appendix b

Flooding

Cardno Lawson Treloar – July 2010

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Shaping the Future

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Attention: Mr Bill Yassine - Director

Dear Sir,

SANDY BEACH NORTH RESIDENTIAL DEVELOPMENT
REVIEW OF ENTRANCE BERM LEVEL/FLOOD EFFECTS AND FLOOD RISK

Preamble

Cardno Lawson Treloar (CLT) have been engaged by Sandy Shores Development Pty Ltd (SSD) to review a range of reports that have been prepared for them and the Department of Planning/Coffs Harbour City Council. These reports cover a range of issues that relate to or affect planned residential development on a site north of Sandy Beach on the north coast of NSW. They are listed in the References section of this letter.

The site is located adjacent to the Pacific Highway, about 20km north of Coffs Harbour. It is referred to as Lot 22 in DP1070182 and adjoins the northern boundary of the existing Sandy Beach township. The site also adjoins the southern and western shorelines of Hearns Lake and extends to the rear of the back beach dunes along Hearns Lake Beach.

Sydney NSW Property Consultants are acting as Project Managers for SSD and have requested that CLT address the following issues:-

- What is the appropriate entrance berm level to adopt for flood modelling of Double Crossing Creek and Hearns Lake; now and in the future?
- What is the degree of flood hazard related to this site?
- Is there an entrance opening policy for Hearns Lake?
- Any other relevant issues

This report does not repeat many of the detailed reporting aspects that have been prepared for this site, but refers to them as needed.

Entrance Berm Level

Hearns Lake is described as an ICOLL - an Intermittently Closed and Open Lake or Lagoon. The entrance berm level for an ICOLL is affected by the local wave climate and sediment volume and characteristics, as well as the catchment flows (frequency, peak flow, volume) and tidal prism of the estuary. BMT WBM (2009) describe the Hearns Lake Entrance berm as being dynamic. The entrance is usually closed, but opens naturally following sufficient catchment rainfall.

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A flood modelling investigation was undertaken for SSD by Patterson Britton and Partners (2005), who have also undertaken a 'Scientific Assessment of Entrance Berm Elevation' (2007) as additional advice to SDD. WMA Water (2009) have reviewed a range of reports for the Department of Planning and their summary of entrance berm elevation is presented on their Page 15. It is higher than that assessed by Patterson Britton and Partners – 2.6m to 3.0m AHD compared with 1.6m AHD by Patterson Britton. However, WMA Water use the term 'maximum berm height' loosely and do not appear to make an assessment of the hydraulic berm level, merely reporting assessments by others and do not acknowledge that berm levels are spatially variable and that that characteristic affects berm overtopping and initiation of the entrance breakout.

There are contrary opinions on what should be adopted as the berm level for flooding.

The Draft Flood Risk Management Guide: Incorporating sea level rise benchmarks in flood risk assessments, including the Appendix - Ocean boundary conditions for hydraulic flood modelling, as published by the Department of Environment, Climate Change and Water (NSW) have been considered in this assessment.

Berm Level Assessment

Patterson Britton and Partners (2007) present plan views and berm levels based on photogrammetric analyses of berm profiles prepared by the Department of Natural Resources. There are seven of these figures relating to analysed dates of 1943, 1964, 1973, 1986, 1996, 2000 and 2004.

Patterson Britton and Partners also mark the minimum level flow path (continuous) across the dune crest. This is the path that rising flood waters will find, and then gradually scour deeper, as the lake level rises and discharge to the sea commences. It is what may be called the functional or hydraulic level. The 'highest' berm levels are not important in this context and it is a mistake to interpret them that way. This level is different in every one of the analysed cases of photogrammetric data.

The maximum hydraulic berm level is limited by the site specific wave climate and the frequency of entrance opening events - as well as the available volume of sand – when opening naturally. The entrance generally opens naturally towards the north, a consequence of site specific wave conditions and greater eastward protection of the shoreline on the southern side of the entrance. Entrance opening characteristics will have been modified by human activity such as land use.

An analysis of the seven available photogrammetric berm level data sets leads to the following limiting hydraulics levels:-

1943 - 1.008
1964 - 1.848
1973 - 1.194
1986 - 1.546
1996 - 1.142
2000 - 1.125
2004 - 1.459

Note that Patterson Britton and Partners (2007) estimated the 1964 berm level to be 2.6m AHD, but there is a lower hydraulic berm level in that photogrammetric data set. Philip Haines of WBM, in his email to Martin Rose and Marcelle Mills dated 19 January 2006, advises that berm levels at the southern end of the entrance berm are higher than those at the northern end 'due to the regularity of entrance breakouts and scouring of the berm'. This point is agreed.and emphasizes the fact that the much lower berm levels at the northern end of the entrance berm are the appropriate levels to be used in flooding analyses. There is no evidential basis for suggesting that the higher southern area berm levels develop at the northern end of the berm. The DECCW guide cited above advises in Section A4.2 to use 'a range of known historical (berm) configurations'.

An extremal analysis of this data leads to an hydraulic berm level at the 20-years average recurrence interval (ARI) of 1.46m AHD. Although there is little data, there is more confidence in this result than an assessed value. Moreover, it has relevance in that it is consistent with the NSW Government's flood modelling policy that advises that the 100-years ARI flood should be modelled with the 20-years ARI ocean level hydrograph - a joint occurrence condition. Where the entrance is closed initially, the hydraulic berm level is commonly the initial controlling downstream boundary condition. The equivalent, joint occurrence relationship is then the 20-years ARI hydraulic berm level. This is the most likely 100-years ARI flood scenario, as considered by the NSW Government's flood modelling policy. ICOLL flood model simulations are best undertaken applying a numerical model that includes sediment transport and the related entrance scour morphological changes, as well as combined flood flows, wave processes and storm tide. These processes then provide a slightly lower peak flood level than is achieved with a fixed bed model. Patterson Britton and Partners (2005) did not include entrance scour in their flood modelling and hence on that basis their flood level results will be marginally conservative having also adopted a berm level of 1.6m AHD. It is acknowledged that the early photogrammetric data is less reliable than the later data. However, removing that data reduces the sample size and that reduces the confidence in the results also.

Patterson Britton (2004) undertook a detailed investigation of the long term stability of the Hearns Lake entrance berm area, extending upstream to the drop-over area. The outcome of that analysis was that 'there is no evidence that there has been any alteration in the general coastal processes at the entrance over the last 60 years.' This outcome is agreed by WBM (2006), Page 3-9.

The DECCW guide is consistent with this analysis and approach described above; this approach is a formalization of the principle of the guide to consider the range of known historic configurations as set out in Section A4.2 to use " a range of known historical configurations"- no mention of an unspecified 'maximum berm level' as mentioned by WMA Water (2009) on their page 6.

The hydraulic berm level for a 'blocked' entrance adopted by Patterson Britton and Partners was 1.6m AHD. This is a less frequent event than the realistic, recommended level of 1.5m (1.46) AHD and is closer to a 60-years ARI entrance berm hydraulic level.

Based on the extremal analysis of the available berm data, the hydraulic level is unlikely to exceed 1.8m AHD (the approximate 100-years ARI berm level, present sea level) in the present climate. A mean sea level rise would gradually build the 20-years ARI berm hydraulic level by an equal amount so that by 2100 it may be $1.46 + 0.86 \approx 2.3$m AHD. This allows for a sea level rise of 0.9m from 1990 levels (DECCW, 2009a), but also accounts for the observed rise in sea levels between 1990 and 2004 (the last photogrammetric date) of 3mm/year (DECCW, 2009b). The berm may also translate landward. This approach to the application of sea level rise is supported by DECCW (pers. comm. Phil Watson DECCW - Doug Treloar). **Note that this berm level would only occur at 2100 and until then it would be lower.** A future hydraulic berm level at the 100-years ARI would be 1.8m + 0.86m $\approx$ 2.7m AHD.

There is no basis for the Sainty & Associates (2006) opinion that the berm level '. . . could reasonably increase to a height of 3m (AHD?)...' and then to add 0.5m as an additional sea level rise effect '.... to accommodate predicted maximum sea levels...' His argument that storms and king tides could raise the berm level to 3m overlooks the fact that storms and king tides have been occurring for millennia, and that their effects are included already in observed berm-crest levels.

Worley Parsons Patterson Britton (2008) recommendation for the 2100 Hearns Lake flood level of 2.95m is realistic. Note that they only adopted a 10% rainfall increase for catchment runoff calculation (using RAFTS) and DECCW advise 20% increase. This change is unlikely to cause a significant increase in lagoon flood level, noting that Worley Parsons Patterson Britton (2008) do not include continuing erosion of the entrance berm. That process would lower the peak water level a little. At peak discharge the velocity through the entrance is about 3m/s. When this speed is greater than ¼ of the nearshore wave celerity (about 5.5m/s = $\sqrt{gd}$), which is the case here, the onshore propagating waves will be blocked and break further offshore - reducing actual wave set-up.

Mr Hurrell appears to criticize this report because the pilot channel and berm crest levels were not increased in line with SLR in the climate change scenarios. This report (CLT 2010) would advise that the 20-years ARI berm level that would be appropriate with the climate change 100-years ARI catchment flood is 2.3m AHD – see above, which is lower than the peak ocean level. In this situation the entrance would break-out rapidly because the flood level in the lake exceeds the ocean level. It is not appropriate to consider that, or likely for, the 100-years ARI flood to occur together with the 100-years ocean level; they being only weakly correlated processes - see also the email of 30 September 2005 from Mr Kevin Gibson of DIPNR to Mr Martin Rose. Mr Hurrel's view that the lake flood level could be significantly higher than 3m AHD is not supported – principally because the hydraulic level of the berm is not likely to exceed 2.7m AHD following SLR of 0.9m and flood levels are flat in the lake itself.

CLT have assessed that the 2100 hydraulic berm level is unlikely to exceed 2.7m AHD and hence that the berm would be overtopped and scour in such flood events. Water level data recorded in the lake by MHL show that as water level peaked in the lake at about 1.6m AHD, the entrance opened rapidly allowing the lake level to fall by about 0.6m - 28 January 2005, for example. Hence berm level would have been less than 1.6m AHD at that time (in order to allow overtopping and scour) and the rapid entrance opening process demonstrates that together with realistic berm levels the blocked entrance case that concerns Mr Hurrell is not a realistic scenario for this site. Other break-out instances are presented in Patterson Britton (2007) using the MHL data. In all flood cases, six or seven over two years, the water level dropped very rapidly indicating a breakout more effective than assumed by Patterson Britton. Hence their pilot channel approach is conservative.

An additional area of conservatism in the Patterson Britton flood modelling is in the adoption of peak ocean water levels of 2.6m and 2.2m AHD for the 100 and 20-years ARI peak ocean levels, respectively. CLT advise that the Hearns Lake entrance is more protected than many lagoon entrances (hence the lower berm levels) and that therefore the wave set-up component of the ocean water level would actually be less, especially in the pilot channel/scoured entrance where full wave breaking would not occur. Moreover, at peak flood flow, nearshore ocean waves would be blocked in the entrance.

Model Calibration

It is understood that there is no data available for model calibration. However, Worley Parsons Patterson Britton (2009) advise that they adopted friction factors consistent with channel and overbank vegetation and which matched friction factors that were similar to those adopted in previous flood studies where calibration data were available. Apart from model schematisation, which was based on reliable survey data, bed friction is the main calibration factor for hydraulic models.

It is understood that Double Crossing Creek is not gauged and calibration of the hydrologic model was not possible. In those circumstances Worley Parsons Patterson Britton adopted model coefficients developed for other coastal catchments. This a reasonable course to adopt.

Hazard Assessment

Patterson Britton and Partners (2005) demonstrate that the extent of high hazard (in terms of depth x velocity), extends only marginally onto the allotments proposed for this development. .

Cardno Lawson Treloar agree that where needed, some land-filling may be appropriate; or alternatively using pad footings.

It is understood that the approved 45 Hearns Lake Road project has a maximum fill depth of 1.6m.

For access to the site, in the event that it is partially inundated, Cardno Lawson Treloar would advise that roadways be designed to be passable in a future 500-years ARI flood; about 3.2m AHD.

It is understood that road works for the approved 45 Hearns Lake Road project are to be at 3m AHD or higher.

Entrance Opening Policy

CLT understand that there is currently no entrance opening policy, that is, artificially, for Hearns Lake. BMT WBM (2009) advise that the lake entrance should not be opened artificially because this is not natural for the lake. The proposed development would be designed so that flood levels in the future (2100 sea level rise) system for the 100-years ARI flood would not affect properties for the future hydraulic entrance bar/berm level of 1.46/1.8 + 0.86m = 2.3m AHD or 2.7m AHD. This requirement would most likely be fulfilled by natural opening because the system opens now in much lower flood flows.

NSW Department of Planning Document CCA 19, prepared by NSW Department of Natural Resources and Patterson Britton and Partners reports findings on ICOLL flushing, based on investigations of ICOLLS; not including Hearns Lake. Based on this information it is likely that Hearns Lake flushes poorly, but water quality may not be compromised, because that is its natural state, provided that catchment flows are not contaminated. Hence runoff from the proposed SSD would need to be treated to a satisfactory level in order to maintain acceptable water quality conditions. Additionally, Coffs Harbour Council needs to ensure that discharges to the lake from sources outside of the lake itself, for example, Double Crossing Creek, also fulfil satisfactory water quality conditions.

Concluding Remarks

Whilst there are some deficiencies in the Worley Parsons Patterson Britton assessment of flood levels in changed climate conditions, there are also conservative aspects to their work. These conservative aspects relate to the adoption of non-site-specific ocean levels and a non-eroding entrance bar of slightly conservative hydraulic level. Worley Parsons Patterson Britton results show little sensitivity to changes in the configuration of their 'pilot channel'. A blocked entrance flood case is unlikely to be important here and the relatively high sheltering of the entrance from Tasman Sea storms leads to entrance berm hydraulic levels that are lower than those observed at other locations. Wave set-up at this site will be lower also because of this sheltering and also because the full extent of wave set-up only develops on a sandy beach, not in an estuarine channel. At the peak of the flood flow waves will be blocked by the high speed (about 3m/s) of the flood flow.

In summary, without undertaking additional simulations, I concur with the Worley Parsons advice that a 100-years ARI flood level of 2.95m AHD at 2100 is realistic.

Yours faithfully,

P. D. Treloar

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for **Cardno Lawson Treloar**

Cardno Lawson Treloar

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