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Project 71976.00-1
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CCK:lll

Attention: Mr Daniel Lacey

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Dear Sirs

Report on Preliminary Hydrogeological Assessment
Proposed Spectator Precinct
Royal Randwick Racecourse, Randwick

1. Introduction

This letter report prepared by Douglas Partners Pty Ltd (DP) summarises the results of a preliminary hydrogeological assessment of the area encompassing the proposed upgraded Spectator Precinct at the Royal Randwick Racecourse, Randwick. The assessment is required as part of the submission relating to the Director-General Environment Assessment Requirements (DGRs).

In particular, this assessment has been developed to identify groundwater issues and potential degradation to the groundwater source that may be encountered during construction. The assessment is based on a desk top study of available hydrogeological information at the site. This study includes reference to the recent Preliminary Geotechnical and Environmental Assessments (also undertaken as part of the submission relating to the DGRs) and to numerous previous DP investigations within Randwick Racecourse and at neighbouring sites.

Works are proposed in two areas of the site; one of which is the Spectator Precinct. Works of particular relevance to the hydrogeology of the site include proposed excavation. These are discussed in further detail in Section 6 of our report.

2. Site Description

The greater Royal Randwick Racecourse area is bounded by Alison Road, Wansey Road, High Street, Anzac Parade and Doncaster Avenue, although private properties are present between the greater racecourse area and Doncaster Avenue.

The site topography of the greater Royal Randwick Racecourse can be summarised as follows:

- The majority of the grounds are flat to gently sloping, between RL 28 and RL 32;
- Ground levels at the south-western corner of the greater area slope gently down towards Anzac Parade (to approximately RL 26);
- Ground levels at the eastern end of the greater area slope gently to steeply up towards the south-eastern corner (to approximately RL 58 at the intersection of Wansey Road and High Street), in part stepping up levelled platforms.

The Spectator Precinct is located in the north-west part of the racecourse, in an area of flat to gently sloping ground and in an area indicated as underlain by basement rock at approximately RL -10 feet (say RL -3 m). This implies that the depth to bedrock in this area is greater than 30 m.

3. Geology

The site falls within the northern portion of the Botany Basin. Erosion of the tertiary coastline near Botany Bay created a topographic depression within the Triassic bedrock. In the late Quaternary period, sea level fluctuations resulted in the dominance of sedimentary deposition processes (Hatley, 2004). This lead to a number of deposition periods, corresponding to the three distinct sediment layers encountered in the basin today.

McNally and Branagan (1998) describe the sequence of sediments in the basin. The following is a summary of their description:

- Pleistocene Sediments – A deeply buried sequence of estuarine and fluvial clays with interbedded aeolian sands, also referred to as the clay beds (Smart 1974). This layer is the basal layer and not often encountered in engineering investigation due to its depth. This layer is known to be up to 30 m thick, especially in paeleochannels, though more frequently of less than 10 m thickness.
- Botany Sands – a sequence of aeolian and littoral sands overlying the weathered and eroded surface of the Pleistocene sediments. This sequence is the dominant water bearing zone and is up to 30 m thick with an average thickness of 15 m. The Botany Sands consist of poorly sorted, clean, fine to medium sized quartz grains. Porosities are typically 30 – 40%. The formation is typically dense to very dense. The surface of this unit typically lies within a few metres of the ground surface.
- Holocene Sediments – comprises mainly loose sands and soft muds, though occasionally also found as an indurated layer ('Waterloo' or 'coffee rock'). The boundary between this and the Botany Sands is poorly defined due to the similarity of the materials of which both layers are comprised. The essential difference is the density of the formation. (The boundary can be defined based on SPT blows; the Holocene Sediment generally having N values of less than 20.)

Reference to the New South Wales Department of Mines Bulletin No 18 (NSW Dept of Mines, 1962a), indicates that the basement rock of the Basin under the greater Royal Randwick Racecourse area falls towards the south from approximately RL 100 feet (say 30 m AHD) at the south-eastern corner of the site, to RL 10 feet (say 3 m AHD) towards the centre of the site, and continuing to fall to RL -20 feet

(say -6 m AHD) at the south-western corner of the area. This results in an average thickness of sediments of about 30 m. Bedrock materials are expected to comprise Hawkesbury Sandstone.

Reference was also made to the mapping of Acid Sulphate Soil (ASS) Risk by the NSW Department of Environment and Climate Change (1994-1998). The site is outside the area of ASS risk mapping. Based on the elevations above sea-level the likelihood of encountering ASS on the site is considered to be low. Further investigation was undertaken in our contamination assessment of the site.

4. Hydrogeology

The Royal Randwick Racecourse is underlain by the Botany Sands Aquifer. A secondary aquifer in the tertiary rocks underlying the sedimentary sequence has also been reported. There is considered to be some connection between these aquifers (Merrick, 1998). Based on the proposed development, there is considered to be no or little potential for impact on this deeper aquifer, hence this section focuses on the Botany Sands Aquifer.

4.1 Recharge and Discharge Areas

At a regional level, groundwater flows south towards Botany Bay and to the south west to Alexandra Canal. Waters in the vicinity of the racecourse would likely discharge to Alexandra Canal (based on inferred groundwater flow directions from Hatley, 2004). Water is also removed from the aquifer by groundwater extraction bores. There are numerous licenses granted for extraction for irrigation and industry.

Recharge of the aquifer is primarily through direct rainfall infiltration and leakage through the base of the ponds and lakes of the upper basin area (Centennial Park, Randwick Racecourse). Increased flow through the sides of the pond walls occurs in wet weather. Minor secondary sources are considered to include water and sewer leakage, irrigation water and flow from the deep aquifer. Rainfall infiltration percentages for sandy parkland (as at the racecourse) are generally quoted as about 36% although figures as high as 96% have been modelled (Timms et al, 2006).

The undeveloped areas of Centennial Park, Randwick Racecourse and the five golf courses above the aquifer are acknowledged as the key areas for recharge of the aquifer.

4.2 Hydrogeological Properties

The Botany Sands Aquifer is generally considered to be an unconfined aquifer, though confining beds of peat and silty clays are known to create regionally discontinuous confined and semi-confined aquifers.

The average saturated thickness of the Botany Sands Aquifer is 15 – 20 m. Hydraulic conductivity within the sand beds is highly variable and is typically around 20 m/day in clean sand. This value decreases to 5 – 10 m/day in silty or peaty sands and to less than 4 m/day in sandy or peaty clay.

The influence of the Waterloo rock and igneous intrusions can also serve to significantly reduce hydraulic conductivity (McNally and Brannagan, 1998).

4.3 Hydrogeochemistry

Water quality in the Botany Sands Aquifer is typically of low salinity (on average less than 250 microSiemens/m (Jankowski and Yu, 1998) and approximately 200 microSiemens/m at the Racecourse. pH is typically low to neutral, which is consistent with the slightly acidic rainfall recharge.

Jankowski and Yu (1998) characterised the spatial distribution of groundwaters in the Botany Aquifer. The Racecourse falls into Group A-1. The water is classified as a Cl – SO^4 – Na – Ca water, which is similar to the characterisation of the rainfall in this area, indicating the direct link between rainfall and recharge. Further down the flow path of the aquifer nearer to Botany Bay, the chemistry becomes more complex due to the influencing factors of contamination and soil water interactions.

Jankowski and Yu (1998) also note the presence of a large plume of nitrate moving from the Racecourse and note that whilst the concentration is not as high as in other polluted areas, in time this plume will be of concern. The plume is considered to be a result of site activities, possibly including fertilisation and disposal of animal effluent.

4.4 Water Level Fluctuations

On average, groundwater levels are less than 9 m below the ground surface in the Botany Sands Aquifer (Jankowski and Beck, 1998). Information derived from DP's latest investigations at the Racecourse (Project Number 71976) indicate that groundwater is approximately 3 – 5 m below the ground surface. No long term monitoring has been undertaken for the current project at this stage. However Merrick (1998) reports groundwater level variations in the Botany Sands Aquifer of up to 2 m, and Timms et al (2006) reports variations of up to 1.8 m measured in a bore in Kensington over an 8 month period in 2003. Water levels are further reviewed in Section 5, below.

5. Review of Available information

5.1 Randwick Racecourse - Registered Groundwater Bores

A search of the NSW Groundwater Works database of licensed groundwater bores indicates the presence of numerous registered bores within the greater area of the Randwick Racecourse and the immediate surrounds. Registered bore locations are indicated on the attached Drawing 1, together with identification numbers of selected bores. Selected information from these bores is summarised in Table 1, below. It is noted, however, that the information below is from raw data provided to the Department of Environment Climate Change and Water, and has not been verified.

Table 1: Summary of Registered Groundwater Bores

Groundwater Bore	Completion Date	Standing Water Level (m)	Depth of Bore (m)
GW040223	Unknown	Unknown	7
GW040224	Unknown	Unknown	7
GW047544	July 1978	4	23
GW057008	October 1981	Unknown	30
GW075018	July 1998	0.5	44
GW100985	August 1995	2.1	5.2
GW102419	January 1978	3	22
GW103124	January 1995	Unknown	Unknown
GW104772	February 2003	4.9	25
GW104773	February 2003	4.9	25
GW106554	November 2004	3	6
GW107342	August 2005	3.4	5.2
GW108971*	June 2008	27	216

* See comments below.

These results indicate groundwater levels generally between 0.5 m and 4.9 m below ground level. A standing water level at 27 m depth was identified at GW108971, however, it should be noted that this bore location is in an area of significantly higher ground levels, east of the Royal Randwick Racecourse. No reduced levels are available for these bores.

5.2 Previous DP Experience

DP has undertaken numerous investigations within Randwick Racecourse and in the general area of the Racecourse. The majority of the previous investigations have been located in the north-western area of the site, in the vicinity of the proposed upgraded Spectator Precinct.

Reference to previous DP investigations within the Royal Randwick Racecourse site indicates groundwater levels at depths of 2.9 m to 5.9 m below ground level. These correspond to levels of approximately RL 24 to RL 27.1, where reduced levels are available. These levels are reasonably consistent with those indicated by the registered groundwater bores, summarised above. It is noted that most of these groundwater measurements consist of isolated measurements taken at the time of fieldwork, rather than a result of ongoing groundwater monitoring at the site.

Groundwater levels are expected generally to fall towards the south-western corner of the site, with higher levels present in the Stables Precinct, than in the Spectator Precinct.

In DP's experience, subsurface conditions typically comprise sandy filling (generally less than 1 m); underlain by loose then medium dense, dense and very dense sand to depths of more than 15 m. Discontinuous peat, silty sand and clay layers have been identified within the sand at some locations.

Measurement of hydraulic conductivity using a variety of methods (Hazen's analysis and slug tests) undertaken on surrounding sites indicates a range of values generally consistent with published data.

6. Proposed Development

Details of the proposed works at the site are yet to be finalised, and some variations from the existing proposal may occur. Nonetheless, the general features of the works, as relevant to the hydrogeology of the area, are outlined below.

At the proposed Spectator Precinct, the general features are understood to be as follows:

- The Paddock Stand will be demolished and a replacement stand constructed.
- Part of the footprint of the new stand will be occupied by a basement, with some parts of the basement area having floor levels of between RL 26.5 m and RL 24.5 m.
- Structural modifications will be made to the existing QEII Stand, requiring the installation of new foundations.
- A parade ring will be constructed in the area currently occupied by the Tea House and the lawn behind it. The parade ring will essentially involve an excavation to 4 m depth (RL 28.0 m), with battered sideslopes for seating, and a three storey buildings at one end.
- A tunnel for the passage of horses will be constructed from the parade ring to the existing race track and will have a base level at RL 27.5 m.

At this site, minor civil and structural works will also be required, such as localised (and minor) cut and fill, retaining walls etc. These are not considered to be significant for the purpose of this preliminary hydrogeological assessment.

7. Comments

Groundwater impacts have been grouped into construction impacts and ongoing impacts. Construction impacts are generally temporary, whilst the ongoing impacts are permanent changes to the aquifer.

7.1 Proposed Spectator Precinct

7.1.1 Construction

Dewatering

Based on the depth to groundwater at the Spectator Precinct and the proposed basement and tunnel excavations, temporary construction dewatering will be required. It is understood that these structures are proposed to be tanked and hence no ongoing dewatering will be required. Dewatering will most likely incorporate spearpoint abstraction, with possible use of sheet pile walls and/or infiltration galleries to limit the drawdown and settlement of adjacent structures.

Modelling of groundwater abstraction rates will be undertaken once detailed design plans are available. Modelling will allow for the design of an abstraction system which limits extensive drawdowns and therefore limits settlement of surrounding structures. The design of the dewatering system is not considered a constraint on the development.

Preliminary investigation for acid sulphate soils at the site has also been undertaken and is reported in the DP Contamination Report. The results indicate that acid sulphate soils are not present at the subject site. Pending further confirmation of the absence of ASS, the dewatering system will not need to consider the effect on ASS.

Initial testing of the groundwater quality (undertaken for the contamination investigation) indicate that the quality of the water abstracted as part of the dewatering process is of suitable quality for reinjection into the aquifer.

Contamination

The development is not considered to have a high potential for contaminating the aquifer during construction. Nonetheless, a Construction Management Plan should be prepared for the construction phase of the project well in advance of commencement. The plan would address the protocols for addressing the envisaged environmental accidents that could occur on site during construction. This plan would cover both soil and groundwater.

7.1.2 Ongoing

Groundwater Mounding

Consideration has been given to the potential for groundwater mounding (localised groundwater rise) upgradient of structures which protrude into the aquifer. Groundwater mounding and aquifer damming are problems more likely to occur in confined built up areas where numerous deep basements are present. A review of the surrounding area indicates that the presence of deep basements in the surrounding areas is limited. UNSW, Kensington and Randwick possess some relatively deep basements, but the distance to these areas precludes problems from aquifer damming.

Groundwater mounding behind long basements (such as tunnels) may occur. This may result in a long term rise in the groundwater upgradient of the structure. Modelling of similar structures in the

Botany Sands Aquifer has indicated only minor mounding, and rapid dissipation of the mound away from the wall. This is as a result of the relatively low groundwater gradients and high porosities. Groundwater mounding is not considered to be a constraint to the development, though further modelling should be undertaken once the proposal is further developed.

8. Limitations

Douglas Partners Pty Ltd (DP) has prepared this report for a project at Royal Randwick Rasecourse, Randwick, NSW in accordance with DP's proposal SYD100697 dated 21 July 2010 and acceptance received from Mr Daniel Lacey of The Australian Jockey Club on 16 August 2010. The report is provided for the exclusive use of the Australian Jockey Club for this project only and for the purpose(s) described in the report. It should not be used for other projects or by a third party. In preparing this report DP has necessarily relied upon information provided by the client and/or their agents.

This report must be read in conjunction with all of the attached notes and should be kept in its entirety without separation of individual pages or sections. DP cannot be held responsible for interpretations or conclusions made by others unless they are supported by an expressed statement, interpretation, outcome or conclusion given in this report.

Yours faithfully
Douglas Partners Pty Ltd

Reviewed by

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