Detailed Flood Study
Proposed Development at
Lawrence Hargrave Drive, Thirroul

for Indesco South Coast Pty Ltd

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Detailed Flood Study for Proposed Development at Thirroul Plaza, Lawrence Hargrave Drive, Thirroul

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INTRODUCTION

1.1 BACKGROUND

The applicant proposes a commercial and residential development on their commensurately zoned parcel of land at Lawrence Hargrave Drive, Thirroul. The site is approximately 9,200 m² and is currently developed for commercial purposes, reflecting the site's current (and long-standing) use as a shopping centre and carpark. As the existing site is affected by mainstream flooding from Hewitts Creek, the applicant has engaged Rienco Consulting to prepare a suitably detailed flood study that addresses the requirements of Wollongong City Council's (WCC’s) DCP Chapter E13.

1.2 PROPOSED DEVELOPMENT

The proposal is for multi-level commercial and residential development. The proposed development includes two levels of basement carparking, a ground floor commercial area and three levels of residential development above. Figure 1.2-1 below describes the proposed development. A full set of design plans is included as Appendix B.

1.3 PURPOSE OF THIS REPORT

The purpose of this report is to:

   a) Establish a ‘base case’ or existing flood model of Thomas Gibson Creek that replicates as best as practical the design flood behaviour in the adopted WCC 2015 Hewitts Creek Flood Study

   b) Modify the existing flood model to include the proposed development.
c) Determine the potential impacts of the proposed development, and the associated flood hazard and risk precinct categorisation.

d) Review the proposed development, together with the hydraulic model results, and assess it against the prescriptive controls of WCC’s DCP2009 (Chapter E13) to confirm the suitability of the proposed development.

e) Prepare a report summarising the above suitable for lodgement with WCC for the Development Application for the proposed development.

1.4 LIMITATIONS AND ASSUMPTIONS

This report has been strictly prepared for the purposes stated in this report for exclusive use by the client. No other warranty, expressed or implied, is made as to the advice included in this report. This study specifically focuses on the quantification of flood behaviour at the subject site, given current conditions. This study does not address flood behaviour for other sites within the overall catchment.

Further, it is understood that Council has adopted a new version of the 2015 Study, in December 2019. However, at the time of authoring this report, the final Study is not available on Council’s website, nor the SES flood data portal. Therefore, it is not possible to refer to this new Study given it is unavailable.
2 BACKGROUND INFORMATION

2.1 SITE DESCRIPTION

The site is approximately 9,200 m² and is located at Lawrence Hargrave Drive, Thirroul, NSW. The subject site is known colloquially as Thirroul Plaza. The subject site is a combination of three adjoining lots, being Lot 103 DP706867 (the main lot), and Lot 2 DP534253 (the middle lot) and Lot 1 DP240526 (the southern-most lot).

It is bounded to the north by King Street and existing commercial development, and to the east by Lawrence Hargrave Drive and Beaches Hotel. It is bounded to the south by the WCC owned W.F. Jackson Park, and to the west by the Illawarra Railway Line. Figure 2.1-1 describes the site and surrounds.

![Aerial Photo of Subject Site and Surrounds](image)

**Figure 2.1-1 Aerial Photo of Subject Site and Surrounds**

*Note: Subject site is shown within the red line work.*

2.2 SURVEY DATA

Detailed topographic survey was available for the site and surrounds, prepared by Bee & Letheridge Registered Surveyors, in 2007. Whist there have no doubt been some minor changes taken place surrounding the site in the 12 years that has passed since the survey was undertaken, the survey does contain a myriad of important details that are not considered to have changed (i.e. the ballast and top-of-rail levels on the railway line). In this regard, it is considered a much better replication of the actual topography than the ALS. The survey was available in full 3D format and allowed for ingestion directly into the flood modelling software. The site survey is included as Appendix A.

Additional survey was undertaken in November 2019 by Utility Scan Surveys. This survey was focused on determining the nature and extent of the existing stormwater network within and around the subject site. The site survey is also included as Appendix A. This survey extends to cater for the stormwater pipe under the Illawarra Railway Line, together with all of the...
stormwater infrastructure under the site, as well as this infrastructure in Lawrence Hargrave Drive, Bath Street and Raymond Road. CCTV footage was also available.

Additional topographic survey information was also available, in the form of Airborne Laser Scan (ALS) data. The NSW Government’s Land & Property Information department (LPI) have supplied a 1m DEM from the 2013 ALS dataset. Aerial imagery (2019) was also supplied for the subject site and surrounds via NearMap.

2.3 PREVIOUS STUDIES

2.3.1 Hewitts Creek Flood Study and FRMS (Forbes Rigby, 2002)

This study quantifies the existing flood extent in the Hewitts, Slacky, Tramway, Woodlands and Thomas Gibson Creeks. The study involved data collection, topographical surveys, preparation of hydrological and hydraulic models, calibration and validation of the models and determination of flood levels and velocities in nominated reaches of each creek for the 5% AEP, 2% AEP, 1% AEP and Probable Maximum Flood (PMF) events. This group of studies also undertook the NSW Government’s Floodplain Risk Management process, and whilst the flood study component is currently being updated (see Section 2.5.2 below) the Floodplain Risk Management Study and Plan are still the most current documents for such matters.

2.3.2 Review of Hewitts Creek Flood Study (WBM-BMT, 2015)

This adopted study updates the 2002 Hewitts Creek Flood Study, using new 2D modelling and improved resolution topographic data. The 2015 study also provides a multitude of model runs assessing the impacts of climate change which was not a requirement when the original 2002 modelling was undertaken. This study comprehensively addresses flood behaviour at the site, however it does so under WCC’s previous blockage policy. As such, its results do not reflect the current and best design flood estimation at the site. This study is referred to as the ‘2015 Study’ in this report.

2.3.3 Review of Hewitts Creek Flood Study Addendum (2019).

It is understood that Council has adopted a new version of the 2015 Study, in December 2019. However, at the time of authoring this report, the final Study is not available on Council’s website, nor the SES flood data portal. Therefore, it is not possible to refer to this new Study given it is unavailable. However, it is not expected that the 2019 Study results would be any more adverse that the results from the 2015 Study, and therefore we do not consider that this report is limited because it does not reference the new (but unavailable) Study. We base this assessment on the Final Draft of the 2019 Study, for which we have a copy from the period of public exhibition. We have been verbally instructed by WCC’s floodplain management team that the adopted Study has not changed since exhibition.

2.4 SITE INSPECTION

Several detailed site inspections were undertaken by the author during late 2019 and early 2020. All existing stormwater pits were visually inspected, and the areas of the floodplain material to influencing flood behaviour at the site were inspected to confirm the surface roughness mapping.
3 HYDRAULIC MODELLING

3.1 HYDRAULIC MODEL DEVELOPMENT – PRE-DEVELOPMENT

3.1.1 Model Domain

TUFLOW has been chosen as the hydraulic model for use in this study. TUFLOW is most appropriate for use in this study as the flood behaviour is two-dimensional at the subject site and its surrounds. It has also been utilised by BMT-WBM on behalf of WCC for the 2015 Study. The model grid was established as a 1m grid across the entire model domain. This abnormally small grid size was specifically chosen to allow for a sound schematisation of the narrow overland flow paths in the study area. The ALS data was used to extract the majority of the elevation data to the TUFLOW grid, and existing site survey was patched into the model where provided.

The TUFLOW model domain extends upstream of the Illawarra Railway Line to Church Street, and downstream of the subject site to Thirroul Beach. The model grid extent is described in Figure 3.1-2, and its northern extent is identical to WCC’s adopted 2015 hydraulic model.

![TUFLOW Grid and Boundary Condition Locations](image)

**Figure 3.1-1 TUFLOW Grid and Boundary Condition Locations**

*Note: TUFLOW 2m grid extent shown as red line. Inflow BC’s shown as yellow lines, downstream BC’s shown as orange lines.*

3.1.2 Model Boundary Conditions

Boundary conditions, in terms of inflow hydrographs, were determined from WBNM modelling. The base WBNM model used in this Study was the WCC-adopted WBNM model in the 2002
Hewitts Creek Flood Study and Floodplain Risk Management Study. The 2015 Study made some minor amendments to the 2002 WBNM mode, however did not change the fundamental model inputs, being the ‘C’ lag parameter and the total catchment area. Only minor changes were made with regards to WBNM model subareas, to allow for their more appropriate inclusion into TUFLOW (as opposed to the 2002 Study which had its input flows used in HEC-RAS). The 2015 and 2002 hydrologic model results at key reporting locations demonstrate negligible changes to peak discharges and critical durations, and as such the WBNM modelling carried out for this project is deemed fit for purpose.

**Table 3.1-1** summarises the various peak flow estimates and confirms those adopted in the modelling for this report. A WBNM catchment plan is included in [Appendix C](#).

<table>
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<tr>
<th>Location</th>
<th>1% AEP Peak Flows (120 min Crit. Dura.)</th>
<th>PMF Peak Flows (30 min Crit. Dura.)</th>
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</thead>
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<tr>
<td>Flows from Thirroul Public School (WBNM Sub #106)</td>
<td>4.6 m³/s</td>
<td>11.3 m³/s</td>
</tr>
<tr>
<td>Flows from Church Street (WBNM Sub #TG2)</td>
<td>0.865 m³/s</td>
<td>1.97 m³/s</td>
</tr>
<tr>
<td>Flows from Seafoam Ave (WBNM Sub #TG3)</td>
<td>1.62 m³/s</td>
<td>3.70 m³/s</td>
</tr>
<tr>
<td>Flows from Commuter Carpark (WBNM Sub #TG1)</td>
<td>2.06 m³/s</td>
<td>4.87 m³/s</td>
</tr>
<tr>
<td>Flows from Railway Yard Areas (WBNM Sub #TG4)</td>
<td>1.75 m³/s</td>
<td>4.12 m³/s</td>
</tr>
<tr>
<td>Flows from Lawrence Hargrave Drive (WBNM Sub #TG5)</td>
<td>0.728 m³/s</td>
<td>1.66 m³/s</td>
</tr>
</tbody>
</table>

Boundary conditions, in terms of the downstream areas in Hewitts and Woodlands Creek, were determined based on a site inspection. They are suitably located downstream of the two major bridges in Sandon Point. They provide for open channel flow with a bed slope of 0.5%, and are far enough downstream of the Illawarra Railway Line structures to not influence flood behaviour at those structures. These are shown in **Figure 3.1-2**.

### 3.1.3 Model Hydraulic Structures

Summarily, there are no ‘culverts or bridges’ within the catchment that influence flood behaviour at the site, that would come under the Class 1 to Class 4 categorisation of WCC’s 2016 conduit blockage policy. However, there is a significant piped stormwater network around the site and this has been extensively included in the TUFLOW model. **Figure 3.1-2** describes the main components of the existing stormwater network.
An approximate 900 mm RCP conveys runoff from underneath the Illawarra Railway Line. This 900 mm RCP is fed by two large inlet pits in the Thirroul Commuter Carpark (u/s of the railway line) and the piped stormwater system located in Church Street and Seafoam Avenue.

A bifurcation pit is located near the sites upstream boundary, behind the current Coles loading dock. At this location, the network bifurcates into 2 x 1,500 mm RCP’s. The southern 1,050 mm RCP heads under the existing Coles building and discharges into the piped network at Raymond Road, whereas the northern 1,050mm RCP runs along the alley adjoining Beaches Hotel and discharges into the piped network at Macauley Street. Both these networks reconverge just downstream of the Honest Don’s Café, at the intersection of Macualey St and Bath Street.

Each inlet pit draining a road was inspected by the author, and the grates and lintels measured. After a review of the data recorded, the measured grate types and sizes were all immaterially different, and the lintels fell into either a smaller range (typically about 1.7m long) or a longer range (typically about 2.4m long). For simplicity of modelling, only two types of pits were included in the TUFLOW model, with identical grates and the two varying lintel dimensions. This was also considered important because there are known and physically modelled capture rates for these types of pits with known blockage values, and using custom pit types requires interpolation of the published research on pit capacities and is not recommended.

The depth-v-inlet capacity relationships for the sag pits was derived from the Sutherland Shire Council Urban Drainage Manual (1992), which includes summary tables and graphs documenting pit grate and lintel capacity information (which itself was derived from Department of Main Roads testing). The guidelines for a standard pit are hydraulically similar to a WCC standard inlet pit, and most importantly, this approach is the one recommended by TUFLOW.

In accordance with DCP 2009 Chapter E14 Clause 7.2(2), on-grade inlet pits have been allocated a 50% blockage factor. Whilst Clause 7.2(2) notes that an 80% factor should apply, we have been advised by WCC’s Stormwater Assessment Officer that the DCP is incorrect and that 50% should apply (and 80% for sag pits).
### 3.1.4 Model Surface Roughness

Manning’s surface roughness ‘n’ values were taken from a detailed site inspection and the values for those surfaces provide in the 2015 Study. **Figure 3.1-1** describes the surface roughness mapping. Whilst the mapping has been undertaken to a much higher level of detail than the 2015 Study, the Manning’s ‘n’ values are entirely consistent with the 2015 Study for the commensurate surface cover. Existing dwellings have been mapped and modelled with a high ‘n’ value as opposed to being excluded from the model grid, allowing for the correct model representation of floodplain storages.

![Detailed Manning's Surface Roughness Map](image)

**Figure 3.1-3 Detailed Manning's Surface Roughness Map**

**Table 3.1-2** describes the Manning’s ‘n’; value used within TUFLOW.

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<th>Surface Description</th>
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<tr>
<td>Dwellings</td>
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<tr>
<td>Pavement</td>
<td>0.020</td>
</tr>
<tr>
<td>Short, Maintained Grass</td>
<td>0.035</td>
</tr>
<tr>
<td>Fenced Urban Lots (Implicit)</td>
<td>0.080</td>
</tr>
<tr>
<td>High Density Vegetation</td>
<td>0.150</td>
</tr>
<tr>
<td>Railway</td>
<td>0.050</td>
</tr>
<tr>
<td>Medium Density Vegetation</td>
<td>0.075</td>
</tr>
</tbody>
</table>
3.2 HYDRAULIC MODEL RESULTS – PRE DEVELOPMENT

The model was run for the 1% AEP and PMF events. Figure 3.2-1 describes the peak flood depths for the 1% AEP design flood. A full suite of detailed results is included as Appendix C.

Runoff is generated by typically shallow flooding upstream of the site in the 1% AEP design flood. Runoff is directed by the topography to the Commuter Carpark upstream of the railway line, as well as a cess drain collecting additional runoff from the north. In the 1% AEP design flood, the railway line overtops, but not all of the flow upstream of the railway makes its way through the subject site. A portion of the flow is directed south along the Illawarra Railway Line, as demonstrated by the model results.

Overall, flood behaviour through the subject site is best described as shallow sheet flow. As the railway line overtops, shallow and broad flow enters the site from the western (upstream) boundary. Runoff makes its way across the carpark, peaking at no more than 200mm depth and typically much shallower in the 1% AEP design flood. Runoff pools in the low-point in the carpark to a depth or approximately 500 mm, before it overtops to ‘weir’ of the pool and can discharge east to Lawrence Hargrave Drive, via the narrow alleyway adjoining Beaches Hotel.

A deeper pool of runoff forms behind the Coles loading dock, until it reaches sufficient height to overtop its ‘weir’, where runoff then also heads east to Lawrence Hargrave Drive, via the southern side of the Coles building.

Runoff flows across Lawrence Hargrave Drive at depths approaching 400 mm at their peak, and then makes its way through the existing commercial and residential areas of Thirroul with little assistance from piped or surface flood mitigation. This typical flood behaviour is replicated for the Probable Maximum Flood, only the peak flood depths are typically 500 mm to 1,000 mm higher.

Figure 3.2-1 1% AEP Pre-Development Flood Extent and Depths

Note: Flood depths shaded 0mm (light blue) to 1,000mm (dark blue). All depths greater than 1,000mm are all shaded dark blue.
PROPOSED DEVELOPMENT

DEVELOPMENT OF A STORMWATER CONCEPT PLAN

Flooding of the area of Lawrence Hargrave Drive occurs frequently. The author of this report lives in the suburb, and has observed runoff sheeting across Lawrence Hargrave Drive ‘every couple of years’. During these times, the shops of the eastern side of Lawrence Hargrave Drive, between Raymond Road and Macauley Street, are particularly hard hit.

The old watercourse was piped at least 100 years ago, based on anecdotal evidence supplied to the author from local historical sources. Figure 4.1-1 below shows flooding of Lawrence Hargrave Drive at the Raymond Road intersection at a time that is estimated by locals to be in the 1930’s. At this time, the watercourse is clearly piped, as the main shopping district of Thirroul is formed. Figure 4.1-2 shows inundated at the same intersection, some 85 years later, where nothing much has changed.

This historic and frequent inundation is caused by principally by two combined factors. Firstly, the size of the downstream piped network is grossly insufficient to cater for flows even of the order of a 1 in 1 year design flood. It is not necessarily the size of the piped network, but more-so the lack of inlet capacity to that network. This is also reflected by the second principal reason for the inundation, which is the broad nature of runoff emanating from above the Illawarra Railway Line. Such broad and shallow sheet flow is difficult to contain when using only a small number of grated inlet pits.

Currently in major design flood events such as the 1% AEP design flood, runoff sheets across the Illawarra Railway line and is conveyed east through the carpark of the shopping centre. It then finds its way through the site via several openings in the building, chiefly the main thoroughfare north of Coles, and the northern alley between the subject site and Beaches Hotel. This overland flow is fragmented and enters Lawrence Hargrave Drive in an uncontrolled manner.

It is considered that the proposed development is a significant opportunity to improve the existing flood behaviour, and in turn reduce the frequency of inundation of a large portion of the commercial hub of Thirroul. In order to achieve this, as well as manage this overland flow through the proposed development, a Stormwater Concept Plan was developed. Essentially, this Stormwater Concept Plan contains:

1. A major inlet structure on the upstream boundary, being the common boundary of the site with the Illawarra Railway Line. This allows the broad sheet flow to be collected and subsequently managed in a modern and ‘best practice’ manner.
2. A storage device that is used to collect and store runoff. This device, when configured correctly, can be used to retard peak flows and therefore reduce flood behaviour downstream of the site.

3. A discharge device downstream of the storage device. This allows runoff in the storage device to be discharged in a manner that is controlled, safe, and does not cause any flood-related issues downstream of the site.

The Stormwater Concept Plan is included in Appendix C and has been drafted by Indesco.

4.2 HYDRAULIC MODEL DEVELOPMENT

In order to simulate the effects of the proposed development, the pre-development flood model was modified as follows:

1. Surface roughness layer was modified to remove the existing buildings.
2. The inlet across the upstream boundary was modelled as a Flow Constriction, to facilitate the ability to simulate any inlet losses and blockages of the inlet structure.
3. The OSD tank was modelled using a geometry modification, based on the architectural layout.
4. The overland flow path and tank outlet was modelled as a geometry modification, based on the architectural layout and the proposed Indesco design surface contours.
5. The piped tank outlets were included as modifications to the pre-development 1D drainage network.
6. Modifications to the existing surface levels along the Lawrence Hargrave Drive frontage were included as a TIN patch, based on the civil design shown on the Indesco plans. It should be noted that the original patch supplied to Rienco was an Indesco design, however was changed prior to the issue of this report at Council’s request. The design shown henceforth is a Council design for this area.

The post-development surface roughness mapping can be found via various figures in Appendix C7.

4.3 HYDRAULIC MODEL RESULTS

The model was run for the 1% AEP and PMF events under ‘design’ blockage conditions. The model results, in terms of flood depths, as shown in Figure 4.3-1. The flood behaviour has responded to the model changes and is reflective of the proposed Stormwater Concept Plan. A full suite of detailed results is included as Appendix C.

As can be seen from the model results, the OSD tank becomes partially full and has maximum water surface levels approximating RL +10.50m AHD. Whilst there is a minor discrepancy between the OSD model results and the underlying architectural layout in Figure 4.3-1, the total volume is the same and the difference is immaterial.

Minor overflows occur in the 1% AEP design flood along the OSD tank discharge flow path – a dedicated flow path along the southern boundary. In the 1% AEP design flood, the peak flow in the 6m wide overland flow path is 0.25 m$^3$/s. In the PMF, the peak flow in this overland flow path increases to 7.8 m$^3$/s.
In terms of the performance of the OSD tank, this can be seen by the extrapolated model results shown in Figure 4.3-2 for the 1% AEP design event. As can be seen, the peak inflow into the OSD tank (emanating from flows over-topping the railway line plus the inflow from the railway piped network) is approximately 8 m$^3$/s. By contrast, the peak flow discharging out of the OSD tank is approximately 4.8 m$^3$/s.
4.4 HYDRAULIC HAZARD AND RISK PRECINCTS

The area where the development is located is classified as Low Provisional Hydraulic Hazard (PHH) for the 1% AEP flood event, when assessed under the NSW Government’s Floodplain Development Manual (Figure L-2). **Figure 4.3-1** below describes the post-development PHH. As such, the proposed development is located within a Medium Flood Risk Precinct.

![Figure 4.4-1 1% AEP Pre-Development Provisional Hydraulic Hazard](image)

*Note: Provisional Hydraulic Hazard designated by TUFLOW in accordance with NSW Government’s Floodplain Development Manual Figure L-2 (2005). Dark blue denotes High Provisional Hydraulic Hazard, and light blue denotes Low or Transitional Provisional Hydraulic Hazard.*

![Figure 4.4-2 1% AEP Post-Development Provisional Hydraulic Hazard](image)

*Note: Provisional Hydraulic Hazard designated by TUFLOW in accordance with NSW Government’s Floodplain Development Manual Figure L-2 (2005). Dark blue denotes High Provisional Hydraulic Hazard, and light blue denotes Low or Transitional Provisional Hydraulic Hazard.*
4.5 FLOOD-RELATED DEVELOPMENT IMPACTS

The development related impacts of the proposal were determined from the model results, for the 1% AEP and PMF events. Figure 4.5-1 to Figure 4.5-2 below describes the nature and extent of flood level increases as a result of the development.

The proposed development achieves some profound reductions in peak flood levels both on and off the site, noting that the onsite reductions are immaterial given the changes in development form. There are considerable reductions in peak flood levels upstream of the site in the railway corridor of over 100 mm.

The most important flood level reductions are on Lawrence Hargrave Drive, which is used extensively in times of emergency as it is the only road ‘in and out’ of the northern suburbs. The intersection of Raymond Road and Lawrence Hargrave Drive is a known flood affected low-point, and peak flood levels are reduced in this area by up to 190 mm in the 1% AEP design flood. The existing commercial area on the southern side of Lawrence Hargrave Drive, between Raymond Road and Macauley Street, also sees reductions in peak flood levels by up to 160 mm. This is profound.

The minor and isolated increases in peak flood levels on Lawrence Hargrave Drive are located to the footpath outside the proposed development. These are driven by the WCC designed footpath and kerb realignment, where the proposed ground surface levels are ~100mm higher than the existing levels in places. This is not attributable to the propose development, and is nonetheless not considered adverse, significant or detrimental.

![Figure 4.5-1 1% AEP Post-Development Impacts](image)

Note: Flood increases shaded various colours from yellow to red, and flood decreases shaded various colours of green. Areas that are +/- 20mm are shaded grey.

The flood related impacts in the PMF are shown in Figure 4.5-2 below. Major PMF flooding affects The Beaches Hotel in the pre-development scenario, and as it is now protected from receiving runoff by the propose development, the PMF level reductions at The Beaches Hotel are significant.
The OSD facility has a more significant discharge along its dedicated overland flow path in the PMF, as would be anticipated. At the location of the discharge from the dedicated overland flow path onto Lawrence Hargrave Drive, there are some flood levels impacts in the PMF. However, there are also corresponding decreases along Lawrence Hargrave Drive, which is a function of the defragmentation of how overland flow is distributed onto Lawrence Hargrave Drive via the subject site.

It is important to note that the PMF is a flood that is so rare, that no meaningful AEP can be assigned to it (ARR, 2019). It is an important consideration, but is only a consideration. It is not a ‘design’ event and infrastructure such as the proposed development cannot reasonably be designed to manage the PMF.

Nonetheless, the PMF has been considered in significant detail, and we consider that the proposed development performs well in the PMF and manages the long-term and existing flood issues in this part of Thirroul admirably.

Figure 4.5-2 PMF Post-Development Impacts

Note: Flood increases shaded various colours from yellow to red, and flood decreases shaded various colours of green. Areas that are +/- 20mm are shaded grey.
5 DEVELOPMENT COMPLIANCE WITH COUNCIL POLICIES

5.1 COMPLIANCE WITH WOLLONGONG LEP CLAUSE 7.3

WCC’s Local Environment Plan (LEP) 2009 sets forth its requirements for land for which the LEP applies (i.e. the subject site). Table 5.1-1 describes each LEP clause and commentary on how the proposed development addresses the requirements of the LEP.

Table 5.1-1 – LEP Requirements for Proposed Development

<table>
<thead>
<tr>
<th>LEP Requirement</th>
<th>How the Proposal Addresses the Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>All habitable floors of the development will be above the flood planning level.</td>
<td>All habitable floors are above the Flood Planning Level.</td>
</tr>
<tr>
<td>The development will not adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties.</td>
<td>The development will not adversely affect flood behaviour resulting in detrimental increases in the potential flood affectation of other development or properties, as demonstrated by the results of the detailed modelling undertaken for this report.</td>
</tr>
<tr>
<td>The development will not significantly alter flow distributions and velocities to the detriment of other properties or the environment of the floodplain.</td>
<td>The development will not significantly alter flow distributions and velocities to the detriment of other properties or the environment of the floodplain, as demonstrated by the results of the detailed modelling undertaken for this report.</td>
</tr>
<tr>
<td>The development will not affect evacuation from the land.</td>
<td>The development will not affect evacuation from the land. The safety of people and property on the site has been enhanced because of the development.</td>
</tr>
<tr>
<td>The development will not significantly detrimentally affect the floodplain environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.</td>
<td>It is our view that the development will not significantly detrimentally affect the floodplain environment or cause avoidable erosion, siltation, destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.</td>
</tr>
<tr>
<td>Development will not result in unsustainable social and economic costs to the community as a consequence of flooding.</td>
<td>It is our view that the development will not result in unsustainable social and economic costs to the community as a consequence of flooding. Flood compatible materials are proposed where required by the DCP, and all habitable FFL’s are at the levels required by the DCP. Moreover, the significant reductions in peak flood levels in frequent events offers a reduction in flood damages to a significant number of Thirroul businesses.</td>
</tr>
<tr>
<td>If located in a floodway area – the development will not be incompatible with the flow conveyance function of, or increase a flood hazard, in the floodway area.</td>
<td>Regardless of the designation of floodway or not, the development is not incompatible with the flow conveyance function of the site. The development contains specific controls and measures to manage the overland flow through the site. These measures ensure the...</td>
</tr>
</tbody>
</table>
It can be seen from Table 5.1-1 that the proposed development meets or exceeds WCC’s LEP criteria.

5.2 COMPLIANCE WITH DCP 2009 CHAPTER E13 PRESCRIPTIVE CONTROLS

WCC’s DCP 2009 (Chapter E13) sets forth its prescriptive controls for all development on the floodplain. Table 5.2-1 describes each prescriptive control, together with comments describing how it can be demonstrated that the proposed development meets those prescriptive controls. For the purposes of this assessment, the development type under Appendix A of Chapter E13 is ‘residential’, and the prescriptive controls have been applied from Schedule 2: Hewitts Creek Floodplain within a Medium Flood Risk Precinct. Commercial controls are discussed in Section 5.3.

Table 5.2-1 – WDCP Chapter E13 Prescriptive Controls Addressed

<table>
<thead>
<tr>
<th>DCP Prescriptive Control</th>
<th>How the Proposal Addresses the Prescriptive Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floor Levels</td>
<td></td>
</tr>
<tr>
<td>Habitable floor levels to be equal to or greater than the 100 year flood level plus freeboard.</td>
<td>With regards to the commercial areas, this is further described in Section 5.3 of this report.</td>
</tr>
<tr>
<td>Garage floor level to be no lower than the 100 year flood level minus 300mm or 300mm above finished adjacent ground (whichever is the greater).</td>
<td>In terms of the residential areas, all habitable FFL’s are located more than 500mm above the 1% AEP flood level. As such, this DCP control is met.</td>
</tr>
<tr>
<td>Building Components - All structures to have flood compatible building components below or at the 100 year flood level plus freeboard.</td>
<td>This can be readily incorporated into the development at construction certificate stage.</td>
</tr>
<tr>
<td>Structural Soundness - Applicant to demonstrate that any structure can withstand the forces of floodwater, debris &amp; buoyancy up to &amp; including a PMF flood plus freeboard.</td>
<td>A Structural Engineer can readily design for hydrostatic, debris impact &amp; buoyancy loads, based on flood level, velocities and design debris mass info provided by us in this report. A Structural Engineer will utilise further design guidance principles in ACBC ‘Construction of Buildings in Flood Hazard Areas’, which can be conditioned in Council’s consent for the proposed development.</td>
</tr>
<tr>
<td>Flood Affectation – Engineer’s report required to certify that the development will not increase flood affectation elsewhere.</td>
<td>This report constitutes the meeting of this prescriptive control.</td>
</tr>
<tr>
<td>Evacuation:</td>
<td></td>
</tr>
<tr>
<td>Reliable access for pedestrians or vehicles is required from the building, commencing at a minimum level equal to the lowest habitable floor level to an area of refuge above the PMF level, or a minimum of 20sqm of the dwelling to be above the PMF level.</td>
<td>PMF refuge is available in the units, well above the peak PMF levels.</td>
</tr>
</tbody>
</table>
The development is to be consistent with any relevant flood evacuation strategy or similar plan.

It can be seen from **Table 5.2-1** that the proposed development meets or exceeds WCC’s assessment criteria.

### 5.3 FLOOD PROTECTION OF SHOPS FACING LAWRENCE HARGRAVE DRIVE

Shops are proposed to be constructed fronting Lawrence Hargrave Drive. The proposed development plans denote these spaces as being used for ‘shops’. Under DCP 2009 (Chapter E13) Appendix A – Land Use Categories, ‘shops’ are explicitly noted as being defined as ‘commercial or industrial’ land uses.

Under the prescriptive controls in DCP 2009 (Chapter E13) for ‘commercial or industrial’ uses in Hewitts Creek (Schedule 2), the prescriptive controls for shop floor levels are as follows:

- **Habitable floor levels to be equal to or greater than the 100 year flood level plus freeboard, or**
- **Floor levels of shops to be as close to the design floor level as practical. Where below the design floor level, more than 30% of the floor area to be above the design floor level or premises to be flood proofed below the design floor level.**

As shops are not habitable areas, the FFL requirement for the shops fronting Lawrence Hargrave Drive is for the FFL’s to be **as close to the design floor level as practical. Where below the design floor level, more than 30% of the floor area to be above the design floor level or premises to be flood proofed below the design floor level.**

In this regard, the proposal is a robust one. The FFL’s meet the DCP requirement, because they are **as close to the design floor level as practical.** The FFL’s of the proposed shops offer a balance between maximising flood protection, and ensuring a consistent façade and urban design outcome, together with the range of other considerations regarding these FFL’s (i.e. disabled access). To this end, the proposal meets the DCP standard for FFL’s.

However, to add robustness to the proposal, where Council has any lingering concerns regarding the FFL height of these shops, they could also be readily flood-proofed, either in isolation or as part of a managed flood protection system. Standard flood barrier systems could be readily established at the shop fronts and entrances. These can be activated by the shop-keeper during business hours when required, and can simply be installed at the end of each evening in case flooding occurs during non-business hours. The need for flood protection needs to be considered in context – all shops are above the 1% AEP peak flood levels, and so the need for protection is not something that is likely to be experienced frequently.

Further bolstering of this approach could be readily achieved via a warning system and an alarm issued via centre management. A trigger level could be set-up inside the OSD tank, and when the runoff in the tank reaches a certain level an alarm could sound to all occupants of the development to install the flood barriers and to expect imminent flooding on Lawrence Hargrave Drive. The development of such a warning system could be conditioned as part of the consent for the proposal.
6 CONCLUSIONS AND RECOMMENDATIONS

Based on the information contained within this report, it can be concluded that:

- The subject site is a series of sites known as Thirroul Plaza, Thirroul. The applicant seeks to demolish the existing plaza building and carpark, and replace it with a multi-level carpark, commercial and residential development.

- The site is currently denoted as flood affected under WCC’s Hewitts Creek Flood Study Addendum Final (WBM-BMT, 2015).

- A detailed 2D TUFLOW model has been developed by Rienco for the Hewitts Creek between areas immediately above the Illawarra Railway Line and immediately downstream of Lawrence Hargrave Drive.

- 1% AEP flood levels throughout the site have been quantified using Rienco’s detailed hydraulic modelling.

- The 1% AEP and PMF peak flood levels at the site varies considerably and is shown in the detailed maps contained within this report.

- Design flood behaviour is generally consistent with Council’s adopted Hewitts Creek Flood Study Addendum Final (WBM-BMT, 2015), with differences in results attributable to:
  - The much finer hydraulic model grid resolution,
  - The inclusion of the 1D stormwater network that has been validated by survey,
  - A much more detailed surface roughness map,
  - Provision of detailed ground survey as opposed to the ALS, for much of the subject site and surrounds.

- The Flood Planning Level for the proposed development has been determined based on the peak water surface level in the OSD tank during the 1% AEP design event.

- The proposed development is located on land designated as Low Provisional Hydraulic Hazard area, and thus a Medium Flood Risk Precinct under WCC’s DCP.

- In terms of offsite impacts, these have been quantified in detail in this report, and are not considered to be adverse, significant or detrimental.

- The proposed development is suitable when taking into account WLEP 2009 (Clause 7.3), and WDCP 2009 Chapter E13’s performance criteria.

- In an extreme flood event, such as the PMF, residential occupants will be safe as all residential floor space is above the PMF.

- The proposed development significantly improves the flood affectation of many existing properties adjoining the site, and develops the land consistent with the objectives of the zone, in a manner that reduces flood risk to life and flood damages considerably.

Based on the information contained within this report, it is recommended this report is included in the submission to WCC for the proposed development.

Prepared by:

Anthony Barthelmess
Dip. Eng, MEng. MIEAust CPEng RPEQ NER
Managing Director
7 REFERENCES AND BIBLIOGRAPHY


# Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEP</td>
<td>Annual Exceedance Probability; The probability of a rainfall or flood event of given magnitude being equalled or exceeded in any one year.</td>
</tr>
<tr>
<td>AHD</td>
<td>Australian Height Datum: National reference datum for level</td>
</tr>
<tr>
<td>ALS</td>
<td>Air-borne Laser Scanning; aerial survey technique used for definition of ground height</td>
</tr>
<tr>
<td>ARI</td>
<td>Average Recurrence Interval; The expected or average interval of time between exceedances of a rainfall or flood event of given magnitude.</td>
</tr>
<tr>
<td>EDS</td>
<td>Embedded Design Storm; synthesised design storm involving embedment of an AR&amp;R design burst within a second design burst of much longer duration</td>
</tr>
<tr>
<td>FSL</td>
<td>Flood Surface Level;</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information Systems; A system of software and procedures designed to support management, manipulation, analysis and display of spatially referenced data.</td>
</tr>
<tr>
<td>IFD</td>
<td>Intensity-Frequency-Duration; parameters describing rainfall at a particular location.</td>
</tr>
<tr>
<td>ISG</td>
<td>Integrated Survey Grid; ISG: The rectangular co-ordinate system designed for integrated surveys in New South Wales. A Transverse Mercator projection with zones 2 degrees wide (Now largely replaced by the MGA).</td>
</tr>
<tr>
<td>LEP</td>
<td>Local Environment Plan; plan produced by Council defining areas where different development controls apply (e.g. residential vs industrial)</td>
</tr>
<tr>
<td>LGA</td>
<td>Local Government Area; political boundary area under management by a given local council. Council jurisdiction broadly involves provision of services such as planning, recreational facilities, maintenance of local road infrastructure and services such as waste disposal.</td>
</tr>
<tr>
<td>MGA</td>
<td>Mapping Grid of Australia; This is a standard 6° Universal Transverse Mercator (UTM) projection and is now used by all states and territories across Australia.</td>
</tr>
<tr>
<td>MHI</td>
<td>Maximum Height Indicator; measuring equipment used to record flood levels</td>
</tr>
<tr>
<td>PMF</td>
<td>Probable Maximum Flood; Flood calculated to be the maximum physically possible.</td>
</tr>
<tr>
<td>PMP</td>
<td>Probable Maximum Precipitation; Rainfall calculated to be the maximum physically possible.</td>
</tr>
<tr>
<td>RCP</td>
<td>Reinforced Concrete Pipe;</td>
</tr>
<tr>
<td>km</td>
<td>Kilometre; (Distance = 1,000m)</td>
</tr>
<tr>
<td>m</td>
<td>Metre; (Basic unit of length)</td>
</tr>
<tr>
<td>m²</td>
<td>Square Metre; (Basic unit of area)</td>
</tr>
<tr>
<td>ha</td>
<td>Hectare; (Area =10,000 m²)</td>
</tr>
<tr>
<td>m³</td>
<td>Cubic Metre; (Basic unit of volume)</td>
</tr>
<tr>
<td>m/s</td>
<td>Metres/Second; (Velocity)</td>
</tr>
<tr>
<td>m³/s</td>
<td>Cubic Metre per Second; (Flowrate)</td>
</tr>
<tr>
<td>s</td>
<td>Second; (basic unit of time)</td>
</tr>
<tr>
<td>WCC</td>
<td>Wollongong City Council; name of the council with jurisdiction over the Wollongong LGA</td>
</tr>
</tbody>
</table>
## Technical Terms

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alluvium</td>
<td>Material eroded, transported and deposited by streams.</td>
</tr>
<tr>
<td>Antecedent</td>
<td>Pre-existing (conditions e.g. wetness of soils).</td>
</tr>
<tr>
<td>Catchment</td>
<td>Area draining into a particular creek system, typically bounded by higher ground around its perimeter.</td>
</tr>
<tr>
<td>Critical Flow</td>
<td>Water flowing at a Froude No. of one.</td>
</tr>
<tr>
<td>Culvert</td>
<td>An enclosed conduit (typically pipe or box) that conveys stormwater below a road or embankment.</td>
</tr>
<tr>
<td>Discharge</td>
<td>The flowrate of water.</td>
</tr>
<tr>
<td>Escarpment</td>
<td>A cliff or steep slope, of some extent, generally separating two level or gently sloping areas.</td>
</tr>
<tr>
<td>Flood</td>
<td>A relatively high stream flow which overtops the stream banks.</td>
</tr>
<tr>
<td>Flood storages</td>
<td>Those parts of the floodplain important for the storage of floodwaters during the passage of a flood.</td>
</tr>
<tr>
<td>Floodways</td>
<td>Those areas where a significant volume of water flows during floods. They are often aligned with obvious naturally defined channels and areas which, if partly blocked, would cause a significant redistribution of flow.</td>
</tr>
<tr>
<td>Flood Fringes</td>
<td>Those parts of the floodplain left after floodways and flood storages have been abstracted.</td>
</tr>
<tr>
<td>Froude No.</td>
<td>A measure of flow instability. Below a value of one, flow is tranquil and smooth, above one flow tends to be rough and undulating (as in rapids).</td>
</tr>
<tr>
<td>Geotechnical</td>
<td>Relating to Engineering and the materials of the earth’s crust.</td>
</tr>
<tr>
<td>Gradient</td>
<td>Slope or rate of fall of land/pipe/stream.</td>
</tr>
<tr>
<td>Headwall</td>
<td>Wall constructed around inlet or outlet of a culvert.</td>
</tr>
<tr>
<td>Hydraulic</td>
<td>A term given to the study of water flow, as relates to the evaluation of flow depths, levels and velocities.</td>
</tr>
<tr>
<td>Hydrodynamic</td>
<td>The variation in water flow, depth, level and velocity with time.</td>
</tr>
<tr>
<td>Hydrology</td>
<td>A term given to the study of the rainfall and runoff process.</td>
</tr>
<tr>
<td>Hydrograph</td>
<td>A graph of flood flow against time.</td>
</tr>
<tr>
<td>Hyetograph</td>
<td>A graph of rainfall intensity against time.</td>
</tr>
<tr>
<td>Isohyets</td>
<td>Lines joining points of equal rainfall on a plan.</td>
</tr>
<tr>
<td>Manning’s n</td>
<td>A measure of channel or pipe roughness.</td>
</tr>
<tr>
<td>Orographic</td>
<td>Pertaining to changes in relief, mountains.</td>
</tr>
<tr>
<td>Orthophoto</td>
<td>Aerial photograph with contours, boundaries or grids added.</td>
</tr>
<tr>
<td>Pluviograph</td>
<td>An instrument which continuously records rain collected</td>
</tr>
<tr>
<td>Runoff</td>
<td>Water running off a catchment during a storm.</td>
</tr>
<tr>
<td>Scour</td>
<td>Rapid erosion of soil in the banks or bed of a creek, typically occurring in areas of high flow velocities and turbulence.</td>
</tr>
<tr>
<td>Siltation</td>
<td>The filling or raising up of the bed of a watercourse or channel by deposited silt.</td>
</tr>
<tr>
<td>Stratigraphy</td>
<td>The sequence of deposition of soils/rocks in layers.</td>
</tr>
<tr>
<td>Surcharge</td>
<td>Flow unable to enter a culvert or exiting from a pit as a result of inadequate capacity or overload.</td>
</tr>
<tr>
<td>Topography</td>
<td>The natural surface features of a region.</td>
</tr>
<tr>
<td>Urbanisation</td>
<td>The change in land usage from a natural to developed state.</td>
</tr>
<tr>
<td>Watercourse</td>
<td>A small stream or creek.</td>
</tr>
</tbody>
</table>
APPENDIX A – SITE SURVEY
APPENDIX B – DEVELOPMENT LAYOUT PLAN
APPENDIX C – DETAILED MODEL RESULTS
APPENDIX C1 – 1% AEP DESIGN MODEL RESULTS – PRE-DEVELOPMENT
Figure C1.1: 1% AEP Flood Levels
Figure C1.2: 1% AEP Flood Depths

Note: Flood depths shaded from 0m (light blue) to 1.0m (dark blue). All depths over 1.0m shaded dark blue.
Figure C1.3: 1% AEP Flood Velocity

Note: Flood velocity shaded from 0 m/s (yellow) to 4.0 m/s (orange). All velocity over 4.0 m/s shaded orange.
APPENDIX C2 – 1% AEP DESIGN MODEL RESULTS – POST-DEVELOPMENT
Figure C2.1: 1% AEP Flood Levels
Figure C2.2: 1% AEP Flood Depths

Note: Flood depths shaded from 0m (light blue) to 1.0m (dark blue). All depths over 1.0m shaded dark blue.
Figure C2.3: 1% AEP Flood Velocity

Note: Flood velocity shaded from 0 m/s (yellow) to 4.0 m/s (orange). All velocity over 4.0 m/s shaded orange.
APPENDIX C3 – PMF MODEL RESULTS – PRE-DEVELOPMENT
Figure C3.1: PMF Flood Levels
Figure C3.2: PMF Flood Depths

Note: Flood depths shaded from 0m (light blue) to 1.0m (dark blue). All depths over 1.0m shaded dark blue.
Figure C3.3: PMF Flood Velocity

Note: Flood velocity shaded from 0 m/s (yellow) to 4.0 m/s (orange). All velocity over 4.0 m/s shaded orange
APPENDIX C4 – PMF MODEL RESULTS – POST-DEVELOPMENT
Figure C4.2: PMF Flood Depths

Note: Flood depths shaded from 0m (light blue) to 1.0m (dark blue). All depths over 1.0m shaded dark blue.
Figure C4.3: PMF Flood Velocity

Note: Flood velocity shaded from 0 m/s (yellow) to 4.0 m/s (orange). All velocity over 4.0 m/s shaded orange.
APPENDIX C5 – ADDITIONAL MODEL EXTRACTS
Figure C5.1: Post-Development Surface Roughness Map
Figure C5.2: 1% AEP Peak Flood Depths for Extent of Model
Figure C5.3: PMF Peak Flood Depths for Extent of Model