REPORT UPON FLOODING ASPECTS

PROPOSED RECLAMATION

HASTINGS POINT, N.S.W.

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21 July 2010

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Job Name: Hastings Point Reclamation

Job No: 10-083

Original Date of Issue: 21 July, 2010

DOCUMENT DETAILS

Title: Report upon Flooding Aspects of Proposed Reclamation, Hastings Point, NSW

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REVISION/CHECKING HISTORY

Version Number	Date	Issued By		Checked By	
1					
2					
3					
4					
5					
6					
7					
8					

DISTRIBUTION RECORD

Destination	Version Number								
	1	2	3	4	5	6	7	8	9
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1.0 INTRODUCTION

1.1 The Brief

MWA Environmental has been briefed by O'Reilly Sever & Co, representing the Save Our Hastings Group, to examine the local flooding potential of a proposed development at Hastings Point which involves reclamation of part of Lot 156 Creek Street, Hastings Point, in the northern floodplain of Christies Creek and adjacent to existing residential and resort development.

This report is based upon information contained in a submission made under Part 3A of the *EP&A Act, 1979* by Planit Consulting, on behalf of Walter Elliot Holdings P/L and described in **Reference 1**.

The location of the site and surroundings is indicated in **Figure 1** from **Reference 1**.

1.2 Site Details

Lot 156 DP 628026 at 32 Creek Street, Hastings Point has a total area of 17.907 ha. It is understood by reference to the heritage report and historical aerial photographs therein (**Reference 2**) that parts of the site have previously been sub-tidal and that all of the site has, on occasions, been inundated by floodwaters. A copy of a 1944 aerial photograph taken from **Reference 2** is included as **Figure 2**.

The site is located adjacent to the estuarine wetlands on the northern banks of Christies Creek, near its junction with Cudgera Creek and that creek's outflow to the ocean below the Pacific Highway bridge.

It is understood that a substantial amount of filling has previously been placed upon parts of the site by dredging material from other parts to create a tidal lagoon and tidal channels. A dwelling has been constructed on part of the site.

The site's boundaries and current contour levels are shown on **Figure 3** from **Reference 3**.

Part of the site, approximately 7.02 ha, as shown on **Figure 4**, has been zoned Residential Zone 2(a) – Residential Tourist, under the *Tweed Shire Local Environment Plan 2000.*The balance is zoned Environmental Protection Zone 7(a) – Environmental Protection (Wetlands and Littoral Rainforests).

1.3 Development Proposal

The development master plan is included as **Figure 5**, with typical cross sections through the developed site included as **Figures 6 - 8**.

It is proposed to create residential, future tourist and integrated housing allotments on the land, laid out as shown on **Figure 5**, with normal road access to the western end of Creek Street and an emergency road access during flooding along the rear of existing housing on the southern side of Creek Street to its higher eastern end.

The lots will be created by filling, grading down to the estuarine wetlands via a rehabilitated area of native vegetation and salt marsh.

The extent of filling and other earthworks proposed to allow the development and the flood access road to proceed is shown on **Figure 9** which has been extracted from **Reference 3.**

The filling to RL 2.4m AHD from existing levels of RL 1.0 – 2.0m AHD may be seen by comparison of the ground levels of **Figures 3 & 9** to be proposed on land that has previously been filled above Highest Astronomical Tide level, RL 1.14m AHD.

The level of RL 2.4m AHD has been adopted in the proposal as the 100 year average recurrence interval design flood level set by Tweed Shire Council's *Development Control Plan No.5.*

1.4 The Issues

The oblique aerial photograph (**Figure 10**) shows the extent of residential, resort and mobile home park development extending westwards from the Tweed Coast Road along Creek Street, mostly on its northern side but with a significant number of residences along the southern side and adjacent to the NE boundary of Lot 156.

Most of Creek Street is lower than RL 2.0m AHD, as are the allotments of most existing residences along Creek Street.

Thus any filling of the Christies Creek floodplain which could lead to increases in flood levels in Creek Street and adjacent properties is strongly resisted by those residents, as it would lead to significant increases in potential flood damage to those properties, reductions in property values and increased hazard and risk during major flood events.

In addition, the more recent resort and mobile home park development to the north has created impediments to the southwards drainage towards Creek Street from the extensive wetlands to the north behind the coastal dunes which has led to likely redirection of the floodwater drainage paths towards the central and eastern parts of Creek Street.

It is considered that the proposed filling to create lots, plus the filling required to create the emergency flood access to the eastern end of Creek Street, have the potential to increase flood drainage flow rates and volumes down Creek Street and through properties adjacent to the street. This problem does not seem to have been addressed in the documents supporting the development application.

The recent *Tweed-Byron Coastal Creeks Flood Study* (**Reference 4**) showed that this area of Creek Street is flood-prone and that a Floodplain Risk Management Study is required under the NSW Government's *Flood Prone Land Policy* to evaluate floodplain management options to minimise the area's flood risks.

The flood study carried out to support the development application (**Reference 3**) shows that further filling of the site will increase flood levels in the flood prone area and thus exacerbate the current level of flood risk – a level which has recently been identified as significant in **Reference 4** and which has yet to be considered by the residents.

While this factor should be sufficient to require much a more-detailed flood impact assessment to be carried out before the development approval process proceeds, it is obvious now that resumption of the land for excavation of a flood bypass channel and specific drainage works to create a levee around the complete Creek Street residential and resort area is a flood risk management option that should be studied and evaluated under the *Flood Prone Land Policy* before the development proposal is considered for approval.

2.0 RELEVANT ASPECTS OF THE TWEED-BYRON COASTAL CREEKS FLOOD STUDY

2.1 Study Objectives and Methodology

The primary objective of the study carried out by BMT-WBM (**Reference 4**) was to examine and define the flood behaviour of Cudgen, Cudgera, Mooball, Yelgun and Marshalls Creeks and their main tributaries, including Christies Creek, between Kingscliff and Ocean Shores. The findings were proposed to form the basis for a subsequent Floodplain Risk Management Study and Plan for each of the coastal creeks.

In this instance, the Cudgen and Cudgera Creek floodplains were modelled as one, due to cross connections occurring in the middle reaches of Christies Creek.

The final report was issued on November 2009.

The methodology adopted in each floodplain study involved:

- compilation and review of available information;
- acquisition of additional data, including resident survey to determine nature and extent of historical flooding;
- development of hydrological and hydraulic models;
- calibration and verification of models;
- modelling of design events under existing conditions; and
- reporting and mapping.

2.2 Catchment & Topographic Details

The catchment boundaries and topographic features of the Cudgen and Cudgera floodplains are shown in a broad scale on **Figures 11 & 12**, which have been extracted from figures included in **Reference 4**.

Airborne Laser Scanning (ALS) data was collected during July 2007, with the data collated to develop a 5m gridded Digital Elevation model (DEM) and 0.5m interval contours on 1:5000 mapsheet tiles. Typical vertical accuracy of this data is claimed to be +/- 0.25m at 90% confidence.

Relevant surveyed cross sections of Cudgera and Christies Creeks were obtained from DECC surveys undertaken during 2008.

2.3 Flood Modelling & Validation

Figure 2-7 of **Reference 4** shows that flood level records for the June 2005 flood were recorded in the vicinity of Creek Street.

This information and other data from elsewhere in the catchment was used to develop a hydrological model of the Cudgen-Cudgera catchment, with **Figures 11 & 12** from **Reference 4** indicating the complexity of the sub-catchments, including those of Christies Creek upstream of Hastings Point.

The outflows from each sub-catchment were then input to a hydraulic model of the creek and overland flood flows in the overall system, using a 15 metre-square grid, two-dimensional model of the floodplain based on the 2007 DEM and assessed surface resistance to flow, bounded with hydraulic controls at the Tweed Coast Road.

The extent of the 1D and 2D elements of the hydraulic model are indicated in **Figure 13 which** has been extracted from **Reference 4**.

The Cudgen-Cudgera Hydraulic Model also contained a one-dimensional (1D) representation of a 3.2 km reach of Christies Creek from Round Mountain to Hastings Point, as well as an 8.5km reach of Cudgera Creek extending downstream to the mouth of the creek. These 1D models represent the in-bank sections of the creeks and were based upon the above surveyed cross section data.

Hastings Point Bridge was modelled within the 2D domains at the creek mouth and was represented as a 2D flow constriction simulating expansion and contraction losses, with additional pier losses.

Surface roughness values were assigned to the creek beds and banks and for the relevant land-use category, as indicated in Figure 4-3 of **Reference 4**.

Four downstream boundary level scenarios were modelled for flood level assessments near the mouth of the creek.

A representation of the extent of inundation and a comparison of modelled and recorded June 2005 flood levels is provided in Figure 5-9 of **Reference 4** which is included as **Figure 14** of this report.

Reference to **Figure 14** shows that the model produced a peak level of RL 2.25m AHD at Creek Street, compared with a recorded level of RL 2.28m AHD. Reference to the other modelled and recorded levels in Christies and Cudgera Creek indicates that the BMT-WBM model is likely to be under-predicting the flow down Christies Creek.

While there is no recorded peak flood level information of the May 1987 or March 1974 floods at Hasting Point, reference to the modelled inundation areas shown on Figures 5-18 and 5-25 of **Reference 4** indicates that the 1974 flood, as modelled, would have inundated a larger area of the developed area off Creek Street than the May 1987 flood but likely to have been comparable with that of the June 2005 flood.

2.4 Results of Modelling Design Floods at Hastings Point

A number of design flood scenarios were modelled by BMT-WBM and the flood profiles down Christies Creek are compared with the June 2005 flood levels on Figure 7-6 of **Reference 4** which is reproduced as **Figure 15**.

The profiles show that the design flood levels within approximately one kilometre of the mouth are influenced markedly by the assumed ocean/tide boundary condition, whereas this was not the case during the June 2005 flood and unlikely to have been the case with the March 1974 flood.

This might be interpreted as being that the design flood levels as modelled by BMT WBM might understate the real situation, in that the hydrological model probably understates the flows in the downstream reaches of Christies Creek which is considered critical to the assessment of this particular development proposal.

However **Reference 2** summarises the flooding situation at Hastings Point as follows:

> *Parcels along Creek Street are predicted to be inundated in a 20 year ARI design flood event.*
> *.....*
> *Peak flood levels of approximately 2.2m AHD are predicted for this event, reaching up to 2.5m AHD in a 100 year ARI design event (i.e. up to 1m of water in places and up to 3.9m AHD in a PMF event.*

The Tweed Coast Road bridge is predicted to remain flood free for all flood events except the PMF with overtopping of up to 0.3m.

The report also looked at the potential impact of climate change, with peak flood levels expected to rise by 0.2m in the downstream floodplains.

2.5 Conclusions which might be reached from the Coastal Creeks Study

1. Independent floodplain modelling to assess the potential exposure to flood inundation has shown that the proposed development site is flood prone.

2. While the BMT-WBM model probably understates the design, flood levels at Hastings Point by a few centimetres, the report concludes that parcels of land along Creek Street would be inundated in 20yr ARI flood and at depths of up to one metre during a 100 yr ARI design flood.

3. As the modelling considers the 2007 DEM, it assumes that the subject land has been filled to its current levels – even though it is claimed that the filling was not approved. The calibration of the BMT-WBM flood model indicates that the flows in the lower parts of Christies Creek past the subject site may be greater than as modelled, indicating that the impact of the existing filling may be greater than as modelled.

4. Upgrading the Christie's Creek hydrodynamic component of the BMT-WBM model to reflect the monitored recorded flood levels in Hasting Point is considered critical to the assessment of this particular development proposal.

5. The detailed consideration of options to minimise flood damage and risk in this section of Hastings Point should be considered during the development of a *Flood Risk Management Plan* and those options should be tested upon an upgraded section of the BMT-WBM model.

6. This development proposal should not be further considered until the *Flood Risk* Management *Plan* has been completed and made available for public comment.

3.0 REVIEW OF THE FLOOD IMPACT ASSESSMENT SUBMITTED WITH THE DEVELOPMENT APPLICATION

3.1 Outline of the Assessment Process

The constraints to development of the site because of flooding were identified in Section 2.7 of the Planit report (**Reference 1**) as follows:

> *Areas of the site are currently below the Q100 flood level, including area proposed to be contained within the developable area of the proposal.....*
>
> *Preliminary hydraulic modelling shows that the site can be filled to the design flood level of 2.4m AHD as required by the Tweed DCP and to an average fill height of 2.8m AHD (for the purpose of achieving adequate drainage), with no detrimental impacts or cumulative impacts on surrounding properties (see Section EA3 and Section 6 of the Engineering Impact Assessment Report for further detail in this regard.*

Reference to Section 6.1 of the *Engineering Impact Assessment Report* (**Reference 3**) to identify the source of confidence in this extraordinary statement, shows that a backwater modelling program, HEC-RAS, was initially used to study the impacts of the proposal under 100 year ARI conditions and that this simplified modelling showed that the proposed filling would increase flood levels by approximately 20mm.

Concerns by residents in February 2007 raised doubts as to the veracity and reliability of the HEC-RAS modelling and a more-detailed flood impact assessment was carried out using a composite 1D/2D model comprising XP-Storm and a 2D TUFLOW module.

However **Reference 3** does not provide any details of the schematisation of that 1D/2D model and it is relevant that Council queried its results. Thus the XP-Storm study was revised to incorporate the flood scenarios and outlet conditions of the BMT WBM study (**Reference 4**) although little evidence is shown as to the extent to which the flood flows and other boundary conditions may have been made comparable.

It is understood that the revised model was of a similar 1D/2D structure to the BMT-WBM model but much less extensive and possibly with less attention paid to the detailed hydrology of the sub-catchments of Christie Creek to the north and NW of the subject site.

There is some confusion as to the extent that the model replicates the BMT-WBM modelling and no information is provided as to how it may have calibrated against the June 2005 flood event.

The so-revised flood model was then run for the “existing” and “proposed” scenarios for a range of flooding and downstream boundary level conditions to determine the range of impacts on flood levels that might be caused by the development.

However, it might be seen from the previous review of the BMT-WBM model that the range of flooding scenarios investigated were those used in the *Coastal Creeks Study* (**Reference 4**) to scope the extent of flood prone land along the Tweed Coast and not those types of flooding scenarios which should be used to examine the impacts of more typical flooding scenarios such as the June 2005 flood.

To not examine the impact of the proposed development under a June 2005 situation and a revised June 2005 scenario with Q100 design flows down Christie’s Creek, in an upgraded hydraulic model, is a serious omission from the flood impact investigation.

It might also be pointed out that the "existing" scenario represents the 2007 post-filling scenario at the subject site and not that which should be considered as "existing" when considering the impact of all the filling proposed for the site, i.e. existing filling plus the additional filling required to take the developed part of the site above the 100 yr ARI design flood level, as well as the filling required to create a flood-free access road eastwards to the Tweed Coast Road.

3.2 Review of Analysis and Interpretation of the XP-Storm Modelling

The information upon what might be seen to be the impact of the development under critical flooding scenarios is presented as a number of graphics of peak water elevation, flow depth and "hazard", with only peak water elevations being provided with any quantification of these variables.

However what information has been made available must be considered in the light that no attempt has been made to calibrate the existing model against the June 2005 flood levels.

Having regard to the above comments upon an appropriate flooding scenario would be most suitable for assessment of the development proposal, it is considered that the results provided for the Q20 storm surge/Q100 flows scenario might be the most appropriate for impact assessment in this instance (**Figure 16**).

Peak elevations for the Existing Case in this scenario are shown to approximate RL 2.91m AHD at the western end of Creek Street, reducing to RL 2.19m AHD at the existing lagoon and 2.10m AHD immediately south of the residences in Creek Street.

It might be noted that the peak level recorded at Creek Street during June 2005 was 2.28m AHD and that the BMT-WBM model generated a peak level of 2.25m AHD.

Thus this Opus case understates the June 2005 recorded peak water level at the adjacent Creek Street residences (potentially a Q20 flood flow event) and does not generate flood levels in the locality that might be ascribed to a Q100 flow down Christies Creek.

Also, at 2.10m AHD, it considerably understates the RL 2.5m AHD 100 yr design flood level established by the BMT-WBM modelling.

Thus, as the "existing" case under-estimates the extend of flooding in a possibly Q 20 flood flow scenario in the locality, it is likely that the modelled Proposed Case will further under-estimate the impact on flood flows and resultant increases in flood levels and flood hazard.

While it is difficult from the meagre quantitative information supplied in the report to match levels at corresponding locations, the peak water levels of the Q20 surge/Q100 flows "Proposed Case" scenario are shown on Figure 8.0 of **Reference 3** which has been included as **Figure 17**.

These comparisons show that the Opus-modelled levels in Creek Street have been increased by the proposed development from RL 2.19m to RL 2.21m AHD at the western end of Creek Street and from RL 2.10 to RL 2.18m AHD at the point where the proposed filling would be most-constrictive to flows past the proposed development.

Thus the impact of the development identified in a supposed Q20 surge/Q100 flow scenario is an increase in peak flood level of 8cm.

As it has been identified above that the Opus hydrological model is likely to have significantly under-estimated the peak flood flows in the lower section of Christie's

Creek past the subject site, the potential impact of the proposed development is considered to be much higher than can be extracted from the Opus model results.

3.3 Review of the Stated Conclusions of the Opus Assessment

The report concludes with regard to this scenario:

> *The Q20 storm surge Q100 flow scenario has increased flood elevations on the northern side of the caravan park by +60mm and +30mm on the north east side of the car park for the proposed case. Inundation is reduced on the eastern end of Creek Street due to the access road. There is a +20mm increase on flood elevation on the north west end of Creek Street.*

Reference to the flood profiles of the BMT-WBM report shows that the assumption of storm surge occurring at the peak of the flood does not replicate a record major flood condition such as the June 2005 flood.

It is considered that the use of these extreme storm surge scenarios masked the real impact of the proposed filling and that the impact is more likely to be +60 mm, as indicated for the northern drainage channel, rather than the +20 to +30mm in the main channel where the peak level is influenced by the storm surge.

Therefore it is considered that the conclusion that ....*these increases are mathematically insignificant in the context of natural variation ...*cannot be justified and that the development, as proposed and as shown by the above modelling, would cause a 60mm increase in peak flood levels in Creek Street. This increase would be measured above what has already likely to have been created by filling of the site to date.

For the above reasons and because the modelling understates the peak water levels recorded during the June 2005 flood, the following conclusions cannot be relied upon:

> *...the increase (and decrease) has no practical significance as the area is already inundated by up to 1.0m of water irrespective of the development and consequently the development is unlikely to result in a measurable increase in damage or nuisance to adjacent properties.*

It is also considered that even a 60mm increase in flood levels in an area that is flood-prone is an unacceptable increase in flood risk – particularly as the developer proposes to construct an emergency access to and from the development that is significantly higher than Creek Street, where the flood risk of existing residents will be exacerbated by the proposed development and nothing is proposed to alleviate this.

As the location of the above 60mm (6cm) increase in peak flood levels is stated to be "on the northern side of the caravan park", a matter not readily detectable from consideration of Figures 7.0 and 8.0, it is obvious that the discussion of results has nor referred to the obstruction of flow down Christies Creek but to the obstruction of flows through the caravan park.

It is most probable that this increase in flood levels is the result of two development-induced mechanisms:

- linking the proposed filling for the development via filling to create an emergency access road to the eastern end of Creek Street impedes the overland flow paths southwards to the estuary, through the caravan park and from the extensive lowland area to the north of the caravan park;
- further filling of the site for development as proposed impedes flood flows in Christies Creek, increasing the volume of water entering the inundation areas

to the north of the caravan park and hence the water levels and durations of flood flows southwards through the caravan park.

Failure to recognise the significance of this very adverse impact of the development is a major omission that requires to be addressed before any more consideration is given to approving this proposal.

3.4 Need for Further Assessment

As is indicated by Council, the flooding impacts of the proposal should be re-assessed by testing the proposed filling and access road on the BMT-WBM model, under a revised June 2005 flood type Q100 scenario – the current BMT-WBM model being updated to calibrate better against the recorded levels in the caravan park and Creek Street during that flood event.

Even then, the impact would be measured as an additional impact to that which is likely to have resulted from the amount of filing which has already been carried out on site.

It is suggested that, as a minimum, the revised BMT-WBM model be again revised to replicate the pre-filling scenario to identify the real extent of the impact of filling this site..

3.5 Summary of Conclusions Regarding the Flood Impact Assessment Report

1. The Opus model of flood hydraulics in the Hastings Point area appears to inadequately incorporate the model boundary conditions that could be expected from a more-detailed analysis of the hydrology of the sub-catchments of Christie Creek to the north and NW of the subject site that is required to examine the potential impacts of this development proposal.

2. Failure to examine the impact of the proposed development under a June 2005 situation and a revised June 2005 scenario with Q100 design flows down Christie's Creek in an upgraded hydraulic model, is a serious omission from the flood impact investigation and which is believed to have caused the flood impacts to be under-stated.

3. Using the limited amount of quantitative information provided in the flood report as the indicated peak flood levels of the report's Figures 7.0 and 8.0, it may be seen that the impact of the development in a supposed Q20 surge/Q100 flow scenario is an increase in peak flood level of 8cm.

4. Failure to recognise this impact in the discussion of the results of the modelling is another serious omission from the report as this increase occurs in the location where the impact is likely to be greatest and to have the most significance as far as existing residential and resort development is concerned.

5. This unstated increase in peak flood levels indicates that the proposed filling extends much too far southwards towards the channel of Christie Creek.

6. This impact probably understates what a more-accurate assessment would indicate and the impact is likely to be much higher if the hydrology of Christies Creek is upgraded after calibration against the June 2005 flood event - which caused significant inundation and flood damage in the Creek Street locality.

7. Analysis of the above result also indicates that the existing filling of Lot 126 probably caused increased flood levels in the Creek Street locality during the June

2005 flood event and that removal of much of the southern section of the existing filling might be one option of reducing flood risk in the locality.

8. Dismissal of the modelled 60mm increase in flood level "on the northern side of the caravan park" and a similar increase "in the northern drainage channel" as being "mathematically insignificant" is quite misleading for the following reasons:

    - linking the proposed filling for the development via filling to create an emergency access road to the eastern end of Creek Street impedes the overland flow paths southwards to the estuary, through the caravan park and from the extensive lowland area to the north of the caravan park;

    - further filling of the site for development as proposed impedes flood flows in Christies Creek, increasing the volume of water entering the inundation areas to the north of the caravan park and hence the water levels and durations of flood flows southwards through the caravan park.

9. These significant impacts upon the flood risks in the caravan park would also be expected to be carried through to existing residential allotments along Creek Street and to the street itself.

10. The flood modelling of the Cudgen/Cudgera Creek system carried out for the *Tweed Byron Coastal Creeks Study* demonstrated that the existing residential development which adjoins the proposed development is flood prone and is subject to significant flood risk and that a Flood Risk Management Study should be undertaken to assess flood management options and a Flood Risk Management Plan should be adopted.

11. As the flood modelling carried out to date by both Opus and BMT-WBM indicates that the locality is subject to significant flood risk and the Opus modelling shows that increases of up to 8cm can be caused by the proposed re-development, it is essential that the development proposal be re-considered in the light of the above impacts.

12. The revised proposal should be tested on an upgraded section of the BMT-WBM hydraulic model, validated against the June 2005 flood event and with the hydrology of the 100 yr ARI design flood event also revised to represent the "worst case" combination of Christie Creek outflow and storm surge/tidal boundary condition that the development proposal should be tested upon.

13. It is also considered likely that the accuracy of the digital elevation model used in the hydraulic model of the Creek Street locality should be validated by ground truthing, so that realistic estimates of the potential impact upon flood risk and flood damage can be properly evaluated and alternative development options assessed.

4.0 CONSIDERATION AGAINST THE *FLOOD PRONE LAND POLICY*

4.1 The Extent to Which the Site and Adjoining Lands are Flood Prone

Reference to the *Tweed Byron Coastal Creeks Study* shows that all of the site and adjacent lands in Creek Street, including the caravan park and the street itself are subject to flooding in floods of a 20 yr ARI frequency or greater and that at some points the depth of inundation could be as much as 1 metre.

The extent to which allotments, habitable floor levels and the roadway in this locality are inundated needs to be revised from a more-detailed consideration of the levels reached during the June 2005 flood and the model adjusted to give a better prediction of the 100 yr ARI flood behaviour in this part of Hastings Point.

This is seen to be a necessary precursor to the assessment of Flood Risk Management Plan for the locality which would be aimed at minimising the extent to which these locations along and off Creek Street would be inundated during major storm events and at finding ways of alleviating the risk.

The *Tweed Byron Coastal Creeks Study* recommends that the Council should update flood planning levels, as well as Local Environmental Plans and Development Control Plans where indicated by the results of the *Study.*

The *Study* also recommended that Council commission a Floodplain Risk Management Study and that the results of this could be then implemented in a Floodplain Risk Management Plan.

It is considered that these actions should be undertaken with regard to the Hastings Point area before the proposed filling is further considered for approval.

4.2 The NSW *Flood Prone Land Policy*

The Policy Statement, as described in the *Floodplain Development Manual* (**Reference 5**) has a primary objective ...*to reduce the impact of flooding and flood liability on individual owners and occupiers of flood prone property and to reduce private and public losses resulting from floods.*

The *Policy* also requires that:

- *a merit approach shall be adopted for all development decisions in the floodplain to take into account social, economic and ecological factors, as well as flooding considerations;*
- *both mainstream and overland flooding shall be addressed;*
- *the impact of flooding and flood liability on existing developed areas identified in floodplain risk management plans shall be reduced by flood mitigation measures, including on-going emergency management measures, the raising of houses where appropriate and by development controls.*

Provisions in the *Policy* provides for:

- *a flexible merit based approach to be followed by Councils, when dealing with the development or redevelopment of flood prone land.*

- *high government priority for flood risk mitigation programs;*

- *a merit based approach to selection of appropriate flood planning levels (FPLs).....FPLs for typical residential development would generally be based around the 1% AEP flood event plus an appropriate freeboard (typically 0.5m).*

- *floodway definition to be based on hydraulic, hazard and potential damage considerations related to the effect of loss of flow conveyance on flood condition;*

- *recognition of the need to consider ways of maintaining and enhancing riverine and floodplain ecology in the development of floodplain risk management plans;*

- *a fundamental principle of floodplain risk management is to assess development applications within the strategic framework of a floodplain risk management plan and not in isolation or individually.*

It is considered that this fundamental principle of floodplain risk management should be applied in this instance and reinforces the need to ensure that no further consideration of the development proposal should be undertaken until all of the flood risk management options have been evaluated and considered for implementation.

5.0 DRAINAGE OF SURFACE RUNOFF AND FLOODWATERS

5.1 Review of Stormwater Management Plan

The proposed Water Cycle Management Plan is described in Section 8 of the Engineering Report (**Reference 3**).

Section 8.1 deals with Stormwater Drainage, describing the existing drainage in the locality, the proposed drainage network, reviewing the impact of the proposed development from drainage calculations based upon existing and proposed drainage sub-catchments and summarising the potential impacts.

Figure 13.0 is a schematic of a Stormwater Management Plan (**Figure 18**) with little engineering detail and indicating four "developed" sub-catchments.

However, Sub-catchment C lies outside the site and has been included to show how runoff from only those allotments on the southern side of Creek Street will be accepted into a swale drain at the rear of those allotments and piped through the proposed emergency access road via culverts of unknown dimensions.

Figure 18 also shows a "Caravan Park Catchment, E3, discharging at the western end of the proposed filling. This is a surprising solution to the existing stormwater drainage system wherein it is considered that there is unlikely to be any significant concentration of flows from Catchment C or Catchment E.

For this reason, together with further reasons as detailed below, it is considered that the proposed Stormwater Management Plan is unrealistic and does not address the real issues of stormwater and floodwater runoff management in this flood prone locality.

5.2 Review of Water Cycle Management Plan

Figure 13.1 of the report (**Figure 19**) provides a schematic representation of the Water Cycle Management Plan, showing the proposed form and directions that stormwater flows would take within the development from the lots and through proposed stormwater pipes to gross pollutant traps (in some locations) and then to outfalls into the estuary.

Figure 13.2 (**Figure 20**) shows schematic cross sections of the proposed means by which roof and surface runoff would be routed into the street drainage and then to the street drainage treatment, stormwater outfalls and "wetlands".

5.2 Obstruction of Drainage of Surface Waters Along Creek Street

The filling of the site to the south of residential allotments along Creek Street above their current level, as is proposed for the residential development and flood access road, will obstruct the natural southwards drainage to the estuary of stormwater runoff and overland flood flows.

Such obstruction would be expected to concentrate flows along the southern boundaries of the existing residential lots, increasing the depths and durations of inundation of those properties unless adequate provision is made within the proposed development site to accept these flows without causing additional inundation of the neighbouring properties.

Reference to the Engineering Report (**Reference 3**) provides no evidence that such a provision has been made and states simply that:

> *Runoff from Catchment C (existing dwellings) will be collected in the concrete swale drain to the north of the emergency access driveway and discharged beneath the driveway to Christies Creek. This piped system should be designed to accommodate Q100 flows as there is no overland flow path for below the flood level for this catchment.*

The Q100 flow from this catchment has been shown to be 0.572 m^3/s.

There appears to be no obvious intent to find means of avoiding the concentration of flows and a concrete swale drain might hardly be considered as "water sensitive urban design" in this locality.

It would also appear that no provision has been made to accept overland flows from the caravan park to the north of Creek Street near the eastern end of the street – which is also an overland flow path for floodwaters from the north. The calculated Q100 stormwater from this 12.4ha catchment is shown on Figure 13.0 to be 6.09 m^3/s.

While there appears to be a minor drainage channel in this location, there is no indication that the drainage of the developments on the northern side of Creek Street is routed through this point.

Thus the proposal to provide a concrete swale drain and piped drainage for Q100 flows for only a 0.89 ha catchment (Catchment C) appears to considerably under-estimate the impact that the proposal will have on the existing residential and other development in Creek Street.

5.3 Increasing Stormwater Runoff Rates and Concentration of Flows

Reference to Table 8.1.4(a) of **Reference 3** shows that a 46% - 49% increase in the stormwater runoff from the proposed 4.8 ha of development is proposed and that

> *...stormwater detention has not been provided as this may have an unwanted hydraulic effect.*

The "unwanted hydraulic effect" is not described.

No reference has been made to the effect of concentrating flows at and around outfalls into the estuarine wetlands nor to the provision to only provide GPTs on some but not all stormwater outfalls.

While bio-retention trenches and stormwater re-use are indicated on schematics, no details have been provided.

It can only be concluded that the drainage design of the proposed development is based simply upon getting runoff out of the development for the least cost and that the principles of water sensitive urban design have not received any consideration at this stage.

It would be expected that the current design of the stormwater management system is unlikely to be acceptable to the NSW Government the Tweed Shire Council because it affects drainage into a SEPP14 wetland.

It is unlikely that it would be acceptable to local residents because of its obstruction of stormwater and flood water runoff from the Creek Street locality.and local residents and the Stormwater Management Plan needs to be completely revised.

6.0 CONCLUSIONS

1. The flood study carried out to support the development proposal showed that the extent of filling required to meet the design flood levels is likely to cause a 6 cm increase in peak flood levels in a community which is inundated during a nominal Q 20 surge/Q100 flow flood scenario and where one metre depths of inundation might be expected.

2. There are general concerns about the reliability that can be placed upon the conclusions reached in this study, as the flood modelling can be shown be inadequate in that

    - it has under-estimated the flood flows in the area in which the filling is proposed;

    - that the flood modelling has not been validated against the worst recorded flood event (June 2005);

    - that no account has been taken of the impact upon existing flood levels of the previous filling of the site – for which there appears to have been no prior approval granted; and

    - the extent of the flood model used for the flood study is insufficient to properly represent the flood flow patterns in the vicinity of the site.

14. Failure to examine the impact of the proposed development under a June 2005 situation and a revised June 2005 scenario with Q100 design flows down Christie's Creek in an upgraded hydraulic model, is a serious omission from the flood impact investigation and which is believed to have caused the above flood impacts to be under-stated.

15. Using the limited amount of quantitative information provided in the flood report, it may be seen that a more significant impact of the development is an increase in the modelled peak flood level of 8 cm in a location where the impact of the proposed filling is likely to be greatest and to have the most significance as far as existing residential and resort development is concerned.

16. This unstated increase in peak flood levels indicates that the proposed filling extends much too far southwards towards the channel of Christie Creek.

17. This impact probably understates what a more-accurate assessment would indicate and the impact is likely to be much higher if the hydrology of Christies Creek is upgraded after calibration against the June 2005 flood event – an event which caused significant inundation and flood damage in the Creek Street locality.

18. Analysis of the results of the flood study also indicates that the existing filling of Lot 156 probably caused increased flood levels in the Creek Street locality during the June 2005 flood event and that removal of much of the southern section of the existing filling might be one option of reducing flood risk in the locality.

19. Dismissal in the flood report of the modelled 60 mm increase in flood level "on the northern side of the caravan park" and a similar increase "in the northern drainage channel" as being "mathematically insignificant" is quite misleading for the following reasons:

    - linking the proposed filling for the development via filling to create an emergency access road to the eastern end of Creek Street impedes the

overland flow paths southwards to the estuary, through the caravan park and from the extensive lowland area to the north of the caravan park;

- further filling of the site for development, as proposed, impedes flood flows in Christies Creek, increasing the volume of water entering the inundation areas to the north of the caravan park and hence the water levels and durations of flood flows southwards through the caravan park.

20. These significant impacts upon the flood risks in the caravan park would also be expected to be carried through to existing residential allotments along Creek Street and to the street itself.

21. Thus the proposed development is likely to increase the real flood risk and real flood damage potential in the Creek Street locality to a far greater extent than has been indicated in the flood report.

22. The flood modelling of the Cudgen/Cudgera Creek system carried out for the *Tweed Byron Coastal Creeks Study* demonstrated that the existing residential development which adjoins the proposed development is flood prone and is subject to significant flood risk and that a Flood Risk Management Study should be undertaken to assess flood management options and a Flood Risk Management Plan should be adopted.

23. Because of the complexity of flood behaviour in the downstream reaches of Christies Creek near the flood prone area it would appear that the Cudgen/Cudgera Creek flood modelling needs to be upgraded in this section of the model so that flood risk management options and development proposals can be adequately tested.

24. As further filling of the site, as proposed, would increase flood risk and damage in a flood prone area, it is suggested that further consideration of the development proposal be deferred until the flood model has been upgraded, the Flood Risk Management Study has been completed and its results have been considered by government and the community.

25. Consideration might be given to a flood management option which provides for resumption of the subject site to allow for fill to be removed from the site and for a flood channel/levee system to be constructed to improve the flood immunity of the existing Creek Street development and restore the ecological values of the estuary.

26. The stormwater drainage system proposed for the development, because of its obstruction of stormwater and flood water runoff from the Creek Street locality, will increase the depth and duration of inundation of Creek Street properties during major storms.

27. As a result, it is unlikely that the Stormwater Management Plan would be acceptable to local residents or to Council and it is recommended that the Stormwater Management Plan should be completely revised to accept the existing stormwater runoff from the north of the site in a sustainable manner.

28. The Water Cycle Management Plan, by not providing on-site detention and replacing natural grassed drainage swales with a concrete drain and piped drainage beneath the proposed emergency access road, will increase and concentrate stormwater flow rates into the estuary at two significant locations, as well as at minor outfalls from the development.

29. It would be expected that the current design of the Water Cycle Management Plan would not be acceptable to the NSW Government, the Tweed Shire Council, nor residents, because it adversely affects the drainage of stormwater runoff from urban development into a SEPP14 wetland.

6.0 REFERENCES

1. Planit Consulting, *Environmental Assessment – Part 3A, EP&A Act 1979, No 156 Creek Street, Hastings Point,* report prepared for Walter Elliot Holdings Pty.Ltd., 17 February 2010.

2. Everick Heritage Consultants Pty.Ltd., *Cultural Heritage Assessment – Lot 156 Creek Street, Hastings Point, NSW*, February 2010.

3. Opus international Consultants (Australia) Pty.Ltd., *Palm Lake Works Pty.Ltd.- Engineering Impact Assessment – Revision 4*, 24 February 2010.

4. BMT-WBM, *Tweed-Byron Coastal Creeks Flood Study*, Report prepared for tweed Shire Council, November 2009.

FIGURES