5 October 2007

Mr Frank van den Brink
The Catylis Group
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NORTH SYDNEY  NSW  2059

Dear Frank

VINEYARDS ESTATE, WORRIGEE
SUMMARY OF FLOOD-RELATED INVESTIGATIONS

I refer to your proposal to develop a parcel of land located at Worrigee, south-east of Nowra, for residential purposes. The land is identified in the Nowra-Bomaderry Structure Plan as a “Future Living Area” and occupies an area of approximately 100 hectares.

As shown in Figure 1, the development site is located adjacent to Brundee Swamp which forms part of the southern floodplain of the Shoalhaven River. During large floods there is potential for floodwaters to overtop the banks of the Shoalhaven River and inundate the adjoining floodplain, including low-lying sections of your site.

As you would be aware, we have completed a range of flood-related investigations for the site. The investigations have aimed to:

§ determine the veracity of Shoalhaven City Council’s current 100 year recurrence flood level estimate for the site; and,
§ assess the potential for development of the land to adversely impact on flood behaviour during large Shoalhaven River floods.

Accordingly, we are pleased to provide in the following a summary of the outcomes of the investigations that we have completed to-date. It is understood that this information will be used as a basis for assessing potential development options for the site.
1. BACKGROUND

Design flood behaviour along the Lower Shoalhaven River is currently defined using the results of hydraulic computer modelling that was originally undertaken as part of the ‘Lower Shoalhaven River Flood Study’ (1990). The hydraulic model of the Shoalhaven River was developed using the CELLS software, which is a quasi two-dimensional modelling package that was originally developed in South Africa in the mid 1970s.

The results from the Flood Study indicate that the entrance topography at Shoalhaven Heads significantly influences flood behaviour along the river downstream of Nowra. Accordingly, separate design flood simulations were undertaken for the Flood Study using the CELLS model assuming that the entrance at Shoalhaven Heads was ‘open’ and ‘closed’. The results of the ‘closed’ entrance simulations were adopted by Council for planning purposes as they provide the most conservative flood levels estimates within the lower reaches of the river.

The results of the CELLS modelling indicate that the current peak 100 year recurrence flood level at the development site is 3.48 mAHD. This peak flood level estimate was derived assuming that the Shoalhaven River entrance is ‘closed’ and that peak inflows from the Shoalhaven River catchment occur in conjunction with elevated ocean levels at Shoalhaven and Crookhaven Heads.

However, Appendix C of the DNR (now DECC) guideline document titled, ‘Floodplain Risk Management Guideline No 5 – Ocean Boundary Conditions’ (in draft, November 2004) outlines that the initial results of research show that there is little evidence of any correlation between catchment floods and elevated ocean water levels. Accordingly, it is considered that the current design flood level estimates for the lower Shoalhaven River are overly conservative. Therefore, we have undertaken additional investigations to develop a more reliable 100 year recurrence flood level estimate for the development site in accordance with Guideline No. 5.

2. REVISED 100 YEAR RECURRENCE FLOOD LEVEL FOR DEVELOPMENT SITE

2.1 Hydrodynamic Model Development

A new, fully two-dimensional hydrodynamic model of the southern floodplain of the Shoalhaven River was developed for the project. It was considered that a fully two-dimensional model would more reliably simulate flood behaviour in the vicinity of the proposed development. Furthermore, the development itself can be more reliably represented in such a model. The hydrodynamic model was developed using the RMA-2 software. The layout of the RMA-2 model is shown in Figure 2.

The RMA-2 model was used to simulate the 100 year recurrence flood for both the ‘open’ and ‘closed’ Shoalhaven River entrance conditions. The results generated by the RMA-2 model were verified against the results generated by the existing CELLS model and were found to reproduce peak 100 year recurrence flood levels at the development site to within 40 mm. This indicates that the RMA-2 model is generating reliable estimates of design flood
behaviour in the vicinity of the development site and is suitable for more detailed flood-related investigations.

2.2 **Guideline No. 5 – Ocean Boundary Conditions**

As discussed, peak flood levels within the lower reaches of the river system are strongly influenced by the ocean level and entrance conditions at the time of the flood. Accordingly, it is difficult to establish a ‘typical’ design flood due to the various combinations of entrance, ocean level and catchment runoff conditions that could potentially occur in isolation or concurrently. That is, no two floods are exactly the same and it is difficult to define an ‘standard’ design flood.

In recognition of the need to provide a consistent approach to defining ocean boundary conditions for flood modelling in coastal catchments, the DNR (now DECC) developed a guideline document titled, ‘Floodplain Risk Management Guideline No 5 – Ocean Boundary Conditions’ (in draft, November 2004). Guideline No 5 provides advice on the derivation of appropriate ocean boundary conditions for a variety of ocean entrance types.

Guideline No. 5 has been applied to a number of coastal catchments throughout NSW. This includes Burrill Lake, which is located within the Shoalhaven City Council Local Government Area.

2.3 **Hydrodynamic Model Results**

The verified RMA-2 model was used to simulate a range of design floods in accordance with recommendations outlined in DECC’s Guideline No. 5 to develop a revised 100 year recurrence flood level estimate for the site. This involved developing a ‘design envelope’ by using the highest peak flood level generated from flood modelling that was undertaken assuming:

- a large design flood (e.g., the 100 year recurrence flood) occurs during a normal (neap) tidal cycle; and,

- a small design flood (e.g., the 10 year recurrence flood) occurs in conjunction with elevated ocean levels (i.e., 2.6 m AHD).

For both design flood simulations it was assumed that the Shoalhaven River entrance remained closed throughout the flood in order to provide a conservative estimate of peak flood levels in the vicinity of the development site. The peak results from both flood simulations were combined to produce the final 100 year recurrence design envelope for the Lower Shoalhaven River.

Peak floodwater depths and velocity vectors were extracted from the design flood envelope and are presented in **Figure 3**. **Figure 3** indicates that the lower-lying sections of the site would be inundated at the peak of the 100 year recurrence flood. However, flow velocities across the site are predicted to remain below 0.05 m/s (i.e., very low).
Predicted peak flood levels in the vicinity of the development site were also extracted from the design flood envelope and show that the revised peak 100 year recurrence flood level at the development site is predicted to be **3.29 mAHD**. That is, the adoption of the methodology outlined in Guideline No. 5 reduces peak 100 year recurrence flood levels at the development site by approximately 190 mm relative to Shoalhaven City Council’s current design flood level estimates (as defined by the CELLS model).

### 2.4 Impact of Sea Level Rise

Guideline No. 5 notes that no specific allowance for increases in ocean level associated with greenhouse effects should be incorporated into the derivation of the ‘design envelope’ as the elevated ocean levels specified in the guideline are considered to be conservative. Nevertheless, the guideline does recommend assessing the impact of further increases in peak ocean levels as part of a sensitivity analysis.

Accordingly, additional hydrodynamic model simulations were completed to assess the sensitivity of the predicted 100 year recurrence flood level at the site to increases in ocean levels.

Guideline No. 5 states that median sea levels are predicted to rise by between 0.075 and 0.15 metres by 2040. In order to provide a conservative estimate of the impact of sea level rise on the development site, the flood simulations outlined in Section 2.3 were re-run assuming an increase in ocean level of 0.2 metres (i.e., 0.05 metres above the predicted upper bound median sea level increase value).

The results of the design flood simulations were combined to produce a revised design flood envelope for the 100 year recurrence flood. Based on this, the peak 100 year recurrence flood level at the development site, incorporating a 0.2 metre allowance for sea level increases, is predicted to be **3.31 mAHD**. That is, a 0.2 metre increase in peak ocean levels is predicted to increase peak 100 year recurrence flood levels at the site by just 0.02 metres. This shows that peak 100 year recurrence flood levels at the site are relatively insensitive to increases in ocean levels.

Nevertheless, it is recommended that a peak 100 year recurrence flood level of **3.31 mAHD** should be adopted for the site.

### 3. IMPACT OF FILLING OF THE DEVELOPMENT SITE ON LOCAL FLOOD BEHAVIOUR

#### 2.1 Indicative Fill Plan

As discussed, lower-lying sections of the development site are predicted to be inundated at the peak of the 100 year recurrence flood. Accordingly, it will be necessary to undertake selected filling across the land to maximise the development potential and so that a suitable building platform can be constructed to meet Shoalhaven City Council’s minimum floor level requirement. Council’s DCP No. 106 requires that the floor level of any new residential development be at least 500 mm above the peak 100 year recurrence flood level.
A development layout and associated fill plan for the development is yet to be prepared. However, in order to provide a conservative initial assessment of the potential for filling across the site to impact on existing flood behaviour, the indicative fill plan shown in Figure 4 was adopted. It should be recognised that the fill plan shown in Figure 4 is likely to significantly over-estimate the extent of filling that will be completed to accommodate future residential development across the site. Accordingly, we consider that it will be necessary to complete additional modelling once a more reliable fill plan is developed for the site.

2.2 Impact of Filling on Local Flood Behaviour

The hydrodynamic model that was developed to define ‘existing’ flood behaviour in the vicinity of the development site, was updated to reflect the fill proposal shown in Figure 4. The modified model was then used to re-simulate the design 100 year recurrence flood for ‘post-development’ conditions. The magnitude of any changes in flood behaviour arising from the proposed filling was then established by comparing hydrodynamic model results from the ‘existing’ and ‘post-development’ scenarios.

Peak 100 year recurrence depths and velocity vectors were extracted from the results of the ‘post-development’ modelling and are presented in Figure 5. Figure 5 indicates that the filling will prevent inundation of that section of the site where filling is proposed. However, the flood extent will remain unchanged across the remainder of the floodplain.

The predicted peak 100 year recurrence flood level for the post-development scenario was determined to be 3.32 mAHD. That is, the filling shown in Figure 4 is predicted to increase peak 100 year recurrence flood levels in the vicinity of the site by 10 mm.

Flow velocity difference mapping was also developed to assess the impact of the floodplain filling on peak flow velocities. Difference maps are created by comparing peak flow velocity estimates at each node in the hydrodynamic model network from simulations undertaken for both ‘existing’ and ‘post-development’ scenarios. This effectively creates a contour map of predicted changes in peak flow velocities and allows easy determination of the impact of the filling on existing flow velocities.

Flow velocity difference mapping was developed for the 100 year recurrence flood and is presented in Figure 6. Increases in peak flow velocity are represented as different shades of red and decreases in peak flow velocity are represented as shades of blue. The white areas indicate changes in peak flow velocity of less than 0.05 m/s (i.e., negligible changes).

Figure 6 shows that the filling is predicted to generate a small, localised increase in peak 100 year recurrence flow velocity of 0.06 m/s. This is predicted to occur outside of the development site, however, does not extend across any existing development.

Overall, the filling shown in Figure 4 is predicted to generate small increases in peak flood level and flow velocity. However, the magnitude of the increases are not predicted to expose any existing development to an increase in flood hazard or flood damages relative to existing conditions.
4. CONCLUSIONS

This report has presented a summary of the outcomes of flood-related investigations that have been completed for the Vineyards Estate development at Worrigee.

The following conclusions can be drawn from the results of the investigations:

- Shoalhaven City Council’s current 100 year recurrence flood level estimate for the development site is 3.48 mAHD. This is considered to be overly conservative.

- The results of additional hydrodynamic model simulations completed using a fully two-dimensional hydrodynamic model indicate that a more reliable 100 year recurrence flood level estimate for the site would be 3.31 mAHD. This incorporates an allowance for increases in ocean levels associated with climate change.

- Although a layout for the proposed development is yet to be developed, a preliminary assessment of ‘post-development’ flood behaviour indicates that filling of the site will generate only small increases in peak 100 year recurrence flood levels and flow velocities in the vicinity of the development site.

Accordingly, it is considered that development of the site, incorporating filling up to the limit shown in Figure 4, could proceed and would not produce any unreasonable impacts on existing flood behaviour.

Nonetheless, we believe that it will be necessary to complete further detailed hydrodynamic investigations once a preferred fill plan for the site is developed. Furthermore, the outcomes of the more detailed investigations will need to be documented in a bound Flood Impact Assessment report in a format suitable for submission to Council. We would be happy to proceed with these more detailed investigations once a fill plan for the site has been finalised.

We trust that the above report addresses your needs. Please feel free to contact Chris Thomas or myself should you require any further information.

Yours faithfully
WorleyParsons

David Tetley
Project Engineer
WorleyParsons
NOTES
Aerial photography dated 2005

LEGEND
Development site

LOCATION OF THE PROPOSED DEVELOPMENT SITE
FIGURE 3

PREDICTED FLOODWATER DEPTHS AND VELOCITIES AT THE PEAK OF THE 100 YEAR RECURRENCE FLOOD FOR EXISTING CONDITIONS

Development site

NOTES
Aerial photography dated 2005
FIGURE 4

ADOPTED EXTENT OF FILLING FOR POST-DEVELOPMENT FLOOD SIMULATIONS

NOTES
Aerial photography dated 2005
Cadastre dated 2002

LEGEND
- Development site
- Assumed extent of area to be filled to above predicted 100 year recurrence flood level

Adopted Fill Extent
Site Boundary

PATRICK SIRMA
& Partners Pty Ltd
Patterson Britton

FIG 0515 Vineyards Estate PS
Fig Fill Extent.doc
FIGURE 5

PREDICTED FLOODWATER DEPTHS AND VELOCITIES AT THE PEAK OF THE 100 YEAR RECURRENCE FLOOD FOR POST-DEVELOPMENT CONDITIONS
PREDICTED CHANGE IN PEAK 100 YEAR RECURRENCE FLOW VELOCITIES

**NOTES**
- Aerial photography dated 2005
- Cadastre dated 2002

**LEGEND**
- Development site
- Assumed extent of area to be filled to above predicted 100 year recurrence flood level

**FIGURE 6**

- Maximum reduction in flow velocity = 0.2 m/s
- Maximum increase in flow velocity = 0.06 m/s

- Adopted Fill Extent
- Site Boundary