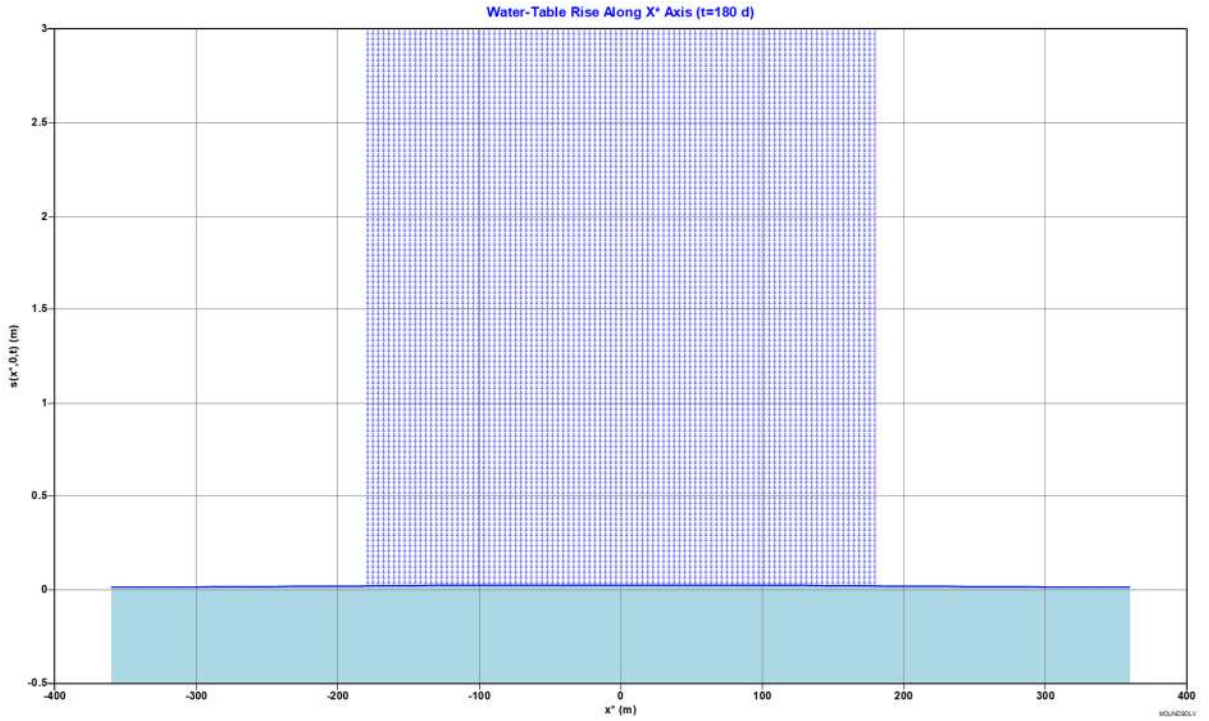
Appendix Figure 8: Groundwater level rise over 180 days with recharge rates of 45.76 m³/d

Lower Bound K_h = 20 m/d, additional 8% rainfall recharge:

Changes to groundwater levels after 180 days with a recharge rate of 28.16 m/d for a lower bound hydraulic conductivity (20 m/d) is provided in Appendix Figure 9, the results show that at the pit perimeter groundwater level rise is <0.02 m. This represents a negligible rise in the water table (Appendix Figure 10).

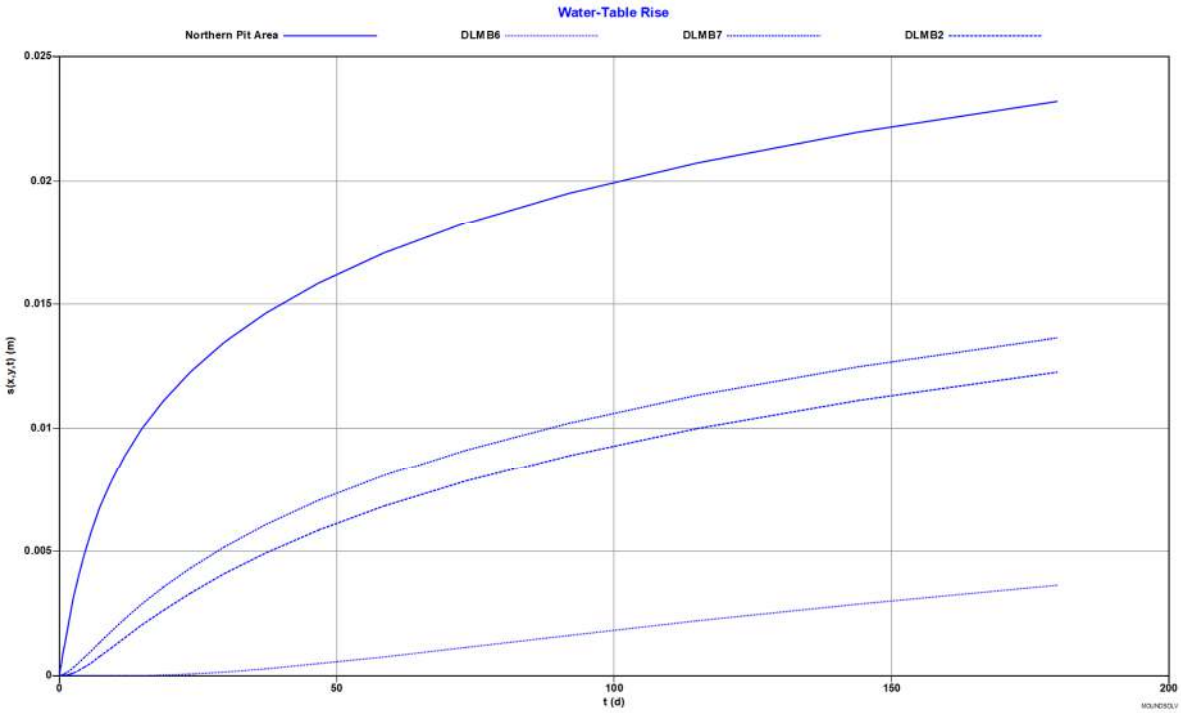


Appendix Figure 9: Groundwater level rise after 180 days with recharge of 28.16 m³/d (an additional 8% total rainfall over approximately half the proposed pit area) (lower bound K_h)



Appendix Figure 10: Cross section showing degree of groundwater mounding beneath the excavated pit after 180 days with recharge rate of 28.16 m³/d (lower bound K_h)

Appendix Figure 11 shows the groundwater level rise with time beneath the northern pit area and at each of the monitoring points. The results indicate a maximum groundwater level rise of 0.023 m beneath the excavated pit, 0.014 m at DLMB7, 0.013 m at DLMB2 and 0.004 m at DLMB6. This level of mounding (< 2.5 cm) will be indistinguishable from the natural seasonable variations at this site, and represents no measurable impact to the groundwater flow direction or velocity.



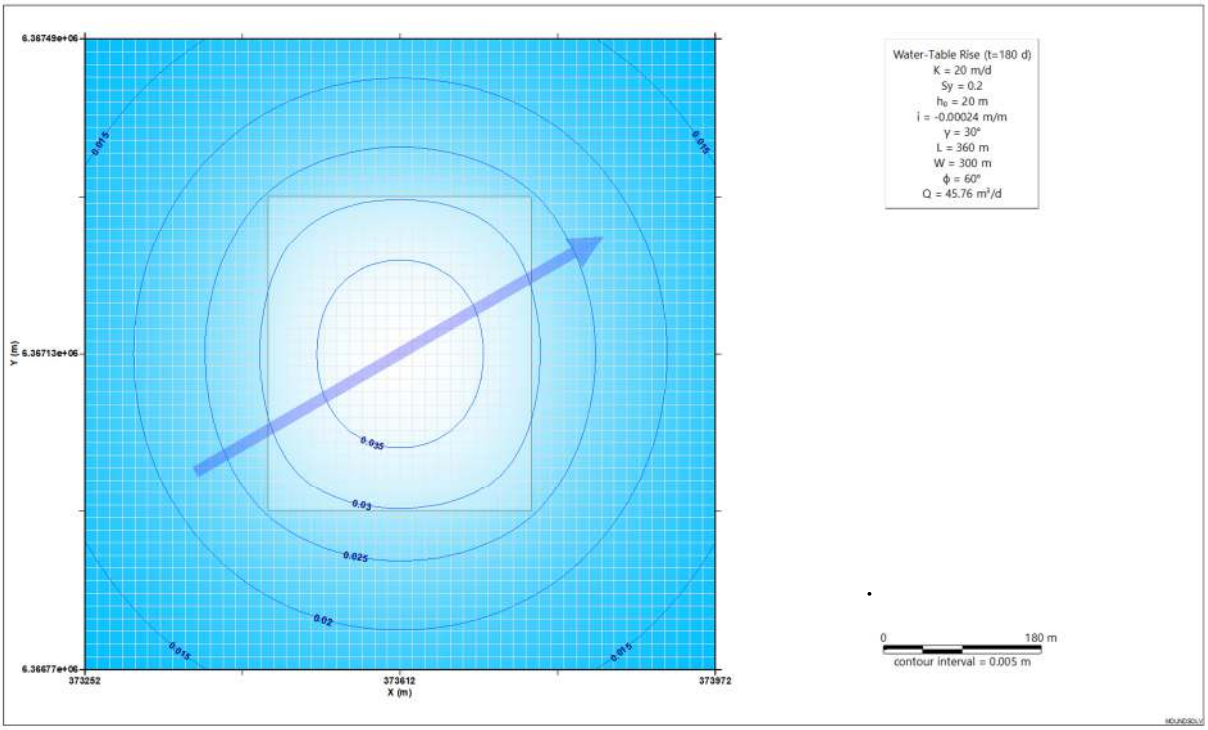
Appendix Figure 11: Groundwater level rise over 180 days with recharge rates of 28.16 m³/d (lower bound K_h)

Lower Bound K_h = 20 m/d, additional 13% rainfall recharge:

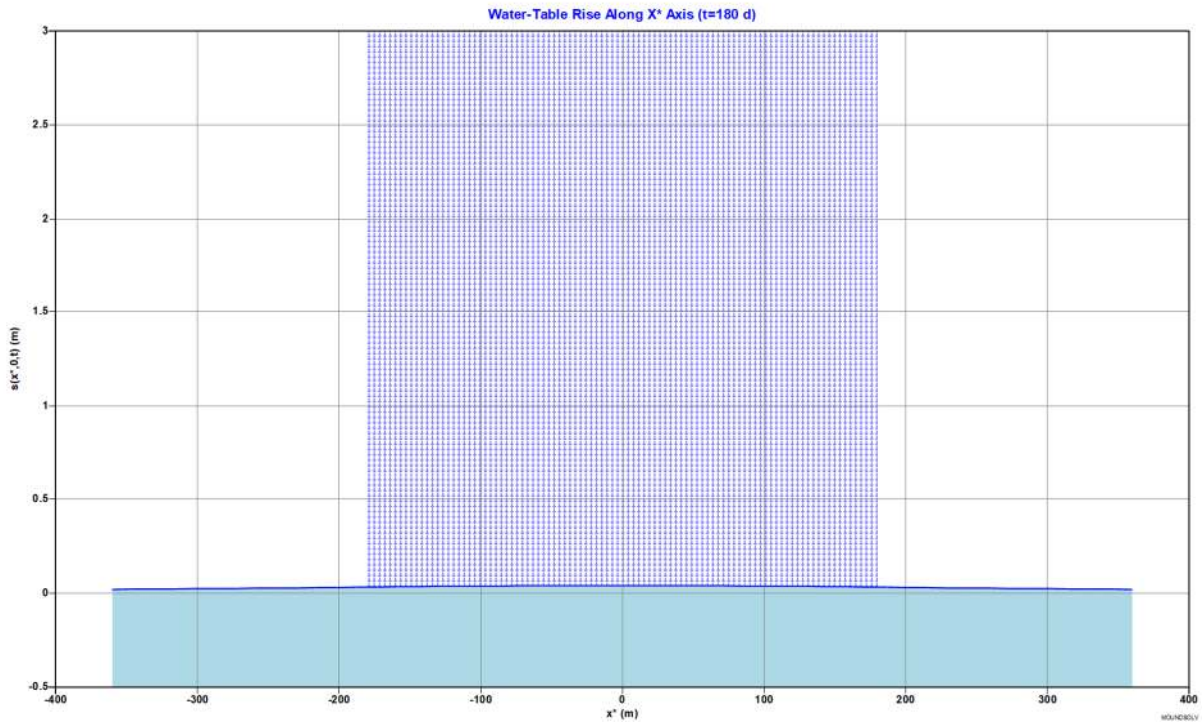
Changes to groundwater levels after 180 days with a recharge rate of 45.76 m/d for a lower bound hydraulic conductivity (20 m/d) is provided in Appendix Figure 12, the results show that at the pit perimeter groundwater level rise is generally <0.03 m. This represents a minimal rise in the water table (Appendix Figure 13).

Appendix Figure 14 shows the groundwater level rise with time beneath the northern pit area and at each of the monitoring points. The results indicate a maximum groundwater level rise of 0.038 m beneath the excavated pit, 0.022 m at DLMB7, 0.020 m at DLMB2 and 0.006 m at DLMB6. This level of mounding (< 4 cm) will be indistinguishable from the natural seasonable variations at this site, and represents no measurable impact to the groundwater flow direction or velocity.

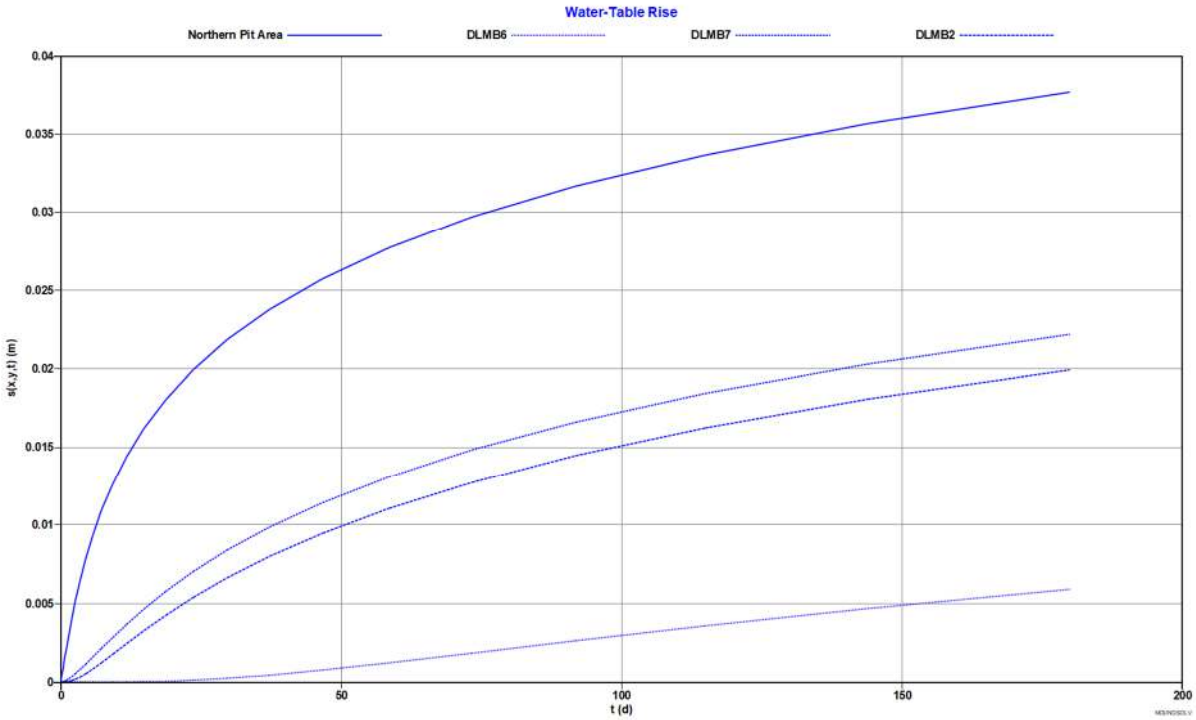
This modelling scenario can be considered to be worse case groundwater mounding, with additional rainfall recharge at the upper bound of potential recharge in the region (total 26% allowing for the assumed 13% natural recharge) and aquifer hydraulic conductivity at the lower bound of plausible values for the Tamala Limestone.



Appendix Figure 12: Groundwater level rise after 180 days with recharge of 45.76 m^3/d (an additional 13% total rainfall over approximately half the proposed pit area) (lower bound K_h)



Appendix Figure 13: Cross section showing degree of groundwater mounding beneath the excavated pit after 180 days with recharge rate of 45.76 m^3/d (lower bound K_h)

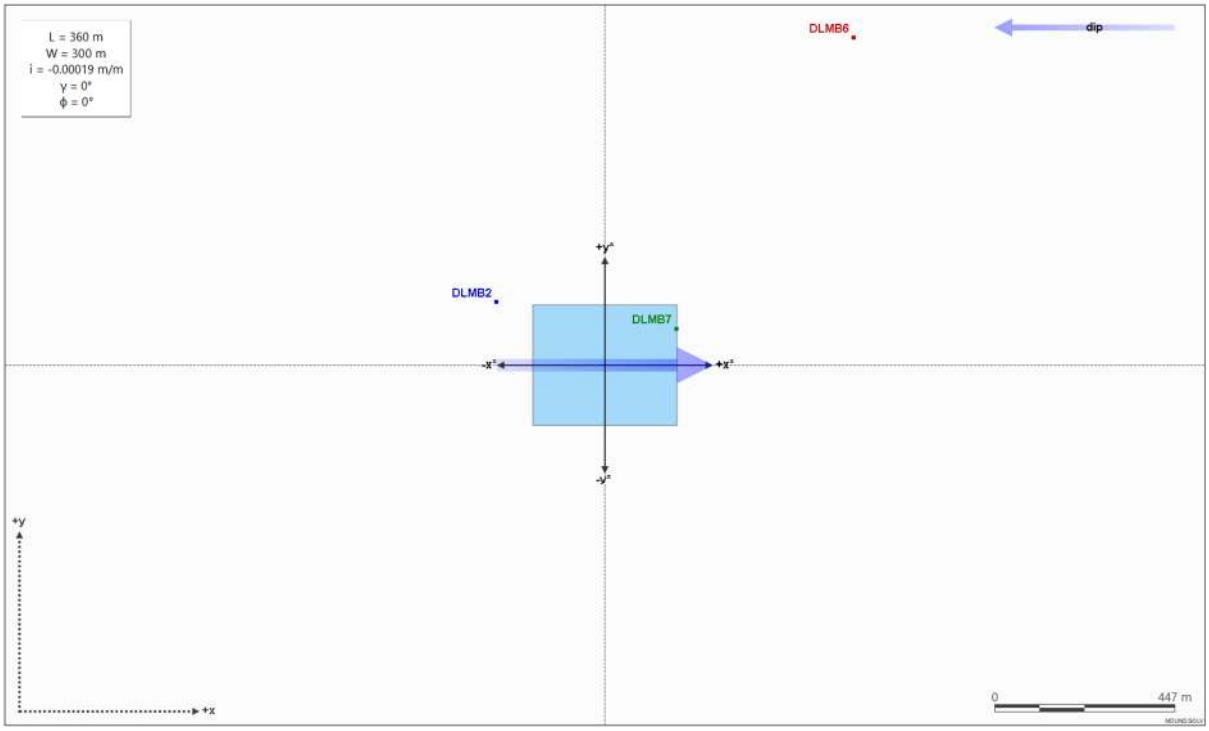


Appendix Figure 14: Groundwater level rise over 180 days with recharge rates of 45.76 m^3/d (lower bound K_h)

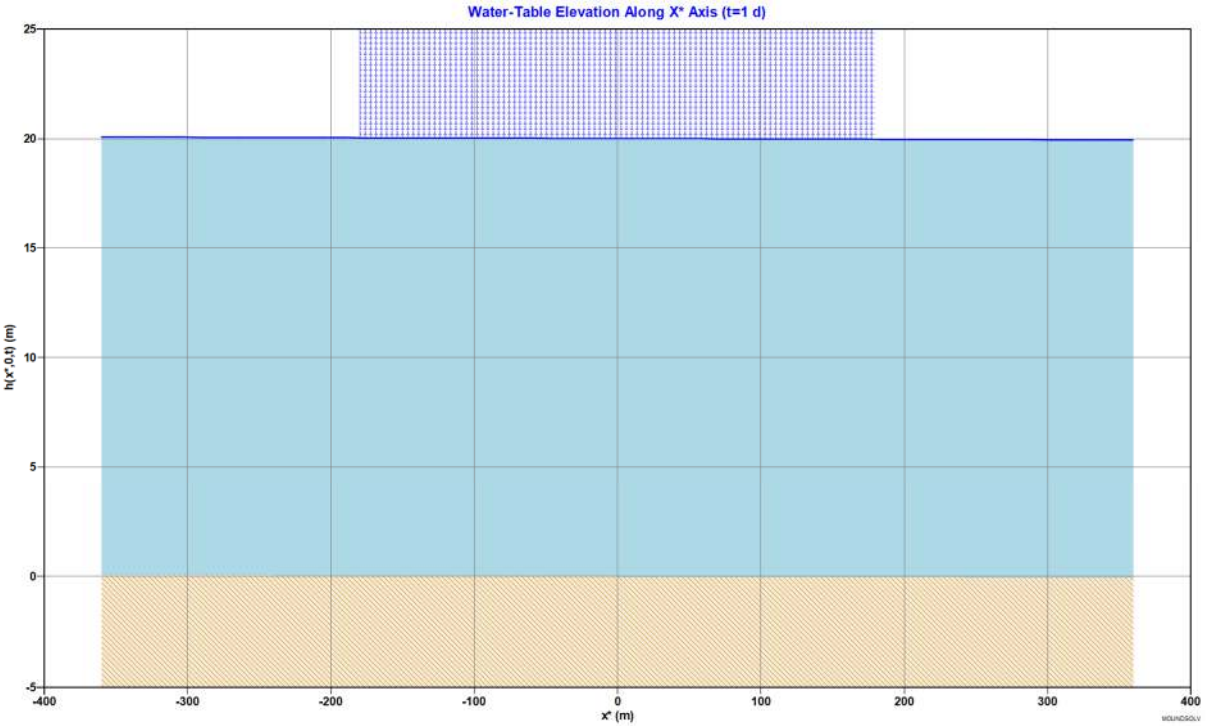
B. Southern Pit Area

a) Model Set-Up and Extent

The model set-up and extent for the Southern Pit area are shown in Appendix Figure 15, and a cross-section through the area is shown in Appendix Figure 16. The recharge area is nominally 360 m long by 300 m wide, giving a total area of 108000 m^2. The aquifer is assumed to be 20 m thick and a low groundwater gradient of 0.0019 has been applied, dipping towards the east. Monitoring points corresponding to monitoring bores DLMB2, DLMB6 and DLMB7 were simulated.



Appendix Figure 15: Southern Pit modelled recharge area, with groundwater flow toward the east under a hydraulic gradient of 0.00019



Appendix Figure 16: Schematic W-E cross section showing modelled aquifer thickness (blue), area of applied recharge (downward arrows) and starting groundwater levels (m above base of aquifer)

b) Input Parameters

The system was modelled with the following input parameters:

- Hydraulic conductivity – 60 m/d and 20 m/d
- Specific yield – 0.2

- Aquifer thickness – 20 m
- Recharge rate – 28.16 m^3/d and 45.76 m^3/d for 180 days.

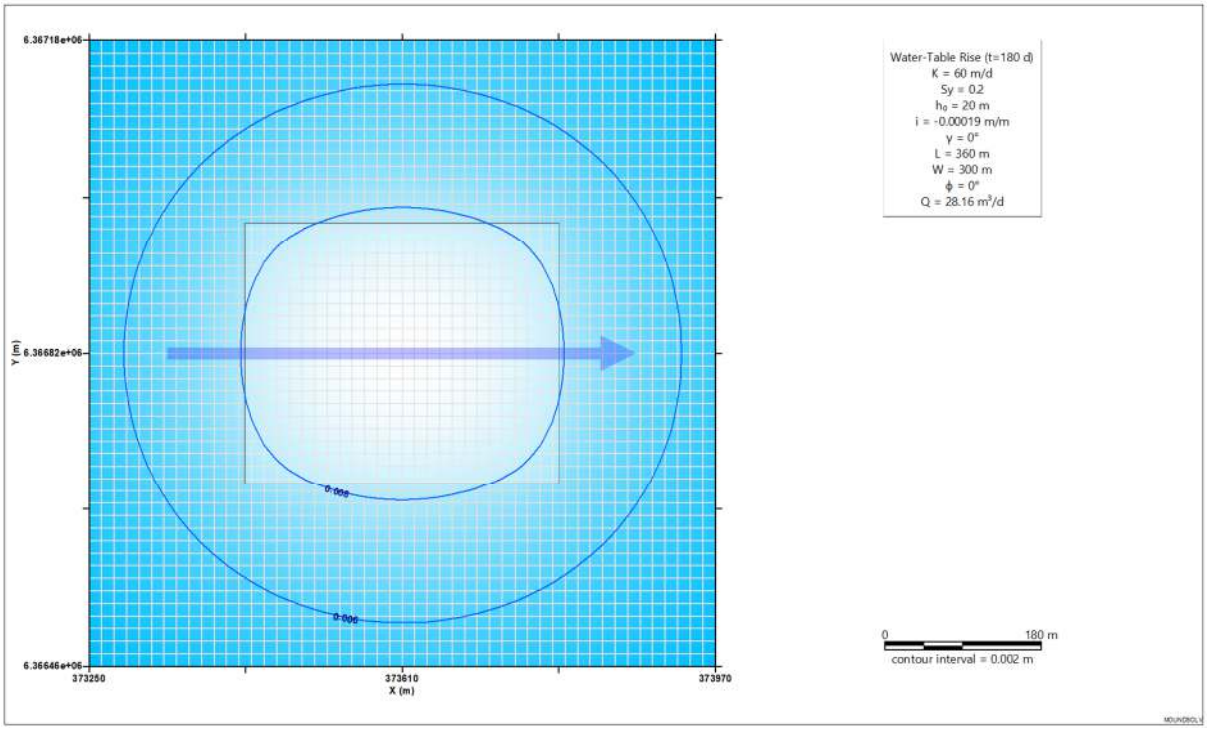
c) Modelling Results

The simulation results for each modelling scenario are presented below.

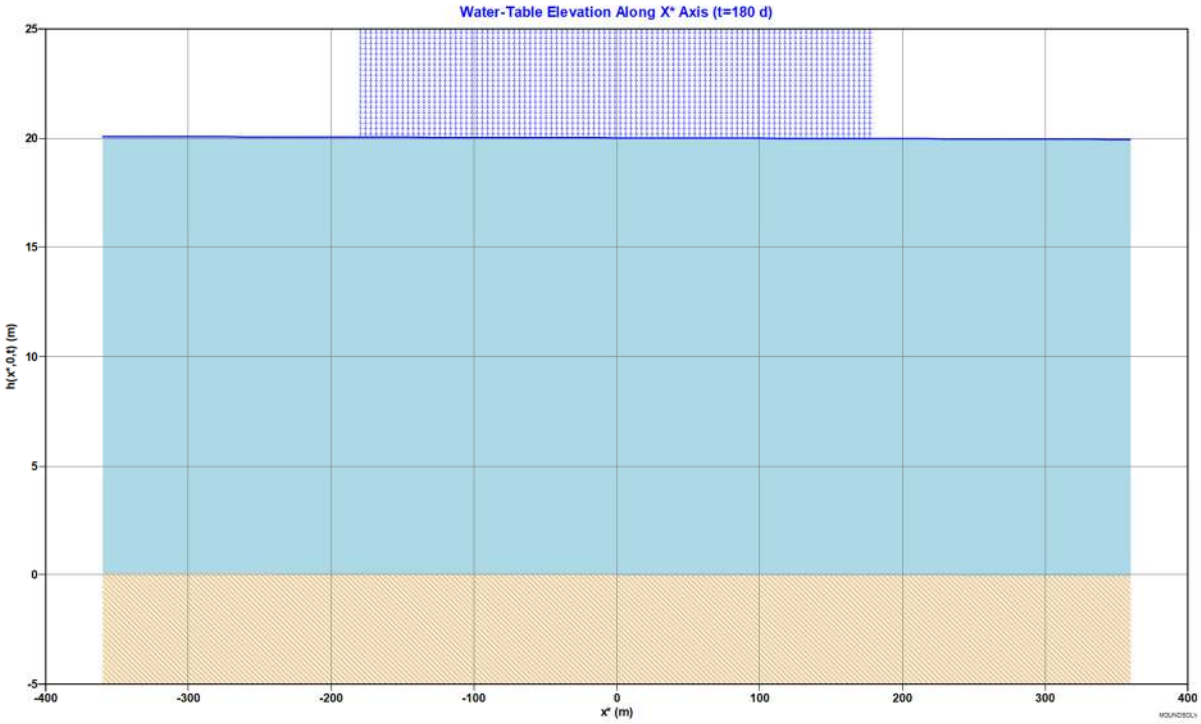
K_h = 60 m/d, additional 8% rainfall recharge:

Changes to groundwater levels after 180 days with a recharge rate of 28.16 m/d is provided in Appendix Figure 17, the results show that at the pit perimeter groundwater level rise is <0.01 m. This represents a negligible rise in the water table (Appendix Figure 18).

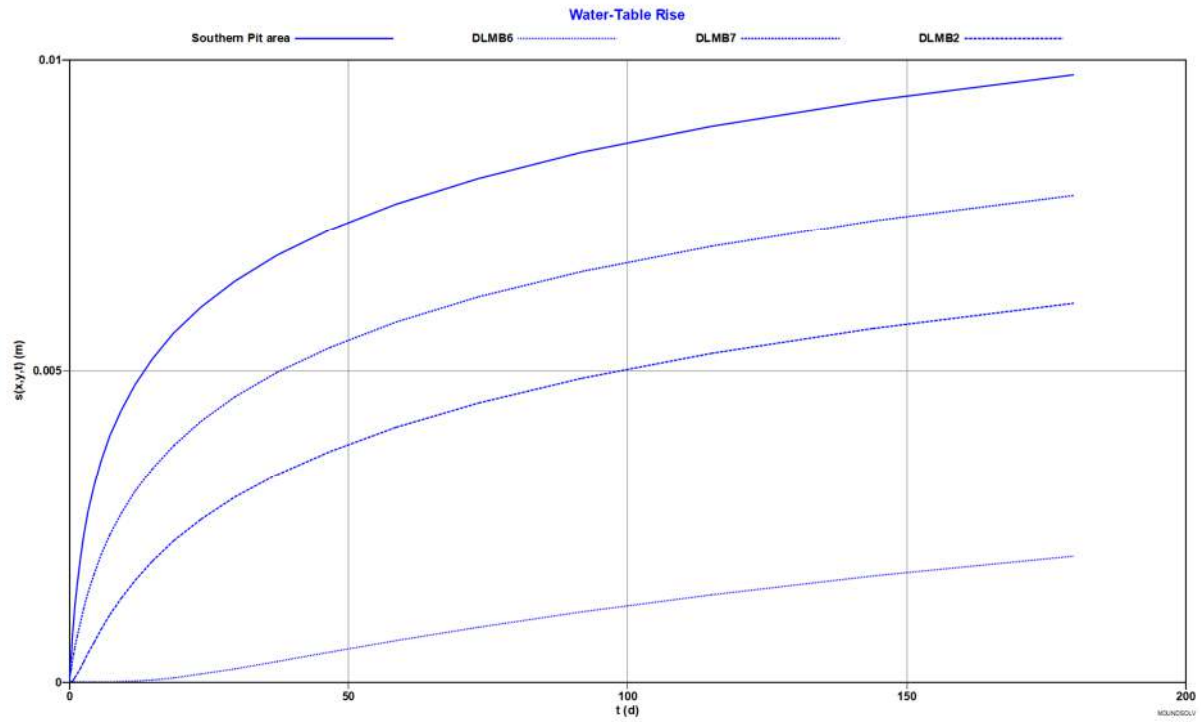
Appendix Figure 19 shows the groundwater level rise with time beneath the southern pit area and at each of the monitoring points. The results indicate a maximum groundwater level rise of 0.010 m beneath the excavated pit, 0.008 m at DLMB7, 0.006 m at DLMB2 and 0.002 m at DLMB6. This level of mounding (≤ 1 cm) will be indistinguishable from the natural seasonable variations at this site, and represents no measurable impact to the groundwater flow direction or velocity.



Appendix Figure 17: Groundwater level rise after 180 days with recharge of 28.16 m^3/d (an additional 8% total rainfall over approximately half the proposed pit area)



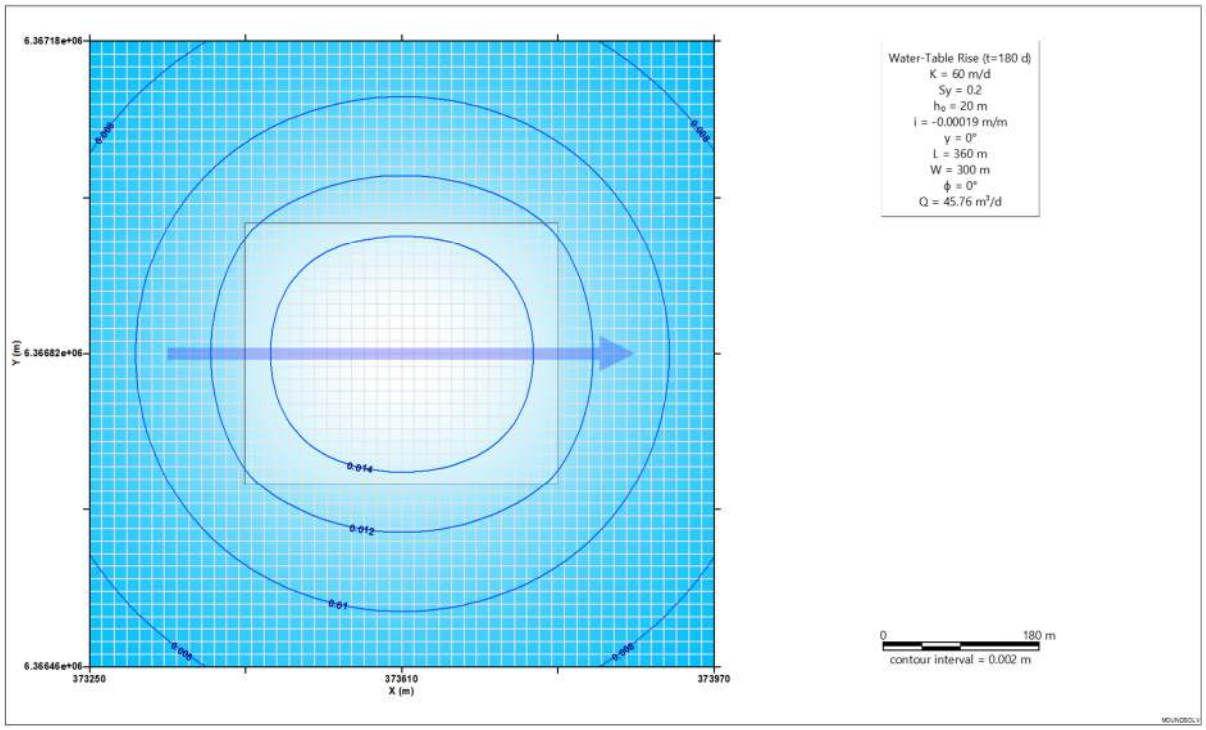
Appendix Figure 18: Cross section showing degree of groundwater mounding beneath the excavated pit after 180 days with recharge rate of 28.16 m³/d



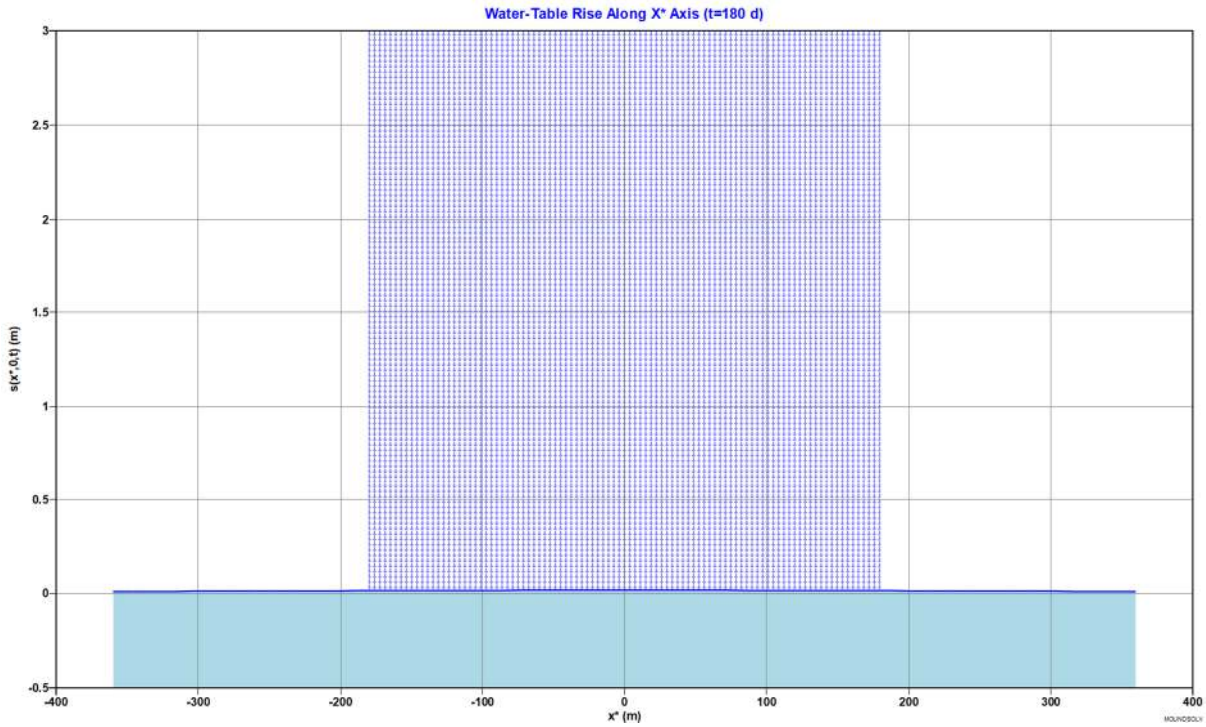
Appendix Figure 19: Groundwater level rise over 180 days with recharge rates of 28.16 m³/d

K_h = 60 m/d, additional 13% rainfall recharge:

Changes to groundwater levels after 180 days with a recharge rate of 45.76 m/d is provided in Appendix Figure 20, the results show that at the pit perimeter groundwater level rise is <0.014 m. This represents a negligible rise in the water table (Appendix Figure 21).

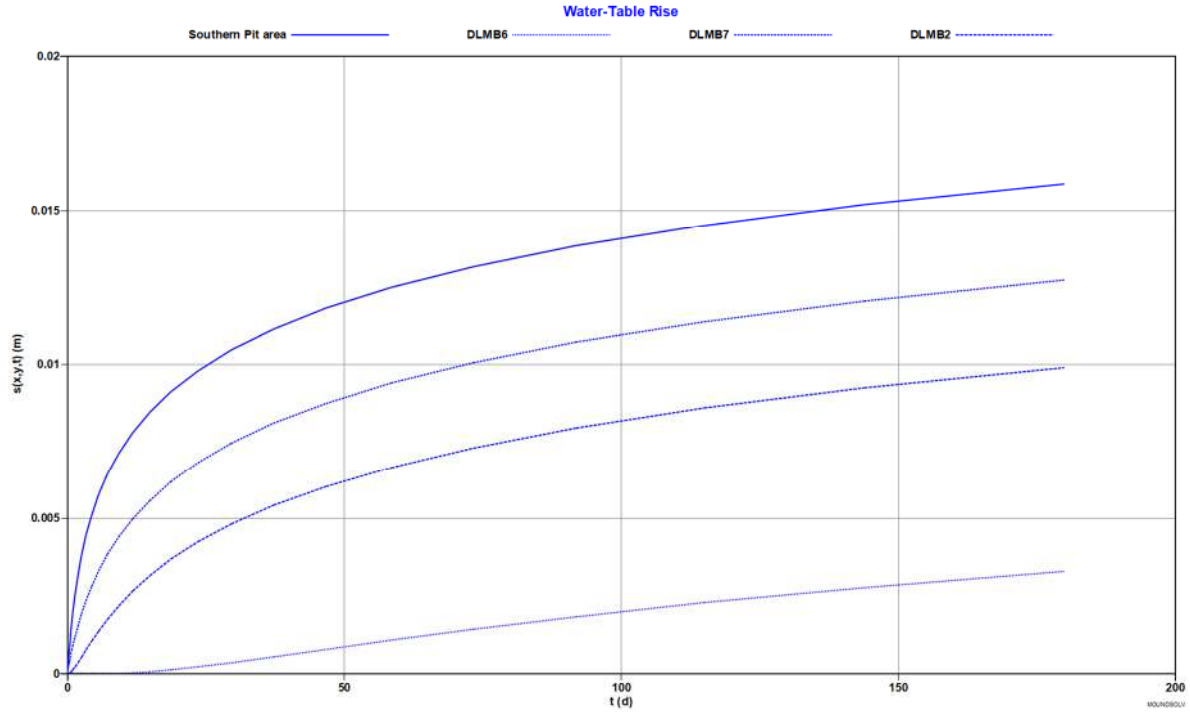


Appendix Figure 20: Groundwater level rise after 180 days with recharge of 45.76 m³/d (an additional 13% total rainfall over approximately half the proposed pit area)



Appendix Figure 21: Cross section showing degree of groundwater mounding beneath the excavated pit after 180 days with recharge rate of 45.76 m³/d

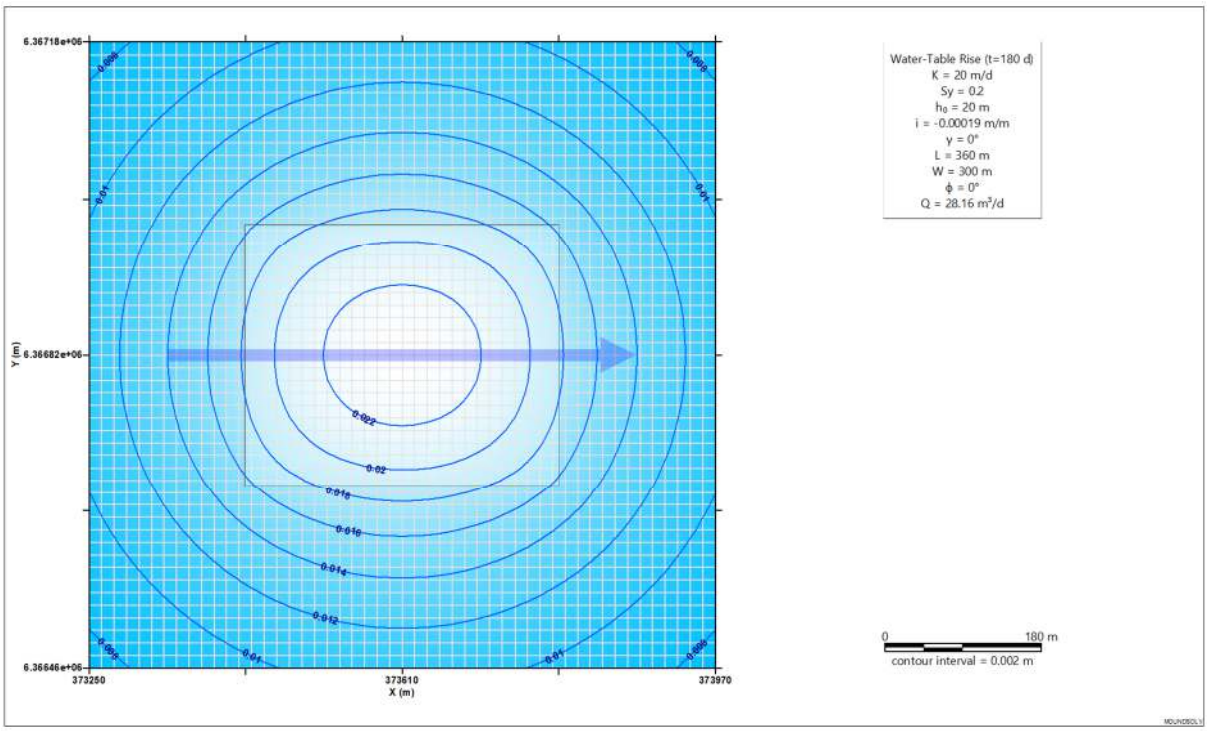
Appendix Figure 22 shows the groundwater level rise with time beneath the southern pit area and at each of the monitoring points. The results indicate a maximum groundwater level rise of 0.016 m beneath the excavated pit, 0.013 m at DLMB7, 0.010 m at DLMB2 and 0.003 m at DLMB6. This level of mounding (< 2 cm) will be indistinguishable from the natural seasonable variations at this site, and represents no measurable impact to the groundwater flow direction or velocity.



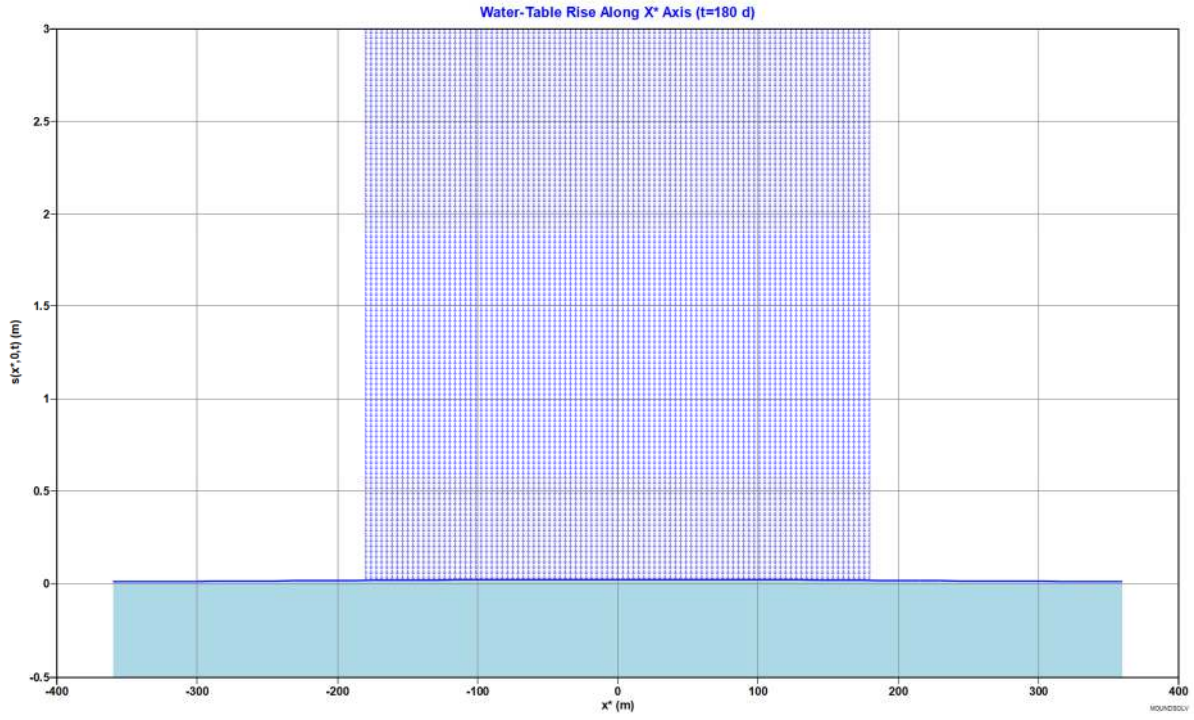
Appendix Figure 22: Groundwater level rise over 180 days with recharge rates of 45.76 m³/d

Lower Bound K_h = 20 m/d, additional 8% rainfall recharge:

Changes to groundwater levels after 180 days with a recharge rate of 28.16 m/d for a lower bound hydraulic conductivity (20 m/d) is provided in Appendix Figure 23, the results show that at the pit perimeter groundwater level rise is <0.02 m. This represents a negligible rise in the water table (Appendix Figure 24).

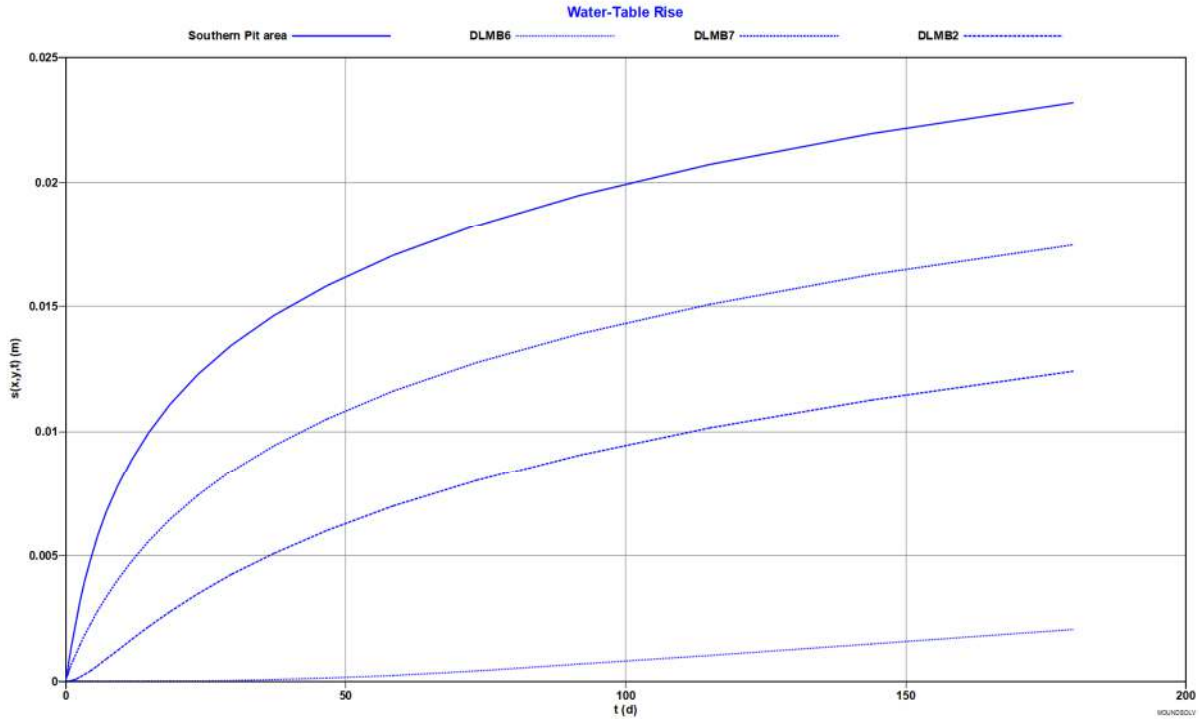


Appendix Figure 23: Groundwater level rise after 180 days with recharge of 28.16 m³/d (an additional 8% total rainfall over approximately half the proposed pit area) (lower bound K_h)



Appendix Figure 24: Cross section showing degree of groundwater mounding beneath the excavated pit after 180 days with recharge rate of 28.16 m³/d (lower bound K_h)

Appendix Figure 25 shows the groundwater level rise with time beneath the northern pit area and at each of the monitoring points. The results indicate a maximum groundwater level rise of 0.023 m beneath the excavated pit, 0.018 m at DLMB7, 0.012 m at DLMB2 and 0.002 m at DLMB6. This level of mounding (< 2.5 cm) will be indistinguishable from the natural seasonable variations at this site, and represents no measurable impact to the groundwater flow direction or velocity.



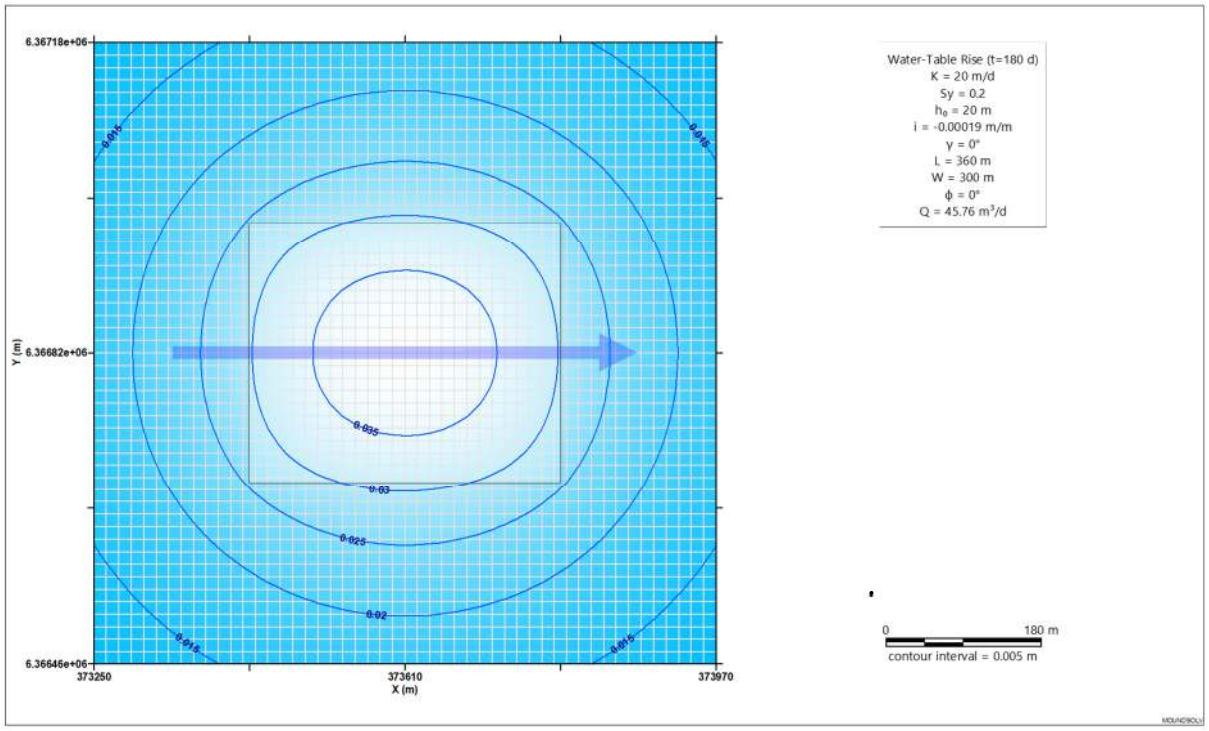
Appendix Figure 25: Groundwater level rise over 180 days with recharge rates of 28.16 m^3/d (lower bound K_h)

Lower Bound K_h = 20 m/d, additional 13% rainfall recharge:

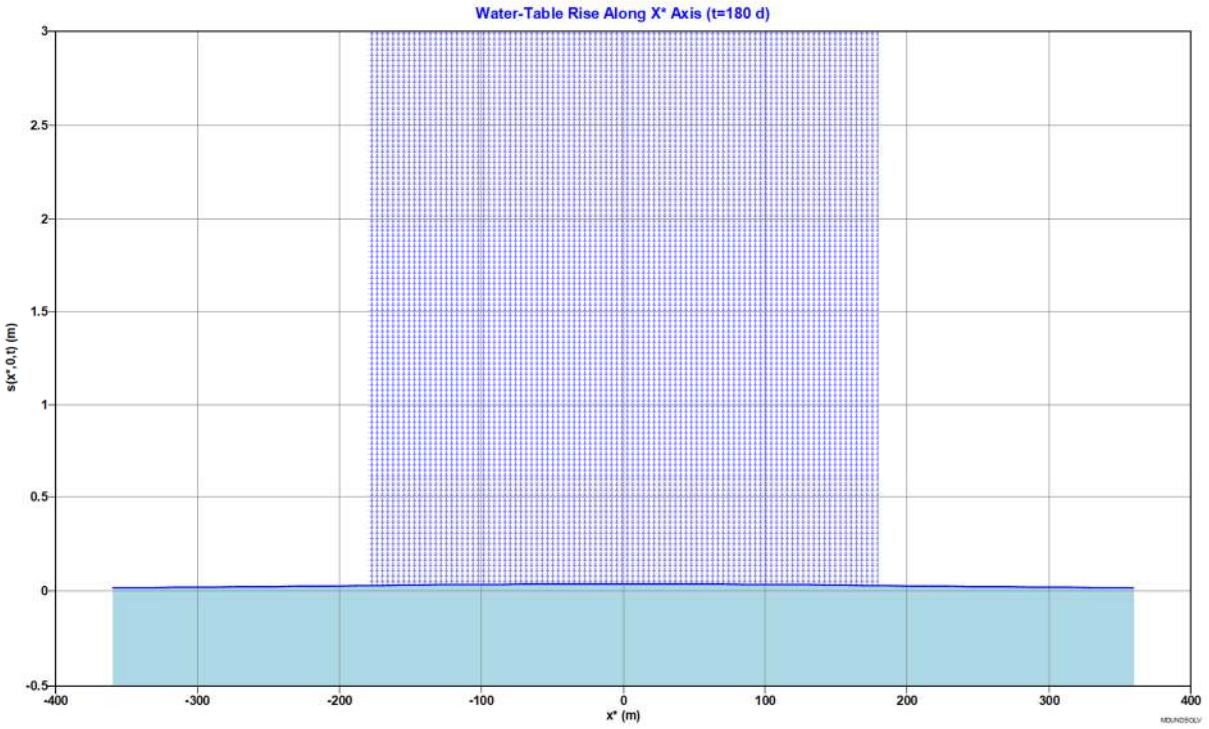
Changes to groundwater levels after 180 days with a recharge rate of 45.76 m/d for a lower bound hydraulic conductivity (20 m/d) is provided in Appendix Figure 26, the results show that at the pit perimeter groundwater level rise is generally <0.03 m. This represents a minimal rise in the water table (Appendix Figure 27).

Appendix Figure 28 shows the groundwater level rise with time beneath the southern pit area and at each of the monitoring points. The results indicate a maximum groundwater level rise of 0.038 m beneath the excavated pit, 0.028 m at DLMB7, 0.020 m at DLMB2 and 0.003 m at DLMB6. This level of mounding (< 4 cm) will be indistinguishable from the natural seasonable variations at this site, and represents no measurable impact to the groundwater flow direction or velocity.

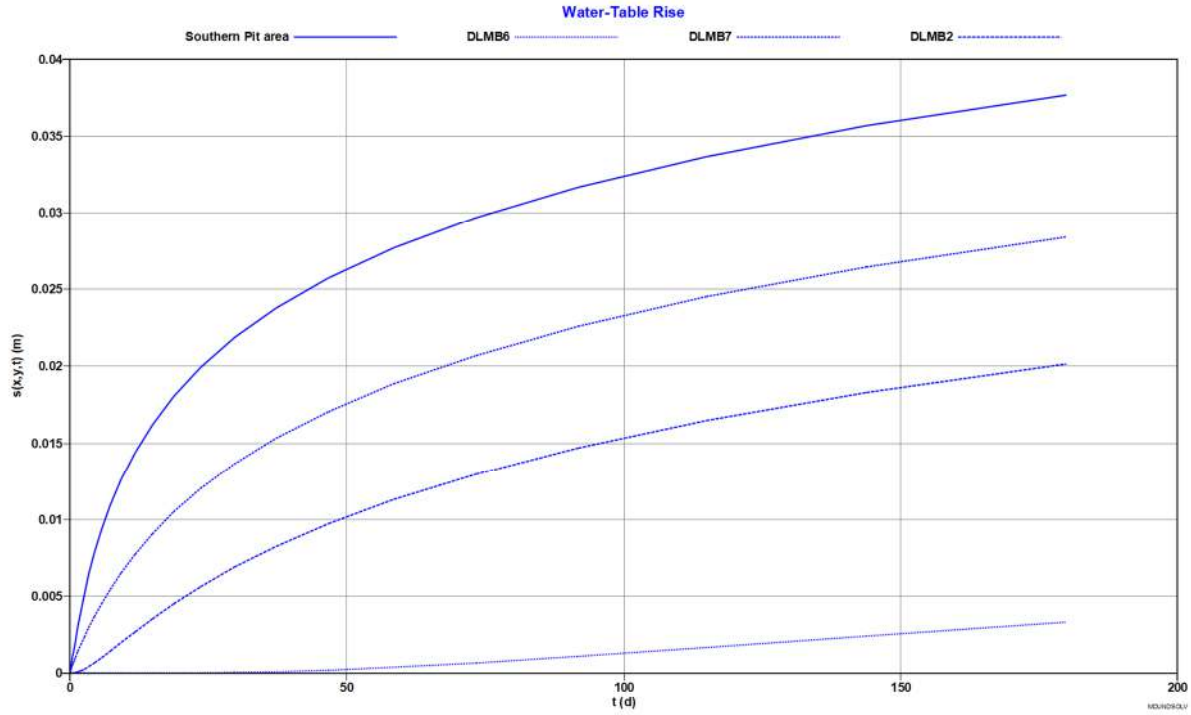
This modelling scenario can be considered to be worse case groundwater mounding, with additional rainfall recharge at the upper bound of potential recharge in the region (total 26% allowing for the assumed 13% natural recharge) and aquifer hydraulic conductivity at the lower bound of plausible values for the Tamala Limestone.



Appendix Figure 26: Groundwater level rise after 180 days with recharge of 45.76 m³/d (an additional 13% total rainfall over approximately half the proposed pit area) (lower bound K_h)



Appendix Figure 27: Cross section showing degree of groundwater mounding beneath the excavated pit after 180 days with recharge rate of 45.76 m³/d (lower bound K_h)



Appendix Figure 28: Groundwater level rise over 180 days with recharge rates of 45.76 m^3/d (lower bound K_h)

References

Estimating Groundwater Mounding in Sloping Aquifers for Managed Aquifer Recharge. **Zlotnik, V.A., Kacimov, A. and Al-Maktoumi, A. 2017.** 6, s.l. : Groundwater, National Groundwater Association, 2017, Vol. 55.

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Appendix F
Excavation and Rehabilitation Management Plan

Excavation and Rehabilitation Management Plan

Lot 1002
Preston Beach Road North
Preston Beach

DOYLES LIME SERVICE

May 2016

Excavation and Rehabilitation Management Plan, Doyles Lime Service, Proposed Preston Beach Pit

Quarry Manager
Doyles Lime Service
P 0 Box 133,
Capel WA 6271

Phone 042 708 4102

Landform Research
Land Systems - Quarries - Environment
ABN 29 841 445 694

Prepared by Landform Research

SUMMARY

Doyles Lime Service proposes to open a limestone quarry on 13 hectares of a limestone ridge on Lot 1002, Preston Beach North Road, Preston Beach.

The limestone on Lots 1001 and 1002 is highly suitable for lime for agriculture and neutralisation of acidity.

A proposal to extract limestone and sand from two small parts of Lot 1002 was prepared in May 2013 and submitted to the Shire of Waroona.

An application was made for a limestone resource on Lot 1001 but that was determined by the Minister for the Environment and then the Environmental Protection Authority to have some potential issues relating to groundwater and the proximity to Lake Pollard. Groundwater flow from that resource flowed towards Lake Pollard.

The proposed pit near lake Pollard has been removed and an amended limestone extraction area proposed.

The changes in the proposal are summarised below

1. A new limestone pit south west from Lake Pollard is now proposed with a disturbance footprint of 13.0 hectares in four stages.

2. The proposed pit lies 600 metres south west from Lake Pollard compared to 200 metres west.

3. Groundwater flow flows east to the south of Lake Pollard rather than directly to Lake Pollard.

4. Groundwater flows to a vegetated area to the south of Lake Pollard and between Lake Pollard and Martin's Tank Lake and not to a lake or open body of water. The groundwater flows more than 1 km before it intersects the areas between Lake Pollard and Martin's Tank Lake.

5. The limestone resource is lower in the landscape at a maximum of around 15 metres AHD compared to 30 metres AHD.

6. The limestone resource lies west of the main 30 metre limestone ridge that now separates the excavation from the Lake Pollard – Martin's Lake chain.

7. The vegetation on the new limestone excvavation area is regrowth vegetation with densely scattered *Xanthorrhoea preissii* or smaller scattered regrowth young Tuart trees.

8. The sand resource area is unchanged but enlarged slightly to 3.0 hectares.

9. The proposed extraction is now 600 from the Lake Pollard walk Trail and 500 metres from the lookout. (increased from 75 metres). The walk trail now lies on the other side of a large limestone ridge to 30 metres AHD.

10. The main limestone ridge will now remain intact and not be excavated.

A limestone and sand resource lie on part of Lot 1002, Preston Beach North Road, Preston Beach.

The resource has been identified by the Geological Survey of Western Australia as a Regionally Significant Basic Raw Material – Limestone.

The material is of high grade and is suitable for the supply of agricultural lime and road bases.

This proposal seeks Development Approval and an Extractive Industries Licence for the extraction of material from 13 hectares of Lot 1002, which represents a very small proportion of Lots 1001 and 1002.

The limestone will be used to prevent soil acidification, which is a well recognised major environmental issue, highlighted in the various State of Environment Reports on Western Australia, where it is estimated that 55% of the agricultural land in Western Australia is susceptible to the problem. Soil acidification also causes stock toxicity from some metals (eg aluminium) which move into solution in acidic or low pH conditions.

The only mechanism to counteract the increasing acidity is the application of calcium carbonate. The sources of calcium carbonate are limesand and Tamala Coastal Limestone.

The proposal seeks to provide a continued resource of strategically located limestone, suited to a variety of end products. The majority of the lime from this pit will be used in the agricultural industry with lime being transported as far as Hyden in the east through Brookton - Wagin and Collie in the south. The northern limit of the limestone supply is north of Perth where the northern supplies of limesand have a transport cost advantage.

A small sand resource is proposed to be excavated to provide fill sand for local projects such as Preston Beach.

The quarry is proposed to provide additional limestone materials for a stable long term supply of limestone products in the Mandurah - Bunbury and Peel Regions. It will help keep the prices of local limestone products at the lowest possible levels, by maintaining small transport distances and competition. This benefits the whole community. It will also comply with State Planning Policy No 2.5 which requires that basic raw materials should be taken prior to sterilisation of the area by development.

The resource has been identified by the Geological Survey of Western Australia as a Regionally Significant Basic Raw Material – Limestone. Figure 1.

The Western Australian Planning Commission in *WAPC 2012, Basic Raw Materials Demand and Supply Study for the Bunbury - Busselton Region*, determined that limestone is in short supply and that all the limestone available including that in the Lake Pollard area was just sufficient to satisfy the grow the demands of the region for the next 30 years. The demand for the next 30 years was listed in Table 7 of WAPC 2012 as requiring 30 359 000 m^3 of limestone within the next 30 years. Lime for agriculture was assessed as being 21 891 000 tonnes.

The Geological Survey estimated that the total limestone available, if all resources are taken is 35 460 000 m^3 (WAPC 2012).

The resource on lots 1001 and 1002 is included as the southern portion of Resource 61 in (WAPC 2012 Map 6). This resource is listed as having a total area of 126 hectares with a nominal thickness of 11 metres and a total nominal volume of 13 860 000 m^3, with a recovery factor of 5 540 000 m^3. That represents 15.6% of the total limestone resources available to the growth and agriculture in the south west of Western Australia.

The extraction of limestone from this location is therefore very important to the State. Of the total volume of limestone in Resource 61 the proposed excavation represents only around 800 000 m^3.

The *Environmental Protection Authority, 2015, Perth and Peel @3.5 million, Environmental Risks and remedies; - Interim strategic advice of the Environmental Pr4otection Authority to the Minister for Environment under section 16(e) of the Environmental Protection Act 1986* recognises that Basic Raw Materials are essential to the future of Perth – Peel. - under *Class of action: Basic raw material extraction.*

The use of the limestone for the correction of agricultural soil acidity and the continued cropping of legumes and the use of nitrogenous fertilisers is also essential and recognised by the EPA for example in the State of Environment Reports.

The proposed limestone extraction is proposed to be used for agricultural lime as it is of sufficiently high grade. This is particularly significant because the State has recently acquired all the limestone resource to the north as part of the conservation estate and thereby sterilising almost all the "Regionally Significant Limestone Resource" identified by the Geological Survey of Western Australia. Limestone in the Myalup pine plantations is small discontinuous and of generally low grade, making it unsuitable for use in agriculture.

See Appendix 7. Notice how the use of this resource on Lot 1002 is capable of reducing truck travel distances and greenhouse gas emissions. All other limestone south of Perth has been sterilised by Government Policy and Conservation.

The use of the resource can be completed with minimal and manageable impacts on the environmental values of the areas=.

Rehabilitation is planned to progressively follow excavation to minimise the amount of land open at any time.

Excavation will take place on the floor of the quarry and will lower the hill to form a gentle rise at an elevation of around 6.0 metres AHD

The planned end use of the site is to restore a natural soil and return the ridge to native vegetation along the buffer to the access road along the eastern boundary of Lot 1002, with pasture in the west, so there is no net loss of native vegetation and the buffer to Lake Pollard will be enhanced. Lake Pollard and the surrounding vegetation are included as part of the Yalgorup National Park. Setback to Lake Pollard edge is 600 metres.

50 000 tonnes of limestone could be extracted in one year, but when the number of contracts is less, smaller amounts of material can be expected to be taken. Actual quantities will depend on the type and size of contracts won, and it is possible that when supplying large contracts tonnages in excess of these figures will be removed from the site.

Perimeter fences and locked gates will be maintained by the landholder and quarry operator.

The quarry is not visible from any road and, with the landform and trees between the quarry and public areas, is not expected to be visible.

The excavation footprint has been determined from Landgate contour mapping and detailed aerial photography. Prior to excavation commencing the site will be ground surveyed, the excavation footprint marked out and a 1 mete contour plan developed.

Whilst there will be some clearing of vegetation, that vegetation is Degraded to Completely Degraded and this needs to be balanced against the community need for limestone.

Without this limestone deposit being developed, the State will not have sufficient limestone for its needs for the next 30 years which is a significant impediment to the State which has large limestone reserves sterilised by dwellings and Conservation.

A 20 year Planning Consent and Extractive Industries Licence is requested.

The Excavation and Rehabilitation Management Plan addresses;

- Groundwater quality and quantity protection;
- Land surface stabilisation and interim rehabilitation, including erosion mitigation and topsoil management
- Waste management
- Dust management
- Dieback management
- Contours and final ground surface levels;
- Fire management;
- Site security
- Provision of high grade agricultural lime and the protection of soil acidification.

Environmental issues including dust, noise and traffic can be managed in such a way to minimise or eliminate any significant impact both on site and offsite. Dust and noise can be contained by the methods of extraction to be used and the control measures which will be put into place. Measures to protect the site and minimise the influence of dieback are addressed under Environmental Management.

Overall the proposed pit is well isolated from any sensitive premises, with none within 1 km.

Project Summary

ASPECT	PROPOSAL CHARACTERISTIC
EXCAVATION	
Area of proposed new excavation	Proposed Pit – 13.0 hectares in four stages of around 3.0 hectares
Limestone extraction	50 000 tonnes per year
Sand Extraction	10 000 tonnes per year
Total estimated resource	Limestone - approximately 500 000 tonnes Sand 150 000 tonnes but with potential to expand
Life of project	20 years
Area cleared per year	Initially about 2 hectares and then 0.5 – 1.0 per year depending on the elevation of the ridge. Sand excavation can occur for the most part without the need to clear native vegetation.
Total area to be cleared	13 hectares in four stages.
Area mined per year	0.5 – 1.0 hectares total
Dewatering requirements	None
Maximum depth of excavations	16 metres
PROCESSING	
Limestone	50 000 tonnes per year
Water requirements	Only required for dust suppression on road transport.
Water supply source	Existing sump for which application will be made to use 5 000 kL per year for commercial purposes.
INFRASTRUCTURE	
Total area of plant and stock	Located within excavation footprint or on adjoining cleared land. 2.0 ha
Area of settling ponds	Not required
Fuel storage	Not required, mobile tankers will be used
TRANSPORT	
Truck movements	Variable but approximately 10 laden trucks per day maximum
Access	Existing limestone Preston Beach North Road from the sealed Preston Beach Road.
WORKFORCE	
Construction	2 –3
Operation	2 - 3
Hours of operation	Monday - Friday 6.30 am to 5.00 pm excluding public holidays.

An Environmental Risk Assessment has been completed and follows.

Environmental Factor	EPA Objective	Identified Issues and Commitments	Proposed Management	References	Residual Environmental Risk
LAND					
Flora and Vegetation	To maintain representation, diversity, viability and ecological function at the species, population and community level.	Vegetation communities and/or biodiversity may be significantly impacted by clearing, and degradation by weeds and dieback.	The area of the proposed limestone pit has been restricted to 13.0 hectares excavated in stages not exceeding 3.0 hectares. The proposed sand pit has a potential area of 3.0 hectares. These extraction areas have been selected as being the most disturbed land available on Lots 1002 away from Lake Pollard. Weston 2014 and the current assessment of flora found the vegetation units in the survey area to be too degraded, floristically, and too reduced in numbers of species to be confidently assigned by meaningful analysis to a floristic community type (SWAFCT).	Flora and Vegetation Report included in Appendix 1 attached. Management Plan Sections 2.5 Flora and 5.6.1 Vegetation and Flora. Figures 3, and 4.	Low
		Threatened Communities may be impacted by inadvertent impacts.	Weston 2014 did not find any Threatened Ecological Communities on either excavation area of Lot 1001 or Lot 1002. Weston 2014 found the vegetation too degraded to ascribe definitive SWAFCT community names.	Flora and Vegetation Report included in Appendix 1.	Very Low
		Priority species may be affected by clearing, disturbance, weeds	Weston 2014 did not find any Priority species on either excavation area of Lot 1001 or Lot 1002.	Flora and Vegetation Report included in Appendix 1.	Very Low
		Threatened Species may be impacted by inadvertent impacts.	No Threatened species were recorded by Weston 2014.	Appendix 1 of the Management Plan.	Very Low
		The developments may fragment communities, biodiversity and ecological linkages.	The extraction areas have been selected on the disturbed and previously cleared land.	Flora and Vegetation Report included in Appendix 1 attached. Management Plan Sections 2.5 Flora and 5.6.1 Vegetation and Flora. Figures 3, and 4.	Low

Environmental Factor	EPA Objective	Identified Issues and Commitments	Proposed Management	References	Residual Environmental Risk
Subterranean Fauna	To maintain representation, diversity, viability and ecological function at the species, population and assemblage level.	The development may have an impact on an isolated population of subterranean fauna.	The Lake Preston North area consists of belts of limestone running north south for approximately 6.5 km. The location of the proposed limestone quarry is not an isolated limestone remnant or feature and not part of the main ridge.	Figure 1 of the Management Plan Management Plan Section 2.6 Fauna.	Low
		The development may fragment subterranean communities.	The proposed limestone extraction is restricted to an area west of the main limestone ridge.	Figures 5, 8, 11A and 11B.	Low
		The diversity of subterranean fauna may be reduced at a population or assemblage level.	An assessment of the impacts on karst was conducted by Lindsay Stephens of Landform Research in May 2014 and 2016 and is attached as Appendix 3. The proposal will impact only a relatively small area of limestone as noted above. The limestone is geologically young and has low potential for the development of widespread karst features. The soils are sand based between limestone outcrops which infills any potential cavities at the surface reducing the potential habitats for karst dependent fauna. The groundwater flows and age of the limestone suggest that cave development is unlikely. The cave development in the area is very low as also identified by Lex Bastian for the Lake Clifton limestone pit in similar but slightly older limestone in the local area. The excavation will be limited in depth to an elevation 4 metres above the highest known groundwater which will eliminate the risk of impact on subterranean karst if any existed at the water table.	Appendix 3 of the Management Plan Figures 5, 8, 11A and 11B.	Low
		The final formed structures may not support continued subterranean fauna and their ecological functions.	The pit will bottom on limestone, which will be deep ripped and planted to a combination of pasture and local native vegetation. This will replicate the pre-excavation soils and landform and will provide similar near surface habitat to that currently existing.	Appendix 3 of the Management Plan of July 2014 and attached. Figure 11 attached	Low

Environmental Factor	EPA Objective	Identified Issues and Commitments	Proposed Management	References	Residual Environmental Risk
WATER					
Hydrological Processes	To maintain the hydrological regimes of groundwater and surface water so that existing and potential uses, including ecosystem maintenance, are protected.	Excavation and development may impact on surface water flow paths and streams.	There are no surface water flows or watercourses on site.	Water Management Plan in Appendix 6 attached. *Management Plan Sections 2.4 Hydrogeology and 5.5 Water Quality and Appendix 6.*	Low
		The ecological functions of watercourses are to be maintained.	Thee are no surface water flows or watercourses on site.	Figures 11 and 12 attached.	Low
		Groundwater may be impacted by changes to recharge, over-pumping, alterations to flow paths or lead to significant evaporation and water loss.	There will be no changes to recharge of site. The site has previously been cleared and will be returned to a mixture of pasture and local native vegetation.	Water Management Plan in Appendix 6 attached.	Low
		Wetlands may be altered by draining or flooding, potentially changing their ecological functions and biodiversity.	A significant amount of investigations were conducted for the Cape Bouvard Investments land adjoining to the north. A line of drill holes and bores were installed at the southern end of that property only 20 metres north of the proposed limestone quarry. This information has been combined with an assessment of the hydrogeology by Lindsay Stephens of Landform Research and attached as Appendix 6. Lake Clifton is some 2 km from the proposed excavation. Lot 1002 lies outside the Lake Clifton catchment*, (EPA Guidance No 28, Protection of the Lake Clifton Catchment 1998).* Groundwater flows are towards Lake Pollard, but the recharge and alteration to the land surface will not be significant nor lead to significant changes to the groundwater flows or	Section 5.6.4 Wetlands Water Management Plan in Appendix 6 attached. Page 53 shows the classification of the wetlands. Figures 1, 2, 7 and 8 and Page 53.	Low

			volumes. Lake Pollard is a Conservation Category Lake (UFI 3100) and is listed under the Environmental Protection (Swan Coastal Plain Lakes) Policy 1992 as an environmentally sensitive area under the Environment Projection (Clearing of Native Vegetation) Regulations 2004. The local lakes are shown on page 53 of the Management Plan. The RAMSAR boundary has been extended to cover all of the Yalgorup National Park but that does not change to buffers to the actual wetlands. There will be no significant changes to the water balance. Lake Pollard accepts fresh water inflows from the west, including from Lot 1001 predominantly with very minor to no inflows from Lot 1002 because Lot 1002 lies to the south of Lot 1001 and the eastwards flow of water predominantly flows to soils south of Lake Pollard. The amended limestone quarry is now 600 metres from Lake Pollard and Lake Pollard is not downstream of the quarry. The groundwater from the quarry travels to a vegetated area between Lake Pollard and Martin's Tank Lake and therefore will not influence the water in the lake. Limestone such as this is crushed to increase the surface area and potential for soil acids to dissolve the calcium carbonate slowly over a number of years. The crushing of the limestone floor may slightly increase the HCO_3^- content of water infiltrating under the floor of the pit, but like all limestone areas the water becomes saturated with respect		

			to HCO_3^- and no further dissolution is possible. The maximum dissolution will occur in winter as a result of the winter rainfall. It is noted that Lake Pollard is saturated in calcium carbonate which can lead to precipitation in summer as a result of water chemistry changes due to evaporation. If there is any change to the calcium carbonate content of the groundwater as a result of the pit the groundwater logically will reach saturation with respect to HCO_3^- closer to the pit and then travel as saturated carbonate water in the same manner as currently exists. Once saturated no further dissolution can occur. Therefore with the saturation of HCO_3^-, dilution factors, distance to the lakes and the water not directly entering the lakes from groundwater from under the pit there would not seem to be any significant mechanism for changes to the calcium carbonate content of the local groundwater and no impacts on the lake system Extractive Industries are well known for their minimal potential impact on groundwater with DOW policy requiring a vertical separation of only 2 – 3 metres to the highest known groundwater. The proposed limestone extraction has a 4 metre separation. *(WQPN Landuse Compatibility in Public Drinking Water Source Areas (2004)* *WQPN 15 Extractive Industries near sensitive water resources).*		

Environmental Factor	EPA Objective	Identified Issues and Commitments	Proposed Management	References	Residual Environmental Risk
Inland Waters Environmental Quality	To maintain the quality of groundwater and surface water, sediment and biota so that the environmental values, both ecological and social, are protected.	Hydrocarbons, fuels and other chemicals are stored in a manner that they pose no risk to the environment.	Extractive Industries are well known for their minimal potential impact on groundwater with DOW policy requiring a vertical separation of only 2 – 3 metres to the highest known groundwater. The proposed limestone extraction has a 10 metre separation. *(WQPN Landuse Compatibility in Public Drinking Water Source Areas (2004) WQPN 15 Extractive Industries near sensitive water resources).* Extensive water management protection procedures are proposed to manage fuels, lubricants and operations.	Water Management Plan in Appendix 6 attached. *Management Plan Sections 2.4 Hydrogeology and 5.5 Water Quality and Appendix 6.*	Low
		Runoff from operations is contained and all water is either retained or treated to removed sediment and any deleterious materials.	The pit will be internally draining. Being highly porous limestone there will be no runoff and all water will be retained where it will have to soak through 10 metres of limestone and sand to intersect the water table.	Water Management Plan in Appendix 6 attached. Figures 5 and 8.	Low
		Water quality during and after development and operations is not adversely affected or altered.	Extractive Industries are well known for their minimal potential impact on groundwater with DOW policy requiring a vertical separation of only 2 – 3 metres to the highest known groundwater. The proposed limestone extraction has a 10 metre separation. *(WQPN Landuse Compatibility in Public Drinking Water Source Areas (2004) WQPN 15 Extractive Industries near sensitive water resources).*	Water Management Plan in Appendix 6 attached.	Low

Environmental Factor	EPA Objective	Identified Issues and Commitments	Proposed Management	References	Residual Environmental Risk
INTEGRATING FACTORS					
Rehabilitation and Closure	To ensure that premises are closed, decommissioned and rehabilitated in an ecologically sustainable manner, consistent with agreed outcomes and land uses, and without unacceptable liability to the State	All infrastructure, roads, hardstand, non natural materials are to be removed from site progressively when not required and all removed at the end of the project.	An extensive closure and rehabilitation plan is proposed.	Management Plan Section 5.9 Figures 3, 4, 5, 9, 11A and 11B. *Management Plan Sections 5.6.5 Dieback Management Plan, 5.6.6 Weed Management Plan and 5.9 Rehabilitation.*	Low
		No materials are to be left on site that may cause long term detrimental outcomes in terms of impacts to soils, water, heritage, vegetation health or other factors.	Commitments are made to remove all foreign and deleterious materials from site. Doyles Limestone Service, which has operated at Myalup for many years, has demonstrated a willingness and ability to undertake rehabilitation.	Management Plan Section 5.9.	Low
		All contaminated materials are to be removed from site prior to closure.	This is committed to in the management Plan with additional information in the attached Water Management Plan in Appendix 6 of the Management Plan (attached).	Management Plan Section 5.9. and Water Management Plan attached as Appendix 6.	Low
		Landforms and other geomorphological features are to be compatible with the local area and end use and be sustainable in the long term.	The proposed pit has been designed to minimise landscape impact and will maintain a ridge along the western side of Lake Pollard.	Management Plan Section 5.9. Figures 3, 4, 5, 9, 11A and 11B.	Low
		Soils are reconstructed to be able to sustain an ecological sustainable vegetation or other cover consistent with the end use and long term proposal for the site.	This is committed to and explained in the Management Plan.	Management Plan Section 5.9. Figures 3, 4, 5, 9, 11A and 11B	Low
		Weed levels are not to cause significant impacts revegetation.	Weed and Dieback Management is proposed, as outlined in Sections 5.6.5 Dieback Management Plan and 5.6.6 Weed Management Plan. Both management plans are committed to.		

		Ongoing monitoring of the rehabilitation will be conducted to ensure that any areas not meeting completion criteria are added to or replaced as necessary to enable the relevant criteria to be met.	Monitoring of the rehabilitation is proposed and will be undertaken for a period of three years or until completion criteria of; • *Stable post-mining landscape, and the minimisation of wind erosion.* • *Provide for the protection of the local groundwater resource in terms of both quality and quantity.* • *Achieve weed species at levels not likely to threaten the vegetation.* • *Provide a self sustaining cover of local native plants at a minimum of 1200 native plant stems per hectare at 3 years for the eastern 20 metre strip of land close to Lake Pollard and on the steeper northern and southern slopes. (Figure 10).* • *Sustainable pasture for the remainder of the excavated area with a minimum of 200 trees in clumps. (Figure 10).*	Management Plan Section 5.9. Figures 3, 4, 5, 9, 11A and 11B	Low

CONTENTS

APPENDICIES

1.0 INTRODUCTION

1.1 Background and Proposal

Doyles Lime Service proposes to open a limestone quarry on 13 hectares of a limestone ridge on Lot 1002, Preston Beach North Road, Preston Beach.

The limestone on Lots 1001 and 1002 is highly suitable for lime for agriculture and neutralisation of acidity.

A proposal to extract limestone and sand from two small parts of Lot 1002 was prepared in May 2013 and submitted to the Shire of Waroona.

An application was made for a limestone resource on Lot 1001 but that was determined by the Minister for the Environment and then the Environmental Protection Authority to have some potential issues relating to groundwater and the proximity to Lake Pollard. Groundwater flow from that resource flowed towards Lake Pollard.

Doyles Lime Service previously operated in Myalup but wishes to expand to another operation closer to potential alternative markets.

The Shire of Waroona received advice from the Department of Parks and Wildlife by way of letter dated 4 September 2013. Issues were raised with respect to flora surveys, Lake Pollard, the potential impacts and the potential impacts on road users. Each of the items raised have been considered within the separate sections of this report. It is noted that DPaW recommended for refusal. However the limestone is of State Significance and required by the community. The proposal has been designed as a compromise to enable some limestone to be extracted, whilst providing protection in the short term of the values outlined by DPaW.

The following has been carried out.

- A Flora and Vegetation Study has been completed in Spring 2013 by Arthur Weston.
- A Traffic Study has been completed by Michael Keane of Greenfields Technical Services.
- Additional research has been conducted.
- The additional information required or highlighted by the authorities has been included in this updated management plan.
- The issues raised by the various authorities have been addressed in the updated management plan.
- Additional plans and sections have been included.
- The additional studies have been included as appendices.

As a result of the EPA determining that the original limestone proposal may not be acceptable or may require formal assessment under *Part 4 of the Environmental Protection Act 1986* the project has been changed as follows;

The proposed pit near lake Pollard has been removed.

The changes in the proposal are summarised below

11. A new limestone pit south west from Lake Pollard is now proposed with a disturbance footprint of 13.0 hectares in four stages.

12. The proposed pit lies 600 metres south west from Lake Pollard compared to 200 metres west.

13. Groundwater flow flows east to the south of Lake Pollard rather than directly to Lake Pollard.

14. Groundwater flows to a vegetated area to the south of Lake Pollard and between Lake Pollard and Martin's Tank Lake and not to a lake or open body of water. The groundwater flows more than 1 km before it intersects the areas between Lake Pollard and Martin's Tank Lake.

15. The limestone resource is lower in the landscape at a maximum of around 15 metres AHD compared to 30 metres AHD.

16. The limestone resource lies west of the main 30 metre limestone ridge that now separates the excavation from the Lake Pollard – Martin's Lake chain.

17. The vegetation on the new limestone excvavation area is regrowth vegetation with densely scattered *Xanthorrhoea preissii* or smaller scattered regrowth young Tuart trees.

18. The sand resource area is unchanged but enlarged slightly to 3.0 hectares.

19. The proposed extraction is now 600 from the Lake Pollard walk Trail and 500 metres from the lookout. (increased from 75 metres). The walk trail now lies on the other side of a large limestone ridge to 30 metres AHD.

20. The main limestone ridge will now remain intact and not be excavated.

Existing Approvals

There are no current approvals.

Proposal

This proposal seeks Development Approval and an Extractive Industries Licence for extraction of limestone from Lot 1002.

1.2 Importance and Rationale

Need for Lime for Mitigating Soil Acidity

Crushed limestone and limesand is an essential resource to the State, for correcting soil acidity caused during normal farming operations through the use of nitrogenous fertilizer and legume crops. The need for crushed limestone for use as agricultural lime is recognised by the *Department of Agriculture and Food (Bulletin 4784)*.

Acidification of soils is seen as one of the major impediments to continued viable farming in Western Australia. The *State Of the Environment Report Western Australia 2007* shows that about two thirds of the South West agricultural soils are at risk of acidification. When the acidity builds up essential nutrients become unavailable to plants, and the crops reduce in vigour and eventually fail. In addition some other elements such as aluminium become soluble and lead to toxicity in stock and plants.

The normal method of treatment of soil acidity is to add agricultural limesand and crushed limestone as explained in *Department of Agriculture and Food Bulletin 4784 Soil Acidity, A guide for WA farmers and consultants.*

Abeysinghe, P B, 1998, *Limestone and Limesand Resources of Western Australia, Geological Survey of Western Australia,* Mineral Resources Bulletin 18, also summarises the uses for limestone and lime and the deposits, but does not list the limestone in this locality. See Attachment 2 of the Mining Proposal.

The need to mitigate soil acidity is also reiterated by the EPA. Acidification of soils is cited by the Environmental Protection Authority (EPA) in Section 3.3 of its *State of the Environment Report* as a serious threat to the sustainability of WA soils and agriculture. The report calls for the increased use of lime sand to combat soil acidification and to arrest the menace of sub-soil acidification and its effects on crops, water quality and native vegetation (EPA 2007).

Lime is also required for the remediation of acid sulphate conditions which occur on the Swan Coastal and Vasse Plains when deep soils are disturbed by development. Lime is also require for some industrial processes.

The draft *State Lime Supply Strategy (2008)* advocates the use of known lime resources especially from those sites which have minimal impact on the conservation values of native vegetation and are well-positioned in terms of existing infrastructure to serve the farming and rural communities (DMP 2008).

Doyles Limes Service supplies lime sand to local farmers to combat soil acidification to local farmers, vineyards and other agricultural activities as well as a source of calcium carbonate for use in other situations such as potential acid sulfate mitigation.

The limestone is essential to the local agricultural industry, but is restricted in distribution and grade south of Perth and the South West. Whilst limestone is more common a significant part lies within the Conservation Estate. Much of the limestone and calcareous dunes are located within coastal Crown land and Reserves.

To be most effective limestone has to be of the highest grade and, whilst coastal calcareous dunes and limestone do contain calcium carbonate the grades are often too low for efficient and economic use. For example using limestone at half the calcium carbonate content will require double the amount to be excavated, leading to additional land clearing, excavation and transport for no greater gain.

Uses of Limestone for Construction

The resource has been identified by the Geological Survey of Western Australia as a Regionally Significant Basic Raw Material – Limestone. Figure 1.

The Western Australian Planning Commission in *WAPC 2012, Basic Raw Materials Demand and Supply Study for the Bunbury - Busselton Region*, determined that limestone is in short supply and that all the limestone available including that in the Lake Pollard area was just sufficient to satisfy the grow the demands of the region for the next 30 years. The demand for the next 30 years was listed in Table 7 of WAPC 2012 as requiring 30 359 000 m^3 of limestone within the next 30 years. Lime for agriculture was assessed as being 21 891 000 tonnes.

The Geological Survey estimated that the total limestone available, if all resources are taken is 35 460 000 m^3 (WAPC 2012).

The resource on Lot 1002 is included as the southern portion of Resource 61 in (WAPC 2012 Map 6). This resource is listed as having a total area of 126 hectares with a nominal thickness of 11 metres and a total nominal volume of 13 860 000 m^3, with a recovery factor of 5 540 000 m^3. That represents 15.6% of the total limestone resources available to the growth and agriculture in the south west of Western Australia. It is proposed to excavate 13 hectares from the total area of limestone.

The extraction of limestone from this location is therefore very important to the State. Of the total volume of limestone in Resource 61 the proposed excavation represents only around 800 000 m^3.

The general geology and deposits have been reviewed by the Western Australian Geological Survey and summarised in Abeysinghe 1998, pages 48 – 50.

The significance of this resource is that there are only scattered deposits between Mandurah and Bunbury of very limited area and volume.

To be most effective limestone has to be of the highest grade and, whilst coastal calcareous dunes and limestone do contain calcium carbonate, the grades are often too low for efficient and economic use. For example using limestone at half the calcium carbonate content will require double the amount to be excavated, leading to additional land clearing, excavation and transport for no greater gain.

The other local factor is that much of the limestone and calcareous dunes are located within coastal Crown land and Reserves.

The importance of the local lime is recognised in the *Department of Agriculture and Food Bulletin 4660, Survey of Western Australia agricultural lime sources* which listed the limestone from this pit on page 70.

Crushed limestone and limesand is an essential resource to the State, for correcting soil acidity caused during normal farming operations through the use of nitrogenous fertiliser and legume crops. The need for crushed limestone for use as agricultural lime is recognised by the *Department of Agriculture and Food (Bulletin 4784).*

Acidification of soils is seen as one of the major impediments to continued viable farming in Western Australia. The *State Of the Environment Report Western Australia 2007* shows that about two thirds of the South West agricultural soils are at risk of acidification. When the acidity builds up essential nutrients become unavailable to plants and the crops reduce in vigour and eventually fail. In addition some other elements such as aluminium become soluble and lead to toxicity in stock and plants.

Lime from limesand is also used for remediation of acid sulfate conditions and a source of $CaCO_3$ for some industrial processes.

Typically the limesand has a calcium carbonate content of over 70%.

Some consideration of the use of limestone for agricultural lime and other purposes is shown in the following documents.

See;

- Abeysinghe P B, 1998, *Limestone and Limesand Resources of Western Australia*, Geological Survey of Western Australia, Mineral Resources Bulletin 18.
- Geological Suvey of Western Australia, 2013, *Regionally Significant Basic Raw materials, _ Pinjarra Sheet.*
- Gozzard J R, 1987, *Limesand and Limestone Resources between Lancelin and Bunbury*, Geol Surv WA, Record 1987/5

- Western Australia, Western Australian Planning Commission*, State Planning Policy 2.4, Basic Raw Materials.*
- Chamber of Commerce and Industry, 1995 and 1996, *Managing the Basic Raw Materials of Perth and the Outer Metropolitan Region*, Parts 1 and 2.
- Chamber of Commerce and Industry, 2008, *Basic Raw Materials Access and Availability*.
- Fetherston J M, 2007, *Dimension Stone in Western Australia*, Volume 1, Department of Mines and Petroleum, Mineral Resources Bulletin 23.
- *WAPC 2012, Basic Raw Materials Demand and Supply Study for the Bunbury - Busselton Region*,

The reality is that the limestone is only extracted for the community benefit.

If there was no community demand for limestone as a building product and for agricultural use it would be unlikely that this natural resource would ever be utilised for any other purpose and would have no economic significance.

The resource is strategically located and has the potential to provide raw materials for 20 plus years.

The need for the resource is well known but is sometimes not given due weight in the assessment process.

Proposals such as this are often considered in isolation without reviewing the wider environmental impacts.

If the resource is not taken from this site it will have to be taken from another site where similar or more land clearing is required. The depth of sand on this site also minimises the area of farm land or vegetation that is likely to have to be cleared on an alternative site.

1.3 Proponent

The proponent is Moresreel Pty Ltd.

Contact can be made through the Manager

Mr Carlo Doyle
Doyles Lime Service
P 0 Box 133,
Capel WA 6271

1.4 Location and Ownership

E J Marchetti
PO Box 238
Waroona WA

Lots 1001 and 1002 lie on the western side of Lake Pollard and Martins Lake, Preston Beach, 6 km from Preston Beach townsite.

Lot	LOT 1001	LOT 1002
Volume	2515	2515
Folio	859	860
Plan	29652	29652
Area	56.811 plus 28.173	98.473 ha

1.5 Description of the Resource

The site covers part of a low limestone ridge with a peak along the west of around 15 plus metres AHD, way below the 30 plus metre high limestone ridges to the east.

The limestone ridge is the closest limestone to Mandurah, south of the Yalgorup National Park and therefore has regional value as a Basic Raw Material resource area. It is of such significance that it is identified by the Geological Survey of Western Australia as a Regionally Significant Basic Raw Material – Limestone. Figure 1 and Appendix 7.

The limestone ridges have harder, higher grade limestone near the surface, which is suitable for agricultural purposes, overlying softer limestone suitable for road making materials.

The limestone on site changes laterally and vertically through changes in the original dune morphology as does the degree of lithification (hardness). These changes determine the use to which each type of limestone can be put.

Although the resource extends to depth, extraction is likely to be limited to 5 metres AHD metres to provide an undulating and consistent final landform and to be consistent with the lower elevations available on site.

An estimated 20 plus years' limestone and sand resources are present, although this depends on the rate of community demand.

1.6 Aims of the Proposal

A major and increasing environmental issue within Western Australian agriculture is the gradual, widespread and increasing levels of acidic soils, created through the use of nitrogenous fertiliser and the growth of leguminous crops. The agricultural industry of Western Australia is one of the most important to our economy through direct value, value added and employment.

Soil Acidification is a well recognised major environmental issue and is highlighted in the various State of Environment Reports on Western Australia, where it is estimated that 55% of the agricultural land in Western Australia is susceptible to the problem. Soil acidification also causes stock toxicity from some metals (eg aluminium) which move into solution in acidic or low pH conditions.

The trend towards acidification of the soils is unavoidable, because legume rotations are best practise farming, and nitrogen is essential for crop growth.

The only mechanism to counteract the increasing acidity is the application of calcium carbonate. The sources of calcium carbonate are limesand, Tamala Coastal Limestone, or other imported limestones, that have to be treated, or dredged lime/shell sand. Most coastal areas of Tamala Limestone are covered by remnant vegetation or are in areas where they are sterilised by increasing numbers of residents such as the Mandurah area.

The aims of the proposal are to;

- Provide reserves of strategically located limestone, suited to a variety of end products.
- Supply lime to the agricultural industry.
- Provide additional limestone materials for a stable long term supply of limestone products in the Mandurah - Bunbury and Peel Regions.

- Comply with State Planning Policy No 2.5 which requires that basic raw materials should be taken prior to sterilisation of the area by development.

2.0 EXISTING ENVIRONMENT

2.1 Climate

The climate of the area is classified as Mediterranean with warm to hot summers and cool wet winters.

Temperatures are between those of Mandurah and Bunbury, where the maximum temperatures in the summer months are 27 to 30 degrees Celsius. In winter the maxima are near 18 degrees Celsius with the minima dropping to an average of 9.0 degrees C in July.

Rainfall for the area is approximately 900 mm with more than 90% of the rain falling during the winter months April to October inclusive. Evaporation exceeds rainfall in all but the wettest winter months.

The wind direction is predominantly from the east in the morning and from the southwest in the afternoon during the summer months. During the winter months the directions are more variable and lighter but with a predominance of east - northeast in the morning and south west in the afternoon due to the presence of winter lows.

2.2 Geology and Geomorphology

The site is a ridge of limestone rising to 15 metres AHD which is slightly above the surrounding plain. Figures 3, 4, 5 and 8.

The limestone of the low ridge was formed as limesand dunes behind beach deposits. The limestone is a calc-arenite made from beach sand containing predominantly shell fragments with minor and variable quartz. The limestone has been lithified and recrystallised on the ridge tops to lift the percentage of calcium carbonate to over 70%.

The geology is shown in;

- Geological Survey of Western Australia 1974, *Geological Map, Southern Part of the Perth Basin.* GSWA Bulletin 124.
- Geological Survey of Western Australia 1987, *Lake Clifton – Hamel 1 : 50 000 Environmental Geology Series.*

Within the local area, several lines of beach ridges formed along the coast, and when created slowed the groundwater flow to form a series of parallel lakes between the ridges. (Lake Clifton in the east, Martins Lake – Lake Pollard and Lake Preston in the west. See Figure 8.

The degree of lithification (hardness) changes over the property, and determines the use to which each type of limestone can be put.

The limestone is ascribed to the Tamala Limestone based on the type of limestone and the degree of litification, although it may well be a younger sequence than Tamala Limestone in some other locations. The degree of lithification can be due to the high calcium carbonate content and therefore the limestone may be part of the older Quindalup sequence which occurs as the coastal dunes to the west.

In other localities dates of between 25 000 and 100 000 years have been obtained for the Tamala Limestone.

The local Geology and geomorphology is expanded on in *Semeniuk V and C, 2009, Quaternary geology, landforms and wetlands between Dawesville and Binningup – Description, key features and geoheritage significance* prepared by the DER.

Borelogs from the Cape Bouvard Investments 2009 show that the site, including the northern boundary of Lot 1001, consists of limestone to depth with the limestone being intersected to depths of 18 – 25 metres and not bottomed. That would indicate some 4 metres at least of limestone beneath the site.

Bores drilled by the Geological Survey of Western Australia at the south eastern corner of Lot 1002 show limestone with 20 metres thickness.

2.3 Soils

Soils on the site consist predominantly of brown to yellow brown sands over limestone at depth. The soils are classified as Cottesloe soils.

The soils have been mapped at a broad scale by Department of Agriculture and Food, 1990, *Land Resources in the Southern Section of the Peel-Harvey Catchment, Swan Coastal Plain,* Western Australia with the site being classified as S2a and S2b soils

S2a *"moderately deep to deep yellow brown sands or pale sands with yellow brown subsoils and minor limestone outcrop".*

S2b *"shallow to moderately deep yellow brown sands and common limestone outcrop".*

The Tamala Limestone is covered by shallow, yellow brown, calcareous loamy sands that have originated as a result of weathering of the limestone on the central ridge. Deeper sand occurs in the swale in the west and to the east.

Approximately 0 - 100 mm of brown sandy soils of the Cottesloe type overly the limestone, although on the ridge top there is very little soil material. Figure 4.

A typical soil profile from the limestone ridge is:

Soil Horizon	Depth	Description
O-A	0 -10 mm	Weakly developed, leaf litter and decomposing organic matter
B	10 - 500 mm	Dark brown siliceous sandy soils that become lighter with depth. In some locations the soils can be 2 metres deep but in others only 100 mm.
C	> 500	Cream recrystallised limestone

2.4 Hydrogeology

See the attached Water Management Plan.

There is no surface drainage due to the porosity and permeability of the limestone, with precipitation draining to the water table. It has been estimated that perhaps <10 - 20 % of the rainfall will reach the water table. Figures 2, 3, 4 and 8.

The amended limestone quarry site lies 600 metres south west from Lake Pollard much greater than the previous 200 metre separation and does not lie up groundwater gradient from Lake Pollard.

As part of the studies for proposed developments, Cape Bouvard Investments (2009) completed extensive hydrogeological studies of the southern portion of their land which abuts Lot 1001 and of the local hydrogeology, including Lake Pollard.

The line of drill holes was placed along the southern boundary of Lot 1000, Cape Bouvard Investments land and is very relevant to the subject site because it lies adjacent to the northern boundary of Lot 1001 and provides a good cross section of the groundwater across Lot 1002 just 500 metre south of the borehole line, on the same geological and geomorphological features.

The groundwater flow is in line with normal hydrogeological principles for a unconfined aquifer that spreads from a central ridge. In such situations the flow paths east and west are similar distances which places the western edge 0f the proposed limestone pit near groundwater divide.

This hydrogeological pattern is shown by the line of borehole monitoring on the Cape Bouvard development (by (Cape Bouvard Investments 2009) and for example *Jackson, J M, 2007, Hydrogeology and Groundwater Flow Model Central Catchment of Bribie Island, South East Queensland MSc Thesis, School of Natural Resource Sciences Queensland University of Technology, Brisbane.* The same pattern is shown by Deeney (undated) attached in the Water Management Plan.

See Cape Bouvard Investments MWS1, MWS2, MWS3, MWS4, MWS 5 and MWS6 and Figure 8.

Groundwater flow can therefore be assumed to flow east from under the proposed limestone excavation.

However groundwater flow from the amended limestone pit now flows east to a south of Lake Pollard rather than directly to Lake Pollard.

From evidence of the soils, the sump and vegetation, the water table lies at about 1 metre AHD. See Figure 3 in Deeney (undated). Figures 7 and 8.

Groundwater flows to a vegetated area to the south of Lake Pollard and between Lake Pollard and Martin's Tank Lake and not to a lake or open body of water. The groundwater flows more than 1 km before it intersects the areas between Lake Pollard and Martin's Tank Lake.

The shallow groundwater on the site is fresh, sitting as a layer overlying the saline ground water. The groundwater is exposed in a sump in the south western corner of Lot 1002. Figures 3 and 8.

The site lies at the south from the Cape Bouvard Investments Land, which was once owned by the landholder of Lots 1001 and 1002.

Lake Pollard is brackish as confirmed by (Cape Bouvard Investments 2009. Figure 8.

A fresh water lens overlays the subject land with water flow both to the east to Lake Pollard and west towards the coast. There is also a suggestion that there could be a connection in water flow between Lake Pollard and Lake Clifton because of the large surface area of Lake Clifton causing a small draw from Lake Pollard.

Cape Bouvard Investments 2009 found that the water elevation in Lake Pollard ranged from -0.4 metres AHD in February 2008 to +0.5 m AHD in July – September 2008 (Cape Bouvard Investments 2009 Figure 9) and Figure 8.

They also found that the ground water along the northern boundary of Lot 1001 was slightly elevated at between 0.2 – 0.3 m AHD with a groundwater divide near the western boundary of Lot 1001. The divide was around 100 metres west of the boundary in February 2008 and around 200 metres east of the western boundary in September 2008, that is well to the west of the proposed excavation. The variation being due to seasonal factors, most likely winter precipitation, evapotranspiration from vegetation and evaporation from Lake Pollard/Lake Clifton (Cape Bouvard Investments 2009 Figure 10).

The groundwater salinity was found by Cape Bouvard Investments, on Monitoring Bores MWS5 and MWS6 located near the western edge of the northern boundary of Lot 1001, to be fresh down to – 7.0 metres AHD where the interface of the saline groundwater occurred, with some reductions in salinity due to mixing from winter precipitation. At MWS1, located east of the eastern end of the northern boundary of Lot 1001, the salt water interface varied from -7.0 - -8.0 mAHD (Cape Bouvard Investments 2009 Figures 14 and 15). This indicates fresh water flows to Lake Pollard.

The same parameters are mapped and interpreted for the amended limestone excavation being in the same geological and geomorphological conditions 500 metres south.

Limestone excavation does not affect the quality of water in the shallow ground water system because the only chemicals used are normal fuels and lubricants; a fact that is recognised by the Department of Environment Regulation who permit extractive industries in Priority Groundwater areas such as Lake Gnangara where sand excavation occurs within 3 metres of the water table.

2.5 Flora

Regional vegetation and flora assessments were made by Freeman, K, B Keighery, G Keighery, V Longman, A Black and S Molloy, 2009, *Flora and Vegetation of the Dawesville to Binningup Region (Swan Coastal Plain)*, prepared for the DPAW.

The local vegetation is originally Cottesloe Complex, Central and South, as identified by Heddle et al, 1980, *Vegetation Complexes of the Darling System, Western Australia in Atlas of Natural Resources, Darling System, Western Australia,* Department of Conservation and Environment (DPaW).

Extensive flora and vegetation studies were conducted for the land to the north and touching the northern boundary of Lot 1001 by Cape Bouvard Investments 2009 in support of proposed developments. Appendix 1.

All these studies provide background to the vegetation on site.

In order to provide additional information, a separate flora and vegetation study was completed by Arthur Weston on 1 November and 3 December 2013. The studies cover both the limestone ridge and the sand resource as separate studies and reports. Both reports are attached as Appendix 1 (Weston 2014).

The vegetation study of the limestone ridge assessed by Weston does not relate to the amended area of native vegetation, which is much reduced in area and quality.

There are only 11 species occurring on the amended limestone extraction area;

Acacia rostellifera
Agonis flexuosa
Banksia (Dryandra) sessilis
Dianella divaricata
Eucalyptus gomphocephala
Hakea prostrata

Hibbertia subvaginata
Melaleuca huegelii (about 20 scattered plants)
Melaleuca systena
Spyridium globulosum
Templetonia retusa

Limestone Ridge Vegetation

The excavation area has been strip cleared and then fully cleared in the past, intensively grazed and in part seeded with pasture species. The provisions of the Clearing regulations provide that land cleared for agricultural purposes from 1994 (20 years previously) can be recleared for agricultural purposes. This does not include for excavation purposes. See Figures 3 and 4 and below.

- ***Species***

On the limestone ridge, despite extensive searches, only 21 native species were found, and 17 exotic species. Weston 2014 noted that this is likely to include 60% of the taxa present. As such the reduced number of species indicates the current level of disturbance. The ground cover is dominated by *Trachyandra divaricata** an exotic species.

- ***Vegetation Communities***

The vegetation communities on Lots 1001 and 1002 were identifed by Weston 2014. The communities are listed below from that report.

Tuart Woodland, Peppermint Low Woodland & Balga Shrubland	**TXp**	CD(-D)	Title Page, Plate 1A
Chenille Honeymyrtle – Mixed Closed Heath *Melaleuca huegelii* – Mixed species Closed Heath	**Mhs**	D-(CD)	Title Page, Plates 1A, 2A, 2B,
***Melaleuca systena* Open to Closed Heath** *Melaleuca systena* Open to Closed Heath	**Ms**	D-CD	Plates 1A, 1B, 2A
Summer-scented Wattle Heath to Closed Tall Scrub *Acacia rostellifera* Closed to Open Heath	**Ar**	CD-D	Plate 2B
Balga Shrubland *Xanthorrhoea preissii* Shrubland	**Xp**	CD	Plates 1A, 1B, 2A

The low lying eastern area is likely to be Balga Shrubland.

The western ridge probably does not fit with any defined communities identified by Weston.

Weston 2014 also speculated what the original vegetation on site would have been and concluded that none should be listed as SWAFCT26a.

Weston could not assign any existing vegetation on site now to any SWAFCT community type and the description of the vegetation is as described by Weston 2014.

Lower elevation limestone with Balga regrowth on pasture

Lower elevation limestone with Balga regrowth on pasture

Limestone ridge vegetation with scattered regrowth on previously cleared and seeded limestone ridge

Limestone ridge vegetation with scattered regrowth on previously cleared and seeded limestone ridge

- ***Vegetation Condition***

Weston 2014 listed the vegetation condition of the site for each community in Section 5.1 of his report as the letter code CD (Completely Degraded) or D (Degraded) using Bush Forever 2000 descriptors. The Condition Codes are listed above under vegetation communities.

The vegetation was strip cleared and heavily grazed in the past. With the Prescribed Clearing Exemptions under the *Environmental Protection Act 1986 Section 51C* and the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004 Section 5* it is possible for the landholder to return the vegetation for agricultural purposes to its 1994 condition under Prescribed Clearing in the Regulations, Section 5 .14.

That Prescribed Clearing does not include clearing for extraction of limestone but if the limestone ridge was returned to its 1994 condition, the vegetation will be significantly more degraded than it currently is. See Figure 3.

- ***Rare and Priority Species***

No Declared Rare or Priority species were recorded. No Threatened Ecological Community was noted.

Weston 2014 did note that most of the 23 locally recorded Threatened and Priority taxa from the datbases were recorded in the Yalgorup National Park, six taxa may have been recorded within 5 km of the site and 4 occur ”nowhere near Yalgorup”.

Sand Resource

On the sand resource only 2 native species were recorded by Weston 2014.

Weston made some comments on what the vegetation may have originally been, but these are not relevant as the sand resource is now pasture.

Weston summarised the vegetation as below in addition to speculating what the original vegetation may have been.

> The only vegetation unit in the survey area is Completely Degraded Dune Onion Weed (**Trachyandra divaricata*) Herbland to Closed Herbland, with a species of Pygmyweed (**Crassula glomerata*) and an unidentified moss in some of the relatively small open areas.
>
> No rare flora plants were found. The only native species found in the survey area are *Xanthorrhoea preissii* and *Hibbertia cuneiformis.* Only a few plants of the former and one of the latter were found. Neither species is rare or uncommon.

The sand resource area has a vegetation condition of Completely Degraded.

Vegetation Representation

EPA Position Statement No 2, December 2000, *Environmental Protection of Native Vegetation in Western Australia*, specifically targets the retention of native vegetation in the Agricultural Areas in 4.1, Clearing in the agricultural areas for agricultural purposes. In 4.3, Clearing in other areas of Western Australia, it is unclear what "other areas" refers to, but may refer to retention of a 30% threshold in non agricultural areas.

Section 4.3 Clearing in other areas of Western Australia, (*EPA Position Statement No 2*, December 2000) expects that clearing will not take vegetation types below the 30% of the pre-clearing vegetation as recommended by ANZECC, 1999, *National Framework for the Management and Monitoring of Australia's Native Vegetation*. The National Objectives and Targets for Biodiversity Conservation 2001 - 2005 (Commonwealth of Australia 2001) also recognise 30% as the trigger value.

EPA Guidance *10 Level of assessment for proposals affecting natural areas within the System 6 region and Swan Coastal Plain portion of the System 1 Region* lists Cottesloe Complex - Central and South as having 41.1% of the pre-European area still occurring and 8.8% in secure tenure. The Quindalup System is listed as having 47% of the pre-European area still occurring and 5% in secure tenure.

Whilst there exists greater then 30% of this Complex it is not well reserved. The Clearing Regulations provide a higher level of protection than was previously available, and the same vegetation complex is included in the Yalgorup National Park.

NRM mapping shows the site as a number of potential vegetation types and Associations that do not quite match the actual vegetation on site but are similar.

The current method of assessing the status of the vegetation is to use Shepherd et al 2002, *Native Vegetation in Western Australia Extent, Type and Status*, Department of Agriculture and Food Resource Management Technical Report 249 which provides a measure of the current status of the Vegetation Associations.

The vegetation on the dune is listed as the following, which distorts the actual vegetation on the ridge because the classifications are so broad scale.

Shepherd et al 2002 lists the Vegetation Associations as having the following for Vegetation Association 998. The data does not list Association 998.1 separately.

	Pre European Extent hectares	Current vegetation remaining hectares	% remaining	% located in IUCN Class I-IV Reserves	% remaining in other Reserves	%i n pastoral leases managed by DEC
998 Medium Woodland Tuart	51,094	18,320	35.9%	32.9%	3.0%	0.0%

The vegetation associations are well represented and are above the 30% retention criteria.

On the other hand the data for the Cottesloe Complex Central South and Quindalup has above the 30% recommendation remaining but less than the 30% in secure tenure.

Considering all the potential impacts, level of degradation and with effective management of weeds and other potential issues, there will be no significant impact on vegetation and at the end of the exercise there will be a net increase in vegetation.

2.6 Fauna

A fauna study was not conducted because the resource area is quite degraded and will be returned to a combination of native vegetation and pasture in a ratio similar to the current vegetation.

Also the fauna has been studied in the assessments for the Dawesville - Binningup region on behalf of the DPaW, and extensively in support of the Cape Bouvard Investments proposal for the development of the land immediately to the north of Lot 1001 only 20 metres from the limestone resource, the limited size of the extraction areas, and the degraded nature of the vegetation.

The studies are

Dell and Hyder 2009, An Assessment of the Avifauna of the area between Dawesville and Binningup, Southern Swan Coastal Plain prepared for the DEC.

Dell and Hyder 2009, Summary of the Vertebrate Values of the area between Dawesville and Binningup, Southern Swan Coastal Plain prepared for the DEC (DPaW).

Dell and Hyder (1) 2009, An Assessment of the Non-Volant mammal Fauna of the area between Dawesville and Binningup, Southern Swan Coastal Plain prepared for the DEC (DPaW).

Bat Call 2009, *Echolochation Survey of Bat Activity in the Lake Clifton and Lake Preston Localities on the Swan Coastal Plain*.

Cape Bouvard Investments 2009, *Rural Subdivision, Lots 1000, 2240, 2275, 2675, and 3045 Preston Beach Road, Lake Clifton*, in support of EPA Assessment 1440, Unpublished Report.

The studies recorded 22 species of animals (not including bats) occurring in the Dawesville – Biningup area of which 6 species were exotic. There are many species of bird which range across the Dawesville Binningup area with 174 species listed by Dell and Hyder.

With the degraded nature of the vegetation and the species present it is unlikely that *Calyptorhynchus latirostris* and *Calyptorhynchus baudinii,* which are listed on State and EPBC conservation databases, would nest or use the site for feeding. The flora species are not regarded as significant habitat species. They are not used for roosting or nesting.

The few *Hakea* and *Dryandra* plants do provide some limited food supply but are not classified as a significant impact on the habitat of the Black Cockatoos or one that would trigger referral under the *EPBC Act 1999*.

The Graceful Sunmoth will not occur because of the lack of habitat, with no *Lomandra* spp being recorded.

Western Australian Museum (undated) lists *Calyptorhynchus latirostris* as visiting pine plantations, parks and gardens and Proteaceae shrubs, *especially Dryandra (Banksia) sessilis, Banksia menziesii, B. attenuata and B. grandis* in the area from March to September. These species are not present on site.

It may be possible for possums and even the Western Ringtail Possum *Pseudocheirus occidenalis* to occur in areas such as this. They are more likely to live in the peppermint trees on the eastern edge of the excavation. These will not generally be impacted on. Peppermint trees *Agonis flexuosa* will be included in the rehabilitation. Preston Beach was a release site for this species. Dell and Hyder (1) 2009. The Western Brushtail Possum is common.

Some other species of Conservation Sigificance have been recorded on some databases such as Chuditch which according to Dell and Hyder (1) 2009 has been recorded from north east of Lake Clifton and may occur locally. This is a mobile species that is unlikly to be impacted by a small limestone quarry.

The Short beaked Echidna has been recorded at Martins Tank and may occur. It is also unlikely to be impacted by a pit that is small in relation to the amount of habitat available.

The Brush Tailed Phascogale has been recorded at Lake Clifton in 1991. Its status is not currently known.

Dell and Hyder (1) 2009 list the Quokka as still possibly occurring associated with thickets around Lake Clifton. No low elevation thickets are to be impacted.

The Western Grey Kangaroo is common and is advantaged by pasture and additional water supply of pasture land.

Other species of conservation significance (Dell and Hyder (1) 2009) are the Quenda and Western Brush Wallaby.

The Quenda is likely to be present and is known to be thriving near human habitation which increases food and water supply. The Western Brush Wallaby may be present but is a relatively large and mobile animal that is unlikely to be affected by excavation.

Other fauna are related to the preservation of habitat. Returning the excavated surface to native vegetation will assist in providing long term habitat for fauna. Considering the relatively small size of the limestone pit in relation to the area of remant vegetation, the disturbed nature of the vegetation on site and the high quality habitat associated with the lake system it is unlikely that fauna species will be significantly impacted.

See Wetlands below for consideration of species associated with the lake systems.

Stygofauna and Troglofauna

The potential presence of cavities within the limestone has been considered by Lindsay Stephens of Landform Research in a summary attached as Appendix 3. Summary from the appendix is provided here.

EPA Guidance 54, concentrates on Stygofauna, which occur in caves and "are aquatic subterranean animals, found in a variety of groundwater systems". Environmental Protection Authority, 2013, *Consideration of subterranean fauna in environmental impact assessment in Western Australia* relates to the level of survey. On the limestone ridge a reconnaissance survey was completed by Lindsay Stephens of Landform Research during the site inspection.

The limestone ridge is not an isolated habitat, but joins similar limestone regolith north and south. The main change will be modification of the two ends of the ridge at an existing swale. Limestone will remain to depth at the end of excavation. The large ridge to 30 metres in elevation lies to the east of Lot 1002 and will be retained.

"Troglofauna occur in air chambers in underground caves or smaller voids".

The issues of these organisms is best addressed on a risks basis, because the water table is not proposed to be impacted on.

Stygofauna relate particularly to Root Mat Communities, which are listed as Endangered Communities. Root mat communities occur in locations where groundwater flows quickly and where Tuart Trees are present because their roots can access the water table. No Tuarts occur on the resource area of Lot 1001. The base of the excavation at 1 to 14 metres AHD is over 4 metres above the highest known water table. The low lying swales between the ridges on Lot 1001 and 1002 drop down to 3 – 4 metres AHD well below the proposed floor of the pit.

Root Mat Communities are briefly considered in Appendix 3 where the risk of caves and karst is discussed.

For Troglofauna, which may occur in air chambers in underground caves or smaller voids, it will be difficult to undertake any meaningful sampling of these. Any crevices or fissures in the adjoining quarries will probably have been contaminated by surface or near surface invertebrate fauna. The existing soils are sands with occasional limestone pinnacles and not rocky outcrops.

The limestone ridge is joined to the north and south of Lot 1001 and is therefore not an isolated feature. Any troglofauna are therfore likely to inhabit the whole ridge and are unlikely to be locally rare. South of Lot 1001, and west and east of the ridge extension to the north, the limestone ridge lies within the Yalgorup National park and is therefore afforded protection.

Groundwater moves from west to east to Lake Pollard which is alkaline. As discussed in Appendix 3 there is little risk of karst or cavities occuring that will be impacted by excavation, and at the end of operations significant limestone vertical buffers of 4 metres to the water table will remain. See Figure 8.

2.7 Wetlands

Lake Pollard lies 600 metres in a north easterly direction from the proposed extraction area.

Lake Pollard, is a recognised EPP wetland with a simialr status to Lake Clifton to the east. It forms part of the Ramsar listed wetlands that have been classified as the boundary of the Yalgorup National Park.

The Ramsar wetlands including Lake Pollard are listed on the Commonwealth EPBC database.

The dune systems within Yalgorup National Park that adjoins Lots 1001 and 1002 are the result of coastal deposition at a time of sea level changes. The limestone rocks and soils that can be seen at the surface inland from the coast are derived from the older Spearwood system, superimposed over the Spearwood system, for up to two kilometres from the beach. These are the sand dunes of the Quindalup Dune System, which have been blown in from the sea or washed ashore over the last 10,000 years.

The lakes that characterise the area lie in the depressions between a series of coastal dunes within the Spearwood system. The lakes form three distinctive lines parallel to the coast. Lake Preston is extremely elongated and lies closest to the coast. The lakes behind the next ridge are far more broken, comprising (from north to south): Swan Pond, Duck Pond, Boundary Lake, Lake Pollard, Martins Tank Lake, Lake Yalgorup, Lake Hayward and Newnham Lake. Lake Clifton is the furthest from the coast and the nearest to the Old Coast Road. It too is extremely elongated. (Modified from DPaW website).

Lake Clifton is some 2 km up groundwater gradient from the proposed excavation. Lot 1001 lies outside the Lake Clifton catchment*, (EPA Guidance No 28, Protection of the Lake Clifton Catchment 1998).*

Rock-like structures known as thrombolites can be seen on the edge of Lake Clifton. The thrombolite-building micro-organisms of Lake Clifton appear to be associated with upwellings of fresh groundwater that are high in calcium carbonate entering from the east and therefore not related to, and environmentally/hydrogeologically isolated from, the proposed limestone pit because the groundwater flows to a vegetated area between Lake Pollard and Martin's Tank Lake, around 1 kilometre from the edge of the limestone pit.

The micro-organisms living in the shallow lake environment are able to precipitate calcium carbonate from the waters as they photosynthesise, forming the mineralised structure that is the thrombolite. (Modified from DPAW website). There do not appear to be any Thrombolites in Lake Pollard although DPaW notes that the lake contains relic microbialite structures.

The Yalgorup lake system is significant for waterbirds and is recognised under the international Ramsar Convention.

The lakes provide important habitat for the international transequatorial waders that migrate from the northern hemisphere. These waders include the bar-tailed godwit, red-necked stint, greenshank, red knot, whimbrel and three species of sandpiper. Other waterbirds that use the lakes include the banded and black-winged stilts, red-necked avocet, hooded and red-capped plovers, Australian pelican and coot.

The quacking frog, turtle frog and slender tree frog are among the eight frog species that inhabit the park and the long-necked oblong tortoise is present in Lake Clifton.

Surveys carried out in south-western Australia between 1988 and 1992, showed that the Yalgorup lakes consistently supported the high numbers of musk ducks, Pacific black ducks, black swans and shelduck.

Black swans also live in high numbers at Lake Pollard, where they graze on extensive growths of stoneworts (musk grasses). The Shire of Waroona has in place a walking trail that runs from well to the south at Martin's Tank to Lake Pollard where a bird hide is located.

Lake Pollard

Lake Pollard is a Conservation Category Lake (UFI 3100) and is listed under the Environmental Protection (Swan Coastal Plain Lakes) Policy 1992 as an environmentally sensitive area under the Environment Projection (Clearing of Native Vegetation) Regulations 2004.

DPaW notes the vegetation surrounding Lake Pollard as Regionally Significant and a regionally ecological linkage is located immediately east of Lake Pollard. (DPaW Appendix 4).

The salinity of Lake Pollard, and Lake Clifton are similar and stratification does not generally occur.

DPaW notes that Lake Pollard is the only lake to support extensive areas of the aquatic plant *Lamprothamnium papulosum* which provides a valuable food source and supports large numbers of grazing water birds, up to 5 000 Australian Shellduck (*Tadoma tadornoides*) and 3000 Black Swan (*Cygnus atratus*). The lake also supports nesting habitat for Black Swans between October to March.

DPAW also notes that the lake contains relic microbialite structures.

As noted under 2.4 Hydrogeology above Lake Pollard accepts fresh water inflows from the west, including from Lot 1001.

Monitoring work performed by Cape Bouvard Investments found that the salinity in Lake Pollard varied from approximately 25,700 to 72,300 mg/L with salinities highest in the summer/autumn period.

The water levels and quality were assessed by Cape Bouvard Investments during the studies. They found that the lowest water level was recorded in March 2008 when the lake was slightly below mean sea level.

Cape Bouvard Investments 2009 found that the water elevation in Lake Pollard ranged from -0.4 metres AHD in February 2008 to +0.5 m AHD in July – September 2008 (Cape Bouvard Investments 2009 Figure 9). The lake was alkaline at pH 8 to 10 and in summer the high pH leads to precipitation of calcium carbonate making the water more turbid.

There have been some questions raised with respect to the carbonate concentrations in Lake Pollard and whether that will change as a result of limestone excavation.

The amended limestone quarry is now 600 metres from Lake Pollard, and Lake Pollard is not downstream of the quarry. The groundwater from the quarry travels to a vegetated area between Lake Pollard and Martin's Tank Lake and therefore will not influence the water in the lake.

Limestone such as this is crushed to increase the surface area and potential for soil acids to dissolve the calcium carbonate slowly over a number of years.

The crushing of the limestone floor may slightly increase the HCO_3^- content of water infiltrating under the floor of the pit, but like all limestone areas the water becomes saturated with respect to HCO_3^- and no further dissolution is possible.

The maximum dissolution will occur in winter as a result of the winter rainfall. It is noted that Lake Pollard is saturated in calcium carbonate which can lead to precipitation in summer as a result of water chemistry changes due to evaporation.

If there is any change to the calcium carbonate content of the groundwater as a result of the pit the groundwater logically will reach saturation with respect to HCO_3^- closer to the pit and then travel as saturated carbonate water in the same manner as currently exists. Once saturated no further dissolution can occur.

Therefore with the saturation of HCO_3^-, dilution factors, distance to the lakes and the groundwater water not flowing directly to the lakes, groundwater, there would not seem to be any significant mechanism for changes to the calcium carbonate content of the local groundwater and no impacts on the lake system

Recharge is not anticipated to change significantly and it if does there will be a slight increase as ground is opened and this will reduce as ground is closed.

See the attached Water Management Plan.

2.8 Yalgorup National Park

The Yalgorup National Park is situated between the Old Coast Road and the ocean. Figures 2 and 8.

The Park contains ten lakes and patches of small Tuart forests and woodlands.

The area was established as a National Park in the 1970's. The Aboriginal name chosen for the park is derived from two Nyoongar Aboriginal words; yalgor meaning 'lake or swamp' and up meaning 'place'.

The Yalgorup National Park is a discontinuous vegetated area extending along the western edge of Lake Clifton, adjoining the eastern boundary of Lots 1001 and 1002 and includes Lake Pollard. It also occurs along the western edge of Lots 1001 and 1002.

Yalgorup National Park has defined walkways within the vegetation that run from Martin's Tank Campground in the south to Lake Pollard where there is an established bird hide on the eastern side of the lake. The bird hide is over a kilometre from proposed excavations.

A walking track then runs around the perimeter of Lake Pollard but there is no connecting link across Lot 1001 which is private land. The walk track is well east from Lot 1002 and located behind a significant limestone ridge. Figure 2 and 11A.

The Park is used at all times of the year but more commonly in spring and autumn and Summer holidays. A camp ground exists at Martin's Tank where camping bays barbecue and picnic facilities are present.

There is an informal lookout at the southern edge of the limestone resource on the firebreak separating the Yalgorup National Park and Lot 1001.

3.0 PLANNING ISSUES

3.1 Current Land use

Most of Lots 1001 and 1002 have been parkland cleared and grazed for many years. The site was used for intense winter grazing by cattle.

A road reserve runs along the eastern boundary of Lot 1002 and cuts Lot 1001.

Lot 1002 was used as an airstrip for the aerial spreading of fertiliser and seed on local farming properties.

The remaining remnant vegetation has previously been strip cleared and intensively grazed to increase the returns from grazing.

The Yalgorup National Park surrounds the land. The Yalgorup National Park in this location is used for conservation and there is effectively no public access and no roads, parking or facilities.

3.2 Land Zonings and Policies

State Planning Policies

The State Planning Policy Framework provides for the implementation of a planning framework through the recognition and implementation of Regional Planning Policies above Local Planning Schemes and Policies.

Within each layer of planning, there are a number of key policies and strategies to provide guidance to planning and development to enable sustainable communities to develop, expand and prosper without compromising the environment and future generations.

Planning is governed under the *Planning and Development Act 2005.* This Act enables Government to introduce State and Regional Planning Schemes, Policies and Strategies to provide direction for future planning. The State and Regional Schemes sit above Town Planning Schemes and Strategies introduced by Local Government.

Strategies and Policies provide guidance on how planning is to be undertaken and how proposed developments are to be considered. These Strategies and Policies are at the State, Regional and Local levels.

Schemes are gazetted documents that provide for consideration and approval of proposed developments. These are normally at the Regional and Local Level.

In addition to the documents produced under the *Planning and Development Act 2005,* the *Local Government Act 1995* provides Local Governments with a mechanism to prepare Local Laws to manage issues of local significance.

As noted above the policies have little relevance over mining tenements on Crown Land in State Forest, but they do have relevance to the local roads, and the recognition of the need for limestone for dwellings, roads and construction.

Even though they are implemented under the *Planning and Development Act 2005,* over which the *Mining Act 1978* prevails, the policies have some relevance in providing guidance on the provision of basic raw materials for the community. They also have relevance in that the Department of Mines and Petroleum seeks advice from the Local Authority when assessing mining proposals.

Some policies do have relevance such as the State Industrial Buffer Policy and Basic Raw Materials Policy.

With respect to the supply of sand and limestone, the overarching document is the;

- State Planning Policy 1.0 State Planning Framework.

Complementing this are a number of Relevant State Policies;

- State Planning Policy 2.0, Environment and Natural Resources Policy
- State Planning Policy 2.4, Basic Raw Materials
- State Planning Policy 4.1, State Industrial Buffer Policy
- State Planning Policy 2.8, Bushland Policy for the Perth Metropolitan Region.

- ***State Planning Policy 2.0, Environment and Natural Resources Policy***

This policy provides for the protection of all natural resources under a number of sections;

5.1 General Measures
5.2 Water Quality including stormwater and wetlands
5.3 Air Quality
5.4 Soil and Land Quality
5.5 Biodiversity
5.6 Agricultural Land and Rangelands
5.7 Minerals Petroleum and Basic Raw Materials
5.8 Marine Resources and Aquaculture
5.9 Landscape
5.10 Greenhouse Gas Emissions and Energy Efficiency.

In addition to recognising the importance of protecting air quality, soil and land quality, water and wetlands and landscapes, the importance of Basic Raw Materials to the community is identified with reference to *SPP 2.4 Basic Raw Materials*, *State Gravel Strategy 1998* and *State Lime Strategy 2001*. See Section 2.1 of this management plan.

Section 5.7 of SPP 2.0, deals with Minerals, Petroleum and Basic Raw Materials.

Part of Section 5.7 states;

> *Basic raw materials include sand, clay, hard rock, limestone and gravel together with other construction and road building requirements. A ready supply of basic raw materials close to development areas is required in order to keep down the cost of land development and the price of housing.*
>
> *Planning strategies, schemes and decision making should:*
>
> *ii. Identify and protect important basic raw materials and provide for their extraction and use in accordance with State Planning Policy No 10 (2.4); Basic Raw Materials.*
>
> *iii. Support sequencing of uses where appropriate to maximise options and resultant benefits to community and the environment.*

The other factors of the natural environment are provided with the best protection possible, by this management plan, by selection of the site, operational staging and footprint and rehabilitation, bearing in mind the constraints of excavating and processing the resource.

- ***State Planning Policy 2.4, Basic Raw Materials, 2000***

This policy makes many statements on the intent and actions which local authorities should use to protect and manage basic raw materials.

Section 3.4 is very specific in explaining that basic raw materials need identification and protection because of increased urban expansion and conservation measures, (3.4.1), (3.4.2) and (3.4.4). Sections 3.4.5 and 3.4.6 recognise that environmental and amenity matters need to be considered.

There are specific provisions in Section 6.2 Local Planning Scheme Provisions, such as;

> *No support for the prohibition of extractive industries in zones that permit broad rural land uses.*
>
> *Providing an appropriate P, D or A use.*
>
> *Not precluding the extraction of basic raw materials on land which is not identified as a Priority Resource Location, Key Extraction Area* or Extraction Area (6.4.2).

The Western Australian Geological Survey has produced new mapping identifying Strategically Important Basic Raw Materials across private land and State Forest. The Geological Survey recognised the sand resources as a valuable community asset.

- ***SPP 2.5 – Agricultural and Rural Land Use Planning***

State Planning Policy No 2.5, Agricultural and Rural Land Use Planning, makes provision for the extraction of basic raw materials.

SPP 2.5 in Point 9 states that "The location of rural residential and rural small holdings should avoid unacceptable impacts on, or sterilisation, of natural primary resources including prospective areas for mineralisation and basic raw materials .....".

State Planning Policies are required to be considered under the Local Authority Town Planning Schemes as is the “identification and protection” for staged use, of basic raw materials.

- ***State Planning Policy No 4.1, State Industrial Buffer Policy***

SPP 4.1 discusses the need to consider adjoining land uses when locating buffers but does not prescribe set buffers for operations such as this. The development and processing of the resource has been designed to maintain maximum buffer distances. In situations where the buffers are less, actions such as the provision of perimeter bunding to provide visual and noise management, tree planting and operational procedures, are used to mitigate and reduce impacts.

This is discussed further in Section 2.8.1 Surrounding Landuses and 3.10 Buffers of this document.

- ***State Planning Strategy, 1997***

The Western Australian Planning Commission (WAPC) released the *State Planning Strategy in 1997*. It comprises a range of strategies, actions, policies and plans to guide the planning and development of regional and local areas in Western Australia and assists in achieving a coordinated response to the planning challenges and issues of the future by State and Local Governments.

The State Planning Strategy contains the following five key principles. These are:

- Environment & resources: to protect and enhance the key natural and cultural assets of the State and to deliver to all Western Australians a high quality of life which is based on sound environmentally sustainable principles.

- Community: to respond to social changes and facilitate the creation of vibrant, accessible, safe and self-reliant communities.

- Economy: to actively assist in the creation of regional wealth, support the development of new industries and encourage economic activity in accordance with sustainable development principles.

- Infrastructure: to facilitate strategic development of regional Western Australia by taking account of the special assets and accommodating the individual requirements of each region.

- Regional Development: to assist the development of regional Western Australia by taking account of the special assets and accommodating the individual requirements of each region.

- ***Directions 2031 and Beyond (WAPC 2010)***

Directions 2031 and Beyond provides data on the land uses and growth of the Perth Metropolitan and Peel areas over the 20 years to 2031.

- ***Basic Raw Materials Demand and Supply Study for the Bunbury - Busselton Region (WAPC 2012).***

The Western Australian Planning Commission in *WAPC 2012, Basic Raw Materials Demand and Supply Study for the Bunbury - Busselton Region*, determined that limestone is in short supply and that all the limestone available including that in the Lake Pollard area was just sufficient to satisfy the demands of the region for the next 30 years. The demand for the next 30 years was listed in Table 7 of WAPC 2012 as requiring 30 359 000 m^3 of limestone within the next 30 years. Lime for agriculture was assessed as being 21 891 000 tonnes.

The Geological Survey estimated that the total limestone available, if all resources are taken, is 35 460 000 m^3 (WAPC 2012).

- ***Inner Peel Region Structure Plan 1997***

The Inner Peel Region Structure Plan 1997, lists Lots 1001 and 1002 as Rural – Broadacre.

- ***Coastal and Lakelands Planning Strategy 1999***

This Policy recognises the location as being in the Coastal precinct, being suitable for low density development and tourism. The Policy also recognises the need for Resource Extraction Activities and their location, as being determined by the “location of the resource”. The Geological Survey of WA recognises the significance of limestone in this location. (Figure 1).

The Policy recommends taking the resource from areas that are covered by remnant vegetation. The location of the proposed limestone pit is determined by the resource being located on a ridge. However the selection has taken into account the generally degraded nature of the site. (Attached Flora and Vegetation Assessment)

- ***Peel Region Scheme 2002***

The Peel Region Scheme overrides the *Town Planning Scheme (Planning and Development Act 2005 Part 9 123 (1 – 3)*. The Town Planning Scheme must be made consistent with the Peel Region Scheme *(Town Planning Scheme (Planning and Development Act 2005 Part 9 123 (1 – 3).*

Lots 1001 and 1002 will fall under the *Peel Region Scheme Strategic Minerals and Basic Raw Materials Resource Policy* dated October 2002. Section 5.0 of that Policy requires the town planning schemes to be consistent with the *Peel Region Scheme Strategic Minerals and Basic Raw Materials Resource Policy.*

Section 4.0 Objectives of the *Peel Region Scheme Strategic Minerals and Basic Raw Materials Resource Policy* direct; to identify land within the Peel Region that contains basic raw materials of State or Regional Significance and to prevent them from being sterilised by incompatible development and land uses.

Lots 1001 and 1002 are listed as Rural under the Peel Region Scheme.

The resource has been identified by the Geological Survey of Western Australia as a Regionally Significant Basic Raw Material – Limestone and therefore it should be used in a staged manner as proposed.

Local Government Planning Documents

- ***Shire of Waroona Town Planning Scheme No 7 (1996 – last updated 2012)***

The site is zoned Rural in the Shire of Waroona Town Planning Scheme No 7. There does appear to be a discrepancy between the Legend and the Scheme Text. The Scheme Text lists the zone as 13A Rural Coastal, whereas the legend that accompanies the Zoning Plans lists the site as 3A Coastal.

The Zoning Table lists the site as 13A but the Scheme Text on page 30 lists the zone as 3A Whilst this creates some confusion it is fairly clear what the intention of the zone is and what its name is.

Extractive Industries are an AA use in the Zone, which means that Council, using its discretion, may approve an Extractive Industry.

The relevant sections of the Rural Coastal Zone, seeks to ensure that appropriate rural activities are consistent with the protection of the coastal environment and the ecology of Yalgorup National Park. It also permits Council to approve the "establishment of commercial uses in accordance with the Zoning Table.

The text requires satisfactory advice from Department of Environment and Conservation (DPAW) and the Environmental Protection Authority to ensure that the proposed use does not detrimentally impact on the Yalgorup National Park.

Preston Beach North Road reserve runs across the southern end of Lot 1002 and an un-named road runs along the eastern boundary of Lot 1002 and cuts through Lot 1001.

- ***Shire of Waroona Local Planning Strategy 2009***

Section 14 of the Shire of Waroona Local Planning Strategy recognises the importance of basic raw materials and recommends that Industry – Extractive to be a permitted use in all Rural zones. Lots 1001 and 1002 lie within the Coastal Precinct and within the Rural Zone.

The Strategy recommends that extraction occur "where clearing of significant vegetation is not required and where the operations can be undertaken without unreasonable impact on the locality and environment. Extensive rehabilitation to be undertaken on a cell by cell basis on all extraction sites upon completion of extraction in that cell."

The location of the pit is determined by the location of the limestone resource. However an area of partially degraded vegetation has been selected for extraction. Only 10 plant taxa are present within the extraction area, which is low and indicates the level of disturbance and grazing.

Excavation is proposed to be progressively followed by rehabilitation. The proposal has been designed to minimise impact on the local environment and the tourism and conservation values of the local area.

- ***Shire of Waroona Extractive Industries Local Law 1999***

The proposed excavation has been designed to comply with the Local Law.

3.3 End Use

The planned end use of the site is to restore a natural soil and return the ridge to native vegetation along the buffer to Lake Pollard and on the steeper southern and northern slopes with pasture in the west so there is no net loss of native vegetation.

3.4 Responsible Authorities

A number of state and local government authorities are responsible for overseeing the safety and management of the proposed quarry. Other authorities have an interest in the proposal but may not hold any responsibility.

Shire of Waroona

- Provides Planning Consent.
- Issues the Extractives Industries Licence for the quarry.
- Regulates land zonings in conjunction with the Western Australian Planning Commission.
- Has control over local roads.

Main Roads

- Has an interest in the transport routes and controls major roads.

Department of Water

- Issues guidelines for water quality management for extractive industries.
- Oversees protection of groundwater and water courses.

Department of Environment Regulation

- Oversees all aspects of environmental impact and management.
- Issues licences for crushing and screening plants.

- Has an interest in the flora and fauna of the area, particularly Lake Preston.
- Provides Approval for clearing under the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004.*

Western Australian Planning Commission

- Responsible for structure plans.
- Responsible for State Planning Policies.
- Responsible with the Shire for land zoning.
- Responsible for State Planning Policy No 2.5, Agriculture and Rural Land Use Planning.

Environmental Protection Authority

- Oversees the potential for significant environmental impacts on environmental matters.

Department of Mines and Petroleum

- Controls the safety and methods of excavation through the *Mines Safety and Inspection Act 1994.*
- Responsible for overseeing the health and safety of the operations and the administration of the *Mines Safety and Inspection Act 1994 and Regulations 1995.*

Department of Planning

- Responsible, in conjunction with the Western Australian Planning Commission, for *Directions 2031 (2010)* and *Draft Industrial Land Strategy Perth and Peel (2009).*

Department of Aboriginal Affairs

- Oversees the Native Title Amendment Act and the *Aboriginal Heritage Act 1972 - 1980*.

Commonwealth of Australia

- Oversees the potential for impacts on matters listed under the *EPBC Act 1999*, including Lake Clifton and Black Cockatoos.

3.5 Social Impacts

The main potential social impacts are to perceived local recreation values.

Lake Pollard lies within the Yalgorup National Park. There is no access to the lake from Lot 1002. The Lake Pollard Walk Trail, which runs from Martins Tank in the south, extends to the bird hide on the eastern side of the lake with an extension running along the fire break south of Lot 1001 to the peak of the ridge which acts as an informal lookout.

The proposed pit is separated by a sigificant distance from the walk trail which is well to the east behind a limestone ridge.

The proposal has been designed to enable use of the lookout to continue near Lot 1001 and it is believed that the quarry will be hidden from view from Lake Pollard Walk Trail.

Whilst Saturday transport is desirable for agricultural supply a compromise has been offerred to restrict operations and transport to Monday to Friday excluding Public Holidays to minimise potential impacts on road traffic and tourism.

The operation of the pit is anticipated to be January to April annually, avoiding the busy spring and Holiday tourist seasons. By Easter operations will be winding down.

4.0 QUARRYING OPERATIONS

The proposed methods of excavation will be the same as those used on the existing pits on Lot 4, Ludlow Road, Myalup operated by Doyles Lime Service. The Myalup operation will be used to demonstrate the nature, size and scale of the proposed operations on Lot 1002. Figures 5, 6 and 10.

The descriptions and photographs of the Myalup limestone pit that are used in this documentation will provide the information on the proposed operations.

Limestone will predominantly be used for agriculture, although road base and minor other products will be produced as the higher grade material becomes exhausted. The taking of road base is more likely to be a second phase of excavation by another operator after all the limestone suitable for agriculture has been taken.

The limestone is relatively soft and can be removed with an excavator or loader without the need for a bulldozer or blasting. It is then screened to produce products of the correct size. A small mobile crusher is required to prepare the correct grainsize.

All screening and crushing equipment is portable and brought to the site as needed. The necessary Licences for the equipment will be obtained from the Department of Environment Regulation for all plant used on site as required.

Quarry operations will be carried out under the *Mines Safety and Inspection Act 1994 and Regulations 1995.*

Environmental issues including dust, noise and traffic can be managed in such a way to minimise or eliminate any significant impact both on site and offsite. Dust and noise can be contained by the methods of extraction to be used and the control measures which will be put into place. Measures to protect the site and minimise the influence of dieback are addressed under Environmental Management.

Overall the proposed pit is well isolated from any sensitive premises with none within 1 km.

Project Summary

ASPECT	**PROPOSAL CHARACTERISTIC**
EXCAVATION	
Area of proposed new excavation	Proposed Pit – 13.0 hectares in four stages of about 4.0 hectares. Sand excavation 3.0 hectares.
Limestone extraction	50 000 per year
Sand Extraction	10 000 tonnes per year
Total estimated resource	Limestone - approximately 1 000 000 tonnes. Sand 150 000 tonnes but with potential to expand
Life of project	20 years
Area cleared per year	Initially about 2 hectares and then 0.5 – 1.0 per year depending on the elevation of the ridge. Sand excavation can occur for the most part without the need to clear native vegetation.
Total area to be cleared	7.5 hectares in proposed pit The future pit of 2.5 ha will also require clearing when applied for and approved.
Area mined per year	0.5 – 1.0 hectares total
Dewatering requirements	None
Maximum depth of excavations	16 metres
PROCESSING	
Limestone	50 000 tonnes per year
Water requirements	Only required for dust suppression on road

	transport.
Water supply source	Existing sump for which application will be made to use 5 000 kL per year for commercial purposes.
INFRASTRUCTURE	
Total area of plant and stock	Located within excavation footprint or on adjoining cleared land. 2.0 ha
Area of settling ponds	Not required
Fuel storage	Not required, mobile tankers will be used
TRANSPORT	
Truck movements	Variable but approximately 10 laden trucks per day maximum
Access	Existing limestone Preston Beach North Road from the sealed Preston Beach Road.
WORKFORCE	
Construction	2 –3
Operation	2 - 3
Hours of operation	Monday - Friday 6.30 am to 5.00 pm excluding public holidays.

4.1 Limestone Extraction

1. Any trees cleared will be utilised for firewood wherever possible. In general the Eucalypt trees around the base of the ridge and through the swale have been excluded from development because the land holder wishes to retain as many as possible. However the removal of some trees may be unavoidable. Figures 5, 6 and 10.

2. An Application for Clearing is concurrently lodged with this application to cover the remaining remnant vegetation on site. A Clearing Permit will be applied for to cover the clearing of the proposal area.

3. The excavation footprint has been determined from Landgate contour mapping and detailed aerial photography. Prior to excavation commencing the site will be ground surveyed, the excavation footprint marked out and a 1 metre contour plan developed.

4. Remove the vegetation cover by pushing it into windrows for use on the batters to minimise soil erosion and assist spreading on the final land surface as part of the final rehabilitation.

5. Where practicable vegetation will be directly transferred to an area being rehabilitated. Smaller indigenous shrub material will be used in the rehabilitation process when available and suitable; for example on batter slopes of completed areas.

6. If direct transfer is not possible the vegetation will be stored in dumps, mulched or swapped with a nearby operator to try and ensure that the material is not wasted.

7. All topsoil will be removed for spreading directly onto areas to be revegetated and screening or perimeter bunds. If direct spreading is not possible the top soil will be stored in low dumps, for spreading at a later date. See 5.9.2 Rehabilitation Procedures. Unfortunately much of the topsoil has a high weed load of pasture species some of which are invasive. It may not always be possible to reuse this apart for creating pasture.

8. Soil and overburden, as yellow and brown sand and low grade limestone, will then be removed and either directly transferred to a rehabilitation area or stored in low dumps for later rehabilitation use. Where this is not used overburden will be stored in dumps for future use in rehabilitation or the creation of bunds.

9. Limestone interburden, if encountered, will be incorporated into the overburden dumps for later use in re-contouring the land surface at the conclusion of excavation.

10. A bulldozer will be used to rip and push the limestone down the excavation face and track roll the limestone in the process.

11. The preliminary crushed limestone will then be picked up by a rubber tyred loader and fed to the mobile crusher.

12. All static and other equipment, such as crushers and screens (where used), will be located on the floor of the quarry to provide visual and acoustic screening. Figures 5, 6 and 10.

13. Excavation will commence on the western ridge and then move to the eastern ridge, working on the floor of the pit towards the edges to minimise the potential visual impact. The face and walls of the pit will act as noise barriers.

14. Upon completion of each section of quarry the section will be reformed and back filled, where subgrade material is available, to achieve the proposed final contours which are shown on the plan "Proposed Finished Contours".

15. It is not anticipated that blasting will be required.

16. At the end of excavation the floor of the quarry will be deep ripped, covered by overburden and top soil, and rehabilitated to a constructed soil. Details of the Rehabilitation are listed under 5.9 Rehabilitation.

Sand Extraction

17. Sand will be sourced by pushing the topsoil into perimeter bunds for later rehabilitation.

18. Sand will then be excavated with a loader, loading directly to a road truck.

4.2 Staging and Timing

The excavation footprint has been determined from Landgate contour mapping and detailed aerial photography. A staging plan is attached and shows indicative staging and the direction of excavation. Figure 11.

Prior to excavation commencing the site will be ground surveyed, the excavation footprint marked out and a 1 mete contour plan developed.

At this stage it is difficult to predict the speed of excavation because the amount of material extracted depends on market conditions.

50 000 tonnes of limestone may be extracted in a year. Limestone extraction will generally only be during the summer and autumn months for agricultural lime. Actual quantities will depend on the type and size of contracts won, and sales.

However it is expected that the quarry will progress by up to 0.5 to 1.0 hectare per year. Twenty years of resource is anticipated to be available on site.

The active area needs to be large to enable a range of limestone products to be available at all times, and to provide sufficient area for processing/screening and for stockpiles.

Wherever possible all completed ground will be rehabilitated as soon as possible to ensure that the amount of ground that is open at any one time is minimised. The nature of the excavation means that it will be difficult to commence rehabilitation of the floor of the quarry until the underlying limestone has been removed.

Sand extraction will be in the order of 5 000 to 10 000 tonnes per year. It is anticipated that it will be used predominantly for sand fill at Preston Beach and nearby.

4.3 Hours of Operation

Hours of operation will be 6.30 am to 5.00 pm Monday to Friday inclusive, excluding public holidays. See Traffic Management in Appendix 2 for additional information.

Transporting material on Saturday would be desirable but is not regulated by reduced truck speeds in order to minimise impact on visitor traffic along Preston Beach Road. Saturday transport is requested to enable farmers to access lime in the autumn period prior to sowing their crops.

4.4 Access, Transport and Security

Access to the site will be along Preston Beach Road which is sealed, and then to Preston Beach North Road which is limestone and will need grading and maintenance. See Traffic Management in Appendix 2 for additional information.

Traffic volumes along Preston Beach Road are greater, with most traffic associated with holiday times and on weekends. On the other hand there is little traffic along Preston Beach North Road which does not lead to any dwellings.

Preston Beach Road exits onto Old Coast Road at a long time established intersection.

Transport from the site is by a variety of trucks depending on the contractor and the type of product carried. In summer – autumn, when the majority of lime is sold, there will be an estimated maximum of 50 laden truck movements leaving the site in one week although this number will vary with market demand. At times when road making materials are being transported from the site the number of truck movements may be greater.

On any week day the number of trucks is anticipated to be 10 to 15 laden trucks which will be 1 to 1.5 per hour. On Saturday the number of laden movements is, from the experience at Myalup, expected to be less with less than one laden truck per hour.

The destination of the lime is normally in the Wheatbelt and any truck will normally only access the site once on any day.

The access and internal roads will be limestone based and watered as needed in the drier months to suppress dust.

The existing perimeter fences and gates will be maintained. Warning signs will be maintained as required by the Department of Mines and Petroleum and the Shire of Waroona.

4.5 Equipment

All static and operational equipment will work on the quarry floor to provide maximum sound and visual screening.

Site office	A caravan is proposed to serve as a site office.
Toilet system	Portable serviced system will be used
Bulldozer	Removal of limestone rubble and road base, track crushing of limestone as required and pushing down the resource.
Excavator	May be used to remove limestone.
Portable crushing plant	Preparation of road base and agricultural lime.
Screening plant	Preparation of limestone for road base.
Water tanker	Used for dust suppression on the access roads and working floors as necessary.
Loader	Loading and handling materials from the stockpiles.
Fuel Storage	Refuelling will be undertaken using potable tankers located 800 metres from Lake Pollard and not upstream of the lake. If required, fuel will be stored in an above ground tank with a capacity of approximately 5 000 litres, appropriately located on the floor of the pit to Department of Environment Regulation, Department of Water and Department of Mines and Petroleum Guidelines. Fuel storage will be located in a bunded area lined with an impermeable membrane a minimum of 800 metres south west from Lake Pollard 4 metres above the highest known water table.

Excavation

During excavation a bulldozer and loader or excavator will be used to move the topsoil, clay resource and overburden.

The loader will then pick up the freed resource and feed it to the mobile crushing plant.

4.6 Final Contours

The slope of the final contours of the proposed pit is an undulating surface at around 5 metres AHD which is consistent with the adjoining land.

Slopes of the batters at the end of excavation will be retained at 1 : 4 vertical to horizontal.

Sand excavation will cut to an elevation of 4 metres AHD because the resource is thin. That retains 3 metres to the water table post mining which complies with all development or rural guidelines.

See Attached Concept Final Contour Plans. Figures 11B.

4.7 Workforce

The workforce will vary, depending on the level of operation and market demands, but usually 2 to 3 persons can be expected to be working on site.

4.8 Water Usage

Water will only be required for dust suppression, which will be carried out as required during drier weather. A water tanker will be used to water the access road and the pit floor whenever necessary to minimise dust generation from transport and during crushing. Normally only small volumes of water will be used for a quarry of this type. A quarry could be expected to require less than 5 000 kL per year.

Water will be drawn from a sump located to the west of Lot 1001. A licence from Department of Water will be applied for to enable the taking of up to 5 000 kL water per year for dust suppression.

There will be no significant change to recharge or water flows to Lake Pollard during excavation or as a result of excavation. See the Water Management Plan Appendix 6.

Potable water will be brought to the site as required.

4.9 Transport Corridors

Lime products are to be transported from this site for about three months through late summer and autumn (January to April). See Traffic Management in Appendix 2 for additional information.

Road transport use a variety of trucks such as semi-trailers or rigid (8) wheeler trucks to a 5 axle dog trailer.

Department of Parks and Wildlife raised a number of issues in relation to the trannsport along Preston Beach North Road.

A traffic Management Study has been commissioned from Greenfields Technical Services and is attached as Appendix 2.

DPaW (Appendix 4) raised concerns with respect to potential impacts on the Yalgorup National Park, visitors and recreational users and on the Martin's Tank Campsite. DPaW note that upgrades to the Martin's Tank Campsite will incorporate some campervan and caravan accommodation.

DPaW also raised the issue of walkers who currently use section of Preston Beach Road North and the intersection of Preston Beach Road and Preston Beach North Roads. In addition potential noise and dust impacts on the amenity of Martin's Tank Campsite was noted.

Greenfield Technical Services assessed the road impacts based on 50 000 tonnes per year of limestone transported during the period December to April annually. See Appendix 2.

Greenfield noted that being public roads there is no restriction on 19 metre semi-trailer trucks using Preston Beach North Road. The Shire has erected a sign on the road "Closed to all vehicles Class 3 and over". An email has been received from the Shire of Waroona that is included in Appendix 2 that states that "When DPaW did some improvements to their campsite at Martin's Tank, which is at the end of the road, we (The Shire of Waroona) negotiated with them to allow them to use larger vehicles, with conditions. We'd be looking to instigate something similar if Doyles' proposal gets up".

Greenfield recorded the road as a flat bladed sandy material with some evidence of limestone sheeting. Road minimum widths vary from 5.4 to 7.0 m plus. Sight distance is compromised by roadside vegetation and varies from 60 – 200 metres. See Appendix 4 for photographs.

It is calculated that "as of right" 19 m long semitrailer combinations with approx 30 tonne payloads would equate to 1563 loads from site. That is 10 loads per day or 20 movements per day and 2 per hour on average.

Greenfields determined that the current road structure will not support that traffic in its present form. Some changes to intersection and sightlines will also be required.

Several scenarios are presented by Greenfield Technical Services which included consideration of the Martin's Tanks Campsite traffic. The most expensive and extensive being Option 2B. See Traffic Management in Appendix 2 for additional information.

It is a little unclear why the Lake Pollard walk trails uses Lake Preston North Road for part of its route. (DPaW Appendix 4). There is another route through woodland and it remains unclear why visitors would walk along the road, from a safety or experience point of view. The trail just touches the road for less than 50 metres at a sharp left dogleg and from observations it appears that there are short cuts removing the need to access the road.

As part of the upgrade a shortcut should be constructed to be part of the track, and the public safety for users of the DPaW walking trail would be improved.

Discussions have been held with Doyles Limes Service who have indicated that the upgrade to the road as Option 2B would be the most suitable and are prepared to commit to that. This work will be completed through the Shire of Waroona in consultation with Department of Parks and Wildlife.

This will mean that;

- The road network will be upgraded to take the required truck traffic.
- Upgraded intersection work and signage.
- Trimming of road vegetation to increase sightlines.
- Grading of the road.
- Additional signage.
- The road will become safer for all users including the caravans and visitor traffic to Martin's Tank.

In addition

- Carting will be December to April inclusive which will avoid the busy spring season and could exclude Christmas and Easter holiday seasons.
- During transport, a water cart will be provided on site to ensure the road is treated for dust as required.
- Speed restrictions could be placed on the road, particularly for truck traffic.
- Construct a short cut to avoid the need for users of DPaW Lake Pollard Walktrail to walk along Lake Preston North Road and increase the safety for walkers.
- Check and modify the entrance to Martin's Tank Campsite to ensure that the safety of walkers is improved.

These measures will benefit all road users.

See Appendix 2.

4.10 Safety

Excavation will be conducted to *Mines Safety and Inspection Act 1994 and Regulations 1995.* Excavation practices, and operations procedures will be in compliance with the Act. Health and safety issues are overseen by the Department of Mines and Petroleum.

Regular inspections and audits will be carried out by officers of the Department of Mines and Petroleum to inspect safety, operational procedures and workplace health such as dust and noise.

Doyles Lime Services has procedures in place to manage safety, health, environmental impact, site completion and rehabilitation. All workers are required to wear full protective safety and high visibility gear when on site.

They have in place Safety Management Plans and a site specific Emergency Response Plan to cover operational procedures, which include workforce induction and training to ensure that all employees involved are made aware of the environmental and safety implications associated with all stages of the mining activities.

Workers and staff on all sites are trained in the use of the procedures and all employees provided with site induction and training as necessary prior to commencing work on the site.

All vehicles have two way radio capability. No light vehicles are permitted on site without registering with mobile plant on site. Full personal protection is required for all persons on site at all times.

The site is registered under the Department of Mines and Petroleum SRS reporting system for minesites and quarries.

It is anticipated that the deepest excavation will be a maximum of approximately 16 metres below natural ground level. Where possible no slope will be left at an angle greater than 1: 2 vertical to horizontal at times when the site is unattended. There may be times when this is not possible or desirable.

At all times excavation will be in compliance with the *Mines Safety and Inspection Act 1994 and Regulations 1995.*

Fencing, locked gates and warning signs will be maintained.

The batter slopes of the pit will be dozed down at between 1 : 1 and 1 : 2 which will prevent any fall situations. A fence will be constructed around the top of the pit, installed with warning signs. The fence will be approximately 1.2 metres high and of farm wire construction.

The edge of the pit will be located 500 metres from the informal lookout separated by remnant vegetation on private land and fences.

Emergency

The site is within mobile phone contact and all vehicles will be equipped with two way radios. Safety management and operating procedures will be in place.

Fire

Fire risk is less than the risk from general farming. The open area of excavation will form a natural firebreak and will be used for the emergency muster area.

Fire Safety is incorporated into safety management for the site.

The site is within mobile telephone range which will assist in fire safety.

Earth moving vehicles, and the water tanker when on site during excavation, will be available for fire fighting if required. Operators are trained in the use of fire extinguishers for all types of fire.

Perimeter fire breaks will be maintained.

Final contours of the batter slopes will be 1: 2 vertical to horizontal with the floor of the excavation left as gently undulating around 6 metres AHD.

SAFETY			
Potential Impact	**Management**	**Outcome Commitments**	**Action Required**
Operational Safety	*Mines Safety and Inspection Act 1994 and Regulations 1995.* ▪ The site is within mobile and landline telephone contact. ▪ Safety Management procedures will be implemented prior to commencement. ▪ All workers will be provided with site induction and necessary training prior to entering the site.	Doyles Lime Service are committed to maintaining a safe working environment and have standard Safety Management Plans for their operations.	Compliance with *Mines Safety and Inspection Act 1994 and Regulations 1995.* Ongoing
Adjoining properties	*Mines Safety and Inspection Act 1994 and Regulations 1995.* • Warning signs are erected around the operating area. • Locked gates and fences will be maintained on site.	Doyles Lime Service are committed to maintaining a safe working environment and have standard Safety Management Plans for their operations.	Compliance with *Mines Safety and Inspection Act 1994 and Regulations 1995* Compliance operating conditions

5.0 ENVIRONMENTAL IMPACTS AND MANAGEMENT

5.1 Surrounding Landuses and Buffers

The site has been used for agriculture and grazing for many years.

A number of Government Policies relate to buffer distances and the protection of basic raw materials. State Planning Policy No 4.1, State Industrial Buffer Policy, (draft July 2004) discusses the need to consider adjoining land uses when locating buffers but does not prescribe set buffers for operations such as this. Figures 1, 2 and 8.

Generic buffer requirements were developed by the Victorian Government and used by the Environmental Protection Authority as the basis for a Draft guideline on recommended buffer distances. These formed the basis of EPA Guidance Statement Number 3, Separation Distance between Industrial and Sensitive Land Uses, June 2005.

The Environmental Protection Authority of South Australia recommends a 300 metre separation for a Quarry - Non Blasting.

EPA guidance "Separation Distances between Industrial and Sensitive Land Uses", June 2005 lists the generic buffers for sand and limestone pits as 300 - 500 metres depending on the extent of processing. A generic buffer relates to the distance at which there are unlikely to be any problems without some further investigations and does not mean that smaller buffers are not acceptable. EPA Guidance for the Assessment of Environmental Factors 3 June 2005 provides for a case by case separation, based on the potential impacts.

For limestone extraction a generic buffer is suggested of 300 to 500 metres with case by case assessment where grinding and milling are used.

These are generic buffers and can be varied on the basis of environmental and management studies.

The same type of quarrying therefore has very different generic buffers developed by State Environmental Protection Authorities, illustrating the need to consider separations on on-site environmental impact and not theoretical or generic buffers.

The main issues are the potential generation of dust and noise, which are addressed later.

The excavation of limestone from the site complies with these policies.

As far as is known there are no dwellings within 1000 metres of the proposed excavation and no new dwellings in the nearby area. The closest dwellings are 2.8 km away to the east of Lake Clifton

The site is set back 600 metres from the edge of Lake Pollard.

The Lake Pollard Walk Trail does not extend onto Lot 1001 or Lot 1002 and is located 600 km from the proposed limestone pit behind the intervening ridge and 500 metres from the lookout. Figure 2.

5.2 Aesthetics

Visual impact can occur in a number of circumstances, by the operation being set too high in the landscape, by being too close to neighbours and by insufficient visual protection.

The limestone will be extracted from a ridge and will result in the ends of the two dunes being reshaped down to the elevation of the intervening swale. The main ridge line will not be modified but maintained. Figures 5 and 8.

See also the notes under 5.1 Surrounding Landuse and Buffers above.

For sand excavation the thin resource and low elevation requires cutting to 4 metres AHD, 3 metres above the water table in compliance with DOW guidelines and matching nearby and adjoining swales.

There are a number of management actions that can be taken in quarries to minimise visual impact and these will be used wherever possible.

The general management actions are summarised below together with the visual impact issues that relate to this site. The actions will be used where applicable and as the opportunity presents to minimise visual impact.

The main risk of view is from the east, east of Lake Clifton and the Lake Pollard walk Trail which will now be separated by a distance of 600 metres behind the main limestone ridge.

It is felt that the operations are unlikely to be seen from any location.

Below is a list of ideal visual management activites with a simple compliance audit for the operations.

IDEAL OPERATIONAL PROCEDURES	**COMMITMENTS ON ACTIVITIES CONDUCTED ON SITE**
• Locate exposed features behind natural barriers and landform.	• The quarry and processing facilities are to be worked from the west behind the ridge of material being excavated. • The limit of the pit is set back 600 metres from Lake Pollard and there is intervening vegetation and high ridge between the pit and Lake Pollard. Figure 3.
• Operate from the floor of the pit below natural ground level.	• The pit is to be worked from the inside below natural ground level via an internal haul road. • The processing area is to be located on the floor of the pit to the west, in the most efficient location. Figure 5.
• Avoid breaks in the skyline due to workings and haul roads.	• Excavation will come from the west. The main ridge will not be altered and the skyline will not change . • There are no sensitive premises or locations from which people are likely to see the pit from the east or south. • At all times the pit will be operated behind a face of natural vegetation. • Based on the site contours and the proposed excavation methods operations are not anticipated to be seen from Old Coast Road. It may just be possible that the northern batter face and the southern batter face will be visible from

	the south east and north east as small glimpse from east of Lake Clifton, but as these will be rehabilitated these views are anticipated to be covered within two years of excavation of that part of the pit.
• Push overburden and interburden dumps into positions where they will not be seen or can form screening barriers.	• Perimeter bunds of overburden and natural face are to be used when material becomes available, but largely in the west and just ahead of excavation to increase the potential screening.
• Construct screening bunds and plant tree and shrub screens to reduce visual impact.	• Some screening bunds and natural vegetation are already in place around the perimeter. • The bunds will be used as overburden becomes available. • A screening belt of trees will be used on the southern edge of the pit. • A separation of 500 metres will be maintained to the lookout on the fire break in the Yalgorup National Park. Figure 3. • It is not anticipated that the quarry will be able to be seen from the Yalgorup National Park or Lake Pollard Walk Trail because of the design of the operations to minimise visual impact and the visual management procedures and actions proposed. Figure 3.
• Stage workings and progressive rehabilitation to provide visual protection of later activities.	• The staging of the pit footprint is designed to minimise visual impact with special attention concentrating on the eastern sightlines.
• Cover barriers and landscaping with forms, colours and textures compatible with the natural environment.	• Natural vegetation will be retained around the perimeter.
• Adopt good house cleaning practices such as orderly storage and removal of disused equipment or waste.	• Doyles Lime Service maintains a tidy work environment at all their sites. Waste is regularly removed off site to an approved waste facility. • Where possible usable materials will be recycled which is part of normal operational procedures.
• Provide progressive rehabilitation of all completed or disturbed areas.	• This has always been used at other pits and is proposed. • Areas not required will be revegetated when each part of the site has reached its final form.
• Minimise the amount of ground used at any one time.	• The amount of ground used will be minimised to that needed for current and future operations and fluctuations.

Light Overspill

No night activities are proposed.

Visual Management - Applicable Legislation / Policies
• None applicable
Commitments to Visual Management
• Doyles Lime Service is committed to management of visual impact and will implement the measures outlined. • Every effort will be made to minimise the visual impact using appropriate methods from those listed above.

5.3 Noise

Offsite noise is governed by the *Environmental Protection (Noise) Regulations 1997.*

The *Environmental Protection (Noise) Regulations 1997*, require that sensitive premises including dwellings in non industrial and rural areas, are not subjected to general noise levels (excluding blasting), during the hours 7.00 am to 7.00 pm Monday to Saturday that exceed 45 dBA. Allowable noise to 55 dBA is permitted for up to 10% of the time and to 65 dBA for 1% of the time. Noise levels are not to exceed 65 dBA during normal working hours.

Between 9.00 am and 7.00 pm on Sundays and Public Holidays and between 7.00 pm and 10.00 pm on all days the base level is 40 dBA.

At night, between 10.00 pm and 7.00 am Monday to Saturday, and before 9.00 am on Sundays and Public Holidays, the permitted level drops to 35 dBA.

The 10% and 1% “time above” allowances apply at night and on Sundays and Public Holidays as well.

There are penalties for tonality of 5 dB, modulation 5 dB and 10 dB for impulsiveness, that are added to the permitted levels. That is, if the noise is tonal or modulated the permitted levels drop by 5 dB. Impulsiveness is not likely to be relevant for the quarry under normal circumstances.

Influencing factors of external noise and nearby land uses such as busy roads, and industrial properties are not applicable to this site.

At a distance greater than 15 metres from the sensitive premises (eg dwelling), and commercial premises a base level of 60 dBA applies at all times with the 10% time permitted to be up to 75 dBA and the 1% permitted to be up to 80 dBA. For Industrial premises the base level is 65 dBA at all times with the 10% time permitted to be up to 80 dBA and the 1% permitted to be up to 90 dBA.

Noise can originate from a number of operations and may impact on onsite workers, or travel offsite and impact on external sensitive premises. Both potential noise impacts are addressed by reducing the noise generated from the quarrying and processing operations.

There are a number of management actions that can be taken in quarries to minimise noise generation or travel .

These actions are routinely used by Doyles Lime Service where applicable and as the opportunity presents to minimise noise on site.

Doyles Limes Service will comply with the *Environmental Protection (Noise) Regulations 1997.*

There are no known sensitive premises within 1 km, with the closest dwellings being 2.8 km away across Lake Pollard and Lake Clifton.

Occupational Noise

Occupational noise associated with the quarrying processes falls under the Mines *Safety and Inspection Act 1994 and Regulations 1995*.

The management of occupational noise is normally handled by providing all necessary hearing protection, as well as conducting worker inductions and educational programs for all staff. Regular site audits of quarry and mining operations are normally conducted by the Department of Mines and Petroleum.

As part of its commitments, Doyles Lime Service continues to be pro-active with its worker safety awareness;

- by providing all necessary safety equipment such as ear protection,
- identifying sections of the plant where hearing protection is required, as well as,
- conducting induction and educational programs for its staff.

The operating noise levels around the site are regularly monitored by independent consultants in accordance with the *Mines Safety and Inspection Act 1994*, and the results communicated to the Department of Mines and Petroleum (DMP). All staff are provided with comprehensive ongoing training on noise protection as part of Doyles' commitment to occupational health and safety.

The DMP conducts Occupational Noise Audits of the Operations, on their existing operations, which have been found to be in compliance.

Warning signs are to be used to identify areas of potential noise for workers.

All static and processing equipment will be located to provide maximum noise screening, behind bunds if sufficient overburden is available. Excavation will be staged from the west, behind the eastern ridge which will provide continuous noise screening.

Not all equipment operates at the same time. Similarly not all resources will be worked at the same time.

Warning signs are to be used to identify areas of potential noise.

IDEAL OPERATIONAL PROCEDURES	**COMMITMENTS ON ACTIVITIES CONDUCTED ON SITE**
• Comply with the *Environmental Protection (Noise) Regulations 1997.*	• The proposed operations are so far from any dwelling, > 1 km and screened by the eastern face, that they will comply with the Regulations.
• Comply with the provisions of the *Mines Safety and Inspection Act 1994 and Regulations 1995*.	• Doyles Lime Service, like any quarry, is regularly inspected by officers of the DMP.
• Maintain adequate buffers to sensitive premises.	• The quarry complies with the Generic EPA Buffer Guidelines. • There are no dwellings within 1000 metres.
• Locate exposed features behind	• The eastern and southern faces of the

natural barriers and landform.	pit will provide hard screening of the operations which will be located on the floor of the pit.
• Operate from the floor of the pit below natural ground level.	• This will be used.
• Push overburden and interburden dumps into positions where they can form screening barriers.	• Perimeter faces, overburden dumps and natural vegetation are proposed where possible.
• Design site operations to maximise the separation and protection from sensitive premises.	• The shape of the pit, setbacks and method of operation have been designed to ensure landform protection is maximised will continue.
• Maintain all plant in good condition with efficient mufflers and noise shielding.	• Doyles Lime Service has efficient equipment that is maintained in good condition and replaced from time to time.
• Maintain haul road and hardstand surfaces in good condition (free of potholes, rills and product spillages) and with suitable grades.	• The access road will be maintained in good condition in conjunction with the landholder's access road.
• Implement a site code outlining requirements for operators and drivers.	• A site induction and training program for all personnel is to be implemented and maintained.
• Shut down equipment when not in use.	• This is normal policy.
• Scheduling activities to minimise the likelihood of noise nuisance.	• Activities are proposed to minimize impacts on the local community.
• Fit warning lights, rather than audible sirens or beepers, on mobile equipment wherever possible.	• Lights or low frequency beepers are to be used rather than beepers. • The design and shape of the pit will maximise noise screening.
• Use transport routes that minimise community disruption.	• There is only one road to access the site, so trucks will be specifically instructed not to interrupt holiday makers on Preston Beach Road.
• Avoid the use of engine braking on product delivery trucks in built up areas.	• The surrounding area on Old Coast Road is generally flat with reduced gradients. • Air brakes are unlikely to be required. Drivers are to be instructed not to use air brakes under normal situations when exiting along the access road.
• Minimise and conduct at the least disruptive times, non day to day activities such as vegetation, topsoil or overburden stripping on exposed ridgelines.	• The hours proposed are designed to minimise impact.
• Provide a complaints recording, investigation, action and reporting procedure.	• A complaints recording procedure is proposed to cover all site activities.
• Conduct training programs on noise minimisation practices.	• Doyles Lime Service conducts site induction and training to all personnel.
• Provide all workers with efficient noise protection equipment.	• All noise protection personal equipment will be provided to staff.

• **Noise Management - Applicable Legislation / Policies** • *Environmental Protection (Noise) Regulations 1997.* • *Mines Safety and Inspection Act 1994 and Regulations 1995.* • *Australian Standard AS 2187.*
Commitments to Noise Management • Doyles Lime Service is committed to minimising noise emissions and will implement the measures outlined above. • Doyles Lime Service will comply with the *Environmental Protection (Noise) Regulations 1997.*

5.4 Dust

High Impact Audits of occupational dust will be completed by Department of Mines and Petroleum from time to time.

Doyles Lime Service provides induction and protective equipment for all persons on sites.

Dust Management Actions

Extensive Dust Management is proposed as outlined in the Dust Management Plan included as Appendix 5.

The proposed dust management will minimise the risk of dust to Lake Pollard and local road users.

Doyles Lime Service will upgrade the road network as outlined in Option 2B in Greenfields Technical Services Traffic Management Plan attached at Appendix 2.

Greenhouse Gas

The development of agriculture in the local area, near wheatbelt, Peel and Bunbury Regions generates the need for lime products for soil neutralisation on farms and developments. There is also a need for roadbase although this will not normally be produced at this pit.

Over the years trucks have become more efficient with respect to greenhouse gas emissions, particularly with the use of truck and trailer and road train configurations.

Doyles Lime Service continually seeks ways to reduce the amount of fossil fuels used, and has obtained more efficient mobile plant and equipment when this has become economically available.

Dust Monitoring

The most effective dust monitoring is through visual diligence. This is instantaneous and any issues can be observed and acted upon before they become a problem.

No other form of monitoring is so immediate, as other measures are either on property boundaries of have significant time delays.

Visual dust monitoring will be conducted on site at all times by all operators and the quarry manager.

The amount and source of dust will be observed before any dust monitoring could trigger. Treatment is therefore more effective and targeted.

When a significant source of dust is noticed it will be dealt with by temporary or permanent changes to procedures and equipment or treatment using water.

A personal (occupational) dust monitoring program will be used as per Department of Mines and Petroleum specifications.

High Impact Audits of occupational dust will be completed by Department of Mines and Petroleum from time to time.

Doyles Lime Service provides induction and protective equipment for all persons on site.

Dust monitoring is tied to a proposed complaints mechanism.

Dust Management - Applicable Legislation / Policies
• *Guidance for the Assessment of Environmental Factors, EPA, March 2000.* • *Land development sites and impacts on air quality, DEP, 1996.* • Department of Environmental Protection Guidelines, November 1996 and *DEC 2008, A guideline for the development and implementation of a dust management plan*
Commitments to Dust Management
• Doyles Lime Service will take the necessary steps to manage and contain dust by implementing and maintaining the Dust Management Plan.

5.5 Water Quality

- **Background**

Limestone excavation is a clean operation similar to sand excavation in the nature of the risk to groundwater. No chemicals are used apart from normal lubricants, which is similar to sand excavation, and sand excavation is one of the few industries that are permitted to operate in a Priority 1 Public Drinking Water Source Area, indicating the clean nature of the activity. See Department of Water *Land Use Compatibility in Public Drinking Water Source Areas.*

The protection of water, whether groundwater or surface water, is an important part of the management of quarries.

The main Environmental Objective relating to water management is;

- Minimise the impact on surface and ground water quality.

The limestone pit site lies on a ridge that is well elevated and set 600 metres away from the edge of Lake Pollard and not upstream of the lake.

Shallow groundwater on Lots 1001 and 1002 is fresh, sitting as a layer overlying the saline groundwater. Groundwater flow is to the east to Lake Pollard.

A sump is present in the north of Lot 1002 that is used for stock.

Water will be sourced from the property by way of the use of a sump that is also used for stock. A Licence from the DOW may be required for the anticipated 1 500 kL of water likely to be required for the management of dust.

The base of the excavation will be over 4 metres to the water table.

Potable water will be brought in from scheme supply and used to fill a tank at the site office.

The management actions are considered in the Water Management Plan attached as Appendix 6. See also Section 2.7 Wetlands.

The proposal is consistent with all Government Policies for extraction of limestone and sand and complies with the same requirements for extracting in Priority Drinking Water Source Protection Area.

Water Management - Applicable Legislation / Policies

DOW – DMP Water Quality Protection Guidelines for Mining and Mineral Processing

- *Overview*
- *Minesite water quality monitoring*
- *Minesite stormwater*
- *Mechanical servicing and workshop facilities*
- *Mine dewatering*
- *Health Act 1911*

Commitments to Water Management

- The site complies with Department of Water Guidelines for separation to groundwater.
- The nature of the operation and the depth to groundwater will minimise any risk to groundwater systems and Lake Pollard.
- Management procedures outlined above are committed to, to protect water quality.
- There will be no alteration to surface water flows or groundwater levels.
- Doyles Lime Service has in place a site code outlining requirements for operators and drivers.
- Doyles Lime Service conducts training programs on pollution minimisation practices.
- Doyles Lime Service conducts regular water sampling of the water source sump and maintains the water quality protection measures listed above.

5.6 Biodiversity Management

5.6.1 Vegetation and Flora

Regional vegetation and flora assessments were made by Freeman, K, B Keighery, G Keighery, V Longman, A Black and S Molloy, 2009, *Flora and Vegetation of the Dawesville to Binningup Region (Swan Coastal Plain)*, prepared for the DEC.

Extensive flora and vegetation studies were conducted for the land to the north and touching the northern boundary of Lot 1001 by Cape Bouvard Investments 2009 in support of proposed developments. Appendix 1.

All these studies provide background to the vegetation on site.

In order to provide additional information, a separate flora and vegetation study was completed by Arthur Weston on 1 November and 3 December 2013. The studies cover both the limestone ridge and the sand resource as separate studies and reports. Both reports are attached as Appendix 1 (Weston 2014).

A separate vegetation study of the amended limestone extraction area was conducted by Lindsay Stephens of Landform Research in October 2015. Only 11 species were identified on site.

The land has been strip cleared in the past and intensively grazed and in part seeded with pasture species. See Section 2.5 Flora for additional information in the vegetation.

In spite of extensive searches only 21 native species were found. Effectively there are only nine species, present. which is very low for this type of vegetation over an area of 7.5 hectares. The vegetation is dominated by *Trachyandra divaricata* an exotic species. The sand resource can be taken with almost no clearing.

The local vegetation is originally Cottesloe Complex, Central and South, as identified by Heddle et al, 1980, *Vegetation Complexes of the Darling System, Western Australia in Atlas of Natural Resources, Darling System, Western Australia,* Department of Conservation and Environment.

EPA Guidance 10 *Level of assessment for proposals affecting natural areas within the System 6 region and Swan Coastal Plain portion of the System 1 Region* lists Cottesloe Complex - Central and South as having 41.1% of the pre-European area still occurring and 8.8% in secure tenure.

Whilst there exists greater then 30% of this Complex it is not well reserved. The clearing Regulations provide a higher level of protection than was previously available, and the same vegetation complex is included in the Yalgorup National Park.

The assessments within the Flora and Vegetation Assessment attached, found that the proposed clearing will have little overall effect on flora and fauna within the local area, with most of the effect relating to the final end use, and that appears to have been the case.

- **Vegetation Condition**

The area covered by the proposal will require a Clearing Permit CPS. It has been strip cleared in the past as shown on the existing aerial photography. See Section 2.5 Flora for additional information in the vegetation.

Weston 2014 listed the vegetation condition of the site for each community in Section 5.1 of his report as the letter code CD (Completely Degraded) or D (Degraded) using Bush Forever 2000 descriptors. The Condition Codes are listed above under vegetation communities. Appendix 1.

The vegetation was strip cleared and heavily grazed in the past. With the Prescribed Clearing Exemptions under the *Environmental Protection Act 1986 Section 51C* and the *Environmental Protection (Clearing of Native Vegetation) Regulations 2004 Section 5* it is possible for the landholder to return the vegetation for agricultural purposes to its 1994 condition under Prescribed Clearing in the Regulations, Section 5 .14.

That Prescribed Clearing does not include clearing for extraction of limestone but if the limestone ridge was returned to its 1994 condition, the vegetation will be significantly more degraded than it currently is.

There will be no clearing of the native vegetation unless a New Clearing Permit is approved.

- **Rare and Priority Species**

No Declared Rare or Priority species were recorded. No Threatened Ecological Community was noted.

5.6.2 Vegetation Clearing

*Clearing is controlled under the **Environmental Protection (Clearing of Native Vegetation) Regulations 2004.** These regulations provide for a number of principles against which clearing is assessed.*

	CLEARING PRINCIPLE *(Schedule 5 Environmental Protection Amendment Act, 1986*
1a	*High Level of diversity*
1b	*Significant fauna habitat*
1c	*Necessary to existence of Rare flora*
1d	*Threatened Ecological Community*
1e	*Significant area of vegetation in an area that has been extensively cleared*
1f	*Wetland or watercourse*
1g	*Land degradation*
1h	*Impact on adjacent or nearby conservation areas*
1i	*Deterioration of underground water*
1j	*Increase flooding*

Although the Clearing Principles consider Biodiversity and other conservation issues, they do not specifically address the issues of the metropolitan area or resource needs. Therefore some additional principles need to be added when considering the need for Basic Raw Materials.

The *Environmental Protection ACT 1986 Section 51O* states that the "CEO may take into account other matters that the "CEO considers relevant" (*EP ACT 1986 Section 51O*). Therefore Section 51O of the *Environmental Protection Act 1986* allows the CEO to take planning matters into account when making clearing decisions, such as a State Planning Policy and community need.

A separate Flora and Vegetation Assessment and Report is prepared for the site and is attached as Appendix 1.

The procedures used for vegetation clearing are documented in 5.9.2 Rehabilitation. These were used and are included here in case a small area of additional clearing is applied for to the immediate north of the existing permited area.

Topsoil and overburden treatment is covered in 5.9 Rehabilitation. All suitable materials will be retained for rehabilitation and directly transferred where possible.

5.6.3 Fauna

A fauna study was not conducted because the site is significantly altered native vegetation that is subject to grazing. Fauna do not seem to have been impacted on by the past clearing and continued excavation.

A summary of the fauna on site is included in 2.6 fauna. Some data on the wetlands of the Yalgorup National Park is provided in 2.7 Wetlands.

The survival and disturbance to fauna depends on the end use of the site. The site is to be cleared progressively and returned progressively to local native vegetation in order to minimise impacts on fauna.

The re-establishment of local native flora species and habitats, with the various commitments to that achievement, will provide a mechanism for a return of fauna.

With the degraded nature of the vegetation and the species present it is unlikely that *Calyptorhynchus latirostris* and *Calyptorhynchus baudinii,* which are listed on State and EPBC conservation databases, would nest or use the site for feeding. The flora species are not regarded as significant habitat species. They are not used for roosting or nesting.

Considering the proposed disturbance and the small number of suitable food species, referral to the Commonwealth under the *EPBC Act 1999* would not be triggered.

The fauna that may potentially occur are listed in 2.6 Fauna and in particular Dell and Hyder (1) 2009.

The key issues are the fauna associated with elevated remnant vegetation and those associated with the lakes.

The dry land fauna will be little impacted. The area proposed to be cleared and progressively rehabilitated is only 12 hectares over 20 years. This is very small in relation to the total area of habitat that remains and is protected by the Yalgorup National Park status. There has been no change to that vegetation in recent years with no additional clearing.

In fact, with regrowth on pasture, habitat will be increasing. Some species such as kangaroos have been advantaged by permanent water soaks on pasture and the introduction of grassland.

The potential for dust to deposit on the adjoining vegetation is less than for a gravel road because the on site activities will be set back further than the vegetation which can be as close as 3 metres along a roadside.

Any risks associated with the potential for Root Mat Communities and stygofauna are regarded as low and if present are unlikely to occur or to be impacted on.

The limestone is too young, there is no evidence of stream caves or notching at wetlands and no Tuart trees are present. The base of the excavation is proposed to be in the order of 20 metres AHD, 20 metres above the water table.

Troglofauna may occur in cracks and crevices of the rocks and limestone, but no evidence of such occurrences have been noted in previous excavations.

The removal of limestone will be progressive and followed by rehabilitation. The limestone will be excavated to a limestone floor and batter slopes that will also contain similar small cracks and joints, which will help replicate any potential habitats that currently exist. Some of the rehabilitated area will be left with limestone rock and boulders scattered on the surface to provide additional habitat. Rehabilitation will be to native vegetation.

All of the above measures will minimise the risk to any troglofauna should they currently occur.

5.6.4 Wetlands

Lake Clifton

It is impossible to think that dust will travel over 2 km and have any significant or noticeable impact on any sensitive premises or Lake Clifton. With a buffer of 200 metres, with intervening vegetation, it is also considered most unlikely that any dust will impact on Lake Pollard. Limestone is predominantly calcium carbonate with some sand grains. It is an integral part of the local environment. Calcium carbonate is an integral substance in the waters and sediments of Lake Clifton and Lake Pollard and is essential for the development of most life within those systems, including the Thrombolites which incorporate it into their structures. (Figures 2, 3 and 8).

Assessment of the proposal against EPA Bulletin 864 and EPA Guidance 28 shows that Extractive Industries are not listed as a landuse requiring management with respect to Lake Clifton. This includes the potential for impacts from quarries which have been actively conducted in the catchment for many years, long before the documents were published.

Lake Pollard

Lake Pollard is brackish as confirmed by (Cape Bouvard Investments 2009 Figure 8). A fresh water lens overlays the subject land with water flow both to the east to Lake Pollard and west towards the coast. There is also a suggestion that there could be a connection in water flow between Lake Pollard and Lake Clifton because of the large surface area of Lake Clifton causing a small draw from Lake Pollard.

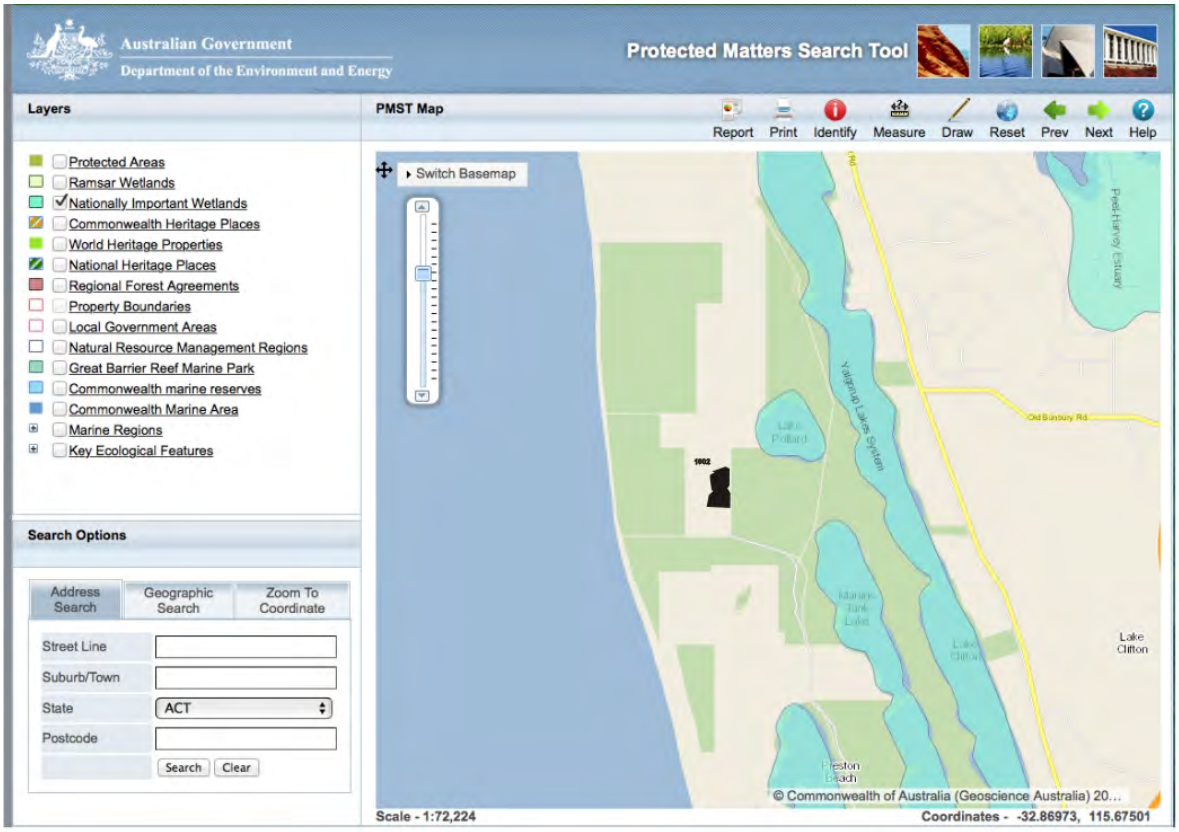
The Guidelines, which include the Department of Health guidelines for spray drift and studies conducted at Emerald in Queensland that are used by the Department of Health, all suggest that a tree buffer of 20 metres width will provide an effective buffer for fine particulates. The site has a 200 metre tree buffer to Lake Pollard. (*Department of Health, 2012, Guidelines for Separation of Agricultural and Residential Land uses*).

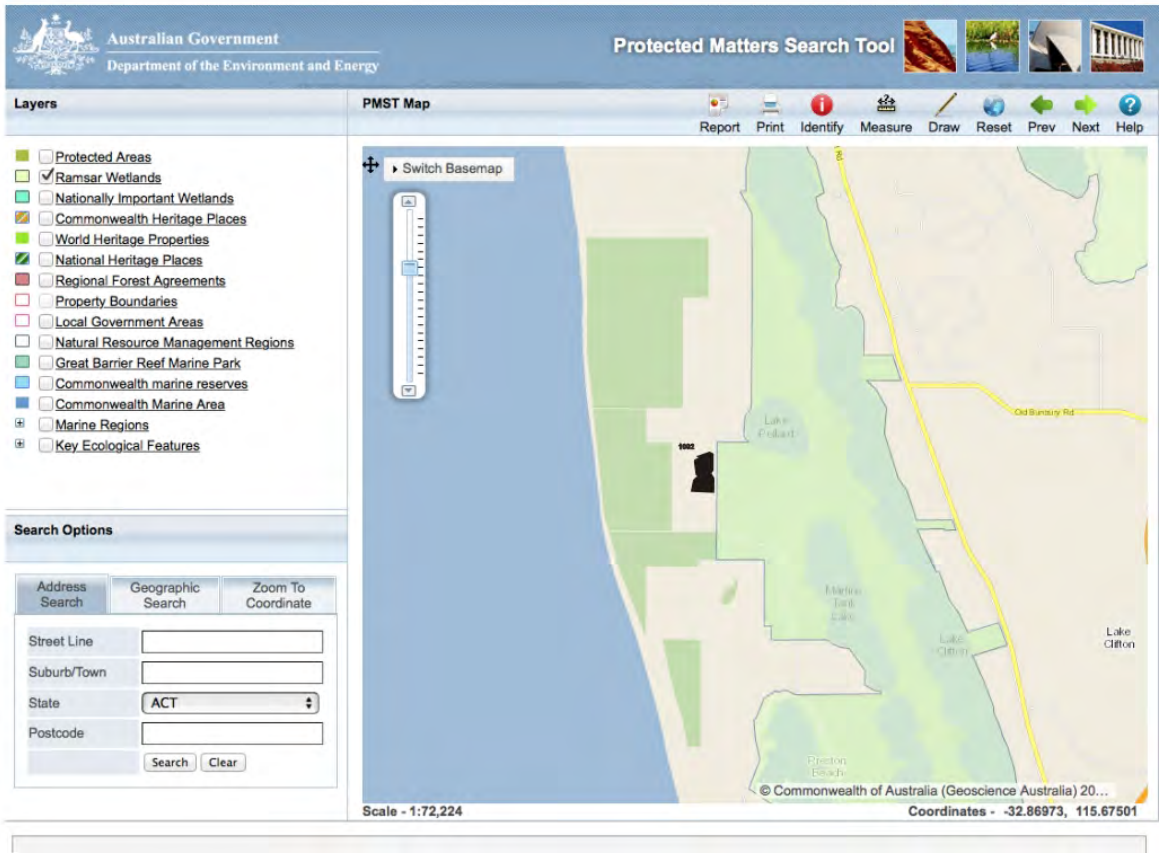
A 600 metre buffer of vegetation is to be retained to the adjoining land of Yalgorup National Park in the south.

Any dust falling on vegetation will have minimal impact as evidenced by native vegetation around limestone pits that are unaffected by the operations. For example at Wesco Road and Hopkins Road limestone quarries. Figure 9.

Any dust is readily washed from leaves by even very small amounts of rainfall. The potential impacts are minimal, and adjacent to gravel roads there is almost always no discernible impacts on the growth and success of native vegetation. Figures 3 and 9.

The bird life on Lake Pollard will be protected because of the 600 metre setback to the lake. It is shown in many locations that some activity set back from lakes does not impact on bird life. For example the Peel Harvey Estuary, Lake Clifton and the Coorong in South Australia still have significant amounts of birdlife even though clearing and human activity occurs in close proximity to the water bodies in some locations.





Lake Pollard and Lake Clifton Wetlands

Lake Pollard Walking Trail

The Lake Pollard Walking Trail runs from Martins Well in the south towards Lake Pollard, It skirts the southern end of the lake and runs to a Bird Hide located on the eastern side of the lake one km from the proposed excavation. Figure 2.

This portion of the walk trail will not be impacted by the proposed excavation. One part of the walk trail directs walkers to the southern boundary of Lot 1001 to walk up the fire break in the Yalgorup National Park to the hill on the ridge immediately south of the proposed excavation. The excavation will not impede the views of the lake but it may be possible to see the pit from the top of the ridge even with an expanded setback of 500 metres combined with a planted tree belt and natural regrowth of the native vegetation. Figure 2.

It is anticipated that the quarry will not be visible from the Lake Pollard Walk Trail which is located to the east behind the large limestone ridge.

A small section of the walk trail accesses Preston Beach Road North.

It is a little unclear why the Lake Pollard walk trails uses Lake Preston North Road for part of its route. (DPaW Appendix 4). There is another route through woodland and it remains unclear why visitors would walk along the road from a safety or experience point of view. The trail just touches the road for less than 50 metres at a sharp left dogleg and from observations it appears that there are short cuts removing the need to access the road.

As part of the upgrade a shortcut should be constructed to be part of the track, and the public safety for users of the DPaW walking trail would be improved.

Operational times are restricted to the summer and autumn months (December to April) on Monday to Friday excluding Public holidays.

Biodiversity - Applicable Legislation / Policies
• None applicable – Likely to be conditioned
Commitments to Biodiversity Management
• The excavation areas are cleared. • The level of bushland disturbance and the use of the site for grazing reduces the potential for significant fauna to be present. • The site will be progressively cleared and rehabilitated.

5.6.5 Dieback Management Plan

Dieback of vegetation is often attributed to *Phytophthora cinamomi* even though there are other *Phytophthora* species and other diseases such as *Armillaria* that can cause dieback like symptoms. Microscopic soil-borne fungi of the genus *Phytophthora* kill a wide range of native plants and can cause severe damage to many vegetation types, particularly those from the families Proteaceae, Epacridaceae, Xanthorrhoeaceae and Myrtaceae.

In most cases dieback is caused by a pathogen which infests the plant and causes it to lose vigour, with leaves dying, and overtime may kill the plant. As such the management of Dieback is essentially related to plant hygiene when coming onto a site and within a site.

There are several guides to the management of Dieback.

- Department of Environment and Conservation (DPaW) Dieback Hygiene Manual 1992 is a practical guide to Dieback management.
- Department of Environment and Conservation (DPaW) Best Practice Guidelines for the Management of Phytophthora cinamomi, draft 2004.
- Dieback Working Group 2005, Management of Phytophthora Dieback in Extractive Industries.

The Department of Environment Regulation generally recognises that Dieback is less likely to impact on vegetation on limestone and Spearwood/Cottesloe Land Systems, Podger F D and K R Vear, 1998, *Management of Phytophthora and disease caused by it, IN Phytophthora cinnamomi and the disease caused by it - protocol for identifying protectable areas and their priority for management*, EPA 2000. The same is noted in DEC 2009.

Dieback is only likely to be an issue when equipment is brought to the site from a dieback affected area either through vehicles or plant and soil materials, therefore the following general principles are applied to Dieback management.

Not all potential impacts will apply to all parts of the proposed quarry operations.

- Excavation will be undertaken using practices recommended by DEC. See *CALM Dieback Hygiene Manual 1992* which is more practical and *CALM Best Practice Guidelines for the Management of Phytophthora cinamomi, draft 2004.* See also *Dieback Working Group 2005, Management of Phytophthora Dieback in Extractive Industries.*
- Dieback diseases are more likely to be transported under moist soil conditions.
- All vehicles and equipment to be used during land clearing or land reinstatement, should be clean and free from soil or plant material when arriving at site.
- Washdown of vehicles and equipment should be prior to arriving on site and to the procedures in CALM Guidelines for Dieback Management.
- No soil and vegetation should be brought to the site apart from that to be used in rehabilitation.
- Plants to be used in rehabilitation should be from dieback free sources.
- Vegetated areas ahead of excavation should be quarantined to onsite access
- Unwanted access to vegetated areas is to be discouraged through a lack of tracks and external fencing.
- Excavation vehicles will be restricted to the excavation area apart from clearing land.
- Rehabilitated surfaces are to be free draining and not contain wet or waterlogged conditions.
- Illegally dumped rubbish is to be removed promptly**.**
- No contaminated or suspect soil or plant material is to be brought onto the site.
- When clearing land or firebreaks vehicles are to work from dieback free areas towards dieback areas; or, in situations where dieback interpretation is not possible, from areas of higher quality vegetation to areas of lower quality vegetation.
- Roads should be free draining and hard surfaced.
- A hygienic site is to be maintained by not bringing any soil or plant material onto the site except for rehabilitation purposes or from known dieback free areas.
- All plants, seeds and other materials used in rehabilitation will be sourced from dieback free areas.
- Compliance with the Weed Management Policy.

Dieback principles will be followed even though there is a reduced risk of spread on calcareous soils such as this. (Podger F D and K R Vear, 1998).

The proposed access road will be the limestone road.

The aim of dieback management during excavation is to minimise the risk of entry of dieback into the site. The calcareous soils of the remnant vegetation are unlikely to allow *Phytophthora* to spread but there may be other pathogens such as *Armillaria.*

In many ways the management of the site for dieback is similar to that for the management of weeds, and the two management practices should be considered together.

The other management is to ensure that all excavation equipment and road transport vehicles are clean and free from soil and vegetable matter prior to entering the operations.

Vehicles are to be prohibited from entering vegetation ahead of excavation, apart from normal travel along made firebreaks and roads for normal security and farm maintenance activities.

Topsoil will be cleared according to 5.9.2 Rehabilitation Procedures.

Dieback - Applicable Legislation / Policies
• *DEC (DPaW) Dieback Hygiene Manual 1992.* • *DEC (DPaW) Best Practice Guidelines for the Management of Phytophthora cinamomi, draft 2004.* • Dieback Working Group 2005, *Management of Phytophthora Dieback in Extractive Industries.*
Commitments to Dieback Management
• Doyles Lime Service will not impact on the adjoining remnant vegetation by the proposed excavation. • Doyles Lime Service willmaintain the Dieback Management Policy to reduce the spread of Plant Pathogens.

5.6.6 Weed Management Plan

The management of weeds is essentially similar to that for plant diseases. The impact of weeds is really the impact within the local area and the more they are controlled the better. It is desirable that the site does not become a haven for environmental weeds and therefore a management and control program is warranted at all sites.

Weeds can be declared under the *Agriculture and Related Resources Protection Act 1976* which requires that Declared Weeds are eradicated. Other weeds are not Declared but may be classified as Environmental Weeds because they are well known for impacting on vegetation.

Generally if the actions taken for Dieback are applied they will also control weeds.

Weed management is an integral part of normal farming operations on Lots 1001 and 1002. However the pasture land has, on the limestone resource, much *Trachyandra divaricata,* a weed that is noted by DEC 2009 as being invasive, but is mostly invasive on pasture and on the limestone resource area occurs on the cleared strips.

- All vehicles and equipment to be used during land clearing or land reinstatement, should be clean and free from soil or plant material when arriving at site.
- No soil and vegetation should be brought to the site apart from that to be used in rehabilitation.

- Plants to be used in rehabilitation should be free from weeds.
- Vegetated areas ahead of excavation should be quarantined to excavation vehicles until required.
- Unwanted access to vegetated areas is to be discouraged through a lack of tracks and external fencing.
- Weed affected top soils may need to be taken offsite, used in weed affected areas, buried by 500 mm soil/overburden or taken offsite or sprayed to minimise the weed impact.
- Illegally dumped rubbish is the major source of weeds and is to be removed promptly.
- No weed contaminated or suspect soil or plant material is to be brought onto the site.
- When clearing land or firebreaks vehicles are to work in conjunction with dieback principles and push from areas of better vegetation towards areas of lower quality vegetation.
- Weeds should be sprayed with broad spectrum spray prior to planting or seeding in weed affected soils.
- Unwanted grasses should be sprayed with grass selective spray prior to seeding or rehabilitation.
- Weed management should work from least affected areas to most affected.
- Declared weeds should be treated promptly by digging out or spraying.
- Weeds will be treated promptly no matter how few there are.
- Ongoing monitoring of weeds should be undertaken at least annually in autumn, prior to winter rains.

The Dieback Management actions will also be used to assist weed management.

Inspections should be conducted to monitor the presence and introduction of weeds on an annual or more frequent basis. On identification, introduced weeds will either be removed, buried, or sprayed with a herbicide.

Weed - Applicable Legislation / Policies
• *Agriculture and Related Resources Protection Act 1976.*
Commitments to Weed Management
• Doyles Lime Service will use the weed policy to try and prevent the introduction of Declared, Environmental or other weeds to the site.

5.7 Fire Protection

The excavation area will form a natural firebreak; the access road will also assist. Water available on site can be used for fire fighting.

Normal rural firebreaks will be maintained.

The safety of workers is managed through a Safety Management Plan developed through *the Mines Safety and Inspection Act 1994 and Regulations 1995*.

There are a number of management actions that can be taken in quarries to minimise fire risk and these will be used wherever possible. The general management actions are summarised below, together with the potential issues that relate to this site. The actions will be used where applicable and as the opportunity presents to minimise fire risk.

- Restrict vehicles to the operational area, particularly on high fire risk days.
- Use diesel rather than petrol powered vehicles.
- Maintain perimeter fire breaks as required.

- Ensure fire risk is addressed and maintained through the site Safety Management Procedures.
- Provide an emergency muster area, communications and worker induction and training.
- Establish on site water supplies for potential use in extinguishing fire.
- Secure the site from unauthorised access.
- Maintain normal farm fire breaks and fire prevention procedures.

There is less potential fire risk from quarries than other land uses because quarries clear land, and vehicles are restricted to cleared access roads, the pit floor, processing and stockpile areas.

These cleared areas form a natural firebreak. The main risk comes from an external fire in the surrounding vegetation, impacting on the quarry. As such the fire risk is no greater than a rural property.

Fire risk is normally controlled through the *Bush Fires Act 1954* and local authority bylaws.

Perimeter firebreaks will be maintained.

Fire Management - Applicable Legislation / Policies
• *Bush Fires Act 1954.* • *Shire of Waroona Bylaws.*
Commitments to Fire Management
• Doyles Lime Service will ensure the quarry operates to the standards in the *Mines Safety and Inspection Act 1994 and Regulations 1995.* • Doyles Lime Service will ensure the quarry complies with the local fire safety requirements and operates in compliance with normal rural fire practise and restrictions.

5.8 Aboriginal Sites

A search of the Department of Aboriginal Affairs database does not reveal any aboriginal sites on the subject land. The land has been significantly disturbed over many years.

Aboriginal Sites
• *Aboriginal Heritage Act 1972-1980*
Commitments to Fire Management
• Should any evidence of early aboriginal occupation be uncovered during the operation of the quarry, development will be stopped pending an assessment by a recognised consultant. • If the site is confirmed as a site under the provisions of Section 15 of the Aboriginal Heritage Act 1972-1980 and Amendments, the proponent will comply with the provisions of the Act, relating to development in areas of recognised aboriginal sites.

5.9 Rehabilitation

5.9.1 Background

The area is currently used for agricultural activities. The excavation site has been cleared in strips and grazed.

It therefore varies between Completely Degraded strips to Degraded to Good strips of vegetation.

- **Land Use Policies**

The land is zoned Rural and is currently used as a grazing property.

- **End Use**

The extraction of limestone and sand is seen as an interim use of the land prior to utilisation of the area by the current land holder.

The eastern 20 metres of pit will be rehabilitated to local native vegetation. The remainder will be pasture with a minimum of 200 trees in clumps which will compensate for the land to be cleared. (Figures 3, 4 and 9).

The remainder, including the sand resource, will be returned to pasture to enable the agricultural productivity of the land to be maintained.

The final contours are shown on the attached Concept Contour Plans.

- **Mine Closure Considerations**

Rehabilitation will be directed towards the final end land use. In general it should be aimed at the highest level of rehabilitation, however there is no point planting good native vegetation or tree belts if they are to be immediately cleared for an alternative land use.

Rehabilitation will contain Dieback and Weed Management in addition to monitoring and replanting failed areas.

Appropriate topsoil management is seen to be an important element in achieving successful rehabilitation and plant re-establishment on the restored surface.

- **Rehabilitation Objectives and End Use**

There are a number of management actions that can be taken in quarries to maximise rehabilitation effort and these will be used wherever possible. The general management actions are summarised below and will be used where applicable and as the opportunity presents.

- **Completion criteria – Interim Final Landuse**

The aim of the rehabilitation is to stabilise the finished floor pending decisions to be made on the end use of the site.

  - Stable post-mining landscape, and the minimisation of wind erosion.

- Provide for the protection of the local groundwater resource in terms of both quality and quantity.

- Achieve weed species at levels not likely to threaten the vegetation.

- Provide a self sustaining cover of local native plants at a minimum of 1200 native plant stems per hectare on the steeper slopes. (Figure 5).

- Sustainable pasture for the remainder of the excavated area with a minimum of 200 trees in clumps. (Figure 5)

5.9.2 Rehabilitation Procedures

- **Vegetation Clearing – Recovery**

1. Vegetation clearing will be progressive, subject to a Clearing Permit being granted. The sand resoruce can be extracted without clearing for much of the resource.

2. Useful timber will be taken for firewood, if feasible and subject to liabilities and site safety.

3. Where practicable vegetation will be directly transferred to a batter slope or bund being rehabilitated. Smaller indigenous shrub material will be used in the rehabilitation process when available and suitable. Vegetation fragments will be laid on re-formed slopes to reduce wind and water erosion as well as provide a source of seeds for revegetation.

4. If direct transfer is not possible the vegetation will be stored in low dumps for later spreading.

- **Landform Reconstruction and Contouring**

1. All buildings, equipment and machinery will be removed from site.

2. The final landform will be formed to the interim final concept plan.

3. The land surface will be a gently undulating floor as shown on the attached Final Concept Plans with sloping batters at less than I : 4 vertical to horizontal and some at 1 : 2 at the steeper northern and southern edges of the ridge.

4. The land surface will be formed to the requirements of the *Mines Safety and Inspection Act 1994 and Regulations 1995* pending decisions to be made on the final end use.

5. Limestone floor will be deep ripped in two directions. The width between rip lines will be 1 metre intervals.

6. A minimum of 300 mm of overburden will be spread over the surface where available to provide a substrate for revegetation.

7. Experience by Landform Research on limestone rehabilitation on mining leases north of Wesco Road is that good revegetation can be achieved by planting into soft overburden and deep ripped limestone floor, if suitable local species are used.

- **Topsoil and Overburden Recovery and Reuse**

1. Where possible topsoil and overburden will be directly transferred from an area being cleared to an area to be rehabilitated.

2. Overburden, as yellow and brown sand and low grade limestone, will be pushed to the perimeters of the excavation, particularly the western edges, to assist with visual and noise screening. From there it can be used for the rehabilitation process.

3. Studies have shown that topsoil stripping and placement is best undertaken in summer for maximum germination, but this raises the potential for additional dust generation from the fine humus particles.

4. Topsoil will be spread directly from an area being cleared where possible, otherwise reclaimed from a topsoil dump.

5. Topsoil will be spread at depths of 5 cm and should be spread during summer, preferably by the end of February.

- **Pre - Vegetation Establishment**

1. Pre-seeding weed control is only likely to be required where topsoils are used that contain weed species.

2. If required this is normally only conducted after overburden and topsoil have been spread and any seeds have been allowed to germinate. Broadscale weed treatment can be detrimental to the germination and growth of native and some pasture species but may be required if the weed load is to be reduced.

3. Any weeds likely to significantly impact on the rehabilitation will be sprayed with Roundup or similar herbicide or grubbed out, depending on the species involved. Weed affected topsoil and overburden will be buried. The Weed Management Plan will form the basis of weed treatment. Depending on the nature of the planting substrate, a broad spectrum spraying program may be used. In areas where grass only is a potential problem grass specific sprays will be used. In some areas where topsoil from cleared native vegetation is available no spraying may be required.

- **Revegetation**

Native Vegetation

1. Doyles Limes Service will spread any native vegetation, plus leaf, root and organic matter collected from the land clearing procedures. This will increase the total organic carbon fraction, improving soil properties such as resistance to water and wind erosion and moisture retention. The difference in properties between existing topsoil and subsoils is not considered a major impediment to rehabilitation of native species in the area.

2. Topsoil will be re-distributed in rehabilitated areas to depths of 50 mm where available. Whilst burning is not always practicable the mixing of topsoil with ash and charcoal from burnt vegetation has shown a demonstrated improvement in the germination of local native species by triggering some species that do not readily germinate and by increasing germination rates. (Landform Research at Pickering Brook Gravel Quarry).

3. Topsoil provides a useful source of seed for rehabilitation of Limestone Heathlands, when the correct handling of the topsoil is used; stripped and replaced dry (autumn direct return). Maximum depth of 50 mm can be used to optimise revegetation of species-rich plant communities. However this needs to be balanced against the weed load as described under Weed Management.

4. Studies have shown that topsoil stripping and placement is best undertaken in summer for maximum germination, but this raises the potential for additional dust generation from the fine humus particles.

5. Topsoil will be spread directly from an area being cleared where possible, otherwise reclaimed from a topsoil dump.

6. Topsoil will be spread at depths of 50 mm and should be spread during summer, preferably by the end of February.

7. Rehabilitation will take place during the first winter months following the restoration earth works of each particular section of quarry. Leaving the completed earth works for one season will reduce the success of rehabilitation by at least 50 %, due to compaction effects.

8. Local provenance seed will be collected from the site or purchased from commercial seed collectors. Tube plants are also desirable because they reduce the risk of failure by providing a third method of establishment;

   - topsoil spreading
   - seed spreading
   - tube plants

   A species list is attached.

9. A combination of the three methods is always preferred by Landform Research and has proven to be the most versatile and successful. The amount and species of additional seed and tube stock depends on the quality and seed store within the topsoil, and may vary from stage to stage.

10. Seeds of indigenous species will be scattered during late summer at the rate of approximately 1 kg seeds per hectare if required.

11. Seeding conducted in summer will use scarified leguminous seeds that have been “dry smoked”. Seeding conducted in July to August will have the leguminous seeds heat treated and all seeds will be smoke treated by soaking in “smoke water” for 24 hours prior to seeding.

12. Seed spreading will be achieved either using mechanical seed dispersal equipment or using manual methods. Bulking with a spreading agent such as sawdust, vermiculite or sand is desirable.

13. Plant an additional 500 tube plants of local native species per hectare, in June. Alternatively establish the vegetation wholey through the use of tube stock.

14. Use a 10 g tree tablet or small handful of fertiliser beside each tube plant.

15. Rehabilitation will progressively follow mining with completed areas of the excavation being revegetated as soon as practicable.

Pasture Regeneration

16. The pit earthworks and restoration are as above including the spreading of overburden and topsoil.

17. Seeds of pasture species are spread during autumn if there is insufficient in the existing topsoil. Seeding is normally undertaken by the land holder or a contractor.

18. Seeds of indigenous species will be scattered during late summer at the rate of approximately 1 kg seeds per hectare if required.

19. Seeding conducted in summer will use scarified leguminous seeds that have been "dry smoked". Seeding conducted in July to August will have the leguminous seeds heat treated and all seeds will be smoke treated by soaking in "smoke water" for 24 hours prior to seeding.

20. Seed spreading will be achieved either using mechanical seed dispersal equipment or using manual methods. Bulking with a spreading agent such as sawdust, vermiculite or sand is desirable.

21. Plant an additional 500 tube plants of local native species per hectare, in June. Alternatively establish the vegetation wholey through the use of tube stock.

22. For the existing rehabilitation there has been sufficient seed within the topsoil to return pasture.

23. However if sufficient seed is not available or does not germinate then additional seed will be added. The establishment of pasture, including the selection of the pasture species is appended to this Management Plan. The documentation is produced by the Department of Agriculture and Food.

24. For pasture land in this situation it is essential that the species are matched to the soil types and rainfall. The location falls into the "High Rainfall Coastal" planting regime with sandy to loamy gravel soils. Suitable perennial legumes include Birdsfoot trefoil, Lucerne, Strawberry Clover, and Sulla. Perennial pasture includes Perennial Ryegrass, Phalaris, Cocksfoot, and Summer Active Tall Fescue, Kikuyu and Rhodes Grass. Annual pasture species include Italian Ryegrass, Serradella, subterranean clover.

25. The actual species used will be determined by the individual season, nature of the rainfall in the preceding months and stocking/hay production proposed by the landholder which may change from time to time.

26. Seeding rates are 2 – 5 kg/ha depending on the species used; for example Ryegrass is seeded at 3 kg/ha whereas Rhodes Grass is seeded at 4 kg/ha.

27. The amount of fertiliser applied will depend on the species used; for example when planting legumes nitrogen fertiliser is reduced or not used as it inhibits nitrifying bacteria. Also the amount of sulphur, phosphate and trace elements used depends on the species and residual amounts retained in the soil. As a guide 50 kg/ha of superphosphate is likely to be used to assist legume and grass based pasture.

- **Fertiliser**

1. Fertiliser is not always required and will add nutrients to the ground water. If used a fertiliser containing low nitrogen, phosphorous and potassium, and trace elements, is recommended to be spread at rates of up to 30 - 50 kg/hectare, applied to rehabilitation areas in the year of planting.

2. Further investigation will be needed to determine suitable rates and the timing of fertilisation. It may be possible to integrate seed dispersal and fertilisation into a single pass. The fertiliser will need to supply macro-nutrients, phosphorus, nitrogen and potassium, and other micro-nutrients.

- **Irrigation**

1. Experience by Landform Research in rehabilitation of quarries in limestone has shown that when completed well there is no need for irrigation of the rehabilitation.

- **Erosion Control**

1. Soil erosion occurs when soil is exposed and disturbed by wind or water. Erosion involves soil particles being detached from areas not adequately protected by vegetation, and moved down-slope. This is not normally a significant problem in limestone, which crusts after the first winter.

2. The soils are very permeable and runoff is normally minimal unless surface materials become non-wetting. Even so experience shows that there is minimal non wetting and surface particle movement under such conditions.

3. Water erosion on the batter slopes can be avoided by the permeability of the materials and by leaving the surface soft, rough and undulating, with the undulations running along contour. The final machinery run should be along contour and not down slope.

4. Wind erosion will be controlled by rehabilitating the disturbed ground as soon as practicable.

5. The interim pasture cover will stabilise the soils pending decisions on the end use of the finished floor.

6. For rehabilitation areas, revegetation will take place as soon as possible following landform and soil reconstruction.

- **Monitoring**

1. During late summer an assessment of the success of the rehabilitation will be made to determine the rehabilitation requirements for the following winter.

2. Monitoring includes visual assessments and, where necessary, counts to determine the success of the soil stabilisation.

3. Native vegetation cover and soil stability will be assessed and corrected if found to be non compliant.

4. As necessary steps will be taken to correct any deficiencies in the vegetation.

5. Rehabilitation of each stage will be monitored for a period of three years to ensure that the revegetation meets the completion criteria of providing self sustaining vegetation cover.

6. In areas of rehabilitation that do not meet the completion criteria measures are to be taken to increase the stem density to achieve the completion criteria. This could include but not be limited to additional seeding or planting.

Temporary Closure

1. If for any reason the site is closed on a temporary basis for any period of time the following will be implemented.

2. The faces will be made safe or protected by bunds and/or fencing with signs in compliance with the *Mines Safety and Inspection Act 1994*.

3. All fluids, liquids and other materials that could leak over time, change or potentially impact on the environment will be removed from site, or stored in a manner that will not permit any environmental impact.

4. Mobile and other plant will be made safe or removed from site in compliance with the *Mines Safety and Inspection Act 1994.*

5. Fencing will be maintained to make the pit safe.

6. Perimeter signage will be maintained.

7. The site will be monitored for weeds and interim rehabilitation success twice per year.

8. Regular site inspections will be made to ensure compliance with the *Mines Safety and Inspection Act 1994,* and any other actions that are required to make the site compliant or environmentally sound will be made as the need arises.

Rehabilitation - Applicable Legislation / Policies
• *EPA, Guidance 6, Rehabilitation of Terrestrial Ecosystems*
Commitments to Rehabilitation
• Doyles Lime Service will ensure the completed land surface is formed to the standards in the *Mines Safety and Inspection Act 1994 and Regulations 1995.* • Doyles Lime Service will rehabilitate the surface as outlined above and monitor the revegetation as described above.

Tree and Shrub Species to be used in rehabilitation for native vegetation and the trees in parkland pasture.

Tree and tall shrub species to be used for rehabilitation occur locally and will include; (Tree or large shrub is listed T)

Acacia cyclops (T)
Acacia lasiocarpa

Acacia saligna (T)
Acacia truncata
Agonis flexuosa (T)
Dryandra lindleyana var *lineleyana (Banksia dallannyei)*
Dryandra (Banksia) sessilis
Eremaea glabra
Eucalyptus decipiens (T)
Eucalyptus foecunda (T)
Eucalyptus gomphocephala (T)
Eucalyptus petrensis (T)
Grevillea vestita
Hakea lissocarpha
Hakea prostrata
Hakea trifurcata
Hardenbergia comtoniana
Kennedia prostrata
Kunzea glabrescens
Melaleuca huegelii (shrub)
Melaleuca lanceolata (T)
Melaleuca systena (shrub)
Myoporum insulare
Olearia axillaris
Templetonia retusa

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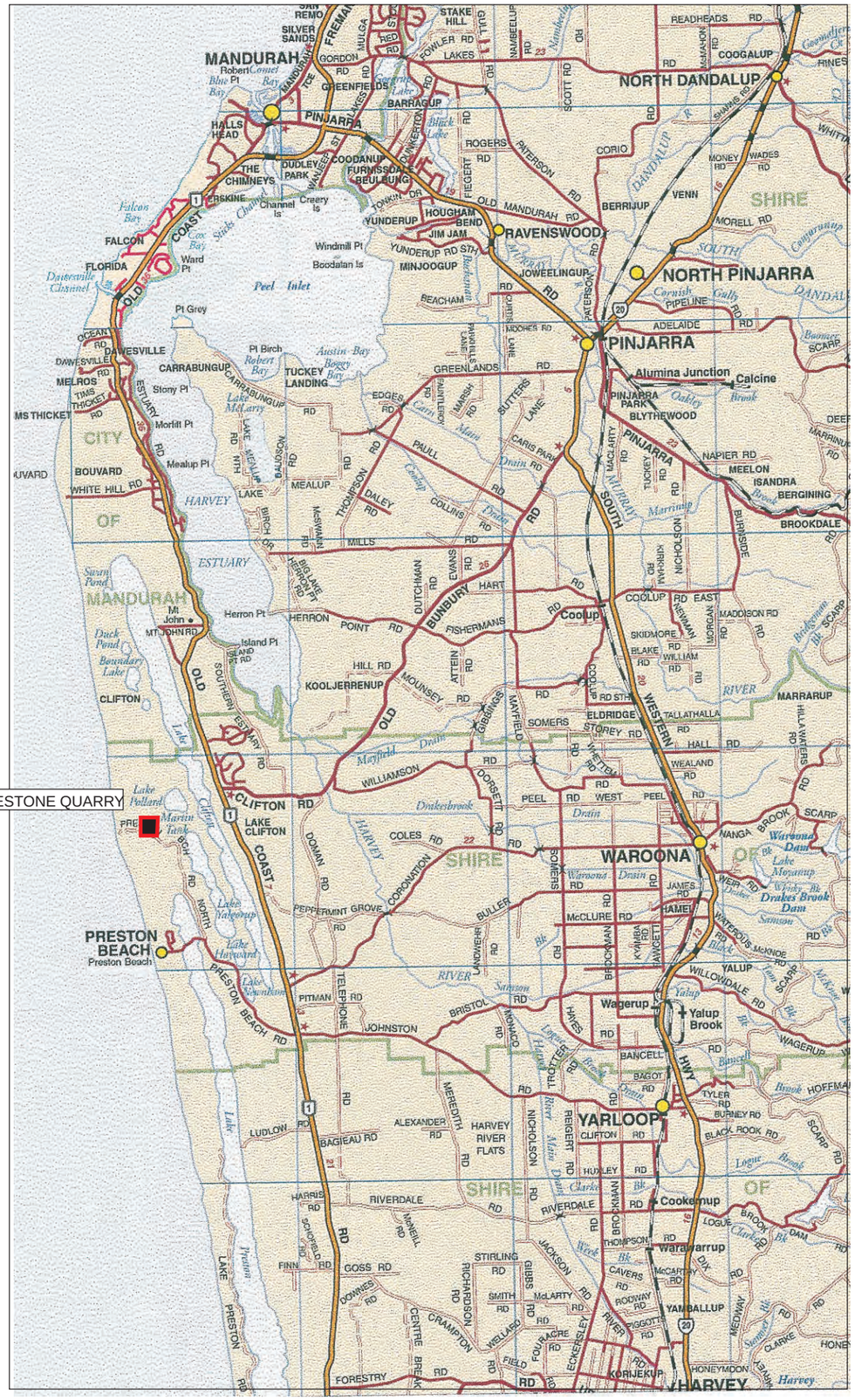
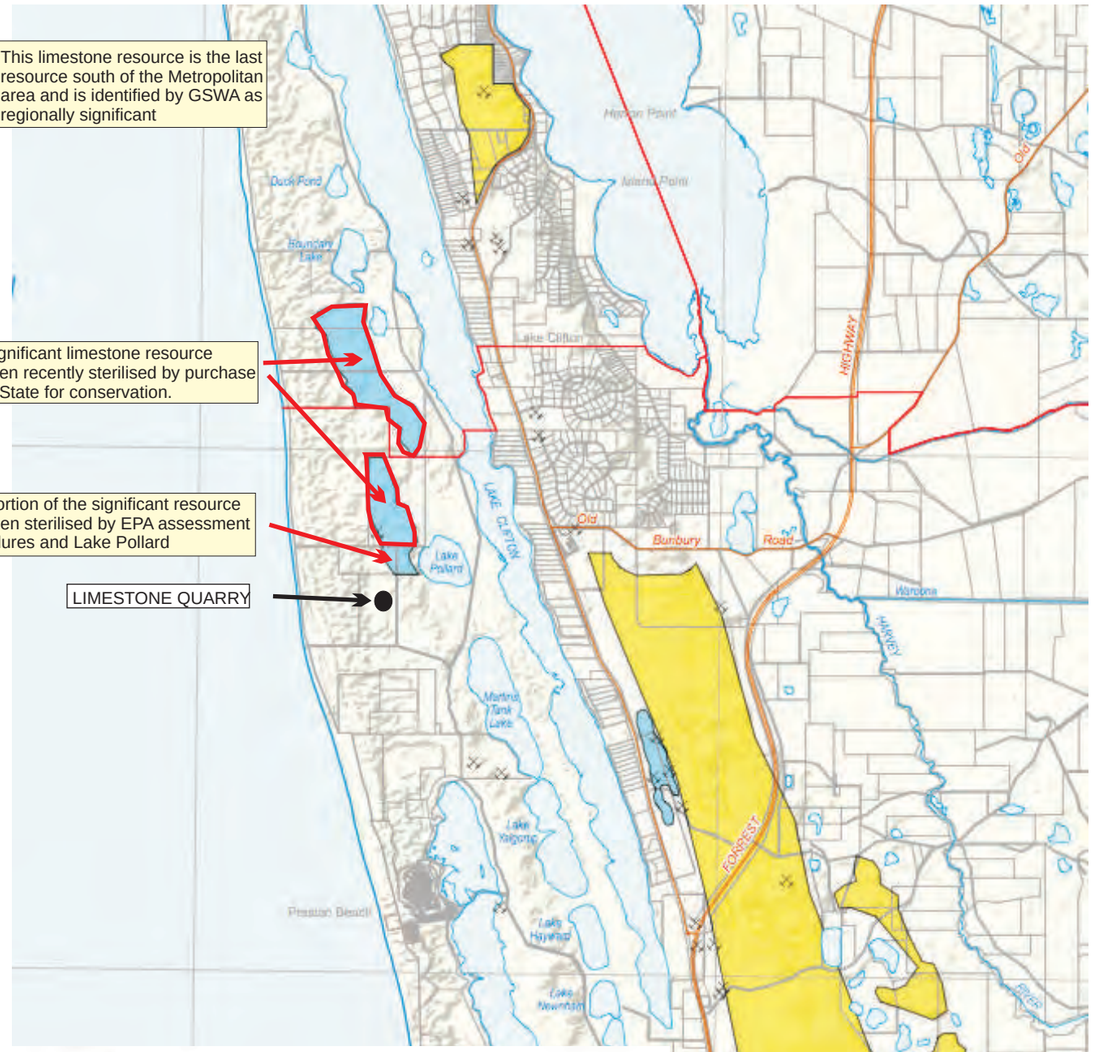




Government of Western Australia
Department of Mines and Petroleum

Geological Survey of Western Australia

Scale 1:100 000

UNIVERSAL TRANSVERSE MERCATOR PROJECTION
HORIZONTAL DATUM: GEOCENTRIC DATUM OF AUSTRALIA 1994

GDA

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

RESOURCE POTENTIAL FOR LAND USE PLANNING

REGIONALLY SIGNIFICANT BASIC RAW MATERIALS

PINJARRA

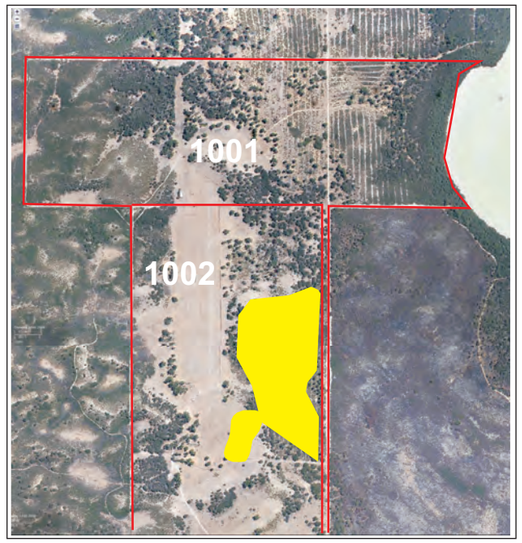
SHEET 2032 FIRST EDITION 2012

Figure 1

DOYLES LIME SERVICE – PRESTON PIT	
LOCATION	
Landform Research	May 2013
Source NEARMAP	Scale See Plan

Figure 2

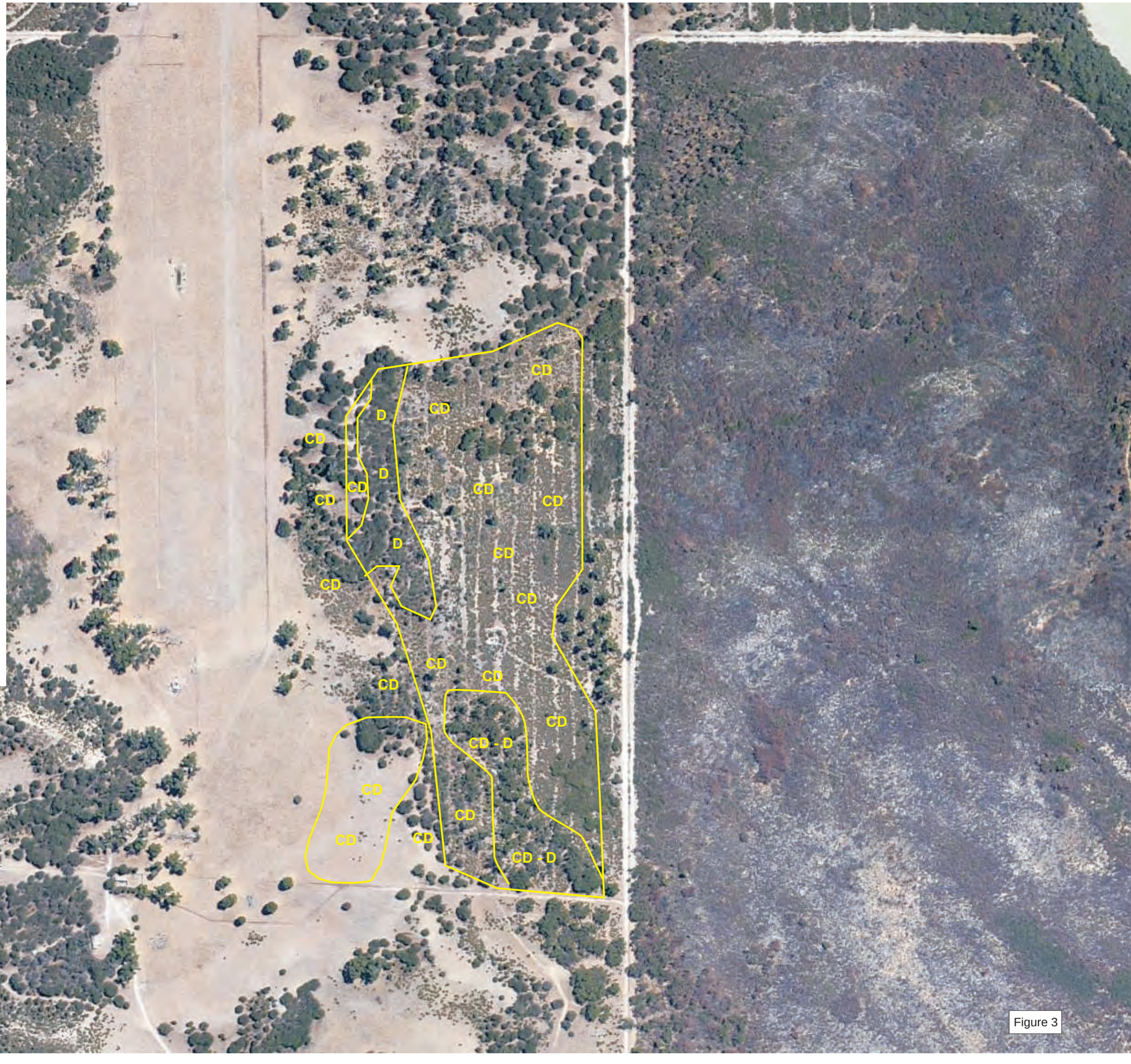
DOYLES LIME SERVICE – PRESTON PIT	
SURROUNDING LANDUSE	
Landform Research	May 2013
Source NEARMAP	Scale See Plan



VEGETATION CONDITION

Vegetation Condition Scale reproduced (Bush Forever 2000).

Condition Score	Vegetation Condition	Vegetation Descriptors
P	Pristine	Pristine or nearly so, no obvious signs of disturbance
E	Excellent	Vegetation structure intact, disturbance affecting individual species, and weeds are non aggressive species.
VG	Very Good	Vegetation structure altered, obvious signs of disturbance. For example disturbance to vegetation structure caused by repeated fires, the presence of some more aggressive weeds, dieback, logging and grazing.
G	Good	Vegetation structure significantly altered by very obvious signs of multiple disturbance. Retains basic structure or ability to regenerate it. For example, disturbance to vegetation structure caused by very frequent fires, the presence of some very aggressive weeds at high density, partial clearing, dieback and grazing.
D	Degraded	Basic structure of the vegetation severely impacted on by disturbance. Scope for regeneration but not to a state approaching good condition without intensive management. For example disturbance to vegetation structure caused by very frequent fires, the presence of very aggressive weeds, partial clearing, dieback and grazing.
CD	Completely Degraded	The structure of the vegetation is no longer intact and the area is completely or almost completely without native species. These areas are often described as “parkland cleared” with the flora comprising weed or crop species with isolated native trees or shrubs.



Showing 2 Feb 2009
100 m
300 ft
Legal

DOYLES LIME SERVICE – PRESTON PIT

LIMESTONE RESOURCE AREA
VEGETATION CONDITION

Landform Research	May 2016
Source NEARMAP	Scale See Plan

Figure 3

Resource are showing limestone and strip clearing. Pasture and exotic species occupy the cleared strips. Other vegetation has been grazed and is regrowth

Sand and Limestone resource area, view east to the limestone ridge. The resource in the trees will not be taken

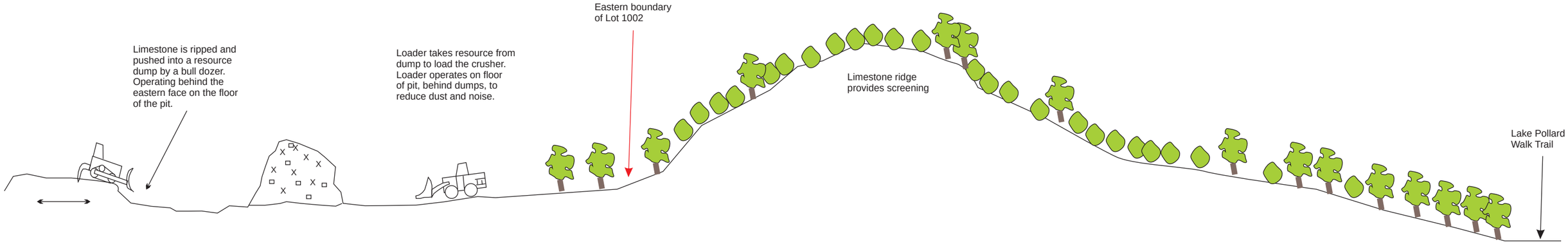
Figure 4

DOYLES LIME SERVICE – PRESTON PIT	
VEGETATION – LIMESTONE PIT	
Landform Research	May 2016
Source NEARMAP	Scale See Plan

RESOURCE EXCAVATION

WEST

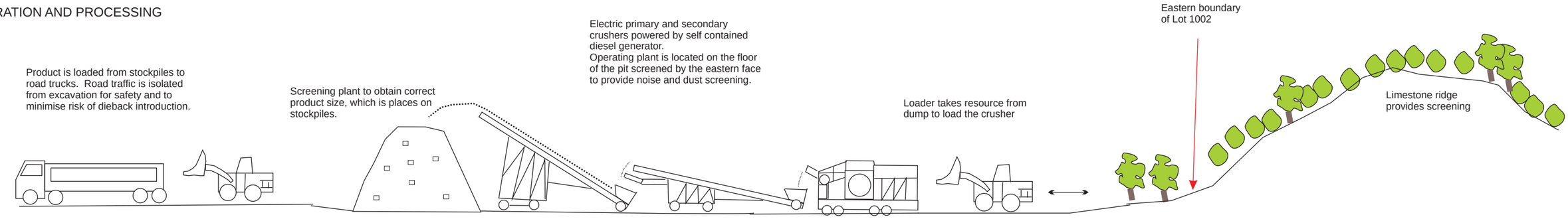
EAST



WEST

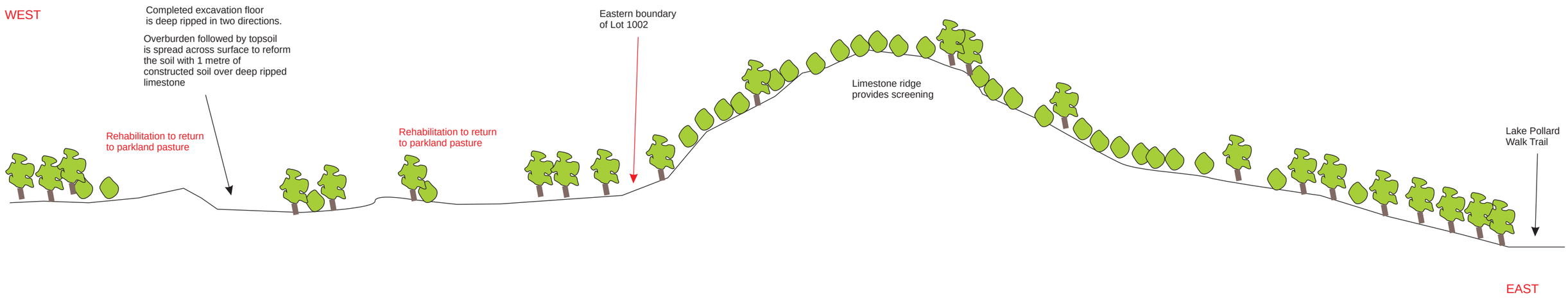
EAST

OPERATION AND PROCESSING



LAND RESTORATION AND REHABILITATION

EAST



EAST

PROCESSING

Landform Research

PROPOSED OPERATIONS - LIMESTONE OPERATIONS - PRESTON
SKETCH SECTIONS

See Figures 4 and 6 for sections and aerial view of typical and proposed operations.

DOYLES LIME SERVICE

Figure 5

Doyles Lime typical operations at Myalup pit. Operations will be similar at the proposed Preston pit.

Typical crushed lime resource showing working behind a face as proposed

Loader used to move materials around the operations.

See Figures 4 and 5 for sections and aerial view of typical and proposed operations.

Processing at Myalup showing the face used for visual, noise and dust screening

Figure 6

DOYLES LIME SERVICE – PRESTON PIT	
OPERATIONAL PHOTOGRAPHS	
Landform Research	May 2013

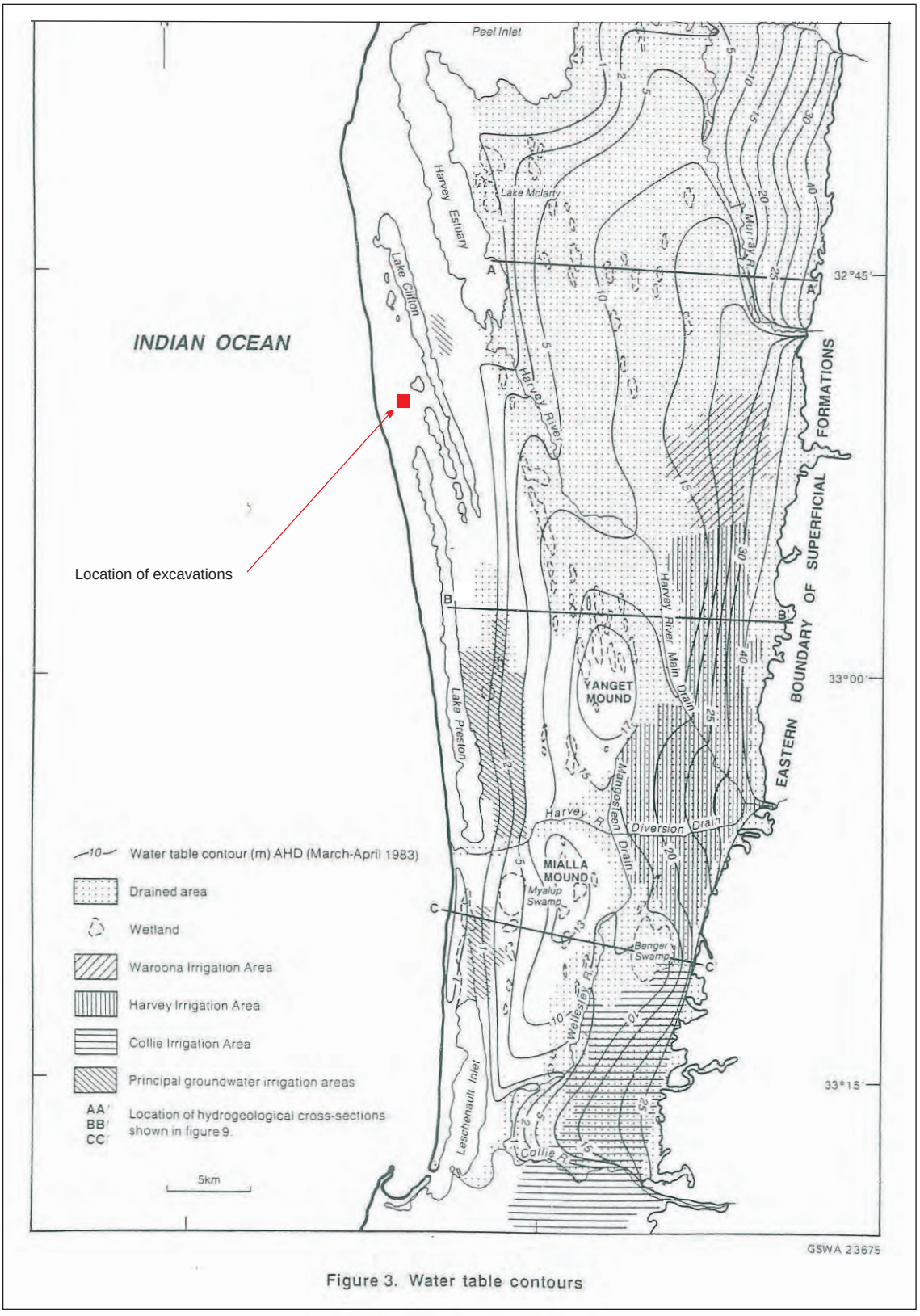
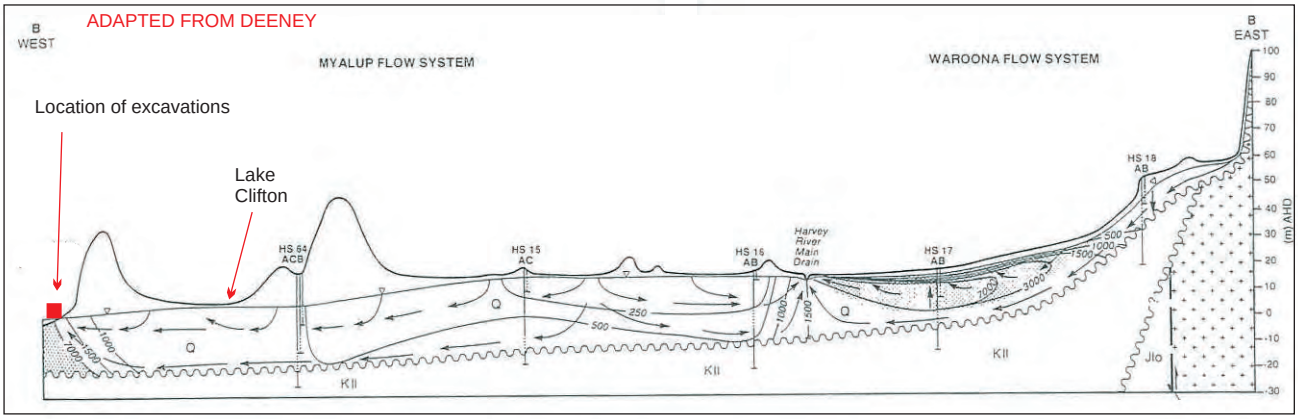


Figure 3. Water table contours

HYDROLOGY - Copied from Deeney (undated) Figures 3 and 9)

Figure 7



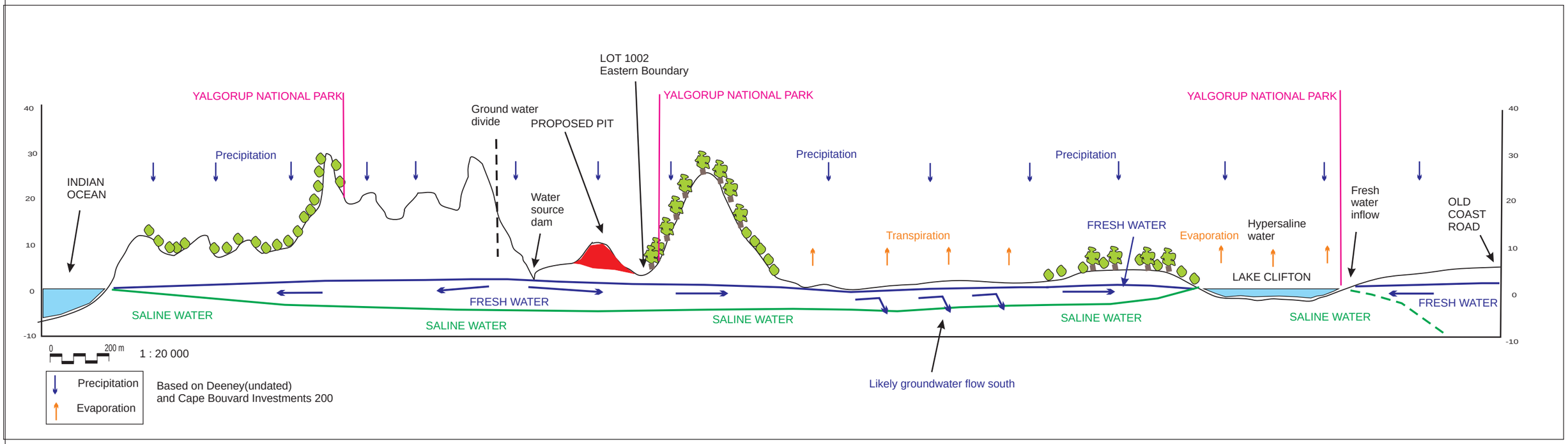
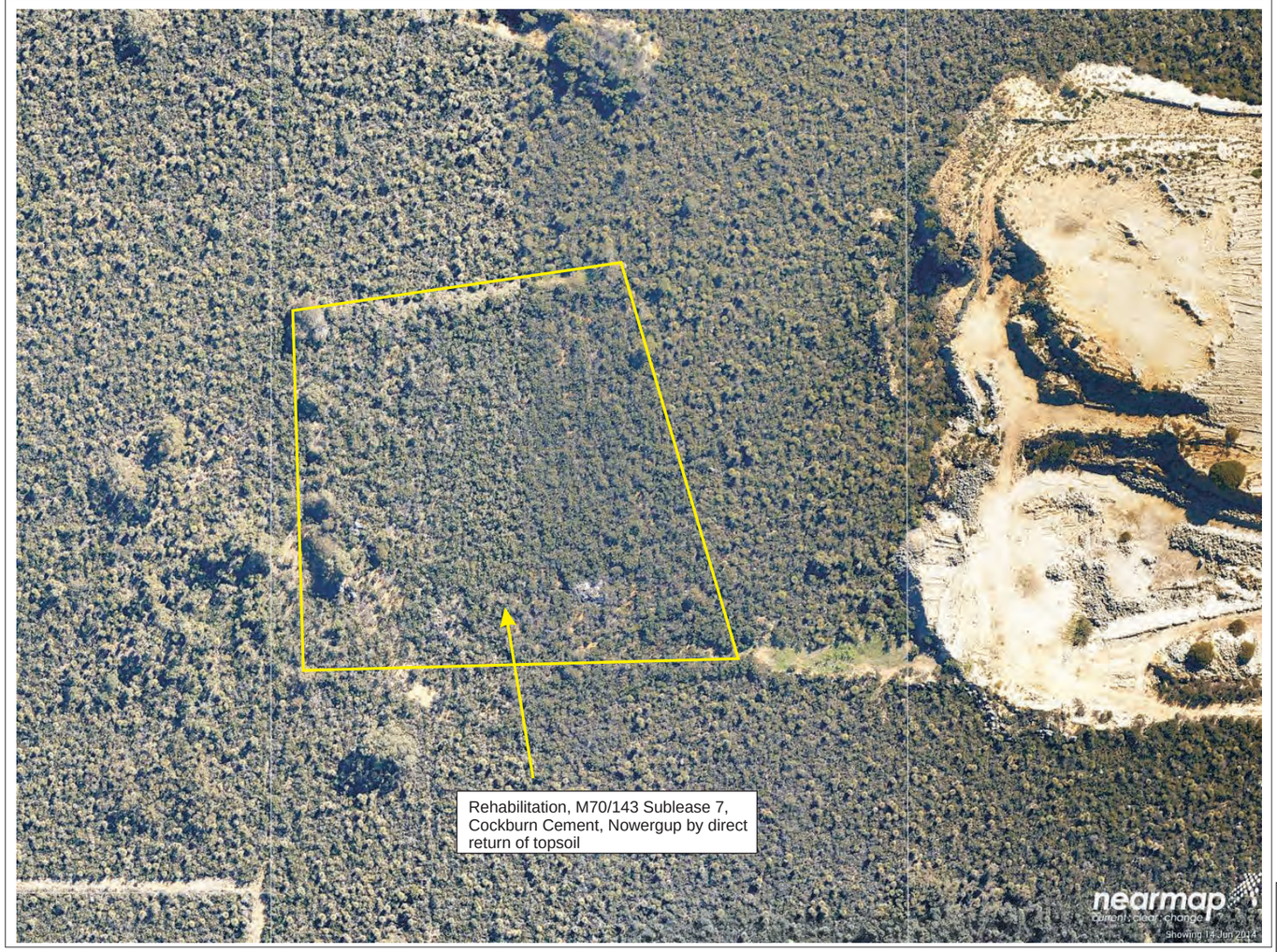


Figure 8

DOYLES LIME SERVICE – PRESTON PIT	
GROUNDWATER FLOWS	
Landform Research	April 2016
Source DPaW	Scale See Plan

The landholder seeding the rehabilitated portion of Lot 4 (Doyles Pit Myalup)

Looking from Lot 5 across part of the resource to rehabilitated land on Lot 4 (Doyles Pit Myalup)



NOTE

Rehabilitation of limestone pits is usually not required because of sequential land use to other uses in the Metropolitan Area such as Industrial land, (Hope Valley and Flynn Drive Nowergup) or has not had sufficient time for rehabilitation to be required.

EXAMPLES OF REHABILITATION

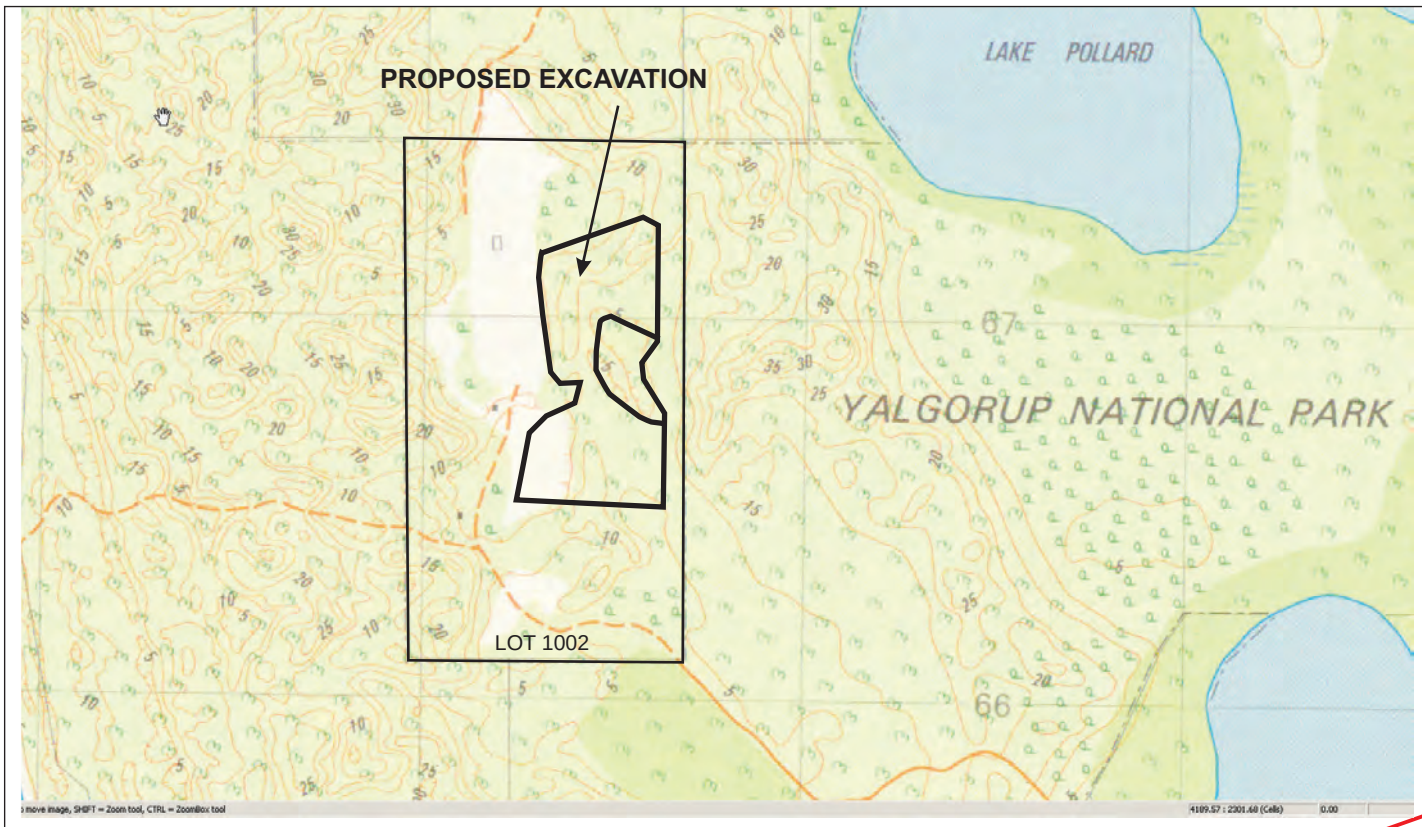
LIMESTONE PITS

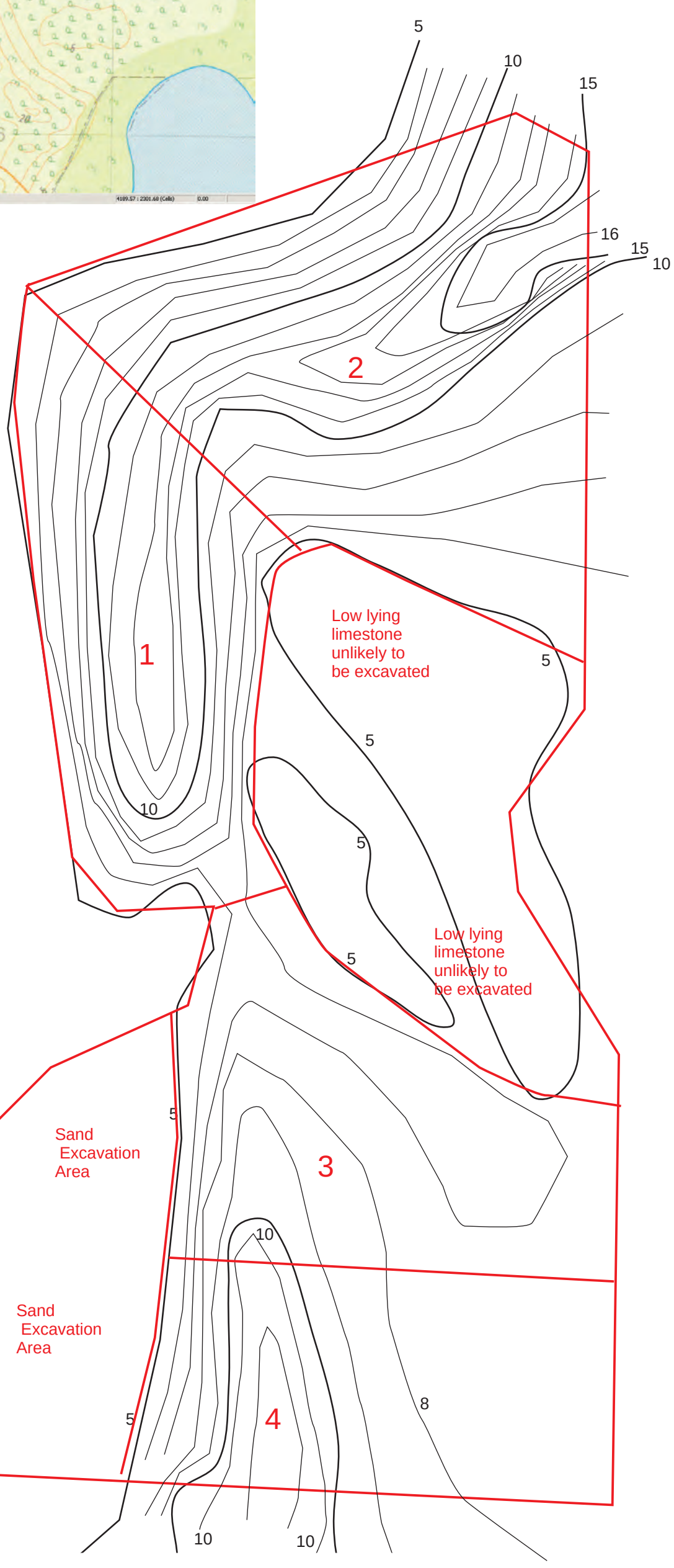
Limestone Building Block Company, Nowergup.
Rehabilitation 3 - 8 years old. Seeded and tube planted. No Topsoil.

Figure 9

Figure 10

DOYLES LIME SERVICE – PRESTON PIT	
MYALUP PIT SHOWING TYPICAL SITE LAYOUT	
Landform Research	May 2013
Source NEARMAP	Scale See Plan



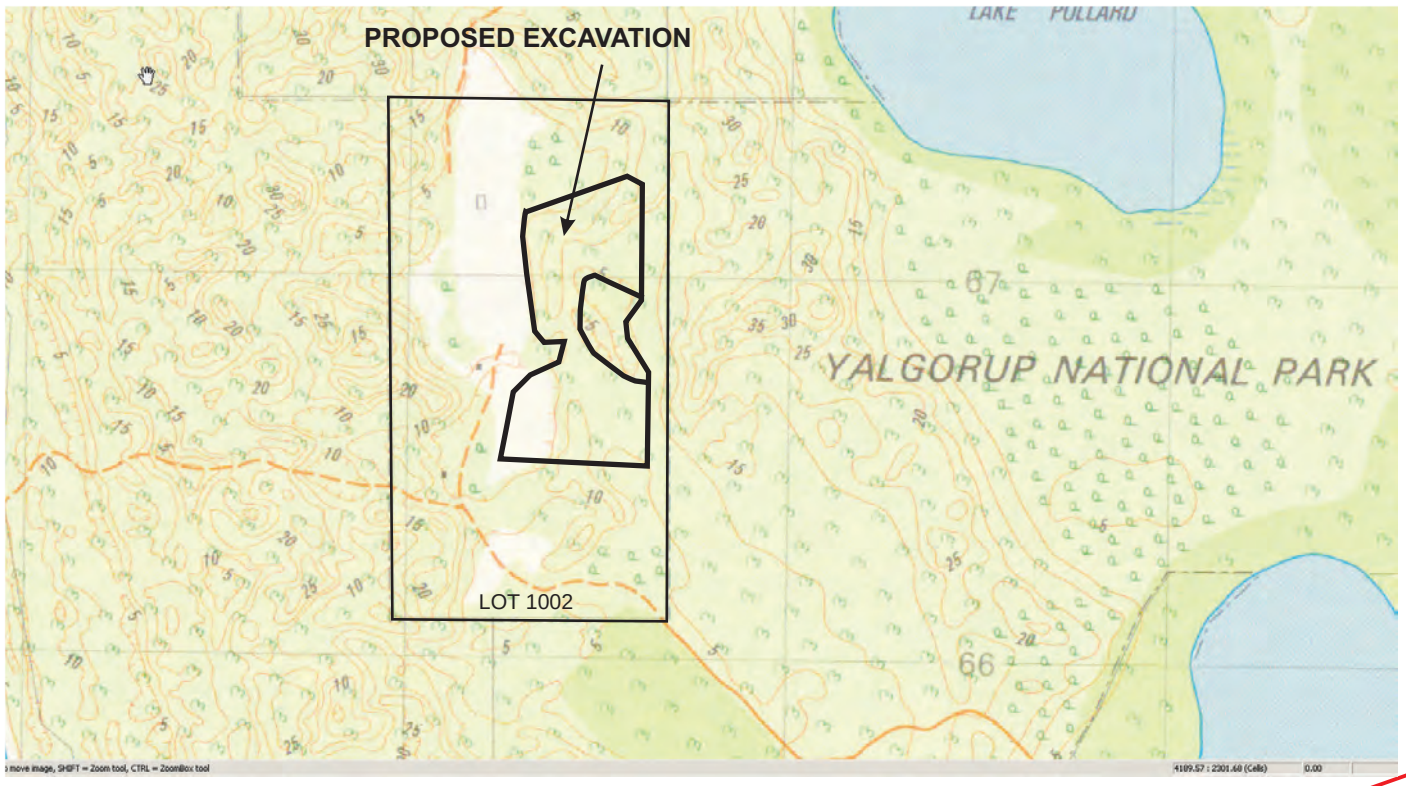


STAGING OF LIMESTONE EXTRACTION

Figure 11A

DOYLES LIME SERVICE – PRESTON PIT	
LIMESTONE PIT EXISTING CONTOURS	
Landform Research	May
Source LANDGATE	Scale

0 100m



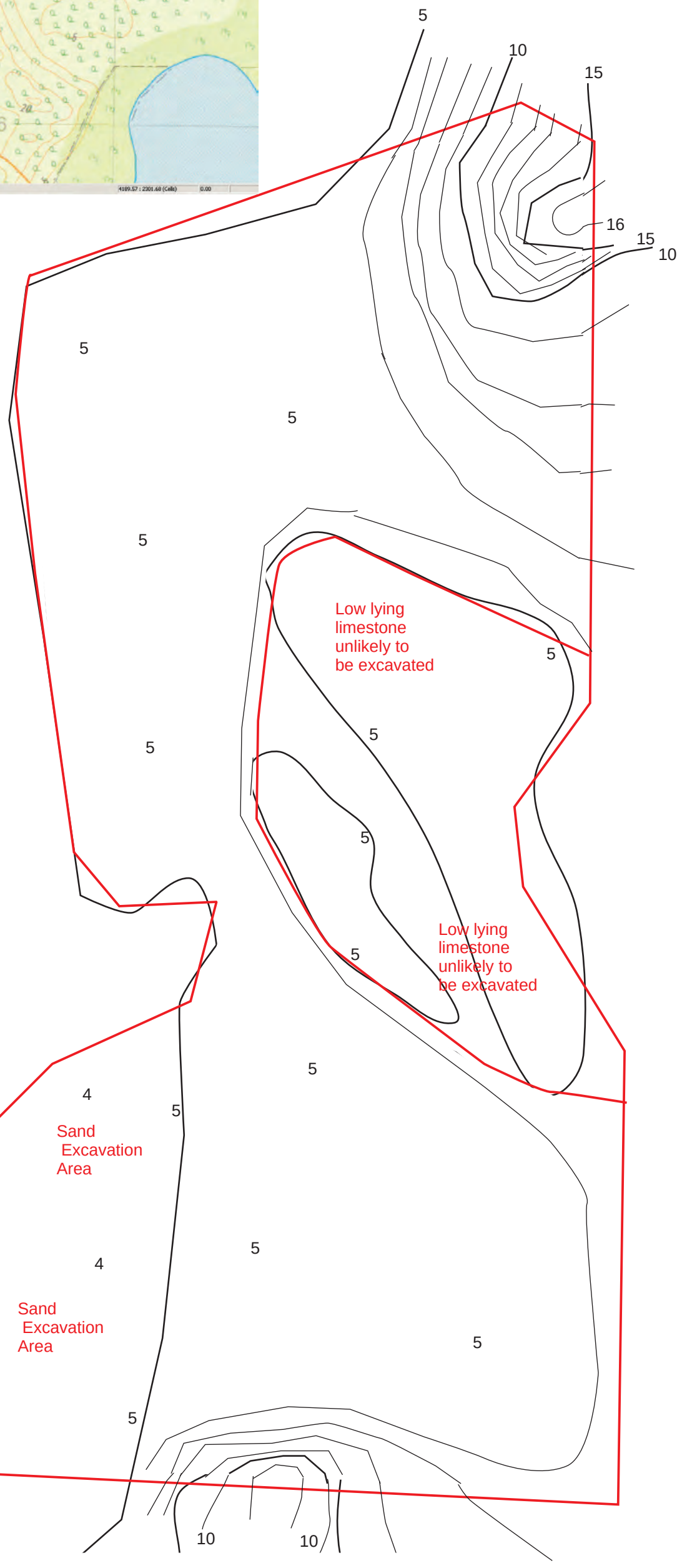


Figure 11B

DOYLES LIME SERVICE – PRESTON PIT	
SAND PIT CONCEPT FINAL CONTOURS	
Landform Research	May 2016
Source LANDGATE	Scale

0 100m