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REF:		**NO. OF PAGES:**	11
SUBJECT:	**W2B Moonimba Borrow Site - Groundwater Review**		

Abstract/Summary

This review of the groundwater systems present in the vicinity of the Moonimba Borrow Site indicates that there are poor aquifer systems operating in vicinity of the site. A groundwater regime of low permeability and storage capacity exists below the Borrow Site in the Walloon Coal Measures and potentially a perched aquifer system occurs in the Kangaroo Creek Sandstone, the material to be quarried.

This review concludes that the activities of the Moonimba Borrow Site will not have a meaningful impact on the permanent groundwater levels and water quality, and existing beneficial uses of groundwater in the area.

Background

The Woolgoolga to Ballina Pacific Highway Upgrade, herein referred to as 'the approved project', involves upgrading approximately 155 km of highway to four-lane dual-carriageway road between Woolgoolga and Ballina on the NSW north coast.

Pacific Complete on behalf of Roads and Maritime Services (RMS) is preparing a Modification Report for the Woolgoolga to Ballina Pacific Highway Upgrade (W2B) for the use of the Moonimba Quarry, known to the project as Moonimba Borrow Site, situated in Bungawalbin, NSW.

The Moonimba Borrow Site is situated approximately 15km south-west of Woodburn. It resides to the west of Portion C of the W2B project. Split between two pits, the site will operate with a total excavation area of 21 hectares. This is consistent with the excavation area given consent under a 2015 Development Application (DA) for an expansion of the existing quarry. Pacific Complete is proposing to intensify the extraction rate at the site to one million tonnes (1,000,000 tonnes), which is equivalent to 400,000m3 of aggregate per annum to provide sufficient material to complete the W2B.

This memo has been prepared as supporting documentation for the Modification Report and considers the potential for local and regional impacts to the groundwater regime in the Moonimba Borrow Site area such that existing bore water users and groundwater dependant ecosystems might be adversely affected.

Previous work

In 2014 Novoplan, on behalf of Newman's Quarry & Landscape Supplies, completed an EIS for the Moonimba Quarry expansion project which was to increase the sandstone quarry annual output limit from 30,000 to 90,000 m3/year from two larger extraction sites totalling 21 ha in area (Novoplan, 2014). As part of this EIS, a Soil and Water Management Plan was prepared within the scope of the Operational Plan of Management (Greg Alderson & Associates, 2014).

The Moonimba Quarry EIS identified two registered groundwater bores within 2 km of quarry area (one on the quarry's property), and one registered groundwater bore within 5 km of the quarry area (Figure 1). The licensed bore on the property, GW305748, was constructed in 2006 and presents the

water bearing zone from 74 m to 90 m below the ground (or RL 20 to 4 m AHD (Australian Height Datum). The second water license identified within 2 km of the quarry, GW053626, is located to the south west of the site and is an excavation to 2 m depth, covering an area greater than 100 m² and was constructed in 1981 for stock, irrigation and domestic purposes, according to the groundwater works summary.

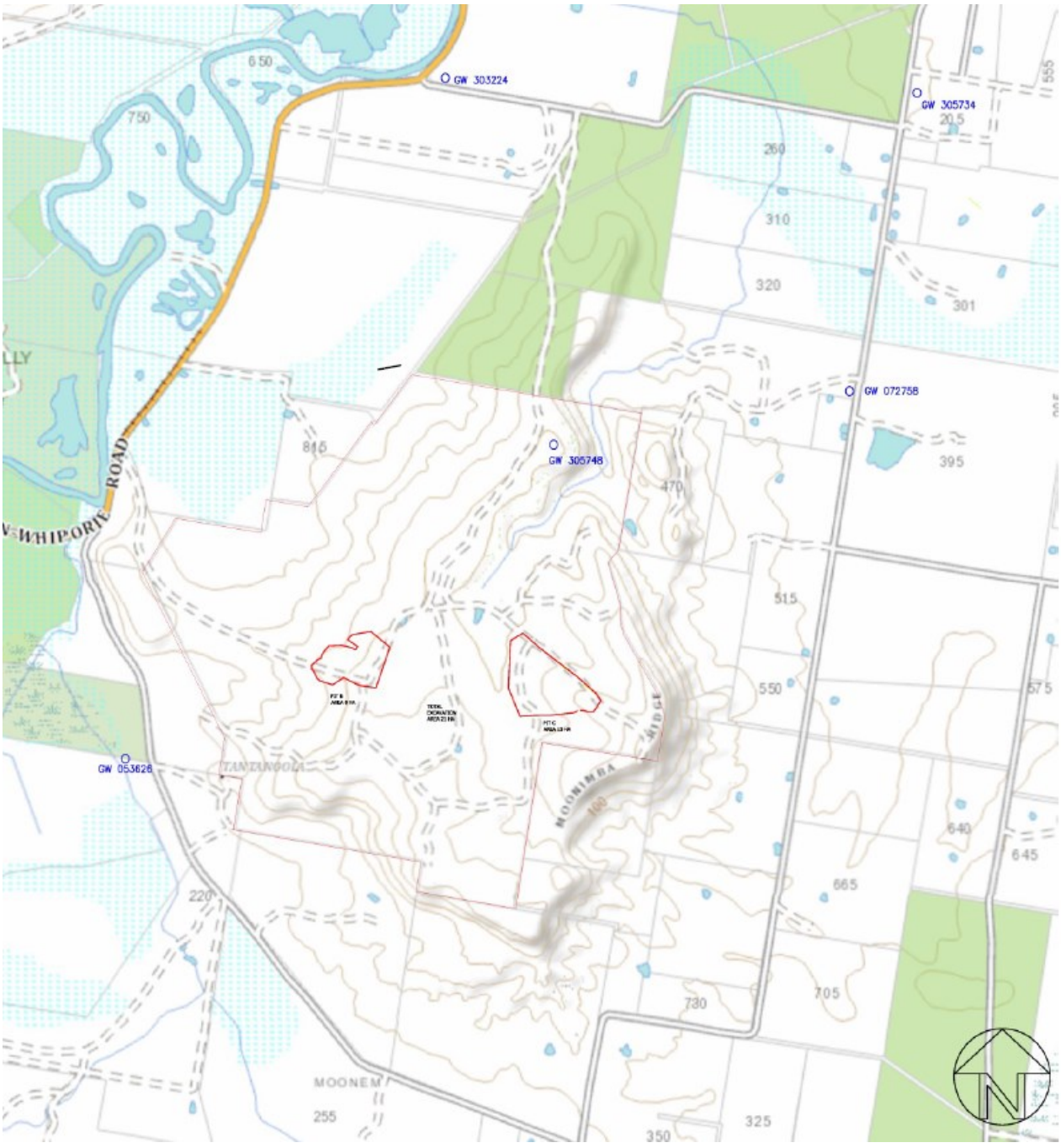

Figure 1 – Location of Licensed Groundwater bores and wells identified in the EIS (Moonimba Borrow Pit Sites shown in red outline)

The Moonimba Quarry EIS determined that the intersection of groundwater at the site is not expected. The proposed floor elevation of the quarry within the western pit was approximated to be 75 m AHD with sediment basins constructed at approximately 73 m AHD, whilst the eastern quarry pit floor was estimated to have a higher elevation at approximately 100 m AHD.

Quarterly groundwater monitoring was recommended for GW305748 (Sample 5, GDA 94 56 524607 E 6781463N) to establish baseline levels as part of the licensing conditions and audits for the following parameters (in addition to those required under the NSW EPA License):

- pH;
- oil and grease
- suspended solids
- biodegradable oxygen demand (BOD)
- turbidity

The EIS noted that during times of prolonged rainfall events, a perched water table may occur due to the slow movement of water through the sandstone bedrock. It also describes that there may be fractures in the rock profile which, at times, may become saturated as rainfall penetrates the subsurface. However, it is not expected that groundwater would be encountered on the site during normal conditions due to the shallow soils that promote run-off and restricts recharge to depth.

Location and characteristics

Moonimba Borrow Site is located at Lot 193 DP 755603, Boggy Creek Road, Bungawalbin, approximately 10 km southwest of the township of Woodburn. The quarry site consists of two excavation areas (the western pit, Pit B, and the eastern pit, Pit C), access track and associated infrastructure. The quarry's current conditions of consent (DA 127/95) are for the extraction of up to 30,000 m^3/year. The quarry has additional consent (DA 2015.0069) for the extraction of up to 90,000 m^3/year over a period of 25 years across the following two pit areas:

- Pit B (8 ha) to the west with depths of extraction extending to approximately 75 m AHD, and
- Pit C (13 ha) to the east with depths of extraction extending to 100-105 m AHD.

The consent however has not been activated.

Pacific Complete's proposal is to extract sandstone at a rate of 400,000 m^3 per year over a period of 2 years. The extraction depths, as well as extraction areas, are to remain the same as those detailed in the Development Application DA2015.0069 as detailed above.

Hydrogeology

The Moonimba Borrow Site is located within the Clarence-Moreton Basin which is an extensive sediment basin in north east New South Wales and southern Queensland. The local groundwater flow systems present at and surrounding the Moonimba Borrow Pit site includes:

→ the Koukandowie Formation,

→ Walloon Coal Measures,

→ Kangaroo Creek Sandstone (potentially present as a perched aquifer system), and

→ Quaternary alluvial aquifer in the low lying areas. A geological map of the site is presented in Figure 2.

<u>Koukandowie formation</u>

The Lower Jurassic Koukandowie formation is the upper unit of the Marburg Subgroup and outcrops over a small area to the South East of the Borrow Site. The formation consist of interbedded

quartzose-feldspathic-lithic sandstone, siltstone, claystone and minor coal. The Koukandowie formation has three members: the Heifer Creek Sandstone Member, the Ma Ma Creek Member and the Towallum Basalt of which the Heifer Creek Sandstone outcrops to the south east of the site. It has a low permeability and is considered as a low permeability aquifer or an aquitard (Rassam et al., 2014).

Walloon Coal Measures

Overlying the Koukandowie formation is the Jurassic age Walloon Coal Measures which outcrops at the base of the mountain ridge. The Walloon Coal Measures consists of a thin-bedded, claystone, shale, siltstone, lithic and sublithic to feldspathic arenites, coal seams and minor limestone. They have a maximum thickness of 700 m and are often considered as an aquitard on a regional scale due to their low permeability and storage capacity (Rassam et al., 2014).

The Maclean Sandstone, which represents the upper part of the Walloon Coal Measures, is a thick-bedded, crossbedded, feldspathic to lithic arenite with thin pebbly conglomeratic lenses and minor siltstone lenses with minor coal. The Maclean Sandstone is considered as a low permeability aquifer, aquitard or aquiclude (Doig and Stanmore, 2012).

Kangaroo Creek Sandstone

The Jurassic Kangaroo Creek Sandstone, the material to be quarried, is composed of quartz arenite with minor quartz and lithic conglomerate. This member is a fluvial channel sandstone which is characteristically thick to very thin bedded with high-angle crossbedding. Following burial, fluids present in the rock caused extra dissolved silica to precipitate out onto the existing sand grains filling in voids (recrystalisation of quartz) and created the Kangaroo Creek Sandstone. This feature causes the sandstone to act as a confined aquifer or aquitard (Parsons Brinckerhoff, 2011) and have poor hydraulic connection outside of a limited area adjacent to the outcrop (Doig and Stanmore, 2012).

Groundwater within the Kangaroo Creek Sandstone bedrock aquifer is present within the fracture overprint affecting the rockmass, and typically occurs locally as a shallow perched aquifer (predominantly in the regolith developed at the surface) where it is most active following heavy or prolonged rainfall. This perched groundwater system is anticipated to be a surficial and ephemeral system, with limited hydraulic connection to the deeper bedrock groundwater system at depth, and, is predominantly sustained by direct rainfall recharge and characterised by a variable horizontal flow pattern.

Alluvial aquifer

The alluvial aquifer consists of Quaternary alluvial deposits of sand, silt, clay and gravel as well as some residual and colluvial deposits. It is an unconfined water table aquifer which is likely to host local groundwater resources that are predominantly sustained by direct rainfall recharge and variable horizontal flow.

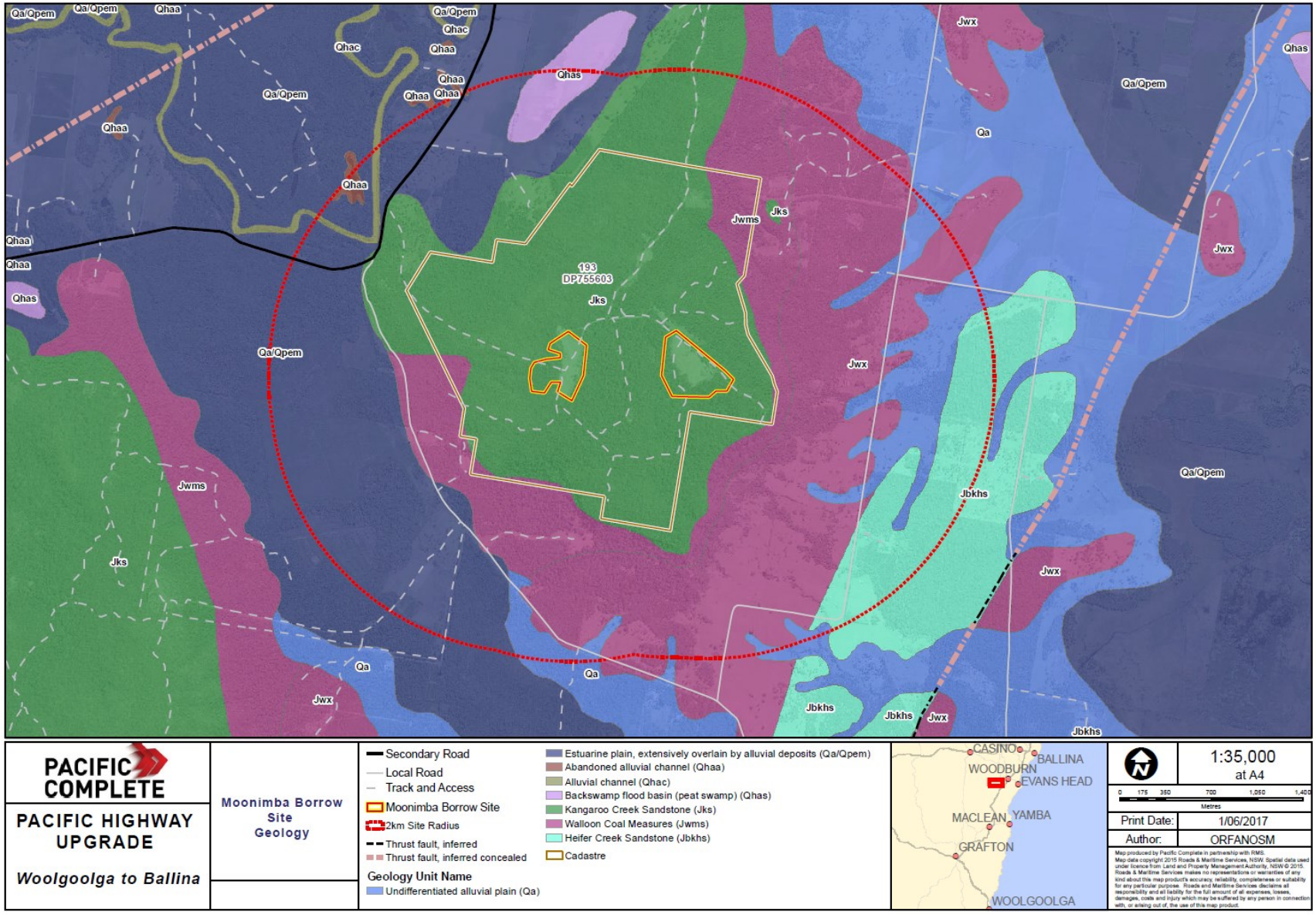

Figure 2 – Geology map of Moonimba Borrow Site

Site groundwater levels

The depth to groundwater at GW305748 at the time of drilling was 66 m below ground level (bgl) (33 m AHD) whilst the minimum final floor depth at west and east pits are approximately 75 and 100 m AHD respectively. Since the water table in the deeper bedrock is likely to be located below the level of the proposed pit floor, it is therefore unlikely to be intersected by the quarry pit activities. As such, it is anticipated that negligible direct impact will be caused to this aquifer by the proposed quarrying activities.

Groundwater may occur locally as a perched aquifer within the Kangaroo Creek Sandstone after heavy or continuous rainfall and is anticipated to be a shallow system (within 1-5 m, bgl) of short duration after direct rainfall recharge. Ponded water has been observed at site over time, this ponded water may also be a source of a temporary perched aquifer. However, as mentioned in the Moonimba Quarry EIS, a perched aquifer is not expected to be present at the Borrow Site during normal conditions.

Beneficial uses

Groundwater users

Registered bores located within a 2 km radius of the Moonimba Borrow Site area are shown on Figure 3 and their corresponding bore cards are attached. Details of the three registered bores within a 2 km of the quarry pits with current water licences are provided in Table 1:

- License *GW053626* (100 m^2 excavation to 2 m depth) was identified in the Moonimba Quarry EIS as a registered groundwater user within 2 km of the Borrow Site however this water license has lapsed and therefore is not licensed for use.

  Groundwater license *GW305748* is located on the same lot number as the Borrow Site and, like the Borrow Site, is the property of the Newman's. The bore is constructed through sandstone and shale from a depth of 4.5 to 60 m and sandstone from 60 to 90 m depth. The groundwater level was recorded at a depth of 66 m bgl (33 m AHD) at the time of drilling (and, as such, is considered indicative). This bore is inferred to target groundwater resources available in the Walloon Coal measures. This bore is owned by the quarry owner and is unlikely to be affected by activities at the Moonimba Borrow Site.

- Groundwater bores *GW032869* and *GW301828* are located over 1.5 km distance from the pits, at lower elevations, and are both shallow bores and are not anticipated to be affected by activities at the Moonimba Borrow Site.

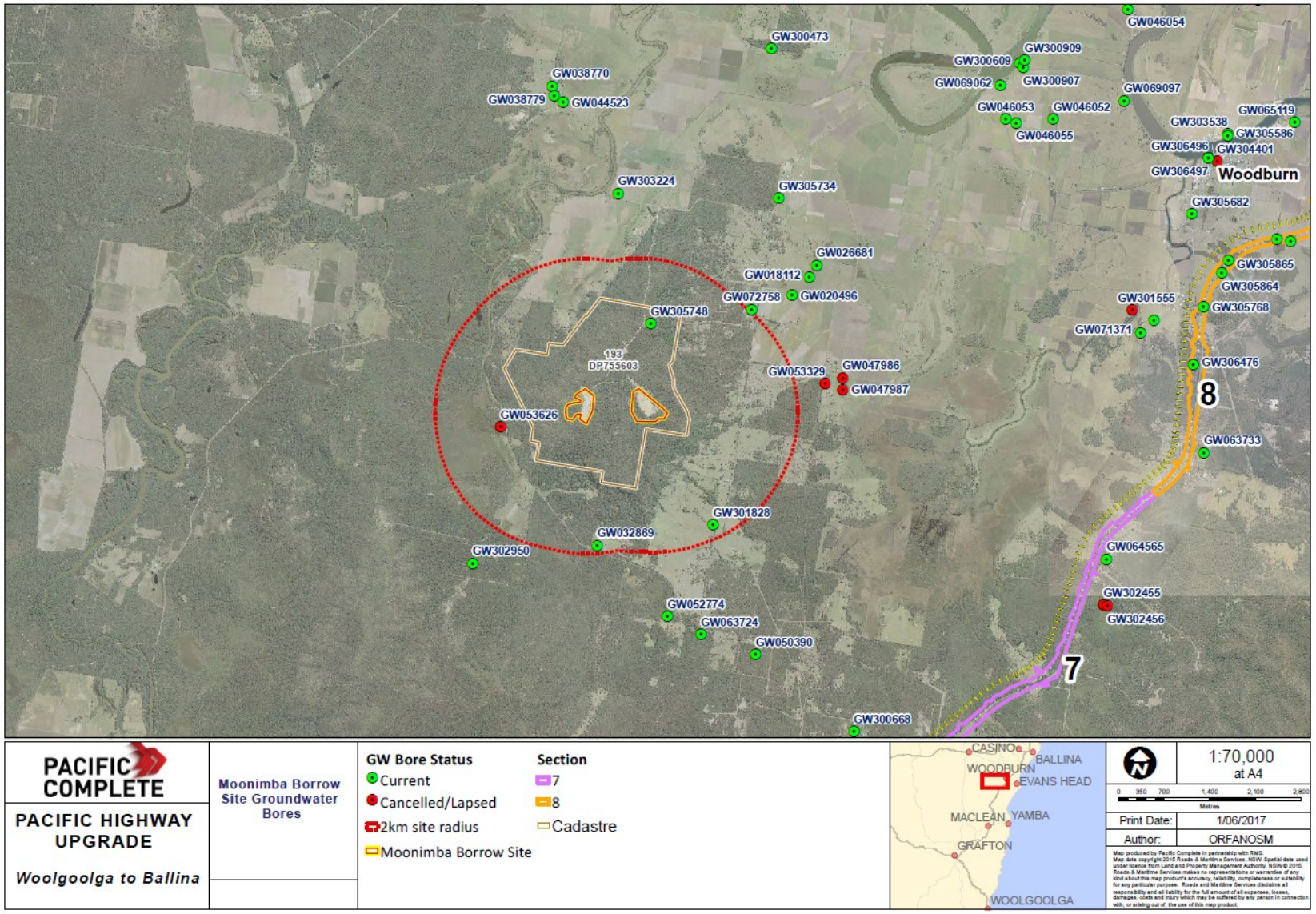

Figure 3 - Register groundwater bores within vicinity of Moonimba Borrow Site showing the license status and a 2 km buffer around the site (DPI-Water, Pinneena database)

Table 1 Details of active groundwater licences within 2 km of the Moonimba Borrow Site

DPI Water registration number	Distance to pits (m)	Purpose	Bore Depth (m)	SWL (m bgl)	aquifer zone (m bgl)	Aquifer geology	Yield (L/s)	Elevation (m AHD)
GW305748	1009	Stock/Domestic	90	66.0	74.0-90.0	Sandstone, shale	1.20	99
GW032869	1885	Stock	15.8	4.6	14.0-15.5	Shale, Coal	0.63	28
GW301828	1791	Stock/Domestic	24.3	12.0	22.0-24.3	Blue Shale and Coal Bands	1.20	24

SWL: - Standing water level; m bgl – metres below ground level; na - not available; m AHD – metres Australian Height Datum

Groundwater dependent ecosystems

Groundwater dependent ecosystems (GDEs) are also beneficial users of groundwater. The GDE Atlas (BOM, 2017) categorises GDEs into three classes:

- Ecosystems that rely on the surface expression of groundwater – this includes all the surface water ecosystems which may have a groundwater component, such as rivers, wetlands and springs
- Ecosystems that rely on the subsurface presence of groundwater – this includes all vegetation ecosystems
- Subterranean ecosystems – this includes cave and aquifer ecosystems

Within a 2 km radius of the Moonimba Borrow Site, five types of ecosystems were identified that rely on the *subsurface presence of groundwater* with these being Lowland Red Gum winter flowering, Paperbark, Lowlands Grey Box, Clarence Lowlands Spotted Gum and Sub-Tropical and Warm Temperate Rainforest (Figure 4). These GDEs have a low to high potential for groundwater interaction.

A search of the GDE atlas also identified that Bungawalbin Creek and associated floodplain wetlands rely on the surface expression of groundwater (Figure 4) and have a low to high potential for groundwater interaction.

Activities at the Moonimba Borrow Site are not anticipated to affect the local and regional surface, nor subsurface, expressions of groundwater. All GDEs that rely on surface expressions of groundwater are associated Bungawalbin Creek and the floodplain areas of Bungawalbin Creek.

GDEs that rely on subsurface expressions of groundwater are expected to occur within localised water bearing zones typically characterised by localised recharge-in/recharge-out processes associated with rainfall infiltration. Limited reductions to the ground-water flow flux to the downgradient side of the site can be anticipated. Since the immediate surroundings of the Borrow Site area lacks any threatened/ endangered communities potentially sustained by groundwater, this constraint to groundwater recharge is not considered to pose a meaningful ecological impact. As such, and given the distance from the quarry pits, activities on site are unlikely to present a risk of adversely affecting GDEs.

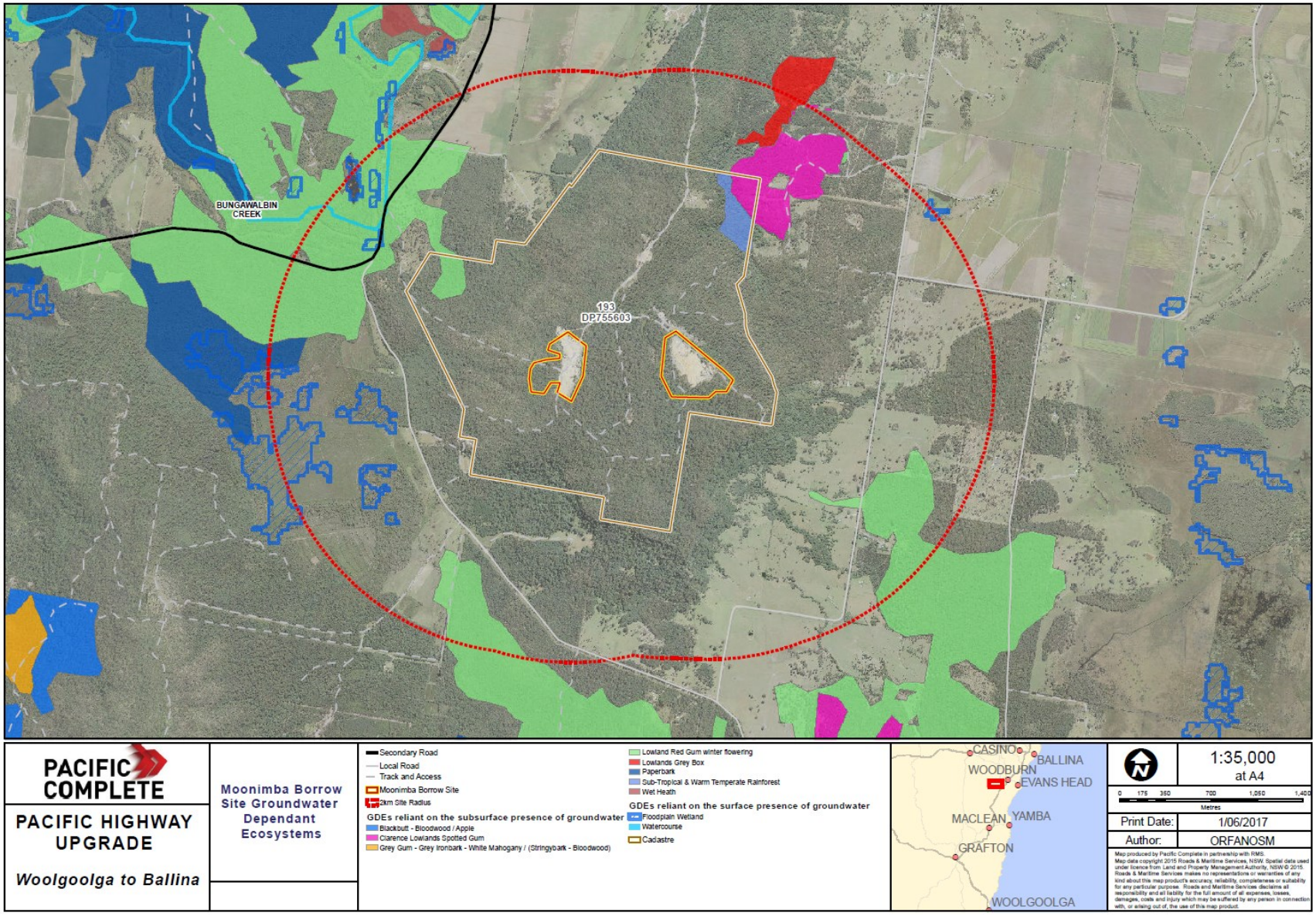

Figure 4 – Groundwater dependant ecosystems within vicinity of Moonimba Borrow Site

Groundwater monitoring requirements

The legislative requirements applicable to groundwater in this project are set out in the State Environment Planning Policy (SEPP) (Mining Petroleum Production and Extractive Industries) 2007 in Section 14 which details natural resource management and environmental management. To assess the legislative requirements falling under the SEPP, the 2015 DA was referred to:

- NSW Office of Water
- Environmental Protection Authority

These organisations provided conditions of approval, none of which are related to groundwater.

The current groundwater assessment indicates that quarry activities will not have a meaningful impact on the permanent groundwater levels and water quality, and existing beneficial uses of groundwater in the area.

Based on the above, the recommendation made in the EIS to monitor groundwater at GW305748 on a quarterly basis has been withdrawn.

Recommendations

The following recommendations should be considered for management of groundwater at the Moonimba Borrow Site:

→ In the unlikely event that the Moonimba Borrow Site does encounter a permanent water table in the bedrock, and penetrates this water table, to a depth in excess of 5 m, a review of management measures shall be undertaken, and these will include re-evaluation of the groundwater impact and return of captured water (inflows) to local drainages after treatment in an appropriate sedimentation pond (to capture suspended solids).

Conclusions

This review of the groundwater systems present in the vicinity of the Moonimba Borrow Site indicates that they are dominated by poor aquifer units, presenting low groundwater fluxes, limited rainfall recharge and gradient profiles which mimic the topography in a muted fashion. The following possible groundwater regimes are identified (from shallow to deep):

→ Alluvial aquifer - unconfined aquifer on the plain (not located beneath the Site)

→ A perched water aquifer in the Kangaroo Creek Sandstone, the material to be quarried, which is anticipated to be a shallow system (within 1-5 m bgl) of short persistence (ephemeral) following direct rainfall recharge, and is not expected to be present at the Borrow Site during normal conditions.

→ The Koukandowie formation - a low permeability aquifer or an aquitard, located beneath the Kangaroo Creek Sandstone

→ The Maclean Sandstone of the Walloon Coal Measures - low permeability aquifer, aquitard or aquiclude located at depth.

On the basis of this analysis, the quarrying activities proposed for the Moonimba Borrow Site are considered to have no meaningful impact on beneficial groundwater users, for the following primary reasons:

(a) Few groundwater users are located close to the site. The closest water bore to the quarry pits is owned by the quarry, at 1 km distance from the pit, and, two other groundwater licences that are located close to 2 km of the Moonimba Borrow pit locations, which are located at lower elevations, are shallow bores (<25 m depth), tap into different aquifer units, and are not anticipated to be affected by quarrying activities proposed for the Moonimba Borrow Site.

(b) the minimum elevation of the base of the Borrow pits (75 m AHD) is above the interpreted permanent local water level (about 33 m AHD), is therefore unlikely to be intersected or meaningfully impacted (in terms of restricted recharge) by the proposed borrow pit activities.

(c) The perched groundwater system present in the Kangaroo Creek Sandstone (in the regolith) is a shallow and ephemeral system, and is predominantly sustained by direct rainfall recharge and variable horizontal flow. The occurrence of a perched aquifer is not expected to occur under normal conditions and would be of short duration. The underlying Kangaroo Creek Sandstone fracture aquifer system is of low permeability and unsaturated to depth (above).

This review therefore concludes that the proposed activities of the Moonimba Borrow Site will not have a meaningful impact on the groundwater levels and water quality, and existing beneficial groundwater users in the area, both water users and GDEs. Based on this, together with there being no conditions of approval related to groundwater, groundwater monitoring is not recommended.

References

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