Review of Environmental Assessment for Lot 156 Creek Street, Hastings Point

2114742A

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NSW Department of Planning

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Contents

1. Introduction

The NSW Department of Planning has requested PB's assistance in assessing the Environmental Assessment (EA) for the proposed residential and tourist subdivision development at Lot 156 Creek Street, Hastings Point. The scope of works is set out in *DoP2010/154 – Invitation to Tender: Hydrological and Geo-technical Assessment of the Environmental Assessment for Major Project 06_153 – Residential and Tourist Development Subdivision, Lot 156 Creek Street, Hastings Point* received by PB on 12th July 2010.

The Department requires assistance in assessing the following aspects of the EA:

- Flooding: Review of the Flood Management Assessment and impacts on flood risk, including assessment of climate change impacts.
- Stormwater and water cycle management: Review the Stormwater and Water Cycle Management Plans to assess the proposed management of stormwater on the developed site and impacts of the development on local drainage processes and the quantity and quality of storm runoff to adjacent waterways.
- Acid sulfate soils: Review proposed measures to manage and mitigate the risks and environmental impacts associated with acid sulfate soils during the construction phase of the development.
- Groundwater: Review of the impacts of the development on groundwater quality.

This report sets out the findings of PB's review of the adequacy of the EA in these technical areas.

2. Flooding

2.1 Documents available for review

The following documents were reviewed for information on flooding:

- *Environmental Assessment Part 3A – EP&A Act 1979, No.156 Creek Street, Hasting Point – Walter Elliot Holdings P/L*, Planit Consulting, March 2010.
- *Palm Lake Works Pty Ltd, Engineering Impact Assessment,* Revision 4, Opus International Consultants (Australia) Pty Ltd., 24 February 2010.
- *Tweed-Byron Coastal Creeks Flood Study,* Final Report, BMT WBM, November 2009.

2.2 General comments

In general the parts of the main EA document and the Engineering Impact Assessment that relate to flooding are clearly worded and directly address the relevant DGRs.

The flood modelling analysis undertaken for the Engineering Impact Assessment is summarised and compared to flood modelling analysis undertaken on behalf of the Council. The results of both analyses are stated to compare well.

However, few details of the flood modelling analysis are provided. The following would be expected to be provided as part of the Engineering Impact Assessment:

- A tabular summary of design flood levels for each event analysed, including the levels adopted for the boundary conditions in the model.
- Comment on model calibration undertaken, if any.
- Graphical comparison of the results of the Opus and Council models.
- Tabular comparison of pre- and post-development flood levels at various locations upstream and downstream of the site to clarify where impacts have been investigated.
- Mapped comparison of pre- and post-development flood extents and/or levels, for example using afflux maps that show the difference between pre- and post-development flooding.
- Details of the methodology and results of the sensitivity analysis of the downstream boundary sea levels to assess climate change (i.e. sea level rise) impacts.

The Engineering Impact Assessment makes reference to sensitivity analysis carried out to determine the impact of sea level rise; however, no results or discussion on this analysis are presented.

The adopted fill levels for the development do not meet the requirements of current Council policy as set out in version 1.3 of Council's Development Control Plan (DCP), which requires

a minimum fill level of 400mm higher than proposed and a minimum floor level of 200mm higher than proposed.

2.3 Specific comments

Proposed fill levels

The minimum proposed fill and floor levels are 2.4 mAHD and 3.1 mAHD respectively, which are 400mm and 200mm lower respectively than those required by Council's current DCP. The levels given in the current DCP have been revised upwards to reflect recent predictions of sea level rise.

Flooding impacts of the development

The proposed filling slightly increases flood levels upstream but impacts are considered to be insignificant. Up to 60mm increase is noted and deemed 'mathematically insignificant', when related to flood depths of up to 1m, presumably for the 100 year Average Recurrence Interval (ARI) event. It is recommended that this be further justified by assessment of impacts for more frequent flood events, e.g. 2 to 10 year ARI events, to confirm that the development will not exacerbate more frequent flooding processes. If flood depths and extents are not significantly impacted for more frequent events then this would provide further justification for classifying impacts as insignificant.

Impacts of Climate Change

The main EA document does not mention climate change. It refers to Chapter 6 of the Engineering Impact Assessment by Opus, which deals with flooding implications. Chapter 6, in turn, refers to *Flood Risk Management Guideline: Practical Consideration of Climate Change,* which was issued by the Department of Environment and Climate Change (DECC) in October 2007. The guideline recommends that, to consider possible impacts of climate change on flood levels in coastal areas, a sensitivity analysis should be undertaken with plausible increases in rainfall intensity of +10%, 20% and 30%, and sea level rises of 0.18, 0.55 and 0.91 metres (m).

Table 1 of the guideline indicates (from 2007 CSIRO reports) a 5% to 10% indicative increase in the 40 year - 1 day extreme rainfall intensity for the Northern Rivers region by 2070. This is broadly consistent with projections from a more recent CSIRO report (*Calculation of Australian extreme rainfall within GCM simulations using Extreme Value Analysis*, T Rafter and D Abbs, report to the Department of Climate Change (DCC), 2009). This paper presents % changes in the 50 year - 1 day rainfall intensity for the adjoining South East Queensland region obtained from eleven climate models. For 2055 the average median change is +14% and for 2090 the average median change is +30.6%. These latest projections support the use of 10%, 20% and 30% increases in rainfall intensities in sensitivity analysis.

Chapter 6 states that the sensitivity of the flood modelling to the sea level on the downstream side of the bridge was assessed by running the hydraulic flood model with the sea level rises outlined in the DECC guideline. However there is no description of what was done, the results obtained or any conclusions drawn. Furthermore, there is no mention of undertaking a sensitivity analysis with a range of rainfall intensity increases and sea level rises, as recommended in DECC, 2007.

Chapter 6 reports that various combinations of catchment floods and ocean storm surge events of different probabilities (Q10, Q20 and Q100) were modelled, but that relates to past climatic conditions, not future climatic conditions.

Of particular relevance to the subject proposed development, on 11 December 2009 the Department of Environment, Climate Change and Water (DECCW) released a draft *Flood Risk Management Guide: Incorporating sea level rise benchmarks.* This provides, amongst other things, guidance on estimation of ocean boundary conditions for hydraulic flood modelling of tidal waterways with sea level rise, for different types of ocean entrances. The guidance would have been very useful for the flood modelling reported in Chapter 6. However, because the Engineering Impact Assessment report is dated February 2010 and Chapter 6 does not mention the December 2009 guide by DECCW, the flood modelling reported in Chapter 6 must pre-date the issuing of that guide.

Significantly, the DECCW draft guide states that, where the site is below 4 m AHD, a conservative assumption for estimating the 100 year ARI flood level under climate change is to add the sea level rise benchmarks to the (existing) 100 year ARI flood level relevant to the site. Chapter 6 in the Engineering Impact Assessment notes that the 100 year flood level at the site is 2.40 m AHD from a superseded version of Council's DCP Section 3 Flood Liable Land. This suggests a 100 year flood level at the proposed development of 3.3 m AHD by 2100, consistent with Council's current DCP, and which is 0.2 m above the adopted minimum floor level for all buildings of 3.1 m AHD.

The NSW Government has issued guidance on planning for sea level rise in Department of Planning (2009) *Draft NSW Coastal Planning Guideline – Adapting to Sea Level Rise*. This recommends adopting, as planning benchmarks, a sea level rise above 1990 mean sea levels of 0.4 metres (m) by 2050 and 0.9 m by 2100.

More recent observations and research reported in *Climate Change Risks to Australia's Coast, A First Pass National Assessment,* DCC, November 2009, support this policy and indicate that higher sea level rise values may be possible. Figure 2 in *Scientific basis for the 2009 sea level rise benchmark, Draft Technical Note,* DECC, February 2009, shows that over the past 20 years the mean global sea level has been rising along a trajectory that would result in a rise of at least 0.9 m by 2100. The Technical Note reported that CSIRO has developed three plausible sea level rise scenarios that would result in rises of 0.5 m (low), 0.82 m (medium) or 1.10 m (high) by 2100. A sea level rise of 1.1 m by 2100 was adopted for the *First Pass National Assessment*.

A further reason for caution is that sea levels will not stop rising in 2100. Regardless of efforts to limit greenhouse gas emissions, thermal expansion of the oceans and ice sheet melt will cause sea levels to continue rising for many centuries. As section 2.4 in NSW Planning, 2009 notes, 'whilst climate change projections extend to the year 2100 this does not mean that sea level rise is projected to cease at that time'. Figure 2.10 in DCC, 2009 shows projected sea level rises of 1.3 m to 3.2 m by 2200 and 2.5 m to 5.0 m by 2300. Accordingly, a projected sea level rise of 0.9 m is no longer considered to be the upper limit when assessing the full range of plausible outcomes by 2100, and particularly so when considering impacts over longer time frames. However, in order to be consistent with current policy, it is recommended that the proposed development be 'stress tested' to identify and assess likely impacts on it when sea levels are 0.9 m higher than in 1990 (the reference year for sea level rises).

Another inevitable consequence of the sea level continuing to rise for centuries is that, based on the projections shown in DCC, 2009, the site filled to a minimum level of 2.4 m AHD will be overtopped by rising sea levels, probably sometime next century. Because of the

criticality of the minimum fill level to the development, it is recommended that the adopted level of 2.40 m AHD be adequately justified in the EA.

It is also recommended that further investigations be carried out to identify (a) the impacts that frequent or permanent sea inundation of the filled site would have on the proposed development; (b) the most feasible adaptation measures that could be undertaken then to protect the development, and (c) adaptation features that could cost-effectively be incorporated into development now to facilitate protecting it from sea level rise next century.

Sea level rise will also greatly increase the frequency of extreme sea level events. NSW will be affected to a greater extent than elsewhere along the Australian coastline. Figure 2.17 in DCC, 2009, from Church et al, 2008, (Church et al, 2008, *Position Analysis: Climate change, sea-level rise and extreme events: Impacts and adaptation issues.* ACE CRC) shows that in the vicinity of Hastings Point a sea level rise of 0.5 m will increase frequency of extreme sea level events by one hundred fold – meaning that the current 100 year extreme sea level event would occur almost every year on average. The increase in frequency for a sea level rise of 0.9 m would be even greater. It is recommended that implications of such a significant change on the proposed development be addressed in the EA.

Furthermore, in light of recent observations and research projecting larger sea level rises by 2100, along with increases in rainfall intensity of up to 30%, it is recommended that the implications of a sea level rise of 0.9 m by 2100 be assessed, in conjunction with 10%, 20% and 30% increases in rainfall intensity. This may prompt reconsideration of the minimum fill level on the development site.

2.4 Statement of commitments

The statement of commitments relevant to flooding is as follows:

- Site levels shall achieve a minimum of 2.4 mAHD across the developable area of the site, inclusive of proposed allotments, road reserves and emergency access fire trails.

As stated previously, this minimum fill level is 400mm lower than the current DCP requirement of 2.8 mAHD.

2.5 Comments on other stakeholder responses

Responses from Tweed Shire Council (dated 28 July 2010), DECCW (dated 1 July 2010) and NSW Planning were reviewed. These responses were consistent with PB's review of the EA and confirmed that the key concerns with the EA relating to flooding were lack of detail provided for the modelling analysis of flooding impacts and results, lack of information on the consideration of climate change impacts and lack of consistency with current Council policy on minimum fill and floor levels.

2.6 Conclusions and recommendations

The following clarifications/additions should be sought:

- Further details of the flood modelling analysis undertaken, including tabular and mapped comparison of pre- and post-development flood levels and extents.
- Clarification of the sea level rise analysis undertaken and the results of the analysis.
- Assessment of the impacts of the development on flood levels in adjacent land for more frequent flood events, e.g. the 2 to 10 year ARI events.
- Full consideration of climate change impacts by:
    - Undertaking a sensitivity analysis by considering a sea level rise of 0.9 m in conjunction with 10%, 20% and 30% increases in rainfall intensity.
    - The proposed development be 'stress tested' to identify and assess likely impacts on it when sea levels are 0.9 m higher than in 1990.
    - Adequate justification of the adopted minimum fill level of 2.4 m AHD having regard to projected sea level rises next century.
    - Identification of the impacts that frequent or permanent sea inundation of the proposed development; the most feasible adaptation measures that could be undertaken then to protect the development, and adaptation features that could cost-effectively be incorporated into development now to facilitate protecting it from sea level rise next century.

3. Stormwater and Water Cycle Management

3.1 Documents available for review

The following documents were reviewed for information on stormwater and water cycle management:

- *Environmental Assessment Part 3A – EP&A Act 1979, No.156 Creek Street, Hasting Point – Walter Elliot Holdings P/L*, Planit Consulting, March 2010.
- *Palm Lake Works Pty Ltd, Engineering Impact Assessment,* Revision 4, Opus International Consultants (Australia) Pty Ltd., 24 February 2010.

3.2 General comments

The assessment of the pre- and post development stormwater processes only considers the local drainage sub-catchments within the site and 1 external sub-catchment that is part of a larger sub-catchment extending into the site. It does not consider impacts of the development, in particular the impact of infilling land, on the drainage processes for local drainage catchments adjacent to, and upstream of, the site.

Water Sensitive Urban Design (WSUD) measures to treat site runoff have not been considered. Instead, proprietary stormwater treatment systems, such as Gross Pollutant Traps (GPTs), have been proposed.

3.3 Specific comments

Impacts on local drainage processes

The caravan park drainage catchment E3 and the northern drainage catchments E4 and E5 are shown to drain towards the north western side of the site. The flows from these catchments have been calculated but there is no consideration on the impact of the development on the discharge of these catchment flows to Christies Creek. It is possible that the filling of land could reduce the capacity of overland flow paths discharging these catchment flows, particularly during large storm events.

Similarly, no assessment is presented of the impacts on other local drainage catchments north of Creek Street and east of the Caravan Park, including the portion of Creek Street itself which borders the northern edge of the site.

It is recommended that hydraulic modelling of the local drainage catchments be undertaken, to include the sub-catchments within the site itself and adjacent catchments that drain directly to the site, or overflow into it during large storm events. The objective of this modelling would be to determine the impacts of the development on local drainage processes during major and minor storm events. These local drainage processes would also be affected by flooding in Christies Creek; however, the impacts of the development on faster responding drainage and flooding processes in the local catchments that occur in advance of peak flooding in the main creek should be determined. It is possible that the

existing XP-Storm hydraulic model developed to investigate main creek flooding could be adapted and developed further to assess the local drainage processes in detail.

WSUD measures

Proprietary stormwater treatment devices have been proposed to treat runoff from site roads. Such devices require regular maintenance, which would presumably be undertaken by Council. Alternative treatment measures such as infiltration and swale drains are briefly mentioned but not considered in detail. Further consideration of alternative WSUD measures is recommended for treatment of road runoff, or further justification should be presented for the use of proprietary devices if alternative measures are not suitable.

3.4 Statement of commitments

The statement of commitments does not include an undertaking to ensure that drainage processes in adjacent catchments are not adversely affected by the development. This should be included.

The statement of commitments also does not include an undertaking to investigate alternative WSUD measures for treating road runoff at later stages of design when the fill material and levels are determined in detail. This should be included.

3.5 Comments on other stakeholder responses

Responses from Tweed Shire Council (dated 28 July 2010), DECCW (dated 1 July 2010) and NSW Planning were reviewed. Council's response was consistent with PB's recommendations on further analysis of the impacts of the development on local drainage processes. NSW Planning requested details of the performance of the effluent disposal system during flood conditions.

3.6 Conclusions and recommendations

The following clarifications/additions should be sought:

- Further analysis of the local drainage catchments should be undertaken; to include the sub-catchments within the site itself and adjacent catchments that drain directly to the site, or overflow into it during large storm events; in order to determine the impacts of the development on local drainage processes during major and minor storm events. The analysis should consider the impacts of the development on fast responding drainage and flooding processes in the local catchments that occur in advance of peak flooding in Christies Creek.

- Further consideration of WSUD measures to treat road runoff or further justification of the proposal to use proprietary stormwater treatment devices should be provided.

4. Acid Sulfate Soils

4.1 Documents available for review

The following documents were reviewed for information on Acid Sulfate Soils (ASS):

- *Environmental Assessment Part 3A – EP&A Act 1979, No.156 Creek Street, Hasting Point – Walter Elliot Holdings P/L*, Planit Consulting, March 2010, incorporating:
  - Acid Sulfate Soil & Contamination Investigation, Proposed Filling, Lot 156 Creek Street, Hastings Point, Soil Surveys Engineering Pty Ltd, July 2004, and
  - Preliminary Acid Sulfate Soil Management Plan, Proposed Filling, Lot 156 DP 628026 Creek Street, Hastings Point NSW, March 2008

4.2 General comments

The information provided in the ASS and contamination report indicates the presence of Actual Acid Sulfate Soils (AASS) and Potential Acid Sulfate Soils (PASS) at the site.

In regard to the mitigation of identified ASS, additional detail should be included in the ASS management plan.

4.3 Specific comments

The presence of ASS at the site has been identified based on a soil investigation undertaken by Soil Surveys Engineering Pty Ltd (Soil Surveys). The ASS at the site has been identified using the results of field and laboratory soil testing. The extent of the ASS was not delineated.

A management plan for ASS was prepared by Opus Qantec McWilliam. Although this plan does provide some treatment and management procedures, it does not meet the requirements for an ASS management plan as detailed in the Acid Sulfate Soil Manual (ASSMAC, 1998).

The elements identified in the ASS Manual as the minimum requirements of an ASS management plan are:

- An overview of the site and surrounding area.
- An overview of the work to be undertaken.
- A description of the ASS mitigation strategies with regard to each phase of construction and operation, addressing:
  - Ground disturbance.
  - Excavated soils.

- Potential acid leachate production.

- A monitoring program for soil quality and both groundwater and surface water quality, outlining:
  - Parameters to be monitored.
  - Monitoring locations.
  - Monitoring frequency.
  - Analyses to be conducted.
  - Laboratory to conduct the analyses.
  - Procedures in the event that monitoring identified exceedances.
  - Reporting procedures (if appropriate).
- A description of pilot project or field trial (if new mitigation strategies are being used or a pilot is required by the determining authority), to:
  - Prove the effectiveness and feasibility of the procedures.
  - Demonstrate the proponent has the capability to implement the procedures.
  - Demonstrate the ability to comply with standards and targets.
- A description of the contingency procedures to be implemented at the site to address any unexpected events or the failure of management procedures, including a Remedial Action and Restoration Action Plan related to:
  - Failure to implement any proposed management strategies.
  - Any mitigation strategies which prove to be ineffective, resulting in failure to meet standards or performance levels.

The ASS management plan prepared for the site provides a limited overview of the site and proposed work. Additional detail of the surrounding area and work should be included.

General mitigation strategies are presented, although details have not been given of the soil stockpiling or stormwater containment procedures. Additionally, there is no monitoring program identified and no discussion of a pilot or field trial. Furthermore, no contingencies have been presented to address unexpected conditions or failures in the management procedures.

Based on the failure to meet the minimum requirements identified in the ASS manual, the ASS management plan prepared does not meet the requirement of a detailed ASS management plan.

4.4 Statement of commitments

The Statement of Commitments relating to ASS (EA Section 7.1.5, p.121) partially addresses the relevant DGRs, although it needs additional detail relating to the procedures that will be used to mitigate the ASS identified at the site.

4.5 Comments on other stakeholder responses

Stakeholder responses submitted by the NSW Planning, DECCW and Tweed Shire Council were reviewed. None of these submissions contained comments relating to ASS.

4.6 Conclusions and recommendations

The information provided does satisfactorily identify the presence of ASS at the site. Additionally, there is a discussion of mitigation measures, although the preliminary ASS management plan does not meet the requirements of a detailed ASS management plan. Clarification on these issues should be sought.

5. Groundwater

5.1 Documents available for review

The following documents were reviewed for information on groundwater:

- *Environmental Assessment Part 3A – EP&A Act 1979, No.156 Creek Street, Hasting Point – Walter Elliot Holdings P/L*, Planit Consulting, March 2010.
- *Palm Lake Works Pty Ltd, Engineering Impact Assessment,* Revision 4, Opus International Consultants (Australia) Pty Ltd., 24 February 2010.

The DGRs indicated that the following guidelines relating to groundwater should be consulted:

- Environmental Guidelines for the Utilisation of Treated Effluent by Irrigation, NSW DEC, 2004).
- The NSW Wetlands Management Policy Action Plan, DLWC, 1999.

Note DLWC, 1999 has been updated by the following revised Wetlands Policy:

- NSW Wetlands Policy (2010), NSW Department of Environment, Climate Change and Water, Report No 2010/39, March 2010.

5.2 General comments

A basic description of the site geology and soils is presented in Section 5.1.1 of the Environmental Assessment (Planit, 2010). No site specific investigations are presented.

No description of the groundwater setting or hydrogeological conditions is outlined in the Environmental Assessment. The Environmental Assessment refers to shallow groundwater conditions within the project area but does not describe the hydrogeology in any detail or outline groundwater quality.

Shallow groundwater conditions are referred to in the description of geotechnical setting (*Sections 2.13* and *3.11*), acid sulfate soil description (*Section 4.5.11*) and Riparian Zone (Section 5.2).There is some confusion in the report about the shallow groundwater conditions encountered. In the geotechnical descriptions the shallow groundwater is described as being monitored in boreholes at depths between 1 m and 1.55m whereas in the acid sulfate soil discussion the depth to groundwater is described as between 0.55 and 1.85 m. Within the riparian zone discussion the shallow groundwater watertable is described as reaching the surface after rainfall.

Shallow groundwater conditions are mentioned in the engineering impact assessment (Opus International Consultants, 2010, *Section 8.2.3*) and suggest that dewatering will be required in the excavation of services trenches. The report indicated that water will be disposed of in accordance with the water management plan in Appendix E. The water management plan is not site specific and does not outline the location of groundwater or surface monitoring points.

Section 4.3.2 of the Environmental Assessment indicates that the project site contains a SEPP14 wetland and in accordance with the SEPP14 legislation an understanding of the environmental effects should be collated including surface water and groundwater quality and salinity. The Environmental Assessment further states that these elements have been satisfactorily addressed. However review of the documents presented has not revealed any description of groundwater quality.

Onsite retention of water is likely to locally increase groundwater levels due to a groundwater mound developing beneath the detention basin due to leakage. Elsewhere groundwater recharge is likely to be reduced as rainfall is captured as roof and pavement runoff and discharged to stormwater, off-site.

5.3 Specific comments

The assessment of groundwater provided in the Environmental Assessment is considered inadequate. It is assessed the following conditions should be investigated:

- Assessment of local hydrogeological conditions.
- Assessment of groundwater flow direction.
- Assessment of groundwater quality.
- Assessment of dewatering requirements (size of excavations required, estimate of volume of groundwater to be pumped, duration of pumping, disposal options, potential impact on surrounding environment).
- Assessment of the proposal on the existing hydrogeological environment for the short term and long term.

5.4 Statement of commitments

The EA indicates the following statements relating to groundwater:

Executive summary – ESD and cumulative impacts

The proposal demonstrates adherence to these principals via the retention of existing riparian vegetation and regeneration of previously disturbed areas, the assurance of negligible impacts upon adjacent sensitive areas, the maintenance of existing groundwater quality and the adoption of management measures relating to energy efficient residential design and traffic efficiency.

It is assessed that the maintenance of groundwater quality cannot be proven until baseline investigations have been undertaken.

Section 4.3.2 State Environmental Planning Policy No 14 – Coastal Wetlands (SEPP14)

(with reference to surface and groundwater characteristics)

It is considered that all of the above elements have been satisfactorily addressed within this Environmental Assessment and supporting documentation.

No groundwater quality information has been provided in the documents reviewed.

Section 4.3.5 State Environmental Planning Policy No 71 – Coastal Protection (SEPP71)

(m) Detailed investigations have been undertaken into the existing water quality of the site and groundwater.

No groundwater quality information has been provided in the documents reviewed.

5.5 Comments on other stakeholder responses

Responses from Tweed Shire Council (dated 28 July 2010), DECCW (dated 1 July 2010) and NSW Planning were reviewed. DECCW note that on-site retention techniques are proposed for the development. DECCW comment that, because of the longer periods of inundation at the site and surrounds, groundwater dependent species may be impacted. The responses from Council and NSW Planning did not raise issues concerning groundwater, hydrogeology or dewatering.

5.6 Conclusions and recommendations

The information provided in the EA and other supporting documentation reviewed is assessed as inadequate in describing the hydrogeology at the site and potential impacts. Specifically there have been no groundwater investigations or assessment that describes groundwater other than referring to shallow boreholes in which groundwater levels have been recorded.

A two staged approach is recommended to adequately address the DGR's with respect to groundwater. Stage 1 is a desktop hydrogeological assessment using available data, and Stage 2 is a field based assessment to more accurately characterise the groundwater conditions at the site. It is recommended that Stage 1 be undertaken at the current concept stage of design and planning, and Stage 2 be undertaken at a later stage following approval of the concept plan.

Stage 1 – Concept Design and Planning

- Desktop assessment of groundwater conditions at the site. The desktop assessment should include a description of aquifers present, groundwater contour map showing flow directions and the water table level, discussion of groundwater recharge and discharge conditions and a description of the known hydrogeochemistry.
- An assessment of the impact of proposed development on the existing hydrogeological environment for the short term and long term should be undertaken.
- An assessment of dewatering requirements should include the estimated size of excavations required, estimate of volume of groundwater to be pumped, duration of pumping, disposal options and potential impact on surrounding environment.
- A gap analysis of the data should be undertaken to clearly identify the required information that needs to be assessed and analysed from the Stage 2 field based assessment. The gaps are likely to be insufficient groundwater level monitoring data,

insufficient groundwater chemistry data, and insufficient aquifer parameters to accurately assess the dewatering requirements.

Stage 2 – Detailed Design and Planning

- A field based investigation is recommended to more clearly define the hydrogeology of the site and to address knowledge gaps from the Stage 1 assessment. The likely assessment should be specific to the site and should include; groundwater levels fluctuations, groundwater chemistry groundwater flow paths, and aquifer parameters.

- Baseline monitoring of groundwater levels and the hydrogeochemistry is required to establish baseline conditions prior to any development. During and after construction monitoring should continue to identify any adverse impacts to groundwater quality and set in place groundwater remediation as required. Groundwater and surface water quality monitoring is required in accordance with the SEPP14 legislative requirements.

- The additional field based information can then be used to refine and more accurately assess the dewatering requirements for the site.